

Mini-EUSO

a telescope on board the International Space Station

M. Casolino

DIMS workshop
5-12-2020

The EUSO program

1. EUSO-TA: Ground detector installed in 2013 at Telescope Array site: currently operational

2. EUSO-BALLOONS:

- 2014, Timmins, Canada
- 2017 NASA Ultra long duration flight. EUSO-SPB

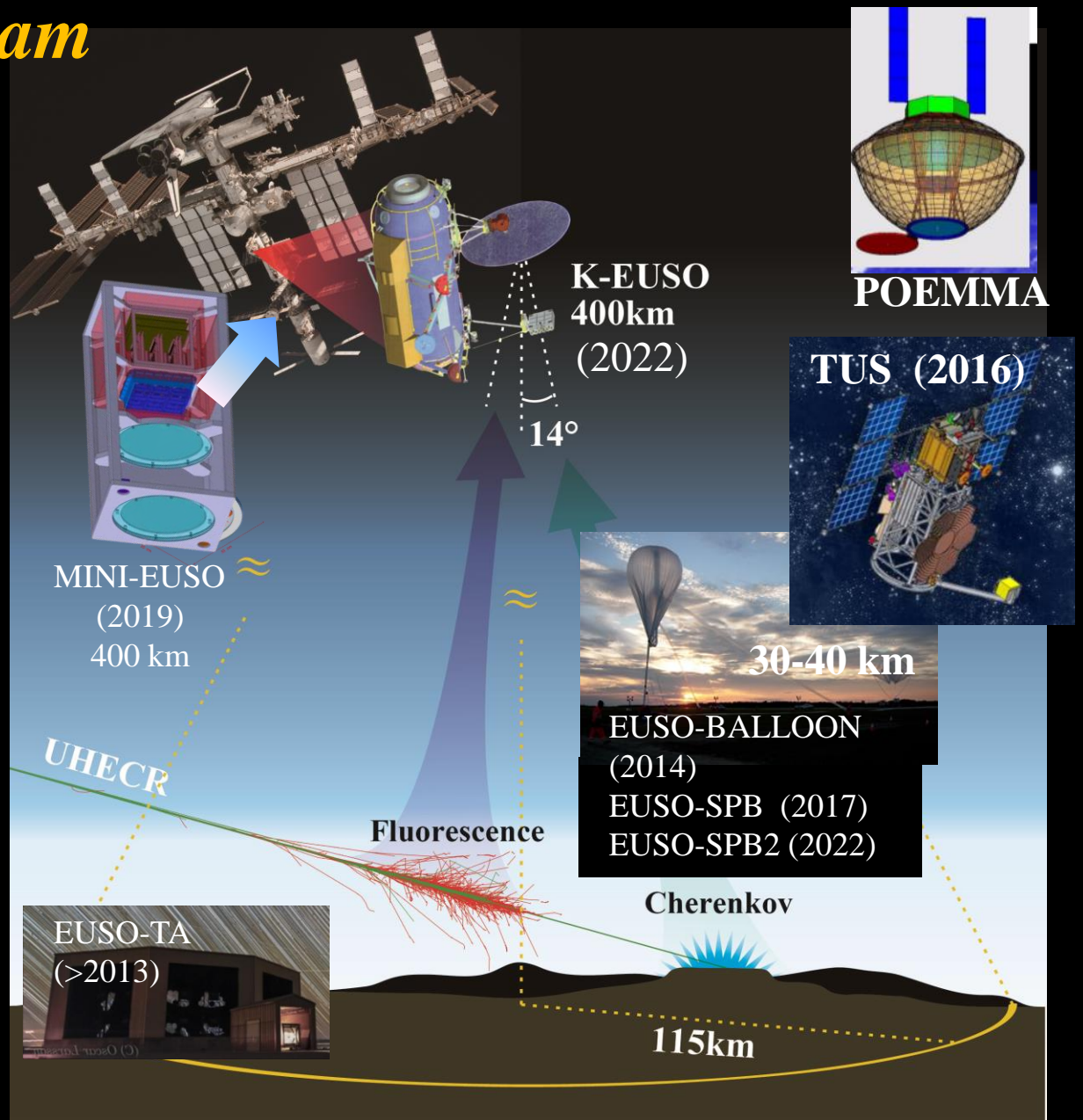
3. TUS (2016): free-flyer on Lomonosov Russian Satellite

4. MINI-EUSO (2019): Detector from International Space Station (ISS): 40 kg total.

5. SPB-2 (NASA) (2022)

6. K-EUSO (2023): ISS Phase A, Russian Space Agency

7. POEMMA (2025+): NASA twin free-Flyer



JEM-EUSO collaboration

16 Countries, 93 Institutes, 351 people





40kg
60 W
62*37*37 cm³

Ultraviolet, with Fresnel lenses

Near Infrared camera

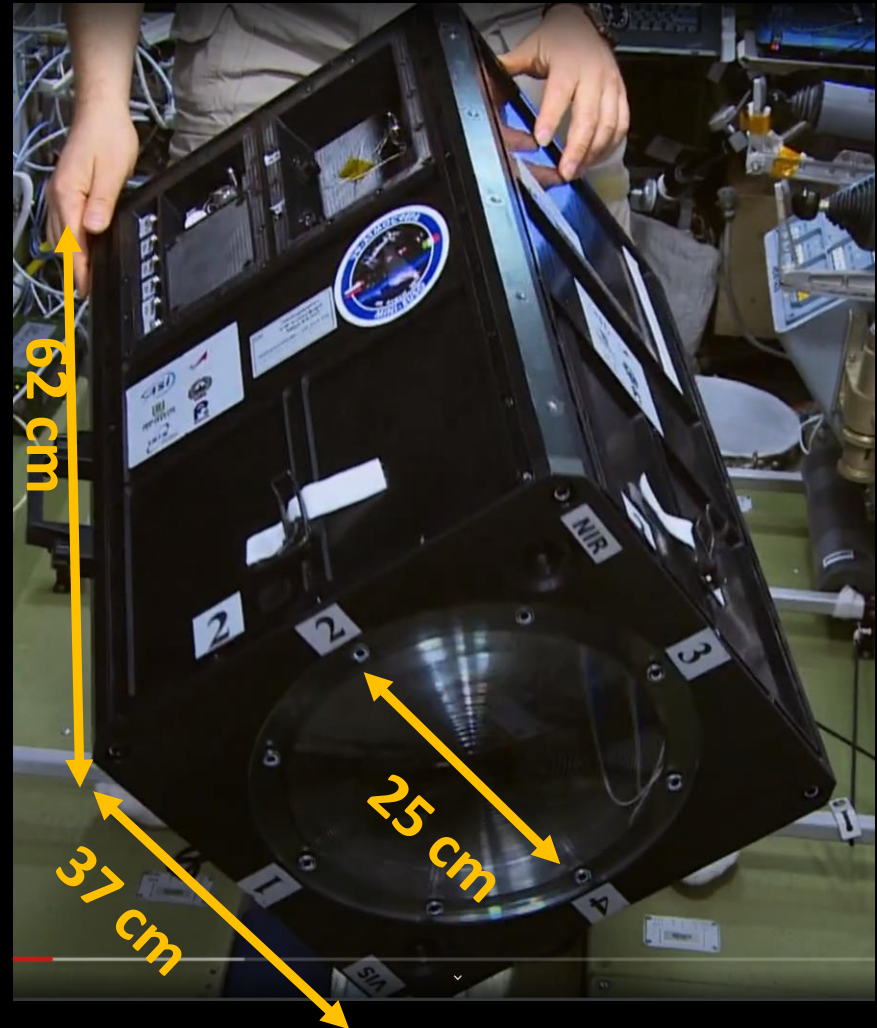
Visible camera

SiPM

2304 pixel

Same light/pixel of K-EUSO design

HVPS switch and dynamic range extension



Focal Surface

Silicon
Photomultipliers
C14047-3050EA08
8*8 pixel Imaging
system



C13365 single pixel

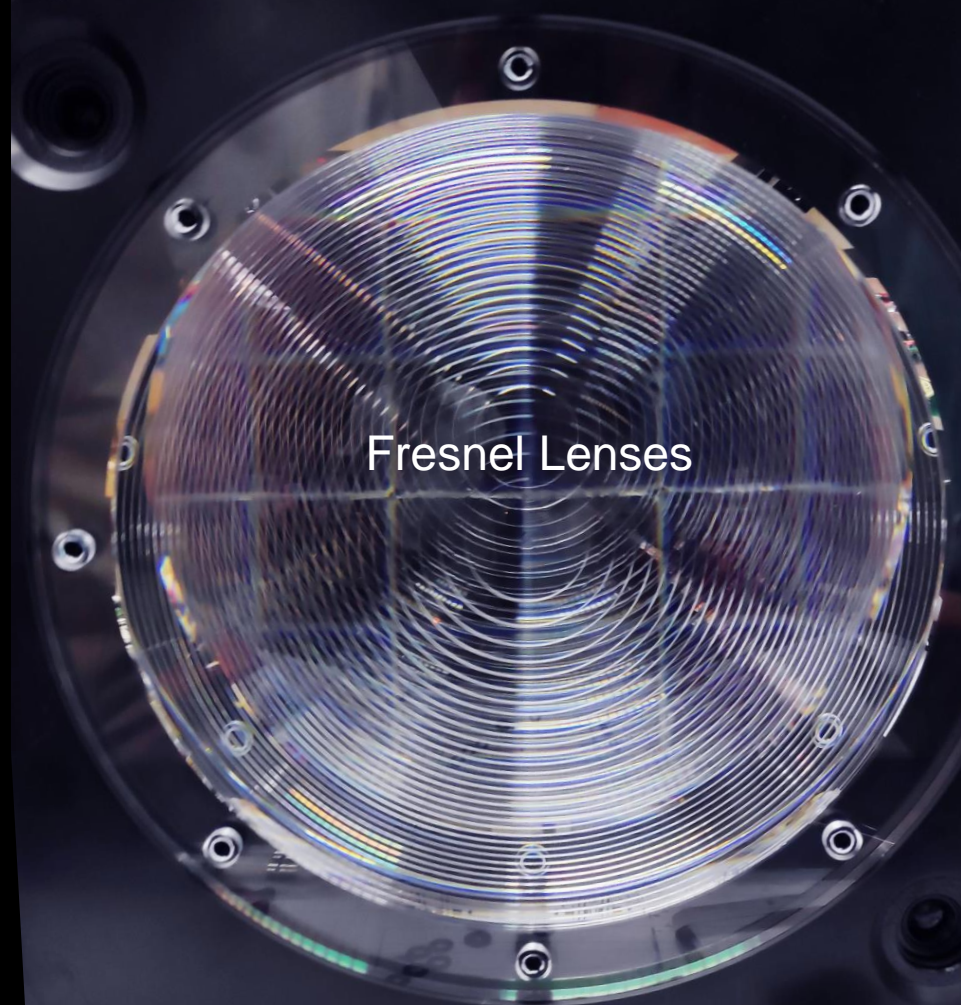
Light sensors
Hamamatsu
S1226-5BQ log
190-1000nm

