

LEReC electron BPM tests

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Givens

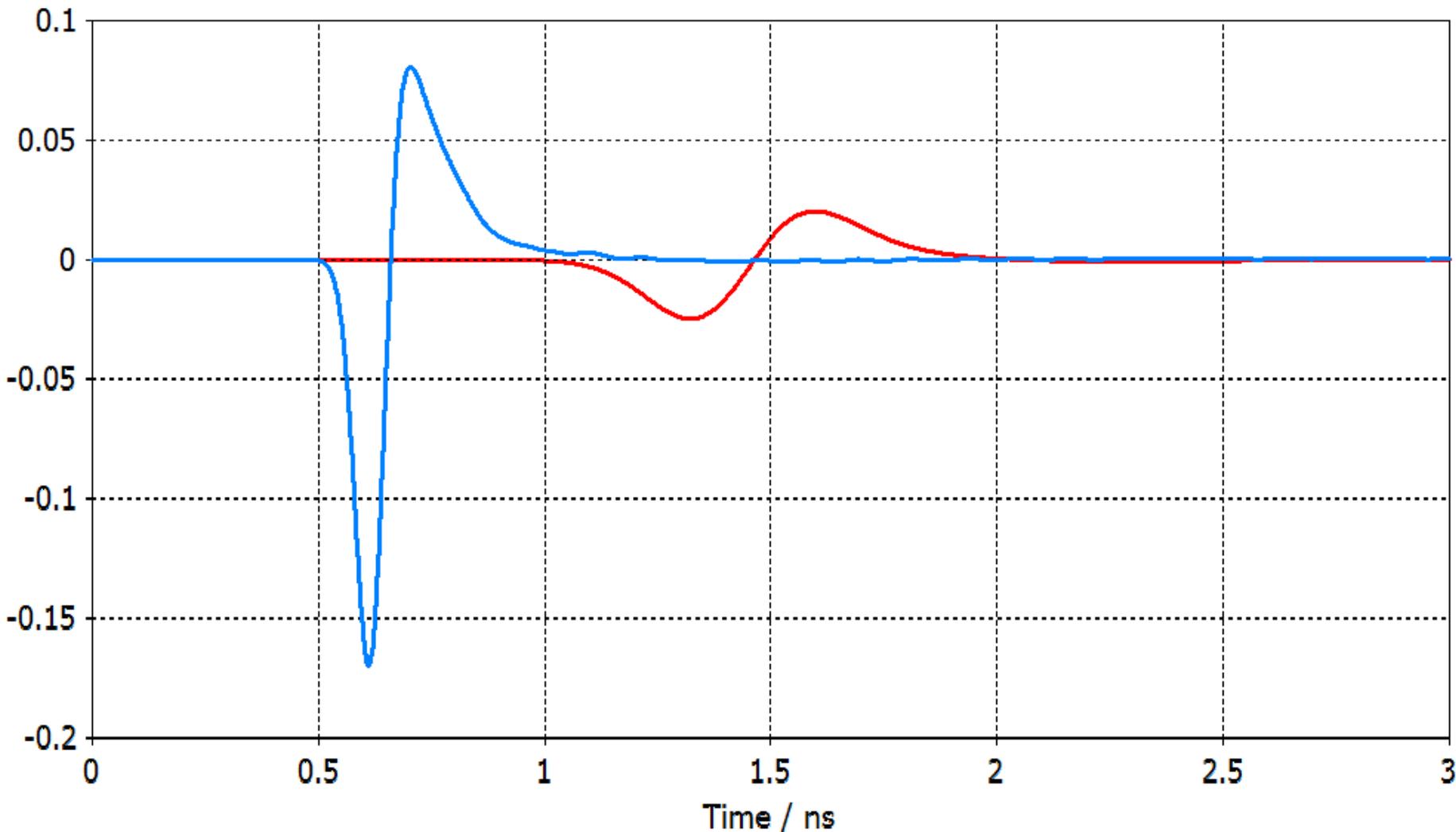
- Single bunch electron measurements will require additional amplification external to BPM electronics module – 20dB or 40dB
- Relays are required in the tunnel to provide online calibration with beam

