Advanced Photon Source Storage Ring Orbit Correction Overview

L. Emery

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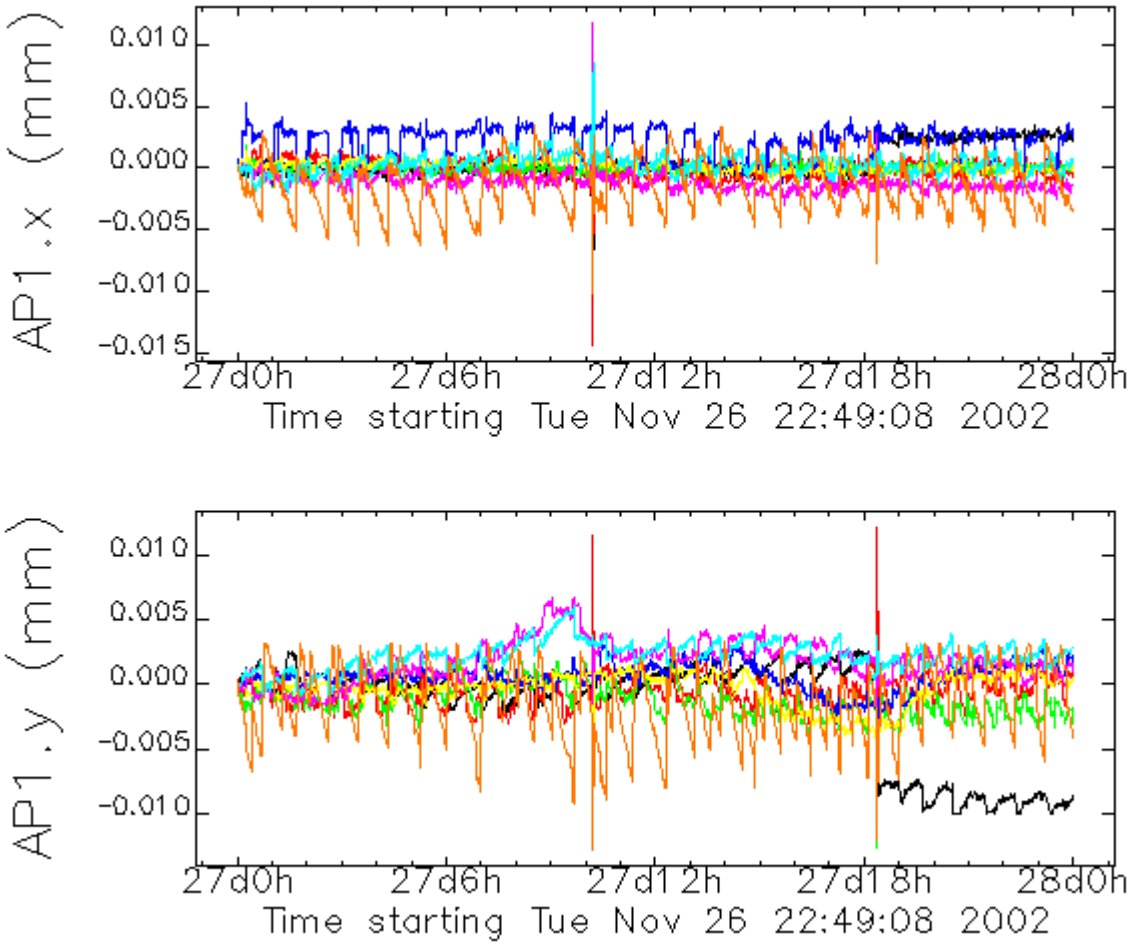
Overview

- Fast orbit feedback (RTFS) and slow orbit feedback (DC OC) running together.
- Seek to correct:
  - Orbit drift (i.e. perturbation from IDs)
  - High frequency noise (corrector noise)
  - Transients (i.e. from pulsed magnets)
- Other:
  - Steering procedure for User source points
  - Orbit recovery from lattice change

Data Requested

- One day stability of orbit.
- Power spectrum density (PSD).
- Quantitative effect of each improvement.
  - Not complete.
- Stability improvement observed by users.
  - No data available to accelerator control system. Informal statements from users say that most stability improvement comes from constant stored current.

One-Day Stability

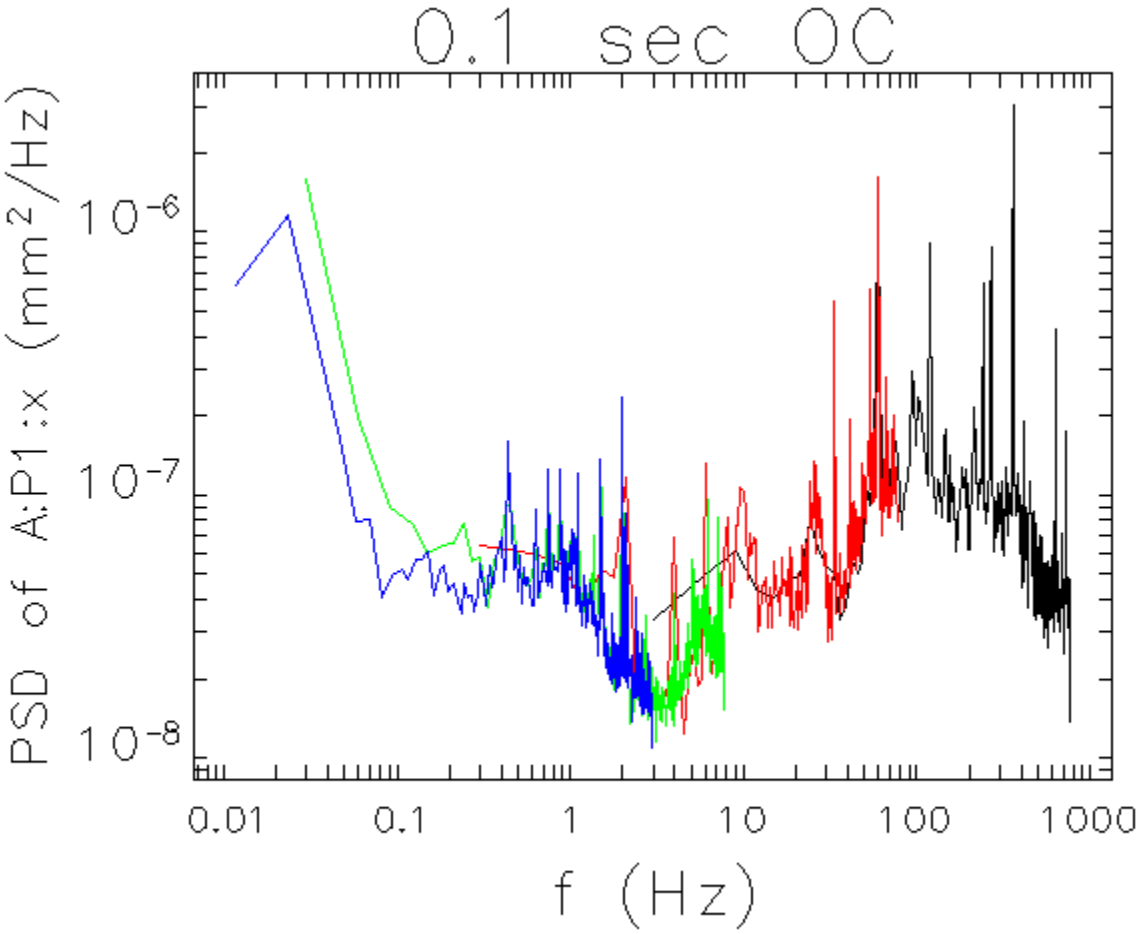


Since DC OC is running continuously, the orbit stays close.

