

# PXIE Beam Instrumentation Status Update - Preparing for MEBT 1.1 Beam

Vic Scarpine

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# Overview

## Previous work:

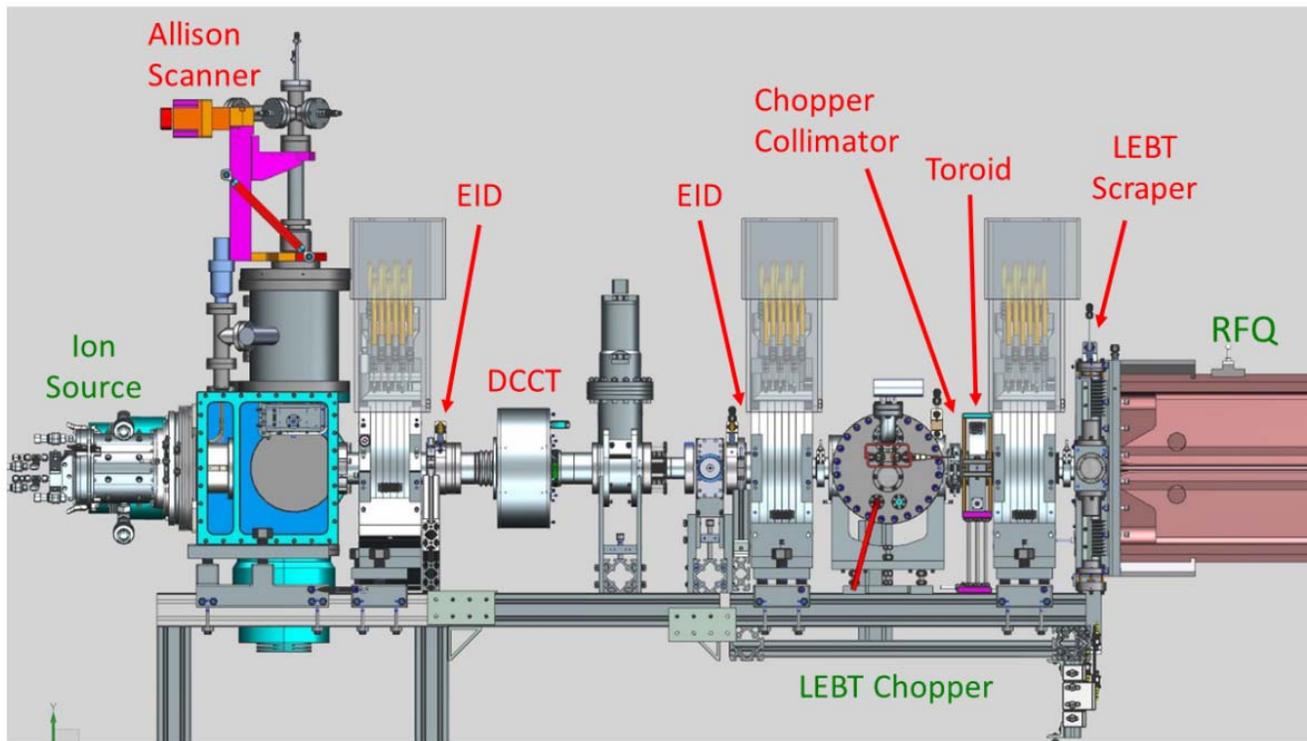
- focus on LEBT instrumentation commissioning and Source/LEBT beam operations
- Simpler systems:
  - DAQ based on HRM digitizers
  - Simple bias technique for isolated beam pickups

## 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 1<sup>st</sup> week of March and BPM system 2<sup>nd</sup> week of March*

