Five+ years of Mini-EUSO telescope on board the ISS.

M. Casolino
INFN – Istituto Nazionale di Fisica Nucleare
Università di Roma Tor Vergata

2-6-2025

JEM-EUSO collaboration 16 Countries, 93 Institutes, 351 people

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***

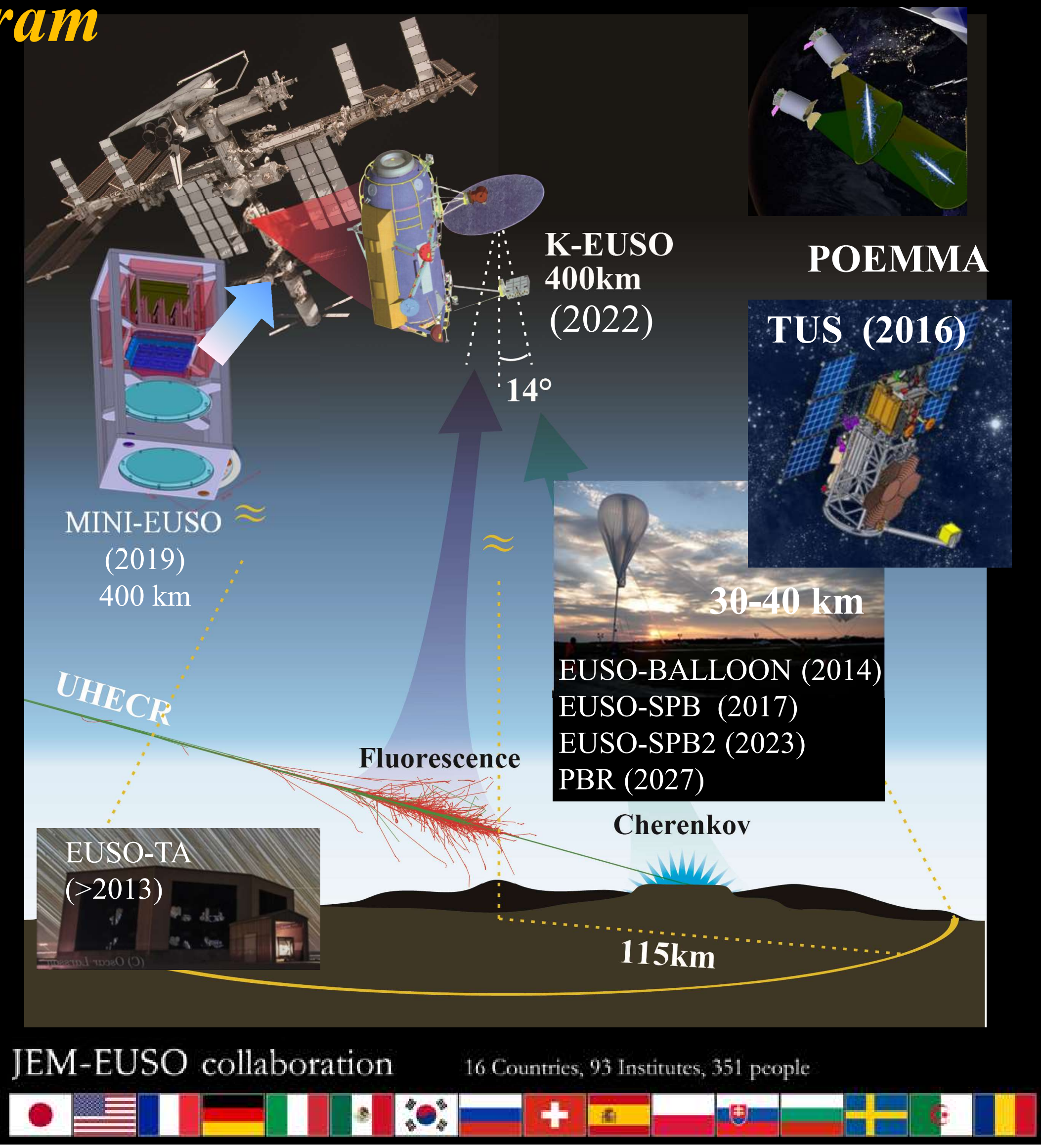
3. **TUS (2016):** free-flyer on Lomonosov Russian Satellite

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

5. ***SPB-2 (NASA) (2023)***

6. **PBR (2027):** ***ISS Phase A, Russian Space Agency***

7. **POEMMA (2030+):** ***NASA twin free-Flyer***



Mini-EUSO/UV-Atmosfera

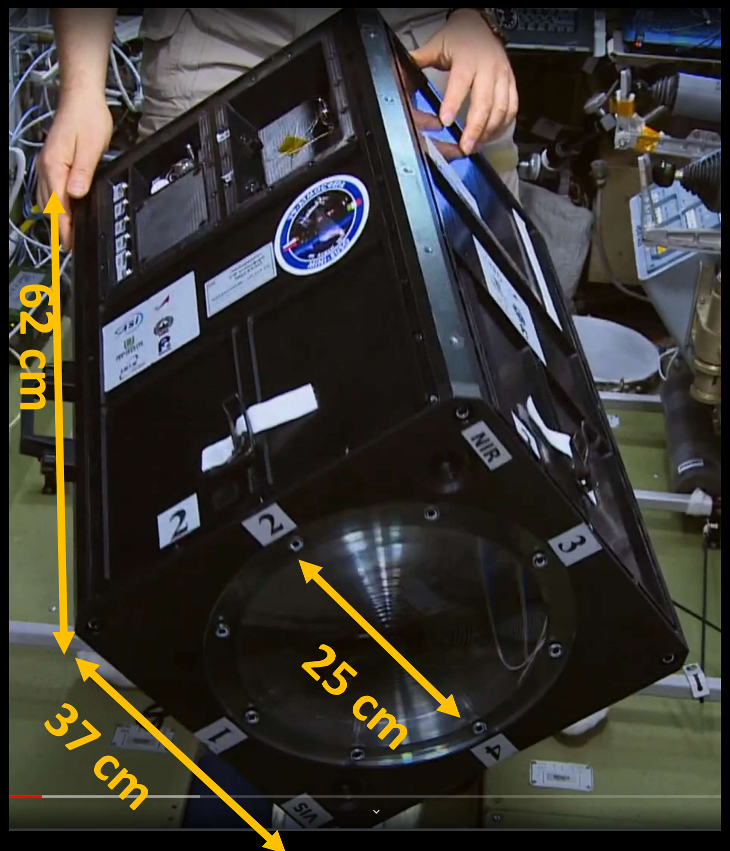
40kg, 60 W, 62*37*37 cm3
Ultraviolet, with Fresnel lenses
Near Infrared camera
Visible camera
SiPM
2304 pixel
Same light/pixel of K-EUSO design

HVPS switch and dynamic range extension

Mini-EUSO: A high resolution detector for the study of terrestrial and cosmic UV emission from the International Space Station. ASR 62(10):2954{2965, Nov 2018.

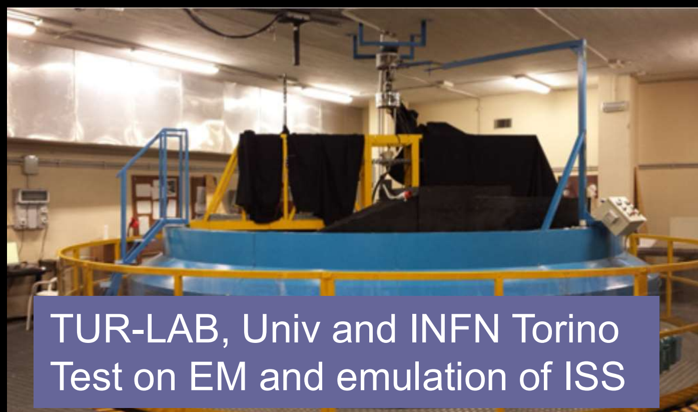
Capel, F., et al. Mini-EUSO data acquisition and control software. JATIS, 5(4), OCT 2019. ISSN 2329-4124. doi:10.1117/1.JATIS.5.4.044009.

The integration and testing of the Mini-EUSO multi-level trigger system, ASR62   Issue: 10   Pages: 2966-2976 , 2018



JEM-EUSO collaboration   16 Countries, 93 Institutes, 351 people

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

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

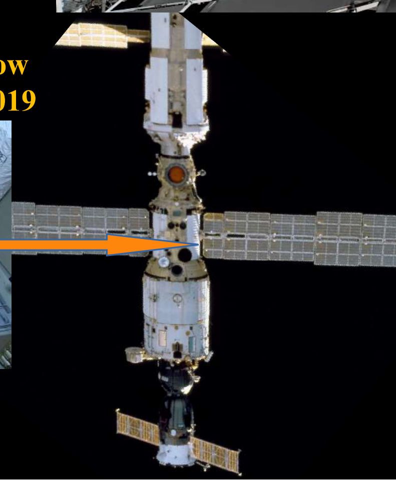
Launch, 22/8/2019

First docking, 24/8/2019
unsuccessful

Relocation of MS-13 from
Zvezda to Poisk

Second docking, 27/8/2019
successful

Installation - Uv transparent window
Zvezda module, first light 07/10/2019



Mini-EUSO/UV-Atmosfera

JEM-EUSO collaboration 16 Countries, 93 Institutes, 351 people

Focal Surface

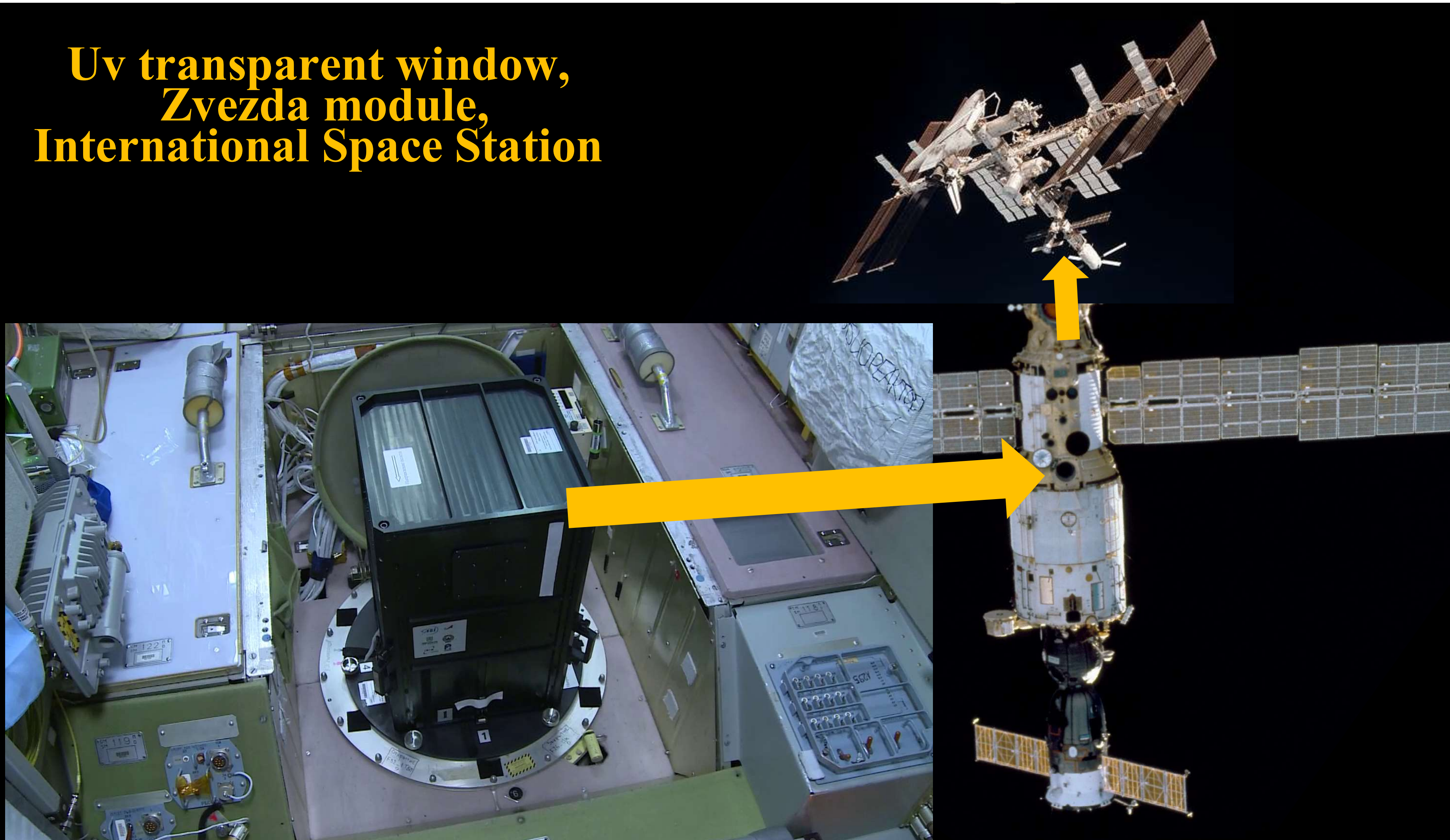
Silicon Photomultipliers
C14047-3050EA08
8*8 pixel Imaging system

