BEAM DYNAMICS ANALYSIS IN THE BEAM HALO EXPERIMENTS AT IHEP

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Abstract

We have measured the beam parameters properly, and also found the RMS matched beam. Now we simulate the matched beam and the mismatched beam using the IMPACT and TraceWin codes. We find the simulations can succeed to reproduce the beam profiles without halo for both matched and mismatched beams, but there are large differences for the mismatched beam with halo.

INTRODUCTION

Beam halo is a major source of beam loss and radioactivation in high-power and high-current proton linacs. More than a decade ago, computer simulation studies identified beam mismatch as the major source of the halo and emittance growth seen in simulations [1]. We believe space-charge forces in mismatched beams are the main source of beam halo in high current proton beams.

In this paper, we present comparisons of simulation results with experimental measurements of the beam core profiles in a high-current proton beam. We also study the beam dynamics in different external focusing strengths for the mismatched beam case.

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.1.

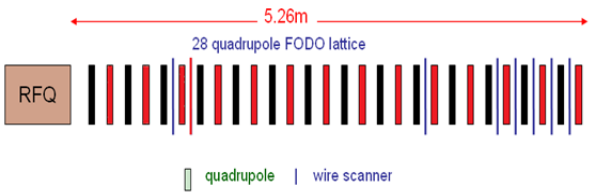

Figure 1: Block diagram of beam halo experiment transport line.

The squares mean quadrupoles, and we change the focusing strength of the FODO channel to obtain the three different zero current phase advances 45° 60° 90° . The lines mean wire-scanners, which are used to measure the beam profiles at the different locations. Quadrupole scans method is used to charactering the beam, firstly. Then we obtain the RMS matched beam by the least squares fitting. We also use the multi-wire scanners to measure the beam parameters, and find the multi-wire scanners method is more accuracy. The beam parameters obtained by multi-wire scanners are shown in the table 1.

Table 1: The Beam RMS Parameters

Direction	Alpha	beta	Emittance (RMS Unnormalized)
Horizontal (x)	3.287	0.4466 (mm/mrad)	3.37 (mm-mrad)
Vertical (y)	-0.165	0.1005 (mm/mrad)	5.45 (mm-mrad)

THE MATCHED BEAM

We have used the IMPACT code to simulate the matched beam and simulations can reproduce the beam profiles properly [3]. The results for matched beam in 90° FODO channel are shown in the Figure 2.

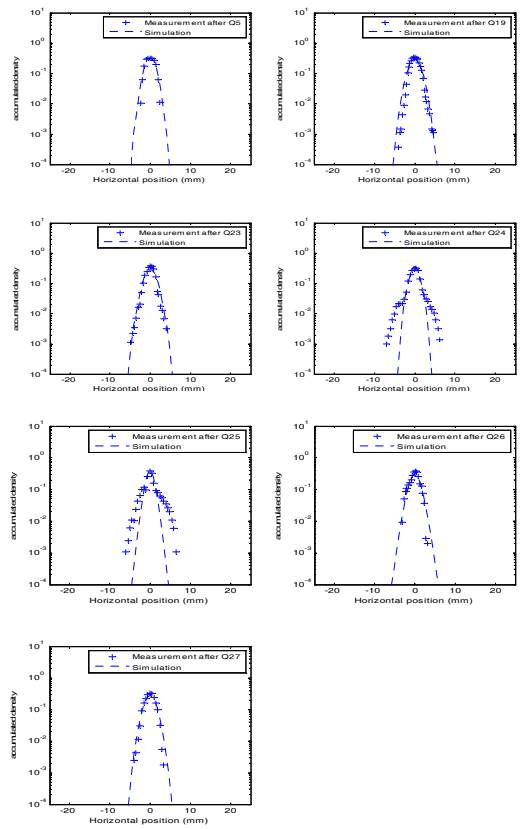

Figure 2: The measured and simulated matched beam profiles in 45° FODO channel.

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From the Figure 2 we can see in the most locations the simulations can properly reproduce the beam profiles, and there are a little halo particles in two locations. That means the beam in the phase space is not elliptic symmetry.

