PMT Characterization and Cosmic Ray Response of a 60x60cm² Hodoscope

Javier Ignacio Gonzalez Cares
Andrés Bello University
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Abstract

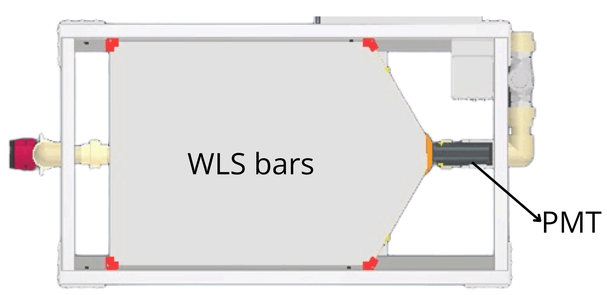
The objective of this project is to analyze the signal characteristics in the 60×60 cm² hodoscope for the detection of cosmic rays. To achieve this, different data acquisitions were analyzed by generating persistence and amplitude distribution histograms. These histograms facilitated the understanding of the signal properties and allowed for a characterization of the detector's response under different conditions

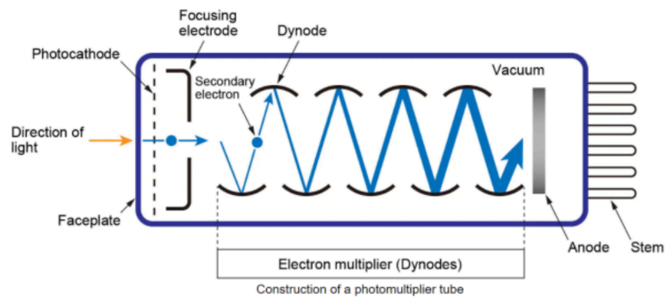
Motivation

Understanding the signal distribution in a photodetection system is essential for ensuring the efficiency and reliability of the detector. In the case of the hodoscope, analyzing the persistence and amplitude distribution provides insights into the stability and performance of the system, which is crucial for prolonged acquisitions where signal integrity must be maintained over extended periods to ensure reliable data collection.

Introduction

Photomultiplier tubes (PMTs) are highly sensitive detectors that amplify weak light signals through a multi-stage electron multiplication process. In this study, the PMT used in the hodoscope is characterized by analyzing the persistence and amplitude distributions of detected signals. Charged particles interacting with the scintillators produce light, which is shifted in wavelength and detected by the MPPCs before being further amplified by the PMT

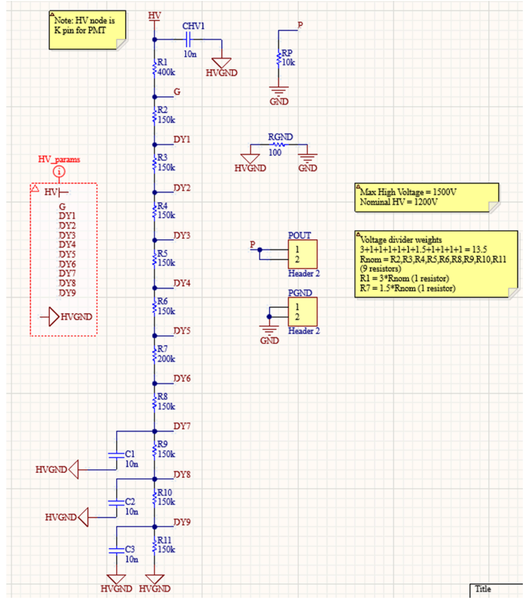




Setup

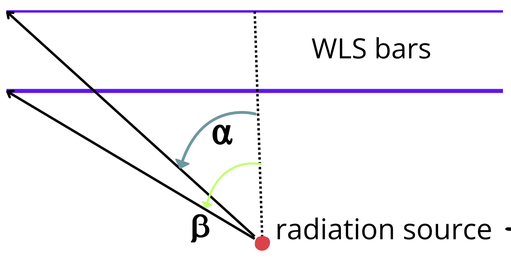
The experimental setup consists of a 60×60 cm² hodoscope composed of scintillating plastics coupled to wavelength shifters (WLS), multi-pixel photon counters (MPPCs), and a Hamamatsu R3998-02 PMT. The PMT operates at a bias voltage of -900 V, within its safe operating range (-600 V to -1500 V).

