DEVELOPMENT OF UNIFORM IRRADIATION SYSTEMS FOR TEST FACILITIES OF PEFP*

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Abstract

Development of beam utilization technologies and their industrial applications are essential in PEFP(Proton Engineering Frontier Project).

For the PEFP's accelerator construction has not completed, some test facilities should be developed and attached to the existing domestic accelerators, in order to support basic experiments and pilot studies of the PEFP's sub-projects.

One of them is the 50MeV user facility developed to supply not only the Bio Technology but also Space Technology with the proton beam. In this system, two scanning systems are attempted : Spiral scanning system and mechanical wobbler system to make dose distributions as large as 8cm in diameter with less than ±5% variation in uniformity.

Film dosimeter has been applied as an integral method to measure the relative fluence distribution of the scanned proton. Moreover, various detection devices will be tested in this system, too.

INTRODUCTION

The Proton Engineering Frontier Project(PEFP) is one of the 21st Century Frontier R&D Programs which have been approved by the Korean government[1]. Beam utilization technologies are being developed in the same time with the accelerator development to link such as NT, BT, ET, ST and IT.

From the middle of 2007, the 20MeV proton beam will be supplied to users for their studies in the PEFP program.

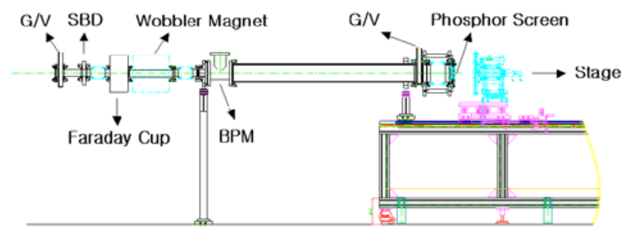
Some test facilities are under developing to support basic experiments and pilot studies of the proton beam application projects before the middle of 2007. The 50MeV user facility is the first one, which has been attached to the MC-50 Cyclotron at the Korea Institute of Radiological and Medical Science.

Most of the beam applications of accelerated ions require uniform irradiation of lager areas. For example, the PEFP's sub-project, "SOI wafer development using ion-cut technology ", requires uniform doses in areas with cross-sectional areas of 6" wafer size.

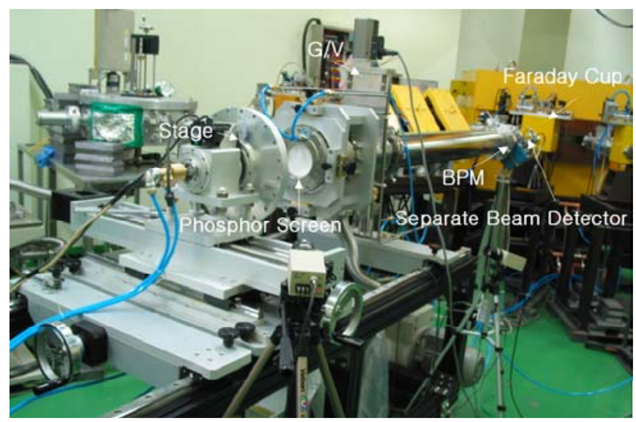
In the work presented here, the mechanical wobbler scanning method and the spiral scanning method are described and the test result of the first beam extraction is described too.

50MEV TEST FACILITY

The 50MeV test facility has been developed and attached to the MC-50 Cyclotron to support the pilot studies of "Development of new genetic resources", "Simulation of space radiation environment" and etc. This facility consists of a vacuum system, an exit window, beam monitoring systems, cooling systems, a DAS & Control system and a target stage, as shown in fig 1.



(a)



(b)

Figure 1: The 50MeV proton beamline

UNIFORM IRRADIATION SYSTEM

Uniform irradiation on a target over a large area is one of the most fundamental techniques in applications of ion beams to research. A relative dose variation of at most ± 10% is required to bring the same irradiation effects of ions.

Two-dimensional beam scanning methods such as a double-scattering beam delivery system[2], a wobbler system[3], a spiral beam scanning system[4] and a raster beam scanning system[5] have been commonly used for uniform irradiation. Among these methods, both the wobbler scanning method and the spiral beam scanning method are attempted in the 50MeV test facility. However a wobbler magnet is under developing, a mechanical wobbler scanning method using a rotative stage is proposed here.

