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**The Second Omega Laser Facility
Users' Group Workshop 28 April - 1 May 2010
Petrasso, R.D., Ed.**

June, 2010

**Plasma Science and Fusion Center
Massachusetts Institute of Technology
Cambridge MA 02139 USA**

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The Second OMEGA Laser Facility Users Group Workshop (April 28 - 30, 2010)

Introduction

More than 115 researchers from 44 universities and laboratories and 9 countries gathered at the Laboratory for Laser Energetics (LLE) for the second OMEGA Laser Facility Users Group (OLUG) workshop (see below). The purpose of the three-day workshop was to facilitate communications and exchanges among individual Omega users and between users and LLE; to present on-going and proposed research; to encourage research opportunities and collaborations that could be undertaken at the OMEGA Laser Facility and in a complementary fashion at other facilities (such as NIF or LULI); to provide an opportunity for students and post-doctoral fellows to present their research involving the OMEGA Facility in an interactive and informal atmosphere; and to provide LLE feedback from the users about ways to improve the Facility and future experimental campaigns. The interactions were spirited and lively, as can be seen in photographs shown in this article. There are 180 members of the OMEGA Users Group, and their names and affiliations can be found at http://www.lle.rochester.edu/about/omega_laser_users_group.php.

The first two mornings were comprised of 17 science and facility presentations (the Workshop

agenda is shown in the Appendix). The facility talks proved especially useful for those not familiar with the art and complexities of performing experiments at the OMEGA Facility. The overview science talks, given by leading world authorities, described the breadth and excitement of high-energy-density science undertaken at the Omega Laser Facility. The next section of this article contains a summary of the range of presentations.

Forty-five students and post-doctoral fellows, 37 of whom were supported by travel grants from NNSA, attended the workshop and presented 31 of the 48 contributed poster and oral presentations. The presentation content ranged from target fabrication to simulating important aspects of supernovae, and the presentations generated spirited discussions, probing questions, and friendly suggestions. In addition, 17 excellent contributed presentations were made by professional scientists and academics.

An important function of the workshop was to develop a set of recommendations and findings to help set future priorities for the OMEGA Laser Facility.



Over 115 researchers from around the world and from 44 universities and laboratories participated in this year's workshop. Plans for the next OMEGA Users Workshop on 27-29 April 2011 are well underway, with significant support from NNSA already allocated for student/postdoc travel expenses.



Forty-five students and post-doctoral fellows attended and made 31 engaging presentations. Thirty-seven received travel assistance from an NNSA grant.

These findings were grouped into 3 areas: 60-beam OMEGA, OMEGA EP, and Broader Facility-improvement issues. These categories comprise a report given to Omega Facility management. The original report, and the management response, can be found at the back of this document. LLE management is currently using these recommendations as a guide for making decisions about Omega Laser Facility operations, priorities, and future changes.

One highlight of the workshop was the panel of students and post-docs that discussed their experiences at the Omega Laser Facility and their thoughts and recommendations on facility improvements. Wide-ranging and engaging discussions were sparked by this forum, which resulted in the student/postdoctoral report reproduced at the end of this document.

Another important event was a job fair designed to bring students together with potential future employers. This fair will be expanded at the next workshop.

Finally, one of the important decisions made at the workshop was the scheduling of the next one. It will be held at LLE on April 27 - 29, 2011. Meetings of the Users Group and interested members of the HED community are formulating plans for this third workshop and reviewing progress on the ***Findings and Recommendations*** of the second workshop. A semiannual meeting will in the future always take place at a satellite meeting during the fall APS-DPP conference (in Chicago, 9 November 2010 at 5:30 this year).

The Presentations

A wide-ranging series of 76 talks and posters was presented over a two-day period. In the morning sessions, invited talks on the facility and science were given. The invited science talks focused on several important topics, including high-energy-density plasmas in general, laboratory astrophysics, ignition in ICF, the physics of fast ignition, and future experiments on OMEGA and the NIF.

The Facility talks presented important details and developments on the status and performance of OMEGA/OMEGA-EP from pulse shaping and duration to beam smoothing; the qualification process for interfacing new experiments; the present, and soon-to-be operating, set of diagnostics; and the critical role of targets, from design, to procurement, to full characterization, to fielding and finally shooting.

In addition to the 17 invited presentations, 59 contributed posters and talks were given, and they covered a wide spectrum of work on OMEGA from target fabrication to fast-ignition experiments to basic and novel nuclear physics experiments. Work was also presented on opportunities for taking physics platforms developed at OMEGA to other facilities that are both larger (the NIF) and smaller (Jupiter, Trident, and LULI, as examples). The invited, contributed, and poster presentations formed much of the basis for spirited and lively discussions resulting in the ***Findings and Recommendations*** for the OMEGA Facilities and future capabilities, found at the end of this document.

The photographs on the following pages provide a representative sampling of the workshop's talks, interactions, and ambience.



In the plenary sessions, seventeen authorities spoke about the science and opportunities of high-energy-density physics, and described the evolving capabilities of the OMEGA Facility needed to reach new science frontiers.



Bob Rosner of the University of Chicago kicked off the workshop with an astrophysicist's perspective on High-Energy-Density Physics.



The challenges and science of fast-ignition were the focus of Rutherford-Appleton Laboratory's Peter Norreys. Peter is a member of the Users Executive Committee.



Guy Dimonte of Los Alamos National Laboratory discussed the role of particle interactions in the equilibration of high-energy-density plasmas.



