X-ray Fluorescence Microprobe (XFM) Instrument Readiness Overview

August 30, 2017

Ryan Tappero, XFM Lead Beamline Scientist
and the XFM Team

Outline

- Background

  Scientific Program, IRR Scope, Beamline Layout, Photon Delivery System

- Pillar I: Documentation:

  Design Reviews, Ray Tracing, FLUKA Calculation, RSC Review, Hazard Identification and Mitigation

- Pillar II: Hardware

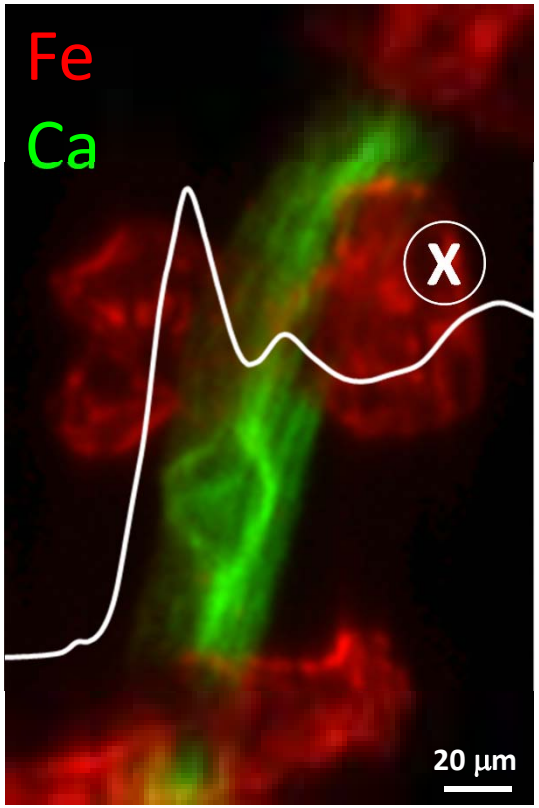
  Radiation Safety Components, Other Credited Controls, Utilities, Beamline Components, EPS, Controls, Diagnostics

- Pillar III: Personnel

  Beamline Commissioning Team

X-ray Fluorescence Microprobe (XFM)

Mission: XFM is a versatile X-ray microprobe optimized for spatially-resolved XAFS spectroscopy and imaging at the micrometer scale



Experimental Capabilities:	
	X-ray absorption spectroscopy (µXANES & µEXAFS)
	X-ray fluorescence imaging (µXRF)
	Fluorescence microtomography (fCMT)
	X-ray microdiffraction (µXRD)

Specifications:		
	Energy range	2 – 23 keV
	Spot size	1-10 micron (tunable)
	Flux	~10^{11} ph/s
	Energy selection	Si(111), Si(220), Si(311)
	Source	Wiggler (3PW)
	Operations	Spring 2018

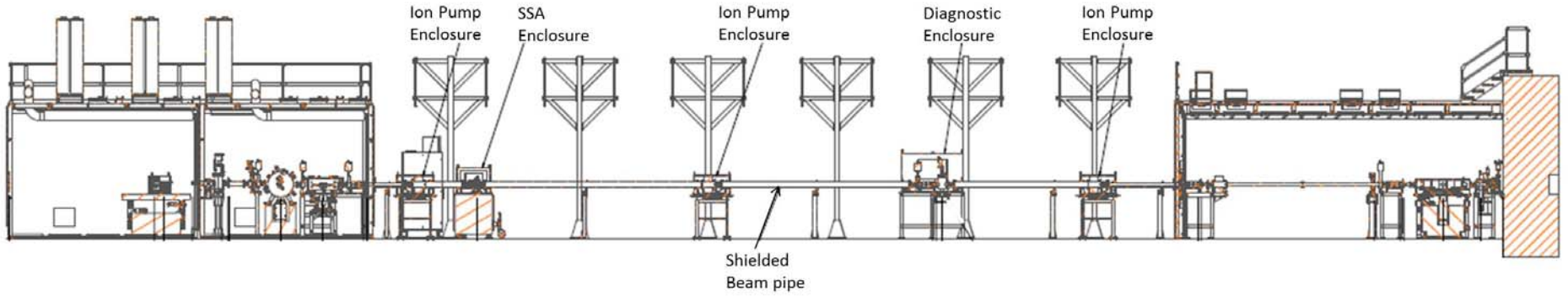
IRR Scope

IRR scope includes:

1. 3PW source, Frontend, and Beamline Photon Delivery System (PDS)
2. Enclosures: 4-BM-A and 4-BM-B/C
3. Motion control and monitoring system of FE and PDS
4. EPS, PPS, all infrastructure necessary for commissioning the PDS
5. Physical installation of Endstation equipment

IRR scope exclusions:

1. Controls for microscopes (including fluorescence and area detectors, detector stages, positioners) are adaptable; their configuration will change for different experiments.



Self-identified Pre- and Post-start Findings

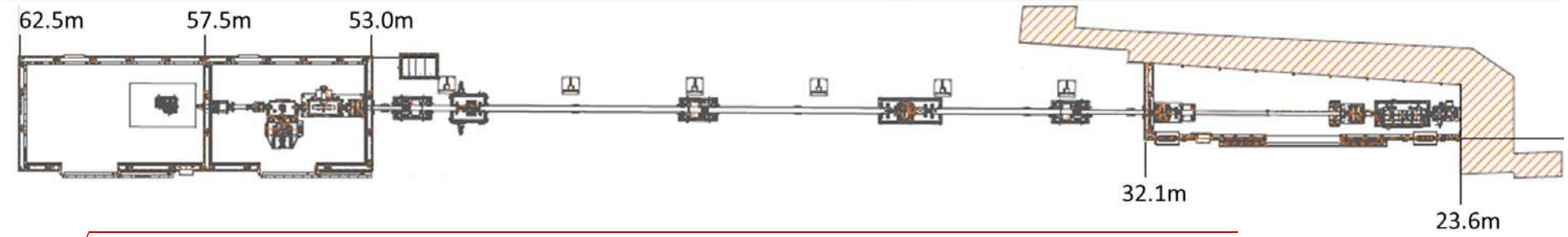
Pre-start findings:

