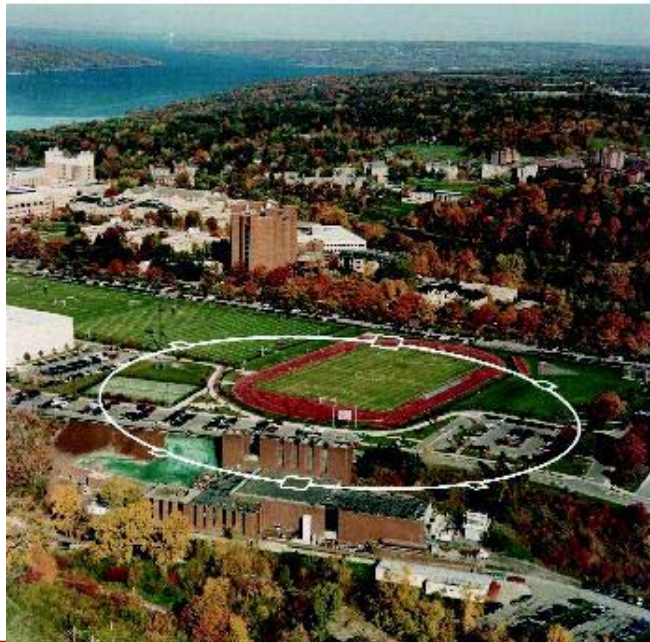




CesrTA Instrumentation and Diagnostics

Don Hartill

*Cornell Laboratory for
Accelerator-Based Sciences and Education*

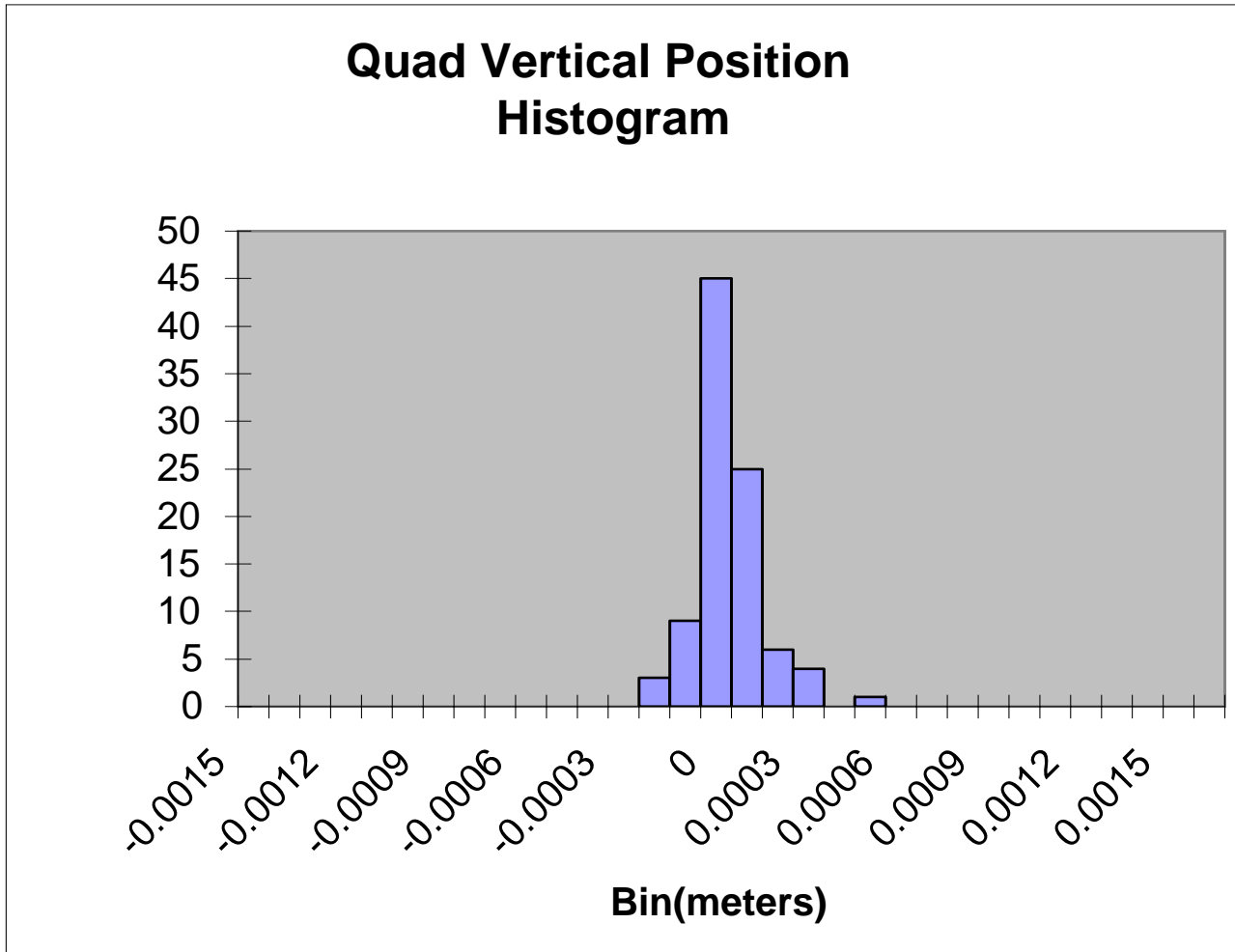




- Magnet positions
 - Survey
 - Stability
- Beam Position Monitor System
- Beam Size Measurement
- Electron Cloud and Ion Instrumentation
- Feedback Systems (Transverse and Longitudinal)