The target stage shown in Fig. 2 is rotative for the spiral scanning method and the mechanical wobbler scanning method. And it can not only control of the linear motion by the AC servo motor and a ball screw but also adjust of the stage offset

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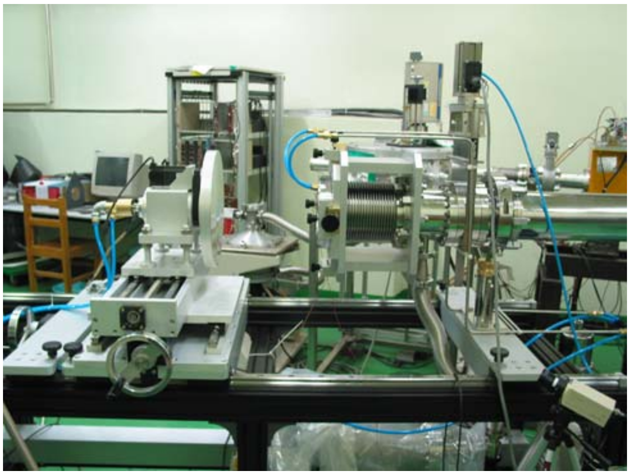


Figure 2: The rotative stage and the exit window

Mechanical wobbler scanning method

The Gaussian density is given as follows;

$$P(x,\mu)=\frac{1}{\sigma\sqrt{2\pi}}\exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right) \qquad (1)$$

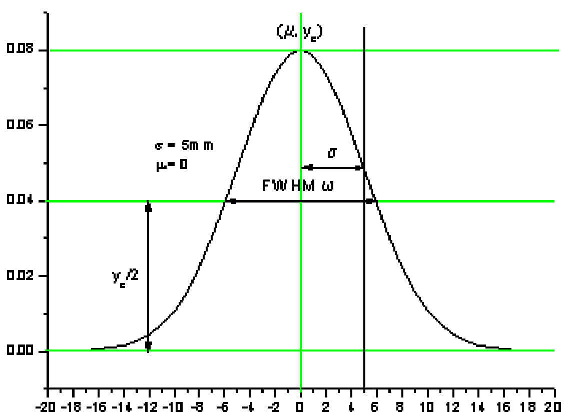


Figure 3: A Gaussian distribution ($\mu=0,\ \sigma=5mm$)

For uniform irradiation of a large target let us transfer the center of the beam. A large uniform field is obtained by transferring the beam center as much as σ and sweeping the beam along the circular trajectory. It has been shown that a superposition of Gaussian-shaped beams at the target position can produce a flat field of 2σ diameter with less than 1% variation in dose uniformity.

It is clear that for larger uniform distribution of irradiation the σ of the Gaussian distribution should be large.

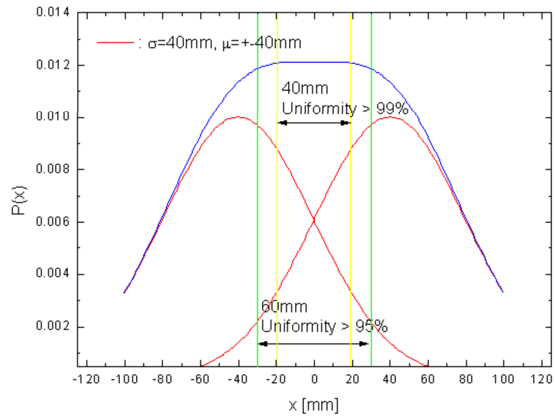


Figure 4: A dose density created by circular trajectory

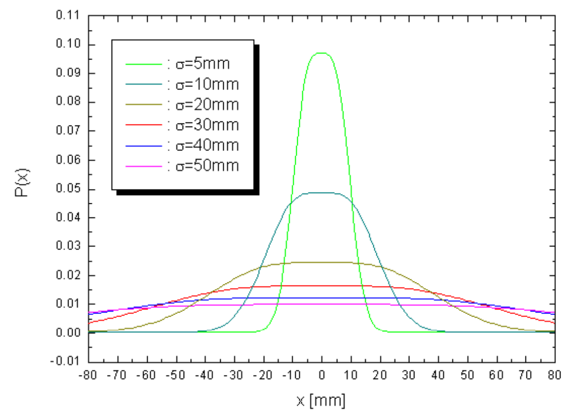
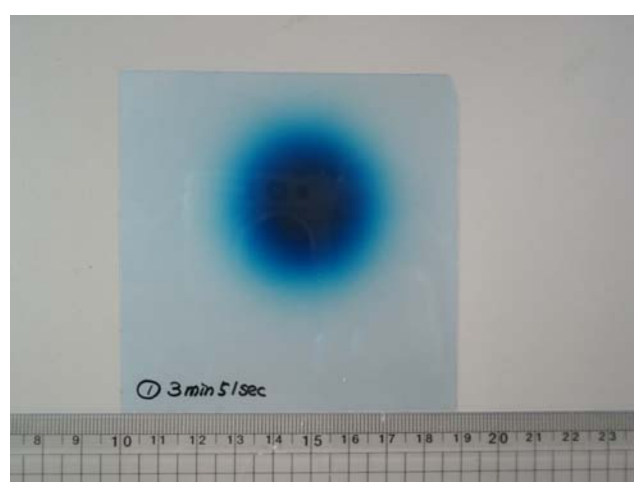


