Pair Distribution Function Beamline (28-ID-1) Instrument Readiness Overview

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March, 15 2018

Outline

- Background

  Scientific Program, Design Reviews, Beamline Parameters, Beamline Layout, IRR Scope, Commissioning Sequence

- Pillar I: Documentation:

  Ray Tracing, RSC Review, Hazard Identification and Mitigation

- Pillar II: Hardware

  Radiation Safety Components, Other Credited Controls, EPS, Controls, Diagnostics, Utilities

- Pillar III: Personnel

  Beamline Staff

Scientific Program

- Pair Distribution Function (PDF) is a relatively new technique that can be used to explore local structural fluctuations in complex materials.

- 28-ID-1 is the dedicated PDF beamline at the NSLS-II.

- The PDF Beamline supports PDF and Wide Angle X-Ray Scattering (WAXS), and complementary Small Angle Scattering (SAXS).

- PDF Beamline facilitates fast exchangeability between setups. O1

- High-energy and High-flux available at the PDF enable time resolved studies of materials in their real world applications (Ex. Batteries, fuel-cells, etc.).

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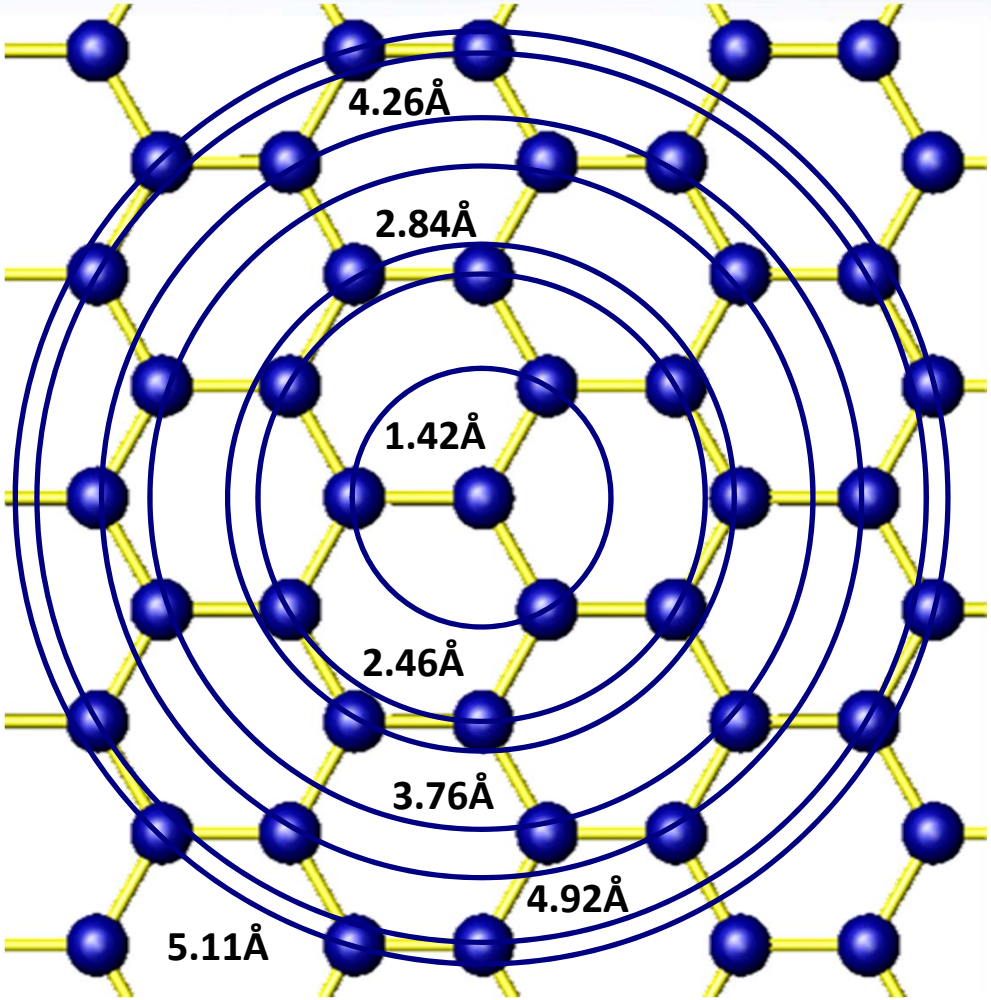
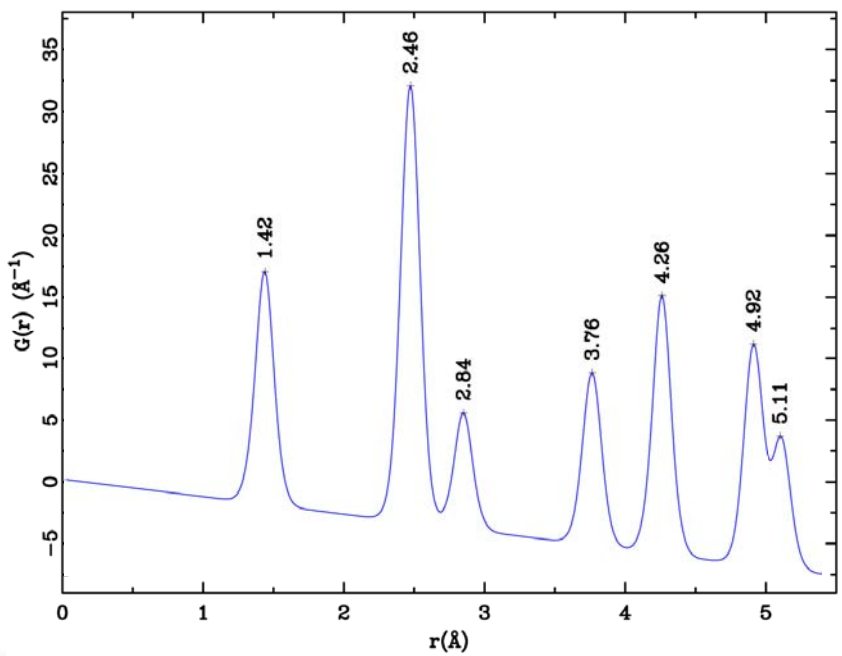
O1 This does not address the scientiffic aspects of PDF
Owner, 3/8/2018

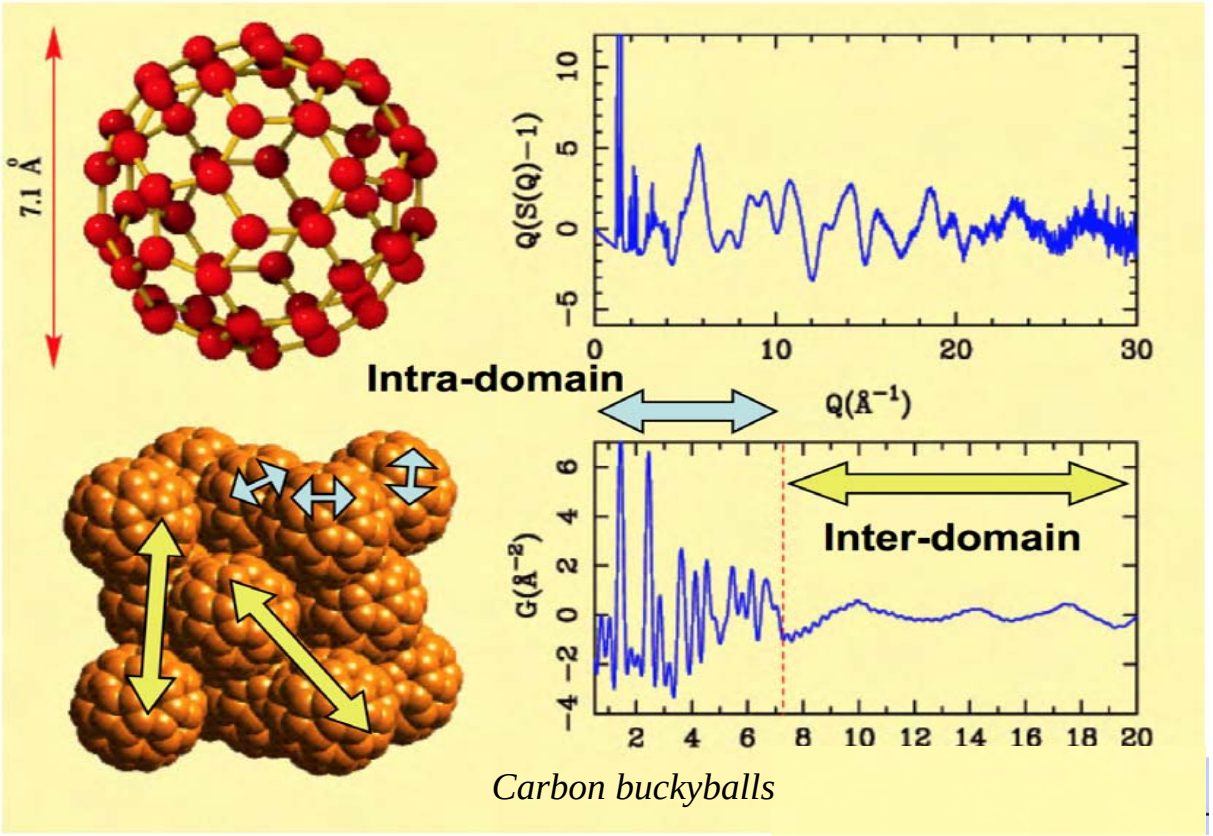
Two dimensional representation of the PDF



Pair distribution function (PDF) gives the probability of finding a neighbor atom at a distance "r" from a given atom.



