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MEDIUM ENERGY IONS TRANSPORT CHANNEL FOR A PULSED LINEAR ACCELERATOR

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Abstract

For a transportation and matching proton and light ion beams (the maximal value A/Z is about 3.2) between RFQ and groups of IH-cavities it is suggested medium energy ions transfer line. That line should provide 100% beam transmission under negligible beam envelope increase and small longitudinal beam size growth during particle transport. MEBT consists of two parts. One of them provides ion transfer with energy of 820 keV/u and the second one provides ion transfer with energy of 2.46 MeV/u.

INTRODUCTION

New linear injector of proton and light ion beams is under design at NRNU MEPhI [1]. This injector will accelerate protons and ions up to oxygen to an energy of 7.5 MeV/nucleon with mass-to charge ratio $A/Z < 3.5$. The main part of linear injector are RFQ linac and two groups of short 5-gaps IH-cavities independently powered. Beams transfer from RFQ linac to the first set of IH-cavities will be done with the help of medium energy beam transport line (MEBT-1). Beams transfer between the first and the second set of IH-cavities will be done by means of MEBT-2. For both transfer lines it is considered to use beam bunchers to control the bunch length and to chop the bunch tails.

MEBT-1 DESIGN

In order to transfer beams of particles from RFQ linac output to the entrance of the first set of IH-cavities MEBT-1 will be used. The suggested layout of the MEBT-1 is shown in Fig. 1. It consists of two quadruple doublets and two quads [2] and its total length is 3.62 m. *B*-field components at the center of the quadruple lens are shown in Fig. 2. Magnetic field distribution in the cross-section of the quad at its center is presented in Fig. 3. Quad gradients for ion beam with $A/Z = 3.2$ are presented in Table 1.

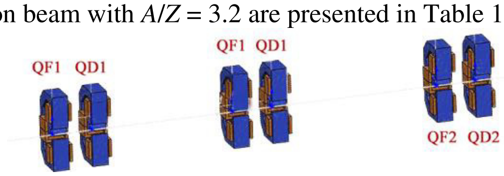

Figure 1: Layout of MEBT-1 line.

Table 1: Quad Parameters

Name	*G*, T/m	*L*, cm
QF1	7.3	10
QD1	-7.3	10
QF2	9.0	10
QD2	−11.3	10

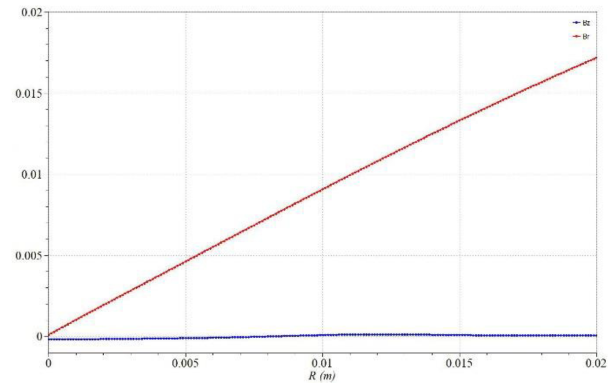

Figure 2: B_z (blue) & B_r (red) field components.

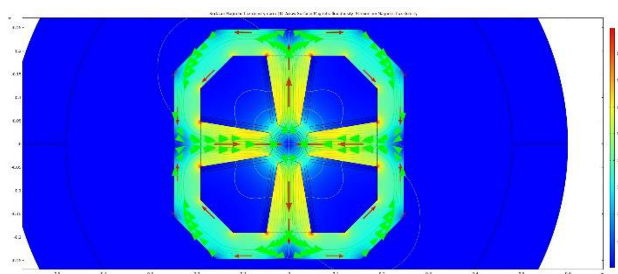

Figure 3: Quad cross-section & B-field distribution. Courtesy to I. Yurin [3].

Also it is supposed that beam buncher will be located in the drift space between doublets. Typical view of that buncher, designed by M. Gusarova, is shown Fig. 4.

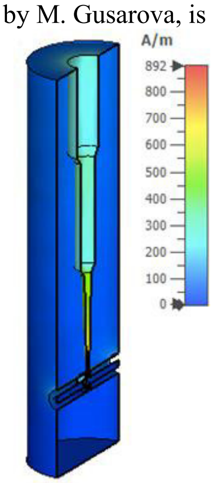

Figure 4: Buncher for MEBT-1.

