Ion Source, LEBT at LBNL: test goals, configuration, and tasks

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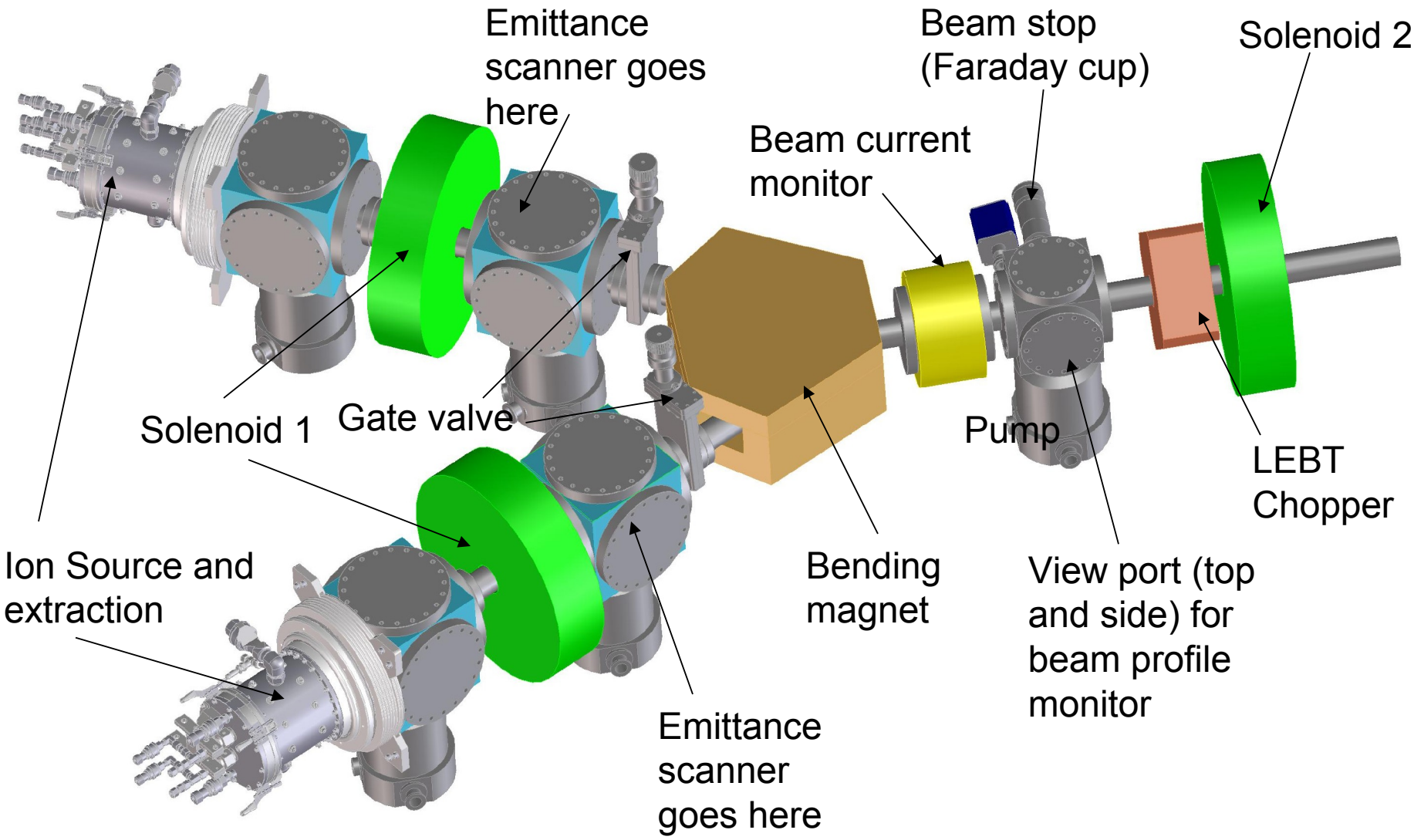
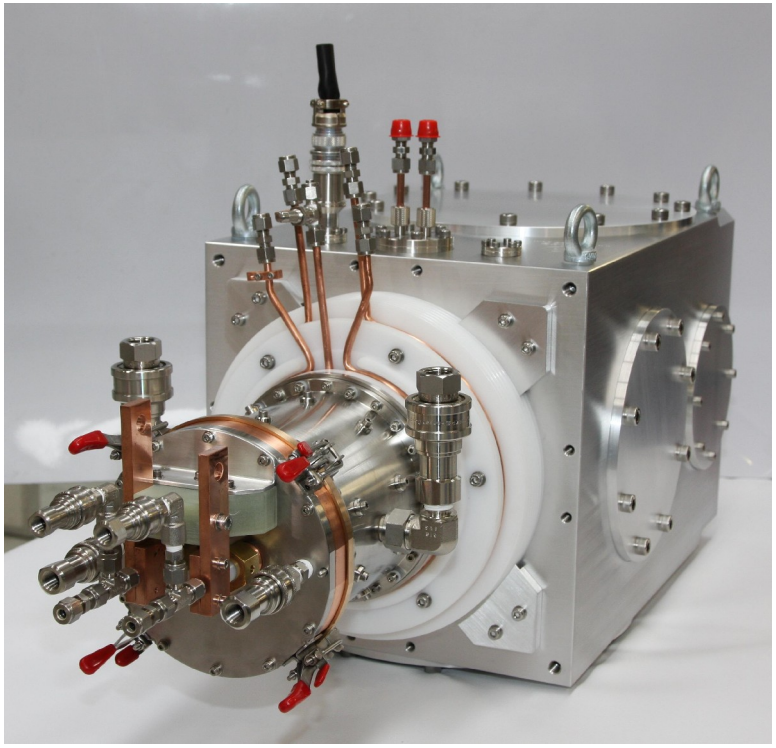
Ion Source and LEBT Beam line and Diagnostics



