LCA Engineered Search Controls
for the LCLS User Facility at SLAC

DOE LSO Workshop May 19-21 at LLNL

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SLAC NATIONAL ACCELERATOR LABORATORY

Stanford University | U.S. DEPARTMENT OF ENERGY

Outline of Talk

LCLS User Facility Overview

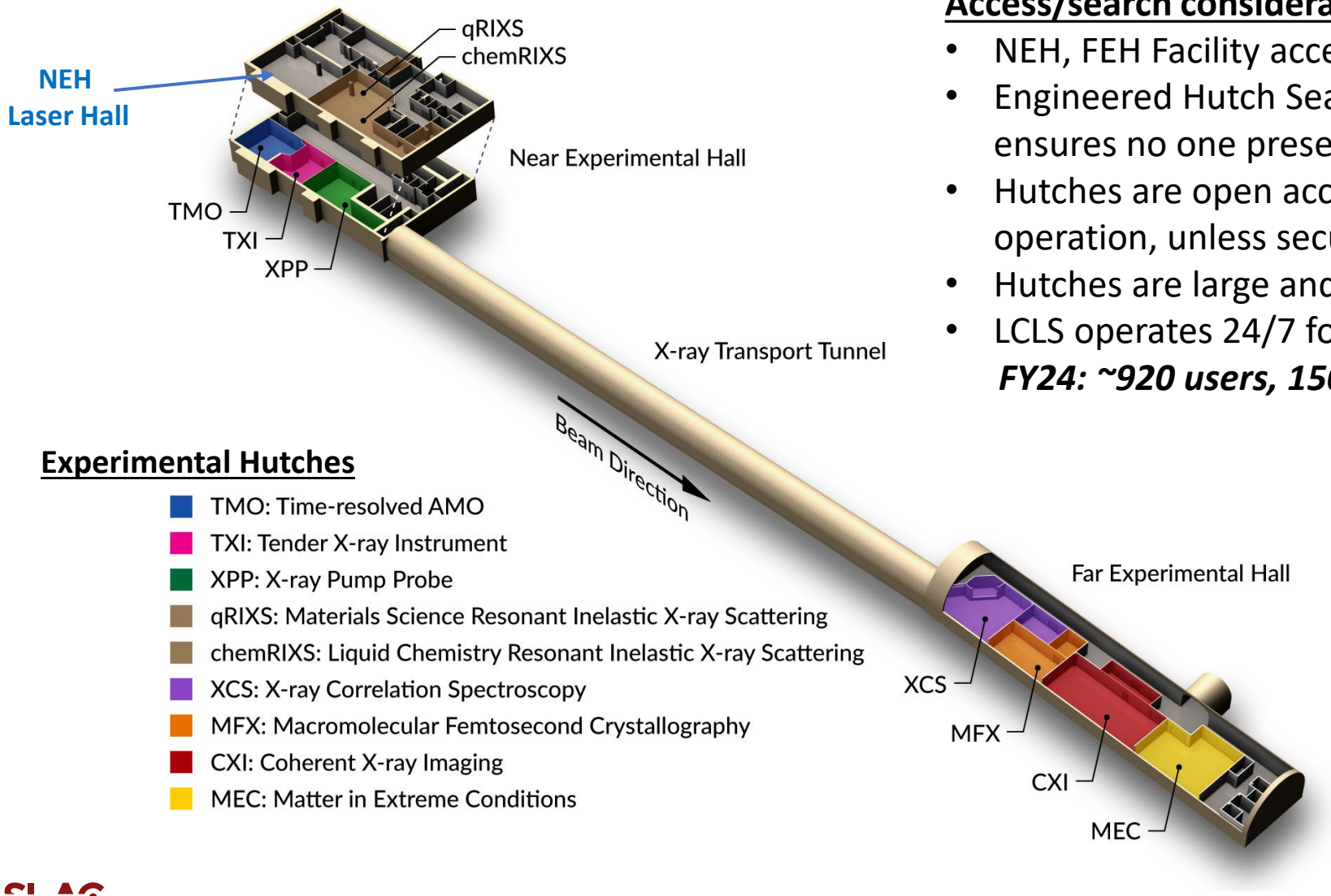
Search Incidents in December 2021 and February 2024

Search Controls
- LCA Control Panel
- Search buttons
- Audio warning messages
- Electronic sign displays
- Search Logic

