Beam Stabilization Systems Development Work Supporting the APS Upgrade

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February 18, 2010

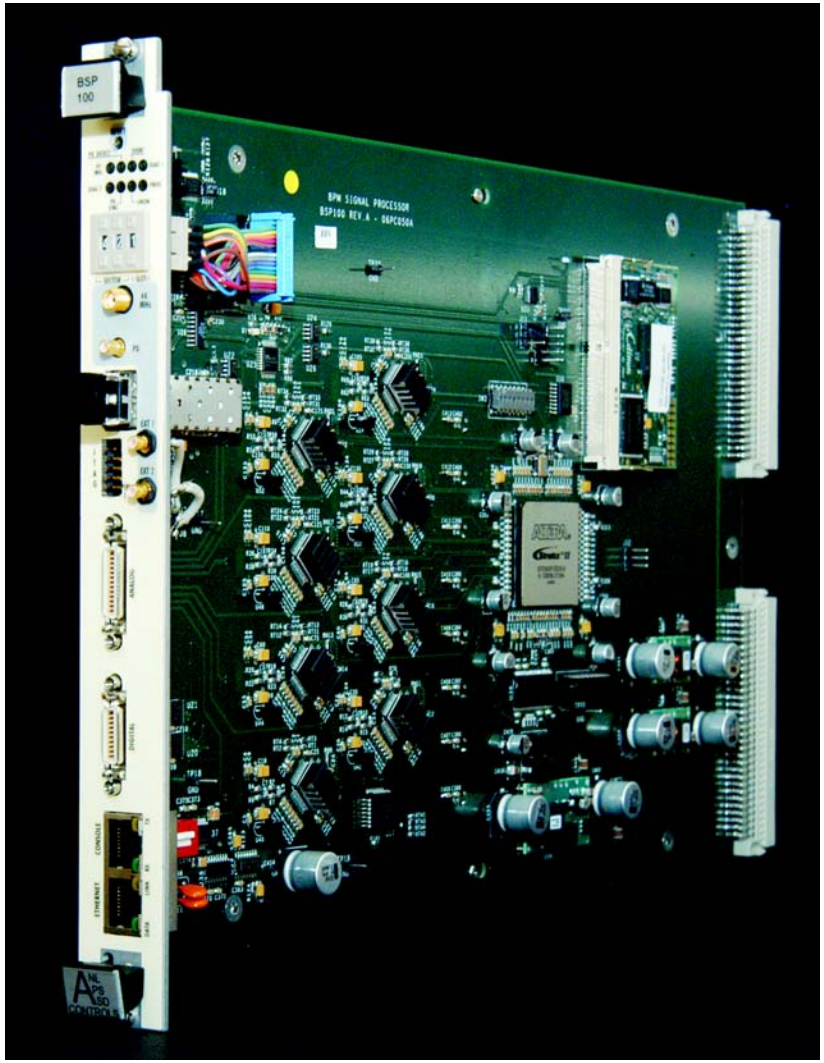
Overview of Planned and Ongoing Beam Stabilization Improvements

- Broadband RF BPM data acquisition system upgrade
- Spurious storage ring vacuum chamber microwave mode dampers
- Real-time feedback system upgrade
- Tunnel temperature issues / solutions
- Front-end hard x-ray beam position monitor developments

APS Beam Stability Goals

	AC Motion, 0.1 - 200 Hz		Long-term Drift, (One week)	
	microns rms	μrad rms	microns p--p	μrad p-p
Horizontal	3.0	0.53	5.0	1.0
Vertical	0.42	0.22	1.0	0.5

Broadband RF BPM data acquisition system upgrade

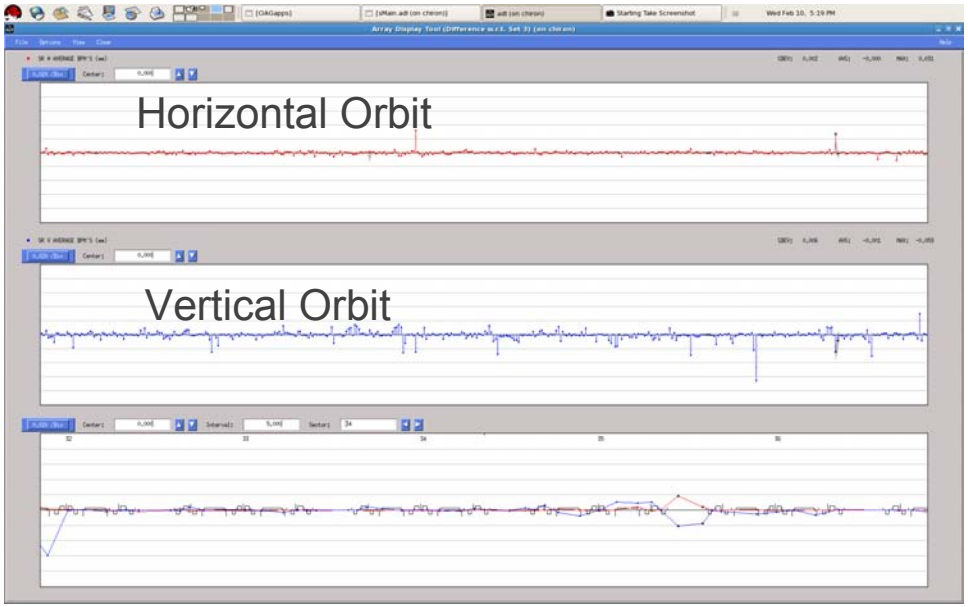


- Eight channels/board, 88 MS/sec sampling.
- One second (262144 samples) turn-by-turn beam history for fault diagnosis.
- Demonstrated 50 nanometer rms noise floor, DC-200 Hz.
- Five sectors instrumented, parts for 3 more sectors in hand.

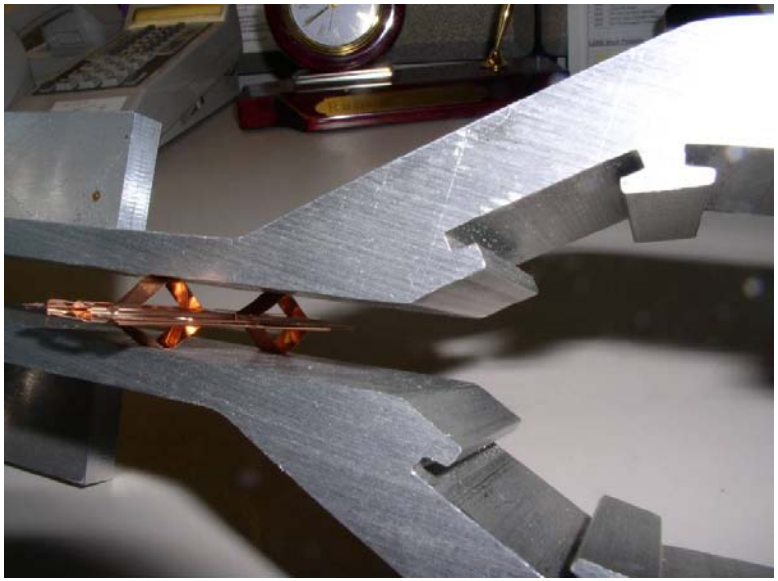
Spurious storage ring vacuum chamber microwave mode dampers

