Status of a Project X Front-End Test Facility

2011 Particle Accelerator Conference

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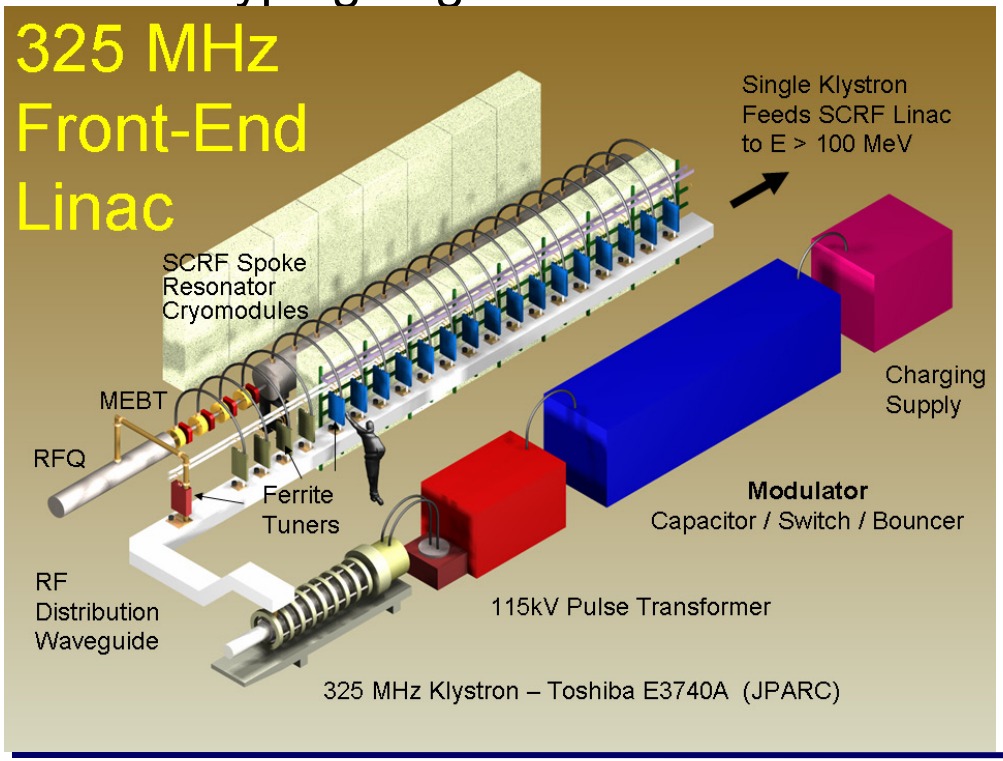
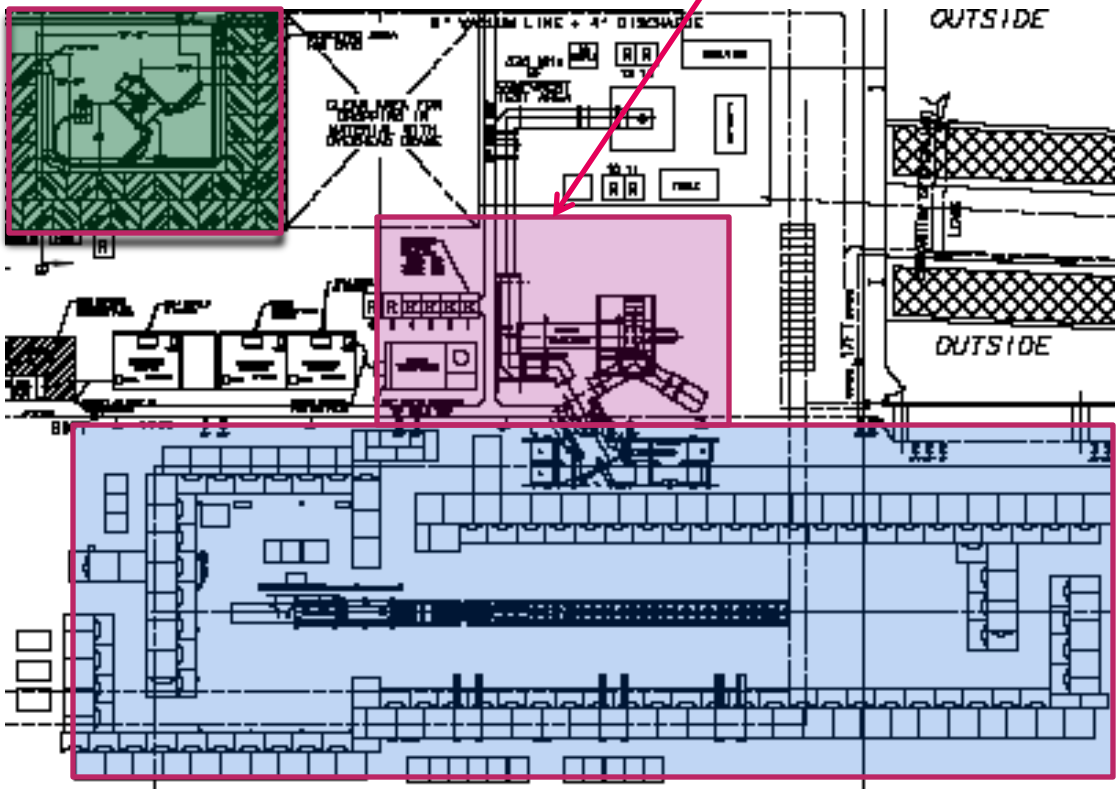
Initial HINS Design

