Recent Thermal Imaging Studies at the APS

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Overview:

- Radiography & Infrared Imaging Capabilities at the APS
- Recent Thermal Imaging Studies at the APS

  Thermal imaging was used to:

  - Assess the surface heating caused by beam scattering on the new GRID XBPM being evaluated at S29-ID-A.
  - Evaluate the thermal stability of the Long Trace Profiler (LTP) instrument located in the Metrology Lab as a function of various room operating conditions.
  - Measure the temperature distribution in a high voltage water bridge under investigation at S11-ID-C.

- Summary and Future Work

Radiography & Infrared Imaging Capabilities at the APS:

FLIR SC6000 (MWIR 3μm-5μm) Photon Detector System Features:

- 640 x 512 focal plane array (FPA) fabricated by hybridizing an Indium Antimonide (InSb) detector array to an readout integrated circuit (ROIC) array
- Measurement range from -20°C to 1500°C
- Temperature sensitivity better than 15 milliKelvin
- 50 Megapixels per second data rate with 14-bit digital image data
- 126 frames per second using the full 640 x 512 FPA
- The FPA can be windowed down to yield frames rates up to 50,000 frames per second
- Image sequences can be recorded in a movie format for high-speed transient analysis
- Synchronized triggering using TTL and CMOS
- Numerous outputs including Gigabit Ethernet, Camera Link, NTSC or PAL

A Display of the IR Camera Sensitivity:

- The palm of my hand placed against the wall of the granite LTP structure for 2 seconds
- Images recorded every second
- Total recording time of 5 minutes
- IR camera sensitivity > 0.025°C

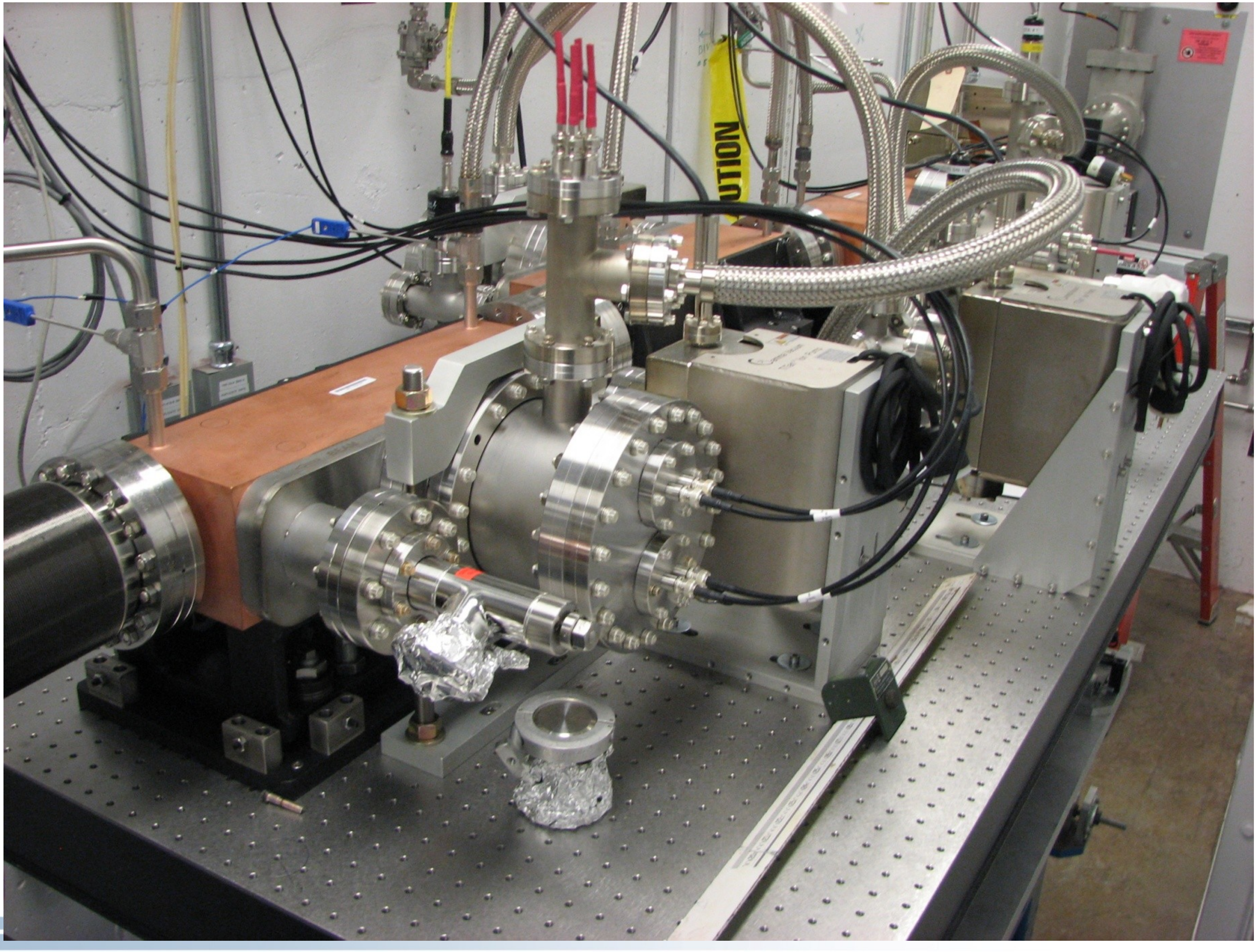
Hard X-Ray Beam Position Monitor (GRID-XBPM):

