

LARIAT1, MICROCAL and IO_UP Instrument Readiness Review

Cherno Jaye

On behalf of the NIST NSLSII Partner Beamline Instrument Readiness Team



Outline

Background - Overview

Pillar I: Documentation

Experimental Station Design (Chamber Design, Beam Termination Point); Radiation Safety CC Checklist; Ray Trace; Survey and Alignment; Shielding Analysis; Radiation Safety Committee Review; Radiation Survey Procedure; Hazard Identification and Mitigation

Pillar II: Hardware

Radiation Safety Components (PPS, Configuration Control); Utilities; Vacuum; Controls

Pillar III: Personnel

Commissioning Team

Acknowledgement

Andrew Broadbent
Howard Robinson
Zhong Zhong
Chris Stebbins
Jean Smiles
John Fabijanic
Steve Hulbert
Steve O'Hara
Andrew Ackerman
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Rich Iaccarino

George Ganetis
Scott Buda
Andrew Sauerwald
Andreas Castiblanco
Ewart Orr
Jerry Malley...+ many
more

NIST Project @ BNL: Successful Partnership

- ❑ NIST has over 35 years of partnership/history with BNL
- ❑ Operated 3 beamlines at the NSLS
 - Provided X-ray spectroscopies that span the entire periodic table
- ❑ Construction of SST 1, SST2 and BMM to improve upon and provide new capabilities (imaging and diffraction) to NSLS

NIST Project @ NSLSII: Design, Construction, Commissioning, Operation of SST1, SST2 and BMM

- ❑ **BMM: IRR held in 6/17**, now in General User operation
- ❑ SST = Spectroscopy Soft and Tender
- ❑ **SST Beamline (w/NEXAFS and HAXPES) IRR held in 2/18**
 - ❑ **LARIAT2** IRR held in **12/18**
 - ❑ **RSoXS** IRR held in **2/19**
- ❑ SST now in commissioning with 4 experimental stations
 - ❑ **LARIAT1** Experimental Station: Large full field NEXAFS spectro-microscopy
 - ❑ **MICROCAL** Experimental Station: X-ray fluorescence spectroscopy
 - ❑ **IO_UP** Section
 - ❑ **VPPEM**: XPS imaging

NIST Project @ NSLSII: Design, Construction, Commissioning, Operation of SST1, SST2 and BMM

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IRR Scope Today

- ❑ **LARIAT1** Experimental Station: Large full field NEXAFS spectro-microscopy
- ❑ **MICROCAL** Experimental Station: X-ray fluorescence spectroscopy
- ❑ **IO_UP** Section
- ❑ Support Infrastructure for Commissioning LARIAT1, MICROCAL and IO_UP

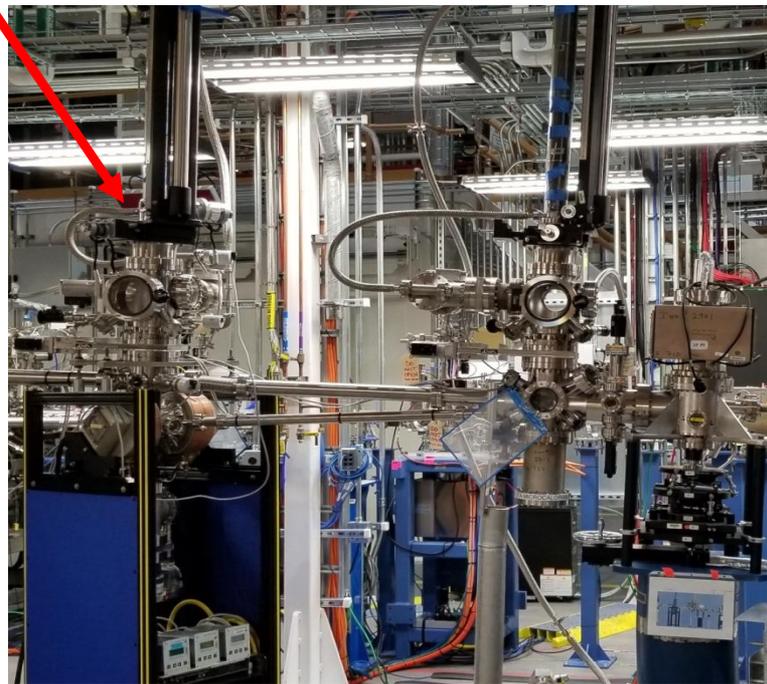
Location at SST1

- ❑ On SST-1, between photon shutters PSH7 and PSH8.
- ❑ Soft, Monoenergetic Beam
- ❑ 150 – 2200 eV

