HINS H^- Beam Diagnostic Development and Test Facility

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AAC Meeting

November 16-17, 2009

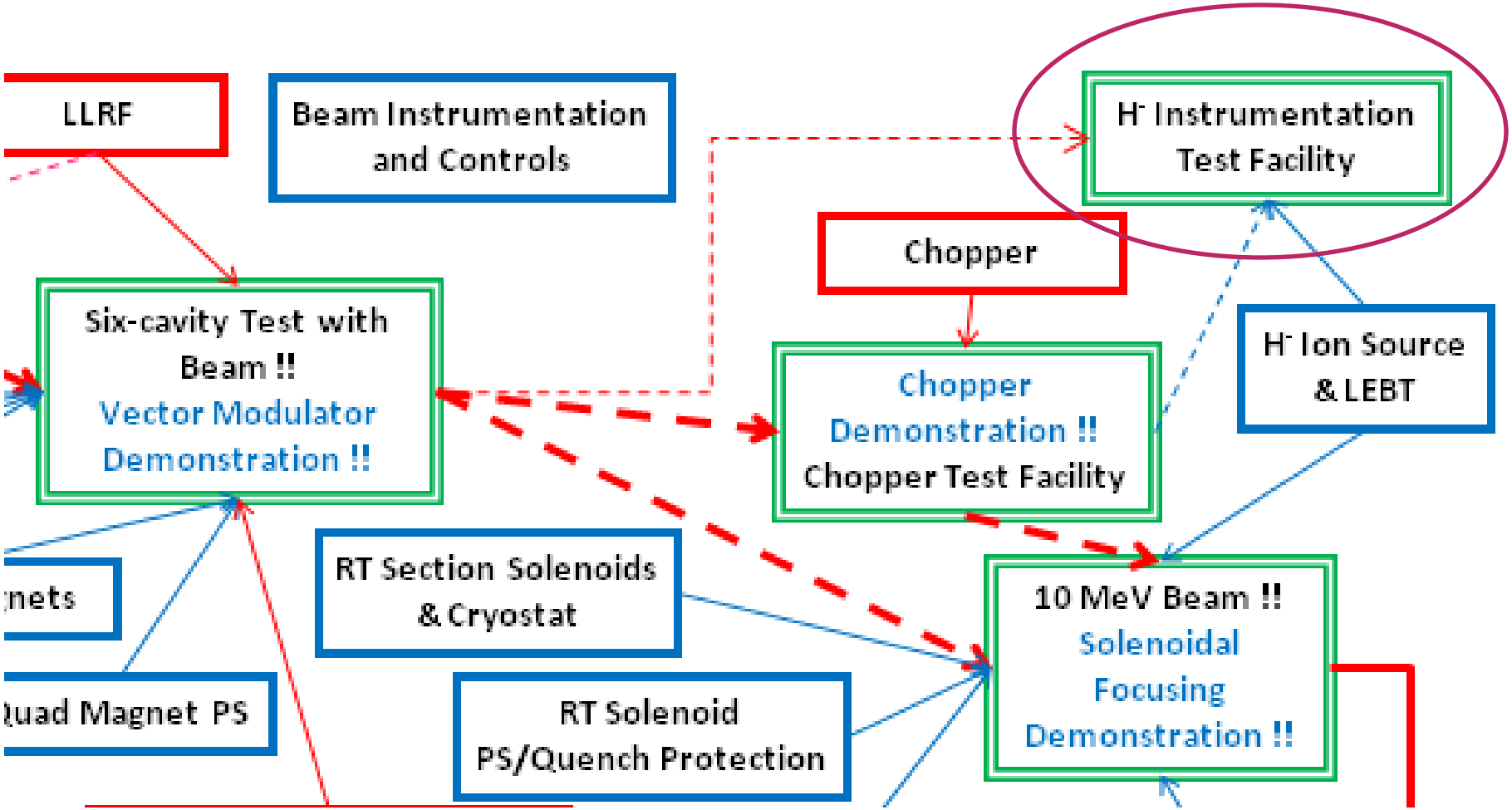
Outline

- Motivation
- Roadmap
- Beam Diagnostic Projects
- Collaborations
- Goals and Timelines
- Conclusions

