Project X

PXIE Instrumentation

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Project X Collaboration Meeting

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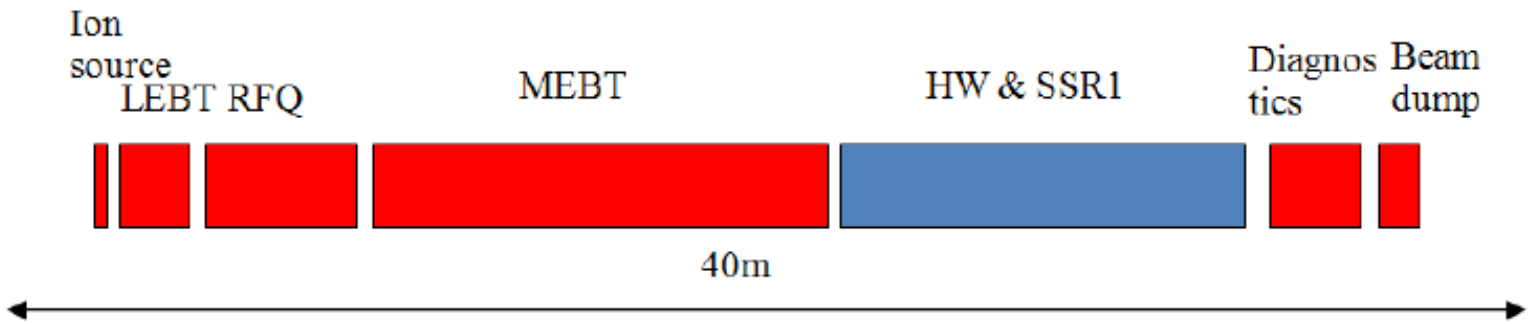
Outline

- Requirements and Goals
- LEBT Instrumentation
- MEBT Instrumentation
- Movable Diagnostics
- Issues for instrumentation development