H- Ion Source

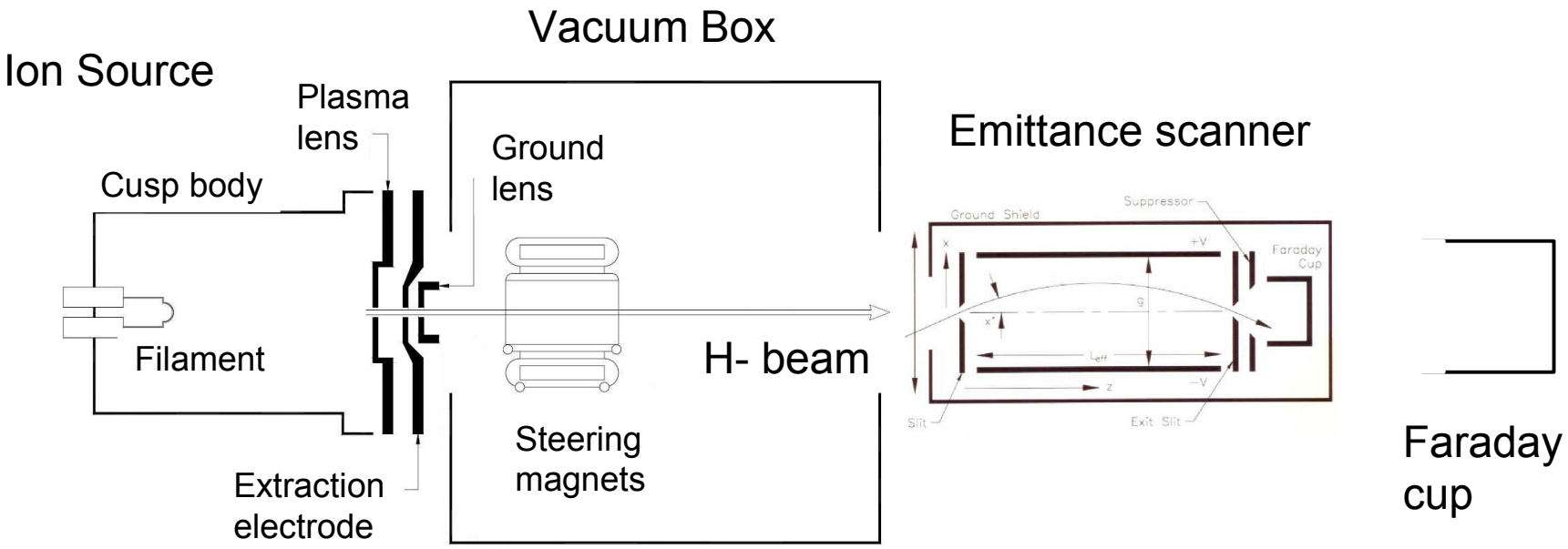


- D-Pace Filament-driven H- ion source delivered
  - cw operation
  - up to 15 mA
  - No Cs
- Acceptance test at TRIUMF (May 2011):
  - Gabriel Cojocaru (TRIUMF)
  - Keerthi Jayamanna (TRIUMF)
  - Thomas Stewart (D-Pace)
  - Lionel Prost (FNAL)
  - Qing Ji (LBNL)
- Test goals:
  - Verify beam current
  - Measure beam emittance
  - Check beam stability

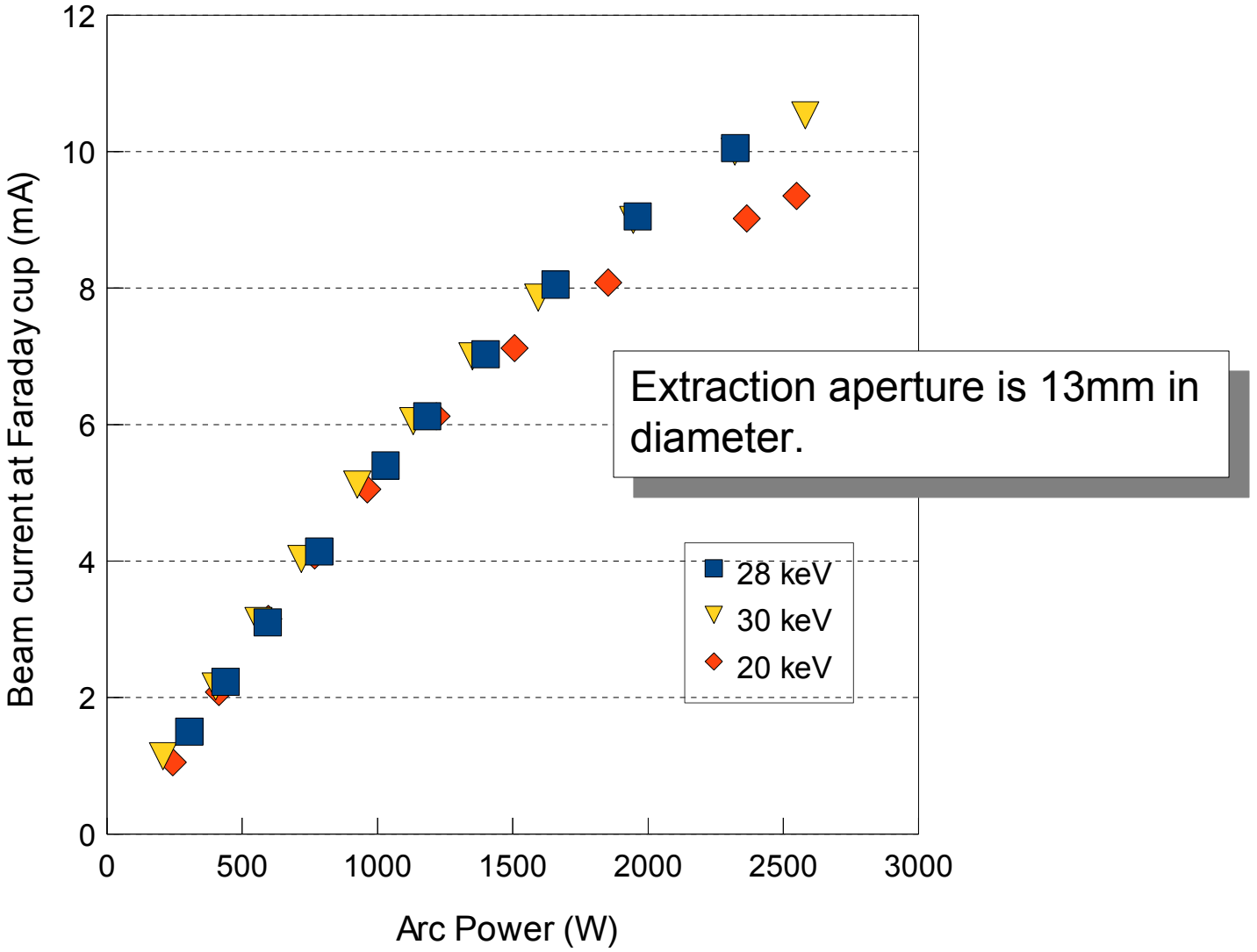
Acceptance Test Activities

- **The H- ion source was manufactured and assembled by Buckley Systems Ltd. (Auckland, New Zealand) and passed the Factory Acceptance Test before shipped to TRIUMF.**
  - Vacuum leak testing of entire assembly
  - Electrical isolation test
  - Verification of the magnetic fields (ion source body, back plate and extraction lens)
  - XY Steering Magnet: electrical isolation, temperature and voltage, magnetic field direction tests and magnet current and magnetic flux densities.
  - Cooling water flow rate test
- **Beam tests at TRIUMF (May 10, 2011 – May 13, 2011)**
  - May 10: Ion Source installed, no vacuum leak. Filament conditioning, and ramping up H- beam current from 1mA to 10mA.
  - May 11: Emittance scan from 1mA to 10mA, at 28keV and 20keV. Beam stability test at 5mA level at 28keV for two hours.
  - May 12: Emittance scan from 1mA to 10mA, at 30keV. Beam stability test at 10mA level at 28keV for over an hours.
  - May 13: Hands-on experience of source operation and tuning the beam at levels of 5mA and 10mA.