Motivation

- 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

Roads to Test Facility



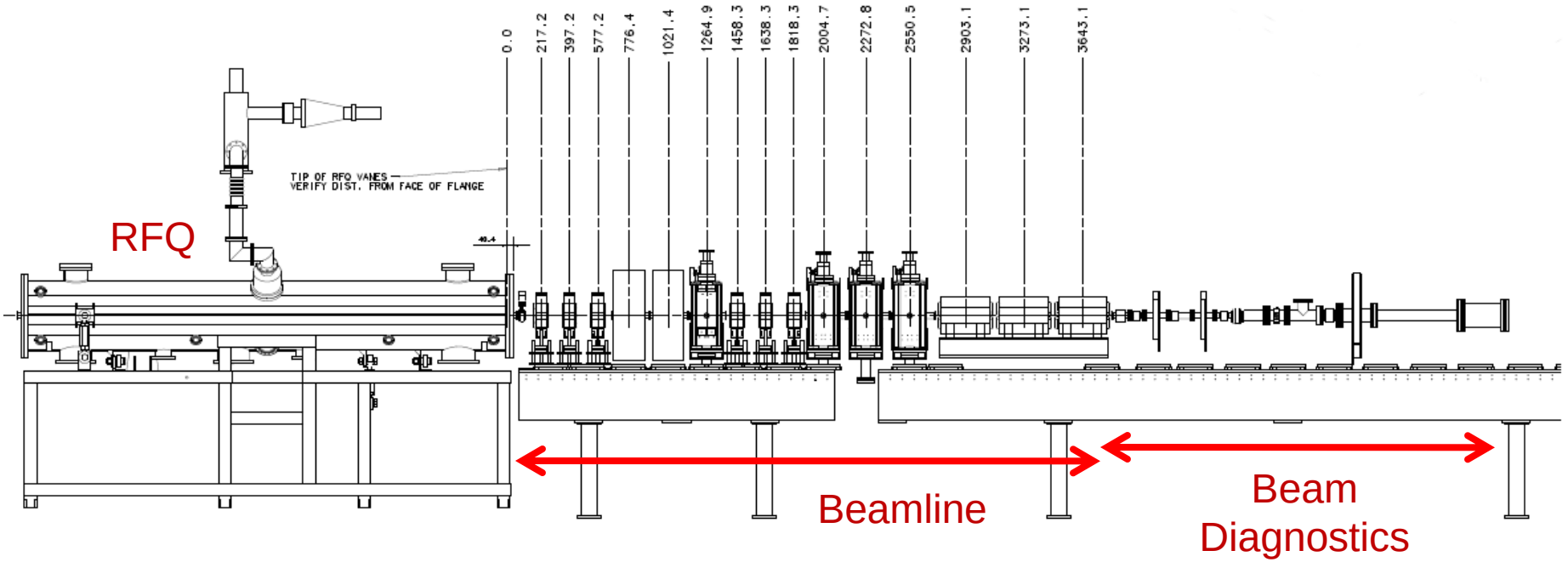
HINS Beam Parameters

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

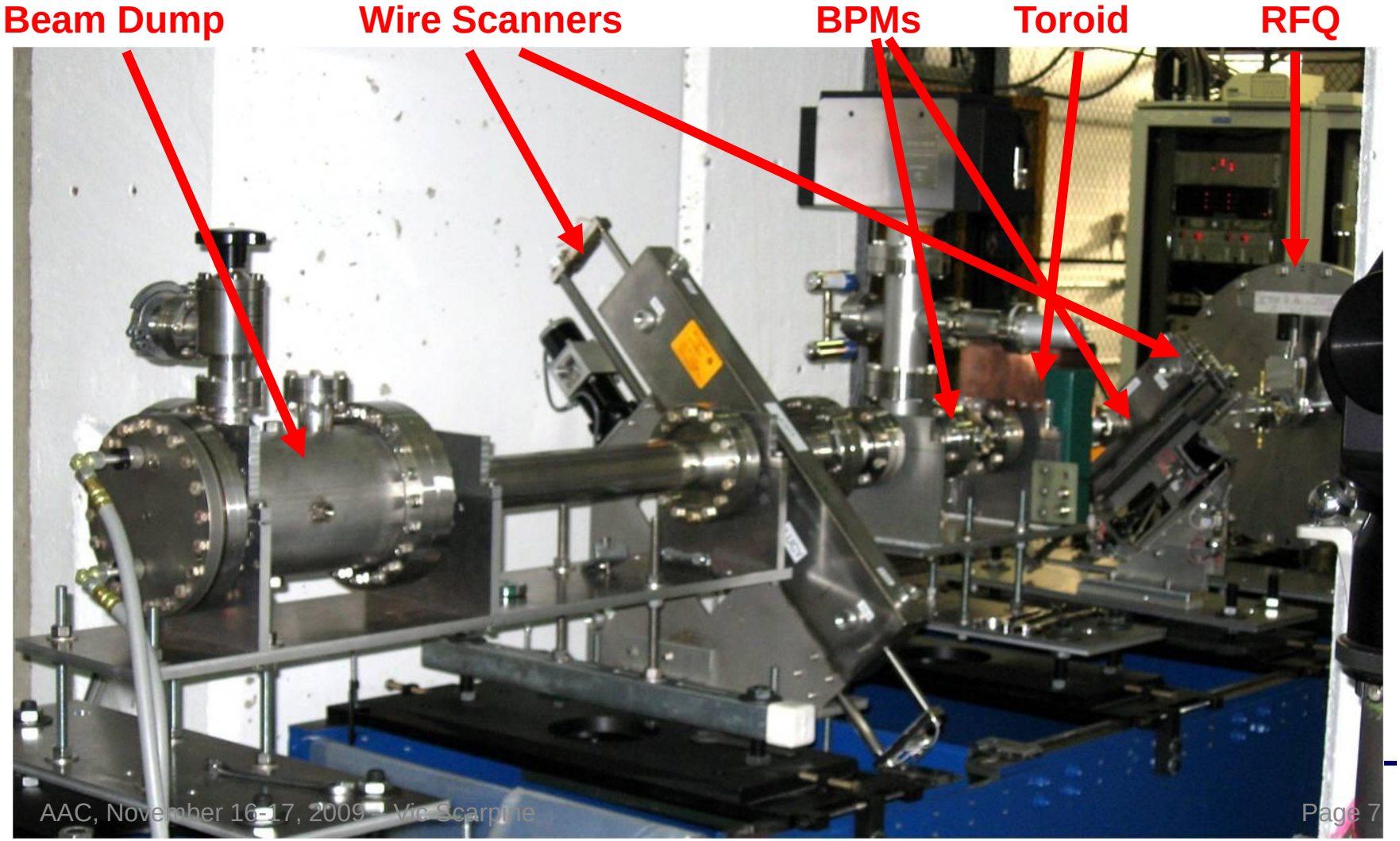
Upcoming 6-Cavity Test

- 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



