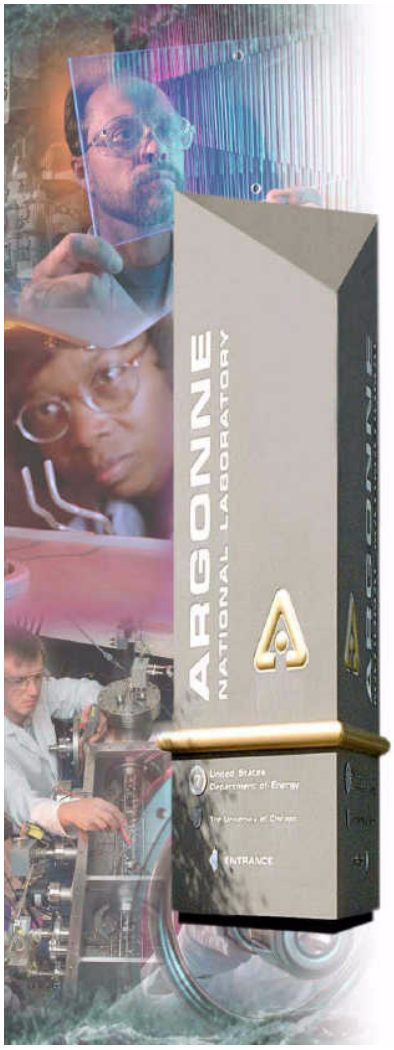


ADVANCED PHOTON SOURCE
APS OPERATIONS DIVISION

Orbit Stabilization at the Advanced Photon Source

Glenn Decker

IWBS 2004

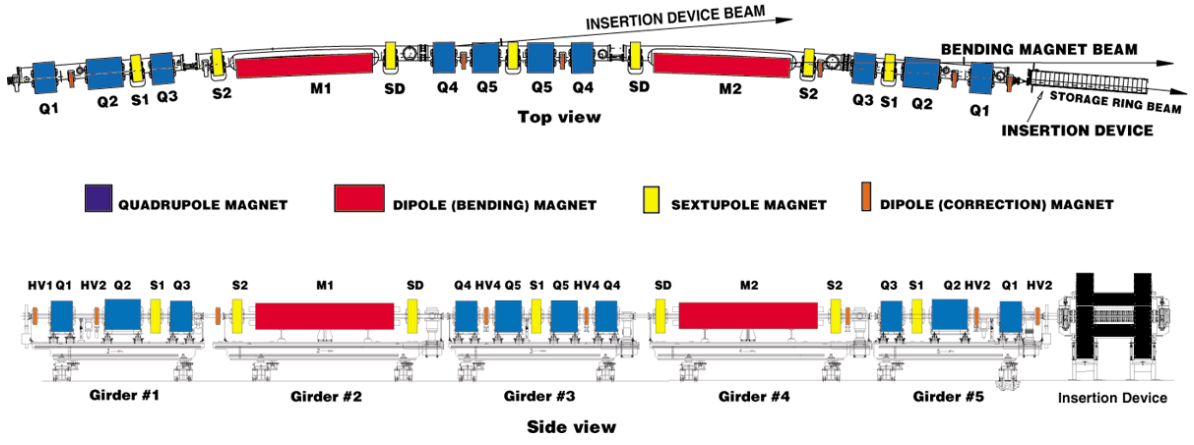
December 6, 2004

Argonne National Laboratory

Office of Science
U.S. Department of Energy

A U.S. Department of Energy
Office of Science Laboratory
Operated by The University of Chicago

One Sector of the Advanced Photon Source Storage Ring



27.6 meters

(The APS has forty sectors - 1104 meters total circumference)

Nominal APS Storage Ring Parameters

Standard Lattice

Emittance: 2.5 nm-rad

Effective emittance at ID: 3.1 nm-rad

Coupling: 1%

	ID	BM sector with chicane	BM sector without chicane
Source Size			
σ_x	271.2 μm	91.5 μm	88.5 μm
σ_y	8.6 μm	25.0 μm	25.2 μm
Divergence			
$\sigma_{x'}$	11.4 μrad	56.5 μrad	57.1 μrad
$\sigma_{y'}$	2.9 μrad	1.2 μrad	1.2 μrad
Beta Functions			
β_x	19.32 m	2.09 m	1.96 m
β_y	2.98 m	24.92 m	25.32 m
Other Parameters			
α_x	0.00	0.95	0.89
α_y	0.00	0.70	0.60
γ_x	0.05 m^{-1}	0.91 m^{-1}	0.91 m^{-1}
γ_y	0.34 m^{-1}	0.06 m^{-1}	0.05 m^{-1}
η_x	0.166 m	0.058 m	0.057 m
$\eta_{x'}$	0.000	-0.032	-0.033

Insertion Device Pointing Stability Specification

$$\sigma_{y'_{xray}} = \frac{\sqrt{(1+K^2)/(2nN_u)}}{\gamma} = \text{X-ray vertical opening angle}$$

$$\gamma = E/(mc^2) = 13700 \text{ @ } 7 \text{ GeV}$$

N_u = Number of undulator periods
= 72 for APS und. A

n = undulator harmonic number

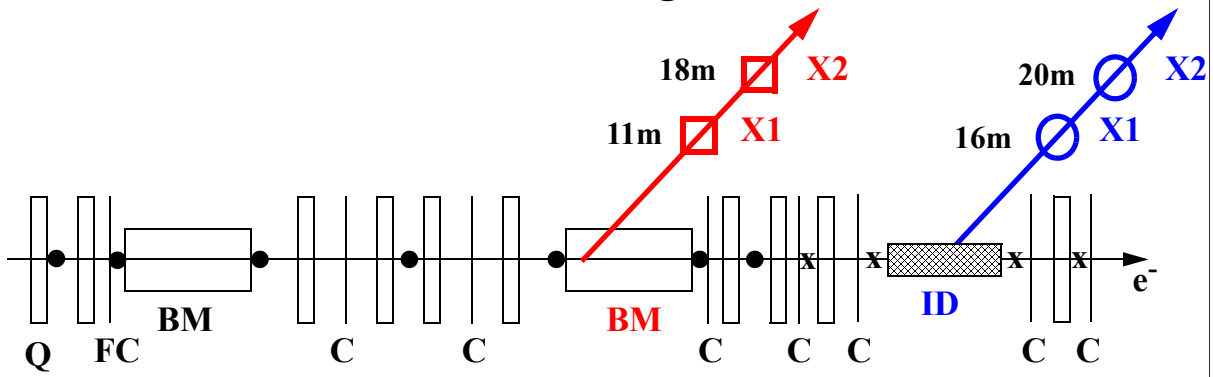
$\therefore \sigma_{y'_{xray}} = 3.3$ μrad rms (n=7, K=1)

