

# Full-field X-ray Imaging (FXI) Beamline 18-ID Instrument Readiness Overview

Wah-Keat Lee, FXI Lead Beamline Scientist  
Instrument Readiness Review

October 18, 2017



# Outline

- **Background**

Scientific Program and Beamline Parameters, IRR Scope, Beamline Layout, Commissioning Sequence

- **Pillar I: Documentation**

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

- **Pillar II: Hardware**

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

- **Pillar III: Personnel**

Beamline Staff

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# Scientific Program

- Transmission X-ray Microscope (TXM): X-ray analog of an optical microscope
- Full field x-ray imaging at 30 nm spatial resolution and 20-40 um FOV
- 5-11 keV range
- Broad range of applications: materials science, energy storage devices, geology/ environmental science
- Focus on high speed imaging for tracking sample dynamics
- In-situ and in-operando dynamics
- 2D or 3D measurements
- Chemical state sensitivity

# Beamline Parameters

Parameter	Value
Photon Delivery System	
Photon Source	Damping Wiggler (DW100)
Energy Range	4– 11 keV
Monochromator	Double crystal channel-cut Si(111)
Energy Resolution ( $\Delta E/E$ ):	$\approx 10^{-4}$
Max mirror cut-off E	15 keV
Flux at TXM condenser	$5 \times 10^{13}$ ph/s/0.01%bw (500 mA ring current)
Transmission X-ray Microscope	
Field of view	20-40 $\mu\text{m}$
Spatial resolution	30 nm
Minimum exposure per image	< 100 ms

# IRR Scope

## **IRR Scope Includes:**

1. 18-ID Front End (G. Fries presentation)
2. Photon Delivery System (GV2 through 18-ID-B)
3. Enclosures: 18-ID-A & 18-ID-B
4. Photon Delivery System Diagnostics
5. EPS, PPS, all infrastructure necessary for technical commissioning the Photon Delivery System
6. Basic control of Transmission X-ray Microscope (TXM) for technical commissioning

## **IRR Scope Excludes:**

1. User-level instrument/data acquisition controls
2. Data workflow and analysis

# Self-Identified Pre- and Post-Start Findings

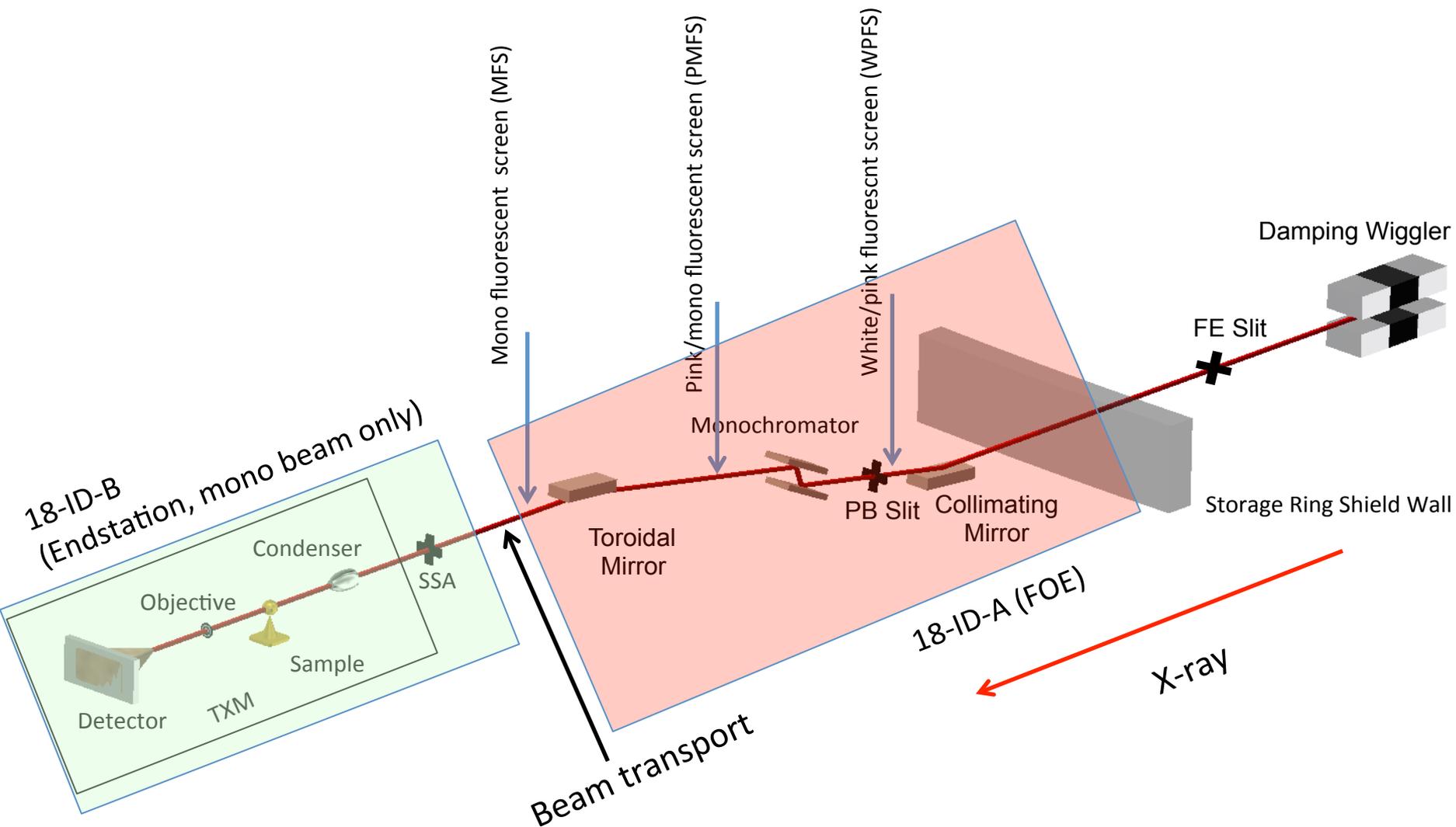
## Pre-start findings:

None

## Post-start findings:

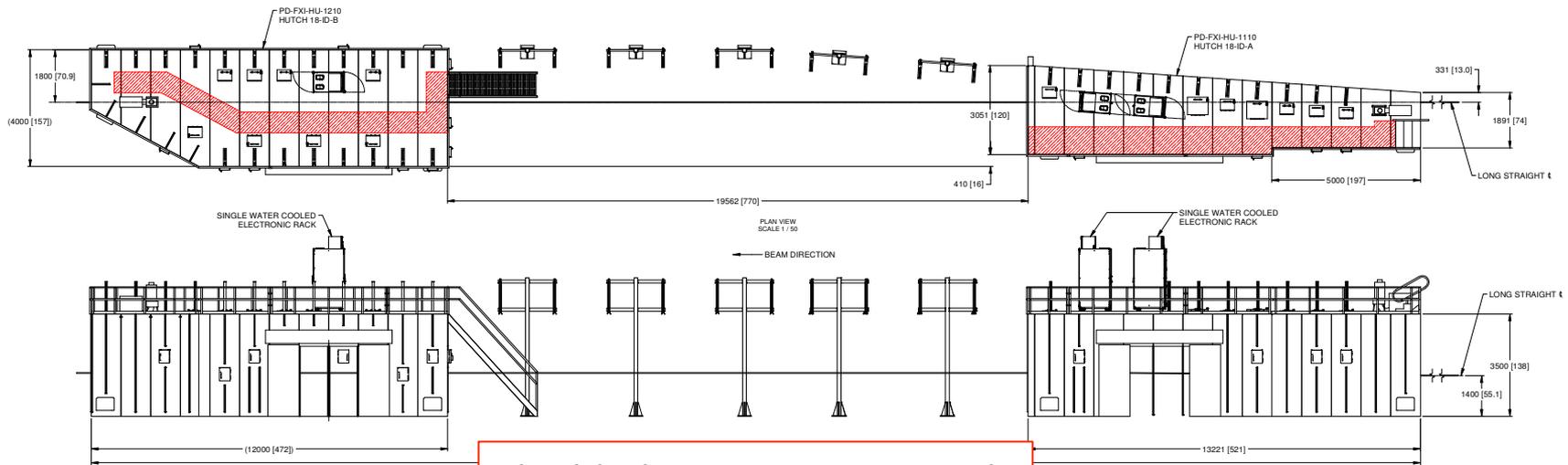
None

# Beamline Layout



## Hutches and transport pipe

X-ray

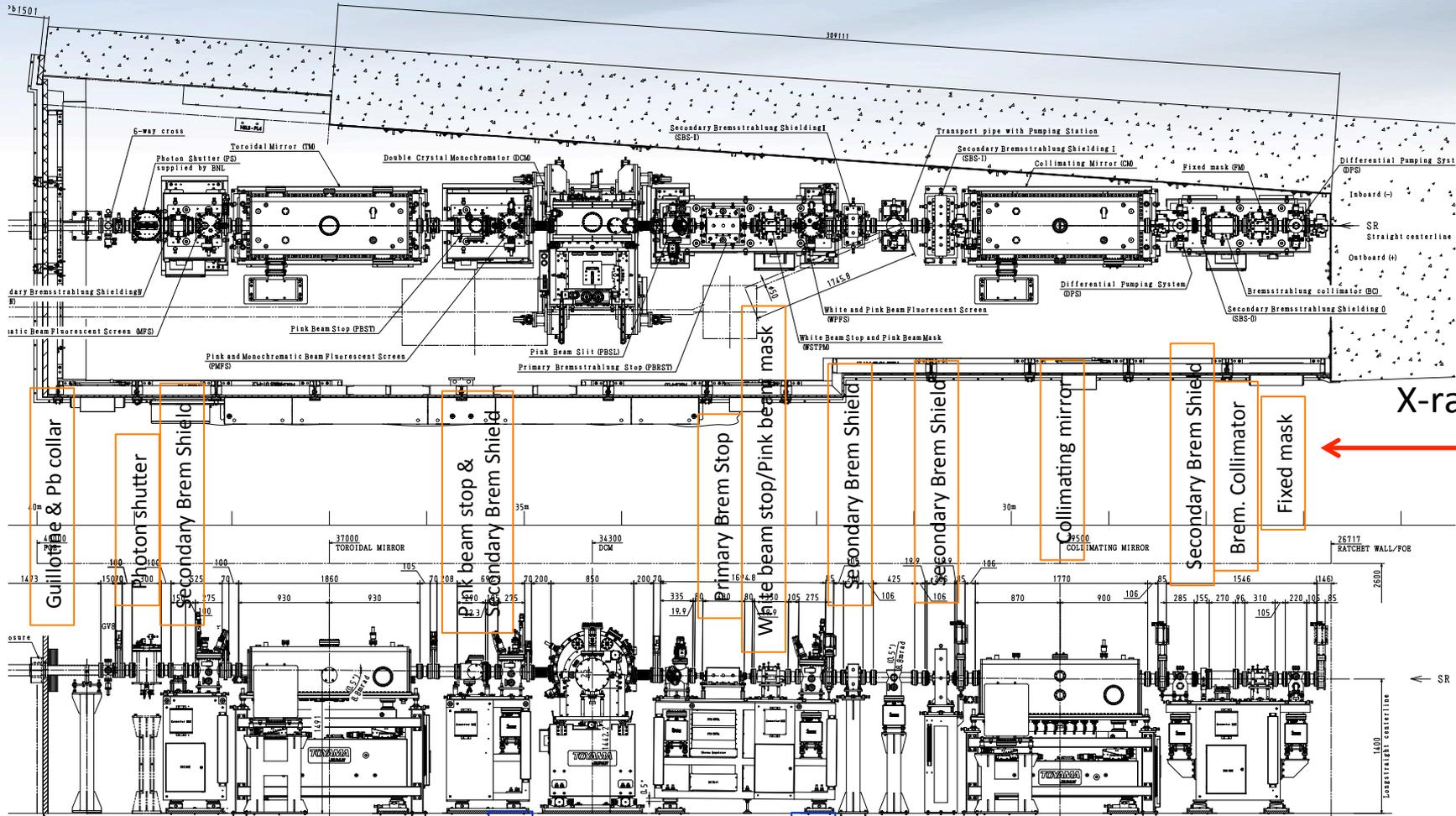


Shielded transport: 6 mm Pb  
No scatterers in the pipe

18-ID-B (Endstation)  
Roof panel: 3 mm Pb  
Side panel: 4 mm Pb  
Downstream panel: 4 mm Pb

18-ID-A (FOE)  
Roof panel: 10 mm Pb  
Side panel: 18 mm Pb  
Downstream panel: 50 mm Pb

