STARS4ALL night sky brightness photometer

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STARS4ALL

A collective awareness platform for promoting dark skies in Europe, funded by the EU. (http://www.stars4all.eu/). Our project aims at representing the right of dark and starry skies or "stars for all the citizens".

We intend to involve citizens within the offered Light pollution initiatives (local or global open working groups who fight against the negative impacts of artificial light at night) and also to help them to create their own.

European Photometer Network

Interested citizens will help us in monitoring the light pollution of European villages.

The European Photometer Network will extend the current existing professional photometer networks to a citizen-based network of photometers.

The citizens will be able to purchase and install low cost photometers, which will be sold in the STARS4ALL marketplace.

Night Sky brightness photometer

TESS-V1, designed to monitor the sky from fixed places, is the first version of a series of cheap but reliable photometers that will be used to measure night sky brightness.

TESS communicates to a router via WiFi and it sends automatically the measurements to our data repository using IoT (Internet of Things) protocols.

It also measures the sky temperature to estimate the cloud coverage.

Figure 1. TESS photometer prototypes (with dichroic and color filters) being tested under dark skies during the LoNNe intercomparison campaign at Montsec.

Main features

- TESS-V1 measures sky brightness and also estimates the cloudiness.
- The box (80x55x35 mm) is weatherproof.
- No additional enclosure is needed.
- Data is sent automatically to a broker via WiFi
- Low price but reliable.
- The hardware, software and data will be open and free.

Hardware

The sky brightness detector is a TSL237 photodiode that convers light to frequency. It is the same sensor used by the SQM photometers. However the bandpass is more extended to the red range with the use a the dichroic filter.

(1) The light from the sky is collected with the optics that includes a dichroic filter to select the bandpass. The filter fully covers the collector.

(2) The sensor (not seen in this picture) is located in a printed circuit board along with the custom made electronics.

(3) The WiFi module. An antenna inside the box extend the WiFi range

(4) IR sensor to measure sky temperature.

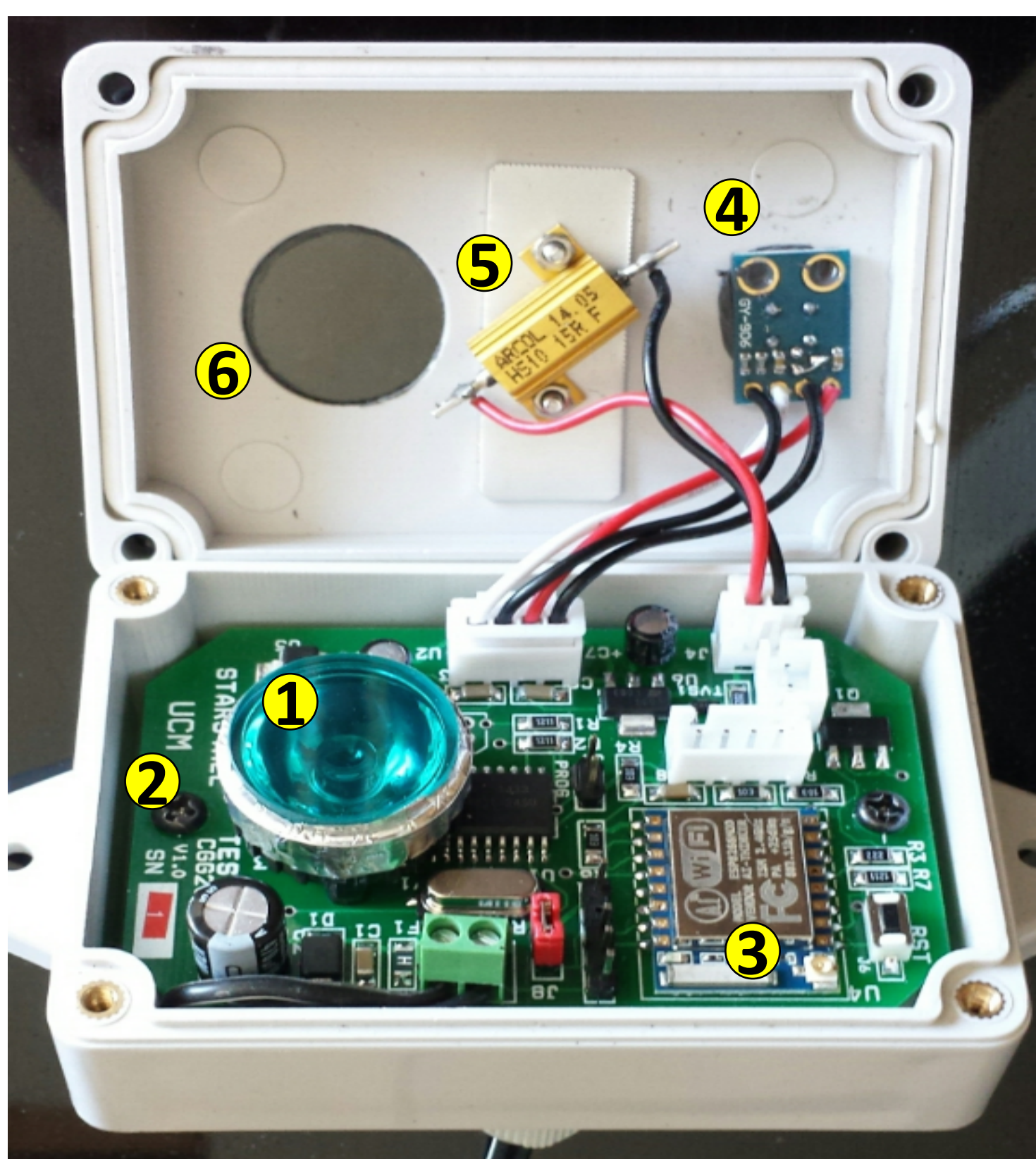(5) The heater is switched on when to get rid of condensation on the window (6)

