BEAM DYNAMIC OF TRANSPORT LINE 1+ WITH NEW HRMS FOR THE SPES PROJECT

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Abstract

SPES (Selective Production of Exotic Species) [1] is integrated Italian facility in LNL (Laboratori Nazionali di Legnaro, Legnaro, Italy) for production of high-intensity and highly charged beams of neutron-rich nuclei for Advanced Studies. The facility is based on 35-70MeV proton cyclotron, an ISOL fission target station and the existing ALPI superconducting accelerator as the post accelerator. In this paper the results of beam dynamic simulation of ^{132}Sn ion beam transport line from Beam Cooler to the Charge Breeder, including HRMS (High Resolution Mass Separator) with mass resolution 1/20000 and electrostatic dipoles are presented.

INTRODUCTION

SPES (Selective Production of Exotic Species) is a CW ion beam facility for neutron-rich radioactive ions production and acceleration to contribute to the study of the nuclear physics processes. The optimization of transport line 1+ from HRMS to Charge Breeder to improve the transportation of these type particles. The considered line 1+ includes:

- HRMS is used to select RNB (Radioactive Nucleolus Beam).
- Dipoles to obtain beam bending which is fixed at the entrance and at the exit of straight periodic transfer line to CB.
- Entrance to Charge Breeder.

The complete layout of the transport line 1+ from High Resolution Mass Spectrometer (HRMS) to Charge Breeder is shown in Fig. 1. The chief purpose of the discussion was to design the matching with new HRMS and with Charge Breeder beam transport line 1+ in carefully way to avoid beam losses.

TRANSPORT LINE 1+ WITH NEW HRMS

HRMS

For the SPES project, the High Resolution Mass Spectrometer has to provide the ^{132}Sn ion beam purifying and ≥97% transmission. New HRMS [1] has a 1/20000 resolution in mass with ± 1 eV energy spread. It will be installed on the High Voltage platform with operating voltage of 260 kV. Developed HRMS is consisting of: two magnet dipoles of R=1.5 m with deflector angle 90°, four electrostatic multipoles, two electrostatic quadrupoles.

The Periodic Transfer Line to Charge Breeder

After HRMS system, there is beam transfer line 1+ [1] to connect HRMS with entrance of Charge Breeder. This transport channel with length of about 45 m has to provide a beam transport without beam losses and with minimum of dispersion (within limits of -80; 80 m). As a bending element the electrostatic dipole was selected. Two triplets after the separator image point and also the electrostatic dipole in transport line help to control the dispersion growth after the HRMS structure. The virtues of this type of dipole, as compared with magnetic dipole, are smaller energy consumption and independence from the ion mass. According to preliminary design of an electrostatic dipole to deflect the beam 90° [2], the main parameters of dipole were chosen. These parameters are shown in Table 1.

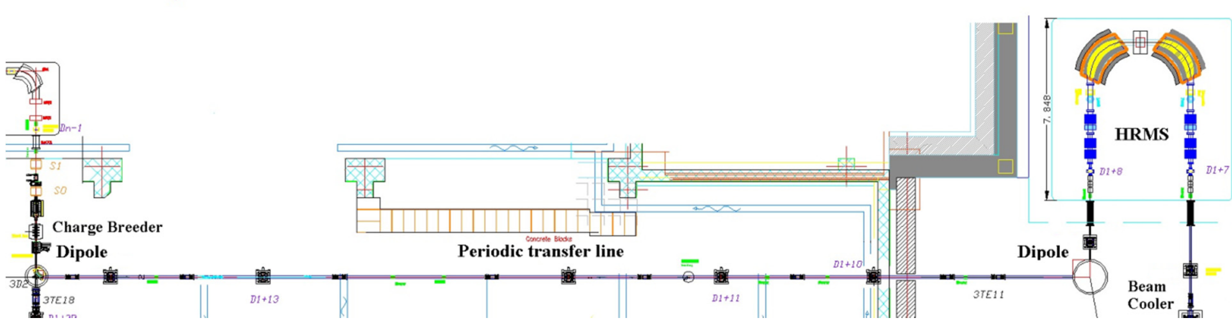

Figure 1: Transport line 1+ from High Resolution Mass Spectrometer (HRMS) to Charge Breeder.

