Refer to Photon Sources Directorate procedure "Design Reviews" in the Photon Sciences Document Center for complete details and requirements for completing design reviews. Contact the PSD Quality Representative for further guidance.

<table>
<thead>
<tr>
<th>PHOTON SCIENCES DIRECTORATE</th>
<th>BROOKHAVEN NATIONAL LABORATORY</th>
</tr>
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<tbody>
<tr>
<td>DESIGN REVIEW REPORT</td>
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</table>

The Design Review Report shall include at least a minimum:
- The title of the item or system;
- A description of the item;
- Design Review Report Number;
- The ESH&Q risk level;
- The design parameters;
- The type of design review;
- The date of the review;
- The names and association of the reviewers;
- The major comments and concerns of the reviewers;
- Any reference not appearing in the EDP used to support the design during the Design Review meeting;
- Completed Design Checklist

<table>
<thead>
<tr>
<th>TYPE OF REVIEW:</th>
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<tbody>
<tr>
<td>[ ] CONCEPTUAL</td>
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</table>

Prepared By: Mike Buckley
Date: 09/4/2015

TITLE of ITEM/SYSTEM: 4-BM (XFM) X-ray Fluorescence Microscopy Beamline Preliminary Design Review

PRESENTED BY: Ryan Tappero (XFM Beamline Scientist), Ed Haas (XFM Mechanical Beamline Engineer), Michael Johanson (Designer)

Purpose/Description:
This is a technical review of the 4-BM beamline which is mostly comprised of existing components which were previously used in NSLS. There are also new components which will have or have gone through separate design reviews. There are no beamline optics located in the Front End.

ESH&Q Risk Level: A-2
(Application of the Graded Approach Table)

REVIEWERS - ASSOCIATION: M. Buckley (Chair), L. Stiegler (ESH), M. Carlucci-Dayton (Engineer), S. Moss (USI), J. Zipper (QA), R. Todd (Vacuum)
Attendees: Refer to attached attendance sheet

DISTRIBUTION: All reviewers and presenters.

Attachments: ☑ Data Sheets ☑ Calculations (Checked and countersigned) ☑ Support documentation
See Continuation Page Design Checklist
An introduction was provided by Julian Adams discussing the general plan for XFM.

Ryan Tappero proceeded with an overview of the XFM beamline including the scientific goal, experimental challenges, overall specifications, optical layout, Three-Pole Wiggler as the XFM source, Front End, First Optical Enclosure (FOE), Secondary Optical Enclosure (SOE), transport line, XFM strategic plan, radiation safety strategy, and the XFM schedule.

**XFM Schedule:**
- NSLS component relocation completed .......... Dec 2014
- Hutch contracts awarded .................................. Mar 2015
- Beamline Procurements to begin ..................... Oct 2015
- Hutches & Utilities to be installed by ............. Apr 2016
- Beamline installation ...................................... May – Dec 2016

**Photon Delivery System components:** (Ryan Tappero)
- **Floor layout**
  - Plan control station layout in advance
  - Sample preparation area is planned to be included near beamline which will consist of general type benches.
- **Optical layout and performance**
- **Transport Pipe** for beamline will be lead wrapped with 5 mm lead although requirement is 2 mm lead (for complete vacuum loss in the beam transport). The ion pumps will be enclosed as well. This will go out for contract along with other BDN beamlines.
- **FOE:**
  - A 220 l/s pump was suggested to be exchanged in the FOE for the existing ion pump between BCO1 & 2.
- **SOE:**
  - Add an ion Pump downstream of GV7.
- **White beam slits:**
  - Need to figure out allowable pressure for water cooling for White Beam Slits based on previous pressure test, and add pressure relief if needed.
  - Water flow sensors will be used and connected to the EPS.
  - Cooling will be provided by DI water system.
  - Previously used at NSLS X27A beamline
- **M1 focusing mirror**
  - Vendor will perform FEA to evaluate cooling and slope errors.
  - A burst disk will be provided although not required.
  - No water, gases, or cryogens will be internal to the chamber during normal operations.
  - Granite Base
- **Secondary Source Aperture**
  - COTS JJ X-ray slits
  - Stepper motors are out of vacuum
  - Slits are rounded
- **M2 collimating mirror**
  - New vacuum vessel
  - More details below in report
- **Scanning Double Crystal Monochromator**
  - Long lead procurement
  - Separate design review and FEA will be performed by the Contractor
  - Initial FEA performed by NSLS-II
  - Burst disk will be included
- **High Resolution Beam Viewer**
  - Will possibly be built in-house or by vendor (under decision)
- **Diagnostic Screen**
  - Previously used at NSLS X6A
  - Water cooled
    - Determine max cooling pressure, perform hydro pressure testing at 1.5 for Diagnostic Screen
    - Use traveler to capture test
- **No Beryllium window in FOE. Graphite window is in place in the FOE during operation but must be removed when up to air.** Procedures will need to be developed to address the extraction of the window.

**M2 Mirror Refurbishment:** (Ed Haas)
• Mirror system extracted from NSLS X16A
• 0.6m-long flat Si mirror coated with Pt
• Mechanics for mirror bending (tune collimation)
• Upward-deflecting geometry
• Mirror pitch: 3 mrad
• Indirect water-cooling
• InSync substrate purchased in 2011 for NSLS-II R&D (IXD)
• Mirror metrology indicates 0.3nm roughness and <1mrad slope error
• Refurbish bender mechanics for XFM as needed
• Motorize stripe translation
• Configure for indirect cooling via braids to external heat exchanger
• Design vacuum vessel for larger lateral motion (stripes)
• Si mirror optic to be re-coated:
  o Coating1 = Rh on Cr
  o Coating2 = bare Si
• ±10 mm lateral adjustment capability to be added
  o New bellows
  o Minor bender refurb (length adjustment)

M2 Mirror Tank: (Ed Haas)
• Will be commercially designed/manufactured
• Original cylindrical vacuum vessel did not meet XFM needs. Added volume reqd for:
  o Mirror X translation
  o Assembly/access
  o Cooling
  o Baffling for side-mounted ion pump
• New Vacuum Vessel
  o Bath-tub design allows lighter lid (can be lifted by 2 people)
  o Side-mounted ion pump
  o Ion pump baffling prevents direct IP view of mirror
• New internal volume :
  o 29.5” x 11” x 10.5” minimum
  o Cylinder ID 10.25”
• Reduces flange-mirror I/F distance for longer bellows
• Superior access for all assembly
  o Consider adding pins for aligning cover during removal/install
• Provision for survey/alignment

