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HST Phase II Proposal Instructions for Cycle 15

SPACE TELESCOPE SCIENCE INSTITUTE

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Revision History

Version	Type	Date	Editor
14.0	GO	March 2005	David Soderblom and Jim Younger
15.0	GO	March 2006	Ron Downes and Jim Younger • Updated for Phase II Cycle 15 (See Section 1.2, “Changes Since the Previous Version,” on page 4)

Version 15.0 is issued in coordination with the APT release and is intended to be fully compliant with Cycle 15 APT.

This is the General Observer version. If you would like some hints on how to read and use the PDF document, click on: Some Pointers in PDF and APT JavaHelp

How to get help

1. Visit STScI’s Web site:

   `http://www.stsci.edu/`

   where you will find resources for observing with HST and working with HST data.

2. Contact your Program Coordinator (PC) or Contact Scientist (CS) you have been assigned. These individuals were identified in the notification letter from STScI.

3. Send e-mail to help@stsci.edu, or call 1-800-544-8125.
   From outside the United States, call 1-410-338-1082.

Table of Contents

HST Phase II Proposal Instructions for Cycle 15

PART I:

Phase II Proposal Writing

The chapters in this section explain how to use the Phase II Instructions, how to fill out your Phase II information file and submit it to STScI. It also explains where to go for help and describes the information that must be submitted to STScI by GOs and GTOs during Phase II.

CHAPTER 1:

About This Document

In this chapter. . .

Proposals to observe with Hubble Space Telescope (HST) are reviewed in two phases managed by the Space Telescope Science Institute (STScI). In Phase I, proposers submitted an Observation Summary for review by the Telescope Allocation Committee (TAC). The Observation Summary provides only general descriptions of the targets and of the proposed observations. The TAC review results in a list of accepted proposals.

During Phase II, General Observers (GOs) with accepted proposals, as well as Guaranteed Time Observers (GTOs), must provide complete details of their proposed observations so that STScI can conduct a full technical feasibility review. The Phase II information will then be used to schedule the actual observations and obtain data.

This document, the *Phase II Proposal Instructions*, has the following purposes:

- To describe the information that must be submitted to STScI by GOs and GTOs during Phase II.
- To describe what you have to provide in APT (Astronomer's Proposal Tool).
- To show how to submit the information to STScI.

Readers of this document should be familiar with the Cycle 15 *Call for Proposals*, issued in October 2005, and with the *Instrument Handbooks*.

***Note on colors in the GO Version:* *Blue text shows active external references and cross-references to other parts of this document. Brown text pertains to use of the Text Proposal File*.**

1.1 Document Design and Structure

These Instructions are meant to be read on-line, not on paper, although many readers may wish to print selected portions. Many cross-references have been added to make navigation easy and convenient. A comprehensive table of contents allows you to go directly to chapters, sections and subsections.

Each chapter starts with a listing of sections and subsections, each linked to its page. Near the beginning of most chapters, a list of figures and tables is provided; this list is cross-referenced for convenient navigation to a particular item you may wish to examine.

Also, an index has been provided.

1.2 Changes Since the Previous Version

Initial Release for Cycle 15. Significant changes include:

- In coordination with the installation of the GSC2, a new fixed target keyword, **Reference_Frame**, has been added (Chapter 3)
- More options have been added to the Category and Description keywords (Chapter 3)
- New ACS Quadrant Apertures have been added (Chapter 11)

1.3 Document Presentation

Navigation

Cross-references and external references highlighted in blue can be accessed by clicking on the item.

Text Proposal File Instructions

Sections and text in brown have been added for those proposers who elect to export, and then edit their proposal in a Text Proposal File. For guidelines on when you might use this template, see “Using the Text Proposal File” in Chapter 2.

Available Formats

Proposers can access this information in two formats: PDF via the Web and Sun JavaHelp via the Astronomer’s Proposal Tool (APT).

- The PDF version available on the Web will be the only one that you can be certain is up-to-date. It can be downloaded and printed if you wish, and when used on-line provides “instant” access to internal and external cross-references.
- The JavaHelp version available in APT should not be printed due to the limitations of printing in Java. You can use the internal cross-references, but the external references in JavaHelp have been disabled.

Reader Feedback

We have striven to present this critical, detailed, and complex information in a form that allows it to be used accurately and effectively. Your comments on its good and bad qualities will help us in the future; send e-mail to help@stsci.edu.

1.4 Technical Content

Available Science Instruments for Cycle 15

The Advanced Camera for Surveys (ACS) and NICMOS are available in Cycle 15, as well as WFPC2 and FGS.

Instrument Modes, Special Requirements, etc.

Some changes have been made to these Instructions since the previous version to correct errors and omissions, and to document new modes or options. There are too many to list, but as long as you use the most recent version the information provided should reflect our current state of knowledge.

1.5 Where to Find Additional Information

As you write your Phase II proposal, you will probably need to consult the *Instrument Handbooks* for additional information on one or more Science Instruments. These handbooks are available on the Web in both PDF and HTML versions at
http://www.stsci.edu/hst/HST_overview/documents

There are some policies that were delineated in the *Call for Proposals*, which asked for Phase I proposals. You may wish to review those, particularly the sections discussing limited resources.

1.6 Some Pointers in PDF and APT JavaHelp

PDF Online and Print

Adobe's Portable Document Format (PDF) is the standard for the commercial sector because it is easily produced with modern documentation software and has many excellent features. If you're new to PDF here are some hints that you may find useful:

- PDF has links, just like HTML. Everything in blue in this document is a link you can click on to go somewhere else.
- PDF can print selected pages. Note that the page numbers you enter are PDF's sequential numbers (look at the bottom of the Acrobat window to see where you are).
- PDF is searchable with most viewing software such as Adobe's Reader and Apple's Preview.
- You can move up or down page by page using the scroll bar on the right of your Acrobat window; just click above or under the indicator that shows your relative position. You can also click and hold on this indicator to speed through the document.
- If you wish to save this document as a PDF file on your local machine, click with your right mouse button on the Institute's Web page that has the Phase II information at the spot where you link to the PDF file. In other words, your left button opens the file in Acrobat, but the right button lets you save the file if you pull down to "Save Link as."
- Look at Acrobat's help facility (the help button is in the upper right corner of the Acrobat window) for more pointers.

APT JavaHelp

The Astronomer's Proposal Tool (APT) user interface provides access to this document via Sun JavaHelp -- a help format specifically designed for Java-based applications.

- The internal cross-references are linked (in blue), but all external references have been disabled.
- The JavaHelp viewer provides access to a table of contents and an index; all the listed items are linked to the referenced sections. Once you are in a document, you can use the table of contents, the index, or the cross-references in the text to navigate to other parts of the document as you would in html.
- JavaHelp has a very useful search utility.
- Some of the sections in the Phase II Instructions are used for "context-sensitive" help in APT. At the top of the APT user interface, click on the "Help" menu item for access to this document and instructions on how to use the context-sensitive help.

We welcome your comments and thoughts for improving how we provide information to you.

CHAPTER 2:

The Basics of Phase II Proposals

In this chapter . . .

2.1 How to Prepare and Submit Phase II Information

The computer software used to schedule and execute HST observations can interpret the proposal information only if it is in the proper format. Therefore, proposals must be filled out accurately, completely, and in strict accordance with the instructions in this document. Observers now have the capability and responsibility, with the help of their Program Coordinator (PC) and/or Contact Scientist (CS) for creating and submitting proposals that are not only syntactically correct but also feasible and schedulable. The Astronomer's Proposal Tool (*APT*) will help you achieve this.

2.1.1 Astronomer's Proposal Tool (APT)

With APT you can prepare your Phase II program on your computer and then submit it electronically to STScI. You will use a copy of your Phase I proposal (marked up in XML), which contains all the information from your Phase I submission. If you haven't done so already, please consult the *APT Web Page* for detailed instructions on how to install and use APT on your computer. Observers without access to a suitable computer platform to run APT for Phase II should contact their PC.

2.1.2 Entering Information: The APT Graphical User Interface (GUI) versus the Text Proposal File

In the previous proposal entry system, RPS2, you could enter and edit information as text (usually in the form <keyword>=<value>) using a template and your favorite text editor. Also, you could use the Proposal Editor (PED), a graphical editor in RPS2 designed for editing your Phase II program.

In APT you can enter proposal information by using either the APT Form/Spreadsheet Editors via a GUI or a **Text Proposal File** that employs a "simplified" RPS2 syntax. This text file has been developed for APT as an alternative method for editing proposals outside of the APT GUI; you use a flat ASCII file format that is similar to the RPS2 .prop file that was used in HST cycles 5-11. Small changes to the original RPS2 format were necessary to accommodate enhancements that came with APT, and some of the syntax has been made stricter in order to make reading of the file more robust. You create this file in APT by exporting your proposal into a text proposal file format (for details please see the *APT Web Page*).

Using the APT GUI

In most of the fields in the APT graphical interface, you choose a keyword or parameter <value> in a list from a pull-down menu, or check a box. In a few other fields (e.g., **Other Fluxes**, **Observing Windows** and **Criteria** in the Targets forms) you enter free text in the field using the formats specified in this document. Required items are marked with a red “**x**” if you haven’t selected or entered a <value>. Also, for many of the keywords, a tooltips message will appear when you place your pointer on the keyword: <value> area.

Using the Text Proposal File

When creating or editing large repetitive proposals, editing with APT’s graphical interface can be inefficient and prone to error. We present two examples where you may want to use a text proposal file.

1. You are building a large repetitive program with many targets and visits in order to create a mosaic. Initially, you would use APT to build a proposal that has one or two targets and one of each of the unique visits. You would then run the Orbit Planner and Visit Planner to make sure that the visits fill the right number of orbits and schedule. Then, you would export this small template proposal to the Text Proposal File format, and use scripts or your favorite editor to build your program into a larger version. You would then import the resulting file back into APT for checking and processing.

2. You have already built a fairly large program in APT by creating unique exposures and visits, and then used the duplicate and multiple duplicate features in APT. Then, you discover that you need to make a small change to a large number of exposures (such as removing or adding an optional parameter). This would be tedious to do in the APT GUI, but straightforward in the Text Proposal File. Simply export your program to the Text Proposal File format, make your changes in an editor, and then import the Text Proposal File back into APT for new processing.

Table 2.1 summarizes some of the differences between the APT GUI and the **Text Proposal File**.

Table 2.1: Comparison of APT GUI and the Text Proposal File

	Data Entry Method	Syntax	Help Features and Error Checking
APT	Use the Form or Spreadsheet Editors via the APT User Interface	For most of the fields (exceptions noted below[1]), choose a keyword <value> from a pull-down list, or check a checkbox, or enter a text <value> in the field provided.	1) Required data marked with a red x 2) Tooltips (e.g., a message noting a required item and its format) provided during data entry 3) Context-sensitive help available
Text Proposal File	After exporting your proposal from APT to the text file, edit it using your favorite editor.	Enter free text in the file in the form <keyword> =<value>. You must conform to the proper syntax described in this document.	None while editing. After editing your proposal, you must import it back into APT (see the APT Web page for instructions). Once you have imported your program back into APT you can run the diagnostics tool.

1. The exceptions are:
- **Other Fluxes** field for all types of Targets
- **Criteria** field for Generic Targets

In these fields you must enter text (<keyword>, <value> and any separators) exactly as described in the relevant sections of this document.

2.1.3 APT Tools

APT also provides tools to help you plan your observations, such as the Visual Target Tuner (VTT), an Orbit Planner and a Visit Planner. If you have any problems using APT, or have any questions about your proposal, please feel free to contact your assigned Program Coordinator (PC) and/or Contact Scientist (CS). Programs without an assigned CS may also contact help@stsci.edu for help with APT.

2.1.4 Submitting Your Program

After you submit your Phase II program, the APT system will give you an automatic electronic acknowledgment. This should be followed in a few days by an acknowledgment from your PC. If, at the time of submission, the proposal contains errors, the APT submission system will give a warning, but will allow the proposal to be submitted. However, the proposal will be flagged, and your PC will contact you within a few days to discuss how to proceed.

The resolution of errors in the Phase II Program is the responsibility of the Principal Investigator. The fact that APT may allow you to submit a program that contains errors does not mean that your program can or will be scheduled.

We strive to make APT a useful aid for preparing and checking your Phase II program, but it is nevertheless imperfect. On rare occasions syntax errors are not detected. Also, APT does not check for guide stars.

2.2 What to Submit

Observers must submit their Phase II proposal to STScI by the Phase II deadline. It should contain the following:

- **Updated Proposal Information:** This section includes the title, the abstract, a Phase II ID, a proposal description, PI and CoI information. Please note that some general information is very useful for a thorough and helpful technical review of your proposal. You may wish to include parts of your Phase I science discussion, but please note that all the Phase II information you provide will be freely available via the Web.
- **Target Information:** The information for one or more of the Fixed, Solar System, or Generic Targets must be completed. If necessary, proper motion and parallax information should be supplied for fixed targets. Detailed instructions for filling out the target data, as well as the proper motion and parallax information, are provided in Chapter 3: Fixed and Generic Targets on page 25 and Chapter 4: Solar System Targets on page 59 of this document.

- **Visit, Exposure Group, and Exposure Specifications:** These specifications include orientation information, scheduling requirements, SI information, exposure special requirements and so on. Required items will be clearly noted as you complete the specifications. General instructions for completing this section are provided in Chapter 5: Visits, Exposures and Exposure Groups on page 87 of this document.

2.3 General Instructions

When you first bring up APT, you will have to convert the information in your Phase I proposal, which is an XML file, into a Phase II program format using the “Phase I->Phase II” conversion button on the APT User Interface.

Note the following general instructions and conventions when entering your Phase II information:

- After converting your Phase I Proposal into Phase II information, please verify that all the general information is correct and readable.
- Entries in text must precisely conform to the formats specified in this document. If you have decided to use the **Text Proposal File**, the order of the entries must be correct as well (see Section 2.5 on page 20).
- Proposal data text may contain only standard ASCII characters. All other symbols must be spelled out. Greek letters must be spelled out (e.g. **BETA-LYR**, **H-ALPHA**). The degree sign should be replaced with “D” (e.g. **BD+16D516**). Subscripts and superscripts are not allowed.
- Additional information not covered by the keywords and values already provided may be entered in the “**Additional Comments”** or **“Comments”** boxes**.**
- When providing a Target “**Description**” please use the target keywords and syntax presented in Tables 3.2 to 3.10 and Table 4.2.

If you are unable to use the APT software, please contact your PC (listed in your notification letter) to make other arrangements.

2.3.1 Proposal Information [Proposal_Information]

This block contains basic information about the proposal including the **Title**, **Abstract**, **Category**, and **Cycle**. After converting your proposal from

Phase I to Phase II, your Phase II program will have the program information filled out based on your Phase I submission.

Proposal Title

Abstract

The Abstract from your Phase I submission has been included in your Phase II information. Please check this since you may need to update this text based on your final TAC allocation.

If a Phase II submission is not based on a Phase I proposal, please fill in missing information.

Phase II ID

This ID will be provided to you by your Program Coordinator.

Proposal Cycle

Unless you have been told otherwise, the **Cycle** should be **15**. Multiple values of **Cycle** are not permitted.

Proposal Category

For those Phase II submissions that are not based on a Phase I proposal, the **Category** should be selected from one of the following:

GO (General Observer)	**GO/DD** (Director’s Discretionary time)
SNAP (snapshot proposals)	**GTO** (Guaranteed Time Observer)

A **Category** of **SNAP** is used for “snapshot” programs. By their nature these programs take advantage of otherwise-unused blocks of telescope time for relatively short exposures. **SNAP** exposures therefore must carry as few restrictions as possible. In particular, Special Requirements should not ordinarily be used with **SNAP** programs (consult with your Program Coordinator if you feel you need to do so). Also, less-restrictive guiding is ordinarily used for **SNAP** exposures because that is adequate for short exposures and because that helps extend FGS lifetimes. Some special policies apply to **SNAP** programs. In particular, STScI will not repeat failed **SNAP** exposures.

For pure parallel proposals (see 6.2 Pure Parallels on page 103), check the “Parallel” checkbox next to the Proposal Category in the Proposal Information form. Please note that **SNAP/PAR** is not a valid proposal type.

Availability

You must choose **supported**. If the observing modes normally offered by STScI to GOs do not meet the needs of your program, please contact your Program Coordinator.

Parallel Pointing Tolerance

This information is required with pure parallel proposals.

The **Parallel_Pointing_Tolerance** gives the maximum acceptable variation in pointing at the parallel aperture during a parallel visit. The units are arcsec but must be explicitly stated. The number must be non-negative (e.g., **10**). This will normally be set to the maximum pointing change that still allows exposures taken at slightly different pointings to be combined later during data analysis.

2.3.2 Proposal Description

Proposal Text Sections

These four sections are needed for STScI to execute your program properly. Not all questions will need to be answered by every observer, and note that the answers to these questions will be made public. As with the **Abstract**, please review this text to make certain the information is correct.

Description of Observations **[Observing_Description]**

Provide a detailed description of your observing plans. Text from your Phase I proposal has been inserted, but it will need updating based on your final TAC allocation and on details worked out in Phase II.

Justification of Real-time observations and Special Scheduling Requirements **[Realtime_Justification]**

Provide an explanation for any real-time or special scheduling requirements, if they have been requested. Information from your Phase I proposal has been inserted, but it is possible that the text will need updating based on your final TAC allocation, to include the details worked out in Phase II, and to remove any special calibration requirements (see below).

Justification of Special Calibration Requirements **[Calibration_Justification]**

Provide a justification for any special calibrations required for your program, if requested.

Additional Comments **[Additional_Comments]**

Provide any additional comments that you feel STScI needs to know in order to properly implement your program.

2.3.3 Investigators

These sections contain the names of the Principal Investigator (**PI**), all Co-Investigators[1] (**CoI**), and their institute affiliations. This information comes from your Phase I proposal submission. If one of the Co-Investigators (or another individual) is to serve as the contact for a program, then the **Contact** keyword box should be checked. The Contact is the person the Principal Investigator has designated to receive all (non-budgetary) questions/information on the program and to be the official voice for the team. Only one person may be designated as the Contact. Once designated, only the Contact may make Change Requests so that conflicting requests are not made.

If any of the Investigators have changed addresses between the Phase I and Phase II submissions (or any time after the Phase I submission), please contact your Program Coordinator with the updated address. You cannot use the Phase II submission to implement address changes.

For Phase II submissions that are not based on a Phase I proposal, please fill in the information accordingly.

2.3.4 Target Information [Fixed_Targets, Solar_System_Targets, Generic_Targets]

Chapter 3: Fixed and Generic Targets on page 25 and Chapter 4: Solar System Targets on page 59 describe how to fill out the Target Lists.

2.3.5 Visit Information [Visits]

Chapter 5: Visits, Exposures and Exposure Groups on page 87 of this document describes how to fill out the Visit and Exposure Specifications. Instructions for submitting parallel observations are given in Chapter 6: Parallel Science Exposures on page 101, and the detailed, instrument-specific parameters are described in Part II: Supported Science Instruments on page 169.

1. The number of CoIs is limited to 99.

2.4 Examples and General Advice

2.4.1 Acquisitions and Pointings

Getting HST located and oriented properly lies at the heart of successful observations, especially when a small aperture is being used, and there are a number of ways to do that. The remarks here apply specifically to fixed targets, and mostly apply to the use of small apertures, although many of them can be applied to moving targets as well. For more information, see Section 3.4 on page 36.

First, you have to acquire an object successfully that is at or near the position at which the science observation will be made. The object to be acquired should meet these conditions:

1. It should be a point source or nearly enough to point-like that the centering algorithms can determine a precise centroid.
2. The object's coordinates must be both precise and accurate and any proper motion must be known. This requirement boils down to the need for the object to fall within the search region at the time of the acquisition. For this to happen the coordinates must also be consistent with the Guide Star Catalog or they must fall within another system that can be related to the GSC. This is why the source of the acquired object's coordinates are required.
3. The object must be neither too bright nor too faint for the instrument mode used. These conditions are described in the various Instrument Handbooks.

The coordinates for the acquired object can be specified in several ways:

- As explicit absolute celestial coordinates, i.e., **RA** and **DEC**. See Section 3.4.2 on page 38.
- As celestial coordinates relative to another nearby object, using offsets in **RA** and **DEC**. See Section 3.4.3 on page 39.
- As a **REGION**; see Section 3.4.4 on page 41.

Second, once the acquisition has been made, the telescope must be repositioned to the precise point desired. This step is unnecessary, of course, if the object acquired in the first instance is the object to be observed. Repositioning can be implicit or explicit.

An **offset** is **implicit** when a target such as "XX-OFFSET" is acquired with some ACQ mode, and then "XX" is observed via a science exposure. This often leads to confusion because no specific motion of the telescope has been provided, but that motion is implied by specifying the separate targets with different coordinates. "XX-OFFSET" is specified for the acquisition because it is bright enough and point-like enough to be acquired successfully, but the coordinates specified by “XX” are what is to be observed.

An **offset** is **explicit** when you use a Special Requirement such as **POS TARG** (see **POSition TARGet <X-value>,<Y-value>**) to move the telescope away from the position acquired. In this scheme, the position specified in the acquisition is placed at the fiducial point for the aperture requested (in general the geometric center of the aperture). The **POS TARG** then moves the telescope relative to that nominal position. Thus **POS TARG**s are not cumulative, and always refer back to the original acquired position.

2.4.2 Examples

People who are looking for examples of APT files are encouraged to go to

http://archive.stsci.edu/hst/abstract.html

and do a search for a selection of proposals from the most recent cycle. For any program that appears as though it could serve as a useful example, the APT file can be obtained by typing the proposal ID number into the search form at

http://www.stsci.edu/hst/scheduling/program_information

Additionally, several examples of ACS dither patterns using POS TARGs which may be used in an APT proposal can be found on the ACS Web site at:

http://www.stsci.edu/hst/acs/proposing/dither

2.4.3 Common Problems

Incorrect Proposal Format

When you are entering text in a field the formats described in this document must be followed **exactly**, since the information in the forms is interpreted by computer software. Some items that warrant repetition are:

- Visit numbers must be unique.
- Target names must be spelled exactly the same throughout the proposal.
- The format for target positions must be followed to the letter. For more information on coordinates, see Section 3.13 on page 57.
- The format for flux data must be followed. Only those defined in these Instructions are acceptable.

- The format for Optional Parameters and Special Requirements must be followed to the letter.
- Observations which cannot be defined using the syntax in these Instructions may be described in Comments fields, but such comments should be used very sparingly, if at all, and their use may impede execution of a program.

Imprecise Target Positions

See the discussion of required position accuracies in Table 3.11: Required Coordinate Accuracies. The requirements are much more stringent than is typically the case for ground-based observations.

Lack of Acquisition Exposures with Small Apertures

When exposures are requested in very small apertures or fields of view, a separate acquisition exposure is generally required. Please consult the Instrument Handbooks for the instrument you are using.

2.4.4 Consideration of Limited Resources

Proposers should be aware that several of the Special Requirements impose serious constraints on the scheduling system because they require the use of limited resources; for example, **RT ANALYSIS** requires real-time use of the TDRSS that is only available some of the time. Hence these Special Requirements should be requested only if they are absolutely necessary to achieve the scientific goals of a project. It is quite possible that some proposals will be impossible to schedule because of their resource requirements, rather than a lack of scientific merit. The limited-resource Special Requirements can force the planning system to schedule the observations at a less than optimal time. The use of limited-resource Special Requirements by many observers can reduce the overall efficiency with which the planning system can schedule the science program. For these reasons, these Special Requirements should only be used when necessary to achieve the science objectives of the program. The STScI will review the necessity for the Special Requirements and in some cases may suggest removing them, or using alternate methods to obtain the same goal.

The following table summarizes the Special Requirements that involve seriously limited resources.

The need for many of these Special Requirements must be justified in the Proposal Description. Note that several of these Special Requirements must have been justified in the Phase I Proposal in order to be used legitimately in Phase II; those are **CVZ**, **SHADOW**, **LOW-SKY**, and **ON HOLD** for Targets of Opportunity.

Table 2.2: Limited-Resource Special Requirements

Limited Resource	Reason for constraint
ON HOLD [FOR <visit-list>]	Requires special handling (e.g., Targets of Opportunity).
RT ANALYSIS, **REQuires UPLINK**	Requires real-time TDRSS links, which are difficult to schedule and may be withdrawn at last moment.
ORIENTation <angle1> TO <angle2>, SAME ORIENTation AS <visit>	A specific orientation can be available for as little as a one-week period every six months.
SHADOW, LOW-SKY, CVZ	Available for only a fraction of orbits.
AFTER <date>, BETWEEN <date1> AND <date2>, BEFORE <date>, SEQuence <visits-checked> WITHIN <time>, SEQuence <exposure-list> NON-INTerruptible (replaced by Exposure Group Containers in the APT User Interface); see Section 5.19, "Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns," on page 98, PHASE <number1> TO <number2>,	Constrain scheduling opportunities. Can be mutually incompatible.

2.5 Text Proposal File

2.5.1 Basic Syntax Rules

Users (particularly RPS2 old-timers) should be aware that some changes to the original RPS2 format were necessary to accommodate enhancements that came with APT; also, some of the syntax has been made stricter in order to make parsing of the file more robust (e.g., for special requirements).

Here are a few basic rules that must be followed:

- Commas or semicolons must be used to delimit items in a list (see specific rules in the following bullets). New lines for each item *will not* be sufficient delimiters.
- Semicolons *must* be used to delimit Special Requirements items.

- Commas *must* be used to delimit items in all other lists including target descriptions, target position, fluxes, optional parameters, and spectral elements.
- Only the shortest forms of the special requirements will be accepted (e.g., **POS**ition **TARG**et must be **POS TARG**). For more information on special requirements see Chapter 7.
- Exposure lists in Special Requirements *must* be specified as a single range. No commas are allowed in an exposure list (e.g., use 1-5 instead of 1,2,3-5). As before, visit lists can have comma delimters.
- The Time_Per_Exposure *must* be specified in seconds.
- Dates should be in the form 01-Jan-2005:00:00:00 (as an example) with the hours:minutes:seconds being optional. Other formats will not be supported except for JD, which is used for **ZERO-PHASE**.

2.5.2 Sample Text Proposal File Template

Your **Text Proposal File** should include the following and in the order given. Optional blocks are in square brackets ([]). The use of colons is required in the form given. Note that at least one of the three target types (Fixed, Solar System, or Generic) must be present. You can make your own template in APT from your Phase I proposal by opening it in APT and changing it to Phase II. Then enter your Phase II ID number, add a visit, and then export to a text proposal file (If you have already retrieved your proposal from STScI using the Phase II ID given to you by your PC, then the Phase II ID number will have already been filled in).

Proposal_Information

```
Title:
Proposal_ID:
Proposal_Category:
Cycle:
[Avail_Ok:]
[StScI_Edit_Number:]
```

[Parallel_Information

```
Parallel_Pointing_Tolerance]
```

Investigators

```
PI_Honorific:
PI_First_Name:
PI_Middle_Initial:
```

```
PI_Last_Name:
PI_Institution:
[CoI_Name:
CoI_Honorific:
CoI_Middle_Initial:
CoI_First_Name:
CoI_Last_Name:
CoI_Institution:
[Contact:]]
```

Abstract

Questions

```
Observing_Description:
[Real_Time_Justification:]
[Calibration_Justification:]
[Additional_Comments:]
```

[Fixed_Targets

```
Target_Number:
Target_Name:
[Alternate_Names:]
Description:
Position:
Equinox:J2000
Coordinate_Source:
[RV_or_Z:]
[RA_PM:]
[Dec_PM:]
[Epoch:]
[Annual_Parallax:]
Flux:
[Other_Fluxes:]
[Comments:]]
```

[Solar_System_Targets

```
Target_Number:
Target_Name:
Description:
Level_1:
[Level_2:]
[Level_3:]
[Window:]
[Ephem_Uncert:]
[Acq_Uncert:]
Flux:
```

```
[Other_Fluxes:]
[Comments:]]
```

[Generic_Targets

```
Target_Number:
Target_Name:
Description:
Criteria:
Flux:
[Other_Fluxes:]
[Comments:]]
```

[Pattern_Data

```
Pattern_Number:
Primary_Pattern:
Pattern_Type:
Pattern_Purpose:
Number_Of_Points:
Point_Spacing:
Line_Spacing:
Coordinate_Frame:
Pattern_Orient:
Angle_Between_Sides:
Center_Pattern:
[Secondary_Pattern:
Pattern_Type:
Pattern_Purpose:
Number_Of_Points:
Point_Spacing:
Line_Spacing:
Coordinate_Frame:
Pattern_Orient:
Angle_Between_Sides:
Center_Pattern:]
[Pattern_Comments:]]
```

Visits

```
Visit_Number:
[Visit_Priority:]
[Visit_Requirements:]
[On_Hold_Comments:]
[Visit_Comments:]

Exposure_Number:
[Exposure_Label:]
Target_Name:
```

```
Config:
Opmode:
Aperture:
Sp_Element:
[Wavelength:]
[Optional_Parameters:]
Number_of_Iterations:
Time_Per_Exposure:
[Special_Requirements:]
[Sub_Exposures:]
[Comments:]
```

CHAPTER 3:

Fixed and Generic Targets

In this Chapter . . .

Tables and Figures

The use of "FIXED_TARGETS" and "GENERIC_TARGETS" are described in this chapter. To make the presentation of this material more concise, the section on solar system targets has been made into a separate chapter; see Chapter 4: Solar System Targets on page 59.

The Target List tells us where you wish to point HST and so must be filled out with care, precision, and accuracy. The Target List also provides the information that defines and describe the targets, and which was used to determine exposure times. Three different kinds of Target Lists exist for the following three classes of targets, but only the Target List(s) required for your proposal need be submitted:

- Fixed targets (all targets outside the solar system whose positions can be defined by specific celestial coordinates);
- Solar-system targets (all moving targets);

- Generic targets (targets defined by certain properties, rather than by specific coordinates).

In this chapter, each heading has a description followed by a keyword in square brackets (e.g., [**Number]**). Elsewhere, items in boldface (e.g., **RA**) show words or phrases that are used as APT Phase II keywords or properties. Items in <> brackets (e.g., <value>) show values you provide. Values of items listed in square brackets (e.g., [**A1**: <value>]) are optional, whereas those **not** in square brackets are required. As you enter information in the *APT interface*, you will be told (via a tooltips message) if an item is required.

3.1 Target Number [Target_Number]

Each target in your program will be assigned its own unique number by APT (they are base 10 and go from 1 to 999). A different target must be defined whenever different coordinates or a different target description are required. Separate targets should be defined and listed if you plan to take observations at several points within an extended object. For example, if you were to take spectra at three different locations in the Crab Nebula, each point must have its own target number, name, and coordinates, such as CRAB1, CRAB2, and CRAB3.

If you are using the **Text Proposal File**, all target numbers and names within a proposal must be unique.

3.2 Target Name [Target_Name and Alternate_Names]

Target names provide unique designations for the targets that will be used throughout the proposal. These names will also be used to designate targets in the HST data archive. Prospective proposers and archival researchers use these names to determine whether HST has observed a particular object. This facility will be most useful if consistent naming conventions are used.

The following conventions must be followed in naming targets:

- A new target name must be defined for each (celestial) target. For example, for several pointings within a galaxy, one might define target names such as **NGC4486-NUC**, **NGC4486-JET**, **NGC4486-POS1**, and **NGC4486-POS2**.
- The length of a target name must be anywhere from 2 to 31 characters.

- **No blanks are permitted in target names**. Blanks between a letter and a numeral must be suppressed (e.g., **HD140283**, **NGC4378**), but a hyphen (and *not* an underscore) must replace blanks between two letters or two numerals (e.g., **ALPHA-CEN**, **NGC224-0040+4058**). Also, a hyphen should be used where required for clarity (e.g., **NGC4486-POS1**).
- Only letters, numerals, hyphens, periods (.), and **+** or **–** are allowed in target names; other punctuation is not permitted (e.g., **BARNARDS-STAR** is valid, but **BARNARD'S-STAR** is not). Greek letters must be spelled out (e.g., **ALPHA-ORI**). Letters may be upper-case or lower-case, but will always be treated as if they are upper case (e.g. **Alpha-Cen** will be treated as if written **ALPHA-CEN**).
- Degree signs must be represented by an upper-case "**D**" (e.g., CD-42°14462 becomes **CD-42D14462**).
- Some special target names are reserved for calibrations and other purposes and may **not** be used for names of external pointings; see Table 3.1: Designations of Special Targets.

Whenever possible, two types of designations should be provided for each target. The first will be a "catalog name" (for example, **HD124897**), and the second will be at most two "common names" (e.g., **ALPHA-BOO**, **ARCTURUS**). The "catalog name" is entered in **Name** and the "common names" are entered in **Alternate_Names**.

Only **Target_Name** is used when the target name is repeated in the Visit and Exposure Specifications. If the target is in the STScI Guide Star Catalog (GSC), the GSC name should be included as one of the common names (e.g., **GSC5637-12345**).

3.2.1 Catalog Name

The preferred order for catalogs to be used for the designation of various classes of objects is provided below. It is arranged in order of decreasing preference.

If a target is not contained in these catalogs, other catalog designations may be used (e.g., 4U X-ray catalog designation, Villanova white-dwarf catalog number, etc.). The use of positional catalogs (SAO, Boss, GC, AGK3, FK4, etc.) is discouraged.

For uncataloged targets, see Section 3.2.2 on page 29.

Stars

1. *Henry Draper Catalog* number (e.g., HD140283)is preferred. HDE numbers are discouraged, except in the Magellanic Clouds.

2. *Durchmusterung* number (BD, CD, or CPD). In the southern hemisphere, adopt the convention of using CD north of –52 degrees and CPD south of there (e.g., **BD+30D3639**, **CD-42D14462**, **CPD-65D7691**).
3. *General Catalog of Variable Stars* designation, if one exists (e.g., **RR-LYR**, **SS-CYG**).
4. AFGL designation.
5. IRC designation.
6. IRAS designation.

Star Clusters and Nebulae

1. *New General Catalog* (NGC) number (e.g., **NGC6397**, **NGC7027**).
2. *Index Catalog* (IC) number (e.g., **IC418**).
3. For planetary nebulae for which you do not have an NGC or IC designation, the Perek-Kohoutek designation (e.g., **PK208+33D1**) may be used.
4. For H II regions for which you do not have an NGC or IC designation, the Sharpless catalog number (e.g., **S106**) may be used.
5. For IR nebulae, AFGL designation.

Galaxies and Clusters of Galaxies

1. NGC number (e.g., **NGC4536**).
2. IRAS designation.
3. IC number (e.g., **IC724**).
4. Uppsala Catalog number, only if an NGC or IC number is not available (e.g., **UGC11810**).
5. For clusters of galaxies, the Abell catalog number, but only if an NGC or IC number is not available (e.g., **ABELL2029**).

Quasars and Active Galaxies

1. The name defined in the compilation by Veron-Cetty and Veron (*ESO Report No. 7*, 1989) must be used (e.g., **3C273**).

3.2.2 Uncataloged Targets

Objects that have not been cataloged or named must be assigned one of the following designations:

1. Isolated objects must be designated by a code name (the allowed codes are **STAR**, **NEB**, **GAL**, **STAR-CLUS**, **GAL-CLUS**, **QSO**, **SKY**, **FIELD**, and **OBJ**), followed by a hyphen and the object's J2000 equatorial coordinates, if possible, rounded to seconds of time and seconds of arc (e.g., for a star at J2000 coordinates RA: 1H 34M 28S, DEC: –15D 31' 38", the designation would be **STAR-013428-153138**).
2. Uncataloged objects within star clusters, nebulae, or galaxies **must** be designated by the name of the parent body followed by a hyphen and the rounded J2000 coordinates, if possible, of the object (e.g., for a target within NGC 224 with J2000 coordinates RA: 0H 40M 12S, DEC: +40D 58' 48", the designation would be **NGC224-004012+405848**).
3. Positions within nebulae or galaxies may also be designated by the name of the parent object followed by a hyphen and a qualifier. The qualifier should be brief, but informative (e.g., the jet in NGC 4486 could be designated **NGC4486-JET**). Other examples are: **NGC5139-ROA24**, **LMC-R136A**, **ABELL30-CENTRAL-STAR**, **NGC205-NUC**.

3.2.3 Common Names

In addition to the catalog name, a target should be assigned at most two "common names," or aliases, if they exist. Examples of common names are the following:

1. Stars: The Bayer (Greek-letter) designation or Flamsteed number with standard three-letter constellation abbreviation (e.g., **ZETA-CAP**, **22VUL**, **OMICRON2-ERI-B**); the *Bright Star Catalog* number (e.g., **HR5270**); other names, if they exist (e.g., **CYG-X1**, **BARNARDS-STAR**, **PROXIMA-CEN**).
2. Star clusters, nebulae, galaxies, and clusters of galaxies: Commonly used names (e.g., **HYADES**, **OMEGA-CEN**, **CRAB-NEBULA**, **ABELL63**, **COMA-CLUSTER**); Messier numbers (e.g., **M13**, **M31**, **M67**).

3.2.4 Special Targets

The names of certain types of targets must be designated by appending a code to the target name. For example, **-CALIB** should be appended to the name of a target that is being observed only as a calibration standard for other observations. These designations will assist in planning of the observing schedule. The possible codes are listed in Table 3.1.

Table 3.1: Designations of Special Targets

Target Type	Code	Description
External calibration target	**-CALIB**	An astronomical target used for calibration (e.g., **BD+28D4211-CALIB**). Internal calibration sources (e.g., **WAVE**) and calibrations using the Earth must not be included in the Target List.
Offset acquisition target	**-OFFSET**	A target that will be used for an offset acquisition; it is the object that will be acquired first, from which an offset will be applied to move to the target of interest (e.g., **3C273-OFFSET**). **Two** separate exposures must be defined on the Visit and Exposure Specifications; an acquisition of the **-OFFSET** target, and a science exposure of the (target of interest) program target. The location of the latter target may be specified either by equatorial coordinates or by an offset (see Section 3.4 on page 36). For example: to observe the **JET** in **3C273,** first acquire "stellar-like" source **3C273-OFFSET,** then offset to program target **3C273-JET**.
Special designations		These are reserved designations and may not be used as the names of external pointing in a target list: **ANTI-SUN, ANY, BIAS, CCDFLAT, DARK, EARTH-CALIB, INTFLAT, KSPOTS, NONE, ORBIT-POLE, ORBIT-POLE-NORTH, ORBIT-POLE-SOUTH, UVFLAT, VISFLAT, WAVE**

3.3 Target Category and Target Description [Description]

A target description must be selected for each target. The Target Description will be one of the key fields used by archival researchers in searching through the HST data archive; thus it is **extremely** important that the information be filled out completely and accurately for each target.

Each target **must** be assigned a single primary **category** from Table 3.2, and at least one **descriptive keyword**, chosen from the appropriate Table 3.3 through Table 3.9 (see Table 3.2 for which table is appropriate for each category). The **discrete features and descriptors** in Table 3.10 may be used as descriptive keywords for any category. A maximum of five descriptive keywords may be selected.

The categories in Table 3.2, and some of the descriptive keywords in Table 3.3 through Table 3.10, are followed by explanatory text in parentheses. This text is provided only for explanatory purposes and is not part of the category or keyword itself.

Text Proposal File

If you are using the Text Proposal File, target description items must be separated by commas.

Table 3.2: Target Categories

Category	Descriptive Keywords	Discrete Features and Descriptors
SOLAR SYSTEM (Solar System Object)	Chapter 4: Solar System Targets on page 59	
STAR (Galactic Stellar Object)	Table 3.3	See Table 3.10
EXT-STAR (Star in an External Galaxy)	Table 3.3	
STELLAR CLUSTER (Galactic Star Cluster, Group, or Association)	Table 3.4	
EXT-CLUSTER (Star Cluster in an External Galaxy)	Table 3.4	
GALAXY (Galaxy or AGN)	Table 3.5	
CLUSTER OF GALAXIES (Galaxy Groupings, Clusters, Large-scale Structure)	Table 3.6	
ISM (Interstellar Medium of the Galaxy)	Table 3.7	
EXT-MEDIUM (Interstellar Medium of an External Galaxy)	Table 3.7	
UNIDENTIFIED (Unidentified Objects)	Table 3.8	
CALIBRATION (Calibration Observations)	Table 3.9	

Table 3.3: Descriptive Keywords for STAR and EXT-STAR

Brown Dwarf	**F0-F2**	**Herbig Ae/Be**
Wolf Rayet	**F3-F9**	**Horizontal Branch Star**
Wolf Rayet – WC	**FP**	**Interacting Binary**
Wolf Rayet – WN	**Late-type Degenerate**	**X-ray Novae**
Main Sequence O	**G V-IV**	**X-ray Burster**
Giant O	**G III-I**	**X-ray Transient**
Supergiant O	**K V-IV**	**LMXB** (Low Mass X-ray Binary)
OE	**K III-I**	**Gamma Ray Burster**
OF	**M V-IV**	**MXB** (Massive X-ray Binary)
SDO	**M III-I**	**RS CVn Star**
WDO	**L**	**W UMa Star**

Table 3.3: Descriptive Keywords for STAR and EXT-STAR(Cont)

B0-B2 V-IV	**T**	**Beta Lyrae Star**
B3-B5 V-IV	**S Star**	**Algol System**
B6-B9.5 V-IV	**Carbon Star**	**Barium Star**
B0-B2 III-I	**Long Period Variable**	**Blue Straggler**
B3-B5 III-I	**Irregular Variable**	**Neutron Star**
B6-B9.5 III-I	**Regular Variable**	**Pulsar**
BE	**Luminous Blue Variable**	**Binary Pulsar**
BP	**Dwarf Nova**	**FK Comae Star**
SDB	**Classical Nova**	**Pulsating Variable**
DB	**Nova-like**	**PG1159 Star**
DA	**Recurrent Nova**	**ZZ Ceti Star**
DC	**Polar** (AM Her Star)	**Cepheid**
DZ	**Intermediate Polar** (DQ Her Star)	**Supernova**
A0-A3 V-IV	**Symbiotic Star**	**Supernova Type Ia**
A4-A9 V-IV	**T Tauri Star**	**Supernova Type Ib**
A0-A3 III-I	**FU Orionis Star**	**Supernova Type II**
A4-A9 III-I	**Shell Star**	**RR Lyrae Star**
AE	**Eta Carinae Star**	**Planetary Nebula Central Star**
AM	**YSO**	**Emission Line Star**
AP	**Extra-solar Planet**	**Circumstellar Matter**
AGB Star	**Extra-solar Planetary System**	
Post-AGB Star	**Pre-main sequence Star**	**Population II**
Composite Spectral Type	**Low Mass Companion**	

Table 3.4: Descriptive Keywords for STELLAR CLUSTER and EXT-CLUSTER

Globular Cluster	**OB Association**
Open Cluster	**T Association**
Young Association	

Table 3.5: Descriptive Keywords for GALAXY

Spiral (Spiral Galaxy)	**Quasar** (Radio Loud)
Lenticular (Lenticular Galaxy)	**Radio Galaxy**
Elliptical (Elliptical Galaxy; Not A Dwarf Elliptical)	**BL Lac** (BL Lac or BLAZAR)
Dwarf Elliptical	**Liner**
Magellanic Irregular	**Starburst**
Amorphous Irregular	**Ultraluminous IR Gal**
Dwarf Compact (Dwarf Compact/HII Galaxy)	**Interacting Galaxy**
Dwarf Spheroidal	**Lyman Alpha Cloud**
BCM (Brightest Cluster Member)	**Protogalaxy**
BGM (Brightest Group Member)	
LSB (Low Surface Brightness/HI Rich Galaxy)	**Einstein Ring**
Seyfert	**High Redshift Galaxy** ($z > 0.5$)
QSO (Radio Quiet)	

Table 3.6: Descriptive Keywords for CLUSTER OF GALAXIES

Supercluster	**Interacting Galaxy**
Void	**BCM** (Brightest Cluster Member)
Group	**BGM** (Brightest Group Member)
Rich Cluster	
Poor Cluster	**Einstein Ring**
High Redshift Cluster ($z > 0.5$)	**Blank Sky**
Galaxy Pair	

Table 3.7: Descriptive Keywords for ISM and EXT-MEDIUM

Herbig-Haro Object	**Cometary Nebula**
Planetary Nebula	**Molecular Cloud**
HII Region	**Bipolar Outflow**
Reflection Nebula	**Absorption Line System**
Dark Cloud	**Absorption Line System – Galactic**

Table 3.7: Descriptive Keywords for ISM and EXT-MEDIUM(Cont)

SNR (Supernova Remnant)	**Absorption Line System – Extragalactic**
Ring Nebula	**Damped Lyman Alpha Cloud** (Extragalactic)
HI Cloud	**Coronal Gas** (10^5–10^6 K)
High Velocity Cloud	**Hot Gas** (10^7–10^8 K)
Intermediate Velocity Cloud	**IGM**
IRAS Cirrus	**ICM**
PDR (Photon Dominated Region)	

Table 3.8: Descriptive Keywords for UNIDENTIFIED

Radio Emitter	**Ultraviolet Emitter**	**Blank Field**	**Low Latitude Field**
Infrared Emitter	**X-ray Emitter**	**Parallel Field**	
Optical Emitter	**Gamma Ray Emitter**	**High Latitude Field**	

Table 3.9: Descriptive Keywords for CALIBRATION

Astrometric	**Narrow Band Filter Calibration**	**Target Acquisition Test**
Photometric	**FGS Stability**	**Detector Sensitivity Test**
Wavelength	**Quantum Efficiency Test**	**Focus Test**
Point Spread Function	**Pointing and Jitter Test**	**Spacecraft Glow**
Occulting Finger Location	**Raster & Step/Dwell Scan Verification**	**Occultation Mode Test**
Ion	**Spatial Distortion Test**	**Throughput Test**
Taled	**Polarimetry**	**Echelle Blaze Function**
Scattered Light Test	**Aperture Location**	**Virtual Pointing**
Sky Background	**Detector Linearity Test**	**FGS Transfer Function Test**
Instrument Sensitivity Test	**Carrousel Stability Test**	**Shutter Control Test**

Table 3.10: Discrete Features and Descriptors for All Categories

Corona	**Disk**	**BLR** (Broad Line Region)
Ring	**Bulge**	**NLR** (Narrow Line Region)
Ansae	**Polar Ring**	**Filament**
Protoplanetary Disk	**Dust Lane**	**Ejecta**

Table 3.10: Discrete Features and Descriptors for All Categories(Cont)

Wind	**Spiral Arm**	**Knot**
Accretion Disk	**Shell**	**Star Forming Region**
Jet	**Tidal Tail**	**Shock Front**
Lobe	**Bar**	**Ionization Front**
Hotspot	**Multiple Nuclei**	**Conduction Front**
Nucleus	**Cooling Flow**	**Undesignated**
Halo	**Emission Line Nebula**	**Gravitational Lens**

3.4 Target Position Type[Position]

A position type is required for each fixed target. It may be expressed in any one of three different ways:

- By specifying the **equatorial** coordinates (RA and DEC) of the target;
- By specifying a positional **offset** from another target; or
- By specifying a **region** (area) of the sky.

