NSLS-II BDN BEAMLINE 18-ID COMMISSIONING PLAN

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REV. 2

NSLS-II BDN BEAMLINE 18-ID COMMISSIONING PLAN

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REVISION HISTORY

REVISION	DESCRIPTION	DATE
1	First Issue	October 18, 2017
2	Added LOTO steps to address concerns about CM hard stop.	October 24, 2017

Acronyms

BDN	Beamlines Developed by NSLS-II
BNL	Brookhaven National Laboratory
CM	Collimating Mirror
DCM	Double Crystal Monochromator
ESH	Environment, Safety and Health
ESR	Experiment Safety Review
FE	Front End
FOE	First Optical Enclosure
FLUKA	Fluktuierende Kaskade (Monte Carlo simulation software)
ID	Insertion Device
IRR	Instrument Readiness Review
mA	milli-Ampere
MFS	Monochromatic Beam Fluorescent Screen
NSLS-II	National Synchrotron Light Source II
PASS	Proposal, Allocation, Safety and Scheduling
PB	Pink Beam
PDS	Photon Delivery System
PMFS	Pink and Monochromatic Beam Fluorescent Screen
PPS	Personnel Protection System
PSD	Photon Science Division
SAF	Safety Approval Form
SSA	Secondary Source Aperture
TCP	Technical Commissioning Plan
TM	Toroidal Mirror
TXM	Transmission X-ray Microscope
WB	White Beam
WPFS	White and Pink Beam Fluorescent Screen

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1. INTRODUCTION

This plan outlines the actions needed to commission the NSLS-II BDN 18-ID (FXI [Full-field X-ray Imaging]) Beamline from the accelerator enclosure ratchet wall to the endstation. Once the readiness process is complete and authorization to begin commissioning the beamline is received, the technical commissioning will proceed, initially hand in hand with a radiation safety commissioning, until the beamline is deemed to be radiation safe in standard X-ray operations. In the latter stages of technical commissioning, the main optical elements of the beamline are optimized for routine operations, and finally the end-stations are also commissioned. There are several processes established to manage the risks associated with this task, which are outlined below.

The scope of this plan includes managing specific commissioning activities for the beamline, reviewing requirements for equipment not needed for commissioning, but planned for operations, and the basis for transitioning to operations. Technical commissioning of the FE and ID is managed separately from the beamline.

2. SHIELDING

Ray tracing (PD-FXI-RAYT-1000) and computer simulations indicate that 18-ID is shielded for the maximum planned stored electron beam current of 500 mA. The ray traces have been completed in accordance with *Synchrotron and Bremsstrahlung Ray Trace Procedure* (PS-C-XFD-PRC-008) and *Insertion Device Front End Ray Tracing Procedure* (PS-C-ASD-PRC-147) and top-off safety analyzed (NSLSII-TOS-RPT-015). There is one primary Bremsstrahlung collimator and a primary Bremsstrahlung stop within the 18-ID-A hutch. Secondary Gas Bremsstrahlung collimators and shields were designed following NSLS-II guidelines. The scattering of Bremsstrahlung has been simulated using FLUKA, which showed that the secondary collimators and shields are adequate at 500 mA beam current. The summary of these simulations, including the simulation of synchrotron beam containment in beam transport and endstation enclosures, are provided in *18-ID FXI Beamline Radiation Shielding Analysis* (Tech Note #266).

3. BEAMLINE COMMISSIONING

The commissioning of the FXI beamline and its transition to operations begins with the IRR. This will be followed by part one (see 7.3.3) of the Technical Commissioning Plan (TCP) where the focus is on the beamline's Photon Delivery System (i.e., delivering photons to the endstation). This part of the plan is divided into 3 sections; Basic, Energy Calibration and Characterization/Optimization. The first section focuses on basic optics alignment to enable execution of the Radiation Survey Procedure. This part of the TCP will performed in close collaboration with the radiation survey team, with the electron current gradually increased while monitoring equipment protection systems and periodic radiation surveys as necessary. When the beamline equipment has been demonstrated to be capable of safe operation during standard X-ray operations, there is a final comprehensive radiation survey. Assuming that the comprehensive radiation survey does not find any issues, the TCP then proceeds to the next two sections, which focus on characterization and optimization of the Photon Delivery System.

Once the beamline optics has been commissioned to a sufficient degree, work will move to the second part of the commissioning plan (see 7.3.4), which is to commission the TXM instrument.

Scientific commissioning (not in the scope of this TCP) will then follow, to verify that the beamline meets the design performance goals, and to build up endstation and beamline parameters, and configurations that optimize beamline performance for routine User Operations. Technical and Scientific Commissioning will follow a phased approach, wherein initial capabilities are commissioned for User Operations, while later capabilities are still in the Technical or Scientific Commissioning stage, provided this is done in a safe manner.

3.1 Radiation Survey Commissioning

A comprehensive *FXI Beamline (18-ID) Radiation Survey Procedure* (NSLSII-18ID-PRC-001) was developed in accordance with *NSLS-II Beamlines Radiation Safety Commissioning Plan* (PS-C-XFD-PRC-004), which guides the steps needed to control radiological hazards. It includes specific hold points to manage identified radiation risks and maintain commissioning within an approved envelope. The Radiation Survey Procedure requires participation and coordination between Beamline, Operations, Radiological Control, and ESH Staff. It identifies specific radiation scatter points along the beamline and provides instruction for mechanical manipulation of the optics to allow for a comprehensive radiological survey along the beamline. Execution of the Radiation Survey Procedure, along with the evaluation of the data collected, will be used as a basis by the PSD Director and ESH Manager to approve commissioning activities at an electron beam current of up to 3 times the electron beam current measured during the survey. Approval of commissioning of the beamline at a higher electron beam current requires re-execution of the Radiation Survey Procedure. The maximum current allowed during commissioning is indicated on the Caution Tag that is applied by Operations Staff to the beamline enable key. Enabling the beamline at a higher current requires re-execution of the full Radiation Survey Procedure and re-approval by the PSD Director and ESH Manager.

3.2 Technical Commissioning

The TCP, described in Section 7 below, documents in some detail the sequence of activities planned to safely commission the beamline. The TCP starts with lowest ring current, and gradually increases ring current until it is at the value for standard operations. At the completion of the TCP, all major beamline components will be ready to use, and parameters that optimize their performance will be documented.

3.3 Scientific Commissioning

The FXI beamline is designed for imaging using a Transmission X-ray Microscope (TXM). A scientific commissioning plan will be developed while the technical commissioning takes place. The goal of the scientific commissioning will be to define the beamline parameters and configurations needed for the anticipated scientific program, and the process to bring the complete beamline into routine operations for users.

