

Studio di meteore con PRISMA

Daniele Gardiol - INAF - Osservatorio Astrofisico di Torino

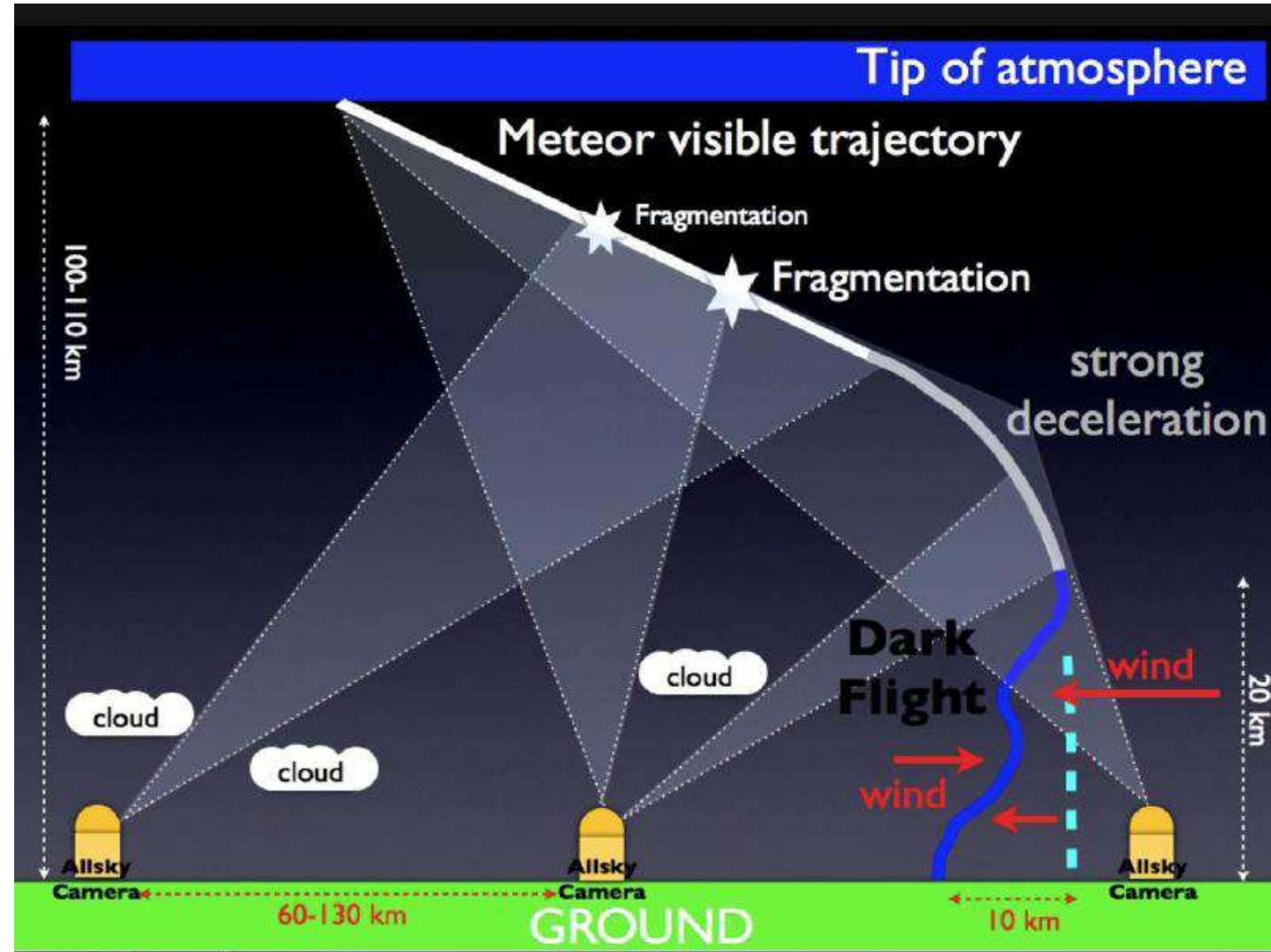
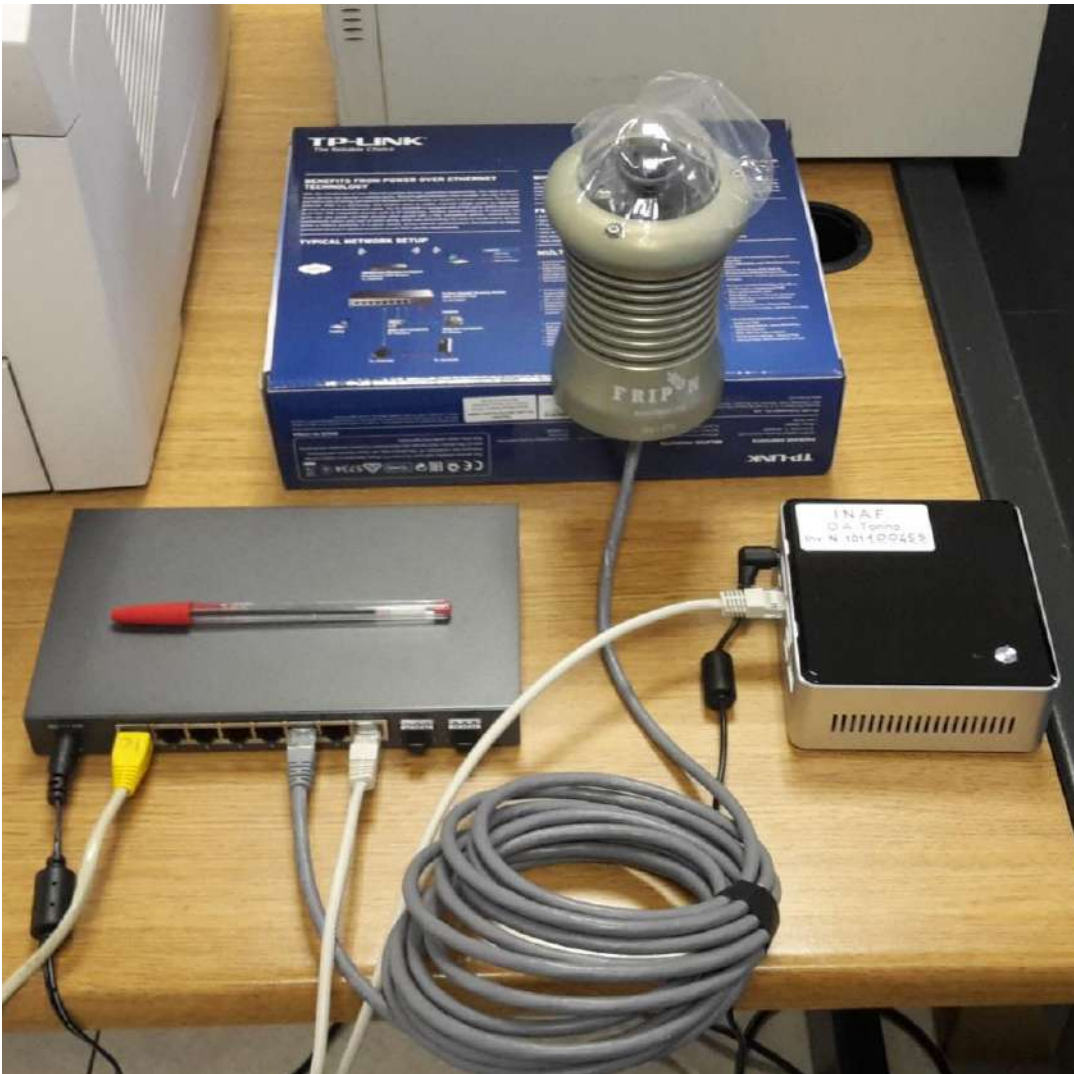
Mario Bertaina – Università di Torino

