The Omega Laser Facility Users Group Workshop 29 April – 1 May 2009

Introduction

More than 100 researchers from 29 universities and laboratories and 4 countries gathered at the Laboratory for Laser Energetics (LLE) for the first Omega Laser Facility Users Group (OLUG) Workshop (see Fig. 120.1). The purpose of the three-day workshop was to facilitate communication and exchanges among individual Omega users and between users and LLE; to present ongoing and proposed research; to encourage research opportunities and collaborations that could be undertaken at the Omega Facility and in a complementary fashion at other facilities (such as LULI or the NIF); to provide an opportunity for students and postdoctoral fellows to present their research on OMEGA in an interactive, yet congenial, atmosphere; and to provide feedback to LLE from the users about ways to improve the facility and future experimental campaigns. Interactions at the workshop were spirited and lively, as can be seen in the photographs shown in this article. The names and affiliations of the 156 members of OLUG can be found at **www.lle.rochester.edu/pub/OLUG/OLUGMEMBERS.pdf**.

Invited talks on the facility and science were given during the first two mornings of the workshop. The facility talks were especially useful for those not intimately familiar with the complexities of performing experiments on OMEGA and OMEGA EP. The six overview science talks, given by leading world authorities, described the breadth and excitement of high-energy-density (HED) science undertaken on OMEGA, both present and future. The final overview talk concerned

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Figure 120.1

More than 100 researchers from around the world, from 29 universities and laboratories, attended this workshop. Workshop reports and nearly all 62 presentations can be found at **http://ouw.lle.rochester.edu**. Plans for the next OLUG Workshop to be held 28 April–1 May 2010 are well underway, with significant financial support from the National Nuclear Security Administration (NNSA) already allocated for student/postdoctoral travel expenses.

the role and importance of science to the National Nuclear Security Administration (NNSA) mission. The next section of this article contains a summary of the range of presentations; nearly all presentations can be found in their entirety at **http://ouw.lle.rochester.edu**.

Thirty-two students and postdoctoral fellows (Fig. 120.2), 27 of whom were supported by travel grants from NNSA, attended the workshop and presented 31 of the 48 contributed poster and oral presentations. The presentations ranged from target fabrication to simulating important aspects of supernovae. The presentations generated lively discussions, probing questions, and friendly suggestions. Seventeen excellent contributed presentations were made by professional scientists and academics.

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Figure 120.2
Students and postdoctoral fellows. Thirty-two students and postdoctoral fellows attended and presented 31 of the 48 contributed poster and oral presentations. Equally important, the student/postdoctoral panel wrote an outstanding report (p. 176) on how to improve the Omega Facility and on the opportunities and challenges young researchers face in implementing experiments at OMEGA and other HED facilities.

An important function of the workshop was to develop a set of recommendations and findings to guide future priorities for OMEGA. These findings were grouped into five areas: 60-beam OMEGA, OMEGA EP, General User Issues, Information Flow, and Broader Issues. These categories comprise a report provided to the Omega Laser Facility management. The original report and the management response are described in **Findings and Recommendations of the Executive Committee** (p. 168) and can be found at http://ouw.lle.rochester.edu. LLE management will use these recommendations as a guide for making decisions about OMEGA operations, priorities, and future capabilities. To cement this process, OLUG Executive Committee members and Omega management have been meeting on a bimonthly basis to assess progress toward achieving these objectives.

One highlight of the workshop was the student/postdoctoral panel that discussed their experiences at the Omega Facility and their thoughts and recommendations on facility improvements. Wide-ranging and engaging discussions resulted in the student/postdoctoral report contained in **Findings and Recommendations of the Student/Postdoctoral Panel** (p. 176) and at http://ouw.lle.rochester.edu.

The next OLUG Workshop will be held at LLE on 28 April–1 May 2010. Meetings of the Users Group and interested members of the HED community are formulating plans for this workshop and reviewing progress on implementing the **Findings and Recommendations** (p. 168) of the first workshop. These meetings were held at the IFSA Conference (8 September 2009) and are planned for the APS conference in Atlanta (3 November 2009).

The Presentations

Sixty-two talks and posters presented during the 2009 workshop focused on ongoing fast- and shock-ignition experiments; materials under extreme conditions on OMEGA and, in the near future, at the NIF; the critical role that simulations play in designing and interpreting experiments; the physics connections between the Omega Facility and the European ICF program; and present and future laboratory astrophysics experiments on OMEGA and the NIF.

