

17-BM XFP Technical Commissioning Plan

PS-C-XFD-XFP-PLN-003

June 21, 2016

XFP Beamline Subsystem Definition

- a) Section A – Mirror and ancillary components:
 - Toroidal focusing mirror in front end
 - Downstream phosphor screen (on Fixed Mask 3 in front end)
 - Front end flag
 - XFP pink beam slits
- b) Section B– Focal position, endstation 1:
 - XFP sample pre-shutter
 - XFP endstation table 1
 - X-Y modular motor assembly 1
 - Z slide
 - Syringe pump
- c) Section C – Defocused beam position, endstation 2:
 - Multiple sample holder slide
 - Uniblitz sample shutter
 - X-Y stage

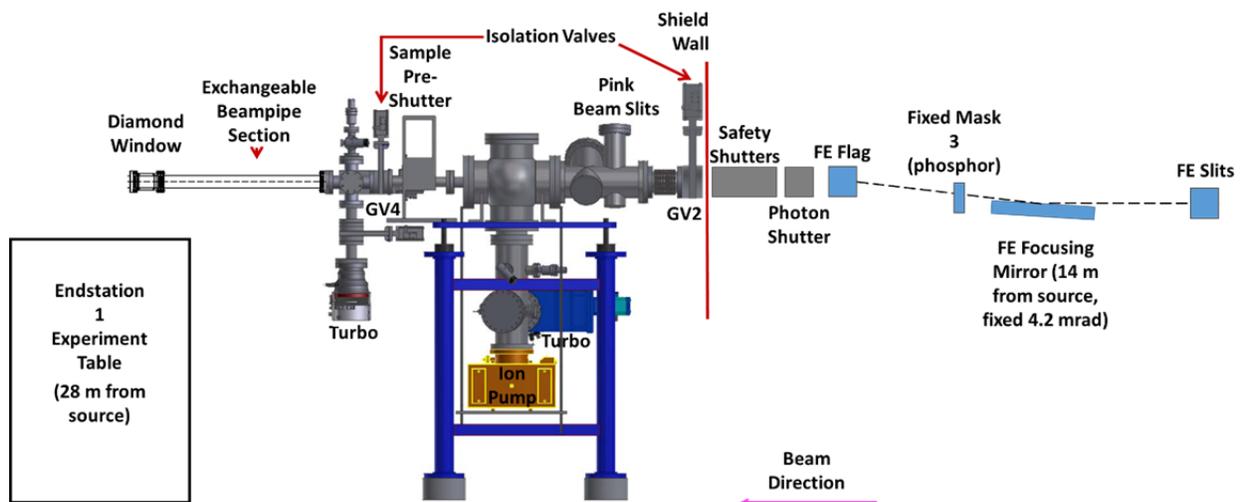


Figure 1: Optical layout of XFP Beamline in NSLS-II Sector 17-BM (FE schematic not to scale)

XFP Beamline Commissioning Without Beam

Subsystem testing of individual beamline components has been performed throughout XFP beamline construction and installation. Technical commissioning of additional beamline endstation equipment is expected to continue as the beamline enters scientific commissioning.

Pre-beam Commissioning Activities

The three pole wiggler (3PW) source has been installed at 17-BM and will be commissioned by the Accelerator Division in July 2016. In the event that this source is not available, initial commissioning of the XFP Front End and beamline with the 3PW extracted (Bending Magnet radiation only) may be possible. However, as prerequisites for beamline commissioning, the following requirements must be met:

- IRR completed and pre-start findings closed
- Commissioning without beam completed
- PPS and EPS functional
- FE mirror controllable by beamline control system
- Front end slits and flags controllable by beamline control system
- Cameras connected and working to align beam with respect to visualization screens
- Beamline control environment with basic capabilities (including motor control) and basic graphics and user interface available
- Commissioning of the 17-BM Front End is completed (beam is observed on the Front End flag) and LOTO has been removed from the FE Photon Shutter and Safety Shutter

First-beam Extraction and Radiation Surveys

About 1/2 day of accelerator studies time is expected to be required to conduct BS radiation surveys as described in the radiation survey plan (PS-C-XFD-PRC-064) and to extract and transport first beam along the beamline. Note that initial beam pipe length after GV4 will be shortened to enable verification of focal position; once verified (after completion of commissioning), this section of beam pipe will be replaced with correct lengths to place sample with optimal minimal air path after the exit window for either full focal position or desired unfocused position. This change has no radiation safety implications and may be done by beamline staff whenever required.

BS radiation surveys: Initially carried out at low electron beam currents (1-2 mA) during accelerator study time dedicated to this purpose, a succession of successful bremsstrahlung radiation surveys will allow increasing the electron current stepwise with the goal to rapidly obtain authorization to operate the beamline during regular accelerator operations for the purpose of beamline optics commissioning, beam characterization and endstation commissioning.

First beam propagation: FE focusing mirror in unfocused configuration at nominal working angle, beam current below 2 mA: front end slits open, beamline slits open.