Dario Barghini – INAF O.A. Torino e Università di Torino

Presentazione Tesi LT e LM – Dipartimento di Fisica – 15 novembre 2023

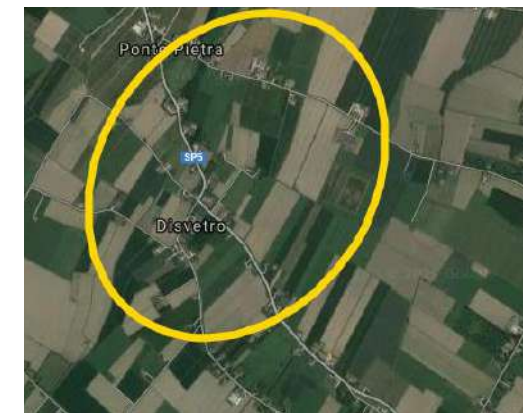
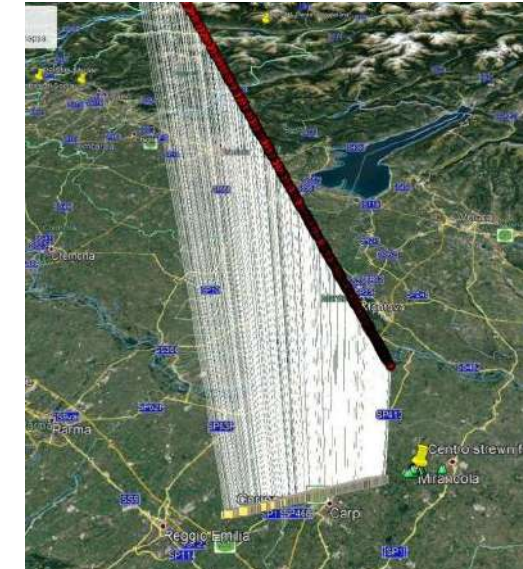
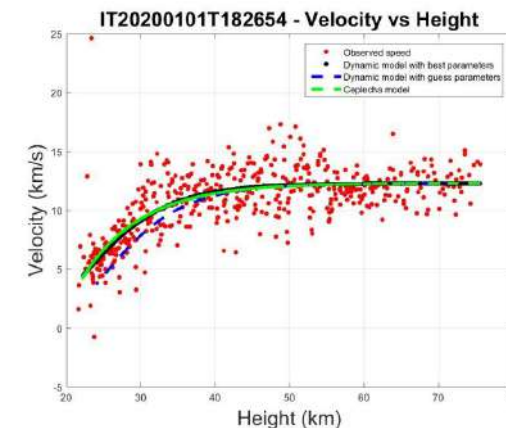
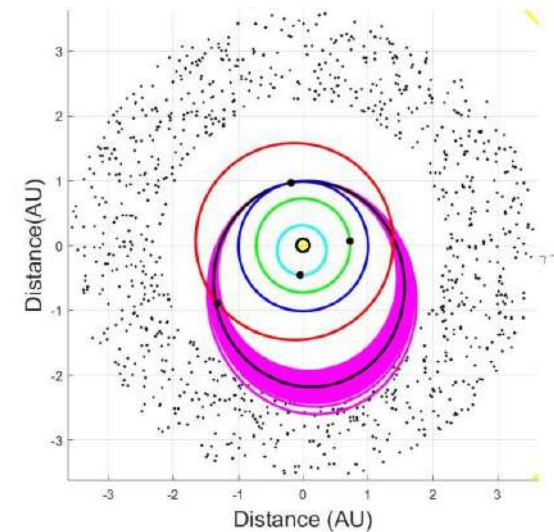
Progetto realizzato con il contributo di

Principio di funzionamento

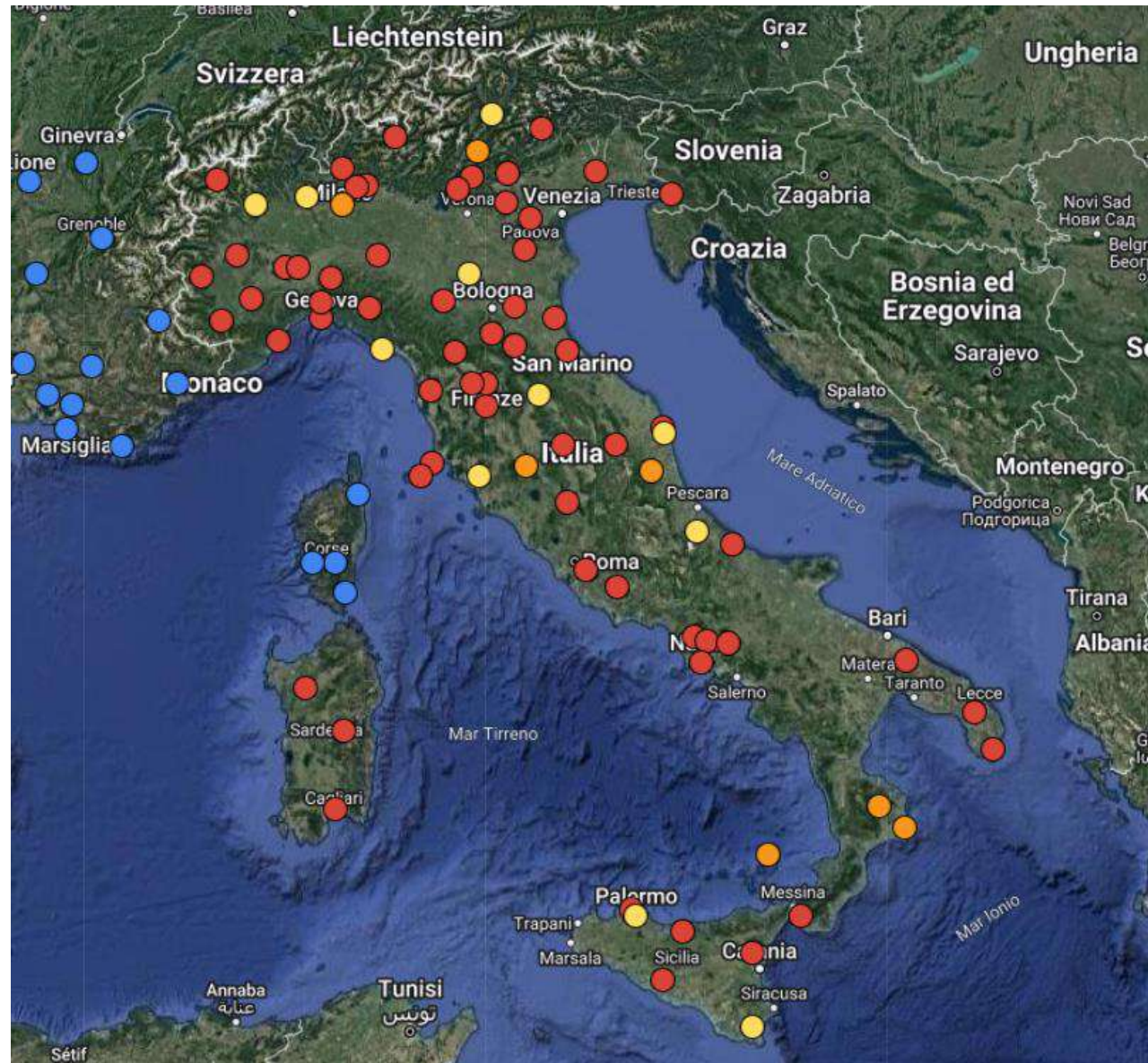


Campi di applicazione di PRISMA

- Calcolo del punto di caduta di eventuali frammenti per il **recupero e l'analisi di meteoriti fresche**
- Studio della dinamica e delle proprietà fisiche dei **bolidi**
- Determinazione dei **parametri orbitali** dei corpi progenitori
- Identificazione di **nuove famiglie asteroidali**
- Formazione ed evoluzione del Sistema Solare
- Monitoraggio dell'**inquinamento luminoso**
- Monitoraggio dei **detriti spaziali** brillanti (LEO)
- **Meteorologia**