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

Forty-eight contributed posters and talks covered a wide spectrum of work on the Omega Facility, from target fabrication to fast-ignition experiments to basic and novel nuclear physics experiments (see http://ouw.lle.rochester.edu). Work on the opportunities for taking physics platforms developed on OMEGA to other facilities that are both larger (the NIF) and smaller (Jupiter, Trident, and LULI) was presented. The presentations, invited and contributed, formed much of the basis for discussions regarding the Findings and Recommendations and future capabilities, found in the next section (p. 168).

The following photographs (Figs. 120.3–120.21) provide a representative sampling of the workshop's talks, interactions, and spirited ambiance. A much larger collection of photographs can be found at http://ouw.lle.rochester.edu.

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Figure 120.3
Postdoctoral fellow Dr. Angelo Schiavi (Roma University) discussed, on behalf of his European colleagues, the latest theoretical developments in fast ignition. Dr. Schiavi delighted workshop attendees, not only with the clarity and depth of his presentation, but with his humorous and entertaining remarks!

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Figure 120.4
Dr. Ryan Rygg, an LLNL postdoctoral fellow, was chair of the student/postdoctoral panel (see their report herein and on http://ouw.lle.rochester.edu). Dr. Rygg is a frequent experimenter at the Omega and Jupiter facilities and is collaborating with MIT researchers on nuclear diagnostics currently being implemented at the National Ignition Facility. He is a member of Dr. Rip Collins's Shock/Materials Group (see Fig. 120.5) at LLNL.

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Figure 120.5
Probing the interiors of the planets through materials experiments on OMEGA, and soon at the NIF, was the focus of LLNL's Dr. Rip Collins's presentation. Here he describes how the inaccessible (planet interiors) becomes accessible through such laboratory experiments. Dr. Collins's gave an animated description of the challenges of compressing a tofu-like material to densities of ~100 g/cm^3 (five times the density of gold).

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Figure 120.6
Professor Peter Norreys of Rutherford-Appleton Laboratory discussed the reasons that the testing and development of fast-ignition concepts on OMEGA are so critical in preparing for and guiding the European consortium's fast-ignition experiments. Dr. Norreys is a member of the OLUG Executive Committee.


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Figure 120.7
Postdoctoral fellow Dr. Carolyn Kurantz (University of Michigan) makes decisive and unequivocal points about the subtleties and challenges of laboratory astrophysics experiments that she and colleagues have been implementing on OMEGA as part of their NLUF program, an effort led by Prof. Paul Drake. Dr. Kurantz is a member of the student/postdoctoral panel, and Prof. Drake is a member of the Executive Committee.


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Figure 120.8
During a coffee break, LLE Ph.D. student Maria Barrios (right) discusses her work and presentation on shock-compressed materials with her former professor Dr. Sharon Stephenson (Gettysburg College).


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Figure 120.9
Postdoctoral fellow Dr. Louise Willingale (University of Michigan) contemplates her response to a workshop attendee's query about aspects of her OMEGA EP experiment involving proton emissions from OMEGA EP's short-pulse beam interacting with a flat target. Dr. Willingale is a member of the student/postdoctoral panel.


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Figure 120.10
Keith Thorp, the Omega Facility Manager, presented an overview of the planning, processes, and coordination needed to conduct a successful experiment on OMEGA. Such talks gave attendees the opportunity to meet with, and hear from, some of the key individuals responsible for operating and improving the facility. Mr. Thorp is one of the many dedicated staff members involved in, and orchestrating, the day-to-day facility operations.

