Comparison of Experimental and Simulated Results for the SSC LEBT

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Abstract

The SSC LEBT (Low Energy Beam Transport) device focuses and steers a divergent 30 mA H^- beam extracted at 35 KV from the volume ion source into a strongly converging beam to match the acceptance of the 2.5 MeV RFQ. Of the LEBT candidates, an einzel lens and HESQ (Helical Electro-Static Quadrupole) are presently under study at the SSC. The experimental emittance results for the einzel lens at the RFQ acceptance plane are compared to AXCEL simulations. A comparison is made between the PARTEQ simulated percent of beam transmitted through the RFQ with the experimentally measured beam and with the simulated AXCEL beam.

I. INTRODUCTION

The SSC LEBT focuses the divergent 30 mA H^- beam from the volume H^- ion source[1] into the 2.5 MeV RFQ as part of the SSC Injector for the Linac. Electrostatic focusing LEBTs were chosen because of the SSC requirement of a short pulse length (9.6-48 μ sec) beam. For such a short pulse length it was decided to avoid a LEBT using magnetic solenoids and neutralization gas focusing. The electrostatic lenses were well understood and were suitable for arbitrarily short pulses. A photograph of the ion source-einzel lens-RFQ entrance assembly is shown in Fig. 1. The RFQ acceptance requirements are quite demanding, requiring a strongly converging (140 mrad)~4 mm diameter beam. The acceptance Twiss parameters are: $\alpha_{x,y} = 1.26$, $\beta_{x,y} = 0.0186$ mm/mrad, and $\varepsilon_{rms,nor} < 0.20\,\pi$ mm-mrad. See Fig. 5.

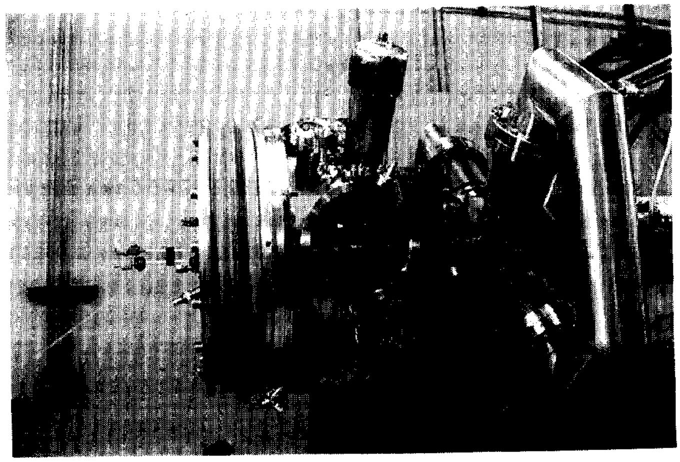

Fig.1 Ion Source-LEBT-RFQ entrance Assembly.

The beam optics geometry, potential lines, and beam ray traces are shown in Fig. 2. Reference Fig. 2 for the following dimensional location descriptions. A magnetic dipole electron separator occupies the axial space 0.0 to 3.2 cm. The axial space between 3.2 and 16.9 cm is expandable and depicts the

