Transverse emittance measurement of the ion source proton beam by the wire scan method

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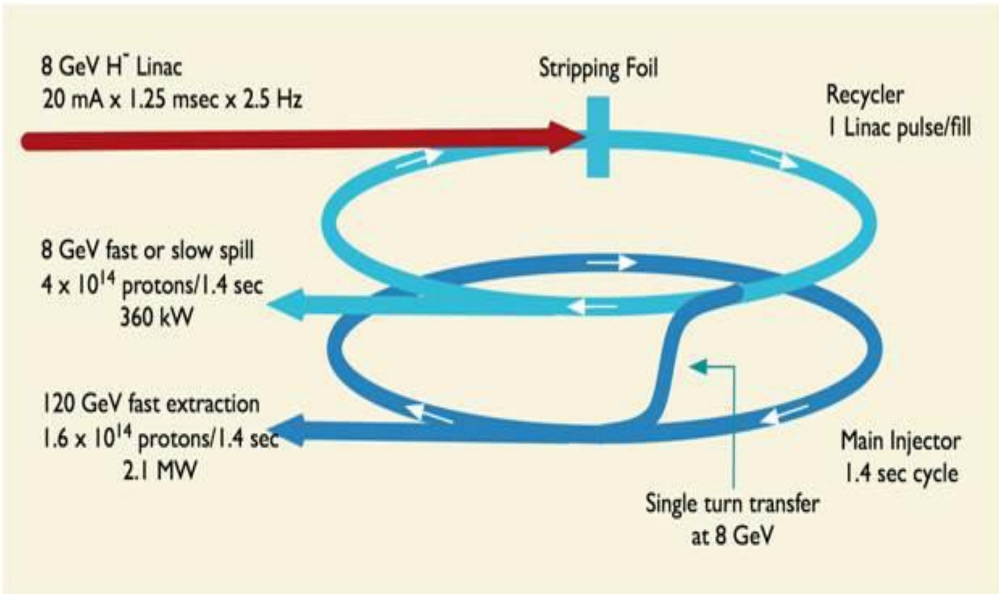
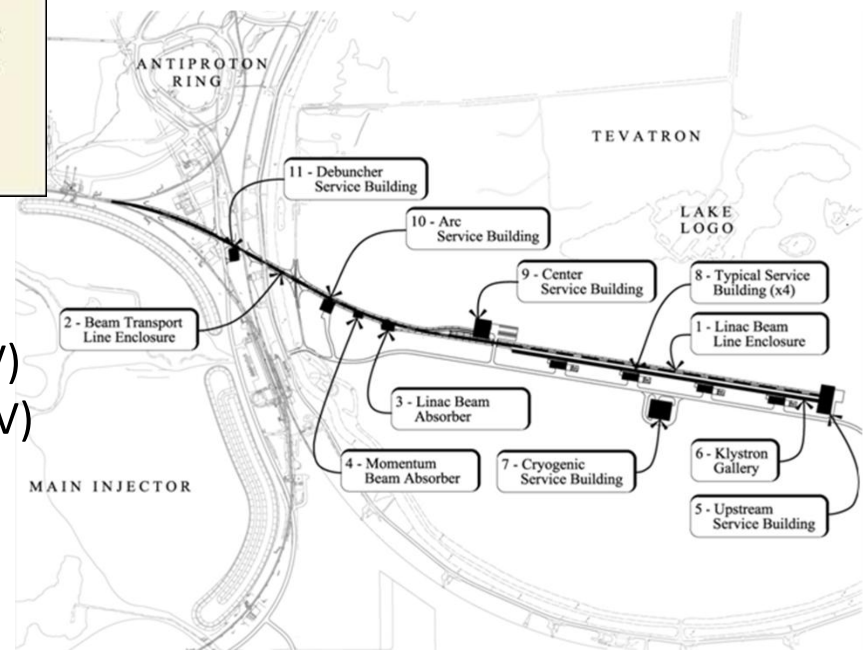
Project X

- One of the most prospective ways of Fermilab development is to improve Intensity Frontier through the so-called "Project X".
- The goal of the Project X is to establish *high intensity proton source* that makes opportunity to study rare processes, especially producing powerful neutrino flux (High Intensity Neutrino Source).