Search Procedure

Implementation Status

LCLS Experimental Halls + NEH Laser Hall



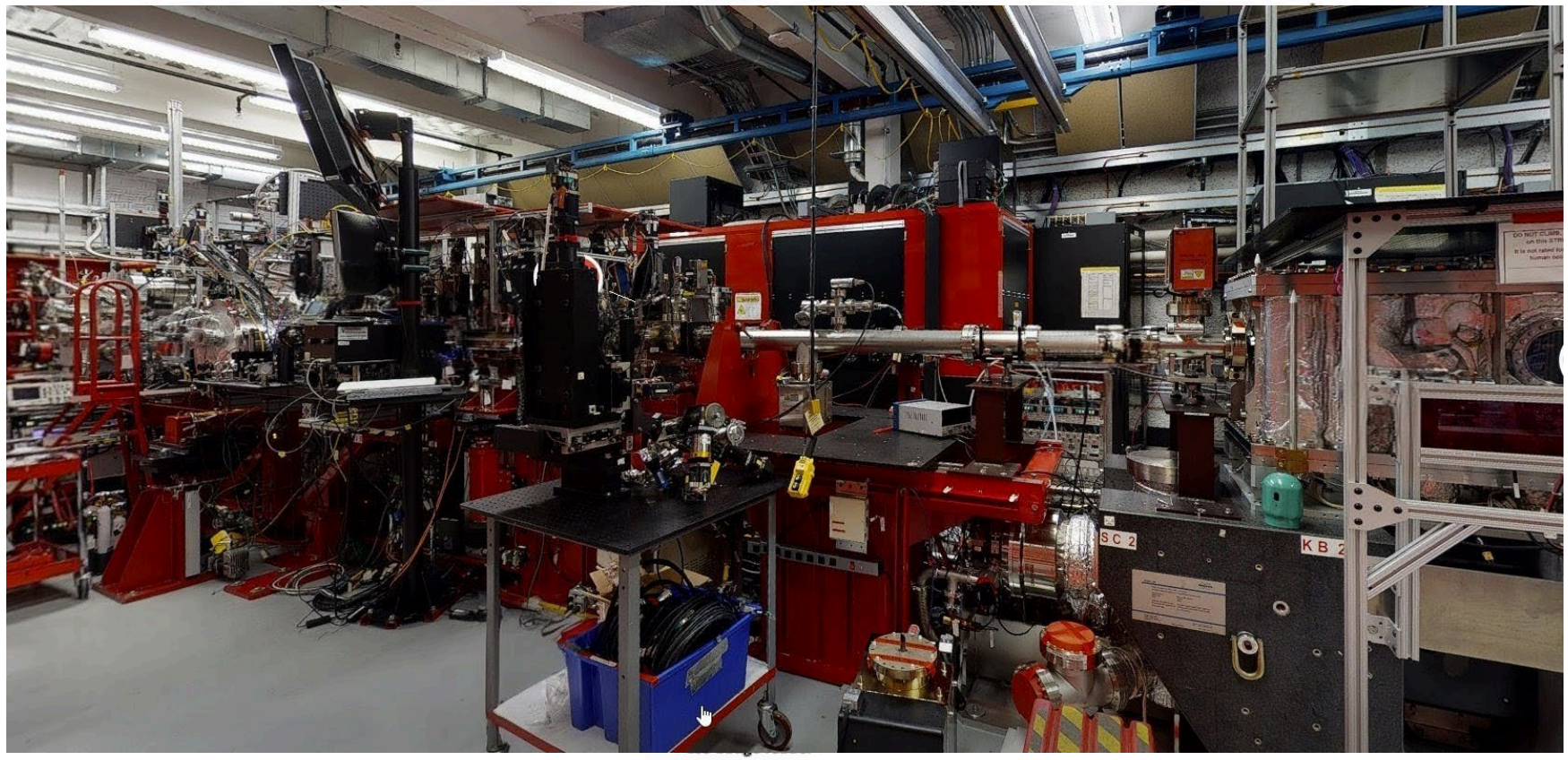
Experimental Hutches

- TMO: Time-resolved AMO
- TXI: Tender X-ray Instrument
- XPP: X-ray Pump Probe
- qRIXS: Materials Science Resonant Inelastic X-ray Scattering
- chemRIXS: Liquid Chemistry Resonant Inelastic X-ray Scattering
- XCS: X-ray Correlation Spectroscopy
- MFX: Macromolecular Femtosecond Crystallography
- CXI: Coherent X-ray Imaging
- MEC: Matter in Extreme Conditions

Access/search considerations

- NEH, FEH Facility access w/ SLAC Badge RFID
- Engineered Hutch Search done prior to x-ray operations; ensures no one present inside Hutch
- Hutches are open access when not secured for x-ray operation, unless secured for Class 4 laser operation
- Hutches are large and complex
- LCLS operates 24/7 for extended periods
  FY24: ~920 users, 150 experiments, 4000 facility hours

