Beam Profile Measurement and its Application to Calculate Beam Emittance Using Wire Scanner for the PEFP 20MeV linac

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1. Introduction

A 20-MeV proton accelerator is developed by Proton Engineering Frontier Project (PEFP) at Korea Atomic Energy Research Institute (KAERI). The 20MeV accelerator consists of 50keV proton injector, 3MeV RFQ (Radio frequency Quadrupole), 20MeV DTL (Drift Tube Linac) and 20MeV beam line. The beam profile was measured at the end of the 20MeV beam line with wire scanner. Moreover the beam emittance was calculated from the quad scan method using beam line quadrupole magnets. In this paper, the beam profile measurement results are presented and the emittance measurement from the quad scan method is discussed.

2. Methods and Results

2.1 Wire scanner setup

In this method, a wire detector is stepped in small increments through to beam. The beam profile is obtained over many pulses by measuring the current through the wire. The current flowing in the wire results from the secondary electrons emitted from the wire [1].

The wire is mounted on a fork which is inserted into the beam trajectory pass by a feed-though mounted in 45 degrees in transverse plane. Then only one actuator which drives the wire and fork is mounted to measure both transverse planes. In addition, the wire scanner is able to cover a cross section of beam trajectory without interruption of surrounding structures.

2.2 Measurement Methods.

Table I shows the operational condition of the beam during the measurement of beam profile by the wire scanner.

Table I : Beam property

Parameter	Value
Beam Voltage	20 MeV
Beam Current	1 mA
Pulse Width	50 microsec.
Repetition Rate	1 Hz

Before the wire scanner was installed in the beam line, numerical simulation of a beam dynamics was performed with PARMILA simulation code. In this process, not only the locations of equipment but also the operation ranges of the quadrupole magnets for the control of a beam radius were calculated. Based on the calculation, we have set the beam line components. The quadrupole magnet which has variable magnetic field gradient ranging from -4kG/cm to 4kG/cm is installed in front of the wire scanner.

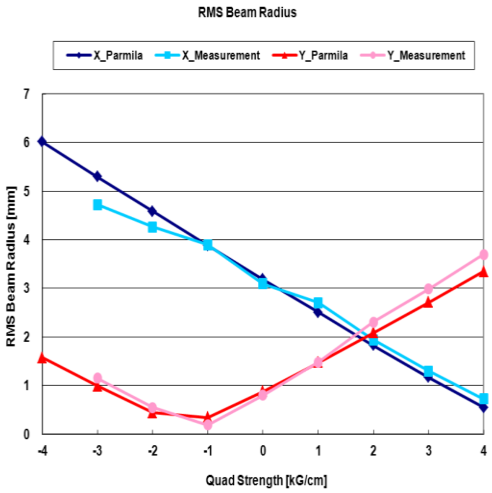


Figure 1. Quad scan measurement results.

As shown in Fig 1 and 2, the result of the beam profile measurement by the wire scanner shows good agreement with the simulation result.

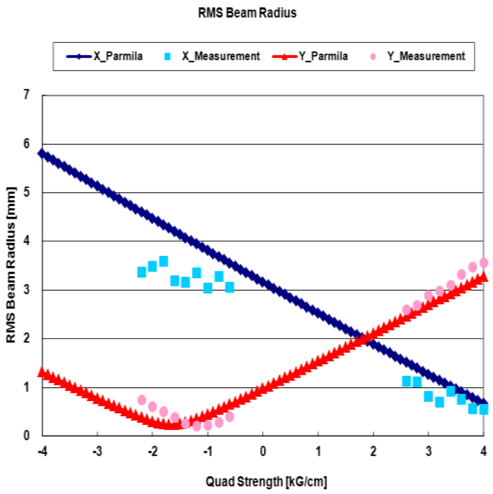


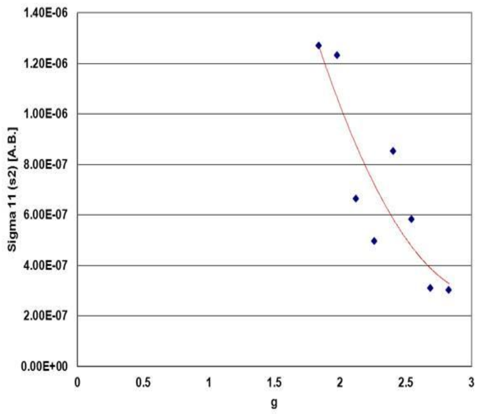
Figure 2. RMS beam radius results.

2.3 Beam emittance.

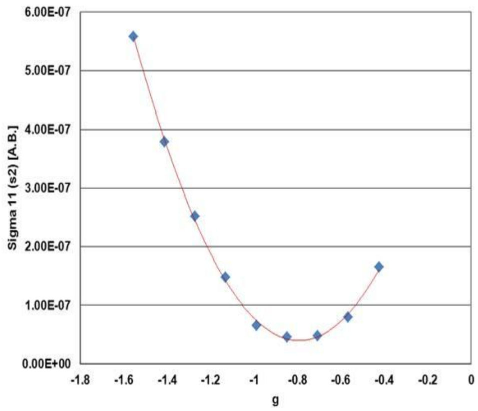
Beam size measurement at three locations at least in different condition is necessary for calculating an emittance [2]. The quad scan steps of 0.2 kG/cm at the minimum regions of the horizontal and vertical profiles are used in beam profile measurement within the field gradient limitation. Measured values are fitted by using Eq. 1 as shown in Fig. 3 and based on the fitting, we calculated the beam emittance by using a thin lens approximation as summarized in Table II.

$$\boldsymbol{\sigma_{11}(s_2)} = \mathbf{R_2^2} = \boldsymbol{\sigma_{11}(s_1)}(1+\frac{\boldsymbol{\sigma_{12}(s_1)}\mathbf{L}}{\boldsymbol{\sigma_{11}(s_1)}}\text{-Lg})^2+\frac{\epsilon_{rms}^2}{\boldsymbol{\sigma_{11}(s_1)}}\mathbf{L^2} \quad (1)$$

g = B'q / Bρ.
L = drift space length from quadrupole to wire scanner.
S_1 = emittance measurement location.
S_2 = beam profile measurement location.



(a)



(b)

Figure 3. Fitting plots of thin lens approximation, (a) $\sigma_{11}(S_2)$ in X-direction, (b) $\sigma_{11}(S_2)$ in Y-direction.

Table I I : Results of X and Y Emittance.

	X (Normalized rms) [PI mm mrad]	**Y (Normalized rms) [PI mm mrad]**
Simulation (PARMILA)	**0.49**	**0.36**
Measurement	**0.79**	**0.36**

3. Conclusions

The measured beam profile was in good agreement with the PARMILA simulation results. The beam emittance was measured by using quad scan method. The Y emittance measurement showed good agreement with the simulation result. Whereas the X emittance was 60% higher than the simulation and that was mainly due to the bad fitting. We are going to measure the X emittance at the region of minimum beam size in x-direction in the future.

4. Acknowledgement

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[2] K. Kubo, ATF internal report ATF-98-35, 1998.