Low Energy Muon Beam Diagnostics - Scintillating Fiber Profile Monitor (SFPM)

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Introduction

The MeV Test Area (MTA) houses the 400 MeV H^- Beam at the end of the Linac and a secondary beamline of muons and pions created from hitting a Tungsten target. The MTA is in the Irradiation Test Area (ITA), where experiments involve studying the effects of radiation on materials in the MTA beam.

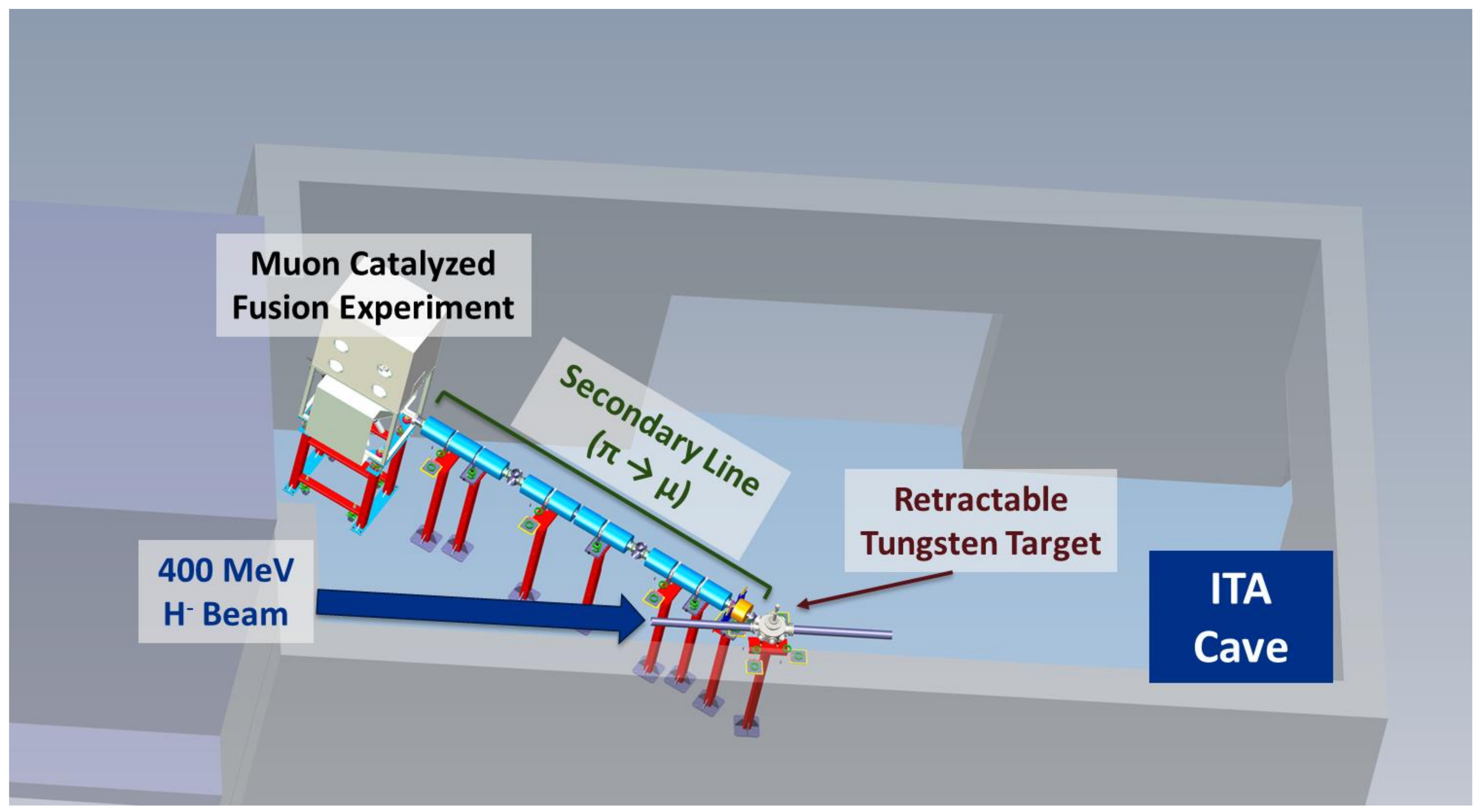

Figure 1. MTA Overview

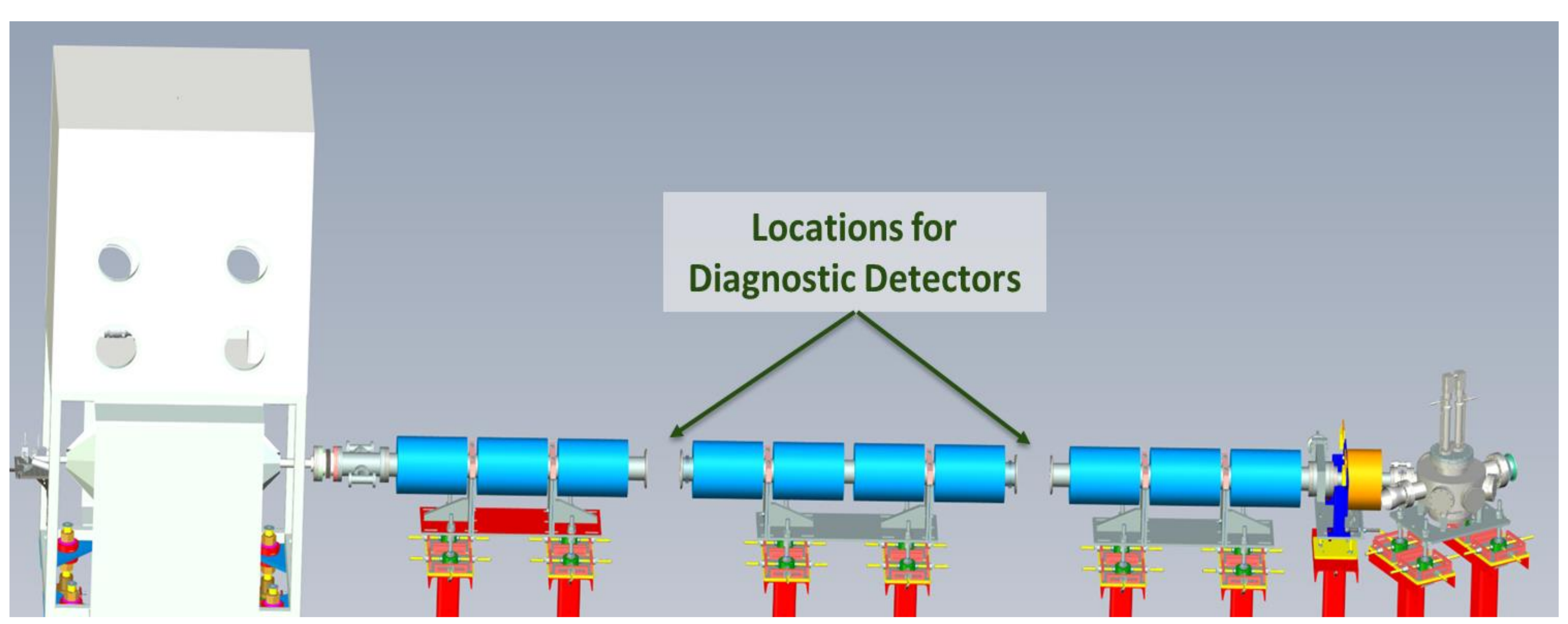

Figure 2. Secondary Beam Line

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Purpose

There is a need for a retractable detector to monitor the secondary beam's intensity and coarse profile. The SFPM was chosen when considering factors like ability to measure low rates and handle high intensities. X/Y array of scintillating fibers paired with photosensor read-outs are common choices for muon beam profiles, including uses at J-PARC, CERN, and g-2 at FNAL. The plan was to use collimated ^{90}Sr source to test detector components offline, test different scintillating fibers & Silicon Photomultiplier (SiPM) models to figure out which combination gives the best signals, and gain familiarity with the detector assembly, operation, and data acquisition software before using with final detectors in beamline.

