Particle Dynamic Simulations of the GSI Test Injector Facility HOSTI

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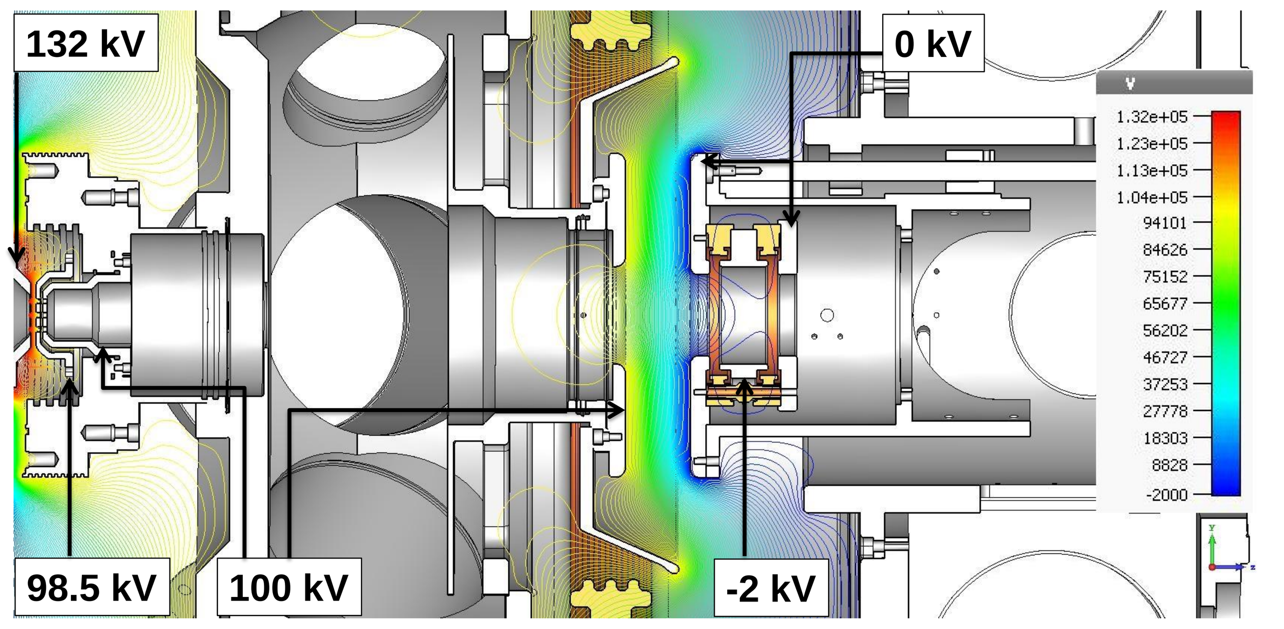
ABSTRACT: At GSI a high current test injector (HOSTI) is in operation since 2009. It has been designed for the experimental investigation of high brilliance low charge states ion beams and for the injection optimization of high current ion beams into the existing and future LINAC. The ion beam from HOSTI is extracted with a three-electrode system and post-accelerated to match the injection energy of 2.2 keV/u of the RFQ. In order to improve the understanding of the effect on the ion beam dynamic of the main components of the post acceleration system, the electric field has been simulated for different configurations. The simulated potential lines have been used to analyze the ion trajectories downstream the extraction system and through the post-acceleration system and the simulated emittances are in very good agreement with the measurement results. Different settings of ion beam have been investigated and several parameters have been tuned to find the optimized configuration determining the highest brilliance of the extracted ion beam and the results of these particle dynamics simulations are described here