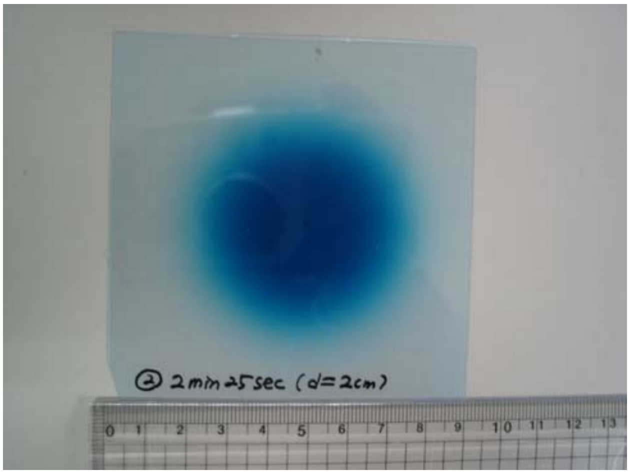
Figure 5: The flat areas vs σ of the Gaussian distribution

Measurement of the beam distribution

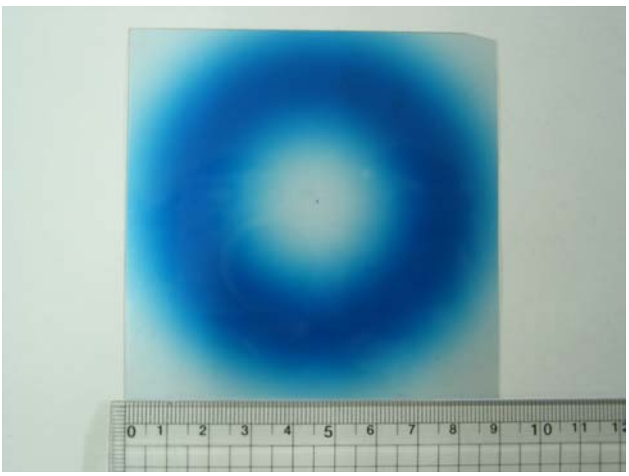
Uniform irradiation test has been done with 35MeV proton beams extracted from the MC-50 Cyclotron. A relative distribution was measured by the Gaf film[6].



(a) $\mu=0$



(b) $\mu = \sigma$



(c) $\mu \rangle \sigma$

Figure 6: The distribution images measured by the Gaf film

FUTURE PLAN

(1) Trying to test the spiral scanning method.
(2) Testing the CTA(Cellulose TriAcetate) film dosimeter to measure the relative fluence distribution of the scanned proton.
(3) Testing various detection devices in this system

CONCLUSION

To develop the beam application technologies, the 50MeV test facility and the uniform irradiation system have been established at the Korea Institute of Radiological and Medical Science.

A mechanical wobbler scanning method has been developed with a rotative stage. In spite of the sample rotation effect, it can produce easily the uniform irradiation field without magnets. After the test of stage motion, the spiral scanning method will be tested. And the Gaf film has been confirmed its fitness for the measurement of beam distribution. And the CTA film dosimeter will be tested.

ACKNOWLEDGEMENT

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REFERENCES

[1] B.H. Choi et al., “Overview of the KOMAC Project”, Proceedings of the 3rd International Conference ADTTA’99 (1999)

[2] A.M. Koehler, R.J. Schneider and J.M. Sisterson, “Flattening of proton dose distributions for large-field radiotheraphy”, Medical Physics, 4 (1977) 297.

[3] T.R. Renner, W.T. Chu, “Wobbler facility for biomedical experiments”, Medical Physics, 14 (1987) 825.

[4] M. Fukuda, S. Okumura and K. Arakawa, ”Simulation of spiral beam scanning for uniform irradiation on a large target”, Nuclear Instruments and Methods in Physics Research A, 396 (1997) 45.

[5] Th. Haberer, W. Becher, D. Schardt and G. Kraft, “Magnetic scanning system for heavy ion therapy”, Nuclear Instruments and Methods in Physics Research A, 330 (1993) 296-305.

[6] http://www.ispcorp.com