NIST and BNL

has over 30 years of history here at BNL. We operated 3 beamlines at the old facility providing photon and electron spectroscopies over an energy range that covered the entire periodic table and formed the basis for our partner project here at NSLS-II.
NIST at NSLS-II

NIST has funded and constructed a suite of spectroscopy beamlines including BMM, SST-1, and SST-2. Together, these beamlines cover and improve upon the capabilities of our user beamlines from NSLS and add a variety of new capabilities in imaging and X-ray diffraction.

BMM is a hard X-ray beamline with end stations dedicated to absorption spectroscopy and diffraction.

The scientific program meets NIST’s mission of developing advanced synchrotron measurement methods and applying synchrotron radiation to all aspects of material Science. In this way, we impact a range of societal challenges in energy, health, environment, national security.
# BMM Beamline Properties

<table>
<thead>
<tr>
<th>Photon Source</th>
<th>Three-pole wiggler</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operating Energy Range</strong></td>
<td>4500 eV to 23000 eV</td>
</tr>
<tr>
<td><strong>Monochromator</strong></td>
<td>Double crystal monochromator, Si(111) and Si(311), lateral translation between crystal sets</td>
</tr>
<tr>
<td><strong>Beam size at sample</strong></td>
<td>5 mm (V) x 20 mm (H) (collimated, unfocused)</td>
</tr>
<tr>
<td></td>
<td>&lt;300 µm (toroidal focusing mirror)</td>
</tr>
<tr>
<td><strong>Flux at sample at 500 mA storage ring current</strong></td>
<td>Si(111): 2x10^{12} ph./sec at 10 keV; 6x10^{10} ph./sec at 20 keV</td>
</tr>
<tr>
<td></td>
<td>Si(311): 4x10^{11} ph./sec at 10 keV; 1x10^{10} ph./sec at 20 keV</td>
</tr>
<tr>
<td><strong>Energy resolution</strong></td>
<td>Si(111): 1.3x10^{-4} ΔE/E; Si(311): 3x10^{-5} ΔE/E</td>
</tr>
<tr>
<td><strong>Detector system</strong></td>
<td>Ionization chambers, silicon drift detectors</td>
</tr>
</tbody>
</table>
IRR Scope

IRR scope includes:
1. Photon Delivery System (GV2 through 06-BM-B)
2. Enclosures: 06-BM-A, 06-BM-B
3. Photon Delivery System diagnostics
4. EPS, PPS, all infrastructure necessary for commissioning the Photon Delivery System

IRR scope excludes:
1. Front-end and TPW source (FE IRR completed 1 June, 2017)
2. Measurement capabilities related to X-ray diffraction
3. Slew scanning of the monochromator
Self-Identified Pre-Start Findings

None as of 11 July, 2017
Mirrors:
- M1: Paraboloid collimating mirror
- M2: Toroidal focusing mirror
- M3: Flat harmonic rejection mirror

Diagnostic modules:
1. Fluo screen, filters
2. Fluo screen, slits, intensity monitors
3. Fluo screen, slits, intensity monitors, beam profile monitor

DM3+FS

DCM: Si(111)/Si(311) monochromator
Commissioning Sequence

1. Using low current ops, steer the beam into the end station, exercising all beamline diagnostics
2. Perform all radiation survey activities
3. Adjust M1 to maximize energy resolution
4. With M1 optimized, characterize the performance of the monochromator and commission a fixed-exit energy axis
5. Characterize the performance of the focusing and harmonic rejection mirrors.
6. For all combinations of end station location, energy range, focused beam, and unfocused beam, create a lookup table of beamline configurations, allowing efficient planning and execution of different experiments.

