The ATF Damping Ring BPM Upgrade

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Fermilab

for the ATF Damping Ring BPM Team

New Hardware

Improvements on the analog downconverter

- CAN-bus controls, IF filter, remote diagnostics, etc.

New RF, DC & CAN-bus distribution. Grounding of tunnel hardware.

Switch to in-house VME digitizer

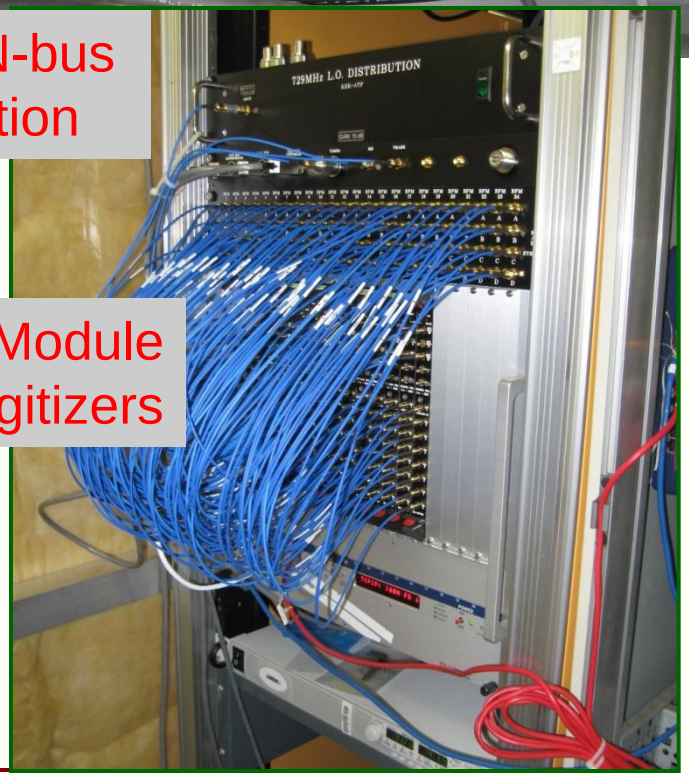
- 8-ch. ,125 MSPS ADC (serial outputs), Cylcone III FPGA, PLL-locked CLK distribution

- Able to measure Injection TBT, Narrowband Orbit, Narrowband Calibration , and Last Turn on every injection

