



*Attività del gruppo di Lecce
Richieste per il 2025*

Image:
S.Saffi

G. Cataldi, M.R. Coluccia, M. Conte, P. Creti, F. de Palma, E. De Vito, I. Epicoco, D. Franco,
U.Giaccari, D.Martello, A. Nucita, L.Perrone, V. Scherini

ANAGRAFICA GRUPPO DI LECCE

Cataldi	Gabriella	60%	Primo Ricercatore INFN
Coluccia	Maria Rita	20%	Tecnologo INFN
Conte	Matteo	100%	Dottorando UniSalento
Creti	Pietro	20%	Primo Tecnologo INFN
de Palma	Francesco	60%	Prof. Associato UniSalento
De Vito	Emanuele	100%	Assegnista di Ricerca UniSalento
Epicoco	Italo	100%	Ricercatore UniSalento
Franco	Danelise	10%	Assegnista INFN (on leave)
Giaccari	Ugo	90%	Ricercatore INFN
Martello	Daniele	100%	Prof. Ordinario UniSalento
Nucita	Achille	60%	Prof. Associato UniSalento
Perrone	Lorenzo	80%	Prof. Associato UniSalento
Scherini	Viviana	80%	RTDA UniSalento

Preliminare
(ma entro piccoli spostamenti)

11 Ricercatori → 8.4 FTE
2 Tecnologi → 0.4 FTE

Attività di analisi a Lecce 2024-2025

Performance del rivelatore ibrido

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

Misura dello spettro energetico

spettro ibrido in particolare (misura di ankle e soppressione)

Open data

Messa a punto dei tool e interazione con task di analisi
- frazione innalzata dal 10% al 30% entro fine 2024

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”

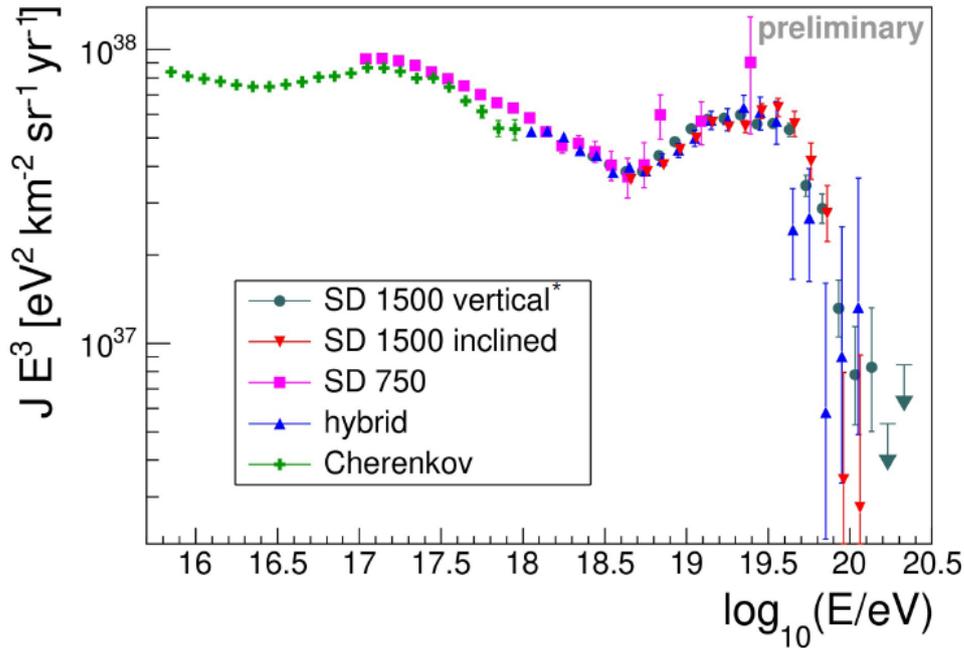
Ricerca di neutrini con il rivelatore di fluorescenza

**astronomia
multi-messenger**

Ricerca di neutroni

Anisotropia

Attività di Lecce in a nutshell



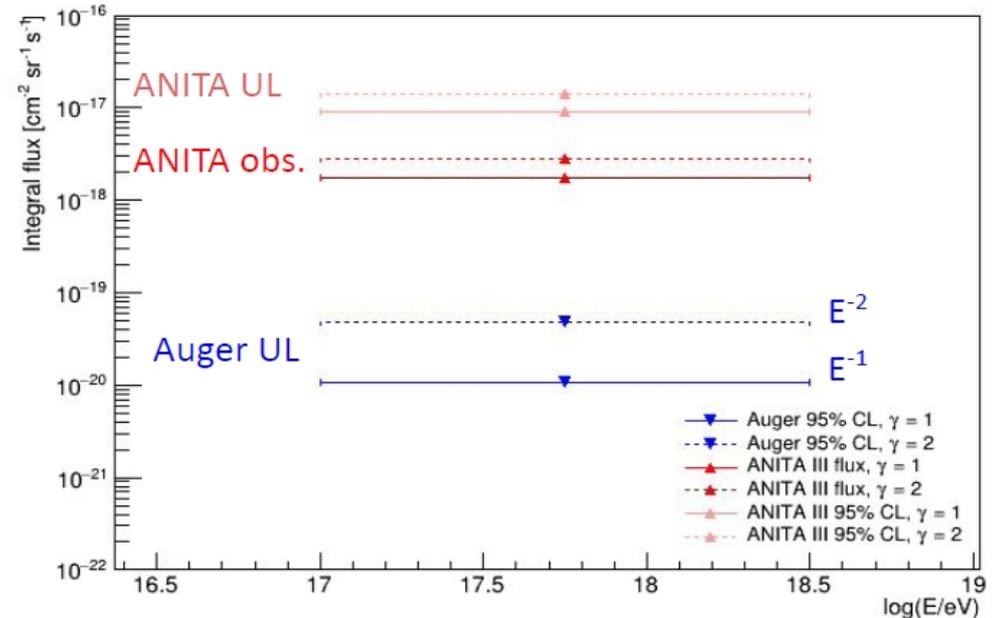
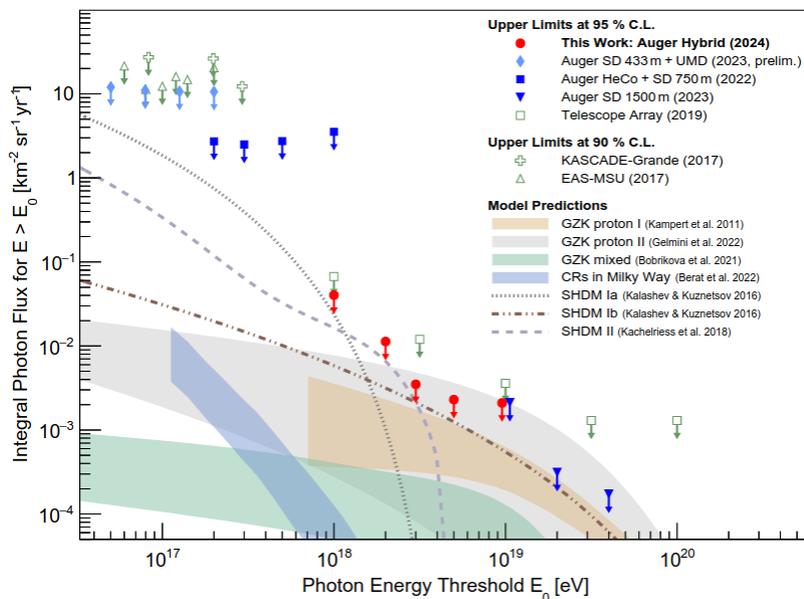
Caratterizzazione della radiazione cosmica

- performance del rivelatore (FD ed SSD)
- spettro energetico
- direzioni di provenienza
- particelle neutre (fotoni, neutrini, neutroni)

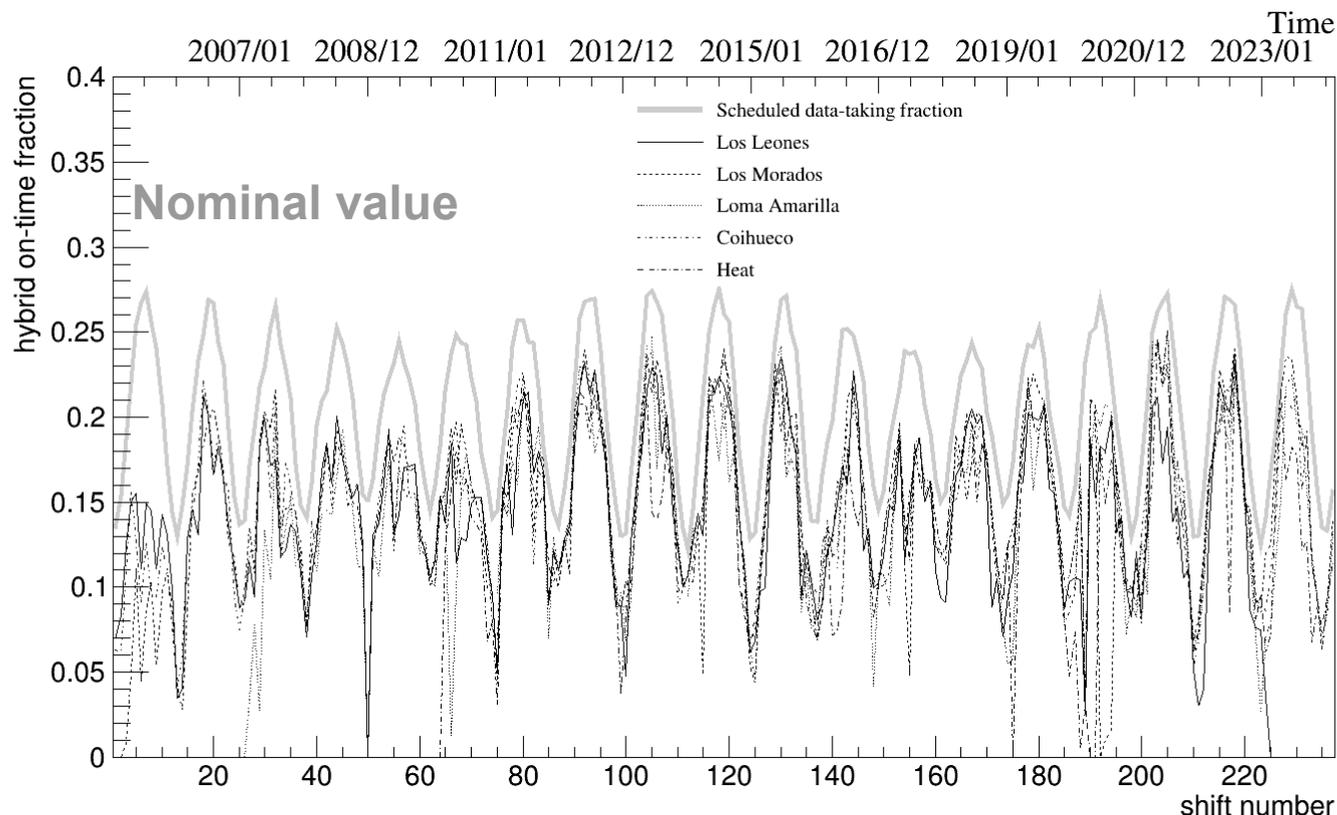


- Ricerca di dark matter
- Scenari BSM

Multi-messenger astronomy per lo studio della fisica fondamentale



Performance e data quality per il rivelatore ibrido



Hybrid detector ontime

Influenced by:

- Telescope status
- Weather conditions
- Connection to SD

Updated to March 2024

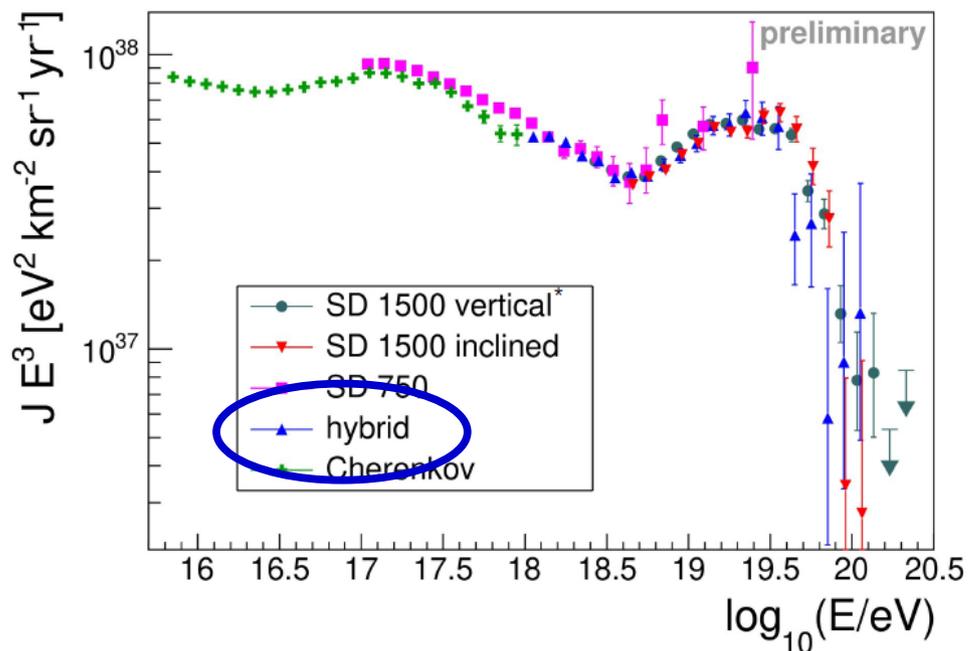
In collaborazione con il gruppo dell'Aquila

Produzione e controllo di qualità dei dati ibridi dell'osservatorio.

processamento sistematico dei dati RAW, allineamento dei database di calibrazione, atmosfera, test di analisi preventivi al rilascio dei dati ridotti per le analisi di Fisica (in collaborazione con Roma2)

- Dati per la calibrazione di SD (spettro verticale, PRL e PRD 2020) prodotti a Lecce.
- Dati per tutte le analisi preliminari ibride di ICRC 2023 sono stati prodotti a Lecce

Spettro energetico con eventi ibridi



normalization shifts after comb.:

SD 1500 m	<1 %
SD 750 m	-2 %
SD 1500 m inclined	+5 %
Hybrid	<1 %
Cherenkov	+7 %

Item “storicamente” coperto in collaborazione con il gruppo dell’Aquila.

Esposizione del detector valutata in modo realistico sulla base di ontime, atmosfera ed efficienza di ricostruzione

[Demanding dal punto di vista del calcolo gestito al CNAF]

Lavoro pianificato a breve:

- includere i dati di Phase 1 (fino al 2021) e produrre le relative simulazioni (offline test tag per ICRC2025 rilasciata da poco)
- estendere fino a 80° e includere vari primari (profili CONEX già prodotti a Lecce)

Ricerca di fotoni primari con tecniche di Universalità

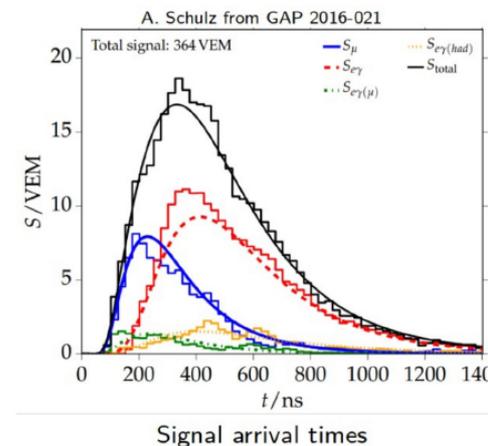
Tesi di dottorato di Pierpaolo Savina

Four universal components can be identified:

