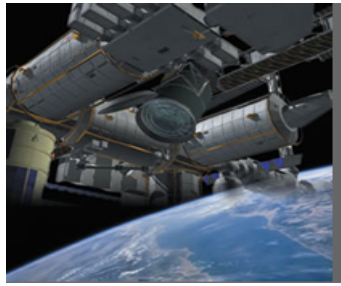
Commissione Scientifica Nazionale 2
Fisica Astroparticellare

OGGI

4 linee scientifiche



JEM-EUSO Program

Extreme Universe Space Observatory

https://jemeuso.org

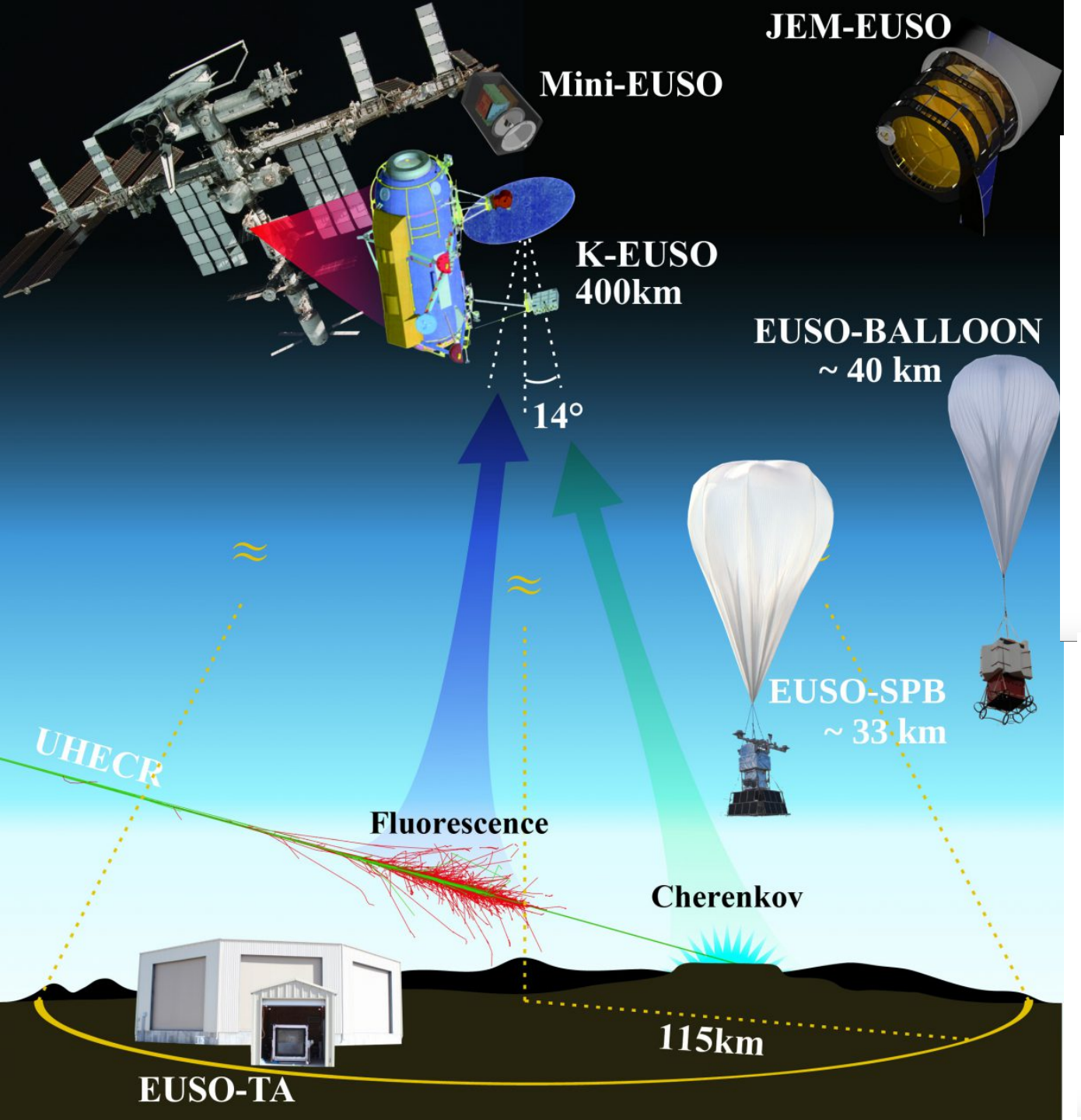
LINEA 2: Radiazione dall'Universo
(raggi cosmici, neutrini, fotoni)
SPB2, AUGER, CTA, KM3

LINEA 1: Fisica del Neutrino
(masse, oscillazioni, ββ, etc.)
ICARUS, JUNO

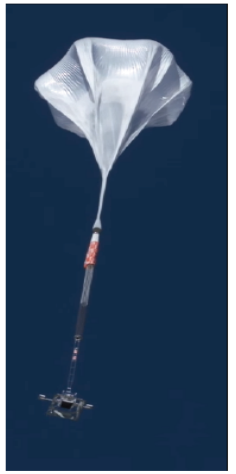
LINEA 3: L'Universo Oscuro
(materia oscura e energia oscura)
DARKSIDE

LINEA 4: Onde gravitazionali, Fisica Generale e Quantistica

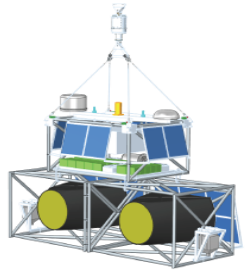
INFN Istituto Nazionale di Fisica Nucleare



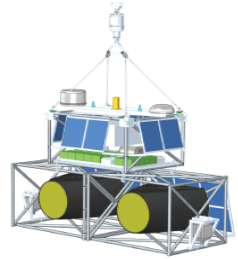
Attività SPB2 (Super Pressure Balloon 2)



Proposta di partecipazione italiana alla missione NASA SPB2 Super Pressure Balloon-2



Il Gruppo Italiano proponente



Torino Univ. e INFN (M. Bertaina)
Roma Tor Vergata Univ. e INFN (M. Casolino)
INFN Laboratori Nazionali Frascati (M. Ricci)
Napoli Univ. e INFN (G. Osteria)
Bari Univ. e INFN (F. Cafagna)
Catania Univ. e INFN + gruppo assoc. INAF Palermo (R. Caruso)

La Collaborazione Internazionale

USA e NASA (MSFC)
Francia
Giappone
Polonia
Russia
Svezia
Slovacchia

EUSO-SPB2

Extreme Universe Space Observatory on NASA Super Pressure Balloon

CT = Cherenkov Telescope
FT = Fluorescence Telescope

Altitude of ~ 33km,
from Wanaka, Nuova Zelanda
around the Southern Ocean

EUSO-SPB2 objectives:

1. FT observe **1st Extensive Air Showers with fluorescence** from sub-orbital space;

2. CT observe **Cherenkov light from Extensive Air Showers** initiated by cosmic rays;

3. CT measure the **background for the detection of neutrino** induced upward going air showers

4. CT **search for neutrinos from astrophysical transient** events (binary neutron star mergers…)

Lancio di SPB2 – 13 maggio 2023

Base **NASA-CSBF** (Columbia Scientific Balloon Facility) **@ Wanaka – Nuova Zelanda** in grado di raggiungere **30 km** s.lm. e **100 giorni** di durata

durata effettiva **36 ore!!**

Agenzia Spaziale Italiana

ACCORDO ATTUATIVO N. 2021-8-HH.0

DELLA CONVENZIONE QUADRO N. 2016-4-Q.0

Codice Unico di Progetto (CUP) F15F21000140005

PER

NOTA: IN ESSERE dal 27/04/2021 fino al 27/11/2024; prevista Proroga + Addendum per il 2025 e Nuovo Accordo ("PBR") per il triennio 2026-2028

"EUSO-SPB2 (Extreme Universe Space Observatory – Super Pressure Balloon

OBIETTIVI:

- progettazione, prototipazione e produzione di hardware per i telescopi di fluorescenza (FT) e Cherenkov (CT) della missione SPB2;
- sviluppo SW di simulazione, ricostruzione, analisi dati e monitoraggio ambientale;
- campagna di integrazione e test del FT.

