Results from the first missions of the JEM-EUSO program

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PoS(ICRC2019)251

Introduction

- **The JEM-EUSO program is a complex effort devoted to the study of UHECR at the most extreme energies**
- **No experience of EAS fluorescence detection from space available**
- **Main points presently open:**
  - **Estimate the Earth UV emission from space**
  - **Test the energy threshold of the instruments based on real data**
  - **Simulations validation**
  - **Study the impact of other types of source (meteors, clouds, lightnings, planes, cities, TLEs...)**

EUSO-TA

L. Piotrowski this ICRC

Since 2015 in operation

Detection of Extensive Air Showers in coincidence with BRM of TA

TA provides trigger and the reconstructed shower parameters

Purpose:

- **Increase the readiness of the JEM-EUSO hardware**
- **Study the performances of the JEM-EUSO detectors**

(C) Oscar Larsson

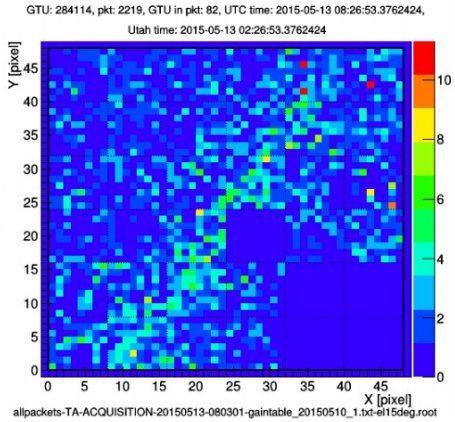
Cosmic ray shower

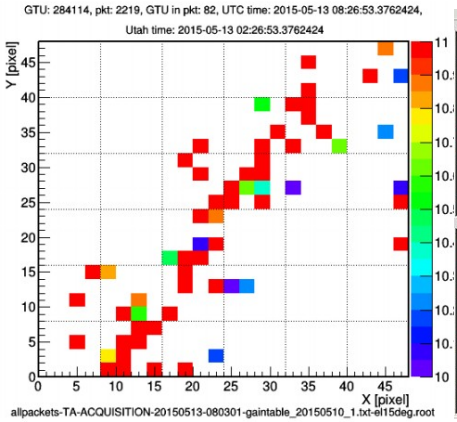
$E=10^{18.38}$ eV

θ= 41.2 deg

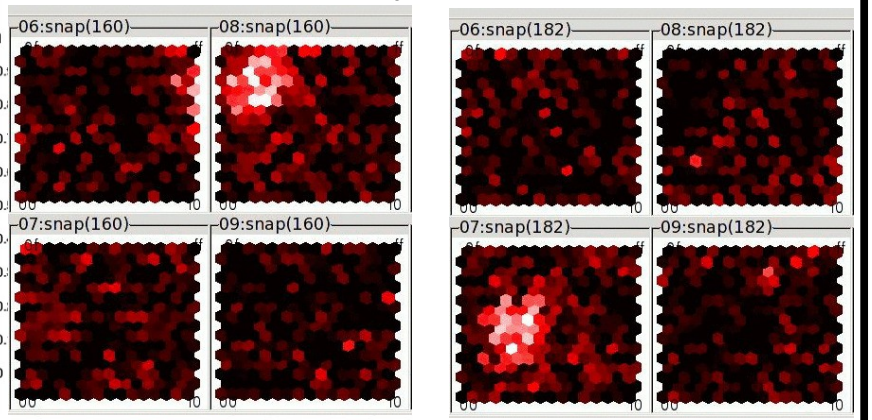
φ= 114. deg

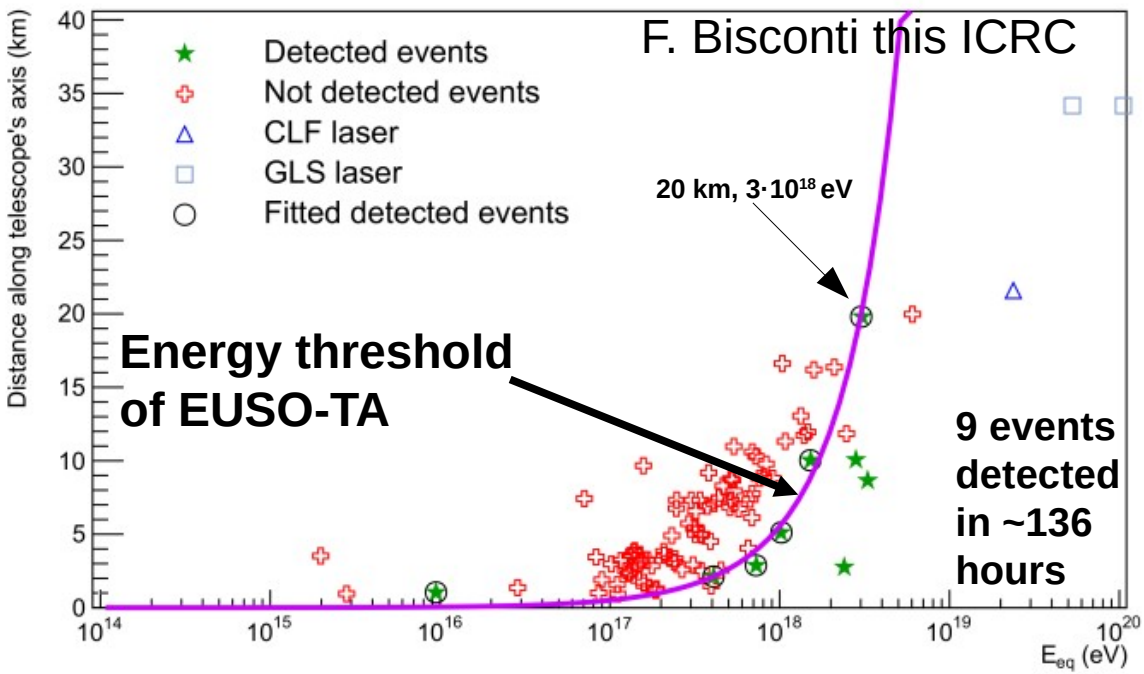
R_p=6.7 km





Courtesy of the TA collaboration



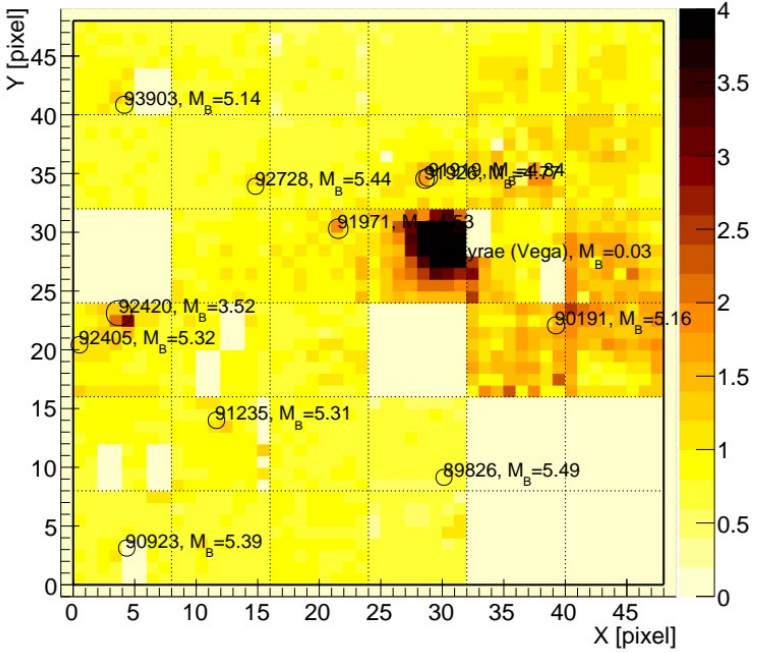


EUSO-TA

Lasers and Cosmic Ray events allow to determine energy threshold of the detector (E_{thr})

