FINAL BEAM TRANSPORT CHANNEL FOR TWAC CALCULATION

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Abstract

The transport line for a beam that is stacking in ITEPs proton synchrotron for Terrawatt Accelerator Complex (TWAC) has been desighned. The aim of this work is to create a small beam spot size (diameter of about 1mm) on the experimental target. The beam consists of the fully stripped Cobalt ions with energy 40 GeV/amu. The special feature of this installation is the high current (500A), high emittance (X*X'=80mm*mrad, Y*Y'=50mm*mrad), and high momentum spread (ΔdP/P=0.005) of storage beam. It is shown that for our beam parameters the influence of space charge forces is not essential. Therefore the main attention is focused on chromatic aberrations in final focusing objective. The efficiency of the beam interaction with the target has been calculated taking into account the spatial features of the target. Numerical simulations using TRANSPORT and REVMOC codes were performed to determine optimal geometries and main parameters of our channel.

1 INTRODUCTION

The aim of this work is to create a beam with small cross-section size (with diameter of about 1 mm) on the experimental target of TWAC [1]. The beam consists of the fully stripped Co ions with energy of about 40 GeV/u after fast extraction from ITEP proton synchrotron U10 used as storage ring. The beam has high emittance (ε_x=80mm*mr, ε_y=50mm*mr), big momentum spread (ΔP/P=±0.5%) and high current (500A). We would like to place the channel in existing buildings and to use available magnetic elements. For final focusing system we hope to use specific strong elements (superconducting or impulse).

The layout of ITEP accelerator facilities is shown on Figure 1. In TWAC project ion beam will be transported after pre-accelerator to ion accelerator. Then ion beam is transported and stored in U10. The last steps are the beam compression in time and the fast beam extraction from storage ring. The building of ITEP hydrogen bubble chambers is empty now and we hope to use it for TWAC final channel and experimental target.

2 CHANNEL DESCRIPTION

On Figure 2 the layout of channel is shown. It will replace the existing channel and will use its two main magnets (M1, M2) and six quadrupoles (q3-q8) just in theirs positions, using its current and water lines. Quadrupoles q1,q2, q9-q12 are standard ITEPs quadrupoles. TRANSPORT [3] codes were used for optic optimization. The optic scheme of the channel is shown on Figure 3. Schematically the channel has three parts.

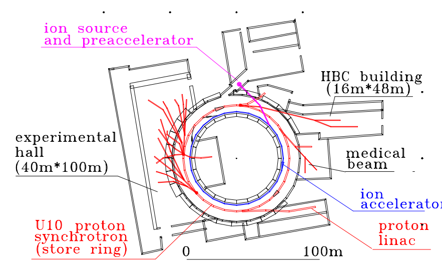

Figure 1. Layout of ITEP accelerator facility.

The first part has focusing septum magnet SM, two quadrupoles q1,q2 and first bending magnet M1. The septum magnet will be used both for injection ion beam into U10, and for extraction ion beam into final channel. The first part will be used to capture the extracted ion beam in channel and bend it in proper direction. Calculated parameters of extracted ion beam were used as input data for TRANSPORT file.

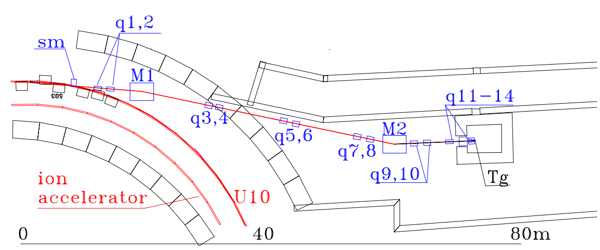

Figure 2. Layout of final beam transport channel for TWAC.

The second part of channel has six quadrupoles q3-q8 and second bending magnet M2. It is used to transport ion beam to HBC building with suppression of linear and angular dispersions on its output.

