PXIE Ion Source & LEBT Commissioning Update

Lionel Prost

on behalf of R. Andrews, B. Hanna, A. Shemyakin, K. Carlson, B. Brooker, G. Saewert, V. Scarpine, R. D'Arcy, T. Zuchnik, M. Kucera, S. Hays, J. Czajkowski, D. Snee, W. Johnson, D. Heikkinen, J. Steimel, mechanical, electrical and other technical support

PIP-II Technical Meeting

April 8th, 2014

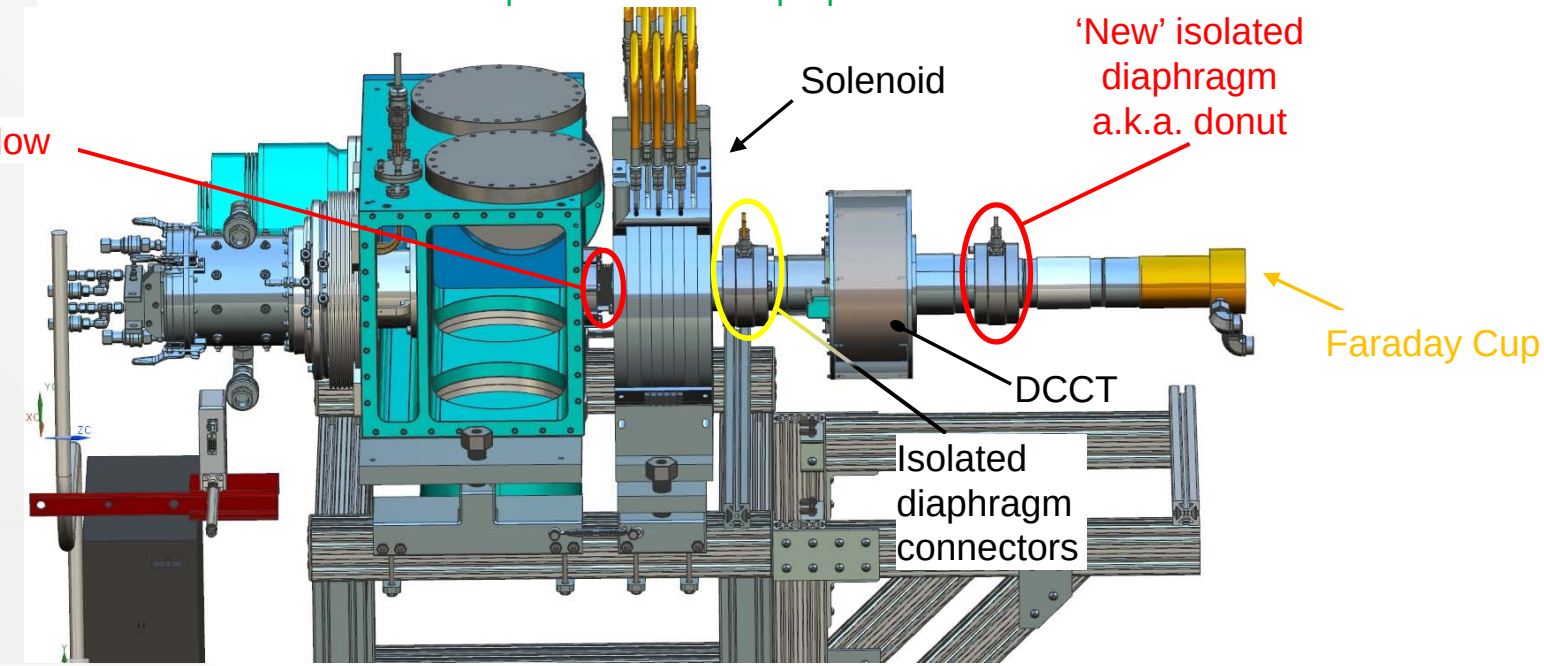
Fermilab

Agenda for today

- Overall status of LEBT commissioning activities (*Lionel*)
- Status of mechanical design of LEBT (*Rich A.*)
- Beam size and emittance measurements in LEBT (*Sasha*)

Setup (reminder)

- Minor beam line modifications w.r.t. the last report
  - Removed gate valve
  - Added an isolated diaphragm between the DCCT and the Faraday cup
    - Also removed restrictive aperture in the FC proper
- Moved pulser/modulator to HV cabinet



Content

- Outline of measurements
- Main issue: Beam size at the bellow
- Operation considerations