This adds in quadrature with the electron beam divergence $\sigma_{y'_{e^-}} = 2.9$ μrad

$$\sigma_{y'_{total}} = 4.4 \text{ μrad}$$

Pointing stability = $0.05 \bullet \sigma_{y'}$ = 220 nanoradians rms ←

Beam Position Monitors and Magnets in One Sector



- ● : Broad-band RF Beam Position Monitors (7) (Turn-by-Turn)
- x : Narrow-band RF Beam Position Monitors (4) (~ 300 Hz)
- □ : BM X-ray Beam Position Monitors (2 - Vertical Only) (~165 Hz)
- ○ : ID X-ray Beam Position Monitors (2) (~165 Hz)
- FC : "Fast" Corrector Magnet (1) (~ 1000 Hz)
- C : "Slow" Corrector Magnets (7) (few Hz)
- Q : Quadrupole Magnets

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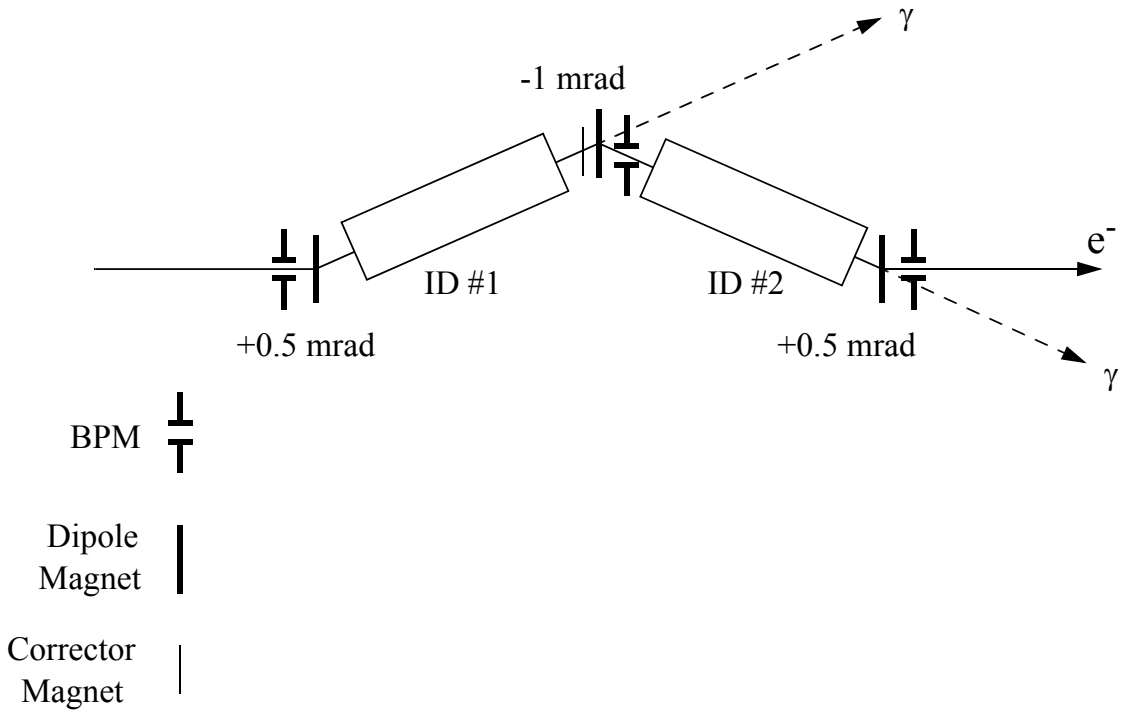
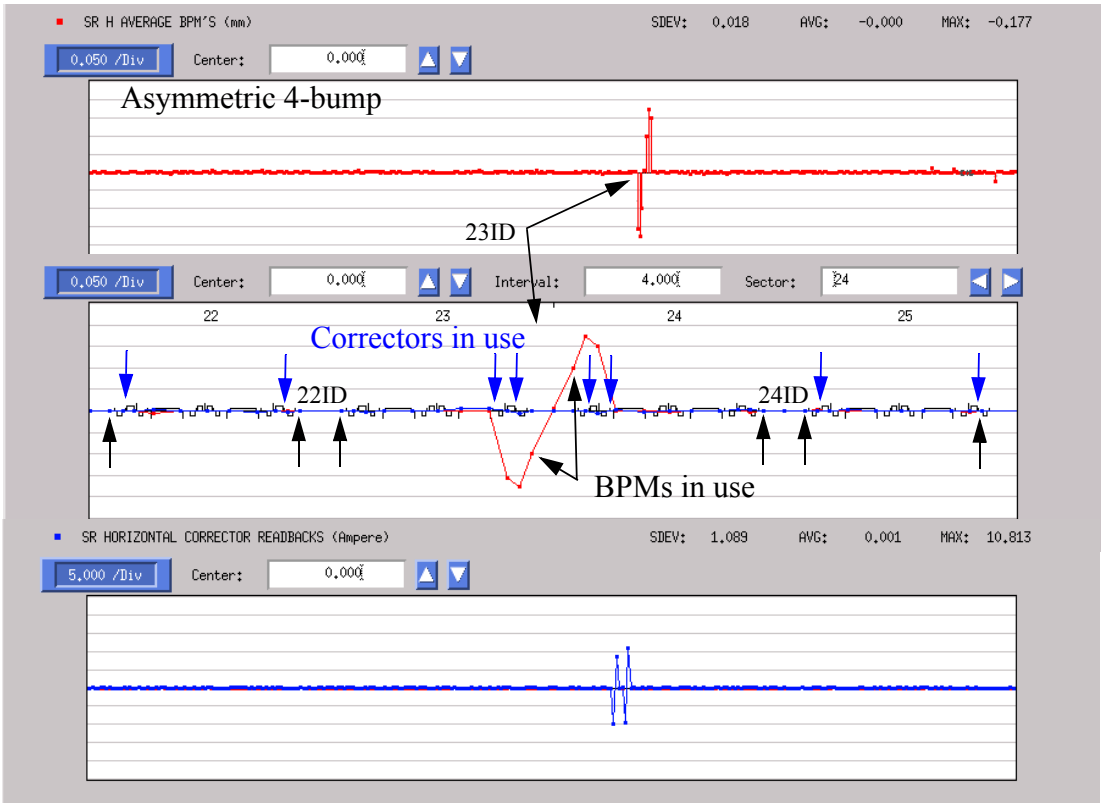
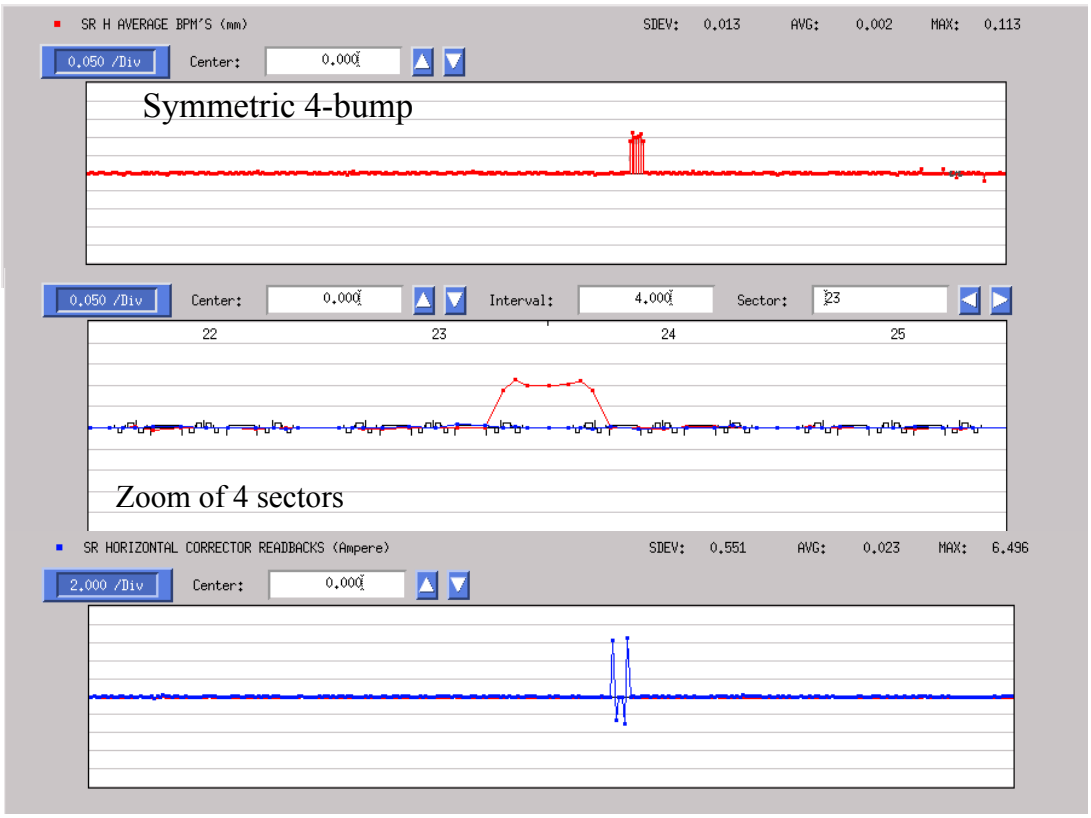
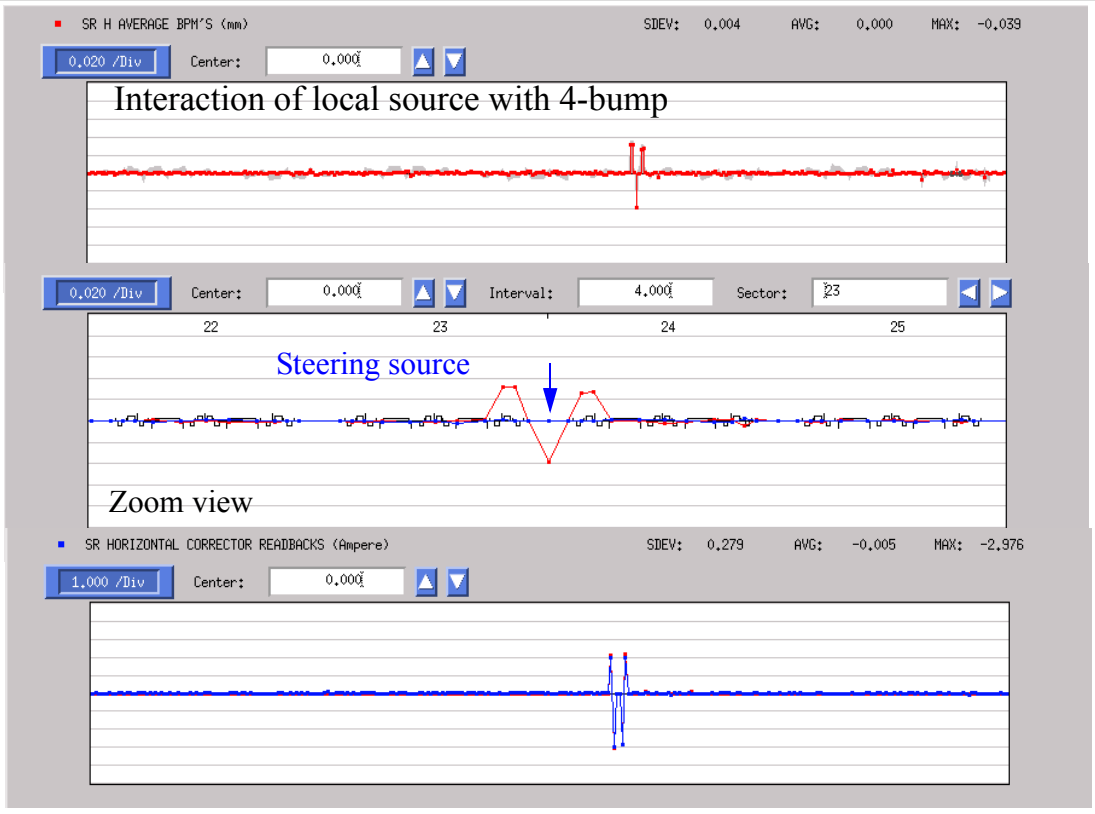
Canted Undulator Geometry
(APS sectors 21,23,24)



