Development of a Hard X-ray Beam Position Monitor for Insertion Device Beams at the APS

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• Advanced Photon Source Beam Stability Goals

• Present Level of Performance

• Hard X-ray Beam Position Monitor Design

• First Results, Future Plans
Advanced Photon Source Beam Stability Goals

AC goals
(based on 5% of present APS beam size, 0.017 Hz to 200Hz)

<table>
<thead>
<tr>
<th></th>
<th>Displacement (microns rms)</th>
<th>Angle (nanoradians rms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical</td>
<td>0.42</td>
<td>220</td>
</tr>
<tr>
<td>Horizontal</td>
<td>3.0</td>
<td>530</td>
</tr>
</tbody>
</table>

One week drift specification

<table>
<thead>
<tr>
<th></th>
<th>Displacement (microns p-p)</th>
<th>Angle (nanoradians p-p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical</td>
<td>1.0</td>
<td>500</td>
</tr>
<tr>
<td>Horizontal</td>
<td>5.0</td>
<td>1000</td>
</tr>
</tbody>
</table>
Existing Insertion Device and BPM Layout

-2.5 0 2.5

RFBPMs

ID’s

UV Photoemission BPMs

P1

P2

\( \gamma \)

Distance from Source

16.3 20 (meters)

\( e^- \)

Top View

End View

Detail of RF BPM
Pickup Electrode Geometry
4 mm Diameter, rotated

Vertical Aperture Size
7.5 or 8 mm
Insertion Device Ultraviolet Photon Beam Position Monitor

Blade Geometries

Upstream X-BPM (P1)  
4.65 mm

A B

C D

4.50 mm

E F

Downstream X-BPM (P2)

A B

C D

Revised P2 Geometry
(Installed at 5-ID, 7-ID, 14-ID)

A B

C D

\[ \mu A \]

\[
\begin{array}{c}
\text{Insertion Device Gap (mm)}
\end{array}
\]

\[ \mu A \]

\[
\begin{array}{c}
\text{Insertion Device Gap (mm)}
\end{array}
\]

\[ \mu A \]

\[
\begin{array}{c}
\text{Insertion Device Gap (mm)}
\end{array}
\]
Correction of Residual ID Photon BPM Gap-dependent Systematic Errors

Background Subtraction Only

Δx / Σ (Absolute)

ID 20 Gap (mm)

Background + Exponent Corrections

Δx / Σ (Absolute)

ID 20 Gap (mm)

Δx / Σ (Relative)

ID 20 Gap (mm)

Δx / Σ (Relative)

ID 20 Gap (mm)
APS AC Pointing Stability, c.2005

Power Spectral Density

Horz. μrad^2/Hz

μrad rms

Frequency (Hz)

Sqrt[Integ[PSD]]

Vert. μrad^2/Hz

μrad rms

Frequency (Hz)

Sqrt[ReverseInteg[PSD]]

with Feedback

without Feedback

220 nrad Goal

Frequency (Hz)
Pointing Angle Drift, One Week*

*Pointing Angles derived from UV photon bpms, \textit{fixed gap} operation
Plan View of Hard X-ray Beam Position Monitor Concept

Shielded PIN Diode X-ray Detectors (4), Above and Below Plane of Beam

Beryllium Filter

White ID X-ray Beam

Beam-defining Aperture (Fixed)

Insertable Filter Array(C)

X-ray Fluorescence

Water-cooled Moveable Scrapers (Target: Cu or W)
Early Assembly of First Hard XBPM Prototype

“Top View”

- Cooling Tubes
- Horizontal Drive Motor #2 Spindle
- Horizontal Drive motor #1
- Water-cooled mounting plates (Copper)
- Vertical Drive Motor
View along beam direction

Vertical direction, “Up”

Outboard Direction, away from the center of the storage ring
Results of Diode Vertical Translation Stage Scan

- **Diode Current \( \mu \text{A} \)**
- **Undulator gap = 26.25 mm**
- **Undulator gap = 180 mm**

Data collected Jan. 30, 2006
By G. Rosenbaum APS Sector 19
Difference / Sum and Linear Fit

XBPM-vscan-060130  Scan #10
laps = 9.7 mA, gap = 26.25 mm

\[ y = -0.019336 - 0.28557x \quad R = 1 \]

Translation stage position y (mm)
Residual

(Difference / Sum - Linear Fit) / Slope and Polynomial Fit

XBPM-vscan-060130 Scan #10
laps = 9.7 mA, gap = 26.25 mm

\[ Y = M_0 + M_1 x + \ldots + M_8 x^8 + M_9 x^9 \]

| \( M_0 \) | -0.086138 |
| \( M_1 \) | 3.0088 |
| \( M_2 \) | 1.0104 |
| \( M_3 \) | -19.721 |
| \( R \) | 0.72675 |

\( \mu m \)

Translation stage position \( y \) (mm)
Result of Scanning Beam Across Aperture with Local Angle Bump

Vertical Beam Position @ 52 meters (mm)
Summary / Future Plans

• Research is underway using the device at 52 meters from the source toward a photon bpm sensitive only to hard x-rays (> 9 keV) to achieve 500 nrad p-p pointing angle stability. Early results are very encouraging.

• Alternate detectors, including photoresistive single crystal CVD diamond (SLS development) and vibrating wires (Arutunian DIPAC ‘05) will be investigated.

• The effects of x-ray spectral shaping using photon filtering remain to be studied.

• A second retractable high-power destructive diagnostic is being designed to be placed 25 meters from the source, downstream of the beam defining aperture.

• Ultimate goal is a non-destructive high-power device to be placed inside the accelerator enclosure, 20 meters from the source using existing UV bpm infrastructure.