Conceptual Design of the Project X



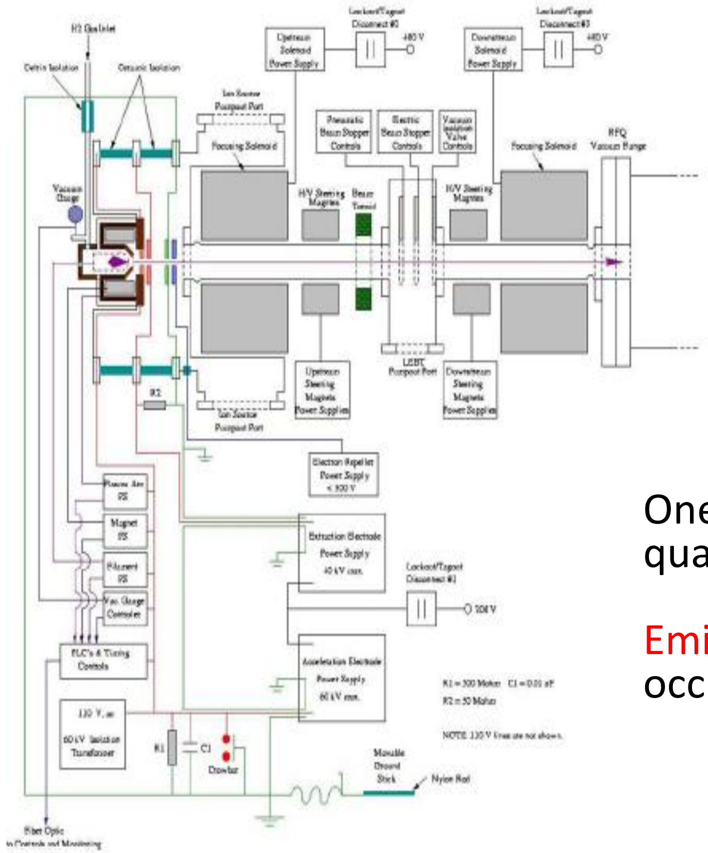
- Should provide 2 MW 120 GeV proton beam for the *High Intensity Neutrino Source*



The main constituents:

1. Ion Source (50 keV ions H^-)
2. Room Temperature RFQ (50 keV ->2.5 MeV)
3. Superconductive cavities (2.5 MeV-> 8 GeV)
4. Stripping foil
5. Main Injector (8 GeV -> 120 GeV)

Ion (proton) source and Low Energy Beam Transport



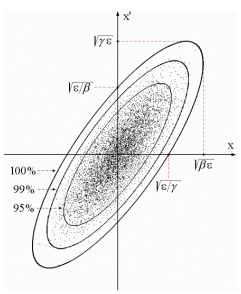
The setup I work at includes ion source and low energy beam transport

How does it work?

1. Plasmatron generates hydrogen plasma
2. Protons are accelerated by the 50 keV voltage
3. 2 Solenoids focus the beam
4. 2 steering dipole magnets manage the beam by the magnetic field in the both ‘x’ and ‘y’ directions each

