LCLS-II High Energy (LCLS-II-HE)

X-ray Instrumentation
LCLS X-ray Instruments: Before LCLS-II-HE

• 7 instruments fed by a single undulator at present
• 8 instruments available for LCLS-II

NEH 1.1: Atomic, Molecular and Optical
NEH 2.1: Resonant Inelastic X-ray Scattering
NEH 2.2: Soft X-ray Research
NEH 1.2: Tender X-ray Instrument
XPP: X-ray Pump Probe
XCS: X-ray Correlation Spectroscopy
MFX: Macromolecular Femtosecond Crystallography
CXI: Coherent X-ray Imaging
MEC: Matter in Extreme Conditions
LCLS X-ray Instruments: Possible Configuration for LCLS-II-HE

- 9 instruments for LCLS-II-HE
- 5 of the 6 Hard-X-ray instruments will directly benefit from LCLS-II-HE

A new inelastic x-ray scattering (IXS) instrument to augment XCS?

All existing instruments will be enabled for high rep-rate (optics, controls, detectors)

Revised distribution of instruments in FEH to increase experimental capacity
NEH 1.2: Combining two XFEL sources

• X-ray pump / X-ray probe capability with two high repetition rate XFEL sources
• Spatial and temporal overlap of two 1 micron XFEL beams with independent control of intensity, polarization and wavelength
• Present LCLS-II design uses:
  • 400 – 1500 eV (SXU)
  • 1000 – 5000 eV (HXU)

LCLS-II-HE offers the potential to extend the energy range both branches
Considerations for Increased Repetition Rate

- Sample Recovery
- Optical Lasers
- X-ray Optics
- Data Storage
- Data Acquisition
- Detectors

LCLS-II-HE Operation
X-ray Optics Development

High Heat Load Mirrors

Variable Length Cooling Mechanism

Before upgrade

After upgrade
# High Average Power Femtosecond Pump Laser

### OPCPA

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Pulse energy</td>
<td>1 mJ, 100 W (signal)</td>
</tr>
<tr>
<td>Wavelength range</td>
<td>0.7-1 μm</td>
</tr>
<tr>
<td>Pulse duration</td>
<td>15 fs</td>
</tr>
<tr>
<td></td>
<td>&lt;5 fs, 60 W with spectral broadening</td>
</tr>
<tr>
<td>Pulse energy</td>
<td>1.5 mJ, 150 W (signal)</td>
</tr>
<tr>
<td>Wavelength range</td>
<td>1.4-1.7 μm</td>
</tr>
<tr>
<td>Pulse duration</td>
<td>50 fs</td>
</tr>
<tr>
<td></td>
<td>&lt;10 fs with spectral broadening</td>
</tr>
<tr>
<td>Pulse energy</td>
<td>1 mJ, 100 W (idler)</td>
</tr>
<tr>
<td>Wavelength range</td>
<td>2.6-3.8 μm</td>
</tr>
<tr>
<td>Pulse duration</td>
<td>70 fs</td>
</tr>
<tr>
<td></td>
<td>&lt;15 fs with spectral broadening</td>
</tr>
<tr>
<td>Pump laser</td>
<td>15 mJ, 1.5 kW</td>
</tr>
<tr>
<td>Wavelength range</td>
<td>1.03 μm</td>
</tr>
<tr>
<td>Pulse duration</td>
<td>1.5 ps</td>
</tr>
<tr>
<td></td>
<td>&lt;200 fs with spectral broadening</td>
</tr>
</tbody>
</table>

### Other Secondary Sources

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Harmonics (OPCPA and pump)</td>
<td>SHG, THG and FHG</td>
</tr>
<tr>
<td>Tunable OPA</td>
<td>(pumped with 1 mJ, 50 fs, 800 nm)</td>
</tr>
<tr>
<td>Pulse energy</td>
<td>μJ-tens of μJ</td>
</tr>
<tr>
<td>Wavelength range</td>
<td>200 nm-20 μm</td>
</tr>
<tr>
<td>Pulse duration</td>
<td>&gt; 40 fs</td>
</tr>
<tr>
<td>THz source</td>
<td>DFG or Optical rectification</td>
</tr>
<tr>
<td>Pulse energy</td>
<td>to be investigated</td>
</tr>
<tr>
<td>Wavelength range</td>
<td>0.1-100 THz</td>
</tr>
</tbody>
</table>

Table 2. Overview on basic parameters and alternative parameter for the LCLS-II PP-laser amplifier (at 0.1 MHz repetition rate). Color code reflects the current development time as follows; black: available day-1; blue: upgrade level-1; magenta: upgrade level-2.
Detector Development

High Speed Imaging
≥ 5-10 kHz

High Energy Sensors

Spectroscopic
~ 1.5 eV @ 7 keV, 10 kHz
Data Systems Development

- High Throughput DAQ (250 GB/s)
- Data Reduction Pipeline (10x)
- Fast Feedback System
- Data Management System (100 PB)
- Data Analysis

**DAQ (per hutch)**
- Timing (input)
- Data compression
- Event level veto
- Event Builder Nodes
- Online Monitoring Nodes
- Fast Feedback (NVRAM)

**Data Reduction Pipeline (shared - 1 for NEH, partitionable)**
- Data compression
- Event level veto
- Event Builder Nodes
- Online Monitoring Nodes
- Fast Feedback (NVRAM)

**FFB (shared - 1 for NEH)**
- 1 PB
- Fast Feedback (NVRAM)

**Offline (shared by all)**
- 100 PB
- Offline Analysis Farm
- Fast Feedback Analysis Farm
- Lustre
Questions?