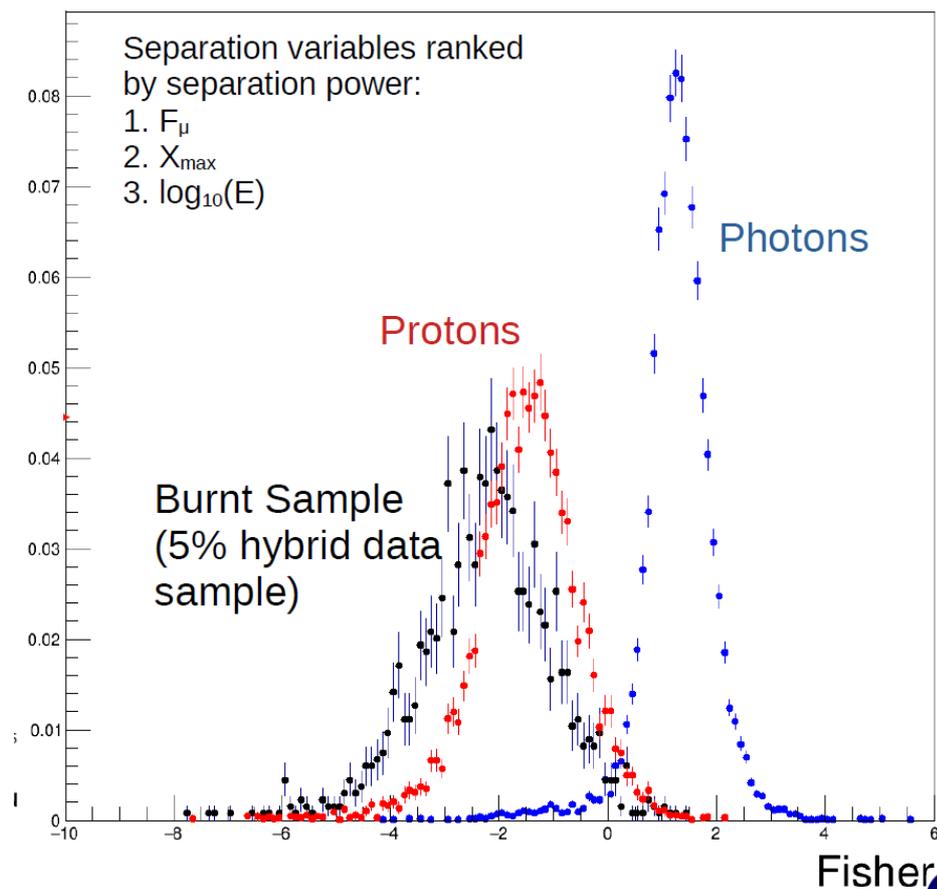
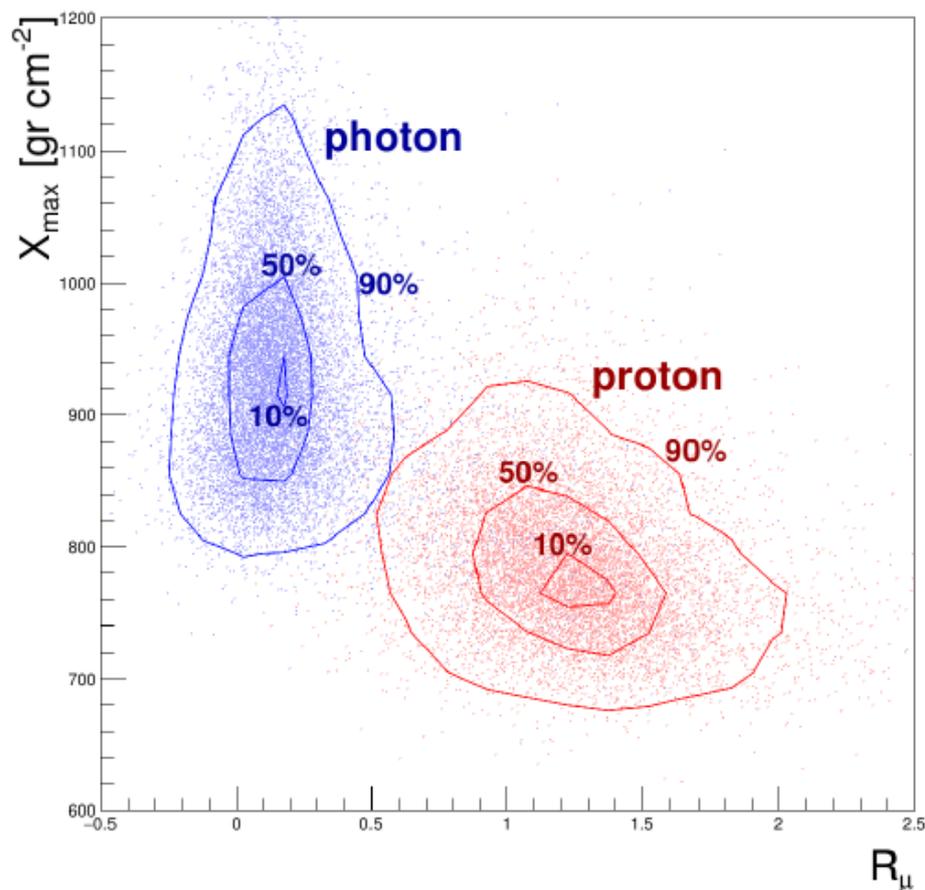
- muons (μ);
- e.m. particles from high energy pions;
- e.m. particles the muons;
- e.m. particles from low energy hadrons;

$$S(r, \Delta X, E, \theta, \psi) = \sum_i (1 + (R_\mu - 1)\alpha_i) S_i \quad (1)$$

$$R_\mu = \frac{S_\mu}{S_\mu^{\text{ref}}} \quad \frac{S_\mu}{S_\mu^{\text{ref}}} = \alpha_i \frac{S_i}{S_i^{\text{ref}}}$$



Sviluppo di un metodo basato sul concetto di “universalità”
[sistema complesso di particelle secondarie descritto da pochi parametri]



Ricerca di fotoni primari con tecniche di Universalità

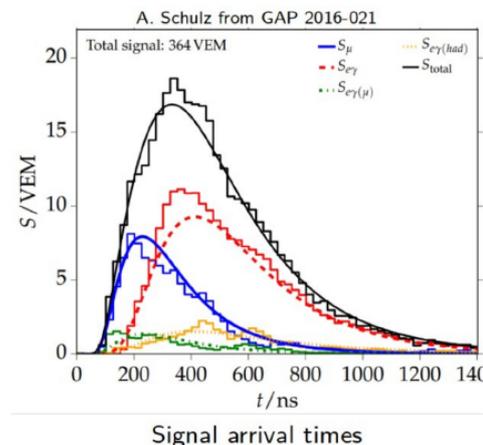
Tesi di dottorato di Pierpaolo Savina

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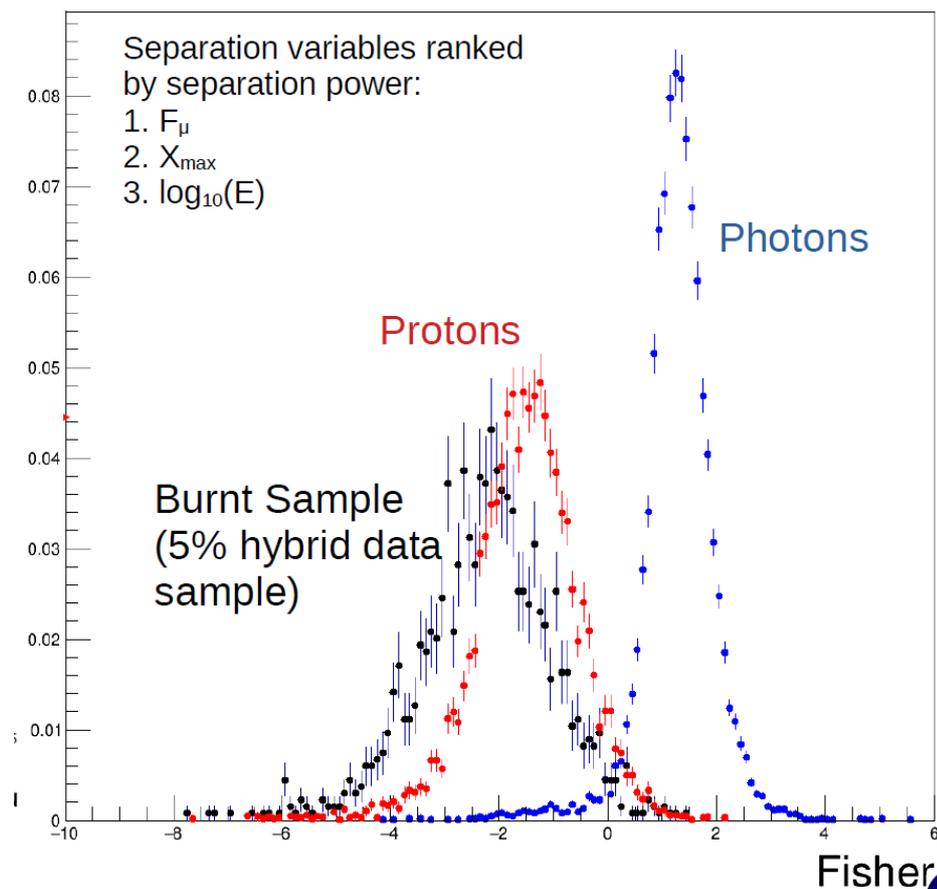
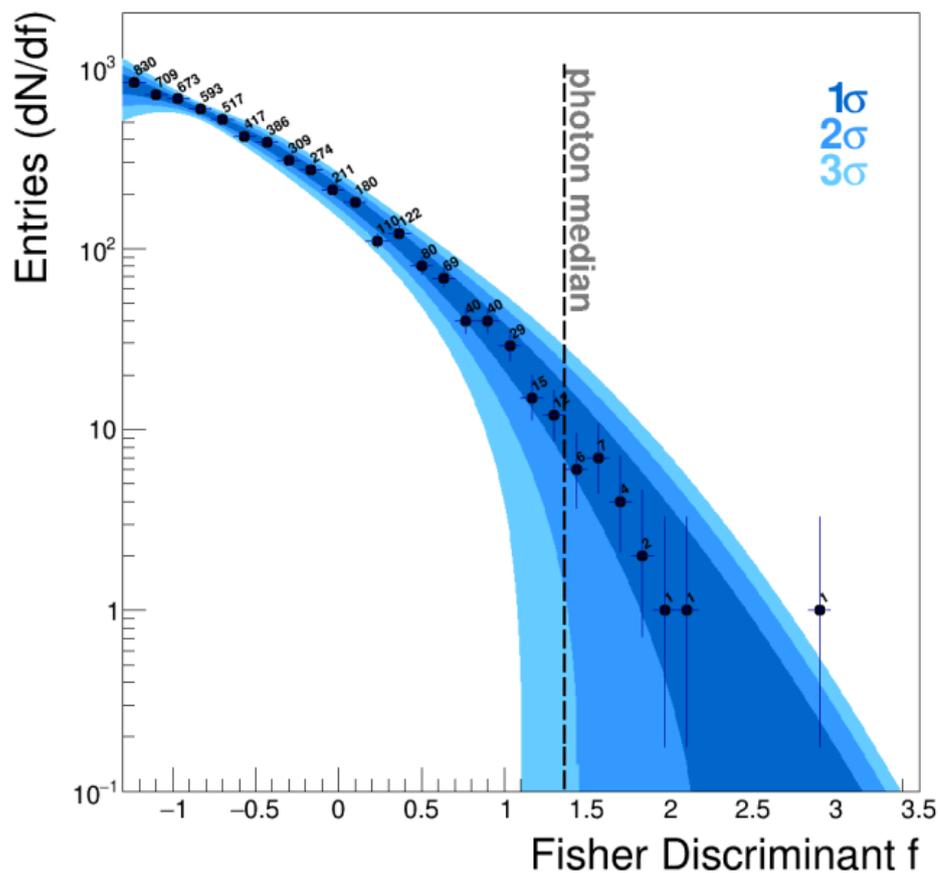
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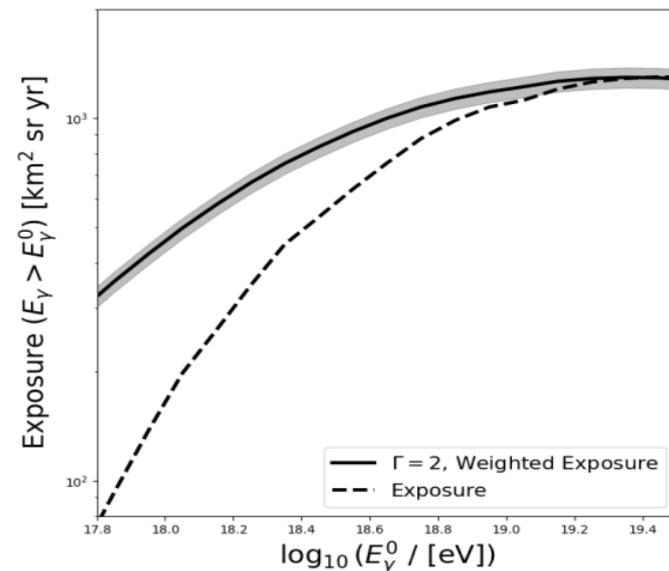
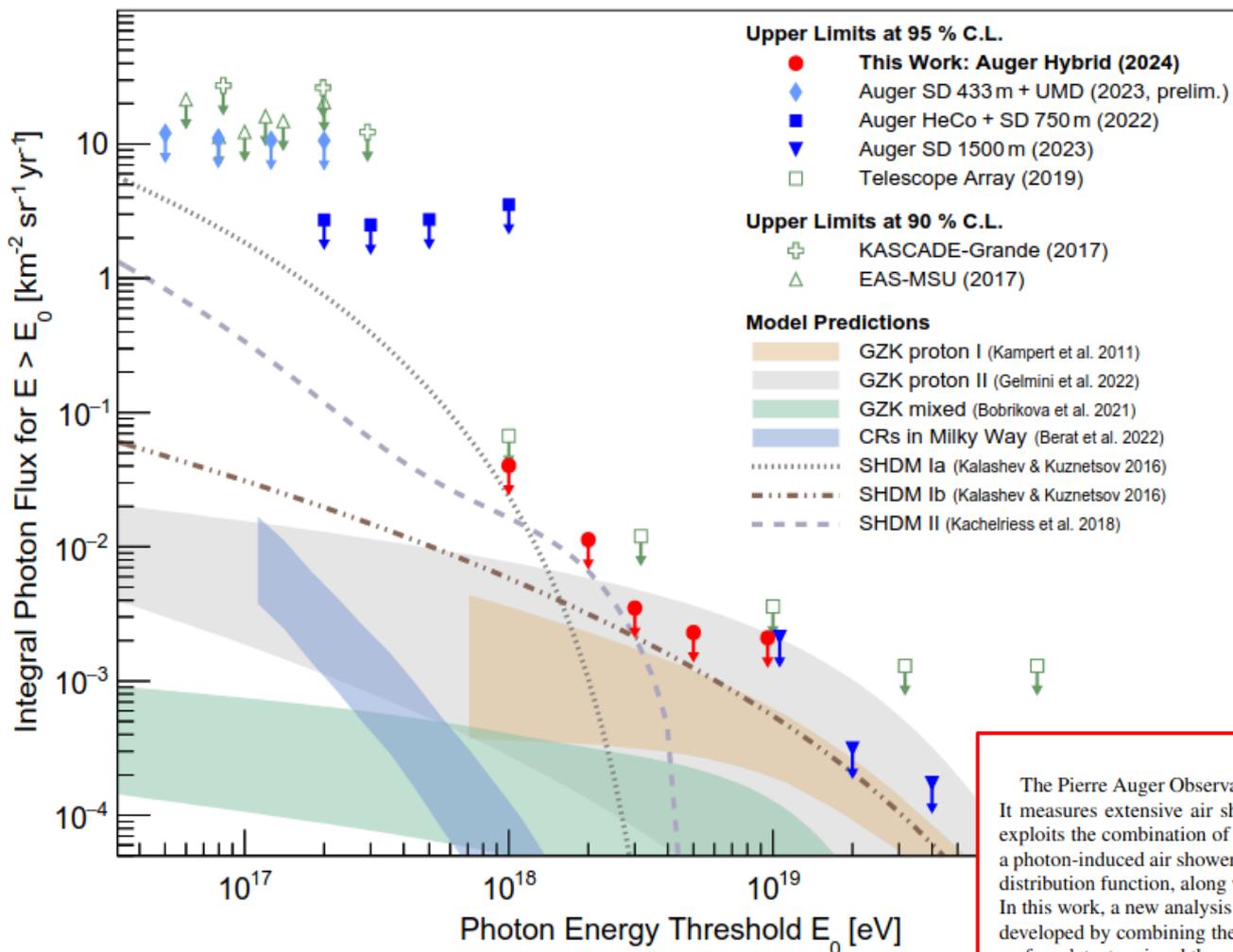
Sviluppo di un metodo basato sul concetto di “universalità”
[sistema complesso di particelle secondarie descritto da pochi parametri]

Background measured from data



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

Submitted to PRD



Analisi sviluppata nella tesi di Pierpaolo Savina

(Dated: June 11, 2024)

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.

Migliori UL nel range 1-10 EeV

Utilizzati per constraints sulla SHDM

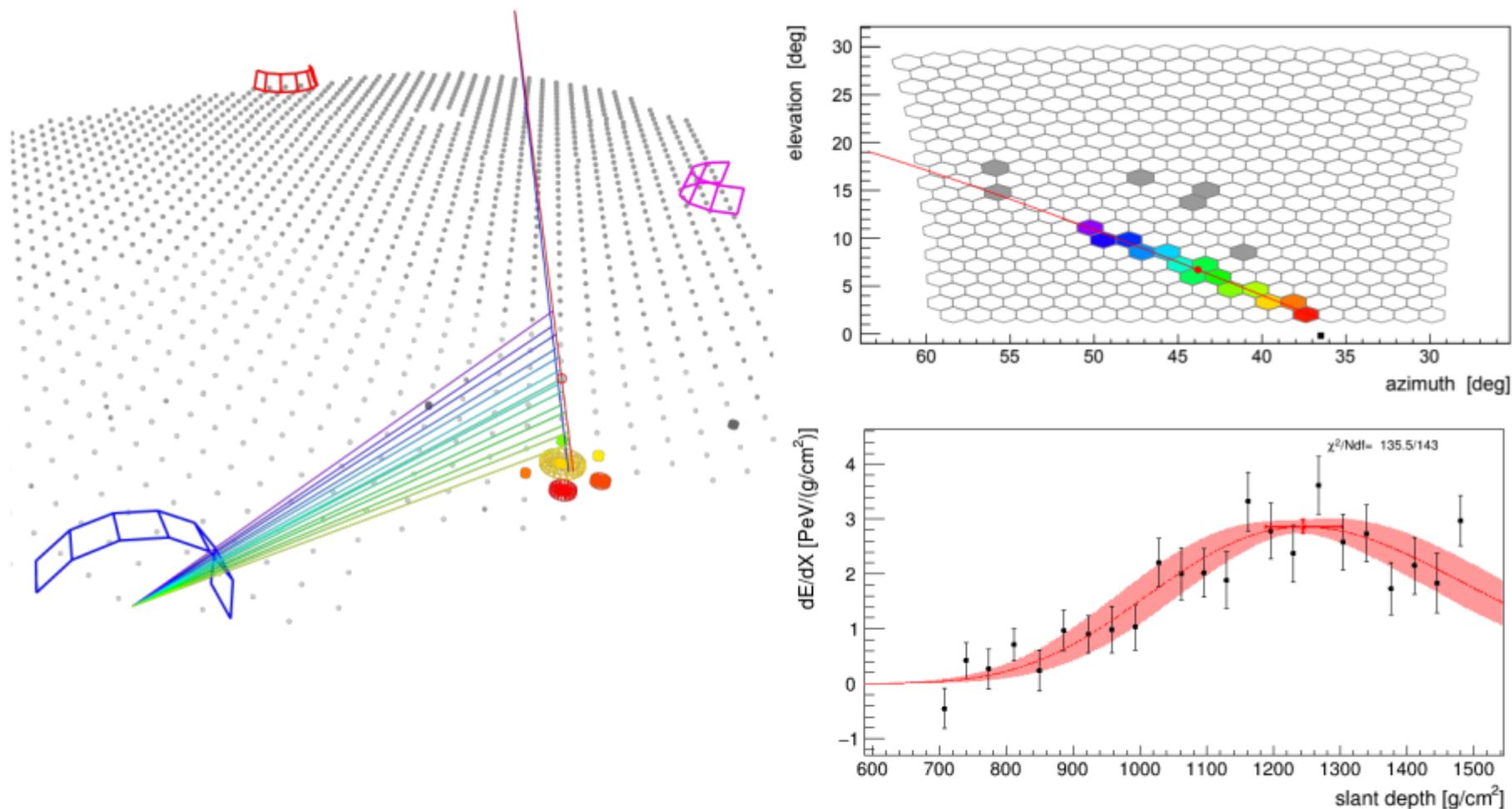
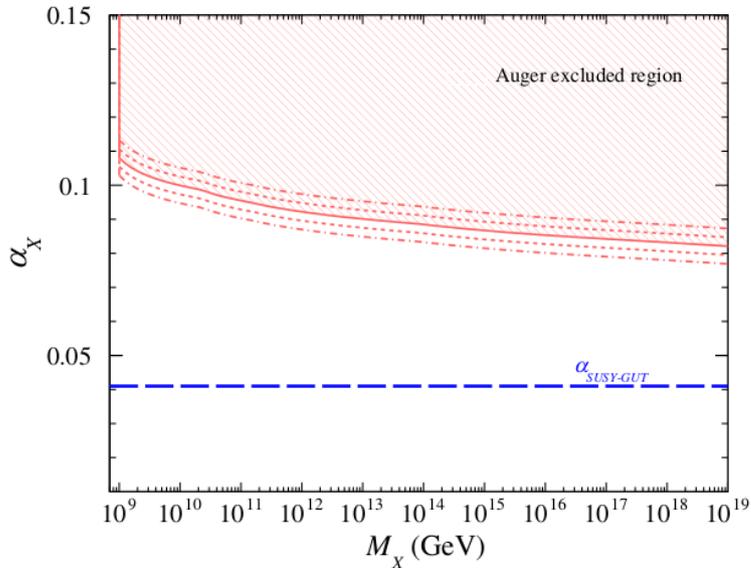


