Development Of Thin Plastic Scintillation Counter For Medium Energy Muon Experiment At MuSIC

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INTRODUCTION

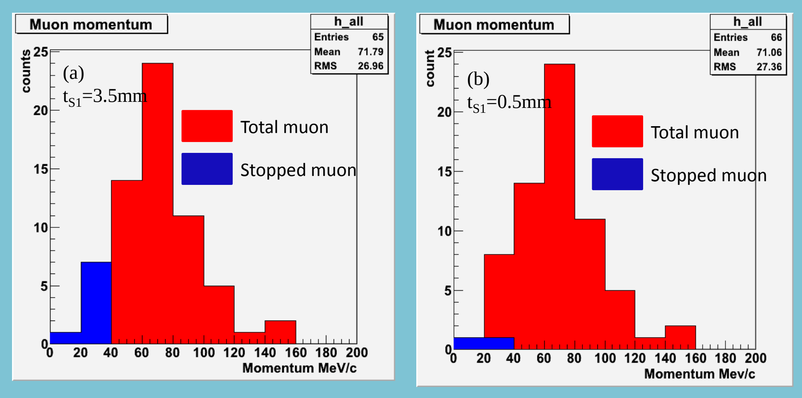

Figure 1: (a) Muon stopped in scintillator in 4th beamtest counter
(b) Expected stop muon yield by thin scintillation counter by Geant4 simulation.

The muon beam in MuSIC is a DC muon source; we hardly get the timing information for the muon arrival time from the accelerator system such as RF timing. The trigger counter was essential to obtain the time information and location information during the MuSIC experiments. Due to low energy muons stopped on a target, the thin plastic scintillation counters were used as the trigger counter in order to avoid low energy muons to stop on the scintillators before hit the target.

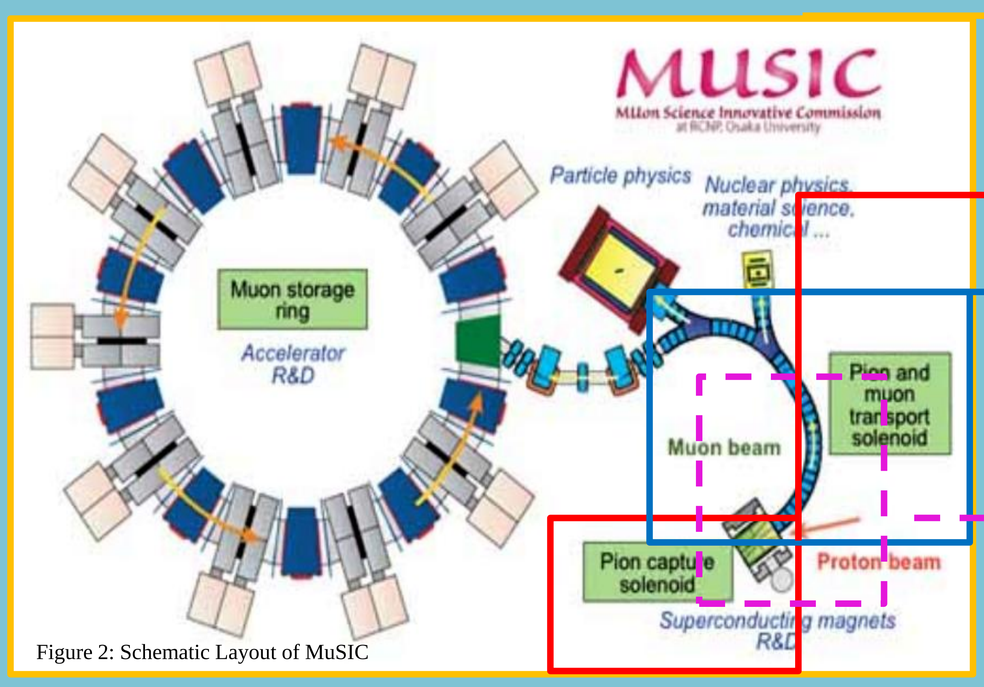

Figure 2: Schematic Layout of MuSIC

MuSIC:
MuSIC facility at RCNP, Osaka University can yield about 10^8 muons per sec and which is equivalent to the highest intensity in the world,. A broad field of muon science can be carried out with the muon beam provided by the MuSIC.

PION CAPTURE SOLENOID:
A 0.4kW proton beam produced by a cyclotron is injected on a graphite target in the pion capture section.

