



Jaime Zamorano

Monitoring Light Pollution with the STARS4ALL TESS Photometers

STARS4ALL

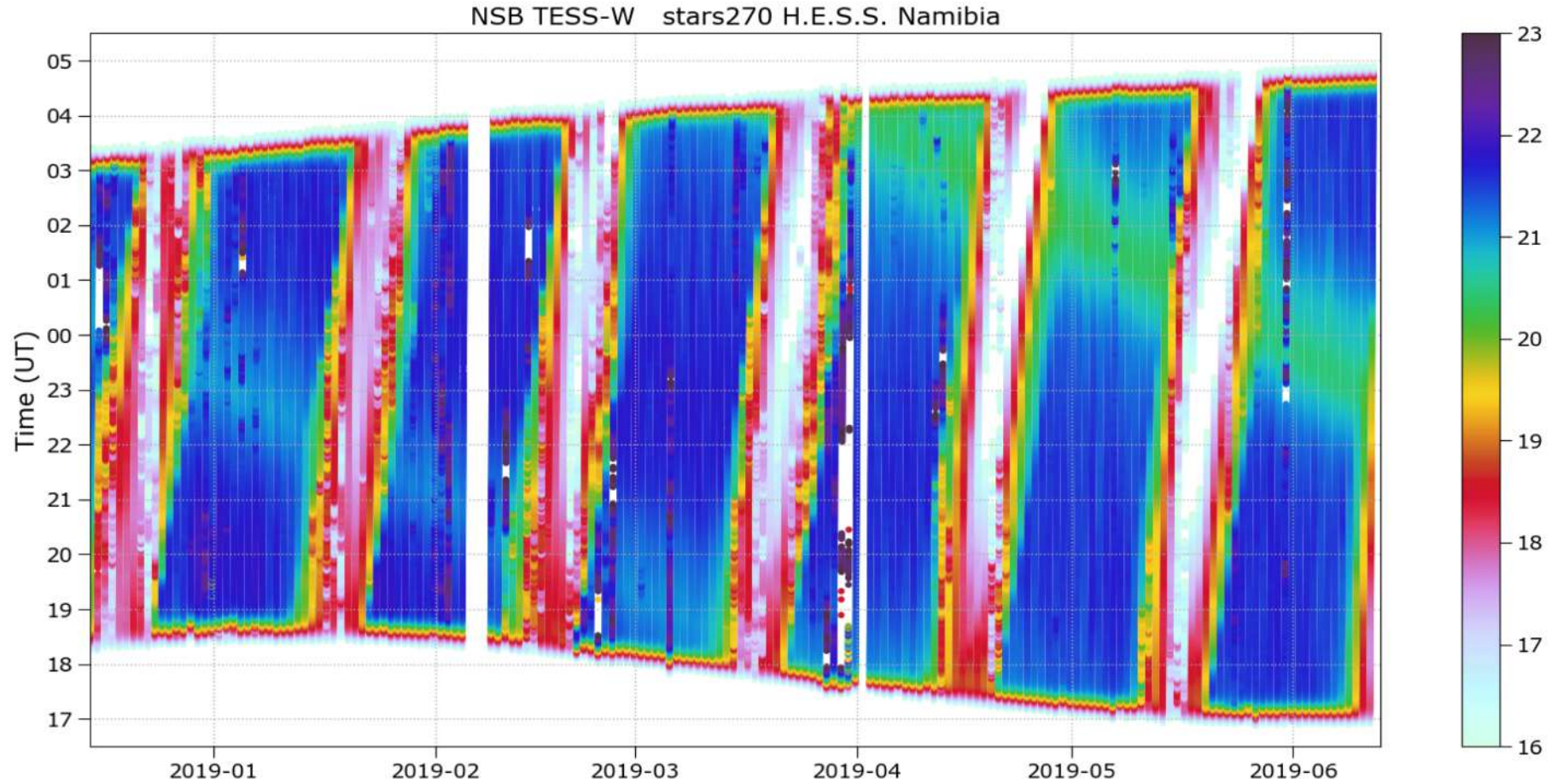
2019/06 LPTMM19



Contents

- Why monitoring ?
- Why to design a new photometer ?
- TESS-W characteristics.
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- Developments in progress (Hardware and software).

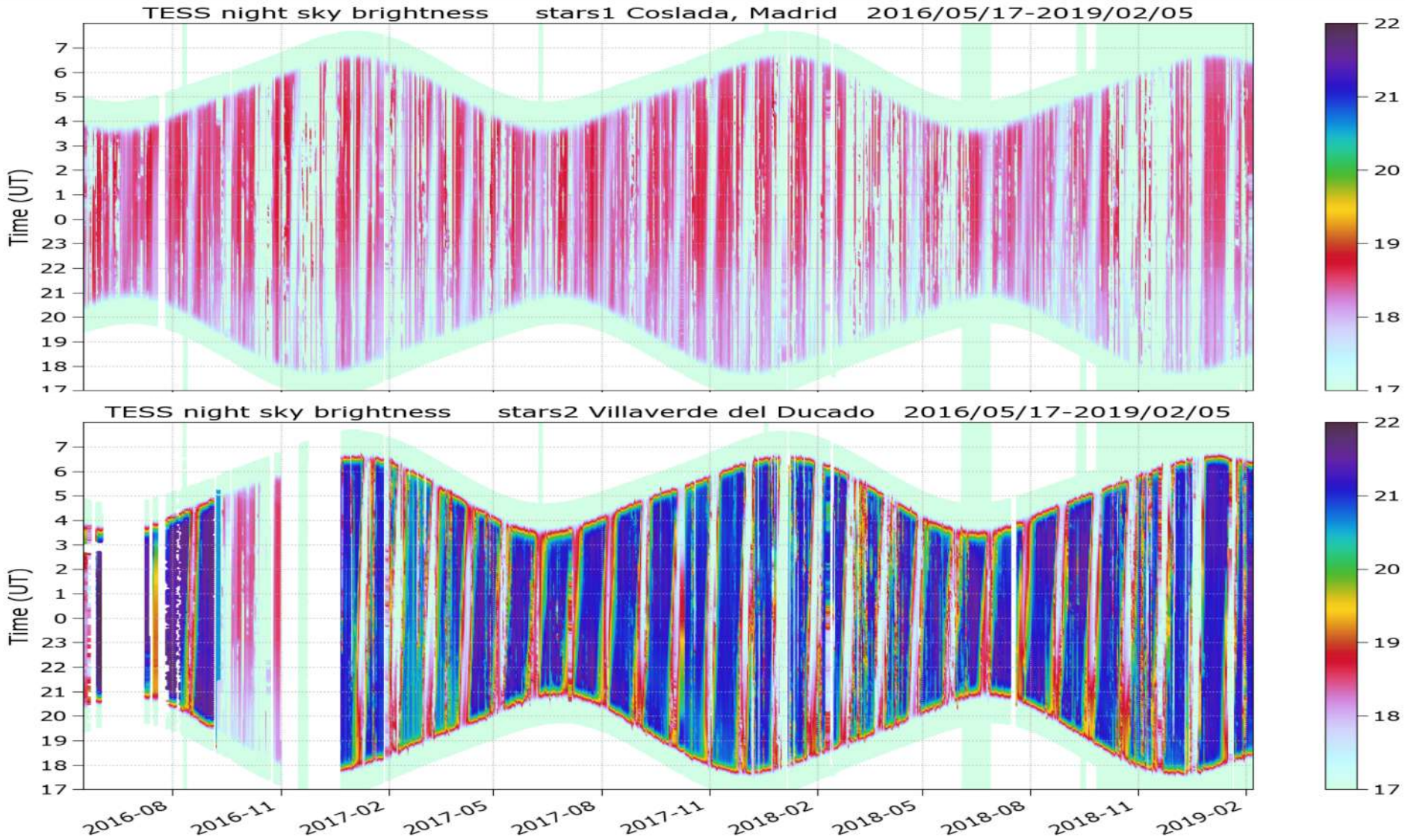
Why monitoring



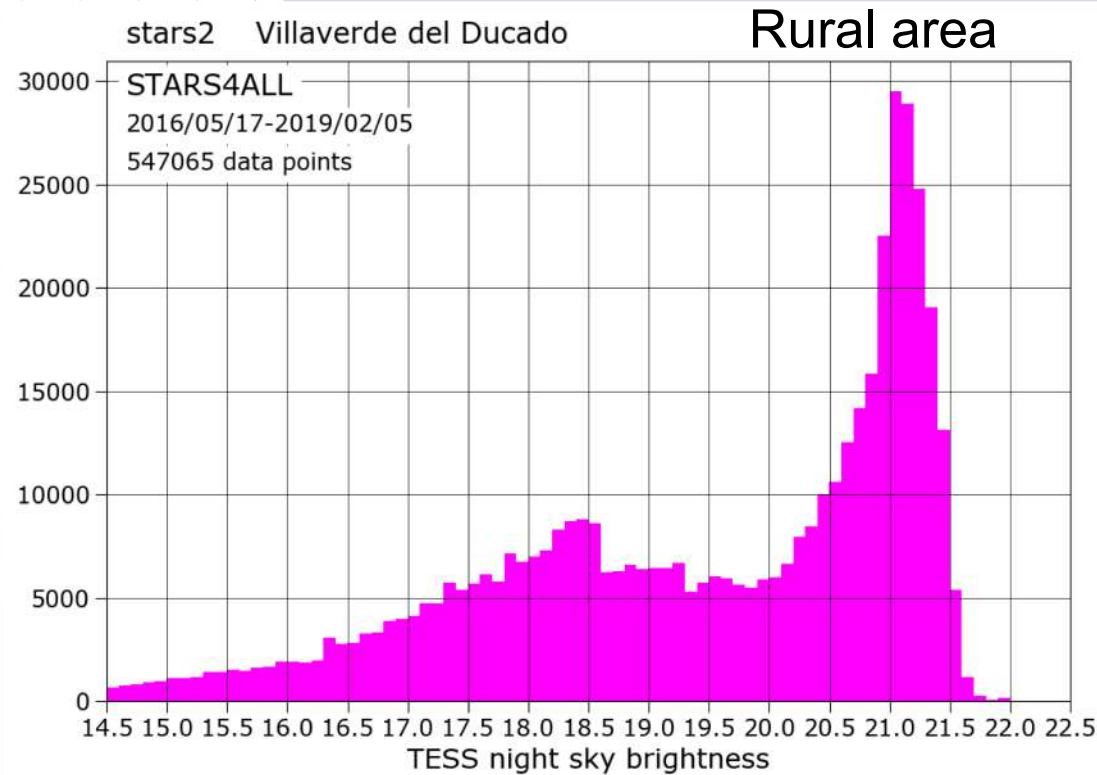
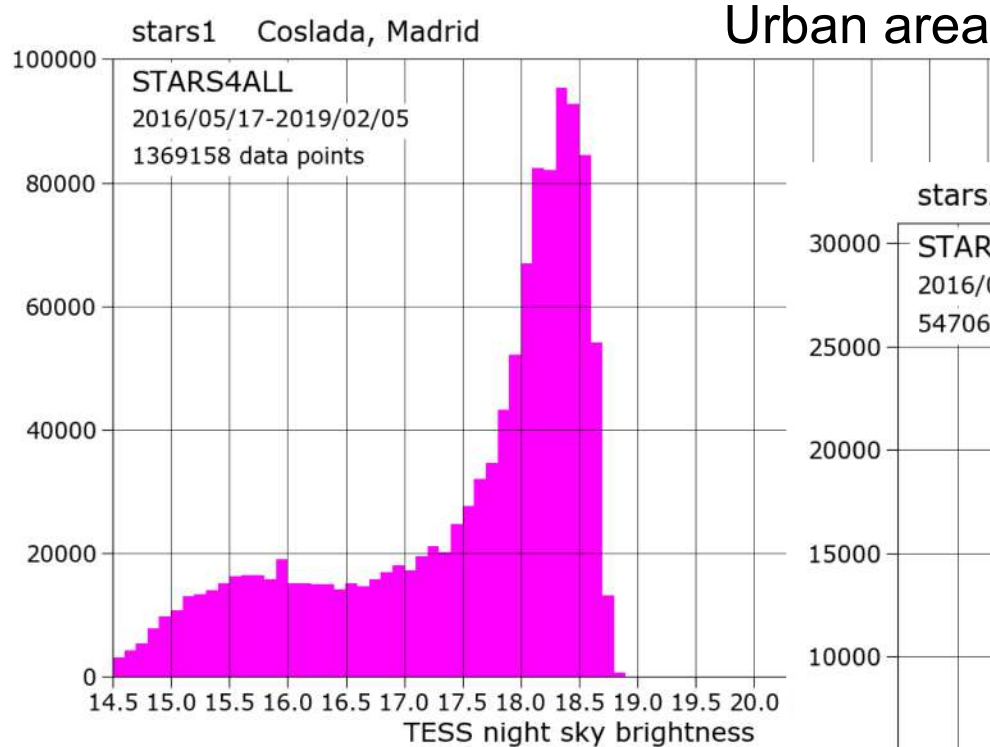
“Night Sky brightness should be treated
as another weather parameter”

(Salvador Bará dixit)

Why monitoring



Why monitoring



Studies on Light Pollution and its evolution based on **statistics** could be made after **monitoring** the Night Sky Brightness

Why to design a new photometer ?