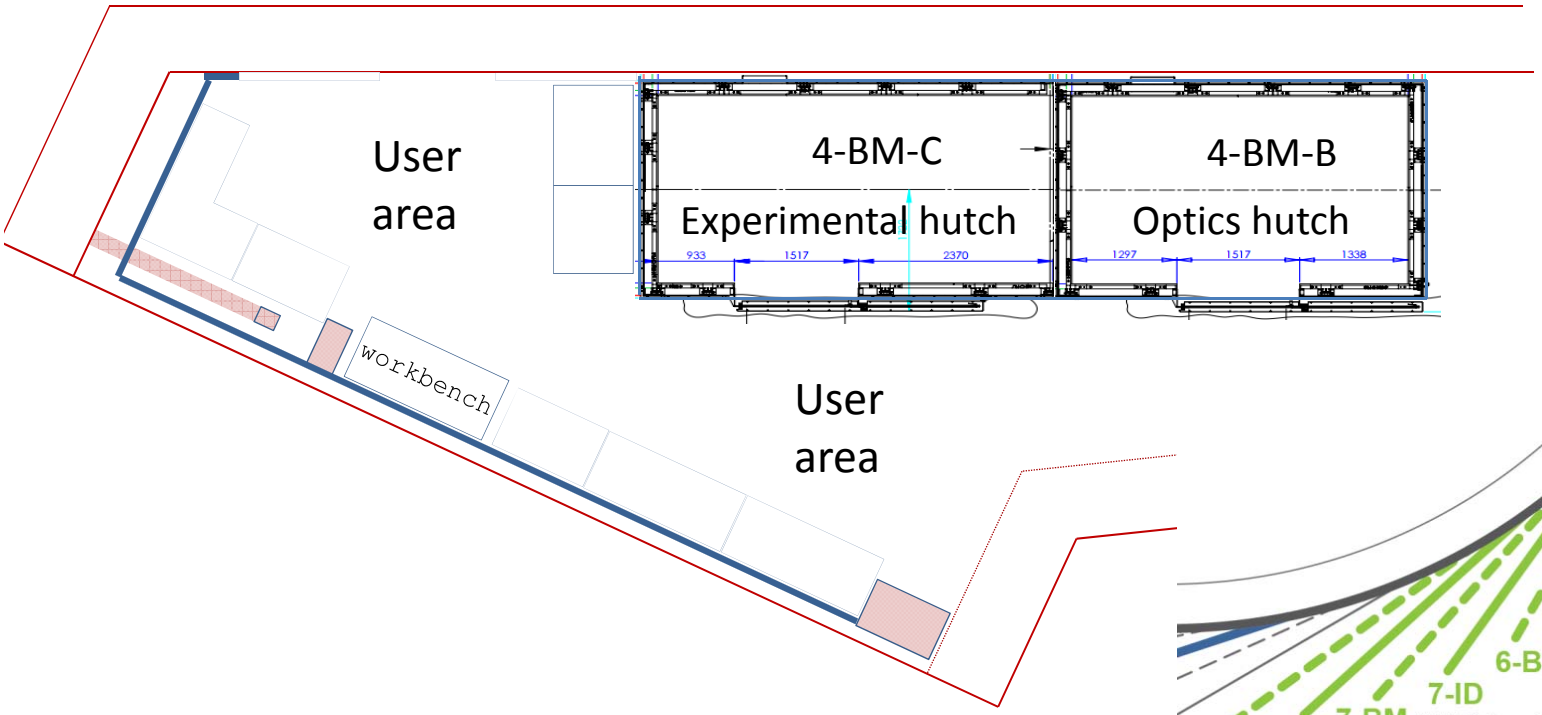
None as of 8/24/17

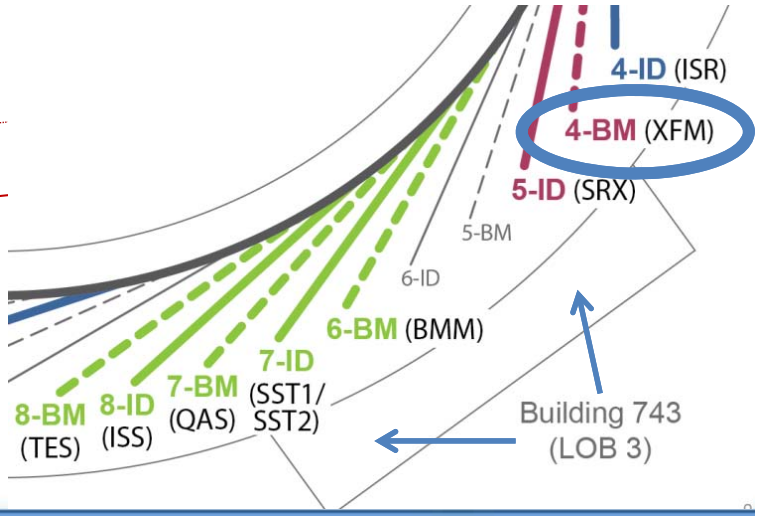
Post-start findings:

None as of 8/24/17

XFM Location and Layout

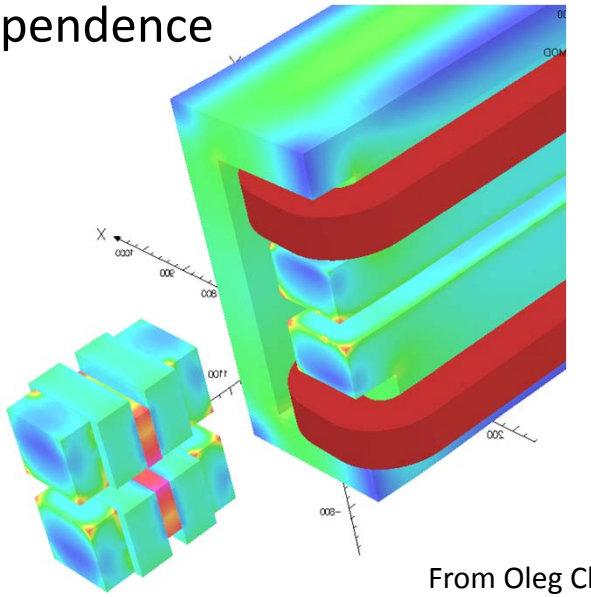






XFM Source: 3-Pole Wiggler (3PW)

- Smooth, broadband source (e.g., bend magnet) needed for energy-scanning experiments
- 3PW has structure from weak poles and adjacent BM
- Vertical acceptance has energy dependence



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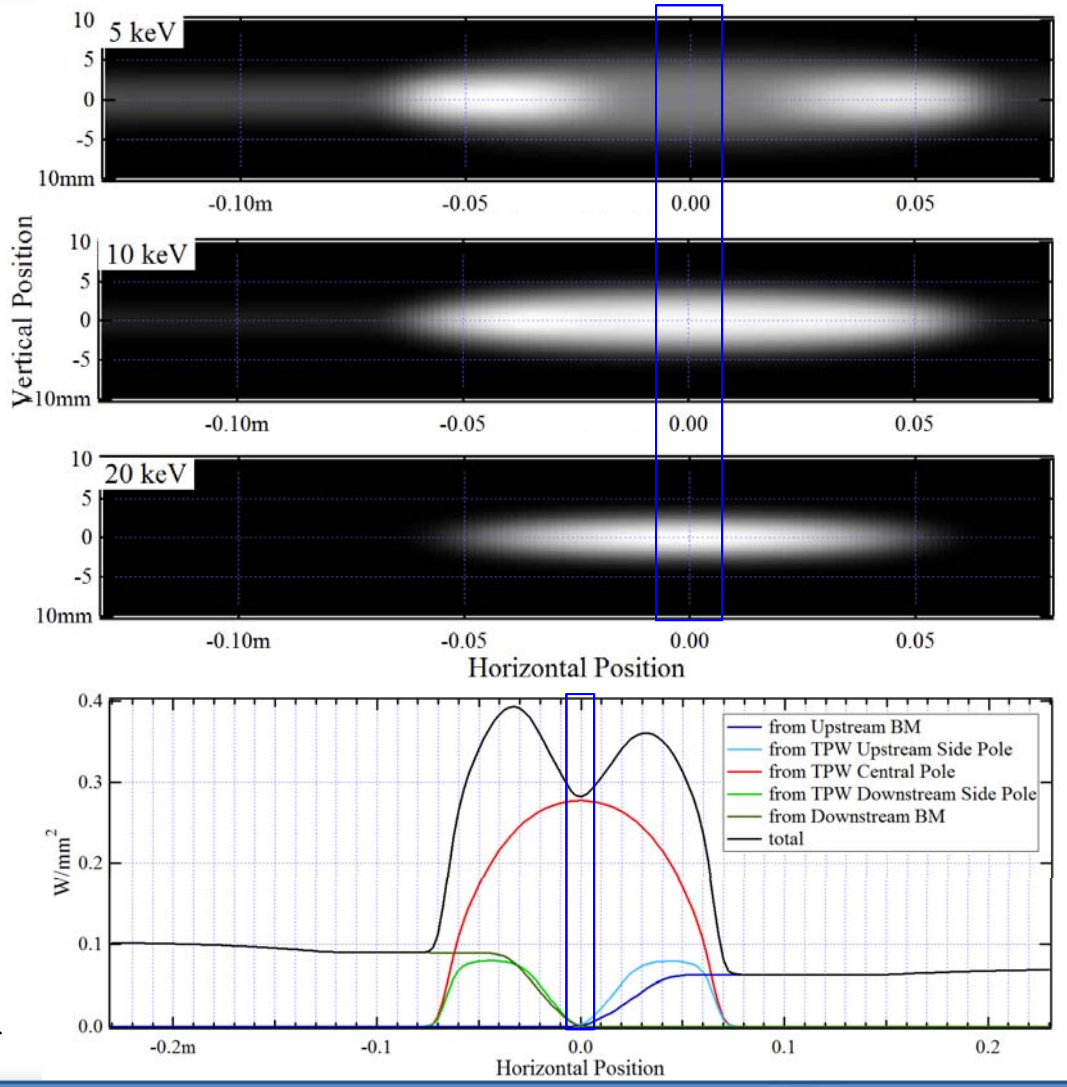
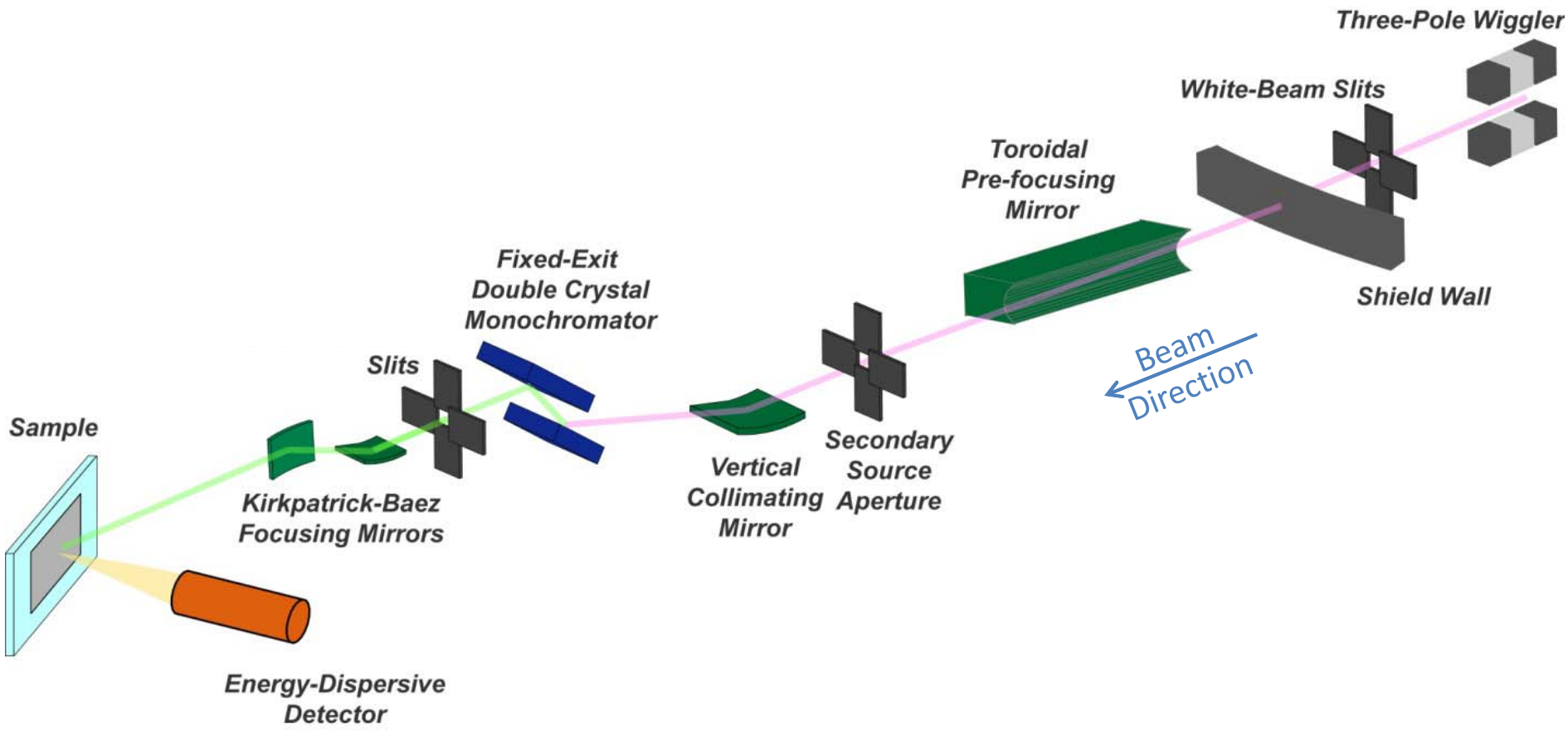


