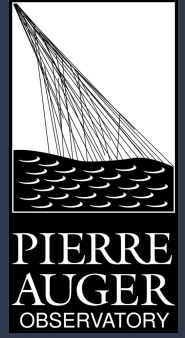

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Atmospheric calibration by the FAST telescope

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Outline

Fluorescence detector Array of Single-pixel Telescopes

What is FAST?

Where are FAST telescopes located?

Atmospheric calibration

Analysis of vertical CLF shots at Auger

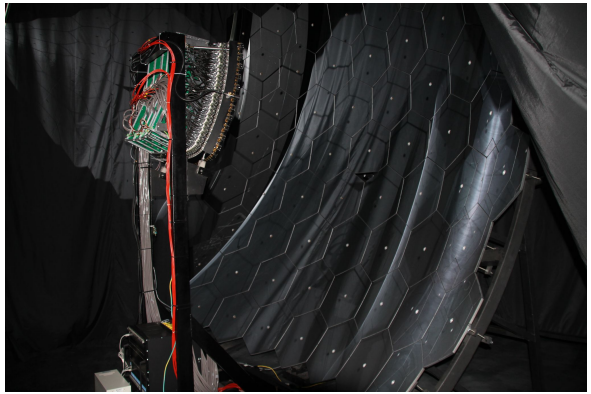
Long exposure detection of CLF

Future plans

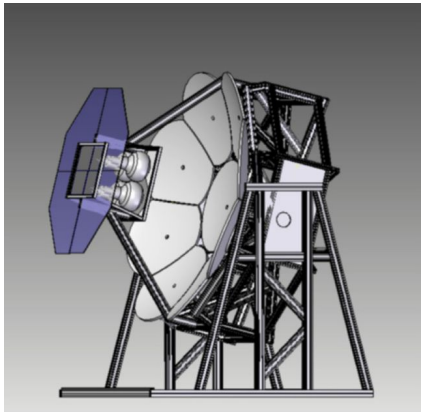
What is FAST?

FAST
Fluorescence detector Array of Single-pixel Telescopes

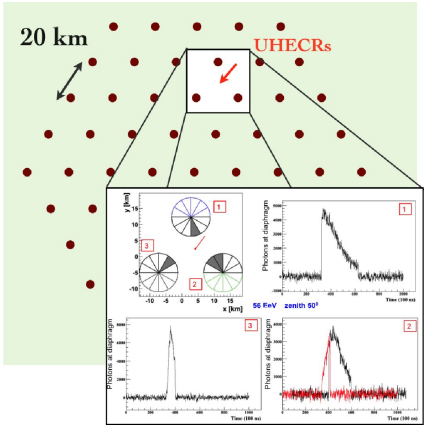
- Measuring UHECR (>10^{x20} eV)
- Fluorescence detector
- Contains 4 PMTs
- Field of view - 30° x 30°



Pic. 3: Fluorescence detector at Pierre Auger Observatory [2].

