Hard X-Ray Instruments

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The Hard X-Ray Instruments @ LCLS

http://lcls.slac.stanford.edu/Instruments.aspx
Hard X-ray mirror upgrades now operational have significantly improved acceptance and beam quality.

- Substantial impact in HXR near-field quality & efficiency
- New periscope to XCS creates “XPP-like” capability
New Modes of Operation and New Detector Capabilities

**Attosecond Hard X-ray Capabilities**

- **Extended photon energy range:** from 0.8–8 to 0.25–12.8 keV
- **Ir L_{III} RIXS**
- **Se K-edge SAD**

Huang et al., PRL 119, 154801 (2017)

**ePix10k Detectors**

- 10k photon dynamic range
- Likely available in Run 17

**Jungfrau Detectors**

- 0.5Mpixel and 1Mpixel available for experiments at atmospheric pressure

HXR Instruments

https://www.psi.ch/detectors/jungfrau
Femtosecond laser capabilities similar to CXI and NEH hutchess like XPP
  * Including time tool diagnostic
  * Multiple user and in-house experiments already performed with XCS laser
XCS Commissioned Upgrades
(ii) New Split and Delay System

- Energy Range: 7-12 keV
  - Delay range varies with photon energy
- Delay Range: -5 to 350 ps at 8 keV
  - Provides continuous coverage for each photon energy reaching beyond 1 ns at 7 keV.

Fully Commissioned in Run 15
Utilized for user experiments in Run 16
Available for proposals in Run 17

HXR Instruments
XCS Commissioned Upgrades (ii) New Split and Delay System

- Time zero confirmed with X-ray interference fringes

- Focus of each branch characterized with wavefront sensor

- Focus position stability \( \approx 1 \mu m \)
MFX New Capabilities

- Ceiling-mounted detector robot available for Run 17
- New large-area detector expected for Run 17
  - Rayonix 340-HS
    - 40 Hz capable with 3.6 Mpixels
XPP Standard Configurations:  
https://lcls.slac.stanford.edu/instruments/xpp/standard-configurations

Standard Configuration 1: Time-resolved Pump-Probe Diffraction

- **X-rays**
  - 9.5 keV
  - 10-200 micron focus
  - Large Offset Double Crystal Monochromator

- **Laser wavelength**
  - 400/800 nm
  - OPA from 480-2400 nm

- **Time Tool (TT) diagnostics for laser arrival**
- **Kappa goniometer with 6-degrees of freedom with standard Huber goniometer head**
- **Cryostream available for cooling down to 100K**
- **Detectors**
  - Ceiling-mounted detector arm with CSPAD 140K
  - Diodes

Standard Configuration 2: X-ray Absorption Spectroscopy (XANES) of 3d Transition Metals

- **X-rays**
  - Energy: Tunable near element absorption edge
  - 2-100 micron focus
  - Channel-cut Monochromator

- **Laser wavelength**
  - 400/800 nm
  - OPA from 480-2400 nm

- **Time Tool (TT) diagnostics for laser arrival**
- **Round jets and flat jets for sample delivery**
- **Detectors**
  - ePix100
  - Diode

Chollet et al., Journal of Synchrotron Radiation 22, 503-507 (2015)
XCS Standard Configurations:
https://lcls.slac.stanford.edu/instruments/xcs/standard-configurations

Standard Configuration 1: Time-resolved solution scattering/emission spectroscopy
- X-rays
  - 9.5 keV
  - 2-100 micron focus
  - Monochromatic or Pink
- Laser wavelength
  - 400/800 nm
  - OPA from 480-2400 nm
- Time Tool (TT) diagnostics for laser arrival
- Helium purged sample chamber with liquid jet
- Von Hamos Spectrometer
- Detectors
  - CSPAD 2.3M for scattering
  - CSPAD 140K or ePix100 for XES

Standard Configuration 2: Time-resolved hard X-ray scattering and diffuse scattering measurements on thin films
- X-rays
  - 9.5 keV
  - 10-200 micron focus
  - Large Offset Double Crystal Monochromator
- Laser wavelength
  - 400/800 nm
  - OPA from 480-2400 nm
- Time Tool (TT) diagnostics for laser arrival
- Helium purged sample chamber with thin film mount at grazing incidence
- Detector
  - CSPAD 2.3M for scattering

MFX Standard Configurations:
https://lcls.slac.stanford.edu/instruments/mfx/standard-configurations

Standard Configuration 1: Goniometer system with sample mounting robot
- X-rays
  - 9.5 keV preferred but flexible
  - 2-100 micron focus with transfocator
  - Pink beam
- No Laser
- SSRL-SMB goniometer and sample exchange robot
  - Cryo or room temperature with humidity control capabilities
- Detectors
  - Rayonix 325 MX (1 Hz readout)
  - Possibly new Rayonix 340-HS (up to 40 Hz)

Standard Configuration 2: Helium-Rich Ambient (HERA) instrument for time-resolved liquid jet crystallography
- X-rays
  - 9.5 keV preferred but flexible
  - 2-100 micron focus with transfocator
  - Pink beam
- Nanosecond Laser Available
  - 410-2200 nm
- Helium-Rich Ambient (HERA) provides reduce background
- Supports a variety of liquid jets
- Detectors
  - Rayonix 170 HS (10 Hz readout)
  - CSPAD 2.3M (120 Hz)

Additional Required Acknowledgment
"The HERA system for in helium experiments at MFX was developed by Bruce Doak and funded by the Max-Planck Institute for Medical Research."

Boutet, Cohen & Wakatsuki, Synchrotron Radiation News 29, 23 (2016)
Standard Configuration: Serial Femtosecond Crystallography with Liquid Jet

- **X-rays**
  - 9.5 keV preferred but flexible
  - 1-2 micron focus with KB mirrors
  - Pink beam

- **Laser wavelength**
  - 400/800 nm
  - OPA from 480-2400 nm
  - ns laser possible (410-2200 nm)

- **Time Tool (TT) diagnostics for laser arrival**

- **CXI 1 micron Sample Chamber (SC1) with liquid jet**
  - Variety of jet systems supported

- **Detectors**
  - Front CSPAD 2.3M
  - Back CSPAD 2.3M available if necessary

Standard Configuration Parasitic: Serial Sample Chamber

- Will be used to perform “parasitic” Protein Crystal Screening
- Reuse the “spent” beam into a second independent experiment
- Used during almost all Standard Configuration primary experiments


Standard Configuration Parameter Tables

If multiple samples are planned, please add rows to the table and list all the samples proposed.

### XPP Parameter Table (Run 17 Standard Configuration)

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Table specific to each standard configuration required with standard configuration proposal submission.