- One of the aims of the H2020 European Project was to build an European network of Night Sky Brightness monitoring stations.
- We designed a new **low cost photometer** with some additional features that improve the well known SQM photometer.
- TESS-W is open hardware and software, and was designed to share the data (**OPEN DATA**).
- TESS-W is an user friendly **research photometer for citizen science**.

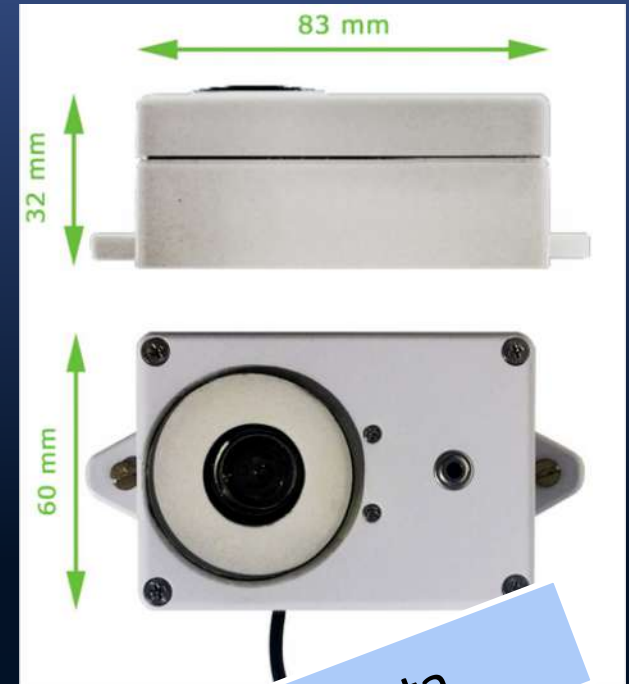
STARS4ALL

A Collective Awareness Platform for Promoting Dark Skies in Europe

TESS-W photometer

- The Telescope Encoder and Sky Sensor (TESS) has been designed to monitor zenith *sky brightness* every night
- Compact photometer mounted inside a *weatherproof enclosure*
- Wherever there is electricity and WIFI you can install it and share measures.
- Internet of Things IoT
'Connect, register and forget'
- **Extra features**
Open data, hardware and software,
Anti-condensation heating, cloud detector...

<https://www.instructables.com/id/TESS-W-Night-Sky-Brightness-Photometer/>



Open data

Open hardware

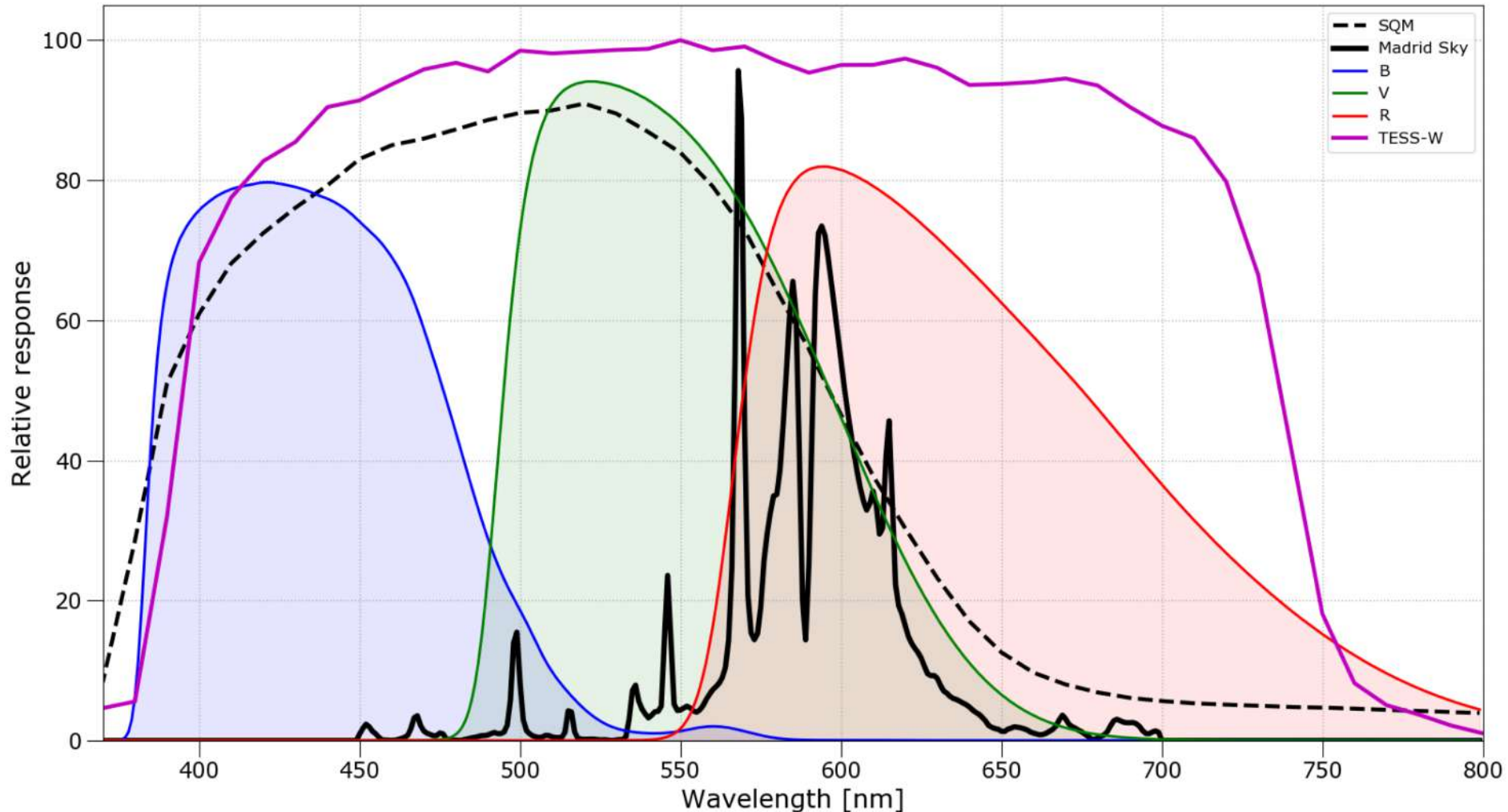
TESS-W photometer



- Clear glass window
- Light collector
- Light sensor
- Dichroic filter glued on top of collector
- Weatherproof enclosure box
- Heater
- Custom printed circuit board
- Infrared thermometer
- WIFI + microcontroller chip
- power supply 5V smartphone charger

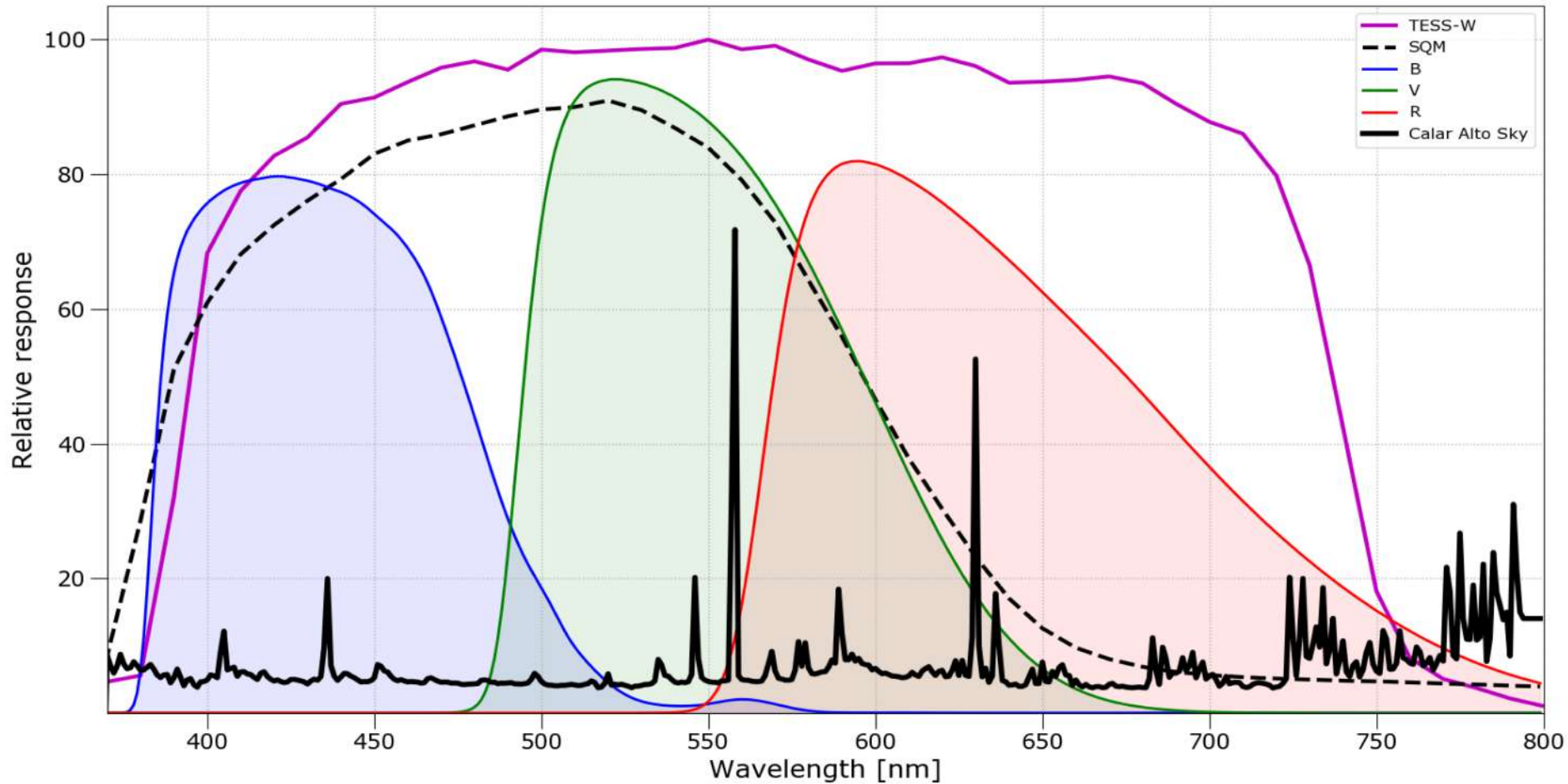
TESS-W characteristics Spectral response

SQM, Johnson B, V, R and TESS-W and Madrid night sky spectrum



TESS-W characteristics Spectral response

SQM, Johnson B, V, R and TESS-W and Calar Alto night sky spectrum

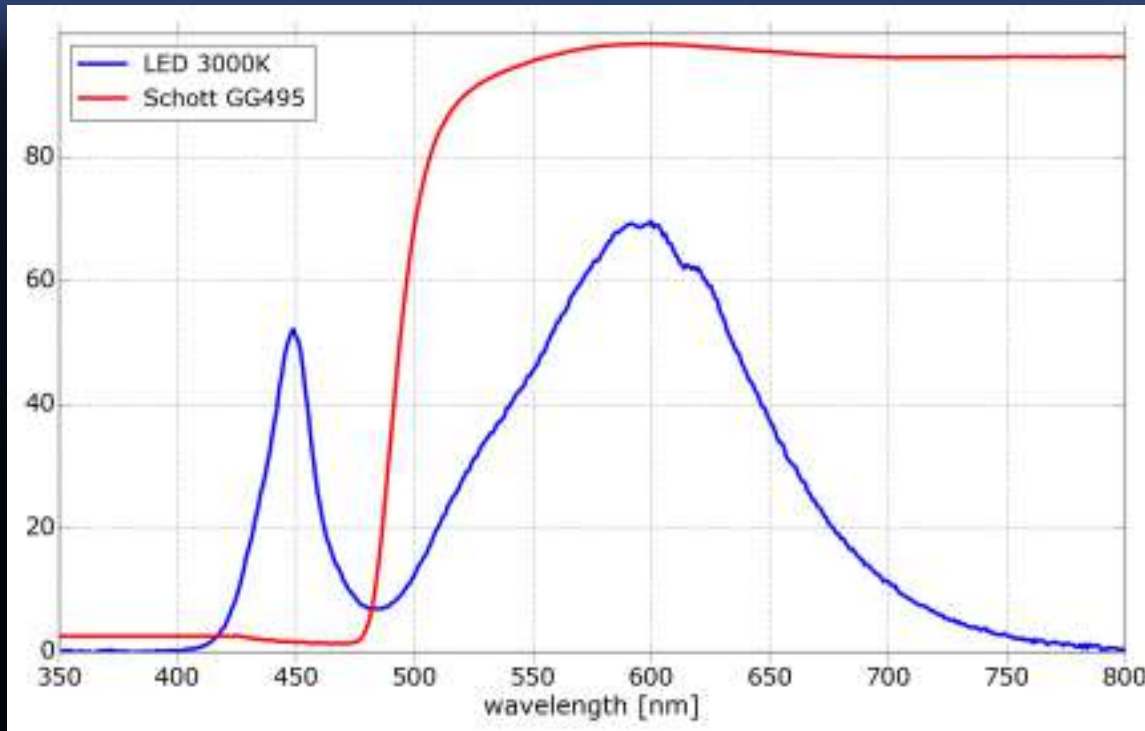


Absolute calibration by Bará et al. *Sensors* 2019, 19(6), 1336

(visit related poster)

TESS-W characteristics Color detection

Detection of blue light from LEDs using two photometers, one of them with a long pass filter rejecting blue light.



