Ion Source/LEBT Physics

R. Keller

Front-End Systems Senior Team Leader

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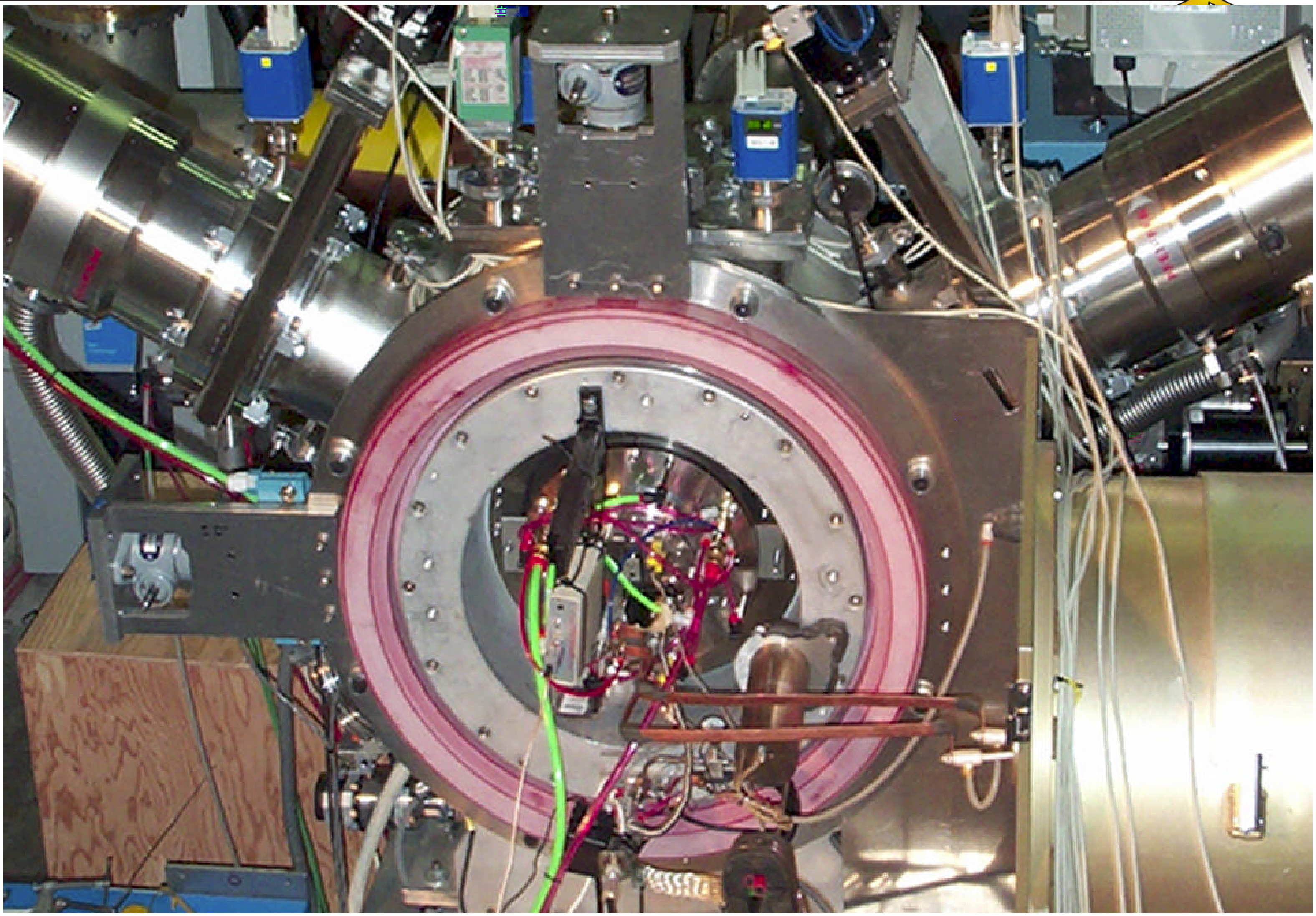
Front-End Requirements