Principle Investigators: Bingxin Yang, Soon-Hong Lee, Glenn Decker

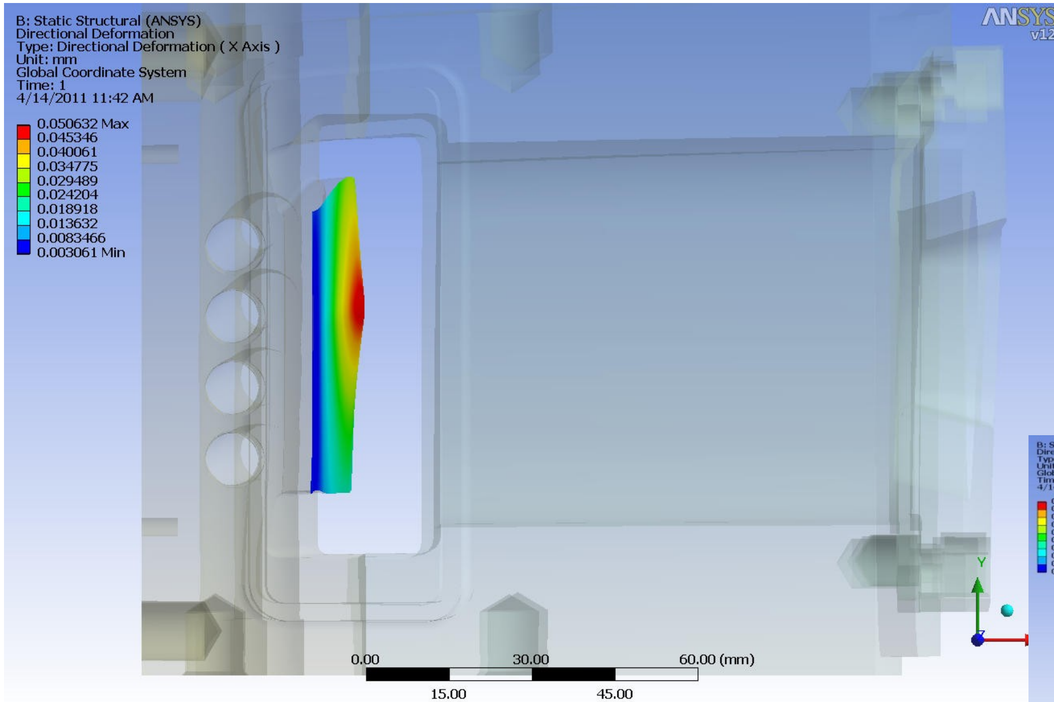
GRID-XPBM Features:

- XBPM based on Cu fluorescence
- Insensitive to bending magnet background
- Linear signal response over a large energy range
- More precise in monitoring undulator beam positions than previous designs
- Designed to handle two in-line Undulator A devices at closed gap (11 mm.) with 200 mA beam current
- Designs suitable for Canted Undulator FE’s and High-Heat-Load FE’s under test at S29-ID-A

Hard X-Ray Beam Position Monitor (GRID-XBPM):