PXIE Parameters

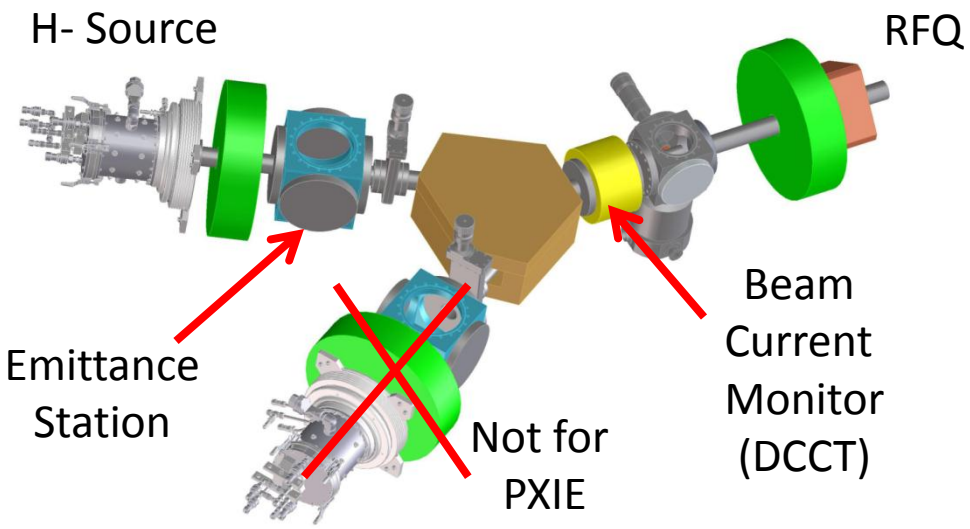


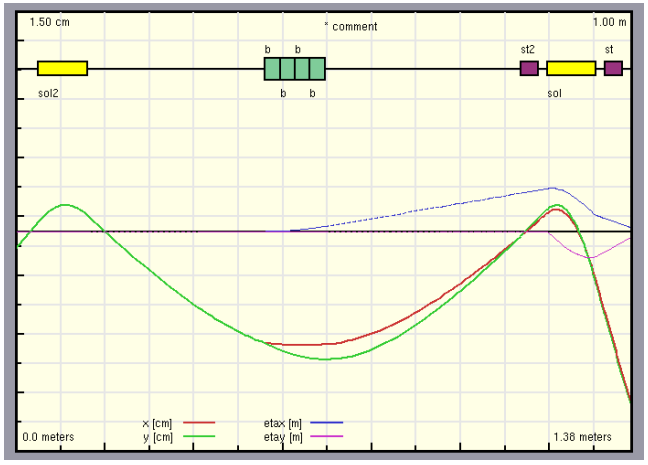
- CW H- source delivering 5 mA at 30 keV
- LEBT with beam pre-chopping
- CW RFQ operating at 162.5 MHz and delivering 5 mA at 2.1 MeV
- MEBT with integrated wide band chopper and beam absorbers capable of generating arbitrary bunch patterns at 162.5 MHz, and disposing of 4 mA average beam current
- Low beta superconducting cryomodules capable of accelerating 1 mA to 15 MeV
- Beam dump capable of accommodating 1 mA at 15 MeV (15 kW) for extended periods.
- Associated beam diagnostics, utilities and shielding

Project X Instrumentation Requirements

- Instrumentation at conceptual phase
  - What beam measurements are required to meet the goals of the PXIE program?