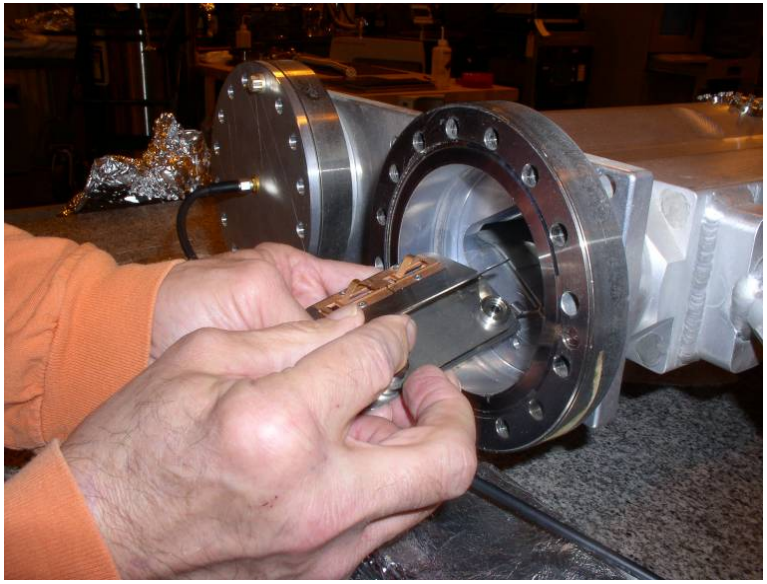
- A design “feature” of the original large-aperture storage ring vacuum chambers is a series of vertically-polarized TE modes falling near 352 MHz.
- As a consequence of this a large number of bpms cannot be used for vertical orbit correction.
- A solution has been developed to eliminate these modes, with plans to implement it in one sector during the May shutdown period.

Orbit Display Showing “Ratty” Vertical Readbacks



EMI Mode Shorting Snubber Installation*

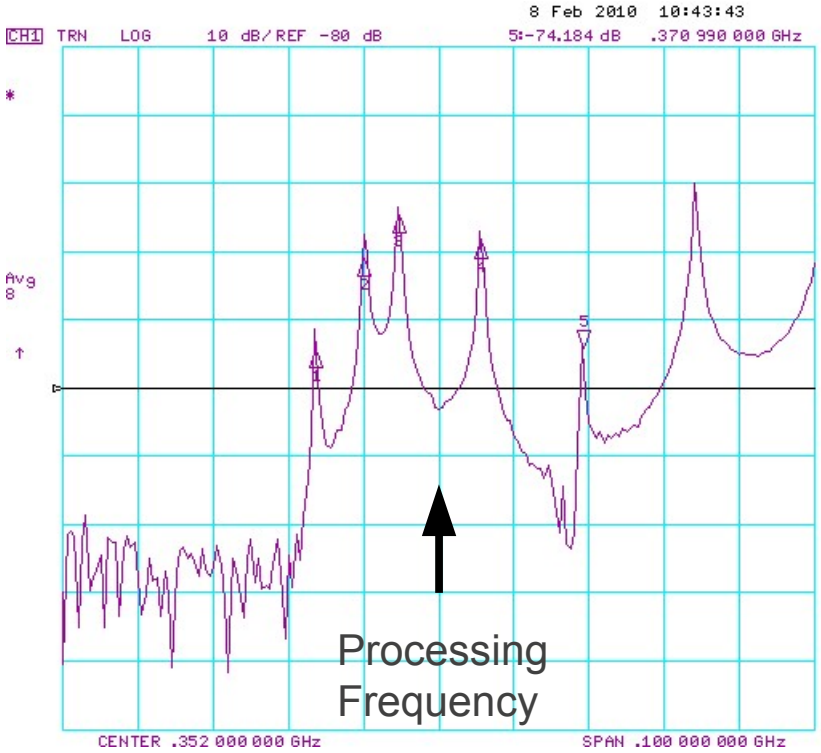




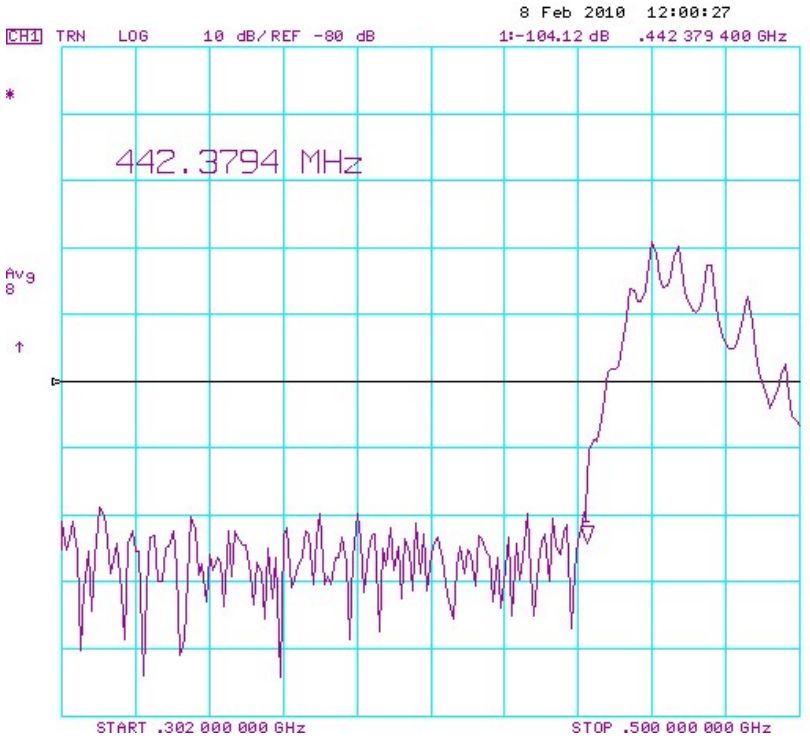
* Courtesy Bob Lill (ASD-DIA), John Hoyt (AES-MOM)

Spurious storage ring vacuum chamber microwave mode dampers

Before Installation of Snubbers



After Installation of 9 Snubbers



* Data courtesy of Bob Lill

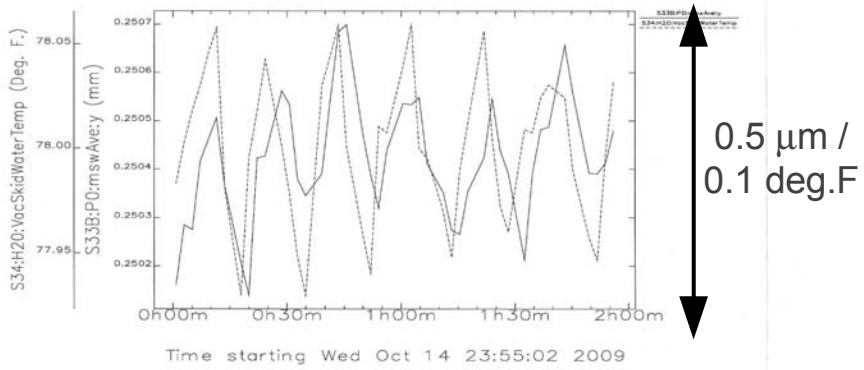
Real-time feedback system upgrade

- Originally commissioned in 1997.
- Limited to 1.5 kHz sample rate => 50 Hz closed-loop bandwidth.
- Modern commercially available hardware should allow closed-loop BW up to 200 Hz or higher.
- Relocation of “B:H4” correctors will double the coverage of fast steering correctors, improving ac stability by factor of 2.