Dichroic filter



Dichroic filter + GG495

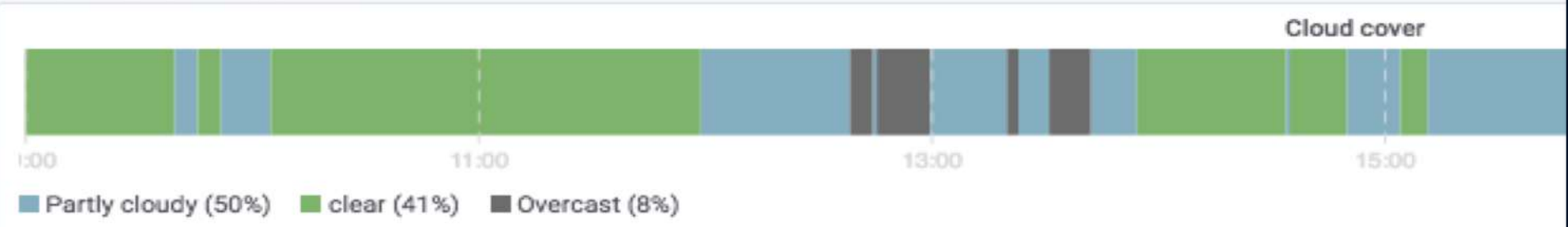


TESS has been designed with room for extra filters inside the box

TESS-W characteristics

Cloud estimate

stars54 - Siding Spring Observatory, Australia



<https://tess.dashboards.stars4all.eu>

TESS-W photometer network

TESS-W photometer sending data today

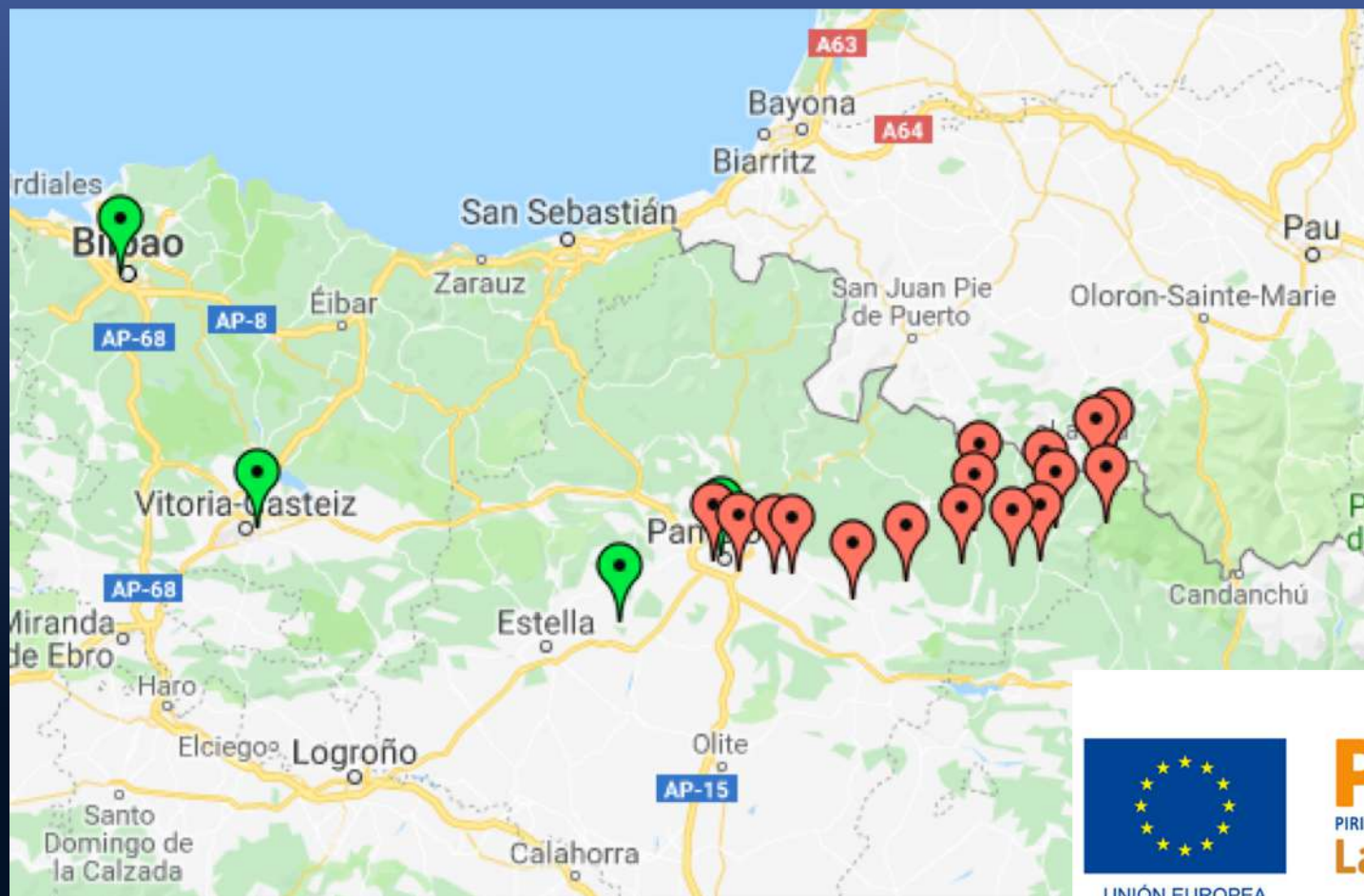
160

Researchers, observatories,
cities and dark places (citizens)



<https://tess.dashboards.stars4all.eu>

TESS-W photometer network



TESS-W being deployed for 'Pirineos La Nuit' European project

<https://tess.dashboards.stars4all.eu>

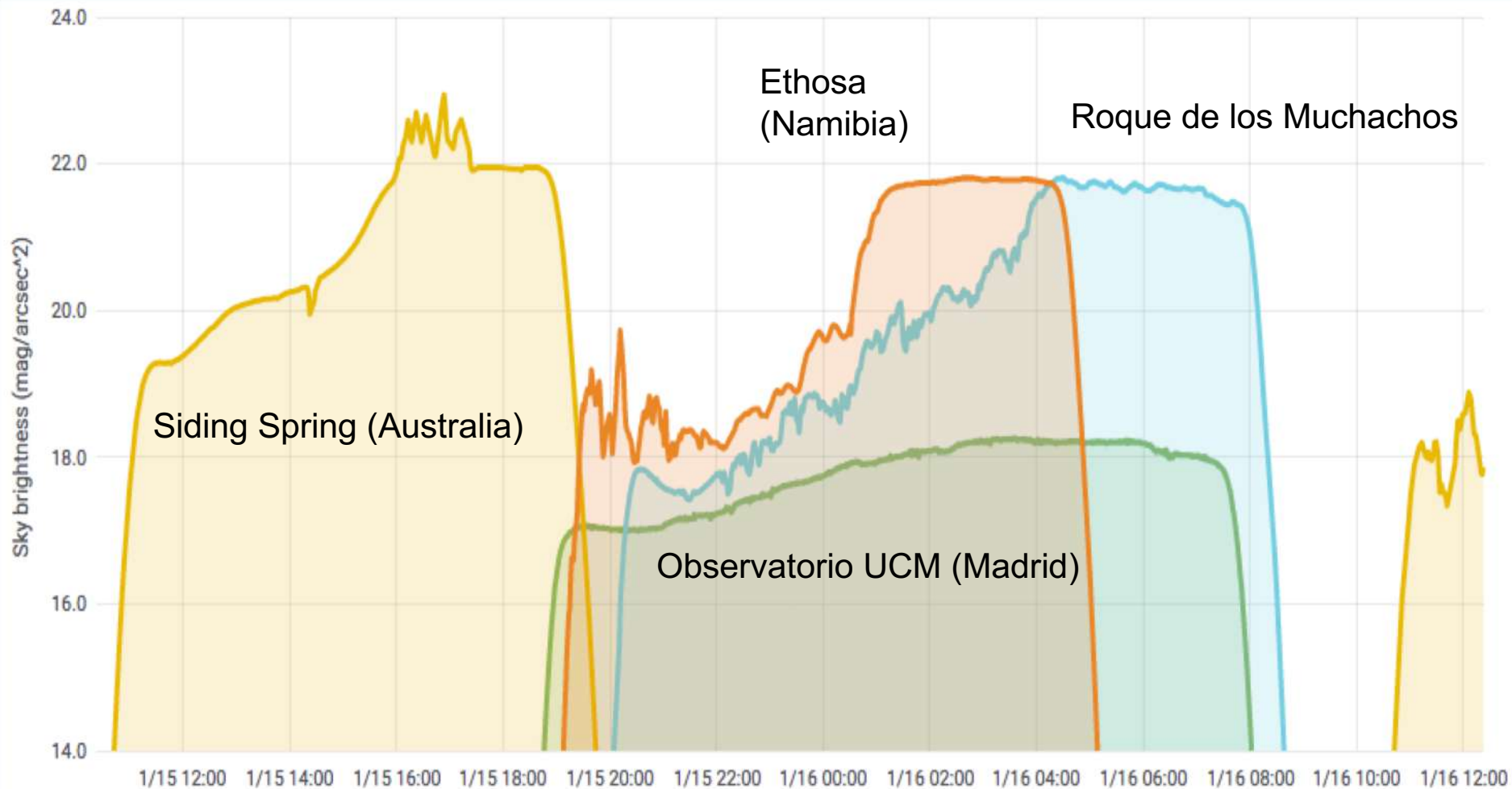
TESS-W photometer network



TESS-W being deployed by citizens protecting ecosystems in Puerto Rico

<https://tess.dashboards.stars4all.eu>

TESS-W photometer network



TESS open data is available online in real time (visit poster by Tapia et al.) or ask me for a demo