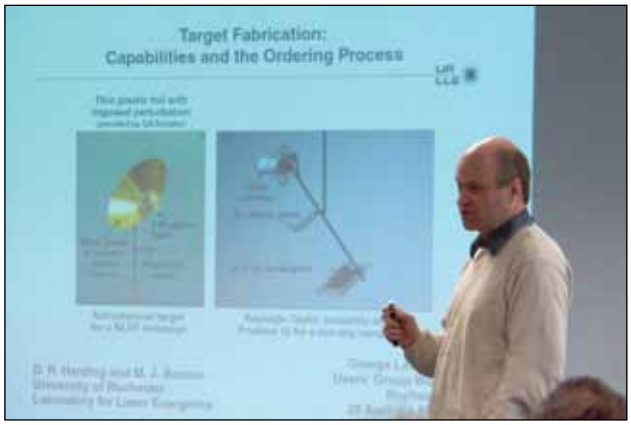

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Figure 120.11
Targets are a critical part of any experiment. Here, LLE's Dr. David Harding describes the range and complexity of targets that are designed and then meticulously assembled and characterized prior to their fielding. Each step in the process requires demanding attention to detail and design, often requiring many interactions between the experimenter and the target-manufacturing team. Most targets are manufactured at General Atomics (GA); the scope of GA's work was presented by Brian Vermillion. As the saying goes, "the targets are just as important as the laser"—a perspective that we are sure is shared by Dr. Harding.

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Figure 120.12
The crucial role that basic science, and OMEGA in particular, plays in NNSA's program was described by Dr. Chris Deeney, who heads the ICF branch of NNSA. NNSA was responsible for providing vital financial aid to 27 students and postdocs who attended the workshop.

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Figure 120.13
Spirited and lively discussions often ensued in poster and workshop breakout sessions, with the results of these discussions contained in the Reports of **Findings and Recommendations** [herein (p. 168) and at http://ouw.lle.rochester.edu]. Many of these "findings" are currently being implemented by OMEGA management, and discussions between management and the OLUG Executive Committee continue on a bimonthly basis.

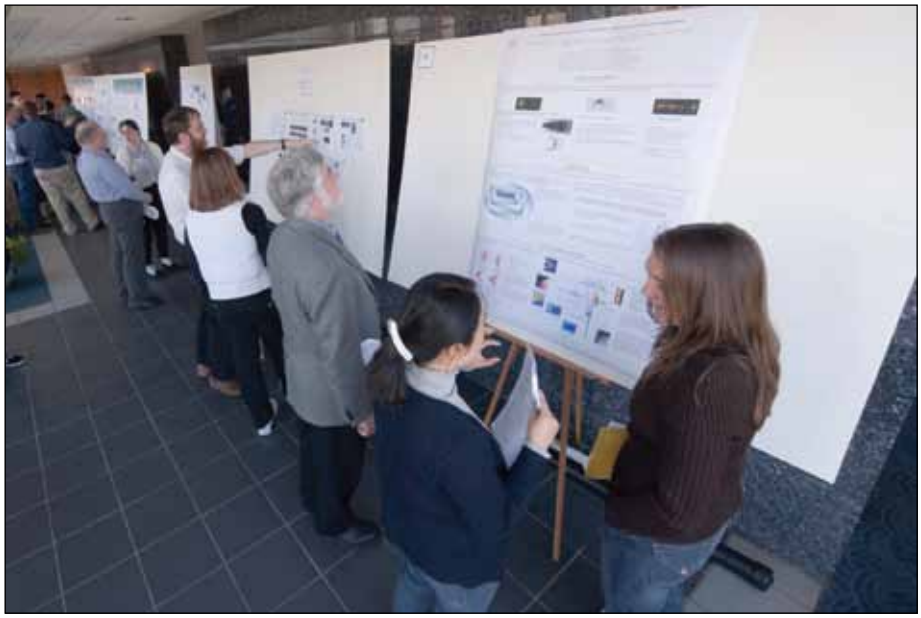
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Figure 120.14
The 62 workshop presentations, some of which are shown here during the poster session, covered a wide spectrum of cutting-edge, high-energy-density science relevant to OMEGA, the NIF, and other HED facilities.


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Figure 120.15
Here, Ph.D. student Teresa Bartel of the University of California–San Diego discusses her OMEGA EP experiments with Dr. Steve Craxton, one of LLE's theoretical physicists. Ms. Bartel's poster focused on proton beams relevant to fast ignition, one aspect of which was the exploration of proton-conversion efficiency achievable on OMEGA EP. A too-low proton-conversion efficiency would preclude this impulsive heating scheme for fast ignition. Ms. Bartel is a member of Prof. Farhat Beg's group.