C13365 single pixel

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

ML8511 linear
280-400 nm

Uv transparent window,
Zvezda module,
International Space Station



Data Cards

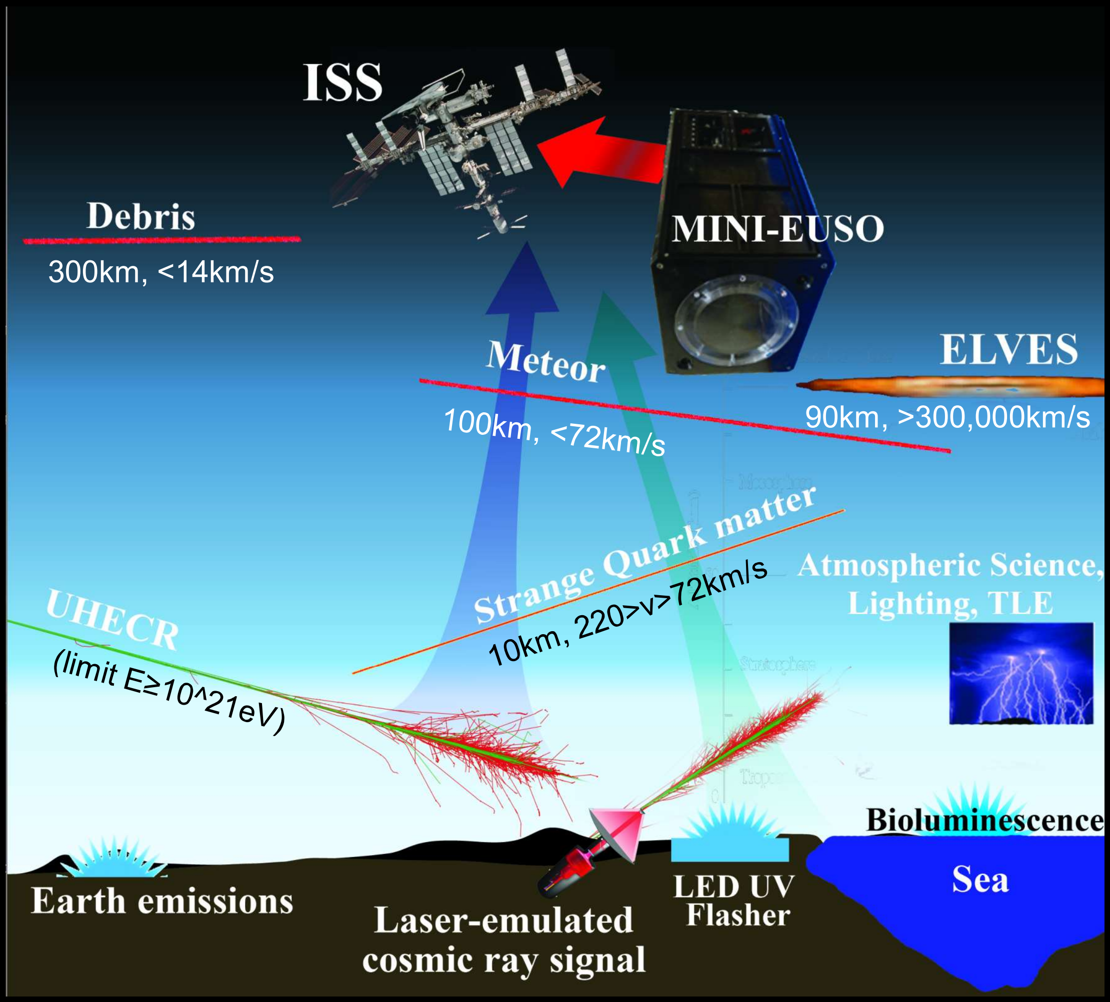
CORSAIR 3.1 – new model

CORSAIR 3.0 – old model
Continuous CPU reset
No longer used

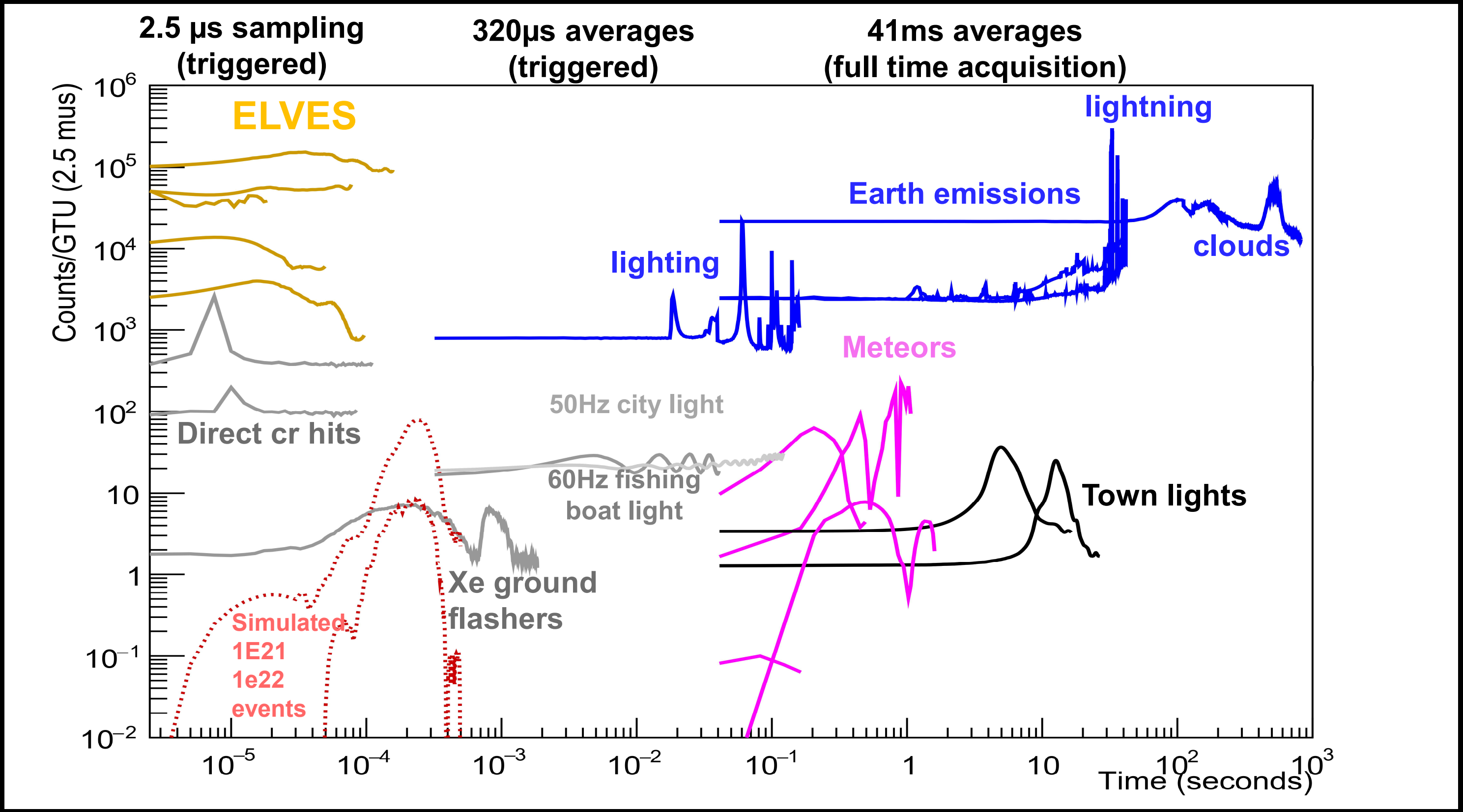
KINGSTON 3.0
Currently used – slow

Pouch 004 - v2 - will be completely equipped with CORSAIR 3.1 pens

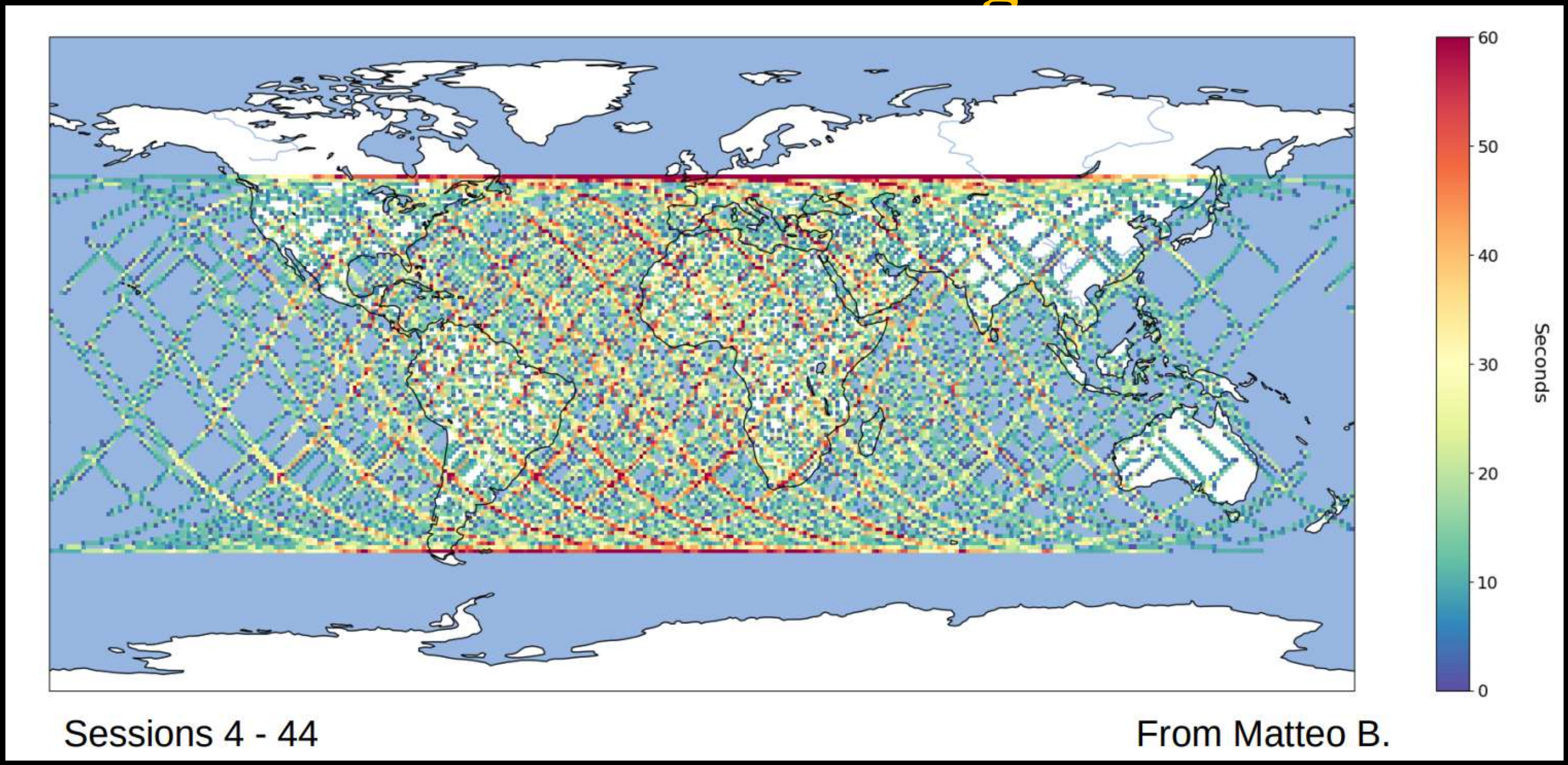
Science Objectives



Time profile of various events



Earth Coverage



>116 sessions
Almost 5 years
More than half of data on board ISS

Night-time Earth Emissions

Time sampling: 40.96 ms

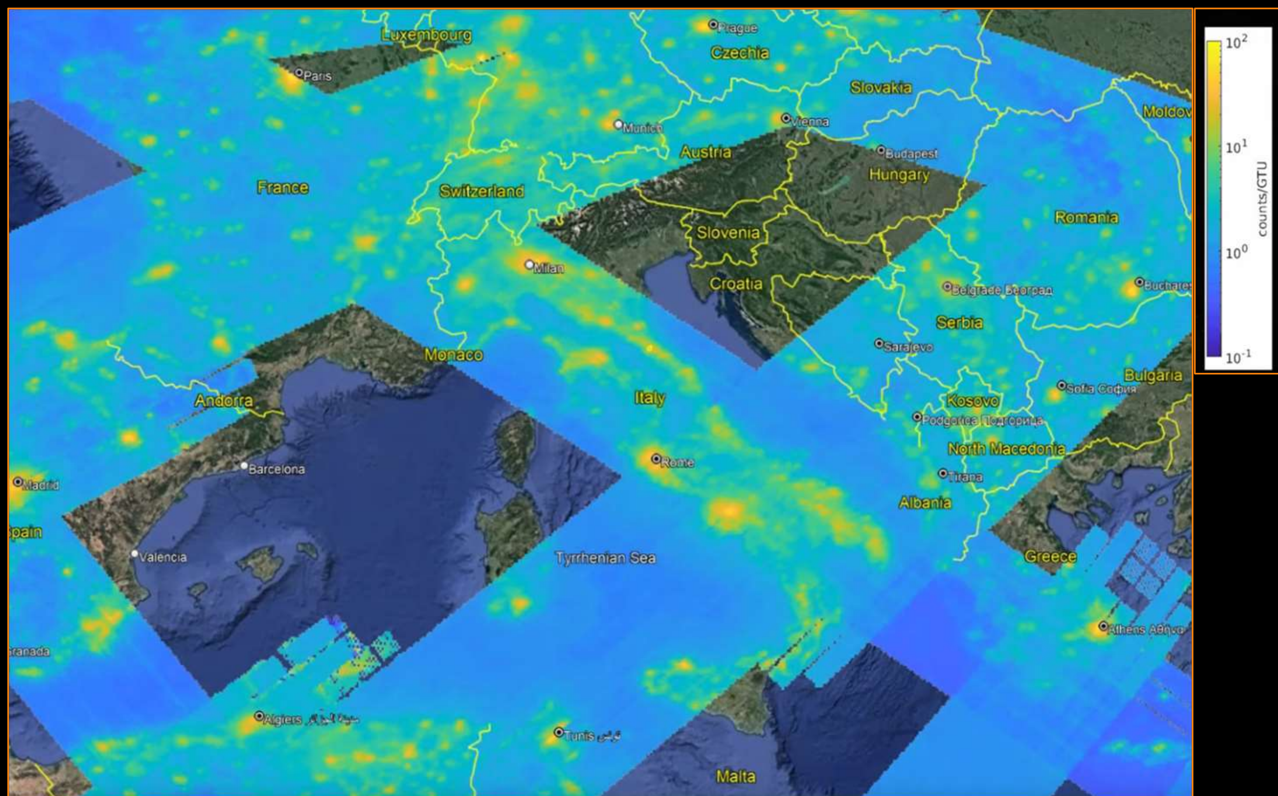
Pixel size: 6 x 6 km^2

Mendeley database: https://data.mendeley.com/datasets/57fmn7rh4n/4

https://youtu.be/X_QATIf38Og

Youtube video: https://youtu.be/X_QATIf38Og

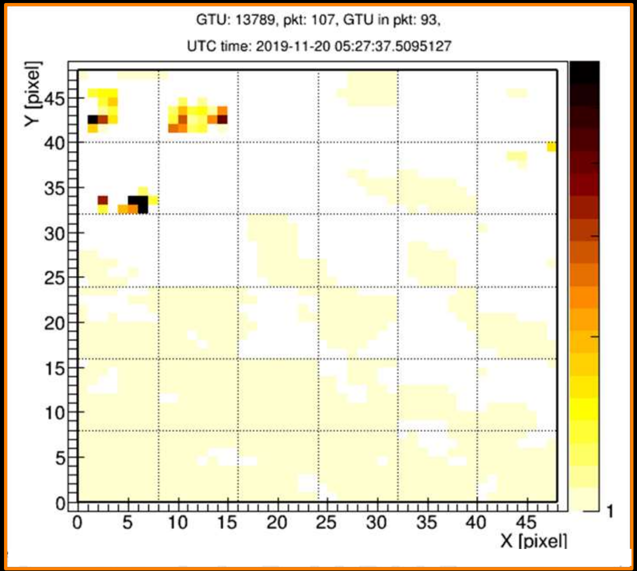
First night UV maps of the Earth

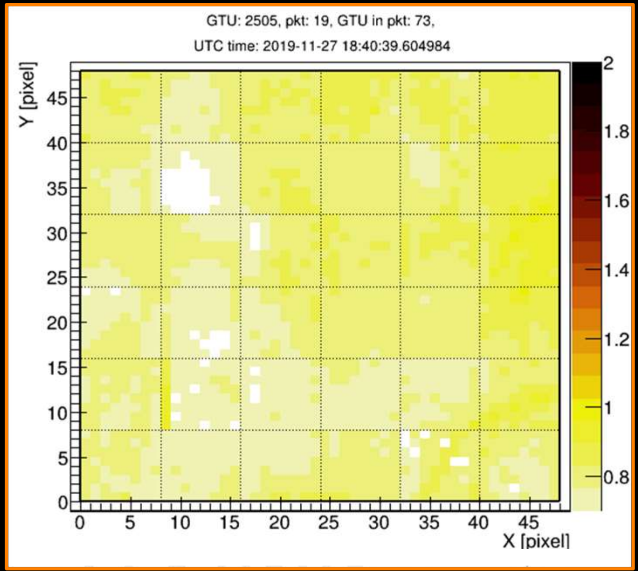


Open data available to the scientific community

ADSC data centre
Observation of night-time emissions of the Earth in the near UV range from the International Space Station with the Mini-EUSO detectorM. Casolino et al**., Remote Sensing of Environment** 284 (2023) 113336
Dataset of night-time emissions of the Earth in the near UV range Marcelli et al., **Data in Brief 48 (**2023) 109105

Meteors





Mini-EUSO detected meteors: 24k
(less than half dataset received)

First systematic survey of meteors from space

rate ~ 3 meteors/min
70% over ocean, 30% over land

Observation of meteors from space with the Mini--EUSO detector on board the International Space Station
D. Barghini et al "Astronomy & Astrophysics",

A&A, 687, A304 (2024)
https://doi.org/10.1051/0004-6361/202449236

Astronomy & Astrophysics

Observation of meteors from space with the Mini-EUSO detector on board the International Space Station

D. Barghini[1,2], M. Battisti[3,4], A. Belov[5,6], M. Bertaina[2,3], S. Bertone[2], F. Bisconti[7], C. Blaksley[8], S. Blin[4], K. Bolmgren[9], G. Cambiè[7,10], F. Capel[11], M. Casolino[7,8,10], A. Cellino[1], I. Churilo[12], A. G. Coretti[2,3], M. Crisconio[13], C. De La Taille[14], T. Ebisuzaki[8], J. Eser[15], F. Fenu[13], G. Filippatos[15], M. A. Franceschi[16], C. Fuglesang[9], D. Gardiol[1], A. Golzio[17], P. Gorodetzky[9], F. Kajino[18], H. Kasuga[8], P. Klimov[5], V. Kungel[19], V. Kuznetsov[12], M. Manfrin[2,3], L. Marcelli[7], G. Mascetti[13], W. Marszał[20], M. Mignone[3], H. Miyamoto[2,3], A. Murashov[6], T. Napolitano[16], H. Ohmori[8], A. Olinto[15], E. Parizot[4], P. Picozza[7,10], L. W. Piotrowski[21], Z. Plebaniak[7,10,20], G. Prévôt[4], E. Reali[7,10], F. Reynaud[2], M. Ricci[16], G. Romoli[7,10], N. Sakaki[8], S. Sharakin[6], K. Shinozaki[20], J. Szabelski[22], Y. Takizawa[8], V. Vagelli[13], G. Valentini[13], M. Vrabel[20], L. Wiencke[19], and M. Zotov[6]

(Affiliations can be found after the references)

Received 15 January 2024 / Accepted 14 May 2024

ABSTRACT

Context. Observations of meteors in the Earth's atmosphere offer a unique tool for determining the flux of meteoroids that are too small to be detected by direct telescopic observations. Although these objects are routinely observed from ground-based facilities, such as meteor and fireball networks, space-based instruments come with notable advantages and have the potential to achieve a broad and uniform exposure.

Aims. In this paper, we describe the first observations of meteor events with Mini-EUSO, a very wide field-of-view telescope launched in August 2019 from the Baikonur cosmodrome and installed on board the Russian Zvezda module of the International Space Station. Mini-EUSO can map the night-time Earth in the near-UV range (290–430 nm) with a field of view equal to $44° \times 44°$ and a spatial resolution of about 4.7 km at an altitude of 100 km from the ground. The detector saves triggered transient phenomena with a sampling frequency of 2.5 µs and 320 µs, as well as a continuous acquisition at 40.96 ms scale that is suitable for meteor observations.

Methods. We designed two dedicated and complementary trigger methods, together with an analysis pipeline able to estimate the main physical parameters of the observed population of meteors, such as the duration, horizontal speed, azimuth, and absolute magnitude. To compute the absolute flux of meteors from Mini-EUSO observations, we implemented a simulation framework able to estimate the detection efficiency as a function of the meteor magnitude and the background illumination conditions.

Results. The instrument detected 24 thousand meteors within the first 40 data-taking sessions from November 2019 to August 2021, for a total observation time of approximately 6 days with a limiting absolute magnitude of +6. Our estimation of the absolute flux density of meteoroids in the range of mass between 10^{-5} kg to 10^{-1} kg was found to be comparable to other results available in the literature.

Conclusions. The results of this work prove the potential for space-based observations to increase the statistics of meteor observations achievable with instruments operating on the ground. The slope of the mass distribution of meteoroids sampled with Mini-EUSO suggests a mass index of either $s = 2.09 \pm 0.02$ or $s = 2.31 \pm 0.03$, according to two different methodologies for the computation of the pre-atmospheric mass starting from the luminosity of each event.

Key words. instrumentation: detectors – methods: data analysis – methods: observational – telescopes – meteorites, meteors, meteoroids

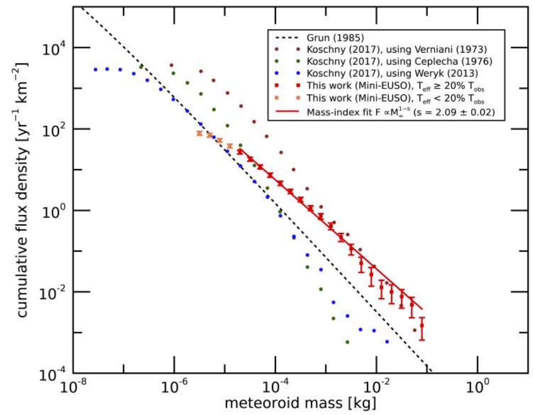


Fig. 10. Cumulative flux density of meteors as a function of the pre-atmospheric mass of the meteoroid estimated from the observations of Mini-EUSO of sessions no. 05-44 (red squares with error bars), when assuming Eq. (12) for the conversion of the peak absolute magnitude to the pre-atmospheric mass of the meteoroid. Orange squares represent magnitude values $\mathcal{M} \geq +5$ that are associated with an overall trigger efficiency $\epsilon(\mathcal{M}) < 20\%$. The red thick lines plot the result of a linear fit in the log-log space to determine the mass-index of the distribution ($N \propto M_{\infty}^{1-s}$), which was estimated as $s = 2.09 \pm 0.02$ from the Mini-EUSO data (see Sect. 5.1). As a comparison, the black dashed line plots the flux estimate of Grun et al. (1985) that was deduced from the study of micro-craters on returned lunar samples and from satellite measurements of micrometeoroid impacts. The three series of dots (brown, green, and blue) plot the results of Koschny et al. (2017), computed from the dataset of ~20 thousand double-station observations of meteors performed at the Canary Island Long-Baseline Observatory (CILBO) during a period of about 3.5 yr. Each series corresponds to a different method used by Koschny et al. (2017) to compute the pre-atmospheric mass from the absolute magnitude (Verniani 1973; Ceplecha & McCrosky 1976; Weryk & Brown 2013, see the legend in the figure adapted from Koschny et al. 2017).

