Calculation of Beam characteristics Variation Induced by Energy Degrader at Low-flux Proton beamline

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1. Introduction

Korea multi-purpose Accelerator Complex (KOMAC) is operating 20 MeV and 100 MeV proton beamlines to provide proton beams to users. The new beamline and target irradiation facility have being constructed for low-flux proton utilization.

Energy degrader was installed at the new low-flux proton beamline for the varying the beam energy without the setting of the accelerator. The proton energy is degraded by the interaction between proton and degrader materials during the proton transmmition. In this process, inevitable perturbation occurs by the multiple-scattering such as the emmittance growth. In this paper we investigate the variation of profile, emmitance and the energy dispersion.

2. Methods and Results

2.1 Design of the Energy degrader

The design criteria of the energy degrader for low-flux proton beamline are described as bellows;

- Energy range: 20 ~ 100 MeV
- Configuration: double wedge
- Degrader material: Aluminum
- Max. degradable enenergy: 13 MeV (at 100 MeV)
- Max. beam diameter: 20 mm

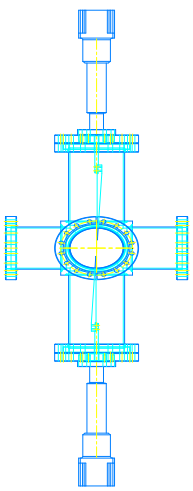


Fig.1 Schematics of energy degrader

2.2 Calculation Method

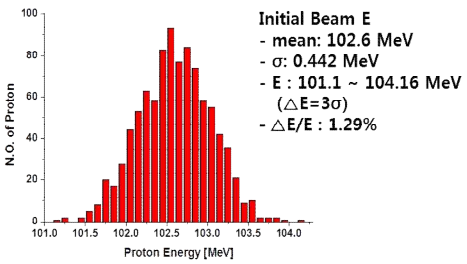
To investigate the variation of the beam characteristics after the energy degrader, the input beam parameter before the energy degrader was calculated by the TraceWin, which is well-known beam dynamics code and the output results of TraceWin was transferred to SRIM input parameter, the varied beam parameters are calculated by SRIM during the energy degrader transmission [2]

Table 1. Input beam parameters

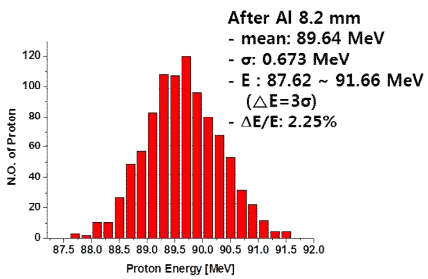
Proton Energy	102.6 MeV
E/Δ E	1%
rms divergence [X']	0.068 mrad
rms divergence [Y']	0.065 mrad
rms radius [X]	0.265 mm
rms radius [Y]	0.26 mm

2.3 Energy Variation

When the maximum energy loss was 13 MeV, the deviation of proton energy was increased from 0.442 to 0.662 MeV.



(a) Initial proton beam

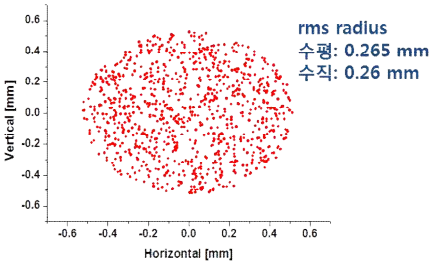


(b) After energy degrader

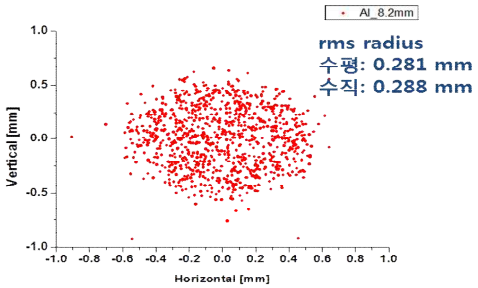
Fig. 2. The calculated Energy Variation

2.4 beam profile vatiation

Figure 3 shows the variation of the beam profile induced by energy degrader. There is no significant change before and after due to relatively short flight length.