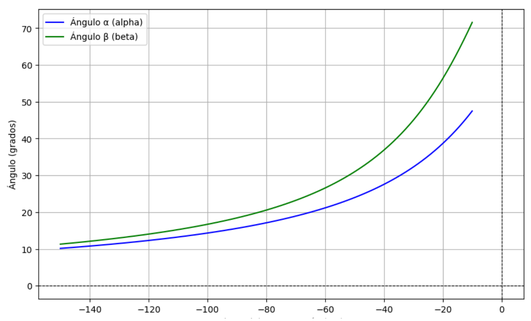
The hodoscope detects charged particles using a multi-layer arrangement. The PMT's resistive chain includes 400 kΩ (first stage), 200 kΩ (seventh stage), and 150 kΩ (others), and a +30 mV trigger.
The hodoscope employs two planes, with one PMT each. The waveforms from these PMTs were recorded using a DRS4 evaluation board.

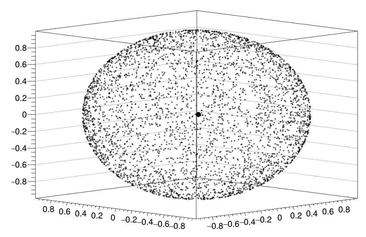


Hodoscope coverage angle for cosmic rays

The hodoscope consists of two layers of scintillator detectors, which register coincident signals when a particle passes through both layers.
The coverage angle of the hodoscope for cosmic rays was calculated for different heights of a radioactive source placed below the detector. Using the geometric configuration of the hodoscope, the aacceptance angle was determined for each height. The results show how the coverage angle varies with the source position, providing insight into the angular acceptance of the system.

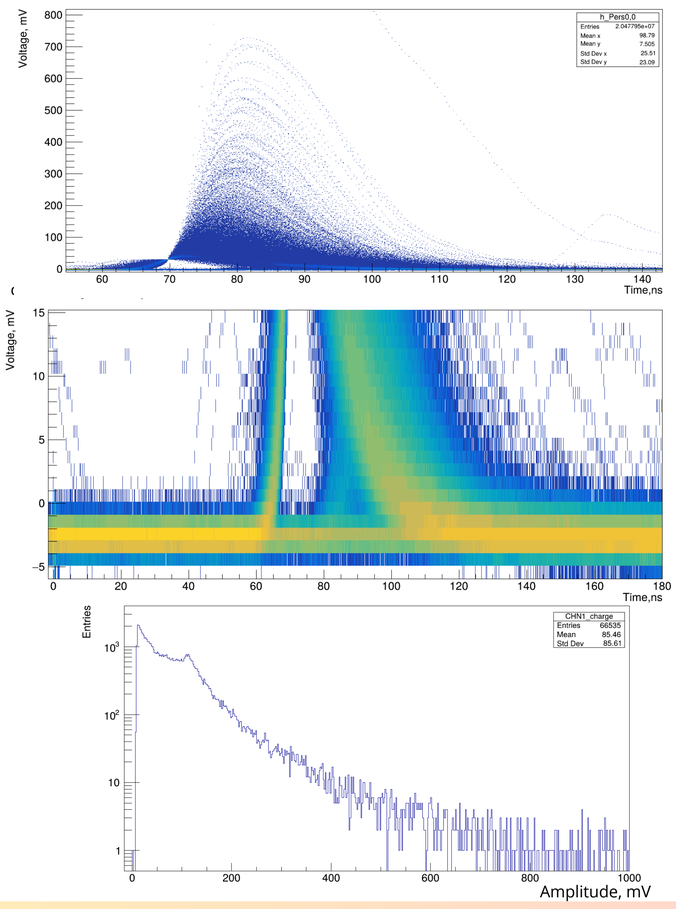






```
void GetRandom_UniformSphere(double &theta, double &phi) {
  theta = acos(1 - 2 * rng.Rndm());
  phi = 2 * M_PI * rng.Rndm();
```

Persistance and Distribution Histogram



Prospects

The analysis of persistence and amplitude distribution histograms provided a foundational understanding of the signal characteristics in the hodoscope. These histograms represent a crucial first step in a more in-depth analysis of detector performance, helping to identify trends and refine the experimental setup for future studies. The ability to visualize the signal properly allows for the definition of a threshold of 20 mV and an integration range of 60 to 140-130, enabling further applications. Additionally, one of the most significant applications of the coverage angle study is its potential use in radiation monitoring for water pipelines, which could offer an effective method for detecting contaminants and ensuring water safety.

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