



U.S. DEPARTMENT OF  
**ENERGY**

Office of  
Science

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# Status of the warm front end of PIP-II Injector Test (PXIE)

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PIP-II technical meeting

21 May 2016

# Outline

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- Operational status
  - Beam line
  - Subsystems
  - Radiation
- Measurements
  - In part, “BPM noise” and scraping
- Plans

# Ion source/LEBT

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- Ion source has recovered after a vacuum failure on April 10
  - Spark frequency dropped to  $\sim 1/\text{day}$
  - Each spark requires a reboot of electronics at HV, but no more permanent damage
    - Changes in grounding and shielding (Greg Saewert & Co)
  - Damage to water hoses by discharges
    - Repaired; may need to modify the cage during the fall shutdown
- Modified the LEBT chopper to improve prevention of catastrophic scenarios
  - HV readback from plates
  - A new modulator with modified controls is being prepared (Greg)



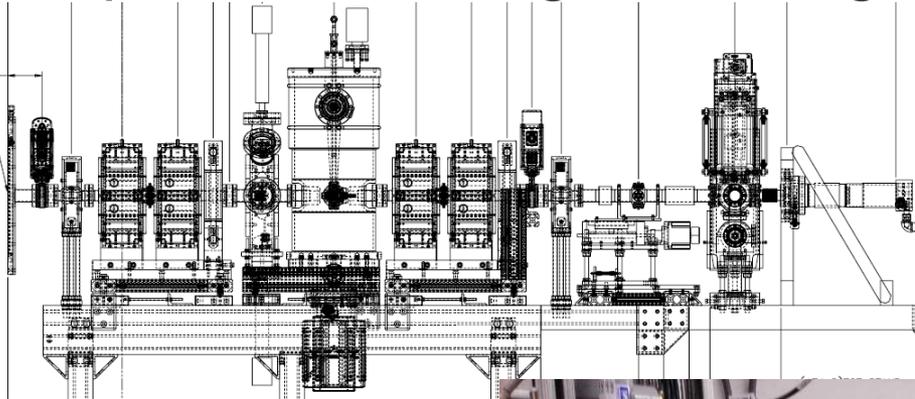
# RFQ

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- Was RF - commissioned in true CW (May 4-5)
  - Only hours of conditioning required
  - Up to 63 kV of vane voltage (vs 60 kV nominal)
- Major failure of a RFQ amplifier (May 6); fully recovered
- There is ~60 kHz frequency offset in the cold RFQ
  - Can't be easily corrected for short – pulse mode of RF
    - Operate both RFQ and bunching cavity at frequency shifted down from 162.5 MHz
- Work with RFQ frequency stabilization continues
- In general, operates stable
- Jim and Jonathan will give a detailed update in a couple of weeks
  - RFQ and LLRF, correspondingly

