NSLS-II NEXT BEAMLINE 2-ID COMMISSIONING PLAN

JANUARY 10, 2017

NSLSII-2ID-PLN-004

REV. 1

NSLS-II NEXT BEAMLINE 2-ID COMMISSIONING PLAN

JANUARY 10, 2017

PREPARED BY:

1/11/2017

X Ignace Jarrige

Ignace Jarrige
SIX Lead Beamline Scientist
Signed by: Jarrige, Ignace

APPROVED BY:

1/19/2017

X

Paul Zschack
Photon Science Division Director
Signed by: Zschack, Paul

REVISION HISTORY

REVISION	DESCRIPTION	DATE
1	First Issue	January 10, 2017

Acronyms

BNL	Brookhaven National Laboratory
ESH	Environment, Safety and Health
ESR	Experiment Safety Review
FE	Front End
FLUKA	Fluktuierende Kaskade (Monte Carlo simulation software)
GB	Gas Bremsstrahlung
ID	Insertion Device
IRR	Instrument Readiness Review
mA	milli-Ampere
NEXT	NSLS-II Experimental Tools Project
NSLS-II	National Synchrotron Light Source II
PASS	Proposal, Allocation, Safety and Scheduling
PPS	Personnel Protection System
PSD	Photon Science Division
RGA	Residual Gas Analyzer
SAF	Safety Approval Form
SIX	Soft Inelastic X-ray Scattering
TCP	Technical Commissioning Plan

Table of Contents

1. INTRODUCTION

This plan outlines the actions needed to commission the NSLS-II NEXT 2-ID beamline from the accelerator enclosure ratchet wall to the end station. Once the readiness process is complete, and authorization to begin commissioning the beamline is received, the technical commissioning will proceed and focus on delivery of photon beam to the experimental station. 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 beamlines, reviewing requirements for equipment not needed for commissioning, but planned for operations, and the basis for transitioning to operations. Technical commissioning of the FEs and IDs is managed separately from the beamline.

2. SHIELDING

Ray tracing and initial computer modeling (FLUKA) indicate that 2-ID is adequately shielded for the maximum planned stored electron beam current of 500 mA and two EPU57. The primary Gas Bremsstrahlung 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 resulted in a Primary Bremsstrahlung collimator and a Primary Bremsstrahlung stop within the 2-ID-A hutch. Secondary Gas Bremsstrahlung shields were designed following NSLS-II guidelines. The scattering of Bremsstrahlung and pink beam was verified using FLUKA, and is provided in the *2-ID SIX Beamline Radiation Shielding Analysis*.

3. BEAMLINE COMMISSIONING

The commissioning of the SIX beamline and its transition to operations begins with the IRR. This will be followed by the first phase of the Technical Commissioning Plan (TCP) in which the electron beam current is gradually increased while monitoring equipment safety. The TCP is conducted in parallel with Radiation Survey Commissioning, which monitors radiation safety as the ring current is increased. When the beamline equipment has been demonstrated to be capable of safely operating during standard x-ray operations, there is a final comprehensive radiation survey. The TCP then moves on to a new phase, in which all the key optical components such as the monochromator and mirrors are commissioned in detail in order to determine optimal operating parameters. Scientific commissioning will then follow, with the participation of expert users, 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.

3.1 Radiation Survey Commissioning

A comprehensive SIX Beamline (2-ID) Radiation Survey Procedure has been 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, radiation 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 NSLS-II 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 NSLS-II PSD Director and ESH Manager.

3.2 Technical Commissioning

The Technical Commissiong Plan (TCP) 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 TCP, all major beamline components will be ready to use, and parameters that optimize their performance will be documented.

3.3 Scientific Commissioning

The SIX beamline will have one endstation, comprised of a sample chamber and an emission spectrometer. These components and automated sample handling are still under development and expected to become operational during scientific commissioning. A scientific commissioning plan will be developed while the technical commissioning takes place, to define the beamline parameters and configurations needed for the anticipated scientific program, test measurements needed to demonstrate beamline performance, and the process to bring the complete beamline into routine operations.

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 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 or ID gap limit). This form will be submitted to the ESH Manager and PSD Manager 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 and automation equipment will 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.

The tailored review plan for the end station equipment is currently under preparation and will be developed 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 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 PS-C-XFD-PRC-030, *Beamline User Readiness* 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.

