Atmospheric monitoring with the Fluorescence detector Array of Single-pixel Telescopes

Presented by Jan Ebr

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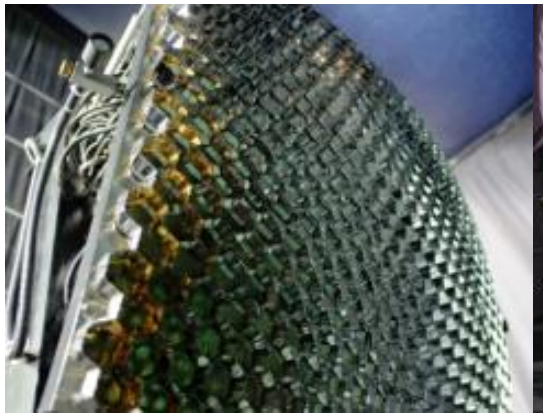
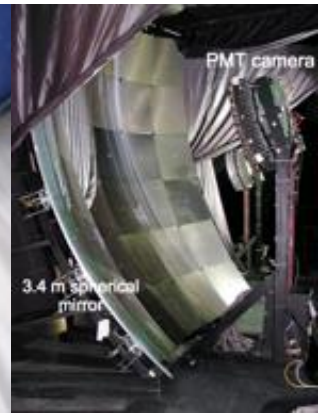
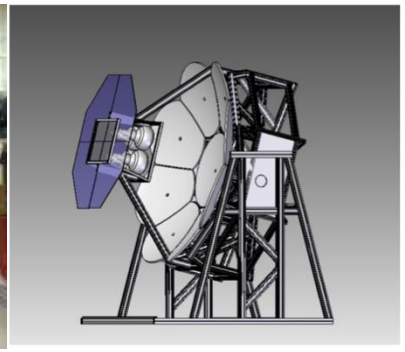
Fast - Fluorescence detector Array of Single-pixel Telescopes

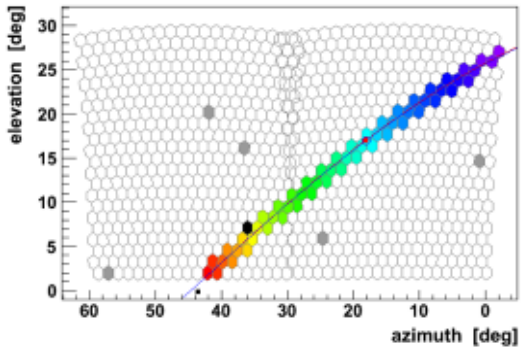
Target: > $10^{19.5}$ eV, ultrahigh-energy cosmic rays (UHECRs) and neutral particles (γ-rays, neutrinos)