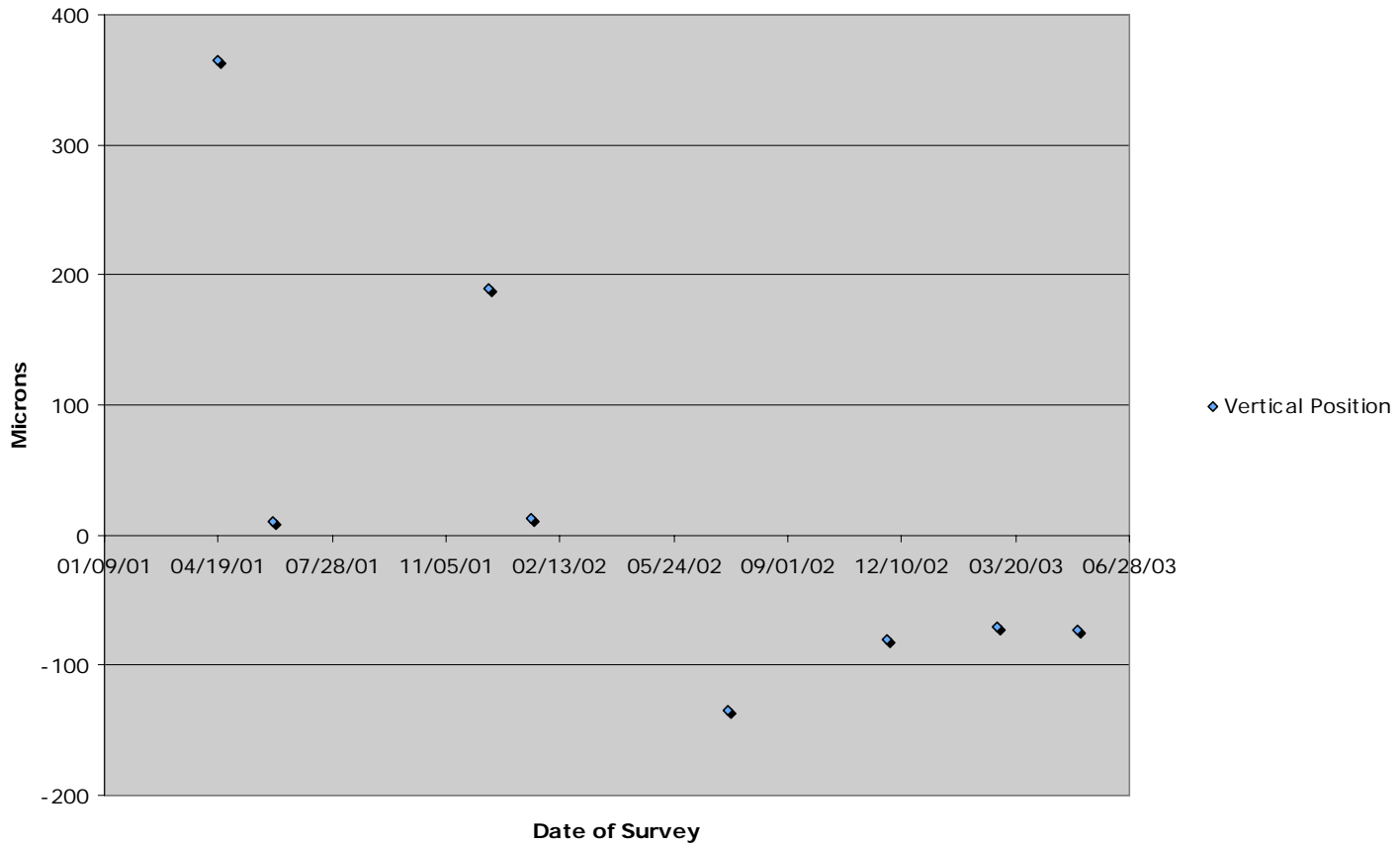
- Currently use a Leica Model TDM 5005 Total Station Optical Survey Instrument and a series of monuments with typical spacing of 20 m.
- Average angular resolution in the tunnel atmosphere is ~ 3 microradians $\rightarrow \sim 30$ micron spatial resolution for a 10 m path length. Longitudinal resolution is ~ 0.5 mm on a 10 m path.
- Have carried out a series of accelerometer measurements on the quadrupoles and other ring magnets with an instrument that has a noise floor of $10 \mu\text{g}$ for short term stability assessment.
- Use our extensive data base of repeated surveys of the magnets during maintenance and upgrade down periods to assess longer term stability.
- Some data on magnet positions....



