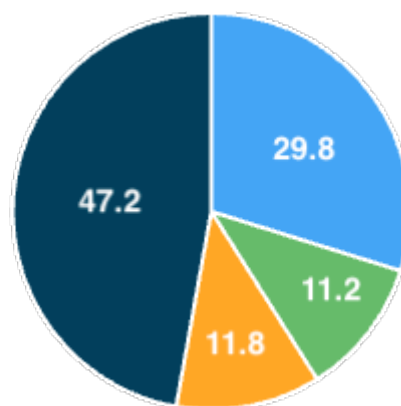


REPORT attività di GRUPPO 2



CSN2
Fisica delle
Astroparticelle



- Fisica del Neutrino
- Radiazione dall'universo
- Universo Oscuro
- Gravità e Fisica Fondamentale

Lorenzo Perrone per il gruppo 2 - CdS 2/7/2025

GRUPPO 2 Lecce

5 Sigle **22** Ricercatori [4 Dottorandi] **4** Tecnologi **18.55** FTE

AUGER	2	Perrone Lorenzo	Attivo	Sigla Locale Attiva
EUCLID_2	2	Nucita Achille	Attivo	Sigla Locale Attiva
HERD_DMP	2	De Palma Francesco	Attivo	Sigla Locale Attiva
NUSES_CSN2	2	Scherini Viviana	Proposta	Sigla Locale Attiva
SABRE	2	Cataldi Gabriella	Attivo	Sigla Locale Attiva

Distribuzione degli FTE

AUGER	→	7.45	FTE
SABRE	→	4.7	FTE
HERD_DMP	→	2.1	FTE
EUCLID_2	→	2.6	FTE
NUSES_CSN2	→	1.7	FTE

Disattivata a Lecce la sigla **SPB2**, attivata la
signa **NUSES_CSN2** (Proposta in CSN2)

+ A. Franco (PNRR – INFN)

ANAGRAFICA PRELIMINARE

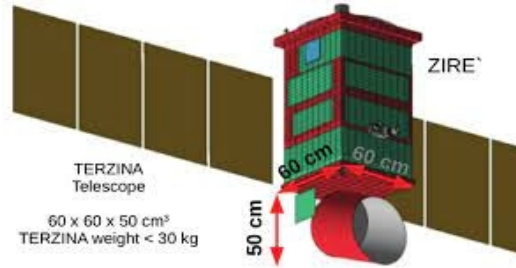
cognome	nome	no	mod	contratto	profilo	stato	af	AUGER	EUCLID_2	HERD_DMP	NUSES_CSN2	SABRE	SPB2	perc	tot
Totale(FTE)								7.45	2.6	2.1	1.7	4.7	0		18.55
Alemanno	Francesca	G1	Dip	Assegno di Ricerca	Scaduto	2				20				HERD_DMP - 20%	20
Ananna	Chemseddine	G1	Ass	Scientifica Assegni no	Attivo	2						100		SABRE - 100%	100
Cataldi	Gabriella	G1	Dip	Primo Ricercatore	Attivo	2	60					30		AUGER - 60% SABRE - 30%	90
Coluccia	Maria Rita	G2	Dip	Primo Tecnologo	Attivo	2	25							AUGER - 25%	25
Conte	Matteo	G1	Ass	Scientifica Dottorandi	Attivo	2	100							AUGER - 100%	100
Creti	Pietro	G2	Dip	Primo Tecnologo	Attivo	2						20		NUSES_CSN2 - 20%	20
D'Elia	Marcella	G2	Ass	Associazione Tecnica	Scaduto	2			20					EUCLID - 20%	20
De Giorgi	Maria Luisa	G1	Ass	Scientifica Ricercatori	Attivo	2						100		SABRE - 100%	100
De Palma	Francesco	G1	Ass	Incarico di Ricerca sci	Attivo	2	60			40				AUGER - 60% HERD_DMP	100
De Paolis	Francesco	G1	Ass	Incarico di Ricerca sci	Attivo	4			50					EUCLID - 50%	50
De Vito	Emanuele	G1	Ass	Scientifica Ricercatori	Attivo	2	100							AUGER - 100%	100
Epicoco	Italo	G1	Ass	Tecnologica Ricercato	Attivo	2						100		NUSES_CSN2 - 100%	100
Ghose	Essna	G1	Ass	Scientifica Dottorandi	Attivo	2				100				HERD_DMP - 100%	100
Giaccarei	Ugo Gregorio	G1	Dip	Ricercatore	Attivo	2	90							AUGER - 90%	90
Khattak	Sana Gul	G1	Ass	Scientifica Dottorandi	Attivo	2						100		SABRE - 100%	100
Martello	Daniele	G1	Ass	Incarico di Ricerca sci	Attivo	2	100							AUGER - 100%	100
Miccoli	Alessandro	G2	Dip	Tecnologo	Attivo	1						20		SABRE - 20%	20
Montanino	Daniele	G1	Ass	Incarico di Ricerca sci	Attivo	4						20		SABRE - 20%	20
Nucita	Achille	G1	Ass	Incarico di Ricerca sci	Attivo	2	60		40					AUGER - 60% EUCLID - 40%	100
Orofino	Vincenzo	G1	Ass	Scientifica Ricercatori	Attivo	4			50					EUCLID - 50%	50
Perrone	Lorenzo	G1	Ass	Incarico di Ricerca sci	Attivo	2	80					20		AUGER - 80% NUSES_CSN	100
Sacquegna	Simone	G1			Contratto n°	2			100					EUCLID - 100%	100
Scherini	Viviana	G1	Ass	Scientifica Borse non	Attivo	2	70					30		AUGER - 70% NUSES_CSN	100
Strafella	Francesco	G1			Contratto n°	4			0					EUCLID - 0%	
Surdo	Antonio	G1	Dip	Primo Ricercatore	Attivo	2				50				HERD_DMP - 50%	50
Zuhra	Samina	G1	Ass	Scientifica Dottorandi	Attivo	2						100		SABRE - 100%	100

+ A. Franco (PNRR – INFN)

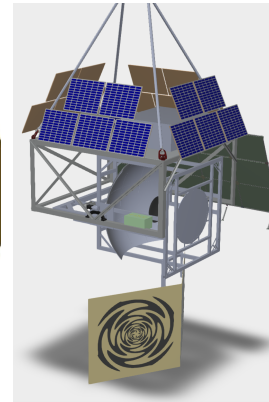
Attività di Lecce in a nutshell



DAMPE (HERD)



NUSES_CSN2



Pierre Auger Observatory

Caratterizzazione della radiazione cosmica per via diretta (**spazio**) ed indiretta (**superficie**)

- spettro energetico
- composizione
- direzioni di provenienza
- particelle neutre (fotoni, neutrini, neutroni)



Multi-messenger astronomy per lo studio della fisica fondamentale

- Ricerca di dark matter
- Interazioni adroniche
- Scenari BSM

SABRE



EUCLID



L'Osservatorio Pierre Auger

Image:
S.Saffi

R. Assiro, G. Cataldi, M.R. Coluccia, M. Conte, A. Corvaglia, P. Creti, F. de Palma, E. De Vito,
U.Giaccari, D.Martello, A. Miccoli, A. Nucita, L.Perrone, F. Ricciardi, V. Scherini

The Pierre Auger Observatory

~ 400 members, 17 countries



3000 km²

Surface detector

array of 1660 Cherenkov stations on a 1.5 km hexagonal grid of 3000 km²
Dense sub-array (750 m) of 24 km²

Fluorescence detector

4+1 buildings overlooking the array (24 + 3 HEAT telescopes)

Radio detector

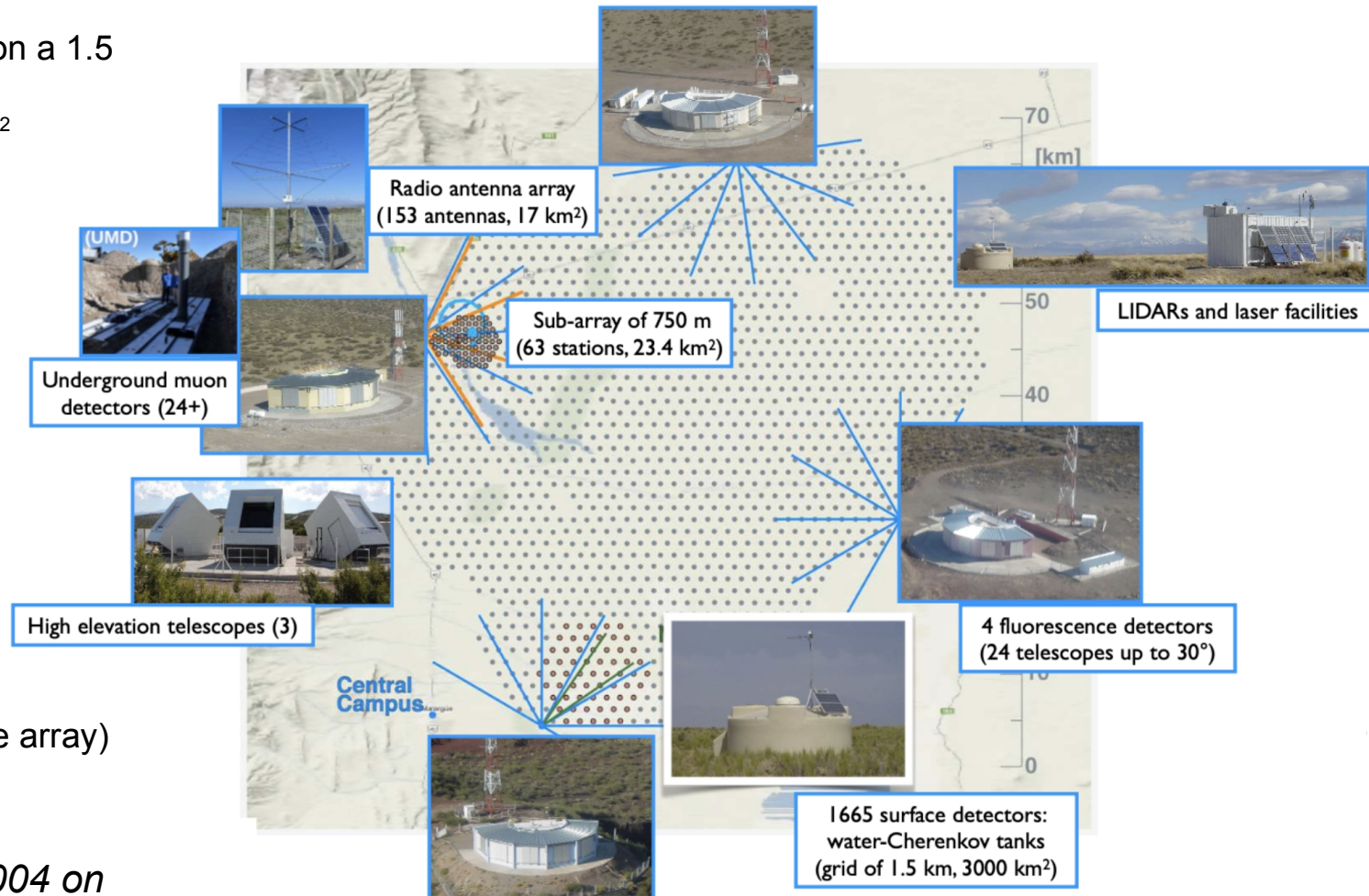
153 Radio Antenna → AERA

Muon Detectors

Buried scintillators (region of dense array)

Phase 1 : data taking from 2004 on
(from 2008 with the full array in operation):

- Over 120.000 km² sr yr for anisotropy studies
- Over 90.000 km² sr yr for spectrum studies



Phase 2 - the AugerPrime upgrade
Data taking from 2023 to 2035
Multiple detectors



Extension of the Auger International Agreement

16-17 November 2024
Pierre Auger Observatory
America/Mendoza timezone

up to 2035

Overview

Program

Registration

[Modify my Registration](#)

Participant List

Hotels

Visit to the Pierre Auger Observatory

Venue and transportation

Contact persons

The Pierre Auger Observatory is the world-wide largest cosmic ray detector covering an area of 3000 km². It is operated by a collaboration of more than 400 scientists from 17 countries. The aim of the observatory is the study of the highest energy particles of the Universe – ultra-high energy cosmic rays. About 15 full-array-size-equivalent years of exposure have been accumulated up to the end of 2021 with the Auger Observatory in the old configuration, referred to as Phase I.

Data from Phase I of the Auger Observatory have revolutionized our understanding of high energy phenomena linked to the most violent processes in the Universe. Scientific breakthroughs have been achieved in several fields. The new perspectives opened by these results called for an upgrade of the observatory, with the main aim of collecting new information about the primary mass of the highest energy cosmic rays on a shower-by-shower basis. The full-efficiency data taking with the upgraded array will start in 2025 and will add data for 10 more years.

The extension of the International Agreement will provide the administrative foundation to continue the operation of the Pierre Auger Observatory in the upcoming Phase II, operating the upgraded detector.

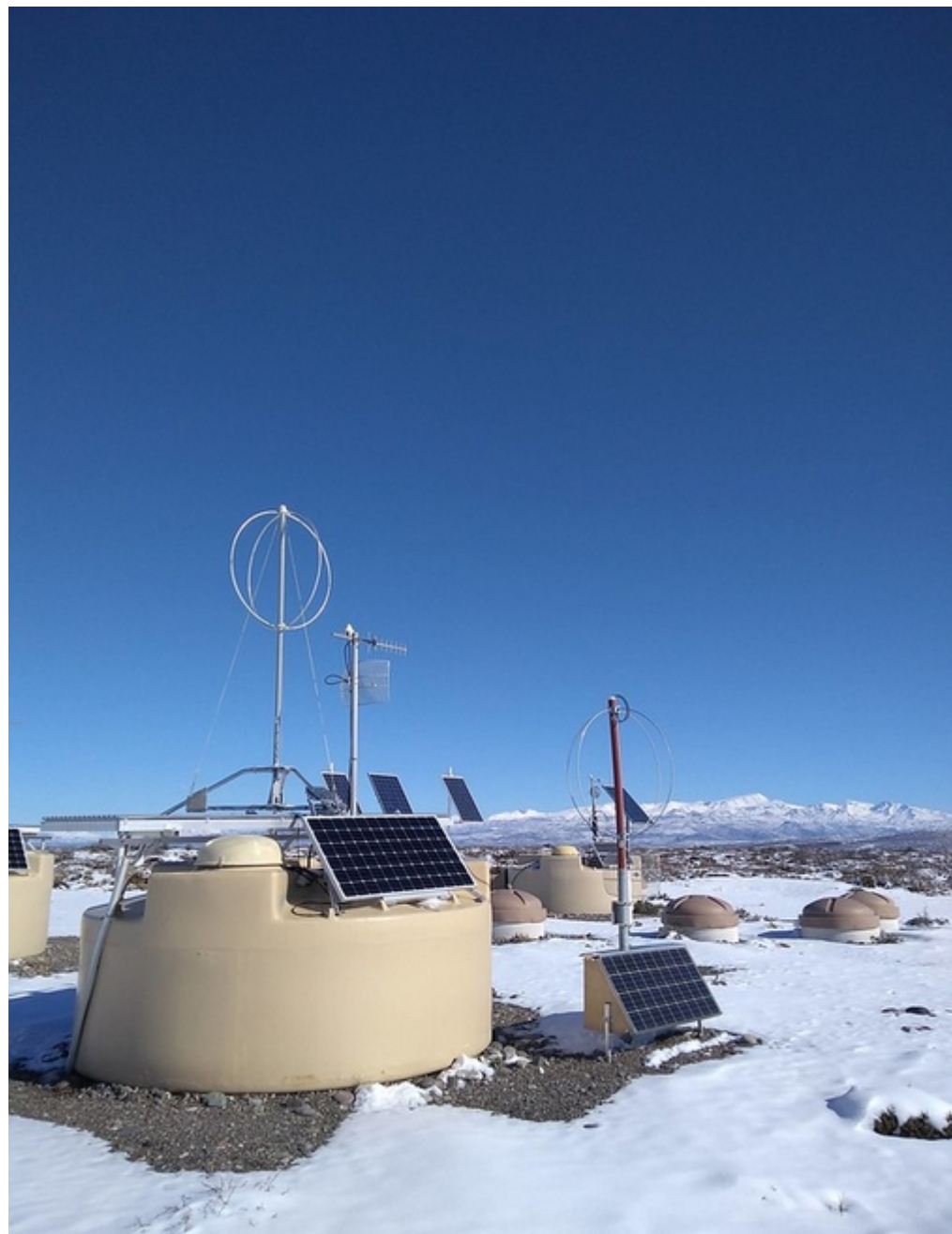
AugerPrime

Attività di design/costruzione di SSD con forte partecipazione del gruppo di Lecce

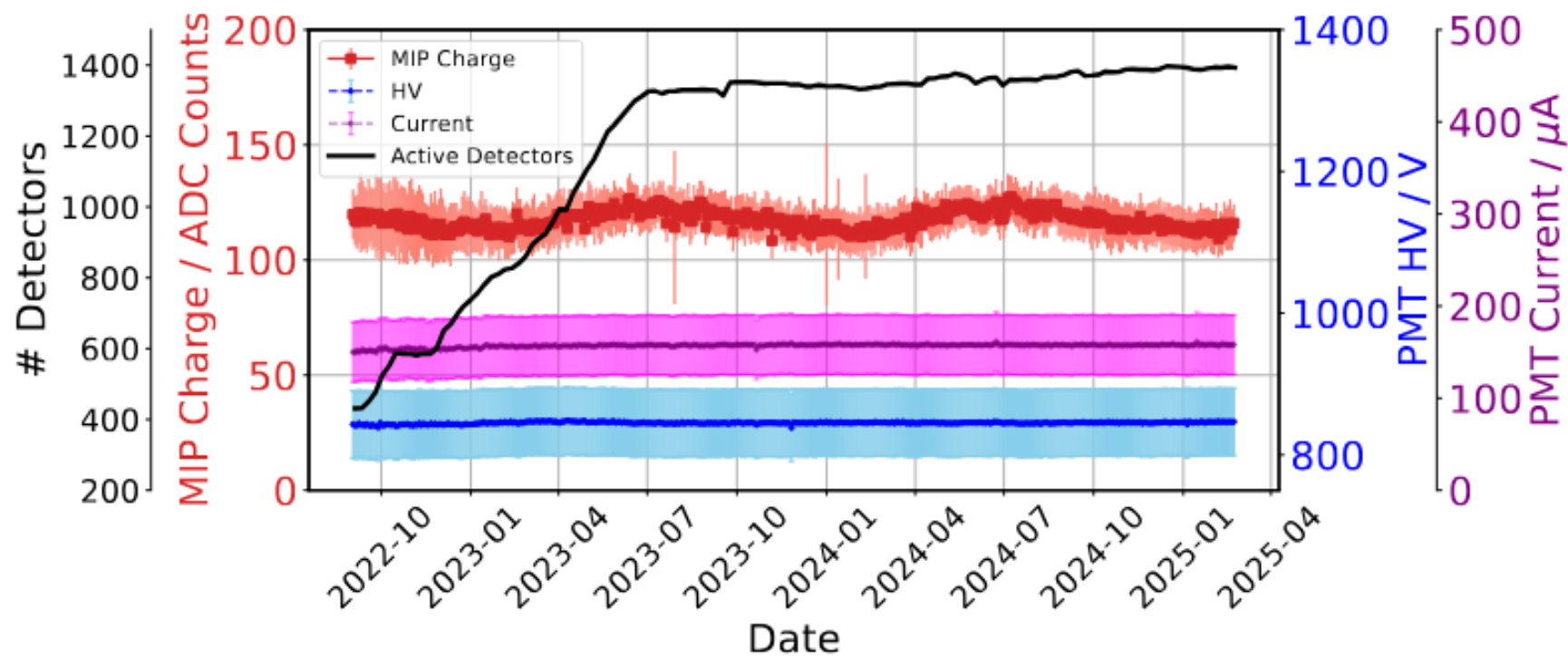
→ Monitoring della performance

Attività di design, implementazione e controllo della UUB con significativa partecipazione del gruppo di Lecce negli anni. Supporto a SITAEL (prod) mantenuto nel tempo fino ad oggi (Roberto, Pietro)

Tutte le stazioni tradizionali sono ora equipaggiate con nuova elettronica UUB, scintillatori (SSD), relativi PMTs e small PMTs e radio detector



Monitoring of the SSD

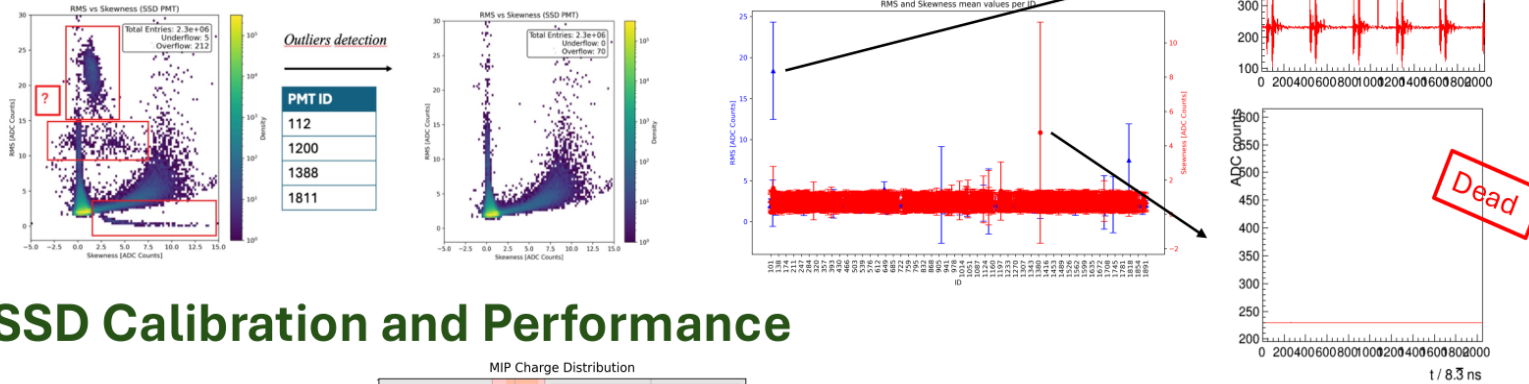


M. Conte at ICRC 2025 (in two weeks)

SSD Monitoring

PMT baseline stability (RMS, Skewness distributions)

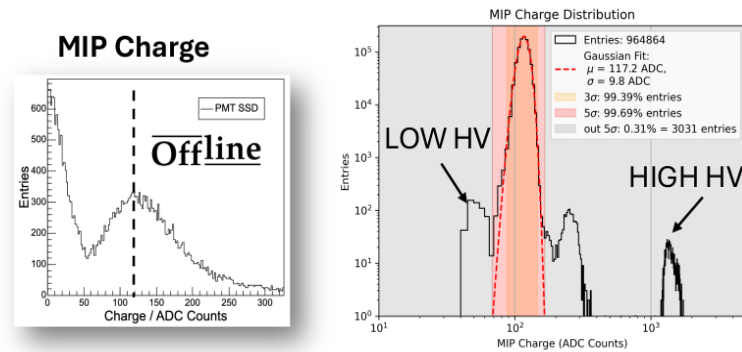
Looking for **noise**, **Instabilities**, **dead channels**, **day/night effects**



Start doing physics with AugerPrime

M. Conte,
U. Giaccari
G. Cataldi
D. Martello

SSD Calibration and Performance



Studies on the offline algorithm to estimate the **calibration factor (MIP Charge)** using atmospheric muons.

Analysis on the **performance** on the whole array and outliers detection.

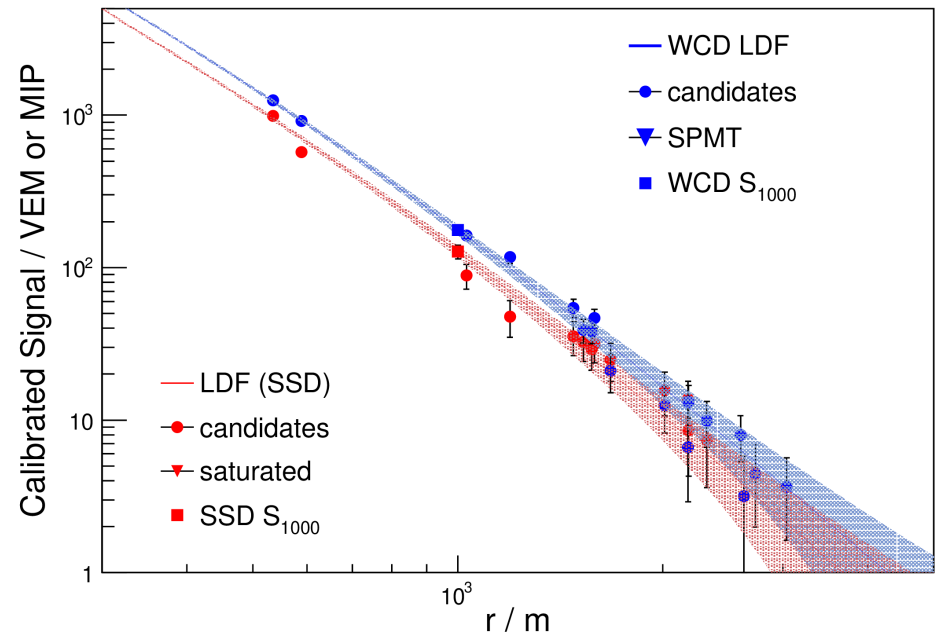
Studies on the effect of **HV instabilities, temperature modulation and aging** on the calibration

SSD-LDF parameterization

find description of expected scintillator signal as a function of distance to the shower-axis

SD event $E \sim 19.7 \text{ EeV}$, $9 \sim 51^\circ$

17 WCDs, 13 SSDs



Attività di analisi a Lecce 2024-2025

Performance del rivelatore ibrido

FD/SD calibrazioni, on-time e produzione dei dati ibridi → attività “adiabatica”
→ grazie a Fulvio e Antonio per il supporto nel calcolo!

Misura dello spettro energetico

spettro ibrido in particolare → finalizzare la misura con i dati di fase1

Open data

Messa a punto dei tool e interazione con task di analisi

→ ***Eur. Phys. J. C 85 (2025) 70***

frazione innalzata dal 10% al 30%, implementazione in corso

AugerPrime

Studio della performance del detector upgradato.

