Outline

• Background
  Scientific Program, SMI Scope, Beamline Layout, Commissioning Sequence

• Pillar I: Documentation:
  Ray tracing, FLUKA Calculation, RSC Review, Design Reviews, Hazard Identification and Mitigation

• Pillar II: Hardware
  Radiation Safety Components, Other Credited Controls, Utilities, EPS, Controls, Diagnostics

• Pillar III: Personnel
  Beamline Commissioning Team
The NEXT Project (NSLS-II Experimental Tools)

- Scope: 5 beamlines (and 1 beamline design)
- DOE funded project
- Timeline:
  - CD-0 start date: May 2010
  - Early completion date: January 2017
  - CD-4 date: September 2017

SMI Beamline:

- Scope: Photon Delivery System, infrastructure, and sample and detector positioning
- SMI beamline construction combines procurements with in-house mechanical design and fabrication
Scientific Programs and Design Goals

SMI Beamline

Focus areas:

- Hierarchical structures: SAXS/WAXS
- Functional soft matter surfaces and interfaces: Grazing Incidence
- Time-resolved studies: reactions, hydration
- Pioneering access to P, S, K, Ca resonance: 1.2–24 keV energy range

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification/Description</th>
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<tbody>
<tr>
<td>Insertion device:</td>
<td>IVU23, 2.8-m, canted, high-β straight</td>
</tr>
<tr>
<td>Operating energy range:</td>
<td>2.1 – 24 keV</td>
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<tr>
<td>Monochromator:</td>
<td>Fixed-exit Si(111)</td>
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<tr>
<td>Beam size at sample (FWHM):</td>
<td>Tunable down to 30 (H) x 2.5 (V) µm²; Low divergence mode &lt; 300 µrad</td>
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<tr>
<td>Flux at sample (500 mA ring current):</td>
<td>~10¹³ photons/s</td>
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<tr>
<td>Detector readout rate:</td>
<td>500 Hz Pilatus 300K-W and Pilatus 1M</td>
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<tr>
<td>Micro-focus optics:</td>
<td>CRL Transfocator ~1.5m from sample</td>
</tr>
</tbody>
</table>
| Endstation configurations: | 12-ID-C: Grazing-Incidence Small/Wide Angle X-ray Scattering (GI-SAXS/WAXS) with Micro-Focus and Low-Divergence Modes  
12-ID-B: Diagnostics and Future Outboard Branch (PLS) |
IRR Scope

IRR scope includes:
1. Photon Delivery System (GV2 through 12-ID-C)
2. Enclosures: 12-ID-A, -B, -B-1, and -C
3. Motion and monitoring system of PDS
4. EPS (related to PDS), PPS, all infrastructure necessary for commissioning Photon Delivery System
5. WAXS Assembly: Sample and Detector Positioners

IRR scope exclusions:
1. SAXS Assembly in 12-ID-C
2. Pilatus Detectors
3. X-ray Beam Position Monitors
4. Beam conditioning (attenuators)
Self-identified Pre-start Findings

Pre-start findings:

None

Post-start findings:

None
Optical Layout

- IVU23 in downstream section of long straight
- Asymmetric canting
- Optimized for 2.1-24 keV

GISAXS/WAXS Experiment: 12-ID-C
Diagnostics: 12-ID-B

Minimum gap: 6.1 mm
Beamline Layout

- First Optics Enclosure:
  12-ID-A (lead lined hutch)
- Steel Hutches:
  12-ID-C: GI-SAXS/WAXS
  12-ID-B: Diagnostics
## Commissioning Sequence

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<tbody>
<tr>
<td><strong>Installations</strong></td>
<td>XBPMs, SAXS Assembly, Attenuators, Detectors (Dec.)</td>
<td>CFN Partner CCD Detector (MAXS)</td>
<td></td>
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<tr>
<td><strong>Capabilities</strong></td>
<td>~10 keV x-ray beam into 12-ID-C</td>
<td>Hard x-rays, 6.5-24 keV <strong>NEXT KPP</strong> (by 31 Jan 2017)</td>
<td><strong>Time resolved GISAXS/WAXS Science Commissioning</strong></td>
<td>Multi-detector experiments; Microbeam experiments</td>
<td>Full energy range available 2.1-24 keV <strong>Goal: GU</strong></td>
</tr>
<tr>
<td><strong>Technical</strong></td>
<td>Photon delivery system</td>
<td><strong>Time resolved GISAXS:</strong> Sample pos’n, Pilatus detector data acquisition</td>
<td>Medium-angle x-ray scattering (MAXS); Micro-focus CRLs</td>
<td><strong>Tender x-ray energy range, 2.1-4.5 keV</strong></td>
<td>Liquid interfaces</td>
</tr>
</tbody>
</table>