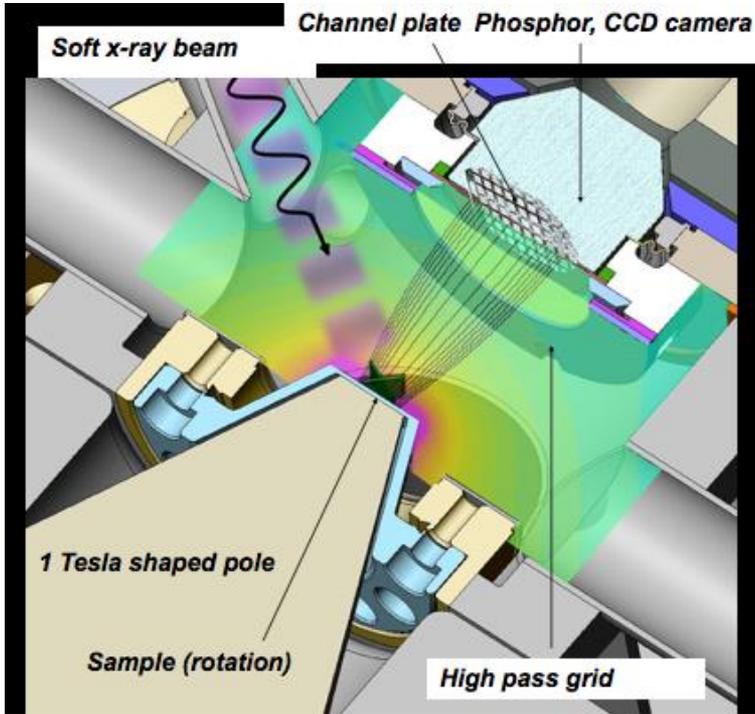


Large Area Rapid Imaging Analysis Tool MK-I (LARIAT1)

- ❑ Operated at NSLS U7A for ~7 years.
- ❑ Highly efficient NEXAFS spectro-microscope.
- ❑ Full Field Imaging on $13 \times 18 \text{ mm}^2$ field of view with $10\text{s } \mu\text{m}$ Res.
- ❑ Chemical and orientation maps of samples, devices, and combinatorial arrays of up to 500 samples at a time.



Large Area Rapid Imaging Analysis Tool MK-I (LARIAT1) – Operating Principles



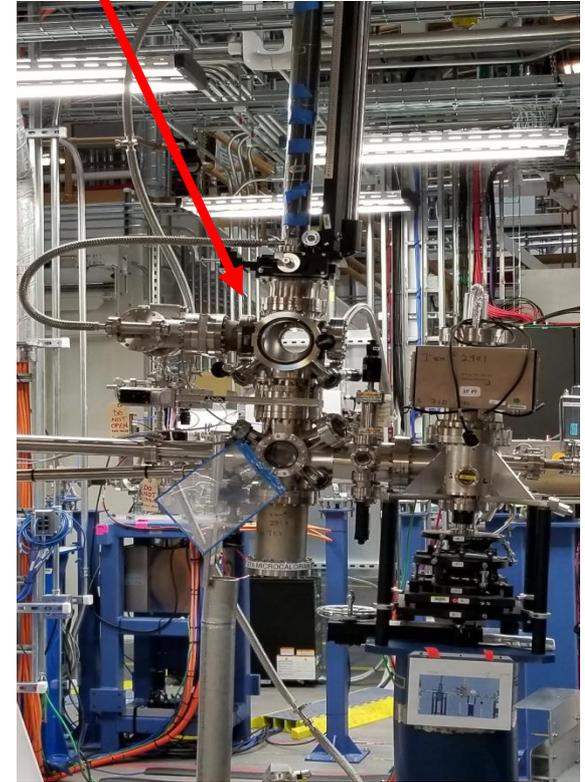
- Low-level electrons promoted to unoccupied electronic states.
- Full field magnetic projection lenses to guide partial electron yield in helical path

$$\mathbf{F} = q\mathbf{v} \times \mathbf{B}$$

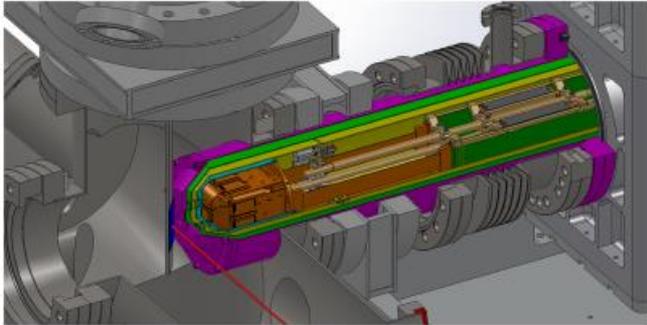
Cyclotron radius (spatial res.), $r \sim \frac{1}{B}$