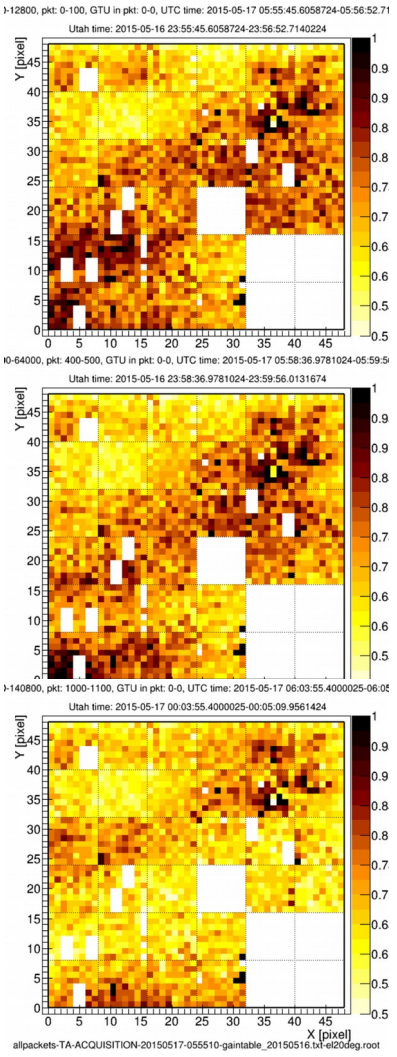
E_{thr} can be rescaled to other detectors of JEM-EUSO

EUSO-TA

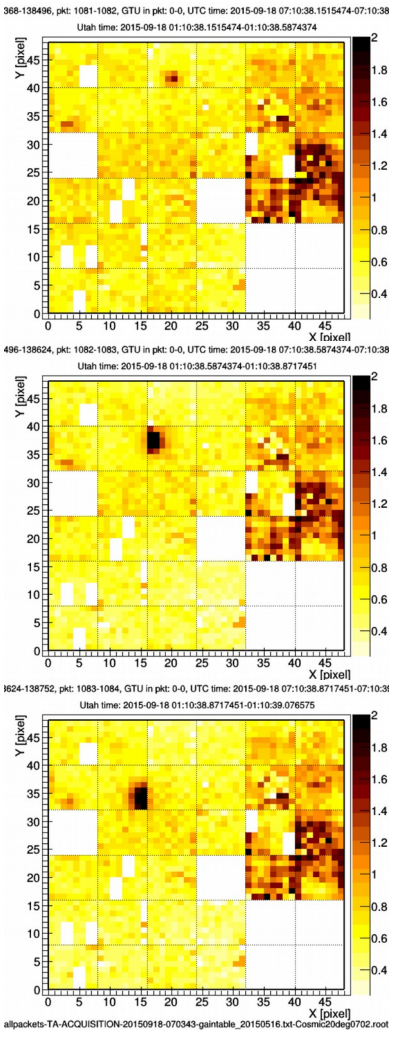


Stars are also used for calibration
(Z. Plebaniak this ICRC)

Clouds



Meteor



Data can be analyzed offline (e.g. used for the design of the trigger)

Meteors, clouds, planes, lightnings can be detected and analyzed

Images: L.Piotrowski

EUSO-Balloon

One night flight to test the operation of the detector in stratospheric environment

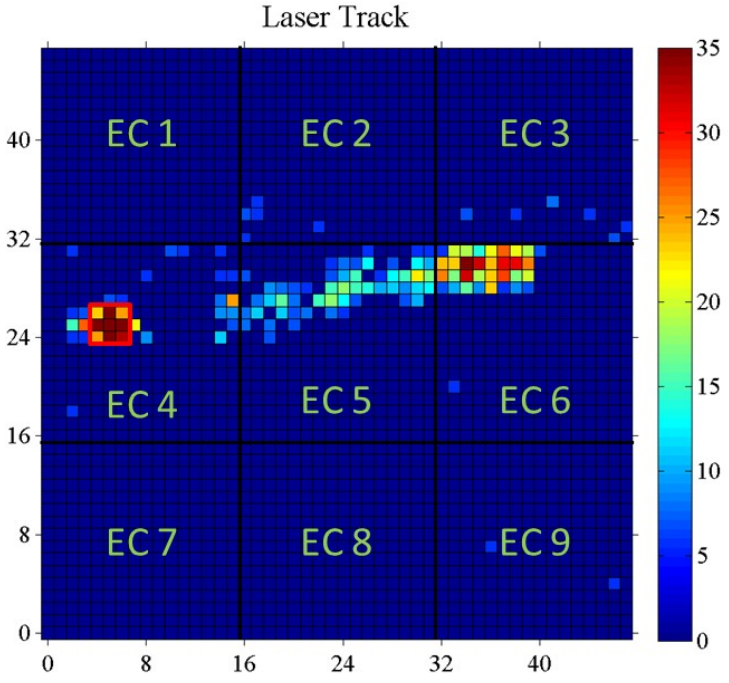
Floating altitude ~38 km

Helicopter-borne laser source to reproduce EAS like signal

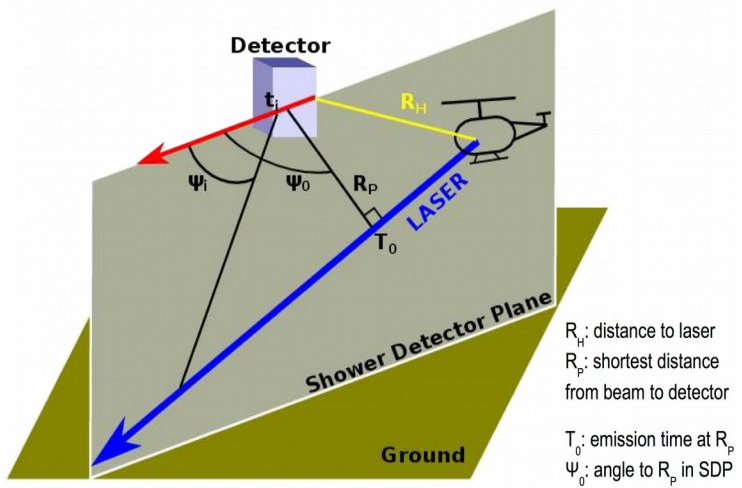
Mapping the UV Earth emission

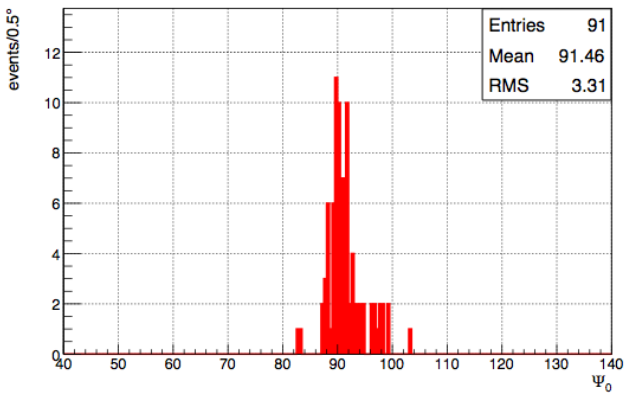
Aug. 25th 2014
Timmins, Canada

EUSO-Balloon



J. Inst. Vol 13 (2018)





An EAS signal is reproduced by a laser

LED and flasher also installed

Fit on the track to reconstruct the direction

Calibration with LED signal (laser is too bright)

EUSO-Balloon

The JEM-EUSO coll.
Astrop. Phys. 111 (2019)

