PRESIDENCIA ESPAÑOLA
CONSEJO DE LA UNIÓN EUROPEA

INSTITUTO DE ASTROFÍSICA DE ANDALUCÍA

CSIC

Meeting on Light Pollution: Challenges and Responses for Monitoring it

Monitoring with ground-based photometers (my personal experience)

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UNIVERSIDAD COMPLUTENSE MADRID

RED ESPAÑOLA DE ESTUDIOS SOBRE CONTAMINACIÓN LUMÍNICA

Session 2: Ground-based light pollution monitoring
2023 November 14th, Tuesday

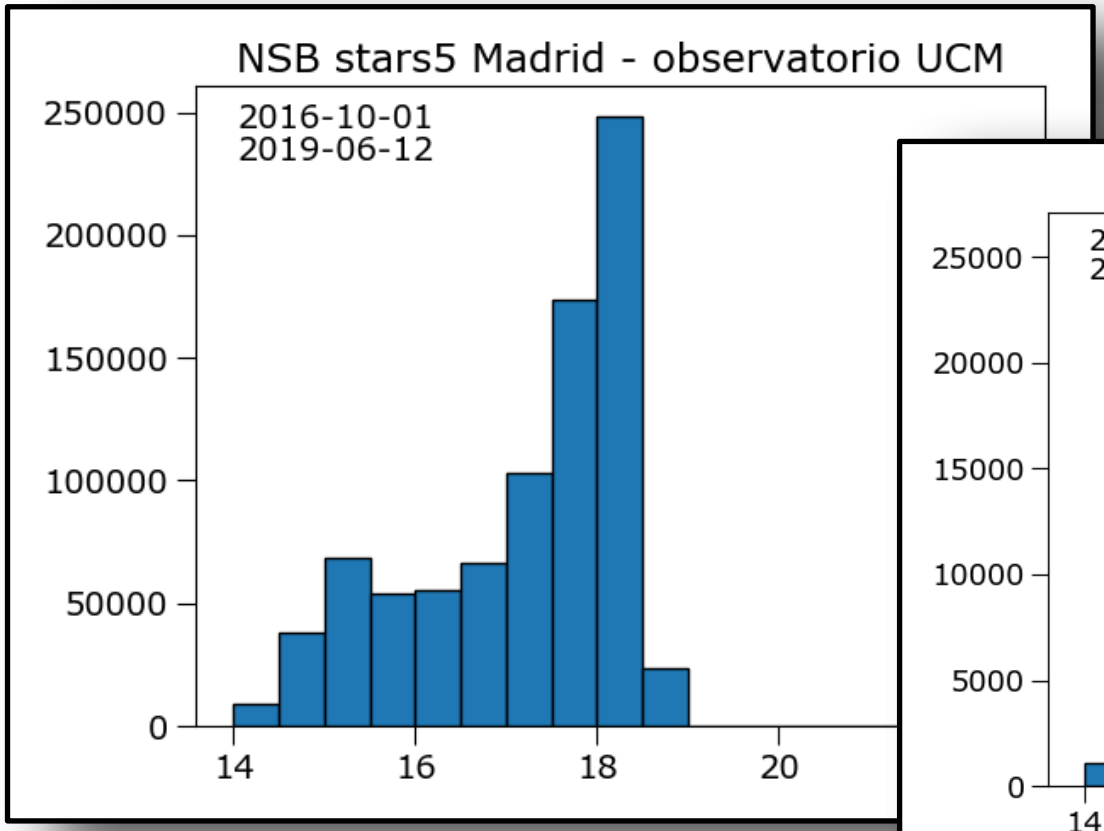
Ground-based Monitoring with photometers

- Why monitoring ?
- Why to design a new photometer ?
- STARS4ALL TESS-W characteristics.
- TESS-W photometer network.
- Developments in progress.
- Monitoring in color bands.
- RGB photometry.
- The need to write open software for analysis.

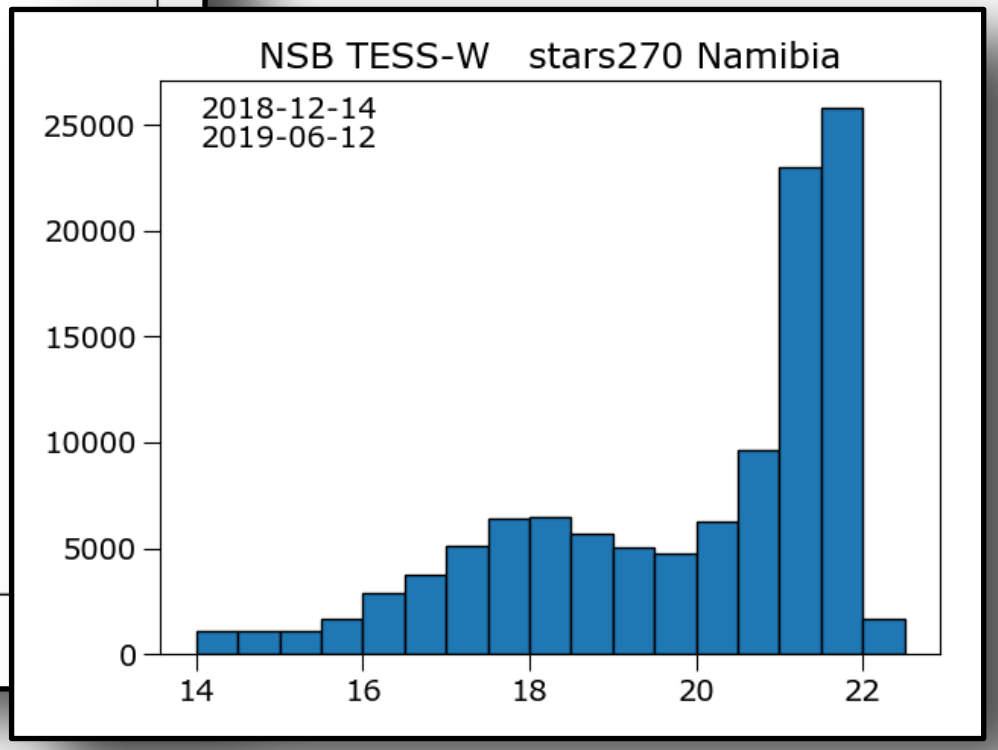
DISCLAIMER
- Not intended to be a review
- Based on my experience with the help of my colleagues

Why monitoring ?