*pending successful completion of preceding activities*
Pillar I: Documentation
• Prepared using Synchrotron and Bremsstrahlung Ray Trace Procedure (PS-C-XFD-PRC-008)
• Includes absolute positioning (±0.22 mm) and manufacturing (±0.14 mm) tolerances; as-surveyed component locations are used.
Shielding Concept: Dual Aperture Masks

• SMI constructed with dual aperture masks and wide stops for drop-in outboard upgrade
• PPS aperture and Fixed Aperture Mask ensure that wide SR fan ends at White Beam Stop
• Outboard branch constrained to similar optics (100μrad FAM, 25mm DCM step-up)
Shielding Concept: Primary Bremsstrahlung

• Primary bremsstrahlung shielding: tungsten collimator, tungsten stop
• One instance where extremal rays are close to tolerance
• FLUKA calculations show that this condition (i/b and u/s) is safe (close to ratchet wall)
Shielding Concept: Secondary Bremsstrahlung (SGB)

- Geometric analysis indicated that SGB shields would be necessary
- Shield 1: after WB Slits
- Shield 2: after DCM
- FLUKA analysis performed with shields in model
- GB on movable optics scatters significantly

Dose on contact with downstream wall ≤ 0.4 mrem/hr
Review held on 11 Oct. 2016

- Findings:
  Doses at FOE d/s wall in range 0.05-0.4 mrem/hr on contact (SGB from movable optics)

- Response:
  Incorporated into Radiation Survey Plan.
Radiation Survey Procedure

• **NSLSII-12ID-PRC-001**

• GB Radiation Survey: IVU gap open, FE slits wide
  • Integrity 12-ID-A, GB on fixed components
  • GB on movable components (WB Slits, DCM 1st crystal)

• Synchrotron radiation survey: IVU gap closed, FE slits wide
  • Integrity 12-ID-A, white beam on fixed components
  • White beam on movable components

• Monochromatic beam surveys:
  • Configuration with beam in 12-ID-C experiment
  • Configuration with beam in 12-ID-B diagnostic

• Plan first comprehensive radiation survey (CRS) at 100mA; will enable SMI to work with ring current ≤ 300mA
# Design Reviews

<table>
<thead>
<tr>
<th>DOE Review Process</th>
<th>BAT Meetings</th>
<th>Formal PDR/FDR Beamline</th>
<th>Package FDR</th>
<th>Internal Design Reviews</th>
</tr>
</thead>
</table>
| CD-0, CD-1, CD-2, CD-3, and intermittent status reviews | 5 BAT meetings | • CD-2 was FDR for SMI  
• Remaining endstation design work treated by internal reviews | Held at BNL, with Subject Matter Experts attending | • Radiation safety  
• Thermal mgt / FEA  
• 2 ES Design reviews  
• 2 Optics reviews |
| Recommendations tracked by project management | Recommendations tracked by project management | Recommendations tracked by project management | Recommendations directly implemented into design (with QA as representative) | Tracked by ATS |
| Review Reports | BAT Reports | PDR, FDR, & Reports | Meeting Notes & Reports | Reports |

- Documents maintained in Vault and Sharepoint
  

- All items closed out

- Review flow:
Hazard Identification and Mitigation

• USI evaluation is negative
• Relevant BNL/NSLS-II safety procedures and practices are followed during design/construction and commissioning (SBMS & ISM)

