DEVELOPMENT OF THE TARGET SYSTEM FOR LARGE-AREA UNIFORM IRRADIATION USING 2D MOTIONAL STAGE*

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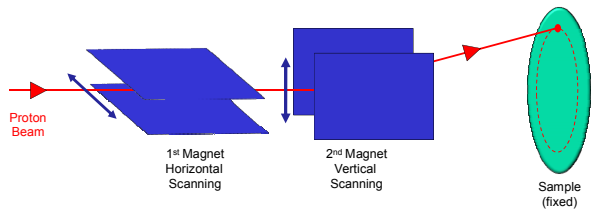
Abstract

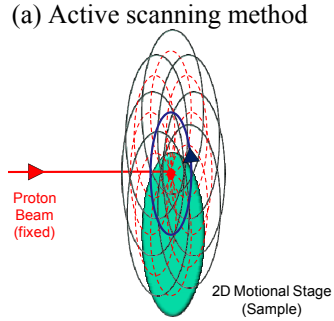
Uniform irradiation is very important for many kinds of experiments of proton beam utilization. In general, scanning magnet have been used for the uniform irradiation of high energy proton beam in the type of wobbler scanning, raster scanning, spiral scanning, etc. In the case of using electro-magnets, it is not easy to install and needs high cost because the magnet size and power become bigger with increase of beam energy accordingly. In this paper we proposed simpler method and apparatus for uniform irradiation using 2D motional stages. It is composed of two motor systems for X- and Y-direction motion and gonio-stage for the control of the incident angle of proton beam. The maximum area is 20 cm x 20 cm and the incident angle can be controlled from +15 to -15 degree. Maximum weight of sample has to be less than 5 kg. In this paper, preliminary results for simple wobbler scanning is shown when the proton energy and beam current are about 40 MeV and 1~10 nA respectively. The uniform area was checked by using GAF film, MD-55 or HD-810. The stage can be used for the beam alignment and beam profile measurement at any position of beam line.

INTRODUCTION

For many kinds of experiments using high energy proton beam, such as radiation hardness test of semiconductor devices for space applications and mutation breeding of plants or vegetables, require large-area uniform irradiation of proton beam. For this purpose, active scanning methods using scanning magnets have been widely used and wobbler scanning [1], spiral scanning [2-3], and raster scanning [4] systems were developed during last few decades. But it is not easy to use these systems without complex magnet system which need high cost. And it is not easy to install at any optional position of the beam line. To make up for these disadvantages of the active scanning methods, we developed rotatable stage with one dimensional linear motion in 2006.[5] In that case, there's another problem of twisting of cooling lines and signal lines from samples caused by rotation of stage. So, we consider a new uniform irradiation technology using 2D linear motional stage. Even though it has some problems of scanning speed limitation, it will be very convenient for many kinds of irradiation experiments which require large-area uniform dose distribution. In Fig. 1, the basic concepts of the conventional active scanning methods and proposed method in this paper are explained. Circular motion can be realized by combination of x- and y- axis linear motion as shown in Fig. 1(b).



(a) Active scanning method



(b) Passive scanning method using 2D motional stage.

Figure 1: Basic concepts of the conventional active scanning and proposed passive scanning methods.

EXPERIMENTS AND RESULTS

Feasibility Study

As a feasibility study, we realized the wobbler scanning by using proto-type 2D linear motional stage which was originally developed for other purpose. The result and proto-type stage are shown in Fig. 2 and Fig. 3. The proton energy was 40 MeV and the beam current was 10nA. The absorbed dose was measured by using MD-55 GAF films. As shown in the Fig. 3, the plateau became be wider comparing to original Gaussian beam profile. The radius for wobbling was 1 cm, which was FWHM value of original Gaussian profile beam. The diameter of the uniform dose area was about 2 cm with uniformity over 95%, and 4.5 cm with 80% during scanning time of 28 sec.

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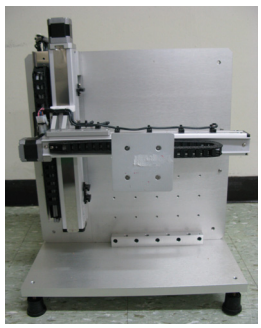


Figure 2: Proto-type 2D motional stage.