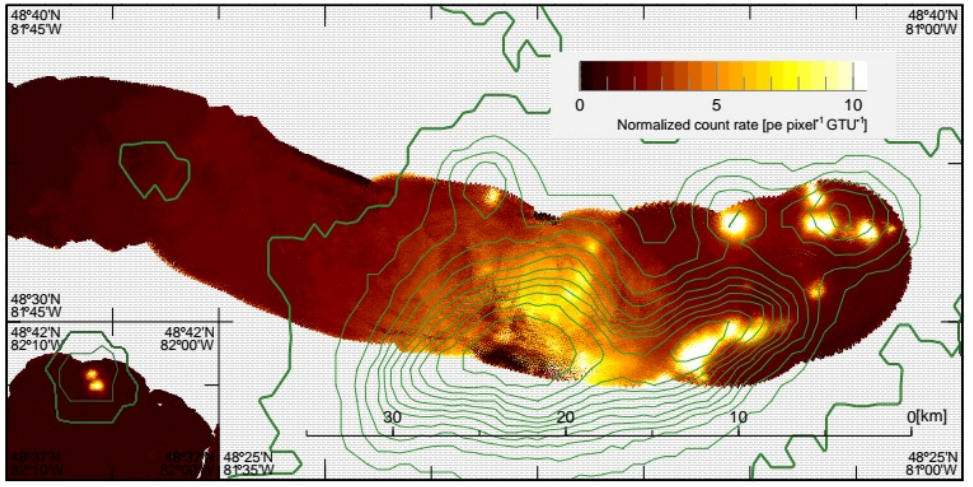
Earth emission was measured over the ~100 km flight

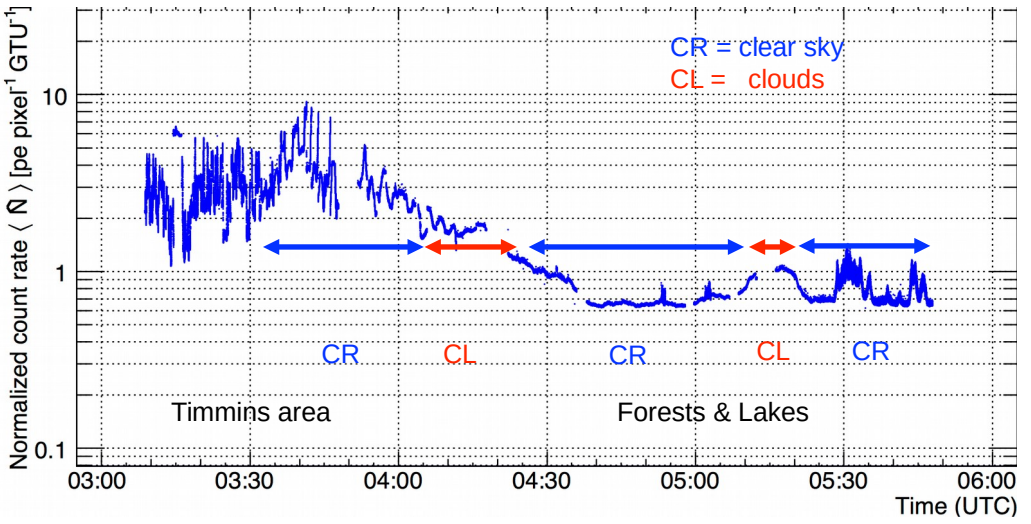
Estimate on dark condition ~0.65 CTS / pixel / frame

Cloud presence implies a factor 2 higher emission

Over cities factor ~10 higher emission

Measurement valid for balloon flights (direct airglow not visible)



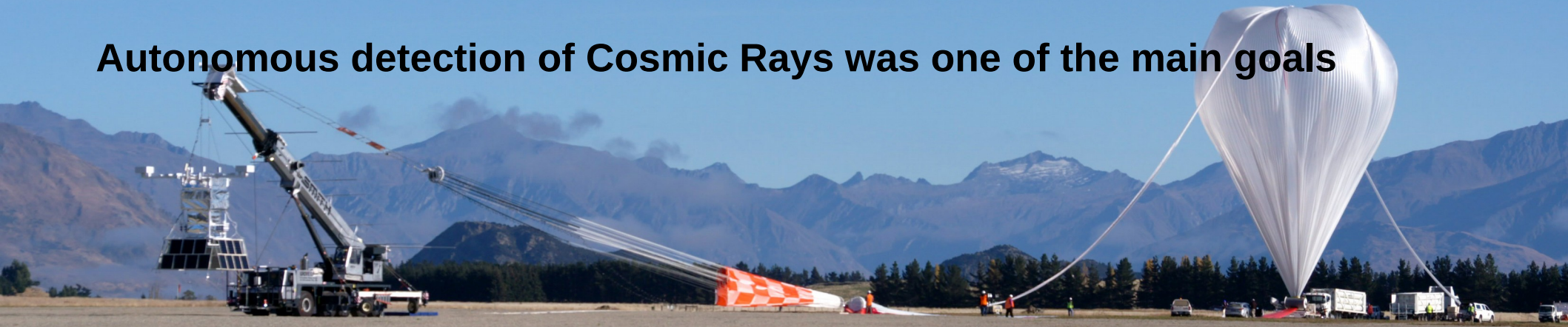


EUSO-SPB1

The EUSO-SPB1 mission was designed to fly 100 days on a Super Pressure Balloon

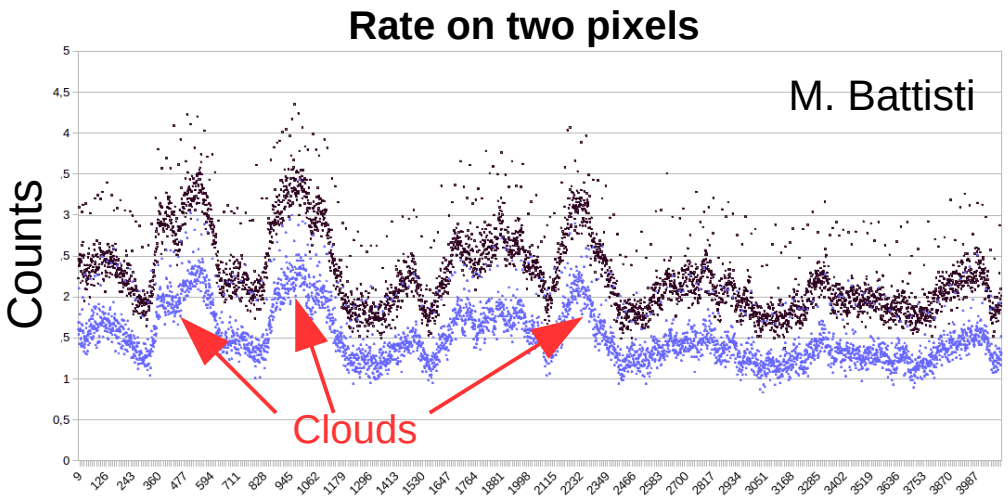
The detector was equipped with trigger logic and transmission equipment