# PXIE LEBT



## Upstream of chopper

- Long pulses
- DCCT, EIDs
- HRM DAQ – single point measurement – **no change**

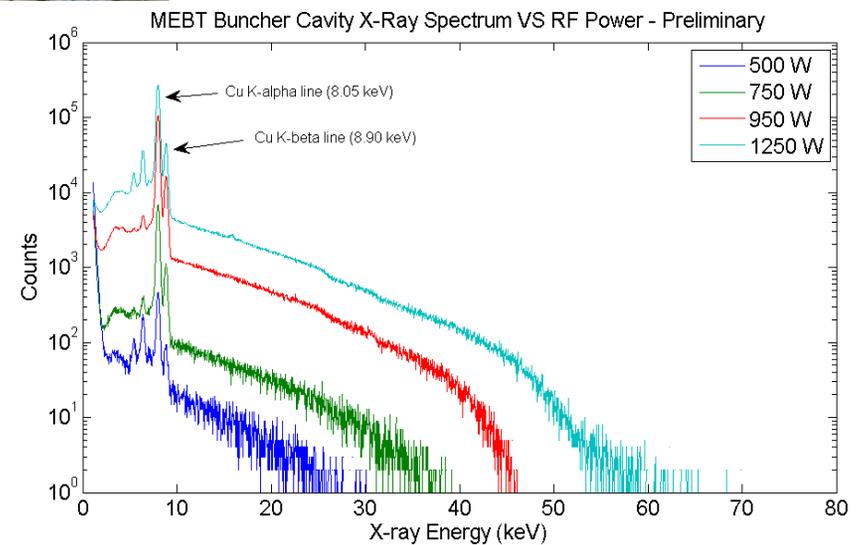
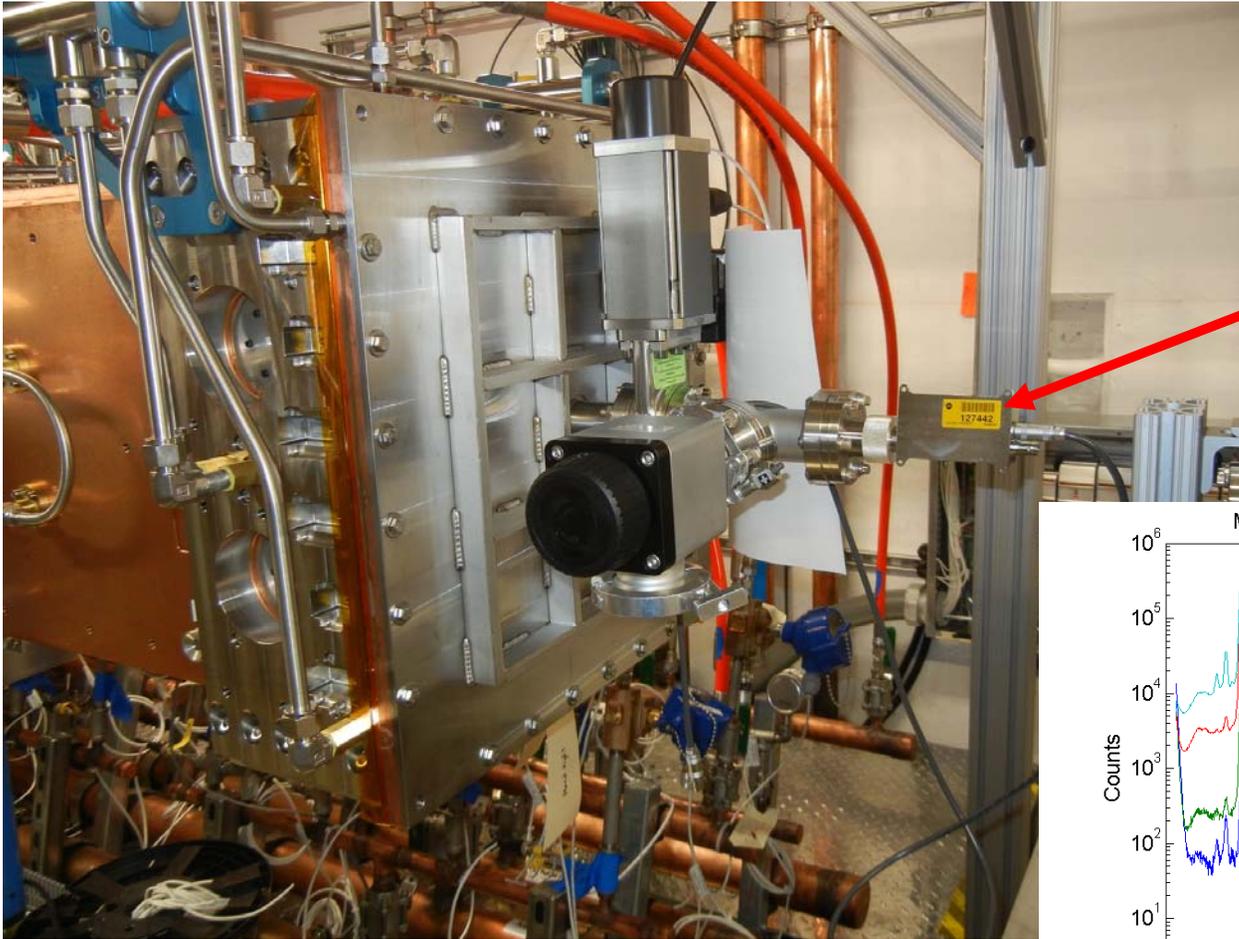
## Downstream of chopper