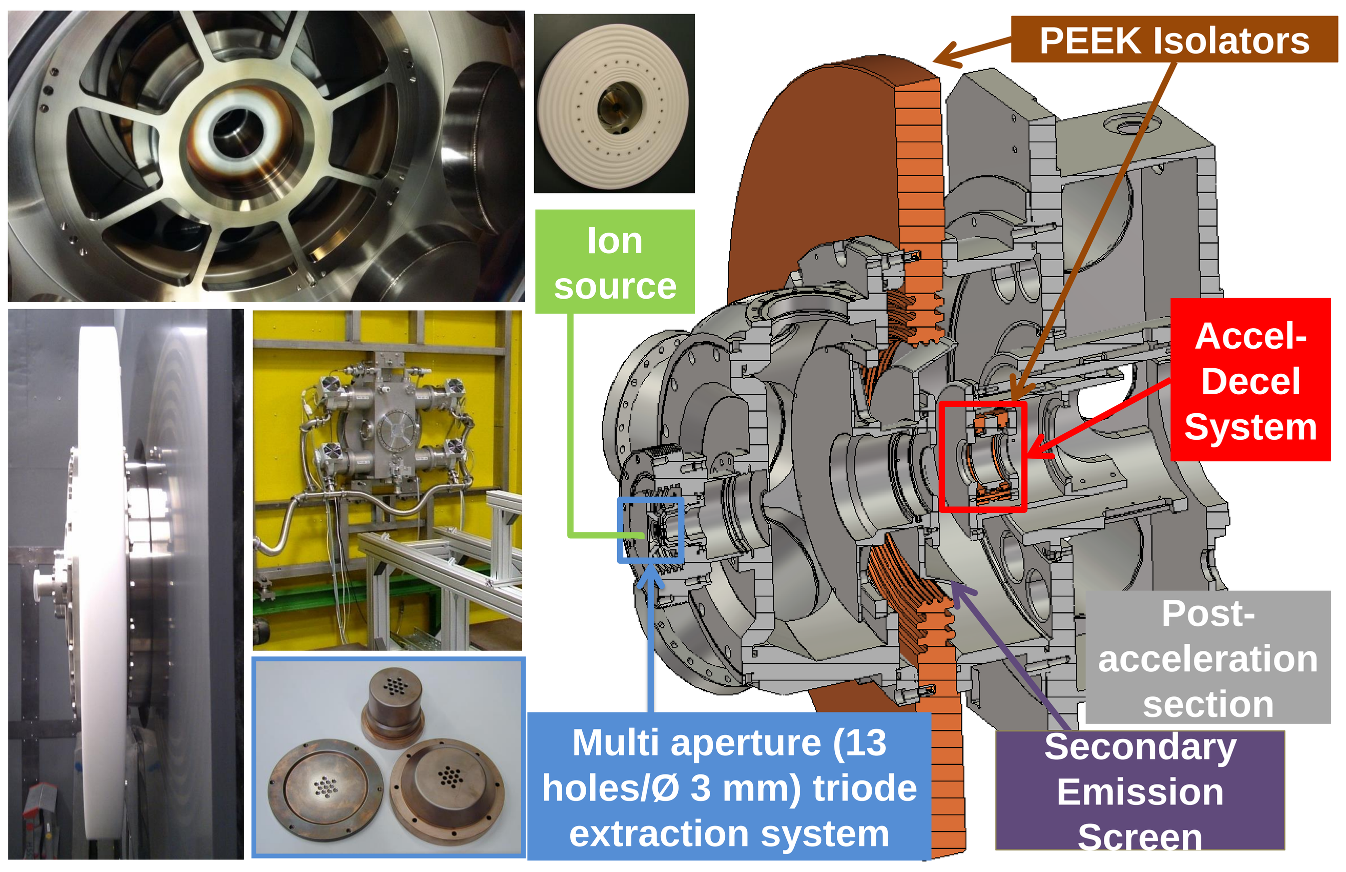
ELECTROSTATIC SIMULATIONS

Isolators: PEEK (3.2 electric permittivity, 10^{14} Ωm resistivity).

Metal parts: Perfect Electric Conductors (PEC).