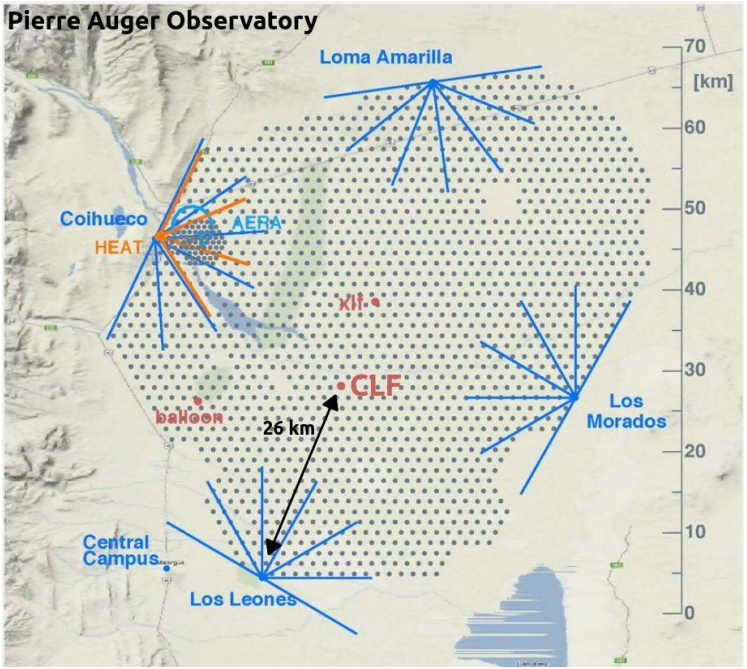


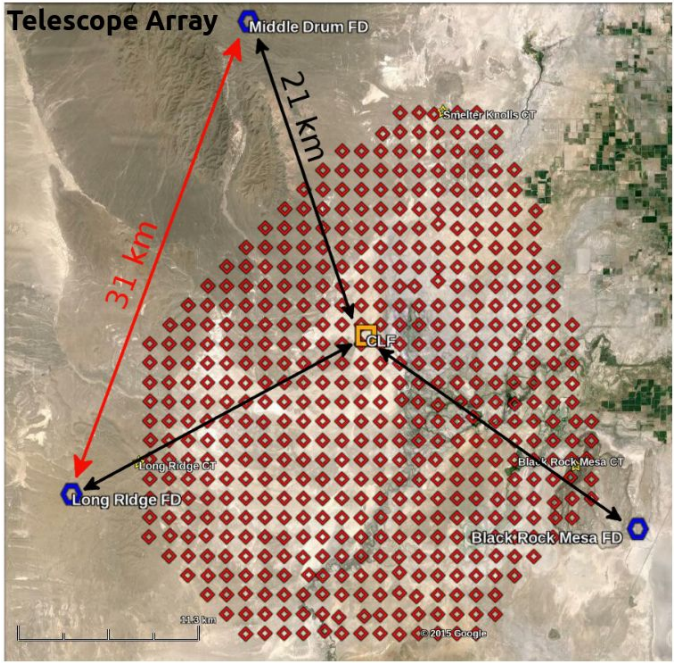
Pic. 1: Design of the FAST telescope prototype [1].



Pic. 2: Concept of array of FAST telescopes with a size of 150,000 km^2 [1].

Where are FAST telescopes located?





a) b)

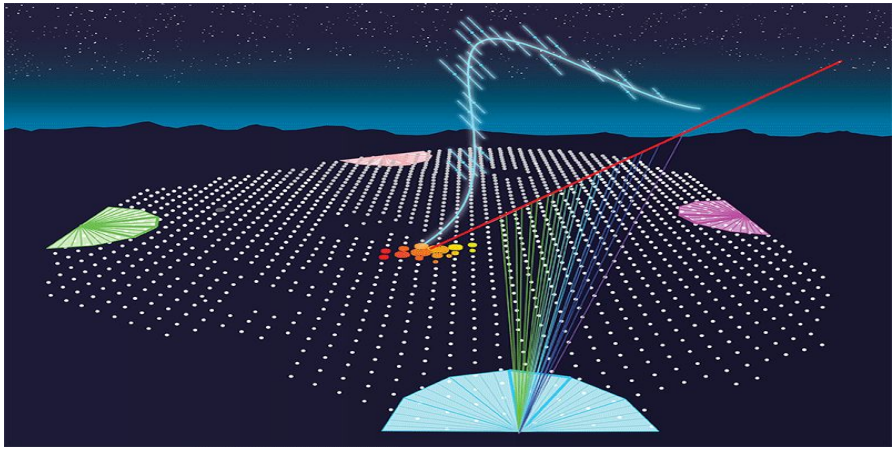
Pic. 4: Maps of a) Pierre Auger Observatory (Auger) [3] and b) Telescope Array [4] with locations of Central Laser Facilities (CLF).