- Short pulses
- Toroid, collimator, LEBT scraper
- Digitizer/FPGA DAQ – waveform measurements
  - *Integrated with MPS*
  - Optional signal to HRMs

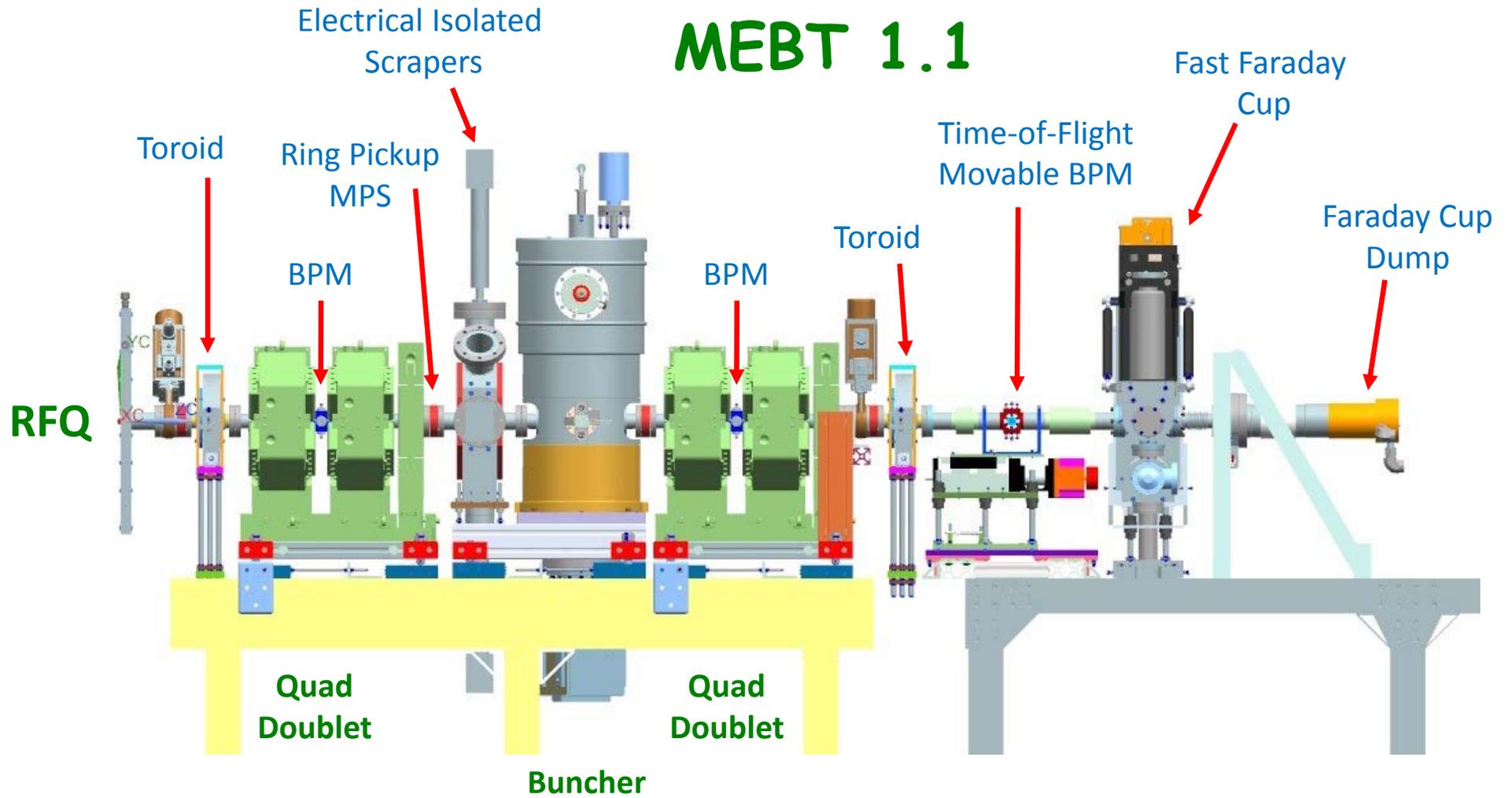
# RFQ Vane Voltage Measurements

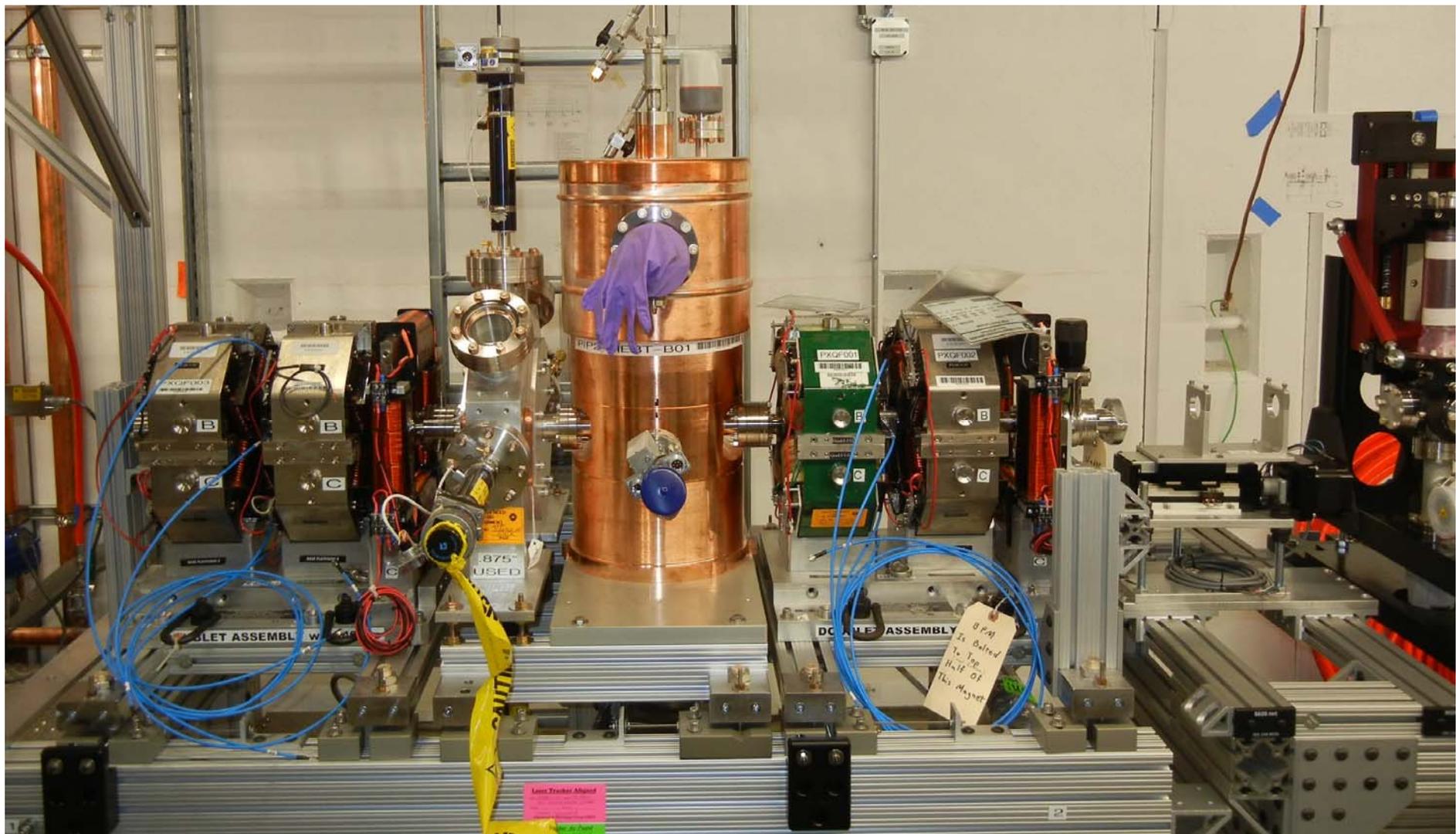
Measure x-ray spectrum to get vane voltage measurement