Electric potentials at the extraction/post acceleration system



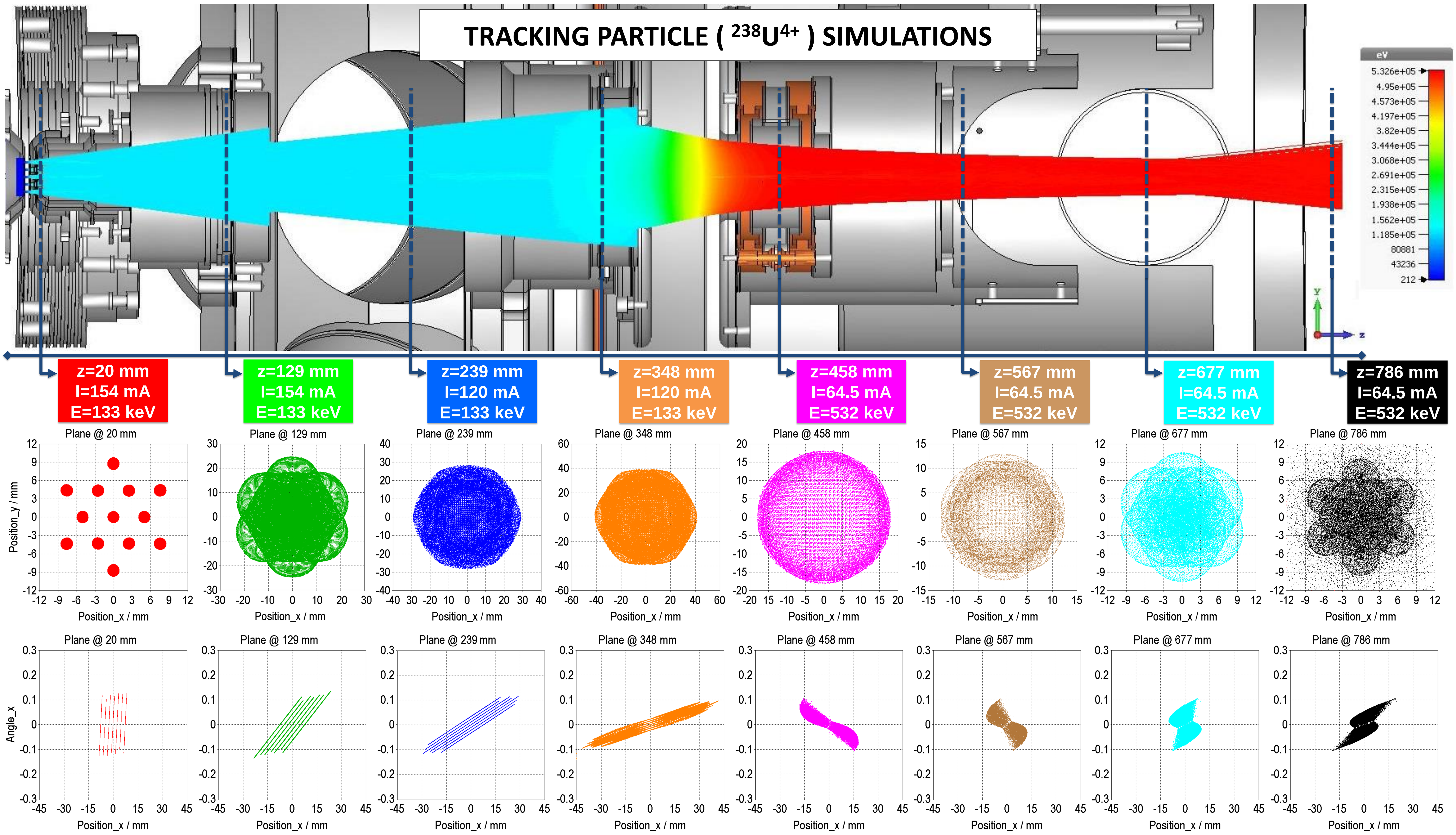
HOSTI post acceleration system layout

Plasma emission - simulation parameters (measured with an 127° cylinder spectrometer)[4]

PARAMETER	
Emission current density	170mA/cm ^{2}
Plasma electron energy	11 eV
Ion initial energy	150 eV
Plasma potential	10 V

