Mingsheng Wei
Manager, National Laser Users’ Facility
University of Rochester
Laboratory for Laser Energetics
UR/LLE operates the Omega Laser Facility (the largest lasers in any academic setting worldwide) primarily for the Stockpile Stewardship Program and Basic Science research supported by DOE/NNSA.

**UR/LLE**
- Faculty equivalent staff: 121
- Professional staff: 178
- Associated faculty: 25
- Graduate and undergraduate students: 145
  - ~40 students from other universities

**OMEGA Laser System**
- Operating since 1995
- 60 beams
- 30 kJ UV on target
- Spherical/cylindrical compression
- Flexible pulse shaping
- up to 1500 shots/year

**OMEGA EP Laser System**
- Operating since 2008
- 4 NIF-like beamlines
- Up to 5 kJ/beam shaped UV
- 2 short-pulse IR beams
  - up to 0.5 kJ/beam in 0.7 ps
  - (>1 kJ in 10 to 100 ps)
- ~800 shots/year

LaserNetUS funds a total of eight OMEGA EP shot days in 2019 and 2020
- 2 experiments are scheduled in Nov. 2019
- 6 shot days available in CY2020
The Omega Laser Facility delivered 329 target shots for academic-led Basic Science (NLUF) experiments in FY2018

- External users perform 60% of the experiments.
- Basic Science (NLUF and LBS) accounted for 524 target shots in FY18.

The large number of shots, state-of-the-art facilities, and university setting provide an attractive environment for training and education.
- Over 500 PhDs (including ~170 through NLUF) have been based on research and data on the Omega Laser Facility over the past 40 years.
All four OMEGA EP beamlines can be operated in the UV long-pulse mode

- IR beam frequency tripled to UV (351 nm)
- 100 ps to 10 ns pulse widths
- Pulse shaping capability
- Energies up to 5000 J per beam
- f/6.5, 3.4-m focal length final lens
- Distributed phase plates provide smoothed on-target spot profile
  - 750 µm, (4 available)
  - 1100 µm (3 available)
  - 400 µm, 2000 µm. (1 available)
- New capability - one UV long pulse beam has wavelength tuning capability (350.2 to 353.4 nm) and can be directed to OMEGA EP or OMEGA chambers
OMEGA EP Beams 1 and 2 can be compressed to IR short-pulse and directed to the OMEGA EP or OMEGA-60 target chambers

- Standard IR short-pulse configuration – Beam 1 and Beam 2 are orthogonally directed into the OMEGA EP chamber
- Short pulse Co-propagation – Beam 1 is combined with Beam 2 propagating along the Beam 2 axis into the OMEGA EP or OMEGA chamber
- Long-pulse beams are available along with the IR short pulses

Pulse Length* | Maximum Energy
---|---
0.7 ps (best compression) | 500 J
10 ps | 1250 J
100 ps | 2300 J

*Other pulse lengths between 1 to 100-ps also available.

High-intensity contrast ~10^{-10} on target at shortest pulse length

- f/2 (1 meter focal length) off-axis parabolic mirror for final focusing
  - ~30-μm spot, 80% encircled energy
  - Peak intensity 10^{20} W/cm^2
  - f/6 to f/10 available with an apodized beam (reduced energy)
The OMEGA EP target area is a versatile experimental platform for instrumentation and target delivery – a suite of optical, x-ray and particle diagnostics are available.

- 3.3 meter diameter chamber
- Ten inch manipulators (TIM) (5 units)
  - >80 qualified payloads
- > 20 fixed diagnostics
- Target positioners (4 units)
  - two fixed-port
  - two TIM-based
- <10⁻⁶-Torr vacuum environment

- Typically 90-minute shot cycle with ~ 7 shots per day.
- 45-minute shot cycle capable (alternating beams)