Sviluppo di algoritmi con NN per la ricerca di cluster nei dati e nelle simulazioni

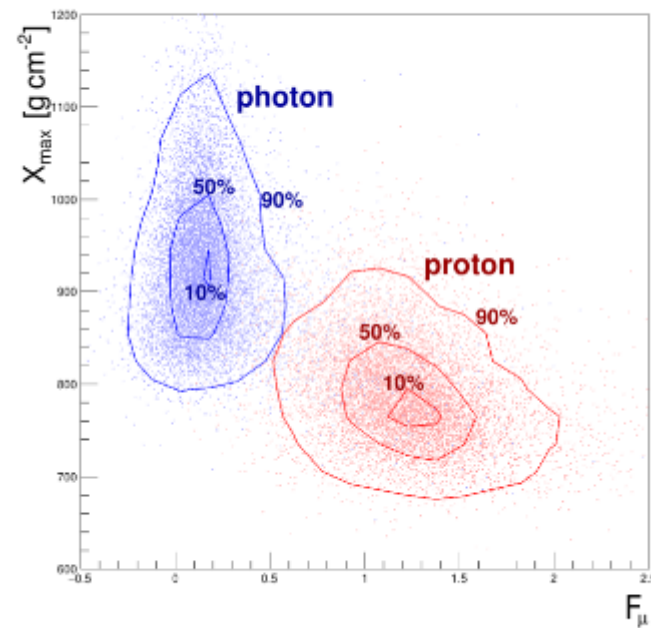
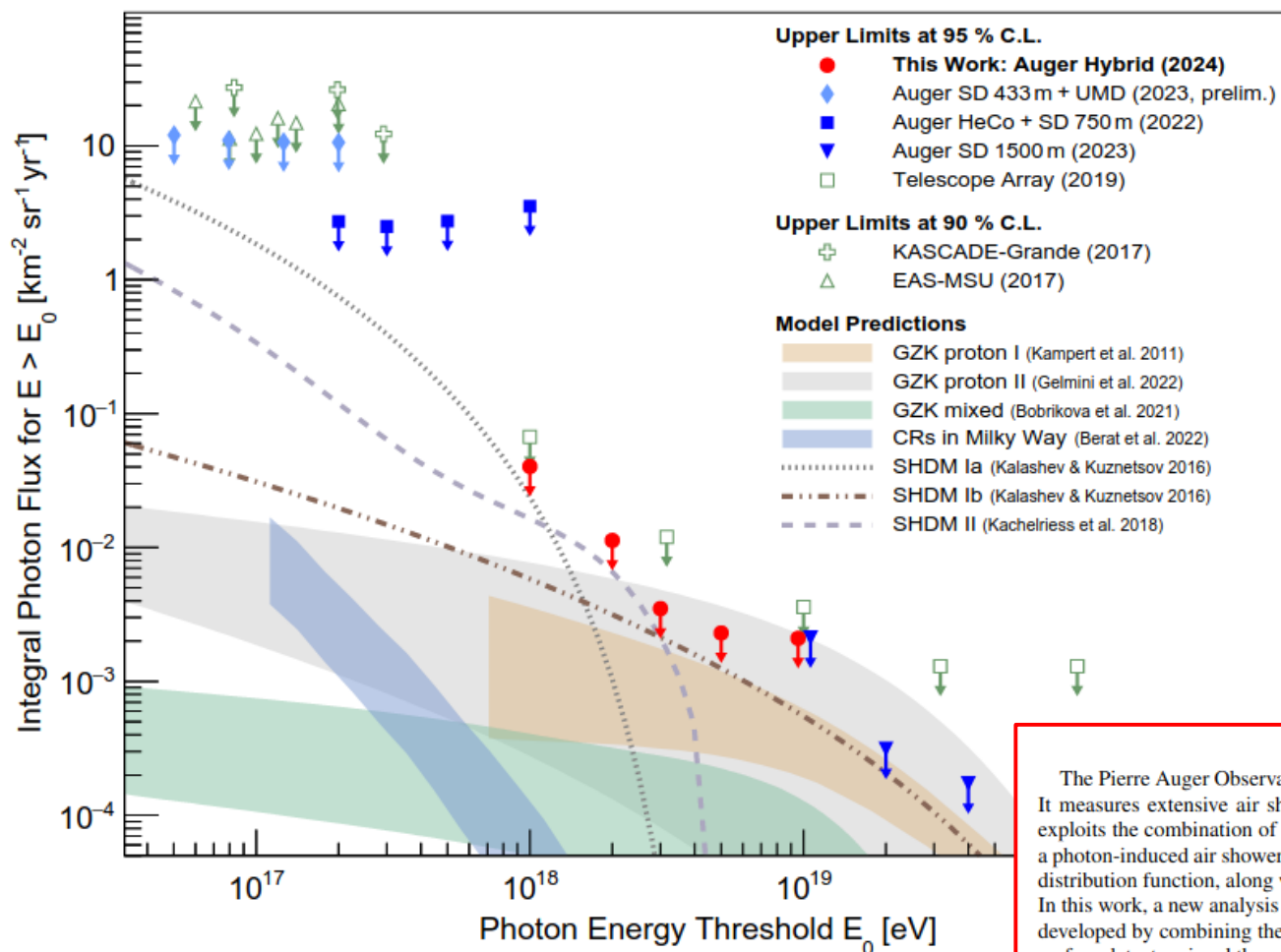
Ricerca di fotoni primari con tecniche di ricostruzione basate sul modello di “universalità” → ***Phys. Rev. D 110 (2024) 062005***

Ricerca di neutrini con il rivelatore di fluorescenza
→ ***Phys. Rev. Lett. 134 (2025) 121003***

**astronomia
multi-messenger**

Search for photons above 10^{18} eV by simultaneously measuring the atmospheric depth and the muon content of air-showers at the Pierre Auger Observatory

Phys. Rev. D 110 (2024) 062005



Analisi sviluppata nella tesi di Pierpaolo Savina

(Dated: June 11, 2024)

Migliori UL nel range 1-10 EeV

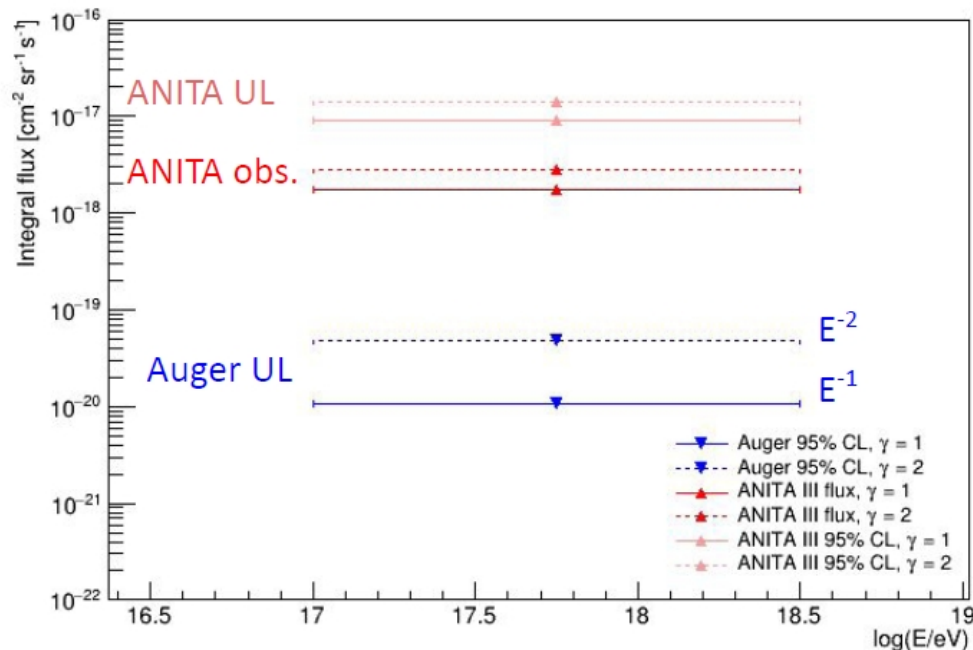
Utilizzati per constraints sulla SHDM

The Pierre Auger Observatory is the most sensitive instrument to detect photons with energies above 10^{17} eV. It measures extensive air showers generated by ultra high energy cosmic rays using a hybrid technique that exploits the combination of a fluorescence detector with a ground array of particle detectors. The signatures of a photon-induced air shower are a larger atmospheric depth of the shower maximum ($X_{\max}$) and a steeper lateral distribution function, along with a lower number of muons with respect to the bulk of hadron-induced cascades. In this work, a new analysis technique in the energy interval between 1 and 30 EeV (1 EeV = 10^{18} eV) has been developed by combining the fluorescence detector-based measurement of $X_{\max}$ with the specific features of the surface detector signal through a parameter related to the air shower muon content, derived from the universality of the air shower development. No evidence of a statistically significant signal due to photon primaries was found using data collected in about 12 years of operation. Thus, upper bounds to the integral photon flux have been set using a detailed calculation of the detector exposure, in combination with a data-driven background estimation. The derived 95% confidence level upper limits are 0.0403, 0.01113, 0.0035, 0.0023, and 0.0021 $\text{km}^{-2} \text{sr}^{-1} \text{yr}^{-1}$ above 1, 2, 3, 5, and 10 EeV, respectively, leading to the most stringent upper limits on the photon flux in the EeV range. Compared with past results, the upper limits were improved by about 40% for the lowest energy threshold and by a factor 3 above 3 EeV, where no candidates were found and the expected background is negligible. The presented limits can be used to probe the assumptions on chemical composition of ultra-high energy cosmic rays and allow for the constraint of the mass and lifetime phase space of super-heavy dark matter particles.

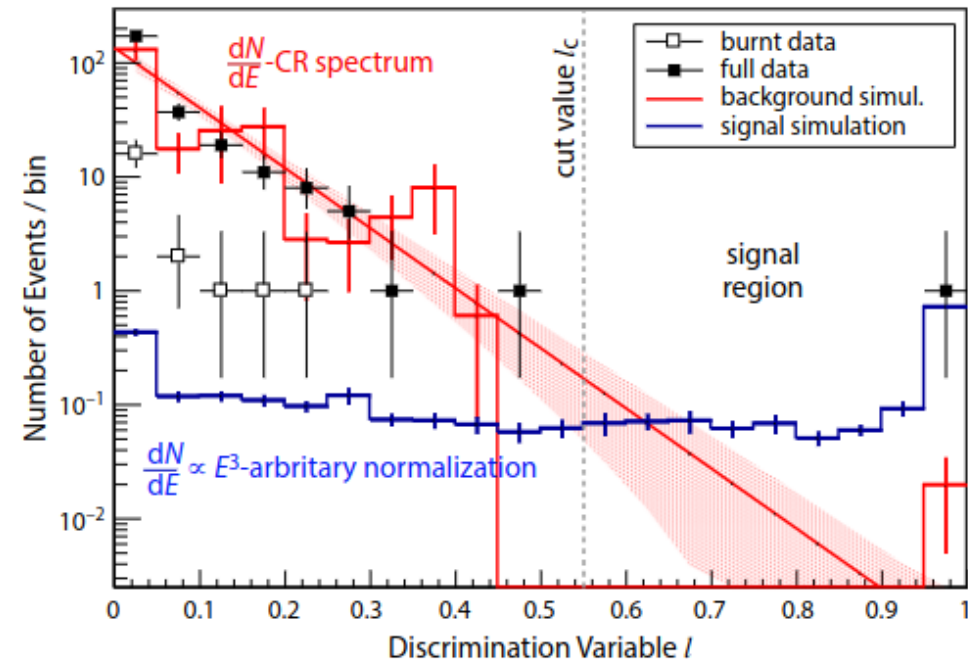
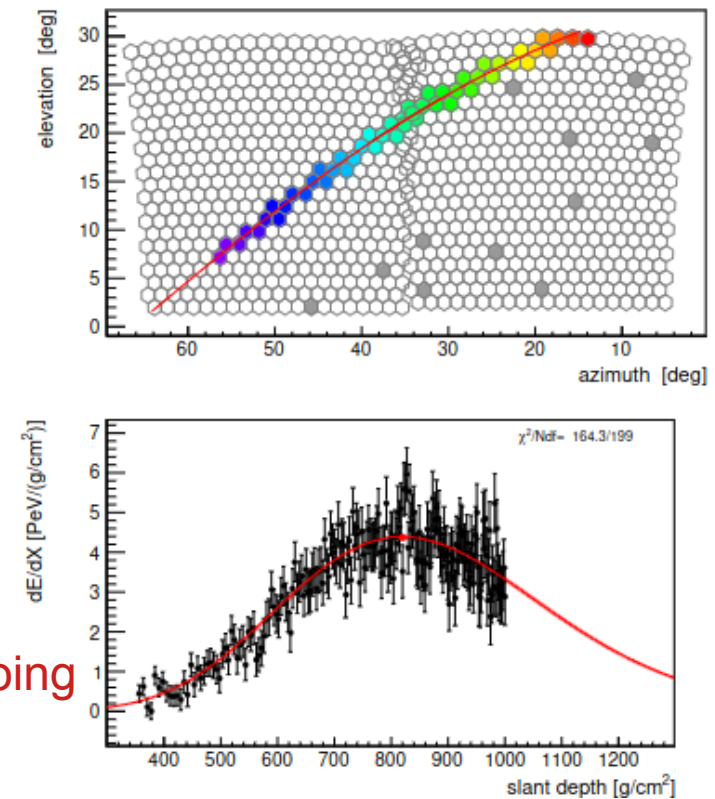
Search for the Anomalous Events Detected by ANITA Using the Pierre Auger Observatory

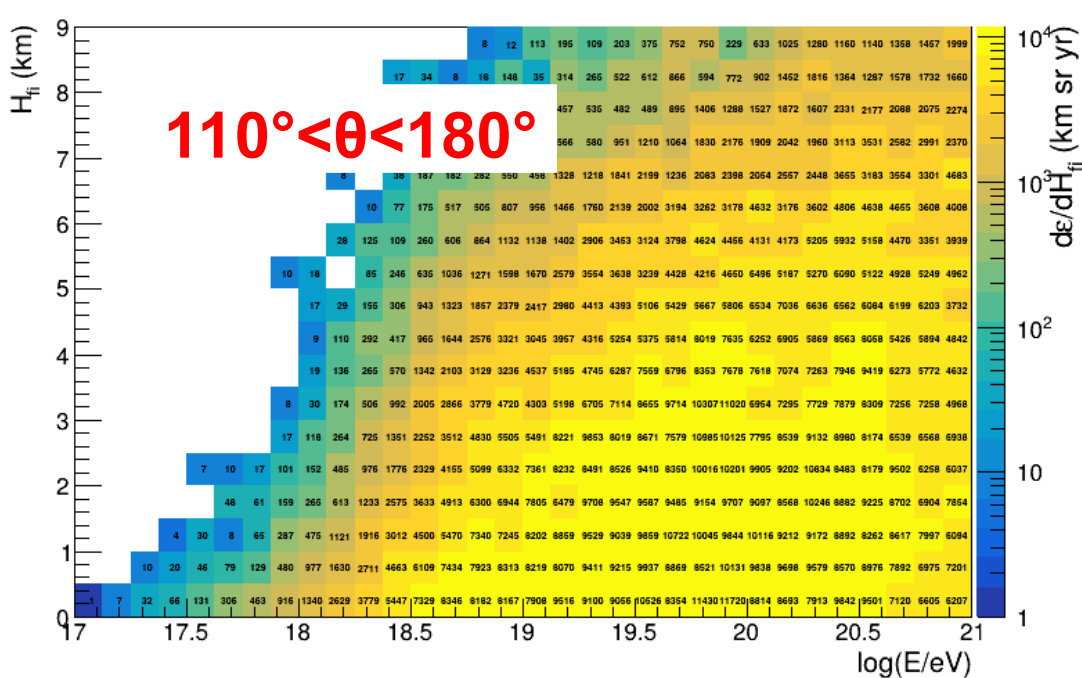
A dedicated search for upward-going air showers at zenith angles exceeding 110° and energies $E > 0.1$ EeV has been performed using the Fluorescence Detector of the Pierre Auger Observatory. The search is motivated by two “anomalous” radio pulses observed by the ANITA flights I and III that appear inconsistent with the standard model of particle physics. Using simulations of both regular cosmic-ray showers and upward-going events, a selection procedure has been defined to separate potential upward-going candidate events and the corresponding exposure has been calculated in the energy range $[0.1\text{--}33]$ EeV. One event has been found in the search period between January 1, 2004, and December 31, 2018, consistent with an expected background of 0.27 ± 0.12 events from misreconstructed cosmic-ray showers. This translates to an upper bound on the integral flux of $(7.2 \pm 0.2) \times 10^{-21} \text{ cm}^{-2} \text{ sr}^{-1} \text{ y}^{-1}$ and $(3.6 \pm 0.2) \times 10^{-20} \text{ cm}^{-2} \text{ sr}^{-1} \text{ y}^{-1}$ for an E^{-1} and E^{-2} spectrum, respectively. An upward-going flux of showers normalized to the ANITA observations is shown to predict over 34 events for an E^{-3} spectrum and over 8.1 events for a conservative E^{-5} spectrum, in strong disagreement with the interpretation of the anomalous events as upward-going showers.

PhD Thesis, E. De Vito → adesso RTDA



Simulated
upward-going
event





Attività attuale:

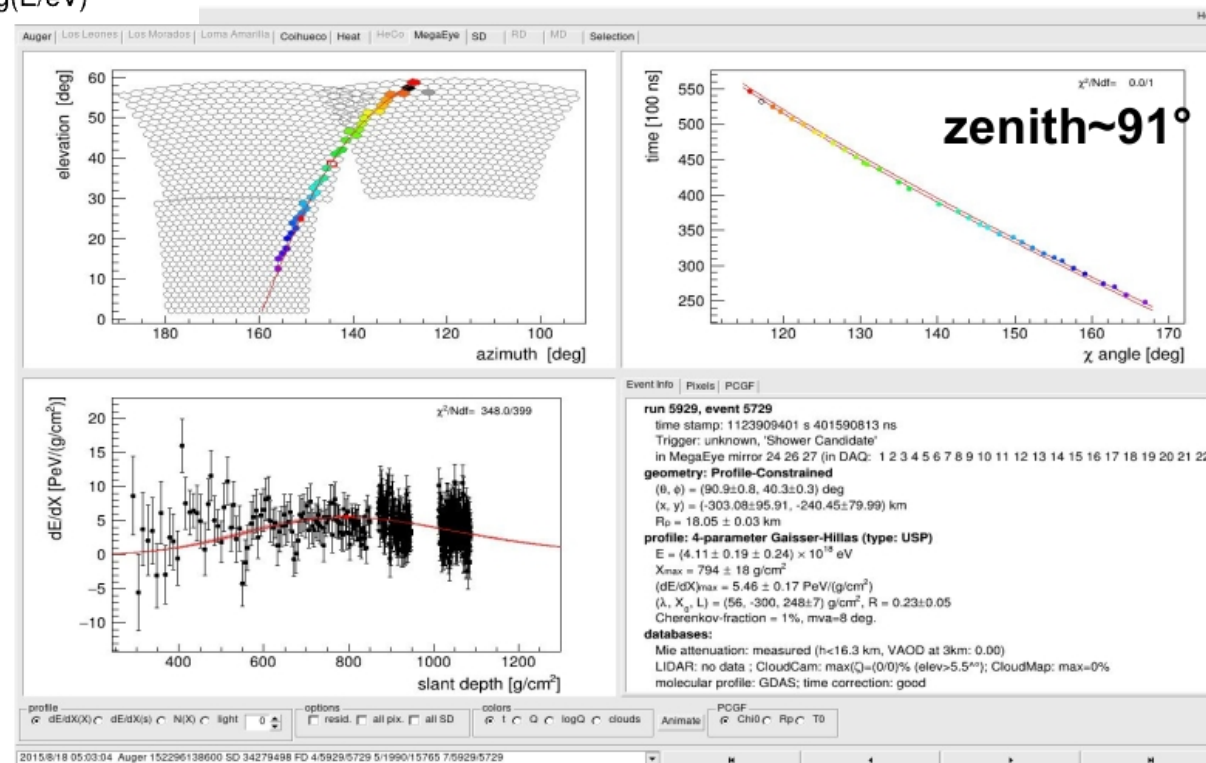
estensione del calcolo della sensibilità (exposure) alle energie piu' alte

Rilevante per indagare scenari BSM

(E. de Vito, LP)

Estensione ad angoli piu' inclinati → eventi stratosferici

Sinergia possibile con future osservazioni dall spazio



Interazione con progetto PNRR Spoke 2 M4C2 (Università del Salento)

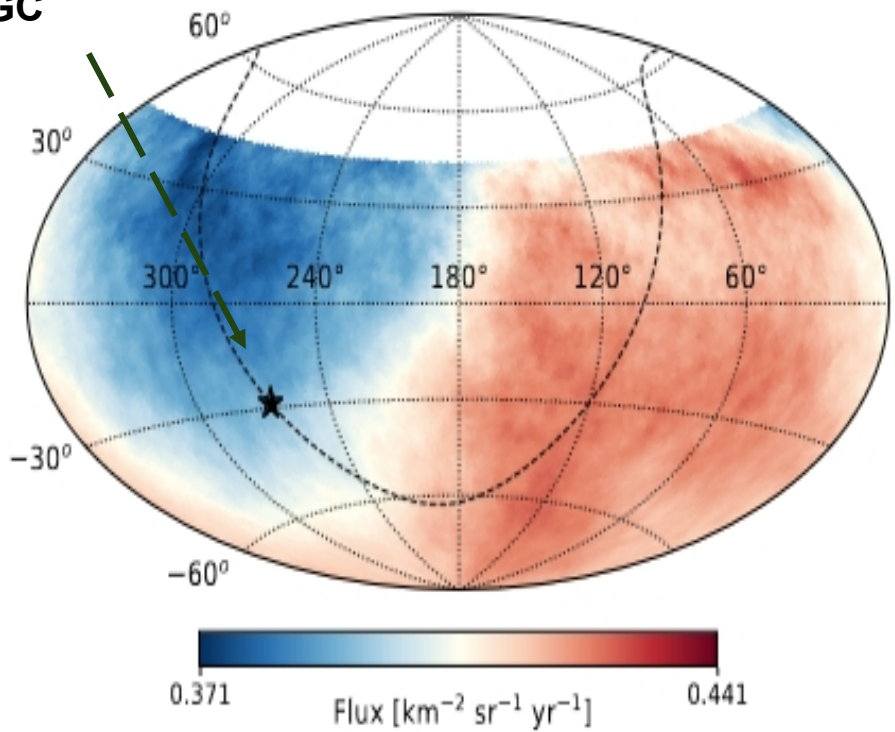
Large scale analysis $E \geq 4$ EeV: dipole 3D reconstruction

Auger Phase 1 dataset

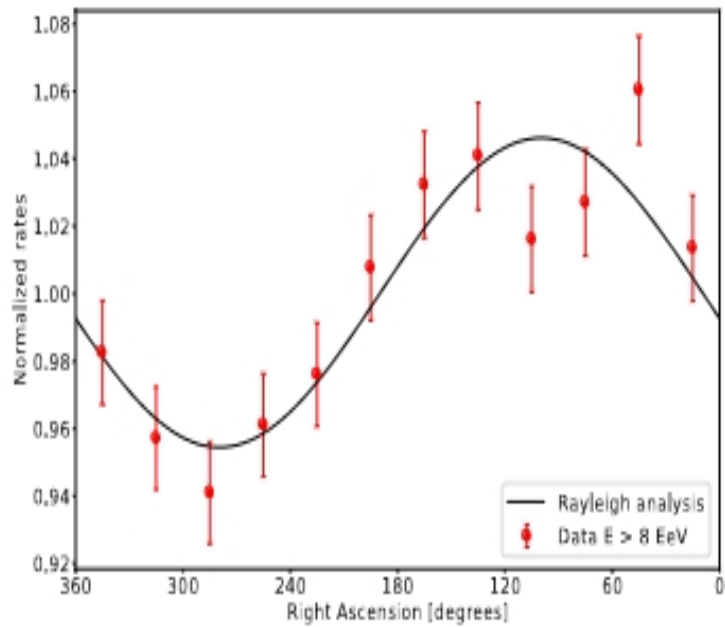
E [EeV]	N	$d_{\perp}$ [%]	d_z [%]	d [%]	α_d [°]	δ_d [°]	$P(\geq r_1^{\alpha})$
4-8	118,722	$1.0^{+0.6}_{-0.4}$	-1.3 ± 0.8	$1.7^{+0.8}_{-0.5}$	92 ± 28	-52^{+21}_{-19}	0.14
≥ 8	49,678	$5.8^{+0.9}_{-0.8}$	-4.5 ± 1.2	$7.4^{+1.0}_{-0.8}$	97 ± 8	-38^{+9}_{-9}	8.7×10^{-12}

→ **6.9 σ**

Dipole direction $\sim 113^\circ$ away from the GC



ApJ 976(2024)48

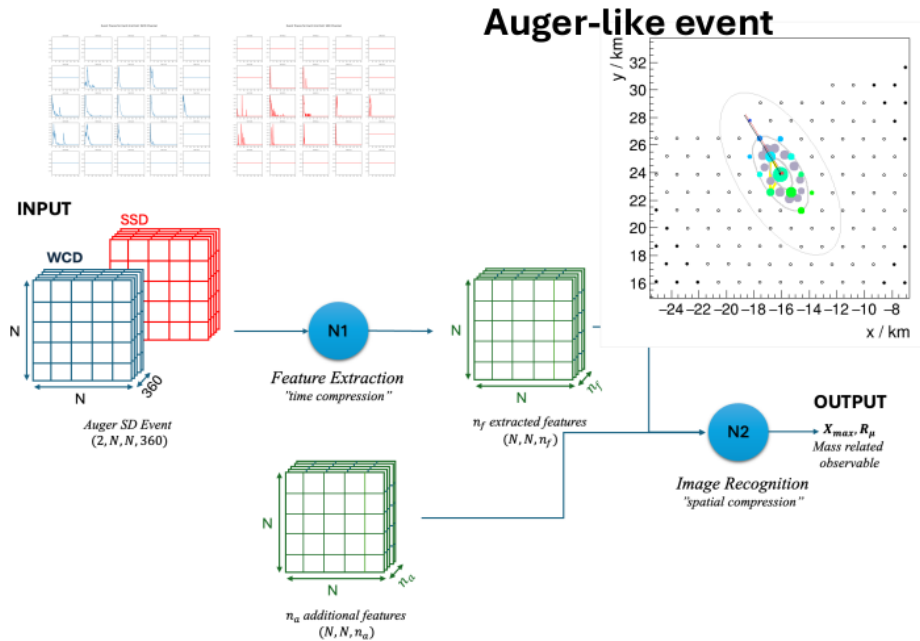


Equatorial coordinates, smoothed by a top-hat window of 45°

EB members: G.Golup, L. Caccianiga, M. Schimassek, S. Mollerach, **U. Giaccari**, R. Menezes de Almeida, B. Dawson (SC)

Analisi dati con Reti neurali, studi di composizione di massa con il rivelatore upgradato (M. Conte)

Ricerca di cluster con reti neurali non supervisionate



The **architecture** of the model is structured as follows.