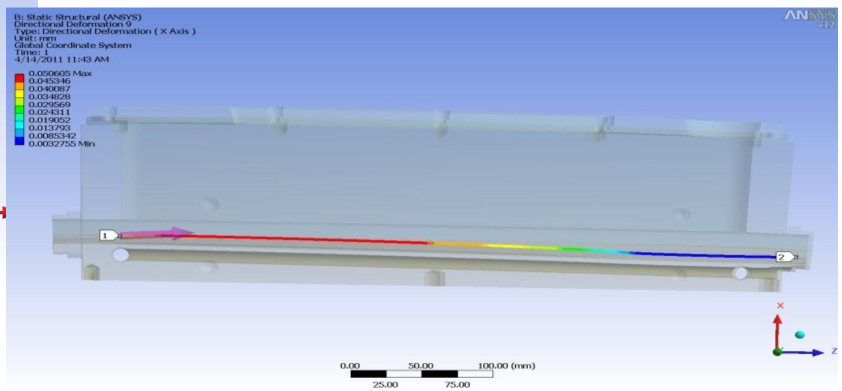


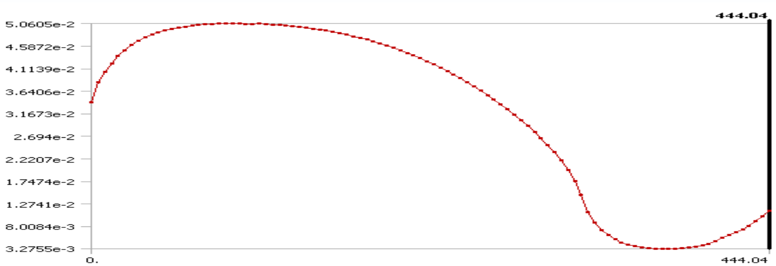
Hard X-Ray Beam Position Monitor (GRID-XBPM):



Surface deflection (Horizontal direction only, 100x)

Thermal bump on the active surface: ~51 µm





Courtesy of Soon-Hong Lee

Hard X-Ray Beam Position Monitor (GRID-XBPM):

Thermal imaging will help address the following issues:

1. Compare the temperature map of the active surface with the model calculations so the thermal bump and the distortion of the primary, active surface can be characterized.

2. Compare the temperature map of the chamber with the model calculations so the distortion of the chamber and the movement of the XBPM under high-power beam can be understood.

3. Determine whether water-cooling is needed for the chamber walls.

Note: For model calculations, Item 1 has been performed many times for many components, the procedure is mature. However, modeling for Item 2 is difficult since the power distributions of fluorescence and scattered x-ray photons are difficult to calculate in a complex collimator geometry.

Hard X-Ray Beam Position Monitor (GRID-XBPM):

Test conditions for the infrared movie:

- Two in-line Undulator A devices
- Closed Gaps, 11 mm.
- Storage ring current = 100 mA
- High-Heat-Load XBPM moved 1.5 mm. down from the aperture center
- Total absorbed power = 3315 Watts (measured using calorimetry)
- Total recording time = 30 min. (15 min. beam on / 15 min. beam off)
- Images recorded every second

The New APS Long Trace Profiler (LTP):

Principle Investigators: Lahsen Assoufid, Jun Qian

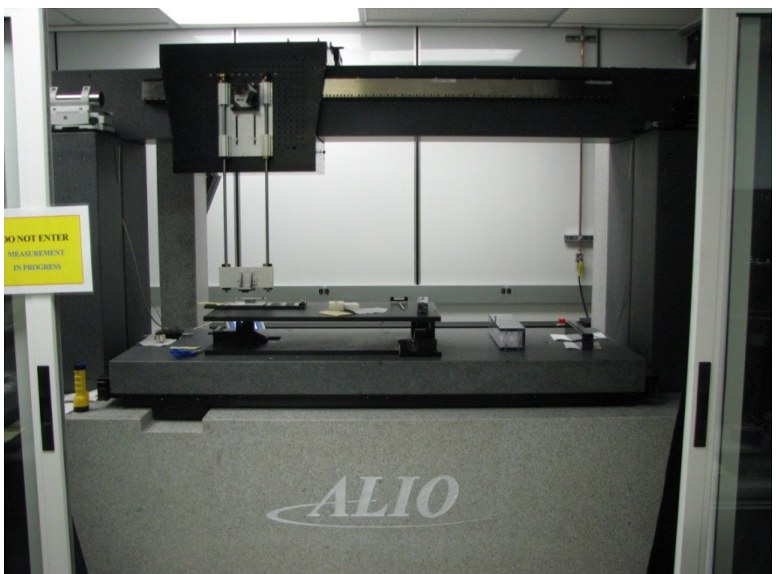
Motivation & Performance Goals:

- Meet new measurement demand: < 500 nrad rms for mirrors over 1 m. long and < 200 nrad rms for mirrors < 300 mm.
- Support upgrade to APS beamlines
- Designed to accommodate multiple sensors
- Phase-I (Current): 100 nrad repeatability
- Phase-II (2-3 year): 50 nrad repeatability
- First sensor based on an autocollimator

