CHARACTERISTIC EXPERIMENTATIONS OF DEGRADER AND SCATTERER AT MC-50 CYCLOTRON

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Abstract

Building proton beam user facilities, especially deciding beam energy level, depends on the attached proton accelerator and users' needs.

To adjust beam energy level, two methods are generally used. One is to directly adjust the beam in the accelerator. The other is to adjust beam energy after extracting from the accelerator. Degrader/Scatterer System has been installed in the MC-50 Cyclotron to adjust energy level of the beam used for various application fields. Its degrader and scatterer are made of Al foils and Au foils, respectively. Al thickness are 2, 1, 0.5, 0.3, 0.2, 0.1, 0.05, 0.03, 0.02, 0.01mm and Au thickness are 0.2, 0.1, 0.05, 0.03, 0.02, 0.01mm, respectively.

In this study, suitable beam condition was adjusted through overlapping Al/Au foils of various thickness through simulation results. After that, LET(Linear Energy Transfer) value was indirectly acquired by measuring the bragg peak of the external beam through PMMA plastic Phantom and profile was measured by film dosimetry.

INTRODUCTION

Recently, many efforts have been made for the development of basic technology, such as biological technology, nano-technology, space technology, information etc. by using proton beam[1].

In this paper, energy degrading system and beam scattering system are introduced. The energy degrading system can offer the desired beam energy and beam scattering system can do the desired beam fluence on target of proton beam[2]. The energy degrader and scatterer are composed of 8 pieces of aluminum(Al) foils and aurum(Au) foils with different thickness, respectively.

The beam energy is converted from the measurement of bragg peaks position by comparing the simulation result of SRIM code. The beam fluence is measured by GAF film.

ENERGY DEGRADER AND BEAM SCATTERER SYSTEM

In cases of general operation from MC-50 cyclotron of 35MeV and 45MeV, the proton energy on the target can be adjusted between 5MeV ~ 38MeV either by cyclotron adjustment or by using Al energy degrader placed just in front of the target. The energy of proton beam is indirectly measured by measuring the bragg peak position with thickness of PMMA phantom. Also, the beam fluence by Au thickness is measured using the GAF film.

In this section, we described the construction of energy degrader and beam scatterer and presented some techniques of the control system.

Structure of Energy Degrader and Beam Scatterer System

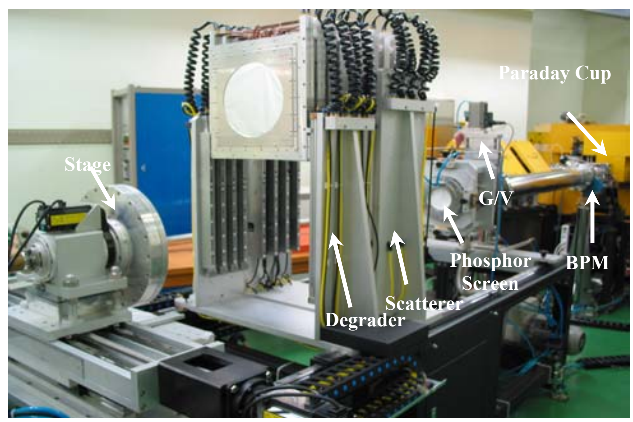

Figure 1: The structure of degrader and scatterer system.

The degrader device can be adjusted the energy of 1MeV interval from 5MeV to 38MeV range. Thicknesses of Al foils used for the degrader are 2, 1, 0.5, 0.3, 0.2, 0.05, 0.03, 0.02mm and the sheets of the degrader can be folded up to 8 folds. We can change the thicknesses to maximum 4.1mm and minimum 20μm. In this case, the degrader can make the energy range of 28~39MeV for 45MeV proton beam tuned in MC-50 cyclotron, 5~27.5MeV by 35MeV proton beam tuned in MC-50 cyclotron.

The scatterer device can be controlled the beam fluence by Au foils various thickness. Thicknesses of Au foils used for the scatterer are 0.2, 0.1, 0.05, 0.03mm and the sheets of the scatterer can be folded up to maximum 8 folds. We can change the thicknesses to maximum 0.38mm and minimum 30μm.

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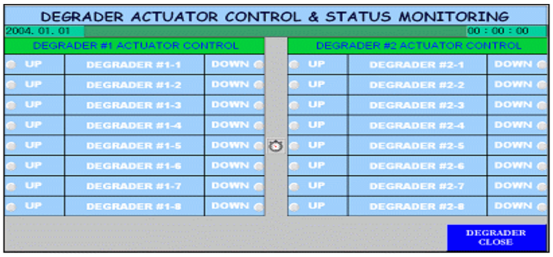
Control and Status Monitoring System



(a) Remote controller.

(b) Manual controller.

Figure 2: System for control and status monitoring.

We adopted the Manual and PC-based control system which is used to LabWindows/CVI Tool using DIO board of National Instrument(NI) CO. And we made each Al and Au foils enable to move up & down and position monitoring foils, by using the solenoid valve and the air cylinder manufactured by SMC CO.

EXPERIMENTAL RESULTS OF DEGRADER AND SCATTERER

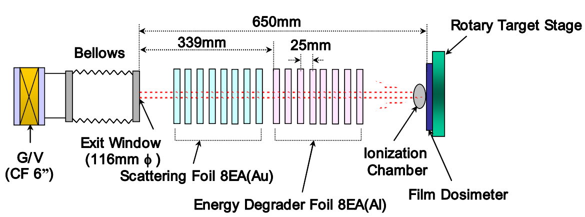


Figure 3: Experimental environment.