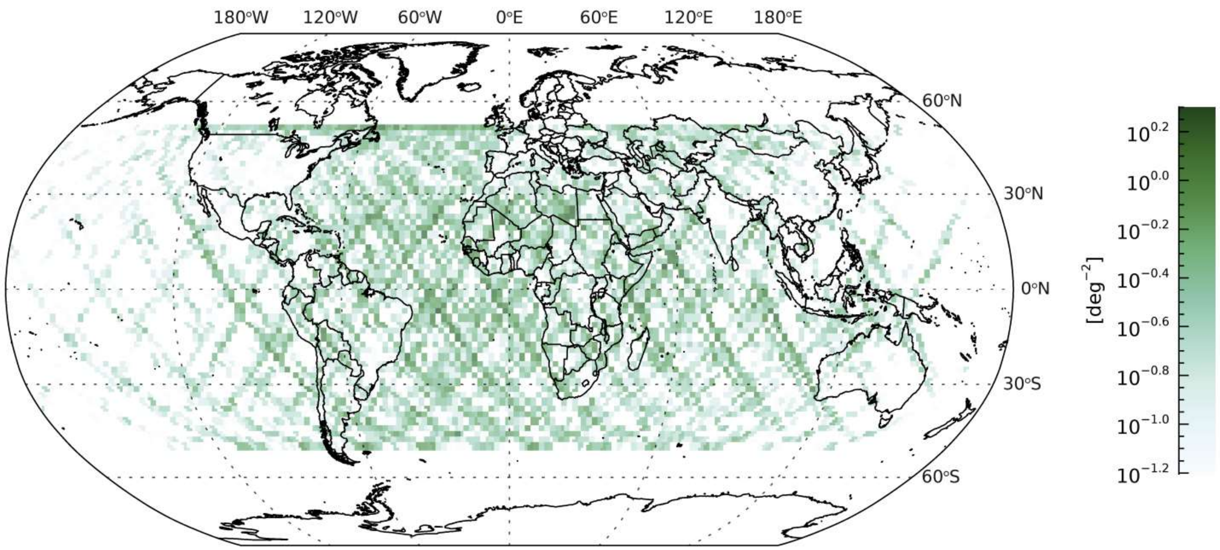
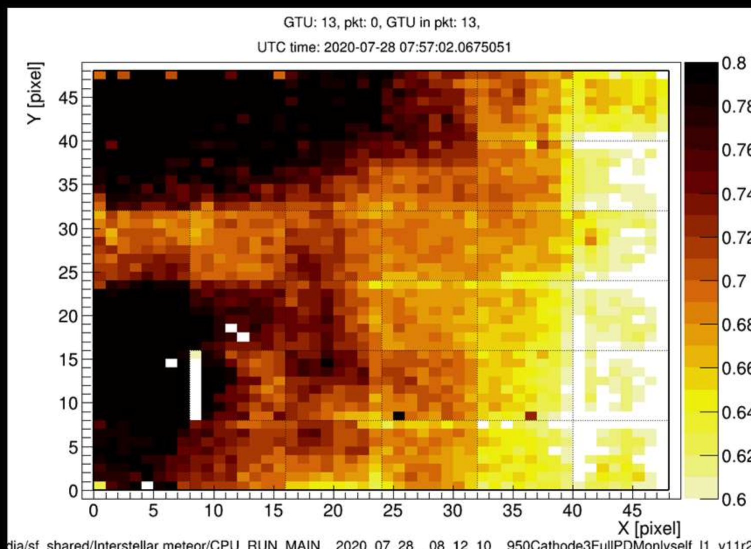
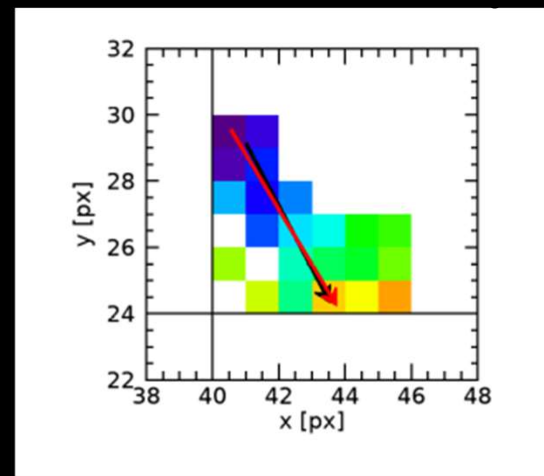
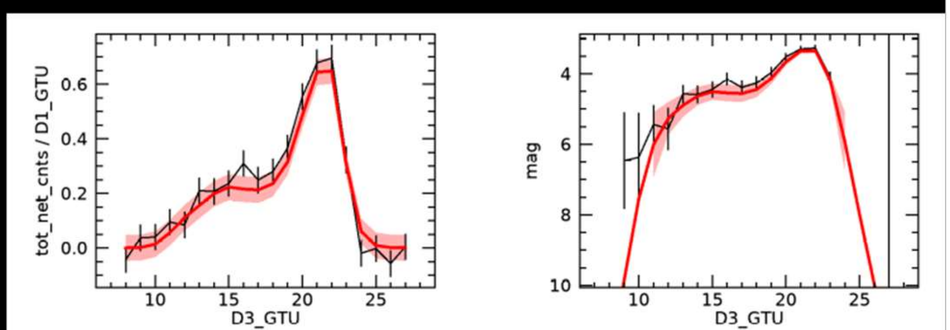


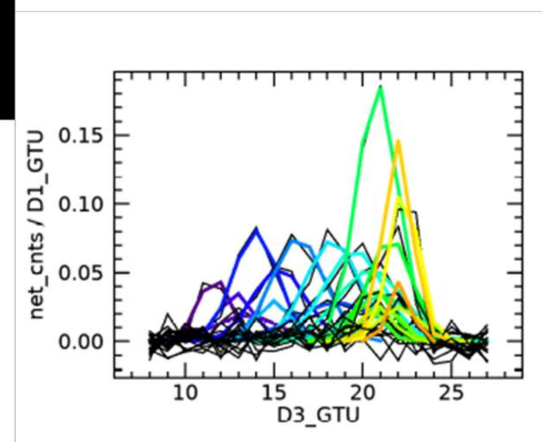
Fig. 5. Map of the spatial density (in logarithmic colour scale, bins of $2^\circ \times 2^\circ$) of meteor events detected by the Mini-EUSO telescope during the data-taking sessions no. 05-44 (from November 2019 to August 2021). The low rate of detections of meteors over the Pacific Ocean is due to the fact that, during the operational time of Mini-EUSO, this area is predominantly in daytime.

Meteors

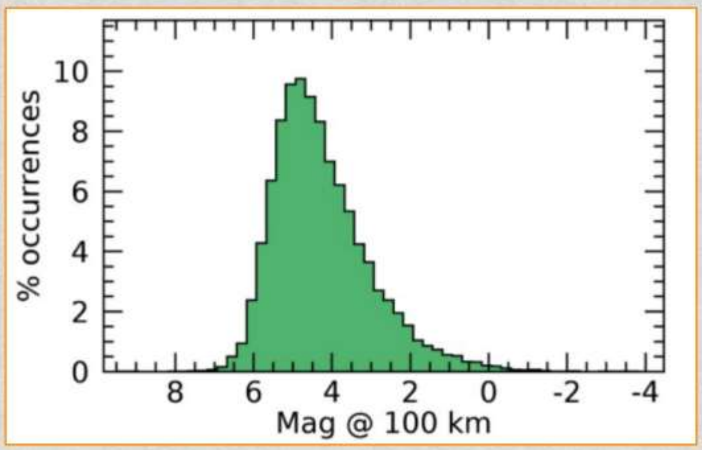

GTU: 13, pkt: 0, GTU in pkt: 13,
UTC time: 2020-07-28 07:57:02.0675051
Y [pixel]
X [pixel]
dia/sf_shared/Interstellar meteor/CPU_RUN_MAIN__2020_07_28__08_12_10__950Cathode3FullPDMonlyself_l1_v11r2.


y [px]
x [px]

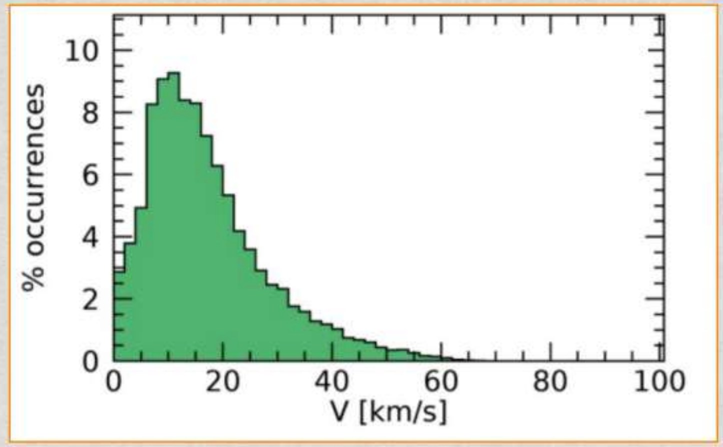

tot_net_cnts / D1_GTU
D3_GTU
mag
D3_GTU


net_cnts / D1_GTU
D3_GTU

Meteors



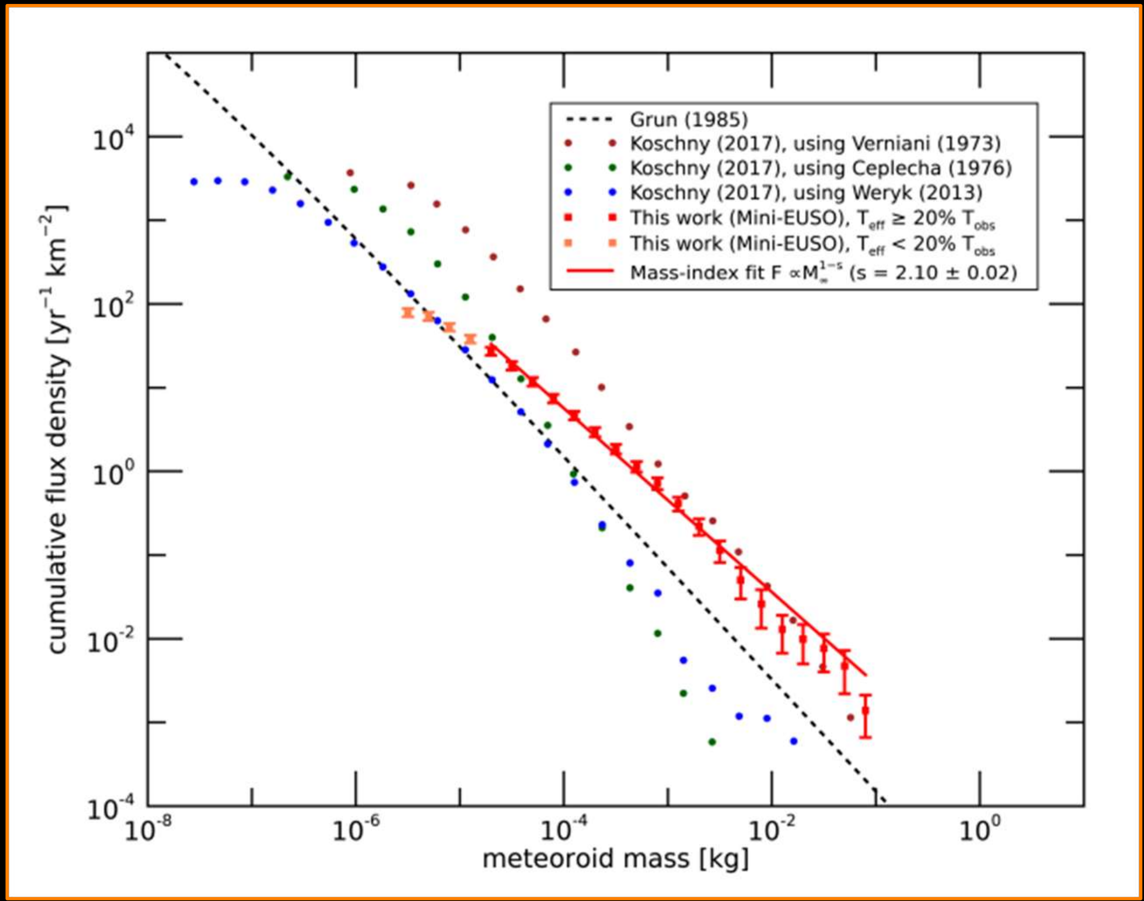
Mag 7 → ~ 2 mg
Mag 5 → ~ 10 mg
Mag 0 → ~ 100 mg



maximum detected speed ~ 65 km/s

Mini-EUSO detected meteors: 24k
half dataset received

Meteors



Observation of meteors from space with the Mini--EUSO detector on board the International Space Station
D. Barghini et al., "Astronomy & Astrophysics

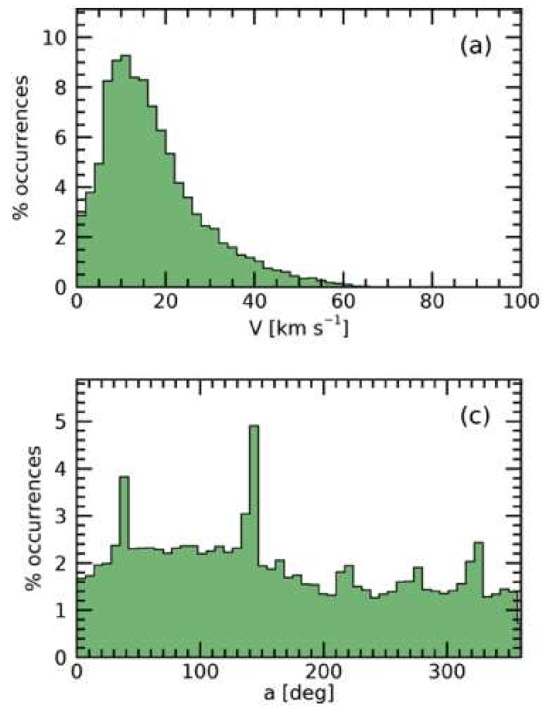
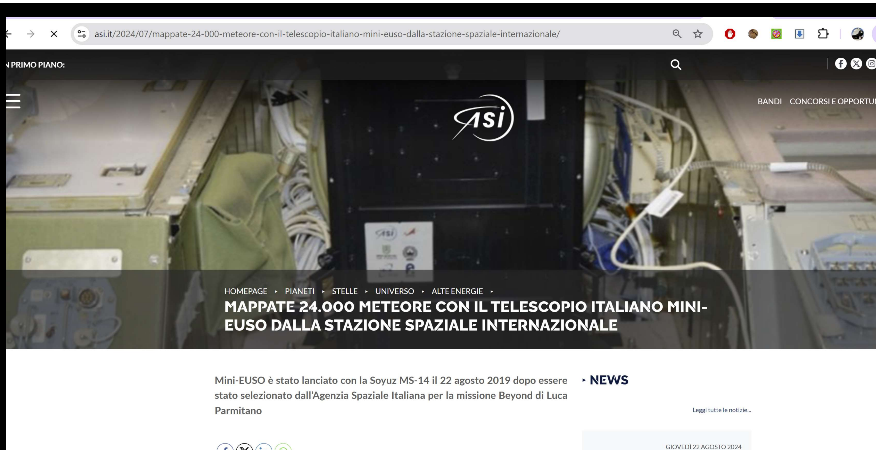


Fig. 6. Distribution of the physical parameters of 24 thousand meteors detected by Mini-EUSO during the data-taking sessions no. 05-44 (see Table 1). (a) Horizontal speed, V (Eq. (4)), at a 100 km reference altitude; (b) duration, Δt, of the event on the Mini-EUSO PDM; (c) arrival azimuth angle, a (Eq. (5)); and (d) minimum absolute magnitude, $\mathcal{M}$ (Eq. (7)).



asi.it/2024/07/mappate-24-000-meteore-con-il-telescopio-italiano-mini-euso-dalla-stazione-spaziale-internazionale/

PRIMO PIANO:

BANDI CONCORSI E OPPORTUN

HOMEPAGE • PIANETI • STELLE • UNIVERSO • ALTE ENERGIE •

MAPPATE 24.000 METEORE CON IL TELESCOPIO ITALIANO MINI-EUSO DALLA STAZIONE SPAZIALE INTERNAZIONALE

Mini-EUSO è stato lanciato con la Soyuz MS-14 il 22 agosto 2019 dopo essere stato selezionato dall'Agenzia Spaziale Italiana per la missione Beyond di Luca Parmitano

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GIOVEDÌ 22 AGOSTO 2024

home.infn.it/en/infn-news/6787-mini-euso-classifies-24-000-meteors-from-space

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INFN News

29 AUGUST 2024

MINI-EUSO CLASSIFIES 24,000 METEORS FROM SPACE

The JEM-EUSO collaboration recently published in the journal Astronomy&Astrophysics the classification of 24,000 meteors observed systematically for the first time from space in the ultraviolet band with the Mini-EUSO (Multiwavelength Imaging New Instrument for the Extreme Universe Space Observatory) detector, installed aboard the International Space Station. Meteors are celestial bodies that enter Earth's atmosphere and, due to friction with the atmosphere, increase their temperature and burn, emitting radiation. Typically, they are observed by ground-based telescopes to reconstruct their mass, direction and flux by detecting light emitted in the visible spectrum. However, the opportunity to analyze these celestial objects from space, as Mini-EUSO has done, has significant advantages, including the possibility of conducting an observational campaign with a wide field of view and of long

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VISTE DA UNA FINESTRA COLLOCATA ALL'INTERNO DEL MODULO ZVEZDA

Con 24mila meteore, ecco la mappa dalla Iss

Lanciato con la Soyuz MS-14 il 22 agosto 2019 dopo essere stato selezionato dall'Asi per la missione Beyond di Luca Parmitano, il rivelatore Mini-Euso ha consentito di osservare sistematicamente per la prima volta dallo spazio le meteore nella banda ultravioletta. I risultati sono stati pubblicati la settimana scorsa su A&A. Il responsabile dell'analisi è Dario Barghini dell'Inaf di Torino

Redazione Asi 31/07/2024

L'atmosfera terrestre è continuamente bombardata da corpi celesti che, per effetto dell'attrito con l'atmosfera stessa, aumentano la propria temperatura e bruciano, emettendo radiazione. Questi oggetti, detti comune-

