Cosmic ray mass composition at the *knee* using azimuthal fluctuations of air shower particles detected at ground by the KASCADE experiment

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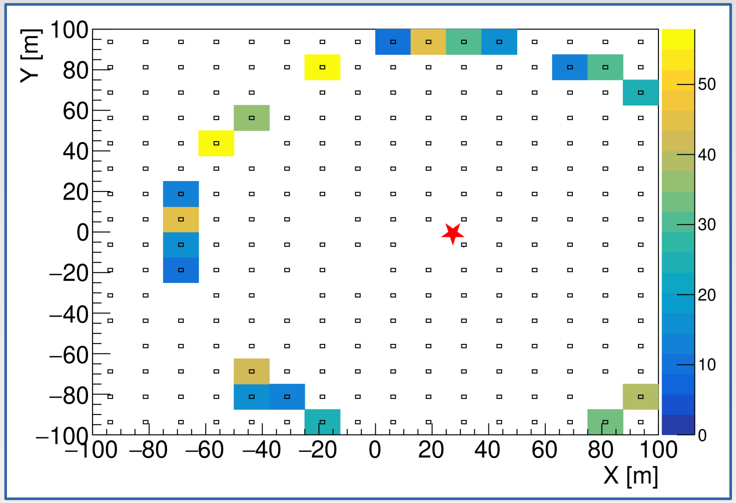
INSTITUTE OF SPACE SCIENCE

The *LCm* observable from EAS at PeV

- **The *LCm* observable, *LCm* = log(C_k)** **[R. Conceição, *et.al.*, JCAP 10, 086 (2022)]**

$$C_k = \frac{2}{n_k(n_k-1)}\frac{1}{\langle S_k\rangle}\sum_{i=1}^{n_k-1}\sum_{j=i+1}^{n_k}(S_{ik}-S_{jk})^2$$

→ Accounts for the non-uniformity in the signal induced in detectors at a given distance from the shower axis in **vertical showers.**



The energy deposited in in e/γ-detectors located in the radial range **r_k = [100 – 110]m** of the 252-detector array of the KASCADE experiment.

The KASCADE experiment @ KIT Germany.

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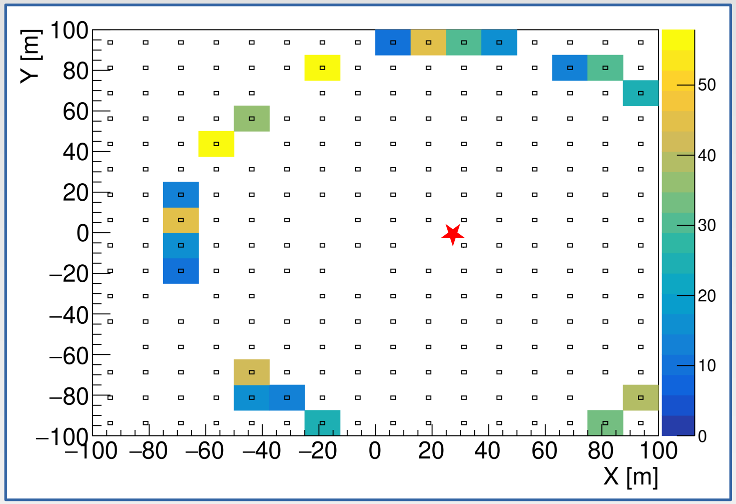

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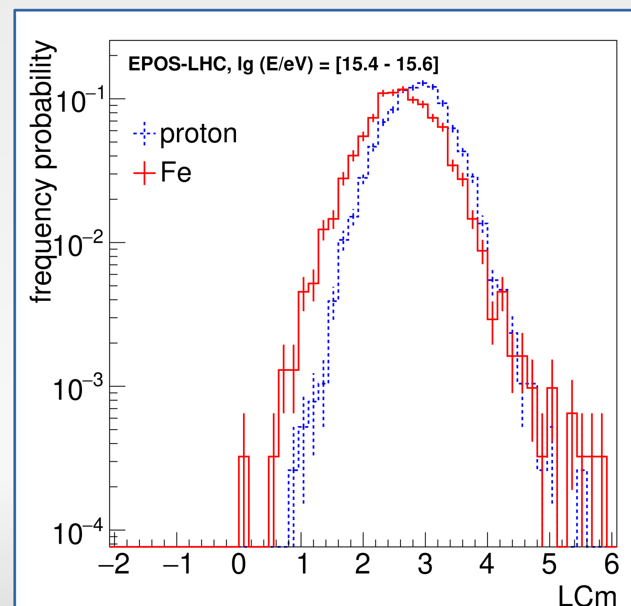
The KASCADE experiment @ KIT Germany.

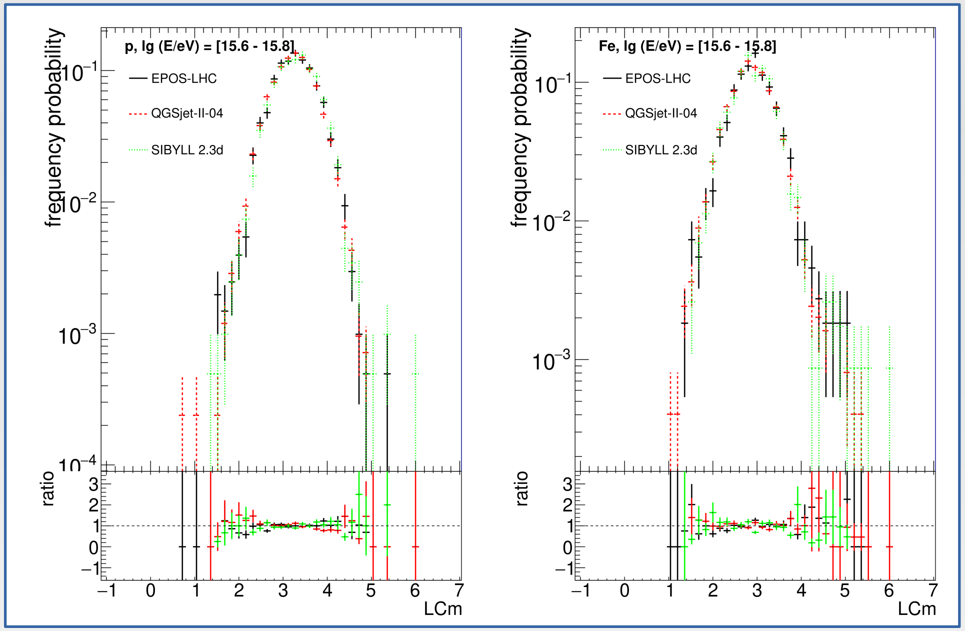
- ***LCm* distributions from Monte Carlo simulations of KASCADE array (CORSIKA + CRES(GEANT 3) + KRETA)**

- **EPOS-LHC**, **QGSjet-II-04,** **SIBYLL 2.3d** and **FLUKA (**E_{lab} < 200 GeV**)**
- (**p, He, C, Si**, and **Fe**)
- **lg(*E*/eV) = [15.0 – 16.0]** with intervals of **lg(*E*/eV) = 0.2**
- **γ = −2.7**
- **θ = [0° - 20°]** and **ϕ = [0° - 360°]**
- **10^3 - 10^4** events / primary species / model in each energy interval