# Major components in 18-ID-A. Radiation Safety Components are boxed in red.



Guillotine & Pb collar

Photon shutter

Secondary Brem Shield

Pink beam stop & Secondary Brem Shield

Primary Brem Stop

White beam stop/Pink beam mask

Secondary Brem Shield

Secondary Brem Shield

Collimating mirror

Secondary Brem Shield

Brem. Collimator

Fixed mask

X-ray



Mono fluorescent screen

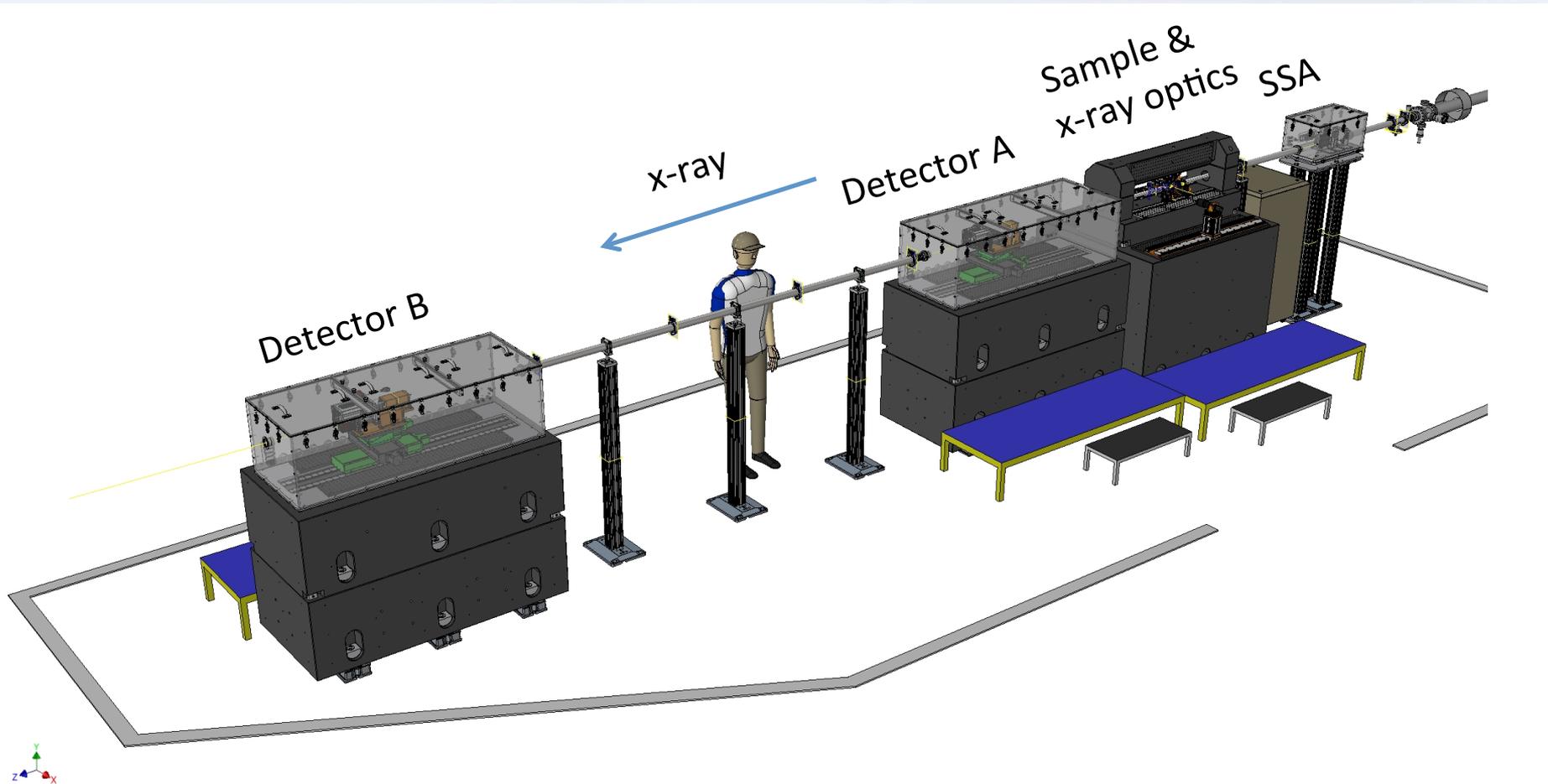
Toroidal mirror

DCM

Pink/mono fluorescent screen

White/pink fluorescent screen

# 18-ID-B components



# Commissioning Sequence

**Commissioning Plan: NSLSII-18ID-PLN-004**

## **Technical Commissioning of Photon Delivery System**

Basic alignment: To enable execution of Radiation Survey Plan

Align CM, DCM and TM to bring mono beam into 18-ID-B

Optics must be aligned well enough to take full beam

