MLF Experimental Report	提出日 Date of Report Jul. 11, 2013
課題番号 Project No. 2012B0117 実験課題名 Title of experiment Development of high-rate positron tracking system for muonium production experiment with high intensity pulsed muon beam 実験責任者名 Name of principal investigator Yoshinori Fukao 所属 Affiliation KEK IPNS	装置責任者 Name of responsible person Yasuhiro Miyake 装置名 Name of Instrument/(BL No.) D2 実施日 Date of Experiment Nov. 25 – Nov. 27

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。(適宜、図表添付のこと)
Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.

No sample used.

2. 実験方法及び結果(実験がうまくいかなかった場合、その理由を記述してください。)
Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.

This experiment aims to develop a new positron tracking detector employed in the muonium production experiment for the J-PARC g-2/EDM experiment (J-PARC E34). The new system features high track-back position resolution and high rate capability for the ultra-high intensity pulsed muon beam at J-PARC. The detector is designed to have a large number of scintillator channels + MPPC (Multi-Pixel Photon Counter, Hamamatsu Photonics K.K.) based photodetector system. The plastic scintillator with fast timing response is finely segmented to operate it in high event-rate condition and is thin enough to suppress multiple Coulomb scattering which contribution to the position resolution is significant. We developed a prototype of the tracking detector and evaluated its performance at J-PARC MLF. Figure 1 shows experimental setup for track-back position measurements.

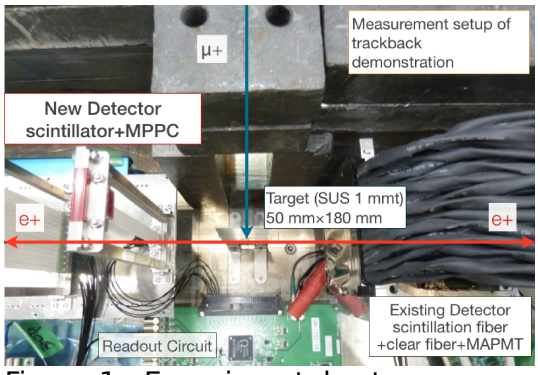

Figure 1 : Experimental setup

2. 実験方法及び結果（つづき） Experimental method and results (continued)

Muon beam was stopped at target and positrons from muon decay were detected by the detector. By reconstructing the image of the target and measuring its width, the track-back position resolution was evaluated. Figure 2 displays measured track-back position resolution when the detector was set at 80 mm from the target, as a function of the thickness of the scintillator used for the detector, as well as a sample of the measured track-back distribution. The measured values are well understood and reproduced by the MC simulation, where material thickness and multiple Coulomb scattering due to them were considered. The track-back resolution can be translated into 80 mm in RMS when the detector is located at 230 mm away from the target, which satisfies requirement of the detector.

The detection efficiency was measured with dedicated setup, which consists of two reference scintillation counters on both side of the tracking detector to determine particle penetration on the tracking detector. Figure 3 and 4 shows the detection efficiency and its dependence property on the distance of the hit position from readout MPPC. Strong distance dependency was observed with scintillator slabs, both with and without painted by light reflector, because of light attenuation in the scintillator. On the other hand, no distance dependency was observed with scintillation fiber. Remarkable feature is that the scintillator slabs without light reflector shows better efficiency than those with reflector. The efficiency with the scintillation fiber achieved to 76%. Although source of the inefficiency is still being investigated, if one assumes that detected photon distribution follows Poisson distribution, the efficiency of 96% is obtained from the measured distribution. Based on the measurements, we finally decided to employ scintillation fiber for the new tracking detector.

Rate capability of the detector was also evaluated using the beam. Because the detector measured decay time distribution of muons, a signal pile-up at high event rate introduces distortion of the exponential distribution. Analyzing data result in detection loss of 1.1% due to signal pile-up at an event rate of 2.8 MHz, which is comparable to the expected highest event rate in the actual use. The measured value is sufficiently small.

Based on the results obtained by the beam test, We started development of the production version of the tracking detector.

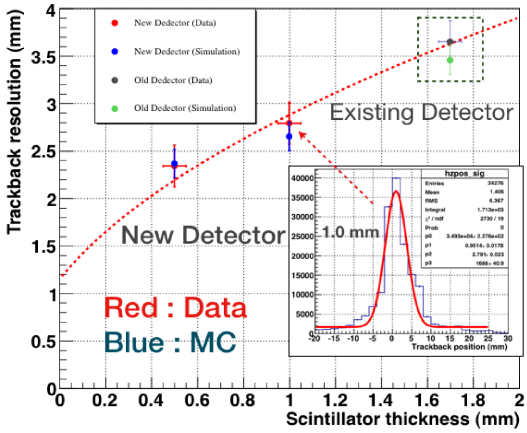

Figure 2 : Track-back position resolution as a function of scintillator thickness.

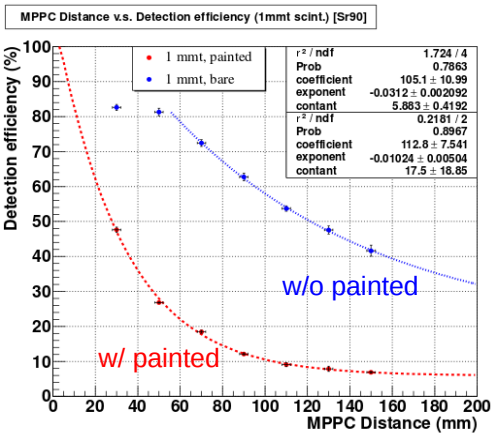

Figure 3 : Detection efficiency as a function of distance of hit position from MPPC. Scintillator slab with 1-mm thickness was used.

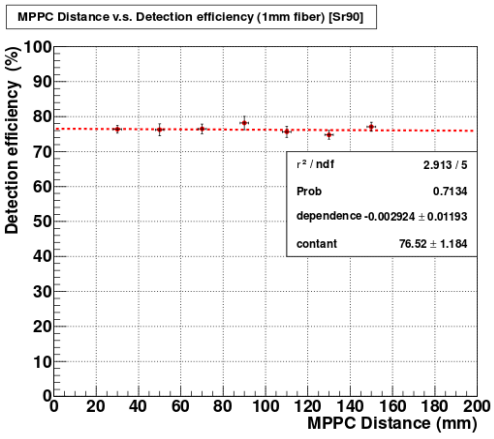

Figure 4 : Detection efficiency as a function of distance of hit position from MPPC. Scintillation fiber with 1-mm thickness was used.