LOW-ABERRATION EXTRACTION OPTICS SYSTEM FOR THE ELECTRON- BEAM-PLASMA ION SOURCE

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Because of the rather long distance between the point of extraction and the center of the quadrupole lens system on the RIB high voltage injector, transmission losses can occur due to the imperfect match of the emittance of the beam and acceptance of the lens system. In addition, the emittances of highly divergent ion beams of half-angle α will be increased due to the α^3 dependence of the spherical aberration coefficient. For other sources with less favorable angular divergences and emittances, the losses will be greater. Therefore, low-angular divergence extraction electrode systems are desirable both from the standpoint of beam transport and beam quality. In an effort to reduce both these effects and ensure the efficient transport of beams extracted from the ORNL/CERN-ISOLDE electron-beam-plasma ion source (EBPIS), a series of computational simulation studies were performed with *PBGuns*[2] in an effort to iteratively design an extraction electrode system that reduced both the angular divergence and aberrational consequences of beams extracted from the source. Comparisons of the optics of 20 keV, 5 μA, mass 40, ion beams for the original tapered extraction electrode system and the improved hemispherical electrode system, are shown, respectively, in Figs. 1 and 2. As noted, the half-angular divergences, α, are, respectively, $\alpha = \pm$ 55 mrad and $\alpha = \pm$ 30 mrad. The aberrational effects of the two systems can be readily observed by comparing the relative curvatures of their respective emittance diagrams. These effects will be further reduced by acceleration at higher extraction voltages. For example, the potential generally used during extraction on the RIB injector is 40 kV, in which case the half-angular divergence for the tapered electrode system will be $\alpha \cong \pm$ 39 mrad and $\alpha \cong \pm$ 21 mrad for the improved system.