One of the main properties implies the beam quality is the beam emittance

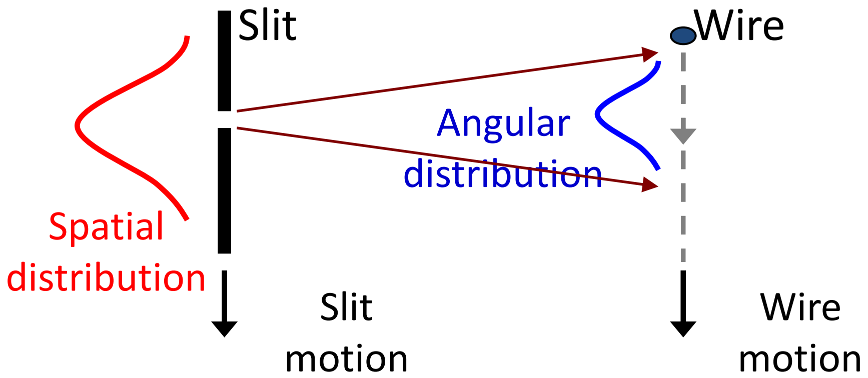
Emittance – measure of the phase space area occupied by the particles involved in the beam



$$\varepsilon_{rms,x} = \sqrt{\langle x^2 \rangle \langle x'^2 \rangle - \langle xx' \rangle^2}$$

If the emittance in the ion source output will be large, the only small part of the ions will be captured by the RFQ!

Slit-wire scan method for transverse emittance measurement



To measure transverse emittance we

•Fix protons coordinates by the slits (2 slits for x&y coordinates)

•Measure angular distribution of protons by the wire scan (2 wires for X'&Y' determination) for the different slits positions

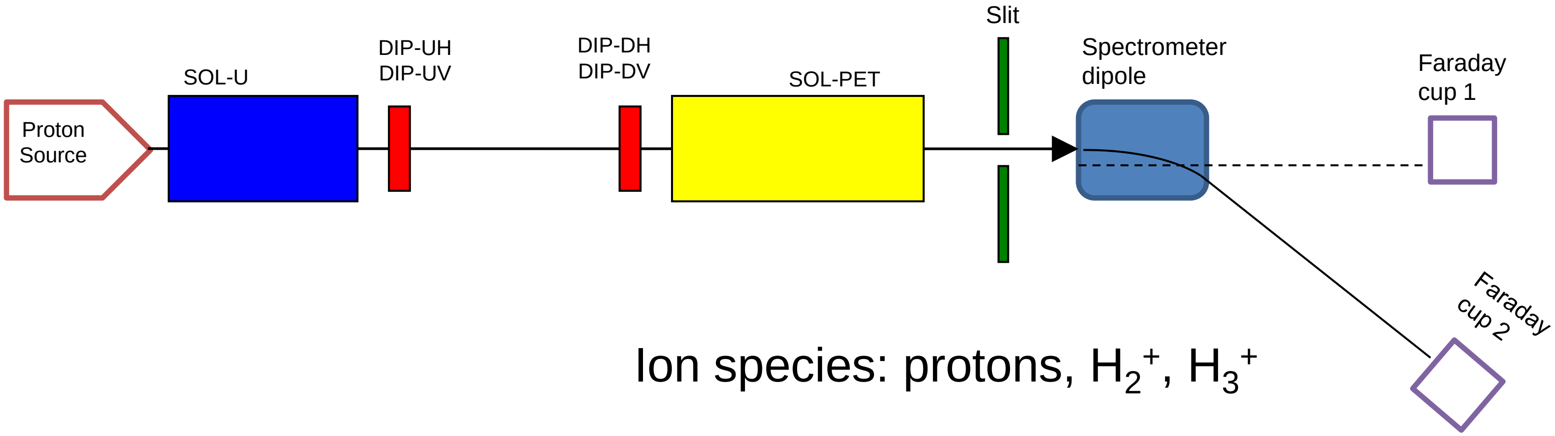
Goals

- Transverse emittance wire-scan measurement of the low energy 50 keV beam and data analysis

