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Development of Liquid scintillator system for the proton flux monitoring

J.H.So [a*], H.J. Kim[a], H. Park[b], Heedong Kang[a], S. Ryu[b].
[a]*Radiation Science Research Institute, Kyungpook National Univ., Daegu 702-701, Korea*
[b]*Basic Atomic Energy Research Institute, Kyungpook National Univ., Daegu 702-701, Korea*
email: blackpooh@mail.knu.ac.kr

1. Introduction

We developed a liquid scintillator (LSC) system for the beam flux monitoring. The LSC has ~10ns decay time and 10 times radiation harder than plastic scintillator. In this system, the LSC was made very thin as possible to minimize energy loss, because of the beam energy is loss in LSC. We also tried to calculate the energy loss in LSC and teflon case. Beam test in KIRAMS(Korea Institute of Radiological & Medical Sciences), We can monitor the proton beam flux up to 10^6 proton/sec accurately using counting method that is made up an ATMEGA128 embedded process equipped with an network system.

It also provides the trigger system for the other detector during the beam test.

2. Liquid scintillator

We used BC501A for this test that is made of xylene with a little PPO and POPOP. The xylene is toxic material, so we must use some diluted solution, such as mineral oil. The mineral oil makes to reduce light output from LSC. After test, if LSC is mixed 10% mass ratio in mineral oil, the light output is as high as 50% of LSC without mineral oil.

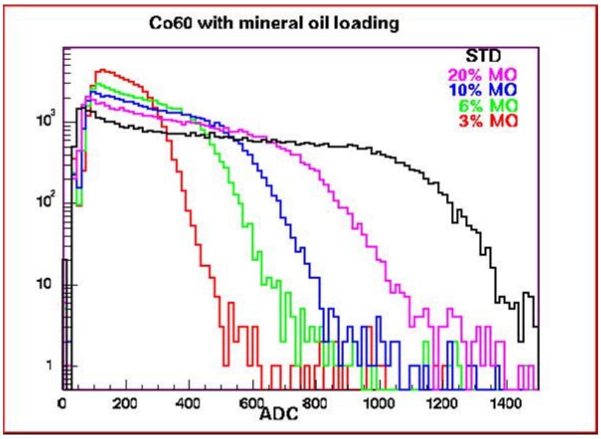

Figure 1. Light output for diluted LSC by Co60.

After we take consideration of radiation damage by proton beam, LSC circulation system is designed. The case was made of teflon for light reflection and very thin as possible to minimize energy loss. The design was 50 ×50×12 mm, thickness of case was 2mm, thickness of LSC was 8mm, so the beam pass through 4mm in teflon and 8mm in LSC.

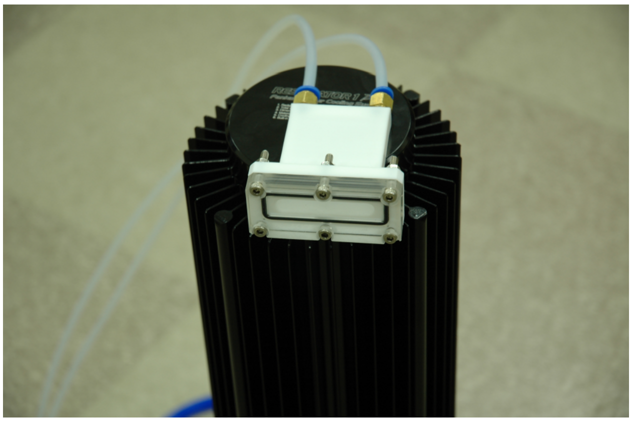
Figure 2. Photograph of circulating LSC.

3. MC-50 cyclotron of KIRAMS

The 50MeV proton beam test facility at the MC-50 cyclotron of KIRAMS (Korea Institute of Radiological & Medical Science) has been established by PEFP (Proton Beam Engineering Frontier Project) of KAERI. This beam line would be for the pilot studies of PEFP, especially, for the studies using very low flux proton beam, $1\times10^4 \sim 1\times10^{10}$ proton/sec.

We had used 35MeV proton beam to test the flux monitoring system. The 35MeV incoming proton beam passes through a 0.2cm thick aluminum window capping the beam pipe, loses its energy down to 26MeV. Then 26MeV proton beam is collimated to a 1mm diameter beam spot by using 1mm aluminum collimator. Finally proton energy becomes 23.3MeV after pass through 77cm in air.