Ion species	**H^-**
Energy (MeV)	**2.5**
Front End peak H^- output current (mA)	**52**
Ion source output current (mA, estimated)	65
Normalized rms output phase space	
LEBT ε transverse (π mm mrad)	0.20
MEBT ε transverse (π mm mrad)	**0.27**
MEBT rms energy spread (keV)	**13.9**
MEBT rms phase spread (degrees)	**8.7**
Duty factor	**6%**
Repetition rate (Hz)	**60**
Chopper system rise time (ns)	**10**
Chopped beam off/on current ratio	**10^{-4}**

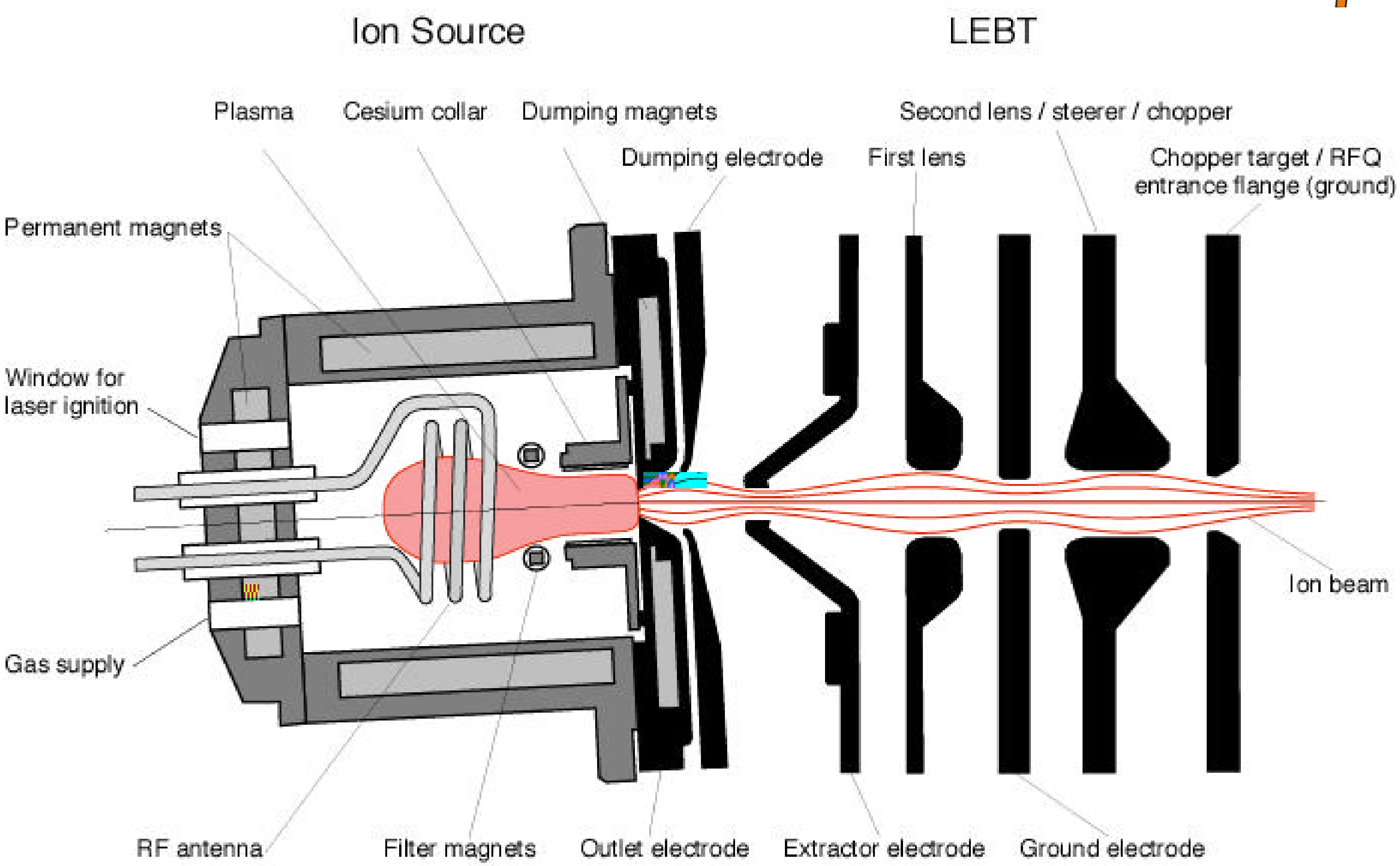
IS/LEBT Technical Characteristics

- Multi-cusp, rf-driven, volume-production, cesium-enhanced H^- Ion Source
- Electron removal from beam at low energy
- All-electrostatic LEBT
  - No space-charge compensation
- LEBT provides pre-chopping and angular steering