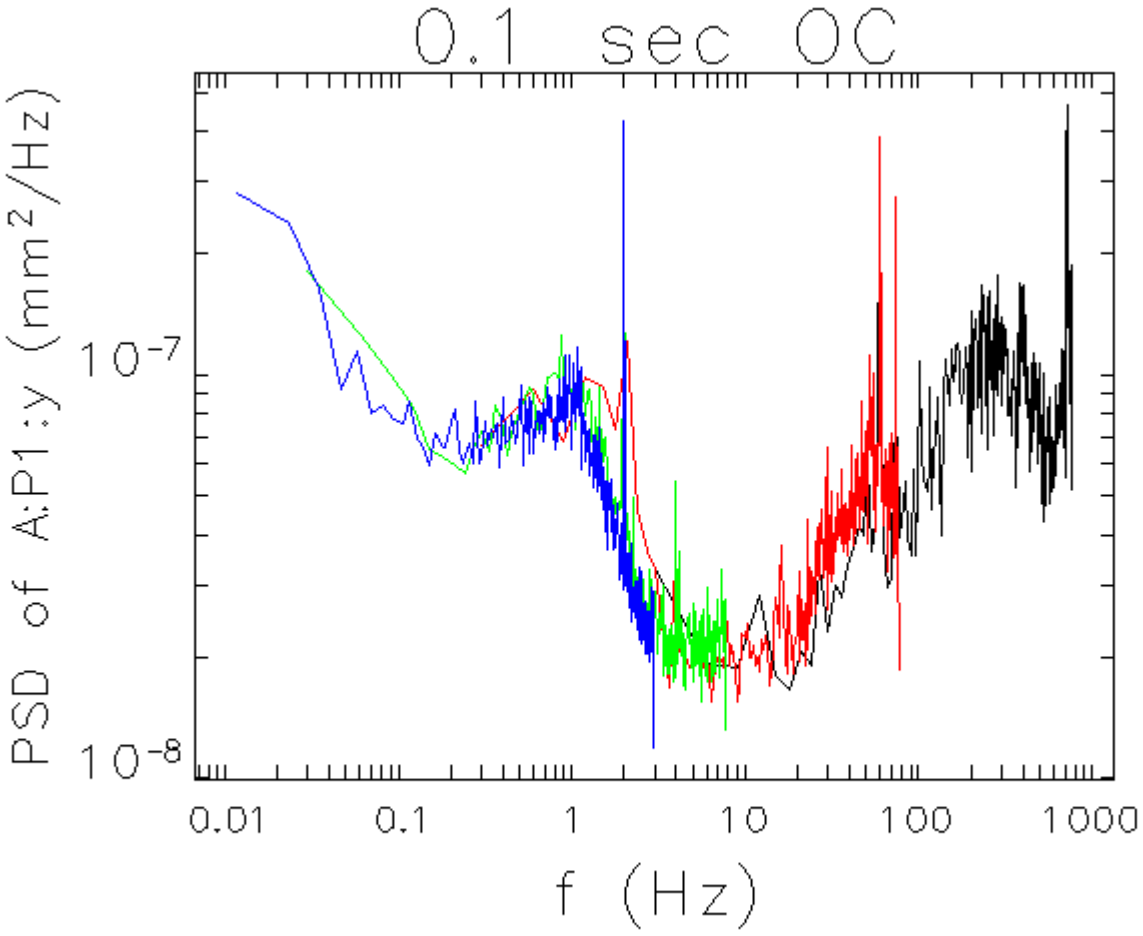
Beam Motion Spectrum

- Following figures show basically the same data with various axes and scales, including requested 0.1 Hz - 200 Hz.
- Data taken with fast feedback running, slow orbit correction running at interval 0.1 sec or other value.