It is also possible to specify that the coordinates were obtained using the Guide Star Selection System (GSSS; see 3.4.5 Determining Coordinates in the Guide Star Selection System (GSSS) Reference System on page 43), or that they are currently uncertain or unknown, and that more accurate coordinates will be provided by the observer after an early acquisition exposure is taken, or in real time during the HST observations.

Text Proposal File

If you are using the Text Proposal File, target position items must be separated by commas.

3.4.1 Required Accuracies of Target Positions

The HST Scientific Instruments (SIs) typically have very small apertures and fields of view. Target-acquisition apertures for several of the SIs are only a few seconds of arc in size. Since the HST has no analog to the video acquisition cameras common on many ground-based telescopes, it is essential to have accurate coordinates for targets. In many cases targets will be placed in the final observing aperture after a sequence of target-acquisition observations. This will only work, however, if the target coordinates are sufficiently accurate and precise to place the target in the first of these acquisition apertures.

HST uses two guide stars to stabilize the pointing of the telescope and to place the target in the desired aperture. The fundamental problem, then, is to determine the position of the target **relative to the guide stars in the surrounding area** with sufficient accuracy to place the target in the aperture. The specific pair of guide stars to be used cannot be determined in advance of the observation; several possible pairs will often be available for each target. The guide stars are chosen from the Guide Star Catalog 2 (GSC2). Over the HST FOV, the relative position errors between guide stars is 0.15" (1 sigma), while the absolute positions on the ICRS have errors of 0.25" (1 sigma). Note that these errors are derived at the epoch of the GSC plate and will increase slowly in time due to proper motion.

The accuracies of positions typically needed for target acquisition with each of the SIs are shown in Table 3.11; these are predicated upon the positions being in International Celestial Reference System (ICRS), which is the reference frame of the GSC2 catalog. Note that several of the SIs have multiple acquisition apertures of different sizes that may be used. Be sure when selecting acquisition apertures to keep the coordinate uncertainties in mind. Furthermore, be sure to provide one sigma uncertainties with your positions so that STScI may check the appropriateness of your acquisition exposures. Inaccurate target coordinates can result in failed target acquisitions and can therefore waste valuable HST observing time. As indicated in Table 3.11, **it is the observer's responsibility to provide accurate coordinates in all cases, but in particular they must be in the ICRS reference frame when using** with the NIC1 and NIC2 detectors. Please contact your PC if you need additional information. Although ICRS frame-based coordinates are not required for FGS and WFPC2 observations, it is still prudent to check the accuracy of your coordinates. All observers will be provided target confirmation charts by their PC to help them verify the target coordinates in the ICRS reference frame. The Principal Investigator of a program is responsible for ensuring that target coordinates are accurate, both at the time of program submission, and later when target confirmation charts are provided. The following address has pertinent information on target confirmation charts:

`http://www.stsci.edu/public/confirmation-chart.html`

Note: HST proposals executed before July 1991, as well as engineering proposals of type **OV**, **SV**, **SMOV**, and **CAL**, should not be used to derive target coordinates. Coordinates from such proposals may be unreliable owing to poor calibration and/or engineering-related pointing changes made during the observations.

Table 3.11: Required Coordinate Accuracies

Instrument Configuration	Accuracy Required (1 sigma, arcsec)	ICRS Coordinates Required?
WFPC2 (WFC)	10	No
WFPC2 (PC)	5	No
FGS	1	No
ACS/WFC	10	No
ACS/HRC	4	No
ACS/SBC	5	No
ACS/HRC-OCCULT	1	Yes
ACS/HRC-CORON	1	Yes
NIC1[1]	3	Yes
NIC2 (2)	5	Yes
NIC3 (2)	10	No

1. If multiple NICMOS detectors are being used in parallel, the primary detector (the detector used for the exposures in the <primary-exp-list> of the PARallel WITH Special Requirement; see PARallel <parallel-exp-list> WITH <primary-exp-list> (replaced by Coordinated Parallel Containers in the APT User Interface)) determines the required coordinate accuracy for the observation and whether GSC2 frame-based coordinates are required.

3.4.2 Equatorial Coordinates

If you specify the target position directly in terms of equatorial coordinates (as opposed to specifying an offset or a region), then the right ascension and declination <values> must be provided:

RA: <value> **DEC:** <value>

RA: +/– <uncertainty> **DEC: +/–** <uncertainty>.

- The uncertainties default to 0.1". They should represent the accuracy (1 sigma) of the target coordinates, **not** the region within which a target could be observed (e.g., for a sky measurement). See 3.4.4 Region of Sky (Extended Targets) on page 41 for instructions on how to designate regions as targets.
- The right-ascension value must be expressed in hours(**H**), minutes(**M**), and seconds of time(**S**).

- The declination value must be expressed in degrees(**D**), minutes ('), and seconds (**"**) of arc.
- The units must be selected (from a pull down list) for both the value and its uncertainty. The uncertainty must be expressed in one and only one of the units used to express the related **RA** and/or **DEC**, with the additional units of minutes (') of arc or seconds (**"**) of arc being allowed for right ascension. (In other words, the RA may be expressed as a combination of three units (**H M S**), but its uncertainty must be in terms of a single unit such as **S** or **"**.) To clarify:

Quantity and units specified	Acceptable units for uncertainty
RA: H-M-S	timemin, timesec, arcmin, arc-sec
DEC: D-M-S	degrees, arcmin, arcsec

Note: If the sign of the declination is not indicated, a positive declination is assumed, but we urge you to always include the sign as a way of reducing errors.

Text Proposal File

In the Text Proposal File you must use the following format for RA and DEC (note the comma delimiters):

RA = <value> +/– <uncertainty>, **DEC** = <value> +/– <uncertainty>

The comma following the right-ascension uncertainty is required.

- The right-ascension value must be expressed in hours (H), minutes (M), and seconds (S) of time. The declination value must be expressed in degrees (D), minutes ('), and seconds (") of arc (For example: RA = 12H 7M 13.33S +/– 0.15S, DEC = +27D 3' 8.0" +/– 0.1")
- Units must be provided for both a value and its uncertainty (see "Acceptable units for uncertainty")

3.4.3 Positional Offsets

The position of a target may alternatively be specified as an offset from a reference target. Note, however, that offsets larger than 30 arcsec may complicate the target acquisition procedure. If larger offsets are desired, please contact your Program Coordinator.

Offsets are always in the sense **offset = target-coordinates** *minus* **offset-reference-coordinates**, while a polar offset is expressed as an angular separation and position angle of a line drawn from the offset reference target to the target. As with other similar quantities, we urge you to include the sign of the offset, even when it is positive, as a means of removing ambiguity.

Note that you select the <target name> which has the equatorial coordinates of the reference target, and that reference-target names have **–OFFSET** appended to them (see Table 3.1).

Positional offsets are only a convenient method of specifying target coordinates, and do **not** automatically imply a particular method of target acquisition; observers must explicitly specify any target acquisitions on the Visit and Exposure Specifications via Special Requirements (see Chapter 7: Special Requirements [Visit and Exposure Special_Requirements] on page 111).

Warning: If your object has significant proper motion no correction may be applied. See 3.8 Is Proper Motion or Parallax Relevant? on page 47, where it notes that the proper motion for the target is taken to be the same as for the offset object.

You specify the offset as a difference in **EQUATORIAL** coordinates from a target <name>:
Position Type: Offset
Offset: **RA:** <value> **DEC:** <value>
Uncertainty: **RA:** <value> **DEC:** <value>
From Target: <target name>

3. The value for **RA** offset may be in units of seconds of time or in decimal degrees, and the value for **DEC** offset may be in units of arcmin (') or arcsec ("), or in decimal degrees (see example below). The uncertainty must be expressed in one and only one of the units used to express the related **RA** and/or **DEC**. Offsets in **RECTANGULAR** coordinates are interpreted as displacements in the tangent plane whose origin is located at the reference target. For displacements of less than about one degree, they may be interpreted as the offsets that are measured on a photographic plate, without making errors larger than about 0.5 arcsec. The format for the specification of an offset in rectangular coordinates is:

   XI-OFF = <value> +/- <uncertainty>, **ETA-OFF** = <value> +/- <uncertainty>, **FROM** <target number>

   Note: North and east displacements are considered positive (+), south and west are negative (–).

   The values of **XI-OFF** and **ETA-OFF** are required to both be expressed in arcmin (') or arcsec ("), and the uncertainties must be expressed in the same units (in other words, all four angular quantities must be in the same units). In the following example, a target has been measured on a sky-survey plate, with a scale of 67 arcsec/mm, to lie 0.5 mm west of, and 1 mm north of, target number 3, with an accuracy of 1 arcsec:

XI–OFF = –33" +/– 1", ETA–OFF = +67" +/– 1", FROM 3

4. The format for a **POLAR** offset specification is:

   R = <value>**, PA =** <value>**, FROM** <target number>

   Note that uncertainties must **not** be included in this type of specification. The separation is expressed in units of minutes (') or seconds (**"**) of arc. The position angle of the target with respect to the reference target is measured east of north, and the unit of measurement (degrees) is required. In the following example, a target lies 10 arcsec from target number 4, at a position angle, measured at target 4 from north through east, of 60 degrees:

   R = 10", PA = 60D, FROM 4

By default APT provides a value of 0.1**"** for the uncertainties.

Example: NGC2654's right ascension is 2.34 seconds of time less than the reference target (NGC2654-OFFSET), and its declination is 1.6 arcsec greater than NGC2654-OFFSET. The specifications for NGC2654 would be:

Position Type: Offset
Offset: **RA:** -2.34S **DEC:** 1.6"
Uncertainty: **RA:** 0.01S **DEC:** 0.1"
From Target: NGC2654-OFFSET

Text Proposal File

The format for an offset specification as a difference in equatorial coordinates is:

RA-OFF **=**<value> **+/–** <uncertainty>**, DEC-OFF = **<value> **+/–** <uncertainty>**, FROM** <target number>

Note the uncertainties and the commas separating the three items. The value for **RA-OFF** may be in units of seconds (**S**) of time, or in decimal degrees (**D**), and the value for **DEC-OFF** may be in units of arcmin (**'**) or arcsec (**"**), or in decimal degrees (**D**). The uncertainty must be expressed in one and only one of the units used to express the related **RA** and/or **DEC**.

3.4.4 Region of Sky (Extended Targets)

Sometimes it is necessary to define a region of sky rather than a specific point. Examples are extended targets (such as emission nebulae and galaxies) and blank-sky regions for background measurements (if it is acceptable to make the observation anywhere within a region). An **Equinox** value should be specified with the region coordinates (see Section 3.5 on page 46).

The units used for regions should be used in the same way as for coordinates; see Section 3.4.2 on page 38. You can choose either a rectangular or a circular region.

- **Rectangular**: Specify the equatorial **coordinates** and the **sides** of a rectangle (for RA in arcsec, arcmin, minutes of time or seconds of time; for DEC in arcsec, arcmin or degrees)
- **Circular**: Specify the equatorial **coordinates** and a **radius** (in arcsec, arcmin or degrees)

Text Proposal File

For a rectangular region, the format for equatorial coordinates must be used followed by a comma and the word **REGION**; the values following +/– will then be interpreted as one-half the lengths of the sides of the rectangular area, rather than as uncertainties in the coordinates.

In the following example, a region 4 arcmin wide in right ascension by 2 arcmin high in declination is specified:

RA = 3H 51M 27S +/– 2', DEC = –37D 13' 25" +/– 1', REGION

For a circular region, **REGION** must be followed by another comma and the radius of the region in the format **R =** <radius>; in this case, no uncertainties should be attached to the **RA** and **DEC**. Here is an example of a circular region with a radius of 2 arcmin:

RA = 3H 51M 27S, DEC = –37D 13' 25", REGION, R = 2'

Note that the units of **R** must be specified.

Circular Region

If it is desired to specify a circular region, **REGION** must be followed by another comma and the radius of the region in the format **R =** <radius>; in this case, no uncertainties should be attached to the **RA** and **DEC**. Here is an example of a circular region with a radius of 2 arcmin:

RA = 3H 51M 27S, DEC = –37D 13' 25", REGION, R = 2'

Note that the units of **R** must be specified.

3.4.5 Determining Coordinates in the Guide Star Selection System (GSSS) Reference System

The HST reference frame is defined by the HST Guide Star Catalog 2 (GSC2) that STScI has created. For observations that require accurate coordinates, such as those listed as “ICRS Coordinates Required” in Table 3.11, it is vital that you provide positions derived in the ICRS reference frame.

Access to the GSC2 and the Digitized Sky Survey (DSS) is available in the VTT portion of the APT which is used to submit HST proposal and program information. You will also find links to query the catalog and retrieve images on the Catalogs and Surveys Group (CSAG) Web server at *http://www-gsss.stsci.edu*. Follow the links to HST support and Phase 2 instructions.

Here are some more detailed guidelines for different categories of brightness and type:

1. Stars visible on the survey plates (typically brighter than about *m(V)=20*) can be retrieved from the GSC2 using either the VTT/APT interface or a Web form available under the HST support links of the *CASG Web site*. When you have the GSC2 coordinates, enter them in the **Position** data for the target and select the **Reference_Frame** as ICRS. We recommend that you also enter the GSC2 name as a target alias in **Alternate_Names**.

   For example, in the **Position** form
   J2000 Coordinates RA: 12 13 14.27 DEC: –13 11 03.3
   Uncertainty: RA: 0.3 (arcsec) DEC: 0.3 (arcsec)
   Reference_Frame: ICRS

   In the **Text Proposal File**
   Position: RA = 12H 13M 14.27S +/– 0.3", DEC = –13D 11' 03.3" +/– 0.3"
   Equinox: J2000
   Reference_Frame: ICRS

   For stars brighter than about *m(V)=11*, the coordinates provided are from the *Hipparcos/Tycho* catalogs rather than the measured plate coordinates since they are more accurate. Enter the GSC2 name and set the **Reference_Frame** as ICRS.

2. For extended sources visible on the survey plates, we strongly recommend that you examine the DSS image and the associated GSC2 coordinate. Depending on the brightness, morphology and structure of the galaxy, the GSC2 coordinate may not correspond to the aperture location you require for your observation. Use the VTT/APT interface or the links available at the *CASG Web site* to access the

GSC2 and DSS images. Contact your Program Coordinator if you need assistance.

3. If your target is not visible on the DSS images, or you wish to use other special plates or CCD images on which you can measure the target, then you must transfer the ICRS reference frame to your images. Typically, this is done by measuring a sufficient number of reference stars (e.g. from GSC2, Tycho, Hipparcos, 2MASS, SDSS - any catalog that uses the ICRS) to derive your astrometric transformation. Alternatively, if your object is measured in another ICRS based catalog you may simply use that as the position and specify ICRS for the **Reference_Frame**.

4. If you have used HST to observe a target in an earlier cycle and already have GSC1 based coordinates, you also have the option of using a 'Coordinate-Converter' that is available at the HST support page of the *CASG Web site*. This is a simple Web-based tool that allows one to enter either a GSC1 ID or coordinate. In the case of an ID it will directly look up the GSC2 coordinate for that object. If you enter a coordinate, it will derive a mean offset between GSC1 and GSC2 over the HST FOV and apply that correction to the position.

As part of preparing your observations, your Program Coordinator will provide, as a final check that the coordinates are correct, a Confirmation Chart showing the target coordinates (as entered in the proposal) overlaid on the field from the plate material used to construct the Guide Star Catalog. **You are responsible for verifying that the coordinates are correct.** (SeeSection 3.4.1, "Required Accuracies of Target Positions," on page 36.)

3.4.6 A Caution on Astrometry Prepared from STScI Plate Scans

Note that the set of plates used to construct the GSC2 coordinates is NOT the same one that is contained in the 102-volume set of CD ROMs distributed as the Digitized Sky Survey (DSS-I). The GSC2 coordinates are primarily derived from the POSS-II Red survey in the northern hemisphere and the AAO-SES/ER Red surveys in the south. These images are only available on-line. If you wish to measure your target coordinates from these images, please download the images using the links from the CASG Web server listed above.

3.4.7 Prohibition on the Use of GSC Version 1.2

In order to provide the best astrometry to the community, a development version of the GSC1 (version 1.2) had been released. This was used to develop some of the astrometric reduction algorithms that are used in

GSC2. **This version was not implemented in the HST ground system and should not be used to provide Phase 2 coordinates**.

Uncertain or Unknown Coordinates

If it is impossible to obtain adequate plate material to measure coordinates to the required accuracy (e.g., a very crowded field which cannot be resolved using ground-based observations), it may be necessary to obtain an early acquisition image or to perform an acquisition that involves real-time interaction with the telescope (see Section 7.3.1 on page 134). In that case, coordinates as accurate as possible must be entered on the Target List.

3.4.8 Special Catalogs

The PLATE-ID can be used to specify one of the special guide star catalogs which have been created by the STScI to accommodate special guide star requirements; to have access to the special plates, you must select GSC1 as the **Reference_Frame**. These catalogs are primarily used for selecting guide stars from a subset of stars in the region which have certain properties or more accurate relative positions. This option is most commonly used when the relative accuracy of guide stars and target stars must be known with great precision.

The Special Catalogs currently available are:

PLATE-ID	SKY REGION
ZZZZ	NGC188
ZZZX	Iota Carinae
ZZZW	HR6636
ZZZV	HR6850
ZZZU	HR6945
ZZZT	NGC5617
ZZZR	Omega Centauri
ZZZQ	Eta Carinae

Only a modest number of specific objects are listed in these catalogs; contact your PC. Note that any proper motion for objects on these plates has been applied through the year 2000, and so an Epoch of 2000 should be specified

3.5 Equinox for Coordinates [Equinox]

The year of the equator and equinox to which the coordinates are referred must be J2000 (Julian).

It is not necessary to apply precession corrections to coordinates from positional catalogs. The *Guide Star Catalog* and the *Hipparcos Input Catalogue* both use the J2000 equinox. (Note, however, that the *Hipparcos* output catalogue is epoch 1991.25, which means proper motions can have significant effects if you are not careful.)

For some notes on Equinox, Epoch, and units, see Section 3.13 on page 57.

3.6 Coordinate Reference Frame [Reference_Frame]

This keyword replaces **Coordinate_Source** starting with Cycle 14 Calibration and all Cycle 15 programs. Select one of the following **Reference_Frame** values for each target.

ICRS

To be used if the coordinate reference frame is tied to the International Celestial Reference System (ICRS). Catalogs tied to the ICRS include: HST *Guide Star Catalog 2* (GSC2), *Hipparcos Catalog* and the *Tycho-2 Catalog*.

GSC1

To be used if the coordinate reference frame is tied to the HST *Guide Star Catalog 1*. Include the Plate ID (from the "Plt" column in the GSC1) with your coordinates. This includes the GSC1 special catalogs (those with ZZZ Plate IDs). If the "Plt" value is 56, then the true source is the *Hipparcos Input Catalogue*. In this case use **Other** for the **Reference_Frame**.

A Plate-ID should be supplied when coordinates are taken from the Guide Star Catalog 1, or measured using a GSC survey plate, or previous HST image using GSC1 coordinates (in which case the guide star plate used in the observation should be specified). This ensures that the correct plate is used for the observation and not some other, overlapping plate. If GSC1 is specified as the reference frame and no Plate-ID is supplied then the plate providing the best astrometry will be used in selecting guide stars.

Other

To be used if the coordinates are neither GSC1 nor ICRS.

3.7 Radial Velocity or Redshift [RV_ or _Z]

Give, if known, the heliocentric radial velocity or redshift of the target. The format is <velocity in km/sec> or <redshift>; examples are **+1198 (Radial Velocity)** and **1.95** (**Z**). The units must not be specified.

Text Proposal File

In the **Text Proposal File** the format is **V = +1198** and **Z = 1.95**.

3.8 Is Proper Motion or Parallax Relevant?

If a small aperture or occulting spot is to be used, even a relatively small proper motion or parallax may cause difficulties in acquiring the target. In such cases, the Proper Motion/Parallax data must be provided. Note, however, that proper motion and parallax values may **not** be specified for a target which is specified by a positional offset. Such targets will be taken to have the same proper motion and parallax as the reference target.

The observer must determine whether or not proper motion or parallax is relevant. In general, this will depend on the size of the acquisition aperture of the SI that will be used and the epoch of the coordinates that have been provided. For example, the STIS uses a target acquisition area of 5 arcsec square. For a star whose coordinates are given for the epoch 1950, and that will be observed in 1997, a proper motion of approximately 0.5*2.5/(1997–1950) = 0.027 arcsec per year would be "relevant," with a resulting offset of half the minimum center-to-edge distance.

If special plate catalogs are being used (see 3.4.8 Special Catalogs on page 45), proper motions are probably not included (the HST Guide Star Catalog, for example, does not include proper motion). If the relative accuracy of the target and guide stars is essential, the proper motion should be included for the target star if the special catalog includes proper motions.

3.8.1 Proper Motion and Parallax Data

The following information is required for targets where proper motion and parallax are "relevant"; note that uncertainties for **RA_PM**, **Dec_PM**, and

Annual_Parallax are not required. If a sign is not given for **RA_PM** or **Dec_PM**, a positive value will be assumed, but it is better to be explicit.

- **RA_PM**: For Proper Motion in RA, the value should be in units of seconds of time/year. To convert from arcsec/year to seconds of time/year, divide by 15 cos DEC.
- **Dec_PM**: For Proper Motion in DEC, the value should be in units of arcsec/year.
- **Epoch**: The "Epoch of position" is the date of the "Target Position" which was defined in the Target List (see Section 3.4 on page 36).
- The "Epoch of position" may or may not be the same as the date of "Equinox for Coordinates" in the Target List (see Section 3.5 on page 46). Remember that the "Epoch of position" is the date the target position is referred to, whereas the "Equinox of Coordinates" is the date of orientation of the coordinate system in which the position is measured. For example, a star with a large proper motion may have its coordinates given in the J2000 system, but the numbers themselves are for epoch 1984, meaning that the star was at the specified position on January 1, 1984. Epoch should be of the form **20yy.y** or **19yy.y**.
- Ordinarily the epoch of position is earlier than the present date. In the *Guide Star Catalog* (GSC), the equinox is J2000 while the epoch depends on the individual plate. Do *not* adjust your coordinates to be those that would be measured if the plate were taken in the year 2000. However, some catalogs contain coordinates already adjusted to an epoch of J2000: the *Hipparcos Input Catalogue* (often used in the GSC for stars brighter than *m*(*V*) ~= 9) and the *PPM Star Catalog*. When these catalogs are being used, it is appropriate to specify an epoch of J2000. (These remarks do not apply to the Hipparcos Output Catalog.)
- **Annual_Parallax**: The unit for parallax is arcsec.

The example below is for the object **DM–9D697 (Epsilon Eridani)**, where the proper motion data are taken from the SAO Catalog.

Keyword	Explanation	Units	Example
RA_PM:	Proper Motion in RA	sec/yr	–0.0662
DEC_PM:	Proper Motion in DEC	arcsec/yr	0.019
Epoch:	Epoch of Position	**20yy.y** or **19yy.y**	1984.5
Annual_Parallax:	Annual parallax	arcsec	0.30488

For some notes on proper motions and units, see Section 3.13 on page 57.

3.9 Flux Data [Flux and Other_Fluxes]

Flux information must be provided for all targets, and there can be more than one entry for a given target. STScI uses flux information to test for over-illumination of sensitive detectors. All entries are values as observed at the Earth, rather than intrinsic values.

The flux information is provided in two separate fields:

- Flux in V Magnitude with an uncertainty, which is required for targets observed by the FGS and ACS/SBC. For all other instrument configurations, it's optional.
- **Other Fluxes** (separated by commas), which is entered in free text.

In the "**Other Fluxes**" field, the spectral type and color index could be provided if you think it's important. As many additional flux values as appropriate for the requested exposures should be provided. For example, ultraviolet or emission-line fluxes should be given if the target is to be observed in the ultraviolet or through a narrow-band filter, or several magnitudes might be provided if the target is a variable star to be observed at various brightness levels. In some cases (Targets of Opportunity, variable objects, etc.) the estimated flux data may be very uncertain, but the best available estimates should nevertheless be given, along with appropriate uncertainties and comments.

It may be important to specify the flux of a background source as well as the target flux. For example, a globular cluster in M87 may be seen against the bright background of the galaxy. The keyword **–BKG** should be appended to a background flux specification in this case (see footnote 2 to Table 3.12). Use a comma to separate entries if more than one flux value is given.

Flux must be given as F(lambda) rather than F(nu). Recall that the conversion is:

$F(lambda) = (3 \times 10^{18} F(nu)) / lambda^2$,
where lambda is in Ångstroms and F(nu) is in erg/(cm^2 sec Hz). For example, if lambda = 1500Å, and F(nu) = 1.0 x 10^{-26}, then F(lambda) = 1.3 x 10^{-14}.

The flux data are to be expressed in the format shown in Table 3.12. Do not enter explicit units.

Text Proposal File

If you are using the Text Proposal File, flux items in a list must be separated by commas.

3.9.1 General Guidelines on What Flux Data to Include

The following summary provides general guidelines for what flux information must be included in five general cases. See the *Instrument Handbooks* for more detailed descriptions of how to make the exposure time calculations.

Point source, non-dispersive instrument

1. Target flux: *V* magnitude, *(B–V), E(B–V),* spectral type.
   Flux at specified wavelength may be substituted for *V* magnitude.
   If no entry for *E(B–V)* is given, *E(B–V)* = 0 will be assumed.
2. Background (optional): Broad-band surface brightness or surface brightness at specified wavelength; **–BKG** must be specified in the name of the flux parameter.
3. Flux in wavelength range of observation.

Extended source, non-dispersive instrument

1. Target flux: *V* surface brightness, *(B–V), E(B–V)*.
   Flux at specified wavelength may be substituted for *V* surface brightness.
   If no entry for *E(B–V)* is given, *E(B–V)* = 0 will be assumed.
2. Background (optional): Broad-band surface brightness or surface brightness at specified wavelength; **–BKG** must be specified in the name of the flux parameter.
3. Surface flux at wavelength of observation and size of the region specified.

Point source, dispersive instrument

1. Target flux: *V* magnitude, *(B–V), E(B–V)*, spectral type.
   Flux at specified wavelength may be substituted for *V* magnitude.
   If no entry for *E(B–V)* is given, *E(B–V)* = 0 will be assumed.
2. Background (optional): Surface brightness of continuum; **–BKG** must be specified in the name of the flux parameter.
3. Continuum flux in wavelength range of observation.
4. Line flux and line width of brightest emission line in the wavelength range of observation.

Extended source, dispersive instrument

1. Target flux: *V* surface brightness, *(B–V), E(B–V)*.
   Flux at specified wavelength may be substituted for *V* surface bright-

ness.
If no entry for *E(B–V)* is given, *E(B–V)* = 0 will be assumed.

2. Background (optional): Surface brightness of continuum; **–BKG** must be specified in the name of the flux parameter.
3. Surface flux at wavelength of observation and size of the region specified.
4. Line surface flux and line width of brightest emission line in the wavelength range of observation.

Infrared source

1. Target flux: *J* magnitude, *(J–K)*. Flux at specified wavelength may be substituted for *J* magnitude.
2. Background (optional): Broad-band surface brightness at specified wavelength; **–BKG** must be specified in the name of the flux parameter.
3. Note that this refers to the astronomical background and **not** the thermal background.
4. Flux in wavelength range of observation. Note that this must be in units of erg/(cm^2 sec Å). The *NICMOS units conversion tool* on the STScI WWW pages can help you convert your source flux from *J* magnitude or flux in Janskys into this flux unit.

Note:* Details of how the above flux information was derived must be given in the proposal text section in the** **Observing_Description** ***(see the Call for Proposals). If any of the required flux data cannot be provided or are deemed to be unnecessary, these points must also be explained in that section. Incomplete flux information may delay the implementation of your proposal.

Table 3.12: Formats for Specification of Target Flux Data

Parameter	Format example	Units
Examples for Stars:		
Broad-band magnitude[1]	**V=13.1 +/– 0.5**	magnitude

Table 3.12: Formats for Specification of Target Flux Data(Cont)

Parameter	Format example	Units
Spectral type	**TYPE=G5III**	
Color Index[1]	**B-V = 0.86 +/– 0.2**	magnitude
Color Excess	**E(B-V) = 0.3 +/– 0.2**	magnitude
Background Surface Brightness[2]	**SURF-BKG(B) = 20 +/– 0.2**	mag/arcsec^2
Examples for Galaxies, Nebulae, and other extended sources:		
Surface Brightness[1,2]	**SURF(V) = 25.0 +/– 1.0**	mag/arcsec^2
Surface Brightness[1]	**SURF(B) = 24.5 +/- 0.5**	mag/arcsec^2
Color Excess	**E(B-V) = 2.5 +/– 0.2**	mag
Plus whatever other fluxes are relevant to your science program. Some other examples are listed below:		
Interstellar Extinction	**A(V) = 1.3 +/– 0.1**	mag
Flux at a specified wavelength	**F(5100) = 51 +/– 3 E-15**	erg/(cm^2 sec Å)
Continuum Flux[3]	**F-CONT(3500) = 57 +/– 3 E-15**	erg/(cm^2 sec Å)
Line Flux[3,4,5]	**F-LINE(3727) = 5 +/– 1 E-14**	erg/(cm^2 sec Å)
Line Width[6]	**W-LINE(3727) = 2.4 +/– 0.2**	Å
Surface Brightness at specified wavelength[2]	**SURF(5100) = 11 +/– 2 E-15**	erg/(cm^2 sec Å arcsec^2)
Surface Brightness at continuum wavelength[2]	**SURF-CONT(5000) = 52 +/– 2 E-15**	erg/(cm^2 sec Å arcsec^2)
Surface Brightness of line emission[3,4,5]	**SURF-LINE(5007) = 52 +/– 2 E-15**	erg/(cm^2 sec arcsec^2)
Size (FWHM of circular region)[7]	**SIZE = 25 +/–5**	arcsec

1. The following broad-band magnitudes may be used: **U,B,V,R,I,J,H,K**.
2. You may append "**–BKG**" to this reference (just before the wavelength designation) to indicate that it is a background flux value (e.g., **SURF-BKG(V) = 18.2 +/– 0.5**; **SURF-CONT-BKG(5100) = 10 +/– 3 E-15**).
3. Give wavelength used in keyword in rest frame, but flux in observed frame.
4. Line flux should be relative to the continuum, if specified, or relative to zero if not specified.
5. Whenever the S/N refers to a spectral line, **W-LINE** must be given along with **F-LINE** or **SURF-LINE**. Values of **F-LINE** and **SURF-LINE** outside the Earth's atmosphere are required.
6. **W-LINE** is the full width at half maximum (FWHM).

7. **SIZE** should be included if the exposure time estimate assumed the flux was spread over an extended region; if omitted, the highest spatial resolution of the observing mode will be assumed.

3.10 Bright-Object Constraints

Several of the Scientific Instruments must be protected against over-illumination. Table 3.13 summarizes the safety restrictions by instrument. You should not propose observations which violate these guidelines. Non-linearity, saturation, or other temporary effects which may occur at substantially fainter limits than those identified below are described in the *Instrument Handbooks*.

The *Visual Target Tuner* (VTT), a tool available to the user in APT, has a Bright Object tool that can be used to check on these constraints.

Table 3.13: Bright-Object Constraints

Instrument	Description
ACS	The ACS/SBC MAMA detector is subject to strict bright-object controls to prevent potentially fatal damage. Maximum permissible local and global count rates have been established for both imaging and spectroscopy; see the *ACS Instrument Handbook (Section 7.5)*. These limits have been translated into a table of magnitudes as a function of spectral type for the various configurations and modes (*ACS Instrument Handbook, Table 7.8*). Some of these limits are quite faint. All potential targets should be checked for safety with the ACS Exposure Time Calculator on the Web. Measured UV fluxes must be provided for any objects within 1 magnitude of the spectroscopic limits. This requirement extends to both targets and field objects on the detector. ORIENTs and/or POS TARGs may be used to avoid the latter. Unless they can be screened with GSC2/DSS, magnitudes and colors, or a UV image, must be provided for all objects in the fields of proposed SBC direct-imaging observations, including the background fields of solar-system targets. There are no safety-related brightness limits for the ACS CCD cameras (HRC and WFC). See the *ACS Instrument Handbook* for a description of saturation levels, residual charge, and other effects.
WFPC2	There are no safety-related brightness limits for the WFPC2. See the *WFPC2 Instrument Handbook* for a description of saturation levels, residual charge, etc.
FGS	The FGS may not be used to view objects brighter than $m_V = 1.8$. The FGS may view objects brighter than $m_V = 8.0$ only if the neutral-density filter is in place.
NICMOS	There are no safety-related brightness limits for the NICMOS. See the NICMOS Instrument Handbook for a description of saturation levels, residual charge, etc.

3.11 Comments [Comments]

Information that cannot be made to conform to the required formats may be entered in "**Comments**" area. Comments are not interpreted by the software, but are maintained in the data base and do appear on printouts of the forms.

3.12 Generic Targets List [Generic_Targets]

Generic targets are those that can only be described in terms of astronomical characteristics or general location in the sky. This category is used only for Targets of Opportunity and parallel exposures.

For parallel exposures, both pure-parallel and coordinated-parallel (see Chapter 6: Parallel Science Exposures on page 101), the pointing is determined by the primary observation, and the specification of a generic target for the parallel exposure denotes a region within which the parallel aperture is expected to point. If the parallel pointing does not matter and the intent is simply to sample whatever the parallel aperture happens to detect, it is not necessary to define a generic target; instead the special target **ANY** should be used (see 5.8 Target Name [Target_Name] on page 92).

Generic targets or target **ANY** (see Table 5.1: Special External Target Names) should only be used in one of these three cases:

1. The exposure is a coordinated parallel or **SAME POS AS** another exposure (so that the pointing is determined by the other exposure), or
2. The visit is a pure parallel (in which case the target will be matched against already-scheduled observations), or
3. The visit is **ON HOLD** (as with Targets of Opportunity, for example). In this case the target should be replaced by a fixed target when the **ON HOLD** is removed.

Note: Generic Target region coordinates are assumed to be in the J2000 reference frame.

3.12.1 Target Number(s) [Target_Number]

The target number will be assigned by the APT software. If you are using the **Text Proposal File**, generic targets should be given individual names and numbers just like fixed targets.

3.12.2 Target Name **[Target_Name]**

A descriptive name must be provided for each target. If a name cannot be specified in advance, a provisional name should be supplied. When the actual observation is made, a more specific name will be added to the target designation. Either the provisional name or the updated name can then be used for archival searches (e.g., **SN** might be the provisional name, while **SN-1995D** might be the updated name). A unique target name **must** be assigned to each generic target.

3.12.3 Target Description **[Description]**

See Section 3.3, “Target Category and Target Description [Description],” on page 31.

3.12.4 Flux Data **[Flux]**

See Section 3.9, “Flux Data [Flux and Other_Fluxes],” on page 49.

Flux data are not required for pure parallel observations of generic targets.

3.12.5 Comments [Comments]

See Section 3.11, “Comments [Comments],” on page 54.

3.12.6 Generic Target Specifications [Criteria}

The "**Criteria**" field is a way to specify generic celestial regions and target lists is described below, and should be used for Generic Targets. These instructions should be followed in order for pure parallels with generic targets to be schedulable.

Two types of generic target specifications are permitted:

- Region generic targets: a celestial region specified in one of three coordinate systems
- Target Lists: lists of fixed or generic targets

The Selection **Criteria** field should use the syntax specified below whenever the selection criteria can be fully specified by a celestial region in one of the supported coordinate systems, or by a list of fixed or generic targets.

Region Generic Targets

Three coordinate systems are supported:

- Equatorial: right ascension (**RA**) and declination (**DEC**)

- Galactic: Galactic longitude (**LII**) and Galactic latitude (**BII**)
- Ecliptic: ecliptic longitude (**LAMBDA**) and ecliptic latitude (**BETA**)

Regions may be any of:

1. “Rectangular” regions, i.e. bounded by latitude and longitude limits in the appropriate coordinate system
2. Circular regions, specified as within some angular limit of a point specified in any of the three supported coordinate systems
3. Polar caps or equatorial bands in any supported coordinate system

The following table provides examples of each of these types of region specifications. Note that the same rules for specifying RA and Dec apply as for fixed targets (Section 3.4.2 on page 38)

Region type	Equatorial coordinates	Galactic coordinates	Ecliptic coordinates
rectangular	**RA = 5H 30M 0S +/- 180M,**	**LII = 45D+/-10D,**	**LAMBDA = 56D+/-5D,**
	DEC = -65D +/- 10D	**BII = 15D+/-10D**	**BETA = 60D+/-15D**
circular	**RA = 1H 30M 0S,**	**LII = 0D,**	**LAMBDA = 45D,**
	DEC = -15D, R=10D	**BII = 15D, R=5D**	**BETA = -15D, R = 5.5D**
polar cap	**DEC > 60D**	**BII < -30D**	**BETA > 10D**
both polar caps	**ABS_DEC > 60D**	**ABS_BII > 30D**	**ABS_BETA > 10D**
equatorial band	**ABS_DEC < 10D**	**ABS_BII < 30D**	**ABS_BETA < 45D**

Note that for rectangular and circular regions, the syntax is identical to that of fixed target regions except that the indicator **REGION** is omitted, and galactic and ecliptic coordinates are allowed.

Target Lists

In some cases it may be desirable to specify as a Generic Target any of a list of Fixed Target positions or Generic Target regions. In this case the fixed targets should be provided as usual on the Fixed Target List, and the generic target regions should be specified as above on the Generic Target List. Then a new generic target can be defined with Selection Criteria specified by:

TARGETS = <target-number-list>

This will be taken to indicate that any of the targets in <target-number-list> are suitable as targets. Note that target numbers are required to be unique across all targets in a proposal, whether on the Fixed, Generic, or Solar System Target Lists.

This type of target is particularly useful when a known list of objects of interest is available, and it is desired to observe one of these objects with an imaging SI when a primary exposure with a spectrograph is positioned appropriately nearby.

3.13 Getting Coordinates Coordinated

Observers are responsible for the accuracy and appropriateness of the coordinates they supply and any changes made to them. Only you can determine where we should point HST.

Equinox is always a critical quantity when specifying coordinates. All astronomical coordinates change with time because of the precession of the Earth's rotation axis. Equinox specifies a time to which a coordinate system is tied. Thus J2000 refers to the location of an object in celestial coordinates for the coordinate reference frame of January 1, 2000.

Epoch is generally important only for objects that move. In particular, the epoch of a star's coordinates refers to a specific time at which the star is at that location. For example, the Hipparcos output catalogue lists coordinates of the brighter stars in the ICRS reference system (which is very nearly the same as J2000), and the coordinates themselves are for epoch 1991.25. The proper motions in the Hipparcos output catalogue are also epoch 1991.25, the midpoint of the mission. If you specify the epoch and equinox correctly, we can easily compute the location of an object at the time it will be observed with HST. (Note: An epoch is purely a time, and one of the form "J1991.25" is nonsensical.)

Proper motions sometimes cause problems. Units are especially crucial. The proper motion in Right Ascension (**RA_PM**) is to be listed in sec/yr, meaning seconds of time per year. If you have a value for RA_PM in arcsec per year, you need to divide it by 15 (to convert from arcsec to time sec), and to then divide by cos δ because lines of constant RA converge in going to the poles. **DEC_PM** is almost always listed in arcsec/yr, which are the units needed for HST observing.

As we have emphasized above, we urge you to use signs on quantities, even when they are not required. A value of +0.060 for **RA_PM**, say, makes it clear that the sign has been considered. Just specifying 0.060 leaves ambiguity because sometimes observers forget a minus.

One more thing: be very careful if your target lies near a celestial pole. Many precession routines break down in this regime, and uncertainties in position can cause problems too. Also, patterns that you may execute with an instrument could cross the pole, leading to confusion in position. All these issues can be resolved, but careful attention is needed.

CHAPTER 4:

Solar System Targets

In this chapter . . .

Tables and Figures

HST is able to point at and track solar system targets with sub-arcsecond accuracy. In order for target acquisition and tracking to succeed, planetary observers must specify positions for their targets in a precise and unambiguous manner. Therefore, it is imperative that the Solar System Target List (SSTL) be carefully and correctly completed. This section explains how to fill out the SSTL for any solar system target.

Ephemerides are generated using fundamental ephemeris information from NASA's Jet Propulsion Laboratory (JPL). Ephemerides can be generated for all known types of solar system targets, including planets, satellites, comets, asteroids, surface features on planets and satellites, and offset positions with respect to the centers of all the above bodies. The following instructions demonstrate how to define solar system targets in a way that allows accurate ephemeris generation.

The body-axes definitions, body dimensions, directions of rotation poles, rotation rates, and the definitions of cartographic coordinates used by STScI are normally identical to the values adopted in the report of the

"IAU Working Group on Cartographic Coordinates and Rotational Elements of the Planets and Satellites: 1982" (Davies, M.E., et al., *Celestial Mechanics*, **29**, 309-321, 1983). In a few instances, the latter data have been updated due to new results obtained from the flyby spacecraft. Also, some new bodies have been added which were unknown at the time of the IAU report. For Jupiter and Saturn, the lambda(III) coordinate system is assumed, but lambda(I) or lambda(II) can be used. For Uranus and Neptune, coordinates follow the "Report of the IAU/IAG/COSPAR Working Group on Cartographic Coordinates and Rotation Rates of the Planets and Satellites" (Celestial Mechanics and Dynamic Astronomy, **46**, 197, 1989). If you need further information on these, please contact your Program Coordinator.

One exception exists to the requirements outlined above. Observers for solar system Targets of Opportunity (e.g. a "new" comet or asteroid, a solar-wind disturbance reaching the Jovian magnetosphere, etc.), should complete the Generic Target List (See "Generic Targets List [Generic_Targets]" in Chapter 3.) and the Visit and Exposure Specifications (to the extent possible) in time for the Phase II deadline. If and when a suitable target appears, the proposer must complete the Solar System Target List and update the Visit and Exposure Specifications. **No target can be observed until the complete Phase II information is provided**.

In this chapter, each heading has a description followed by a keyword in square brackets (e.g., **[Target_Number]**). Elsewhere, items in boldface (e.g., **RA**) show words or phrases that are used as APT Phase II items or properties. Items in <> brackets (e.g., <value>) show values you provide. Items listed in square brackets (e.g., [**A1** : <value>]) are optional, whereas those **not** in square brackets are required. As you enter information in the APT interface. You will be told (via a tooltips message) if an item is required, and its format.

4.1 Target Number [Target_Number]

Each target must have a unique target number (base 10 from 1 to 999) and are usually assigned by the APT software. Target numbers must be positive, monotonically increasing integers. You should define a different target whenever a different target position or timing description is required. For example, separate targets should be defined if you plan to take spectra of several different surface features on a planet, or if you plan to observe the same feature with different timing constraints.

4.2 Target Name [Target_Name]

The name is used to identify a target; **all target names within a proposal must be unique**. The target name can be selected from the STScI list of **standard** targets (see Table 4.1; explanations of “Level 1” and “Level 2” are given below), or a name can be defined by the GO. The use of standard names is encouraged whenever possible.

The following conventions should be followed in naming targets:

- The length of a target name can be anywhere from 2 to 31 characters.
- **No blanks are permitted in target names**. A hyphen should replace blanks that would normally be used to separate fields (e.g. **IO-TORUS**, **COMET-BRADFIELD-1979X**).
- Only letters and numerals are allowed in target names; punctuation (other than hyphens and **+** or **–**) is not permitted.
- Construct target names so they make sense for your observing program. For example, if your program consisted of consecutive observations of three surface features on Mars, then three appropriate target names might be: **MARS-FEATURE1**, **MARS-FEATURE2**, and **MARS-FEATURE3**.

Do not use just a standard name for a target when a specific portion of a body is being observed. For example, do not use “Saturn” as the target name for a feature or specific location that is defined relative to the position of Saturn as a standard body because this is confusing for the software that computes the positions of moving targets.

Table 4.1: Solar System Standard Targets

Level 1	Level 2	
Sun		
Mercury		
Venus		
Earth	Moon	Hubble
Mars	Phobos	Deimos

Table 4.1: Solar System Standard Targets (Cont)

Level 1	Level 2		
Jupiter	Io	Europa	Ganymede
	Callisto	Amalthea	Himalia
	Elara	Pasiphae	Sinope
	Lysithea	Carme	Ananke
	Leda	Thebe	Adrastea
	Metis	Callirrhoe	Themisto
	Taygete	Chaldene	Harpalyke
	Kalyke	Iocaste	Erinome
	Isonoe	Praxidike	Autonoe
	Thyone	Hermippe	Aitne
	Eurydome	Euanthe	Euporie
	Orthosie	Sponde	Kale
	Megaclite	Pasithee	
Saturn	Mimas	Enceladus	Tethys
	Dione	Rhea	Titan
	Hyperion	Iapetus	Phoebe
	Janus	Epimetheus	Helene
	Telesto	Calypso	Atlas
	Prometheus	Pandora	Pan
	Paaliaq	Tarvos	Ijiraq
	Suttungr	Kiviuq	Mundilfari
	Albiorix	Skathi	Erriapo
	Siarnaq	Thrymr	Ymir
Uranus	Ariel	Umbriel	Titania
	Oberon	Miranda	Cordelia
	Ophelia	Bianca	Cressida
	Desdemona	Juliet	Portia
	Rosalind	Belinda	Puck
	Caliban	Sycorax	Prospero
	Setebos	Stephano	Trinculo

Table 4.1: Solar System Standard Targets (Cont)

Level 1	Level 2		
Neptune	Triton	Nereid	Naiad
	Thalassa	Despina	Galatea
	Larissa	Proteus	
Pluto	Charon		

If you are uncertain whether or not your target can be referenced by name, contact your Program Coordinator for guidance.

4.3 Target Description [Description]

The target description is used to sort the solar system targets by class and will be useful to archival researchers. The first word in any target description **must** be one of the + listed below. The keyword is then followed with text that depends on the target class as described below.