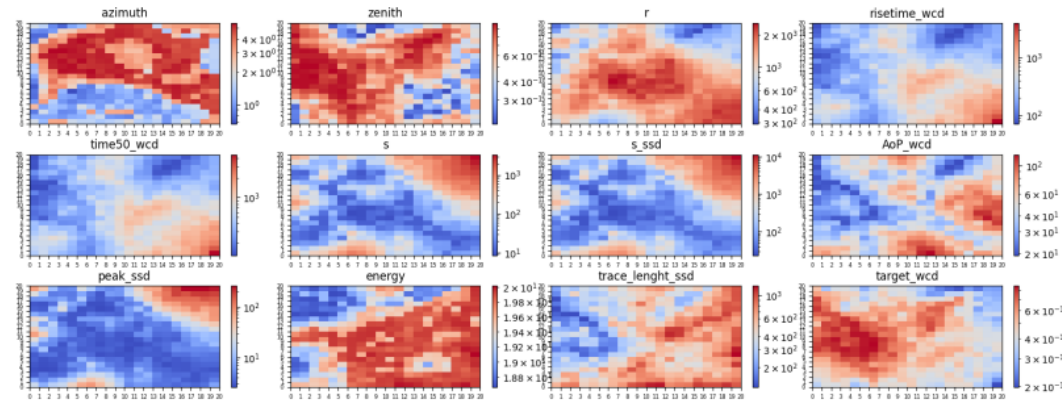
1. **N1: initial neural network designed to extract essential features from the time traces** of the two detectors.
2. These secondary features are **combined with additional features**
3. The combined features are passed **to a second neural network, N2**, with a dense layer **to predict a target variable**, such as X_{max} or R_μ .

Test su dati simulati.

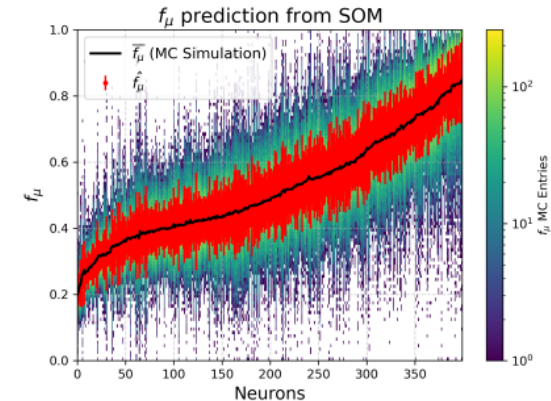
osservabili ricostruite passate alla rete

1 target (proxy per il numero di muoni)

**Simulazioni,
p, He, CNO e FE**



A **Self-Organizing Map**, or **SOM**, is a method of data dimensionality reduction. It involves an unsupervised neural network to construct a discretized low-dimensional representation from the input space of training samples. Providing local features from the time traces and global features from the event reconstruction, we aim to determine the number of muons deposited in the station



Muon fraction

$$f_\mu = s_\mu / s$$

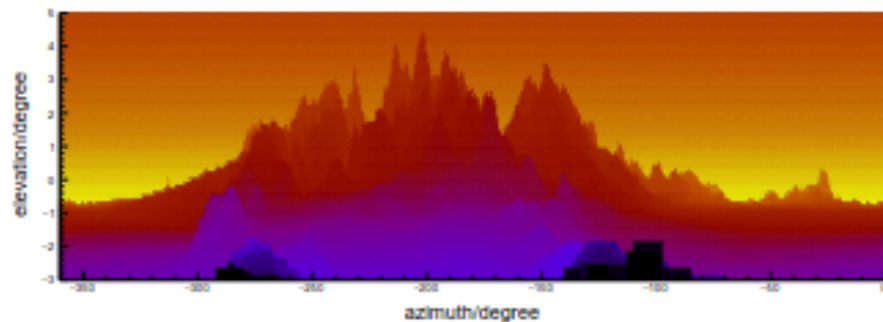
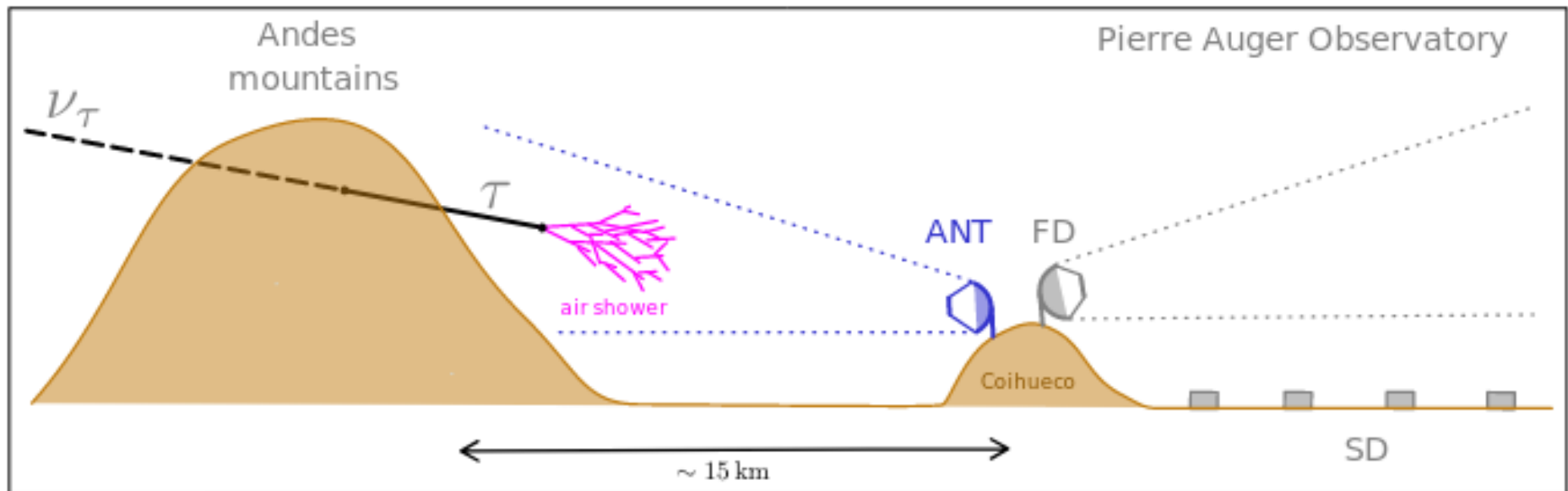
In coll. con A.Nucita e A. Franco

Calcolo condotto su GPU della sezione

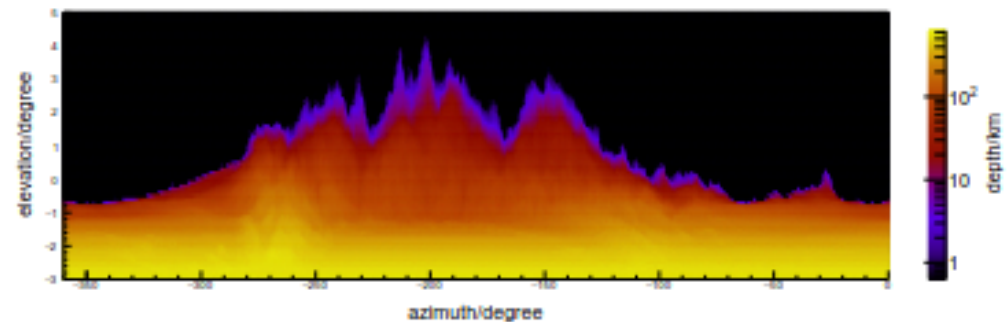
Idea per un possibile telescopio per neutrini ad Auger

ANT – Auger Neutrino Telescope M. Unger (IAP, KIT)

detect UHECR source neutrinos at $E_\nu = 1/20 E_p = 10^{17}$ eV



distance/km



depth/km

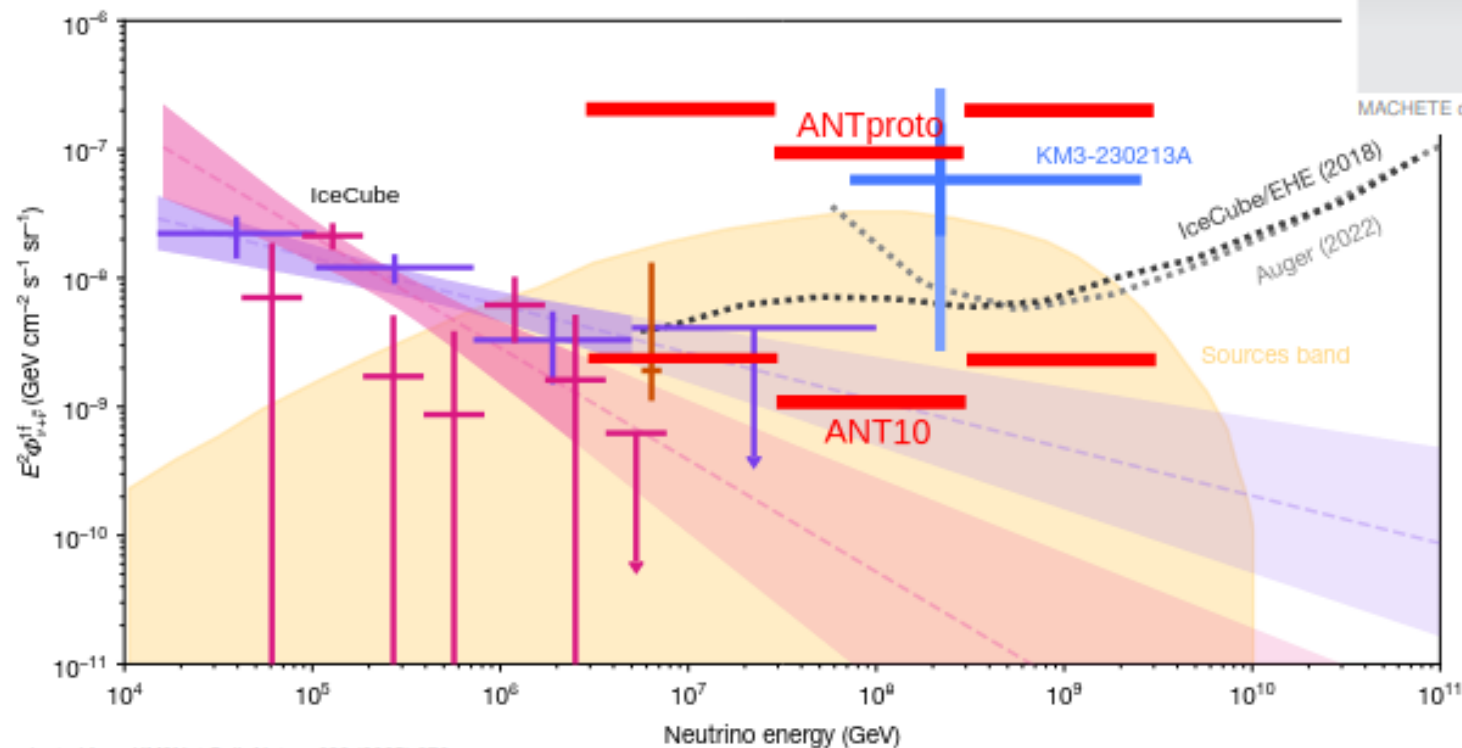
Primo passo:

- Misura del background fondo cielo
- Richiesti fondi per partecipare alla campagna di misura (Iniziativa Auger)
- L.P., U. Giaccari, V. Scherini, E.De Vito

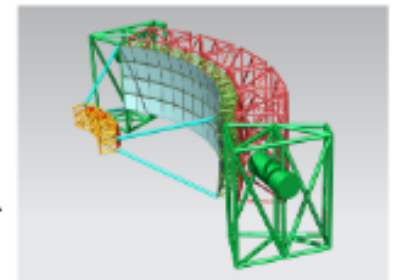
ANT – Auger Neutrino Telescope

M. Unger (IAP, KIT)

preliminary sensitivity using wide-field Cherenkov telescope(s)



adapted from KM3Net Coll. Nature 638 (2025) 376



MACHETE optics (Cortina et al., Otte et al.)

Pierre Auger Observatory Open Data

March 2024 release

<https://opendata.auger.org>

doi 10.5281/zenodo.4487613

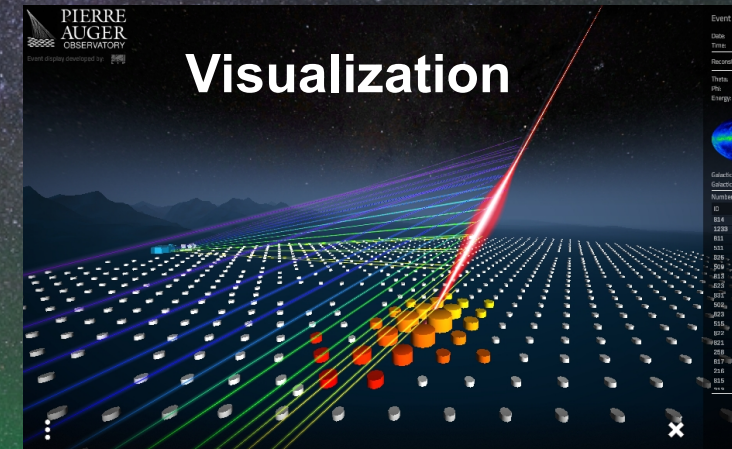
10% cosmic ray data → 30% at the end of 2025
100% atmospheric data

Close to raw data and higher level reconstruction

Surface and Fluorescence Detectors

JSON and summary CSV files

Python code for data analysis



V. Scherini



Datasets

the released datasets and their complementary data



Visualize

an online look at the released pseudo raw cosmic-ray data



Analyze

example analysis codes in online python notebooks to run on the datasets



Outreach

a page dedicated to the general public

The Open Data Portal

The Pierre Auger Collaboration,
Eur. Phys. J. C 85 (2025) 70

- **Datasets**

Description of CR physics,
detection principle and file content

- **Visualization**

Event selection and 3D browser

- **Analysis**

Python code for exploring data &
understanding physics results

- **UHECR Catalog**

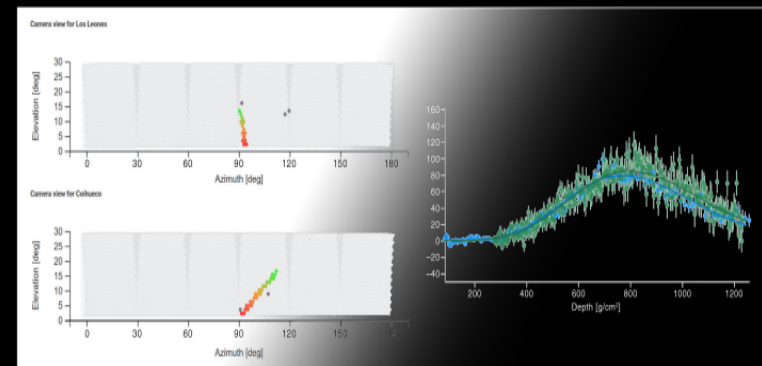
Details of the 100 Highest energy
events

- **Outreach**

Section dedicated to the general
public



From "The Pierre Auger Observatory open data"
by Pierre Auger Collaboration, Eur. Phys. J. C 85, 70 (2025).

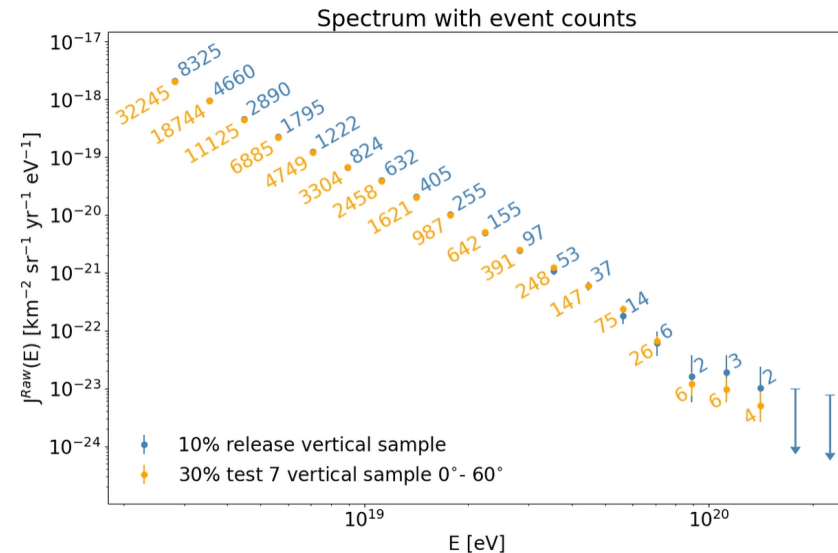


Visualization of an exemplary event. Left panel: camera view of the fluorescence detector; the cosmic-ray shower is seen as a trace that moves along the pixels of the camera, from early (green) to late (red) pixels. Right panel: reconstructed energy deposit as a function of atmospheric depth as measured with the two telescopes participating in the event.

Task activities: 30% dataset production

**Next release: 30% of PHASE I vertical
SD1500 + HYB for calibration**

- **CR dataset:**
 - production of Phase I data
 - data selection & JSON - CSV files production
- extensive tests and comparison with published data and results by experts



The most energetic hybrid event

Immersive and interactive view
High-level info & raw data

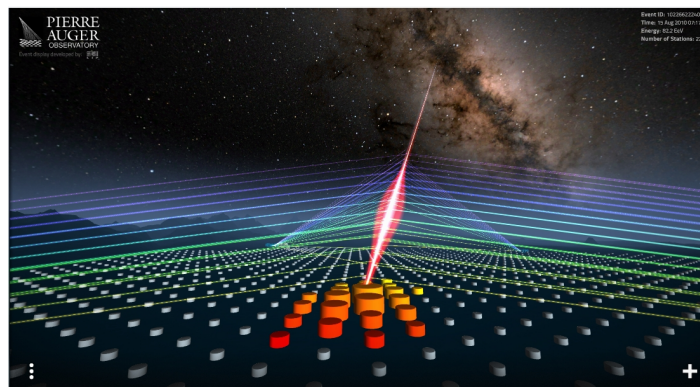
PAO100815:

energy of 82 EeV

zenith of 54 degrees

triggered 22 SD stations

fluorescence telescopes in 4 FDs



Open data test server migration to Lecce

V. Scherini,
thanks to Enrico for
help!

The transfer of the Auger Computing Center from Lyon (IN2P3) to CNAF (INFN)

Endorsement from the CB for Italy to host at CNAF the Auger data center

- ~ 300 T disk
- ~ 1 PB Tape
- ~ 3000 HS06 computing power

**Resources all
allocated at CNAF**

- significant effort to migrate RAW data → **done**
- now starting the migration of simulations from GRID and/or irods to TAPE@CNAF
- synchronization of data from Argentina to Lyon and CNAF in parallel (test phase)

Coordinated and under the responsibility of the Lecce group

→ credit to Emanuele De Vito

Control room remota per il rivelatore di fluorescenza



Turni FD remoti

- **Pianificato: Ottobre 2025**

Maggio 2025:

Eseguito upgrade del OS sui computer come richiesto dalla collaborazione. Disponibile ora anche nuovo hardware per rimpiazzare il vecchio (10 anni)

Il gruppo di Lecce: partecipazione a conferenze 2025

V. Scherini	ICRC2025	Luglio 2025, Geneve
M. Conte	ICRC2025	Luglio 2025, Geneve
E. De Vito	EPS-HEP 2025	Luglio 2025, Marseille
L. Perrone	ACME	Aprile 2025, Tolouse

Ruoli di responsabilità

Task leader per Data Release Task (V. Scherini)

Task leader per SSD (D. Martello)

Membro del Conference Committee (U. Giaccari)

Responsabile della migrazione di Auger data center da Lyon al CNAF (L. Perrone)

Accesso a servizi per il 2026

Supporto e software/hardware upgrade della control room remota di Auger
Assistenza nella transizione del data center di Auger da Lyon al CNAF

Supporto per organizzazione di ISVHECRI 2026 (Luglio 2026)

Setup di un server locale di test per la gestione degli open data di Auger

Richieste al servizio **calcolo e reti**
3 mesi/persona

Supporto per la verifica della performance sul campo (gestione eventuali emergenze)
(Potenziale) Supporto misure di background per ANT

Richieste all'officina **meccanica**
2 mesi/persona

Verifica dell'installazione del funzionamento delle schede UUB

Richieste al laboratorio di **elettronica**
2 mesi/persona

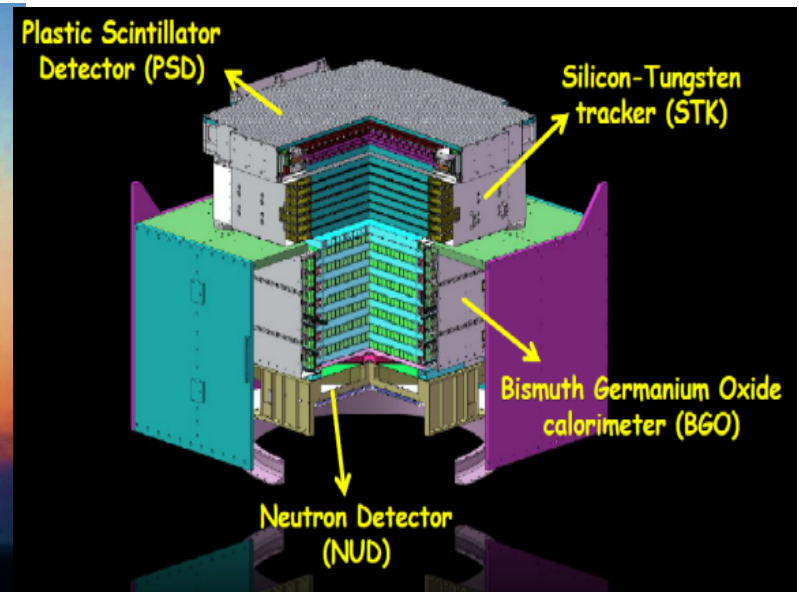
Richieste per il 2026 (Preliminari)

Consumo
Missioni
Trasporti

7K
63K
7K

consumo	Componenti e altre minuterie per supporto all'attivita' di test dell'elettronica in situ, per la calibrazione dei moduli SSD in laboratorio e per interventi di manutenzione dei moduli SSD in situ.	5.00	0.00			7	0
	Materiale di supporto per la strumentazione relativa alla misura di background a ridosso delle Ande, in vista dello studio di fattibilita' per la realizzazione di un telescopio per neutrini a luce Cherenkov	2.00	0.00				
missioni	2 missioni per 2 fisici (2K * 2) al CNAF per le operazioni di trasferimento dell'Auger data center da Lyon al CNAF	4.00	0.00			63	0
	Partecipazione a meeting di collaborazione in situ. Due meeting (Marzo 2026 e Novembre 2026) 4 Fisici per il meeting di Marzo (3K x4) 6 Fisici per il meeting di Novembre (3Kx6)	30.00	0.00				
	2 turni FD presa dati in situ (4K per partecipante)	8.00	0.00				
	1 Fisico e 1 Tecnico per la partecipazione ad una misura del background UV a ridosso delle Ande (in prossimita' del sito di Coihueco), in vista dello studio di fattibilita' per la realizzazione di un telescopio per neutrini a luce Cherenkov	8.00	0.00				
	1 turno tecnico con 1 Fisico ed 1 Tecnico, in concomitanza con il meeting di collaborazione di Novembre (4K x 2). Verifica sui moduli SSD installati nel campo e commissionig nuova elettronica UUB.	8.00	0.00				
	Riunione con i referee, 2 Fisici (0.5 K x 2)	1.00	0.00				
	Partecipazione di 4 Fisici al meeting Auger Italia (1K x4)	4.00	0.00				
trasporti	Trasporti in situ per 1 turno FD (2K) 1 turno tecnico (2K) + Trasporti per partecipazioni ai meeing (1K per meeting di Marzo + 2 K per meeting di Novembre)	7.00	0.00			7	0
Totale						77	

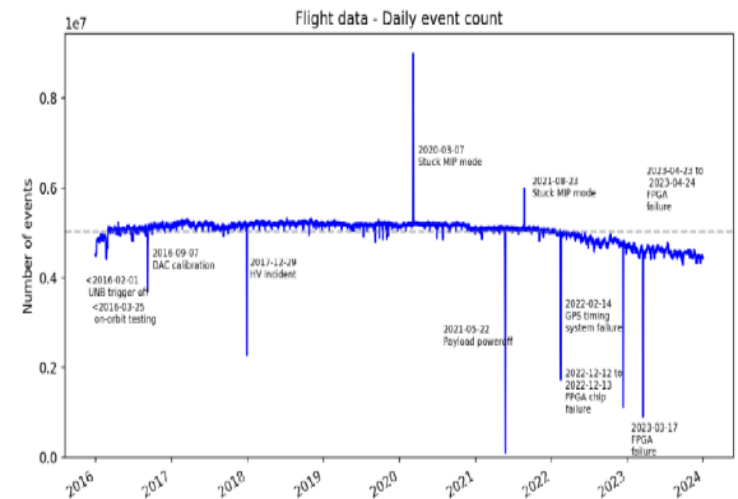
DAMPE mission



ALTITUDE: 500 km
PERIOD: 95 minutes
ORBIT: Sun-synchronous
FULL SKY SCAN: two/year

The Lecce group mainly involved in data analysis for the flux measurement of Cosmic Ray components