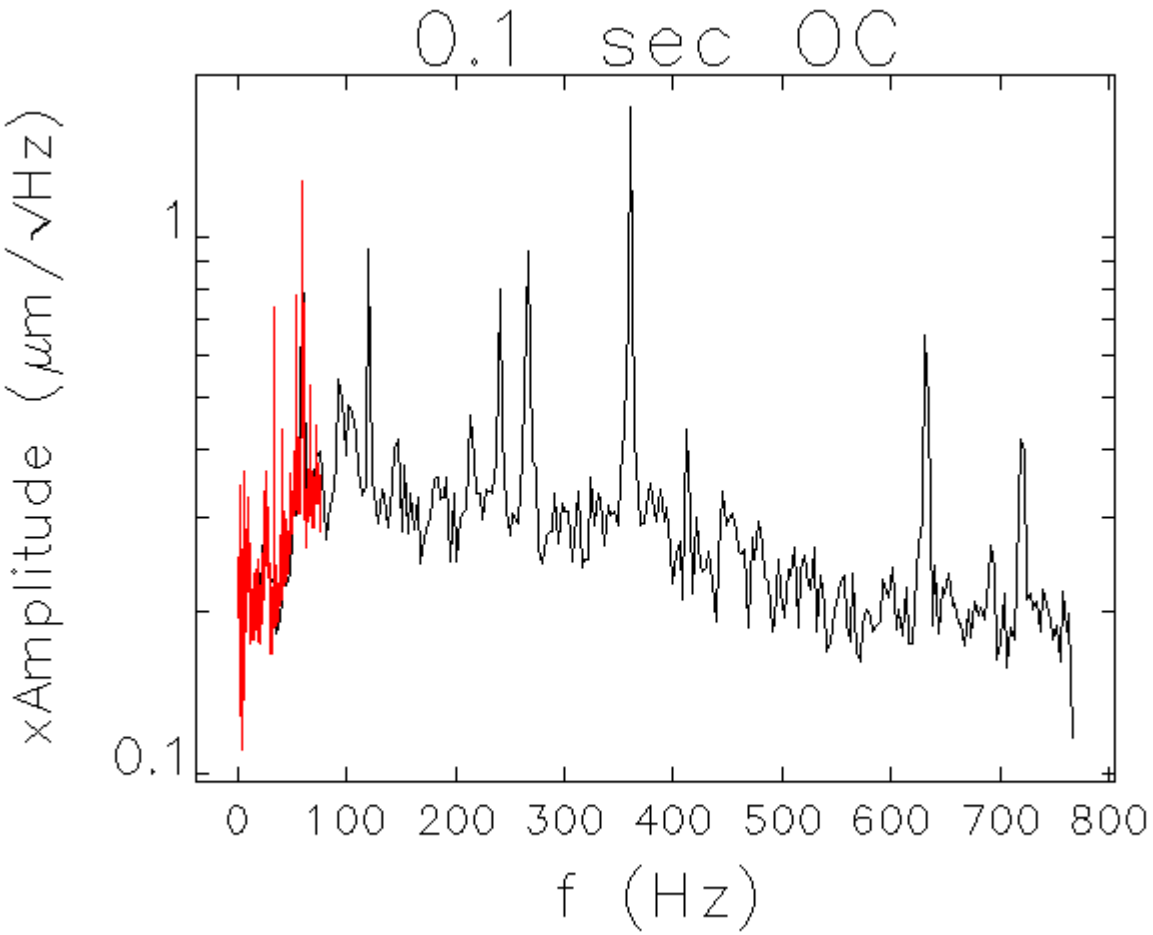
Beam Motion Spectrum



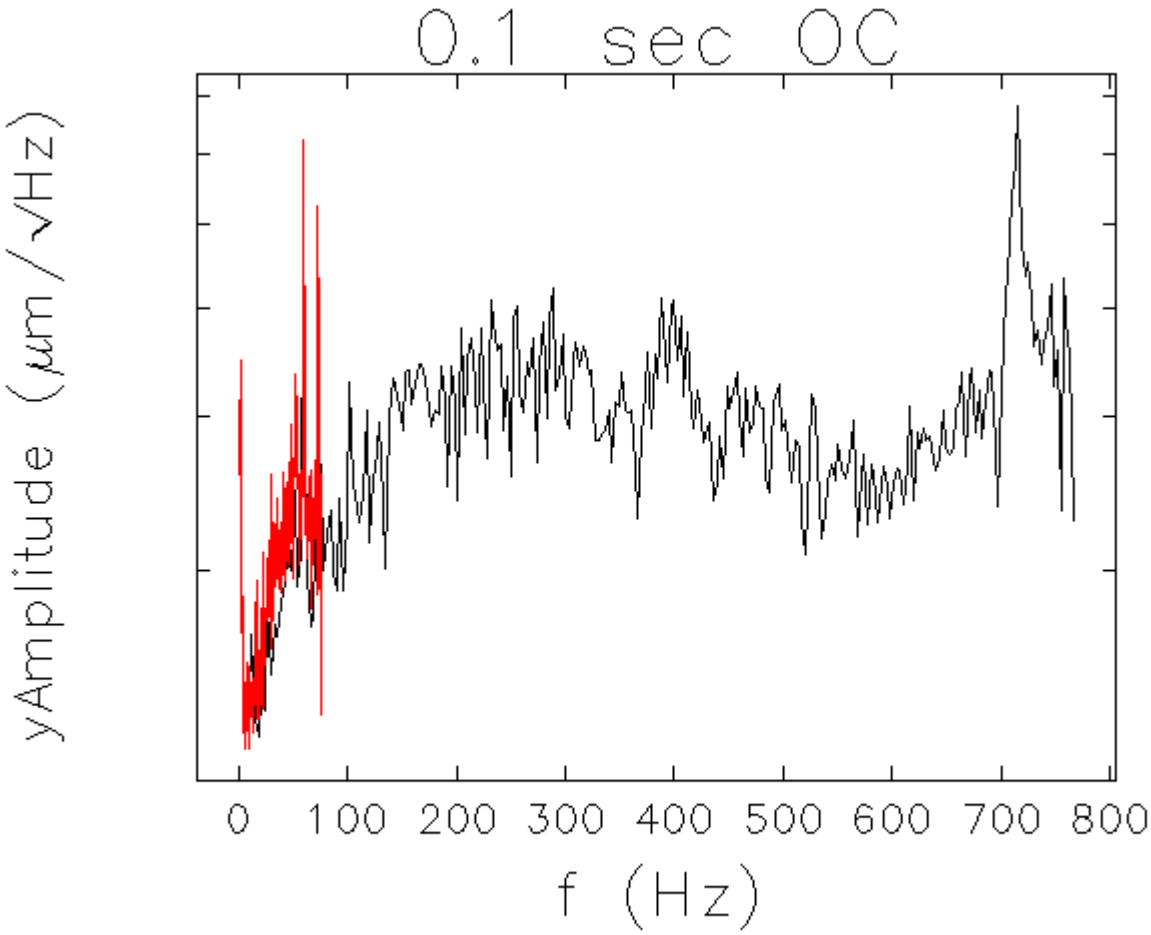
Beam Motion Spectrum



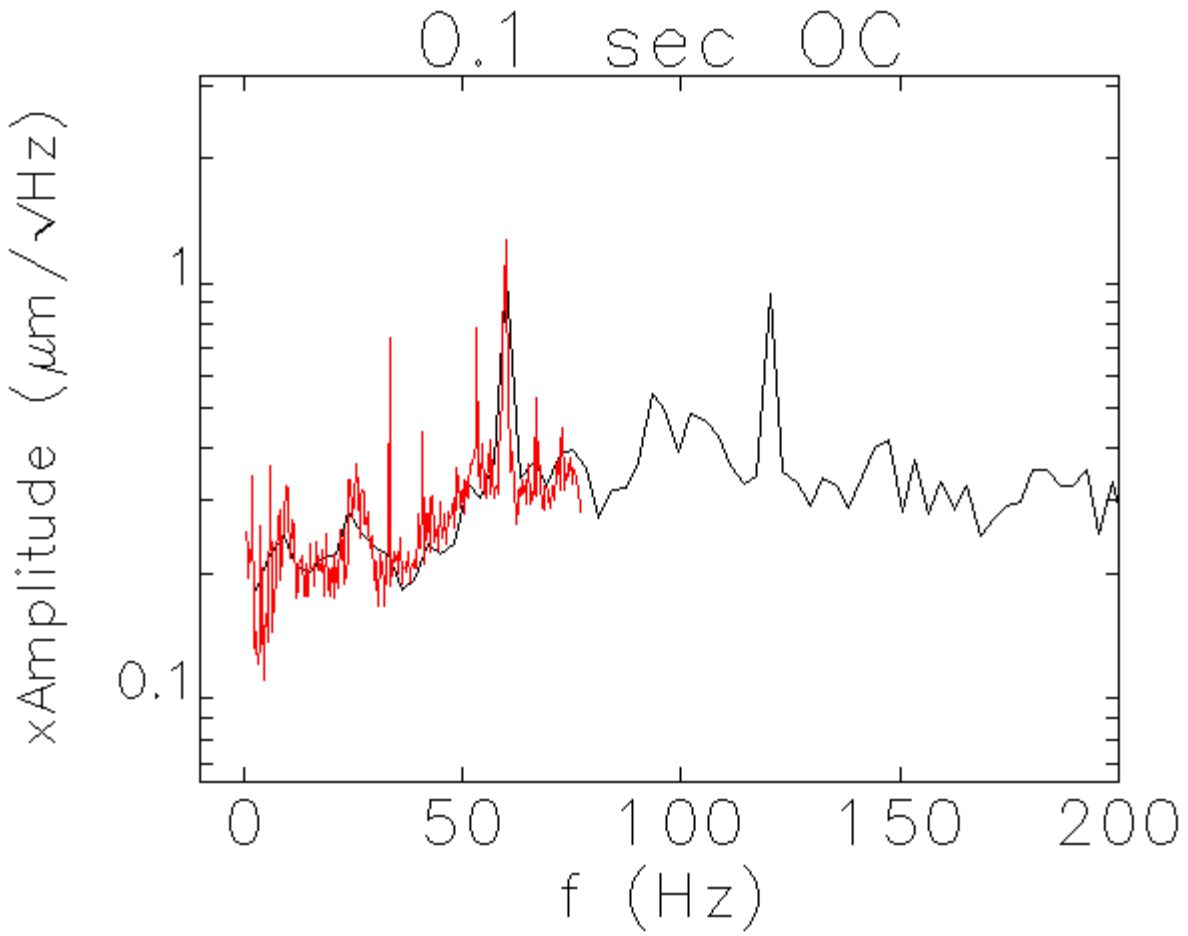
Beam Motion Spectrum



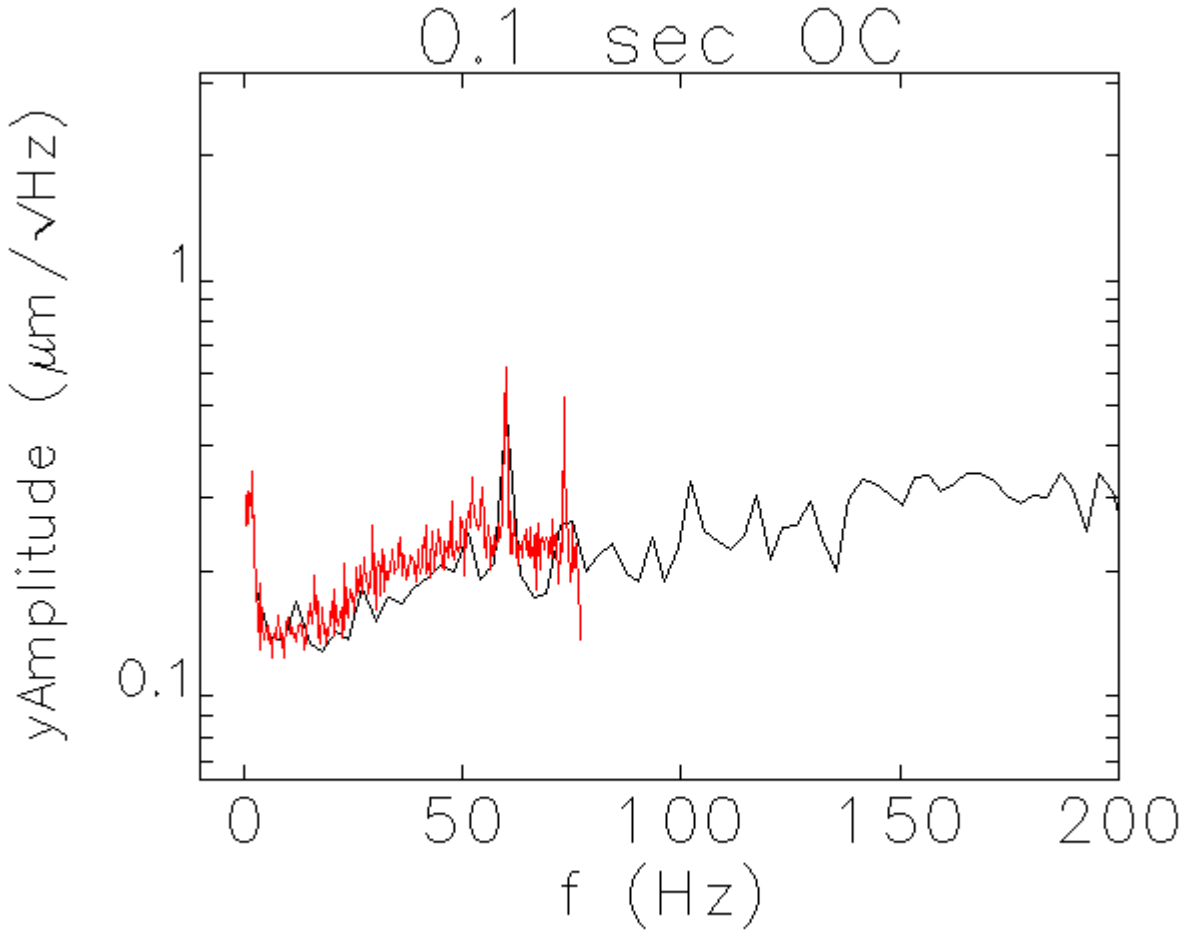