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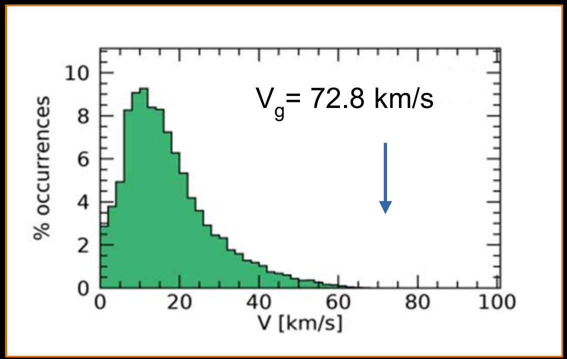
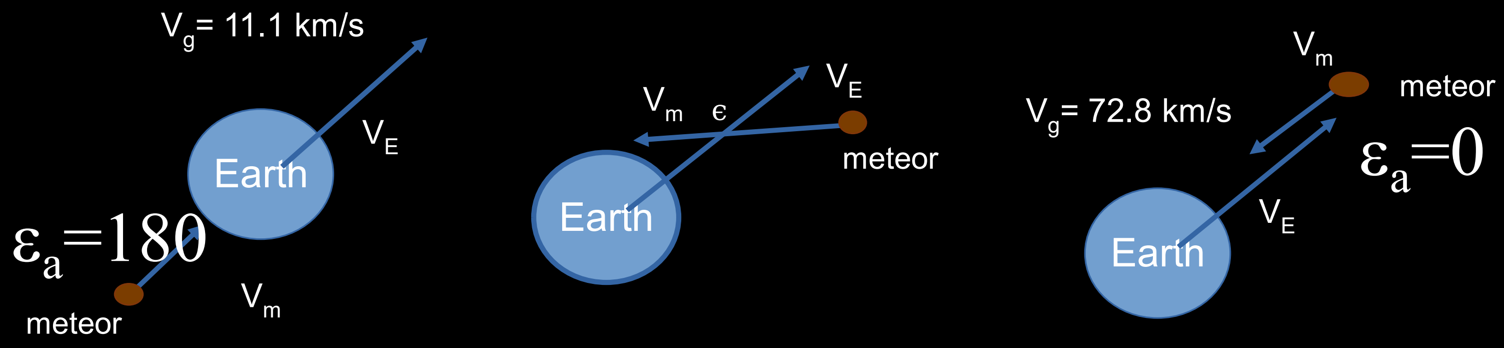
Do il consenso al trattamento dei dati

Video del giorno

Search for Interstellar meteors

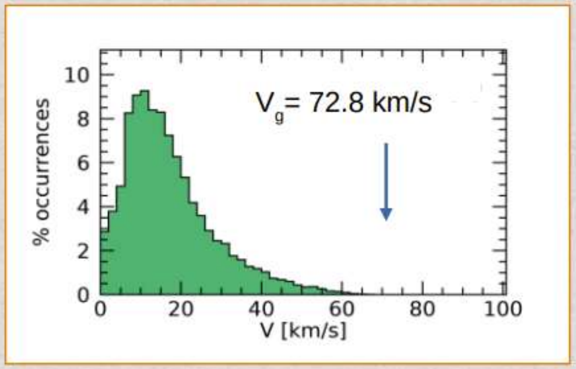


Solar system meteors:
11.1 km/s < V_g < 72.8 km/s

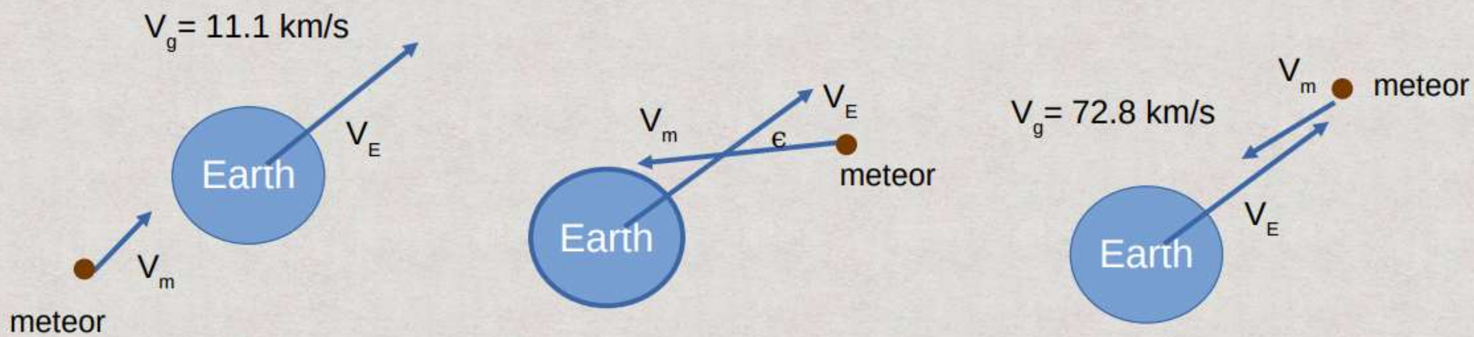


Interstellar meteors: meteor with a speed above solar system allowed speed

Search for Interstellar meteors

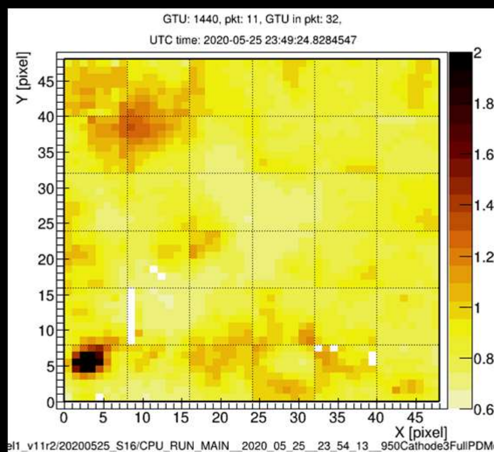


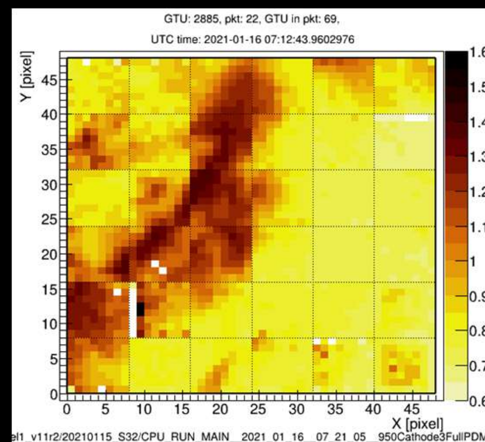
Solar system meteors: 11.1 km/s < v_g < 72.8 km/s

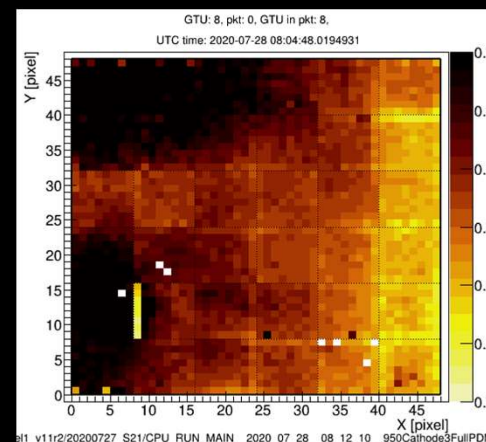


Interstellar meteors: meteor with a speed above solar system allowed speed

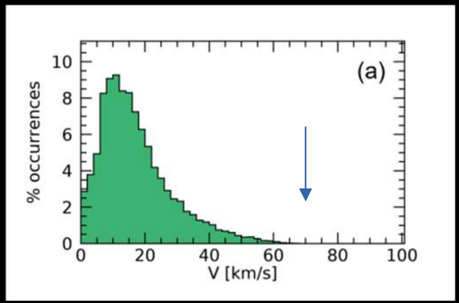
Interstellar meteors: three candidates



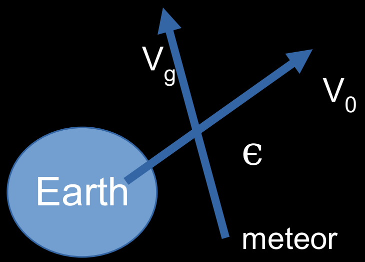




Interstellar meteors

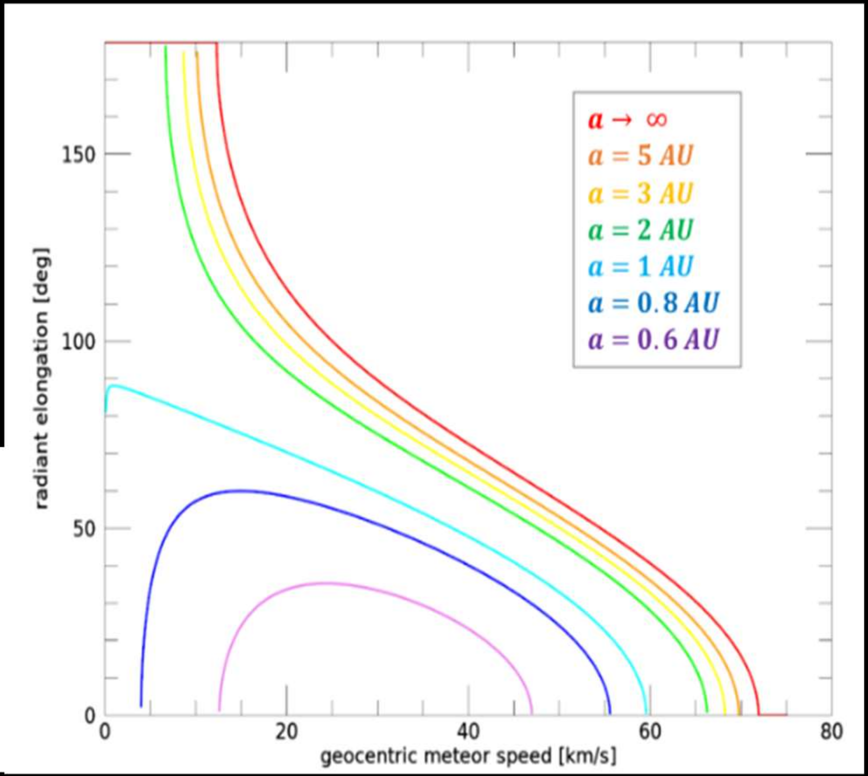


Solar system meteors: 11.1 km/s < v < 72.8 km/s



Vg = **geocentric speed** =
= meteor pre-atm. speed corrected for Earth's gravity attraction

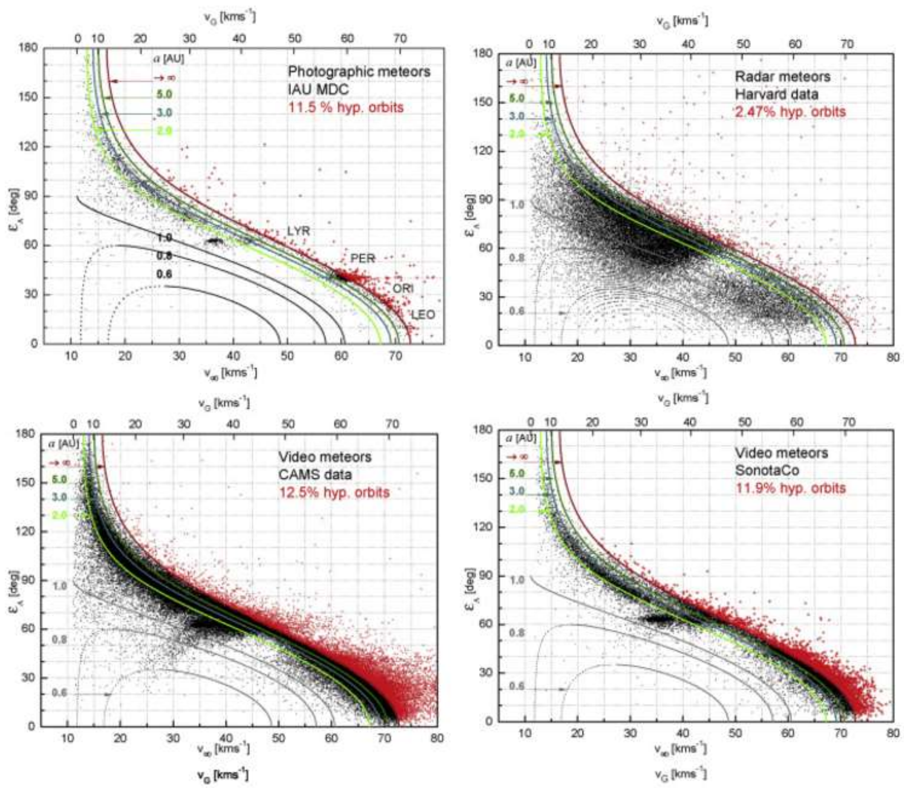
ε = **radiant elongation** =
= angle between $\vec{V_g}$ and $\vec{V_0}$ (Earth orbital speed)



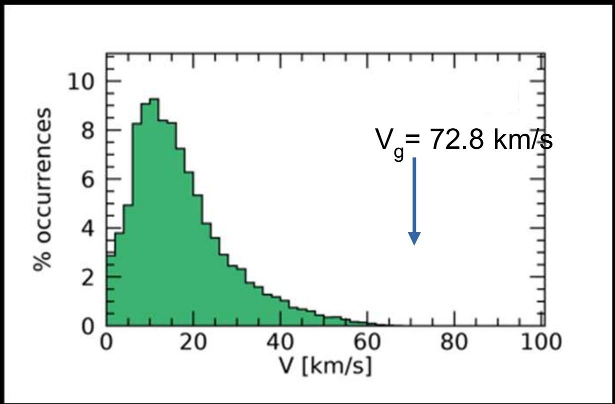
utline

gures (3)

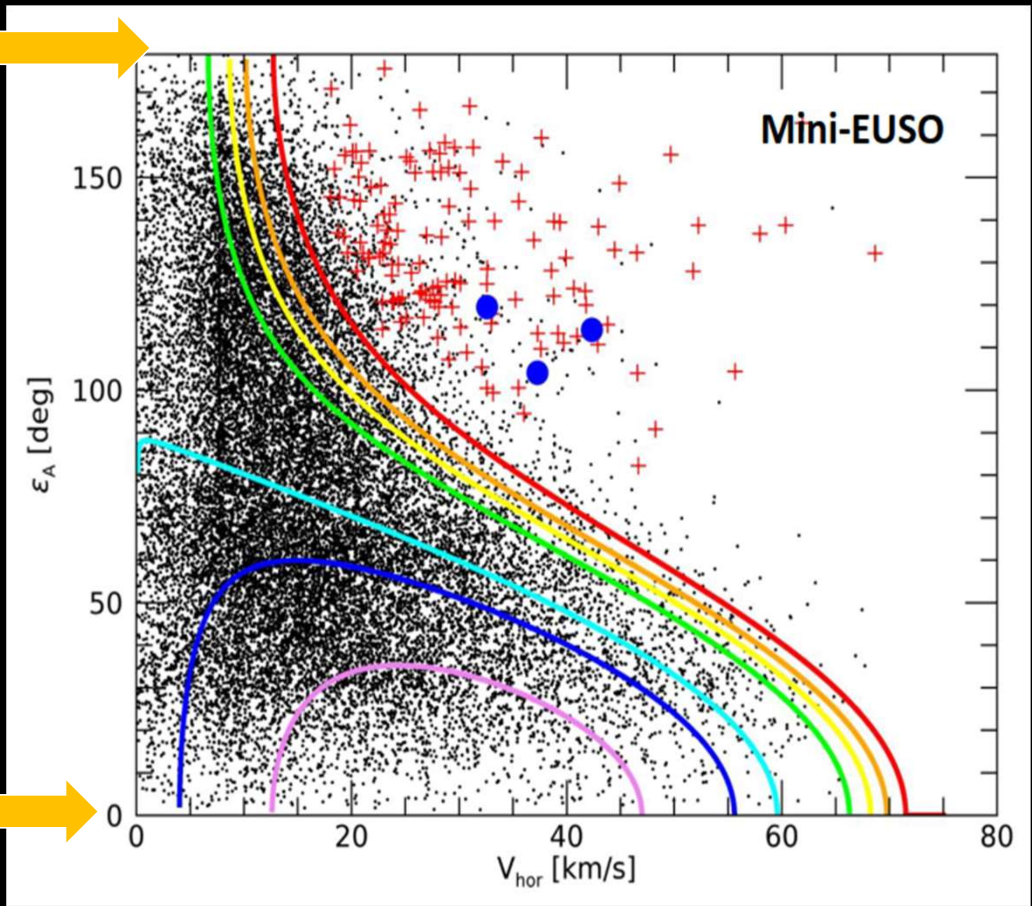
The effect of both the measured speed and the measured radiant position on the semimajor axis can be demonstrated in a graph showing the relation between the non-atmospheric velocity v_{inf} (or geocentric velocity v_G) and the angular elongation of the apparent radiant from the apex, ε_A: $v_H^2 = v_G^2 + v_0^2 - 2v_G v_0 \cos \varepsilon_A$, where v_0 is the mean heliocentric velocity of the Earth. Based on Kresák and Kresáková (1976), we constructed graphs (Fig.2) for different values of semi-major axis *a* (different curves in each plot) and used various meteor data (different plots).



