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The Construction of Beam loss monitoring system for the PEFP 100MeV Proton acclerator

Sang-Pil Yun*, Hyeok-Jung Kwon, Kyung-Tae Seol, Bum-Sik Park, Young-Gi Song, Han-Sung Kim, Yong-Sub Cho
Proton Engineering Frontier Project, Korea Atomic Energy Research Institute
Daedeok-Daero 989-111, Yuseong-Gu, Daejeon, Korea
**Corresponding author : spyun@kaeri.re.kr*

1. Introduction

The 100MeV proton linear accelerator of the Proton Engineering Frontier Project (PEFP) has been developed and has been installed at the Gyeong-ju site. After the 100 MeV machine is installed, the beam commissioning will be performed in 2012. The accelerator operation has to be carried out with the objective of limiting beam losses to less than 1 W/m [1]. When the un-intended excessive beam loss occur, the BLM(Beam Loss Monitor) inform this beam loss to operator and transmit the signal to the MPS (Machine Protection System) for the rapid shut-off of the machine. The scintillating detector and proportional counter were selected as the BLM detector because of their fast response time and high sensitivity. At the beam commissioning stage, 12 BLMs will be prepared for the beam loss monitoring.

2. Design Criteria for BLM

- Slow and low level beam loss for monitoring

The long-term, low level beam loss (<1 W/m) will be averaged over 10 seconds in the IOC and compared against a 1 W/m reference. If it is exceeded the reference level, warnings will be sent to the operator.

- Fast loss for the Machine protection system

A inhibit signal will be generated if the fast and high level beam loss occur compare to 10 times higher than a 1 W/m reference level.

3. Expected beam loss

To determine the dynamic range of the beam loss monitor, we have tried to calculate the radiation field distribution induced by beam loss by Monte Carlo Method. (Figure 1)

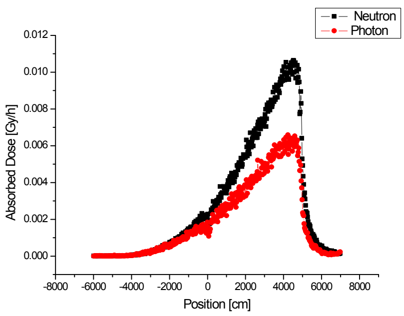


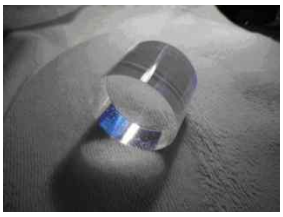
Fig. 1. The expected dose rate at the linac

4. Detector selection

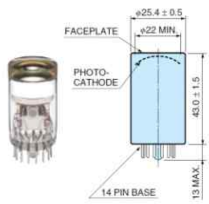
The ion chambers are widely utilized at the most of the accelerator facilities due to their high dynamic range, radiation hardness and easy calibration. But ion chamber is not sensitive at the low energy section of the accelerator and have the slow response time due to the slow ion mobility in the gas. Therefore, the proportional counter and the scintillation are selected as a detector of beam loss monitoring due to their fast response time and high sensitivity.

- The scintillation detector

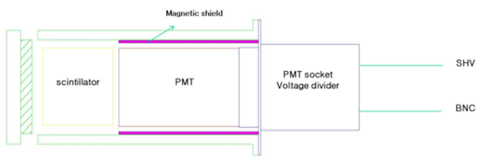
The scintillation detector will be consisted of plastic scintillator (BC-408, Saint-Gobain) [3] and Photo-multiplier tube (R1924A, Hamamatsu), magnetic shield, optical coupling, light reflector and metal casing for noise shielding. (figure 2). The specification of the scintillator and PM-tube is summarized in Table 2 and Table 3.