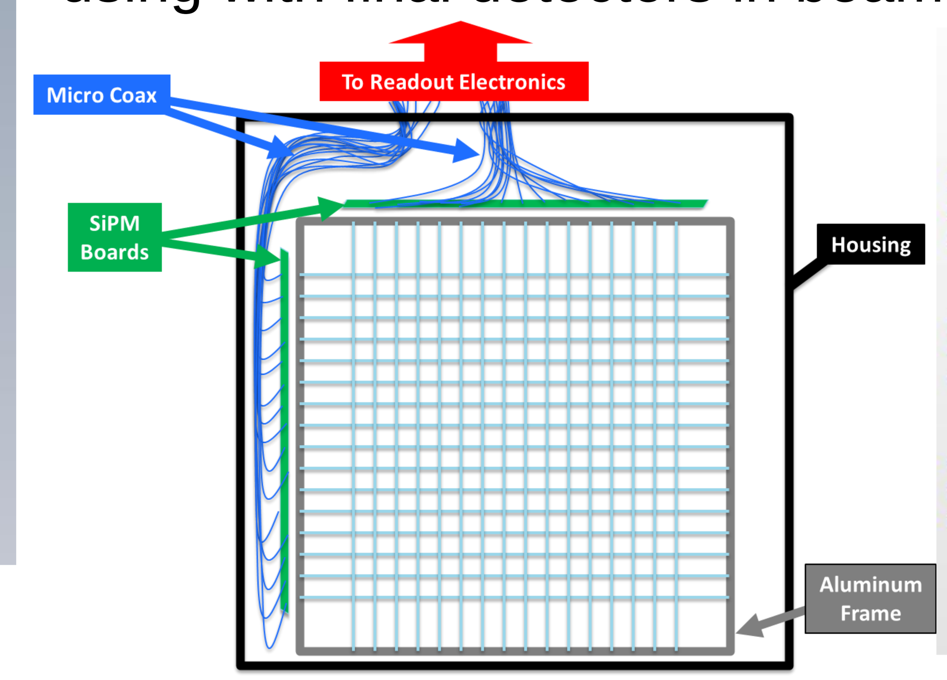

Figure 3. Profile Monitor Final Design

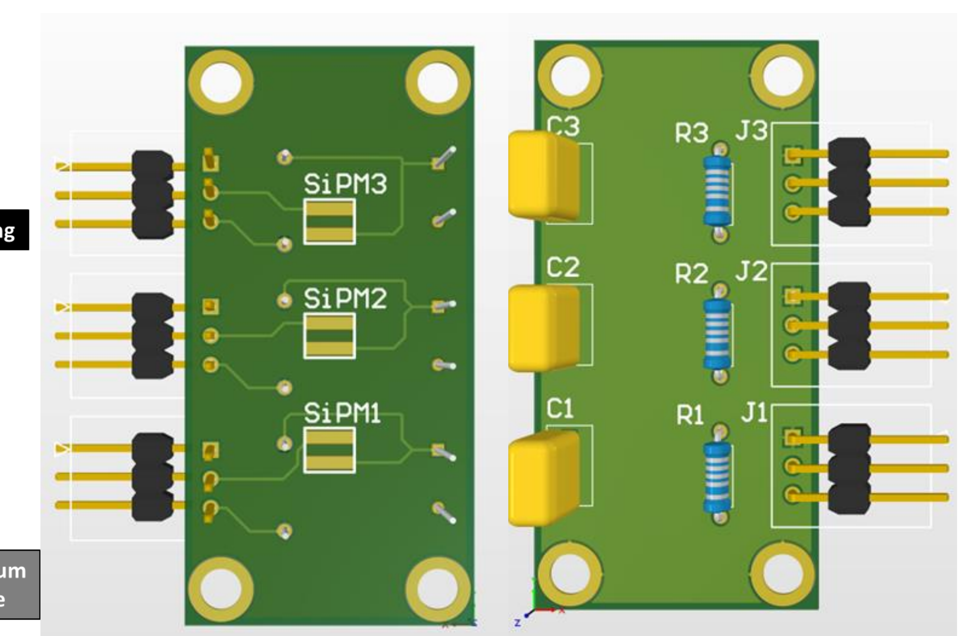

Figure 4. PCB SiPM Design

Process, Materials, and Methods

Assembly of the profile monitor was needed, starting with polishing the scintillating fibers to allow light to escape the out of their ends to reach the SiPM. After, a metal deposition was added on the side opposite the SiPM to reflect light back to the SiPM. To fasten the optical fibers to the monitor, optical cement was used to prevent distortion, scattering, and other undesirable optical events. The SiPM boards are attached to the sides by screws with the SiPM's facing the fibers. The are connected to a Front-End Readout System, the Caen DT5202. It houses an FPGA, 64 channels, has multiple modes of operation to support single-particle counting or full signal integration, and a software with a Graphical User Interface to plot and interpret data.