Must be completed for next steps

Energy calibration: Enable optimization and operation

Calibrate DCM and mirror angles

Must be completed for next steps

Characterization and optimization:

Individual component measurements with varying operational parameters (eg, ring current, coolant flow rates).

Does not need to be completed for next steps.

## **Technical Commissioning of Transmission X-ray Microscope**

Align TXM and acquire first image

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# Ray Tracing

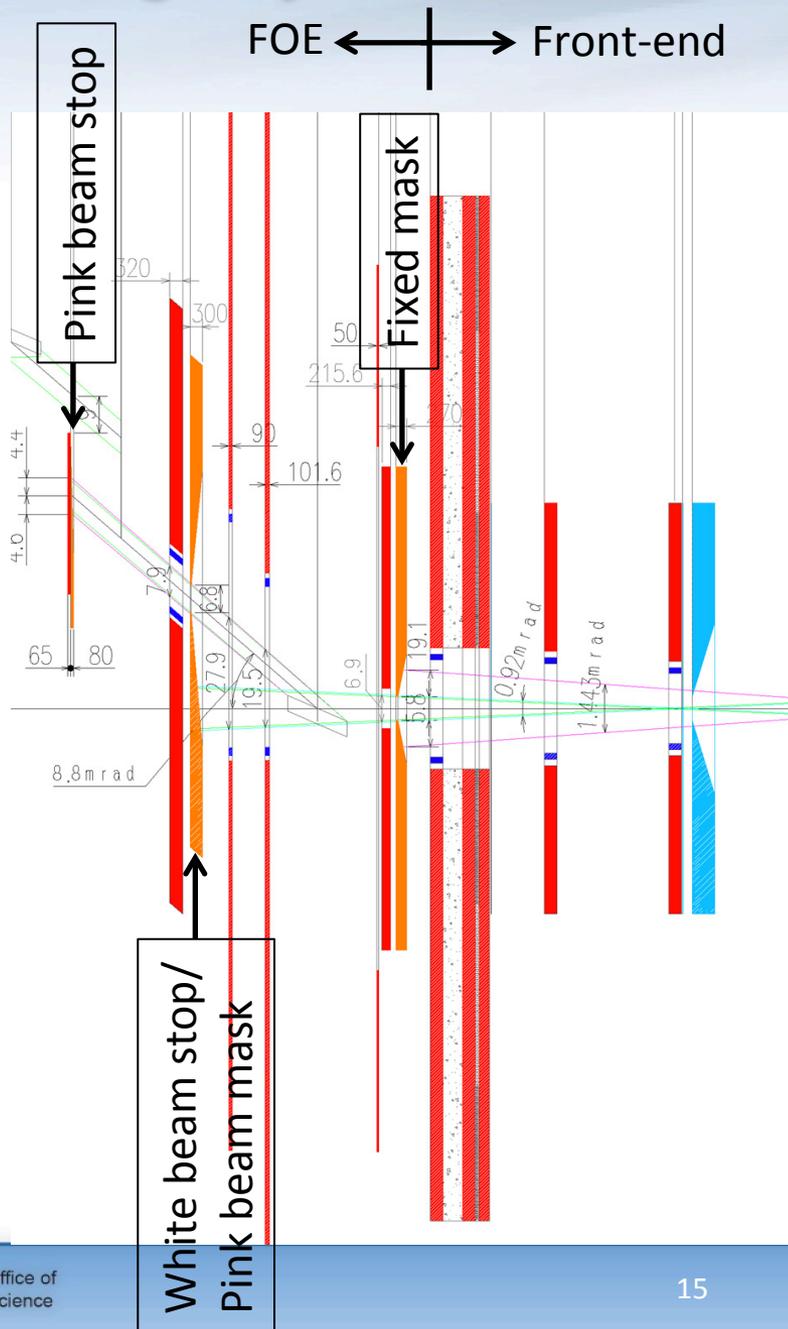
Drawing reference: PD-FXI-RAYT-1000

Ray traces prepared using PS-C-XFD-PRC-008 (*Synchrotron and Bremsstrahlung Ray Trace Procedure*)

Preliminary ray traces reviewed by RSC ray trace sub-committee

Final ray traces reviewed, approved and released.