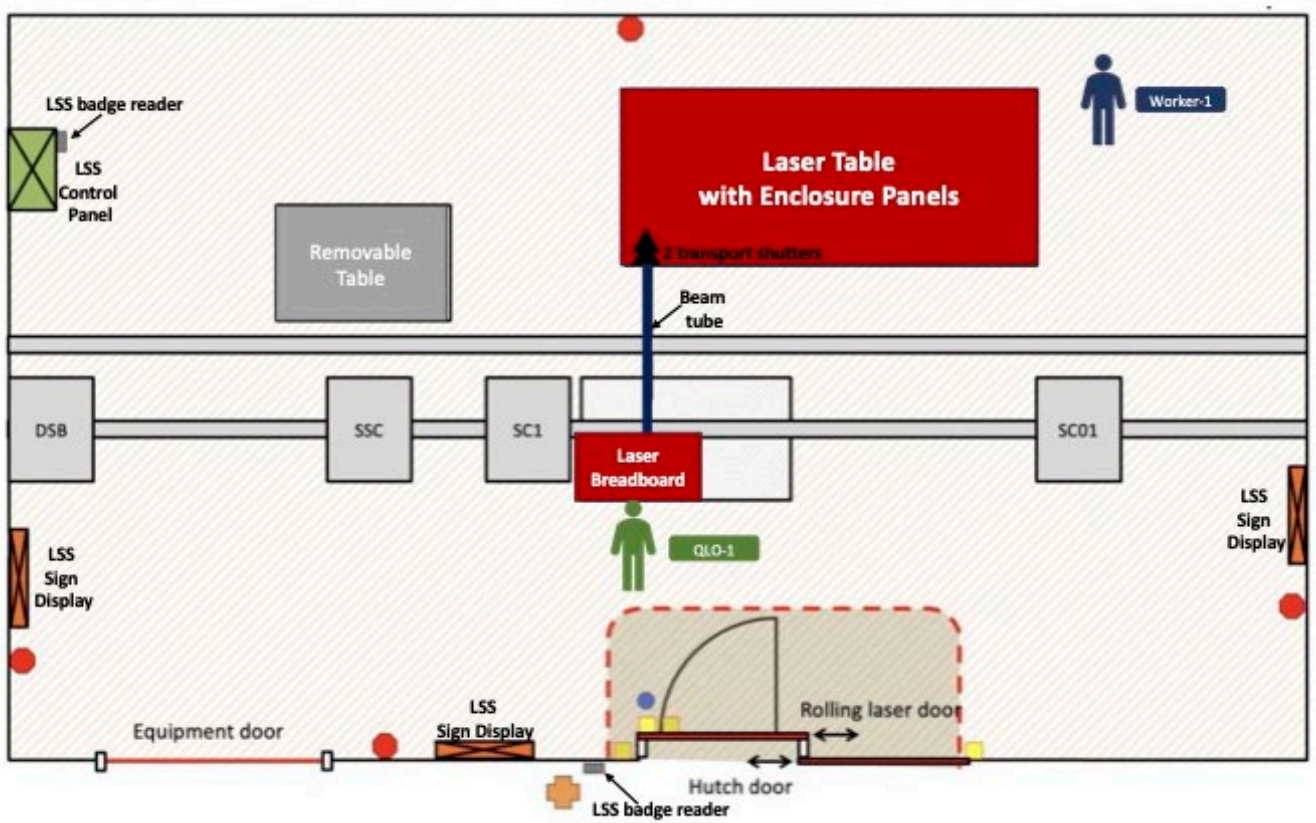
CXI Search Incident in February 2024



Hutch is approximately
67 feet long by 20 feet wide

Qualified Laser Operator (QLO-1) set Hutch to Class 4 mode
while Worker-1 was present without laser eyewear