Figure 17. Characteristics of the most significant photon candidate event, ID 3478968: 3D visualization (left panel), camera view of the triggered FD telescope (top right panel). The colors (violet to red) reflect the times (early to late) at which the light reaches each pixel. Gray pixels indicate background triggered pixels. Bottom right panel, reconstructed energy deposit as a function of atmospheric slant depth (black points) along with the fit to the shower longitudinal profile (red line).

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

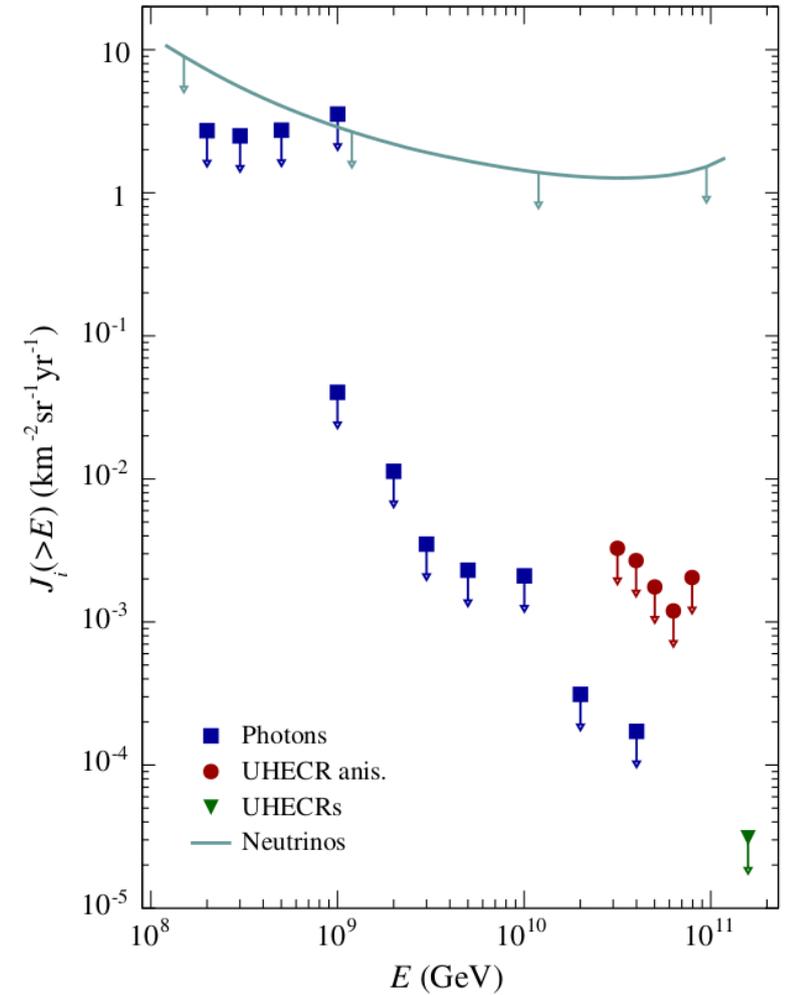


FIG. 3. Upper limits on secondaries produced from the decay of SHDM particles.

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

Ricerca di neutrini astrofisici con il rivelatore di fluorescenza

Ricerca motivata dall'osservazione di due eventi sospetti (neutrini?) da parte dell'esperimento ANITA (Antartide)

- Ricerca di sciami upward-going (sciami indotti dal decadimento dei tau generati per corrente carica dalla propagazione di neutrini nella roccia)
- Ricerca delicata a causa del background (Laser, fulmini, inefficienze strumentali)

Working group dedicato nel task dei Multi-messenger: obiettivo confutare (o confermare) l'osservazione di ANITA

In collaborazione con il gruppo dell'Aquila e input dal gruppo di Torino e Napoli

Gruppo di Lecce impegnato nell'analisi dei dati, nella reiezione del background e nella simulazione del segnale

Tesi di dottorato di Emanuele De Vito

A search for the anomalous events detected by ANITA using the Pierre Auger Observatory*

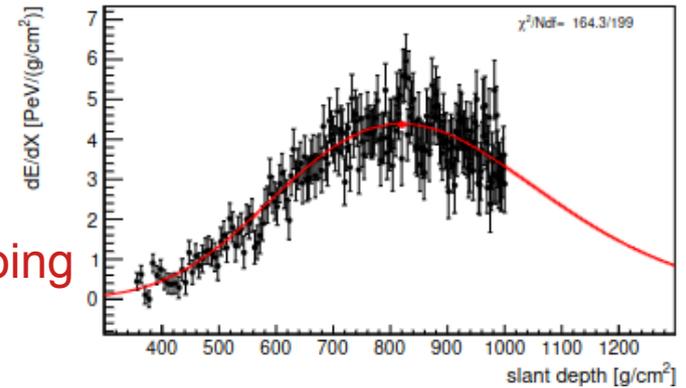
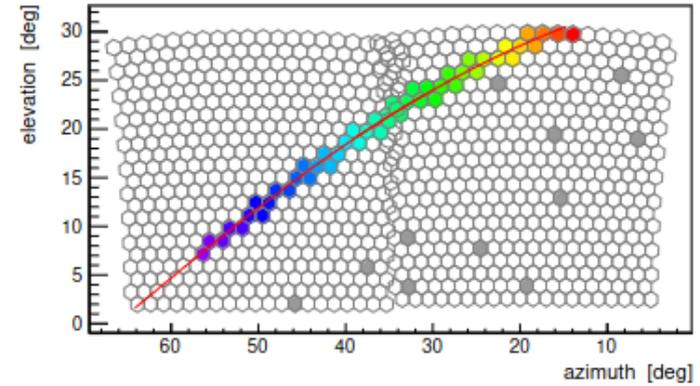
(Dated: January 17, 2024)

A dedicated search for upward-going air showers at elevation angles exceeding 20° 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 which 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 $[0.1-33]$ EeV. One candidate event has been found in the search period between 1 Jan 2004 and 31 Dec 2018, consistent with an expected background of 0.27 ± 0.12 events from mis-reconstructed cosmic ray showers. This translates to an upper bound of 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, effectively dismissing the interpretation of the anomalous events as upward-going showers.

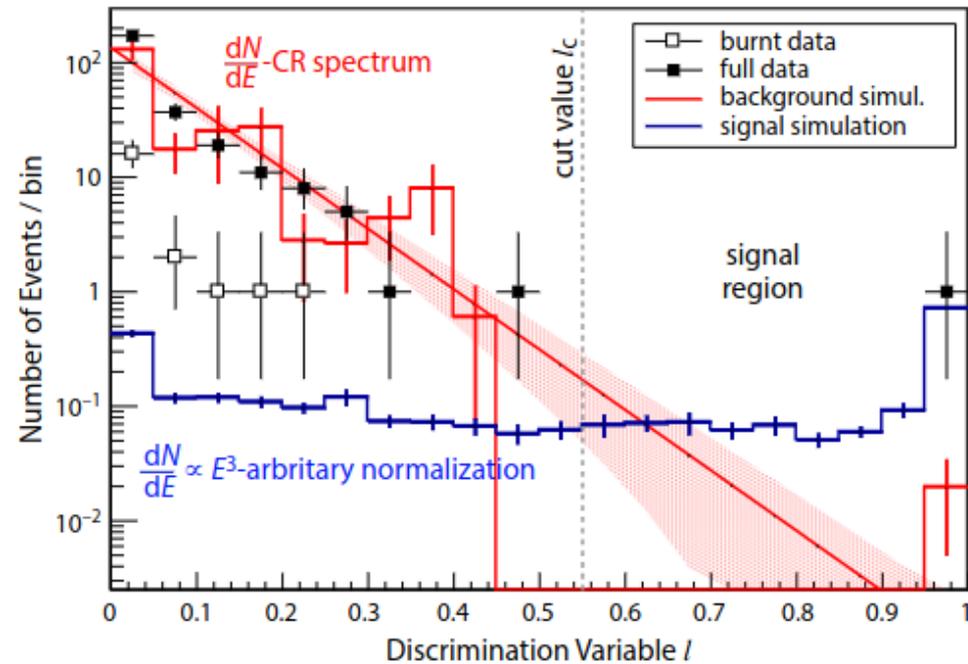
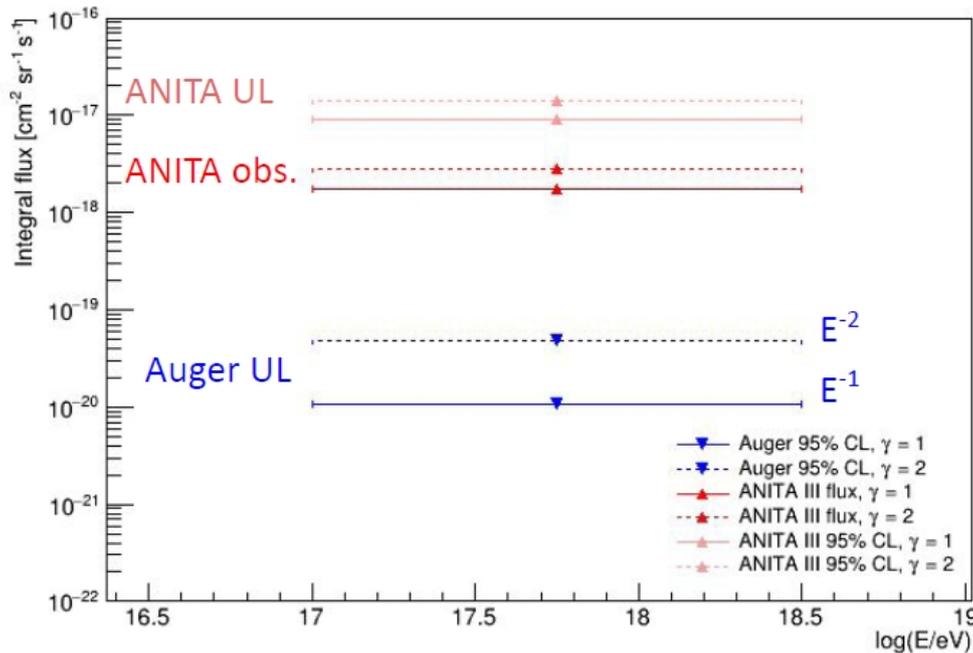
Submitted to PRL

PhD Thesis, E. De Vito → adesso RTDA

Presentato a ICRC 2023 e CRIS-MAC 2024



Simulated upward-going event



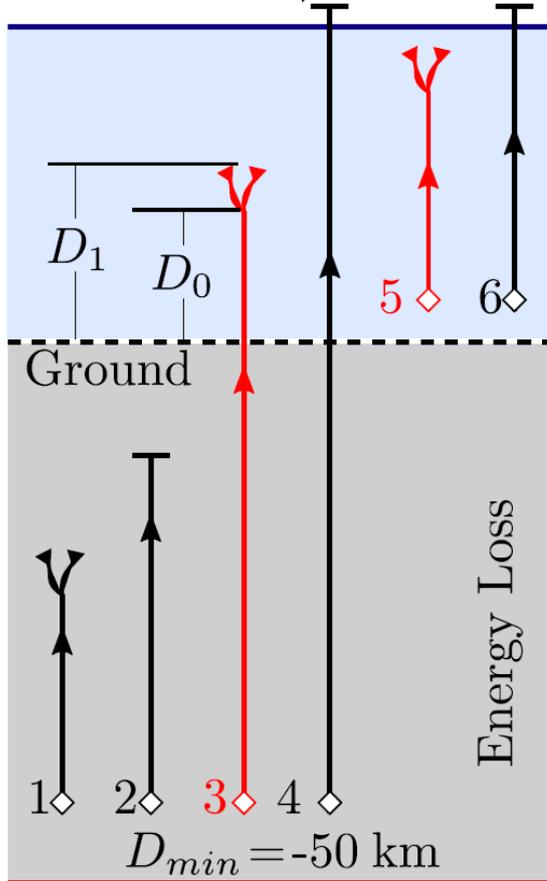
Tau scenario

B. Biao@ICRC2023

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

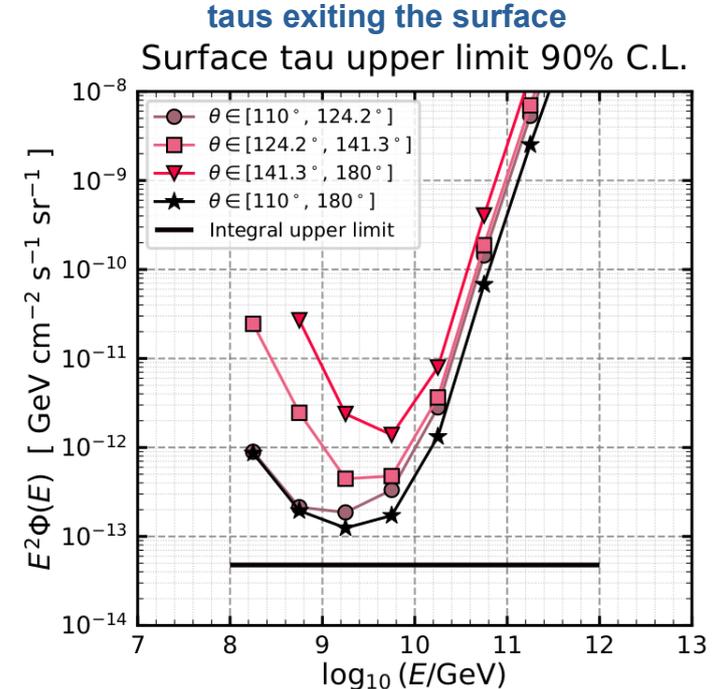
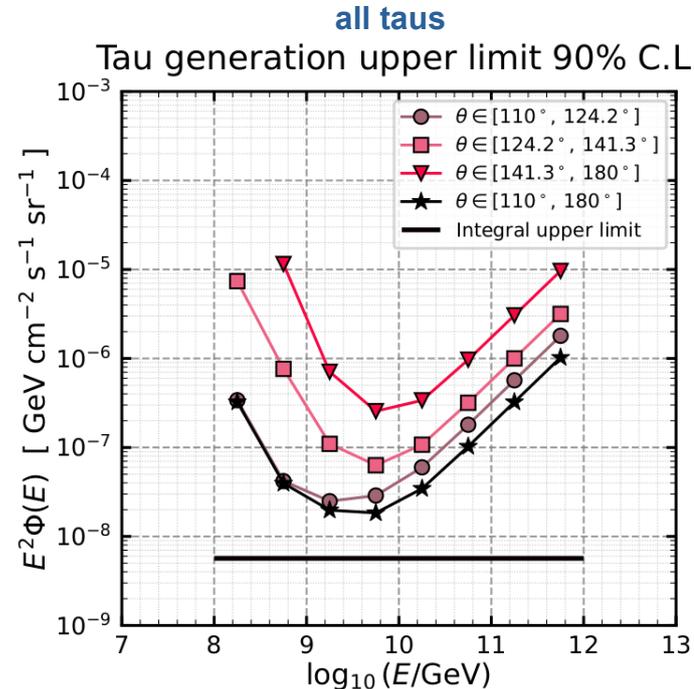
Taus are simulated (energy losses and decay) starting at 50 km below the ground.
Emerging taus can decay and generate air-shower.