PARTNERS: ASI

- INFN – Sezioni di Catania, Napoli (capofila con il P.I. Dott. Giuseppe Osteria),
- Roma Tor Vergata, Torino e Laboratori Nazionali di Frascati;
- Università di Catania, Università di Napoli "Federico II".

ASSEGNAZIONI 2024 – ANAGRAFICA sigla SPB2- INFN-CT

RICERCATORI

		%
1. Anzalone Anna	Ric. INAF/IASF PA	50
2. Caruso Rossella	Prof. Ass. UniCT (Resp.locale)	40
3. Lombardo Claudio	Dottorando	20
4. Pagliaro Antonio	Ric. INAF/IASF PA	40
5. Petta Catia	Prof. Ass. UniCT	20

TOTALE: 5 unità **<FTE/persone> = 0.36** **FTE TOT. 1.7**

SERVIZI

Servizi ELETTRONICA

TOTALE: 2 mesi uomo **FTE TOT. 0.2**

ASSEGNAZIONI 2024 - sigla SPB2 – CT

Missioni Estere e Nazionali: **Richiesti 17.5 keuro/ASSEGNATI 7.0 keuro**

- Meeting generali di Collaborazione nazionali e internazionali (USA/JAPAN);
- Meeting Working Groups In Italia e all'estero
- Incontro Referees;

Consumo: **Richiesti 9.5 keuro/ASSEGNATI 4.0 keuro**

- Metabolismo Laboratorio R&D SiPMs
- Acquisto kit lenti calibrate e collimatore
- Acquisto SiPMs

Altro Consumo: **Richiesti 10.0 keuro/ASSEGNATI 10.0 keuro**

Acquisto strumentazione di precisione finalizzazione banco ottico

Inventario: **Richiesti 20.0 keuro/ASSEGNATI 20.0 keuro**

Acquisto tavolo micrometrico XY

TOTALE **Richiesti 57.0 keuro/ASSEGNATI 21.0 keuro**

UNIVERSITÀ degli STUDI di CATANIA

Dipartimento di Fisica e Astronomia "Ettore Majorana"

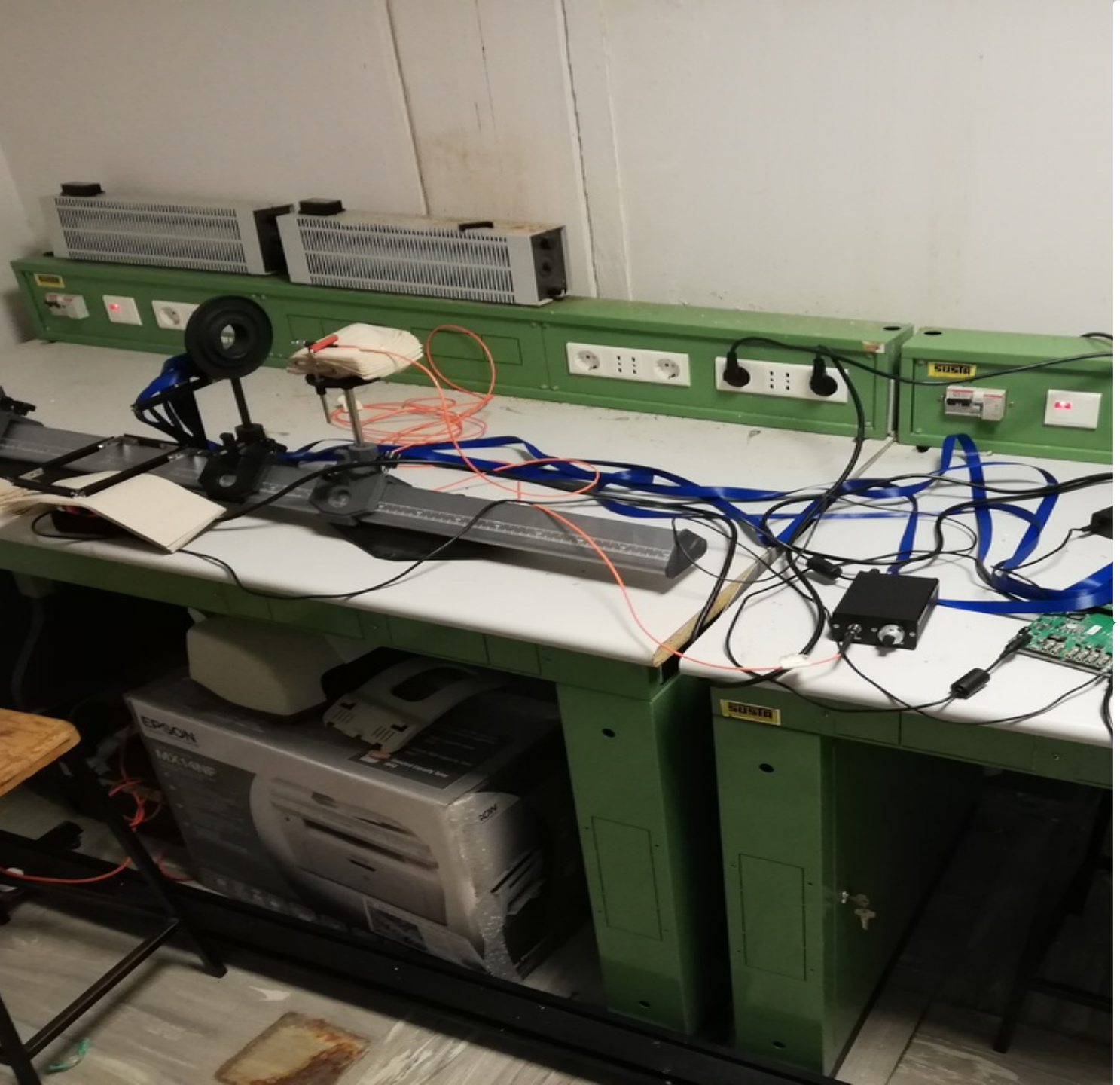
INFN CATANIA
Istituto Nazionale di Fisica Nucleare
Sezione di Catania