CXI Search Incident in February 2024



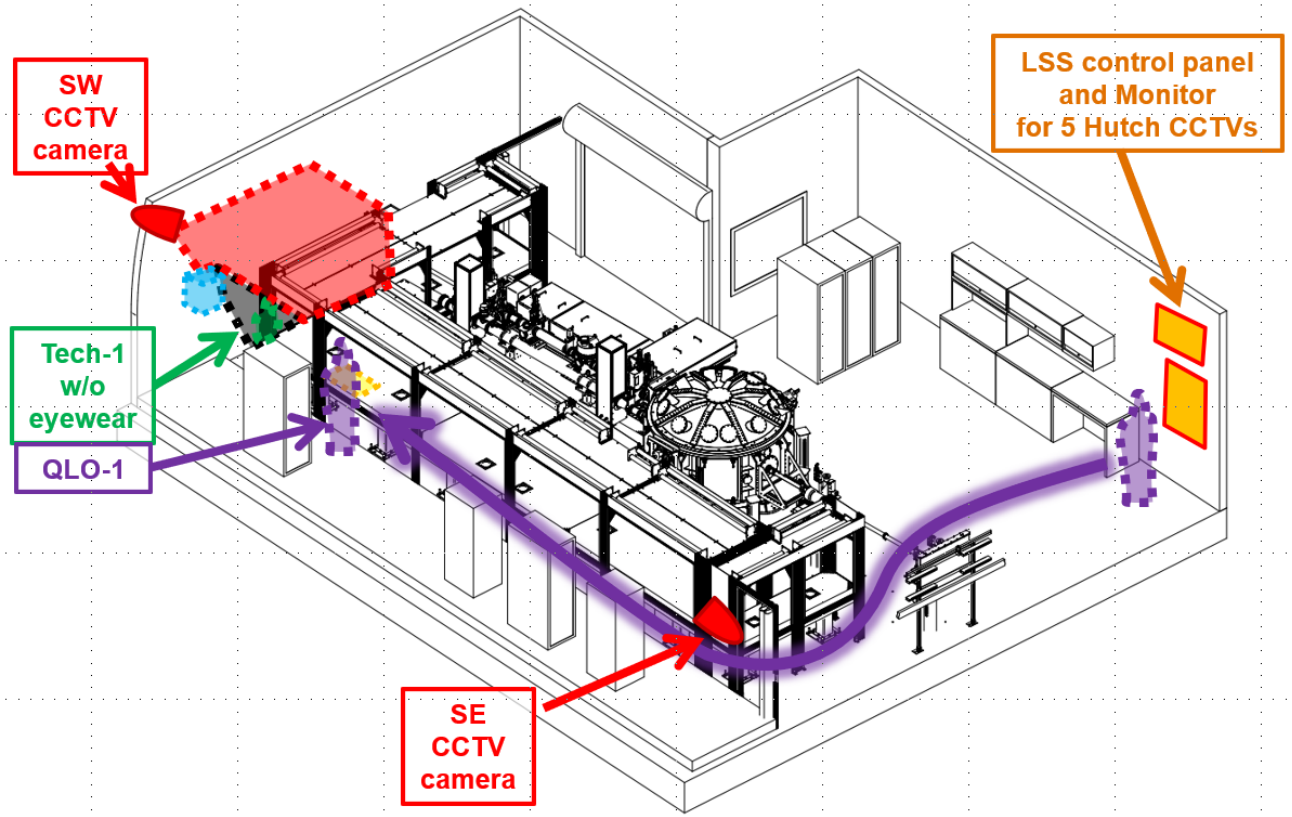
Hutch is ~ 67 feet long, 20 feet wide

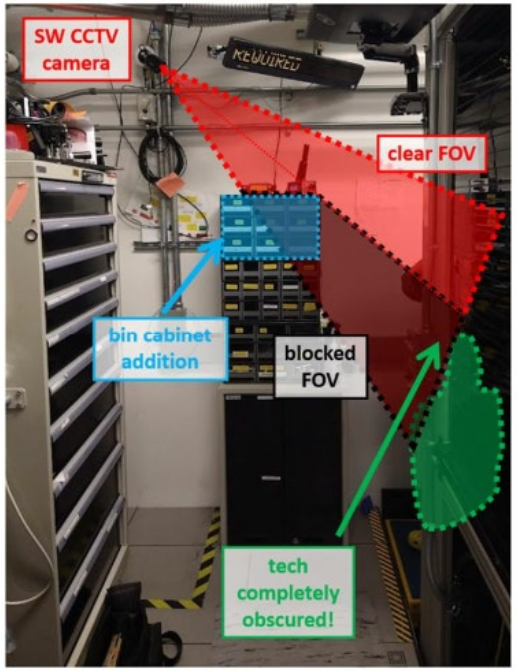
Qualified Laser Operator (QLO-1) set Hutch to Class 4 mode while Worker-1 was present without laser eyewear

- QLO-1 failed to do required search; Worker 1 did not hear 10s audible warning alarm for transport shutters opening
- After <10 minutes, Worker-1 noticed LSS sign display indicated Laser Class 4 alternating with GOGGLES REQUIRED and alerted QLO-1 who set Class 1 – Laser Enclosed mode
- There was no credible exposure risk and no injury occurred

Inadequate work coordination, schedule pressure, QLO-1 was in Hutch for 20' prior to setting Class 4 and thought Hutch was empty