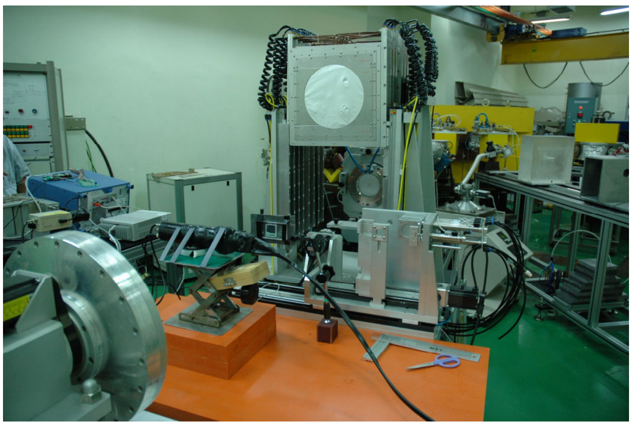
Figure 3. Photograph of beam line and experimental alignment for counting.

4. Experimental setup

The BC501A 10% in mineral oil was prepared for the proton beam flux monitoring. The LSC case was made of Teflon for light shielding and 2 inch PMT (Hamamatsu Co.) was attached to window of LSC case.

An analog signal from the PMT attached to window of LSC case was connected into the analog input to preamplifier. After amplifying signal input to discriminator to change TTL signal. This TTL signal was into ATMEGA 128 embedded board with Ethernet connection which has counting function. The width of TTL is 50ns. Thus we are able to record up to 2×10^7 proton/sec. This data was recorded into the personal computer and data was analyzed with C++ based data analysis program, ROOT package.

Moreover a digital oscilloscope (LeCroy Waverunner 6100A) was used for the pulse shape monitoring.

The schematic diagram of experimental setup is shown in Fig 4.

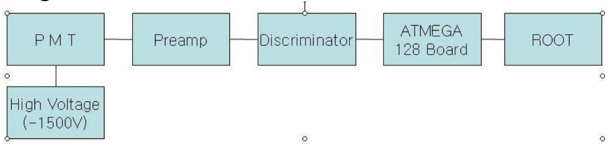

Figure 4. Schematics diagram of experimental setup.

5. Result and Discussion

The proton beam flux in LSC was measured with 23.3MeV proton beam and 1nA, 2nA, 5nA and 10nA currents. The beam flux increased linearly as beam current increase. The background level of flux is a few counts/sec when there is no proton beam.

As shown in Fig 5, there are flux deviations with the time variation as large as 10%.

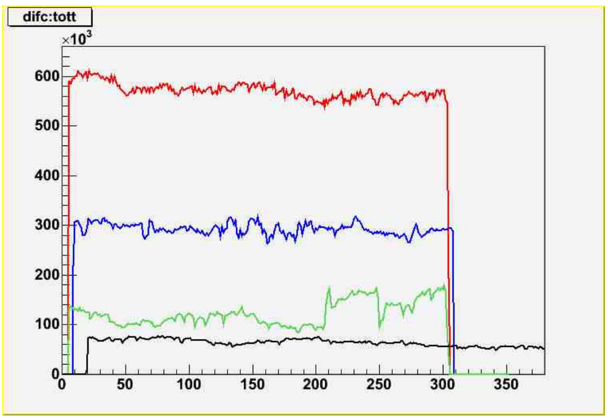

Figure 5. Proton beam flux with 1nA, 2nA, 5nA, and 10nA beam currents.

We have calculated mean flux of proton beam to use ROOT code, and the results are

Beam current	1nA	2nA	5nA	10nA
Mean flux	6.072×10^4	1.229×10^5	2.915×10^5	5.671×10^5

When the flux was more than 10^7 proton/sec, then present setup didn't work, since TTL signal is continuous in time. So in this case we need another method to monitoring such as integration method.

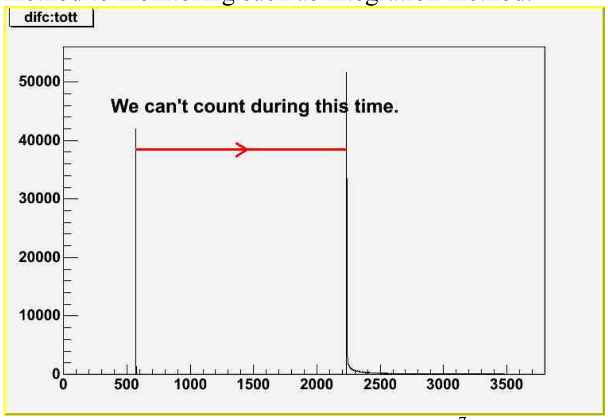

Figure 6. Flux monitoring of More than 10^7/sec region.

6. Conclusion & Discussion

Proton beam flux was measured accurately with LSC to use 35MeV proton beam from MC-50 cyclotron at the Korea Institute of Radiological & Medical Science. We can monitor the proton beam flux up to 10^7 proton/sec accurately using counting method that is made up an embedded process with network system during the beam time. In case of more than 10^7 proton/sec region, every count would be zero, so we need another method such as integration method, to monitor high flux region. In future, we will develop an integration method.

7. References

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