Atmospheric calibration

- Detection of cosmic ray shower -> need to know optical properties of the atmosphere
  - Detection of the laser pulses (CLF shots)
  - Analysis of the data
  - Determination of atmospheric conditions - vertical aerosol optical depth (VAOD)

- VAOD used in reconstruction of the detected shower

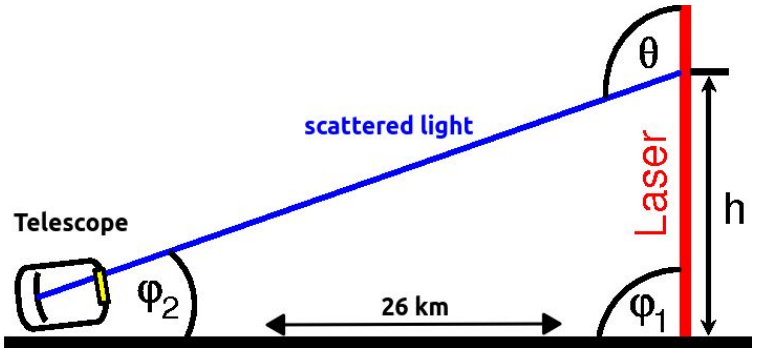
- CLF at Auger
  - Horizontal CLF shots X **Vertical CLF shots**
    - 1 shot per sec
    - precise time of shot in 100 ns



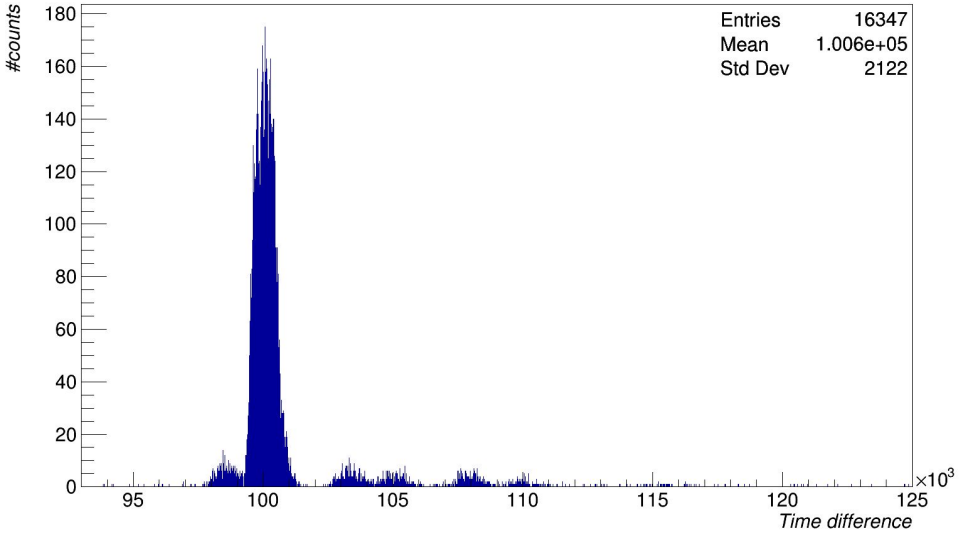
Pic. 5: Illustration of hybrid detection of cosmic-ray shower at Auger [5].

Analysis of vertical CLF shots at Auger

- Condition for selecting events contains CLF shots
  - time synchronization
  - Theoretical time delay between shot and detection by FAST is 87 μs (laser is aimed directly at the telescope)



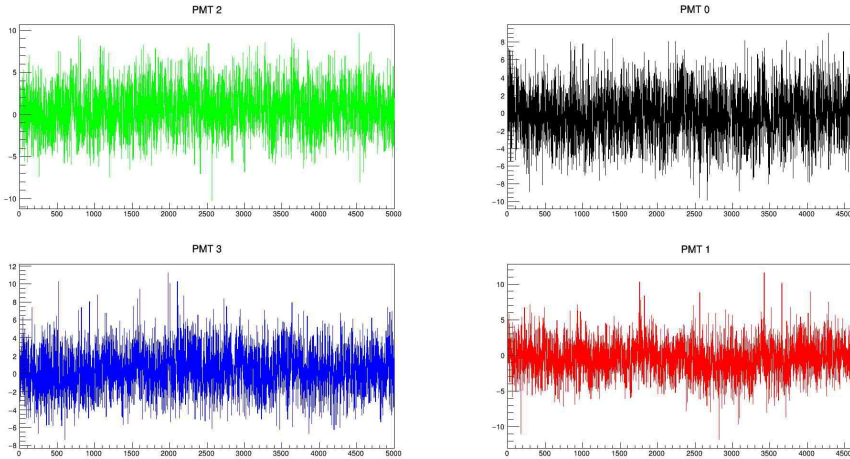
Pic. 6: Drawing geometry of CLF and telescope at Auger [6].