MEC Search Incident in December 2021



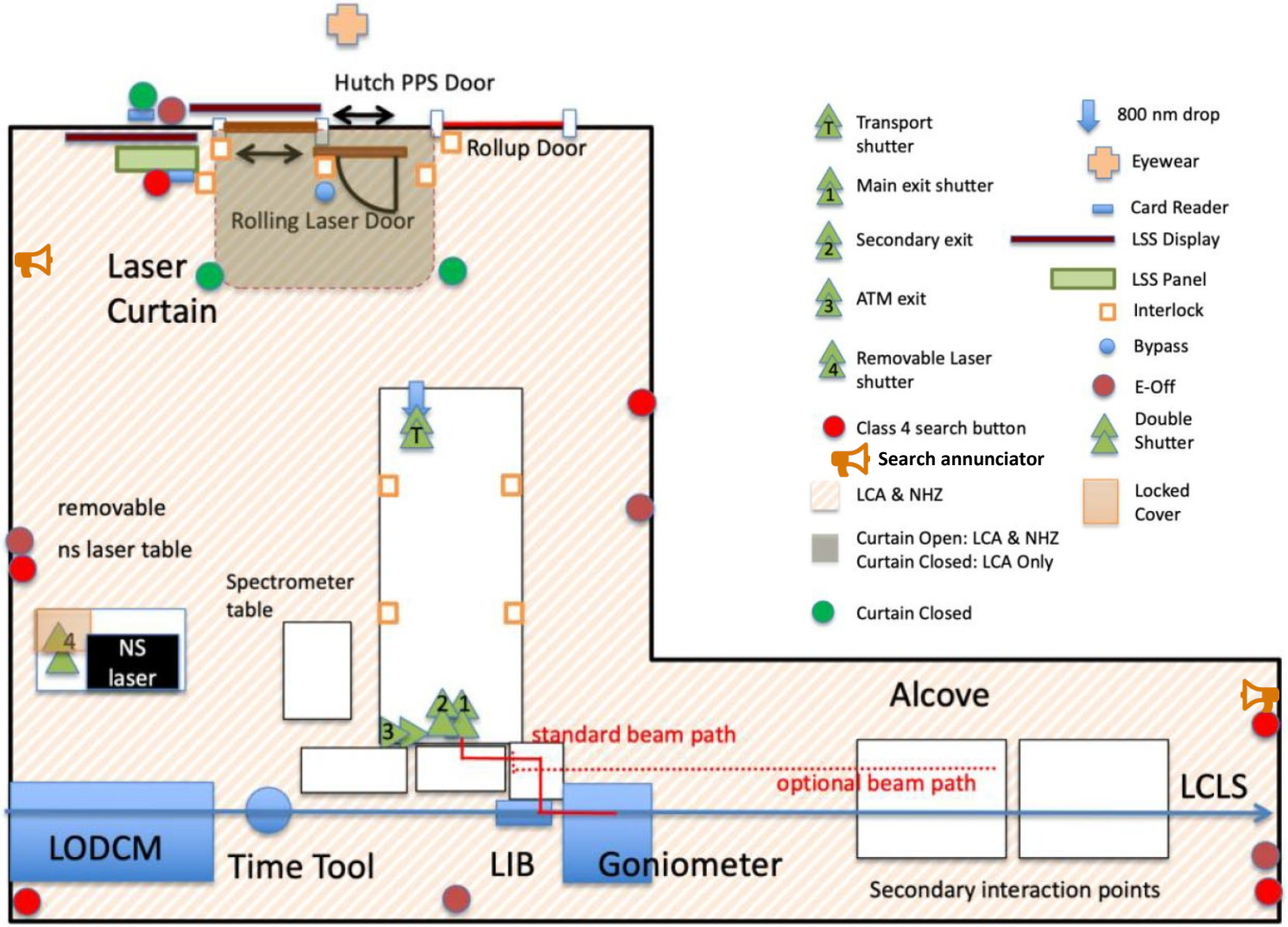


QLO-1 set Hutch to Class 4 mode while Tech-1 was present without laser eyewear

- QLO-1 relied on Hutch CCTV camera/monitor system for the search, prior to setting Class 4 mode
- Tech-1 not visible from location where QLO-1 began laser work (storage cabinet moved, blocking camera view)
- <10 minutes later, QLO-2 escorts Tech-2 (both wearing LPE) and find Tech-1 (w/o LPE)
- Hutch then put to Class 1 – Laser Enclosed mode. There was no credible exposure risk and no injury occurred