New '*temporary*' isolated diaphragm

- Works *as expected*
  - i.e. understandable solenoid and solenoid correctors scans
    - Basically no beam current change was observed in (most) earlier correctors scans [*when the limiting FC aperture was electrically equivalent to the 'collector'*]
  - Allows performing meaningful measurements
    - Beam size ⇨ Emittance

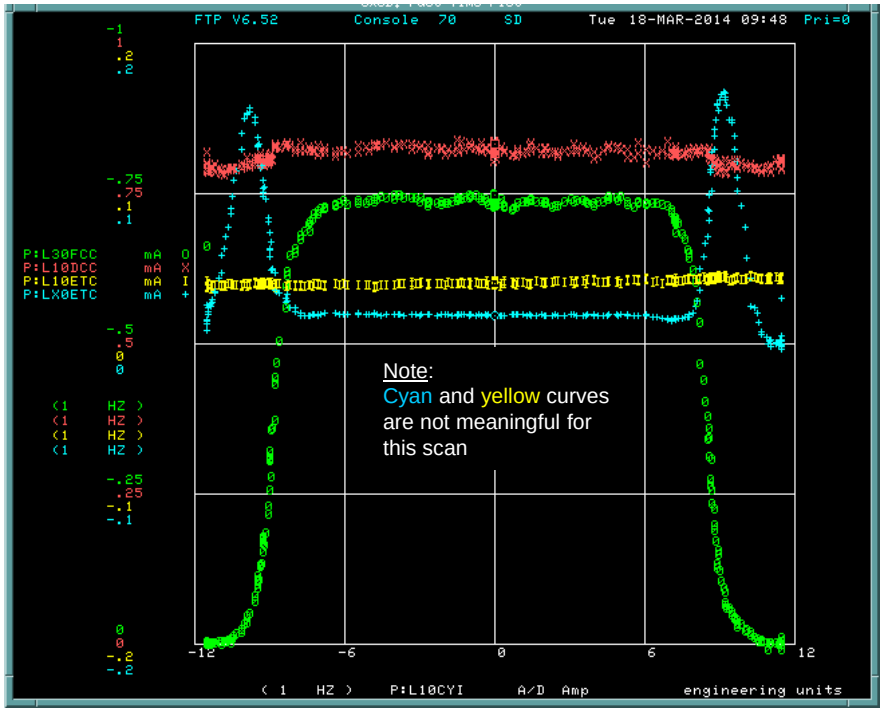