Photon Delivery System Overview



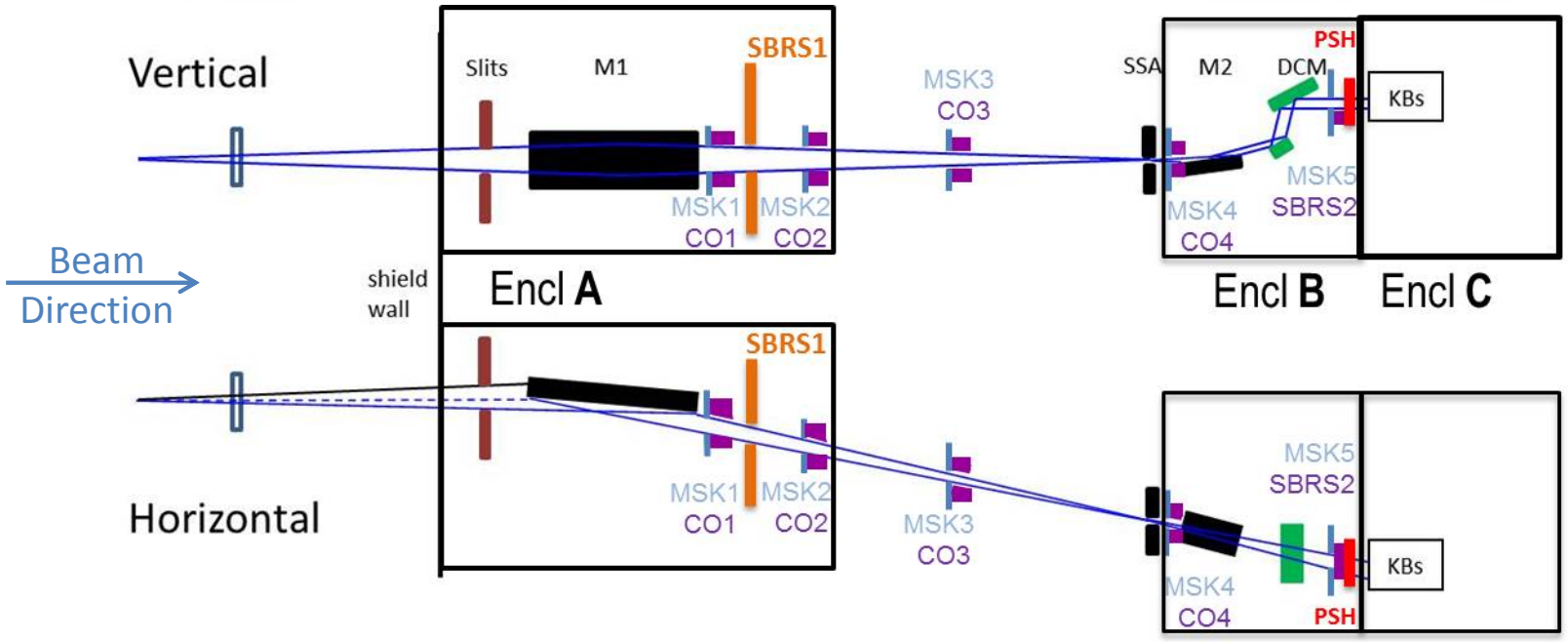
Pillar 1: Documentation

XFM Design Reviews

Review	Date
Shielded Enclosures	April, 2015
4-BM Front End Design Review	June, 2015
XFM Beamline Engineering Design Review	Sept. 4, 2015
Radiation Safety Components Design Review	Feb. 11, 2017
Radiation Safety Committee Review	August 15, 2017

- Several beamline components repurposed from NSLS, modified to NSLS-II requirements

Radiation Safety Overview



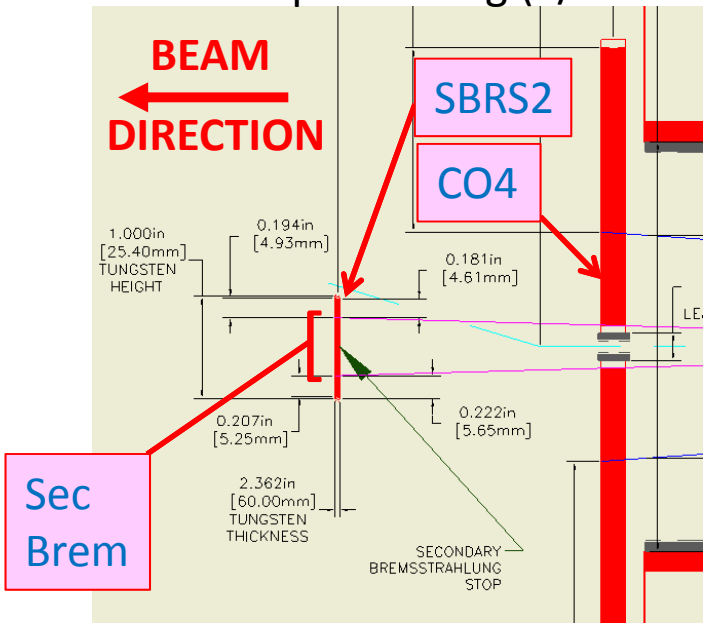
- FOE & Transport pipe (betw A & B hutches) are Pb shielded
- Two masks, two collimators, & one Secondary Bremsstrahlung shield (SBRS) are in FOE
- One mask and one collimator are in the transport line inside a lead-shielded box
- Two masks and two collimators are used inside the B Enclosure (SOE)
- A 30 mm x 60 mm aperture photon shutter (PSH) is at the downstream end of the SOE
- Standard lead guillotines are used inside each enclosure

