Single Photoelectron Response of Scintillator Bars using Cosmic Ray Data

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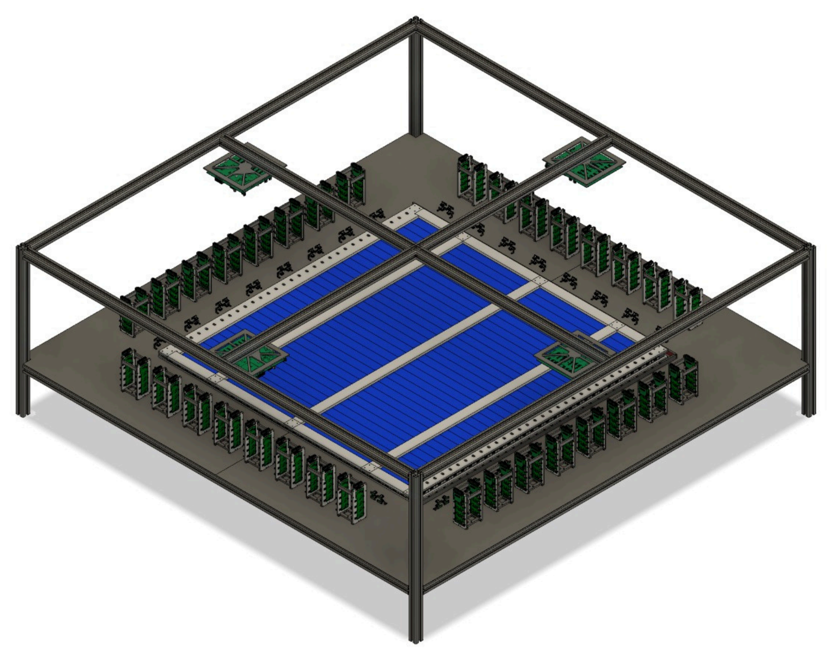
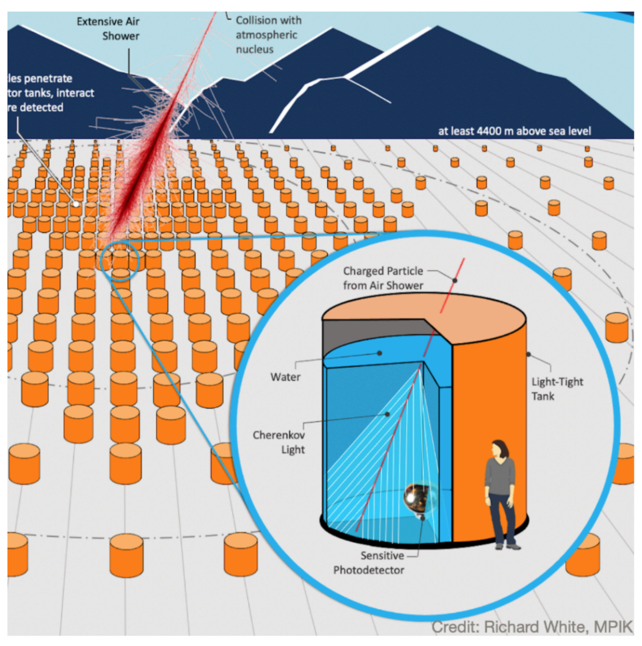
Abstract

This work focuses on the single photoelectron calibration of two 125cm x 4cm x 0.7cm scintillator bars, each with two embedded wavelength-shifting fibers and four attached silicon photomultipliers. The bars will be used for the construction of a 1.25m x 1.25m hodoscope array composed of 62 such bars. This hodoscope will be integrated with a water Cherenkov detector for gamma-ray observatories. The calibration yielded a typical photoelectron spectrum and offers an alternative way to calibrate the detector response during hodoscope operation without the need for a dedicated LED calibration system.

