JEM-EUSO and pathfinders

Observation of ultra-high-energy cosmic rays from space

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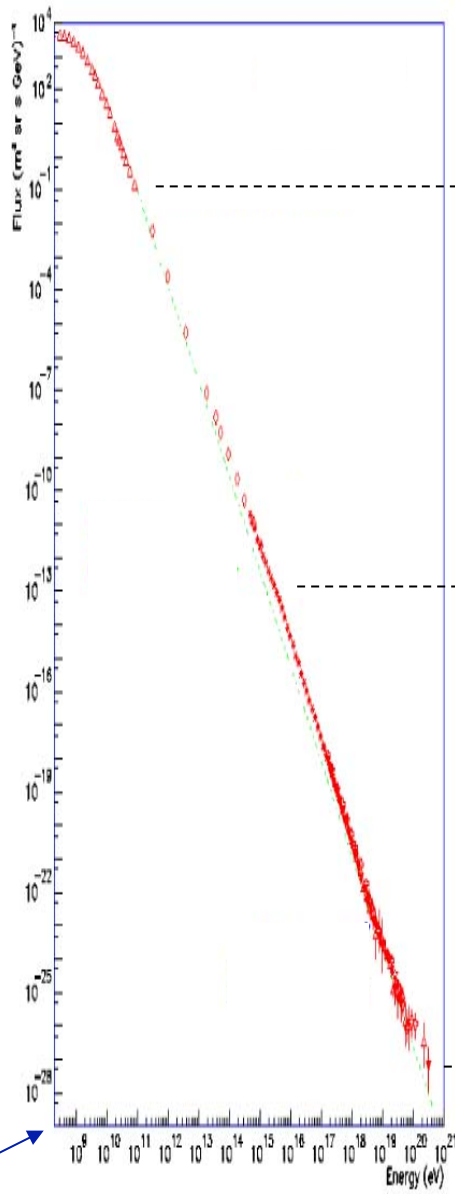
The cosmic ray energy spectrum

Flux



~ 1 particle/m^2/second

~ 1 particle/m^2/year

10^{21} eV

~ 1 particle/m^2/billion year!

Ultra-high-energy cosmic rays (UHECRs)

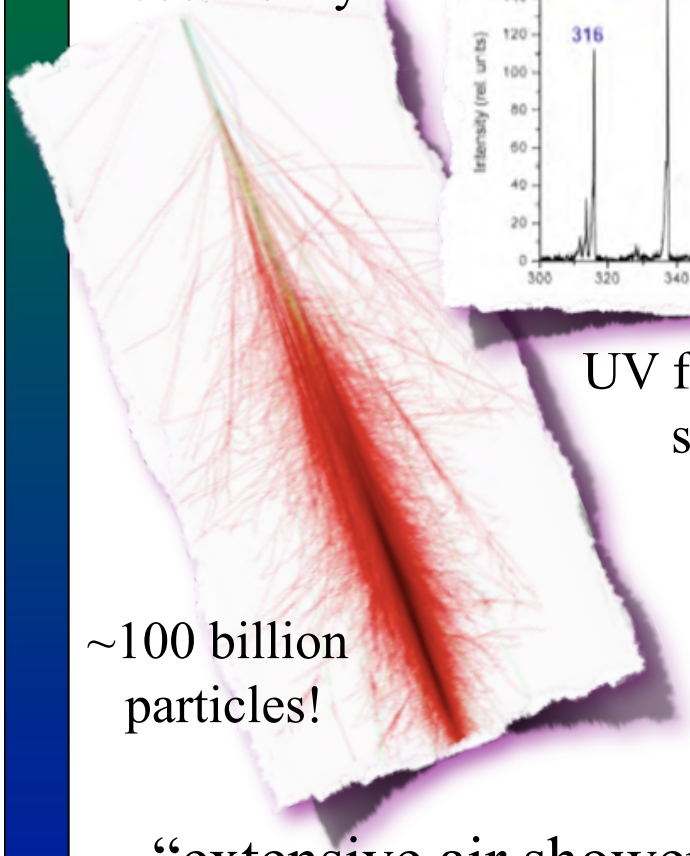
100 MeV

Energy

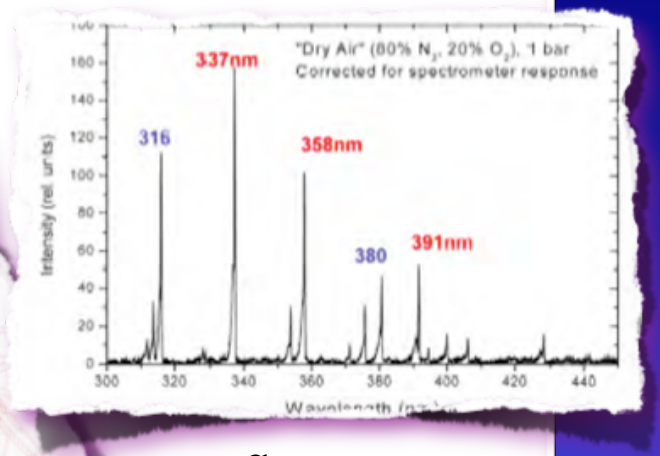
How JEM-EUSO works

Detect UHECR-induced showers through the fluorescence light generated in the atmosphere

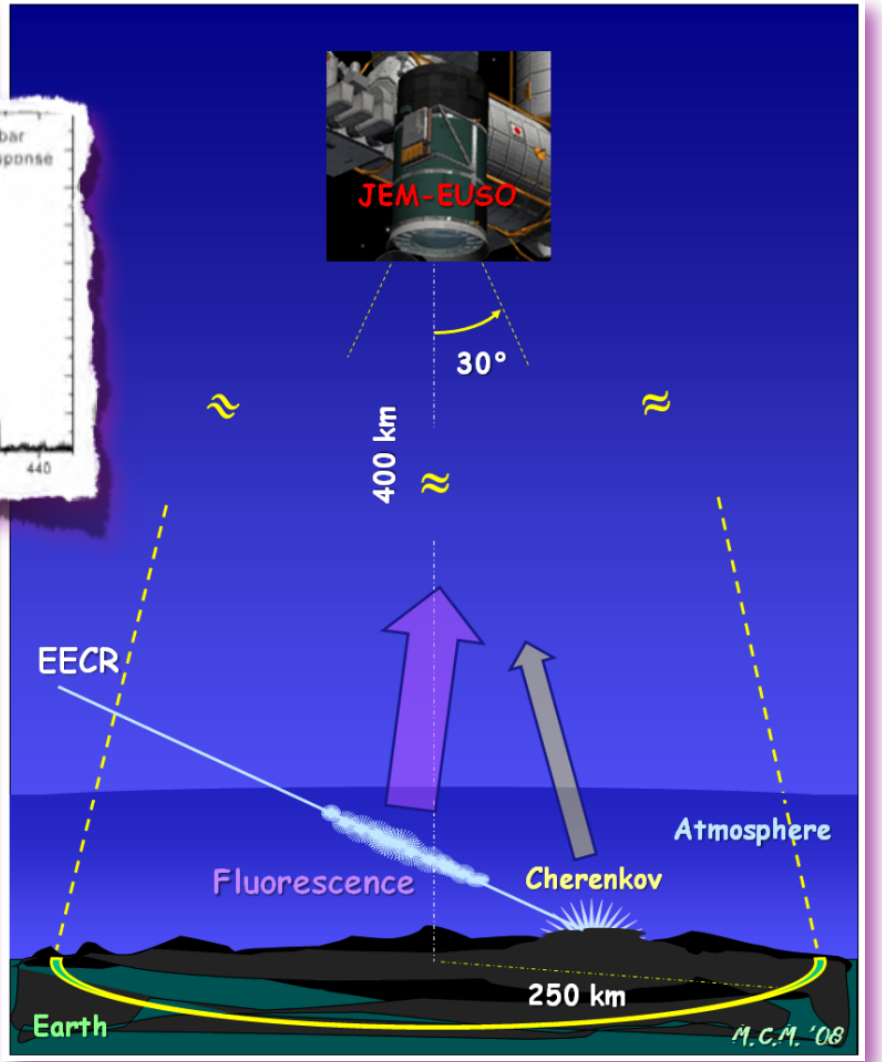
1 cosmic ray



~100 billion particles!