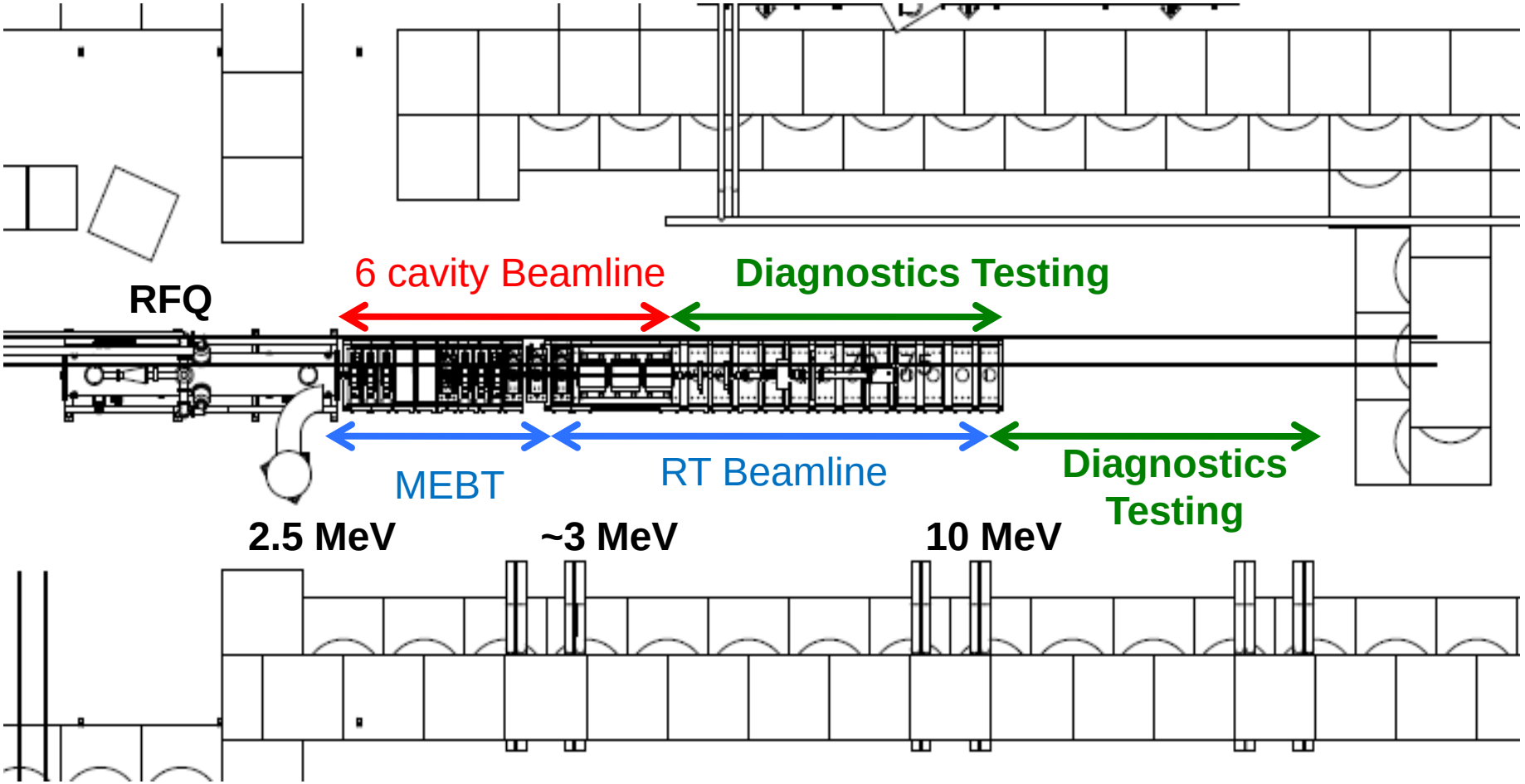
Movable Beam Diagnostics

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



HINS Cave Layout

HINS beamline will evolve – diagnostics section will adapt to changes



Beam Diagnostic Projects for Project X

- *Transverse Diagnostics*
  - Laser Transverse Profile Monitor*
  - Ionization Profile Monitors
  - Electron Wire Transverse Profile Monitor
- *Longitudinal Diagnostics*
  - Laser Longitudinal Profile Monitor*
  - Wire Longitudinal Profile Monitor*
  - Broadband Faraday-cup**
- Halo Monitoring – transverse and longitudinal
  - vibrating wire*
  - Laser wire*
- MEBT Emittance station
  - slit-collector*
  - *Laser Slit**

