Status of Operations and Orbit Stability

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Argonne NATIONAL LABORATORY

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Outline

- Operational Modes
  - Bunch patterns
  - Lattices and their set up
  - Lifetime optimization
  - Sextupole tip extension
  - Steering
    - Optimization
    - Canted undulators
- Beam Stability
  - Goals and levels achieved
  - Enhancement in DC stability using xray bpms and ID feedforward
  - Long term plans (Decker's 5-year plan)

Bunch Pattern

- All 102 mA total current
- 24 bunches (150 ns spacing, 2-minute top-up)
- 324 bunches (non-topup)
- Hybrid mode (16 mA + 8x7 bunches, 1-minute top-up)
- Special hybrid during machine studies with one user so far
  - 16 mA + 3x7 bunches
  - Possibly 4 mA + 8 mA + 16 mA + 3x7 bunches
- Schedule
  - http://www.aps.anl.gov/Facility/Schedule/
  - Number of 8-hour user shifts in FY 2008
    - Total 556 (4448 h), 98% up-time, 100h mean duration

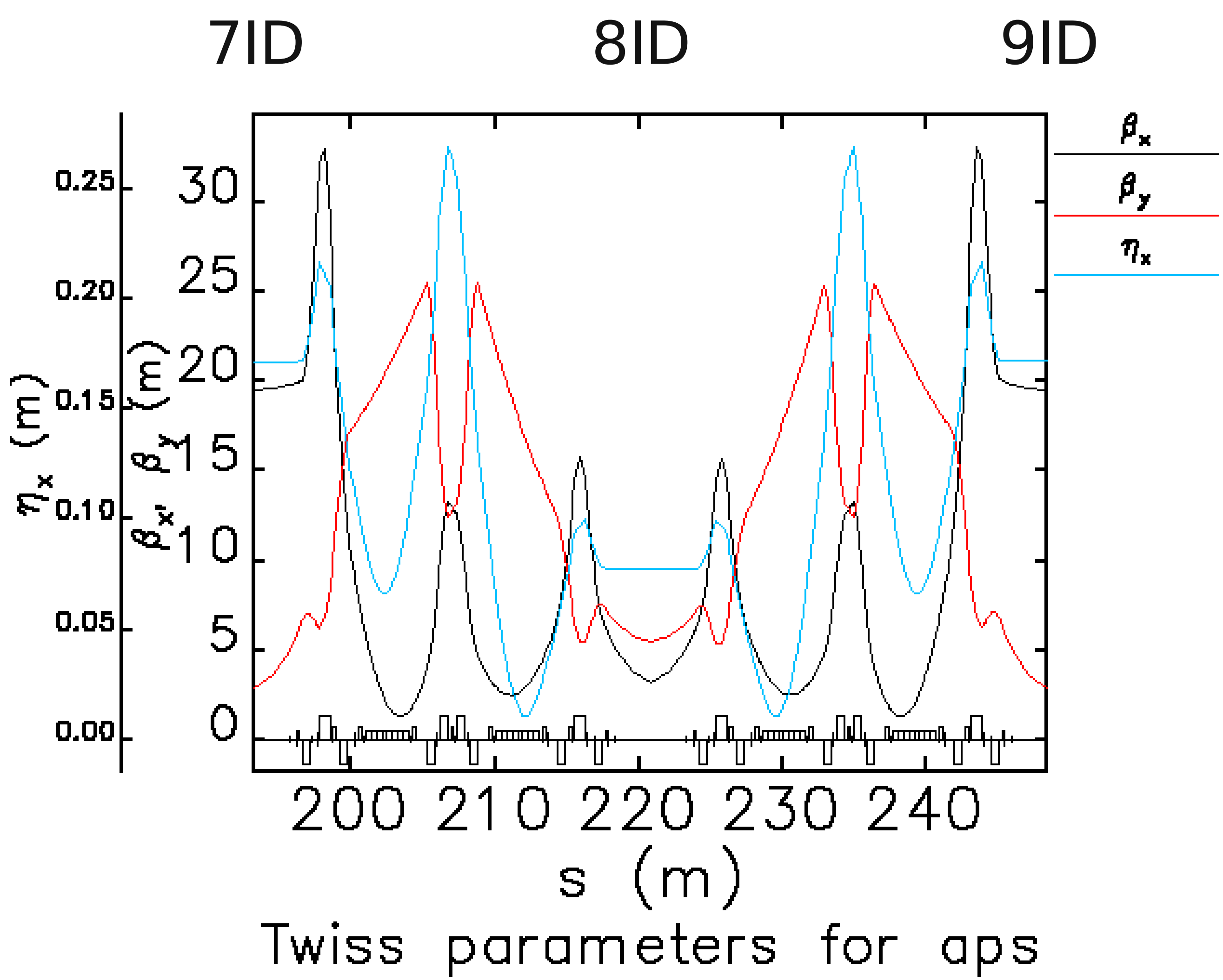
Lattice	Bunch Pattern		
	24 bunches	324 bunches	Hybrid
Symmetric	227	129	92
RHB	108		