$$D_{max} = 9 \text{ km} / \cos 110^\circ$$



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

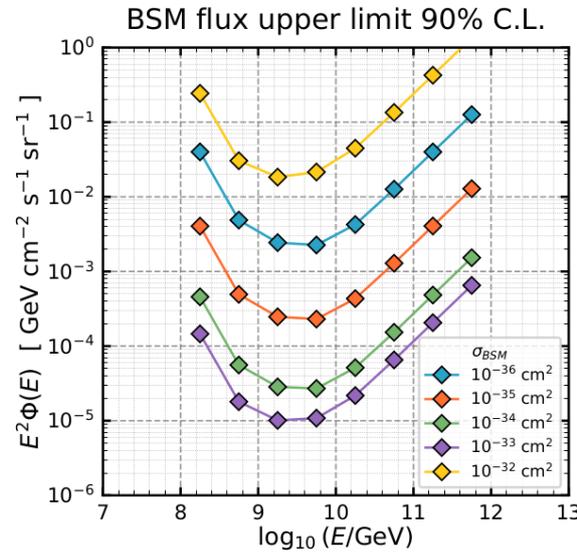
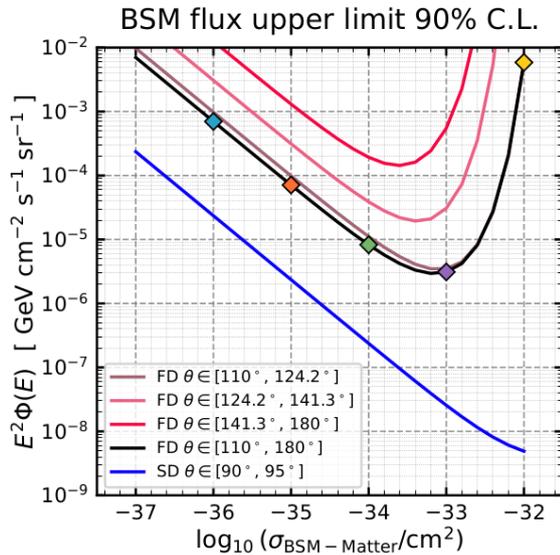
→ **UL on showers is then converted in tau upper limits**



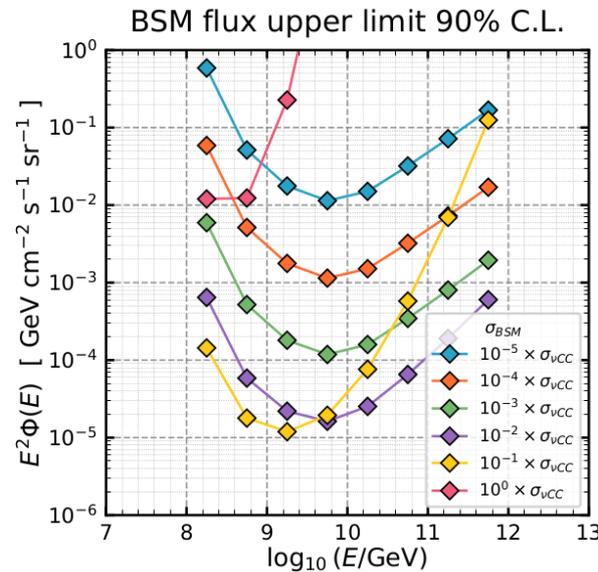
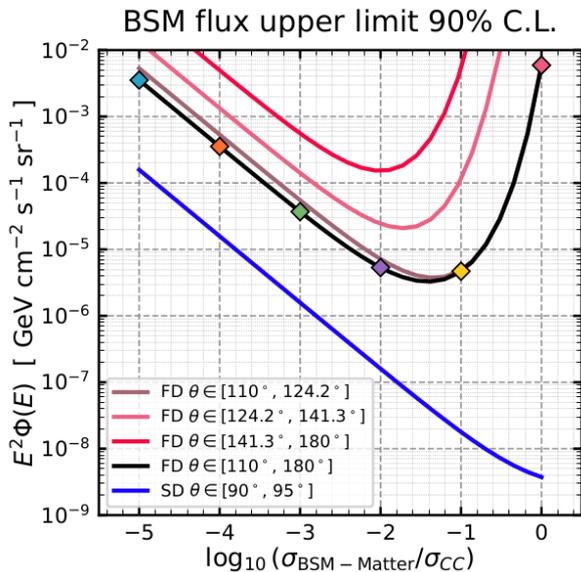
Testing BSH scenarios

B. Biao@ICRC2023

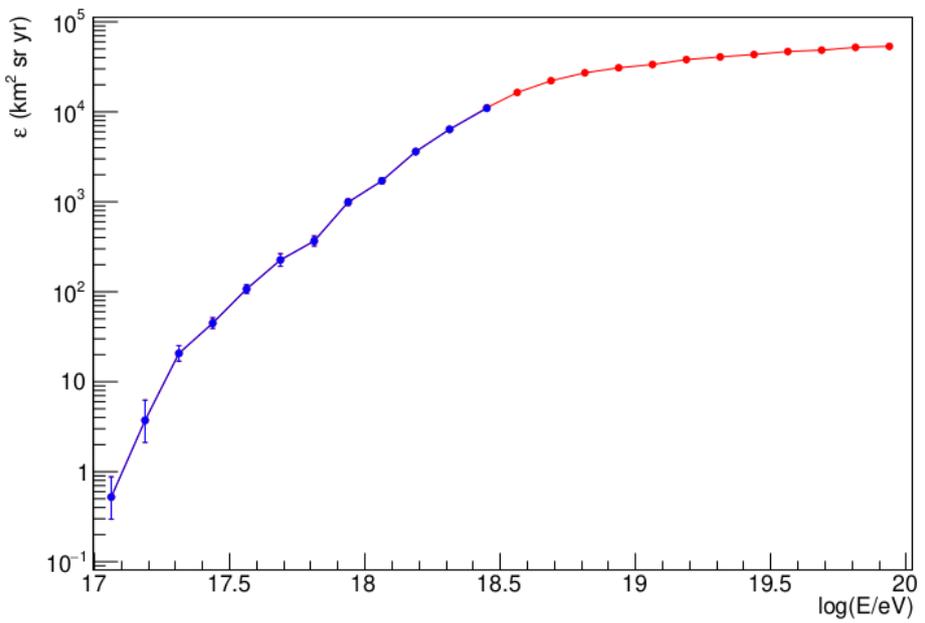
Any BSM scenario producing taus (with lower cross section then for SM) can be tested using the UL on upward-going showers derived from the Pierre Auger Observatory



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}

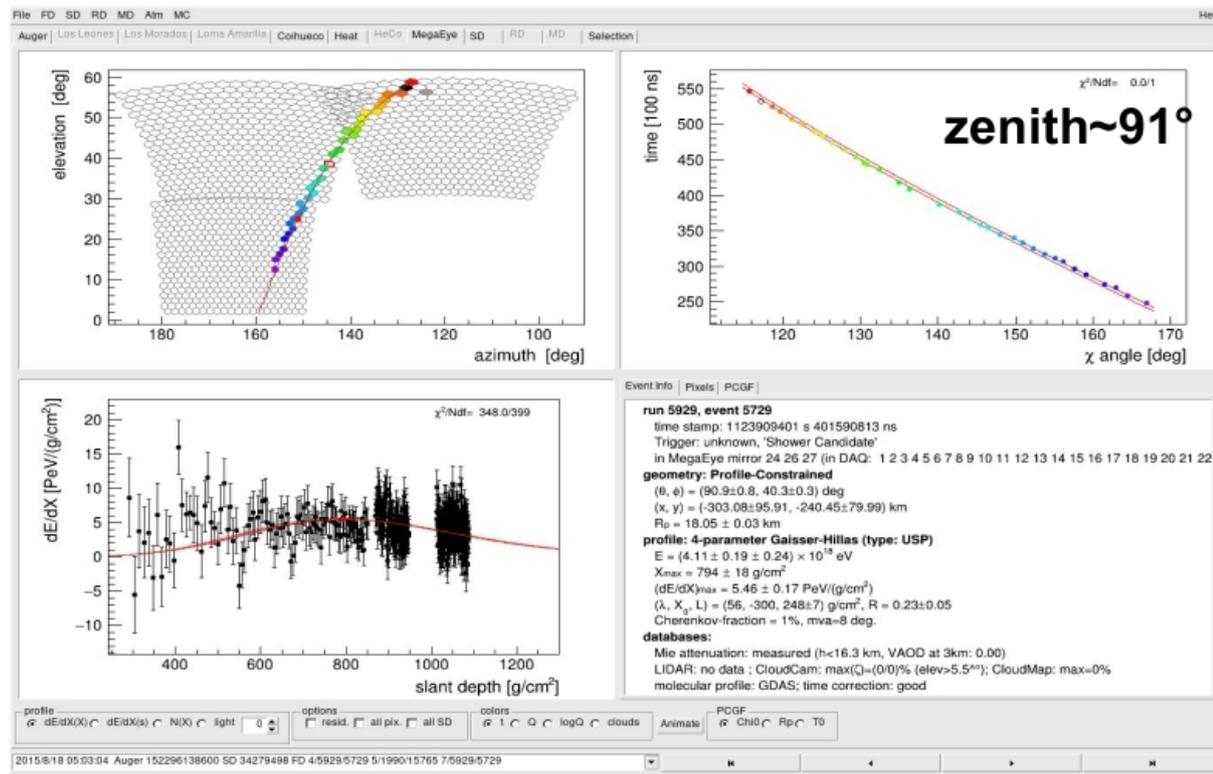


Attività attuale: estensione del calcolo della sensibilità (exposure) alle energie piu' alte

Rilevante per indagare scenari BSM

Estensione ad angoli piu' inclinati → eventi stratosferici

Sinergia possibile con future osservazioni dallo spazio



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

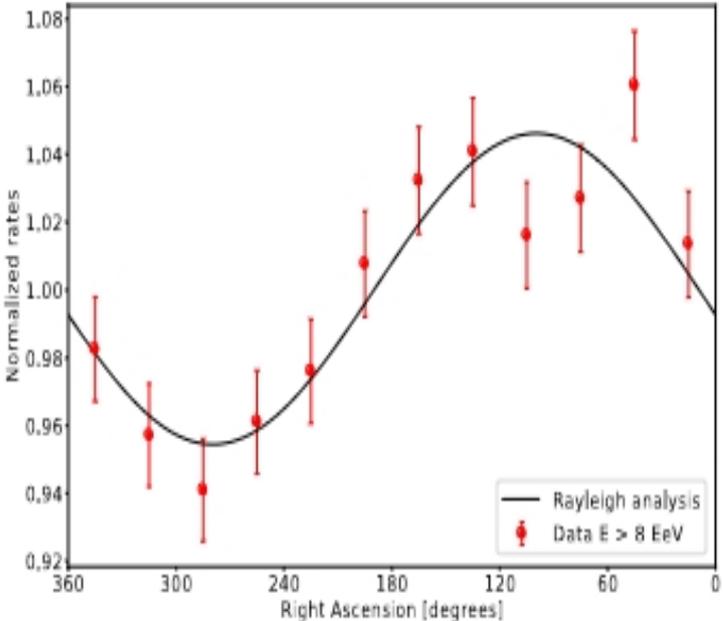
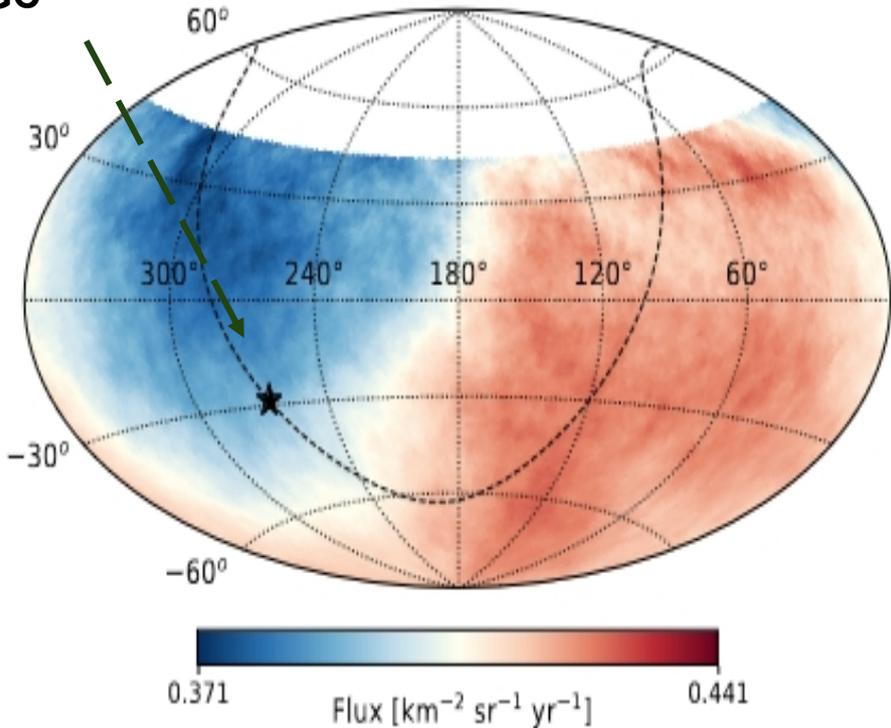
Large scale analysis $E \geq 4$ EeV: dipole 3D reconstruction

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



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)

Neutron analysis

EB members: Lorenzo Caccianiga, **Danelise de Oliveira Franco**, Federico Maria Mariani, Paul Sommers, Geraldina Golup, Esteban Roulet, Lorenzo Cazon

We search for an event excess that could indicate a neutron flux.

Observed CR density



CR density obtained from isotropic distributions

We assign a weight representing the probability density of an event coming from the direction of the target:

$$w_i = \frac{1}{2\pi\sigma_i^2} \exp\left(-\frac{\xi_i^2}{2\sigma_i^2}\right)$$

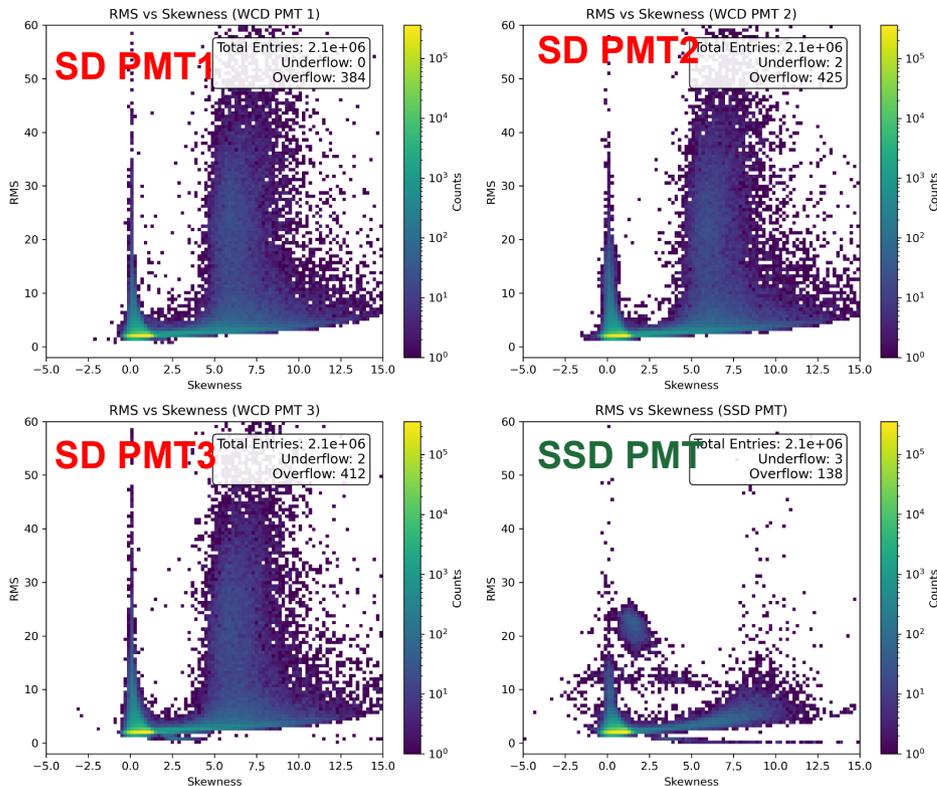
ξ_i : angular distance
 σ_i : angular uncertainty

By summing all the weights in the data set, we obtain the cosmic ray density at the position of the target:

$$\rho = \sum_i^N w_i$$

Number of events in the data set

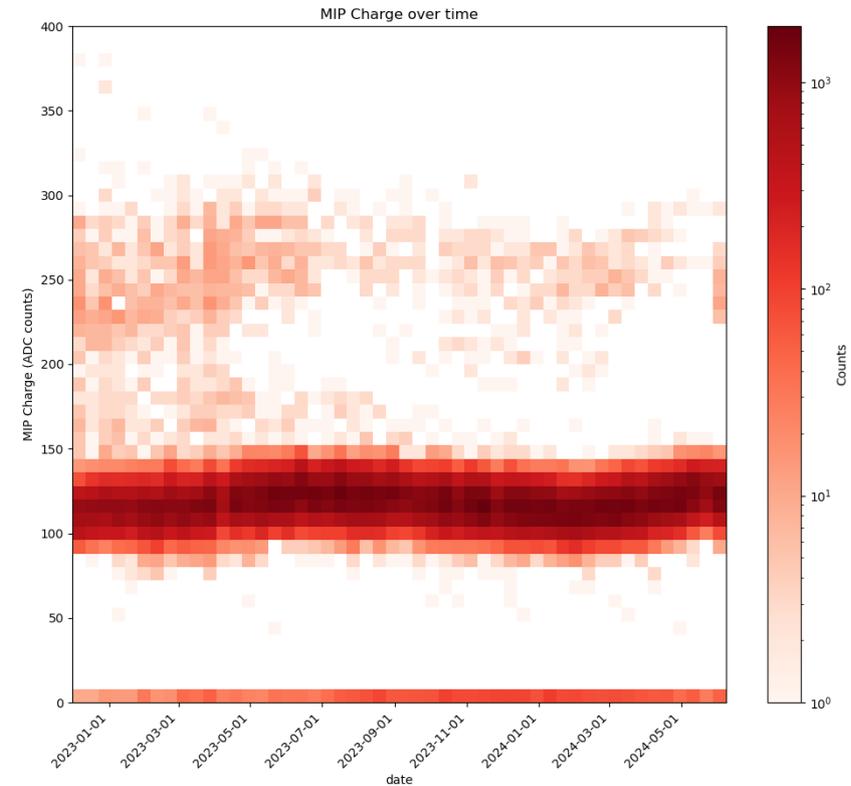
Studio della performance del rivelatore upgradato