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

Project X Collaborations

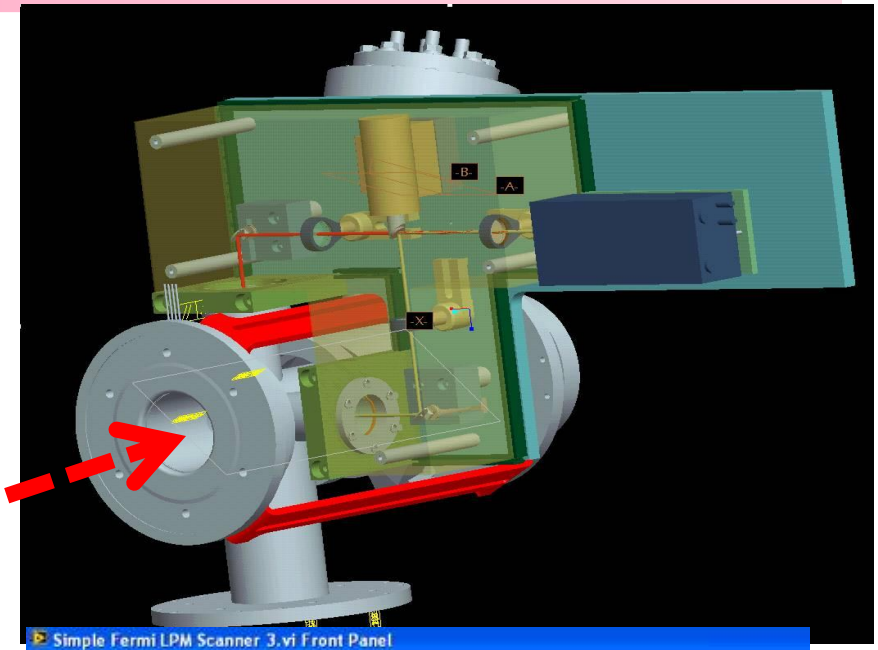
- Project X Collaboration Initiative (November 2008):
  - Interest on beam instrumentation collaboration projects from SNS, LBNL, and SLAC
- SNS
  - Various advanced diagnostics systems (broadband Faraday-cup, e-beam scanner, MEBT beam instrumentation, Allison scanner, laser wires, etc.)
  - Support, information exchange, RD&D help, visits, reviews, etc., but no design or development activities
- LBNL
  - Development of a mode-locked fiber laser system for longitudinal bunch profile measurements (also bunch tails), distribution of laser light with fiber optics
    - Critical to use HINS at testing facility
- SLAC
  - Collaboration on a new, xTCA-based electronics platform (Controls).
  - [potential collaboration for broadband chopper driver]

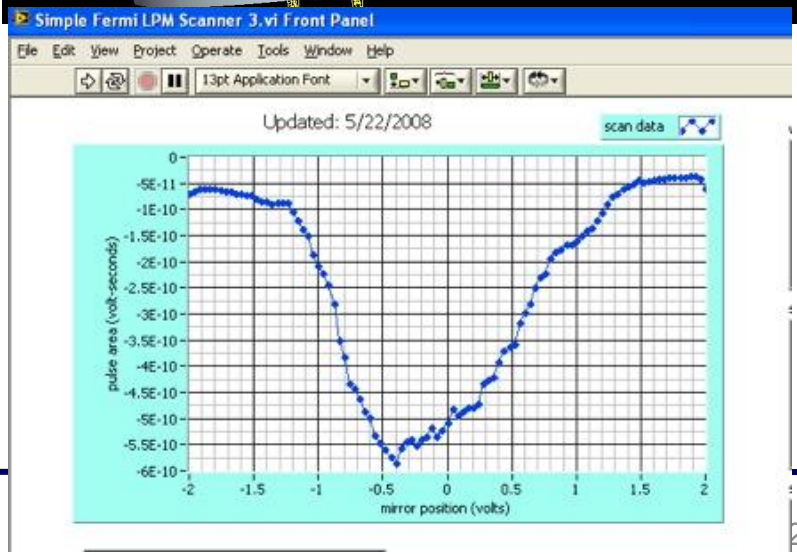
Basic Transverse Laser Profile Monitor (LPM)

- Profile measurements difficult in intense H- beams
  - Wire dangerous near superconducting cavities
- Use narrow laser to ionize H- and measure profile
  - H^- + photon -> 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-
- Integration into HINS after H- source arrival