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



- 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

Project X Layout of Test Facility

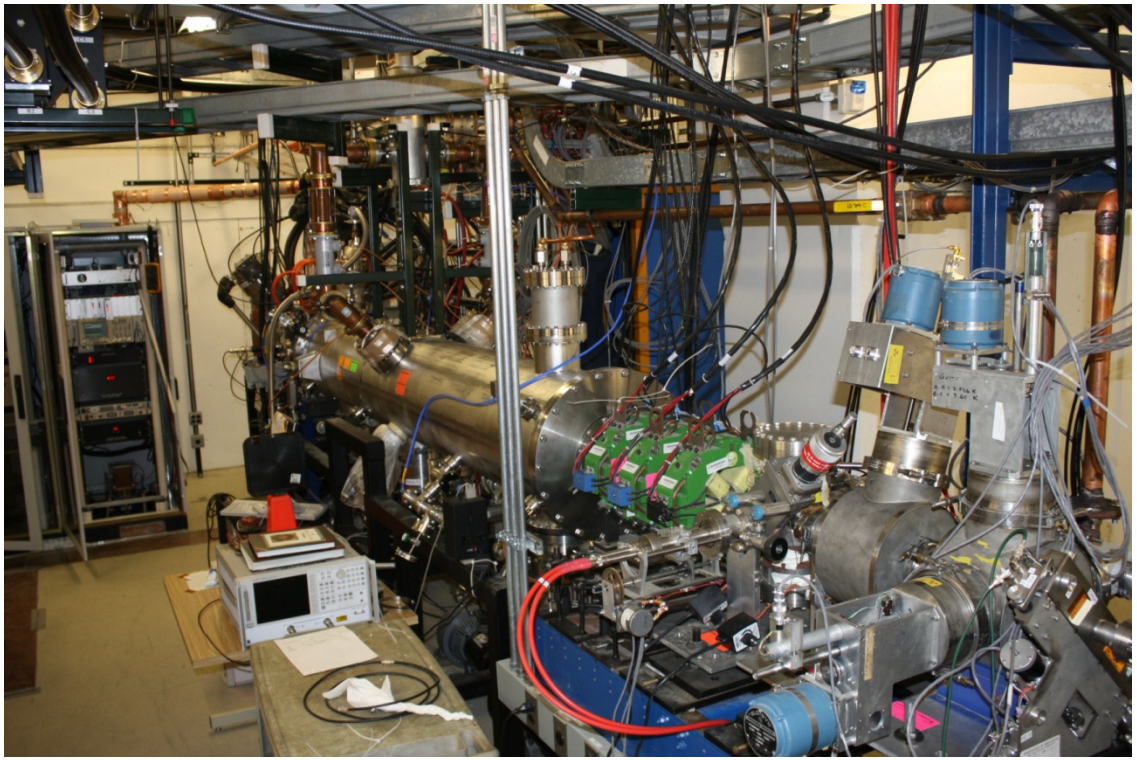


2.5 MW Klystron and RF Distribution

- 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

2.5 MeV Beam Line

- Starts with ion source and 325 MHz RFQ
- The rest of the beam line is focusing and instrumentation