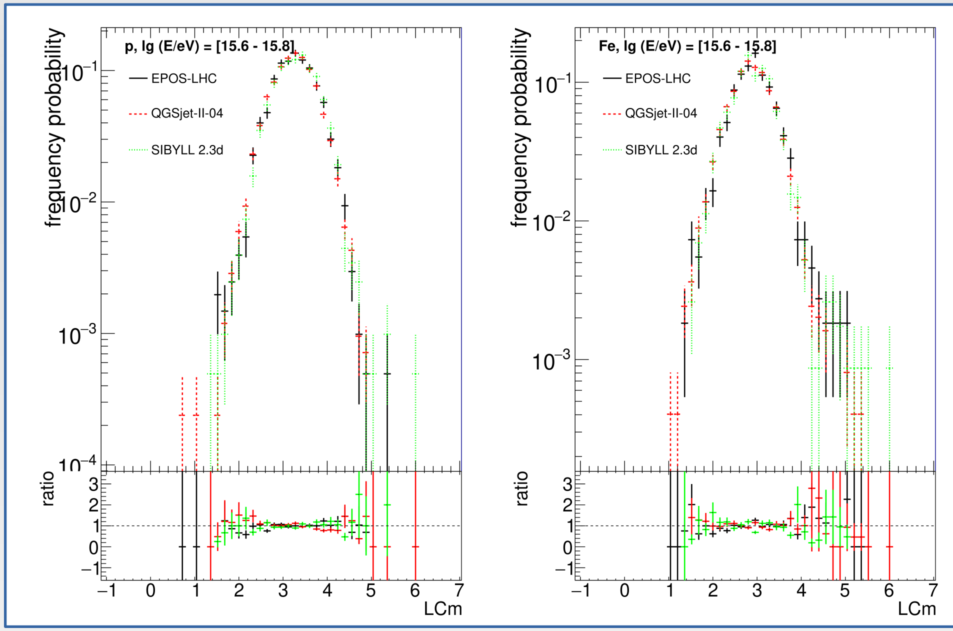
The *LCm* observable from EAS at PeV

- ***LCm* dependence on hadronic interaction models**



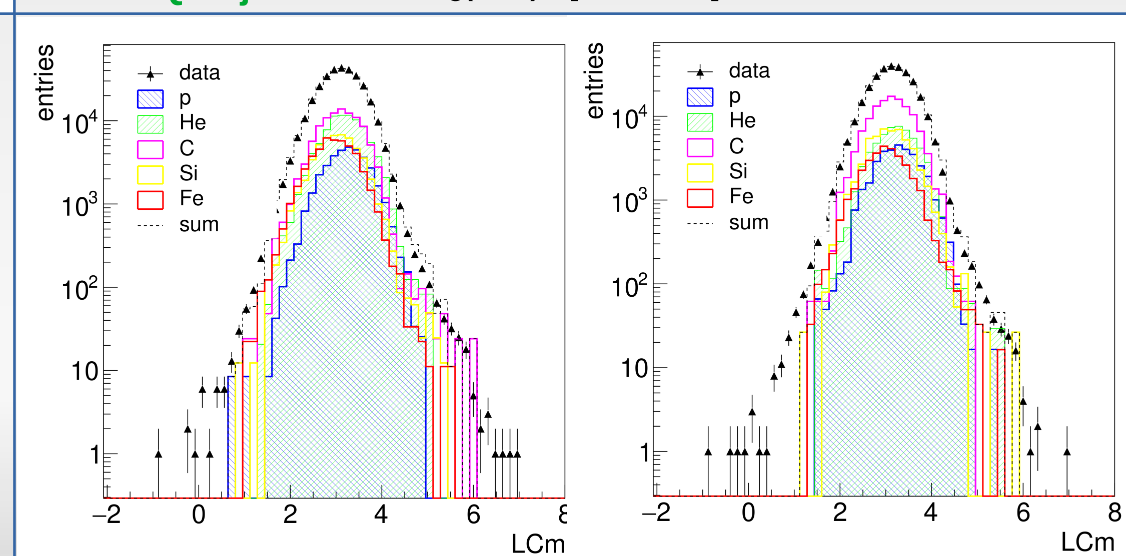
The *LCm* observable from EAS at PeV

- ***LCm*** **dependence on hadronic interaction models**

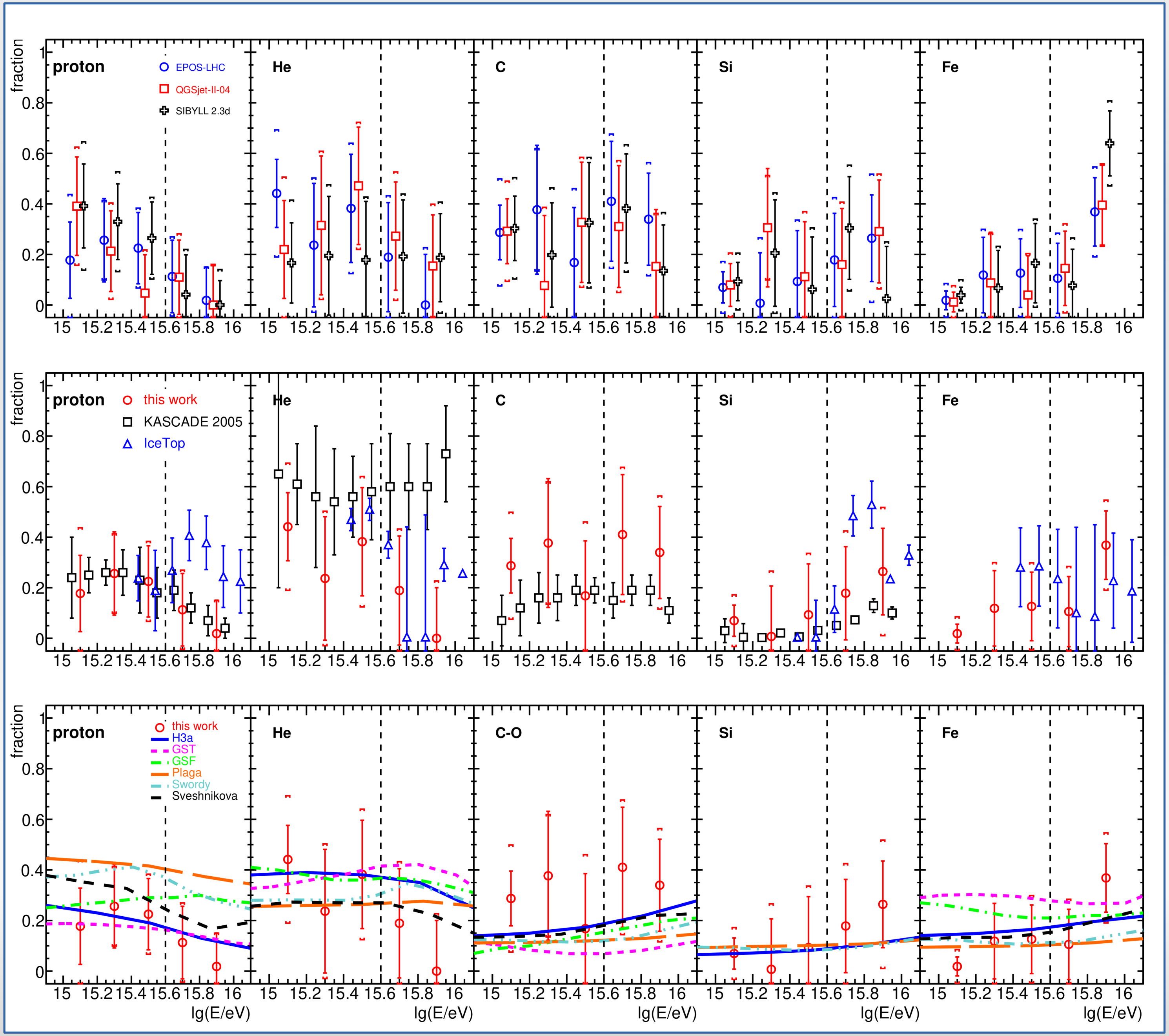


- **Fitting experimental *LCm* distributions with MC predictions**

QGSjet-II-04 **lg(*E*/eV) = [15.6 – 15.8]** **EPOS-LHC**



Mass composition around the *knee*



A New Computational Approach to Gamma-Ray Flux Modeling for WIMP Annihilation Detection

Daniele Ambrosino[1,2], **Carla Aramo**[1], **Fabio Iocco**[1,2]

[1]Istituto Nazionale di Fisica Nucleare (INFN), sezione di Napoli.