  - Machine interventions/studies every week for 24 h or 48 h.

Lattices

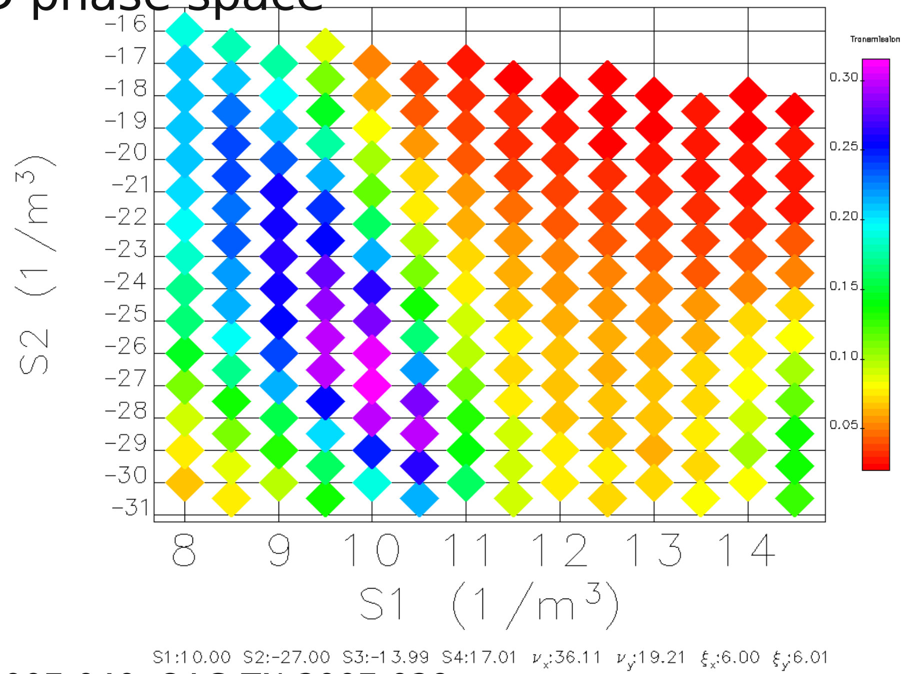
- Symmetric, ϵ_x=2.5 nm-rad, ϵ_{eff}=3.1 nm-rad
- Reduced-Horizontal Beam size (normally 270 μm)
  - 8ID only (90 μm), 2007
  - 8ID + 32 ID (120 μm), 2008
  - Minor increase in horizontal emittance (<10%)
- Chromaticity
  - 324 bunches: +3 both planes
  - 24 bunches: +6 both planes
  - 16 mA bunch: +11 both planes
  - Between +6 and +11 chromaticity there are sufficient differences to require repeating set up work in optics, injection bump and incoming trajectory