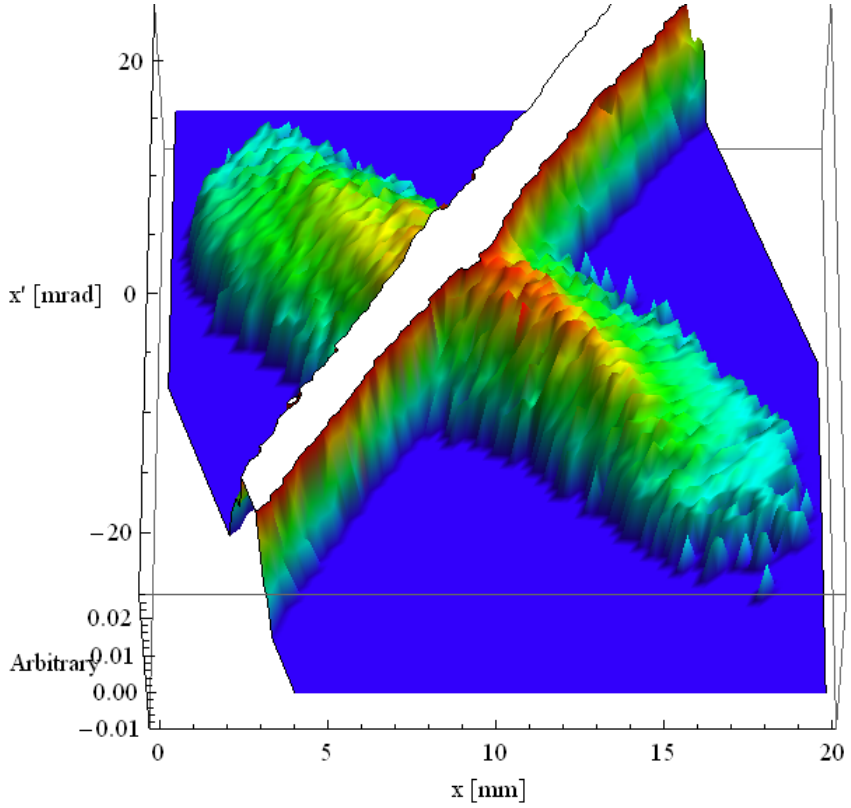
- Used to test the beam quality out of the 2.5 MeV RFQ
- Enclosure is rated for 10 MeV, 25 mA protons at 1% duty cycle

Beam Line Results

Parameter	Specified	Measured
Beam Energy	2.5 MeV	2.5 MeV
Pulse Width/Rep Rate	3 ms/ 2.5 Hz	100 μs/1 Hz
Output Current	20 mA	4 mA
Transverse Emittance (axi-symmetric beam)	0.26π mm/mR	???
Longitudinal Emittance	150π keV*deg (rms)	???