Radiation Shielding Strategy

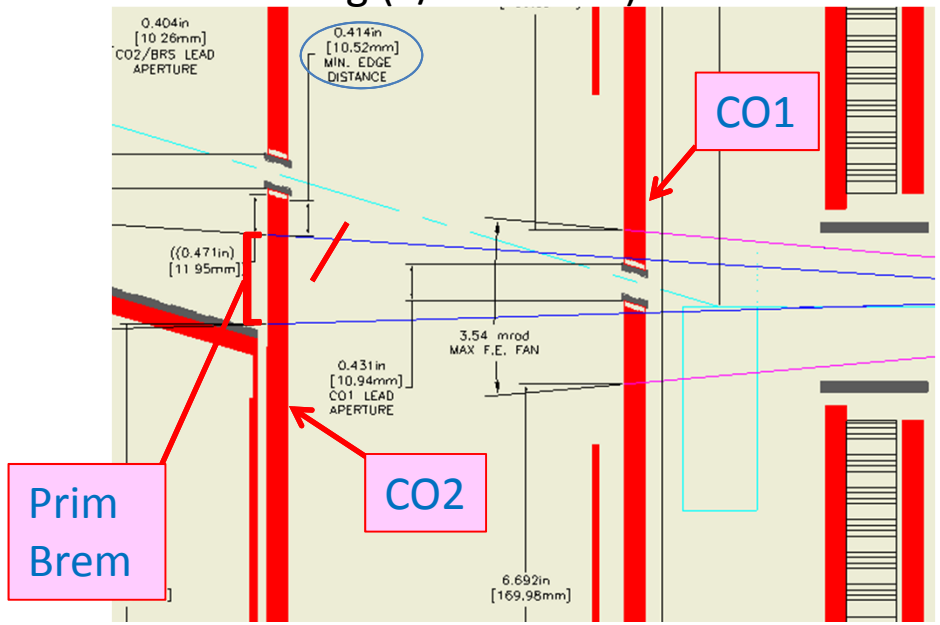
- Primary Bremsstrahlung blocked in FOE by CO2
- Synchrotron white beam stopped in FOE by MSK2
- Uncollimated pink beam stopped in SOE by MSK5
- Secondary Bremsstrahlung Management
  - Scatter outside of CO1 is blocked by the secondary Bremsstrahlung shield (SBRS) in FOE
  - Scatter down the beamline is collimated by CO3 in the beam transport and CO4 in the SOE and stopped by tungsten secondary Bremss. stop (SBRS2)

Ray Tracing: Bremsstrahlung

PD-XFM-RAYT-0001;
absolute positioning (+/-0.22 mm) and manufacturing (+/-0.18 mm) tolerances



VERT. BREMSS. LINE OF SIGHT



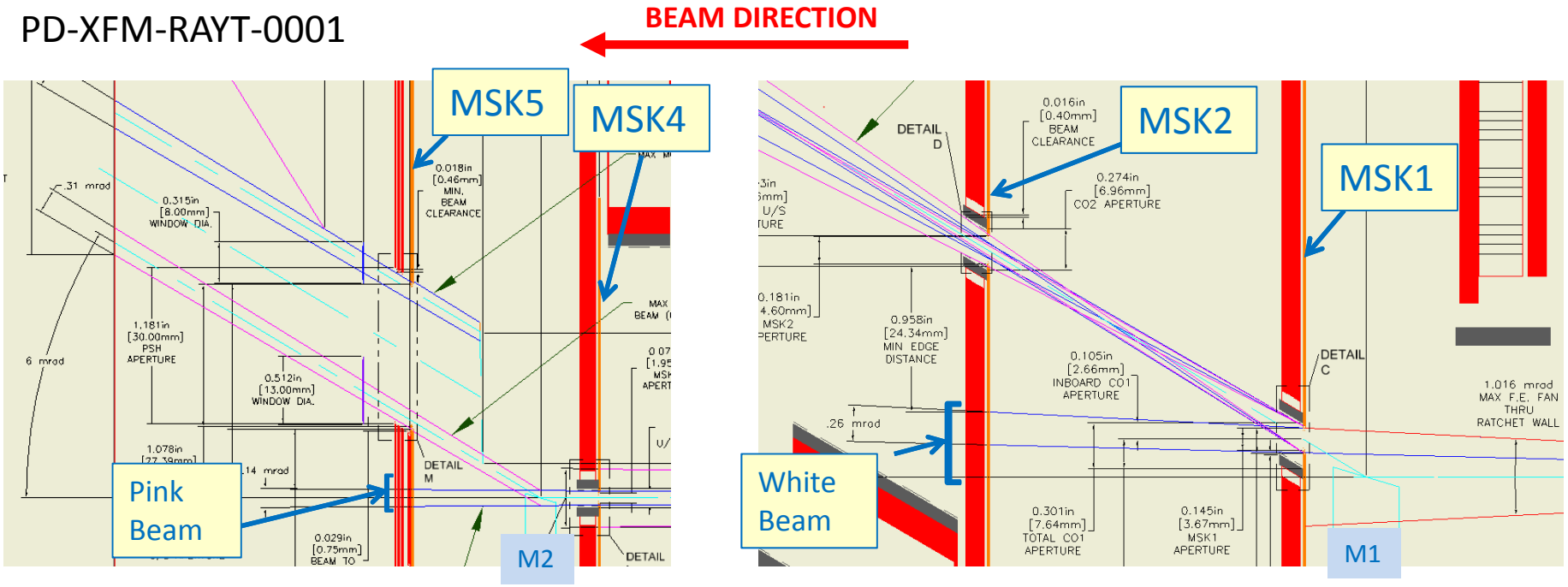
HORIZ. BREMSS. RAY TRACE

1- Primary Bremsstrahlung is stopped in FOE by CO2

2- Possible secondary Bremsstrahlung is stopped in SOE by tungsten secondary Bremss. stop (SBRS2)