Beam Motion Spectrum



Beam Motion Spectrum

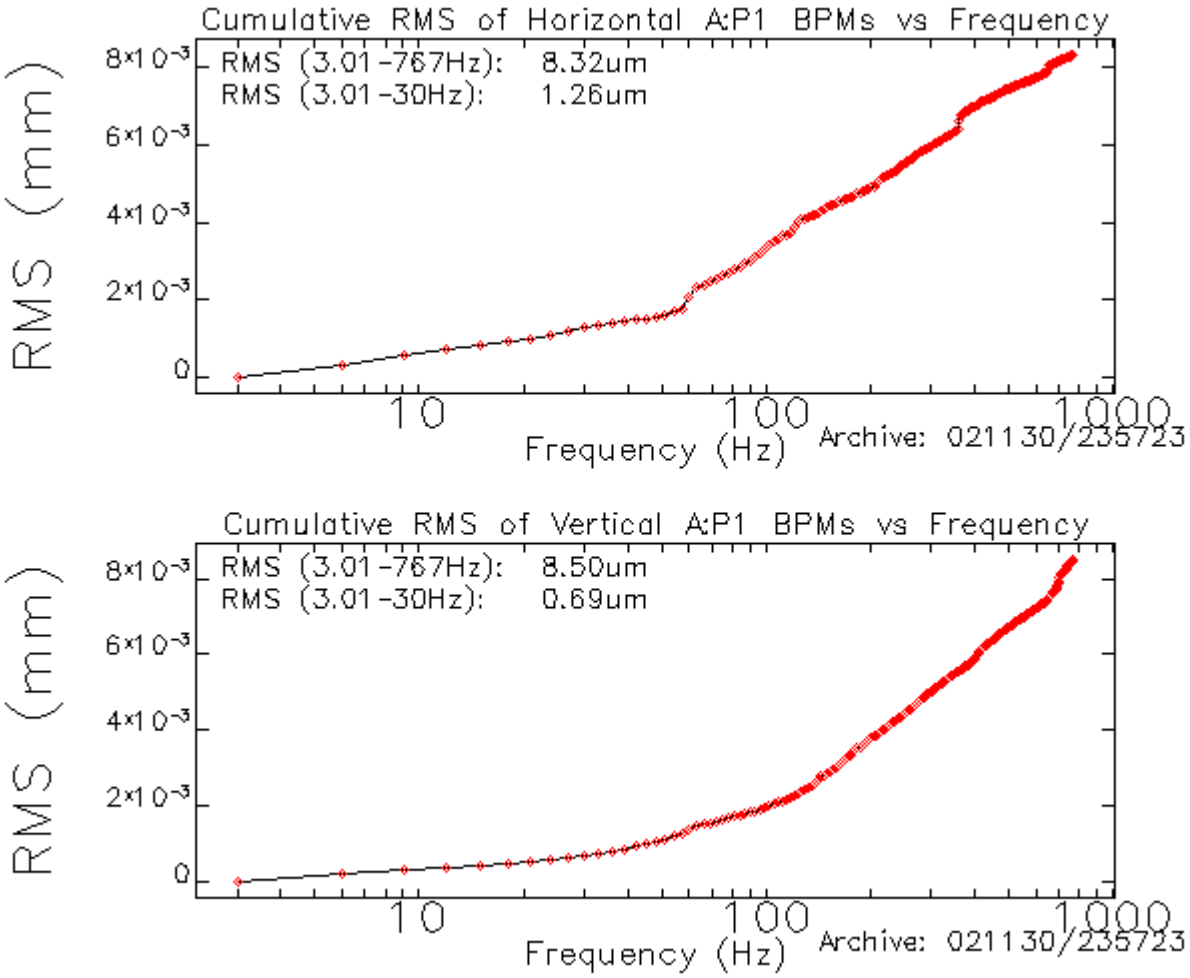


Beam Motion Spectrum



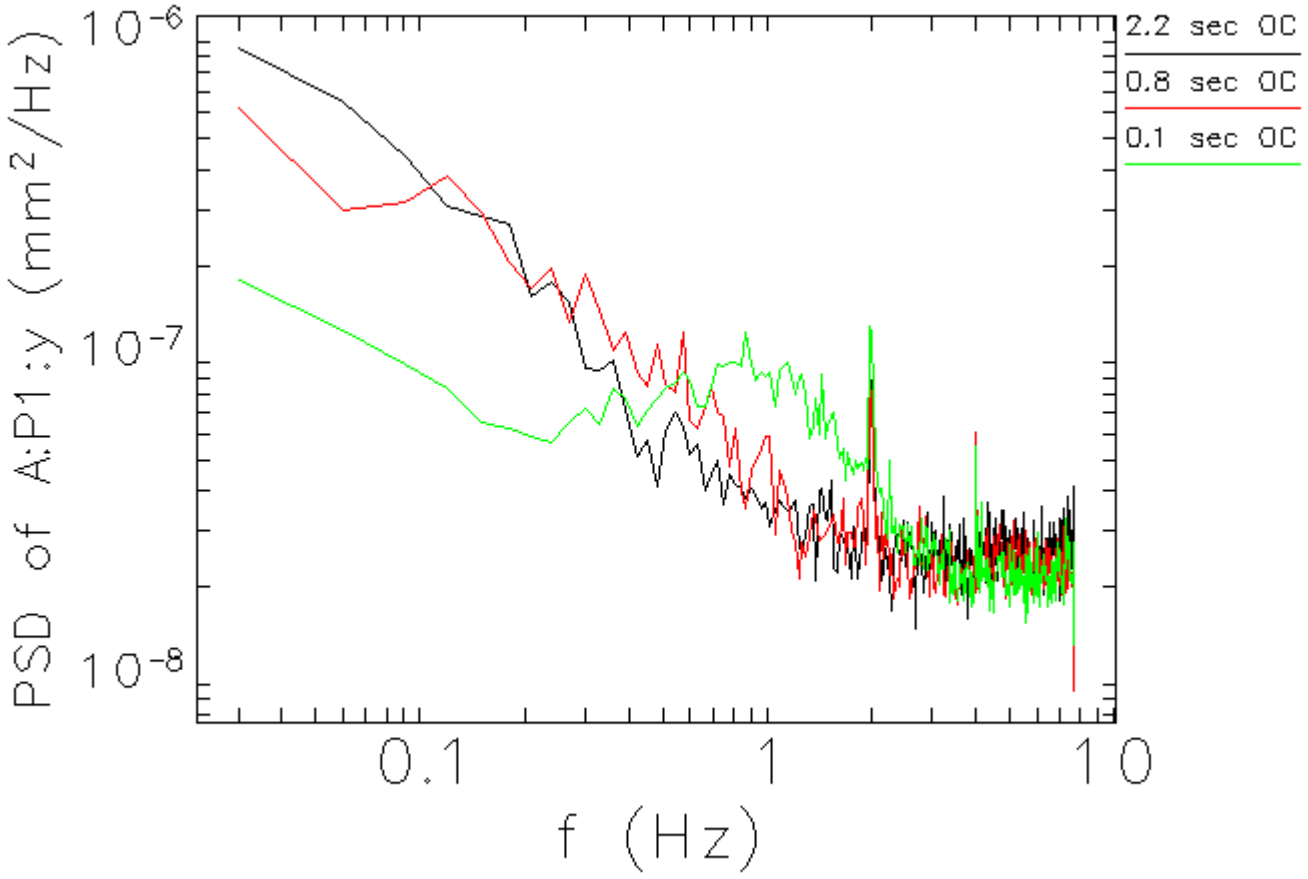
Beam Motion Spectrum

Routine archive plot:



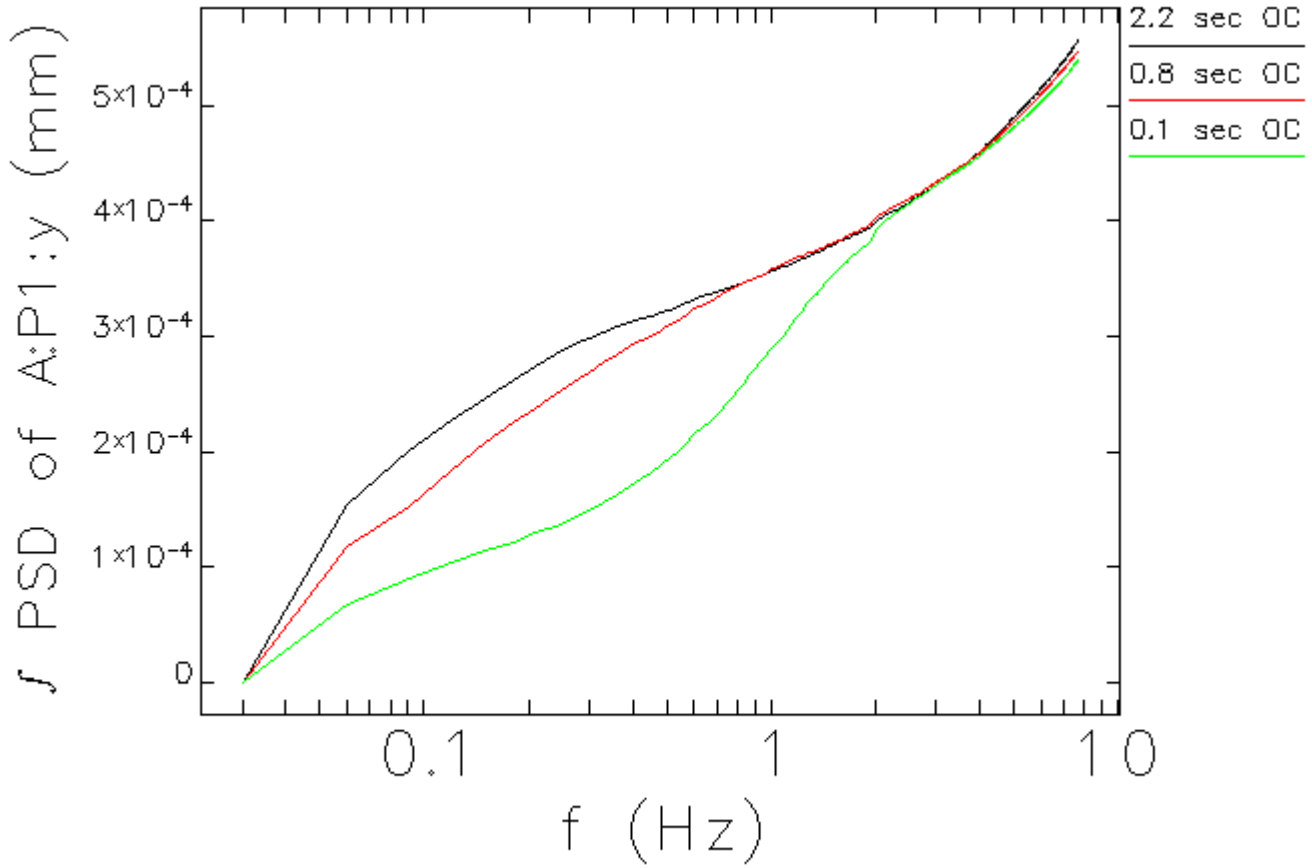
Beam Motion Spectrum

Effect of DC OC interval:



Beam Motion Spectrum

Cumulative RMS of previous figure:

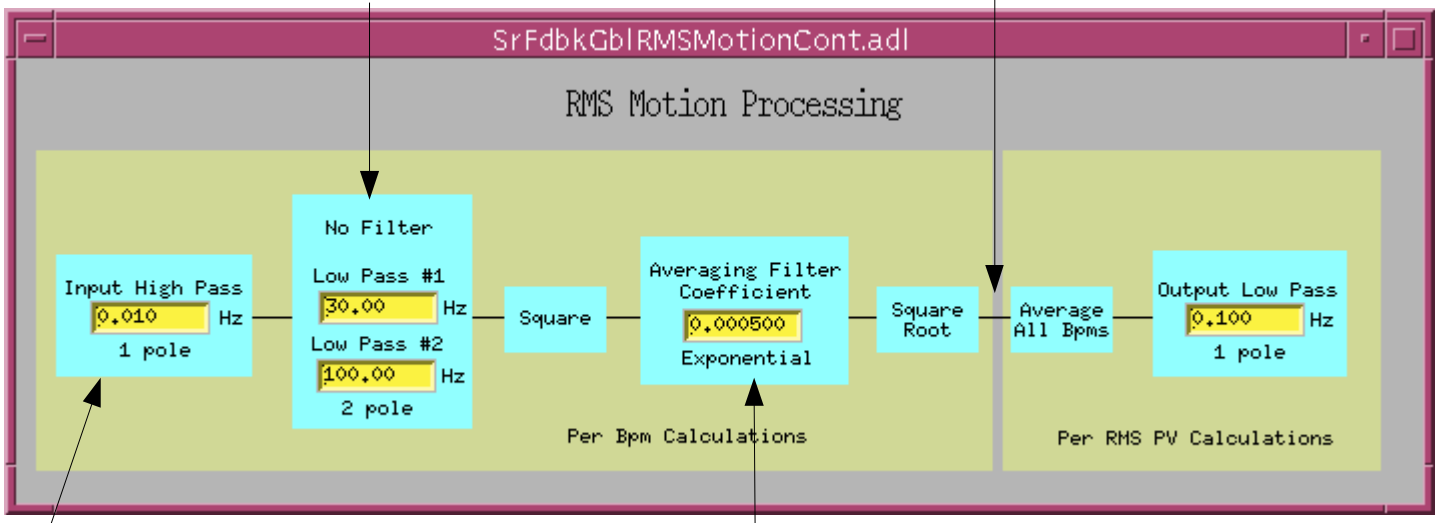


Beam Motion RMS

Real-time calculation of RMS in three bands simultaneously

Three settable bands

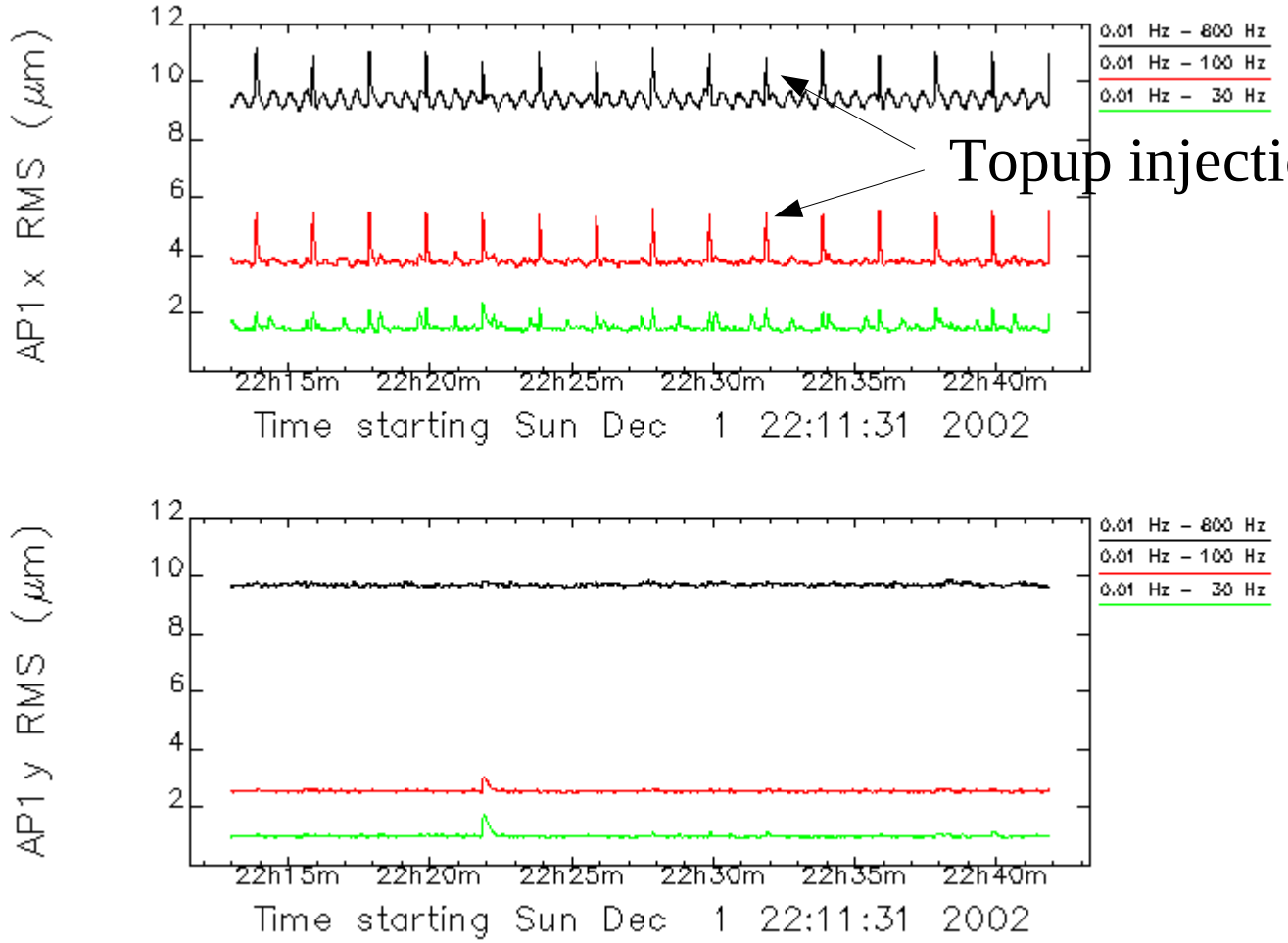
RMS values



Data input
at sample rate

Take average of
positive values

Beam Motion RMS



Topup injection pulses

Data logger has similar data but with peak-hold of 60 seconds.