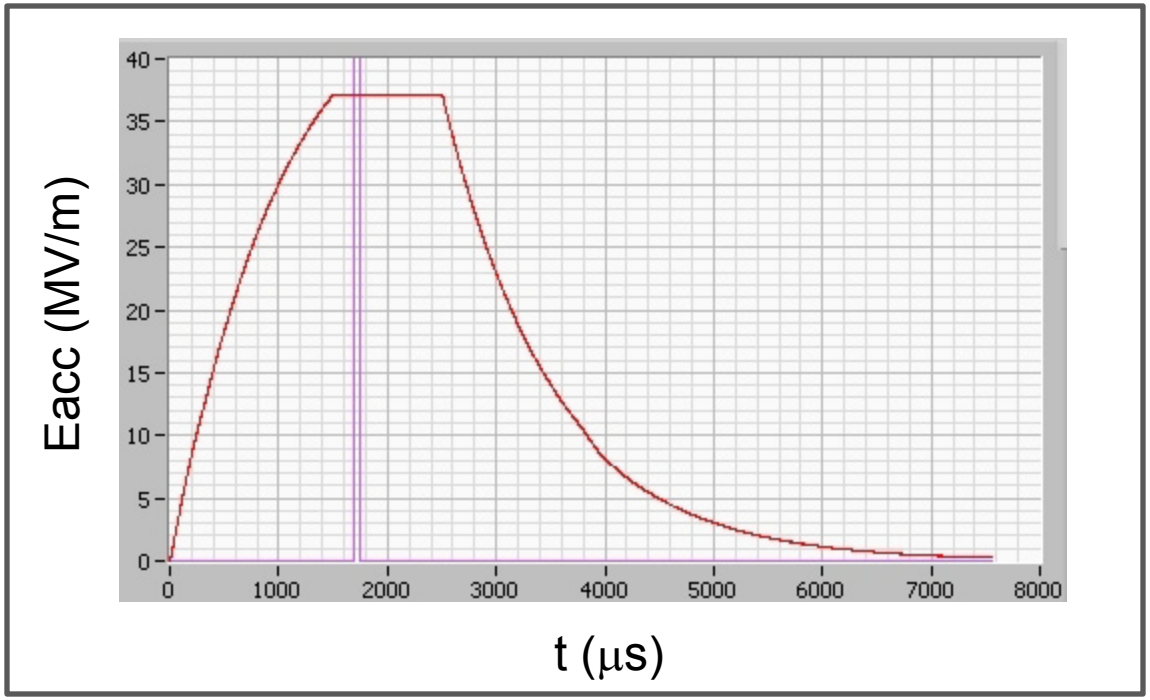
- RFQ output energy confirmed last year.
- Initial problems with cooling water leaks into vacuum system limited average power.
- RFQ water lines have been modified and repaired.
- Expect to re-commission beam line next week.
- Output current and emittance measurements affected by ion source issues.

Ion Source



- 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.