[2]Dipartimento di Fisica E. Pancini, Università degli Studi di Napoli Federico II.

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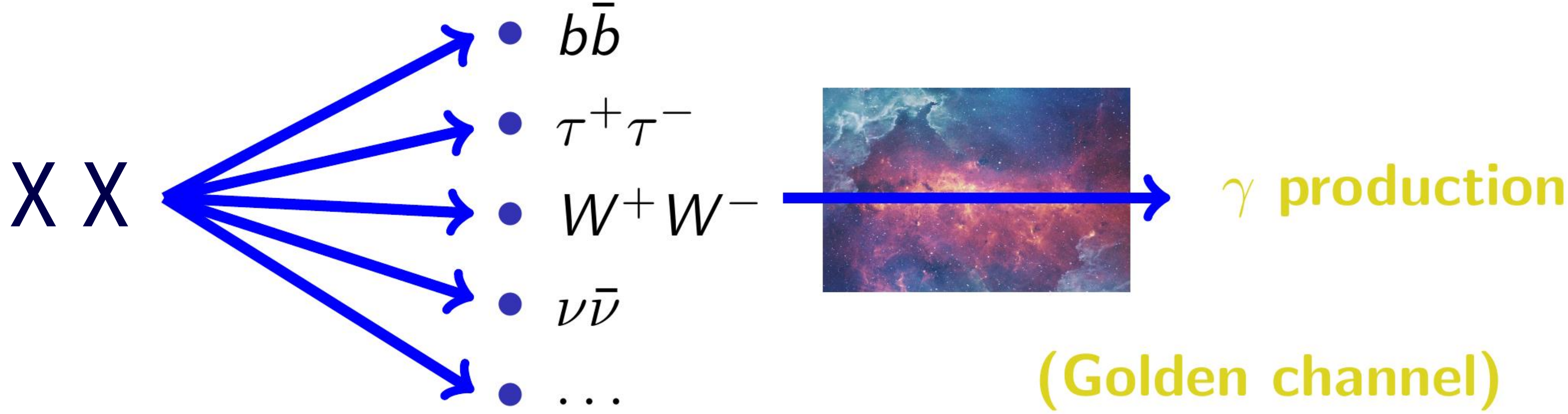
WIMP Indirect Detection



Expected gamma-ray flux on Earth:

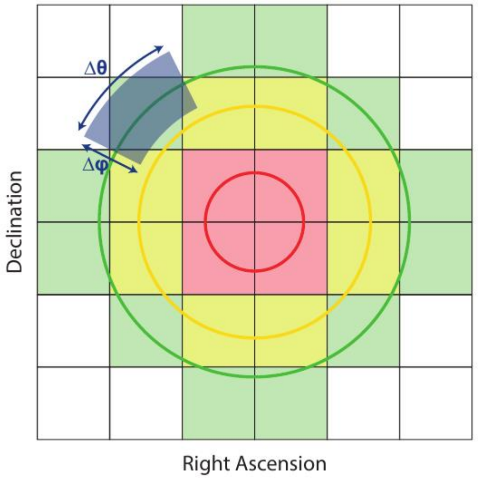
$$\frac{d\Phi_\gamma}{dE} = \int_V \frac{\Phi}{dEdV} dV = \frac{1}{8\pi} \frac{< \sigma v >}{m_\chi^2} \frac{dN_\gamma}{dE} \int_{\Delta\Omega} d\Omega \int_{l.o.s.} dl \rho_\chi^2$$

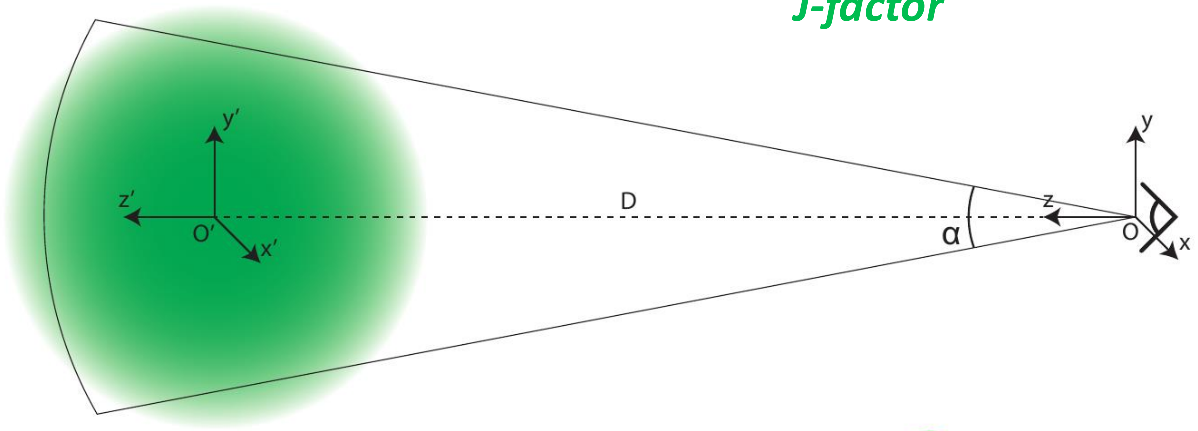
Spatial Model Computation

$$\frac{d\Phi_\gamma}{dE} = \int_V \frac{\Phi}{dEdV} dV = \frac{1}{8\pi} \frac{<\sigma v>}{m_\chi^2} \frac{dN_\gamma}{dE} \int_{\Delta\Omega} d\Omega \int_{l.o.s.} dl \rho_\chi^2$$

J-factor

Method developed and implemented in:

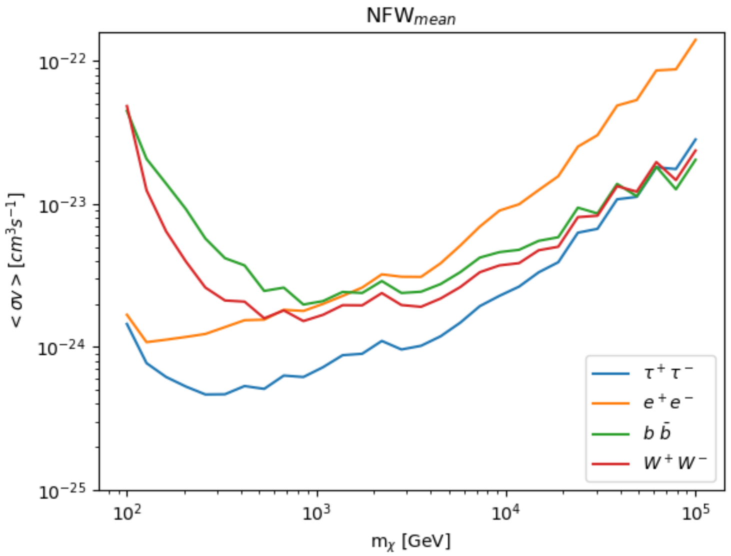


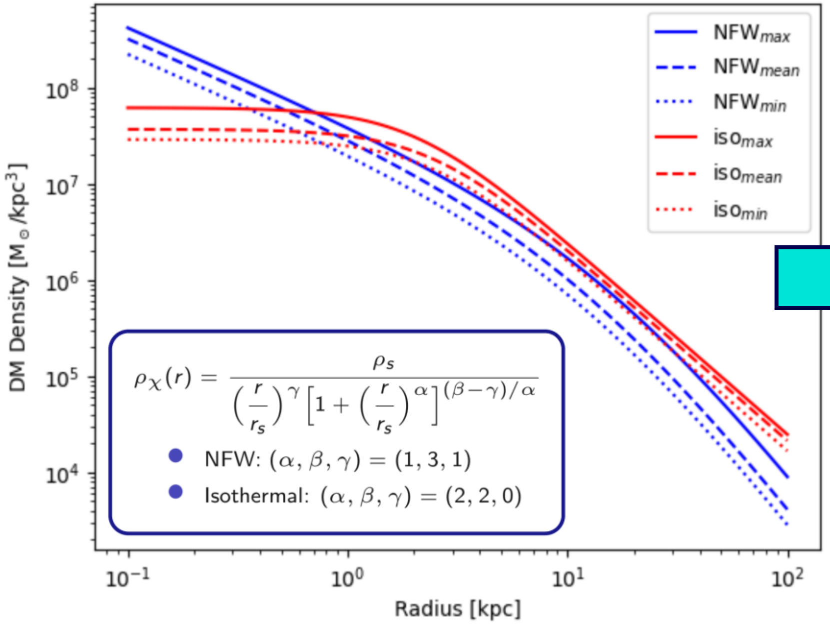


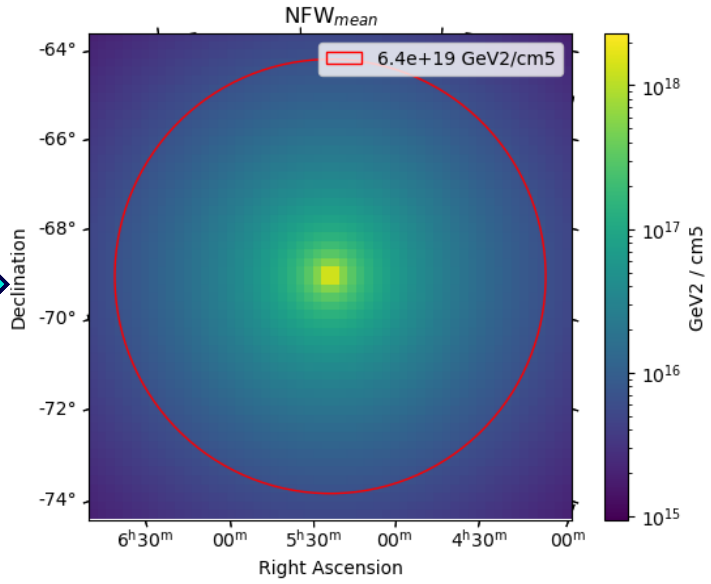
$$dl = dr,\ \Delta\theta = 2\pi / n_{pix},\ \Delta\phi = \frac{\Omega}{\Delta\theta \sin\bar{\phi}}$$

Sanity Checks

To test the validity of my method, I reproduced J-factor values computed by M. R. Buckley et al. (2015) for the DM halo in the Large Magellanic Cloud, also computing sensitivity curves for the detection with the Cherenkov Telescope Array Observatory.



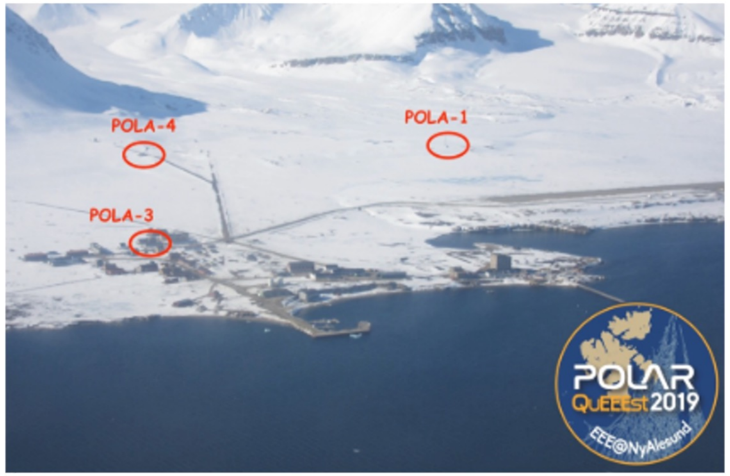




Annual quasiperiodicity in muon rate observed by PolarquEEEst detectors at 79° N

CENTRO RICERCHE ENRICO FERMI
Consiglio Nazionale delle Ricerche
Extreme Energy Events Science inside Schools
CERN

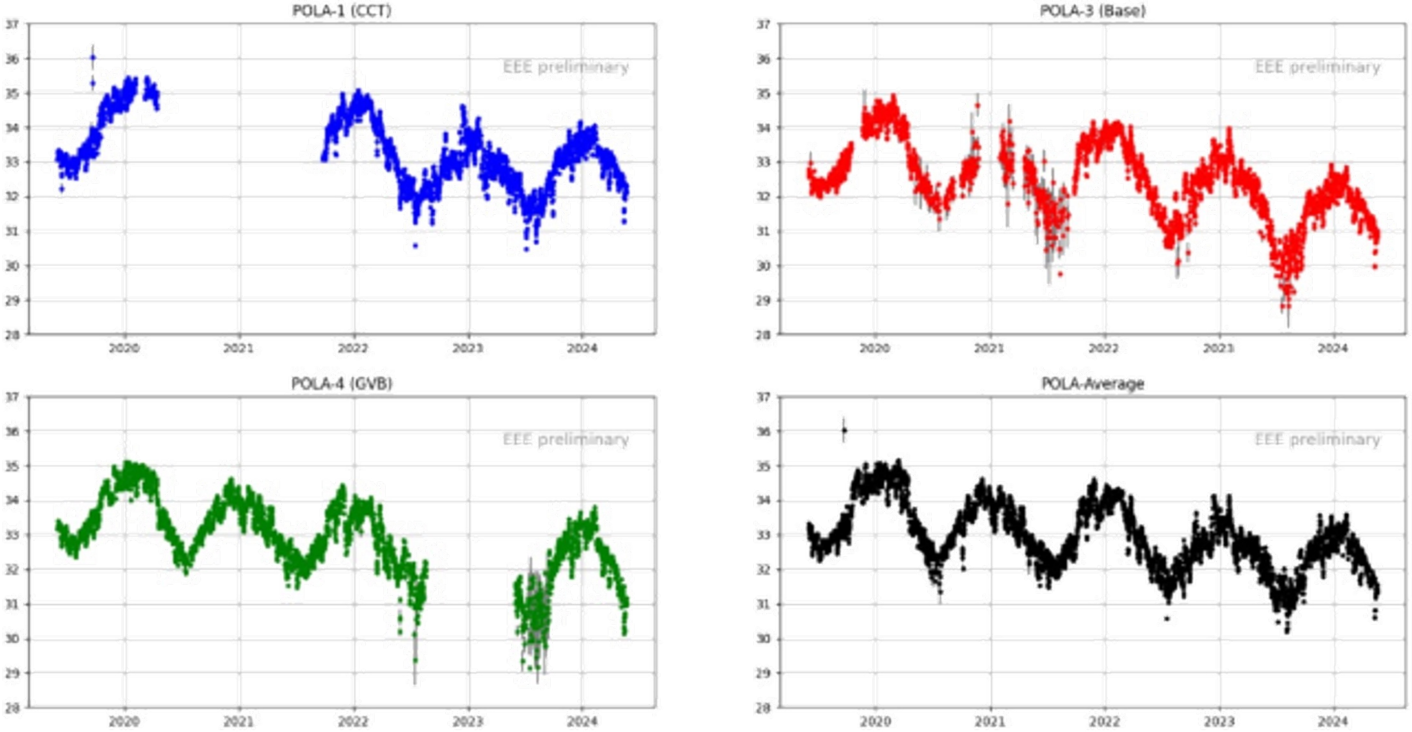
Since 2019



3 scintillator detectors permanently installed at Ny Alesund – Svalbard

(The detectors are part of the **EEE Project**)

Muon rate recorded by the 3 POLA-R detectors binned over 12h



The gaps are due to malfunctioning periods, power failures and other data taking issues.