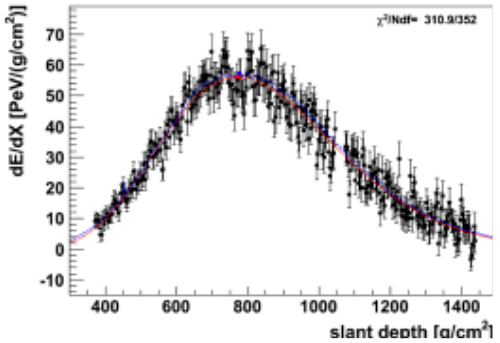




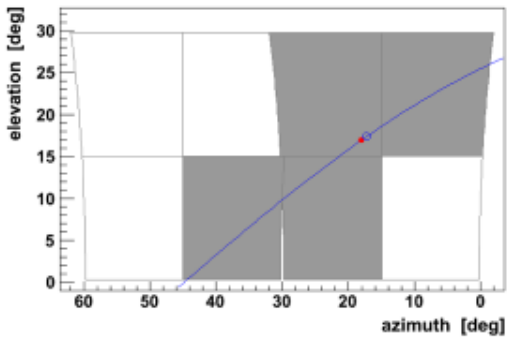
Low-cost, a few pixels telescope

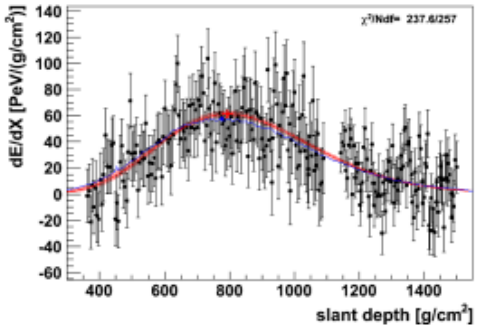






Shower profile reconstruction using given geometry

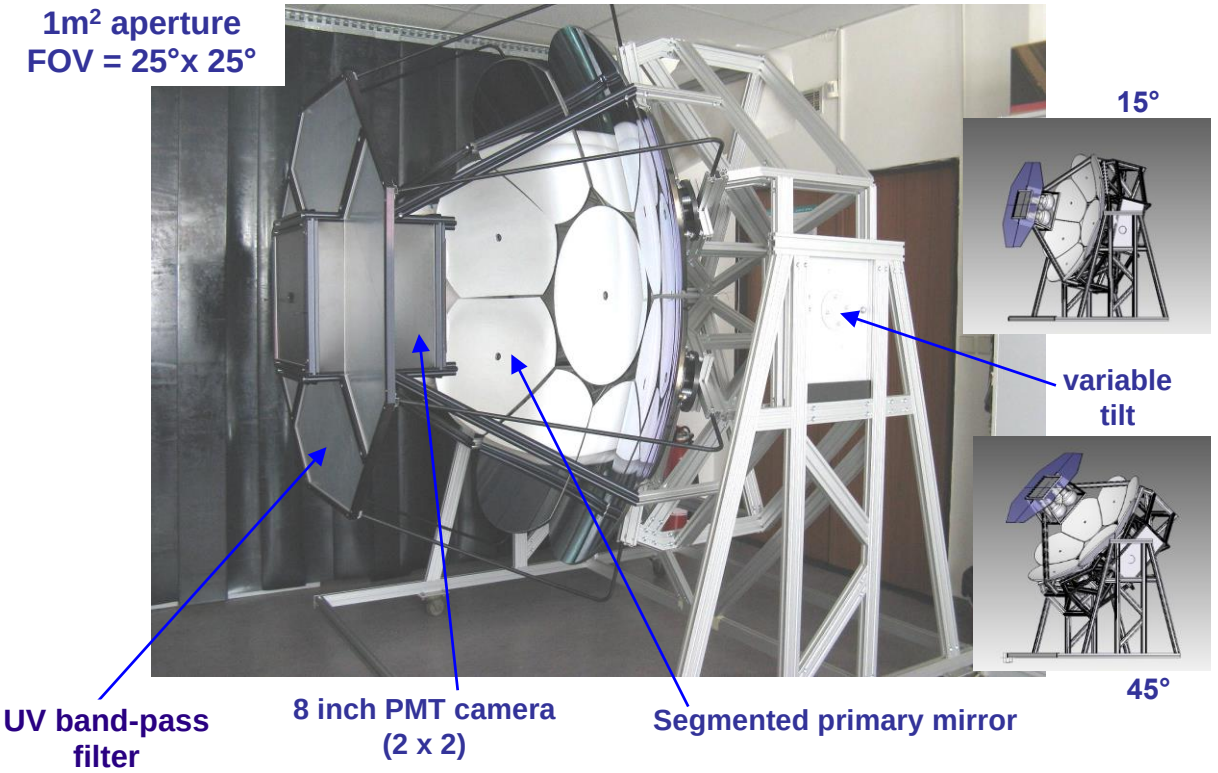




Full-scale FAST prototypes – Utah

4 PMTs (8 inch, R5912-03MOD, base E7694-01), UV band-pass filter (ZWB3)

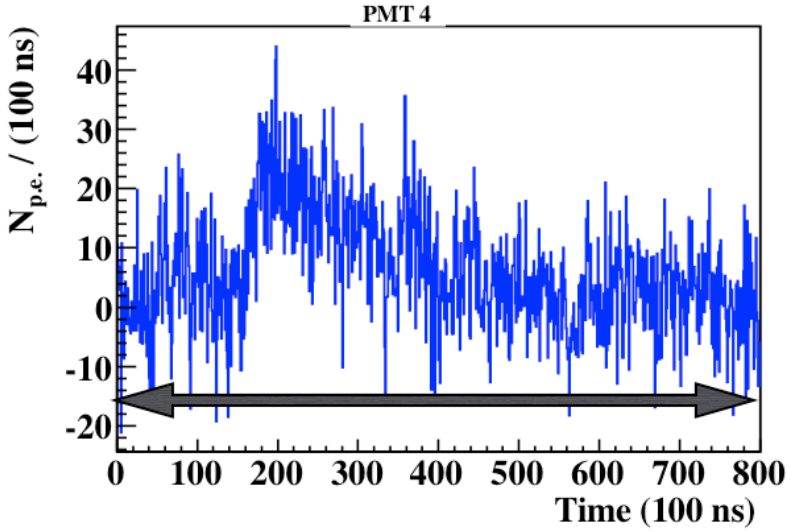