Startup Ion Source and LEBT



Ion Source and LEBT Schematic



Some magnet orientations are rotated into the viewing plane of this illustration

Ion Source and LEBT Status

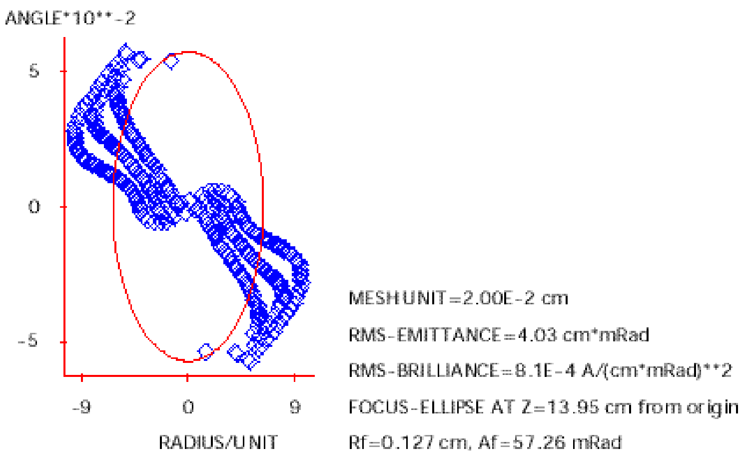
- Exceeded startup beam current goal of 35 mA
  - Measured 42 mA using startup LEBT at full duty factor
  - 46 mA peak beam current
  - No emittance measurement yet for this current range
- Fabricated and operated 65-mA capable LEBT
  - Unexpected steering effect
  - Intense electron beam hitting extractor electrode when operating ion source without cesium
- Routinely operating at 65-keV beam energy up to nominal duty factor
- Fabricated first production Ion Source and tested it on separate test stand
- Using coaxial quartz/steel-tube antenna

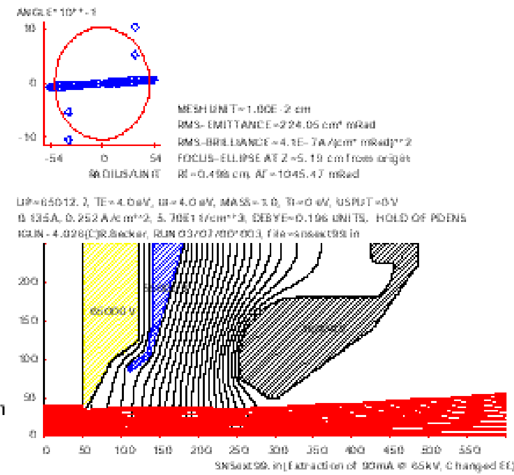
Ion Source Issues Currently Being Pursued

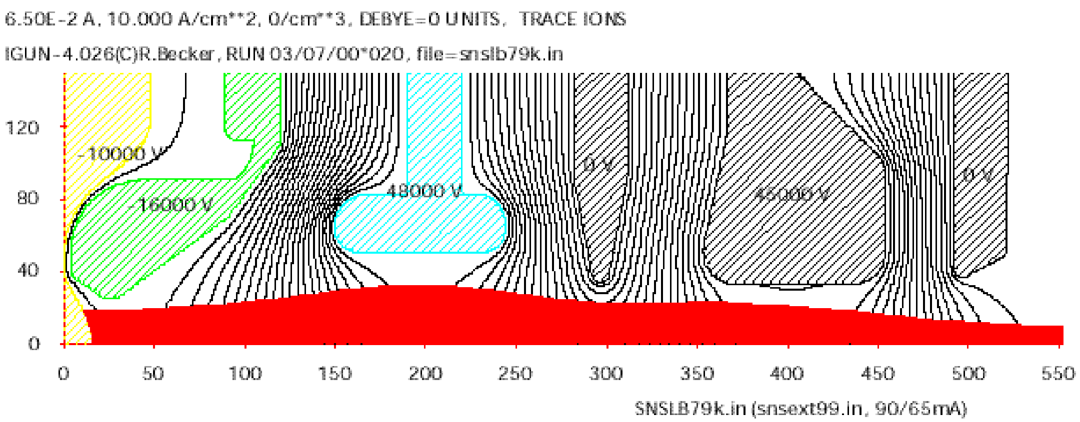
- Source conditioning
- Plasma ignition
- Cesium management and detection
  - Spectroscopy
  - Residual gas analyzer
- Electron-dumping configuration
- RF matcher configuration