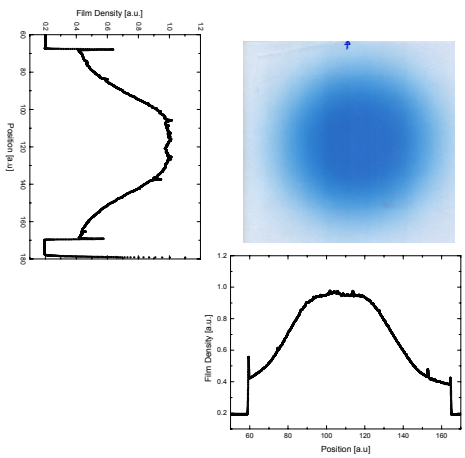


Figure 3: Realization of wobbler scanning by using proto-type 2D linear motional stage.

Design of the 2D Linear Motional Stage

Reflecting the results of the feasibility study, we designed an original stage as shown in Fig. 4. The stage composed of two step motor and robotics for 2-axis motion and one gonio-stage for the control of incident angle of proton beam to samples. It has maximum scanning area of 20 cm x 20 cm, the incident angle can be controlled from -15 to +15 degree, and the weight of sample has to be less than 5 kg. The maximum speed of scanning is 250 mm/sec.

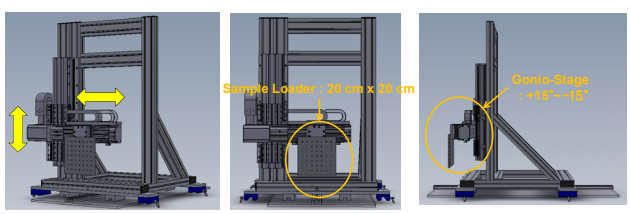


Figure 4: Design of the 2D linear motional stage with incident angle control function.

Development of Uniform Irradiation System

For the uniform irradiation of high energetic proton beam over large area more than a few tens cm in diameter, 2D linear motional stage is controlled by Labview based control system. The system consists of 4-axis motion controller (NI-PXI-7350) installed in PXI (NI-8196) as shown in Fig. 5. The wobbler scanning, spiral scanning, raster scanning is well realized by using this system as shown in Fig. 6. More complicated and arbitrary motion can be made by using this system.

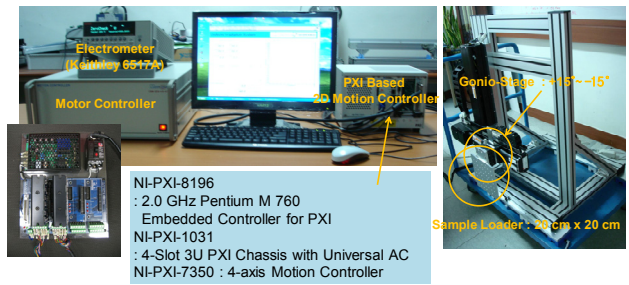
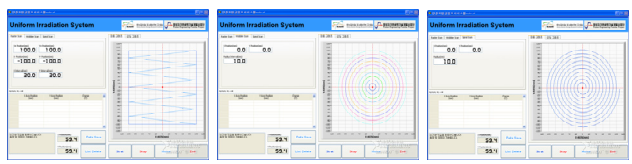


Figure 5: Uniform irradiation system using 2D linear motional stage controlled by Labview based control system installed in PXI.



(a) (b) (c)

Figure 6: Realization of (a) raster scanning, (b) wobbler scanning, and (c) spiral scanning.

CONCLUSION

We developed an uniform irradiation system by using 2D linear motional stage controlled by Labview-based motion control system to make up for the weak points of conventional scanning system using electromagnets, such as, wire twisting between samples and some data acquisition systems. Some kinds of scanning methods, such as raster scanning, wobbler scanning, and spiral scanning, were successfully realized by using this system. It will very useful for the uniform irradiation in the experiments which requires irradiation of large-area sample with high uniformity over 90%. And it can be also utilized for the beam profile measurement and alignment of beam center when it combined to the diagnostic device, such as ionization chamber. We already acquire some preliminary results by using proto-type stage for 40 MeV proton beam with 10nA beam current. The advanced results will be taken by using this original system in near future.

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