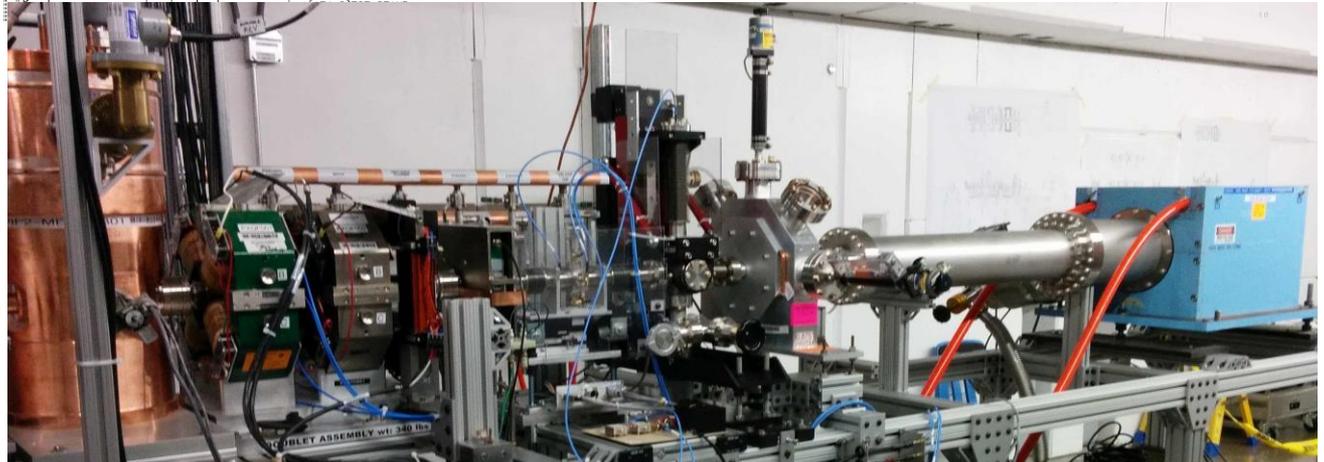
# Present MEBT configuration

- Since previous report (3-May-2016), a second set of scrapers and the “SNS/HINS” beam dump is installed to move toward operation with higher average power



MEBT-1.1 in May 2016

MEBT-1.1a in June 2016  
Two doublets, one bunching cavity, two scraper sets, beam dump, and diagnostics



# Modes of operation

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- Work mainly with a short pulse to avoid damage (“tuning mode”)
  - 1.2 ms, 10 Hz, 5 mA pulse from the ion source
  - Chopping down to 10-20  $\mu$ s with the LEBT chopper
- Recently received permission from Safety to start increasing the pulse length (“operation mode”)
  - Longest pulse so far 0.3 ms ( $\times 10 \text{ Hz} \times 5 \text{ mA} = 15 \mu\text{A}$ )
- Presently beam timing is changed “manually”
  - Arden works toward having these modes implemented in MPS
    - With clear indication when insertable devices are allowed

# Diagnostics

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- Almost all diagnostics works to some extend
  - The only exception is Fast Faraday Cup
    - No explanation yet for the signal shape
  - See Vic's presentation on June 7, 2016 for details
  - Work continues with the noise, error analysis etc.
  - Still need to learn how to use all capabilities
- A big challenge is to move toward long pulses/CW
  - Present scheme assumes reporting parameters after measuring the entire pulse

# RF (Ralph Pasquinelli)

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- RFQ amplifiers
  - Work with no problems
    - Most of the time, they are used in low-duty mode
  - Plan to assemble a test stand to have a spare module ready
    - Sigmaphi has most of spare parts ready; troubleshooting the main controller
- COMARC amplifier for bunching cavity work with no problems
  - With Fermilab's controls and temporary circulator
  - Still no up-to-specs amplifiers with final controls
  - 7 kW 162.5 MHz circulator from McManus was received
    - Preparing for tests

# Radiation

- Radiation from the dump is significantly lower than it was from the temporary Faraday Cup
  - Max measured rate is  $\sim 0.2$  mR/hr at  $12 \mu\text{A}$  average current at the top (with shielding removed) at contact
- Will move up with the pulse length
  - Limit for being allowed to enter the cave with beam running is 5 mR/hr @1'



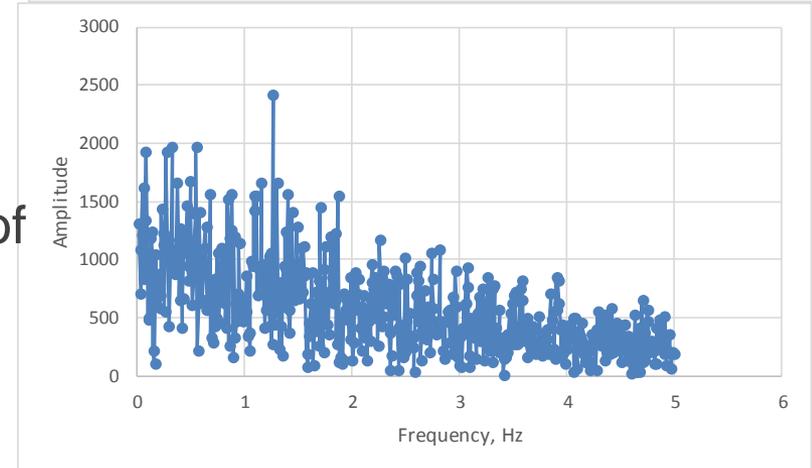
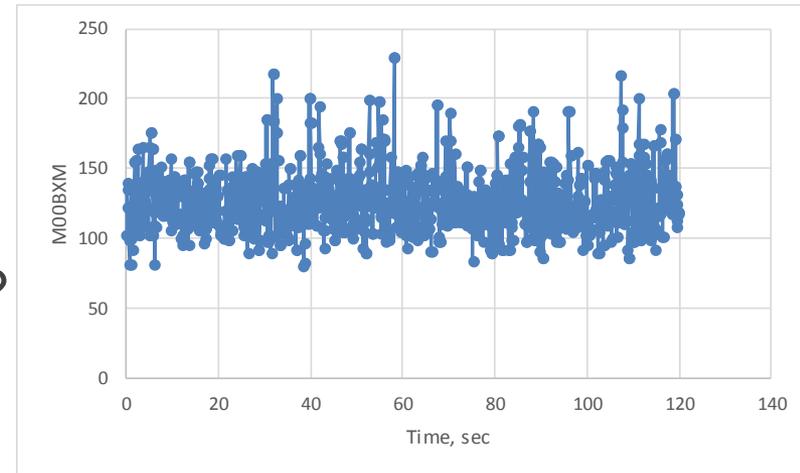
# Measurements