Microcalorimeter (Microcal)

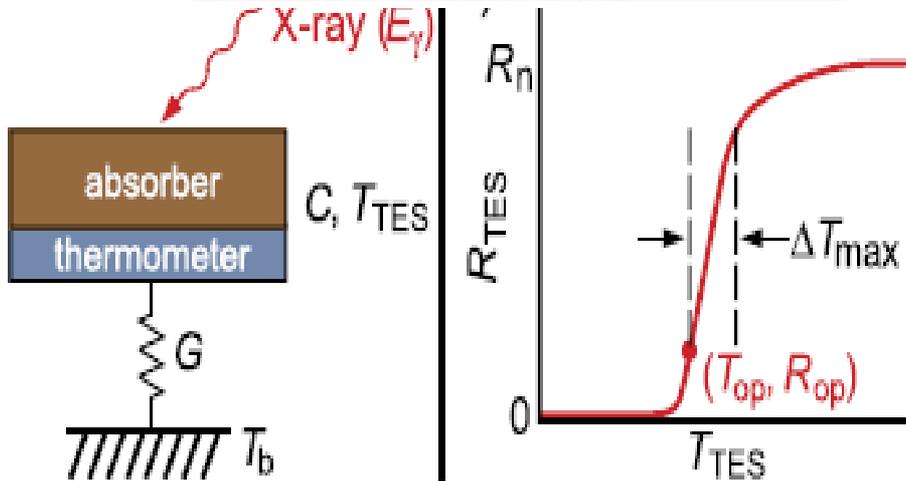
- ❑ Operated at NIST NSLS U7A for ~5 years.
- ❑ Highly efficient XES
 - X-ray fluorescence spectroscopy of low concentration samples and devices.
- ❑ XAS
 - Near Edge X-ray Absorption Fine Structure spectroscopy of radiation-sensitive samples and devices.



Microcalorimeter (Microcal) – Operating Principles



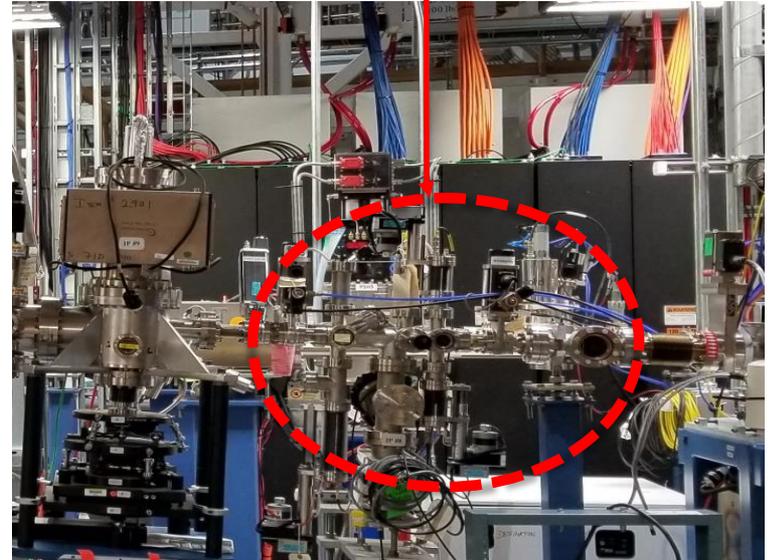
- Sensitive to occupied electronic states
- Detector uses transition-edge - sensor microcalorimeter