Table 4.2: Target Description Keywords

Keyword	Description
PLANET	If the target is the center of a planet, enter **PLANET** followed by the name of the planet (e.g., **PLANET JUPITER**, **PLANET SATURN**).
SATELLITE	If the target is the center of the satellite of a planet, enter **SATELLITE** followed by the satellite name (e.g., **SATELLITE GANYMEDE**, **SATELLITE 1980S27**)
COMET	If the target is the nucleus of a comet, enter **COMET** followed by its common name or catalog designation (e.g., **COMET HALLEY**, **COMET 1979X**)
ASTEROID	If the target is the center of an asteroid, enter **ASTEROID** followed by its common name or its catalog number (e.g., **ASTEROID CERES**, **ASTEROID 452**)
FEATURE	If the target is a surface feature, enter **FEATURE** followed by the name of the parent body (e.g., **FEATURE JUPITER**, **FEATURE IO**)
OFFSET	If the target is an offset position with respect to a solar system body (but not a feature on its surface), enter **OFFSET** followed by the name of the parent (reference) object (e.g., **OFFSET COMET HALLEY**, **OFFSET JUPITER**)
RING	If the target is in a ring, enter **RING** followed by the name of the parent object (e.g., **RING JUPITER**, **RING SATURN**)
TORUS	If the target is a plasma torus, enter **TORUS** followed by the name of the parent object (e.g., **TORUS JUPITER**)

Table 4.2: Target Description Keywords (Cont)

Keyword	Description
OTHER	If your target cannot be classified under any of the categories above, then enter **OTHER** followed by some description of the type of observation planned (e.g., **ASTROMETRIC REFERENCE**, **INTERPLANETARY MEDIUM**, **ZODIACAL LIGHT**)

4.4 Target Position

Target Pointing Specification (TPS) and "Levels"

Three fields are used to describe the target's position, referred to here as the **Target Pointing Specification** (TPS). The TPS has been defined using a hierarchical structure.

- **Level 1 refers to a target in orbit about the Sun.** Examples of Level 1 targets include planets, asteroids, and comets. When a Level 1 object is the desired target for observation, complete the Level 1 field and leave the other two target position fields blank.
- **Level 2 refers to a target whose motion is normally described with respect to a Level 1 object.** Examples of Level 2 targets include planetary satellites, surface features on planets or asteroids, and non-nuclear positions in the coma of a comet. When a Level 2 object is the desired target for observations, the Level 1 field contains information on the **parent** body, and the Level 2 field gives positions relative to this body. In this case, leave the Level 3 field blank.
- **Level 3 refers to a target whose motion is normally described with respect to a Level 2 object.** Examples are a surface feature on a planetary satellite or a pointing which is offset from the center of a planetary satellite. When a Level 3 object is the desired target for observation, then all three fields must be completed, with Level 1 giving the **parent** of the body described in Level 2, and Level 3 giving the position of the observed target with respect to the body in Level 2.

No more than three levels are allowed. If you believe that your target cannot be described in this form, contact your Program Coordinator.

Text Proposal File

If you are using the Text Proposal File, **TPS** items must be separated by commas.

Describing Targets

The targets specified in the target position fields can be described in up to four ways:

- By a name selected from a list of targets
- By orbital elements
- By coordinates with respect to another object
- Via target selection during a real-time observing session

Table 4.1 gives the list of valid names for solar system targets. PIs are responsible for obtaining up-to-date orbital elements for bodies not in this table. Objects must be denoted by their IAU-adopted name. A good reference for object names can be found in the *Astronomical Almanac*, and in the Marsden comet catalog (Marsden, B. G., *Catalog of Cometary Orbits*, Enslow Publishers, Hillside, NJ, 1983). If you are uncertain whether or not your target can be referenced by name, contact your Program Coordinator.

In those cases where the target's position is given with respect to one of the **standard** objects, the latest available data from JPL on the bodies' physical dimensions, orientation, and rotation rates are used in calculating the target's position. **In those cases where all or part of the TPS for your target can be described using standard names, we strongly recommend that you do so**. Generally, this will result in the most accurate ephemeris generation for your target.

Specifying Time

Wherever there is an entry involving time, the format for that entry must be:

DD-MMM-YYYY:hh:mm:ss.s,

where **DD** is the day of the month, **MMM** is the first three letters of the month name, **YYYY** are the full four digits of the Gregorian calendar year, **hh** is the hour, **mm** is the minute, and **ss.s** are the decimal seconds. Only the necessary precision need be specified **(*NOTE: But the time after the colon it must be completely specified or not at all*)**

Examples:

02-AUG-1993:13:04:31

15-JAN-1994

Two different systems of time are used in this document. TDB refers to *Barycentric Dynamical Time* and can be considered synonymous with ET (*Ephemeris Time*), which was used before 1984. UTC refers to *Coordinated Universal Time*. The precise interpretation of each time value depends on the context in which it is used.

4.4.1 Target Position Level 1 [Level_1]

Specify your target in this field in **one** of the following ways:

1. **STD =** <object name>, where the name must be from Table 4.1, or
2. **TYPE =** <name>.
   The **TYPE =** <name> target description allows the specification of non-standard targets in a variety of formats and must be the first entry in the field if it is used.
   - If **COMET** is chosen, then a set of 2-body orbital elements in the *IAU Circular* format must be supplied for the target.
   - If **ASTEROID** is chosen, then a set of 2-body orbital elements in the *Minor Planet Circular* format must be supplied.

   For all cases, the required input data are described below. If the data are valid only over a specific period of time, then specify this time interval in the **Window** field according to the rules given later.

COMET and ASTEROID Positional Parameters

Table 4.3: **Positional Parameters for TYPE = COMET**

Q = <value>	Perihelion distance, in AU
E = <value>	Eccentricity
I = <value>	Inclination, in degrees
O = <value>	Longitude of ascending node, in degrees
W = <value>	Argument of perihelion, in degrees
T = <value>	Time of perihelion passage, in TDB
EQUINOX = <value>	either **B1950**, or **J2000**
EPOCH = <value>	Osculation date, in TDB (4 digits)
[A1 = <value>]	Radial component of non-gravitational acceleration (AU/day^2)
[A2 = <value>]	Component of non-gravitational acceleration lying in the orbital plane and parallel to the instantaneous velocity vector (AU/day^2)
[A3 = <value>]	Component of non-gravitational acceleration directed perpendicular to the plane defined by **A1** and **A2** (AU/day^2)

Table 4.4: **Positional Parameters for TYPE = ASTEROID**

A = <value>	Semi-major axis, in AU
E = <value>	Eccentricity
I = <value>	Inclination, in degrees

Table 4.4: **Positional Parameters for TYPE = ASTEROID** (Cont)

O = <value>	Longitude of ascending node, in degrees
W = <value>	Argument of perihelion, in degrees
M = <value>	Mean anomaly at **EPOCH**, in degrees
EQUINOX = <value>	**J2000**
EPOCH = <value>	Osculation date, in TDB (4 digits)

The elements given above refer to the mean ecliptic and equinox of either B1950 or J2000 depending on which "value" is specified for **EQUINOX**. An example of **TYPE = COMET** is shown in the "Example Target List Blocks" below for Example 3.

It is the responsibility of the observer to supply accurate orbital elements to STScI when specifying TYPE=COMET or TYPE=ASTEROID.

4.4.2 Target Position Level 2 [Level_2]

Five **Target Reference Systems** (TRSs) are described in the following paragraphs. Please pay careful attention to the definitions of each TRS. Specify your target in **one** of the following ways:

STD = <object name> or TYPE = <name>

In this case <object name> is from Table 4.1: Solar System Standard Targets, or the Type is:

PGRAPHIC
planetographic coordinates relative to Level 1 target

POS_ANGLE
polar coordinate offsets from Level 1 target

MAGNETO
position in magnetic coordinate system

TORUS
line-of-sight projected coordinate system

SAT
orbital elements of a satellite

PCENTRIC

planetocentric coordinates relative to Level 1 target

For the **PGRAPHIC**, **MAGNETO**, and **TORUS** coordinate systems, the north pole is defined to be the rotational pole in the northern celestial hemisphere. For planets with **direct** rotation, the angular momentum vector coincides with the north pole. For planets with **retrograde** rotation, the angular momentum vector coincides with the south pole.

Planetographic Coordinate System

Table 4.5: Parameters for TYPE = PGRAPHIC

LONG = <value>	planetographic longitude in degrees,
LAT = <value>	planetographic latitude in degrees; use – to denote south latitude.
[ALT = <value>]	planetographic altitude above the reference ellipsoid, in kilometers,
[R_LONG = <value>][1]	rate of change of LONG, in degrees/day,
[R_LAT = <value>][1]	rate of change of LAT, in degrees/day,
[R_RAD = <value>][1]	rate of change of RAD, in kilometers/day, and
[EPOCH = <value>]	the reference time for the temporal variation, in UTC (4 digits).

1. **EPOCH** must also be specified with this quantity.

The **PGRAPHIC** TRS is the IAU planetographic coordinate system. It is a non-spherical coordinate system aligned with and rotating about the rotation axis of the Level 1 body, positive north, whose origin lies at the center of the reference body. Locations within this TRS are specified by longitude, latitude, and altitude above the surface. (The lambda(III) coordinate system defines the prime meridian in this coordinate system; if lambda(I) or lambda(II) coordinate systems are desired, note this in the **Comments** field.)

Planetographic Latitude is defined as the angle between the equator and the normal to the surface of the reference ellipsoid at the point of interest.

By definition, the planetographic longitude of the sub-Earth point increases with time. For planets with **direct** rotation, the planetographic longitude increases in a **left-handed** direction. For planets with **retrograde** rotation, the planetographic longitude increases in a **right-handed** direction.

If **ALT** is omitted, then the surface of the reference ellipsoid is assumed.

If the coordinates are constant in time, then none of the other **optional** entries should be used. If any coordinate is given as a function of time, then **EPOCH** is **required** and the time-varying coordinate is interpreted in the following way.

Example:

LONG = 20

LAT = -5

R_LONG = 45

EPOCH = 5-JAN-1990:15

For this example the longitude at any time, **T**, is given by:

longitude = **LONG + R_LONG * (T – EPOCH)**

or, numerically,

longitude = **20 + 45 * (t – 5–JAN–1990:00:15:00)**

The same interpretation for time-varying coordinates also applies to the other TRSs described below.

Position Angle Coordinate System

Table 4.6: **Parameters for TYPE = POS_ANGLE**

RAD = <value>	Radius, in arcseconds
ANG = <value>	Position angle relative to the reference axis, in degrees
REF = NORTH	Reference axis is celestial north, or
REF = SUN	Reference axis is the apparent direction to the Sun as projected on the sky, or
REF = <value>[1]	User specified position angle of the reference measured in degrees eastward from north.
[R_RAD = <value>][1]	Rate of change of RAD, in arcseconds/sec
[R_ANG = <value>][1]	Rate of change of ANG, in degrees/day
[EPOCH = <value>]	the reference time for the temporal variation, in UTC (4 digits).

1. **EPOCH** must also be specified with this quantity.

The **POS_ANGLE** TRS is a position-angle coordinate system (i.e. a two-dimensional polar-coordinate system). This TRS is useful for pointing at targets whose positions are known only in terms of an offset in projected celestial coordinates from another body. The origin of the system lies at the center of the Level 1 body. Locations are specified by giving the **apparent** distance from the origin (in projected celestial coordinates as viewed from the Earth) and the position angle from some **reference axis** to the target point. For **REF = NORTH**, angles are measured from celestial north (positive angles are measured in the same sense as rotating from celestial north through east). For **REF = SUN**, angles are measured from the direction to the Sun as projected on the sky (positive angles are measured in the same sense as rotating from celestial north through east). For **REF =** <value>, the proposer must specify the position angle of the reference axis, measured in degrees East of celestial north (once again, positive angles are measured in the same sense as rotating from celestial north through east).

Magnetic Coordinate System

Table 4.7: **Parameters for TYPE = MAGNETO**

LONG = <value>	Magnetic longitude, in degrees
LAT = <value>	Magnetic latitude, in degrees; use – to denote south latitude.
RAD = <value>	Magnetic radius, in kilometers
[POLE_LAT = <value>]	Cartographic latitude of the pole, in degrees
[POLE_LONG = <value>]	Cartographic longitude of the pole, in degrees
[O_LAT = <value>]	Cartographic latitude of the origin in degrees; use – to denote south latitude.
[O_LONG = <value>]	Cartographic longitude of the origin in degrees
[O_RAD = <value>]	Cartographic radius of the origin, in kilometers

The **MAGNETO** TRS is intended to support observations fixed with respect to a planetary magnetic field. It is a spherical coordinate system rotating with the Level 1 body around the rotation axis, with a specified offset of the coordinate origin and inclination of the coordinate pole. The **MAGNETO** coordinate system is defined in the following manner:

- Define a “cartographic” reference frame identical to the planetographic TRS, except use **spherical** latitudes.
- Rotate the new coordinate system relative to the cartographic frame so the new pole is located at **POLE_LAT** (latitude) and **POLE_LONG** (longitude).
- The final step is to translate the origin of the new system to the specified cartographic latitude, longitude, and radius (**O_LAT**, **O_LONG**, and **O_RAD**, respectively).

While the origin and coordinate axes may differ from those of the cartographic system, the rotation axis and rotation rate are identical to those of the cartographic system. Locations in the **MAGNETO** TRS are specified by longitude, latitude, and radius from the origin of the defined coordinate system.

Torus Coordinate System

Table 4.8: **Parameters for TYPE = TORUS**

LONG = <value>	Torus longitude, in degrees
LAT = <value>	Torus latitude, in degrees; use – to denote south latitude.
RAD = <value>	Torus radius, in kilometers
[POLE_LAT = <value>]	Cartographic latitude of the pole, in degrees
[POLE_LONG = <value>]	Cartographic longitude of the pole, in degrees
[O_LAT = <value>]	Cartographic latitude of the origin in degrees; use – to denote south latitude.
[O_LONG = <value>]	Cartographic longitude of the origin in degrees
[O_RAD = <value>]	Cartographic radius of the origin, in kilometers

If the **optional** fields above are left blank, the following **default** values are used:

O_LONG = 0

O_LAT = +0

O_RAD = 0

POLE_LAT = +83

POLE_LONG = 202

The **TORUS** TRS is defined primarily to support observations of Jupiter's plasma torus and is closely related to the **MAGNETO** TRS. **TORUS** is also useful for observers who want to observe in a coordinate system that is fixed relative to the apparent disk of the Level 1 body, e.g. central meridian observations (see special instructions below). The difference between the two systems is in the definition of the prime meridian. For the **TORUS** TRS, the prime meridian is defined by the instantaneous longitude of the sub-Earth point. Therefore, the **TORUS** TRS **does not** rotate with the Level 1 body. A typical observation would be of the east or west ansa (point of maximum elongation) of an equatorial circle whose radius is roughly five times the equatorial radius of Jupiter (in this case, **LONG = 270** (90 for the west ansa), **LAT = 0**, **RAD = 3.57E05**). As the planet rotates, the target moves up and down in celestial coordinates as Jupiter rotates. This coordinate system can also be used to support observations of a planetary ring ansa.

Special Instructions: The TORUS system can be useful for observations that want to remain fixed at a position of the observable disk of the Level 1 body rather than tracking a particular longitude. The most frequent example is observations on the central meridian at a specified latitude without regard to the longitude. To use TORUS in this way you must set the optional parameter POLE_LAT = +90.

Satellite Elements Coordinate System

Table 4.9: **Parameters for TYPE = SAT**

A = <value>	Semi-major axis of satellite orbit, in km
EPOCH = <value>	Epoch of the elements, in TDB (4 digits)
N = <value>	Mean motion of satellite, in degrees/day
L = <value>	Mean longitude at **EPOCH**, in degrees
[E = <value>]	Eccentricity of satellite orbit
[I = <value>]	Inclination of satellite orbit to the planetary equator, in degrees
[O = <value>]	Longitude of ascending node of the satellite orbit, in degrees
[W = <value>]	Longitude of periapse, in degrees
[O_RATE = <value>]	Rate of change of longitude of ascending node, in degrees/day
[W_RATE = <value>]	Rate of change of periapse, in degrees/day
[RAP = <value>]	Right Ascension of the parent planet pole at **EPOCH**
[DECP = <value>]	Declination of the parent planet pole at **EPOCH**
[EQUINOX = <value>]	**B1950** or **J2000**

When the target is a satellite of the object defined in the Level 1 field, but the satellite itself is not among the **standard** objects, then orbital elements must be specified. These elements refer to the motion of the satellite around the Level 1 object.

The “reference” axis for the angles defined above is the intersection of the Earth’s equator at the standard epoch implied by the **EQUINOX** with the parent planet’s equator at the **EPOCH** of the elements. The positive X-axis for the coordinate system used in the orbit calculation is obtained by taking the cross product of the Z-axis of the standard system (i.e. the system defined by the standard equator and equinox given by **EQUINOX**) with the pole of the planet. If **E**, **I**, **O**, **W**, **O_RATE**, and **W_RATE** are not supplied, then their values are assumed to be **0**. If **RAP** and **DECP** are not supplied, then the standard IAU values are used. If **RAP** and **DECP** are supplied, then they should be referred to the standard equator and equinox given by **EQUINOX**. If **EQUINOX** is not provided, we will assume J2000.

STScI maintains its ephemeris data base with the best available elements, and you should use the **STD =** form for objects in Table 4.1: Solar System Standard Targets unless there is compelling scientific justification for specifying orbital elements. **Note:** It is the responsibility of the observer to supply accurate orbital elements to STScI when specifying **TYPE=SAT**.

Planetocentric Coordinates

PCENTRIC: planetocentric coordinates relative to Level 1 target

For the PCENTRIC coordinate system, the north pole is defined to be the rotational pole in the northern celestial hemisphere. For planets with direct rotation, the angular momentum vector coincides with the north pole. For planets with retrograde rotation, the angular momentum vector coincides with the south pole.

Table 4.10: **Parameters for TYPE = PCENTRIC**

LONG = <value>	planetocentric longitude in degrees,
LAT = <value>	planetocentric latitude in degrees; use – to denote south latitude.
[RAD = <value>]	planetocentric radius in kilometers,
[R_LONG = <value>][1]	rate of change of LONG, in degrees/day,
[R_LAT = <value>][1]	rate of change of LAT, in degrees/day,
[R_RAD = <value>][1]	rate of change of RAD, in kilometers/day, and
[EPOCH = <value>]	the reference time for the temporal variation, in UTC (4 digits).

1. EPOCH must also be specified with this quantity.

The PCENTRIC TRS is the IAU planetocentric coordinate system. It is a right-handed spherical coordinate system aligned with and rotating about the rotation axis of the Level 1 body, positive north, whose origin lies at the center of the Level 1 body. Locations within this TRS are specified by longitude, latitude, and radius from the origin. (The lambda(III) coordinate system defines the prime meridian in this coordinate system; if lambda(I) or lambda(II) coordinate systems are desired, note this in the Comments field.)

Planetocentric longitude increases in a right-handed direction for all planets. For planets with direct rotation, the planetocentric longitude of the sub-Earth point does not increase with time.

If RAD is omitted, then RAD is assumed to be the equatorial radius of the Level 1 body. Note that in general, if RAD is omitted, the point specified will not necessarily be on the visible surface of the planet. This is of special concern for oblate planets, e.g. Jupiter and Saturn, where a point at high latitude at the equatorial radius can appear above the limb of the planet in projection. When using this coordinate system for surface features on Jovian planets, it is best to specify the radius explicitly.

For spherical planets, planetographic and planetocentric latitudes are identical. For significantly nonspherical objects, there is no simple conversion between the two latitude systems.

For planets with retrograde rotation, the planetocentric and planetographic longitudes of a point are identical. For planets with direct rotation, the planetocentric and planetographic longitudes of a point have opposite sign.

4.4.3 Target Position Level 3 [Level_3]

The instructions for this field are identical to those for the Level 2 field except that "Level 3" should be substituted wherever "Level 2" occurs, and "Level 2" should be substituted wherever "Level 1" occurs.

4.5 Ephemeris Uncertainty [Ephem_Uncert]

The <value> for ephemeris uncertainty is the distance along its trajectory that the target is expected to be from its ephemeris position, in kilometers (**KM**), or seconds of time (**S**). The latter reflects the fact that in general, the least well known parameter in an ephemeris is the perihelion time. This parameter is required for any moving target used in an exposure with the **REQ**uires **EPHEM**eris **CORR**ection Special Requirement (see REQuires EPHEMeris CORRection <id>).

Note: A realistic estimate of ephemeris uncertainty is needed to schedule the time necessary to repoint the telescope to the improved position when it is known. It will not be possible for STScI to apply a correction larger than the specified uncertainty.

4.6 Acquisition Uncertainty [Acq_Uncert]

The <value> for acquisition uncertainty is the uncertainty in the position of the target in a direction perpendicular to the line of sight, in kilometers (**KM**) or arcsec (**"**).

Note: A realistic estimate of acquisition uncertainty is needed to schedule the time necessary to repoint the telescope to the improved position when it is known. It will not be possible for STScI to apply a correction larger than the specified uncertainty.

4.7 Observing Windows [Windows]

The observability of solar system targets is often constrained by various geometrical conditions (e.g. satellites observed at greatest elongation from their parent planet), or the desirability of coordinated observations (e.g. the observation of a planetary system at the same time as a spacecraft encounter with the system). The **Window** field is provided to allow the proposer to define geometric and timing constraints. The proposer should specify any constraints necessary to achieve the scientific objectives of the program. However, care should be taken in specifying constraints, since they can render the observations difficult or impossible to schedule.

In general, “windows” which define when the target is visible to HST need not be explicitly identified, since these windows will be calculated by the STScI. Windows in this category include:

- Times when the target is not occulted by the Earth.
- Times when the target is not too close to the Sun, Moon, or the bright Earth limb.
- If the target is a planetary satellite, the times when it is not occulted by any other object in the planetary system.
- If the target is a surface feature on a body, the times when the feature is within the field of view of the HST (i.e. the feature is on that part of the body “facing” HST).

If you require **other** specific conditions to be satisfied (e.g. to observe when a satellite is near elongation, to observe when the central meridian longitude lies in a particular range, etc.), then these conditions must be specified in the **Window** field. However, the proposer must recognize that proposer-supplied windows might not overlap with the “visibility” windows defined above (calculated by STScI), in which case the observation cannot be scheduled. Note that atmospheric drag and other effects make it difficult to predict the exact position of the HST in its orbit far in advance. This leads to uncertainty in the exact timing of the "visibility" windows more than two or three months in advance.

The various keywords used to define windows are given in the following table and described in detail below.

Table 4.11: **Keywords for Observing Windows**

SEP	angular separation of two bodies as viewed from a third body
RANGE	distance between two bodies in AU
A_VEL	angular velocity in arcsec/sec
R_VEL	radial velocity of one body relative to another in km/sec
SIZE	angular diameter of one body as seen from another in arc-sec
PHASE	phase of one body as seen from another
OCC	when two bodies overlap as viewed from a third body
TRANSIT	when one body crosses another as viewed from a third body
ECL	when one body is in the shadow of another body
CML	central meridian longitude
OLG	orbital longitude

Table 4.12: **Operators for Observing Windows**

LT	short for **less than**
GT	short for **greater than**
EQ	short for **equals**
MAX	short for **maximum**
MIN	short for **minimum**.
NOT	logical complement. May be used to specify when a condition does not exist. Each of the above keywords may be preceded by the **NOT** operator.

The operator NOT, if present, should precede the keyword for the solar system target observing window, as in these examples:

NOT SEP OF IO JUPITER FROM EARTH GT 10
NOT RANGE JUPITER EARTH GT 10
NOT A_VEL IO RELATIVE JUPITER FROM EARTH GT 10

SEP

SEP is short for “Separation” and is used to find the times when the apparent separation between two objects, as observed from a third object, satisfies certain conditions. The separation between two bodies is defined as the angle between the closest points on the observed limbs of the spheres representing the objects as viewed from the observer (the radius of the sphere is equal to the largest radius of the tri-axial ellipsoid representation of the object). The syntax is:

[NOT] SEP OF <object 1> <object 2> **FROM** <observer> <condition> <angle>

where <object 1>, <object 2>, and <observer> must either be **standard** bodies, or objects that have been previously defined in the target position fields. The unit for “angle” must be chosen from one of **D** (degrees), **'** (arc-minutes), or **"** (arc-seconds). The interpretation of the **SEP** keyword is as follows. When the <condition> is either **LT**, **GT**, or **EQ** then times are found when the separation of “objects 1 and 2”, as viewed from <observer>, is **less than** <angle>, is **greater than** <angle>, or **equals** <angle>, respectively. When the <condition> is **MAX** (**MIN**), then times are found when “objects 1 and 2” are at **maximum elongation** (**minimum separation**), as viewed from <observer>.

RANGE

RANGE is used to select windows based on the separation of objects in terms of distance (AU). The syntax is:

[NOT] RANGE <object 1> <object 2> <condition> <distance>

A_VEL

A_VEL is used to select windows based on the angular velocity of objects in terms of arcsec/sec. The syntax is:

[NOT] A_VEL <object 1> [**RELATIVE** <object 2>] **FROM** <object 3> <condition> <velocity>

<Velocity> is the angular velocity of <object 1> as observed from <object 3>. If **RELATIVE** is used, <velocity> is the apparent angular velocity of <object 1> relative to <object 2> as observed from <object 3>.

R_VEL

R_VEL is used to select windows based on the change in distance between two objects (i.e. the Radial Velocity) in km/sec. The syntax is:

[NOT] R_VEL <object 1> <object 2> <condition> <velocity>

Positive values of <velocity> mean that the objects are moving away from each other while negative values mean that the objects are moving closer to each other.

SIZE

SIZE is used to select windows based on the apparent angular diameter of an object in arc-seconds. The syntax is:

[NOT] SIZE <object> <condition> <angle>

PHASE

PHASE is used for solar phase angle, and is used to find times when the angular phase of one body as seen from another is within a specified range. The syntax is:

[NOT] PHASE OF <object> **FROM** <observer> **BETWEEN** <angle 1> <angle 2>

where <angle> is the observer-object-sun angle, in degrees.

OCC

OCC is short for “Occultation” and is used to find times when one body appears to pass behind another body as viewed from a third body. The syntax is:

[NOT] OCC OF <occulted object> **BY** <occulting object> **FROM** <observer>

The <occulted object>, <occulting object>, and <observer> must be **standard** bodies from Table 4.1: Solar System Standard Targets. An occultation is defined to begin when the limb of the sphere representing the <occulted object> first touches the limb of the sphere representing the <occulting object>, as seen from the vantage point of the <observer>.

TRANSIT

TRANSIT is used to find times when one body appears to pass across the disk of another body as viewed from a third body. The syntax is:

[NOT] TRANSIT OF <transiting object> **ACROSS** <transited object> **FROM** <observer>

The <transiting object>, <transited object>, and <observer> must be **standard** bodies from Table 4.1: Solar System Standard Targets. A transit is defined to begin when the disk representing the <transiting object> is entirely in front of the disk representing the <transited object>, as seen from the vantage point of the <observer>. The transit ends when the limbs of the two disks come into contact again. Thus at any time in the transit the <transiting object> is entirely surrounded by the <transited object>.

ECL

ECL is short for “Eclipse” and is used to find times when one body is in the shadow (cast in sunlight) of another body. The syntax is:

[NOT] ECL <type> **OF** <eclipsed object> **BY** <eclipsing object>

The <eclipsed object> and <eclipsing object> must be **standard** bodies from Table 4.1. An eclipse is defined to begin when the trailing limb of the <eclipsed object> enters the penumbra (<type> = **P**) or the umbra (<type> = **U**) of the <eclipsing object>. An eclipse is defined to end when the leading limb of the <eclipsed object> exits the penumbra (<type> = **P**) or the umbra (<type> = **U**) of the <eclipsing object>. One of the values **P** or **U** must be specified.

CML

CML is short for “Central Meridian Longitude” and is used to find times when the sub-observer meridian of an object lies within a particular range. The syntax is:

[NOT] CML OF <object> **FROM** <observer> **BETWEEN** <angle 1> <angle 2>

The <object> and <observer> must be **standard** bodies from Table 4.1: Solar System Standard Targets. The keyword specifies those times when the central meridian longitude lies between <angle 1> and <angle 2> (both in degrees) as seen by the <observer>.

OLG

OLG is short for “Orbital Longitude” and is used to select observation times based on a geocentric view (usually) of the object. **OLG** can be used on either a Level 1 or a Level 2 object. The syntax is:

[NOT] OLG OF <object 1> [**FROM** <object 2>] **BETWEEN** <angle 1> <angle 2>

where <angle 1> and <angle 2> are in degrees. **OLG** specifies those times when the orbital longitude lies between <angle 1> and <angle 2>. The default for <object 2> is the Earth. If <object 1> refers to a Level 2 body, usually a satellite, the orbital longitude is defined as follows (see Figure 4.1 Orbital Longitude for Satellites):

1. Construct a vector from <object 2> (Earth) to the Level 1 parent (planet) of the <object 1> (satellite).
2. Extend the vector “behind” the planet and project it onto the orbital plane of the satellite. This is the reference axis.
3. The orbital longitude is the angle from the reference axis to the position of the satellite measured in the direction of motion of the satellite. Valid values for the orbital longitude lie in the range 0–360 degrees.

Orbital Longitude of 0 degrees corresponds to superior conjunction, Orbital Longitude of 180 degrees corresponds to inferior conjunction, and 90 degrees and 270 degrees correspond to greatest eastern and western elongation, respectively.

If “object 1” refers to a Level 1 body, e.g. a planet, asteroid, or comet, the orbital longitude is defined to be the angle between the Sun-Earth vector and the Sun-Planet vector, projected onto the planet’s orbital plane, increasing in the direction of the planet’s orbital motion (see Figure 4.2: Orbital Longitude for Planets).

Orbital Longitude of 0 degrees corresponds to opposition, Orbital Longitude of 180 degrees corresponds to conjunction with the Sun. However, Orbital Longitude of 90 degrees or 270 degrees does **not** correspond with quadrature. Orbital Longitude is **not** synonymous with “elongation” or “separation” from the sun.

4.7.1 Default Target Windows

Please note that the following defaults apply for solar system targets:

All targets:

SEP OF <target> **SUN FROM EARTH GT 50D**

All targets in the Martian system except Mars:

SEP OF <target> **MARS FROM EARTH GT 10"**

All targets in the Jovian system except Jupiter:

SEP OF <target> **JUPITER FROM EARTH GT 30"**

All targets in the Jovian system except Io:

SEP OF <target> **IO FROM EARTH GT 10"**

All targets in the Jovian system except Europa:

SEP OF <target> **EUROPA FROM EARTH GT 10"**

All targets in the Jovian system except Ganymede:

SEP OF <target> **GANYMEDE FROM EARTH GT 10"**

All targets in the Jovian system except Callisto:

SEP OF <target> **CALLISTO FROM EARTH GT 10"**

All targets in the Saturnian system except Saturn:

SEP OF <target> **SATURN FROM EARTH GT 45"**

All targets in the Saturnian system except Rhea:

SEP OF <target> **RHEA FROM EARTH GT 10"**

All targets in the Saturnian system except Titan:

SEP OF <target> **TITAN FROM EARTH GT 10"**

All targets in the Uranian system except Uranus:

NOT OCC OF <target> **BY URANUS FROM EARTH**

All targets in the Neptunian system except Neptune:

NOT OCC OF <target> **BY NEPTUNE FROM EARTH**

All **TYPE=PGRAPHIC**, and **TYPE=MAGNETIC** targets:

NOT OCC OF <target> **BY** <parent body> **FROM EARTH**

These default windows will be superseded by any similar windows specified in the solar system target list. For example, if the target is Io and an Io-Callisto separation window is specified by the observer, then the observer's Io-Callisto separation window will apply and the default will not.

4.8 Flux Data [Flux and Other_Fluxes]

Flux information for all targets is required. There can be more than one entry for a given target. STScI will use this flux information to prevent over-illumination of sensitive detectors. Proposers should refer to Section 3.9 on page 49 for instructions and guidelines on how to provide flux data for their targets. The flux data must be given in the format and units shown in Table 4.13: Formats for Specification of Target Flux Data. The units should not be entered on the Target List.

Text Proposal File

If you are using the Text Proposal File, other flux items must be separated by commas.

Table 4.13: Formats for Specification of Target Flux Data

Parameter	Format example	Units
Examples for Stars:		
Broad-band magnitude[1]	**V=13.1 +/– 0.5**	magnitude
Spectral type	**TYPE=G5III**	
Color Index[1]	**B-V = 0.86 +/– 0.2**	magnitude
Color Excess	**E(B-V) = 0.3 +/– 0.2**	magnitude
Background Surface Brightness[2]	**SURF-BKG(B) = 20 +/– 0.2**	mag/arcsec^2

Table 4.13: Formats for Specification of Target Flux Data (Cont)

Parameter	Format example	Units
Examples for Galaxies, Nebulae, and other extended sources:		
Surface Brightness[1,2]	**SURF(V) = 25.0 +/– 1.0**	mag/arcsec^2
Surface Brightness[1]	**SURF(B) = 24.5 +/- 0.5**	mag/arcsec^2
Color Excess	**E(B-V) = 2.5 +/– 0.2**	mag
Plus whatever other fluxes are relevant to your science program. Some other examples are listed below:		
Interstellar Extinction	**A(V) = 1.3 +/– 0.1**	mag
Flux at a specified wavelength	**F(5100) = 51 +/– 3 E-15**	erg/(cm^2 sec Å)
Continuum Flux[3]	**F-CONT(3500) = 57 +/– 3 E-15**	erg/(cm^2 sec Å)
Line Flux[3,4,5]	**F-LINE(3727) = 5 +/– 1 E-14**	erg/(cm^2 sec Å)
Line Width[6]	**W-LINE(3727) = 2.4 +/– 0.2**	Å
Surface Brightness at specified wavelength[2]	**SURF(5100) = 11 +/– 2 E-15**	erg/(cm^2 sec Å arcsec^2)
Surface Brightness at continuum wavelength[2]	**SURF-CONT(5000) = 52 +/– 2 E-15**	erg/(cm^2 sec Å arcsec^2)
Surface Brightness of line emission[3,4,5]	**SURF-LINE(5007) = 52 +/– 2 E-15**	erg/(cm^2 sec arcsec^2)
Size (FWHM of circular region)[7]	**SIZE = 25 +/–5**	arcsec

1. The following broad-band magnitudes may be used: **U,B,V,R,I,J,H,K**.
2. You may append "**–BKG**" to this reference (just before the wavelength designation) to indicate that it is a background flux value (e.g., **SURF-BKG(V) = 18.2 +/– 0.5**; **SURF-CONT-BKG(5100) = 10 +/– 3 E-15**).
3. Give wavelength used in keyword in rest frame, but flux in observed frame.
4. Line flux should be relative to the continuum, if specified, or relative to zero if not specified.
5. Whenever the S/N refers to a spectral line, **W-LINE** must be given along with **F-LINE** or **SURF-LINE**. Values of **F-LINE** and **SURF-LINE** outside the Earth's atmosphere are required.
6. **W-LINE** is the full width at half maximum (FWHM).
7. **SIZE** should be included if the exposure time estimate assumed the flux was spread over an extended region; if omitted, the highest spatial resolution of the observing mode will be assumed.

4.9 Comments [Comments]

This field should include in words what you are trying to define by coordinates and windows in the other fields. For example, for Target No. 3 on the sample form the TPS and **Window** fields define mathematically the location of the target and the valid observation times, but the **Comments** field is probably much more useful in helping an observation planner determine the proposer's objectives. Use only alphanumeric characters and hyphens.

4.10 Illustrations of Orbital Longitude

Figure 4.1: Orbital Longitude for Satellites

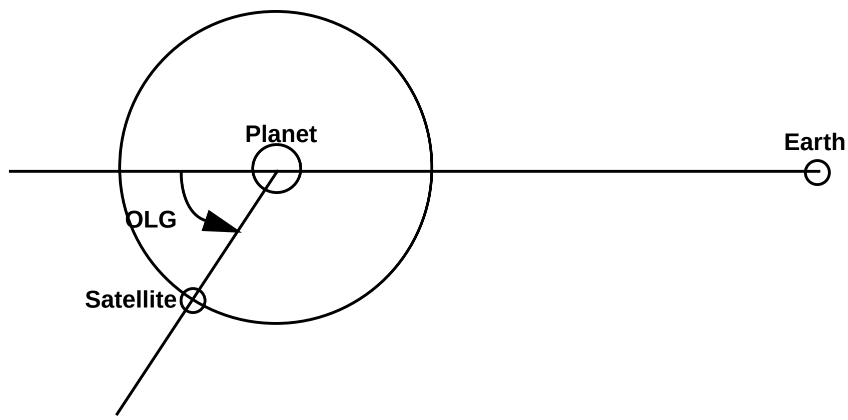
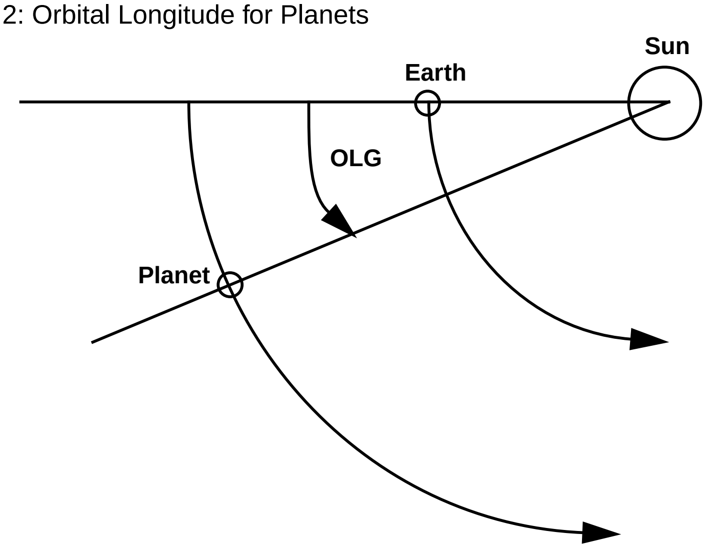


Figure 4.2: Orbital Longitude for Planets



4.11 Examples of Target List Blocks

The sample targets defined in this section are provided as examples of completed forms using the syntax described in these instructions. This collection does not provide an example for every type of keyword but does give a good overall representation of the types of target selections that can be accommodated. Numerical data in these examples is fictional.

- **Example 1**: In this example the proposer wants to perform spectroscopy of a volcano on Io. The position of the target is given in planetographic coordinates. The proposer also wants to observe the target when it lies close to the central meridian and, thus, uses **CML** to specify the allowable range of the central meridian longitude.

Target_Number:	**1**
Name:	**IO-VOLCANO**
Description:	**FEATURE IO**
Level_1:	**STD = JUPITER**
Level_2:	**STD = IO**
Level_3:	**TYPE = PGRAPHIC,**
	LONG = 310,
	LAT = 13
Window:	**CML OF IO FROM EARTH BETWEEN 280 340**
Flux:	**SURF(V) = 5 +/– 0.5,**
	SURF-CONT(2300) = 5.2 +/– 0.2 E–14,
	SIZE = 1.0
Comments:	Observe IO volcano Loki when it is near the central meridian.

- **Example 2**: In this example the proposer wants to perform spectroscopy of the western ansa of the Io torus when Io is near greatest eastern elongation. The elongation condition is specified using the **OLG** keyword.

Target_Number:	**2**
Name:	**IO-TORUS**
Description:	**TORUS JUPITER**
Level_1:	**STD = JUPITER**
Level_2:	**TYPE = TORUS,**
	LONG = 90,
	LAT = 0,

	RAD = 4.3E5
Window:	**OLG OF IO BETWEEN 90 100**
Flux:	**SURF-LINE(1304) = 1 +/– 0.5E–13,**
	W-LINE(1304) = 2 +/– 1,
	SIZE = 1
Comments:	West ansa of IO Torus when IO is at greatest eastern elongation.

- **Example 3**: In this example the proposer wants to perform spectroscopy in the tail of comet Halley near the time of the Giotto spacecraft encounter. The latest orbital elements for the comet have been supplied by the proposer and these will be used for the ephemeris generation. The **POS_ANGLE** target reference system is used to specify the tailward pointing.

Target_Number:	**3**
Name:	**COMET-HALLEY-TAIL**
Description:	**OFFSET COMET HALLEY**
Level_1:	**TYPE = COMET,**
	Q = 0.5871167,
	E = 0.9672815,
	I = 162.2397156,
	O = 58.144397,
	W = 111.8489075,
	T = 09-FEB-86:11:01:04,
	EPOCH = 01-MAR-86,
	EQUINOX=B1950
Level_2:	**TYPE = POS_ANGLE,**
	RAD = 30,
	ANG = 180,
	REF = SUN
Flux:	**SURF(V) = 12 +/– 1,**
	SURF-LINE(1216) = 3.1 +/– 0.5E10,
	W-LINE(1216) = 0.1 +/– 0.5,
	SIZE = 1
Comments:	30 arcsec into tail of Halley during Giotto encounter. New orbital elements based on recent observations are provided.

CHAPTER 5:

Visits, Exposures and Exposure Groups

In this chapter . . .

Tables and Figures

The *Visit and Exposure Specifications* are used to define the proposed exposures for all the Scientific Instruments. While the number of parameters needed to define all possible instrument configurations is large, the Visit and Exposure Specifications has been simplified by using standard Instrument Configurations and Operating Modes to set most of the instrument parameters to default values. The rest of the exposure keywords are used to define parameters that usually change from one exposure to the next, such as filters, exposure times, and special scheduling requirements.

Before proceeding further, it is useful to define more carefully what is meant by an **exposure**, a **subexposure**, and by a **visit**. (Note: APT also uses Exposure Groups or Containers; see Section 5.19, "Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns," on page 98)

Exposures

An **exposure** consists of the events and data corresponding to a unique **Exposure_Number** within a given visit. The full description of an exposure is called an Exposure Specification. Although many data samples (see APT subexposures) may result from a single execution of an Exposure Specification (due to the Instrument Configuration, Operating Mode, and Optional Parameters chosen), they are considered to be **one** exposure. Also, you may specify multiple exposures in an Exposure Specification by entering an integer greater than 1 for the **Number_of_Iterations** keyword (see Section 5.14 on page 95); additional exposures will be obtained consecutively (except for possible interruptions by Earth occultations, guide star acquisitions, and SAA passages).

Exposures defined within a visit will be obtained consecutively and in the order specified within a visit.

APT subexposures

Within an Exposure Specification, each data sample that will be taken onboard HST is represented in APT by a separate entity called a **subexposure**. Subexposures are used to track the duration of the sample (actual_duration) and the orbit number in which it occurs (orbit_number).

Visits

A **visit** is an exposure or series of consecutive exposures, with overheads, on a given target, and may consist of the following parts:

1. Guide-star acquisition (to point HST at the target)
2. Target acquisition (to place the target in an instrument aperture)
3. Science exposure(s) (to obtain the data)
4. Instrument overheads (to set up the instrument and read out the data)
5. Instrument calibrations (if more than the standard calibration is required)

If the visit lasts more than one orbit, it will continue with the following for each subsequent orbit:

6. Guide-star re-acquisition (to keep HST pointed and locked after Earth occultations)
7. Science exposure(s)
8. Instrument overheads
9. Instrument calibrations

Whenever one of the following occurs, a new visit must be defined:

- A change in target position of greater than 1 degree. (Contact your Program Coordinator for details regarding solar system objects that move more than about 30 arcsec during the observation and thus are likely to require multiple sets of guide stars).
- Repeated, periodic, or other time-separated observations with an interval between exposures such that one or more empty visibility periods (orbits with no exposures) would otherwise be required.
- Required change in spacecraft roll orientation.

5.1 Visit Number [Visit_Number]

You must assign each visit a unique visit number (base 36 values ranging from 01 - ZZ).

5.2 Visit Priority [Visit_Priority]

This field is required for visits in Pure Parallel and SNAP programs. This field does not apply to primary exposures or programs.

Pure Parallel Visits

The priority should be a positive integer between 1 and 999. This number gives the scheduling priority for a particular parallel visit; higher numbers have higher priority. If a primary pointing matches the target of two or more visits in a parallel proposal, the system will schedule the highest-priority parallel visit that will fit into the opportunity. Therefore, to allow maximum use of long opportunities, visits designed for longer opportunities should have higher priority.

No two parallel visits in a proposal should have the same priority.

SNAP Visits

For SNAP visits the priority must be "**H,**" "**M**" or "**L**" corresponding to High, Medium and Low. The default is "**M**," and the number of **H** values may not exceed the number of **L** values.

5.3 Visit-level Special Requirements [Visit_Requirements]

A variety of visit-level Special Requirements may be chosen; these requirements apply to all exposures in the visit (exposure-level Special Requirements are discussed in Chapter 7, Special Requirements [Visit and Exposure Special_Requirements], on page 111). These requirements will be interpreted by the computer software that is used to schedule the observations; therefore **it is essential that the specific formats shown in Chapter 7, Special Requirements [Visit and Exposure Special_Requirements], on page 111 are followed precisely**. If none of the allowed Special Requirements appears to be sufficient, you can describe the requirements with a text explanation in **Visit_Comments**. **You should contact your Program Coordinator prior to entering such a comment in your proposal.**

Several of these Special Requirements require the use of limited resources or may impose serious constraints on the scheduling system (e.g., **ORIENT**, **CVZ**, **BETWEEN**). Use these Special Requirements with care.

The visit-level Special Requirements are described in detail in Chapter 7, Special Requirements [Visit and Exposure Special_Requirements], on page 111.

Text Proposal File

If you are using a **Text Proposal File** to modify your program, please be aware that only the shortest form of the special requirements will be accepted when you import your template back into APT (e.g., use

ORIENT <angle1> **TO** <angle2>). Also, new lines will not be sufficient delimiters for a list of special requirements. You *must* use semicolons to separate special requirements items.

5.4 On Hold Comments [On_Hold_Comments]

If you have requested via the Special Requirement **ON HOLD** that a given visit be placed "on hold" (which means that the visit will not be scheduled until **you** have cleared the hold), then indicate why the visit is on hold, and how the hold is to be released. Examples of **On_Hold_Comments** are:

- Target of Opportunity
- Waiting for Early Acquisition data from visit <number>
- Waiting for non-HST data [to be obtained <date>]
- Conditional if <text>
- Conditional on <exposure-list> if <text>
- Select <number> of <exposure-list>

5.5 Visit Comments [Visit_Comments]

The comments field should be used only to record observing notes; it should **not** be used to specify scheduling requirements. Comments are not interpreted by the software, but are maintained in the database and do appear on printouts of the programs. Please contact your Program Coordinator prior to inserting comments to make certain there is no other way to specify the information. An Example of a Visit **Comments** is:

- UV observation of Target X

5.6 Exposure Number [Exposure_Number]

APT will assign a unique integer number to an exposure. The smallest exposure number permitted is **1**, and the largest is **999**.

Note that exposure numbers for coordinated parallels must (and will be) sequential; see Section 6.3 on page 105.

5.7 Exposure Label [Exposure_Label]

You can assign a label to each exposure. This allows you to call each exposure by a name that has more meaning than just the exposure number.

For example given three filters and multiple positions, the you might elect to call a sequence of 6 exposures North/U, North/V, North/B, Center/U, Center/V, and Center/B.