PION AND MUON TRANSPORT SOLENOID:
The secondary pions produced at the target are transported by the muon transport solenoid of 2.0 T solenoidal magnetic fields. In the transport solenoid, the dipole field of 0.4T is applied to select charge and momentum of charged particles.

MUON EXPERIMENT:
Since 2010, the pion capture system and 36 degree of muon transport system were officially operated. Many muon experiment have been done since the first beam test until 5th beamtest such as muon lifetime measurement, muonic X-ray measurement and muon momentum measurement.

RESEARCH AIM

The main purpose of this research is to develop a thin plastic scintillation counter with the dimension of 380mm x 30mm x 500μm to make trigger signal for the stopping muons. The combination of Multi Pixel Photon Counter (MPPC) with Wavelength Shifting (WLS) fiber may enhance the capability of both components to detect particle. The performance of three configurations of the thin plastic scintillation counter will be check using ^{241}Am source. The best detector configurations will be used as the MuSIC beamtest counters. The performance of the detector was also checked with muon beam.

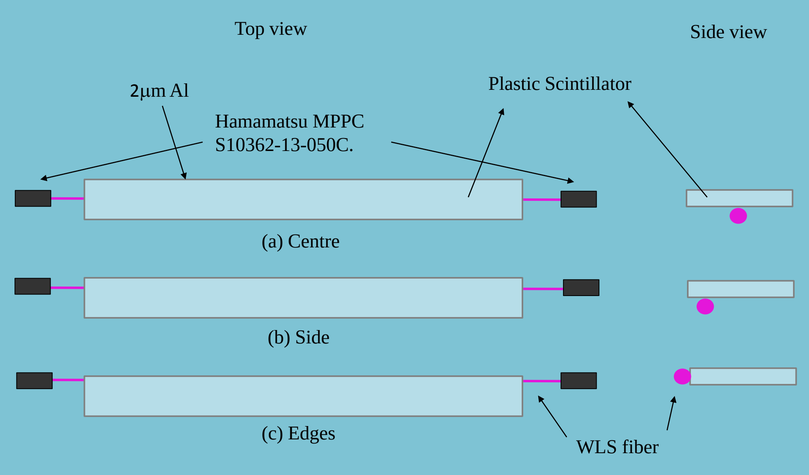

Figure 3: Three Configuration of tested thin scintillator.

EXPERIMENTAL PROCEDURE

Performance study of thin plastic scintillation counter with MPPC readout
3 configurations was designed: centre, side and edge.

Checking the detector performance with ^{241}Am source
The rate of event, signal to noise ratio and photon yield was determined.

Construction of detector and the beamtest performance check
The gain and threshold for each MPPC was check through their ADC signal.

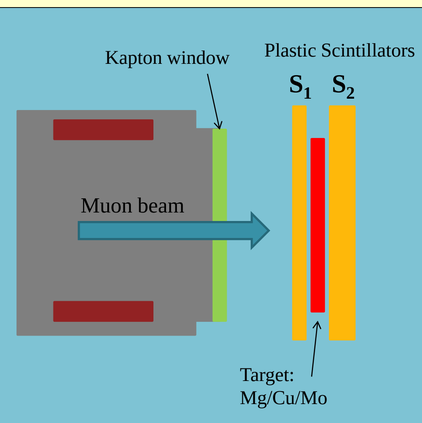

Figure 4: Eight sets of thin plastic scintillators were used for position and momentum distribution measurement.

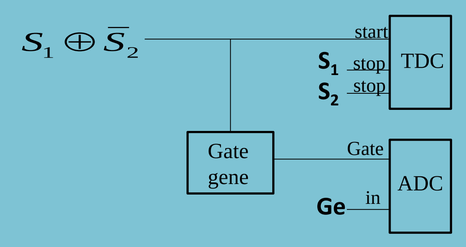

Figure 5: Detector Trigger setup during beam test.