PRISMA in a nutshell



- 6 years of operations
- 61 **operating** cameras, 7 in **installation** and 12 in **purchasing**
- More than **70 institutions** involved in the project
- More than **130 collaborators**
- More than **2500 observed bolides** in the Italian skies
- Server for **Data processing (CRAB Pino T.se)** and **Archive (IA2 Trieste)**
- Complete **data reduction pipeline**
- 6 observed potential **meteorite-dropping bolides**
- **2 meteorites recovered** (Cavezzo, 2 fragments, 55 gr.; Matera, many fragments, 118 gr.)

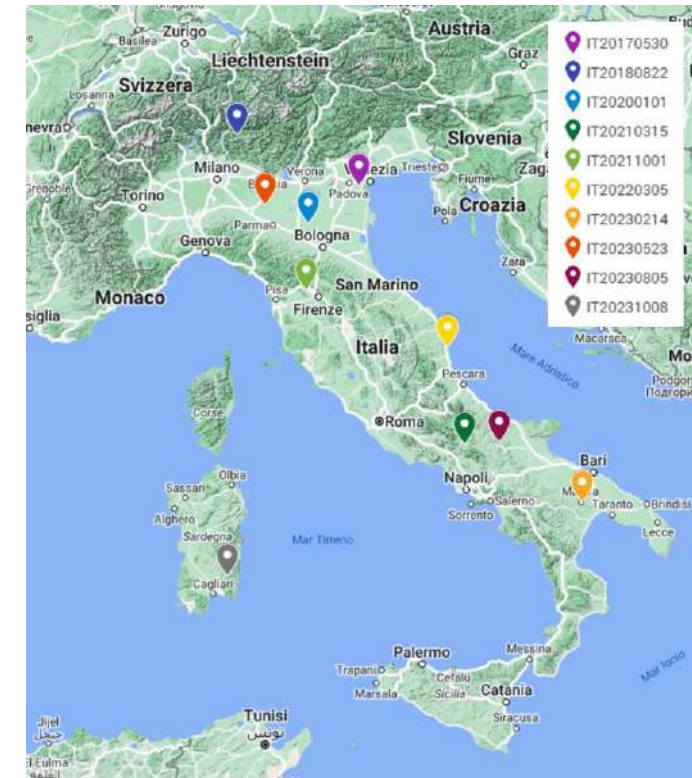
Recorded potential falls in Italy



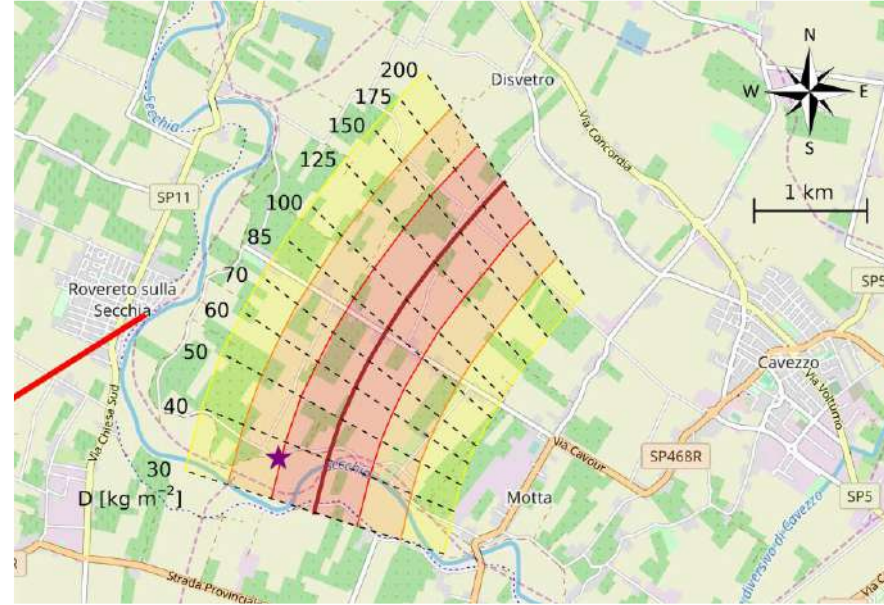
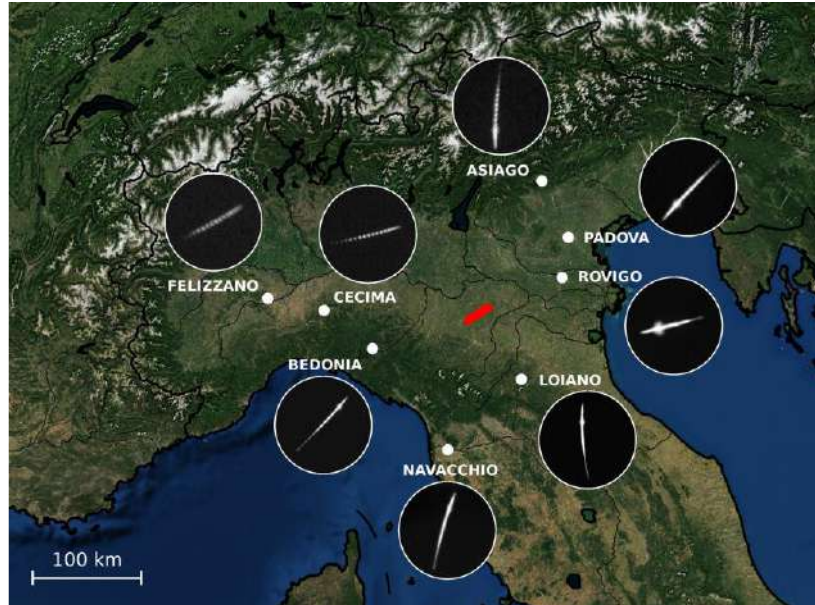
- PRISMA has the potential to detect fireballs of **apparent magnitude $m < 0$** (for very dark observational sites, usually -1 is the limiting magnitude)
- This corresponds to a meteoroid size **greater than 1 cm** and mass **above few grams**
- At the same time, we would expect **1 meteorite-dropping fireball per year** over Italy.

