TRANSVERSE MATCHING OF THE SNS LINAC BASED ON PROFILE MEASUREMENTS *

Dong-o Jeon#, Oak Ridge National Laboratory, Oak Ridge, TN37831, U.S.A.

Abstract

For a high intensity linac such as the SNS linac, it matters to match transversely adequately to minimize the beam mismatch and potential beam loss. The technique of doing the matching using the wire-scanners in series was employed [1]. It was verified that matching was improved through the matching technique based on the beam profile measurements from wire-scanners in series.

INTRODUCTION

The Spallation Neutron Source (SNS) linac accelerates intense H^- beams to energy of 1-GeV, delivering more than 1.4 MW of beam power to the neutron production target [2]. Being a high intensity linac, a primary concern is the uncontrolled beam loss and radio activation of accelerator components. Mismatch generating beam halo, it is important to accomplish adequate level of transverse matching between sections of linac.

When emittance measurement device is available, minimization of rms emittance proves to be effective in doing the matching as for the SNS DTL (Drift Tube Linac) tank 1 commissioning [3].

Alternatively wire-scanners installed in series can be used to transversely matching between two different structures of the SNS linac [4,1]. During the beam operation runs, the matching technique based on beam profile measurements was tested and the results are presented here. The previous work [5] was for a relatively low beam current around 15 mA. This study is focused on the performance for high current (~ 32 mA) and for an incoming beam with a large envelope oscillation.

MATCHING DTL TO CCL

We applied the technique based on profile measurements to matching the Drift Tube Linac (DTL) to the Coupled Cavity Linac (CCL). The beam energy is 86.6 MeV coming out of DTL. The peak beam current used for the measurement was 34 mA. We performed a Gaussian fit to the measured beam profile and obtained its beam size σ. By fitting the beam envelope from the Trace3D code to the wire-scanner profile data, we obtained the input beam Courant-Snyder parameters β and α, and the beam emittance ε, as shown in Fig. 1. With the beam parameters of the incoming beam determined, the matching quadrupoles are optimized using the Trace3D code to do the matching.

The first four wire-scanners were used by the matching program to predict a better matching. This matching technique is robust for quite high peak current beam. Figure 1 shows the data before the matching exercise and Fig. 2 the data after the matching. The solid circles in Figs. 1 and 2 represent profile measurements from wire-scanners in CCL module 1 and 2. The blue color represents the x beam size and the red the y beam size. It is clear that the matching in x plane is improved significantly and that a slight improvement is observed in y plane (y plane was already close to well matched condition). We observe an overall improvement in matching. The measured normalized rms emittances are ε_x=0.283 and ε_y=0.320 [mm mrad] of the equivalent uniform beam distribution having the same rms beam size as the beam profile.

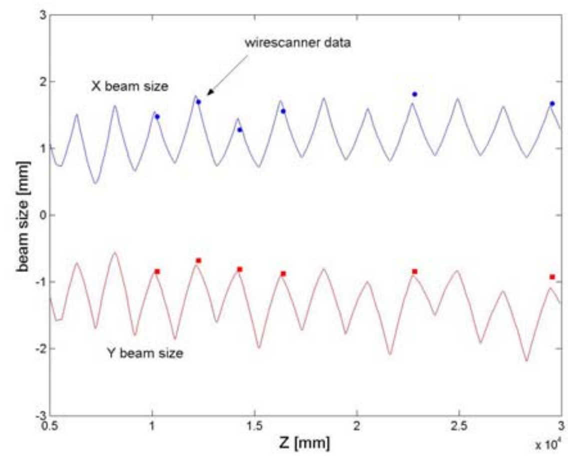

Figure 1: Plots of beam profiles before matching DTL to CCL. Solid lines are plots of beam size σ [mm] from the Trace3D program and solid circles are wire-scanner profile data. The peak beam current is 40 mA.

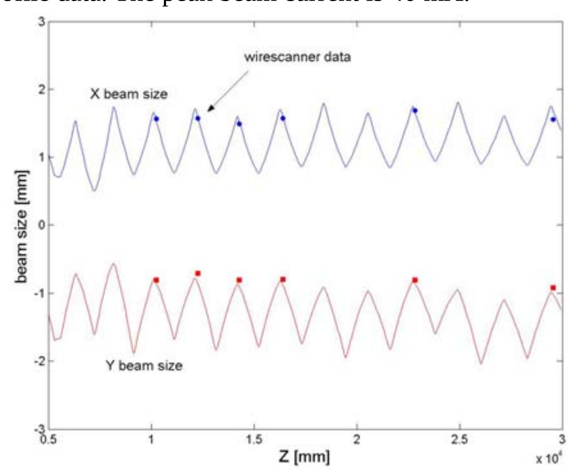

Figure 2: Plots of beam profiles after matching DTL to CCL. Solid lines are plots of beam size σ [mm] from the Trace3D program and solid circles are wire-scanner profile data.