New Downmix & Calibration

LO & CAN-bus Distribution

New Timing Module & Custom Digitizers

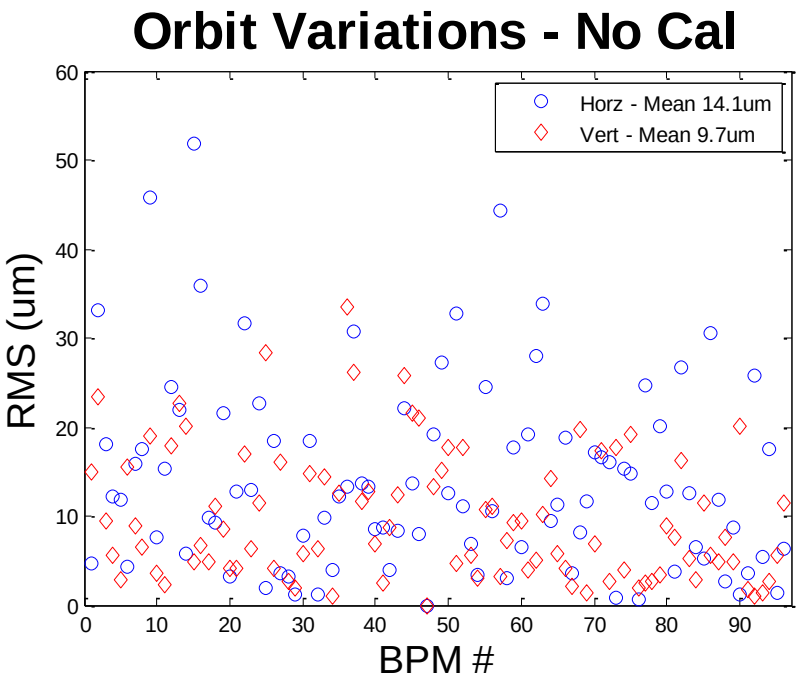


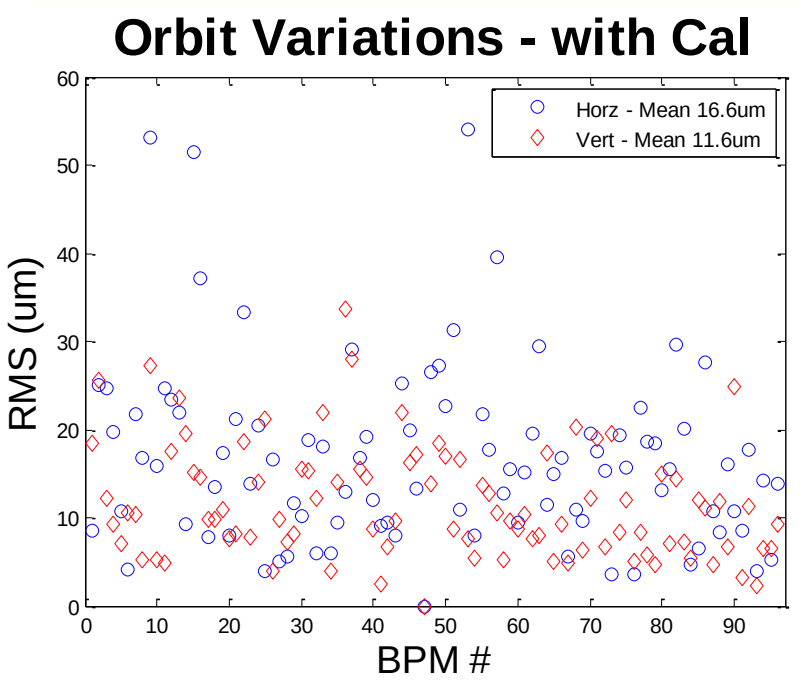
Current Status

- 95 of 96 Ring BPMs were switched to the new system during the May shutdown
- Beam commissioning began the last week of May
  - Initial Timing tests revealed an issue with clock synchronization
  - The echoteks used a 69.2MHz clock (32 samples/turn) synthesized from the 714MHz
    - The turn by turn data collection was initiated by an external turn marker
    - Fine for 1024 turns
  - The new system counts turns internally from injection to provide turn by turn data at any turn and last turn data
    - The synthesized 69.2MHz clock was found to drift over a full machine cycle
    - This caused problems with the turn by turn data at the end of the cycle
  - The solution was to bypass the clock synthesizer on the Timing Module
    - Simply use the clock divider, 714MHz/10 = 71.4MHz (33 samples/turn)
    - Solved the locking issue but required a major system modifications
- Operation of all bpms was demonstrated over the remaining shifts
  - Orbit data was read into the ATF control system
  - First beam studies
    - Two Sets of Narrowband Orbits were collected, without and then with calibration
    - Several Turn by Turn data files were collected both at injection and by kicking the beam after 500k turns

First Look at Narrowband Orbit

- Narrowband orbit for each injection (shot) is measured
  - The mean orbit and rms over 160ms is reported for Horz, Vert
- For each data set, 128 shots are collected
  - Large shot to shot mean orbit variations are observed in both
  - Horizontal shows larger RMS than vertical -> Beam related