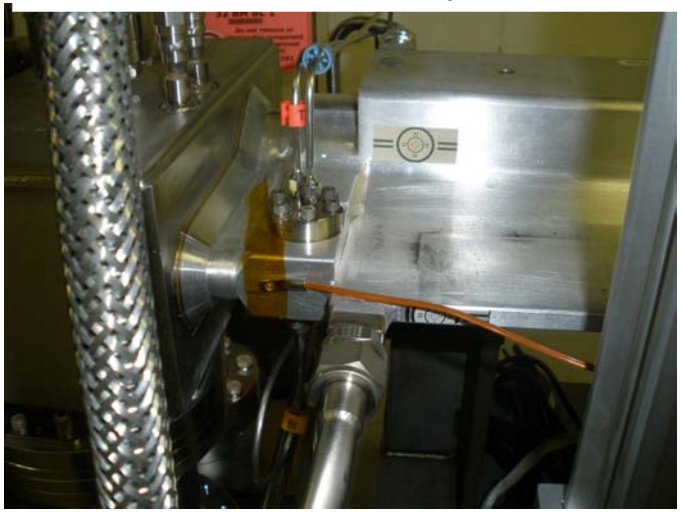
Tunnel temperature issues / solutions

- Tunnel Air / Water temperature regulation is pretty good, at the level of 0.6 – 1.0 deg. F p-p for air, and 0.1 deg. F p-p for water.
- Improving this significantly will likely be expensive.
- Investigations are underway to develop mechanical sensors to monitor the physical location of critical beam position monitor pickups: A BPMPM (BPM^2).

