# STATUS OF NEW 2.5 MeV TEST FACILITY AT SNS

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*Abstract*

A new 2.5MeV beam test facility is being built at SNS. It consists of a 65 keV H- ion source, a 2.5MeV RFQ, a beam line with various beam diagnostics and a 6 kW beam dump. The facility is capable of producing one-ms-long pulses at 60Hz repetition rate with up to 50mA peak current. The commissioning with reduced average beam power is planned for fall 2014 to verify operation of all systems. The full power operation is scheduled to begin in 2015. The status of the facility will be presented as well as a discussion of the future R&D program.

## INTRODUCTION

The Integrated Test Stand Facility (ITSF) consists of an $H^-$ ion source, a Low Energy Beam Transport (LEBT), a Radio Frequency Quadrupole Accelerator (RFQ), a Medium Energy Beam Transport (MEBT), a high power beam stop and support systems. Functionally these systems replicate the SNS Front End systems to ensure relevance of the results obtained on the ITSF for the SNS Front End. The current layout of ITSF is shown in Fig. 1.

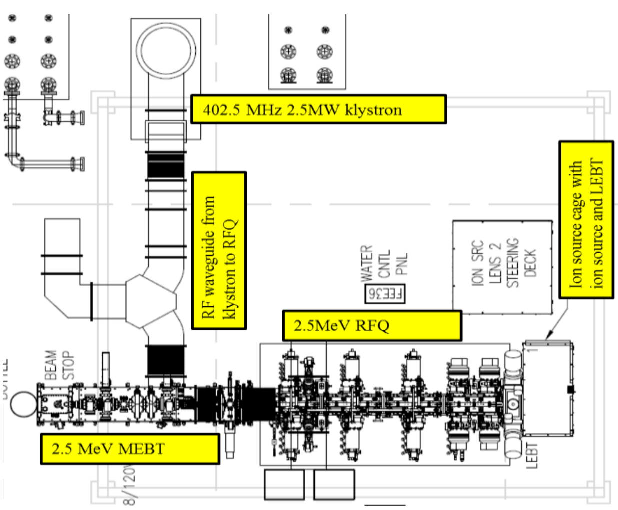


Figure 1: Current layout of the SNS Integrated Test Stand Facility.

The main goals of the ITSF are:

- Verifying operation of the SNS spare RFQ with full power beam test
- Providing a platform for testing existing equipment and developing new equipment for improving SNS reliability and power capability.
- Providing a platform for conducting R&D for novel accelerator physics and technological concepts related to high intensity hadron beam generation, acceleration, manipulation and measurement.
- Providing proton beams for a short pulse neutron source for the SNS Second Target Station moderator development.

This document provides a general description and status of the ITSF major systems.

## ION SOURCE AND LEBT SYSTEMS

### *Ion Source*

The $H^-$ Ion source is identical to the ion source used at the SNS Front End with identical or similar support systems [1]. The developmental External Antenna Ion source will also be tested on this test stand [2].

### *LEBT*

Several LEBT configurations are considered for the ITSF:

- An electrostatic LEBT that is identical to the baseline SNS Front End LEBT The main purpose of this LEBT is to verify operation of the spare RFQ.
- An experimental 2-solenoid magnetic LEBT with chopper. The main purpose of this LEBT is to explore the possibility of incorporating a fast chopper into a magnetic LEBT with neutralized beam. If successful, this development can lead to a 2-source magnetic LEBT design suitable for a high reliability high current Front End [3].

A schematic view of the ion source and electrostatic LEBT that is currently in use is shown in Fig. 2.

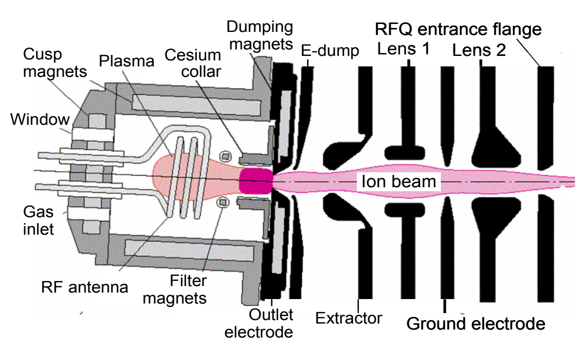


Figure 2: Schematic view of the $H^-$ ion source and electrostatic LEBT

## RFQ

The SNS spare RFQ [4] with associated support systems is used in the ITSF. When the spare RFQ is moved to the SNS Front End, the old SNS RFQ will be




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used in the ITSF. A schematic view of the RFQ is shown in Fig.3; its main parameters are:

| | |
|---|---|
| Structure Type | 4 vane |
| Total Length | 3.723 m |
| RF Frequency | 402.5 MHz |
| Input Energy | 65 keV |
| Output Energy | 2.5 MeV |
| Peak output Current | 50 mA |
| Vane-to-vane Voltage | 83kV |
| RF duty Factor | 10% |