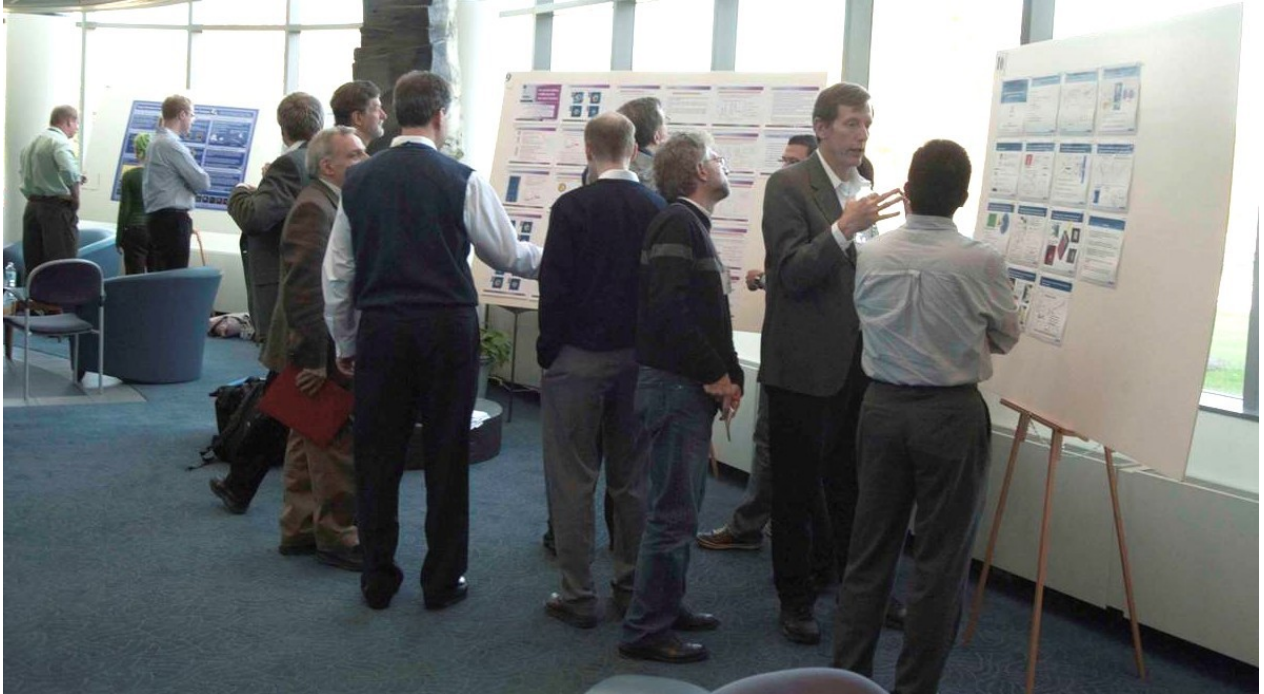
Brent Blue from General Atomics, Inc., discussed the science and technology of developing and fielding complex targets for OMEGA experiments.



Moving physics platforms and experiments from OMEGA to the NIF was the focus of remarks by General Atomics's Joe Kilkenny. Joe gave many concrete examples of this migration including x-ray, neutron, and charged-particle diagnostics.



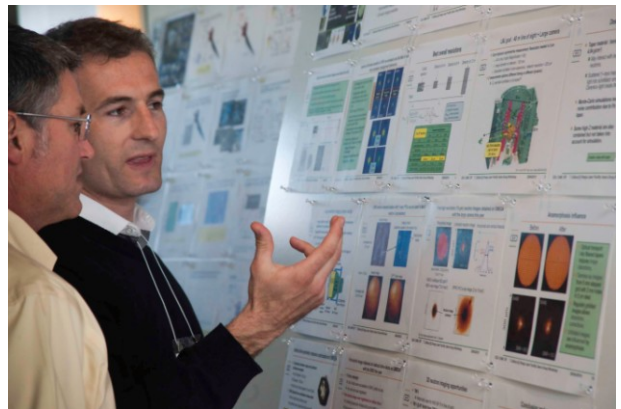
Roberto Mancini from the Univ. of Nevada (top), and Carolyn Kuranz from the University of Michigan (bottom), posed questions in a plenary session. Roberto is a member of the Users Executive Committee.



Two poster sessions presented an opportunity for informal discussion about OMEGA experiments and their connections to important work at other HED facilities.



University of Michigan Student Elision Gamboa discussed his work on x-ray Thomson-scattering imaging with National Nuclear Security Agency's (NNSA) Allan Hauer. Allan presented a talk on the importance to NNSA of high-energy-density laboratory physics.



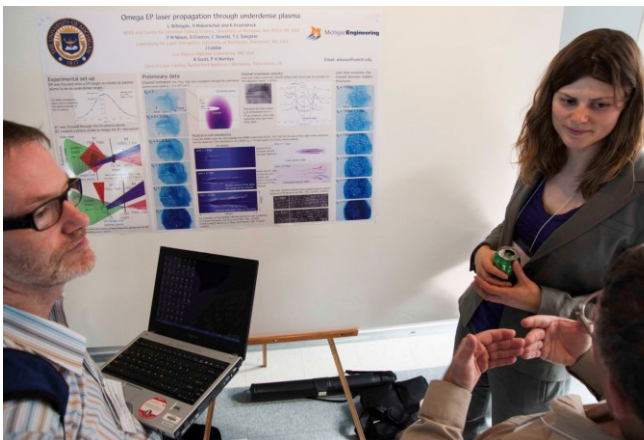
Tony Caillaud, from France (Commissariat à l'Energie Atomique), showed Linn Van Woerkom of Ohio State University neutron images of OMEGA DD and DT implosions.



Frank Phillipe (left), from France (Commissariat à l'Energie Atomique), chatted with Chikang Li of MIT. Frank and Chikang recently collaborated on OMEGA experiments involving rugby-shaped hohlraums.



Kazuo Tanaka (Osaka Univ.) and Wolf Seka (LLE) conversed during the poster session. Kazuo presented work on the self-focusing of relativistic electrons.



Postdoc Louise Willingale, from Karl Krushelnick's group at the Univ. of Michigan, and Peter Norreys of RAL listen to comments about her OMEGA-EP research on proton backlighting of laser channeling.