So far, this estimation was confirmed

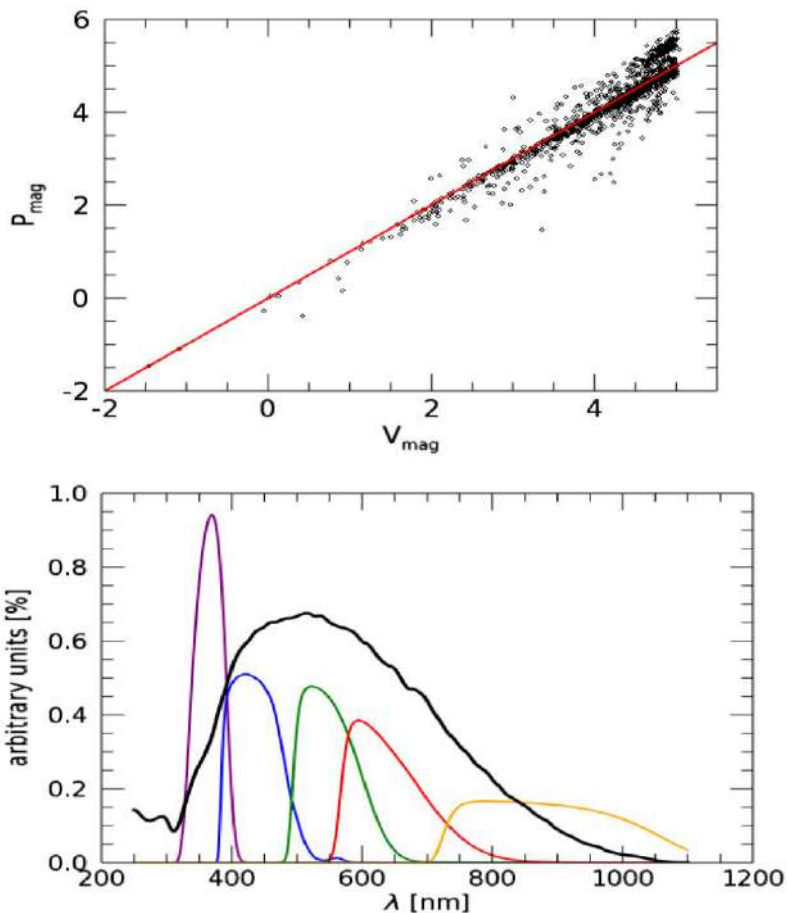
	Date	Time UT	Region	N° of cams	Speed [km/s]	Inclin. [deg]	Init. mass [kg]	Fin. Mass [kg]
IT20170530	30/05/2017	21:09:26	Padova	2	15.5	29°	4 – 12	0.2 – 4
IT20180822	22/08/2018	21:37:28	Sondrio	6	17.9	72°	2 – 5	0.4 – 1.2
IT20200101	01/01/2020	18:26:54	Modena	8	12.2	68°	10 – 40	0.5 – 1.5
IT20210315	15/03/2021	19:57:32	Isernia	1	14.7	84°	~ 2	~ 1
IT20211001	01/10/2021	01:04:57	Pistoia	8	16.0	31°	3 – 8	0.01 – 0.1
IT20220305	05/03/2022	18:55:52	Ascoli P.	10	15.5	17°	10 – 90	0.3 – 1.5
IT20230214	14/02/2023	17:58:29	Matera	3	16.4	57°	6 – 22	0.1 – 0.5
IT20230523	23/05/2023	22:21:04	Cremona	11	15.4	35°	5 – 7	0.4 – 2.3
IT20230805	05/08/2023	20:21:22	Campobasso	2	13.5	60°		0.3 – 1.4
IT20231008	08/10/2023	21:53:30	Cagliari	2	16.5	78°		0.1 – 0.2



Bolide di Capodanno 2020 (Cavezzo)

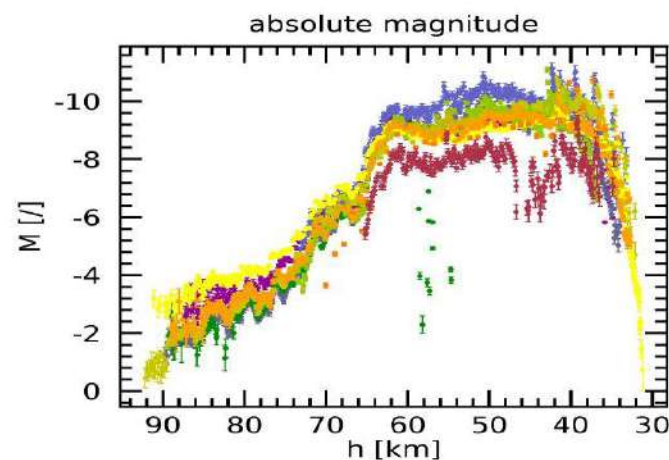


Attività proposte

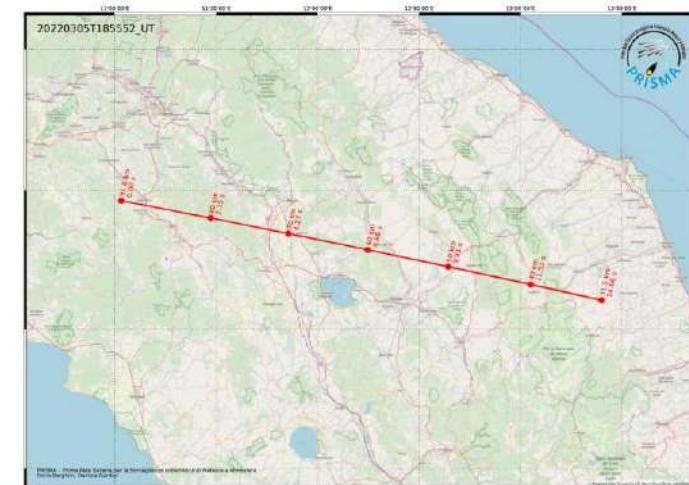


**Studio della risposta spettrale
delle camere PRISMA**

Processamento astrometrico dei video di bolidi



ITER01 - LOIANO
2020-01-01 @ 18:26:52.93 UT



**Determinazione dello
strewn-field per la ricerca di
meteoriti**

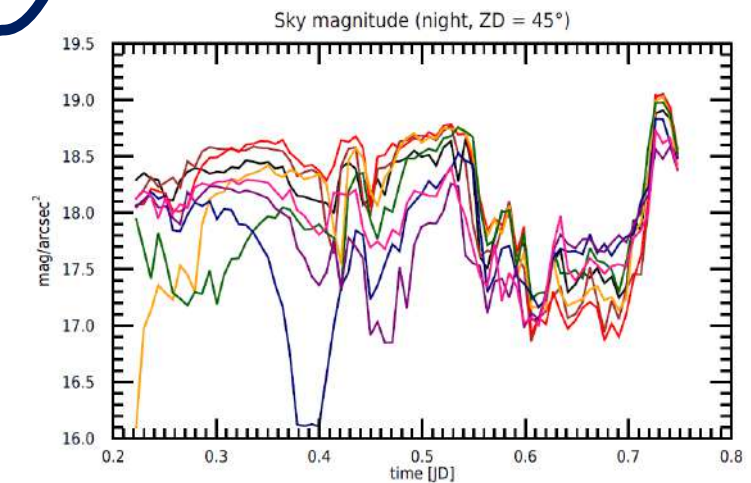
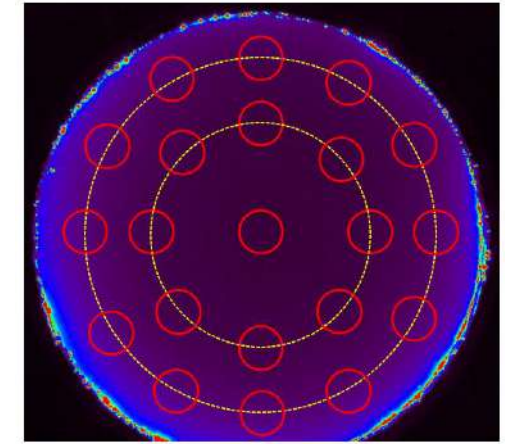
Attività proposte