Figure 2. The inside of enclosure with the optics and electronics of the TESS-V1 photometer.
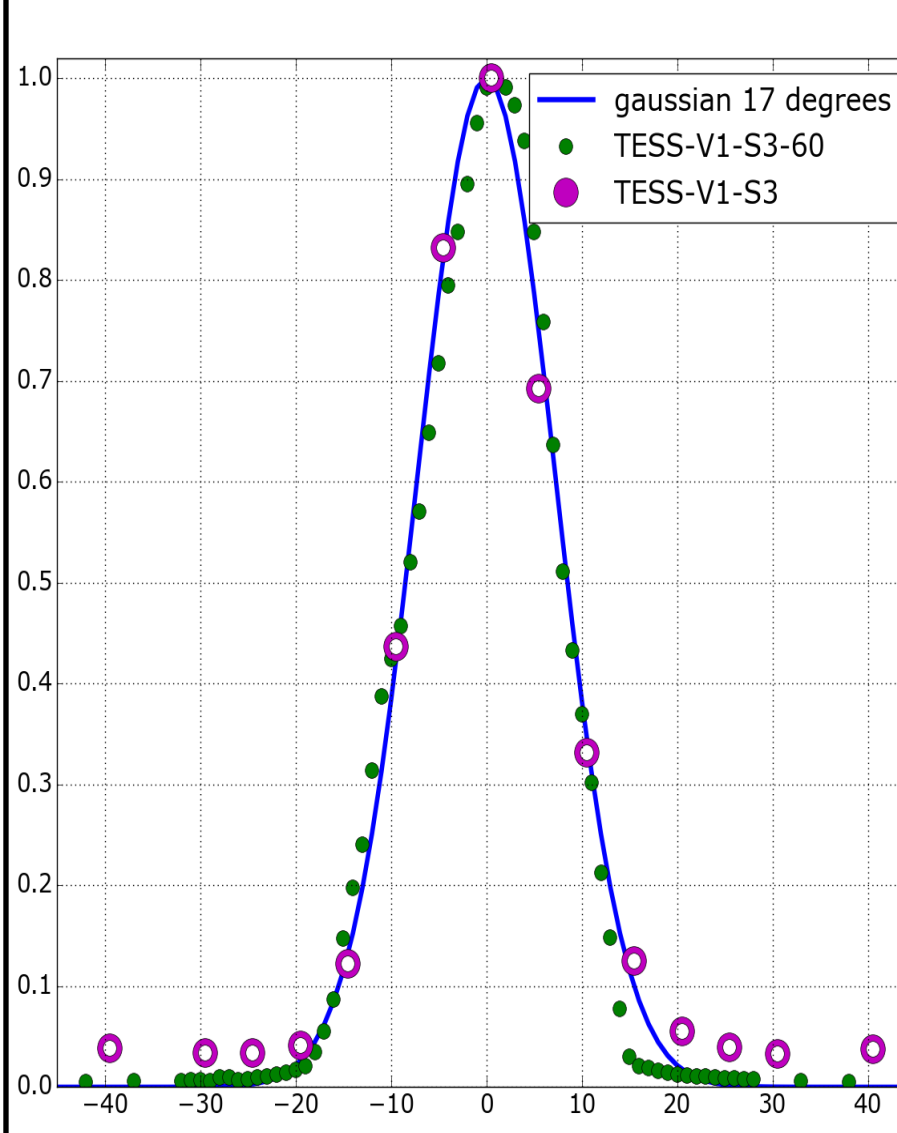
Field of View