End Beryllium Window and Vacuum: (Ed Haas)
• 'No Be window in Front End'
• Fast valve in Front End
• Fast valve sensor >10m from fast valve (per R. Todd)
• Graphite window (valve-mounted) outside shield wall
  o Obtain position indicators for valve
• Burst discs installed where required (M1, DCM)
• 6 differential pumping sections along ~60m length
• UHV to Endstation hutch
• End Be window(s)
  o 12.5 micron Moxtek Duraberyllium for monochromatic
  o 25.0 micron Moxtek Duraberyllium for polychromatic
  o Offset vertically by 25 mm
  o Ed Haas has been in touch with the Be Window Supplier.
  o “It appears that the dual window design should be acceptable from a pressure safety aspect”; M. Gaffney
• Small (10 l/s) Ion Pump at GV outside RWCO (per R. Todd)
  o Consider installing a 60 l/s pump if design allows. [Action]
• Medium (~75 l/s) Ion Pump on WB slits with RGA port
• Large Ion Pump on new M1 mirror system in FOE
• Spec port location for NEG
• Medium Ion Pump between BCO1&2/Msk1&2
• In-line Ion Pumps (220 l/s) in Beam Transport
• Minimal conductance at BCOs (tight apertures)
• Configuration analysis underway with C. Hetzel to optimize spacing
• Large Ion Pumps on M2 mirror and new DCM system in SOE
• Small Ion Pump downstream of Photon Shutter
• Small (10 l/s) Ion Pump at GV outside RWCO (per R. Todd)
• Medium (~75 l/s) Ion Pump on WB slits with RGA port
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• Configuration analysis underway with C. Hetzel to optimize spacing
• Large Ion Pumps on M2 mirror and new DCM system in SOE
• Small Ion Pump downstream of Photon Shutter
• Presently 7 vacuum sections (see next slide for vacuum section logic)
• GV4 (between sections 3 & 4) is under evaluation for removal
  o Add an outer port in place of GV4 that goes outside the diagnostic box.
• Additional ion pump in section 1 or 2 being considered

Dual Be window:
• Two Be windows mounted on single 2.75” NR double-sided CF flange
• Std Moxtek COTS windows used
• Location: 4-BM-C @ Z = 58.06 m
• Be foils are metal-bonded (brazed) & tested 25 cycles (0 – 18 psig) followed by He leak test
• Designs qualified using lower safety factor (8μm/ 7 mm ID) window:
  o 10,000 (0-18 psig) cycles then He leak test w/ leak rate <1.0e-10 mbar*L/sec
  o 8μm x 9.2 mm OD (7 mm ID) Be window withstood 96psi without bursting
• Shift location of Be window apertures so that they do not interfere with copper gasket seal. [Action]
• Window includes fiducial mounting provisions for indexing/positioning & embossed beam direction to assure proper installation & alignment
• Change the number of fiducial mounts from 6 to 3. [Action]

**Radiation Safety:** (Mike Johanson, Ed Haas)
The beamline Ray-Tracing drawings were reviewed directly from Vault.
• Ray trace needs to include the shielded pipe [Action]
• Need to illustrate extreme conditions on Ray Trace [Action]
• Remove Secondary Ray trace on drawing on official drawing because RSC does not review it. [Action]
• Show cross sections of shielding on Ray Trace [Action]
• Beamline Radiation Shielding Analysis and Fluka calculations need to be completed [Action]
• Hutch shielding:
  o All shielding requirements have been met NSLS-II shielding guidelines.
  o A separate design review was completed with the Hutch Contractor.

**Endstation:** (Ryan Tappero)
• Sample cold stage needs to go through the Cryo Safety BNL ESH Approval [Action]
• Calculations for ODH will need to be completed to confirm if ODH detection is needed. [Action]

**ESH:**

**Pressure Safety:**
For pressure piping components in the system, they will need proof testing to have documented proof testing to 150% of the maximum supply pressure.

**QA:** In addition to travelers for new equipment, travelers for re-used equipment will also have to be created and executed. These particular travelers may need to verify more than just installation as is typically done. Verification of operation and performance may need to be included in these travelers, if this information is not available. Documentation for configuration management purposes needs to be defined, and may require that interface control drawings be created for re-used equipment.

**USI:**
USI Screening has been determined to be Negative.

---
Actions resulting from this review have been identified within the body of this report and will be included in the NSLS-II Family
Action Item 1: Determine max cooling pressure, perform hydro pressure testing at 1.5 X design pressure for Diagnostic Screen
Action Item 2: Consider and evaluate the installation of a 60 l/s pump as design allows.
Action Item 3: Shift location of Be window apertures so that they do not interfere with copper gasket seal. Change the number of fiducial mounts on the Beryllium from 6 to 3.
  Action Owner: Ed Haas
  Status: Completed
  Description: Drawing PD-XFM-WIN-0100-01 “XFM Beamline - WINDOW, Be, DBL RND, 2.75D CF FLNG” has been revised.

Action Item 4: Revise Ray Trace drawings to address the following:
  a. Ray trace drawings needs to include the shielded pipe.
  b. Remove Secondary Ray trace on drawing on official drawing because RSC does not review it.
  c. Show cross sections of shielding on Ray Trace
Action Item 5: Beamline Radiation Shielding Analysis and Fluka calculations need to be completed
Action Item 6: Sample cold stage needs to go through the Cryo Safety BNL ESH Approval
Action Item 7: Calculations for ODH will need to be completed to confirm if ODH detection is needed.

### REVIEWED DRAWINGS / SPECIFICATIONS

<table>
<thead>
<tr>
<th>Ray Tracings</th>
<th>Presentation Material</th>
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<td><img src="image" alt="PD-XFM-RAYT-0001_9-2-2015" /></td>
<td>XFM Preliminary Design Review: Overview</td>
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<tr>
<td><img src="image" alt="SR-FE-3PW-6001_03DEC2014" /></td>
<td>XFM Preliminary Design Review: Photon Delivery System</td>
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<td><img src="image" alt="SR-FE-3PW-6001_REV_10JUN2015" /></td>
<td>XFM Preliminary Design Review: M2 Mirror Refurbishment</td>
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<tr>
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<td>XFM Preliminary Design Review: End Beryllium Window and Vacuum</td>
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<td>XFM Preliminary Design Review: Radiation Safety</td>
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<td>XFM Preliminary Design Review: Endstation</td>
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**APPROVAL:**

Review Committee Chairperson: M. Buckley  
Date: 10/12/2015

Please forward completed original to the PSD Quality Assurance Group.

10/21/2015

Michael Buckley  
Research Operations Support Group Leader  
Signed by: Buckley, Michael
Agenda for 4-BM (XFM) Beamline PDR Meeting 4-September-2015.

This review will serve two purposes:

(1) Primarily it is a design review for the 4-BM Beamline – Photon Delivery System; which will be a mixture of major beamline components used in operations at NSLS, and new components.

(2) The PDR also serves as a first safety review, which will used to assist the Instrument Readiness Review (IRR) process. A successful review will help to mitigate many of the potential risks associated with installation and commissioning activities.

The following staff is formally invited. All are welcome to attend the review for any or all of the sessions. Please attend the sessions that are applicable to your area of review. If they cannot attend the session please send someone on your behalf to review that area and provide comments as needed.

Following the PDR, the Design Review Chair will provide a final report. Individuals participating in the review should take his/her own notes during the meeting. The Design Review Chair will distribute the report for review to many of the above individuals who will provide their comments.