Ray Tracing: Synchrotron Radiation

PD-XFM-RAYT-0001



VERT. SR RAY TRACE

HORIZ. SR RAY TRACE

1- White beam is stopped in FOE by MSK2

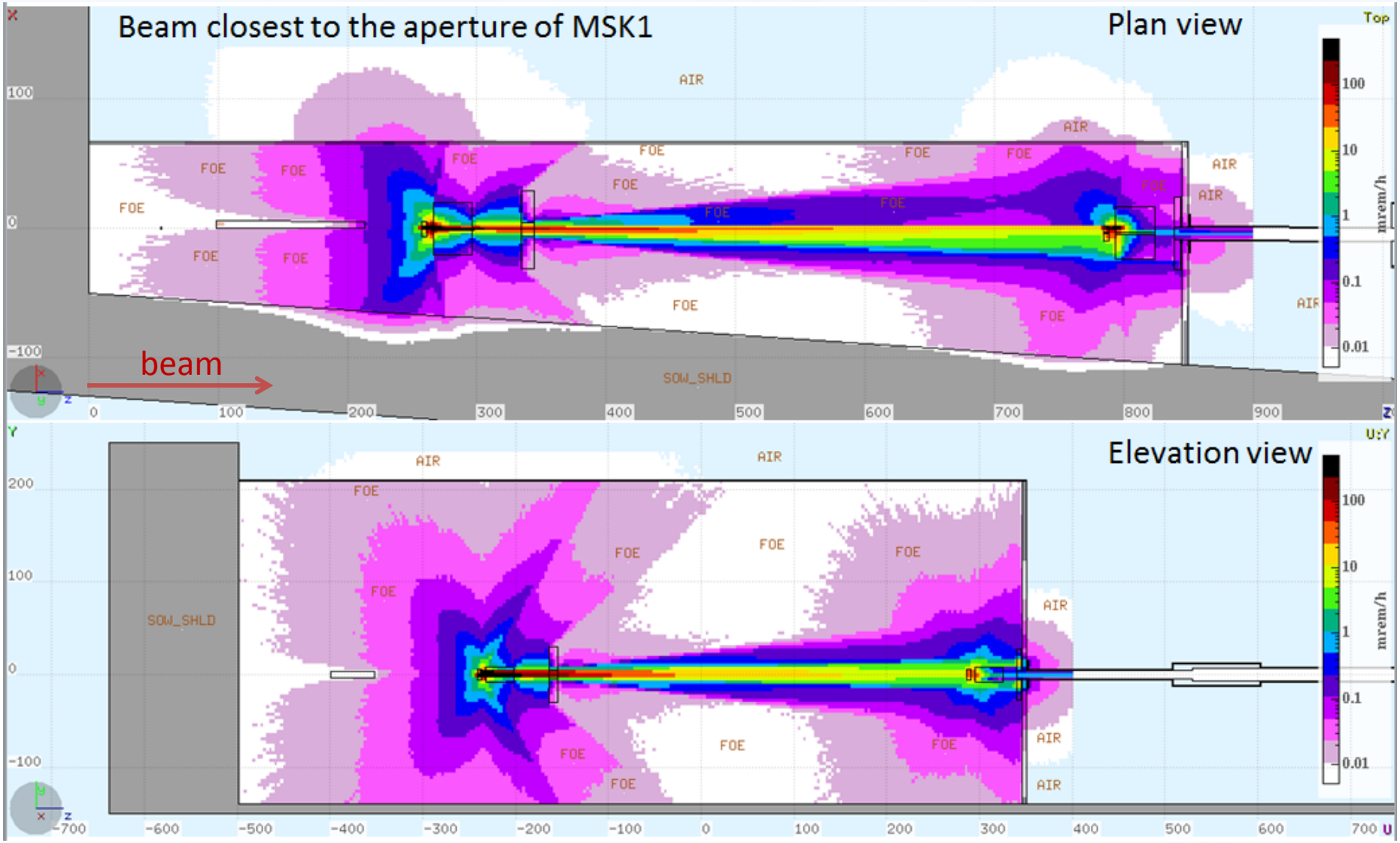
2- Uncollimated pink beam is stopped in SOE by MSK5

FLUKA: Bremsstrahlung Scatter

- Calculations by Sunil Chitra and Mo Benmerrouche
- **Worst case** is GB hits a point close to the aperture of fixed mask 1
- Dose rate outside the side wall is expected to be 0.03 mrem/h and less than 0.01 mrem/h outside the roof.
- Dose rate on contact outside the downstream FOE wall is expected to be 0.3 mrem/h and 0.03 mrem/h at 30 cm away, which is acceptable as per the new ALARA policy [1]

[1] R Lee, NSLS-II Issue and Decision Paper: ALARA Analysis for Installation of Secondary Bremsstrahlung Shields in the First Optics Enclosure, PS-C-ESH-STD-005.

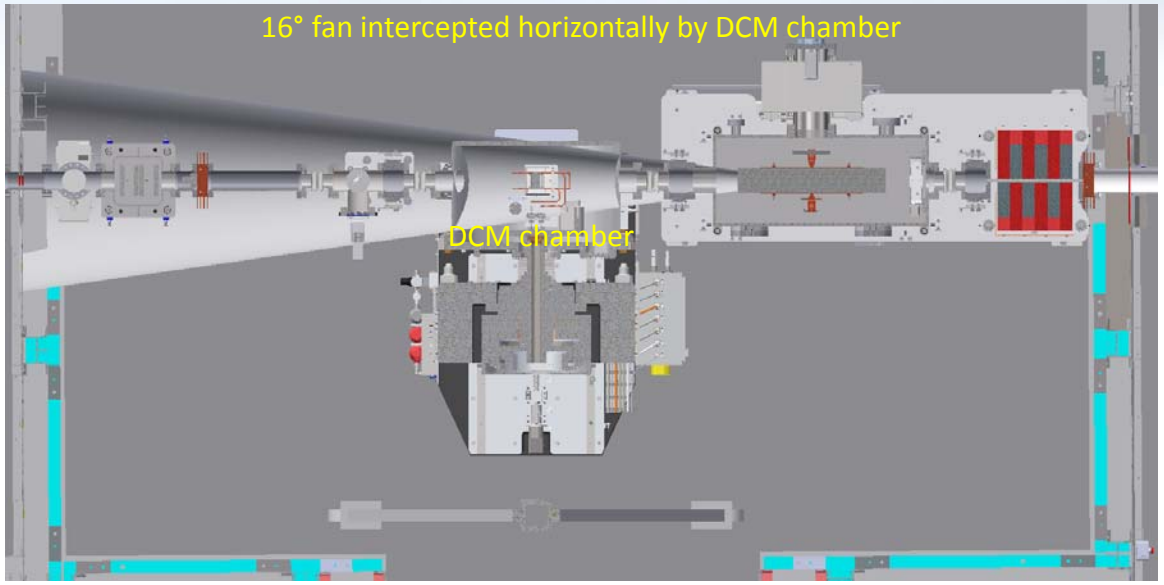
FLUKA: Bremsstrahlung Scatter

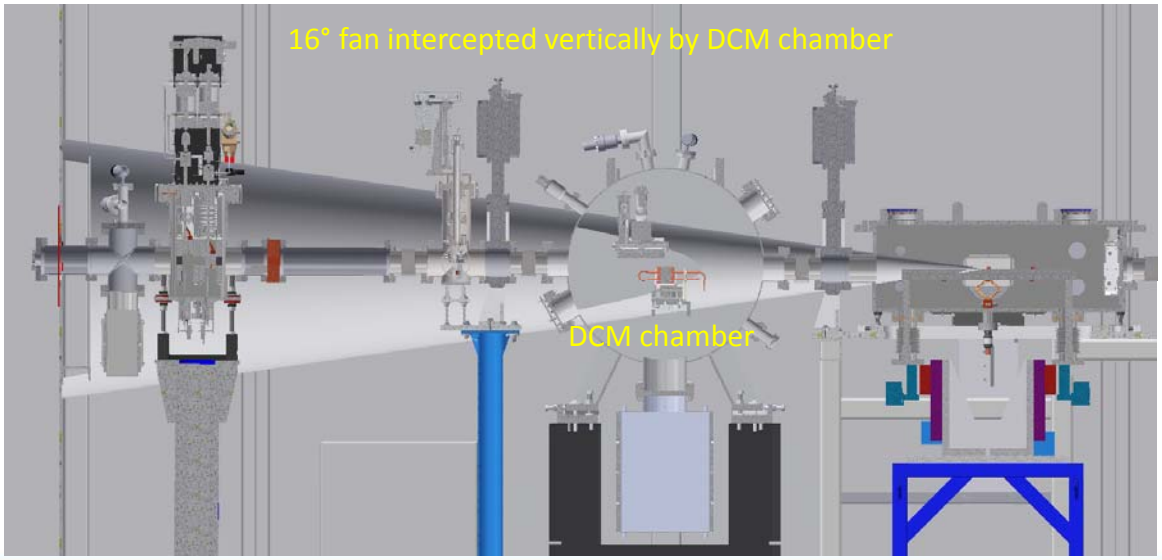


FLUKA: Synchrotron Radiation

- **Worst case** is pink beam hitting the M2 mirror (neglecting its reflective property)
- Dose rate is estimated to be 0.03 mrem/h outside the 4-BM-B roof while outside the lateral walls it is expected to be 0.05 mrem/h on contact
- Outside the downstream wall and at angles that are outside the shadow of the guillotine, the dose rates are expected to be 0.13 mrem/h on contact, with 6 mm of steel as shielding (FLUKA simulations indicate additional 2 mm needed)
- DCM vessel now under configuration control to provide additional shielding >2 mm thick steel