Urban area

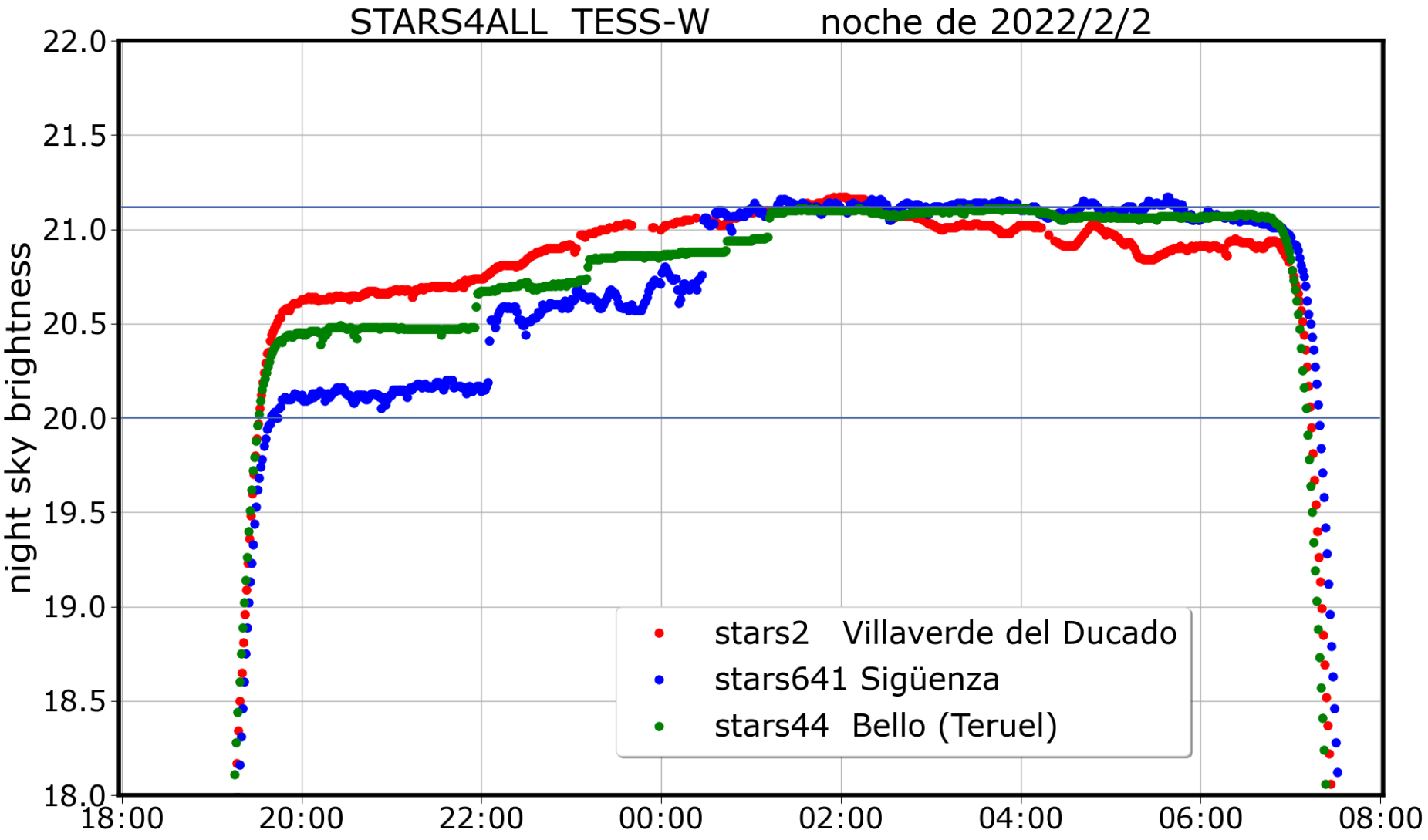


Natural area



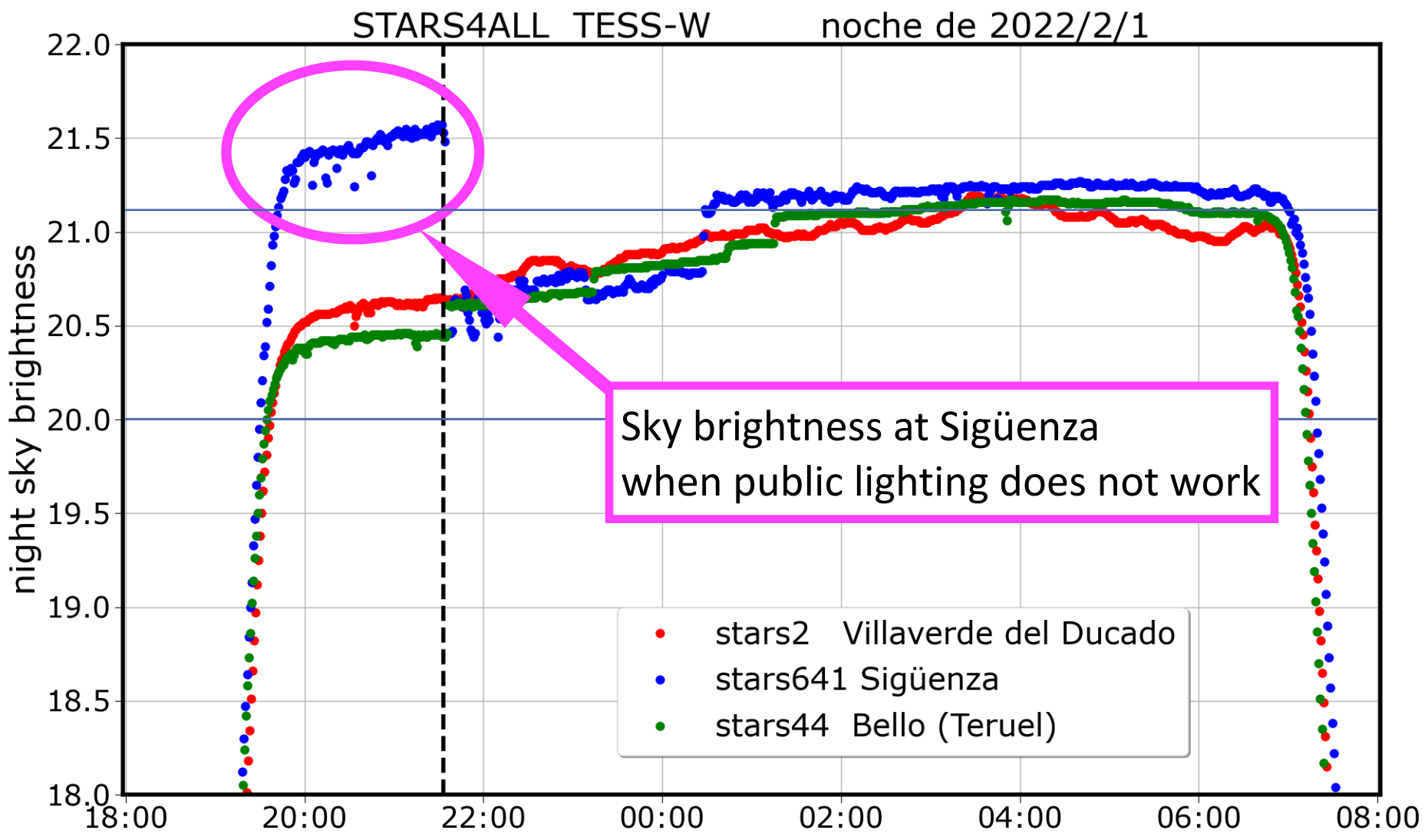
- Studies on Light Pollution and its evolution based on **statistics** could be made after **monitoring** the Night Sky Brightness.
- Night Sky Brightness measures are key for light pollution models.

Why monitoring ?



- Night sky brightness varies along the nights and from night to night

Why monitoring ?



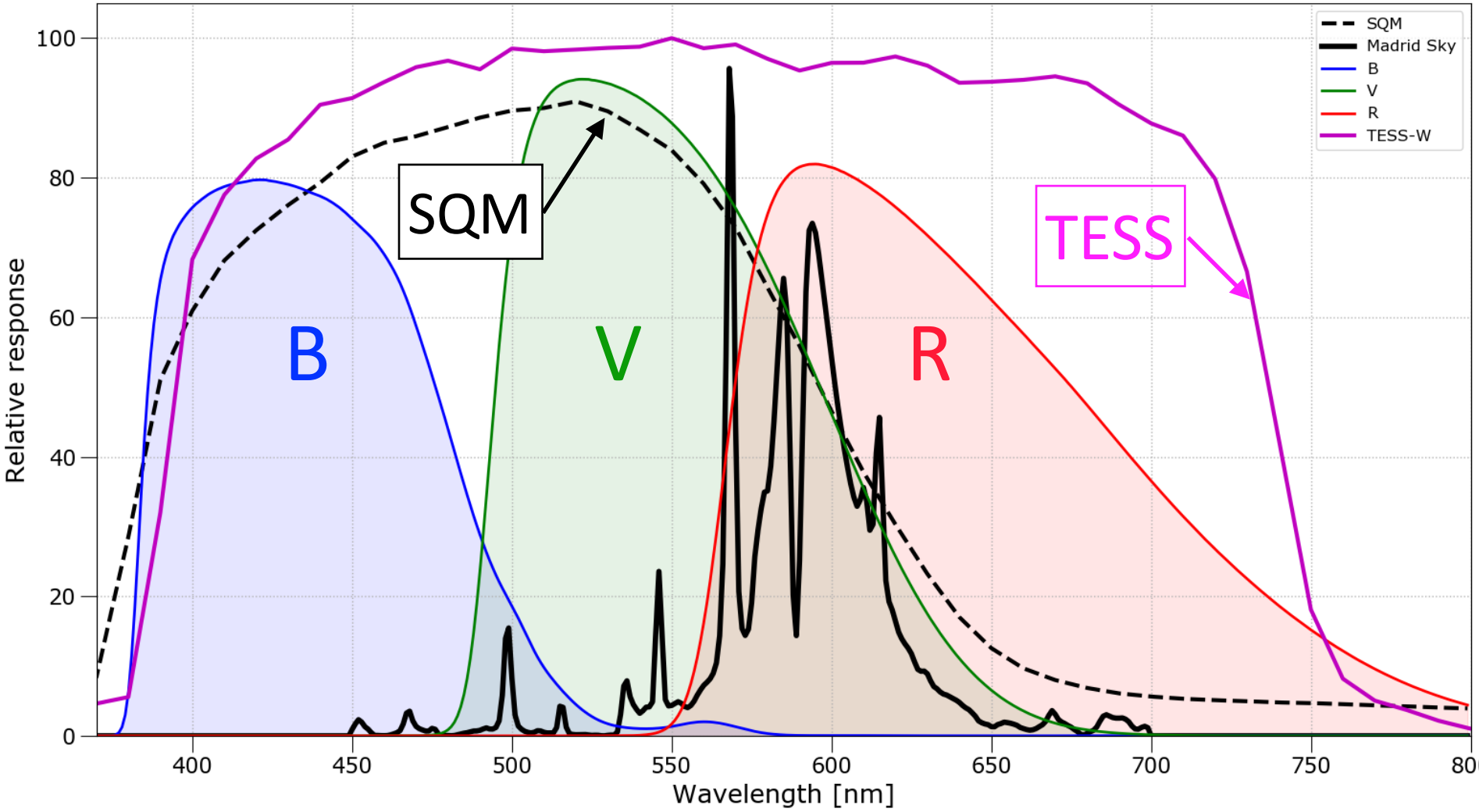
- Night sky brightness varies along the night and from night to night

Why to design a new photometer ?

- One of the aims of the H2020 European Project was to build a European network of Night Sky Brightness monitoring stations.
- We designed a **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 a user friendly **research photometer for citizen science**.

Why to design a new photometer ?

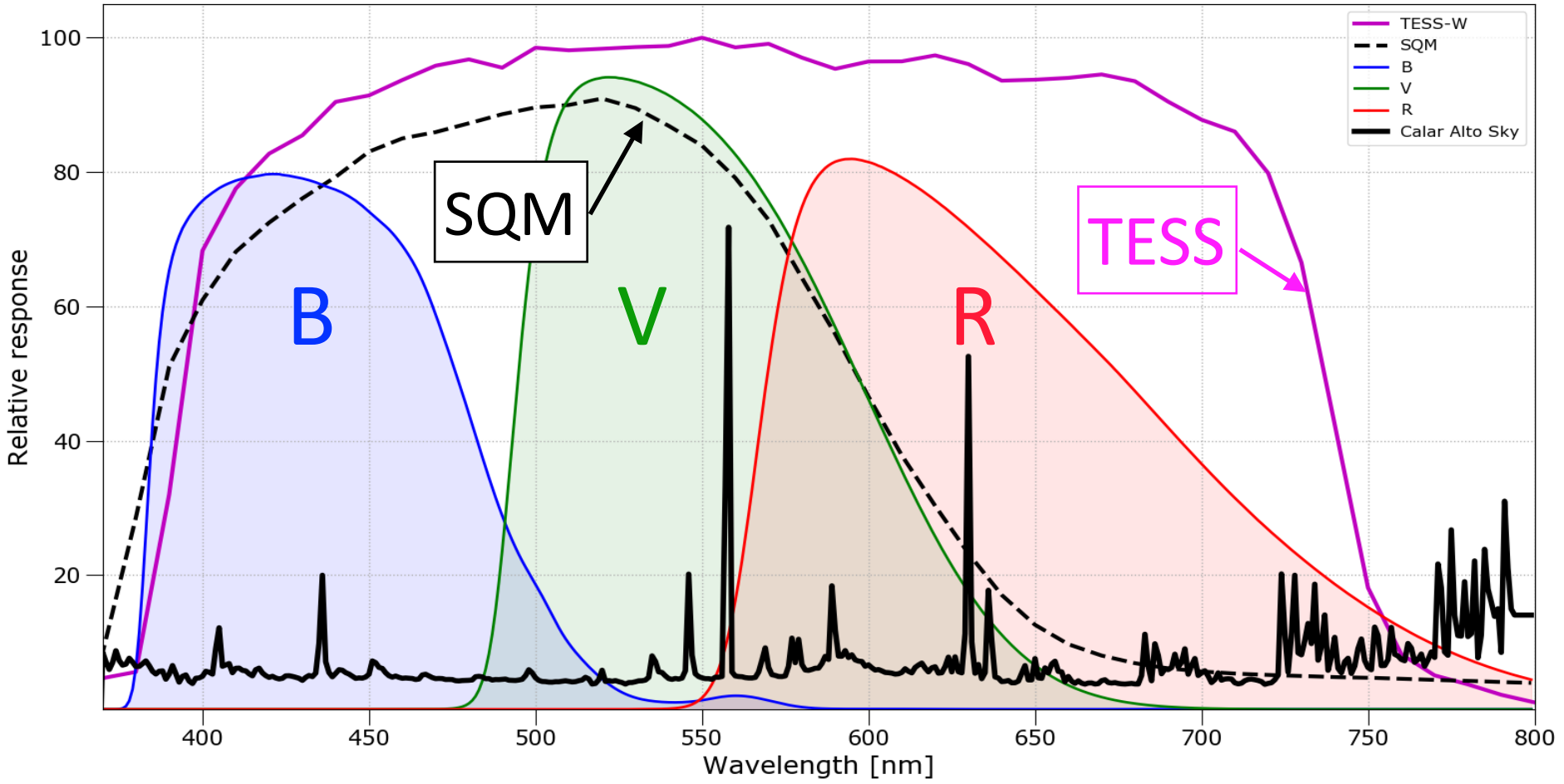
SQM, Johnson B, V, R and TESS-W and Madrid night sky spectrum



- Spectral response of TESS extended to the red

Why to design a new photometer ?