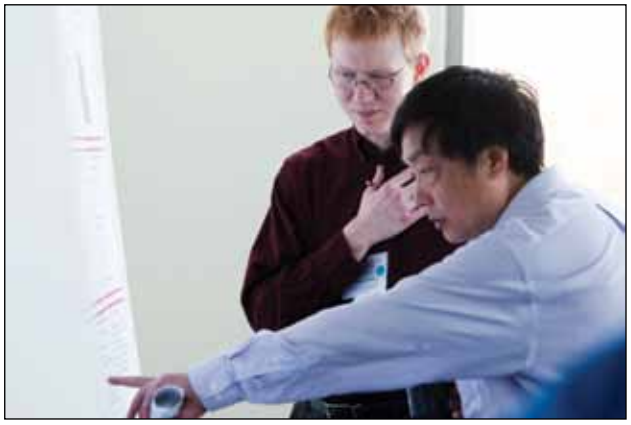
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Figure 120.16
Theoretical Ph.D. student Matt Terry of the University of Wisconsin–Madison listens intently to the query of experimentalist Dr. Chikang Li of MIT, regarding Matt's work on the stopping power of energetic particles in dense, hot plasmas. Such problems, while of basic interest to HED physics, are of special relevance to ICF where, for example, the stopping and energy deposition of alphas are crucial to the ignition instability. Matt discussed several theoretical stopping models and the differences between them. Could such differences, sometimes small, have subtle but nontrivial consequences on ignition criteria, making it either easier or more difficult to achieve ignition at the National Ignition Facility?


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Figure 120.17
At his poster about the measurements of fields associated with Rayleigh–Taylor (RT) instabilities, MIT Ph.D. student Mario Manuel talks with theoretical physicist Dr. Serge Bouget of CEA, France. Mr. Manuel's experimental investigation, conducted as part of MIT's NLUF program, utilizes monoenergetic 15- and 3-MeV protons to probe, via the Lorentz force, magnetic fields in RT experiments. Such posters, informal working groups, and frequent coffee breaks led to many opportunities for young researchers to interact and discuss their research with workers from a broad range of fields and experience within the world-wide high-energy-density physics community.


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Figure 120.18
The Omega Users Executive and Student/Postdoctoral Committees discuss details and assignments for writing the findings and recommendations of the workshop. The two committee reports and the initial management response can be found at http://ouw.lle.rochester.edu and in this document. The process of improving the Omega Laser Facility is an ongoing activity involving bimonthly meetings between the Executive Committee members and Omega management. Progress on the recommendations will be given in a satellite session at the Atlanta APS meeting (3 November 2009) and at the next OLUG Workshop (28 April–1 May 2010). An important finding of both committees was the excellence with which the Omega Laser Facility is run, offering exciting opportunities to users to perform world-class experiments.


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Figure 120.19
The French came in full force to the workshop, bringing a dashing but friendly contingent with exciting ideas and zest! Vive La France!


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Figure 120.20
A workshop banquet at the University of Rochester's Faculty Club offered an enjoyable evening for all workshop attendees.


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Figure 120.21
Our European colleagues share a light moment at the workshop banquet.

Findings and Recommendations of the Executive Committee

Executive Committee:

Richard Petrasso, Committee Chair, Massachusetts Institute of Technology
Hector Baldis, University of California–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
Marilyn Schneider, Lawrence Livermore National Laboratory

1. Introduction

Extensive formal and informal discussions occurred during the workshop regarding (1) ways in which the Omega Facility could be more effective in using existing resources and (2) new capabilities or technologies that would be highly desirable. It is important to stress that there was a resounding response by the workshop attendees that the Omega Laser Facility is extremely well run and that the team operating it is both highly dedicated and very skilled.

Two workshop reports were written. The first, by the OLUG Executive Committee, was a summary of the views of the workshop attendees (108 professional scientists and engineers, academics, students, and postdocs from four countries). Its findings were grouped into five areas: 60-beam OMEGA, OMEGA EP, general user issues, information flow, and broader issues. The second report was written by the student/postdoctoral panel.

These two reports have many common issues, especially those relating to information flow and to the process of preparing for and executing campaigns in the OMEGA environment. This commonality is, in part, due to the challenging complexity, especially for new users, of the facility and its operations, even though there are myriad tools at the Omega Facility to navigate through this process. As will be obvious in the different sections of the Executive Committee report, these themes were often repeated. The management response was written to address the issues that were raised on the last day of the workshop (1 May 2009), and because sections of the Executive Report, as well as the management response, were written several days after the workshop, there is a slight mismatch between the issues of the formal Executive Report (contained herein in Secs. 2–6, pp. 168–172) and the Management Response. Because of the complexity of the issues involved and the need to iterate from recommendations to what is actually achievable from the management point of view, this report must be considered a work in progress. To that end, OLUG meets bimonthly with Omega management to discuss (1) what can be realistically achieved and (2) progress toward implementing the workshop findings and recommendations. Progress on the recommendations will be presented at the Atlanta APS meeting (3 November 2009) and at the next Omega Laser Facility Users Group Workshop (28 April–1 May 2010).