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Mitigation</th>
</tr>
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<tbody>
<tr>
<td>Radiation</td>
<td>Shielding, PPS, ARM</td>
</tr>
<tr>
<td>Fire</td>
<td>Future: fire suppression and fire alarm system in 4-ID-D for gas handling system (ESR)</td>
</tr>
<tr>
<td>Cryogenics</td>
<td>ODH system installed in 12-ID-A</td>
</tr>
<tr>
<td>Hazardous material - Lead</td>
<td>Painted and/or covered</td>
</tr>
<tr>
<td>Pressure safety vessel</td>
<td>FEA calculations, over-pressure tests (if appropriate), burst discs</td>
</tr>
<tr>
<td>Electrical</td>
<td>EEI, grounding, installation according to code</td>
</tr>
</tbody>
</table>
Pillar II: Hardware
Shielded Enclosures and Transport Pipes

Inboard and outboard beam penetrations in 12-ID-B-1

Removable beam stop block and shielded beam pipe in 12-ID-B

• Lead-shielded FOE: 10 mm roof, 18 mm sidewall, 50 mm downstream wall
• Steel hutches B, C, and D: 3 mm roof, 6 mm side and downstream walls
• Lead-shielded beam transport pipes, pump enclosures, and flange covers: 5 mm
• Lead-shielded hutch interfaces: ≥ 10 mm
• Hutch doors and one or more labyrinths per hutch are PPS-interlocked
• Removable shielded beampipe in 12-ID-B, constructed like walkway transport
Radiation Safety Components

1. PPS Aperture/ Fixed Aperture Mask
2. GB Collimator
3. (White Beam Slits. Movable, SGB scatterers, not rad safety component)
4. (Pinhole aperture. FUTURE movable device, SGB analysis only, not RSCmpt, not installed)
5. SGB Shield 1
6. (DCM. Movable, SGB scatterer, not rad safety component)
7. SGB Shield 2
8. White Beam Stop
9. GB Stop
10. Photon Shutter
11. Guillotine

Mono beam enclosures:
1. Guillotines
2. Beam Stops
Radiation Safety Components

• Critical components are surveyed into position. All installations complete.

• Components under configuration control are labeled and inspected according to NSLS-II procedure PS-C-ESH-PRC-025

• Checklist for 12-ID is PS-R-XFD-CHK-015
Other Credited Safety Components

(a) Area Radiation Monitor (ARM) at 12-ID FE sliding door

(b) ARM on 12-ID-A near door

(c) Oxygen Deficiency Hazard (ODH) Monitor
Utilities

- Documentation: PD-SMI-UT-1500, Travelers
- Electric: only ‘dirty’ power
- Gases: gaseous nitrogen, compressed air (CA), high-capacity CA for DCM Bragg theta air bearing
- Cooling Media: DI-water (only FOE), process chilled water (control racks, 12-ID-B/C and -D), LN2 in FOE (through cryocooler)
Equipment Protection System

- Pressures, temperatures, and flow rates are measured, recorded, and displayed.
- Easy-to-understand screens allow beamline staff to monitor component status.
- Cryocooler is fully integrated into the EPS system.

Photograph of live monitor at SMI control station.
• Motors and actuation required for first light have been tested
• EPICS software ready
Diagnostics

Access with photodiodes  XBPMs after DCM, VFM, SSA

Other diagnostics: screens and photocurrent measurements

- IRR scope:
  - White beam slit photocurrent
  - White beam stop phosphor + camera
  - HFM stripe photocurrent
  - Retractable fluorescent screen after HFM
  - Secondary Source Aperture slit photocurrent
  - Photodiodes + cameras in diagnostic and sample positions
- November/December installation:
  - XBPM1 after DCM, XBPM2 after VFM, XBPM3 before SSA
Pillar III: Staff
| Authorized Beamline Staff | Mikhail Zhernenkov (Assoc. Scientist)  
|                          | Sung-Leung Ivan So (Controls Engineer)  
|                          | Richard Greene (Program Technician)  
| Beamline Supporting Staff | Daniel Bacescu (Mechanical Engineer)  
|                          | Scott Coburn (Mechanical Engineer)  

All staff members have completed the required training
*(with the exception of training dependent on PPS completion)*
Summary

- The Photon Delivery System + WAXS Ass’y in IRR scope
- Commissioning will be carried out in five stages:
  - Photon Delivery System
  - Time Resolved GISAXS
  - Multi-detector acquisition + Microfocusing
  - Tender X-ray Energies
  - Liquid Interfaces
- Beamline is ready for first light
- Endstation installation is performed in parallel with commissioning activities