What the PDF can say about the crystal structure of materials



Carbon buckyballs

Radiation Survey Procedure

Beamlines, XPD/PDF (28-ID) Radiation Survey Procedure (NSLSII-28ID-PRC-001)

Reviews

Event	Date
28-ID PDR	Sept. 2010
SBM PDR (FMB Oxford)	Sept. 30-Oct. 01, 2015
SBM FDR (FMB Oxford)	Dec. 9-10, 2015
VFM PDR (Winlight X)	April 25, 2016
VFM FDR (Winlight X)	June 20-21, 2016
BTS PDR (Axilon)	Dec. 6-7, 2016
BTS FDR (Axilon)	March 8-9, 2017
RSC Preliminary Review	February 13, 2018
RSC Final Review	February 28, 2018

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Slide 6

O2 Include Year, and include RSC preliminary and final review?
Owner, 3/8/2018

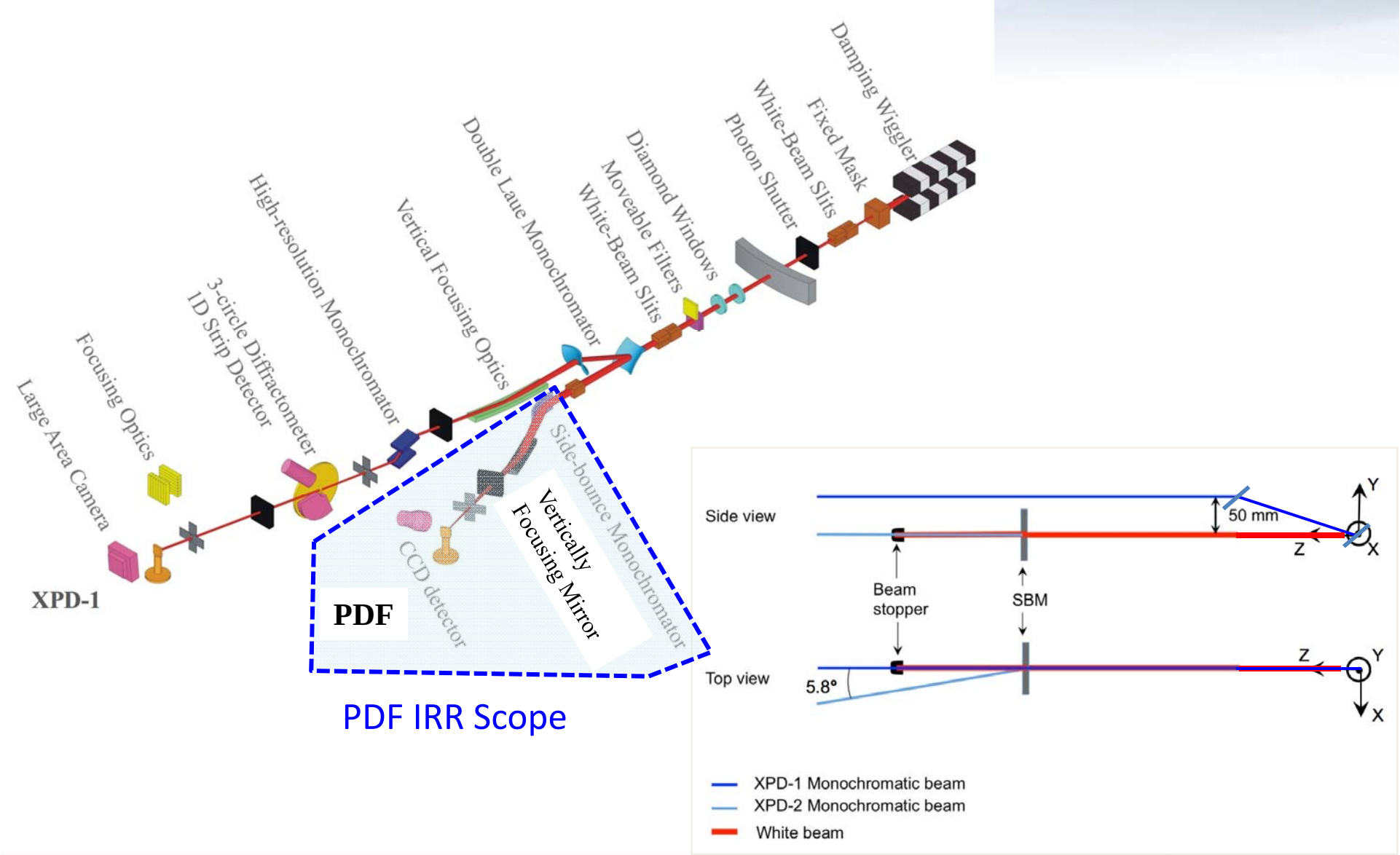
Beamline Design Parameters

Photon Source	3-pole wiggler
Operational Energies	39 keV, 64 keV, 75 keV, and 117 keV
Monochromator type	Focusing Laue (Si Crystal)
Energy Bandwidth (ΔE/E)	≈ 0.7 % with a horizontal fan of 0.3 mrad on the SBM
Beam size at sample	(0.25 x 0.25) mm – (1 x 1) mm
Flux at sample at 500 mA:	10^{13} photons/sec/0.1% BW at 75 (keV)
Detectors	2 PerkinElmer area detectors, 2 scintillator counters, and 2 photodiodes each embedded in a beamstop.

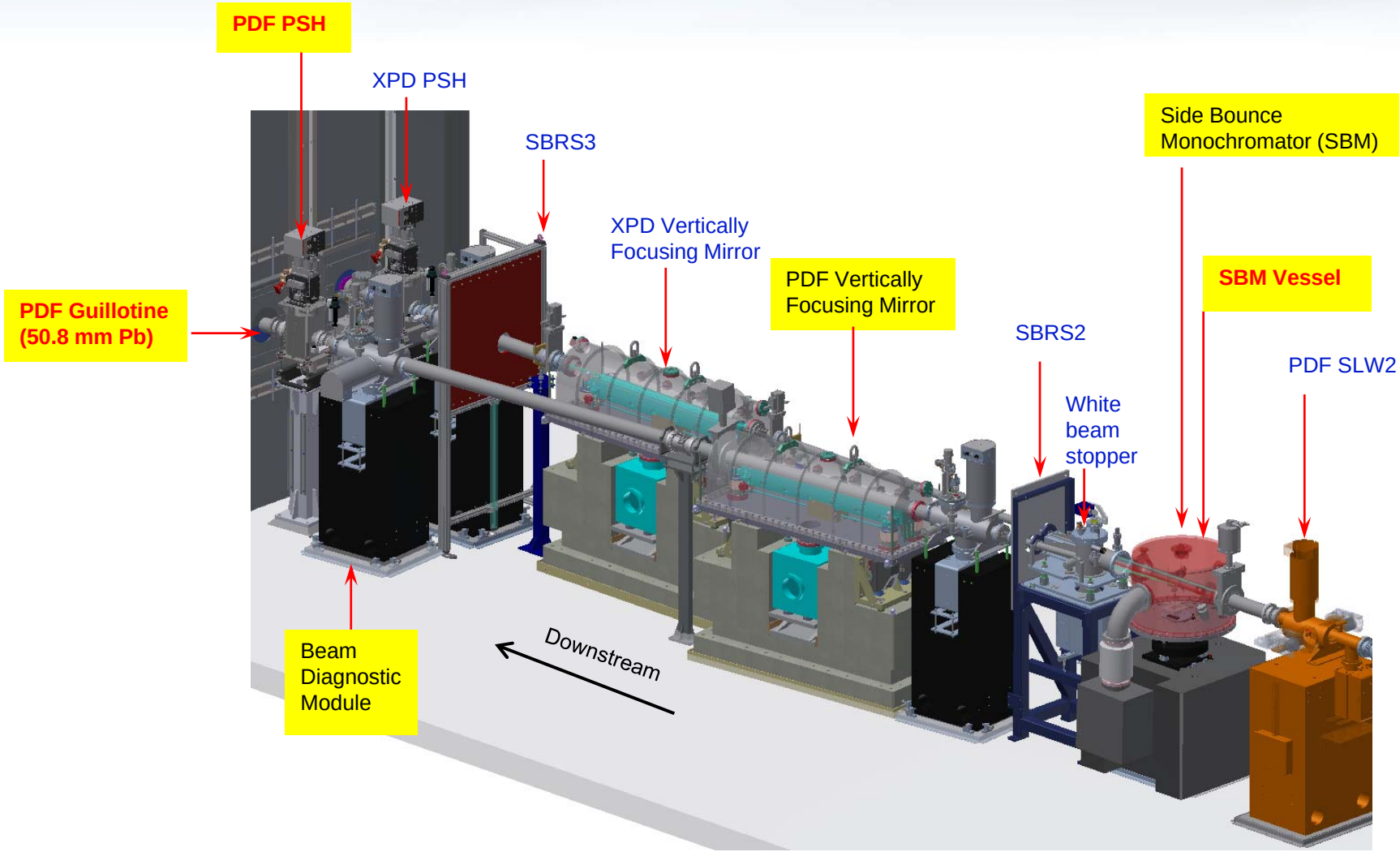
<u>Monochromator crystals</u>

Crystal number	1	2	3	4
Bragg planes (hkl)	(111)	(022)	(311)	(115)
Diffracted X-ray energy (keV)	39.078	63.815	74.829	117.25