Correlation of beam position and Chamber temperature

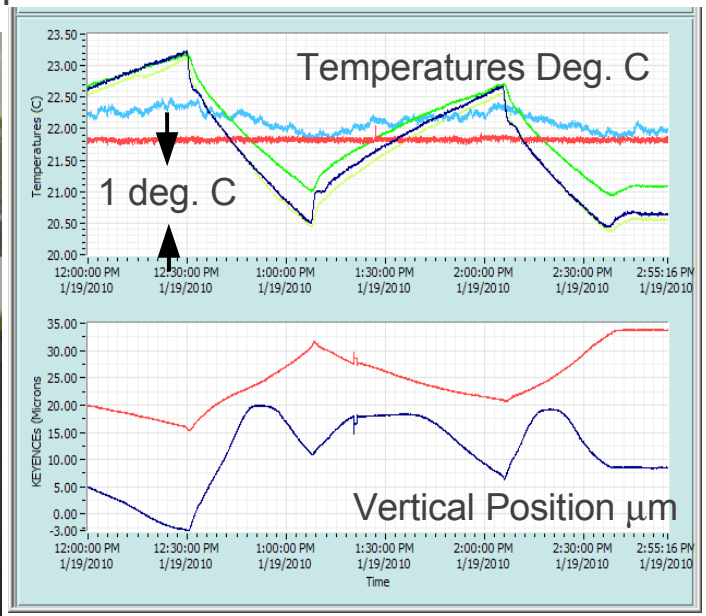


ID Chamber BPM Pickup Electrode



Tunnel temperature issues / solutions

Laser proximity sensor



Cyan= Air
Red= Stand
Green= BPM
Yellow= Thick Chamber
Blue = Thin Chamber

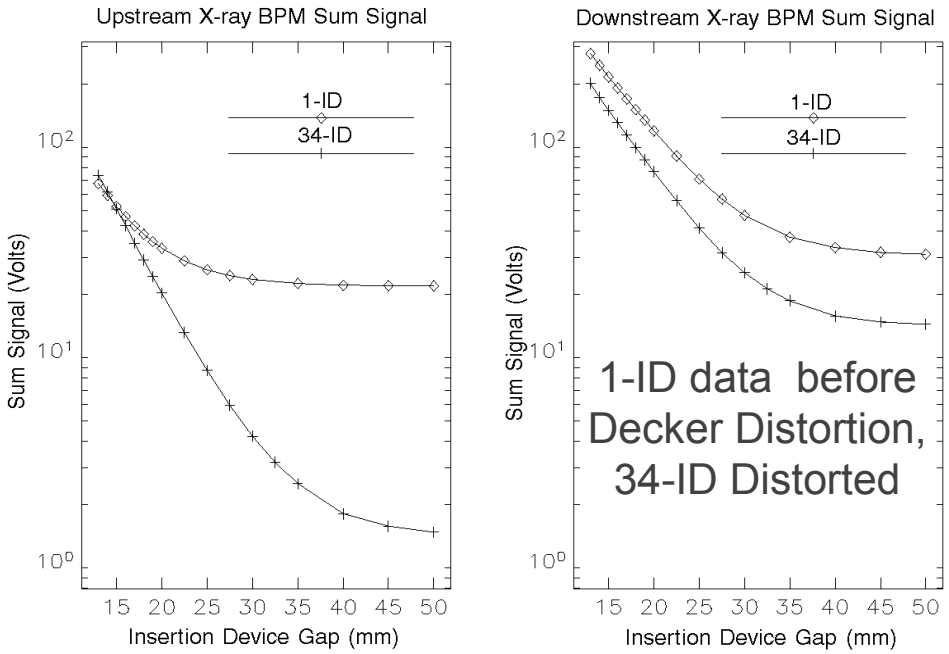
Red = Chamber Center
Blue = BPM Block

Keyence Proximity Sensor, 50 nm resolution

* Data courtesy of Bob Lill

Front-end hard x-ray beam position monitor developments

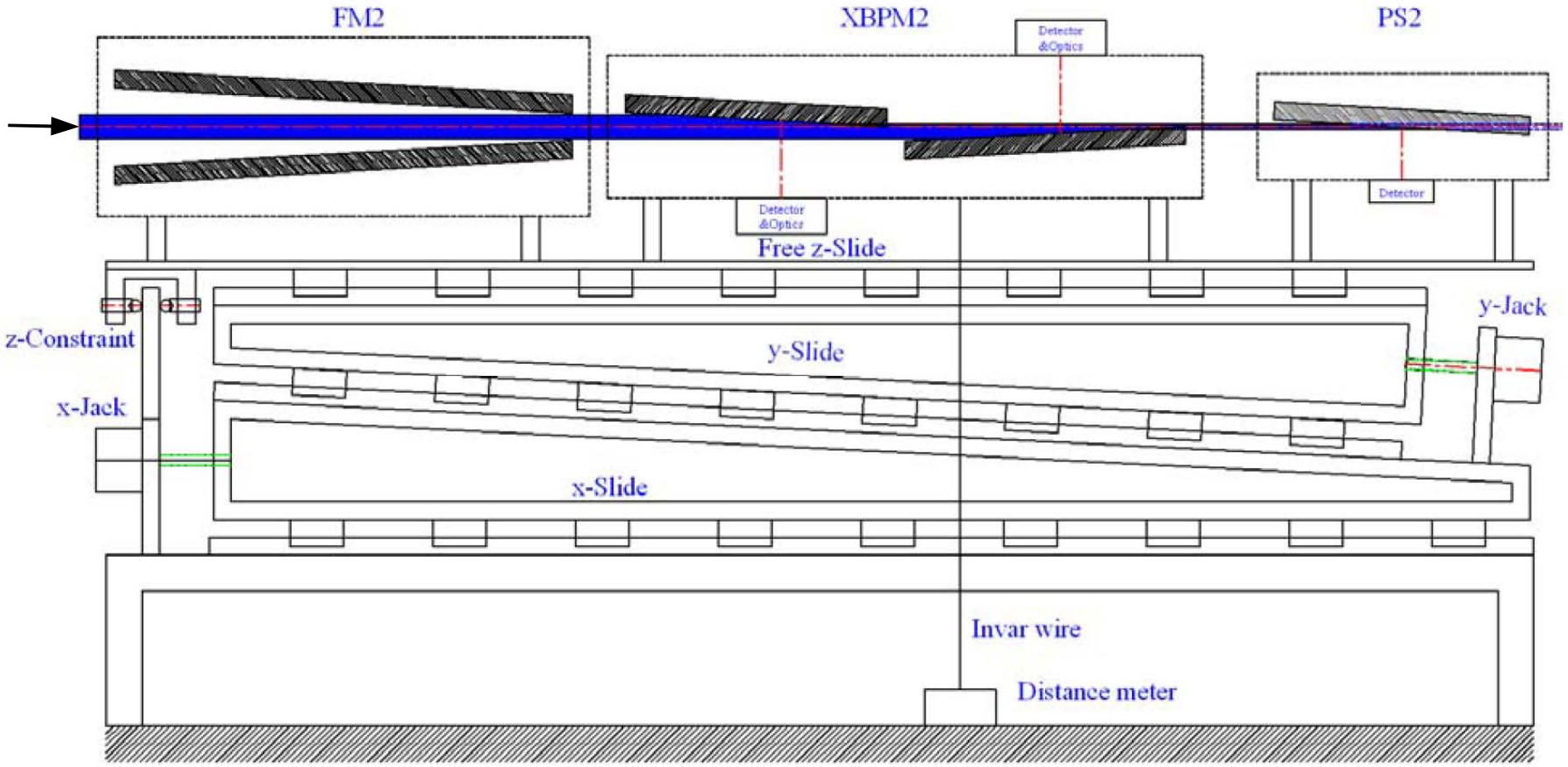
- Presently, there is an installed base of about four dozen photoemission-based insertion device photon beam position monitors.
- Realignment of the entire accelerator (1999-2005) reduced stray radiation background levels.
- Residual effects of background at the 10-20 micron level.



Front-end hard x-ray beam position monitor developments

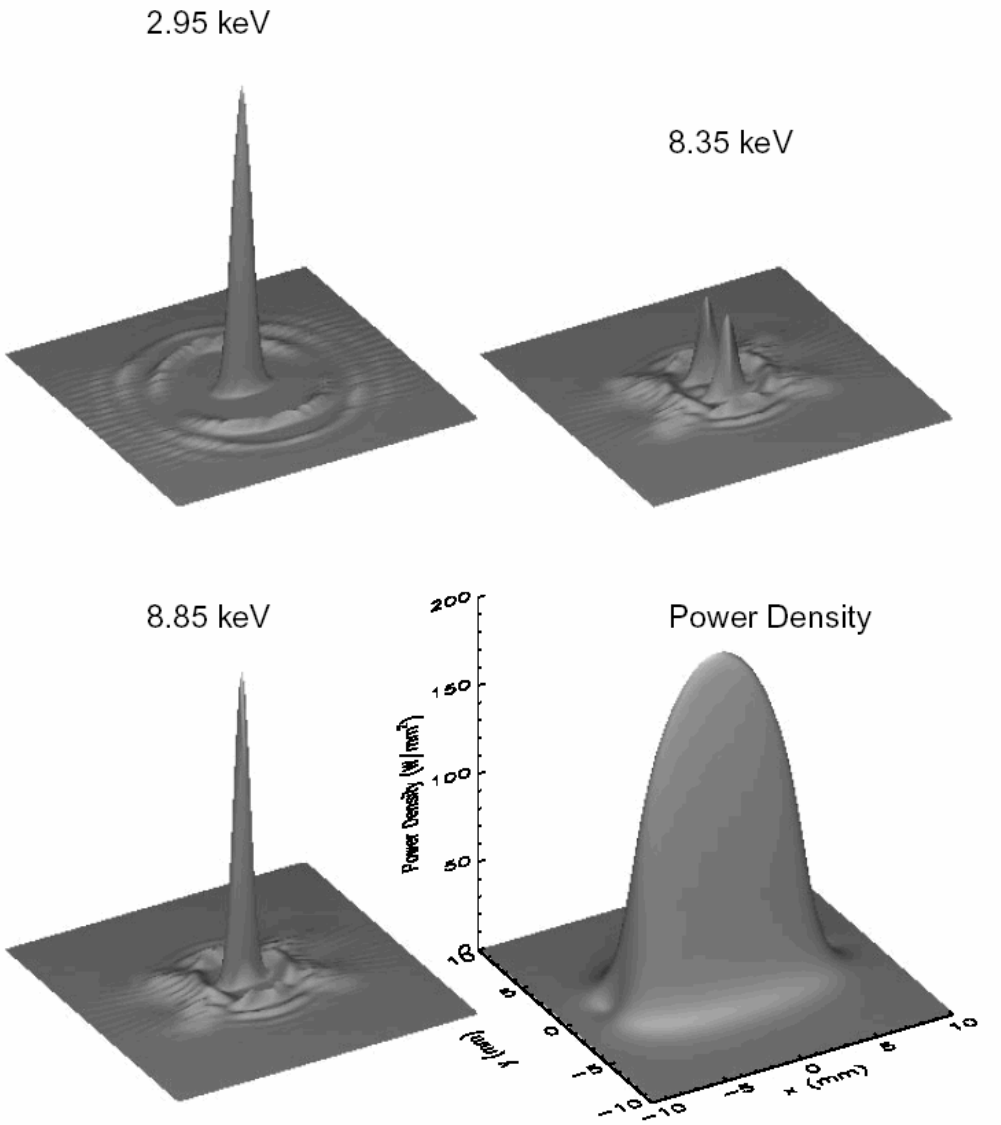
- Extensive studies have taken place over the past 4 years investigating copper x-ray fluorescence vs. photoemission for photon beam position monitoring.
  - Soft bending magnet radiation background essentially eliminated.
  - High power densities remain a challenge.
- An AIP project has received funding to design and build a first production version of a high-power hard x-ray beam position monitor for installation into insertion device beamline front ends.
- An in-air prototype of a device of this type has been installed at 35-ID and is undergoing extensive testing.