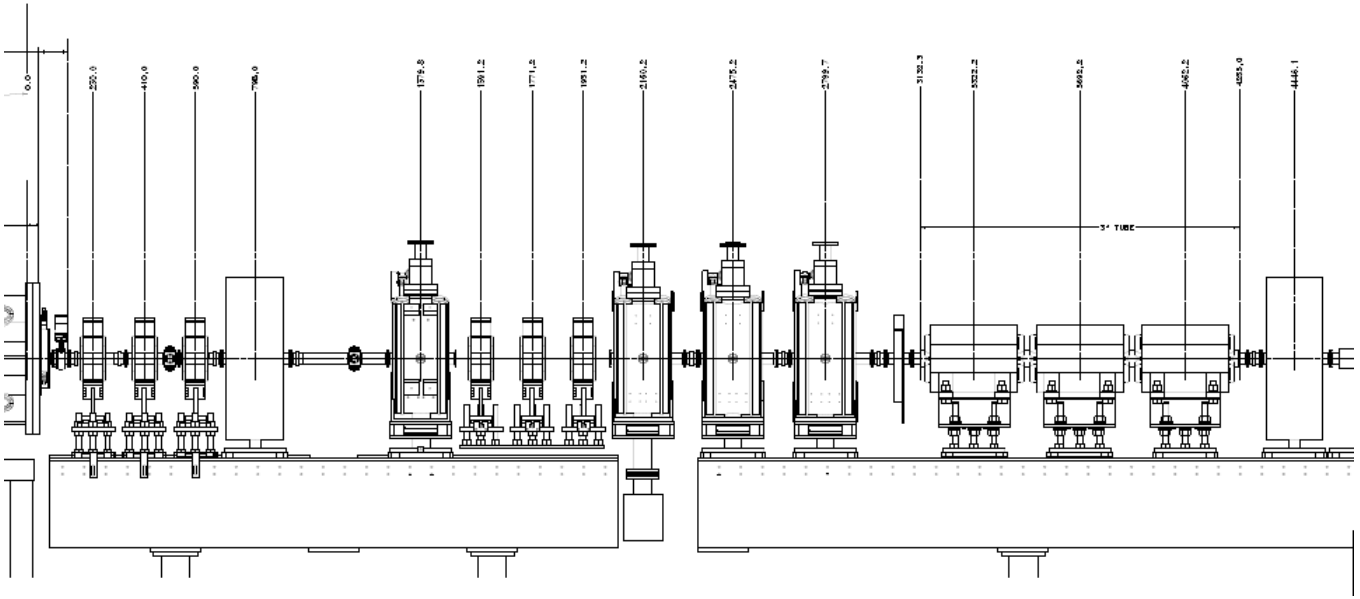
Cavity Test Cave with Cryostat



- Successful test of 325 MHz SC spoke resonator pulsed to ~37 MV/m by R. Madrak.