Laboratori didattici su asteroidi e meteoriti nelle scuole del Piemonte



Sviluppo di HW e SW di nuova generazione



Studio dell'inquinamento luminoso

JEM-EUSO and Mini-EUSO

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The JEM-EUSO program

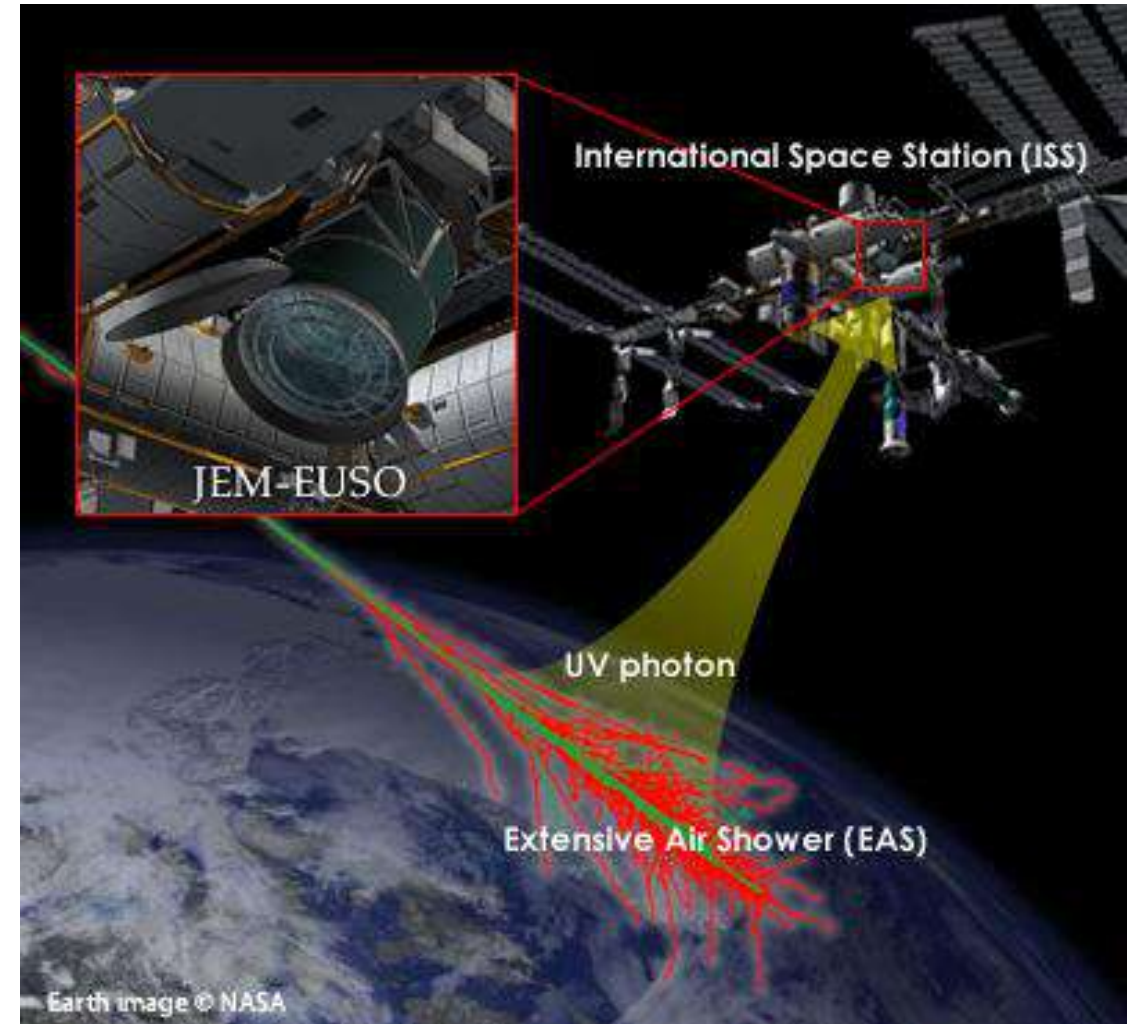


Joint Experiment Missions for Extreme Universe Space Observatory

- **Main goal:** detection from space of UV fluorescence and Cherenkov light from Extensive Air Showers (EAS) produced by Ultra High Energy Cosmic Rays (UHECR, $E \geq 5 \cdot 10^{19}$ eV)
- Other scientific objectives:
 - Night UV emission, airglow
 - Space debris
 - **Meteors***
 - Nuclearites (SQM)
 - Lightnings, TLEs

*Adams Jr. et al, "JEM-EUSO: Meteor and nuclearite observations" *Exp. Astron.* 40, 253 (2015)

*Abdellaoui et al., "Meteor studies in the framework of the JEM-EUSO program", *Planet. Space Sci.* 143, 245 (2017)



The JEM-EUSO program



Past missions:

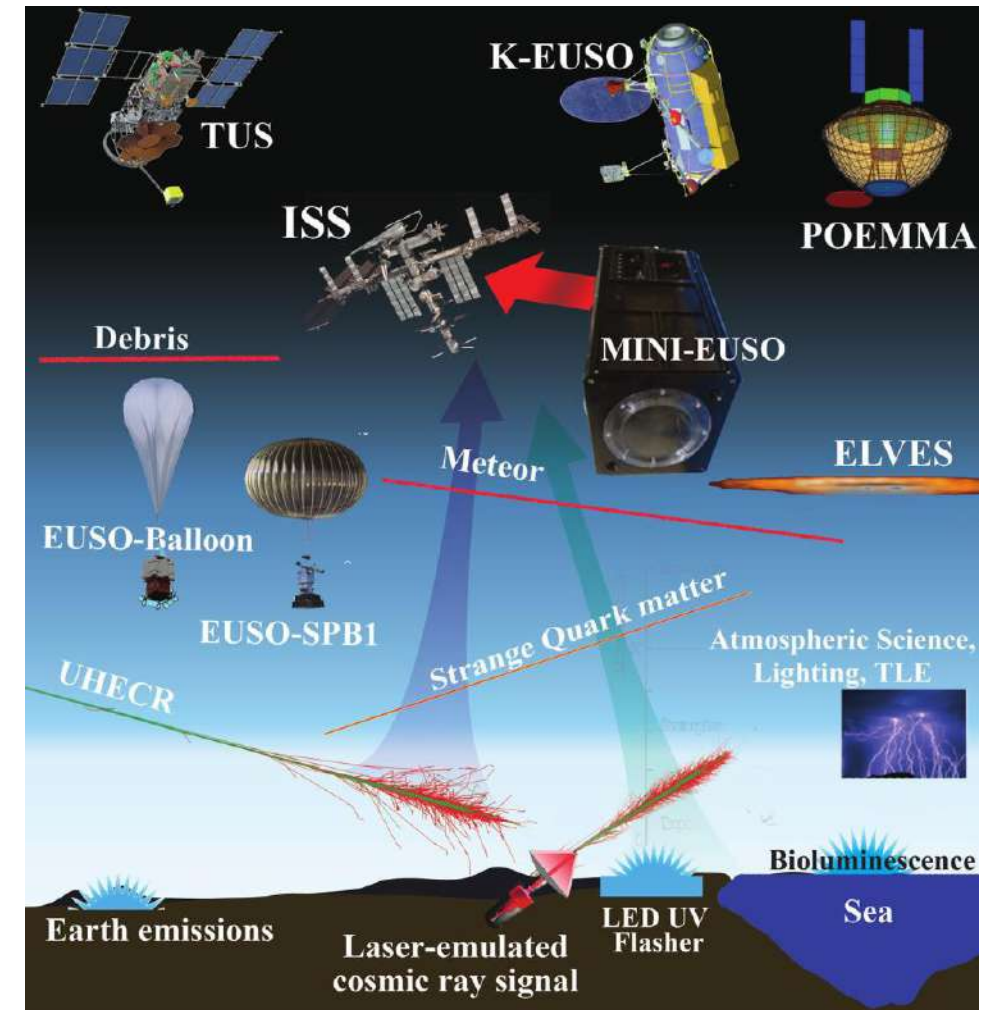
- EUSO-TA (2013): ground detector installed at Telescope Array site
- EUSO Balloon (2014): 1-night flight, Canada
- EUSO-SPB1 (2017): first Super Pressure Balloon flight (NASA) from Wanaka, New Zealand
- TUS (2016): free-flyer on Lomonosov Russian Satellite

