ACCELERATOR DIVISION DEPARTMENT PROCEDURE

IOTA/FAST DEPARTMENT

ADDP-FF-3005

IOTA PROTON INJECTOR DUOPLASMATRON ION SOURCE STANDARD OPERATING PROCEDURE

RESPONSIBLE DEPARTMENT: IOTA/FAST Department

PREPARED BY: ______________________ DATE: __________
Dean R Edstrom, Jr

REVIEWED BY: ______________________ DATE: __________
Kermit Carlson

APPROVED BY: ______________________ DATE: __________
Alexander Valishev
AD/APC IOTA/FAST Department Head

REVISION NO. 1 REVISION ISSUE DATE: 7/13/2017

Table of Contents

1.0 PURPOSE AND SCOPE 1

2.0 TERMS AND DEVICES 1

2.1 Source Cross-section 1
2.2 Source Components 1

3.0 TURN-ON 3

3.1 NOMINAL SETTINGS 3
3.2 STEPS TO TURN ON THE IS 3

4.0 NOMINAL OPERATION 4

5.0 PROCEDURE TRAINING REQUIREMENTS 5

6.0 PROCEDURE DISTRIBUTION 5

1.0 PURPOSE AND SCOPE

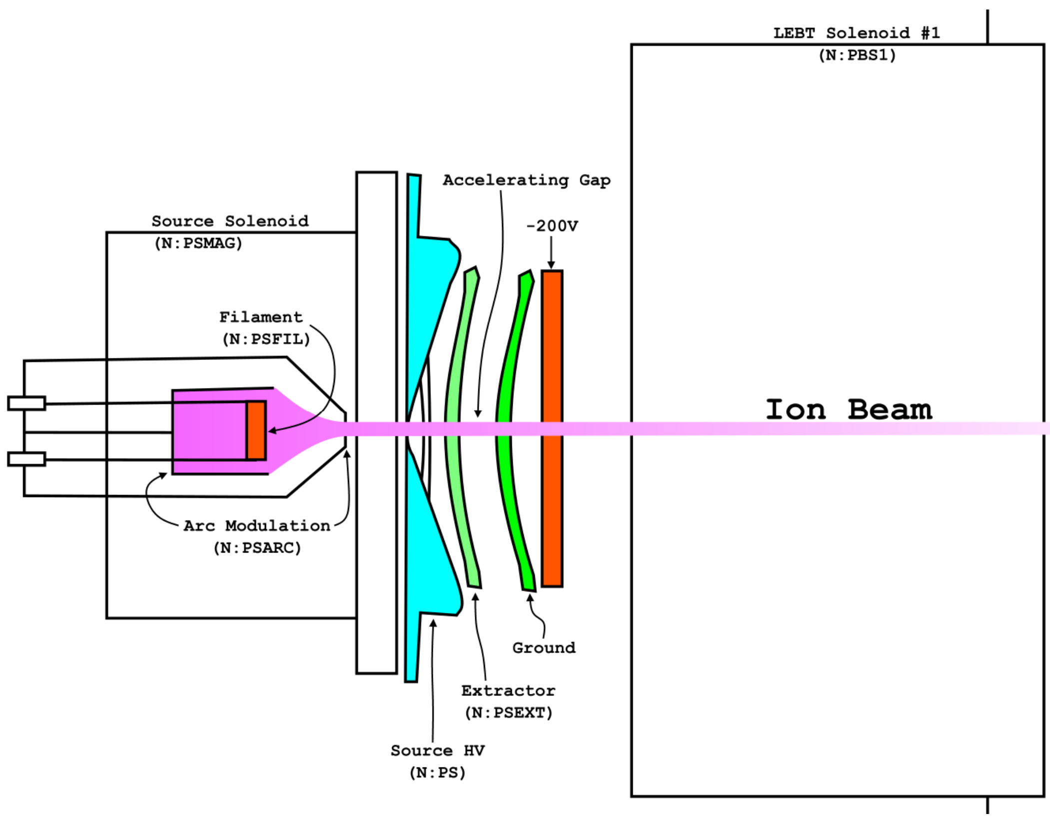
This Standard Operating Procedure introduces new operators to standard operations of the IOTA Proton Injector duoplasmatron ion source (IS). This presumes that the source is ready for standard operation according to ADDP-FF-3001 and all LOTO has been removed in following ADDP-FF-5001. These can be found in the FAST departmental procedures web page:

https://www-ad.fnal.gov/fast/procedures.shtml

2.0 TERMS AND DEVICES

There are a number of source-specific and training-specific terms as well as the ACNET Devices associated with the IS. This procedure assumes a basic knowledge of ACNET and accelerator components.