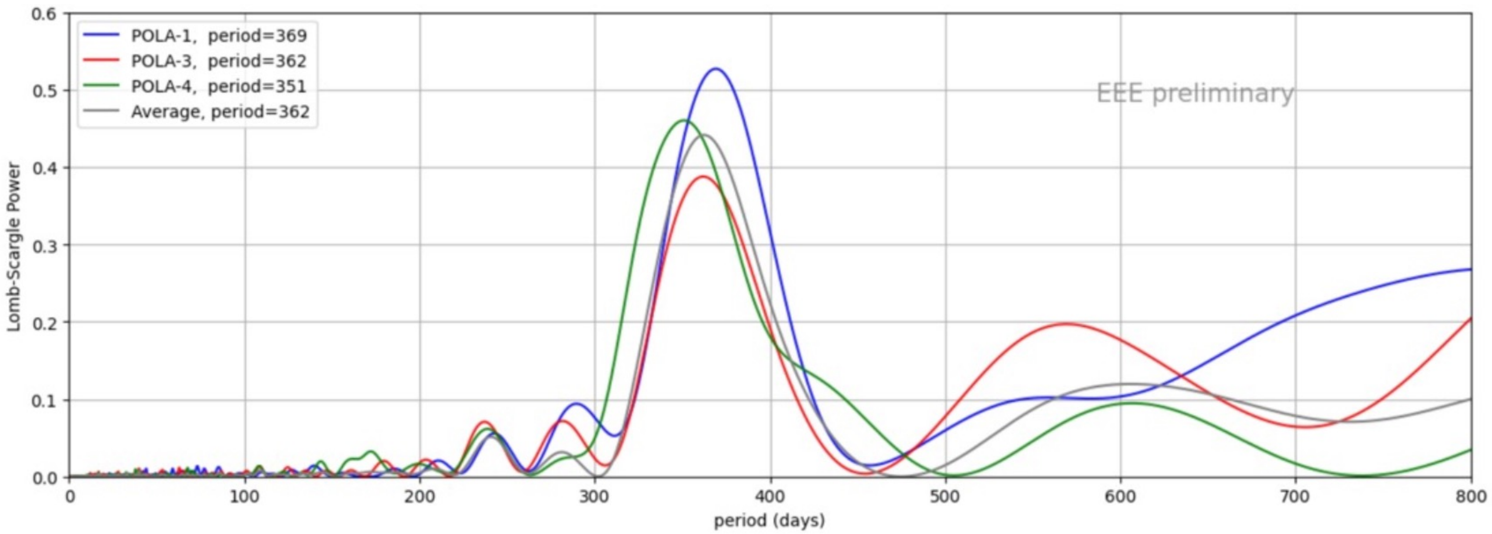
Average of the three time series

Preliminary analysis of the muon rate time series after collecting **5 years of data**

Evident **oscillating component** with a period of about **one year** observed

Mathematical and computational methods

Applying the *Lomb-Scargle periodogram technique**,
it is possible quantify the annual component and verify its independence from environmental and experimental factors.



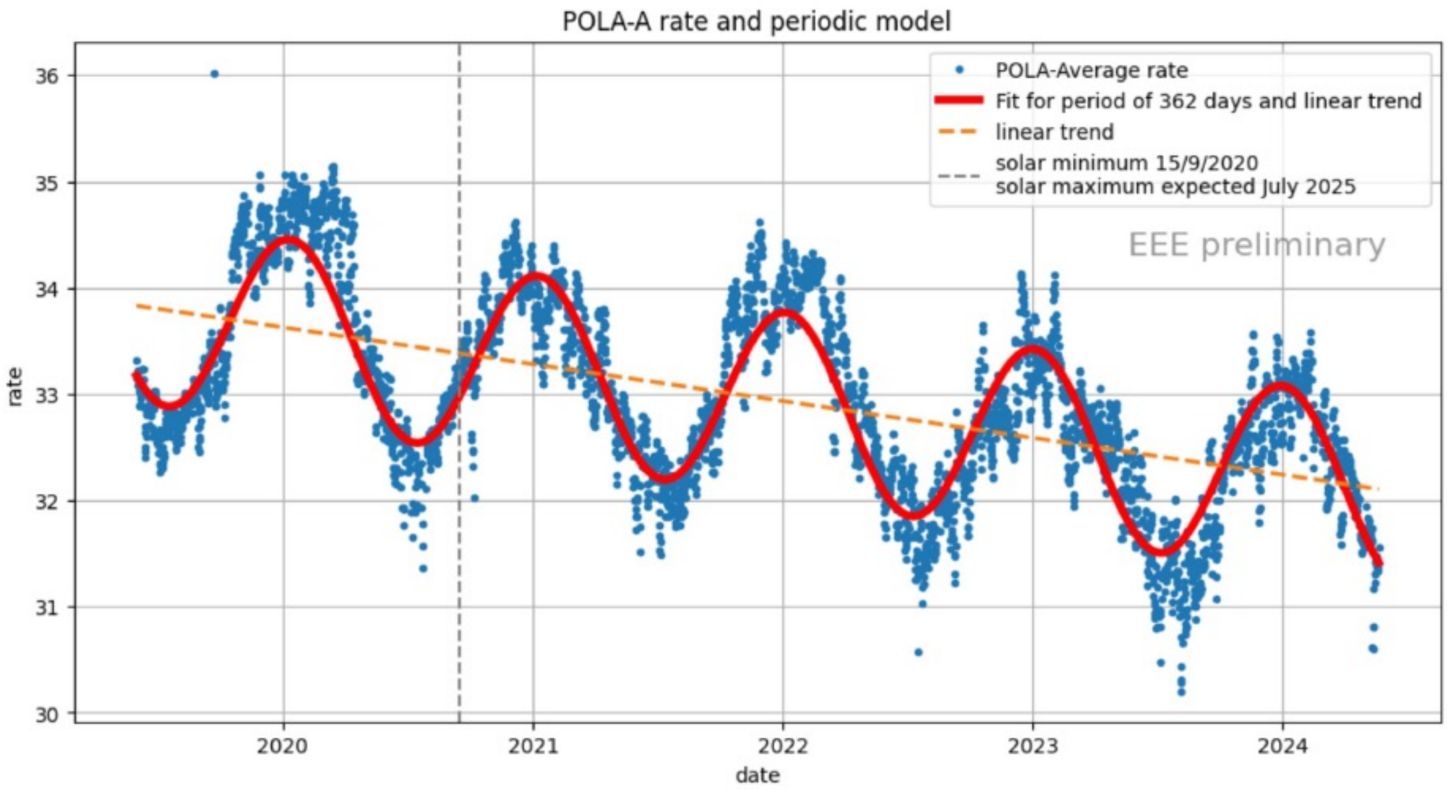
Frequency power plotted as a function of the period expressed in days

**Lomb-Scargle periodogram* technique, based on sinusoidal fit optimization, developed in astronomy for frequency analysis of irregularly spaced data, consisting of least-squares fitting of sinusoidal waves.

The highest peak corresponds to the dominant periodicity:
POLA-R muon rates have an evident periodic oscillation, whose duration is between 350 and 370 days, with a maximum occurring between the 1st and the 15th of January, compatible with an annual periodicity.

The implemented method consents to build a periodic model.

Quasiperiodic rates for POLA-R



Average rate with the first **periodicity model**
The annual model fits very well with
the main oscillations in the muon rate.

The decreasing trend is likely related to
the undecennial solar cycle and
is the subject of a further analysis.

