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Development of the muon beam monitor for COMET experiment using SiC detector

The COMET experiment aims to search for the muon-to-electron $\mu - e$ conversion process, one of the lepton flavour violation processes, with a sensitivity better than 10^{-16} in J-PARC. To achieve this sensitivity, precisely controlling the secondary muon beam and suppressing the backgrounds is essential. The muon beam monitor will measure the muon beam profile directly, and monitor its stability and intensity. This provides key information for beam control and suppressing the background caused by sudden beam fluctuation. However, since this monitor will be exposed to a high-intensity muon beam, the radiation level is expected to become a 1-MeV equivalent neutron fluence of $1.6 \times 10^{13}/\mathrm{cm}^2$and ionising radiation of 1.2 MGy. The standard silicon sensors will lose their functionality in such an environment. Therefore, we utilise silicon carbide (SiC) for detectors, which is a wide-bandgap semiconductor with higher radiation tolerance than silicon. Our SiC detectors were fabricated by the National Institute of Advanced Industrial Science and Technology (AIST). In this beam monitor system, SiC detectors are read out by ASIC, which KEK is developing. The overall system is under development for installing the actual experiment.
To investigate the response of SiC detectors to the pulsed muon beam, we performed a beam test at the J-PARC MLF D2 line, which provides the pulsed muon beam with the same momentum region as in the COMET experiment. In this beam test, we used a commercial preamplifier instead of ASIC, which was under development. As a result of the analysis, we found that our SiC detector can detect a single muon by employing the waveform fitting and also confirming the sufficient linearity up to around 35 incident muons.
This beam monitor is planned to be installed upstream of the primary detector system. This provides the information on the shape of the muon beam entering the detector. However, its installation will cause a reduction in the muon yield and an increase of background rates in the detector. In contrast, a downstream installation will preserve the muon yield and enhance the maintainability of the beam monitor system. We are conducting further simulation analysis to determine realistic installation locations and optimal designs. We report the results of the performance evaluation of the SiC muon beam monitor prototype based on the analysis of the beam test and the development for its implementation in the experiment.

Secondary track

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