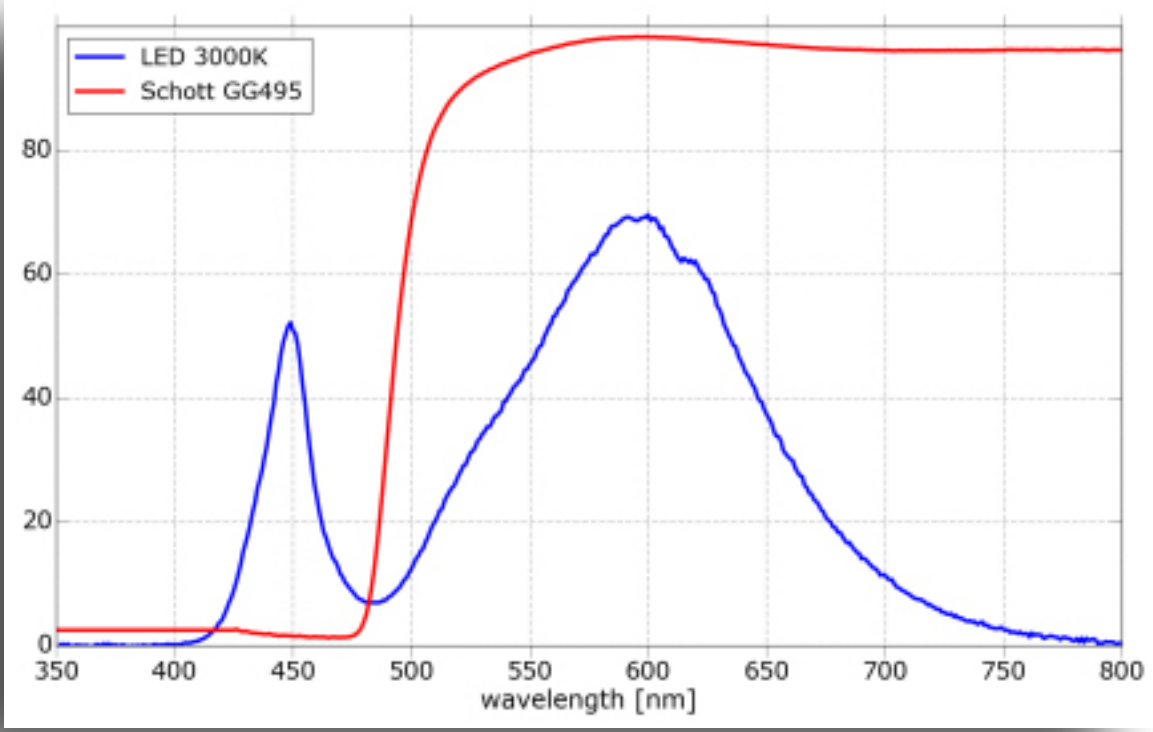
SQM, Johnson B, V, R and TESS-W and Calar Alto night sky spectrum



- Spectral response of TESS extended to the red

Why to design a new photometer ?

TESS-W designed with room for an extra filter inside the enclosure

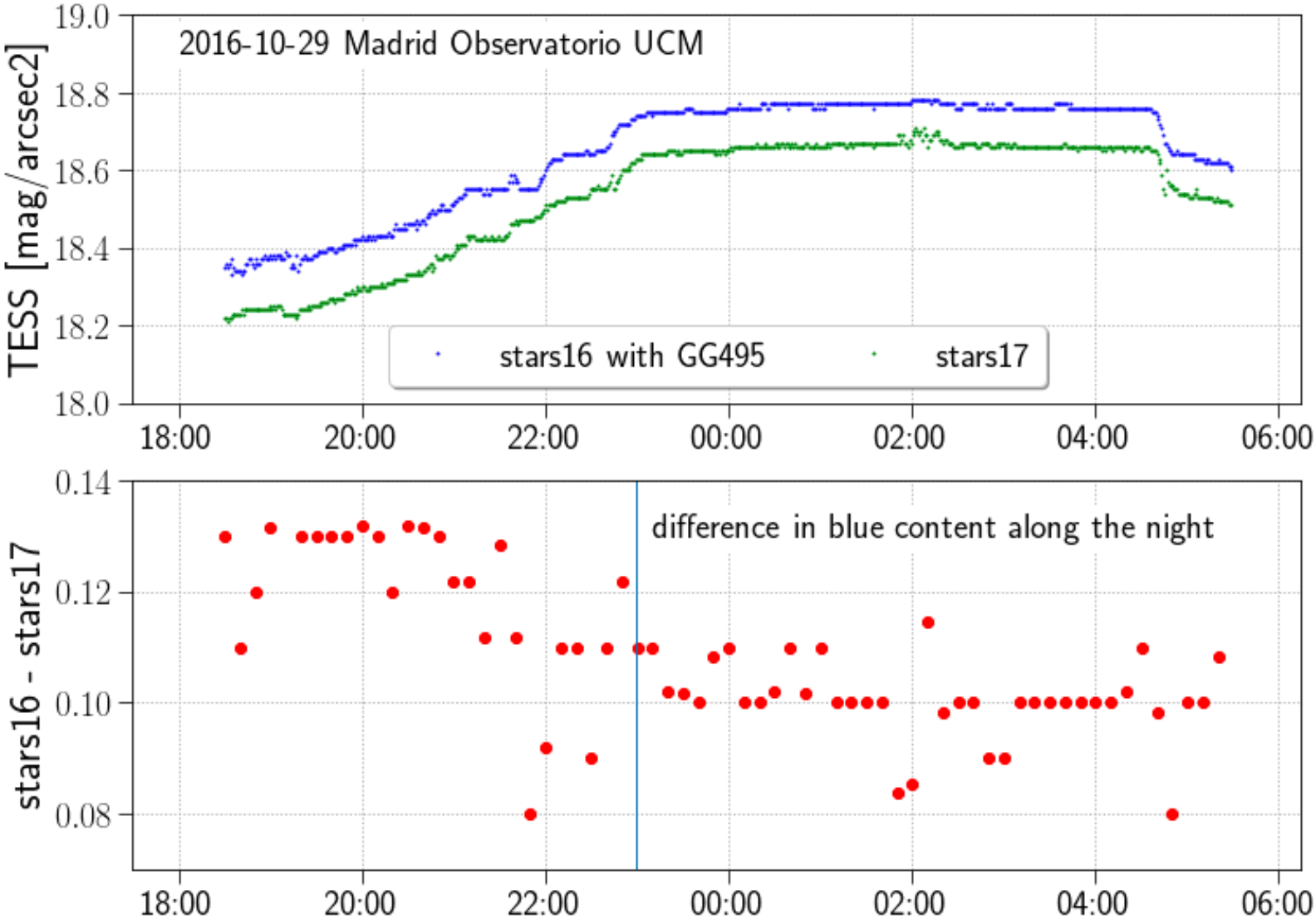


Dichroic filter + GG495

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

- It is possible to select your favourite passband with a filter

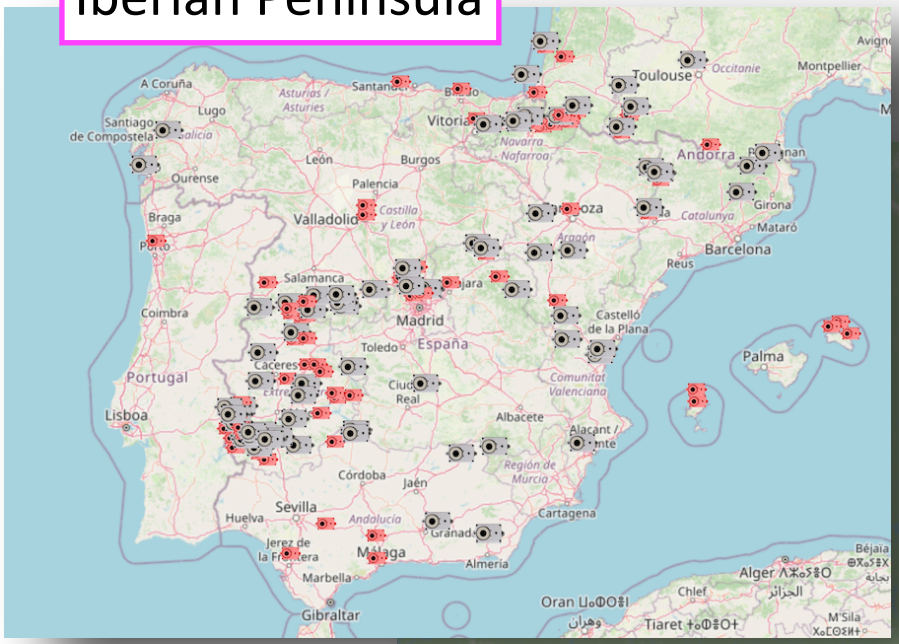
Why to design a new photometer ?



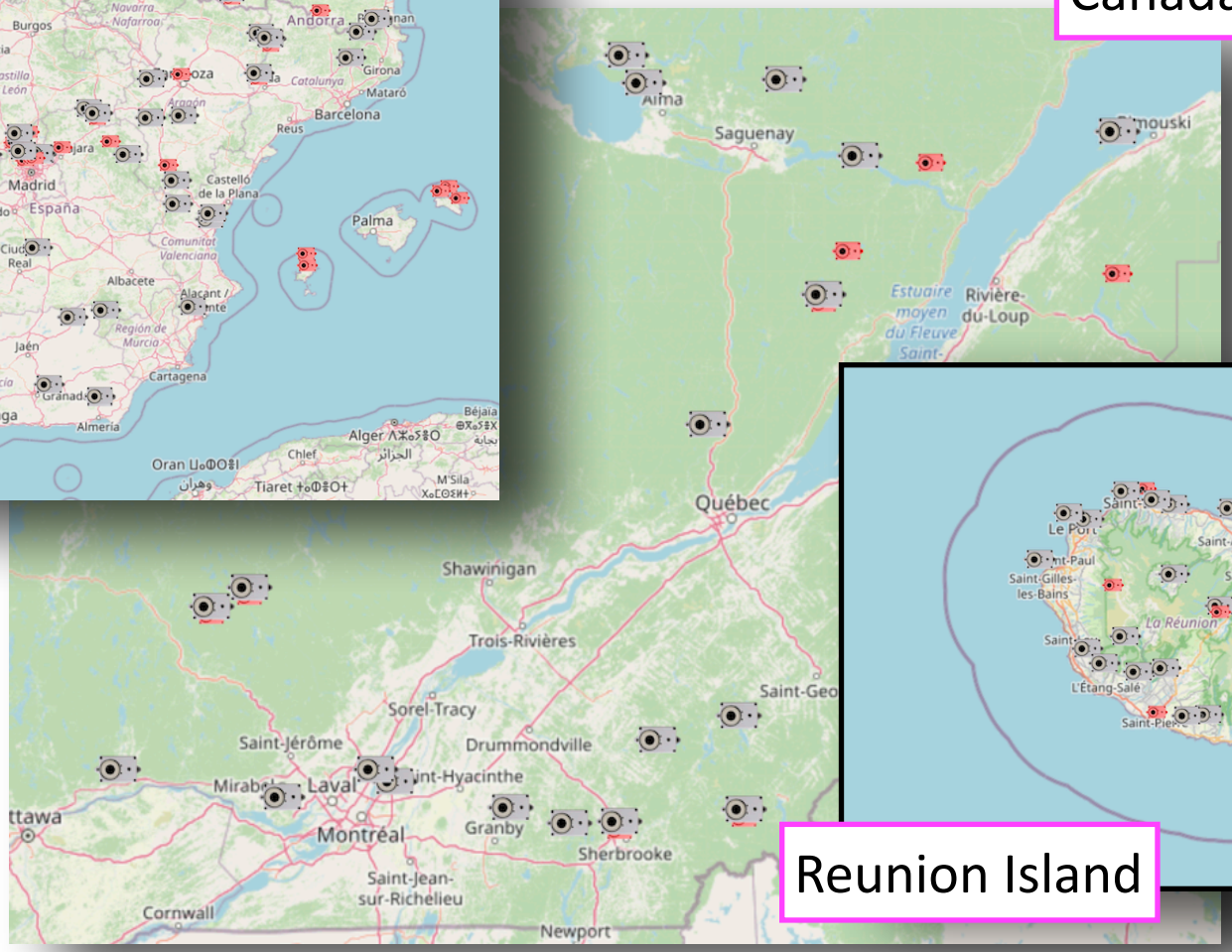
- Color variation along the night measured with two photometers with different passband