65-mA LEBT Physics Design

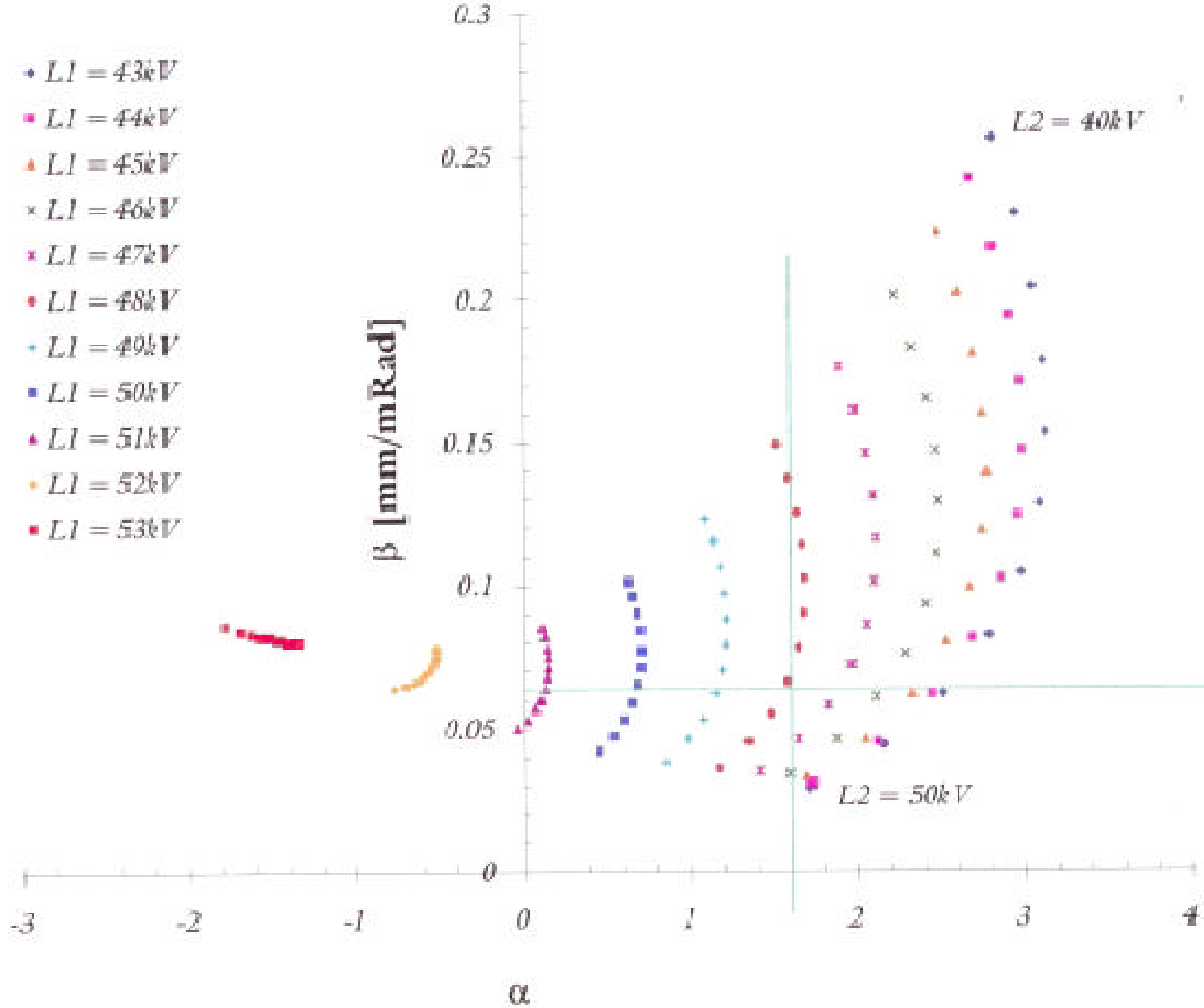
Given values represent 4*rms, unnormalized x/x' emittances