4. COMMISSIONING ACTIVITY APPROVAL

Work planning needed for safe and efficient commissioning, requires a commissioning SAF and is performed in accordance with *Experiment Safety Review* (PS-C-ESH-PRC-039). This process drives definition of scope, identification of hazards and controls, and review and approval of requirements for all commissioning activities. A commissioning SAF describing the commissioning tasks to be undertaken by the commissioning team will be submitted. This form will include the equipment and materials that will be used, the personnel authorized to participate in the commissioning and any controls that will be placed on the beamline (such as a current limit). This form will be submitted to the ESH Manager and PSD Director for approval. This commissioning activity approval process authorizes the commissioning team for a specific task or tasks (such as performing a radiation survey) thereby enforcing a step-by-step and HOLD point approach to commissioning. Most commissioning tasks are expected to take approximately one week to complete, though some may be longer. All commissioning activities will be reviewed on a weekly basis to determine if a new commissioning SAF is needed. This allows for flexibility in the commissioning process, but at the same time ensures that during commissioning the work is periodically reviewed and that the necessary controls are placed on the commissioning activities.

An approved commissioning SAF is required for the beamline to be enabled. Beamline enable is managed in accordance with *Enabling Beamlines for Operations* (PS-C-XFD-PRC-003). This procedure defines the process for enabling the beamline safety shutter and for giving control of that shutter to the Beamline Staff. The process requires participation and coordination between Beamline, Operations, and ESH Staff. A checklist is employed to assure systems are ready (PPS and safety system configuration control) and that staff is prepared to begin.

5. END STATION EQUIPMENT ADDITIONS

Experimental modules may be added to the end station as commissioning moves from technical to scientific, and the focus is shifted to optimizing the photon beam and preparing end station instrumentation for the expected scientific program. All equipment will be added in accordance with the *NSLS-II Process Description: Review Process for Facility Additions and Modifications* (PS-C-CMD-PLN-001), which provides a process for determining the type and extent of reviews warranted.

These additions will be reviewed through the BNL ESR process, in accordance with *Experiment Safety Review* (PS-C-ESH-PRC-039). This system allows for the treatment of the end stations as experiment areas and provides an electronic mechanism to gather the information needed to define and review equipment and materials in that area. The BNL ESR system contains fields for entry of the equipment and materials to be used, task analyses, control requirement definition, and for ESH review and approval. This approach will be documented in a Tailored Review Plan in accordance with the *NSLS-II*

Process Description: Review Process for Facility Additions and Modifications (PS-C-CMD-PLN-001).

6. END OF COMMISSIONING; TRANSITION TO OPERATIONS

Commissioning ends when the beamline has shown, through the execution of procedures and surveys, that it meets the NSLS-II Shielding Policy, that radiation leakage or scatter is controlled to as low as reasonably achievable, that the photon beam is prepared for User Operations, that the beamline control system is ready for data collection, and that the necessary authorizations for beginning operations have been obtained. Prior to the beamlines commencing User Operations, the process outlined in *Beamline User Readiness (*PS-C-XFD-PRC-030) will be completed.

The safety of ongoing beamline operations will be managed with the *Experiment Safety Review* (PS-C-ESH-PRC-039) process, which will control materials, equipment, and tasks at the end station areas through the use of the BNL electronic ESR system. A Cognizant Space Manager is assigned to the area and has responsibility to assure that the system is current and accurate. This system provides a valuable envelope for the resources and allows operations at each location.

Individual experiments will be managed with the electronic SAF section of PASS; a system for Proposal, Allocation, Safety, and Scheduling for User science. The SAF will allow collection of information specific to each experiment and will be reviewed by NSLS-II Staff to determine what hazards are outside the safety envelope established. The SAF will provide the mechanism for definition of scope, analysis of hazards, establishment of controls, and collection of feedback for each experiment. Users must identify the materials and equipment they wish to bring along with a task analysis describing how those items will be used. An iterative review between the User, Beamline, and ESH Staff results in a final approval with definition of requirements.

The SAF process combined with the BNL ESR safety envelope provides the basis needed to assure ongoing control of beamline operation and changes. No additional readiness reviews are expected for the 18-ID beamline at this time.

7. FXI Beamline Technical Commissioning Plan

7.1 FXI Beamline Subsystem Definition

Photon Delivery System:

FXI has 9 vacuum sections, with windowless vacuum from the FE to the Beryllium window in the B station. Each section can be pumped separately.

I. Differential Pump Assembly:
   - Upstream and downstream ion pump crosses with RGA on upstream cross
   - Water cooled fixed mask
   - Bremsstrahlung collimator
   - Secondary bremsstrahlung shield (SBS-0)

II. Collimating mirror

III. Secondary bremsstrahlung shields (SBS-I & SBS-II) and transport pipe section

IV. White/pink beam fluorescent screen, white beam stop/pink beam mask, primary bremsstrahlung stop, pink beam slits

V. LN2 cooled DCM

VI. Pink/monochromatic beam fluorescent screen, pink beam stop and secondary bremsstrahlung shielding (SBS-III)

VII. Toroidal mirror

VIII. Monochromatic fluorescent screen, secondary bremsstrahlung shield (SBS-IV), photon shutter

IX. Beam transport from A to B stations, ion pumps and the end Be window

Transmission X-ray Microscope in 18-ID-B:

I. The TXM comprise of the following (see Appendix):
   - Secondary slit assembly box with SSA, ion chambers, rotating diffuser and filter box
   - Sample and main optics granite table carrying the sample rotation stage, the condenser,
   - Beam stop, pinhole, objective zone plate, phase ring, Bertrand lens
   - Detector A granite table
   - Detector B granite table

7.2 FXI Beamline Commissioning Without Beam

a. Beamline Vacuum System

- Verify that all ion pumps and gauges are functional
- Pump down each vacuum section; vacuum leak check and remedy if necessary
- Verify water flow in cooling system for mirrors, diagnostics and monochromator using flow switches integrated into the EPS system
- Verify the functionality of the EPS system in response to vacuum failures, by simulating trip signals from the vacuum gauge controller
- Verify the functionality of the EPS system in response to insufficient water flow on water-cooled components
- Verify the functionality of the EPS system in response to temperature faults on water-cooled components
- Test photon shutter and verify that the PPS system is functional
- Verify the functionality of the CSS vacuum screen

b. Collimating Mirror

- Verify all motor motion, including the mirror support stages and the mirror bender
- Verify mirror surveyed in place and hard-stops are set
- Verify the functionality of the CSS screen
- Place mirror in its nominal out-of-beam position based on the survey results obtained during installation, in preparation for alignment with beam

c. Double-Crystal Monochromator (DCM)