ML8511 linear
280-400 nm

Fresnel Lenses

VISIBILE CAMERA

1



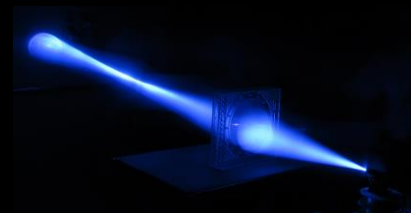
Fresnel Lenses

3

NIR CAMERA

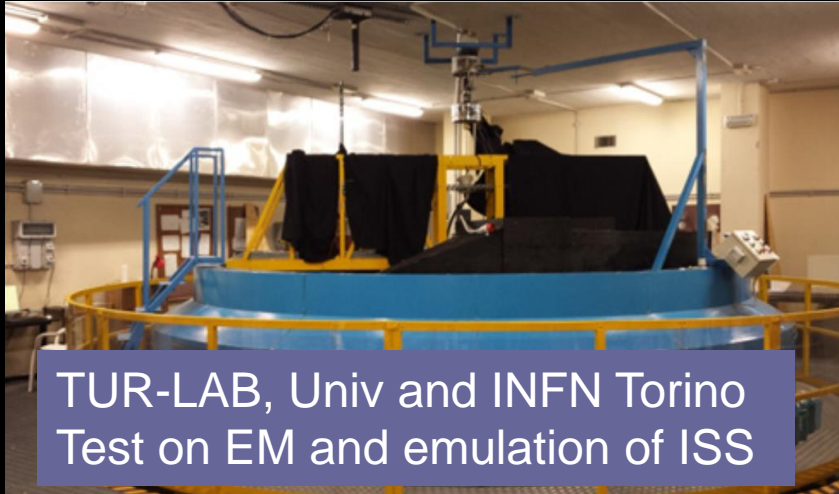


P. Nespoli con lente di Fresnel FM



*Realizzate al Riken (Giappone)
5ns rms sulla superficie*

Test and Integration of EM and FM 2017-2019



TUR-LAB, Univ and INFN Torino
Test on EM and emulation of ISS



INFN LNF
Mechanics and Integration



INFN Tor Vergata
Qualification and
Acceptance
procedures



INFN Tor Vergata
Sky tests

Acceptance tests in Baikonur and integration with Soyuz MS-14



Building 254, assembly of Soyuz/Progress

Roll-out of Soyuz MS-14, 19/8/2019



Launch, 2/8/2019



First docking, 24/8/2019 unsuccessful



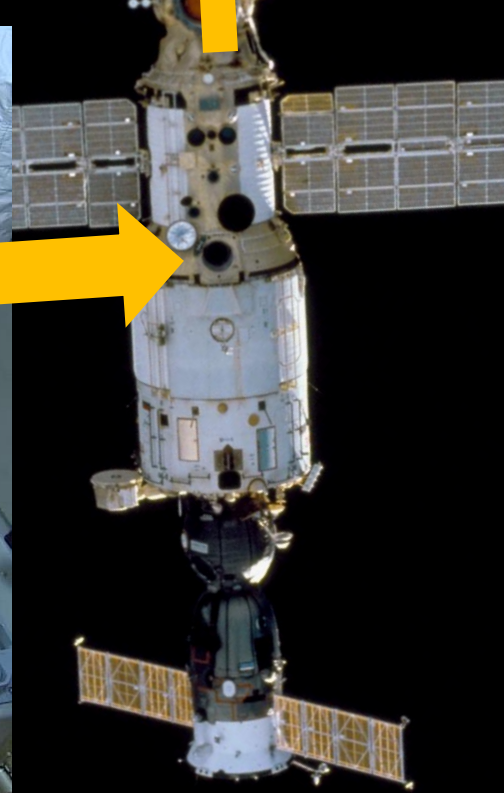
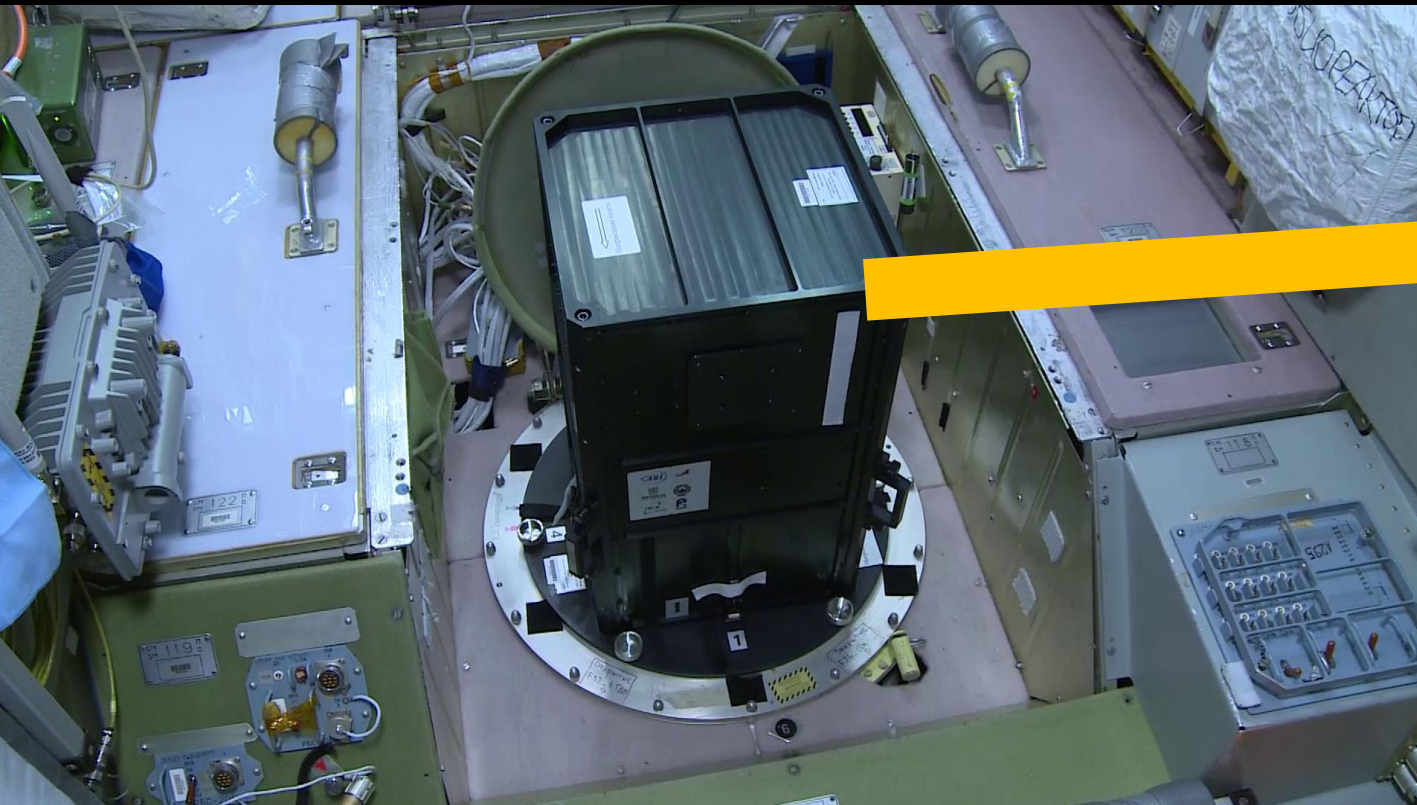
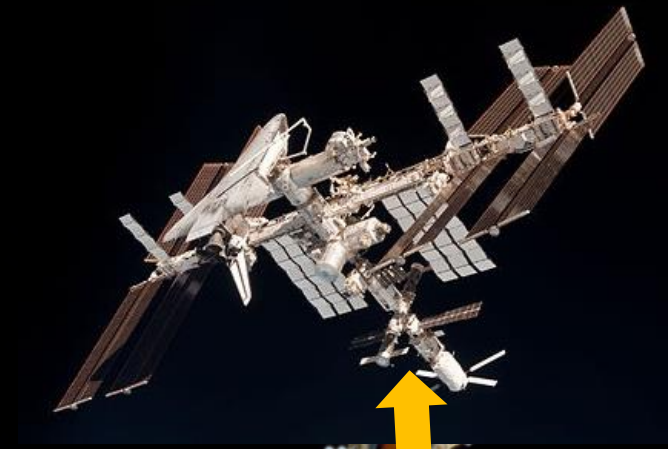
Relocation of MS-13 from Zvezda to Poisk



Second docking, 27/8/2019 successful



Uv transparent window, Zvezda module, International Space Station



Missione Beyond – outreach videos



L. Parmitano in visita
a Tor Vergata con FM
Mini-EUSO



Video Roscosmos

<https://www.youtube.com/watch?v=IXedBGVHc4>



Video di Outreach da ISS

<https://www.youtube.com/watch?v=QincAp4V-SM&t=1s>



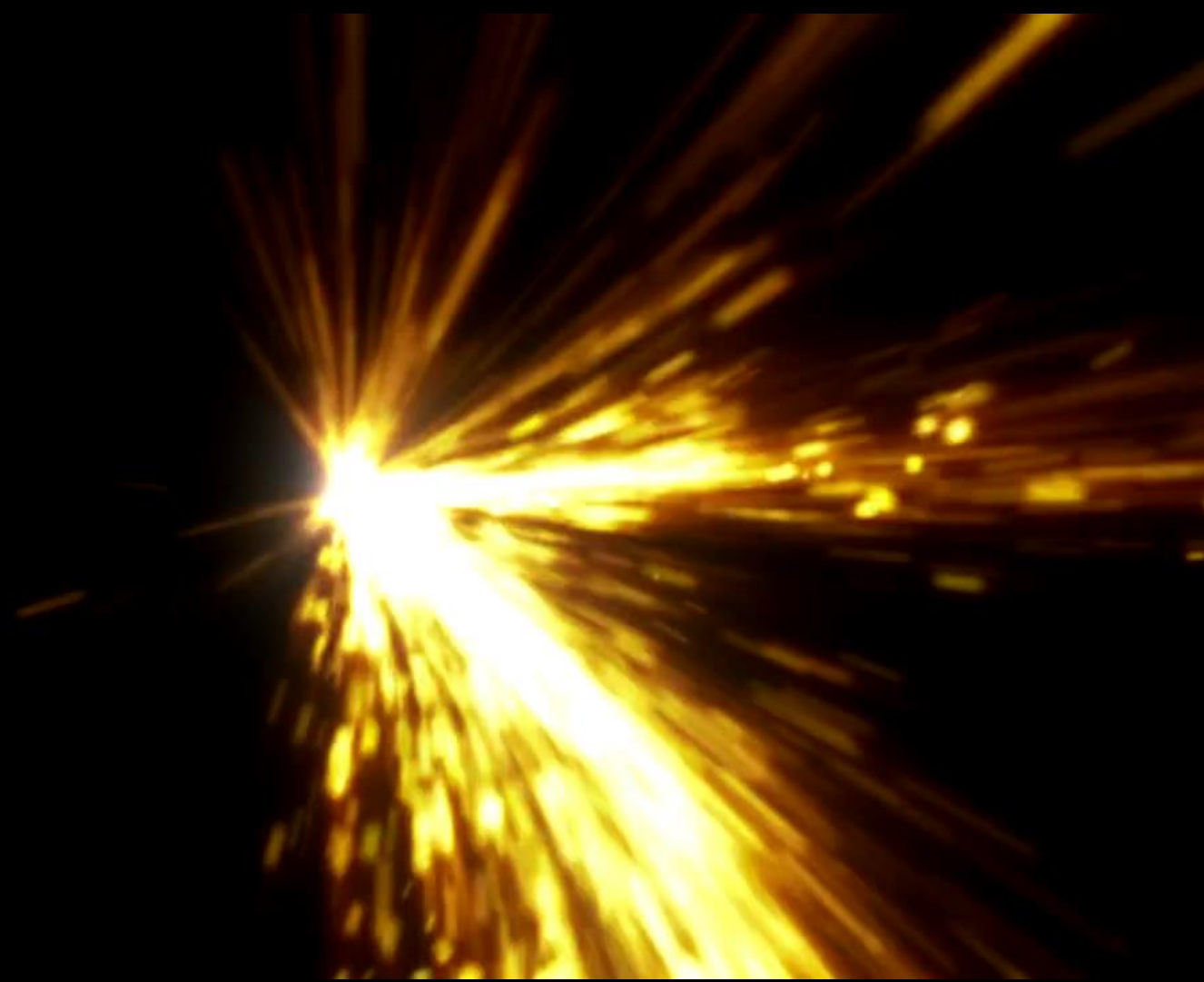
Video di outreach ASI/Corriere della Sera