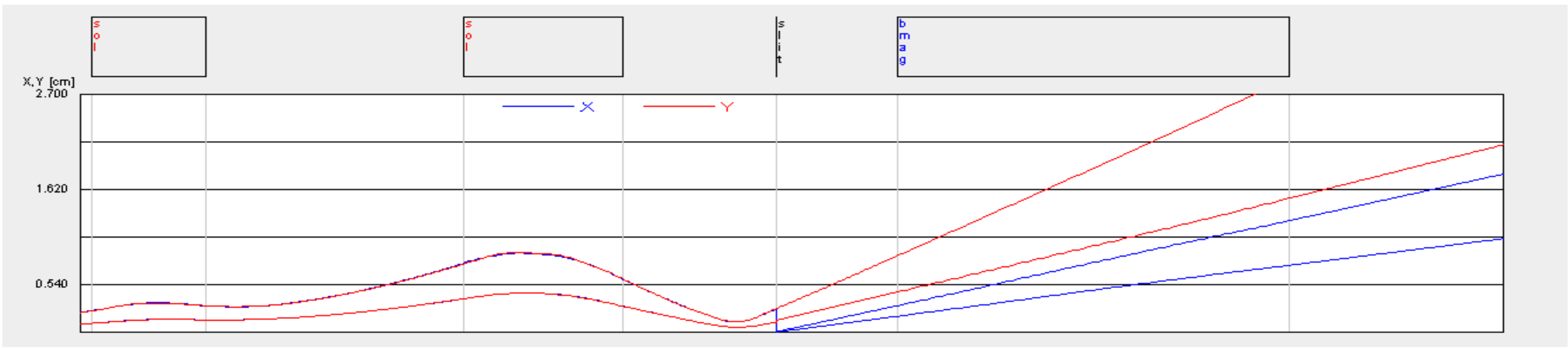
But…

- The emittance measurements not carried out yet (because of technical problems with the ion source)
- Several days ago it was set up to the operation regime (W=50keV, no sparking)
- So, I have made some useful simulations (Track v39)

Beam-line diagnostic simulations

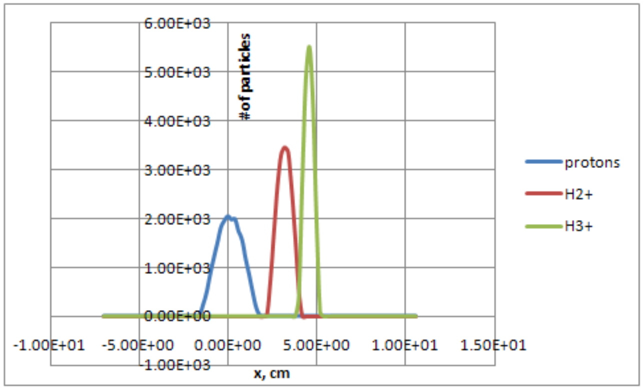


Ion species: protons, H_2^+, H_3^+



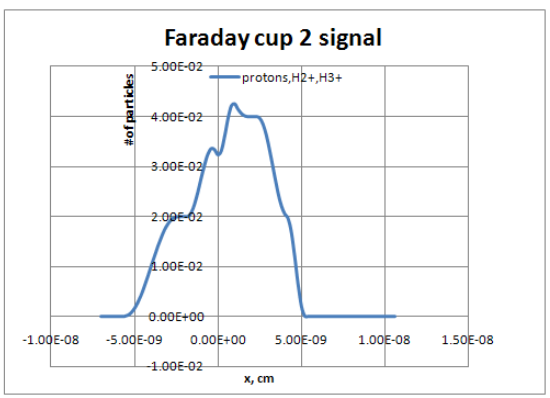
Beam RMS and total envelopes for X&Y coordinates. Deviation from the central trajectory is plotted.

