MEASUREMENTS OF BEAM HALO BY WIRE SCANNER MONITOR[*]

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Abstract

A wire scanner is used in the beam halo experiment at the Institute of High Energy Physics (IHEP) to measure the beam halo for the study of beam halo dynamics. The beam energy in the FODO transport line is 3.5 MeV and the peak current is 24 mA. Firstly we get the emittance value for the vertical and the horizontal plane respectively by measuring the matched beam. Then we measure the beam halo of the mismatched beam.

INTRODUCTION

The beam halo formation is an important characteristic of high intensity beams. Beam halo particles are more easily lost on the walls and increase unwanted radioactivity [1]. The experimental study of beam halo formation is very important and necessary. So we built a 28-quadrupole beam transport line after the IHEP RFQ [2]. We have designed a beam profile and halo measurement system and have installed the system in the transport line [3]. In the experiments we used the measured beam profile data to character the proton beam with quadrupole scans method, firstly [4]. Then we measured the RMS matched beam profiles. We also measured the mismatched beam profiles and beam halos, lastly.

In this paper, we introduce the beam profile and halo measurement system and the beam halo experiments. Then we present the measured RMS matched beam profiles with beam halo and the measured mismatched beam profiles with beam halo.

THE BEAM PROFILE MEASUREMENT SYSTEM

We have designed a wire scanner system to measure the transverse beam profile and the emittance. The schematic view of the wire scanner is shown in Fig. 1. The wire scanner will be mounted at 45 ° to the horizontal plane. The outer assembly that resides outside the vacuum consists of a stepper motor, a linear encoder and an electric control platform. The inner consists of a movable frame that carries a sensing wire. And the 32micron diameter carbon wire is selected for use.

Figure 1: The Schematic view of the wire scanner.

BEAM HALO EXPERIMENT

The 28-quadrupole beam transport line is installed at the end of the IHEP RFQ, which accelerates the proton beam to 3.5MeV and operates at the frequency of 352MHz [2]. The block diagram of this transport lattice is shown in Fig. 2.
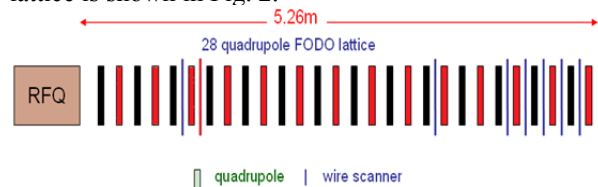

Figure 2: Block diagram of beam halo experiment transport line.

The squares mean quadrupoles, and we change the focusing strength of the FODO channel to obtain the different zero current phase advances. The lines mean wire-scanners. The red line is used to measure the vertical beam profile; the blues are used to measure the horizontal beam profiles at the different locations. Quadrupole scans method is used to charactering the beam, firstly. And the results are presented in Table 1.

Table 1: The Beam rms Parameters

Direction	Alpha	Beta	Emittance (RMS Normalized)
Horizontal (x)	3.287	0.4466 (mm/mrad)	0.29 (mm-mrad)
Vertical (y)	-0.165	0.1005 (mm/mrad)	0.47 (mm-mrad)

THE MATCHED BEAM PROFILES

Due to the lack of vertical wire scanners at the end of transport line, the beam was matched by adjusting the first four quadrupoles to produce equal rms sizes in horizontal position at the last 6 wire scanners. A least-squares-fitting procedure was used based on measurements of derivatives of rms sizes with respect to matching quadrupole gradients. Under matched conditions, the beam is expected to be transported along a linear transport channel with minimal emittance growth, and no significant change in the equilibrium distribution [5]. The measured results with different location equilibrium horizontal beam profiles were shown in Fig. 3.
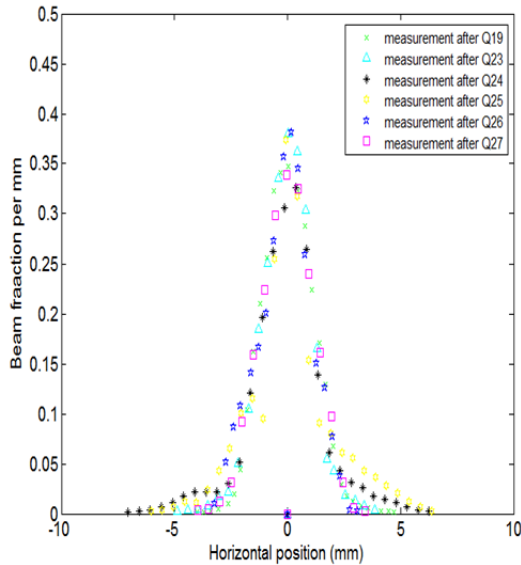

Figure 3: The measured equilibrium horizontal profiles at different locations.