Beam energy tuned in the MC-50 cyclotron at this experiment is 45MeV. The experimental environment for measurement of beam energy and fluence is that the PMMA plastic Phantom equivalent to water was installed at the distance of 650mm in air from the exit window. Position of degrader and scatterer is between exit window and target. And we installed an ion chamber to measure the Bragg peak which could be measured by various thicknesses of PMMA Phantom at the target. The beam fluence in Au thicknesses could be measured by using the GAF film(MD-55) at the target.

Energy Measurement of Proton Beam

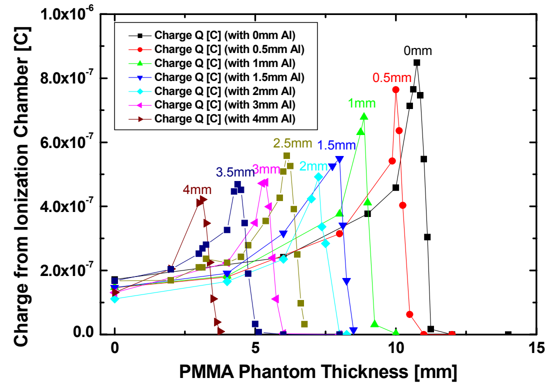


Figure 4: Bragg peak using PMMA phantom.

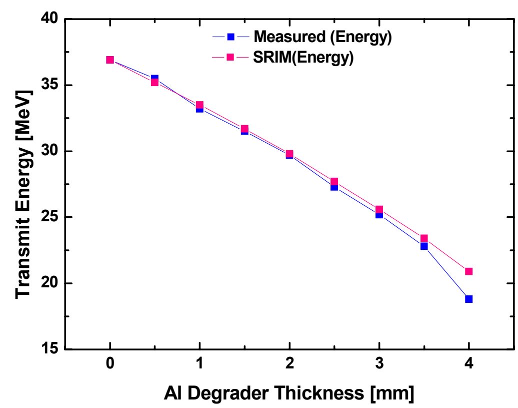


Figure 5: Transmission energy by Al thickness.

Figure 4 shows the bragg peaks with thickness of Al foils. Figure 5 shows the beam energy to measure indirectly from the position of bragg peaks and beam energy at the simulation results of SRIM code.

In the situation Al foil is thin moderately, they have small energy spread therefore this is matched with the energy of the simulated result. But as the thickness is thicker, the measured energy is smaller than those of the simulation results and we can find out this is due to the wide and large energy spread.

Divergence of Proton Beam

Figure 6, 7 show respectively the two-sigma of beam divergence with thickness of Au and Al foils. Beam divergence of proton beam measured by GAF film(MD-55) that should acquire the net density using film dosimeter. In the figure 6, 7, we can find out the beam divergence of Au foils has the higher divergence than those of the Al foils. Figure 8 shows density of MD-55 by proton beam.

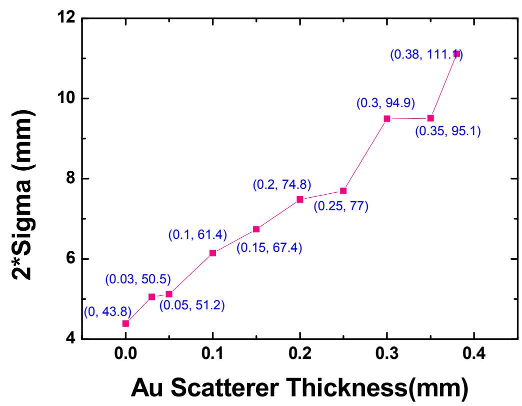


Figure 6: Proton beam divergence using Au foils.

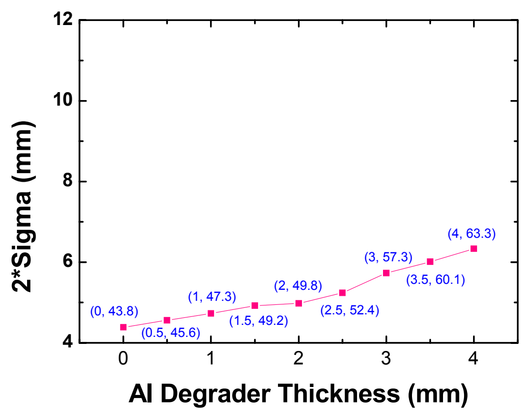


Figure 7: Proton beam divergence using Al foils.

(a) GAF film of scatterer. (b) GAF film of degrader.

Figure 8: MD-55 film.

CONCLUSION

In this paper, we tested the assembled degrader and scatterer system to MC-50 cyclotron located in Korea Institute of Radiological & Medical Sciences (KIRAMS). In case of Al foils, we could know the measured beam energy was moderate according as the thickness of the foils was changed and that the simulated results of SRIM code were matched nearly with the energy measured experimentally. But also we could find out that as the thickness was thicker, the measured values were smaller than those of the simulated results. In case of Au foils, we could also find out that the beam divergence measured by our beam scatterer had very high divergence because the beam was scattered very widely according to the thickness of the foils.

We will provide the acquired data in this experiment with users by supplementary experimentation.

REFERENCES

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