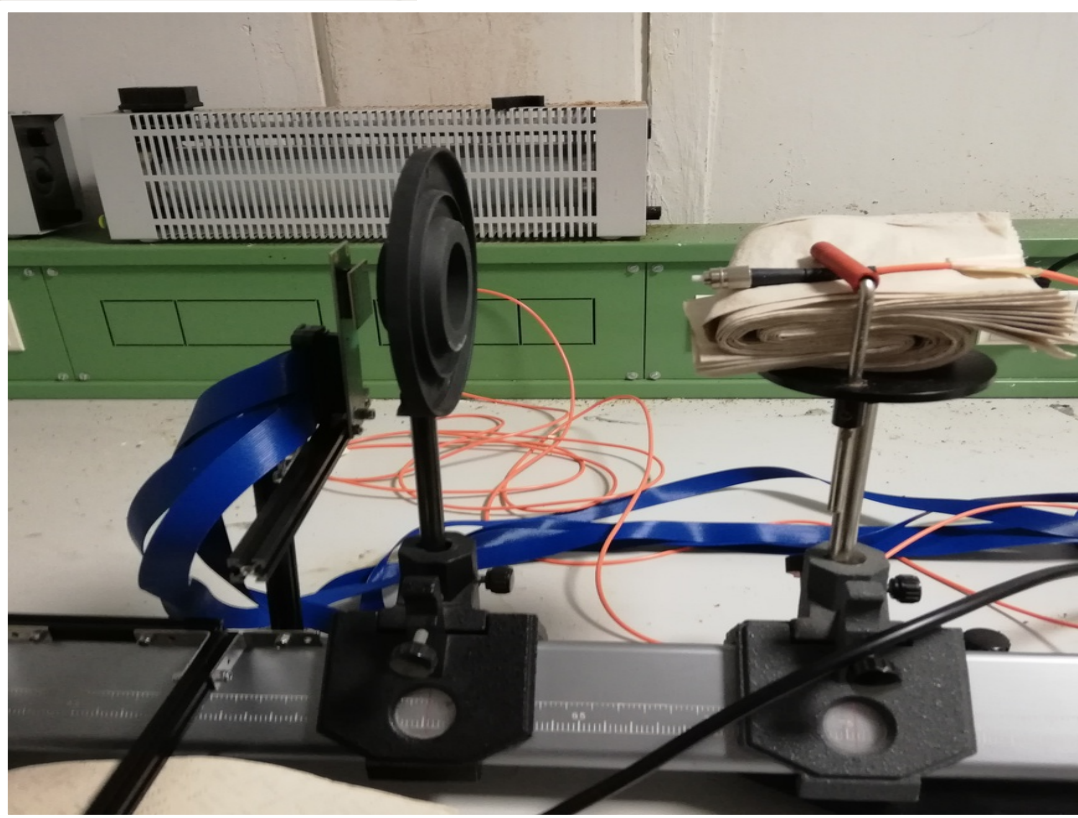
Activities: a) R&D on SiPMs for the SPB2 mission

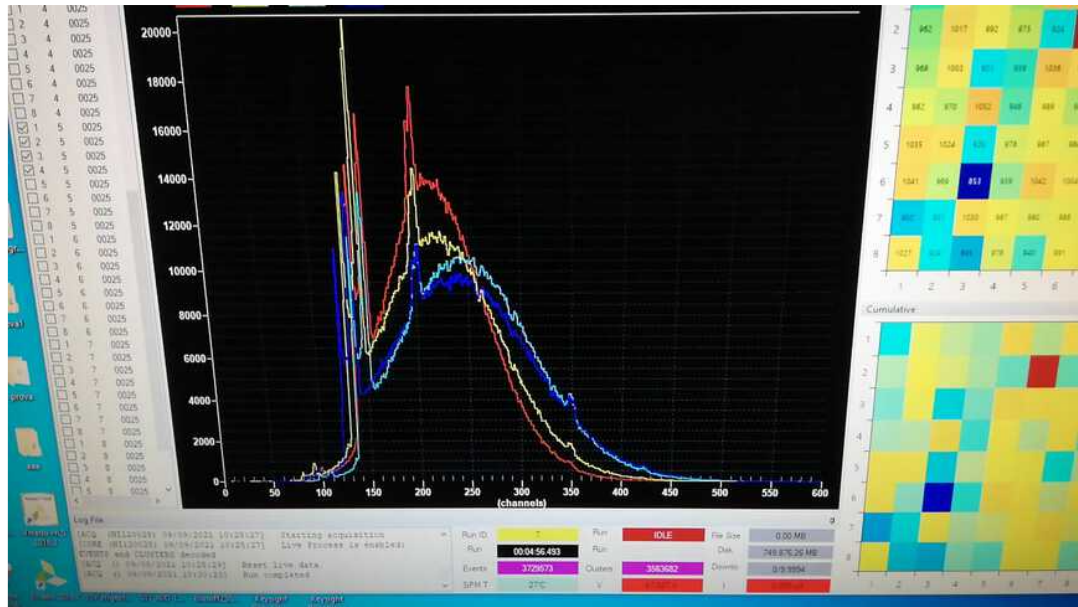
Involved members: **Rossella Caruso, C.Lombardo, C.Petta, Servizi Elettronica**

Measurements of SiPM features:

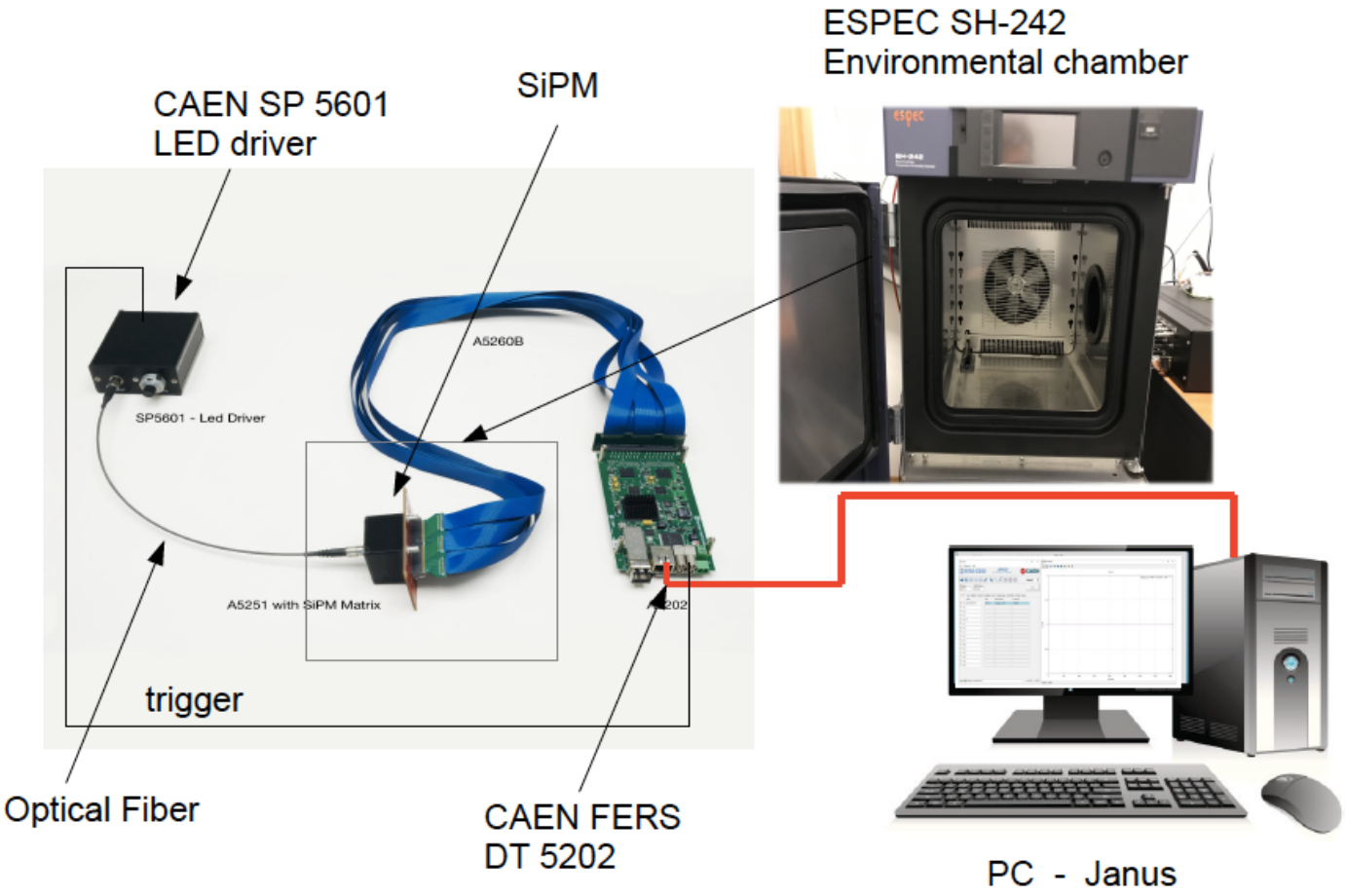
- R&D on SiPMs: several prototypes from Hamamatsu, SensL, AdvanSid (FBK), Kernell, Ketek manufactures;
- Visual inspection (scratches, bubbles…): in clean room using a microscope;
- Measurements at temperature variations (- 40 °C ÷ + 150 °C) in a climate chamber: Dark Current Ratio (DCR); Gain; Cross-Talk; After-Pulse; I-V (Current-Voltage) curve, Multi-photon Spectrum;