<https://video.corriere.it/cronaca/mini-euso-luca-parmitano-protagonista-web-serie-beyond/2582bd90-aa06-11e9-a88c-fde1fa123548>



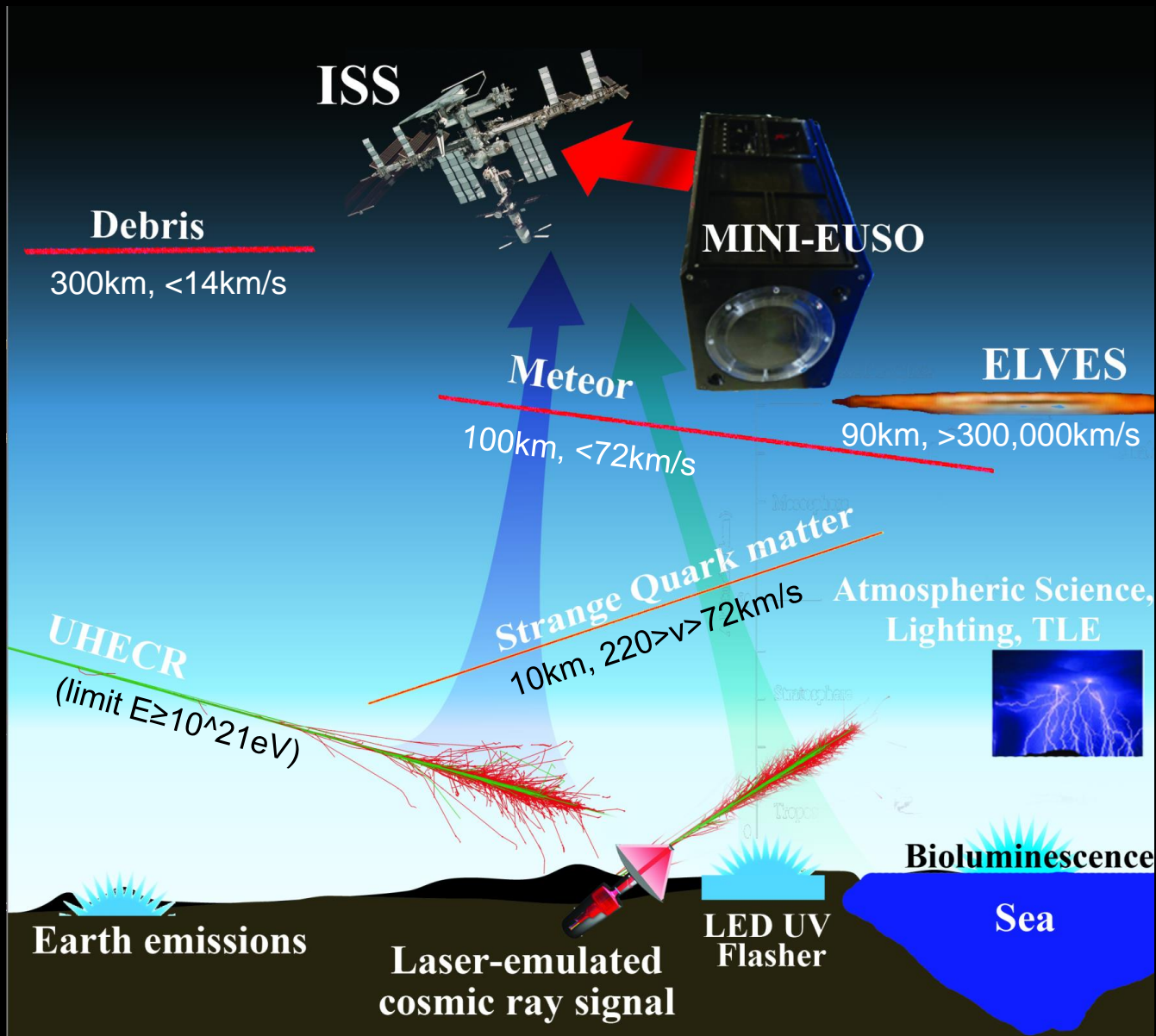
Menzionato nel collegamento con Presid. Mattarella

<https://www.youtube.com/watch?v=NMTTSB6BVaw>

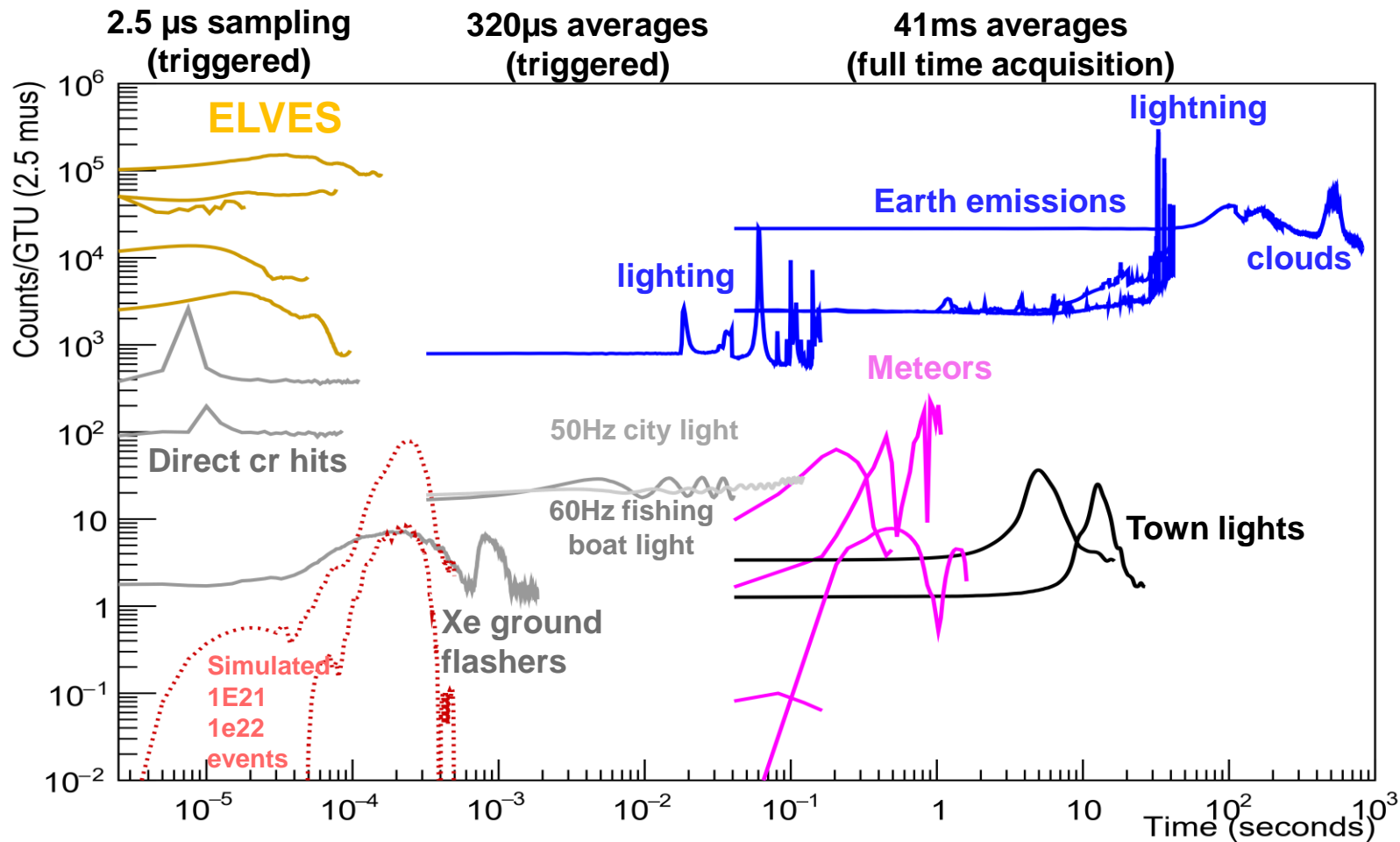


https://www.youtube.com/watch?v=OKIFN1u_Wdk

Science Objectives



Time profile of various events (selected from 10% of data)