1. Observe the beam on the FE flag
2. Extract the FE flag, open the photon and safety shutter to allow the synchrotron light to arrive in the FOE
3. Observe the beam on burn paper at the rear of the hutch and/or a phosphor screen downstream of the exit window (using a camera)

Transition to Operation Condition & Beamline Optics Commissioning

Prerequisites

Preliminary commissioning phase of the 3PW and Front End performed by the accelerator division (FE in conjunction with beamline control of FE focusing mirror):

- 3PW insertion
- Primary FE slits scans / alignment with electrometer current signals
- FE focusing mirror initial alignment
- Diagnostics
 - Phosphor screen on FM3
 - Front End Flag
- Vacuum conditioning

Preliminary commissioning phase of the photon delivery system:

- Be able to observe unobstructed beam from FE focusing mirror through exit window
- Be able to adjust beamline slits
- Be able to block the beam with the sample pre-shutter
- Vacuum conditioning to maintain vacuum level better than EPS set point

Goals of Beamline Optics Commissioning

Achieve complete control and understanding of beamline optics operation, beamline alignment procedures, beamline tuning, and control of beam spot size and flux density.

This commissioning phase includes the XFP FE Mirror and Photon Delivery System – all beamline optics from the FE beryllium window inside of the ratchet wall down to the experimental endstations. Successful completion of preliminary commissioning of photon delivery system as described above will enable subsequent use of full operational beam current. During these tests, the FE slits will be gradually opened as soon as this can be done safely i.e., preserving $<10^{-8}$ Torr vacuum conditions downstream of the Be window at the mirror location and acceptable heat loads on the mirror (thermocouples can be monitored). Take precautions to minimize ozone production (beam stops, nitrogen enclosures, minimal exposure times, as appropriate).

Commissioning Sequence

1. Close FE slits until beam is no longer visible on any diagnostic.
2. With beam current at full operational value, slowly open FE slits, maintaining FE and BL vacuum levels at better than EPS set points.
3. Once FE slits can be fully opened without degrading vacuum levels, repeat first beam propagation, adjusting Z position using Z slide of phosphor screen until horizontal beam size appears minimal and record Z position.

4. Close the XFP pink beam slits to create a <2 mm vertical beam.
5. Insert diamond BPM at measured Z position on X-Y translation stage, center in beam and measure current and beam size (record values) – if available, use diamond imaging detector for beam shape observation.
6. Increase FE focusing mirror meridional focus in a stepwise fashion until the vertical beam size is minimized and then becomes overfocused, recording current and beam size at each setting .
7. Optimize alignment of FE focusing mirror to maximize flux density at focal position (adjustment of Z position and retesting of beam size, tweaking of mirror X and Y position, pitch, roll, yaw and focus as needed): obtained by monitoring beam shape on diamond imaging detector, record mirror encoder counts for optimum focal position.
8. Close the sample pre-shutter to observe loss of beam signal on the monitor.
9. Test mirror motion reproducibility by moving optic positions away from focus and returning to recorded values to re-measure beam properties.
10. Move monitor to expected defocused beam position and optimize alignment of FE focusing mirror to create ~ 2.6 mm diameter beam (adjustment of Z position and retesting of beam size, tweaking of mirror X and Y position, pitch, roll, yaw and focus as needed): obtained by monitoring beam shape on diamond imaging detector or by line scans of quadrant detector through beam spot, record mirror encoder counts for optimum defocused position.
11. At focal position, test beam stability from mirror using a nitrogen enclosure with beam stop and diamond beam position monitor including recording of any beam motion or change during mirror equilibration to incident beam and long-term stability (overnight test).

Endstation Commissioning & Transition to Scientific Commissioning

Prerequisites

FE focusing mirror optimization using short beam pipe for focal position and measurement of beam size, shape and flux at nominal focal position and defocused position and recording of respective mirror motor encoder counts. Testing and control of relevant endstation motor control systems.

Goals of Beamline Endstation Commissioning

Achieve control over minimal beamline endstation equipment required to perform basic X-ray Footprinting experiments to prepare for scientific commissioning and use benchmarking standard to measure beamline performance.

This commissioning phase includes the first endstation table, syringe pump, modular X-Y stage, the multiple sample holder (MSH), uniblitz shutter and X-Y stage.

Note that as new equipment with the potential to act as sources of vibration are commissioned, vibration testing will be performed and any required mitigation implemented.

Commissioning Sequence

1. Mount, prepare and test capillary flow cell and syringe pump apparatus at first sample position.
2. Perform exposure of fluorophore sample and measure with fluorimeter for benchmarking.
3. Set up MSH at second sample position.
4. Align to beam and measure beam size (adjust Z position if needed to obtain ~ 2.6 mm diameter beam).
5. Use Uniblitz shutter to run exposures of samples.
6. Measure fluorophore dose with fluorimeter for benchmarking.
7. Cool MSH to minimum achievable temperature and measure value.

Successful completion of endstation commissioning as described above will enable scientific commissioning of capillary flow cell and multiple sample holder experiments in the subsequent operational cycle.