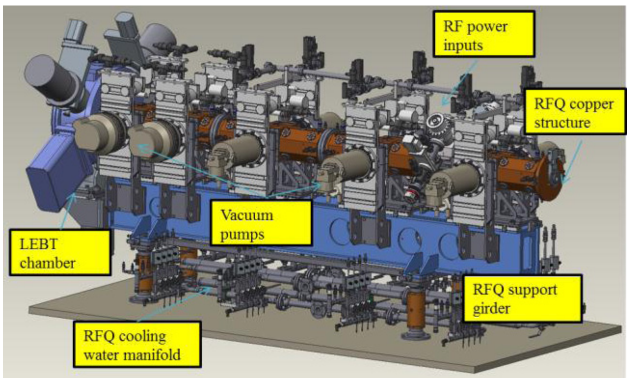


Figure 3: Schematic view of the new SNS RFQ.

## MEBT AND BEAM STOP

### *Medium Energy Beam Transport Line*

The main goals of the MEBT are

- Providing a loss-free beam transport from the RFQ to the beam stop
- Providing space for beam diagnostics
- Providing space for R&D equipment

Transverse beam focusing is provided by six quadrupole magnets. Two of the magnets are equipped with dipole steering coils for the beam trajectory correction. Currently, there is no provision for longitudinal bunch focusing. The transverse beam envelope is shown in Fig. 4. A schematic view of the MEBT and beam stop is shown in Fig. 5.

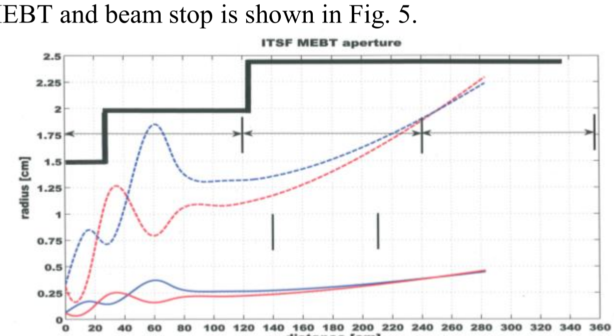


Figure 4: Transverse beam envelope size in the MEBT.

The initial suit of MEBT beam diagnostics includes:

- A beam current transformer.
- A beam emittance measurement system consisting of two pairs of slits, one horizontal and one vertical, separated by a 1 m drift space. The horizontal and vertical slits are offset axially to allow simultaneous scans in both planes without collision. This arrangement allows measuring the beam charge distribution in the full 4-D phase space.
- A movable Beam Position and Phase Monitor for beam energy measurements using the time-of-flight technique.
- A Fast Faraday Cup for longitudinal bunch profile measurements.
- A view screen with digital camera.
- A beam current attenuator consisting of movable semi-transparent grids with 25% and 50% transmission
- A movable stripping foil for converting $H^-$ beam to protons.

### *High Power Beam Stop*

A 6 kW, 2.5MeV beam stop is located at the end of the MEBT. The beam stop is made of TZM alloy, is water cooled and is insulated from the ground to serve as a Faraday cup. The same beam stop was used during the SNS Front End commissioning in 2003. A radiation level of about 300 mRem/hour @ 30cm is expected at full beam power, and therefore radiation shielding will be installed for high beam power operation.

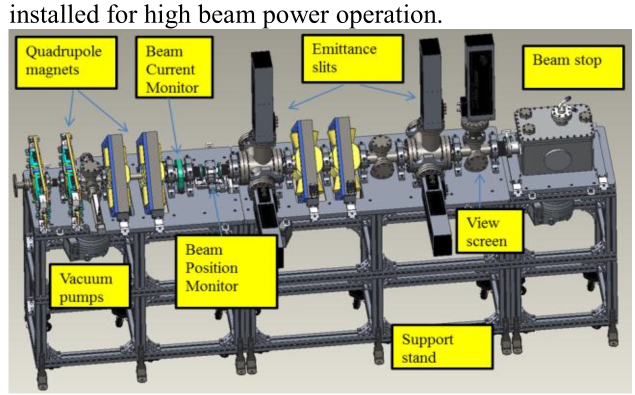


Figure 5: Schematic view of the MEBT and beam stop.

## STATUS AND NEAR TERM PLANS

All ITSF equipment required for low power beam operation has been installed as shown in Fig. 6 and is being tested.