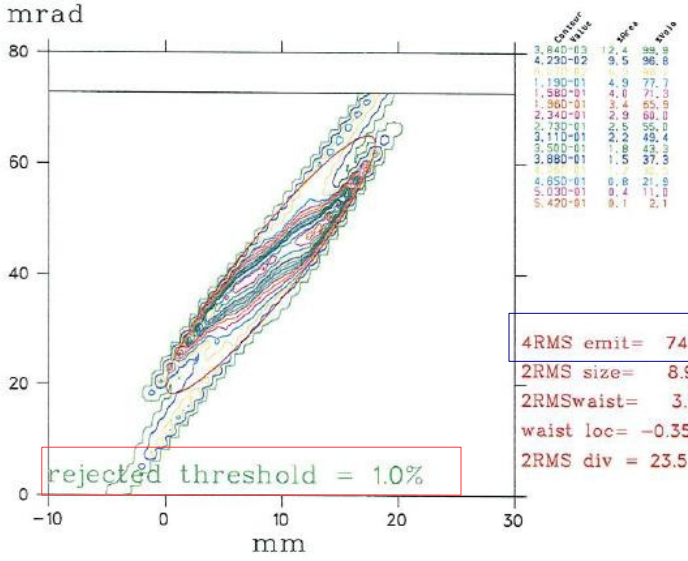
Experiment Setup

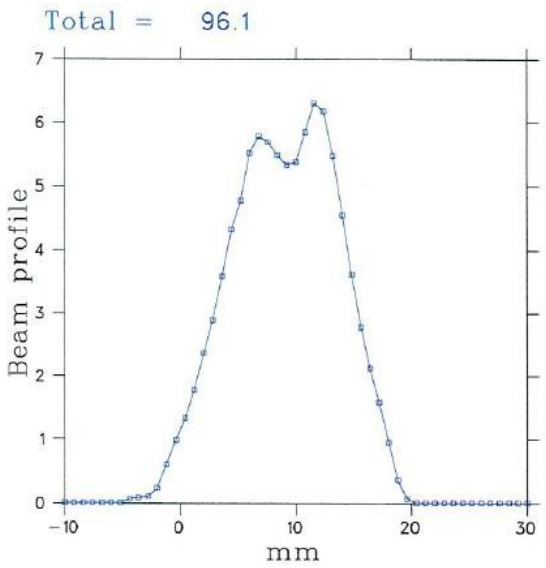


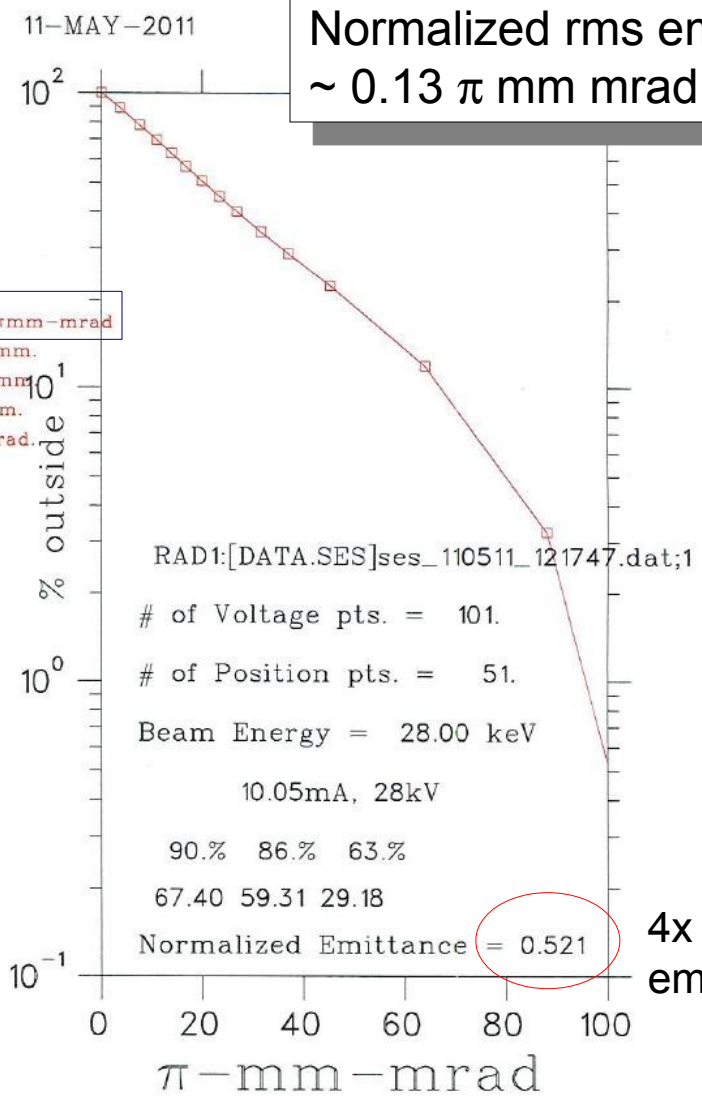
Beam Current vs. Arc Power



Emittance Measurement – 10mA, 28keV



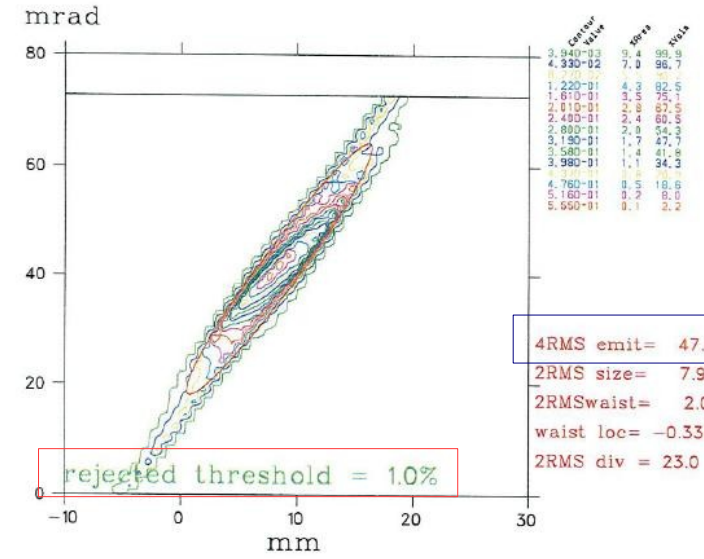


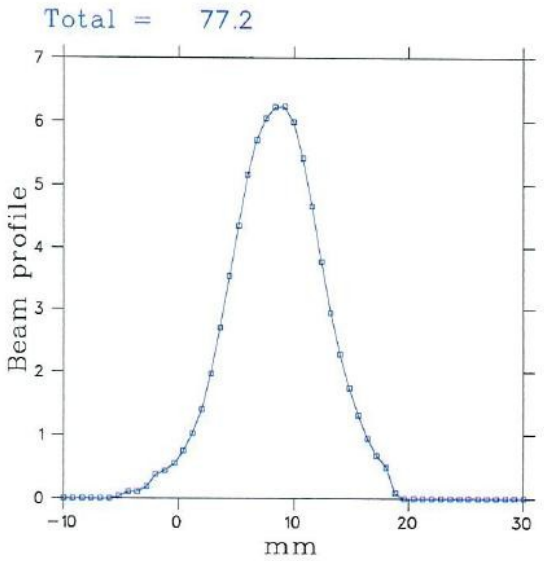


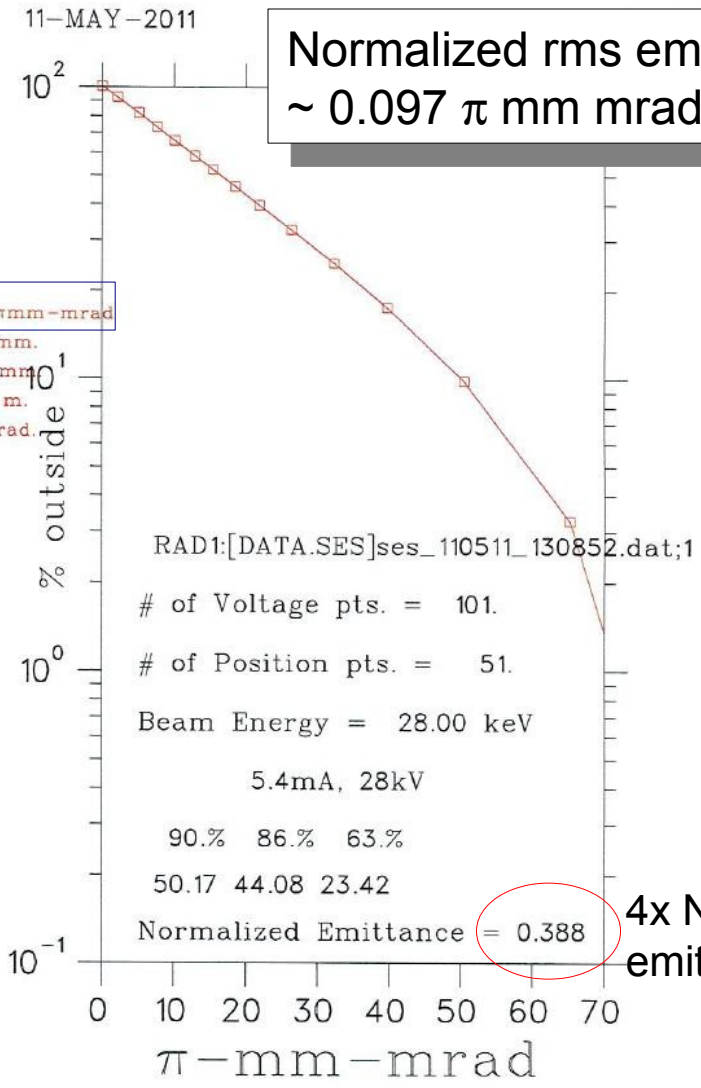
Normalized rms emittance:
~ 0.13 π mm mrad