We have used the IMPACT code to simulate the matched beam with the measured initial beam parameters and simulations can reproduce the beam profiles properly [3]. The results for matched beam are shown in the Fig. 4. From the measured results Fig. 4, we can see that the scanner can provide intensity measurements over a dynamic range of about 10^3. And it can cover the scope of 3 RMS radiuses of the beam profiles, it is enough for measure of the beam halo, Shoulders [7].
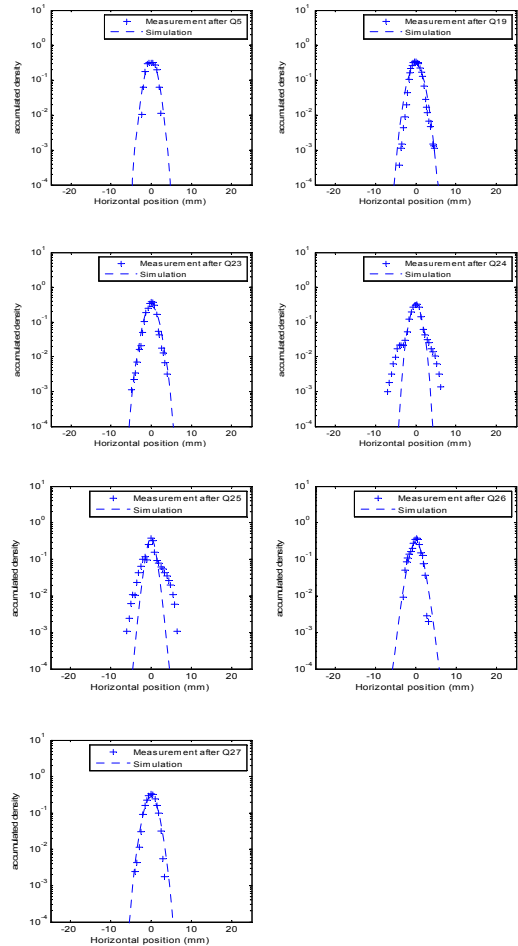

Figure 4: The measured and simulated matched beam profiles.

From the Fig. 4 we also can see in the most locations the simulations can properly reproduce the measured beam profiles without beam halo, but there are a little halo particles in two locations. That means the beam in the phase space is not elliptic symmetry. If we want to know there are beam halo particles or not in beam phase space, we need change the strength of the quadrupole to measure more 1-D beam profiles, the different projections of the 2-D phase space.

We also analyse the matched beam transported in a weaker focusing FODO channel, and the results are shown in Fig. 5.
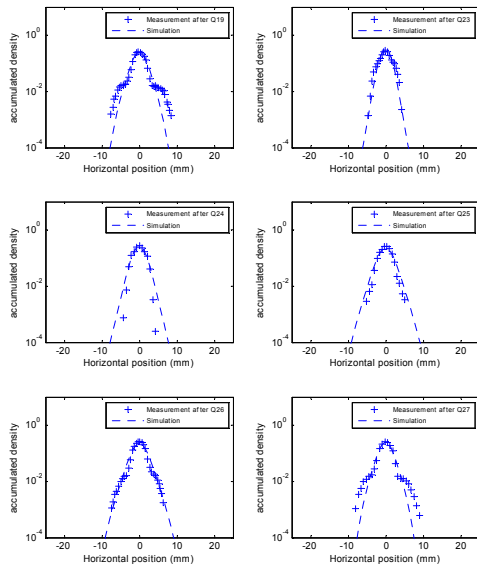
Figure 5: The measured and simulated matched beam profiles.

From Fig. 5 we can see the beam profiles have larger radius and more obvious beam halo 'shoulder' at two locations.

THE MEASURED MISMATCHED BEAM PROFILES

Then we obtain mismatched beam by adjusting the matching quadrupoles and measure the beam profiles. We use the IMPACT to simulate the beam.
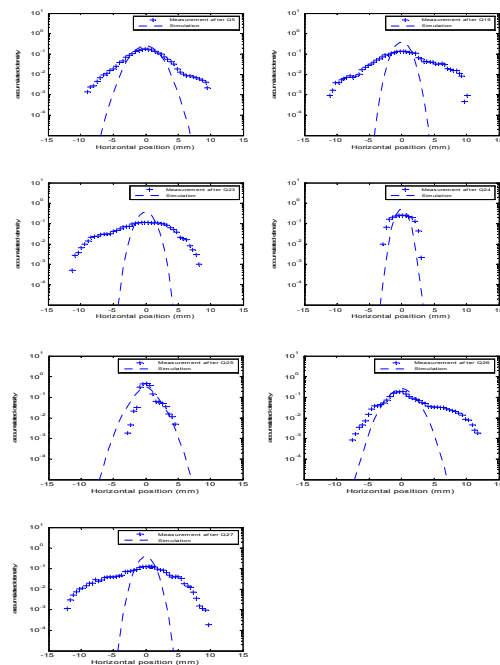

Figure 6: The measured and IMPACT simulated mismatched beam profiles.

From Fig. 6 we find that the beam halos are formed in measured profiles at all locations, and we can see the simulations can't reproduce the measured beam profiles with beam halo.

CONCLUSION

We have built a transport line and designed a wire scanner system to measure the transverse beam profile and the emittance. We find dynamic range of the wire scanner is enough for us to measure the beam halo. And if we want to know there are beam halo particles or not in beam phase space, we need change the strength of the quadrupole to measure more 1-D beam profiles, the different projections of the 2-D phase space, because there are still a little halo particles in two locations for the matched beam profiles.

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