TESS-W photometer network

Iberian Peninsula



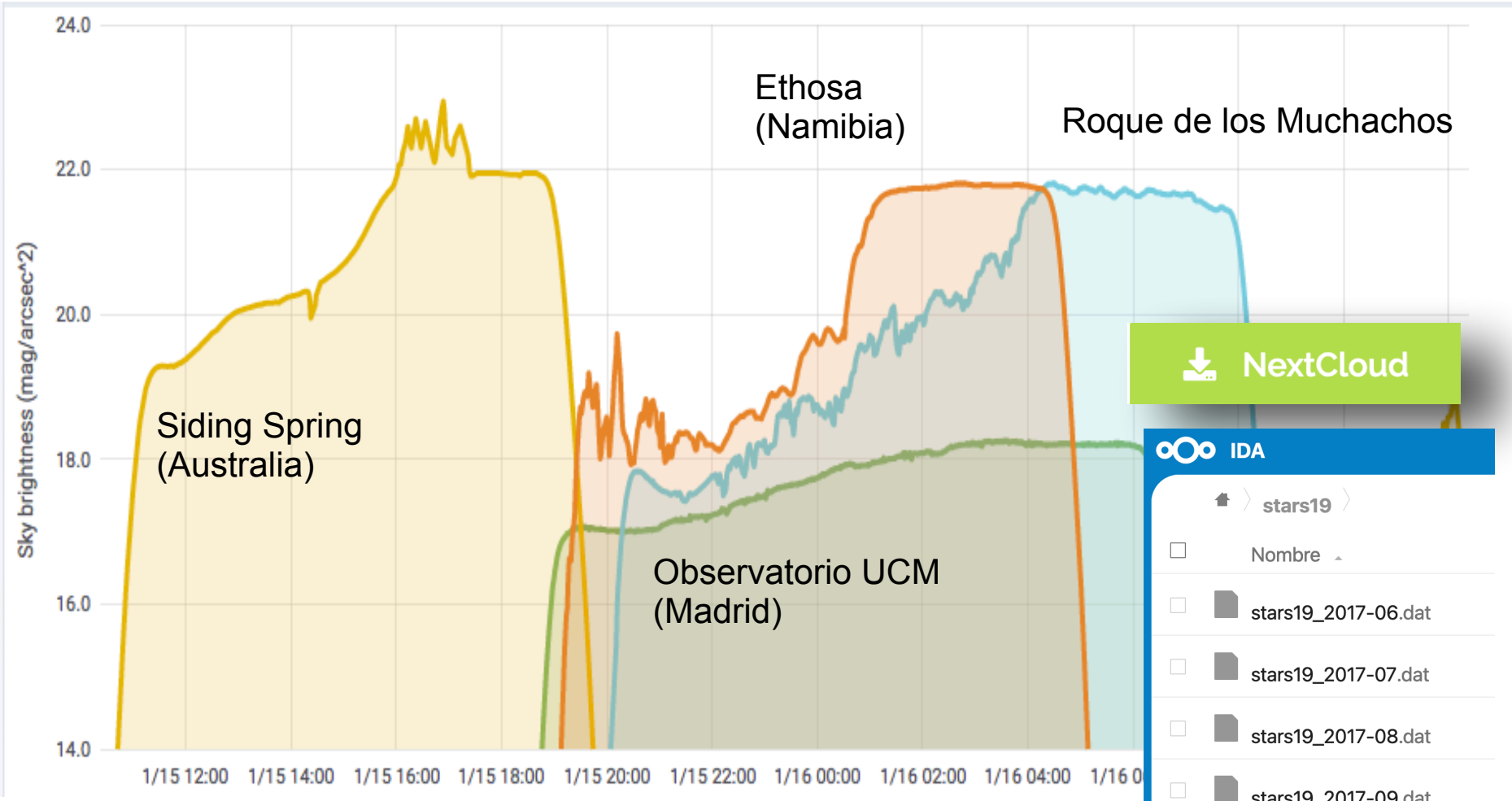
Canada



Reunion Island

- Examples of monitoring stations along the world

TESS-W photometer network



NextCloud

IDA

stars19

Nombre

stars19_2017-06.dat

stars19_2017-07.dat

stars19_2017-08.dat

stars19_2017-09.dat

stars19_2017-10.dat

Zenodo

- TESS open data is available online in real time and also in the archives.
- https://tess.dashboards.stars4all.eu

New TESS photometer models

TESS-W
mainly for fixed
monitoring stations

TESS-P
Handheld
Portable

TAS
All-sky
Auto scan

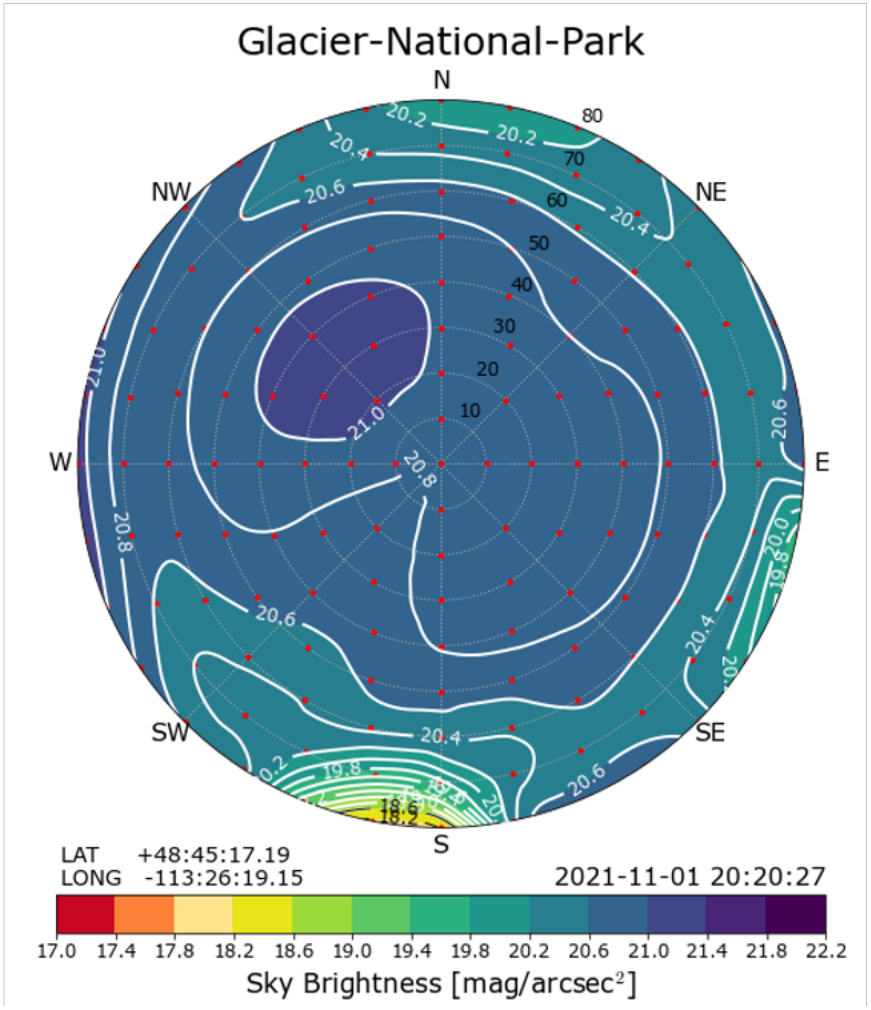
TESS-4C
Four channels
Fixed station

- New models for all-sky maps and color detection

TAS for all-sky brightness maps

- Full automatic scan (144 points) NSB all-sky maps on the fly

TAS for all-sky brightness maps



Comparison of fisheye picture and all-sky map with TAS (www.nps.gov/glac/learn/nature/night-sky.htm) Glacier National Park (USA).

- All-sky maps allow the detection of the origin of light pollution

TESS-4C for night sky brightness and color detection

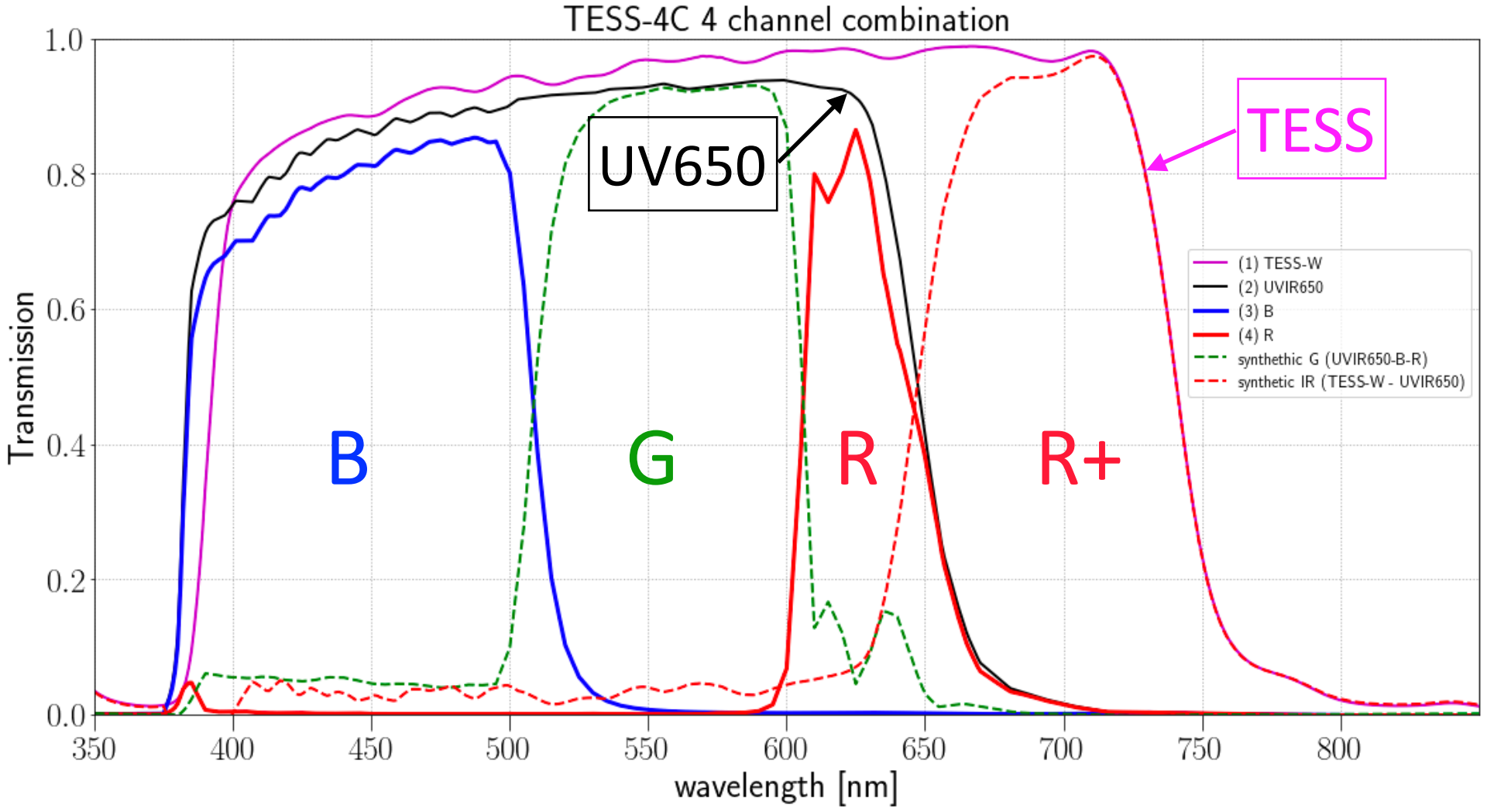
Version 1

Version 2

- Weather resistant to perform monitoring.
- No moving parts.
- 4 channels with interchangeable filters to select the bands.