Beam-line diagnostic simulations

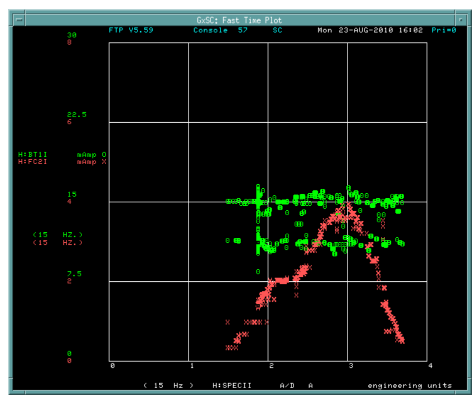


FC 2 scanning

- Different species separation due to spectrometer dipole magnet.
- Equal number of each type of particles is assumed.
- On this step a bug in Track v39 code was found (edited by Mustapha Brahim).



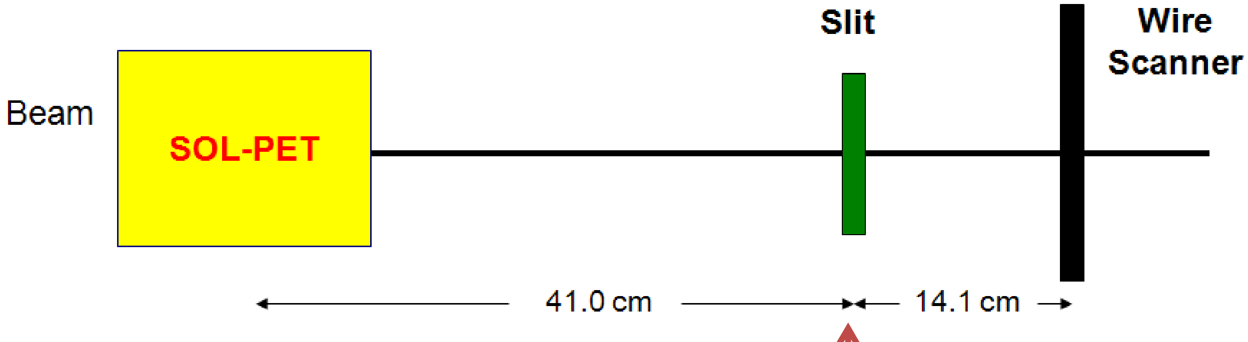
# of particles vs. Faraday cup position



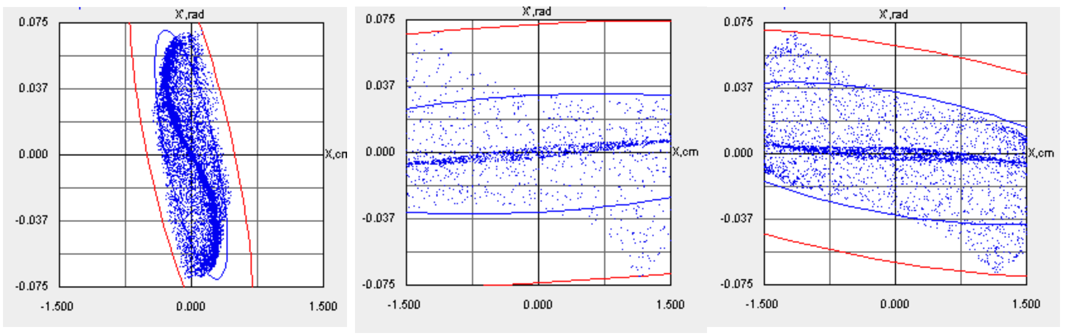
Faraday cup current vs. spectrometer dipole current

•Using such kind of simulations one might extract actual value $\frac{I_p}{I_{tot}}$