Current mission:

- **Mini-EUSO** (2019): telescope installed on the ISS

Future / planned missions:

- EUSO-SPB2: second SPB flight
- K-EUSO: medium-size detector to be installed on the ISS (approved by the Roscosmos)
- POEMMA: twin free-flyer (project under evaluation, NASA)

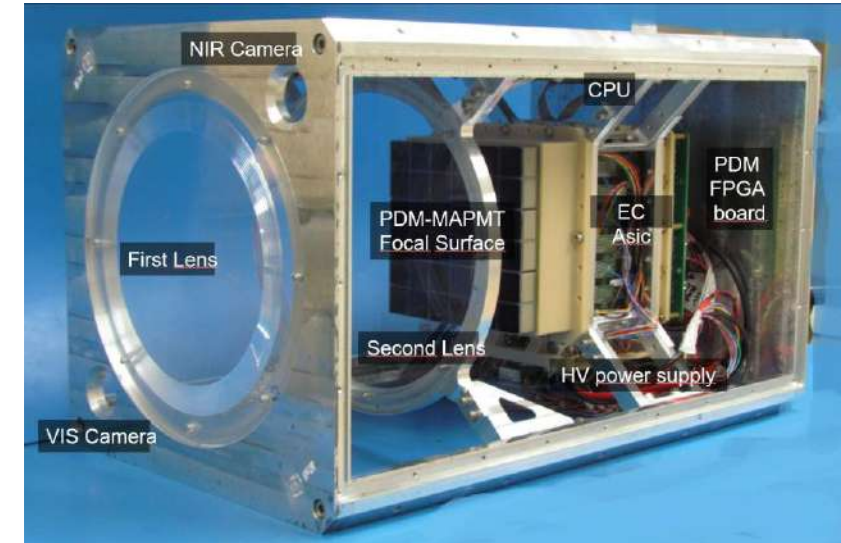


The Mini-EUSO telescope



Multiwavelength Imaging New Instrument for Extreme Universe Space Observatory*

- Installed on the nadir-facing UV transparent window in the Russian Zvezda module of the ISS on 7 October 2019 (Beyond mission, Luca Parmitano)
- Small detector ($37 \times 37 \times 62 \text{ cm}^3$) equipped with two Fresnel lenses, $\varnothing 25 \text{ cm}$
- **UV range** (290 – 430 nm)
- 0.05 m^2 focal surface, 48×48 pixels in **single photon counting** mode for a $44^\circ \times 44^\circ$ FOV (pixel resolution on ground $\sim 6.5 \text{ km}$)
- Three different timescales: D1 (2.5 μs), D2 (320 μs) and **D3 (40.96 ms)**



*Capel et al., "Mini-EUSO: A high resolution detector for the study of terrestrial and cosmic UV emission from the International Space Station", *Adv. Space Res.* 62, 2954 (2018)

*Bacholle et al. "Mini-EUSO Mission to Study Earth UV Emissions on board the ISS", *Astrophys. J. Suppl. Ser.* 253, 36 (2021)

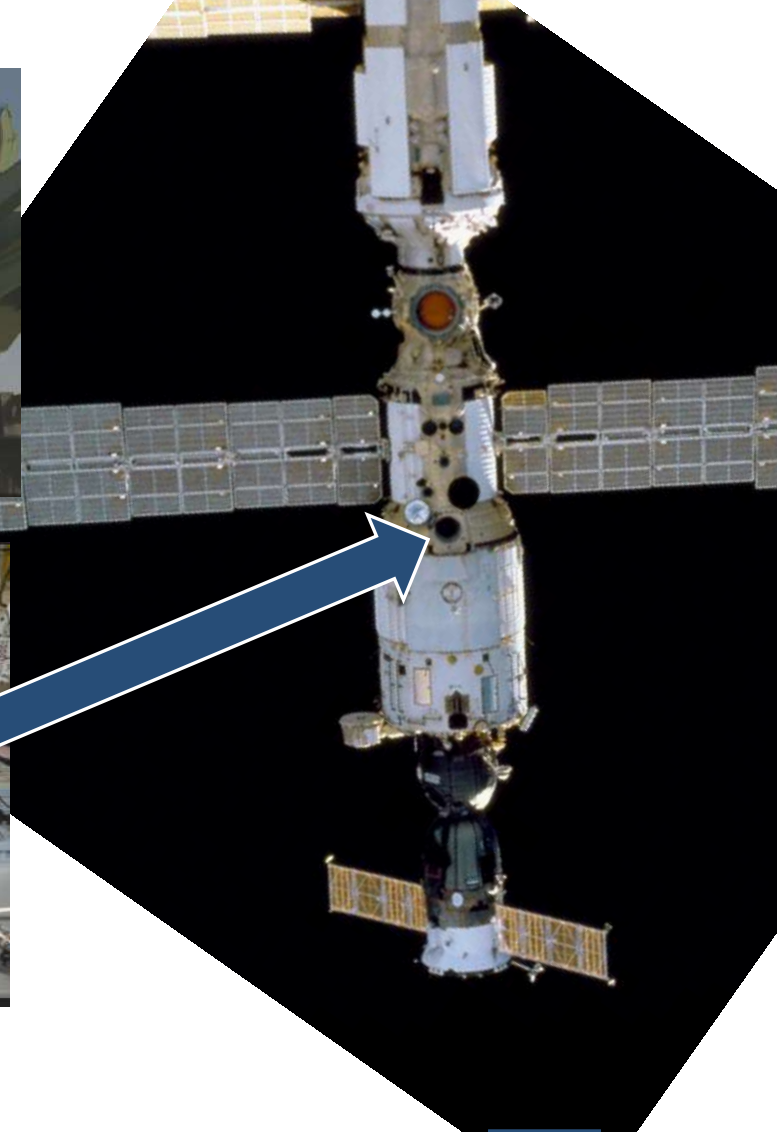
Mini-EUSO on the ISS



Launch 22/08/2019



Мы установили его на одном из окон российского модуля «Звезда», смотрящем на надир, то есть прямо на Землю.

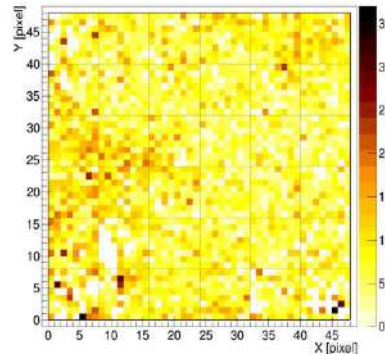


Mini-EUSO operated ~ 2 /month for ~ 12 h.
Data are transferred to ground with ISS crew once/year.
At the moment 71 sessions, $\sim 1/2$ available for analysis.