*Jim Cobble (left, from LANL), a Users Executive Committee member, spoke with David Meyerhofer (LLE) about the **Recommendation and Findings** report for the LLE management. This Report, reproduced later in this document, is used to help prioritize LLE Facility upgrades and directions.*

Fredrick Seguin (MIT) gave a contributed talk about observations of the electromagnetic fields associated with coronal filamentation in direct-drive ICF implosions.





Productive discussions among researchers from around the world occurred in several informal settings.



Benchmarks for achieving ignition were the subject of Riccardo Betti's presentation.



Al Trivelpiece (left) and Jim Decker brought some unique experience and valuable insights to the workshop.



Paul Drake (Univ. of Michigan), a Users Executive Committee member, presented a talk about the opportunities for doing laboratory astrophysics at OMEGA and OMEGA EP.



Alberto Marochinno (Univ of Rome; far left), Tazio Levato (INFN Frascati), Patrizio Antici (INFN Frascati), Rich Petrasso (MIT), Riccardo Betti (LLE), Lois Buitano (NNSA), Orlando Ciricosta (Univ. of Pisa), and Angelo Schiavi (Univ. of Rome), are captured together during the poster session.



The student-posdoc panel presented important insights from young researchers working at the OMEGA Facility. Their report is reproduced later in this document. Left to right: Maria Barrios (Univ. of Rochester; LLE), Tammy Ma (Univ. of California, San Diego), Hioshi Sawada (Univ. of California, San Diego), Ryan Rygg (LLNL), Dan Casey (MIT), Andrea Kritcher (LLNL), and Louise Willingale (Univ. of Michigan).



A “town-hall” meeting on the importance and role of high-energy density physics, from the DoE perspective, was lead by Mark Koepke (left; Office of Fusion Energy Science), Kim Budil (Office of the Under Secretary for Science), and Lois Buitano (National Nuclear Security Agency).



Kim Budil (Office of the Under Secretary for Science) discussed her Office’s perspective on high-energy-density physics.



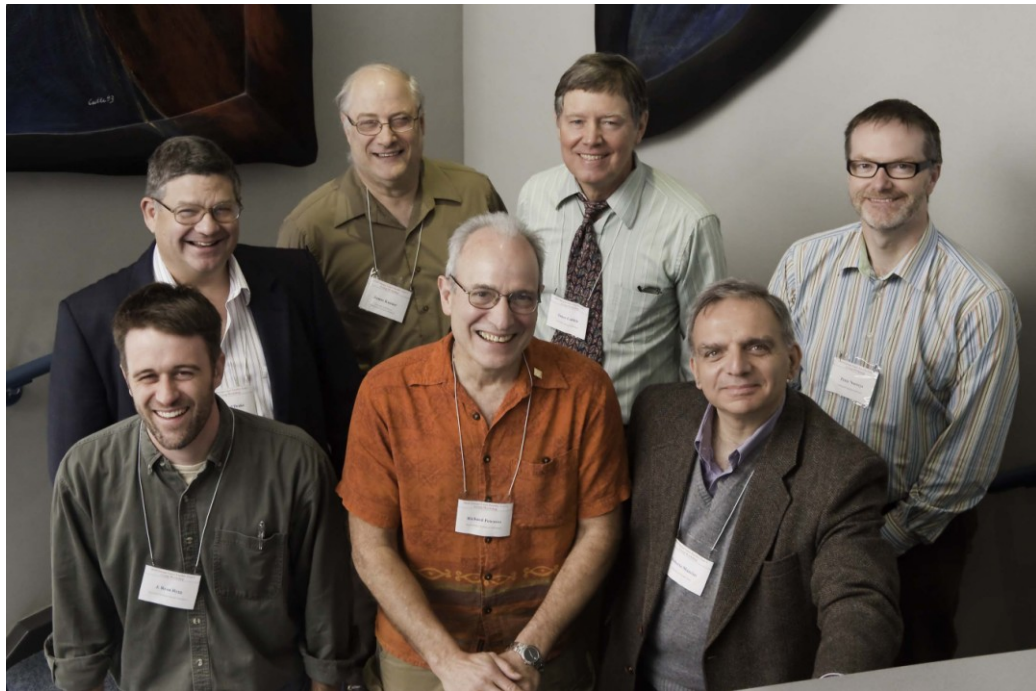
Facility presentations, like this one by Sam Morse (LLE), related new and on-going developments at OMEGA and briefed younger researchers on effective use of the Facility.



Brian Kruschwitz (LLE) discussed the latest techniques for characterizing the OMEGA-EP laser focal spot. Such information is essential for the planning of experiments.



Dave Canning (LLE) led a tour of the OMEGA-EP laser and discussed its capabilities. For many new researchers, this was an ideal opportunity to learn about the Facility.



Members of the OMEGA Users Executive Committee. Front row (left to right): Ryan Rygg (LLNL), Rich Petrasso (MIT), Roberto Mancini (Univ. of Nevada). Back row (left to right): Paul Drake (Univ. of Michigan), Jim Knauer (LLE), Jim Cobble (LANL), and Peter Norreys (RAL).



The OMEGA Users banquet at Delmonico's Italian Steakhouse offered another opportunity for attendees to interact informally, reinforce old friendships, and create new working relationships.

Findings and Recommendations of the Executive Committee

Executive Committee

Richard Petrasso, Committee Chair,
Massachusetts Institute of Technology

Hector Baldis, UC Davis

James Cobble, Los Alamos National Laboratory

Paul Drake, University of Michigan

James Knauer, LLE, University of Rochester
(designated)

Roberto Mancini, University of Nevada, Reno

Peter Norreys, Rutherford Appleton Laboratory

This report includes the following subsections:

- I. Introduction
- II. OMEGA (60 Beams)
- III. OMEGA EP
- IV. Other Facility Improvements

I. Introduction

The OMEGA Laser User Group warmly thanks the Laboratory of Laser Energetics management for taking actions on the recommendations from our last report and expeditiously addressing the issues identified therein. It is a strong testament to the professionalism of the staff of the facility that the tasks were assigned to people with appropriate skills and were executed with good speed and due diligence. The activities undertaken are a great credit to the Laboratory and to the University of Rochester. They are certainly highly appreciated by the academic user community.