UV fluorescence spectrum



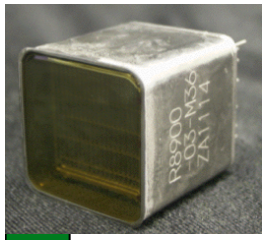
"extensive air shower"

JEM-EUSO and its pathfinders…

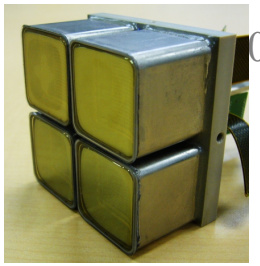
(+ KLYPVE-EUSO)

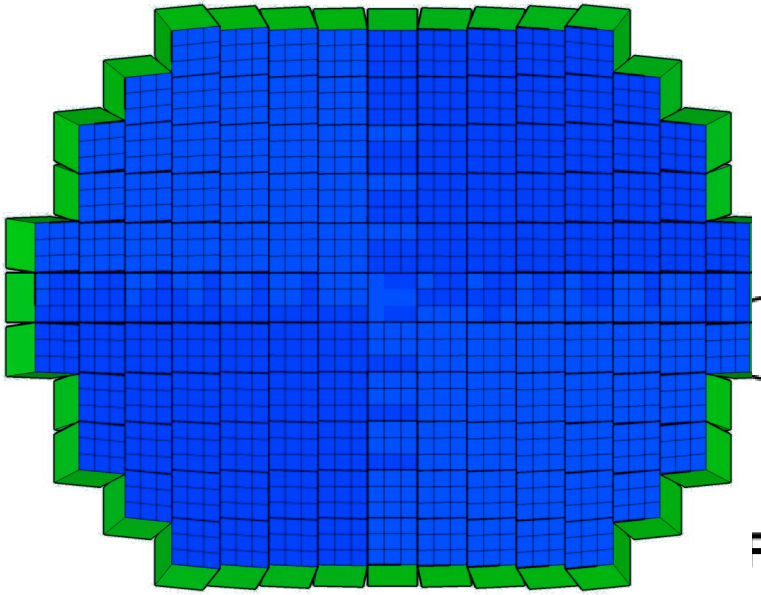
Mini-EUSO

JEM-EUSO




Focal surface





PDM

Elementary Cell

(2x2 PMTs = 144 pixels)

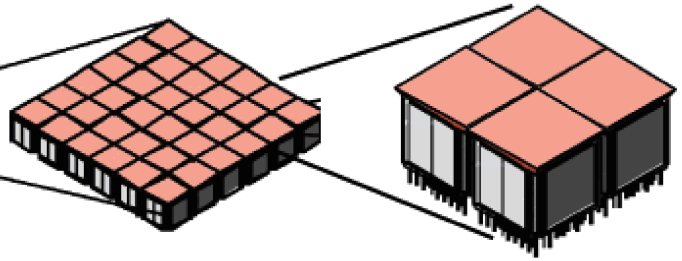
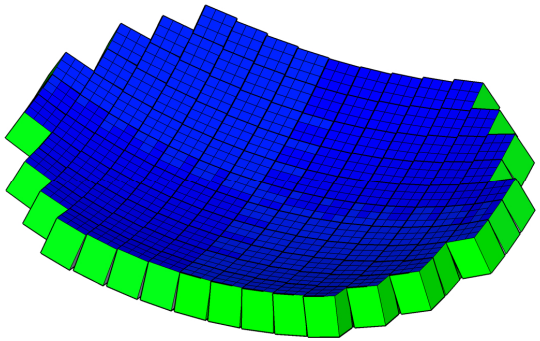


Photo-Detector Module

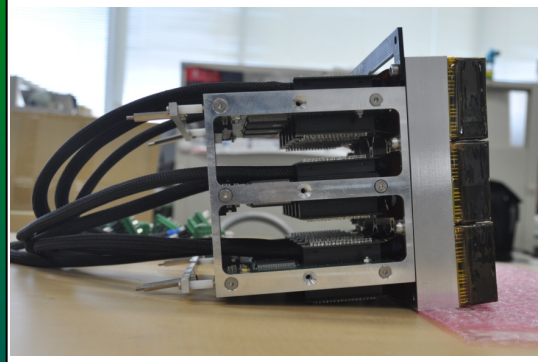
ECs = 1296 pixels)

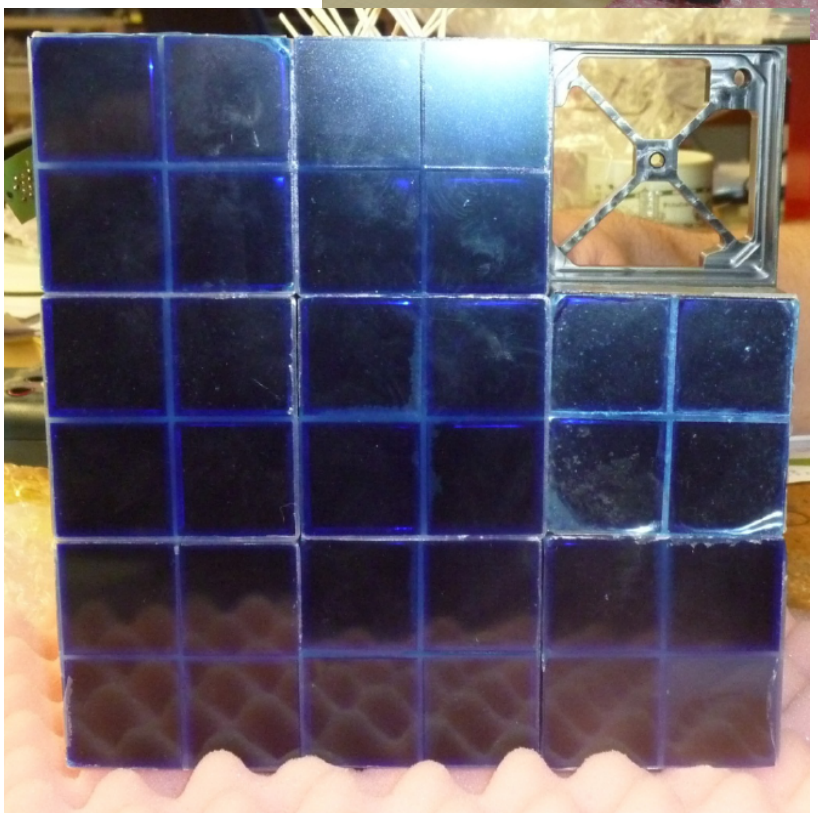


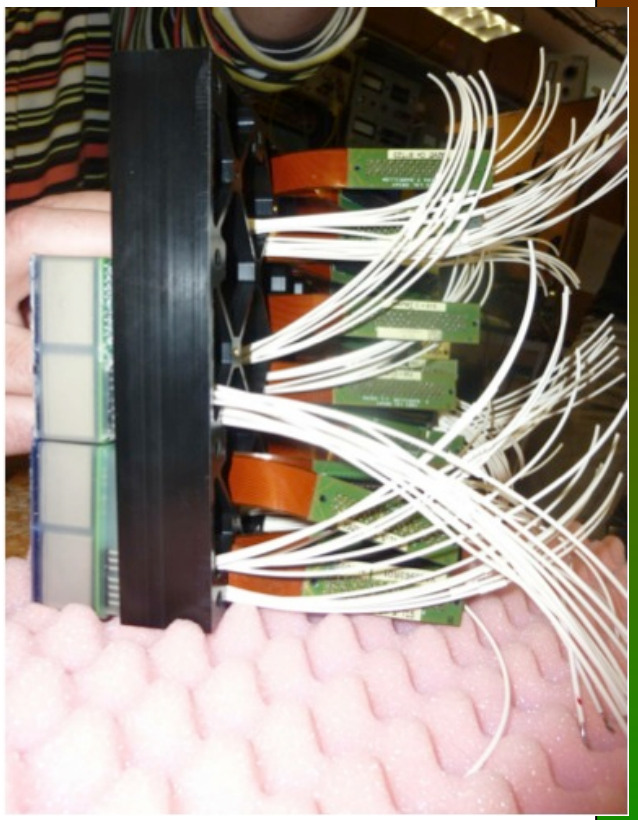
137 PDM of 9 EC, each EC has 4 PMT with 64 pixels each

4932 PMT and 0.3156 Megapixels

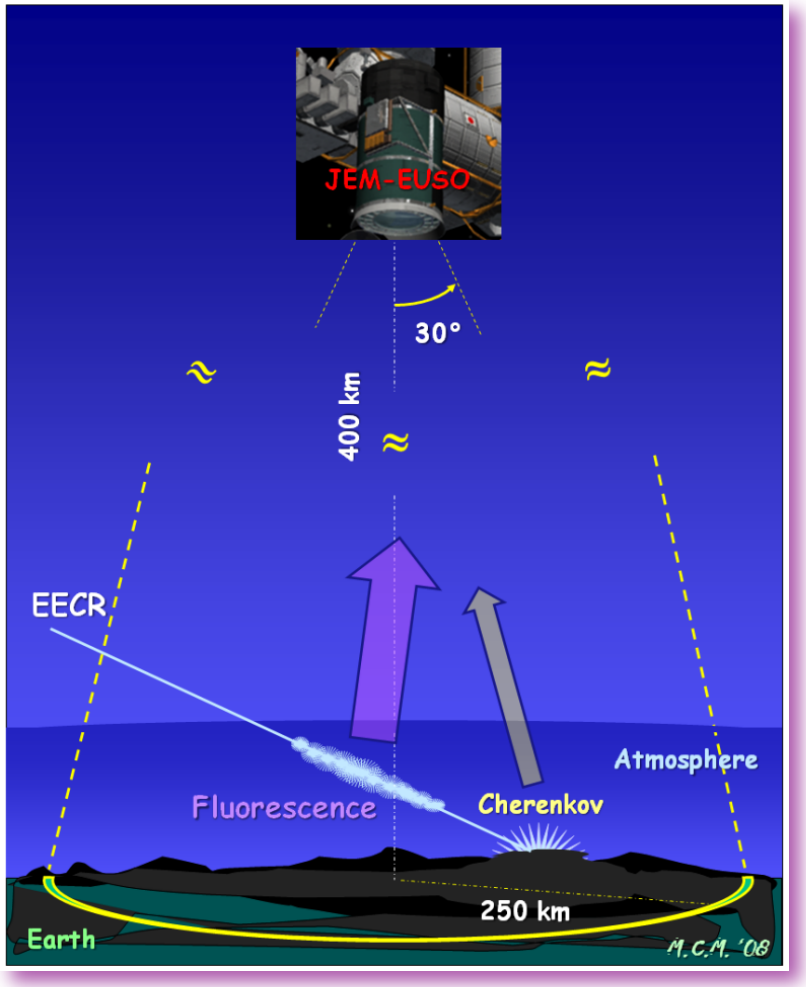
Photo-Detection Module (PDM)







Characteristics and advantages



- Huge field of view (60° aperture)
- Ultra-sensitive UV camera (single photon counting)
- Ultra-fast camera (2.5 μs → 400 000 images/second)
- Large dynamic range (automatic gain switches)
- Over 300 000 pixels
- Full-sky coverage, over several years
- + infrared camera + LIDAR

Many possible synergies

Atmospheric sciences

- TLEs (sprites, jets, elves, halos…)
- Cloud coverage
- Links between cosmic rays and lightning
- Airglow (nightglow) monitoring

Sciences of the ocean

- Surface bioluminescence
- Can a surface water temperature survey (3K accuracy) be useful?
- LIDAR reflection → water level?