$$\alpha = \frac{d \log R}{d \log T} = \frac{T dR}{R dT}$$

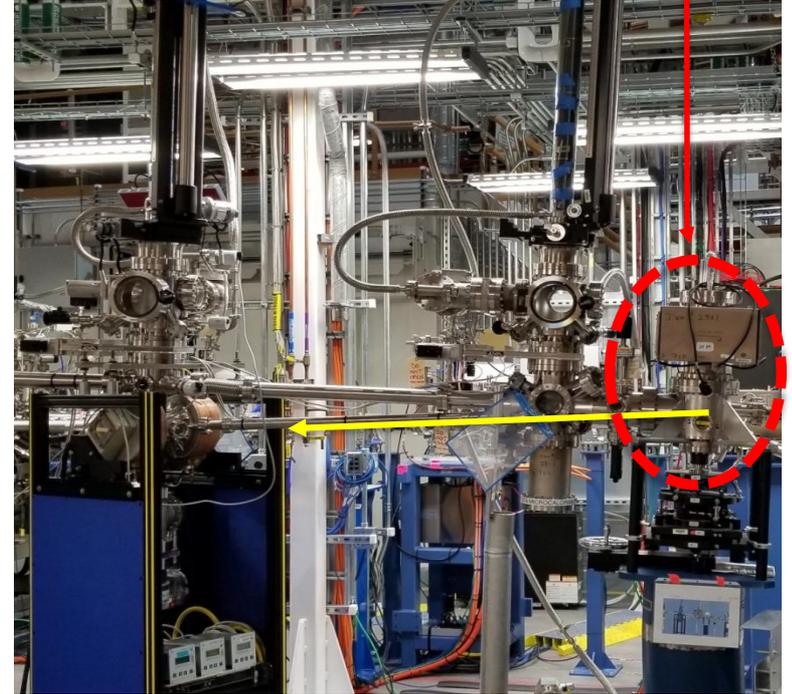
IO_UP

- ❑ Operated at NIST NSLS U7A for > 15 years.
- ❑ Retractable Screen; Slits (vert. motorized, horiz. manual); Diodes; Motorized Multi-Mesh Array; Mirror Optic.
- ❑ Beam Visualization, Size Control, Diagnostics, Energy Calibration, Expansion and Path Selection.



Mirror M5W

- ❑ Operated at NIST NSLS U7A for > 7 years.
- ❑ Au-coated Plane Mirror.
- ❑ Dithers and deflects beam downward to LARIAT1 sample position.
- ❑ Retracts down when not in use.



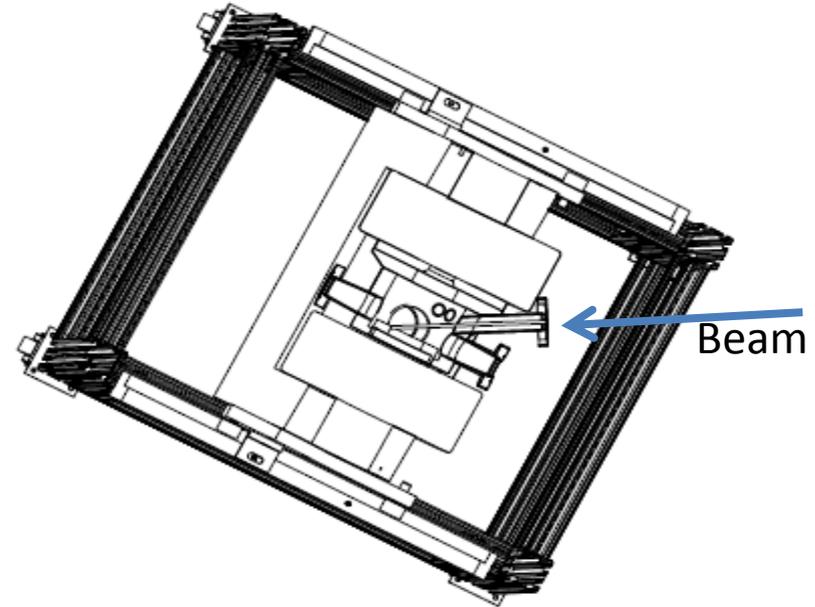
Pillar I: Documentation

Experimental Station Design

- Re-purposed stations.
- Pre-Installation Presentation and Walk-thru with Subject Matter Experts (SMEs) held in 10/17.
- Recommendations for upgrade made by SMEs documented on Installation Travelers.
- Post-Installation/Upgrade verification by SMEs and Installation Traveler Sign-off completed.
- Interface Control Drawings for the components reviewed and approved (PD-SST-MICR-1000, PD-SST-MCAL-1000, PD-SST-MIR-1000, PD-SST-BL-1030).