$\sigma = 109$ microns

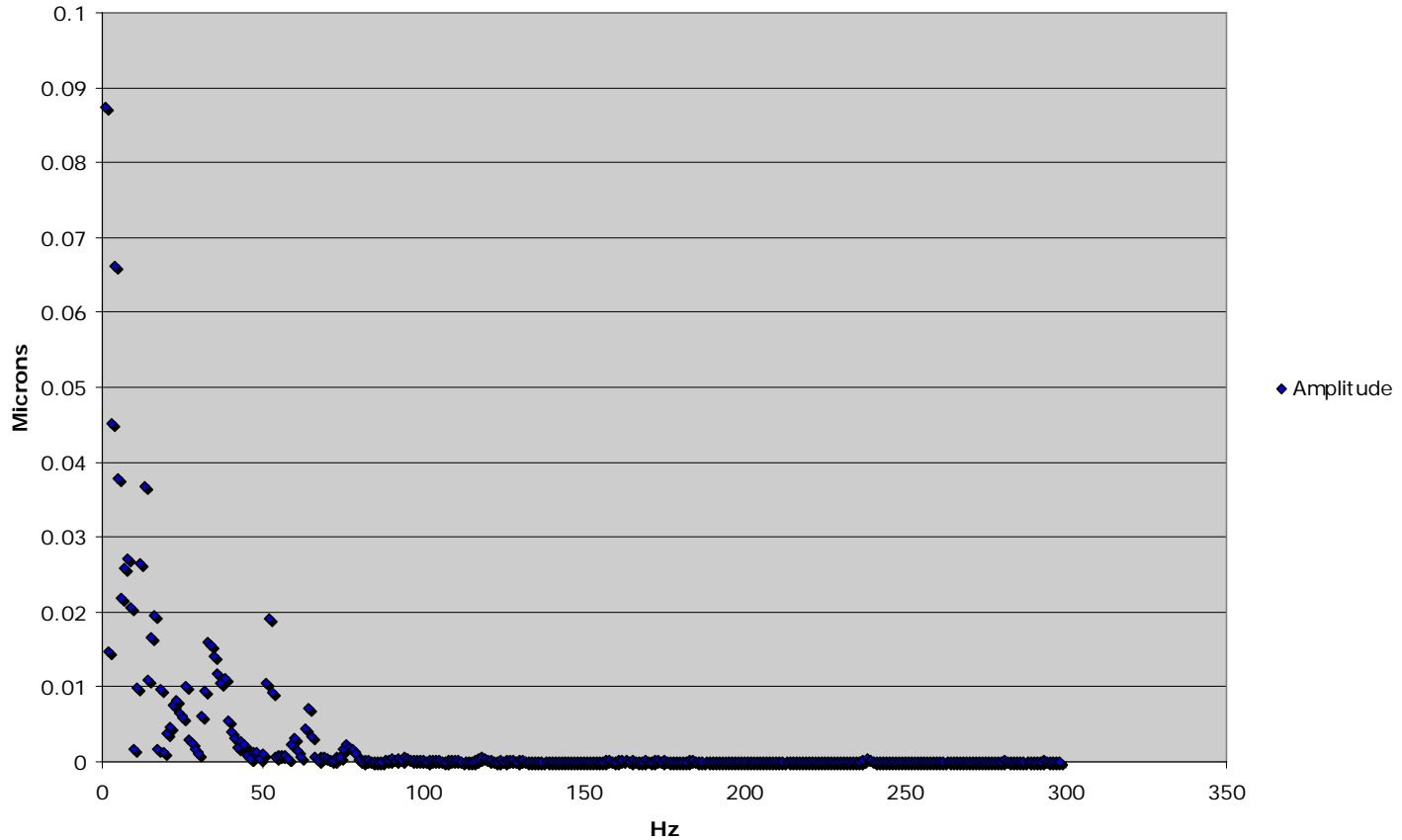


Q16W Vertical Position



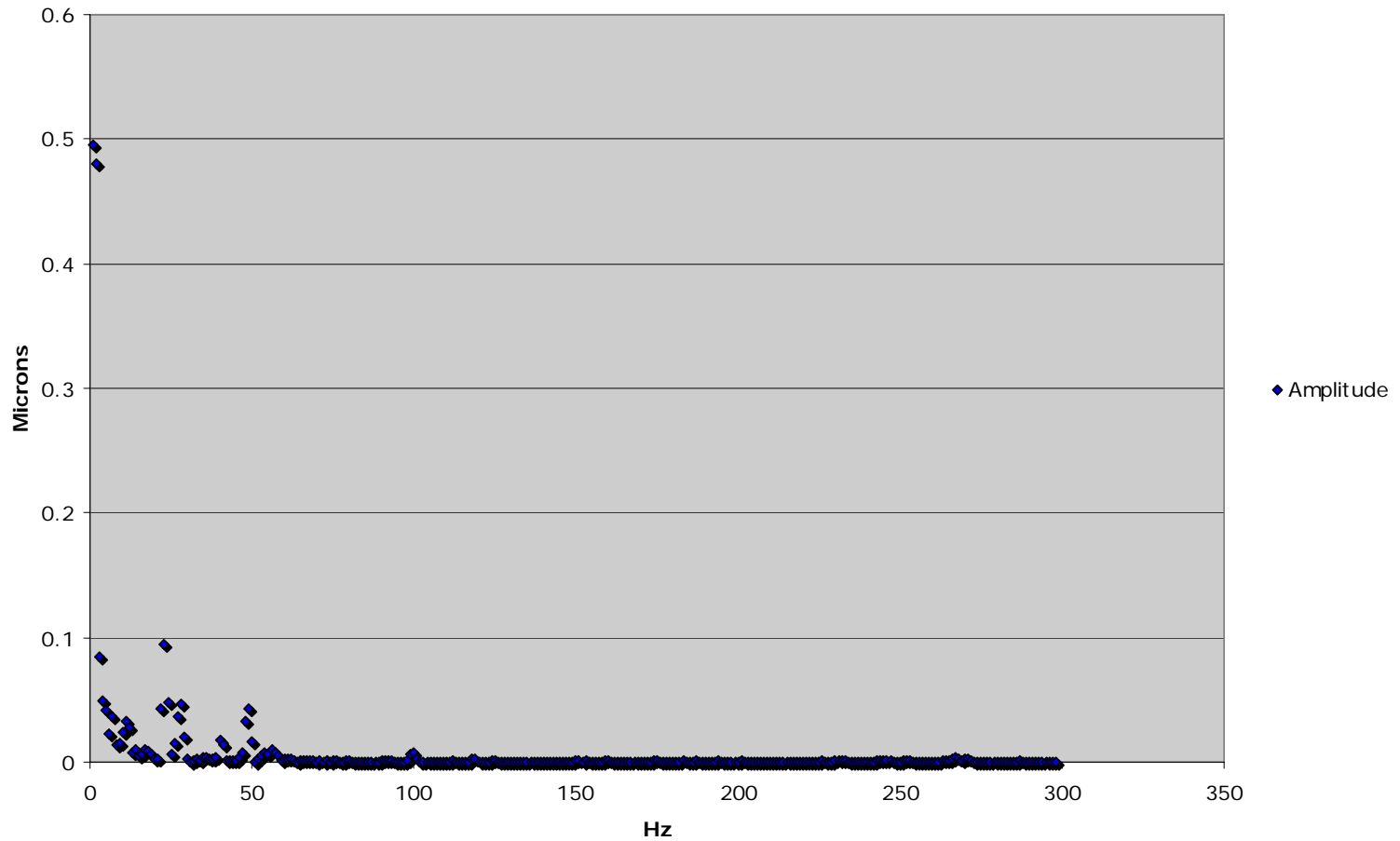


RMS Amplitude Q23W



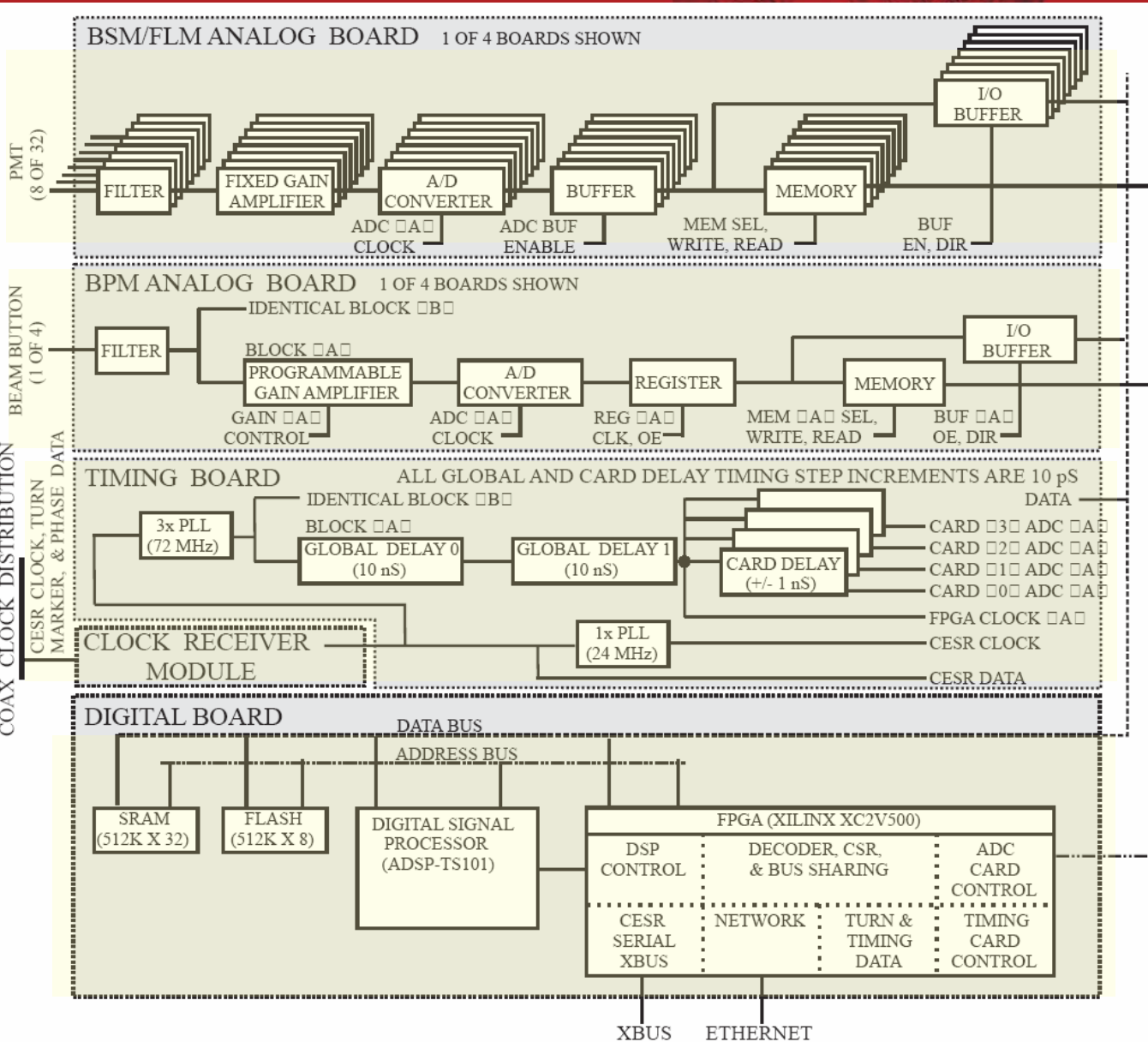


Floor





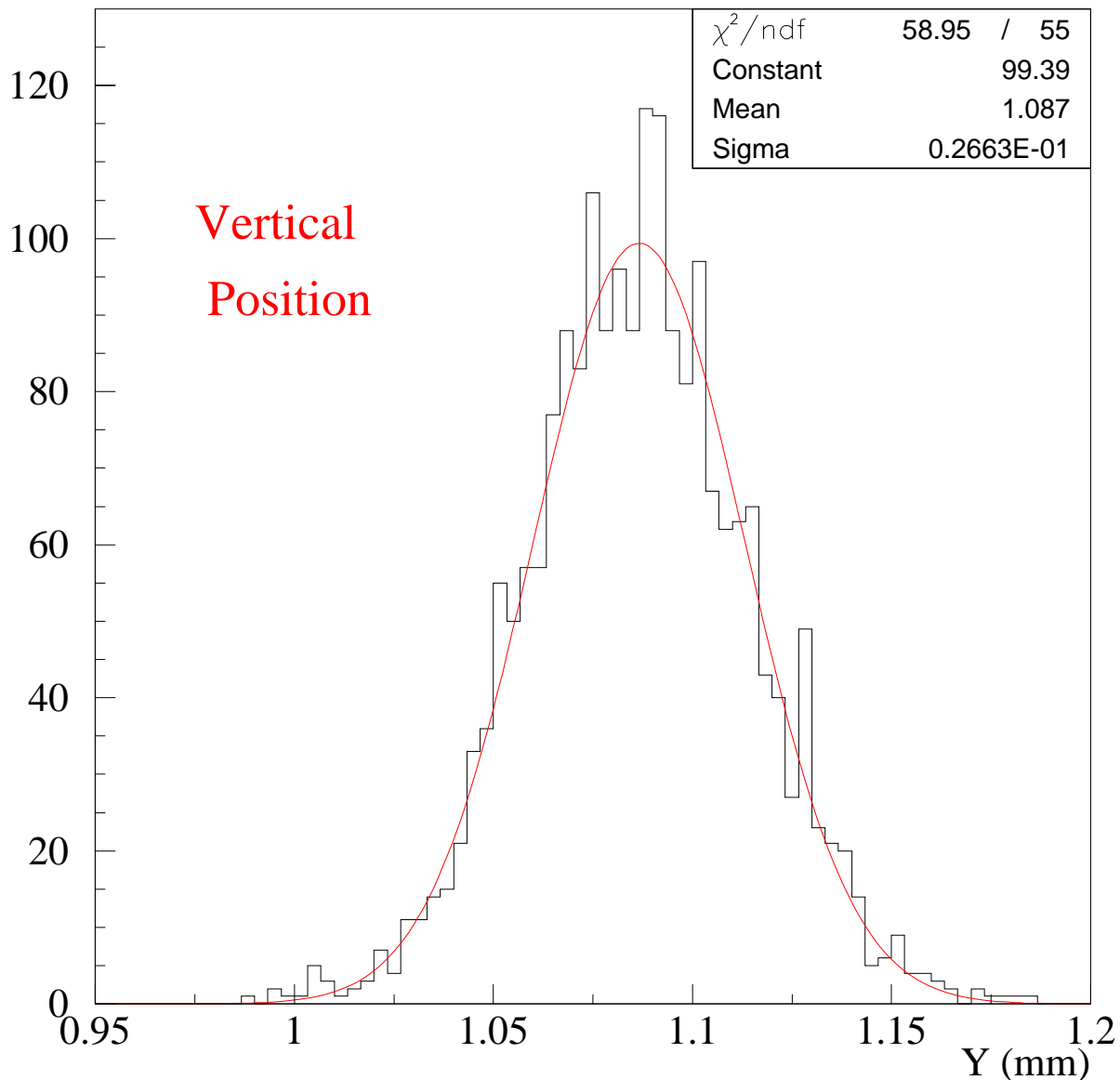
- Presently have a mixed dedicated digital system with twelve stations and a coaxial relay switched analog to digital system with ninety stations.
- Digital system stores up to 10 K turns of bunch by bunch positions with a typical single pass resolution of ~ 30 microns.
