R&D of the J-PARC muon spin polarization monitor Hardware Development

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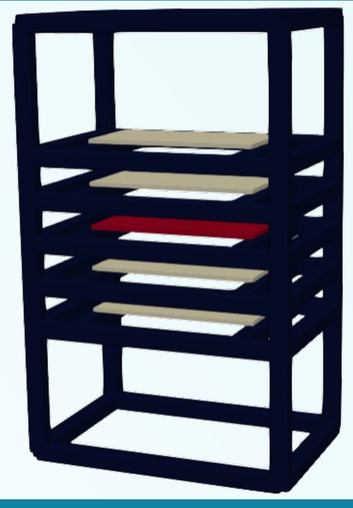
Overview

This poster is part of the R&D of the J-PARC muon spin polarization monitor and mainly focuses on the experiment apparatus development

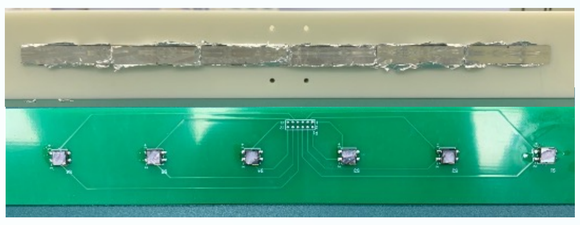
Introduction

- The polarization monitor is developed as a part of the data quality control (DQC) in the J-PARC muon g-2/EDM experiment[1]
- Before building the apparatus, a comprehensive and detailed simulation is completed to design the detector size and evaluate its performance
- The apparatus is built to validate the simulation result



The DIY Apparatus

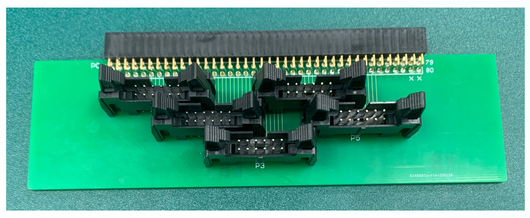
- Each detector plate consists of 6 scintillator bars wrapped with aluminum foil for reflection
- Scintillator bars are fixed by a self-designed 3D-printed holder



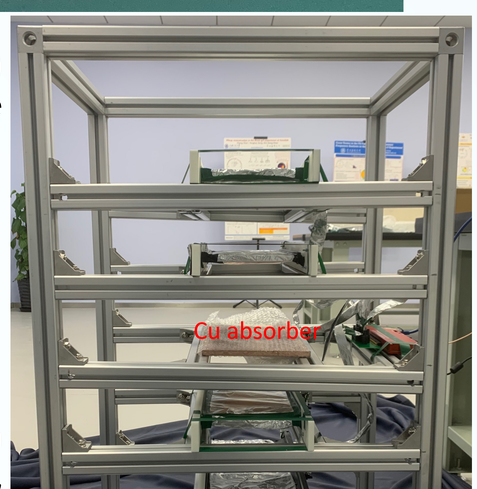
- Each scintillator is read out by an individual SiPM soldered on a self-designed readout board
- The PCB board can be fixed on the holder, forming a detector

- The flexible flat cable (FFC) is used to connect the readout board and the interface board
- To protect weak signals in FFC (~uA) from the electromagnetic field, cables are wrapped with the aluminum foil

- To connect the detector (6 channels) to DT5702 (32 channels), an interface board is designed



- We designed and built an aluminum alloy frame to support detector plates, the absorber and DT5702 digitizer
- During DAQ, the whole apparatus is covered by a black curtain to block external light



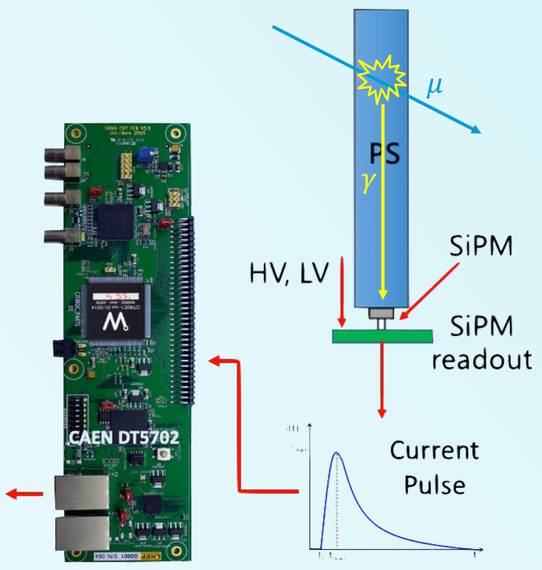
Conclusion & Future Prospects

- The self-designed atmospheric muon spin polarization detector has successfully been built and started DAQ
- So far, the analysis of passing-through and showering events have been completed, and the muon ADC value distribution fits well with the Landau distribution
- The calibration between energy deposition (simulation) and ADC value (DAQ) is to be built using the landau distribution fitting
- The polarization measurement algorithm will be transplanted after the energy deposition calibration is completed