Application of Configurable SVD







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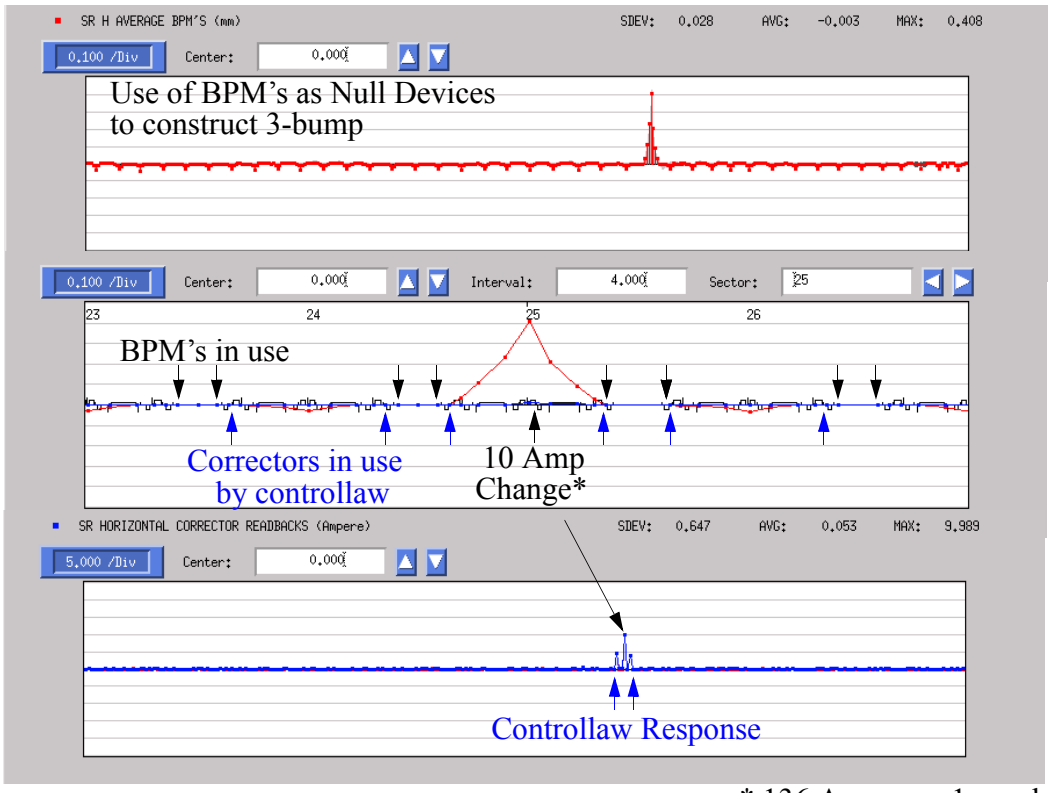
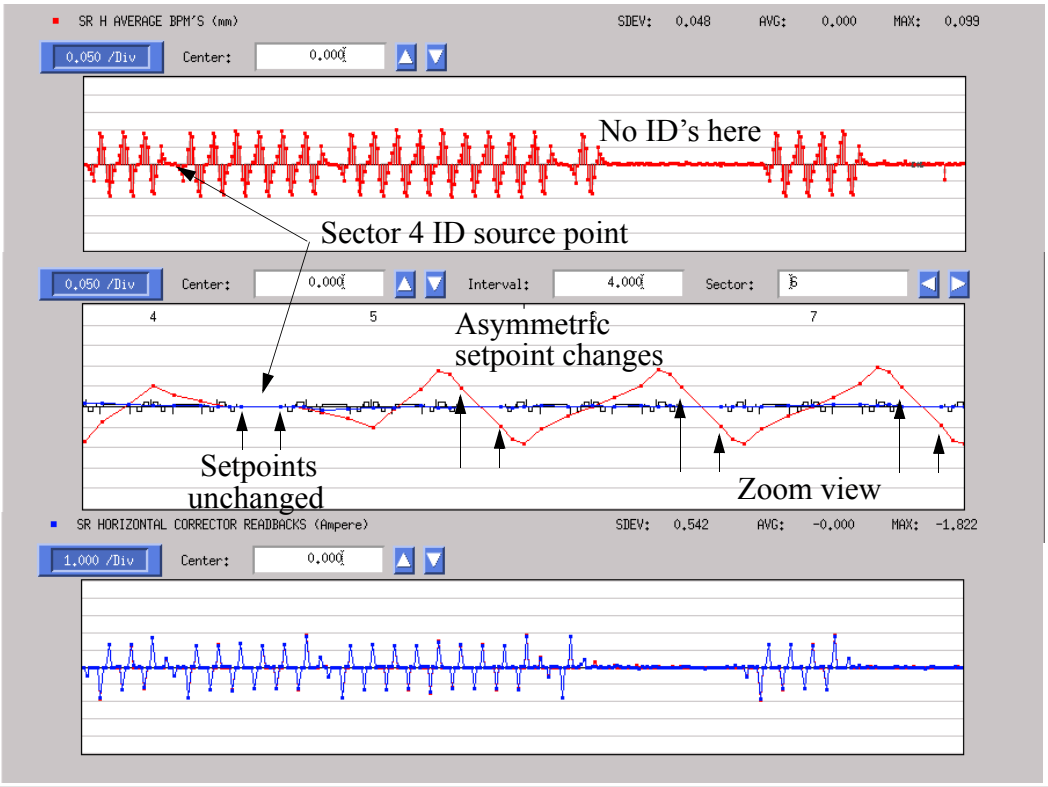