4x Normalized rms emittance

Emittance Measurement – 5mA, 28keV



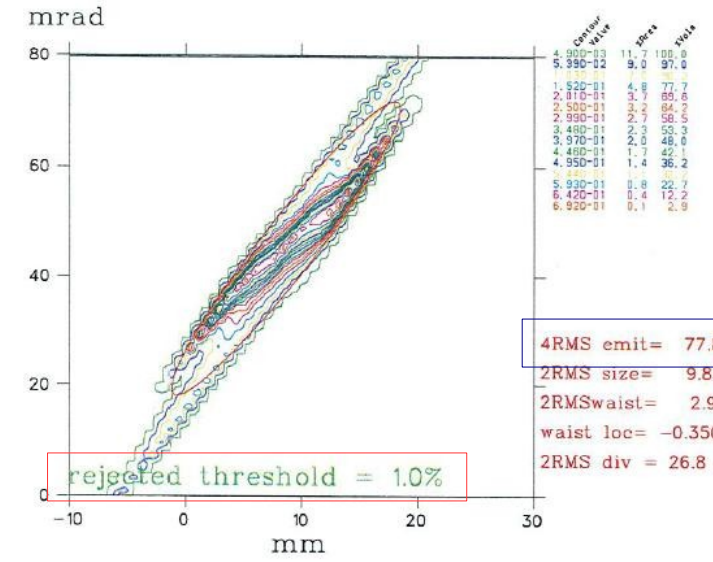


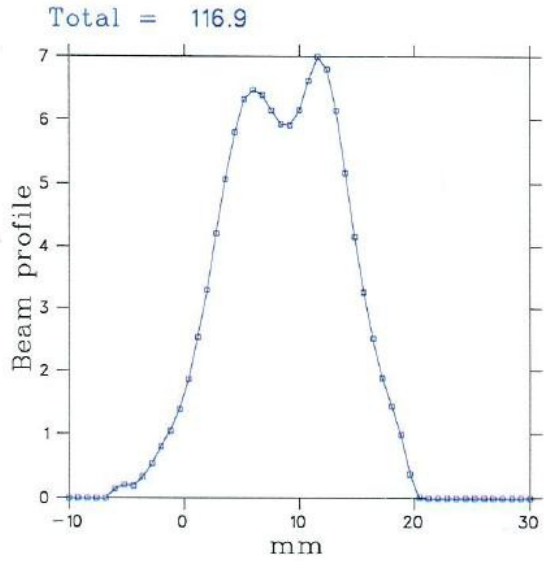


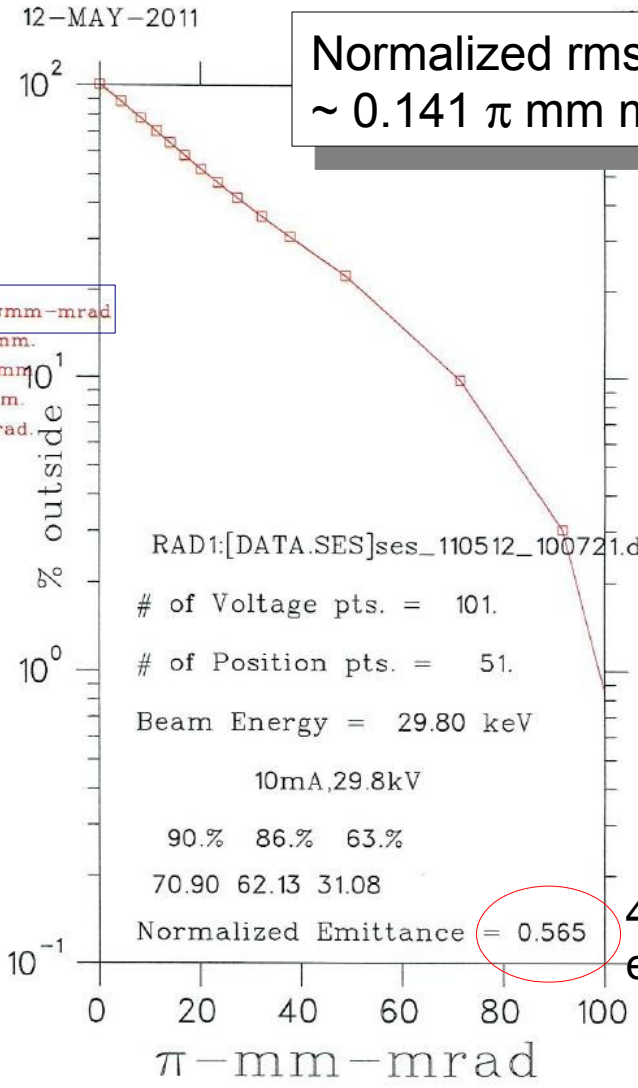
Normalized rms emittance:
~ 0.097 π mm mrad