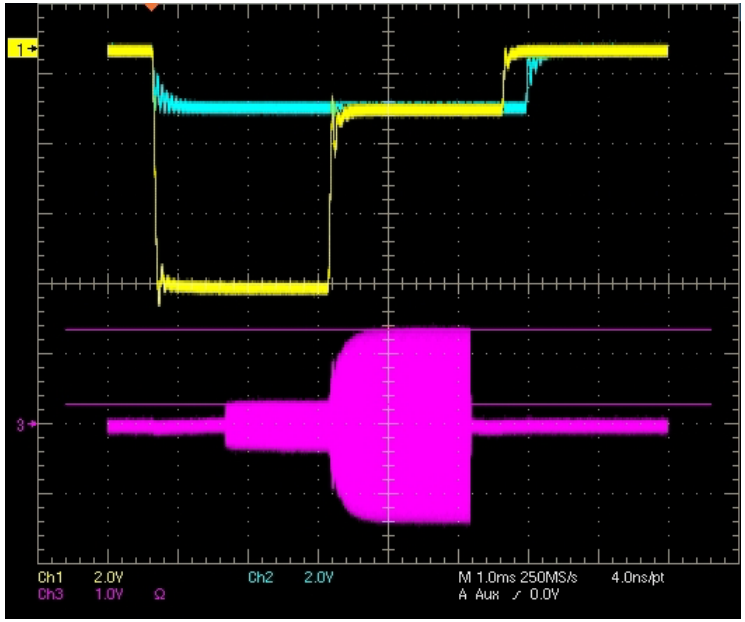
Six Cavity Test

- 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 with Vector Modulators

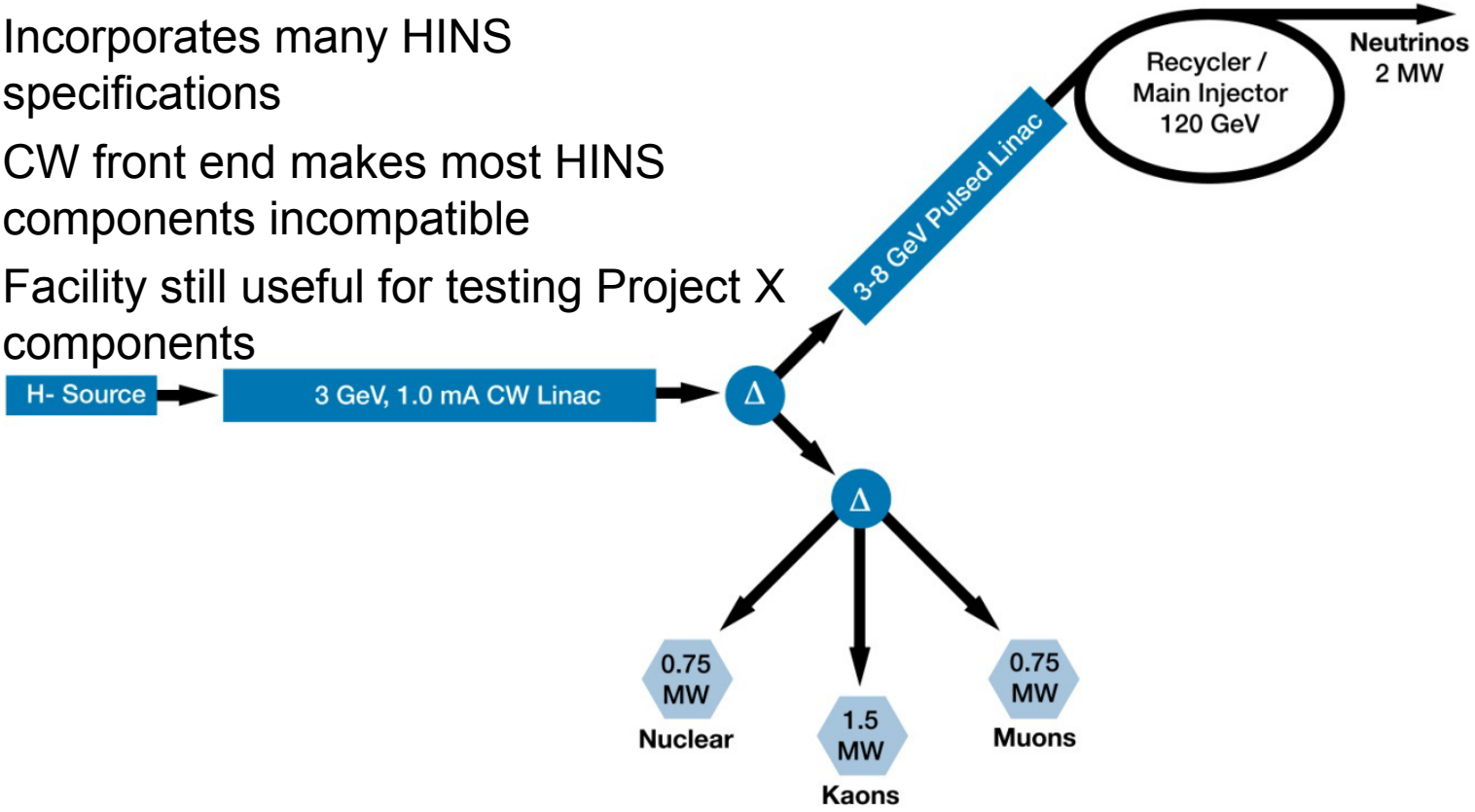
- RF Distribution for six cavity test is in place.
- Large boxes are variable delay lines. Vector modulators are in front of lights.



- Test of VM with 6 kW RF.
- Purple trace is amplitude modulated RF..