Autonomous detection of Cosmic Rays was one of the main goals



April 25th 2017
Wanaka, New Zealand

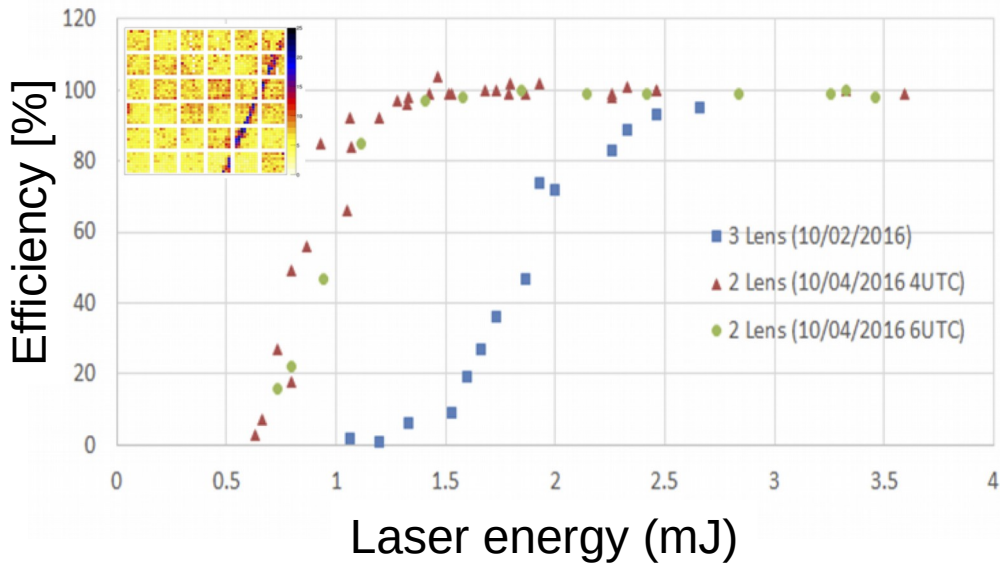
EUSO-SPB1



Measured count rate (two times higher than EUSO-Balloon) and trigger rate

Trigger algorithm is properly working

Used for exposure estimation



Ground tests in Utah at the EUSO-TA site with lasers

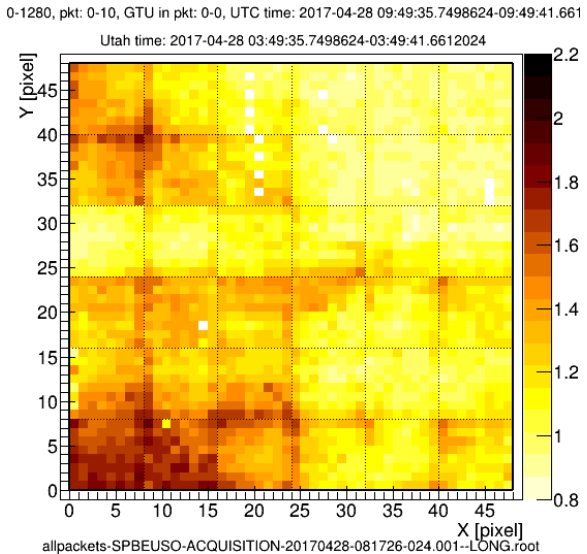
Threshold estimated to be
$3\ 10^{18}$ eV @ 33 km for a 45 degrees shower

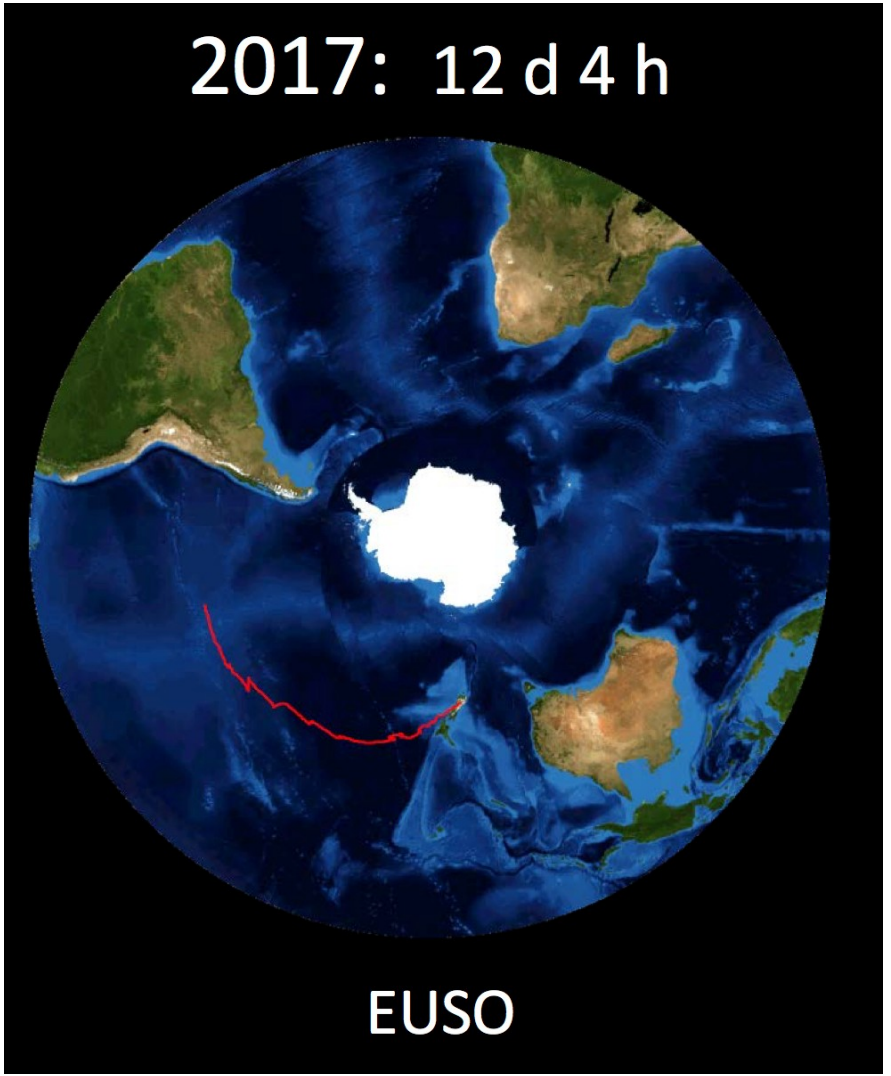
EUSO-SPB1

After only 12 days a leak in the balloon caused the flight termination

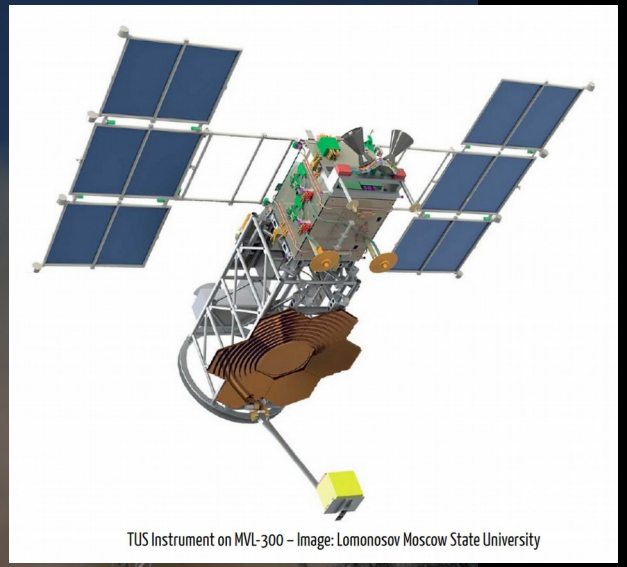
~30 hours of scientific data have been aquired