Meteorites sciences

- Statistics, Trajectories, Recovery…

Space debris removal

identification, trajectory → laser shot

Others?

Plant fluorescence…

EUSO-Balloon

- Pathfinder to JEM-EUSO (CNES mission)

Successful flight on August 24th, 2014 (Timmins, Ontario)

EUSO-Balloon

- Pathfinder to JEM-EUSO (CNES mission)

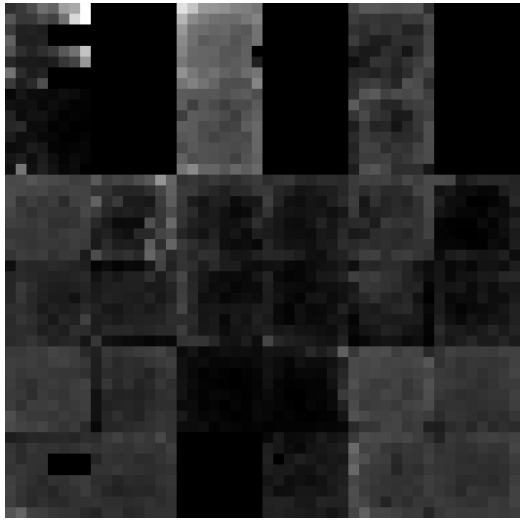
  Technology demonstration

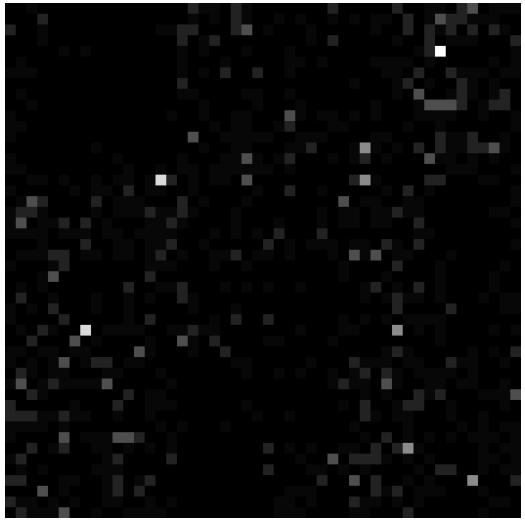
  Data on the UV background and its space/time variability

  - additional to the airglow
  - investigation of different types of ground / albedos

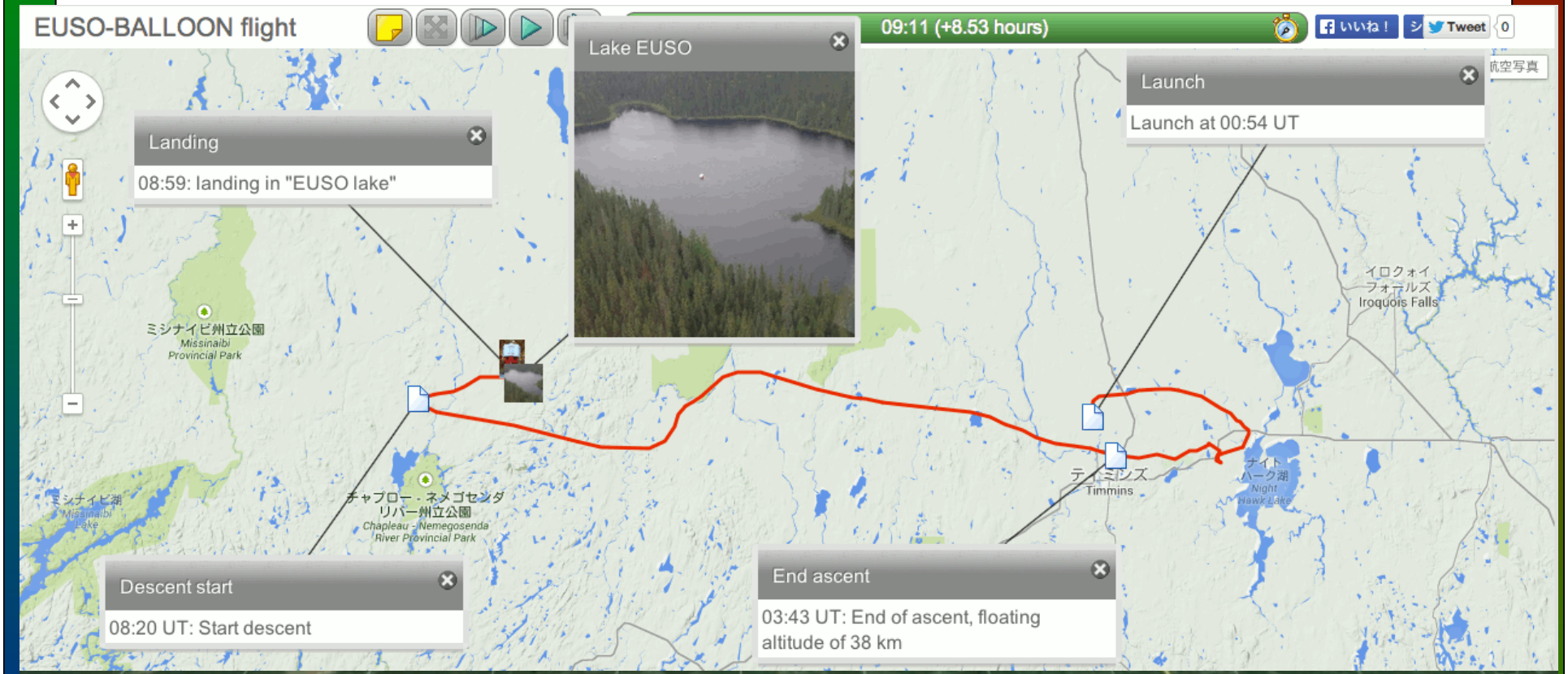
  Observation of artificial transient events

  laser shots + LED + Xenon flashers (US/NASA)



