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# Development of the Target Room For the 20 MeV PEFP Linacs

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## 1. Introduction

Proton Engineering Frontier Project (PEFP) has developed A 20 MeV proton linear accelerator, which consists of a 50 LEBT, a 3 MeV RFQ and a 20 MeV DTL. [1] Additionally, we have developed the target room for proton irradiation experiments at the 20 MeV proton linacs to utilize the 20 MeV proton beam for the scientific research. And the 20 MeV proton beam has the characteristics of 20mA peak current, 50μsec pulse width and 1Hz repetition rate. Thus, its average current is 1 μA.

Recently, we obtained the authorization for operating this facility from the KINS(Korea Institute of Nuclear Safety).

## 2. Construction of the Target room

The target room for irradiation test was consisted of the proton beam line, the radiation shielding block, and the graphite target stage. Fig. 1 shows the schematics of irradiation facility.

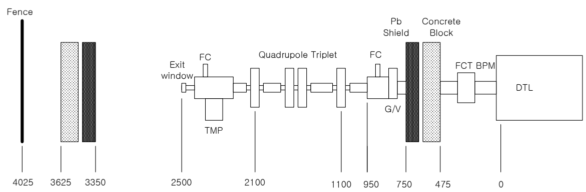


Fig.1 Schematics of Irradiation Test Facility

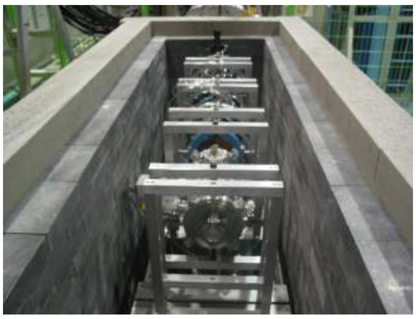

Fig. 2. The Constructed beam line

### *2.1 Construction of the beam line*

The beam line was designed to achieve the desired proton beam which has circular shapes and their size was 10 cm diameter. Thus, the beam line was consisted of quadrupole magnets, faraday cup and the beam exit window.

The 4 units of quadrupole magnets transport the 20 MeV proton beam from the DTL of the Linacs to the beam exit window which was made of 0.5 mm aluminum plate, also construct the triplet magnetic lens For adjusting the shapes of proton beam using their magnetic fields. The results of Trace 3D and Parmila calculation support the design of beam transportation.

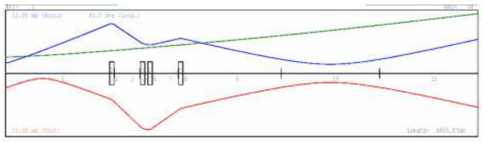

Fig. 3. Beam optics of the beam line

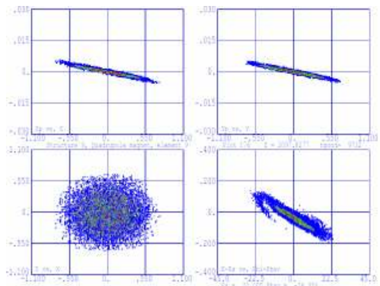

Fig. 4. Proton beam shapes at the end of the 4th quadruple

The evacuated proton beams through the exit window made of 0.5 mm aluminium arrive diverged due to multiple-scattering with the exit window and air. Thus, when the proton beams of which the initial beam size was 2 cm arrived at the graphite target, the spatial distribution of the proton beam have the gaussian distribution which have 10cm of FWHM. The beam size was estimated by the MCNP-X calculation. Fig. 5 shows the spatial distribution of the proton beams.

The 20 MeV incoming proton beam passed through a 0.5-mm-thick aluminum window and 1m-thick air and finally they have a reduced energy of 14 MeV. The energy of proton beam was estimated by MCNP-X calculation. Fig. 6 indicates the energy dispersion of the proton beam.

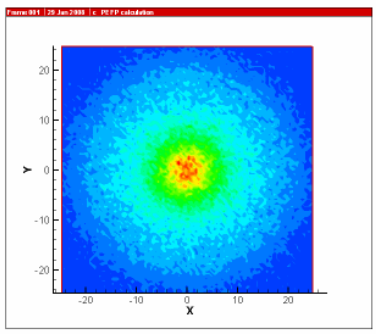


Fig. 5. 2-D spatial distribution of the proton beam

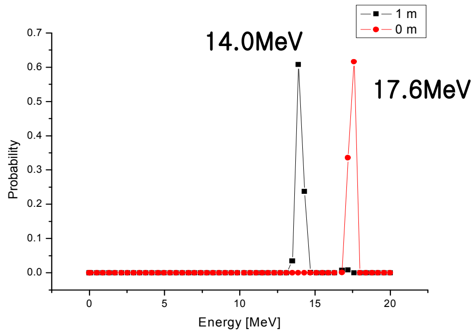


Fig. 6. The energy of proton beam at the target stage

*2.2 Radiation Shielding*

The beam dump was made of graphite to minimize the radiation creation, the graphite have the minimum nuclear reaction cross-section which can create the neutrons. And then, the radiation shielding blocks is consisted of the lead blocks which have 10 cm thickness for the photon shielding and the concrete blocks which have 15 cm thickness for the neutron shielding. Fig. 7 shows the constructed radiation shielding Blocks. This shielding block was designed by the MCNP-X calculation (Table 1).

Fig. 7. The constructed lead and concrete shielding

| Design Limit: 500uSv/week (4hr/week) | | | | |
|---|---|---|---|---|
| Thckness of Concrete | | 10cm | 20cm | 30cm |
| Neutron (uSv/week) | Front | 353.71 | 157.15 | 71.54 |
| | Back | 155.32 | 66.07 | 31.78 |
| | Right | 177.24 | 83.94 | 33.54 |
| | Left | 189.67 | 79.06 | 36.45 |
| | Top | 2178.19 | 828.19 | 293.88 |
| Photon (uSv/week) | Front | 3.79 | 1.55 | 0.80 |
| | Back | 26.95 | 11.43 | 4.68 |
| | Right | 4.93 | 2.19 | 0.91 |
| | Left | 4.97 | 2.26 | 1.06 |
| | Top | 449.19 | 154.84 | 57.58 |

Table 1. The Result of MCNP-X Calculation

For our shielding calculation, the lead and concrete shielding are satisfied with legal dose rate restriction of 1 mSv/week. Additionally, our self design limits are 500 μSv/week.

## 3. Conclusions

The PEFP has developed the target room for the proton beam irradiation experiment. It was designed for the proton beam to have the circular shapes by the quadruple triplets. When the proton beam arrives at the graphite target stage, the proton beam has the energy of 14 MeV and the gaussian distribution which have 10cm of FWHM.

The lead and the concrete shielding blocks shield the radiations which created by proton beam and they were designed to satisfy legal dose rate restriction of 1 mSv/week.

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## REFERENCES

[1] Y. S. Cho, H.J. Kwon, J. H. Jang, H.S. Kim, K.T. Seol, D.I. Kim, Y.G. Song and I.S. Hong "The PEFP 20-MeV Proton Linear Accelerator" JKPS, vol. 52, No.3, pp. 721.