- "Operational" vs "Commissioning" Requirements
  - Operational Instrumentation required to monitor normal beam operations as well as identify potential problems
  - Commissioning instrumentation required to characterize beamline performance
    - Nominally a super-set of operational instrumentation
    - What defines a full set of beamline characteristics?
- Operating modes – continuous vs pulsed
  - Continuous desired but not possible for beam intercepting techniques
  - Pulsed beam available from LEBT chopper
- Generate a set of beam measurements techniques for LEBT, MEBT, Cyromodules and end of beamline

PXIE LEBT "Operational" Instrumentation





Working Parameters

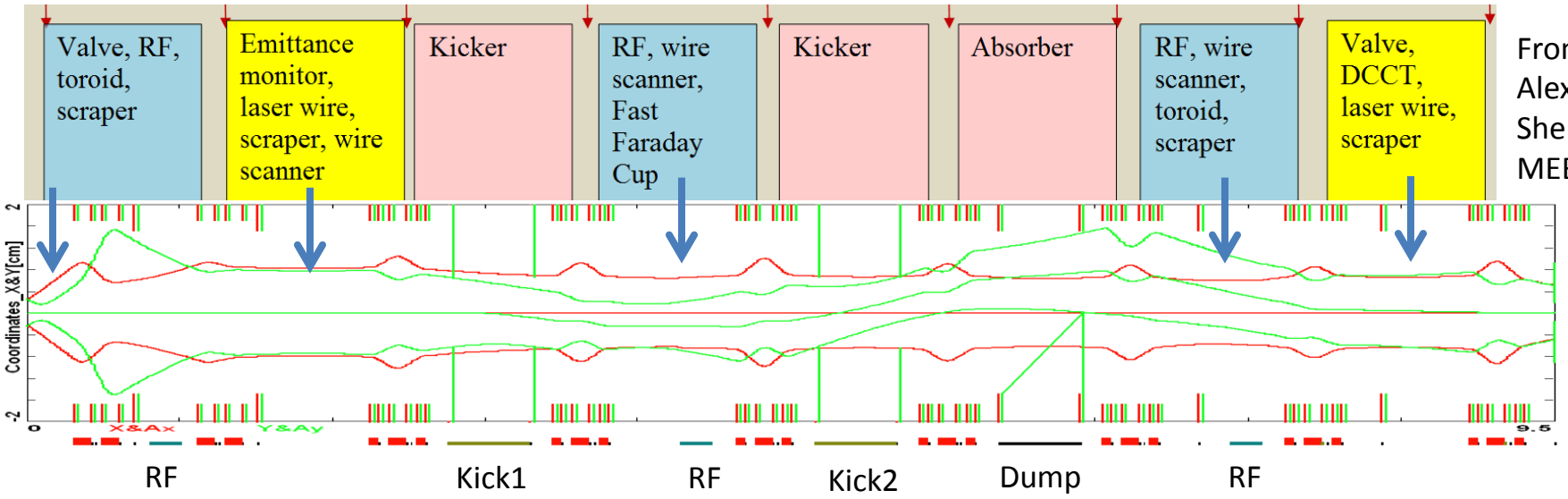
- One 30 KeV H- source for PXIE
- 5 mA DC beam
- Two solenoids
- Continuous beam only