20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
50
100
150
200
250
300
350
400
450
500
550
600
(channels)
Cumulative

Experimental set-up and kit of SiPMs



Available SiPMs

SiPM w/o connector

SiPM w conenctor

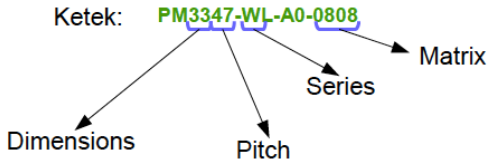
SiPM characterized

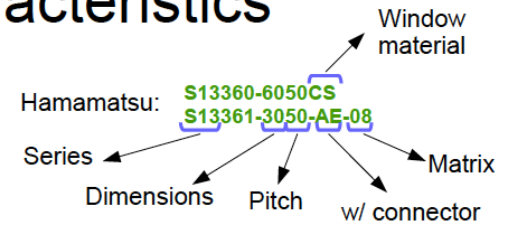
SenSL:
ARRAYJ 30035 16P PCB
ARRAYC 60035 64P PCB
MICROFC 10010 SMT TR1
MICROFC 30035 SMT TR1
MICROFC 60035 SMT TR1
MICROFC SMA 10010 GEVB
MICROFC SMA 30035 GEVB
MICROFC SMA 60035 GEVB
MICROFC SMTPA 10010 GEVB
MICROFC SMTPA 60035 GEVB

Ketek:
PM3315-WL-A0
PM3335-WL-A0
PM3347-WL-A0
PM3347-WL-A0-0808

Hamamatsu:
S14160-1310PS
S14160-1315PS
S14160-3010PS
S14160-3015PS
S14160-4050HS
S13360-1325CS
S13360-1350CS
S13360-6025C
S13360-6050CS
S13361-3050-AE-08

SiPM characteristics





Operating temperature: -40 °C / 60 °C

Operating temperature: -20 °C / 60 °C

Spectral response range: 320 – 900 nm (270 – 900 nm for HPK with CS option)

Peak sensitivity wavelength: 450 nm

	N of pixels	Fill Factor (%)	Window R-index	Active Area (mm²)
PM3335-WL-A0	7396	80	1.52	3.0 x 3.0
PM3347-WL-A0	4096	80	1.52	3.0 x 3.0
PM3347-WL-A0-0808	4096	80	1.52	3.0 x 3.0
S13360-1350CS	667	74	1.41	1.3 x 1.3
S13360-6050CS	14400	74	1.41	6.0 x 6.0
S13361-3050-AE-08	3584	74	1.55	3.0 x 3.0

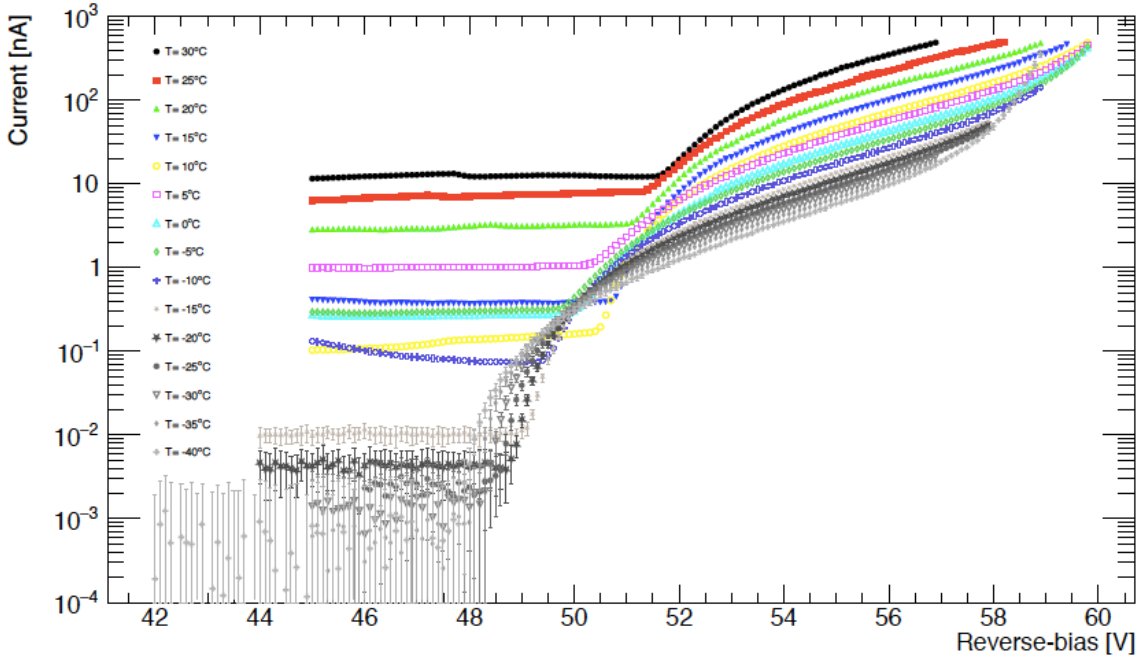


Figure 4: Reverse-bias I-V curves acquired at different temperatures. The errors depend