Grazing-incidence Hard X-ray Fluorescence-Based Insertion Device X-ray Beam Position Monitor Conceptual Design (GRIID-XBPM)



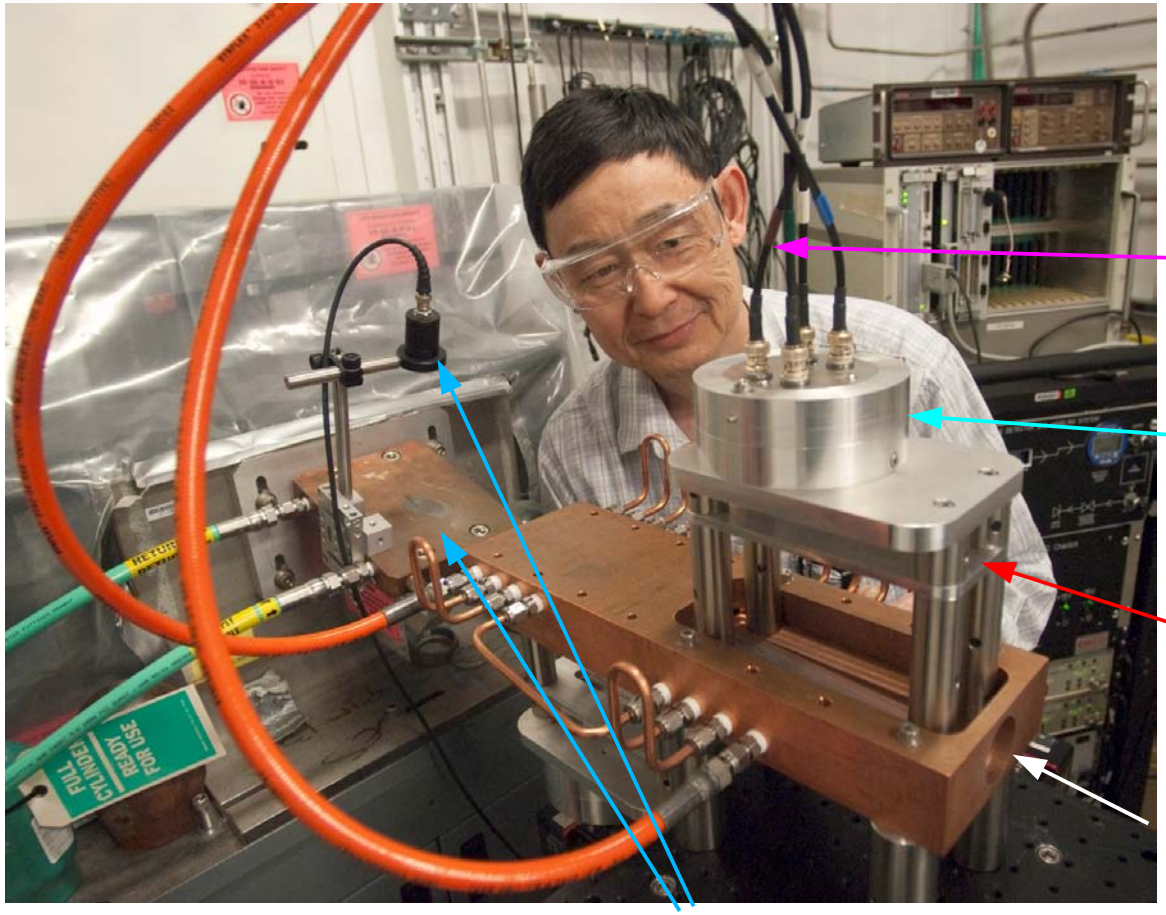
Concept courtesy of Bingxin Yang

Power Density Profiles @ 30 m, APS undulator A, 100 mA