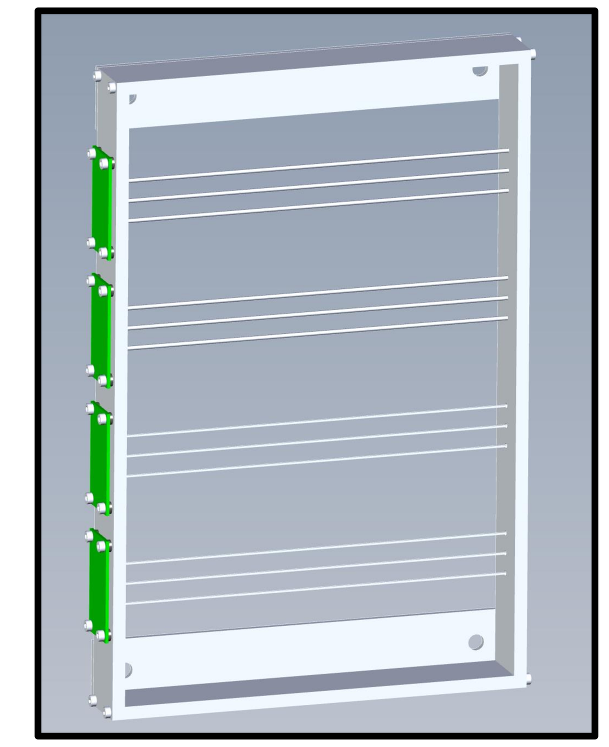

Figure 5. Test Monitor Model

Figure 6. Caen DT5202 Front-End Readout System

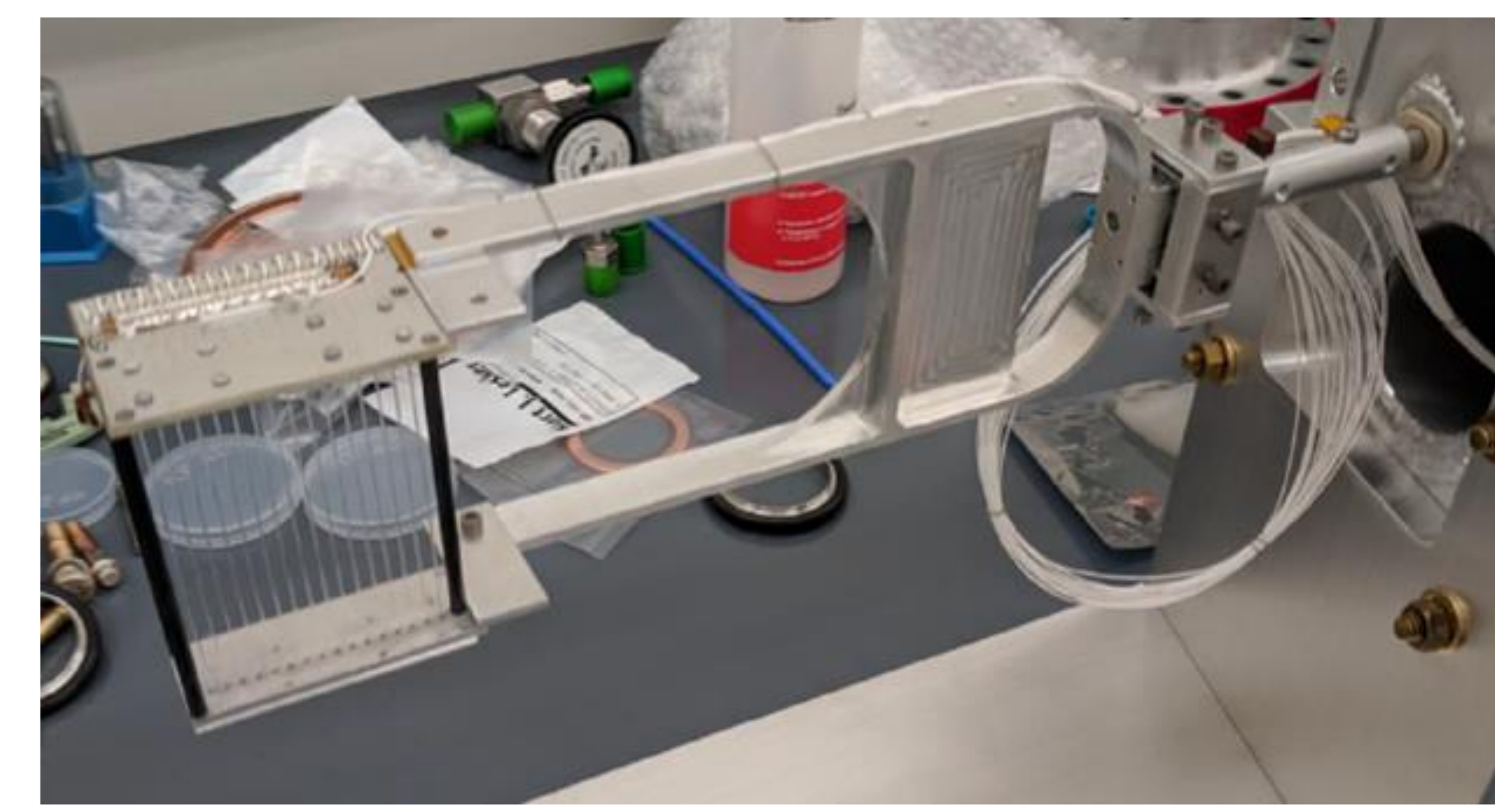

Figure 7. IBMS3 Detector from Muon g-2 experiment at Fermilab

Conclusions and Future Work

The SiPM circuit has been tested with a LED pulser successfully. The immediate steps that follow will be to set the SiPM up on the monitor with three different types of optical fibers, use the Caen software to configure the best mode of data acquisition, and proceed with an offline source test using Strontium-90. Once the most efficient measurement method is clear, they will be ready for use in the beamline.

References

1) Izzo, C. (2022, September). *Low Energy Muon Beam Diagnostics* [PowerPoint Slides]. Accelerator Division. Fermi National Accelerator Laboratory. Izzo_Muon_Beam_Diagnostics - Updated Sept 2022.pptx
2) Collins, W. (2016). Building IBMS Detectors for Muon g-2. 2-6.