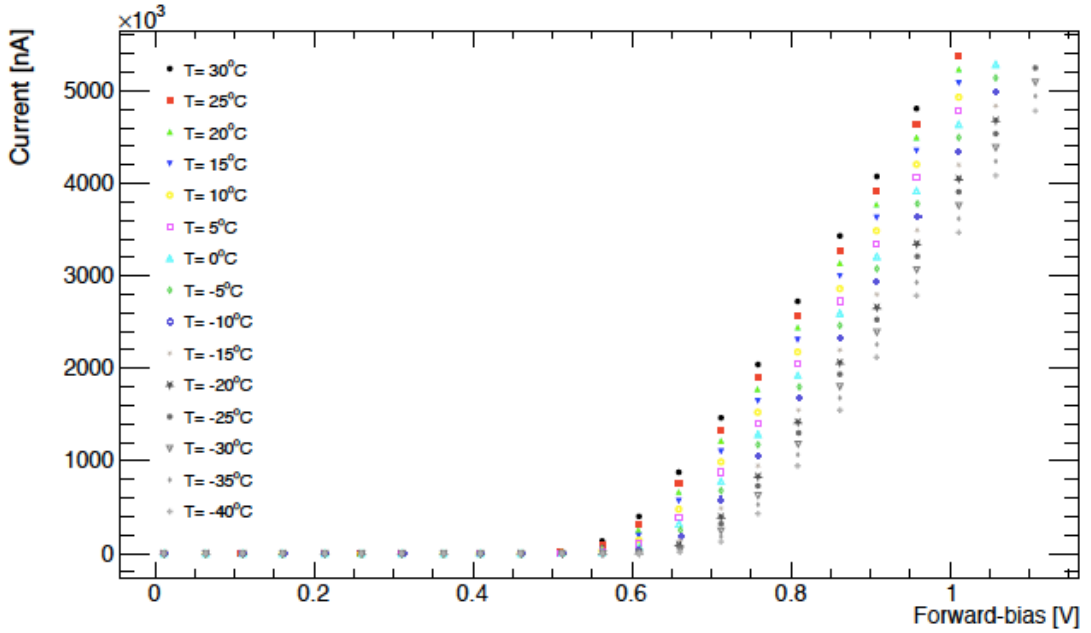
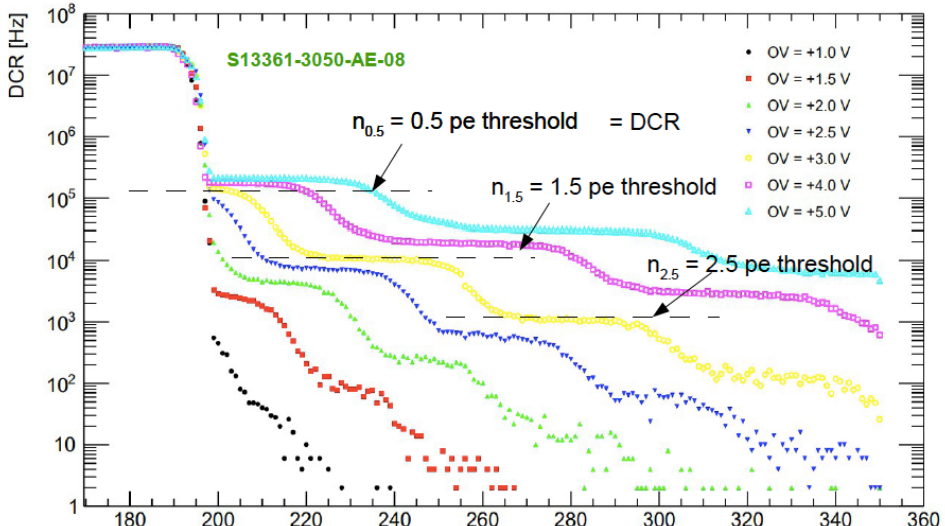


Figure 7: Forward-bias I-V curves acquired at different temperatures. The errors depend

Staricase - DCR(V_{ov})



On the left and right top:

I-V curve in
reverse bias and forward bias
at different temperatures

On the left bottom: Staircases plot - measurements of Dark Current Ratio (DCR)

NOTA:
Lavoro sviluppato nell'ambito di una sinergia locale ***"SynWorkingGroup SiPMs"*** tra diverse sigle sperimentali INFN di R&D sui SiPMs

Characterisation of Hamamatsu S13161-3050AE-08 SiPM (8 x 8) array at different temperatures with CAEN DT5202

R. Persiani[a,b], C. Lombardo[a,b,*], S. Millesoli[a,b], E. Tortorici[a,b], S. Albergo[a,b], F. Cappuzzello[a,c], R. Caruso[a,b], C. M. A. Petta[a,b], C. Tuvè[a,b]

[a] *Department of Physics and Astronomy "E.Majorana", University of Catania, Via S. Sofia 64, Catania, 95125, Italy,*
[b] *INFN section of Catania, Via S. Sofia 64, Catania, 95125, Italy,*
[c] *INFN Laboratori Nazionali del Sud, Via S. Sofia 62, Catania, 95125, Italy,*

NIM A, Vol. 1057, December 2023, 168732
PUBLISHED ONLINE October 5th, 2023
doi: 10.1016/j.nima.2023.168732

Abstract

Silicon PhotoMultipliers, SiPMs, constitute the enabling technology for a diverse and rapidly growing range of applications: medical imaging, experimental physics, and commercial applications are only a few examples. In this work, a characterisation protocol for SiPM qualification has been applied to Hamamatsu S13161-3050AE-08 SiPM (8 x 8) array in the (-40 ÷ +30)°C temperature range. The protocol foresees to measure several parameters: breakdown voltage, quenching resistance, gain, dark count rate and probability of cross-talk. Methods to extract them and their dependence on temperature at fixed overvoltage are shown and the results are discussed.

Keywords: SiPM characterisation, breakdown voltage, quenching resistance, gain, dark count rate, probability of Cross-Talk.

5. Conclusions

This work is mainly focused on the characterization of an (8x8) SiPM matrix (Hamamatsu model S13360-3050AE-08) over a wide range of temperatures from 30 °C down to -40 °C. Two different configurations were adopted: the first uses a picoammeter to measure accurately the leakage currents in order to determine both V_{bd} and R_q, and the second one adopts a CAEN DT5202 readout system to evaluate gain, DCR and pCT. V_{bd} decreases as the temperature decreases, while the R_q seems almost independent [illegible] of fixing the same bias voltage for all temperatu[illegible] constant is more convenient. Consequently, the ga[illegible] the DCR level decreases as the temperatures decre[illegible]

Characterization of HAMAMATSU SiPM tile
64 channels: (8x8) matrix, (3x3) mm^2 area
from -40°C to + 30°C

6. Acknowledgements

Special thanks to R. Santoro from INFN section of Milan for the several discussion on technical aspects. This work was possible thanks to the support of the University of Catania, in particular with *Finanziamento di Ateneo-Linea, di intervento 2 Piaceri, progetto MODICO*, *Finanziamento di Ateneo-Linea, di intervento 2 Piaceri, progetto MAYORANA*. This work would not have been possible without the financial support of the "A.S.I. (Italian Space Agency)"; in particular, thanks to the "ACCORDO ATTUATIVO ASI-INFN n.2021-8-HH.0 e suo Addendum n.2021-8-HH.1-2021 Accordo Quadro ASI/INFN", Research Project "EUSO-SPB2 (Extreme Universe Space Observatory-Super Pressure Balloon)", WP4400 "Characterization, Selection & Test of SiPM tiles". This

Thanks to dedicated funds by ASI, in agreement with INFN in the framework of Project "EUSO-SPB2"