5.8 Target Name [Target_Name]

Choose a target from the Target List provided. In the case of certain internal and external calibration sources, a special code must be used (see Tables 5.1 and 5.1). In general, calibration observations will be requested only rarely, since most calibrations will be carried out by STScI (see the *Call for Proposals*).

Due to scheduling constraints, fixed external targets and solar system targets may not be used in the same visit. Also, none of the external calibration targets (**EARTH-CALIB**, **ANTI-SUN**, **ORBIT-POLE-NORTH, ORBIT-POLE-SOUTH**) may be used in the same visit with another external target.

5.8.1 Astronomical Targets

The target name should be **exactly** as you entered it in the Target List (see Section 3.2 on page 27). Only the prime target name is used; alternate names are not used.

5.8.2 Special Targets

If an internal calibration observation is requested on the Visit and Exposure Specifications, one of the specific “target” names in Table 5.1 must be chosen. The calibration source should **not** be chosen in the Target List. See the *Call for Proposals* for discussions of the routine calibrations that will be performed by STScI. See the *Instrument Handbooks* for further details of the calibrations for each instrument.

Name without including them in the Target List.

Table 5.1: Special External Target Names

Name	Description
EARTH-CALIB	The sunlit Earth is used for a flat-field calibration. Because of bright object constraints, **EARTH–CALIB** may not be used in the **ACS/SBC** configuration.
ANTI-SUN	Target will be nearly opposite the Sun whenever scheduled.
ORBIT-POLE or ORBIT-POLE-NORTH	Target will be the North orbit pole.
ORBIT-POLE-SOUTH	Target will be the South orbit pole
ANY	Allowed on pure-parallel and coordinated-parallel exposures. The target will be wherever the parallel aperture happens to point.

Specific astronomical objects used as external calibrators (e.g., standard stars) should be chosen in the Target List and Visit and Exposure Specifications as normal exposures, and the suffix **-CALIB** should be appended to their names, as discussed in Section 3.2.4 on page 30.

5.9 Instrument Configuration [Config]

Choose the Instrument Configuration to be used. The available choices are listed in Table 5.2, along with the corresponding Operating Modes that may be chosen in “Opmode” (see Section 5.10 on page 94). Legal Apertures, Spectral Elements, and Optional Parameters are uniquely determined by the choice of the Instrument Configuration and Operating Mode. Detailed descriptions are provided in Part II: Supported Science Instruments of these *Instructions* and the *Instrument Handbooks*.

Table 5.2: Instrument Configurations and Operating Modes

Instrument Configuration	Operating Modes
WFPC2	**IMAGE**
FGS	**POS, TRANS**
NIC1 or NIC2 or NIC3	**ACCUM, MULTIACCUM**
NIC2	**ACQ**
ACS/WFC or ACS/SBC	**ACCUM**
ACS/HRC	**ACQ, ACCUM**

5.10 Operating Mode [Opmode]

Choose the Operating Mode to be used. Table 5.2 lists all possibilities. See the *Instrument Handbooks* for a detailed discussion of each Operating Mode.

5.11 Aperture or Field of View [Aperture]

The desired aperture or field of view of the Scientific Instrument should be chosen (see Table 5.3). However, observers are cautioned that not all combinations of Apertures, Operating Modes, and Spectral Elements are available. See the *Instrument Handbooks* for details.

Table 5.3: Aperture and Field of View Names

WFPC2		FGS	ACS	NICMOS
Wide variety of FOVs are available; refer to Chapter 9, Wide Field Planetary Camera 2 (WFPC2), on page 171		**1** **2** **3**	See Chapter 11, Advanced Camera for Surveys (ACS), on page 193	NIC1, NIC1–FIX, NIC2, NIC2–ACQ, NIC2–CORON, NIC2–FIX, NIC3, NIC3–FIX

5.12 Spectral Element [Sp_Element]

The desired Spectral Element should be chosen. Spectral Elements include filters (**F**), gratings and grisms (**G**), echelles (**E**), prisms (**PR**), polarizers (**POL**), linear ramps (**FR**), quadrant filters (**FQ**) and mirrors (**MIRROR**). The names of the filters, gratings, grisms, and echelles include the wavelength of the approximate midpoint of the bandpass, in nanometers.

Examples of the Spectral Element designations are the following:

F122M	A medium-band (**M**) WFPC2 filter (**F**) with midpoint of coverage near 1220 Å
G206	A NICMOS grism (G) with midpoint of coverage near 2.06 microns
POLQN33	WFPC2 polarizer at 33 degree angle

Polarizer or Crossed Filter

More than one element may be specified, if necessary, using these fields Choose the desired element from the list provided in Part II of these *Instructions*. They are also are described in the *Instrument Handbooks*.

Text Proposal File (Sp_Element)

If you are using the Text Proposal File, a second spectral element can be specified after the first one separated by a comma.

5.13 Central Wavelength or Range if Grating or Prism Used [Wavelength]

If a linear ramp filter, quadrant filter, grating, or prism is to be used, the central wavelength should be entered. NICMOS exposures do not require a central wavelength or range.

Wavelengths should be expressed in Å in the **observed** frame (but the units should be omitted). Use vacuum wavelengths below 2000 Å, and air wavelengths above 2000 Å.

5.14 Number of Times to Iterate the Exposure [Number_of_Iterations]

Choose the number of times the defined exposure is to be iterated; Choose **1** if only one execution of the exposure is desired. Typical reasons for iterating an exposure are to monitor temporal changes in a target or to keep CCD exposures short to minimize blooming by a bright star. If more than one execution is requested, iterations (in the form of additional subexposures) will be created and executed contiguously. Also note that for STIS, these subexposures can be interrupted by an autowavecal. The autowavecal can be suppressed; see SEQuence <exposure-list> NON-INTerruptible (replaced by Exposure Group Containers in the APT User Interface).

5.15 Time per Exposure [Time_Per_Exposure]

Enter the exposure time (*in seconds*) for each separate exposure. It is important that observers consult the *Instrument Handbooks*, and the tools on the STScI Web pages.

Note that the exposure time is the **total** time for one execution of a defined exposure. Multiple executions may be specified by entering a value for **Number_of_Iterations** (see Section 5.14 on page 95), or with certain Special Requirements. The exposure time entered may be divided among many samples or spectra (**subexposures**), depending on the Instrument Configuration, Operating Mode, and Optional Parameters. Generally, the exposure time is used only for the collection of photons, but there are exceptions for which instrumental overheads are included in the exposure time. For details, see the specification for each Operating Mode in Part B of these *Instructions*. In the normal case, the exposure time entered may be used to obtain a single image, to obtain a series of spectra, or to perform a complex, autonomous target acquisition.

Routine calibration exposures will be performed by STScI. If special internal calibrations are required for your program, consult the Internal Calibration Target tables in Part II of these *Instructions* for information about what exposure times to use.

Use the Target Acquisition sections of the *Instrument Handbooks* and STScI Web tools to estimate exposure times used for acquisition exposures.

Exposure times may be changed during scheduling by STScI in order to place exposures in observing windows defined by orbital constraints (Earth blockage, passage through the SAA, etc.) and to improve overall efficiency. Changes to exposure times will be such that the exposure time is not changed by more than about 20%; note that increases, as well as decreases, in exposure time are possible.

Target acquisition and peakup exposure times are not altered during scheduling.

5.16 Exposure-level Comments [Comments]

Information that cannot be made to conform to the required formats may be entered as a comment. Comments are not interpreted by the software, but are maintained in the database and do appear on printouts of the programs. Comments should be used sparingly, if at all. They are intended only for the small number of programs whose requirements cannot be met with standard and supported features. Please contact your Program Coordinator before entering comments that would affect the execution of an exposure.

5.17 Optional Parameters[Optional_Parameters]

The Operating Modes of the instruments frequently have parameters that may be adjusted. The default parameter values that have been defined for the various Instrument Configurations and Operating Modes can be overridden by entries in Optional Parameters form. See the instrument chapters in this document and the *Instrument Handbooks* for descriptions of the Optional Parameters.

If no values are changed in the Optional Parameters form, default values will be used (e.g., **BINAXIS1=1** would be used in **STIS/CCD ACCUM** Mode; see Section 14.4 on page 300).

Text Proposal File

If you use more than one Optional Parameter, they must be separated by commas (e.g., **BINAXIS1=1**, **BINAXIS2=1**).

5.18 Exposure-level Special Requirements[Special_Requirements]

A variety of exposure-level Special Requirements may be chosen; these requirements apply to individual exposures in a visit (visit-level Special Requirements are discussed in Chapter 7, Special Requirements [Visit and Exposure Special_Requirements], on page 111). These requirements will be interpreted by the computer software that is used to schedule the observations; therefore **it is essential that the formats of the keyword values shown in Chapter 7 are followed precisely**. If none of the allowed Special Requirements appears to be sufficient, you can describe the requirements with a text explanation using the "**Comments**" keyword.

You should contact your Program Coordinator prior to entering such a comment in your proposal.

Several of these Special Requirements require the use of limited resources or may impose serious constraints on the scheduling system (e.g., **RT ANALYSIS**, **REQ UPLINK**). These Special Requirements should be used with care.

Text Proposal File

If you are using a **Text Proposal File** to modify your program, please be aware that only the shortest form of the special requirements will be accepted by APT (e.g., **POS**ition **TARG**et must be entered as **POS TARG**). Also, new lines will not be sufficient delimeters for a list of special requirements. You *must* use semicolons to separate special requirements items.

5.19 Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns

Whenever you wanted to create a set of exposures to be executed in a special way in RPS2 (e.g., a mosaic pattern on a region of the sky), you could specify exposures separately and then link them with exposure-level special requirements. In APT, some of these exposure-level special requirements (listed below) have been replaced with the use of exposure "containers" or groupings. Once an exposure container has been created in APT, you then place the related exposures in this container instead of using Special Requirements to link them.

See APT Help for the mechanics (i.e., a "how to") of placing exposures into containers.

The special requirements (see Table 7.2: "Supported Formats for Exposure Level Special Requirements" on page 114) that have been replaced by these exposure containers or groupings (in parenthesis) are:

- **Exposure Group Container** (**Type: Sequence**)
  (replaces **SEQ**uence <exposure-list> **NON-INT**erruptible)**:**
  The exposures placed in this container will be observed without gaps due to Earth occultation or SAA passages. See Section 7.3.3 on page 137.
- **Coordinated Parallel Container**
  (replaces **PAR**allel <parallel-exp-list> **WITH** <primary-exp-list>):
  The exposures in this container using the “primary” SI will execute in parallel with a sequence of exposures using a “parallel” SI. The “primary” SI will be the SI used in the first exposure in this container. See Section 6.3 on page 105 for more information.

- **Pattern Container**
  (replaces **PATTERN** <#> [<exposure-list>]):
  Each exposure placed in this container will be repeated at each point in a pattern of discrete pointing offsets from a target. The pattern # is assigned by APT. See Section 8.2, “Introduction to Patterns,” on page 145 for more information.

Note: You can place containers within containers (e.g., a coordinated parallel container can be inside a pattern container).

5.20 Subexposures

In an Exposure Specification, each data sample collected is represented in APT by a separate entity called a **subexposure**. A subexposure tracks the orbit number (**orbit_number**) of the sample, as well as any override to the default duration (**actual_duration**). You need not supply these values.

5.20.1 Actual_Duration

Unless the user (or the Autoadjust feature in the Orbit Planner) fills in this field, it will be blank and defaults used. For example, if the exposure is CR-SPLIT, the sum of the exposure times of the subexposures will be equal to the parent exposure’s exposure time. In all other cases the exposure time of each subexposure will be equal to the exposure time of the parent exposure.

Note, however, that if the **actual_duration** field is filled, this value overrides the default. So the total exposure time for an exposure will be equal to the sum of the actual_durations of the subexposures regardless of the original exposure time.

5.20.2 Orbit_Number

This determines which orbit the subexposure will be placed in. Generally, unless you need to control the orbit structure of the visit, this field can be left alone and will be filled in by the Orbit Planner.

CHAPTER 6:

Parallel Science Exposures

In this chapter . . .

HST is, of course, a telescope with instruments that have relatively small apertures that must be accurately pointed to achieve useful scientific results. However, the value of “parallel” observations was recognized during the earliest stages of HST’s design because by turning on other instruments one could discover new objects and new phenomena, or just acquire highly detailed images of random regions of the sky that are the equivalent of a survey. This parallel capability was present to a limited degree at launch, but it has become especially important since the fourth servicing mission because now WFPC2 can work at the same time with ACS and NICMOS.

Parallel science refers to the use of two or more Science Instruments at the same time. The **primary** observation is the one that has determined the pointing of HST and it always takes precedence. The **parallel** observation is the one enabled to take place because the primary observation permits suitable conditions, but the parallel observation must *never* interfere with the primary. Although parallel observations are conceptually simple (e.g., “Turn on ACS while NICMOS is in use”), they are, in fact, complex to execute. Commanding the instruments for parallels and primaries at the same time requires strict observance of complex timing rules in order to avoid damage to instruments. Some special restrictions must be applied in order to effectively schedule and execute parallel observations.

From the point of view of the HST ground systems there are two types of parallel exposures: **pure** and **coordinated** parallels.

- **Coordinated parallels** are written to be part of the same proposal, with the intention of scheduling the primary and the parallels together. Coordinated parallels are inextricably linked with their primaries: *both* must be scheduled in order for *either* to be scheduled.
- **Pure parallels** are scheduled separately from primaries late in the scheduling process (essentially after the primary science schedule has been completely constructed). This type of parallel must be used whenever the primary and parallel exposures come from different proposals. The scheduling of pure parallels has no effect on the primary schedule: pure parallels will be placed on the schedule only when there are suitable opportunities available.

The HST pointing control system will automatically correct for differential aberration effects for the PRIMARY observations. There will be a small smearing effect in the parallel SI which cannot be corrected on-board. The magnitude of the effect will vary with the primary target location and aperture, but will be a maximum of +/– 0.020 arcsec.

6.1 Parallel Science Limitations

These restrictions are to ensure that parallels can be scheduled and executed safely and efficiently:

- Parallel observations have some special restrictions on the targets that may be specified; see Section 6.2 Pure Parallels on page 103 and Section 6.3 Coordinated Parallel Containers on page 105 for details.
- All scheduling constraints (pointing, orientation, and relative timing) that apply to coordinated primaries and parallels must be specified only on the primary exposure.
- No visit-level special requirements, and only a few exposure-level special requirements, are applicable to pure parallel visits.
- Exposures parallel with any instrument mode which permits interactive or autonomous motion of HST (e.g., interactive or onboard acquisitions) are *not* supported.
- Neither parallel exposures nor the primary of a coordinated parallel may have real-time (i.e., TDRS contact) requirements of any kind.
- In order to protect the ACS SBC detector from inadvertent overillumination, the ACS/SBC configuration may be used for coordinated parallels only if an exact ORIENT (e.g., ORIENT 20D to 20D) is

specified. Also, the coordinates of the parallel field must be determined and the parallel target or field must pass the same bright-object screening applied to SBC primary observations.

These limitations are discussed further below.

6.2 Pure Parallels

Pure parallel proposals are identified by the Proposal Category (see Section 2.3.1 Proposal Information [Proposal_Information] on page 13). All visits in such proposals will be interpreted as pure parallel visits.

- Pure parallel proposals require additional information at the proposal level to specify pointing tolerances (see “Parallel Pointing Tolerance” on page 15).
- At the visit level, the **Visit_Priority** (see Section 5.2 Visit Priority [Visit_Priority] on page 89) must be specified to provide guidance for the scheduling system.

Parallel visits using the same target will be considered in order of **Visit_Priority**. A range of visits designed for opportunities of different lengths (say 1 to 10 orbits) is recommended, with the longer visits being given higher priority. At each opportunity on the calendar which matches the pointing of a set of parallel visits and whose pointing is stable within the proposal’s Parallel_Pointing_Tolerance, STScI will schedule the highest-priority visit that fits in the opportunity. Exposures within a visit will be obtained consecutively and in the order specified, just as with primary visits.

How Pure Parallels Are Scheduled

Observer-defined visits correspond to **scheduling units** (SUs) in the HST ground system. An SU is a set of exposures which must be scheduled at the same time. An SU with coordinated parallel exposures is scheduled just like one without parallels. However, pure parallel SUs are scheduled through a separate process.

First the scheduling system builds a calendar from primary visits. Once the primary calendar is complete, a description of it is used to find appropriate parallel SUs to match the opportunities from the primary calendar. These parallels are then scheduled, subject to the constraints of the primary SUs already on the calendar.

While a primary visit is only scheduled once, a parallel visit may be scheduled many times (and generating a new SU each time) whenever it is the most appropriate use of an opportunity on the calendar. On the other hand, if a parallel visit never turns out to be the most appropriate, it will never be scheduled at all.

Instrument Configuration

Pure parallel exposures are limited to the following instrument configurations and modes:

Configuration	Operating Mode
WFPC2	**IMAGE**
ACS/WFC	**ACCUM**
ACS/HRC	**ACCUM**
NIC1 or NIC2 or NIC3	**ACCUM, MULTIACCUM**

Every exposure in a pure parallel proposal must use the same instrument. For NICMOS, coordinated parallel exposure containers using different detectors are not allowed in pure parallel visits.

Special Requirements

No visit-level special requirements are allowed in pure-parallel visits. Exposure-level special requirements are limited to the following:

- **END ORBIT**; **EXPAND**;
- **MAX DUR**; **MIN DUR**;
- **NO-SPLIT**;

We recommend that **MIN DUR**, plus either **MAX DUR** or **EXPAND**, be specified on all pure-parallel exposures, except with NICMOS, where no adjustment of exposure time is possible. If **MIN DUR** is omitted, the default minimum exposure time is set to 80% of **Time_Per_Exposure**. If **MAX DUR** is omitted, the default maximum exposure time is unlimited if **EXPAND** is specified, and is otherwise set to 120% of **Time_Per_Exposure**.

For visits intended to span multiple orbits, **END ORBIT** should be specified on the exposure that is intended to end each orbit in order to provide STScI with better guidance in matching parallel visits to the sizes of opportunities.

Exposure Containers

In pure-parallel visits you can use the following container (see Section 5.19, "Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns," on page 98):

- **Exposure Group Container (Type: Sequence**)

Optional Parameters

Dithering parameters and wavelength scans with the WFPC2 linear ramp filter are not permitted with pure parallels because the pointing is determined by the primary observation.

For ACS pure parallels, no automatic image exposures in conjunction with HRC prism observations will be scheduled. The usual default of **AUTOIMAGE=YES** does not apply, and the **AUTOIMAGE** optional parameter may not be specified.

6.3 Coordinated Parallel Containers

Text Proposal File

In the text proposal file format, coordinated parallel exposures are indicated with the exposure-level special requirement:

PAR <parallel-exp-list> **WITH** <primary-exp-list>

This designates a set of one or more parallel exposures which will execute in parallel with a set of one or more primary exposures in the same visit. The PAR WITH special requirement must be specified on the first exposure in the <primary-exp-list>. Exposures in the <parallel-exp-list> have to appear immediately after the exposures in <primary-exp-list>. Parallel exposure numbers must follow this sequence as well.

The APT User Interface.

This special requirement has been replaced in the APT GUI with the use of Coordinated Parallel Exposure Containers. See Section 5.19 Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns on page 98.

A **Coordinated Parallel Container** designates a set of one or more parallel exposures (`<parallel-exp-list>`) that will execute in parallel with a set of one or more primary exposures (`<primary-exp-list`) in the same visit. The SI used in the first exposure defines the primary SI (and therefore defines the <primary-exp-list>). All other exposures that use the same SI will also be considered primary.

All exposures using a different SI will be considered parallel. Parallel exposures using the same SI or NICMOS detectorwill be executed in the order specified in the container. The first parallel exposure which uses a given instrument or NICMOS detector will be executed as early as possible, but not before the first primary exposure.

6.3.1 Instrument Configuration

The exposures in <primary-exp-list> and <parallel-exp-list> are limited to the following instrument configurations and modes:

Configuration	Operating Mode
WFPC2	**IMAGE**
FGS[1]	**POS**
ACS/WFC[2]	**ACCUM**
ACS/HRC[2]	**ACCUM**
ACS/SBC[2,3]	**ACCUM**
NIC1 or **NIC2** or **NIC3**[4]	**ACCUM**, **MULTIACCUM**

1. FGS may only be used as primary, never parallel.
2. ACS exposures cannot be used in both the <primary-exp-list> and the <parallel-exp-list>, and all ACS exposures in the <parallel-exp-list> must use the same configuration.
3. In order to protect the ACS SBC detector from inadvertent overillumination, the ACS/SBC configuration may be used for coordinated parallels only if an exact ORIENT (e.g., ORIENT 20D to 20D) is specified. Also, the coordinates of the parallel field must be determined and the parallel target or field must pass the same bright-object screening applied to SBC primary observations.
4. The foci of NIC1 and NIC2 are close enough that they can be used simultaneously, whereas the focus of NIC3 is sufficiently different from the foci of NIC1 and NIC2 that it should not be used in parallel with either camera. See section 2.4.4 of the *NICMOS Instrument Handbook*.

All exposures in <primary-exp-list> must have the same Instrument Configuration (Config) and the same Aperture or Field of View (Aperture). Except for the NICMOS, no exposure in <parallel-exp-list> may use the same SI as the primary exposures. NICMOS parallel exposures may use the same SI but only in a different configuration.

6.3.2 Targets

Coordinated parallels may specify fixed, generic, or solar system targets; the special target **ANY**; or internal targets. However, the pointing of HST will be determined only by the primary exposures. Any pointing conditions to be applied on the primary+parallel combination must be specified on the **primary** exposures via exposure-level special requirements, or on the visit as a whole via visit-level special requirements. All external exposures in a given <primary-exp-list> must have the same pointing (this generally means the same target, aperture, and POS TARG), except for NICMOS background patterns (see the discussion of optional parameters below).

If a parallel exposure specifies a fixed target, it should be a different target from the primary ones and should appear in the Target List. In this case, an **ORIENT** special requirement is **required** to ensure that the parallel target is in the aperture. It is the observer’s responsibility to verify that the specified orientation will place the parallel target in the aperture; STScI will not check the geometry. Contact your Program Coordinator if you need assistance.

If the parallel target is diffuse and the orientation does not matter, or if there is no parallel target as such and the intent is just to sample whatever the parallel aperture happens to fall on, you should select the **ANY** target (which should not appear in your Target List).

6.3.3 Special Requirements

The following exposure-level special requirements are disallowed for both primary exposures (any exposure in a <primary-exp-list>) and parallel exposures:

EXPAND
MAXimum **DUR**ation [<time or percentage>]
MINimum **DUR**ation [<time or percentage>]
RT ANALYSIS

The following exposure-level special requirements are allowed for primary exposures, but not for parallels:

END ORBIT
LOW-SKY
PHASE <number1> **TO** <number2>
POSition **TAR**get <x-value>, <y-value>
REQuires **EPHEM**eris **CORR**ection <id>
REQuires **UPLINK**
SAME POSition **AS** <exposure>
SAVE OFFSET <id>
SHADOW
USE OFFSET <id>

The following exposure-level special requirements are allowed without restriction:

SEQuence <exposure-list> **NON-INT**erruptible *(replaced by the Exposure Group Container in APT*; see Section 5.19 Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns on page 98)

SAA CONTOUR (WFPC2 only)

No parallel exposure may appear in the <exposure-list> of an **RT ANALYSIS FOR** Special Requirement, or be the <exposure> referenced by a **SAME POS AS** special requirement.

6.3.4 Optional Parameters

The WFPC2 **READ=NO** option is not allowed, because the WFPC2 CCDs are erased during delays between exposures to avoid cosmic-ray effects.

For ACS coordinated parallels, no automatic image exposures will be scheduled when in conjunction with HRC prism observations. In this case the usual default of **AUTOIMAGE=YES** does not apply, and the **AUTOIMAGE** optional parameter may not be specified.

Normally, the proposal processing system will automatically attempt to add an ACS/WFC exposure in parallel with an ACS/HRC exposure. However, the system will not automatically attempt to add an ACS/HRC exposure with an ACS/WFC exposure (for details refer to Chapter 11 and the *ACS Instrument Handbook).* Also, when ACS and WFPC2 are in a coordinated parallel set, the ACS "auto-parallels" *will not* be added automatically. To request addition of ACS auto-parallels in this case, specify Optional Parameter **PAREXP = MULTIPLE** in the ACS exposure specification. Note that this will not guarantee addition of the auto-parallels. If an ACS buffer dump introduced by addition of ACS auto-parallels conflicts with a WFPC2 readout, the ACS auto-parallels will not be added. The normal restrictions on ACS auto-parallels also apply. ACS auto-parallels may be disabled by specifying Optional Parameter **PAREXP = NONE**.

The parameters used with patterns for NICMOS may be used for coordinated parallels subject to the following restrictions and interpretations:

1. Only a single NICMOS exposure in a coordinated parallel container may use a pattern; this exposure must be the **only** exposure designated as primary. Background pattern parameters may not be used on a parallel exposure, because they involve pointing changes.
2. All NICMOS parallel exposures will be taken at each pattern position (defined in the primary exposure). Any parallel exposures using other SIs will also be taken at each pattern position.

3. If the primary is a NICMOS exposure that uses a pattern, no other exposure in the container may use the same configuration.
4. Background pattern parameters may be used on a parallel exposure only if **OFFSET=FOM** and the primary exposures use an SI other than NICMOS.
5. All other NICMOS parallel exposures will be taken at each pattern position. If the exposure using the background patterns is the primary, parallel exposures using other SIs will also be taken at each pattern position.
6. If **OFFSET=FOM,** each sequence of NICMOS exposures in the parallel exposure list using a different detector must take no longer to execute than the exposure with **OFFSET=FOM**.

In a **Coordinated Parallel container**, the NICMOS **CAMERA-FOCUS**, **FOMXPOS, FOMYPOS**optional parameters (see Sections 12.2.4 and 12.3.4) may be used only by one NICMOS detector, referred to as the "primary detector," which is the SI detector used in the first exposure in the container. If the primary exposures use the NICMOS, the primary detector is the one used in those exposures. Otherwise, the primary detector is determined by the configuration used for the first NICMOS exposure in the parallel exposures.

6.3.5 Ordering Restrictions and Interpretations

In Coordinated Parallel Containers, the SI used in the first exposure defines the "primary" SI.

If the exposures in the <parallel-exp-list> contain exposures that use different SIs or NICMOS detectors, an attempt will be made to execute each set of exposures with the same SI or NICMOS detector in parallel with the other sets. All exposures within a given set must be contiguous in the container. Also, sets of parallel exposures using different NICMOS detectors must be contiguous in the container. Within a set, exposures will be executed in the order they appear.

Due to readout conflicts and limits on the number of SIs which may execute simultaneously, parallel exposures sometimes have to be delayed. If a parallel exposure conflicts with an exposure in its primary list, the parallel will be delayed. If two parallel exposures using different SIs or NICMOS detectors conflict, the exposure which appears later in the container will be delayed.

Following a set of exposures in a Parallel Container, subsequent exposures not in the container will be delayed until after all the primary and parallel exposures have completed.

Text Proposal File

In the **Text Proposal File**, the exposures in the <parallel-exp-list> of a **PAR WITH** special requirement must appear immediately after the exposures in <primary-exp-list>.

6.3.6 Efficiency Considerations

Within a set of coordinated-parallel exposures, the ground system will not break up sequences of exposures that are too long to fit in an orbit, as it does for non-coordinated-parallel exposures. Each group of exposures with the same SI or NICMOS detector **must** be short enough to fit in one orbit. If it is necessary to take coordinated-parallel data over multiple orbits, a separate **Parallel Container** – with a new set of exposures – should be specified for each orbit.

CHAPTER 7:

Special Requirements [Visit and Exposure Special_Requirements]

In this chapter . . .

Tables and Figures

Hint: To go directly to information for a particular Special Requirement, go to the tables that follow below, and click on any entry.

7.1 Introduction to Special Requirements: Syntax and Rules

Special requirements provide flexibility in specifying the scheduling requirements of observations. Many Special Requirements, directly or indirectly, restrict the times when observations can be scheduled. These should be used to provide the schedulers at STScI with enough constraints to ensure that the observations are properly scheduled. **Special Requirements should not be used unless necessary to accomplish the scientific objectives of the program.**

The Special Requirements are summarized in Table 7.1: Supported Formats for Visit Level Special Requirements and Table 7.2: Supported Formats for Exposure Level Special Requirements, and a detailed description of each requirement is provided in the following subsections.

Rules and Conventions

You should observe the following conventions and rules for Special Requirements:

- Items inside angular brackets (< >) in the Special Requirement descriptions are to be replaced with the relevant information. All indicated items must be provided, except for items inside square brackets ([ ]), which are optional.
- A <date> specification in a Special Requirement must either be a geocentric date expressed in Universal Time (UT) or a heliocentric Julian Date. A UT date must be entered in the form DD-MMM-YYYY:hh:mm:ss.s, where MMM represents the first three letters of the month name. For example, **14-DEC-2001:17:05:41.1** refers to 14 December 2001, geocentric UT 17H05M41.1S. Only the necessary precision need be employed (e.g., **14-DEC-2001** might be adequate), but four-digit years are now mandatory. Julian Dates must be entered in the form JDnnnnnnn.nnn (e.g., **JD2444123.4**). Only the required precision need be provided. All Julian Dates will be interpreted as **heliocentric**.
- You should select the units of all <time> specifications from a list provided to you. The options are: days (**D**), orbits (**ORBITS**), hours (**H**), minutes (**M**), or seconds (**S**).
- A visit-level Special Requirement (**Visit_Requirements**) applies to **ALL** the exposures within that visit.
- An exposure-level Special Requirement (**Special_Requirements**) applies **ONLY** to that exposure **and any other referenced exposures within the same visit**.

Additional Rules and Conventions for the Text Proposal File

If you are editing the Text Proposal File to modify your program, please observe these additional syntax rules:

- You *must* use only the portions of the keywords that are shown in upper-case letters in Table 7.1 and Table 7.2 and in the discussion below. The portions in lower-case letters are included for clarity only. For example, **SEQ** must be entered rather than **SEQUENTIAL**.
- Exposures must be referred to by their exposure numbers. <exposure> must be replaced by the number of a single exposure. An <exposure-list> must be replaced by a single range of exposure numbers separated by a hyphen (e.g. **SEQ 2-5 NON-INT)**. *Commas are NOT allowed in exposure lists.*
- Multiple Special Requirements *must* be separated by a semi-colon (**;**). Please note that separate lines are not sufficient to delimit items in a list. Do not use commas to separate Special Requirements items.

Table 7.1: Supported Formats for Visit Level Special Requirements

FORMAT	EXAMPLE
Guiding Requirements	
PCS MODE Fine	**PCS MODE Fine**
PCS MODE Gyro	**PCS MODE Gyro**
GUIDing TOLerance <angle> (arcsec)	**GUID TOL 0.020"**
DROP TO GYRO IF NECESSARY [NO REACQuisition]	**DROP TO GYRO IF NECESSARY**
NUMBER OF GYROS <number>	**NUMBER OF GYROS 2**
Target Orientation Requirements	
ORIENTation <angle1> TO <angle2>	**ORIENT 18D TO 22D**
ORIENTation <angle1> TO <angle2> FROM <visit>	**ORIENT 18D TO 22D FROM 5**
SAME ORIENTation AS <visit>	**SAME ORIENT AS 5**
Special Observation Requirements	
CVZ	**CVZ**
SCHEDulability <percentage>	**SCHED 100%**
NOTRACK	**NOTRACK**
Timing Requirements	
AFTER <date>	**AFTER 12-JUL-2001:12:06**
AFTER <visit> [BY <time1> TO <time2>]	**AFTER 6 BY 7D TO 9D**
BEFORE <date>	**BEFORE 14-SEP-1999**
BETWEEN <date1> AND <date2>	**BETWEEN 21-DEC-1999 AND 31-DEC-1999**
GROUP <visits> WITHIN <time>	**GROUP 5-10 WITHIN 60D**
PERIOD <time> ZERO-PHASE (HJD) <date>	**PERIOD 1.23H AND ZERO-PHASE (HJD) 2444000**
SEQuence <visits-checked> WITHIN <time>	**SEQ Visits 5-7 WITHIN 24H**
VISIBILITY INTERVAL CORON	**Note: This requirement cannot be used in current Two Gyro Mode Operations**
Conditional Requirements	
ON HOLD [FOR <visit-list>]	**ON HOLD FOR 15**

Table 7.2: Supported Formats for Exposure Level Special Requirements

FORMAT	EXAMPLE
Target Acquisition Requirements	
INTeractive ACQuisition (obsolete)	**No longer available; see text.**
USE OFFSET <id>[1]	**USE OFFSET 9100-1**
Target Position Requirements	
POSition TARGet <X-value>,<Y-value>	**POS TARG +6.3,-8.1**
SAME POSition AS <exposure>	**SAME POS AS 6**
PATTERN <#> [<exposure-list>] (*Replaced by Pattern Containers in the APT User Interface*)	See 5.19 Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns on page 98 and Chapter 8: Pointings and Patterns on page 145 **PATTERN 5 1-4**

Table 7.2: Supported Formats for Exposure Level Special Requirements

FORMAT	EXAMPLE
Special Observation Requirements	
PARallel <parallel-exp-list> WITH <primary-exp-list> (replaced by Coordinated Parallel Containers in the APT User Interface)	See 5.19 Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns on page 98 **PAR 4-6 WITH 1-3**
SAA CONTOUR <model number>: (WFPC2 only)	**SAA CONTOUR 02**
Special Communications Requirements	
RT ANALYSIS	**RT ANALYSIS**
REQuires UPLINK	**REQ UPLINK**
REQuires EPHEMeris CORRection <id>	**REQ EPHEM CORR OFF-13**
Timing Requirements	
EXPAND (pure parallel exposures only)	**EXPAND**
LOW-SKY	**LOW-SKY**
MAXimum DURation (time or %) <value> (pure parallel exposures only)	**MAX DUR 115%**
MINimum DURation (time or %) <value> (pure parallel exposures only)	**MIN DUR 1800S**
PHASE <number1> TO <number2>	**PHASE 0.09 TO 0.11**
SEQuence <exposure-list> NON-INTerruptible (replaced by Exposure Group Containers in the APT User Interface)	See 5.19 Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns on page 98 **SEQ 2-5 NON-INT**
SHADOW	**SHADOW**

1. This special requirement is supported only for config=ACS/HRC, mode=ACCUM exposures that use one of the coronagraphic spot apertures (**HRC-CORON1.8, HRC-CORON3.0, HRC-SUB1.8**).

7.2 Visit-level Special Requirements

The following Special Requirements are applicable at the visit level, and they will affect **all** the exposures within that particular visit.

7.2.1 Guiding

There are currently two tracking modes available during HST observations. One of the modes employs guide stars and the Fine Guidance Sensors: Fine Lock. Alternatively, observations can be made while the HST is stabilized with gyros. (In this scenario no guide star acquisition occurs, and the absolute error of positioning is 14 arcsec with a drift rate of about 0.0014 arcsec/sec.) The typical guiding accuracies for the two modes are listed in Table 7.3.

Table 7.3: Accuracies of Guiding Modes

Guiding Mode	Guiding Accuracy[1]
Gyro hold	Drift rate 0.0014 arcsec/sec
Fine lock	RMS jitter 0.005 arcsec

1. Excluding periods during day/night terminator crossings, where jitter can be as high as 0.035 arcsec rms over a period of 5 minutes.

For Two Gyro Mode guiding accuracy information, please go to the Two Gyro Science Mode Web site.

All observations will be performed using Fine Lock guiding by default whenever possible. If difficulties are encountered finding guide stars, you will be contacted by STScI. If you cannot find what you feel to be an appropriate tracking mode, you are urged to contact your Program Coordinator for help resolving the issue.

PCS MODE Fine

Specifies the use of Fine Lock as the guiding mode for the exposures defined in that particular visit. This Special Requirement is the default and any use of the **GUIDing TOLerance <angle>** overrides this Special Requirement.

PCS MODE Gyro

This special requirement cannot be used in Two Gyro Science Mode.

Specifies the use of Gyro hold as the guiding mode for the exposures defined in that particular visit. This mode is available **ONLY** with the WFPC2, ACS/WFC, ACS/HRC and NICMOS. It is prohibited with other SIs because of concern that gyro drift will result in inadvertent exposure to bright objects. Note that the RMS absolute pointing error for gyro hold is 14 arcsec with a drift rate of about 0.0014 arcsec/sec. This Special Requirement overrides the default and any use of the **GUIDing TOLerance <angle>** Special Requirement.

GUIDing TOLerance <angle>

This special requirement cannot be used in Two Gyro Science Mode.

This special requirement specifies a non-default guiding tolerance for the exposures contained within that particular visit. The <angle> is the allowed maximum pointing error for the observations; the units must be given (arcsec is typical, but arcmin or degrees are acceptable). It should be used in situations when it is permissible for a portion of the observation to be taken while guiding on gyros. It is also used as a trigger for the guide star handoff capability and is useful for fast moving targets. The handoff process involves using a single pair of guide stars for as long as possible. When a given exposure cannot be completed with a given pair of guide stars, guidance is transferred to gyro control. The fine guidance sensors are slewed to and acquire a new pair of guide stars before the exposure in question begins. The error in this procedure is due to the accumulated drift during gyro control, typically a few tenths of an arcsec at most. Note that this is much less than the nominal error between guide star pairs. The planning system will schedule the observations so that the expected pointing-error buildup remains below the <angle> specified. Guide star handoff will only be used if a single pair of guide stars cannot be found for the observation. If you need to use the guide star handoff capability, then set **GUIDing TOLerance** to at least 0.11".

Note that the difficulty in finding guide stars for these types of observations may prevent them from being scheduled. **If you plan to use this Special Requirement, please contact your Program Coordinator for further details and discussions.**

DROP TO GYRO IF NECESSARY [NO REACQuisition]

This special requirement cannot be used in Two Gyro Science Mode.

This Special Requirement allows the system to drop guide-star control for exposures with pointings (target/aperture positions) that are too far (more than 2 arcmin) from the first pointing in the visit to use the same guide stars. If this Special Requirement is not used, such exposures will have to be taken using a separate pair of guide stars. The **NO REACQ** qualifier will disable guide-star reacquisition after dropping to gyro control, even if subsequent pointings are close enough to the first pointing in the visit to allow guide-star control to be resumed. This Special Requirement has no meaning for internal observations and visits with **PCS MODE Gyro**. This Special Requirement is allowed **ONLY** with the WFPC2NICMOS, ACS/WFC, ACS/HRC (see the above discussion of PCS MODE Gyro). **DROP TO GYRO** is not allowed with the ACS/SBC configuration because of concern about bright objects.

See the discussion of the **GUIDing TOLerance <angle>** Special Requirement concerning the pointing drift that will occur while the spacecraft is under gyro control. Due to this drift, this requirement is useful primarily for short observations (bright targets) where pointing is not critical (e.g. imaging). This capability might be used if, after spending most of an orbit obtaining spectra of a target, you want to get a quick image without having to acquire a new set of guide stars. Some uses of the WFPC-2 linear ramp filters might be more efficient if this requirement is used.

NUMBER OF GYROS <number>

This specifies whether the visit is to be executed in Two Gyro mode.The allowed values for <number> are None Selected, 2 or 3. Normally, the value is set to None Selected; do not change it unless your PC tells you to do otherwise.

7.2.2 Target Orientation

The solar arrays of HST must be kept pointed at the Sun (to within a modest angle) in order for the spacecraft to have the electrical power it needs. As the Sun moves through the heavens over the course of a year, this requirement for the solar arrays translates into a position angle on the sky on which HST's detectors lie. Therefore an observer-imposed requirement to, say, orient a slit in a particular position angle means that observation must be done at a specific time. When a special aperture orientation is requested, this will generally be accommodated by scheduling the observation during the time interval when that orientation naturally results in the solar array being positioned nearly perpendicular to the Sun (this is called the "nominal" orientation).

In order to achieve a specific orientation and satisfy spacecraft roll constraints, an observation generally must be scheduled within a fairly narrow time interval. The placement and duration of time intervals that satisfy this constraint will depend on the ecliptic coordinates of the target. The observer must take this into consideration when specifying additional timing constraints (e.g. **BETWEEN**, **BEFORE**, **AFTER**). For a discussion of nominal roll and how it changes with time based on ecliptic latitude, see the section on **Nominal and Off-Nominal Roll** below.

Observers should specify orientations by specifying the position angle of the orientation reference vector U3, as listed in Table 7.4: Instrument Orientations with respect to U3-Direction. To avoid confusion with the spacecraft V2, V3 axes, we define U2, U3 axes which lie in the HST focal plane as projected onto the sky. The U2- and U3-directions are defined by the "nominal" Optical Telescope Assembly (OTA) axis, which is near the center of the WFPC2 CCDs, and the nominal centers of the projected FGS1R, FGS3 and FGS2R FOVs, respectively.

To specify a special orientation of an aperture, slit, aperture pair, etc., the observer should algebraically add two angles:

- The position angle on the sky of the feature to be aligned.
- The "offset angle," which is the angle from an aperture axis to the +U3 axis.

This aperture axis may be the X or Y axis of an SI, or one of the aperture-related features given in Table 7.4. The "offset angle" could also be the angle of the line separating two instruments (Table 7.5) if that is the relevant orientation. The axes for the SIs are given in the SI-specific chapters in Part B.

The algebraic sum of the aperture orientation and the offset angle is the U3 orientation, which should be specified in the **ORIENTation <angle1> TO <angle2>** and **ORIENTation <angle1> TO <angle2> FROM <visit>** Special Requirements described below. All angles are measured North through East, or counterclockwise when referring to the figures in this section. If there is any uncertainty in specifying an orientation, please document the calculations in the Visit_Comments and contact your Program Coordinator for clarification.

If a visit contains multiple targets requiring different guide stars, the spacecraft orientation will normally be reset to the "nominal" orientation each time a new set of guide stars is acquired. However, if the visit has an **ORIENTation <angle1> TO <angle2> FROM <visit>**, **SAME ORIENTation AS <visit>**, or **ORIENTation <angle1> TO <angle2> FROM <visit>** Special Requirement, the spacecraft orientation will *not* change during the visit, even if multiple sets of guide stars are needed.

ORIENTation <angle1> TO <angle2>

Specifies that a specific absolute roll angle or orientation of the spacecraft is required for the exposures within the current visit. <angle1> and <angle2> denote a region within which the position of the U3 axis on the sky (measured North through East) must fall at the time of the observation; both limits must be between 0 (**0D**) and 360 degrees (**360D**). If necessary, it is possible for <angle1> and <angle2> to be equal, but the size of the region between the two limits should be made as large as possible to make scheduling easier. Note that in most instances the angles can have a 180 degree offset and still work. If this is desired (for greater scheduling flexibility), please specify the additional possible angles.

Note also that this Special Requirement can now list several acceptable angle ranges:

ORIENTation <angle1> **TO** <angle2>

ORIENTation <angle3> **TO** <angle4>

ORIENTation <angle5> **TO** <angle6>

ORIENTation <angle7> **TO** <angle8> . . .

Both angles are measured in a counterclockwise direction, so if the orientation region crosses zero (celestial North), <angle1> would be greater than <angle2>. Otherwise, <angle1> should be less than <angle2>. It is also possible for the orientation region to be larger than 180 degrees. You are encouraged to enter both the aperture angle(s) and the offset angle used to calculate these angles in the **Visit_Comments**.

Note: If the visit uses multiple targets, the direction of North from the first target will be used. The spacecraft will not roll between targets, so that the U3 position angle at the new target may be slightly different from that of the first target.

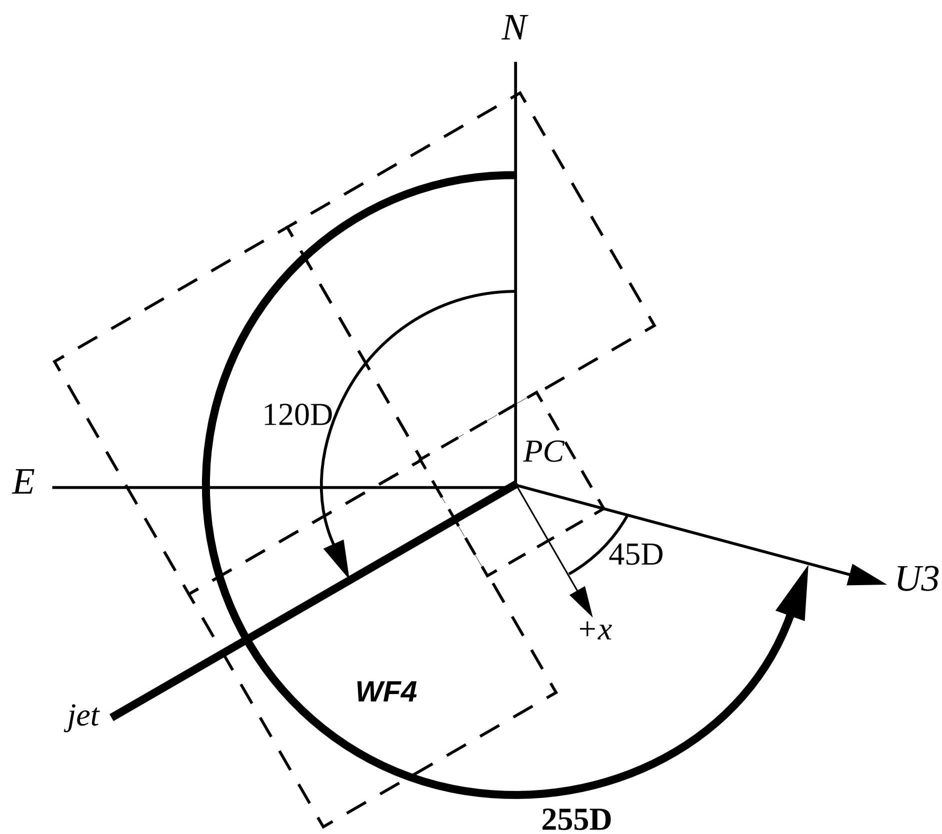
It is sometimes desirable for a new observation to be taken at the same orientation as an existing archival image, using the "PA_V3" field from the header in the archive. For the WFPC2, it is necessary to add or subtract 180 degrees from the "PA_V3" angle before using it in the **ORIENT**ation Special Requirement.

ORIENTation Special Requirements are a limited resource and should be used only when necessary.

Examples of Orientation Angle Computations

We show five examples in Figures 7.1 to 7.5 of how to compute an orientation angle for four of the Cycle 15 instruments (WFPC2, FGS and ACS).