4x Normalized rms emittance

Emittance Measurement – 10mA, 30keV



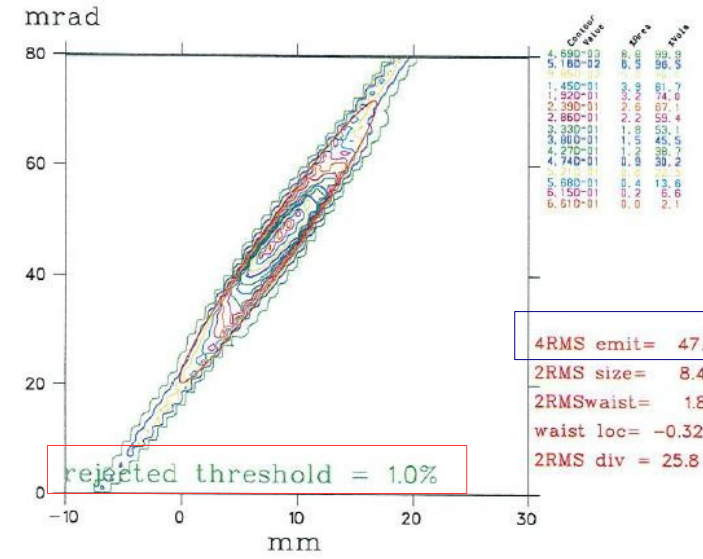


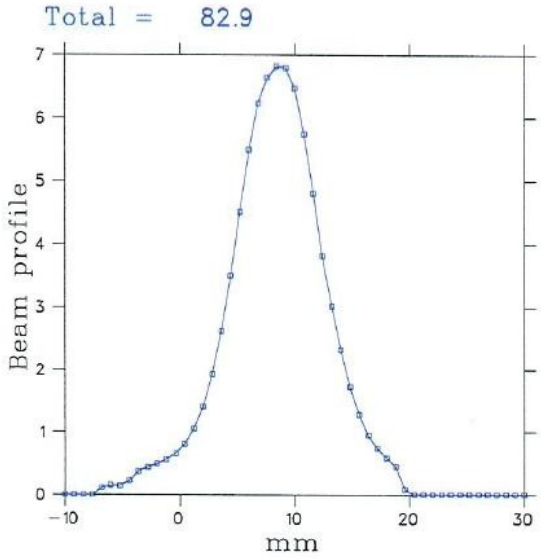


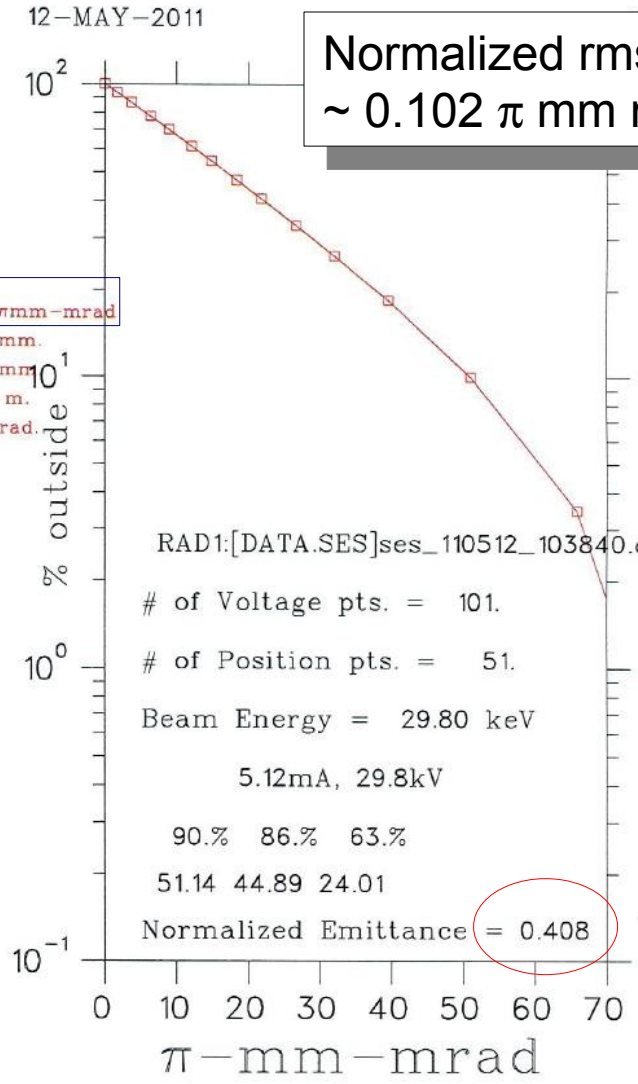
Normalized rms emittance:
~ 0.141 π mm mrad

4x Normalized rms emittance

Emittance Measurement – 5mA, 30keV



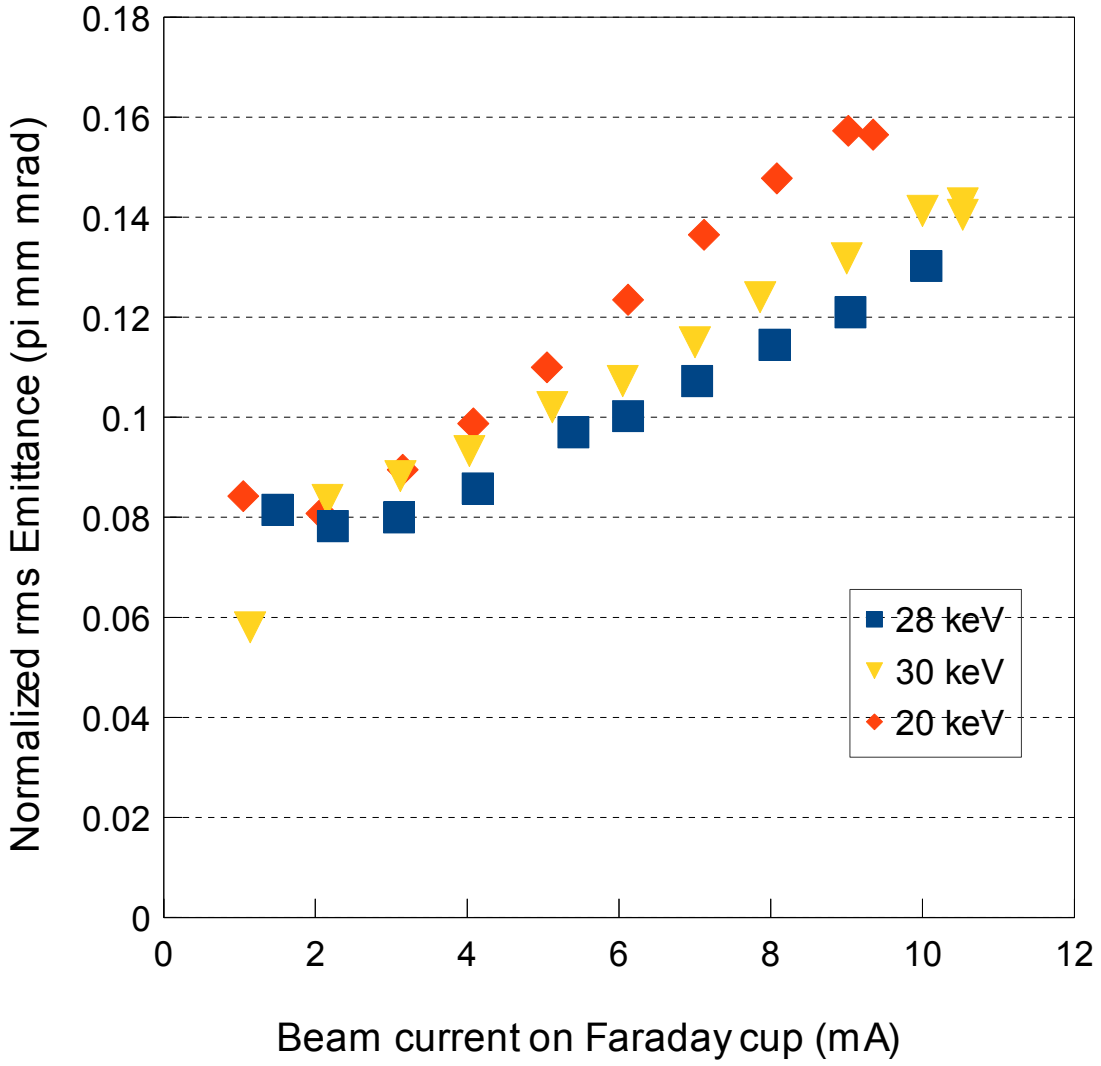




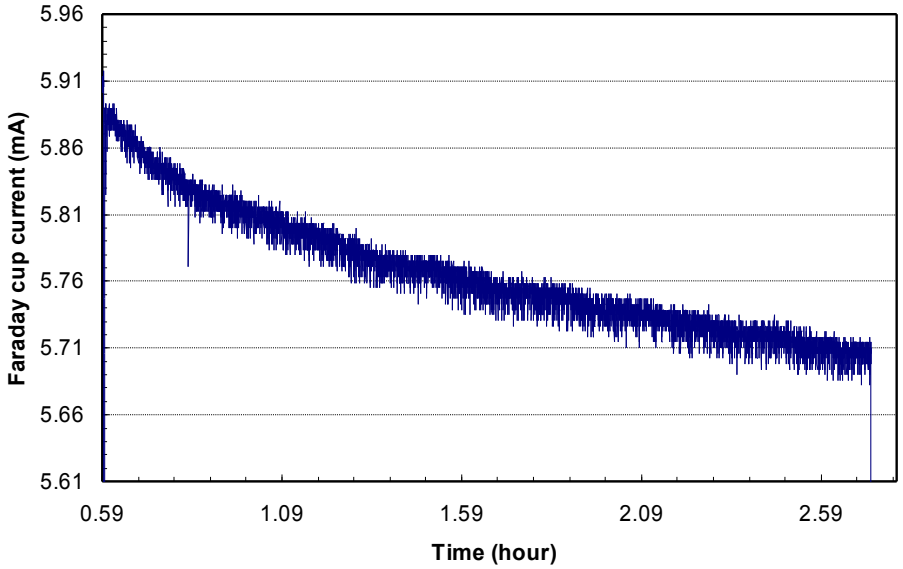
Normalized rms emittance:
~ 0.102 π mm mrad