Features of DC OC System

- Flexibility in configuration and sophisticated database for bpm setpoints, offsets, correction configurations for various focusing lattices.
- Low-pass filtering of bpms.
- Testing of quantities for valid conditions.
- Despiking to remove bad bpms.
- Intensity-dependent component to bpm offsets.

Features of DC OC

- Frequency overlap compensation.
- Xray bpms included in y-plane.
- Almost ready to run OC in EPICS ioc for 15x speed.

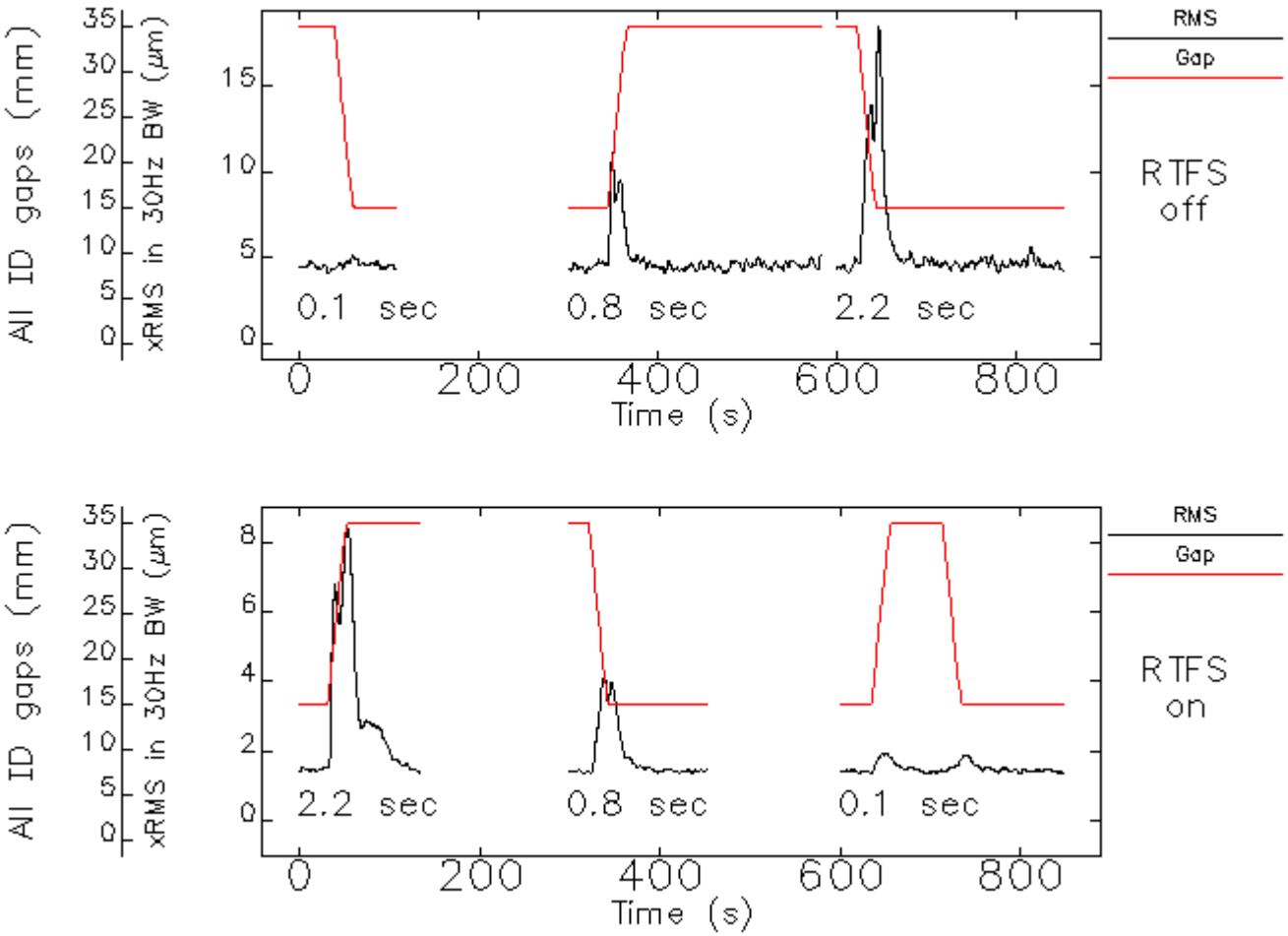
Fast Orbit Correction

- Wide band correction (~50 Hz) but with fewer correctors and bpms (i.e. reduced spatial modes.)
- All bpms including Xray bpms will soon be available.
- Configured with the same tools as DC OC.

Source of Beam Motion

- Ground motion and cooling water
  - In 1995, reduced by damping pads and by lowering of cooling water flow, and by making pipes more rigid. No rms beam motion data.
- ID gap motion.
  - 50 micron DC orbit for worst offender, 100 microns for all IDs closing together. O. Singh has data.

Source of Beam Motion



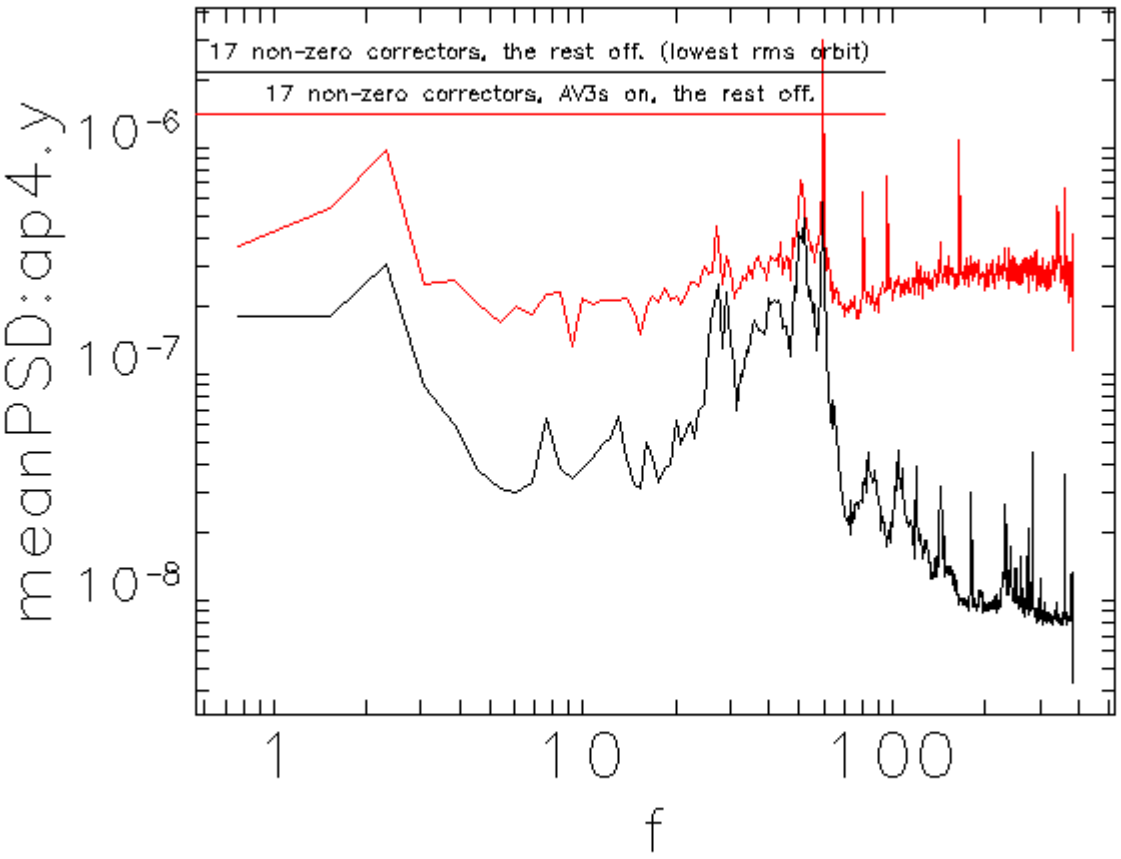
Reduction of RMS motion with reduction of DC OC interval.

Source of Beam Motion

- Corrector power supplies.
  - In 1 Hz-400 Hz band, 38 "fast" correctors produce more noise (3 microns), than 262 "slow" correctors (1.5 microns).
  - As "bad correctors" get replaced, RMS motion over the years has decreased.
- Low-α_c rings are good detectors of earthquakes! Possible to setup data collection for very small (<1 micron) circumference change at time scales of interest.