7. SIX Beamline Technical Commissioning Plan

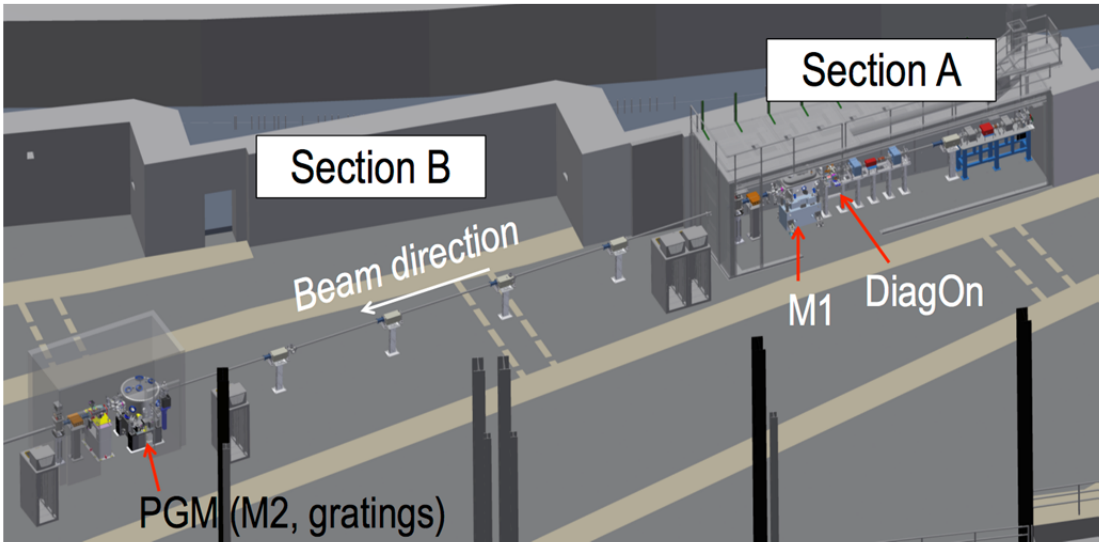
7.1 SIX Beamline Subsystem Definition

a) Section A – FOE Hutch:
- DiagOn Diagnostic
- M1 mirror chamber
- Downstream M1 baffle slits

b) Section B – Monochromator:
- Upstream PGM baffle slits
- VLS-PGM (M2 and gratings)
- Downstream PGM baffle slits

c) Section C – M3 and M4 chambers:
- Upstream M3 baffle slits
- Diagnostic unit (Diode, YAG, Au mesh)
- M3 mirror chamber
- VLS PGM slits
- Gas-chamber and diagnostic unit (Diode)
- Diagnostic unit (Diode, YAG, Au mesh)
- Absorption reference materials unit
- Upstream M4 baffle slits
- M4 chamber

d) Section D – End station:
- Sample chamber and emission spectrometer



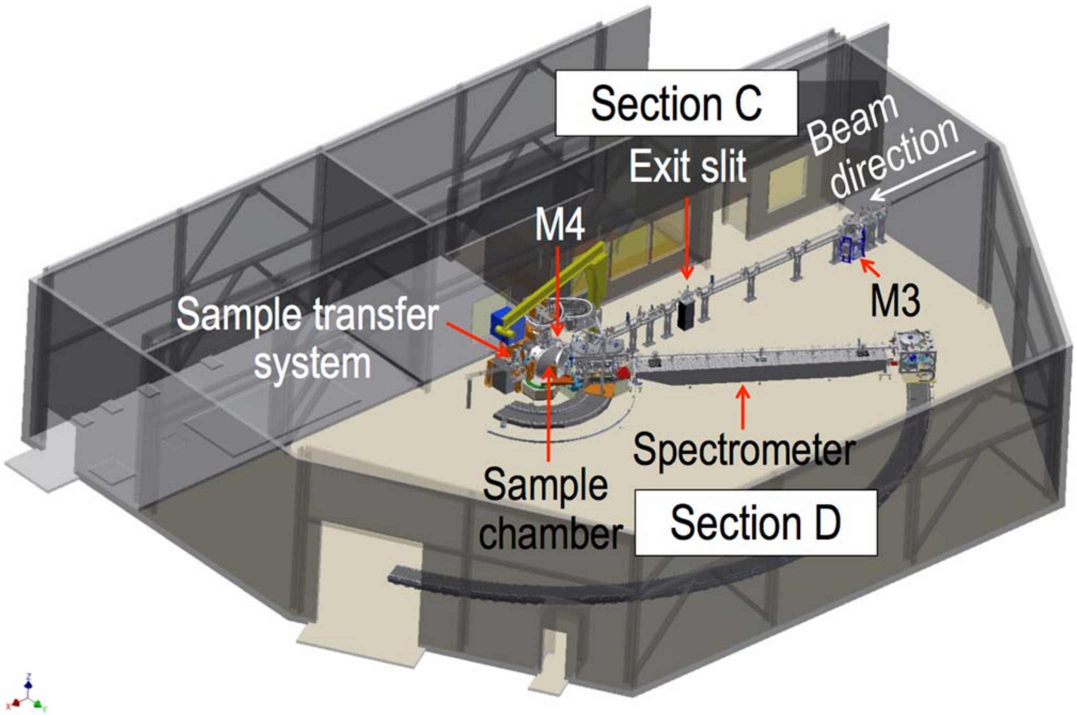


Figure 1: Optical layout of SIX photon delivery and end station systems in sector 2-ID of NSLS-II.

7.2 SIX Beamline Commissioning Without Beam

Extensive subsystem testing of the SIX beamline major optical assemblies was successfully carried out during factory and site acceptance tests. Most of these tests were repeated or verified in the course of the installation of the photon delivery system in the past few months. Integrated testing of the entire beamline is under way.