~1 event is expected ***No CR candidate so far…***

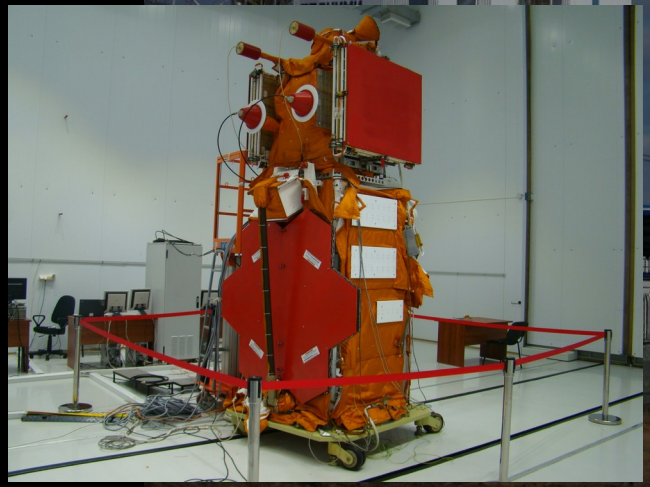




TUS

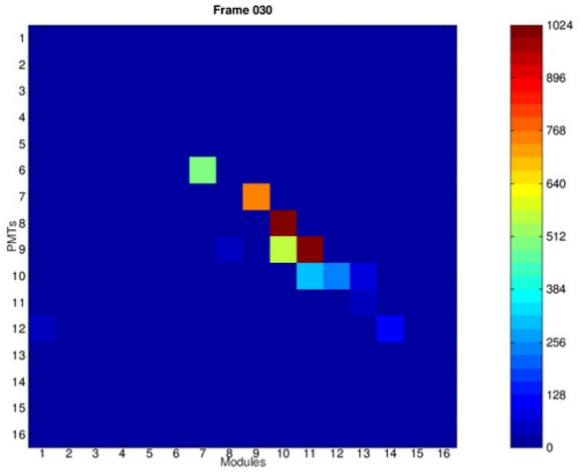


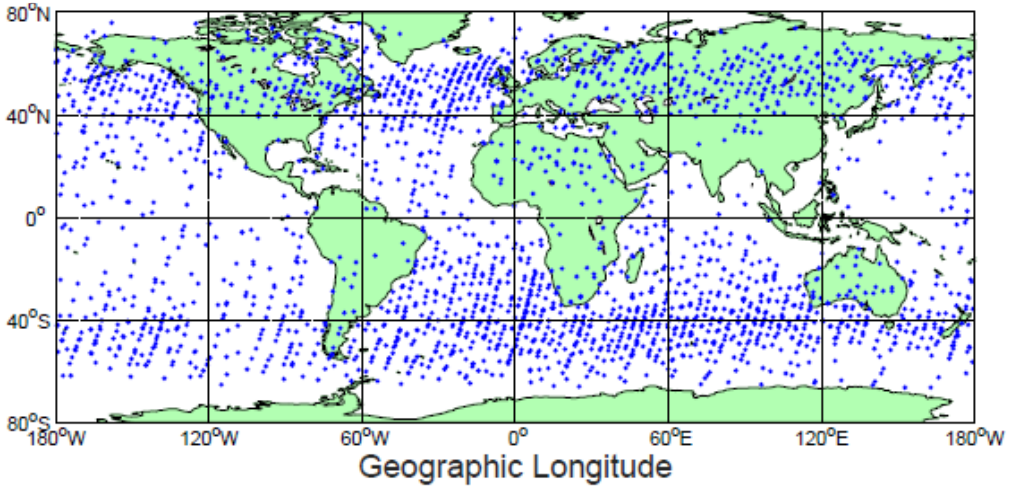
TUS Instrument on MVL-300 – Image: Lomonosov Moscow State University



April 28th 2016
Vostochny, Russia

TUS





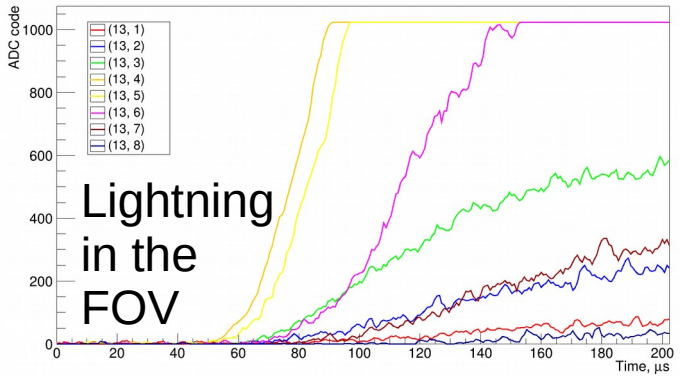
Many triggers were caused by ~1 μs tracks

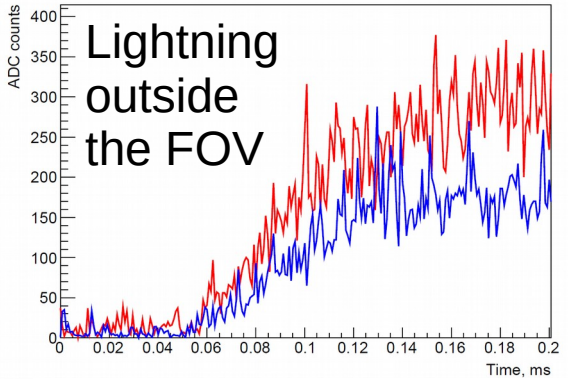
Similar events detected by EUSO-SPB1

Caused by low energy CRs interacting in the detector

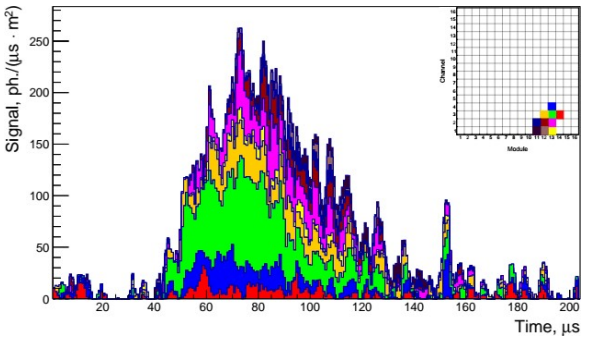
Trigger was modified to reject such events

