

# **Project X Instrumentation R&D at HINS**

Vic Scarpine  
Project X Collaboration Meeting  
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- Motivation
  - HINS Parameters
  - HINS Measurements to Date
  - Beam Diagnostic Projects
  - Collaborations
  - Goals and Timelines
  - Conclusions



- HINS (High Intensity Neutrino Source) is a unique Linac Injector R&D facility
  - Outside of HINS, regular access to high-intensity, low-energy H- beam for R&D is limited
- Potential exists to operate HINS as a low-energy, high-intensity H-test facility during Project X R&D phase
  - Allows for the development of Fermilab projects as well as a facility for external collaborators
  - An accessible test facility is critical for a number of Project-X R&D areas
- Potential project areas:
  - **Beam diagnostics R&D**
  - Beam dynamics at low-energy
  - Beam chopper R&D
  - Low-energy material studies



Particle	H+ then H-	
Nominal Bunch Frequency/Spacing	325 3.1	MHz nsec
Particles per Pulse	37.5 *	E13
Pulse Length	3/1	msec
Average Pulse Current	~ 20	mA
Pulse Rep. Rate	2.5/10	Hz
Bunch Current	32	mA
Bunch Intensity	6.1 98	E8 pCoul

**\* full un-chopped 3 msec pulse at klystron-limited 20 mA**

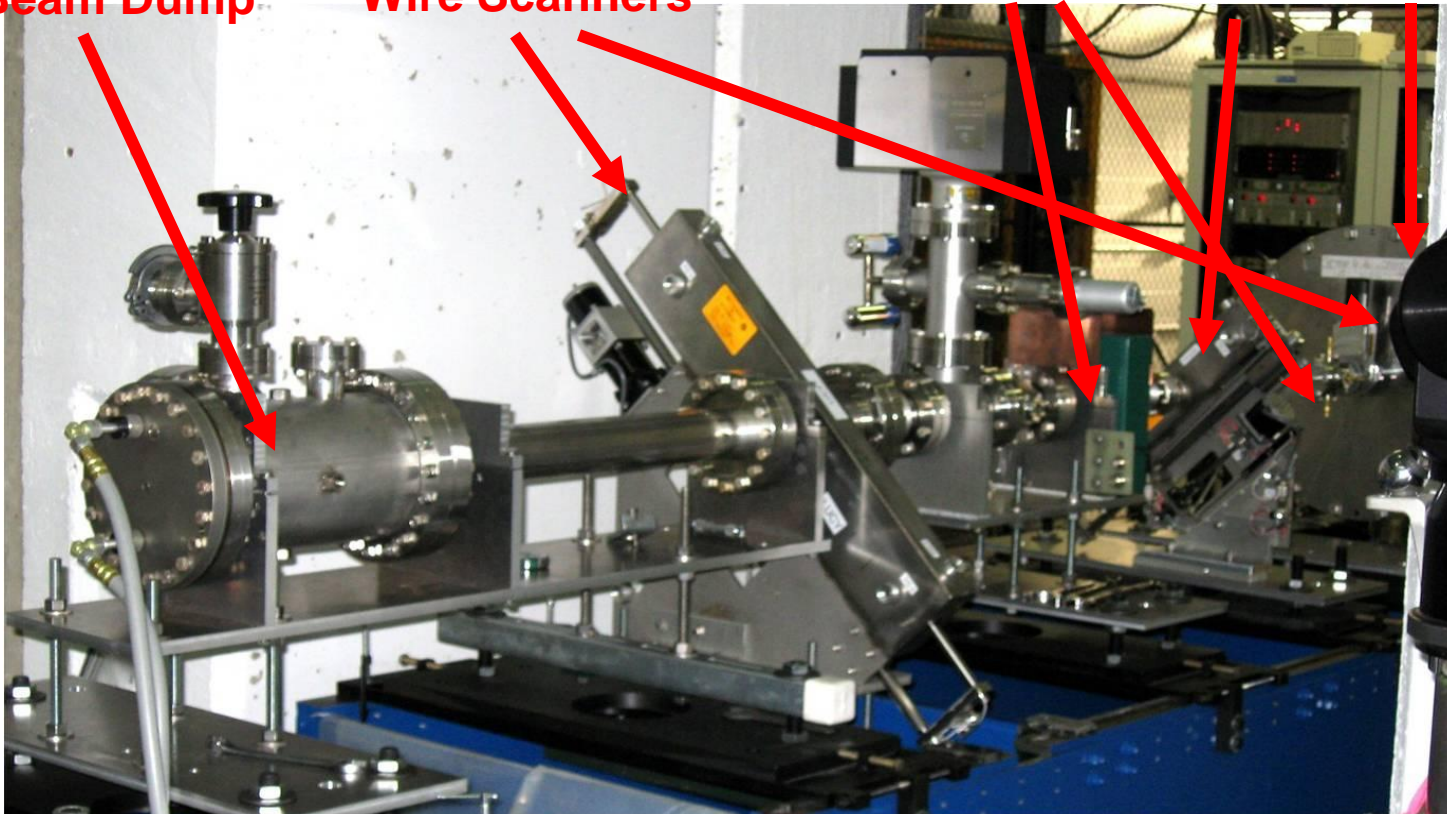


- First proton beam through RFQ in Spring 2010
- Beam parameters:
  - Ion source (protons): 500 usec @ 1 Hz
  - RF: 50 usec @ 0.5 Hz
    - RFQ operated without cooling
- Ion Source Toriod ~ 15-20 ma
  - <50%?? protons; >50%?? other (H2+, H3+)
  - Ion source species are being measured
- RFQ Output Toriod Current ~ 3-4 ma
  - Possible beam loss after RFQ but before toroid
- *Basic diagnostics line to make transverse profiles and energy measurements*

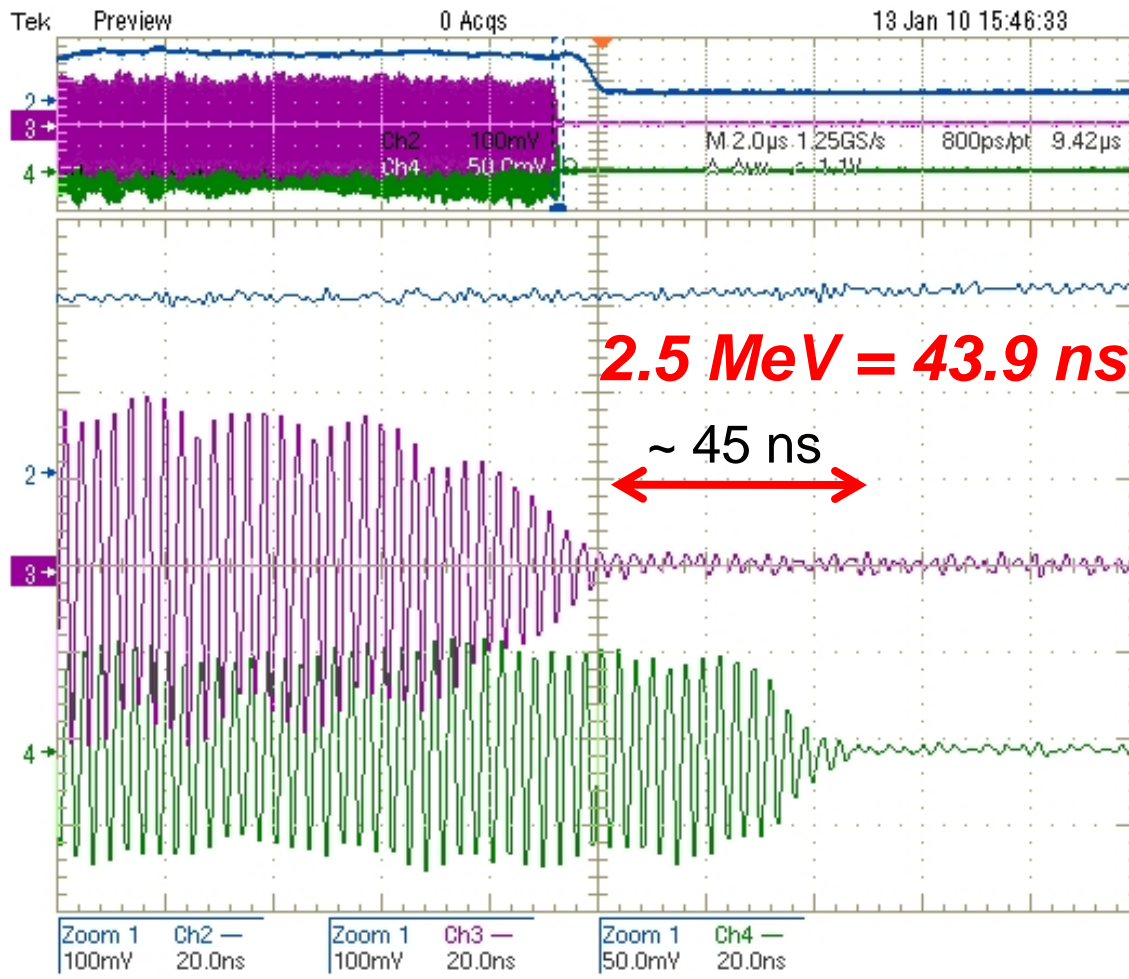


The HINS linac is equipped with a reconfigurable, movable diagnostics station at the end of the linac

