The EUSO-TA detector: status and performance

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The EUSO-TA experiment

A single-photon UV detector – an on-ground EUSO telescope
The EUSO-TA experiment

A small single-photon UV detector – an on-ground EUSO telescope

- Optimised for looking from space (time, pixel size)

See “The EUSO missions to study UHECR from space: status and perspectives” by M. Casolino on Saturday.
The EUSO-TA experiment

A small single-photon UV detector – an on-ground EUSO telescope

- Optimised for looking from space (time, pixel size)
- Focal surface: $17 \times 17$ cm, 36 MAPMTs, 2304 pixels
The EUSO-TA experiment

A small single-photon UV detector – an on-ground EUSO telescope

- Optimised for looking from space (time, pixel size)
- Focal surface: 17 × 17 cm, 36 MAPMTs, 2304 pixels
- Two 1 m² Fresnel lenses
- Field of view: \( \sim 10.6° \times 10.6° \)
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- Mount: fixed az angle, \( 0° – 30° \) alt angle
- Sampling rate: 2.5 \( \mu s \) (30 ns single pulse resolution)
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- Mount: fixed az angle, $0^\circ - 30^\circ$ alt angle
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- Location: in front of Black Rock Mesa TA FD station, Utah, USA
The EUSO-TA experiment

Work modes:
- External trigger – trigger from TA the main mode of operation for detecting UHECR
- Internal trigger (undergoing testing) (not optimized for ground observations)
- Untriggered data taking

Main aims:
- Tests/modifications of electronics for other EUSO experiments
- Calibration with TA’s facilities (CLF & ELS) and EUSO lasers/LEDs
- Gathering data (CR and artificial) for testing algorithms/software
- Comparison with TA results for CR and artificial sources
- Measurement of the UV night background
EUSO-TA campaigns

EUSO-TA had 5 observation campaigns:

**February/March 2015**  Detector installation & initial observations

**May, Sep., Oct., Nov. 2015 & Oct. 2016**  Cosmic ray and lasers observations

Observation statistics:

- Days with any observation: 58
- Good UHECR trigger data: 130 h
- Data with other trigger: 21 h
- Detected UHECR: 9 (∼ 1 event/week)
- Meteors: 5
UHECR, confirmed track

All shower parameters come from Telescope Array:

- $E \approx 10^{18} \text{ eV}$
- Distance: 2.5 km
UHECR, confirmed track

An event moving through 2 frames

Preliminary data from TA:

- \( E \approx 10^{18.63} \text{ eV} \)
- Distance: 6.7 km
UHECR, confirmed track + simulation

Preliminary data from TA:

- \( E \approx 10^{18.36} \text{ eV} \)
- Distance: 2.6 km

See poster “Simulation study of the detected and expected events for the EUSO-TA fluorescence detector” by F. Bisconti
UHECR statistics

UHECR seen by EUSO-TA over all TA events in EUSO-TA field of view

See poster “Simulation study of the detected and expected events for the EUSO-TA fluorescence detector” by F. Bisconti
Central Laser Facility

- Distance from EUSO-TA: 21 km
- Shoots 300 shots for 30 s (10 Hz) every 30 minutes

Energy: $\sim 3-7 \text{ mJ} (4 \text{ mJ} \approx 10^{19} \text{ eV}, \text{ intrinsic spread } \sim 6\%)$
Central Laser Facility

- Distance from EUSO-TA: 21 km
- Shoots 300 shots for 30 s (10 Hz) every 30 minutes
- Energy: \( \sim 3-7 \) mJ (4 mJ \( \approx 10^{19.2} \) eV, intrinsic spread \( \sim 6\% \))

Reconstructed brightness spread \( \sim 5\% \)
Laser tests

Global Light System mobile laser:

- Movable – in a trunk, energies 1–89 mJ, automatic change of pointing
Laser tests

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- Sweep in energy → laser @ 33 km threshold 2-4 mJ

![Graph showing the relationship between laser energy and laser track brightness]
Laser tests

Global Light System mobile laser:
- Movable – in a trunk, energies 1–89 mJ, automatic change of pointing
- Sweep in energy → laser @ 33 km threshold 2-4 mJ
- Sweep in direction → testing direction reconstruction algorithms

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Limiting magnitude in B Johnson filter: $\sim 5.5$ on sums of 1280 frames

PSF from stars: elliptic, $\sim 3$ and $\sim 2.5$ pixels FWHM

(See poster “Point Spread Function of EUSO-TA detector” by Z. Plebaniak)
Meteors

- Five candidates so far (meteors are vetoed by default)
- All cross $>2^\circ$ in $<1$ s (5 mach airplane 100 m above does $<1^\circ$ in 1 s)

Dedicated observations, with additional hardware, planned in the future

See poster “Study of Fast Moving Nuclearite and Meteorite using High Sensitivity CMOS Camera with EUSO-TA” by F. Kajino
Thunderstorm lightcurve

Lightcurve of observations performed during thunderstorm (judged by eye) not in our FoV – average number of counts on the whole PDM vs frame (GTU).

Gives information how to recognise thunderstorm in other EUSO missions
Clouds

EUSO-TA can see (some) clouds in UV if we use a flat frame
Summary

EUSO-TA had 5 campaigns since 2015. We have seen:

- 9 UHECR
- 5 meteors
- stars, planes, thunderstorms, clouds

Other achievements:

- the EUSO hardware was extensively tested
- prompted changes (already introduced in EUSO-SPB and Mini-EUSO)
- upgrade planned this Autumn
  - increased sensitivity (new SPACIROC 3 ASIC)
  - self triggering on fast and slow timescales (Zynq FPGA board)

EUSO-TA will remain a critically important test apparatus for future EUSO missions

We are deeply grateful to Telescope Array collaboration for all the help!