TUS

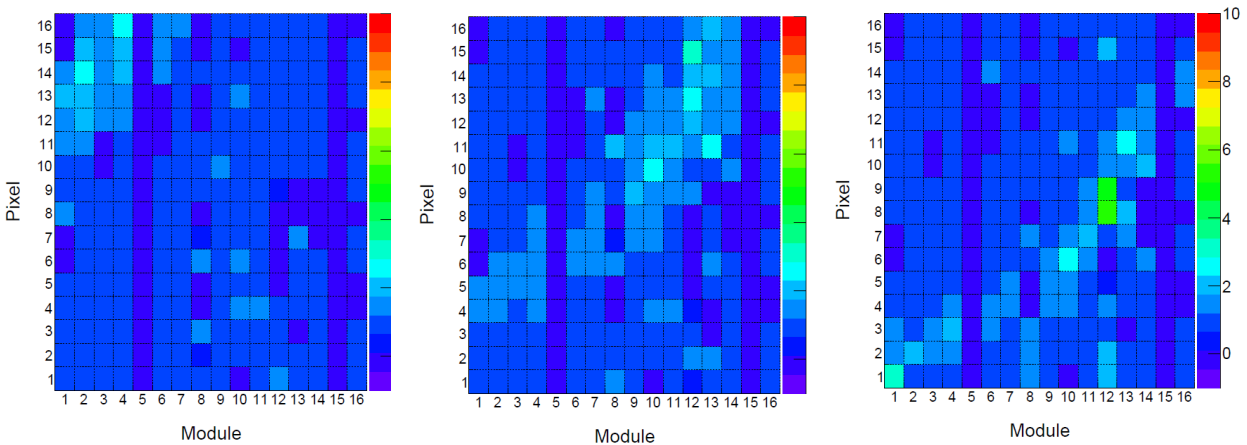


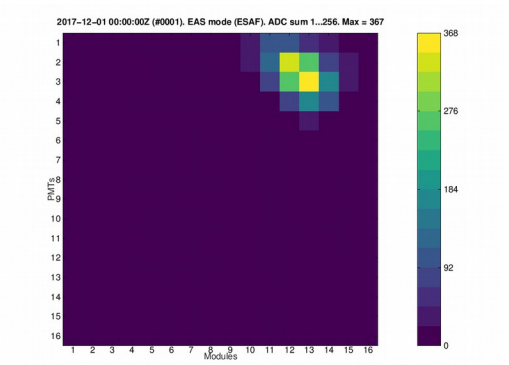


Fast events under study



ELVES





M. Bertaina this ICRC

Mini-EUSO

Mini-EUSO is a detector that will fly on the Russian section of the ISS

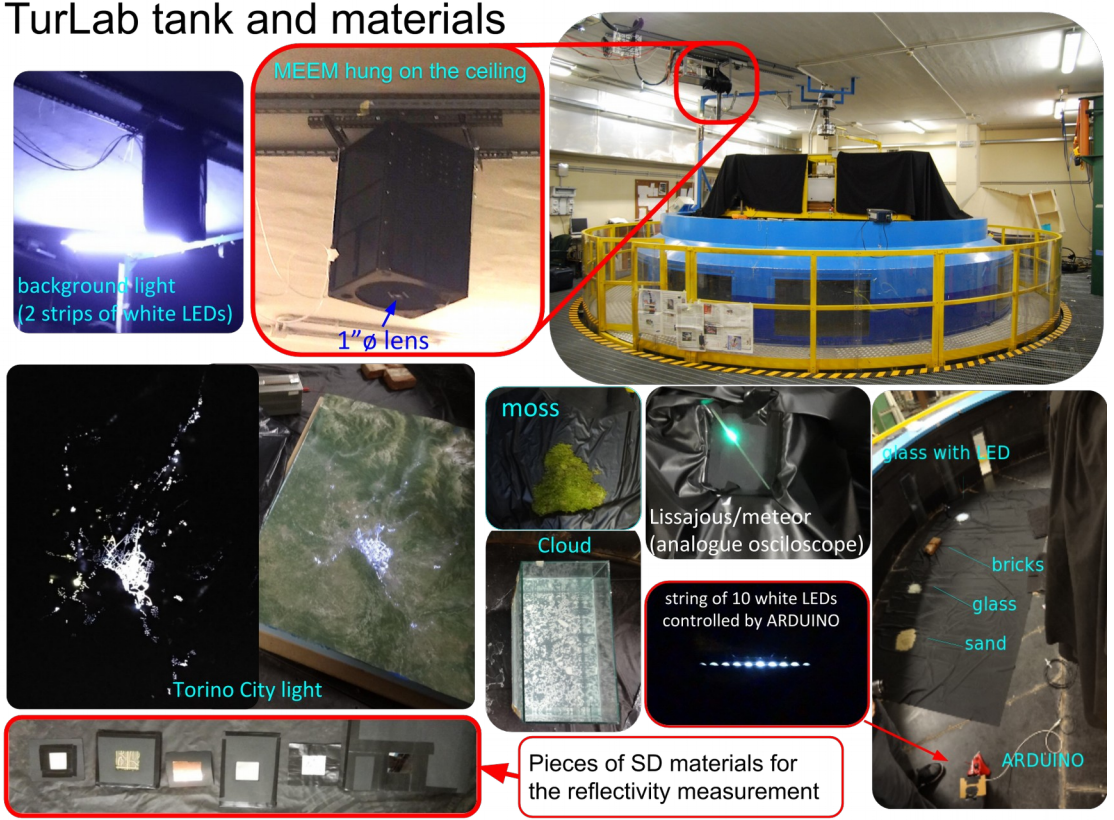
Monitor the Earth emission from orbital altitude

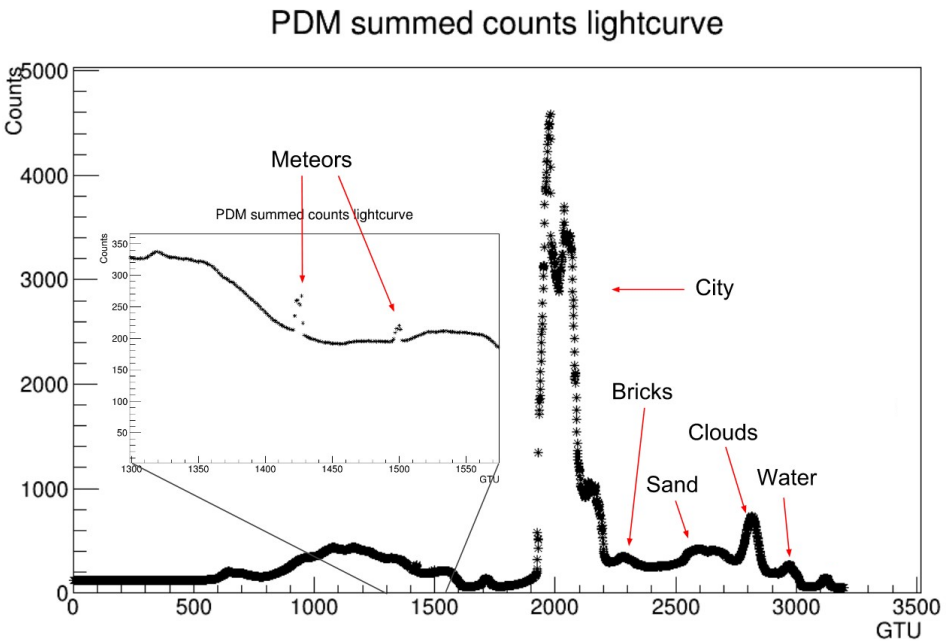
Test detector threshold with ground laser sources