Figure 3. TESS photometer field of view (FoV) is similar to a gaussian function of FWHM=17 degrees.
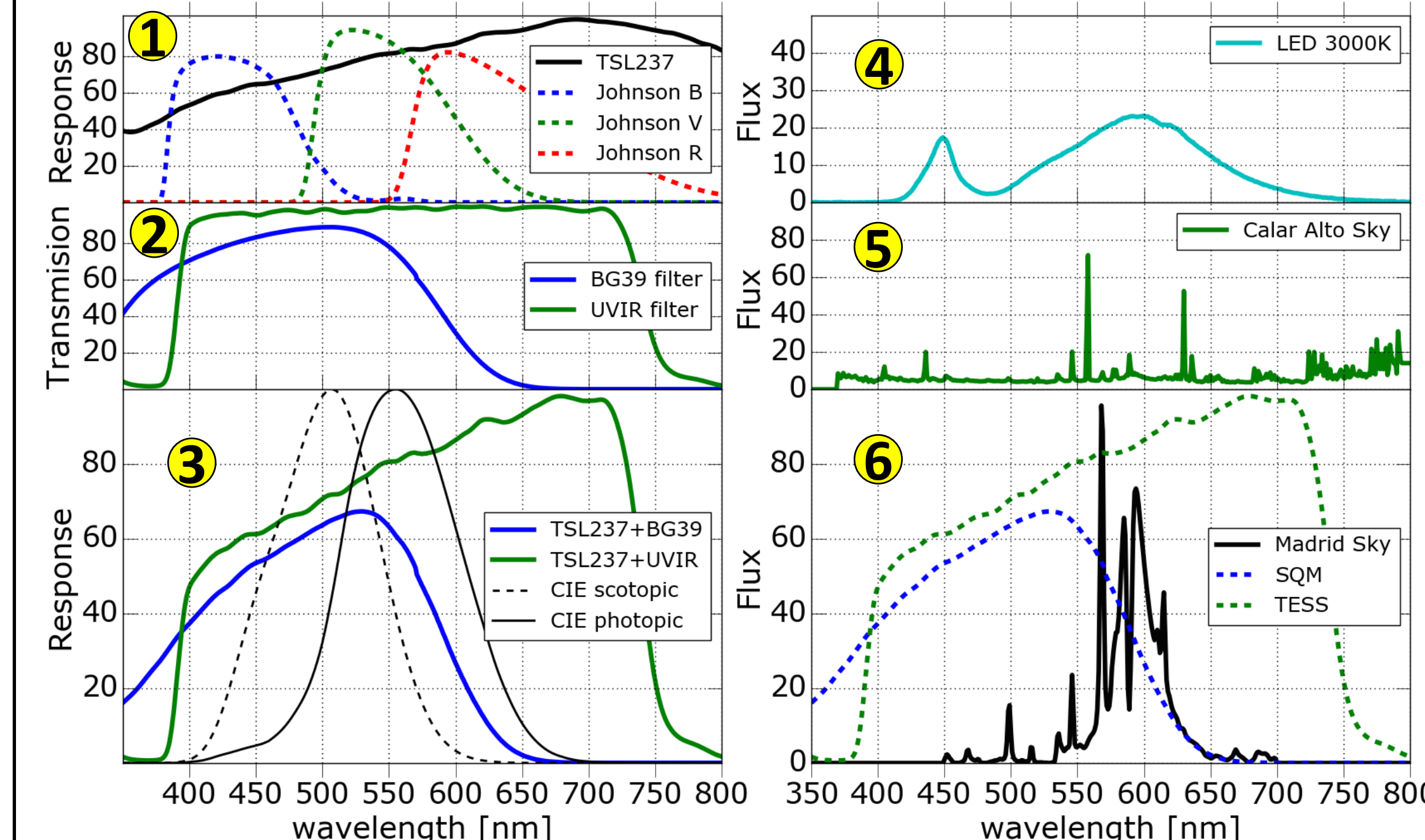
Spectral response