- Color and brightness detection with a single photometer

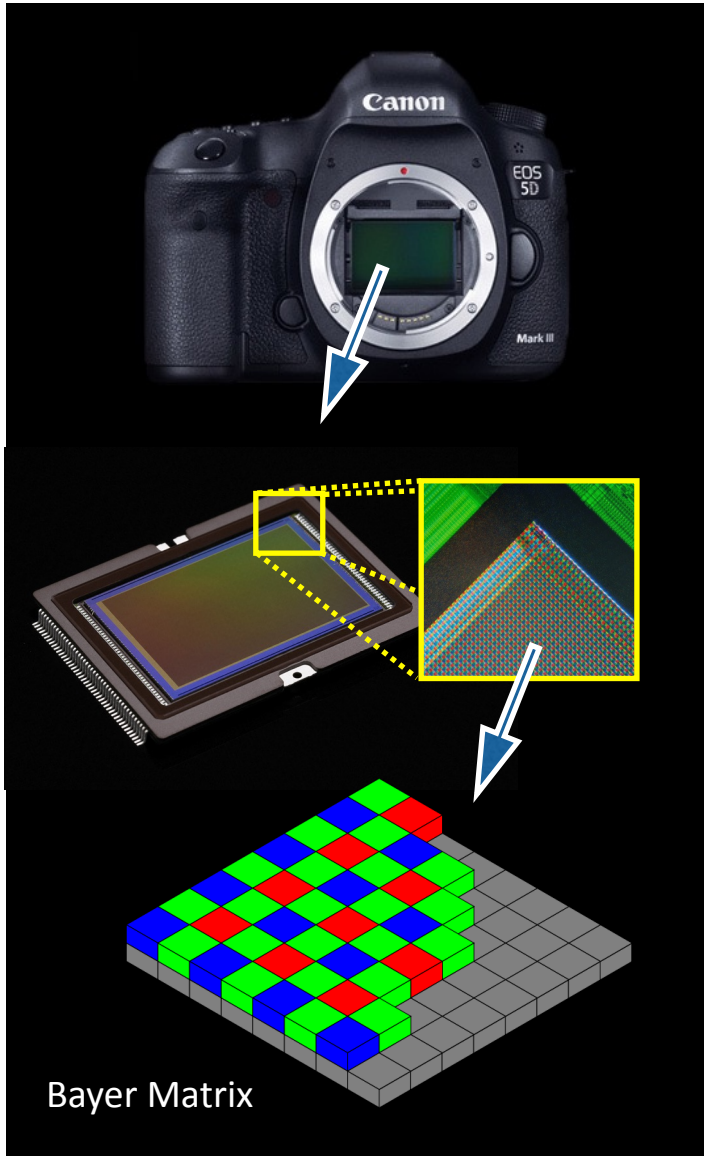
TESS-4C for night sky brightness and color detection



- Four channels allow to measure more than 4 bands

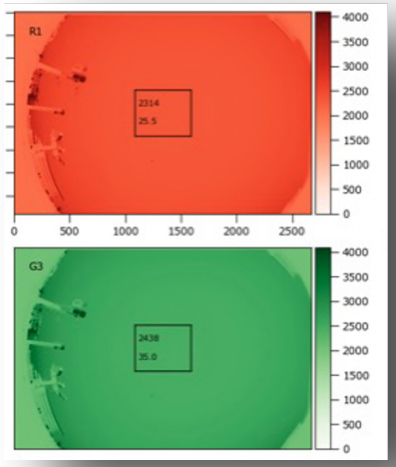
Why RGB photometric system

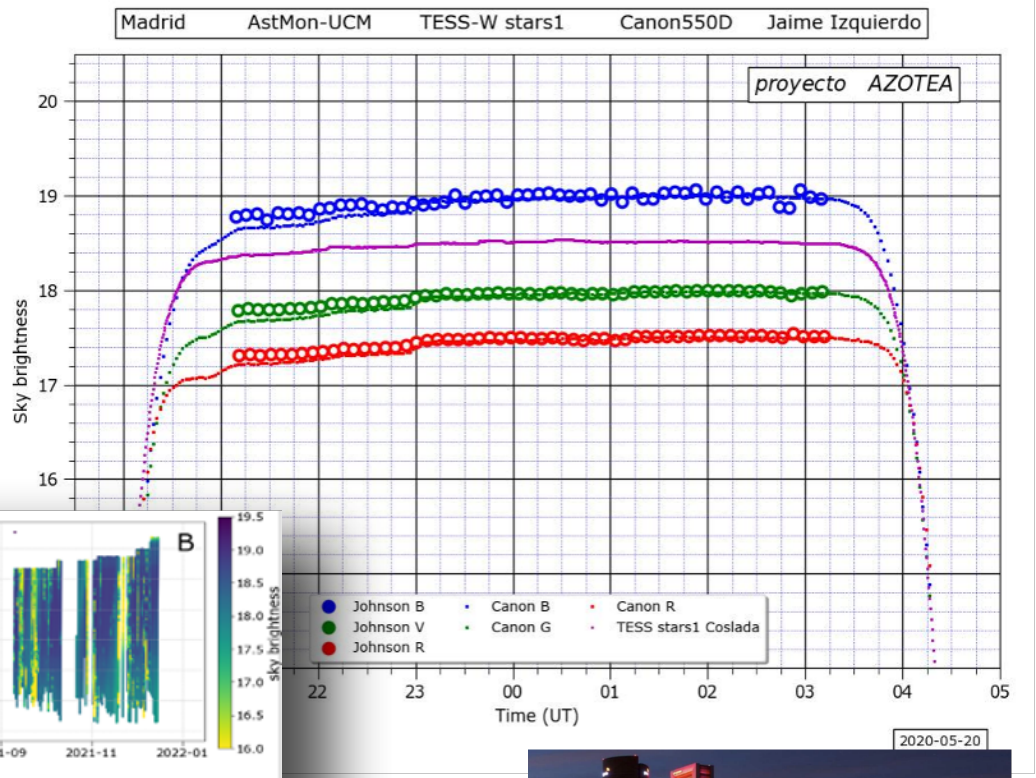
- RGB cameras everywhere:
  DSLR and astronomical color cameras (Bayer Matrix)
  and monochrome cameras with RGB filter wheel.
- Transforming the RGB camera images to the
  Johnson photometric system is a nightmare.
- It is better to observe and calibrate in RGB directly.

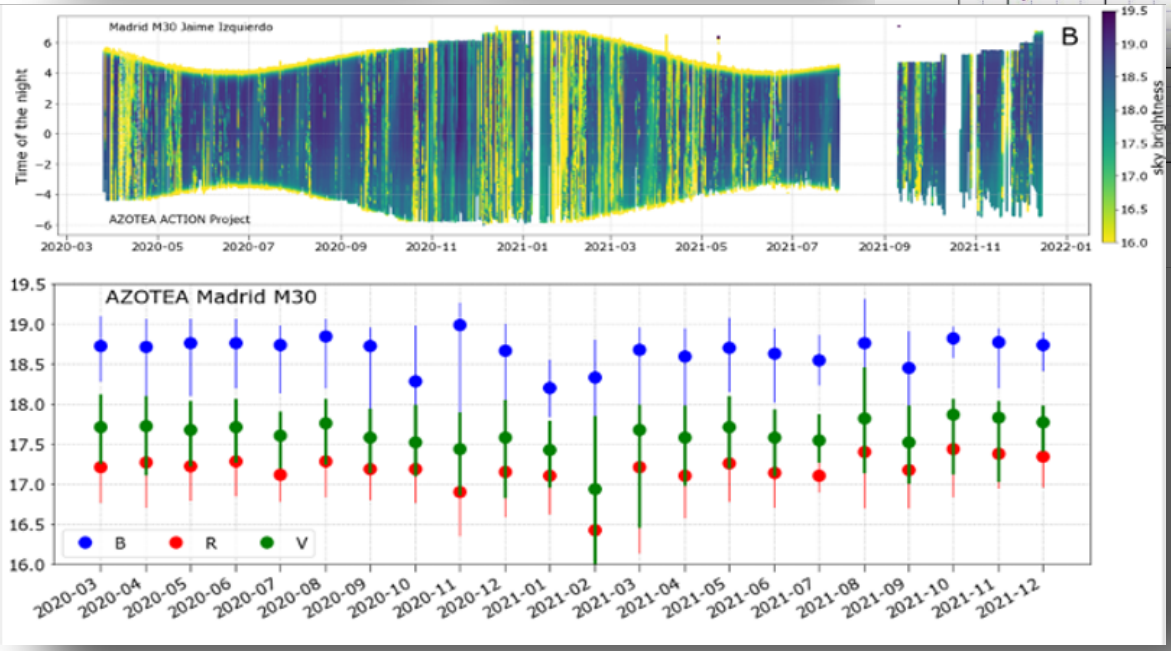


- Why are we still using Johnson photometry with RGB cameras ?