2. OMEGA (60 Beams)

The users developed a list of desired improvements to enhance the use of the 60-beam OMEGA Laser. The following information reflects both the degree of resonance across the users and the degree of importance to specific subgroups of users.

a. Delay and conflict information: A web page could be designed to provide the top 15 or so typical delays generated by decisions about how an experimental day is constructed. Examples would include the delays associated with repointing beams or moving a framing camera. This is of value to help users better develop their initial plans for shot days.

b. More options for driving the laser legs: The minimum functionality sought here is less than the ultimate one. The ultimate functionality would be the ability to drive any leg from any driver. We recognize that this is a tall order. The minimum functionality is the ability to use the smoothing by spectral dispersion (SSD) driver on one leg while using another driver on the other two legs. (This may include enabling the backlighter to drive on any two legs.) Having the capability to operate SSD and main drivers simultaneously could be quite important to x-ray Thomson-scattering experiments, an emerging area where much greater activity can be anticipated.

c. More static x-ray pinhole cameras: These diagnostics are rarely, if ever, critically important but are of value in assessing whether an experiment performed as intended. Their number has decreased in recent years and it would be helpful to see a few cameras re-activated.

d. More SG8 or similar phase plates: This would be particularly useful when users share shot days. Whether SG8's are the right choice or how this integrates with phase plates for OMEGA EP was not addressed. Most users agree that having some phase plates for OMEGA EP is far more important than having additional ones for the 60-beam OMEGA.

e. Spherical crystal imaging: This would be a very useful diagnostic if implemented and engineered to the point of being routinely available. The users understand that this would be an expensive prospect and do not rank it above other ways to spend the necessary funds. The users strongly encourage support for any effort by a major laboratory to implement this diagnostic.

3. OMEGA EP

a. Beam smoothing: Distributed phase plates (DPP's) significantly improve the spatial uniformity of irradiation in the focus of high-power laser beams. They reduce the growth of parametric instabilities, which have a number of deleterious effects, such as the generation of hot electrons (this causes preheat of the irradiated targets) and reduced coupling of laser energy to the plasma.

OLUG recommends the installation of 1-mm-spot-size DPP's on the long-pulse beamlines. This provision would benefit a number of users of the facility.

Temporal smoothing can be achieved with the implementation of smoothing by spectral dispersion (SSD). OLUG is aware that a preamplifier module (PAM) is being installed on the OMEGA laser to study two-dimensional SSD for direct-drive ICF at the National Ignition Facility (NIF).

OLUG urges facility management to make the necessary modifications to the NIF PAM so that it can be used as an alternate front end for OMEGA EP and allow for 2-D SSD studies to be implemented for the user community.

b. Pulse shaping: The NIF will be using long-pulse durations for some studies. Staging experiments from OMEGA EP to the NIF may need similar pulse shapes in the future.

OLUG recommends that options for implementing pulse shapes similar to the NIF's (100 ps to 30 ns) be explored by management so that an assessment of priorities can be made at the next OLUG meeting.

c. Intensity-contrast-ratio enhancement: The coupling of energy from the intense laser pulse to the fast-electron beam may be significantly affected by magnetic fields formed near the ablation front by the plasma generated by the prepulse. These fields have the effect of reducing the number of fast electrons entering the target. It may be necessary to improve the intensity contrast ratio to get better coupling.

OLUG recommends that options for enhancing the intensity contrast ratio be explored by management so that an assessment of priorities can be made at the next OLUG meeting.

d. Implementation of low-energy probe beams: Optical probes provide a range of powerful diagnostic tools that can be used to extract information from underdense laser-produced plasmas. Density gradients, for example, can be obtained from both shadowgraphy and Schlieren imaging, while density information can be extracted by unfolding interferograms and magnetic fields can be obtained with the simultaneous use of polarimetry. The working group is aware of the funded project to implement a 10-ps fourth-harmonic probe line for OMEGA EP by the end of this fiscal year.