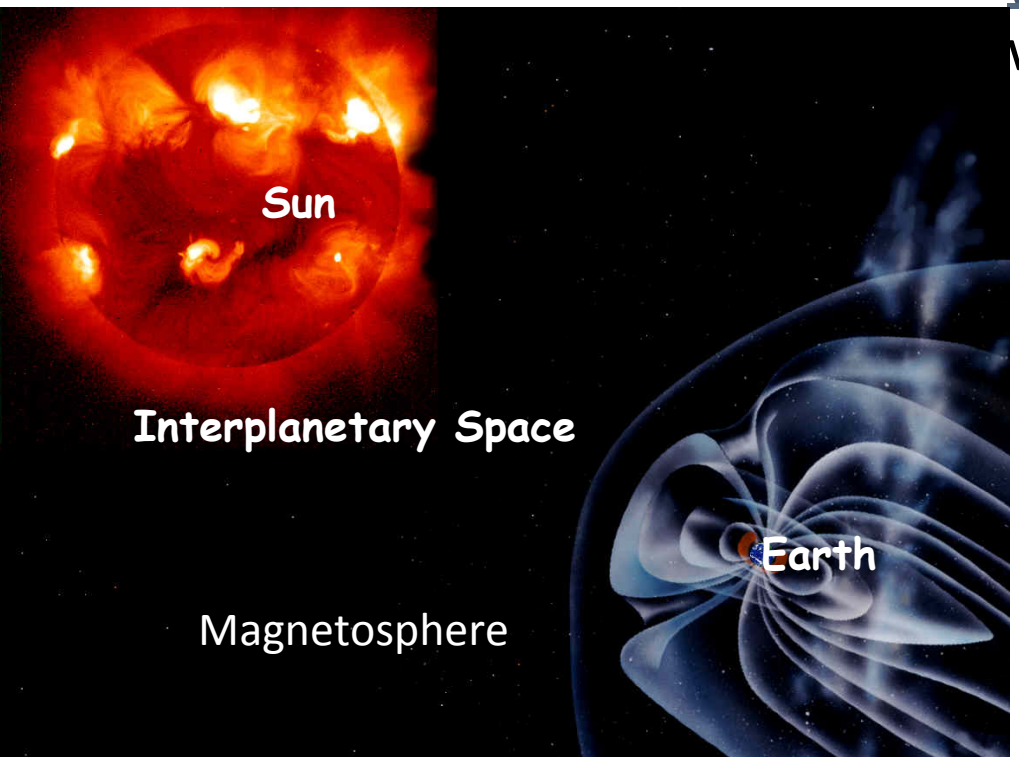
Dipartimento di Fisica e Astronomia "Ettore Majorana"

INFN CATANIA
Istituto Nazionale di Fisica Nucleare
Sezione di Catania

Activities b):

CME (*) solar events and U.V. Transient Luminous Events in MiniEUSO data

involved members: F. Zuccarello →R. Caruso



(*) CME (Coronal Mass Ejection): A disturbance in the solar wind caused by an eruption on the Sun.

Active Region on the Sun erupts

1. Solar Flare (Visible, UV, EUV, X-ray)
2. Shock (energetic particles)
3. Coronal Mass Ejection (particles and fields)

- Radiation reaches Earth in 8 minutes (speed of light)
- Energetic Particles reach Earth in 15 min to 24 hours
- Coronal Mass Ejection reaches Earth in 1-4 Days

FLOW-CHART - Data Analysis CME vs MiniEUSO

1. **Compilation of candidate geo-effective CME** events using different catalogues present on the web:

- https://www.helcats-fp7.eu/catalogues/wp2_cat.html
- http://www.srl.caltech.edu/ACE/ASC/DATA/level3/icmetable2.htm
- https://wind.nasa.gov/ICME_catalog/ICME_catalog_viewer.php
- https://helioforecast.space/arrcat

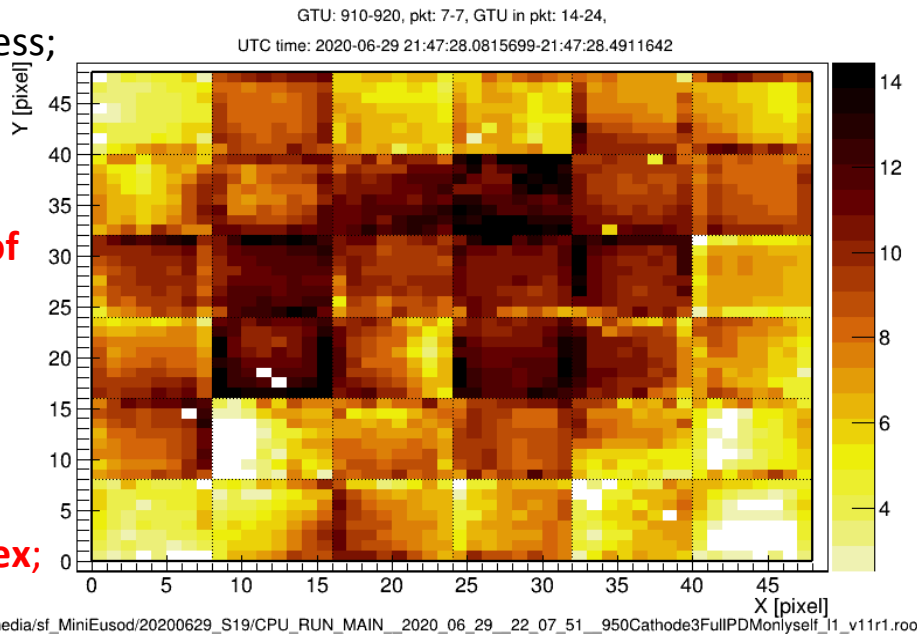
2. **determination of CME arrival time** in the Earth atmosphere in order to correlate with MiniEUSO events;

3. **determination of the CME angular width** in order to evaluate its geo-magnetic effectiveness;

4. **dowload MiniEUSO data e lista Sessioni dati utili** (“Sessions” i.e. ROOT files);

5. **comparison** between geo-effective **CME arrival time at Earth** with **data acquistion time of MiniEUSO data** in order to search for possible candidates;

6. **analysis of possible candidate files using ETOS** code searching for signature in the data (i.e. no new or strange signal) ;



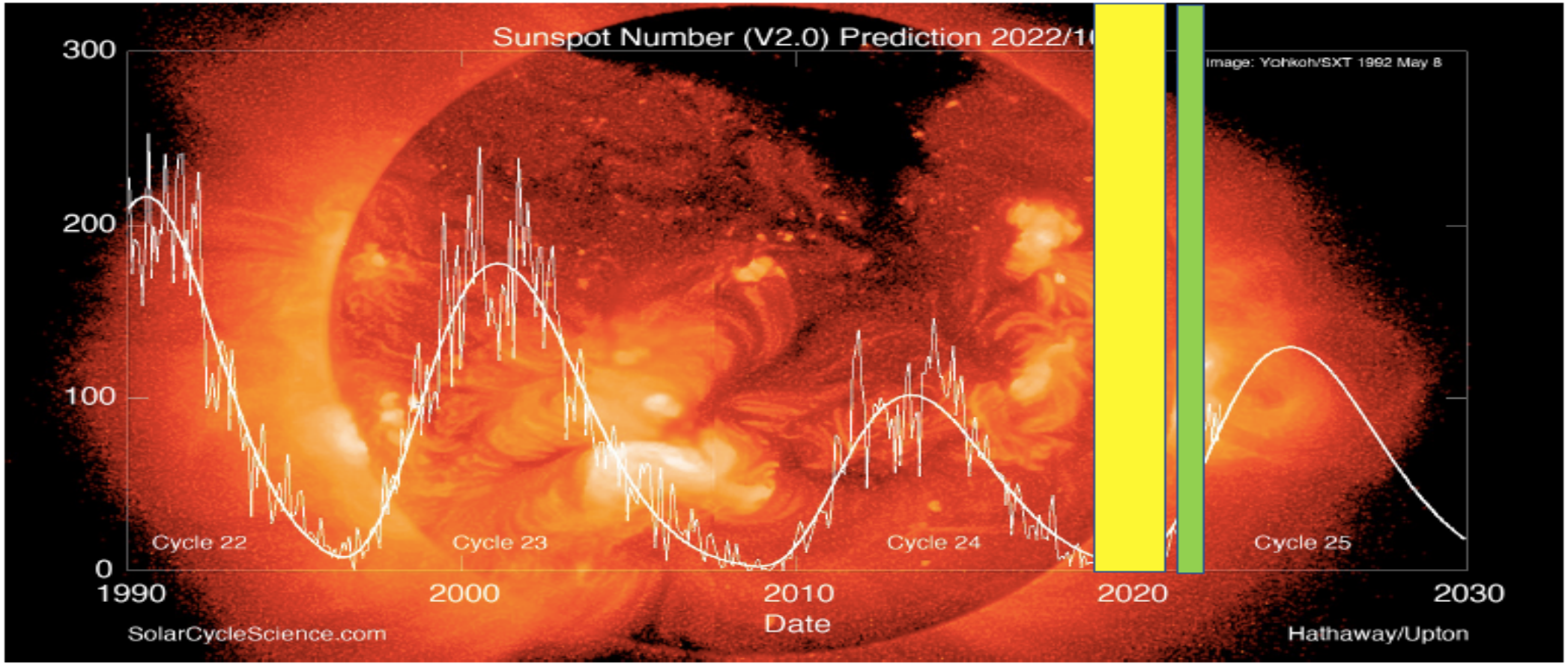
7. **cross-check** by means of comparison between CME arrival time at Earth **with the DST index;**