Inadequate work coordination, schedule pressure, reliance on CCTV monitor system

XPP (X-ray Pump Probe) Hutch



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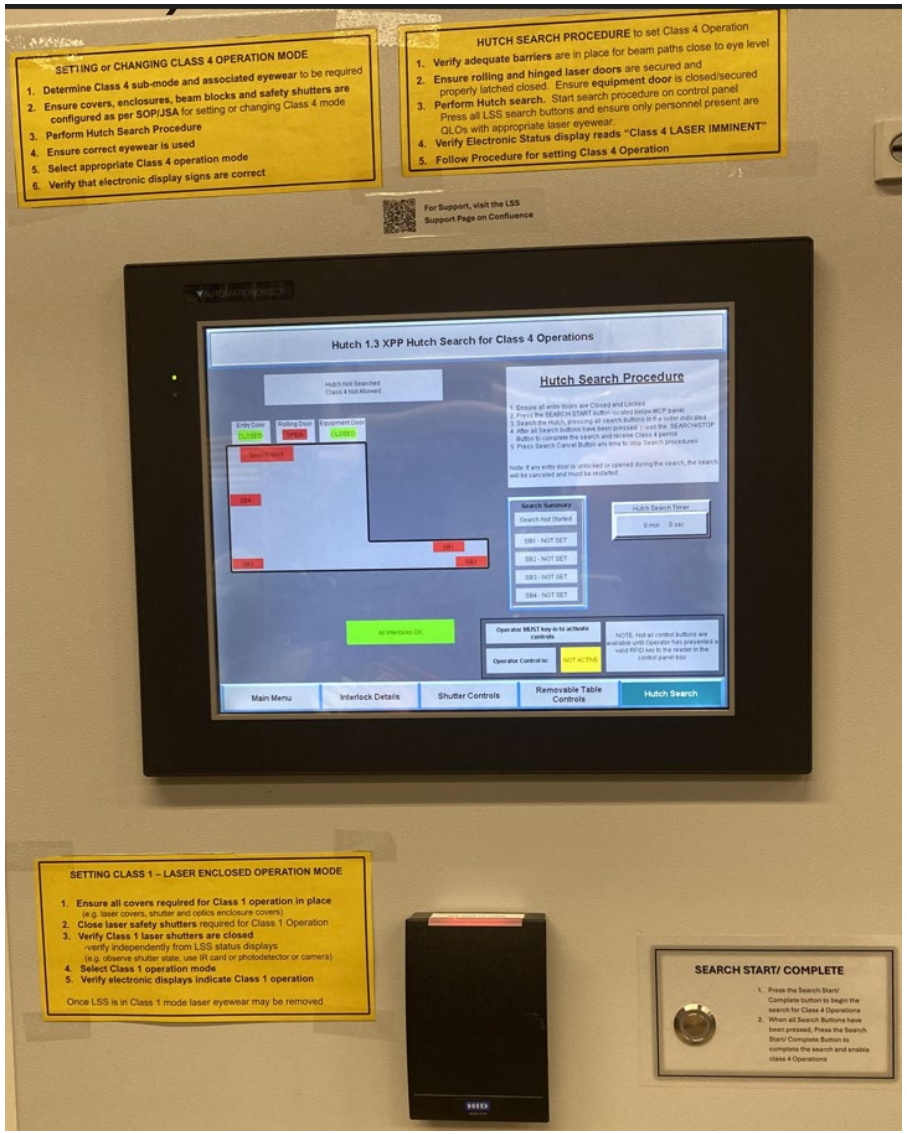
Laser Operation Mode Summary

LSS Operation Mode	Transport Shutters	Laser Table Exit Shutters	Laser Entry Door Access	Hutch Search Complete?	LSS Sign Display
Laser Off	Disabled Closed	Disabled Closed	-	No	LASER OFF … NO LASER HAZARD
			RFID*	Yes	LASER IMMINENT … CARRY GOGGLES
Class 1	Enabled	Disabled Closed	-	No	LASER ENCLOSED – CLASS 1 … NO LASER HAZARD
			RFID*	Yes	LASER IMMINENT … CARRY GOGGLES
Class 4	Enabled	Enabled	RFID*	Yes	LASER ON … GOGGLES REQUIRED

*RFIDs authorized for laser workers with all training current, including OJT and SOP review

