

Early-Stage Exploration of AI Opportunities for Enhancing CXFEL Beamlines at ASU

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Chief Engineer

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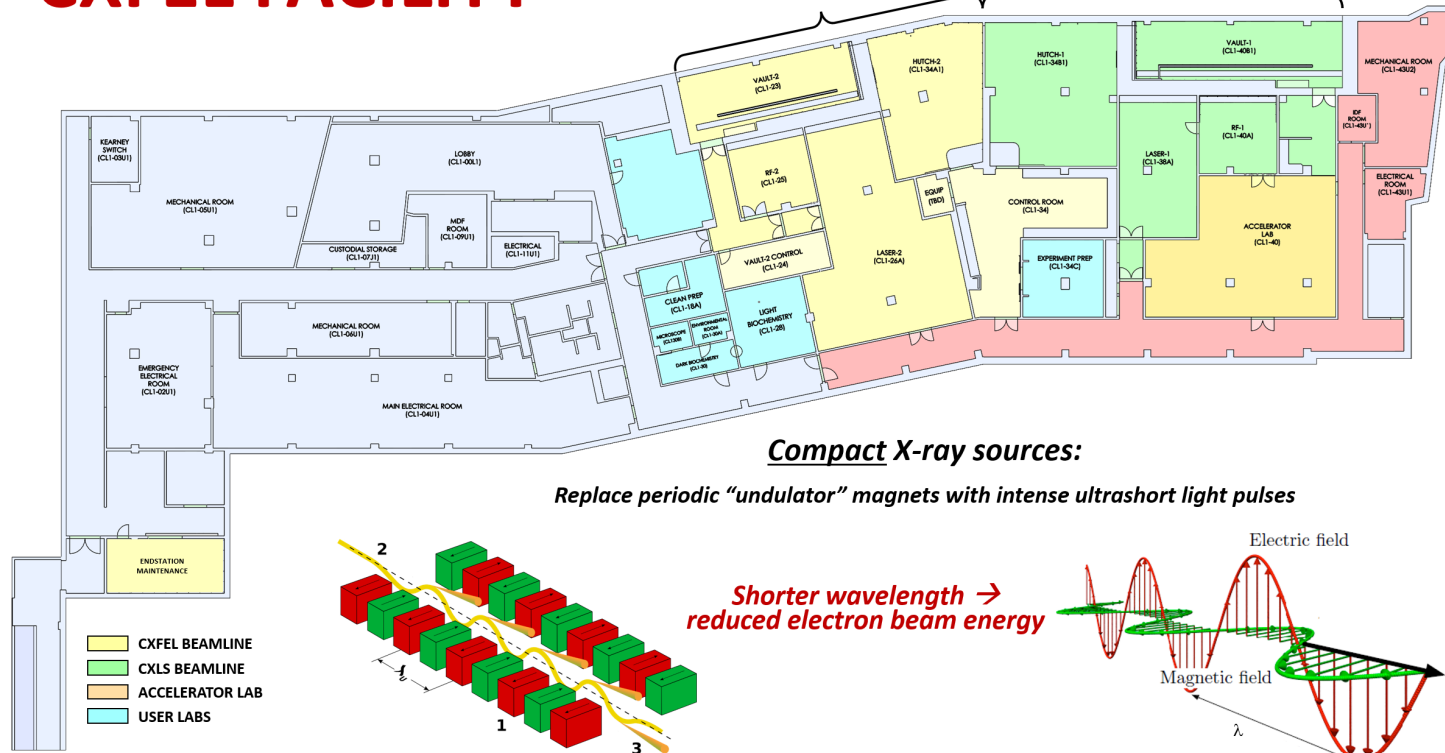
CXFEL Data Analysis