Questions to answer

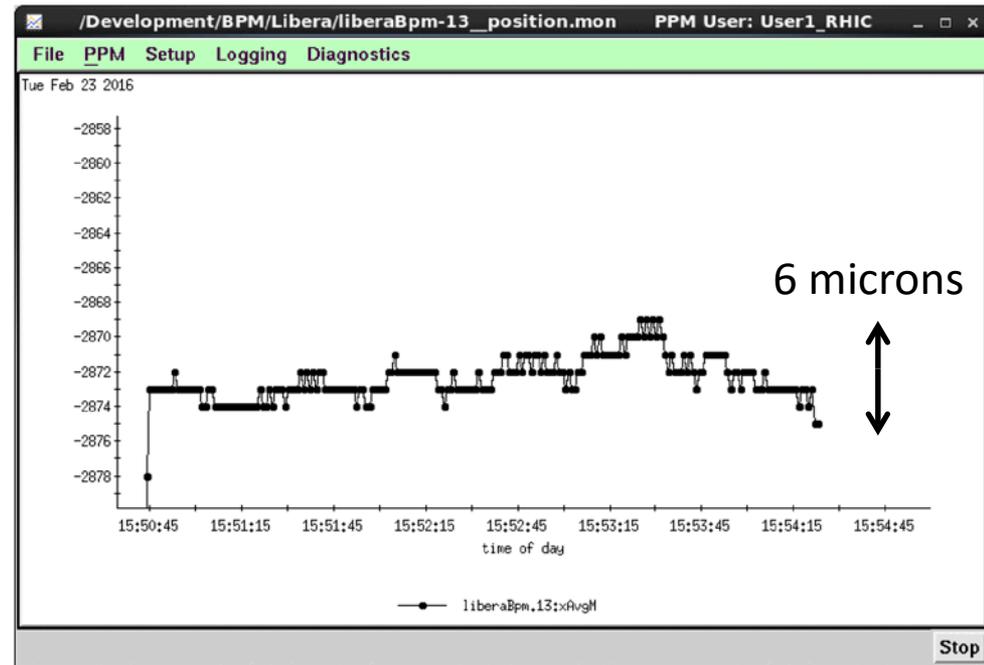
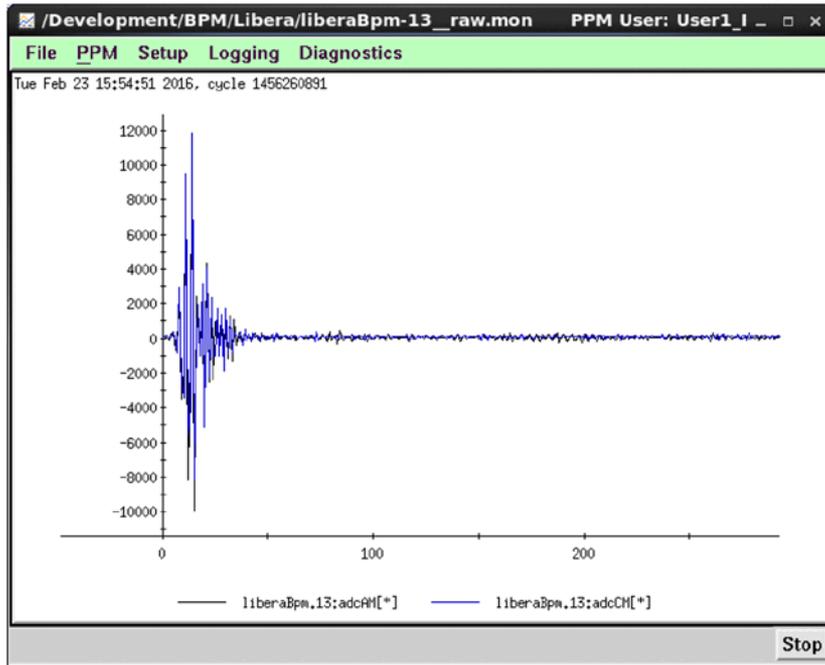
- Should existing 9mm buttons be used in the transport line or should we purchase 15 mm buttons to provide 2.6x the signal amplitude?
- Should amplifiers be installed in the tunnel?