Conclusions

The present preliminary study qualifies as a starting point for future analysis:

- the residual decreasing trend suggests the existence of a possible periodicity with a long period, that will need a longer time series to be exploited
- with a different binning and a careful selection of events studies of possible higher frequencies are also being carried out
- comparison with other muon detectors and neutron counters may also give indications about the nature and origin of these oscillations.

Calibration procedures for the ASTRI Mini-Array Cherenkov cameras

Davide Mollica - **INAF-IASF Palermo**

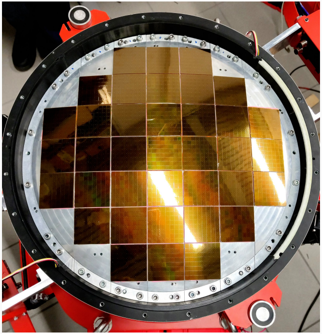
for the ASTRI Project

13th Cosmic-Ray International Studies and
Multi-messenger Astroparticle Conference / 17-21 June 2024

ASTRI Cherenkov camera

Focal plane

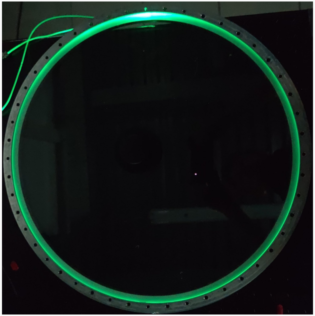
- 37 Photon-Detection Modules (PDMs) arranged to cover the spherical focal surface
- Each PDM has a 8×8 SiPM tile (Hamamatsu S14521) and two 32-channels CITIROC-1A ASICs

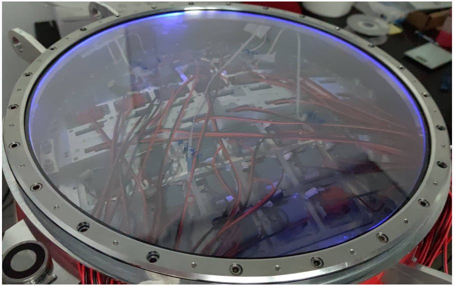


ASTRI Cherenkov camera

Embedded calibration system

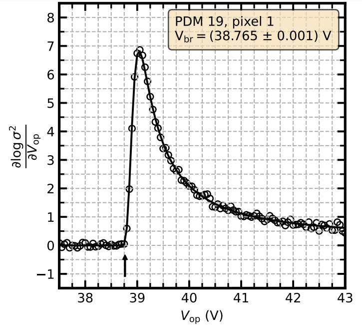
- Two LEDs (green and blue) coupled with an optical fiber
- Both can operate in pulsed and continuous mode
- Both can operate simultaneously

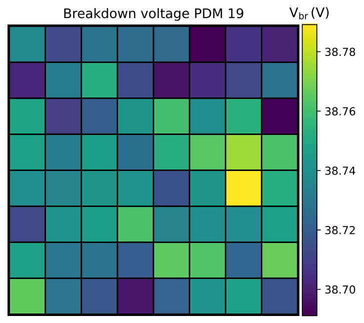




Breakdown voltage determination

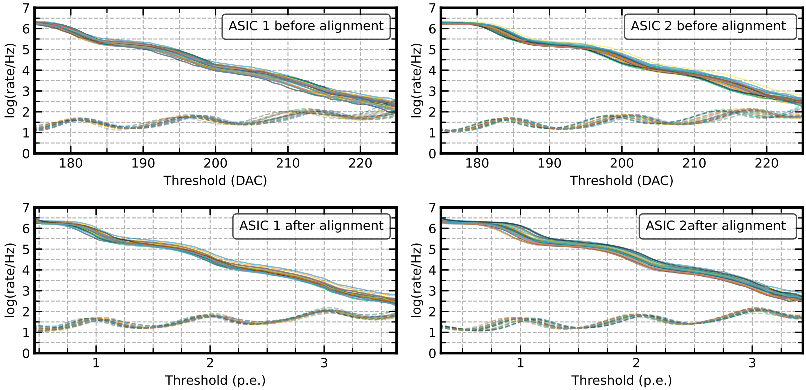
1. Illuminate pixels with a continuous light
2. Measure signal variance of each pixel as a function of the bias voltage
3. Fit the obtained curve with a model derived assuming a Borel distribution for cross-talk discharges





Trigger channel alignment

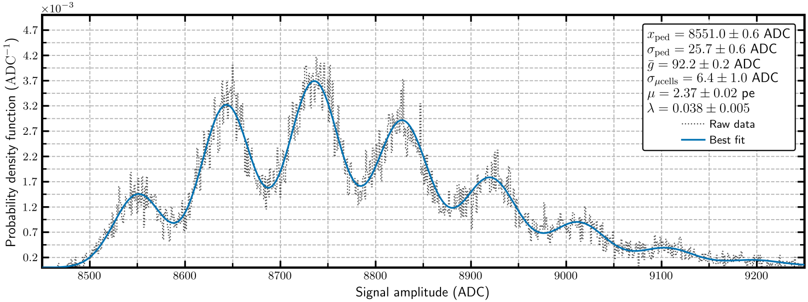
Fix ASIC discriminator offsets by means of a programmable 4-bit DAC. The method is based on the measurement of the inflection points of the dark staircase curve (dark count rate as a function of discriminator threshold)



Main relative calibration procedures

Pulse-height distribution (PHD) analysis

- Based on a Gaussian smeared generalized Poisson distribution model
- Provides the calibration coefficients needed for the Cherenkov image analysis
  - pedestal position x_{ped}
  - pedestal dispersion σ_{ped}
  - photo-electron equivalent $\bar{g}$
  - cross-talk probability λ



SWGO
The Southern Wide-field Gamma-ray Observatory

A multiPMT for SWGO water Cherenkov detectors

Muhammad Waqas on behalf of the SWGO collaboration
Università degli Studi di Napoli “Federico II”, Italy
Istituto Nazionale di Fisica Nuclare - INFN, Sezione di Napoli, Italy

CRIS-MAC 2024
13th Cosmic Ray International Studies and Multi-messenger Astroparticle Conference
Trapani, Italy, June 17 – 21, 2024

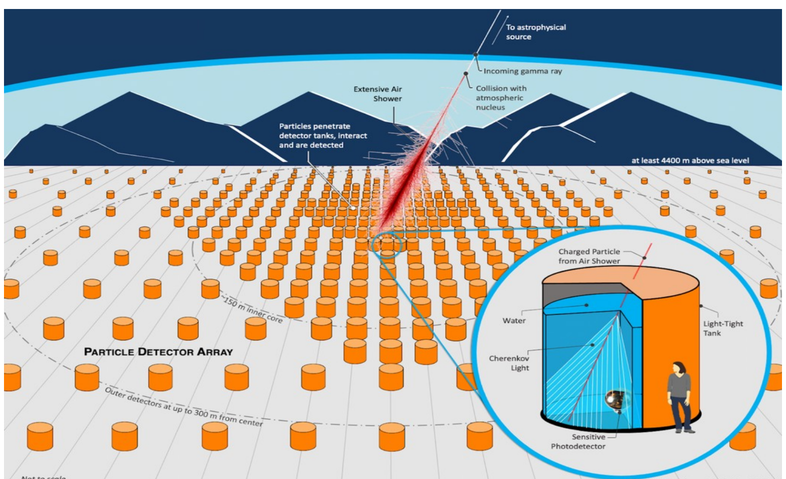
INFN
Istituto Nazionale di Fisica Nucleare

