EUSO-TA prototype telescope

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for the JEM-EUSO Collaboration

FRONTIER DETECTORS FOR FRONTIER PHYSICS
13th Pisa Meeting on Advanced Detectors

The JEM-EUSO mission

- Designed for the International Space Station
- Largest UV telescope in space
- First instrument able to observe an area ~10^5 km^2
- Full-sky observation

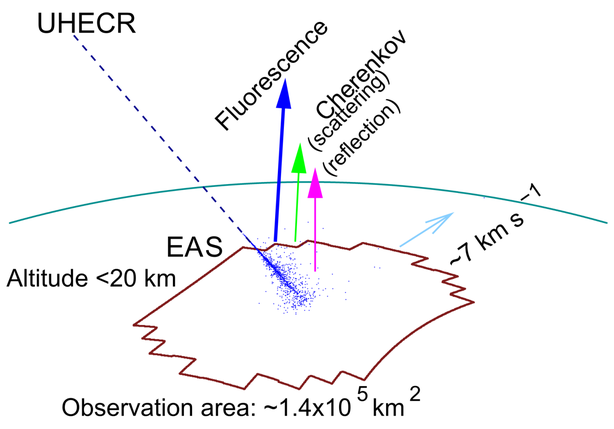
Scientific objectives

- Detection of Ultra High Energy Cosmic Rays (UHECR)
- A high statistics measurement of the trans-GZK spectrum
- Identification of sources and source regions

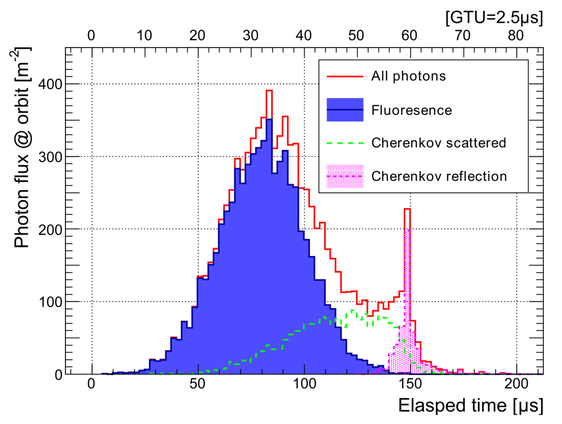
Exploratory objectives

- Study of UHE ν and γ-rays
- Study of galactic and local extragalactic magnetic fields
- Atmospheric science (lightning, night glow…)
- Meteors and meteorites

Detection principle



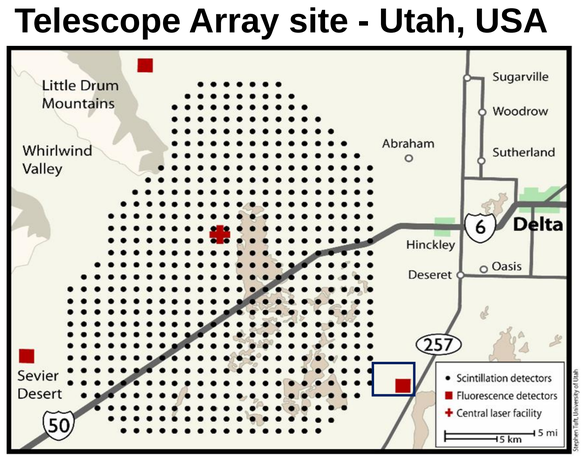
- Production of Extensive Air Showers (EAS) by interaction of UHECRs with atmospheric nuclei
- Detection of UV photons of Fluorescence and Cherenkov light from EAS

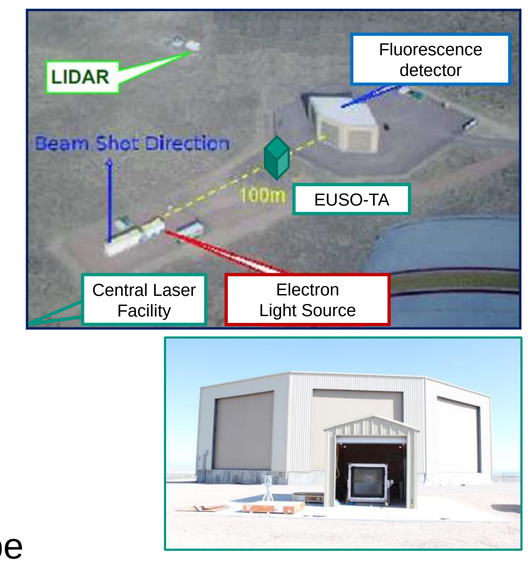


J.H. Adams Jr. et al. / Astroparticle Physics 44 (2013) 76–90

EUSO-TA prototype

Telescope Array site - Utah, USA



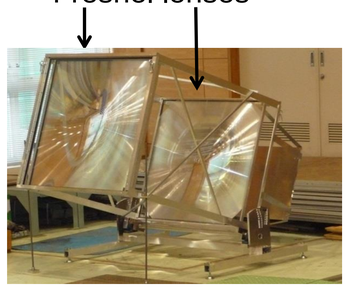


Objective

Validation of the JEM-EUSO prototype

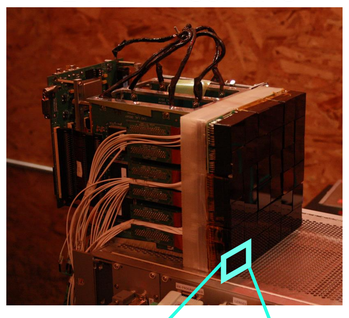
- Calibration with Central Laser Facility and Electron Light Source
- Cross-calibration with TA Fluorescence Detector through comparison of noise and signal
- Observation of extensive air showers triggered by TA