Figure 4
1. Spectral response of the TSL237 sensor.
2. Transmission of the HOYA CM-500 (BG39) used by Unihedron SQM and that of the dichroic filter used in TESS.
3. Combined response of filter and sensor.
4. 3000K LED spectrum.
5. Calar Alto Sky spectrum (Sánchez et al. 2007PASP..119.1186S)
6. Spectral response of SQM and TESS over the night sky spectrum of Madrid (Aubé, SAND spectrometer)

Software

The photometer is configured using a web browser to connect via WiFi to a router (SSID, password, name, interval between measures etc.).

In normal use the reading of the sensors are received by the MQTT broker and stored. This is the method for monitor the sky brightness in fixed stations.

The user can also read the data of its device in local mode with a computer or Android device.

This method is useful for measures from a moving vehicle to map the sky brightness of extended regions. The GPS data is provided by the Android device that connects to the photometer.
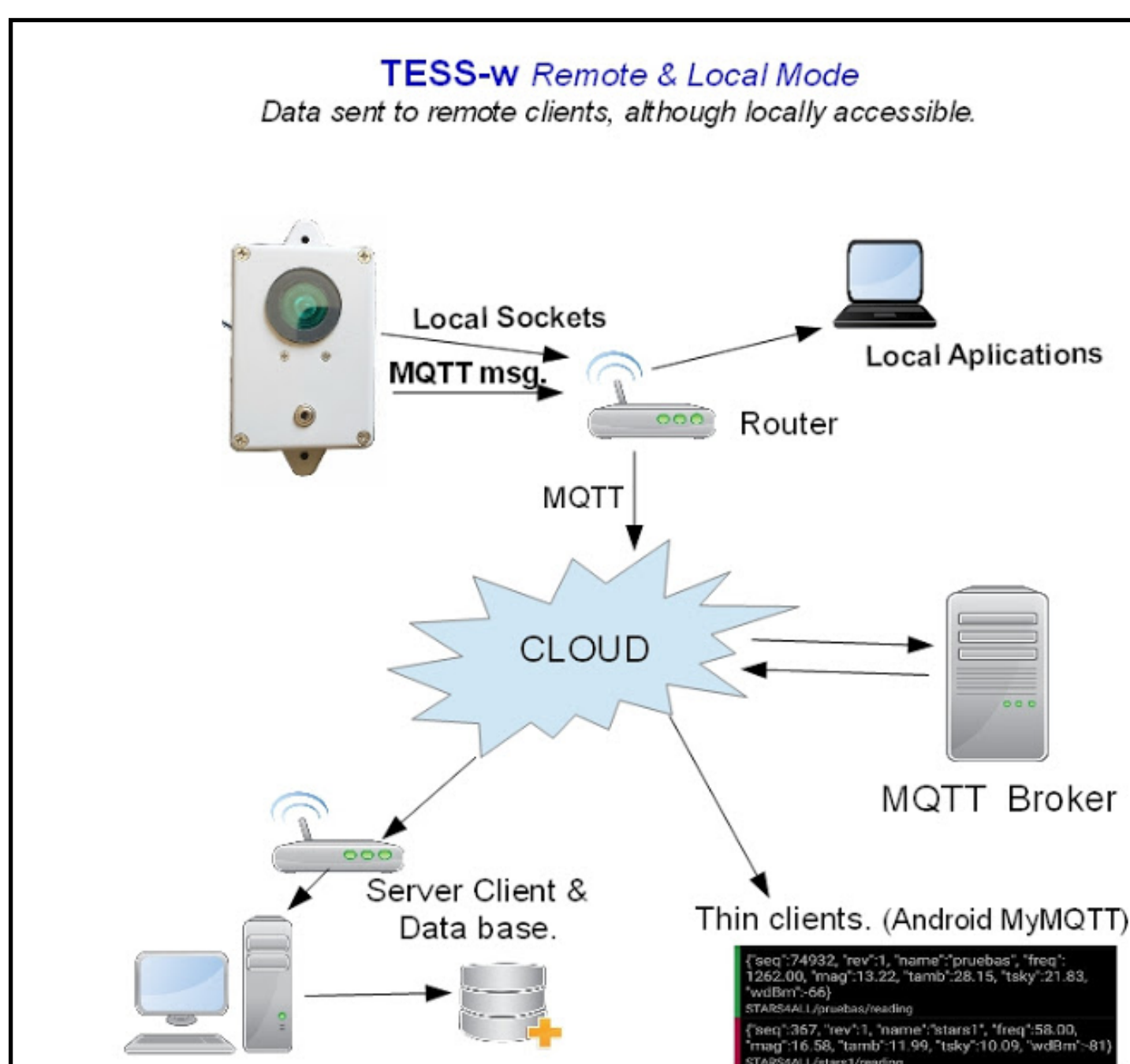
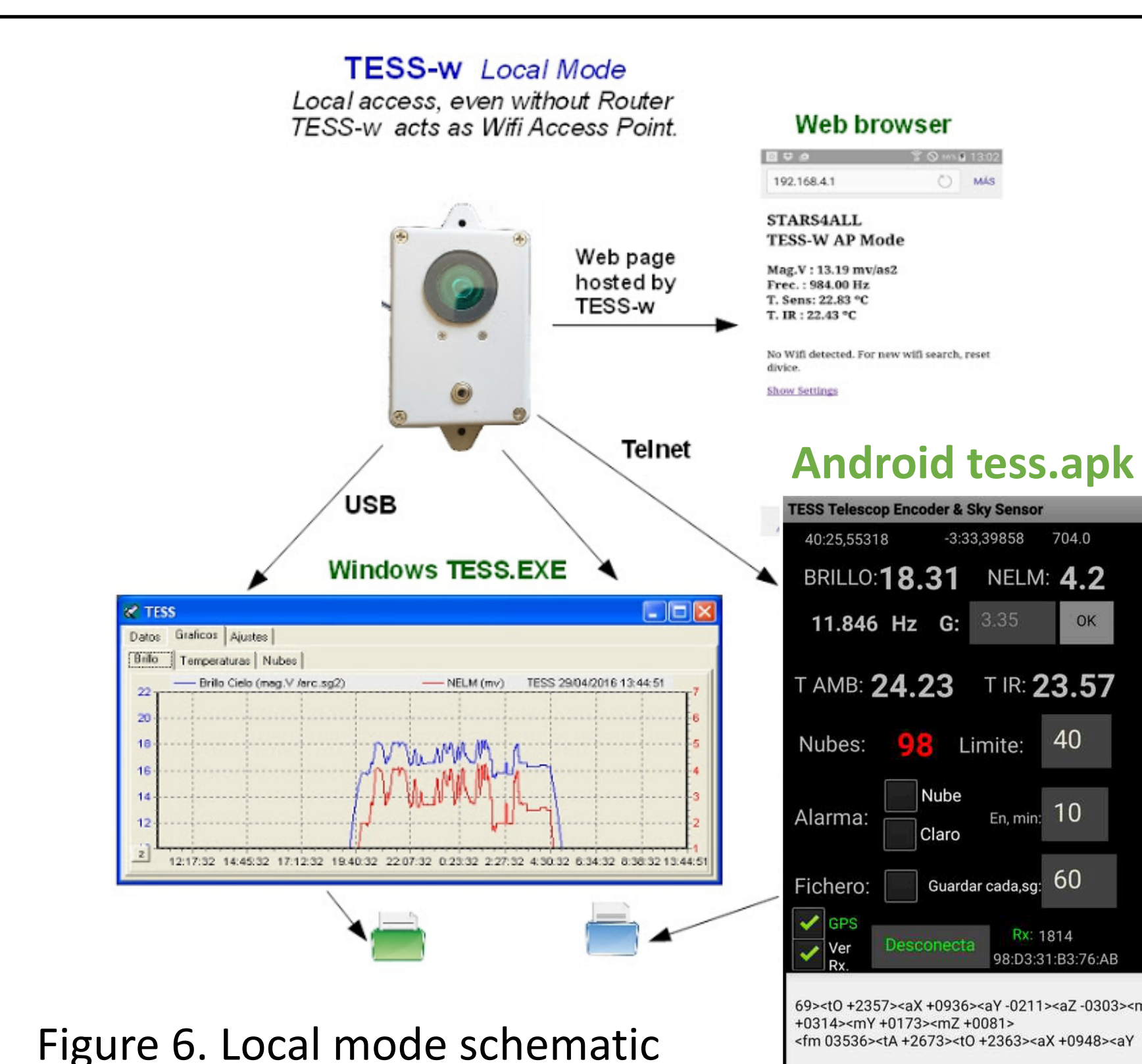