FLIGHT DATA



> 8 years of smooth Data-taking in Flight

DAMPE/HERD: Attività 2025

DAMPE

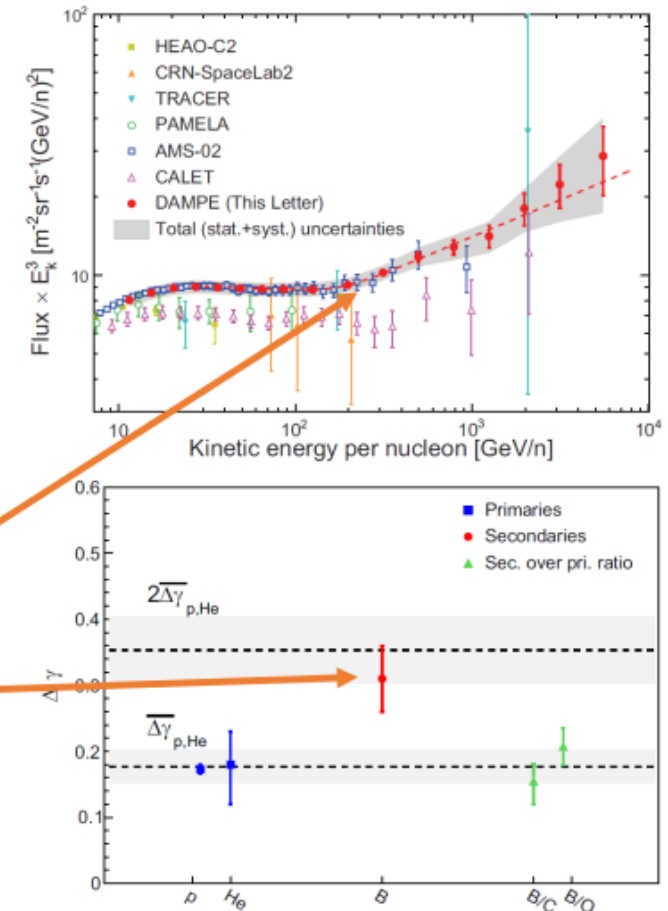
- Analisi dei dati di volo (>8 anni): flusso e spettro energetico dei nuclei dei Raggi Cosmici
 - **Spettro (p+He)**, pubblicato recentemente su PRL (F. Alemanno)
 - **Spettro del gruppo di nuclei massa intermedia Ne, Mg, Si** (E. Casilli)
- Produzione dati simulati per le analisi
 - Partecipazione a Shift/Monitor per la produzione Monte Carlo in Europa
- **Responsabilità**
 - Coordinamento della produzione MC in Europa (Recas/Bari e Ginevra) e del Calcolo dell'esperimento F. de Palma
 - Convenor Working Group sui raggi Cosmici A. Surdo

HERD

- Attività software e di laboratorio:
 - Simulazione eventi con *HERDSoftware* per design e ottimizzazione geometria del PSD (accettanza, ermeticità, reiezione del back-splash, ..) (E. Ghose)
 - Test dell'elettronica (ASIC) + Trigger per i gamma col gruppo di Barcellona (E. Ghose)
-

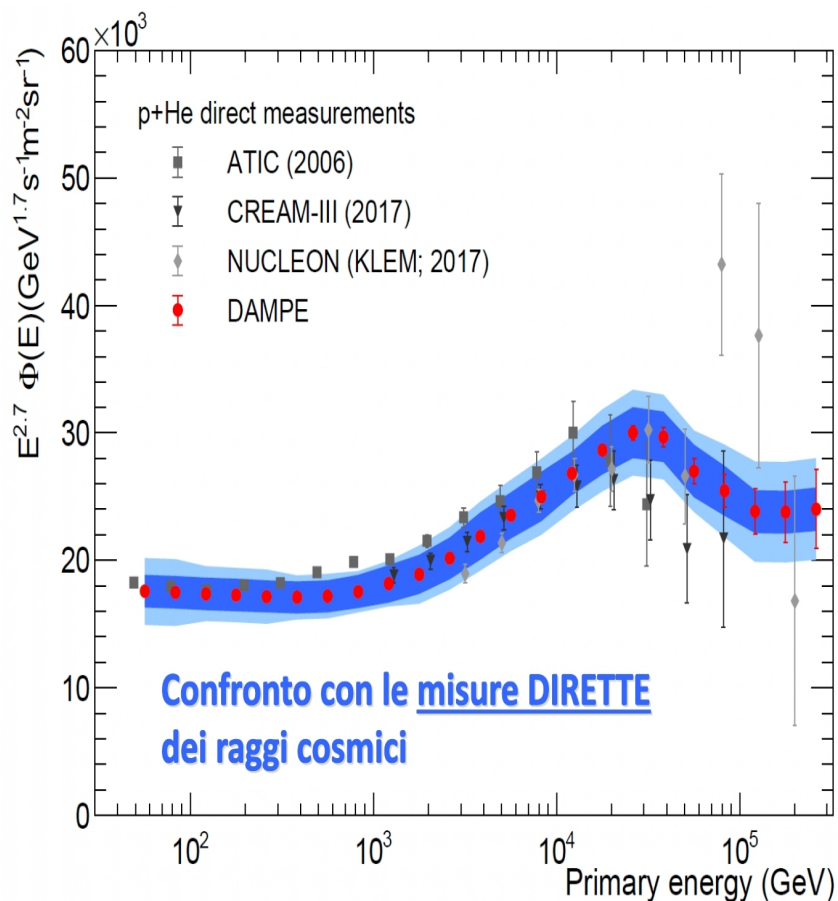
Spectral Hardening in Cosmic Ray Boron Spectrum

- The flux of cosmic ray boron, with 8 years of DAMPE data, was measured from 10 GeV/n to 8 TeV/n.
- Compared with previous measurements, the DAMPE spectrum presents a much-improved precision at high energies ($> 1 \text{ TeV}/n$).
- For the first time, the DAMPE measurement provides an observation of **spectral hardening** at $E_{br} = 182 \pm 24 \text{ GeV}/n$, with a significance of 8σ and a spectral change of $\Delta\gamma = 0.31 \pm 0.05$.
- Previous measurements by AMS-02 and CALET suggested such hardening with limited statistical significance

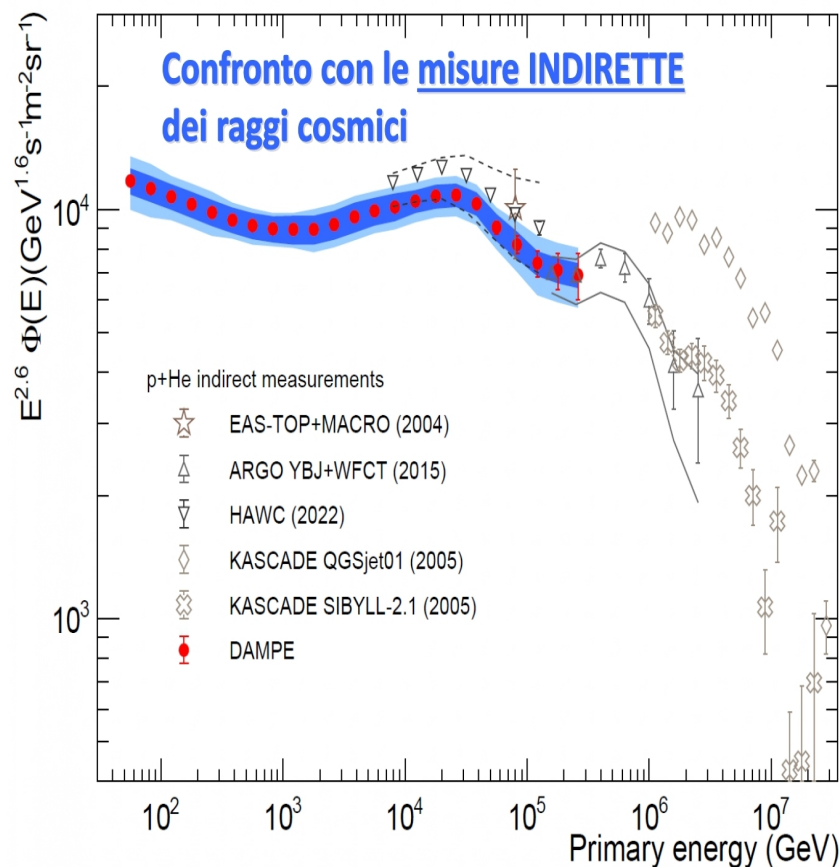


DAMPE: Combined spectrum p+He

- Presented at ICRC-2023 (Nagoya, Japan) and several Conferences ...
- SIF-2023: Talk selected as one of the best -> Published on Nuovo Cimento (F. Alemanno)
- Invited talk at "Cosmic Rays and Neutrinos in the Multi-Messenger Era", Paris December 2024



Spectrum softening feature in agreement with that observed in the separate p and He spectra



Energy range bridging to indirect measurements

Dampe Ne-Mg-Si analysis Track reconstruction

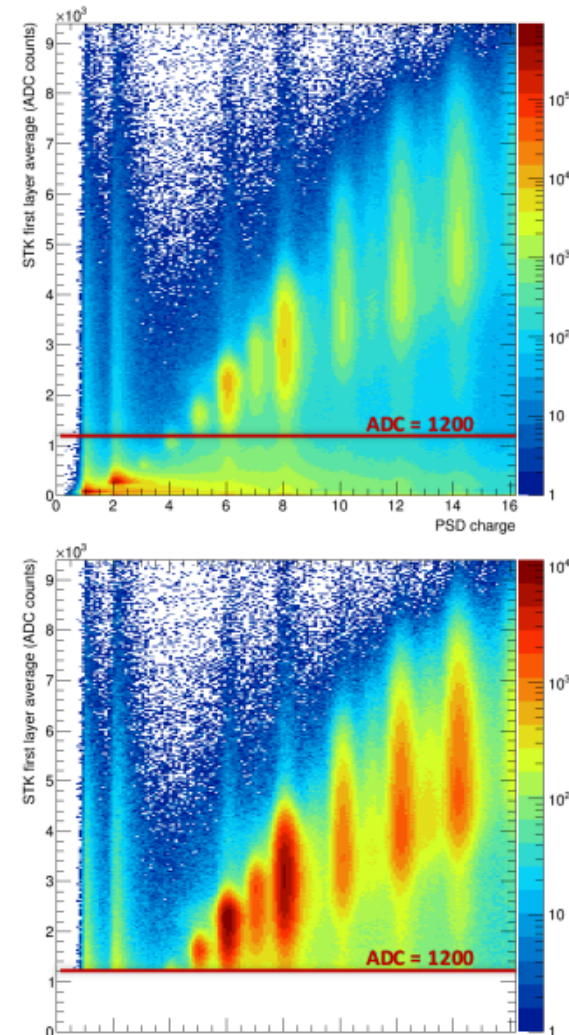
from (E. Casilli Phd dissertation 9/5/25)

Particle track reconstruction is performed using the **Machine Learning (ML)** algorithms* developed within the DAMPE software framework.

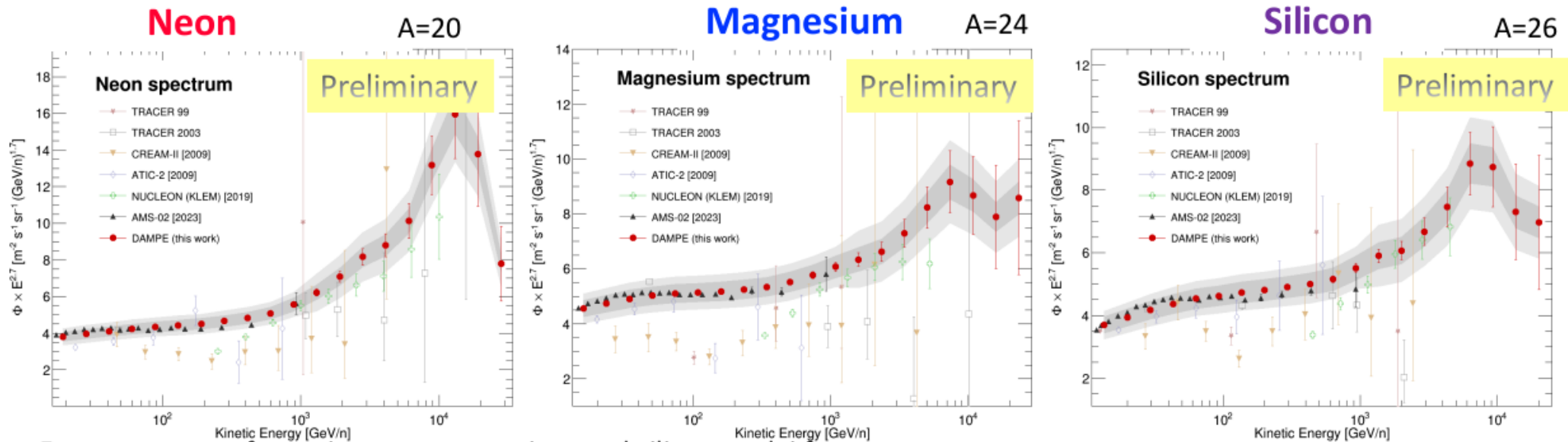
The selection criteria include:

- Presence of at least one cluster in either the XZ or YZ plane of the first STK layer.
- Track containment inside a fiducial volume:
 - STK track projection on the first PSD sublayer must be the active area.
 - Distance between the BGO shower axis and the STK track projections on the first and second BGO layers must be < 30 mm.
- The average signal on the first STK layer must exceed 1200 ADC counts, to suppress the background from lighter nuclei.

* A. Tykhonov et al., *Astropart. Phys.* **146** (2023) 102795.



Preliminary fluxes up to 560 TeV



- Energy spectra of cosmic neon, magnesium and silicon nuclei from 380 GeV to 560 TeV, based on 8 years of DAMPE data.
- Clear confirmation of the spectral **hardening** around 0.5 TeV/nucleon with high statistical significance, previously suggested by the data of AMS-02 and NUCLEON.
- Indications of a spectral **softening** around 10 TeV/n, consistent with similar features observed by DAMPE in proton and helium spectra.

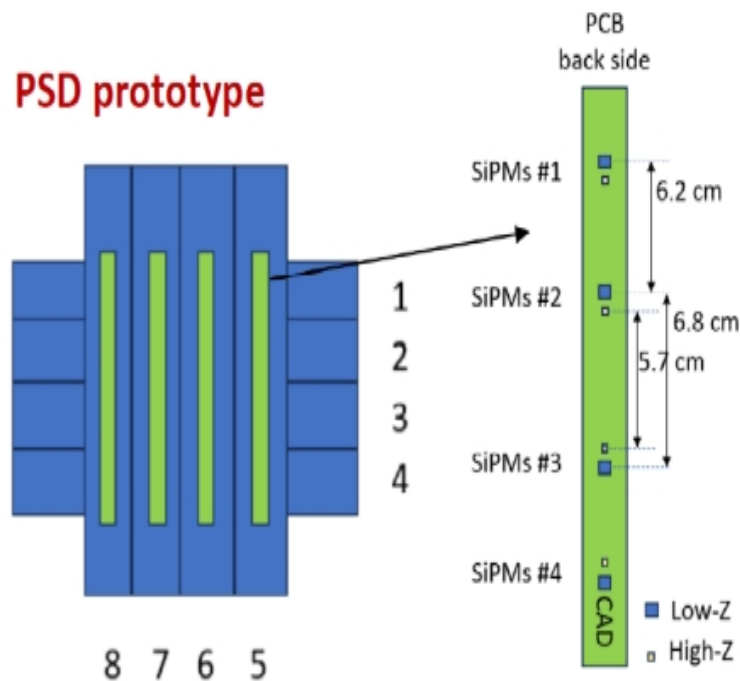
- *Poster at ICRC-2023 (Nagoya, Japan) & Talk at SIF & ECRS-2024*
- *SIF-2024: Talk selected as one of the best -> Accepted on Nuovo Cimento*
- *Oral presentation at ICRC 2025 in Geneva, Switzerland.*

HERD activities

- Event Simulation with *HERDS*Software for detector design and PSD optimization
- Contribution to the development of PSD, whose main goal is to implement the trigger for gamma-rays
- Tests/validation of Trigger electronics for gamma rays with Barcellona group (E. Ghose)

Partecipation to the Beam-test campaign at CERN for testing the detector prototypes (in 2025 or 2026(?), depending on ASI funding)

2023 Beam-test @ CERN



Attività per il 2025-2026

DAMPE

- Continuazione analisi dati di volo sul flusso dei Raggi Cosmici
- Coordinamento, shift e monitor della produzione MC per le analisi

HERD

Stato attuale

- Completamento finanziamento ASI il 2025
- Test di SiPM ed elettronica (ASIC) di frontend + Trigger per i gamma col gruppo di Barcellona (E. Ghose)
- Simulazione eventi con HERDSoftware (E. Ghose)

Attività prevista per il 2026

- Supporto a integrazione del prototipo ed a possibile ulteriore test Beam-test al CERN nel corso del 2026
- Possibile partecipazione di istituzioni italiane su software e (futura) analisi-dati dati (tre sezioni INFN per ora coinvolte)

Richieste finanziarie 2026 (preliminari)

Missioni

- MEETING: 1 meeting di Collaborazione DAMPE in Cina (2 pp x 5 gg). 4.5 k €
- MEETING: 1 meeting di Collaborazione DAMPE in Europa (2 pp x 4 gg). 2.0 k €
- MEETING: 1 meeting di Collaborazione HERD in Cina (1 pp x 5 gg) 2.5 k€
- MEETING: 1 meeting di Collaborazione HERD in EU (1 pp x 5 gg) 1.5 k€
- Integrazione del prototipo di HERD per test-beam in Italia (1pp x 5gg) 1.0 k€

N.B. le richieste dipendono dall'effettiva organizzazione dei meeting.

Anagrafica (2026)

Nome	Ruolo	%
Alemanno Francesca	Assegnista	20
Bernardini Paolo	Prof Ordinario	0
de Palma Francesco	Prof Associato	40
Ghose Essna	Dottoranda – Dott. Nazionale	100
Surdo Antonio	Primo ricercatore - INFN	40
TOTALE FTE		2.0

La missione NUSES

Italian led mission conceived as a **pathfinder** for **new observation methods and technologies** in the study of high and low energy radiations from space enabling new sensors and tools

60+ persons from many institutions.

Large **expertise** (and **synergies**) from space missions/R&D: AMS, DAMPE, Fermi, LIMADOU, GAPS, HERD, PAMELA, SPB, newASTROGAM, POEMMA, ...

Participating Research Institutes:

- Gran Sasso Science Institute
- Laboratori Nazionali del Gran Sasso
- Università dell'Aquila
- Università di Torino and INFN Torino
- Università di Trento and INFN-TIFPA
- Università di Bari, Politecnico di Bari and INFN Bari
- Università di Padova and INFN Padova
- Università "Federico II" and INFN Napoli
- Università del Salento and INFN Lecce
- University of Geneva
- Columbia University
- NASA Goddard Space Flight Center
- Pennsylvania State University



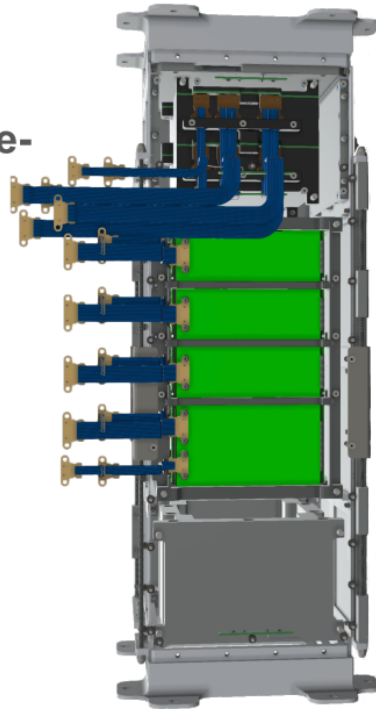
Other Industrial Partners:



La missione NUSES: payloads

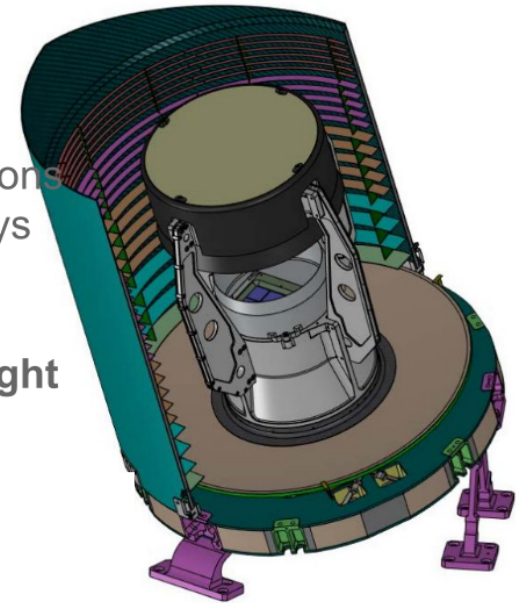
Zirè

- Measure the flux ($E < 300$ MeV) of cosmic e^- , p and light nuclei of solar/galactic origin;
- Study of the cosmic radiation variability (Van Allen belt system);
- Possible correlation with seismic activity due to **Magnetosphere-Ionosphere-Lithosphere Coupling (MILC)**;
- Detection of **0.1 - 30 MeV** photons for the **study of transient gamma sources**;
- Paving the way for future **applications of new technology** (SiPM, Fiber Tracker, GRB detection...);



Terzina

Pathfinder for future missions devoted to UHE cosmic rays and neutrino astronomy through **space-based atmospheric Cherenkov light** detection.



New Technologies and approaches

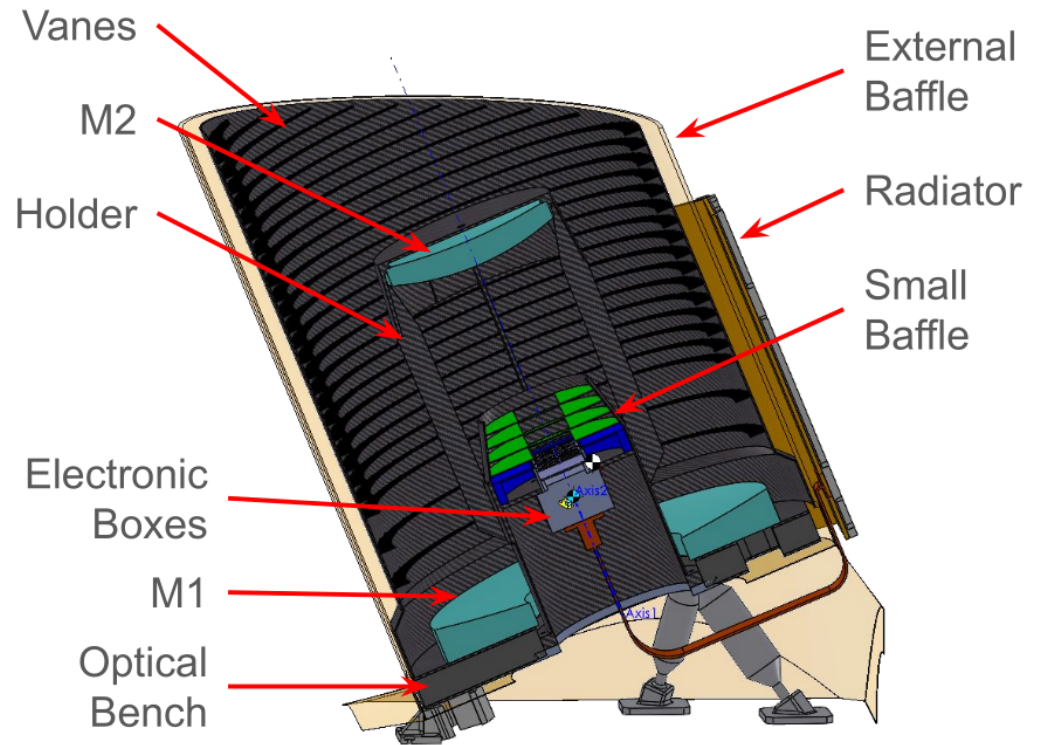
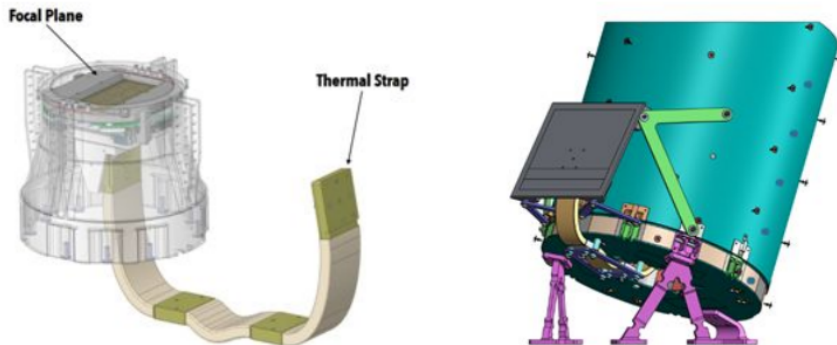
Development of new observational techniques, testing new sensors (e.g. **SiPM**) and related electronics, DAQ, onboard AI, for space missions. New solutions for the satellite platform.



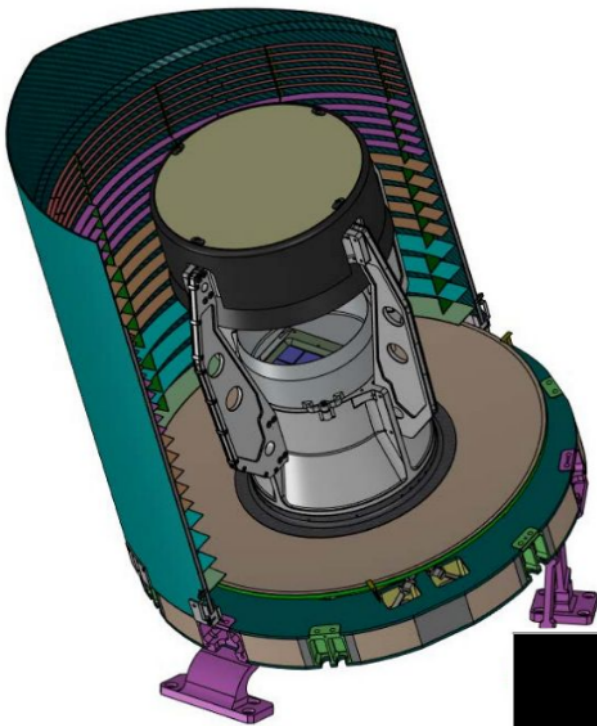
Terzina: struttura

A near-UV-optical telescope composed of:

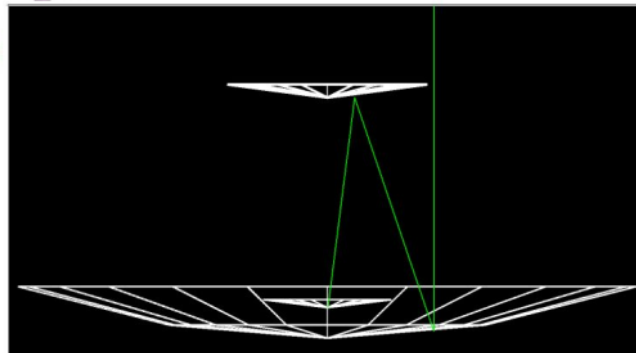
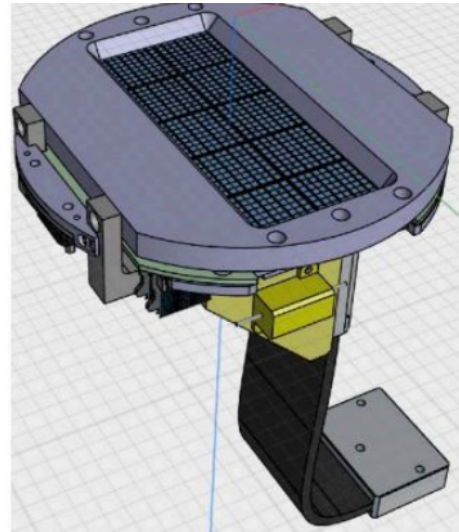
1. the structural (mechanics) and thermal control (TC) assembly,
2. the optical head unit,
3. the focal plane assembly (FPA),
4. the front-end electronics (FEE) and data acquisition (DAQ) boards.