FLUKA: Synchrotron Radiation

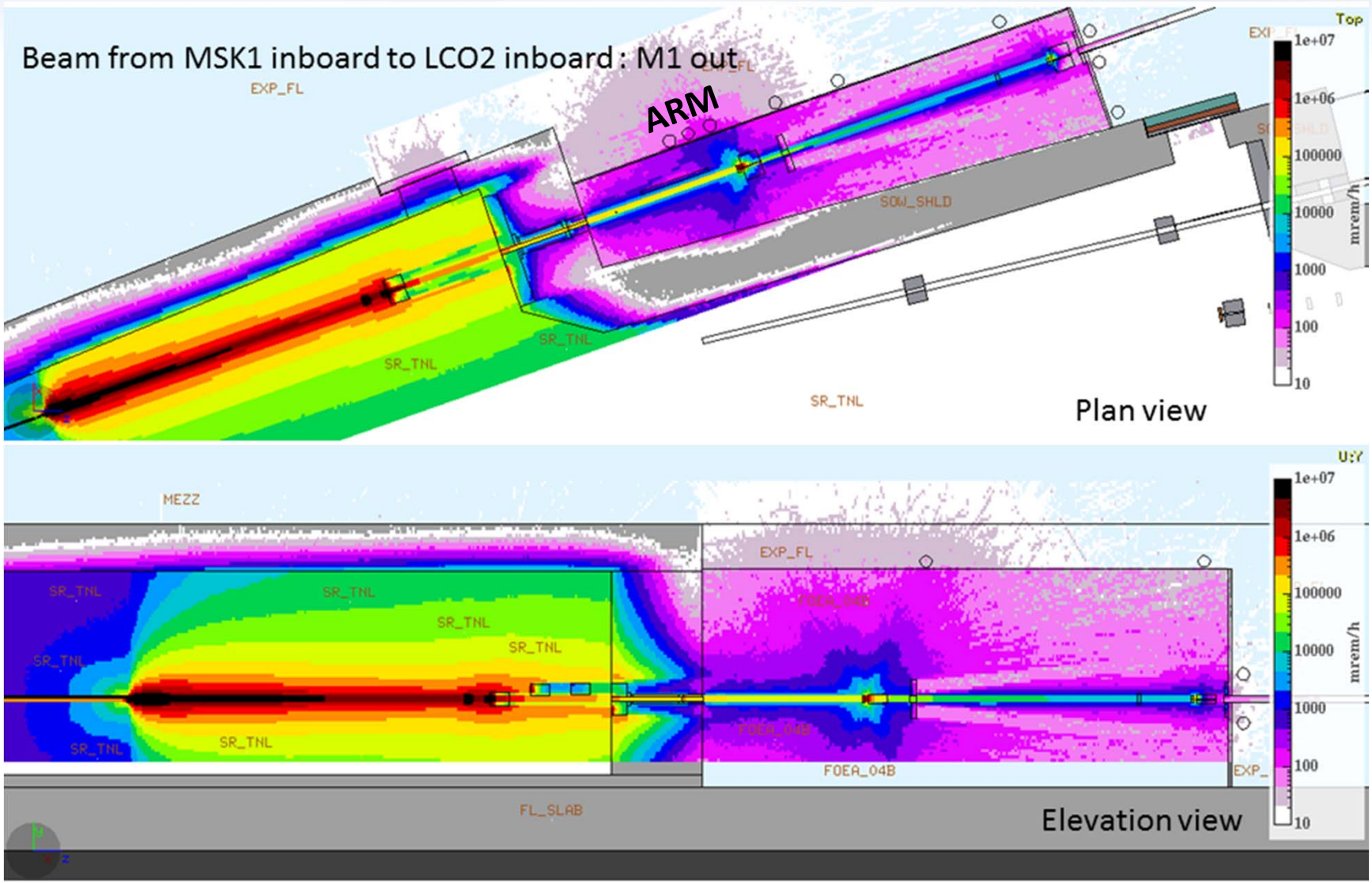




FLUKA: Top-off Radiation

- **Worst case** is FE and FOE Slits Open, M1 Out
- Dose rates are expected to be in the range of 130-150 mrem/h outside the side wall and about 30-50 mrem/h outside the roof
- Outside the downstream wall, the dose rate is expected to be about 70-80 mrem/h
- ARM is required and located ~2.0 m from the downstream end of the ratchet wall

FLUKA: Top-off Radiation



Radiation Safety Committee Review

- **XFM** RSC Review held August 15, 2017
- Review of XFM beamline 4-BM:
  - Synchrotron and Bremsstrahlung ray tracing
  - Secondary Bremsstrahlung management
  - Radiation shielding analysis
  - Thermal management related to radiation safety
- Memo issued August 24, 2017

Commissioning, Radiation Survey

Commissioning Plan:

- NSLSII-4BM-PLN-001
- Sequential optimization of photon delivery system components

Radiation Survey procedure:

- NSLSII-4BM-PRC-001
- Systematic confirmation of shielding from source to beam stop

Hazard Identification and Mitigation

- USI 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
Fire	Fire detection system installed in 4-BM-A and 4-BM-B/C
Hazardous material - Lead	Painted and/or covered
Pressure safety vessel	FEA calculations, pressure tests of windows, burst discs on M1 & DCM
Electrical	EEI, grounding, installation according to code

Pillar II: Hardware

Hutches

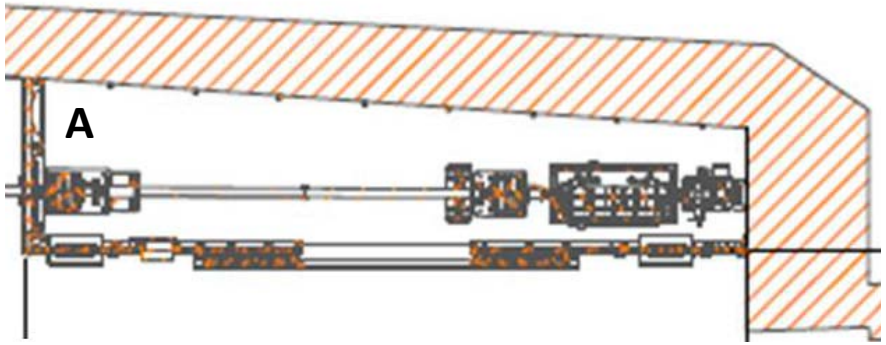
- Hutch contract part of BDN package
  - 4-BM-A by GPS
  - 4-BM-B/C by Caratelli

Lead Hutch 4-BM-A

4-BM-A

Lead shielding:

Lateral	**18 mm**
Downstream	**50 mm**
Roof	**4 mm**

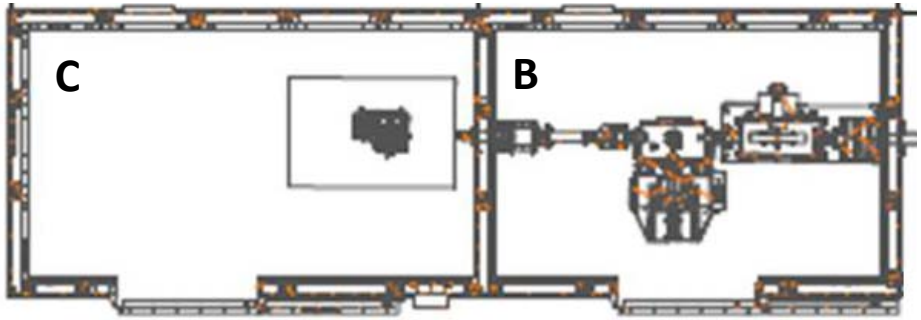


4-BM-B/C

Steel shielding:

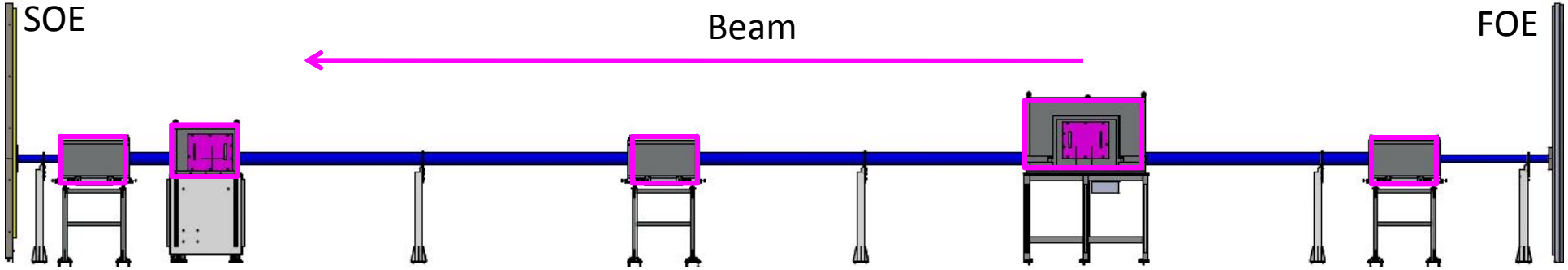
Lateral	**3 mm**
Downstream	**6 mm**
Roof	**2 mm**

