MLF Experimental Report	提出日 Date of Report 24th May 2010
課題番号 Project No. 2009A0023 実験課題名 Title of experiment Measurements of an Extinction Ratio and a Muonic Atom Formation Rate 実験責任者名 Name of principal investigator Masaharu Aoki 所属 Affiliation Osaka University	装置責任者 Name of responsible person Naritoshi Kawamura 装置名 Name of Instrument/(BL No.) D2 実施日 Date of Experiment 2009/6/2 10:00 ~ 22:00 2009/6/17 10:00 ~ 6/18 10:00 2009/11/17 12:30 ~ 11/19 7:00

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.

N/A

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.

The experiment was performed at D2 beam line in the muon facility of J-PARC MLF. The polarity of the D2 beam line was set for the negative charged particles. A simple counter assembly was installed at the exit of the D2 beam line as shown in Fig. 1. Negative muons below 60 MeV/c were all stopped in the Lead absorber plate, and absorbed via nuclear capture process with the lifetime less than 100 nsec. The detection efficiency for electrons is 50% due to Bremsstrahlung in the Lead plate.

The purpose of this measurement is to estimate the yield of delayed electrons coming through the D2 beam line from the muon production target. In order to make detectors work during the delayed timing, they should be protected against the prompt burst of the beam coming in coincidence with the primary proton pulse timing. In this measurement, this issue was solved by the following methods:

1) Read the fast scintillation light from plastic scintillators by photomultipliers (PMT),

2) Apply "gating" to the PMT to effectively switch-off the PMT during the prompt timing.

Figure 2 shows typical signals from each counter. In the "on" state, the shape of the signal baseline is not flat but shows monotonically decreasing offset due to the delayed fluorescence. However, individual signals are easily recognizable. In order to pick up the timing of these individual pulses, the whole waveform was recorded by using flash ADC. Those waveforms were analyzed afterwards by software to find individual signals on the baseline, and the coincidence between B1 and B2 was taken. Figure 3 shows time spectrum of

the coincidence. Exponential shape of the spectrum is seen. The decay constant of the spectrum is 2.10 ±0.02 μsec, and that is very closed to the lifetime of μ^- in carbon (2.00 μsec). The cause of small difference is currently under study.

After establishing the method to measure the yield of the delayed electron yield as described above, the yield dependence on the D2 beam line momentum setting was measured as shown in Fig. 4. The momentum of the edge of the spectrum is about 50 MeV/c, which is consistent with the edge of Michel spectrum of muon decay. Based on these observations in time spectrum and momentum spectrum, we concluded that the delayed electrons we observed at the exit of D2 beam line was coming from the muonic carbon atom in the muon target.

The muonic carbon yield at the muon target was obtained from the above delayed electron yield with correction from the D2 beam line acceptance. The D2 acceptance was estimated by Monte Carlo calculation (G4Beamline). The muonic carbon yield at the muon target is 10^9/sec for 120 kW proton beam power. This yield is consistent with the Monte Carlo calculated estimation.

From this measurement, we successfully obtained very important information about the muonic carbon yield. However, we still have to complete the following study before the publication:

1) Understand the cause of decay constant being slightly off from 2.0 μsec,

2) Estimate systematic errors.

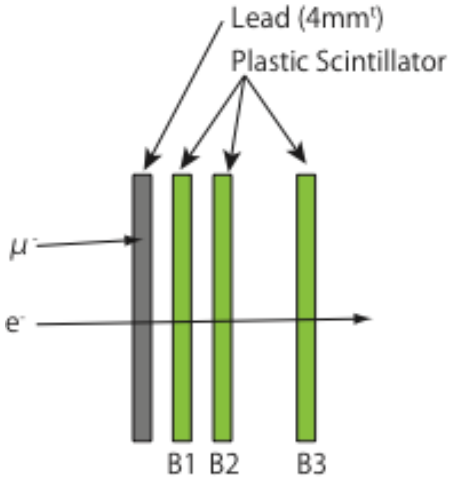

Fig. 1 Counter Setup

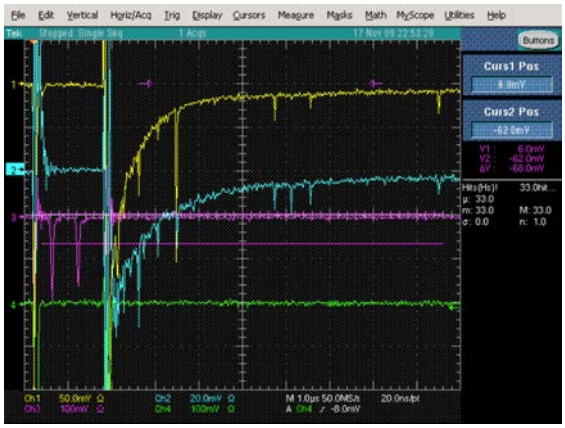

Fig. 2 Typical signals from counters, yellow:B1, blue:B2, purple:B3.

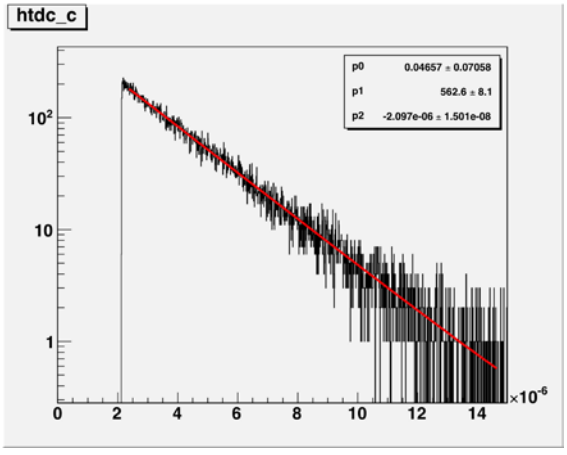

Fig. 3 Time spectrum of electron.

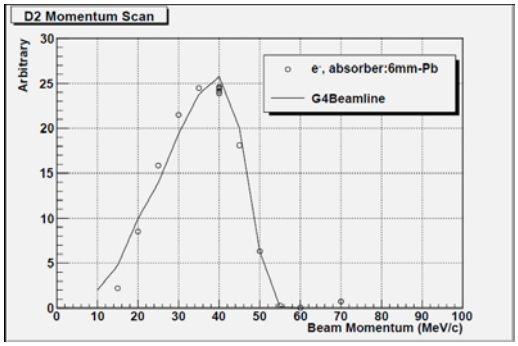

Fig. 4 Momentum spectrum of delayed electron.