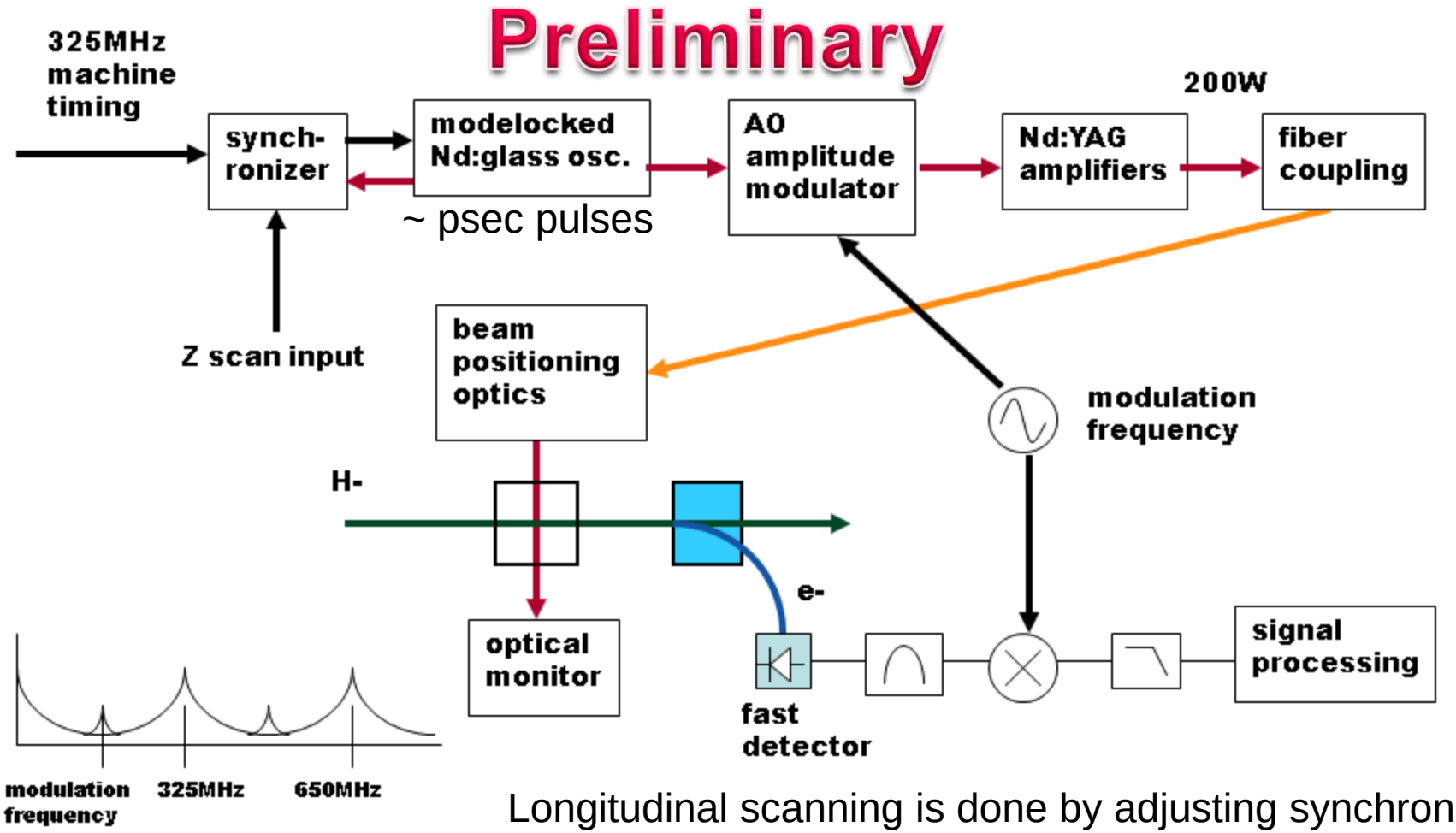
Fermilab Transverse Laser Profile Monitor

- Developed by BNL in collaboration with Fermilab
  - Tested with 750 KeV H- at BNL
- Laser Profile Monitor details
  - Q-switch laser
  - Laser energy: 50 mJoule
  - Wavelength: 1064 nm
  - Pulse length: 9 nsec
  - Fast rotating mirrors ($\pm 4^0$ / 100 µsec)
  - e^- detector: scintillator & PMT
- Installation:
  - 1st Test with 400 MeV H^-
    - Controller damaged by radiation?
  - HINS: 2.5 to 10 MeV