- https://www.ngdc.noaa.gov/stp/GEOMAG/dst.html
- https://wdc.kugi.kyoto-u.ac.jp//dstdir/
- https://web.archive.org/web/20120209110443/http://www.esa-spaceweather.net/swenet/login cmd=swenet_latest_alerts

8. **further cross- check** for any evidence of significance in the **Kp index level**

- https://www.spaceweatherlive.com/en/auroral-activity/top-50-geomagnetic-storms/year/2022.html

The first Mini-Euso dataset was acquired during the phase of minimum of solar activity (Nov 2019 – Aug 2021), indicated by the yellow box.
The second dataset was acquired during the growing phase of Cycle 25 (Nov 2021 – Aug 2022), indicated by the green box.



Analisi dati attualmente estesa fino a dicembre 2023!

L'attuale ciclo solare, **il numero 25**, è iniziato nel 2020 e si sta dirigendo verso il periodo di attività solare più intensa, previsto per l'estate 2025 (previsto anticipo fine autunno 2024!).

INAF - IASF Palermo
ISTITUTO DI ASTROFISICA SPAZIALE E FISICA COSMICA DI PALERMO

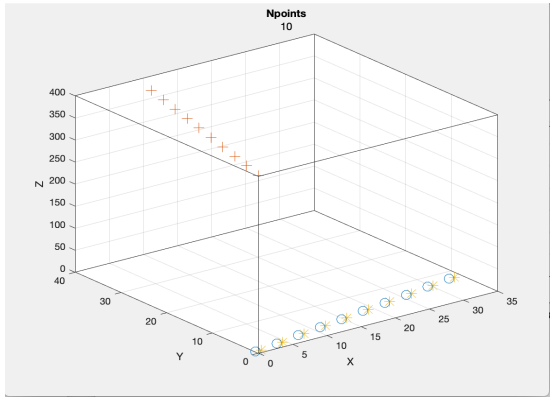
Activity in Palermo (Associated to Catania)

Involved members: A.Anzalone, A.Pagliaro

Mini-EUSO Data Analysis:

3D reconstruction of meteor trajectory

- Test of the computer vision method on the real meteor data

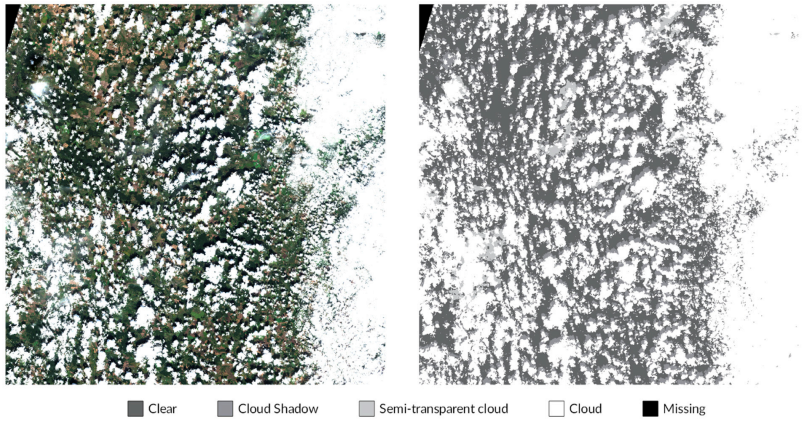


Cloud Masking:

“Application of Machine and Deep Learning methods for Cloud Mask Retrieval: a review”

Invited Review Paper in preparation for Applied Sciences Journal, Special issue

"Hardware-Aware Deep Learning"



Pubblicazioni JEM-EUSO (MiniEUSO, SPB2, POEMMA)

luglio 2023/luglio 2024 = **N.6**

- ***POEMMA (Probe Of Extreme Multi-Messenger Astrophysics) Roadmap Update***

POEMMA Collaboration, PoS ICRC2023 (2023) 1159 • Contribution to ICRC2023

- ***N. 26 Contributions of the JEM-EUSO Collaboration to ICRC2023***

JEM-EUSO Collaboration, PoS ICRC2023 (2023) 1159

- ***Developments and results in the context of the JEM-EUSO program obtained with the ESAF simulation and analysis framework***

JEM-EUSO Collaboration , Eur.Phys.J.*C* 83 (2023) 11, 1028

- ***Characterization of Hamamatsu S13161-3050AE-08 SiPM (8 × 8) array at different temperatures with CAEN DT5202*** Persiani R., Lombardo C., Millesoli S., Tortorici F., Albergo S., Cappuzzello F., Caruso R., Petta C., Tuvè C., Nucl.Instrum.Meth.A 1057 (2023) 168732

- ***EUSO-Offline: A comprehensive simulation and analysis framework,***

JEM-EUSO Collaboration, JINST 19 (2024) 01, P01007

- ***EUSO-SPB1 mission and science***

JEM-EUSO Collaboration, Astropart.Phys. 154 (2024)

We are a strong, efficient and resilient collaboration!

Efficient:

EUSO-Balloon
EUSO-TA
EUSO-SPB1
MINI-EUSO
EUSO-SPB2
+TUS

Not a single failure !!!