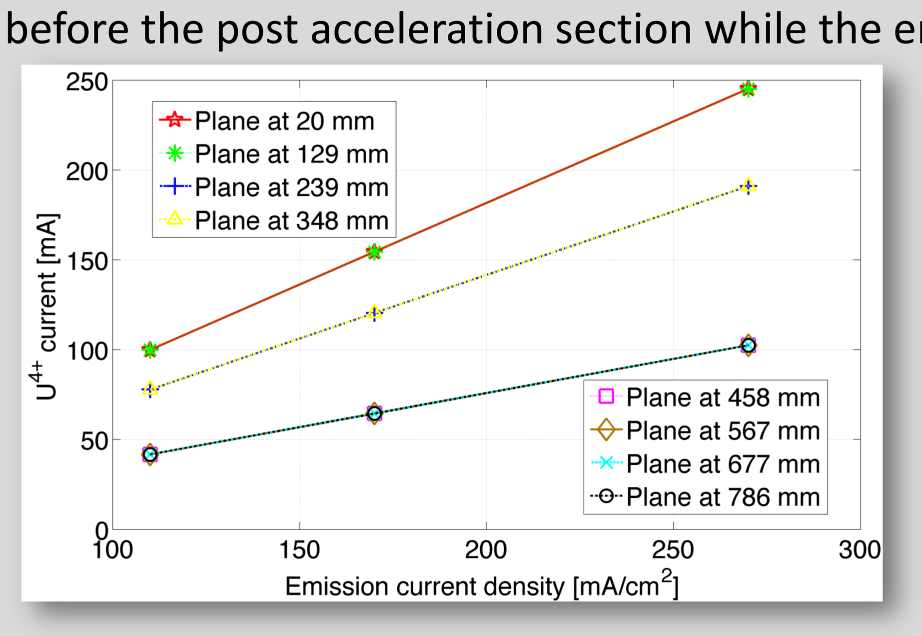
- More than 400000 $^{238}U^{4+}$ ions emitted from an equipotential surface spanning across the multi aperture holes extraction system, the plasma meniscus, defined by the emission potential. [3]
- This plasma sheath emission model includes a plasma core modelled by an appropriately shaped PEC solid at a fixed potential, i.e. 10 V higher than the plasma electrode potential. [2]

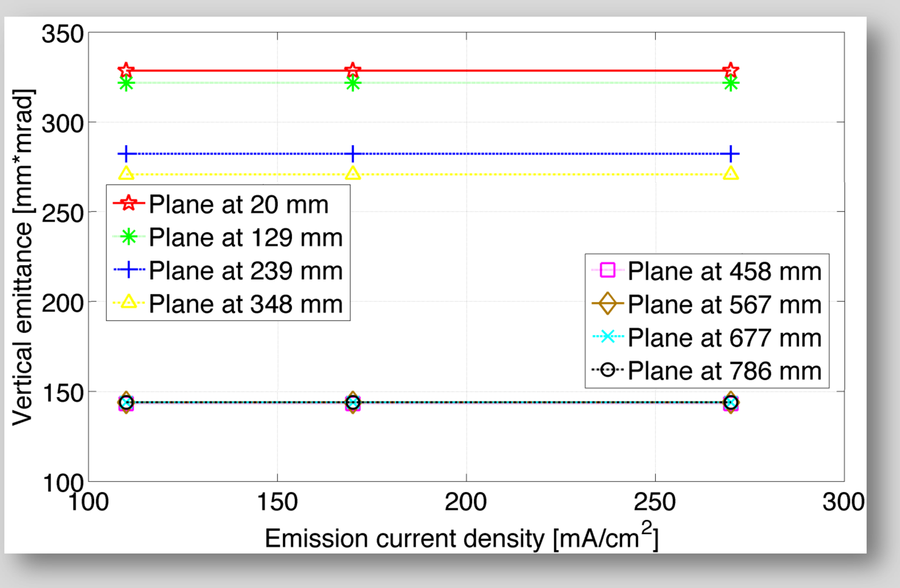
TRACKING PARTICLE ($^{238}U^{4+}$) SIMULATIONS