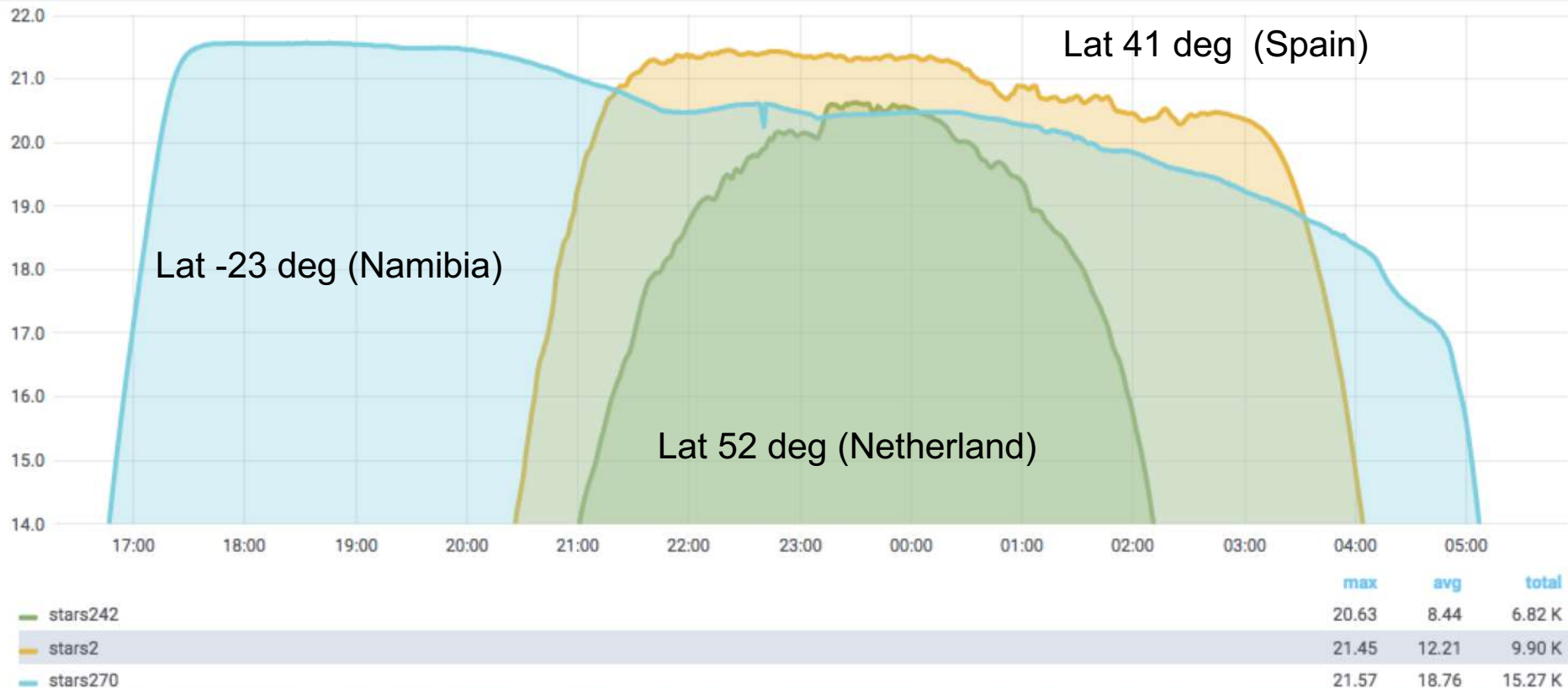
TESS-W photometer network

TESS 1 stars242 - JIVE, Joint Institute for VLBI ERIC, Netherlands

TESS 2 stars2 - Villaverde, Spain

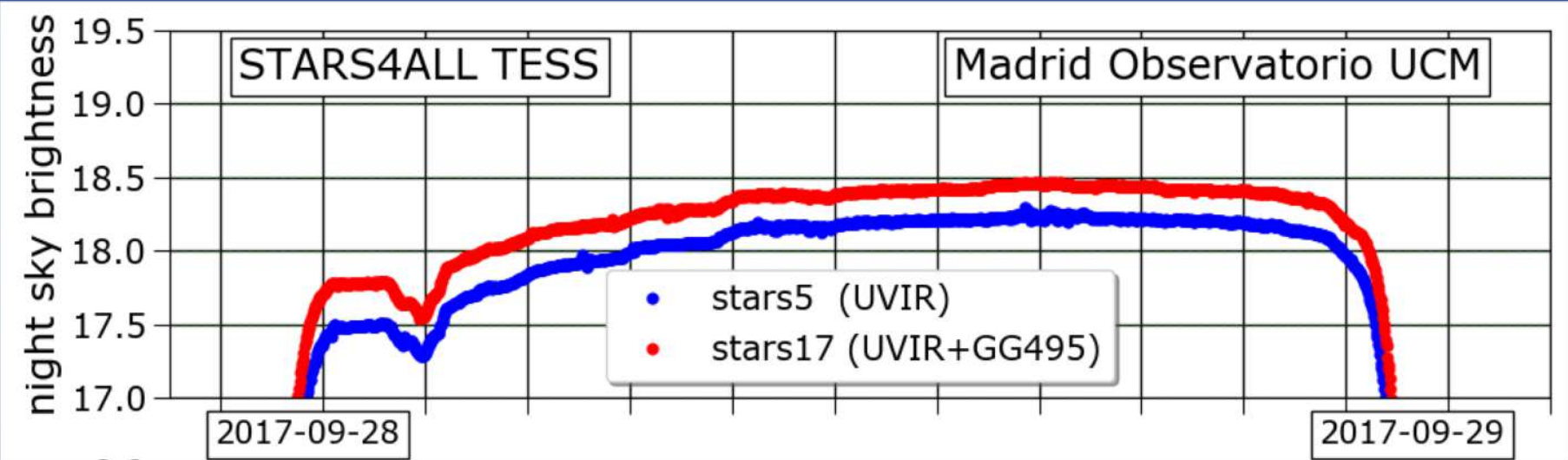
TESS 3 stars270 - H.E.S.S., Namibia

Comparison



TESS open data is available online in real time (visit poster by Tapia et al.) or ask me for a demo

Example of research with TESS photometers

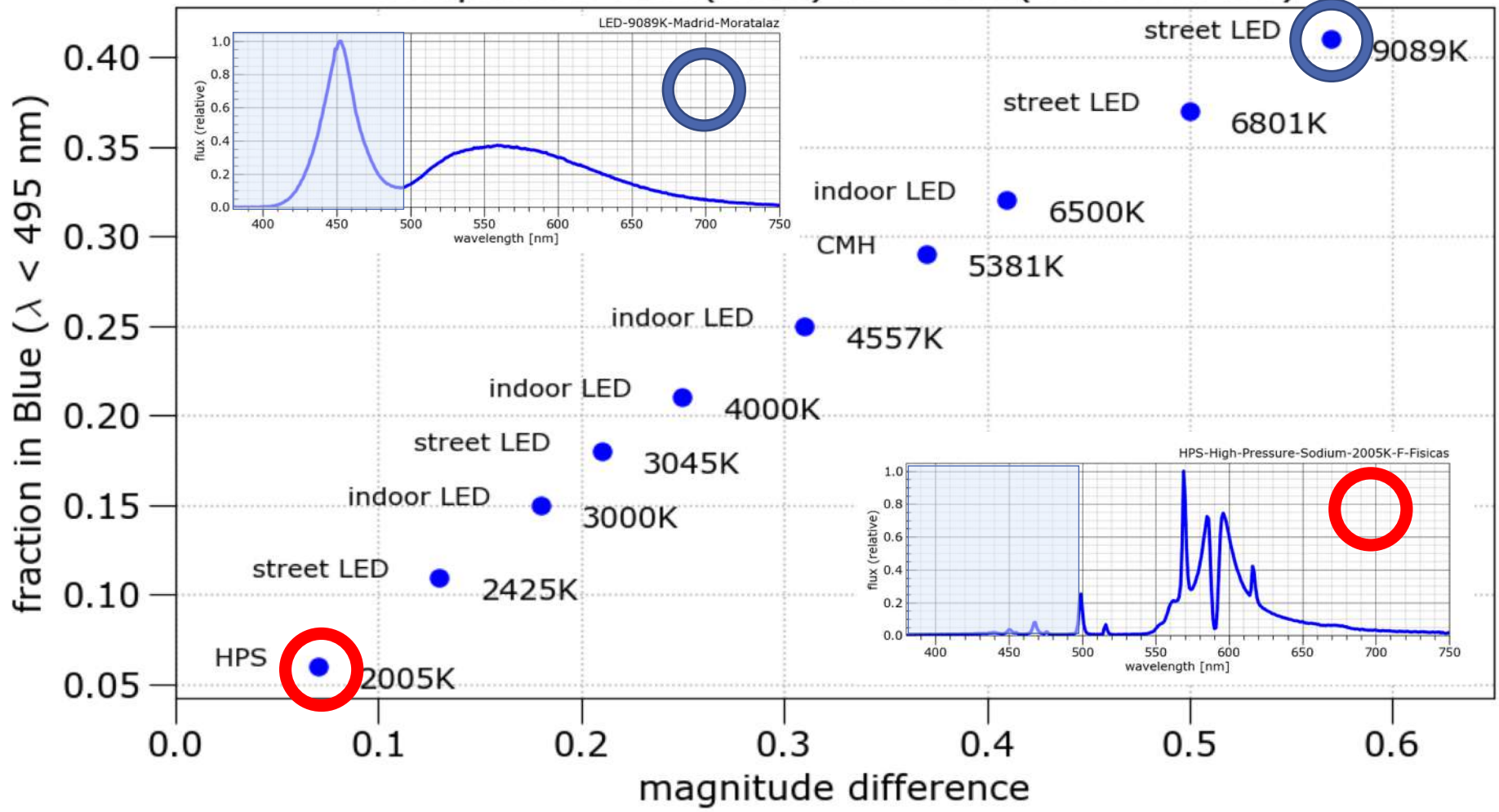


Observing simultaneously with two photometers
One of them with an blue rejecting filter (GG495)

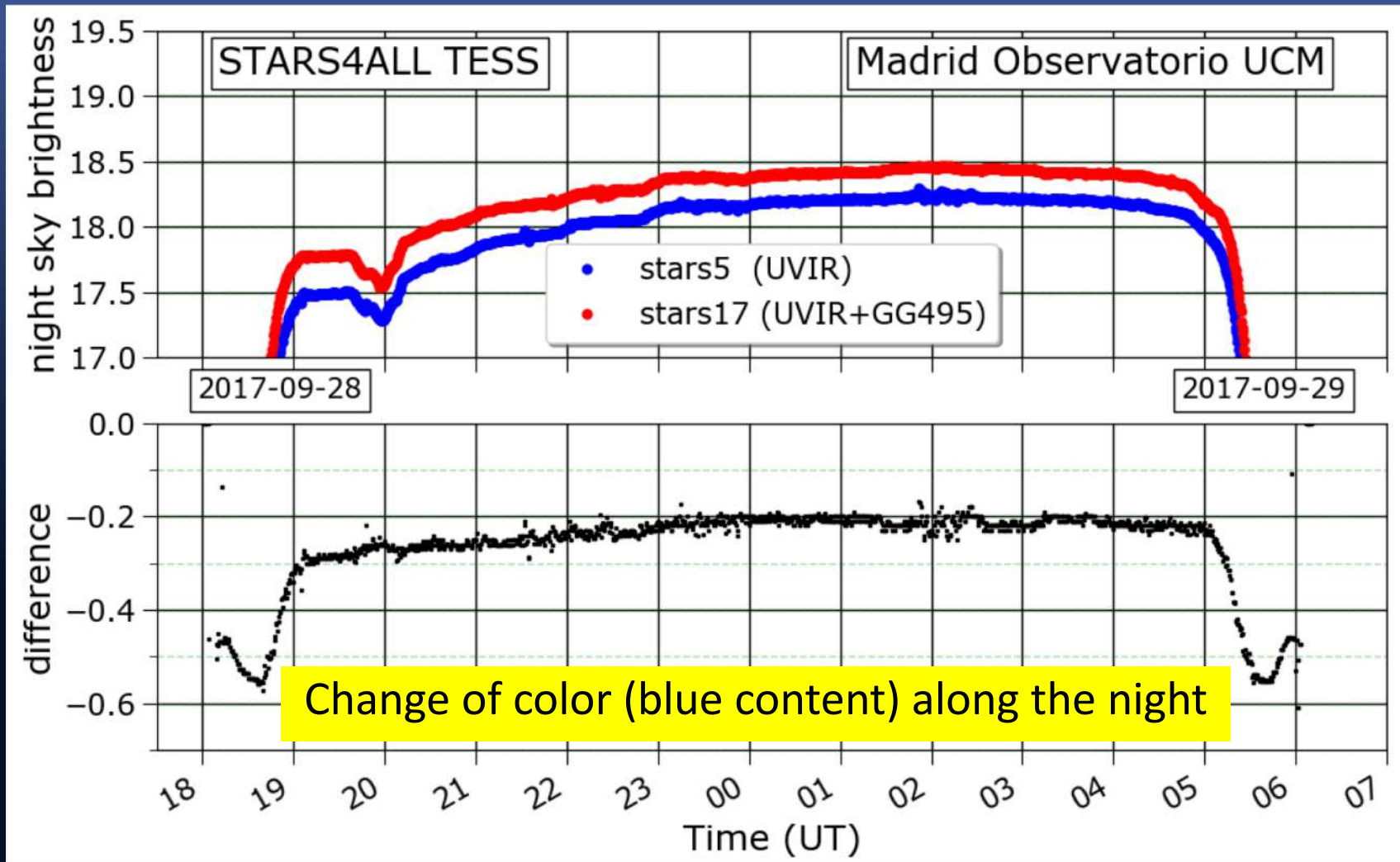


Example of research with TESS photometers

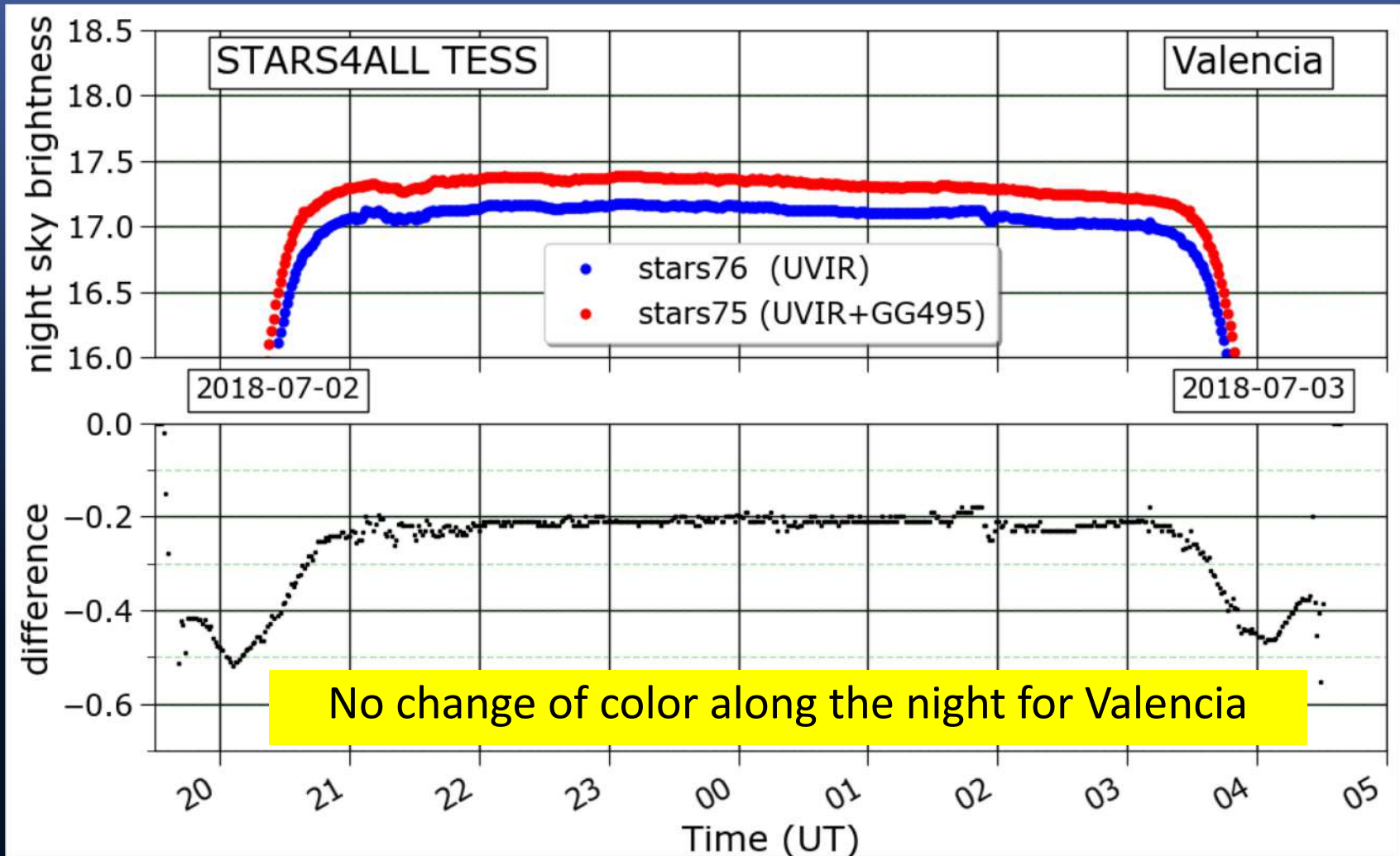
Comparison TESS(UVIR) and TESS(UVIR+GG495)