Visible camera data

3-seconds frames

Correlation with UV

Meteors, cloud, town

Ageing from radiation

Single cosmic ray hits



Clouds and sea emission

2019_12_05 18:30 UTC

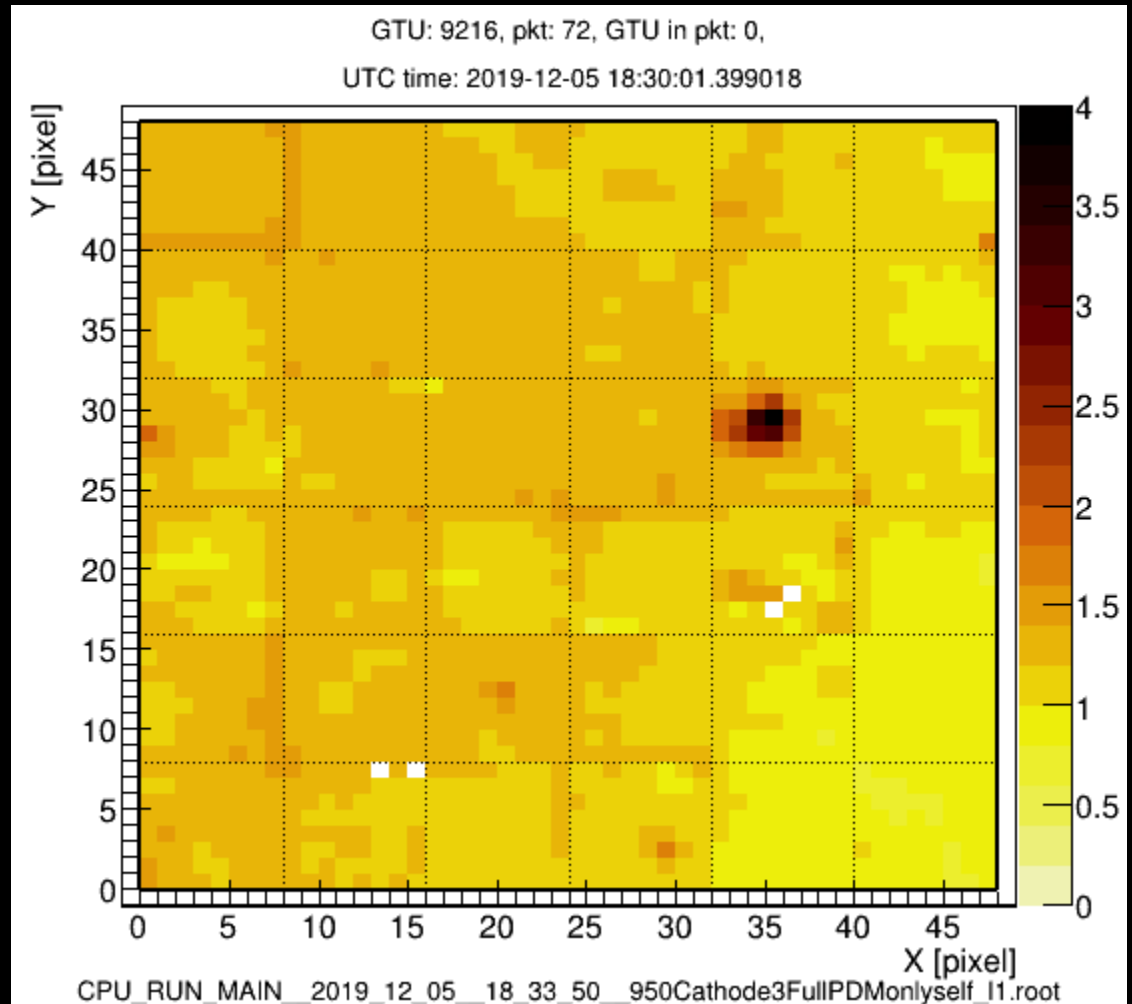
Counts/pixel/GTU

Indian Ocean

Pixel size 6.1km

ISS speed 7km/s

Yaw of 4 degrees



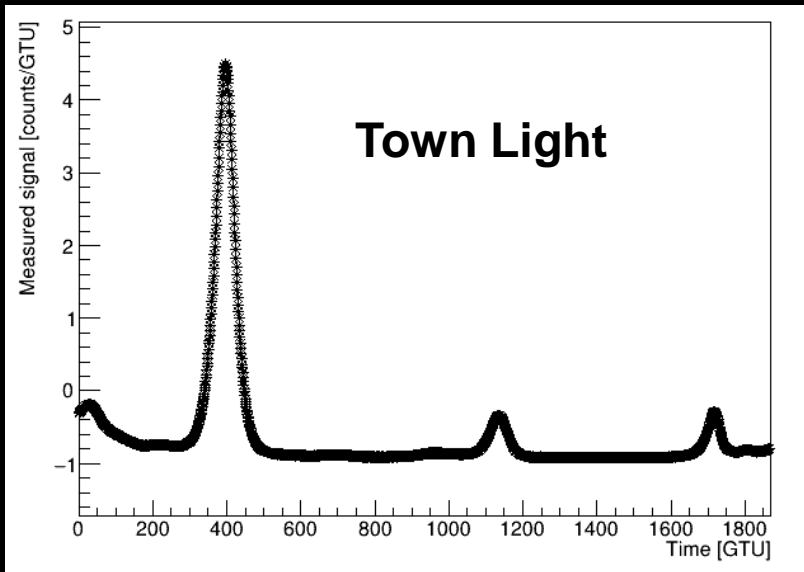
1 frame = signal integrated in 40.96 ms

~14 min video (1 frame every 128 frames) ~5s

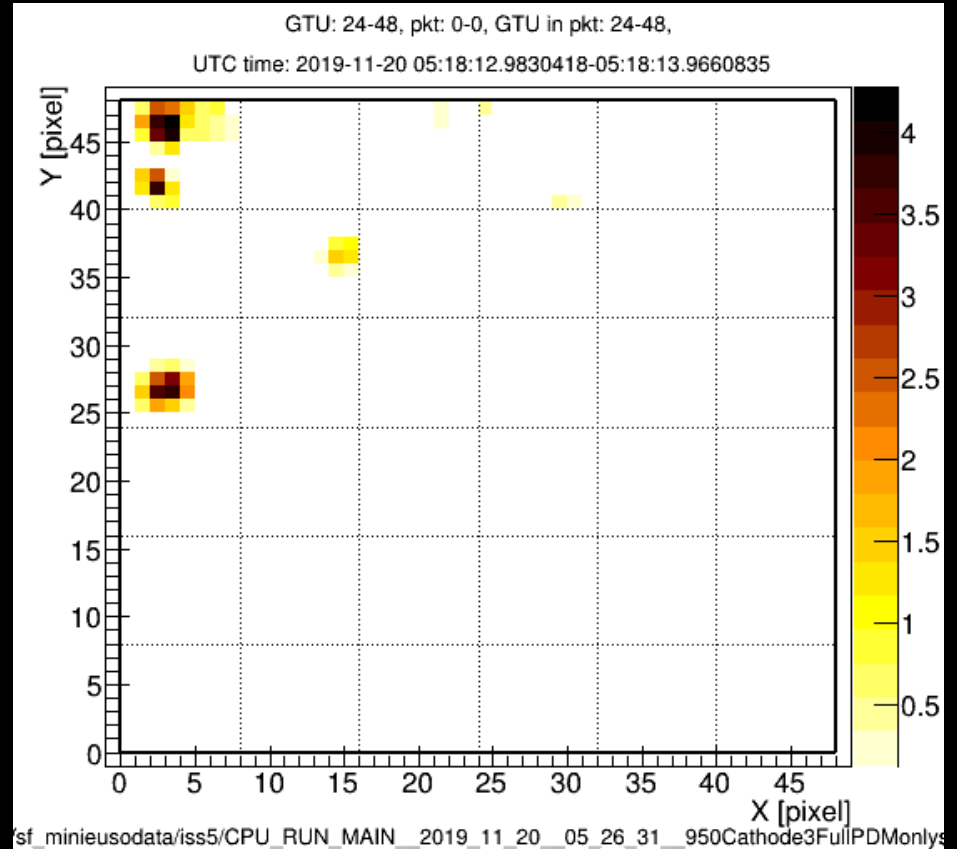
Ground emissions (between Vancouver and Calgary)

41ms continuous sampling

Pixel size 6.1km
ISS speed 7km/s
Yaw of 4 degrees



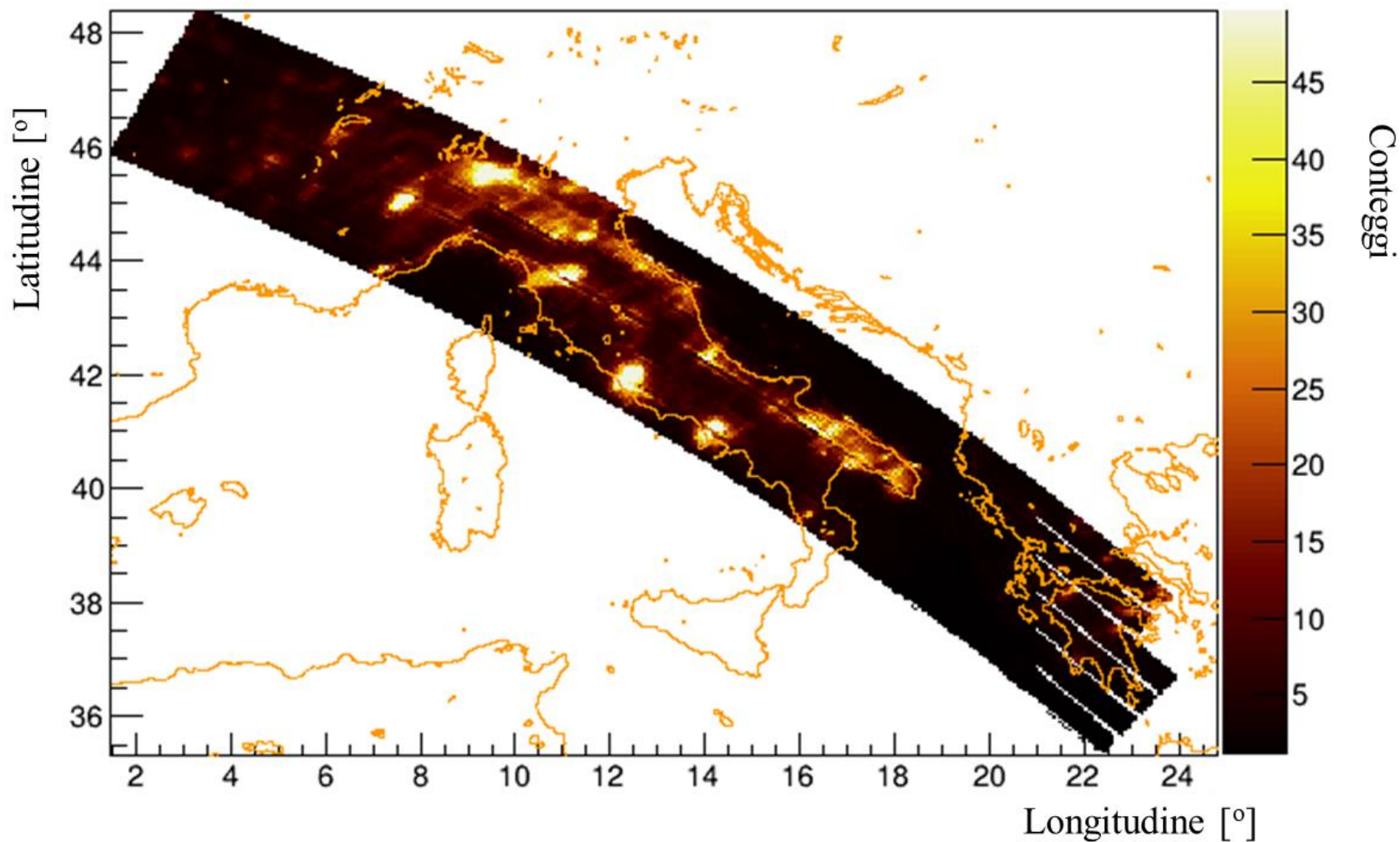
41ms samples



1s 25D3 frames average

Prima mappa notturna dell'Italia in banda ultravioletta (300-400nm) dalla Stazione Spaziale Internazionale con il telescopio Mini-EUSO

Missione Beyond, 2019-2020



From L. Piotrowski

1 conteggio $\cong 10^{20}$ fotoni UV/ (km² s sr)