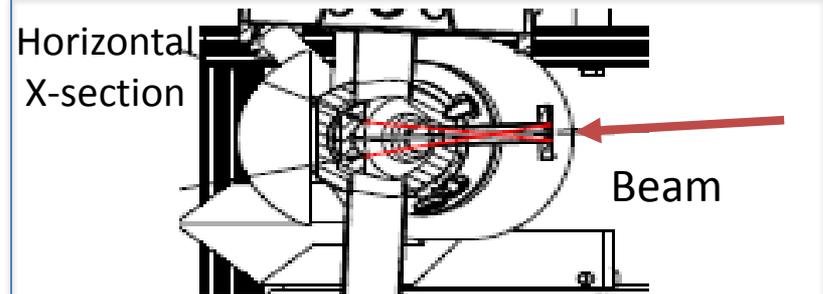
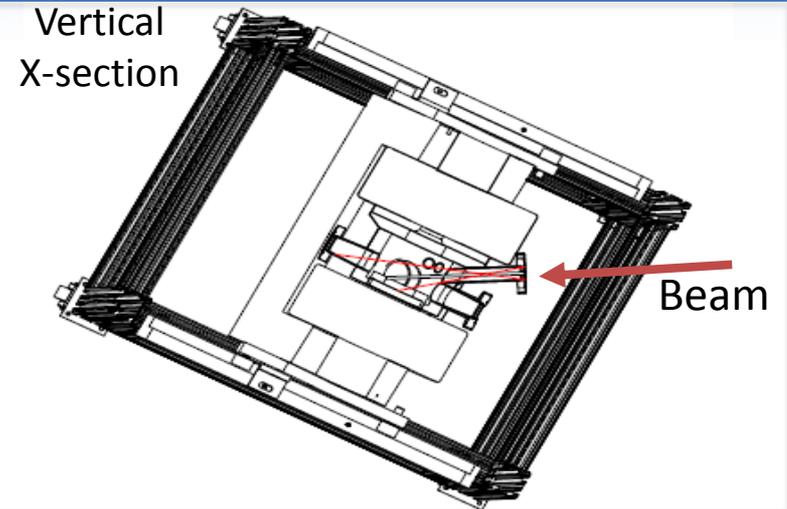
LARIAT1 Experimental Station: Chamber Design

- ❑ Stainless Steel Chamber
- ❑ Sandwiched between 2 shaped magnet pole pieces
- ❑ Minimum wall thickness of 3 mm



LARIAT1 Experimental Station: Beam Termination Point

- ❑ With no sample, beam impacts chamber sidewall.
 - Chamber sidewall serves as Beam Stop
 - Chamber under Configuration Control



Radiation Safety CC Checklist

PSH7, SW5 and SW11 already on list.

- 7-ID1-PSH-07 Check that photon shutter 7, including vacuum section between GV28 and PSH7 is in place and labeled.

SECTION D:

The following section does NOT need to be verified subject to SSWP# _____ and LOTO has been applied to the Beamline Photon Shutter 7 OR Photon Shutter 10 OR Photon Shutter 4.

Lead Beamline Scientist (signature): _____ Date: _____

- 7-ID1-VA-26 Check that contiguous vacuum section between GV 28 and GV 29 is in place and labeled.
- 7-ID1-SW-11 Check that pair of vacuum switches are in place and labeled, and that valve connecting to chamber is open.
- 7-ID1-SW-05 Check that pair of vacuum switches are in place and labeled, and that valve connecting to chamber is open.
- 7-ID1-PSH-08 Check that photon shutter 8 is in place and labeled.

SECTION E:

The following section does NOT need to be verified subject to SSWP# _____ and LOTO has been applied to the Beamline Photon Shutter 8 OR Photon Shutter 7 OR Photon Shutter 10 OR Photon Shutter 4.

Lead Beamline Scientist (signature): _____ Date: _____

- 7-ID1-VA-28 Check that contiguous vacuum section between PSH8 and GV 31 is in place and labeled.

- 7-ID1-PSH-07 Check that PSH7, including vacuum section between GV28 and PSH7 is in place and labeled.

SECTION D:

The following section does NOT need to be verified subject to SSWP# _____ and LOTO has been applied to the Beamline Photon Shutter 7 OR Photon Shutter 10 OR Photon Shutter 4.

Lead Beamline Scientist (signature): _____ Date: _____

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- 7-ID1-VA-27 Check that contiguous vacuum section between GV29 and GV29B is in place and labeled.
- 7-ID1-SW-11 Check that pair of vacuum switches are in place and labeled, and that valve connecting to chamber is open.
- 7-ID1-VVS-03 Check that LARIAT-1 vacuum vessel which serves as the end of the beamline is in place and labeled.
- 7-ID1-SW-05 Check that pair of vacuum switches are in place and labeled, and that valve connecting to chamber is open.
- 7-ID1-PSH-08 Check that PSH8 is in place and labeled.

SECTION E:

The following section does NOT need to be verified subject to SSWP# _____ and LOTO has been applied to the Beamline Photon Shutter 8 OR Photon Shutter 7 OR Photon Shutter 10 OR Photon Shutter 4.

Lead Beamline Scientist (signature): _____ Date: _____

- 7-ID1-VA-28 Check that contiguous vacuum section between PSH8 and GV31 is in place and labeled.

- LARIAT1 vac. vessel (7-ID1-VVS-03) added.
- New section (7-ID1-VA-27) added
- Reviewed by sub-committee.