# Ray Tracing: Synchrotron Beam



White beam collimated by fixed mask and stopped by white beam stop/pink beam mask

All pink beam (including mis-steered) stopped by white beam stop/pink beam mask and the pink beam stop





# Radiation Safety Committee Review

**Took place 9/28/17**

- Based on our assessment of the ray-tracing drawings and radiation simulation results, the RSC find that the FXI beamline shielding design meets the NSLS-II shielding policy. Subject to experimental verification by radiation survey, we believe the installed shielding will provide adequate personnel protection for normal operation and against failures of synchrotron orbit.
- Based on our review of the max. synchrotron ray-tracing drawings, the RSC believes that the FXI masks, collimators, white- and pink- beam-stops are adequately designed to protect against thermal failure of shielding components.
- Based on our review of the beamline layout, the RSC finds that all Radiation Safety Components meet NSLS-II design requirements.

# Radiation Survey Procedure

## Radiation Survey Procedure NSLSII-18ID-PRC-001

- Survey of Front End to be completed before beamline survey
- GB and White Beam scatterers
  - Fixed mask (non-movable)
  - Collimating mirror (movable)
  - White beam stop (non-movable)
- Pink beam scatterer
  - DCM
- Monochromatic beam scatterer
  - Target in B hutch
  - Mono beam stop
- Plan comprehensive radiation survey at  $\sim 1/3$  of current maximum operating current

# Design Reviews

Event	Date	
Beamline Advisory Team	April 2012	NEXT
DOE review of NEXT project	September 2012	
ALD Preliminary Design Review of NEXT	March 2013	
Beamline Advisory Team	April 2013	
DOE CD2 review of NEXT project	August 2013	
FXI beamline Final Design Review	November 2013	
ALD Final Design Review of NEXT project	December 2013	
DOE CD3 review of NEXT project	March 2014	
Beamline Advisory Team	April 2014	
DOE review of NEXT project	August 2014	
Preliminary Design Review of Toyama PDS	September 2015	BDN
Final Design Review of Toyama PDS	December 2015	
Beamline Advisory Team	March 2017	
Final Design Review of TXM	May 2017	

All ATS closed.

# 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 behind 18-ID-A
Cryogenics	ODH system installed in 18-ID-A for LN <sub>2</sub>
Fire (amount of polycarbonate in B hutch)	Worked with J. Terranova (Fire Protection Dept). O <sub>2</sub> sensors and reduced motor voltage. ATS closed.
Hazardous material - Lead	Painted and/or covered
Pressure Safety	FEA calculations, over-pressure tests, burst disks
Electrical	EEl, grounding, installation according to code

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# Shielded Enclosures and Transport Pipes