Instrumentation

- One beam current monitor
- Emittance station → two Allison-type scanners
  - ~ 150 watts beam power
- Instrumentation supplied by LBNL?
- No real instrumentation issues

- Full LEBT characterization at LBNL

PXIE MEBT



From Alexander Shemyakin's MEBT Talk

- Ion type: H-
- Output energy: 2.1 MeV, same as input
- Max bunch freq: 162.5 MHz
- Operational beam current: 1 – 10 mA
- Nominal input beam current: 5 mA
- Particles per bunch: 1.8e8 nominal

MEBT Operational Beam Measurements:

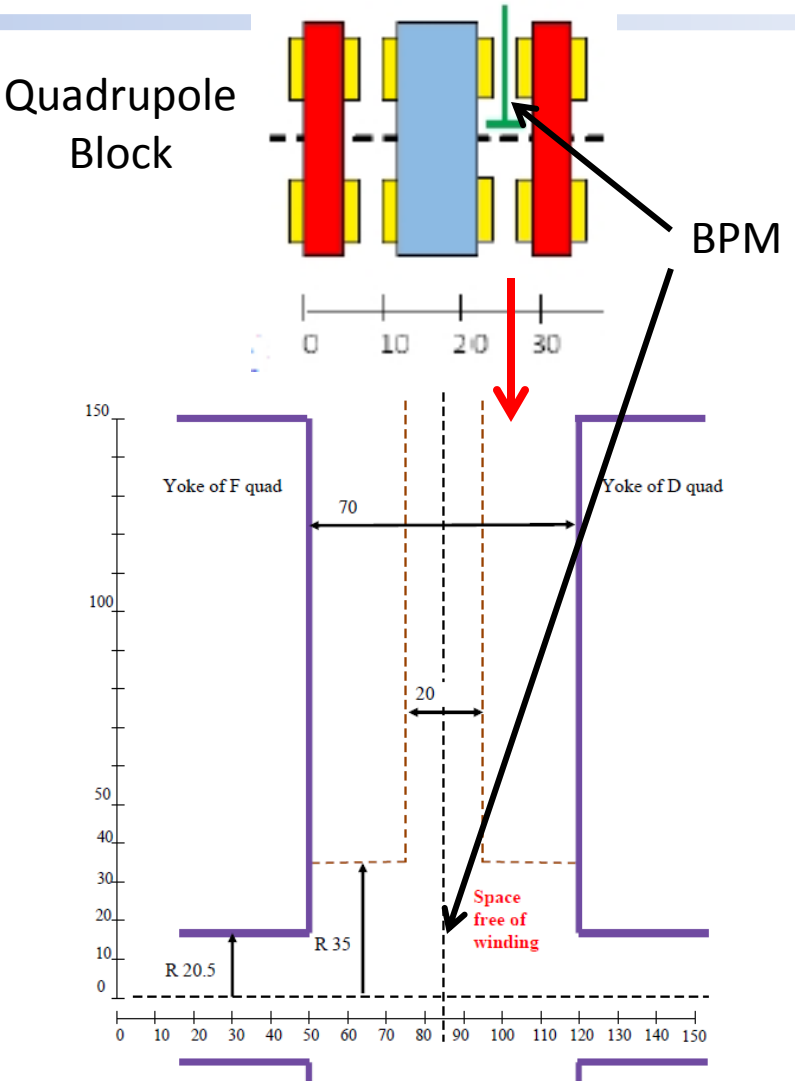
- Transverse position - BPMs
- Beam Current – Toroid/DCCT
- Bunch Phase – BPMs
- Transverse shape – wire scanners, emittance monitor, laser wires
- Longitudinal shape – Fast Faraday Cup, BSM, laser wires (red = CW)