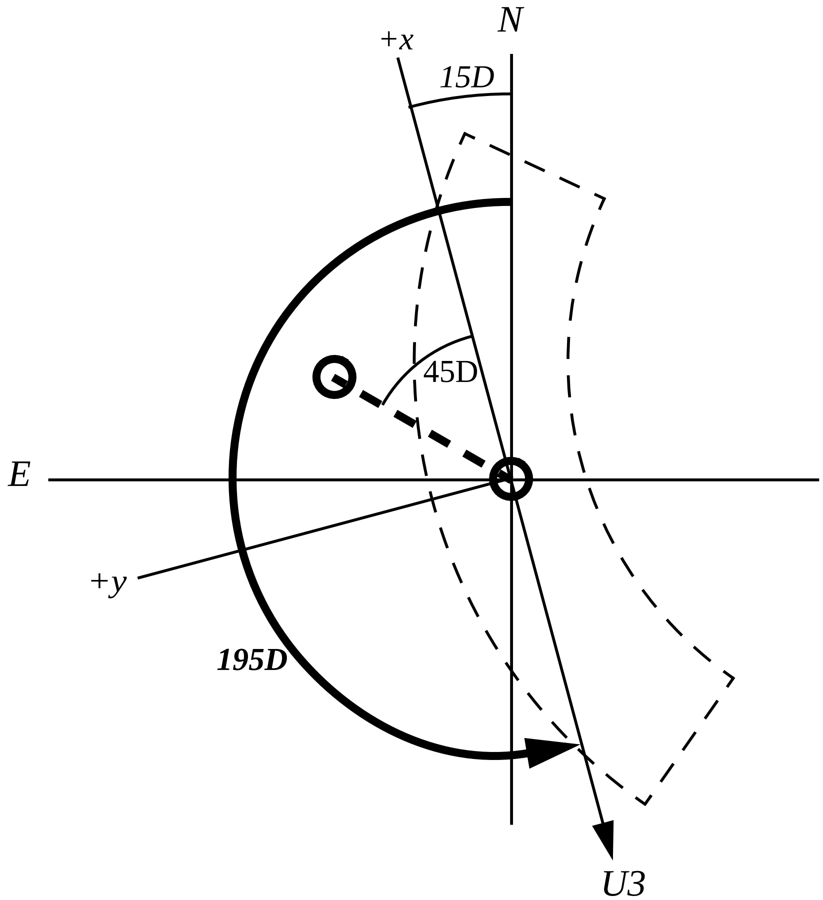
Figure 7.1: ORIENTation computation for WFPC2



In this example we wish to observe an object with a jet that lies at PA 120 degrees. There is some additional structure to the north of this jet, so we have chosen to center the object in the PC chip (for the best spatial resolution) with the jet to lie across the WF4 chip. As shown in Table 7.4, for WFPC2 the +X axis is 45D away from the U3 axis. Therefore the nominal orientation is 120D (the angle from north to the jet) + 90D (from the jet to the +X axis) + 45D (from the +X axis to U3), or 255D. The nature of the object leads us to estimate that this angle can differ from nominal by up to 10 degrees, and therefore we specify:

ORENT 245D TO 265D

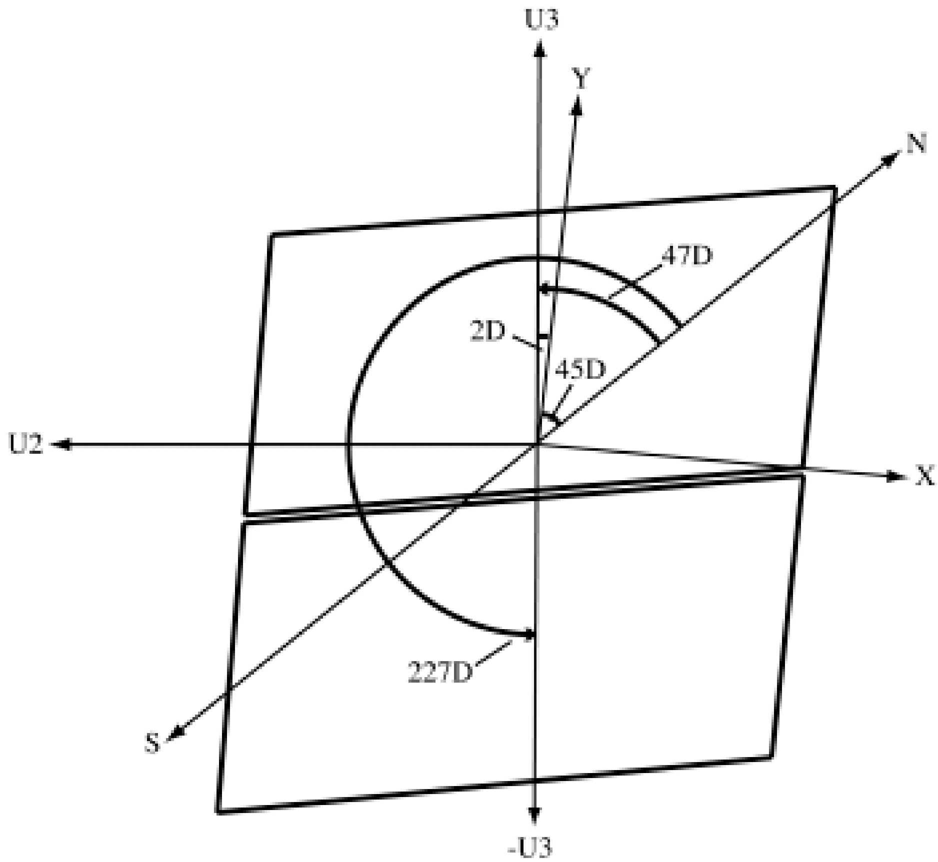
Figure 7.2: ORIENTation computation for FGS1R, in TRANS mode.



In this example we consider the same close binary system in which the position angle of the line joining the stars is 60D. The scans will be done parallel to the line joining the binary components, with a tolerance of 20 degrees. TRANS mode scans move the instantaneous field of view at an angle of 45 degrees relative to the FGS1 axes. The +X axis will have a PA of 60 degrees, minus the 45 degree offset, or 15D. The U3 axis is 180 degrees from +X (Table 7.4), thus we specify:

ORIENT 175D TO 215D

Figure 7.3: ORIENTation computation for ACS/WFC

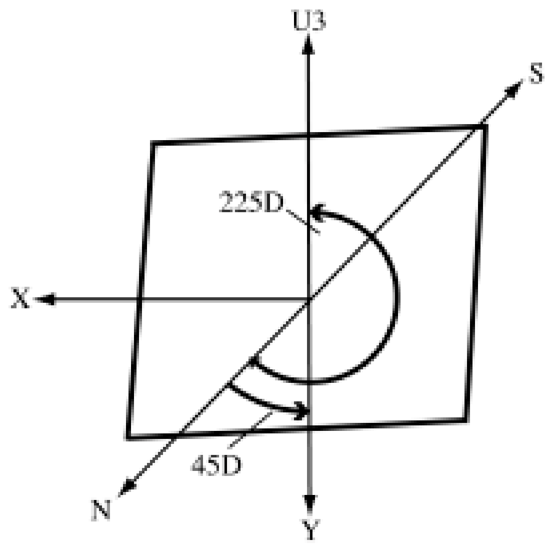


The target has a very bright neighboring star $10''$ away Northeast (PA = $45°$).This star will saturate, leaving a bleeding trail along the entire y-axis of the detector. A user should therefore orient the telescope so the bleeding trail does not run through the target; in other words the target should not be placed on the y-column of the bright star.

From Table 7.4, we know that the U3 axis is $2°$ from the +y axis (measured north to east). Therefore, avoid the ORIENT angle that places the bright star on the y axis: $47°$ ($45° + 2°$, PA_star + angle from U3 to Y). Since blooming affects the entire detector y-axis, also avoid the angle $180°$ away, $227°$ ($47° + 180°$). For added caution, avoid $\pm 10°$ about those angles. The ORIENTs to avoid are from $37°$ to $57°$ and from $217°$ to $237°$.

Therefore, it's safe to use ORIENT 57D TO 217D and ORIENT -123D TO 37D

Figure 7.4: ORIENTation computation for ACS/HRC and SBC



As in the previous example, the target has a very bright neighboring star $10''$ away Northeast (PA = $45°$).This star will saturate, leaving a bleeding trail along the entire y-axis of the detector. A user should therefore orient the telescope so the bleeding trail does not run through the target; in other words the target should not be placed on the y-column of the bright star.

From Table 7.4 we know that the U3 axis is $180°$ from the y axis. Therefore, avoid the ORIENT angle that places the bright star on the y-axis: $45°$ (PA_star + angle from U3 to Y). Since blooming affects the entire detector y-axis, also avoid the angle $180°$ away, $225°$ ($45° + 180°$). For added caution, avoid $\pm 10°$ about those angles. The ORIENTs to avoid are from $35°$ to $55°$, and $215°$ to $235°$.
Therefore, it's safe to use ORIENT 55D TO 215D and ORIENT 125D TO 35D.

ORIENTation <angle1> TO <angle2> FROM <visit>

Specifies that a roll angle or orientation of the spacecraft, **relative** to another visit's spacecraft orientation, is required for the exposures within the current visit. <angle1> and <angle2> denote a region of permitted orientation of the current visit relative to <visit>. <angle1> and <angle2> must be between –180 degrees (**–180D**) and +180 degrees (**180D**). If necessary, it is possible for <angle1> and <angle2> to be equal, but the size of the region between the two limits should be made as large as possible to make scheduling easier.

Both angles are measured in a counterclockwise direction, so if the orientation region crosses a point 180 degrees from <visit>, <angle1> should be positive and <angle2> negative. Otherwise, <angle1> should be less than <angle2>. It is possible for the orientation region to be larger than 180 degrees.

This Special Requirement is a limited resource and should be used only when necessary. To specify that the current visit be scheduled at the same orientation as another visit, use the **SAME ORIENTation AS <visit>** Special Requirement

Note that only one "ORIENT ... FROM " may be specified for a visit.

Nominal and Off-Nominal Roll

Orientation constraints translate into timing constraints. Generally, if the spacecraft is unable to roll far enough "off-nominal" to satisfy the required difference in orientation between the two visits, they will be forced apart in time in order to schedule both at near nominal roll. “Nominal roll” is the orientation determined by the necessity of keeping the solar panels perpendicular to the Sun. Targets near the ecliptic have two values of nominal roll through the year 180 degrees apart. Near the ecliptic pole, nominal roll varies by about a degree per day.

In general, the off-nominal roll is limited to less than +/– 30 degrees except when the target is within two degrees of opposition (i.e., exactly opposite the Sun in the sky as viewed from the Earth). Observations scheduled with solar elongations between 90 degrees and 178 degrees can be done at up to 15 to 30 degrees off nominal, depending on the exact elongation. For observations scheduled when the target is within 90 degrees of the Sun, the off-nominal roll is limited to 5 degrees. The legal syntax for <angle1> and <angle2> allows angles between –180 degrees (**–180D**) and +180 degrees (**180D**). Please contact your Program Coordinator for details if necessary.

Instrument Orientation Tables

Table 7.4: Instrument Orientations with respect to ***U***3-Direction

Instrument	Item	Offset Angle[1]	Comments
FGS (see Figure 10.1: The FGS POS TARG and interferometer coordinate systems.)	+X axis for FGS1	180	
	+X axis for FGS2	90	
	+X axis for FGS3	0	
WFPC2 (see Figure 9.1: WFPC2 Aperture Coordinate System)	WFC +X axis	45D	
	WF2 bloom direction	45D, 225D	
	WF3 bloom direction	135D, 315D	
	WF4 bloom direction	45D, 225D	
	PC1 +X axis	45D	
	PC1 bloom direction	135D, 315D	
	Linear Ramp Filters,		
	Nominal	135D, 315D	Coincident with CCD
	Polarizers		Relative polarization angles
	POL0-WF2	45D	
	POL45-WF3	0D	
	POL90-WF4	315D	
	POL135-PC1	270D	
	POL-33-WF2/WF3	303D	
ACS (see Figure 11.1 ACS Coordinate system	WFC1 + Y axis	2D	
	WFC2 + Y axis	2D	
	HRC + Y axis	180D	
	SBC + Y axis	180D	
	WFCENTER + Y axis	2D	
	WFC + Y axis	2D	

Table 7.4: (Cont) Instrument Orientations with respect to ***U***3-Direction

Instrument	Item	Offset Angle[1]	Comments
NICMOS (see Figure 12.1: NICMOS Coordinate System. and Figure 12.2: Definition of Orientation for NICMOS.)	NIC1 +Y axis	225D	Nominal, +/– 4D
	NIC2 +Y axis	225D	
	NIC3 +Y axis	225D	
	Line joining NIC3 and NIC1	225D	
	Line joining NIC3 and NIC2	225D	
	NIC3 Grism Dispersion (toward increasing wavelength)	135D	

1. The Offset Angle is the angle from the axis defined in the Item column to the +U3 axis in the counterclockwise (or +U3 through +U2) direction. To compute the angle needed in the **ORIENT** Special Requirement, add this Offset Angle in column 3 to the Sky Position Angle (measured North through East). These angles are calculated from current alignment calibrations and reflect uncertainties of +/– 3 degrees, except where greater uncertainties are indicated in the table comments.

WARNING: For any detailed orientation requirements, please describe your requirements clearly in the proposal text and give angles and offsets. Please feel free to contact your Program Coordinator for assistance in preparing your orientations.

Table 7.5: Approximate Separation and Orientations between Instrument Detectors

Instrument	Apertures[1]	Separation[2] (arcsec)	Offset Angle[3] (degrees)
ACS	WFALL-FIX to WFC	345	314.3D
	WFALL-FIX to HRC/SBC	510	337.9D
FGS	WFALL-FIX to FGS1	721 +/ 3	88.6D
	WFALL-FIX to FGS2	737 +/ 3	89.8D
	WFALL-FIX to FGS3	728 +/ 3	270.1D

Table 7.5: (Cont) Approximate Separation and Orientations between Instrument Detectors

Instrument	Apertures[1]	Separation[2] (arcsec)	Offset Angle[3] (degrees)
WFPC2	WFALL-FIX to WF4-FIX	55 +/- 1	75D +/- 0.3D
	WFALL-FIX to WF3-FIX	39 +/- 1	180D +/- 0.3D
	WFALL-FIX to WF2-FIX	55 +/- 1	285D +/- 0.3D
	WFALL-FIX to PC1-FIX	39 +/- 1	0D +/- 0.3D
	WFALL-FIX to APEX	14 +/- 1	0D +/- 0.3D
	APEX to WF4	53 +/- 1	90D +/- 0.3D
	APEX to WF3	53 +/- 1	180D +/- 0.3D
	APEX to WF2	53 +/- 1	270D +/- 0.3D
	APEX to PC1	25 +/- 1	0D +/- 0.3D
NICMOS	WFALL–FIX to NIC	420 +/– 15	227D +/– 3D
	WFALL–FIX to NIC2	453 +/– 15	227D +/– 3D
	WFALL–FIX to NIC3	372 +/– 15	227D +/– 3D

1. WFALL-FIX is defined as the point 10x10 arcsec from the WFPC2 pyramid apex in the WFPC2 X-Y coordinate frame (see Figure 9.1 WFPC2 Aperture Coordinate System). APEX refers to the WFPC2 pyramid apex. This apex is close to the OTA optical axis. The U2-U3 coordinate frame is not centered at the OTA optical axis.
2. The vector Separations are calculated from current estimates of the locations of the WFPC2, FGS and NICMOS apertures. These values can change with time.
3. The Offset Angle is defined as the angle from the line connecting the two Science Instruments to the +U3 axis in the counterclockwise direction. These numbers are calculated from current estimates and reflect uncertainties of +/– 1 degree, except where greater uncertainties are indicated in the table.

WARNING: For any detailed orientation requirements, please describe your requirements clearly in the proposal text and give angles and offsets. Please feel free to contact your Program Coordinator for assistance in preparing your orientations. The above tabulated values are meant to be representative, and because of instrument-specific details the value you need may differ. Please refer to the Observatory Pointing and Apertures pages for current values:
http://www.stsci.edu/hst/observatory

SAME ORIENTation AS <visit>

Sometimes any orientation (or any orientation within the range of the **ORIENT** Special Requirement) is acceptable the first time an object is observed, but must then be the same for subsequent observations of that target. This Special Requirement requests that the exposures in the current visit be made at the same telescope roll angle as the observations specified in <visit>. If timing Special Requirements are also used, then an incompatibility may result or the observations may be difficult to schedule.

7.2.3 Special Observation Requirements

CVZ

Requests that a visit be scheduled within the Continuous Viewing Zone. When this requirement is specified, observers are allowed the entire 96-minute orbit in which to schedule their observations, instead of restricting them to a visibility interval. Only observers with proposals **approved by the TAC** for CVZ-usage should use this Special Requirement.

Caution: CVZ visits are limited to a few narrow scheduling opportunities during a cycle. A detailed definition of the CVZ for Cycle 15 is given in the Call for Proposals.

Note: The CVZ Special Requirement does not necessarily enforce scheduling in an uninterrupted manner. Observations could be scheduled in SAA impacted or earth occulted orbits if that would benefit the overall efficiency of the telescope. If it is required that all (or a subset) of the exposures be done without interruption, the exposure level Special Requirement **SEQ**uence <exposure-list> **NON-INT**erruptible should be used.

SCHEDulability <percentage>

This Special Requirement allows the observer to adjust the amount of target visibility allowed in each orbit. The visibility at a given pointing varies throughout the year with the 56-day precessional cycle of the HST orbit. This variation is small at zero declination (about 4 minutes between best case and worst case) but increases sharply as the Continuous Viewing Zone is approached. There is a trade-off between visibility and schedulability: visits with longer visibilities allow more science to be packed into each orbit, but are harder to schedule because the long visibility may only be attainable for a few short intervals during the year.

Visits with shorter visibilities are less efficient in terms of how much can be done in each orbit, but are easier to schedule.

<Percentage> specifies the percent of HST orbits in which the visit should be schedulable. The higher the percentage, the shorter the visibility. For example, **SCHEDulability 40** would allow only enough visibility in each orbit for the visit to be schedulable in the best 40% of HST orbits. **SCHEDulability 100** would allow the least amount of time per orbit, but would ensure that the visit would "fit" in every available HST orbit. Schedulability values are only defined at 10% intervals, so percentages will be rounded to the nearest multiple of 10%. If this Special Requirement is not supplied, visits will default to 30% schedulability. <Percentage> values below 30% are not allowed.

The **SCHEDulability** Special Requirement may be necessary when an **ORIENTation <angle1> TO <angle2>** or **BETWEEN <date1> AND <date2>**) visit-level Special Requirement or a **PHASE <number1> TO <number2>** exposure-level Special Requirement is specified with a very small tolerance, restricting the visit to only a few days during the cycle. In this case <percentage> should be set to a high enough number to ensure that the visit can schedule in orbits within its time window.

NOTRACK

In certain cases a program will observe a moving target, but without tracking it. For example, a fast-moving comet might be observed by first executing a guide star acquisition, to remove pointing uncertainty, followed by an observation on gyros to acquire the comet data. This should be done without tracking both to save time and to avoid unnecessary use of spacecraft hardware.

The default is to track a moving target, but tracking can be turned off by specifying **NOTRACK** for each exposure as appropriate. **NOTRACK** has no effect on an exposure unless it is for a moving target.

7.2.4 Timing Requirements

For examples of formats of times, see Section 7.1 on page 112, and Table 7.1: Supported Formats for Visit Level Special Requirements.

AFTER <date>

Specifies that the visit must start after the date given by <date>. The capability to designate a specific exposure within a visit to start after a certain time is not supported by this Special Requirement; that case is intended to be handled by adjusting timing within the visit.

AFTER <visit> [BY <time1> TO <time2>]

Specifies that the visit must start after the indicated <visit>. The **BY** <time1> **TO** <time2> option allows specification of the time interval (and its allowable range) that must elapse between the **start** of the referenced visit and the **start** of the current visit. For example, **AFTER 6 BY 7H TO 9H** requests that the current visit start no earlier than 7 hours and no later than 9 hours after the start of visit 6. The capability to designate a specific exposure within a visit to start after a certain time is not supported by this Special Requirement; that case is intended to be handled by adjusting timing within the visit.

Note: If the difference between <time1> and <time2> is too small, the visit may be impossible to schedule. A difference of at least 90 minutes (about 1 orbit) is recommended. Also note that <time1> must be as long as the anticipated duration of the referenced visit.

BEFORE <date>

Specifies that the current visit must start before the <date> given. The capability to designate a specific exposure within a visit to start before a certain time is not supported by this Special Requirement; that case is intended to be handled by adjusting timing within the visit.

BETWEEN <date1> AND <date2>

Specifies that the current visit must start between <date1> and <date2>. For example, BETWEEN 14-SEP-1999 AND 21-SEP-1999 indicates that the visit must be started after 14 September 1999 and before 21 September 1999. The capability to designate a specific exposure within a visit to start at a certain time is not supported by this Special Requirement; that case is intended to be handled by adjusting timing within the visit.

Multiple BETWEEN Special Requirements may be specified on a visit. The visit will be allowed to execute during any of the time intervals specified. For example, the combination of BETWEEN 14-SEP-1999 AND 21-SEP-1999 and BETWEEN 10-OCT-1999 AND 1-NOV-1999 means that the visit must be started either between 14 September 1999 and 21 September 1999, or between 10 October 1999 and 1 November 1999. Multiple BETWEEN intervals on the same visit may not overlap: all the other intervals must either end earlier than <date1> or start later than <date2>.

Note: The BEFORE, AFTER <date>, and BETWEEN Special Requirements are mutually exclusive. A visit which specifies one may not specify either of the other two, although multiple BETWEENs are allowed. Note that any BEFORE or AFTER <date> may be replaced by a BETWEEN with a sufficiently early start date or late end date. However, AFTER <visit> may be combined with BETWEEN or BEFORE.

GROUP <visits> WITHIN <time>

Specifies that visits included in the visit list provided must all start within the <time> given. If the interval given is shorter than the least interval possible, the visits will be scheduled as close together as possible. For example, GROUP 7–10 WITHIN 12H requests that visits 7 through 10 all start execution within a 12-hour interval.

Note that **GROUP WITHIN** is only a timing Special Requirement, and it implies nothing about relative ordering. **GROUP 7-10 WITHIN 12H** could possibly execute in the order 10, 7, 9, 8, for example.

PERIOD <time> ZERO-PHASE (HJD) <date>

Supplies the period and zero-phase for observations to be made at a specific phase of a periodically variable target. <time> is the period in days, hours, minutes or seconds, and <date> is the date of the zero-phase with respect to the Sun (i.e., HJD, not a calendar date). Note that, while this requirement is at the visit level, the actual **PHASE** Special Requirement is on the exposure level.

If a target has multiple periods which must be satisfied simultaneously, the **PERIOD ZERO–PHASE** Special Requirement should refer to the shorter of the two periods and the longer period can be specified using multiple **BETWEEN** Special Requirements that cover the next year and a half. Be sure to discuss this with your Program Coordinator. (Example: The target is a X-ray pulsar. The observation needs to occur in a particular phase of the 35-hour binary period as well as a particular phase of the 2-month on/off period. Use the **PERIOD ZERO–PHASE** Special Requirement for the 35-hour period and then specify the 2-month period with multiple **BETWEEN**s.)

SEQuence <visits-checked> WITHIN <time>

Specifies that visits included in the provided visit list must start within the <time> given, and must be ordered according to their visit number. If the interval given is shorter than the least interval possible, the visits will be scheduled as close together as possible. For example, SEQuence Visits 7–10 WITHIN 10H means that visit 10 must begin execution within 10 hours of the start time of visit 7, with visits 8 and 9 executing between. SEQuence does not change the order of visits.

Note that all SEQ WITHIN visits will be executed in numerical order, so SEQuence Visits 2, 1, 4 WITHIN and SEQuence Visits 1, 2, 4 WITHIN do the same thing.

VISIBILITY INTERVAL CORON

This special requirement cannot be used in Two Gyro Science Mode.

This special requirement overrides the visibility interval normally computed for the visit. The calculated CORON visibility interval is based on the target declination and the amount of slew time needed to execute the orientation change specified in the proposal. This should not be used in conjunction with the CVZ or SCHEDulability <percentage> Special Requirements.

This special requirement may only be used with NICMOS and ACS coronagraphic observations.

7.2.5 Conditional Requirements

ON HOLD [FOR <visit-list>]

Specifies that the current visit should not be executed without further guidance **from the observer** (such as with a Target of Opportunity program, for example). When the **FOR** <visit-list> is specified, the current visit is linked to follow all the visits in <visit-list> by at least sixty days. This will allow these visits to execute early enough in the Cycle to provide needed data. This Special Requirement should be used for early acquisitions: the acquisition image is taken in the visit in <visit-list>, and the **ON HOLD** visit will be modified later based on the acquisition data.

7.3 Exposure-level Special Requirements

The following Special Requirements apply to individual exposures within a visit. All instances of <exposure-list> or <exposure> refer **only** to exposures in the same visit as the exposure carrying the requirement.

7.3.1 Target Acquisition

Separate target acquisition exposures must be specified at the beginning of most visits, depending on the target and the science instrument used. Target acquisition exposures are used to remove coordinate uncertainties and to identify targets. Once a target acquisition has been performed, HST can move the target from aperture to aperture or move the aperture around the target (with slew accuracies of about 10 milliarcseconds) as long as the same guide stars can be used. Onboard acquisitions are automatically identified by the software. Acquisition exposures must still be specified, but no Special Requirement is needed or appropriate.

Acquisition of a target using an offset target requires that both be defined in the Target List(s). The first exposure will be an onboard or interactive acquisition of a target from which the offset will be made. This target must be designated as an offset acquisition target by appending **-OFFSET** to the end of the target name (see Table 3.1: Designations of Special Targets). The appropriate offsets will automatically be made from this position to slew to the target of interest.

INTeractive ACQuisition (obsolete)

Interactive acquisitions may no longer be performed with HST. However, the same results can be achieved in other ways, and you should consult your Program Coordinator for more information.

USE OFFSET <id>

This Special Requirement is used to apply offsets to ACS coronagraphic observations that use one of the spot Apertures (**HRC-CORON1.8**, **HRC SUB1.8**,or **HRC-CORON3.0**). ACS target acquisition ends with the target positioned at the nominal location of the small coronagraphic spot. A slew to the nominal location of the large spot or occulting finger precedes any sequence of observations at either of those locations. However, the ACS coronagraphic spots have been observed to drift randomly up to a few pixels per month. This Special Requirement is used to correct for the drift away from the nominal spot location.

STScI will monitor the spot positions weekly. When ACS coronagraphic observations with USE OFFSET are scheduled, STScI will calculate the required offset from the most recent monitoring data. The offset will be loaded into spacecraft memory via real-time command, and used by a special slew command scheduled for this purpose. No observer action is required.

The <id> is an alphanumeric string of up to six characters in length. Although there is no formal requirement for it, we suggest using your proposal number, followed by a number such as the visit number or a counter that increments with each ACQ mode exposure in the proposal.

If you would like to employ the USE OFFSET Special Requirement for NICMOS observations, please contact a Program Coordinator.

7.3.2 Target Position

Patterns

The Pattern Special Requirement has been replaced in the APT User Interface with the use of Pattern containers. See 5.19 Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns on page 98.

The patterns used with instruments to create dithers or mosaics fall within "target position," but the details have been incorporated into a separate chapter because of the scope of the subject. See Chapter 8: Pointings and Patterns on page 145

POSition TARGet <X-value>,<Y-value>

Specifies a non-default placement of the target, relative to the aperture fiducial point in the instrument field of view, for the current exposure, which must be on an external target. The X and Y positions are implicitly assumed to be in units of arcseconds (i.e. do **not** enter "arcsec" after each value). The X-Y coordinate system and the default positioning for each scientific instrument are defined in Part II of these *Instructions*. An aperture's fiducial point is ordinarily close to the geometric center of that aperture. Details may be found in the *Instrument Handbooks*. Note that the fiducial point and geometric centers are significantly different for the WFPC2 RAMP filters in particular.

Note that a POS TARG is a motion relative to the original pointing of the target, and so they are not cumulative.

Note: Changing the pointing in this way can cause overheads to be repeated at each **POS TARG** pointing in the case of WFPC2. If a large number of pointings need to be obtained within one visibility period, it may be more efficient to use a pattern designed for this purpose; see Chapter 8: Pointings and Patterns on page 145.

SAME POSition AS <exposure>

SAME POS AS <exposure> requests that the current exposure be done at the same position on the sky and with the same telescope roll as <exposure>. Note that <exposure> *must* be in the same visit as the current exposure. This requirement is implicit for exposures within a visit with the same aperture, target, and **POS TARG** combination.

This requirement is used in many astrometric observations, so that the telescope doesn't try to center successive targets in the astrometer pickle before observing it.

For other instruments, **SAME POS AS** should be used sparingly and with caution. For example, **SAME POS AS 1** will cause the *spacecraft* to return to the pointing of exposure 1. Thus if the current exposure has a different (non concentric) aperture from 1 and specifies **SAME POS AS 1**, the target will be placed in the aperture used by exposure 1, not the aperture currently requested. Further, specifying **SAME POS AS** an onboard acquisition exposure will undo the offsets determined in the acquisition process.

SAME POS AS should not be used with WFPC2 exposures which use different partially-rotated filters.

Do not use SAME POS AS with dithering patterns (Chapter 8:** Pointings and Patterns **on page 145) because it will negate them. SAME POS AS means exactly the same position as another exposure.

7.3.3 Special Observation Requirements

PARallel <parallel-exp-list> WITH <primary-exp-list>

(replaced by Coordinated Parallel Containers in the APT User Interface)

This special requirement specifies that the exposures in <parallel-exp-list> will execute in parallel with a sequence of exposures in <primary-exp-list>. In the **Text Proposal File**, both <primary-exp-list> and <parallel-exp-list> must be replaced by either a single exposure number, or a range of exposure numbers separated by a hyphen. See Section 6.3 on page 105 for more details.

This special requirement has been replaced in the APT User Interface with the use of Coordinated Parallel Containers. See 5.19 Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns on page 98.

SAA CONTOUR <model number>: (WFPC2 only)

This specifies the contour of the South Atlantic Anomaly (SAA) to be used for scheduling this exposure. If this parameter is not provided, a default SAA contour appropriate to the SI will be selected. Observations that can tolerate higher radiation levels may benefit, through improved schedulability, from use of less restrictive models. The following model numbers (ordered from most to least restrictive) are allowed:

SAA Model	Instrument for which model is default
23	NICMOS
26	WFPC2
27	ACS/CCD

SAA Model	Instrument for which model is default
28	ACS/MAMA
02	FGS
11	no avoidance

More information on these models may be found at:

http://www.sesd.stsci.edu/et/seu/seu.html

02 is the minimal FGS contour needed to avoid radiation at levels that would interfere with guide star lock. The default contours vary by SI but are more restrictive (meaning lower maximum radiation levels and longer SAA interruption times) than the 02 contour for all instruments.

A value of 11 means the SAA constraint will be ignored entirely. This requires a drop to gyro control for the exposure (also see the discussions under **PCS MODE Fine**, **PCS MODE Gyro**, and **DROP TO GYRO IF NECESSARY [NO REACQuisition]**), even if the visit as a whole is done under FGS control.

This Special Requirement is now Restricted for all SIs except WFPC2.

7.3.4 Special Communications Requirements

RT ANALYSIS

Specifies that the current science exposure must be made available to the observer for analysis in real time. (See the *Call for Proposals* for a discussion of real-time observing.) Any science exposures whose execution depends upon a decision based on the real-time analysis should have **RT ANALYSIS** specified. The REQuires UPLINK Special Requirement may also be used with **RT ANALYSIS** to establish the ground-to-spacecraft link. The current exposure will be available for analysis at least 16 minutes (for fixed targets) prior to that uplink; for moving targets the time is 24 minutes.

This Special Requirement is a limited resource and should only be used when necessary. Justification for its necessity should be included in the **Real_Time_Justification** text. Note that:

- the exposures in the <exposure-list> **must** be in the same visit as the current exposure, and
- **RT ANALYSIS** may not be used if the exposure uses patterns or if Number_of_Iterations > 1.

REQuires UPLINK

Indicates that a real-time command uplink is needed to execute this exposure. An uplink will be scheduled prior to the current exposure. This Special Requirement should be used with **RT ANALYSIS** to replace the capability formerly available with **INTeractive ACQuisition (obsolete)** and it should specifically identify which exposures need an uplink, assuming that the uplink already provided is not sufficient. This Special Requirement can also be used without **RT ANALYSIS** if the information which needs to be uplinked is not dependent on real-time analysis of HST data. Usage of this Special Requirement is considered a limited resource and should only be used when necessary. Justification for its necessity should be included in the **Real_Time_Justification** text.

REQuires EPHEMeris CORRection <id>

Indicates that a correction for position errors due to moving-target and/or HST ephemeris uncertainty may be needed to execute the exposure. This Special Requirement is only valid for exposures with moving targets. The offset will be uplinked during an available (“generic”) uplink prior to the earliest exposure that uses it. The pointing correction may require a minute or two of target visibility time.

An ephemeris correction is needed in two cases:

1. When observing an object within about 1 AU of the Earth. In this case, the uncertainty in the position of HST accumulated between the time the schedule is built and the time it is executed can cause the observation to miss the target. (The HST ephemeris is inaccurate by as much as 60 seconds, which translates into a positional error on the moving target). The offset can be easily calculated by STScI personnel in this case.

2. When observing an object with an uncertain ephemeris. In this case, updated positions may be used until shortly before the observation actually executes, even though the elements in the program are out of date. Again, STScI personnel can easily determine the proper offset.

With moving targets, the maximum target ephemeris uncertainty must be specified in the solar-system target list (see Section 4.5 on page 75). STScI will be unable to schedule corrections larger than the maximum offset derived from this uncertainty, so too small an uncertainty may limit the usefulness of the **REQ EPHEM CORR** procedure. However, offsets larger than about 1 arcminute may make scheduling difficult. If your observation requires a correction this large, contact your Program Coordinator.

The <id> is an alphanumeric string of up to six characters in length. Exposures with the same **REQ EPHEM CORR** ID (whether in the same visit or in different visits) will use the same offset and must be taken at the same orientation. If exposures in different visits use the same ID, the visits involved are all subject to the same scheduling restrictions as **SAME ORIENTation AS <visit>**. The **SAME ORIENT** Special Requirement is implied across such a set of visits, and need not be specified directly.

Note that REQ EPHEM CORR uses the uncertainties in target coordinates to determine the size of a possible offset maneuver. Therefore those uncertainties must be supplied accurately.

7.3.5 Timing Requirements

EXPAND (pure parallel exposures only)

Allows the proposer to choose which exposures within an orbit will be expanded to take advantage of unused time at the end of the orbit (note that the exposures will be expanded to fill the orbit unless the **MAXimum DURation (time or %) <value> (pure parallel exposures only)** Special Requirement is also listed). This special requirement can only be used in pure parallel observations; it has no effect on primary exposures. If there is no **EXPAND** within the orbit, the last exposure in the orbit will be considered for expansion (up to an additional 20%) first, followed by the previous one and the one before that, etc. Exposures containing the **EXPAND** requirement are considered first for expansion. See the discussion of **MINimum DURation (time or %) <value> (pure parallel exposures only)** below for a list of types of exposures which cannot be expanded.

LOW-SKY

Requests that the current exposure be taken when the total background light is no more than 30% greater than the yearly minimum value of the zodiacal background for that target. To minimize Earth shine, the exposure will also be taken when the target is at least 40 degrees from the bright Earth. This limits visibility time to about 48 minutes per orbit. Efficiency and schedulability are reduced with this Special Requirement, but to a much lesser degree than with **SHADOW**. This Special Requirement may not be combined with **SHADOW** or used in a CVZ visit.

Due to uncertainties in scheduling observations in Two Gyro Mode, it is possible that an observation that is correct in the Orbit Planner may be unschedulable when the Visit Planner is executed. In this case, you need to reduce the time used in the orbit until the visit schedules

MAXimum DURation (time or %) <value> (pure parallel exposures only)

Allows the proposer to set limits on the expansion of exposures to take advantage of unused visibility. This special requirement can only be used in pure parallel observations; it has no effect on primary exposures. If the **MAX DUR** requirement is not given, exposures with the **EXPAND (pure parallel exposures only)** requirement may be lengthened up to 120% of the specified exposure time. **MAX DUR** allows the proposer to increase or decrease this limit, and to apply it to exposures with **EXPAND**. If <time> is specified, the exposure will not be lengthened beyond <time>. If <percentage> is specified, (e.g., **MAX DUR (%) 125**), the exposure will not be lengthened beyond <percentage> of the specified exposure time. If <time or percentage> is omitted, the exposure will not be lengthened at all.

MINimum DURation (time or %) <value> (pure parallel exposures only)

Allows the proposer to limit shortening of exposures to allow them to fit in a visibility period. This special requirement can only be used in pure parallel observations; it has no effect on primary exposures. If the **MIN DUR** requirement is not given, exposures will not be shortened to less than 80% of the specified exposure time. **MIN DUR** allows the proposer to increase or decrease this limit. The exposure may be shortened until its duration is <time> but not further. If <time or percentage> is omitted, the exposure will not be shortened at all. If a percentage is used (e.g., **MIN DUR (%) 80**) the exposure will be shortened until its duration is decreased to, at most, <percentage> of the specified exposure time.

PHASE <number1> TO <number2>

Requests that the exposure start in the specified phase range (<number1> to <number2>) of a periodic variation. <number1> and <number2> should be between 0.0 and 1.0. The **PERIOD <time> ZERO-PHASE (HJD) <date>** used in the calculation should have been already entered at the visit level. With short periods, the phase range (difference between <number1>

and <number2>) should be made as wide as possible to make scheduling easier.

Please note that there is no need to repeat the **PHASE** Special Requirement for multiple exposures within the same Visit (unless you are attempting to specify different phases for those exposures). Instead, specify **PHASE** for only the first exposure in the Visit. If the phase window you specify is short, you may need to adjust **PHASE** for the first exposure so that the subsequent ones start before the phase window ends.

Note that Number_of_Iterations must be 1 if PHASE is specified

SEQuence <exposure-list> NON-INTerruptible

(replaced by Exposure Group Containers in the APT User Interface)

This has been replaced in APT with the use of Exposure Group Containers. See 5.19 Exposure Containers: Exposure Groups, Coordinated Parallels and Patterns on page 98.

Specifies that exposures defined in the <exposure-list> be observed without gaps due to Earth occultation or SAA passages. Gaps between exposures may still be necessary to allow time for activities which are necessary to set up for the next exposure, such as pointing changes, readouts of the SI buffers, and SI reconfigurations. This requirement must be included for a series of FGS exposures which are to be executed within the same orbit.

In the **Text Proposal File**, the exposure list must be a range of numbers separated by a hyphen, such as SEQ NON-INT 55-60.

Note: If this requirement is placed on **one** exposure (e.g., **SEQ 20 NON-INT**) and **Number_of_Iterations** > 1, the sequence of subexposures will not be split.

SHADOW

Requests that the current exposure be taken while HST is in the umbral shadow of the Earth. It is primarily useful when contamination by geocoronal emission (Lyman alpha, OI 1304Å, etc.) must be minimized. However, it does not minimize zodiacal light, which is the principal source of background at wavelengths longer than 3500Å (see the **LOW-SKY** Special Requirement).

Exposures using this Special Requirement are limited to about 32 minutes per orbit (including overheads). Scheduling may only be feasible for a small percentage of the year. This Special Requirement is a limited resource and should only be used when necessary; most usages of **SHADOW** will have been approved by the TAC during the Phase I review process. This Special Requirement may not be combined with **LOW-SKY** or used in a **CVZ** visit.

CHAPTER 8:
Pointings and Patterns

In this chapter . . .

8.1 Pointing the Telescope

Acquiring an astronomical target and keeping it fixed in an aperture is the heart of observing with HST. Properly specifying target coordinates and motions is essential, of course, as is finding and acquiring suitable guide stars. Earlier chapters in this document have provided detailed instructions on how to specify coordinates and acquisitions for both fixed and moving targets; see Chapter 3: Fixed and Generic Targets on page 25 and Chapter 4: Solar System Targets on page 59.

8.2 Introduction to Patterns

Only rarely does an observer ask to look at precisely one point on the sky. Instead, small-scale repositionings of the aperture may be made to fully sample a region spatially, or larger-scale movements may be made to mosaic a region of the sky. These movements are known as patterns.

In the past we have defined patterns on an case-by-case basis in a manner that seemed appropriate to each instrument. In rewriting the software that transforms your Phase II program into detailed observations, we realized that these different patterns were sometimes contradictory and incompatible, and that a common basis for describing patterns was needed for the current and future instruments. At the same time, we do not wish to further confuse observers by abandoning terms they may be familiar with, especially if they have continuing programs that could be affected by a change at an arbitrary time.

Here we describe the patterns syntax in APT for both the User Interface and the **Text Proposal File**; these descriptions provide both general capabilities and pre-defined "convenience" patterns.

8.2.1 APT User Interface

Creating Patterns

1. First, you specify the pattern or patterns you want to use by using the "**Patterns**" form; then you select the type of pattern (or patterns) you want from a list, filling in the fields (where you can) with the values you want, or leave them to their assigned default values.
2. Then you can create a **Pattern Container** (see Section 5.19 on page 98) in a visit, and then place your exposures in this container.

If the exposures in the Pattern Container contain other expansion constructs (such as **Number_Of_Iterations** > 1 or one of the **CR-SPLIT** Optional Parameters), the multiple exposures will be taken at each pattern point.

General Pattern Container Rules

If the exposures contain coordinated parallels, it must contain the entire parallel sequence (both parallel and primary exposures in the Coordinated Parallel Container; see Section 5.19 on page 98), and only those exposures. All parallel exposures will be taken at each pattern point. Only one pattern is allowed within any sequence.

All primary exposures in the exposure list (container) must have the same initial pointing: i.e., the same instrument configuration, aperture, target, and POS TARG offsets (if any).

Patterns may be specified for a moving target. In this case the pattern is taken while the target is being tracked and the offsets obtained will be a combination of target motion and motion imposed by the pattern relative to the target.

The following exposure-level Special Requirement is **not** allowed on an exposure that is part of a pattern:

SAME POSition AS <exposure>

Patterns are also not allowed with FGS TRANS mode (which specifies a separate scan with the FGS star selectors).

8.2.2 Text Proposal File

In the Text Proposal File, a pattern is specified as an exposure-level Special Requirement.

PATTERN <#> [<exposure-list>]

This specifies that each exposure in <exposure-list> (or the current exposure if no <exposure-list> is provided) should be repeated at each point in a pattern of discrete pointing offsets from the target. The <#> should be an integer between 1 and 999 that corresponds to the **Pattern_Number** of a pattern defined in the **Pattern_Data** block of the Text Proposal File. Details for providing **Pattern_Data** are given in the next section.

If the exposures in the <exposure-list> contain other expansion constructs (such as **Number_of_Iterations** > 1 or one of the **CR-SPLIT** Optional Parameters), the multiple exposures will be taken at each pattern point.

If the <exposure-list> contains coordinated parallels, it must contain the entire parallel sequence (both <parallel-exp-list> and <primary-exp-list> from the **PARALLEL WITH** Special Requirement; see **PARallel <parallel-exp-list> WITH <primary-exp-list>**), and only those exposures. All parallel exposures will be taken at each pattern point. Only one **PATTERN** Special Requirement is allowed within any sequence.

All primary exposures in <exposure-list> must have the same initial pointing: i.e., the same instrument configuration, aperture, target, and POS TARG offsets (if any).

Patterns may be specified for a moving target. In this case the pattern is taken while the target is being tracked and the offsets obtained will be a combination of target motion and motion imposed by the pattern relative to the target.

Notes: The exposure-level Special Requirement, SAME POSition AS <exposure>, is **not** allowed on an exposure that is part of a pattern: Also, Patterns are not allowed with FGS **TRANS** mode (which specifies a separate scan with the FGS star selectors).

8.3 How to Fill Out the Pattern Parameters Form

The Pattern Parameters Form allows a pattern of pointing offsets to be defined. Patterns are useful for several different purposes: dithering to remove the effects of detector artifacts or to increase spatial resolution, mosaicing to cover a larger area on the sky, or moving away from the target to sample the background.

It is also possible to specify two nested patterns for an exposure or set of exposures. In this case, instead of taking the exposures at each point of the first pattern, the entire **Sub-Pattern** (or **Secondary_Pattern** in the **Text Proposal File**) will be executed at each point, creating a two-dimensional matrix of pointing offsets.

Text Proposal File

Patterns are identified by the **Pattern_Number** field under the **Pattern_Data** block in the **Text Proposal File**. The value of **Pattern_Number** must be an integer between 1 and 999. If an exposure anywhere in the proposal uses the **PATTERN <#> [<exposure-list>]** Special Requirement and <#> matches **Pattern_Number**, the specified exposures will be repeated at each point of the pattern. It is also possible to specify two nested patterns for an exposure or set of exposures. In this case, instead of taking the exposures at each point of the first pattern, the entire **Secondary_Pattern** will be executed at each point, creating a two-dimensional matrix of pointing offsets. The parameters for the first pattern appear under the **Primary_Pattern** label in the **Text Proposal File**. If a second pattern is to be used, a similar **Secondary_Pattern** label followed by the same set of parameters should be added below the first.

The Pattern Parameters form looks like this in the **Text Proposal File**:

```
Pattern_Data

Pattern_Number:11 !unique identifier
Primary_Pattern:
Pattern_Type:WFPC2-BOX
Pattern_Purpose:DITHER
Number_of_Points:4
Point_Spacing:0.559
Line_Spacing:0.559
Coordinate_Frame:POS-TARG
Pattern_Orient:26.565
Angle_Between_Sides:60
Center_Pattern:?
```

Not all fields are required in all cases (see the examples below), and for some patterns both a **Primary_Pattern** and a **Secondary_Pattern** must be described. If none of the instrument-specific patterns will work, it is also possible to specify more generic lines and spirals.

8.3.1 Pattern Parameters

The Pattern Parameters Form has the following fields:

Pattern_Number

A unique identifier from 1 to 999; this is assigned in APT.

Pattern_Type

This specifies the type (and shape) of a pattern (generally an instrument-specific name; see "Convenience Patterns" on page 152), and, depending on the type, may constrain or completely determine the values of the other parameters. Many pattern types have been defined for the different instruments, as given below. Pattern parameters that are determined by the pattern type, or have default values, need not (or cannot) be changed in the form.

Some pattern types are intended for use with a combination of two patterns (**Primary_Pattern** and **Sub-Pattern**). With such pattern types the **Sub-Pattern** is mandatory. The **Pattern_Type** may specify that a parameter of the **Sub-Pattern** is constrained or determined by the value of the corresponding parameter of the **Primary_Pattern**. Whenever two patterns are used, the **Pattern_Type** of the **Sub-Pattern** defaults to the pattern type of the **Primary_Pattern**.