The New APS Long Trace Profiler (LTP):

LTP

Enclosure wall and door



Curtain

The New APS Long Trace Profiler (LTP):

- Survey with both temperature point probes (placed around the measurement volume) and an IR Camera.
- Measurements performed under various conditions and duration

L. Assoufid et al. (unpublished)

The New APS Long Trace Profiler (LTP):

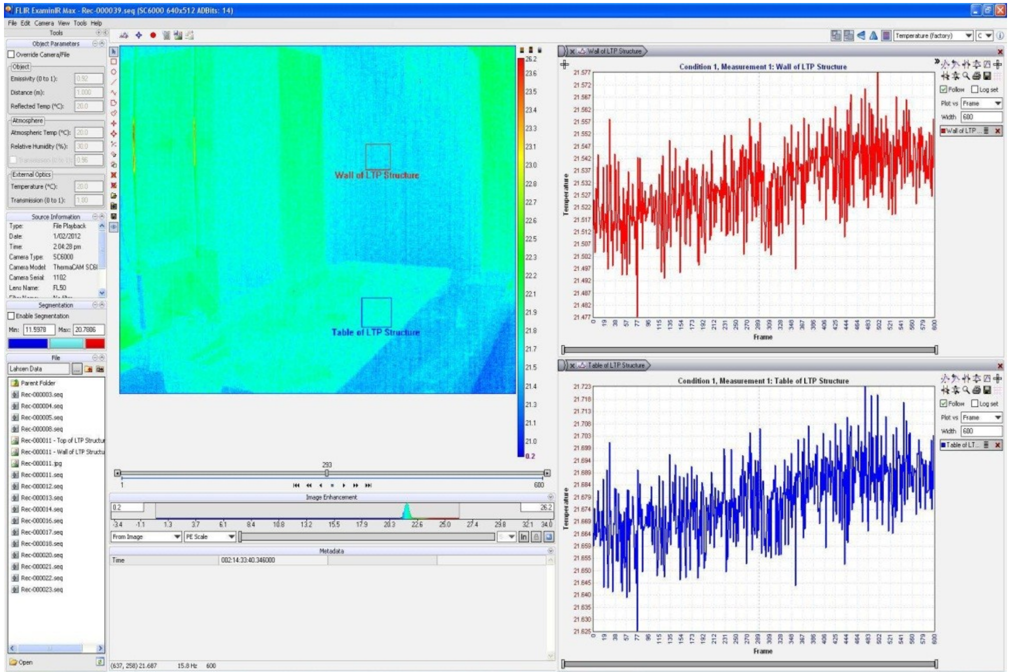
- Air temperature data and infrared surface temperature data were taken simultaneously
- Four different measurement conditions were tested:

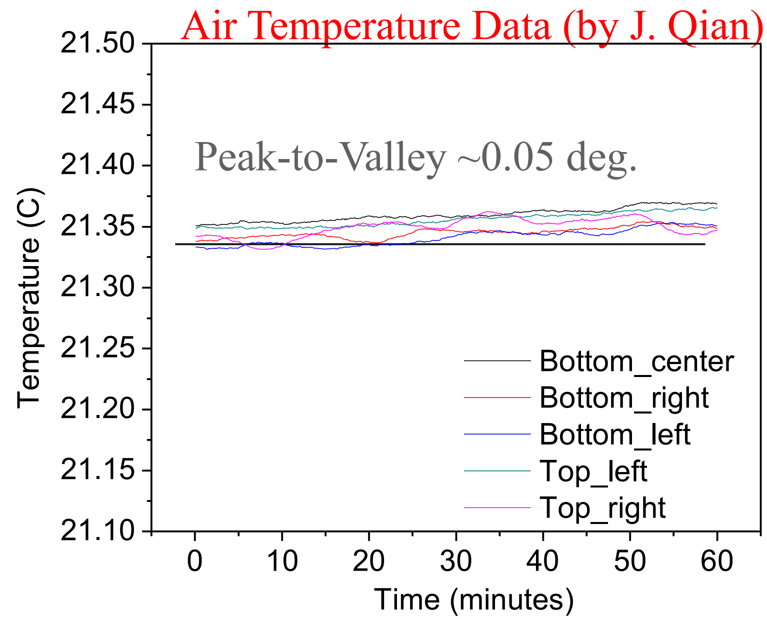
1.) Room air on, Enclosure air on, Enclosure door closed
2.) Room air on, Enclosure air on, Enclosure door open
3.) Room air off, Enclosure air off, Enclosure door closed
4.) Room air on, Enclosure air off, Enclosure door closed