RHB lattice 8ID + 32 ID



Lattices

- Optics corrected by fitting a model to response matrix and then correcting beta and dispersion functions of this model (Sajaev)
- Four sextupole families optimized for lifetime (momentum aperture) and dynamic aperture
  - Difficult to do empirical search
  - Solution found in simulation using linux cluster and parallel `elegant`: Optimize the transmission of a group of particles with large 6D phase space*



S3 and S4 families for each point are adjusted for given chromaticities

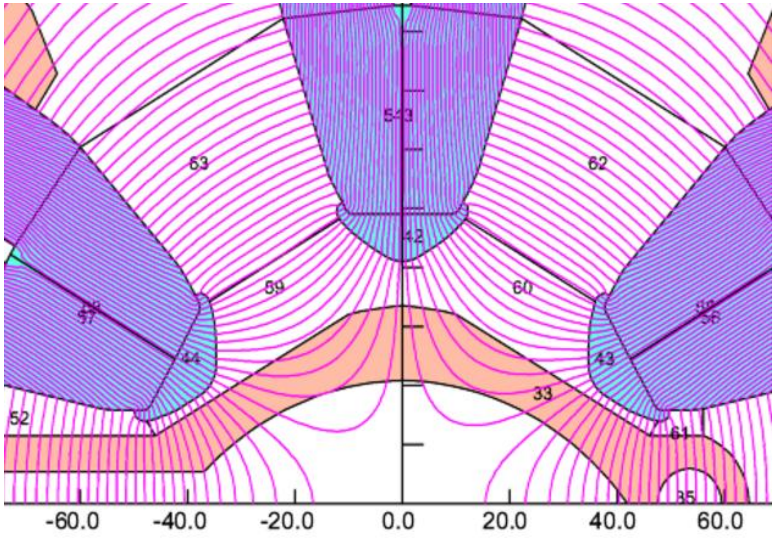
*Borland, OAG-TM-2007-040, OAG-TN-2007-029

Vertical Beam Size

- To achieve a reasonable lifetime we operate with an emittance ratio of 1% to 1.5%
- Provide horizontal and vertical beam size for each straight section from calibrated model (Sajaev) http://www.aps.anl.gov/Accelerator_Systems_Division/Operations_Analysis/SRSourceParameters/sourcePointResults/
- Plan to add beam tilt calculated from skew quadrupole error model
- Electromagnetic circular-polarizing undulator (CPU) produces some skew quadrupole error which is corrected locally for the most part (some hysteresis is not correctable with present control)

Sextupole Pole Tip Extension

- Add extension to the pole tip to effectively reduce the radius by 20%, and increase the strength by 40%



Magnetic modeling by S. Kim

- An initial 2004 study[1] showed that a momentum aperture (i.e. lifetime) improvement could be achieved with higher sextupole gradients in the S2 family given a fixed chromaticity
- S2 family of sextupole magnets were modified in May 2006
- Other families don't need the modification for now

