Report of PXIE H^- ion source commissioning at Fermilab (11/20/13-11/26/13)

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Purpose and Goal:

The purpose of the commissioning was to help and guide Fermilab personnel with the start up of the PXIE H^- ion source that has been tested and operated at LBNL. The goals of the commissioning are to ignite the hydrogen plasma, condition the filament, extract beam, and measure the H^- beam current on the Faraday cup.

Set up status:

The new ion source assembly has been nicely set up in the CMTF building by the Fermilab crew. All the power supplies and their control systems have been installed and tested, except for the x- and y-steering magnets. All the vacuum system was up and running, except for the mass flow controller.

Commissioning results:

We managed to ignite plasma using rough flow control of shut-off valves instead of needle valves. H^- beam was extracted and accelerated to 20kV. The Faraday cup measurement indicated a maximum beam current of 6.6mA extracted during commissioning.

Problems identified:

1. *Mass flow controller not installed*
   The device installed on the gas manifold was a mass flow meter, which only measures the gas flow, but can't regulate it.
   During the commissioning, we had to rely on two shut-off valves to roughly regulate the gas flow.

2. *Mass flow meter readout mis-calibrated*
   The readout of the mass flow meter was a factor of ten off (e.g., 20 sccm reading was actually only 2 sccm) at the very beginning. It was later corrected.

3. *Discharge along the ceramic high voltage break of the gas line*
   The mass flow meter/controller was installed at ground potential many meters away from the ion source body. Since the gas inlet on the ion source is biased at -30kV, a ceramic high voltage break is installed for high voltage insulation. There is a potential problem for such kind of setup. When the ion source is biased at high voltage, the potential difference across the two ends of the ceramic high voltage break is the source bias. Depending on the gas pressure within the HV break, a Paschen discharge may occur.
   Indeed, Paschen breakdowns were observed at 5kV (with 2sccm gas flow), and 19kV (with 20sccm gas flow). Even though the hi-pot test was very successful at high vacuum, we weren't able to apply more than 20kV on the ion source at the operational pressure.
   The setup at the LBNL ion source test stand was different. The mass flow controller was floating at high voltage (ion source potential); therefore, the high voltage break was installed at the

compressed pressure end of the mass flow controller as opposed to the low pressure side at Fermilab. In such a way, discharges in the gas line were avoided.
A quick fix onsite was implemented: a valve was installed between the HV break and the ion source chamber so that a higher pressure than in the source chamber could be achieved in the HV break, in turn avoiding Paschen breakdowns.

4. *Filament power supply*
   During the ion source operation, for some unknown reasons, the filament power supply was tripped several times.

Suggestions:

- It was suggested that the mass flow controller be installed closer to the ion source; ideally at the high voltage potential. In the existing set up, the mass flow controller on the gas manifold is mounted on the East wall of the building (outside the shielding cave), tens of feet away from the ion source. It takes more than 30mins for the source pressure to stabilize for any adjustment of the gas flow.
- Diagnostics to elucidate the reason for which the filament power supply trips during beam extraction are needed.