Interstellar meteors



From the back



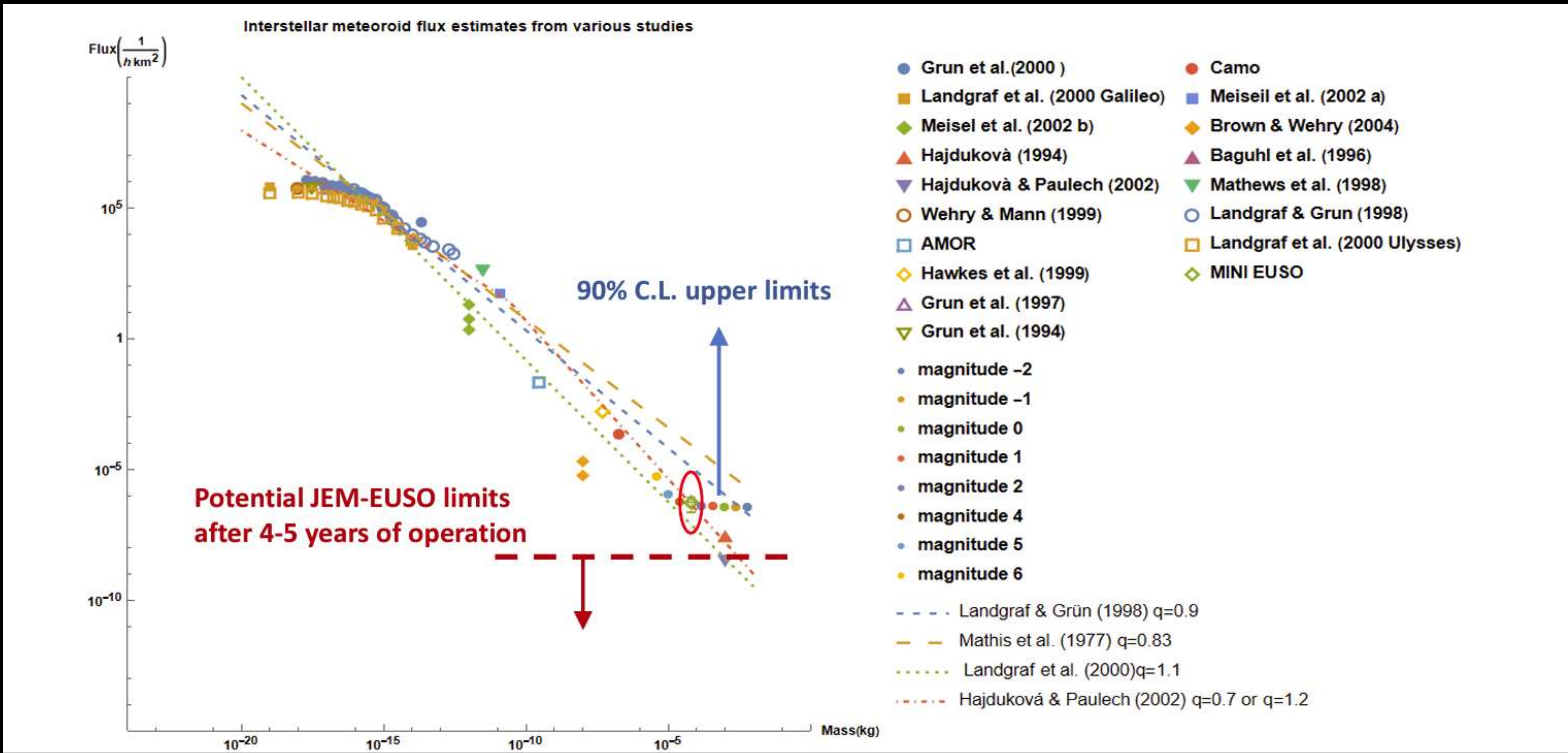
Head on

3 Candidates

Selection criteria:

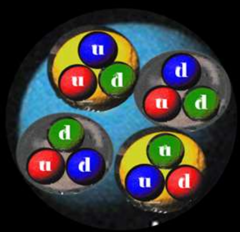
robust track reconstruction (n. pixel, magnitude, ...)

correct estimation of uncertainty on velocity measurement (trajectory inclination info missing)

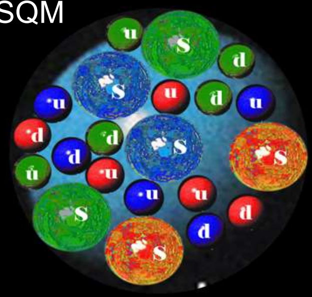

Interstellar meteoroid flux estimates from various studies
Flux(1/h km²)
10⁵
1
10⁻⁵
10⁻¹⁰
10⁻²⁰
10⁻¹⁵
10⁻¹⁰
10⁻⁵
Mass(kg)
90% C.L. upper limits
Potential JEM-EUSO limits
after 4-5 years of operation
Grun et al.(2000)
Camo
Landgraf et al. (2000 Galileo)
Meiseil et al. (2002 a)
Meisel et al. (2002 b)
Brown & Wehry (2004)
Hajdukovà (1994)
Baguhl et al. (1996)
Hajdukovà & Paulech (2002)
Mathews et al. (1998)
Wehry & Mann (1999)
Landgraf & Grun (1998)
AMOR
Landgraf et al. (2000 Ulysses)
Hawkes et al. (1999)
MINI EUSO
Grun et al. (1997)
Grun et al. (1994)
magnitude −2
magnitude −1
magnitude 0
magnitude 1
magnitude 2
magnitude 4
magnitude 5
magnitude 6
Landgraf & Grün (1998) q=0.9
Mathis et al. (1977) q=0.83
Landgraf et al. (2000)q=1.1
Hajduková & Paulech (2002) q=0.7 or q=1.2

Search for Strange Quark Matter

Ordinary matter



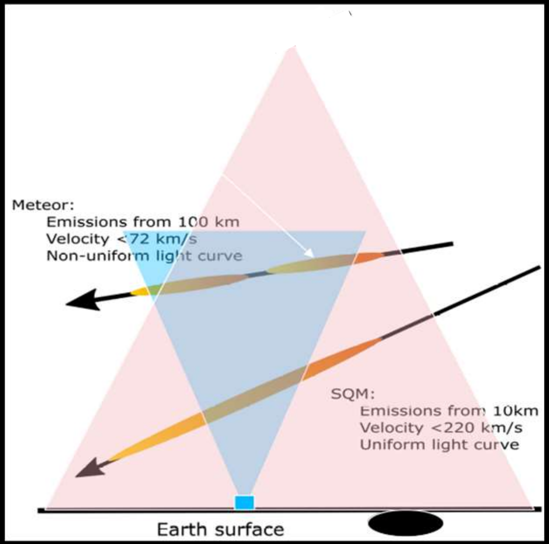
SQM

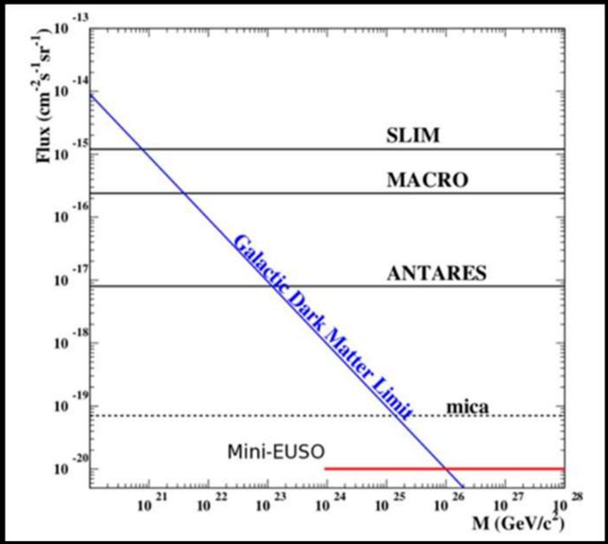


Roughly equal numbers of u,d,s quarks in a single 'bag' of cold hadronic matter:

- u,d,s quark matter might be stable
- Not limited in A: A=100, 1000….
- Z is almost zero due to cancellation of quark charge

- Could account for a (small) part of DM
- Also candidate of UHECR

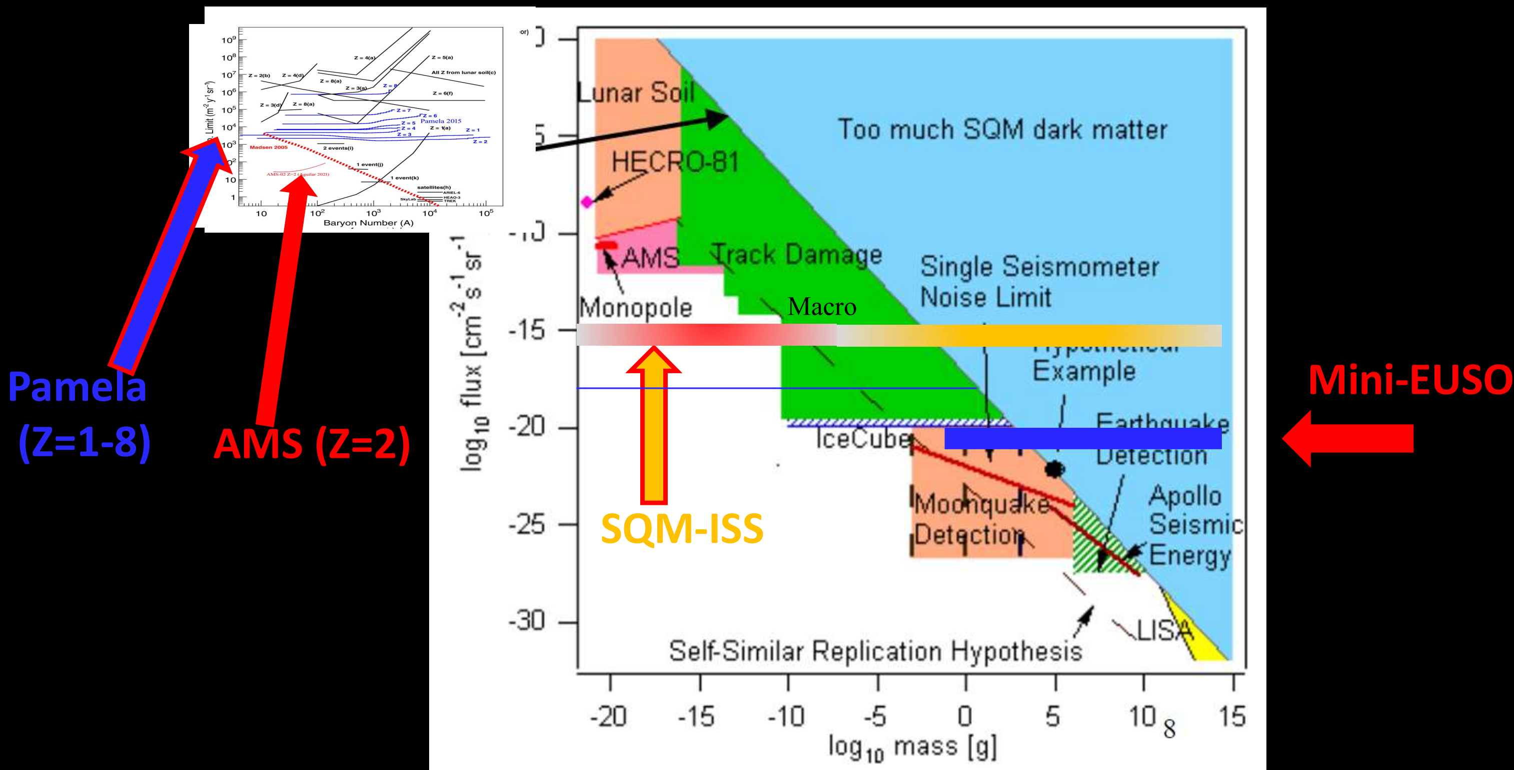




Meteor studies in the framework of the JEM-EUSO program. PLANETARY AND SPACE SCIENCE, 143(SI):245-255, 2017.

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

SQM-ISS
Expected upper limit for three years of operations

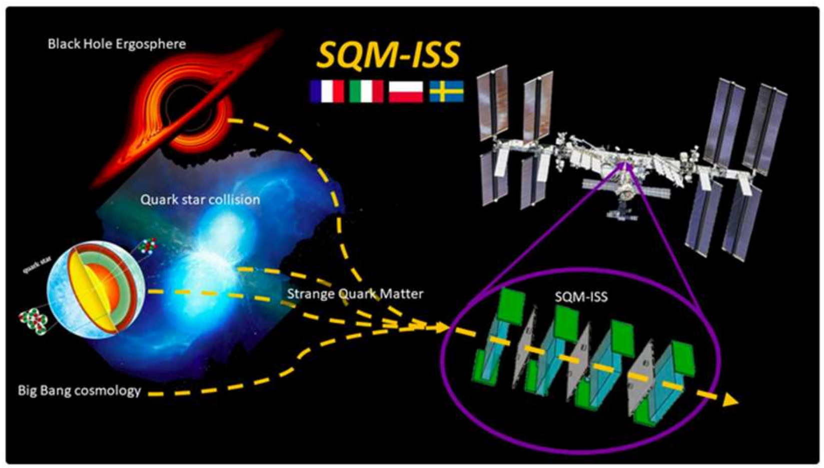


esa Start Activity Explore Help Log In Register

IDEA: I-2022-02839

SQM-ISS Search for Strange Quark Matter and nuclearites on board the International Space Station

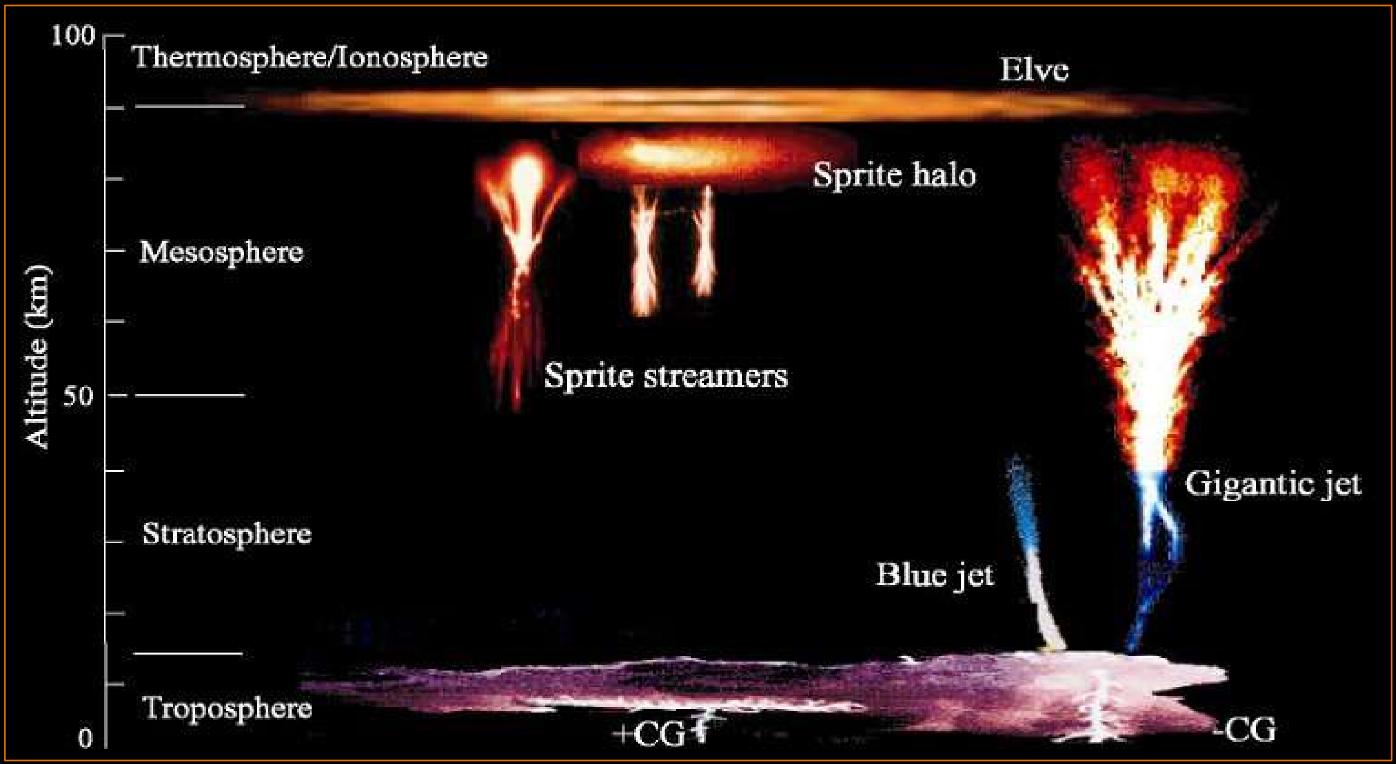
Campaign: Reserve pools of Science Activities for ISS: A SciSpacE Announcement of Opportunity



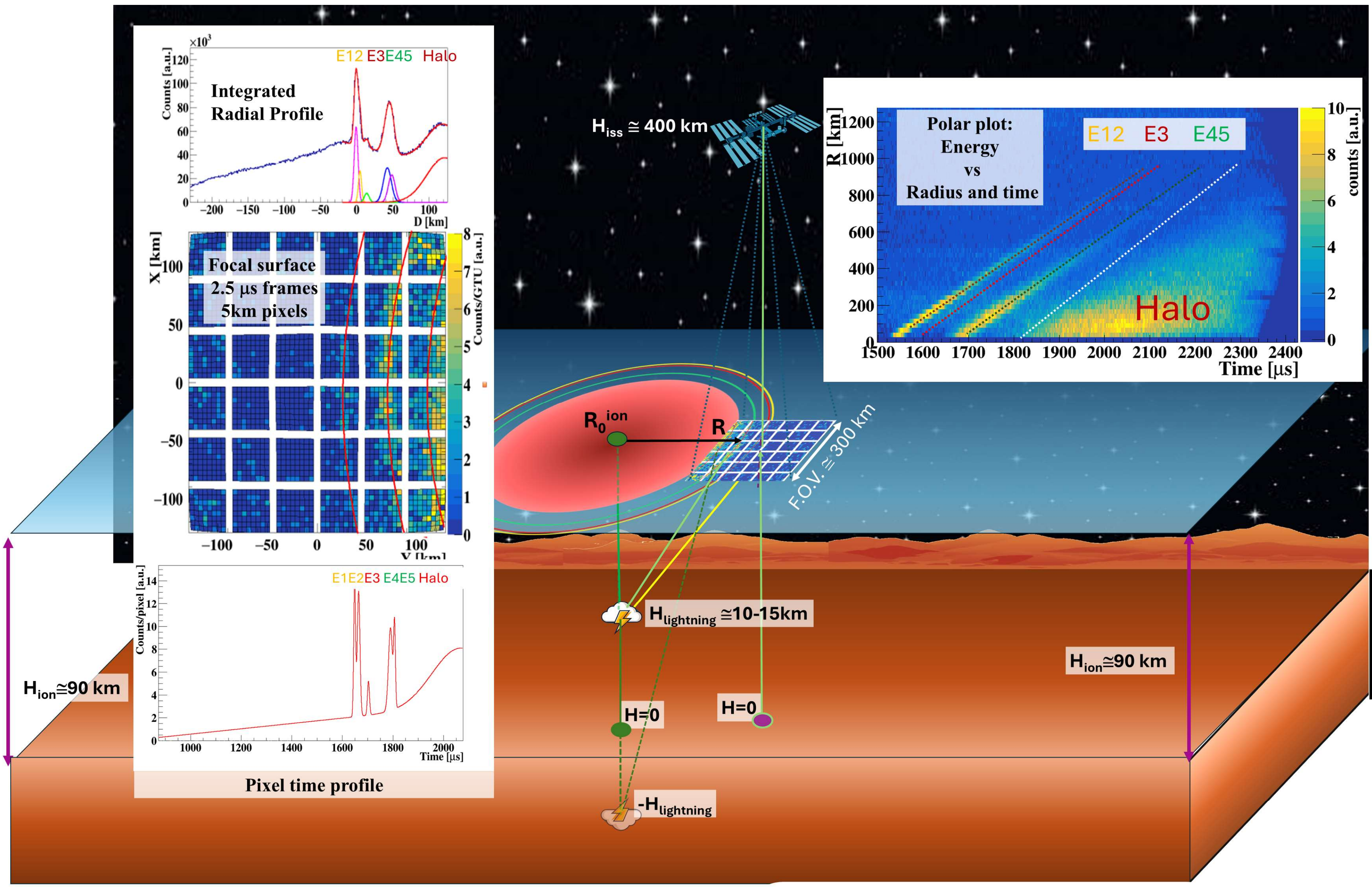
SELECTED

"…. It is our pleasure to inform you that your proposal, with the registration code AO-2022-ISS-I-2022-02839 and the title "SQM-ISS Search for Strange Quark Matter and nuclearites on board the International Space Station" was judged favourable by the peers and has been selected for definition. The overall scientific merit was ***Excellent (90/100)."***