**Beam Dump**      **Wire Scanners**      **BPMs**      **Toroid**      **RFQ**



# RFQ Beam Energy – Time of Flight



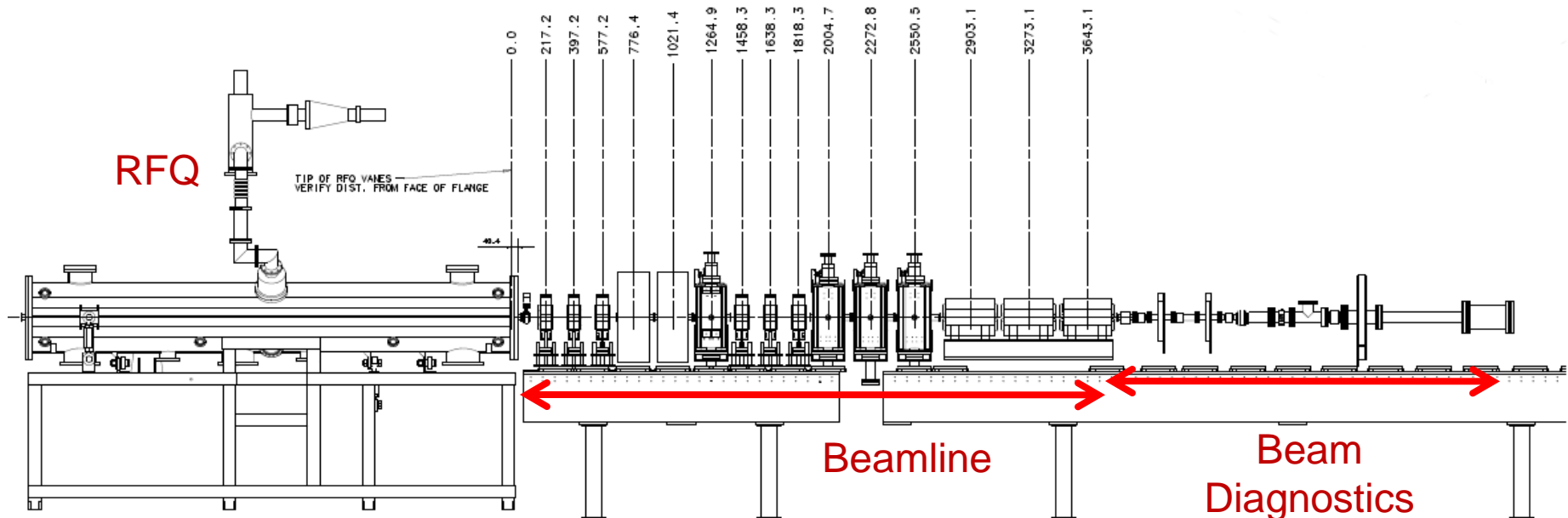
- Sparked RFQ

- Up BPM

- Down BPM



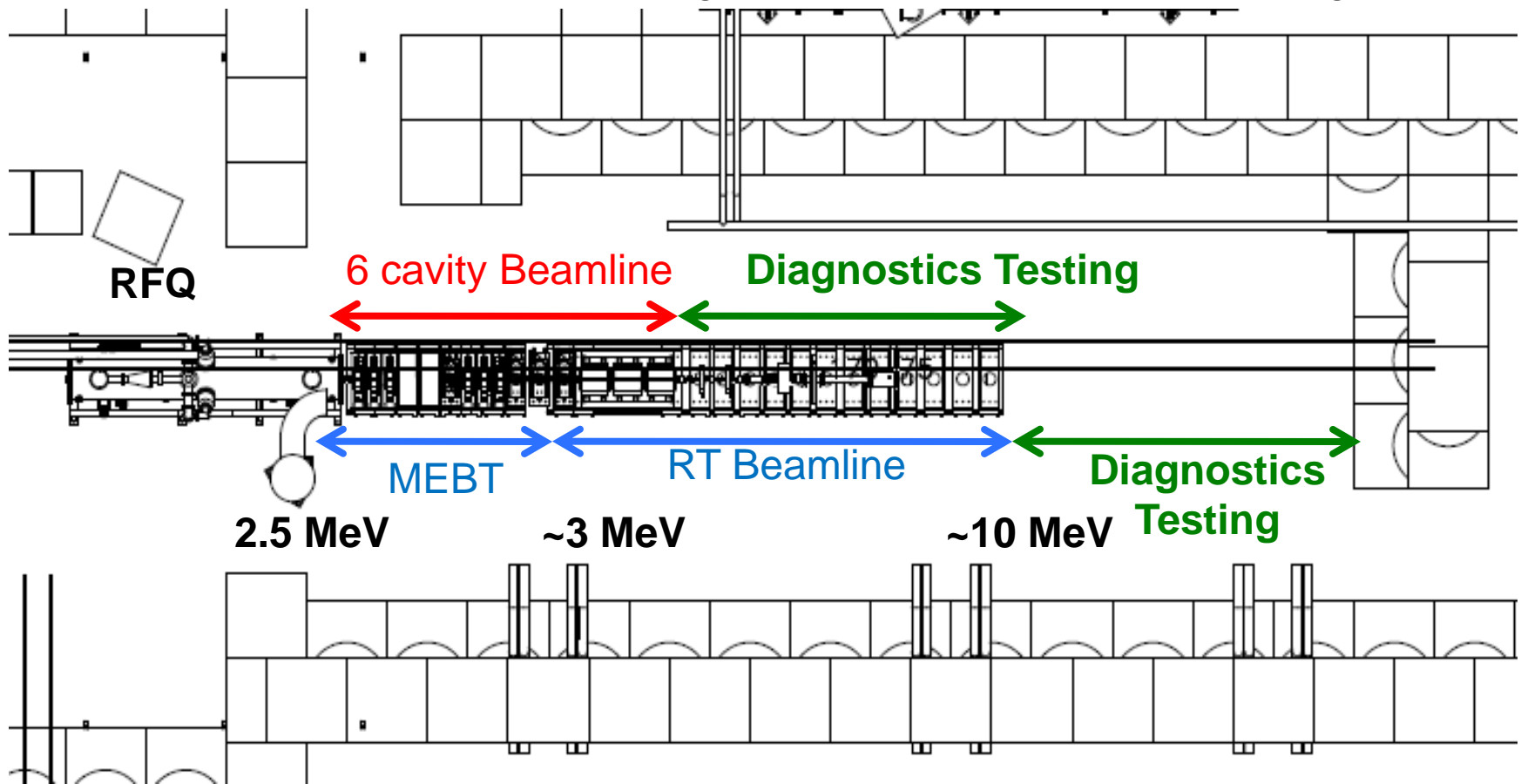
- To test vector modulator concept
- Two buncher cavities - Quadrupole focusing instead of superconducting solenoids
- ~2.7 to 3.0 MeV protons
- Diagnostic line primarily for beam evaluation / phase evaluation







HINS beamline will evolve – diagnostics section will adapt to changes





- *Transverse Diagnostics*
  - Laser Transverse Profile Monitor\* - *previous collaboration with BNL*
  - Ionization Profile Monitors
  - Electron Wire Transverse Profile Monitor
- *Longitudinal Diagnostics*
  - Wire Longitudinal Profile Monitor\*
  - Laser Longitudinal Profile Monitor\* - *collaboration with LBNL*
  - Broadband Faraday-cup\* - *collaboration with SNS*
- Halo Monitoring – transverse and longitudinal
  - Vibrating wire\* - *from Bergoz Instrumentation*
  - Laser wire\*
- **MEBT Emittance station**
  - Slit-collector\*
  - Laser Slit\*

\* *Project X related instrumentation to be tested at HINS*



- Project X Collaboration Initiative (November 2008):
  - Present beam instrumentation collaboration projects with SNS, LBNL, and SLAC
- SNS
  - Various advanced diagnostics systems (**broadband Faraday-cup**, e-beam scanner, **MEBT beam instrumentation**, **laser wires**, etc.)
  - Support, information exchange, R&D help, visits, reviews, etc.,
- LBNL
  - **Development of a mode-locked fiber laser system for longitudinal bunch profile measurements (also bunch tails), distribution of laser light with fiber optics**
    - *see LBNL talk by Bryd & Wilcox*
    - **Critical to use HINS at testing facility**
- Others?