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



# MEBT 1.1





# 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 1<sup>st</sup> week of March**
- Need to understand noise and systematic effects
  - Large gain on toroids
  - **Tight beam loss requirements for MPS**
  - Needs further study

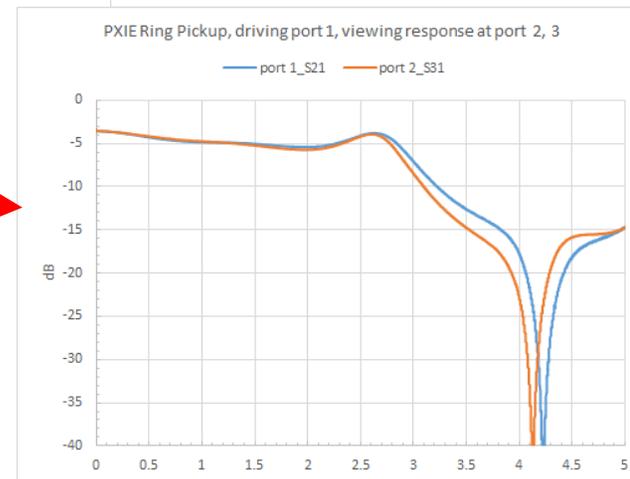
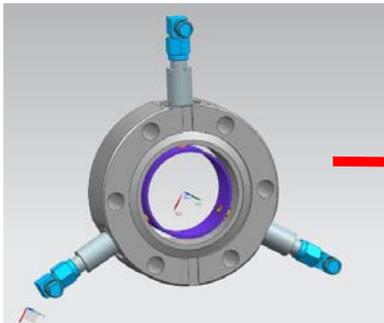
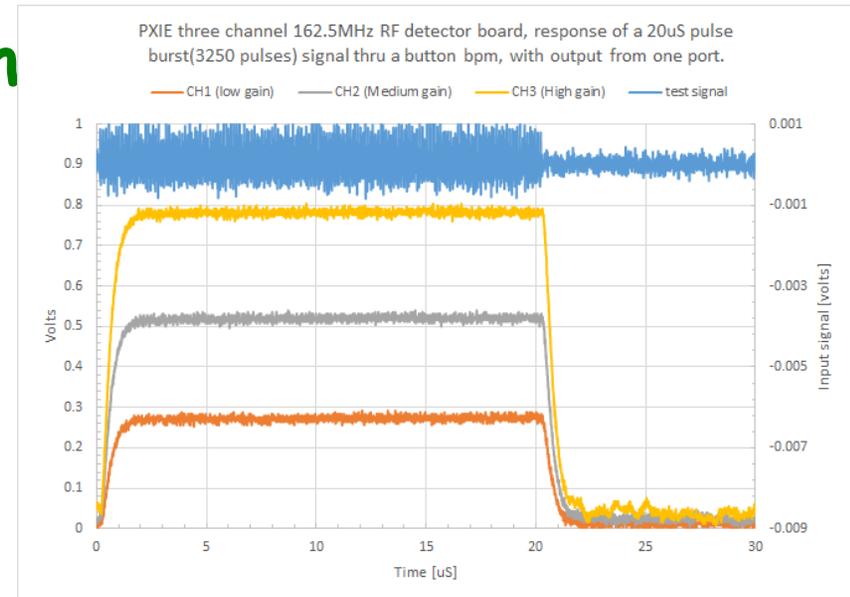