- Verify all motor motion: Bragg, second-crystal offset, second-crystal pitch, and second-crystal roll
- Place all motors in operational position (in beam) based on survey results obtained during installation
- Verify the functionality of the CSS vacuum screen

d. Toroidal Mirror

- Verify all motor motion, including the mirror support stages and the mirror bender
- Verify the functionality of the CSS screen
- Place mirror in its nominal position based on the survey results obtained during installation, in preparation for alignment with beam

e. Beam Visualization Diagnostics

- Verify motion and move diagnostics into nominal position
- Verify diagnostic cameras are aligned and in focus based on visible references
- Verify the functionality of the CSS vacuum screen

f. Secondary Source Aperture (SSA)

- Verify all motor motion
- Verify the functionality of the CSS screen

g. Transmission X-ray Microscope

- Condenser
  - Verify all motion
  - Verify the functionality of the CSS screen
- Pinhole
  - Verify all motion
  - Verify functionality of the CSS screen
- Sample stack stages
  - Verify all motion
  - Verify slip-ring functions correctly
  - Set EPICS soft limits as necessary
  - Verify functionality of the CSS screen
- Zone plate, phase ring, Bertrand lens
  - Verify all motion
  - Verify functionality of the CSS screen.
- Detectors
  - Verify all motion
  - Verify camera function
  - Verify visible light approximate focus
  - Verify functionality of the CSS screen

h. Data Acquisition System

- Test cameras that view various beam visualization screens
- Test data collection and handling as required for commissioning

7.3 FXI Beamline Commissioning With Beam

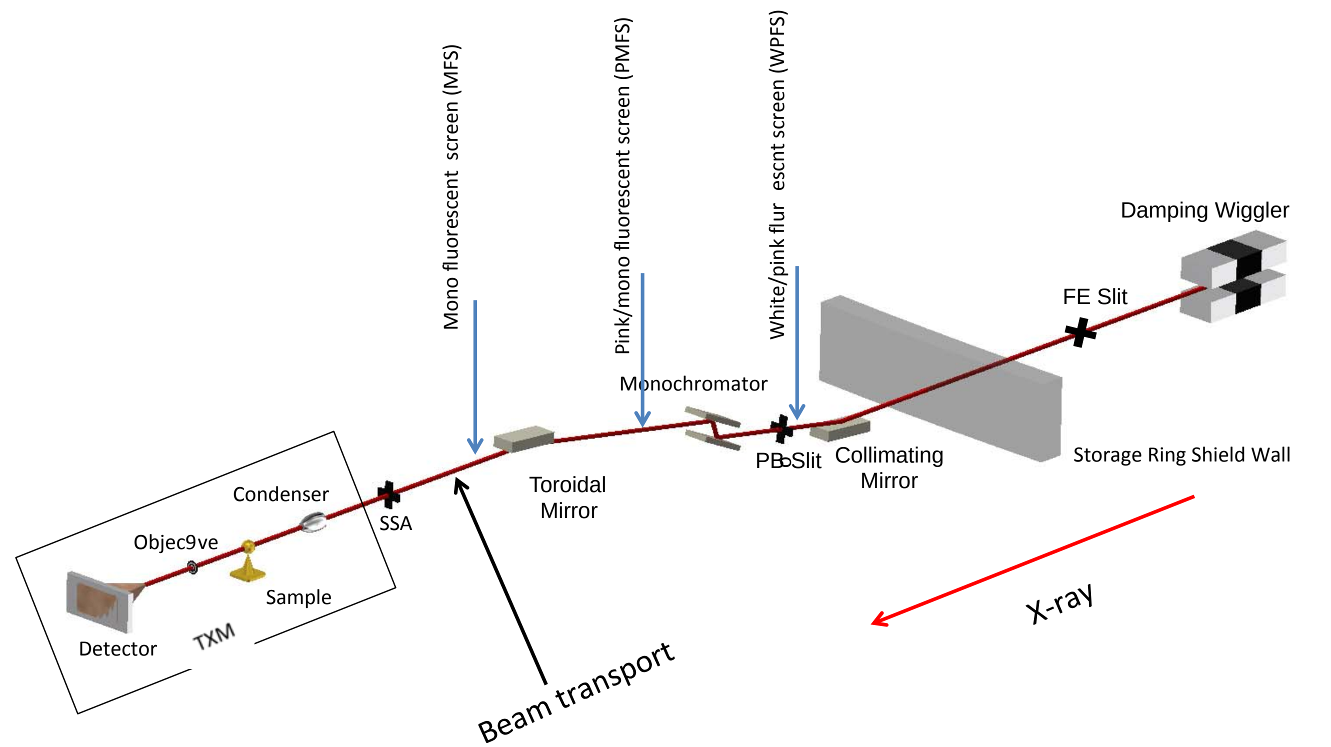

Figure 1: Schematic illustration of FXI beamline optical scheme. For more details, see **Appendix: FXI Beamline Component Layout.**

7.3.1 Pre-beam Commissioning Activities

The FE will be commissioned by the Accelerator Division prior to FXI beamline commissioning.

Prior to the beamline commissioning activities, the following prerequisites shall be satisfied:

- IRR completed and pre-start findings closed
- PPS and EPS functional
- Accelerator operating at current determined by the accelerator division
- DW100 source and FE commissioned
- FE slits calibrated and controllable by beamline control system
- Cameras connected and working to align beam with respect to visualization screens
- Beamline control environment with basic capabilities (e.g., motor control) and basic graphics and user interface available
- For a given commissioning-with-beam activity, relevant commissioning-without-beam activities are completed

7.3.2 First-beam Extraction and Radiation Surveys

Accelerator studies time is required to conduct Gas Bremsstrahlung (GB) and Synchrotron white, pink, and monochromatic beam radiation (SR) surveys as described in the Radiation Survey Procedure (NSLSII-18ID-PRC-001). These radiation surveys are initially carried out at low electron beam currents; a succession of successful radiation surveys will allow increasing the electron current stepwise with the goal to obtain authorization to operate the beamline during regular accelerator operations for the purpose of beamline optics commissioning, beam characterization and endstation commissioning. However, in order to execute the Radiation Survey Procedure, the beamline optics need to be aligned to ensure that the beam can be properly transmitted to the various scattering targets and also to ensure that the beam is hitting the optics properly. The details of this alignment procedure is described in section 7.3.3.3.1 under Basic Commissioning. The alignment will be performed in close collaboration with the radiation survey team and paused for periodic surveys as necessary.

7.3.3 Transition to Operation Condition & Beamline Optics Commissioning

I. Prerequisites for Beamline Technical Commissioning

Preliminary commissioning phase of the FE performed by the Accelerator Division:

- Primary FE slits positioning and alignment, with electrometer current signals
- Vacuum conditioning

II. Goals of Beamline Optics Commissioning

The goal of beamline optics commissioning is to achieve complete control and understanding of beamline optics operation, energy selection, and the beamline alignment procedure. This activity is broken into three parts: Basic commissioning, Calibration and Characterization/Optimization. Part one is to get the beam into the B station to verify general alignment and enable execution of the Radiation Survey Procedure. Part two is to perform energy calibration for the beamline. Part three is expected to take the longest, and involves detailed characterization and optimization of the optical components. Pauses in activity for vacuum conditioning is expected.