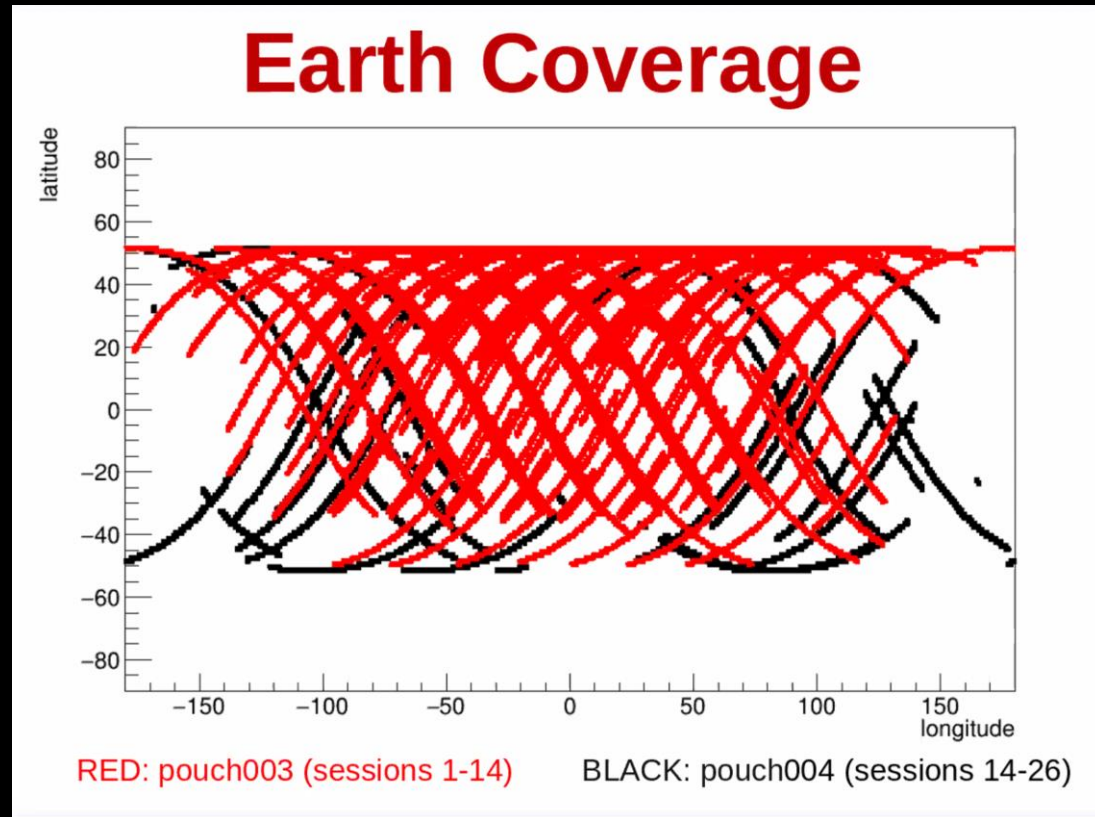
Earth Coverage (up to march 2020)

Pouch 3

15 sessions
160GB RAW
133GB (good, post-commissioning)
Raw Files
60GB zipped (rar)
50GB root «level1» files
About 33E6 PDM frames
 3E6 D3 (41ms frames)
1275 PDM «runs» (acquisition files)
42 (34) hours of night time data
62000 VIS Camera pics

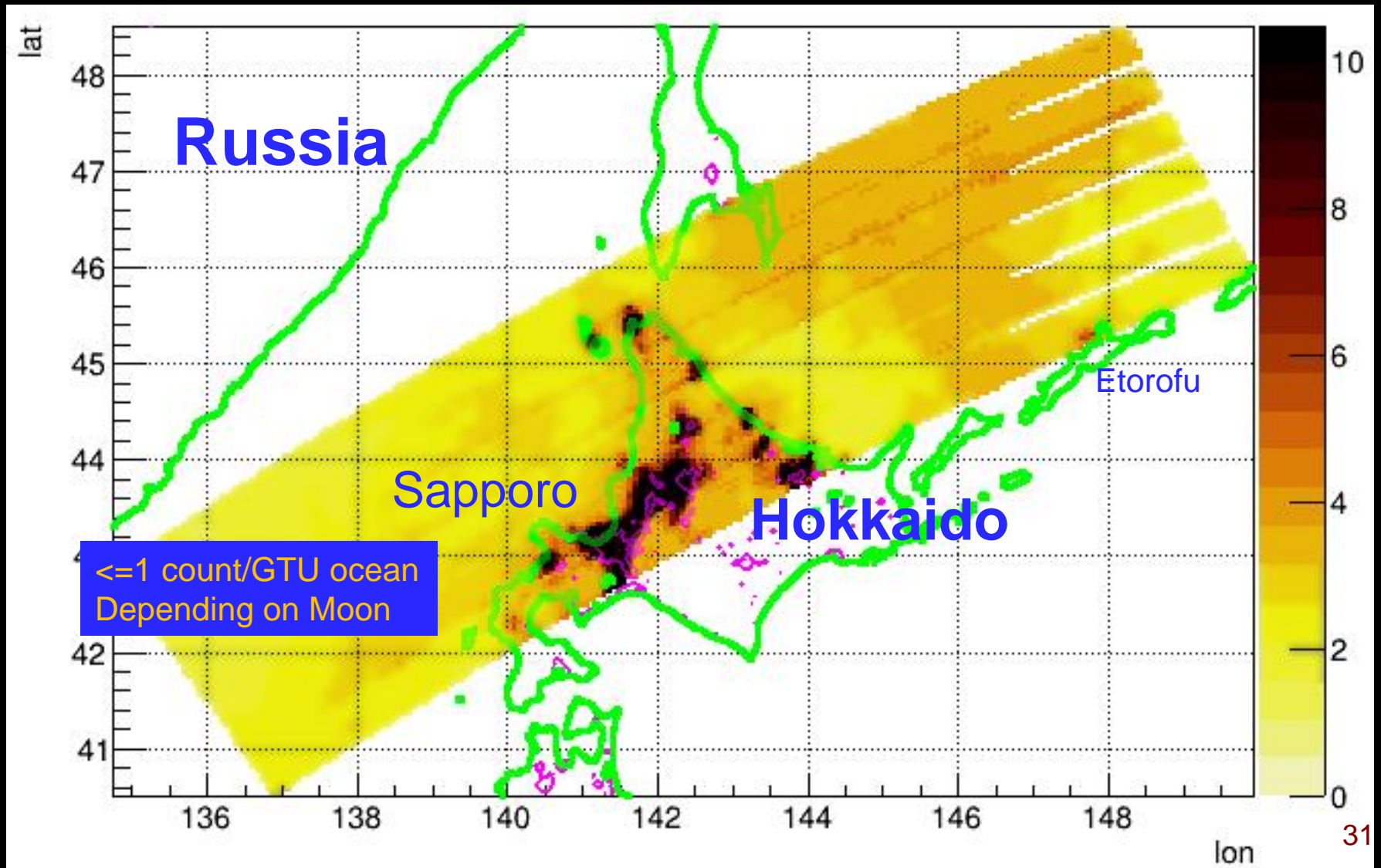
11 sessions so far

D1 = 35.8 hours (sess. 4-26) (but 10% of 15-26,
up to 34)