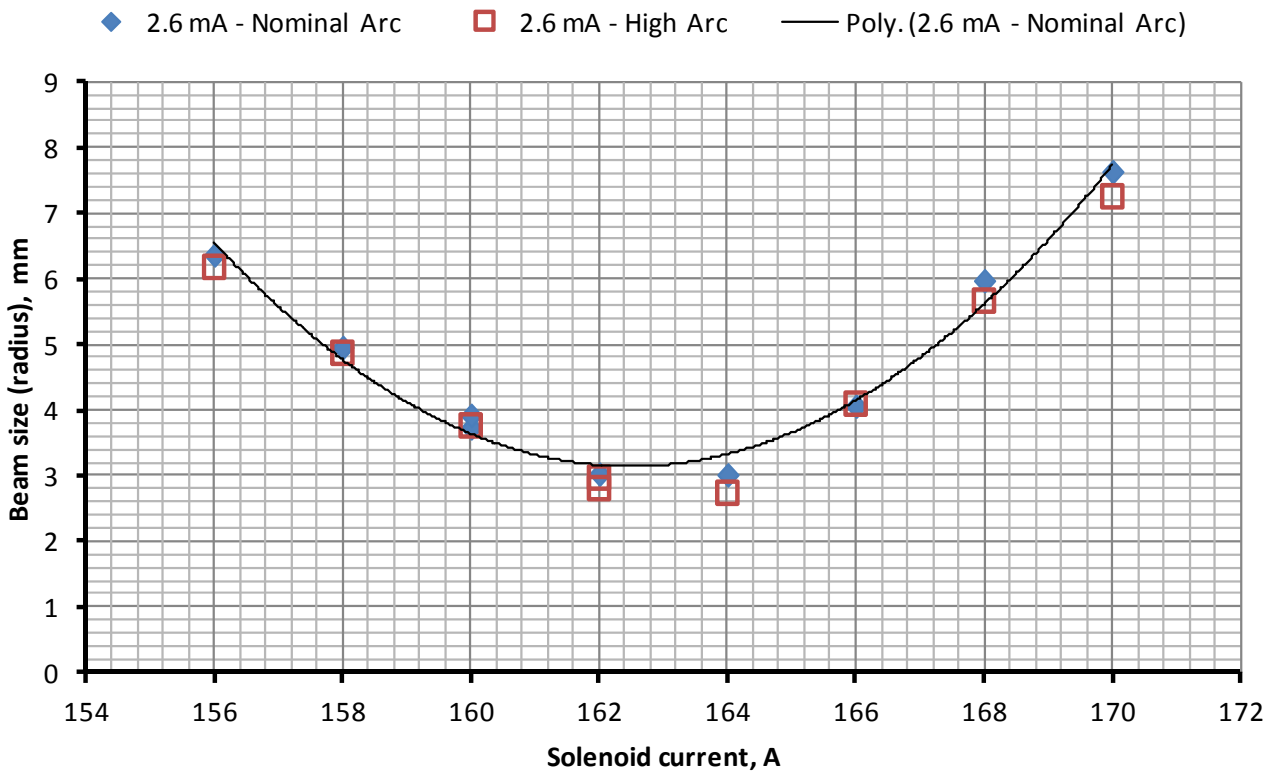
Illustration:
Solenoid Y-corrector scan

Green: FC
Red: DCCT
Yellow: Solenoid diaphragm
Cyan: *New* diaphragm

Here the new diaphragm is not biased

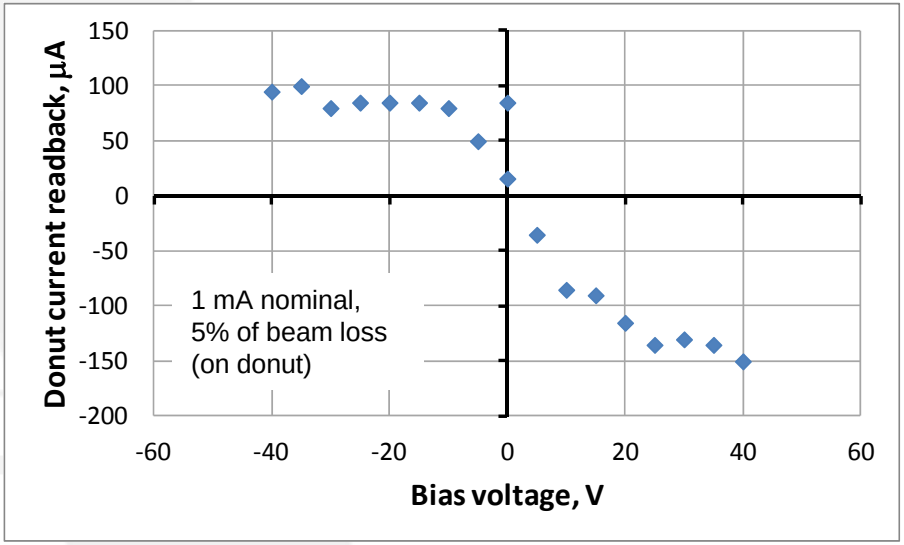
Emittance estimation

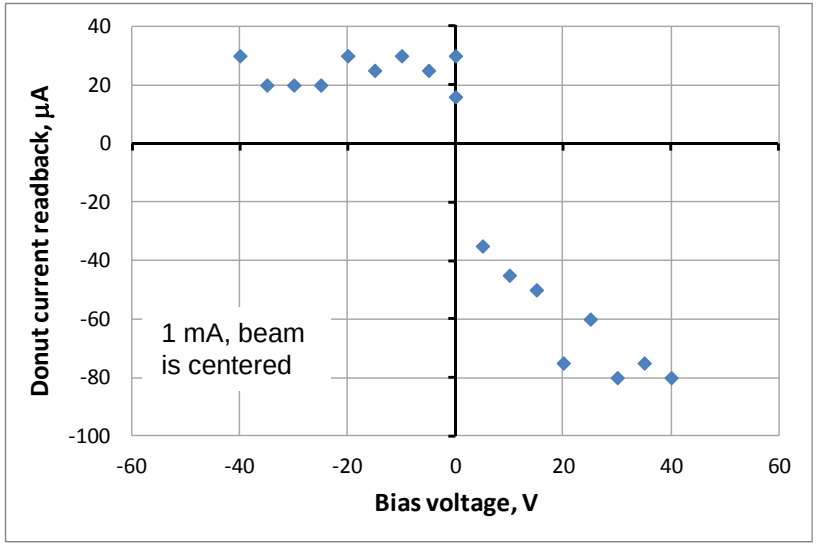
- Beam size vs. Solenoid current
  - e.g.: ⇨
  - Determine minimum beam size
  - Analysis: Sasha's report