Ray Tracing

- ✓ Carefully checked by RSC, signed/approved and released (PD-SST-RAYT-0001)
- ✓ Updated to reflect the chamber vessel as a beam termination point.

Survey and Alignment

- ✓ Carefully checked by RSC, signed/approved and released (PD-SST-BL-1070).
- ✓ Shows LARIAT1 vacuum chamber wall as a beam stop.

Shielding Analysis: STAC-8 Simulations

- ❑ Simulations for soft, monoenergetic beam (150 -2200 eV) entering the LARIAT1, MICROCAL and IO_UP chambers.
- ❑ 3 mm thick stainless steel chamber walls are adequate for shielding.

SST Tech Note 275...by S. Chitra & M. Benmerrouche

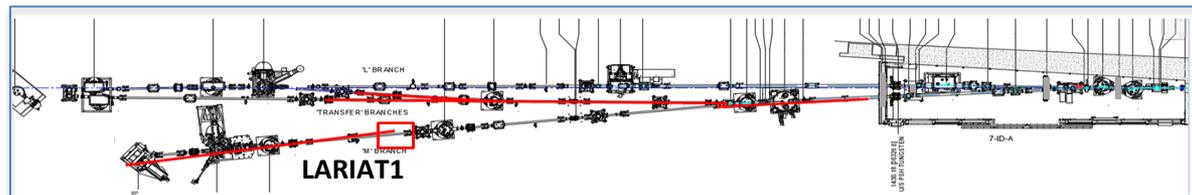
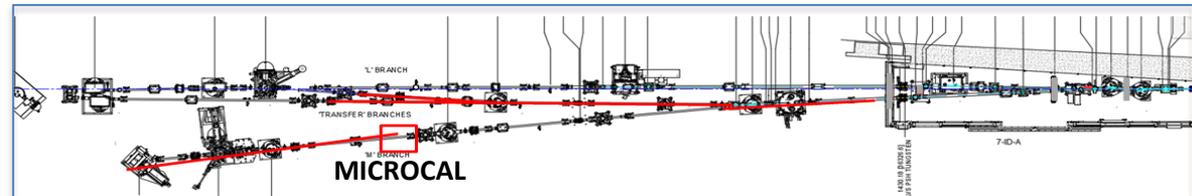
RSC Review

□ Review on April 16, 2019

- Panel reviewed revised Ray-tracing, Survey and Alignment drawings
- Reviewed Memo (ref Tech Note 275)
- No recommendations
- RSC Conclusion: Concurrence with the radiation safety design and analysis of the LARIAT1 and MICROCAL experimental stations; and IO_UP chamber

Radiation Survey Plan

- ❑ NSLSII procedure *NSLSII-7ID-PRC-001*
 - ❑ Already developed and reviewed before the beamline IRR
 - ❑ Available from SharePoint at <https://ps.bnl.gov/docs/default.aspx>.
- ❑ The procedure includes with and without samples in LARIAT1 and MICROCAL stations to verify shielding integrity
- ❑ Comprehensive Radiation Surveys required at ring current ≥ 175 mA (to be ready for up to 3 times the ultimate operating beam current; soft and monoenergetic beam)



Hazard Identification and Mitigation

- USI evaluation is Negative; hazards covered by existing SAD/ASE
- BNL/NSLS-II safety procedures and practices are adhered to during design/construction and commissioning

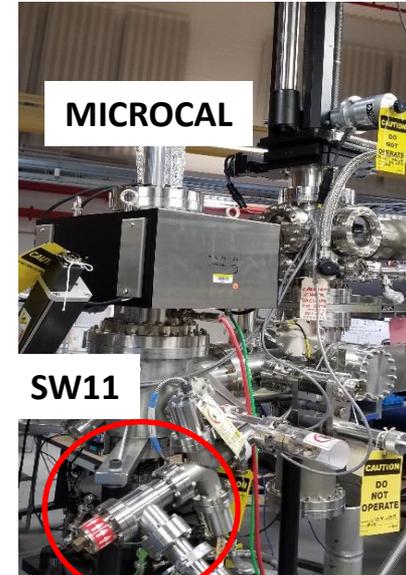
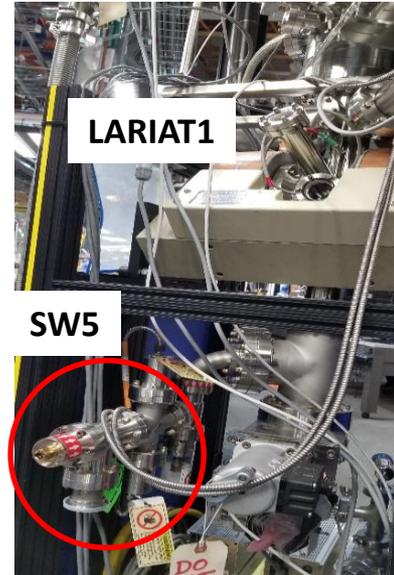
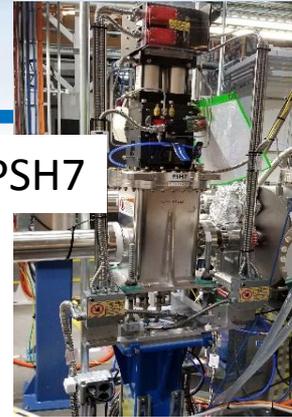
Hazard	Mitigation
Radiation	Shielding with thick SS vessel ; Vacuum Switches interlocked with PPS
Electrical	Proper Grounding and EI on all electrical equipment performed; Hazardous or High Voltage Warning Signs posted where applicable
Pressure safety – vacuum vessels	PRVs are installed where necessary to prevent over-pressure during venting using GN2 backfill; Work instructions for venting by beamline staff only
Electromagnet	Presence of thermal switch to prevent overheating; Magnetic field survey performed to determine 5 Gauss line; Magnetic field hazard signs posted when the magnet is on.

