Readout Electronics for Scintillating Fiber-Based Muon Beam Monitor in the COMET Experiment

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Poster #15

Introduction

The COherent Muon to Electron Transition (COMET) experiment was born with the intention to search for a special process of CLFV (Charged lepton flavour violation), the $\mu^- N \rightarrow e^- N$ process, by the interaction of a muon and a nucleus. The COMET Phase-I aims at a single event sensitivity (SES) of 3.1×10^{-15}, roughly 100 better than the current experimental limit.

The COMET experiment leads an 8 GeV proton beam out of the main ring of J-PARC. The COMET collaboration intends to operate an engineering run called Phase-α in JFY2022, with the purpose of understanding the proton beam which is transported to the experiment area and the production yield of π/μ at 8 GeV protons before the Pion Capture Solenoid is installed in the COMET primary beamline area. The layout which contains the entire beamline and facility components are shown in Fig.1.

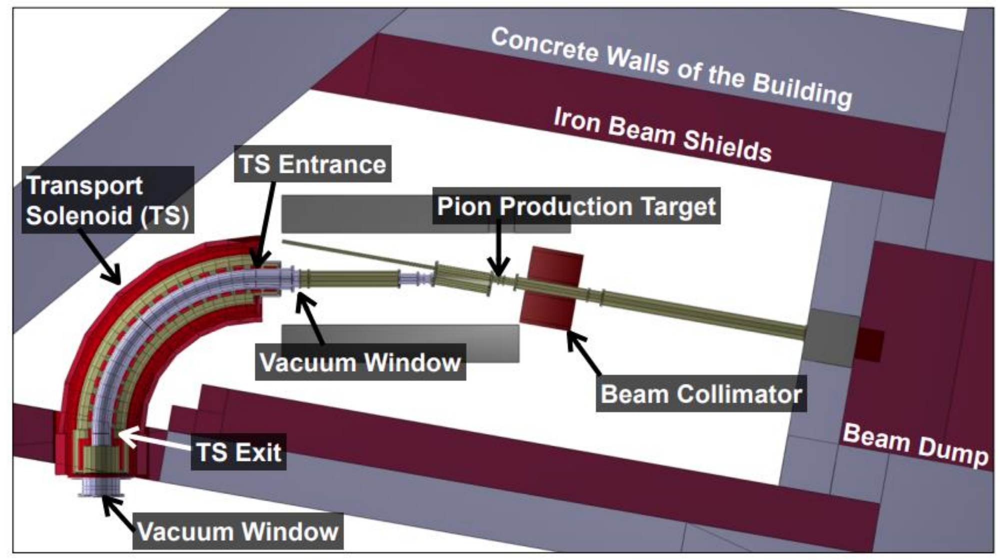

Fig.1 Layout of COMET Phase-alpha

Muon Beam Monitor

The Muon Beam Monitor is designed for measuring the timing and position of incoming particles to profile the beam, which is located at the exit of the Transport Solenoid. The location of the apparatus is shown in Fig.2.

The total size of the Muon Beam Monitor is 90 x 90 cm^2, which includes the detector part, the electronics part and the mechanical support structure. The central detector occupies an area of 30 × 30 cm^2. There are 128 + 128 scintillating fibers (SCSF-3HF), which are used to weave the mesh structure. The estimate gives the yield of about 20 photoelectrons per hit from cosmic muons, while the COMET experiment can produce more than 40 photoelectrons per hit almost every time. The cross- sectional area of the fiber is 1 × 1 mm^2, where the spacing of the fibers in the same dimension is 0.4 mm.

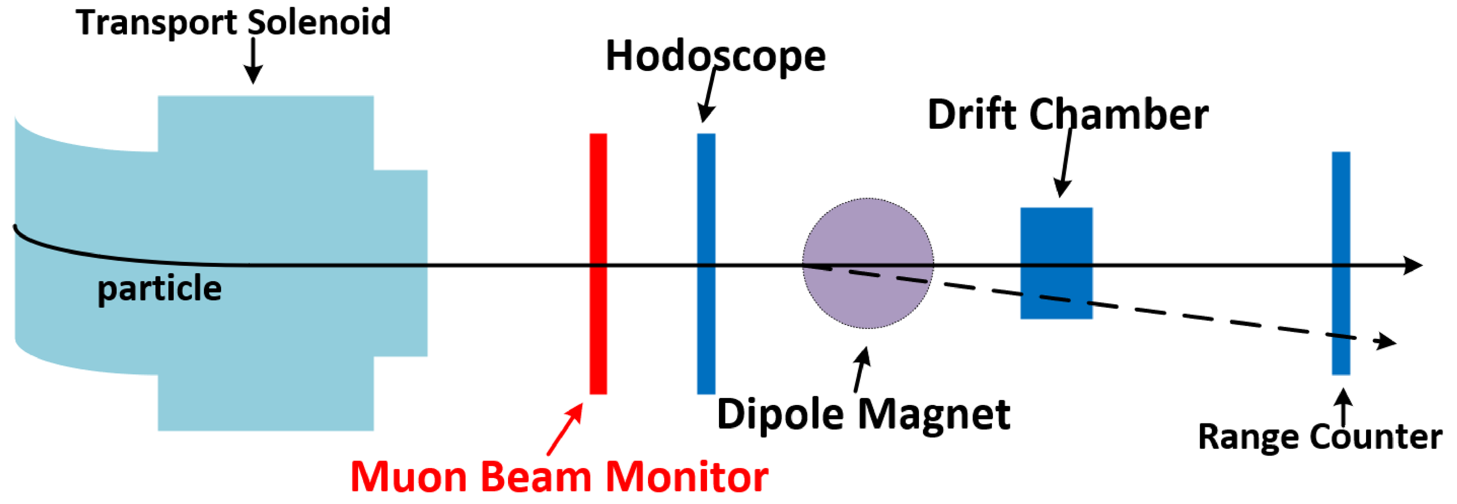

Fig.2 Phase-α apparatus in COMET experiment.