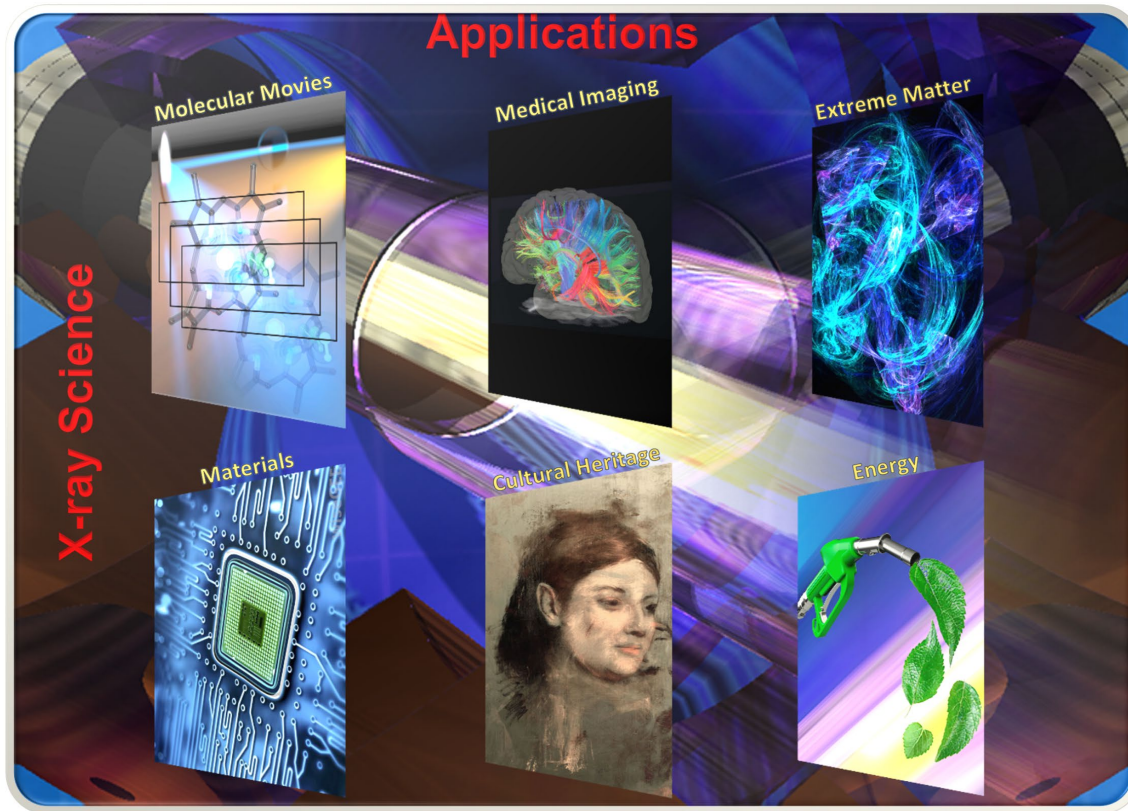
CXFEL FACILITY

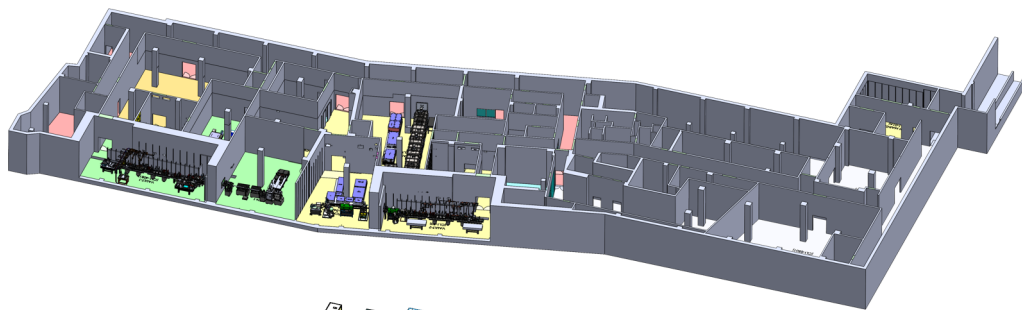
CXFEL: Soft X-ray Suite

CXLS: Hard X-ray Suite



We have thematic application areas;
how can AI help us
to reframe and
expand our
understanding of
what CXLS and
CXFEL can do in
these areas and
beyond?