Simulated BPM signals for a 30 pC bunch with rms lengths
of 10 mm (blue) and 37 mm (red)
(P.Thieberger, 01/08/2016)

Discrete Port Voltage Time Signals

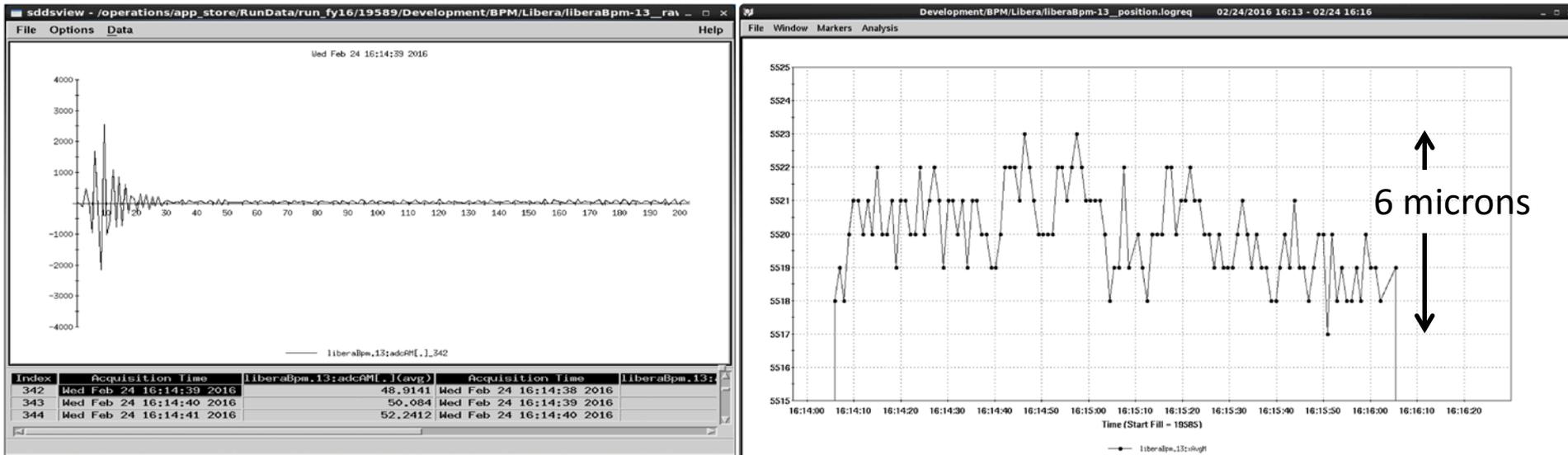


Simulated electron bunch train into Libera electronics 40dB gain board in service building



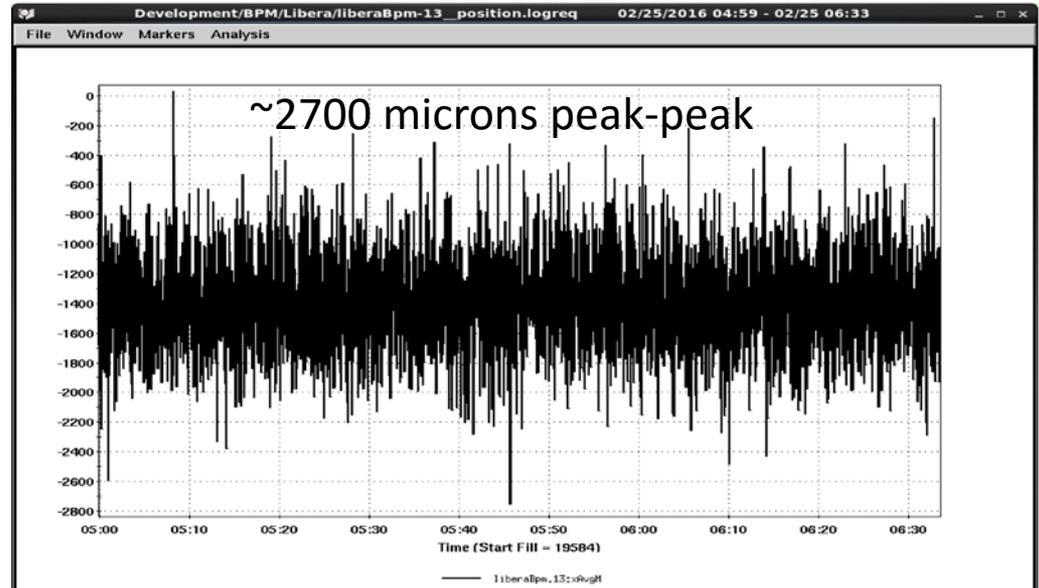
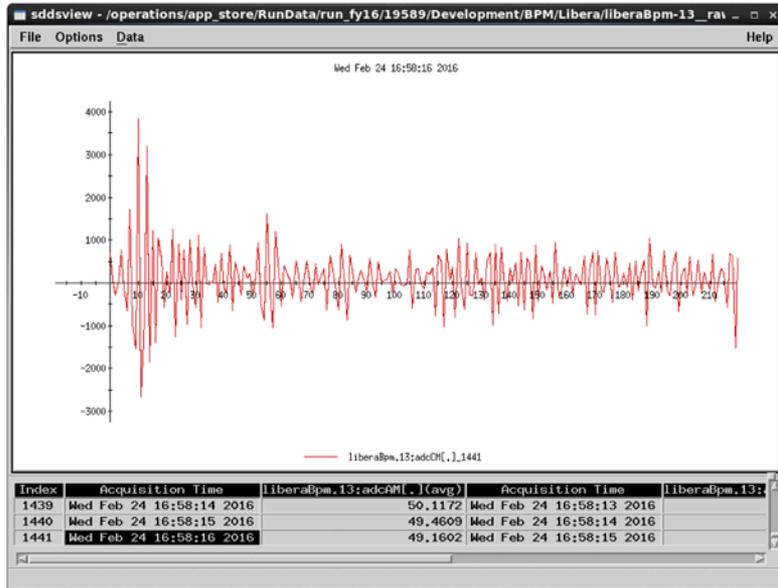
42 ns 704 MHz bunch train, -25 mV,
libera 18dB gain, position coefficient=20000,
40 dB amplifiers as if in service building,
280' cables