The OMEGA 60 and OMEGA EP lasers are world class facilities that provide academic access to cutting-edge energies and intensities on target. However, as with any high performance device critical enhancements are needed to continue to enable progress in forefront science. This document describes the observations of the academic and research user community, distilled from its April 2010 workshop, of those elements and components that can maintain LLE's leading position at the forefront of high energy density physics. The OLUG looks forward to hearing progress on these recommendations at the semiannual satellite meeting in November (at the APS conference) and at its next annual Workshop (27-29 April, 2011).

II. OMEGA (60 beams)

1. Three independent legs will add substantial improvement and flexibility to experiment design.

Greatly expanded experimental design options would develop if it were possible to use all three of the existing drivers, with each driving one of the Omega legs. Ideally, each driver would be able to drive any leg to accommodate the constraints imposed by diagnostic configurations. Improved experiments and new classes of experiments would then become possible. OLUG considers this a high priority.

Request: Present a plan to the Executive Committee on the implementation of three independent legs. In addition, include this and additional options for discussion at next year's Workshop.

LLE Response: Preliminary concepts for this project have been developed and will be advanced further in FY11. Pending the availability of LLE resources, the implementation will commence in FY11. At a minimum, LLE will complete a plan for the implementation.

2. **Request:** A list of qualified diagnostics that can be fielded for joint operations is needed.

LLE Response: The requested information will be made more readily accessible and the OLUG Executive Committee will be notified as soon as the data are published on the website.

3. It is common to drive experiments with 10 Omega beams, and very common to do two separate experiments in one day. The workhorse DPPs have turned out to be the SG8s. Many users have found that the limited number of these specific DPPs has compromised the quality or productivity of their experiments, especially when they had shots on the second half-day of a shared day. In the area of chamber optics, OLUG would prioritize this item second behind the provision of four 750- μ m phase plates for EP.

Request: The facility should purchase enough SG8's to make 20 available to the user community (if this will not jeopardize the higher priority 750- μ m phase plate purchase needed for EP).

LLE Response: The acquisition of additional SG8 DPP's is included in FY11. The implementation date is contingent on vendor availability. There are currently 12 SG8 DPP's available and these can continue to be shifted to accommodate campaign transitions as required in the interim period.

4. **Request:** A high-resolution neutron spectrometer to measure neutrons with energies in the range 2-3 MeV is needed.

LLE Response: LLE is working with Users to develop the requirements for this diagnostic and will then determine if it is feasible. If so, LLE will initiate a project to implement it.

5. Upgrade the backlighter driver to operate at the nominal specified performance.

The existing backlighter driver is unable to support the full energy that the Omega 60 beams are capable of producing. Because most backlighting and x-ray probing experiments are photon-limited, this is a significant shortfall for some experiments.

Recommendation: The backlighter driver should be improved so as to support full energy operation of the beams it drives.

LLE Response: The backlighter source will be reworked in FY11 to increase the available operating envelope to match the other Laser Drivers.

6. EP PW beam delivering two foci onto target.

There is a need for simultaneous pump/probe experiments on OMEGA using the EP PW beam. The availability of this feature would greatly increase the capability of the facility and lead to the undertaking of many new experiments. Examples include hard X-ray radiography of integrated fast ignition experiments. However, the OLUG recognises that space limitations impose a restriction on the provision of a single off-axis focusing parabolic mirror. The OLUG considered the possibility of splitting the PW beam into two beam-lets at the final turning mirror so that two focal spots are generated.

Request: The OLUG requests that LLE investigate the possibility of splitting the PW beam and report back to the Executive Committees.

LLE Response: In FY11 the beam-combiner optic in the Grating Compressor Chamber will be re-installed. With this optic the two short-pulse beams can be independently directed to two foci with a small separation. This capability will be developed and demonstrated on the OMEGA EP target chamber initially in FY11 and may be available on OMEGA in late FY11. The requirements for focal spot separation, quality, and timing need to be refined to determine if this flexibility will meet user requirements. LLE will provide status updates on this effort to the OLUG Executive Committee. Should a “split-mirror” be required, the design, fabrication, integration effort is likely to take on the order of 18-24 months. LLE recommends that users that need this feature refine their requirements so that this assessment can be made as soon as practical.

7. Integrated experiments require smaller focal spots for the PW beam.

This is the same problem as issue 7 in the section devoted to EP Improvements.

Endorsement: OLUG strongly endorses the development and implementation of the new phase front corrector as a matter of high priority.

LLE Response: The FY11 phase front correction effort will initially concentrate on a proof-of-principle experiment. If this demonstration is successful, then a second-generation device will be fabricated at large aperture to refine the technique. Concurrent with this work is the LLE effort to operate the existing adaptive optic, closed-loop system as close as practical to shot time to improve repeatability. Finally, high-spatial-resolution phase-front control will be investigated using the active device presented to the OLUG community on 29 April 2010. Note that the implementation of dynamic control may not be complete until FY12.

8. Omega 60 beam timing measurement accuracy.

At present, for delays or advances (offsets) of beams beyond about 10 ns from time zero, the accuracy within which one knows the beam timing drops to ± 0.5 ns. This often becomes the largest uncertainty in experiments with offsets in the 10 ns to 30 ns range.

Request: Develop the means to know the beam temporal offsets actually achieved on each shot, with an accuracy of order ± 0.1 ns. Such a capability would significantly improve the quality of experimental results from certain experiments.

LLE Response: The P510 streak camera system has an option currently available for a 40-ns sweep speed that is calibrated to give timing to < 0.1 ns over the requested 10-30 ns window. LLE recommends consulting with the Laser Facility Manager during the proposal phase (~2 months prior to shot day) to optimize configuration of the laser streak system to yield satisfactory pulse shape measurement simultaneously with precision timing.