TERZINA: layout

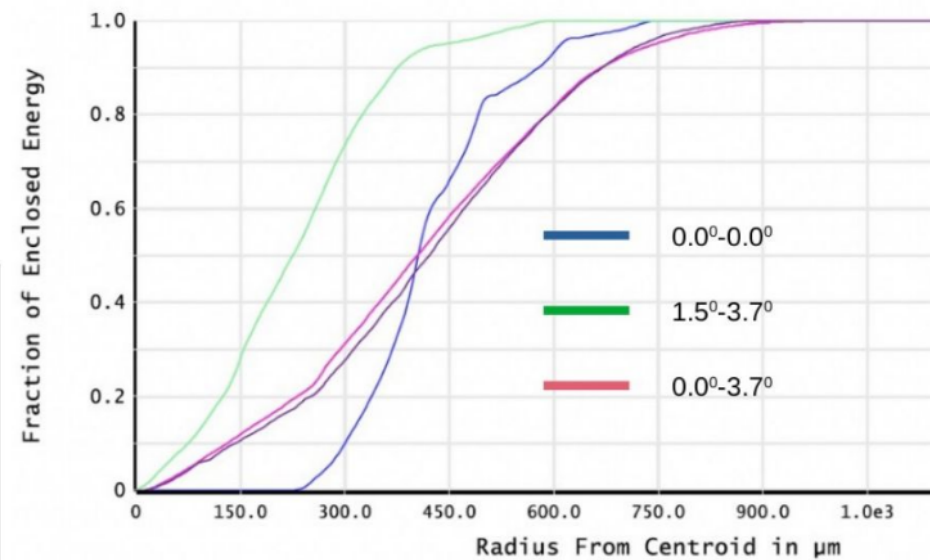


A and B are the primary and secondary mirrors composing the Terzina optical system (Cassegrain).



- ✓ Equivalent focal length 925 mm
- ✓ Field of View (FoV) : 7.2°
- ✓ Point spread function (PSF) : <1.0 mm
- ✓ Effective area of the telescope : 0.1 m^2
- ✓ M1 paraboloid, M2 hyperbole

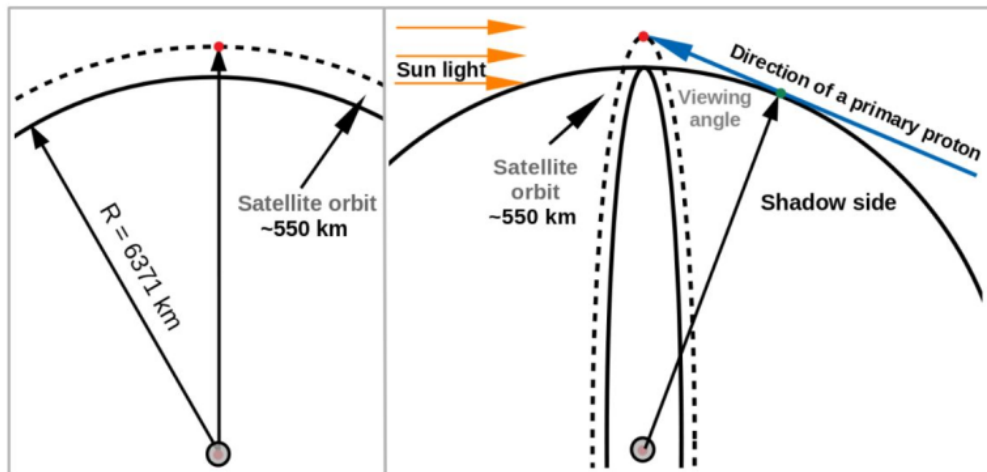
Point spread function for different inclination angles



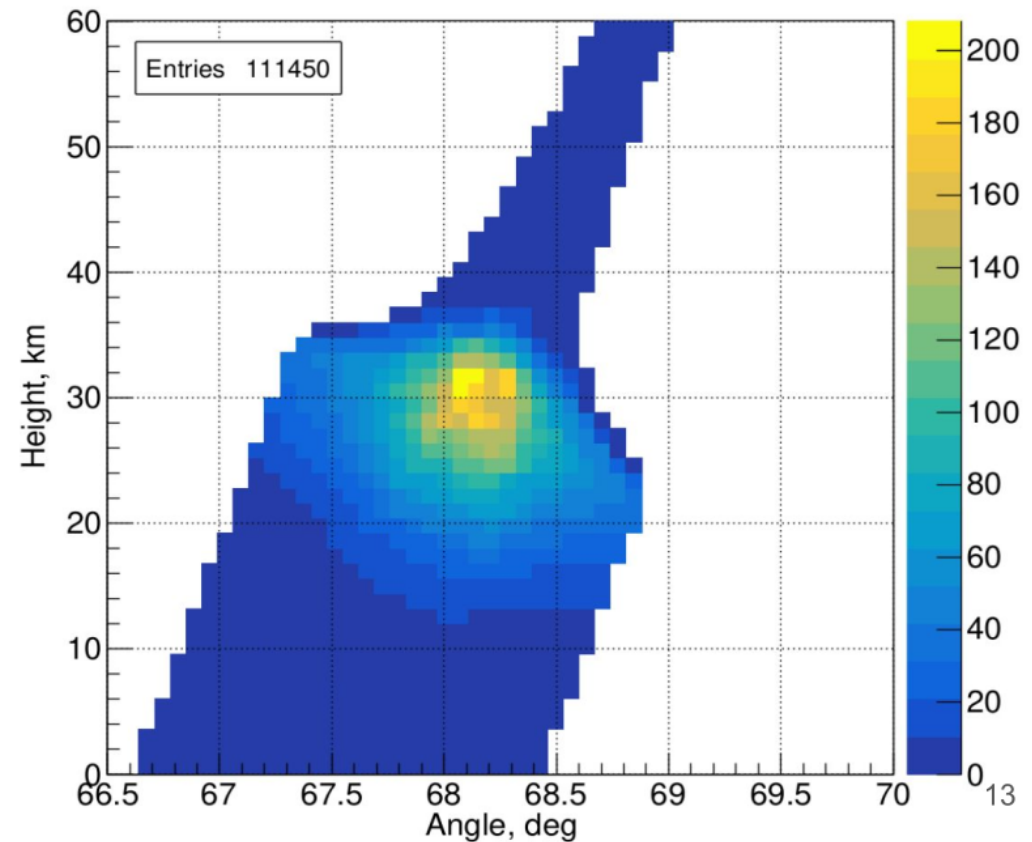
Terzina: rivelazione Cherenkov

CR Detection: Above Limb

Neutrino Detection: Below Limb



Most contributing atmosphere layers @ 550 km:
between 20 - 40 km altitude



Telescope focal plane

SiPM arrays: **8 x 8 channels**

Pixel: **3 x 3 mm²**

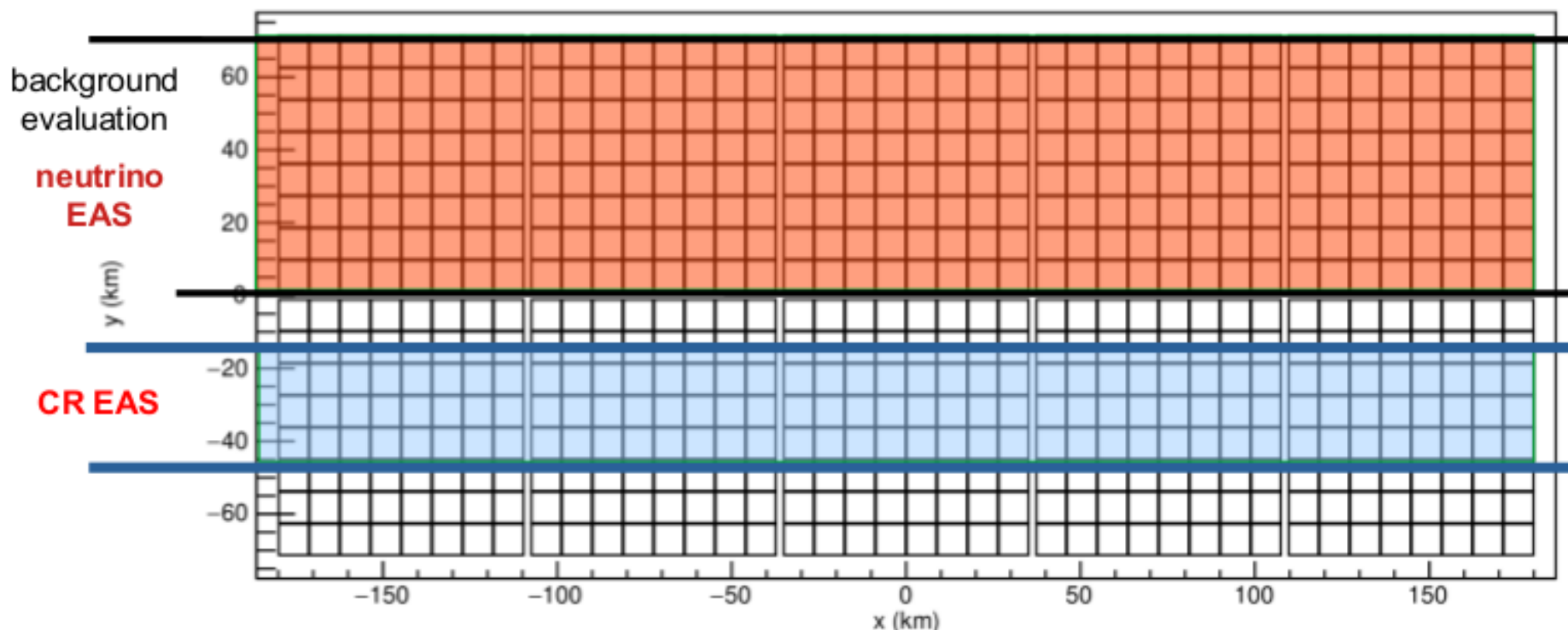
Pixel FoV: $\text{atan}(r_{\text{pix}}/F_L) \sim 0.18^\circ$

5 x 2 = 10 SiPM arrays in total
(8 x 8) x 10 = 640 pixels (channels)

Array dim. : 25.3 x 25.3 mm²
Array Eff. area : 24 x 24 mm²



Camera plane with projection on the Earth (total area 360x140 km²)



Attività per NUSES a Lecce

People involved:

Terzina Simulation Working Group

- L. Perrone
- V. Scherini

Software firmware

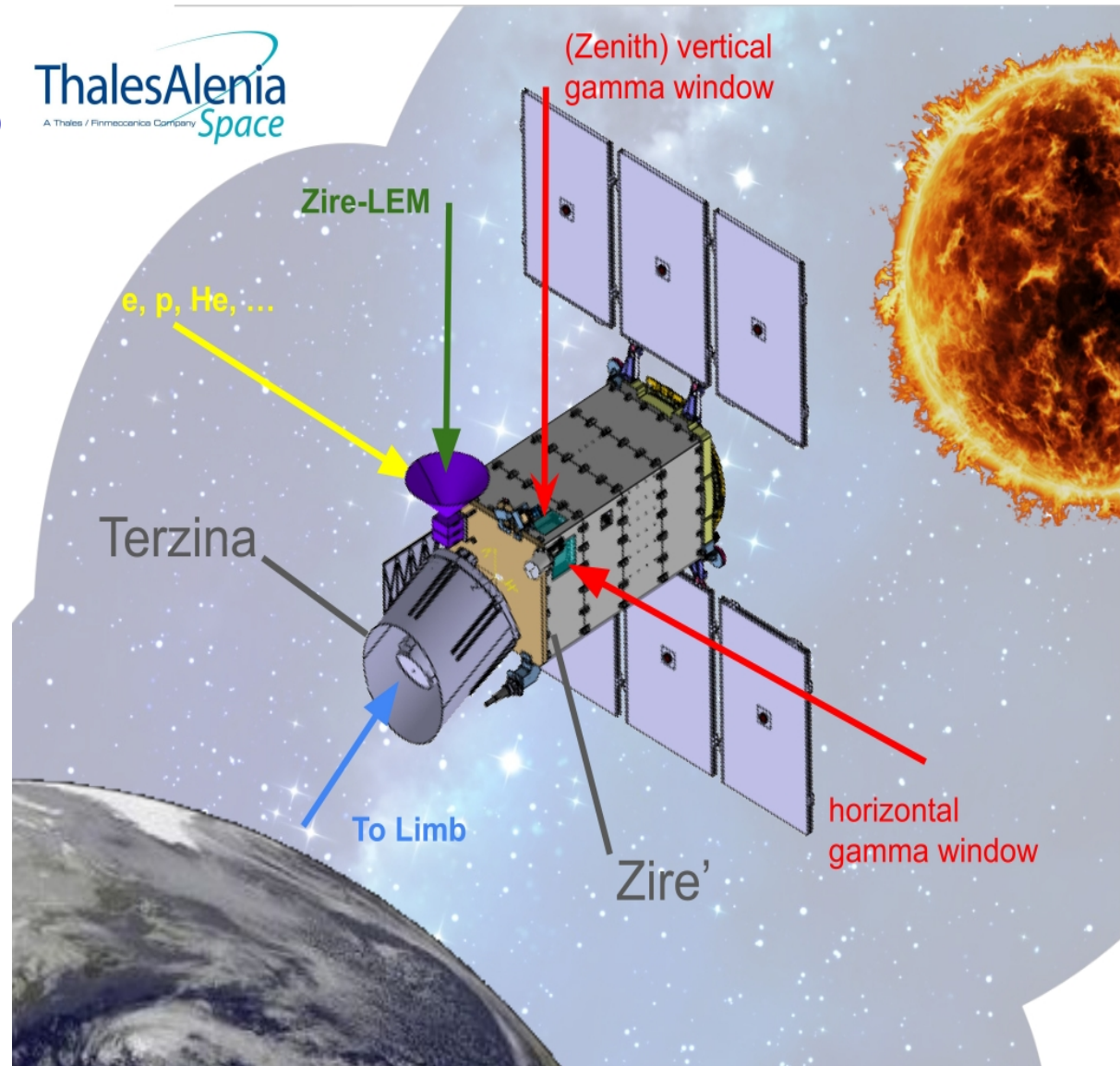
- I. Epicoco

ILBoard:

- Lorenzo Perrone

Publication and Conference Committee

- V Scherini



Simulation activities in Lecce

CORSIKA simulation productions

Test set

- fixed energy 10^{17} , zenith angle $79^\circ - 89^\circ$
100 showers per bin (1° steps)
- different primaries P – Fe – O

Energy dependence set

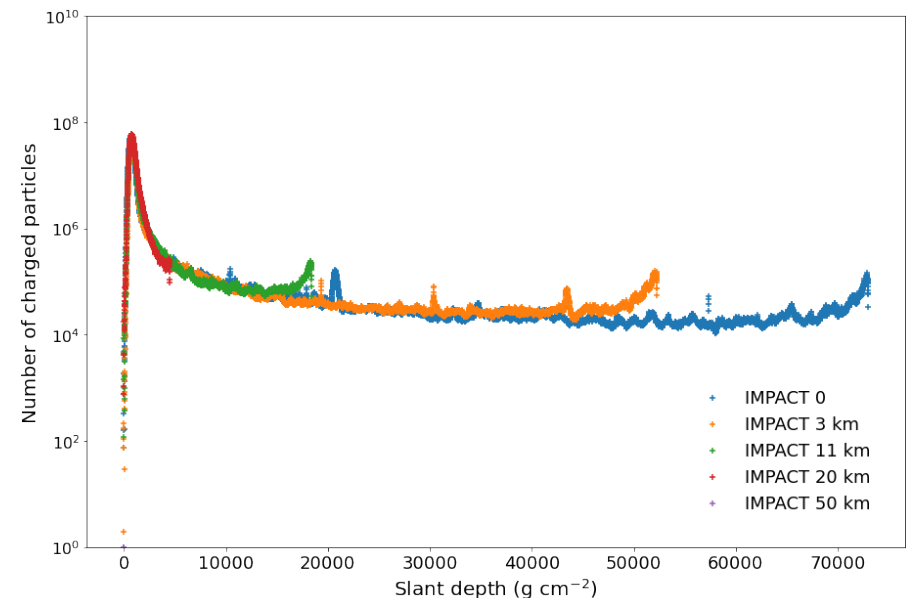
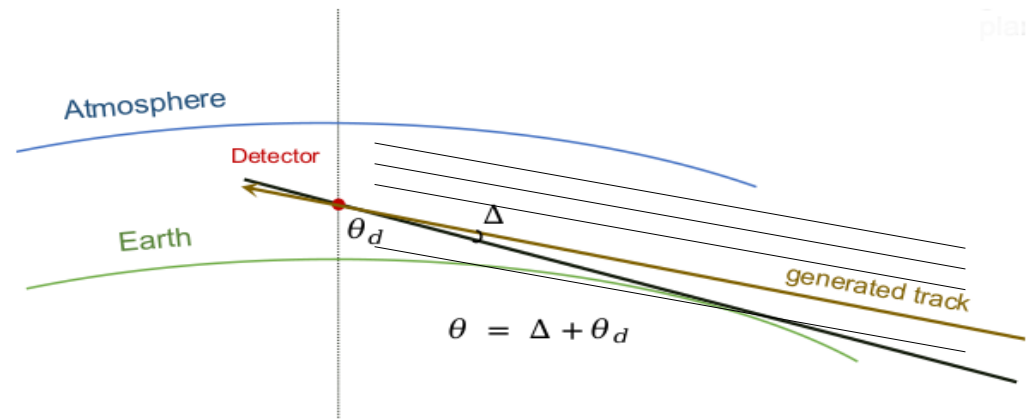
- energy bins $\lg(E/\text{eV})$ 15 – 20
100 showers per bin (0.5 in log steps)
- fixed angle 89° , Proton

Impact parameter option ~15000 sh/prim

- Corsika v 77500 with Fluka 2021-2
- P – He – O – Fe
- energy spectrum $E^{-1} \lg(E/\text{eV})$ [15.5,20],
different impact parameter (horizontal shower)

impact parameter

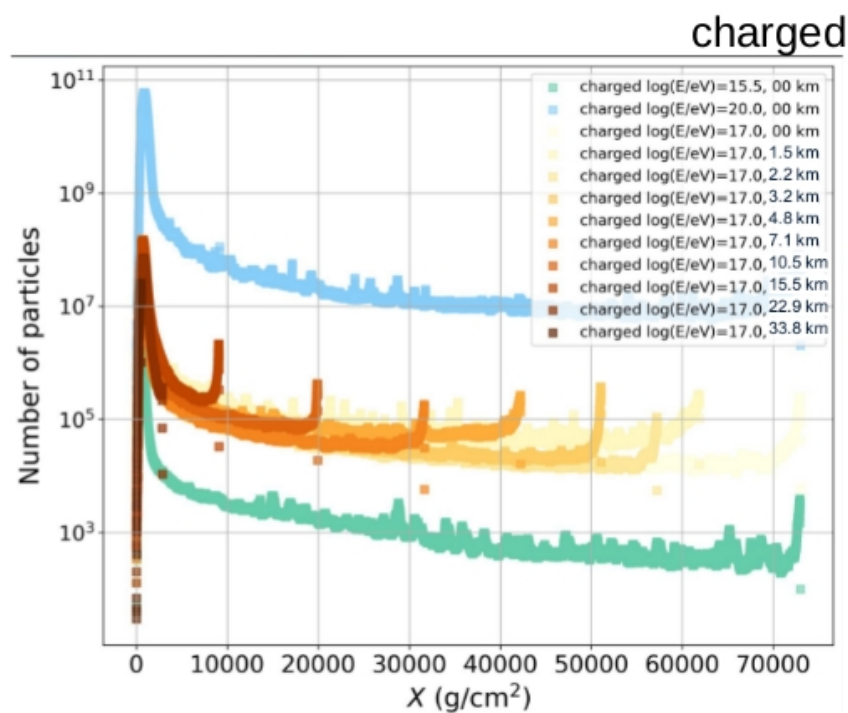
[0, 1.5, 2.2, 3.2, 4.8, 7.1, 10.5, 22.9, 33.8, 50] km



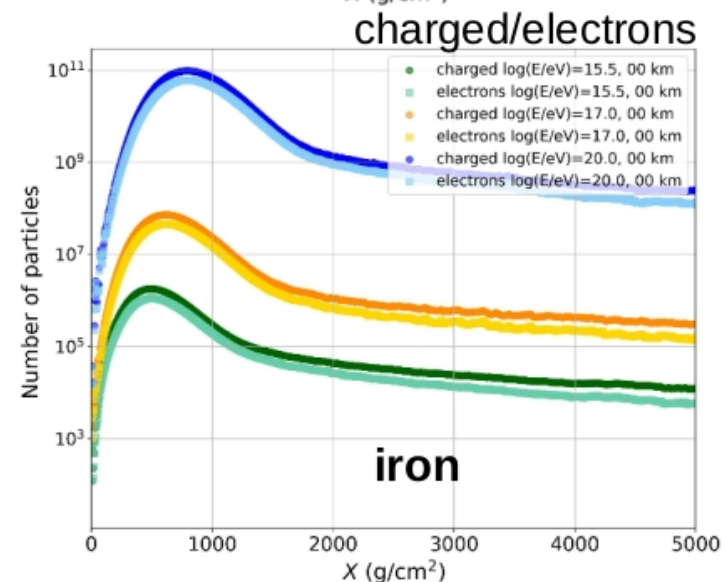
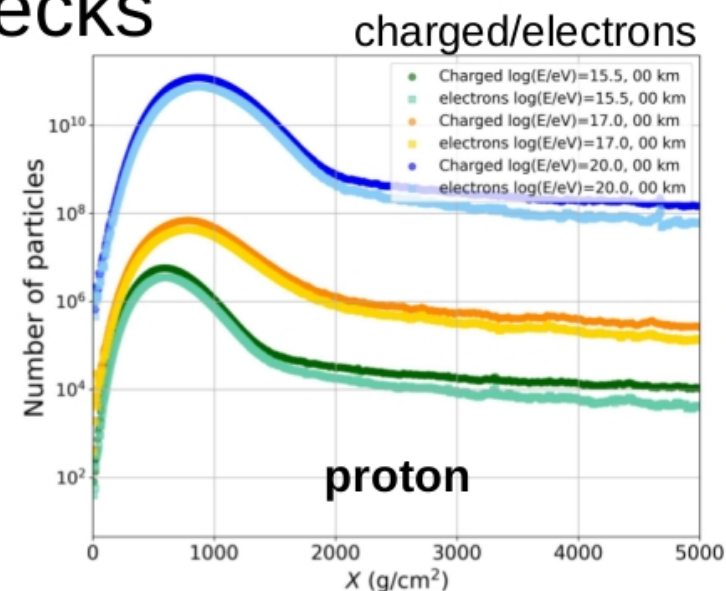
Longitudinal profile checks

Check on test productions

- particle distributions (charged – gamma – hadrons - nuclei)
- different primaries P – He – O – Fe
- energy bins $\lg(E/eV)$ 15.5 – 20



20
10 eV
17
10 eV
15.5
10 eV



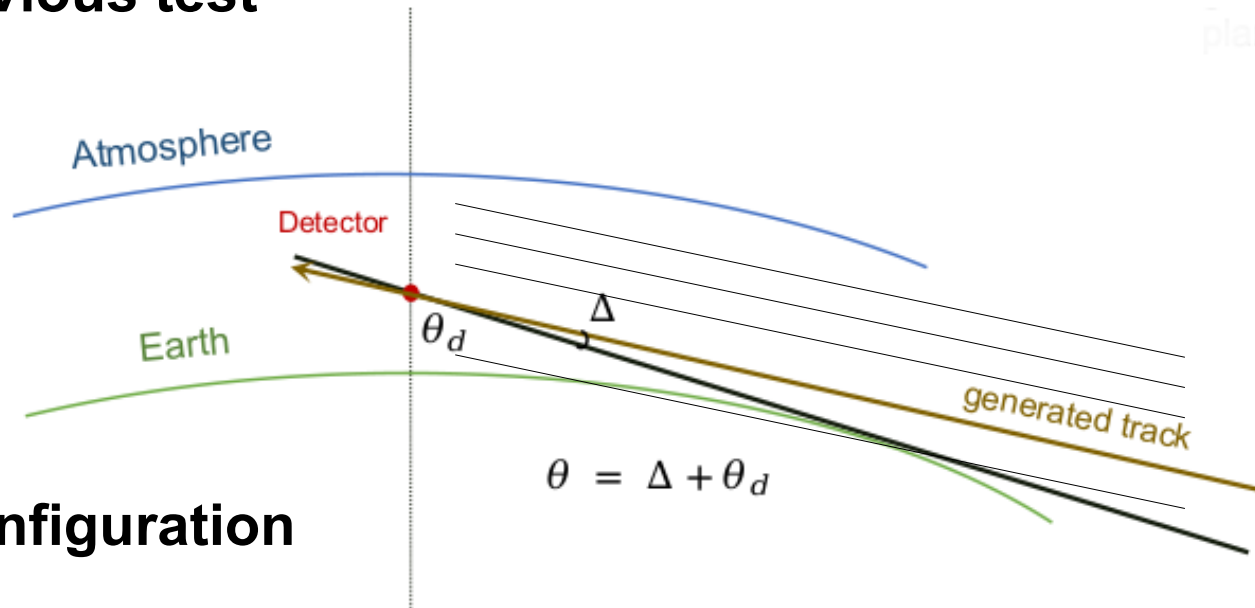
Current productions in the pipeline

Extending statistics on previous test productions

- 90° zenith
- different impact parameters
- energy spectrum
- different primaries