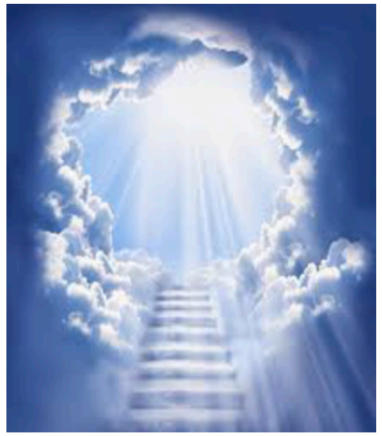
+ our technology is used in other projects…

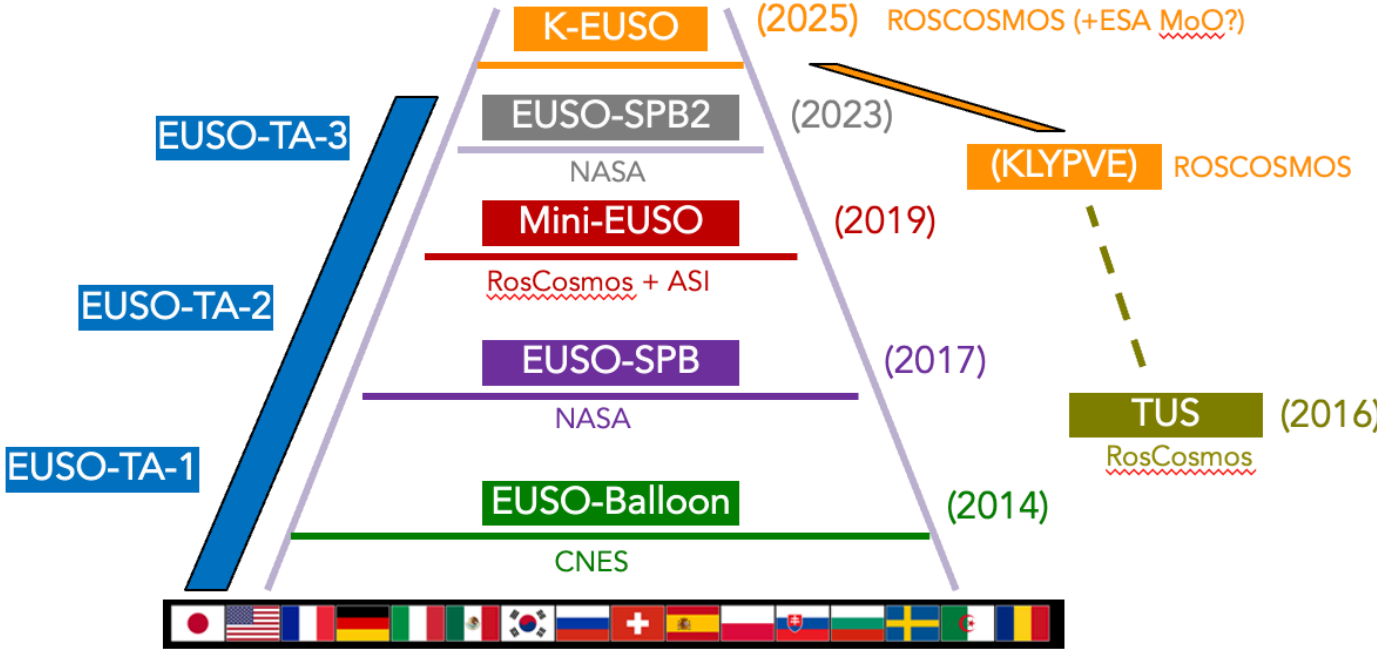
Strong: 35rd Collaboration meeting!

Strong together and credible together!

The JEM-EUSO collaboration delivers!

Stairway to heaven!





ASTROPHYSICS RESEARCH AND ANALYSIS
(NNH23ZDA001N-APRA)
PANEL EVALUATION

Proposal No.: 23-APRA23-0025
PI/Institution: Olinto, Angela/University Of Chicago
Proposal Title: POEMMA-Balloon with Radio (PBR)

Brief Summary of Research Objectives:

A balloon mission borrowing in design from the possible future probe-class mission Probe Of Extreme Multi-Messenger Astrophysics (POEMMA) is proposed to be known as POEMMA-Balloon with Radio (PBR). PBR would fly on a sub-orbital ultra-long duration balloon (ULDB). The payload would include a Fluorescence Camera (FC) and a Cherenkov Camera (CC) along with a 50 - 550 MHz radio system optimized for the detection of extensive air-showers (EASs). The proposal covers the full construction, testing, flight, and data-analysis aspects of the mission. The mission science goals are to detect from altitude fluorescence signals generated by UHECRs, observe CR EASs, particularly in an energy range above the cosmic ray knee, in both optical and radio, and to search for very high energy neutrinos (VHENs) that are the target of opportunity (ToO) from multi-messenger alerts. PBR would advance the technology that would be required for a space-based platform, such as the conceptual POEMMA for utilizing the Earth's atmosphere to detect CRs and cosmic neutrinos.

OVERALL ADJECTIVAL RATING: Excellent/Very Good

21 GIUGNO 2024: NEWS!!
La NASA seleziona e APPROVA il prossimo lancio di Pallone aerostatico a super-pressione per il 2026!

La missione si chiamerà **PBR (POEMMA Balloon & Radio)** e NON SPB3 (Super Pression Balloon 3)

The future is bright!

PREVENTIVI 2025 – ANAGRAFICA sigla SPB2- INFN-CT

RICERCATORI

		%
1. Anzalone Anna	Ric. INAF/IASF PA	50
2. Del Popolo Antonino	Ric. Univ. UniCT	20
3. Caruso Rossella	Prof. Ass. UniCT (Resp.locale)	40
4. Pagliaro Antonio	Ric. INAF/IASF PA	50
5. Petta Catia	Prof. Ass. UniCT	30

TOTALE: 5 unità **<FTE/persone> = 0.38** **FTE TOT. 1.9**

SERVIZI

Servizi ELETTRONICA

TOTALE: 2 mesi uomo **FTE TOT. 0.2**

Planning attività 2025

- **Responsabilità internazionale: " CALIBRAZIONE dei SiPMs matrice focale del Telescopio Cherenkov (CT)" per la missione PBR (lancio 2026) " (R.Caruso);**

- **Il Laboratorio di R&D SiPMs di Catania (postazione SPB2 presso "Laboratorio di fotorivelatori per la Fisica Astroparticellare" – Sezione INFN di Catania & DFA-UniCT) diviene SITO di CALIBRAZIONE e TEST dei prototipi di Telescopio Cherenkov per la missione PBR nel 2025 per l'intera Collaborazione internazionale PBR: previsti turni di misura e test da parte di altri gruppi italiani ed esteri.**

- **Progettazione, realizzazione, test, calibrazione e caratterizzazione superficie focale SiPMs per il Telescopio Cherenkov IN SEDE e presso i siti di realizzazione e integrazione elettronica di NAPOLI e ROMA2 e di caratterizzazione in condizioni realistiche di volo presso il TurLab di TORINO;**

- **Monitoraggio atmosferico, cloud imaging, analisi dati traiettorie meteore, etc.**
- **Analisi dati CME solari e ricerca di Eventi Transienti Luminosi nei dati di MiniEUSO e di SPB2 per ottimizzazione rapporto segnale/rumore e trigger Telescopi di Fluorescenza e Cherenkov.**

PREVENTIVI 2025 - sigla SPB2 – CT

Missioni Estere e Nazionali: **Richiesti 25 keuro**

- Meeting generali di Collaborazione nazionali e internazionali (USA/JAPAN);
- Meeting Working Groups In Italia e negli USA
- Turni di integrazione elettronica prototipi a Napoli e Roma
- Turni di test e caratterizzazione prototipi presso TurLab Facility a Torino
- Incontro Referees;

Consumo: **Richiesti 15 keuro**

- Metabolismo Laboratorio R&D SiPMs
- Acquisto matrici SiPMs per superficie focale telescopio Cherenkov
- Ottimizzazione banco ottico per finalizzazione sito calibrazione prototipi per Collab. Italia

Inventario: **Richiesti 20.0 keuro**

Acquisto tavolo micrometrico XY

(NOTA: fondi 2024 stornati su altra sede e impiegati per acquisto urgente PMTs Telescopio Fluorescenza, su base accordo Referees e decisione CSN2)

TOTALE **Richiesti 50.0 keuro**