### OMEGA EP Facility Update and Progress on OLUG Recommendations

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#### Summary

**OMEGA EP Continues to Evolve into a More-Effective User Facility**
- Availability and effectiveness are improving as the system matures
- The number of shots per day has seen an increase in the last year

**OMEGA EP Availability and Experimental Effectiveness**
- More-Effective User Facility
- OMEGA EP Continues to Evolve into a More-Effective User Facility

**OMEGA EP Focal Spot Quality Continues to Improve**
- Static wavefront corrections have been added to beams 1 and 2
- Focal spot performance is now dominated by low-order wavefront drift between stopping active correction and shot time

**OMEGA EP Now Offers Increased Operational Flexibility**
- Beam-to-beam timing can be improved on subsequent shots, but only if the beam-to-beam timing accuracy is zero
- Beam-to-beam timing on the first target shot of the day can be expected to be within 100 ps for UV beams and 50 ps for SP beams

**OMEGA EP Facility Update and Progress**
- A discrete set of additional subnanosecond UV pulse lengths are available
- Subnanosecond UV Pulses have been Activated on OMEGA EP
- Short-Pulse Front Ends will be Upgraded to Improve Contrast
- An FY13–FY17 project is being developed to support the OLUG request for short-pulse frequency conversion

**Maximum Available Energy Continues to Increase**
- LLNL is working to acquire new capabilities in high-energy lasers
- LLNL has achieved the full specified energy on target for a limited number of Beam 4 shots
- Work continues to improve the UV performance of Beams 1 and 2

**New laser diagnostics have improved the beam-to-beam timing accuracy**
- Pre-shot timing is set using diagnostics that have been calibrated to on-shot target diagnostics
- Beam-to-beam timing on the first target shot of the day can be expected to be within 100 ps for UV beams and 50 ps for SP beams

**A Beam Combiner has been Installed in the GCC to Support Co-Propagation of Beams 1 and 2**
- Co-propagation of Beams 1 and 2 will first be activated to the OMEGA EP backlighter path and then to OMEGA
- Significant differential wavefront between the beams reflected off and propagated through the beam combiner results in one or both beams picking up significant aberrations

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#### Table: OMEGA EP Focal Spot Quality

<table>
<thead>
<tr>
<th>Beam</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP</td>
<td>-95</td>
<td>-85</td>
</tr>
<tr>
<td>UV</td>
<td>-80</td>
<td>-70</td>
</tr>
</tbody>
</table>

#### Table: OMEGA EP Focal Spot Size

<table>
<thead>
<tr>
<th>Beam</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP</td>
<td>50 μm</td>
</tr>
<tr>
<td>UV</td>
<td>20 μm</td>
</tr>
</tbody>
</table>

#### Table: OMEGA EP Focal Spot Energy

<table>
<thead>
<tr>
<th>Beam</th>
<th>Energy (J)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP</td>
<td>500 J</td>
</tr>
<tr>
<td>UV</td>
<td>100 J</td>
</tr>
</tbody>
</table>

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#### Diagrams

- OMEGA EP Facility Map
- OMEGA EP Focal Spot Comparison
- OMEGA EP Focal Spot Size Distribution
- OMEGA EP Focal Spot Energy Distribution
- OMEGA EP Focal Spot Quality Improvement Timeline

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#### References

- OLUG Request for OMEGA EP Configuration Flexibility
- A vacuum vessel containing frequency-conversion crystals will add 3x3x0 capability to the OMEGA EP short pulse

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Summary

OMEGA EP Continues to Evolve into a More-Effective User Facility

- Availability and effectiveness are improving as the system matures
- The average number of shots per day has seen an increase in the last year
- Timing performance is benefiting from new pre-shot timing diagnostics
- Available energy, focal performance, and contrast have improved and will continue to do so in the coming year
- Several OLUG recommended projects will add flexibility to the OMEGA EP Laser System to facilitate new experimental platforms
OMEGA EP Availability and Experimental Effectiveness
Continue to Improve

• Availability
  – overall availability = 84%

• Effectiveness
  – overall effectiveness = 95%
OMEGA EP Averaged 5.8 Shots per Day Over the Past Year, Up from 5.4 for the Previous Year

- 482 target shots 4/11 to 4/12
Maximum Available Energy Continues to Increase

- LLE is working to acquire new gratings with an increased short-pulse laser damage threshold in FY13-14
- LLE has achieved the full specification energy on target for a limited number of Beam 4 UV shots
- Work continues to improve the UV performance of Beams 1 and 2

### OMEGA EP performance envelop descriptive values*

<table>
<thead>
<tr>
<th>Short pulse (IR)</th>
<th>Pulse length</th>
<th>Beam</th>
<th>1 (current)</th>
<th>1 (full spec)</th>
<th>2 (current)</th>
<th>2 (full spec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-target energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No disposable debris shield</td>
<td>0.7 ps</td>
<td>50 J</td>
<td>700 J</td>
<td>400 J</td>
<td>700 J</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 ps</td>
<td>850 J</td>
<td>2600 J</td>
<td>1500 J</td>
<td>2600 J</td>
<td></td>
</tr>
<tr>
<td></td>
<td>100 ps</td>
<td>1000 J</td>
<td>2600 J</td>
<td>2000 J</td>
<td>2600 J</td>
<td></td>
</tr>
</tbody>
</table>