9. Photographic documentation of some diagnostic and related systems.

In order to understand complex mechanical systems, it is often helpful to have photographic (and/or CAD) images to complement sets of mechanical drawings. This is definitely true of the TIM's. We suggest that such images be made available online for the TIM's. Both users and the facility should consider whether there are other systems that would also merit photographic and/or CAD documentation.

LLE Response: LLE concurs with the request to make a photograph-enhanced diagnostic glossary and will develop a standardized “cut-sheet” for each diagnostic. The OLUG Executive Committee will be notified as soon as the data are published on the website.

III OMEGA EP

1. Bring EP performance up to its full specification.

We fully appreciate that the OMEGA EP IR and UV beam energy must be limited to ensure that damage to expensive and difficult-to-obtain optical components is minimized during operations with the existing gratings and UV optics. On the other hand, it is OLUG’s duty to note that the user community needs access to the full performance of the laser facility to ultimately allow the exploration of the exciting new regimes in high-energy-density physics. The constraints, while essential, limit the experiments that have been conducted as well as the results that have been obtained so far. Though it should be also pointed out that outstanding results have been obtained with the present operating parameters of OMEGA EP, it is still the desire of the user community to have the facility operating at its specified performance at the earliest practical opportunity.

Endorsement: OLUG endorses LLE’s plan to develop and acquire high laser damage threshold IR and UV optics that will allow OMEGA EP to routinely operate at its design performance. OLUG requests that the facility management keep the OLUG Executive Committee apprised of the research and development plans that will allow OMEGA EP to reach design performance.

LLE Response: LLE is aggressively working to expand the operational envelope limits of OMEGA EP. The IR and UV energies on target are currently limited by laser induced damage. The constraints are due to the Laser Damage Threshold limits of gratings (short-pulse IR) and transmission optics (long-pulse UV). LLE will continue to share progress and plans on this item with the OLUG Executive Committee.

2. Bring design options forward to next OLUG workshop for 2ω and 3ω conversion of the PW beam.

There are some preliminary and tentative indications, from experiments performed in France, that the fast electron energy transfer and heating of background plasma is enhanced with frequency-converted light. More evidence will be gathered using the TITAN facility later this summer that will add to the knowledge base. Certainly, much greater control over the energy content of amplified spontaneous emission pedestal associated with petawatt laser pulses is ensured with conversion to 2ω and 3ω . This has been established as an important factor in cone-guided experiments. It is

prudent to have available engineering plans for frequency conversion of the PW beam if that is required for future experiments by the user community.

Recommendation: The OLUG requests that the facility management provide options for discussion at the next OLUG Workshop for frequency conversion of the PW beam.

LLE Response: LLE will commence a scope study to identify viable concepts for implementation of short-pulse frequency conversion. There is a high likelihood that conversion crystals, mounts, diagnostics, beam transport, and focusing systems will constitute a significant investment of LLE resources and require an NNSA approved construction project. A case study representing the need for this item would be beneficial in garnering NNSA support for a capital project.

3. Two Cu K-alpha imaging crystal spectrometers are needed for both OMEGA 60 and EP.

Understanding the physics of fast electron energy transport from petawatt-power laser-plasma interactions with solid targets requires the deployment of sophisticated x-ray diagnostics. Cu K-alpha imaging spectrometers have been developed in the United States over the past decade and have proved to be a powerful tool in diagnosing the heating of dense matter using intense laser pulses. These instruments are required on both chambers so that independent experiments can be carried out simultaneously. In each target chamber, they need to be deployed in orthogonal directions, so that spatial non-uniformities can be identified and characterized.

Recommendation: The OLUG requests that LLE management validate and deploy these imaging spectrometers as a matter of high priority in the coming year. The OLUG recognizes that the deployment of orthogonal instruments may pose difficulties, but the requirement for these instruments for each chamber is vital to the user program. We request that OMEGA provide a deployment plan to the Executive Committee for their consideration and report to the Workshop next year on issues arising.

LLE Response: A prototype crystal imager is being developed for MTW with plans to install a complete system on OMEGA EP in FY11. In the interim a “fast-track” crystal imager will be installed on OMEGA EP in FY10. In FY11, LLE will initiate projects to add a second crystal imager on OMEGA EP and two on OMEGA. Depending on resources available and other priorities, these projects may be carried out in FY11.

4. Two electron spectrometers are also needed for both target chambers.

Electron spectrometers are important tools for characterizing the behavior of intense laser-plasma interactions. They have applications in many areas, including wakefield acceleration, betatron x-ray source characterization, channel formation, and positron generation, among many others. The development of a university-based program requires the deployment of spectrometers with electromagnets that provide a wide window of particle energies, up to GeV particle energies. OLUG understands that LLNL colleagues have validated and deployed low-energy electron spectrometers in their experiments – these instruments need to become available to the wider community.

Recommendation: The OLUG requests that LLE management initiate a design and validation program for an electromagnet-based electron spectrometer for wakefield acceleration studies up to GeV particle energies. They request that electron spectrometers based on the LLNL design be made available to the wider academic community.

LLE Response: In FY11, LLE will initiate projects to ensure that there are two electron spectrometers on OMEGA EP and two on OMEGA. Depending on resources available and other priorities, these projects may be carried out in FY11.

5. LLE's contrast-ratio improvement program.

The OLUG were impressed with the presentation of Christophe Dorrer relating to the intensity contrast issues of the petawatt beam. The audience appreciated the identification of all the different components in the laser chain that contribute to the pedestal over its full range, some nanoseconds ahead of the pulse, some on its leading edge. The enhancement program was warmly received by the audience.

Endorsement: The OLUG strongly endorses LLE's contrast ratio improvement program. They fully endorse the timeframe outlined and want to be kept informed at the next OLUG Workshop on progress.

LLE Response: The OLUG Executive Committee will be kept abreast of all developments in short-pulse laser contrast enhancement.