Launch date Aug. 22nd 2019

Mini-EUSO EM* ground tests

TurLab tank and materials

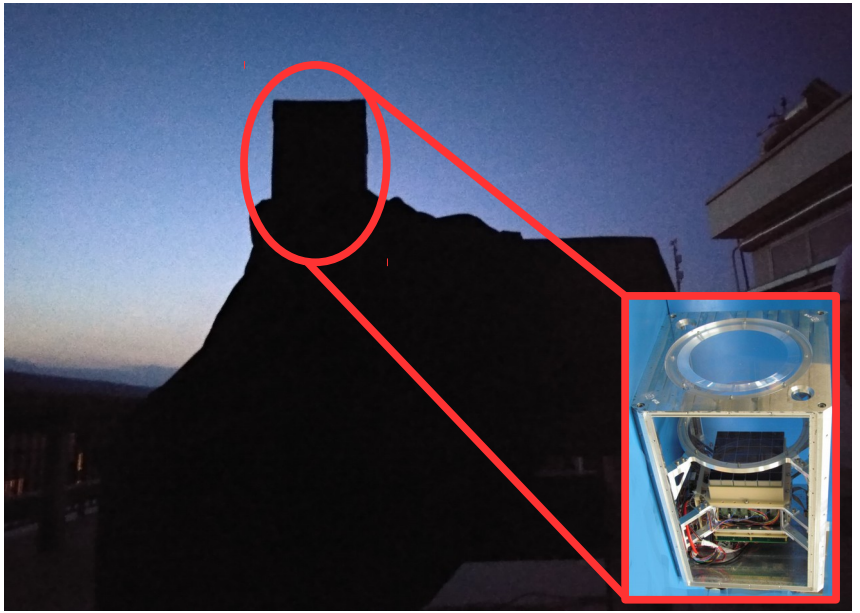




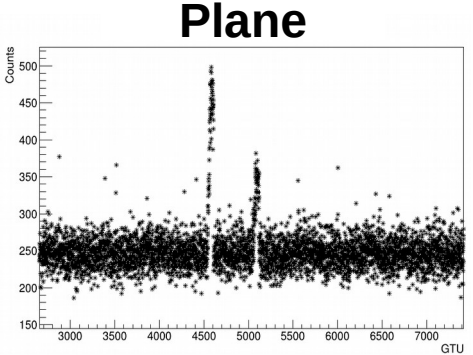
H. Miyamoto this ICRC

*Engineering Model

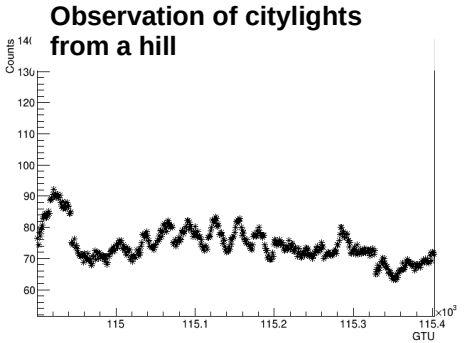
Mini-EUSO EM ground tests



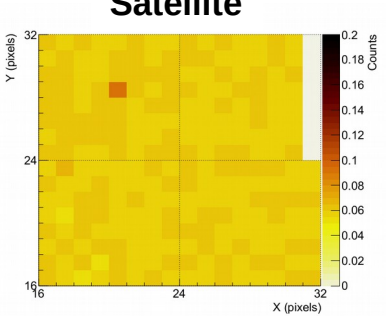
Plane

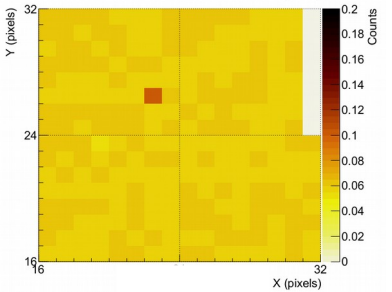


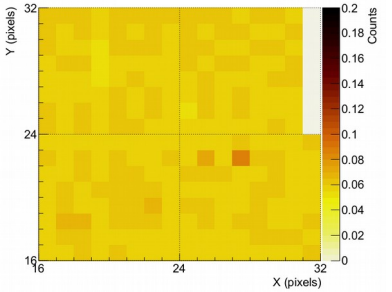
Observation of citylights from a hill



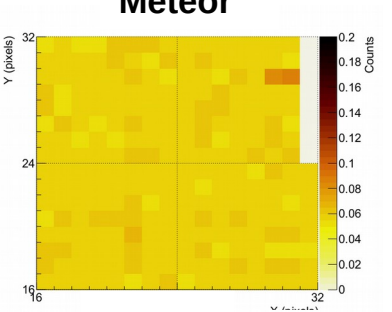
Satellite

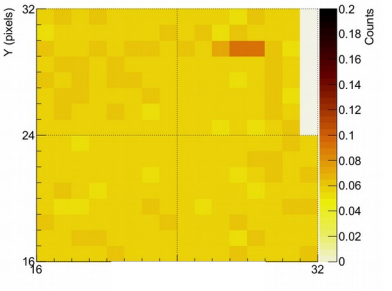


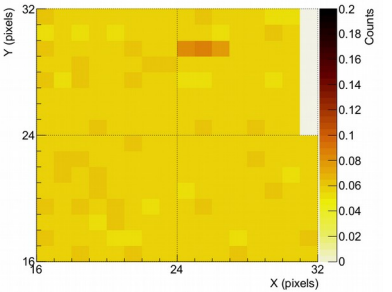




Meteor







Meteor 1-31 rocket body

F. Bisconti this ICRC

Summary

- **Background rate**
  - **-UV background rate compatible with expectations**
  - **-2 times higher rate in presence of clouds**
  - **-One order of magnitude higher rate over cities**
  - **-Rate from space to be determined (Mini–EUSO flying soon)**

- **Energy threshold**
  - **-Estimates with EUSO-SPB ground tests and and EUSO-TA give ~3 10^{18} eV @ 20-25 km distance, for 1 m^2 detector**

- **Fundamental for exposure calculation and simulations validation**

- **9 CR events detected by EUSO-TA over ~136 hours of acquisition**

- **Analysis ongoing for some fast event detected by TUS**

- **Performances of the detectors being studied, hardware being validated in space conditions**

Backup slides

JEM-EUSO PROGRAM

EUSO-TA (2013-)

EUSO-Balloon (2014)

TUS (2016-17)

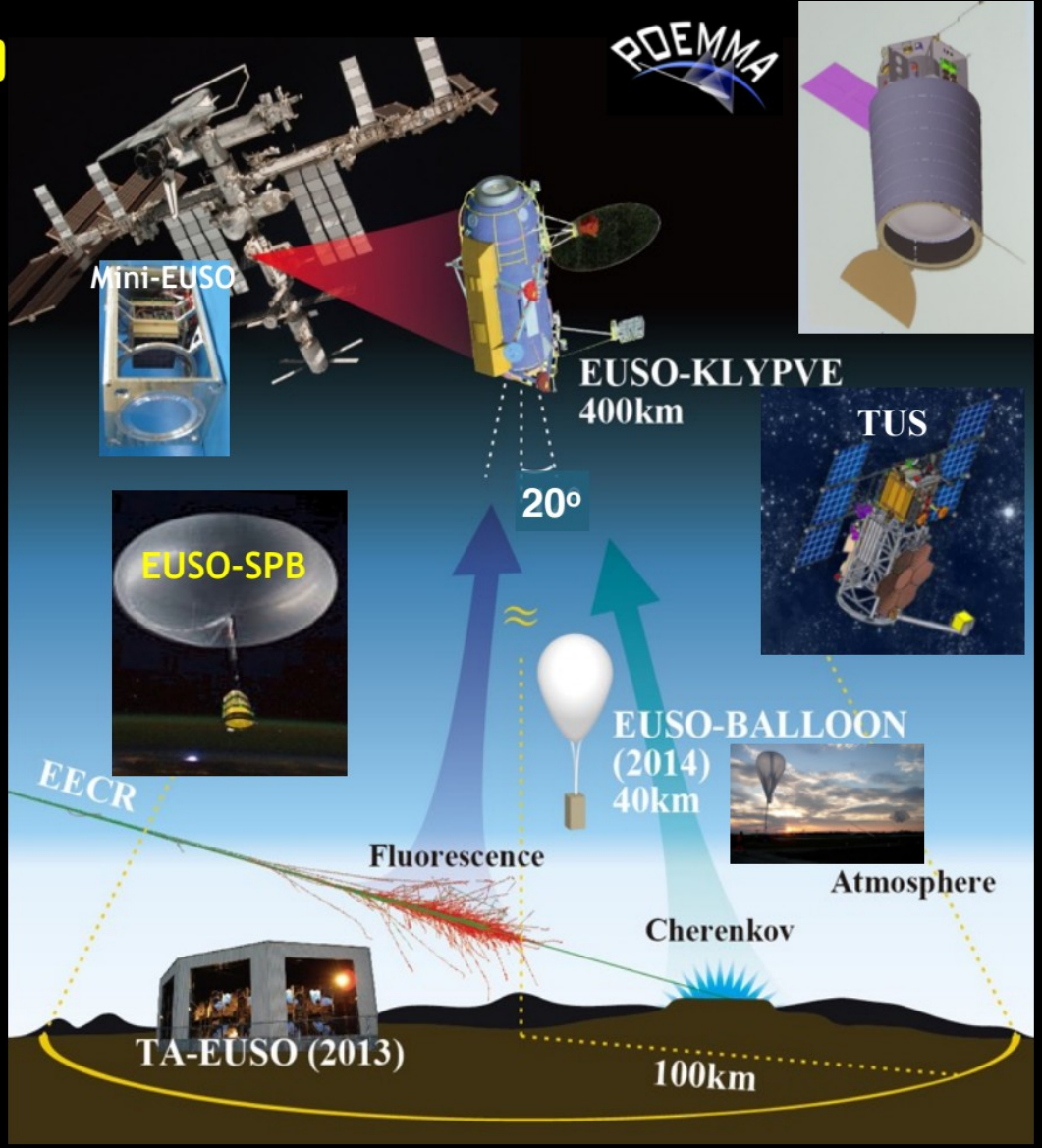
EUSO-SPB1 (2017)