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Table 1: Electrostatic Dipole Performances

Parameter	Value
Type	Cylindrical
Total extraction potential	42 kV
Bend angle in the rotation plane	90°
Curvature radius of central trajectory	250 mm
Gap between the electrodes	50 mm

Using these parameters the potential on each electrode is

$$V_p = \frac{d}{R} V_e \; = 8.4 \text{ kV}. \tag{1}$$

Where R is curvature radius of central trajectory, d is the gap between electrodes; V_e is the total extraction potential. For the better beam focusing before and after dipole the electrostatic triplets are used. The distance has to be at least 400 mm from the intersection of the two beam lines, for both planes [2], that was taken into account in the simulation.

BEAM DYNAMIC SIMULATION

The beam dynamics simulation in Trace Win [3] was carried out in several steps.

The input Twiss parameters used for simulation is measurement from Beam Cooler: $\alpha_{x,y}$=-3, $\beta_{x,y}$=0.66 mm/(π·mrad) The norm.emittance is: ε_{norm}=0.0014 π·mm·mrad for x, y axis [4].

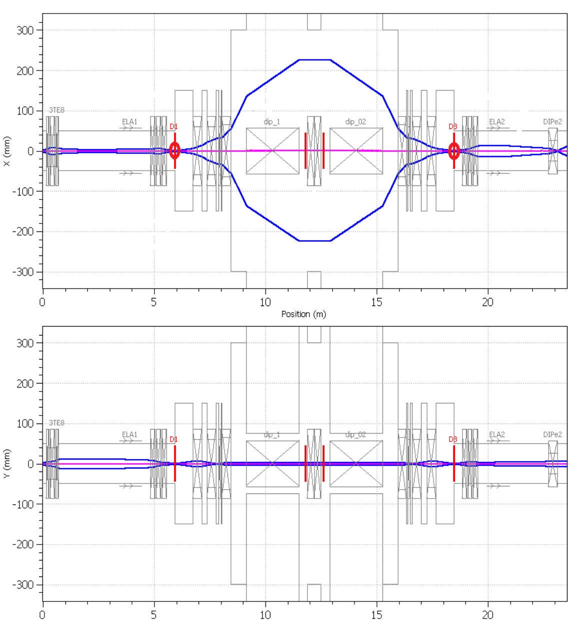

Figure 2: Beam multiparticle envelopes of matching mew HRMS structure with Beam Cooler in horizontal (x) and vertical (y) directions.

At the beginning the initial part of the transport channel (from end of Beam Cooler) with new HRMS was matched for correction the beam transmission (Fig. 2, 3). The transmission of more than 99% was achieved.

The next step was modernization of periodic transport line and its connection with new HRMS and Charge Breeder by electrostatic dipoles. The location and potentials of triplets before and after electrostatic dipole were defined. The periodic structure with a period of about 6.6 m for the part transport line was created (the main parameters in Tab.2). This was done in order to reduce of dispersion, because its growth is the major problem in this work. The envelopes and dispersion function of transport line are shown in Fig. 5. The scatter of dispersion is in the range of -45 to 79 m, after the HRMS the 100% transmission are observed.

In the third step the beam matching with Charge Breeder entrance using fields map of electrostatic electrode, magnetic first coil and the plasma potential was made to test the obtain results (Fig. 4, 6). Growth of dispersion is a result of the bending by dipole and velocity decrease by the influence of the field map.

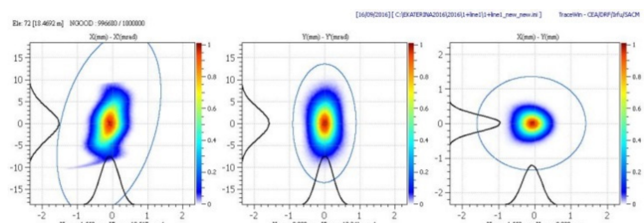

Figure 3: Phase space at the HRMS image point.

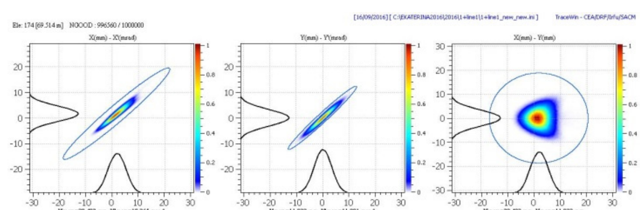

Figure 4: Phase space at the entrance of Charge Breeder.