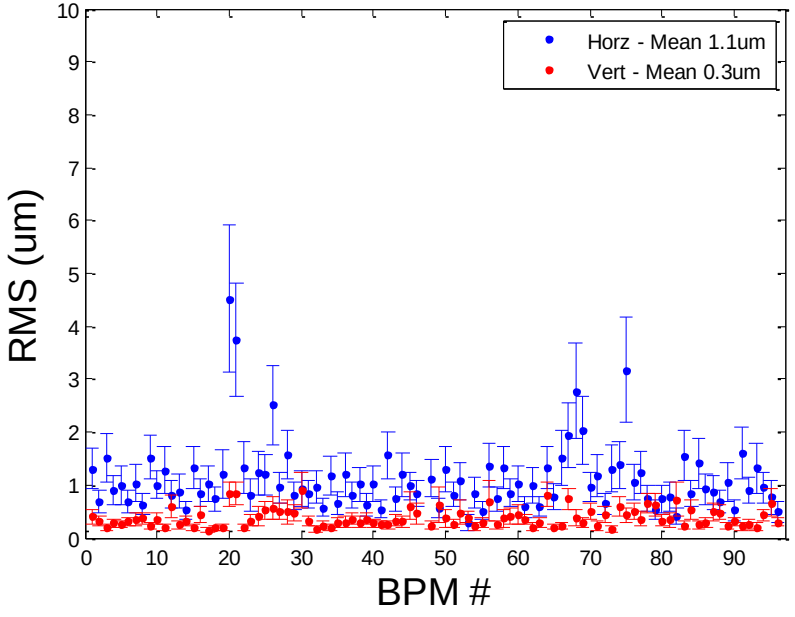




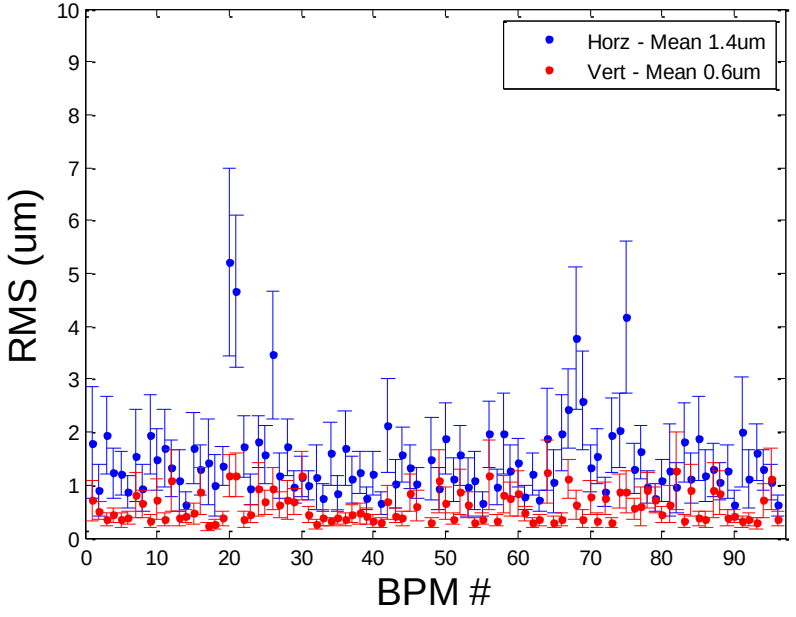
Narrowband Orbits

- **Single shot RMS is much smaller than shot to shot orbit variations**
  - **Plotted as mean shot RMS with variation on RMS as error bars**
  - **Observe larger RMS in Horizontal than Vertical -> Beam related**
  - **Data with Calibration has larger RMS than without Calibration**