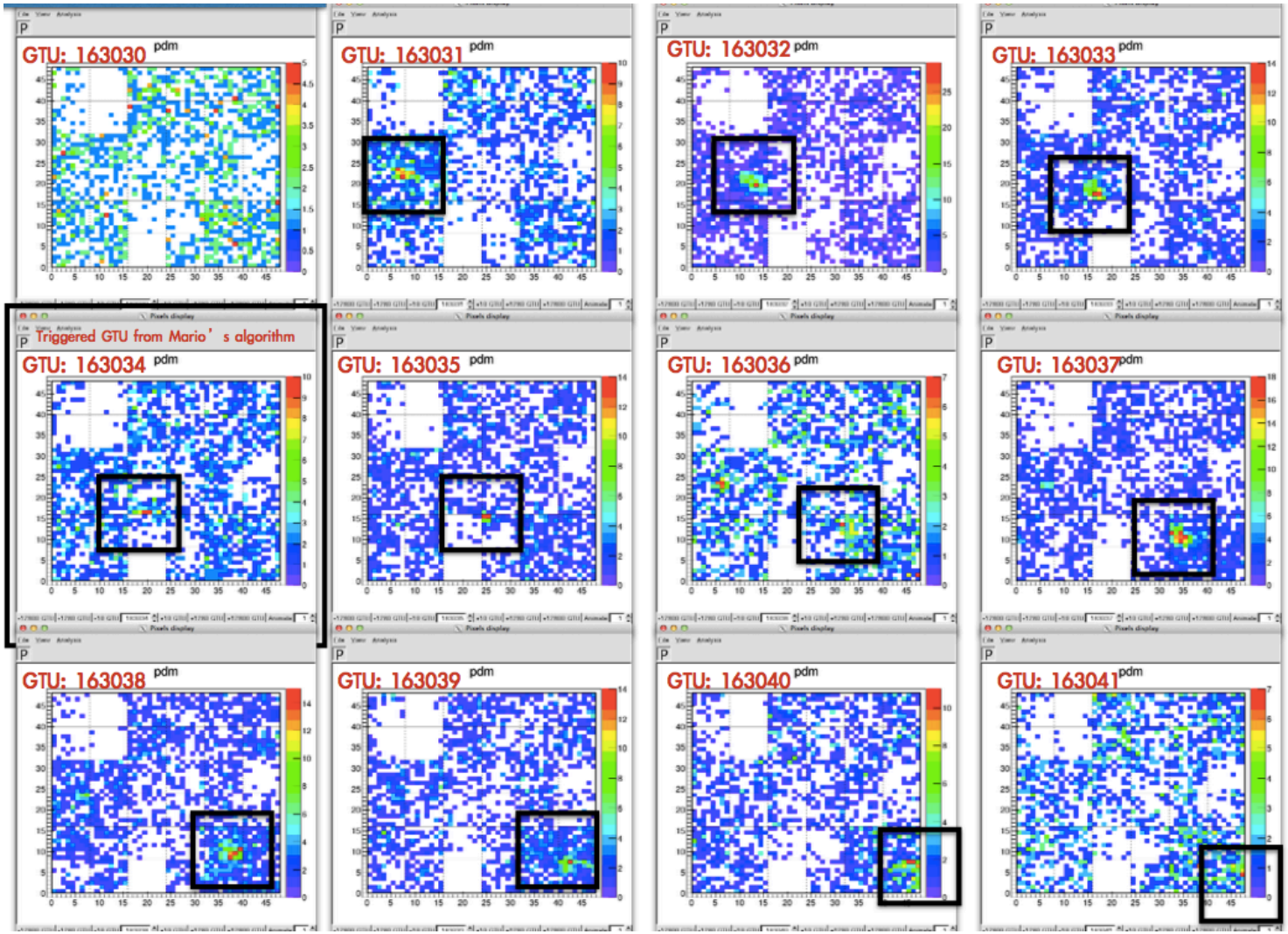


EUSO-Balloon + helicopter

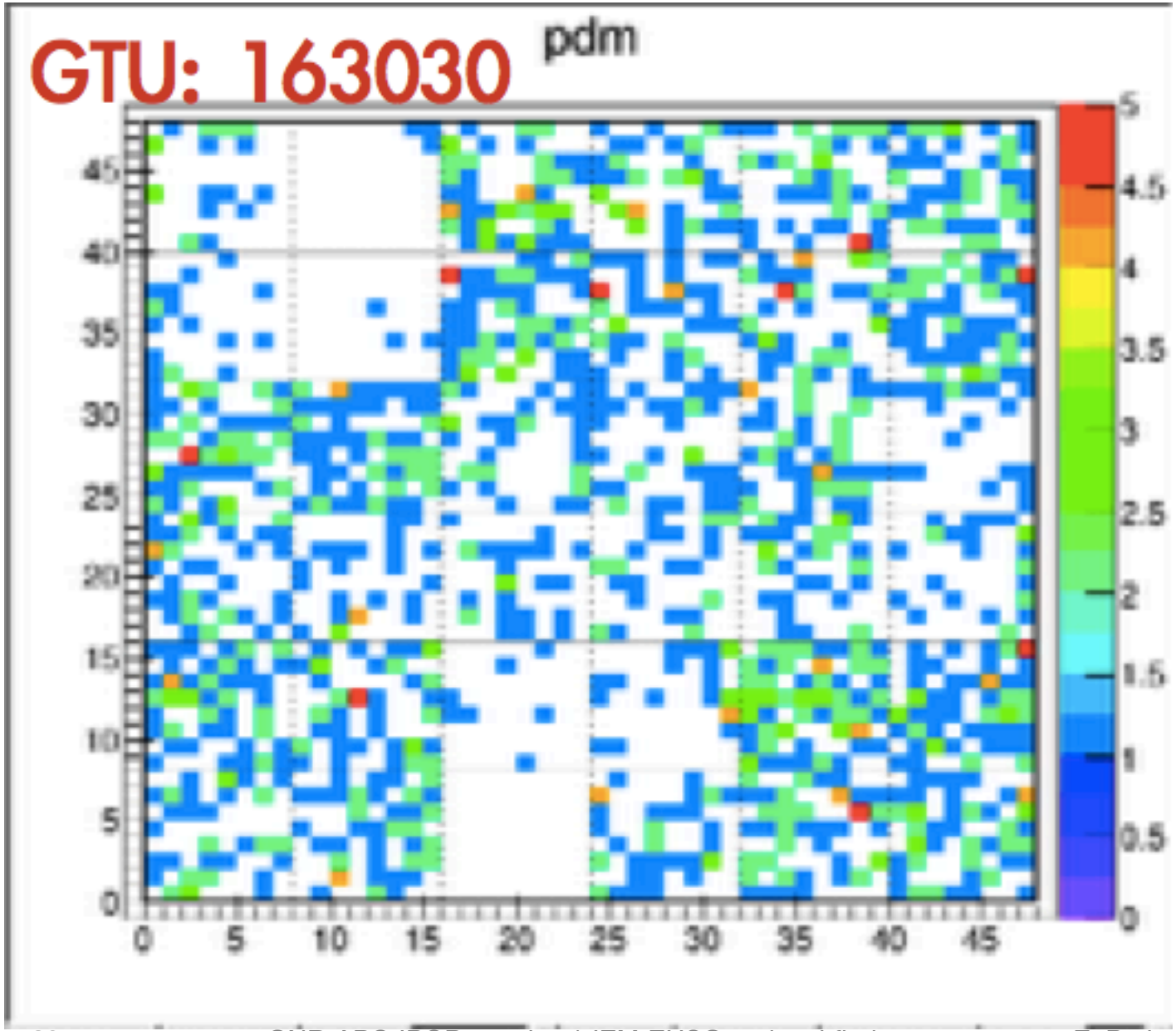


EUSO-Balloon

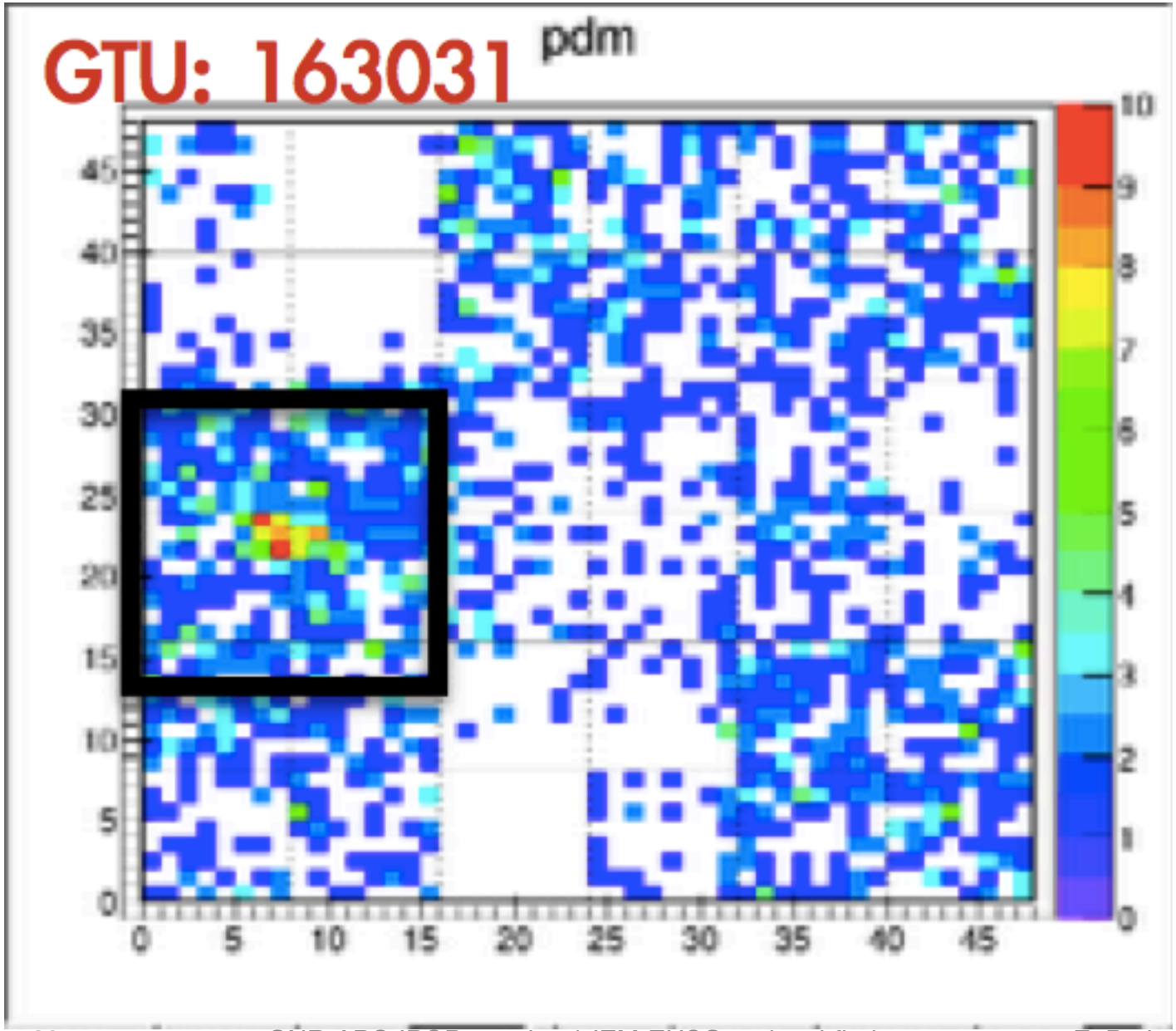
- The data are being analyzed right now!