(a) Initial beam profile

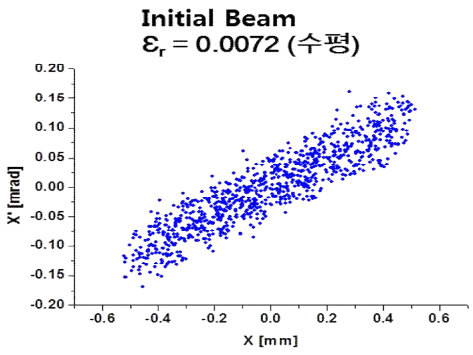


(b) after the energy degrader

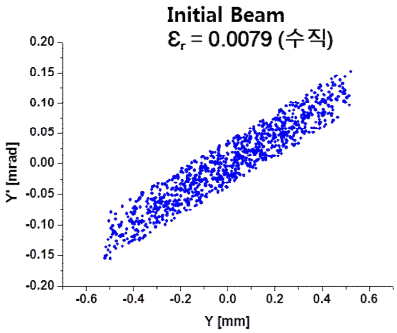
Fig. 3. The calculation results of the beam profile variation

2.5 Emittance Growth

Figure 4 shows the unnormalized beam emmittance of the initial proton beam. and figure 5 shows the variation of the unnormalized emmittance after the energy degrader. These results shows the dramatic emmittance growth. The unnormalized emmittnace are increased about 1000 times. The beam spot size was unchanged but the angular spread of the beam was grown dramatically by the multiple scattering in the energy degrader.

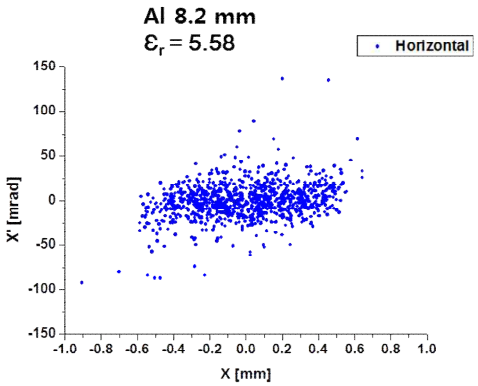


(a) Horizontal

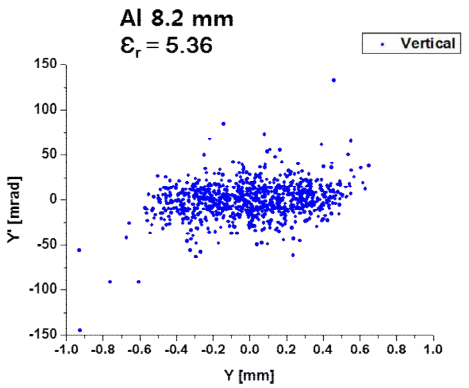


(b) vertical

Fig. 4. The unnormalized rms emmitance of initial beam



(a) Horizontal



(b) vertical

Fig. 4. The unnormalized rms emmitance after The energy degrader

3. Conclusions

We have prepared the energy degrader for the new low-flux proton beamline. And we have investigated the variation of proton beam characteristics, which is the energy dispersion, the beam profile and the emmittance, induced by energy degrader.

The combined TraceWin and SRIM calculation results shows there is no significant change in beam

profile but the dramatic emmitance growth. These results are expanded to the analysis of the beam transport after energy degrader in the new low-flux proton beam.

Acknowledgements

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REFERENCES

[1] A. Oberstedt, S. Oberstedt, Nucl. Instrum. Meth., "Energy degrader technique for light-charged particle spectroscopy at LOHENGRIN" A 570, 51, 2007

[2] J. F. Ziegler, J. P. Biersack, "SRIM-2000, 40: The Stopping and Range of Ions in Matter", IBM-Research, Yorktown, NY 2000.