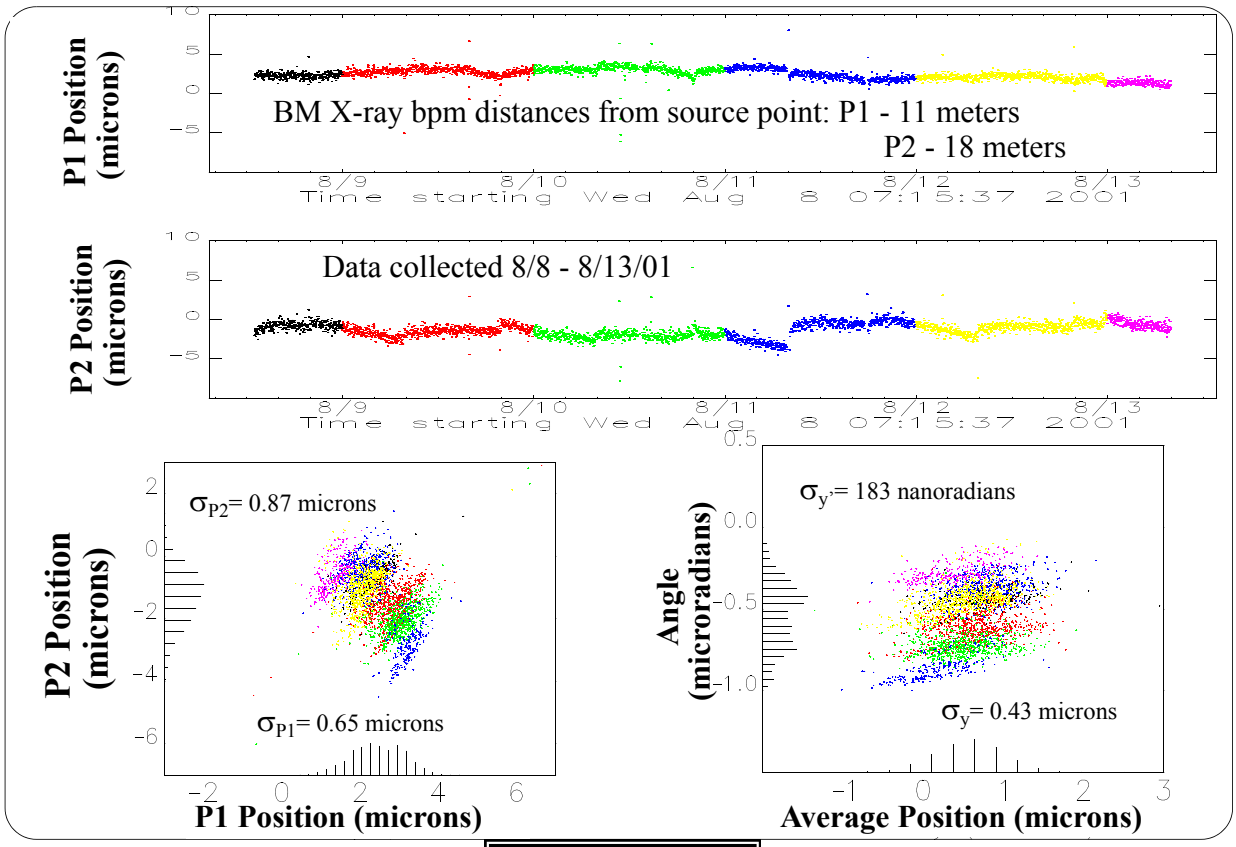
* 136 Amps = ~ 1 mrad

"Simo-bump" used for cross-calibration of ID photon bpm's

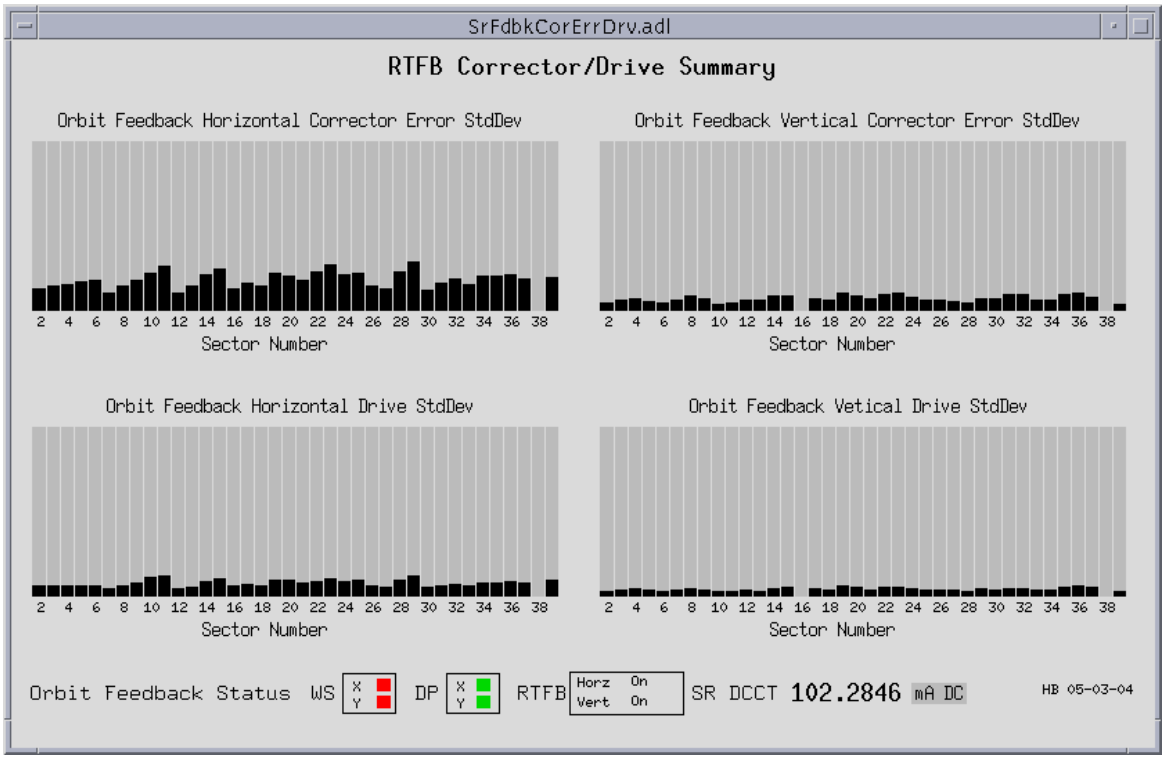


Plots showing < 200 nanoradian rms vertical beam stability over a 5 day period