Pillar II: Hardware

Rad Safety Component - PPS

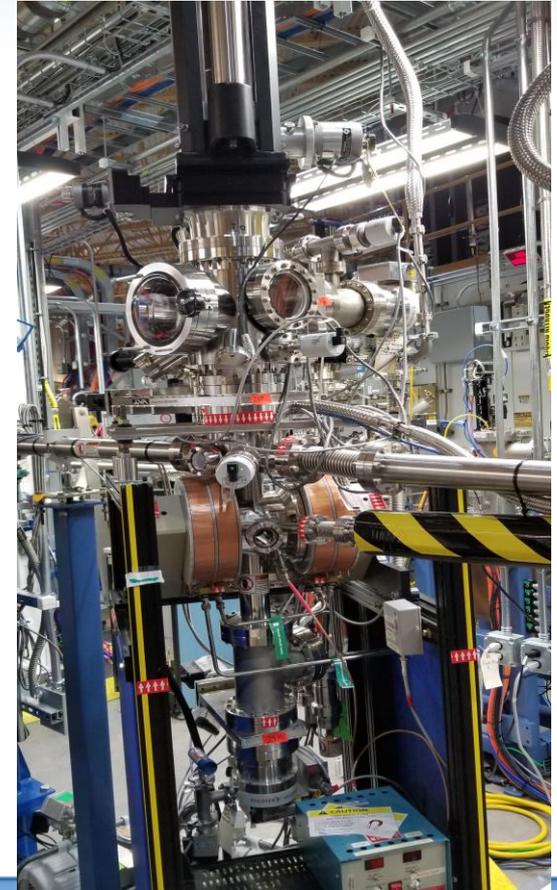
- ❑ Photon Shutter, PSH7
 - ✓ U/S of LARIAT1 (and MICROCAL)
 - ✓ Reviewed during SST Beamline IRR
- ❑ Vacuum Switches, SW5 and SW11
 - ✓ Interlocked with PSH7
 - ✓ Integrated with PPS
 - ✓ Reviewed during SST Beamline IRR

Form checklist



Radiation Safety Component – Config. Control

- ❑ Photon Shutter, PSH7
 - ✓ U/S of LARIAT1
 - ✓ Reviewed during SST Beamline IRR
- ❑ Vacuum Switches, SW5 and SW11
 - ✓ Interlocked with PSH7
 - ✓ Integrated with PPS
 - ✓ Reviewed during SST Beamline IRR
- ❑ Beam Stop, LARIAT1 Vessel (in Configuration Control)
- ❑ Checklist updated
 - LARIAT1 vac. vessel (7-ID1-VVS-03) added.
 - New section (7-ID1-VA-27) added
- ❑ Checklist reviewed by RSC Sub-committee



