ESM Beamline Subsystem Definition

a) Section A – FOE Hutch:
   - Visible Light Reflector (VLR)
   - Double DiagOn Diagnostic (DDD)
   - M1 mirror chamber
   - Downstream M1 baffle slits (D_M1_BS_HOR/VER)

b) Section B – Monochromator and M3 Chamber:
   - Upstream PGM baffle slits (U_PGM_BS_HOR/VER)
   - VLS-PGM (M2 and gratings)
   - Downstream PGM baffle slits (D_PGM_BS_HOR/VER))
   - Upstream M3 baffle slits (U_M3_BS_HOR/VER))
   - Diagnostic unit (Diode, YAG, Au mesh)
   - M3 mirror chamber

c) Section C:
   Outboard Branch (ARPES):
   - VLS PGM slits (hor/vert)
   - Gas-chamber and diagnostic unit (Diode, YAG, Au mesh)
   - Absorption reference materials unit
   - Upstream KB mirror baffle slit
   - KB mirror
   - I_zero Au mesh

   Inboard Branch (XPEEM):
   - VLS PGM slits (hor/vert)
   - Gas-chamber and diagnostic unit (Diode, YAG, Au mesh)
   - Uptream M4 baffle slits
   - M4 chamber
   - Downstream M4 baffles
   - Diagnostic unit (Diode, YAG, Au mesh)
   - Absorption reference materials unit

   Section D:
ESM Beamline Commissioning without Beam
Extensive subsystem testing of the ESM beamline major optical assemblies was successfully carried out at the factories during the FAT sessions. Most of these tests were repeated or verified in the course of the installation of the photon delivery systems in the past few months. Integrated testing of the entire beamline is under way.

Pre-beam Commissioning Activities
The EPU57 of 21 ID short straight has been installed and will be commissioned by the Accelerator Division in July 2016. This ID commissioning is a prerequisite to any ESM 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 devices 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
- User interface for experimental stations available

First-beam Extraction and Radiation Surveys
A few days of dedicated study time may be needed to conduct BS radiation surveys as described in the radiation survey plan (PS-C-XFD-PRC-063) and to extract and transport first beam along the beamline.

**BS radiation surveys:** Gap fully open, survey for BS radiation leaks around the FOE and the first part of the beamline down to the ARPES and XPEEM shutters. Initially carried out at the 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...
soon obtain permission to operate the beamlines with open ID gaps 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 the gap is around 40 mm, which corresponds to ~ 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 full beam. Low incident power can be achieved by closing the FE slits so as to achieve similar conditions to the one obtained with small machine beam current.

**First beam propagation:** Gap closed to 40 mm (corresponding to a nominal photon energy ~ 700 eV), low machine current maybe 1 mA: front end slits open:

1. Monitor the synchrotron radiation with DiagOn optics
2. Extract the DiagOn and let the light arrive at M1: monitor general direction of reflected light using photoemitted current from M1 baffle slits (downstream of M1 mirror)
3. Let the light arrive at the mono: monitor the general direction 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. For ARPES branch: let the light be reflected by M3A and monitor current with downstream ARPES exit slits currents and visually inspect with YAG crystal at slits position
6. For XPEEM branch: let the light be reflected by M3B and monitor current with downstream XPEEM exit slits currents and visually inspect with YAG crystal at slits position

**Transition to Operation Condition & Beamline Optics Commissioning**

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

- EPU Energy selection
- EPU Energy scans
- Primary FE slits scans / alignment
- XBPM commissioning and calibration
- Also DiagOn, located in the FOE, can be used at low currents

Preliminary commissioning phase of the photon delivery:

- Be able to select the monochromator energy and to take short energy scans around 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
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 ESM Photon Delivery System – all beamline optics downstream of the ratchet wall, from the FOE down to the experimental stations.

Commissioning Sequence
1. Repeat first beam propagation: gap closed to 40 mm (~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 (200 mA ?)
4. Open the FE slits so as to read currents along the beam similar to the ones when in the machine there was 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 as soon as this can be done safely i.e., preserving $10^{-9}$ Torr vacuum condition and acceptable heat loads on mirrors (thermocouples can be monitored).

Two main objectives will be achieved at this stage (for both the ARPES and XPEEM branch)
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

With the monochromator is optimized, we will be in a position to tackle the last bit of optimization for the refocusing optics; for ARPES, the KB mirror and for XPEEM, the ellipsoidal mirror.