Simulated electron bunch train into Libera electronics no gain

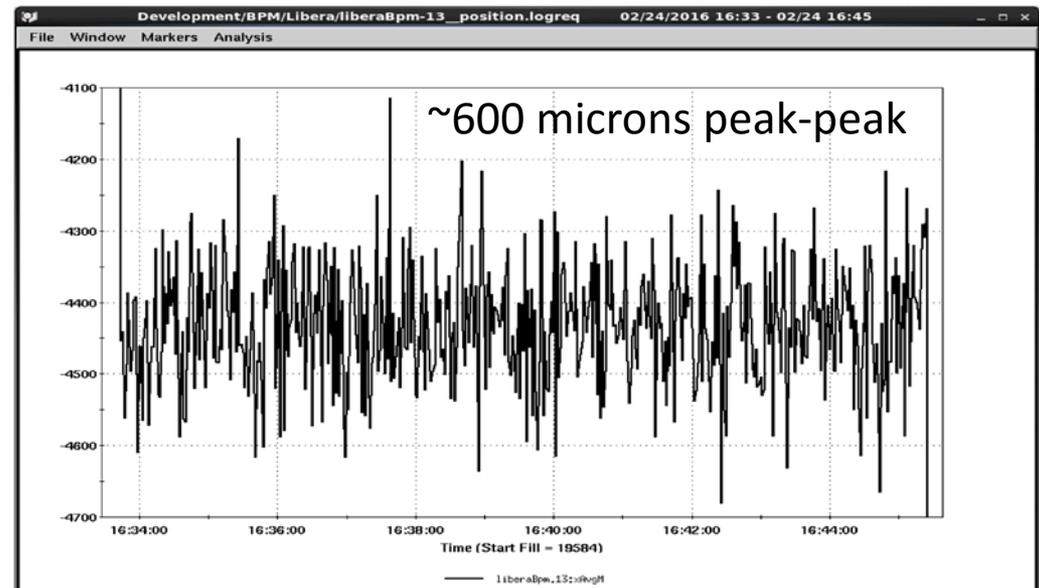
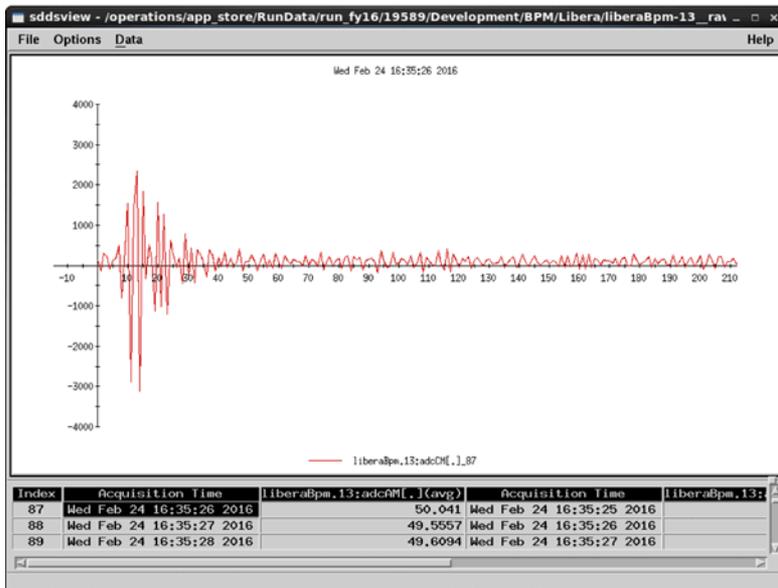