<u>Note: This commissioning plan has been revised to address the concerns raised at the IRR regarding the CM hard stops. It requires that CM Y motions be locked out via LOTO. The exception to this is when the current is ≤ 10 mA *and* the FOE Photon Shutter is LOTO closed. When a satisfactory CM hard stop has been approved and implemented, this commissioning plan will be updated accordingly.</u>

III. Commissioning Sequence

a. Basic Commissioning of the Photon Delivery System:

<u>Goals</u>: Basic optics alignment to enable full beam full current radiation surveys.

- Initial alignment of FE slits (performed with help of ASD):
  - The FE white beam slits will be commissioned and aligned by ASD prior to beamline commissioning

- Adjust FE slits to 0.5 mm x 0.5 mm, centered along the straight section center line
- With the FE shutter closed, check that the drain currents from the slit blades are consistent with the desired slit size/position

o Lock out FOE Photon Shutter per PS-C-XFD-PRC-024 '*Beamline Photon Shutter Centrally Controlled Lockout/Tagout Procedure*'.

o Ensure CM is out of the way for white beam on white beam stop survey:

- ≤ 10 mA ring current, FE shutters closed.
- Set FE WB slits to ~ 0.5 mm x 0.5 mm, centered.
- Set CM to zero degrees and -4 mm below WB.
- Open FE shutter. Look for WB on WPFS.
- Fully open FE WB slits while monitoring WPFS. Move CM up and down by < 1 mm to ensure WB clearance.
- Close FE shutter. Retract WPFS.

o Lock out CM vertical motions:

Once full beam at low current (≤ 10 mA) is confirmed to be hitting the white beam stop, lock out the CM Y motors to enable operation at > 10 mA. The steps to do this are as follows:

- FE shutter closed.
- The 3 motors shall first be disabled in software. These are referred to as Y1, Y2 and Y3 in the CM control section.
- The 3 associated orange motor cables shall be disconnected from the collimating mirror connector box (see Appendix). These 3 associated connectors are labeled as CN11-1, CN12-1 and CN13-1 on the connector box (see Appendix).
- Once the 3 orange motor cables are disconnected from the connector box, they shall be locked out per NSLSII-ESH-PRC-006 '*Centrally controlled Lockout/Tagout (LOTO)*'

The LOTO of these motor cables will prevent the CM of getting into the beam.

o Complete white beam on white beam stop radiation survey at > 10 mA

o Go back to ≤ 10 mA operations

- Close FE shutter
- Go to ≤ 10 mA ring current
- At ≤ 10 mA ring current, unlock the 3 CM Y motors.

o Initial alignment of the vertically deflecting CM:

    - ≤ 10 mA ring current, FE shutter closed. FOE Photon Shutter remains locked out.
    - Set FE WB slits to ~ 0.5 mm x 0.5 mm, centered.
    - Insert WPFS. Open FE shutter. Check white beam on WPFS.
    - Close FE shutter. Move CM into nominal operating position (4.4 mrad incidence angle).
    - Check CM Y alignment: Open shutter. Look for PB on WPFS. Translate mirror vertically up/down and tweak pitch to verify CM Y center relative to WB.
    - Start opening FE slits while monitoring WPFS, checking to make sure CM is not clipping pink beam.
  - Initial alignment of the monochromator (DCM):
    - Continuation from above; ≤ 10 mA ring current, FE and FOE shutters closed
    - Pink beam slits wide open.
    - Move Bragg angle for 11 keV.
    - Retract WPFS. Insert PMFS. Open FE shutter.
    - Look for monochromatic beam on PMFS. Vary second crystal pitch as necessary.
    - If monochromatic beam cannot be seen, move to zero Bragg angle and try to look for incident pink beam. Tweak CM angle if necessary.
  - Initial alignment of the TM:
    - Continuation from above; ≤ 10 mA ring current, FE and FOE shutters closed
    - Set TM to nominal operation condition (4.4 mrad incidence angle)
    - Retract PMFS. Insert MFS. Open FE shutter.
    - Look for reflected beam on the MFS.
  - Low current full beam check of CM, DCM and TM with FOE shutter closed and locked out:
    - Continuation from above; ≤ 10 mA ring current, FE shutter closed
    - MFS in, WPFS and PMFS out.
    - Open FE shutter.
    - Looking at TM reflected beam on MFS, move CM up/down a little to check alignment. Repeat for DCM and TM.
    - Confirm that we see the full TM-reflected monochromatic beam.
    - Confirm beam is monochromatic by tweaking DCM.

- At this point, we know that the beam is fairly well aligned through the CM, DCM and TM, and the beam is fully confined within the FOE since the FOE shutter is closed. We confirmed that the beam we see at MFS is monochromatic.
- Lock out of CM vertical motions:

Once monochromatic full beam at low current (≤ 10 mA) is confirmed to be hitting the MFS, lock out the CM Y motors. The steps to do this are as follows:

  - FE shutter closed.
  - The 3 motors shall first be disabled in software. These are referred to as Y1, Y2 and Y3 in the CM control section.
  - The 3 associated orange motor cables shall be disconnected from the collimating mirror connector box (see Appendix). These 3 associated connectors are labeled as CN11-1, CN12-1 and CN13-1 on the connector box (see Appendix).
  - Once the 3 orange motor cables are disconnected from the connector box, they shall be locked out per NSLSII-ESH-PRC-006 '*Centrally controlled Lockout/Tagout (LOTO)*'

The LOTO of these motor cables will prevent any possible pink beam mis-steer.

- Unlock the FOE Photon Shutter to enable low current monochromatic beam into B station.
- Initial alignment of SSA:
  - Continuation from above; ≤ 10 mA ring current, FE and FOE shutters closed
  - Survey SSA into expected beam position. Open slits wide.
  - Place a fluorescent screen in front of Be window.
  - Open FE and FOE shutters and look for beam on screen.
  - Close FOE shutter. Move screen to downstream of SSA.
  - Open FOE shutter and look for beam on screen.
  - Repeat previous two steps until monochromatic beam is seen at the back of the B station.

Further adjustments on TM and DCM may be necessary to ensure that the beam is not clipped. CM Y is locked. At this point, we know that the monochromatic beam is in B station and the CM, DCM and TM are fairly well aligned with low current, fully opened FE slits.

- Current ramp to complete Radiation Survey Procedure:
  - With the CM, DCM and TM in nominal positions (from above) and monochromatic beam can be seen in the B station.

- Start at 10 mA, FOE and FE shutters open. Visualize monochromatic beam in B station.
- Proceed with the rest of the Radiation Survey Procedure. Ramp up current as required. Pause for survey or vacuum conditioning as required.

b. Energy calibration of the Photon Delivery System

Goals: Calibrate the energy of the DCM and check the cut-off energies of the CM.