2.1 Source Cross-section



2.2 Source Components

IS: For the purposes of this procedure, the IS refers to the duoplasmatron gun and low energy beam transport (LEBT) section of the beamline up to but not including the RFQ.

Source Rack: This is the relay rack atop an isolation transformer, both of which are enclosed within a High Voltage enclosure to protect personnel from shocks during normal operation.

HVPS: The High Voltage Power Supply (HVPS) is a Glassman supply that provides the initial acceleration potential of the gun. External to the High Voltage Cabinet, the potential is applied to the source rack through a contactor assembly below the gun.

Gun: The gun refers to the set of components that generates a plasma and extracts an ion beam to the LEBT as shown below. A potential gradient is established across the gun from the HVPS potential (common with the source rack) to Earth ground at the downstream face. As such the gun is also enclosed to protect personnel during normal operation.

Extractor: The extractor power supply, found in the source rack, provides a tunable intermediate step between the HVPS potential and Earth ground in the accelerating column. It is nominally linked in controls to output at 25% of the HVPS output using the polarity commands through ACNET.

Source Gate: A timing gate generated based on the controls clock (N:PSTE = HINS Clock $AB). The gate originates in the relay rack that contains the Glassman HVPS and is transported to the source rack by fiber optic. The pulse width (determining the maximum arc modulator length) is settable through N:PSTW.

Arc: The arc modulator is powered through a bulk power supply, both of which are found in the source rack. It generates the plasma arc in the gun along the filament in the source gate.

Filament: The filament ionizes the plasma, providing the beam for extraction. Its power supply is found in the source rack.

Solenoids: There are three (3) solenoids associated with the IS as defined above. One, kept at high voltage in the source rack, is commonly referred to as the 'source magnet' or 'source solenoid' in various documentation of the IS in its current incarnation and its former life as the High Intensity Neutrino Source (HINS).

Source Scope: The source scope is in the source rack and monitors the pulse (Channel x), arc current (Channel y), and arc voltage (Channel z). A remote picture is available on the controls network at: http://131.225.143.61/image.png. Note that browsers may not be able to save this image. Methods for working around this include taking 'copy image' from the browser and pasting it into mspaint, and taking a screen capture.

Source PLC: A programmable logic controller in the source rack that provides reference settings to and collects readings from each of the gun component supplies above.

Ion Gauge: Source pressure is monitored with a vacuum gauge attached to the back side of the gun. The source PLC uses this readback to regulate the source valve.

Source Valve: A VAT valve that allows flow of hydrogen from the source bottle to the gun. It nominally operates on a PID loop in the source PLC with proportional and integral gains set to over-damp, preventing oscillations.

3.0 TURN-ON

Initial conditions following maintenance or extended periods of downtime should be as follows: The HVPS should be found switched off from the front panel, and all source rack supplies (N:PSARC, N:PSBULK, N:PSEXT, N:PSFIL, and PSMAG) with front panel power switches set to on, but their ACNET parameters set to 'off' to remove appropriate enable signals. A set of nominal settings and readbacks is listed below, and should be restored unless an understood state is being restored.

3.1 NOMINAL SETTINGS

Source Supplies		Setting
Arc Modulator	N:PSARC	0.344 – 1 A
Bulk	N:PSBULK	200 V
Filament	N:PSFIL	21.5 A
Source Magnet	N:PSMAG	1 A
HVPS	N:PS	20 kV
Extractor	N:PSEXT	0.25 x N:PS

LEBT		Setting
Solenoid 1	N:PBS1	250 A
Solenoid 2	N:PBS2	250 A
Horz Trim 1	N:PBH1	0 A
Vert Trim 1	N:PBV1	0 A
Horz Trim 2	N:PBH2	0 A
Vert Trim 2	N:PBV1	0 A

3.2 STEPS TO TURN ON THE IS

1. Ensure that the HV Enable indication is lit on the front panel of the extractor supply. If not, access the front of the HV cabinet using the LOTO procedure and turn it on. This cannot be turned on remotely.

2. Check the source pressure through N:PSVAC and check that this matches the front panel display in the source rack. In the event that there are latched trips for any devices in noted here, a reset issued to the device should clear the trip so long as a nominal running condition has been restored.