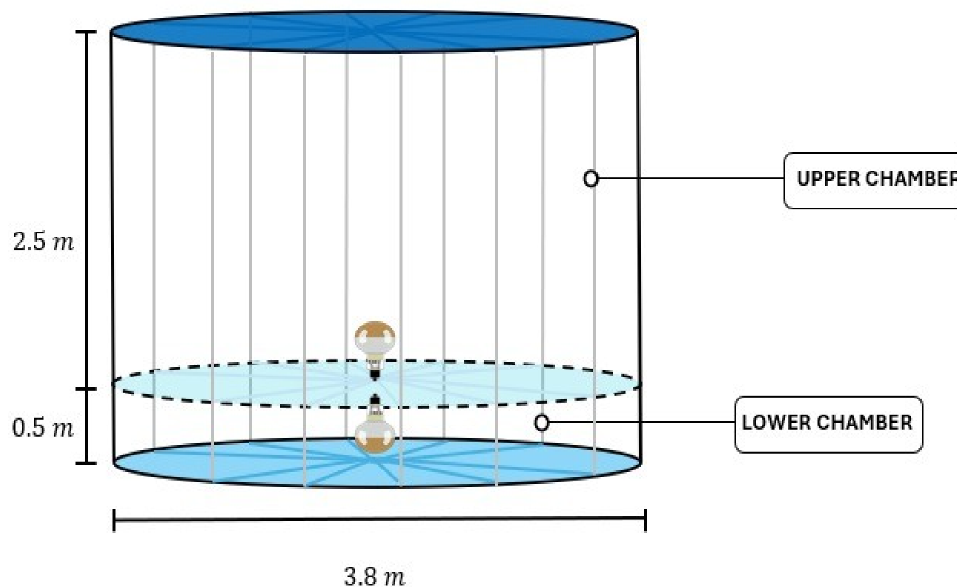
SWGO Experiment:
Enhancing Water Cherenkov Detectors

SWGO

Proposed ground-based gamma-ray observatory in South America (10-30° S latitude, 4.4 km altitude).

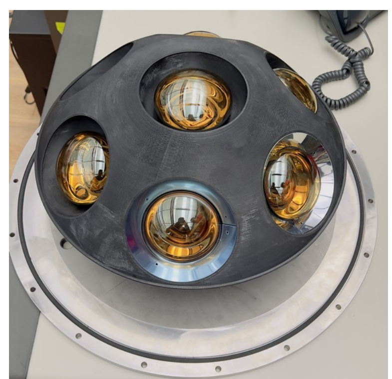
- Features high fill-factor core detector
- Enhanced sensitivity
- Low-density outer array.





Why multiPMT….

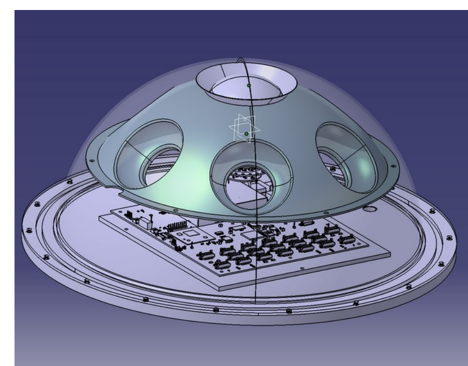
An alternative to Large Area PMT



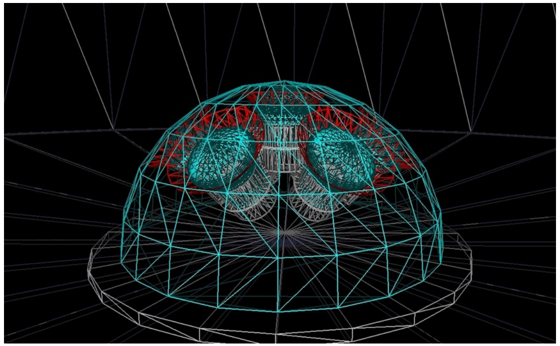
multiPMT advantages:

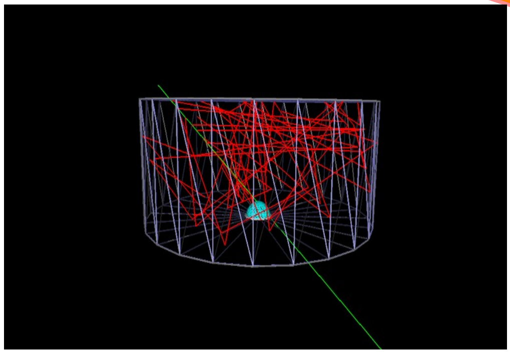
- Cost effective
- Flexible detector design
- Intrinsic directional sensitivity
- Modularity to prevent failure
- Fully Integrated in SWGO Tanks
- Better timing
- Extended dynamics
- Integrated electronics

The complete design



Geant4 Simulations: multiPMT performance

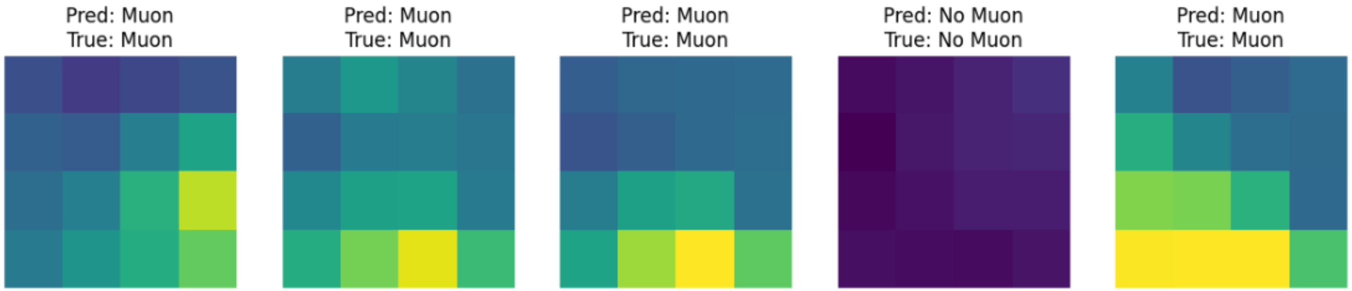




Full study of detector performance and efficiency including all materials and optical properties

A prelimary attempt to assess Muon Tagging Capabilities

Cosmic shower particles (from CORSIKA) injected in one tank



Output of a CNN algorithm for muon identification

Crystal Eye

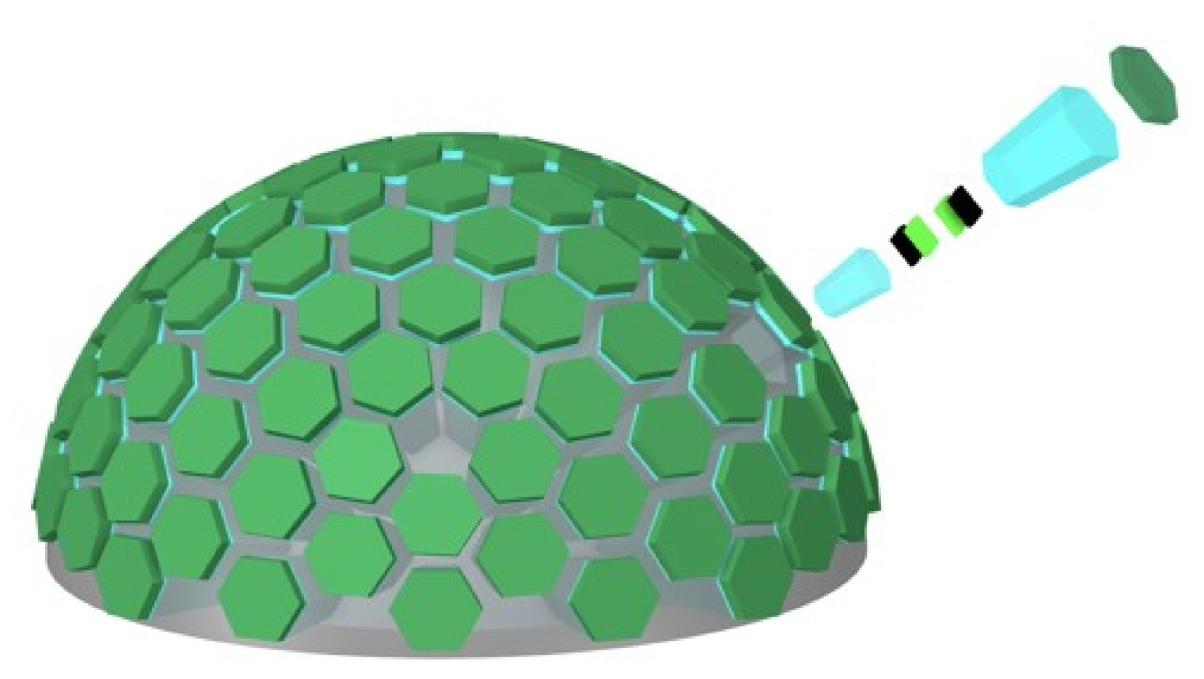
A wide view of the Universe in high energy