- From the multi-turn data, individual bunch betatron tunes can be easily determined to < 10 Hz.
- Planned upgrade of fully implementing the digital system with installation of 1/2 of the stations at the vertically focusing quadrupoles during year 1, with the other 1/2 during year 2 and all of the stations at the horizontally focusing quadrupoles during year 3.

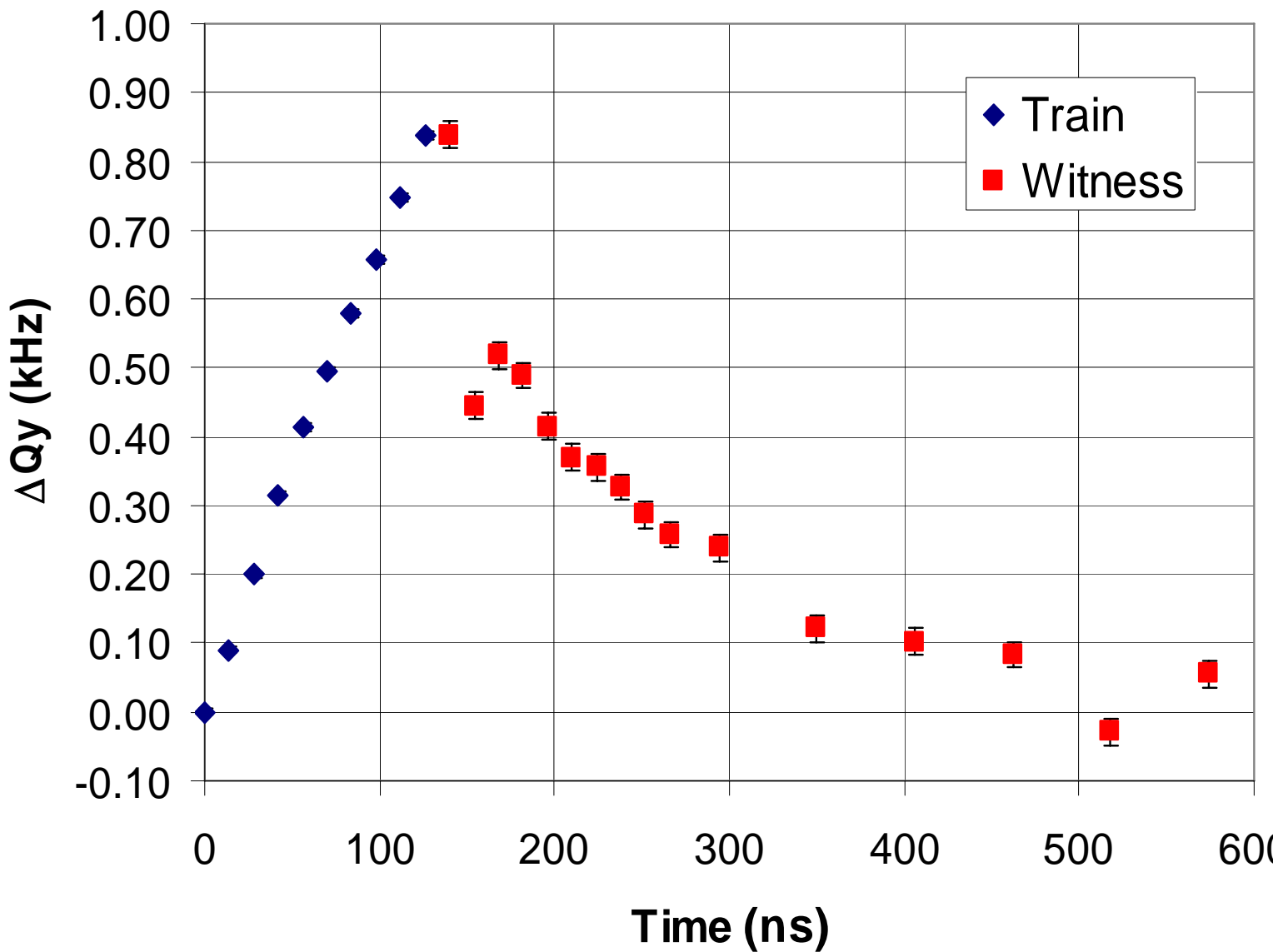


- DAQ is based on a 72 MHz Digital Signal Processor (DSP) capable of turn-by-turn and bunch-by-bunch data acquisition
- Similar architecture for BPM and BSM