Self-consistent ion beam dynamics simulation in the calculated 3D fields of MEBT-1 line was carried out by means

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of [4]. Beam current were equal to 2 mA, normalized transverse emittace was equal to 0.04 π·μm·rad. Initial particle distribution used for simulation is presented in Fig. 5. Calculated RMS beam envelopes are presented in Fig. 6 and particle density along the transfer line is shown in Fig. 7. Ion beam at the end of MEBT-1 is shown in Fig. 8.

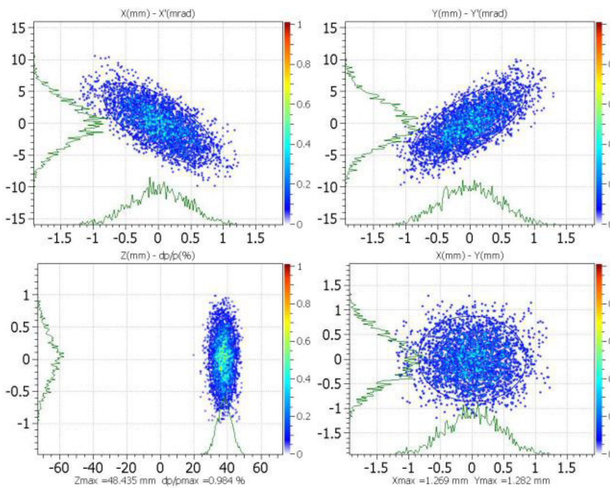

Figure 5: Beam at the MEBT-1 start.

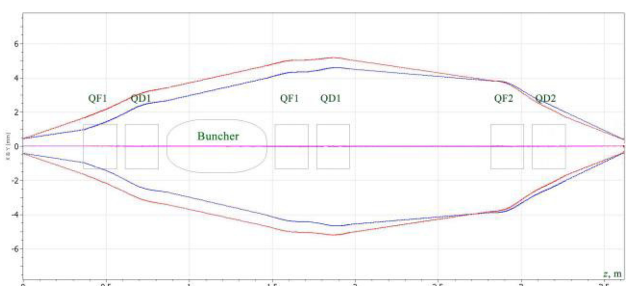

Figure 6: Beam envelope (x - blue, y - red) in MEBT-1.

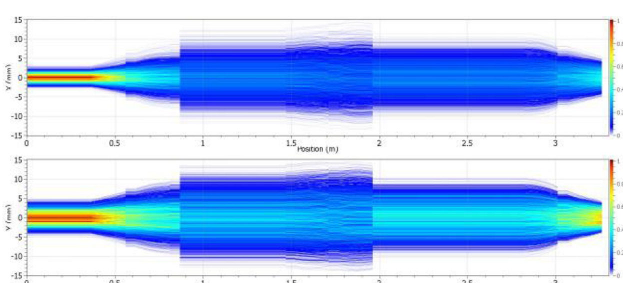

Figure 7: Particle density along the transfer line: x – top; y – bottom.

One can see that beam size at MEBT-1 output does not increase in comparison with its start under 100% transmission. Vacuum chamber diameter should be not smaller than 30 mm.

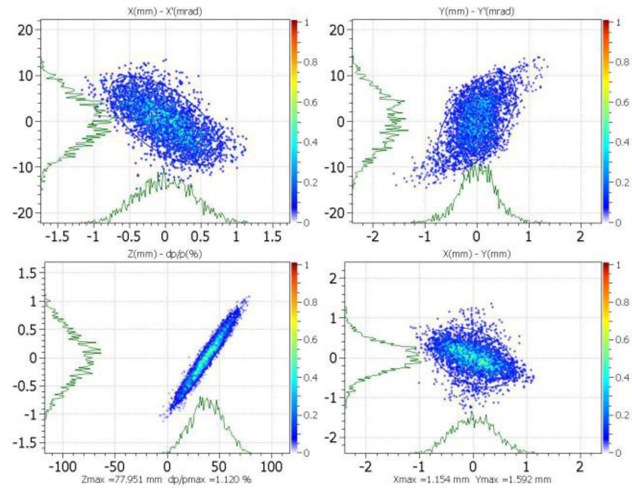

Figure 8: Beam at the MEBT-1 end (buncher is switched off).

MEBT-2 DESIGN

MEBT-2 will be used for beam transfer from the output of the first set of IH-cavities to the input of the second set of IH-cavities at with energy of 2.46 MeV/u. MEBT-2 consists of three identical quadruple doublets. Lenses have the same length as for MEBT-1. Its gradients are 14.7 T/m and −11.6 T/m correspondingly. Length of MEBT-2 line is equal to 3.29 m. Buncher similar to that is for MEBT-1 can be used in MEBT-2. Self-consistent ion beam dynamics simulation in the calculated 3D fields of MEBT-2 line was carried out in the same way as for MEBT-1. Initial particle distribution used for simulation here is presented in Fig. 9. Calculated RMS beam envelopes are presented in Fig. 10 and particle density along the transfer line is shown in Fig. 11. Ion beam at the end of MEBT-2 is shown in Fig. 12.

