Cosmic Muon Detector Development

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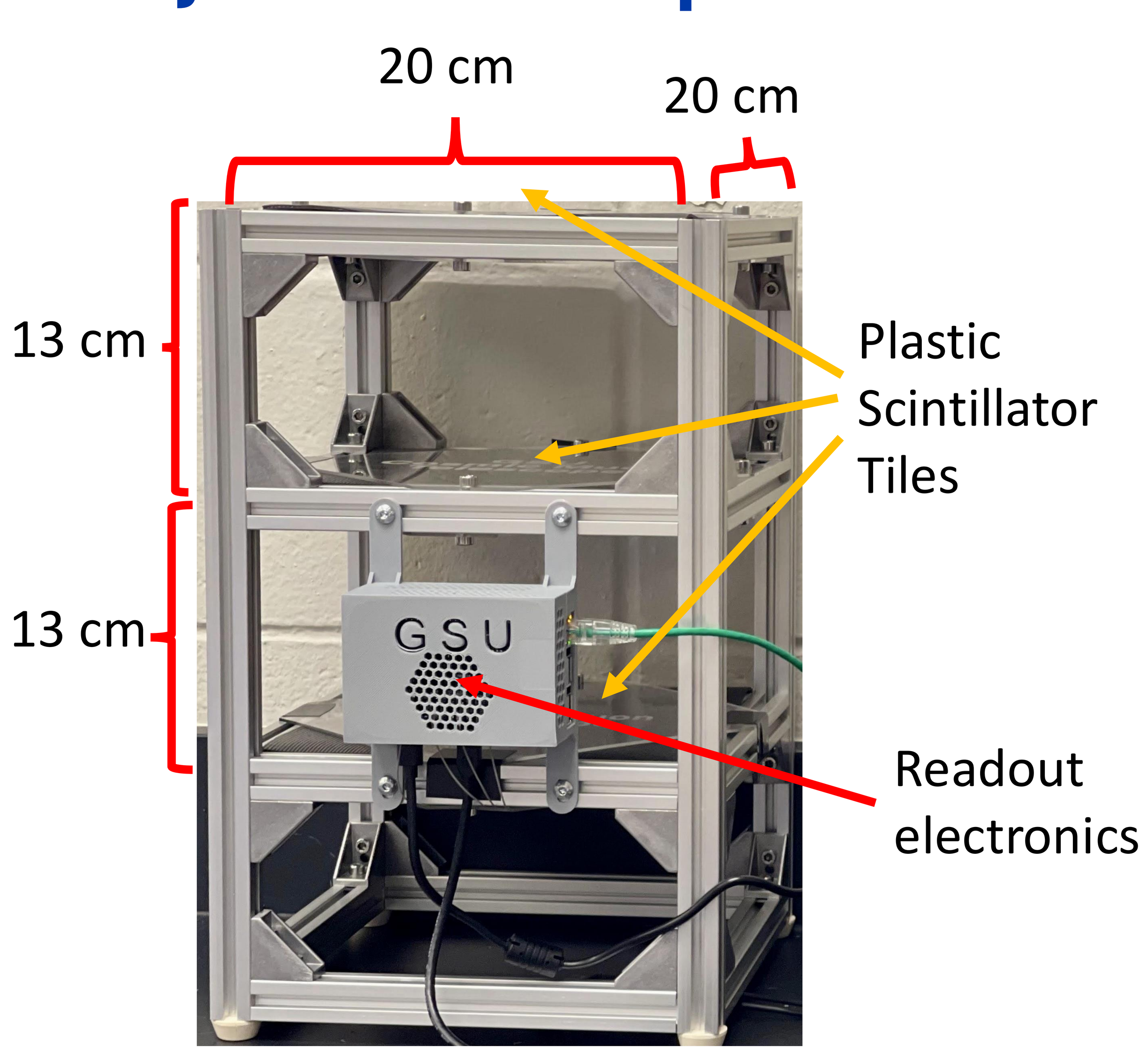
Abstract

The gLOWCOST project, as a part of the GSU RISE initiative, aims to develop and deploy a global network of low-cost cosmic muon detectors. Using Silicon Photomultipliers (SiPM) and plastic scintillators, these detectors monitor cosmic ray activity and contribute to space and terrestrial weather forecasting. Continuous design improvements ensure that the detectors become more reliable and affordable with each iteration. This poster details the detector readout, the preparation of the detector, the detector validation process, and the importance of global deployment for improving our understanding of cosmic ray impacts on Earth.

Introduction

The gLOWCOST project (global low-cost cosmic detector for space and terrestrial weather) aims to establish a network of affordable cosmic muon telescopes, designed to detect cosmic muons through a simple yet effective setup. These telescopes utilize Silicon Photomultipliers (SiPM) paired with plastic scintillators to register muons passing through the scintillator tiles. Each detection is recorded and transmitted to the Georgia State University servers for further analysis. By leveraging this scalable and low-cost design, the project facilitates global monitoring of cosmic ray activity, contributing to advancements in both space weather and terrestrial weather forecasting and monitoring.