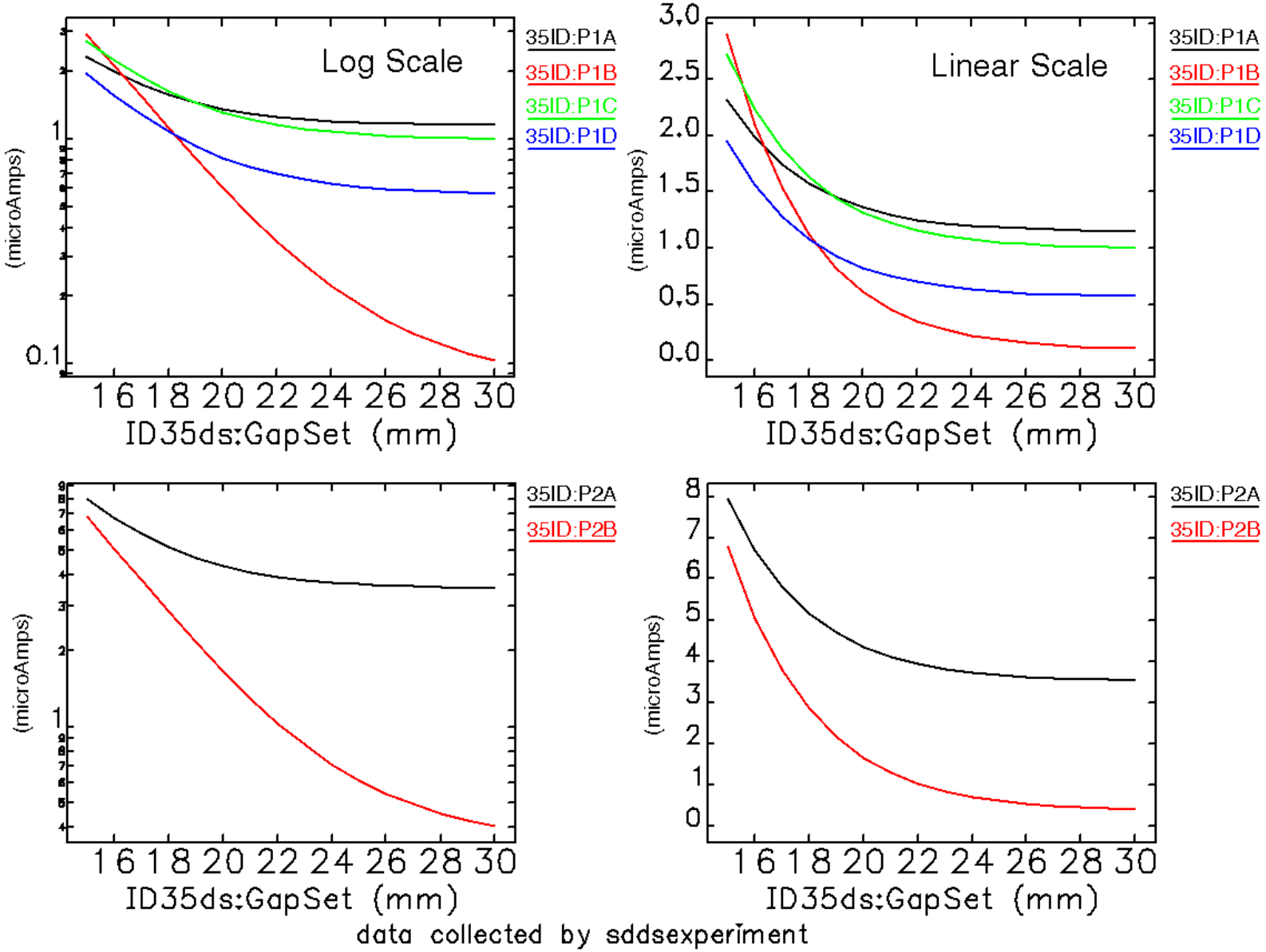


Courtesy of Roger Dejus

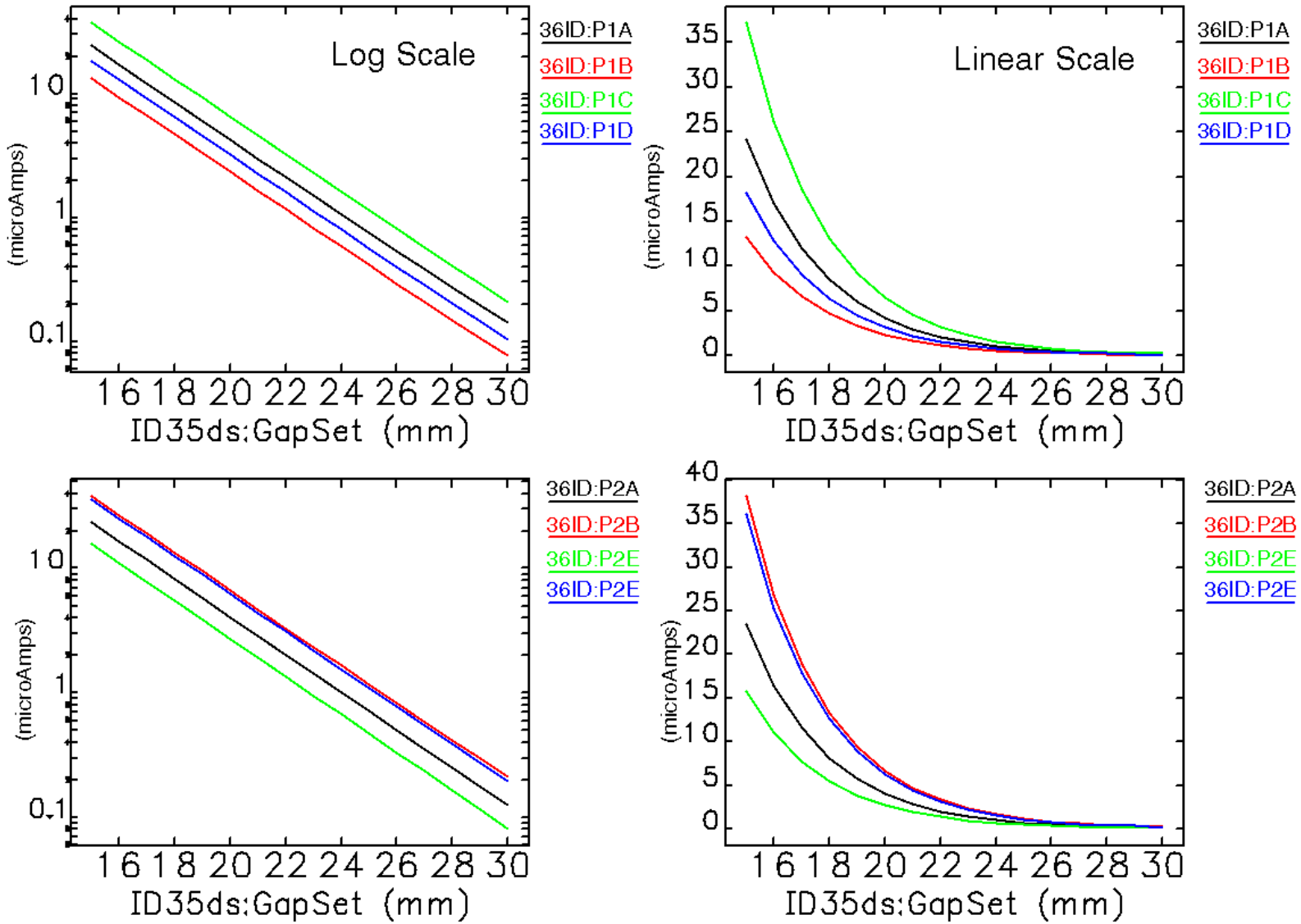
Prototype In-air GRID-XBPM @ 35-ID



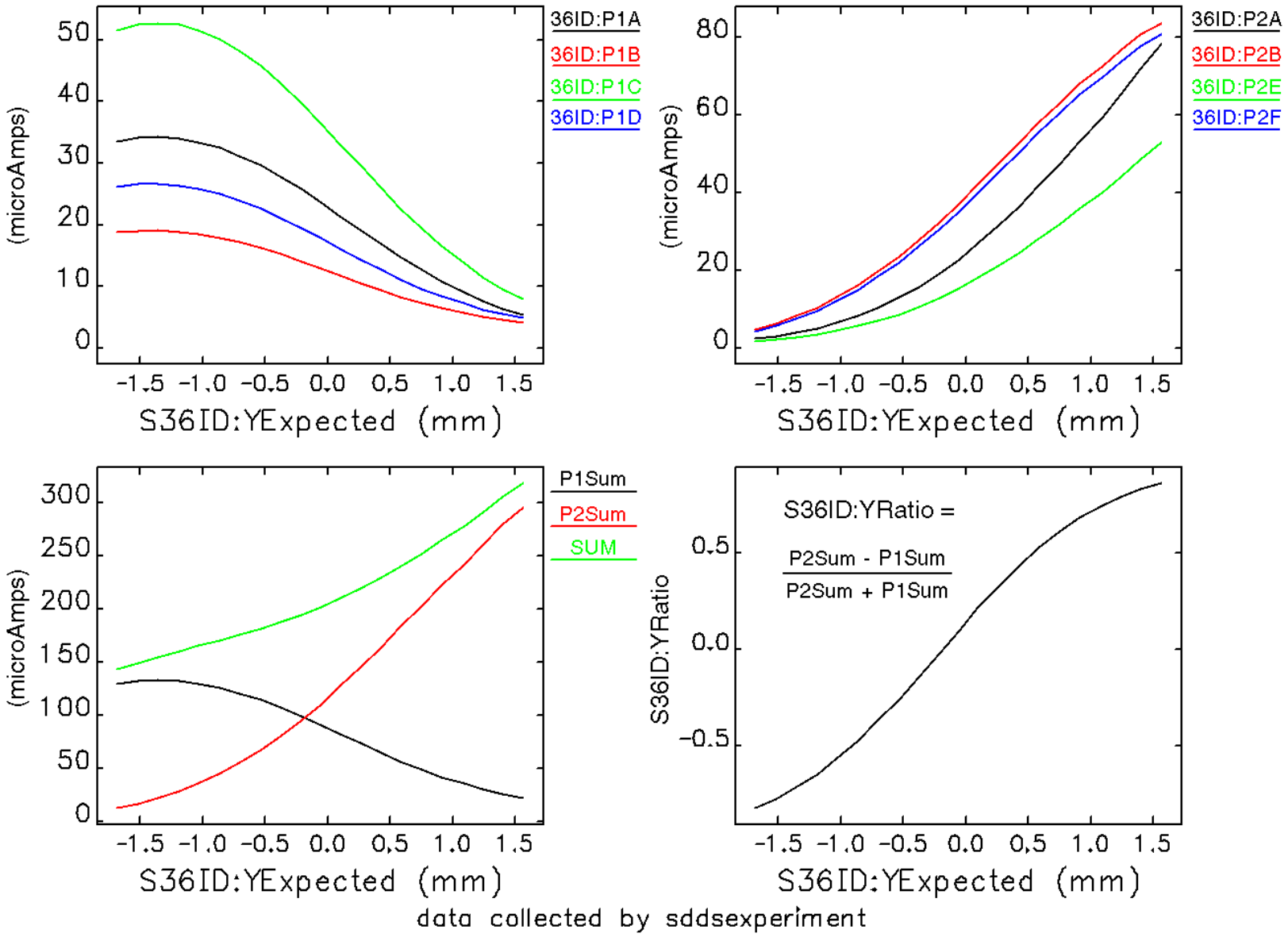
Photoemission Photon Beam Position Monitor Blade Signals vs. ID gap