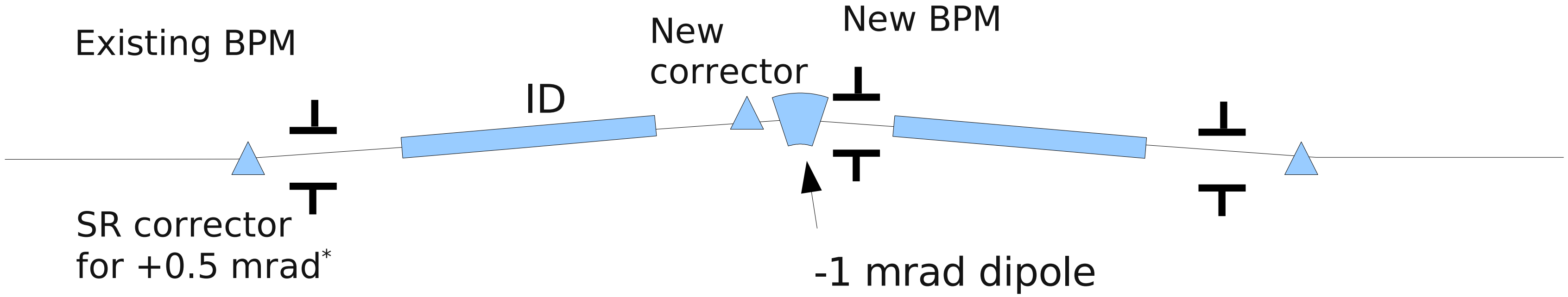
[1]Sajaev, ASD/APG/2004-16

Aside on Lifetime Optimization

- For a period of a year, a sextupole was reversed, which caused a reduction of lifetime of about 30% for all configurations
- Assumed that a sextupole magnet was somehow “bad”; we suspected a S2 sextupole. We eventually attempted (slow) beam-based method to search for a bad sextupole
  - Measure tunes with local bump turned on and off and a selected sextupole turned on and off → problem with not knowing exactly the remnant field
  - Select sector and turn off all sextupoles, and measure chromaticity
  - Found the bad sextupole by visual inspection before we finished the time-consuming methods
- In the meantime over the past year we optimized lifetime as usual with:
  - Linear optics correction
  - Tune search (needed to move nux)
  - Sextupole family setpoint search and
  - Optimize injection trajectory as well as possible, plus making sure that the sextupoles in the injection bump do not generate a large betatron oscillation

Canted Undulator Steering

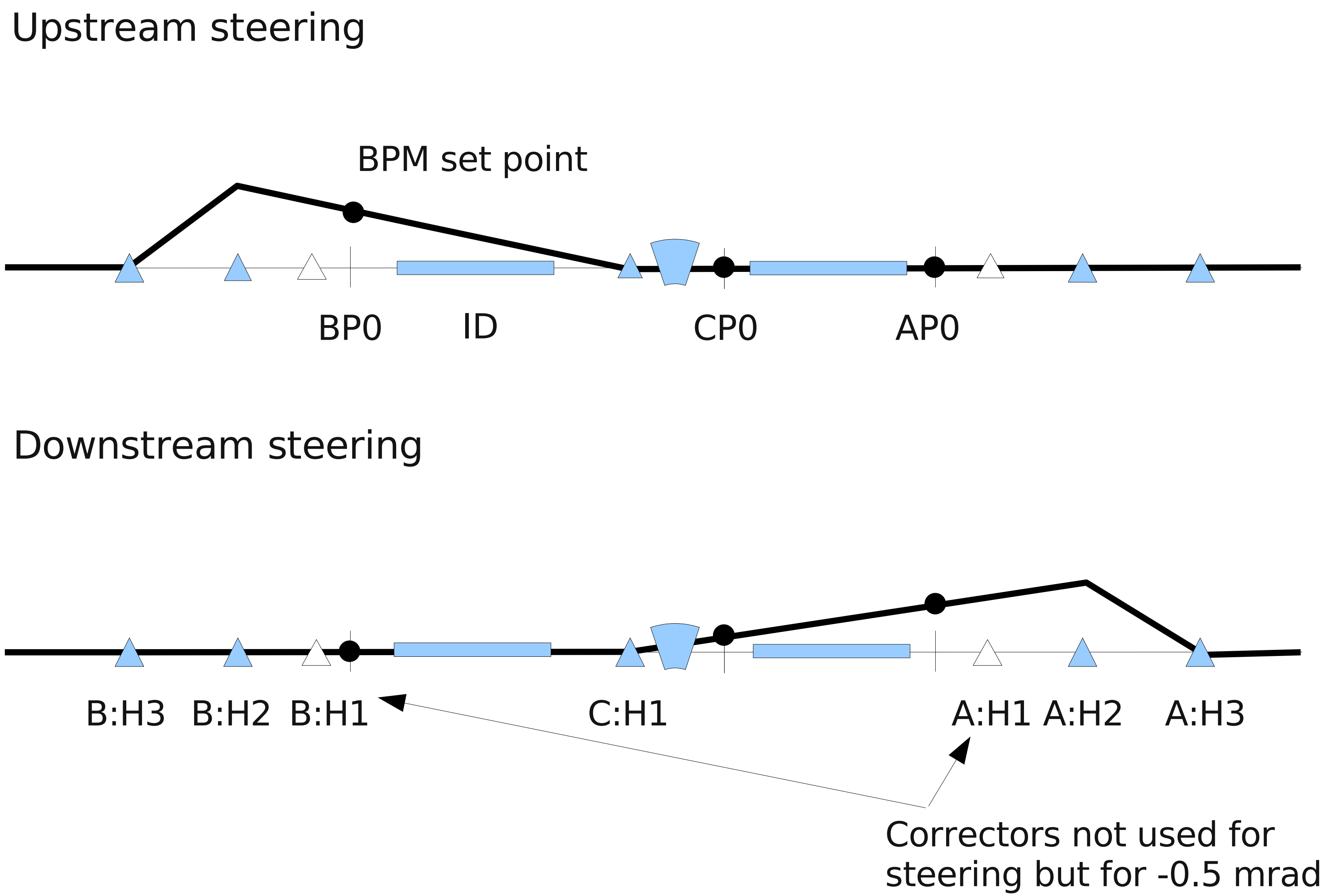
- Two undulators in same straight section with -1 mrad dipole between them (2005)
  - Use SR correctors for the outside +0.5 mrad bends
- Additional hardware: 40-μrad H- and V-correctors, one bpm