Ritabrata Sarkar, Pierpaolo Savina*
on behalf of Crystal Eye collaboration
Gran Sasso Science Institute

13th Cosmic-Ray International Studies and Multi-messenger Astroparticle Conference, June 17-21, 2024, Trapani

Overview

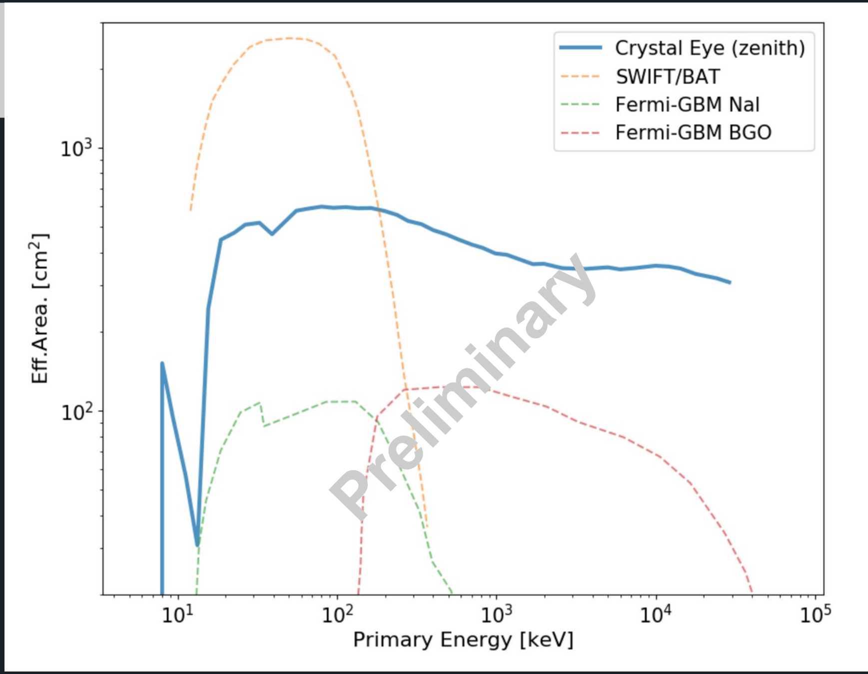
Crystal Eye is a novel concept of space-based all sky monitor for the observation of about 30 keV - 50 MeV photons.

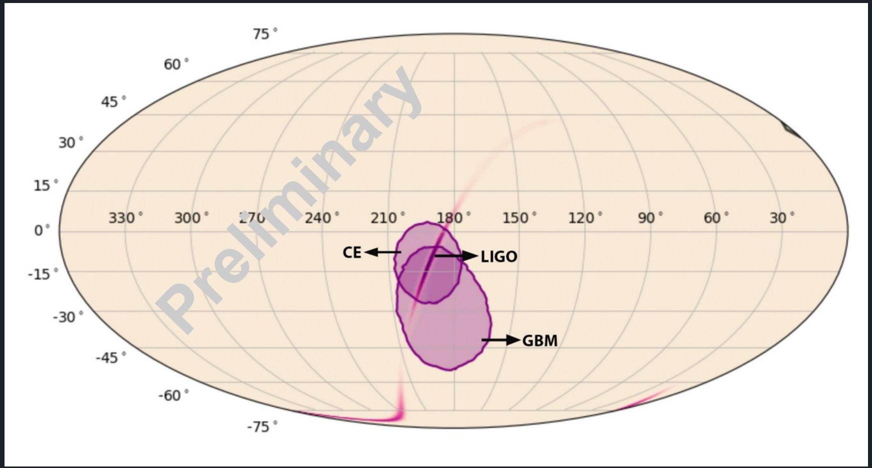


Main features:

- Wide FOV: ~ 6 sr.
- Full sky coverage.
- Very large effective area: ~ 5 times Fermi-GBM at 1 MeV.
- High localization capability: few degrees.
- Use LYSO/GAGG scintillator with SiPM for the signal readout.

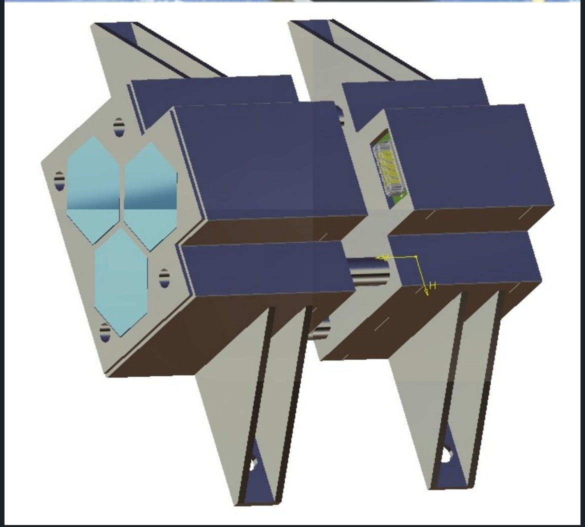
Science Goals





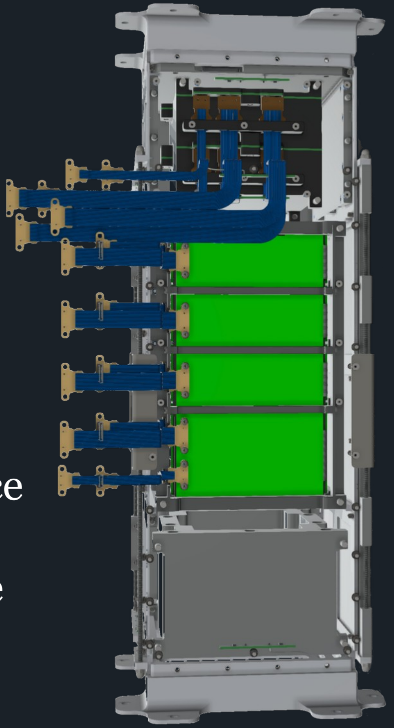
- Wide field and precise monitoring and localization of astrophysical transient phenomena to help the multimessenger scientific studies.
- Study the interesting and diverse astrophysical phenomena in the keV and low MeV region exhibiting spectral features which are, to date, not extensively measured.
- Primary scientific targets of the instrument are GRBs, GW electromagnetic counterparts and other transients, accreting systems, supernovae and particular γ emission lines.

The Crystal Eye Pathfinders: WINK & ZIRÈ



A smaller prototype with 3 pixels has been set up to fly aboard of the Space Rider (ESA) on a LEO orbit (400 km, 5.3° of inclination) for two months in 2025.

ZIRÈ detector in the NUSES mission uses the similar material (LYSO/GAGG) for its calorimeter as Crystal Eye (along with other sub-detectors) with similar science goals. While the technological advancements can be used for the mutual benefits of both the detectors.
[For more details see the presentation on Thursday by P. Savina]



Please visit the poster for more details about the Crystal Eye detector and its performance estimation.

Thank You...