42 ns 704 MHz bunch train, libera 31dB gain, no amplifiers, 280' cables.

Single simulated electron bunch per RHIC turn



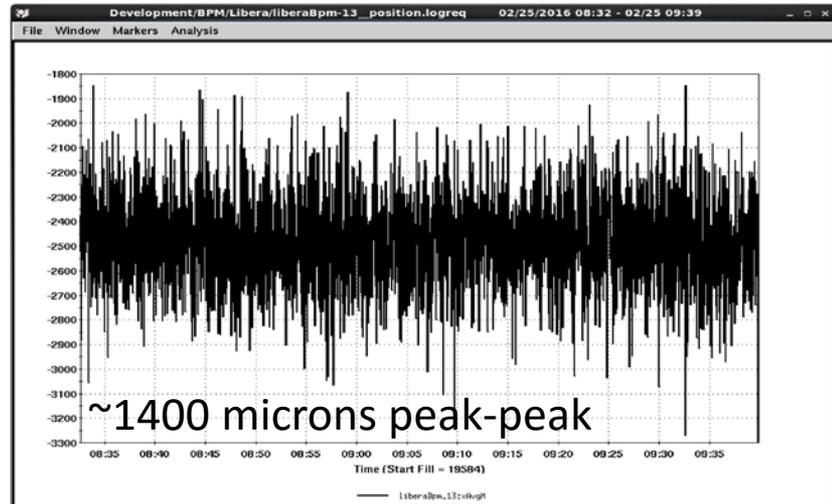
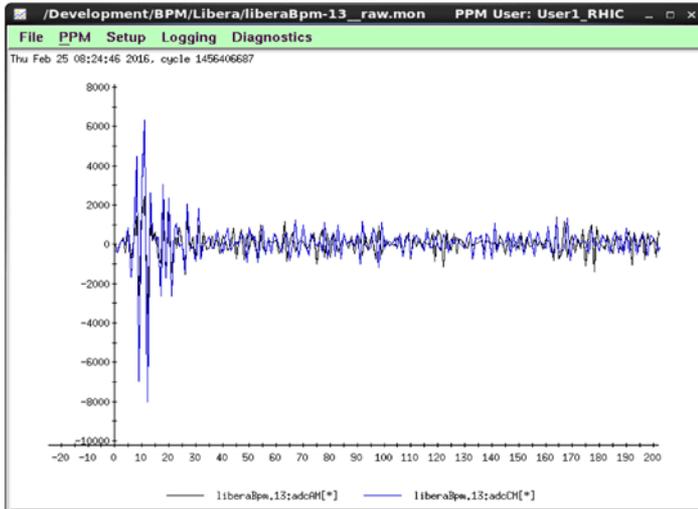
1 bunch, 25 mV, libera 31dB gain, 40 dB amplifiers as if in service building, 280' cables.