0.5 m x 0.5 m x 12 mm
Lead Beam stop



Steel Hutch 4-BM-B/C

Shielded Beam Transport



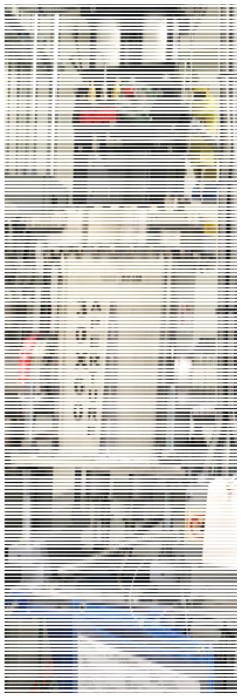
- 20 m length
- 5 mm lead shielding minimum throughout includes hutch collars, shielded pipe, flange covers, and ion pump enclosures
- 10 mm lead at hutch interfaces

Radiation Safety Components

- Critical components are surveyed into position
- Components under configuration control are labeled and inspected according to NSLS-II procedure PS-C-ESH-PRC-025
- Checklist for 4-BM is NSLSII-R-XFD-CHK-020

Guillotine + MSK + CO

PSH



Shielded beam transport

SBRS

Other Credited Safety Components

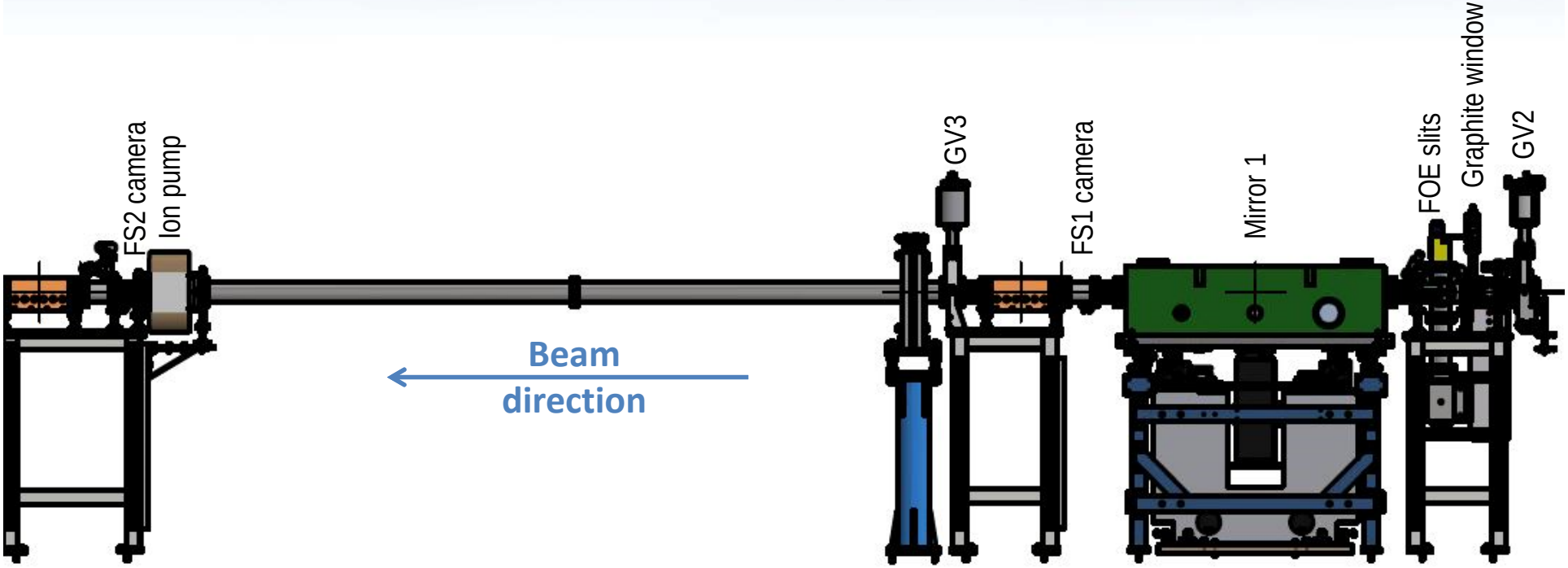
Area Radiation Monitor (ARM)

ARM location on FOE exterior wall determined by FLUKA simulations

DCM vacuum vessel

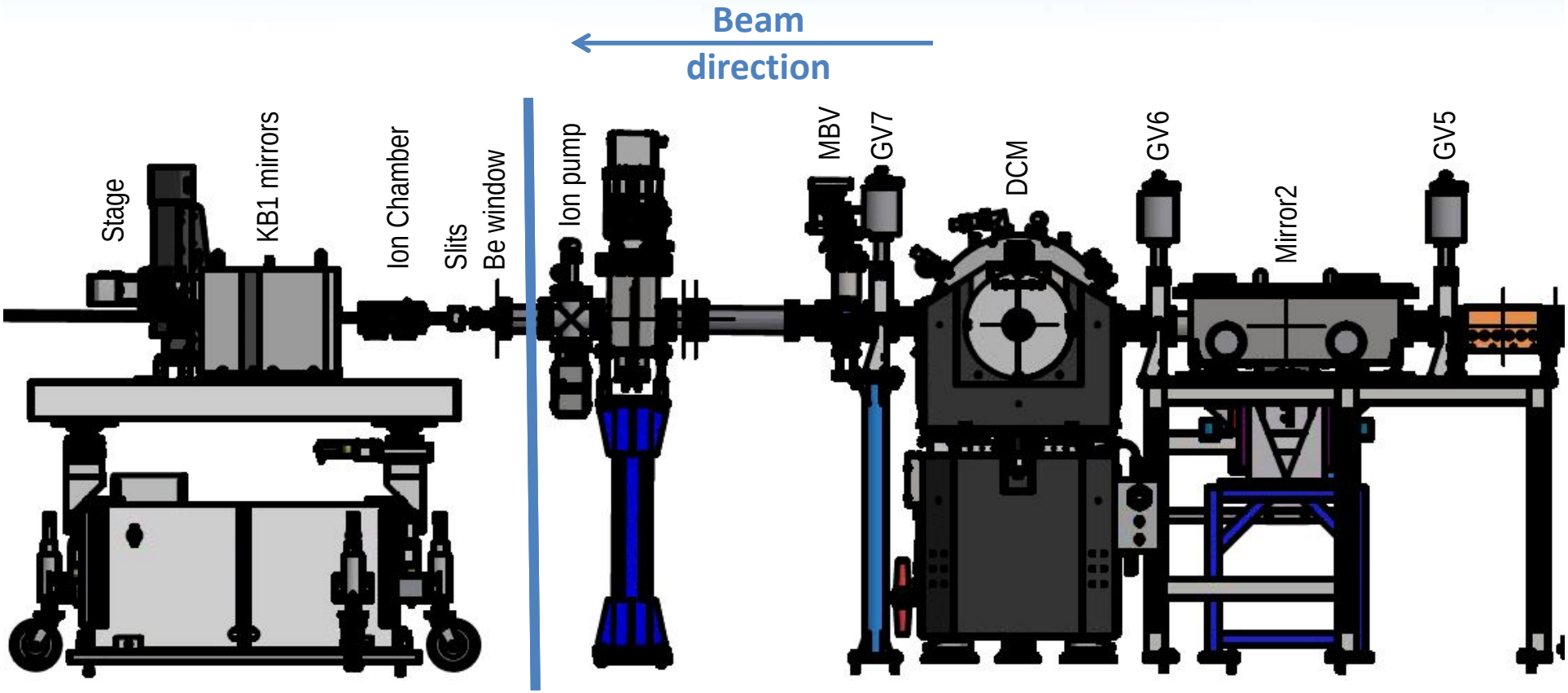
Under configuration control as supplemental hutch shielding as determined by FLUKA simulations