The last part of the channel has to focus the beam on the target as strongly as possible. It uses two strong quadrupoles q13 and q14 for final beam focusing and four usual quadrupoles q9-q12 for beam matching. Optimization of this part was made for the beginning in the opposite direction, from experimental target. Distance from the target to the last quadrupole q14 was constant, 0.4m. For optimization we used beam dimensions on target (X and Y), length, radius, gradients and positions of all quadrupoles (q9-q14). Optic scheme of the last part of the channel is shown on Figure 4.

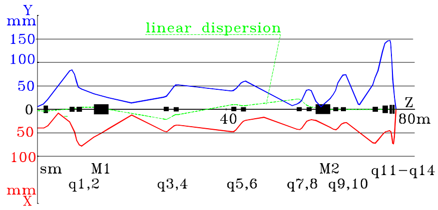

Figure 3. Optic scheme of final beam transport channel for TWAC.

After first order optimization optic scheme of the whole channel was calculated from point of extraction to the target in second order by TRANSPORT and REVMOC [4] codes. The calculations have shown significant influence of chromatic aberration on beam sizes at the target. For the first order calculations the sizes are equal 1mm*1.6mm. For the second order sizes are equal 1.4mm*2.5mm (ΔP/P = ±0.5%). We tried to decrease the chromatic aberration using sextupoles in the intermediate channel point, but this usual method was not successful. Due to a big emittance of the ion beam in our building and with available magnetic elements it is impossible to design intermediate point in channel with good momentum resolution.

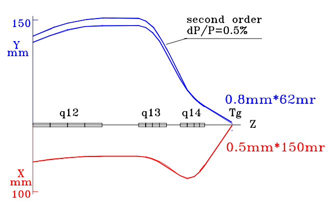

Figure 4. Optic scheme of the last objective.

The spherical aberration of the last two quadrupoles is the second possible significant reason of an increasing of the beam spot. q13 and q14 have small length by comparison with their radius (see Figure 3,4). Therefore their magnetic fields will differ from used in TRANSPORT or REVMOC ideal quadrupole fields both for superconducting and impulse design. We hope to calculate its influence after designing of quadrupoles.

Finally, we must consider influence of mutual electrostatic ion repulsion on the beam. The space charge effect for the microkanonical (K-V) distribution of the beam phase density has been calculated. The increase of the beam focal spot varies directly with beam current and inversly with the magnetic field gradient of the last focusing objective (q13,q14). In our beam transport line the focal spot increase is not more than 10% for the beam current 500A.

To improve “channel-ion beam-target” system properties we attempted to optimize target shape. For this goal we used results of M.K. REVMOC calculations for beam on the target without influence of interactions of ions with target. It was shown that for ΔP/P=±0.2% about 100% of ions will be in zone with dimensions of 1.4mm*2.2mm, and about 94% - in zone of 1.2mm*1.2mm. However if ΔP/P = ±0.5% in the same zones there will be only 94% and 61% of ions.

Using M.K. REVMOC calculation of beam shape we estimated geometric mean of ions range (without interactions with target) in targets with constant volume and length (10mm), and with elliptical cross-sections. It was shown that if target was the cylinder with diameter of 1.2mm, the average ion range in the target was 6.8mm, but this range could be increased up to 8.6mm, if target cylinder cross-section is an ellipse with axes of 0.8mm*1.8mm.

In conclusion we consider the possibility of chromatic aberration decreasing by matching of chromatic properties of storage coil U10 with chromatic properties of channel, but these calculations are not finished now.

3 CONCLUSIONS

According to our calculations the properties of designed final beam transport channels can be rather good.

4 ACKNOWLEDGEMENTS

Authors express the gratitude to P.Spiller (GSI) and P.Zenkevich (ITEP) for useful discussions and advices.

5 REFERENCES.

[1]. N.N.Alekseev, D.G.Koshkarev, B.Yu.Sharkov TWAC status. EPAC-98.
[2]. K.L.Brown et all TRANSPORT CERN, 4, 1980.
[3] C.Kost, P.Reeve REVMOC TR-DN-82 -28, 1982.