### Agenda for the PDR meeting

<table>
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<th>Time</th>
<th>Detailed Technical Review</th>
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<td>Stiegler</td>
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<td>• Be window and vacuum considerations (<strong>Hass</strong>)</td>
<td>Moss</td>
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<td><strong>Radiation Safety</strong></td>
<td>Zhong, Zhong*</td>
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<td>• FE Ray Trace Review (<strong>Johanson</strong>)</td>
<td>Benmerrouche, Mohamed</td>
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<td>• BL Ray Trace (<strong>Johanson</strong>)</td>
<td>Buckley, Michael*</td>
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<td>• Shielding for Transport (<strong>Haas</strong>)</td>
<td>Sherwood, Stephen</td>
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<td>**Endstation (<strong>Tappero</strong>)</td>
<td>Adams, Julian (BDN)</td>
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<td>Miller, Lisa (PM)</td>
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<td></td>
<td>• Safety Q&amp;A</td>
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* IRR core committee members
You are invited to this preliminary design review for the XFM (4-BM) beamline. Included in this design review will be a mixture of major beamline components, that were used in operations at NSLS and new components that will be procured.


Thank You,
Mike
4-BM (XFM) Beamline Preliminary Design Review
Attendance Sheet

Date: September 4, 2015

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Department/Division or Company</th>
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<tbody>
<tr>
<td>Mike Buckley</td>
<td>RS Group Leader</td>
<td>NSLS-II</td>
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<tr>
<td>Ed Haas</td>
<td>13L ENGR</td>
<td>NSLS-II</td>
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<td>Ted Adams</td>
<td>1st Place Manager</td>
<td>NSLS-II</td>
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<td>Ryan Tappero</td>
<td>LBS</td>
<td>NSLS-II</td>
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<td>Michael Johnson</td>
<td>Design Engineer</td>
<td>NSLS-II</td>
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<td>Luke Lithard</td>
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<td>Steven Ewertich</td>
<td>Scientist</td>
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<td>Steve Moser</td>
<td>APD Mgr</td>
<td>RC/LNSLS-II</td>
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<td>Lori Stiegler</td>
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<td>Fred Sommerfield</td>
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<td>Joe Zipper</td>
<td>QA</td>
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<td>Robert Todd</td>
<td>Vacuum</td>
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<td>Zhang Zhong</td>
<td>Scientist</td>
<td>NSLS-II</td>
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<td>Steve Hart</td>
<td>Mech Eng</td>
<td>NSLS-II</td>
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<tr>
<td>Erik Farquhar</td>
<td>Scientist</td>
<td>CREU</td>
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<tr>
<td>Mary Corlazz-Dayton</td>
<td>Bl Eng Gr</td>
<td>PS</td>
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<td>Paul Northrup</td>
<td>Scientist</td>
<td>PS</td>
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XFM Preliminary Design Review: Overview
XFM is located at port 4-BM; it utilizes a 3PW source with no FE optics
Detailed presentations to follow:

• Photon Delivery System Components
• M2 Collimating Mirror Refurb
• End Be Window and Vacuum Considerations
• Radiation Safety (Ray Tracings) and Shielding
• Endstation
OUTLINE

– History of program (brief)
– Scientific aims of program
– Technical requirements (to achieve aims)
– Photon Delivery System (to meet requirements)
– Major Procurements Overview
– Schedule Overview

Mark Rivers, Steve Sutton et al. at X26A
• Pair of X-ray Fluorescence Microscopes (X26A & X27A)

• ‘X26A’ developed by U. Chicago, CARS (Rivers, Sutton) and BNL (Jones) in 1985
  – 1st gen: Polychromatic (pink-beam) XRF imaging using pinhole
  – 2nd gen: Add monochromator and KB mirror focusing

• Development of routine microprobe capabilities:
  – XRF imaging
  – X-ray absorption spectroscopy
  – X-ray microdiffraction
  – Fluorescence microtomography

• X-ray microprobes become heavily subscribed worldwide; X27A developed by NSLS and CARS in 2004 to meet user demand

• NSLS microprobes accounted for ~150 NSLS users annually with oversubscription rate of 3.6 x (> 500 “users at large”)

• XFM accommodates NSLS microprobe communities at NSLS-II and compliments nanoprobes (HXN, SRX) and tender probes (TES)
**AIMS:**
Materials and Nanoscience;  
Molecular Environmental Science;  
Energy Science, Chemistry and Catalysis;  
Climate, Earth, and Planetary Science

**EXAMPLES:**
- *In-situ* and *Operando* Studies toward Development of Novel Catalysts
- Characterization of Materials for Energy Storage and Energy Production
- Role of Aerosols in Climate Change Processes
- Mineral-fluid Interface Reactions Relevant to Carbon Sequestration
- Biogeochemistry of Contaminants in the Environment at the Micro- and Mesoscale
- Characterization of Paleontological, Archeological and Cultural Heritage Artifacts

**XFM:** a versatile X-ray fluorescence microprobe optimized for *in-situ* and spatially-resolved characterization of elemental abundance and chemical speciation.

Elucidating the complex structure-property-rate relationships of nanocatalysts in *Operando*

Li et al., 2015.  
*Nature Comm.* 6:7583
μXRF imaging: ‘2-D’ elemental localization/associations (pink/mono)

μXRF tomography (fCMT): ‘3-D’ elemental localization/associations (pink/mono)

μEXAFS & XANES spectroscopy (2.3 – 23 keV):
  XANES - fingerprint info/valence state
  EXAFS - short-range order/speciation

μXRD: phase identification (~crystalline)
### TECHNICAL REQUIREMENTS

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<td><strong>Energy Range</strong></td>
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<td>2.3 - 23 keV.</td>
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<td><strong>Spot Size</strong></td>
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<td>user-tunable from ~1 μm to ~1 mm, with independent control of horizontal and vertical size.</td>
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<tr>
<td><strong>Flux</strong></td>
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<tr>
<td>up to $10^{11}$ ph/sec at 10 keV at 500 mA current. up to $10^{15}$ ph/sec (polychromatic) at 500 mA current.</td>
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<tr>
<td><strong>Energy scanning</strong></td>
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<tr>
<td>up to 1000 eV, in both step and on-the-fly (at up to ~1000 eV/min) modes.</td>
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<tr>
<td><strong>Positional stability</strong></td>
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<tr>
<td>within ~1% of spot size, over 1000+ eV energy scan, over 12+ hours.</td>
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<tr>
<td><strong>Energy stability/repeatability</strong></td>
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<td>0.1 eV or better, scan-to-scan and over 24+ hours.</td>
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3-POLE WIGGLER (3PW)

• Smooth, broadband source (e.g., bend magnet) needed for energy-scanning experiments
• 3PW has contamination from weak poles and adjacent BM
• Vertical acceptance has energy dependence

From Oleg Chubar
PROCUREMENTS

MAJOR PROCUREMENTS:
- Toroidal focusing Mirror System (M1)
- Fixed-exit Scanning Double Crystal Monochromator (DCM)
- Secondary Source Aperture (SSA)
- High-resolution beam viewing diagnostic (HBV)

REFURBISHMENTS:
- X16A mirror system for M2 at XFM
- Recoating M2 substrate (Rh, Si stripes)
- Upgrade motor cables and controllers/drivers to NSLS-II standards
NEW PHOTON DELIVERY SYSTEM COMPONENTS