4x Normalized rms emittance

Normalized rms Emittance vs. Beam current

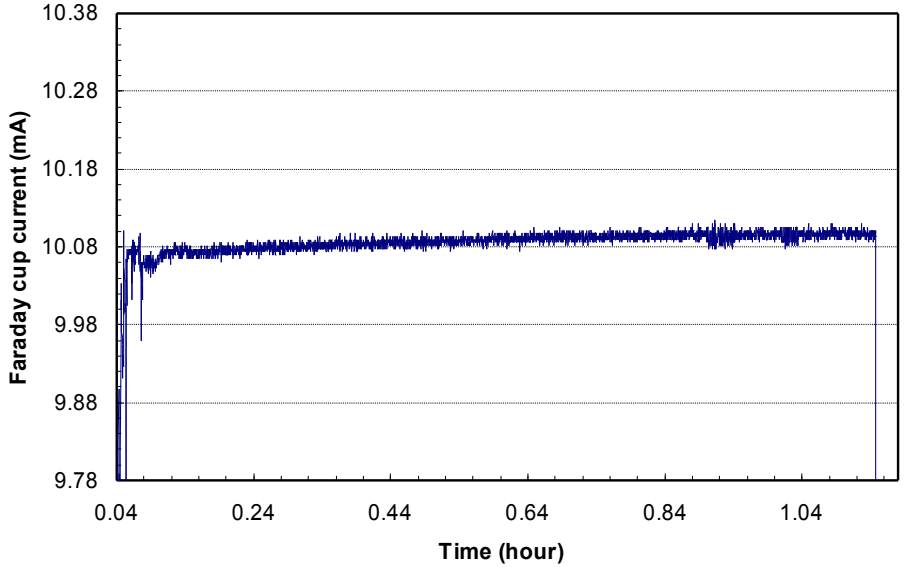


Beam Stability Test: No feedback control loop



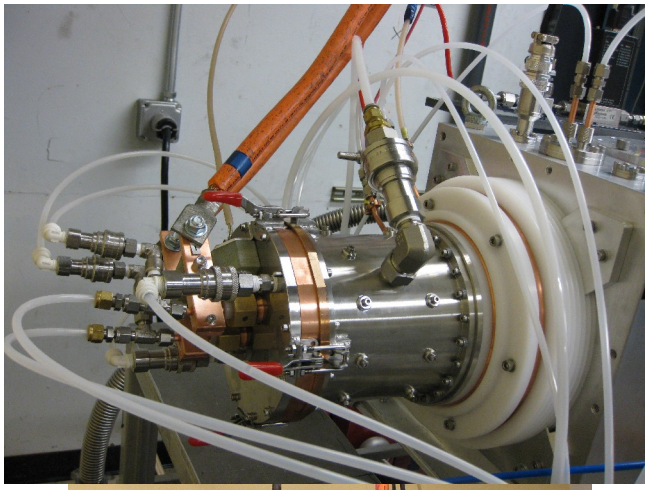
~ +/- 1.9% after the filament conditioned for less than 48 hours

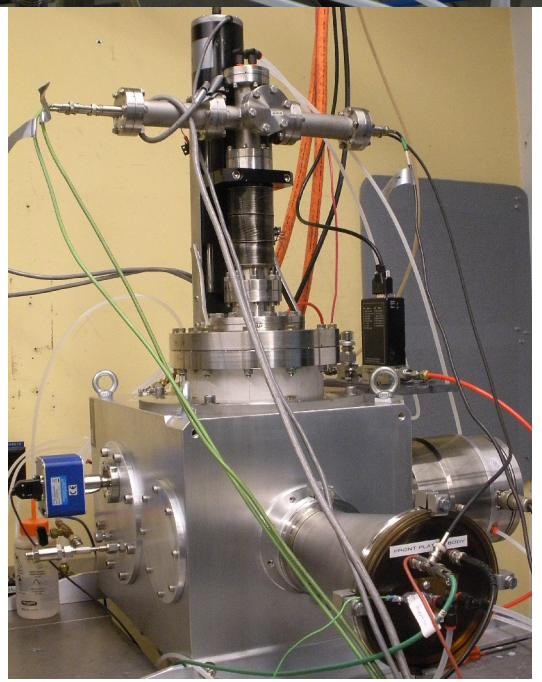
~ +/- 0.4% after longer source conditioning