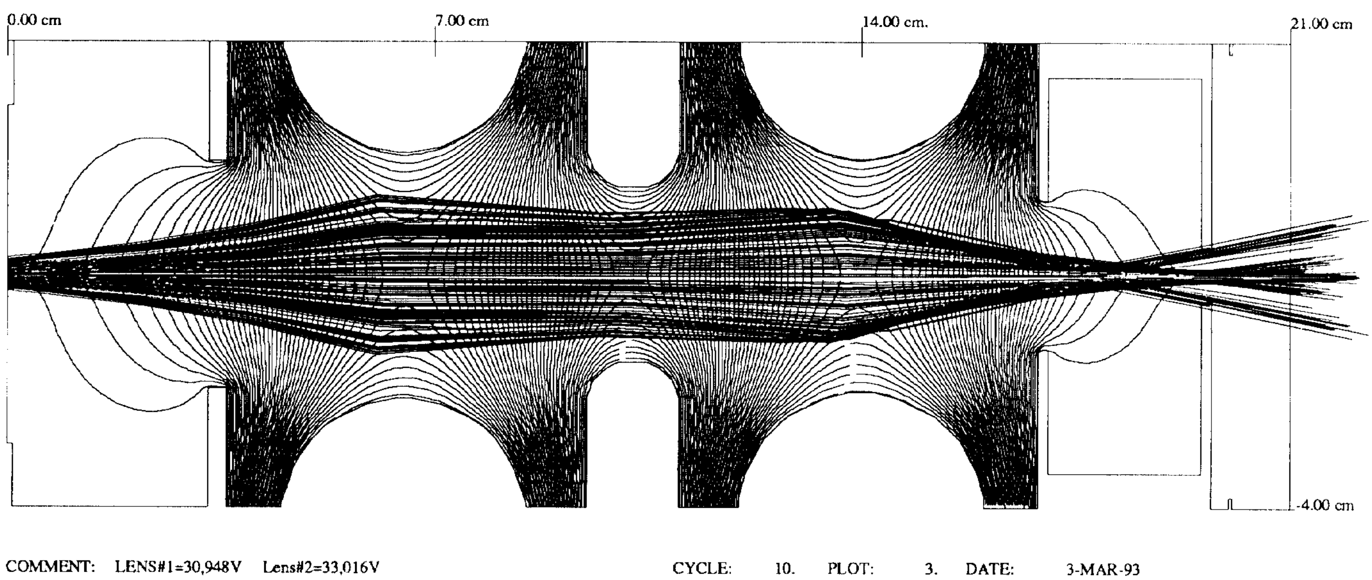

Fig. 2 Einzel lens geometry, potential lines,beam trajectory.

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LEBT. The center electrode of the einsel lens is a split quadrant used both as a quasi ground plane for the lenses and to steer the beam vertically and horizontally. The acceptance plane for the RFQ is at 20 cm (as shown by the indentation in Fig. 2). The axial space between 17 and 20 cm is reserved for diagnostic insertion. This drift space does limit the beam convergence of this LEBT design.

II. CALCULATIONAL METHOD

An experimental phase-space plot of the extracted beam is shown in Fig. 3. The H^o beam has been subtracted. The Twiss parameters are: α_x= -21.38, β_x= 0.1217 cm/mrad, and $\varepsilon_{rms,unnor}$= 1.59 cm-mrad at the 91.8% contour line, assuming a gaussian beam. The Y-plane phase-space plot is very similar except angled upward at 22 mrad because of the electron separator magnet. Because AXCEL[2] assumes cylindrical symmetry, the X-plane plot was used for this simulation input. The experimental ion source phase-space plot was generated within AXCEL. With the experimental voltages applied to the lenses (nominally 31KV upstream and 33KV downstream), the phase-space plot of Fig. 4 was simulated at the RFQ acceptance plane. Ten iterations with 1,000 rays was used. The experimental phase-space plot from a slit and collector is shown in Fig 5. In both Figs. 4 and 5 the nominal RFQ acceptance ellipse is shown. The particles within the described RFQ acceptance ellipse are transmited through the RFQ. The other particles are not transmited, due mainly to transverse mismatching [3].