## LEBT Toroid

- Calib signal
- 1 mA, 20  $\mu$ s
- 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



# MEBT BPMs

Requirements:

	Accuracy	Precision
Position, $\mu\text{m}$	10	30
Phase, degrees of 162.5 MHz	0.05	0.2
Relative intensity, %	1	3

DAQ with FPGA-based electronics for CW and pulsed beam

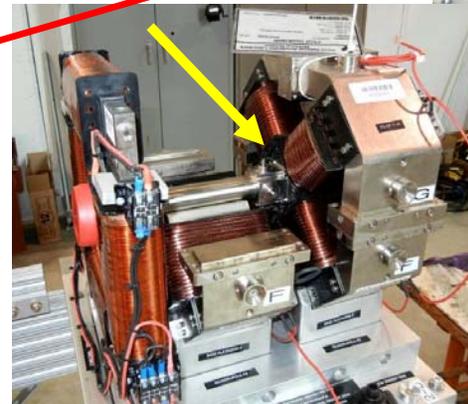
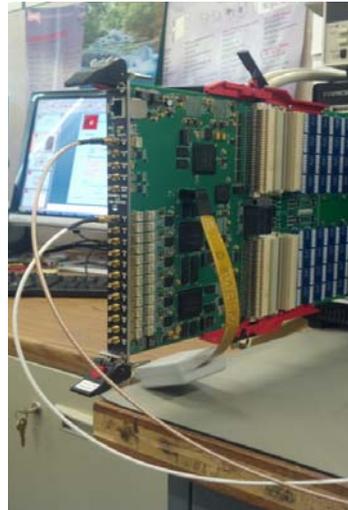
- 12 channel, 14 bit, 250 MSPS boards

Analog filter & amp boards built and tested

- 162.5 MHz 1<sup>st</sup> and 3<sup>rd</sup> 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<sup>nd</sup> week of March*



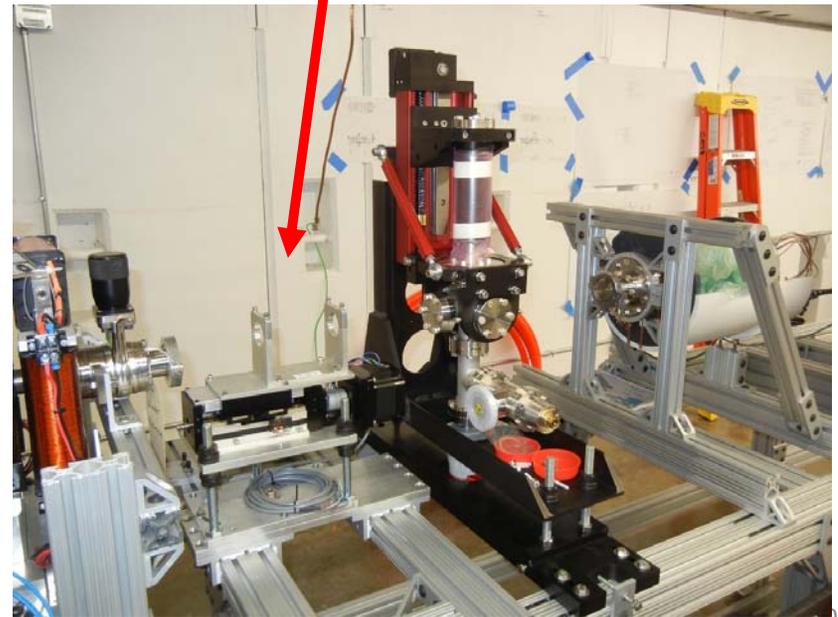
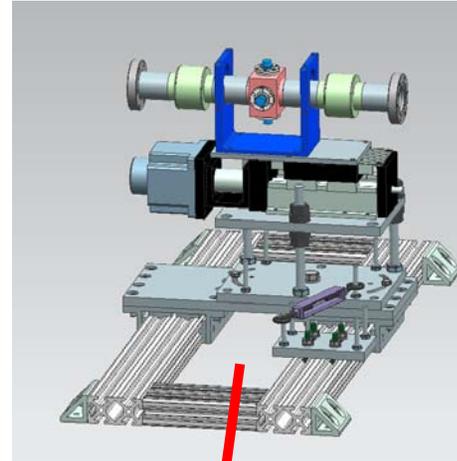
# Time of Flight (ToF) Movable BPM