MEBT Instrumentation

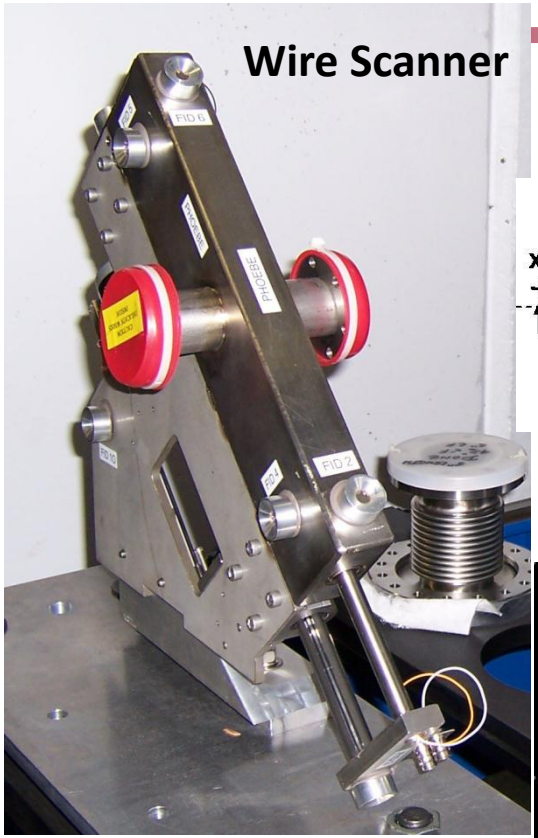
Tight squeeze for MEBT BPMs

MEBT BPMs - 9 (one inside each quadrupole block)

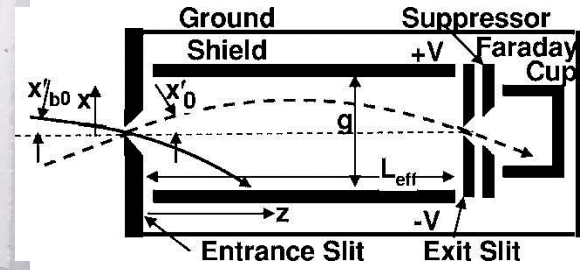
- Each BPM station measures position in 3 dimensions
- Internal diameter - 35 mm
- Available length - 50 mm
- *Transverse resolution*
  - *0.1 mm (for a single 1μs macro-pulse)*
  - *0.01 mm (CW, 0.1 sec update)*
- *Accuracy of absolute positioning- 1 mm*
- *Phase resolution - 0.1 deg = **~ 2ps***
- Nominal intensity- 2E08 H- per 162.5 MHz bunch (range 0.2 - 4· E08 ppb)
- Typical rms beam half-size - 3mm
- Typical rms longitudinal half-size - 10 degree (162.5 MHz)
- Bakeable to 150C
- *The BPMs are welded in and cables are connected before the quads are mounted.*



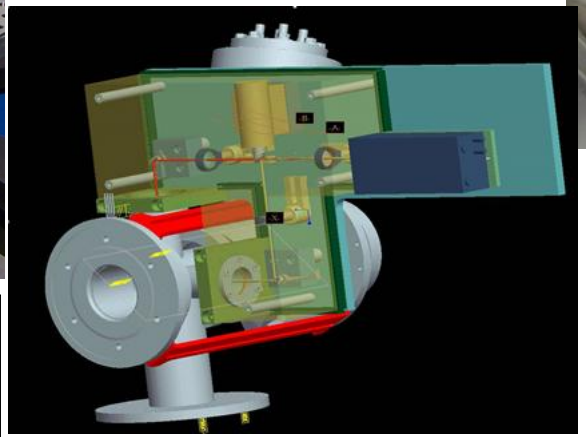
Project X MEBT Instrumentation "6-Pack"