- Steer two photon beamlines independently by as much as 40-μrad, the typical dipole error of IDs
  - Only angle steering allowed
- Initial steering is done on both IDs using local steering
- New correctors can take part in global orbit correction to help compensate while gaps are moving

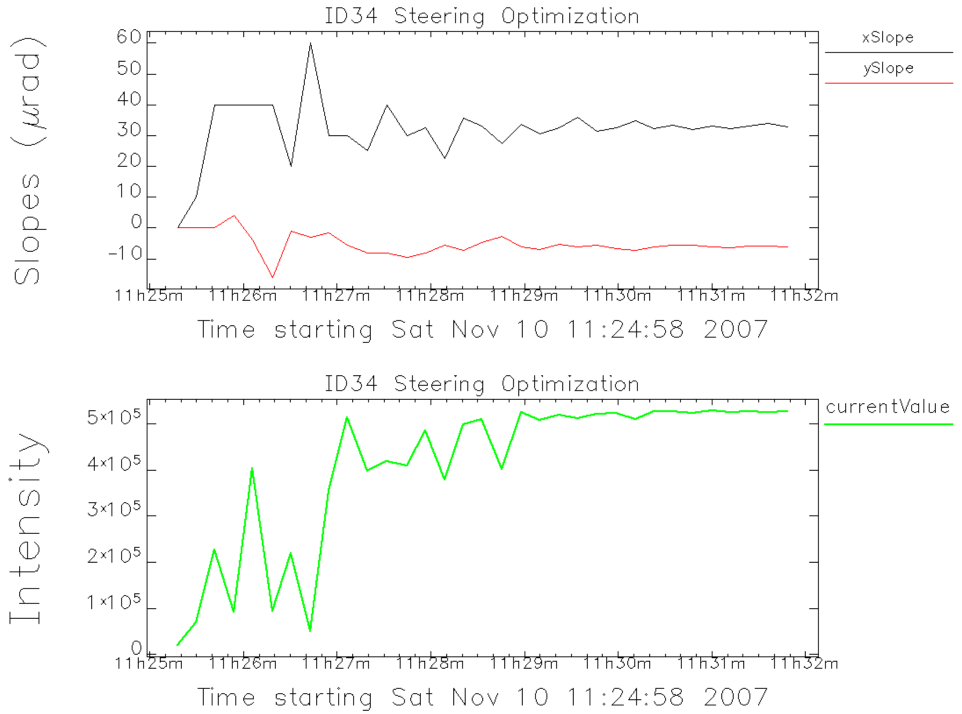
*Not shown is the original -1 mrad angle of the corrector needed for Decker distortion, thus the corrector actually makes a -0.5 mrad bend