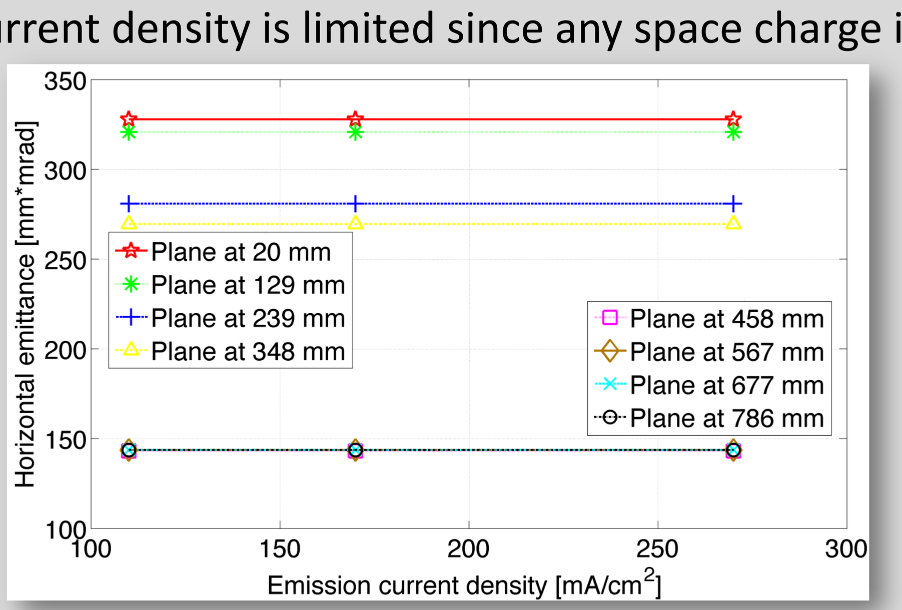


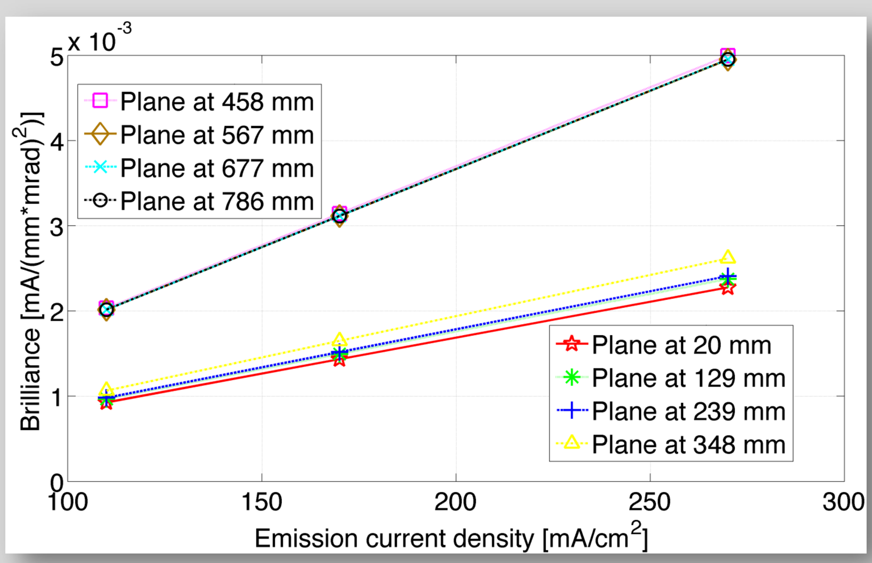
EMISSION CURRENT DENSITY VARIATION

The main characteristics of the accelerated beam, i.e. intensity, emittances and brilliance, are investigated by tuning the plasma emission parameters. The influence of the initial ion energy variation of ±50 eV on the beam emittance and intensity is limited and the plasma potential hump increase to 50 V or 100 V slightly affects these parameters as already observed in [1] The **increase of the emission current density from 110 mA/cm² to 270 mA/cm²** affects conversely the ion beam intensity and the brilliance. This variation is mostly affecting the ion beam intensity before the post acceleration section while the emittance variation due to the increased emission current density is limited since any space charge interaction is included in the model.









CONCLUSIONS AND FUTURE PERSPECTIVES

According to the simulations results and to the good matching with the emittance and real space measurements results [5], it is proven that CST Particle Studio® [2] is able to provide consisting particle tracking results for complex and large geometries in limited computational times (<8 hours with a workstation equipped with a 128 GB RAM). Future investigations will include a space charge compensation degree and the effect of the distributed plasma sheath space charge on the potential map.

[1] W. Xiang *et al*, GSI Internal Report 02.07.2004 [2] CST PARTICLE STUDIO® (https://www.cst.com/products/cstps) [3] I. G. Brown,The Physics and Technology of Ion Sources,Wiley-VCH, Weinheim,2004
[4] R. Hollinger, M. Galonska, Nucl. Instr. Meth. Phys. Res. B 239, (2005) [5] A. Adonin and R. Hollinger, Rev. Sci. Instrum. 85, 02A727 (2014)