Optical Beam Profile Diagnostics by Using the Beam Image Quantification at PEFP Proton Linac

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1. Introduction

Diagnostics of beam profile and their monitoring are important during accelerator operation as well as investigation of beam parameters. For example, beam emittance and width and so on [1]. There are many beam profile diagnostics methods. Among them, optical beam profile diagnostics method using scintillation screen was selected to measure the beam emittance through 'Quad scan method' from 20-MeV proton linac.

In this paper, optical diagnostics of beam profile is conducted by using scintillation screen are described and their representative results are presented.

2. Methods and Results

When 20-MeV Proton beam bombard scintillation screen, light spot is produced, which their intensity profile is similar to actual beam profile. These light spot simply can be observed by CCD camera and converted to beam profile by appropriate quantification method.

2.1 Experimental set up

Cr doped Al_2O_3 (Chromox) was selected as scintillation screen material due to their robustness against the radiation and thermal damage induced by proton beam bombardment [2]. Table 1 indicated general performance of Chromox .

Table 1. General performance of scintillation screen

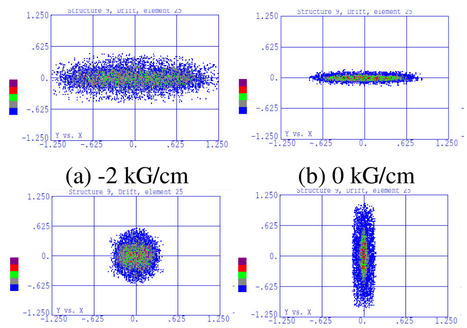
Material	Chromox
Composition	Al_2O_3:Cr
Max. light Emmission	700 nm
Decay time (90% to 10%)	some ten ms
Decay time (10% to 1%)	~ min

The measurement unit is consisted of scintillation screen holder, support, quartz window mounted onto CF flange and CCD camera. This measurement unit is inserted in the beam line at an angle of 45 degree. Therefore a factor of $\sqrt{2}$ has to be taken into account for the spacing of the lines due to the 45 degree mounting.

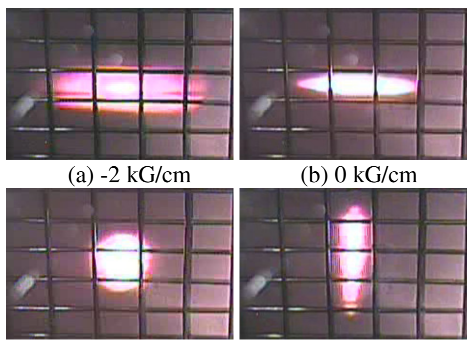
A Proton beam was accelerated up to 20-MeV, its intensity was 1 mA of peak current and pulse width was 30 μsec. During experiment, a Proton beam bombardments on the scintillation screen create light spot. And then, the shape of 20-MeV proton beam was changed with the magnetic field of the quadrupole magnet which was installed upstream of the beam line. The induced beam image was observed and captured by CCD camera

2.2 Comparison between calculation and beam image

For our analysis, beam profile was evaluated by PARMILA calculation (Figure 1). Figure 2 indicates comparative results of beam image obtained from scintillation screen. From these results, it can be observed that the obtained beam image have a good agreement with calculated beam profile.



(a) -2 kG/cm (b) 0 kG/cm
(c) 2 kG/cm (d) 4 kG/cm
Fig. 1. Calculated beam profile by PARMILA



(a) -2 kG/cm (b) 0 kG/cm
(c) 2 kG/cm (d) 4 kG/cm
Fig. 2. Obtained beam image from scintillation screen

2.3 Quantification of beam image

To calculate the RMS beam width from the obtained beam image, the beam images are quantified by ImageJ which is the java-based digital image processing program developed at the NIH (National Institute of Health) [3]. The pixel value of image was measured by imageJ. And then, line integrated profile was constructed at the regular intervals along to X and Y axis (Figure 3)

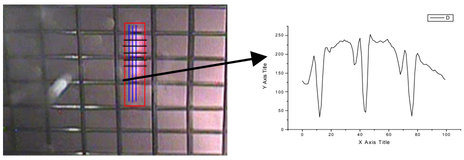
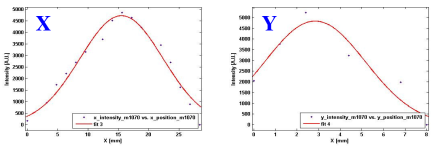
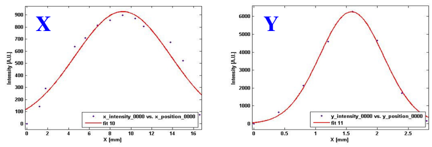


Fig. 3 Quantification of beam image by ImageJ

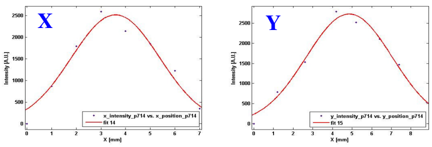
Through above quantification process of image, beam images were converted to the quantified beam profile against X and Y axis. Figure 4 indicates the quantified transverse 1-D beam profiles which were varied to magnetic field of quadrupole.



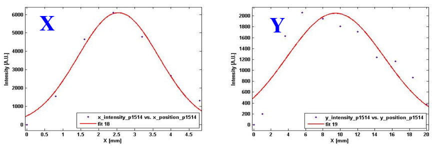
(a) -2 kG/cm



(b) 0 kG/cm



(c) 2 kG/cm



(d) 4 kG/cm

Fig. 4. Variation of measured beam according to the magnetic field of quadrupole

2.4 Calculation of RMS beam radius

Through the quantified 1-D beam profiles, RMS beam radius of transverse space can be estimated. Determination of the beam width from a profile measurement is important for matching different parts of an accelerator facility in the transverse phase planes.

To verify the validity of the measured RMS beam radius, RMS beam radius was calculated by PARMILA. Figure 5 indicates the comparison between the measured RMS beam radius and calculated RMS beam radius. There is a little difference between measured and calculated data, but both of data show a good agreement.

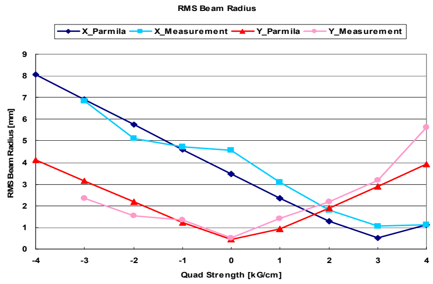


Fig. 5 Comparison of RMS beam radius between measured value and calculated value

3. Conclusions

In this paper, optical beam profile diagnostic method is introduced for monitoring the 20-MeV proton beam. Through the beam image quantification, the quantified 1-D beam profile was measured. And then, the obtained beam profile was verified by PARMILA calculation. These results show that optical beam profile measurement using scintillation screen is simple, reliable and can be useful diagnostic tools for monitoring the beam status and measuring the beam parameters.

Acknowledgement

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REFERENCES

[1] Peter Strehl, Beam Instrumentation and Diagnostics, Springer, 2006

[2] A. Peters, P. Forck, A. Weiss, A. Bank, Transverse beam profile measurements using optical methods, DIPAC 2001 Processing-ESRF Grenoble

[3] Wayne Rasband, "ImageJ", http://rsb.info.nih.gov/ij, National Institute of Health.