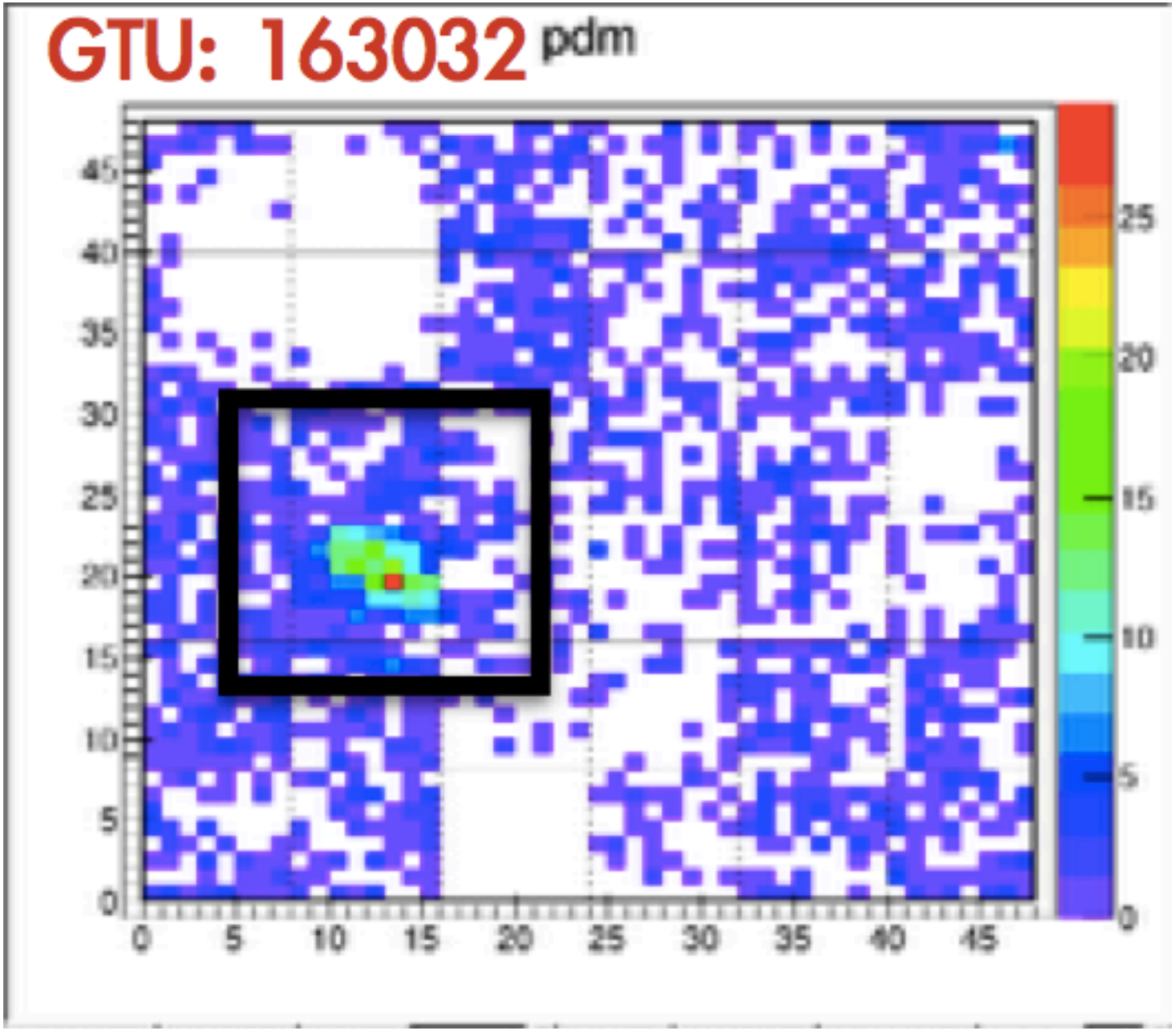
EUSO-Balloon



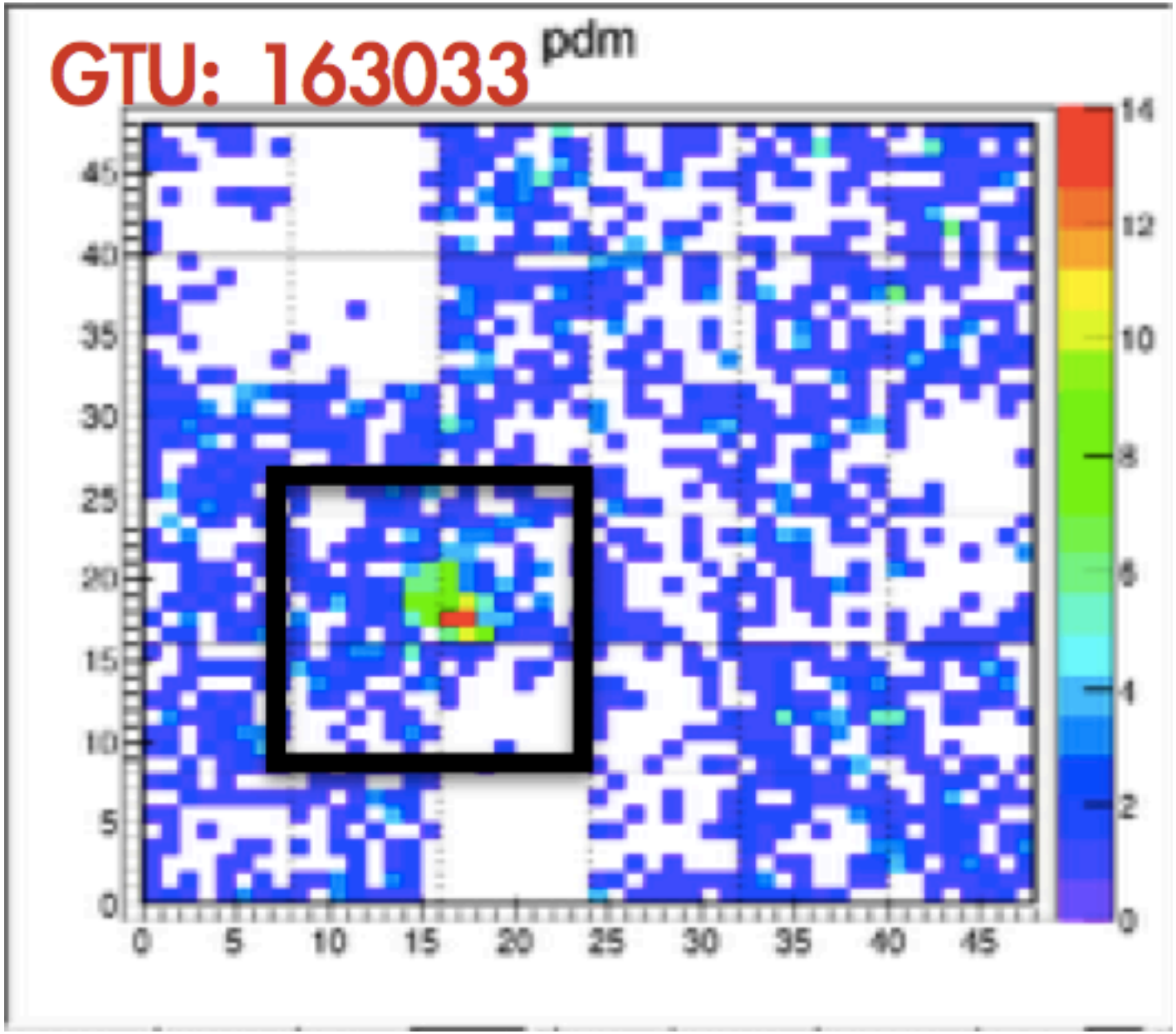
EUSO-Balloon



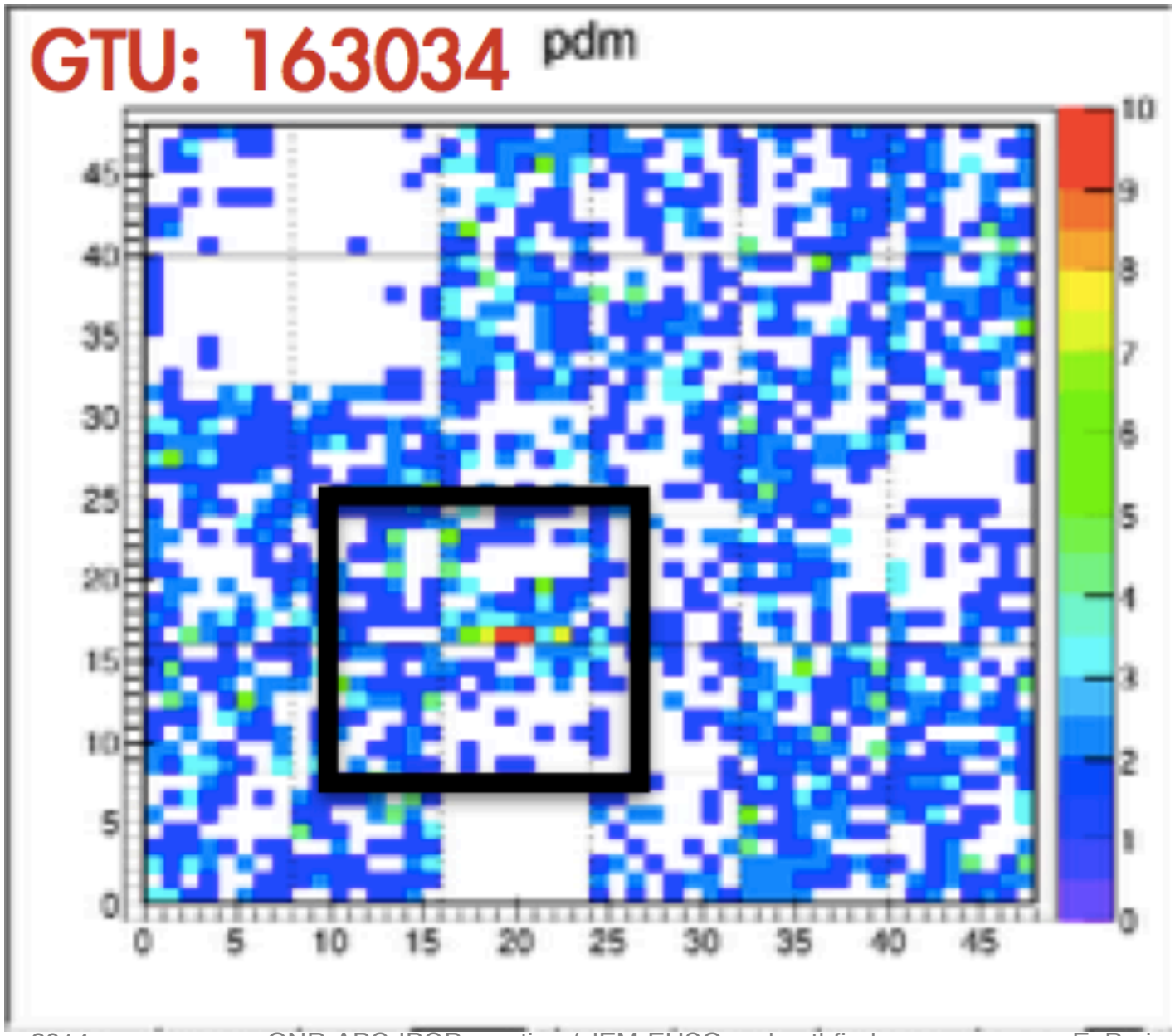
EUSO-Balloon



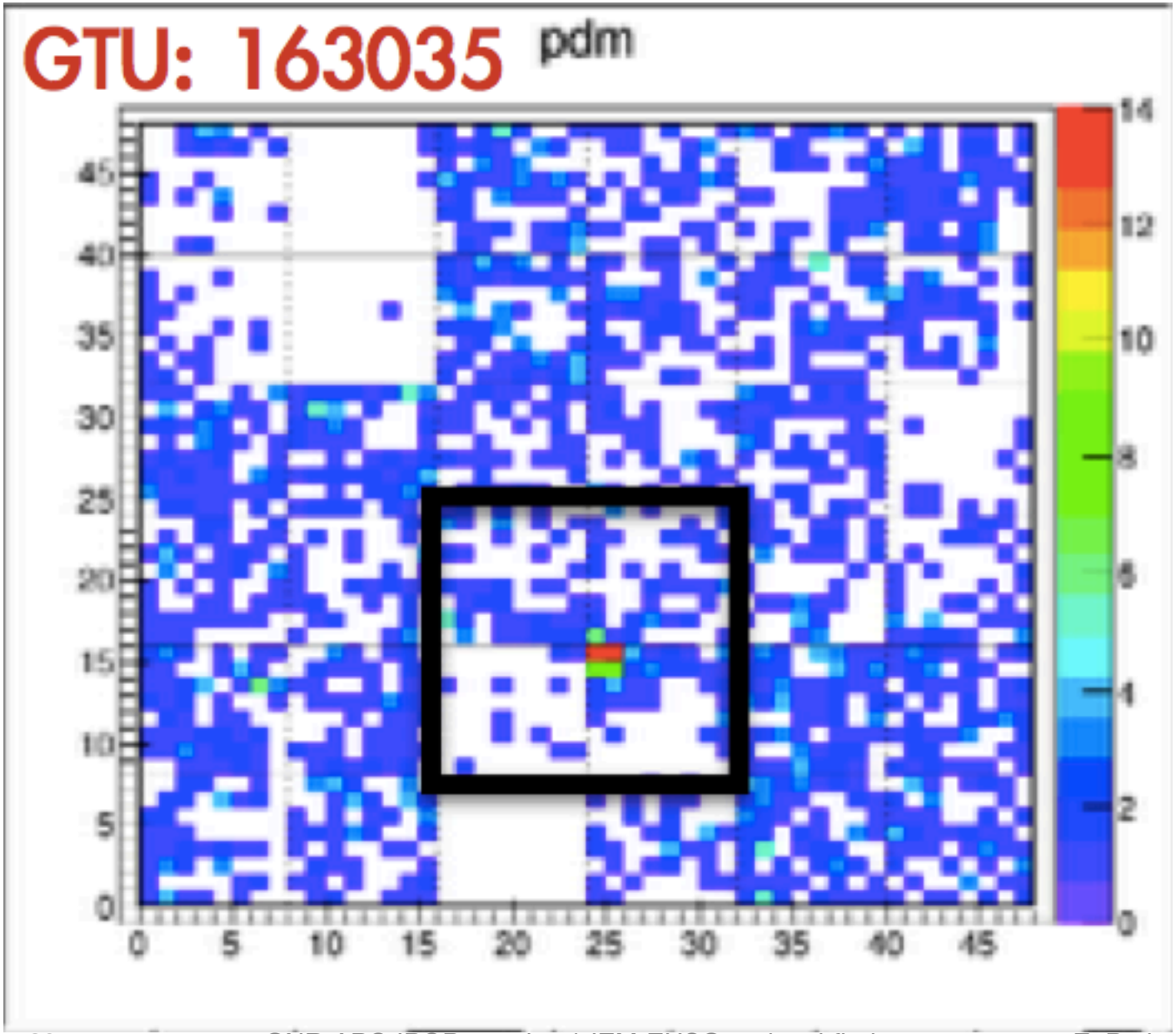
EUSO-Balloon



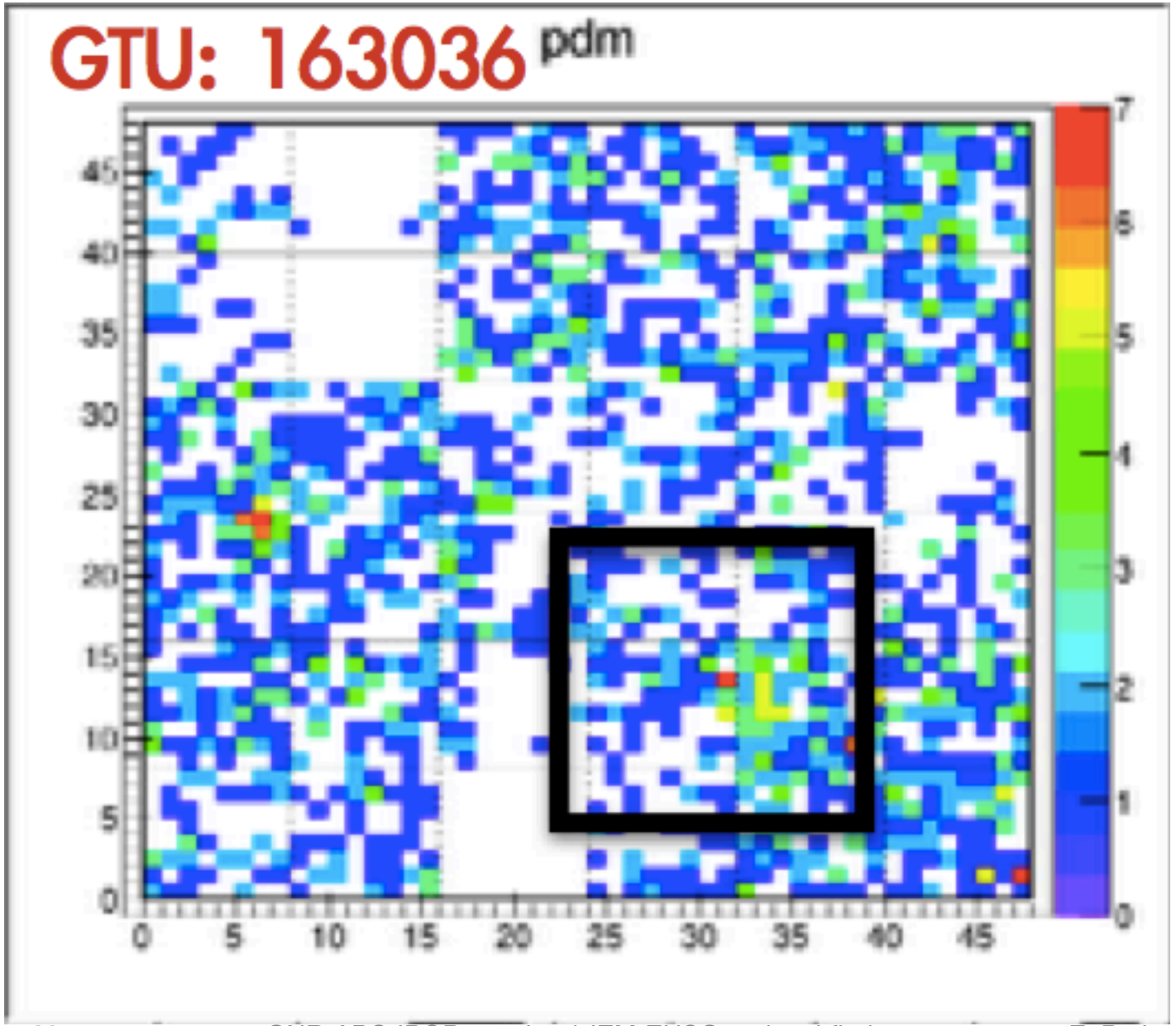
EUSO-Balloon



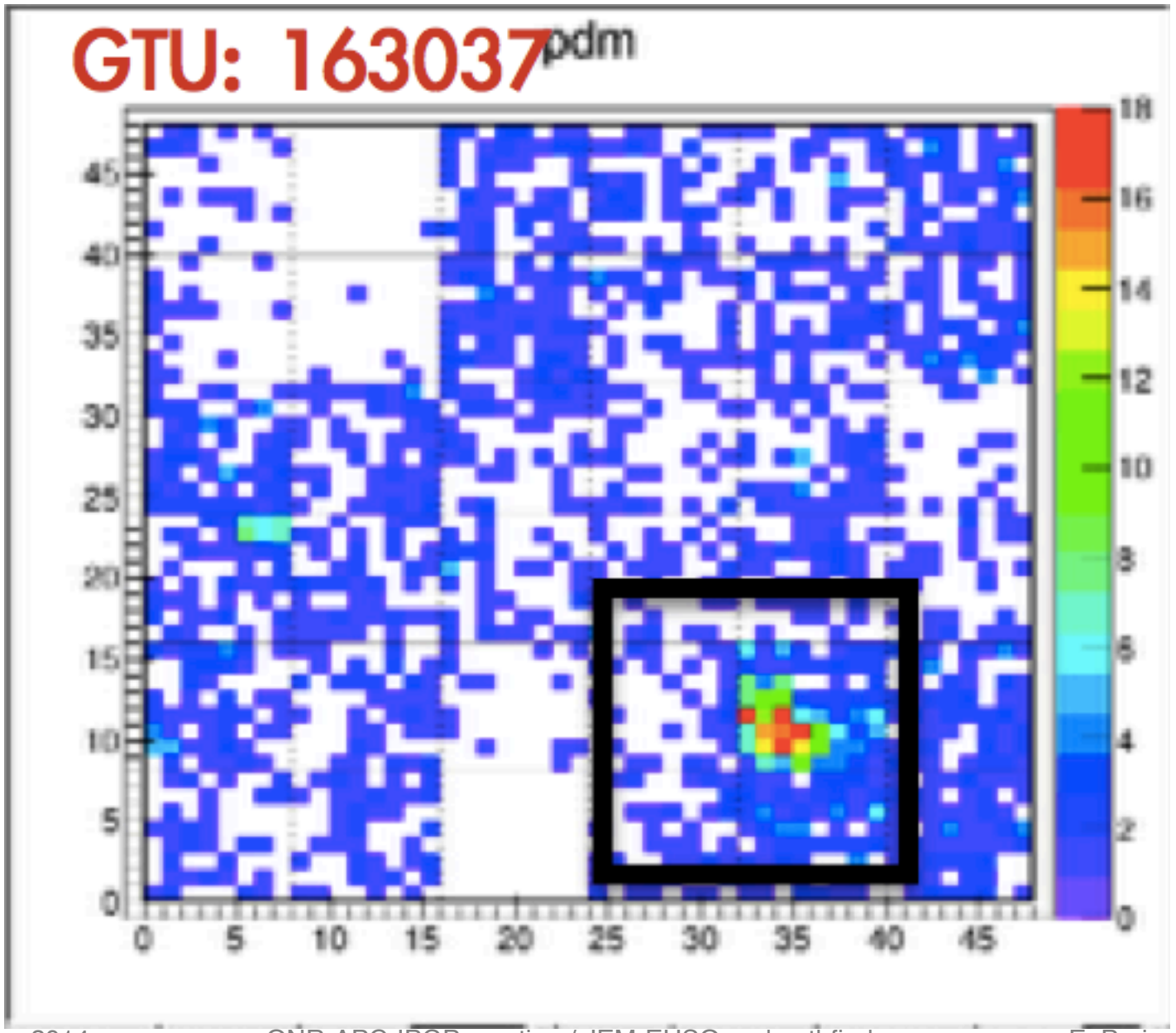
