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The Feasibility Test of the Flat Panel Detector as a Beam Profile Monitor for the External Proton Beam at KOMAC

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1. Introduction

The 100-MeV proton linear accelerator of the Korea Multi-purpose Accelerator Complex (KOMAC) has been developed and has been installed at the Gyeong-ju site in 2013. Nowadays, 20-MeV or 100-MeV proton beam are supplied to users. For the quality assurance of the supplied proton beam, currently the radio-chromic films, which provide the required spatial resolution and the absorbed dose of proton beam. However, there are some inconveniences for the quantification of radio-chromic film [1]. For the on-line measurement of the proton beam, the large sensitive flat panel detector was tested to substitute the radio-chromic film. In this work, the preliminary test results of the flat panel detector were reported.

2. Methods and Results

2.1 Flat Panel Detector

The flat panel detector based on amorphous silicon was developed for the digital X-ray radiography, but The investigated detector ATAL8C (ATLAIM, Korea) has a sensitive area of 43 ×43cm^2. It consist of a CsI: Tl scintillator screen, 3072 × 3072 pixels of photo diodes and thin film transistor with 139 μm pitch. The available analog to digital conversion resolution was 14 bits. Figures 1 indicate the investigated flat panel detector.

Fig. 1. ATAL8C flat panel detector

Irradiations by proton beam, using 45 MeV of beam energy, 100 μsec of pulse width and 1 mA of peak current. The detector was positioned 100 cm from the beam exit window, perpendicular to the incoming beam (Fig. 2.)

Two dimensional images of the incident proton beam were obtained by image viewer software which is provided by the manufacturer and were corrected for dead pixels and dark current. The acquired pixel values indicate the gray value and the range of the pixel value was from 0 to 16383 with 14 bits resolutions. The pixel data were analyzed by imageJ software [2].

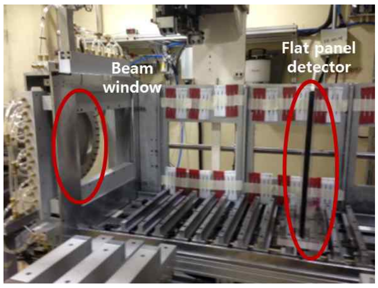


Fig. 2. Installation of FPD for proton beam irradiation

2.2 Response of detector versus the proton beam

To investigate the sensitivity of detector, the single pulse of proton beam was irradiated. The obtained image shows the incident proton beam have the typical parabolic shape with vertical width 101 mm and horizontal width 78 mm. and then, this result shows the flat panel detector can provide the information of the beam position and beam size with good spatial resolution (Fig. 3.). However we couldn't obtain the beam profile due to the overflow of pixel values.

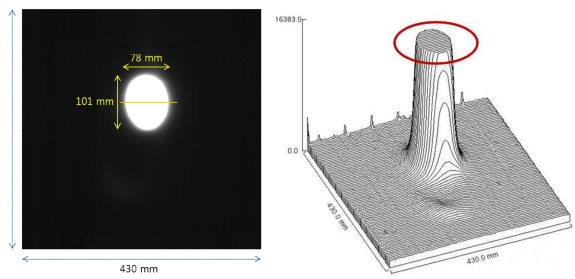


Fig. 3. The first obtained image and profile of proton beam

2.3 Adjusting the beam energy by using the Al plates

To lower the sensitivity of detector for the proton beam profile measurement, we have added the aluminum plates in front of the flat panel detector to lower the energy of incident proton beam because the light yield efficiency of scintillator is in proportion to incident particle's energy (Fig. 4.). The incident proton beam energy was adjusted from 42.3 MeV to 3.3 MeV as a function of aluminum plate thickness. The beam energy was calculated by SRIM (Table I) [3].

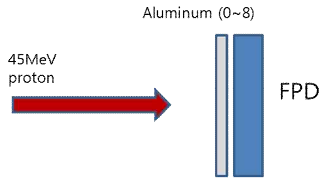


Fig. 4. The beam energy adjustment by aluminum plates

Table I: the calculated beam energy

Al thickness [mm]	**Incident beam energy [MeV]**
0	42.32
2	36.07
4	28.77
6	19.59
8	3.28

The beam profile measurement was conducted as a function of the incident beam energy. We couldn't obtain the beam profile at the thickness of 2 ~ 6 mm aluminum plates due to the overflow of pixel value. However, we could measure the low intensity of the beam profile at the thickness of 8 mm (Fig. 5). Figure 6 shows the obtained image and the profile by adjusting the range of the gray value.

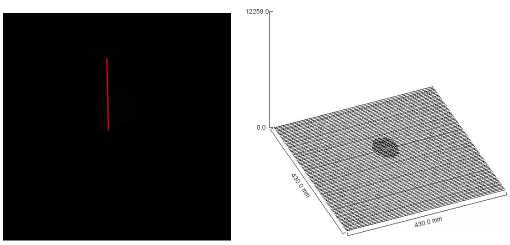


Fig. 5. The obtained image and profile at 8 mm-thick Al

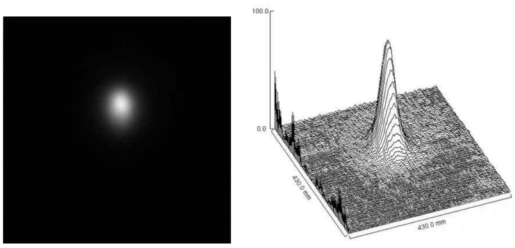
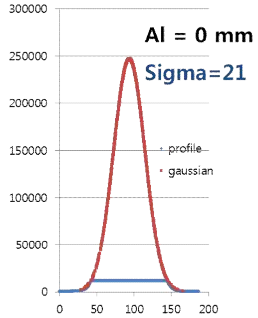
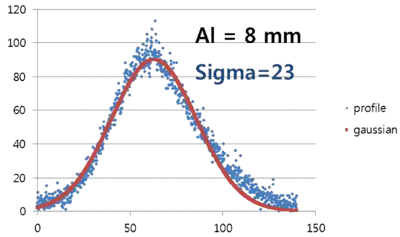


Fig. 6. The adjusted image and profile at 8 mm-thick Al

The aluminum plates in front of the detector can affect the measured beam profile due to the multiple scattering and secondary radiations. Therefore we have calculated the rms radius from the measured beam profile by Gaussian fitting to investigate the effect of the aluminum plates. Figure 6 shows there is no the significant difference the beam profile by aluminum plates.



(a) No aluminum, rms radius is 21 mm



(b) 8 mm aluminum, rms radius is 23 mm

Fig. 6. The rms radius before and after aluminum plates

3. Conclusions

To investigate the feasibility of the flat panel detector as a beam profile monitor for the external proton beam, we have conducted the proton beam irradiation test. Only bare flat panel detector can indicate the image of incoming proton beam with a good spatial resolution but didn't obtained the beam profile due to the overflow of pixel value. However, we have obtained the beam profile by inserting the aluminum plates in front of the detector and confirmed the a little effect of the inserted aluminum plates from the measured beam profile. The presented results show the flat panel detector for X-ray imaging can be promising beam profile monitor for the external proton beam.

Acknowledgements

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