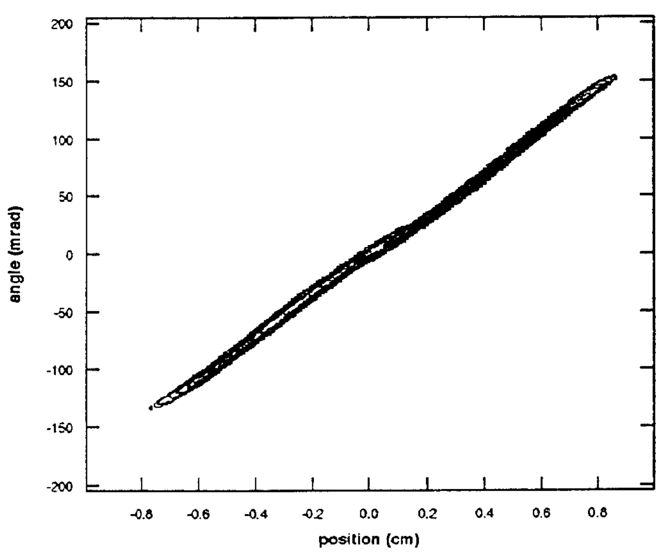

Fig. 3 Experimental beam extracted from the ion source

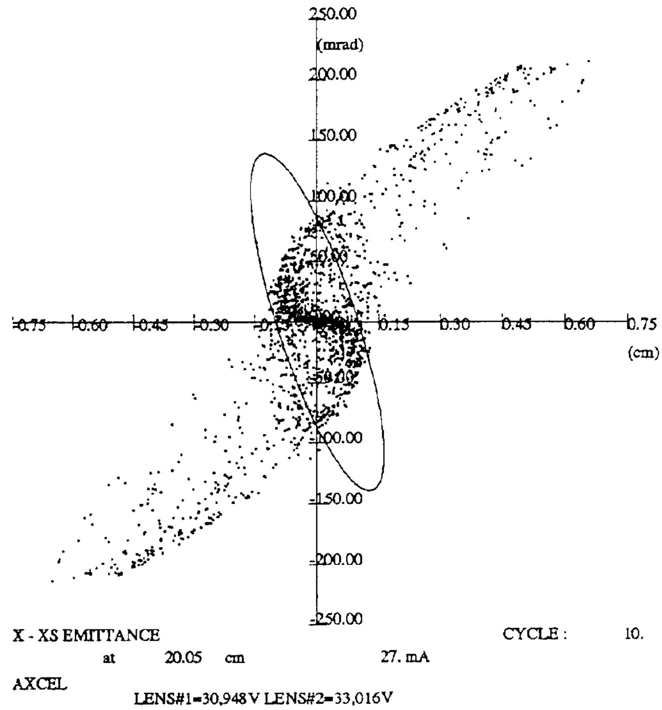

Fig. 4 AXCEL phase-space plot

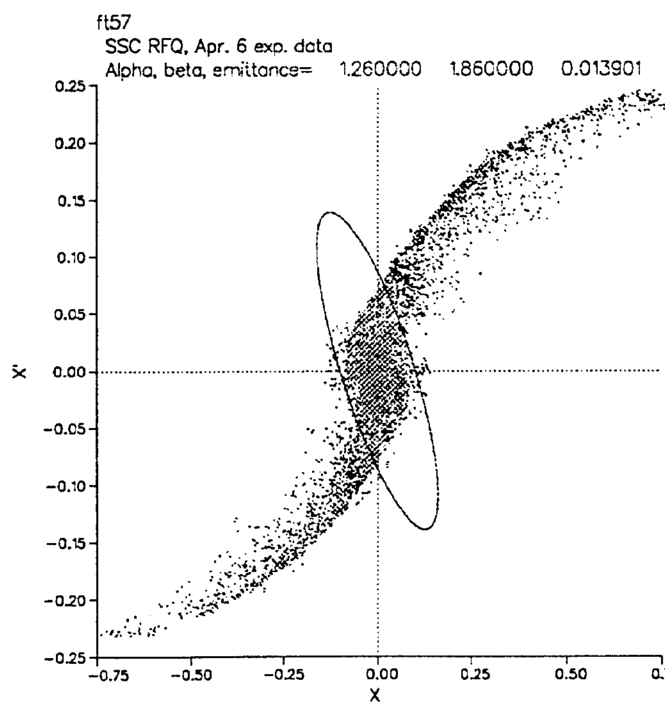

Fig. 5 Experimental phase-space plot

III. CONCLUSIONS

For comparison, the resultant Twiss parameters for all the particles are shown in Table 1. Included is the important comparison of the sub-set of particles transmited through the RFQ, simulated by the multiparticle code PARTEQ [4].

Table 1.

	α	β cm/mrad	$\varepsilon_{rms,unnor}$ cm-mrad	RFQ % trans. simul
Exper. 91.8%cont	-2.018	0.0040	9.240	38.8
AXCEL 90%cont	-2.029	0.0054	10.722	62.

Considering that neither the spacial and angular translations of the experimental beam nor the steering voltages were included in the AXCEL simulation, the comparison in Table 1 indicates reasonable agreement of the Twiss parameters for all the particles (a macro comparison). However in the region of special interest, that portion of the emittance plot whithin the RFQ acceptance ellipse, the PARMTEQ simulated percent transmission through the RFQ using AXCEL simulated and experimental beam as input is only whithin ~60% agreement.

The AXCEL input file asks for the Twiss parameters (α, β and ε) of an input beam then a particle-by-particle input file is created from these parameters. When one knows the particle-by-particle parameters, such as in our slit-collector emittance data, one might enter these data directly into the input file. This method may improve the accuracy of AXCEL when a particle-by-particle emittance is known, incorporating spacial and angular translation.

IV. ACKNOWLEDGEMENTS

We wish to acknowledge the efforts of Jun Wu in revising the AXCEL SSC code from a VAX to a UNIX operatable code.

V. REFERENCES

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