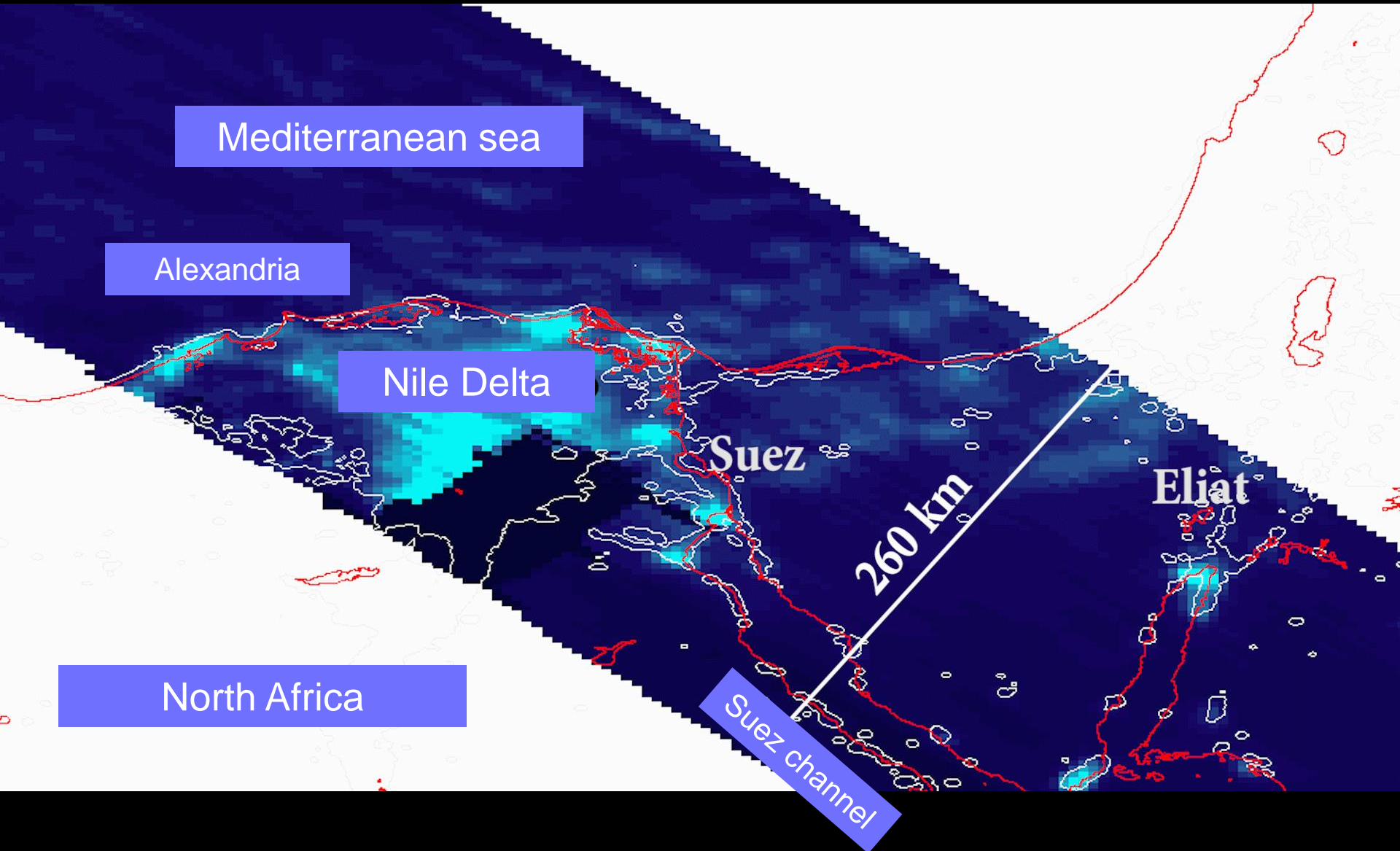


From L. Marcelli

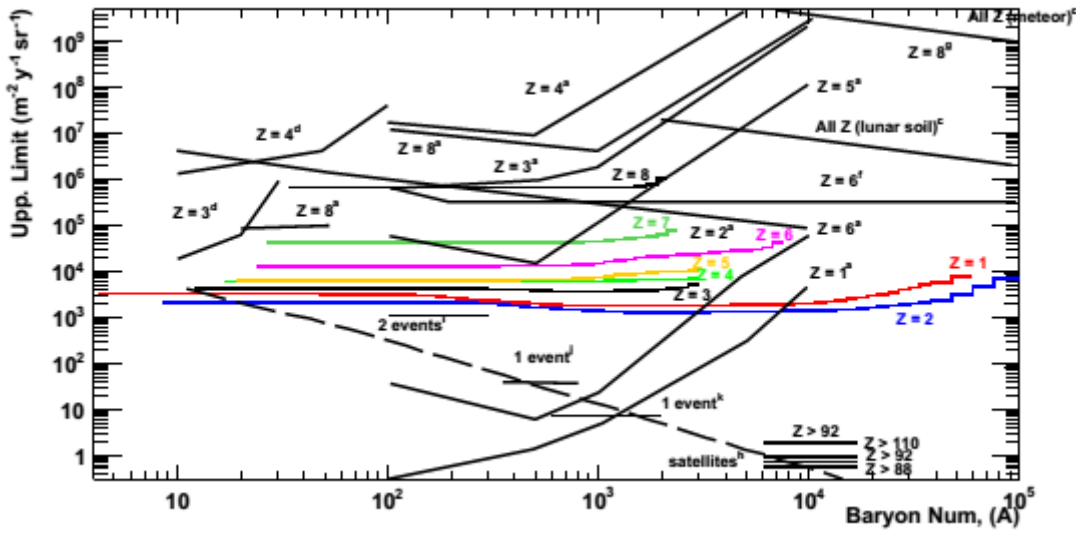
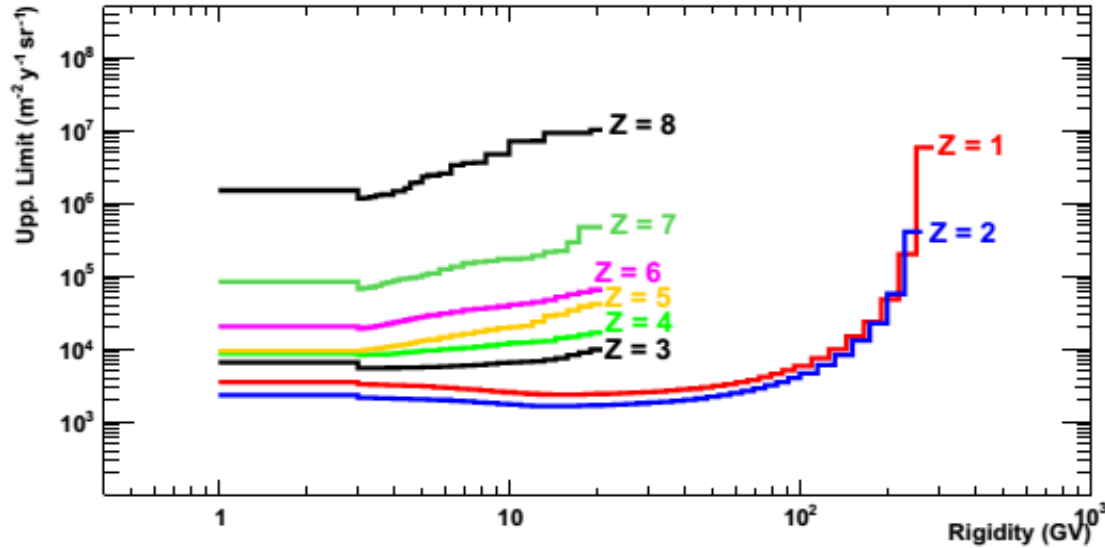
UV maps: Northern Japan



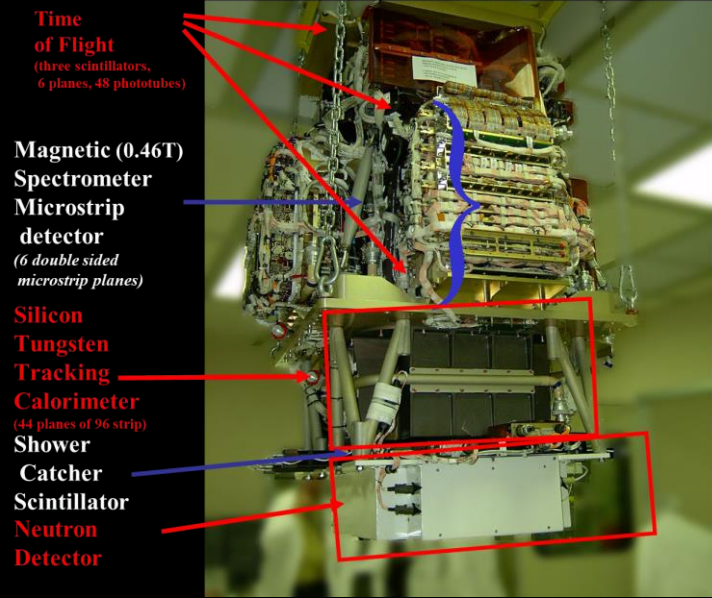
Egypt and Suez Channel



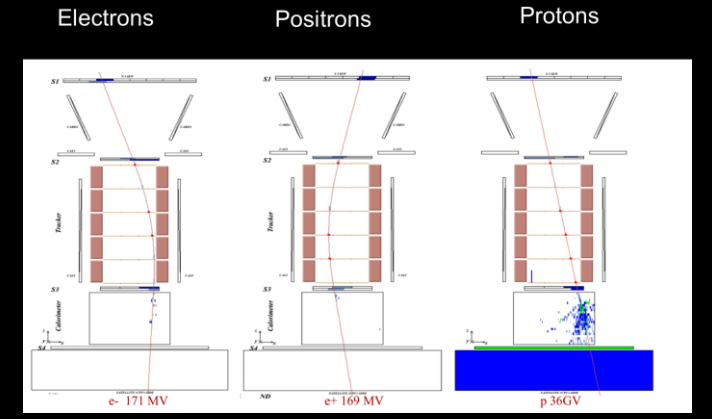
PAMELA Strangelet upper limit



The detector



Principle of detection



Interstellar Meteors and Search for Strange quark matter

200 meteors detected so far
Near Earth Objects,
complementary to ground
arrays (joint observations)

About 2000 in data cards

Maximum speed 72 km/s

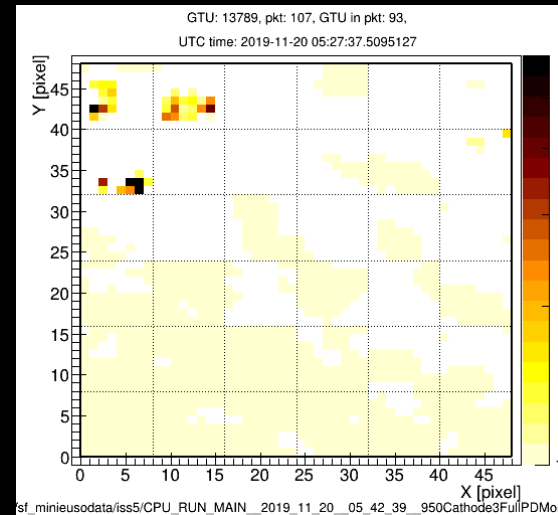
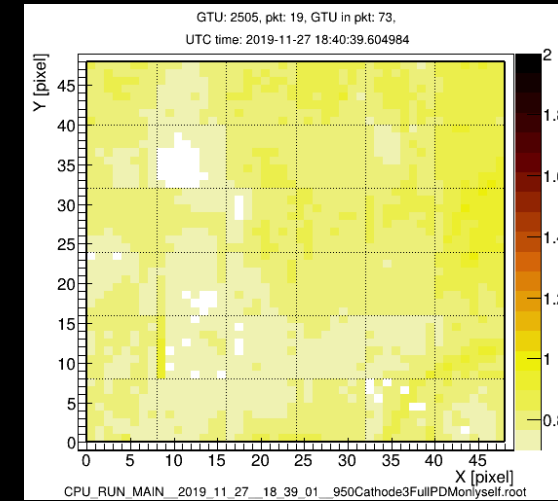
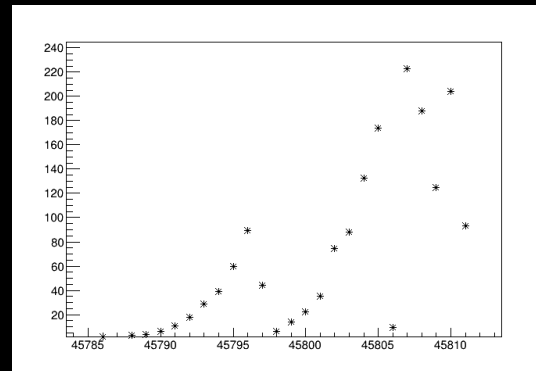
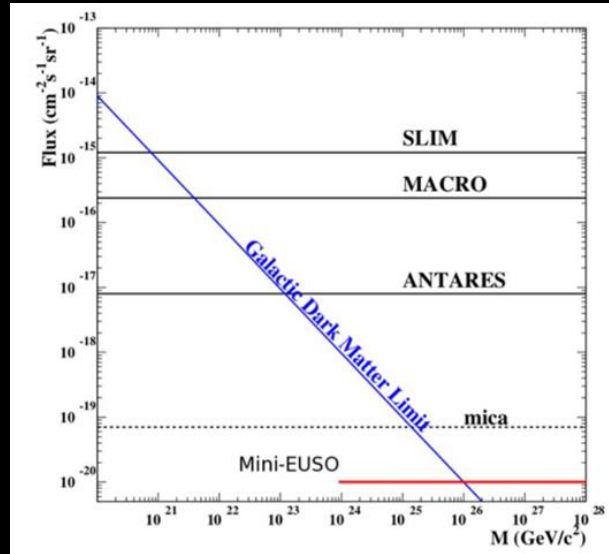
Interstellar meteors:

$220\text{km/s} > V > 72\text{ km/s}$

Relevance for solar system
formation, Kuiper belt.

SQM: $220\text{km/s} > V > 72\text{km/s}$

Long continuous track



Meteor studies in the framework of the JEM-EUSO program. PLANETARY AND SPACE SCIENCE, 143(SI):245{255, SEP 1 2017.