Lower Altitude / Balloon configuration

- zenith downward/upward-going very inclined (80°-100°)
- energy spectrum
- different primaries



NUSES: proposta di transizione in CSN2

2022-2024 sigla esterna monitorata da CSN5

- L.Perrone (RESP) → 20%
- V. Scherini → 20%

2025 CSN2

Totale: 1.7 FTE

- V.Scherini (RESP) → 30%
- L Perrone → 20%
- I. Epico (Ing.) → 100%

STATO ITER

TDR sottomesso dal PI alla CSN2 (30/6)
Preventivi per sedi in fase di definizione

SPB2 → sigla cessata a Lecce

SABRE@cds Lecce -2 July 2025



Collaboration Meeting in LECCE NOVEMBER 2024

RL: **Gabriella Cataldi (30)**

- Chemseddine Ananna (100)
- Maria Luisa De Giorgi (100)
- Sana Gul Khattak (100)
- Alessandro Miccoli (20)
- Daniele Montanino (20)
- Samina Zuhra (100)



PRIN 2022 PNRR: PUNTO (ProdUction of ultra-pure NaI detecTOrs by zone refining) - PI: Aldo Ianni.
INFN Lecce and UniSalento (ML De Giorgi)

External funds

[HOME](#) [Obiettivi Realizzativi](#) [Partners](#) [Risultati](#) [Documenti](#) [Eventi](#) [Contatti](#)

[HOME](#)

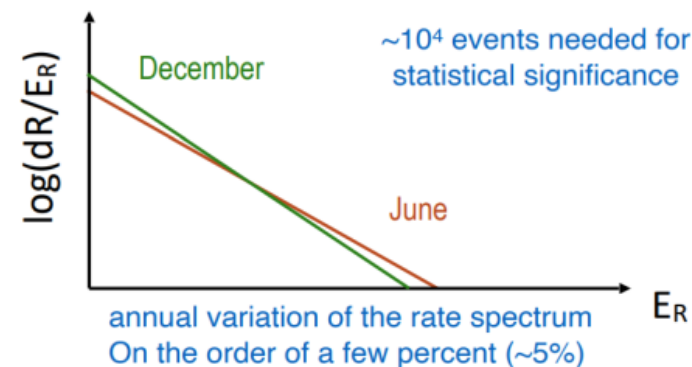
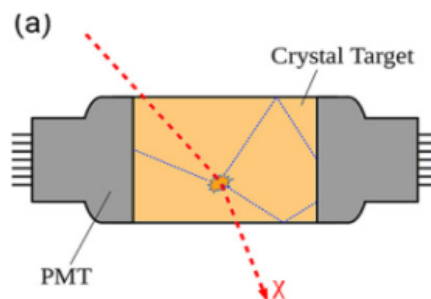
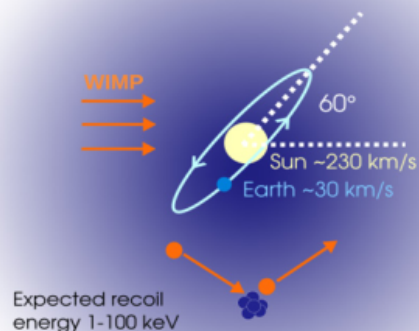
Il Progetto MAD – **La metamorfosi Additiva del Design** (Cod. ARS01_00717) – presentato in risposta all'Avviso Pubblico Prot. n. 1735 del 13/07/2017 emanato dal MIUR (Ministero dell'Istruzione, dell'Università e della Ricerca) – è finanziato dal Fondo Europeo di Sviluppo Regionale (FESR) nell'ambito del PON R&I 2014-2020 – Asse 2 – Azione II – OS 1.b) e dal FSC (Decreto di Concessione Prot. n. 1547 del 29/09/2020).

Il Soggetto Capofila del partenariato pubblico-privato è l'**Istituto Nazionale di Fisica Nucleare (INFN)**.

The SABRE enclosure is the scientific demonstrator of MAD

- Talk at UCLA_DM 2025 (G. Cataldi)
- Poster presentation at ISAPP 2025 (S.G. Khattak-S. Zuhra)
- SIF Contribution 2025 (S.G.Khattak)

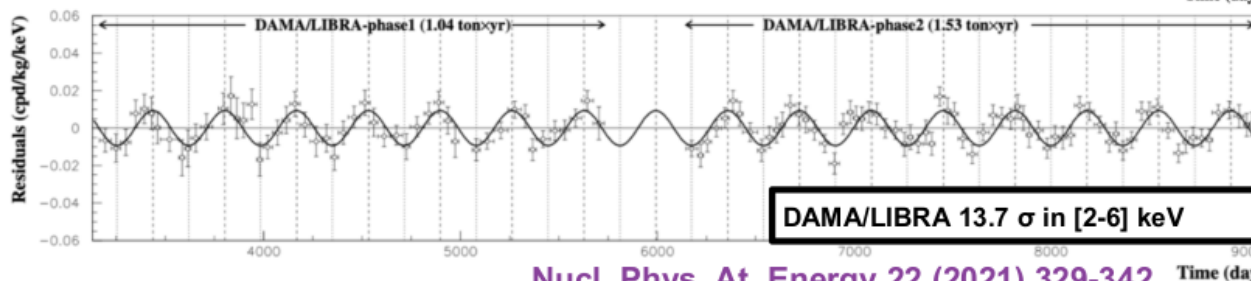
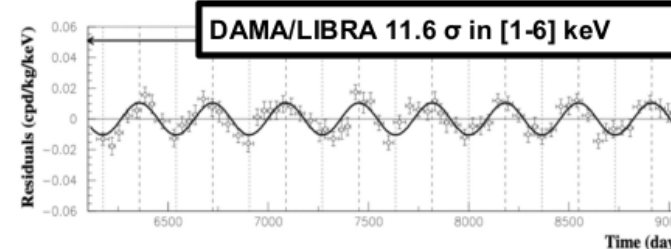
The physic contest: Dark Matter with annual modulation



- ✓ Expected rate in an Earth-based detector is modulated
- ✓ Small modulation fraction $S_m/S_0 = O(\sim \text{few } \%)$
- ✓ Region of interest [1-6] keV

Rate vs time

$$R = S_0 + S_m \cos\left(\frac{2\pi}{T}(t - t_0)\right)$$

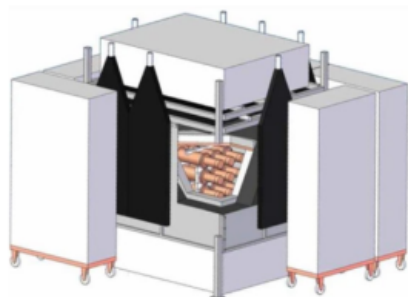


Nucl. Phys. At. Energy 22 (2021) 329-342 2

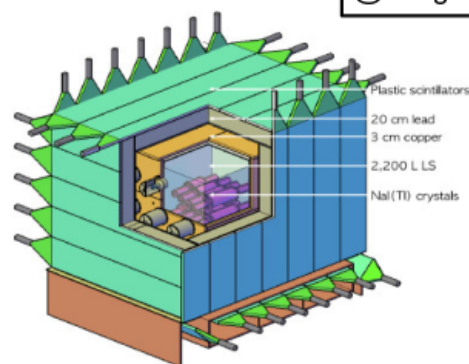
Nal(Tl) experimental landscape worldwide



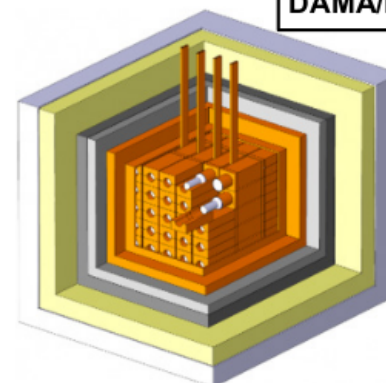
ANAIS112
@Canfranc, Spain



COSINE-100
@Yang Yang, South Korea



DAMA/LIBRA @LNGS, Italy



ENDED
DATA TAKING IN 2024

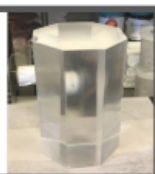
SABRE's strategy to exploit the physics case

Two site experiments: SABRE North and SABRE South

Purification of Astro Grade powder by zone refining
Crystal growth from purified Astro Grade powder
Grow crystals from chunks of zone refined powder
Expected background order of 0.5 dru in ROI [1,6] keV

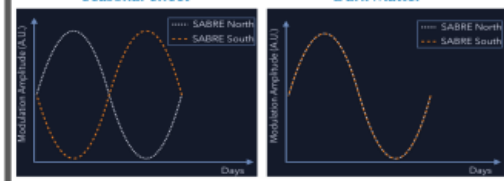
45 kg mass allows 4σ statistical sensitivity to DAMA-like signal in 3 years assuming negligible cosmogenic activity

Ultra radio-pure
crystals



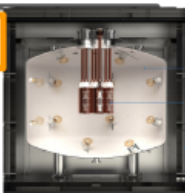
Double location:

Northern and Southern hemisphere
Seasonal effect Dark Matter



@ SABRE South only

Active veto with
liquid scintillator



Main activities since September 2024



Nal-41 : first crystal grown from chunks

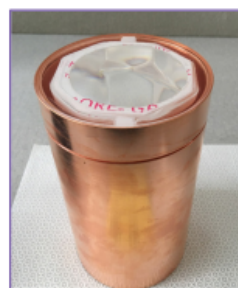
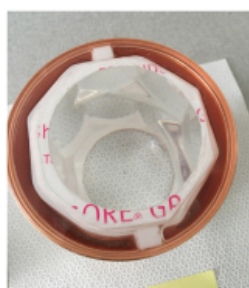
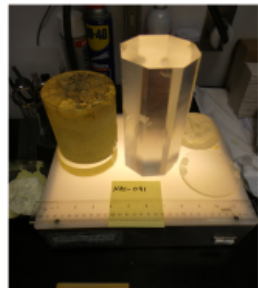
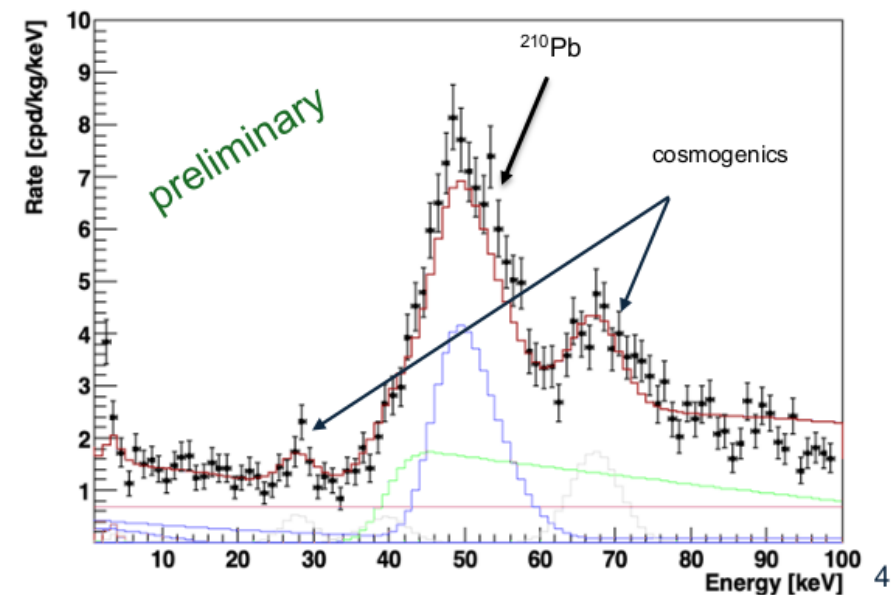
LY = 10.02 +/- 0.03 phe/keV

FWHM energy resolution: 15.7% @59.6 keV

^{39}K : 5.7 ± 0.9 ppb

Results of ICP-MS measurements

	^{39}K [ppb]	^{65}Cu [ppb]	^{85}Rb [ppb]	^{138}Ba [ppb]	^{133}Cs [ppb]	^{208}Tl [ppm]
Tip	<4	<5	<0.8	<0.2	<0.3	520 ± 4
Tail	13.4 ± 0.3	<5	<0.8	1.1 ± 0.2	1.7 ± 0.1	1343 ± 10
Far Tail	20.2 ± 0.4	10.8 ± 0.8	<0.8	2.8 ± 0.3	4.2 ± 0.3	1607 ± 12



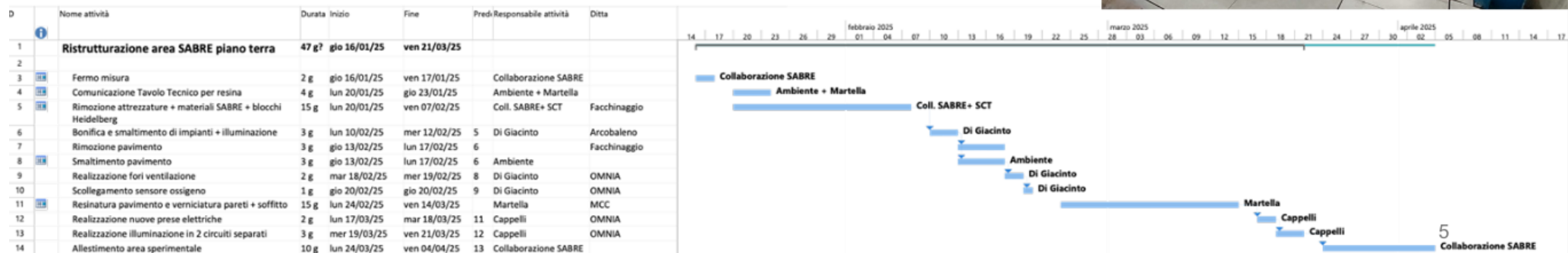
The successful growth of the NaI-41 crystal from chunks and its excellent optical properties represent an important step in our approach to producing high radiopurity crystals.

Main activities since September 2024

Refurbishment of Underground area@LNGS



- A plan to refurbish the SABRE building ground floor was agreed with LNGS in 2024
- Schedule foresaw $\approx$ 3 months works
- The area was cleared from SABRE materials at the begin of January 2025
- Resin coating work is now completed
- Electrical works + ventilation has just started
- The area has not yet been made available to the Collaboration as of today



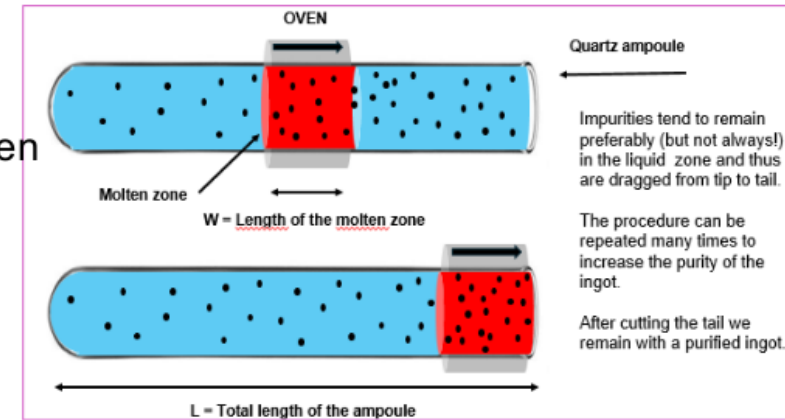
ZR Activities – from measurement to modeling



- ✓ Zone refining technique successfully used in semiconductor industry
- ✓ Impurities are segregated to one side of the ingot moving the ovens
- ✓ Tested on Nal Astro grade powder by Princeton group at Mellen company, Concord, NH (USA)

ZR was successfully run in sep2023-mar 2024

ZR run	Date start	Date stop	Ampoule anti-sticking treatment	Astrograde lot #	Loaded mass [gr]	ZR speed [mm/h]	Number of Passes
1	29-sep-23	10-oct-23	C coating	76650	893	38	26
2	15-oct-23	6-nov-23	C coating	76650	900	50	51
3	4-gen-24	19-gen-24	SiCl ₄	MKCC0371	900	50	60
4	18-mar-24	8-apr-24	SiCl ₄ + gas removed prior to ZR	MKCC0371	900	50	56



Unfortunately the following ZR runs (with proposed protocol and larger dimensions of ampoules) have not been successful

- In order to optimise the use of the zone refining equipment, we have undertaken an in-depth study of the technique and analysed the collected data of the successful zone-refining.
- Results obtained used for:
 - Optimizing ZR procedure (time, powder use, output)
 - Use data and results for a publications

See Results in BACK-UP

Main activities since September 2024



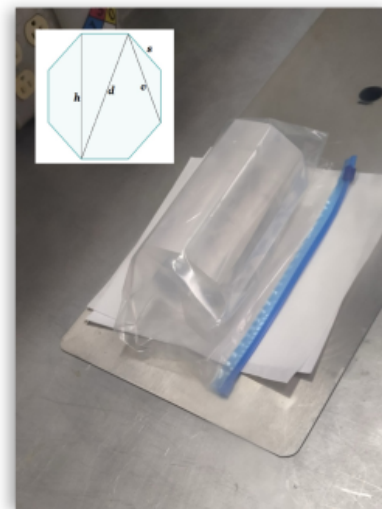
Crystal from COSINE powder: NaI-47

In the framework of an international agreement between INFN and IBS, INFN received 15 kg of powder in-kind from COSINE Collaboration
Powder screening at LSC by ICP-MS (*)

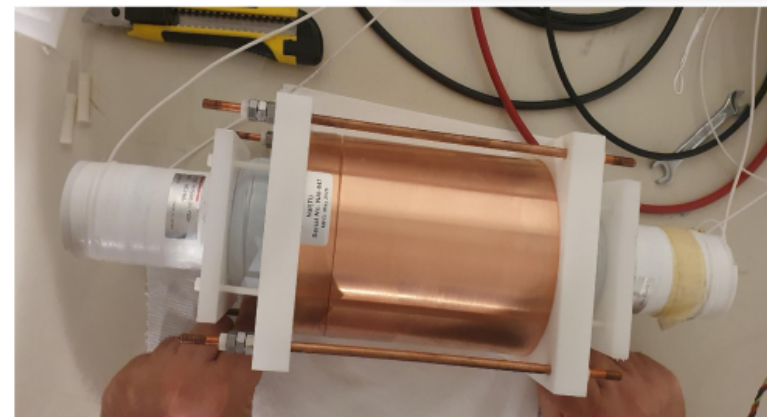
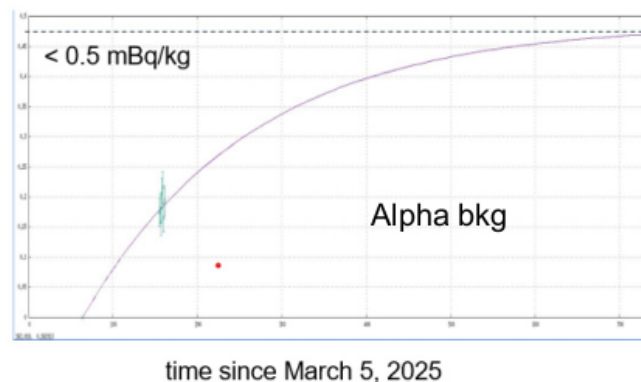
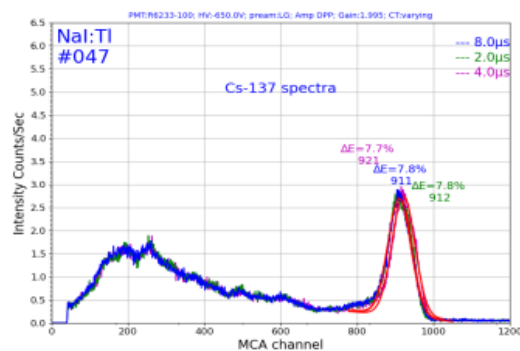
Powder	³⁹ K [ppb]	⁸⁶ Sr [ppb]	⁸⁵ Rb [ppb]	¹³³ Cs [ppb]	¹³⁸ Ba [ppb]	⁶⁵ Cu [ppb]	²⁰⁸ Pb [ppb]
in-kind Cosine-200	12.5	<0.8	<0.3	6	1.2	82 ± 3.5	0.6
Astro Grade	~4-18	0.3	< 0.4	< 1	3.6	79.4 ± 2.8	~1

(*) LNGS has now the same spectrometer used at LSC. Soon we will be able to perform ICP-MS assays at LNGS with same sensitivity.

- Mass: 3.65 kg
- Dimensions: 152 mm length, 89.1 mm octagon side to side (h)
- Copper enclosure dimensions: 162 mm length, 114.3 mm diameter, thickness: 2.75 mm
- Crystal out of oven March 5, 3.65 kg
- Crystal received at LNGS by air in RMD enclosure May 30, 2025
- Alpha background characterization underway



ICP-MS on sample of the crystal are ongoing in Canfranc (part of the PhD Thesis of S.G, Khattak.Lecce)



Main activities since September 2024

Activities on PMTs (Lecce setup)

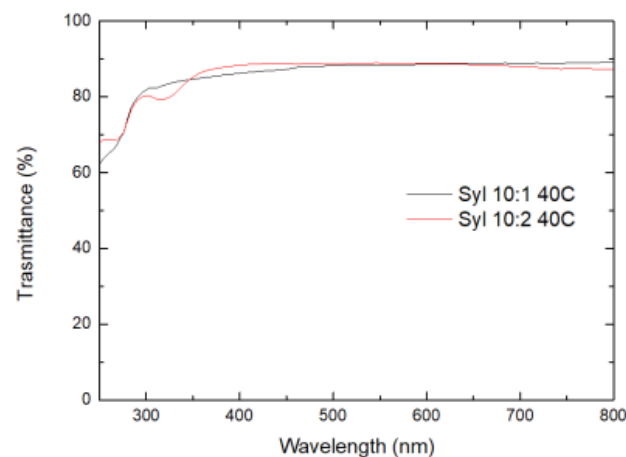
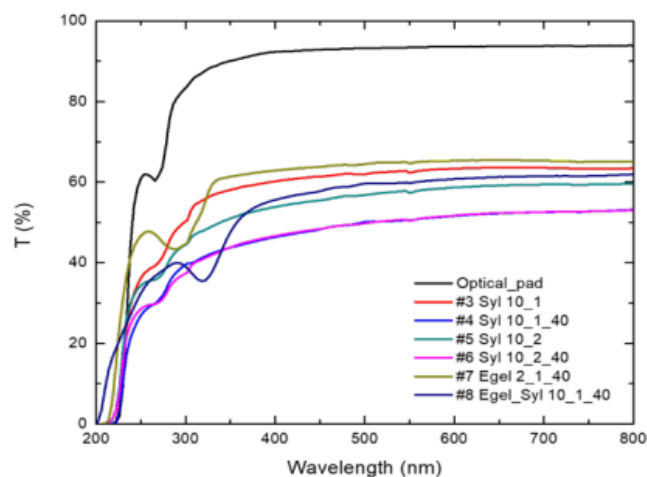
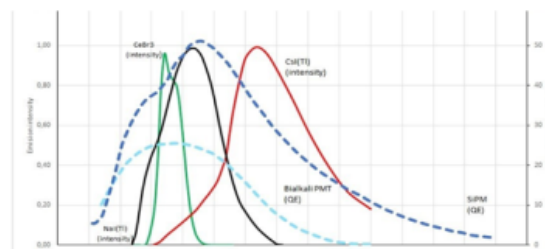


- Two Plug-in/plug-out couple of dividers ready for Hamamatsu R11065-20
- + Two Hamamatsu R11065-20 arranged with “PMT mount”
- “3D printed” envelope support – ongoing (use of load cell)
- V1730D – CAEN digitizer (from Auger group)



Activities on coupling materials

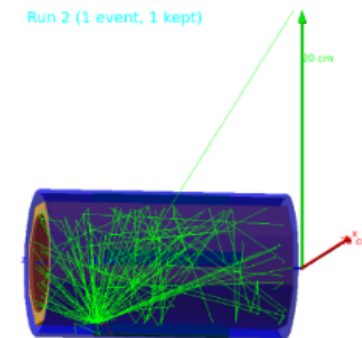
transmission measurements on different coupling materials have been performed



Simulazioni ottiche con Geant4

È stata realizzata una simulazione Monte Carlo con Geant4 per studiare la propagazione dei fotoni ottici all'interno della geometria del cristallo (vedi Figura 1), con particolare attenzione all'interazione con i materiali riflettenti come PTFE e silicone. Le misure ottiche sui materiali sono state eseguite nel laboratorio di fotonica del Dipartimento di Matematica e Fisica "E. De Giorgi" dell'Università del Salento. L'obiettivo è ottimizzare la raccolta di luce da parte dei PMT.

Run 2 (1 event, 1 kept)



1. Propagazione dei fotoni ottici nella geometria del cristallo. Simulazione Monte Carlo realizzata con Geant4.

Un esempio mostrato riguarda la distribuzione spaziale della luce nella finestra in silicone generata dal decadimento del ^{40}K nel PTFE. I primi risultati indicano una produzione media di circa 7 fotoni ottici per ogni decadimento del ^{40}K nel materiale.



TO DO in 2026

- SABRE IS A «SMALL COLLABORATION» therefore is a global involvement in many activities
- Main financial Request in Lecce for 2026: For the full scale EXP: **PMTs procurement** (12 PMTs for the full scale) (70 k Euro)

Given the involvement and setup. request of
3 m.FTE electronics
3.m.FTE. mechanical



EUCLID Lecce

Status and present results. The future.

Main Activity 2025 as Lead of Euclid SSO-SWG and as members of Euclid Transient-SWG, SL-SWG, and LU-SWG

- **Calibration Phase: Phase Diversity Campaign**
- **Developing codes for the detection of SSOs to be run at the EUCLID SOC in ESA/ESAC (Madrid, Spain) in DATALAB infrastructure**
- Simulations for LU-SWG
- AI to be applied on REDSHIFT estimates
- Our calibration software used by the Transient-SWG for Supernova Detections (with success)



Attività del gruppo INFN di Lecce nell'anno 2025

Il gruppo INFN di Lecce ha la leadership del gruppo di ricerca denominato SSO-SWG per la ricerca, classificazione e caratterizzazione degli oggetti del sistema solare osservati dal satellite Euclid.