AZOTEA citizen science project







ACTION

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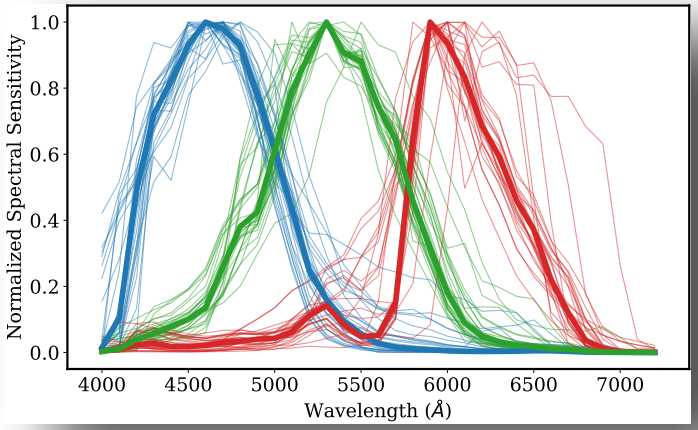
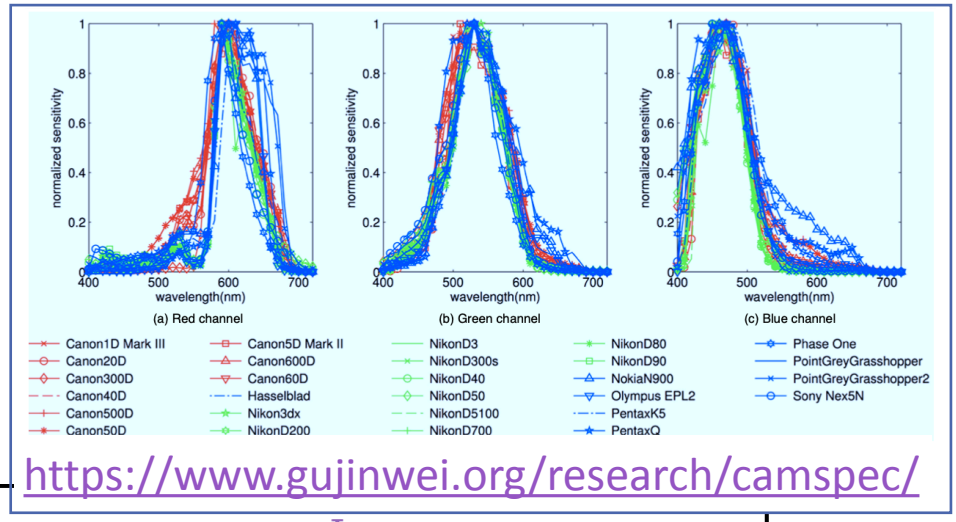
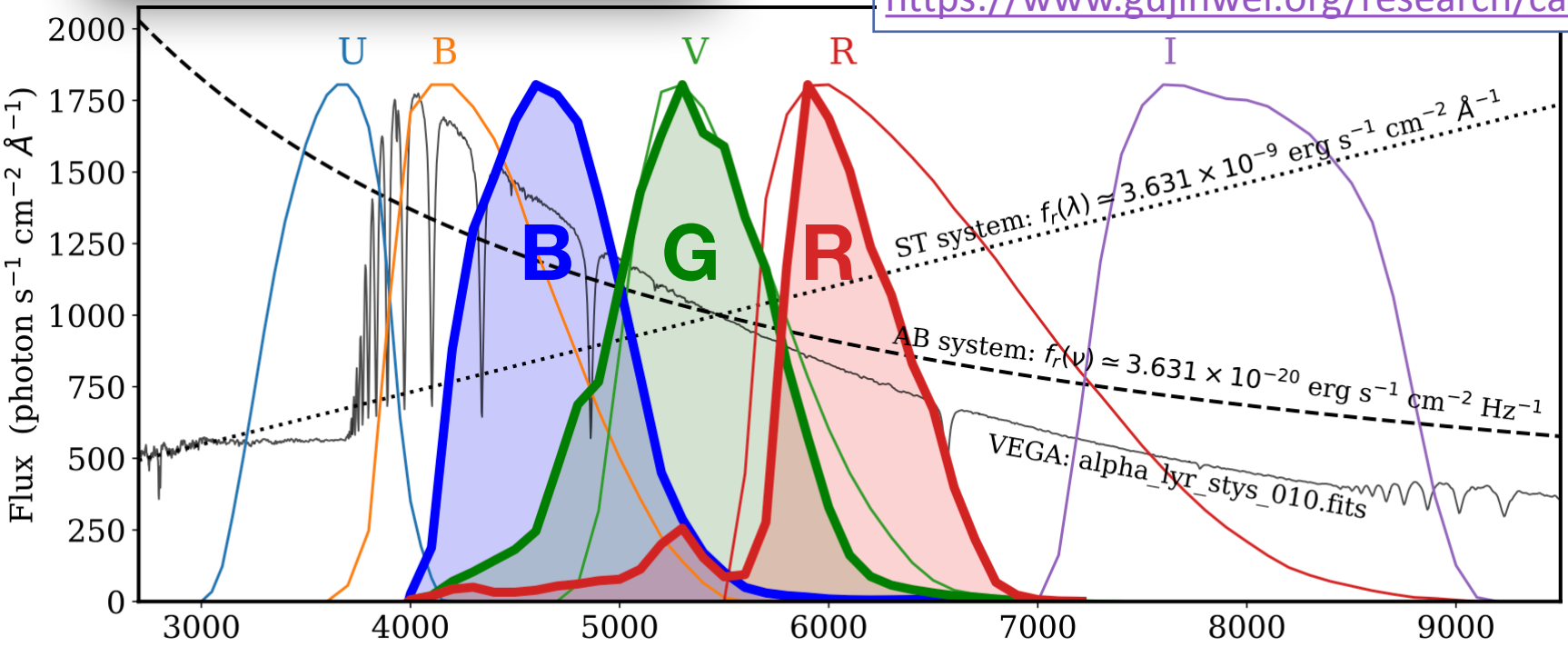
- DSLR cameras to monitor brightness and color of the night sky

RGB photometric system: The passbands





https://www.gujinwei.org/research/camspec/



- Passbands definition using spectral response of DSLR cameras

RGB photometric system: The standard stars

remote sensing MDPI

Article

Photometric Catalogue for Space and Ground Night-Time Remote-Sensing Calibration: RGB Synthetic Photometry from *Gaia* DR3 Spectrophotometry

Josep Manel Carrasco [1,2,3,*], Nicolas Cardiel [4,5], Eduard Masana [1,2,3], Jaime Zamora, Alejandro Sánchez de Miguel [4,5,6], Rafael González [4] and Jaime Izquierdo [4]

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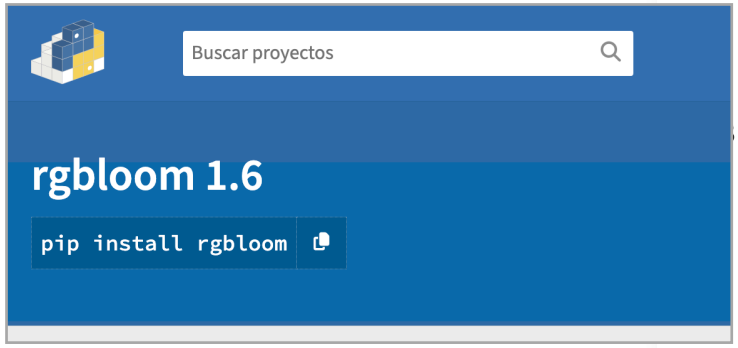
2 Departament de Física Quàntica i Astrofísica (FQA), Universitat de Ba 08028 Barcelona Barcelona, Spain
3 Institut d'Estudis Espacials de Catalunya (IEEC), c. Gran Capità, 2-4, (
4 Departamento de Física de la Tierra y Astrofísica, Facultad de CC. Físi Madrid, Plaza de las Ciencias 1, 28040 Madrid, Spain
5 Instituto de Física de Partículas y del Cosmos, IPARCOS, Facultad de (de Madrid, Plaza de las Ciencias 1, 28040 Madrid, Spain
6 Environment and Sustainability Institute, University of Exeter, Penryn
* Correspondence: carrasco@fqa.ub.edu

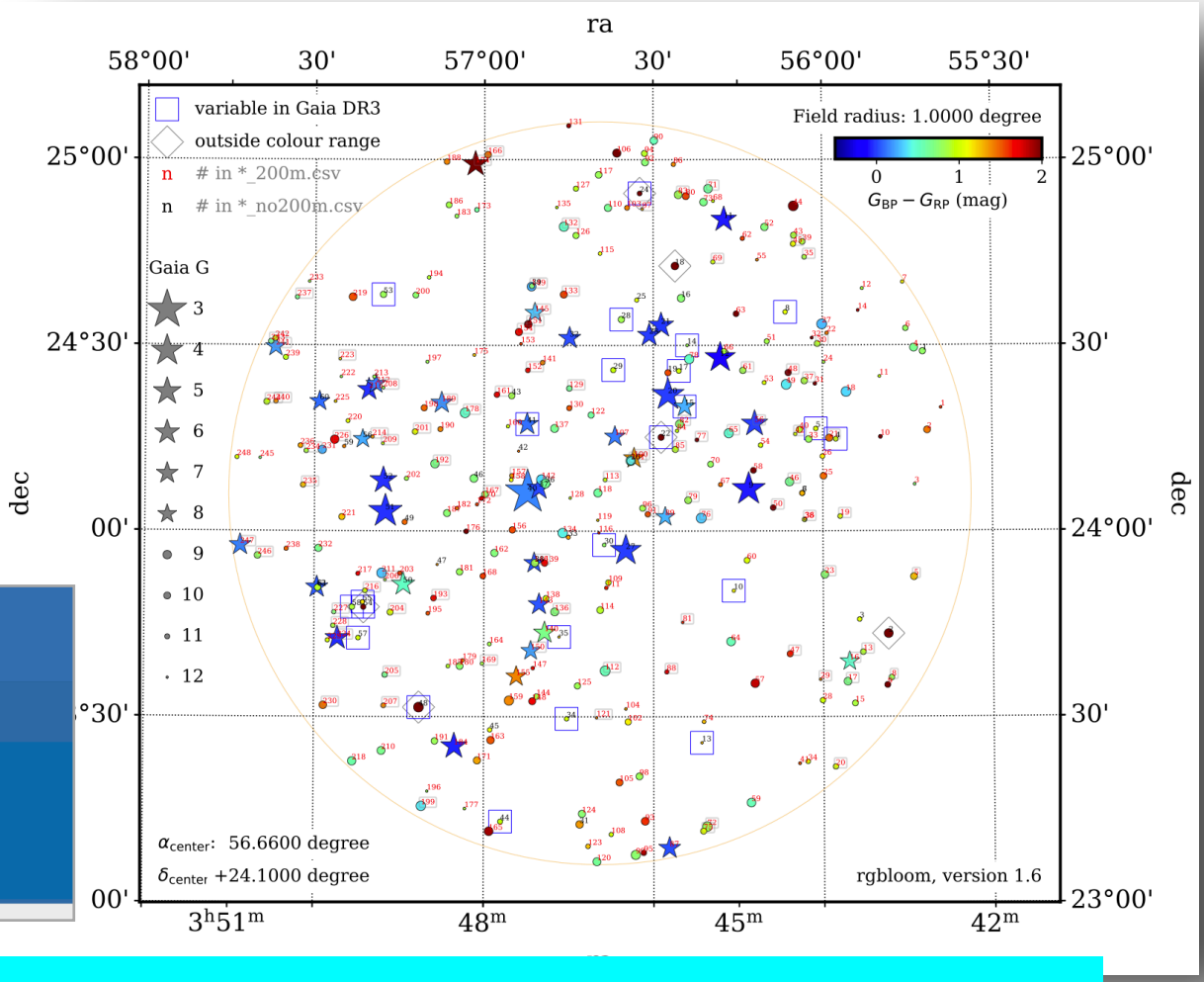
RGB magnitudes for 213 064 002 stars (non variables; Gaia DR3, June 2022)

https://cdsarc.cds.unistra.fr/viz-bin/cat/II/374

Open software to list and chart RGB standard stars in your field of view.