Majority of the PDS will consist of new hardware
Refurbishment of M2 vertical collimating mirror
• NSLS component relocation completed Dec 2014
• Hutch contracts awarded Mar 2015
• Beamline Procurements to begin Oct 2015
• Hutches & Utilities to be installed by Apr 2016
• Beamline installation May – Dec 2016
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<td>BL Team</td>
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<td>10:15-10:30</td>
<td>Break</td>
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<td>10:30-11:30</td>
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XFM Preliminary Design Review: Photon Delivery System
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– Optical layout and performance
– M1 focusing mirror
– Secondary Source Aperture
– M2 collimating mirror
– Scanning Double Crystal Monochromator
– Diagnostic
Performance Estimates for XFM Beamline

<table>
<thead>
<tr>
<th>Energy (keV)</th>
<th>Flux* (ph/sec)</th>
<th>Spot Size (μm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.3</td>
<td>$2 \times 10^{11}$</td>
<td>2-10</td>
</tr>
<tr>
<td>10.0</td>
<td>$1 \times 10^{11}$</td>
<td>1-10</td>
</tr>
<tr>
<td>23.0</td>
<td>$5 \times 10^{10}$</td>
<td>1-10</td>
</tr>
<tr>
<td>2.3-23</td>
<td>$2 \times 10^{15}$</td>
<td>1-10</td>
</tr>
</tbody>
</table>

*Flux estimates incorporate acceptance, reflectivity, monochromator bandpass, and absorption by filters and windows.
PERFORMANCE MODELING

Horizontal Optics Layout

- 3PW Source
- Front-End Aperture
- Toroidal Mirror (Horiz Deflect.)
  - \( L = 1.0 \text{m} \)
  - \( \text{DeMag} = 1.0 \)
  - \( \text{RMS} = 0.3 \text{mm} \)
- Secondary Source Aperture
  - \( \text{FWHM}_{\text{ap}} = 380 \mu\text{m} \)
- Collimating Mirror (Vertical)
  - \( L = 200 \text{mm} \)
  - \( \text{RMS} = 0.2 \mu\text{rad} \)
  - \( \text{DeMag} = 5 \)
- KBH
  - \( L = 200 \text{mm} \)
  - \( \text{RMS} = 0.2 \mu\text{rad} \)
  - \( \text{DeMag} = 45 \)
- Focal Point @ 60.5m
  - \( fwhm_H = 10.6 \mu\text{m} \)
  - \( fwhm_V = 5.0 \mu\text{m} \)

Vertical Optics Layout

- 3PW Source
- Front-End Aperture
- Toroidal Mirror (Horiz Deflect.)
  - \( L = 1.0 \text{m} \)
  - \( \text{DeMag} = 1.0 \)
  - \( \text{RMS} = 0.006 \mu\text{rad} \)
- Secondary Source Aperture
  - \( \text{FWHM}_{\text{ap}} = 70 \mu\text{m} \)
- Collimating Mirror (Vertical)
  - \( L = 200 \text{mm} \)
  - \( \text{RMS} = 0.2 \mu\text{rad} \)
  - \( \text{DeMag} = 10 \)
- KBV
  - \( L = 200 \text{mm} \)
  - \( \text{RMS} = 0.2 \mu\text{rad} \)
  - \( \text{DeMag} = 10 \)
- Focal Point @ 60.5m
  - \( fwhm_H = 5.0 \mu\text{m} \)
<table>
<thead>
<tr>
<th>ES (4-BM-C)</th>
<th>SOE (4-BM-B)</th>
<th>Transport Line</th>
<th>FOE (4-BM-A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IP, Be Window</td>
<td>Mask4/BCO4, GV5</td>
<td>Diagnostic</td>
<td>GV2, Graphite Window</td>
</tr>
<tr>
<td>Optical Tables</td>
<td><strong>M2 Collimating Mirror</strong></td>
<td>GV4</td>
<td>WB Slits</td>
</tr>
<tr>
<td>KB mirrors</td>
<td>GV6, <strong>DCM</strong>, GV7</td>
<td>Mask3/BCO3</td>
<td><strong>M1 Focusing Mirror</strong></td>
</tr>
<tr>
<td></td>
<td>Diagnostic, Mask5/BCO5</td>
<td>SSA</td>
<td>GV3, Mask1/BCO1</td>
</tr>
<tr>
<td></td>
<td>Photon Shutter</td>
<td>Beam pipe, pumps, gages,...</td>
<td>Mask 2/BCO2</td>
</tr>
<tr>
<td></td>
<td>Beam pipe, pumps, gages, bellows,...</td>
<td>Beam pipe, pumps, gages, bellows,...</td>
<td></td>
</tr>
</tbody>
</table>
WHITE BEAM SLITS

- Water-cooled UHV slits from X27A
- Built by ADC, mounted on custom MDC 6-way 6” CF cross (w/ four 1.5” tube ports)
- Blade material: Tungsten
- Stepper motor & manual drive capabilities
- Std COTS slits
- Total photon beam power into white beam slits: 7.1 W (power spectrum from O. Chubar, beam power from XOP 2.3)
M1 FOCUSING MIRROR SYSTEM

- 1:1 toroid located in FOE at 25.167 m (illuminates SSA at 50.334 m)
- Side-deflecting geometry (inboard)
- 1m-long Si mirror
- Mirror pitch fixed at 3 mrad
- Indirect water-cooling via foils/braids
- Vendor will perform FEA to evaluate cooling and slope errors
- Long lead time procurement
M1 FOCUSING MIRROR SYSTEM

SPECS / FEATURES:

• White beam parameters
  – Beam size: ≤ 3 mm Horiz x 10.3 mm Vert
  – Maximum power input: 6.5 W
  – Absorbed power: 0.8 W (per XOP)

• Mirror Optic:
  – 1 m long optical length
  – Si with 50±5 nm Rh coating on Cr base
  – 75.5 mm sagittal radius (20 mm high)

• Granite mirror base assures mirror stability

• Alignment provisions on base plate (allows mirror to be aligned with vacuum vessel removed or installed)

• Steel frame decouples vacuum vessel support from mirror support
TRANSPORT LINE COMPONENTS

SSA

Diagnostic for M1

Diagnostic for M1
Diagnostic acquired from X6A:
- Accel-designed
- Water-cooled
- Pneumatically-actuated
- $Y_2O_3$:Eu-coated Cu
- Complete with:
  - Vacuum vessel
  - Festo air cylinder & solenoid valve
  - Viewport
  - Limit switches
  - Ion pump
- Mounts (to be customized)
- Std camera & mounts to be added
• Located at the focal plane of M1 focusing mirror (50.334 from 3PW)

• Independent control of horizontal and vertical aperture

• Heat load analysis shows total power ~5.7 W (closed tight); otherwise M2 & DCM get 5.7 W

• Mounted on granite base

• COTS JJ X-ray slits with heat exchanger & braid cooling

• New procurement

JJ X-ray model IB-C30-UHV slits
## Specs:

- **Stepper-motor driven (not in vacuum):**
  - 30 x 30 mm range
  - 2 mm W-Carbide blades close past 0
  - 0.5 \( \mu \text{m} \) resolution
  - with shielded encoders