- BPM resolution



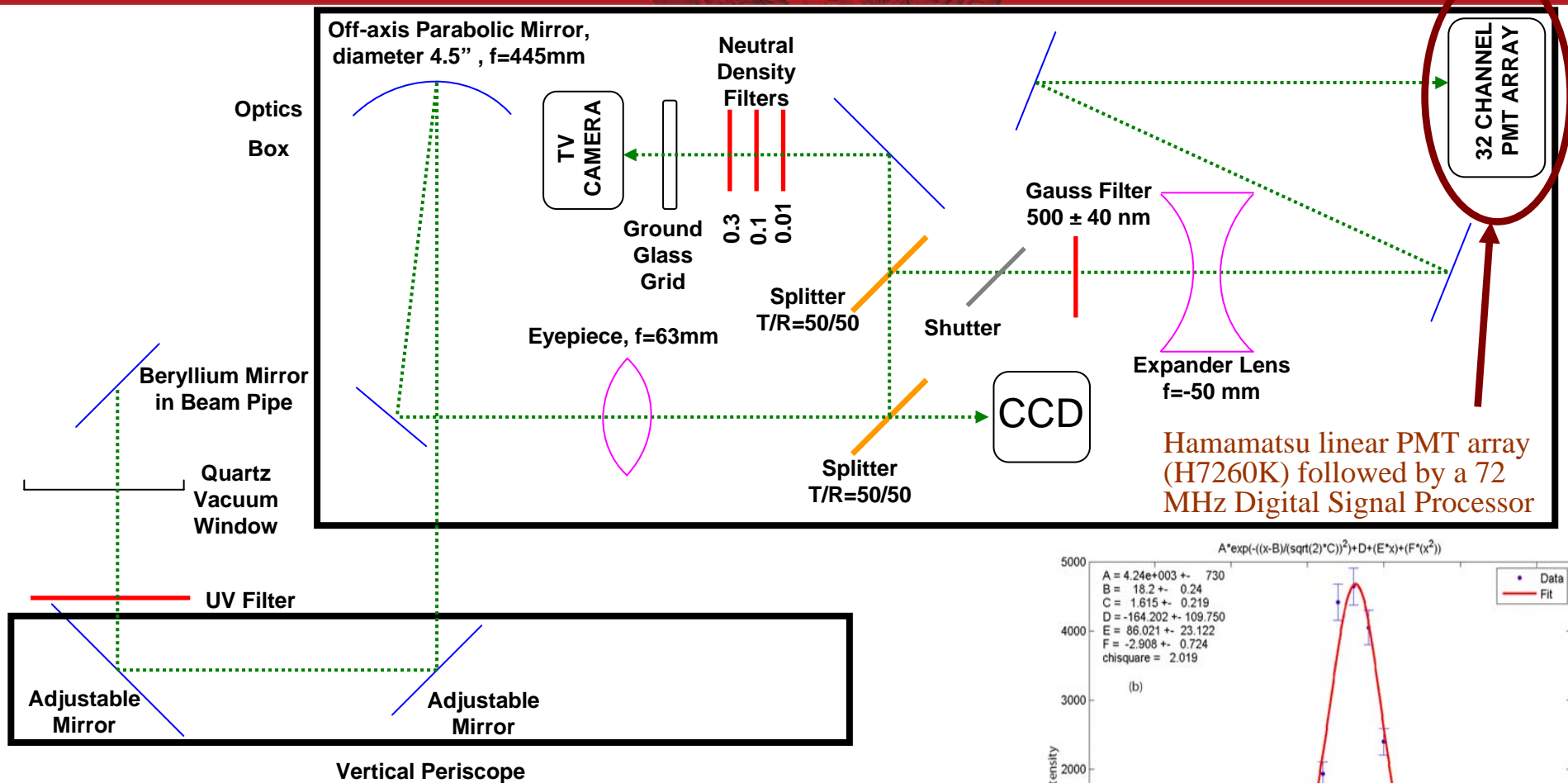




- Conventional visible synchrotron light imaging system for light from arc dipoles for both electrons and positrons with a vertical beam size resolution of ~ 140 microns.
- 32 element linear photomultiplier array enables multi-turn bunch by bunch vertical beam size measurements using the same electronics as the digital beam position monitor system.
- A double slit interferometer system using the same 32 element linear photomultiplier array can provide ~ 70 micron single pass bunch by bunch vertical beam size resolution and better than 25 micron multi-pass bunch by bunch vertical beam size resolution. 25 micron vertical beam size is \sim twice the beam size at the light source location for 5 pm vertical emittance.

