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

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Outline

• Operational status
  – Beam line
  – Subsystems
  – Radiation

• Measurements
  – In part, “BPM noise” and scraping

• Plans
Ion source/LEBT

- Ion source has recovered after a vacuum failure on April 10
  - Spark frequency dropped to ~ 1/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

• 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 scrapers sets, beam dump, and diagnostics

Fermilab
Modes of operation

- 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 µs with the LEBT chopper

- Recently received permission from Safety to start increasing the pulse length ("operation mode")
  - Longest pulse so far 0.3 ms (x 10 Hz x 5 mA = 15 µA)

- Presently beam timing is changed "manually"
  - Arden works toward having these modes implemented in MPS
    - With clear indication when insertable devices are allowed
Diagnostics

• 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)

- 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 \(~0.2\) mR/hr at 12 µA 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

• 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

Will be reported in coming weeks
“BMP noise”

- At constant settings, BPM readings as seen by eye vary up to ~0.2 mm
  - Electronics noise or beam motion?
- Recorded 10 Hz signals (i.e. position of each pulse) for 2 min
  - Rms of 3rd BPM noise is 21 µm
  - 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 µm
- 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

- 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/mm²
  - Can create damage even at tens of μs 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 µs 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

- Plan stays as it was several months ago
  - proceed with installations of MEBT-2 in Sep 2016
    - + 4 riplets 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
Recent contributors (partial list)

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