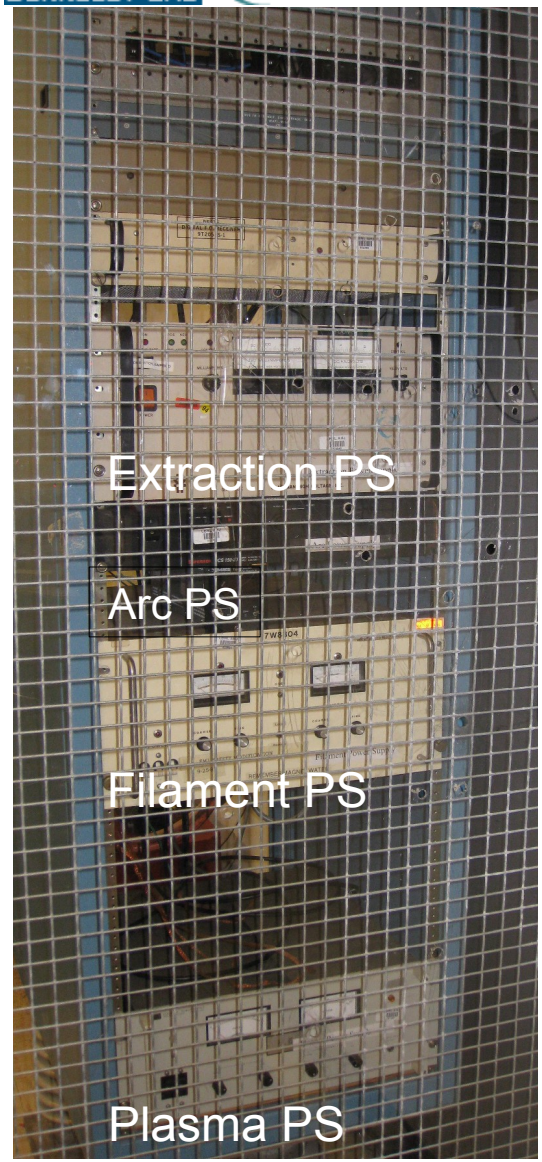
Test Stand at LBNL

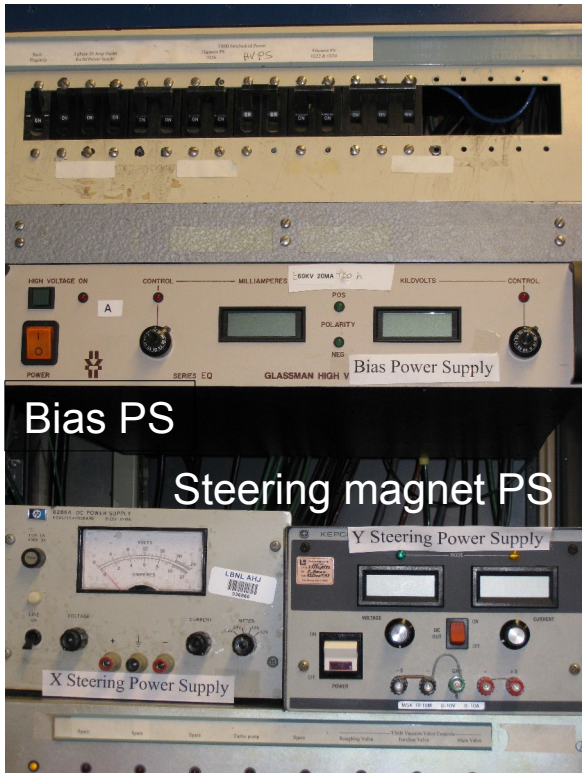
- Ion source has been mounted on the test stand and is fully operational
  - Two Turbo pumps (1000l/s and 500l/s) with one roughing pump installed.
  - Cooling water for the ion source, steering magnet are all connected.
  - Mass flow controller and ion gauge are installed.
  - All the electrical cables are connected to the ion source and beam extraction system.
  - A newly built Faraday cup with water cooling and magnetic filter has been mounted for beam diagnostics.
  - One-axis emittance scanner has been installed.