OLUG urges management to make the completion and realization of this project a very high priority. These diagnostics will be of great assistance to a large number of users of the facility.

e. Addition of streaked optical pyrometry (SOP) with the active shock breakout (ASBO) diagnostic: The active shock breakout (ASBO) diagnostic has proved to be a valuable tool to study high-pressure equation of state of materials, as well as shock timing for inertial confinement fusion. The instrument has been used extensively by investigators based at a number of universities and national laboratories since the upgraded instrument was commissioned in 2006. A laser probe beam is used to illuminate the rear surface of the target. When the shock wave reaches the back surface of the witness plate, it rapidly heats the surface, resulting in a dramatic reduction in reflectivity of the probe beam. This makes it possible to measure shock-breakout times with high temporal and spatial resolution.

The provision of two "velocity interferometer for any reflector (VISAR)" channels is a unique feature of the upgraded instrument. These channels have different velocity sensitivities that make it possible to resolve any 2-D ambiguity that arises at velocity discontinuities. The working group agreed that the addition of passive streaked optical pyrometry (SOP) channels would be a valuable addition. These channels would make it possible to measure the lower radiation temperatures and shock pressures.

OLUG recommends the simultaneous provision of SOP with the ASBO diagnostic suite.

f. Spherical crystal imaging: Monochromatic x-ray imaging of high-photon-energy K_α radiation has proved to be a valuable tool in diagnosing energy transport in intense laser–plasma interactions. This has provided information in cone wire plasmas: for example, the energy coupling and the resistive electric field required to draw the return current. Many experiments will benefit from the provision of Ti, Cu, and higher-Z K_α imaging spectrometers.

OLUG recommends the provision of a spherical crystal imaging diagnostic on OMEGA EP.

g. Record of electromagnetic pulse (EMP) and radiological noise: High-intensity laser environments are harsh. Active diagnostics suffer considerable damage because of EMP, x-ray bremsstrahlung radiation, and (p,n)-induced activation of diagnostics placed close to the targets.

OLUG recommends that a record of instruments and detectors that have suffered from EMP and radiological noise damage be made available to facility users so that mitigation strategies can be undertaken when planning experiments.

h. Penalty and conflict information: It would be very useful when preparing experiments to have an appreciation of the time delays that are likely to occur as a result of changes to diagnostics, target alignment, and laser specifications during experimental campaigns.

OLUG recommends that a record of known delays be made available to facility users so that users are more aware of the costs of decisions.

4. General User Issues

A number of issues common to users of both OMEGA and OMEGA EP were discussed. These issues are based on operational details relevant to preparing and executing experiments, as well as the flow of information and communication between facility personnel and users, as well as among users themselves. The following points summarize these issues and *recommendations*:

(a) A number of users have indicated that it would be important to have available a larger volume of information and knowledge about facility operational details and the way in which they can impact the setup and execution of experiments. The information could include relationships between changes in laser-pulse energy, shaping, and smoothing options during a shot day, and their impact in shot delays, including a possible loss of shots. In general, the issue is, What is the optimal way to plan for these changes during a shot day (e.g., what is best to do first, second, etc.)? The idea is that what actually happens during the day (or half day) of shots is likely to be a compromise determined by practical facility operational details and considerations of science goals. How can changes and modification of diagnostic configurations during the shot day, relative to what was discussed in the initial plan, impact shot execution, and what conflicts or incompatibilities may arise?

The idea was proposed of having the option of starting the discussion process with relevant personnel in the facility several months ahead of time to detail the experimental proposal for the shots.

This is currently being done as the result of submitting the detailed experimental proposal two months ahead of the planned time. OMEGA and OMEGA EP users would like to have the option of starting this discussion process earlier or have alternative avenues available to them to address these issues.

(b) Another point of common concern is that of calibrating and characterizing diagnostics available on OMEGA and OMEGA EP. Flat fielding of streak and framing cameras is a typical example relevant to many users but certainly not the only one. The performance of streak and framing cameras has a broad impact on experiments since they are used in a variety of experimental campaigns, in different ways, to record valuable time-resolved data. Currently, users have to plan for characterizing and flat fielding these cameras as part of their own shot campaigns. The information they produce in this regard is potentially useful to many users. It would be more efficient and effective if this information could be made available to users on a standard basis and if it could be generated in such a way that it would not tax the shots dedicated to a given science campaign; i.e., it would not require dedicated shots allocated to a user that could have otherwise been used to address a science point. Two possible ways to address this issue were discussed. Characterization and flat fielding of streak and framing cameras could be done as a ride-along task; this would require planning and organization so that opportunities are not missed and sufficient and reliable information is recorded to achieve this goal. The facility could dedicate shots to perform this task or could include it as part of their regular facility maintenance.

