Status of the OMEGA EP High-Energy Petawatt Laser Facility

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Summary

Two 2.6-kJ petawatt beamlines will be integrated into OMEGA: OMEGA Extended Performance (EP)

- OMEGA EP is under construction and will be completed in April 2008
  - Most technical issues have been solved (21 of 27 gratings delivered)
  - Beamline 1 is being commissioned in October 2006 (long pulse)
- Two short-pulse (SP) beams can be combined colinearly and routed into the OMEGA target chamber
  - SP beam 1: up to 2.6 kJ at \( \geq 10 \) ps or 1 kJ at 1 ps
  - SP beam 2: up to 2.6 kJ at \( \geq 80 \) ps
- It has a variety of configurations with up to four 10-ns, 6.5-kJ UV beams to a new target chamber; two can be used in short-pulse mode
  - SP beams: up to 2.6 kJ at \( \geq 10 \) ps or 1 kJ at 1 ps

OMEGA/OMEGA EP will provide a flexible HED facility, significantly extending LLE’s research capabilities.
Short-pulse OMEGA EP beams can be directed either to OMEGA or to the new OMEGA EP target chamber.

<table>
<thead>
<tr>
<th>Short pulse combined</th>
<th>Beam 1</th>
<th>Beam 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR energy (kJ)</td>
<td>2.6</td>
<td>2.6</td>
</tr>
<tr>
<td>Pulse duration at full energy (ps)</td>
<td>10 to 100</td>
<td>80 to 100</td>
</tr>
<tr>
<td>Focusing (diam)</td>
<td>&gt;80% in 20 μm</td>
<td>&gt;80% in 40 μm</td>
</tr>
<tr>
<td>Intensity (W/cm²)</td>
<td>$3 \times 10^{20}$</td>
<td>$2 \times 10^{18}$</td>
</tr>
</tbody>
</table>

- Each beam duration can be as short as 1 ps at reduced energy (grating damage and $B$-integral)
- Beam 2 can produce 2.6 kJ in 10 ps when propagating on a separate path.
The OMEGA EP long-pulse UV energy is a function of pulse width with a potential of 6.5 kJ per beam at 10 ns per beam.

- Frequency conversion crystals are separate from the target chamber.
  - mirror transport to the target chamber
  - decouples on-target pointing from crystal tuning
  - no unconverted light in the chamber
  - long-pulse performance is limited by the first UV mirror

<table>
<thead>
<tr>
<th>Square pulse width (ns)</th>
<th>1.0</th>
<th>4.0</th>
<th>10.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential UV on target (kJ)</td>
<td>2.5</td>
<td>4.8</td>
<td>6.5</td>
</tr>
<tr>
<td>Potential intensity (1-mm spot) (W/cm²)</td>
<td>$3 \times 10^{14}$</td>
<td>$1.5 \times 10^{14}$</td>
<td>$8 \times 10^{13}$</td>
</tr>
</tbody>
</table>

With 4-beam, long-pulse operation greater than 25-kJ UV total in 10 ns is available.
The beams from OMEGA EP will be focused with a 23° f/2 off-axis parabola inside the OMEGA target chamber.

- A fast-focusing optic is necessary to meet the 20-μm-diam focal-spot requirement.
- The size of the target chamber port limits the input beam size.
- The beam path has to stay clear of the cryogenic target handling equipment.

Combined short-pulse beams
2.6 kJ 10 ps and
2.6 kJ 80 ps
Simultaneous sidelighting and backlighting will be possible in the new OMEGA EP target chamber.

- **Backlighter** parabola
- **Target**
- **Backlighter** 2.6 kJ, 10 ps
- **Sidelighter** 2.6 kJ, 10 ps
- **Diagnostic inserter**
- **Up to four long-pulse UV beams** 10 ns, 6.5 kJ
Experimental capabilities for OMEGA EP beyond the original baseline are under development

- The OMEGA EP user workshop in January 2006 identified a number of desired capabilities.
  - a laser contrast diagnostic was identified to be a high-priority requirement
  - simultaneous side- and backlighting in the OMEGA EP target chamber is now part of the project baseline
  - a $4\omega$-probe beam is under development
  - a planar cryogenic target handling system is being designed
  - a number of new target diagnostics were proposed and development has started on some of them
- A second OMEGA EP user workshop is planned for the Spring of 2007 to start the detailed development of experimental campaigns.

User experiments on OMEGA EP will start in FY09
A $4\omega$ probe beam will be installed on OMEGA EP

<table>
<thead>
<tr>
<th>$4\omega$ laser parameters</th>
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<tbody>
<tr>
<td>Energy</td>
<td>50~100 mJ</td>
</tr>
<tr>
<td>Pulse duration</td>
<td>10~100 ps</td>
</tr>
<tr>
<td>Input $f#$</td>
<td>5</td>
</tr>
<tr>
<td>Collection $f#$</td>
<td>2</td>
</tr>
</tbody>
</table>
A comprehensive suite of diagnostics is planned to characterize the on-target pulse intensity.

- Pulse-width measurement in the range <1 ps to 100 ps using a combination of streak cameras (~8 to 100 ps) and EO-SPIDER (0.5 to 30 ps)
- Near-field intensity and phase measurements, along with transport optic characterization are used to calculate the focal spot.
Significant progress was made in 2006

• The OMEGA EP grating compressor vessel was completed.
  – the chamber vacuum system was activated and achieved its nominal performance ($< 10^{-5}$ Mbar)

• The OMEGA EP target chamber installation was completed.
  – the vacuum system was activated successfully

• The structures for four beamlines were installed.

• The laser sources for beam 1 were activated.

• Power conditioning and amplifiers were completed for beams 1 and 2.
  – all flash-lamps of beamlines 1 and 2 were successfully operated at maximum voltage
OMEGA EP is on track for completion in April 2008

April 2004

January 2005

January 2006

October 2006
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