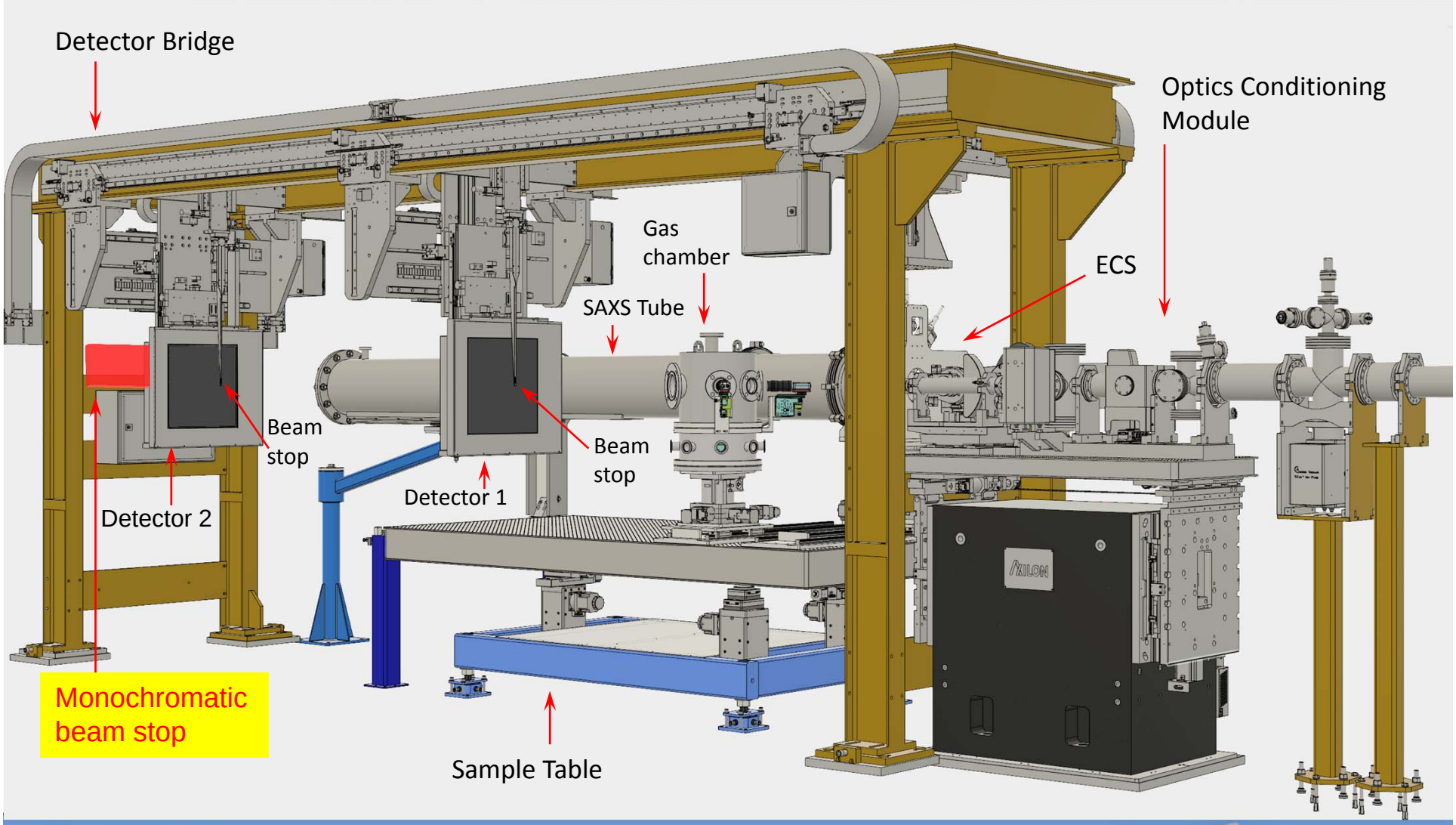
28-ID Beamline Layout



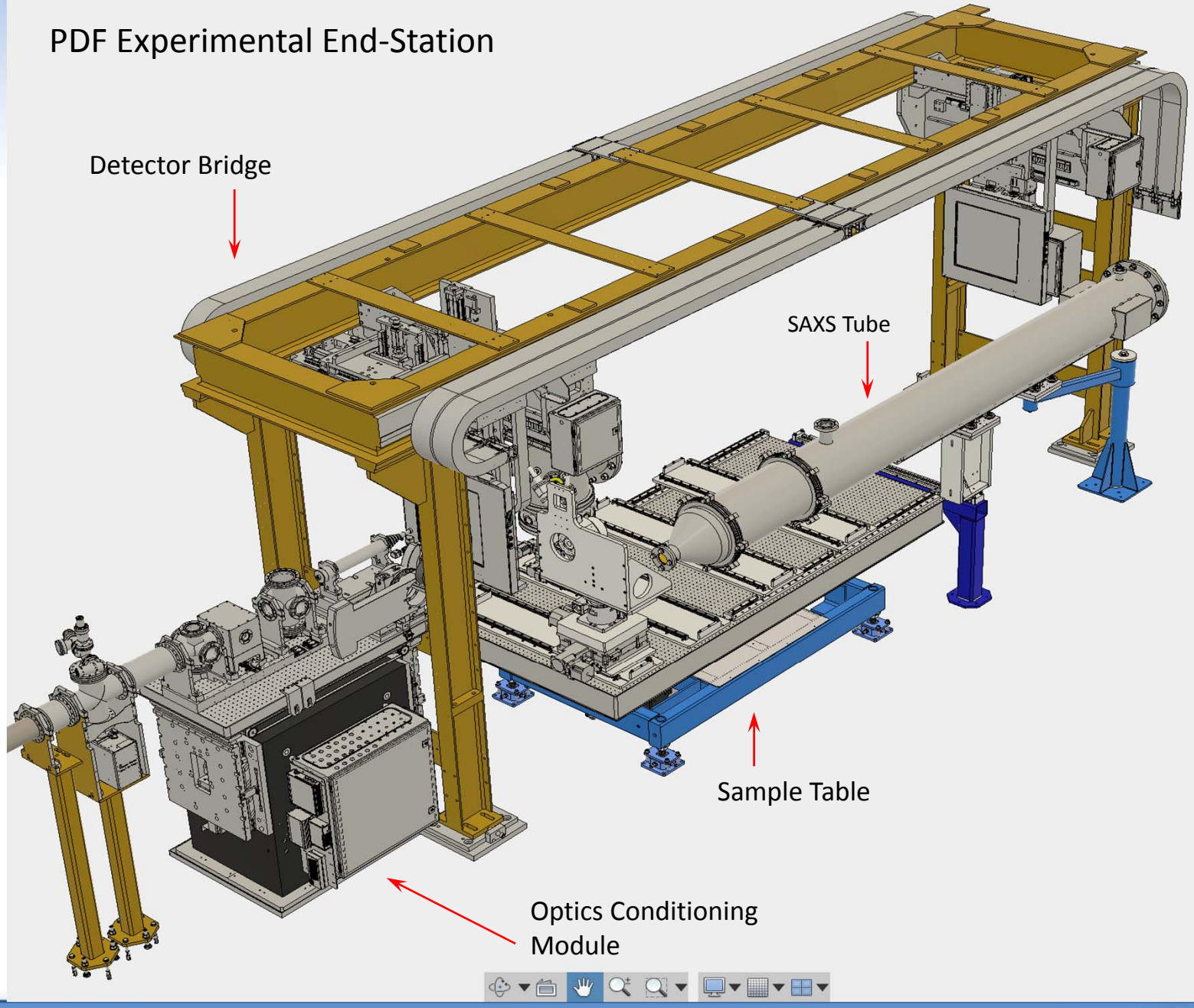
PDF FOE Components



Beamline Layout (3-D) PDF Experimental End-Station



PDF Experimental End-Station



IRR Scope

PDF IRR Scope Only Includes:

1. PDF Components in 28-ID First Optical Enclosure (FOE)
   - Side Bounce Monochromator (SBM)
   - Vertically Focusing Mirror (VFM)
   - Beam Diagnostic Module (BDM)
   - Monochromatic Photon Shutter (MPSH)
2. Shielded beam transport between FOE and hutch B, and the guillotines on the FOE downstream and hutch B upstream walls.
3. Experimental hutch B
   - Optics Conditioning Module (OCM)
   - Detector Bridge
4. EPS, PPS, all infrastructure necessary for commissioning the photon delivery system.
6. Installation and basic control of the experimental table.

Commissioning Sequence BSA document NSLSII-28-ID-1-PLN-001.pdf

All equipment in the FOE at 75 keV at 375 mA

1. Radiation survey of the FOE
2. Beam Diagnostic Module (BDM)
3. SBM
4. VFM

Experimental hutch B and the end-station at 75 keV

1. Radiation survey at 120 mA (during Machine Studies)
2. Radiation survey at 375 mA
3. OCM, detectors at 375 mA

Experimental hutch B and the end-station at other discrete energies

1. All beamline equipment at 39 keV, 64 keV, and 117 keV

Note: Radiation survey already performed without crystal in SBM after installing the PDF shielded beam transport.

Self-Identified Pre- and Post-Start Findings

Pre-start findings:

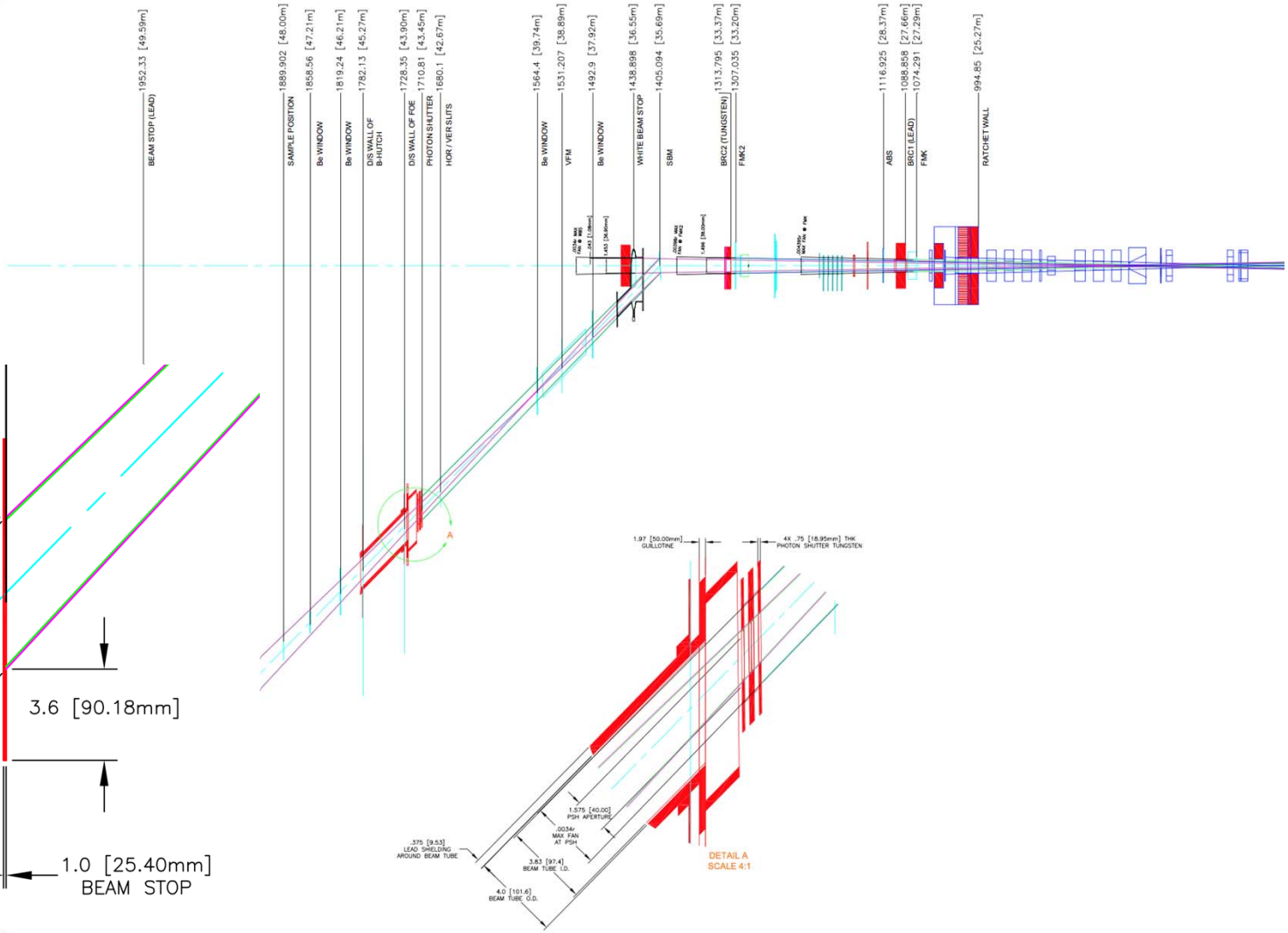
None

Post-start findings:

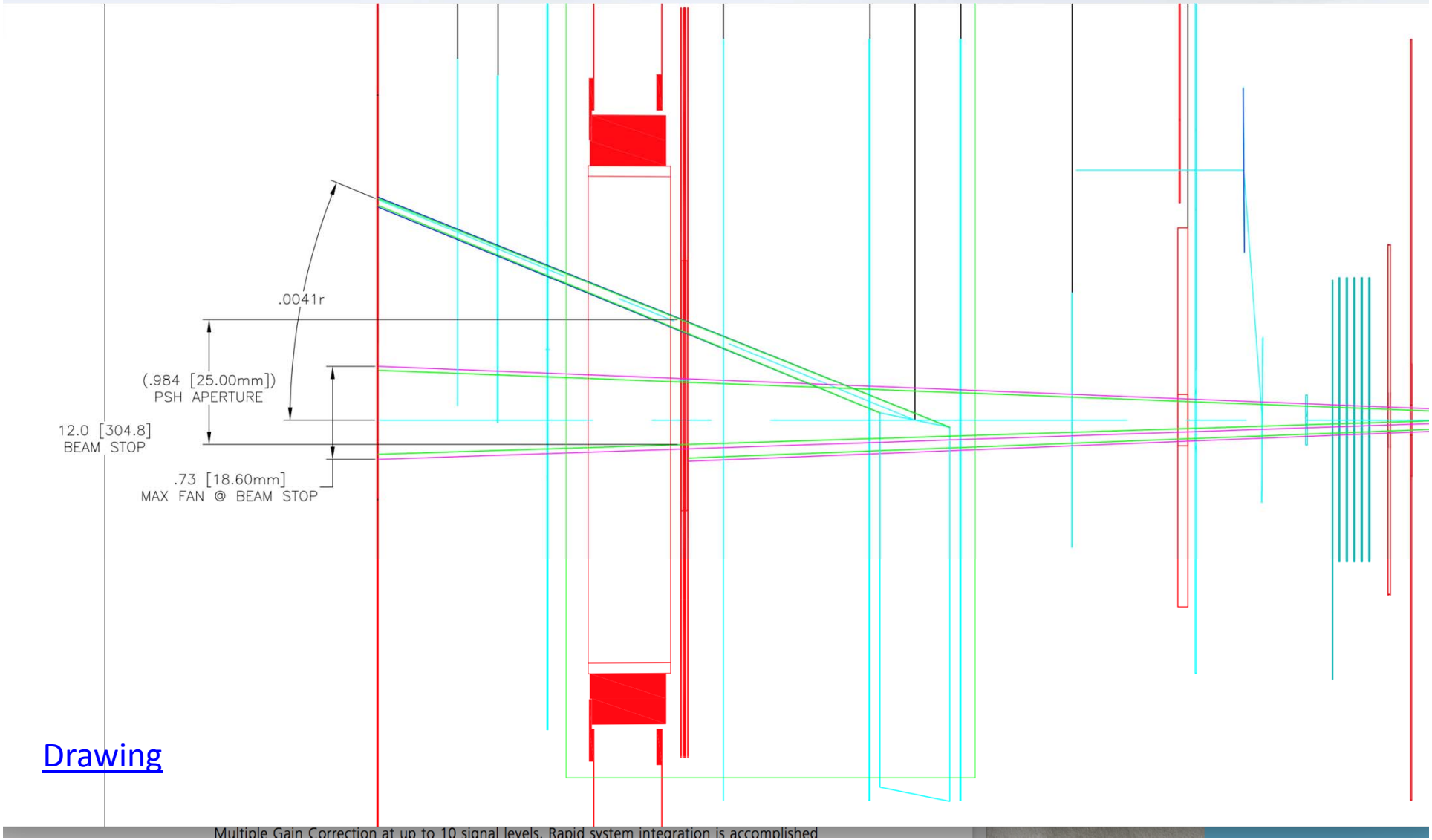
None

Ray Tracing: Synchrotron Beam (Horizontal)

Drawing



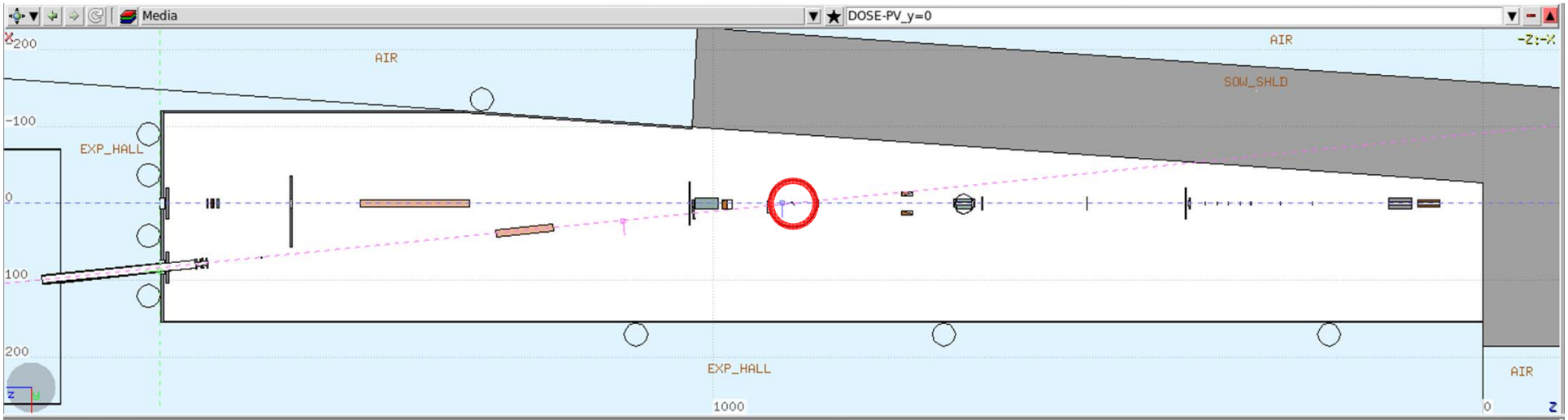
Ray Tracing: Synchrotron Beam (Vertical)

