

Hodoscope bars response to secondary particles from cosmic rays

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Prácticas de Verano SAPHIR-UNAB 2024 January 02 - 19, 2024

SAPHIR ARM 2024 January 17 - 19, 2024

In our experimental investigation we aimed at analyzing the distribution of cosmic rays, we employed scintillating plastic and integrated Wavelength Shifters (WLS) into our particle detector prototype. The detector, with a surface area of $500 \times 500 \text{ mm}^2$ and featuring 4 Multi-Pixel Photon Counters (MPPCs) SI4160-3050PE attached at the edges, facilitated the collection of scintillation light. Our results reveal that our setup needs to be improved to obtain an homogeneity response along the length of the scintillating plastic bar. In this work will elaborate on the specifics of our experimental approach, emphasizing the importance of the homogeneous distribution in enhancing the performance of particle detectors for cosmic ray studies.

Motivation

The aim was to characterize 50 cm bars, identifying correlations between both sides and observing a uniform distribution of cosmic rays along the bars. Subsequently, a configuration of perpendicular bars, measuring $2.5 \text{ m} \times 2.5 \text{ m}$, will be developed for the The Southern Wide-field Gamma-ray Observatory (SWG0) experiment. This involves a pool with Cherenkov detectors and placing the hodoscopic bar array underneath. SWG0 aims to detect gamma rays.

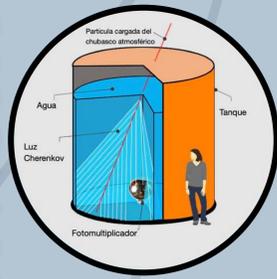


Fig 1. SWG0 Diagram

Introduction

This work presents a detailed study of an experimental system. The main objective of this setup is to investigate the response and performance of this system to cosmic rays radiation, providing crucial information for its application in future projects, particularly in the scope of the The Southern Wide-field Gamma-ray Observatory (SWG0). By analyzing the response of our detector, we can analyze the homogeneity of the radiation in addition to allowing the reconstruction of trajectory and energies of the particles that pass through it.

Cosmic rays consist of high energy particles and carry valuable information, the intensity depends on the altitude at which we are detecting and it's composition after passing the atmosphere are mostly muons, photons and neutrons.

Set Up

The setup consists in 5 scintillation bars, each equipped with 2 Wavelength Shifters (WLS), 4 Multi-Pixel Photon Counters (MPPCs) per scintillation bar at each side, and a single digitizer (CAEN) connected to 5 amplifier circuit boards with four entries each (one for each WLS). This being powered by 42 V using voltage dividers to power each channel corresponding to each WLS, leaving with 20 channels for all the bars.

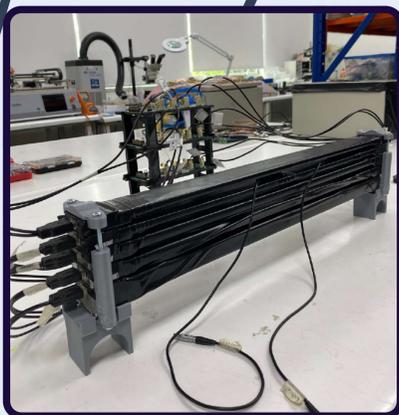


Fig 2. Experimental set up.

Conclusion

Our experiment investigating the distribution of cosmic rays yields a compelling conclusion: thanks to the experimental setup and the configured response channels, we observe that this detector has a higher probability of detecting particles passing through its center. This is evident in the ratio histograms, as the ratio value approaches 1, it confirms that, despite the homogeneity in the distribution of cosmic rays along the scintillating plastic bars, events are predominantly detected at its center.

Results and Analysis

The analysis centered on capturing the cosmic rays's response as electric signals, with a threshold of 8160. This yielded in a dataset consisting of 1024 rows for 20 channels with 10569 events each.

To refine the signals, these were filtered by calculating the noise distribution's mean. This mean was subtracted from all data rows and was then multiplied by -1 . This enabled us to determinate the maximum amplitude value for each signal.