Shot RMS Variations - No Cal

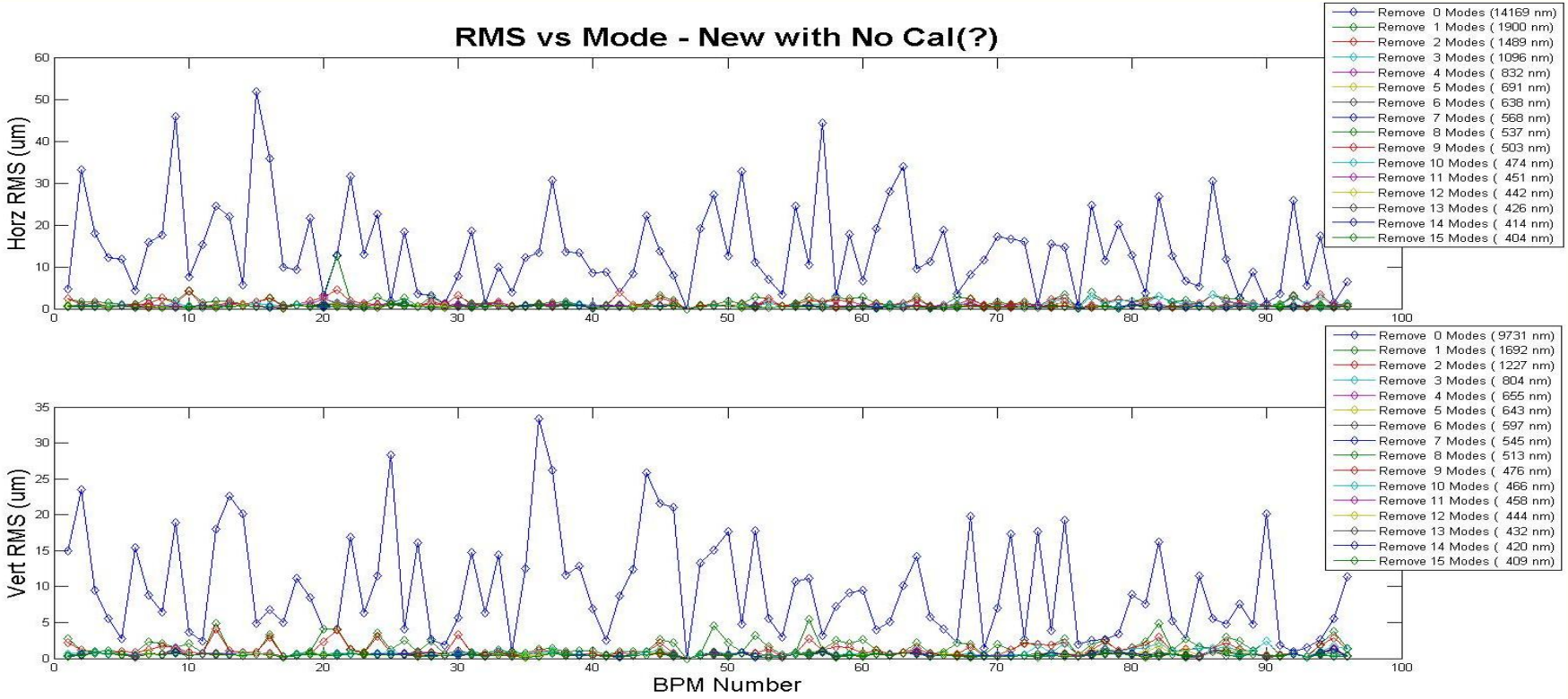


Shot RMS Variations - with Cal



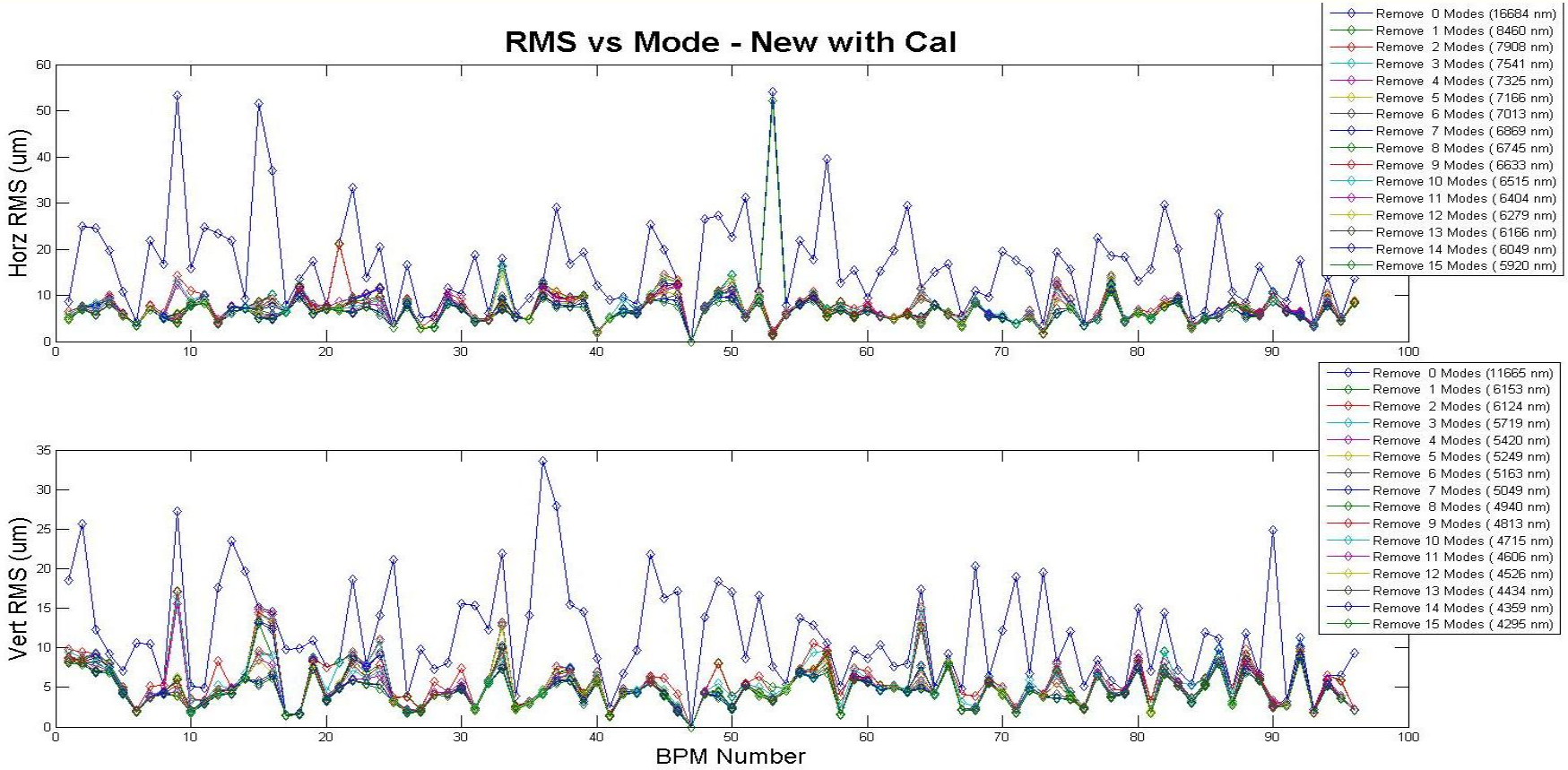
Preliminary SVD Orbit Analysis

- **Use Singular Value Decomposition to look for correlated motion and estimate resolutions**
  - **Ignoring beam effects, the horizontal and vertical resolution of the pickup/electronics should be the same…**