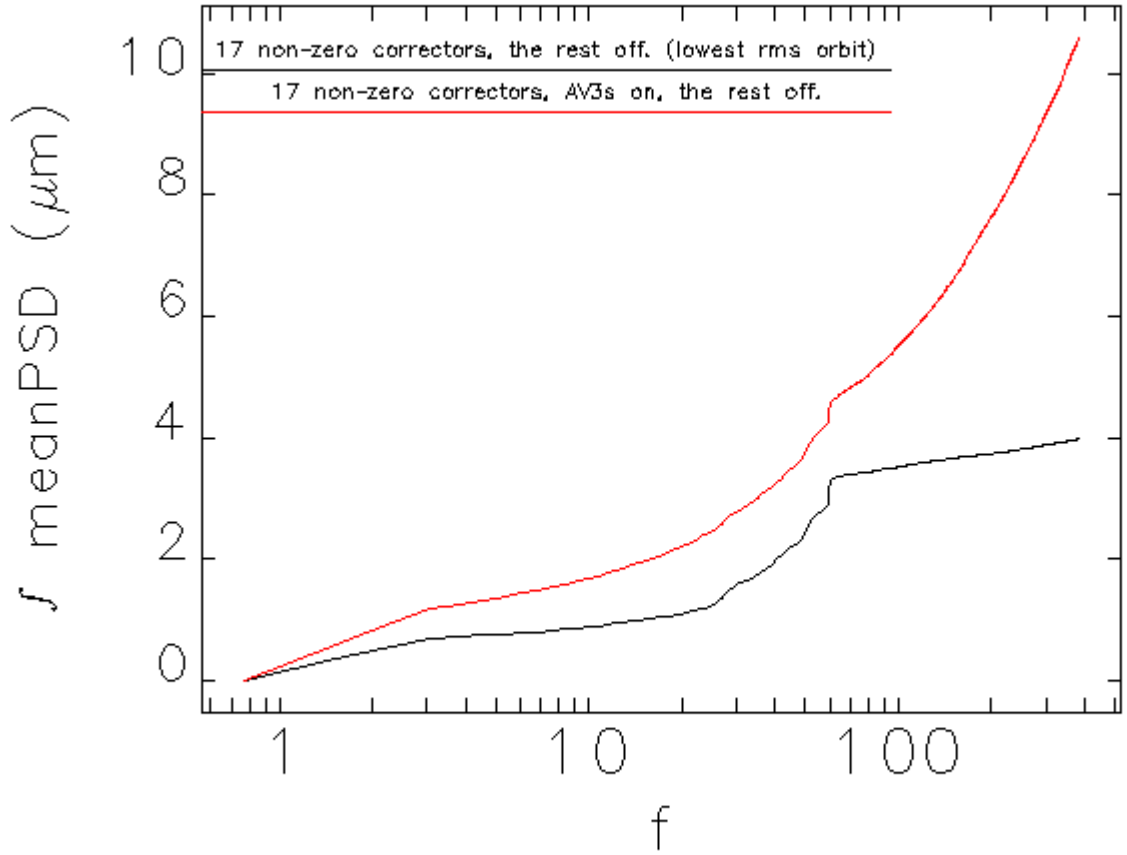
Source of Beam Motion

Effect of running 38 "fast" correctors at 0 A:



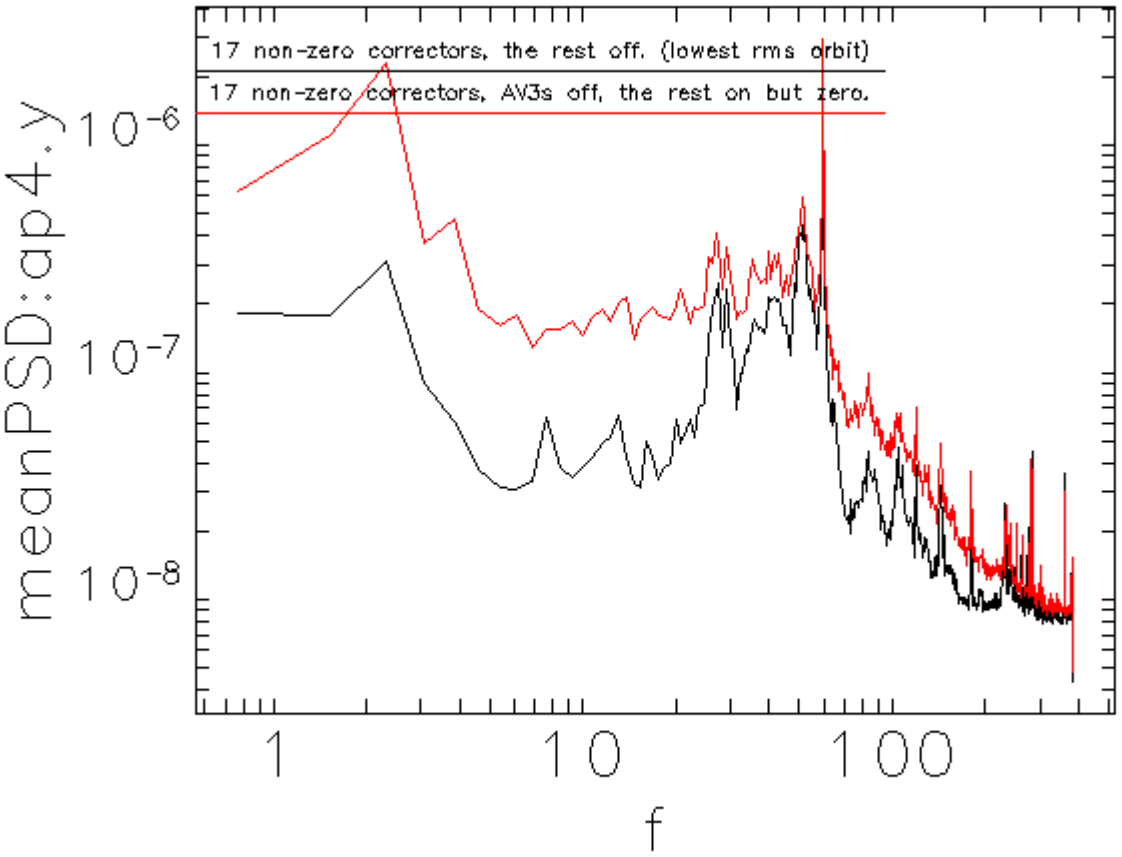
Source of Beam Motion

Effect of running 38 "fast" correctors at 0 A:



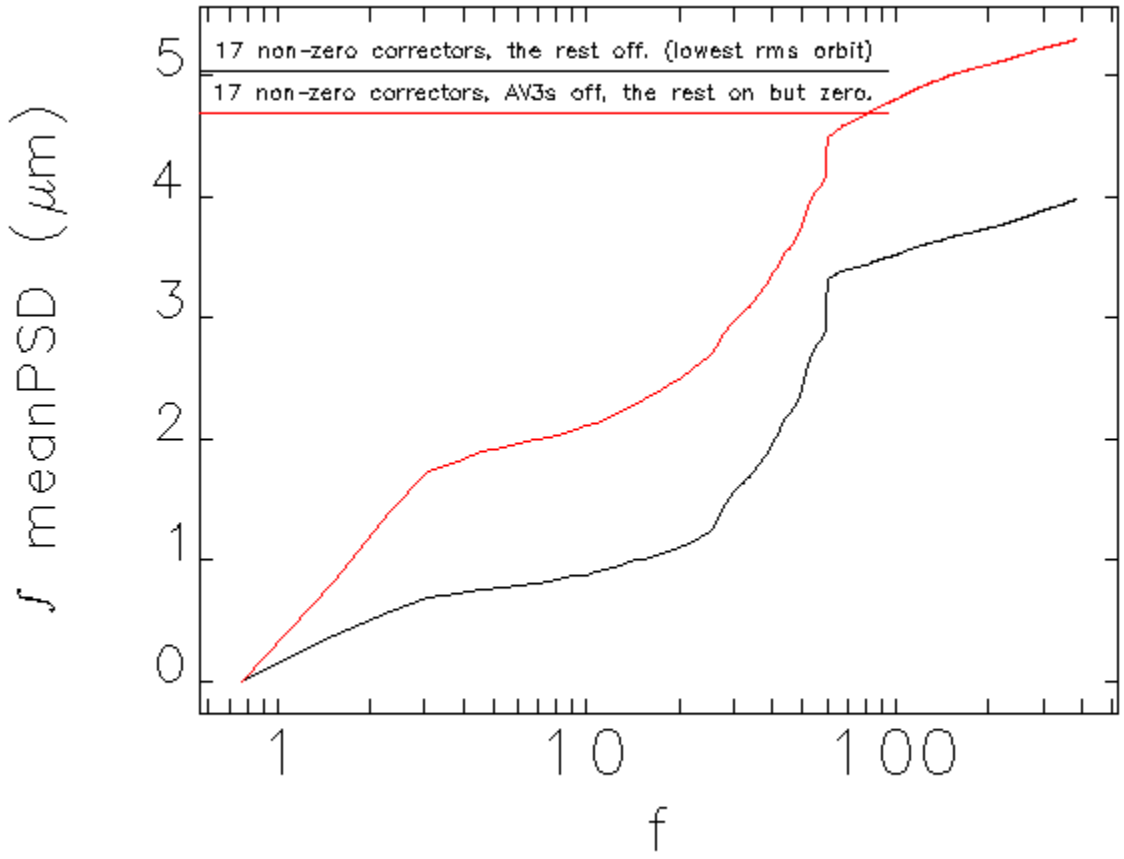
Source of Beam Motion

Effect of running 262 "slow" correctors at 0 A:



Source of Beam Motion

Effect of running 262 "slow" correctors at 0 A:



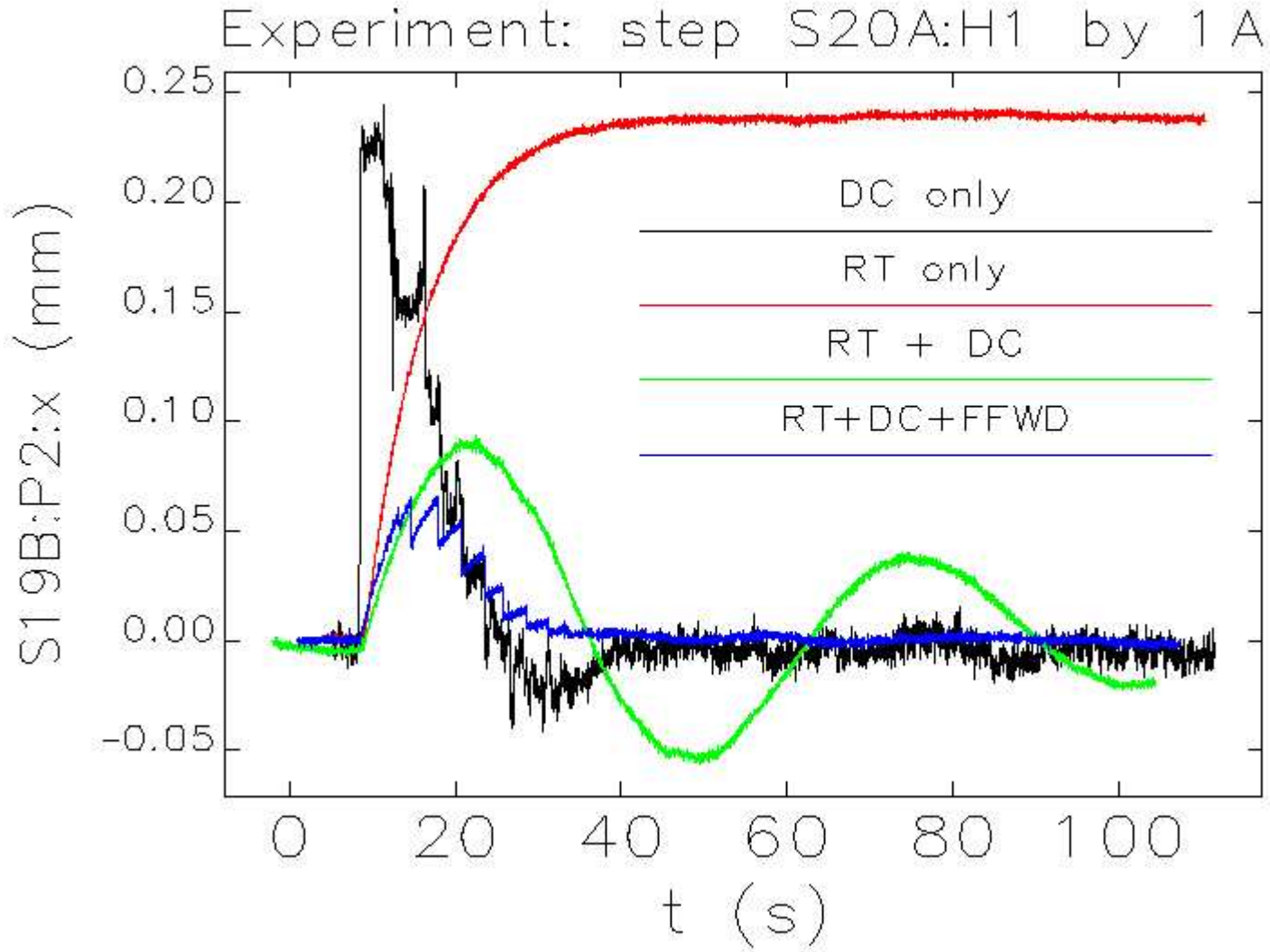
Rogue HOM in Vacuum Chamber

- In v-plane, weakly coupled HOM causes sudden jumps in bpm readback (10 microns-100 microns) in most bpms.
- Despiking doesn't work because there are too many bad bpms.
- Narrowband bpms not affected -> use mostly Nb bpms and Xray bpms for vertical OC.

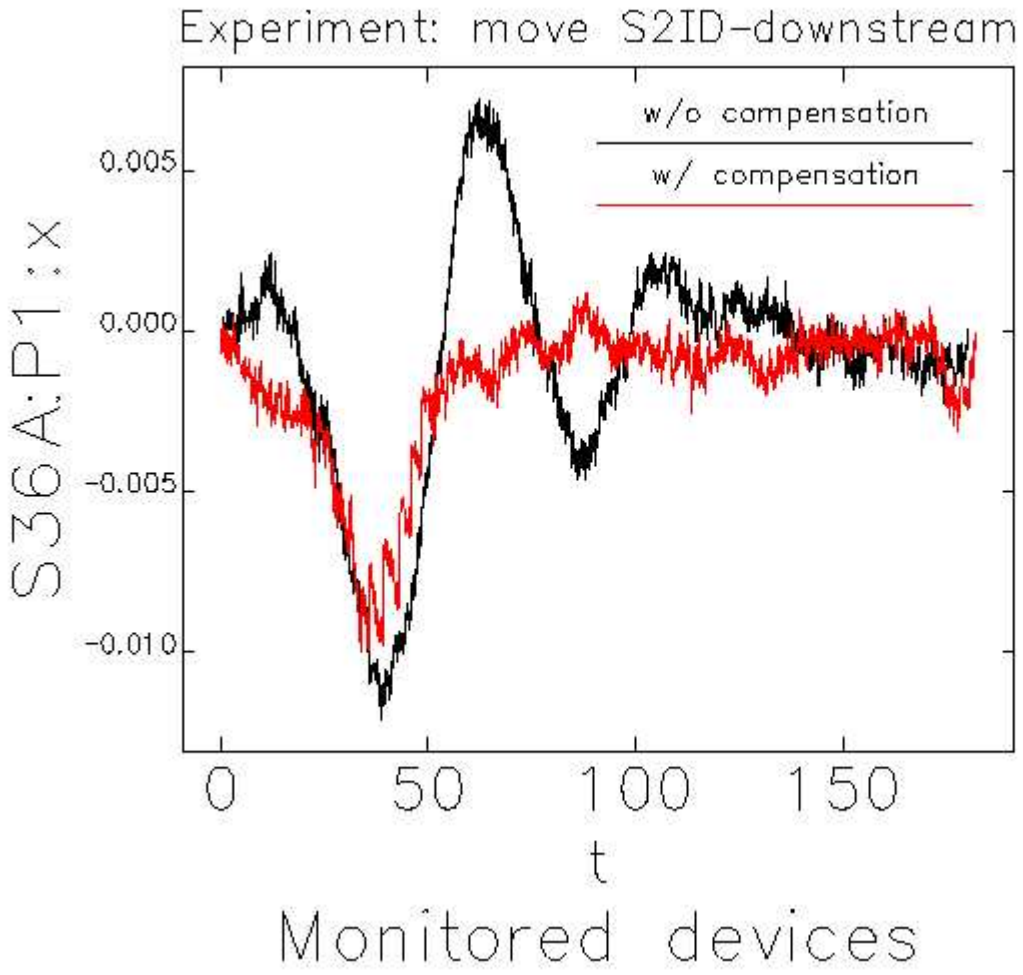
Frequency Band Overlap Compensation

- Separating frequency bands of RTFS and DC OC produces undesirable deadband where ID perturbation is seen.
- Overlap of band produce slow (1 minute) orbit oscillation.
- Solution is feedforward of bpm septoints to RTFS with expected orbit contribution from DC OC.

Overlap Compensation



Overlap Compensation



Operation of Pulsed Undulator

- Orbit transient from polarity switch, which lasts ~40 ms, can be corrected with small correctors and AFGs.
- Used RTFS for data acquisition, and for some computations.
- Note photon beam is not compensated.
- Circularly Polarized Undulator is almost ready for pulsed User operations.

Summary

- Large effort to reduce orbit motion by active correction.
- Orbit noise source not agressively pursued at this point.