‘*Secondaries*’ emission

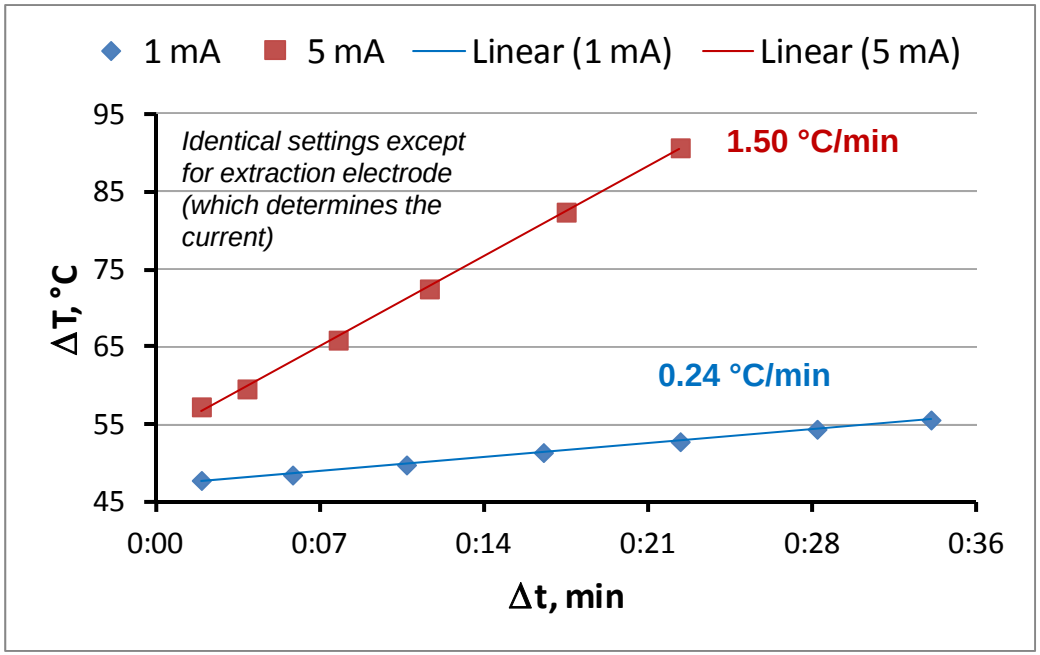
- Applied bias to donut vs. donut current readback
  - Faraday cup is grounded
  - PS limited to 40 V
  - Scans indicate that a few 10s of volts *may be* enough to saturate the donut current (positive bias), <u>not kV</u>
  - ⇨ Low energy (soft) electrons





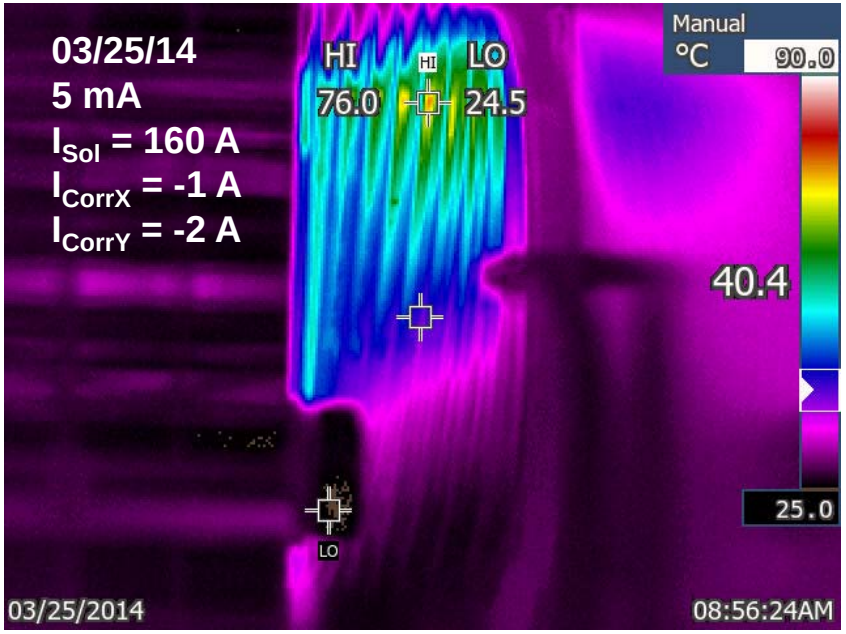
Neutrals

- With the beam well centered in the donut, its temperature still rises significantly
  - Indicates *particles* loss
    - Primary beam (halo) ?
    - Neutrals ?
  - Rate of temperature increase is *not* merely proportional to the beam current
    - 6.5 vs. 5 for the beam current here
    - There *must* be energetic neutrals bombarding the donut



Beam size at the bellow – Issue ?