This section assumes that basic commissioning is successful and the beam is nominally transmitted to the B station, and that the Radiation Survey Plan has been substantially successfully executed.

- DCM energy calibration:
  - CM set to Rhodium stripe.
  - In the B hutch, place a Ti calibration foil between two ion chambers (I0 and I1). Plot I1/I0 as a function of DCM energy. Set DCM angles according to K edge positions.
  - With the DCM calibrated against the Ti K-edge, repeat above with Zn or Cu foil to check.
- Calibrate CM and TM angle:
  - Set TM to nominal position. Set CM to Silicon stripe.
  - Do an energy scan with the DCM and monitor ion chamber in B.
  - Compare cut-off energy with simulations. Calibrate CM angle as necessary. **CAUTION:** The CM angle should be fairly close since it was carefully surveyed in and checked during Basic Commissioning.
  - Repeat for Chromium CM stripes.
  - If cut-off energies for Si and Cr stripes are consistent, repeat for Rh stripe.
  - For the Rh stripe, if the cut-off energy is not consistent with simulation, it is likely that the TM angle calibration is not correct.

c. Characterization and optimization of the Photon Delivery System (assumes that CM has acceptable operating hard stops)

Goals: Characterize and optimize performance of PDS.

This section assumes that Basic Commissioning and Energy Calibration commissioning has been completed. It assumes that the CM has an acceptable and operating hard stop. Ideally, some measurements below should be done as a function of storage beam current.

- DCM performance:

  - Bragg angle reproducibility. Perform multiple energy scans across an absorption edge.
  - Thermal distortion. Perform rocking curve and ‘zebra scan’ measurements. The latter are a series of rocking curve scans with a small vertical slit after the DCM at different slit positions. Repeat for different LN2 flow settings.
  - Vibration. Perform rocking curve and sit on side of rocking curve. Measure standard deviation of ion chamber counts at 1 kHz acquisition. Repeat for different LN2 flow settings. Also, track this through a LN2 fill cycle.
  - Chi2 optimization. Track monochromatic beam horizontal motion as DCM energy is changed. Adjust Chi2 to minimize motion.
- CM performance:
  - Set CM bend radius I. TM set to flat. Full vertical beam size. Look at beam in B hutch downstream of a Cu calibration foil. Scan DCM across K edge. Adjust PZT bender until the beam intensity changes uniformly as DCM is scanned across the absorption edge.
  - Set CM bend radius II. Place a small vertical slit upstream of I0 and I1 in B station. Place calibration foil between I0 and I1. Scan DCM across absorption edge. Repeat for different vertical slit positions (vertically).
- TM performance:
  - Assume CM radius is correctly set. By scanning the SSA, measure beam size as a function of TM PZT bender. Compare optimum TM bender load cell readout with expected value obtained during FAT.
- Beam stability at SSA:
  - CM, DCM, TM and LN2 flow at nominal settings. Scan SSA to get vertical beam profile.
  - Sit SSA at edge of beam profile.
  - Track ion chamber fluctuations.

IV. Transition to TXM Technical Commissioning

a. Pre-requisites for TXM Technical Commissioning

Beamline optics (Photon Delivery System) has been commissioned and nominally functioning (beam is reasonably stable, calibrated and reproducible). Optimization of PDS need not be complete. Of crucial importance is the establishment/verification of the beam center line in the B hutch because the TXM will be defined according to this line. TXM optics roughly aligned using optical telescope.

b. Goals of TXM Technical Commissioning

The goal is to initiate alignment of the TXM instrument. For now, this commissioning is confined to absorption contrast. Zernike phase contrast will be done at a later date. Due to the interdependence on all the TXM components (eg, to optimize the condenser, an aligned zone plate is needed and vice versa), the steps below are general guidelines.

c. Commissioning Sequence

- Alignment of detectors:
  - With all TXM components out of the beam, image the incident beam on the detector. Focus detector-scintillator using a dummy sample. Center detector(s) on beam. This serves as the center reference.
- Alignment of condenser:
  - Move condenser into the beam. Using the 2X detector, look for the magnified “circle” of the post-focus beam out of the condenser. Adjust condenser to optimize the circle and get the circle centered on the detector.
- Alignment of zone plate objective:
  - Move condenser out of the way. Using the 2X detector, move zone plate into the beam. Find and roughly align zone plate to the center.
  - Move to the 10X detector. Look at focused beam at sample. Make fine condenser adjustments.
  - Move the pinhole in and align.
- Alignment of sample stage:
  - Insert test pattern on sample stage.
  - Look at image focus and adjust manual pitch and yaw of objective zone plate as necessary.
  - Remove condenser and objective zone plate.
  - Place a pin on sample stage. Find rotation axis.
  - Move sample rotation axis to center of detector FOV.
  - Using the xz stages above the rotation stage, align the sample rotation axis to be parallel with the columns of the detectors. This is achieved by a combination of the manual adjustments of the roll and pitch under the rotation stage and the detector rotation (roll).

