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Silicon Strip Detector for J-PARC Muon g-2/EDM Experiment

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The muon anomalous magnetic moment $(g-2)_\mu$ and electric dipole moment (EDM) are sensitive to new physics beyond the Standard Model. J-PARC muon g-2/EDM (E34) experiment [1] aims to measure $(g-2)_\mu$ with a precision of 0.1 parts per million and search for EDM with a sensitivity of $10^{-21}e$·cm with different concept from the muon g-2/EDM experiment at BNL and FNAL. We utilize high intensity proton beam at J-PARC and newly developed technique of ultra-cold muon beam, which is produced by thermal muonium productions [2] followed by laser ionization [3] and muon linear acceleration [4]. The ultra-cold muon beam accelerated up to 300 MeV/c are injected into the storage magnet with a 3 Tesla magnetic field [5]. The positron from muon decay is detected by the silicon strip detector.

The 40 silicon strip vanes are placed radially inside the storage ring. Each vane has single-sided p-on-n type silicon strip sensors on both sides with mutually orthogonal strips. Two-dimensional position of a positron track is detected by two layers of the silicon strip sensor. The silicon strip sensor has 1024 readout strips at a constant strip pitch of 190 μm pitch [6]. The active area is 97.28 mm$\times$ 97.28 mm with 320 μm thickness. We started to fabricate the silicon strip sensors with Hamamatsu photonics and estimate its characterization. The readout ASIC is required to tolerate a high hit rate of 1.4 MHz per strip, to be stable to the change of hit rate by a factor of $1/150$, and to have deep memory for the period of ~ 40 μs with 5 ns resolution. The prototype readout ASIC "SliT128A" has been fabricated using the Silterra 0.18-μm CMOS process. We connected the SliT128A with a silicon strip sensor thorough signal fan-out flex circuit (i.e., pitch adapters) made by Fujikura Ltd. and tested them with a pulsed muon beam at J-PARC.

We developed software tools for our silicon strip detector. The timing stability is important for the precise measurement of the $(g-2)_\mu$. Therefore, we implemented the behavior of the ASIC into the simulation, and estimated the timing shift due to the pileup. Track reconstruction efficiency should be high and stable against change of hit rate. We developed a track finding tool based on Hough transform method and confirmed the track reconstruction efficiency keeps greater than 90% even at the expected highest hit rate.

In this talk, we present the design of the silicon strip detector, development status of the each component, and the expected tracking performance based on simulation.

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