A Preliminary Study on Beam Loss Monitor Calibration for KOMAC DTL tanks

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***Keywords :** Beam loss monitor, Drift tube linac, Machine protection system, Scintillation detector, Radiofrequency

1. Introduction

A beam loss monitor (BLM) is a key device for protecting accelerator systems, as it measures secondary radiation produced by a particle beam colliding with the inner wall of the accelerator. Therefore, in the KOMAC 100 MeV proton accelerator, BLMs were installed on the 20 MeV DTL (Drift Tube Linac) and 100 MeV DTL tanks for the purpose of machine protection. These BLMs are scintillator-based radiation detectors capable of operating in high-radiation environments, with two or more devices installed on each DTL tank [1]. In this study, the nonlinearity between BLM signal intensity and beam loss was analyzed to demonstrate that considering not only beam current but also other conditions is essential for calibrating BLMs.

2. Methods and Results

2.1 BLM specifications

In this study, two types of scintillator detectors were utilized, and both detectors have the same electrical systematic structure, as described in Fig. 1[2]. The first old scintillator detector type for BLMs is a hand-made type developed at KOMAC, while the other new type is a full-packaged Libera BLM [3]. Detailed BLM specifications are summarized in Table I.

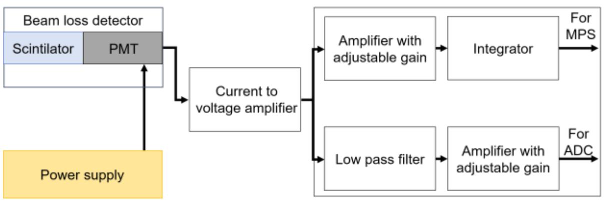


Fig. 1. Typical beam loss monitor structure

Table I: BLM specifications at KOMAC [3]

	Old BLMs	New BLMs
Scintillator type	BC-408 plastic (Saint-Gobain)	EJ-200 plastic (Scionix)
Scintillator size	ϕ25.4 × 30 mm	ϕ22 × 100 mm
PMT type	R1924A (ϕ25.4 mm, Hamamatsu)	H10721-110 (ϕ8 mm, Hamamatsu)
Applied voltage	-500 V	PoE
Sampling rate [kHz]	800	976.6

BLMs at the KOMAC 100 MeV proton accelerator are installed as shown in Fig. 2. The two old, hand-made BLMs are installed in one DTL tank, located from DTL 24 to 107. Proton energy passing through DTL24 is 20 MeV while that after DTL 107 is 100 MeV. Additionally, the eight new BLMs are mounted from DTL 21 to 24. BLM placed at the center of each DTL tank is defined as 'Ch1', and that at the high energy end of the tank is denoted as 'Ch2'. Under these conditions, the preliminary beam loss monitor calibration experiments were conducted by varying beam duty.

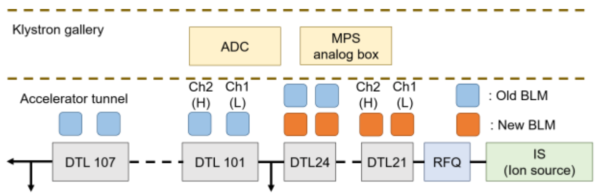


Fig. 2. Scintillator BLM spots at KOMAC 100 MeV accelerator

2.2 BLM signal acquisition results

Fig 3 and Fig 4 illustrate the signals generated at both old and new BLMs when a 100 MeV proton beam is extracted for 100 μs. Unlike the old BLMs, background radiation signals whose width is 400 μs are reduced at the new BLMs due to the thin cover around them. Since the main component of the cover is aluminium, it can be deduced that the main flat background is the cavity x-ray induced by the klystron radiofrequency.

