MEC Science in Run 21
LCLS Virtual Town Hall

Gilliss Dyer
MEC Department Head
March 3rd, 2022
MEC Department at LCLS

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](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

<table>
<thead>
<tr>
<th>X-ray Parameters</th>
<th>Repetition rate (Hz)</th>
<th>Pulse Duration (fs)</th>
<th>Modes</th>
<th>Energy Range (eV)</th>
<th>Energy per pulse*</th>
<th>Bandwidth (FWHM)</th>
<th>Spot Size (FWHM)</th>
<th>Polarization</th>
<th>Multi-bucket mode (requires substantial setup and tuning)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repetition rate (Hz)</td>
<td>Up to 120 Hz</td>
<td>40 (nominal)</td>
<td>SASE</td>
<td>4000 – 25,000</td>
<td>0.6 – 2 mJ</td>
<td>~ 30 eV @ 25 keV;</td>
<td>~ 2.0 - 50 (µm) dia;</td>
<td>Linear, Vertical</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 4 or 8 bunches (under development, offered at risk) Two trains of 4 pulses; 700 ps between each pulse in the same train</td>
</tr>
<tr>
<td>Pulse Duration</td>
<td></td>
<td></td>
<td>Self-seeded</td>
<td>4500 – 11,000</td>
<td>0.5 – 0.2 mJ</td>
<td>~ 8 eV @ 4 keV;</td>
<td>to &lt;200 nm with MXI + mono</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.5 eV @ 11 keV;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Range (eV)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.35 eV @ 4.5 keV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy per pulse*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bandwidth (FWHM)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spot Size (FWHM)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polarization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multi-bucket mode</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(requires substantial setup</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>and tuning)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 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

* Pulse energies presented do not include transmission losses to hutch
• **Seed:** custom diode-pumped Nd:YLF
  - >100 mJ, 5-35 ns (arbitrary), 10 Hz
• **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: 150 µm, 300 µm, 600 µm diameter
  (intensity >10^{13} W/cm² with 150 µm CPPs)
MEC Short Pulse Laser System

- **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)
  - ~1 J, <50 fs, >107 contrast @ >3 ps
  - Max ~10^{19} W/cm^2 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
Recent changes and helpful reminders

Recent changes:
• MEC now considered as two laser safety facilities: MEC **Target** and **Laser** Areas
  • Target Area typically for **users**, Laser Area typically for **staff**
• Recent operational improvements
  • **LPL**: new waveform refresh and optimization functions in Python
  • **SPL**: new cameras, motors, energy meters for remote monitoring + control

Helpful reminders:
• Engage early with Laser POC on proposals, design reviews, etc. for best results
• Consider not just on-shot needs but also before/after shot (shutters? probe?)
• **LPL**: specify (a few) shapes ahead of time; easier to make if similar to existing
• **LPL**: shoot all arms for better results; can shape directly for lower energy
• **SPL**: plan extra time for everything (more to consider when non-standard!)
• **SPL**: include testing, characterization, etc. as part of preparation and schedule!
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
MEC 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