Readout Electronics

The overall architecture of the electronics is shown in Fig3. There are 4 front-end electronics modules which are used to read out a total of 128x4 outputs from each end of the detector in the X and Y directions. The optical signal is converted into a weak current signal by SiPM. After the front-end amplifier and over-threshold screening, the hit information will be transmitted to the trigger unit in real time through optical fiber. Then the time stamp will be fed back to the front-end electronics after the trigger unit's compliance judgment. The four-way data are connected to the PC for data processing via a switch in the end.

The front-end electronics readout modules is divided into three main parts, SiPM Carrier, Front-End Bottom (FEB) Board and DAQ Board. The role of the SiPM Carrier is to place the SiPM to complete the first step of photoelectric conversion. According to the estimation of the front-end detector, a single hit can produce at about 20 ~ 40 photoelectrons. The function of the FEB board is mainly the amplification of the signal and the initial processing of the data.

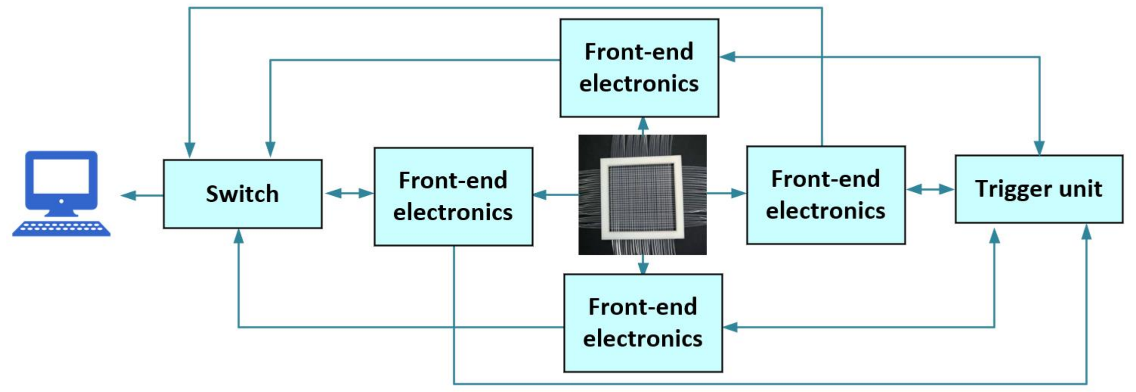

Fig.3 The overall architecture of the electronics.

Test Results

We have recently conducted proton beam experiments at CSNS. The histogram of statistical distributions were calculated for hit events and times as shown in Fig.4. The clear beam pulses with an interval of about 40 ms can be seen, which is with the information provided by CSNS. This experiment provides a preliminary verification of the readout electronics.

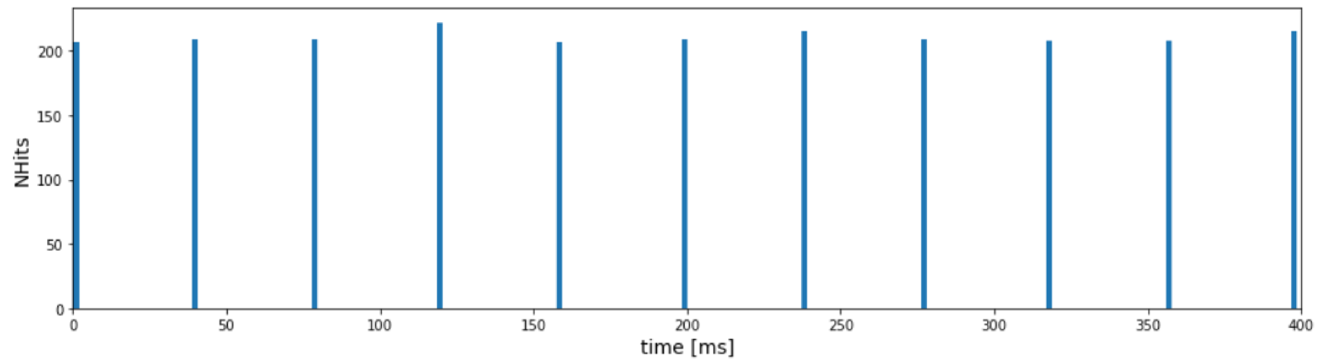

Fig.4 Histogram of hits vs time.

Conclusion

We investigated the front-end detector of Muon Beam Monitor in the COMET experiment. SiPM Hamamatsu 13360-1350PE is used as photosensor to receive the optical signals from scintillating fibers SCSF-3HF, and MaPMT is used to do highly integrated front-end digital processing and the trigger unit is used to filter out the valid hits from multiple front-end digital modules. The modular design makes the electronics a clear division of function

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