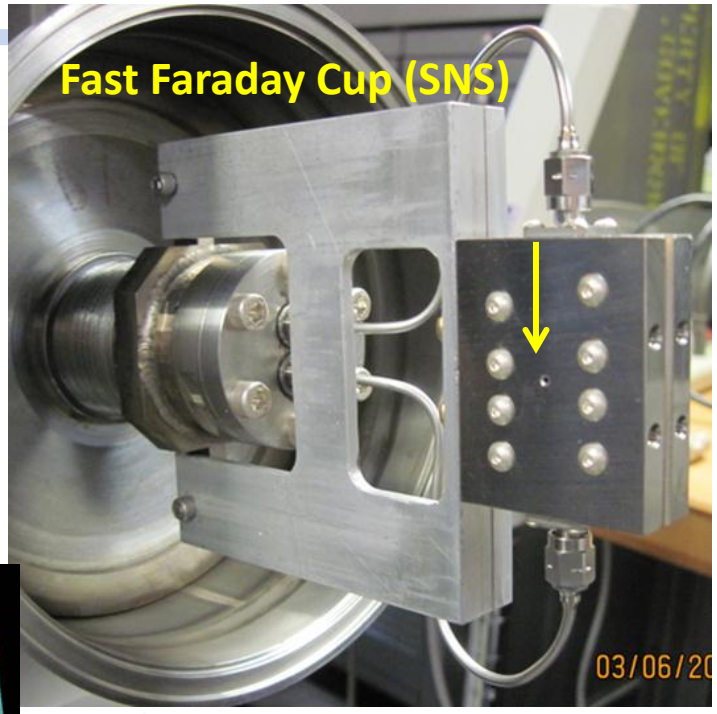


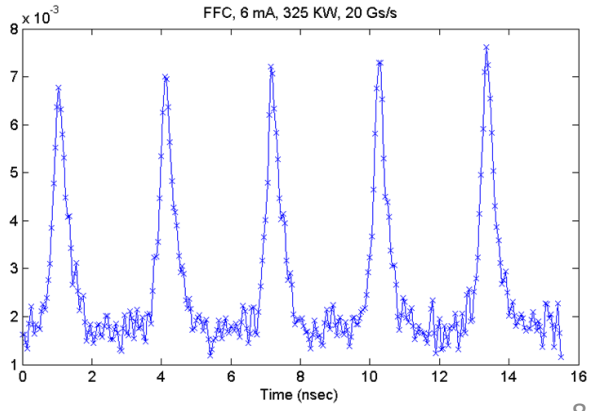
Allison Emittance Scanner



Laser Profile Monitor







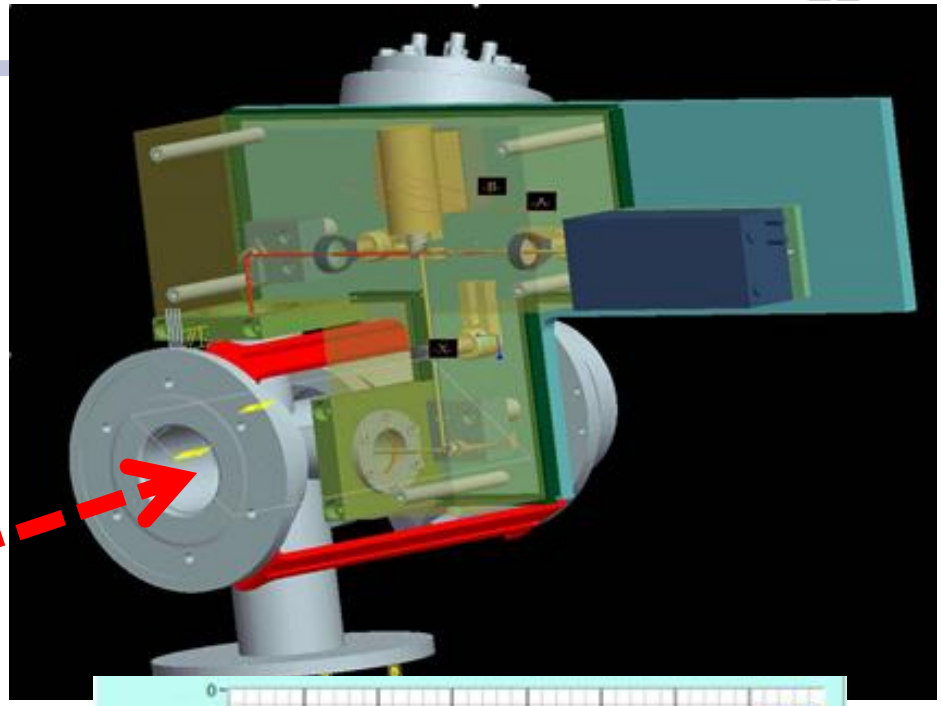
Need to fit all this into ~600 mm

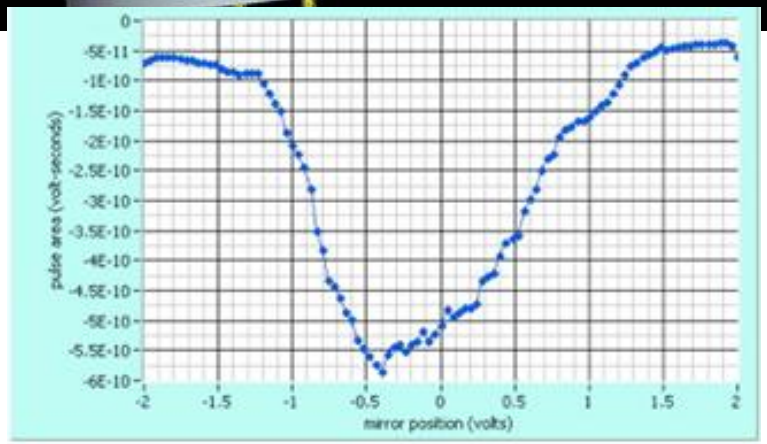
Laser Profile Development

Brute-force transverse profiles - *less risk*

- Q-switch laser
- Laser energy: ~ 50 mJ/pulse
- Wavelength: 1064 nm
- Pulse length: 9 nsec
- Pulse rate: 20 Hz
- Fast rotating mirrors ($\pm 4^0$ / 100 µsec)
- e^- detector

- Prototype in FNAL linac
- R&D unit for HINS
  - Study photoionization
  - Emittance monitor