Atmospheric Muon Detection

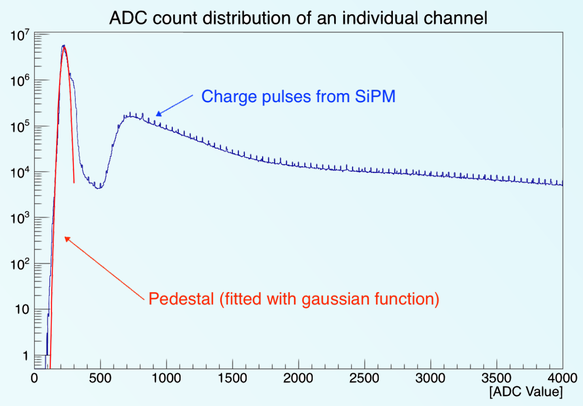
- When muon hits the scintillator, the photon it produces will be received by SiPM
- The current pulse from SiPM will be transferred to DT5702 digitizer
- DT5702 will integrate the pulse (charge) and turn it into ADC value, which is proportional to the photon number received by SiPM

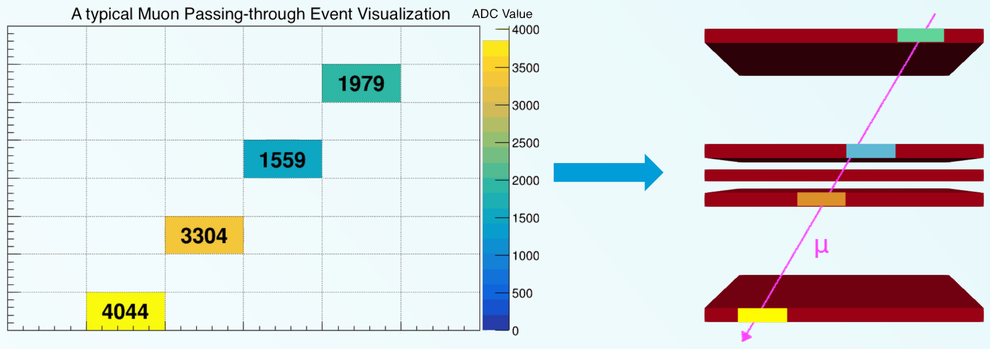
ADC Value (0-4089) $\propto \int i(t)\,dt$



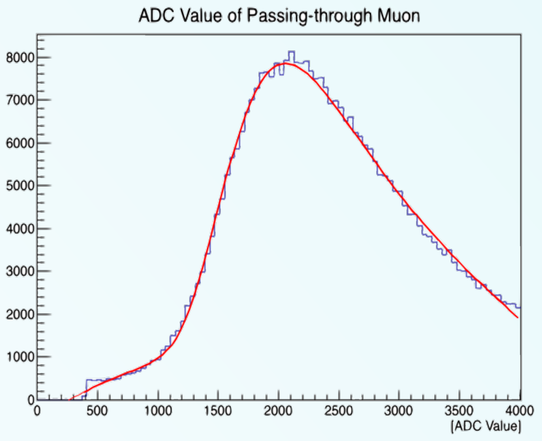
DAQ & Cosmic Ray Hit Visualization

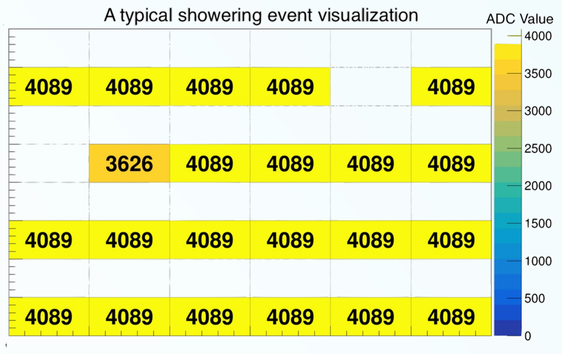
- During DAQ, the DT5702 will count and record the ADC value of each channel
- The right histogram is the ADC distribution of a channel in a 2-day DAQ
- The left peak, pedestal, fits well with the Gaussian function[2]



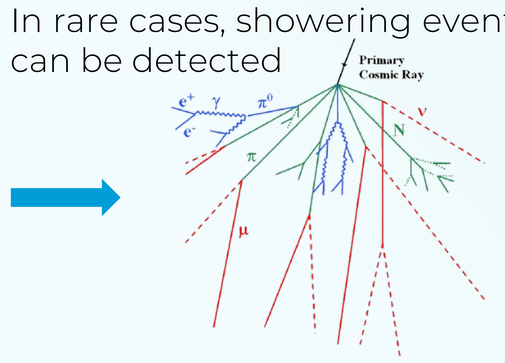


- With visualization, the track of muons that pass through four detectors can be reconstructed
- Picking the ADC value of these passing-through hits can reject backgrounds such as pedestals and hits from other particles
- The distribution fits well with the Landau distribution
- The distribution within 1000 is fitted by 2nd polynomial function





- In rare cases, showering events can be detected



References

[1] Abe, M. et al. A New Approach for Measuring the Muon Anomalous Magnetic Moment and Electric Dipole Moment. arXiv. https://doi.org/10.48550/arXiv.1901.03047 (2019)

[2] Pillera, R., et al. 'Development of a Portable SiPM Scintillator Tracker for Cosmic Rays'. PoS, vol. ICRC2021, Sissa Medialab Srl, 3 2021, p. 1371, https://doi.org10.22323/1.395.1371.

Acknowledgments: This work is supported by National Natural Science Foundation of China (Grant No. 1211101353) and Zhiyuan Scholars Program (Grant No. 2022-09)