Steering Configurations



Steering Optimization for Regular IDs

- Diagnostics (available to EPICS) in beamline outside the tunnel to tells an generic optimizer where to steer the beam
- Optimizer interacts with beam steering system by sending rf bpm set points as variables
- ID gap can be also be variable (important for y' steering)
- Eight <u>beamlines</u> ID1, ID5, ID7, ID14, ID15, ID17, ID30, ID34 have used it since 2006



ID34 often requires a new steering of about 40 urad due to a beamline configuration change

Photon Beam Stability Goals

AC goals 0.017-200 Hz BW, rms

	Position	Angle
Vertical	0.42 μ	0.22 μrad
Horizontal	3.0 μ	0.53 μrad

One-week drift, p-p

	Position	Angle
Vertical	1.0 μ	0.50 μrad
Horizontal	5.0 μ	1.0 μrad

Achieved

	Position	Angle
Vertical	1.6 μ	0.26 μrad
Horizontal	5.0 μ	0.33 μrad

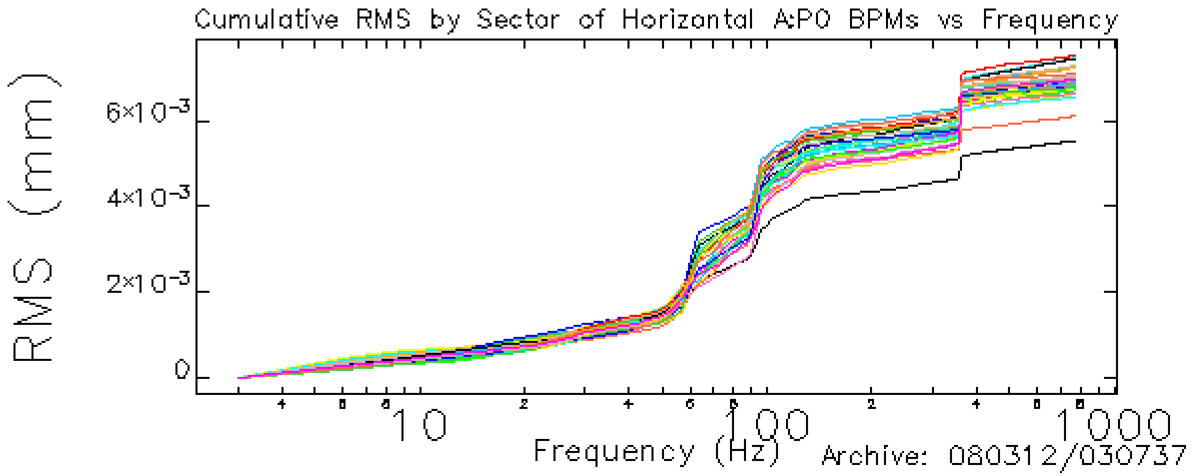
Achieved one-day drift

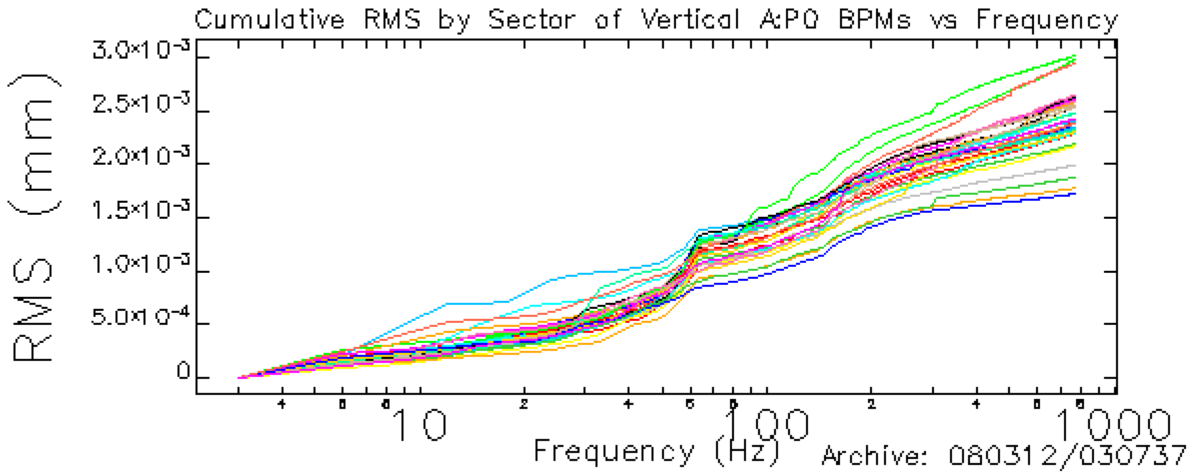
	Position	Angle
Vertical	No data	0.6 μrad
Horizontal	No data	0.6 μrad

- A Five-Year plan (draft) for orbit stability was recently written by G. Decker, on which the above and the plan explained later is based

Recent Orbit Noise at BPMs in Straight Section

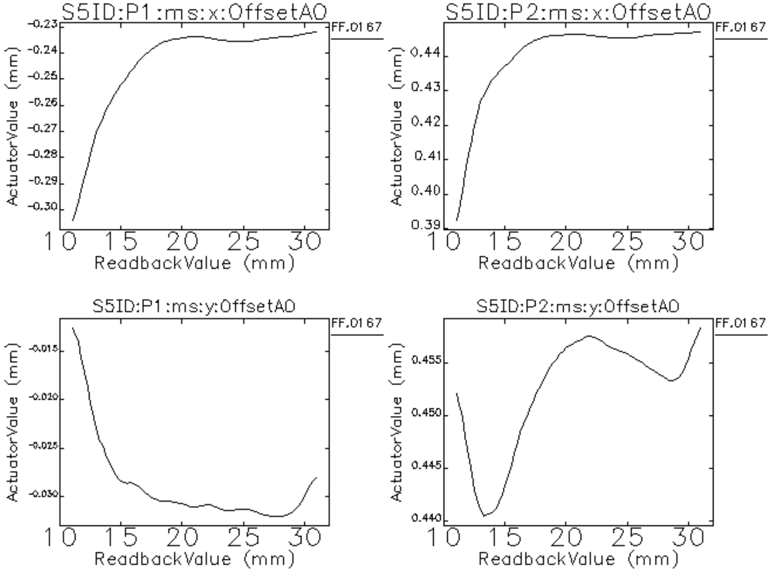
- Rf BPMs at the end of a straight section (β_x=20 m, β_y=5m)
- Fast orbit feedback on (effective in 0-60 Hz)