Figure 5. Communication schematic

Figure 6. Local mode schematic

Figure 7. SQM and TESS photometers on top of a car to map night sky brightness. TESS is connected to an android tablet in local mode

Field tests

The first 12 working units of the TESS photometer have been assembled and they are being tested under both bright and dark skies.

Most of the locations are fixed stations of the Spanish Network of Light Pollution Studies which provides SQM readings for intercomparison.

The absolute calibration will be performed on LICA-UCM optical lab and the astronomical observatory of the Universidad Complutense de Madrid.

Preliminary results of the field test show that TESS-V1 photometer is around 0.5 magnitudes more sensible than the Unihedron SQM photometer on polluted skies as Madrid.

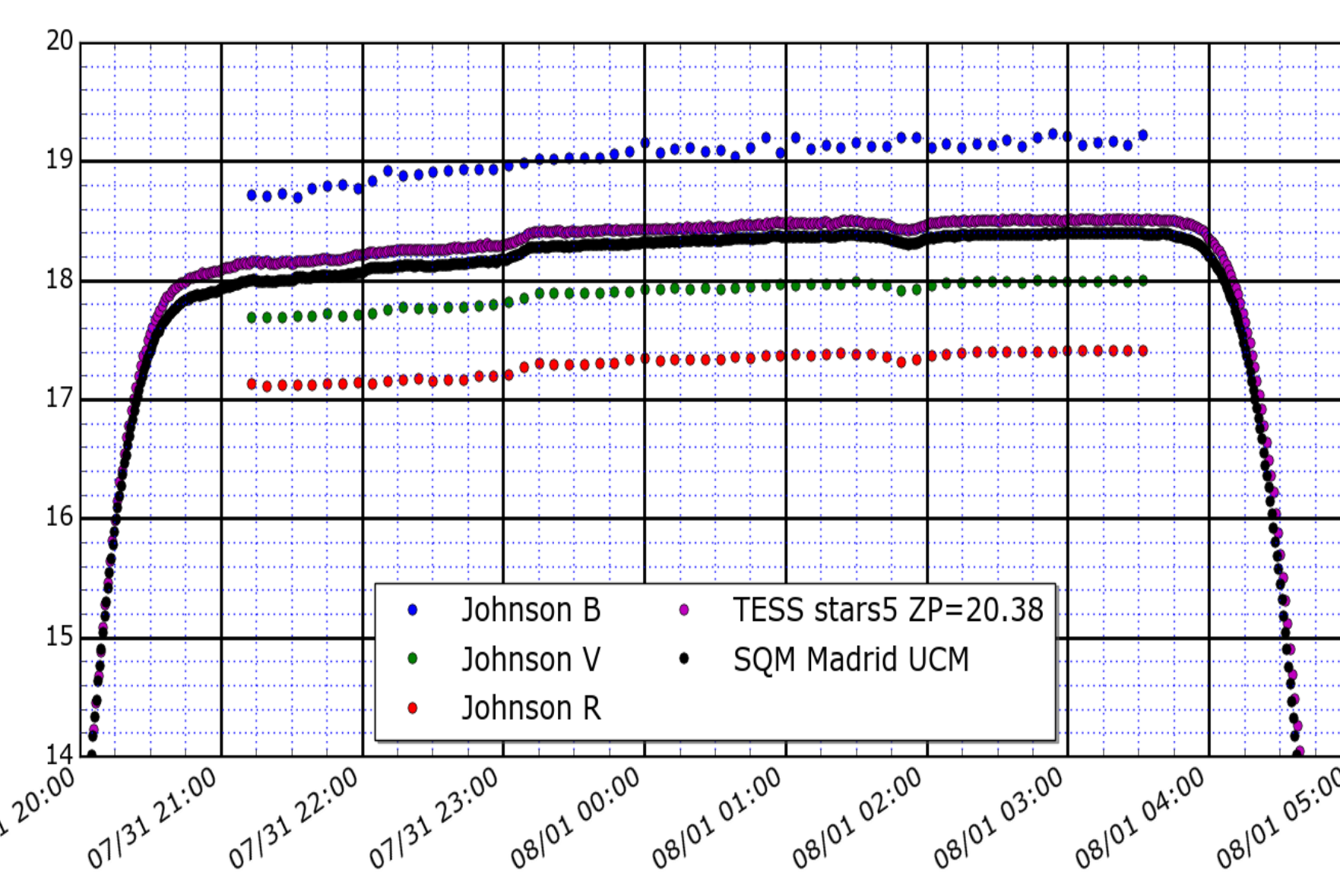The offset between SQM and TESS depends on the color of the sky, as expected.