3. Check that the valve regulation is set correctly and is enabled. The valve regulation uses the setting for N:PSVAC as its reference and is nominally between 100 and 150 mTorr. The valve will generally regulate between 71% and 73%, with the lower end effectively fully closed and the upper end effectively fully open. The PID loop is controlled through N:PSVLV, which should be on during nominal operation. If it is found off, contact system experts to investigate and for further instructions.

4. Check the gate valve status through N:PBBS and contact system experts if it is found closed. The beam stops (separate from the

gate valve), may be retracted at this time if found closed by issuing an 'on' to N:PBBS.

5. LEBT supplies may be turned, with nominal setting for the solenoids and trim dipoles. These can be found on a parameter page, N14 Survey <11>, or on the IS synoptic display.

6. The next steps establish the arc in the source starting with the source magnet supply (N:PSMAG), which should be turned on and set to nominal from ACNET, N14 Survey <10>, or synoptic.

7. Turn on the bulk supply (N:PSBULK) and arc modulator (N:PSARCI) and set both to nominal from ACNET or synoptic.

8. The Filament supply (N:PSFIL) ramps slowly to the target value, but this can still result in out-gassing that can result in a vacuum trip. To avoid this the filament may be turned on and brought up to a readback of 9 amps (the setting may be significantly lower, so if there is any doubt knob up slowly until current appears in the readback, and then bump up from there accordingly). Bump up to nominal operating levels from there while paying close attention to the source pressure (N:PSVAC). Once the source pressure exceeds its set position by 20 mTorr, verify that the valve is moving appropriately, closing down slowly to compensate due to the PID loop. Continue to increase the filament current as it comes back into range until the nominal setting for the filament is reached.

9. Verify that both the wall breaker and front panel breaker for the HVPS are on and then turn on the HVPS (N:PS) from ACNET or synoptic. Issuing an 'HVPS on' will turn on the contactor to clear the ground and provide the safety signal to the HVPS if the door interlocks on the High voltage cabinet are complete. The 'HV On' button must also be pressed on the Glassman supply locally to turn on the high voltage. Set the HVPS to 1 kV and verify that the front panel shows the supply is outputting 1 kV according to the digital display. If the supply shows 0 kV but is current-limited, this indicates a ground fault and the position of both ground sticks should be re-verified. Also verify that the extractor supply (N:PSEXT) is on and following N:PS in the appropriate ratio dependent/independent control is effected through the polarity setting.

10. Continue bumping N:PS up to the nominal 20 kV, verifying that N:PSEXT follows in the appropriate ratio.

4.0 NOMINAL OPERATION

Once all power supplies are running at nominal settings, beam should be visible on the Faraday cup where it is absorbed (this is fully-destructive and no residual radiation is detected beyond for the nominal 20 keV beam generated by the ion source making it safe to occupy the enclosure during ion source operation). Measurements of the ion beam on the Faraday cup can be read from the LeCroy oscilloscope through the IOTA Proton aggregate of the NML sequencer using the fast_get_faraday_cup ACL command and a set of traces can be recorded using the fast_get_faraday_trace ACL command.

A number of interlocks may trip various supplies including source pressure (N:PSFIL), glycol flow (N:PSMAG), and the rack smoke detector (all rack power supplies will trip with this). These interlocks latch and will require a reset from a supply device after the condition is resolved to make-up the interlock.

The source is currently only allowed to be run while attended, requiring that personnel be at MDB and actively monitoring the source during run mode. If not attended, the beamline solenoids (N:PBS1 & N:PBS2), gun arc (N:PSARC & N:PSBULK), and gun high voltage (N:PS & N:PSEXT) should be turned off, and the filament (N:PSFIL) should be turned down (below 18 A) if not off. All maintenance activities are subject to the LOTO procedure ADDP-FF-5001.

As operation of the proton ion source progresses, various components will be placed between the source and Faraday cup including an Alison scanner and spectrometer magnet. Once beam from the ion source is fully characterized, the source will be moved to the FAST Facility at NML, where it will be installed alongside the high-energy Electron Injector beamline to provide protons through an RFQ to the IOTA ring at 2.5 MeV. This procedure will be updated along with these steps to reflect the current location and mode of operation of the IOTA Proton Injector ion source.

5.0 PROCEDURE TRAINING REQUIREMENTS

On-the-job training on this procedure shall be performed before solo operation of the IS.

6.0 PROCEDURE DISTRIBUTION

An electronic copy of this procedure shall be made available through the FAST Web Page (http://fast.fnal.gov/). A signed hard copy of the latest revision shall be maintained in the NML control room.