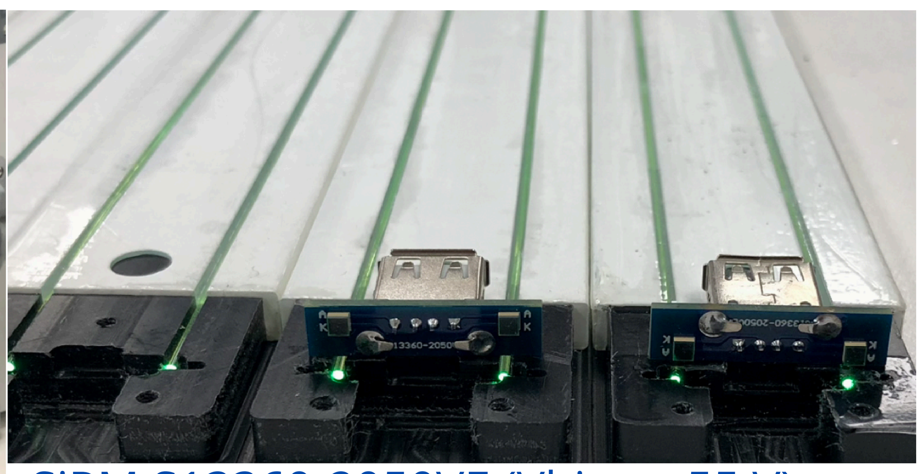
Introduction

The hodoscope consists of 62 orthogonal scintillator bars coupled to Wavelength Shifting Fibers (WLS) and silicon photomultipliers. The system detects charged particles by converting scintillation light into digital signals for analysis. Data acquisition electronics record the ADC values, which are processed to study signal amplitude, charge distribution, and photoelectron identification.