Table 2: Transport line 1+ to the Charge breeder main parameters

Parameter	Value
Electrostatic triplet lengths (mm	(121+50+222+50+121)
Electrostatic triplet aperture	40 mm
Max voltage of electrostatic triplets	2.8 kV
Number of triplets	8
Triplets number of periodic part	5

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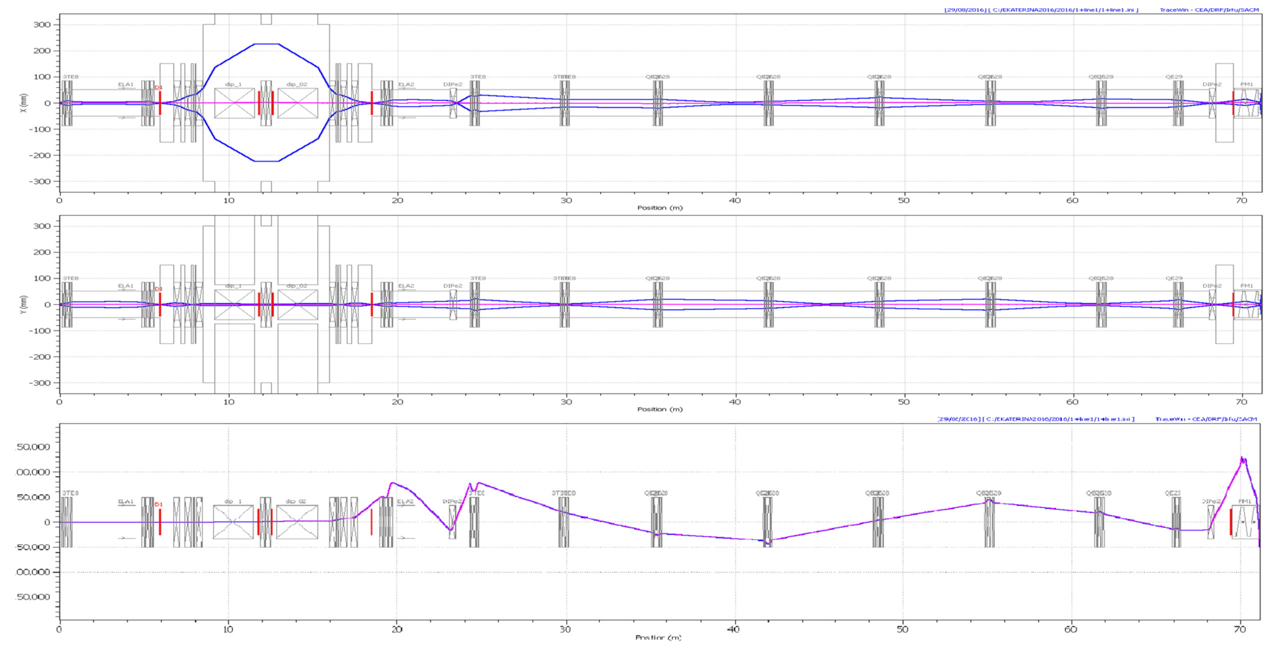

Figure 5: Beam multiparticle envelopes and dispersion of Transport line 1+ from High Resolution Mass Spectrometer (HRMS) to Charge Breeder.

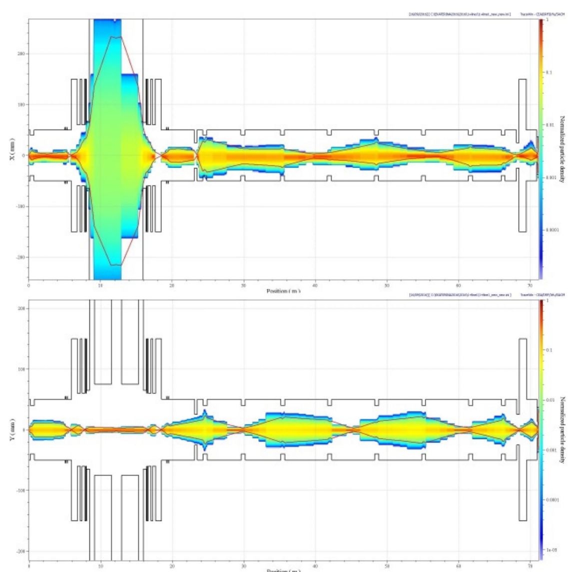

Figure 6: Multiparticle normalized-densities y and x of the Transport line 1+ from High Resolution Mass Spectrometer (HRMS) to Charge Breeder.

CONCLUSIONS

The beam dynamic simulation with new optimized design of HRMS (High Resolution Mass Spectrometer), using electrostatic dipoles located at the ends of the straight periodic transfer line was carried out.

As a result of simulation the modernization transport line allows to pass Sn^{132} beam through all section with minor losses only in HRMS (0.35%). The dispersion for this section is inside the acceptable margins (± 80 m). Test of beam transport channel output with real field distribution of the Charge Breeder matching results was performed. In a near future a full errors study of the transport line will be done.

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