LSS Search Hardware

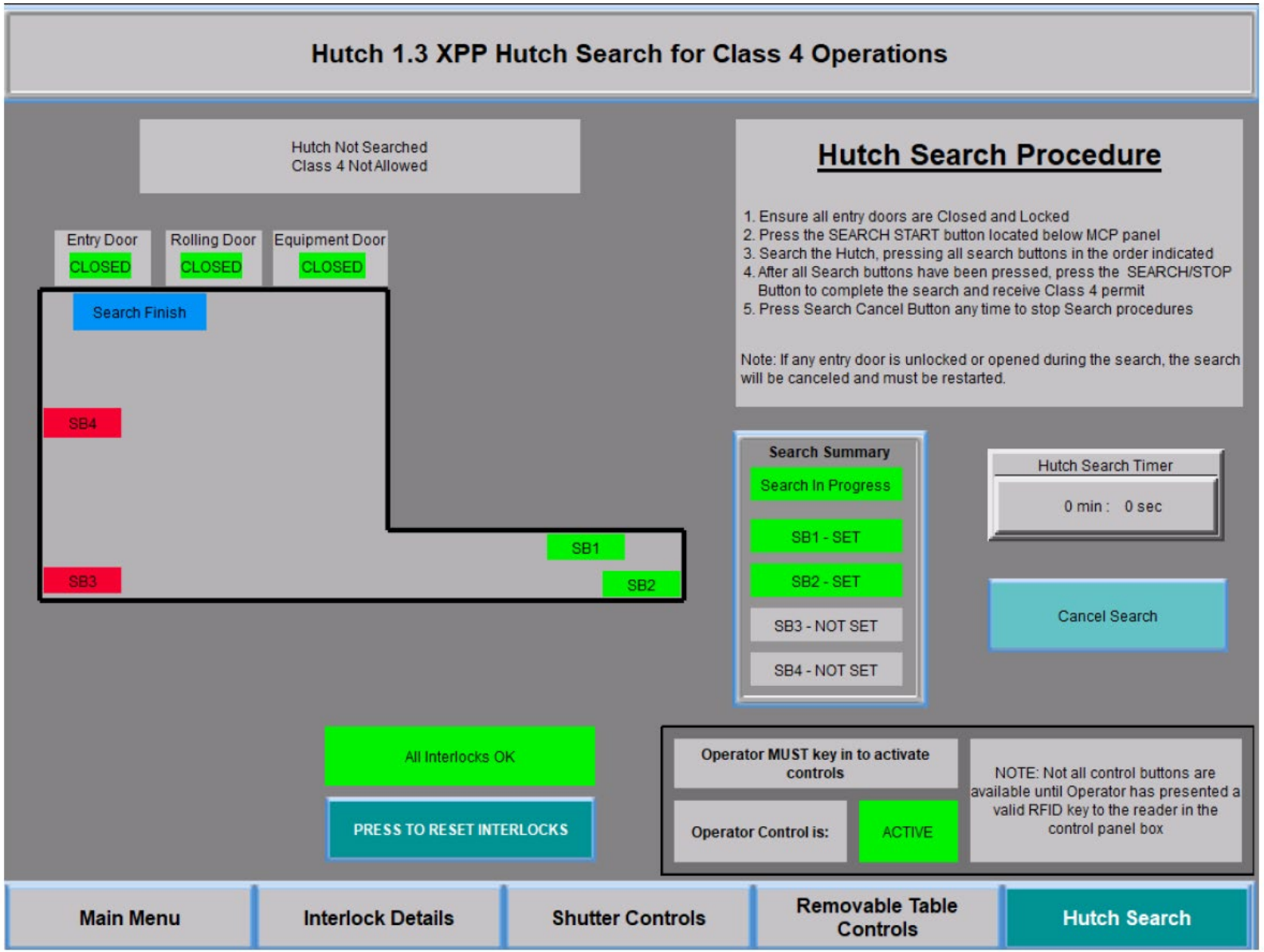
LSS Control Panel

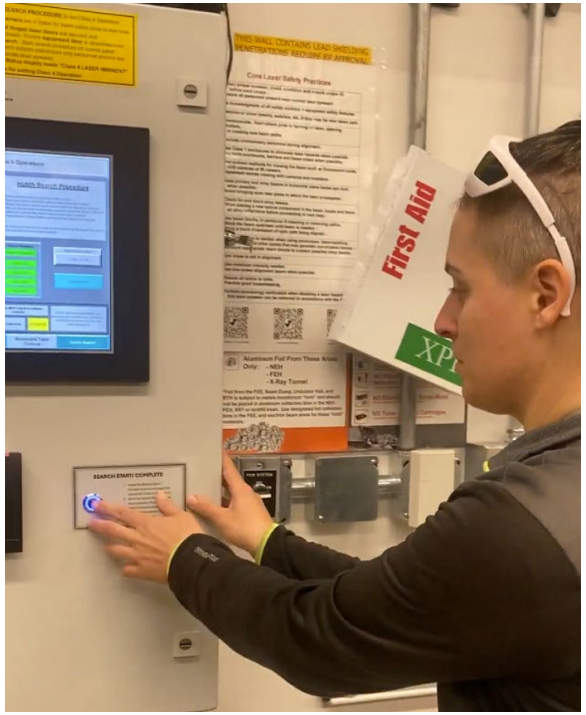


Audio Annunciator

Electronic Sign Display

LSS Control Panel – Hutch Search screen





XPP Hutch Search Video

https://www.youtube.com/watch?v=UuEbRSwHnjI

XPP Hutch Search Video taken by searcher using Apple Vision Pro

https://www.youtube.com/watch?v=gAjgpkejXjM

LSS Hutch Search Procedure and Indicators

LSS Search Status	Requirements	Search Button Color	LSS Sign Display	Audio Warning
Not Searched	• Search not in progress, and • Search not complete	None	LASER OFF or LASER ENCLOSED – CLASS 1	None
Search Imminent	• All doors closed, and • Search not in progress or complete	Solid Red		
Search in Progress	Search Start Button pressed after valid RFID badge presented	Flashing Blue	Search in Progress … Laser Workers Only	***Warning, Hutch Search in progress for Laser Operations. Only authorized laser workers permitted*** played on loop during the Search
	Search Button pressed in correct order	Solid Green		
Laser Imminent	• Search Complete, and • Laser Off or Class 1 mode set, • and no latched faults	Solid Green	LASER IMMINENT … CARRY GOGGLES	***Hutch search is completed for Laser Operations*** played once
Transition to Class 4	Class 4 mode set, transitioning from Laser Off or Class 1	Solid Green	LASER ON … GOGGLES REQUIRED	***Hutch Class 4 laser operations are beginning. Goggles Required*** played once

Search Invalidators

Search in Progress Faults

- **Power removed from Control Panel**
- **Master Key removed from Control Panel**
- **Emergency Entry fault**
- **Emergency Off fault**
- **Entry Door open**
- **Equipment Door open**
- **Search not completed within allotted time**
- ***Search Cancel* button pressed on Control Panel**

Search Complete Faults

- **Power removed from Control Panel**
- **Master Key removed from Control Panel**
- **Emergency Entry fault**
- **Emergency Off fault**
- **Entry Door open without bypass***
- **Equipment Door open**

*When Hutch Search is complete, *Laser Entry Door* can be open for ~10s timed bypass when valid *Entry RFID* presented or *Exit Bypass Button* pushed. Bypass is only valid in Class 4 mode if *Entry Curtain* is closed.