Figure 8. (Top) NSB data obtained at UCM observatory using AstMon astronomical camera, SQM and TESS along one night .

(Left Bottom) Dependence of differences between TESS and SQM with the sky color.

(Bottom) Several TESS being tested at UCM observatory with the help of AstMon, SAND spectrometer and SQM photometers.
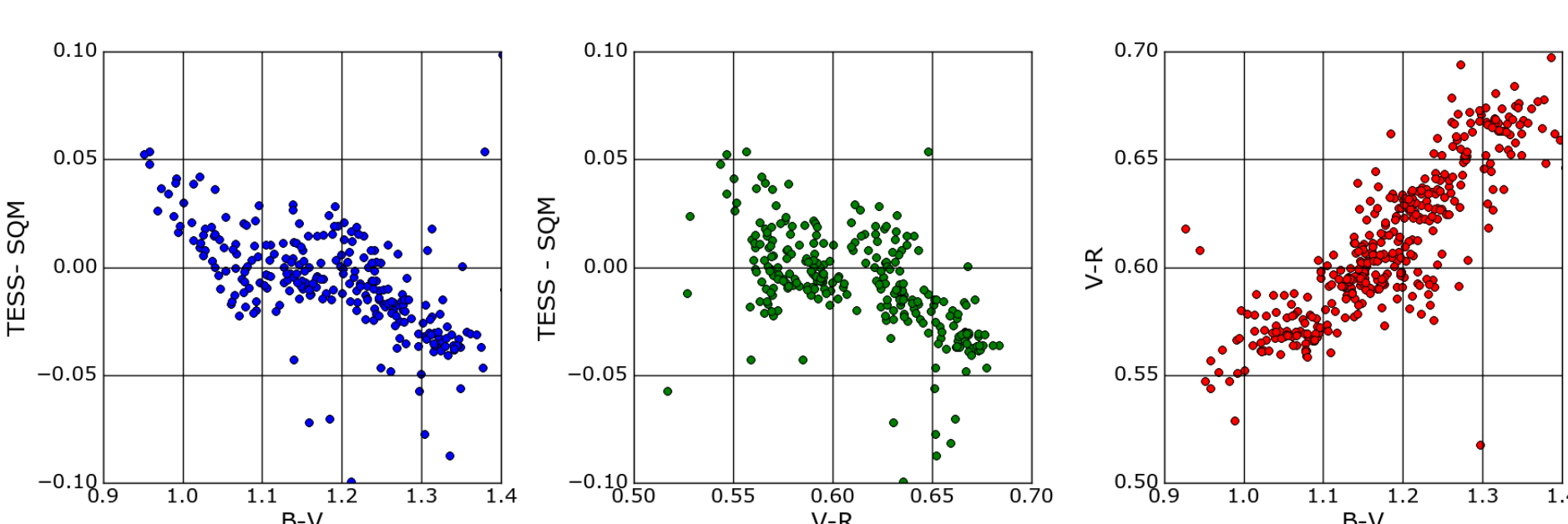
Work in progress

- The hardware and communication software are working without any problem.
- Next 70 units are being assembled.
- The photometers will be cross calibrated on the LICA-UCM optical lab.
- We hope that the photometers will be ready for distribution in the next months.

Funding