A **Pattern_Type** defined for a particular instrument is legal only if the first primary exposure in the pattern uses that instrument. Generic pattern types are valid with any instrument. Patterns specific to individual instruments are described in Section 8.4 on page 152. The following are generic pattern types.

- ***Pattern_Type: LINE***

This specifies a linear pattern of offsets; all other parameters are open.

- ***Pattern_Type: SPIRAL***

This specifies a spiral pattern: all other parameters are open.

- ***Pattern_Type: BOX***

This specifies a box pattern; the **Number_Of_Points** = **4** and all other parameters are open.

Pattern_Purpose

This is a required text field which describes the scientific purpose of the pattern, but it is treated as a comment to help evaluate the Phase II program. There are four legal values: **DITHER**, **MOSAIC**, **BACKGROUND**, and **OTHER:**

- **DITHER** means small-scale motions used to improve spatial resolution and data quality.
- **MOSAIC** means movement of the aperture to sample different parts of an object or regions of sky.
- **BACKGROUND** means a movement away from a source to sample the sky background, ordinarily used with infrared instruments.
- If **OTHER** is used, the reason for the pattern should be provided in the **Comments** field. Unless a default is determined via the **Pattern_Type**, this parameter is required, although you may edit it from the default value to another valid value.

Number_Of_Points

This specifies the number of points in the pattern; allowed values are from 2 to 50. Unless a default is determined via the **Pattern_Type**, this parameter is required.

Point_Spacing

This specifies the spacing between adjacent points in a pattern, in arcsec. For parallelogram patterns such as **WFPC2-BOX**, **Point_Spacing** will specify the length of the segment between the first two pattern points (the spacing between adjacent lines is determined by the **Line_Spacing** and is not user-specifiable). The value of **Point_Spacing** ranges from 0 to 1440 arcsec. Unless a default is determined via the **Pattern_Type**, this parameter is required.

Note: patterns larger than about 130 arcsec (defined by the maximum pointing change between any two points in the pattern) may not be done on a single set of guide stars. For such patterns, unless the entire visit uses gyro guiding (**PCS MODE Gyro; see** **PCS MODE Gyro**), the visit-level Special Requirement **DROP TO GYRO IF NECESSARY** (see **DROP TO GYRO IF NECESSARY [NO REACQuisition]**) must be specified to allow the farther pattern points to execute under gyro guiding.

Unless **PCS MODE Gyro** is specified on the visit, all patterns must be contained within a circle of radius 24 arcmin (1440 arcsec), with the first pattern point at the center.

In Two Gyro Mode DROP TO GYRO IF NECESSARY [NO REAC-Quisition] and PCS MODE Gyro are not permitted. Offsets from the target that cannot be supported a small angle maneuver (SAM) while locked onto the guide stars will require a new guide star acquisition.

Line_Spacing

This parameter is relevant only for parallelogram (box) patterns; it specifies the distance between adjacent lines of the parallelogram in arcsec. The allowed range is from 0 to 1440.0 arcsec.

Angle_Between_Sides

This parameter is relevant only for parallelogram (box) patterns; it specifies the angle (from 0 to 360) between sides of the parallelogram in degrees measured clockwise from the first pattern segment to the second.

Coordinate_Frame

This field has two legal values, **POS-TARG** and **CELESTIAL**. It specifies whether the pattern is being done in the **POS TARG** (spacecraft) frame or the celestial frame (by specifying offsets from the original target position on the sky). For patterns with a **Pattern_Purpose** of **DITHER**, **POS-TARG** is the only legal value.

Note: If the NICMOS **OFFSET=FOM** optional parameter is used, the pattern will be executed by moving the NICMOS Field Offset Mirror, rather than the telescope. In this case, Coordinate_Frame must be set to **POS-TARG**. All primary exposures in a pattern must use this parameter if any do, and all such exposures must specify the same set of values (if any) for the **FOMXPOS** and **FOMYPOS** Optional Parameters.

Pattern_Orient

This field specifies the orientation of the first segment of the pattern with respect to the chosen frame, in degrees. If **Coordinate_Frame**: **POS-TARG**, this angle will be measured from the POS TARG +X axis toward the +Y axis. If **Coordinate_Frame**: **CELESTIAL**, it will be measured North through East, and will specify the direction of an offset from the target on the sky.

A value of 0 will cause the first pattern segment to be oriented along the POS TARG +X axis if **Coordinate_Frame**: **POS-TARG**, and along the North vector on the sky if **Coordinate_Frame**: **CELESTIAL**.

Center_Pattern

This indicates whether the pattern should be centered relative to the pointing (hereafter referred to as the "default pointing") that the exposures would have had in the absence of a pattern. For a primary pattern (**Primary_Pattern**), the default pointing is the target position, unless the **POS TARG** Special Requirement (see **POSition TARGet <X-value>,<Y-value>**) is used to shift the target relative to the aperture. For a secondary pattern (**Sub-Pattern**), the default pointing is the pointing offset from the target determined by the given pattern point in **Primary_Pattern**.

Legal values for **Center_Pattern** are **YES** (check in box provided) and **NO** (no check). The default is **NO**, unless overridden via the **Pattern_Type**. If **Center_Pattern**: **NO**, the first pattern point is placed at the default pointing. If **Center_Pattern**: **YES**, the first pattern point is offset so that the default pointing is placed at the geometric center of the pattern.

Sub-Pattern (or Secondary_Pattern in the Text Proposal File) Information

If applicable, the **Sub-Pattern** information must be provided (Type, Shape, Number of Points, etc.).

Note that if you are using the **Text Proposal File**, a **Sub-Pattern** is labeled as a **Secondary_Pattern**.

8.4 Convenience Patterns

To minimize confusion, the following patterns use the new syntax but have been constructed to duplicate the earlier pattern forms. Their nomenclature is meant to be obvious, so that "**WFPC2-LINE**" means the former "**LINE**" pattern for WFPC2, for example. After each description we show what the information would look like.

A specific entry for a parameter (such as 0.559 for **Point_Spacing** with **WFPC2-BOX**) means that value may not be changed and doing so will cause an error. An indicated range (such as 2-10 for **Number_of_Points** in **WFPC2-LINE**) means you may select from within that range, and a "?" means any numeric value may be entered.

As noted above, you may also nest patterns, but not all combinations make sense. In the first place, if you use both a **Primary_Pattern** and a

Sub-Pattern (or **Secondary_Pattern** in the **Text Proposal File**), they should be for the same instrument or at least one should be generic. Do not mix instrument-specific patterns. We have shown below which other patterns may validly be used as a **Sub-Pattern** when the indicated one is the **Primary_Pattern**. When both a **Primary_Pattern** and a **Sub-Pattern** are shown for a given **Pattern_Type**, both must be used.

8.4.1 WFPC2 Patterns

Note that these new patterns move HST in the opposite direction to the previously-provided WFPC2 patterns. Consult the *WFPC2 Instrument Handbook* ***for more information.***

To see an illustration of the WFPC2 **POS-TARG** reference frame, go to Section 9.4 on page 182.

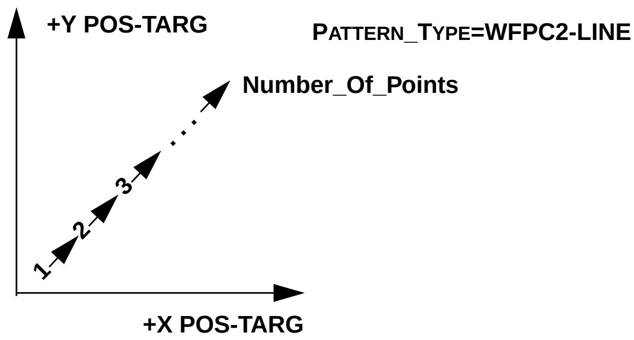
Pattern_Type: WFPC2-LINE

This produces a single-line scan, with its default orientation along a 45-degree diagonal with respect to the pixels of the primary camera. The default and strongly recommended single-line dither scan is a two-point scan with a spacing of 0.3535 arcsec between points. This yields an offset of (2.5, 2.5) pixels in the WFC CCDs and (5.5, 5.5) pixels in the PC. This default offset is optimized for resolution enhancement.

If these defaults are not acceptable, the **Number_Of_Points**, **Point_Spacing**, and **Pattern_Orient** parameters may be used to vary the spacing and number of points along the line, and to change the orientation of the line. For example, observers interested only in removing CCD artifacts may prefer to use an integral-pixel offset, as this will simplify the data analysis. An example of an integral-pixel line dither is **Point_Spacing: 0.707**, which provides offsets of (5,5) pixels in the WFC CCDs and (11,11) pixels in the PC. Please discuss the use of these parameters with your Contact Scientist (or contact help@stsci.edu).

```
Pattern_Type: WFPC2-LINE
Pattern_Purpose:DITHER
Number_of_Points:2-10 (default 2)
Point_Spacing:0.01-3.0 (default 0.3535)
Coordinate_Frame:POS-TARG
Pattern_Orient:? (default 45)
Center_Pattern:?
```

Permitted **Sub-Pattern** (**Secondary_Pattern**) values: **LINE**, **SPIRAL.**



Pattern_Type: WFPC2-BOX

This will produce a four-point parallelogram scan. The four points of the parallelogram will be obtained at the following POS TARG (X,Y) offsets relative to the default aperture position:

(0.0", 0.0") (0.5", 0.25") (0.75", 0.75") (0.25", 0.5")

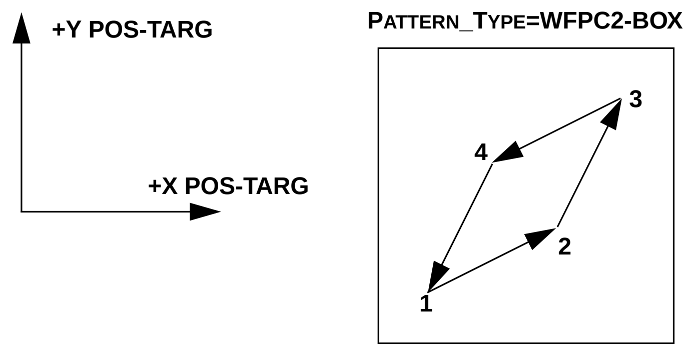
This default box pattern produces offsets on 0.25 arcsec centers, which represent 2.5 WFC pixels and 5.5 PC pixels. These offsets are optimized for resolution enhancement. If a box-type pattern other than this recommended parallelogram is desired, the POSition TARget special requirement may be used; see **POSition TARGet <X-value>,<Y-value>**.

The **Pattern_Purpose** for WFPC2-BOX is **DITHER**. The **Number_Of_Points** is **4**. The **Point_Spacing** is **0.559** arcsec. The **Coordinate_Frame** is **POS-TARG**. The **Pattern_Orient** is fixed at **26.565** degrees.

```
Pattern_Type:WFPC2-BOX
Pattern_Purpose:DITHER
Number_of_Points:4
Point_Spacing:0.559
Line_Spacing:0.559 (may not be changed)
Angle_Between_Sides:143.13 (may not be changed)
Coordinate_Frame:POS-TARG
Pattern_Orient:26.56505
Center_Pattern:?
```

Permitted **Sub-Pattern** (**Secondary_Pattern**) values: **LINE**, **SPIRAL.**

To see an illustration of the WFPC2 POS-TARG reference frame, go to Section 9.4 on page 182.



8.4.2 ACS Patterns

For general information on ACS pointing, and a library of carefully designed dither and mosaic pointing patterns (ready for use in a Phase II proposal), see the following Web page:

http://www.stsci.edu/hst/acs/proposing/dither

In addition to the default patterns provided below, many non-default variations are included in the pattern library (e.g., for hot pixel rejection, sub-pixel dithering, etc.) and parameters are updated using the latest distortion solution. Helpful diagrams and descriptions are provided along with Phase II pattern parameters.

Pattern_Type: ACS-WFC-DITHER-LINE

General WFC dither line pattern. The default for this pattern shifts the image by 5 pixels in **x** and 60 in **y** in order to span the gap between the two WFC detectors.

```
Pattern_Type: ACS-WFC-DITHER-LINE
Pattern_Purpose: DITHER
Number_Of_Points: 2-9 (default 2)
Point_Spacing: 0.01 - 10.0 (default 3.011)
Coordinate_Frame: POS-TARG
Pattern_Orient: ? (default 85.28)
Center_Pattern: ? (default NO)
```

Permitted **Sub_Pattern** (**Secondary_Pattern**) values: any other ACS/WFC patterns, **LINE**, **BOX**, **SPIRAL**

Note: All ACS/WFC users are encouraged to use some form of dithering to allow for correction of hot pixels during data processing. The standard CR-SPLIT approach does not eliminate hot pixels (See Section 11.2.4). Users who would normally have taken that approach in the past are now encouraged to define and use instead the pattern:

Pattern_Type: ACS-WFC-DITHER-LINE
Pattern_Purpose: DITHER
Number_Of_Points: 2
Point_Spacing: 0.146
Coordinate_Frame: POS-TARG
Pattern_Orient: 47.17
Center_Pattern: NO

This pattern will allow simultaneous elimination of hot pixels and cosmic ray hits in post-observation processing. The pattern parameters shift the image by 2 pixels in x and 2 in y along the direction that minimizes the effects of scale variation across the detector.

Pattern_Type: ACS-WFC-DITHER-BOX

This is the default WFC box pattern. It is a 4-point pattern with relative pixel coordinates (0, 0), (5.0, 1.5), (2.5, 4.5), (-2.5, 3.0)—a parallelogram pattern with a combination of integer and sub-pixel shifts, which is relatively compressed in one dimension compared to its WFPC2 and STIS counterparts. This minimizes the effect of scale variation across the detector.

```
Pattern_Type: ACS-WFC-DITHER-BOX
Pattern_Purpose: DITHER
Number_Of_Points: 4
Point_Spacing: 0.01 - 10.0 (default 0.265)
Line_Spacing: 0.01 - 10.0 (default 0.187)
Angle_Between_Sides: 0 - 360 (default 69.05)
Coordinate_Frame: POS-TARG
Pattern_Orient: 0 - 360 (default 20.67)
Center_Pattern: ? (default NO)
```

Permitted **Sub_Pattern** (**Secondary_Pattern**) values: any other ACS/WFC patterns, **LINE**, **BOX**, **SPIRAL**

Pattern_Type: ACS-WFC-MOSAIC-LINE

General WFC mosaic line pattern. The default shift is in the **y** direction by 47% of the detector dimension, resulting in a field-of-view that is about

200x300 arcsec. This is a compromise which allows the 2-point WFC mosaic to be performed with one set of guide stars and to cover the inter chip gap as well.

```
Pattern_Type: ACS-WFC-MOSAIC-LINE
Pattern_Purpose: MOSAIC
Number_Of_Points: 2-9 (default 2)
Point_Spacing: 10.0 - 130.0 (default 96.816)
Coordinate_Frame: POS-TARG
Pattern_Orient: ? (default 90.0)
Center_Pattern: ? (default YES)
```

Permitted **Sub_Pattern** (**Secondary_Pattern**) values: any other ACS/WFC patterns, **LINE**, **BOX**, **SPIRAL**

Pattern_Type: ACS-WFC-MOSAIC-BOX

This is a 4-point box pattern for creating a WFC mosaic roughly 400x300 arc seconds. This pattern strikes a compromise with a *y*-shift that covers the inter chip gap (with one set of guide stars) and the maximum *x*-shift to expand the field of view. So another set of guide stars would be needed only for the *x* shifts, which are 95% of the detector *x* dimension (~193 arcsec).

Note: This pattern is not supported in the STScI ground system because it would require two sets of guide stars, so no pattern parameters are given. The pattern can be set up by hand using the following POS TARG offsets:

Point 1: -96.497, -55.801
Point 2: -96.497, 41.015
Point 3: 96.497, 55.801
Point 4: 96.497, -41.015

Another useful WFC mosaic box pattern would maximize the field of view (~400x400 arcseconds). For this pattern, both the *x* and *y* shifts are ~95% of the detector dimensions, and would require multiple guide stars.

This pattern is also not supported in the ground system, but may be set up by hand using the following **POS TARG** offsets:

Point 1: -96.497, -104.084
Point 2: -96.497, 89.298
Point 3: 96.497, 104.084
Point 4: 96.497, -89.298

Pattern_Type: ACS-HRC-DITHER-LINE

General HRC dither line pattern. The default for this pattern shifts the image by 5 pixels in **x** and 5 in **y** (i.e., on the diagonal) and is useful for removing WFC artifacts.

```
Pattern_Type: ACS-HRC-DITHER-LINE
Pattern_Purpose: DITHER
Number_Of_Points: 2-9 (default 2)
Point_Spacing: 0.01 - 10.0 (default 0.198)
Coordinate_Frame: POS-TARG
Pattern_Orient: ? (default 44.28)
Center_Pattern: ? (default NO)
```

Permitted **Sub_Pattern** (**Secondary_Pattern**) values: any other ACS/HRC patterns, **LINE**, **BOX**, **SPIRAL**

Pattern_Type: ACS-HRC-DITHER-BOX

Same as ACS-WFC-DITHER-BOX, but for the HRC detector.

```
Pattern_Type: ACS-HRC-DITHER-BOX
Pattern_Purpose: DITHER
Number_Of_Points: 4
Point_Spacing: 0.01 - 10.0 (default 0.150)
Line_Spacing: 0.01 - 10.0 0.(default 0.098)
Angle_Between_Sides: 0 - 360 (default 63.50)
Coordinate_Frame: POS-TARG
Pattern_Orient: 0 - 360 (default 19.89)
Center_Pattern: ? (default NO)
```

Permitted **Sub_Pattern** (**Secondary_Pattern**) values: any other ACS/HRC patterns, **LINE**, **BOX**, **SPIRAL**

Pattern_Type: ACS-HRC-MOSAIC-LINE

General HRC mosaic line pattern. The default creates a mosaic that shifts the images by 95% of its size in **y** to roughly double the FOV.

```
Pattern_Type: ACS-HRC-MOSAIC-LINE
Pattern_Purpose: MOSAIC
Number_Of_Points: 2-9 (default 2)
Point_Spacing: 10.0 - 130.0 (default 24.130)
Coordinate_Frame: POS-TARG
Pattern_Orient: ? (default 90.0)
Center_Pattern: ? (default YES)
```

Permitted **Sub_Pattern** (**Secondary_Pattern**) values: any other ACS/HRC patterns, **LINE**, **BOX**, **SPIRAL**

Pattern_Type: ACS-HRC-MOSAIC-BOX

This is a large 4-point box pattern for creating a mosaic roughly 4 times the HRC field-of-view, or ~52x52 arcsec. The shifts are 95% of the detector dimensions (~973 pixels or ~27.5 arcsec) along both the *x* and *y* axes of the detector. Center_Pattern defaults to YES so the target will be at the center of the pattern.

```
Pattern_Type: ACS-HRC-MOSAIC-BOX
Pattern_Purpose: MOSAIC
Number_Of_Points: 4
Point_Spacing: 0.01 - 10.0 (default 24.130)
Line_Spacing: 0.01 - 10.0 (default 27.670)
Angle_Between_Sides: 0 -360 (default 95.85)
Coordinate_Frame: POS-TARG
Pattern_Orient: 0 - 360 (default 90.0)
Center_Pattern: ? (default YES)
```

Permitted **Sub_Pattern** (**Secondary_Pattern**) values: any other ACS/HRC patterns, **LINE**, **BOX**, **SPIRAL**

Pattern_Type: ACS-SBC-DITHER-LINE

General SBC dither line pattern. This pattern shifts the image on the diagonal (10 pixels in **x** and **y**).

```
Pattern_Type: ACS-SBC-DITHER-LINE
Pattern_Purpose: DITHER
Number_Of_Points: 2-9 (default 2)
Point_Spacing: 0.01 - 10.0 (default 0.472)
Coordinate_Frame: POS-TARG
Pattern_Orient: ? (default 44.40)
Center_Pattern: ? (default NO)
```

Permitted **Sub_Pattern** (**Secondary_Pattern**) values: any other ACS/SBC patterns, **LINE**, **BOX**, **SPIRAL**

Pattern_Type: ACS-SBC-DITHER-BOX

Same as ACS-WFC-DITHER-BOX, but for the SBC detector.

```
Pattern_Type: ACS-SBC-DITHER-BOX
Pattern_Purpose: DITHER
Number_Of_Points: 4
Point_Spacing: 0.01 - 10.0 (default 0.179)
Line_Spacing: 0.01 - 10.0 (default 0.116)
Angle_Between_Sides: 0 - 360 (default 63.65)
Coordinate_Frame: POS-TARG
Pattern_Orient: 0 - 360 (default 20.02)
Center_Pattern: ? (default NO)
```

Permitted **Sub_Pattern** (**Secondary_Pattern**) values: any other ACS/SBC patterns, **LINE**, **BOX**, **SPIRAL**

Pattern_Type: ACS-SBC-MOSAIC-LINE

General SBC mosaic line pattern. This pattern shifts the image by 95% in **y** to roughly double the FOV.

```
Pattern_Type: ACS-SBC-MOSAIC-LINE
Pattern_Purpose: MOSAIC
Number_Of_Points: 2-9 (default 2)
Point_Spacing: 10.0 - 130.0 (default 28.801)
Coordinate_Frame: POS-TARG
Pattern_Orient: ? (default 90.0)
Center_Pattern: ? (default YES)
```

Permitted **Sub_Pattern** (**Secondary_Pattern**) values: any other ACS/SBC patterns, **LINE**, **BOX**, **SPIRAL**

Pattern_Type: ACS-SBC-MOSAIC-BOX

This is a large 4-point box pattern for creating a mosaic roughly 4 times the SBC field-of-view, or ~64x64 arcsec. The shifts are 95% of the detector dimensions (~973 pixels or ~32 arcsec) along both the *x* and *y* axes of the detector.

```
Pattern_Type: ACS-SBC-MOSAIC-BOX
Pattern_Purpose: MOSAIC
Number_Of_Points: 4
Point_Spacing: 10.0 - 130.0 (default 28.801)
Line_Spacing: 10.0 - 130.0 (default 32.957)
Angle_Between_Sides: 0 - 360 (default 95.76)
Coordinate_Frame: POS-TARG
Pattern_Orient: 0 - 360 (default 90.0)
Center_Pattern: ? (default YES)
```

Permitted **Sub_Pattern** (**Secondary_Pattern**) values: any other ACS/SBC patterns, **LINE**, **BOX**, **SPIRAL**

8.4.3 NICMOS Patterns

See the NICMOS Instrument Handbook for a full discussion of how and why to use patterns and for complete illustrations of their geometries.

Pattern_Type: NIC-XSTRIP-DITH

This specifies a linear pattern of offsets in the POS TARG +X direction.

```
Pattern_Type:NIC-XSTRIP-DITH
Pattern_Purpose:DITHER
Number_of_Points:?
```

```
Point_Spacing:?
Coordinate_Frame:POS-TARG
Pattern_Orient:? (default 0)
Center_Pattern:?
```

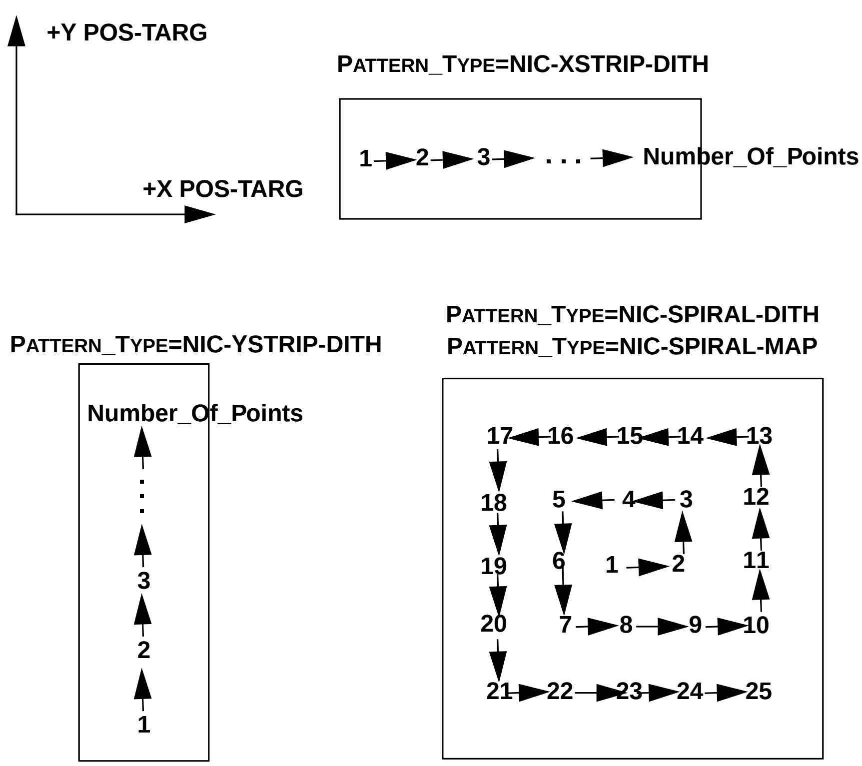
Permitted **Sub-Pattern** (**Secondary_Pattern**) values: **NIC-YSTRIP-DITH**, **NIC-SPIRAL-DITH**, **NIC-SPIRAL-MAP**, **NIC-SQUARE-WAVE-DITH**, **LINE**, **SPIRAL**.

Pattern_Type: NIC-YSTRIP-DITH

This specifies a linear pattern of offsets in the POS TARG +Y direction.

```
Pattern_Type:NIC-YSTRIP-DITH
Pattern_Purpose:DITHER
Number_of_Points:?
Point_Spacing:?
Coordinate_Frame:POS-TARG
Pattern_Orient:? (default 90)
Center_Pattern:?
```

Permitted **Sub-Pattern** (**Secondary_Pattern**) values: **NIC-XSTRIP-DITH**, **NIC-SPIRAL-DITH**, **NIC-SPIRAL-MAP**, **NIC-SQUARE-WAVE-DITH**, **LINE**, **SPIRAL**.



Pattern_Type: NIC-SPIRAL-DITH

This specifies a spiral dither pattern.

```
Pattern_Type:NIC-SPIRAL-DITH
Pattern_Purpose:DITHER
Number_of_Points:?
Point_Spacing:?
Coordinate_Frame:POS-TARG
Pattern_Orient:? (default 0)
Center_Pattern:?
```

Permitted **Sub-Pattern** (**Secondary_Pattern**) values: **NIC-XSTRIP-DITH, NIC-YSTRIP-DITH, NIC-SPIRAL-MAP, NIC-SQUARE-WAVE-DITH, LINE, SPIRAL**.

Pattern_Type: NIC-SPIRAL-MAP

This specifies a spiral mosaic pattern.

```
Pattern_Type:NIC-SPIRAL-MAP
Pattern_Purpose:MOSAIC
Number_of_Points:?
Point_Spacing:?
Coordinate_Frame:CELESTIAL
Pattern_Orient:?
Center_Pattern:?
```

Permitted **Sub-Pattern** (**Secondary_Pattern**) values: **NIC-XSTRIP-DITH, NIC-YSTRIP-DITH, NIC-SPIRAL-DITH, NIC-SQUARE-WAVE-DITH, LINE, SPIRAL.**

Pattern_Type: NIC-SQUARE-WAVE-DITH

This specifies a square-wave pattern with the “amplitude” of the square wave along the POS TARG +Y axis and the main direction of motion along the POS TARG +X axis.

```
Pattern_Type:NIC-SQUARE-WAVE-DITH
Pattern_Purpose:DITHER
Number_of_Points:?
Point_Spacing:?
Line_Spacing:Equal to Point_Spacing (may not be
changed)
Angle_Between_Sides:270 (may not be changed)
Coordinate_Frame:POS-TARG
Pattern_Orient:? (default 90)
Center_Pattern:?
```

Permitted **Sub-Pattern** (**Secondary_Pattern**) values: **NIC-XSTRIP-DITH, NIC-YSTRIP-DITH, NIC-SPIRAL-DITH, NIC-SPIRAL-MAP, LINE, SPIRAL.**

Pattern_Type: NIC-ONE-CHOP

This requires two pattern definitions. It specifies a repeated “chop” back and forth along the POS TARG +X axis.

Primary pattern:

```
Pattern_Type:NIC-ONE-CHOP
Pattern_Purpose:BACKGROUND
Number_of_Points:?
Point_Spacing:0
Coordinate_Frame:POS-TARG
Pattern_Orient:0
Center_Pattern:NO
```

Sub-pattern:

```
Pattern_Type:NIC-ONE-CHOP
Pattern_Purpose:BACKGROUND
Number_of_Points:2
Point_Spacing:?
Coordinate_Frame:POS-TARG
Pattern_Orient:? (default 0)
Center_Pattern:NO
```

Other permitted **Sub-Pattern** (**Secondary_Pattern**) values: none.

Pattern_Type: NIC-TWO-CHOP

This requires two pattern definitions. It specifies a repeated “chop” along the POS TARG +X axis, similar to NIC-ONE-CHOP, but using four points instead of two.

```
Primary pattern:
Pattern_Type:NIC-TWO-CHOP
Pattern_Purpose:BACKGROUND
Number_of_Points:?
Point_Spacing:0
Coordinate_Frame:POS-TARG
Pattern_Orient:0
Center_Pattern:NO
```

Sub-pattern:

```
Pattern_Type:NIC-TWO-CHOP
Pattern_Purpose:BACKGROUND
Number_of_Points:4
Point_Spacing:?
Line_Spacing:Equal to Point_Spacing (may not be
changed)
Angle_Between_Sides:0 (may not be changed)
Coordinate_Frame:POS-TARG
Pattern_Orient:? (default 0)
```

```
Center_Pattern:NO
```

Other permitted **Sub-Pattern** (**Secondary_Pattern**) values: none.

Pattern_Type: NIC-XSTRIP-DITH-CHOP

This requires two pattern definitions. It specifies a combination of a line pattern and a two-point line at right angles (the “chop”).

Primary pattern:

```
Pattern_Type:NIC-XSTRIP-DITH-CHOP
Pattern_Purpose:DITHER
Number_of_Points:?
Point_Spacing:?
Coordinate_Frame:POS-TARG
Pattern_Orient:? (default 0)
Center_Pattern:? (default NO)
```

Sub-pattern:

```
Pattern_Type:NIC-XSTRIP-DITH-CHOP
Pattern_Purpose:BACKGROUND
Number_of_Points:2
Point_Spacing:?
Coordinate_Frame:POS-TARG
Pattern_Orient:? (default 90)
Center_Pattern:NO
```

Other permitted **Sub-Pattern** (**Secondary_Pattern**) values: none.

Pattern_Type: NIC-YSTRIP-DITH-CHOP

This requires two pattern definitions. It specifies a combination of a line pattern and a two-point line at right angles (the “chop”).

Primary pattern:

```
Pattern_Type:NIC-YSTRIP-DITH-CHOP
Pattern_Purpose:DITHER
Number_of_Points:?
Point_Spacing:?
Coordinate_Frame:POS-TARG
Pattern_Orient:? (default 90)
Center_Pattern:? (default NO)
```

Sub-pattern:

```
Pattern_Type:NIC-YSTRIP-DITH-CHOP
Pattern_Purpose:BACKGROUND
Number_of_Points:2
Point_Spacing:?
Coordinate_Frame:POS-TARG
Pattern_Orient:? (default 0)
Center_Pattern:NO
```

Other permitted **Sub-Pattern** (**Secondary_Pattern**) values: none.

Pattern_Type: NIC-SPIRAL-DITH-CHOP

This requires two pattern definitions. It specifies a combination of a spiral pattern and a two-point line (the “chop”).

Primary pattern:

```
Pattern_Type:NIC-SPIRAL-DITH-CHOP
Pattern_Purpose:DITHER
Number_of_Points:?
Point_Spacing:?
Coordinate_Frame:POS-TARG
Pattern_Orient:? (default 0)
Center_Pattern:?
```

Sub-pattern:

```
Pattern_Type:NIC-SPIRAL-DITH-CHOP
Pattern_Purpose:BACKGROUND
Number_of_Points:2
Point_Spacing:?
Coordinate_Frame:POS-TARG
Pattern_Orient: Equal to <Primary_Pattern value>
Center_Pattern:NO
```

Other permitted **Sub-Pattern** (**Secondary_Pattern**) values: none.

Pattern_Type: NIC-MAP

This specifies a linear mosaic pattern oriented on the sky.

Primary pattern:

```
Pattern_Type:NIC-MAP
Pattern_Purpose:MOSAIC
Number_of_Points:?
Point_Spacing:?
Coordinate_Frame:CELESTIAL
Pattern_Orient:?
Center_Pattern:?
```

Sub-pattern:

```
Pattern_Type:NIC-MAP
Pattern_Purpose:MOSAIC
Number_of_Points:?
Point_Spacing:?
Coordinate_Frame:CELESTIAL
Pattern_Orient:?
Center_Pattern:?
```

Other permitted **Sub-Pattern** (**Secondary_Pattern**) values: none.

Pattern_Type: NIC-SKY-ONE-CHOP

This requires two pattern definitions. It specifies a pattern similar to NIC-ONE-CHOP, except that it is oriented on the sky.

Primary pattern:

```
Pattern_Type:NIC-SKY-ONE-CHOP
Pattern_Purpose:BACKGROUND
Number_of_Points:?
Point_Spacing:0
Coordinate_Frame:CELESTIAL
Pattern_Orient:0
Center_Pattern:NO
```

Sub-pattern:

```
Pattern_Type:NIC-SKY-ONE-CHOP
Pattern_Purpose:BACKGROUND
Number_of_Points:2
Point_Spacing:?
Coordinate_Frame:CELESTIAL
Pattern_Orient:?
Center_Pattern:NO
```

Other permitted **Sub-Pattern** (**Secondary_Pattern**) values: none.

Pattern_Type: NIC-SKY-TWO-CHOP

This requires two pattern definitions. It specifies a pattern similar to NIC-TWO-CHOP, except that it is oriented on the sky.

Primary pattern:

```
Pattern_Type:NIC-SKY-TWO-CHOP
Pattern_Purpose:BACKGROUND
Number_of_Points:?
Point_Spacing:0
Coordinate_Frame:CELESTIAL
Pattern_Orient:0
Center_Pattern:NO
```

Sub-pattern:

```
Pattern_Type:NIC-SKY-TWO-CHOP
Pattern_Purpose:BACKGROUND
Number_of_Points:4
Point_Spacing:?
Line_Spacing:Equal to Point_Spacing (may not be
changed)
Angle_Between_Sides0 (may not be changed)
Coordinate_Frame:CELESTIAL
Pattern_Orient:?
Center_Pattern:NO
```

Other permitted **Sub-Pattern** (**Secondary_Pattern**) values: none.

(**Secondary_Pattern**) Pattern_Type: NIC-SKY-SPIRAL-DITH-CHOP

This requires two pattern definitions. It specifies a combination of a spiral pattern and a two-point line (the “chop”), similar to NIC-SPIRAL-DITH-CHOP except that the pattern is oriented on the sky.

Primary pattern:

```
Pattern_Type:NIC-SKY-SPIRAL-DITH-CHOP
Pattern_Purpose:DITHER
Number_of_Points:?
Point_Spacing:?
Coordinate_Frame:POS-TARG
Pattern_Orient:? (default 0)
Center_Pattern:? (default NO)
```

Sub-pattern:

```
Pattern_Type:NIC-SKY-SPIRAL-DITH-CHOP
Pattern_Purpose:BACKGROUND
Number_of_Points:2
Point_Spacing:?
Coordinate_Frame:CELESTIAL
Pattern_Orient:(default 0)
Center_Pattern:NO
```

Other permitted **Sub-Pattern** (**Secondary_Pattern**) values: none.

Part II:

Supported Science Instruments

The chapters in this part describe the configurations and modes for the supported instruments on HST for Cycle 13: WFPC2, ACS, NICMOS and FGS.

CHAPTER 9:

Wide Field Planetary Camera 2 (WFPC2)

In this chapter . . .

Tables and Figures

9.1 Introduction to WFPC2

The Instrument Configurations and Operating Modes described in the following section are used to specify exposures on the Visit and Exposure Specifications. The legal Visit and Exposure Specifications entries are summarized in the following sections. More complete descriptions of Instrument Configurations, Modes, Apertures, Spectral Elements, Detector Characteristics, etc. are available in the *WFPC2 Instrument Handbook*.

Note that many of the Optional Parameters have default values; in such cases, **an entry for an Optional Parameter in the Visit and Exposure Specifications is necessary only if it is desired to override the default value.** The physical units of Optional Parameter quantities are always implicit and should never be entered by the observer.

Optional Parameters whose descriptions begin with the phrase "USE WITH CAUTION" pose a risk to the intended science if a non-default value is used inappropriately. These parameters are italicized in Table 9.1. You may wish to discuss the use of these parameters with your Contact Scientist or an Instrument Scientist (via help@stsci.edu).

The following table lists the permitted Instrument Configurations, Operating Modes, Field of View, Spectral Elements, and Optional Parameters for the WFPC2.

Table 9.1: Supported Instrument Parameters for WFPC2

Config.	Mode	Field of View	Spectral Elements	Optional Parameters
WFPC2	**IMAGE**	**WF2, WF3, WF4, WFALL, WF2-FIX, WF3-FIX, WF4-FIX, WFALL-FIX, PC1, PC1-FIX, LRF, F160BN15, FQUVN33, FQCH4N33, FQCH4N15, FQCH4P15, FQCH4W2, FQCH4W3, FQCH4W4, POLQN18, POLQN33, POLQP15P, POLQP15W**	Enter any Name from Table 9.4	**ATD-GAIN, CR-SPLIT, CR-TOLERANCE, PRE-FLASH, SUM,** ***CLOCKS*****, READ**

The sections on the following pages provide further details of the entries to be made on the Visit and Exposure Specifications when a particular **WFPC2** configuration is chosen.

9.2 Mode = IMAGE Config = WFPC2

The **IMAGE** Mode is the only one available to GOs with the **WFPC2** configuration. The **WFPC2** configuration provides the largest field of view of any instrument on HST. Three wide field CCDs (**WF2–WF4**) each provide a 800x800 pixel format with a pixel size of 0.10x0.10 arcsec at the center of each CCD. The planetary CCD (**PC1**) provides higher spatial resolution and a correspondingly smaller field of view in a 800x800 pixel format with a pixel size of 0.046x0.046 arcsec at the center of the CCD. Each CCD has an approximately 40-pixel vignetted region (i.e., a blank area not exposed to the sky) at its adjoining edge which corresponds to the facets of the pyramid mirror. The composite WFPC2 FOV is shown in Figure 9.1: WFPC2 Aperture Coordinate System. See the *WFPC2 Instrument Handbook* for details.

9.2.1 Aperture or FOV

The specification of the FOV for the WFPC2 controls where the target is placed. The target will be placed at the default location (see below) within the specified FOV, unless the **POS**ition **TARG**et exposure-level Special Requirement (see POSition TARGet <X-value>,<Y-value>) is used. The **ORIENT** visit-level Special Requirement (see ORIENTation <angle1> TO <angle2>) may be used to request a specific orientation of an extended scene in the WFPC2 FOV.

Two types of apertures are defined for each CCD. The first type is designed for placing targets at the “optimum center” of the CCDs, based on the current performance of the CCDs. These are identified as **WF2, WF3, WF4**, **WFALL**, and **PC1**. The default location within these apertures will be routinely adjusted by STScI to reflect any changes in CCD performance (e.g., new charge transfer traps, bad columns, etc.). These apertures should be used for targets which are small compared to the scale size of defects in the chips (which are on the order of 10 pixels).

The second set of apertures define the “geometric center” of the CCDs and will remain FIXED in aperture coordinates. They will NOT be adjusted for changes in CCD characteristics. These apertures are designated **WF2–FIX** through **WF4–FIX**, **WFALL–FIX**, and **PC1–FIX**. These apertures should be used to specify the location of the target relative to the CCDs. Pointings designed to position an extended scene within the WFPC2 FOV should normally be done with the “geometric center” set of apertures. At present WF3 is the only CCD for which the optimum and geometric centers differ.

The WFPC2 X,Y coordinate system defined in Figure 9.1: WFPC2 Aperture Coordinate System is to be used for the **POS TARG** Special Requirement.

Generally all four CCDs are read out even when only one CCD (e.g., **WF2**) is specified as the FOV. If data volume constraint problems are encountered during the planning and scheduling of your observations, you will be contacted by STScI to discuss subsetted CCD readouts.

Table 9.2: WFPC2 Apertures

Aperture	Default position
PC1	Optimum Center of PC CCD1
WF2	Optimum Center of WFC CCD2
WF3	Optimum Center of WFC CCD3
WF4	Optimum Center of WFC CCD4
WFALL	Same as **WFALL-FIX** (see *WFPC2 Instrument Handbook*)
PC1-FIX	Geometric center of PC CCD1

Aperture	Default position
WF2-FIX	Geometric center of WFC CCD2
WF3-FIX	Geometric center of WFC CCD3
WF4-FIX	Geometric center of WFC CCD4
WFALL-FIX	Approximately 14 arcsec from apex of pyramid on WFC CCD3
LRF	This aperture is required when the **LRF** filter is specified as the spectral element. The target position will be derived from the central wavelength specified in the Visit and Exposure Specifications.
F160BN15, FQUVN33, FQCH4N33, FQCH4N15, FQCH4P15, FQCH4W2, FQCH4W3, FQCH4W4, POLQN18, POLQN33, POLQP15P, POLQP15W	These apertures should be specified when a partially rotated spectral element of the same name is used. They are the optimum target positions based on the FOV/filter overlap and the response characteristics of the CCDs. See Table 9.5 for specific FOV/filter combinations which are supported. The positions of these apertures are shown in the *WFPC2 Instrument Handbook*. **Note that only one partially-rotated filter may be specified as the spectral element for a given WFPC2 exposure.**

9.2.2 Spectral Elements

The Spectral Elements for the WFPC2 are listed in Table 9.4. If a partially-rotated filter is chosen, only one such spectral element may be specified for a given WFPC2 exposure.

9.2.3 Wavelength

For the **LRF** filter specification, the desired central wavelength of the filter passband must be specified. STScI will translate the specified wavelength to a filter orientation and default target position. For details on the mapping from wavelength to target position, see the *WFPC2 Instrument Handbook* or the WWW Linear Ramp Filter Calculator at:

http://www.stsci.edu/instruments/wfpc2/Wfpc2_lrf/wfpc2_lrfcalc.html

Note that use of the **LRF** filter will cause an error if you impose the **SAME POSition AS <exposure>** Special Requirement because the desired wavelength is achieved by positioning the source in the **LRF**, which may conflict with **SAME POS**.

For exposures using the quadrant transmission filters (**FQUVN** and **FQCH4N**), the central wavelength of the intended quadrant must be specified. It will be used as a consistency check on the aperture specified for the exposure.

9.2.4 Optional Parameters

ATD-GAIN

=7 (default); 15

This parameter specifies the analog-to-digital gain of the CCD readout electronics in units of e-/DN. (See the *WFPC2 Instrument Handbook* for the exact gains of the readout electronics. **ATD-GAIN=15** is really better approximated as 14 e-/DN, but for historical reasons the former number is used.)

CLOCKS

=NO (default); YES

USE WITH CAUTION – When taking exposures containing saturated pixels, the observer can minimize the amount of image "blooming" by leaving the serial clocks running (**CLOCKS=YES**). This procedure minimizes the amount of transference of charge from one column to the next through the readout channel. Exposures obtained with serial clocks (**CLOCKS=YES**) must be equal to or longer than 1 second. Use of **CLOCKS=YES** is not generally recommended. For a full discussion, see the *WFPC2 Instrument Handbook*.

CR-SPLIT

=DEF (default); range between 0.0 to 1.0; or NO

All WFPC2 external exposures longer than 10 minutes will automatically be split into two exposures to allow for easier identification of cosmic-ray events. The two exposures will be of approximately equal length; the maximum deviation from equal length can be controlled via the **CR–TOLERANCE** parameter. If the default method of splitting the exposure is not acceptable, **CR-SPLIT** should be used to set the fraction of the exposure time that should be used for the first subexposure. Note: If the derived exposure time does not equal one of the discrete times in Table 9.3, the next lower value in the table will be used. **CR-SPLIT=NO** must be entered if the exposure should not be split. The number of exposures should not count these subexposures as separate exposures, so 1 should generally be entered for the **Number_of_Iterations** keyword. If multiple iterations are specified, the total number of exposures will be 2 * **Number_of_Iterations**.

CR-SPLIT values of 0.0 or 1.0 are not allowed.

CR-TOLERANCE

=0.2 (default); range from 0.0 to 1.0

CR-SPLIT exposures are split into two parts whose default lengths are nominally equal. Scheduling efficiency can sometimes be increased if the split is adjusted according to the scheduling situation. This parameter defines the amount of adjustment that the observer wishes to allow in the exposure ratio defined by **CR-SPLIT**. For example, the default value, **0.2**, allows a **CR-SPLIT** value of **0.5** to vary between 0.3 and 0.7.

READ
=YES (default); NO
USE WITH CAUTION – The default is to read out all four CCDs for each exposure. Multiple exposures of a target on different parts of the same CCD image can be made without reading out each exposure (**READ=NO**). A different target position may be defined for each exposure by using the **POSition TARGet** exposure-level Special Requirement on subsequent exposures. The **SEQuential NON-INT** exposure-level Special Requirement must be included to link the exposures, minimizing cosmic-ray and dark-count backgrounds and the final exposure must use **READ=YES**.

SUM
=1X1 (default); 2X2
The default is to read out each individual pixel (**1X1**) resulting in a 1600x1600 format for the four CCDs (800x800 per CCD). A **2X2** pixel on-chip summation may be used, resulting in an 800x800 format for the four CCDs (400x400 per CCD). This reduces spatial resolution by a factor of two and increases signal-to-noise for cases where CCD readout noise is a large contribution to the error budget.

9.2.5 Number of Iterations

The value entered is the number of times this Visit and Exposure Specifications line should be iterated. There are many observational situations when two or more exposures should be taken of the same field (e.g., to keep a bright object from “blooming” by keeping the exposure time short). See the *WFPC2 Instrument Handbook* for details.

9.2.6 Time Per Exposure

The value entered is the duration of the exposure. Although the possible exposure times for the WFPC2 are quantized (see the *WFPC2 Instrument Handbook*), an observer may enter any value for the exposure time. However, if that value does not equal one of the discrete times in Table 9.3, the next lower value in the table will be used.

Since readout noise is present in the WFPC2, exposures are not split for scheduling reasons except as needed for cosmic-ray removal as described under **CR-SPLIT**. Remember that if **CR-SPLIT** is used, the total exposure time will actually be apportioned among two shorter exposures.