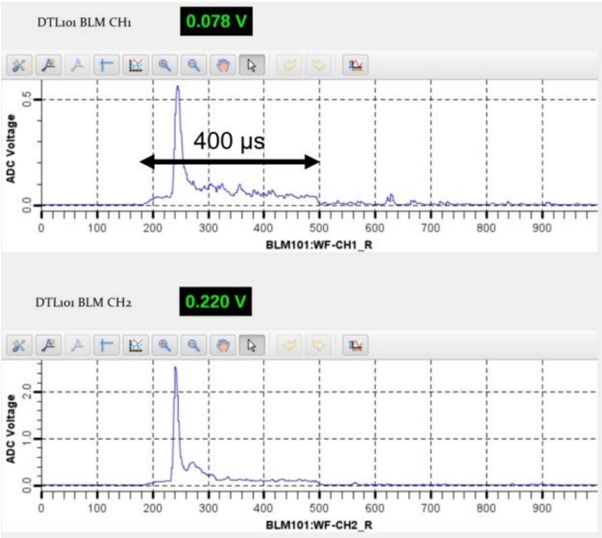


Fig. 3. BLM signal acquisition results at the DTL 101

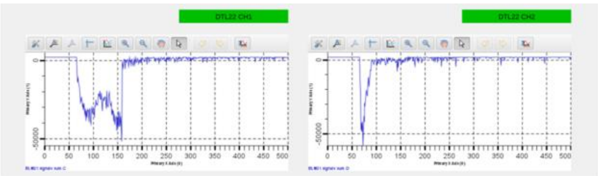
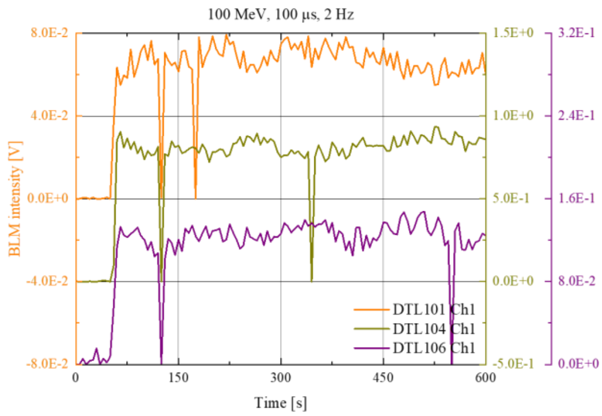


Fig. 4. Example of reduced background radiation effects at the new BLMs

As presented in Fig. 5 and Table II, significant discrepancies are identified among beam conditions and beam loss monitor intensity at each tank. Therefore, it is expected that the reduction of the beam loss at the front DTL tank may lead the increase of beam loss at the back tank.



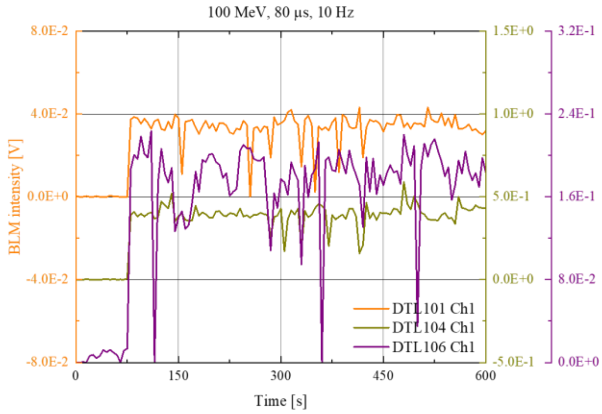


Fig. 5. BLM intensity when the beam duty is 0.02 % (upper) and 0.08 % (lower)

Table II: Beam loss statistics at Fig. 5

Beam duty [%]	0.02	0.08
Beam loss mean [W/m]	9.146E-2	3.326E-1
Beam loss standard deviation [W/m]	3.501E-2	1.185E-1

3. Conclusions

Beam loss monitoring through the scintillator detectors in the KOMAC DTL tanks was conducted in this study, and significant nonlinearity between the actual beam loss and BLM signals was observed as an experiment result. Therefore, for minimizing the total beam loss, it is certified that the selection of a high beam loss tank is essential.

DAQ system of BLMs improvement based on pulse shape discrimination method is on progress to separate neutron signals from cavity X-ray. After completion of this improvement, calibration of BLM signals to appear the beam loss in unit of 'W/m' with only BLMs would be achievable.

Acknowledgements

This work was supported through KOMAC operation fund of KAERI (KAERI ID no.524320-25 & 524320-26) funded by MSIT (Ministry of Science and ICT).

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