Nuova elettronica UUB

Stabilità temporale di SSD

MIP vs time since 2023



Stabilità della baseline per SD (PMT 1,2,3) and per SSD

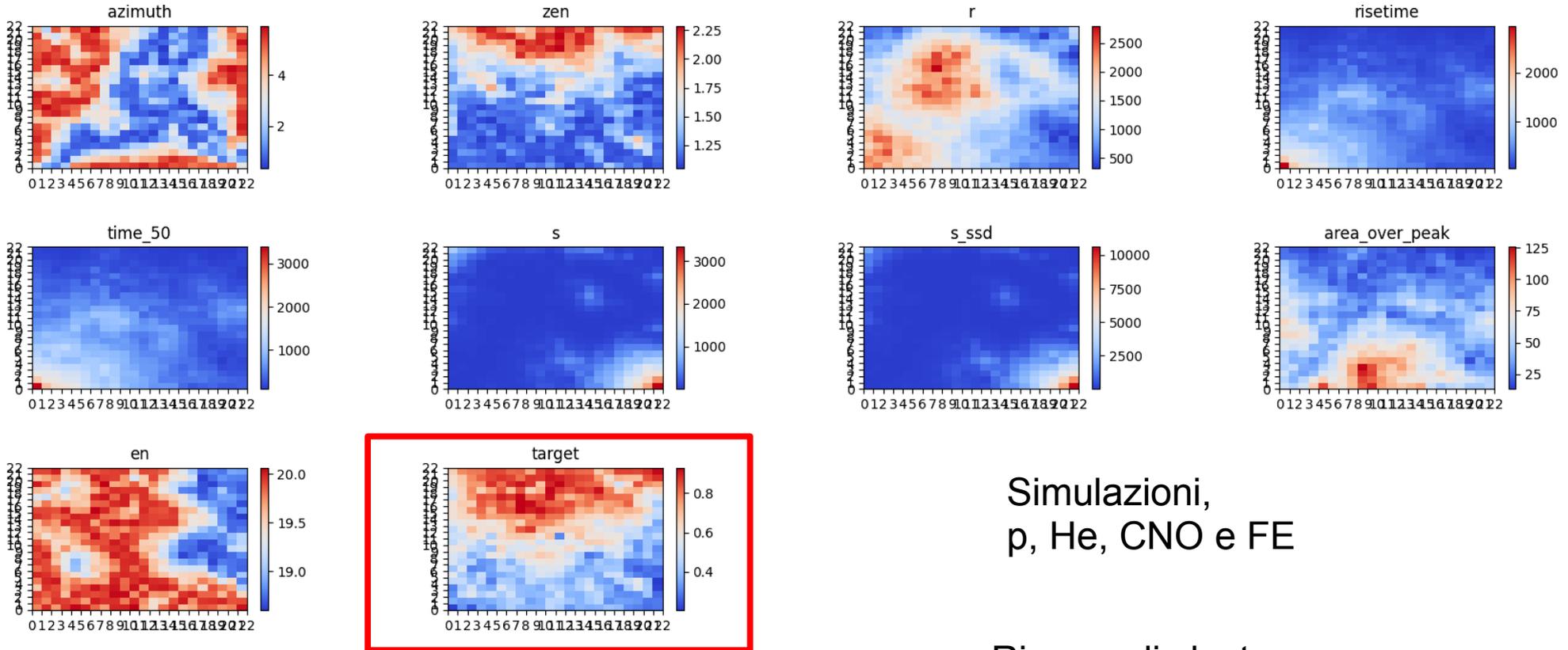
RMS vs Skewness

Presenza residuale di bad periods (alta RMS e bassa Skewness) e/o segnali con early peaks (alta RMS, alta Skewness)

Analisi dati con Reti neurali, studi di composizione di massa con il rivelatore upgradato

Ricerca di cluster con reti neurali non supervisionate

M. Conte
A Nucita



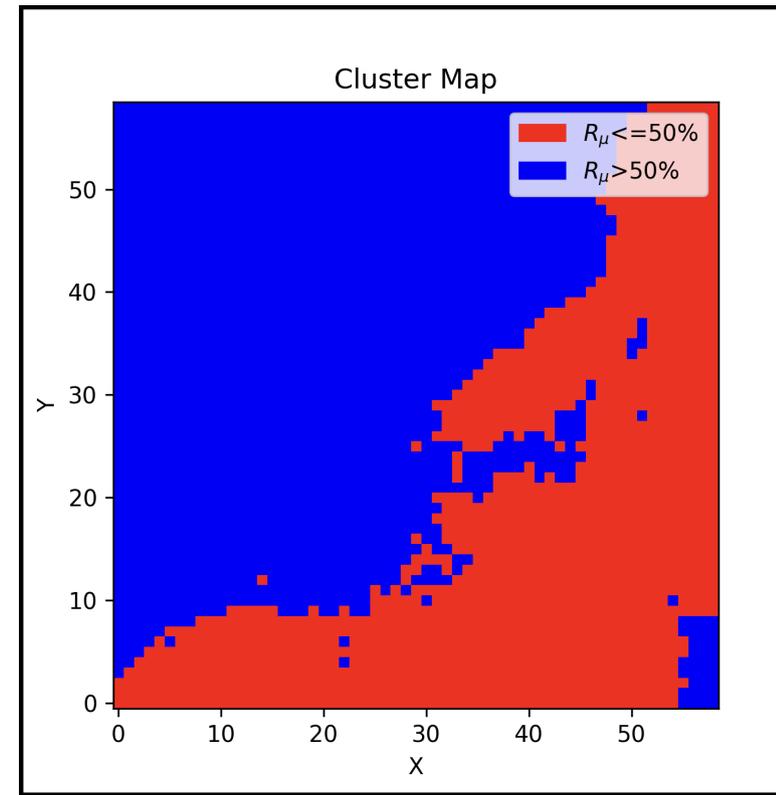
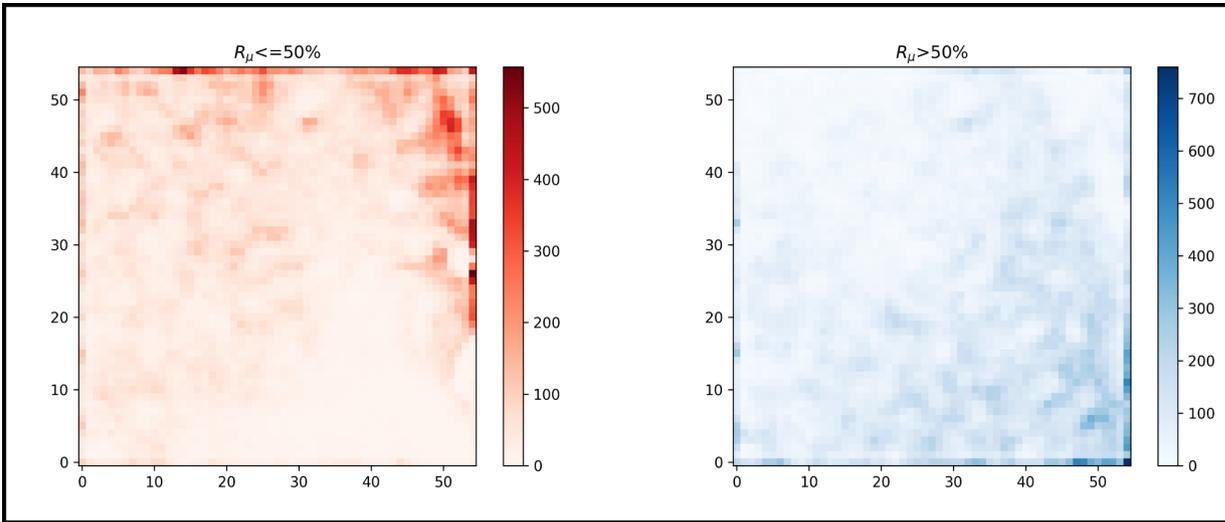
Simulazioni,
 p , He, CNO e FE

Ricerca di cluster correlati tra il target e le osservabili passate alla rete

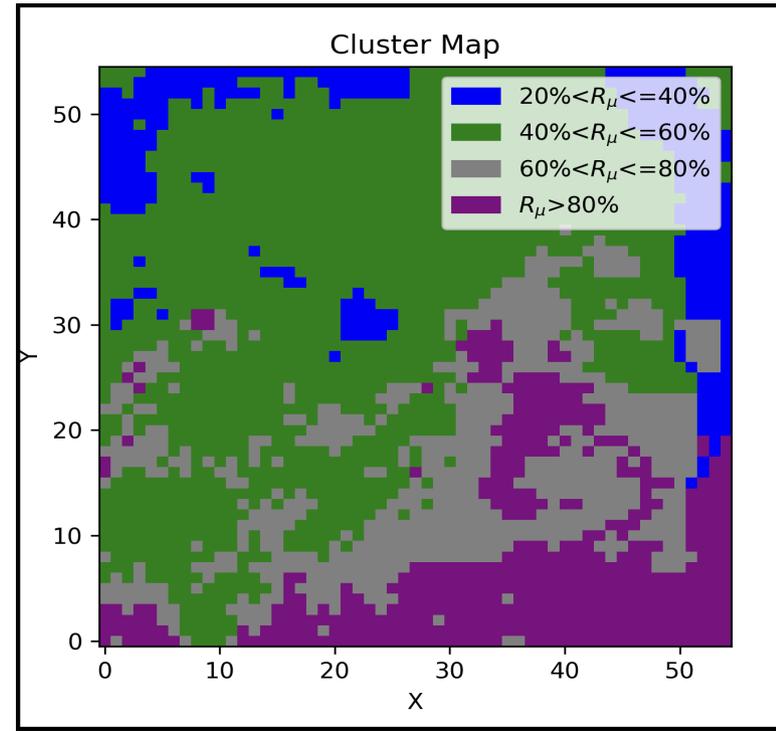
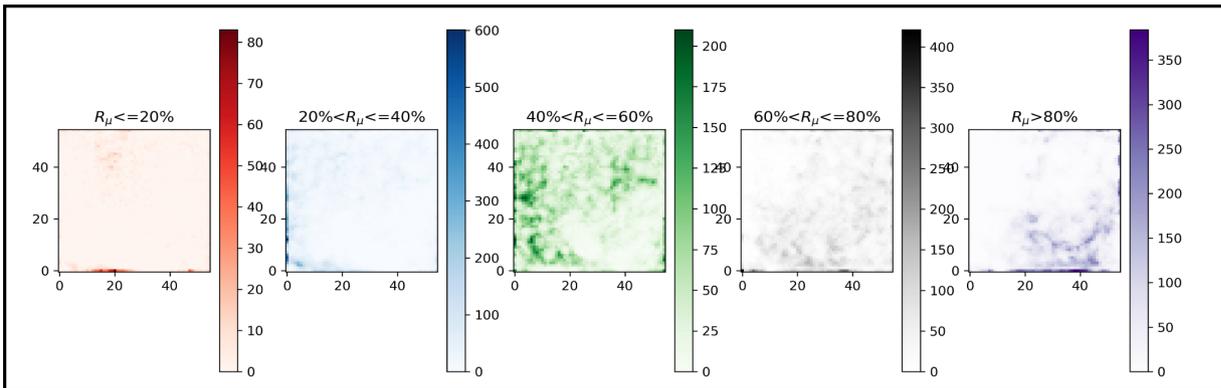
Test su dati simulati.
9 osservabili ricostruite passate alla rete
1 target (proxy per il numero di muoni)

Calcolo condotto su GPU della sezione

Mappa a due livelli



Mappa a cinque livelli



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

Upgrade del detector di superficie

Attività di design/costruzione di SSD con leadership del gruppo di Lecce che oggi coordina la verifica e messa a punto della performance sul campo (Malargue) delle stazioni SSD e le failures di produzione

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 Assiro)



Pierre Auger Observatory Open Data

March 2024 release

<https://opendata.auger.org>

doi 10.5281/zenodo.4487613

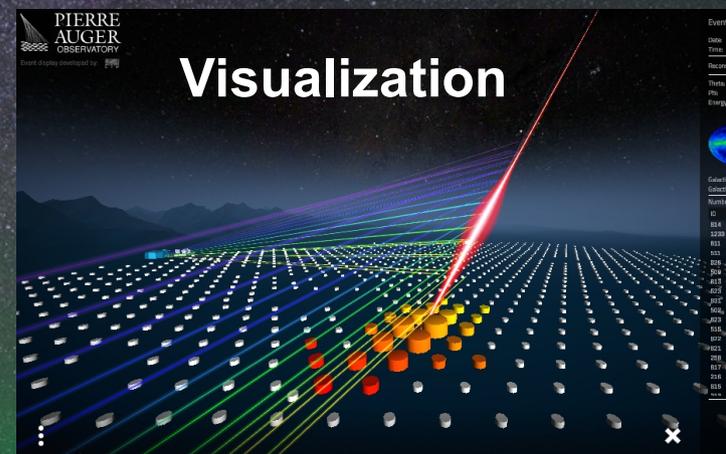
10% cosmic ray data → 30% at the end of 2024
100% atmospheric data

Close to raw data and higher level reconstruction

Surface and Fluorescence Detectors

JSON and summary CSV files

Python code for data analysis



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

March 2024 release

Dataset: 10% SD-750 events + HeCo hybrid events
used for calibration

[Eur. Phys. J C \(2021\) 81:966](#)

Source: [AugerWiki/InfillSpectrumPaper2021](#)

- data tar files (Herald, ADST, root)
- scripts (SDCalib.cc, CIC ...)
- plots

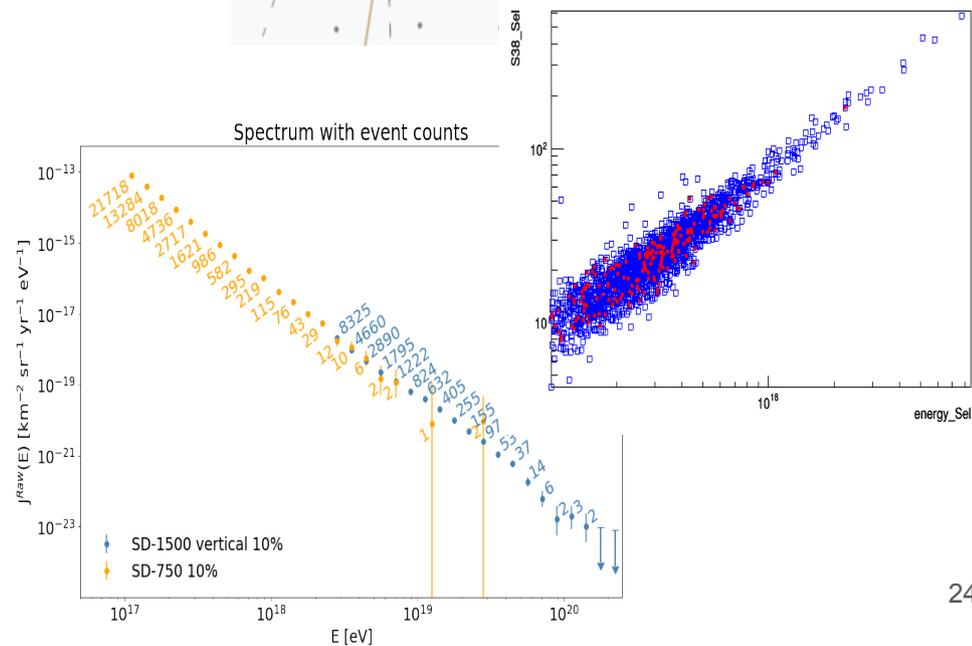
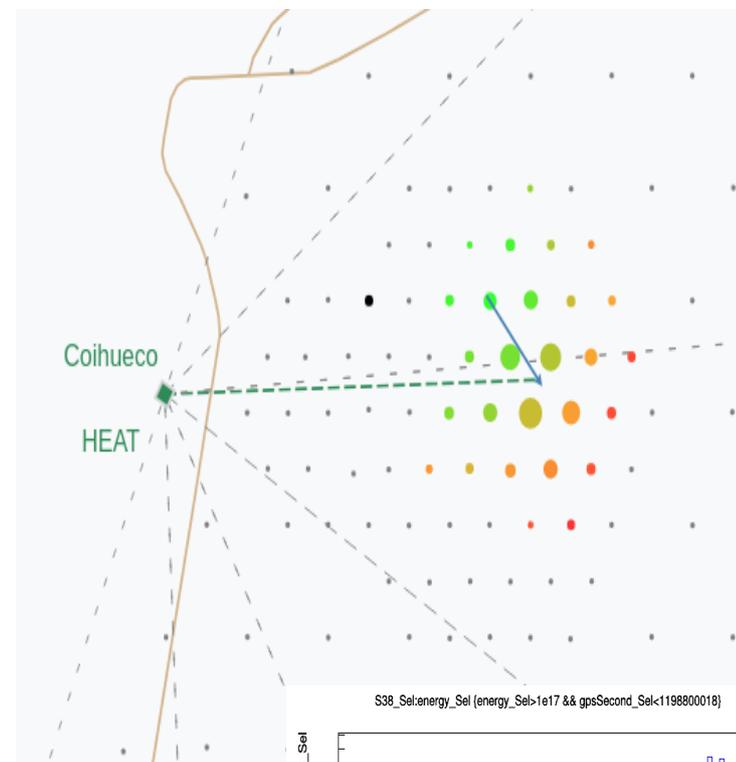
SD-750: 54477 events $E > 0.1 \text{ EeV}$ $H < 40^\circ$
He-Co hybrids for calibration: 197 events