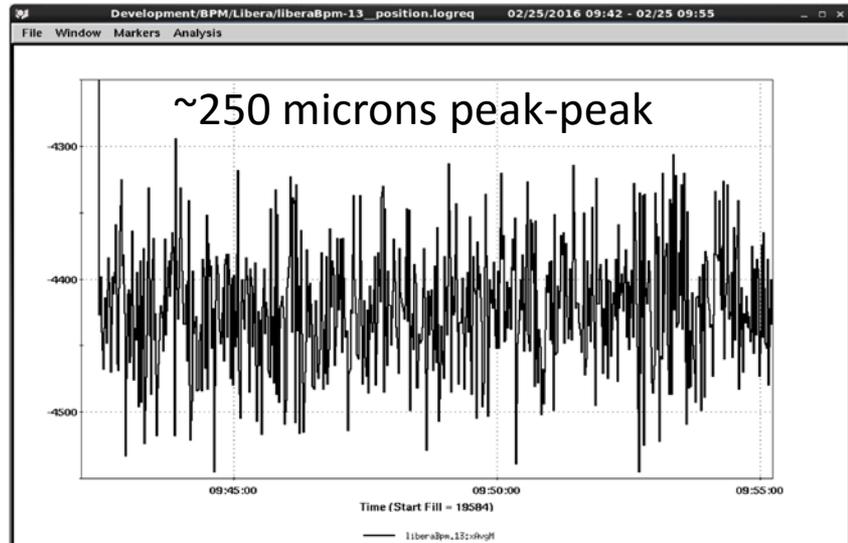
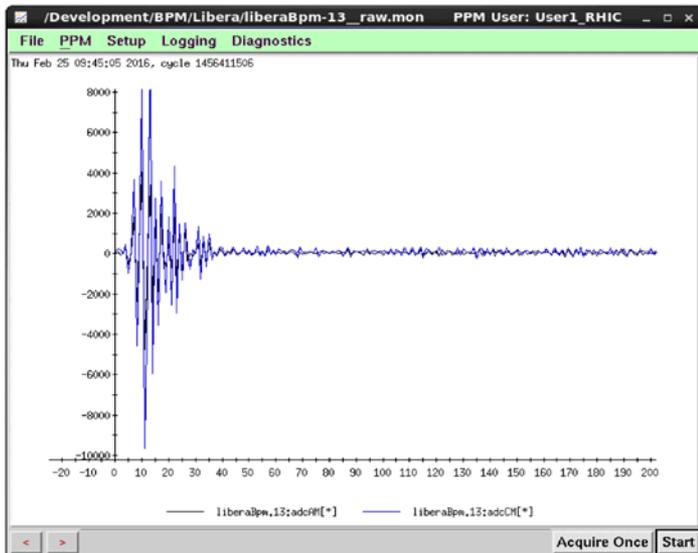
1 bunch, 25 mV, libera 31dB gain, 40 dB amplifiers as if in tunnel 280' cables.

Single Simulated electron Bunch per RHIC turn

These plots are with 8 dB less attenuation on output of pulse to simulate ~ 2.5 times the signal as would be achieved with 15 mm buttons as opposed to 9mm buttons.