We also analyse the matched beam transported in 45° focusing FODO channel, and the results are shown in Figure 3.

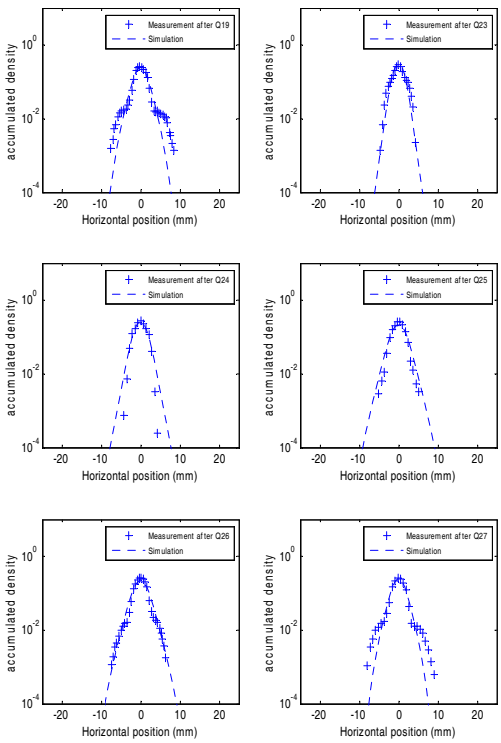

Figure 3: The measured and simulated matched beam profiles in 45° FODO channel.

Comparison of the different focusing strengths, we find the matched beam have similar results. There are also a little halo particles in some locations and the simulation can reproduce the beam profiles.

THE MISMATCHED BEAM

Then we obtain mismatched beam by adjusting the matching quadrupoles and measure the beam profiles. We use the IMPACT and TraceWin code to simulate the beam dynamics. Firstly, we analyze the beam with 0.5 mismatch factor transported in 45 ° FODO focusing channel. The results are shown in Figure 4. We also use the same method to analyse the beam transported in 60° FODO focusing channel, and the results shown in Figure 5.

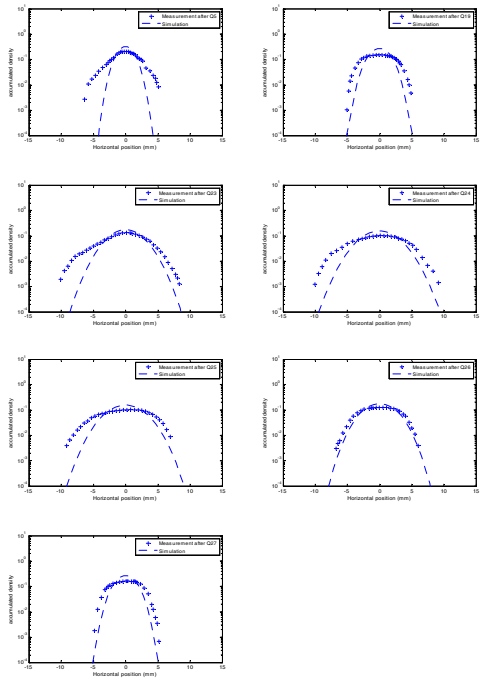

Figure 4: The measured and simulated mismatched beam profiles in 45° FODO channel.

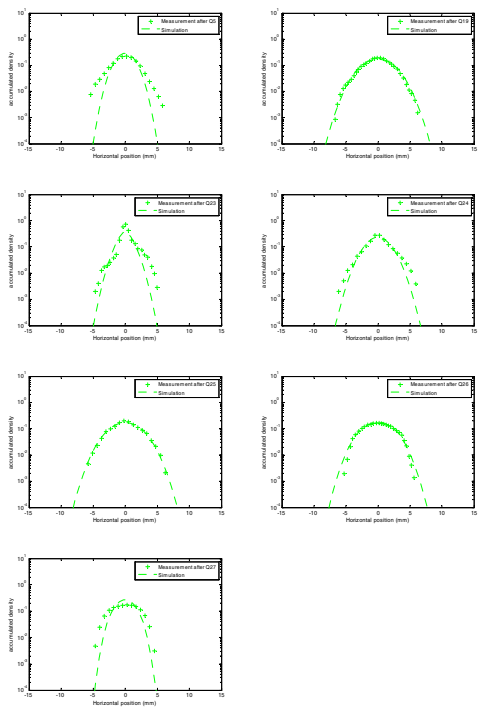

Figure 5: The measured and simulated mismatched beam profiles in 60° FODO channel.

