MEC Science in Run 21
LCLS Virtual Town Hall

Gilliss Dyer
MEC Department Head
March 3rd, 2022
SRD @ MEC

Gilliss Dyer
Eric Cunningham*
Eric Galtier
Philip Heimann
Dimitri Khaghani
Hae Ja Lee
Bob Nagler
Hai-En Tsai*

* Lasers

Research Areas

Ultra-intense Laser Matter Interactions
Dynamic Materials
Warm Dense Matter
Hot Dense Plasmas
We are always open to and interested in collaborations!

DOE Office of Science Graduate Student Research (SCGSR) Program:
https://science.osti.gov/wdts/scgsr
Applications due 05/04/2022
MEC Hutch for Run 21

- Standard configurations for coaxial shock + WAXS and side-drive shock + PCI
- New beam delivery platform for short pulse
- Opportunities for direct imaging experiments and multi-pulse
- New spectrometers commissioned
# Hard X-Ray Parameters for Run 21

**New MEC X-ray Imager (MXI) used for tighter focusing (CRL lens stack)**

Collaborative use of Ultrafast X-ray Imagers for using multi-bucket mode in imaging configurations

<table>
<thead>
<tr>
<th><strong>X-ray Parameters</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Repetition rate (Hz)</strong></td>
<td>Up to 120 Hz</td>
</tr>
<tr>
<td><strong>Pulse Duration</strong></td>
<td>40 fs (nominal)</td>
</tr>
<tr>
<td><strong>Modes</strong></td>
<td>SASE</td>
</tr>
<tr>
<td><strong>Energy Range (eV)</strong></td>
<td>4000 – 25,000</td>
</tr>
<tr>
<td><strong>Energy per pulse</strong></td>
<td>0.6 – 2 mJ</td>
</tr>
<tr>
<td><strong>Bandwidth (FWHM)</strong></td>
<td>~ 30 eV @ 25 keV; 1.5 eV @ 11 keV;</td>
</tr>
<tr>
<td><strong>Spot Size (FWHM)</strong></td>
<td>~ 2.0 - 50 (µm) dia; to &lt;200 nm with MXI + mono</td>
</tr>
<tr>
<td><strong>Polarization</strong></td>
<td>Linear, Vertical</td>
</tr>
<tr>
<td><strong>Multi-bucket mode</strong> (requires substantial setup and tuning)</td>
<td>Two pulses: 350 ps increments of relative delay up to 120 ns. Energy separation up to ~1%; 0.5 to 1 mJ per pulse</td>
</tr>
<tr>
<td></td>
<td>4 or 8 bunches (<em>under development, offered at risk</em>)</td>
</tr>
<tr>
<td></td>
<td>Two trains of 4 pulses; 700 ps between each pulse in the same train</td>
</tr>
</tbody>
</table>

*Pulse energies presented do not include transmission losses to hutch*
MEC Long Pulse Laser System

- **Seed:** custom diode-pumped Nd:YLF
  - >100mJ, 5-35ns (arbitrary), 10Hz
- **Power amp:** 4 x 50mm Nd:Glass
  - Total >60J for >10 ns; 6J/ns for < 10 ns
  - Energies are for flat-top beams
  - Divided in 4 arms polarization multiplexed to two beams
  - Typical shapes: flat-top, ramp, step, etc.
  - CPPs: 150um, 300um, 600um diameter
  
  (intensity >1013 W/cm² with 150um CPPs)

Seed from front end

1" Nd:glass heads

2" Nd:glass heads

Frequency doublers

2" Nd:glass heads

1" Nd:glass heads

>60J combined output
• Front end: Vitara + Legend
  • 4.1 mJ, 45 fs, 120 Hz
• Nonlinear pulse cleaner
  • TOPAS-Prime + NDFG (SFG)
• Back end: two home-built MPAs
  • MPA1: 4 pass → ~14 mJ (120 Hz)
  • MPA2: 3 pass → ~1.5 J (5 Hz)
  • ~1J, <50fs, >107 contrast @ >3ps
  • Max ~10^{19} W/cm² with f/5 OAP

Alternate schemes delivered previously:
• MPA1 only (compressed)
• MPA2 (uncompressed)
• Secondary optical sources:
  • SHG (~mJ @ 120Hz or ~100s mJ @ 5 Hz)
  • OPA (<mJ, 50fs, 120Hz)
    • S: 1140-1600nm
    • I: 1600-2600nm
  • other wavelengths too* (THz, HHG, betatron)
• ns-OPO also newly acquired
  • S: 650-1064nm
  • I: 1064-2600nm
MEC Standard Configurations

Coaxial shock with XRD
VISAR for 0° target
Sacrifice Q2 for Forward XRTS

Orthogonal shock with XRD and PCI
VISAR for 90° target
Removes Q2
**Phase contrast**

**Direct imaging**

**Ultrafast X-ray imager**

**Concept:**
- Uses Be CRLs to produce phase contrast or amplitude sensitive indirect X-ray images from the FEL passing through a sample
- PCI (upstream TCC) or direct imaging (downstream TCC) mode

**Capabilities:**
- 200 nm resolution over a 100-µm field of view at about 8 keV
- Imaging with a 92-lens stack demonstrated at 18 keV
- Can carry 3 CRL stacks to adjust spatial resolution and field of view

* Contact Philip Hart (detectors) for inquiries about the UXI’s potential availability in a collaborative experiment: philiph@slac.Stanford.edu
New Standard Short Pulse Beam Delivery

• Substantially reduces setup time, helping with experiment feasibility

• Supports delivery of full power, uncompressed, or frequency-doubled modes

• Leaves 3 quadrants of the chamber clear for diagnostics

• Contact Eric Galtier for more details
  • egaltier@slac.stanford.edu