Ion extraction simulations for the proton injector for FAIR*

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Introduction

IBSIMU (IonBeamSIMUlations) is a 3D simulation code developed to simulate H\(^{-}\) Beams [1]. The code is further used to analyze the behavior of positive ion beams. For the proton injector it is necessary to analyze the emittance, brilliance and perveance of the ion beam to find optimized working parameters for experiments during commissioning of the proton injector. The commissioning will take place at the end of 2016 at CEA/Saclay.

IBSIMU simulations

The proton injector front end for FAIR consists of an ECR-type ion source and a pentode extraction system consisting of a plasma electrode, a puller electrode, two ground electrodes and a encapsulated screening electrode [2]. A short LEBT (Low Energy Beam Transport) including two solenoid-steerer systems and a diagnostics chamber behind the extraction and provides for transport of the ion beam to the RFQ. For the simulations shown in this report, the following plasma parameters are defined: temperature of the ions \( T_i = 0.5 \) eV, temperature of the electrons \( T_e = 5 \) eV. \( 1 \times 10^6 \) particles are used for the simulation with a fraction of 95.5\% \( H^+ \), 2.5\% \( H^+_2 \) and 2\% \( H^+_3 \) and the related masses and charge state. The potential of the plasma electrode is set to \( U_{Pl} = 95 \) kV. A distribution of the electric field could be reached with the following voltages in the system: Puller electrode \( U_{Pu} = 52 \) kV, screening electrode \( U_{SE} = -2.5 \) kV and \( \omega_{max} = 75 \) mrad (1) Plasma electrode (2) Puller Electrode (3) Ground electrode (4) Screening electrode.

The proton beam current is set to 100 mA as needed for FAIR operation. Figure 1 shows the so called matched case extraction for the ion beam. Only the ion extraction picture section is shown. The maximum divergence angle of the ion beam is \( \omega_{max} = 94 \) mrad at the entrance to the LEBT at 0.124 m. Figure 2 shows the adjustment of the divergence angle \( (\omega_{max}, \omega_{90\% particles}, \omega_{90\% angle}) \) to the ion beam current density at the entrance of the LEBT at 0.124 m. In all cases the simulated divergence angle for the system is not lower than \( \omega_{90\% particles} = 44 \) mrad and \( \omega_{90\% angle} = 60 \) mrad for \( I_{ionbeam} = 100 \) mA, taking only 90\% of the particles into account. Beam losses in the extraction system occur due to the loss of secondary ions and recombination processes. All simulated data has to be verified during the commissioning.

References


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