9.3 Tabular Reference Data

Table 9.3: Valid WFPC2 Exposure Times (seconds)[1]

0.11[2, 3]	0.12[2, 3]	0.14[2, 3]	0.16[2, 3]	0.18[2, 3]
0.20[2, 3]	0.23[3]	0.26[3]	0.30[3]	0.35[3]
0.40[3]	0.50[3]	0.60[3]	0.70[3]	0.80[3]
1.00	1.20[3]	1.40[3]	1.60[3]	1.80[3]
2.00	2.30[3]	2.60[3]	3.00	3.50[3]
4.00	5.00	6.00	7.00	8.00
10.00	12.00	14.00	16.00	18.00
20.00	23.00	26.00	30.00	35.00
40.00	50.00	60.00	70.00	80.00
100.00	120.00	140.00	160.00	180.00
200.00	230.00	260.00	300.00	350.00
400.00	500.00	600.00	700.00	800.00
900.00	1000.00	1100.00	1200.00	1300.00
1400.00	1500.00	1600.00	1700.00	1800.00
1900.00	2000.00	2100.00	2200.00	2300.00
2400.00	2500.00	2600.00	2700.00	2800.00
2900.00	3000.00	3100.00	3200.00	3300.00
3400.00	3500.00	3600.00	3700.00	3800.00
3900.00	4000.00	4100.00	4200.00	4300.00
4400.00	4500.00	4600.00	4700.00	4800.00
4900.00	5000.00	5100.00	5200.00	5300.00
5400.00	5500.00	5600.00	5800.00	6000.00
6200.00	6400.00	6600.00	6800.00	7000.00
7500.00	8000.00	8500.00	9000.00	10000.00

1. Exposure times below the heavy line will automatically be split into two exposures unless **CR-SPLIT=NO**.
2. These very short exposure times are affected by shutter movement; see the *WFPC2 Instrument Handbook*.
3. These exposure times should *not* be used with CLOCKS=YES; see the *WFPC2 Instrument Handbook*.

Table 9.4: WFPC2 Supported Spectral Elements (Filters)

Name	Wheel	Description	Central Wavelength (Å)	Effective Width (Å)
F122M	1	H Ly - Alpha (Red Leak)	1420	438
F130LP	2	CaF_2 Blocker (zero focus shift)	5116	4776
F160AW	1	Sodium filter A	1492	449
Note: The **F160BW** filter is superior to the **F160AW** filter. If you feel you need to use the **F160AW** filter, please contact your Contact Scientist or help@stsci.edu.				
F160BW	1	Sodium filter B	1492	449
F160BN15	1	Sodium filter B rotated -15 degrees	1492	449
F165LP	2	Suprasil Blocker (zero focus shift)	5196	4541
F170W	8		1750	546
F185W	8		1953	335
F218W	8	Interstellar feature	2192	388
F255W	8		2586	393
F300W	9	"Wide U"	2943	736
F336W	3	"WFPC2 U", "Strömgren *u*"	3342	381
F343N	5	Ne V	3433	27
F375N	5	[O II]	3738	27
F380W	9		3964	673
F390N	5	CN	3889	45
F410M	3	"Strömgren *v*"	4090	147
F437N	5	[O III]	4370	25
F439W	4	"WFPC2 *B*"	4300	473
F450W	10	"Wide *B*"	4519	957
F467M	3	"Strömgren *b*"	4669	167
F469N	6	He II	4694	25
F487N	6	H Beta	4865	26
F502N	6	[O III]	5012	27
F547M	3	"Strömgren *y*"	5476	483
F555W	9	"WFPC2 *V*"	5398	1226
F569W	4	**F555W** is generally preferred	5614	966
F588N	6	He I & Na I	5894	49
F606W	10	"Wide *V*"	5935	1497
F622W	9		6163	917
F631N	7	[O I]	6306	31
F656N	7	H Alpha	6564	21
F658N	7	[N II]	6590	29
F673N	7	[S II]	6732	47
F675W	4	"WFPC2 *R*"	6696	866

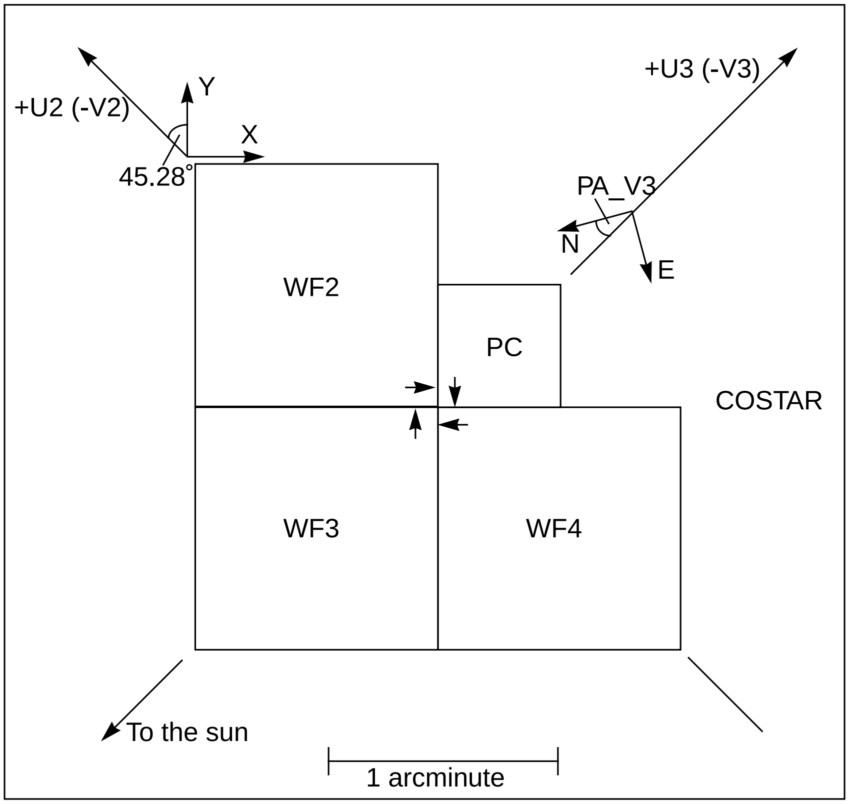
Name	Wheel	Description	Central Wavelength (Å)	Effective Width (Å)
F702W	10	"Wide R"	6868	1383
F785LP	2	**F814W** is generally preferred	8617	1332
F791W	4	**F814W** is generally preferred	7826	1205
F814W	10	"WFPC2 I"	7921	1489
F850LP	2		9072	986
F953N	1	[S III]	9545	53
F1042M	11		10184	365
Quadrant Filters				
FQUVN	11	Redshifted [O II]	3765–3992	63 (avg.)
FQUVN33	11	Redshifted [O II] rotated -33 degrees	3765	73
FQCH4N	11	Methane Bands (Jewel Quad)	5433–8929	49 (avg.)
FQCH4N33	11	Methane quad filter rotated -33 deg	6193	44
FQCH4N15	11	Methane quad filter rotated -15 deg	6193	44
FQCH4P15	11	Methane quad filter rotated +15 deg	8929	64
POLQ	11	Polarizer (0, 45, 90, 135) - zero focus shift		
POLQN33	11	Polarizer rotated -33 degrees		
POLQN18	11	Polarizer rotated -18 degrees		
POLQP15	11	Polarizer rotated +15 degrees		
Linear Ramp Filters				
LRF	12	Linear ramp filter set	3710–9762	1.3% CW

Table 9.5: Linked Spectral Element/Aperture Combinations for Wood's and Quadrant Filters

Spectral Element	Aperture	Central Wavelength (Å)	Effective Width (Å)	Comments
F160BN15	F160BN15	1600	900	on CCD WF3
FQUVN	WF2	3992	64	nominal rotation
FQUVN	WF3	3913	59	nominal rotation
FQUVN	WF4	3830	57	nominal rotation
FQUVN33	FQUVN33	3765	73	–33 degree rotation, on CCD WF2
FQCH4N	FQCH4W2	5433	38	nominal rotation, on CCD WF2
FQCH4N	FQCH4W3	8929	64	nominal rotation, on CCD WF3
FQCH4N	FQCH4W4	7274	51	nominal rotation, on CCD WF4
FQCH4N33	FQCH4N33	6193	44	–33 degree rotation, on CCD WF2
FQCH4N15	FQCH4N15	6193	44	–15 degree rotation, on CCD PC1
FQCH4P15	FQCH4P15	8929	64	+15 degree rotation, on CCD PC1
POLQ	PC1			pol. angle 135 degrees; POS TARG +8, +8 recommended to avoid cross-talk
POLQ	WF2			pol. angle 0 degrees
POLQ	WF3			pol. angle 45 degrees
POLQ	WF4			pol. angle 90 degrees
POLQN33	POLQN33			pol. angle 102 degrees, on CCD WF2
POLQP15	POLQP15W			pol. angle 15 degrees, on CCD WF2
POLQP15	POLQP15P			pol. angle 15 degrees, on CCD PC1; not recommended: clear FOV only 3 arcsec
POLQN18	POLQN18			pol. angle 117 degrees, on CCD WF2

9.4 WFPC2 Aperture Coordinate System

Figure 9.1: WFPC2 Aperture Coordinate System



The figure above shows the coordinate system projected onto the sky for the **POS**ition **TARG**et Special Requirement. The short lines indicate the blooming directions of the CCDs. Units are seconds of arc. See **POSition TARGet <X-value>,<Y-value>** for details.

Note that the **POS TARG** *X*– and *Y*–axes are not the same as the *U*2– and *U*3–axes, and that **POS TARG** axes are associated with each aperture selected (i.e., there is a **POS TARG** coordinate frame centered on each aperture).

CHAPTER 10:

Fine Guidance Sensors (FGS)

In this chapter . . .

Tables and Figures

10.1 Introduction to the FGS

The Instrument Configurations and Operating Modes described in the following section are used to specify exposures on the Visit and Exposure Specifications. A summary of the legal Visit and Exposure Specifications entries is provided; more complete descriptions of Instrument Configurations, Modes, Apertures, Spectral Elements, etc. are available in the *FGS Instrument Handbook*.

Note that many of the Optional Parameters have default values; in such cases, **an entry as an Optional Parameter on the Visit and Exposure Specifications is necessary only if it is desired to override the default value**. In the STScI proposal system the physical units of Optional Parameter quantities are always implicit and should never be entered by the observer.

Optional Parameters whose descriptions begin with the phrase "USE WITH CAUTION" pose a risk to the intended science if a non-default value is used inappropriately. These parameters are italicized in Table 10.1. You may wish to discuss the use of these parameters with your Contact Scientist, if you have one, or with an Instrument Scientist via help@stsci.edu.

Please note that spatial scans are *not* permitted with the FGSs. Also note that *only* FGS1 will be calibrated as a science instrument for Cycle 15.

Table 10.1 lists the permitted Instrument Configuration, Operating Modes, Fields of View, Spectral Elements, and Optional Parameters for the FGS.

Table 10.1: Supported Instrument Parameters for the FGS

Config	Mode	Field of View	Spectral Elements	Optional Parameters
FGS	**POS** 10.2	**1, 2, 3**	FGS 1, 2, and 3: **F583W, F5ND, F550W, PUPIL** FGS 1 and 3: **F605W;** FGS 2 only: **F650W**	**NULL,** ***ACQ-DIST, COUNT, FES-TIME***
	TRANS 10.3	**1, 2, 3**	FGS 1, 2, and 3: **F583W, F5ND, F550W, PUPIL** FGS 1 and 3: **F605W;** FGS 2 only: **F650W**	**SCANS, STEP-SIZE,** ***ACQ-DIST***

The sections on the following pages provide further details of the entries to be made on the Visit and Exposure Specifications when a particular **FGS** Mode/Configuration is chosen.

10.2 Mode = POS Config = FGS

This is the basic single-star positional Operating Mode of the FGS. It may be used to measure the relative positions of fixed or slowly moving (<= 0.080 arcsec/sec) targets with a precision of 0.001 to 0.002 arcsec per single observation. To measure the relative position of a target with respect to field stars, several reference targets must be observed in the same visit. In addition, a few stars (reference and/or target) should be observed multiple times during a visit to map any positional drift of the field due to HST pointing characteristics (see the *FGS Instrument Handbook*). In this Operating Mode the program star or asteroid is first acquired and then held in fine lock for the specified exposure time. This procedure is repeated for the other targets.

The default values of the Optional Parameters are set in this Mode to provide acceptable data for single, zero angular diameter stars. The default acquisition consists of a spiral search for a target within a radius of 15 arcsec, followed by fine-lock tracking of the target. In this default mode star selectors are moved to null the Fine Error Signal and their positions are recorded every 0.025 sec.

10.2.1 Aperture or FOV

1, 2, 3

Requests use of a specific FGS (see Figure 10.1 The FGS POS TARG and interferometer coordinate systems.).

10.2.2 Spectral Element

The available spectral elements are listed in Table 10.2: Spectral Elements for the FGS. Only one filter can be used at a time. The **F583W** is the recommended element for all observations requiring the Optical Field Angle Distortion (OFAD) calibration. **F583W** cannot be used if the target magnitude $m < 8.0$. **F5ND** must be used if $m < 8.0$. An **F5ND**/**F583W** cross-filter calibration is supported.

10.2.3 Optional Parameters

NULL
=YES (default), NO

NULL determines whether the Star Selectors will be repositioned immediately after the **FES-TIME** or after a small delay. Consult with your Contact Scientist or an Instrument Scientist (via help@stsci.edu) before specifying the non-default value; most astrometry programs require **NULL=YES**.

NULL=YES (the default) means that the next fine-error-averaging time (FEAT) interval will not begin until the star selectors have completed the repositioning of the FGS instantaneous field of view (IFOV) to the null position determined by the just-completed FEAT. This is the recommended procedure for all fixed targets.

NULL=NO means that the next FEAT begins immediately after the previous FEAT, implying that the star selectors will not necessarily remain fixed during the FEAT. If the FES-TIME = 0.025 sec, **NULL=NO** has no effect. **NULL=NO** is ordinarily useful only for observations of moving targets.

ACQ-DIST
=DEF (default); 0.0 - 90.0

USE WITH CAUTION—This Optional Parameter determines the size (in arcsec) of the acquisition search region. The default value is 15 arcsec. A larger search radius takes more time and is generally not necessary given HST’s pointing performance.

COUNT
=DEF (default); 1 - 2621400

USE WITH CAUTION—The default count rate will be determined from the target *V* magnitude, and the filter and FGS, using simple scaling rules.

The *FGS Instrument Handbook* should be consulted for the default background rates. These Optional Parameters are used to verify the value of **FES-TIME.** If a non-default value is needed, enter the expected target and sky count rates (in counts per second) for the FGS (see the *FGS Instrument Handbook* and consult with your Contact Scientist or an Instrument Scientist).

FES-TIME
=DEF (default); 0.025, 0.05, 0.1, 0.2, 0.4, 0.8, 1.6, 3.2

USE WITH CAUTION—This optional parameter sets the averaging time (in seconds) for the Fine Error Signal, and consequently, the interval at which the star selectors are adjusted to null the Fine Error Signal.

For POS mode, the default value **DEF** will be calculated from the default or specified **COUNT** optional parameter value and the selected FGS and FILTER. For TRANSfer mode, the default (and required) value is 0.025 sec, regardless of target brightness. See the FGS *Instrument Handbook* for details.

It is necessary that the proposer include the target *V* magnitude for all targets. We recommend including the *B–V* index so that the Instrument Scientist who reviews your Phase II program can assess your calibration needs.

10.2.4 Special Requirements

Enter the **ORIENT**ation visit-level Special Requirement (see **ORIENTation <angle1> TO <angle2>**) if the arrangement of the target or reference stars requires a particular orientation of the FGS field of view. **ORIENT**ation may be required to keep the targets in the field of view when more than one target is observed.

The **POSition TARGet <X-value>,<Y-value>** special requirement can be used to offset a target from the aperture reference position. For the FGS, the aperture reference frame is centered near the geometric center of the field of view, and is *not* equivalent to the FGS detector reference frame. The two frames have different parities and origins (see Figure 10.1 The FGS POS TARG and interferometer coordinate systems. and the FGS Instrument Handbook).

The **SAME POSition AS <exposure>** special requirement should be used to keep the position of the spacecraft held constant over the course of all observations within a visit. To ensure that all exposures within a visit are scheduled within the same orbit, use the **SEQuence <exposure-list> NON-INTerruptible (replaced by Exposure Group Containers in the APT User Interface)** special requirement.

10.2.5 Time Per Exposure

The value to be entered is the photon-collecting time (in seconds) for measuring the position of the target. See the *FGS Instrument Handbook* for exposure time calculations.

10.3 Mode = TRANS Config = FGS

This Operating Mode is useful for the measurement of the relative positions of close binary stars or the sizes of extended targets. In this Mode the interference fringe pattern (or "S-curve") is measured by scanning the FGS instantaneous FOV across the target at 45 degrees with respect to the interferometer axes and recording the Fine Error Signal (FES) every 0.025 sec.

Acquisition is accomplished with a nominal 15 arcsec-radius spiral search. The S-curve is measured by a series of continuous sweeps of the field of view across the target.

Moving targets can be observed if they are listed as a series of fixed targets. This observing strategy is discussed in the *FGS Instrument Handbook*.

10.3.1 Aperture or FOV

1, 2, 3

Requests use of a specific FGS (see Figure 10.1 The FGS POS TARG and interferometer coordinate systems.).

10.3.2 Spectral Element

The available spectral elements are listed in Table 10.2: Spectral Elements for the FGS. Only one filter can be used at a time. The **F583W** is the recommended element for programs requiring the use of POS and TRANS modes combined because of the Optical Field Angle Distortion (OFAD) calibration, which is available only for **F583W**. **F583W** cannot be used if the target magnitude m<8.0. **F5ND** must be used if m<8.0. Unless special S-curve calibration observations are requested, only certain combinations of filter and target color will be calibrated. Please refer to the Instrument Handbook for more information.

10.3.3 Optional Parameters

SCANS
=1 (default) - 200

The value entered is the number of individual scans to make through the target, with alternate scan lines taken in the same direction.

STEP-SIZE
=1.0 (default); 0.3 - 10.0

The resolution by which the S-curve is sampled (in milliarcseconds) is specified by this Optional Parameter. The instantaneous field of view moves SQRT(2) x **STEP-SIZE** between samples (since the motion is always at 45 degrees with respect to the interferometer axes). **STEP-SIZE** values of 0.6 or 1.0 are recommended (see the FGS *Instrument Handbook*).

The exposure time is calculated as follows:

- Texp = [**SCANS** * t(samp) * L(axis)] / **STEP–SIZE,** where
- **SCANS** = the number of individual scan lines,
- *t(samp)* = 0.025 sec, and
- *L(axis)* = the length of each scan in milliarcseconds as projected onto the *x* or *y* axis (see the *FGS Instrument Handbook* for recommendations and minimum length)

The minimum scan rate is 0.035 arcsec/sec along the diagonal.

ACQ-DIST
=0.0 - 90.0

USE WITH CAUTION—This Optional Parameter determines the size (in arcsec) of the acquisition search region. The default value is 15 arcsec. A larger search radius takes more time and is generally not necessary given HST's pointing performance.

10.3.4 Time Per Exposure

The exposure time (*Texp*) is the total photon-collecting time (in seconds) for all *Nscan* scans. The time per individual scan line is *Texp*/*Nscan*. See the discussion in **STEP-SIZE** above and the *FGS Instrument Handbook*.

10.3.5 Special Requirements

Enter the **ORIENT**ation visit-level Special Requirement (see **ORIENTation <angle1> TO <angle2>**) if the arrangement of the target or reference stars requires a particular orientation of the FGS field of view.

ORIENTation may be required to keep the targets in the field of view when more than one target is observed.

The **POSition TARGet <X-value>,<Y-value>** special requirement can be used to offset a target from the aperture reference position. For the FGS, the aperture reference frame is centered near the geometric center of the field of view, and is *not* equivalent to the FGS detector reference frame. The two frames have different parities and origins (see Figure 10.1 The FGS POS TARG and interferometer coordinate systems. and the FGS Instrument Handbook).

The **SAME POSition AS <exposure>** special requirement should be used to keep the position of the spacecraft held constant over the course of all observations within a visit. To ensure that all exposures within a visit are scheduled within the same orbit, use the **SEQuence <exposure-list> NON-INTerruptible (replaced by Exposure Group Containers in the APT User Interface)** special requirement.

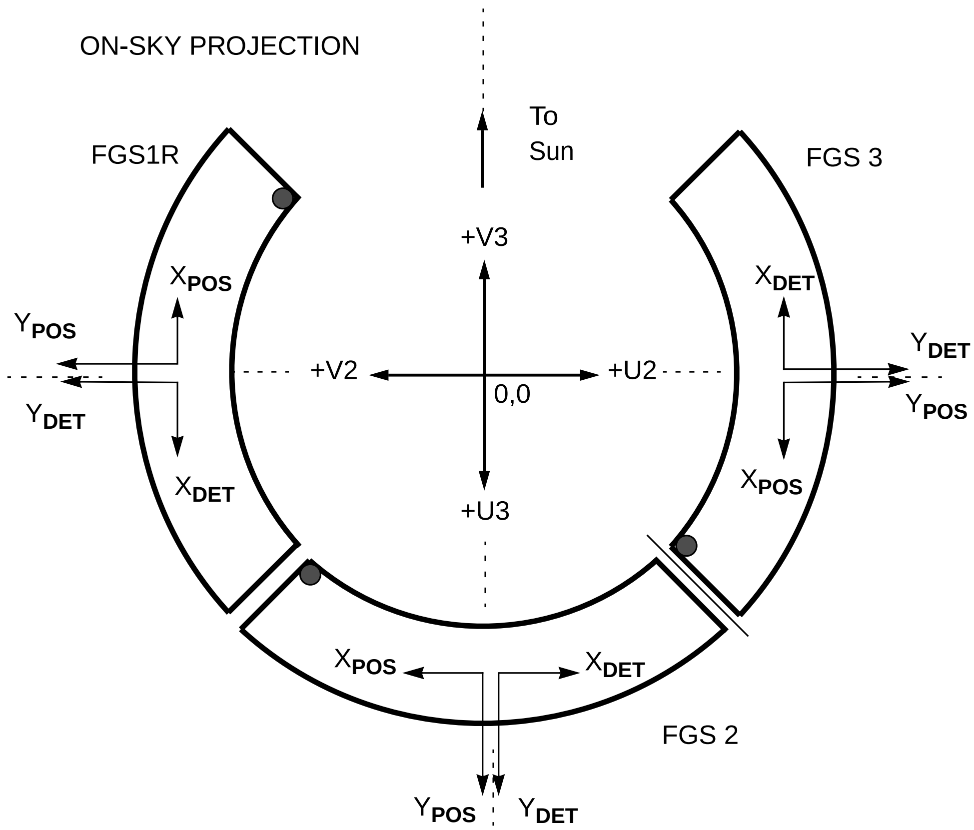
10.4 Tables and Illustrations

Table 10.2: Spectral Elements for the FGS

Name	Comments	Effective Wavelength (Å)	Full Width at Half Maximum (Å)
F583W	"Clear" filter	5830	2340
F5ND	Neutral Density (5 mag)	.....	.....
F605W[1]	"Astrometry Clear" filter	6050	1900
F650W[2]	"Red" filter	6500	750
F550W	"Yellow" filter	5500	750
PUPIL	Pupil stop	5830	2340

1. F605W is to be specified with FGS3 and FGS1.
2. F650W is to be specified with FGS2 only.

Figure 10.1: The FGS **POS TARG** and interferometer coordinate systems.



X,Y_{DET} = Detector Coordinate Frame in Object Space

X,Y_{POS} = POS TARG Reference Frame Used in Phase II Proposal

The **POS TARG** reference frame must be used to specify Special Requirements **POS TARG** and **ORIENT**ation. Note that the FGS interferometer axes and **POS TARG** axes have different origins and parities. The interferometer reference frame is used in pipeline processing only.

CHAPTER 11:

Advanced Camera for Surveys (ACS)

In this chapter...

Tables and Figures

11.1 Introduction to the ACS

The Instrument Configurations and Operating Modes described in this chapter are used to specify exposures on the Visit and Exposure Specifications. The legal Visit and Exposure Specifications entries are discussed in the following sections. More complete descriptions of Instrument Configurations, Modes, Apertures, Spectral Elements, etc. are available in the *ACS Instrument Handbook*.

Note that many of the Optional Parameters have default values. In such cases an entry as an Optional Parameter in the Visit and Exposure Specifications is necessary only if it is desired to override the default value. In the STScI proposal system, the physical units of Optional Parameter quantities are always implicit and should never be entered by the observer.

The following tables list the permitted Instrument Configurations, Operating Modes, Apertures, Spectral Elements, and Optional Parameters for the ACS.

Table 11.1: Supported Instrument Parameters for the ACS

Config	Mode	Aperture	Spectral Elements	Optional Parameters
ACS/WFC	**ACCUM**	**WFC, WFC-FIX, WFC1, WFC2, WFC1-CTE, WFC1-FIX, WFC2-FIX WFCENTER, WFC1-512, WFC1-1K, WFC1-2K, WFC2-2K, WFC1-IRAMP, WFC1-MRAMP, WFC2-MRAMP, WFC2-ORAMP, WFC1-IRAMPQ, WFC1-MRAMPQ, WFC2-MRAMPQ, WFC2-ORAMPQ**	See Table 11.2.	**CR-SPLIT, GAIN, PAREXP, AUTOIMAGE**
ACS/HRC	**ACCUM**	**HRC, HRC-FIX, HRC-OCCULT0.8, HRC-CORON1.8, HRC-CORON3.0, HRC-512, HRC-SUB1.8**	See Table 11.2.	**CR-SPLIT, GAIN, PAREXP, AUTOIMAGE**
	ACQ	**HRC-ACQ**	**See Table 11.2, F220W & F606W, F220W & F550M, F220W & F502N**	
ACS/SBC	**ACCUM**	**SBC, SBC-FIX**	See Table 11.6.	

11.2 Mode = ACCUM Config = ACS/WFC

Photons are counted on the Wide Field Channel CCD as accumulated charge, which is read out at the end of the exposure and converted to DN at a selectable gain. The DN are stored as 16-bit words in a data memory array. A full detector readout is 4144x4136 pixels, which includes 24 leading pixels and 24 trailing pixels of overscan per line and 40 virtual overscan lines.

11.2.1 Aperture or FOV

Allowed apertures for this mode are:

WFC, **WFC-FIX**, **WFC1**, **WFC2**, **WFC1-FIX**, **WFC2-FIX, WFCENTER, WFC1-CTE, WFC1-512, WFC1-1K, WFC1-2K, WFC2-2K, WFC1-IRAMP, WFC1-MRAMP, WFC2-MRAMP, WFC2-ORAMP, WFC1-IRAMPQ, WFC1-MRAMPQ, WFC2-MRAMPQ, WFC2-ORAMPQ**

An appropriate ramp aperture (names contain "**RAMP**") must be specified when a ramp filter (names begin with "**FR**") is used, and may be specified for other spectral elements.

Only apertures **WFC**, **WFC1** or **WFC2** may be used with the following spectral elements: **POL0UV**, **POL60UV**, **POL120UV**, **POL0V**, **POL60V**, **POL120V**, and **F892N** (unless a ramp aperture and filter are also specified).
The actual position of the target within the FOV for these spectral element/aperture combinations will be determined by the STScI based on detector performance.

The aperture **WFC1-CTE** is available to mitigate CTE loss. The **WFC1-CTE** aperture has the same area as the **WFC1** aperture except that the reference position is 200 pixels from the upper-right corner of Chip 1, in both the AXIS1 and AXIS2 directions. Therefore **WFC1-CTE** is not appropriate for highly extended targets. Observations of targets placed here will be less affected by CTE loss than those placed at other commonly used apertures that are closer to the center of the detector.

For apertures **WFC1-512**, **WFC1-1K**, **WFC1-2K**, **WFC2-2K** and the quadrant ramp apertures (names end with "**RAMPQ**"), the proposal processing software will assign a subarray encompassing the field of view of the aperture. Applicable overscan and bias calibrations are automatically available. See the *ACS Instrument Handbook* for details. These subarrays cannot be modified.

Target location on the detector is the same for a full-frame ramp aperture and the corresponding subarray readout quadrant ramp aperture.

Table 11.7 summarizes rules for Aperture and Spectral Element combinations, and whether a full-frame or fixed subarray readout is done.

11.2.2 Spectral Element

For the available ACS/WFC spectral elements, see Table 11.2 on page 205.Note: When F892N or a polarizer is specified, STScI will automatically assign a subarray containing the entire FOV provided by those spectral elements. The subarray is approximately one-quarter the size of the full WFC array. Those subarray parameters may not be overridden.

11.2.3 Wavelength

If a ramp filter (any spectral element beginning with the letters "**FR**") is specified, enter the desired central wavelength in Ångstroms. Table 11.5 gives the allowed minimum and maximum wavelength for each ramp filter.

Note: A wavelength should not be specified if a ramp filter is not being used.

11.2.4 Optional Parameters

CR-SPLIT
= 2 (default) - 8; NO

Specifies the number of sub-exposures into which the exposure is to be split for the purpose of cosmic ray elimination in post-observation data processing (see the ACS *Instrument Handbook*). The specified exposure time will be divided equally among the number of **CR-SPLIT** exposures requested. If **CR-SPLIT=NO**, the exposure is taken without splitting. If a pattern is also specified (see Chapter 8: Pointings and Patterns on page 145), the specified number of sub-exposures will be taken at each pattern point.

Note: The hot pixel population in WFC is growing at a rate similar to the one observed in HRC and STIS. We expect that during Cycle 15 the number of hot pixels will rise to about 1.2% of the total number of available pixels, which is similar to the number of pixels affected by cosmic rays in a 1000 sec exposure (between 1.5% and 3%). The standard CR-SPLIT approach allows for cosmic-ray subtraction, but without additional dithering, does not allow for correction of hot pixels. Hence, we recommend that users who would otherwise have used a single CR-SPLIT, now use some form of dithering instead. For example, a simple ACS-WFC-DITHER-LINE pattern has been developed based on integer pixel offsets (see Section 8.4.2). This will allow the simultaneous removal of both hot pixels and cosmic ray hits in post-observation processing. For more details, refer to item #2 in ACS STAN 03-Apr-2003:
http://www.stsci.edu/hst/acs/documents/newsletters/stan0302.html

GAIN
= 1, 2 (default)(e/DN)

Specifies the gain of the CCD electronics in e/DN. The default has been changed to **2** in order to better sample the WFC full well. Proposals for

Cycle 13 and earlier, should they need to be reprocessed, will continue to have a default **GAIN** value of **1**.

PAREXP
= DEF (default), NONE, MULTIPLE

Specifies how ACS/HRC parallel exposures will be automatically added to ACS/WFC external exposures during proposal processing. This parameter is not allowed to be specified when Number_of_Iterations > 1, in which case no parallels will be added.

The value **MULTIPLE** will cause the proposal processing software to attempt to add an ACS/HRC exposure in parallel with each exposure resulting from an Exposure Specification (e.g., an HRC exposure in parallel with each CR-Split WFC exposure). If parallels cannot be added when specifically requested via **PAREXP=MULTIPLE**, a warning will be issued.

If the value **NONE** is specified, no HRC parallel will be added. The default value (**DEF** or no specification) is equivalent to NONE.

AUTOIMAGE
= YES (default), NO

Controls the automatic scheduling of image exposures for the purpose of spectra zero point determination of grism observations. By default, a single short image through a standard filter will be taken in conjunction with each Exposure Specification using the grism for external science observations. A value AUTOIMAGE=NO will disable the automatic scheduling of the image exposure for the Exposure Specification on which it is specified. The parameter is allowed only on external science observations using the grism.

11.2.5 Number of Iterations

Enter the number of times this Exposure Specification should be iterated, each with the specified **Time_per_Exposure**. Note: **CR-SPLIT** and multiple iterations are mutually exclusive capabilities. If **Number_of_Iterations** > 1 on an external exposure, **CR-SPLIT=NO** must be specified.

11.2.6 Time Per Exposure

Enter the exposure time, in seconds, for the Exposure Specification. If **Number_of_Iterations** = 1, the **Time_per_Exposure** is divided equally among the **CR-SPLIT** copies, if any. If **Number_of_Iterations** > 1, each iteration comprises a single exposure whose duration is **Time_per_Exposure**.

Note that exposure time for an individual WFC exposure, after any CR-SPLIT is applied, must be an integer multiple of 0.1 second and in the range of 0.5 to 3600 sec. The value 0.6 sec. is not allowed.

11.3 Mode = ACCUM Config = ACS/HRC

Photons are counted on the High Resolution Channel CCD as accumulated charge which is read out at the end of the exposure and converted to DN at a selectable gain. The DN are stored as 16-bit words in a data memory array. A full detector readout is 1062x1044 pixels, which includes 19 leading and 19 trailing pixels of overscan per line and 20 virtual overscan lines.

11.3.1 Aperture or FOV

Allowed apertures for this mode are:
HRC, **HRC-FIX**, **HRC-OCCULT0.8**, **HRC-CORON1.8**, **HRC-CORON3.0, HRC-512, HRC-SUB1.8**

HRC must be specified if spectral element **PR200L** is specified (STScI software will adjust the HST pointing to compensate for the refraction).

Note: The ACS/HRC has an occulting finger. Consequently, all ACS/HRC observations have part of their field of view obscured by this finger (for illustrations of the finger location, see Section 4.4 of the ACS Data Handbook and Figure 5.6 of the ACS Instrument Handbook). Please use caution when placing a target in an ACS/HRC aperture so that important parts of the target are not obscured. We advise using the Visual Target Tuner for this purpose during program preparation.

To ensure a consistent position of the coronagraphic mechanism for all ACCUM exposures using Apertures **HRC-CORON1.8**, **HRC-CORON3.0** and **HRC-SUB1.8**, you should request such exposures and their ACQ Mode exposure(s) consecutively within a single visit without interleaving exposures that use other Apertures.

The coronagraphic spots have been drifting randomly up to a few pixels per month. To take advantage of weekly monitoring of spot locations, Special Requirement **USE OFFSET** <id> should be used with Apertures **HRC-CORON1.8**, **HRC-CORON3.0**, and **HRC-SUB1.8** to correct for the most recent measured offset from the nominal location of the desired spot. All coronagraphic exposures using the same Aperture and whose pointing depends on the same ACQ Mode exposure should use the same short (6 character maximum) <id> string. Although there is no formal requirement for it, we suggest using your proposal number, followed by a number such as the visit number or a counter that increments with each ACQ mode exposure in the proposal.

11.3.2 Spectral Element

For the available ACS/HRC spectral elements, see Table 11.2 on page 205. Note: For HRC exposures using a polarizer, STScI will automatically apply corrections for small polarizer-induced shifts in the target position only when aperture HRC is specified.

11.3.3 Wavelength

If a ramp filter (any spectral element beginning with the letters “FR”) is specified, enter the value of the desired central wavelength in Ångstroms. Table 11.5: Wavelength Ranges for the WFC/HRC Ramp Filters gives the allowed minimum and maximum wavelength for each ramp filter. Any HRC aperture may be used with the ramp filters.

Note: A wavelength should be not specified if a ramp filter is not being used.

11.3.4 Optional Parameters

CR-SPLIT
= 2 (default) - 8; NO

Specifies the number of sub-exposures into which the exposure is to be split for the purpose of cosmic ray elimination in post-observation data processing (see the ACS *Instrument Handbook*). The specified exposure time will be divided equally among the number of **CR-SPLIT** exposures requested. If **CR-SPLIT=NO**, the exposure is taken without splitting. If a pattern is also specified (see Chapter 8: Pointings and Patterns on page

145), the specified number of sub-exposures will be taken at each pattern point.

Note: The hot pixel population in HRC is growing at a rate similar to the one observed in WFC. We expect that during Cycle 15 the number of hot pixels will rise to about 1.2% of the total number of available pixels, which is similar to the number of pixels affected by cosmic rays in a 1000 sec exposure (between 1.5% and 3%). The standard CR-SPLIT approach allows for cosmic-ray subtraction, but without additional dithering, does not allow for correction of hot pixels. Hence, we recommend that users who would otherwise have used a single CR-SPLIT, now use some form of dithering instead. For example, a simple ACS-HRC-DITHER-LINE pattern has been developed based on integer pixel offsets (see Section 8.4.2). This will allow the simultaneous removal of both hot pixels and cosmic ray hits in post-observation processing. For more details, refer to item #2 in ACS STAN 03-Apr-2003:
http://www.stsci.edu/hst/acs/documents/newsletters/stan0302.html

GAIN= 2 (default), 4(e/DN)

Specifies the gain of the CCD electronics in e/DN.

PAREXP
= DEF (default), NONE, MULTIPLE

Specifies how ACS/WFC parallel exposures will be automatically added to ACS/HRC external exposures during proposal processing. This parameter is not allowed to be specified when Number_of_Iterations > 1, in which case no parallels will be added. If the value **NONE** is used, no ACS/WFC parallels will be added.

The default value will cause the proposal processing software to attempt to add an ACS/WFC exposure in parallel with each exposure resulting from an Exposure Specification (e.g., a WFC exposure in parallel with each CR-SPLIT HRC exposure), unless the Exposure Specification is part of a **PAR WITH** sequence that includes WFPC2, in which case no such attempt will be made.

The value **MULTIPLE** may be specified to request the addition of parallel exposures explicitly. If an ACS automatic parallel is desired when both ACS and WFPC2 are in a coordinated parallel then **MULTIPLE** must be specified. Otherwise, automatic parallels will not be added. If parallels cannot be added when specifically requested, a warning will be issued.

Note: The addition of the WFC parallel may introduce a serial data dump into the sequence of specified exposures, delaying the next specified exposure. If this occurs and is not acceptable to you there are two actions you may take. First, you may increase the **Time_per_Exposure** of the following Exposure Specification by enough to accommodate a parallel dump of the WFC parallel image (contact your Program Coordinator for details). Second, you may use **PAREXP=NONE** on this Exposure Specification.

AUTOIMAGE
= YES (default), NO

Controls the automatic scheduling of image exposures for the purpose of spectra zero point determination of grism and prism observations. By default, a single short image through a standard filter will be taken in conjunction with each Exposure Specification using a grism or prism for external science observations. A value AUTOIMAGE=NO will disable the automatic scheduling of the image exposure for the Exposure Specification on which it is specified. This parameter is allowed only on external science observations using a grism or prism, with the following exceptions: It is not allowed for pure parallel prism observations, or for prism observations included in either the <parallel-exp-list> or <primary-exp-list> of a **PAR WITH** special requirement (coordinated parallel specification). For these exceptions, the normal default does not apply, and no automatic exposures will be scheduled.

11.3.5 Number of Iterations

Enter the number of times this Exposure Specification should be iterated, each with the specified Time_per_Exposure. Note: **CR-SPLIT** and multiple iterations are mutually exclusive capabilities. If **Number_of_Iterations** > 1 on an external exposure, **CR-SPLIT=NO** must be specified.

11.3.6 Time Per Exposure

Enter the exposure time, in seconds, for the Exposure Specification. If **Number_of_Iterations** = 1, the **Time_per_Exposure** is divided equally among the **CR-SPLIT** copies, if any. If **Number_of_Iterations** > 1, each iteration comprises a single exposure whose duration is **Time_per_Exposure**.

Note that the exposure time for an individual HRC exposure, after any CR-SPLIT is applied, must be an integer multiple of 0.1 second and in the range of 0.1 to 3600 sec.

11.4 Mode = ACQ Config = ACS/HRC

For HRC science observations using one of the coronagraphic apertures (**HRC-OCCULT0.8**, **HRC-CORON1.8**, **HRC-CORON3.0, HRC-SUB1.8**), you will need to perform a target acquisition (ACQ Mode exposure) prior to the science observations in order to accurately position the target behind the occulter. In ACQ mode, the ACS onboard flight software locates the brightest target in the acquisition subarray of the HRC FOV by determining the total flux within a sequence of overlapping "checkboxes" within that subarray. The target position is located within the brightest checkbox and *HST* is repositioned to place the target at the position of the small spot (**HRC-CORON0.8, HRC-SUB1.8**). A slew to a different aperture for an ACCUM exposure will be separate and requires a small amount of additional time.

11.4.1 Aperture or FOV

HRC-ACQ is the only valid aperture for this Mode.

11.4.2 Spectral Element

In addition to any of the allowed filters or polarizer/filter pairs specified in Table 11.2 on page 205, the filter pairs **F220W & F606W**, **F220W & F550M** or **F220W & F502N** are allowed for ACQ mode exposures. These paired filters should be used for bright targets that would otherwise saturate the HRC detector. The neutral density equivalents of these paired filters can be found in the *ACS Instrument Handbook*.

11.4.3 Wavelength

If a ramp filter (any spectral element beginning with the letters "**FR**") is specified, enter the value of the desired central wavelength in Ångstroms. Table 11.5: Wavelength Ranges for the WFC/HRC Ramp Filters gives the allowed minimum and maximum wavelength for each ramp filter.

Note: A wavelength should not be specified if a ramp filter is not being used.

11.4.4 Optional Parameters

There are no optional parameters available to the GO in this mode.

11.4.5 Number of Iterations

The **Number_of_Iterations** must be 1 in this Mode.

11.4.6 Time Per Exposure

The procedures to determine the exposure time for ACQ exposures are given in the *ACS Instrument Handbook*. Observers should take care to obtain a signal-to-noise ratio of at least 40 from their sources, integrated over the checkbox. Note that the gain of the CCD electronics is 4 e/DN for ACQ exposures. The acquisition overhead is typically dominated by factors other than the exposure time itself, and observers may wish to consider adding an extra pad to the exposure time to ensure the required signal-to-noise, taking care not to saturate the CCD pixels or to exceed the maximum acquisition exposure time.

Note that Time per Exposure for individual HRC exposures must be an integer multiple of 0.1 second and must be in the range of 0.1 to 300 sec.

11.5 Mode = ACCUM Config = ACS/SBC

The SBC uses a MAMA detector which is a photon-counting device that provides a two-dimensional ultraviolet capability. The MAMA accumulates photons in the ACS data buffer as they are received, producing images with 1024x1024 pixels. For a more detailed description, see the discussion of SBC ACCUM mode in the *ACS Instrument Handbook*.

If there are SBC and HRC exposures in the same visit, and the SBC exposures are less than two hours (including overheads), precede them with the HRC exposures in order to avoid scheduling problems.

11.5.1 Aperture or FOV

The permitted apertures for this mode are **SBC** or **SBC-FIX**.

SBC must be specified if spectral element **PR110L** or **PR130L** is specified (STScI software will adjust the HST pointing to compensate for the refraction).

11.5.2 Spectral Element

See Table 11.6: Spectral Elements for use with the ACS/SBC Configuration.

11.5.3 Wavelength

No wavelength should be specified for this mode.

11.5.4 Optional Parameters

There are no Optional Parameters in this Mode.

Unlike WFC or HRC, SBC exposures with a dispersing spectral element (**PR110L** or **PR130L**) will not have an additional image exposure scheduled automatically . If an image exposure is desired in combination with a prism exposure, it must be entered as a separate exposure specification. It is best to place it immediately before or after the prism exposure in the same visit (see the *ACS Instrument Handbook* for more details).

11.5.5 Number of Iterations

Enter the number of times this Exposure Specification should be iterated.

11.5.6 Time Per Exposure

Enter the exposure time to apply to each iteration.

Note that **Time_per_Exposure** for individual SBC exposures must be an integer multiple of 0.1 second and must be in the range of 0.1 to 3600 sec.

11.6 Tabular Reference Data

11.6.1 Spectral Elements for WFC and HRC

Table 11.2: Spectral Elements for use with ACS/WFC and ACS/HRC Configurations[a]

Wheel	Position	Name	Description	Allowed Configurations
1	2	**F555W**	Johnson V	**ACS/WFC**, **ACS/HRC**
1	3	**F775W**	SDSS i	**ACS/WFC**, **ACS/HRC**
1	4	**F625W**	SDSS r	**ACS/WFC**, **ACS/HRC**
1	5	**F550M**	narrow V	**ACS/WFC**, **ACS/HRC**
1	6	**F850LP**	SDSS z	**ACS/WFC**, **ACS/HRC**
1	8	**POL0UV**	UV polarizer 0 deg	**ACS/WFC**, **ACS/HRC**
1	9	**POL60UV**	UV polarizer 60 deg	**ACS/WFC**, **ACS/HRC**

Wheel	Position	Name	Description	Allowed Configurations
1	10	**POL120UV**	UV polarizer 120 deg	**ACS/WFC**, **ACS/HRC**
1	11	**F892N**	methane	**ACS/WFC**, **ACS/HRC**
1	12	**F606W**	broad V	**ACS/WFC**, **ACS/HRC**
1	13	**F502N**	O III	**ACS/WFC**, **ACS/HRC**
1	14	**G800L**	GRISM	**ACS/WFC**, **ACS/HRC**
1	15	**F658N**	Hα	**ACS/WFC**, **ACS/HRC**
1	16	**F475W**	SDSS g	**ACS/WFC**, **ACS/HRC**
2	2	**F660N**	N II	**ACS/WFC**, **ACS/HRC**
2	3	**F814W**	Johnson I	**ACS/WFC**, **ACS/HRC**
2	4	**FR388N**	O II Ramp	**ACS/WFC**, **ACS/HRC**
2	4	**FR423N**	O II Ramp	**ACS/WFC**
2	4	**FR462N**	O II Ramp	**ACS/WFC**
2	5	**F435W**	Johnson B	**ACS/WFC**, **ACS/HRC**
2	6	**FR656N**	Hα ramp	**ACS/WFC**, **ACS/HRC**
2	6	**FR716N**	Hα ramp	**ACS/WFC**
2	6	**FR782N**	Hα ramp	**ACS/WFC**
2	8	**POL0V**	visible polarizer 0 deg	**ACS/WFC**, **ACS/HRC**
2	9	**F330W**	HRC u	**ACS/HRC**
2	10	**POL60V**	visible polarizer 60 deg	**ACS/WFC**, **ACS/HRC**
2	11	**F250W**	near-UV filter	**ACS/HRC**
2	12	**POL120V**	visible polarizer 120 deg	**ACS/WFC**, **ACS/HRC**
2	13	**PR200L**	HRC PRISM	**ACS/HRC**
2	14	**F344N**	Ne V	**ACS/HRC**
2	15	**F220W**	near-UV filter	**ACS/HRC**
2	16	**FR914M**	Broad Ramp	**ACS/WFC**, **ACS/HRC**
2	16	**FR853N**	IR Ramp	**ACS/WFC**
2	16	**FR931N**	IR Ramp	**ACS/WFC**
2	17	**FR459M**	Broad Ramp	**ACS/WFC**, **ACS/HRC**
2	17	**FR647M**	Broad Ramp	**ACS/WFC**
2	17	**FR1016N**	IR Ramp	**ACS/WFC**
2	18	**FR505N**	O III Ramp	**ACS/WFC**, **ACS/HRC**
2	18	**FR551N**	O III Ramp	**ACS/WFC**
2	18	**FR601N**	O III Ramp	**ACS/WFC**

a. Note: Normally only one spectral element may be specified for an exposure. The exceptions are:

1) As noted in Section 11.4 Mode = ACQ Config = ACS/HRC, three filter pairs are permitted for ACQ mode exposures of bright targets.