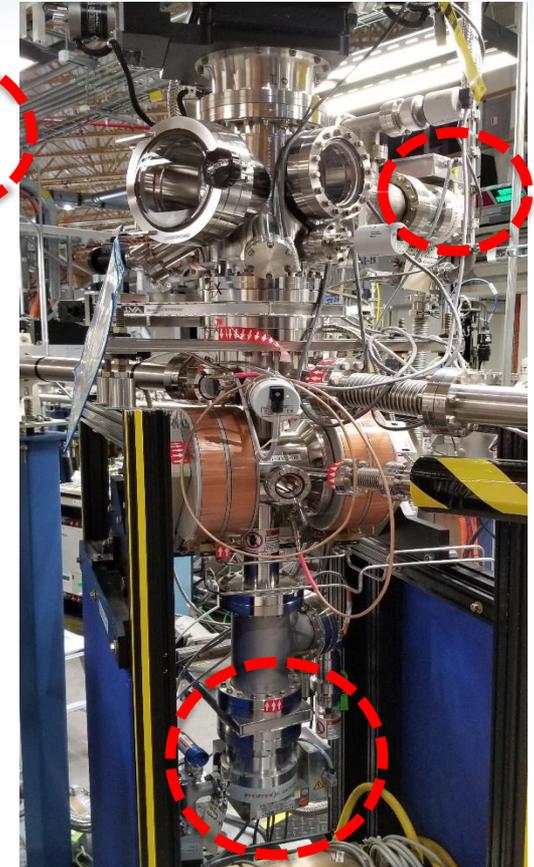
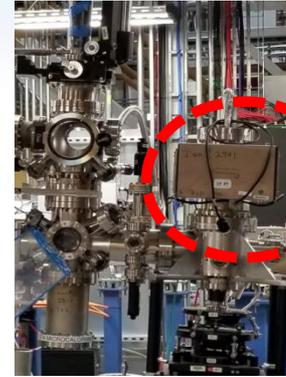
Utilities

- ❑ Located by the Experimental Stations via pylons
- ❑ Liquids
 - Processed Chilled Water – **Tubing added to existing drop.**



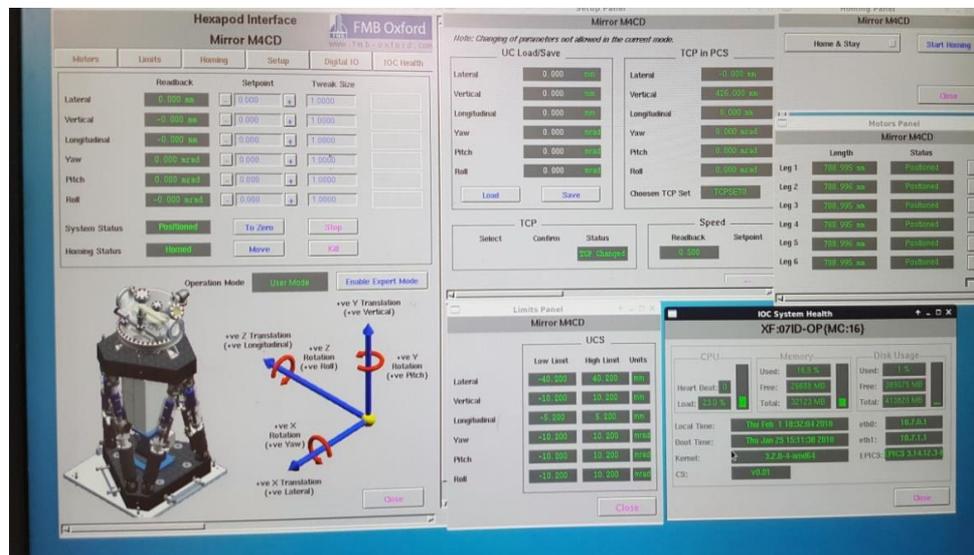
Vacuum

- ❑ Vacuum provided by ion pumps and air-cooled turbo pumps.
- ❑ Vacuum $\sim 10^{-8}$ Torr or better.
- ❑ Gauge and pump controllers located in instrument racks nearby.



Controls

- ❑ Motion control for sample manipulators and beam-defining slits.
- ❑ All motions and motion control have been established and tested.
- ❑ Uses existing motion controllers (H2O-cooled racks on the XF) for photon delivery system.
- ❑ Beamline control system to be integrated with EPICS.



Pillar III: Personnel

Commissioning Team

NIST Project Leader	Daniel Fischer	
LARIAT1 & MICROCAL Lead Scientist	Cherno Jaye	
Authorized Staff	Conan Weiland ,	SST2 LBS
Authorized Staff	Johnny Kirkland	Controls Engineer

✓ All beamline staff have completed their assigned training 😊

Summary

- ❑ Documentation completed in accordance with NSLS-II guidelines.
- ❑ LARIAT1, MICROCAL and IO_UP chambers are compliant with radiation shielding requirement for soft, monoenergetic X-ray (see Tech. Note #275, Memos 20190415, 20180912).
- ❑ Experimental stations READY for first light/beam
 - Infrastructure and support system complete and ready
 - All beamline staff training completed.

Acknowledgement

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Jean Smiles
John Fabijanic
Steve Hulbert
Steve O'Hara
Andrew Ackerman
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