6. 4 ω probe status.

The OLUG were impressed with the presentation of Wolfgang Theobald on the 4th-harmonic probe status. The probe commissioning is proceeding with good speed and the audience was delighted with progress so far. Nevertheless, concern was raised that the seeds are not from the same source and much closer attention to minimizing and measuring timing jitter is needed. In addition, the pulse energy is marginal and needs to be increased by an order of magnitude.

Recommendation: The OLUG requests that the timing jitter issue be addressed and an additional amplifier stage be added so that the probe energy can be increased when required. These changes should be reported to the Executive Committee.

LLE Response: The concerns of the OLUG have been communicated to the development team and will be closely monitored through the initial implementation of the 4 ω probe laser at its baseline performance level. Any requirements analysis for specific experiments that users can provide to the team would be helpful in motivating changes to the baseline requirements for this system. LLE will work to include design features for operation of the probe with maximum precision timing and as much energy as practical.

7. EP focal spot size of the PW beam.

The community welcomed the characterization by Brian Kruschwitz of the EP focal spot quality. They were satisfied that the encircled energy measurements he reported were consistent with other plasma diagnostics. However, concern was raised that the focus of the EP was insufficient for many future experiments and that effort is needed to reduce the 80% encircled energy radius by at least a factor of 2 (from 40 μ m to 20 μ m). They were delighted to hear about the new phase-front-corrector technology that will allow this development.

Endorsement: OLUG strongly endorses the development and implementation of the new phase front corrector as a matter of high priority.

LLE Response: See OMEGA section, response to item 7.

8. Polarization smoothing on all four UV beams.

The community was very impressed by the quality of the presentation from Sam Morse. They received the news of the concerted effort to address issues raised at the last workshop with great pleasure. They were particularly struck by the quality of his argument that the polarization smoothing technology had reached sufficient maturity to implement on EP and that the advantages over SSD smoothing were apparent.

Endorsement: OLUG unanimously accepted LLE's recommendation for polarization smoothing on all beams. They look forward to rapid implementation of the proposal and to receiving an updated progress report at next year's meeting.

LLE Response: User need for this feature remains unclear. If there is any specific analysis of an experiment that would benefit from this capability, please communicate to LLE as it will aid in justification of the cost. LLE is pursuing this item with no guarantee

that the acquisition will be selected for funding in FY11. The timeframe for implementation of polarization smoothing is 18-24 months after optics are ordered. Every effort will be made to expedite this acquisition as well as the mounts that will support the optics once the funding commitment is secured.

9. The planar cryogenic target handler needs to be implemented on EP for users.

A number of academics in the community raised the issue of fielding planar cryogenic deuterium targets for the EP chamber. They expressed concern that this technology was not available for cutting-edge transport and hydrodynamic experiments.

Recommendation: OLUG strongly endorsed the implementation of planar cryogenic target handling technology as a high priority. The community wants to see this target handling technology made available at the earliest opportunity.

LLE Response: LLE will consider the OLUG endorsement of this project in prioritizing laboratory resources in FY11. It is likely to take 12-18 months from project inception to initial capability deployment. LLE will keep the OLUG Executive Committee informed of the project status.

10. A full set (4) of 750- μm phase plates is needed.

The community expressed great pleasure that a number of phase plates had been acquired in response to their requests at last year's workshop. After considerable debate between different phase plate sizes, it was felt that a full set (4) of 750 phase plates are needed. These would be useful in the context of the long-duration hydrodynamics and laboratory astrophysics experiments that EP uniquely makes possible, by stacking beams in time. Running the specified maximum of 6 kJ in a 10 ns pulse, a 750- μm phase plate produces an average intensity of $1.4 \times 10^{14} \text{ Wcm}^{-2}$. Going to 1100 μm reduces the intensity to below $7 \times 10^{13} \text{ Wcm}^{-2}$. This is an important difference. One definitely wants to be above rather than below 10^{14} Wcm^{-2} for most experiments. In solid plastics, shocks will be driven not much more than 1 mm in 40 ns, so that 2D expansion is a smaller concern than having adequate intensity.

Recommendation: A full set of 750 phase plates is purchased and made available to community.

LLE Response: LLE appreciates the aggregation of OLUG requirements and distillation to a well defined recommendation. The acquisition of additional 750- μm Distributed Phase Plates to obtain a full set of four operational optics is in the FY11 acquisition plan.

11. Requirement for a limited reservoir gas jet target

Some academics expressed the view that gas-jet targets should be implemented on EP. They accepted the facility management's argument that an unlimited reservoir gas line risked the EP compressor grating actuators. However, they also recognized that many experiments would benefit from a gas-jet arrangement. It was felt that the burden of commissioning this technology should not fall on a single institution, but should be shared as a common resource. They agreed that a limited reservoir would add capability to a wide range of experiments.

Recommendation: The facility should design, validate and implement a limited reservoir gas jet target and make this available to the user community.

LLE Response: Development of equipment to provide a gas jet in the Omega Facility will require significant resources. Users interested in this capability should contact J. Soures, who will facilitate formation of a sub-committee to investigate the development of this capability. LLE resource allocation to this project is subject to balancing laboratory priorities. Project selection depends on developing a set of requirements that can be met within the system safety constraints.

12. Requirement for added flexibility for long-pulse operation.

The community was delighted by the performance of the long-pulse beams in their current configuration. The arrangement had produced some outstanding results and these were received by the audience with acclaim. After much debate, the community felt that if different ports, originally earmarked for long pulse operation, were made available, it would add substantial flexibility to experiment design and effectiveness. They endorsed the option of irradiation from opposite sides as one example.

Recommendation: The OLUG recommends that all ports originally earmarked for long pulse operation be brought into facility capability. The OLUG welcomes a report at next year's meeting on progress with options.