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- Still only preliminary results
    - With downtime from failures and shutdowns, only several full weeks of beam measurements so far
    - Commissioning and understanding the diagnostics takes time
  - Partial list
    - Optimization of beam at the RFQ entrance
    - Optics measurements
    - Beam alignment
    - Energy measurements
    - “BPM noise”
    - Preparing to work with high-power beam
      - Scraping
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- Will be reported in coming weeks

# “BMP noise”

- At constant settings, BPM readings as seen by eye vary up to  $\sim 0.2$  mm
  - Electronics noise or beam motion?
- Recorded 10 Hz signals (i.e. position of each pulse) for 2 min
  - Rms of 3<sup>rd</sup> BPM noise is  $21 \mu\text{m}$ 
    - Deviation at BPMs are correlated
  - Subtracting a linear combination of signals of first 2 BPMs from the last BPM’s signal decreases the noise to  $6 \mu\text{m}$
- Likely most of the noise comes from the beam motion



Typical data and its spectrum. 1-June-2016.  
No reproducible lines in spectrum.

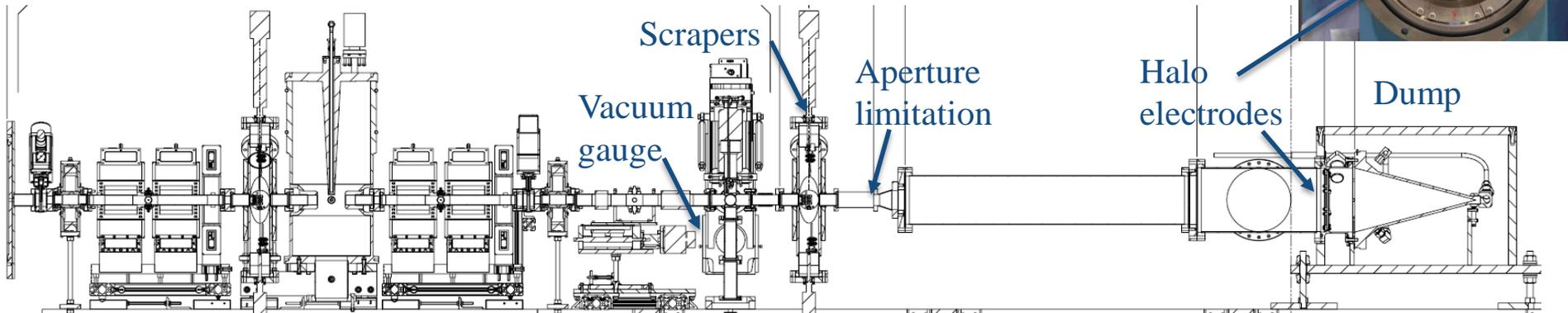
# Preparing to work with high-power beam

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- In regular part of MEBT, beam power density is too high to be directly deposited to a surface when in CW mode
  - 2 mm rms, 2 MeV, 5 mA => 400 W/mm<sup>2</sup>
  - Can create damage even at tens of  $\mu$ s pulses due to local overheating
- Solution
  - Expand the beam into the dump
  - Cut transverse tails with scrapers
  - Avoid any large uncontrolled loss
- Spent several shifts with preparations and increasing the pulse length