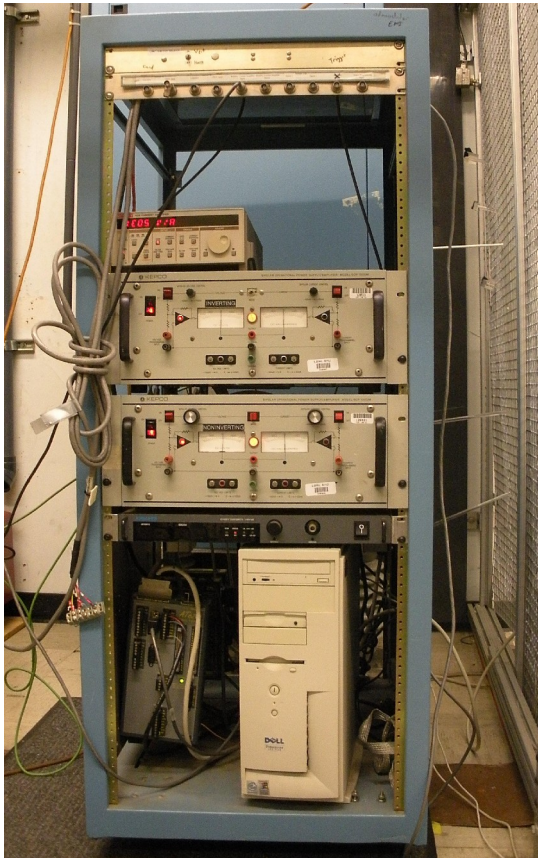




Power Supplies and Control System

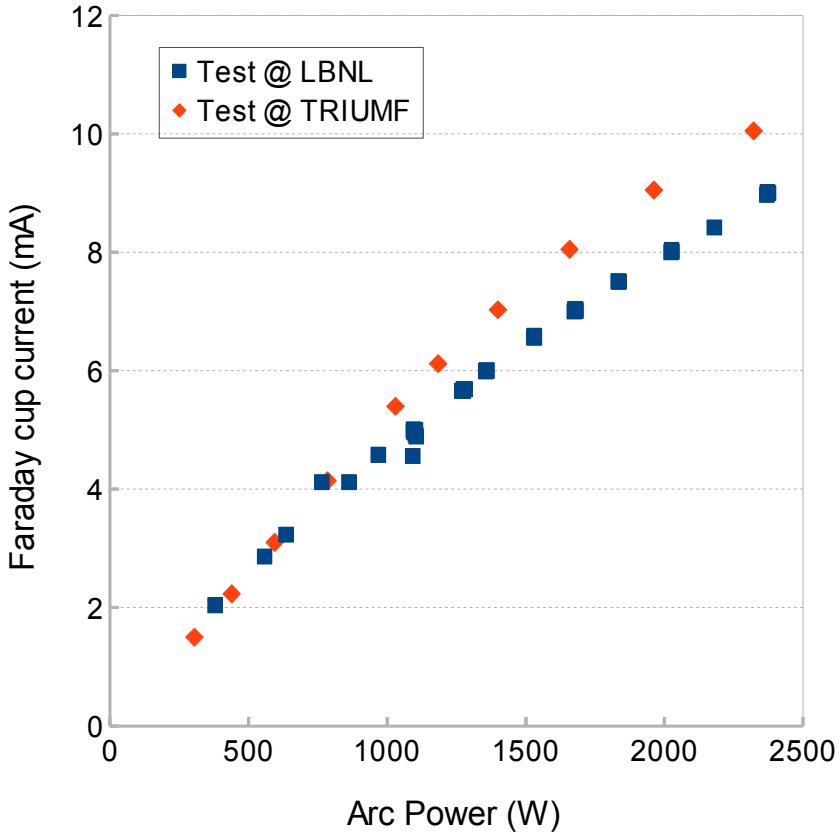






Emittance scanner control rack

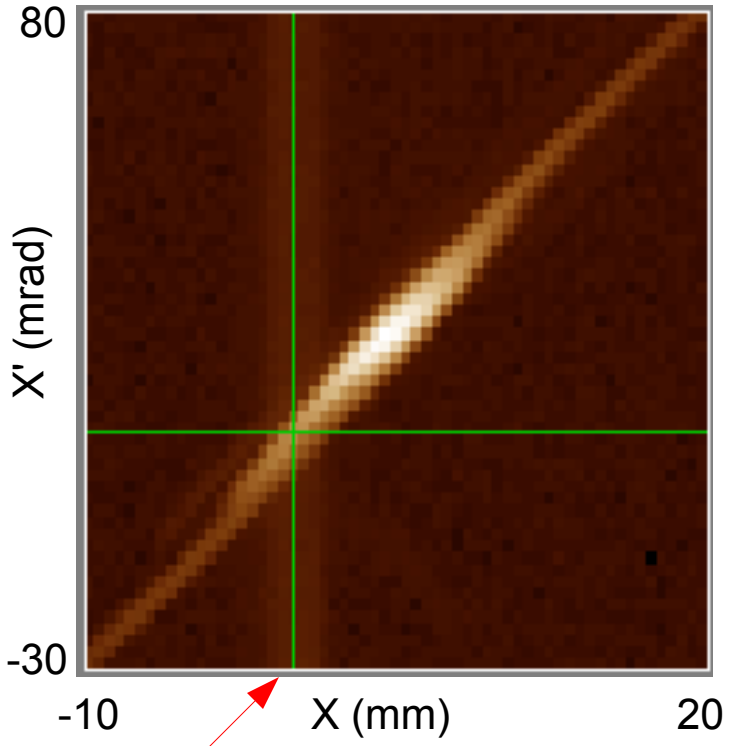
Beam Test at LBNL: Current Measurement



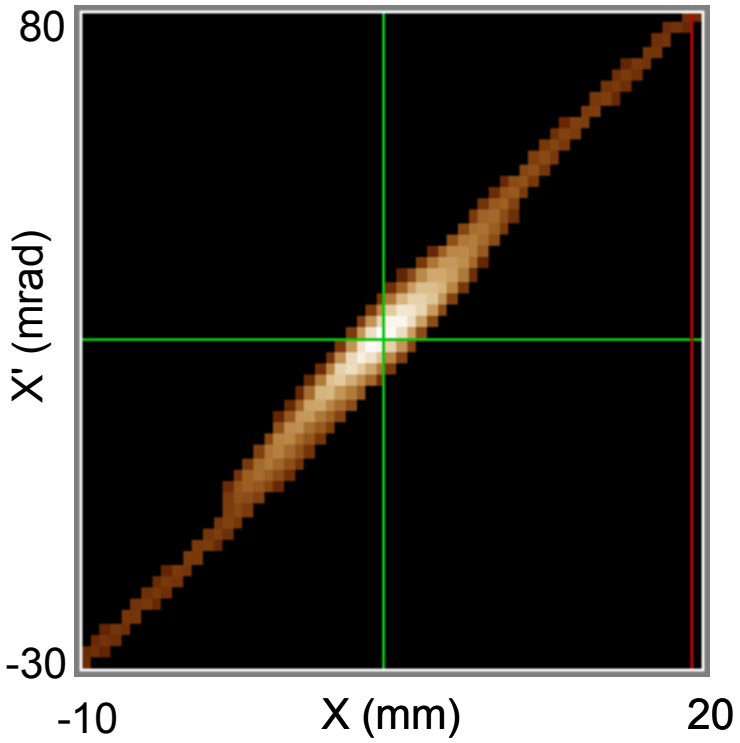
- At low power operation (arc power less than 1 kW), both results agree with each other quite well.
- When the ion source was operated at the arc power higher than 1 kW, the current measured at LBNL was approximately 10% lower compared to TRIUMF test results.
  - Lower pumping speed at LBNL
  - More charge exchange
    - H- beam current reduced

Beam Test at LBNL: Emittance Measurement

Beam condition: 30 keV, 5 mA



Raw data

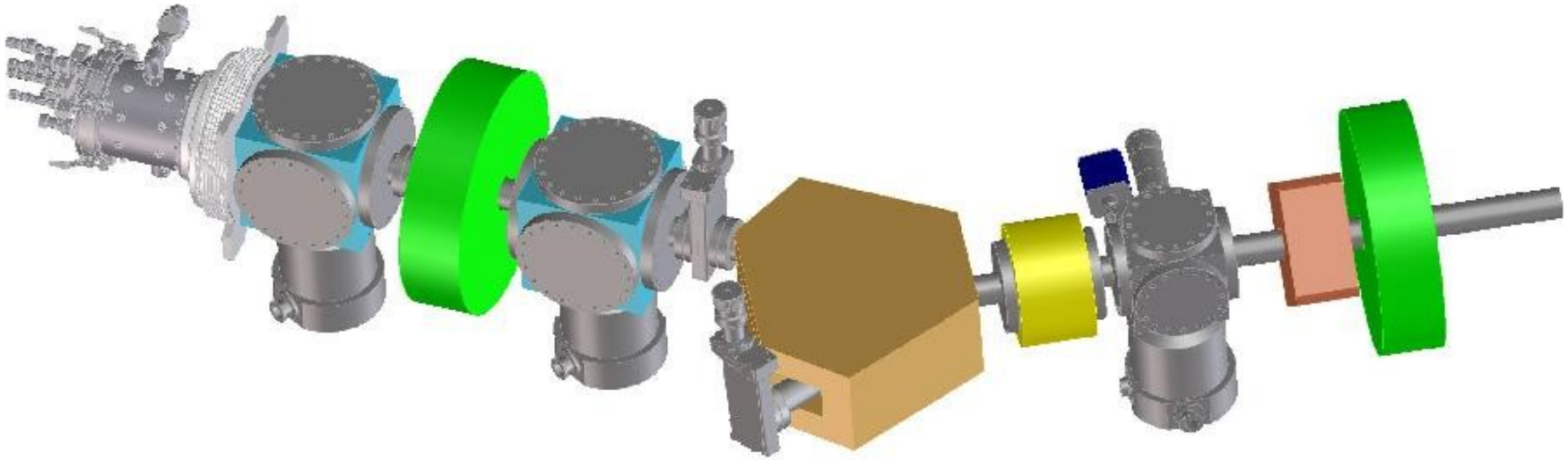


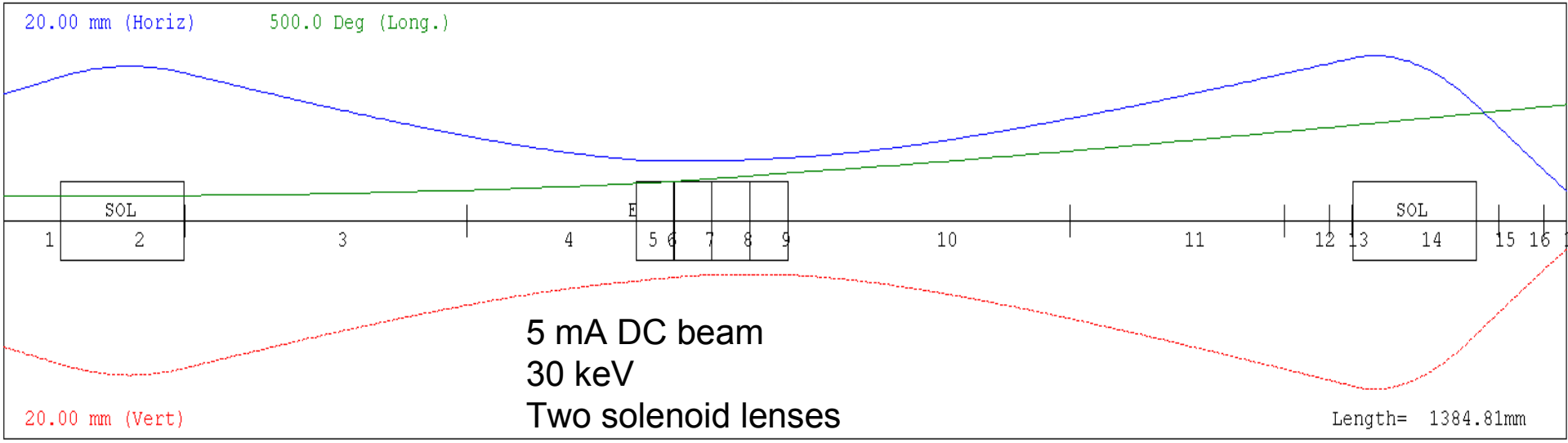
Threshold at 2.4%

Neutrals

Normalized rms emittance: 0.083 π mm mrad

LEBT Configuration





5 mA DC beam
30 keV
Two solenoid lenses
One selector magnet with edge angle

LEBT R&D Program

- LEBT and chopper beam dynamics study
  - Use the experimental data from acceptance tests to conduct end-to-end simulation on LEBT and RFQ
  - Time-dependent simulation of LEBT chopper using WARP and Vorpal
- LEBT engineering design and fabrication
  - Solenoid and bending magnets
  - Chopper
  - End-to-end beam line
- LEBT and chopper assembly and beam test:
  - Install magnetic LEBT prototype incrementally
  - Emittance and neutralization time measurement of chopper beam

Summary

- The D-Pace ion source was delivered to LBNL after a smooth and successful acceptance test at TRIUMF. The H- ion beam currents from 1mA to 10mA have been verified. Emittance were measured from beam level from 1mA to 10mA, at various beam energy. Normalized rms emittance were less than 0.2 π mm mrad, which met the specification. Without any feedback control loop, the beam current stability was better than +/- 0.4% after filament conditioning.
- The ion source has been set up at LBNL ans is fully operational. Both beam test and emittance measurements have been carried out at LBNL, with results agreeing well with the data from TRIUMF.
- Improvements are expected after the roughing and turbo pumps are upgraded.
- Plan to construct a LEBT and chopper prototype and conduct beam test with the ion source.