Status of a Project X Front-End Test Facility

2011 Particle Accelerator Conference

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March 30, 2011
Initial HINS Design

- Novel High Intensity Neutrino Source (HINS) design to increase neutrino flux out of Fermilab Main Injector
- Prototyping began in 2005 under HINS program

325 MHz Front-End Linac

- Beam Specification: 25 mA peak, 1 ms pulse length, 10 Hz rep-rate
- All RF components driven by a single 325 MHz RF klystron
- Superconducting RF transition energy at 10 MeV
- Low beta acceleration by 325 MHz superconducting spoke cavities
2.5 MW Klystron and RF Distribution

- 325 MHz Toshiba klystron
- Capable of 3 ms pulse at 2.5 Hz or 1 ms pulse at 10 Hz
- Series of waveguide switches can route power to beam line or cavity test cave
• Starts with ion source and 325 MHz RFQ
• The rest of the beam line is focusing and instrumentation

• Used to test the beam quality out of the 2.5 MeV RFQ
• Enclosure is rated for 10 MeV, 25 mA protons at 1% duty cycle
RFQ output energy confirmed last year.

Initial problems with cooling water leaks into vacuum system limited average power.

RFQ water lines have been modified and repaired.

Expect to re-commission beam line next week.

Output current and emittance measurements affected by ion source issues.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specified</th>
<th>Measured</th>
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<tbody>
<tr>
<td>Beam Energy</td>
<td>2.5 MeV</td>
<td>2.5 MeV</td>
</tr>
<tr>
<td>Pulse Width/Rep Rate</td>
<td>3 ms/ 2.5 Hz</td>
<td>100 μs/1 Hz</td>
</tr>
<tr>
<td>Output Current</td>
<td>20 mA</td>
<td>4 mA</td>
</tr>
<tr>
<td>Transverse Emittance (axi-symmetric beam)</td>
<td>0.26π mm/mR</td>
<td>???</td>
</tr>
<tr>
<td>Longitudinal Emittance</td>
<td>150π keV*deg</td>
<td>???</td>
</tr>
<tr>
<td></td>
<td>(rms)</td>
<td></td>
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</table>
• More than half of proton source current due to $H^{2+}$ and $H^{3+}$.
• Higher order species saturates wire signal making emittance measurements difficult.
• Plans to replace proton source with $H^-$ source in June 2011.
• Successful test of 325 MHz SC spoke resonator pulsed to ~37 MV/m by R. Madrak.
Six Cavity Test

- Extended beam line contains four copper spoke resonators and two buncher cavities
- Increases beam energy from 2.5 MeV to 3 MeV
- Main purpose is to test concept of single RF source for multiple cavities
- Expect to start commissioning in June 2011
• RF Distribution for six cavity test is in place.
• Large boxes are variable delay lines. Vector modulators are in front of lights.

• Test of VM with 6 kW RF.
• Purple trace is amplitude modulated RF.
• Incorporates many HINS specifications
• CW front end makes most HINS components incompatible
• Facility still useful for testing Project X components
A beam chopper is necessary to deliver proper bunch patterns to the Project X experiment. Chopper must be capable of extinguishing an arbitrary pattern of single bunches from the bunch train.

Kickers require 250V voltage swing with <1.2 ns rise times. Beam dump must handle ~12 kW of beam power.

Verification of operation is an important step in proving the feasibility of Project X.
SSR0 Cryomodule

- Project X transition to superconducting RF at 2.5 MeV
- Lowest transition energy for any high intensity hadron accelerator
- Figure shows spoke resonator cryomodule design used for low beta section (SSR0)
- Spoke resonators have never been tested with beam
- Beam enclosure needs 2K cryo distribution upgrade.
• The facility will be available for any Project X component and instrument testing with beam parameters listed below.
• The facility will also be available for testing low-beta spoke resonators in test cryostats.

<table>
<thead>
<tr>
<th>Beam Energy</th>
<th>2.5 or 3 MeV</th>
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<tbody>
<tr>
<td>Bunch Spacing</td>
<td>325 MHz</td>
</tr>
<tr>
<td>Pulse Width/Rep Rate</td>
<td>Up to 1ms at 10Hz or 3ms at 2.5Hz</td>
</tr>
<tr>
<td>Beam Species</td>
<td>H⁺ or H⁻</td>
</tr>
<tr>
<td>Ion Source Energy</td>
<td>50 keV</td>
</tr>
<tr>
<td>Available RF Power</td>
<td>2.5 MW (peak)</td>
</tr>
</tbody>
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