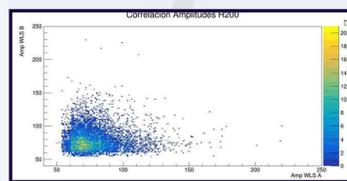


Fig 3. Correlation H200 Bar.

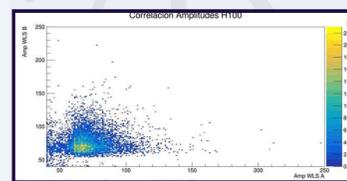


Fig 4. Correlation H100 Bar.

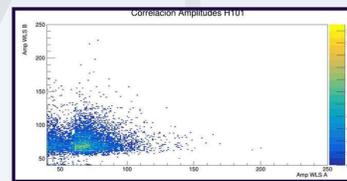


Fig 5. Correlation H101 Bar.

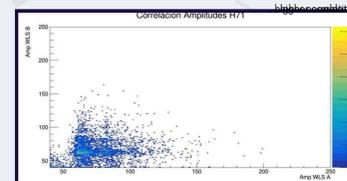


Fig 6. Correlation H71 Bar.

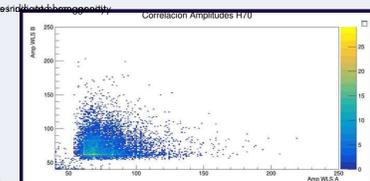


Fig 7. Correlation H70 Bar.

Additionally, we conducted calculations involving the ratio sum of the amplitudes of the signals from the MPPC attached to the same WLS fiber, the sum is an approximation of the amount of photons collected by each WLS fiber. This approach permitted us to analyse the homogeneity response of our bars from an uniform secondary particle flux traversing our detector. We can pinpoint areas within the bars where the detection is more likely to be effective (center). This observation is made possible through the implementation of the threshold and the requirement for detection across all four channels.

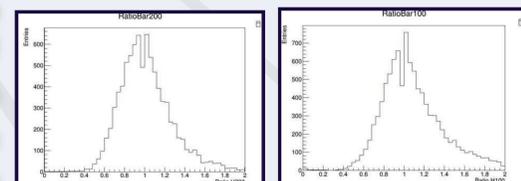


Fig 8. Ratio H200 Bar.

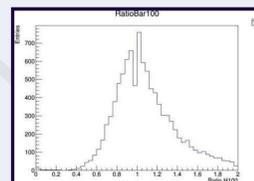


Fig 9. Ratio H100 Bar.

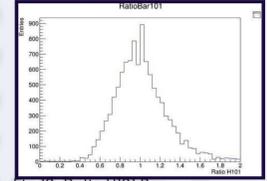


Fig 10. Ratio H101 Bar.

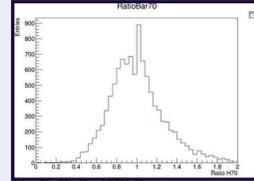


Fig 11. Ratio H70 Bar.

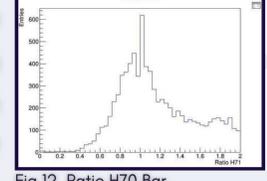


Fig 12. Ratio H71 Bar.

[1] Zizhao Zong, Giulia Hull, Mikta Imre, Michae'l Josselin, Alain Maroni, Tiina Suomija rvi: *Study of light yield for different configurations of plastic scintillators and wavelength shifting fibers*

[2] W.R.Leo *Techniques for Nuclear and Particle Physics Experiments*, Second Revised Edition

Acknowledgments

This work was supported by ANID Millennium Program ICN2019 044. We would like to thank the staff of the millennium institute SAPHIR and UNAB for their assistance. The authors thank Eng. Matías Henriquez for helping with the FEE electronics and setup configuration. We acknowledge Dr. Marco Ayala's significant contributions and valuable guidance in this work.