LLE Response: The 48°-cone-angle ports were proposed as an option in the OMEGA-EP project, but it was not supported by the users or NNSA at that time. It would be very expensive to fit out with UV beam transport paths, would take significant facility time, and would require capital project support from NNSA. A potential smaller-scale, higher-payoff alternative, was suggested at the OLUG meeting in April 2010: bring one or more beams to the back side of the target chamber. A feasibility study will be conducted to assess potential UV beam routing to the opposite side of the target chamber from the existing 23° UV beam ports.

13. Equivalent plane monitors for all UV beams.

The community felt that while the focal-spot monitor was adequate for some experiments, all experiments were complicated by a lack of knowledge of the quality of all beams away from their foci.

Recommendation: Equivalent plane monitors should be implemented for all beams. The OLUG welcomes a report on this issue at next year's meeting and trusts that this can be implemented with little disruption to operations.

LLE Response: The request for UV far-field measurements on all beams will be carefully considered. It would be helpful if the experimentalists requesting this feature would provide a range of spot sizes of interest for measurement. The UV-Diagnostic Package has provision for locating a far-field monitor and the LLE plan is to implement a phase plate holder in the diagnostic path for at least one beam. LLE will keep OLUG apprised of the progress in meeting this recommendation.

14. A new gamma-ray spectrometer diagnostic is required.

The community felt that a new gamma-ray spectrometer needs to be designed, validated and commissioned for the facility. Users requested that the spectrometer have a spectral range up to 20 MeV.

Recommendation: The OLUG requests that management consult the Executive Committee on the design, validation and implementation of this new instrument for the community.

LLE Response: OLUG scientists interested in this spectrometer should contact J. Soures, who will facilitate formation of a sub-committee on high energy photon spectroscopy. Once a consensus of requirements for sensitivity, spectral range, resolution, and other features are generated, the sub-committee and OLUG Executive Committee can provide LLE more definition of what is desired. LLE resource allocation to this project is subject to balancing laboratory priorities.

IV Other Facility Improvements

1. Dedicated user support for experiment design and theoretical modeling.

To maximize the productivity of both OMEGA 60 and OMEGA EP, it is important to have access to theoretical and computational support for both experiment design and data interpretation for university-based academics. Individual academics, who are motivated by curiosity-driven research in high energy density science, often find that they do not have

access to the necessary sophisticated computational models at all stages in the training cycle. The very nature of university life, where there is a high turnover of doctoral and post-doctoral research fellows, means modeling skills that the teams nurture and apply to specific problems can suddenly evaporate, leaving them without vital tools at critical stages in the research effort.

Ideally, the theoretical support team needs to be located within the larger-scale facilities. It must be of critical mass to provide the facility users with a wide range of modeling capability (e.g. one- and two-dimensional magneto-hydrodynamics simulations, implicit and explicit particle-in-cell and hybrid models for high intensity laser-matter interactions, quantum molecular dynamics for WDM studies etc.) and have dedicated access to large scale High Performance Computing (HPC) resources. Here are some desirable characteristics of the support team:

- Team members need to be involved at all stages in the experiment cycle and this obviously requires a collaborative approach by all parties.
- The team needs to be university focused and highly responsive to user demand. The team should assist with interpretation of smaller scale experiments undertaken on university scale facilities. This is particularly important with the reduction in cost and size of intense laser systems and the proliferation within academic institutions.
- The team needs to be of sufficient size so that members have enough time to develop their own research interests, in addition to their support duties. This should allow time to be devoted to the development of new codes, algorithms and possibly visualization routines.
- They need to be involved in training students and post-doctoral fellows in high energy density science, e.g. by co-supervision of PhD students etc.

Clearly, a balance must be struck between supporting experiments themselves and in maintaining a critical mass in the modeling support team.

Recommendation: The OLUG requests that LLE management establish a university focused support team, ideally comprising four staff members, with academics from other programs at LLE and/or other institutions. The team will make a huge difference to the quality and depth of publications arising from the facility.

LLE Response: After the 2010 OLUG Report is completed, LLE will request additional funding from NNSA and the Office of Science to support this request. LLE may request a letter from the Executive Committee endorsing this request.

2. Increased support from DoE to the NLUF program.

The OLUG recognizes and applauds the increased funding to the NLUF program in FY 2011/12 from the DoE (\$1.3M to \$1.6M). This has allowed the facility management to increase access under the NLUF program for the university community. The OLUG is also highly appreciative of the efforts of DoE officials to achieve this increase. The OLUG firmly believes that the establishment of new academic positions for young researchers in high-energy-density physics, working in partnership with the established academics and consortia (e.g. the Fusion Science Center) is a high priority for the growth of the field.

Recommendation: The OLUG strongly urges DoE to maintain the percentage increase in funding to the NLUF.

Recommendation: The OLUG urges DOE to develop and fund a program to accelerate the career progression for the brightest young dynamic researchers working in experimental high-energy-density physics by sharing the cost of their appointment with universities while they are at the assistant-professor level.

LLE Response: LLE recognizes the value of these requests, but clearly it is an issue for OLUG to communicate directly with DOE.

Findings and Recommendations of the Student/Postdoctoral Panel

Student/Postdoc Committee

Ryan Rygg (LLNL), Chair
Maria Barrios (Univ. of Rochester; LLE)
Tammy Ma (Univ. of San Diego)
Hioshi Sawada (Univ. of San Diego)
Dan Casey (MIT)
Andrea Kritcher (LLNL)
Louise Willingale (Univ. of Michigan)

1. There was continued interest in having extensive diagnostic information available online, such as reference papers and sample/calibration data linked from the Shot Request Form. The OMEGA staff has created a diagnostics forum, with threads for individual diagnostics, but it is up to the users to take the discussion there and populate it with useful

information, such as optimal setup or analysis techniques.

