EXPERIMENTAL TEST OF TRANSVERSE MATCHING ROUTINE FOR THE SNS LINAC*

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Abstract

It is important to accomplish adequate matching for a high intensity linac to minimize mismatch and potential beam loss. We proposed a technique of minimizing rms emittances to accomplish transverse matching in a robust manner. During the DTL commissioning, this technique was put to test. This technique reduced tail and rms emittance.

INTRODUCTION

The Spallation Neutron Source (SNS) accelerator system is designed to accelerate intense proton beams to energy of 1-GeV, delivering more than 1.4 MW (upgradeable to 2 MW) of beam power to the neutron production target [1]. The peak current in the linac is 38mA and the macropulse average current is 26mA due to chopping. A primary concern is potential damage and radio activation of accelerator components resulting from uncontrolled beam losses. A major source of loss is beam halo that intercepts the bore of the linac.

Mismatch is one of the driving mechanisms of halo formation. SNS being a high power machine, it is vital to accomplish adequate matching to minimize uncontrolled beam loss induced by mismatch at downstream linac.

Generally matching condition is obtained by using Trace3D code or multiparticle tracking codes such as Parmila. Now the question is how accurate this matching provided by the model. We studied feasible schemes of transversely matching various sections of SNS Linac utilizing wire-scanners or emittance measurement devices. The study indicates that for a robust MEBT-DTL matching, the rms emittances should be minimized [2]. This technique does not require knowledge of the optics. The problem of fitting rms beam sizes obtained from wire-scanners is that the matching solution is not unique. During the DTL Tank 1 commissioning of the SNS linac, a study was done to verify experimentally if the resultant matching is adequate or not.

MEASUREMENT

To test the effectiveness of the proposed matching technique, emittance measurement was performed using the x and y plane emittance slits and collectors installed on the Diagnostics plate shown in Fig. 1. The nominal Medium Energy Beam Transport (MEBT) optics was used, which is the baseline MEBT optics. Through studies

it was shown that the nominal MEBT optics generates significant halo [3,4]. This particular optics was chosen intentionally because of that reason. The beam size plot obtained from the Trace3D for this nominal optics is shown in Fig. 2. There are four quadrupoles (quadrupoles depicted as squares in Fig. 2) dedicated for matching between MEBT and DTL. The initial matching condition was obtained from using the Trace3D. Then the matching was performed minimizing rms emittances in both planes. During the matching study, 50μs 38mA 3Hz beam was used.
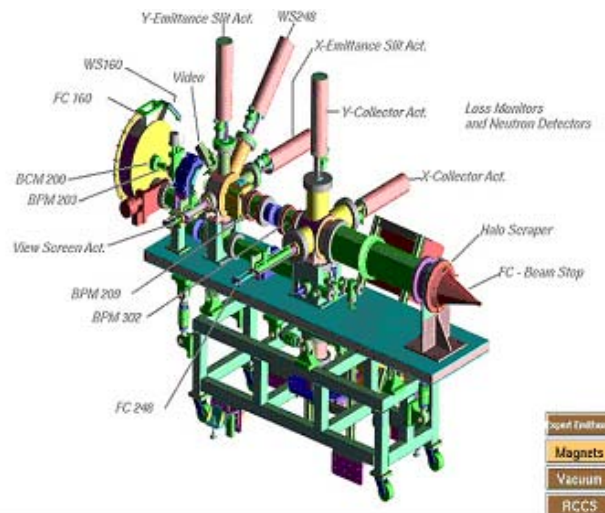

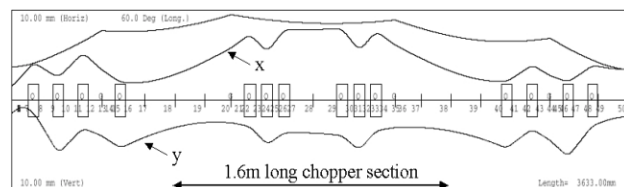Figure 1: Schematic view of the Diagnostics plate used for the DTL Tank 1 commissioning.

Figure 2: Plot of Trace3D output for the MEBT. Plotted are $\sqrt{5}\sigma$ of beam sizes for each plane.

Optimization was done using a minimization routine of MATLAB®. This routine uses the simplex search method [4].

The phase space plots before and after the matching are shown in Fig. 3. The tail was visibly reduced after the matching. The rms emittance was also reduced from 0.39 mm-mrad to 0.31 mm-mrad. Minimizing rms emittance technique reduced the tail and core emittance. There was not much change in x emittance.
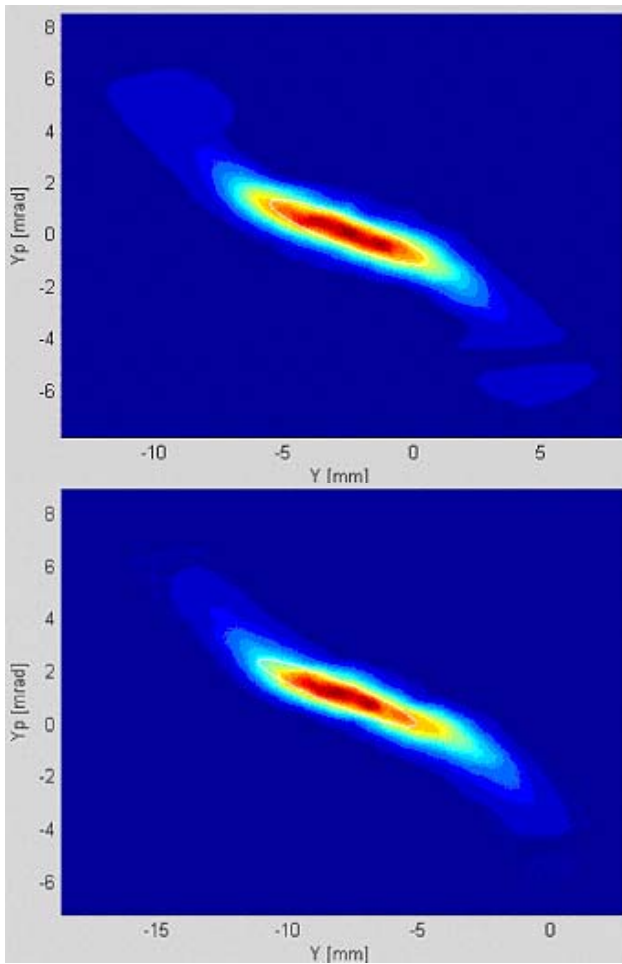
CONCLUSIONS

The proposed matching technique was effective in establishing a transverse matching experimentally. The tail was reduced after the matching. The rms emittance was also reduced from 0.39 mm-mrad to 0.31 mm-mrad. Minimizing rms emittance technique seems to reduce the tail and core emittance.

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Figure 3: Plots of beam distribution in y plane phase space before (the upper plot) and after matching (the lower plot).