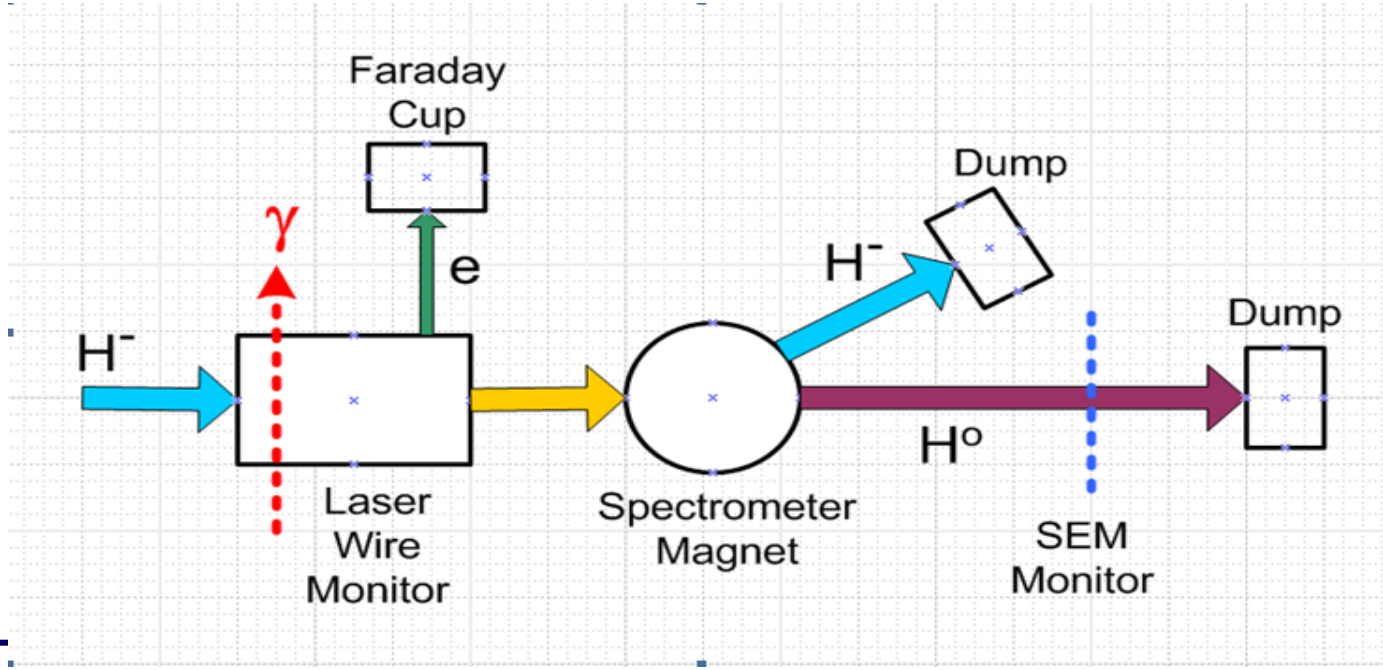
LBNL Laser Longitudinal Bunch Shape Proposal



Longitudinal scanning is done by adjusting synchronizer

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 will destroy any material in beam
  - Use a non-intercepting method to block beam
- Scan laser across bunch to act as a virtual slit to convert H- to H^o
- Collect electron to measure intensity in slit
- Measure angular distribution of H^o



Goals and Timelines

- FY10
  - Continue laser diagnostics collaboration with LBNL, and formalize collaborations with SNS and SLAC.
  - 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
  - Summarize operation experience on some prototypes
- FY12
  - Finalize design and development activities.
  - Freeze designs, overall system layout.

Conclusion

- HINS beamline construction pathway gives an opportunity for H- beam diagnostics development
  - 2.5-3.0 MeV H-
  - 10 MeV H-
- 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 H- that is not readily available outside of Fermilab
- Operating HINS as a test facility, even after HINS goals are meet, is critical to Project X beam diagnostic instrumentation R&D phase