### Specifications

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Details</th>
</tr>
</thead>
</table>
| **Aperture size**    | Maximum: 30 mm x 30 mm  
                       Minimum: Full Overlap |
| **Resolution**       | 1 micron per full step |
| **Accuracy**         | \( \pm 2 \) micron over 3 mm in open loop and 0.5 micron in closed loop |
| **Vacuum**           | Stainless steel housing, copper gaskets, only UHV rated materials & hardware (incl UHV-rated full metal guides and switches) |
| **Mechanical dimensions** | UHV chamber external diameter: 202.50 mm  
                              Distance from center to outer motor part: 196 mm  
                              Thickness (flange-flange, excluding bolts): 140 mm |
| **Standard blades**  | 2 mm thick tungsten carbide blades |

JJ X-ray model IB-C30-UHV slits
Specs:

- Linear encoders shielded by 3mm SST
- ‘Scale wheels’ allow manual adjustment
- Bakeable to 120°C
- Interfaces:
  - 6” CF (NR) flanges machined into upstream & downstream faces
  - Patch panel supplied with motor, encoder, & limit switch connections
- ‘Beam Direction’ arrow included
- Linear in-vacuum limit switches supplied on all blades
SOE COMPONENTS (4-BM-B)
M2 VERTICAL COLLIMATING MIRROR

- Located in SOE at 54.334m
- Collimation and harmonic rejection
- 0.6m-long flat Si mirror (bendable)
- InSync metrology indicates 0.3nm roughness and <1μrad slope error
- Upward-deflecting geometry
- Mirror pitch: 3 mrad
- Indirect water-cooling via foils/braids
- Bender mechanics from X16A
M2 MIRROR REFURB:
- Si mirror optic to be re-coated:
  - Coating1 = Rh
  - Coating2 = bare Si
- ±10 mm lateral adjustment capability to be motorized
  - New bellows
  - Minor bender refurb
- New Vacuum Vessel
  - Bath-tub design allows lighter lid (can be lifted by 2 people)
  - Side-mounted ion pump
  - Ion pump baffling prevents direct IP view of mirror
DOUBLE CRYSTAL MONOCHROMATOR

- Scanning DCM located in SOE at ~55.4m from 3PW
- Side-by-side Si(111) and Si(220) crystal pairs with 25mm offset (+ deflection)
- Synchrotron beam deflected out of secondary Bremsstrahlung in SOE
- Indirect water-cooling via Cu block
- Vendor will perform FEA to evaluate cooling and slope errors
- Long lead time procurement
DOUBLE CRYSTAL MONOCHROMATOR

**FEA ANALYSIS:**

- **Heat Load**
  - Heat load from XOP
  - Maximum power input: 5 W
  - Incident angles: 3.6° - 59°
  - Maximum power density: 4.9 W/mm²
  - Beam size: .55 mm x 1.6 mm (normal)

- **FEA modeling:**
  - FEA by S. O’Hara
  - Clamped OFHC side-blocks
  - Heat exchanged to NSLS-II DI water
  - Flow rate: 1 GPM
  - Tube size: 0.25” I.D.
DOUBLE CRYSTAL MONOCHROMATOR

THERMAL FEA DETAILS:
Load Cases:
1. 5W heat load, 9 mm thick Si, Rh stripe of M2, crystals at 59°
2. 2.5W heat load, 9 mm thick Si, Si stripe of M2, crystals at 59°
3. 5W heat load, 9 mm thick Si, Rh stripe of M2, crystals at 3.6°

FEA results:
- Max Temp: 42.5°C (load case 1)
- Max Stress: 1.95 MPa (max allowable stress is >6,000 MPa\(^1\))
- Max Slope Error:
  - 17.54/3.57** µrad longitudinal [Case 1, uncorrected/cylindrically corrected]
  - 15.31/.231** µrad lateral [Case 1]
  - 4.04/1.49** µrad longitudinal [Case 3, uncorrected/cylindrically corrected]
  - 2.15/.030 ** µrad longitudinal [Case 3]

* Max stress is usually not specified; Si is very brittle
** with correction to normalize cylindrical curvature included

\(^1\) Ref. Petersen: “Silicon as a Mechanical Material”
XFM DCM THERMAL FEA RESULTS:

- Max Temps & stresses are far below critical values
- Cylindrical slope errors can be corrected by PCM (Mirror2)
- ‘Normalized’ slopes errors are w/in acceptable limits
A phosphor view-screen with digital camera downstream of mono (and mirrors) to align mono, set true roll=0, measure mono beam offset, and calibrate M2 mirror pitch. *Vital to operation!*
**BEAMLINE DIAGNOSTICS OVERVIEW**

**DIAGNOSTICS** required for **XFM** include:

- Slits with drain current (in FOE)
- Retractable fluorescence screen (in Transport)
- Retractable intensity and beam-position monitor (at SSA)
- High-resolution beam viewer (in SOE)

<table>
<thead>
<tr>
<th>Distance (m)</th>
<th>Diagnostic</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>24.50</td>
<td>White beam slits with drain current</td>
<td>Isolate &quot;clean&quot; on-axis 3PW beam</td>
</tr>
<tr>
<td>38.50</td>
<td>Retractable fluorescence screen</td>
<td>Tune M1</td>
</tr>
<tr>
<td>50.33</td>
<td>Intensity and beam position monitor</td>
<td>Adjust M1 focus at SSA</td>
</tr>
<tr>
<td>57.33</td>
<td>Retractable YAG screen (mono beam) and sintered diamond screen (white beam)</td>
<td>Align beam on DCM, set true roll=0, measure mono beam offset, and calibrate M2 mirror pitch</td>
</tr>
</tbody>
</table>
## XFM PDR AGENDA

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<tr>
<th>Time</th>
<th>Detailed Technical Review</th>
<th>Attendees</th>
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<tbody>
<tr>
<td>8:30-8:40</td>
<td>Introduction (Adams)</td>
<td>All</td>
</tr>
<tr>
<td>8:40-8:55</td>
<td>XFM Overview (Tappero)</td>
<td>All</td>
</tr>
</tbody>
</table>
| 8:55-10:15 | **XFM Engineering Design**  
  - Photon Delivery System Components (Tappero)  
  - M2 Mirror Refurb (Haas)  
  - Be window and vacuum considerations (Hass) | Carlucci - Dayton  
  Todd  
  Stiegler  
  Moss  
  Gaffney  
  O’Hara  
  Zipper  
  BL Team |
| 10:15-10:30| Break                                                                                   | All                        |
| 10:30-11:30| Radiation Safety  
  - FE Ray Trace Review (Johanson)  
  - BL Ray Trace (Johanson)  
  - Shielding for Transport (Haas) | Zhong  
  Stiegler  
  Zipper  
  BL Team |
| 11:30-12:00| Endstation (Tappero)  
  - Endstation  
  - Safety Q&A | Carlucci-Dayton  
  Stiegler  
  Gaffney  
  Zipper  
  BL Team |
XFM Preliminary Design Review: M2 Mirror refurbishment
• Mirror system extracted from NSLS X16A
• 0.6m-long flat Si mirror coated with Pt
• Mechanics for mirror bending (tune collimation)
• Upward-deflecting geometry
• Mirror pitch: 3 mrad
• Indirect water-cooling
• InSync substrate purchased in 2011 for NSLS-II R&D (IXD)
• Mirror substrate to be recoated with two stripes
• Mirror metrology indicates 0.3nm roughness and <1μrad slope error
• Refurbish bender mechanics for XFM
• Motorize stripe translation
• Configure for indirect cooling via braids to external heat exchanger
• Design vacuum vessel for larger lateral motion (stripes)
• Si mirror optic to be re-coated:
  – Coating1 = Rh on Cr
  – Coating2 = bare Si