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#jeond@ornl.gov

In the previous work [5], when matching in one plane is improved significantly, matching of the other plane degraded slightly. We improved fitting routine with a modified figure of merits. This routine seems to be robust to a high current beam or to a beam with a significant envelope oscillation as shown in the following section.

MATCHING SCL TO HEBT

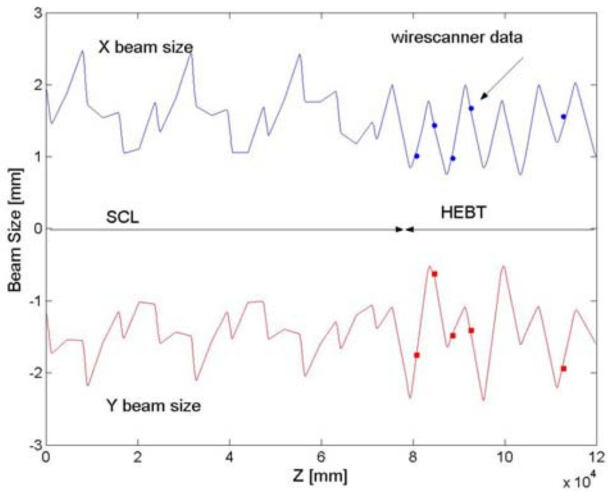

Figure 3: Plots of beam profiles before matching SCL to HEBT. Solid lines are plots of beam size σ [mm] from the Trace3D program and solid circles are wire-scanner measurement data.

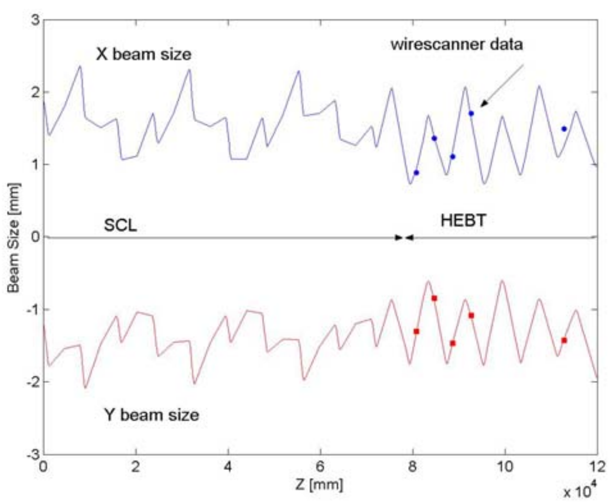

Figure 4: Plots of beam profiles after matching SCL to HEBT. Solid lines are plots of beam size σ [mm] from the Trace3D program and solid circles are wire-scanner measurement data.

We applied the same technique to matching the Superconducting Linac (SCL) to the High Energy Beam Transport (HEBT). The focusing of SCL is provided by doublets and HEBT by FODO. The solid circles in Figs. 3 and 4 represent the beam profile data from the wire-scanners in the HEBT and the solid lines represent simulated beam profile obtained from the Trace3D code. The blue color represents the x beam size and the red the y beam size. It should be noted that there is a mild beam envelope oscillation at the SCL.

By fitting the beam envelope from the Trace3D code to the wire-scanner profile data, we obtained the input beam Courant-Snyder parameters β and α, and the beam emittance ε, as shown in Fig. 3. Table 1 lists the input beam parameters at Z=0 in Fig. 3. ε_x=0.420 and ε_y=0.358 are the normalized rms emittance [mm mrad] of the equivalent uniform beam distribution having the same rms beam size as the beam profile. Figure 3 shows the data before the matching exercise and Fig. 4 the data after the matching. The envelope oscillation in the SCL is pretty severe, resulting in relatively high rms emittance values.

The matching exercise primarily improves the matching in the plane where the mismatch is pronounced. This routine proves to be quite robust even when there is a significant mismatch/envelope oscillation to the incoming beam, as demonstrated in this case.

Table 1: Input Beam Parameters

	X plane	Y plane
ε [mm-mrad]	0.420	0.358
β [m]	15.107	6.556
α	-1.938	-0.544

CONCLUSION

A study of transverse matching of the SNS linac is performed. Positive results are obtained showing that the matching is improved for high current and significant mismatch. Further matching study will be conducted for other sections of the SNS linac.

REFERENCES

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