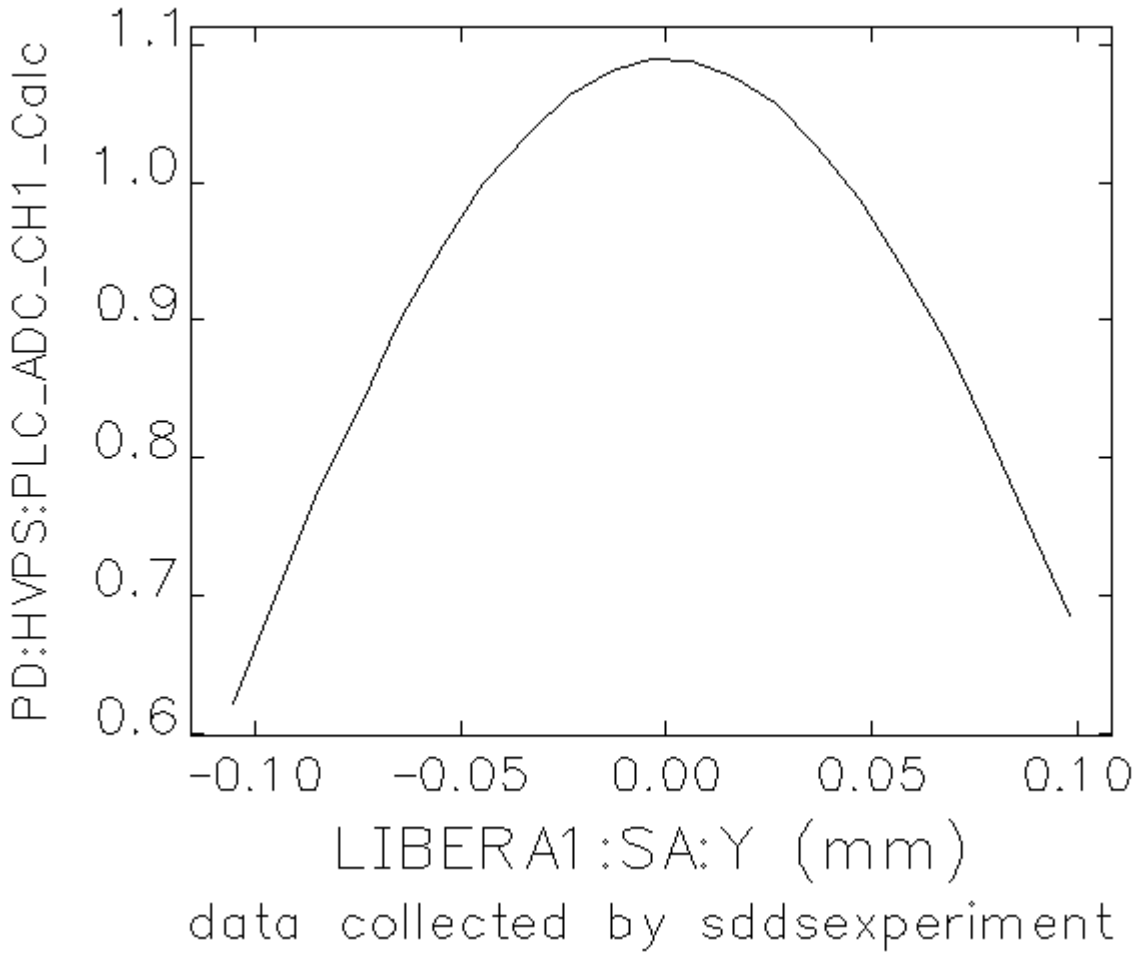
Hard X-ray Fluorescence Beam Position Monitor Photodiode Signals



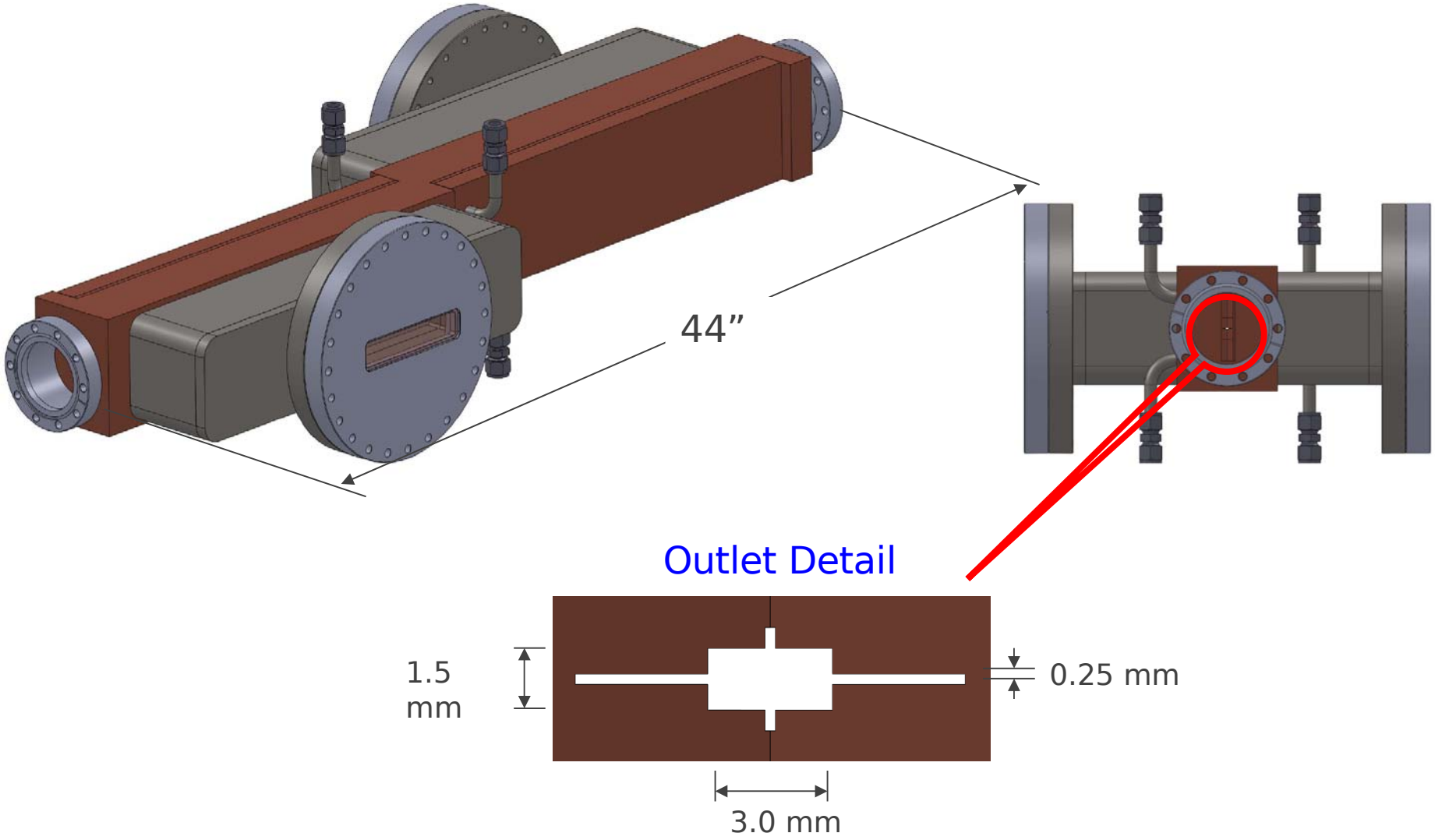
Hard X-ray BPM Signal Variation with Vertical Position