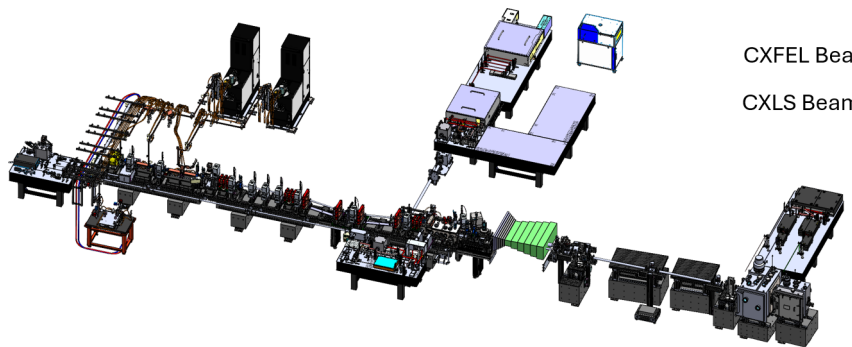




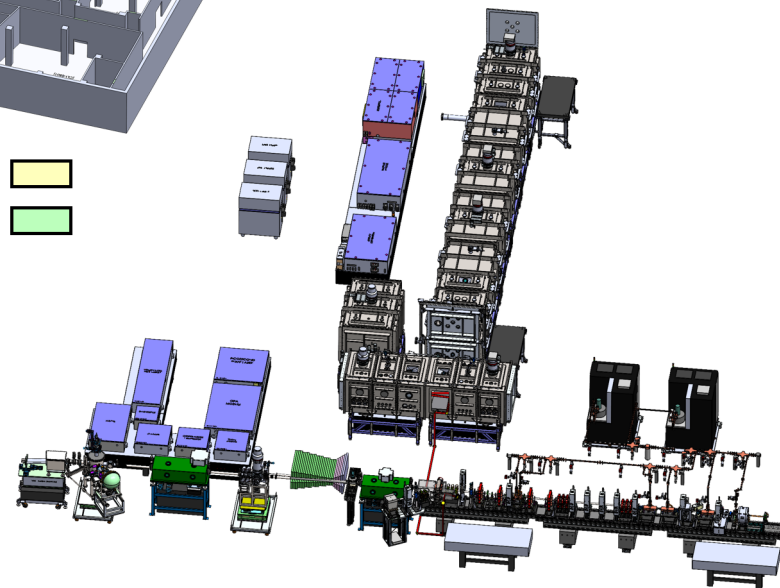
CXFEL Beamline



CXLS Beamline



CXLS Beamline (being commissioned)



CXFEL Beamline (under construction)



CI

CXLS

NETWORK

COMPUTATION

STORAGE

CONTROLS
(EPICS)

Light Conversion Yb:KGW
1030/515/258 nm
1.5 mJ/pulse at 1030 nm
0.15 mJ/pulse at 258 nm
200 fs
1 kHz

Scandinavia Solid-State
Modulators &
Stellant Klystrons
9.3 GHz
6 MW for 1 μ s at 1 kHz
<100 ppm stability

Trumpf IR Laser
Yb:YAG
1030 nm
200 mJ/pulse
1 ps
1 kHz
 $M^2 \approx 1.2$

ASU-TibaRay
Photoinjector
9.3 GHz
1 kHz
120 MV/m
4.5 cell
4 MeV Energy
200 pC
1 ps

TibaRay
Linac
9.3 GHz
Standing Wave
1 kHz
25-30 MV/m
20 cells/section
3 sections
30 MeV Energy

Diagnostics and
matching quadrupoles
Chicane
Compressor

Final focus and
interaction point

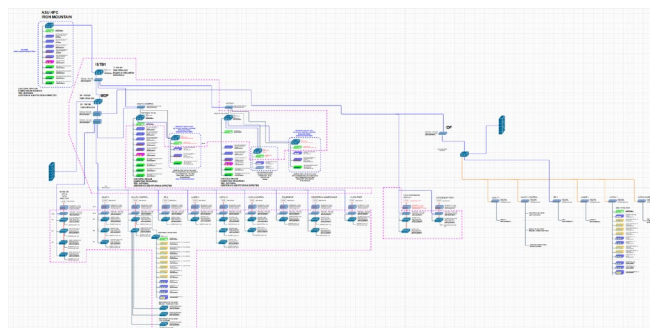
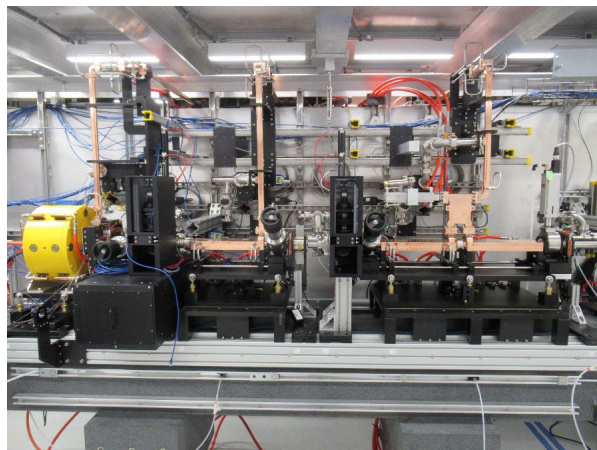
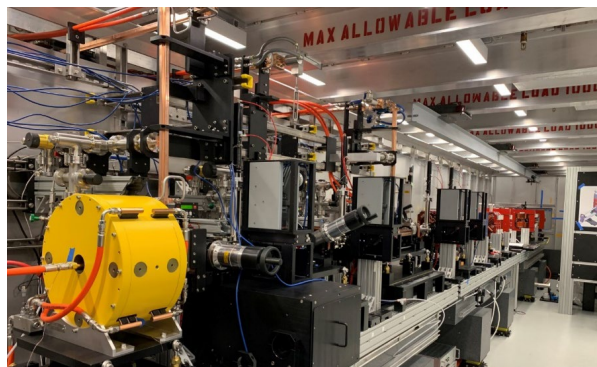
Diagnostics