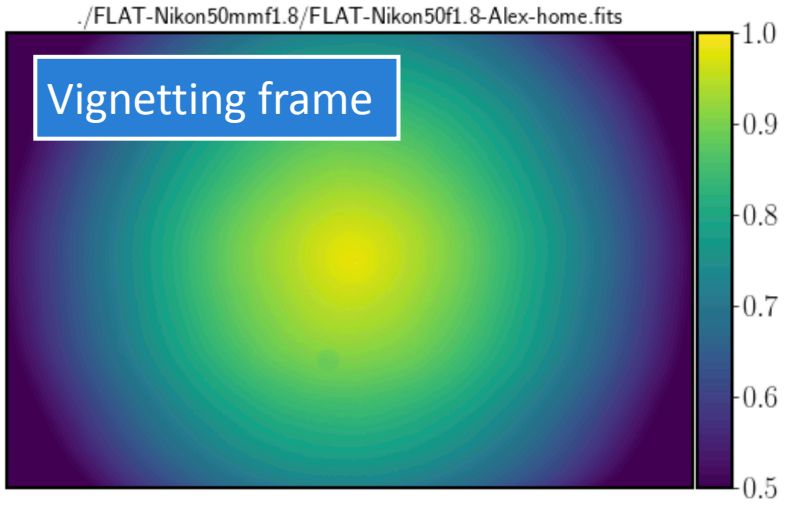
https://pypi.org/project/rgbloom/





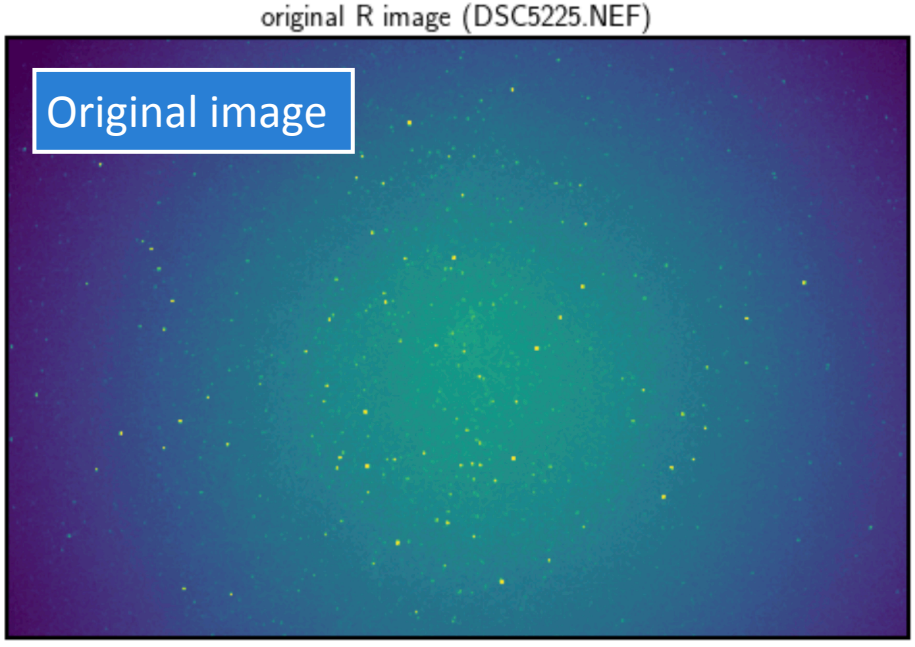
- There are more than 200 million of standard stars

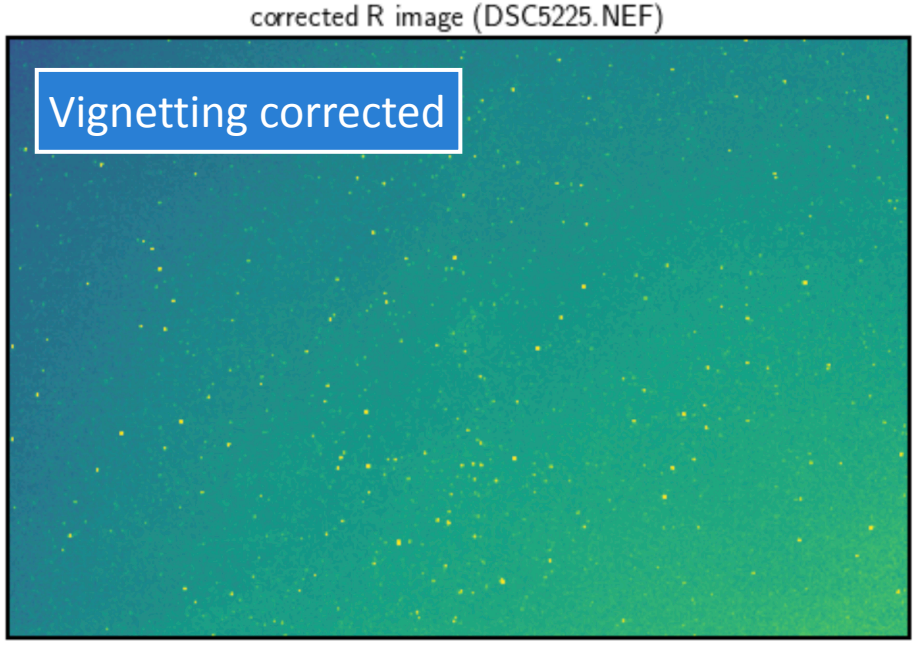
RGB photometry example DSLR calibration



observations at Berlin 2013/10/25
Nikon D3 50 mm F/1.8

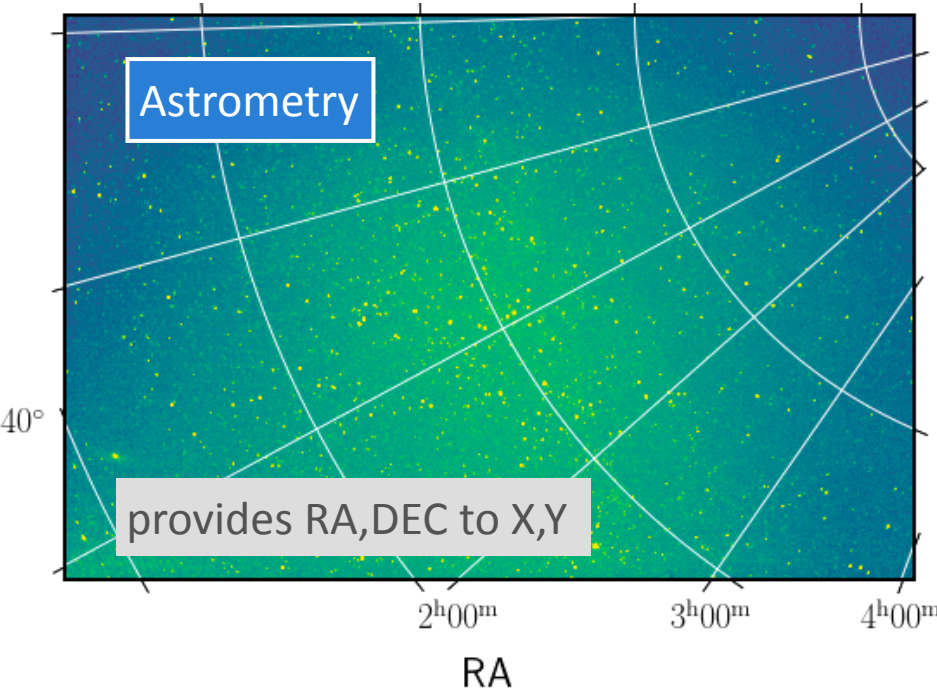
Astronomical absolute photometry:
Several frames at different elevation or air masses (zenith to horizon) to determine zero point and extinction coefficients