Slit-wire scan assembly



Expected phase-space distribution



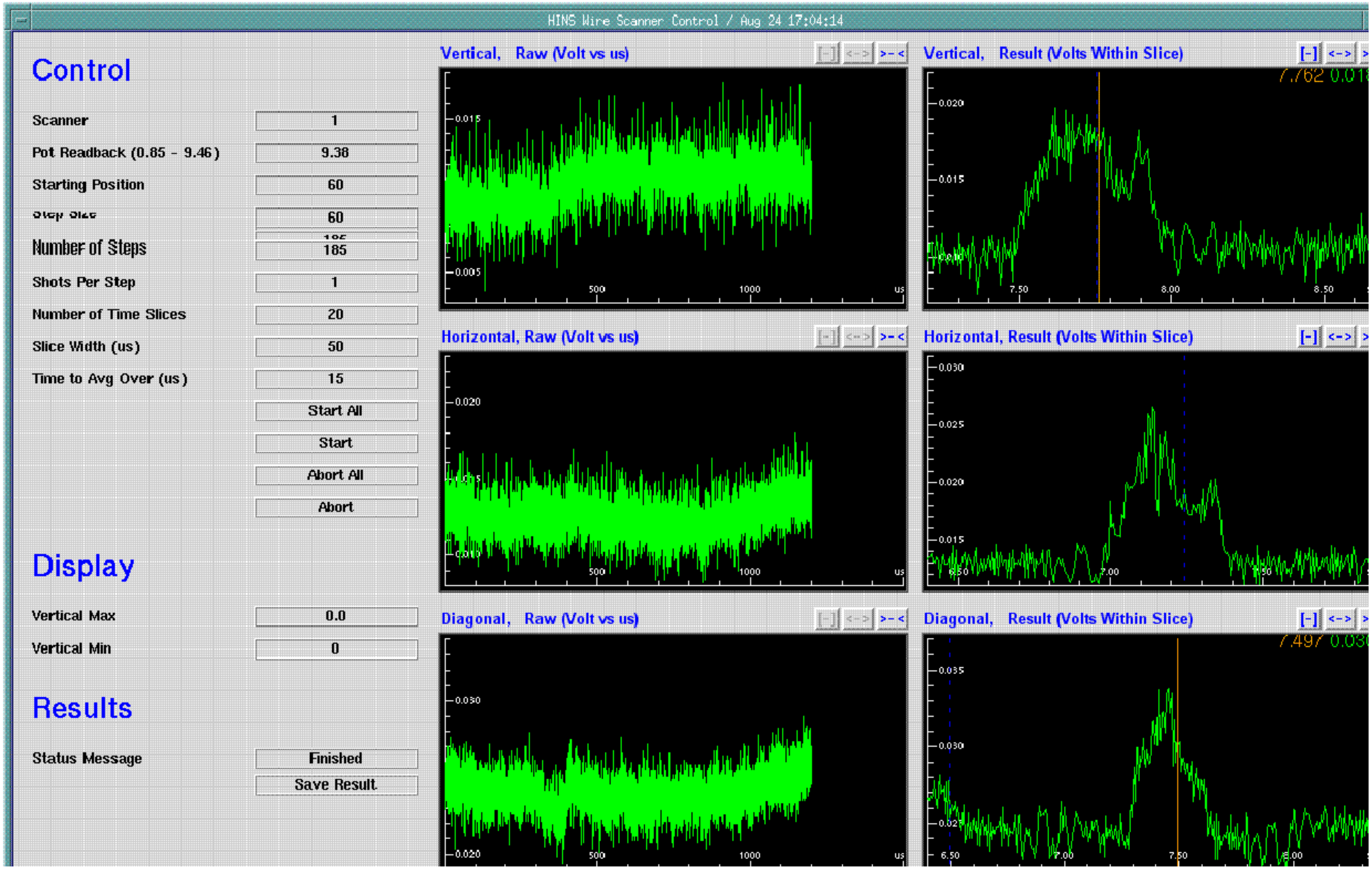
protons H2+ H3+

$I_p = I_{H2+} = I_{H3+} = 6$ mA

Conclusion

- Ion source is starting to be operated, slit-wire scan emittance measurements will be done and analyzed soon.
- Track v39 simulations for the beam-line diagnostics were made. These results will be useful for the future data analysis (ion species contribution, space charge effect)

First wire-scan data (Aug 24)



Space charge effect