Transient Luminous events and ELVES

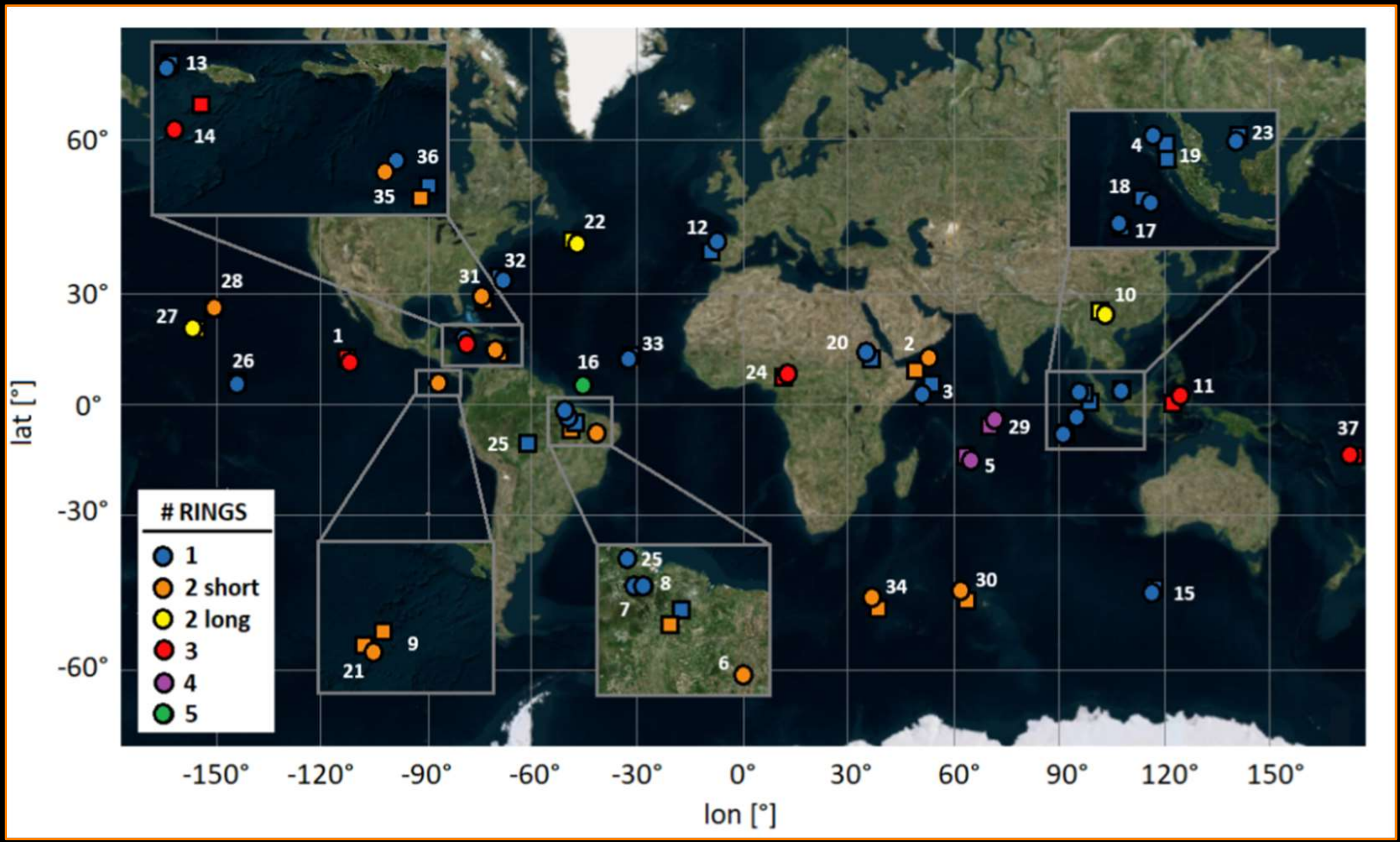


C0.2-0014-24 09:30 - 09:50 (solicited)
Observation of Atmospheric ELVES and Their Multiple Rings by Mini-EUSO Detector onboard ISS
Plebaniak, Zbigniew Team: The JEM-EUSO Collaboration p. 459

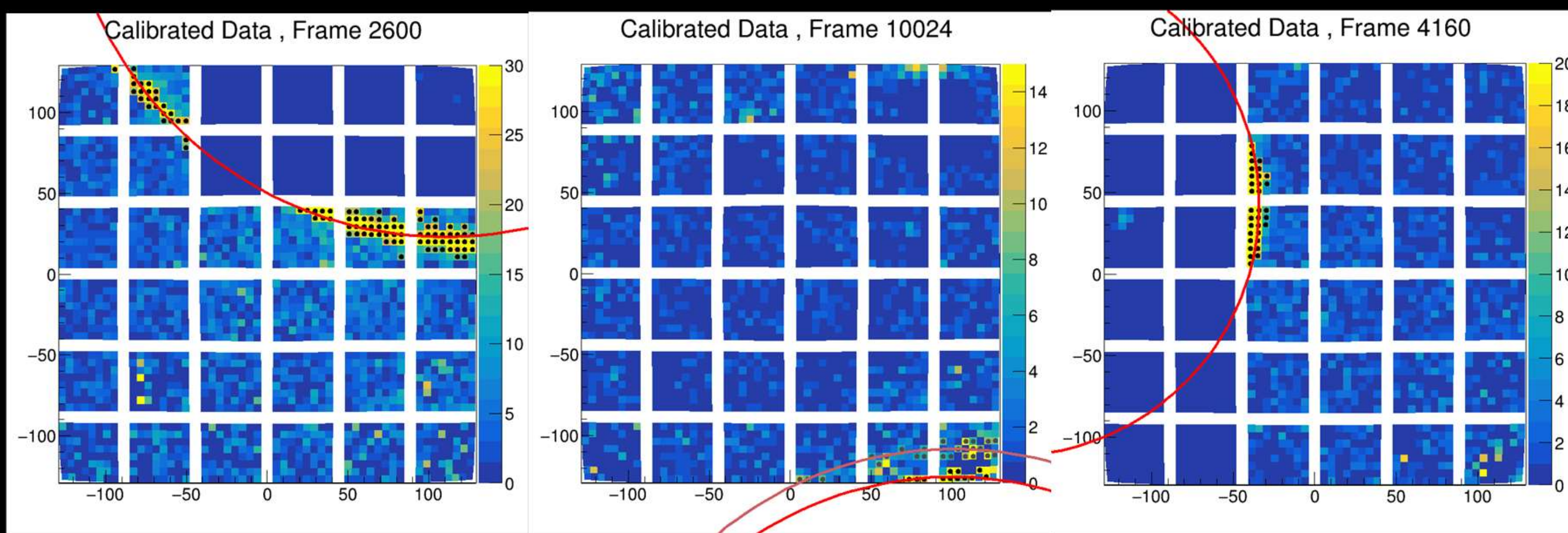


E12 E3E45 Halo
Integrated
Radial Profile
Counts [a.u.]
D [km]
Focal surface
2.5 μs frames
5km pixels
X [km]
Y [km]
Counts/GTU [a.u.]
E1E2E3 E4E5 Halo
Counts/pixel [a.u.]
Time [μs]
Pixel time profile
H_iss ≅ 400 km
Polar plot:
Energy
vs
Radius and time
E12 E3 E45
Halo
R [km]
Time [μs]
counts [a.u.]
R_0^ion
R
F.O.V. ≅ 300 km
H_lightning ≅10-15km
H_ion≅90 km
H=0
H=0
-H_lightning
H_ion≅90 km

37 ELVES detected so far (less than half dataset received)
mostly in the equatorial region

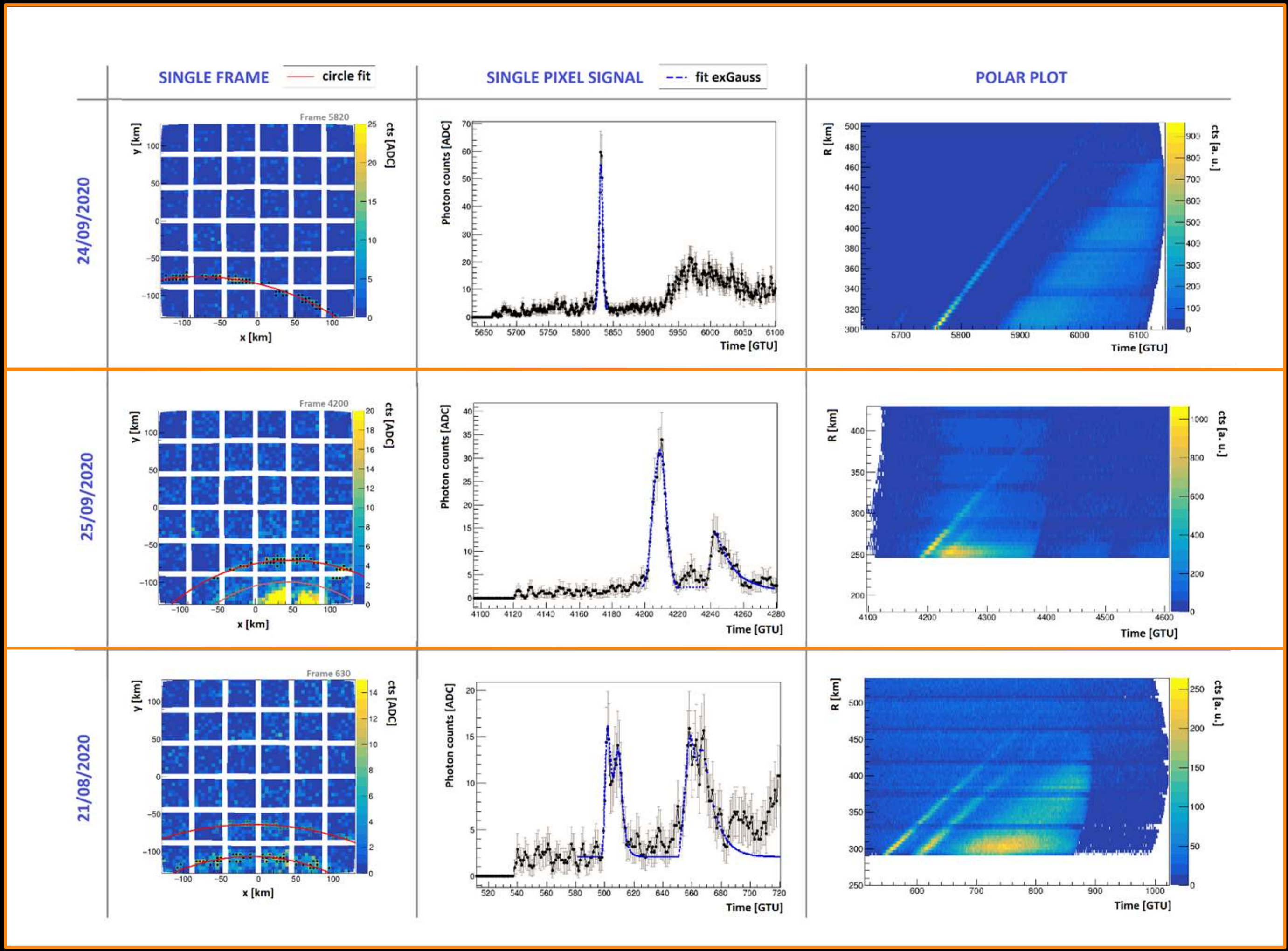


ELVES

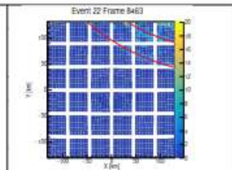
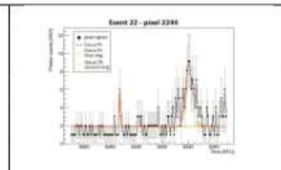
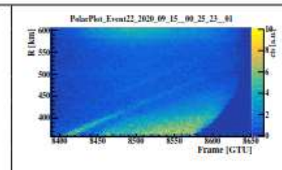
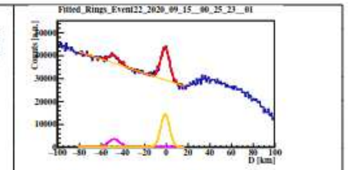
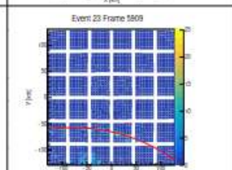
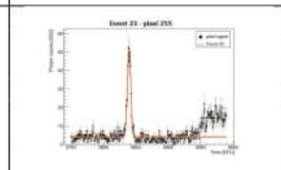
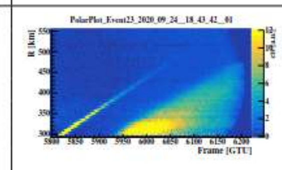
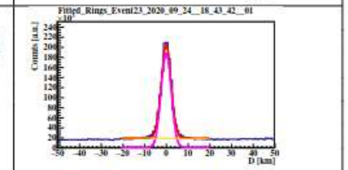
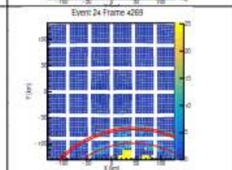
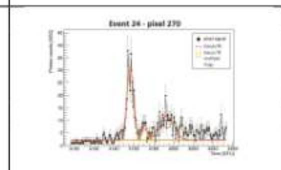
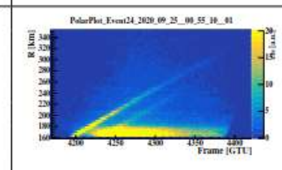
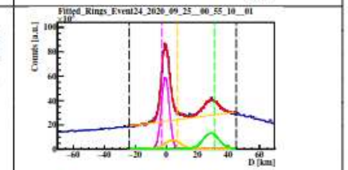
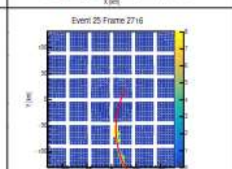
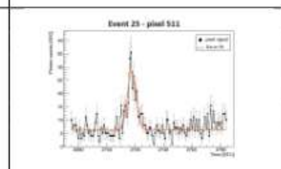
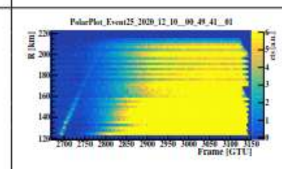
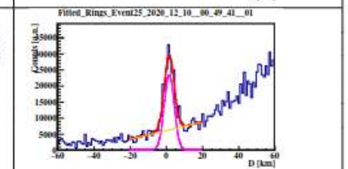
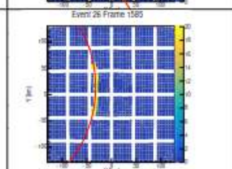
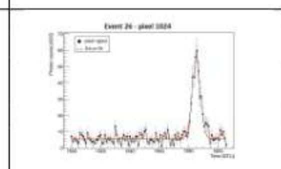
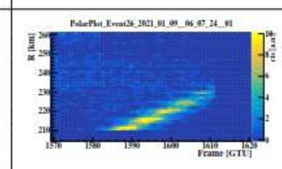
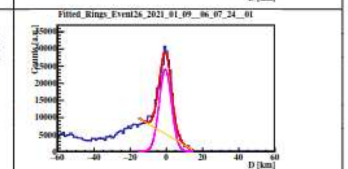
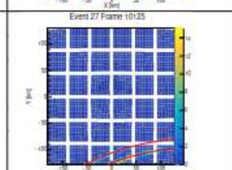
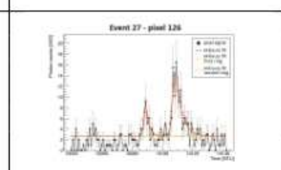
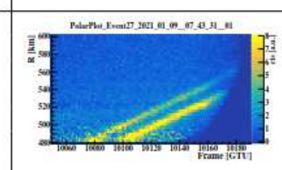
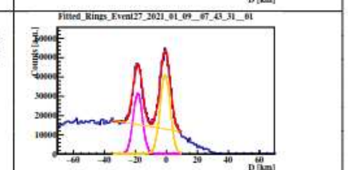
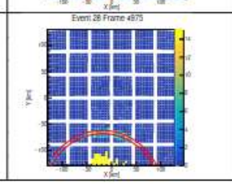
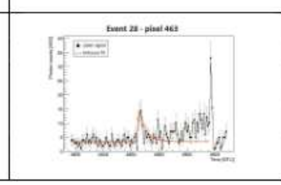
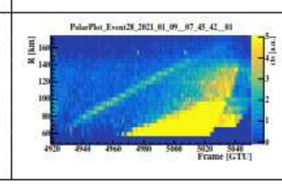
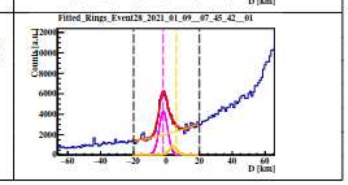


Calibrated Data , Frame 2600
Calibrated Data , Frame 10024
Calibrated Data , Frame 4160

