PXIE Beam Instrumentation
Status Update - Preparing for MEBT 1.1 Beam

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Overview

Previous work:
• focus on LEBT instrumentation commissioning and Source/LEBT beam operations
• Simpler systems:
  • DAQ based on HRM digitizers
  • Simple bias technique for isolated beam pickups

Now:
• Focus on MEBT instrumentation development for RFQ commissioning
  • Primarily beam current system and BPM system
• Transition from HRMs to FPGA-based digitizer frontends
  • Allows for more flexibility and dynamic operation
  • Integration into MPS
• Preparing instrumentation for initial pulsed beam operation through RFQ into MEBT 1.1

Goal of initial beam current system ready 1st week of March and BPM system 2nd week of March
Upstream of chopper
• Long pulses
• DCCT, EIDs
• HRM DAQ – single point measurement – no change

Downstream of chopper
• Short pulses
• Toroid, collimator, LEBT scraper
• Digitizer/FPGA DAQ – waveform measurements
  • *Integrated with MPS*
  • Optional signal to HRMs
**RFQ Vane Voltage Measurements**

Measure x-ray spectrum to get vane voltage measurement

- X-ray detector installed at beam output of RFQ
- Previous measurements made of MEBT buncher cavity
MEBT 1.1

- Toroid
- Quad Doublet
- Ring Pickup MPS
- BPM
- BPM
- Toroid
- Time-of-Flight Movable BPM
- Fast Faraday Cup
- Faraday Cup Dump
- RFQ
- Electrical Isolated Scrapers
- BPM
- BPM
- Buncher
- Quad Doublet
- Quad Doublet
- MPS
Frontend Electronics for Beam Current Measurements

- Toroids, Faraday cup dump, scrapers
- Signal cables scheduled to be pulled
- Racks being dressed
- Utilize FPGA-based 8-channel, 125 MHz, 14 bit digitizer cards
  - Allows for pipeline or snapshot DAQ and signal processing
  - Only pulsed beam for initial operations
  - Initial FPGA and VME code - reuse FAST code
  - Integrated with MPS
- Initial goal ready for beam 1st week of March
- Need to understand noise and systematic effects
  - Large gain on toroids
  - Tight beam loss requirements for MPS
  - Needs further study

LEBT Toroid
- Calib signal
- 1 mA, 20 μs
- 50 mV signal
- 60 db gain
**Ring Pickup – Machine Protection**

- Dedicated ring pickup to measure bunched-beam current
  - Wide bandwidth pickup but narrowband electronics
  - Simple analog circuit give rectified signal pulse
- Pickup installed in beamline
- Analog electronics completed and tested
- Signal measured through beam current frontend
- High/Low threshold for MPS
- Short beam pulse software installed and being tested
  - Software for MPS installed

Pickup response out to 2 GHz
**MEBT BPMs**

Requirements:

<table>
<thead>
<tr>
<th></th>
<th>Accuracy</th>
<th>Precision</th>
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<tbody>
<tr>
<td>Position, µm</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>Phase, degrees of 162.5 MHz</td>
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<td>0.2</td>
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<tr>
<td>Relative intensity, %</td>
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<td>3</td>
</tr>
</tbody>
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DAQ with FPGA-based electronics for CW and pulsed beam

- 12 channel, 14 bit, 250 MSPS boards
- Analog filter & amp boards built and tested
  - 162.5 MHz 1\(^{st}\) and 3\(^{rd}\) harmonics
  - Pseudo bunch length measurements

Status:

- First two BPMs being installed in quads
- Stretched wire measurements performed
- Electronics assembled with initial testing on bench
- Instrumentation rack being filled
- Reuse frontend software from other systems
  - Pulsed beam initially
  - Average position, phase, intensity per pulse
- *Initial system ready goal of 2\(^{nd}\) week of March*
Time of Flight (ToF) Movable BPM

Measure beam velocity (→ energy) via ToF

• Utilize movable BPM to minimize systematics
  • e.g. BPM response, bunch shape effects

• Use HINS BPM on linear stage
  • ~ 1” of travel; ~10 μm resolution
  • Allows for “continuous” phase measurements
  • MEBT energy resolution: 0.1%

Status:

• Motion stage installed; BPM ready
• Use MEBT BPM electronics to acquire phase
• Working on motion control (cables and software)
Bunch Length - New Fast Faraday Cup

- Embedded 50 Ω stripline – initially designed by SNS
- High Bandwidth (> 6 GHz) – need scope DAQ
  - Beam damage at HINS (2.5 MeV protons)
  - We redesigned with better thermal properties
- Old model tested at HINS and Linac
- Prototype new design tested in PXIE LEBT
- Assembly into beamline occurring now
- DAQ via scope – manual operation

Old design - Damage with HINS beam

Linac MEBT Measurements

New design
Allison Scanner for MEBT Emittance Measurements

Design a water cooled Allison-style MEBT emittance scanner based on LEBT scanner

• Gives faster phase-space measurement
• Reuse most LEBT hardware except scanner head
• 2.1 MeV → requires longer deflector plates → requires more beam line space
• Higher beam power → no CW operation

• Preliminary numbers:
  • HV plate length: 300 mm
  • Flange-to-flange: < 450 mm
  • HV plate separation: 6 mm
  • Plate HV: ± 1 kV
  • ~ ± 10 mrad angular range

• Status:
  • Vacuum enclosure under design
  • Design mostly finished
  • Ordering hardware
  • Estimate May/June for MEBT installation
Summary

• Instrumentation focus now is on preparation for first RFQ beam

• All MEBT configuration 1.1 instruments proceeding
  • No perceived delays for beam line installation
    • Software development manpower limited/priorities
  • Initial instrumentation software for pulsed mode only
    • Average values per pulse
    • Basic beam measurements at first beam
  • Noise and systematics may be an issue → filters, averaging, signal processing

• Integration of instrumentation signals into MPS proceeding and added as needed

Goal of initial beam current system ready 1st week of March and BPM system 2nd week of March - Manpower limited – lower priority

COMMISSIONING WILL TAKE TIME – NOT PLUG-N-PLAY SYSTEMS
Extra
Prototyping Wire Scanner

Developing prototype wire scanner for profile measurements
- Test in diagonal port of MEBT scraper
- Constructed mock-up to test wire stretching and mounting issues