DC Orbit Stability - Present Capability

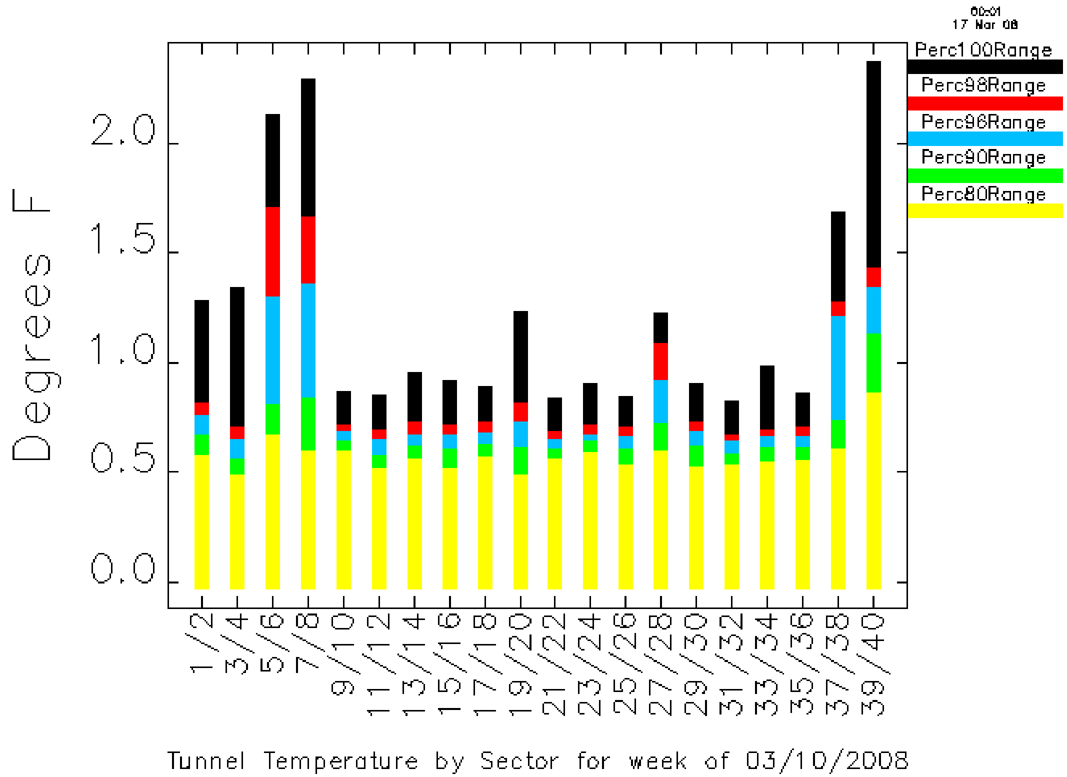
- Use xray bpms in DC orbit correction (Decker)
  - Systematic effects in xray bpms from background radiation reduced by Decker distortion
  - Use look-up tables for xray bpm offset (10's of microns) as a function of ID gap
    - Measured during studies and also during run
    - Valid only for one particular steering



  - For straight section with two IDs
    - Restrict operation or remove xray bpms from correction
    - All both ID gaps move together, or have one fixed
- SR tunnel temperature stability short-term goals achieved

SR Tunnel Temperature Stability

- Recent goal of 1 degree F peak-to-peak for the storage ring tunnel temperature. Eventual goal is 0.2 deg F peak-to-peak or use BPM position monitors
- Present improvements to air handling: replacement of control valves to smaller ones, loop tuning, decoupling of outside air
- Recent weekly plot of twenty air handling “sectors”



Several Enhancement Planned – AC performance

- BH4/BV4 corrector relocation (increases the number of fast correctors per sector from 1 to 2)
- Power supply interface board replacement (includes correctors)
- Fast digitizer for narrowband and xray bpms (to allow higher sampling rate)
- Upgrade of data acquisition system of original monopulse rf bpm (decrease noise floor by sampling many more times the beam per turn). Testing first articles with beam now.
- Upgrade of fast orbit feedback processors and other hardware (to allow higher sampling rate of 10 kHz)

Several Enhancement Planned – DC performance

- SR Tunnel temperature upgrade
- Xray bpm system enhancement
  - Upgrade of the standard UV-sensitive bpms
  - Xray-only sensitive detectors: pin-diode and vibrating wire
- Remediate the “rogue microwave” in SR chambers that affects the vertical plane