8 REFERENCES

1. NSLSII-18ID-PRC-001, *FXI Beamline (18-ID) Radiation Survey Procedure*
2. NSLSII-TOS-RPT-015, *Beamline 18-ID (FXI) Top-Off Radiation Safety Analysis*
3. PS-C-ASD-PRC-147, *Insertion Device Front End Ray Tracing Procedure*
4. PS-C-CMD-PLN-001, *NSLS-II Process Description: Review Process for Facility Additions and Modifications*
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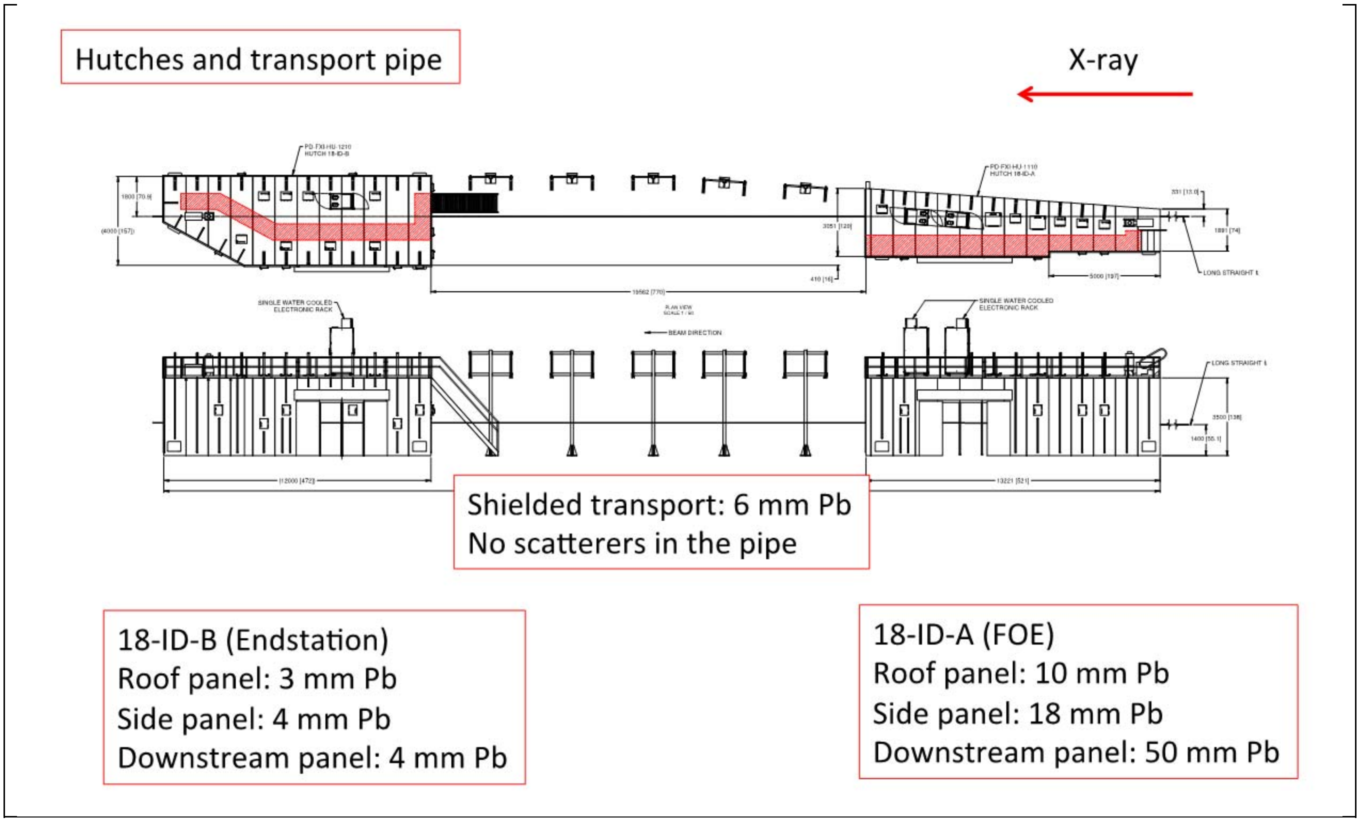
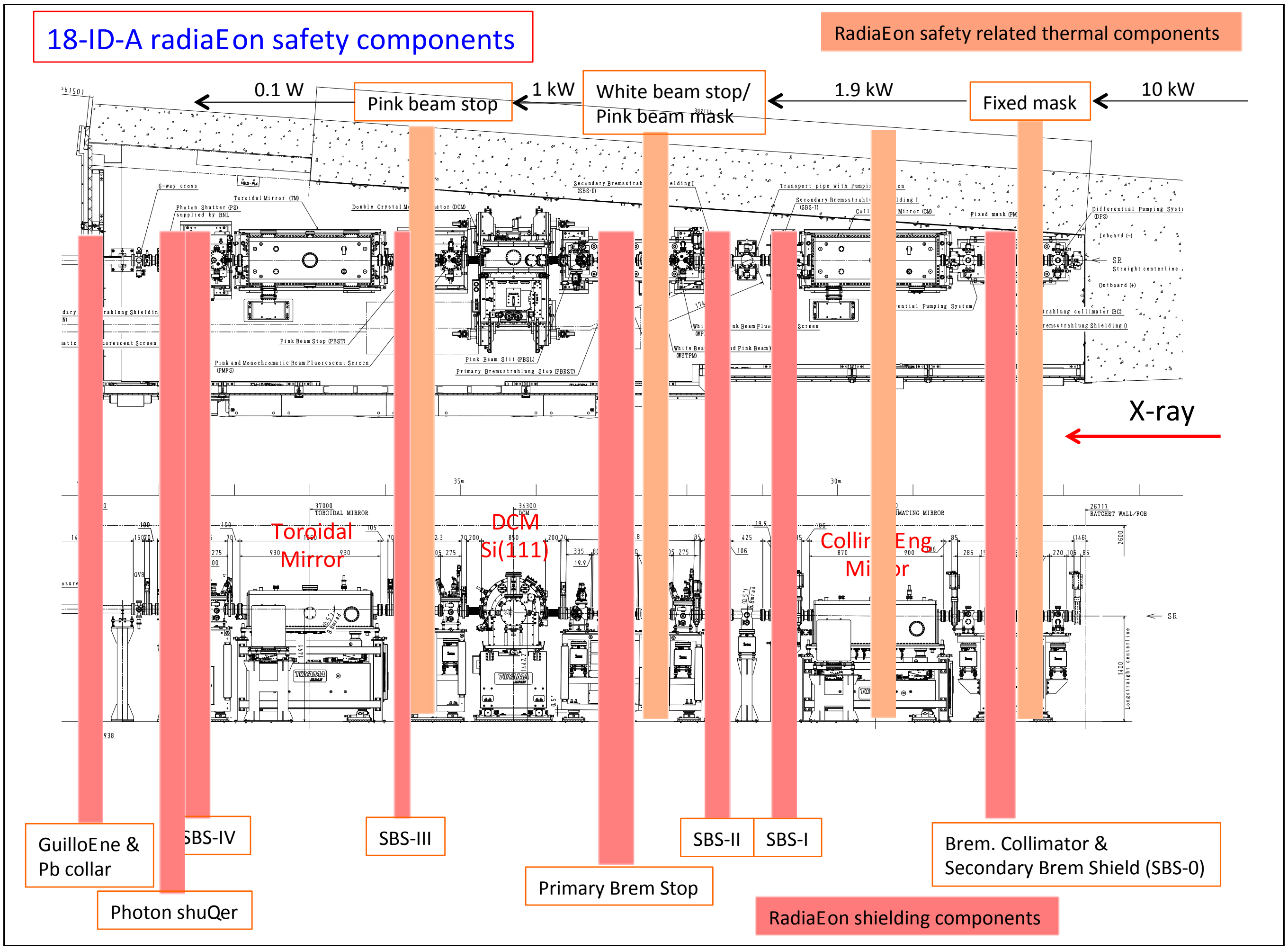
7. PS-C-XFD-PRC-004, *NSLS-II Beamlines Radiation Safety Commissioning Plan*
8. PS-C-XFD-PRC-008, *Synchrotron and Bremsstrahlung Ray Trace Procedure*
9. PS-C-XFD-PRC-030, *Beamline User Readiness*
10. Tech Note #266, *18-ID FXI Beamline Radiation Shielding Analysis*
11. PS-C-XFD-PRC-024, *Beamline Photon Shutter Centrally Controlled Lockout/Tagout Procedure*
12. NSLSII-ESH-PRC-006, *NSLS-II Procedure: Centrally Controlled Lockout/Tagout (LOTO)*