(a) Plastic scintillator



(b) PM-tube



(c) fabrication of detector

Fig. 2. The fabrication of scintillation detector

Table 1: Specification of plastic scintillator

Model	BC-408
Manufacturer	Saint-Gobain
Density	1.032 g/cm3
Refractive index	1.58
Rise time	0.9 ns
Max. emission wavelength	425 nm

Table 2: Specification of PM-tube

Model	R1924A
Size	25 mm (1”)
Spectral response	425-650 nm
Dynode structure	L/10
Typical gain	2E+6
Rise time	1.5 ns

- The Proportional counter

The proportional counters are manufactured by Toshiba for beam loss monitor, which is installed and operated at the J-parc successfully.

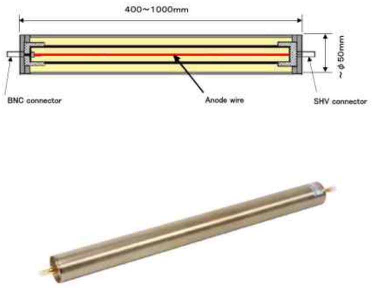


Fig. 3: Proportional counter (E6876-600)

Table 3: Specification of proportional counter

Model	E6876-600
Manufacturer	Toshiba (Japan)
Gas	Ar + Co$_2$
Response time	0.1 usec
Typical gain	1000 (at 2000 V)

5. Signal Processing Unit

The scintillation detector and the proportional counter are typical current source. Therefore, the current pre-amplifier is required, to transform the voltage analog signal which can process the signal at the ADC (Analog to digital convertor) for the beam loss monitoring. And also, the signal processing unit can produce the inhibit signal and transfer to the MPS for the rapid beam shut-off. Figure 4 shows the design of the signal processing unit

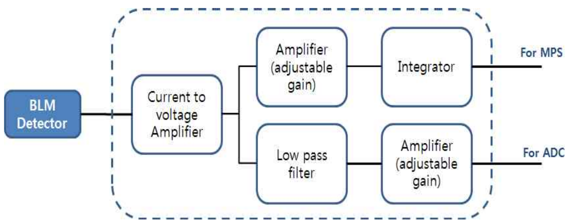


Fig. 4: block diagram of signal processing unit

4. Installation of Beam loss monitoring system

The 8 of scintillation detectors will be installed at the middle of each DTL section . the 4 proportiona counter detector will be installed at the 45 degree bending magnets in the 20 MeV, 100 MeV beam line. The total 12 beam loss monitors will be installed at the at the beam commissioning stage.

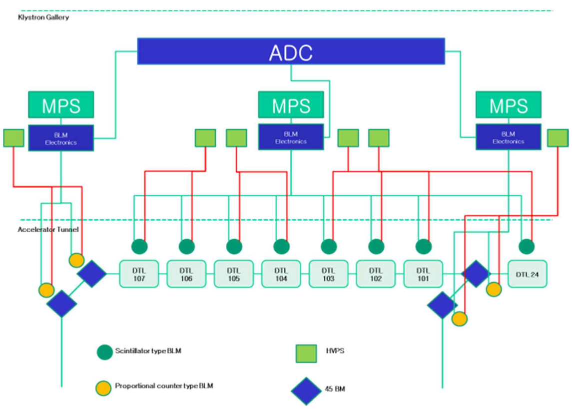


Fig. 5: The installation plan of beam loss monitoring system.

4. Summary

At the beam commissioning stage, the total 12 beam loss monitors will be prepared for the beam loss monitoring. The scintillation detector and the proportional counter are selected as a beam loss monitor. Through the signal processing unit, the status of beam loss at the linac monitored by ADC, A inhibit signal will be generated and transferred to MPS when the unintended excessive beam loss occur.

Acknowledgements

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REFERENCES

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[2] A. Miura et al., “STUDY OF BEAM LOSS MEASUREMENT IN J-PARC LINAC”, Proc. Of PAC09, May 2009, TH5RFP096, Vancouver, CANADA.

[3] Saint-Gobain Industrial Ceramics, Inc “Organic Scintillators, Related Materials and Detectors”, 12345 Kinsman Road, Newbury, OH. (http://www.saint-gobain.com)