2) The polarizers must be used with another spectral element. This is required to maintain focus. The UV polarizers (**POL0UV**, **POL60UV**, **POL120UV**) must be used with a spectral element on wheel 2 except for: **POL0V**, **POL60V**, **POL120V**, and any inner or outer ramp filter segment (see Table 11.5). The visible polarizers (**POL0V**,

POL60V, **POL120V**) must be used with a spectral element on wheel 1 except for: **F850LP**, **F892N**, **POL0UV**, **POL60UV**, and **POL120UV**.

Permitted Filter Combinations

Only a subset of possible combinations of spectral elements are permitted. In the following tables, an "**S**" indicates combinations that are supported. Combinations marked with "**O**" are permitted ONLY for **Mode = ACQ** exposures and are intended for use with bright targets.

Table 11.3: Permitted WFC filter combinations for **Mode = ACCUM**

	Filter Wheel 1 Spectral Element														
Filter Wheel 2 Spectral Element	**F555W**	**F775W**	**F625W**	**F550M**	**F850LP**	**POL0UV**	**POL60UV**	**POL120UV**	**F892N**	**F606W**	**F502N**	**G800L**	**F658N**	**F475W**	
F660N															
F814W															
FR388N															
FR423N															
FR462N															
F435W															
FR656N															
FR716N															
FR782N															
POL0V		**S**								**S**				**S**	
F330W															
POL60V		**S**								**S**				**S**	
F250W															
POL120V		**S**								**S**				**S**	
PR200L															
F344N															
F220W															
FR914M															
FR853N															
FR931N															
FR459M															
FR647M															
FR1016N															
FR505N															
FR551N															
FR601N															

Table 11.4: Permitted HRC Filter Combinations for **Mode = ACCUM** and **Mode = ACQ**

		Filter Wheel 1 Spectral Element														
		F555W	F775W	F625W	F550M	F850LP	POL0UV	POL60UV	POL120UV	F892N	F606W	F502N	G800L	F658N	F475W	
Filter Wheel 2 Spectral Element	F660N															
	F814W						S	S	S							
	FR388N															
	FR423N															
	FR462N															
	F435W						S	S	S							
	FR656N															
	FR716N															
	FR782N															
	POL0V		S	S							S			S	S	
	F330W						S	S	S							
	POL60V		S	S							S			S	S	
	F250W						S	S	S							
	POL120V		S	S							S			S	S	
	PR200L															
	F344N															
	F220W			O			S	S	S		O	O				
	FR914M															
	FR853N															
	FR931N															
	FR459M															
	FR647M															
	FR1016N															
	FR505N															
	FR551N															
	FR601N															

11.6.2 Ramp Filter Wavelength Ranges

Table 11.5: Wavelength Ranges for the WFC/HRC Ramp Filters

Name	Minimum Wavelength (Å)	Maximum Wavelength (Å)	WFC FOV location
FR388N	3710	4049	middle
FR423N	4049	4420	inner
FR462N	4420	4824	outer
FR505N	4824	5266	middle
FR551N	5266	5748	inner
FR601N	5748	6274	outer
FR656N	6274	6848	middle
FR716N	6848	7474	inner
FR782N	7474	8158	outer
FR853N	8158	8905	inner
FR931N	8905	9719	outer
FR1016N	9719	10609	outer
FR459M	3810	5366	middle
FR647M	5366	7574	inner
FR914M	7574	10709	middle

11.6.3 Spectral Elements for ACS/SBC

Table 11.6: Spectral Elements for use with the ACS/SBC Configuration

Wheel	Position	Name	Description
3	2	**F115LP**	MgF_2
3	3	**F125LP**	CaF_2
3	5	**F140LP**	BaF_2
3	6	**F150LP**	crystal quartz
3	8	**F165LP**	Suprasil
3	9	**F122M**	Ly-α
3	11	**PR130L**	CaF_2 PRISM
3	12	**PR110L**	LiF_2 PRISM

11.6.4 Allowed Combinations of Aperture, Spectral Element & Readout

Table 11.7: Allowed Aperture, Spectral Element & Readout Combinations

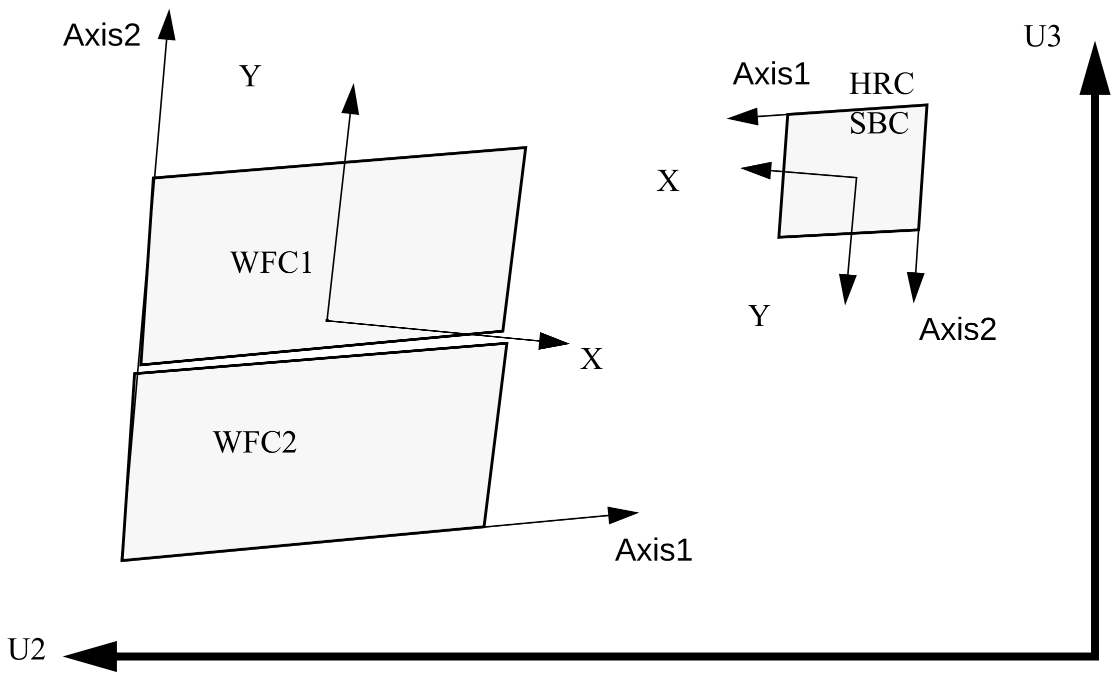
Aperture	Allowed Spectral Elements[1]	Readout
WFC	F S	full frame[2]
WFC-FIX	F	full frame
WFC1	F S	full frame[2]
WFC1-FIX	F	full frame
WFC2	F S	full frame[2]
WFC2-FIX	F	full frame
WFCENTER	F	full frame
WFC1-CTE	F	full frame
WFC1-512	F	subarray fixed by STScI
WFC1-1K	F	subarray fixed by STScI
WFC1-2K	F	subarray fixed by STScI
WFC2-2K	F	subarray fixed by STScI
WFC1-IRAMP	F I	full frame
WFC1-MRAMP	F M S	full frame
WFC2-MRAMP	F M S	full frame
WFC2-ORAMP	F O	full frame
WFC1-IRAMPQ	F I	subarray fixed by STScI
WFC1-MRAMPQ	F M S	subarray fixed by STScI
WFC2-MRAMPQ	F M S	subarray fixed by STScI
WFC2-ORAMPQ	F O	subarray fixed by STScI

1. F = normal WFC filters and **G800L**
   S = small HRC sized elements (polarizers and **F892N**)
   I = inner ramp filter segments
   M = middle ramp filter segments
   O = outer ramp filter segments
2. A subarray fixed by STScI will apply to **WFC**, **WFC1**, **WFC2** when a small spectral element (polarizer of **F892N**) is selected.

11.7 ACS Aperture Coordinate System

Figure 11.1 shows how the POS-TARG coordinates, X and Y, are related to the U2,U3 and detector Axis1 and Axis2 directions. The Y axis is parallel to Axis2. The X axis is normal to Y but differs from the Axis1 direction by about 5 degrees. This diagram correctly shows the WFC and HRC orientations, but it does **not** represent their relative sizes or positions.

Figure 11.1: ACS Coordinate system



CHAPTER 12:

Near Infrared Camera and Multi-Object Spectrometer (NICMOS)

In this chapter . . .

Tables and Figures

12.1 Introduction to NICMOS

There are three cameras available for use on the NICMOS. The choice of camera will be dictated by the desired filter, pixel scale and field of view.

- Camera 1 (**NIC1**) provides the highest available spatial resolution with an 11x11 arcsec field of view and pixels that subtend 0.043 arcsec on a side. **NIC1** will fully sample a diffraction-limited image at wavelengths 1.0 microns or greater.
- Camera 2 (**NIC2**) provides intermediate spatial resolution with a 19.2x 19.2 arcsec field of view and 0.075 arcsec pixels. **NIC2** will fully sample a diffraction-limited image for wavelengths 1.75 microns or greater. **NIC2** contains a coronagraphic hole and must be selected for all observations that require use of this feature.
- Camera 3 (**NIC3**) provides a large field of view, 51.2x51.2 arcsec, with 0.200 arcsec pixels. **NIC3** will undersample the Point-Spread Function at all wavelengths, though some recovery of information may be possible by employing dithering techniques. **NIC3** must be specified for all observations that use the grism Spectral Elements (see Table 12.5: Spectral Elements for the NICMOS).

Note: Target flux for NICMOS observations must be given in units of erg/(cm^2 sec Å) (see Section 3.9 on page 49 or Section 4.8 on page 82). The NICMOS units conversion tool on the STScI WWW pages can help you convert your source flux units.

The following table lists the permitted Instrument Configurations, Operating Modes, Apertures, Spectral Elements, and Optional Parameters for the NICMOS.

Table 12.1: Supported Instrument Parameters for NICMOS

Config.	Mode	Aperture	Spectral Elements	Optional Parameters
NIC1, NIC2, NIC3	**ACCUM**	See Table 12.4	See Table 12.5	**CAMERA-FOCUS, NREAD, OFFSET**
	MULTIACCUM	See Table 12.4	See Table 12.5	**CAMERA-FOCUS, SAMP–SEQ, NSAMP, OFFSET**
NIC2	**ACQ**	**NIC2–ACQ**	See Table 12.5	

The following sections provide further details of the entries to be made on the Visit and Exposure Specifications when a particular **NIC1**, **NIC2**, or **NIC3** Mode/Configuration is chosen. The two modes that will be used by the majority of NICMOS observers are described first: **ACCUM** Mode in "Mode = ACCUM Config = NIC1 or NIC2 or NIC3" on page 215, and **MULTIACCUM** Mode in "Mode = MULTIACCUM Config = NIC1 or NIC2 or NIC3" on page 218.

- **ACCUM** is the simplest operational mode for NICMOS observing. **ACCUM** exposures begin with one or more initial readouts of the array, followed by a specified integration period, and end with one or more readouts of the array (the number of initial and final readouts is the same).
- **MULTIACCUM** is a more flexible operational mode which allows for a wide variety of initial, intermediate, and final readouts. More information on **ACCUM** and **MULTIACCUM** Modes can be found in Chapter 8 of the *NICMOS Instrument Handbook*.
- **ACQ** is a specialized mode used for coronagraphic observations, and is described in "Mode = ACQ Config = NIC2" on page 223. More information on this Mode can be found in Chapter 5 of the *NICMOS Instrument Handbook*.

12.2 Mode = ACCUM Config = NIC1 or NIC2 or NIC3

ACCUM is the simplest readout mode available on NICMOS. One or more non-destructive readouts occur at the beginning and at the end of the exposure. **ACCUM** Mode will be appropriate for many targets, particularly for short integrations of relatively bright targets.

12.2.1 Aperture or FOV

See Table 12.4: NICMOS Apertures.

12.2.2 Spectral Elements

See Table 12.5: Spectral Elements for the NICMOS.

12.2.3 Wavelength

The **Wavelength** parameter is not required for NICMOS observations and should be left blank.

12.2.4 Optional Parameters

CAMERA-FOCUS
=DEF (default); 1-2

Specifies the NICMOS focus position to be used. If **DEF** is specified or this parameter is omitted, NICMOS will be focussed in the best position for the selected camera. A value of 1-2 selects a compromise focus position between the optimum foci for cameras 1 and 2. This will mainly be useful with coordinated parallels, but **CAMERA-FOCUS** may be specified only on exposures using the primary NICMOS detector in the sequence as defined in Section 6.3, "Coordinated Parallel Containers," on page 105.

CAMERA-FOCUS is allowed only with **NIC1**, **NIC1-FIX**, **NIC2**, or **NIC2-FIX** as the chosen aperture.

NREAD

=1 (default), **9**Each **ACCUM** exposure is preceded and followed by a set of detector readouts, which are used to determine the initial and final pixel values. **NREAD** specifies the number of readouts. Multiple readouts may be used to reduce read noise at the cost of extra overhead.

OFFSET
=SAM (default)

Specifies the method of FOV offset to be used in a predefined pattern of offsets.

If the default value of **SAM** is used, offsets from the target that cannot be supported by small angle maneuvers (**SAM**s) while locked onto the target guide stars will require new guide star acquisitions.

12.2.5 Number of Iterations

If **Number_Of_Iterations > 1**, the specified number of iterations will be taken at a single pointing. For a pattern (see Chapter 8: Pointings and Patterns) the specified number of iterations will be taken at each point in the pattern.

12.2.6 Time Per Exposure

Exposure times in **ACCUM** Mode are quantized. The exposure consists of a set of **NREAD** initial readouts, followed by a period of data accumulation, followed by a set of **NREAD** final readouts. The **Time_Per_Exposure** (in seconds) refers to the total integration time, which begins at the start of the first initial readout and ends at the start of the first final readout. The NICMOS Timing Pattern Generator (TPG) uses a list of discrete values for the time between the last initial readout and the first final readout, known as TPG expose time (**TPG_TIME**), which is given in Table 12.3. The specified exposure time will be one of a set of possible values allowed by the following table:

NREAD	Exposure Time (seconds)
1	**TPG_TIME** + 0.598
9	**TPG_TIME** + 5.158

For example, suppose the desired exposure time is 10 seconds. With **NREAD=1**, the ideal TPG expose time is 9.402. The closest TPG expose time to that, from Table 12.3, is 9.117. So the corresponding exposure time is 9.117 + 0.598 = 9.715 seconds.

With **NREAD=9**, the ideal TPG expose time is 4.842. The closest TPG expose time to that is 4.781. So the corresponding exposure time is 4.781+ 5.158 = 9.939 seconds.

If the exposure time entered by the user is not one of the values allowed by the above formula, it will be reduced to the next lowest legal value. It is illegal to specify an exposure time which corresponds to a **TPG_TIME** below the minimum value of 0.0. In other words, do not specify an exposure time shorter than 0.598 sec, which is the fastest **ACCUM** read time for **NREAD**=1. If the brightness of the source requires a shorter exposure time, **MULTIACCUM** Mode or **BRIGHTOBJ** Mode is suggested instead.

12.2.7 Special Requirements

The three NICMOS detectors may be operated in parallel. Coordinated parallels are not possible with certain special requirements; see Chapter 6: Parallel Science Exposures on page 101 for details.

12.3 Mode = MULTIACCUM Config = NIC1 or NIC2 or NIC3

MULTIACCUM is a flexible mode that allows multiple non-destructive readouts of the array during integration spaced at user-specified intervals throughout the integration, with the results from each readout being recorded onboard and returned to the ground for analysis. See the NICMOS *Instrument Handbook* for more information. This mode differs from the use of multiple readouts with **NREAD** in **ACCUM** Mode, because it actually produces multiple images whereas the multiple initial and final readouts in **ACCUM** Mode are used to reduce read noise in the generation of a single image. **MULTIACCUM** Mode may also be used with a single sample time to achieve integration times as short as 0.203 seconds (the shortest allowed in **ACCUM** Mode is 0.598 seconds).

12.3.1 Aperture or FOV

See Table 12.4: NICMOS Apertures.

12.3.2 Spectral Elements

See Table 12.5: Spectral Elements for the NICMOS.

12.3.3 Wavelength

The **Wavelength** parameter is not required for NICMOS observations and should be left blank.

12.3.4 Optional Parameters

CAMERA-FOCUS
=DEF (default); 1-2

Specifies the NICMOS focus position to be used. If **DEF** is specified or this parameter is omitted, NICMOS will be focussed in the best position for the selected camera. A value of **1-2** selects a compromise focus position between the optimum foci for cameras 1 and 2. This will mainly be useful with coordinated parallels, but **CAMERA-FOCUS** may be specified only on exposures using the primary NICMOS detector in the sequence as defined in Section 6.3 on page 105.

CAMERA-FOCUS is allowed only with **NIC1**, **NIC1-FIX**, **NIC2**, or **NIC2-FIX** as the chosen aperture.

SAMP–SEQ
=SCAMRR, MCAMRR, STEP1, STEP2, STEP8, STEP16, STEP32, STEP64, STEP128, STEP256, SPARS4, SPARS16, SPARS32, SPARS64, SPARS128, SPARS256

Specifies the name of a predefined sequence of times from the start of the exposure at which the nondestructive readouts (samples) are performed. The number of samples (up to 25) taken for each exposure is controlled by the **NSAMP** parameter (see below). Table 12.2 gives the sample times (from the start of the exposure) for each sequence. **SAMP–SEQ** is required.

Four different types of sequences are provided. The **SCAMRR** and **MCAMRR** sequences are rapid sequences with linear steps, which obtain the densest temporal sampling. **SCAMRR** is designed for use with a single camera and provides the densest sampling available, but may not be used with multiple cameras. **MCAMRR** should be used if rapid sequencing is desired with two or three cameras (**NIC1**, **NIC2**, **NIC3**) operating in parallel.

Sequences **STEP1**, **STEP2**, **STEP8**, **STEP16**, **STEP32**, **STEP64**, **STEP128**, and **STEP256** begin with logarithmic spacing up to the given number of seconds (1–256), and then continue with linear spacing for the remainder of the sequence, with adjacent steps separated by 1–256 seconds. These sequences all include three readouts during the first second to compensate for any nonlinear effects which may arise at the start of the exposure.

Sequences **SPARS4, SPARS16, SPARS32, SPARS64, SPARS128** and **SPARS256** begin with two readouts during the first second, and then continue with sparse linear spacing for the remainder of the sequence, with adjacent steps separated by the given number of seconds (4, 16, 32, 64 128 or 256). These are similar to **STEP1** to **STEP256**, except that the linear sampling begins immediately after the first two readouts rather than being preceded by a series of readouts with logarithmic spacing.

NSAMP
=1–25

Specifies the number of samples in a predefined sequence that should actually be taken. Table 12.3 defines 25 sample times for each sequence. If an **NSAMP** value smaller than **25** is used, samples will be taken at only the first **NSAMP** times from this table. **NSAMP** must be specified.

The number of readouts will be **NSAMP** plus one for the initial readout, giving a maximum of 26 readouts (the initial readout plus a maximum of 25 samples) for a single execution of a **MULTIACCUM** exposure. Each readout will be recorded and will appear in the final data set.

OFFSET
=SAM (default)

This is the same as in **ACCUM** Mode; see "OFFSET =SAM (default)" on page 216.

12.3.5 Number of Iterations

If **Number_Of_Iterations > 1**, the specified number of iterations will be taken at a single pointing. For a pattern (see Chapter 8: Pointings and Patterns) the specified number of iterations will be taken at each point in the pattern.

12.3.6 Time Per Exposure

Time_Per_Exposure must be **DEF** in this Mode. The exposure time is unnecessary, because it is specified by **SAMP–SEQ** and **NSAMP**.

12.3.7 Special Requirements

The three NICMOS detectors may be operated in parallel. Coordinated parallels are not possible with certain special requirements; see Chapter 6: Parallel Science Exposures on page 101 for details.

The exposure time sequences denoted by **SAMP–SEQ** are defined in the following table. These values are approximated for simplicity; actual exposure times may be reduced by up to 7 msec.

Table 12.2: Predefined Sample Sequences for MULTIACCUM Mode (seconds)

Sequence Name	Sample Times				
SCAMRR	0.203	0.406	0.609	0.812	1.015
	1.218	1.421	1.624	1.827	2.030
	2.233	2.436	2.639	2.842	3.045
	3.248	3.451	3.654	3.857	4.060
	4.263	4.466	4.669	4.872	5.075
MCAMRR	0.303	0.606	0.909	1.212	1.515
	1.818	2.121	2.424	2.727	3.030
	3.333	3.636	3.939	4.242	4.545
	4.848	5.151	5.454	5.757	6.060
	6.363	6.666	6.969	7.272	7.575
STEP1	0.303	0.606	0.995	1.993	2.991
	3.989	4.987	5.985	6.983	7.981
	8.979	9.977	10.975	11.973	12.971
	13.969	14.967	15.965	16.963	17.961
	18.959	19.957	20.955	21.953	22.951
STEP2	0.303	0.606	0.995	1.993	3.987
	5.981	7.975	9.969	11.963	13.957
	15.951	17.945	19.939	21.933	23.927
	25.921	27.915	29.909	31.903	33.897
	35.891	37.885	39.879	41.873	43.867
STEP8	0.303	0.606	0.995	1.993	3.987
	7.981	15.975	23.969	31.963	39.957
	47.951	55.945	63.939	71.933	79.927
	87.921	95.915	103.909	111.903	119.897
	127.891	135.885	143.879	151.873	159.867
STEP16	0.303	0.606	0.995	1.993	3.987
	7.981	15.975	31.969	47.963	63.957
	79.951	95.945	111.939	127.933	143.927
	159.921	175.915	191.909	207.903	223.897
	239.891	255.885	271.879	287.873	303.867
STEP32	0.303	0.606	0.995	1.993	3.987
	7.981	15.975	31.969	63.969	95.969
	127.969	159.969	191.969	223.969	255.969
	287.969	319.969	351.969	383.969	415.969
	447.969	479.969	511.969	543.969	575.969
STEP64	0.303	0.606	0.995	1.993	3.987
	7.981	15.975	31.969	63.969	127.967
	191.965	255.963	319.961	383.959	447.957
	511.955	575.953	639.951	703.949	767.947
	831.945	895.943	959.941	1023.939	1087.937

Sequence Name	Sample Times				
STEP128	0.303	0.606	0.995	1.993	3.987
	7.981	15.975	31.969	63.969	127.967
	255.961	383.955	511.949	639.943	767.937
	895.931	1023.925	1151.919	1279.913	1407.907
	1535.901	1663.895	1791.889	1919.883	2047.877
STEP256	0.303	0.606	0.995	1.993	3.987
	7.981	15.975	31.969	63.969	127.967
	255.961	511.961	767.961	1023.961	1279.961
	1535.961	1791.961	2047.961	2303.961	2559.961
	2815.961	3071.961	3327.961	3583.961	3839.961
SPARS4	0.303	0.606	3.998	8.000	12.002
	16.004	20.006	24.008	28.010	32.012
	36.014	40.016	44.018	48.020	52.022
	56.024	60.026	64.028	68.030	72.032
	76.034	80.036	84.038	88.040	92.042
SPARS16	0.303	0.606	15.997	31.998	47.999
	64.000	80.001	96.002	112.003	128.004
	144.005	160.006	176.007	192.008	208.009
	224.010	240.011	256.012	272.013	288.014
	304.015	320.016	336.017	352.018	368.019
SPARS32	0.303	0.606	32.004	64.004	96.004
	128.004	160.004	192.004	224.004	256.004
	288.004	320.004	352.004	384.004	416.004
	448.004	480.004	512.004	544.004	576.004
	608.004	640.004	672.004	704.004	736.004
SPARS64	0.303	0.606	63.994	127.992	191.990
	255.988	319.986	383.984	447.982	511.980
	575.978	639.976	703.974	767.972	831.970
	895.968	959.966	1023.964	1087.962	1151.960
	1215.958	1279.956	1343.954	1407.952	1471.950
SPARS128	0.303	0.606	127.997	255.998	383.990
	512.000	640.001	768.002	896.003	1024.004
	1152.005	1280.006	1408.007	1536.008	1664.009
	1792.010	1920.011	2048.012	2176.013	2304.014
	2432.015	2560.015	2688.017	2816.018	2944.019
SPARS256	0.303	0.606	255.996	511.996	767.996
	1023.996	1279.996	1535.996	1791.996	2047.996
	2303.996	2559.996	2815.996	3071.996	3327.996
	3583.996	3839.996	4095.996	4351.996	4607.996
	4863.996	5119.996	5375.996	5631.996	5887.996

12.4 Mode = ACQ Config = NIC2

This mode requests the NICMOS flight software to locate the brightest target in the acquisition aperture of camera 2 (one quarter of the full **NIC2** FOV, or 9.6x 9.6 arcsec) and place it behind the coronagraphic spot of camera 2. It is only necessary as a preparation for coronagraphy with the **NIC2-CORON** aperture. Two images will be taken and downlinked, each with a single non-destructive readout at the beginning and the end of the exposure. Two each of background and lamp-on exposures will be taken to locate the coronagraphic hole.

12.4.1 Aperture or FOV

The **NIC2–ACQ** aperture must be used in this Mode.

12.4.2 Spectral Elements

Use any in Table 12.5: Spectral Elements for the NICMOS for the **NIC2** configuration.

12.4.3 Wavelength

The **Wavelength** parameter is not required for NICMOS observations and should be left blank.

12.4.4 Optional Parameters

There are no Optional Parameters in this Mode.

12.4.5 Number of Iterations

Always enter **1**. However, two exposures of the duration given in **Time_Per_Exposure** will be executed, for purposes of onboard cosmic ray elimination by the NICMOS flight software.

12.4.6 Time Per Exposure

Exposure times in **ACQ** Mode are quantized. The exposure consists of an initial readout, followed by a period of data accumulation, followed by a final readout. The **Time_Per_Exposure** (in seconds) refers to the total integration time, which begins at the start of the initial readout and ends at the start of the final readout. The NICMOS Timing Pattern Generator

(TPG) uses a list of discrete values for the time **between** readouts (**TPG_TIME**), which is given in Table 12.3: Quantized Legal NICMOS TPG Expose Times. The specified exposure time should be one of a set of possible values allowed by the following formula:

Time_Per_Exposure = **TPG_TIME** + 0.228

If the exposure time entered by the user is not one of the values allowed by the above formula, it will be reduced to the next lowest legal value. It is illegal to specify an exposure time below the minimum of 0.228 seconds.

12.4.7 Special Requirements

Science exposures associated with this acquisition must be identified as part of the <exposure–list> and must use the **NIC2** configuration and the coronagraphic aperture **NIC2–CORON**.

The Special Requirement **PAR**allel **WITH** is not allowed in this Mode.

12.5 Tabular Data

12.5.1 TPG_TIME Values

The following table gives the legal TPG expose times (**TPG_TIME**) in seconds, needed to calculate legal exposure times in **ACCUM** and **ACQ** Modes. These values are approximated for simplicity, so that exposure times derived from them may be reduced by up to 1 msec.

Table 12.3: Quantized Legal NICMOS TPG Expose Times

0.000	0.014	0.021	0.028	0.035
0.042	0.050	0.057	0.064	0.071
0.078	0.085	0.100	0.107	0.114
0.128	0.143	0.157	0.172	0.186
0.207	0.229	0.250	0.272	0.301
0.329	0.358	0.394	0.437	0.473
0.523	0.573	0.630	0.688	0.759
0.831	0.910	0.996	1.096	1.197
1.318	1.440	1.584	1.734	1.906
2.085	2.286	2.508	2.752	3.017
3.311	3.626	3.978	4.365	4.781
5.246	5.755	6.307	6.917	7.583
8.314	9.117	9.999	10.959	12.020
13.181	14.450	15.848	17.375	19.052
20.887	22.908	25.116	27.539	30.198

33.108	36.305	39.811	43.645	47.860
52.476	57.544	63.092	69.178	75.858
83.177	91.198	100.000	109.648	120.221
131.826	144.542	158.484	173.780	190.546
208.925	229.082	251.188	275.423	299.980
301.994	331.125	359.998	363.073	398.103
419.994	436.516	478.628	479.990	524.805
575.439	630.956	691.826	758.575	831.760
839.989	899.985	912.006	959.981	1000.000
1079.995	1096.474	1199.987	1202.259	1259.983
1318.252	1319.980	1379.997	1439.993	1445.434
1559.986	1584.887	1679.999	1737.795	1739.996
1859.988	1905.455	1919.984	2039.998	2089.292
2099.994	2219.986	2279.983	2290.864	2339.979
2399.996	2459.993	2511.882	2519.989	2639.981
2699.999	2754.225	2759.995	2819.991	2879.987
2939.983	2999.980	3019.950	3059.997	3179.989
3239.986	3299.982	3311.307	3359.999	3479.992
3539.988	3599.984	3630.778	3981.071	4365.154
4786.295	5248.072	5754.398		

12.5.2 NICMOS Apertures

Each camera has two apertures defined near the center of the FOV. Only exposures using the corresponding configuration (**NIC1**, **NIC2**, **NIC3**) may use a given camera's apertures. The **CAMERA-FOCUS** optional parameter may be used to select a compromise focus position not optimized for either **NIC1** or **NIC2**, but intended to work well with both.

One of the two FOV-center apertures (**NIC1**, **NIC2**, **NIC3**) is an optimal location near the center of the FOV considering detector efficiency and pixel quality, which will be updated by the STScI as the detectors change on orbit. One aperture in each camera (**NIC1–FIX**, **NIC2–FIX**, **NIC3–FIX**) corresponds to a fixed pixel at or near the center of the detector array, which will not change on orbit.

The aperture **NIC2–CORON** is the location of the coronagraphic spot in the **NIC2** camera. It will be used by science exposures which have been preceded by a target acquisition exposure using the **NIC2–ACQ** aperture or by a real-time acquisition image obtained using the **NIC2-CORON** aperture. The acquisition aperture will be slightly offset from the coronagraphic aperture, but within the acquisition detector subarray.

Table 12.4: NICMOS Apertures

Aperture	Required Configuration	Description
NIC1 **NIC1–FIX**	**NIC1**	Optimum Location of NIC1 FOV Geometric Center of NIC1 FOV
NIC2 **NIC2–ACQ** **NIC2–CORON** **NIC2–FIX**	**NIC2**	Optimum Location of NIC2 FOV Coronagraphic Acquisition Aperture NIC2 Coronagraphic Spot Geometric Center of NIC2 FOV
NIC3 **NIC3–FIX**	**NIC3**	Optimum Location of NIC3 FOV Geometric Center of NIC3 FOV

12.5.3 NICMOS Spectral Elements

The following Spectral Elements, including filters, polarizers, and grisms, are available for the three NICMOS cameras. Only exposures using the corresponding configuration (**NIC1**, **NIC2**, **NIC3**) may use a given camera's spectral elements. The **CAMERA-FOCUS** optional parameter may be used to select a compromise focus position not optimized for either **NIC1** or **NIC2**, but designed to work well for both. See the *NICMOS Instrument Handbook* for details.

Table 12.5: Spectral Elements for the NICMOS

Name	Wheel Position	Central Wavelength (microns)	Bandwidth (microns)	Description
Config = NIC1				
F090M	18	0.900	0.800 – 1.000	
F095N	19	0.953	1%	S III
F097N	20	0.970	1%	S III Continuum
F108N	16	1.083	1%	He I
F110M	17	1.100	1.000 – 1.200	
F110W	2	1.100	0.800 – 1.400	
F113N	15	1.130	1%	He I Continuum
F140W	6	1.400	1.000 – 1.800	Broad Band
F145M	13	1.450	1.350 – 1.550	Water
F160W	14	1.600	1.400 – 1.800	
F164N	11	1.644	1%	Fe II
F165M	10	1.650	1.550 – 1.750	
F166N	12	1.660	1%	Fe II Continuum
F170M	7	1.700	1.600 – 1.800	
F187N	8	1.875	1%	Paschen Alpha
F190N	9	1.900	1%	Paschen Alpha Continuum

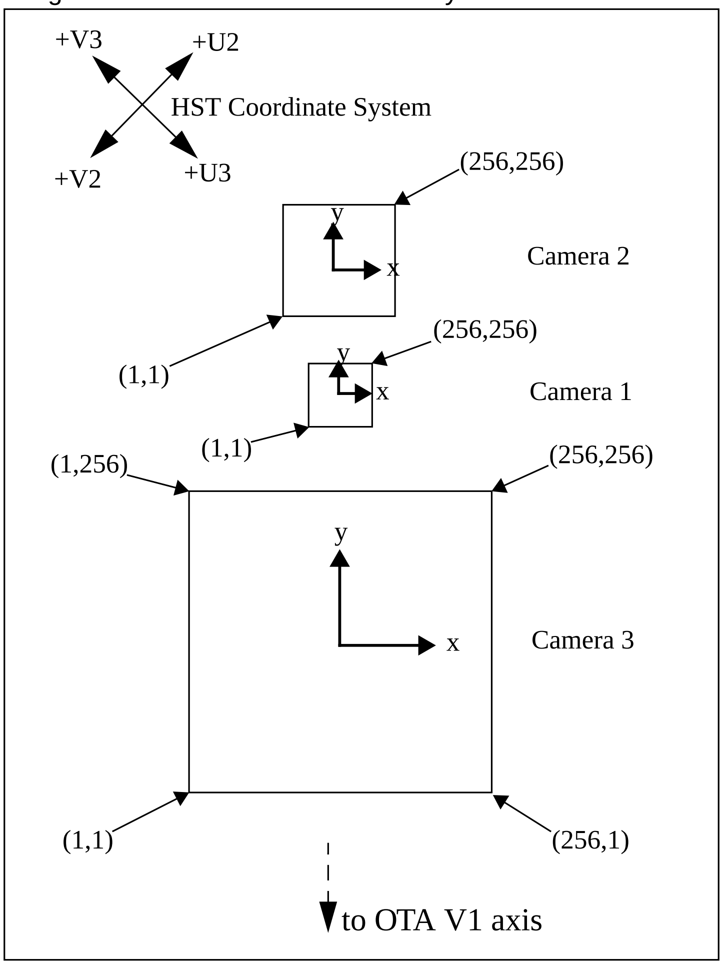
Name	Wheel Position	Central Wavelength (microns)	Bandwidth (microns)	Description
POL0S	5	1.050	0.810 – 1.290	Short Polarizer – 0 deg
POL120S	4	1.050	0.810 – 1.290	Short Polarizer – 120 deg
POL240S	3	1.050	0.810 – 1.290	Short Polarizer – 240 deg
BLANK	1	N/A	N/A	Blank (opaque)

Name	Wheel Position	Central Wavelength (microns)	Bandwidth (microns)	Description
Config = NIC2				
F110W	18	1.100	0.800 – 1.400	
F160W	19	1.600	1.400 – 1.800	Minimum Background
F165M	20	1.650	1.550 – 1.750	
F171M	7	1.715	1.680 – 1.750	HCO2 & C2 Continuum
F180M	8	1.800	1.765 – 1.835	HCO2 & C2
F187N	10	1.875	1%	Paschen Alpha
F187W	9	1.875	1.750 – 2.000	
F190N	11	1.900	1%	Paschen Alpha Continuum
F204M	2	2.040	1.990 – 2.090	
F205W	17	2.050	1.750 – 2.350	Methane Imaging
F207M	6	2.075	2.000 – 2.150	Broad Band
F212N	12	2.121	1%	
F215N	13	2.150	1%	H2
F216N	14	2.165	1%	H2 & Brackett Gamma Continuum
F222M	15	2.225	2.150 – 2.300	
F237M	16	2.375	2.300 – 2.450	Brackett Gamma
				CO Continuum
				CO Band
POL0L	3	2.050	1.900 – 2.100	Long Polarizer – 0 deg
POL120L	4	2.050	1.900 – 2.100	Long Polarizer – 120 deg
POL240L	5	2.050	1.900 – 2.100	Long Polarizer – 240 deg
BLANK	1	N/A	N/A	Blank (opaque)
Config = NIC3				
F108N	4	1.083	1%	He I
F110W	2	1.100	0.800 – 1.400	
F113N	5	1.130	1%	He I Continuum
F150W	9	1.500	1.100 – 1.900	Grism B Continuum
F160W	6	1.600	1.400 – 1.800	Minimum Background
F164N	8	1.644	1%	Fe II
F166N	7	1.660	1%	Fe II Continuum
F175W	20	1.750	1.200 – 2.300	
F187N	11	1.875	1%	Paschen Alpha
F190N	12	1.900	1%	Paschen Alpha Continuum
F196N	13	1.962	1%	
F200N	14	2.000	1%	SI VI
F212N	18	2.121	1%	SI VI Continuum
F215N	19	2.150	1%	H2
F222M	15	2.225	2.150 – 2.300	H2 Continuum
F240M	16	2.400	2.300 – 2.500	CO Continuum
				CO Band

Name	Wheel Position	Central Wavelength (microns)	Bandwidth (microns)	Description
G096	3	0.967	0.800 – 1.200	Grism A
G141	10	1.414	1.100 – 1.900	Grism B
G206	17	2.067	1.400 – 2.500	Grism C
BLANK	1	N/A	N/A	Blank (opaque)

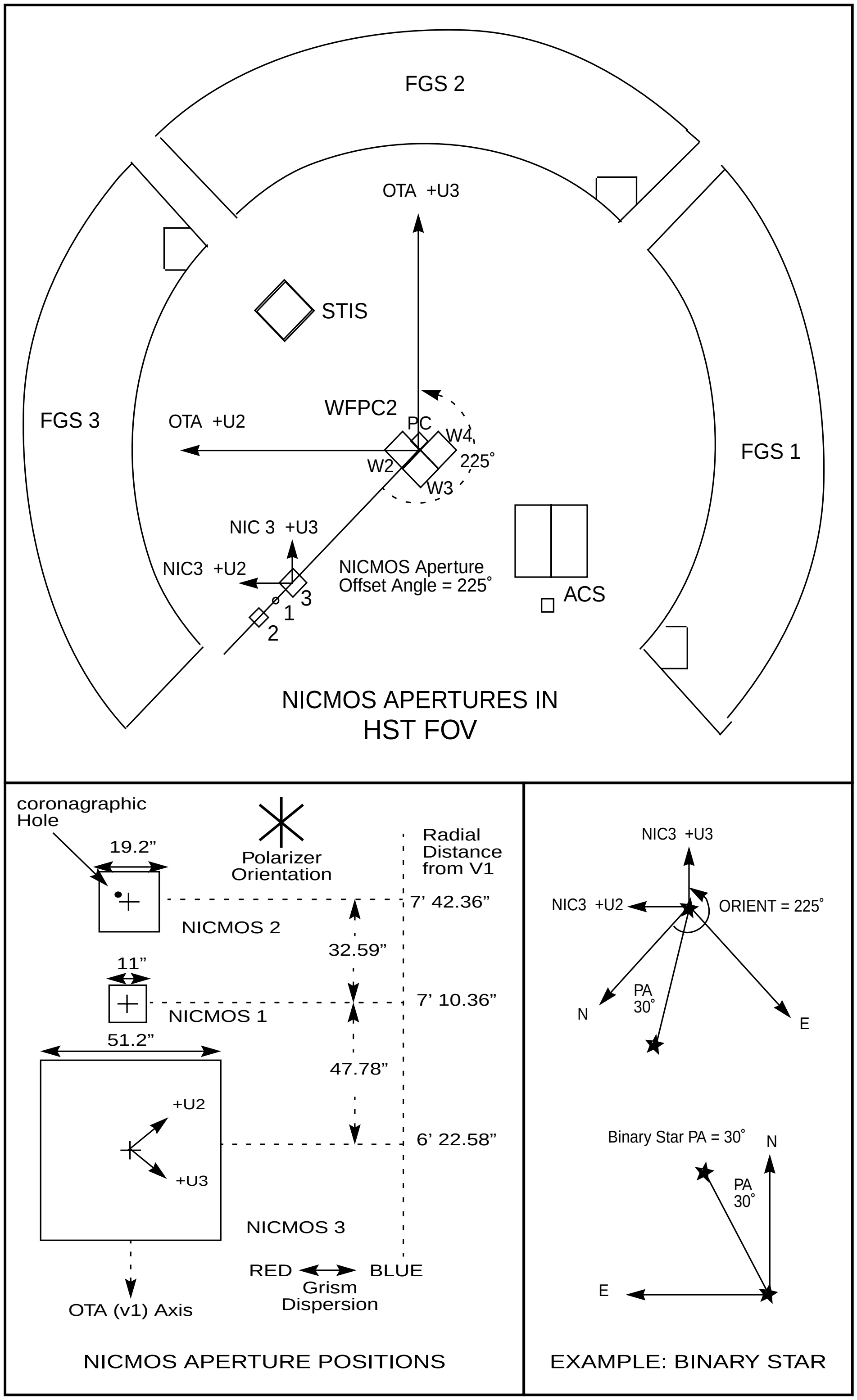
12.6 Illustrations

Figure 12.1: NICMOS Coordinate System.



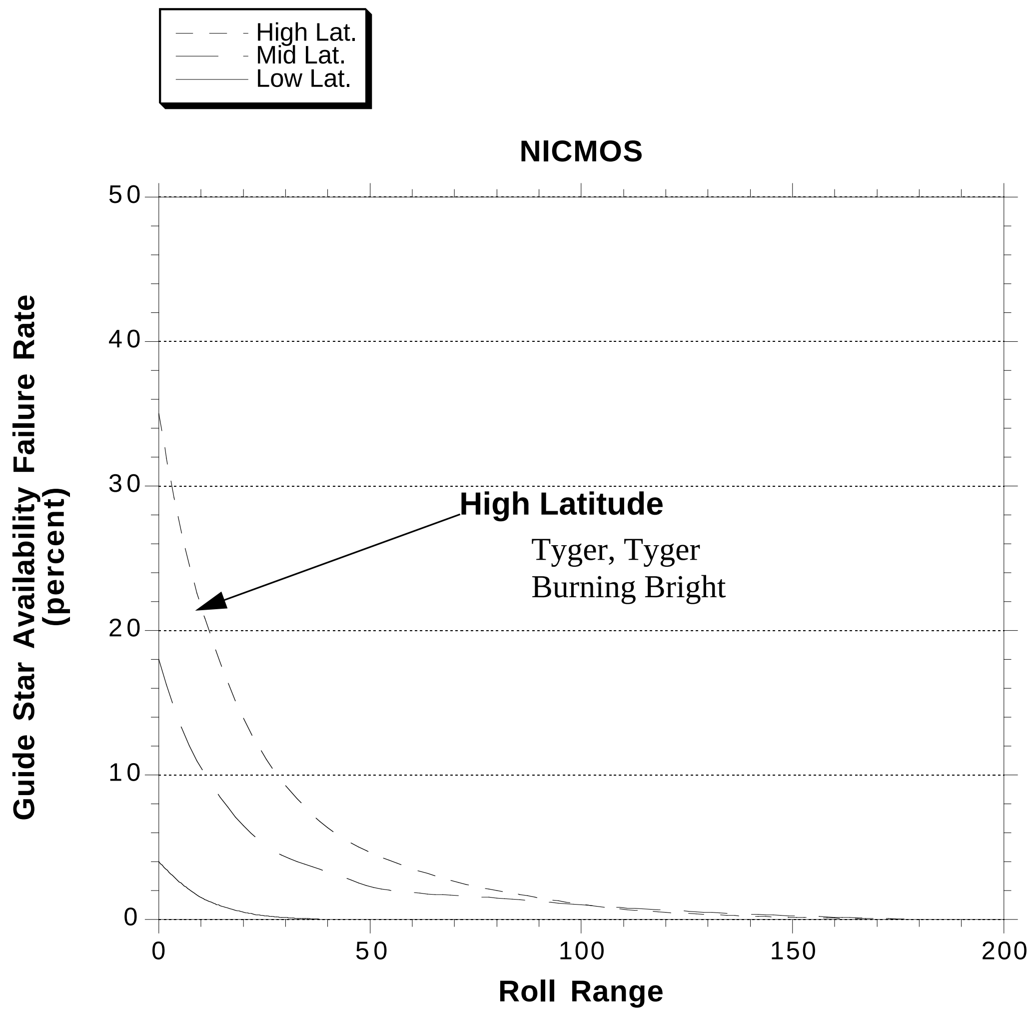
This figure shows the NICMOS coordinate system projected onto the sky for the **POS**ition **TARG**et Special Requirement. The **POS TARG** coordinate system will be aligned parallel to rows and columns in each camera as shown in the diagram above. The alignment of each camera is not exact, and the internal coordinate systems attached to each of them will differ by small rotations (probably less than 2 degrees). The FITS format data files generated for NICMOS observers will have a World Coordinate System specified appropriately for each camera. The origin of the coordinate system will be located as shown in the diagram above.

Figure 12.2: Definition of Orientation for NICMOS.



Due to the linear arrangement of the three NICMOS cameras on the sky, it is sometimes advantageous to specify a unique telescope orientation. A simple example is shown above. A binary star with a position angle (PA) of 30 degrees measured east from north is to be positioned with the southern star in Camera 3 and the northern star in Camera 2. That is, we want the line connecting the two stars to lie along the NICMOS +Y axis. The resulting HST orientation is 225 + 30 = 255 degrees. (The NICMOS offset angle for orientation specifications is 225 degrees; see Table 7.4: Instrument Orientations with respect to U3-Direction.)

Figure 12.3: Guide-Star Availability with NICMOS Patterns.



The above graph shows the probability that guide stars will **not** be available ("failure rate") as a function of the tolerance in roll ("roll range") that the visit allows, for targets at high galactic latitude. For visits with **ORIENT**ation requirements, the roll range would be half the difference between <angle1> and <angle2>. Note however that other special requirements, such as **SAME ORIENT**, **ORIENT FROM**, and **BETWEEN**, can also restrict the orientation at which a visit may be scheduled. Unavailability versus roll range is plotted for the full range of pointings within each of the **NIC1**, **NIC2**, and **NIC3** apertures. Note that in all three cases the unavailability rises dramatically as the roll range shrinks to zero. The risk of not finding guide stars is considerably higher for patterns that cover the larger **NIC3** aperture. For patterns larger than the **NIC3** aperture, and which may approach the maximum pointing variation of 2 arcmin, unavailability will be still higher. Therefore, observations at high galactic latitude (above 45 degrees) with large patterns and tight **ORIENT** restrictions carry a high risk of having to be reworked later for lack of guide stars. At lower galactic latitudes, the risk still exists but is considerably reduced.

Index

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