Experiment Probe Laser

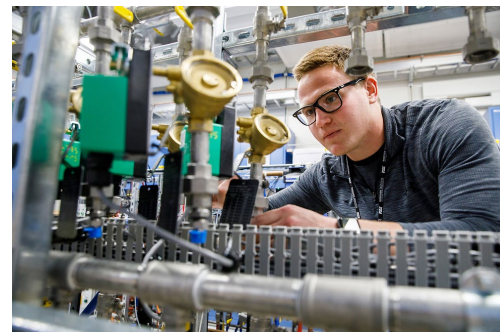
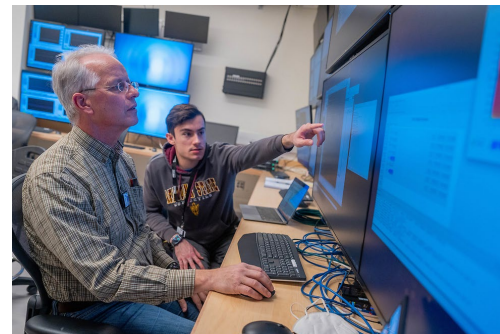
XIS Endstation Chamber

Detector Chamber





Controls are Experimental Physics
and Industrial Control System
Enabled (EPICS 7)



Automated Accelerator Tuning for Brightness Optimization in X-Ray Light Sources using CXLS and CXFEL Testbeds

Sami Tantawi, Lucas Malin, Ji Qiang, William Graves

Objectives:

- **Develop** a digital twin that can be extended to Basic Energy Sciences (BES) x-ray light sources including LCLS/LCLS-II/LCLS-HE, ALS-U injector, APS-U injector, NSLS-II injector. **Develop** the potential to significantly improve commissioning and operational efficiency, as well as enhance reliability and availability of the facility.
- **Explore** the use of AI methods in the design and implementation of optimization strategies that use the conceptualized digital twin.

Investigative Elements:

- *Unified Coding Infrastructure for Automated Control of System Parameters*
- *Real-Time Beamline Model for Fast S2E Simulations with Realistic Error Parameters*
- *Fast Measurement of Beam Parameters and Constraint Monitoring for Multi-Objective Optimization*
- *High-Speed Bayesian Optimization for Beamline Tuning*
- *Evaluate use of AI to help enhance expert knowledge in the design of systems and optimization configurations.*



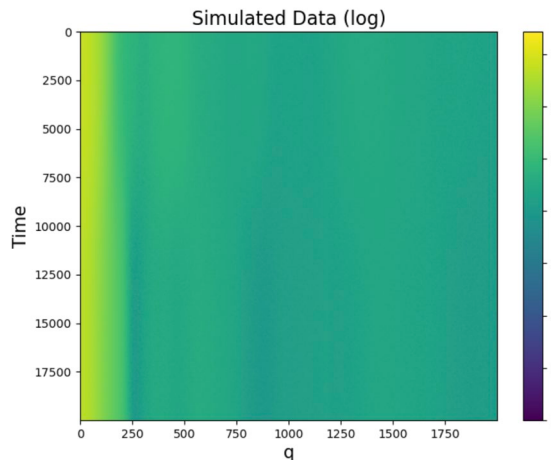
Data Analysis by Manifold Learning

Ahmad Hosseinizadeh, Adam Opperman, Tom Grant, Rick Kirian and Kevin Schmidt



Signal extraction for TR-SAXS/WAXS Results

- Simulate time-resolved Solution Scattering Data using Reborn and DENSS
- Perform NLSA (and SVD for comparison) on raw data
- Reconstruct de-noised Data
- **Improved time-resolution and signal extraction!**



→ Submitted to Nature Scientific Reports 12/31/2025