From Figure 4 and 5 we can find the beam halo isn't formed in the both cases and the simulation can reproduce the beam profiles properly.

We also analyze the mismatched beam transported in 90° FODO focusing channel and the results shown in Figure 6.

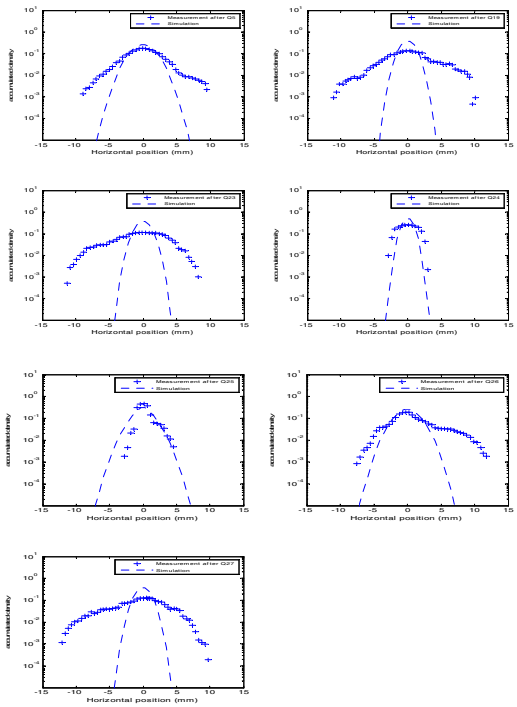

Figure 6: The measured and IMPACT simulated mismatched beam profiles in 90° FODO channel.

From Figure 6 we find that the beam halos are formed in measured profiles and the IMPACT code can't reproduce the beam profiles. We think the beam halo isn't formed in 45° and 60° FODO channel, because the FODO channel isn't long enough to Betatron oscillations. We use the TraceWin codes do the same simulations to understand the difference between the measured and simulated beam profiles and the results are shown in Figure 7.

From Figure 7 we find the TraceWin code have the same results with IMPACT simulations, they can't reproduce the beam profiles with beam halo.

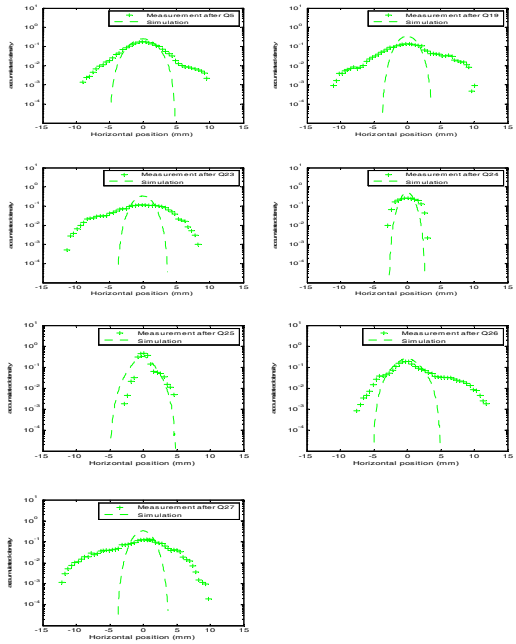

Figure 7: The measured and TraceWin simulated mismatched beam profiles in 90° FODO channel.

CONCLUSION

We use two different methods to measure beam RMS parameters, and find the multi-wire scanner method is more accuracy. And we also obtain the RMS matched beam. We find the simulations can succeed to reproduce the beam profiles without beam halo for both matched and mismatched beams, but there are some differences for the mismatched beam with halo.

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