EUSO-Balloon



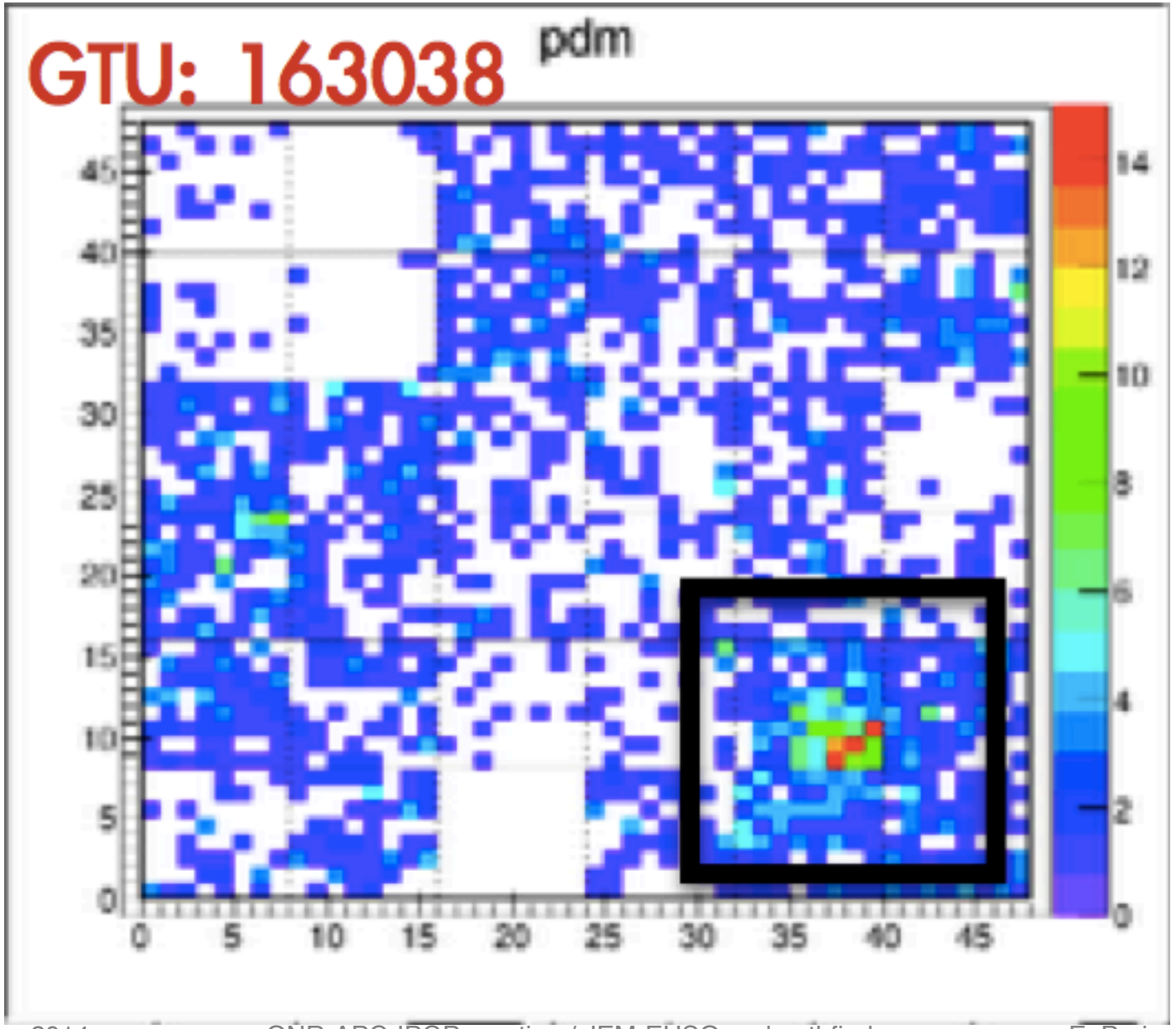
EUSO-Balloon



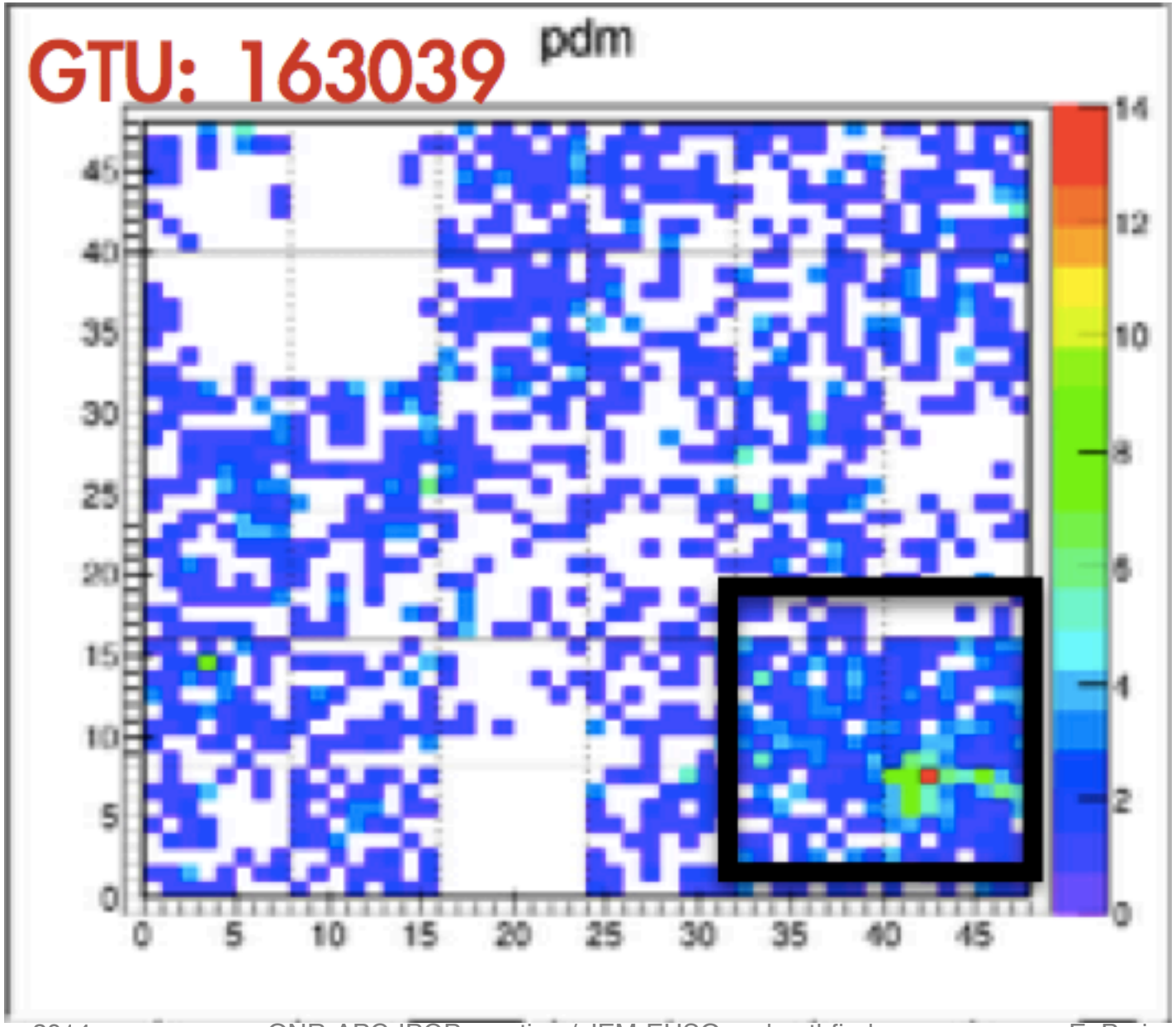
EUSO-Balloon



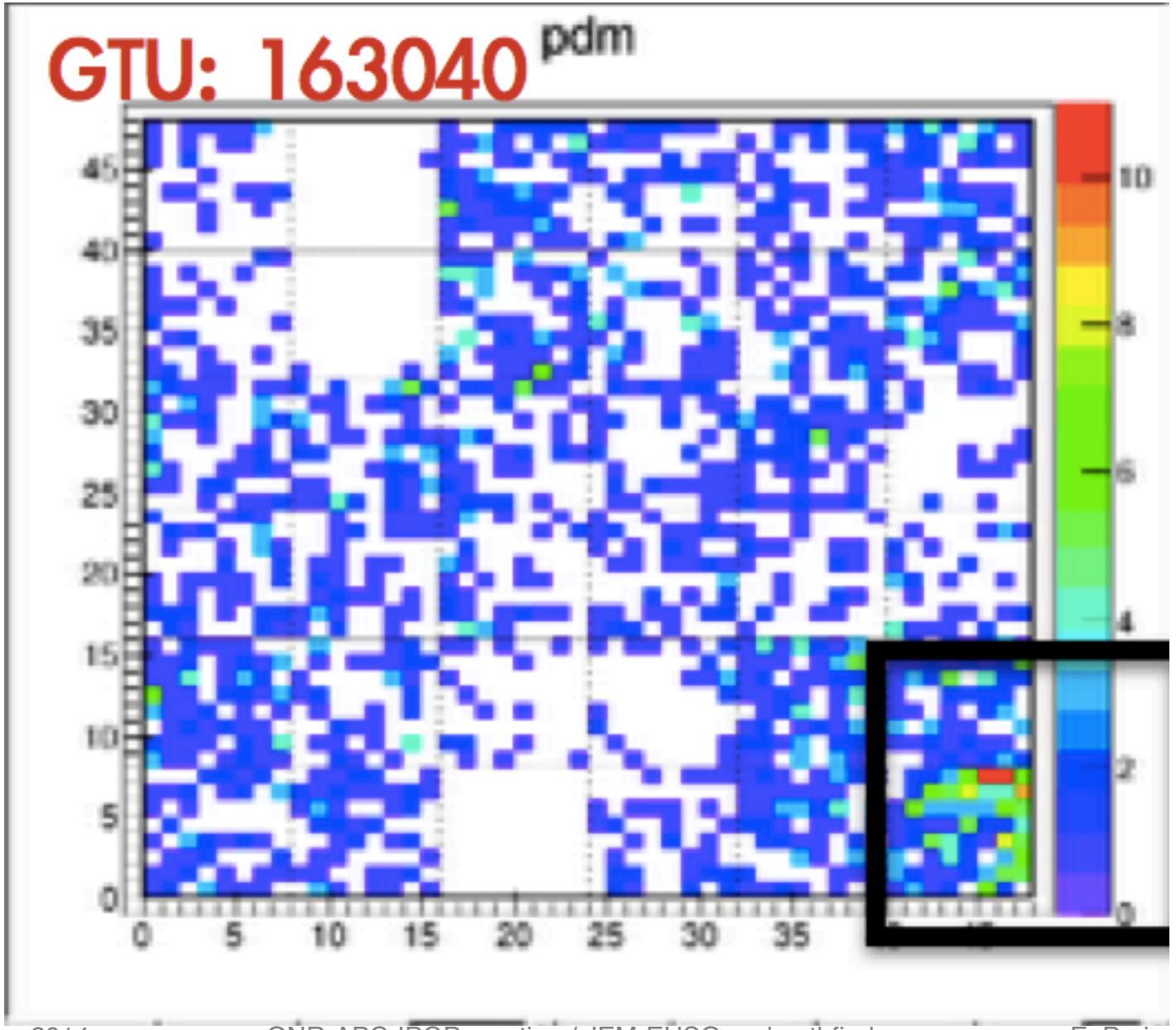
EUSO-Balloon



EUSO-Balloon

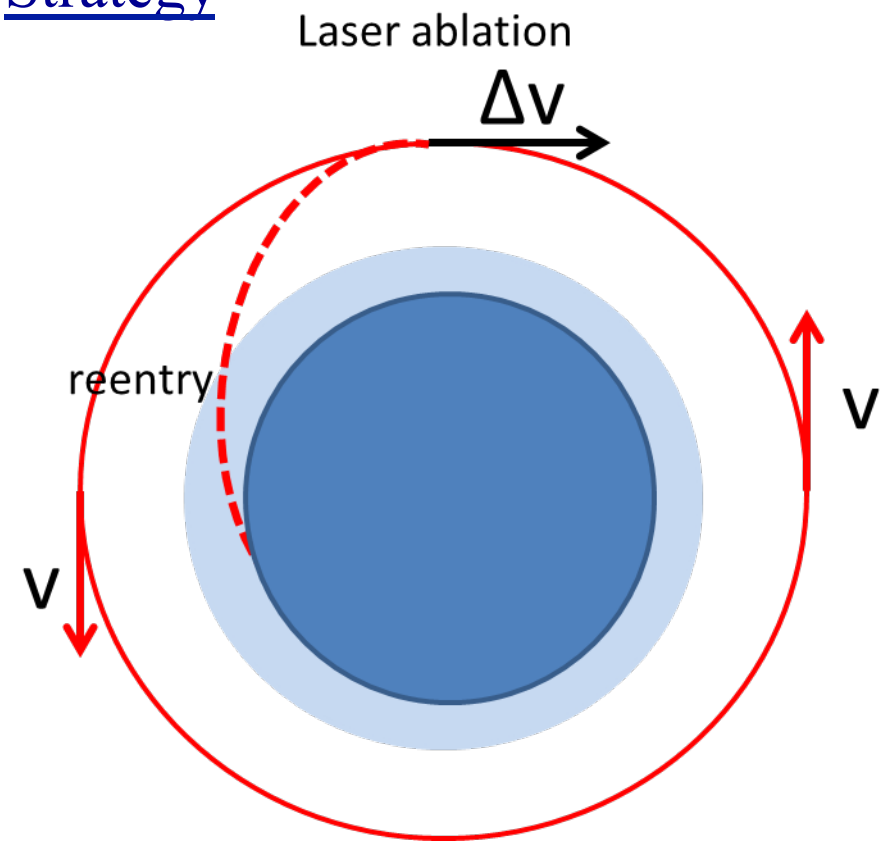


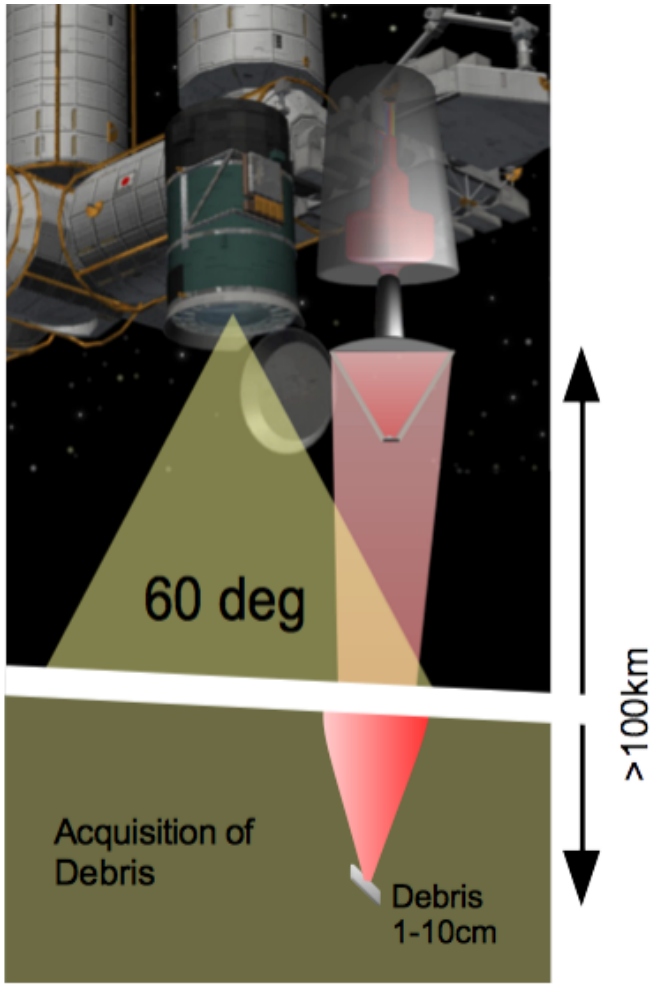
EUSO-Balloon



Space debris removal

Strategy





JEM-EUSO can detect and determine the trajectory of debris in the critical 1 cm – 10 cm range!

Next steps

Long duration balloon flight

Expected strong support from both CNES and NASA

Key milestone: detect the first UHECR showers from above
(with the fluorescence technique, well established on ground)

Mini-EUSO

Approved mission ASI (Italian Space Agency) and ROSCOSMOS)

JEM-EUSO demonstrator onboard the ISS (inside, not outside)

Will include test SiPMT detectors

Will observe airglow from space
Will observe TLEs and meteors

Can demonstrate space debris removal strategy

(to be operated in the ISS in 2017)


Thank you!