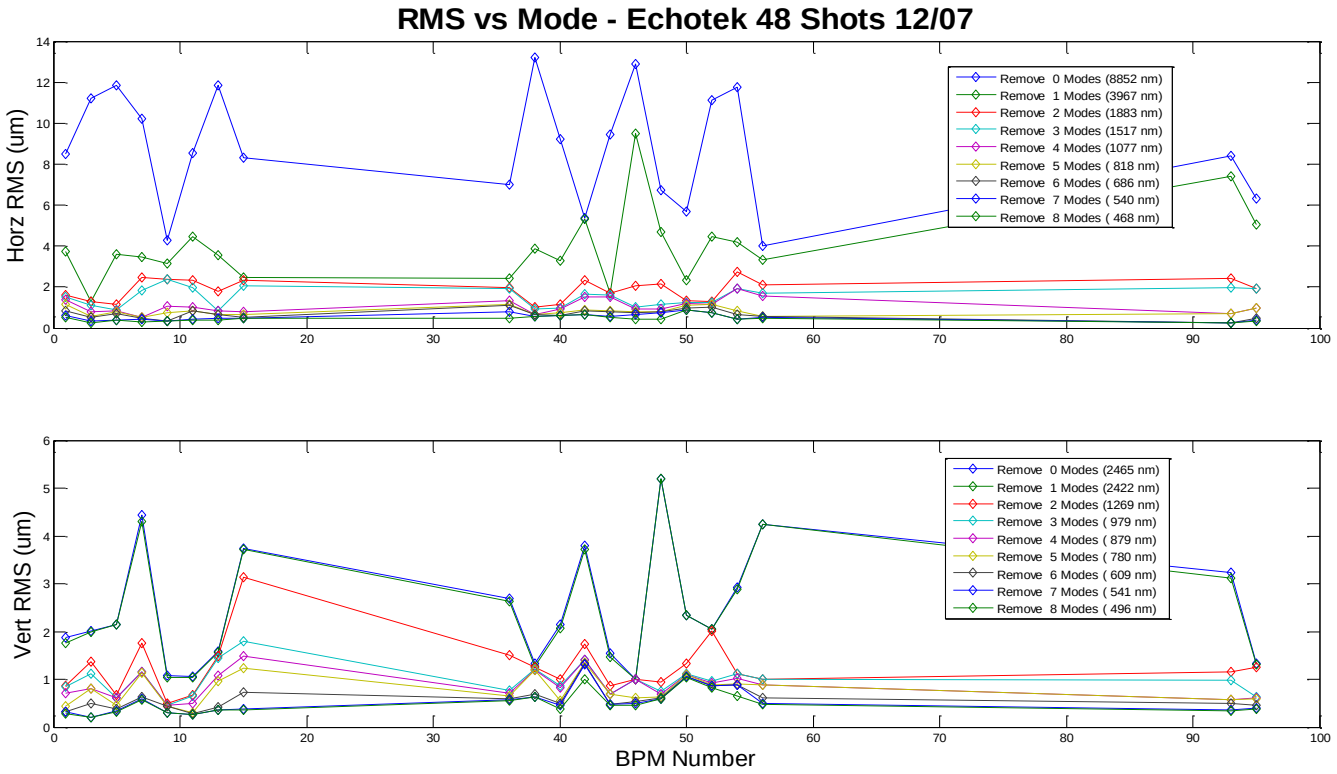
Preliminary SVD Orbit Analysis

- See much larger residual RMS in Calibrated Data
  - Still 6um Horizontal and 4um Vertical after removing first 15 modes!
  - Something is not working correctly with Calibration…