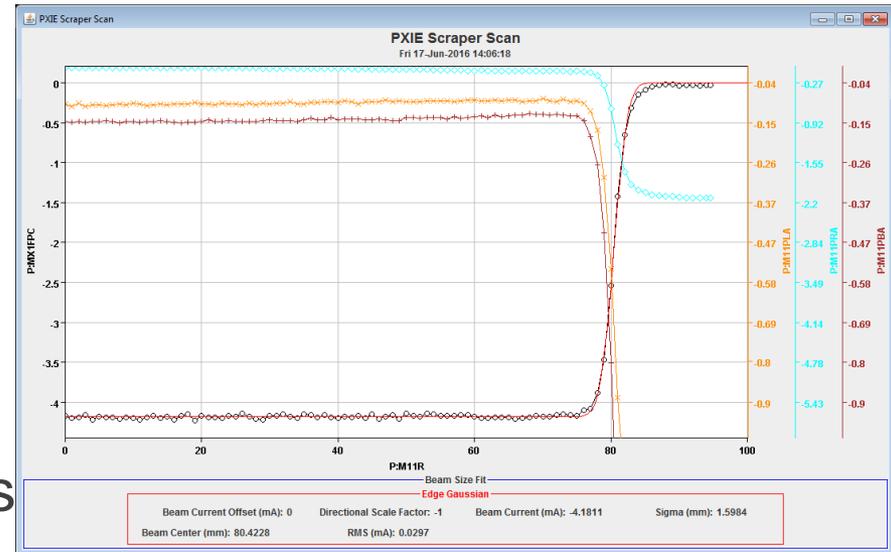
# Procedure

- Prepare settings working with  $10\ \mu\text{s}$  beam
  - Pass the beam to dump without measurable losses ( $<5\%$ )
  - Increase the beam size until there are changes in vacuum and dump current; back a bit
  - Align the beam using halo electrodes
  - Insert all scrapers until scraping is clear
    - To protect vacuum chamber
- Increase the pulse length



# Scraping

- Unforeseen problem: cross-talk between scrapers is large
  - With all scrapers inserted close to the beam, moving one of them into the beam results in a similar increase of currents in all scrapers
- Present solution
  - Move each of scrapers forth and back and measure the dump current changes
  - Set each corrector to the position with similar derivatives
- Caveats
  - Beam is elliptical
  - Upstream scrapers shield others



Current from the dump (black, 5 mA scale) and 3 scrapers while moving in the Right scraper. Horizontal axis scale is 100 mm. Scales for scraper currents: Right (blue) ~5 mA, Left (orange) and Bottom (brown) ~1 mA. All scrapers are initially close to beam.

# Plans

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- Plan stays as it was several months ago
  - proceed with installations of MEBT-2 in Sep 2016
    - + 4 triplets with dipoles, bunching cavity, kickers
  - Install the LEBT bend at the same time
- Vacuum chambers and supports are being prepared
- Magnets for the next MEBT step are mostly done at BARC
  - Finalizing the magnetic measurement stand
  - On schedule to have the magnets ready for installation in Sep
- Bunching cavities production is delayed by leaks in all 3
  - No new delivery dates yet
- 50 Ohm kicker is ready; 200 Ohm kicker is being assembled
- LEBT bend is being prepared for magnetic measurements

## Present team (partial list)

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- In beam shifts:
  - B. Hanna, J.-P. Carneiro, V. L. S. Sista, L. Prost, A. Saini, J. Steimel, A. Shemyakin, F. Garcia
- RF: R. Pasquinelli, D. Peterson, D. Sun
- LLRF: J. Edelen, B. Chase, A. Edelen, D. Bowring
- Controls: M. Kucera, T. Zutnik, W. Marsh, L. Carmichael
- MPS: A. Warner, J-Y. Wu
- Instrumentation:
  - V. Scarpine, N. Patel, A. Saewert, B. Fellenz, N. Eddy, N. Liu, J. Bogaert
- EE: G. Saewert, K. Carlson, R. Brooker, J. Simmons
- Mechanical:
  - C. Baffes, R. Andrews, A. Chen, M. Alvarez, B. Hartsell, M. Wong-Squires, J. Batko, D. Snee, L. Valerio, K. Kendziora, T. Hamerla, S. Opit, D. Lambert, R. Kellett, D. Franck, M. Jones, J. Czajkowski
- TD: L. Ristori, T. Khabiboulline, S. Kazakov, S. Krave, S. Stoynev, G. Romanov