Notebooks: updated spectrum

Catalog: raw traces and updated description

TODO:

- update arXiv paper in view of submission to journal
- transfer the development page hosted in Catania
<https://labauger.ct.infn.it/opendata/>



Il gruppo di Lecce:

partecipazioni ad Editorial Boards attivi

NIM paper su SSD : D. Martello, G. Cataldi, R. Coluccia, M. Conte

PRL, search for upward-going neutrinos : E. De Vito, L. Perrone

Open Data : V. Scherini

PRD, search for photons : P. Savina, L. Perrone, V. Scherini

APJ, anisotropy: U. Giaccari

JCAP, search for neutrons: D. Franco

Responsabilità

Referente per il calcolo di Auger al CNAF (fino a Giugno 2024) (G. Cataldi)

Task leader per Data Release Task (V. Scherini)

Task leader per SSD (D. Martello)

Chair del Collaboration Board (fino ad Aprile 2024, ora Lecce rappr.) (L. Perrone)

Membro del Conference Committee (U. Giaccari)

Partecipazione a conferenze

V Scherini ICHEP 2024

M. Conte SIF 2024

E. De Vito RICAP 2024

E. De Vito CRIS.MAC 2024

The image shows a screenshot of a Mini-Workshop agenda titled "Mini-Workshop: the multi-messenger physics program at the Pierre Auger Observatory". The event is scheduled for Monday, 29 Jan 2024, from 15:00 to 17:00 in Europe/Rome, at aula magna M0 (Dip. Matematica e Fisica - Ed. Fiorini). The organizer is Lorenzo Perrone (Istituto Nazionale di Fisica Nucleare). The description is "Overview of experimental results and advanced analysis techniques. Multi-flavor pastries." The agenda lists several sessions:

- 15:00 → 15:15: **The Pierre Auger Observatory in the context of Multi Messenger Physics** (Speaker: Viviana Scherini)
- 15:15 → 15:35: **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** (Speaker: Pierpaolo Savina)
- 15:35 → 15:55: **Search for upward-going showers consistent with the anomalous ANITA events with the Fluorescence Detector of the Pierre Auger Observatory** (Speaker: Emanuele De Vito)
- 15:55 → 16:15: **Search for point sources of neutrons in the data of the Pierre Auger Observatory** (Speaker: Danellise Franco)
- 16:15 → 16:35: **Studies of anisotropies in the arrival direction of cosmic rays at different scales** (Speaker: Ugo Gregorio Giaccari)
- 16:35 → 16:55: **AugerPrime: enhanced capability of separating primary masses with machine learning techniques** (Speaker: Matteo Conte)
- 16:55 → 17:00: **Multi-flavour pastries**

Control room remota per il rivelatore di fluorescenza



Turni FD remoti eseguiti

- Maggio – Giugno 2024

2 Turni SD remoti eseguiti

- Ottobre 2023

- Luglio 2024

Necessità di un upgrade software prima della prossima campagna di presa dati
Procedura richiesta a tutte le remote control room.

Attività di Outreach

G Cataldi → Responsabile Nazionale di “art and science”

Rita Coluccia → Responsabile Nazionale di OCRA (2025)

Masterclasses Pierre Auger Observatory

Iniziativa globale promossa da **IPPOG** con più di **13000** studenti in 60 paesi in tutto il mondo → 3a edizione a Lecce svolta il **19/3/2024**: 32 studenti da 6 scuole di LE, BR, TA

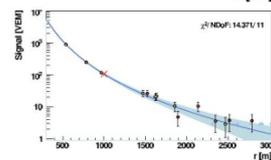
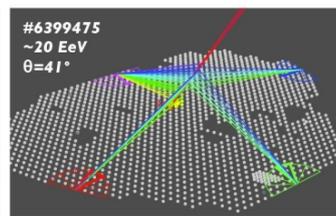
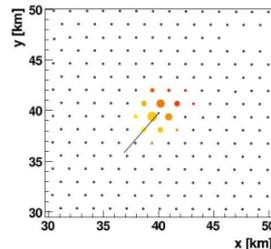


International Particle Physics Outreach Group

<https://physicsmasterclasses.org/>

Scoprire la fisica delle astroparticelle

- seminari introduttivi sui raggi cosmici
- attività sperimentale con gli eventi reali
- ricostruzione e analisi eventi
- discussione con esperti internazionali



3

V.Scherini



OCRA Outreach Cosmic Ray Activity

- Responsabile locale
 - Maria Rita Coluccia
 - Responsabilità Nazionale a partire dal 2025 con Alessia Giampaoli (LNGS)
- persone coinvolte (anagrafica preliminare 2025)
 - MR. Coluccia, G. Cataldi, F. Alemanno, E. Casilli, M. Conte, F. de Palma, E. De Vito, A. Franco, E. Ghose, U. Giaccari, D. Martello, A. Nucita, L. Perrone, S. Saquegna, V. Scherini, A. Surdo.

EDIZIONE IV NOV 2022 - MAG 2024

Art & Science ACROSS ITALY

INFN CERN

93 opere artistiche – 270 studenti e studentesse hanno completato l'intero percorso biennale.

7 opere «vincitrici della fase locale» esposte a Napoli (mostra nazionale)

2 opere tra i vincitori «assoluti»: Master al Gran Sasso (Liceo «Ciardo Pellegrino»-Lecce)-Master al CERN (Liceo Da Vinci-Maglie)-Settembre 2024

Creare immaginando
Ragazze e ragazzi mettono in arte la scienza
Una mostra a cura di Art & Science across Italy

le mostre di A&S

BARI
BIELLA
CAGLIARI
FERRARA/BOLOGNA
FIRENZE
FRASCATI
GENOVA
LECCE
LNGS
LNS
MILANO
NAPOLI
PADOVA
PERUGIA
POTENZA
PISA
ROMA
TORINO
TRIESTE

Lecce
Mostra 14-24 Marzo 2024

ex Chiesa di San Francesco della Scarpa
Piazzetta Carducci
tutti i giorni dalle 10.00 alle 20.00
Inaugurazione 14 marzo ore 10.00

INGRESSO LIBERO

Richieste per il 2025 (Preliminari)

Sommario → Consumo 5K
 Missioni 63K
 Trasporti 7K

consumo	Componenti e altre minuterie per supporto all'attivit� 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			5	0
missioni	2 turni tecnici (1 Fisico, 1 Tecnico, in concomitanza con il meeting di collaborazione di Novembre 2K x 4). Verifica sui moduli SSD installati nel campo e commissionig nuova elettronica UUB.	8.00	0.00			63	0
	Riunione con i referee, 2 Fisici (0.5 K x 2)	1.00	0.00				
	Partecipazione al meeting Auger di analisi (L'Aquila, Maggio 2025), 6 fisici (1.5x6)	9.00	0.00				
	Partecipazione gruppo di lavoro europeo su attivita' multi-messenger per 2 fisici.	3.00	0.00				
	2 missioni per 2 fisici (2K * 4) al CNAF per le operazioni di trasferimento dell'Auger data center da Lyon al CNAF	4.00	0.00				
	Partecipazione a meeting di collaborazione in situ. Due meeting (Marzo 2025 e Novembre 2025) 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				
trasporti	Trasporti in situ per 1 turno FD (2K) 1 turno tecnico (2K) + Trasporti per partecipazioni ai meeting (1K per meeting di Marzo + 2 K per meeting di Novembre)	7.00	0.00			7	0
Totale						75	0

Accesso a servizi per il 2025

Supporto nella gestione e software upgrade della control room remota di Auger
Assistenza nella fase di transizione del data center di Auger da Lyon al CNAF
Supporto durante la scuola internazionale ISAPP (Giugno 2025)
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)

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

Verifica dell'installazione del funzionameneto delle schede UUB

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

BACKUP

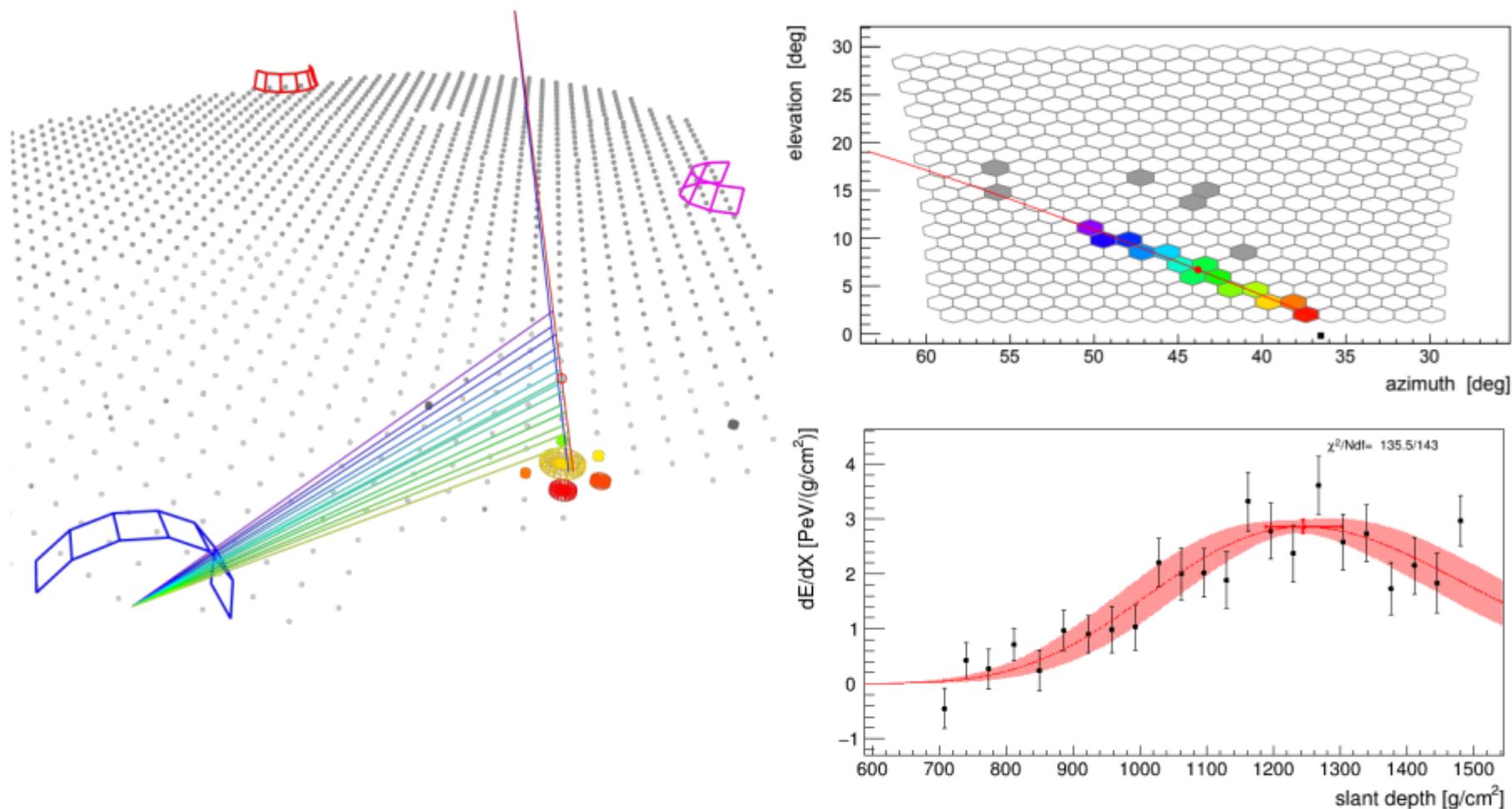
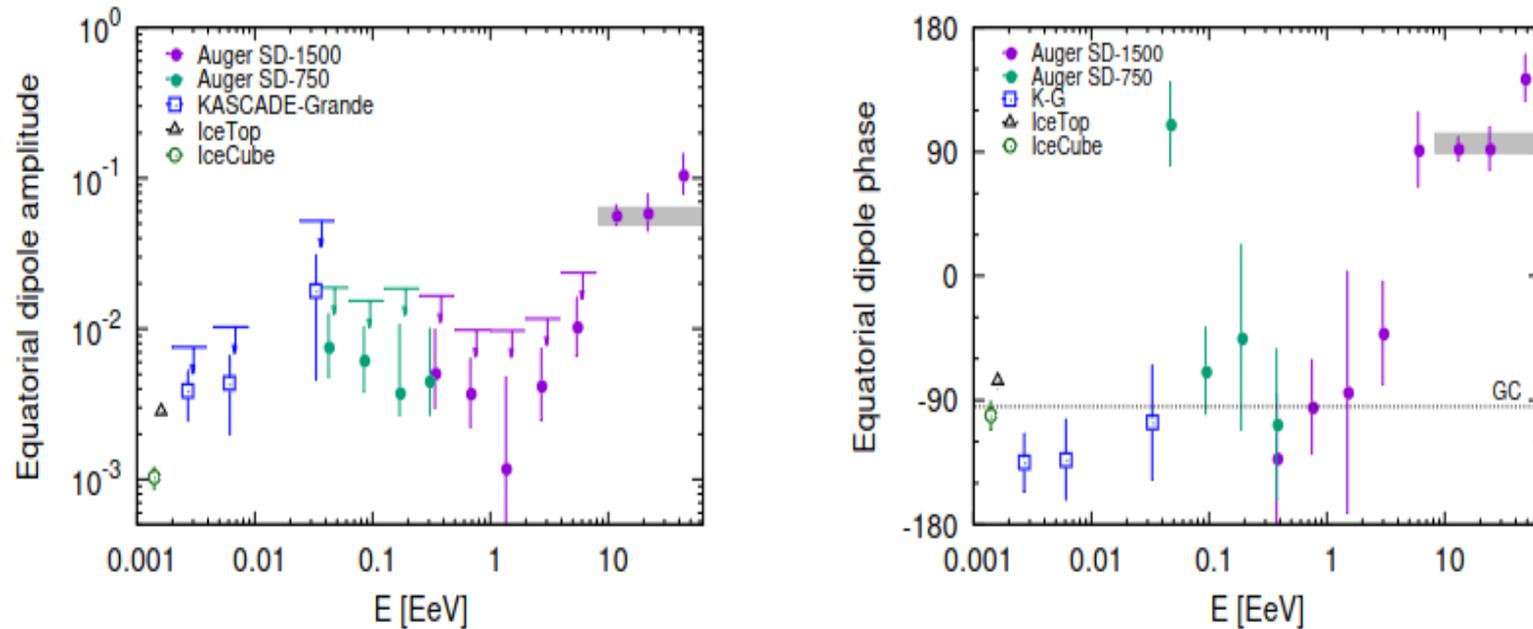


Figure 17. Characteristics of the most significant photon candidate event, ID 3478968: 3D visualization (left panel), camera view of the triggered FD telescope (top right panel). The colors (violet to red) reflect the times (early to late) at which the light reaches each pixel. Gray pixels indicate background triggered pixels. Bottom right panel, reconstructed energy deposit as a function of atmospheric slant depth (black points) along with the fit to the shower longitudinal profile (red line).

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

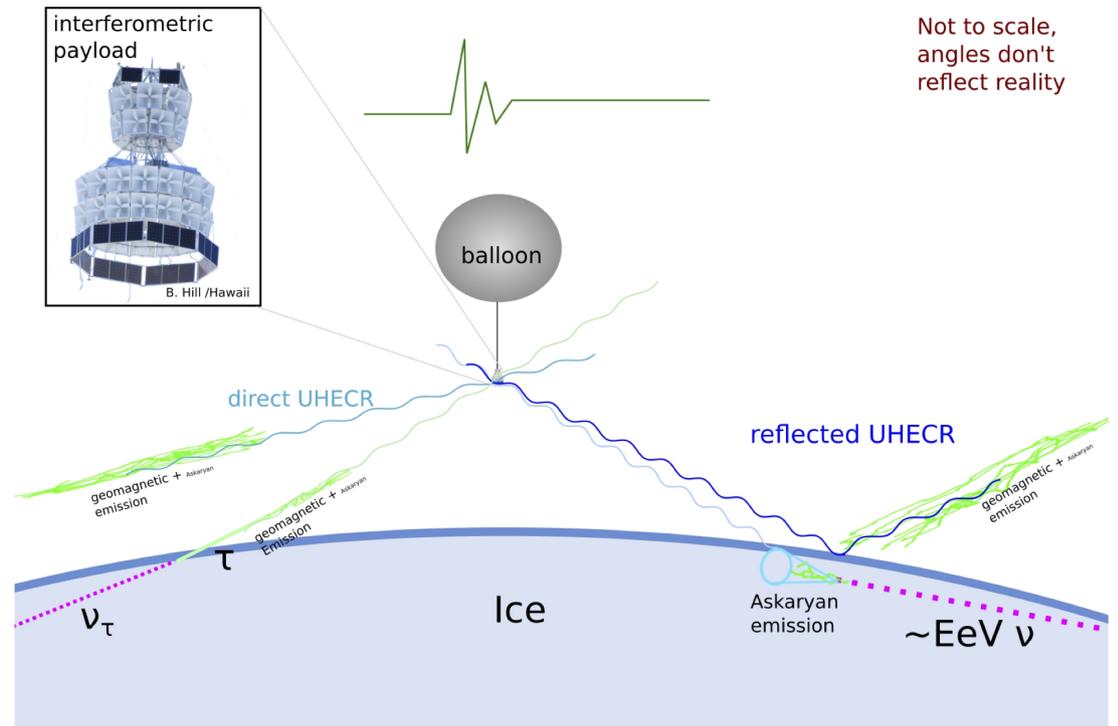
=> suggests a transition of the origin of the anisotropies from galactic to extragalactic

Search for upward-going showers with FD

The ANITA experiment detected two anomalous events with non-inverted polarity, consistent with upward-going showers
PRL 117 071101 (2016)
PRL 121 161102 (2018)