4-BM-A "Other" Beamline Components



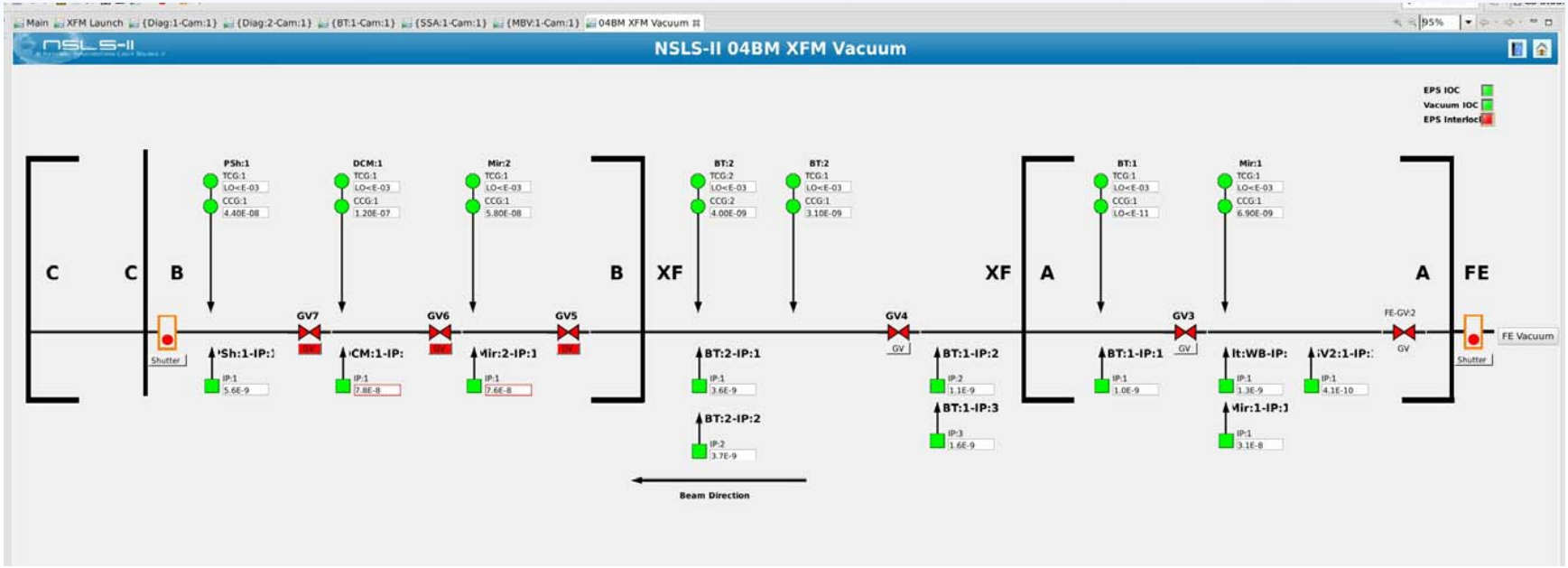
- Physical installations complete
- Utilities complete (PCW, dirty power, dry nitrogen and compressed air)
- All vacuum components under UHV
- Motion controls complete: FOE slits, M1 toroidal mirror (incl. over-travel limits)
- Diagnostic screens (x2) installed, ready for commissioning

4-BM-B/C “Other” Beamline Components



- Physical installations complete
- Utilities complete (PCW, dirty power, dry nitrogen and compressed air)
- Motion controls complete: M2 mirror, DCM, MBV | Slits, KB1 mirrors

Equipment Protection System (EPS)



- Easy-to-understand screens allow beamline staff to monitor component status
- Pressures, temperatures, and flow are measured, recorded, and displayed
- Vacuum and pneumatic controls are fully integrated into the EPS system

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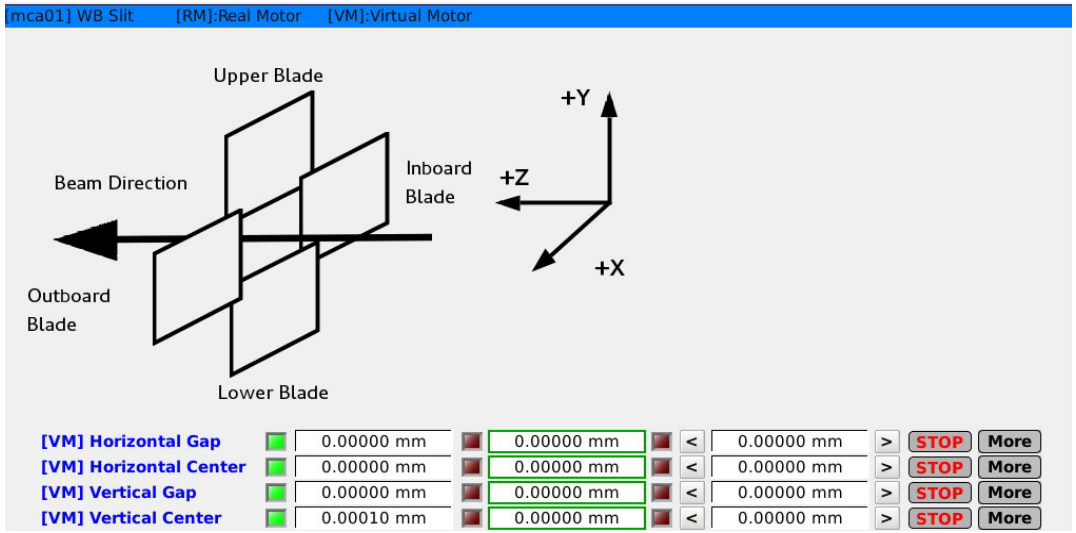
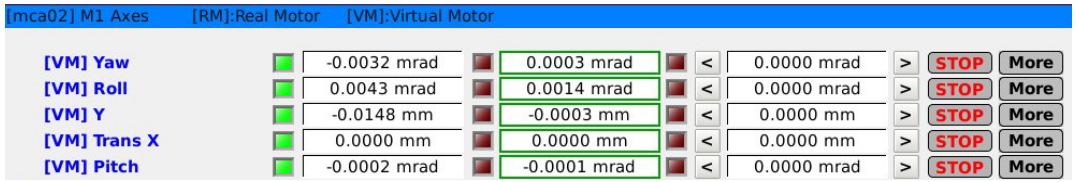
Controls

FOE slits



M1 Mirror



Delta Tau Motion Controllers in Hutch 4-BM-B1 Rack

- Motors and actuation required for first light have been tested
- EPICS/CSS software ready

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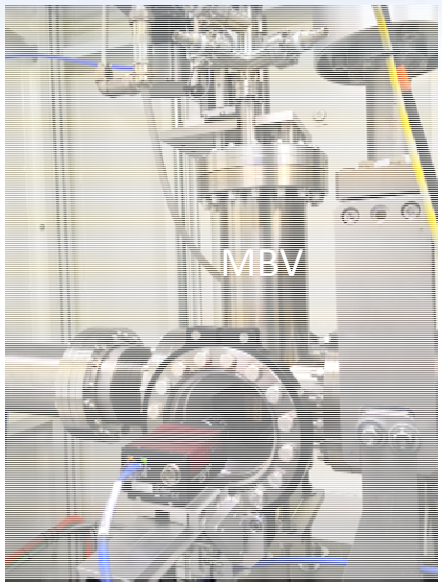
Diagnostics

XFM DIAGNOSTICS include:

- Slits with drain current (in FE)
- Instrumented masks (FOE)
- Retractable fluorescence screen (in SBT)
- Retractable intensity monitor (at SSA)
- High-resolution Multi-Beam Viewer (in SOE)



Distance (m)	Diagnostic	Comment
9	White beam slits with drain current	Isolate 3PW fan
26	Mask 1 fluorescent screen	Visualize white beam
31	Mask 2 fluorescent screen	Visualize pink beam
38	Retractable fluorescence screen	Tune M1
50	Intensity monitor	Adjust M1 focus at SSA
57	(MBV) Retractable YAG screen (mono beam) and sintered diamond screen (pink beam) viewed by camera	Align beam on DCM, set true roll=0, measure mono beam offset, and calibrate M2 mirror pitch

Pillar III: People

XFM Beamline Staff

Lead Beamline Scientist	Ryan Tappero
Authorized Beamline Staff	Alvin Acerbo (CARS Partner User Group, Beamline Scientist) Paul Northrup (TES Lead Beamline Scientist)
Beamline Supporting Staff	Ed Haas (Mechanical Engineer) Jun Ma (Controls Engineer) Mike Maklary (Mechanical Technician)

All staff members have completed the required training.

Summary

- XFM commissioning will be carried out in stages; FE, BL radiation surveys, BL technical commissioning, BL scientific commissioning
- Technical and scientific commissioning interspersed to bring online additional experimental capabilities as commissioning progresses
- Beamline is ready for first light