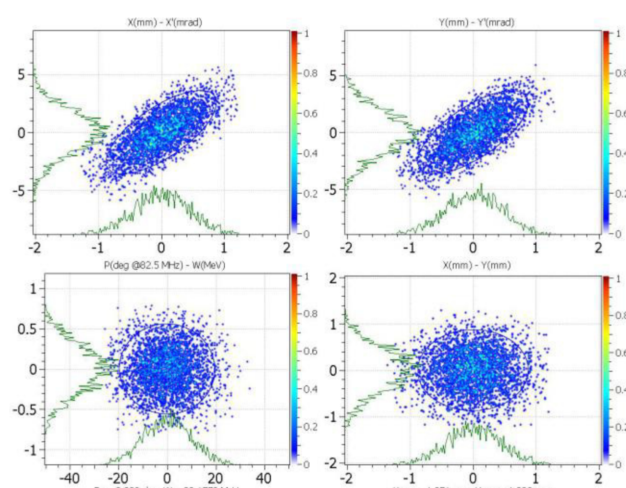

Figure 9: Beam at the MEBT-2 start.

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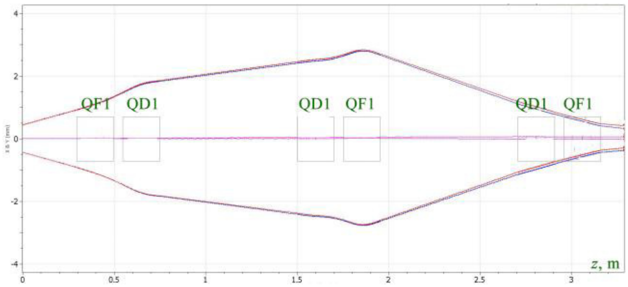

Figure 10: Beam envelope (*x* - blue, *y* - red) in MEBT-2.

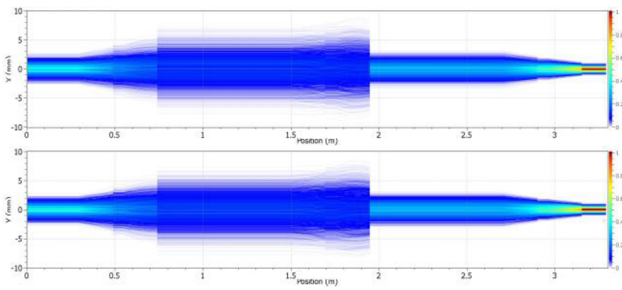

Figure 11: Particle density along the transfer line: *x* – top; *y* – bottom.

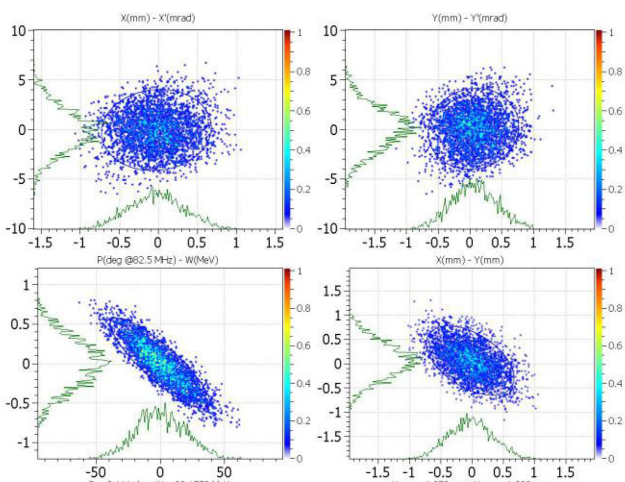

Figure 12: Beam at the MEBT-2 end.

Beam size at the MEBT-2 output does not increase in comparison with its size at the start 100% transmission. Vacuum chamber diameter can be equal to 20 mm.

CONCLUSION

Design of MEBT-1 and MEBT-2 lines for ion beam transfer with mass-to charge ratio $A/Z < 3.5$ is suggested. Self-consistent ion beam dynamics simulations in the "real" 3D fields are performed. Defined parameters of the quads provide 100% beam transmission.

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