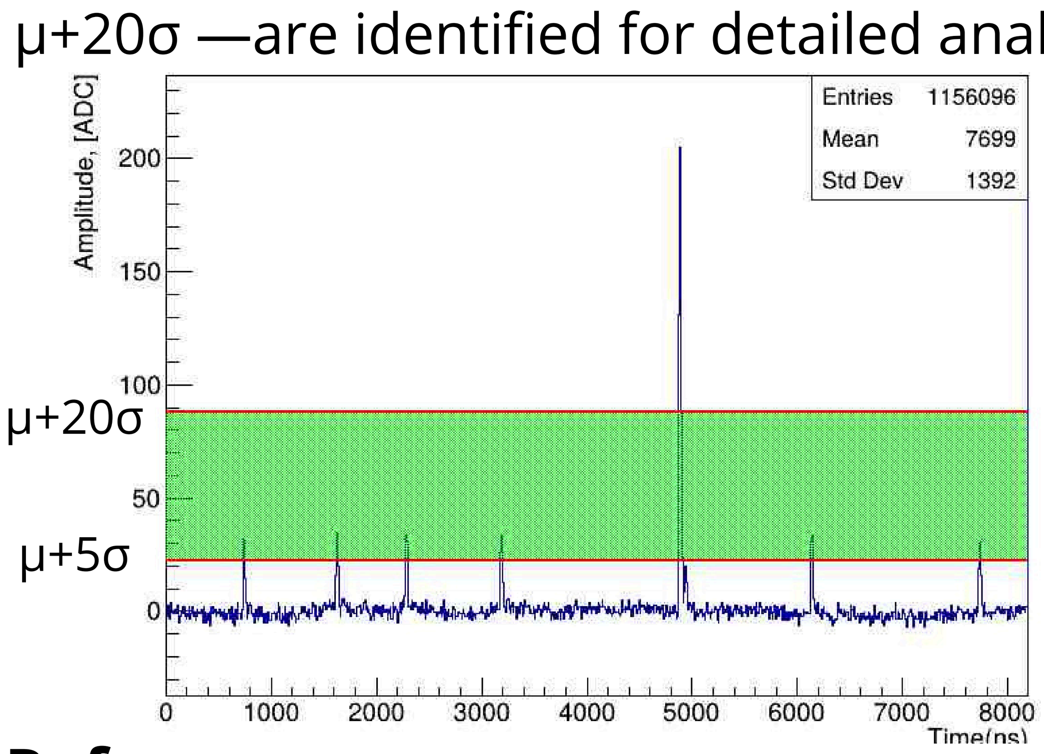
Experiment setup

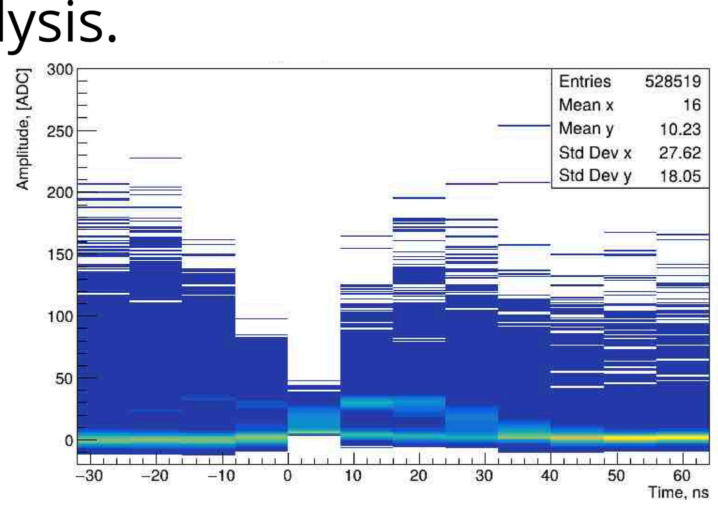


SiPM S13360-2050VE (Vbias = 55 V)
Readout: 32ch CAEN Digitizer DT5560SE

Single photoelectron search

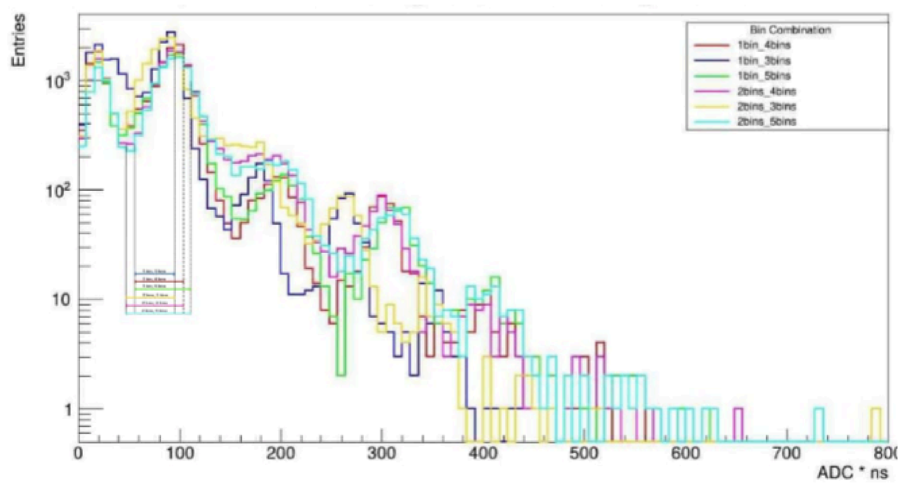
The calibration begins by filtering and adjusting raw signals to correct the baseline and invert the data. For the baseline, we determine its mean (μ) and RMS values (σ). From this, significant signals—those with maximum amplitude between μ+5σ and μ+20σ —are identified for detailed analysis.