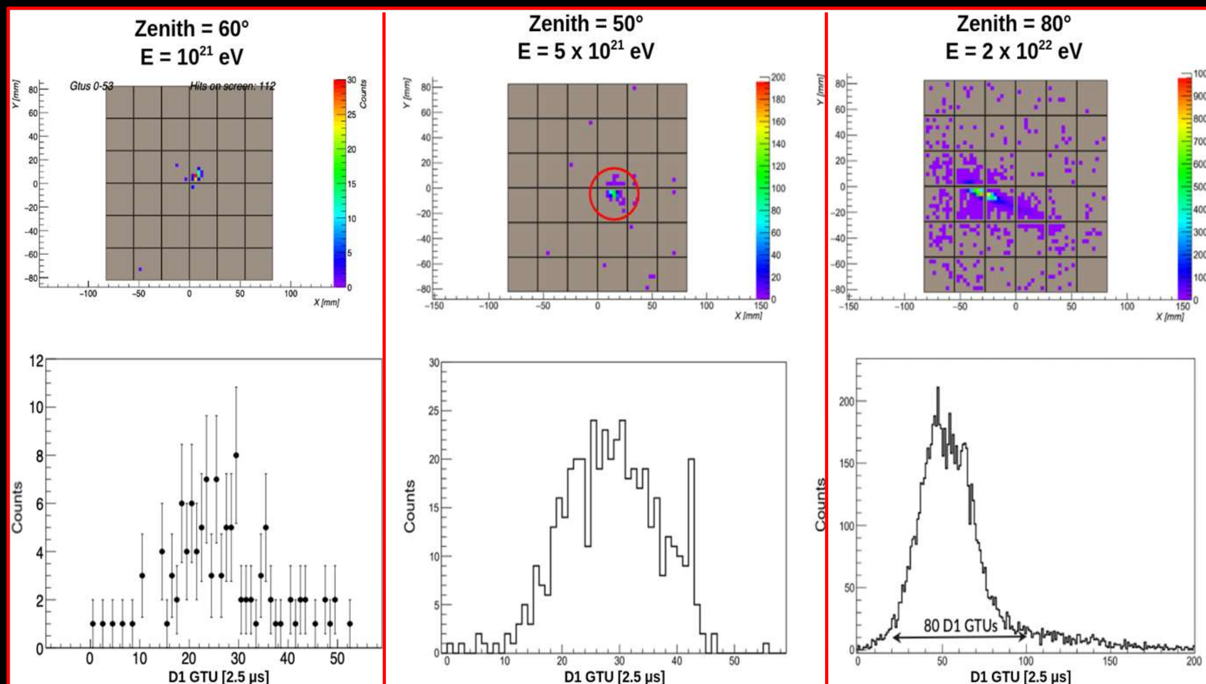
ELVES



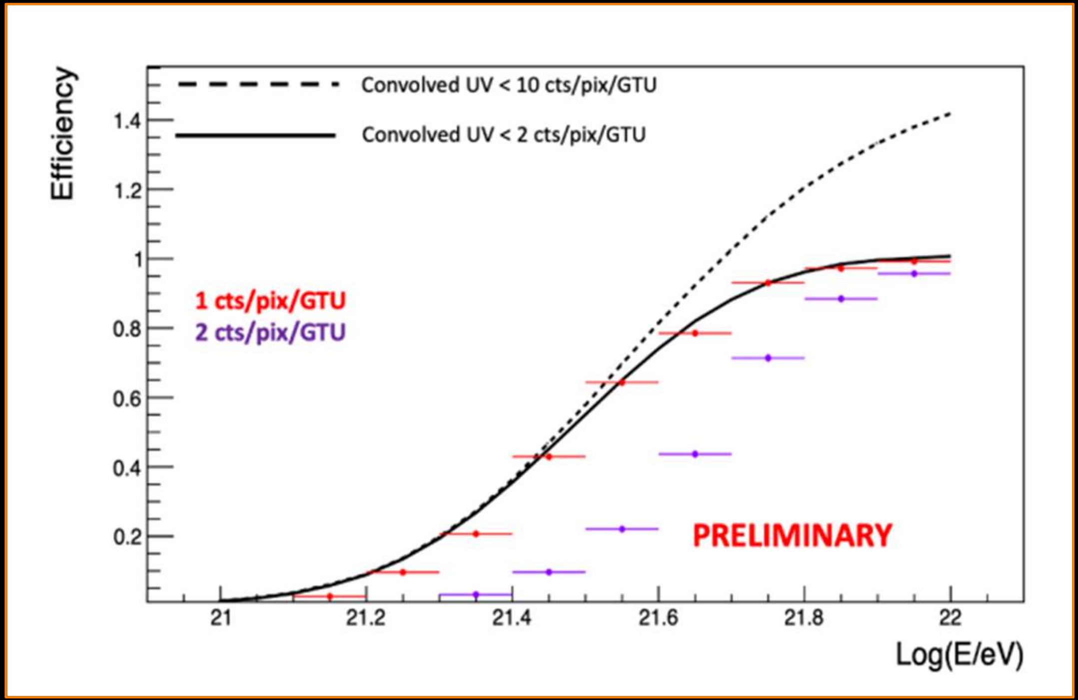
SINGLE FRAME
circle fit
SINGLE PIXEL SIGNAL
fit exGauss
POLAR PLOT
24/09/2020
25/09/2020
21/08/2020
Frame 5820
Frame 4200
Frame 630
x [km]
y [km]
cts [ADC]
Photon counts [ADC]
Time [GTU]
R [km]
cts [a. u.]

Event 22 15-09-2020 double-ringed (long) dynamic halo				
Event 23 24-09-2020 single-ringed dynamic halo				
Event 24 25-09-2020 3-ringed static halo				
Event 25 10-12-2020 single-ringed dynamic halo**				
Event 26 09-01-2021 single-ringed no halo				
Event 27 09-01-2021 double-ringed (long) no halo				
Event 28 09-01-2021 double-ringed (short)*** dynamic halo**				

UHECR: simulated EAS



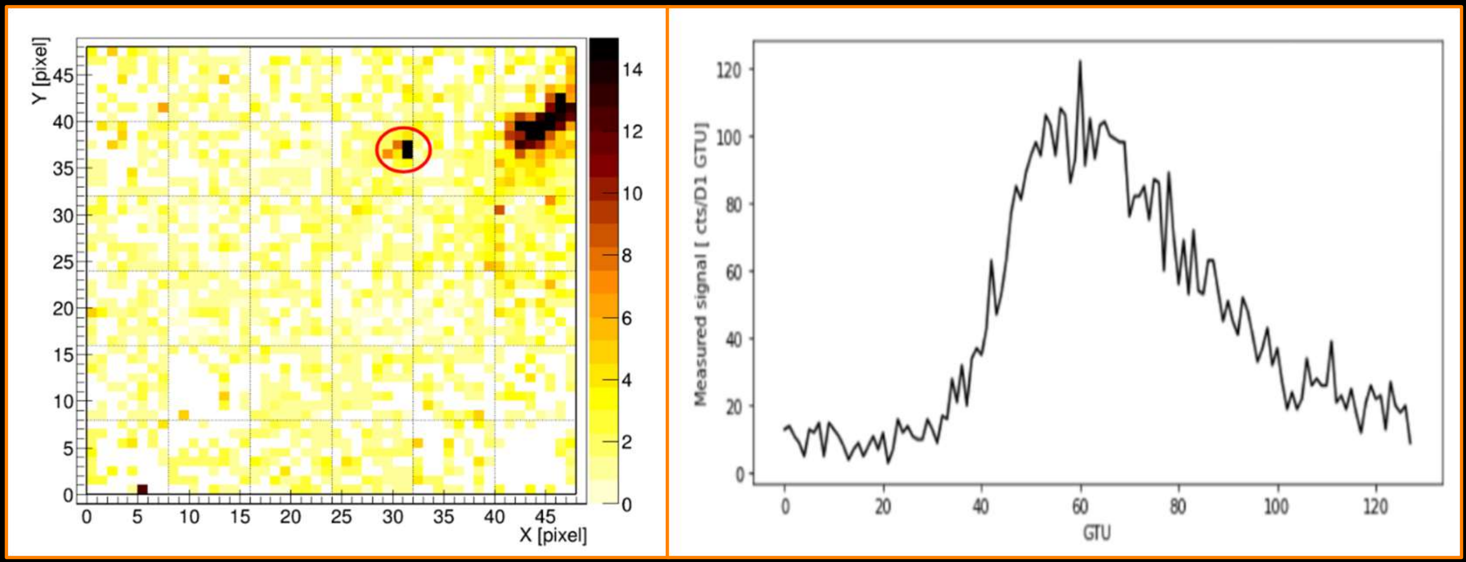
UHECR detection efficiency



Implications of Mini-EUSO measurements for a space-based observation of UHECRs
M. Bertaina et al., EPJ Web of Conferences 283 , 06008 (2023).

E1.1-0069-24 12:00 - 12:20
Implications of Mini-EUSO measurements for a space-based observation of UHECRs
Battisti, Matteo; Bertaina, Mario Edoardo; Bianciotto, Marta; Fenu, Francesco Team: JEM-EUSO Collaboration p. 453

Short Light Atmospheric Transient events



SLT lightcurves

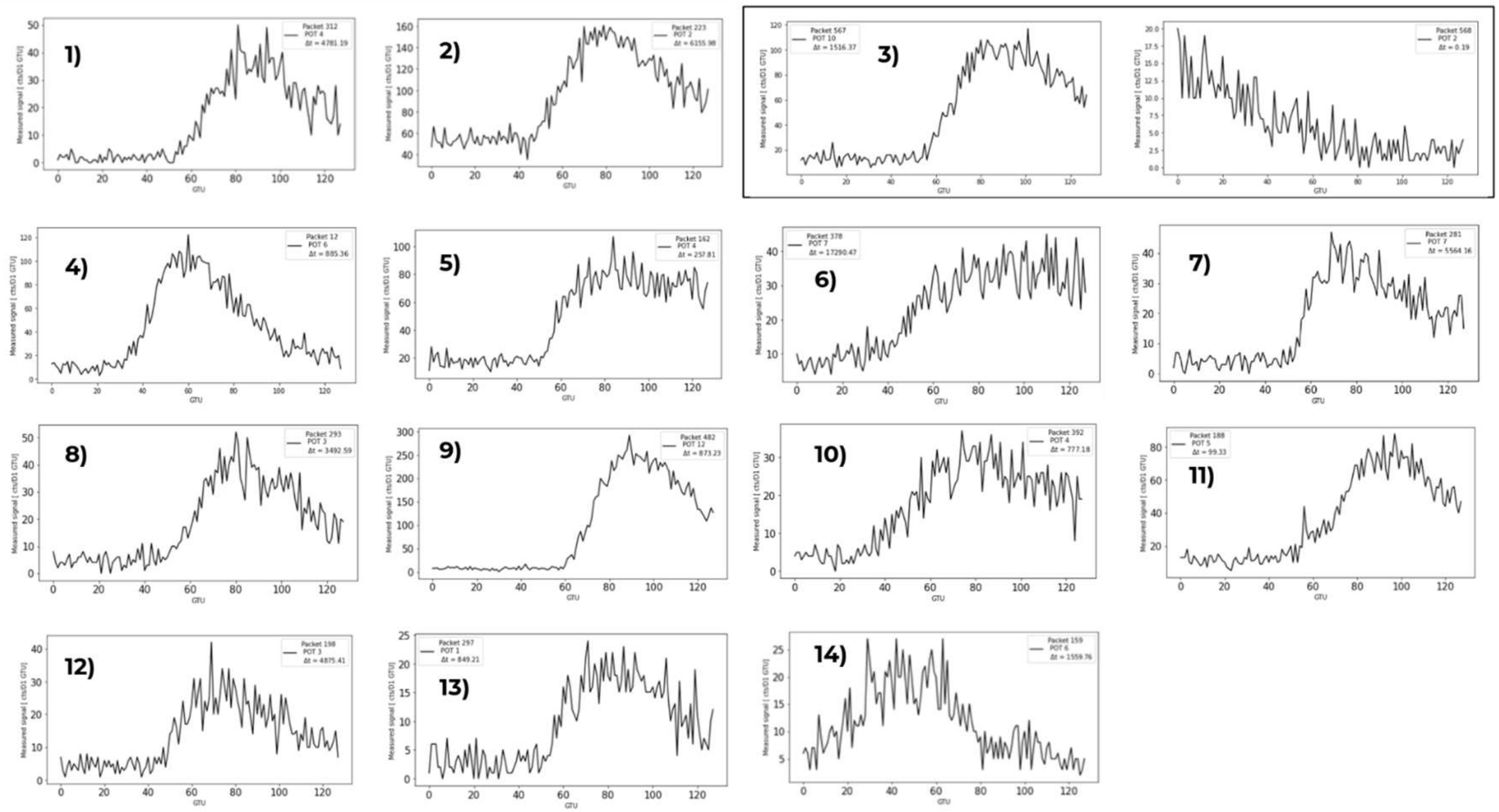
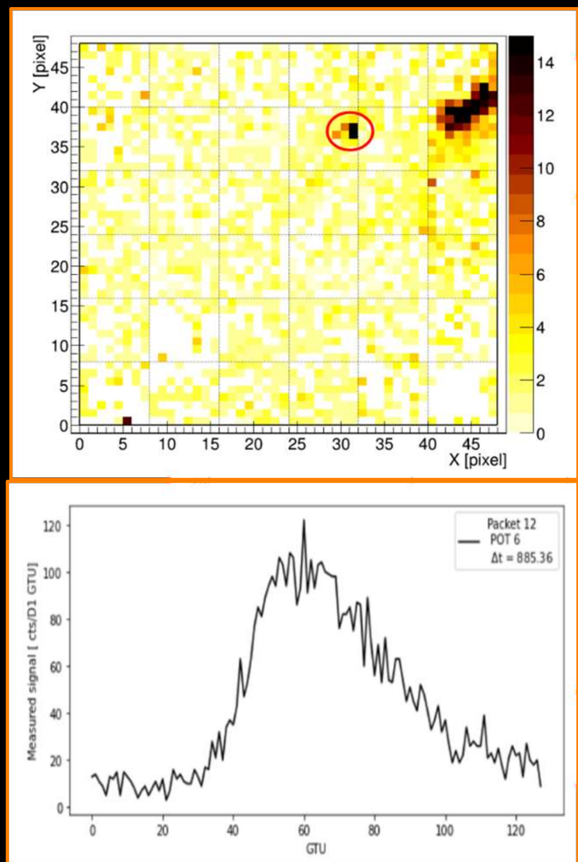
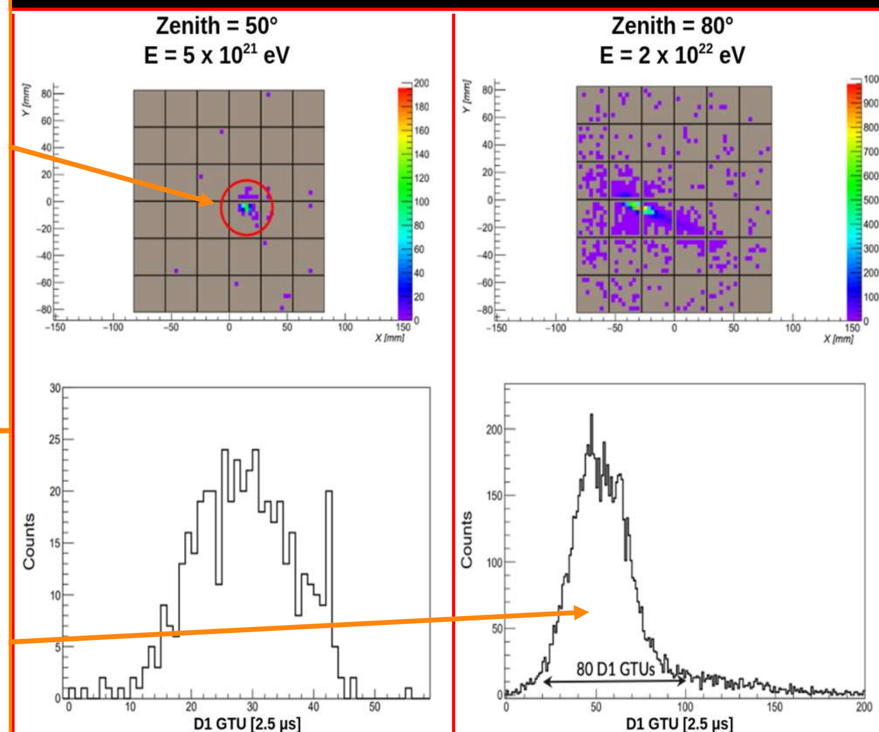


Figure 5. Ligtcurves of the 14 SLTs. Event 3 is the only one triggered in two consecutive packets. For events 1, 2, 6, 8, 12, and 13 an atmospheric event has been detected from the exact same position within a few ms after the EAS-like events. Event 4 is the one already shown on the right side of Fig. 2. See the text for more details. Image taken from [25].