Measure beam velocity ( $\rightarrow$  energy) via ToF

- Utilize movable BPM to minimize systematics
  - e.g. BPM response, bunch shape effects
- Use HINS BPM on linear stage
  - $\sim 1''$  of travel;  $\sim 10 \mu\text{m}$  resolution
  - Allows for “continuous” phase measurements
  - MEBT energy resolution: 0.1%

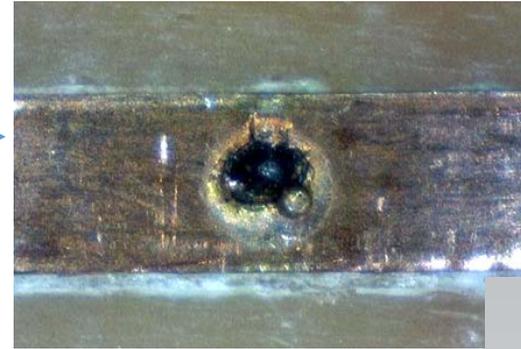
## Status:

- Motion stage installed; BPM ready
- Use MEBT BPM electronics to acquire phase
- Working on motion control (cables and software)

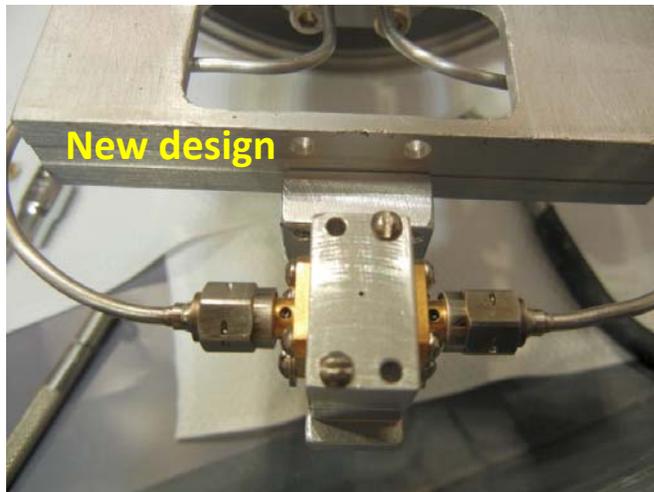
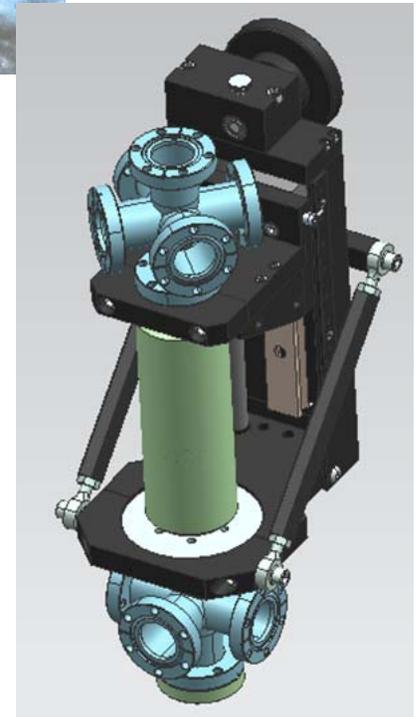