Segmented mirror of 1.6 m diameter



Telescope array FDs

FAST telescopes

Laser event

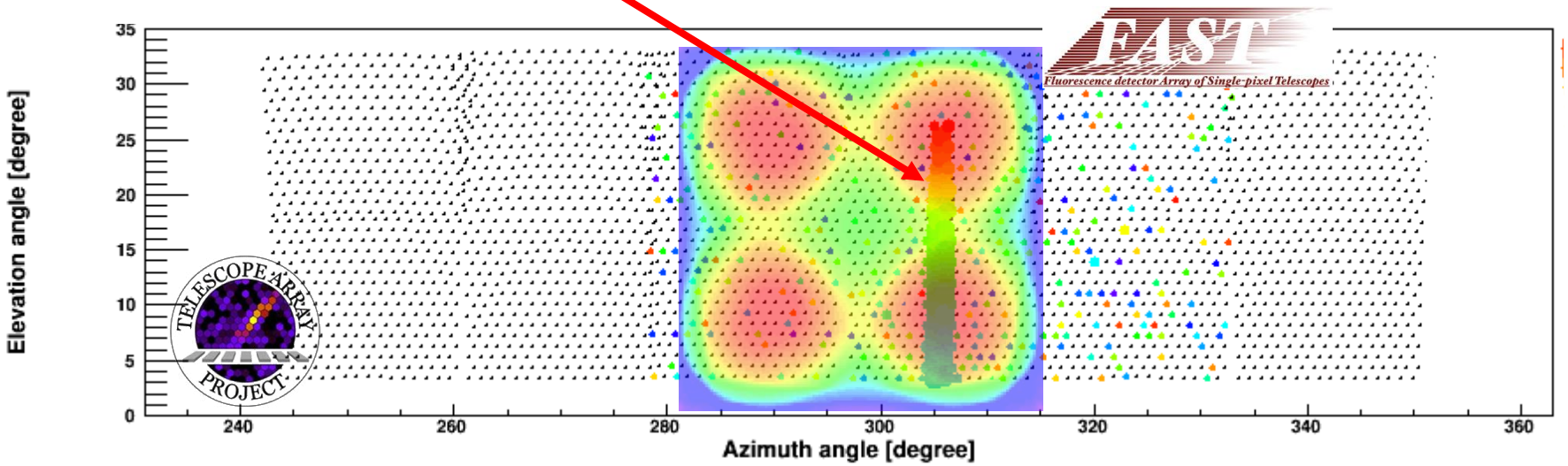


Time window 80 μs

DAQ synchronized with the external trigger of TA FD

- 12 bit, 50 MHz sampling
- Sum up 5 adjacent bins to be 10 MHz
- 80 μs trigger window

Field-of-view of this prototype is set to detect a vertical UV laser signal at a distance of 20.85 km.