# Basic Transverse Laser Profile Monitor (LPM)

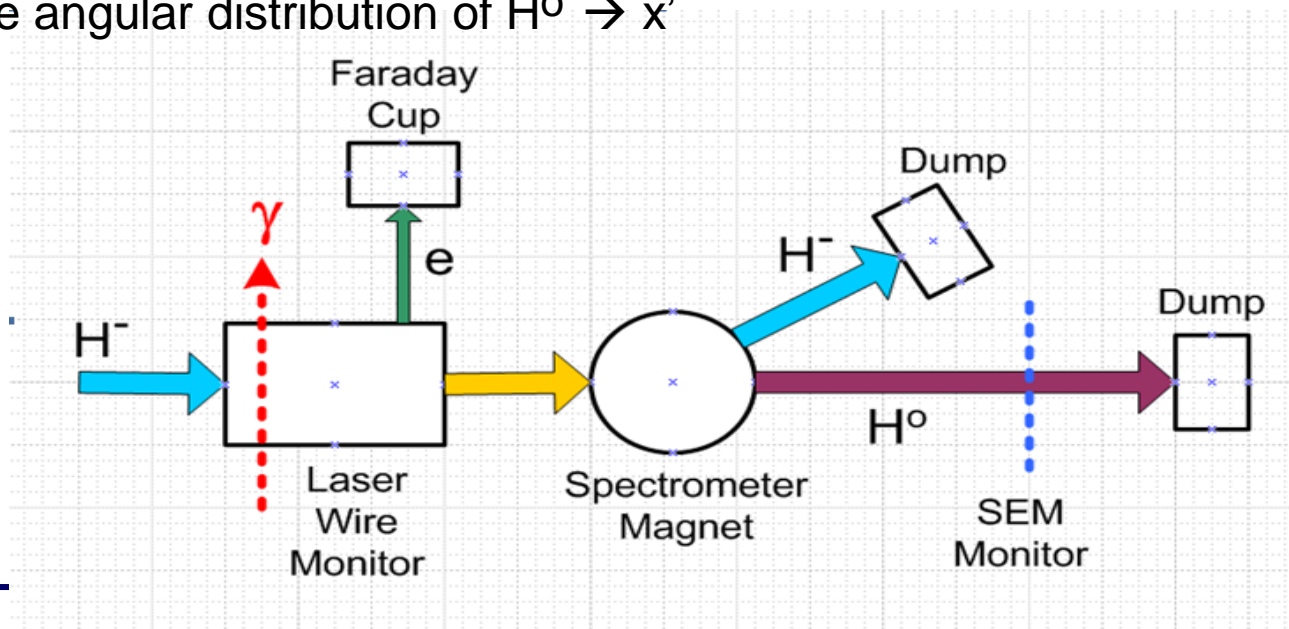


- Profile measurements difficult in intense H- beams
  - Wire dangerous near superconducting cavities
- Use narrow laser to ionize H- and measure profile
  - $H^- + \text{photon} \rightarrow H^0 + e^-$
  - Collect electrons or measure reduction of H- current
- Collaboration formed between FNAL and BNL to produce LPM for HINS
  - Other groups, such as SNS, have also produced LPMs
- LPM demonstrated at BNL with beam and delivered to FNAL in summer of 2008
- Unit redesigned at FNAL and installed at end of FNAL Linac during summer 2009 shutdown – 400 MeV H-
  - Laser suffered radiation damage – repaired this past shutdown
- Studies of LPM in Linac
- Integration into HINS after H- source arrival at HINS

# Laser Transverse Emittance Monitor



- Best method to measure emittance when space charge effects are large is to use a scanning slit or pepper pot method
  - A low-energy, high-intensity beam may damage/destroy material in beam
  - Use a non-intercepting method to block beam - *laser*
- Scan laser across bunch to act as a virtual slit to convert  $H^-$  to  $H^0$
- Collect electron to measure intensity in slit  $\rightarrow x$
- Measure angular distribution of  $H^0 \rightarrow x'$





- FY10
  - Continue laser diagnostics collaboration with LBNL, and instrumentation collaboration with SNS.
  - Setup and commissioning of HINS basic beam instruments, e.g. beam intensity, orbit, phase, etc.
  - Focus on Project X mission critical RD&D projects, e.g. laserwire, MEBT instrumentation, halo measurements, beam loss monitoring, and more.
    - Construct prototype systems
- FY11
  - Install and test prototypes at HINS
  - Install H- source at HINS
- FY12
  - Summarize operation experience on prototypes
  - Finalize design and development activities



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- HINS beamline construction pathway gives an opportunity for proton and H- beam diagnostics development
    - 2.5-3.0 MeV H-
    - 10 MeV H-
  - Low-energy Project X beam diagnostics R&D can be performed using the HINS pulsed beam format
  - HINS can provide a unique and critical test facility for low-energy high-intensity proton and H- that is not readily available outside of Fermilab
  - Operating HINS as a test facility, even after HINS goals are met, is advantageous to Project X beam diagnostic instrumentation R&D phase