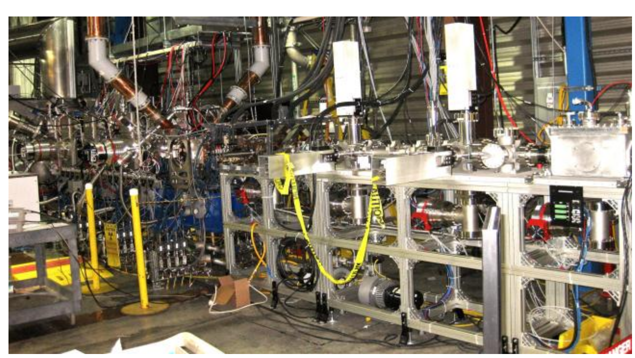

Figure 6: ITSF view as of August 15th 2014.

The beam line is under vacuum end-to-end from the ion source to the beam stop. The diagnostics systems have been tested to the extent possible without beam.

The RFQ high power RF test has been successfully completed. The RF power has reached 590 kW average peak power in open loop and 550 kW in closed loop operations in 1000 µsec, 60 Hz pulses. The test has shown that vacuum pressure in the RFQ has steadily improved over time with decreasing vacuum activities and corresponding RF trips. The RFQ cavity vacuum was around $1 \times 10^{-7}$ torr and the coupler vacuums were around $2 \times 10^{-8}$ torr. A typical energy spectrum of X-rays generated in the RFQ cavity is shown in Fig. 7.

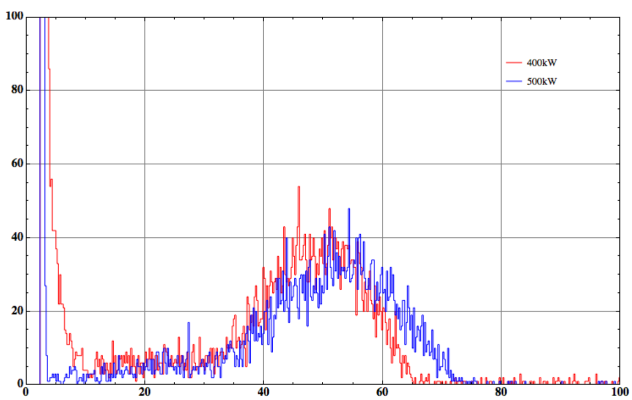


Figure 7: Energy spectrums of the X-ray emission from the RFQ cavity measured at different RF power.

Testing of the ion source high voltage and high power RF systems is in progress. We anticipate starting low power beam operation with pulse width limited to 50us and repetition rate to 5 Hz in the fall of 2014. This will allow characterizing the RFQ transmission, the output energy, and the transverse beam emittance.

An active Personnel Protection System (PPS) and a beam stop radiation shield have to be added to allow safe operation at the maximum design beam power. It is anticipated for these systems to be ready in early 2015 together with a fully integrated EPICS controls system to allow remote operation from the SNS central control room.

## FUTURE DEVELOPMENT PLANS

### *Short Pulse Neutron Source*

The future development of the ITSF includes building a short pulse neutron source for testing novel concepts of neutron moderators in preparation for the SNS Second Target Station project. A fast chopper will deflect a portion of the available beam to the neutron target as shown in Fig. 8. The remaining can be used for other studies in MEBT-2. Funding for the design of the moderator test facility will start in October 2014 with the goal to have the proton beam line and fast chopper built in 2015 and the rest of the facility in 2016-2017.

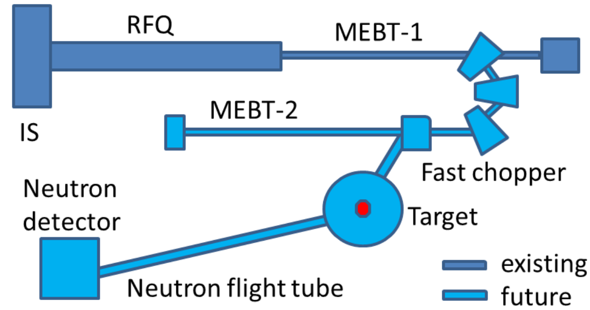


Figure 8: Schematic layout of the ITSF development to include a short pulse neutron source.

### *High Intensity Beam Dynamics Test Bench*

The addition of dipole magnets for the neutron source beam line allows adding diagnostics for direct beam energy distribution measurements at the location with large dispersion. An RF deflector can be added at a convenient location in the MEBT to allow for a time selection within the bunch. These, together with the existing 4-D emittance scanner, will form a system for direct measurement of the bunch charge distribution in the 6-D phase space. We plan to conduct an experimental study of the beam particle distributions in the 6-D phase space with the ultimate goal of developing a method for generating initial beam distributions for realistic linac simulations.

The available real estate at the ITSF allows for building a dedicated FODO beam line, schematically shown in Fig. 8 as MEBT-2, to repeat the halo development experiment conducted at LEDA a decade ago [5]. The lack of a full characterization of the initial bunch distribution was named as the most probable reason for the inconclusive results of the experiment. With the 6-D phase space diagnostics available at the ITSF this gap in halo formation understanding can be closed.

## ACKNOWLEDGMENT

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