7.3 Pre-beam Commissioning Activities

The EPU57 of the 2ID long straight section has been installed and commissioned by the Accelerator Division in October 2016. This ID commissioning is a prerequisite to the SIX photon delivery commissioning. In addition to this prerequisite for beamline commissioning, the following requirements have to be met:

- IRR completed and pre-start findings closed
- Commissioning without beam completed
- PPS and EPS functional
- Insertion device controllable by beamline
- Front end slits and flags controllable by beamline
- Cameras connected and working to align beam with respect to visualization screens
- Micro-ammeters connected to detect drain currents along beam path
- Beamline control environment with basic scanning capabilities (including undulator gap scanning) and basic graphics available

7.4 First Beam Extraction and Radiation Surveys

A few days of dedicated study time may be needed to conduct GB radiation surveys as will be described in the radiation survey plan and to extract and transport first beam along the beamline.

GB radiation survey: Gap fully open, survey for GB radiation leaks around the FOE and the first part of the beamline down to the PGM. Initially carried out at low electron beam currents (1-2 mA) during accelerator study time dedicated to this purpose, a succession of successful GB radiation surveys will allow increasing the electron current stepwise with the goal to obtain permission to operate the beamline with a tunable ID gap during regular accelerator operations for the purpose of the beamlines' optics commissioning.

Beamline conditioning: Soft X-ray mirrors suffer from carbon contaminations of their surfaces. They must be extensively conditioned adjusting the incident flux so as to preserve vacuum levels in the 10^{-9} range. This can be achieved starting with small machine current (maybe 1 – 2 mA) and fully opened undulator gaps and reducing the gap while monitoring the vacuum. After the vacuum recovers, the gap is further closed. This process is continued until closing the gap to achieve ~ 700 eV photon energy. At this energy the undulator diagnostic can be used and first beam propagation along the beamline can be attempted.

To further speed up beamline conditioning, it will be useful to be able to operate during user time with regular operation beam current. Low incident power similar to a low ring current or a larger undulator gap can be achieved via control of the FE slit opening, starting at the smallest opening values and slowly increasing as vacuum levels recover.

First beam propagation: Gap closed to achieve a nominal photon energy of ~ 700 eV, low machine current maybe 1 mA, front end slits open:

1. Monitor the synchrotron radiation with DiagOn optics
2. Take the DiagOn out of the beam path and let the light travel downstream to M1. Monitor location of reflected light using photoemitted current from M1 baffle slits (downstream of M1 mirror)
3. Let the light travel downstream to the mono. Monitor location of diffracted light after the mono using photoemitted current from the baffle slits downstream of the mono
4. Visually inspect the light with the YAG upstream the M3 mirror
5. Let the light reflect off M3 and monitor current with exit slits currents, visually inspect with YAG crystal at exit slit position
6. Let the light reflect off M4 and monitor reflected beam current with photodiode (downstream of M4 mirror)

7.5 Transition to Operation Condition & Beamline Optics Commissioning

7.5.1 Prerequisites

Preliminary commissioning phase of the ID and frontend performed by the accelerator division:

a. EPU energy selection
b. EPU energy scans
c. Primary FE slits scans / alignment
d. XBPM commissioning and calibration
e. DiagOn, located in the FOE, can also be used at low currents

Preliminary commissioning phase of the photon delivery:

- Be able to select a monochromator energy and take short energy scans around an absorption edge
- Be able to scan all baffle slits
- Be able to take and record images of YAG crystals with cameras
- Be able to read and record currents from diagnostic units with picoammeter during mono scans

7.5.2 Goals of Beamline Optics Commissioning

Achieve complete control and understanding of beamline EPU and beamline optics operation, energy selection, beamline alignment procedure, beamline tuning, control of beam spot size.

This commissioning phase includes the SIX Photon Delivery System – all beamline optics downstream of the ratchet wall, from the FOE down to the M4 mirror system.

7.5.3 Commissioning Sequence

1. Repeat first beam propagation: gap closed to achieve ~700 eV, machine current 1 mA; record currents along the beamline
2. Close completely FE slit; check zero currents on beamline monitors
3. Increase the machine current to regular operation current (250 mA as of November 2016)
4. Close the FE slits to match diagnostic current readings along the beamline with the ones obtained when the machine runs at 1 mA
5. Perform synchrotron radiation survey

The beam is now ready to conduct optical alignment / commissioning of the beamline. During these tests, the FE slits will be gradually opened while ensuring that < 10^{-8} Torr vacuum condition and acceptable heat loads on mirrors are maintained.

Two main objectives will be achieved at this stage:

1. Optimization of photon flux: Obtained by optimal alignment of mirrors along the beam path
2. Optimization of mono energy resolution (positioning of exit slits and/or tweaking of gratings roll and yaw): Obtained by monitoring gas absorption spectra

Once the monochromator is optimized, the refocusing of the beam by the M4 ellipsoidal mirror will then be optimized.