I software sviluppati hanno permesso di osservare oltre 12000 oggetti SSO dei quali circa 2000 sono nuove scoperte.

I codici sono stati anche condivisi con il gruppo INAF responsabile del Transient-SWG che, con il supporto del nostro codice, ha raggiunto la precisione astrometrica tale da permettere la scoperta di nuove supernovae (circa 200) nelle immagini di calibrazione Euclid/VIS. I risultati ottenuti sono stati apprezzati dal consorzio Euclid tanto da meritare 2 contributi nelle sessioni plenarie dell'ultimo Euclid Consortium Meeting.

Il codice è stato installato nell'ambiente ESA DATALAB e la pipeline è fatta girare giornalmente da remoto.

Stiamo ultimando la ri-analisi dei dati acquisiti verso l'eclittica per

1) Nuovo algoritmo di ricerca dei raggi cosmici e produzione delle maschere

A partire dalla metà di Luglio 2015, i codici gireranno sui dati della survey wide di Euclid.

SSO-SWG → solar system objects – science working group

2024-2025 Activity of SWG-SSO in the framework of a pilot study (with CAL field) endorsed by ESA and EC
A golden recipe to solve astrometry and achieve a reasonable good level (and routinely) at quadrant level
Down to ~ 10 mas (depending on # references)

- 1) Reduction done on quadrant level (144 HDUs): bias, flat, mask, prescan/overscan. Output is a 144 HDU mosaic.
- 2) A few fundamental keywords copied from 0 header in raw data to any of the other 144 HDUs (RAOBS, DECOB, PA).

A few other keywords generated:

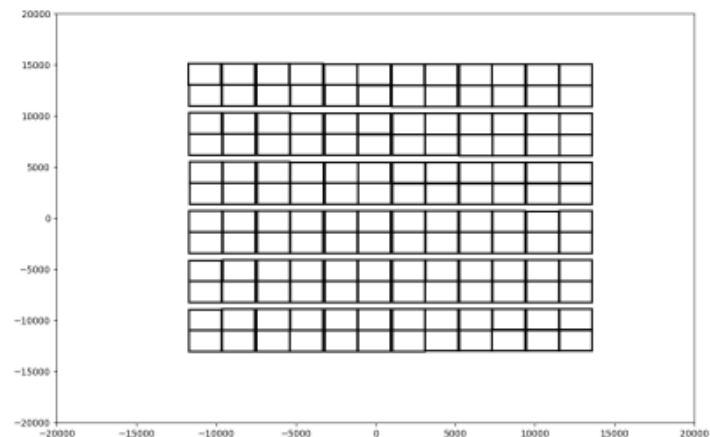
CRVAL1, CRVAL2 (from RAOBS, DECOB),
CDELTA1, CDELTA2 (from pixel size),
CROTA2 (from PA)
CRPIX (updated to account for cuts on
prescan/overscan regions)



A first guess on quadrant WCS

$$\begin{aligned} \text{CD1_1} &= \text{CDELTA1} * \cos(\text{CROTA2}) \\ \text{CD1_2} &= -\text{CDELTA2} * \sin(\text{CROTA2}) \\ \text{CD2_1} &= \text{CDELTA1} * \sin(\text{CROTA2}) \\ \text{CD2_2} &= \text{CDELTA2} * \cos(\text{CROTA2}) \end{aligned}$$

- 3) Run a local installation of **astrometry.net**. During the call, using a set of **CRPIX1**, and **CRPIX2** values coming from an observation already astrometrically corrected (let's call this VIS Geometry Map). **C_{dij}** values are updated by **astrometry.net**. **Downsampling 5.**



Output could be a feedback for further OBS ID

Using **GAIA DR3**, **UNWISE** and **PANSTAR** catalogues extracted towards (**RAOBS**, **DECOBS**) and extraction radius **R=3** degrees. When astrometry fails, **CRPIX1,2** kept from the VIS Geometry Map, **C_{dij}** kept from the surrounding successful quadrants. **No-Tweak** (no polynomial deformations) at this stage.

(R. Vavreck, B. Carry, M. Granvik, B. Altieri et al): PDC planning and data acquisition

During the PDC, target fields with ecliptic longitude in range $\sim 6.5 - 14.8$ degrees will be observed (Dec 23rd - Dec. 31°)

The patch is fully centered on the ecliptic plane, the height of the patch is $\sim 3 \times \text{FoV}$.

OBS LOG:

MJD from 60301.8 to 60309.58.

OBSID from 66202 to 66350

EC ENDORSEMENT FOR USING PDC data

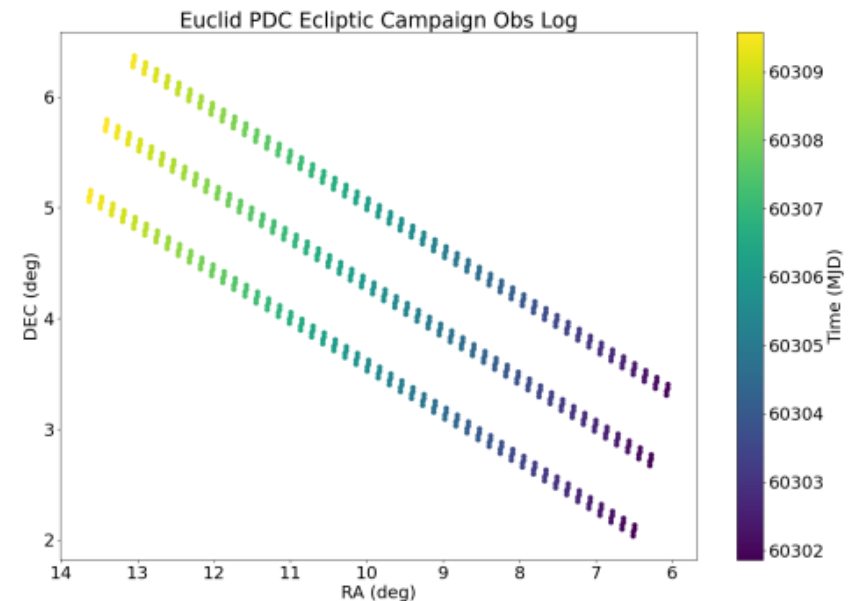
PRESENT ANALYSIS on DATALAB .

1 PhD students full time (M. Pontinen)

1 PNRR Fellow (A. Franco up to December 2025 !!)
working on synergic project

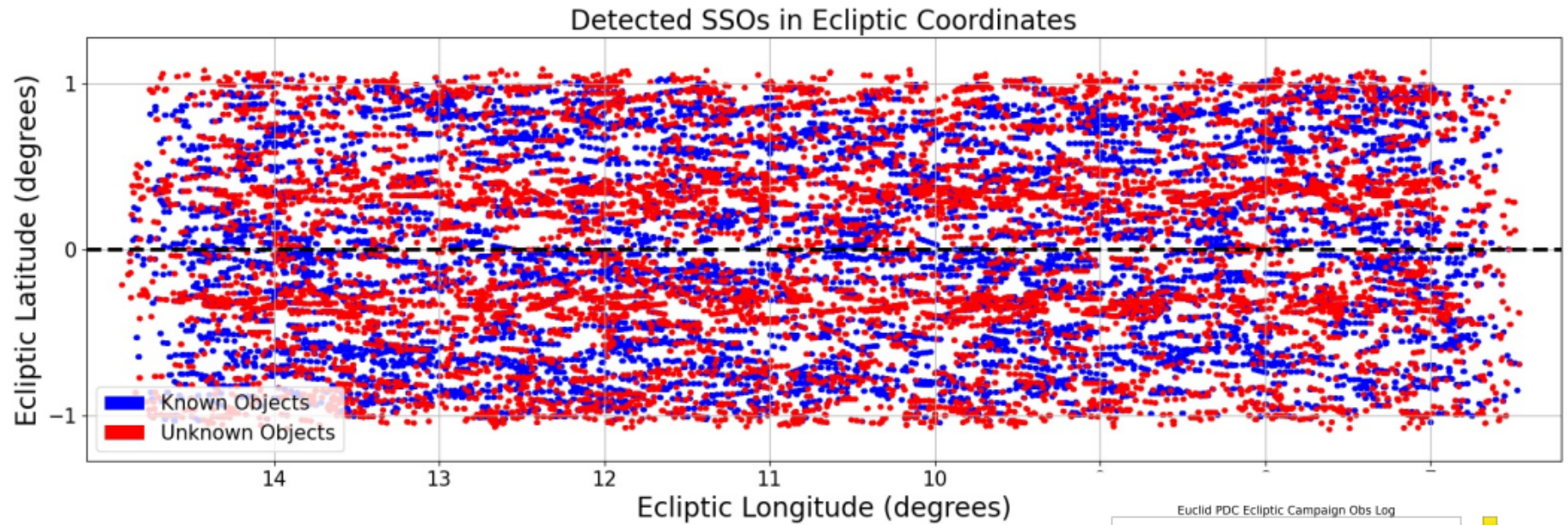
1 part time external –INAF- post doc (S. Sacquegna)

Analysis of the PDC Observation IDs (above) **terminated** using the described pipeline (Source Extractor, Astrometry.net, Scamp, SSOFinder and StreakDet) on DATALAB. This was also a mile-stone of the INFN EUCLID project for 2025



PDC → photometric dispensor corrector

PDC Results

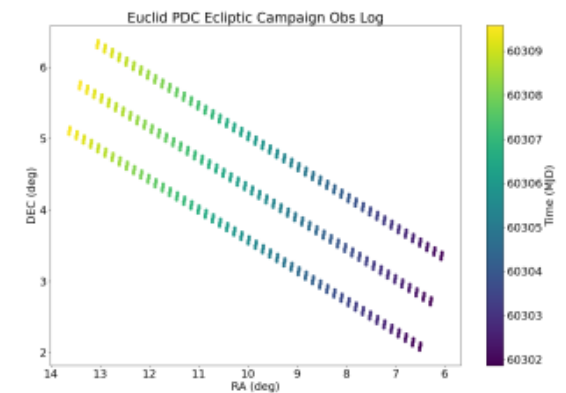


43 179 detected SSO streaks

23 048 (53.4%) matched to 2334 known SSOs: ~10 streaks per SSO

20 131 (46.6%) streaks from unknown objects: ~2000 new SSOs

<1% false-positive rate



Attività prevista per il 2026

Nel corso dell'anno 2026, il gruppo INFN di Lecce manterrà la leadership del gruppo di ricerca denominato SSO-SWG per la ricerca, classificazione e caratterizzazione degli oggetti del sistema solare osservati dal satellite Euclid.

La migrazione della pipeline di detezione (originariamente installata su un server INFN presso la sezione di Lecce) sui server ESA è stata completata in Aprile 2025 in ritardo rispetto alle previsioni a causa della necessità di implementare la creazione di maschere dei raggi cosmici identificati nelle immagini.

Da Agosto 2025 il gruppo inizierà ad analizzare i dati della wide survey di Euclid. L'attività è prevista continuare per tutto il 2026.

In collaborazione con il gruppo SL-SWG, il gruppo di Lecce applicherà un software di classificazione sviluppato per l'analisi non supervisionata dei dati per la ricerca di lenti gravitazionali forti.

Abbiamo applicato la nostra rete neurale alla stima via MACHINE LEARNING di redshift cosmologici fino a $z=2.5$ solo attraverso l'analisi di misure fotometriche. Paper in sottomissione su un campione di validazione della survey VISTA. Applicazione nel 2026 a dati Euclid-like o parzialmente mancanti di misure fotometriche.

De Paolis	Francesco	50%
Franco	Antonio	0%, borsa PNRR ma lavora sul progetto sinergico
Nucita	Achille	40%
Orofino	Vincenzo	50%
Sacquegna	Simone	10%, INAF. Osservatorio di Teramo. Scadenza associatura INFN Lecce 30 Giugno 2025. Nulla osta associatura INFN Lecce per il 2026 in corso
Strafella	Francesco	*
Portaluri	Elisa	10%, INAF. Tecnologa Osservatorio di Teramo. Distaccata presso il Dipartimento dal Primo Luglio 2025. Nulla osta associatura INFN Lecce per il 2026 in corso
D'Elia	Marcella	20%

Capitolo	Descrizione	Parziali (K-EUR)	Parziali SJ (K-EUR)	Richieste	SJ
missioni	4 ke per la partecipazione al prossimo meeting internazionale Euclid (3 persone), 1 ke (s.j) per la partecipazione di 2 persone al prossimo meeting italiano su Euclid.	4	1		
pubblicazioni	Spese di pubblicazione su una rivista di interesse astrofisico (ApJ)	1.00	0.00		
Totale	/	5	1	5	1

Si richiede l'intervento del servizio di Calcolo per 2 m/uomo

RESUME:

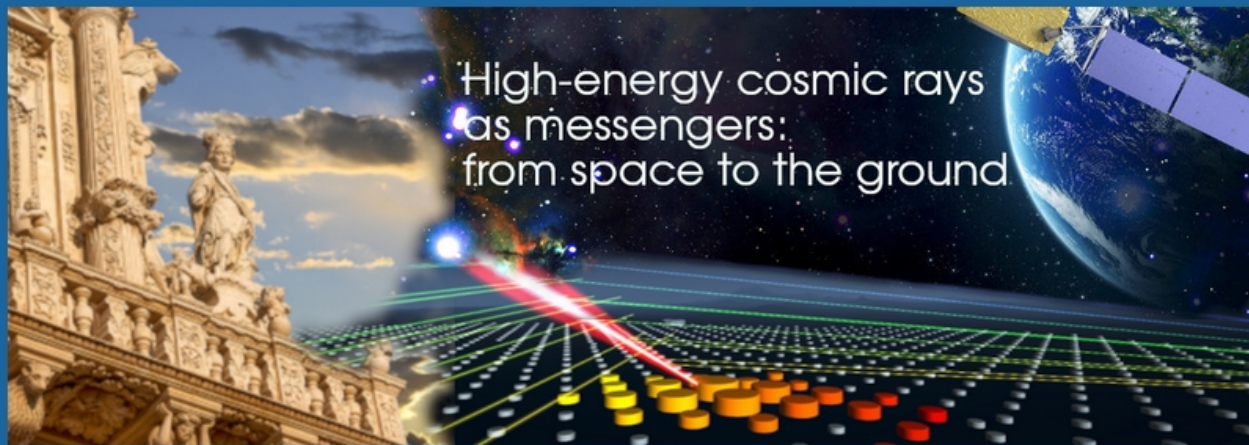
Richieste 2026: 5k +1k sj

FTE TOTALI

1.8 se le nuove associature saranno completate

1.6 (De Paolis, Nucita, Orofino, D'Elia)

ISAPP school 9-20 Giugno - Rettorato



ISAPP 2025 Lecce

9-20 Jun 2025
Rettorato Università del Salento
Europe/Rome timezone



Thanks for participating in ISAPP 2025 Lecce!

[Overview](#)

[Timetable](#)

[Registration](#)

[Participant List](#)

[Payment](#)

[Venue](#)

[Local Organizing
Committee](#)

[Software Instructions](#)

[Tips from Locals](#)

[Excursion to Otranto on
Sunday 15](#)

[School photo](#)

[Contact](#)

lorenzo.perrone@le.infn.it

daniela.dellanna@unisa.it

School photo



**Grazie a tutti
coloro che
hanno
collaborato!**

BACKUP

Telescope focal plane

SiPM arrays: **8 x 8 channels**

Pixel: **3 x 3 mm²**

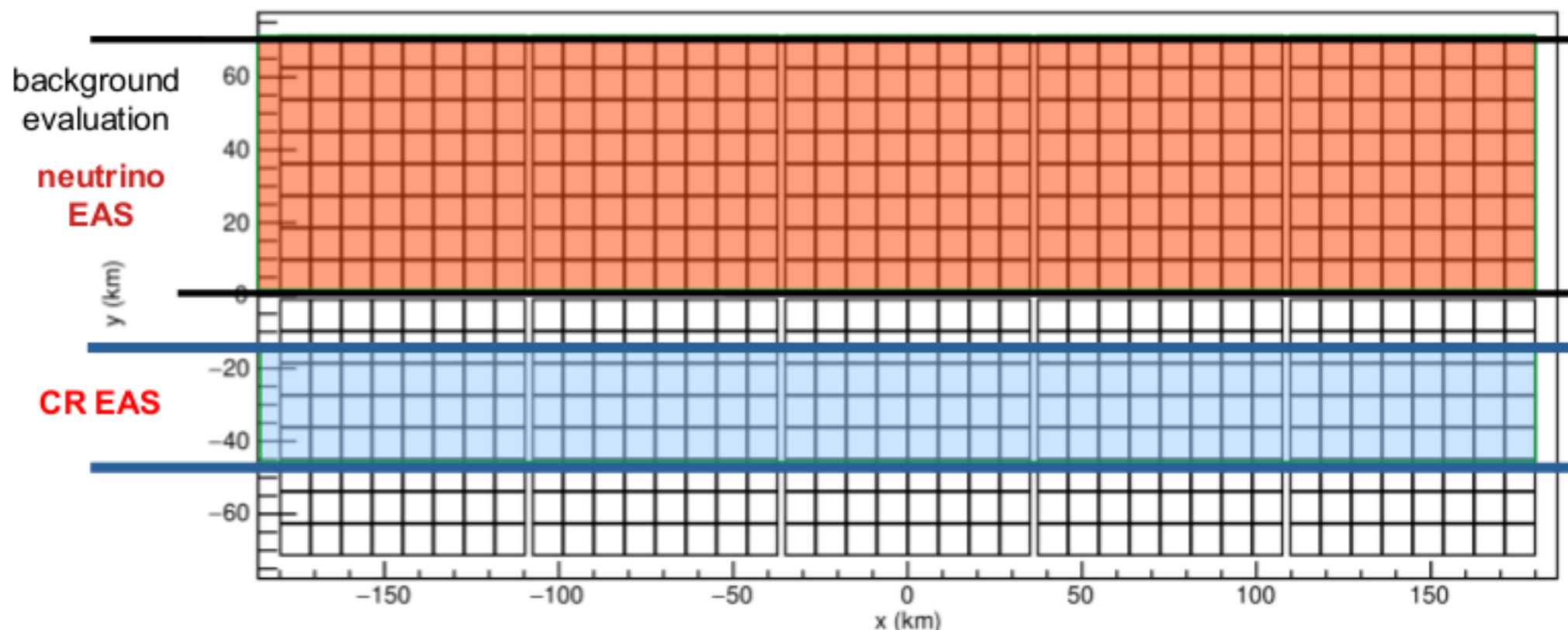
Pixel FoV: $\text{atan}(r_{\text{pix}}/F_L) \sim 0.18^\circ$

5 x 2 = 10 SiPM arrays in total
(8 x 8) x 10 = 640 pixels (channels)

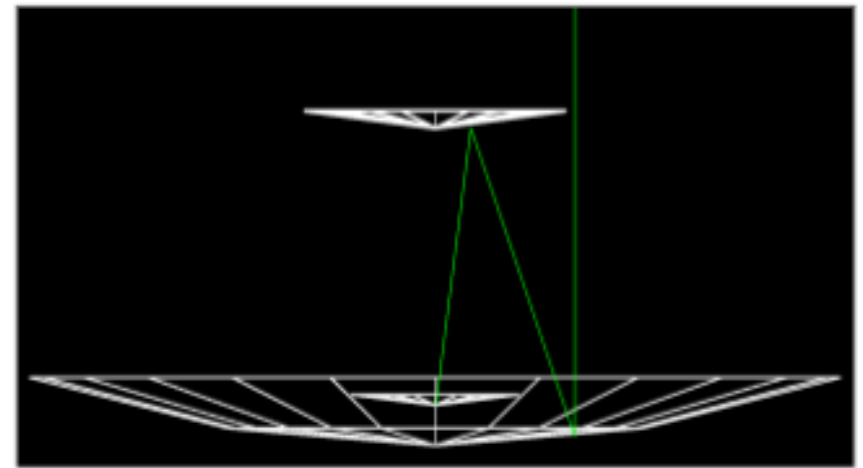
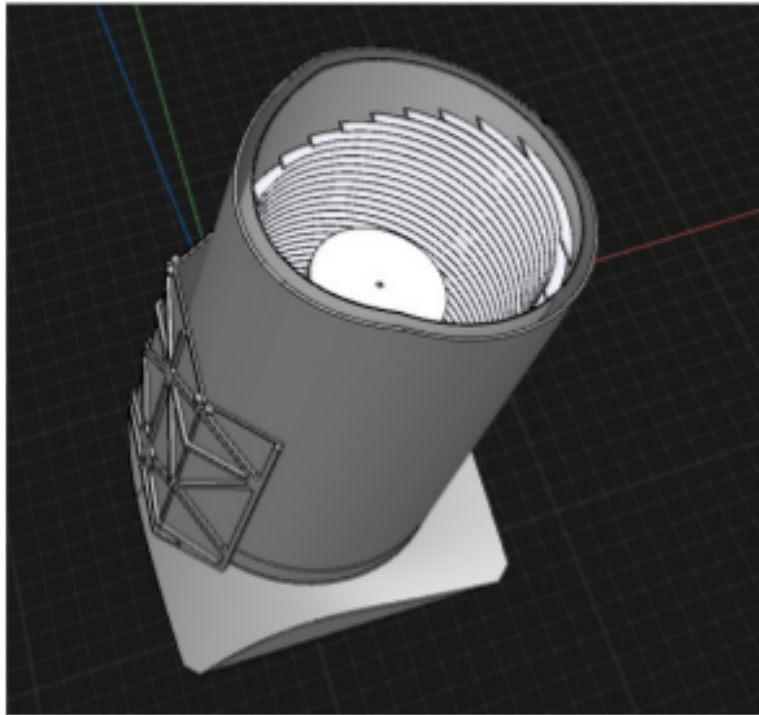
Array dim. : 25.3 x 25.3 mm²
Array Eff. area : 24 x 24 mm²



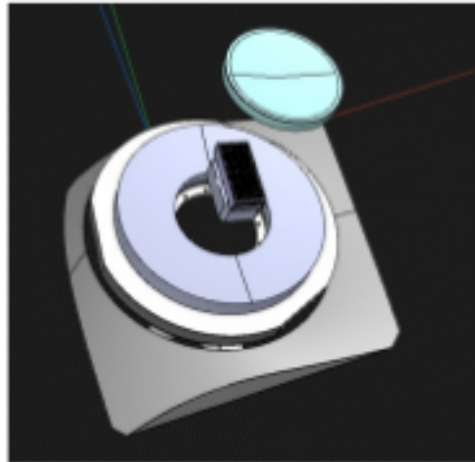
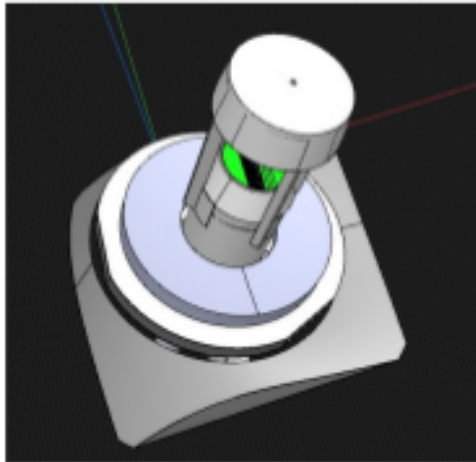
Camera plane with projection on the Earth (total area 360x140 km²)



Terzina telescope

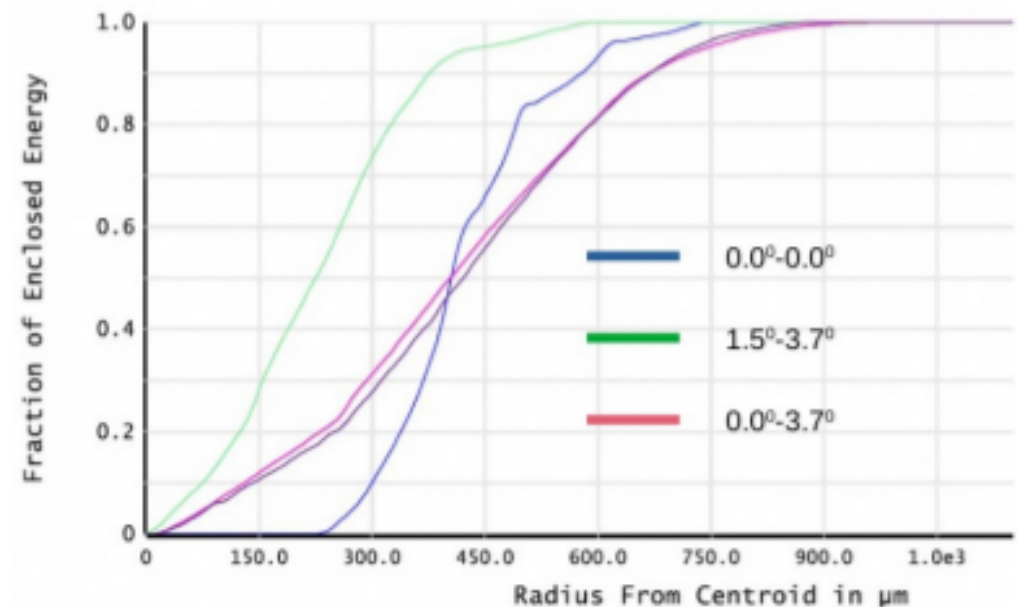


- ✓ Equivalent focal length $F_L = 925$ mm
- ✓ Field of View (FoV) : 7.2°
- ✓ Point spread function (PSF) : <1.0 mm
- ✓ Effective area of the telescope : 0.1 m²
- ✓ M1 paraboloid, M2 hyperbole