Implementation Status for LCA Search Controls

Near Experimental Hall (NEH) Hutches

TMO May 2026

TXI -- 2027

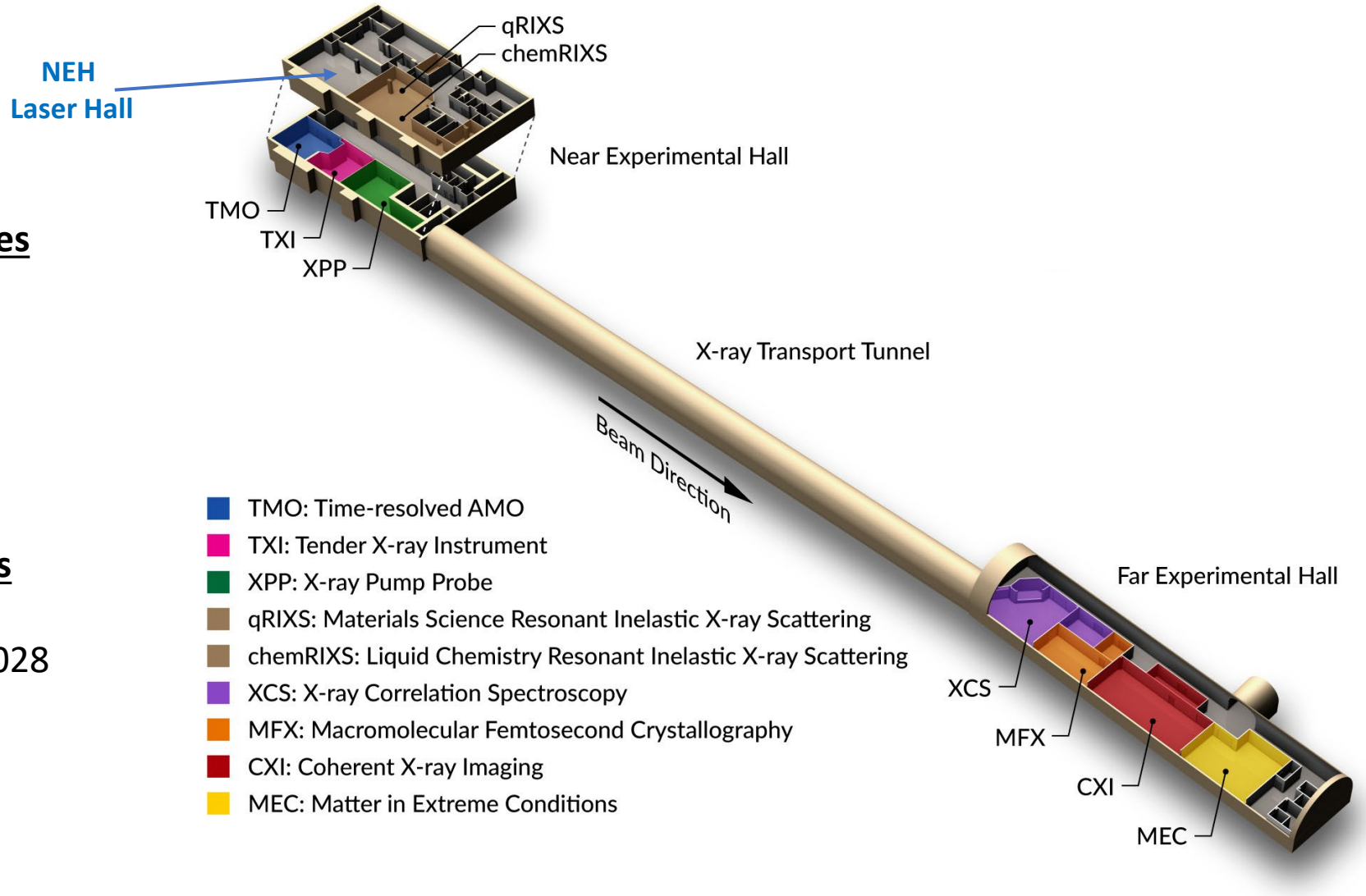
XPP completed Feb 2026

RIXS August 2026

Far Experimental Hall (FEH) Hutches

XCS, MFX, CXI during FEH reconfiguration in 2027-2028

MEC Dec 2026



LCA Engineered Search Controls
Summary

Pro

- Reduce risk of an incident and potential injury
  - Investigations and corrective actions are also costly
- A single person can complete search; no need for guard at entry door
- Increases confidence among workers of integrity for the LSS and laser safety

Con

- Added cost, complexity of the engineered LSS

Recommendation

➢ Consider implementing for large, complex laser facilities that alternate frequently between open access, restricted access