At this stage, we will have commissioned step-scanning, transmission-mode XAFS. This provides the foundation for all near- and long-term plans for development of measurement capabilities.
Ray Tracing

- Prepared using Synchrotron and Bremsstrahlung Ray Trace Procedure (PS-C-XFD-PRC-008)
- Includes absolute positioning (±0.22 mm) and manufacturing (±0.18 mm) tolerances
**Shielding Concept: Synchrotron Beam**

- White beam intersects the front-end mirror (M1) (88W)
- Fixed mask 3 blocks white beam when M1 is lowered out of beam path
- Pink beam is transported into the FOE (70W)
- Pink beam passes a filter assembly before the DCM (24W-57W)
- A pink beam stop blocks the pink beam in the case where the mono crystal is lowered out of the beam path
- Mirror M2 or M3 (or both) redirects the mono beam into the end station (≈20mW)
- Shielded transport pipe protects against mono beam incorrectly steered by M2 or M3

---

**Diagram Details:**
- Beam Direction
- Z Axis, Scale 1:1
- Y Axis, Scale 1:100

**Key Components:**
- M1
- M3&M2
- PBS
- Transport pipe
Shielding Concept: Primary Bremsstrahlung

- Front end collimator 1 defined Bremsstrahlung aperture
- Primary stop located downstream of DCM, just below the synchrotron aperture
Shielding Concept: Secondary Bremsstrahlung

**Shielding Concept:**

- **Secondary Bremsstrahlung Shield #1**
- **Secondary Bremsstrahlung Shield #2**
- **Secondary Bremsstrahlung Shield #3**

**Note:**

The mono vessel position is *not* under configuration control, in line with recommended practice.

The DM1 and M2 vessels are under configuration control.

**Beam direction**

---

Renderings provided by FMBO
Review held on May 9, 2017

“Based on our assessment of the ray-tracing drawings, the RSC finds the Bremsstrahlung and synchrotron shielding designs for the front-end of the BMM beamline meeting the NSLS-II shielding policy.”
 Radiation Survey Plan

- **NSLSII-6BM-PRC-001**
- Survey of front end at 100 mA conducted June 6, 2016 with no finding above background
- Beamline survey procedure (the short version)
  - Since BMM is an energy scanning beamline, surveys to be conducted at ≈10 keV and ≈20 keV
  - Pink beam scattering targets identified, scattered radiation to be measured in configurations with beam striking each target
  - Mono beam targets identified in FOE and end station, scattered radiation to be measured in configurations with beam striking each target
- First comprehensive radiation survey (CRS at 120mA); allowed to take up to 3 times the beam current after each CRS
### Design Reviews

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>SST+BMM Beamline Optics Package PDR</td>
<td>5-7 May, 2015</td>
</tr>
<tr>
<td>SST+BMM Photon Delivery Systems FDR</td>
<td>1-2 September, 2015</td>
</tr>
<tr>
<td>BAT meeting</td>
<td>14-15 July, 2016</td>
</tr>
<tr>
<td>FDR Teleconference for the BMM Contract Additions</td>
<td>29 November, 2016</td>
</tr>
<tr>
<td>BMM Beamline FDR</td>
<td>8 February 2017</td>
</tr>
<tr>
<td>Front-end IRR</td>
<td>1 June, 2017</td>
</tr>
</tbody>
</table>
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>
</thead>
<tbody>
<tr>
<td>Radiation</td>
<td>Shielding, PPS, ARM*</td>
</tr>
<tr>
<td>Cryogenics</td>
<td>ODH system installed in 06-BM-B</td>
</tr>
<tr>
<td>Hazardous material - Lead</td>
<td>Painted and/or covered</td>
</tr>
<tr>
<td>Pressure safety</td>
<td>Over-pressure tests, burst discs</td>
</tr>
<tr>
<td>Electrical</td>
<td>EEI, grounding, installation according to code</td>
</tr>
</tbody>
</table>

*ARM not required as a result of TOSS analysis NSLSII-TOS-RPT-012, 06-BM (BMM) Top-Off Radiation Safety Analysis and Tech Note #249, 06-BM BMM Beamline Radiation Shielding Analysis – Addendum.
Shielded Enclosures and Transport Pipes

Lead FOE + large aperture shutter

Shielded transport pipe + ion pump coffin

Roof Labyrinths on 06-BM-A

**Hutch A (FOE, pink beam hutch):**
- Lateral wall: 18 mm lead
- Downstream wall: 50 mm lead
- Roof: 4 mm lead

**Transport section:**
- Transport pipe: 19 mm steel + 8 mm lead
- Ion pump coffin: 18 mm steel + 8 mm lead

**Hutch B (FOE, monochromatic beam hutch):**
- Side walls: 3 mm steel
- Upstream wall: 3 mm steel
- Downstream wall: 6 mm steel
- Roof: 2 mm steel
- Beam stop: 19 mm lead
Radiation Safety Components