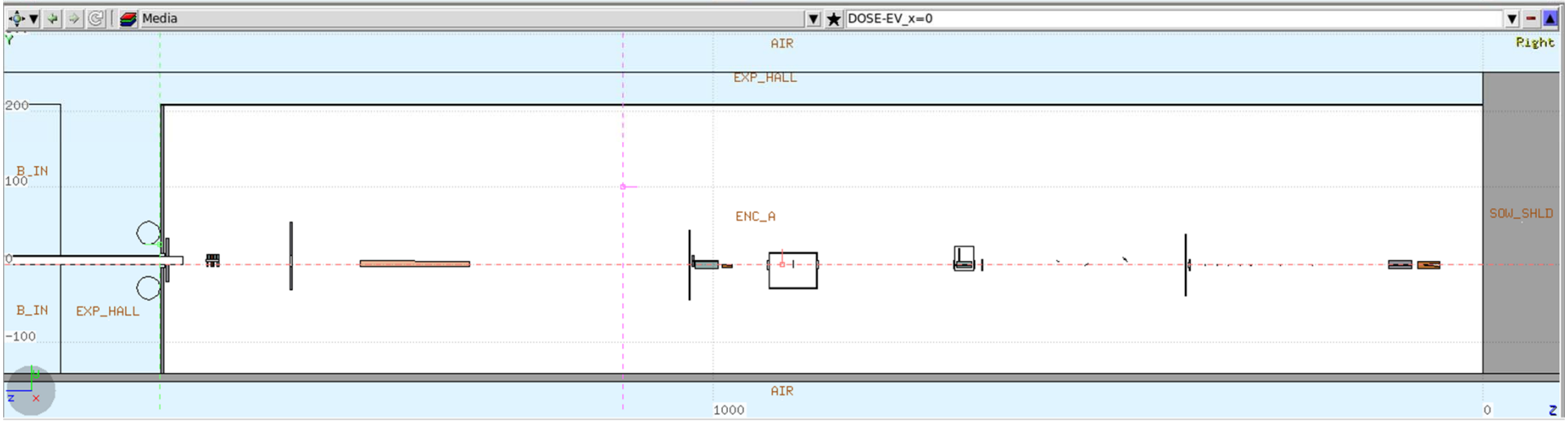


Drawing

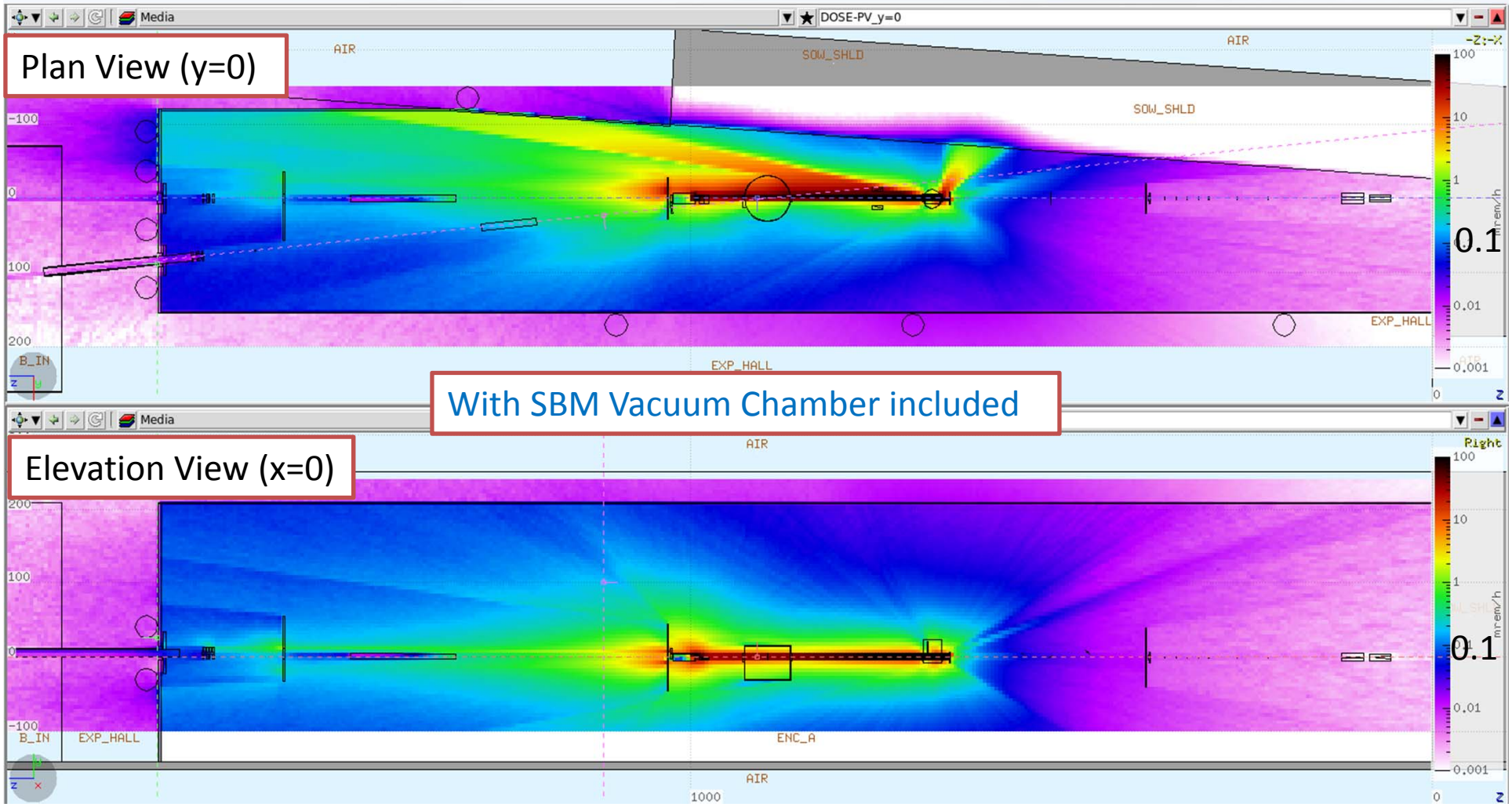
Multiple Gain Correction at up to 10 signal levels. Rapid system integration is accomplished

SBM vacuum vessel added as a radiation safety component in FLUKA



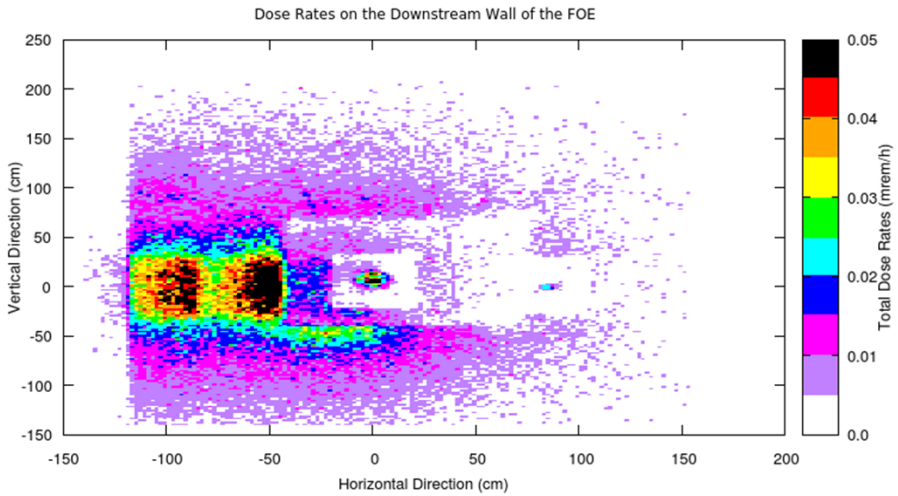


GB on FMK2 aperture – O/B side
Total Dose Rates (mrem/h)

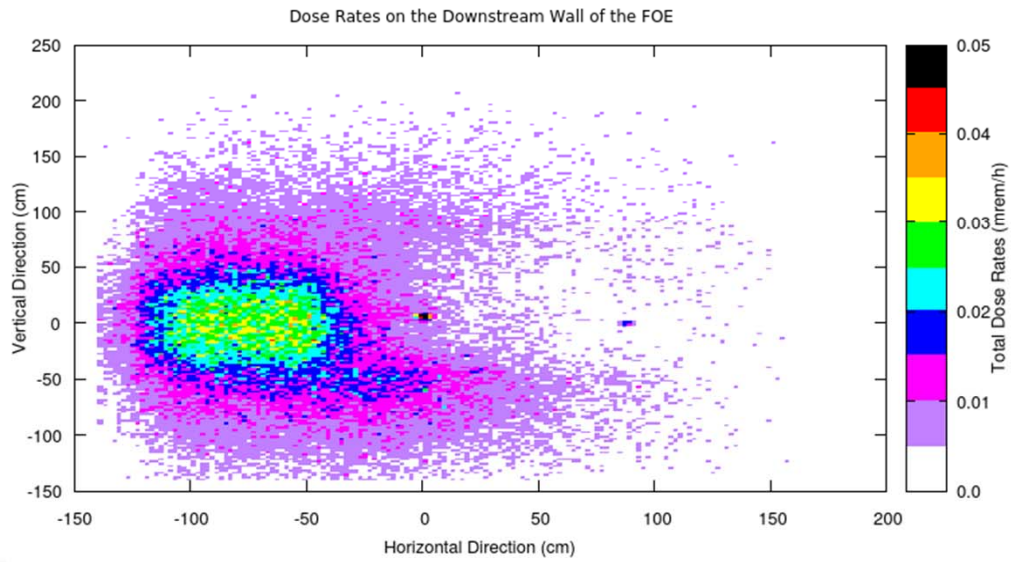


GB on FMK2 aperture – O/B side
Total Dose Rates (mrem/h)