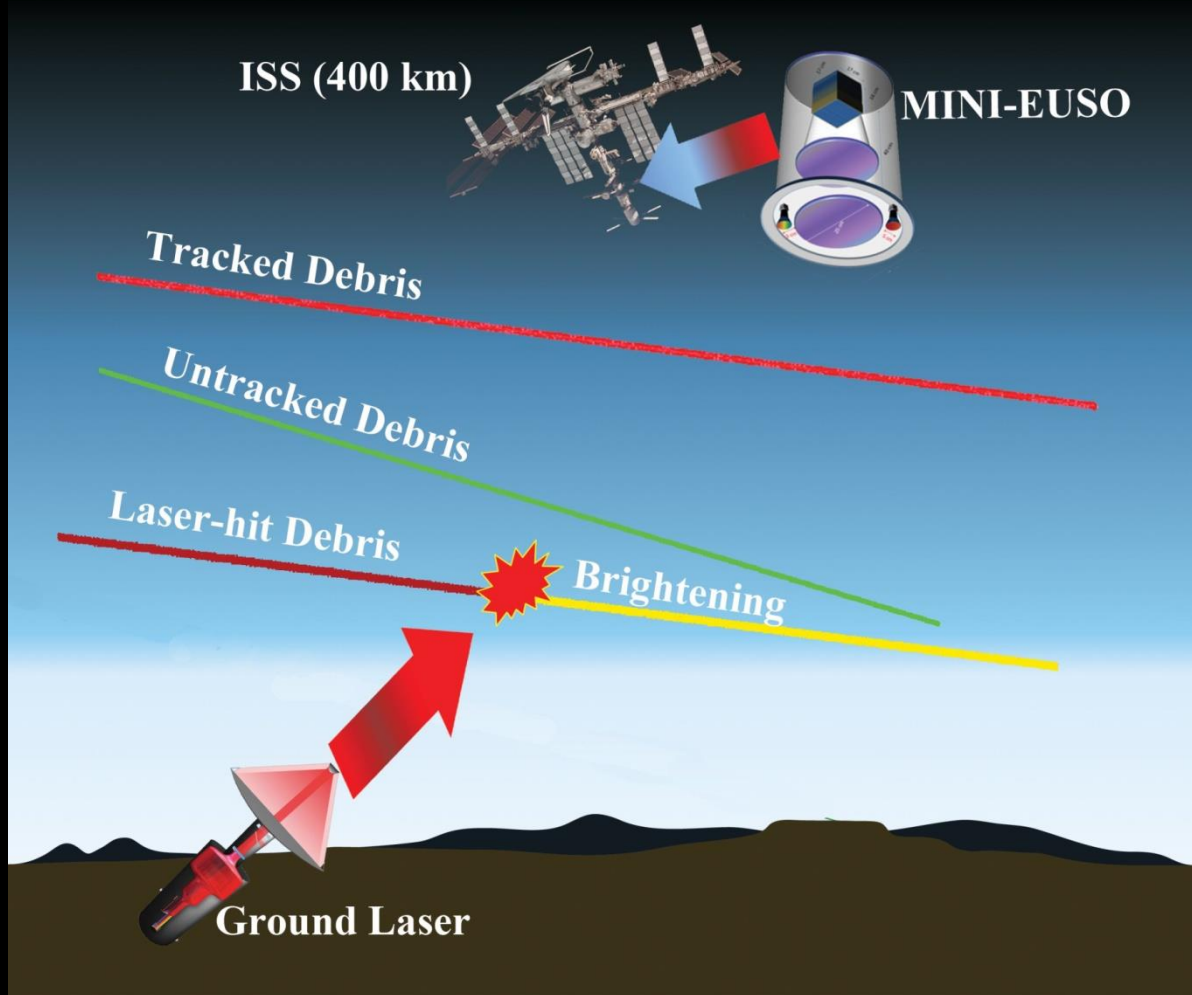
JEM-EUSO: Meteor and nuclearite observations. Experimental Astronomy, 40:253{279, November 2015.

Mini-EUSO & Space Debris remediation

Search for known objects in
f.o.v of minieuso
(in termination line between
dark and light)

Norad and other catalogues

Look for unknown debris
(includes meteors for this
purpose)



Acta Astronautica 112 (2015) 102–113

Contents lists available at ScienceDirect

Acta Astronautica

ELSEVIER

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Demonstration designs for the remediation of space debris
from the International Space Station

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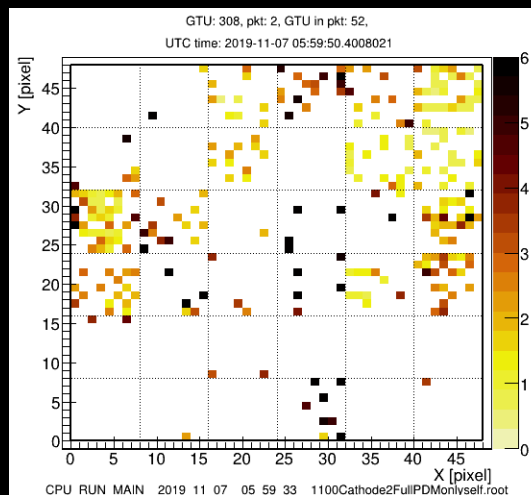
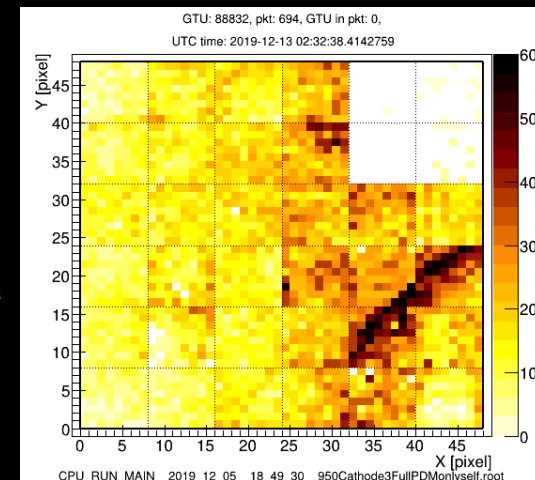
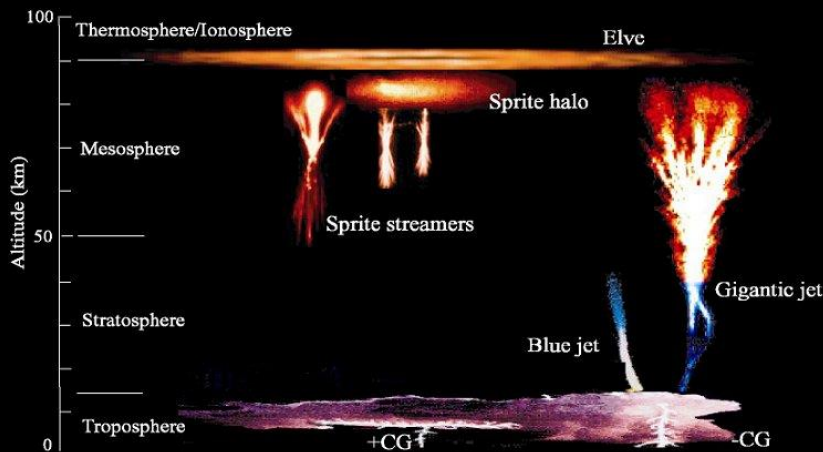
^fDepartment of Physics and Astron, University of California at Irvine, Irvine, CA 92697, United States

ELVES (transient luminous events)

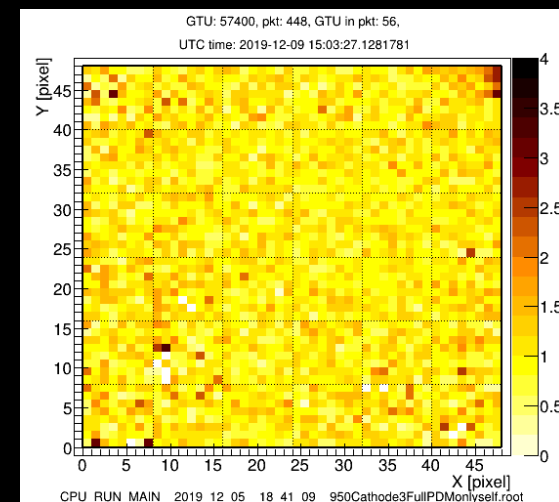
Superluminal rings
100km+ radius

Upper atmospheric
lighting releases
e.m. wave which
heats the
ionosphere
Transient Gamma
Flash relationship