Regardless of the way in which it is done, it was clear from discussions that there is a strong consensus among users

that characterizing and calibrating diagnostics available on OMEGA and OMEGA EP is an important point that affects many users and a critical issue that must be addressed.

(c) Evaluating and assessing the facility performance and the experimental campaign was an important topic of discussion since it provides an opportunity for users to convey feedback and comments to the facility management. Current procedures on OMEGA include an Effectiveness Assessment form that must be returned by the principal investigator (PI) to the Shot Director after each shot and an Experimental Critique sheet that is submitted during the week subsequent to the week of the shots. The sense among users was that, while there is value in the feedback provided in the Effectiveness Assessment form, this is done under pressure and too hurried. The quality of the feedback and comments provided in the Experimental Critique sheet is better the week after the shots. A thorough assessment of the experimental campaign, including the quality and quantity of the data recorded and how well the science goals were achieved, is something that often requires considerably more time.

OLUG recommends having the option to provide feedback on the experimental campaign, including facility performance, target fabrication, and level of accomplishment of science goals a few months after the shots. This feedback is likely to be the most accurate and realistic. The idea was also suggested to provide a place on the OMEGA web site accessible by users (via log-in and password) indicating the current status of OMEGA and OMEGA EP diagnostics.

(d) Better and more-complete information about the instruments and diagnostics available on OMEGA and OMEGA EP is needed.

This could be accomplished by establishing links in suitable web pages on the OMEGA web site, including (but not limited to) Shot Request Forms (SRF's), to internal reports and journal papers that document the details of instruments and diagnostics.

(e) The role that C. Sorce plays in LLNL experimental campaigns as a technical link between scientists (PI's) and facility engineers and technicians has been noted and praised by many users not involved in LLNL campaigns.

It was suggested that it would be useful to have a similar resource person to perform that task for all experimental campaigns.

(f) *OLUG recommends the continued use of Be in OMEGA and OMEGA EP shots.*

(g) *OLUG recommends additional office space be allocated for (outside) users when they are visiting and preparing for their shots.*

(h) *OLUG recommends that space be provided on the OMEGA web site to post information of common interest to many users as well as to establish web pages for areas of interest for groups of users, e.g., Thomson scattering, x-ray spectroscopy, particle measurements, etc.*

5. Information Flow

This topic involves better communication with Omega Facility users. In general, there is very good communication between LLE and users; however, the amount of information required for a successful campaign on OMEGA is very large. The suggestions represent the distilled recommendations of the Users Group to improve communication, *which is especially important for new users or those who have no LLE collaborators*.

a. Diagnostics: Just as the laser-pulse-shape "Help" page describes choices for laser pulses, a "Help" page for diagnostics would be of great benefit. This might be accomplished with an upgrade to the ***Diagnostic Status*** link on the OMEGA operations page. To the list of "Diagnostic Name" and "Lead Scientist," etc., the *upgrade* would add a brief description (a couple of sentences) of available SRF choices and links to published papers employing the diagnostic. For x-ray imagers, the page could list the date of the last flat fielding.

- If possible, a search-engine capability for diagnostics is attractive because it could enable would-be users to find out *who has recently used or is planning to use* specific diagnostics. The search could cover all SRF's within a +2/–1-month window with the idea of returning the names of PI's (who composed the SRF's) so that potential users of that diagnostic could contact them regarding how well it functioned and exchange details of actual/intended use. This should not violate accessibility/restriction of SRF's to users who may not be authorized to view an SRF in totality but is intended only to better communicate reasonable knowledge from one user to another. A corollary to this is an LLE-sponsored blog or "wiki" for areas of user interest, e.g., x-ray Thomson scattering or x-ray framing cameras.