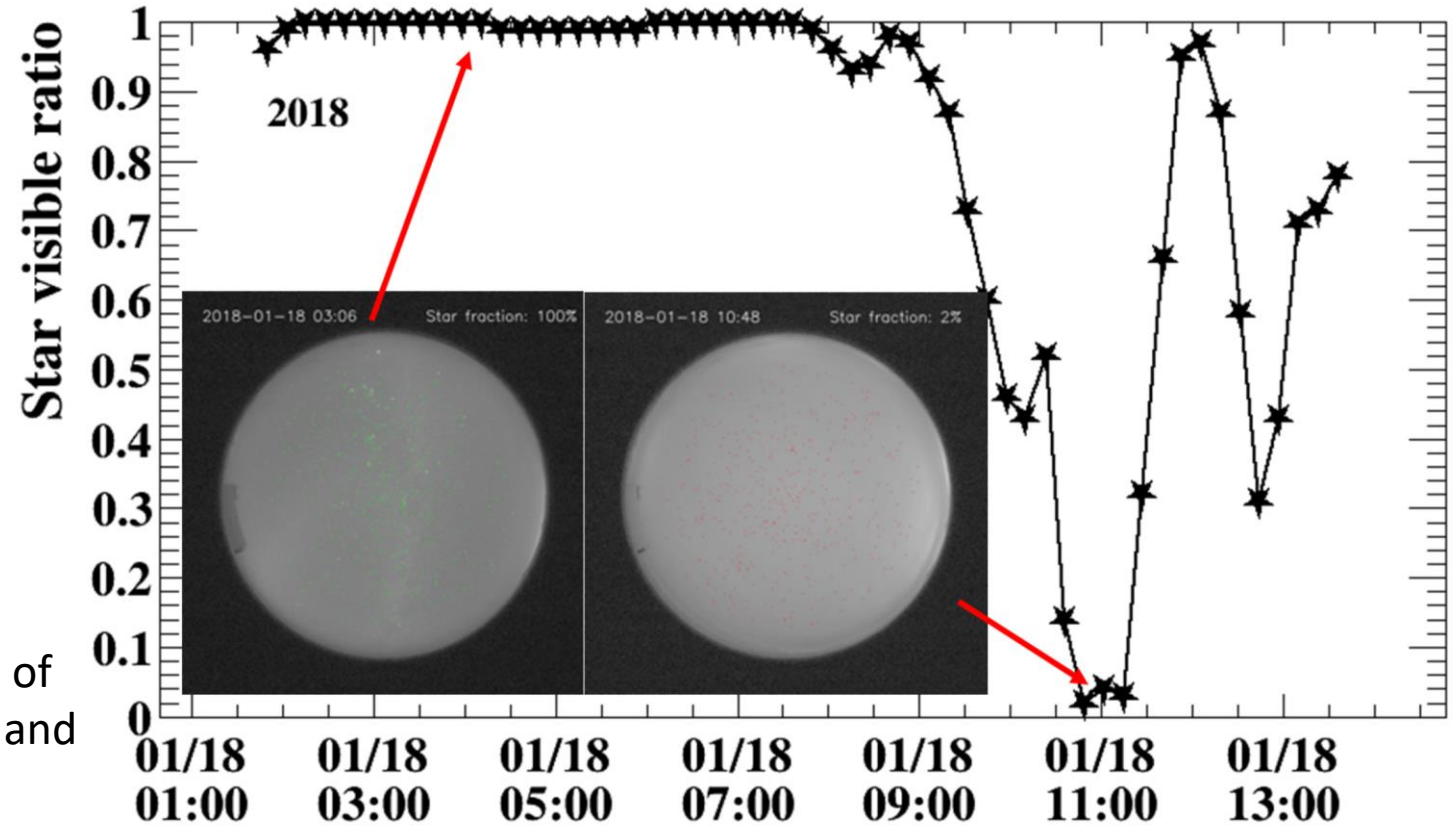
TA and FAST telescopes FOV

400 hours observation time with the FAST fluorescence telescopes has been achieved (08/2018) . We will continue to operate the telescopes and search for ultrahigh-energy cosmic rays.

FASCam – FAST All Sky Camera

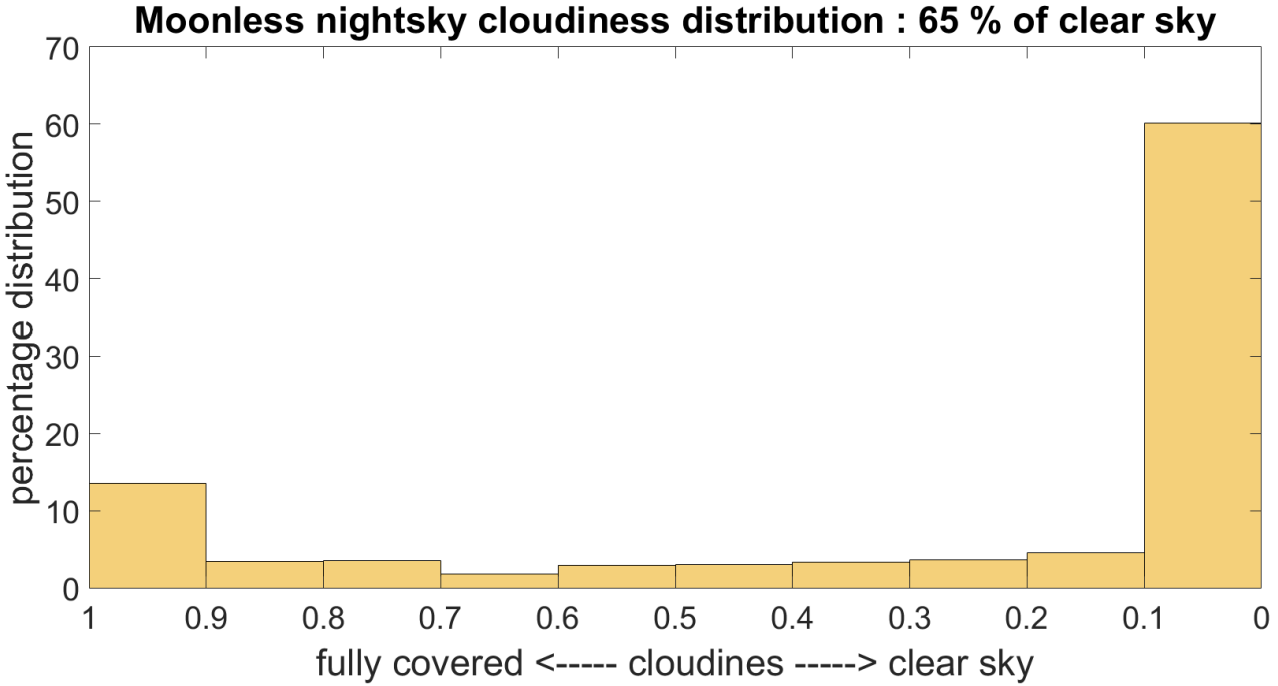
Fluorescence detector Array of Single-pixel Telescopes

The FASCam is a fully automated all sky camera designed to measure the cloud coverage. FASCam has a ~180° field of view and is equipped with a series of Johnson filters, as well as a UV filter.