Pass-through flux vs. vertical angle

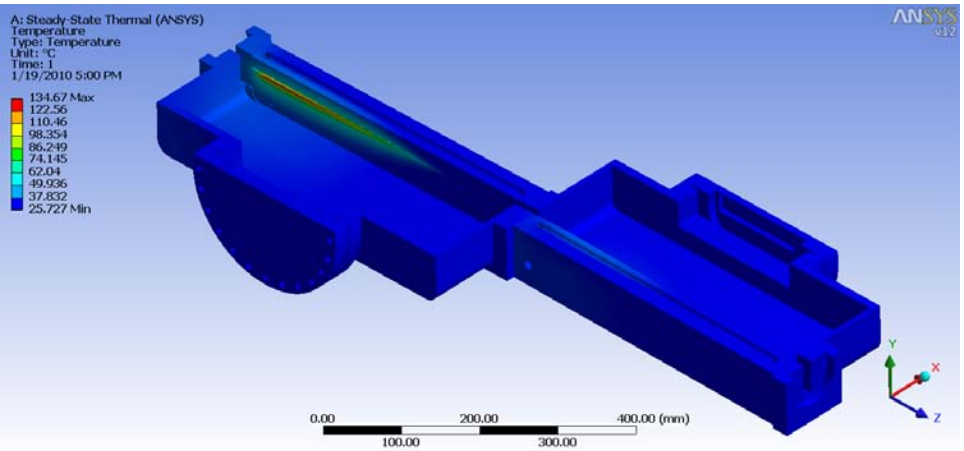


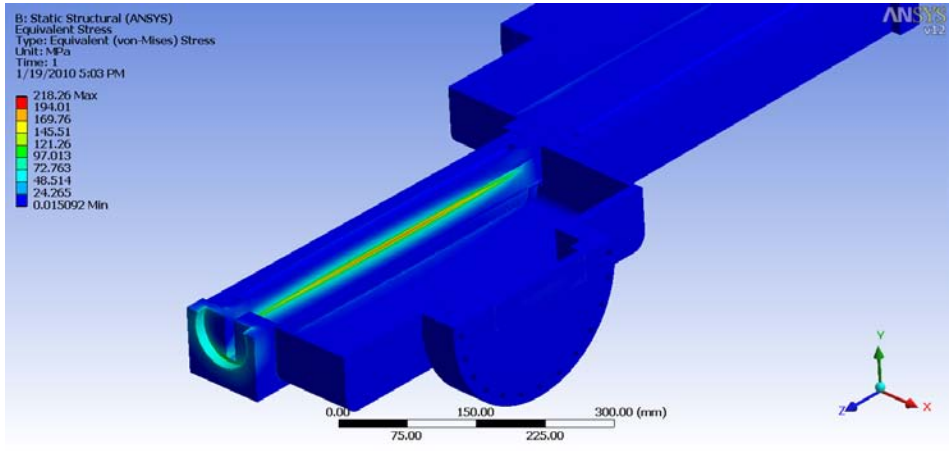
Conceptual Design of the first article GRIIDXBPM



Courtesy of Soon-Hong Lee, AES-MED

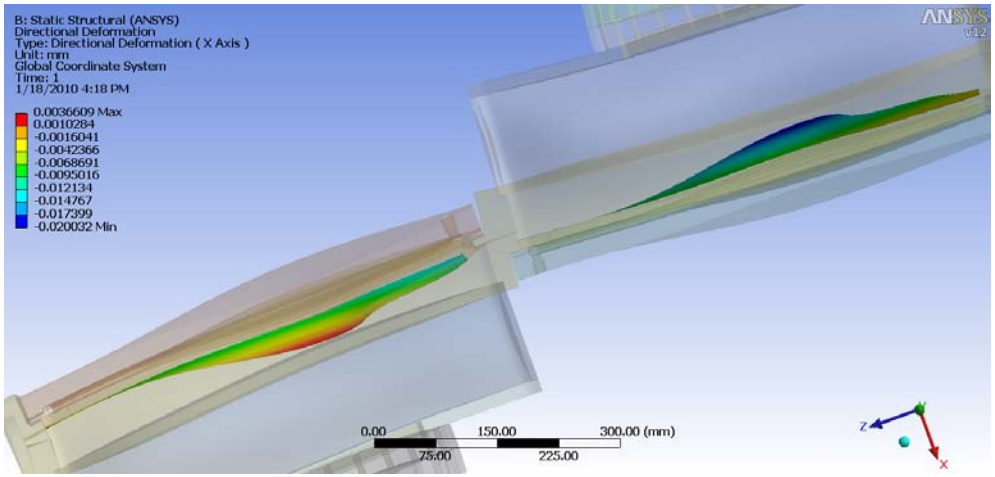
Simulation Result (Preliminary) - Vertical





Temperature Distribution @ Case 4 (Max. 134.7 °C) Stress Distribution @ Case 3 (Max. 218.3 MPa)

~ 11.3 µm bump



Surface deflection @ Case 1
(Horizontal direction only, 2100x)

Beam stability specification (<200Hz)
- Vertical : 0.3 µm rms
- Horizontal: 3.0 µm rms

Note: 10 kW = 5 m
Undulator A @ 100 mA

Courtesy of Soon-Hong Lee, AES-MED

Beam Stabilization Systems Summary

- Present limitations on beam stability are well-understood and several lines of development are converging on a set of proposals supporting a final system conceptual design.
- High-speed field programmable gate arrays with associated embedded controllers are the path forward in many areas. Both ASD-DIA and AES-CTL are aggressively pursuing this technology.
- Thermal effects on long-term drift and means for mitigation are being seriously investigated.
- Beamline 35-ID has played a critical role in the development of a new generation of photon beam position monitoring and many other technologies, and will continue to play a significant QA role once the new hard x-ray fluorescence-based beam position monitors go into serious production.