About 400μs
Overall duration

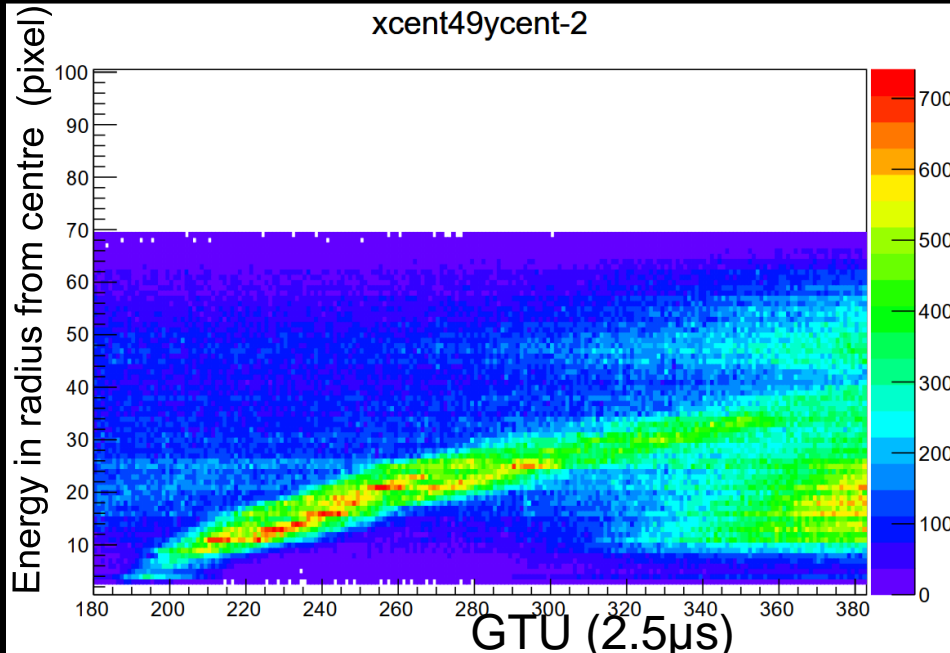


2.5μs
GTU



ELVE: 2019-12-05_n1

Polar histogram

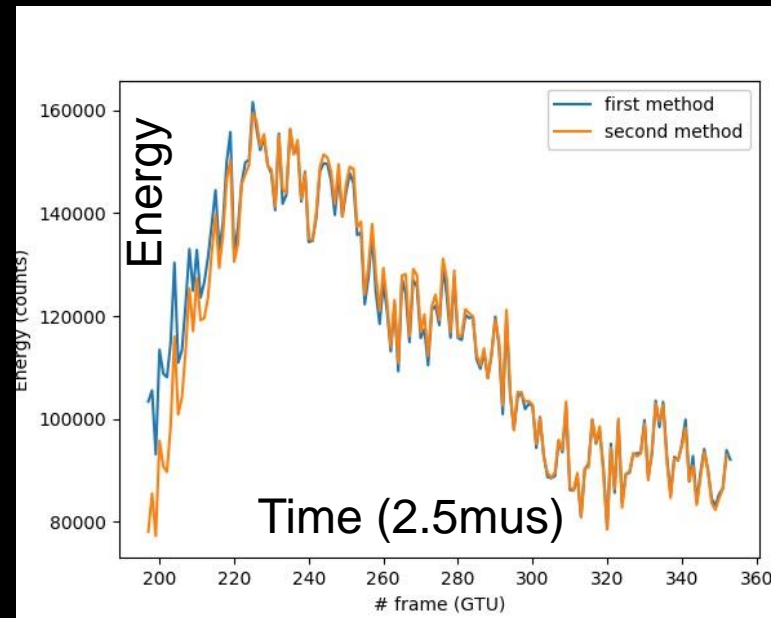
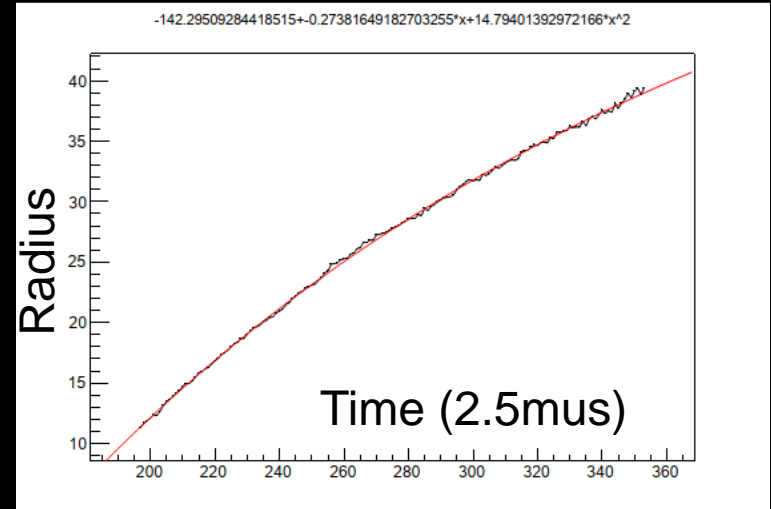


Speed ≈ 0.18 pix/GTU $\approx 338\,400$ km/s

Pixel size:

6.1 km on ground

4.7 km at 100 km



From L. Marcelli

Shower simulation and end-to-end calibration with ground UV laser and UV flasher

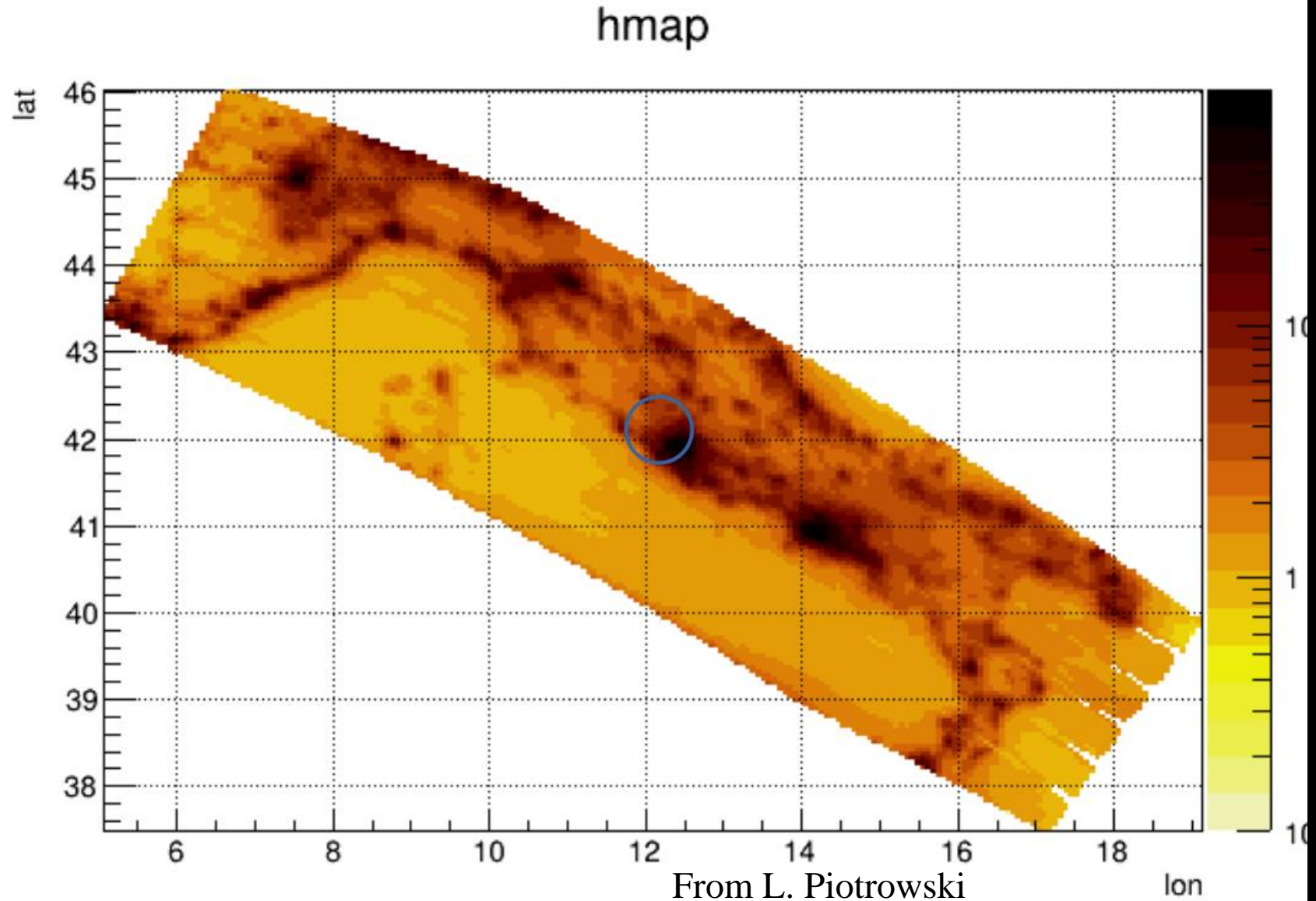
- Norio Tajima (Riken)
- E. Reali (smaller, test prototype)
- 2kW pulsed UV LED array
- PORTABLE!
- Calibration from ground
- Shoot when in field of view
- Pulsed and coded shots
- First system developed in Japan. Other systems in Europe and USA.



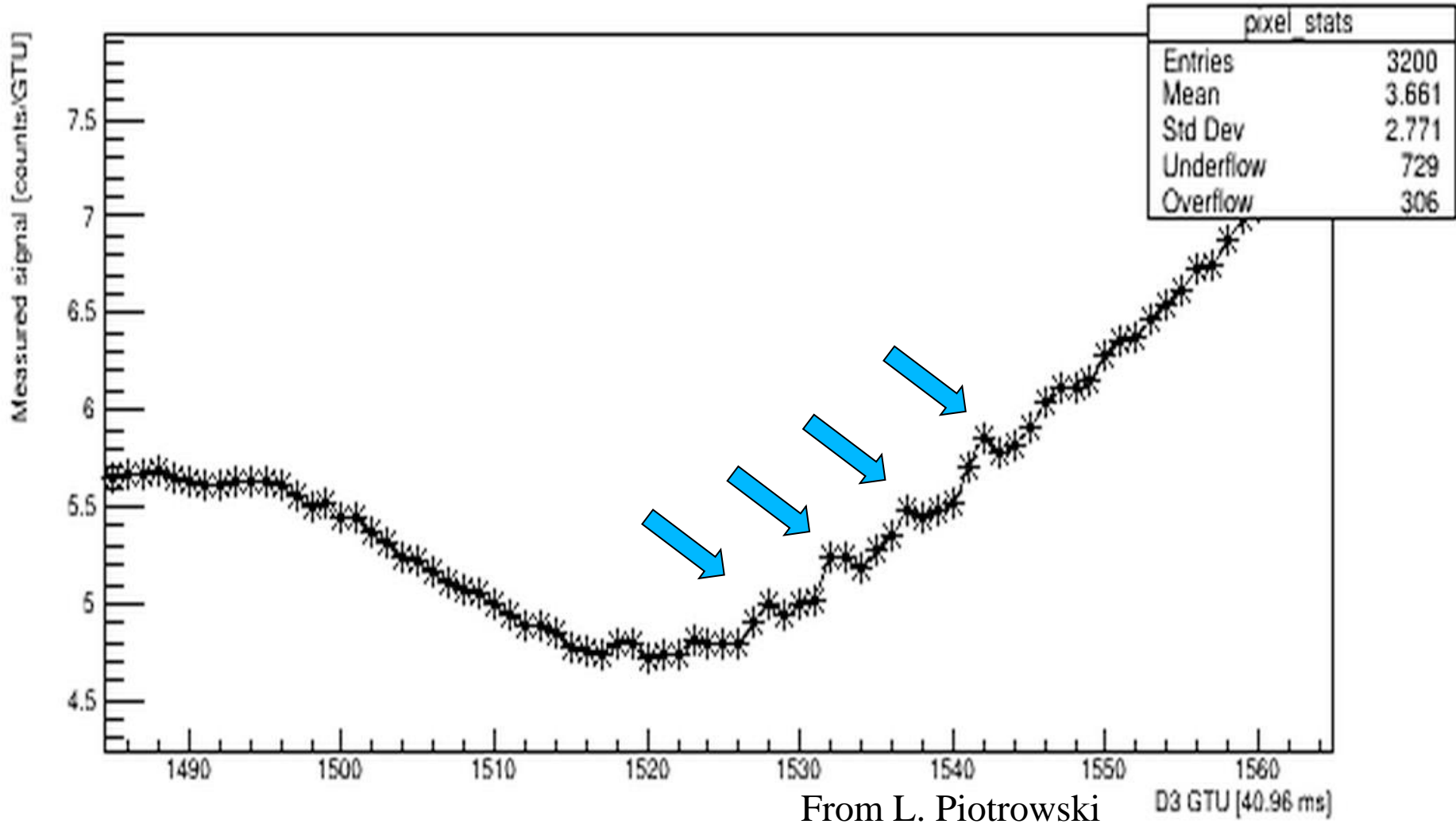
Session 24, 15 September 2020



Passage of 15-9-2019 morning

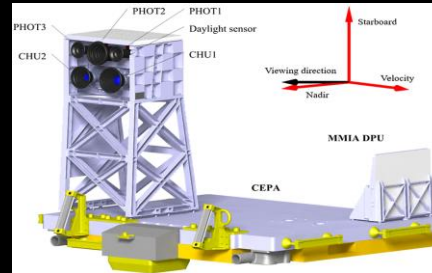


Pixel 24-26



Joint observations with other detectors on the ISS

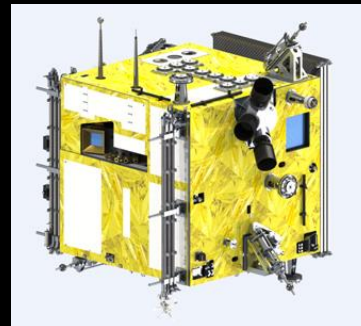
ASIM:
UV transients and ELVES



ALTEA-LIDAL («our»)
Correlation with radiation environment
of cosmic rays 100 Mev – GeV and
Transient Luminous Events



CSES-Limadou («our»)
(different orbit)





Godspeed, JEM-EUSO Program!

岩澤 駿
SHUN IWASAWA