• ±10 mm lateral adjustment capability to be added
  – New bellows
  – Minor bender refurb (length adjustment)

• New Vacuum Vessel
  – Bath-tub design allows lighter lid (can be lifted by 2 people)
  – Side-mounted ion pump
  – Ion pump baffling prevents direct IP view of mirror
M2 COLLIMATING MIRROR REFURB

M2 Mirror Tank:
- Original cylindrical vacuum vessel did not meet XFM needs. Added volume reqd for:
  - Mirror X translation
  - Assembly/access
  - Cooling
  - Baffling for side-mounted ion pump
- New internal volume:
  - 29.5” x 11” x 10.5” minimum
  - Cylinder ID 10.25”
- Reduces flange-mirror I/F distance for longer bellows
- Superior access for all assembly
- Provision for survey/alignment
QA PLAN FOR M2 REFURBISHMENT

Testing and Evaluation Plan:
• Evaluate heat transfer & slope error
• Design Review (as reqd)
• Use existing bender; add/adjust hard stops as reqd
• Procure vacuum vessel
• Add motors for X translation to existing slides
• Test

Documentation:
• ICD to be produced for M2 System including:
  • Interfaces
  • Requirements
  • Table of Specifications
• Procedures
  • Vacuum, alignment, etc.

± 10 mm X translation
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<tr>
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<td><strong>Break</strong></td>
<td>All</td>
</tr>
<tr>
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<tr>
<td></td>
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<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>• Safety Q&amp;A</td>
<td></td>
</tr>
</tbody>
</table>
XFM Preliminary Design Review: End Be window and vacuum
VACUUM OVERVIEW

- No Be window in Front End
- Fast valve in Front End
- Fast valve sensor >10m from fast valve (per R. Todd)
- Graphite window (valve-mounted) outside shield wall
- Burst discs installed where required (M1, DCM)
- 6 differential pumping sections along ~60m length
- UHV to Endstation hutch
- End Be window(s)
  - 12.5 micron Moxtek Duraberyllium for monochromatic
  - 25.0 micron Moxtek Duraberyllium for polychromatic
  - Offset vertically by 25 mm
BEAMLINE VACUUM SYSTEM

- Small (10 l/s) Ion Pump at GV outside RWCO (per R. Todd)
- Medium (~75 l/s) Ion Pump on WB slits with RGA port
- Large Ion Pump on new M1 mirror system in FOE
  - Spec port location for NEG
- Medium Ion Pump between BCO1&2/Msk1&2
- In-line Ion Pumps (220 l/s) in Beam Transport
  - Minimal conductance at BCOs (tight apertures)
  - Configuration analysis underway with C. Hetzel to optimize spacing
- Large Ion Pumps on M2 mirror and new DCM system in SOE
- Small Ion Pump downstream of Photon Shutter
Presently 7 vacuum sections (see next slide for vacuum section logic)
• GV4 (betw sections 3 & 4) is under evaluation for removal
• Additional ion pump in section 1 or 2 being considered
VACUUM SECTIONS

VACUUM SECTION 1 (& 2)

- Accel Div supplies GV2 w/ valve-mounted Pirani & CC gauges
- Small (~10 L/s) Ion pump reqd
  US of WIN1 to open GV2
- Ion Pump located below white beam slits (~75 L/s)
- 2.75” CF RGA port provided on Tee section below white beam slits (per Vacuum Group request)
<table>
<thead>
<tr>
<th>Section</th>
<th>Length (m)</th>
<th>Key Components</th>
<th>Purpose</th>
<th>Boundaries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (FE Vac)</td>
<td>0.212</td>
<td>Gr window</td>
<td>WIN1 separates FE &amp; XFM</td>
<td>GV2 – WIN1</td>
</tr>
<tr>
<td>2 (FOE-US)</td>
<td>2.082</td>
<td>Slits; M1 Mirror</td>
<td>Access to M1 Mirror &amp; Slits (bake-out @ lower temp)</td>
<td>WIN1 – GV3</td>
</tr>
<tr>
<td>3 (FOE-TL)</td>
<td>11.930</td>
<td>MSK1,2; BCO1,2; Diagnostic</td>
<td>Separates &gt;27m long transport section into 2 bake-out zones</td>
<td>GV3 – GV4</td>
</tr>
<tr>
<td>4 (TL-SOE)</td>
<td>15.723</td>
<td>SSA; MSK3,4; BCO3,4</td>
<td>As above</td>
<td>GV4 – GV5</td>
</tr>
<tr>
<td>5 (SOE US)</td>
<td>1.206</td>
<td>M2 Mirror</td>
<td>Separates M2 Mirror</td>
<td>GV5 – GV6</td>
</tr>
<tr>
<td>6 (SOE Center)</td>
<td>1.160</td>
<td>DCM</td>
<td>Allows access to DCM with min pump-down volume</td>
<td>GV6 – GV7</td>
</tr>
<tr>
<td>7 (SOE-ES)</td>
<td>2.029</td>
<td>MSK5; BCO5; PSH; Diagnostic</td>
<td>Separates DCM from DS components</td>
<td>GV7 – Be Win</td>
</tr>
</tbody>
</table>
XFM VACUUM SECTION 3
Assumed uniform outgassing 2e-10torr*l/s/cm²
VACUUM PRESSURE

XFM VACUUM SECTION 4
Assumed uniform outgassing $2 \times 10^{-10}$ torr*l/s/cm²

Pressure in mbar

COURTESY CHARLIE HETZEL
• Provides UHV/HV barrier (to assure clean M1 mirror surface)
• Located DS of GV2, US of White Beam Slits/M1 Mirror @ Z = 23.892 m
• 2 μm thick, Gate valve-mounted
• Energy absorption: ~0.1W
• Transmission ≥~90% for photon energies ≥ 2.3 keV
• COTS DN100 71644 VAT valve has window mount & retainer
• Minteq 2 μm Graphite foil
• Custom-made Graphite window holder prevents foil damage on installation
• Position sensors
VACUUM VALVES & GAUGES

Pneumatic Gate Valves:
- VAT series 48 all-metal valves
  - BNL part number PI-VLV-0010
  - VAT number 48240-CE44
  - 6” NR CF flanges

Manual Right Angle Valves (for pump-out):
- Manual valves acquired from NSLS

Gauges & Controllers:
- MKS P/N 103170044SH Bakeable Pirani
- MKS P/N 1004220036 Bakeable Cold Cathode
- MKS model 937B controller (controls & reads out up to 6 sensors & gages)

Note: XFM uses NSLS-II std vacuum compts
**Dual Be window:**

- Two Be windows mounted on single 2.75” NR double-sided CF flange
- Std Moxtek COTS windows used
- Location: 4-BM-C @ Z = 58.06 m
- Be foils are metal-bonded (brazed) & tested 25 cycles (0 - 18 psig) followed by He leak test
- Designs qualified using lower safety factor (8µm/ 7 mm ID) window:
  - 10,000 (0-18 psig) cycles then He leak test w/ leak rate <1.0e^-10 mbar*L/sec
  - 8µm x 9.2 mm OD (7 mm ID) Be window withstood 96psi without bursting
- Window includes fiducial mounting provisions for indexing/positioning & embossed beam direction to assure proper instl & alignment
• Upper Be window:
  • 12.5 μm thick Be foil
  • 8 mm I.D.
  • 12 mm O.D.