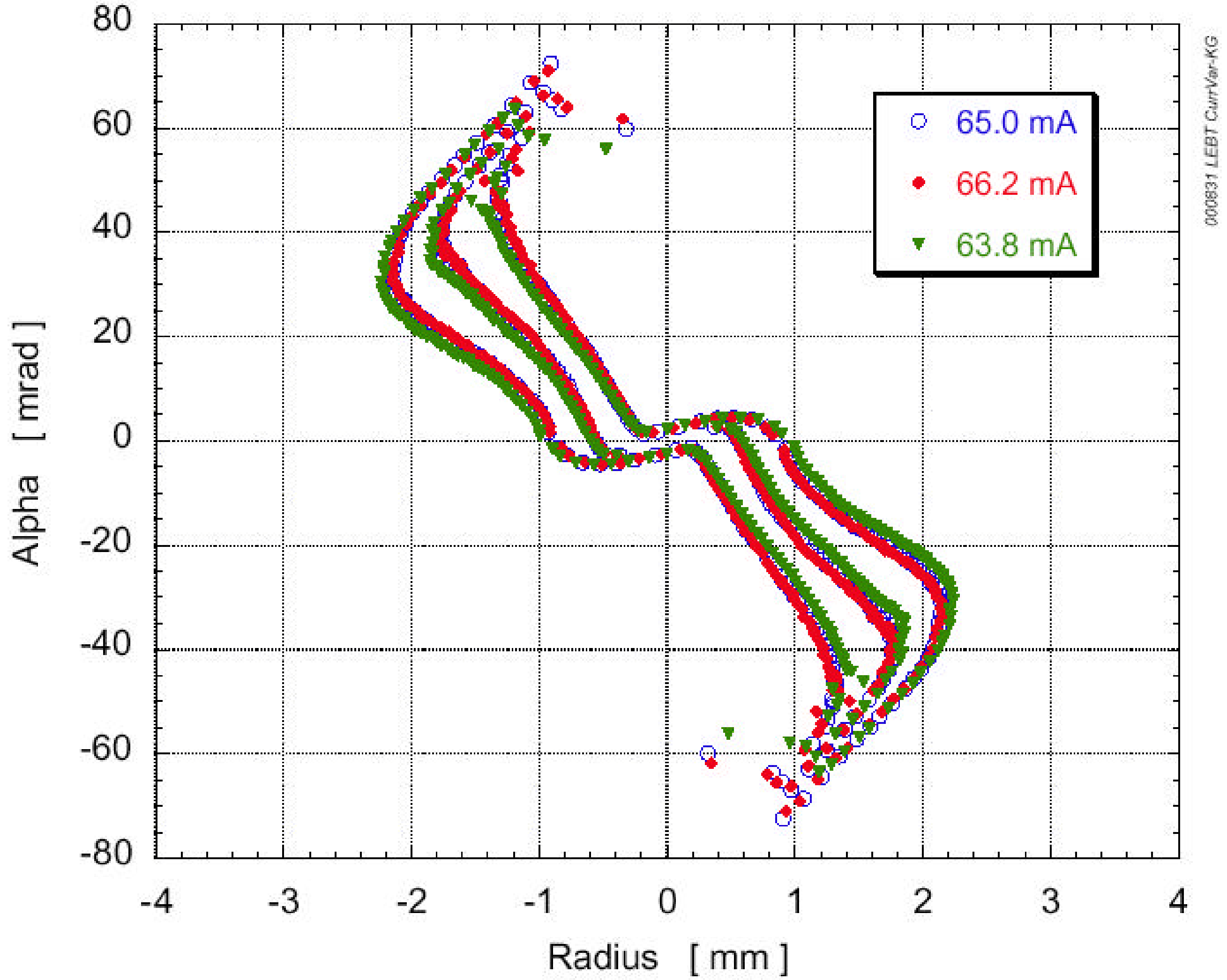




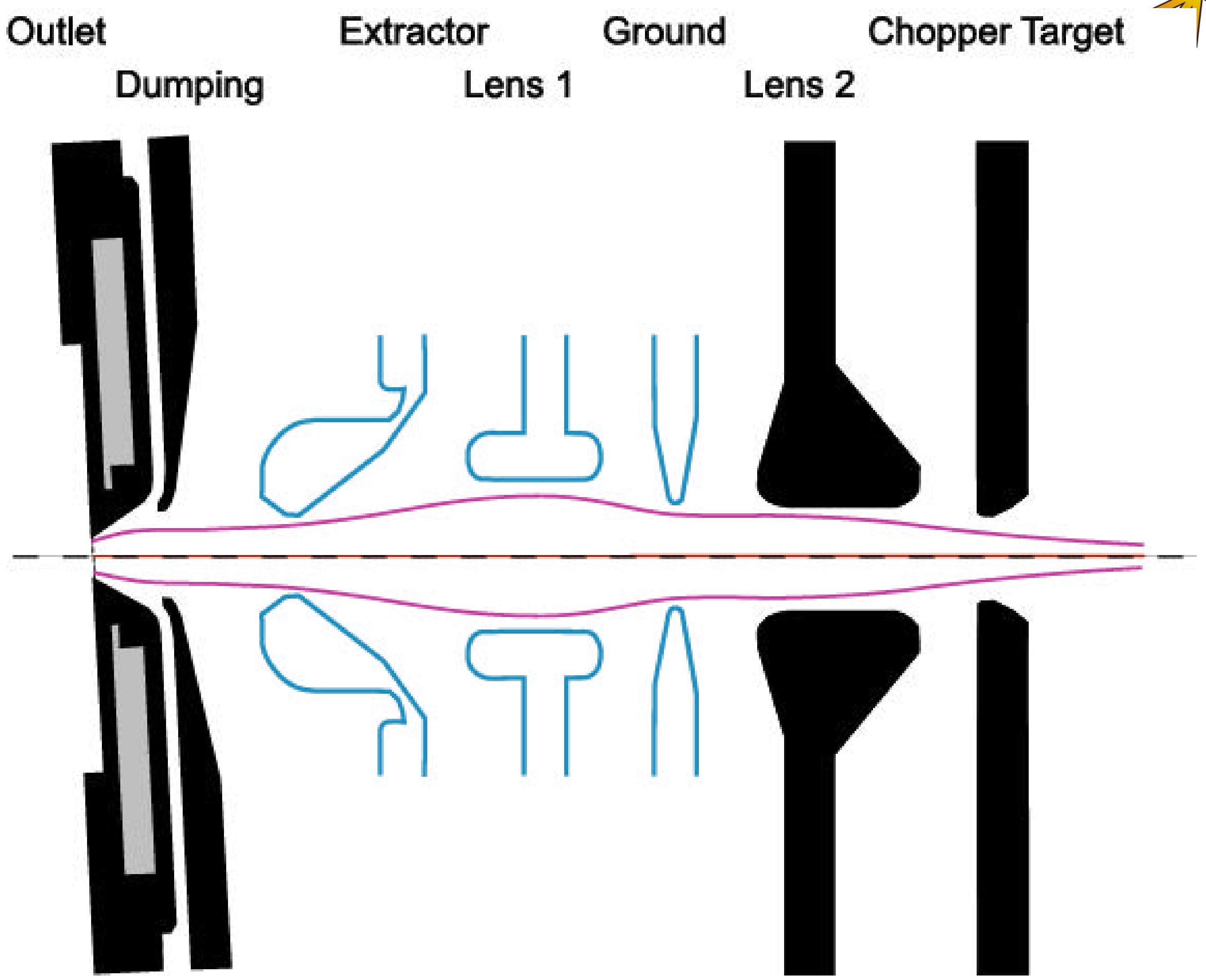
Production LEBT Tuning Matrix



Current-Sensitivity of Production LEBT



65 mA Production LEBT Layout



Recent and Future LEBT Work

- Electrostatic steering action by second lens verified
- LEBT chopper to be tested
  - Modeled after successful proton-beam steerer
  - Nominal beam deflection more than sufficient for “full” beam extinction
  - Actual level of beam-in-gap extinction to be evaluated

Summary

- Good progress with startup IS/LEBT
  - Exceeded beam-current requirement
  - Emittance to be verified
- 2-dim beam transport calculations
  - Tuning matrix for LEBT lenses
  - Low sensitivity to beam-current variations
  - Useful to interpret measurements
- Unexpected steering effect and intense electron beam
  - Most likely caused by slow electrons near plasma
  - Going to be improved with cesium operation
- Systematically commissioning entire system