Short Light Transient events

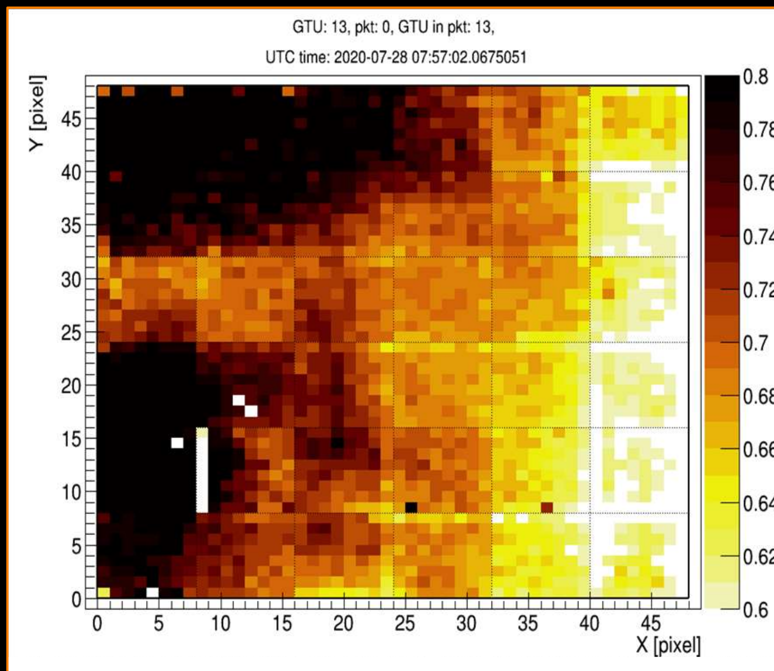


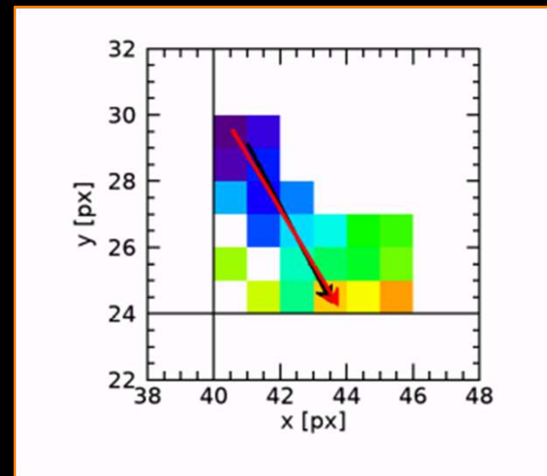
Mini-EUSO Data



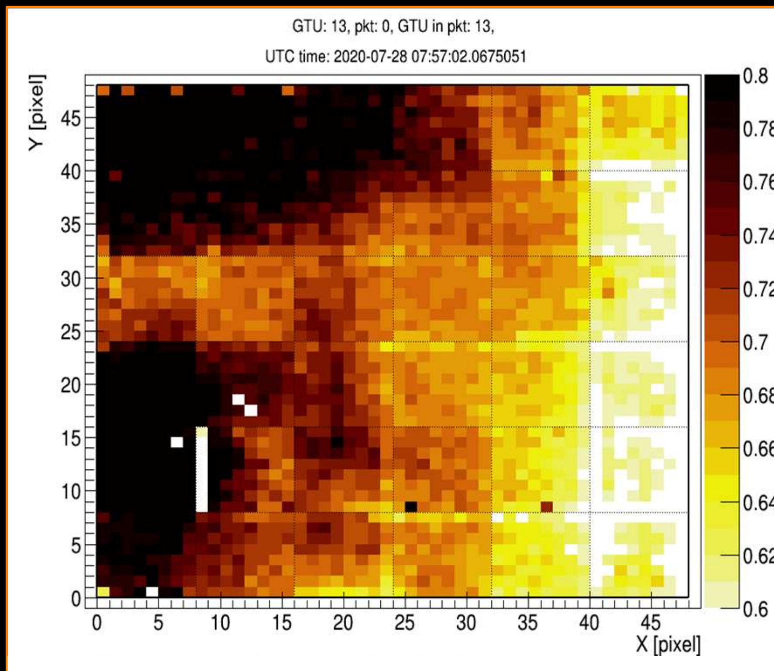
MC SIMULATIONS

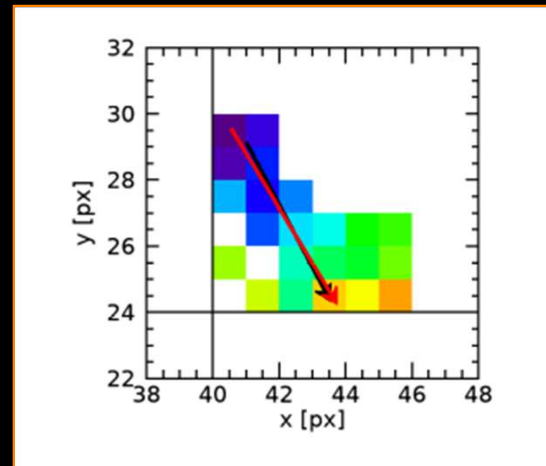
Meteor tracking algorithm

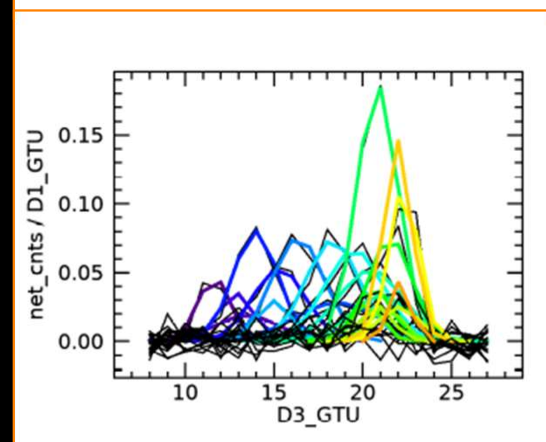




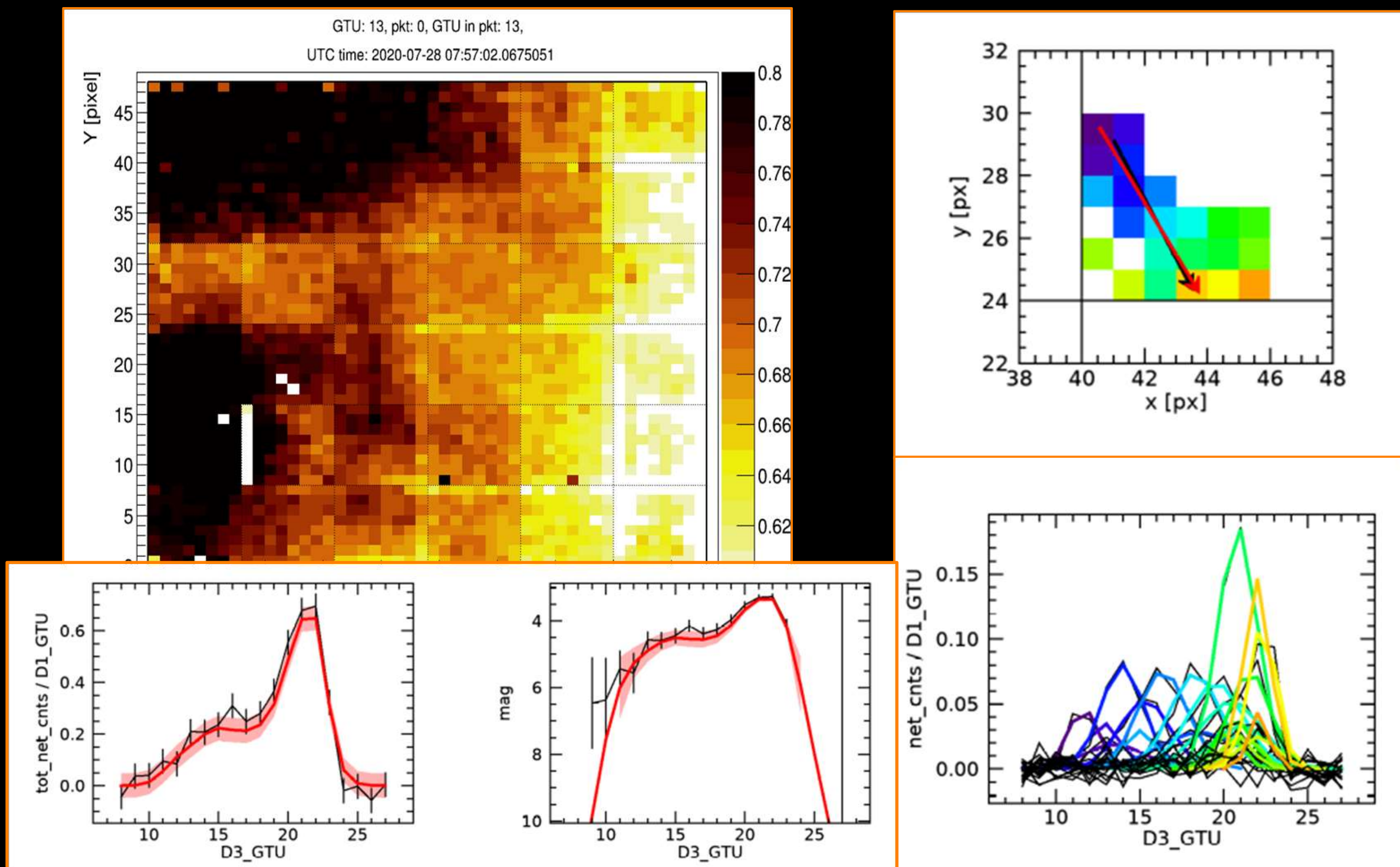
Meteor tracking algorithm



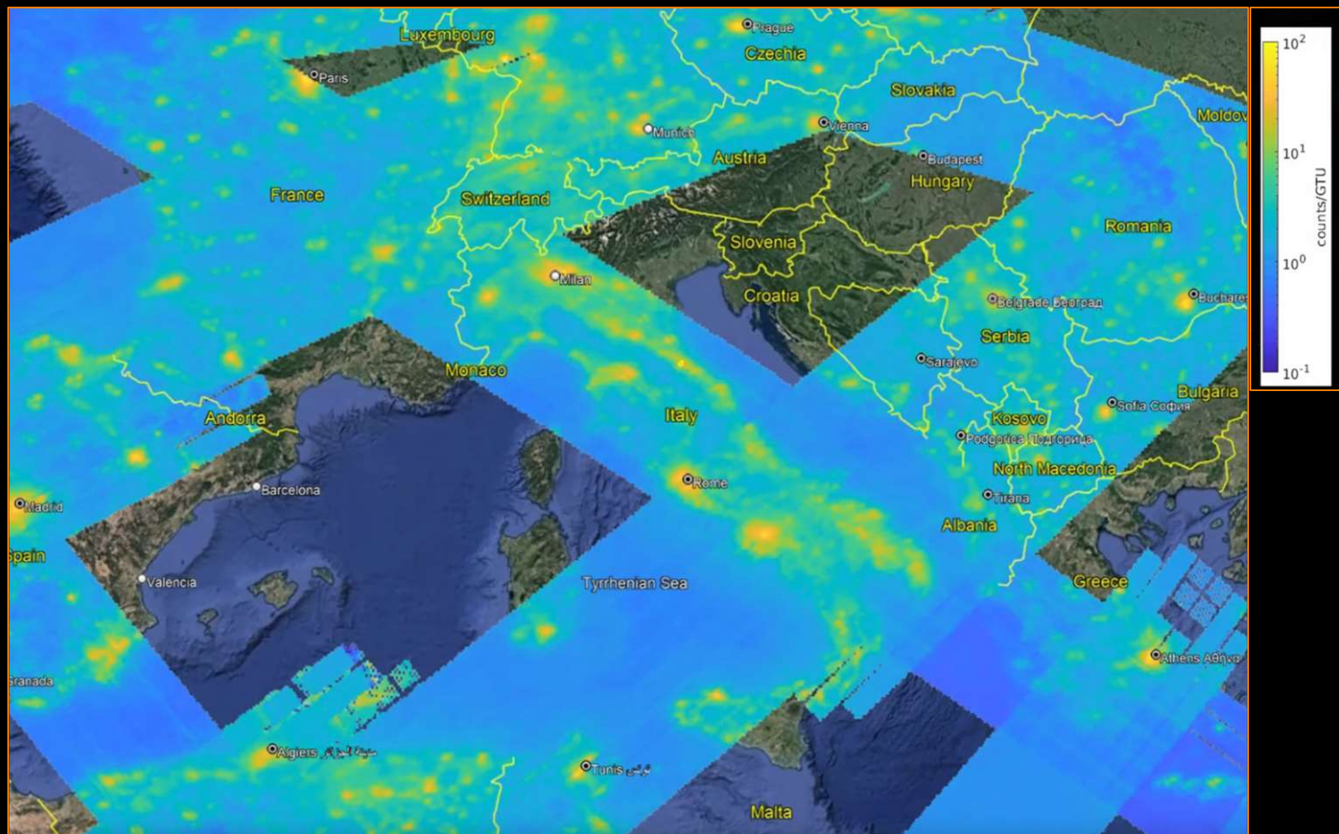




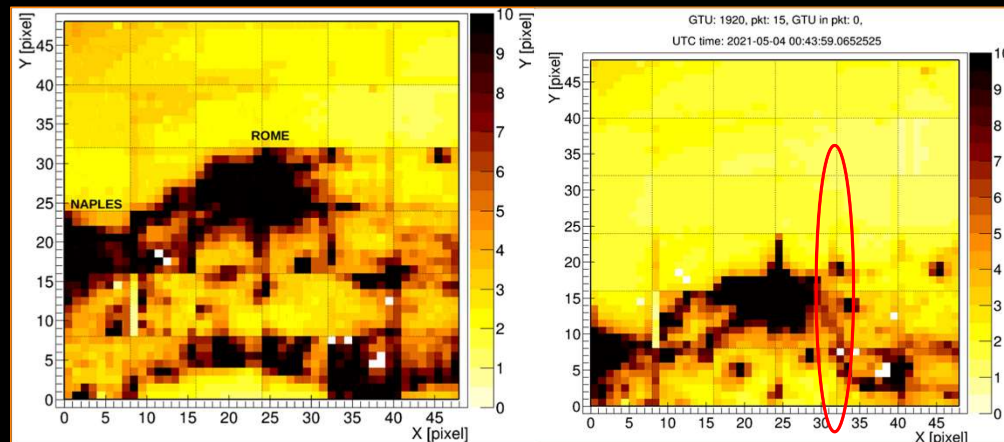
Meteor tracking algorithm

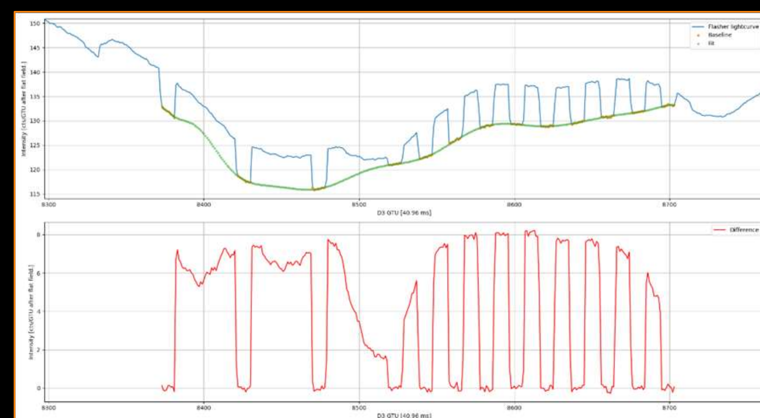


Night-time Earth Emissions



End-to-end in-flight Calibration with ground UV flashers





09:00	**MINI-EUSO: Status of the detector**	*105 and 153, Olympe de Gouges*	*Marco Casolino, Pavel Klimov*	09:00 - 09:15
	MINI-EUSO: Updates on Mini-EUSO data	*105 and 153, Olympe de Gouges*	*Laura Marcelli*	09:15 - 09:20
	MINI-EUSO: Scurves and Pile-up	*105 and 153, Olympe de Gouges*	*Enzio M'sihid, Etienne PARIZOT*	09:20 - 09:40
	MINI-EUSO: Meteor events in coincidence with ground based observatories	*105 and 153, Olympe de Gouges*	*Anike Bowaire*	09:40 - 09:55
10:00	**MINI-EUSO: Nuclearites**	*105 and 153, Olympe de Gouges*	*Mario Bertaina, Rosario Pullano*	09:55 - 10:10
	MINI-EUSO: Elves - status and results	*105 and 153, Olympe de Gouges*	*Laura Marcelli*	10:10 - 10:20
	Break	*105 and 153, Olympe de Gouges*		10:20 - 10:50
	MINI-EUSO: Nasa review	*105 and 153, Olympe de Gouges*	*Federico Reynaud*	10:50 - 11:00
11:00	**MINI-EUSO: Exposure estimation based on Mini-EUSO data**	*105 and 153, Olympe de Gouges*	*Mario Bertaina*	11:00 - 11:20
	MINI-EUSO: Stack CNN Evolution	*105 and 153, Olympe de Gouges*	*Antonio Giulio Coretti*	11:20 - 11:35
	EUSO-TA: Neural networks for EUSO-TA - Recent progress	*105 and 153, Olympe de Gouges*	*Mikhail Zotov*	11:35 - 11:50

Selected publications

An end-to-end calibration of the Mini-EUSO detector in space https://www.sciencedirect.com/science/article/pii/S0927650524001348 M. Battisti Astroparticle Physics
ELVES Measurements in the "UV Atmosphere" (Mini-EUSO) Experiment Onboard the ISS and Their Reconstruction https://link.springer.com/article/10.1134/S0010952524600379 S. Sharakin Cosmic Research
Refined STACK-CNN for Meteor and Space Debris Detection in Highly Variable Backgrounds https://ieeexplore.ieee.org/document/10521686 L. Olivi IEEE JOURNAL OF SELECTED TOPICS IN APPLIED EARTH OBSERVATIONS AND REMOTE SENSING,

Observation of meteors from space with the Mini--EUSO detector on board the International Space Station
D. Barghini et al., Astronomy & Astrophysics,

Mini-EUSO on Board the International Space Station: Mission Status and Results
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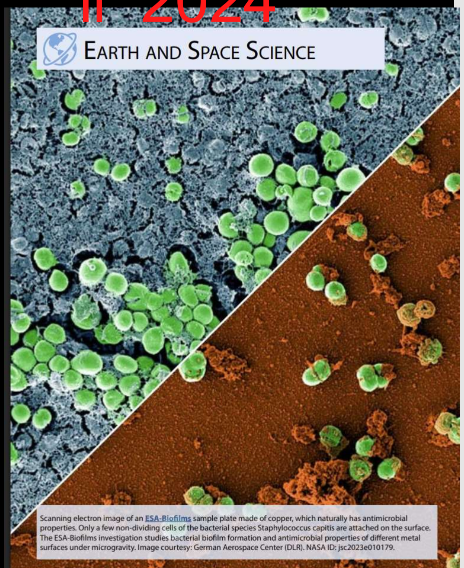
Highlight NASA per la ISS per il 2024



BENEFITS FOR HUMANITY

The Roscosmos-ASI-ESA investigation Multiwavelength Imaging New Instrument for the Extreme Universe Space Observatory (Mini-EUSO) is a state-of-the-art multipurpose telescope designed to examine terrestrial, atmospheric, and cosmic ultraviolet emissions entering Earth's atmosphere. Its optical system of 36 multianode photomultiplier tubes capable of detecting single photons allows exceptional imaging during day/night and night/day transitions (Figure 15). Mini-EUSO has been onboard station since August 2019 and is the first mission of a larger program (JEM-EUSO) that includes about 300 scientists from 16 countries.

Figure 15. Digitized image of space debris around Earth. *Image adopted from Mini-EUSO research team video.*

Data from Mini-EUSO has recently been used to test a new machine learning algorithm to detect space debris and meteors when space objects move across the field of view of the telescope. The study, published in the *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, reports that the highly sensitive algorithm, called Refined Stacking Method and Convolutional Neural Network (R-Stack-CNN), is an improved version of a previous machine learning method expected to become more significant and useful as increasing traffic of satellites and spacecraft sharing the same orbits add to the risk of collisions.[14] Millions of unidentified pieces of space debris could be removed from their orbit once detected.

The R-Stack-CNN model showed precision of 88.2%, a 2% improvement over the standard method used before, and detected 63.4% more events. Researchers improved the detection of space debris and meteors by using many instances of simulated and real data, enabling offline detection, and including light curves that provide information about the rotation rates of the objects and their physical characteristics. These upgrades allowed researchers to reduce false positives and increase the reliability of the algorithm.

Despite the challenges of detecting opaque objects with a moving telescope, a changing background of clouds, light emissions from cities, Moon reflections, and the small fraction of optimal conditions during twilight, researchers employed an advanced neural network used in computer vision that allowed them to classify information more accurately.

Conclusions

After 136+ sessions

(**about 5 years in space**) Mini-EUSO works nominally

Mini-EUSO is a multisciplinary experiment (ELVES, UV Earth maps, SQM...)

UHECR detection efficiency estimation validated for future missions

Mini-EUSO (+ balloons) results pave the way for UHECR detection from space