## Hutch B (mono beam)

Roof panels: 4 mm Pb

Side panels: 4 mm Pb

Downstream panels: 4 mm Pb



## Transport

6 mm Pb

No scatterers



## Hutch A (FOE)

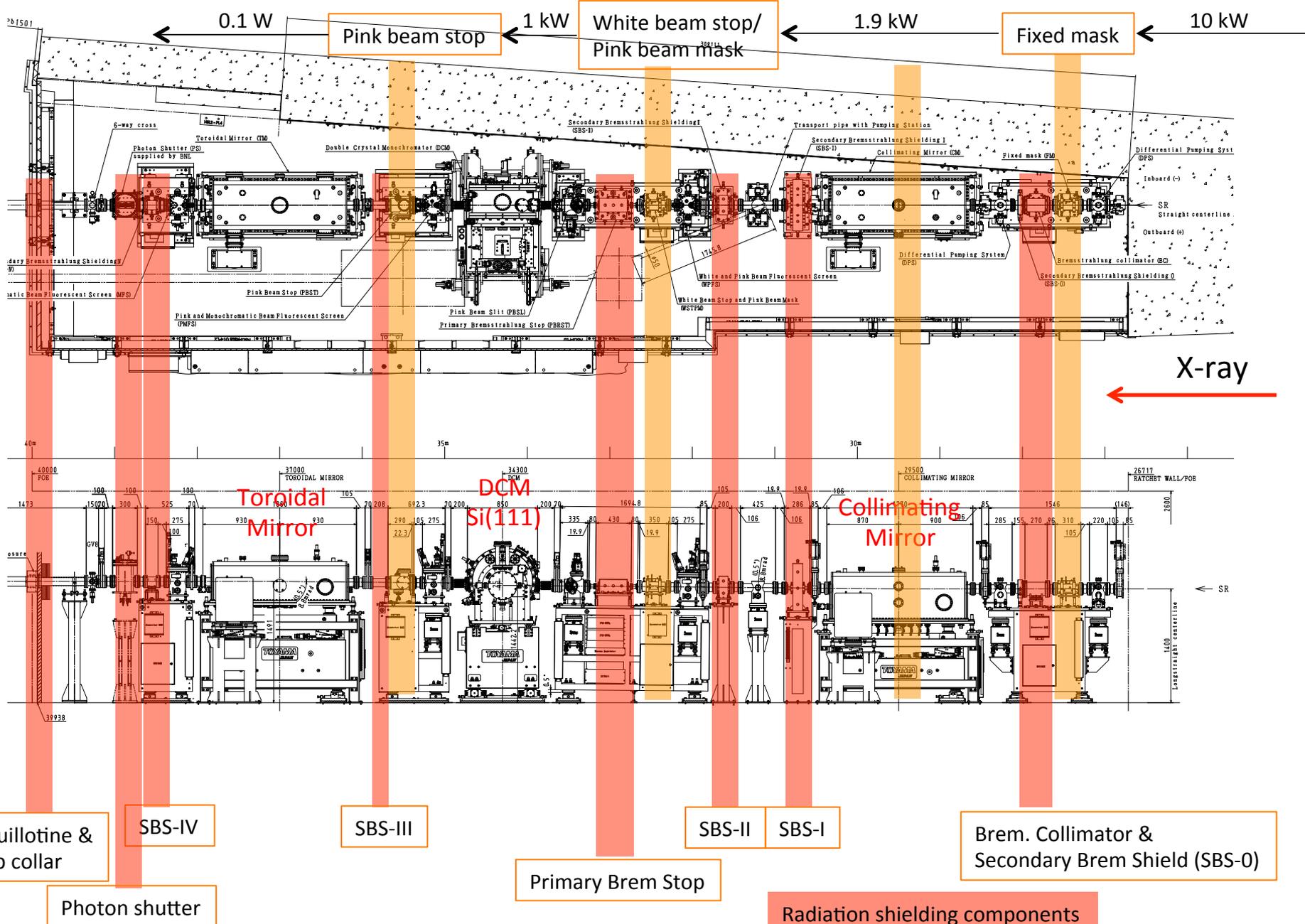
Roof panels: 10 mm Pb

Side panels: 18 mm Pb

Downstream panels: 50 mm Pb

# 18-ID-A radiation safety components

# Radiation safety related thermal components



# Radiation safety components in 18-ID-A

Pink beam stop



Coll. Mirr.



WBS/PBM



Fixed Mask



Guillotine



Phot. Shutter



Brem. Stop



Brem. Coll.