• Lower Be window:
  • 25 μm thick Be foil
  • 13 mm I.D.
  • 16 mm O.D.

• Beampipe connections:
  • Downstream: He flight tube at 1 atm
  • Upstream: UHV vacuum section from Encl 4-ID-B

• Thin Be windows are reqd for good transmission in tender energy range
END Be WINDOW

Std COTS Be window designs:

- DuraCoat® inorganic refractory low-Z film provides chem & oxidation resistance
- Mtl certs & cycle testing data to be supplied by Moxtek
- Guaranteed to 2 atm front pressure, or 1 atm back pressure (differential)
- Std COTS windows with long record of safe performance
- 12.5 μm design approved by Press Safety SME (M. Gaffney) & Be SME (N. Bernholc)
- Approval efforts for 25 μm design are ongoing
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</tr>
<tr>
<td></td>
<td>Safety Q&amp;A</td>
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</tr>
</tbody>
</table>
XFM Preliminary Design Review: Radiation safety
• Designed for FE use (by Aftab Hussain)
• Cu-Cr-Zr (C18150) design:
  • Similar properties to AL-15 GlidCop, but 1/4\textsuperscript{th} the cost & not weldable
  • Readily available in different sizes
• Water cooling not required—fins allow natural convection to keep mask from failing at full power load;
  • Designed \textit{for} 3PW FE mask use (max temp: 305°C at 319 W with natural convection)
  • XFM max power load: 7.1 W (at M1)
• Compact Design: 1¾” (44 mm) thick (in Z-direction)
• Apertures sized individually by XFM ray tracing
Analysis Parameters:

- Distance from Source ~ 7.9m
- Total Power (3PW & BM) = 319 W
- Assumed heat transfer coefficient of 10 W/m².K for natural convection
- Assumed film coefficient of 0.4 W/cm².°C for a flow rate of 1GPM in Ø0.375” cooling channel

Temperature Contour Plot, Tmax ~ 93°C

Temperature Contour Plot, Tmax ~ 305°C

- Beamline power density @ 25 m ~0.55 W/mm² max
- Beamline nominal heat load @ 25 m ~80W
- Beamline max heat load @ 25 m ~190W

Courtesy of Aftab Hussain
STANDARD LEAD COLLIMATORS

- FE collimator design adapted to XFM
  - Pb outer dimensions: 15” Horiz x 3” Vert
  - Apertures sized by ray tracing
- Four Pb collimators used:
  - (2) in FOE, (1) in Transport line, (1) in SOE

12 Inch Thick Lead
Base Plate
Stainless Steel Lead Cover
CUSTOM TUNGSTEN ‘COLLIMATOR’

**Tungsten Collimator used for Secondary Bremsstrahlung stop:**

- Located at downstream end of SOE, downstream of mirrors & DCM
- Stop reqd only for secondary Bremsstrahlung (below photon beam centerline)
- Collimator sized by ray tracing:
  - 6 cm thick (per LT-ESH-STD-001)
  - In-vacuum, pinned to M5 Mask
  - Horiz & Vert dimensions from ray trace dwgs
  - Collimator & aperture to be bench surveyed
RAY TRACING OVERVIEW

• Synchrotron & Bremsstrahlung max fans are taken from the F.E. raytrace: SR-FE-3PW-6001

• Synchrotron *white* beam blocked in FOE

• Primary Bremsstrahlung blocked in FOE
  – M1 focusing mirror with 6 mrad horizontal beam deflection (inboard)

• Secondary Bremsstrahlung blocked in SOE

• Monochromatic & ‘purple’ beams delivered safely to endstation and stopped there
F.E. HORIZONTAL SYNCHROTRON RAYTRACE

F.E. HORIZONTAL SYNCHROTRON MAX FAN = .922 mrad
F.E. VERTICAL SYNCHROTRON RAYTRACE

F.E. VERTICAL SYNCHROTRON MAX FAN = 1.389 mrad
F.E. HORIZONTAL BREMSSTRAHLUNG RAYTRACE

F.E. HORIZONTAL BREMSSTRAHLUNG MAX FAN = 3.920 mrad
F.E. VERTICAL BREMSSTRAHLUNG MAX FAN = 2.895 mrad
RAY TRACING

LIVE:
from AutoCAD
Sept 4\textsuperscript{th} 2015
• Nominal beam size in H is small (<1mm) at end Be window
• Max fan of monochromatic beam is significantly larger than nominal due to 0.05mrad uncertainty in M1 pitch
• Accommodation for adjustment of end Be window position
• Procedure to align end Be window to nominal fan with beam
• Guarantees that monochromatic beam will not hit SS flange
RADIATION SHIELDING

Shielding elements include:

- Hutch enclosures 4-BM-A (FOE), 4-BM-B (SOE), 4-BM-C (ES)
- Collimators (discussed separately)
- Transport line shielding (discussed separately)
- Photon shutter
- Beamstop
SHIELDING REQUIREMENTS

Reference LT-C-ESH-STD-001 “Guidelines for NSLS-II Beamline Radiation Shielding Design”

<table>
<thead>
<tr>
<th>Beamline source</th>
<th>Lateral panel (Pb)</th>
<th>Roof panel (Pb)</th>
<th>Downstream panel (Pb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All ID sections</td>
<td>18 mm</td>
<td>10 mm</td>
<td>50 mm</td>
</tr>
<tr>
<td>BM/3PW</td>
<td>18 mm</td>
<td>4 mm</td>
<td>50 mm</td>
</tr>
</tbody>
</table>

From Table 7.1-1: Recommended shielding for white beam enclosures

<table>
<thead>
<tr>
<th>Beamline source</th>
<th>Lateral &amp; upstream walls</th>
<th>Roof</th>
<th>Downstream panels</th>
</tr>
</thead>
<tbody>
<tr>
<td>DW100</td>
<td>4 mm Pb</td>
<td>3 mm Pb</td>
<td>7 mm Pb</td>
</tr>
<tr>
<td>IVU20</td>
<td>6 mm Fe</td>
<td>3 mm Fe</td>
<td>11 mm Fe</td>
</tr>
<tr>
<td>3PW</td>
<td>3 mm Fe</td>
<td>2 mm Fe</td>
<td>6 mm Fe</td>
</tr>
<tr>
<td>BM</td>
<td>1 mm Fe</td>
<td>1 mm Fe</td>
<td>2 mm Fe</td>
</tr>
</tbody>
</table>