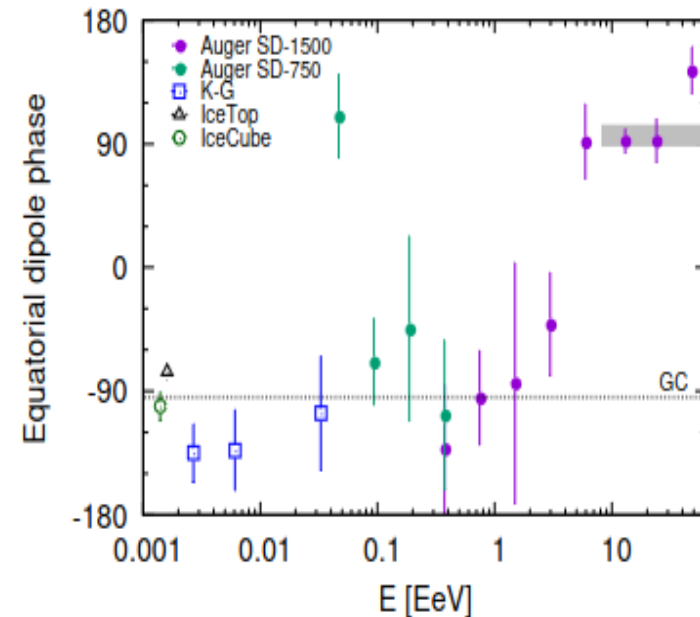
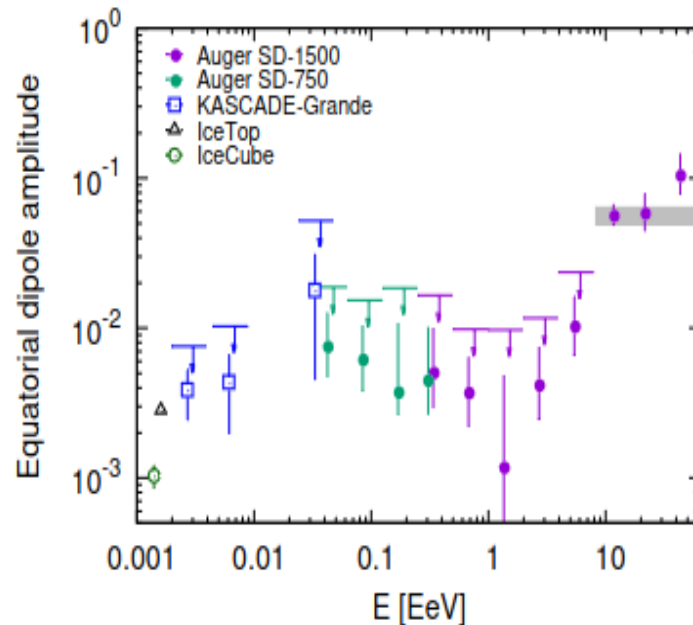


Terzina total weight ~40 kg

Point spread function for different inclination angles



Large scale analysis in R.A. at $E \geq 0.03$ EeV

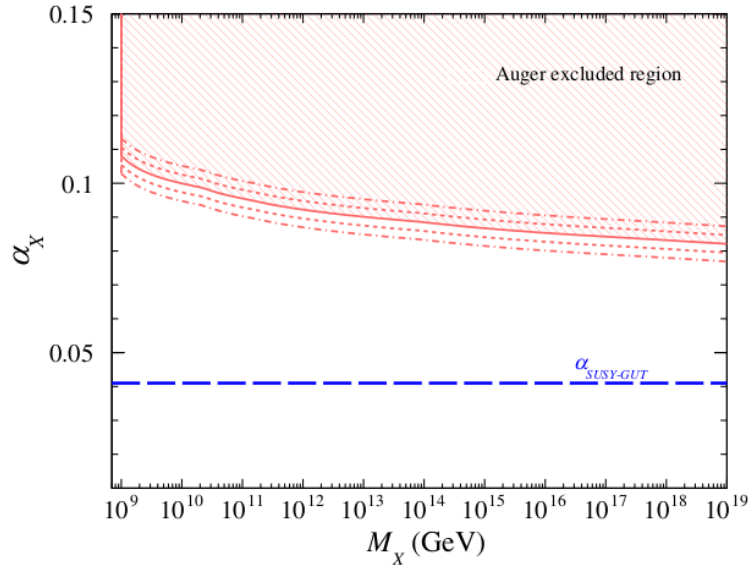


Even though the results for the lower E have a $P > 1\%$, amplitudes grow from below 1% to above 10% and phases shift from $\sim$ GC to the opposite direction

=> suggests a transition of the origin of the anisotropies from galactic to extragalactic

Cosmological implications of photon-flux upper limits at ultrahigh energies in scenarios of Planckian-interacting massive particles for dark matter

Using the data of the Pierre Auger Observatory, we report on a search for signatures that would be suggestive of super-heavy particles decaying in the Galactic halo. From the lack of signal, we present upper limits for different energy thresholds above $\gtrsim 10^8$ GeV on the secondary by-product fluxes expected from the decay of the particles. Assuming that the energy density of these super-heavy particles matches that of dark matter observed today, we translate the upper bounds on the particle fluxes into tight constraints on the couplings governing the decay process as a function of the particle mass. Instantons, which are nonperturbative solutions to Yang-Mills equations, can give rise to decay channels otherwise forbidden and transform stable particles into metastable ones. Assuming such instanton-induced decay processes, we derive a bound on the reduced coupling constant of gauge interactions in the dark sector: $\alpha_X \lesssim 0.09$, for $10^9 \lesssim M_X/\text{GeV} < 10^{19}$. Conversely, we obtain that, for instance, a reduced coupling constant $\alpha_X = 0.09$ excludes masses $M_X \gtrsim 3 \times 10^{13}$ GeV. In the context of dark matter production from gravitational interactions alone during the reheating epoch, we derive constraints on the parameter space that involves, in addition to M_X and α_X , the Hubble rate at the end of inflation, the reheating efficiency, and the nonminimal coupling of the Higgs with curvature.



SHDM scenario
assuming dark
matter interaction
(lifetime stabilized)
with SM particles
using photon
upper limits

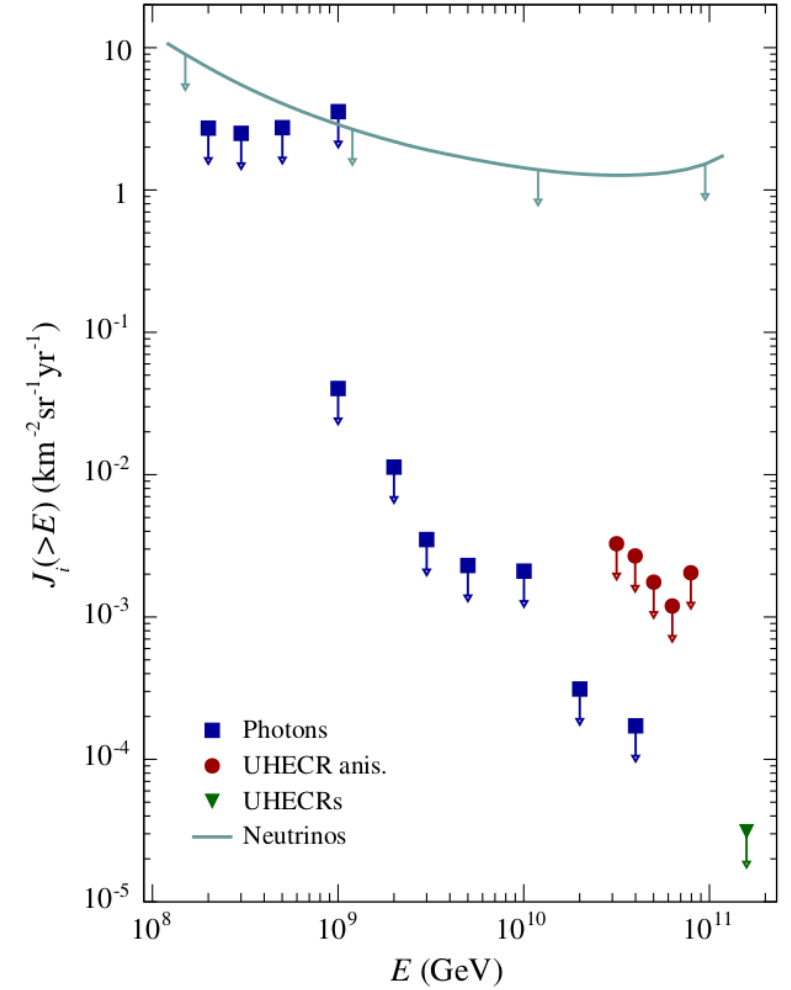


FIG. 3. Upper limits on secondaries produced from the decay of SHDM particles.

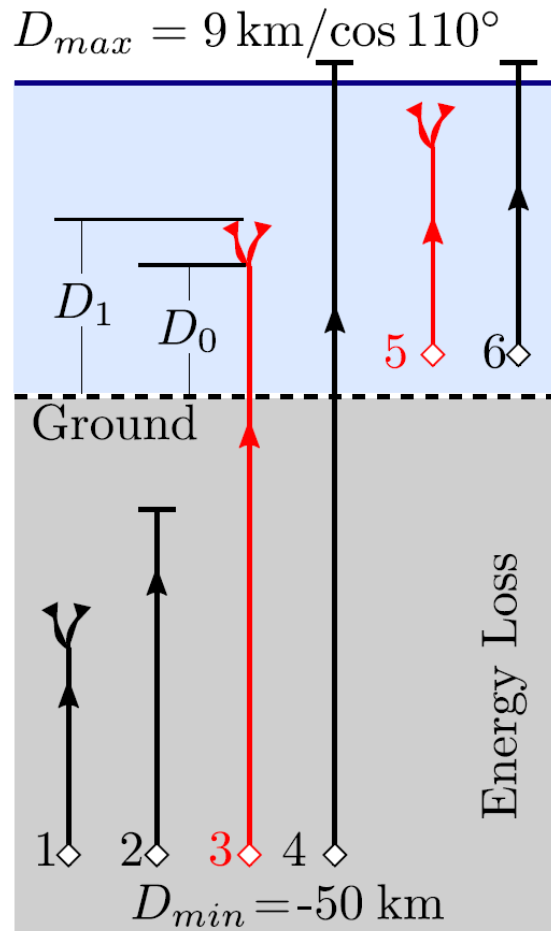
Defining an exclusion region in the **coupling-mass** phase space

Tau scenario

B. Biao@ICRC2023

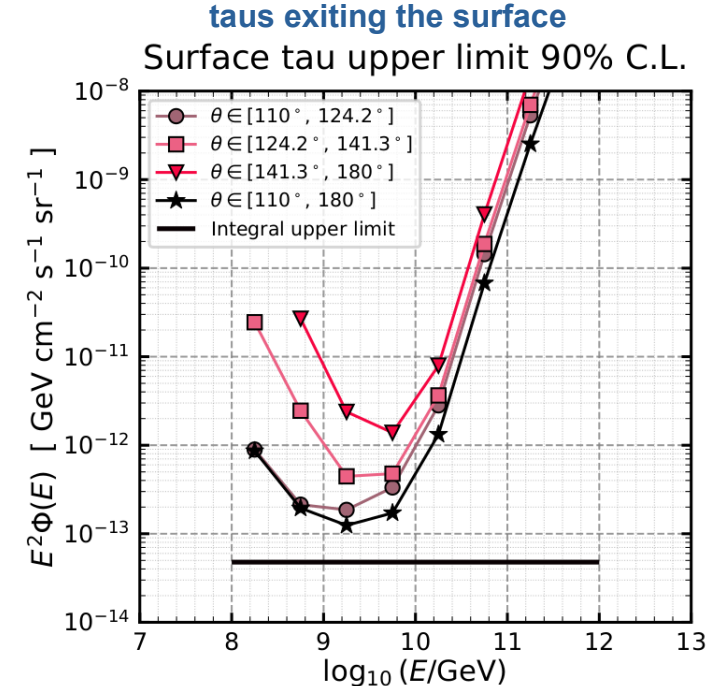
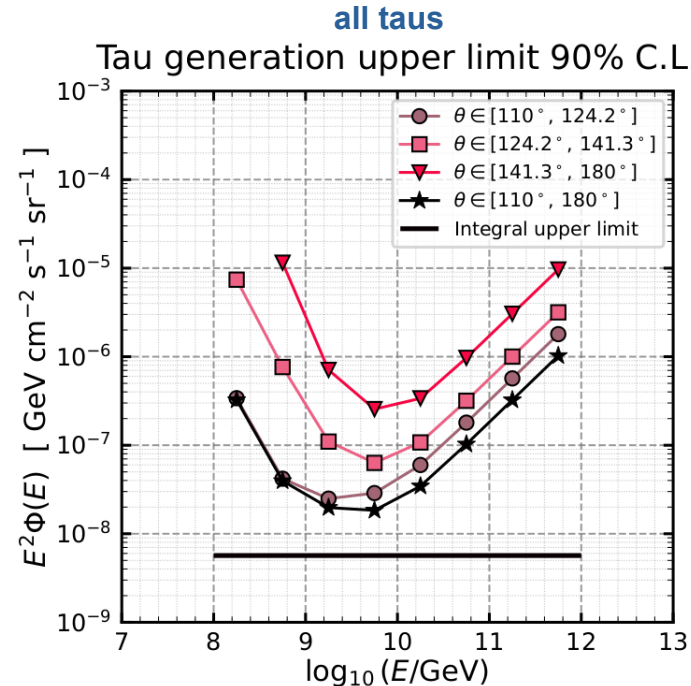
The Earth is opaque to standard model particles at the highest energies

Taus are simulated (energy losses and decay) starting at 50 km below the ground.
Emerging taus can decay and generate air-shower.



Expected flux of taus is folded with the FD shower detection efficiency (exposure).

→ **UL on showers is then converted in tau upper limits**

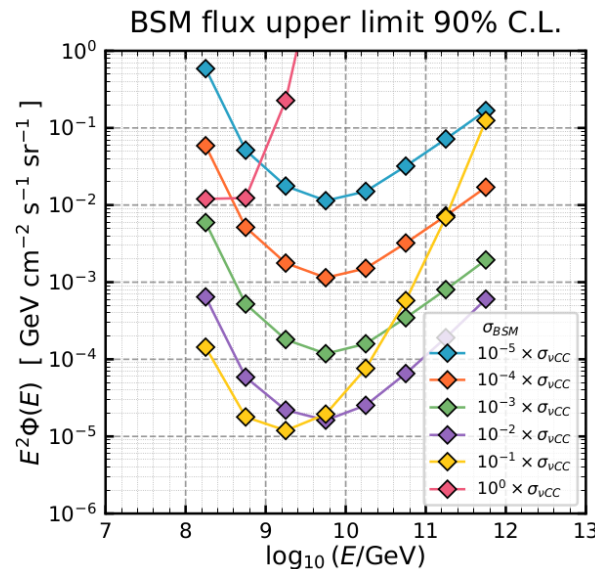
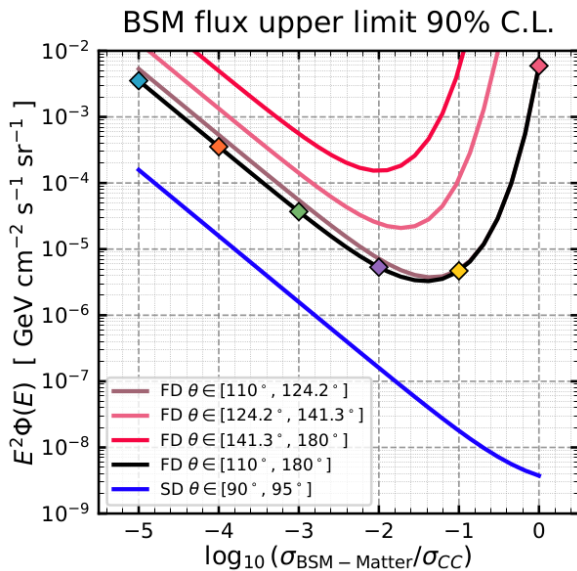
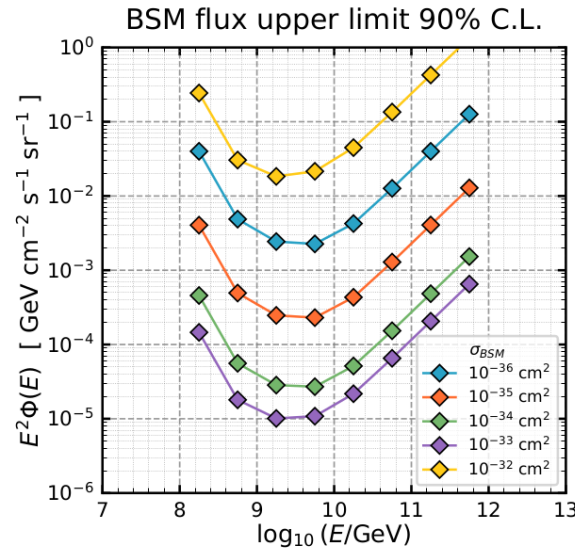
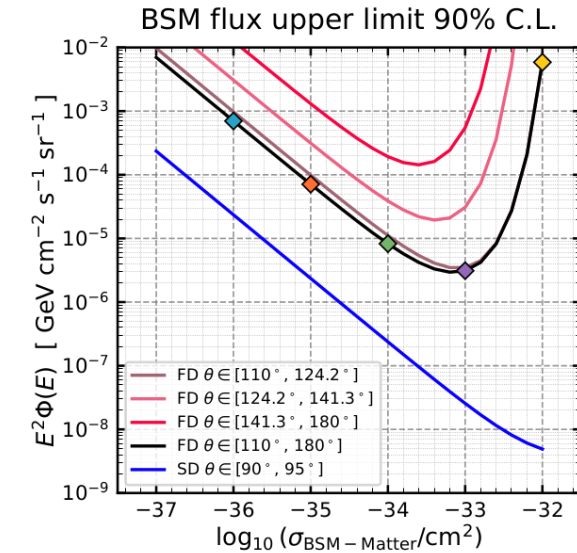


Testing BSH scenarios

B. Biao@ICRC2023

Any BSM scenario producing taus (with lower cross section then for SM) can be tested using the UL on upward-going showers derived from the Pierre Auger Observatory

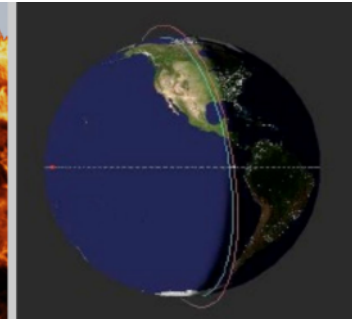
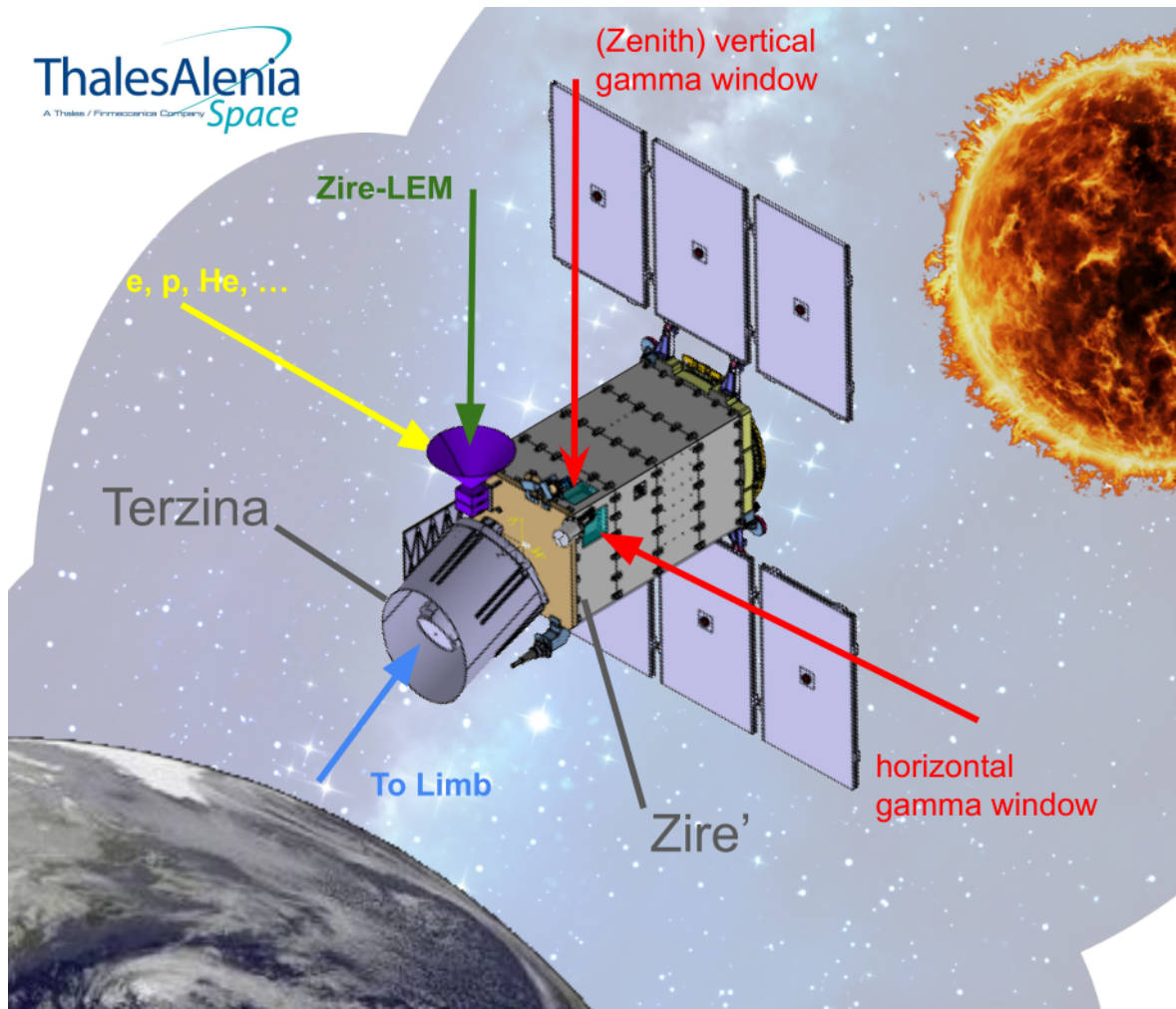
First case:
assuming a constant cross-section.
Strongest limits at $\sigma \sim 10^{-33} \text{ cm}^2$



Second case:
assuming to scale the (energy dependent) SM σ_{cc}
Strongest limits if σ_{BSM} is 3% of neutrino charged current σ_{cc}

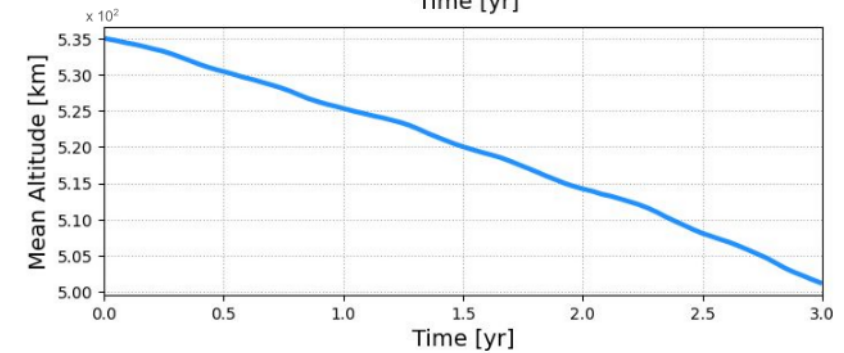
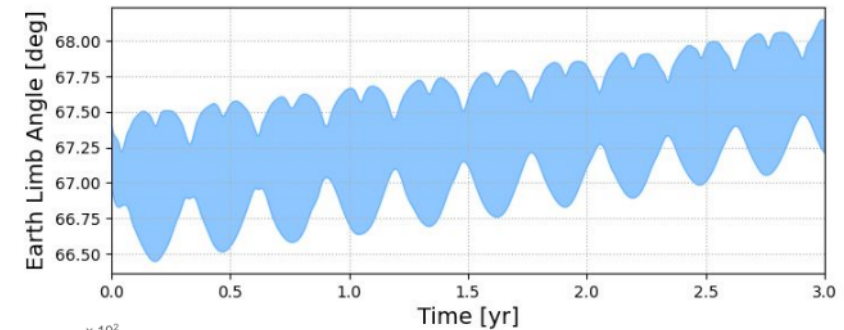
Orbita

ThalesAlenia
Space
A Thales / Finmeccanica Company



Low Earth Orbit (LEO) with high inclination, **sun synchronous orbit** on the day-night border.

- ❖ Altitude ~550 km
- ❖ Inclination = 97.8 deg
- ❖ LTAN = 18:00)



Caso scientifico/tecnologico

OBIETTIVI:

- Misurare elettroni, protoni e nuclei fino a centinaia di MeV
- Rivelazione di fotoni da 100 keV fino 30 MeV (pathfinder di Crystal eye)
- Studiare la correlazione del flusso di particelle con l'attività sismica e i fenomeni dispace-weather
- Monitorare il flusso di elettroni a bassa energia (0.5-5 MeV)
- Cross correlations tra elettroni di bassa energia, protoni-alpha, fotoni in coincidenza con GRBs
- Prima osservazione di sciame indotti da raggi cosmici dallo spazio attraverso la luce Cherenkov
- Certificare la fattibilità della rivelazione di neutrini di altissima energia attraverso l'emissione Cherenkov in configurazione Earth skimming (limbo)

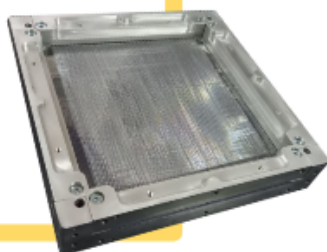
Uso di nuove tecnologie:

- Test dell'uso dei SiPM nello spazio
- Test dell'uso di un tracciante a fibre scintillanti ($\sim 300\mu\text{m}$) letto da arrays di SiPM
- Ottimizzazione di un array di cristalli di LYSO/GAGG come rivelatore di γ astrofisici (0.1-30 MeV)
- Design di elettronica a basso consumo ($\sim$ pochi mW/canale)
- Test / Ottimizzazione onboard di tecniche per riduzione dei dati (Standard e/o Machine Learning)
- Test di nuovi approcci per il design di piattaforme satellitari

ZIRÈ: LAYOUT

Fiber TracKer (FTK)

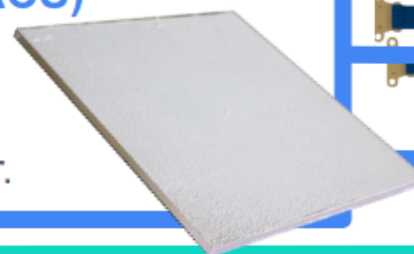
3 double layer XY modules of fibers to be used for track identification.



More details on FTK presented by Roberta

Anti-Coincidence System (ACS)

9 PS layers surrounding the detector.



Plastic Scintillator Tower (PST)

Tower of 32 Plastic Scintillator layers. Each layer is composed by 3 bars.

6 layers:
4x12x1 cm³
26 layers:
4x12x0.5 cm³



Calorimeter (CALOg)

Matrix 4x4x2 of LYSO/GAGG crystals. Segmented in cubes to be Crystal Eye pathfinder.