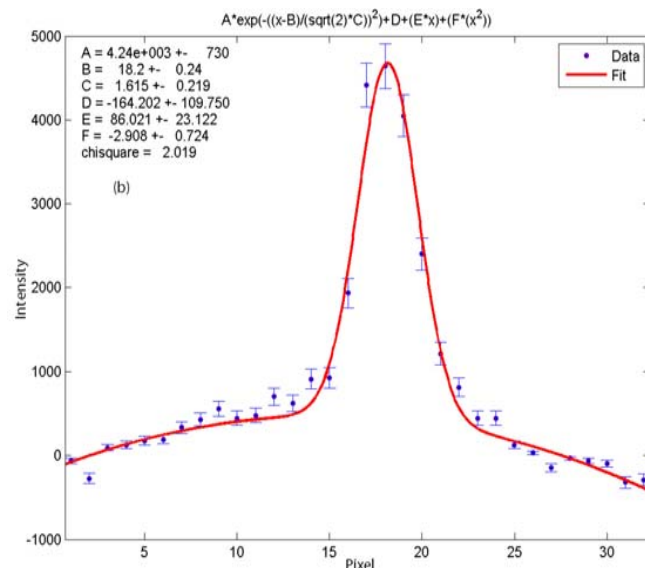


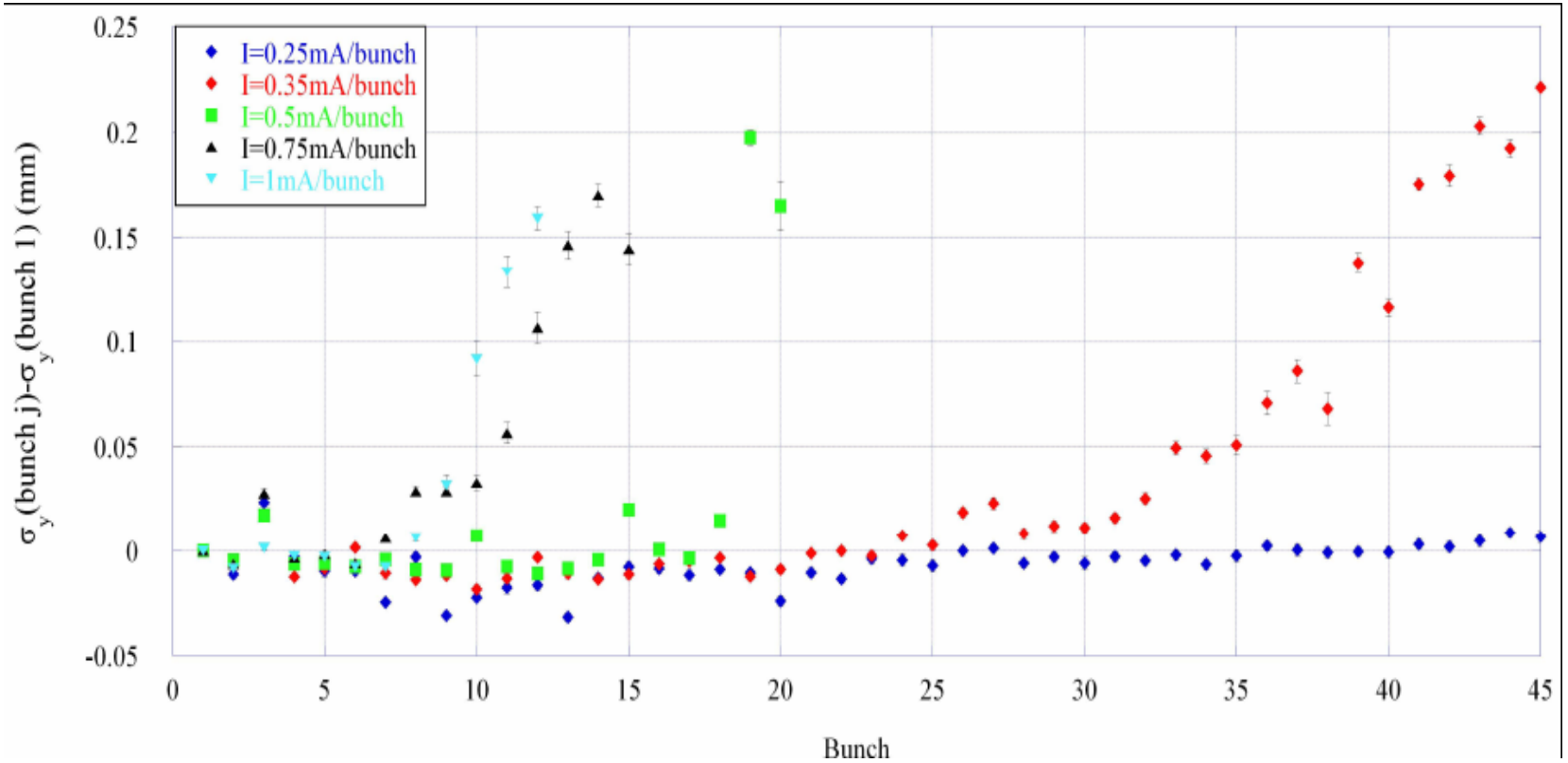
Beam Size Monitor



Positron optics (electron optics similar)

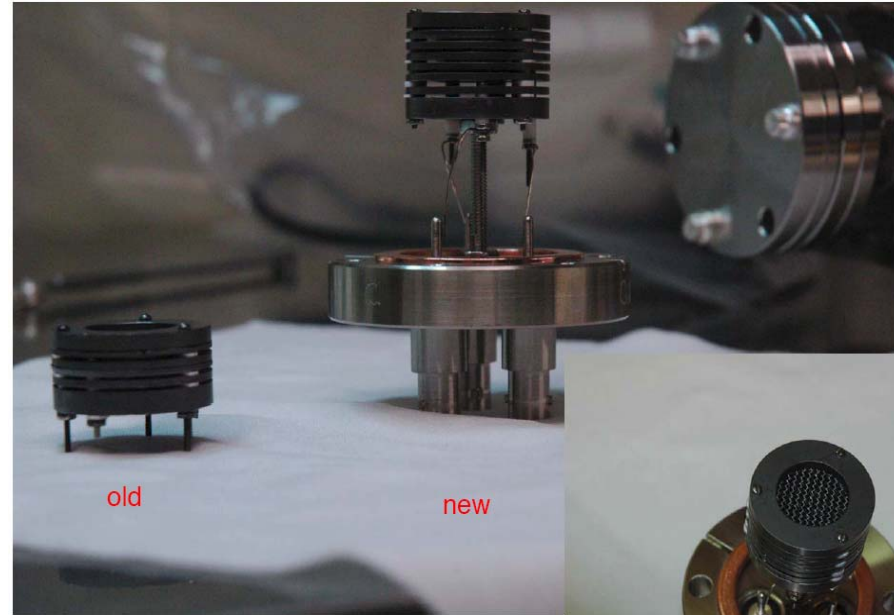
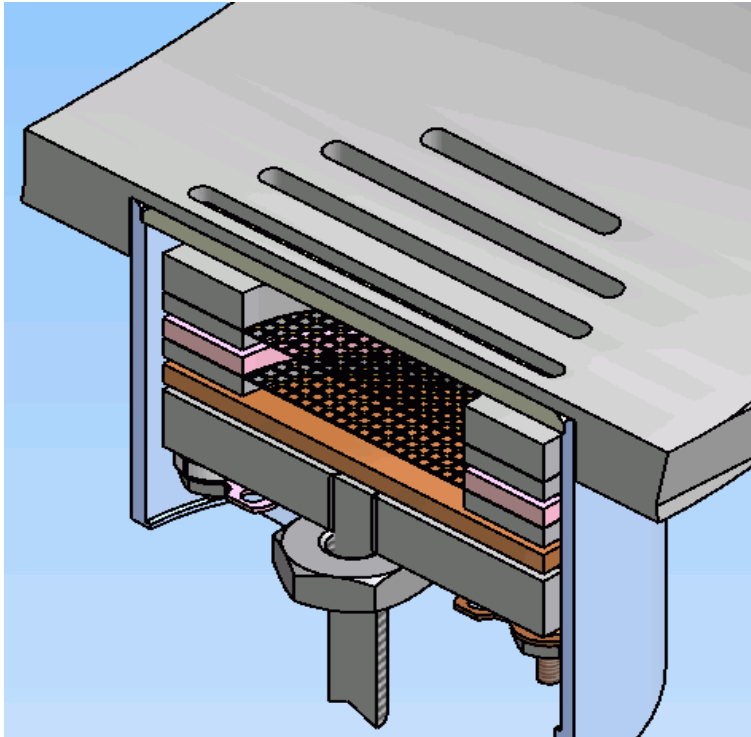
e^+ Single Turn Fit