Detecting variation in Sky Color

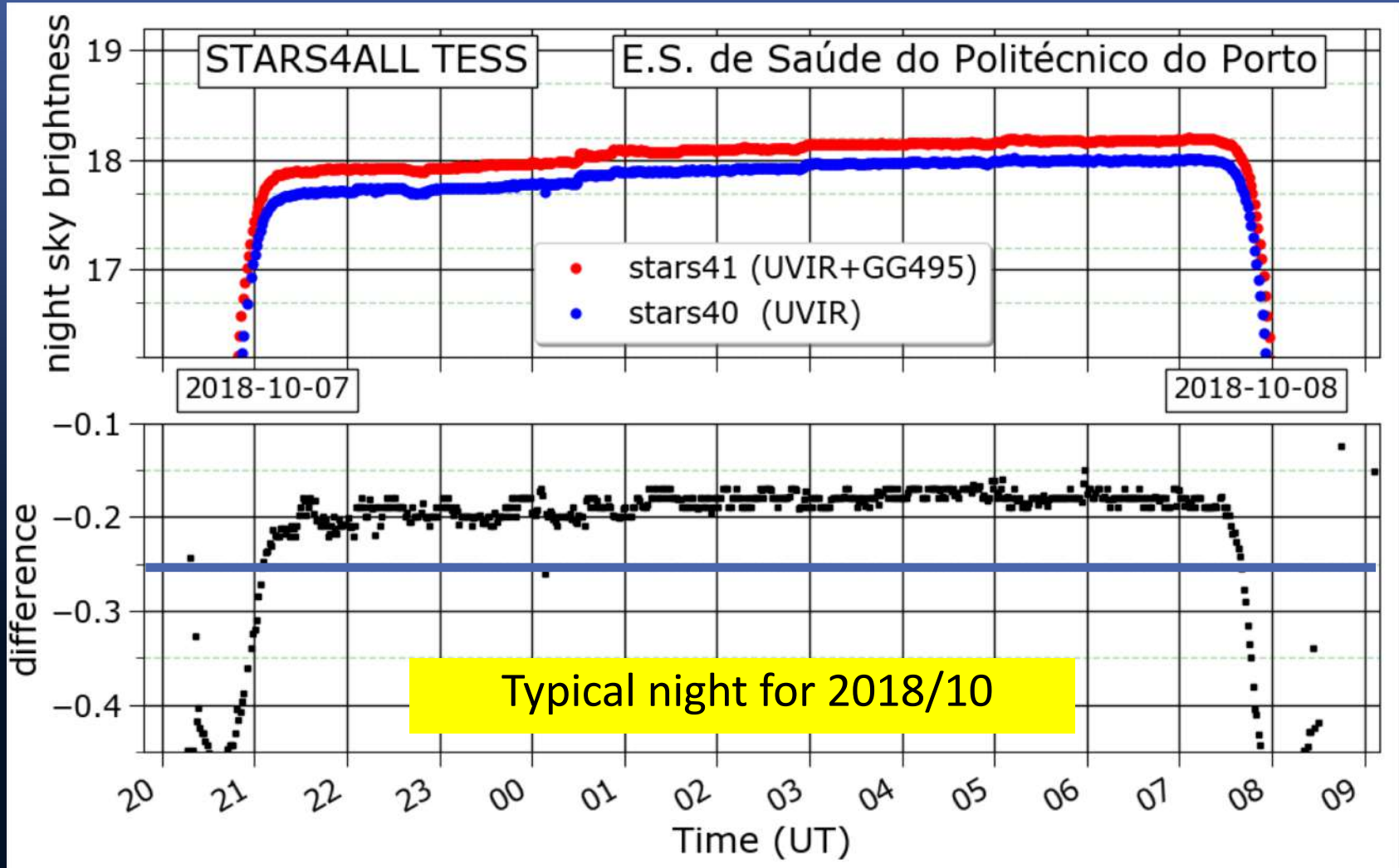


Detecting variation in Sky Color



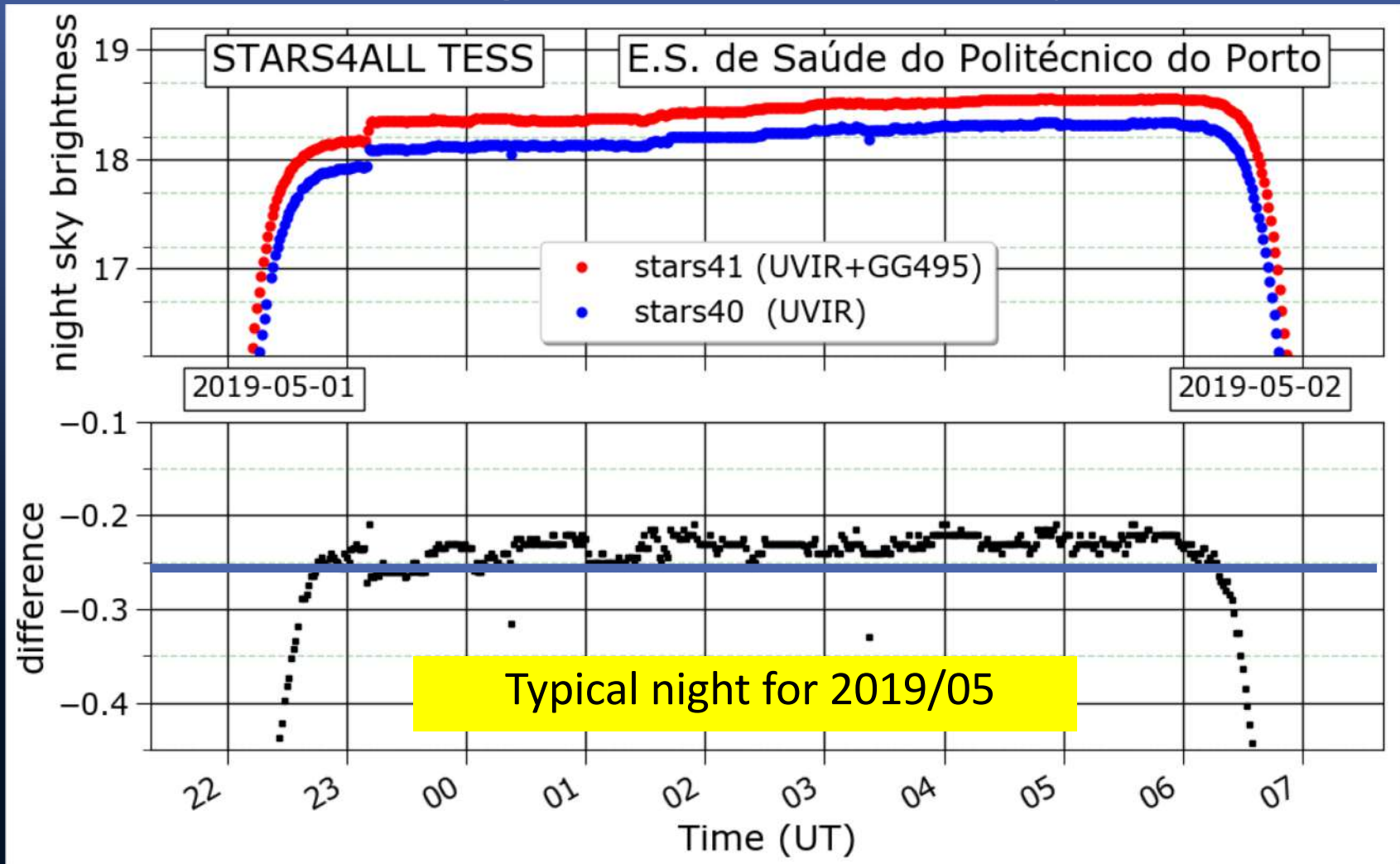
In collaboration with Enric Marco & Ángel Morales (UV)

Detecting variation in Sky Color



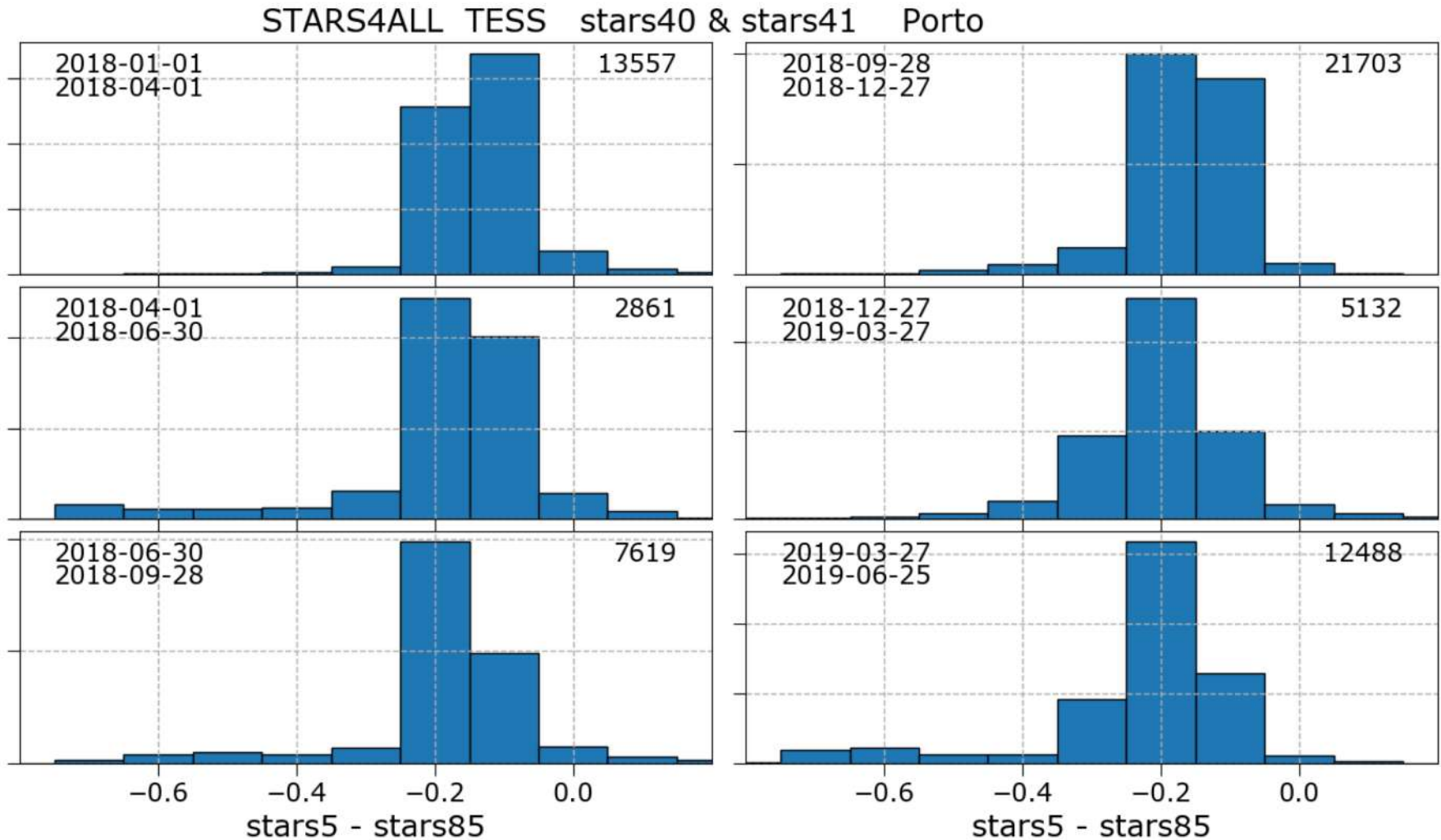
In collaboration with Raul Lima & Salvador Bará

Detecting variation in Sky Color



In collaboration with Raul Lima & Salvador Bará

Detecting variation in Sky Color



Histograms show the evolution of night sky color in Porto

Developments in progress

Hardware and software

Portable (hand held) TESS-P

- Provides Sky Brightness and pointing information. Bluetooth connection to smartphones



- In the wish list of Light Pollution researchers and fighters.
- Useful for awareness campaigns and for teaching