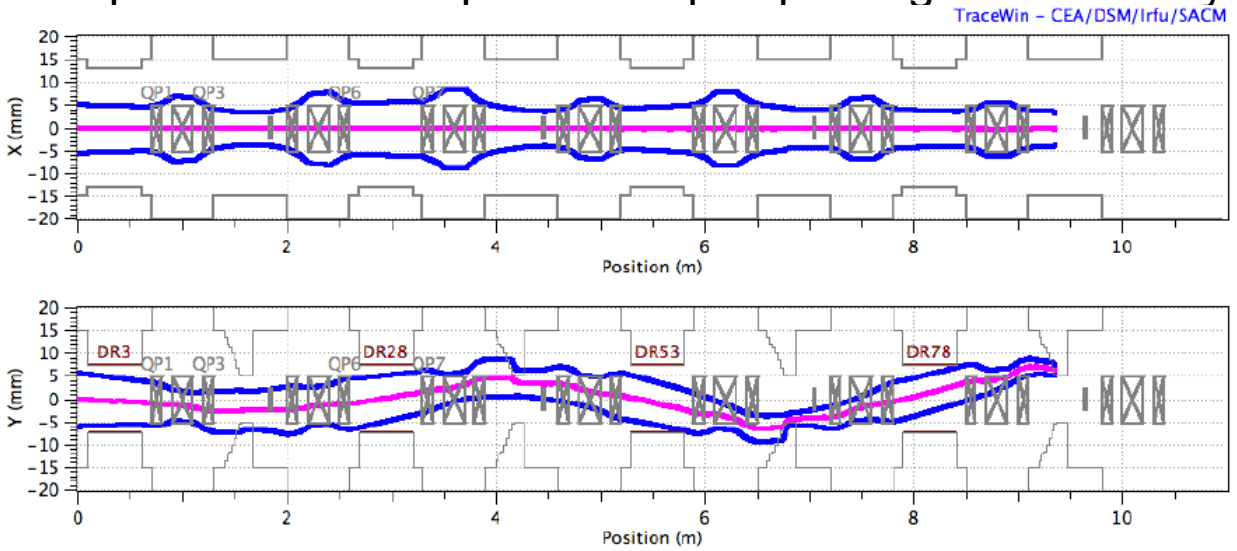
Project X

- Incorporates many HINS specifications
- CW front end makes most HINS components incompatible
- Facility still useful for testing Project X components

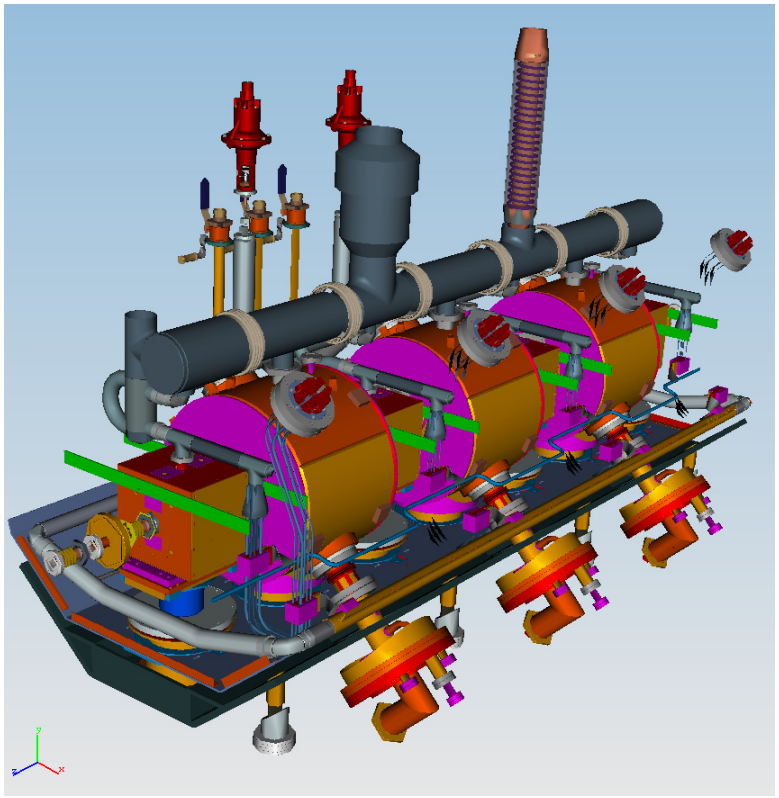


MEBT Chopper

- 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.

Table 1: Summary of Test Beam Specifications

Summary

- 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.

Beam Energy	2.5 or 3 MeV
Bunch Spacing	325 MHz
Pulse Width/Rep Rate	Up to 1ms at 10Hz or 3ms at 2.5Hz
Beam Species	H^+ or H^-
Ion Source Energy	50 keV
Available RF Power	2.5 MW (peak)