### Partial list of commonly used diagnostics supported by the facility

<table>
<thead>
<tr>
<th>Fixed-port</th>
<th>TIM-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-ps 4ω probe (263-nm): shadowgraph, reflectometry, interferometry, polarimetry</td>
<td>Magneto-Inertial Fusion Electrical Discharge System (MIFEDS)</td>
</tr>
<tr>
<td>Active shock break out diagnostic (ASBO)</td>
<td>Gas-jet system (GJS)</td>
</tr>
<tr>
<td>Velocity interferometry (VISAR) and streaked optical pyrometry (SOP)</td>
<td>Powder x-ray diffraction diagnostic (PXRDIP)</td>
</tr>
<tr>
<td>Sub-aperture backscattered light diagnostic (SABS)</td>
<td>X-ray spectroscopy:</td>
</tr>
<tr>
<td>Visible camera</td>
<td>- Rowland(Yaakobi) x-ray spectrometer (XRS)</td>
</tr>
<tr>
<td>High resolution spectrometer (HRS): 7950 to 8150 eV</td>
<td>- Dual-channel HOPG x-ray spectrometer (DC-HOPG)</td>
</tr>
<tr>
<td>– ps temporal, &gt;2000 spectral resolving power</td>
<td>- Zinc Von Hamos x-ray spectrometer (ZVH)</td>
</tr>
<tr>
<td>Single-photon counting spectrometer (SPC)</td>
<td>- Transmission crystal spectrometer (TCS)</td>
</tr>
<tr>
<td>Bremsstrahlung MeV x-ray spectrometer (BMXS)</td>
<td>LANL Imaging X-ray Thomson spectrometer (IXTS)</td>
</tr>
<tr>
<td>Kirkpatrick-Baez x-ray imager (KB-MICRO)</td>
<td>Ultrafast x-ray streak camera (UFXRSC)</td>
</tr>
<tr>
<td>X-ray pinhole cameras (XRPHC)</td>
<td>Gated x-ray framing cameras (XRFC)</td>
</tr>
<tr>
<td>Neutron time-of-flight detector (NTOF)</td>
<td>High-energy x-ray radiography imager (HERIE)</td>
</tr>
<tr>
<td>EMP monitor (EMPMON)</td>
<td>Electron/positron/proton spectrometer (EPPS), Osaka University electron spectrometer (OU-ESM)</td>
</tr>
<tr>
<td>Thomson parabola ion-energy analyzer (TPIE)</td>
<td>Near Target Arm (NTA) for proton imaging/radiography</td>
</tr>
<tr>
<td>Fresnel Zone Plate (new)</td>
<td></td>
</tr>
</tbody>
</table>
LLE continues to develop and add new experimental capabilities including those recommended by external users

**High pressure Gas-jet target**

- Available on both OMEGA and OEMGA EP including operation with the short pulse beam

**Magnetized target capability using MIFEDS**

- Gen 2 (current) and 2.x (upgrades)
- Gen 3 (new) 2.2 kJ at 30 kV

- Gen 2.x will double the field - first use in Aug. 2019
- Gen 3 (completely new design) will provide > 100T field over mm³ – available in late FY20

A new TIM-based angularly resolved optical Thomson (ARTS) scattering has been developed on OMEGA to measure arbitrary electron distribution functions

**Wavelength tunable OMEGA Port 9 (TOP9) beam using the OMEGA-EP OPA to achieve (Δλ_{UV} = 3 nm) for focused LPI and plasma physics study**

**Plasma**

120° k-resolved OTS

**Collection Optic**

f/0.25 x f/4

- Successful 1st use on 23 July 2019
The Omega experimental template and shot configuration submittal and approval process are formally administrated

- Once the proposed experiment is selected for shots, LLE/FASC and PI’s communicate regularly:

  **Annual FASC “experiment summaries”**
  - Three months prior: Proposal submitted and reviewed
  - Two weeks and one week prior: Shot Request Form reviews
  - Two days prior: Target metrology and target positioning plans
  - Shot day: Effectiveness forms
  - One week post: Critique form

  The proposal captures all campaign information in the database.

• Omega PI account – username and password protected.
• Experimental lead PI completes the required onsite training (at least 3-month) before the scheduled shot day.
The Omega Laser User Group (OLUG), a self-organized group guided by its bylaws, provides findings & recommendations to enhance the facility capabilities.

- OLUG represents over 450 scientific users from 55 universities, over 35 centers and national laboratories in 21 different countries on 4 continents.
- Provides an annual forum to discuss cutting-edge research at the Omega Laser Facility:
  - Travel funds to support students/postdocs.
- Enhances the capabilities of Omega facilities through findings & recommendations (F&Rs):
  - Compiled at the OLUG Workshop in April.
  - Follow-up at APS-DPP.
- Offers mentorship and networking for young researchers.
- Represents the Omega users at national meetings and forums.

http://ouw.lle.rochester.edu/
Extra slide
NNSA supported NLUF and LBS Basic Science experiments are awarded through competitive and peer-review proposal processes

National Laser Users’ Facility (NLUF)
http://www.lle.rochester.edu/about/nluf.php
- For U.S. university and industry users
- DOE grant program
  - Annual support to users ~$1.8M
  - Additional funding for target fabrication support
- Two-year cycle (typically 10-14 awards each cycle)
  - ~34 Omega shot days each year
- NLUF has received 376 proposals with 202 of these approved since its inception in 1979
- NLUF has produced over 170 PhDs

Laboratory Basic Science (LBS)
- For users from NNSA and Office of Science laboratories and LLE
  - Basic Science experiments that are not of the immediate NNSA mission need
- LLE administrates the LBS program
  - Annual facility-time proposal submission (typically 15-20 awards)
    - ~21 Omega shot days each year
  - Proposals are subjected to a similar level of peer review and facility feasibility assessment as the NLUF grant proposals
- LBS has received 315 proposals since its inception in 2008
  - 50% of those were approved
- Many LBS projects have collaborators including graduate students from universities

Point of Contact at UR/LLE:
Dr. Mingsheng Wei
NLUF Manager Mingsheng@lle.Rochester.edu
(585) 275-3866