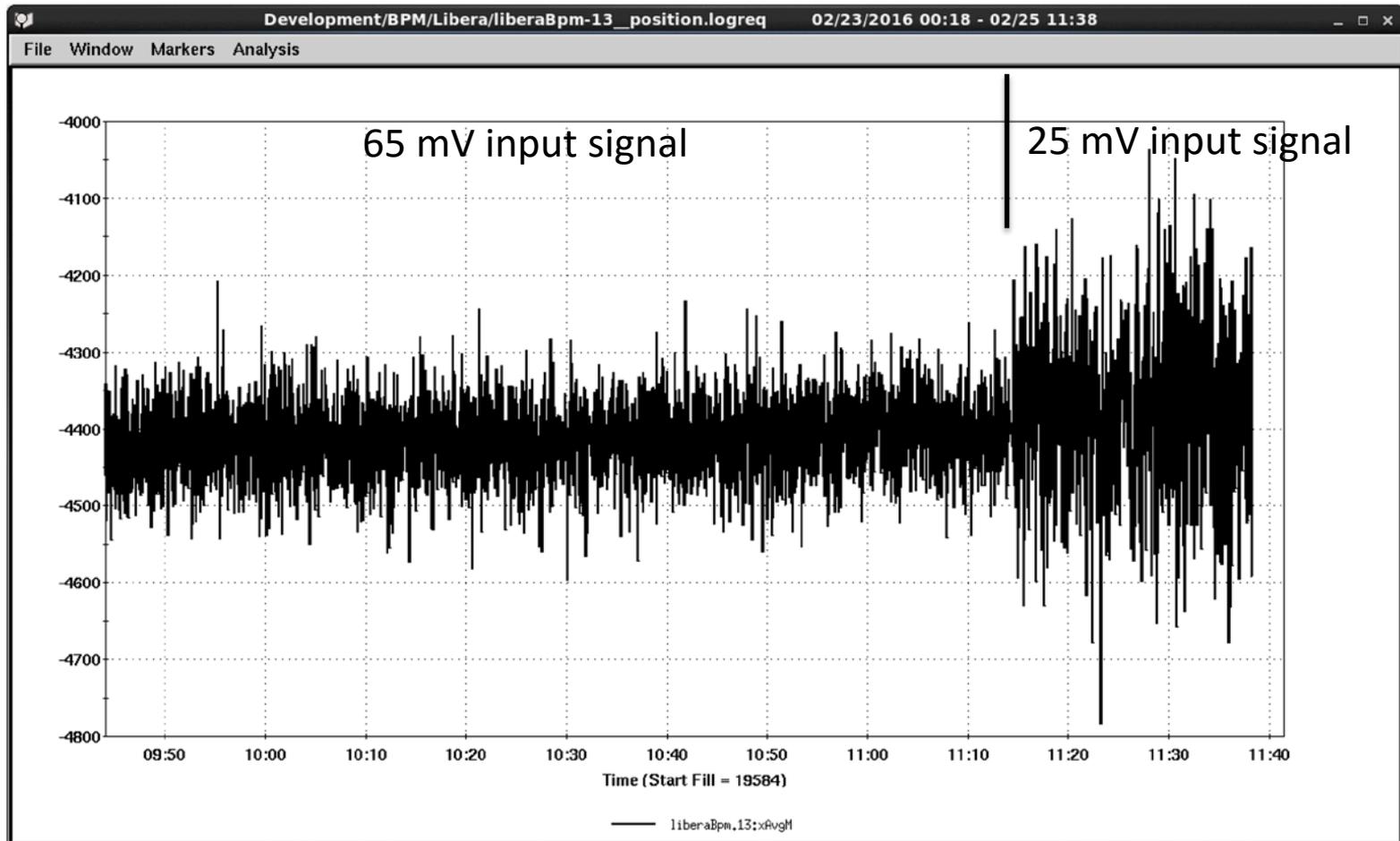


1 bunch, 65 mV, libera 31dB gain, 40 dB amplifiers as if in service building, 280' cables.



1 bunch, 65 mV, libera 31dB gain, 40 dB amplifiers as if in tunnel, 280' cables.

65 mV input pulse vs. 25 mV input pulse with amplifiers in the tunnel



1 bunch, 65 mV (before 11:15), 25 mV (after 11:15),
libera 31dB gain, 40 dB amplifiers as if in the tunnel, 280' cables.

Summary of test results

Input signal	Amplification	Average position variations (position coefficient K=20000)
25 mV, 42 ns train	40 dB in service building	6 microns
25 mV, 42 ns train	No amplifiers	6 microns
25 mV, 1 bunch	40 dB in service building	2700 microns
25 mV, 1 bunch	40 dB in tunnel	600 microns
65 mV, 1 bunch	40 dB in service building	1400 microns
65 mV, 1 bunch	40 dB in tunnel	250 microns

Notes:

- Input signal amplitude is measured before 6dB/3dB to each input signal. Each pulse is 70ps FWHM.
- Cable length for measurements was 280 ft. 350 ft or longer cables may be required for some BPMs.
- All measurements used ERL Libera Brilliance single pass electronics.
- Each plotted data point is average of 1 second period, and bunches at 78 kHz rate
- Bunch trains are 42 ns long, 704 MHz spacing

Recommendations

- Design relay board to be installed in the tunnel, and include 2 20 dB amplifiers per channel with solder jumper configurability to select 0dB, 20dB, or 40dB gain.
 - packaging and installation details will require careful consideration
- 15 mm buttons will improve single electron bunch (no 704 MHz train) measurements in the transport line and are desirable.
 - However, if cost savings are essential then the existing 9mm buttons may be adequate.

Other thoughts

- Relays may create additional mismatches; prototype and testing is required
- Additional tests are required to simulate ion beam and determine gain needs.
- With 40dB gain in the tunnel, electron bunch trains may saturate amplifiers.
- When noise level is high (that is, poor signal to noise), several settings seem to affect the absolute position measurement:
 - Number of ADC samples used, number of bunches, bunch spacing, etc.
- Cost estimate needed to include
 - Relay/gain boards, enclosure, mounting
 - Power installation requirements
 - Control cabling
 - Control hardware