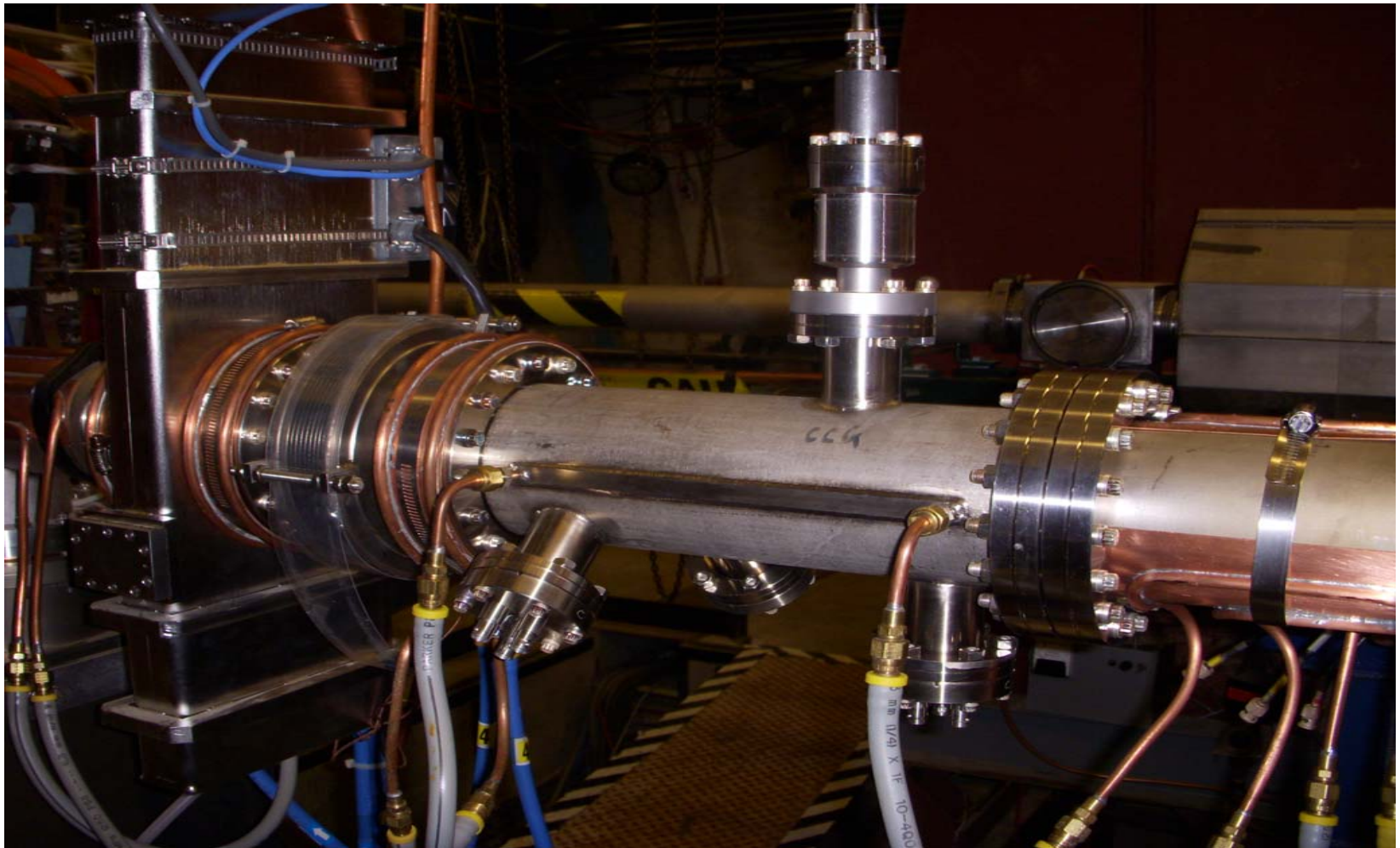


- Retarding Field Analyzers to provide energy spectrum measurements of the electron cloud.
- Flexible bias controls on the RFA's to provide both electron cloud measurements and with the opposite bias voltage, ion energy and density measurements.
- Well instrumented vacuum system with the ability to introduce local pressure bumps in a controlled manner to further isolate ion effects.
- Finally, the ability to use either electron beams or positron beams in the same storage ring configuration is essential to understanding Electron Cloud effects and Ion effects separately.



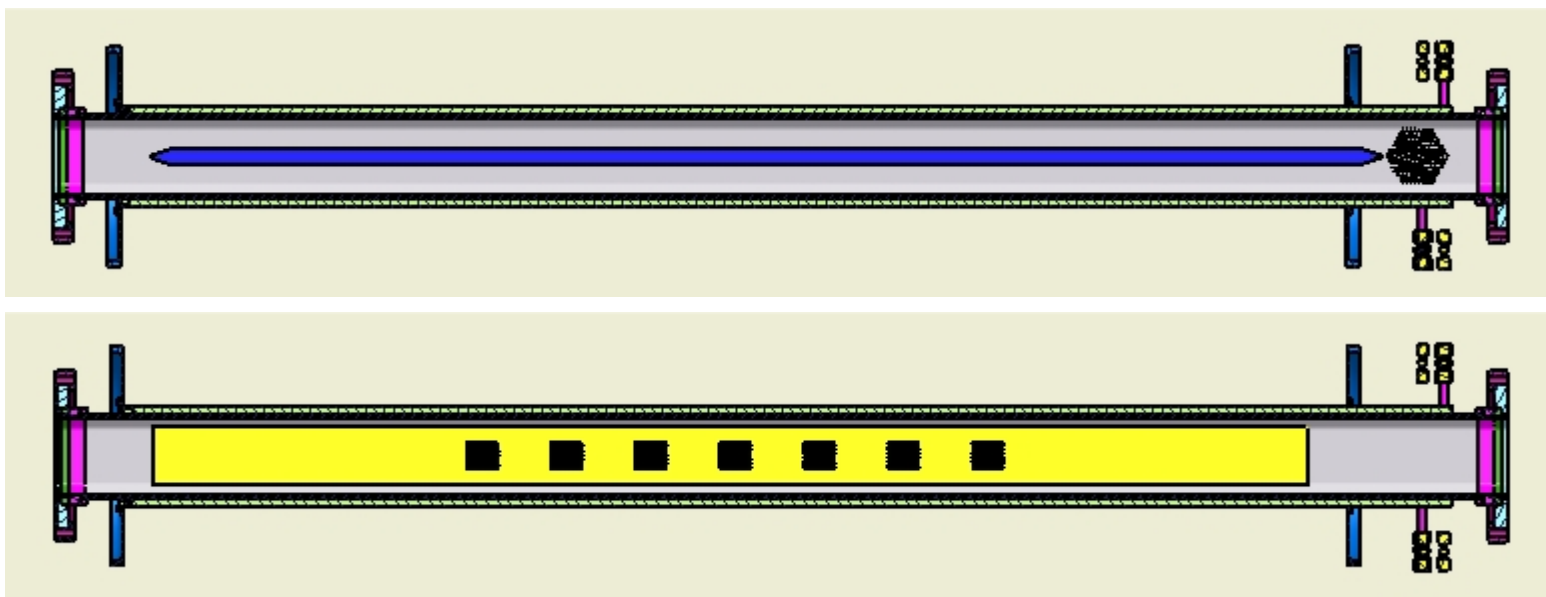
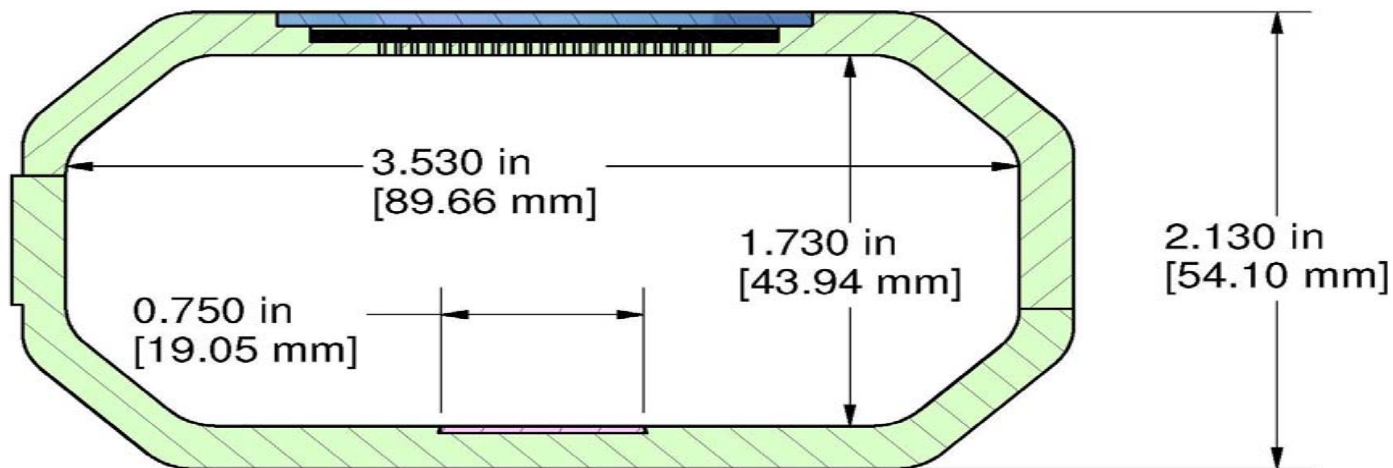