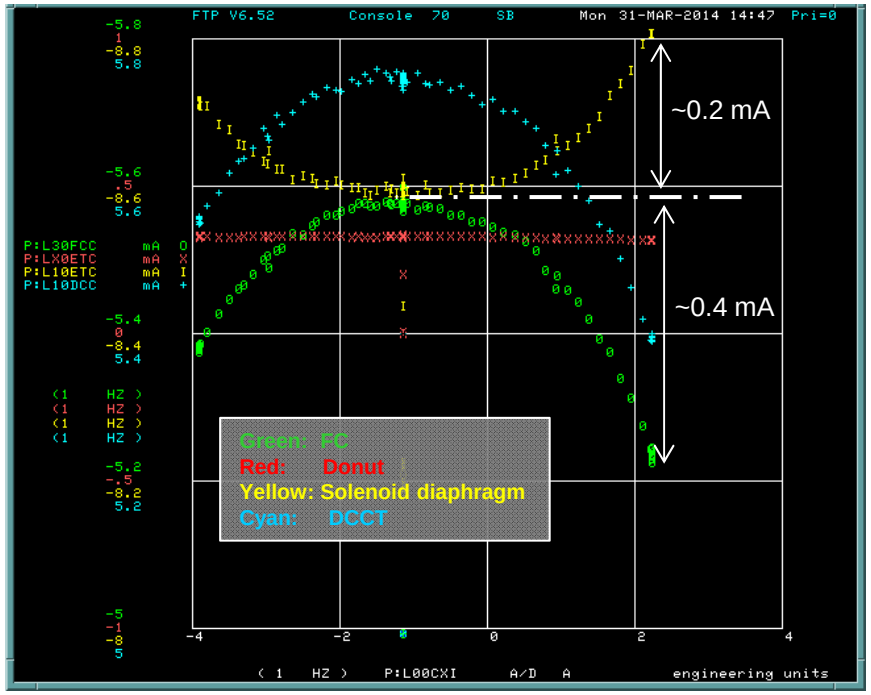
- The bellow before the solenoid gets hot !!
  - Even with the beam well centered
    - Indication, in part, from temperature spatial distribution over the bellow which is quite uniform with maximum beam measured by the Faraday cup
      - *And no beam loss observed between the solenoid diaphragm and the Faraday cup*
  - Cannot be electrons
    - IS correctors too strong
  - Maximum temperature increases with the total beam current



- <u>Conclusion</u>: the beam is too big (or the bellow too small)

Beam loss estimation at the bellow

- IS correctors scans
  - Plot currents (FC, DCCT and isolated diaphragms)
    - There is a **2:1 ratio** between the Solenoid diaphragm current increase and the FC current decrease
- When turning on the beam, the solenoid diaphragm current jumps (more negative) by **~0.4 mA**
  - From the 2:1 ratio the beam loss to the bellow is **~0.2 mA**
- At 30 kV, it corresponds to 6-12 W of beam loss to the bellow
  - Not an issue from a thermal point of view
  - The problem is sputtering and <u>blistering</u>
    - Pretty much maximized at this energy for protons/H^-
    - Thin walls



Corrective actions

- Two stages: short term/temporary & long term fix
  - Shutdown ***this*** Thursday to install a limiting aperture on the upstream side of the IS vacuum chamber downstream wall
    - Will increase the total beam loss but protect the bellow
  - When installing the rest of the LEBT (this summer), increase aperture between IS vacuum chamber exit and solenoid diaphragm
    - The solenoid diaphragm is designed to intercept beam

- More on this from Rich A.

Operation

- Stable and reliable operation since the last shutdown (March 11-14)
  - No breakdowns
  - Established a weekly 'shift schedule' for measurements
    - Currently, Bruce H., Vic S., Jim S., Sasha S., Richard D. and I
  - Weekly (mostly) coordinating meeting
- Almost ready to move on to *remote* operation
  - i.e. don't have to stand by the machine
  - Waiting on a warning light indicating 'HV enabled'
- A Sequencer aggregate has been written to turn the beam on
  - Help from the Operations Dpt
  - Next is to generate a set of Sequencer files with appropriate settings
- A preliminary Finite State Machine java application has been written
  - Rudimentary (software) machine protection system

Next

- Installation of the emittance scanner
  - Being assembled and tested here
  - A couple of weeks away?

- Installation of the remaining of the LEBT all at once
  - Goal is to start commissioning mid- to late July
    - All solenoids have been delivered and are being measured
    - A lot of the infrastructure is ready or nearly ready (e.g.: water distribution system)
    - Current ‘push’ on the design of the chopper