Mounts for automatic all-sky maps



For building all-sky maps similar to



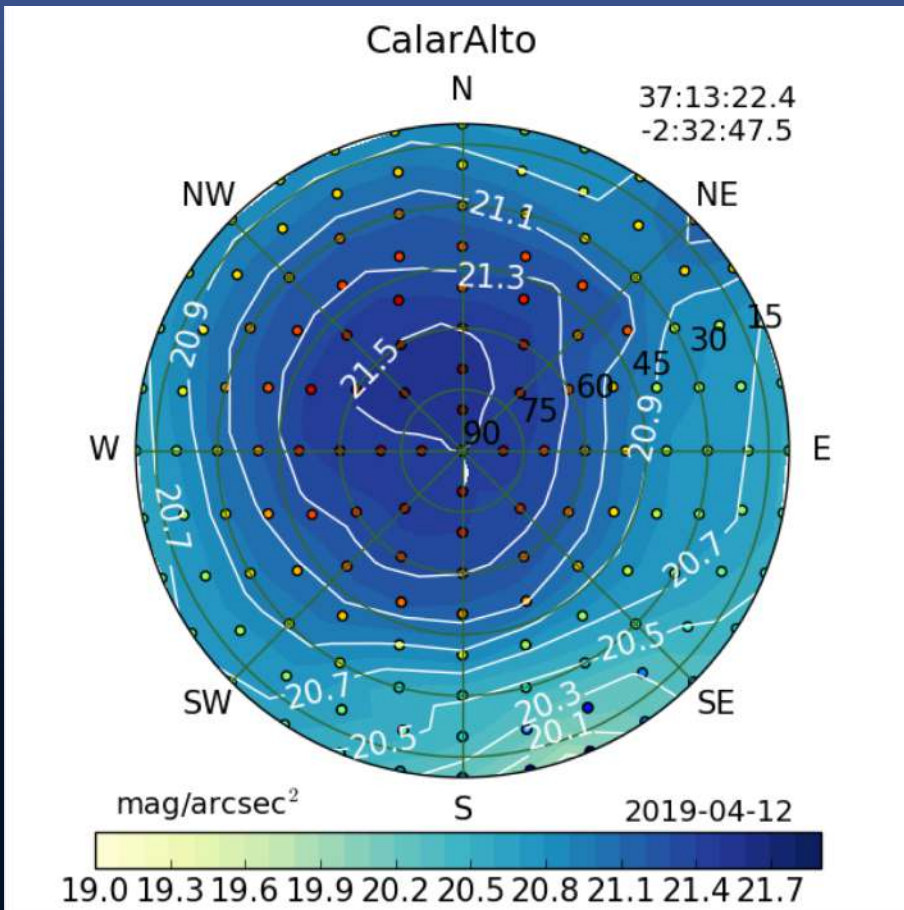
www.nixnox.stars4all.eu

Mounts for automatic all-sky maps

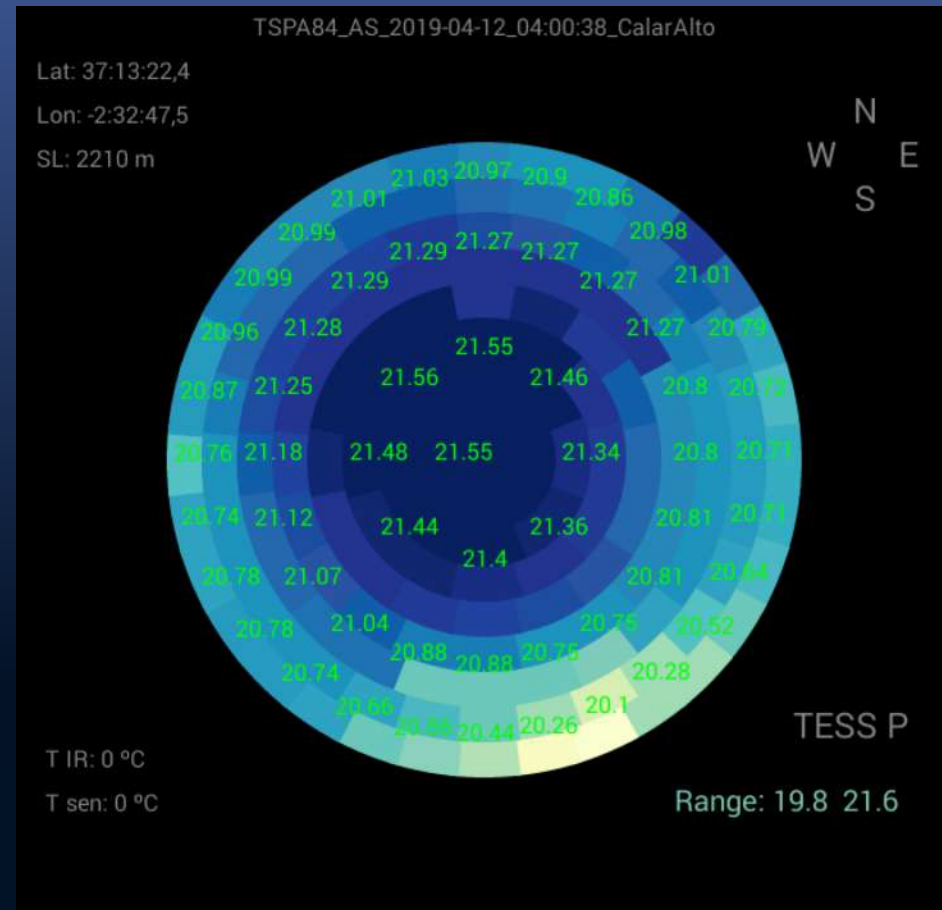


- Fully automatic scanning
- NSB all-sky map on the fly

Mounts for automatic all-sky maps

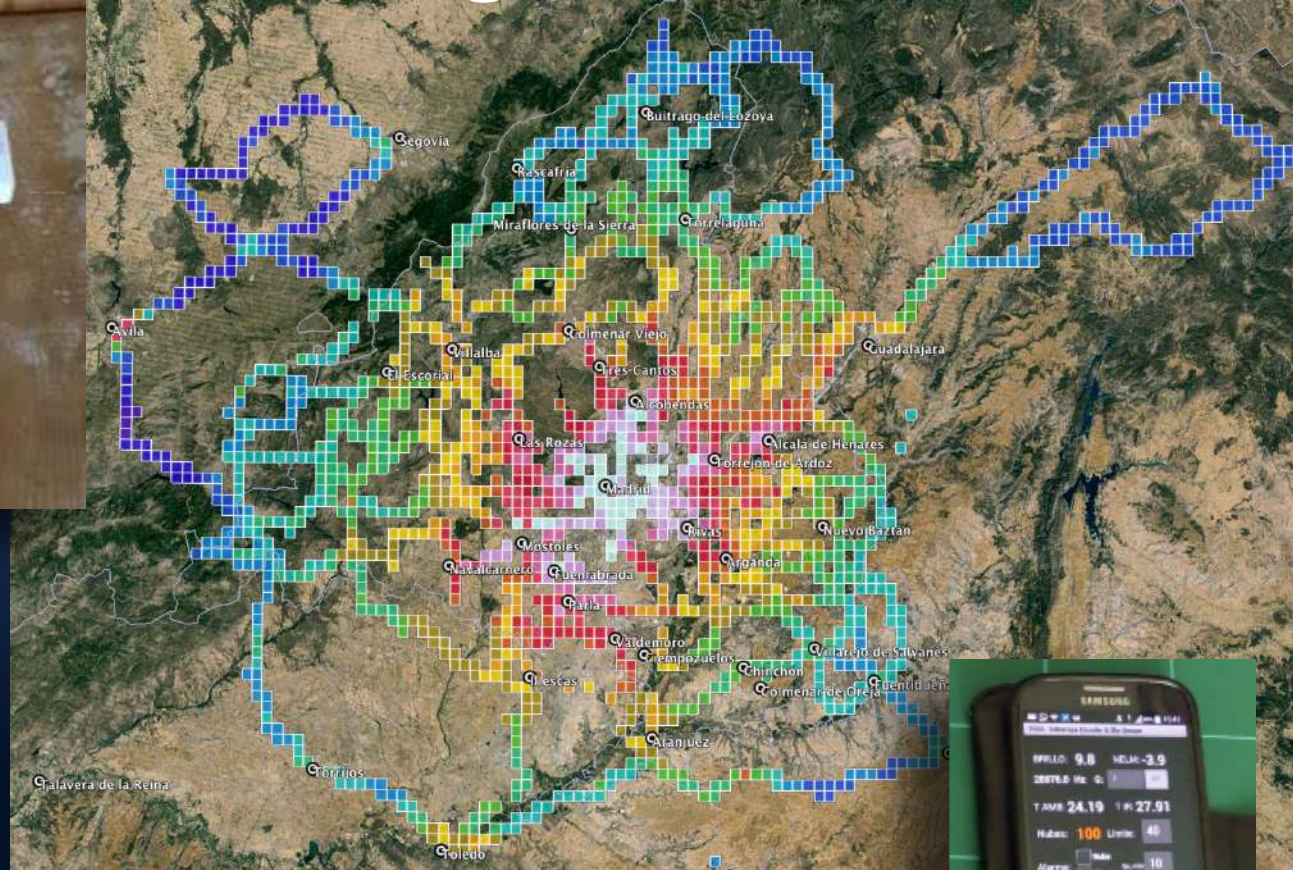


Similar to www.nixnox.stars4all.eu



Result map on the Smartphone screen

Mapping from moving vehicles



TESS Telescop Encoder & Sky Sensor

40:25,55318 -3:33,39858 704.0

BRILLO: **18.31** NELM: **4.2**

11.846 Hz G: 3.35 OK

T AMB: **24.23** T IR: **23.57**

Nubes: **98** Limite: 40

Alarma: Nube En, min: 10
 Claro

Fichero: Guardar cada,sg: 60

GPS Rx: 1814
 Ver Desconecta 98:D3:31:B3:76:AB

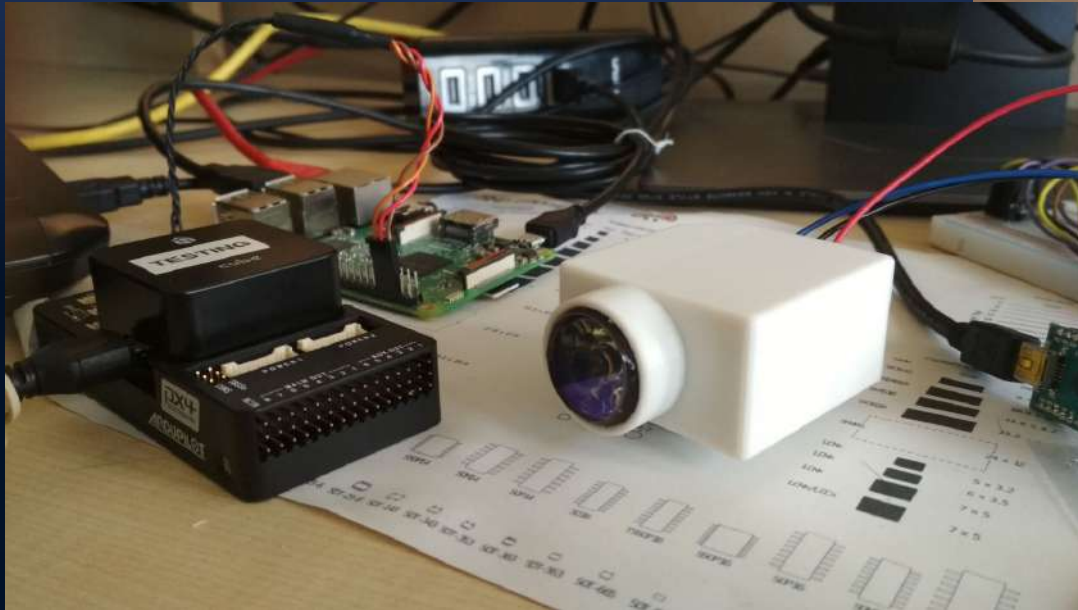
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<fm 03536><tA +2673><tO +2363><aX +0948><aY
```

NSB map around Madrid



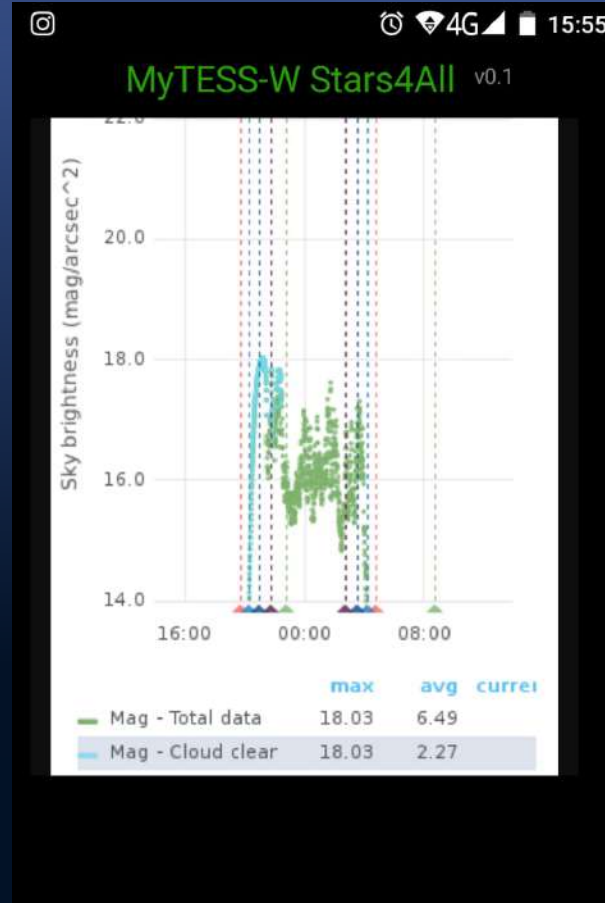
GPS from mobile

TESS-W onboard a drone ?



TESS software

Smartphone APP



APP to check any TESS-W

APP for portable TESS



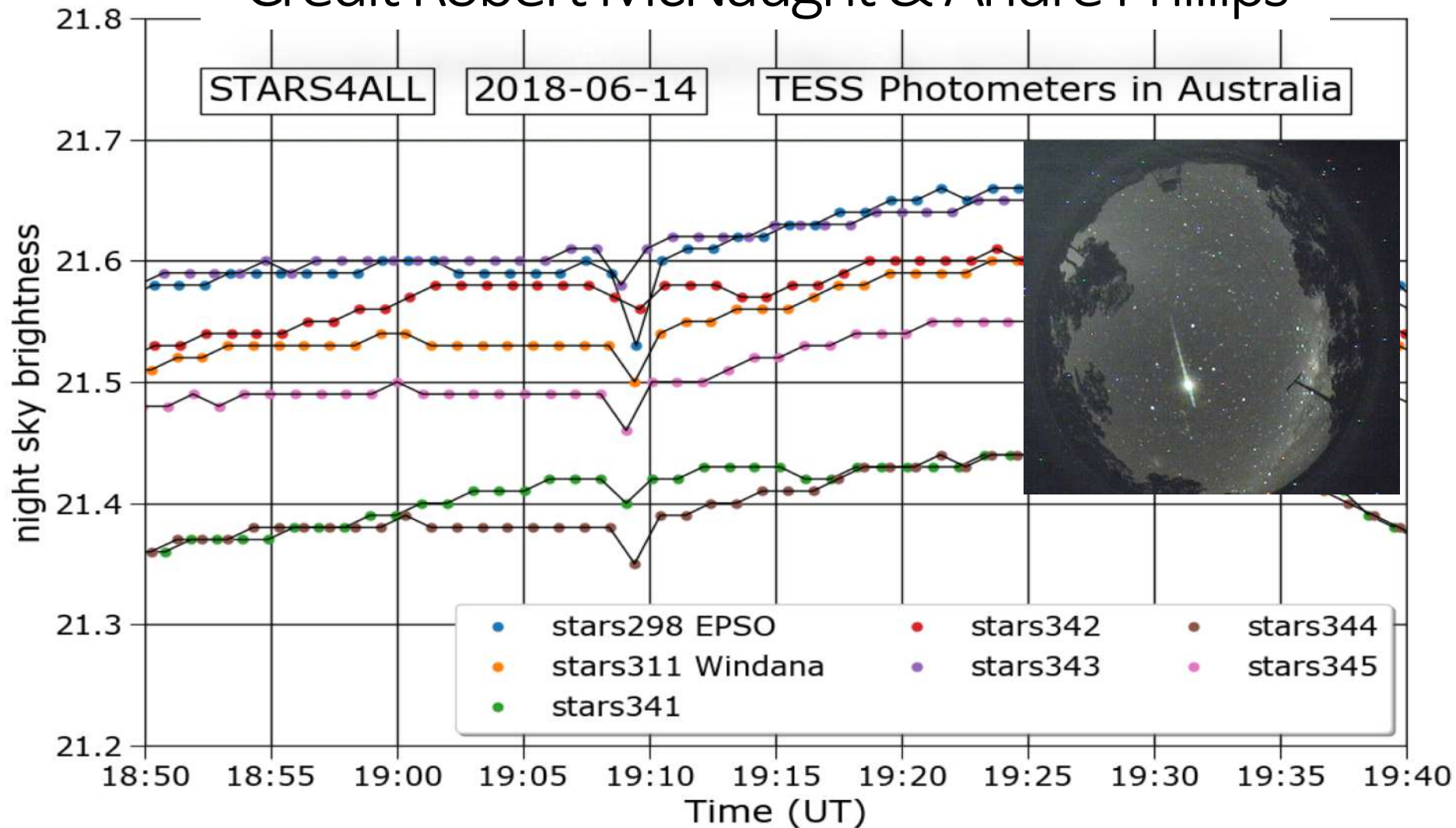
We are a Pro-Am team



+ People from UPM (Politécnica de Madrid)

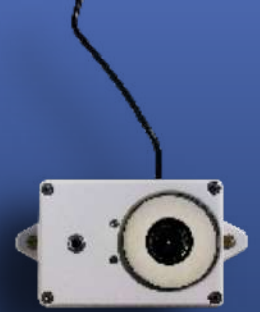
Detection of a satellite flare

Credit Robert McNaught & Andre Phillips

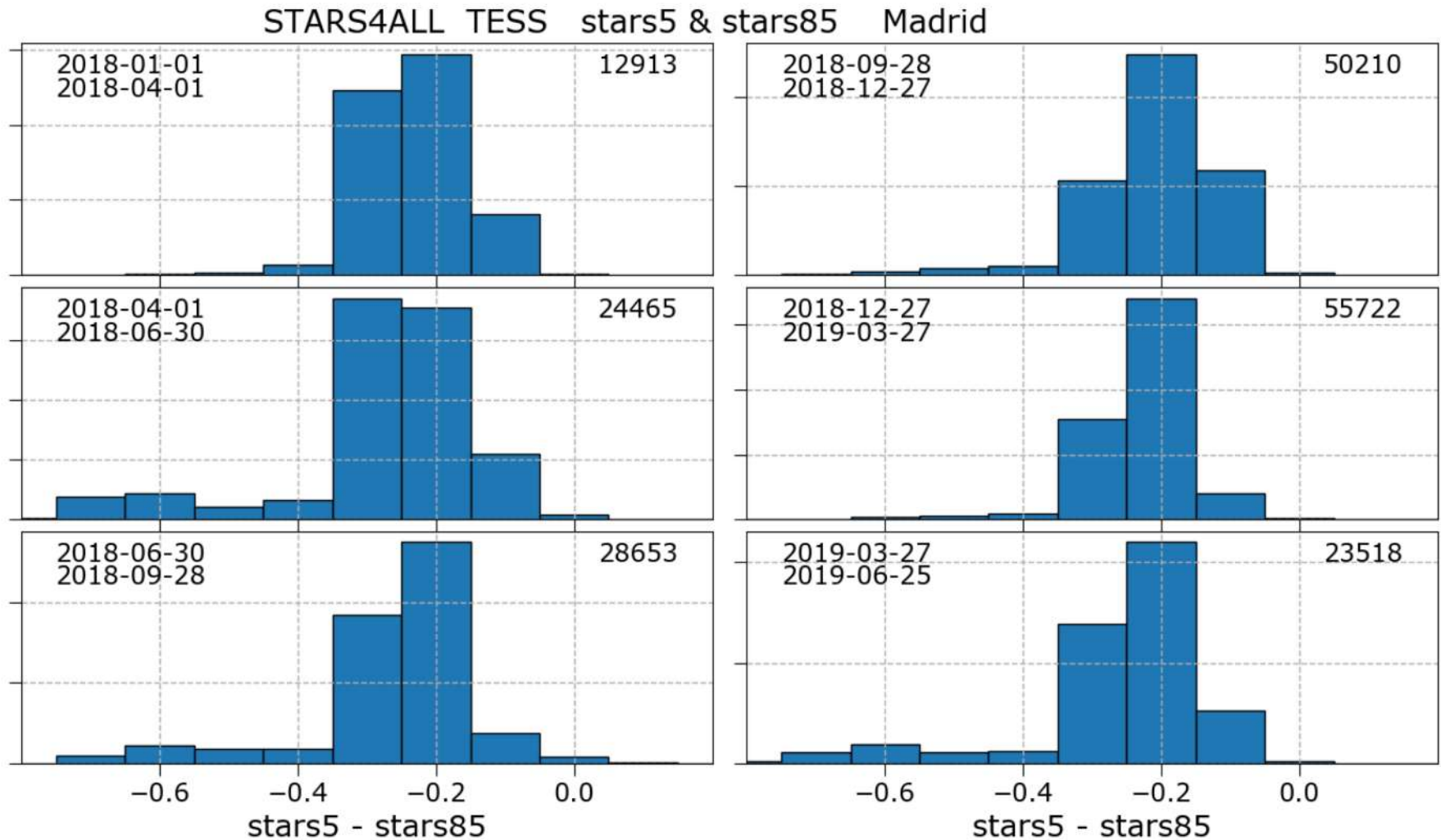


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Collaborative effort



Detecting variation in Sky Color



TESS-W photometer network



Coslada (Spain) - stars1



Villaverde del Ducado (Spain) - stars2



UCM Madrid (Spain) - stars5 & stars85



Pamplona (Spain) - stars7



Añora (Spain) - stars9



Oukaimeden (Morocco) - stars27



Ajdovščina (Slovenija) - stars35



Huércal de Almería (Spain) - stars52



Monfragüe (Spain) - stars66



Saõ Vicente (Cape Verde) - stars79



Helechosa de los Montes (Spain) - stars202