Sec. Brem. Shld-IV



Sec. Brem. Shld-III



Sec. Brem. Shld-II



Sec. Brem. Shld-I



Sec. Brem. Shld-0



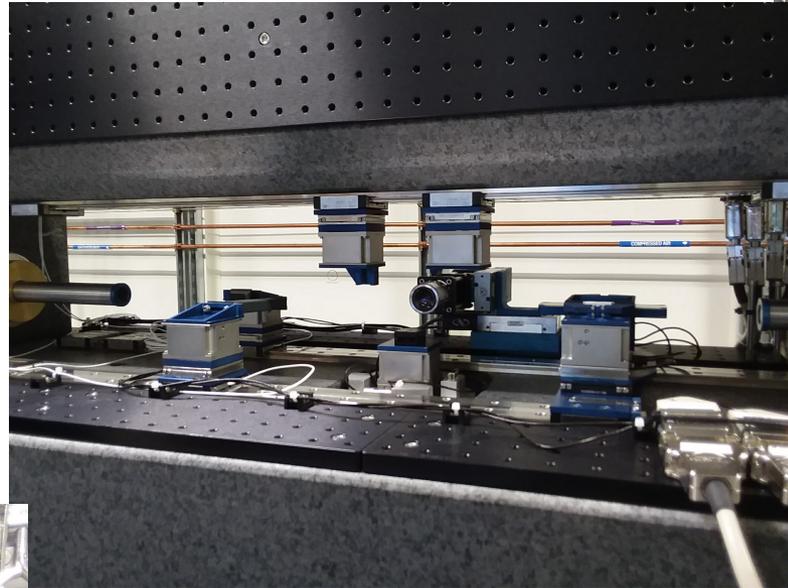
# 18-ID-B: TXM instrument

All motions required for commissioning working

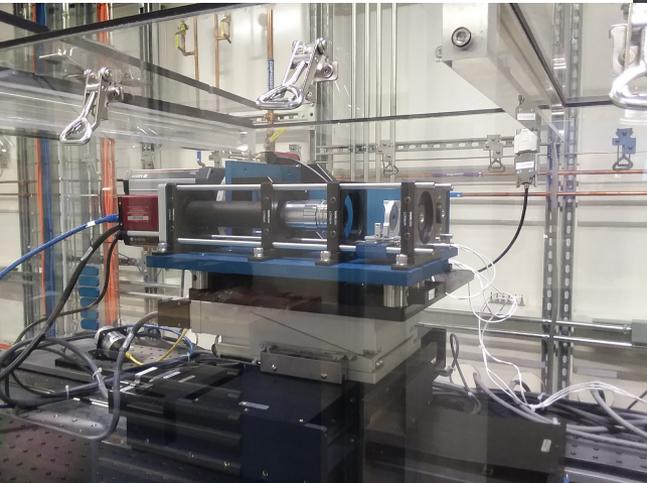
Sample and x-ray optics table



SSA table



Detector A table



# Other Credited Safety Components



Oxygen Deficiency Hazard (ODH)  
Monitor in 18-ID-A



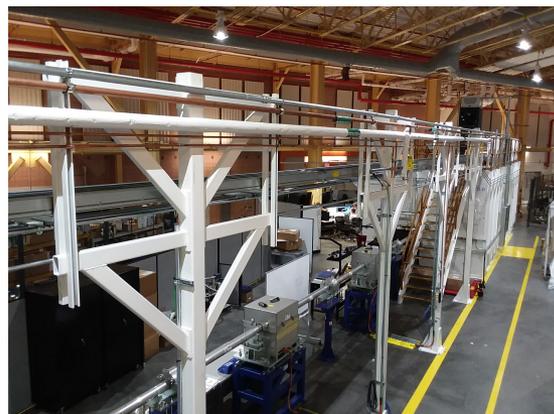
ARM downstream of 18-ID-A

# Utilities

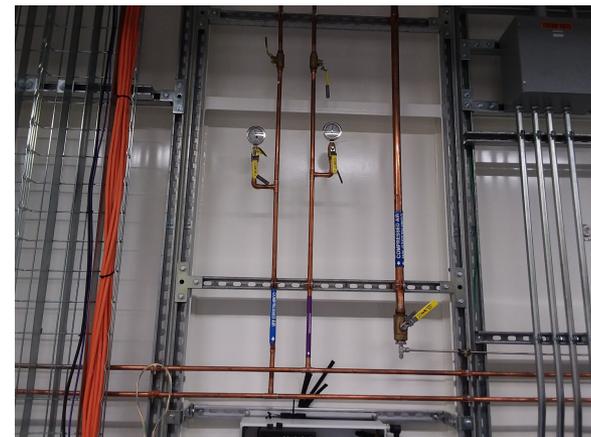
	Mezzanine	A hutch	Pylons	B hutch	B roof/ outside
Electric 110V	X	X	X	X	X
Electric 208V	X	X	X	X	X
Chilled process water			X	X	
DI water		X			
Compressed air	X	X	X	X	
N2 gas	X	X	X	X	



18-ID-A

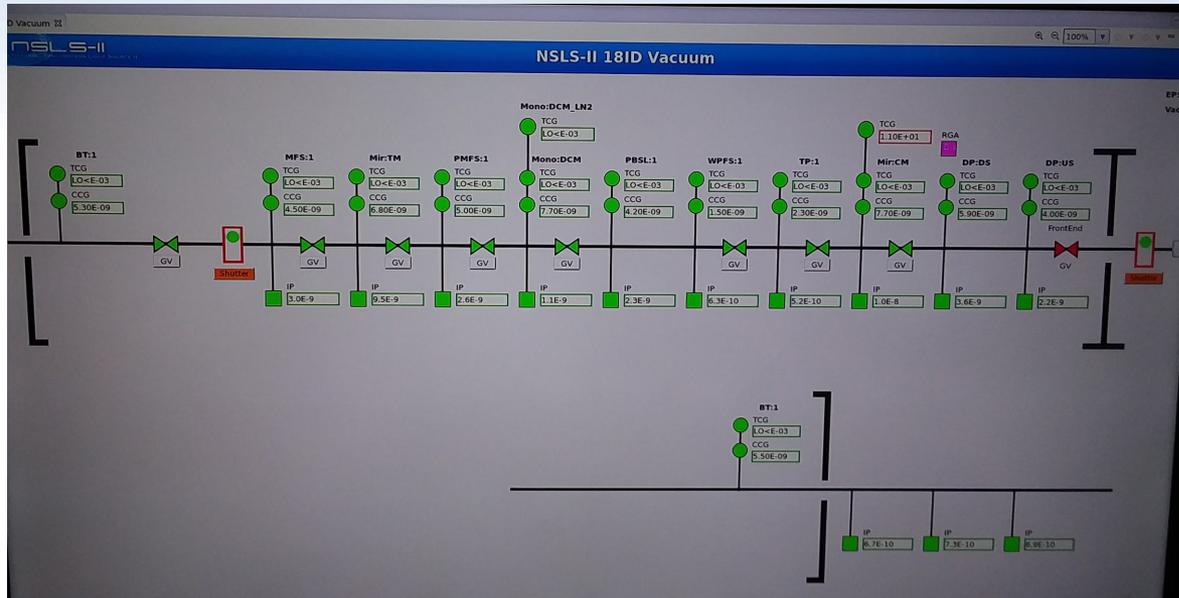


Pylons

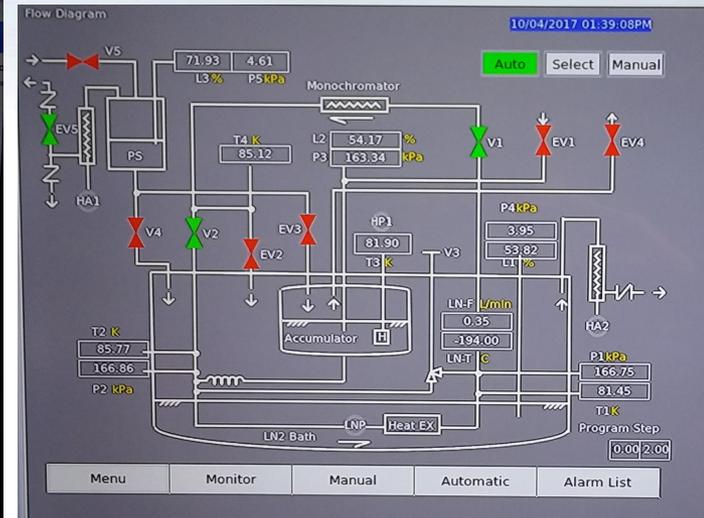


18-ID-B

# Equipment Protection System (EPS)



Vacuum screen



LN2 pump screen

Monitors: Vacuum pressure, flow rates, LN2 pump, temperatures

Easy to read display screens

Adjustable trip points and action. Can close FE shutter if needed.