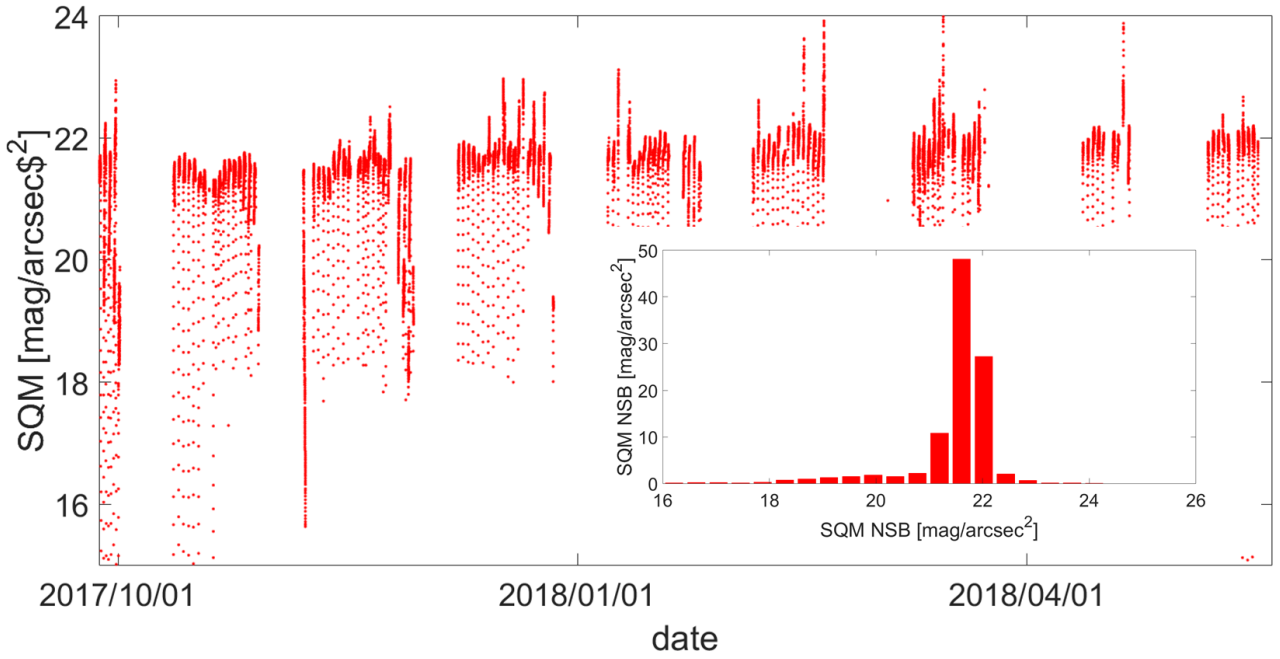
The astrometry-based cloud analysis compares images of star positions with a catalog in each wavelength band, and calculates the ratio of the number of visible to observable stars in order to estimate the could coverage. The setup is similar to that of the CTA All Sky Camera and the Pierre Auger Observatory's Background Camera