Key Detector Components



GSU Cosmic Muon Telescope

Readout

Workflow

Silicone photomultiplier generating an analog pulse from scintillation from charged particle encounters in scintillator tiles

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Analog signal amplification

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FPGA- Peak detection & coincident count logic operation

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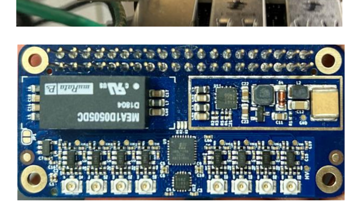
Raspberry Pi- Coincident count detection, data logging and data transfer to GSU servers

For temperature compensation		Coincident Counts			
1st Layer raw counts	Dark counts	Layer 1&2	Layer 1&3	Layer 2&3	Date & Time stamp
1463,	1511,	144,	73,	139,	Wed Jun 26 14:27:56 2024
1395,	1417,	141,	72,	130,	Wed Jun 26 14:28:56 2024
1366,	1466,	161,	93,	163,	Wed Jun 26 14:29:56 2024
1403,	1408,	154,	82,	166,	Wed Jun 26 14:30:56 2024
1407,	1431,	166,	90,	179,	Wed Jun 26 14:31:56 2024
1424,	1438,	163,	77,	158,	Wed Jun 26 14:32:56 2024

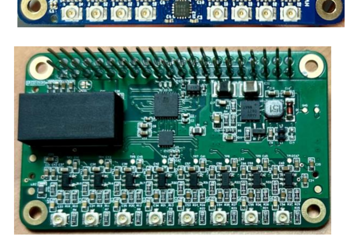
Data Logging Format

Readout Evolution

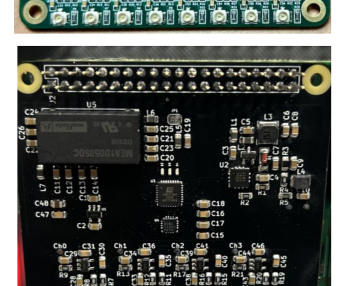
Edition 1 : Amplification stage is placed near the SiPM
Designed by Sawaiz Sayed



Edition 2 Version 1:
FPGA 8 channel design
Designed by Sawaiz Sayed



Edition 2 Version 2:
FPGA 8 channel design
Designed by Sijei Chen



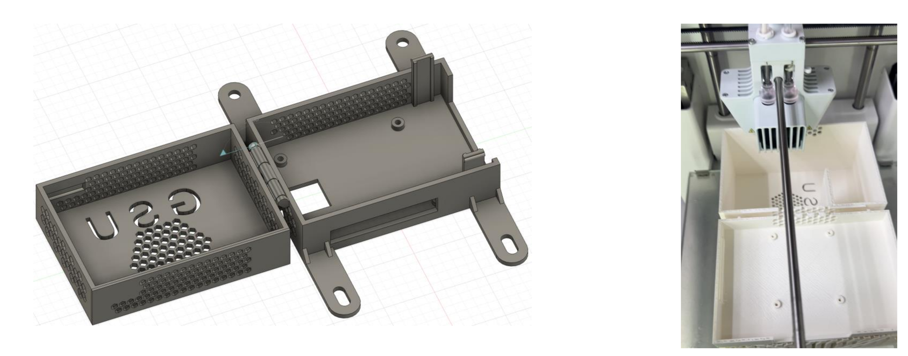
Edition 2 Version 3:
FPGA 4 channel design & integrated pressure sensor
Designed by Tharindu Hettiarachchi

Assembly

The frame is made from aluminum v-slot extrusion beams.

Frame Assembly

Readout electronics' housing is 3D printed at GSU.



3D Design and 3D Printing

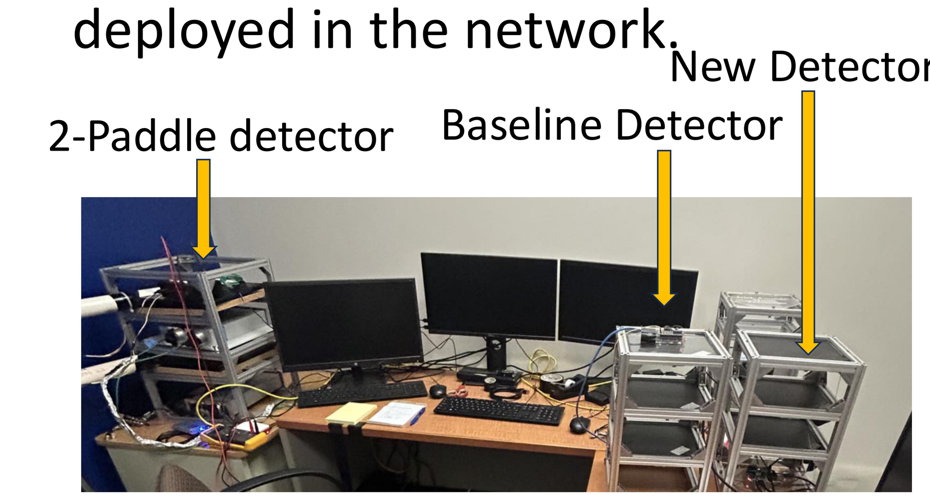
Ready-to-install scintillator tiles are securely attached to the detector frame. For detectors requiring custom dimensions, bare scintillator tiles are machined to accommodate the installation of wavelength-shifting optical fibers. Each tile is carefully sealed to prevent any ambient light leakage, ensuring optimal performance and accurate muon detection.

Bare Scintillator Tiles with Optical Fiber

Ready to install Scintillator Tile

Testing & Validation

Once assembled, each new detector undergoes performance testing against a baseline detector. The baseline detector, identical in design and previously validated at GSU, ensures reliable comparison. This testing process involves using a 2-paddle detector equipped with photomultiplier tubes. Both the new and baseline detectors are placed in the same location at least for seven days, allowing for the verification of consistent coincident count behavior. This method ensures that the new detector performs as expected before being deployed in the network.



Future of the Detector

With the goal of deploying detectors in around the world to enhance monitoring and modeling of both space weather and terrestrial weather, the design of the detectors undergoes continuous refinement. Each iteration focuses on improving reliability and affordability, ensuring that the technology remains accessible and effective as the network expands globally.

Acknowledgement

Supported by the GSU RISE initiative, ongoing design improvements and precise tile preparation ensure reliable, cost-effective detectors for global deployment, enhancing space and terrestrial weather monitoring.

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