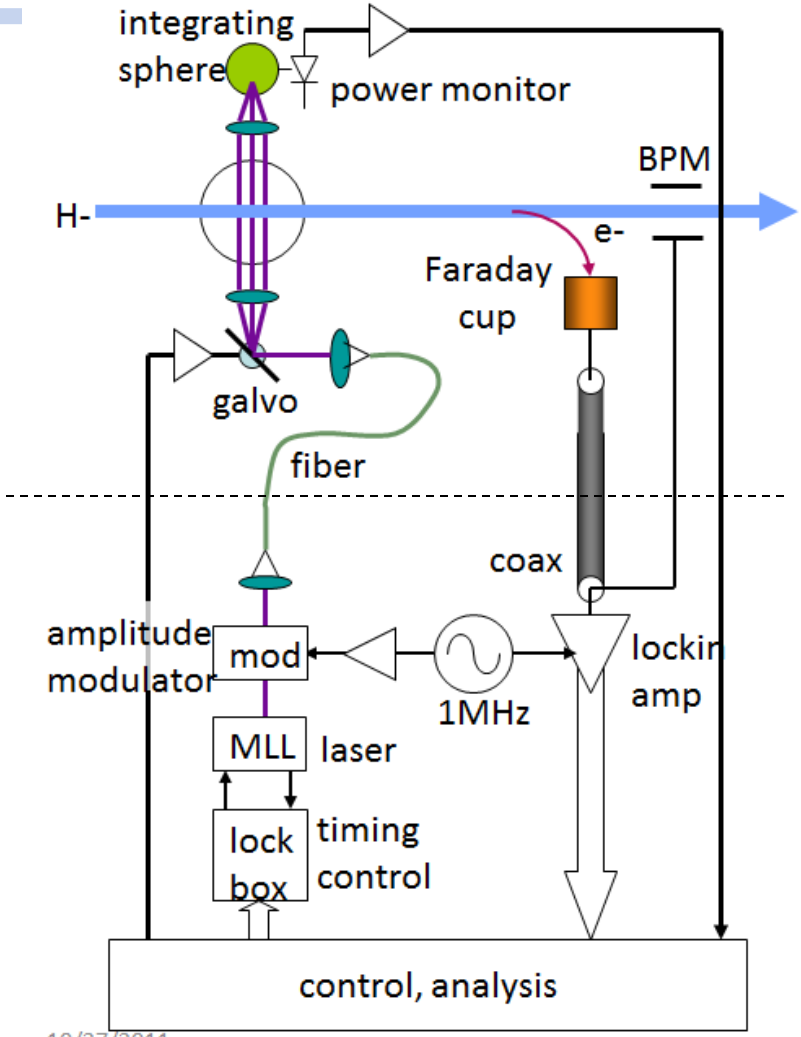
Fiber Laser Profile R&D

LBNL proposal to distribute laser via fibers

- Narrow band lockin amp detects 1MHz modulated signal
- Laser rep-rate is locked to 162.5 MHz RF
- Galvo scan is triggered by macropulse event signal
- Upper components are in tunnel, lower are in a laser hutch
- *Mode-locked psec laser can be used to measure both transverse and longitudinal beam profiles*
- V. Lebedev suggestion to use BPM as notched-beam pickup would allow laser monitor to fit between cryomodules

Questions:

- What is the photodissociation efficiency?
- What are the noise issues?
- What are the nonlinear limits to power in the fiber?
- What signal-to-noise ratios and averaging times are practical?
  - Plan to provide R&D at HINS

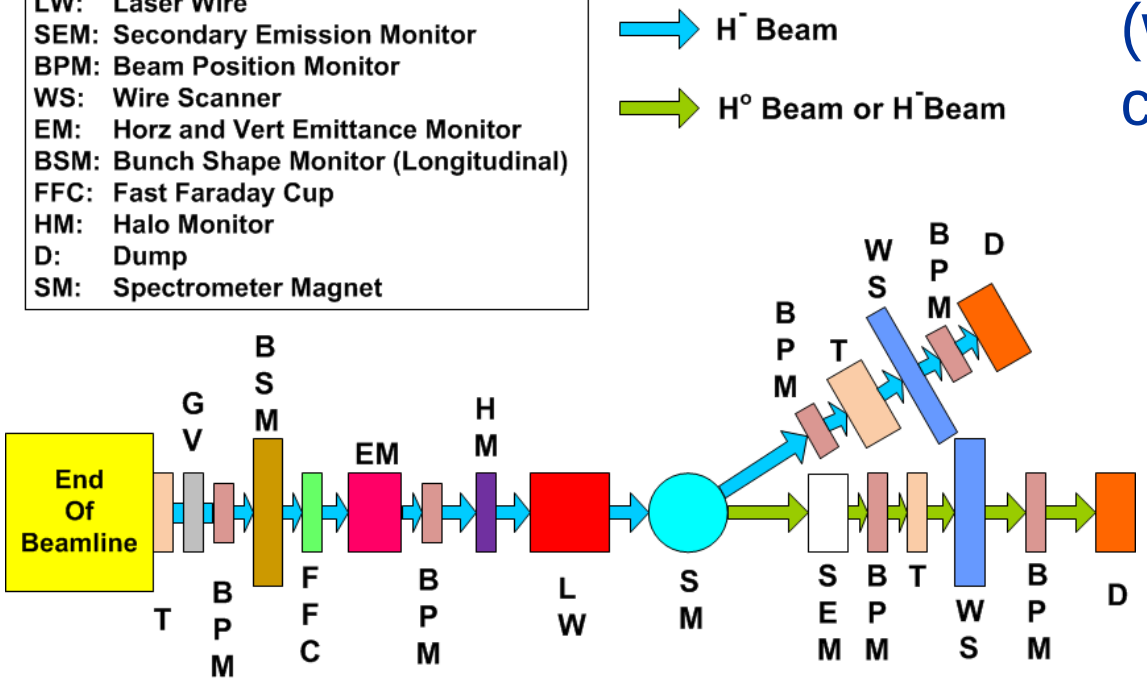


10/27/2011

Downstream "Movable" Diagnostics

Very Preliminary

T:	Toroid
GV:	Gate Value
LW:	Laser Wire
SEM:	Secondary Emission Monitor
BPM:	Beam Position Monitor
WS:	Wire Scanner
EM:	Horz and Vert Emittance Monitor
BSM:	Bunch Shape Monitor (Longitudinal)
FFC:	Fast Faraday Cup
HM:	Halo Monitor
D:	Dump
SM:	Spectrometer Magnet



Possible Beam Measurements

(which are required for comissioning?)