# Bunch Length - New Fast Faraday Cup

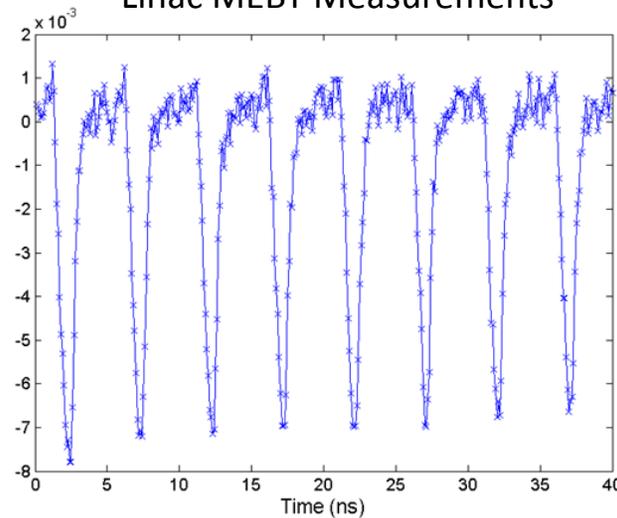
- Embedded 50  $\Omega$  stripline – initially designed by SNS
- High Bandwidth (> 6 GHz) – need scope DAQ
  - Beam damage at HINS (2.5 MeV protons)
  - We redesigned with better thermal properties
- Old model tested at HINS and Linac
- Prototype new design tested in PXIE LEBT
- Assembly into beamline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



Old design -  
Damage with  
HINS beam



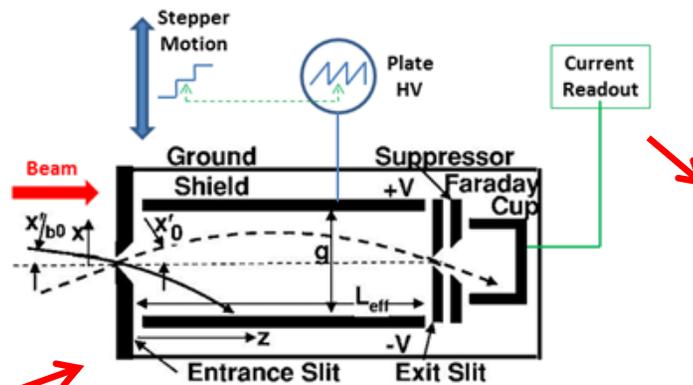
Linac MEBT Measurements



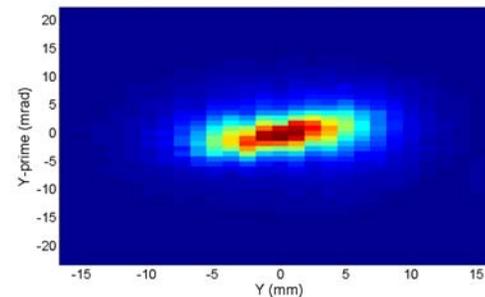
# Allison Scanner for MEBT Emittance Measurements

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  $\rightarrow$  requires longer deflector plates  $\rightarrow$  requires more beam line space
- Higher beam power  $\rightarrow$  no CW operation



- Preliminary numbers:
  - HV plate length: 300 mm
  - Flange-to-flange: < 450 mm
  - HV plate separation: 6 mm
  - Plate HV:  $\pm 1$  kV
  - $\sim \pm 10$  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 a issue → filters, averaging, signal processing
- Integration of instrumentation signals into MPS proceeding and added as needed

*Goal of initial beam current system ready 1<sup>st</sup> week of March and BPM system 2<sup>nd</sup> 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