FASCam – FAST All Sky Camera



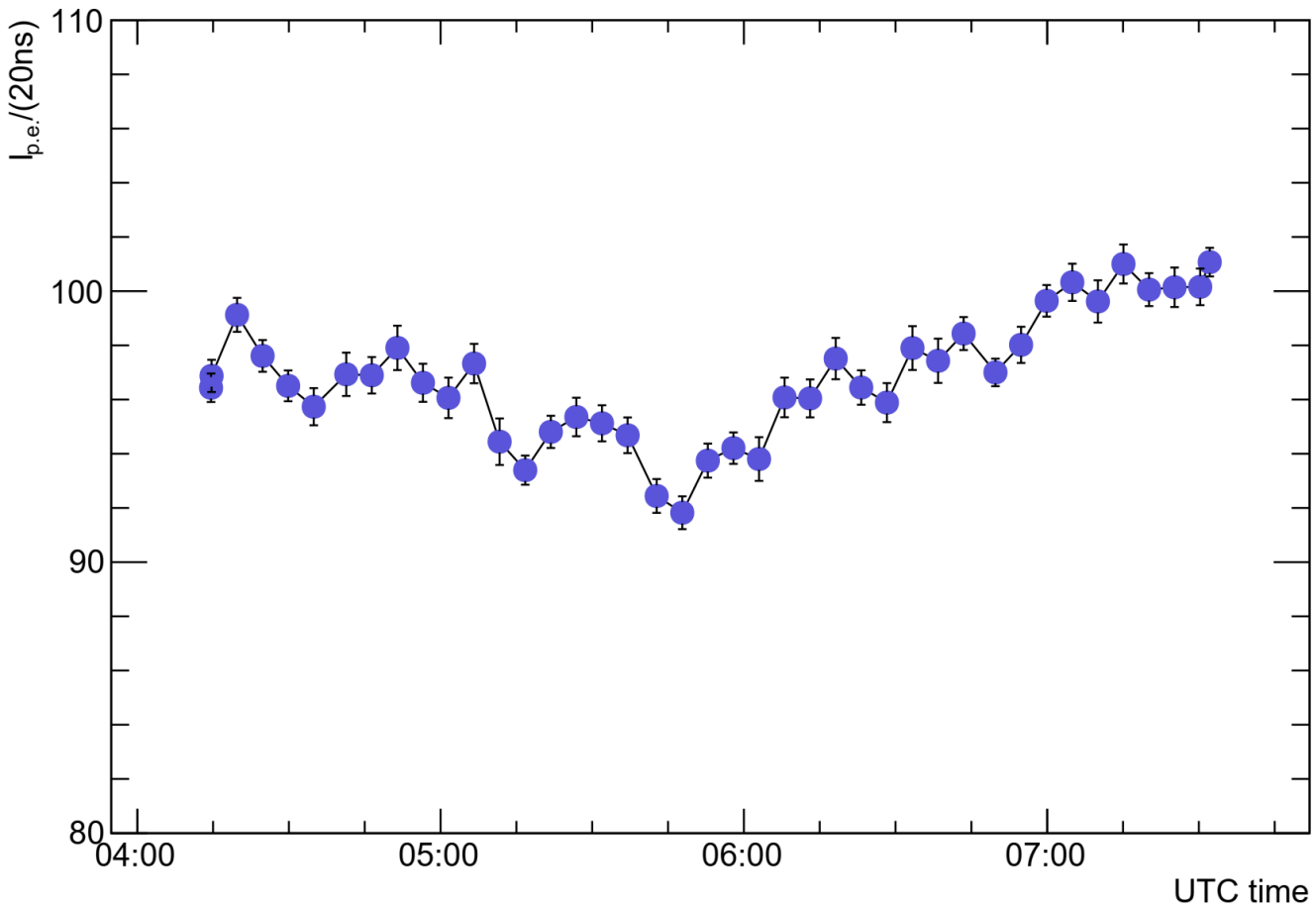
Cloudiness of the FAST site. The visible star fraction (ratio of visible stars to observable catalog stars) defines the cloudiness. A cloudiness of 0 corresponds to a cloud-free sky, while a cloudiness of 1 corresponds to an overcast sky.

SQM -Sky quality monitor



The night sky background measured using the SQM. The inset shows a histogram of the NSB. The median of the dataset is 21.6 mag/arcsec^2

Measurement of the night-sky background using the FAST telescopes



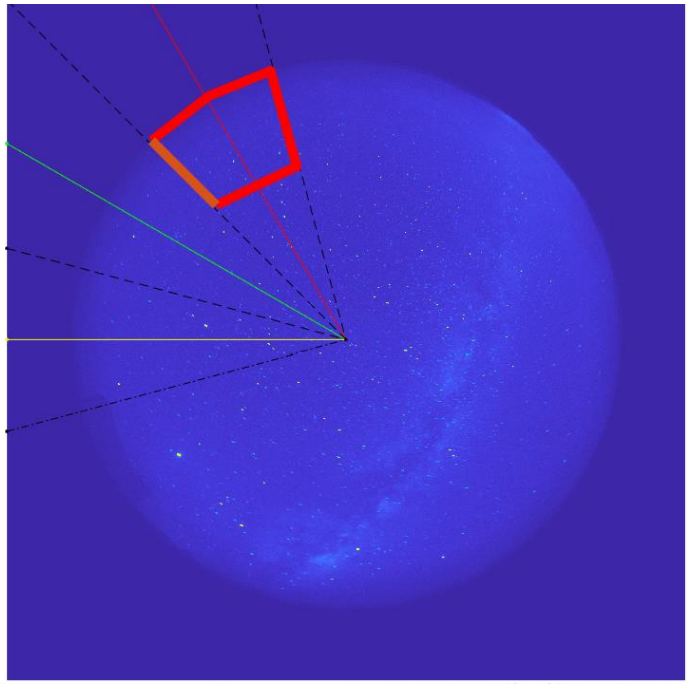
The evolution of the photocathode current during a clear-night run