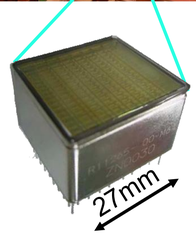
EUSO-TA design



- 2 Fresnel lenses
- 1 PDM
  - 1 PDM = 9 ECs
  - 1 EC = 4 MAPMTs
- Concave focal surface
- UV transmitting filter (330-400 nm)
- Axis elevation: 26°
- FOV: ±5.5°

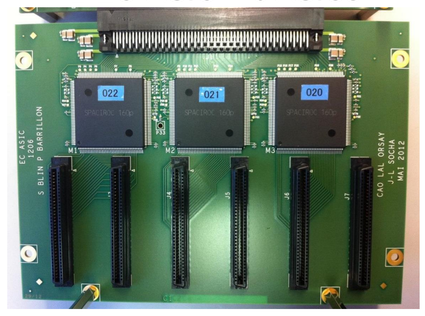
PDM
1 PDM = 36PMTs





64ch MAPMT
2.9x2.9 mm^2 /ch

EC-ASIC board
1 EC-ASIC = 6 ASICs



- Readout performed by one ASIC per MAPMT
- 3 (+3 on the back) ASICs ⟶ 6 MAPMTs
- 64 channels per ASIC

PDM = Photo-Detector Module
EC = Elementary Cell
MAPMT = Multi-Anode PMT

First measurements

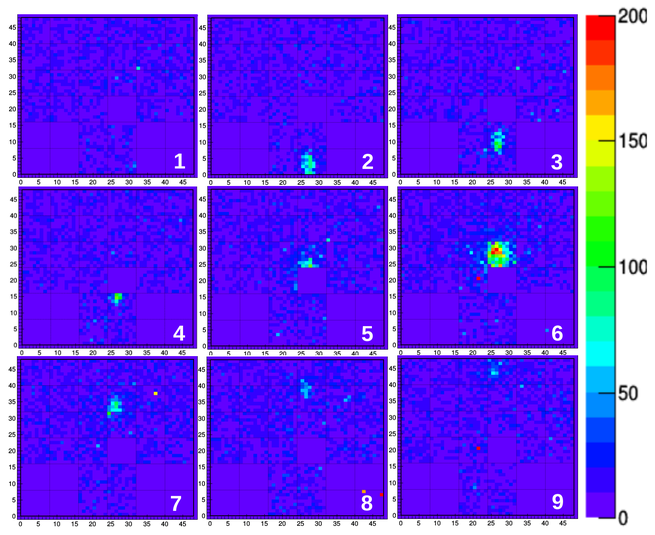
EUSO-TA campaigns

- First two campaigns in March and May 2015
- Moonless and clear sky conditions
- Trigger on TA fluorescence detectors or on portable triggering systems
- Tests using
  - Central Laser Facility (CLS) of TA
  - LEDs
  - Portable lasers
  - Airplanes
  - Stars

Next campaign (June 2015)

On EUSO-Balloon's PDM

- Self triggering of the shower
- Calibration of at least two ECs units



Laser shot from the CLF

- Shots with energy of 4-6 mJ (2.2 mJ pulse corresponds to $10^{19.2}$ eV shower seen from 21 km)
- Time evolution of the laser shot in GTUs (1 GTU = 2.5 μs)
- PDM dead time of 60 ms after data acquisition of 128 GTUs

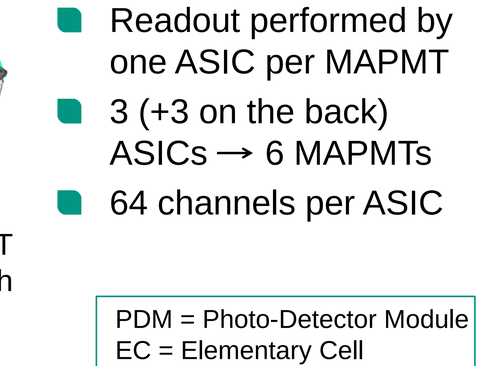
Silicon photomultipliers option

Advantages

- High gain (10^5-10^6)
- Low Voltage (<100 V)
- Excellent photon-counting capability and time resolution
- Robust enough to be used under moon light conditions
- Insensitive to magnetic fields
- Compact size
- Light weight

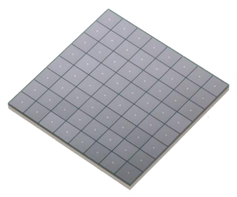
Disadvantages

- Temperature dependency: (high noise for T>30°C)
- Radiation hardness
- Sensitive λ range

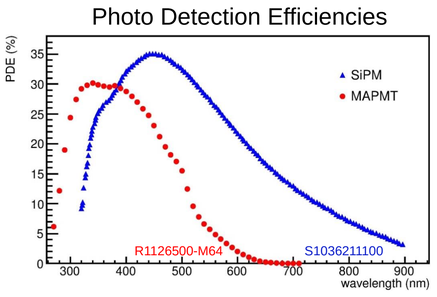


Foreseen new model of SiPM (HAMAMATSU)

- Larger active area
- Faster read out
- Better time resolution
- Size compatible with structure hosting MAPMTs



64ch TSV SiPM
3x3 mm^2 /ch



Preliminary simulations of cosmic air showers:
$N_{MAPMT} \geq N_{SiPM}$
Wider sensitive λ range ⟶ significant improvement of photon detection

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