$E_{1,2} \gtrsim 0.2 \text{ EeV}$
exit angle $\approx 27^\circ \approx 35^\circ$

More recently, observation of 4 events very close to horizon
PRL 126 071103 (2021)



Fervent debate about the interpretation of these observations

- Quantify the sensitivity of the FD to upward-going showers
- Use 14 years of FD data (2005-2018) for a dedicated search

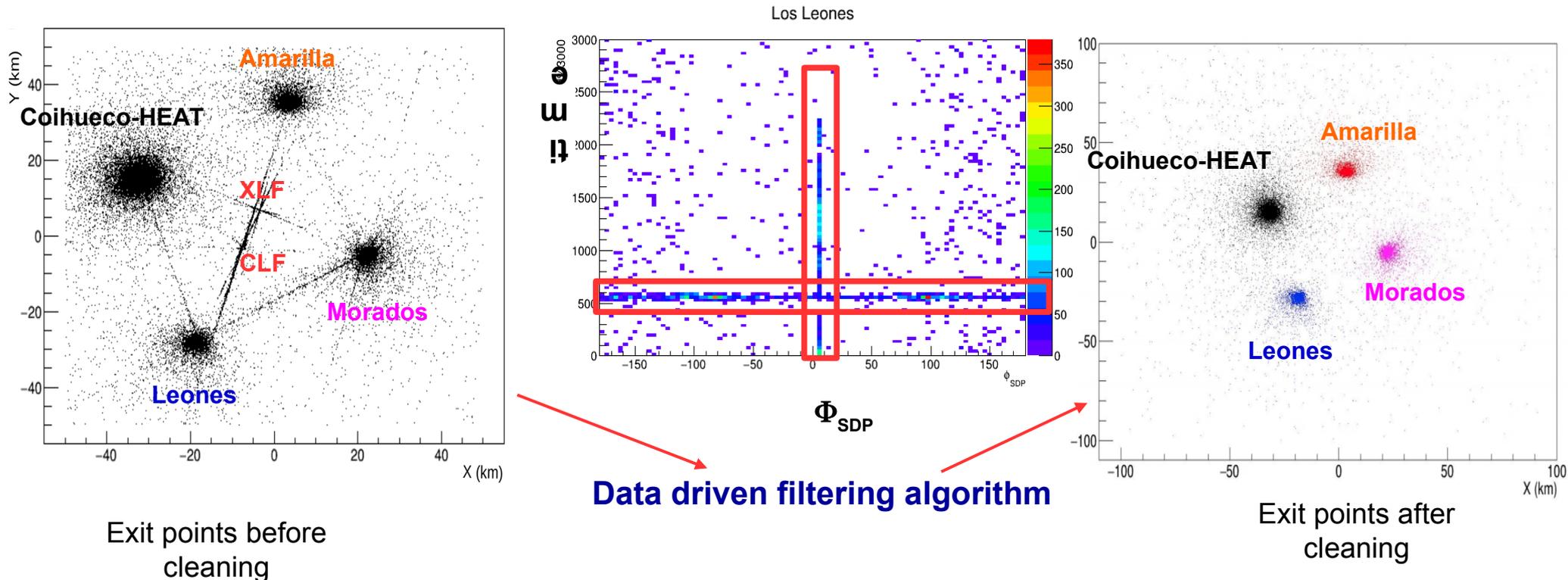
Data cleaning using a burnt data sample

Blind analysis performed using 10% of the FD data from 14 years of FD operation

FIRST STEP: remove untagged laser events used to monitor the atmosphere

Lidar shots have a specific frequency of 333 Hz \rightarrow they pile up in a `GPSMicroSecond%3000` histogram

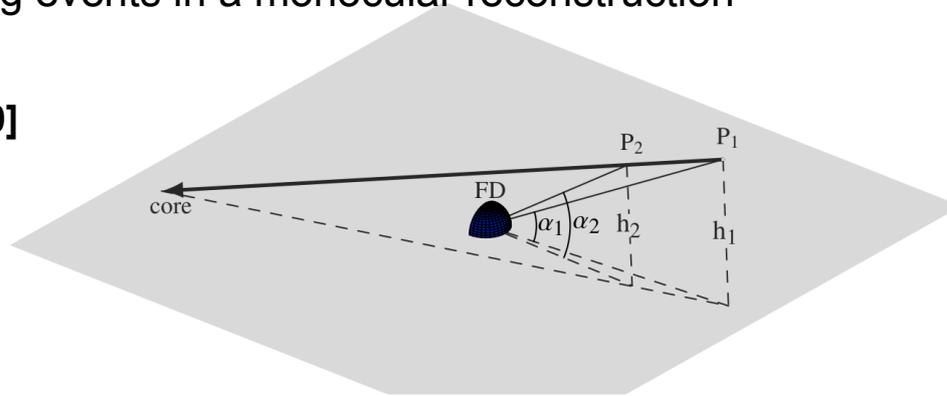
CLF and **XLF** have a known position \rightarrow the angle Φ_{SDP} that define the intersection of the shower detector plane (SDP) with the ground can be used to identify the associated event



BACKGROUND SIMULATION

Downward-going events with specific geometries can mimic upward-going events in a monocular reconstruction

Zenith [$0^\circ - 90^\circ$]
 $\log_{10}(E/eV)$ [17-20]



$$\alpha_1 < \alpha_2$$

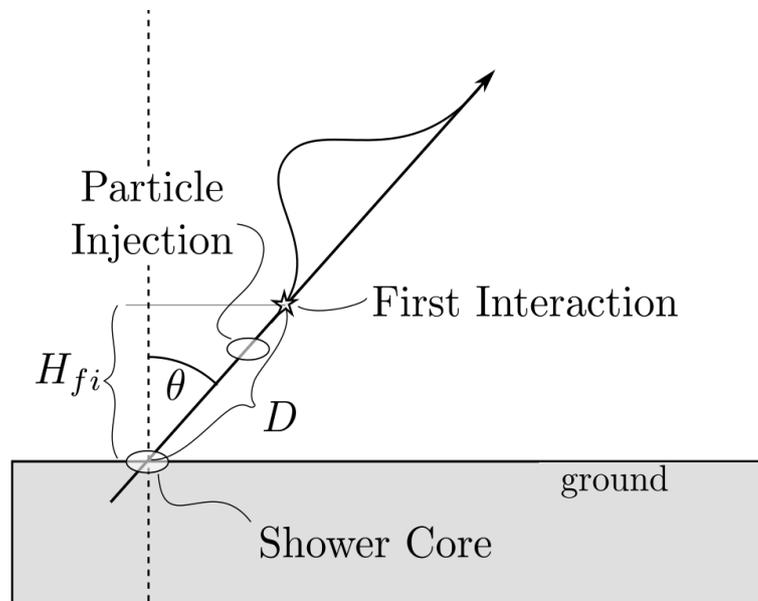
$$h_1 > h_2$$

Signal from P_1 reaches the FD before the signal from $P_2 \rightarrow$ downward-going event reconstructed as upward-going

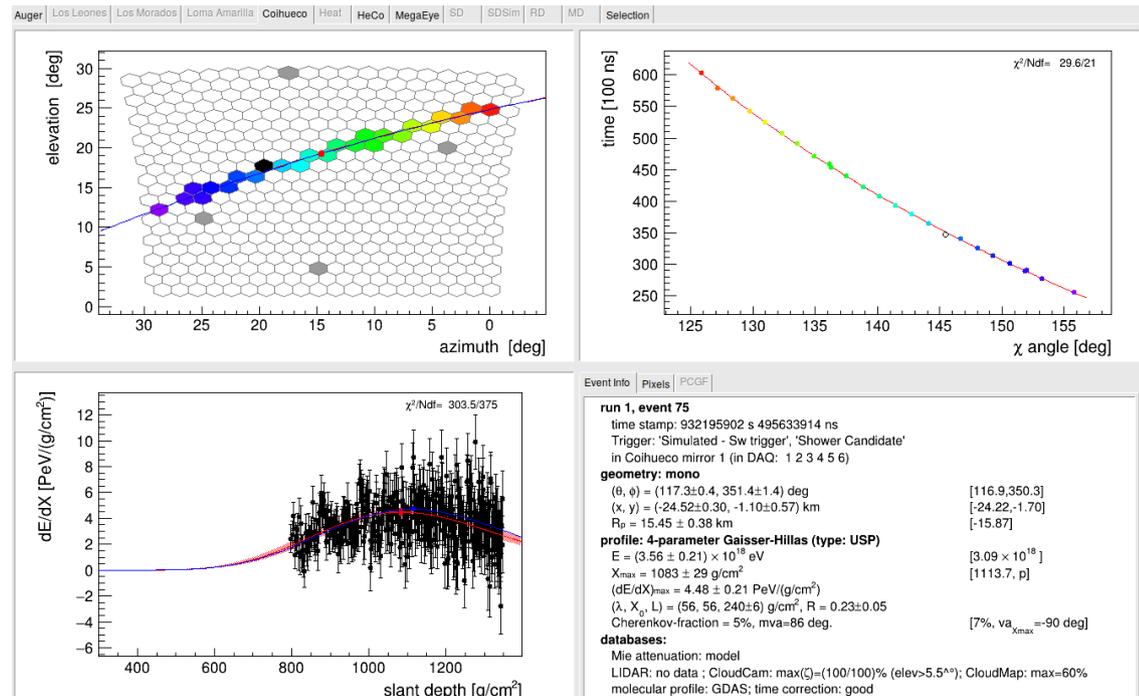
Also events with a core far away from the array can produce background and need to be simulated

Detector and atmospheric effects included in simulation: Real Monte Carlo approach

SIGNAL SIMULATION

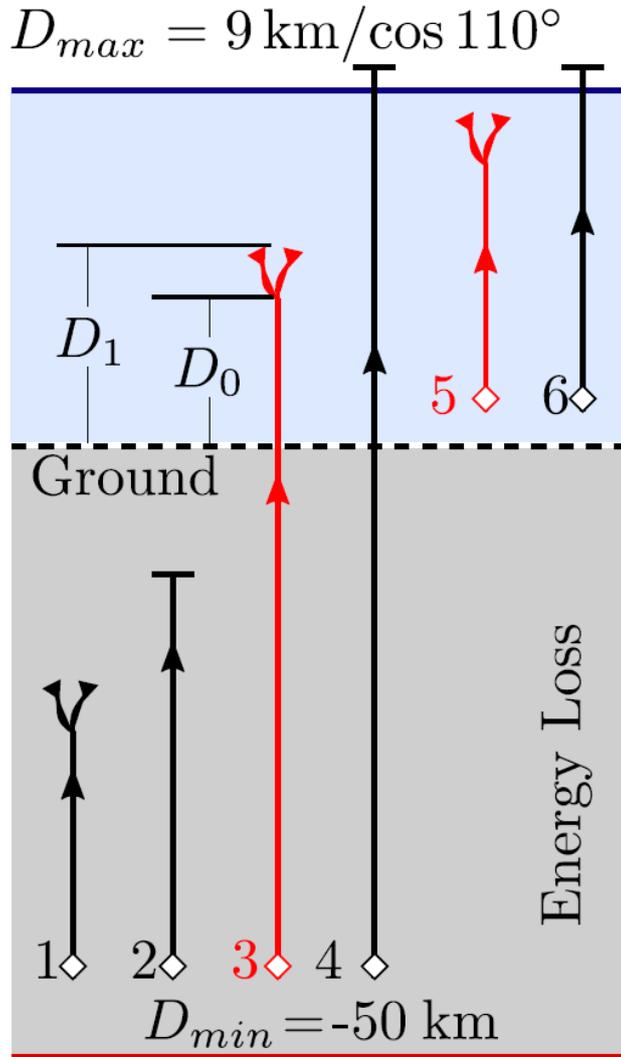


Zenith [$110^\circ - 180^\circ$]
 $\log_{10}(E/eV)$ [16.5-18.5]



A specific case: the tau scenario

I. Caracas for the Pierre Auger Collaboration, PoS (ICRC2021) 1145



Tau propagation --> NuTauSim

J. Alvarez-Muñiz et al., Phys. Rev. D 97 (2018) 023021

Tau decay → Tauola

M. Chruszcz, et al. Comput. Phys. Commun. 232 (2018) 220

main decay branches considered

$e^{+/-}$, $\pi^{+/-}$, π^0 , $K^{+/-}$, K^0 , contributing to the formation of air showers.

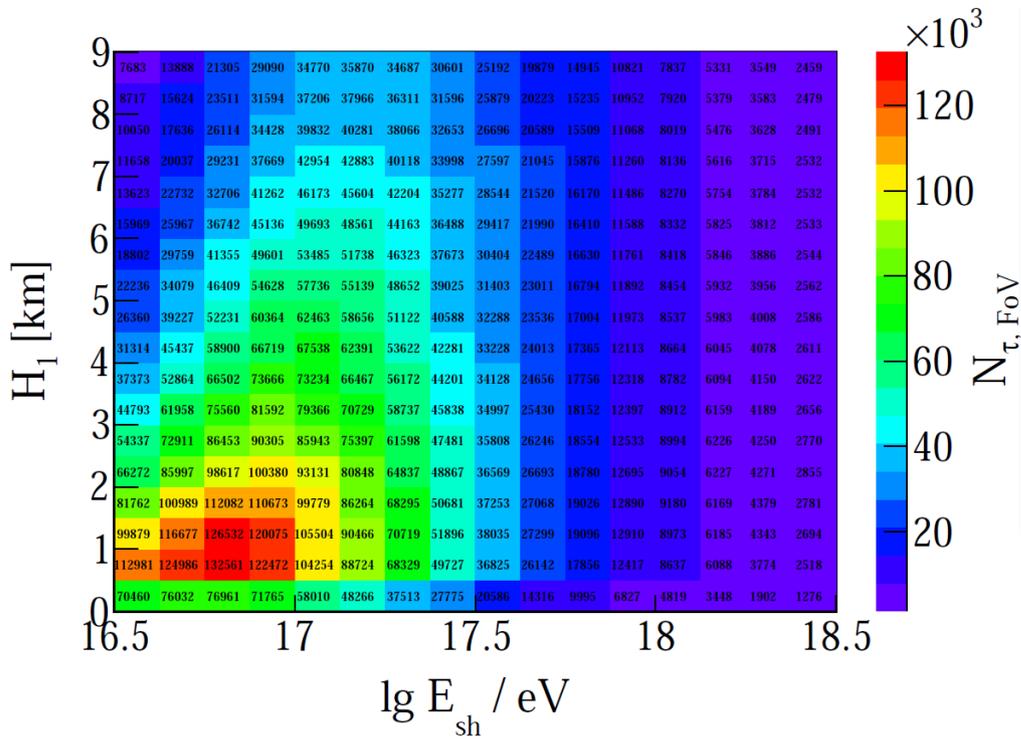
Dmin set by the tau range in standard rock

Dmax set by the FoV of the FD

Channel **3** and **5** are producing air showers within the field of view of FD

Height of first interaction H1 derived from average of the first interaction depth of each secondary, zenith and atmospheric profile

Folding the FD response with taus in FOV



H_1 → height of first interaction
 E_{sh} → energy of the induced shower

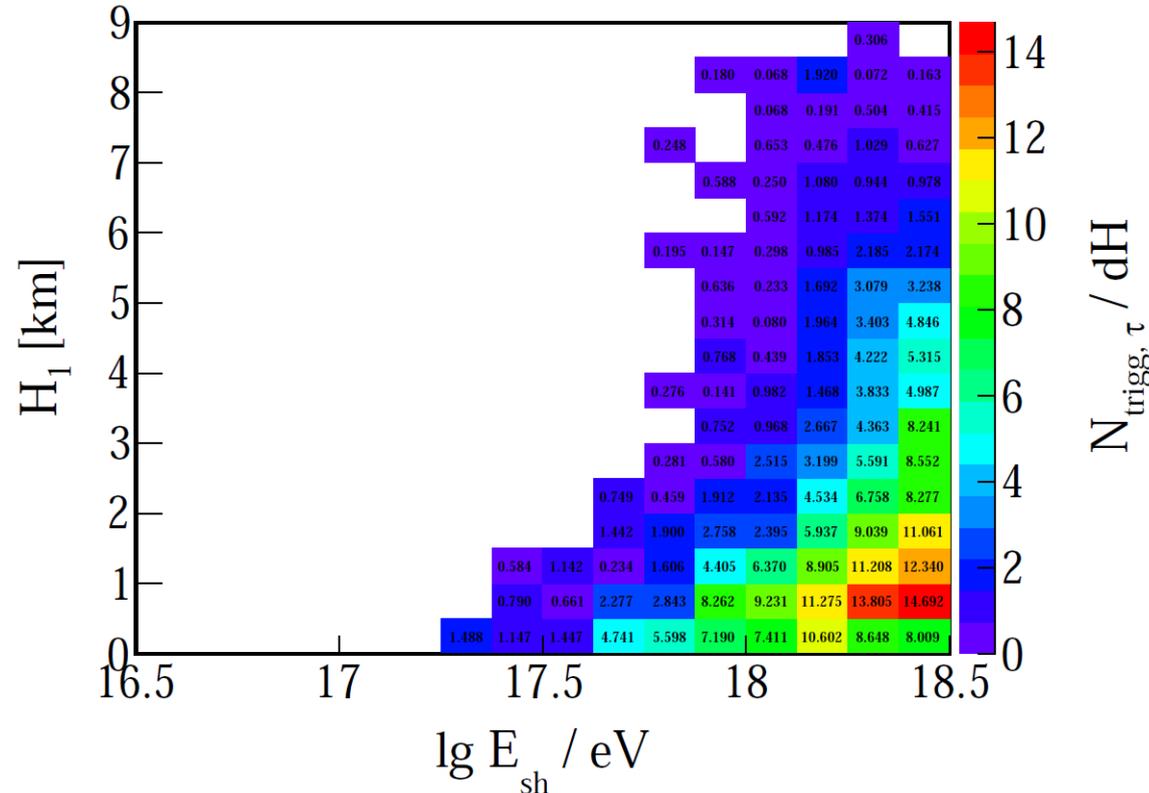
Selection criteria and energy range inherited from the generic search