Test conditions for the infrared movie:

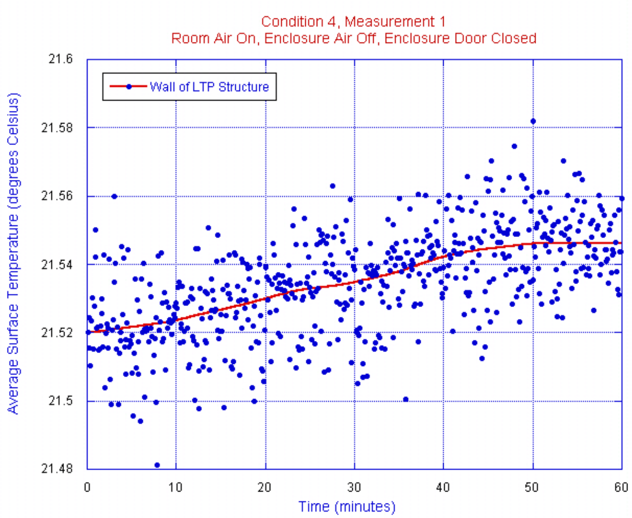
- Condition 4: Room air on, Enclosure air off, Enclosure door closed
- Data collected over a 24 hour period
- IR movie images captured once every minute
- Enclosure air turned off at the start of the data collection

dition 4: Room Air On, Enclosure Air Off, Enclosure Door Closed

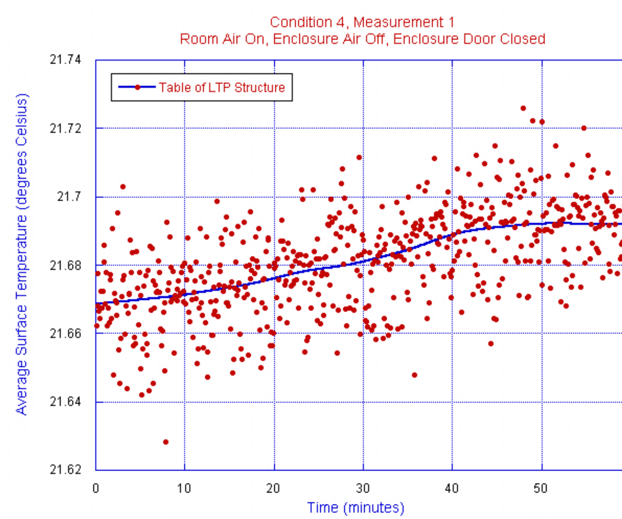




LTP Enclosure Infrared Camera Temperature Measurements:
Wall of LTP Structure



LTP Enclosure Infrared Camera Temperature Measurements:
Table of LTP Structure



High Voltage Water Bridge Experiment at S11-ID-C:

Principle Investigators: Lawrie Skinner, Chris Benmore, John Parise, Richard Weber, Badri Shayam

History:

- The phenomena was first reported in a public lecture in 1893 by British engineer William Armstrong
- High voltage (10-30 kV, direct current) is passed between two glass beakers filled with deionized water
- At some critical voltage (~ 12 kV) the water jumps out from the beakers and forms a wire-shaped connection
- Theories exist, but the phenomena is still not fully understood

Experimental Motivation:

- Gain more understanding of this phenomena using high energy (115 KeV) x-rays to accurately measure the pair distribution function of the water bridge
- Determine the arrangement of the water molecules relative to each other
- Compare data with recent measurements on normal water

High Voltage Water Bridge Experiment at S11-ID-C:

Movie of a high voltage water bridge:

- http://www.youtube.com/watch?v=Actr2E_v26w

Infrared movie of a high voltage water bridge at S11-ID-C:

- Total recording time = 20 minutes
- Images captured every 0.1 seconds (10 frames per second)
- Applied voltage, current, and beaker separation distance are the variables

Summary and Future Work:

- Collect more surface temperature data on the GRID-XBPM and compare with model calculations so the distortion of the chamber and the movement of the XBPM under high-power beam can be understood.

- Install a sapphire window on the detector array flange to allow thermal imaging of the beam strike surface inside of the GRID-XBPM. Compare the temperature map of the beam strike surface with the model calculations so the thermal bump and the distortion of the primary, active surface can be characterized.

- Perform more long-term (~ 24 hour) thermal stability surveys on the LTP device under various room/enclosure operating conditions.

- Help the principle investigators at 11-ID-C reduce the infrared data obtained during the high voltage water bridge experiments.

The End