# Controls

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

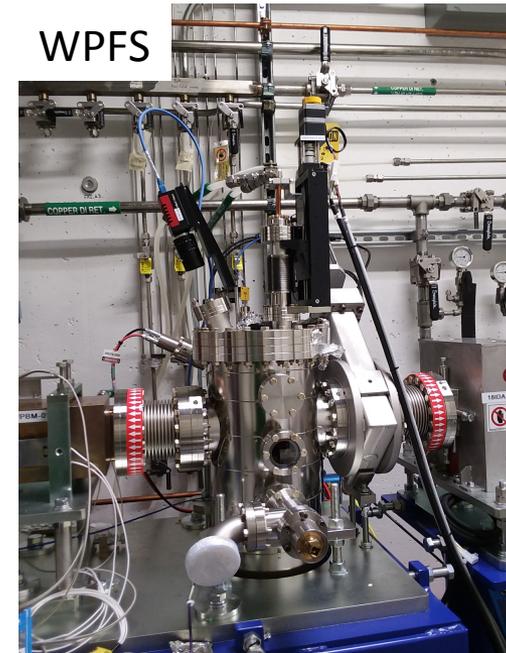
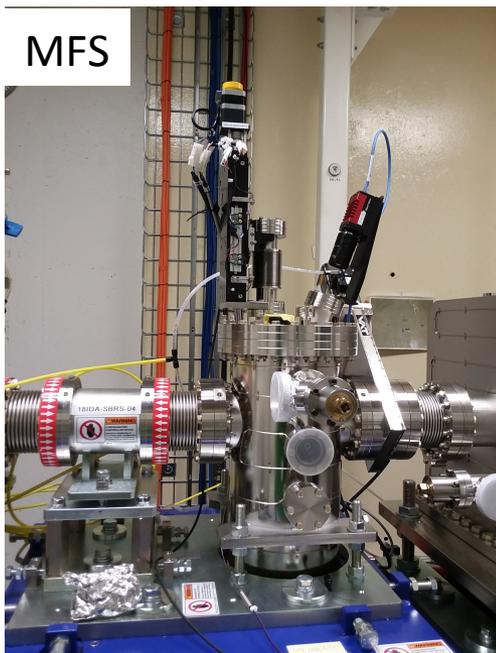
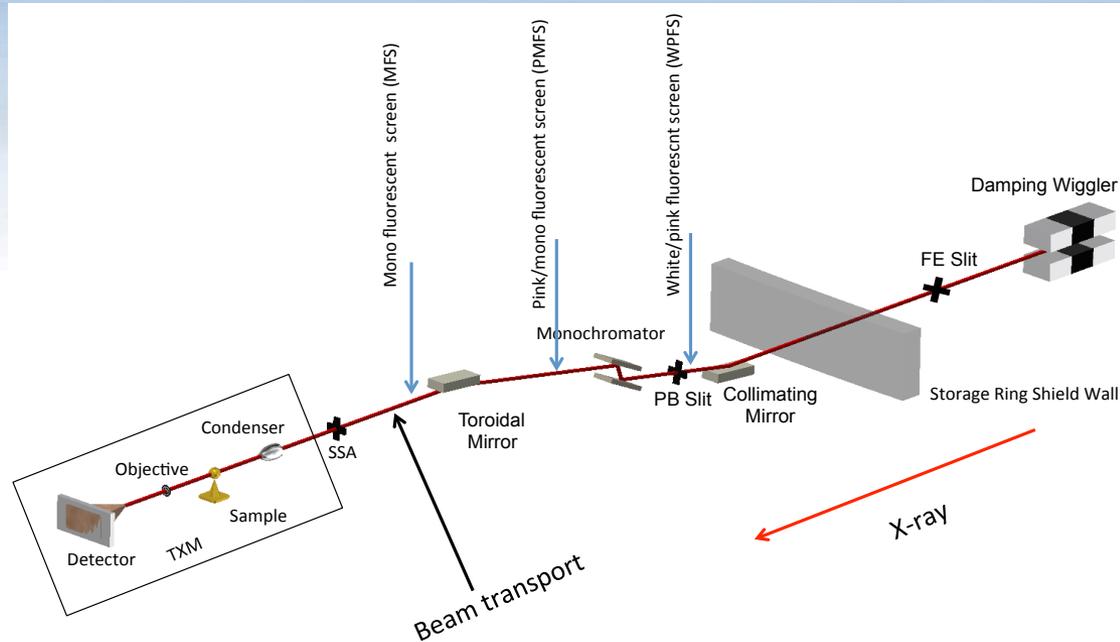
18-ID main controls page

Motor	Value	Unit	Control
CM X	-0.00006	mm	STOP More
CM Yaw	0.00	mrاد	STOP More
CM Y	0.00000	mm	STOP More
CM Pitch	-0.00	mrاد	STOP More
CM roll	-0.00	mrاد	STOP More
Mir:CM Real Motors			
X Up	0.0000	mm	STOP More
X Dn	-0.0001	mm	STOP More
Y Up	-0.0001	mm	STOP More
Y Dn-In	0.0000	mm	STOP More
Y Dn-Out	-0.0001	mm	STOP More

CM detailed user page

# Diagnostics

There is a retractable fluorescent screen after every optical component in the FOE



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# FXI Beamline Staff

Lead Beamline Scientist	Wah-Keat Lee
Authorized Beamline Staff	Mingyuan Ge (Scientist)
Beamline Supporting Staff	Mike Maklary (Program Technician) Huijuan Xu (Controls Engineer) Kazimierz Gofron(Controls Engineer) Scott Coburn (Engineer)