FD detector acceptance for generic upwards-going EAS



Observable events



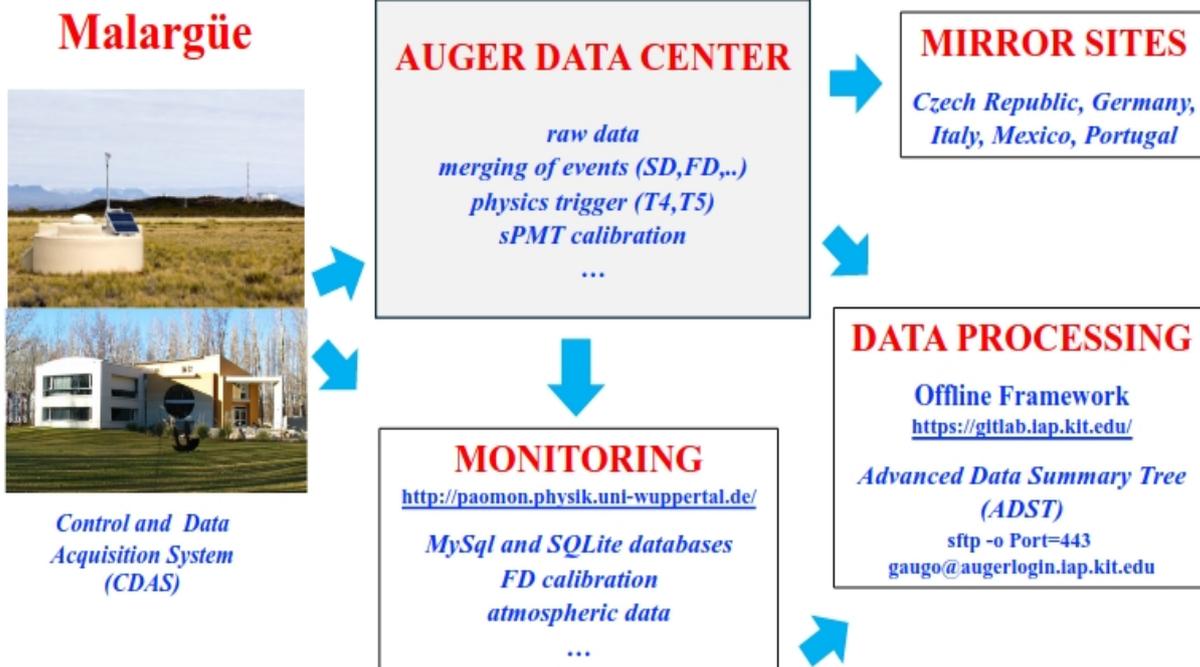
Status

- ◆ We have the final results for the **SD-1500** and the **SD-750** data sets.
- ◆ We are investigating an interesting candidate source, the pulsar **J1946-5403**. For the SD-1500, we obtained a p -value of **5×10^{-5}** for the direction of this target. We are studying the possibility of including it as a **single-element target set** for the **SD-750 data set**.
- ◆ We are preparing two GAP notes related to the neutron analysis: one with a detailed description of the method and the other with details about the feasibility of testing the pulsar J1946-5403 using the SD-750 data set.
- ◆ We are writing the paper and hope to have the first draft in the coming weeks.

Auger Data Center Lyon → CNAF

Endorsement dal CB di Auger a INFN per il trasferimento da Lyon al CNAF (Aprile 2024)

Impegno per Auger Italia, gruppo di Lecce coinvolto direttamente



Requisiti in breve:

600 TiB disco

1.3 PiB tape

Incontro preliminare al CNAF per iniziare la procedura in caso di approvazione delle richieste

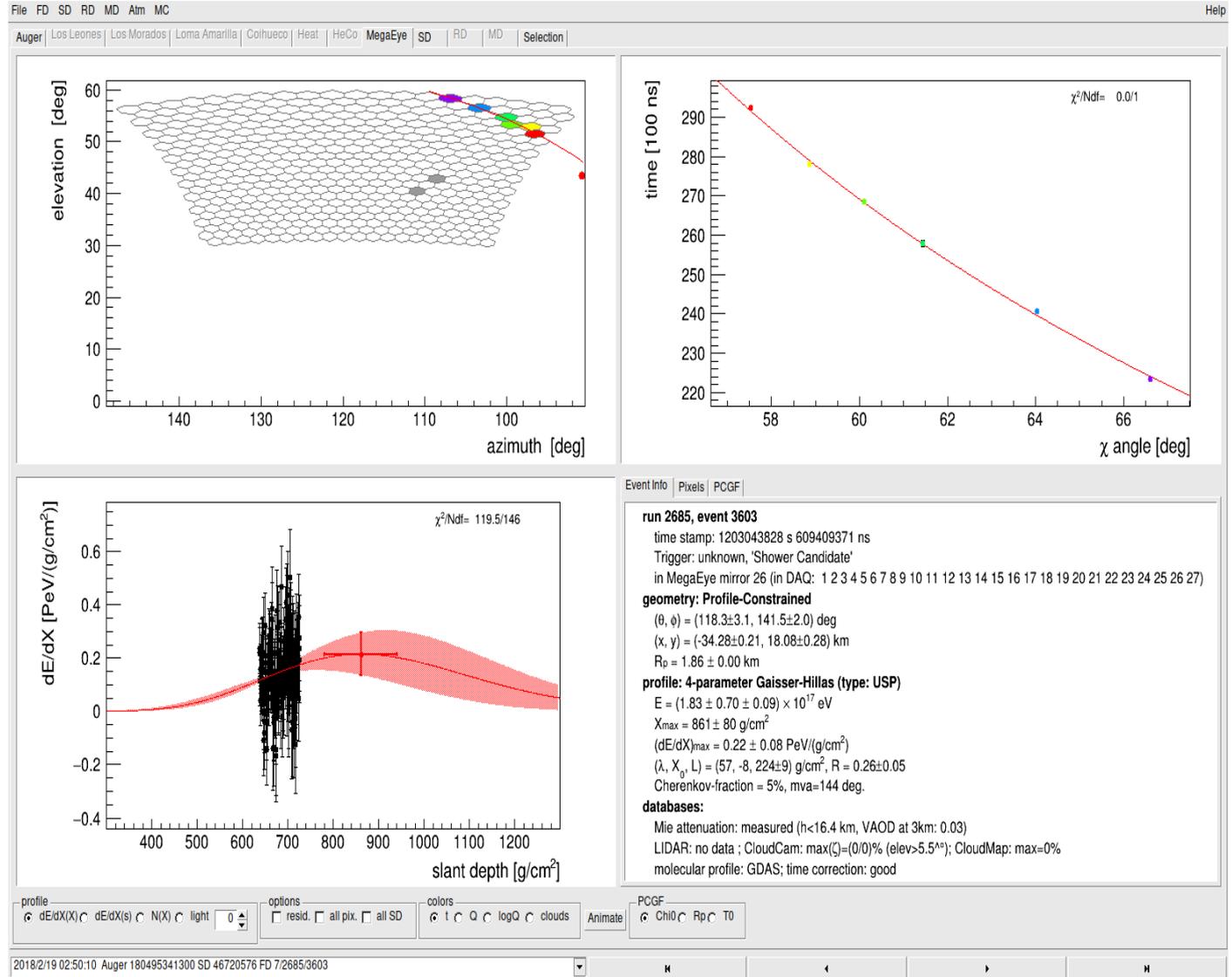
Ringrazio Enrico Fasanelli per i consigli ed il supporto in questa fase preliminare. Supporto del servizio calcolo richiesto per il 2025 (3 Mesi/Persona)

The new “candidate”

Display of the event passing all selection criteria

Not a laser (no burst, time, profile)

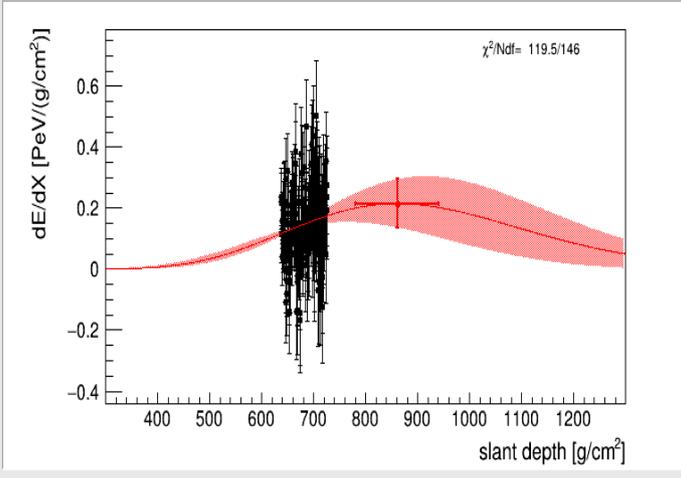
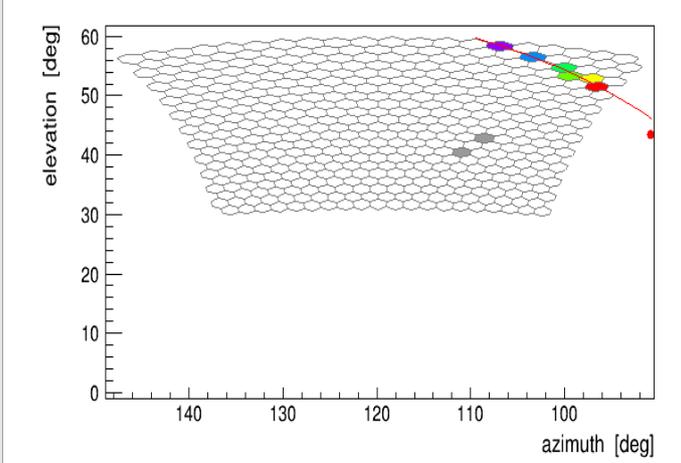
Seems like a downward going event landing behind the telescope, but downward reconstruction fails. No good downward geometry is found even using HEAT only (not MegaEye).



The new "candidate"

File FD SD RD MD Alm MC Help

Auger | Los Leones | Los Morados | Loma Amarilla | Colihueco | Heat | HeCo | MegaEye | SD | RD | MD | Selection



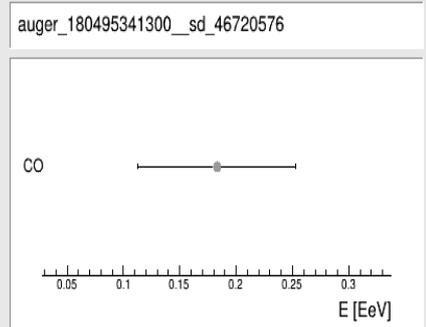
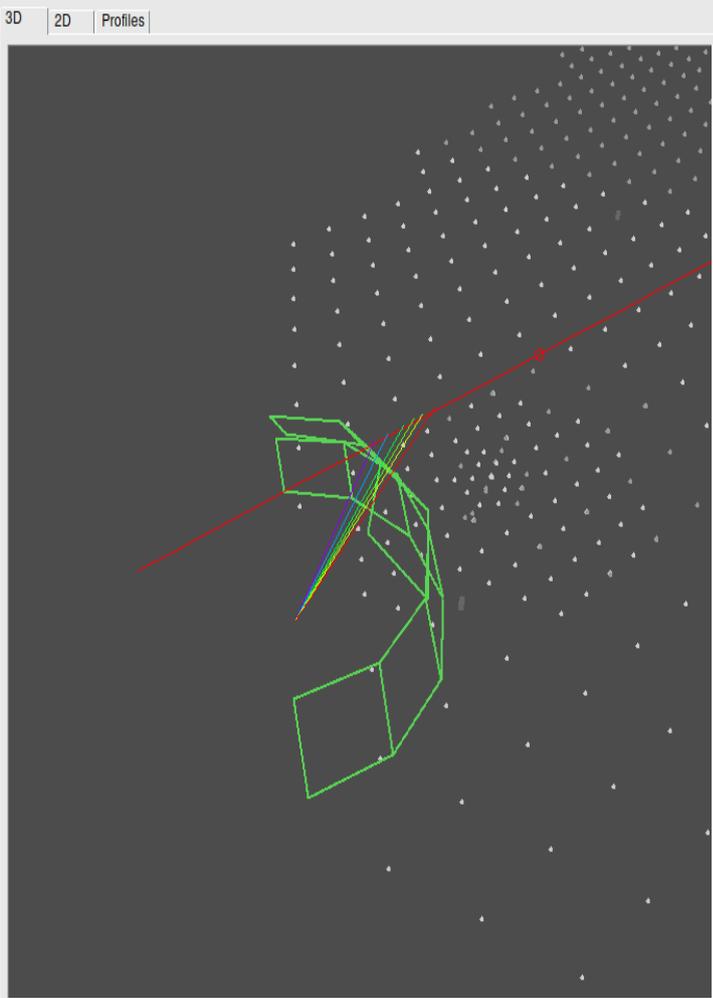
Event Info | Pixels | POGF

run 2685, event 3603
 time stamp: 1203043828 s
 Trigger: unknown, 'Shower in MegaEye mirror 26 (in D.

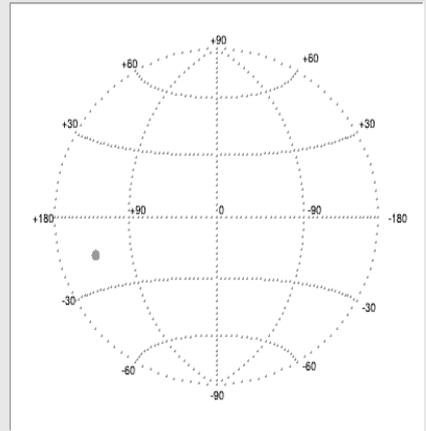
geometry: Profile-Constrain
 $(\theta, \phi) = (118.3 \pm 3.1, 141.5 \pm \dots)$
 $(x, y) = (-34.28 \pm 0.21, 18.08)$
 $R_p = 1.86 \pm 0.00$ km

profile: 4-parameter Gaisser
 $E = (1.83 \pm 0.70 \pm 0.09) \times \dots$
 $X_{max} = 861 \pm 80$ g/cm²
 $(dE/dX)_{max} = 0.22 \pm 0.08$ PeV/(g/cm²)
 $(\lambda, X_0, L) = (57, -8, 224 \pm 9)$
 Cherenkov-fraction = 5%, n

databases:
 Mie attenuation: measured
 LIDAR: no data ; CloudCan
 molecular profile: GDAS; tir



shower parameters
 Energy Xmax



profile: dE/dX(X) dE/dX(s) N(X) light 0

options: resid. all pix. all SD

colors: t Q logQ clouds

PGPF: Chi0 Rp T0

2018/2/19 02:50:10 Auger 180495341300 SD 46720576 FD 7:2685:3603

FD options: rays signal

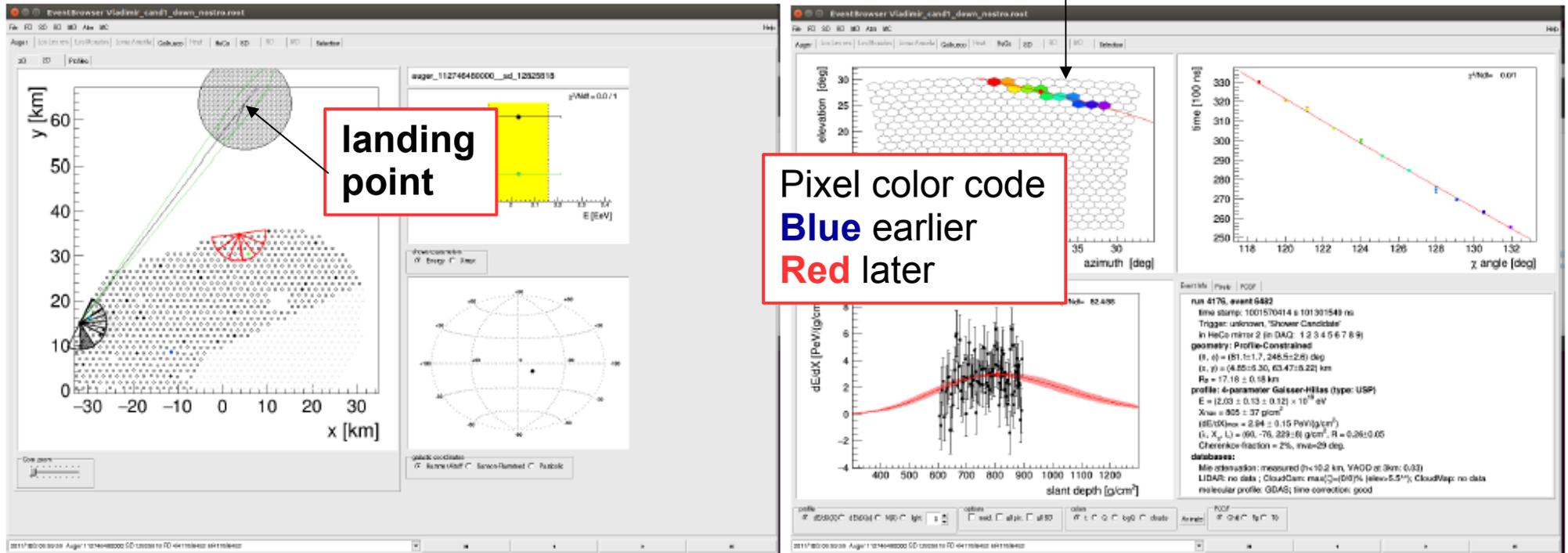
SD options: all tanks radius

other options: show MC fixed view

Save PDF

Exemplary background event AugerId=11274648000

Time sequence in the camera just “apparently” upward-going



Inclined event ($\sim 80^\circ$) passing over Coihueco and landing behind Loma Amarilla