RFA Installation in L3 section of CESR





Retarding Field Analyzer Installation in Wiggler Vacuum Chamber





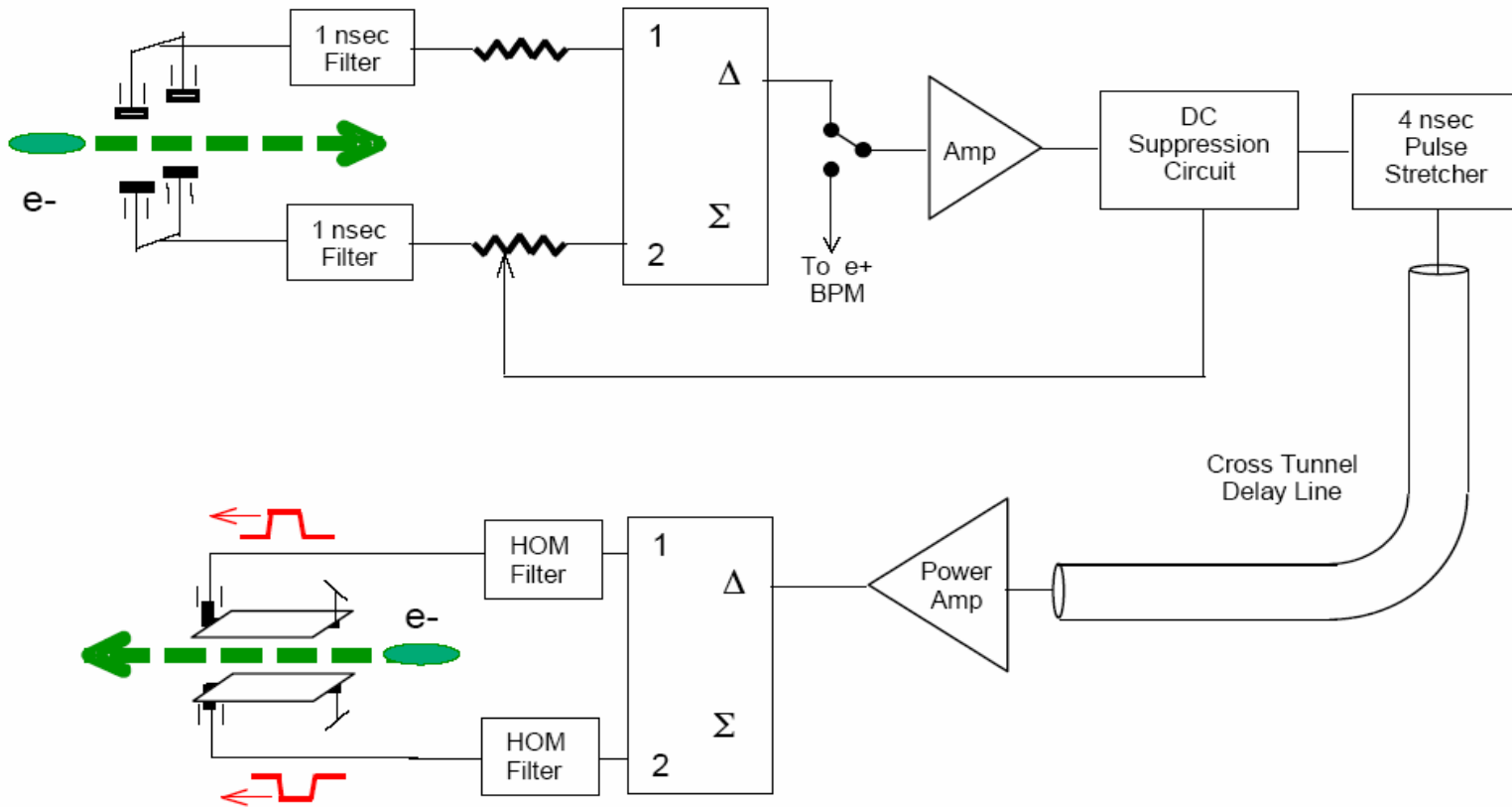
- Present digital transverse feedback systems are based on 0.75 meter long stripline kickers driven by 200 W linear amplifiers. The system is based on using a 14 nsec bunch spacing.
- A wideband analog systems using pickups in the north area of the ring and fast coax cables directly driving the 200 W amplifiers after passing through a gating system stabilizes both electron and positron beams with 4 nsec bunch spacing. Witness bunches can be accommodated by combining the present digital system with the new wideband system.
- Recent machine studies indicate a longitudinal instability threshold at ~ 20 bunches each with ~ 1 ma.
- Present digital longitudinal feedback system is based on a low Q cavity driven by a TWT operating with a center frequency of 1142 MHz. It is based on a 14 nsec bunch spacing and as a result only couples to every 7th bunch in a train with 4 nsec spacing. A new cavity along with a new amplifier and associated front end electronics will be assembled to provide longitudinal feedback for the 4 nsec bunch spacing.



- Simulations predict a longitudinal instability threshold of ~ 18 ma primarily driven by the impedance of the two vertical beam separators in CESR.
- Without the vertical separators which are to be removed, the calculated threshold rises to over 130 ma.
- With the new longitudinal system and the removal of the vertical separators confident that the beams for CEsrTA will be stable.

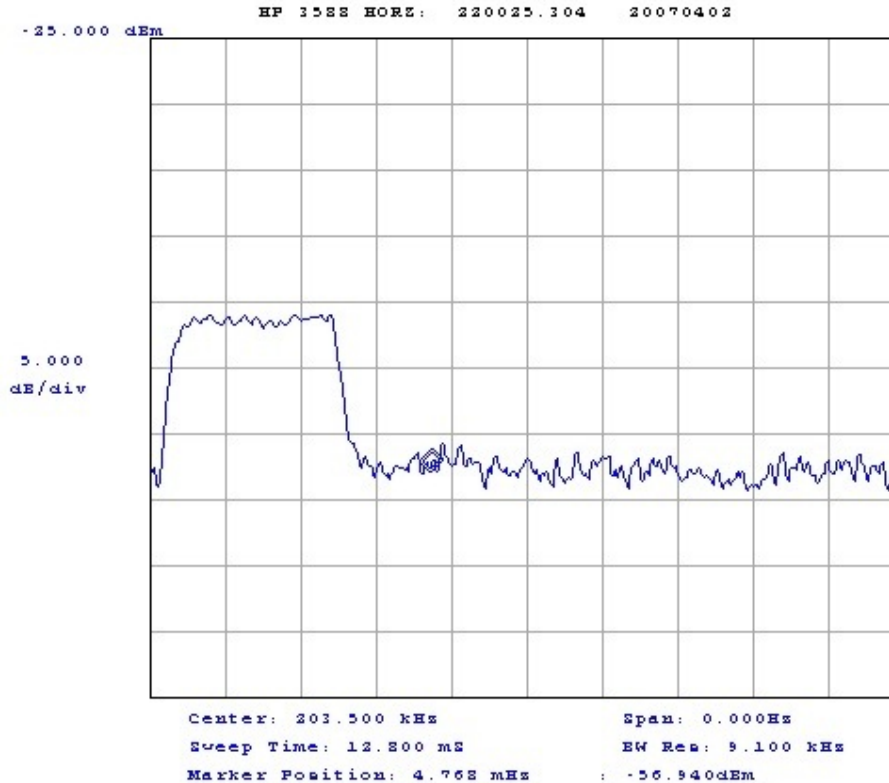


Wideband Transverse Feedback System





Grow damp measurements for transverse feedback system with 4 nsec bunch spacing





- Optical survey techniques in place will provide an adequate means for aligning CESR magnetic elements.
- New LaserTracker system will significantly reduce the time required (x 2 to 3) to align magnets at the beginning of each CEsrTA running period to maximize the running time during that period.
- Magnet stability is more than adequate for CEsrTA program.
- Digital beam position monitoring system has the demonstrated resolution and analysis capability to carry out the CEsrTA program.
- Optical beam size monitoring system is capable of resolving beam sizes within a factor of two of the sizes expected for beam with a 5 pm vertical emittance. This enables early testing of ultra low emittance tuning strategies.
- Testing of prototype RFA in CESR drift section is underway.
- New wideband transverse feedback system stabilizes both beams with 4 nsec bunch spacing.
- Design for longitudinal feedback system for 4 nsec bunch spacing well developed.
- Eager to get started on the challenges that await us and the new understanding that will come from the CEsrTA Program.