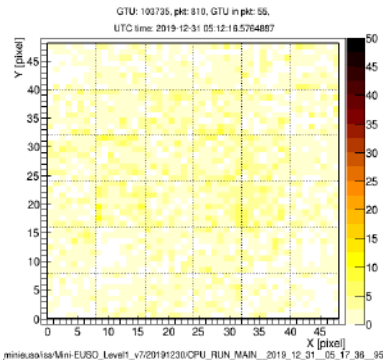
Mini-EUSO events zoo



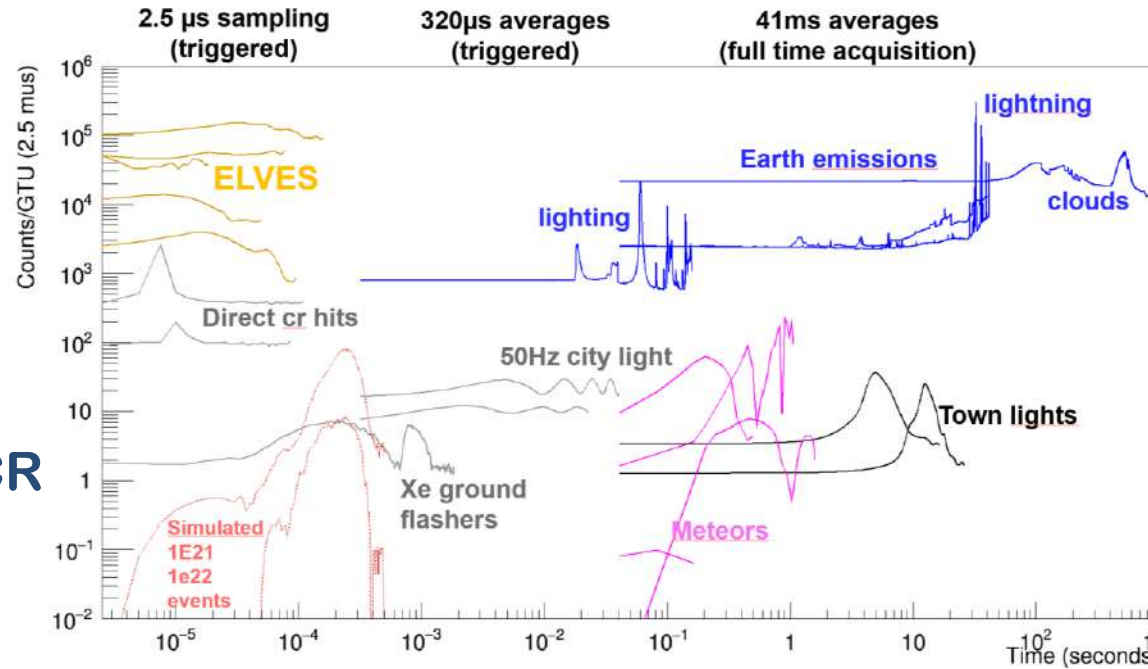
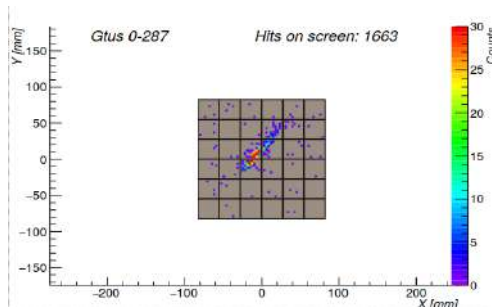
TLEs



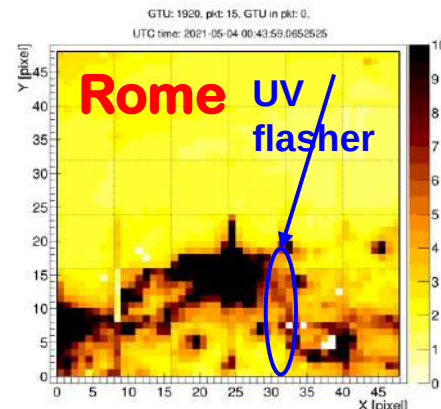
Direct CR



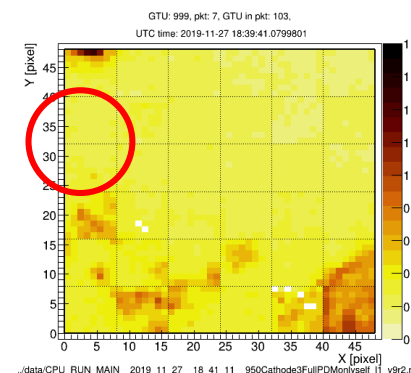
Simulated EAS



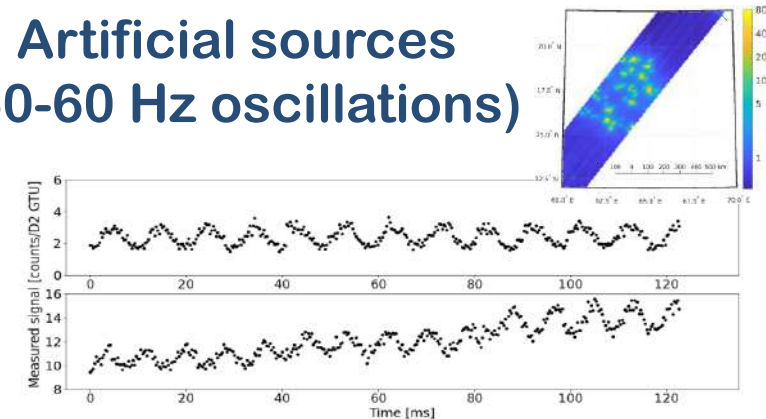
Artificial sources



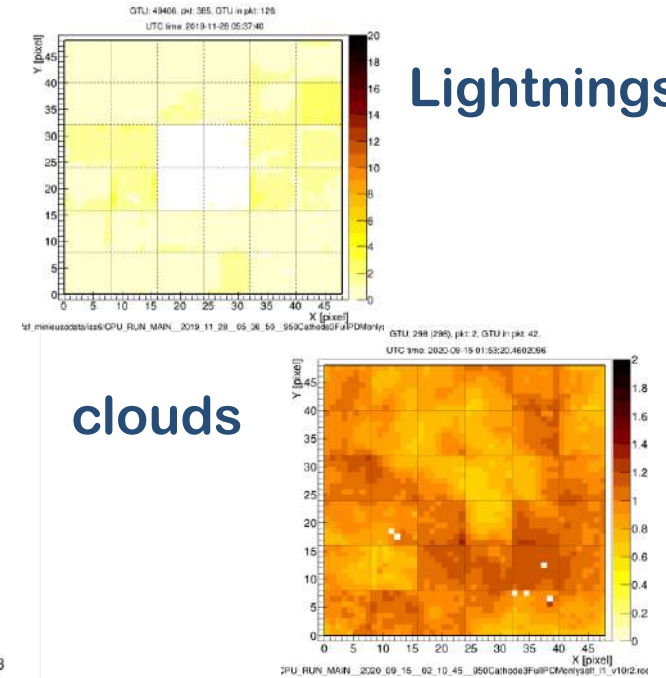
Meteors



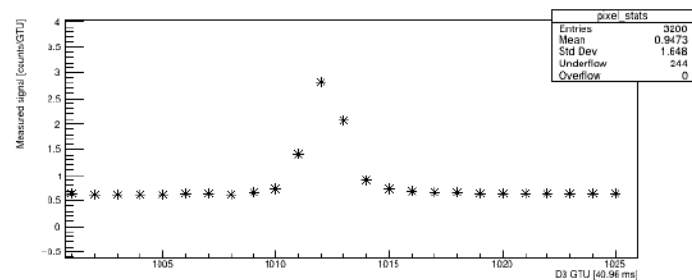
Artificial sources
(50-60 Hz oscillations)