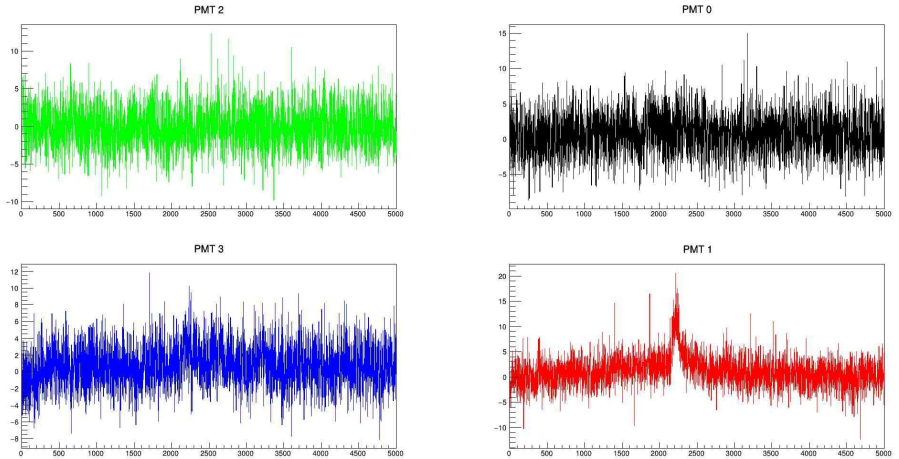
Pic. 7: Time delay between shot and trigger time of FAST telescope ta Auger.

Analysis of vertical CLF shots at Auger

- Condition for selecting events contains CLF shots
  - signal strength (optional)
- Impact of the position of the CLF in the field of view of the FAST



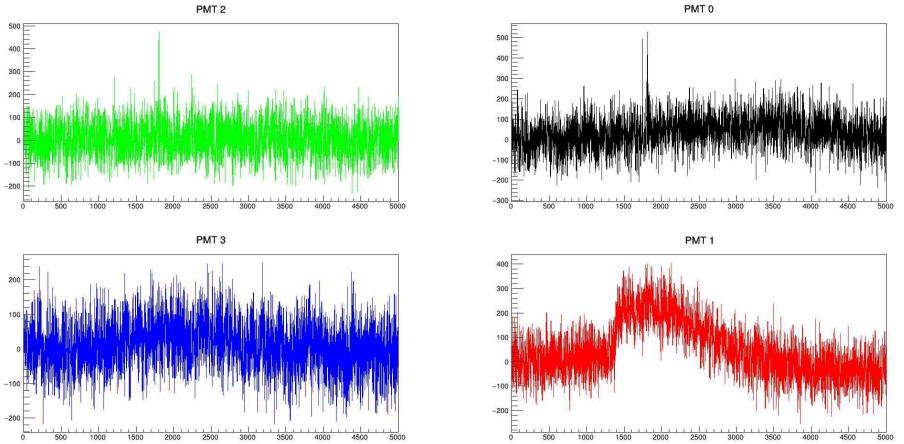
Pic. 8: Signal from CLF detected in good weather conditions or very bad conditions.