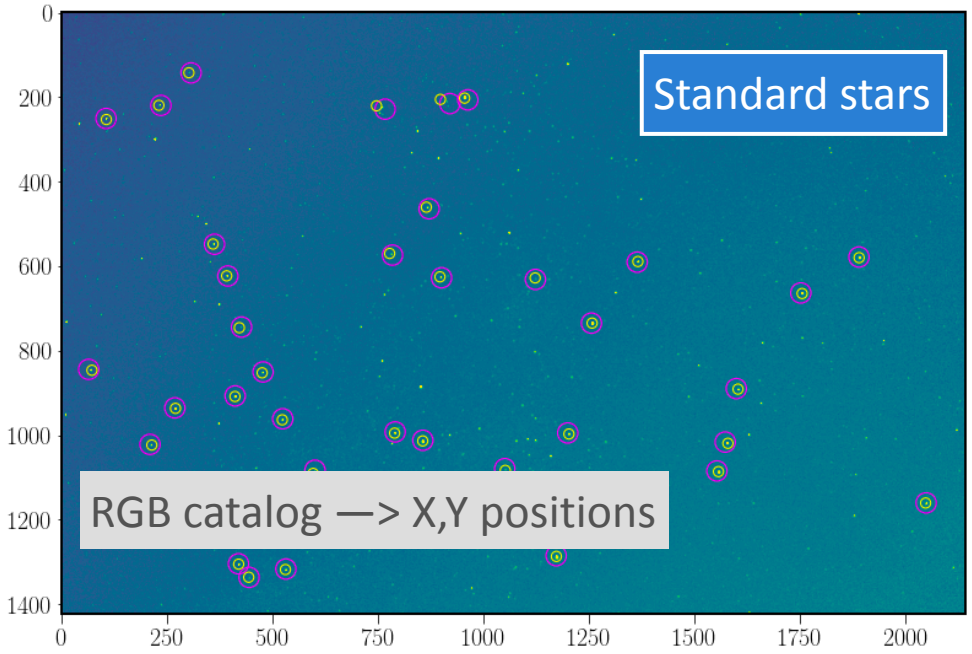


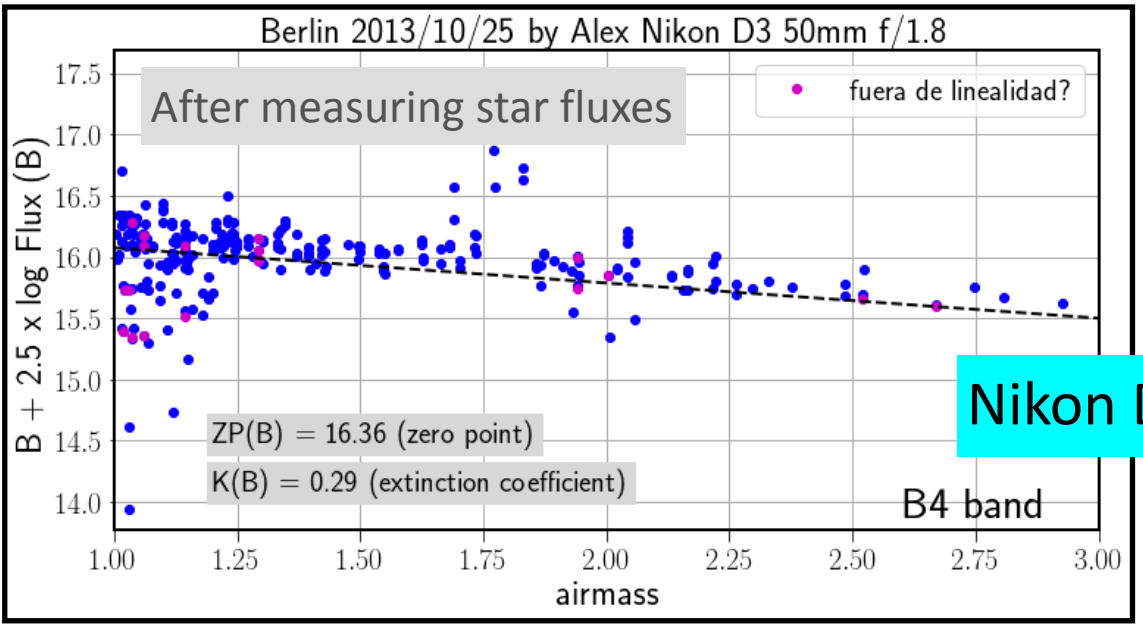


- Vignetting correction if the hard step in the procedure

RGB photometry example DSLR calibration



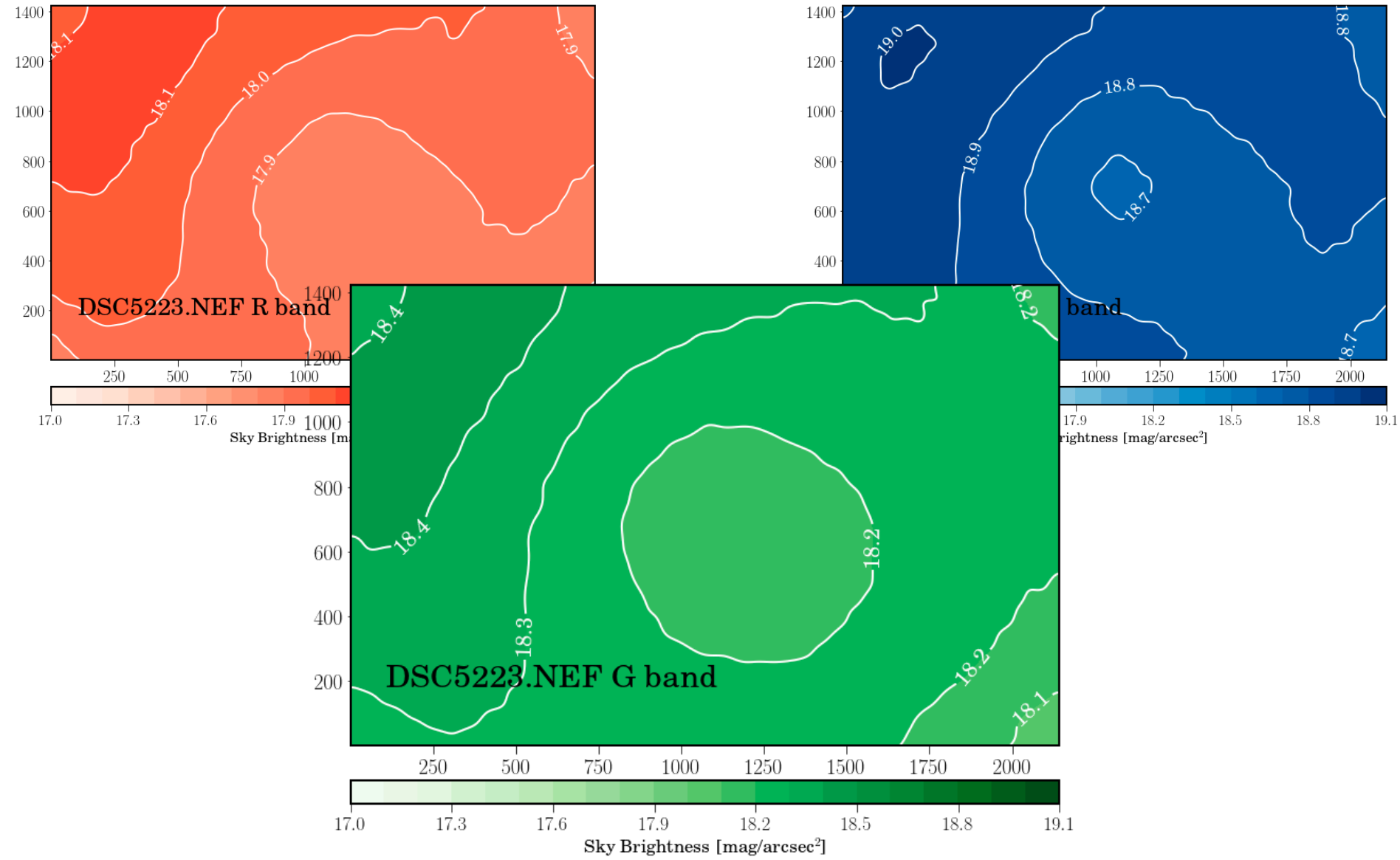




Astrometry using astrometry.net
Standard stars found with RGBloom
Bouger fit for each channel

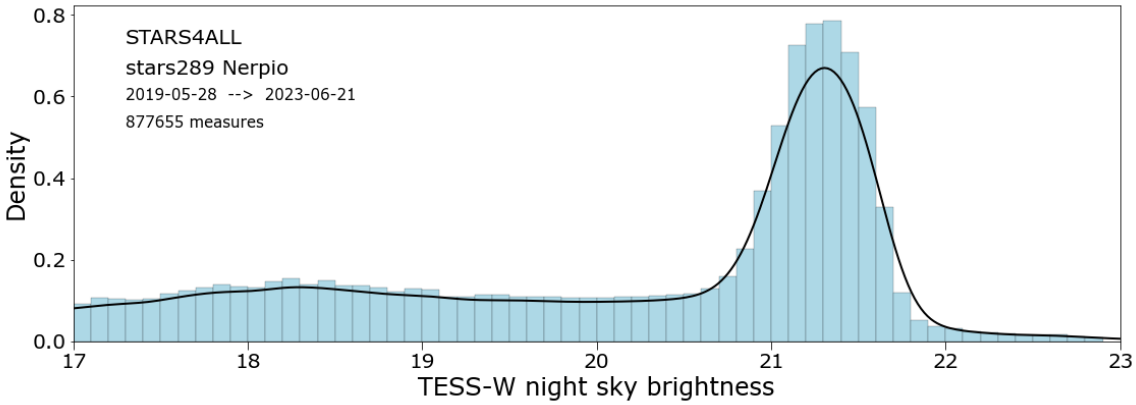
Nikon D3 + 50mm F/1.8 calibrated

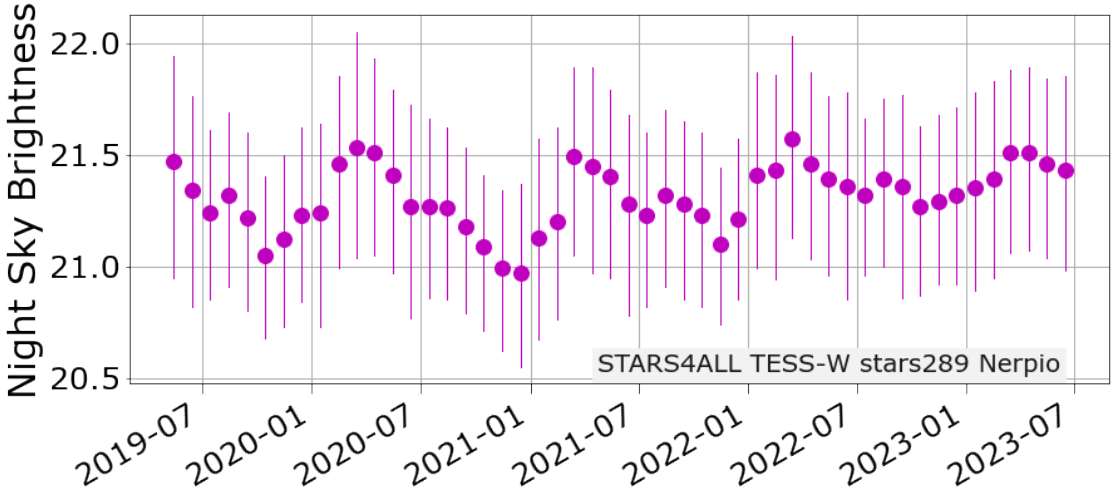
RGB photometry example DSLR calibration

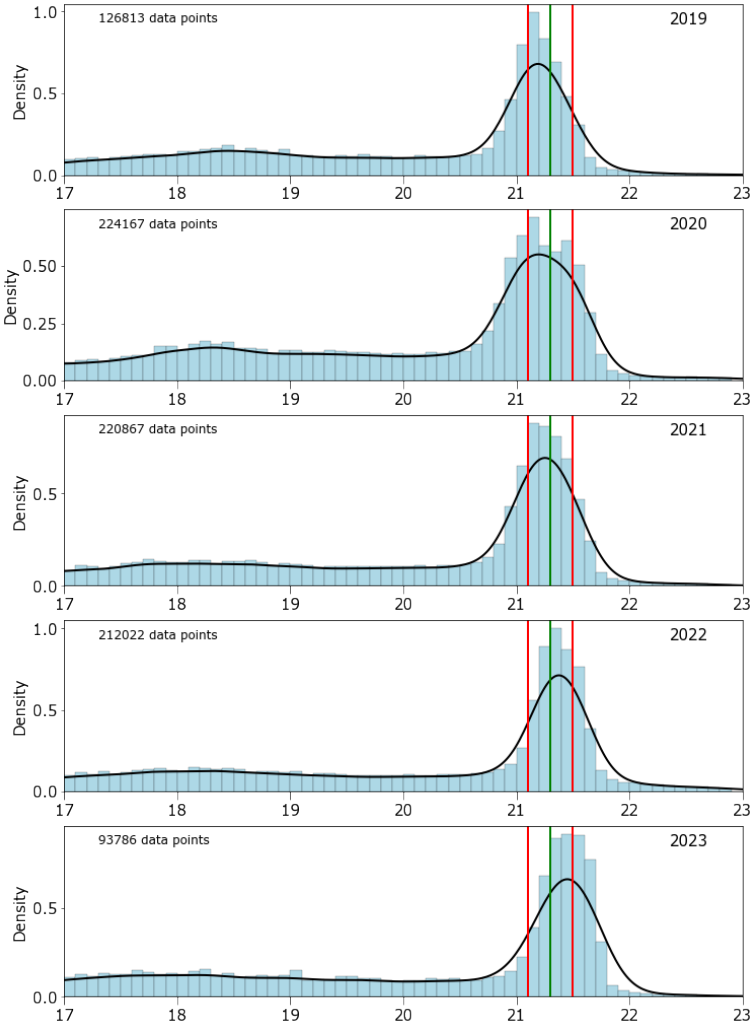


- Sky brightness map in RGB, Berlin 2023/10/13 near zenith

Sky brightness monitoring OPEN SOFTWARE







- Open software to facilitate the analysis and statistics of the Night Sky Brightness series is needed

Wrapping up

- Monitoring gives you the statistical parameters and informs about status and evolution.
- You can design a photometer for your needs (photometric bands) choosing the appropriate filter.
- RGB photometry is a cheap method to monitor the night sky in color.
- Monitoring night sky brightness was the task of astronomical observatories, then of citizens.
  The public administration should monitor light pollution now.
- Sky brightness open data should be mandatory for ‘dark places’. When they are certified and afterwards to check whether the light pollution is decreasing.
- Open software to analyse sky brightness time series is desirable.

We have a lot of work ahead of us

Grave of the Fireflies (火垂るの墓, *Hotaru no Haka*)
(高畑 勲, *Takahata Isao*)　1988