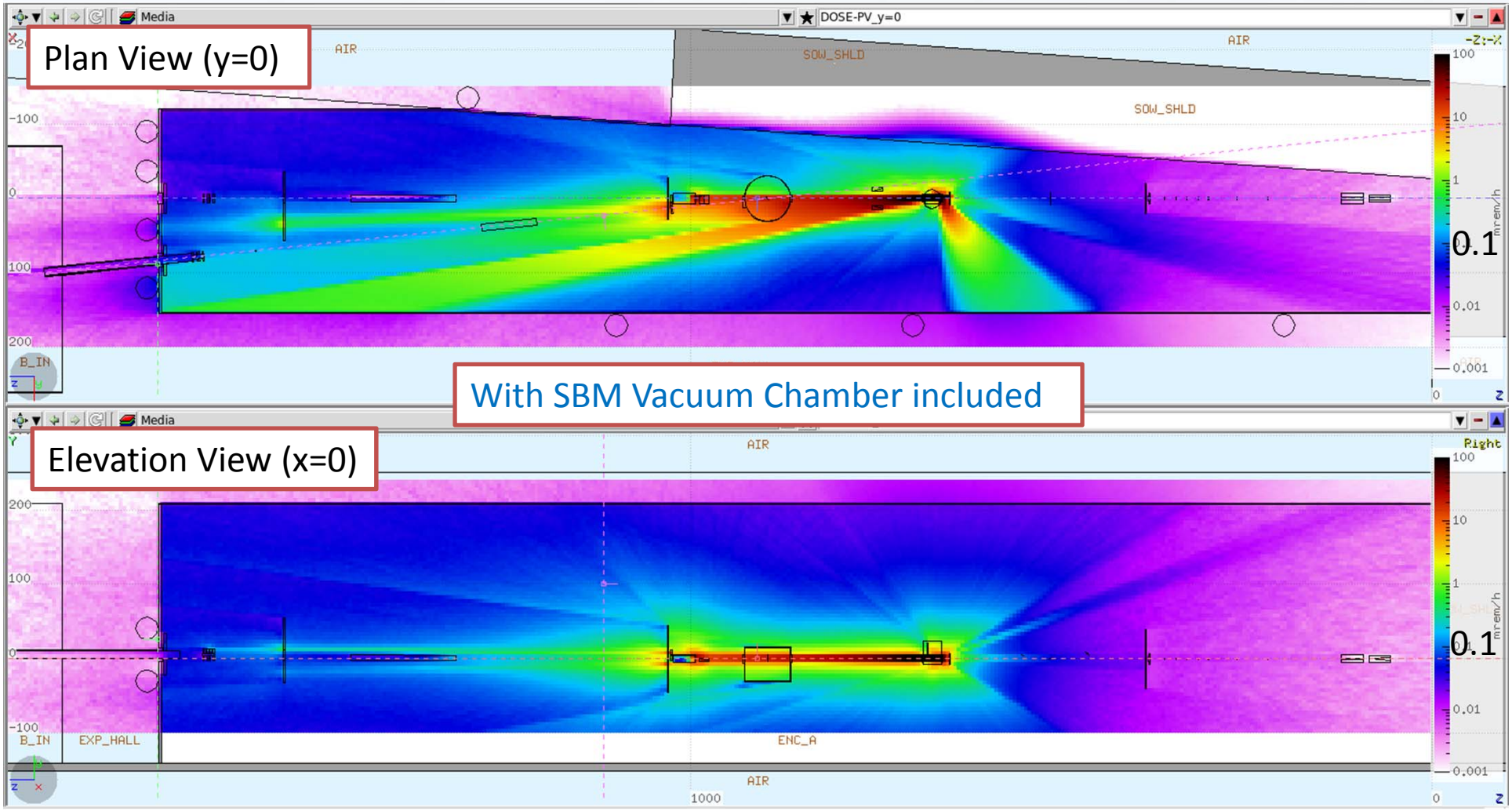
D/S Wall (Contact)



D/S Wall (30cm)

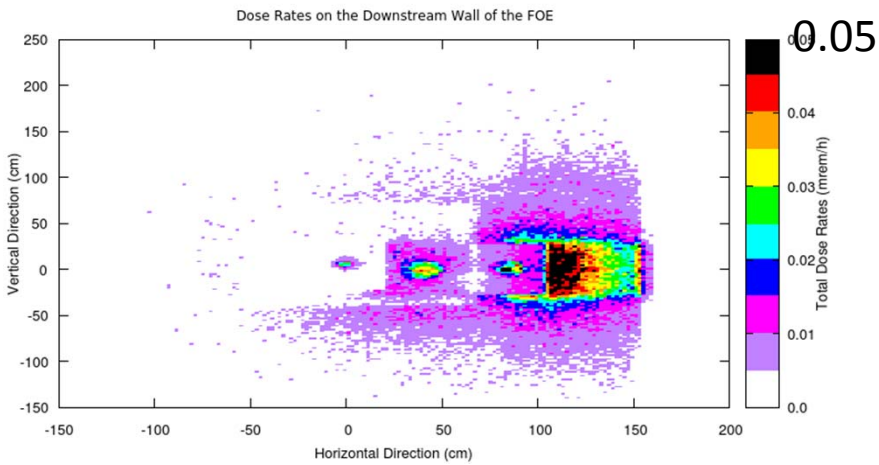


GB on FMK2 aperture – beam hitting I/B side Total Dose Rates (mrem/h)

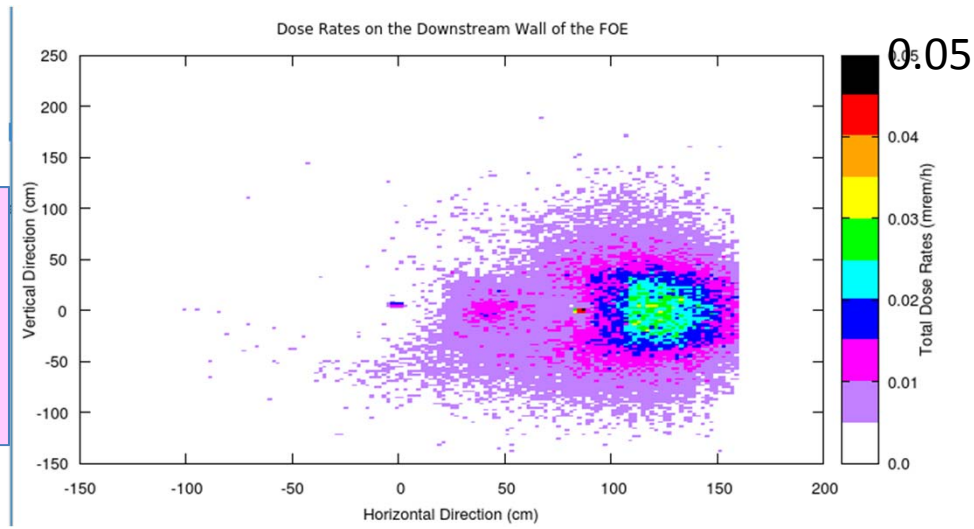


GB on FMK2 aperture – O/B side
Total Dose Rates (mrem/h)

D/S Wall (Contact)

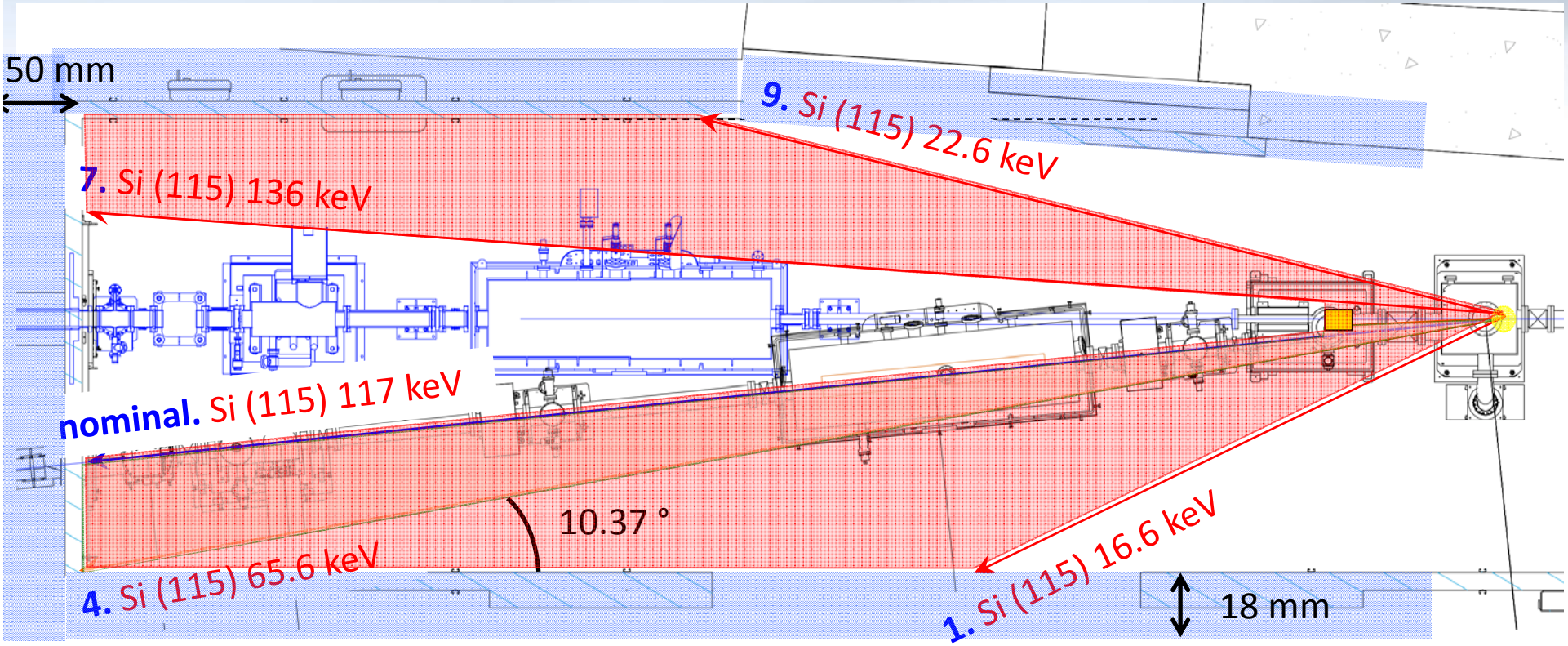


D/S Wall (30cm)



CONCLUSION: DOSE RATES ARE WITHIN ACCEPTBLE LIMITS

Synchrotron Beam (FLUKA calculations)



Conclusions:

- SBM direct Monochromatic beam on 28ID-A (FOE) lateral wall: 2.7E-12 mrem/h
- SBM direct monochromatic on Downstream Wall of 28ID-A (FOE): 7.5E-07 mrem/h

Conclusions of RSC review and FLUKA analysis

- Ray traces meet current requirements, excluding legacy non-compliances found with the previously-reviewed part of 28-ID that are deemed either minor or acceptable based on conservative FEA or dose calculations.
  (Reference. RSC review on Feb. 28, 2018, & Memo:pdf_rsc2018_V002)

- PDF (and XPD) Radiation Safety Components are shown to provide adequate shielding for GB and SR.
  (Reference: 28ID-PDF_BeamlineRadiationShieldingAnalysis_180307)

O3

- In all cases analyzed the total dose rates on the FOE lateral walls and roof were all below 0.05 mrem/h (on contact). In one case, including the SBM Vacuum chamber (under Configuration Control) reduces the dose rate a foot away to less than 0.05 mrem/h thus meeting NSLS-II requirements.