Mini-EUSO (2019)

EUSO-SPB2 (2022)

K-EUSO (2023+)

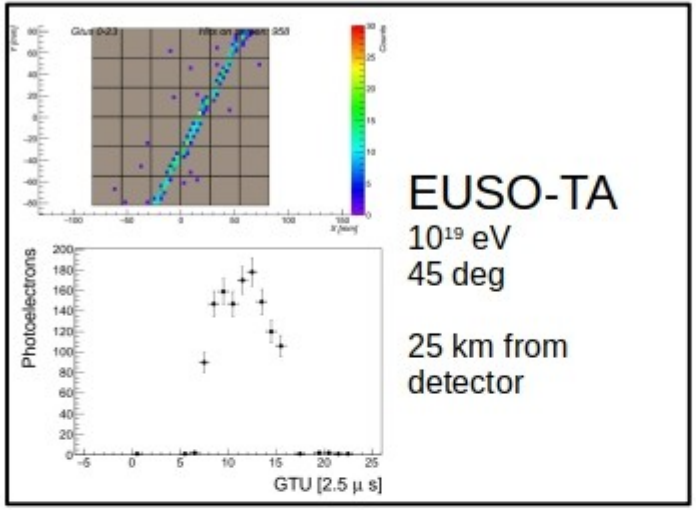
POEMMA (2029+)



M. Bertaina
This ICRC

The JEM-EUSO detectors

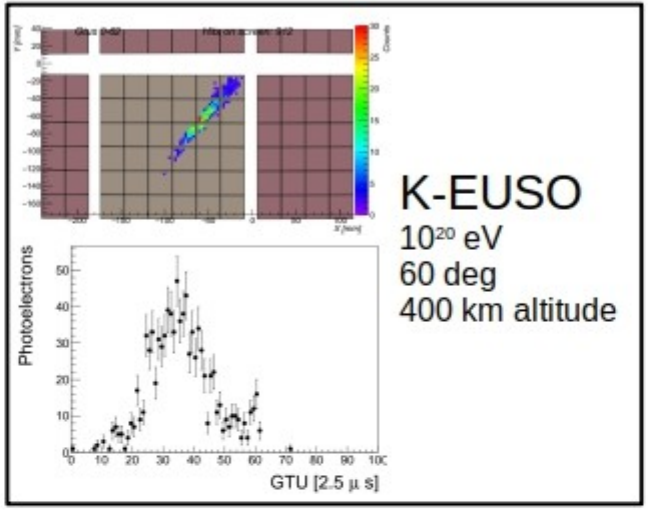
Simulated with ESAF



EUSO-TA

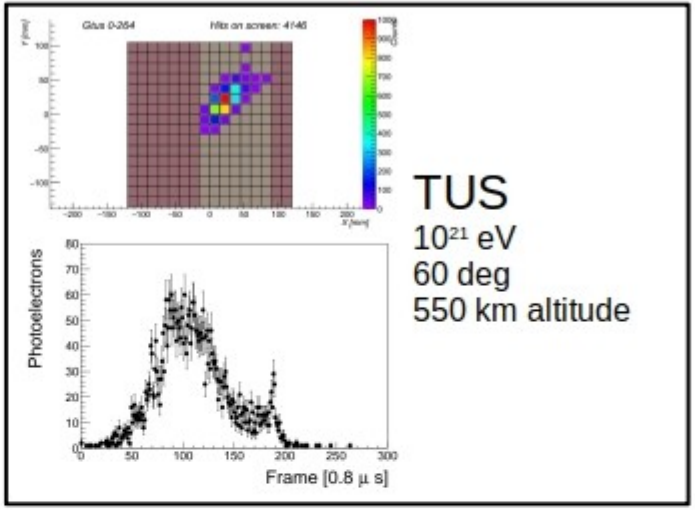
10^{19} eV
45 deg

25 km from detector



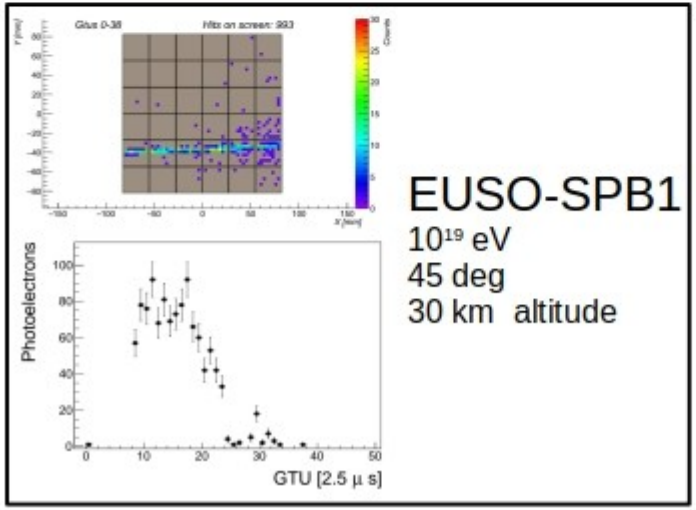
K-EUSO

10^{20} eV
60 deg
400 km altitude



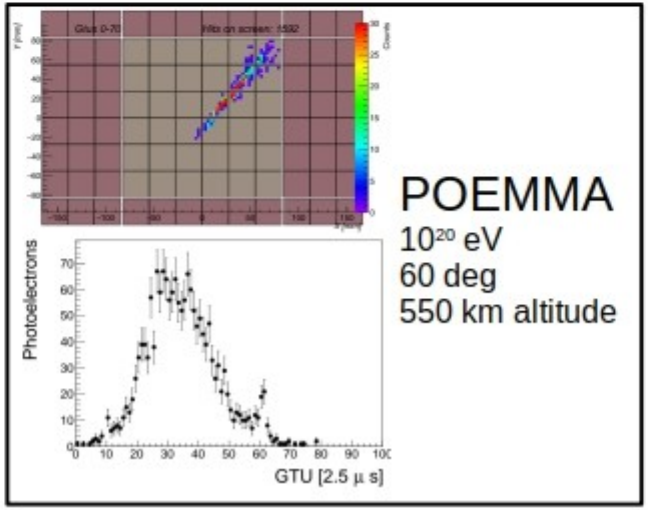
TUS

10^{21} eV
60 deg
550 km altitude



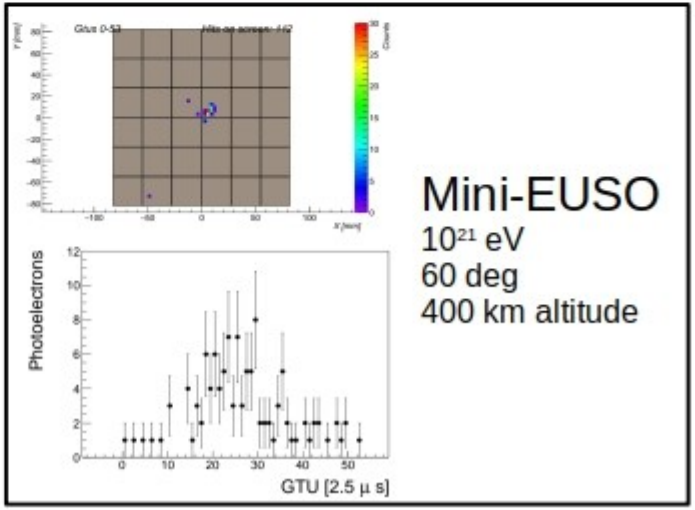
EUSO-SPB1

10^{19} eV
45 deg
30 km altitude



POEMMA

10^{20} eV
60 deg
550 km altitude



Mini-EUSO

10^{21} eV
60 deg
400 km altitude