2. Published papers typically include descriptions of the basic experimental setup, results, and conclusions, but rarely include the full nitty-gritty details necessary to run experiments at OMEGA, or to analyze the raw data produced. Completed theses of prior students were identified as often including many of the useful details left out of published articles. University of Rochester theses containing work done at OMEGA are available on the LLE website, but it would be useful if theses from other institutions performed using OMEGA diagnostics were also collected and made available. It was also pointed out that the LLE Review has many articles which include such useful details not contained in published articles. Back issues of the LLE Review are available on the LLE website, but the content is not easily searchable.

3. Since HEDP is still a growing field, most academic institutions do not have enough interested students to hold dedicated classes on topics relevant to HEDP. It was suggested that experts in the field may be able offer lecture series or entire courses online. Roberto Mancini's recent spectroscopy class was held up as an excellent example, and additional topics would also be of interest. The MIT open courseware site was recommended as a model to enable instructors and students to share lecture notes and assignments.

4. The forum concluded with a discussion of the availability and acquisition of jobs in the field, including those in academia, government laboratories, publishing, and government administration.

Conclusions and Future Workshops

This OLUG workshop, with over 115 attendees, was part of a process that will keep members of the Inertial-Confinement-Fusion and High-Energy-Density Physics communities involved in conversations and collaborations with each other and with the OMEGA facility. In addition, OLUG Executive Committee members and the OMEGA Management have been meeting on a bi-monthly basis to assess progress, compatible with facility resources and impact, towards the implementation of the *Findings and Recommendations*. Progress will be reported upon at a satellite meeting at the Chicago APS Meeting (9 November 2010), and in depth at the next Users Workshop.

The next OMEGA Users Workshop will be held at LLE on April 27-29, 2011, and plans for it are already well underway. To this end, significant financial support from NNSA has already been procured to help defray the cost of student and post-doc

travel. We anticipate that this next workshop will be as exciting and memorable as the first two. Come join us!

Acknowledgments

For capturing the ambiance and spirit of the workshop through his camera lens, we thank Eugene Kowaluk. To NNSA, we gratefully acknowledge the financial assistance for student/postdoc travel expenses. We thank the University of Rochester Fusion Science Center, and the Office of Fusion Energy Science, for cosponsoring the OMEGA Users Group Workshops. We thank LLE for supporting this effort in numerous ways.

This synopsis was compiled and edited by R. D. Petrasso (petrasso@psfc.mit.edu) of the MIT Plasma Science and Fusion Center, with critical input and contributions from Workshop attendees, the Executive and Student/Postdoc Workshop committees, and the LLE management. Please send corrections to R. Petrasso. The final synopsis will be posted at http://www.lle.rochester.edu/about/omega_laser_users_group.php.

Appendix: Agenda of the Second OMEGA Users Group Workshop April 28 – 31, 2010

Wednesday, 28 April 2010

7:15	Registration (East entrance to LLE)	
7:30-8:20	Continental breakfast	
8:25-8:30	Welcome	Robert L. McCrory, Jr.
8:30-8:45	Workshop objectives, working groups, announcements, queries	Richard Petrasso
8:45-9:15	High energy density physics: an astrophysicist's perspective	Robert Rosner
9:15-9:45	How charged particles equilibrate in HED plasmas, and why we care	Guy Dimonte
9:45-10:15	Transitioning diagnostics and platforms from OMEGA to NIF	Joseph Kilkenny
10:15-10:30	Break (refreshments, 10:00-12:00)	
10:30-10:45	Role and importance of HED laboratory physics from a DoE/NNSA perspective	Allan Hauer
10:45-11:15	Facility update: progress on 2009 OLUG recommendations	Sam Morse
11:15-11:45	EP and OMEGA performance improvements	Keith Thorp
11:45-12:00	EP contrast measurements	Christophe Dorrer
12:00-12:30	Target Basics	Brent Blue
12:30-12:50	Workshop photo; student/postdoc/young researcher photo	
12:50-1:45	Lunch (Box lunches); OMEGA and OMEGA-EP tours	
1:30-4:15	Poster Session I (east entrance lobby)	
3:30-5:00	Refreshments	
4:15-7:00	Poster Session II (east entrance lobby)	

Thursday, 29 April 2010

7:30-8:20	Continental breakfast			
8:20-8:30	Announcements & Queries			
8:30-9:00	Diagnostic qualification and infrastructure update	Greg Pien		
9:00-9:15	EP focal spot characterization	Brian Kruschwitz		
9:15-9:30	4th harmonic probe status	Wolfgang Theobald		
9:30-9:45	Spherical Imaging Diagnostic progress	Gennady Fiksel		
9:45-10:15	Laboratory astrophysics at OMEGA and the NIF	Paul Drake		
10:15-10:30	Break (refreshments, 10:00- 12:00)			
10:30-11:00	Critical physics issues for fast ignition	Peter Norreys		
11:00-11:30	Benchmarks for achieving ignition	Riccardo Betti		
11:30-12:30	Role and importance of HED laboratory physics from a DOE perspective:			
	11:30-11:45	Office of Fusion Energy Sciences	OFES representative	
	11:45-12:00	Office of the Under Secretary for Science	Kim Budil	
	12:00-12:30	Panel and open discussion with DOE		
12:30-1:30	<i>Lunch (box lunches); OMEGA and OMEGA-EP tours</i>			
1:30-2:30	Student/postdoc/young researcher's forum and discussion			
3:00-5:00	<i>Refreshments</i>			
2:30-6:30	Working group breakout sessions; contributed oral talks			
7:00-10:30	<i>Dinner and no-host reception: Delmonico's Italian Steakhouse</i>			

Friday, 30 April 2010

7:30-8:30	Continental breakfast	
8:30-9:30	Working group breakout sessions continue	
9:30-11:30	Presentation and discussion of working group findings with LLE management; Executive committee begins write-up of findings/workshop report	
10:30-12:00	<i>Refreshments</i>	
11:00-12:30	Job fair and interviews for postdocs, young researchers	
12:30-1:30	<i>Lunch (box lunches); OMEGA and OMEGA-EP tours</i>	
1:30-4:00	Job fair and interviews for postdocs, young researchers; adieu	