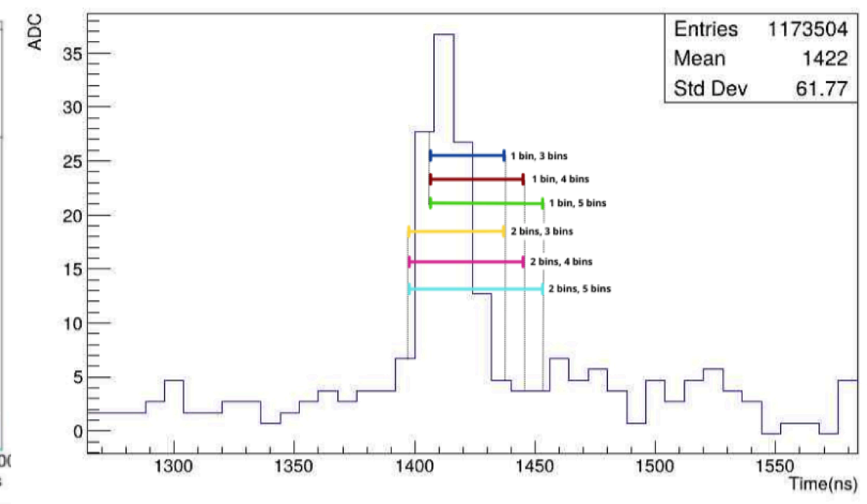


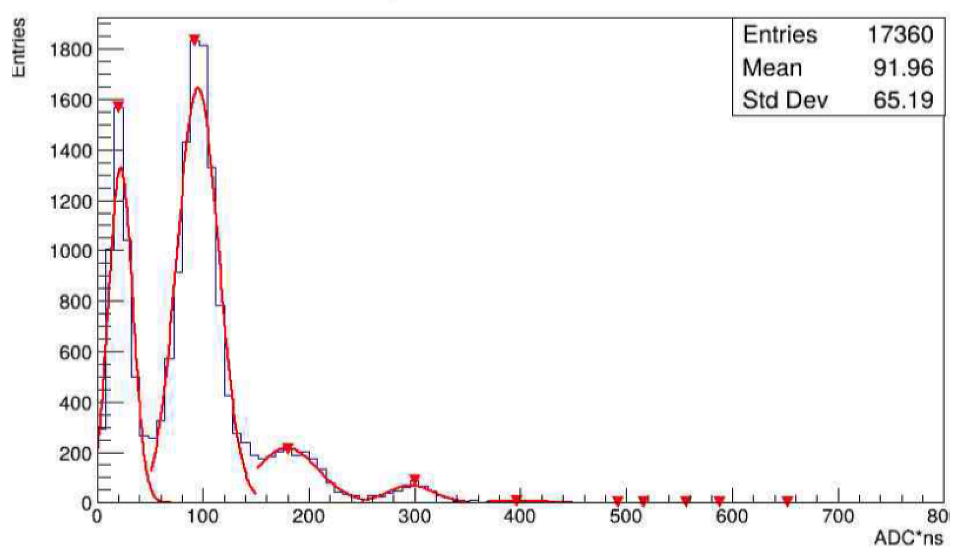


Single photoelectron charge

The identified signals are used to generate histograms for ADC distribution, charge, and gaussian fits applied to model the single photoelectron response. This ensures accurate identification of photoelectrons, with the best integration window resolution being 2 bins before and 4 bins after the signal.



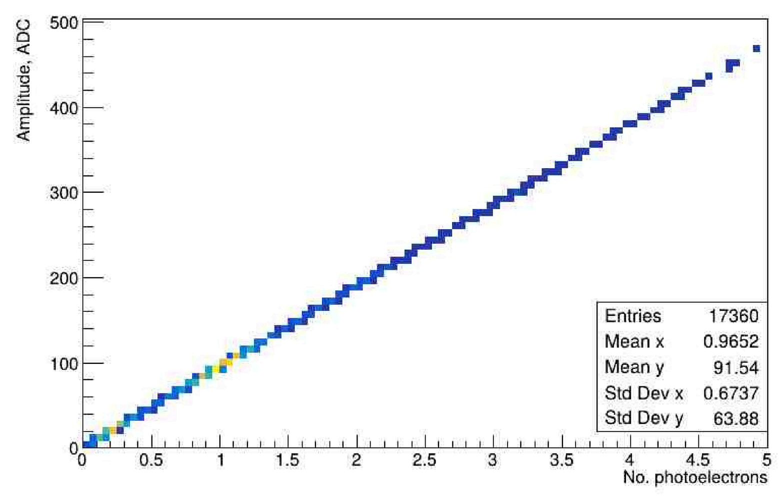




The charge distribution is fitted with Gaussians under the conditions:

1. The baseline and first photoelectron have free parameters (A, μ,σ).
2. Higher-order photoelectrons follow:

$\mu_n = n \cdot \mu_1$ and $\sigma_n = \sqrt{n} \cdot \sigma_1$



ADC amplitude vs No. of photelectron

Results and/or Prospects

We analyzed the signal processing steps—baseline subtraction, photoelectron filtering, and Gaussian fitting—used to reconstruct the single photoelectron charge. Demonstrated with a ten minutes dataset of cosmic ray events, this calibration technique successfully reconstructs the single photoelectron charge, eliminating the need for an external LED system and simplifying the calibration process.

Acknowledgments

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References

[1] ARAPUCA, light trapping device for the DUNE experiment - H. Viera

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