Synchrotron beam:
- PPS aperture
- M1 intercepts the white beam
- Pink beam mask (DM1) and water cooled pink beam stops (after DCM)
- Two monochromatic beam masks (one each in FOE and SOE)
- Photon shutter in FOE
- Beam stop in 06-BM-B

Bremsstrahlung: F.E. collimation, primary stop, three secondary shields, beam stop
Other Credited Safety Components

Oxygen Deficiency Hazard (ODH) Monitor
Utilities

- Electric: dirty mains power + 3-phase and 208 in end station
- Gases: compressed air, gaseous nitrogen
- Cooling Media: DI-water (only FOE), process chilled water (control racks, 06-BM-B), experimental LN2 in 06-BM-B
Equipment Protection System

- Pressures, temperatures, and flow rates are measured, recorded, and displayed.
- Easy-to-understand screens allow beamline staff to monitor component status.
Motor controllers for photon delivery system on roof of 06-BM-A

EPICS back-end to be integrated into NIST’s beamline controls system.
Diagnostics

Diagnostic module 1:
- visualize beam from FE mirror M1
- filter beam to manage heat load on DCM

Diagnostic module 2:
- visualize beam after DCM
- slits instrumented for drain current, control size of beam on M2 and M3
- foil intensity monitor for DCM feedback

Diagnostic module 3 in end station:
- visualize beam from M2 and M3,
- foil intensity monitors
- instrumented slits for mirror feedback,
- beam profile monitor
# NIST Staff

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIST Project Leader</td>
<td>Daniel Fischer</td>
</tr>
<tr>
<td>Lead Beamline Scientist</td>
<td>Bruce Ravel (NIST)</td>
</tr>
<tr>
<td>Authorized Beamline Staff</td>
<td>Joseph Woicik (NIST)</td>
</tr>
<tr>
<td></td>
<td>Jean Jordan-Sweet (IBM)</td>
</tr>
<tr>
<td></td>
<td>Johnny Kirkland</td>
</tr>
<tr>
<td>Authorized Beamline Staff</td>
<td>Beamline Scientist</td>
</tr>
<tr>
<td></td>
<td>Beamline Scientist</td>
</tr>
<tr>
<td></td>
<td>Controls Engineer</td>
</tr>
</tbody>
</table>

All staff members have completed their training.
Without the many talents and hard work of our excellent technical staff, BMM would not be nearly so fine a beamline.

- Chris Stebbins
- Greg Fries
- Jean Smiles
- John Fabijanic
- Andrew Ackerman
- Kristen Rubino
- Jimmy Biancarosa
- Mike Maklary
- Rodger Hubbard
- Ming Ke
- Steve Bennett
- Travis Herbst
- Steve Sauter
- Rick Skelany
- Garrett Bischof
- Huijuan Xu
- Harman Bassan
- Mo Benmarrouche
- Rob Todd
- Charlie De La Parra
- Jim Grandy
- Mary Carlucci-Dayton
- Kim Wehunt
- Ken Harsch
- Ed Granger
- Guillermo Aparicio
- ZY Yin
- Guimei Wang
- Brian Walsh
- Russ O'Brien
- Joe Zipper
- Danny Pedrazo
- Paul Northrup
- Chris Danneil
- Mike Fulkerson
- Matt Cowan
- Leon Flaks
- Keith Detmer
- Art Harris
- Rich Gagliardi

(And many others I certainly should have remembered...)
The Photon Delivery System is the scope of this IRR

Initial Commissioning:
- Configuration of all modes of the Photon Delivery System
- Establishment of step-scanning, transmission XAS on the XAS end-station

Future Commissioning:
- Goniometer end-station
- Continuous scanning of the monochromator

Beamline is ready for first light
Endstation installation is complete for XAS end-station