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O3 or "with FLUKA and STAC8"?
Owner, 3/8/2018

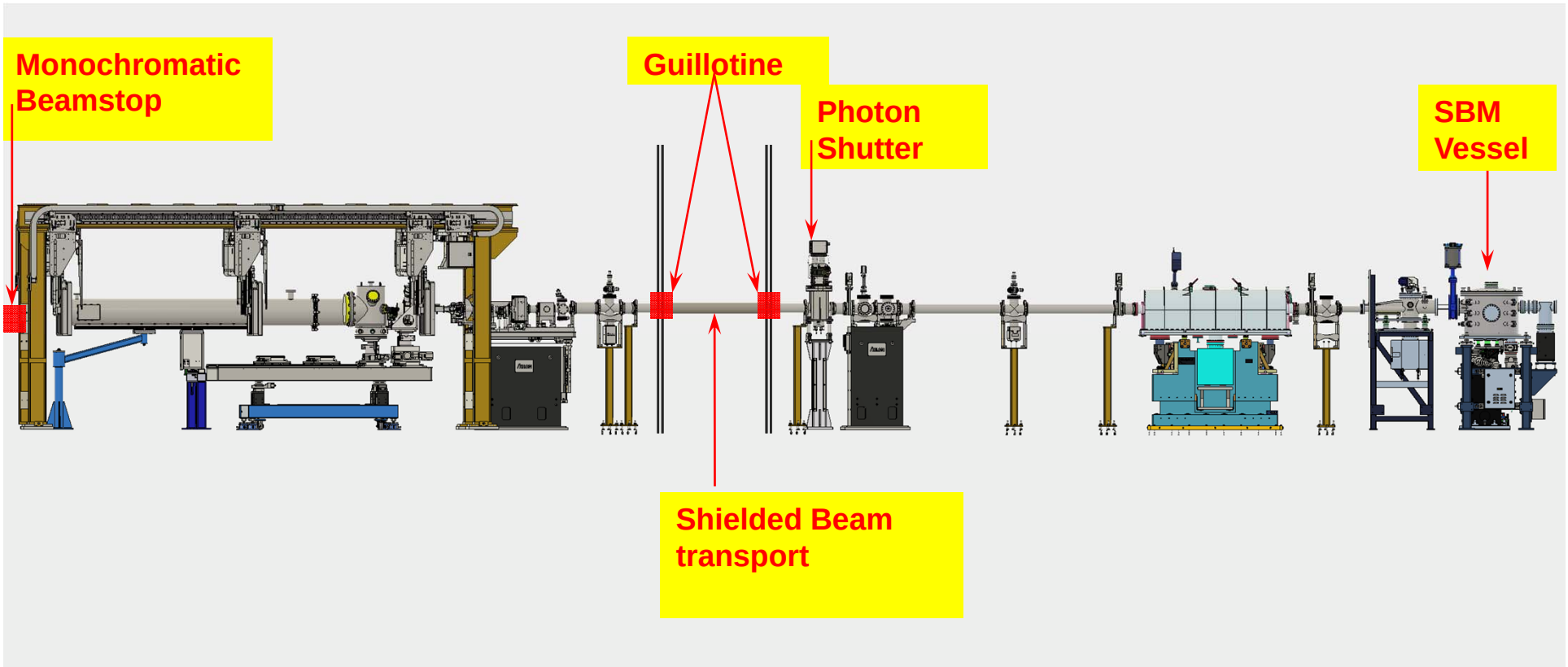
Hazard Identification and Mitigation

- USI (Unreviewed Safety Issue) evaluation is negative
- Relevant BNL/NSLS-II safety procedures and practices are followed during design/construction and commissioning (SBMS & ISM)

Hazard	Mitigation
Radiation	Shielding, PPS, ARM
Pressure Safety	FEA calculations, over-pressure tests, burst disks
Electrical	EEI, grounding, installation according to code
Detector Bridge large moving mass	PPS interlocked motion. (Reference: NSLSII-28ID1-WIN-002, PDF End Station Bridge Safe Operation, E-stop and Interlock Test)

*** The detector bridge only allows positioning of the attached detectors and does not manipulate other equipment or material as is common for industrial robots. Therefore the detector bridge does not meet the OSHA robot definition (Reference: BSA Memo, NSLSII-28ID1-MEM-001)

PDF Radiation Safety Components



Shielded Enclosures and Transport Pipes

Hutch B (mono beam hutch)
(Not in PDF IRR Scope)

- Side walls: 4 mm lead
- Upstream wall: 4 mm lead
- Downstream wall: 4 mm lead
- Roof: 3 mm lead
- Monochromatic Beam stop: 305 mm (H) x 305 mm (V) x 25 mm (t) lead

Hutch A (FOE): (Not in PDF IRR Scope)

- Side wall: 19 mm lead
- Downstream wall: 50.8 mm lead
- Roof: 10 mm lead

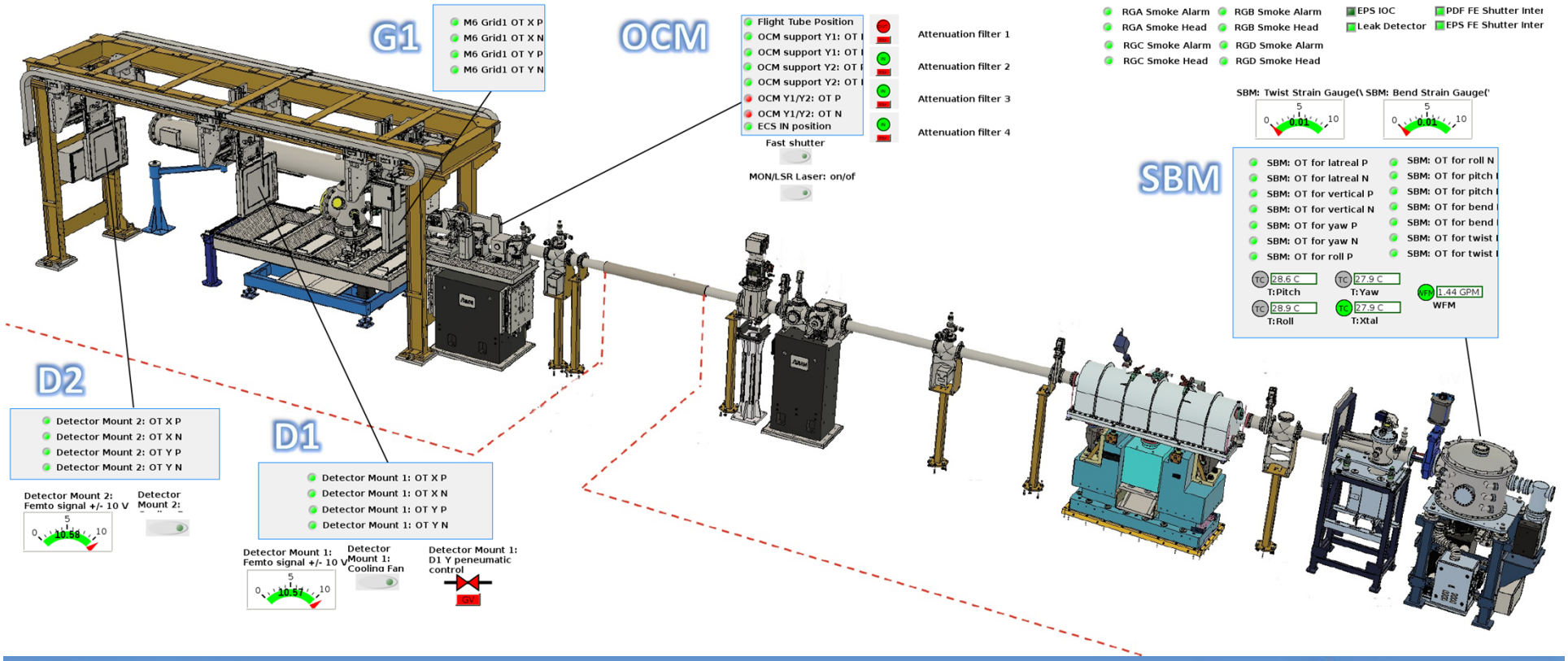
Shielded Beam Transport:

- Transport pipe: 13 mm lead
- Shielded Tube Outside Diameter: 4 inch

Other Credited Safety Components

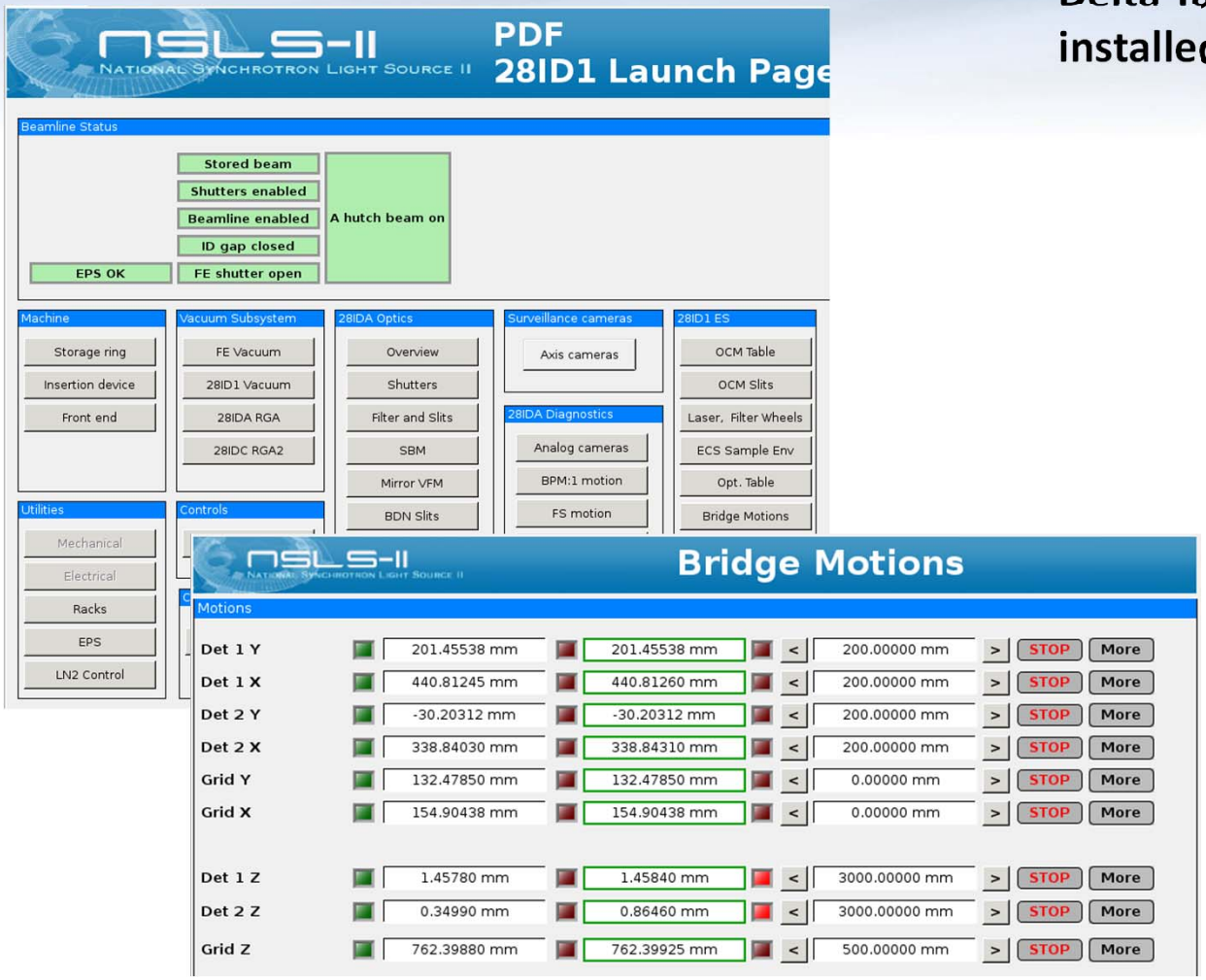
- <u>Oxygen Deficiency Hazard (ODH) Monitor</u> - Hutch B

- <u>Area Radiation Monitor (ARM)</u> – FOE Outboard wall



Controls

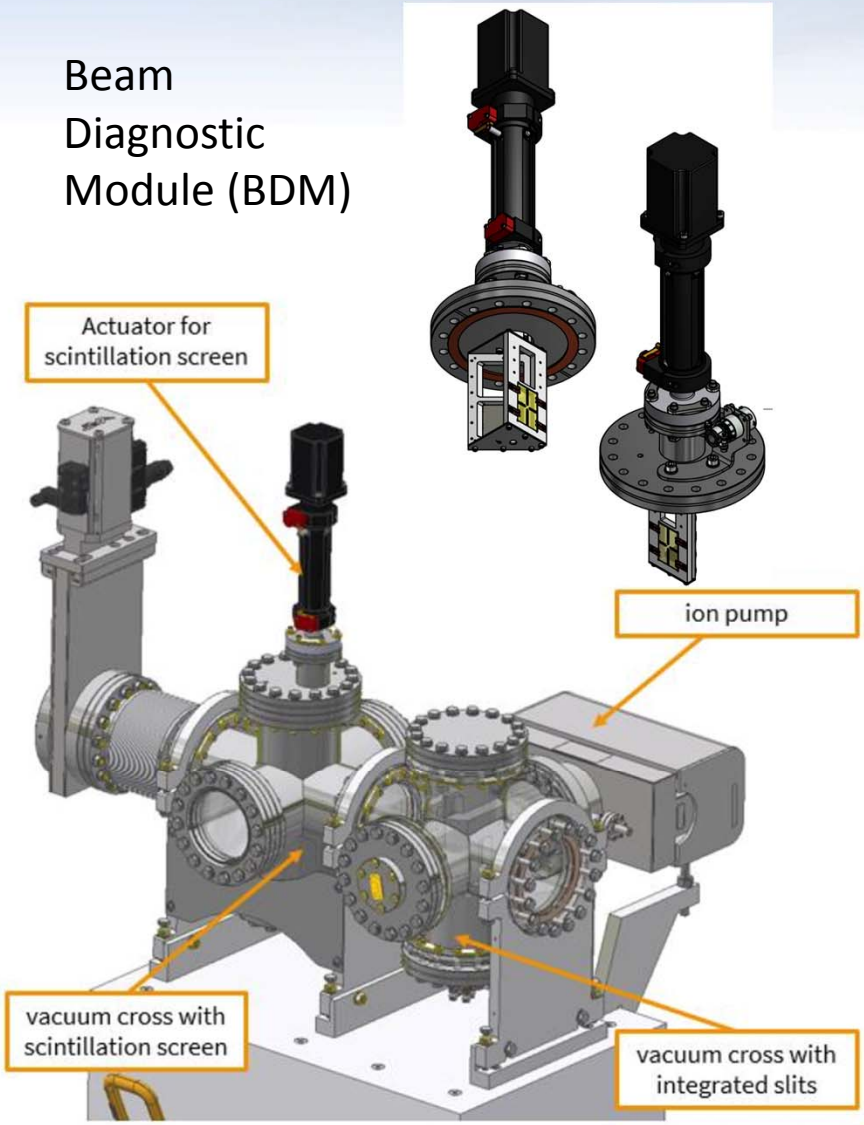
Delta Tau Motion Controllers are installed in 3 Roof Racks



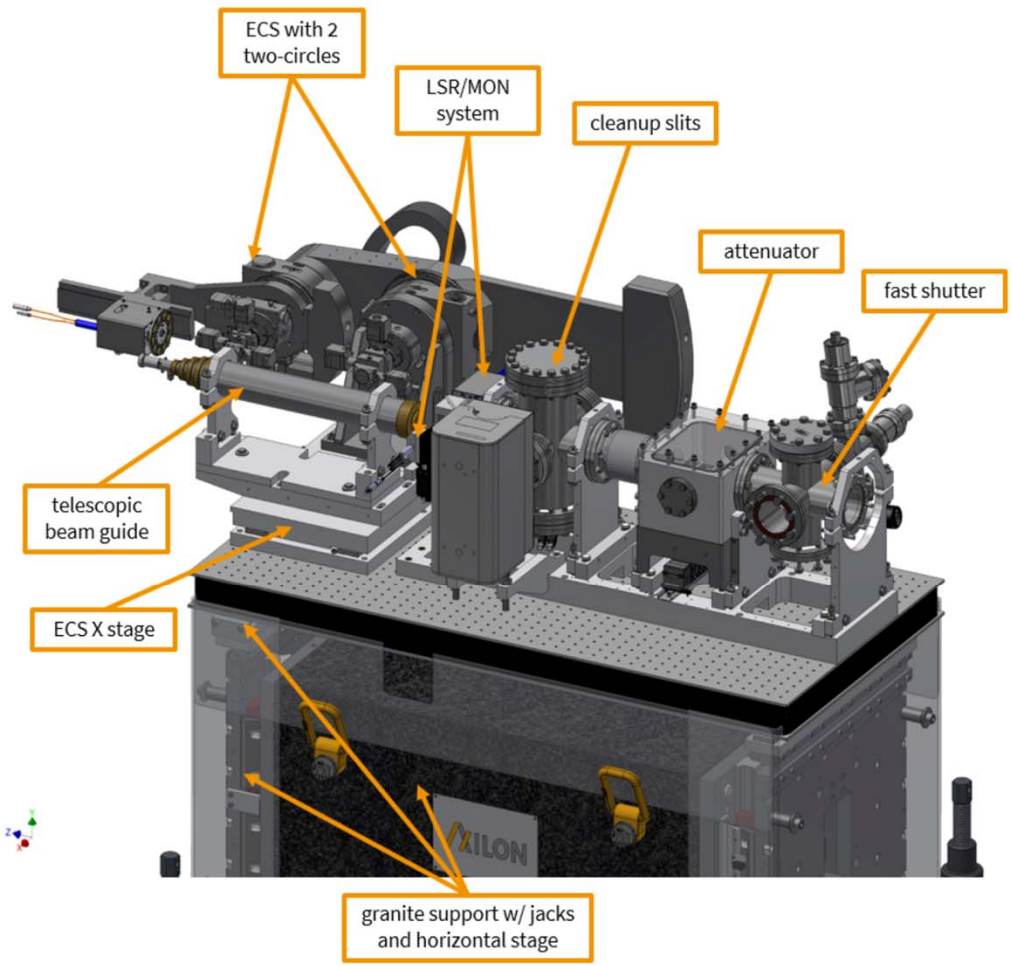
- All connected motors and actuation have been tested.
- EPICS software ready.

Beam Diagnostics

Beam Diagnostic Module (BDM)



Optics Conditioning Module (OCM)



Utilities

- Electric power
- Gases: compressed air, gaseous nitrogen (IRR scope does not include beamline experimental gas handling system which is being installed)
- Process chilled water (PCHW)
- Experimental LN_2 in hutch B
- DI water

Note- most Utilities systems including LN_2, PCHW, & DI water were previously designed, installed, & reviewed. Only PDF connections (SBM cooling system) to these systems are within PDF IRR scope.

PDF Beamline Staff

Lead Beamline Scientist	A. M. Milinda Abeykoon
Authorized Beamline Staff	**Eric Dooryhee** (XPD Lead Scientist, DISC Program manager)
Beamline Supporting Staff	**Ed Haas** (Beamline Mechanical Engineer) **Christopher Stelmach** (Beamline Design Engineer) **Oksana Ivashkevych** (Beamline Control Engineer) **John Trunk** (DISC Program Technical Coordinator)

** All staff members have completed the required training

BDN Staff

Project Manager	Julian Adams
Project Controls	Peter Selgrad, Phillip Hollabaugh,
Business Operations	Heather Turbush

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