Appendix: FXI Beamline Layout Diagrams

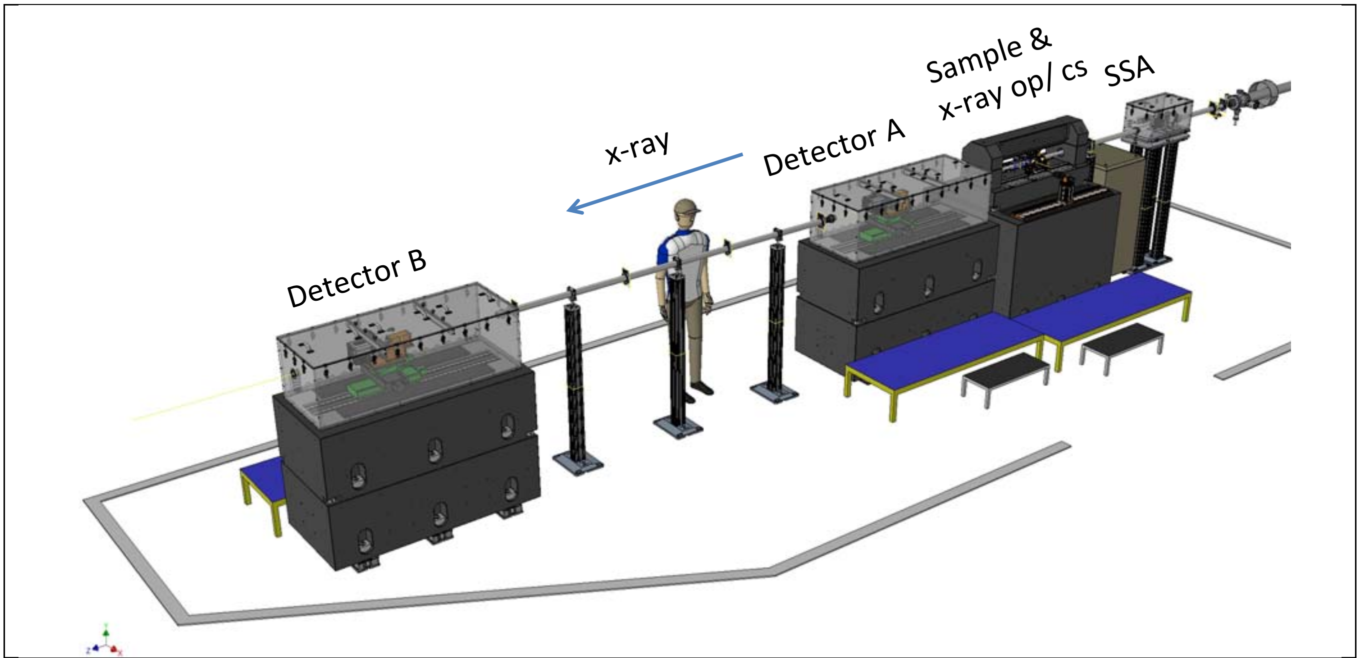
FXI OVERALL BEAMLINE LAYOUT:

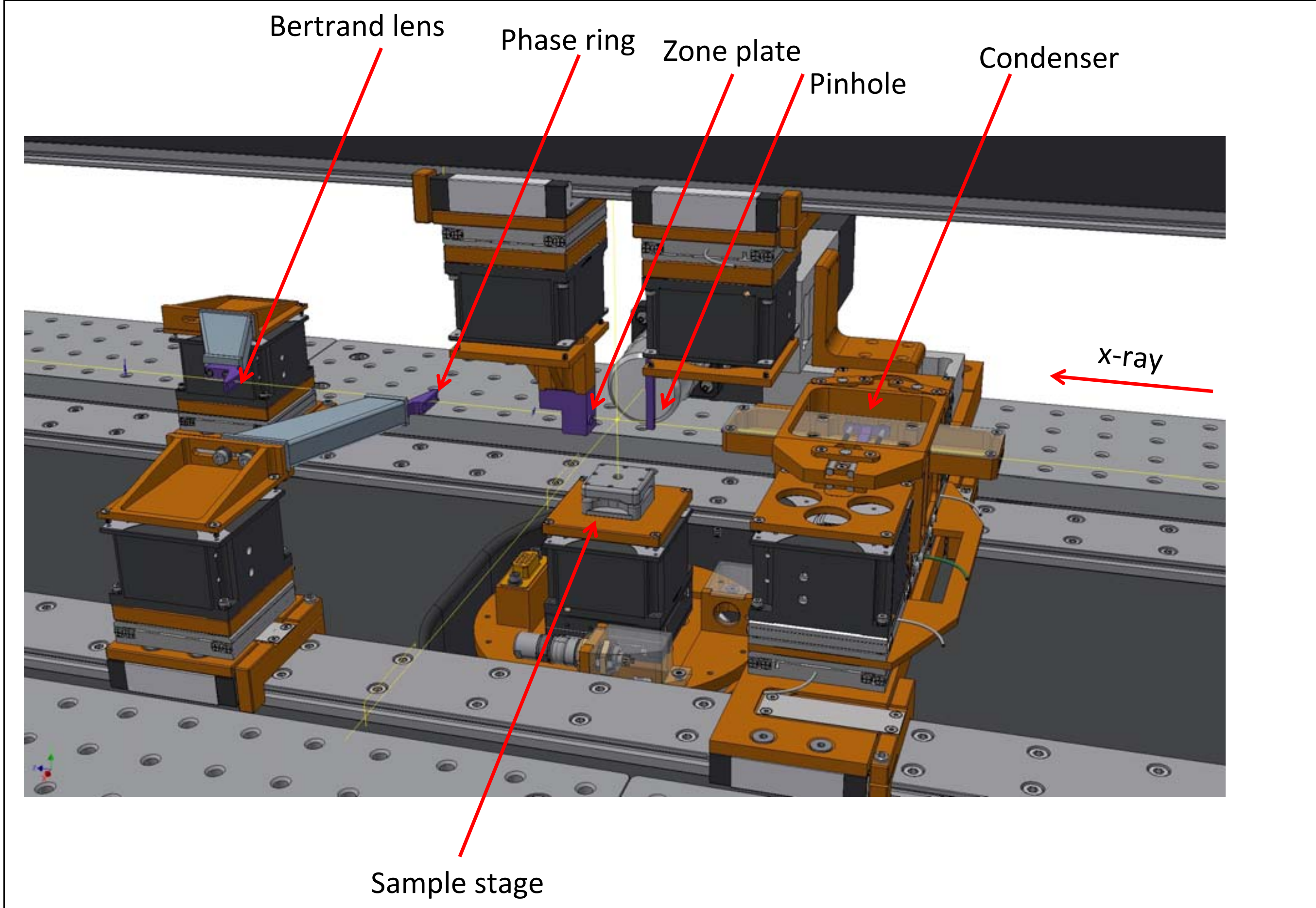


FXI DETAILED 18-ID-A LAYOUT SHOWING RADIATION SAFETY COMPONENTS:

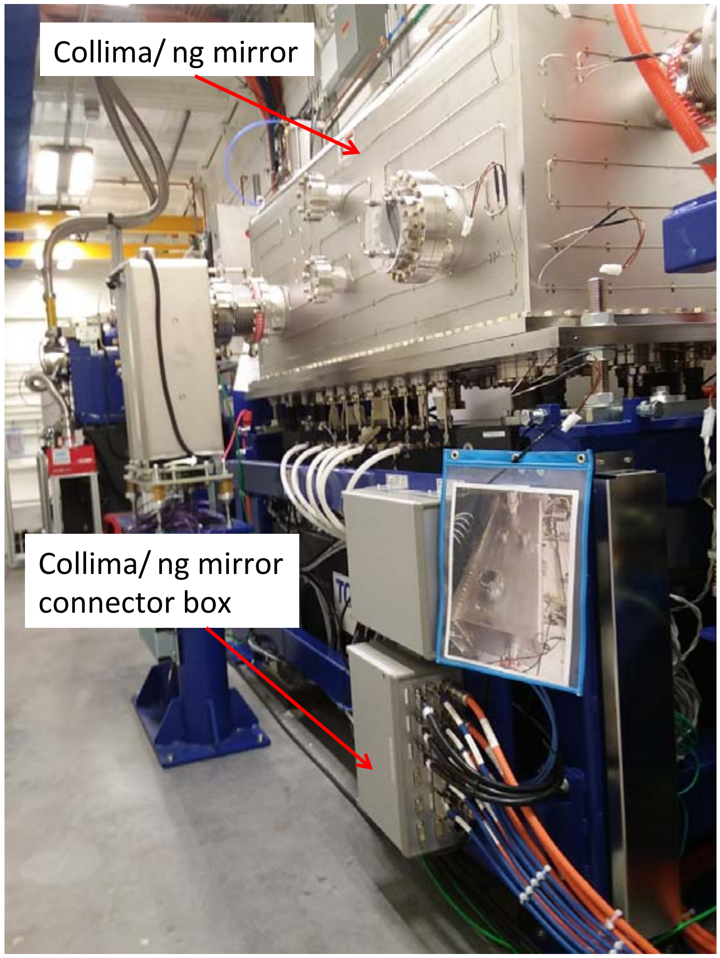


FXI 18-ID-B LAYOUT:

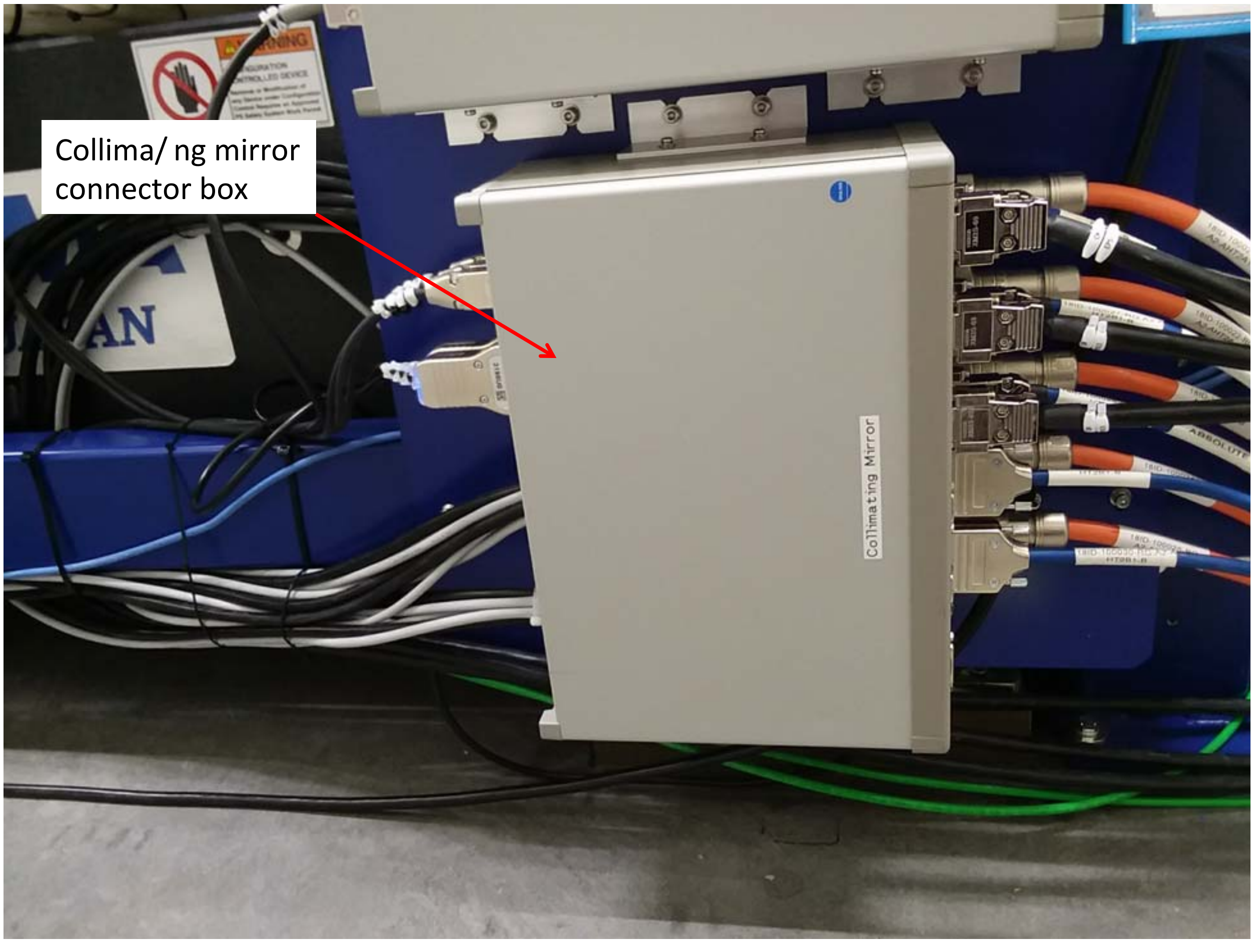




Top: B hutch layout **Bottom:** Close up of Sample and x-ray optics table



Location of the Collimating mirror connector box. View is looking downstream.



Closer view of the collimating mirror connector box.

Close-up view of the three motor cable connectors to be disconnected from the collimating mirror connector box and LOTOed. The three connectors are labeled CN11-1, CN12-1 and CN13-1.