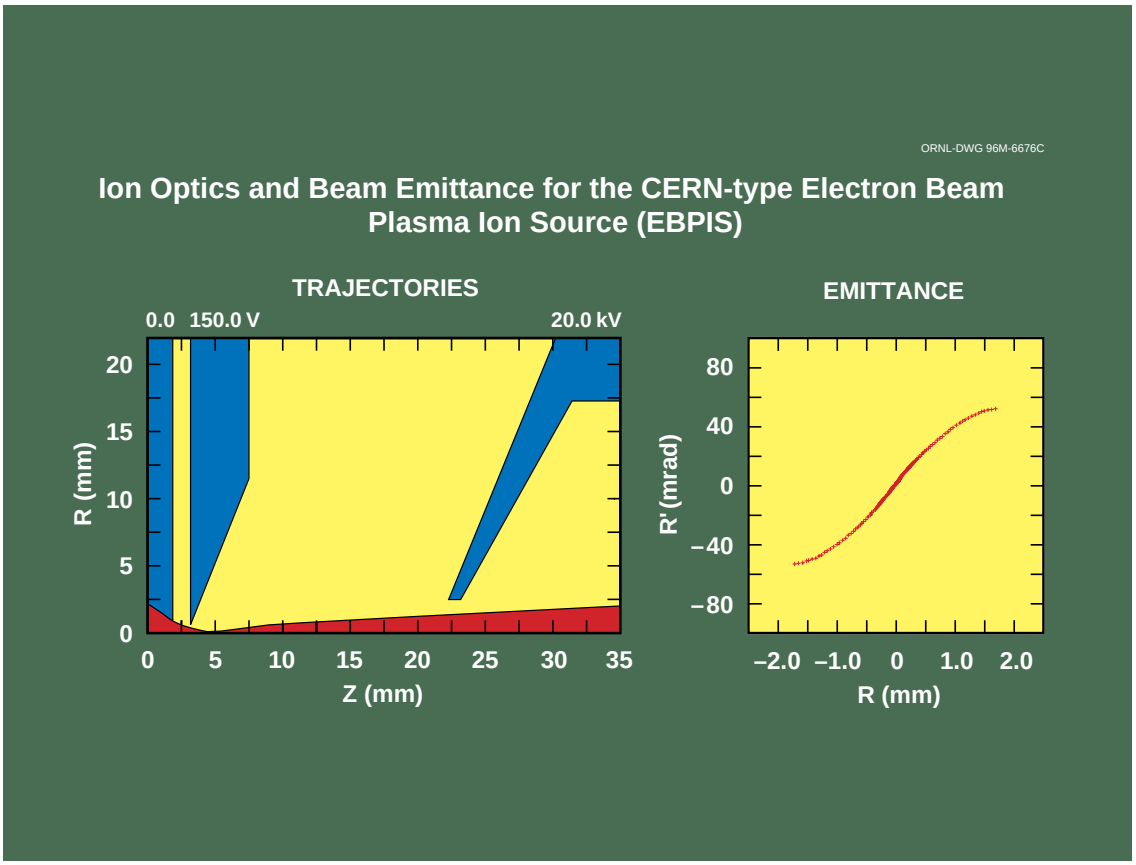

Fig. 1. Simulation of the ion optics and beam emittance of the ORNL/CERN-ISOLDE electron beam plasma ion source (EBPIS) with a tapered geometry focus electrode. Extraction voltage: 20 kV; Beam intensity: 5 μA; half-angular divergence: $\alpha \cong \pm 55$ mrad.

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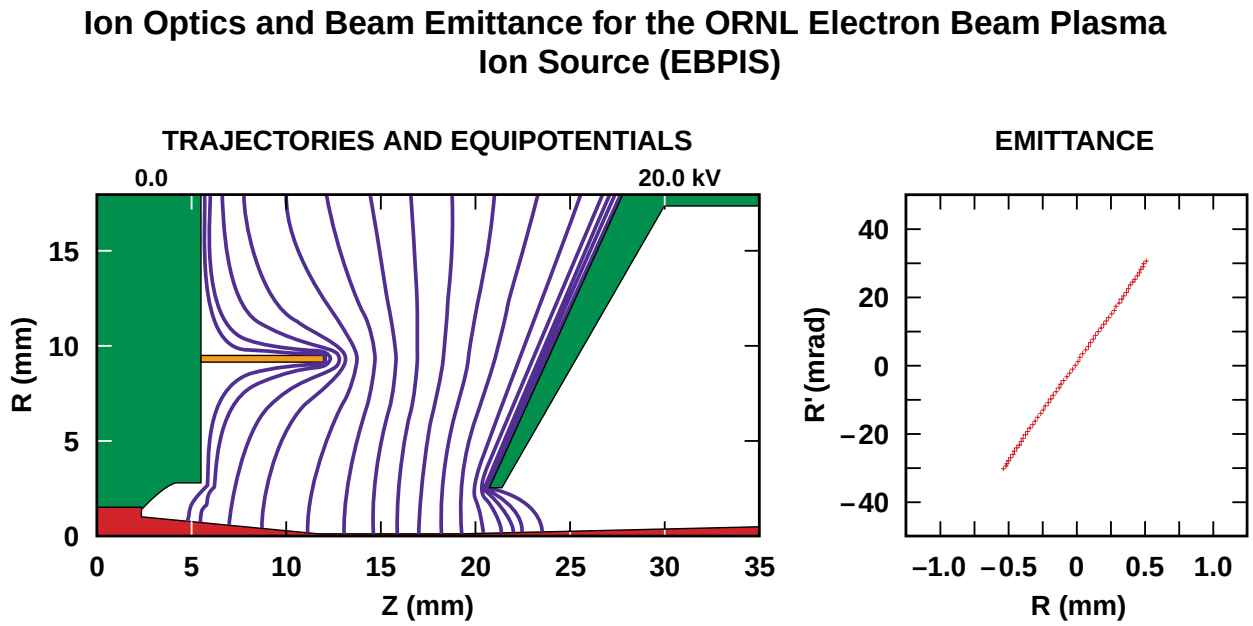

Fig. 2. Simulation of the ion optics and beam emittance of the ORNL/CERN-ISOLDE electron beam plasma ion source (EBPIS) with a hemispherical geometry focus electrode. Extraction voltage: 20 kV; Beam intensity: 5 μA; half-angular divergence: $\alpha \cong \pm 30$ mrad.

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[2] *PBGuns* is an electron/ion optics simulation code, developed by Thunderbird Simulations, Garland, TX.