From Table 7.2-1: Recommended shielding for monochromatic/pink beam enclosures

FOE /SOE /ES Hutch Shielding:
- FOE requires 18 mm Pb in side wall, 4 mm in roof & 50 mm in DS walls; vendor is providing ¾” (19.05 mm), ¼” (6.35 mm) & 2” (50.8 mm) Pb respectively (+ steel)
- SOE/ES requires 3 mm of Fe in side & upstream wall, 2 mm in roof & 6 mm in DS wall; vendor is providing 3 mm, 4 mm & 6 mm of steel, respectively
- Guillotines provide radiation protection equal to attached walls (as reqd by BSA)
- Labyrinth design guidelines supplied by BSA; vendor designs reviewed by BSA
- PPS provisions to be supplied by NSLS-II Safety Systems
SHIELDING REQUIREMENTS

Reference LT-C-ESH-STD-001 “Guidelines for NSLS-II Beamline Radiation Shielding Design”

Beampipe Shielding:
• 5.0mm Pb in transport line (built by vendor to BSA Specs)
• Shielding reqmts standardized for XFM, QAS, and CMS beamlines:
  • Std shielded enclosures & stands for Perkin-Elmer 220 L/s ion pumps supplied by vendor
  • Transport line uses 4” & 6” pipe sections (similar to QAS/CMS)
• Special shielded enclosures to be procured (per BSA Specs) for:
  • SSA (must enclose SSA & translation stage)
  • Diagnostic, GV4, Mask3 & BCO3

From Table 8.1-1: Recommended shielding for monochromatic/pink beam transport

<table>
<thead>
<tr>
<th>Beamline source</th>
<th>Mono/Pink beam stop</th>
</tr>
</thead>
<tbody>
<tr>
<td>DW100</td>
<td>50 cm x 50 cm x 2 cm Pb</td>
</tr>
<tr>
<td>IVU20</td>
<td>50 cm x 50 cm x 1.4 cm Pb</td>
</tr>
<tr>
<td>3PW</td>
<td>50 cm x 50 cm x 1.2 cm Pb</td>
</tr>
<tr>
<td>BM</td>
<td>1 mm Pb; Forward scattering negligible, size determined by ray trace</td>
</tr>
</tbody>
</table>

From Table 6.4-1: Recommended monochromatic/pink beam stops

<table>
<thead>
<tr>
<th>Beamline source</th>
<th>Shielding required for &lt; 0.5 mrem/hr due to complete vacuum loss in the beam transport</th>
<th>Shielding required locally on beam transport for &lt; 0.05 mrem/hr for a solid scatterer</th>
</tr>
</thead>
<tbody>
<tr>
<td>DW100</td>
<td>5 mm Pb</td>
<td>12 mm Pb</td>
</tr>
<tr>
<td>IVU20</td>
<td>3 mm Pb</td>
<td>7.0 mm Pb</td>
</tr>
<tr>
<td>3PW</td>
<td>2 mm Pb</td>
<td>5.0 mm Pb</td>
</tr>
<tr>
<td>BM</td>
<td>1 mm Fe</td>
<td>1.0 mm Fe</td>
</tr>
</tbody>
</table>
• Shielded enclosures with 5 mm Pb walls for SSA and Diagnostic section (similar to ion pumps in transport section)
• One-inch stainless steel plates for base (PK: 5mm Pb equivalent to 20 mm SS)
PHOTON SHUTTER

- Std NSLS-II design w/ normal-incidence water-cooled GlidCop absorbers for “purple” beam
- XFM photon beam energy:
  - 5.23 W from M2 w/ Rh stripe
  - 3.71 W from M2 w/ Si stripe
- Photon shutter designed for ID beamline heat loads
- Stops X-rays w/ redundant 0.75”t (19 mm) W blocks
- 0.75”t W aperture plates w/ 30 x 60 mm rect apertures
- Location: DS end of SOE @ at Z = 57.19 m
- Nominal stand supplied by JUV for ~1.45 m photon beam height
Requirements from Hutch Specs & ICD:

- Beam stop 50x50cm by 1.5cm t Pb
- Mono beam centered on beam stop at $Y = 1473$ mm, “purple” beam 25 mm below mono beam
- Located on DS wall of ES @ $Z = 62.389$ m
- Mono beam energy range 2.3 – 23 keV
- “Purple beam” mirror cut-off @ approx. 23 keV
# XFM PDR AGENDA

<table>
<thead>
<tr>
<th>Time</th>
<th>Detailed Technical Review</th>
<th>Attendees</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30-8:40</td>
<td>Introduction (Adams)</td>
<td>All</td>
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<td>8:40-8:55</td>
<td>XFM Overview (Tappero)</td>
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<td>8:55-10:15</td>
<td>XFM Engineering Design&lt;br&gt;Photon Delivery System Components (Tappero)&lt;br&gt;M2 Mirror Refurb (Haas)&lt;br&gt;Be window and vacuum considerations (Hass)</td>
<td>Carlucci - Dayton&lt;br&gt;Todd&lt;br&gt;Stiegler&lt;br&gt;Moss&lt;br&gt;Gaffney&lt;br&gt;O’Hara&lt;br&gt;Zipper&lt;br&gt;BL Team</td>
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<tr>
<td>10:15-10:30</td>
<td>Break</td>
<td>All</td>
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<tr>
<td>10:30-11:00</td>
<td>Radiation Safety&lt;br&gt;FE Ray Trace Review (Johanson)&lt;br&gt;BL Ray Trace (Johanson)&lt;br&gt;Shielding for Transport (Haas)</td>
<td>Zhong&lt;br&gt;Stiegler&lt;br&gt;Zipper&lt;br&gt;BL Team</td>
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XFM Preliminary Design Review: Endstation
USER-CONFIGURABLE ENDSTATION:

- KB microfocusing mirrors
- High-precision sample scanning stages
- Cameras and illuminators
- Motorized optical table
- Positioners for hardware (e.g., ccd beamstop, etc.)
- Detectors and beam monitors
EXPERIMENTAL SYSTEMS

DETECTORS:

• XRF
  – MAIA-384 large pixel array detector with FPGA electronics
  – Vortex ME4 SDD with Xspress3 electronics
  – Single element SDDs with XIA XMAP electronics

• XRD
  – Rayonix SX165 CCD
  – Mar 345

• BEAM MONITORS
  – Ion chambers
  – Diodes (Si and CVD diamond)
  – Amps, V2Fs, scalers (Struck)
EXPERIMENTAL SYSTEMS

MICROFOCUSING OPTICS:

• Kirkpatrick-Baez (KB) mirrors located in helium enclosure

• 20cm-long trapezoidal-shaped single-crystal Si substrate coated with Rh

• Elliptically bent using mechanics designed by P. Eng (U. Chicago, CARS)

• Variable mirror pitch (0-7 mrad)

• Polished to roughness better than 1 Å rms with <1.5 μrad figure error
SAMPLE ENVIRONMENTS:

• Versatile and customizable sample environment

• Sample environment will default to ambient atmosphere

• Accommodations for:
  - He(g) atmosphere,
  - cold stage and cryo-stream sample cooling,
  - custom in-situ environmental chambers,
  - physically-large samples.
SPECIFIC HAZARDS

- Endstation hazards covered in beamline ESR
- Experimental hazards covered in SAF
- High voltage (ion chambers, etc.)
- Be windows (beamline, detectors)
- Inert gases only
  - No toxic, corrosive or flammable gases
- Lead (Pb) used sparingly for shielding
- Cryogens used for sample cold stage
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