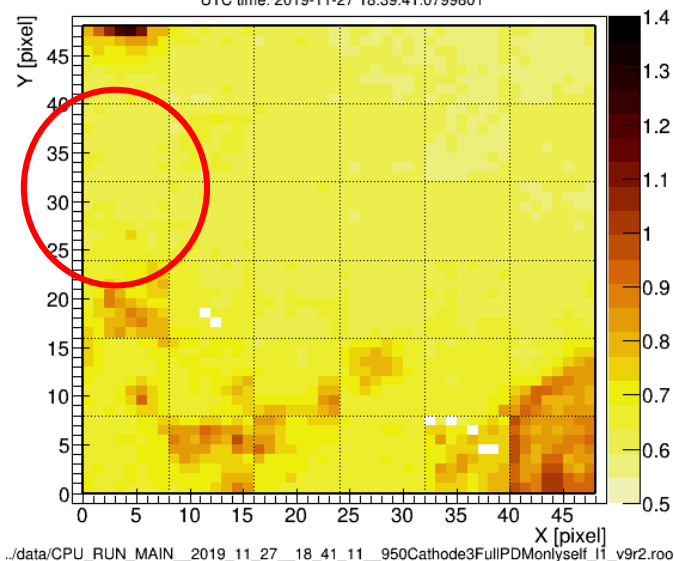
Lightnings



Meteors seen by Mini-EUSO

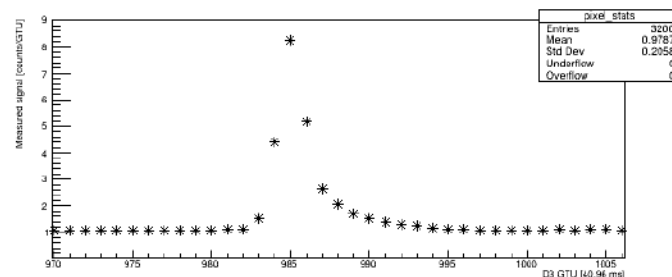


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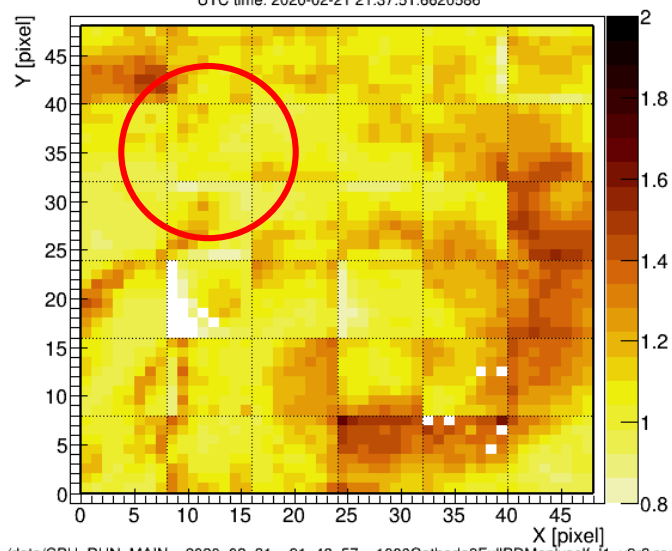


./data/CPU_RUN_MAIN_2019_11_27_18_41_11_950Cathode3FullPDMonlyself_11_v9r2.roo

Session 06, 27/11/2019, 18:41:11 UTC
Andaman sea (near Thailand)

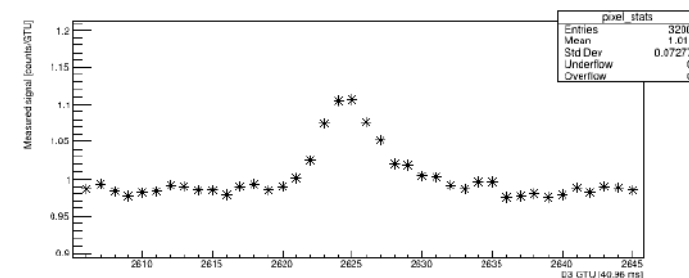


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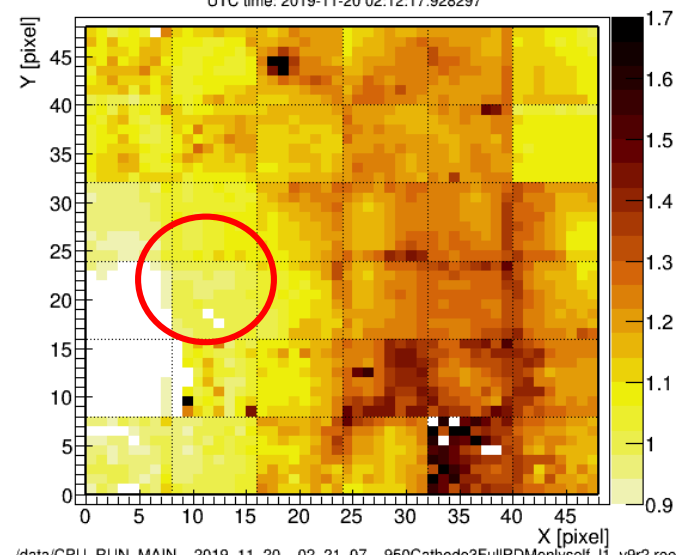


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Session 11, 21/02/2020, 21:48:57 UTC
Indian Ocean



GTU: 2622, pkt: 20, GTU in pkt: 62,
UTC time: 2019-11-20 02:12:17.928297



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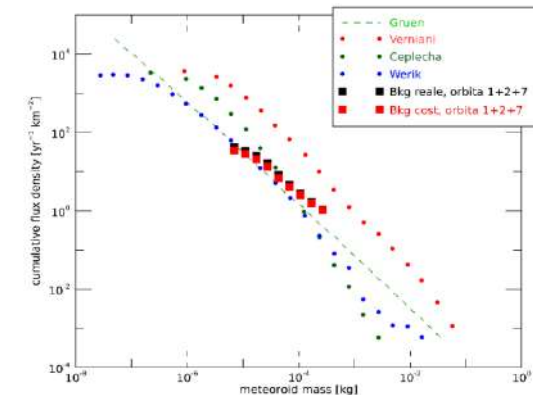
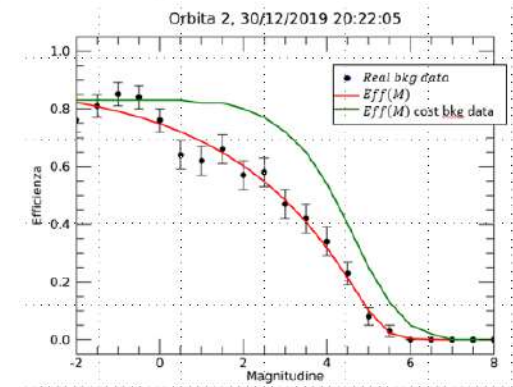
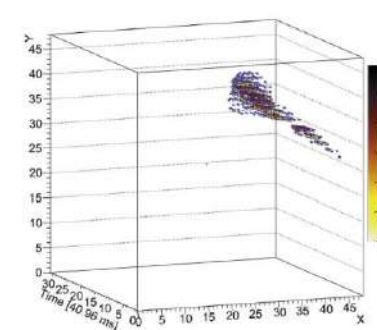
Session 05, 19/11/2019, 02:21:07 UTC
North Atlantic Ocean

Proposed thesis activities



Cosmic rays studies and simulations

- **Analysis of meteor events** in Mini-EUSO data
 - Application of **machine learning techniques** to Mini-EUSO data (trigger, tracking, analysis, classification)
 - **Simulation studies** for the detection of meteors and other events in JEM-EUSO experiments
 - Study of the capabilities of EUSO experiments for the detection of **exotic events** (interstellar meteors, nuclearites – SQM / MACRO)
 - **Search for candidates of interstellar meteors / nuclearites** in Mini-EUSO data
- ... and more



Thanks for your attention



CONTATTI:

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