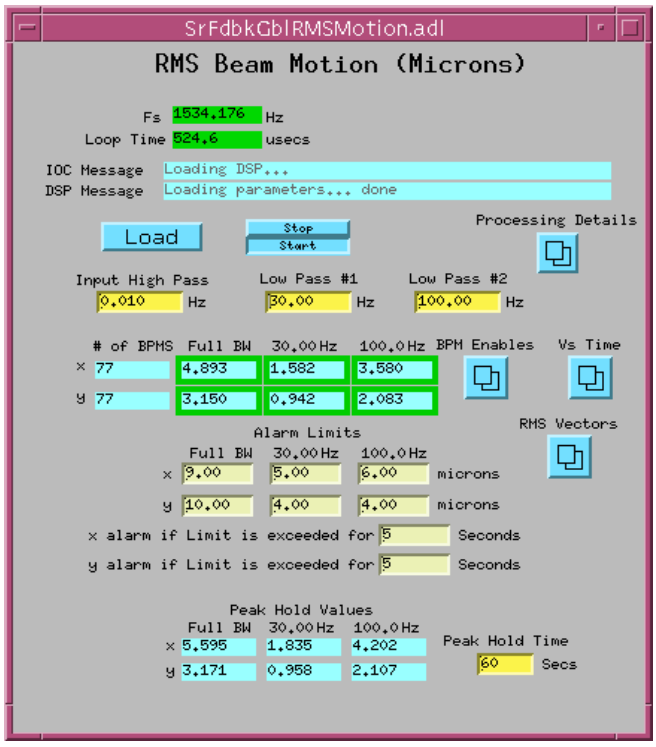
Colors indicate data for individual days



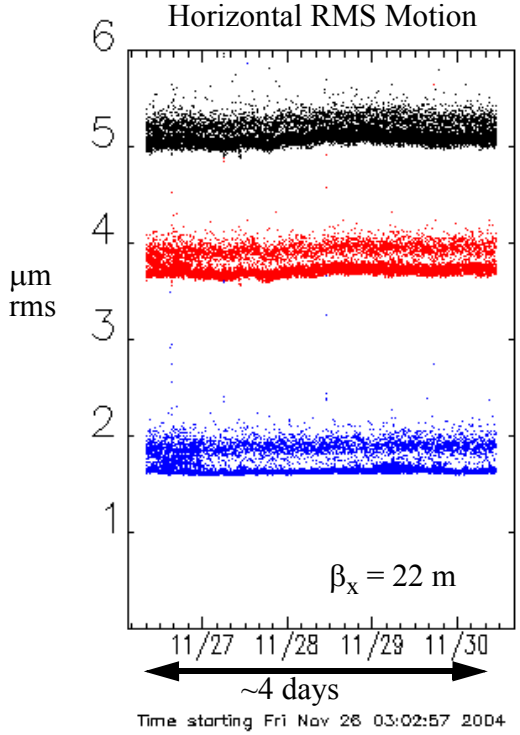
AC Beam Stability: Real-time feedback corrector statistics



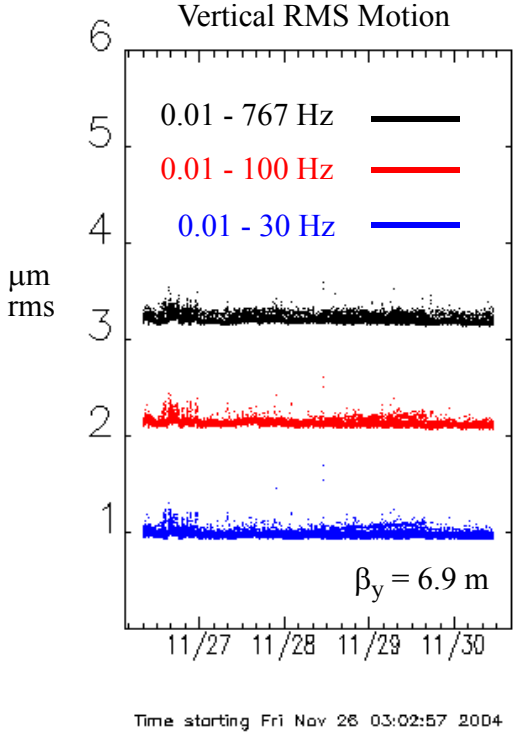
Real time calculation of rms beam motion