DETECTOR PERFORMANCE

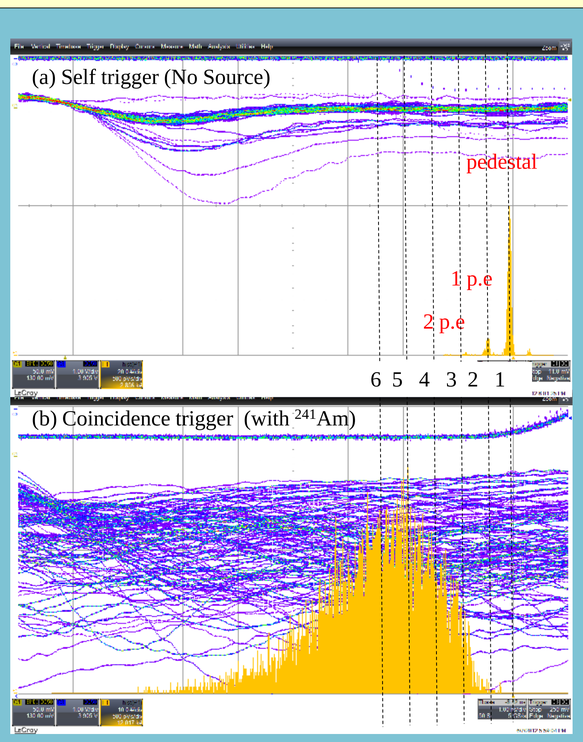

Figure 6: Signal from MPPC

From the self trigger signal with no ^{241}Am source, the photon peak can be clearly separated.

About 6 photons yield at each MPPC was determined by comparing the gain of each photon peak in self trigger to the coincidence trigger histogram.

CENTER CONFIGURATIONS:
Smallest dark current rate, highest signal to noise ratio.

Source	MPPC	V_{op} (V)	Dark current @1.5pe, I_{ref} (kHz)	Rate@2.5pe, I_{obs} (kHz)		
				Center	Side	Edges
No	TJ5359	71.37	57.9	15.0	15.0	8.9
	TJ5362	71.38	56.7	12.3	12.1	36.5
^{241}Am	TJ5359	71.37	57.9	32.3	18.8	16.3
	TJ5362	71.38	56.7	21.2	16.5	55.3

Table 1: Rate of events for MPPC

BEAMTEST PERFORMANCE

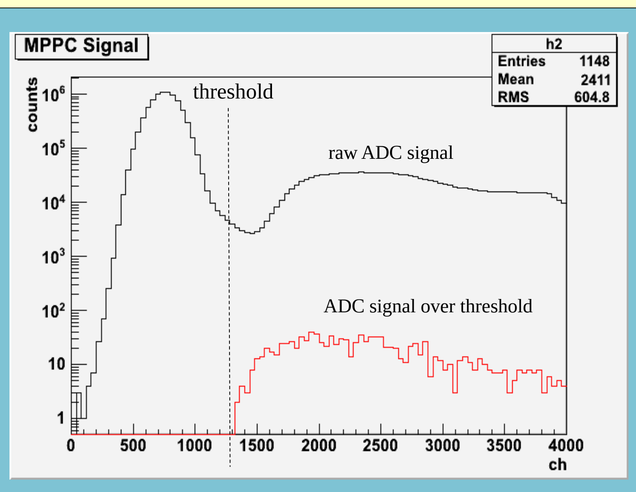

Figure 7: ADC Signal of MPPC during beam test

The MPPC signal during the beamtest can be observe by charge sensitive ADC(V792) by CAEN. The trigger signal from thin counter was based on hit on S_1 (upstream) and not hit on S_2 (downstream). The threshold and the gain of each MPPC was set at the level which enough to separate between pedestal and muon signal. In Figure 6, we can clearly see the separation between pedestal and muon signal with the thin plastic scintillators. The signal observe with ADC was similar to the signal observe in the oscilloscope during the checking of detector performance. As expected by using Geant 4 simulation, the number of muon stopped on scintillator reduces by 7% by employing the thin plastic scintillation counter for the low energy muon experiment at MuSIC.

CONCLUSION

In this study, we quantitatively compared the rate of event on three different configurations of thin plastic scintillation counter. We also employed a coincidence technique which effectively rejected dark noise produced by each MPPC. We found that the position of WLS fiber and the MPPC readout do affect the event rate at each MPPC and the coincidences of two opposite MPPC effectively reduce the dark count. We can conclude that the average number of photon yield at each MPPC was about 6 photons. The separation between photo peak also can be clearly distinguished with this thin counter by the test with ^{241}Am source and also test with muon beam. The thin plastic scintillation counter was completed and have been use in MuSIC 5th beamtest last June. Various muon experiments with larger range of muon momentum can be use for experiments.

REFERENCES

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