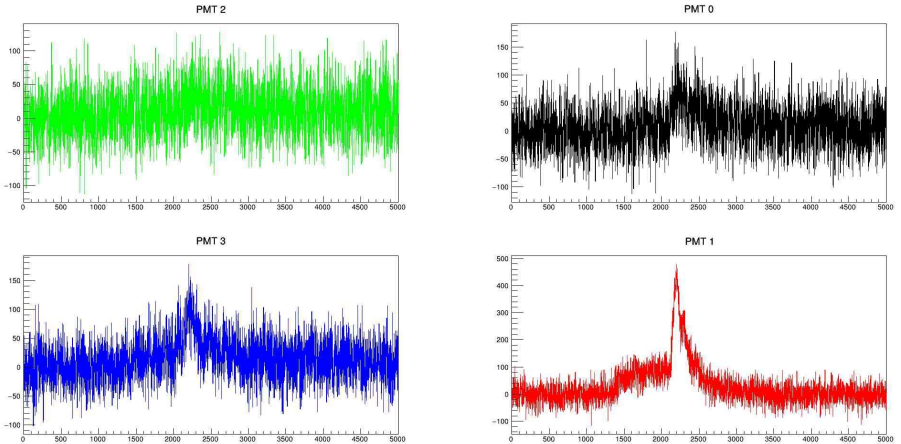
Pic. 9: Signal from CLF reflected light from clouds.

Long exposure detection of CLF

- Integration of signal from individual events - one hour
- Slow changes of aerosols in the atmosphere



Pic. 10: Signal from CLF with good conditions, signal from 200 CLF shots.

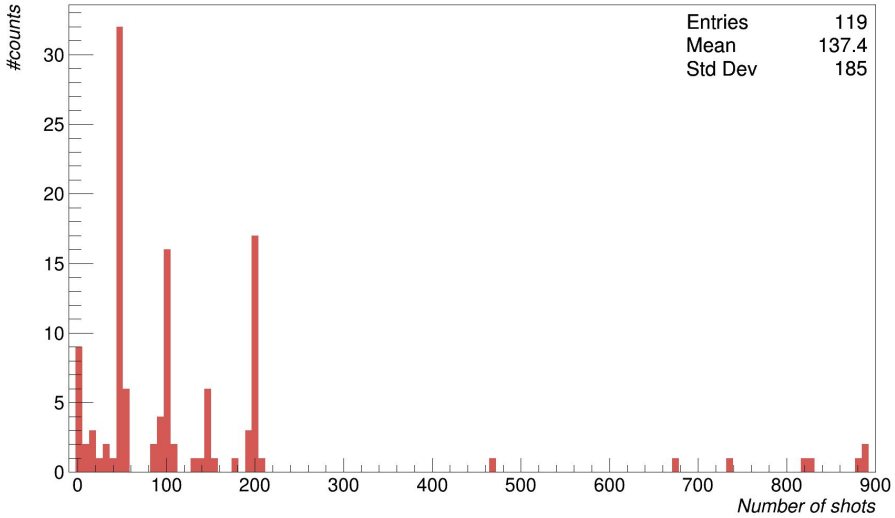


Pic. 11: Signal from CLF with reflected light from clouds, signal from 50 CLF shots.

Long exposure detection of CLF

- Possibility to integrate signal of the set CLF shots
  - one hour of measurements
  - one night

- Advantages
  - better signal to noise ratio
  - lower computational time of VAOD
  - the possibility to select time interval and study data in more detail (influence of clouds, mist, moon,...)

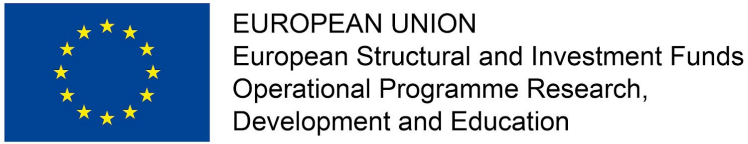


Pic. 12: Number of vertical CLF shots detected in one hour at PAO.

Future plans

- Compare data detected by FAST with data from fluorescence telescope at Los Leones PAO
- Cross-correlate the result with auxiliary systems
- Sort CLF data to categories
- Calculate VAOD
- Compare values of VAOD with other independent measurement of VAOD (FRAM, Raman lidar)
- Do same analysis on data from Telescope array
- Compare results
- Integrate the online analysis in to the FAST DAQ and correction of the real shower analysis

Acknowledge



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