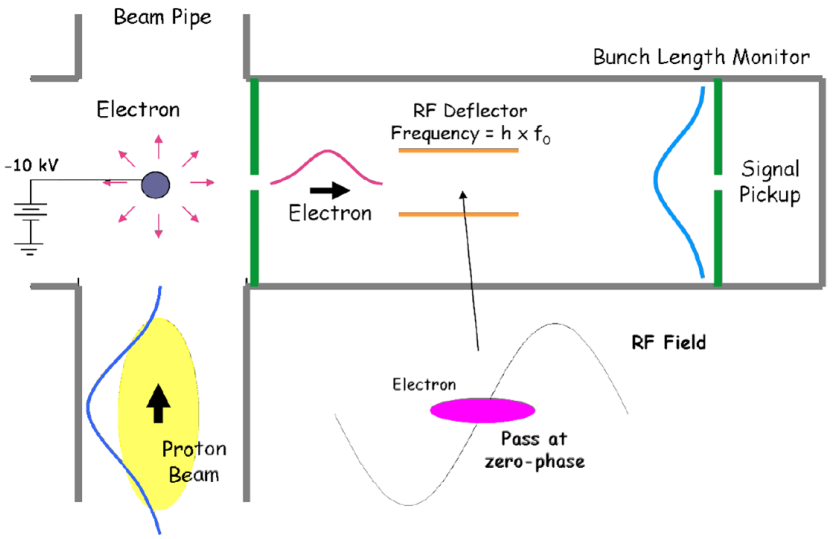
- Beam Current
- Transverse emittance
- Longitudinal profile
- Transverse Halo
- Longitudinal Halo
- Beam energy and energy spread

Many systems may be available from HINS

Project X Other Beam Diagnostics R&D

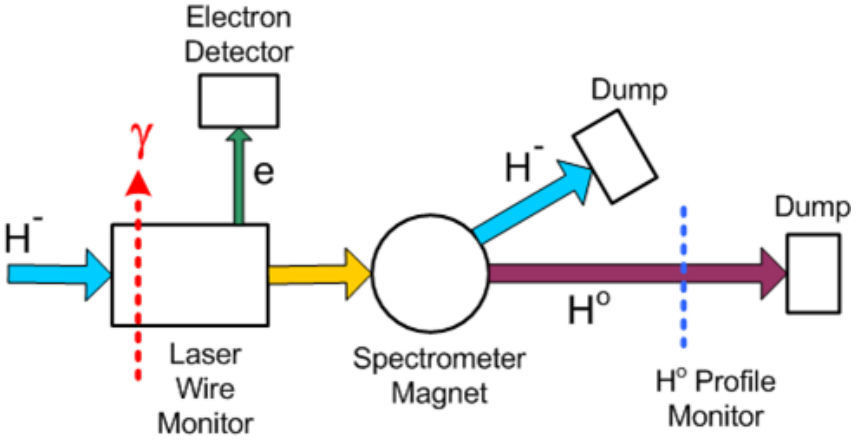
Longitudinal Bunch Shape Monitor

- Similar to streak camera
- Investigate x-ray version (Ostroumov, ANL)



Laser Wire Station for Transverse Emittance

- Transverse and longitudinal profiles
- Transverse emittance from H0 profile
- Emittance can be measured CW



Issues

Two major PXIE instrumentation issues

1. Space in MEBT for desired instruments
   - A lot of instrumentation into small longitudinal space
   - Need support of mechanical engineer for “6-pack” design
2. Development of laser profiling technology critical
   - High-power laser option progressing
   - Low-power fiber laser needs equipment
   - New laser room available for R&D soon
   - *Need beam to develop technology → HINS only near-term option or else have to wait for PXIE to do laser profiling R&D*

Operation of HINS until PXIE RFQ up and running will allow beam diagnostics development and testing

– Advantage that PXIE will have operational diagnostics immediately

Summary

- Instrumentation for PXIE in conceptual stage
  - Identifying space requirements has highest priority
- Progress needed on measurement requirements
- Risk items: MEBT space and laser technology development
  - Mechanical engineering support needed
- Operation of HINS until PXIE beam available would be a huge advantage in providing beam diagnostics for PXIE