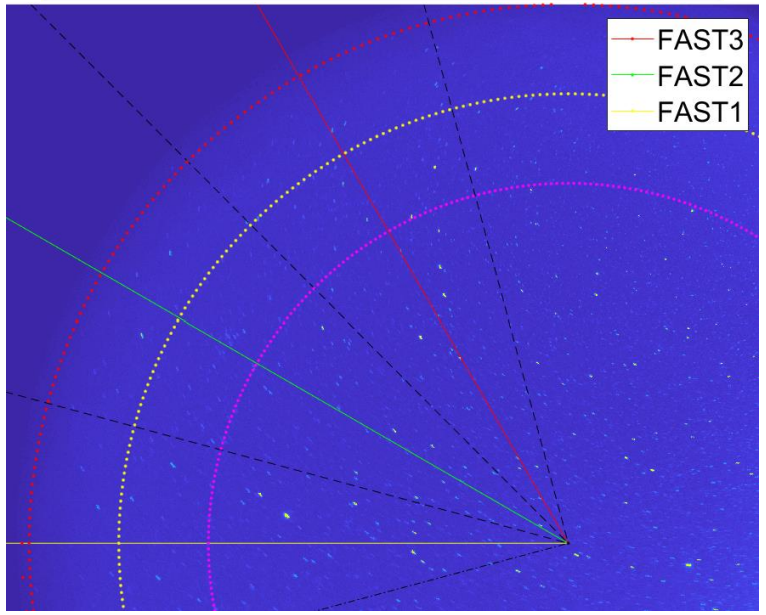
The average photocatode current I_{pe} of the PMTs in a FAST telescope is dominated by the night-sky background (NSB). The NSB is caused by bright stars, and other natural or artificial light sources.

Fluorescence detector Array of Single-pixel Telescopes

Measurement of the night-sky background using the FASCam

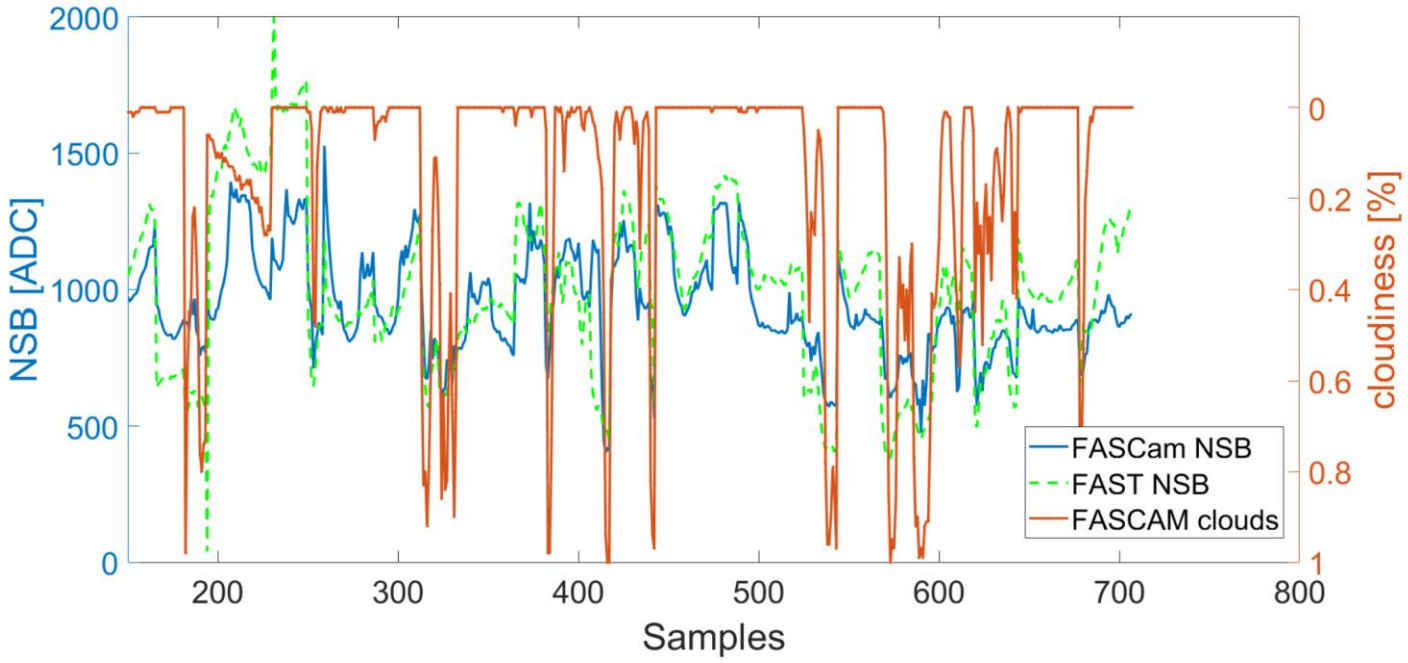
Knowledge of the night-sky background before and during data-taking is very important. The NSB decreases after sunset, and must monitored to determine the time at which it is safe to open the telescope shutter and begin data acquisition. The NSB can also fluctuate throughout the night, and can increase as a result of both artifical (such as car headlights, aeroplanes, and light pollution) and natural (eg. lightning) light sources, as well as being affected by cloud coverage and atmospheric transparency (eg. aerosols). The FASCam can be used for monitoring of the NSB in the field of view of the FAST telescopes.