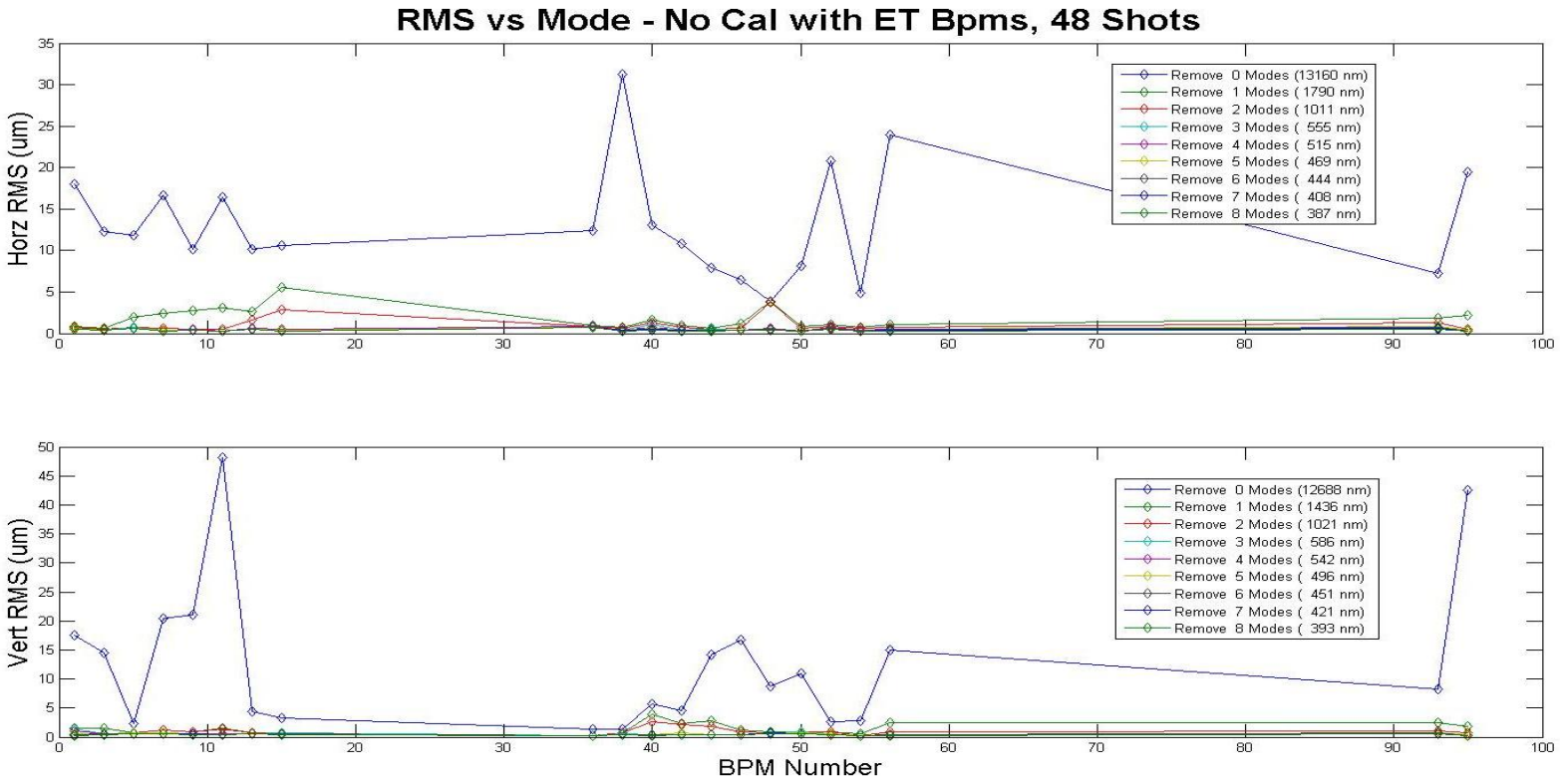
Analysis with Echotek System

- **Perform same analysis on Data taken with Echotek system 12/07**
  - **48 shots were analyzed with 21 BPMs instrumented**
  - **See resolution of 540nm after removing 7 modes**
  - **Largest mode is all Horizontal**



Re-Analysis Uncalibrated Data

- **Perform the same statistical analysis on new data**
  - **Use 48 shots and the same 21 bpms as in the echotek system**
  - **Resolution is 390nm after removing 8 modes**
  - **Larger initial variations and all modes are mixed Horizontal/Vertical**



Summary

- The Damping Ring BPM upgrade installation is now complete and commissioning has begun
  - Major change to digitizer clock during commissioning
- The Narrowband Orbit data and Turn by Turn data are available
- Preliminary Analysis of the Narrowband data
  - Horizontal RMS > Vertical RMS -> measuring beam not noise!
  - Clear problem with the Calibrated orbit data
    - Should be resolved before operation resumes
  - Large shot to shot orbit variations…
    - Variations are larger than observed with Echotek system in 12/07
    - Simple estimate of system resolution from shot to shot data is slightly better with new system
- Results from Turn by Turn Analysis are presented next

The Future

- Continue Commissioning the system
  - Optics and Machine studies – more analysis needed
  - Determine resolutions for all measurements
- Update the position scaling for the injection bpms
  - Use correct bpm geometry for bpms 20 & 21
- Investigate odd behavior of bpm 53
  - Flagged by SVD and TBT analysis
- Implement a history for the calibration data
  - Allow tracking of channel performance
  - Show large drifts which may indicate impending failure
- User requests?

Backup

Overview of the BPM Upgrade

- New read-out hard-, firm- and software, BPM pickups (button-style) stay unchanged.
- R&D activities over the last couple of years on 20 BPMs in the arcs, utilizing mixed analog/digital signal processing
  - Test of different analog downconverters (w/o CAL)
  - Digital signal processing based on spare *Echotek* digital receivers.
- Final upgrade scenario (96 BPMs, plus spares)
  - 714-to-15.1 MHz analog downconverter with CAN-bus controlled calibration tone, located in the tunnel.
  - VME hard- & software, in 4 rack locations
    - 8-ch. 125 MSPS digitizer with an *Altera* Cyclone III FPGA
    - 12 ch. VME timing generator (Fermilab).
    - *Motorola* 5500 VME controller, with CAN-bus interface, running VxWorks & EPICS software
  - Auxiliary hardware, e.g. power supplies and distribution, LO-signal distribution, CAN-bus distribution, etc.