Hoegaarden (Belgium) - stars209



Wellington (New Zealand) - stars214



Mount Martha (Australia) - stars215



La Roca de la Sierra (Spain) - stars218



Pierre Auger Observatory, Malargüe (Argentina) - stars220



stars224_Jerez_de_la_Frontera_Spain

IES Caballero Bonald, Jerez de la Frontera



Parco Astronomico Lilio (Italy) - stars232



Badajoz (Spain) - stars233

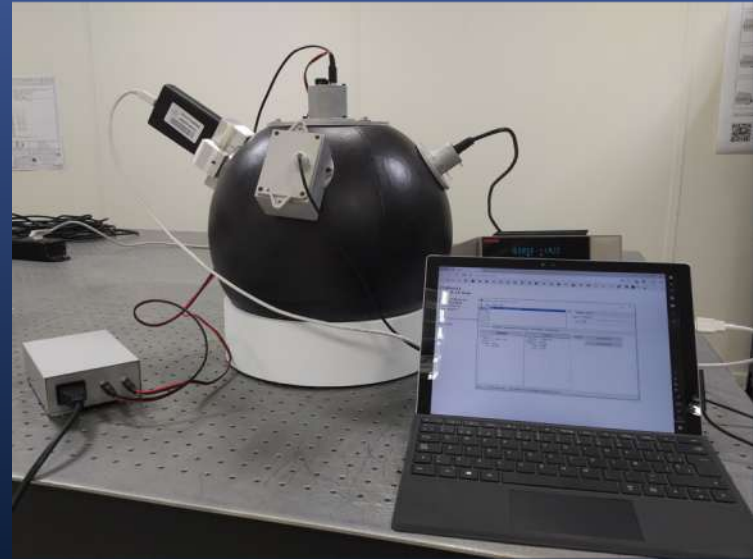
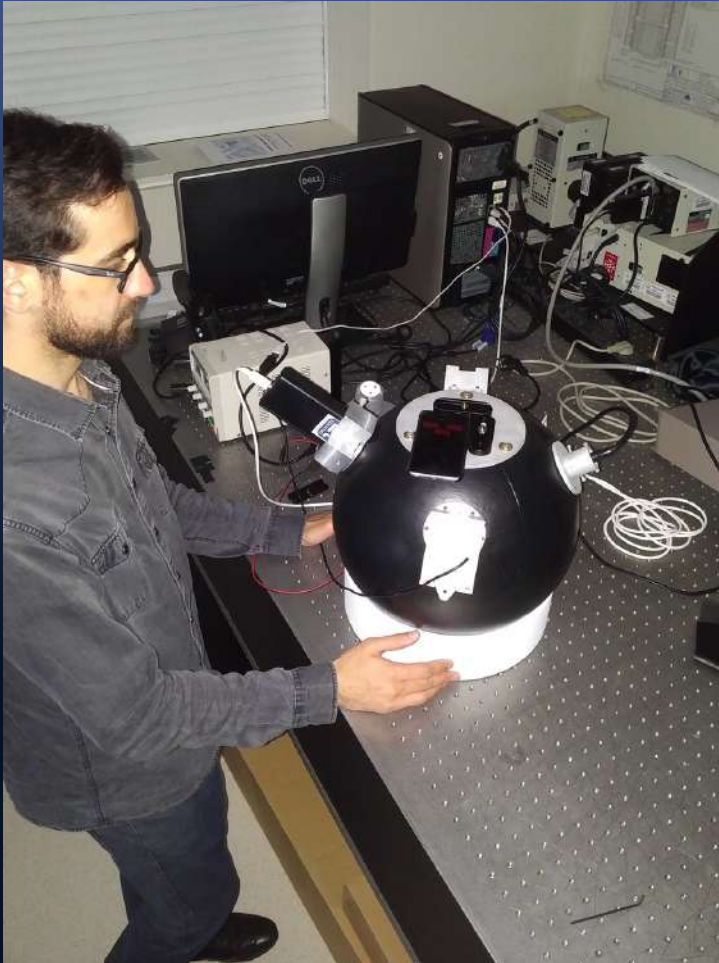


Hong Kong (China) - stars238

STAR

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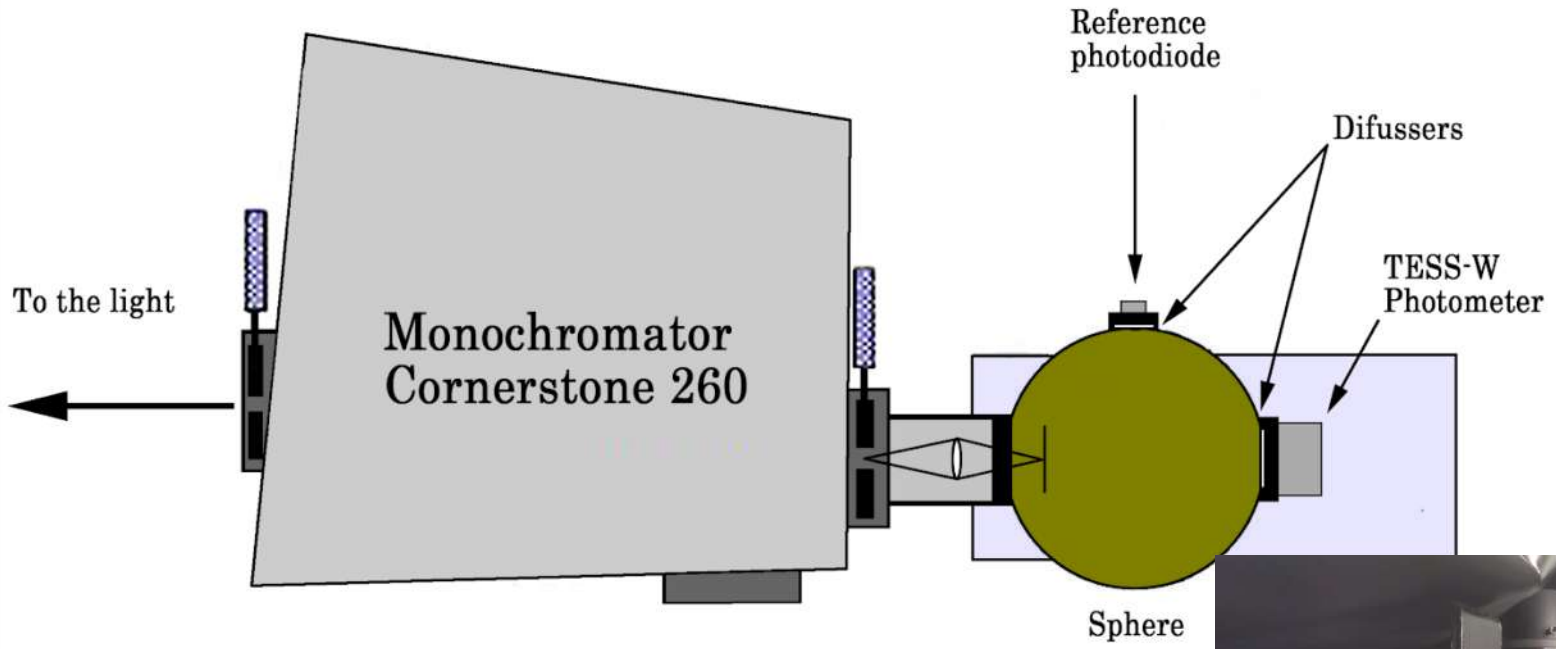
Calibration process at optical lab.



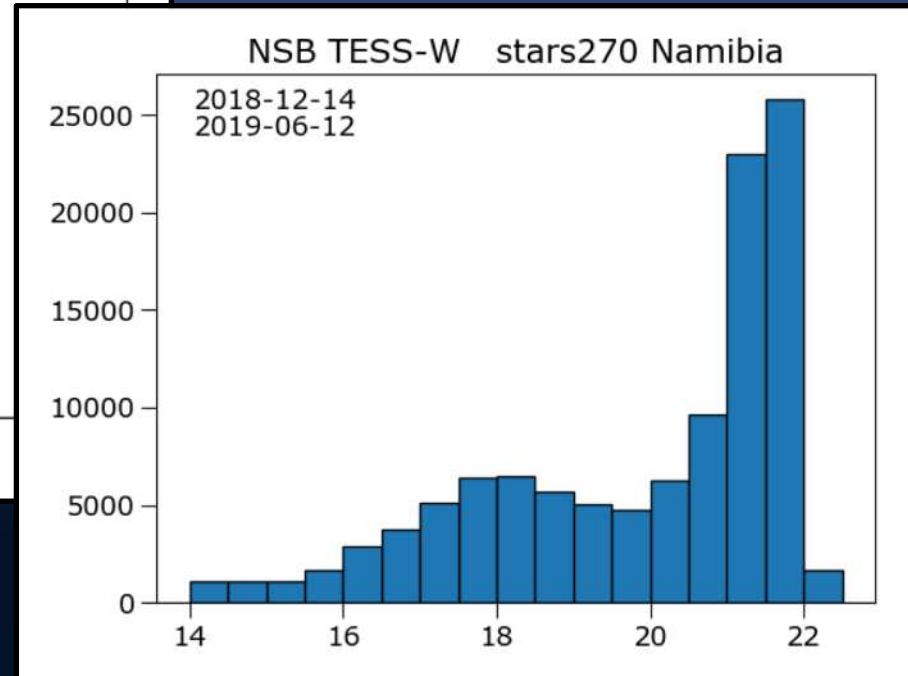
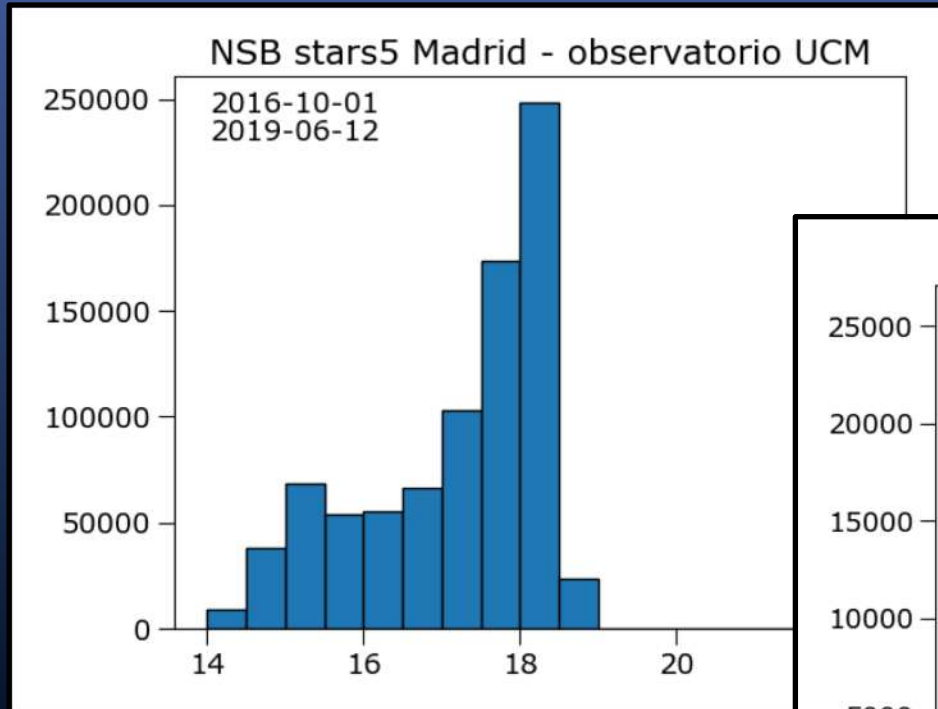
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Calibration process at optical lab.



Why monitoring



Studies on Light Pollution and its evolution based on **statistics** could be made after **monitoring** the Night Sky Brightness

TESS software

JAVA software extends local mode to non Windows computers

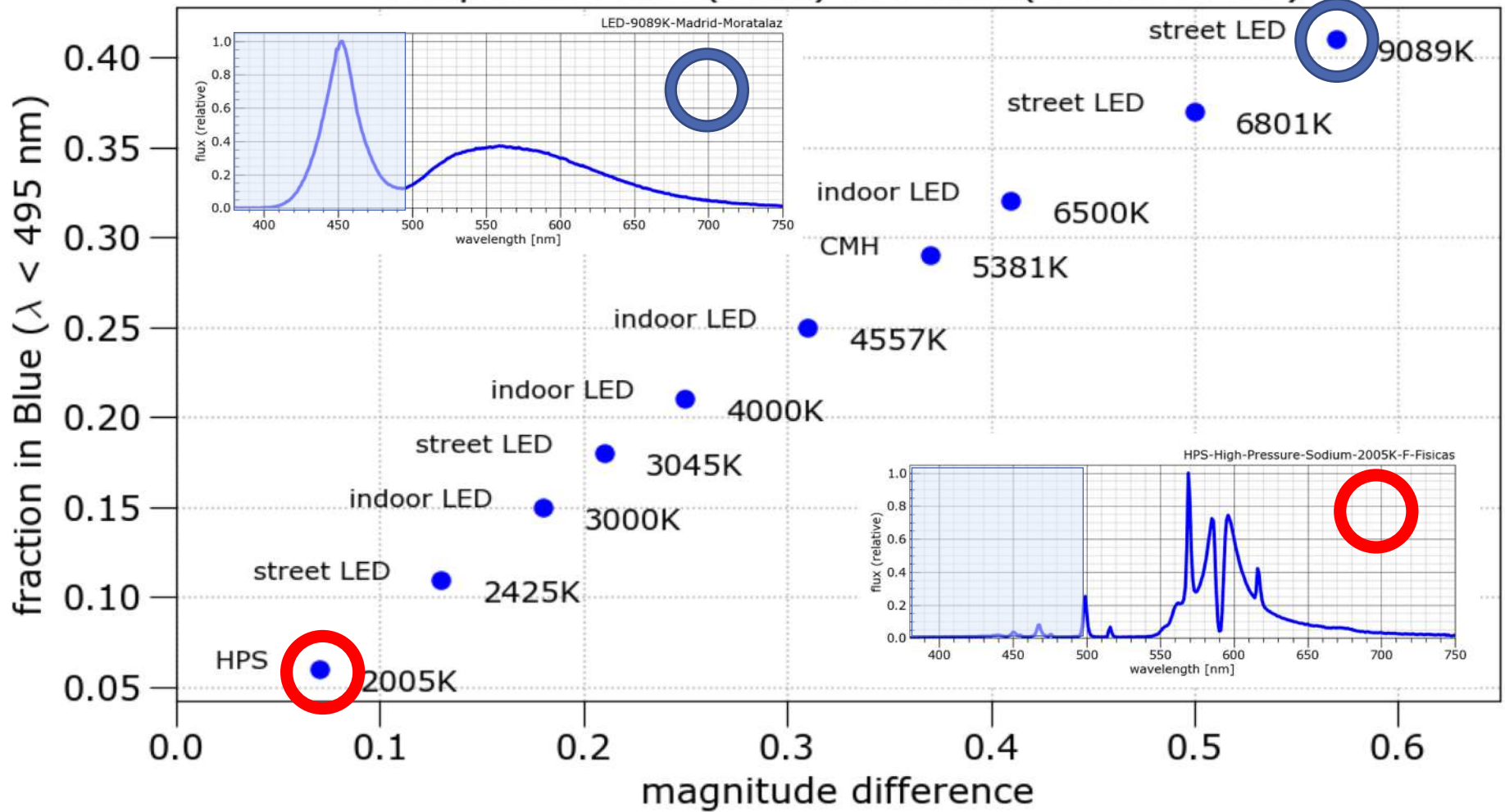
Smartphone APP



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Comparison TESS(UVIR) and TESS(UVIR+GG495)



TESS-W photometer network

— Stars273 - Ir-Rabat, Malta

stars273

TITLE	LAST MODIFIED
 stars273_2019-01.dat	May 13 JAIME ZAMORANO CALVO
 stars273_2019-02.dat	May 13 JAIME ZAMORANO CALVO
 stars273_2019-03.dat	May 13 JAIME ZAMORANO CALVO
 stars273_2019-04.dat	May 13 JAIME ZAMORANO CALVO
 stars273_2019-05.dat	Jun 4 JAIME ZAMORANO CALVO
 stars273_2019-06.dat	Jun 14 JAIME ZAMORANO CALVO

+ stars 274 - Old Police Station, Beltana (Australia)

+ stars 275 - Thiên văn Việt Nam - VACA, Hanoi (Vietnam)

+ stars 277 - Astronomical observatory, Burlage (Germany)

+ Stars288 - Entre Encinas y Estrellas, Fregenal de la Sierra, Badajoz, Spain

TESS-W photometer network