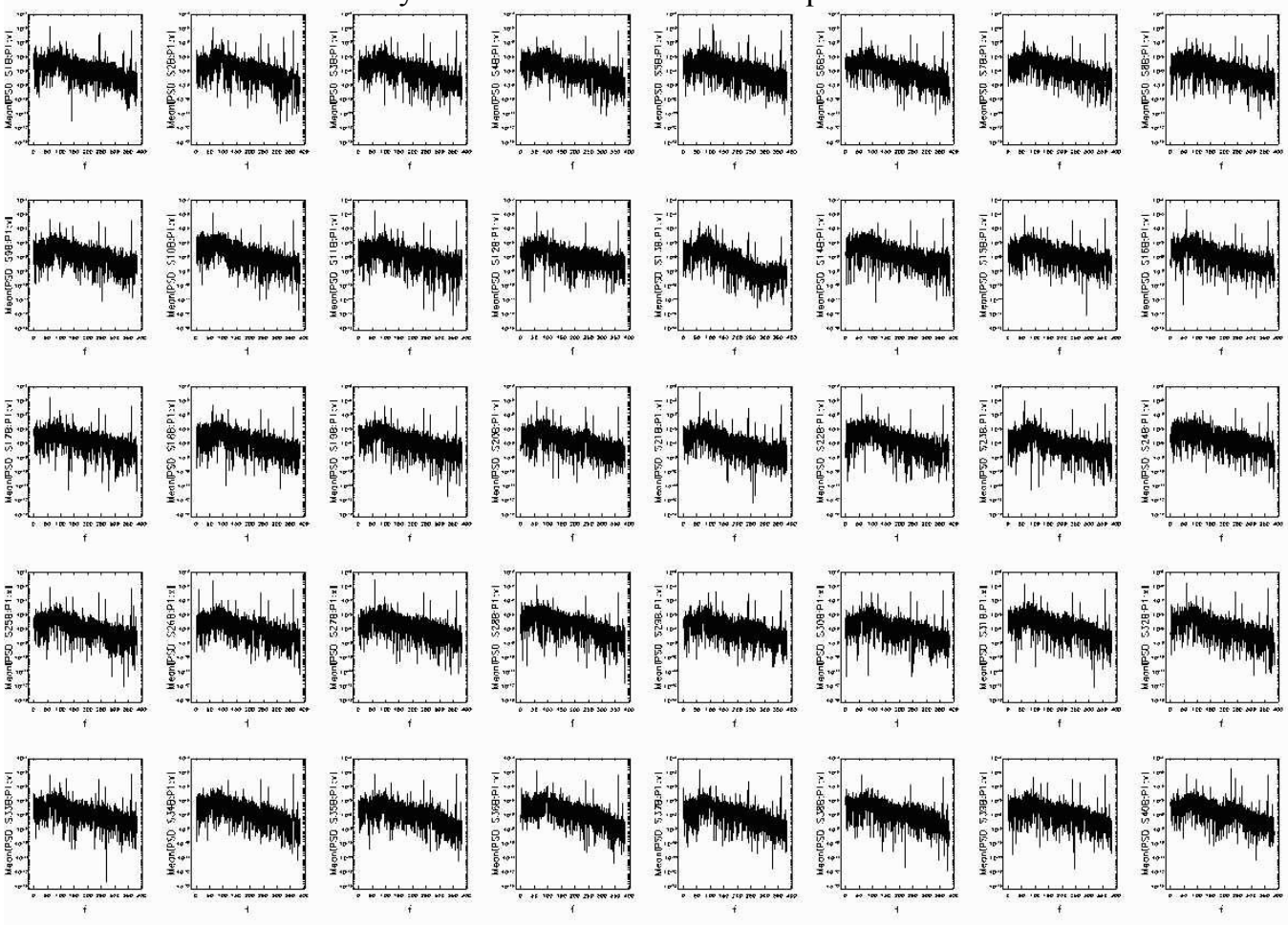
Horizontal RMS Motion



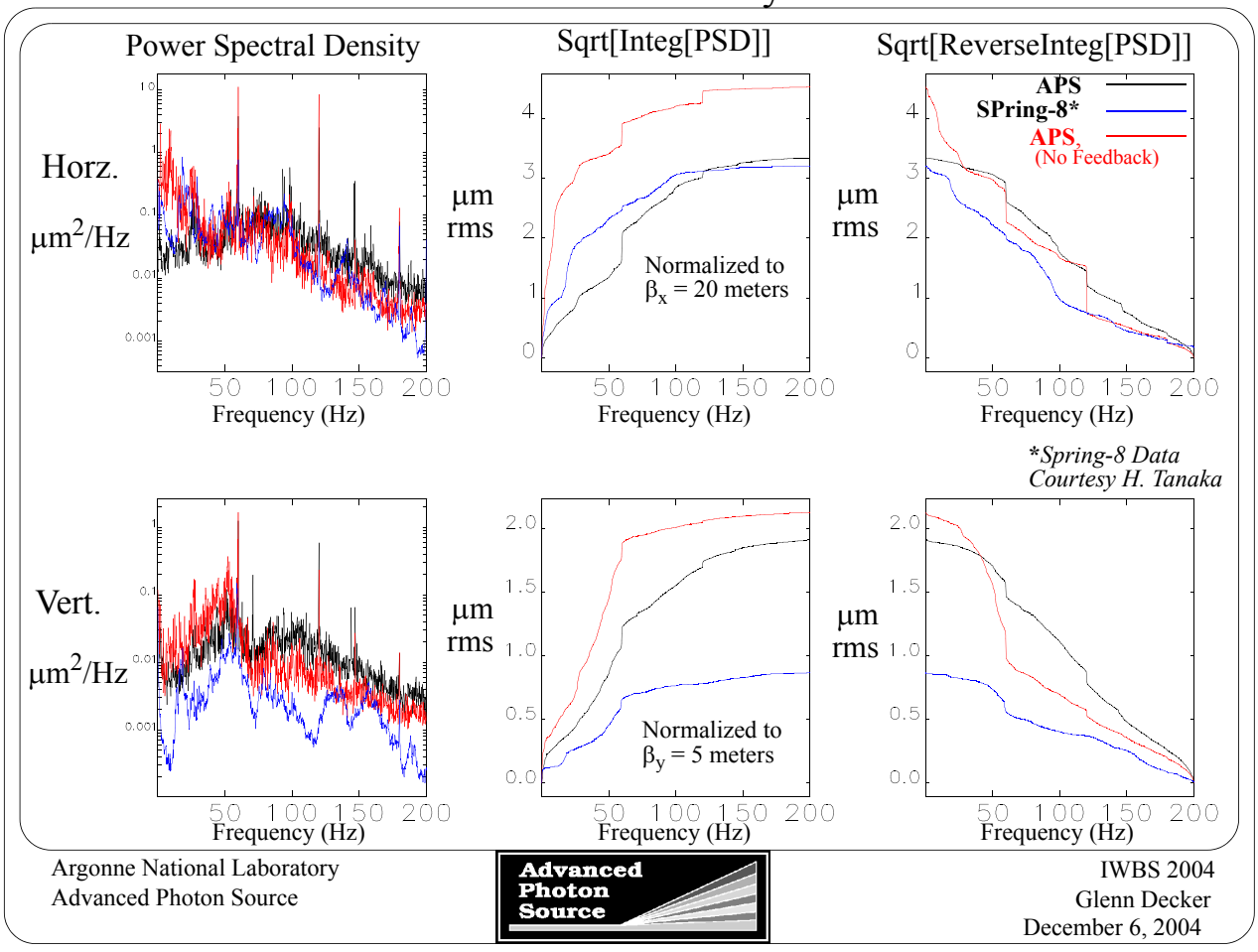
Vertical RMS Motion



APS Real-time feedback system allows simultaneous acquisition of 40 waveforms



AC Beam Stability



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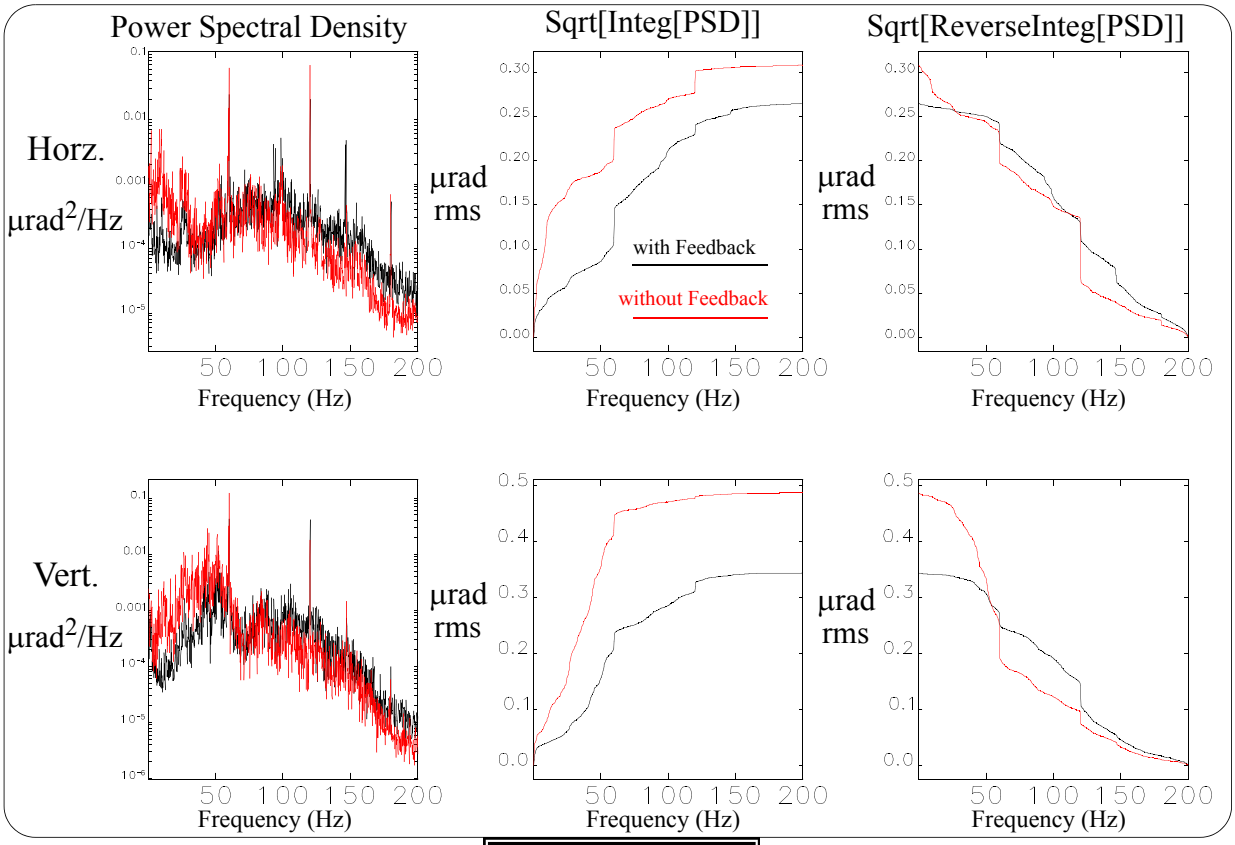
AC Pointing Stability



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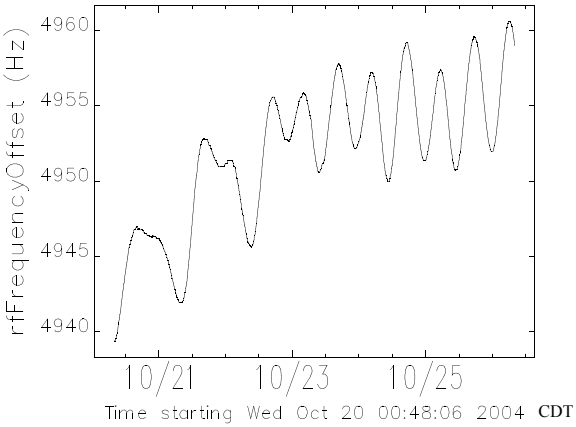
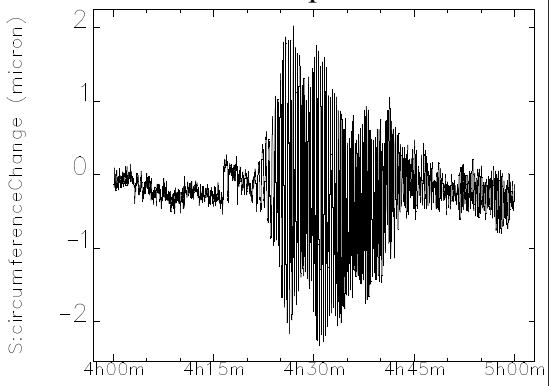
Earth Tides



2004 Phases of the Moon
Universal Time

NEW MOON	FIRST QUARTER	FULL MOON
d h m	d h m	d h m
OCT. 14 2 48	OCT. 20 21 59	OCT. 28 3 07

Earthquakes



004/10/08 08:27 M **6.9 SOLOMON ISLANDS** Z= 37km 10.84S 162.18E

This information is provided by the USGS
National Earthquake Information Center.

A magnitude 6.9 earthquake IN THE SOLOMON ISLANDS has occurred at:
10.84S 162.18E Depth 37km Fri Oct 8 08:27:54 2004 UTC

Time: Universal Time (UTC) Fri Oct 8 08:27:54 2004
Time Near Epicenter Fri Oct 8 19:27:54 2004
Central Daylight Time (CDT) Fri Oct 8 03:27:54 2004

Location with respect to nearby cities:
285 km (180 miles) ESE of HONIARA, Guadalcanal, Solomon Islands
2070 km (1290 miles) NNE of BRISBANE, Queensland, Australia
http://earthquake.usgs.gov/recenteqsww/Quakes/uspiav.htm .

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Summary

- The APS is a mature facility with a lot of sophisticated orbit control capability
- Use of BM and ID photon beam position monitors has improved long term pointing stability and repeatability in the past few years.
- The real-time feedback system continues to run well, in operation since 1997.
- Future plans include upgrades to broadband rf bpm data acquisition and real-time feedback system.
- A “hard x-ray” beam position monitor is being designed to be placed in the beamline first optic enclosure 25 meters from the insertion device source point. Objective is to achieve 100 nrad-scale long-term pointing stability, making local steering requests unnecessary.