The FOV of FAST telescopes.

Measurement of the night-sky background using the FASCam

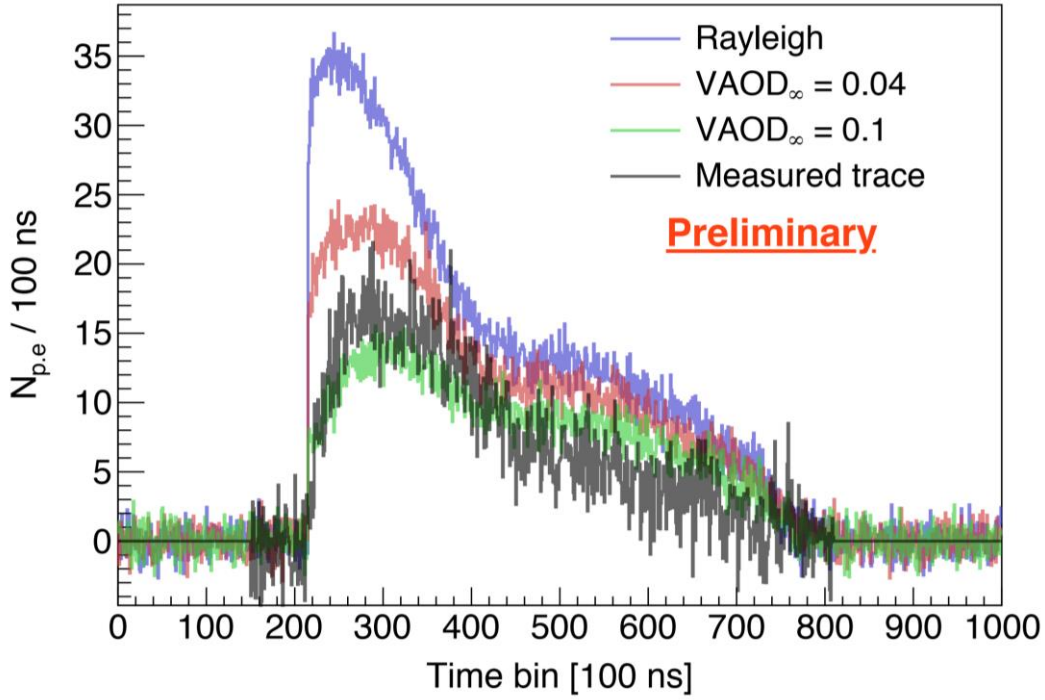


NSB comparison between FAST PMT data and FASCam images

As the pointing direction of each pixel of FASCam is calculated using photometry, we are able to map the FASCam pixels onto the FAST PMTs, and hence estimate the NSB signal from the sky exposure in the UV band. The signal is compared with the NSB from the PMTs and shows good agreement with the data.

FAST
Fluorescence detector Array of Single-pixel Telescopes

The faint fluorescence light produced during the development of an air shower is attenuated on its way to a FAST telescope due to elastic molecular (Rayleigh) and aerosol (Mie) scattering. FAST can be used as an atmospheric monitoring tool by observing vertical laser shots fired by the Telescope Array's Central Laser Facility (CLF). The TA CLF fires 300 vertical shots (~4.0 mJ at 355 nm, 10 Hz, near the middle of the fluorescence wavelength range) every 30 minutes during data taking for atmospheric monitoring purposes.



Average measured signal from 250 vertical CLF shots measured at the TA site, compared with the expectation from simulations for 3 different aerosol atmospheres. An aerosol scale height of 1 km was assumed for all atmospheres, consistent with the TA assumption.

FAST
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Conclusions

- FAST telescopes are remotely operated and we achieved 400 hours of observation in 08/2018
- The FASCam is used during the standard operation of the clouds and NSB in the FOV monitoring
- The SQM is used for the long time characterisctics of the night sky background
- The CLF could be also used for the atmospheric characterisation in the direction of the CLF facility