Note: Beam 1 is also known as the “sidelighter” or the “lower compressor”
Beam 2 is the “backlighter” (OMEGA EP or OMEGA) or the “upper compressor”

### Long pulse (UV)升降级

<table>
<thead>
<tr>
<th>Long pulse (UV)</th>
<th>Pulse length</th>
<th>Beam</th>
<th>1 (current)</th>
<th>2 (current)</th>
<th>3 (current)</th>
<th>4 (current)</th>
<th>Any beam (full spec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-target energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Square pulse shape values</td>
<td>100 ps</td>
<td>100 J</td>
<td>100 J</td>
<td>100 J</td>
<td>100 J</td>
<td>100 J</td>
<td>100 J</td>
</tr>
<tr>
<td></td>
<td>1 ns</td>
<td>950 J</td>
<td>950 J</td>
<td>1250 J</td>
<td>1250 J</td>
<td>2000 J</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 ns</td>
<td>1350 J</td>
<td>1350 J</td>
<td>1800 J</td>
<td>1800 J</td>
<td>2900 J</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 ns</td>
<td>1900 J</td>
<td>1900 J</td>
<td>2500 J</td>
<td>2500 J</td>
<td>4100 J</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6 ns</td>
<td>2300 J</td>
<td>2300 J</td>
<td>3100 J</td>
<td>3100 J</td>
<td>5000 J</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 ns</td>
<td>3000 J</td>
<td>3000 J</td>
<td>4000 J</td>
<td>4000 J</td>
<td>6500 J</td>
<td></td>
</tr>
</tbody>
</table>

Revision date: 02/21/12
OMEGA EP Now Offers Increased Operational Flexibility

• Short-pulse (SP) and UV focal-spot size changes may be made between shots without extending the shot cycle

• SP and UV pointing changes can be supported with a minimal (30-min) extension to the shot cycle when planned in advance

• UV timing changes can be made at no cost to the shot cycle

• SP timing changes will have minimal impact on the shot cycle if they are specified immediately post shot

• UV pulse shape changes will typically not extend the shot cycle if they are started immediately post shot

• SP pulse length changes between 10 and 100 ps can be accomplished with a 30-min extension to the shot cycle and some modest energy restrictions

• Changes to or from best compression will cost approximately one shot cycle

• It is imperative that an SRF for every potentially desired energy and pulse shape/width be in the system at the one week brief
Subnanosecond UV Pulses have been Activated on OMEGA EP

- 100-ps UV pulses with an energy of 100 J are now available on all four beamlines
- A discrete set of additional subnanosecond UV pulse lengths with energies greater than 100 J will be activated in FY12 Q3
New laser diagnostics have improved the beam-to-beam timing accuracy

- Pre-shot timing is set using diagnostics that have been calibrated to on-shot target diagnostics
  - to determine absolute on-shot timing, a time-resolved target diagnostic must be used
- Beam-to-beam timing on the first target shot of the day can be expected to be within 100 ps for UV beams and 50 ps for SP beams
- Beam-to-beam timing can be improved on subsequent shots, but only if an on-shot target diagnostic such as the UFXRS or PJX is deployed

*Calibrated to target on-shot timing diagnostics
OMEGA EP Focal Spot Quality Continues to Improve

- Static wavefront correctors have been added to beamlines 1 and 2
  - the number of shots with $R_{80} < 20 \ \mu m$ has significantly increased
  - a 10% to 20% reduction in the average focal-spot size has been realized

- Focal spot performance is now dominated by low-order wavefront drift between stopping active correction and shot time

- A project to permit active wavefront correction much closer to shot time is underway and expected to provide significant improvement

Before

\[
\langle R_{80} \rangle = 17.5 \ \mu rad
\]

After

\[
\langle R_{80} \rangle = 13.0 \ \mu rad
\]

Ensemble average of ten measurements with active wavefront control
Short-Pulse Front Ends will be Upgraded to Improve Contrast

- An additional stage of OPA is being added to Beams 1 and 2
- Contrast is anticipated to improve by a factor of ~100 to 1000
A Beam Combiner has been Installed in the GCC to Support Co-Propagation of Beams 1 and 2

• Co-propagation of Beams 1 and 2 will first be activated to the OMEGA EP backlighter path and then to OMEGA

• Significant differential wavefront between the beams reflected off and propagated through the beam-combiner optic results in one or both beams picking up significant aberrations

• Co-located foci will be activated before spot separation is explored
A FY13–FY17 Project is being Developed to Support an OLUG Request for OMEGA EP Configuration Flexibility

- Beams 2 and 4 would be reconfigurable to illuminate the back side of a target entering the target chamber at ports 44 and 59

![Diagram of OMEGA EP target chamber with various components labeled, including Frequency-conversion crystals, Vacuum window, Phase plate, UV diagnostic beamsplitter, Focus lens, Debris shield, New UV transport mirror, and New focus lens assembly.]
An FY13–FY17 project is being developed to support the OLUG request for short-pulse frequency conversion.

- A vacuum vessel containing frequency-conversion crystals will add $2\omega/3\omega$ capability to the OMEGA EP short pulse.