```
# Definition of the community standard for skyglow observations 1.0
# URL: http://www.darksky.org/NSBM/sdf1.0.pdf
# Number of header lines: 35
# This data is released under the following license: ODbL 1.0 http://opendatacommons.org/licenses/odbl/summary/
# Device type: TESS-W
# Instrument ID: stars273
# Data supplier: Alexei Pace / Unknown
# Location name: Ir-Rabat/Unknown/Malta - Ir-Rabat
# Position: 35.8768, 14.3958, 201.0
# Local timezone: Europe/Malta
# Time Synchronization: timestamp added by MQTT subscriber
# Moving / Stationary position: STATIONARY
# Moving / Fixed look direction: FIXED
# Number of channels: 1
# Filters per channel: UVIR
# Measurement direction per channel: 0.0, 0.0
# Field of view: 17.0
# Number of fields per line: 6
# TESS MAC address: 5C:CF:7F:76:67:EE
# TESS firmware version: 1.0
# TESS cover offset value: 0.0
# TESS zero point (latest): 20.43
# Comment:
# Comment:
# Comment:
# Comment:
# Comment:
# Comment:
# Comment:
# blank line 30
# blank line 31
# blank line 32
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# YYYY-MM-DDTHH:mm:ss.fff;YYYY-MM-DDTHH:mm:ss.fff;Celsius;Celsius;Hz;mag/arcsec^2;mag/arcsec^2
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TESS open repositories in IDA-IAU standard format