- A new LLE notification procedure concerning *diagnostic status* would benefit users. Just like Laboratory staff are notified when credit for various training courses necessary for employment is about to expire, PI's could be notified if a primary diagnostic for their upcoming campaign becomes "unavailable." The implementation for this might involve automated email to all PI's for shots for the next ~2 months (a time period to be determined) when a diagnostic goes "off line." This may result in an increase of email to PI's who are not interested but could result in a reduction of surprises to PI's who are counting on using a particular diagnostic for future shots for which SRF's have not yet been created.

- Not all diagnostics are LLE diagnostics. Occasionally, it is desirable to test or flat field a user's diagnostic prior to the user's shot day. One means through which this might be accomplished is to provide an "empty-TIM" web page. Similar to the *Diagnostic Status* page, this page would list all empty TIM's for shots occurring during the next quarter. It could list the shot PI, the campaign, the target characteristics, and the laser energy on target. The intent is to make possible the *ride-along* testing of a user's diagnostic. Such multiplexing of experiments may increase the overall productivity of the facility. For example: the "neutron days" often conducted by V. Yu. Glebov attract a host of users with various TIM diagnostics that benefit from testing; the pointing shots conducted for LLE cryo shots can also be used in a similar way. If a user's imaging diagnostic or spectrometer can be fielded as a ride-along, or an x-ray flat fielding can be accomplished without costing a shot, this would increase productivity.

b. OMEGA EP Information: A high level of enthusiasm for OMEGA EP exists. Although it is recognized that OMEGA EP is a work in progress, the users' community is eager for status reports on OMEGA EP. OLUG recommends that, as soon as is practical, members of the users' group receive updates on OMEGA EP pulse-shaping capabilities, including

- minimum pulse length
- energy limits in relation to pulse width
- OMEGA EP contrast
- blast-shield status
- energy/power/focusability limits with blast shields

c. Miscellaneous: Similar updates are desirable for other OMEGA systems:

- phase-plate availability and numbers for both the 60-beam OMEGA and OMEGA EP
- DT-fill capability, especially with regard to changes in procedure that may affect LLE's ability to fill and field targets

6. Broader Issues

The Executive Committee, while recognizing that this issue is outside the scope of this report, expressed concern about the absence of direct support for diagnostic development at universities in general. This has an exacerbating effect on hands-on training in an era of increasingly formal facility operations. This issue is especially important to students and postdocs.

There is a general need for more small facilities as staging grounds for hands-on training, diagnostics, and experiment development. Again, students and postdocs are significantly impacted by this circumstance.

With regard to related research at other facilities, OLUG recommends that we proceed with the HIPER/US workshop to promote joint and complementary research on HEDP physics. In a similar vein, efforts should be made to coordinate and promote complementary physics research among Omega and other important HED laser facilities such as the NIF, LULI, RAL, Trident, and Texas PW. Through such coordinated activities and research, there are substantial opportunities to significantly advance the science of high-energy-density physics.

Initial Response of Omega Management to Findings and Recommendations

1. Introduction

LLE Management responded to the OLUG recommendations. Their response below was written on 1 May 2009. Since then, ongoing progress and updates have occurred and will be reported at the Atlanta APS Meeting (3 November 2009) and at the next Users Workshop. In addition, Omega management is meeting bimonthly with members of the OLUG Executive Committee to assess progress toward achieving these objectives.

2. OMEGA (60 beams)

(a) Penalty and conflict information would be helpful: e.g., pointing, framing-camera moves, phase plates, etc.

LLE Response: The LLE web site will be modified to make it easier to find this type of information.

(b) It would be desirable to be able to drive any legs from any driver, which has become a major problem for x-ray Thomson scattering.

LLE Response: Will submit a project in FY10 for evaluation. Cost and schedule are currently unknown. Significant resources are likely to be required.

(c) More static x-ray pinhole cameras would be helpful.

LLE Response: OMEGA H8 camera is now operational. LLE will evaluate target chamber (TC) port allocation for possible addition of fixed PHC's. It may be possible to deploy two or three decommissioned units.

(d) Spherical crystal imaging (diagnostic) would be a very useful diagnostic.

LLE Response: A crystal-imager project has been proposed by LLE for OMEGA EP but deferred until FY10. LLE is reviewing the requirements and benefits, but there are concerns that with the high energy of the OMEGA EP beams, significant target heating could shift the K-shell lines out of the imager-wavelength acceptance band. Any suggestions for system requirements are welcome from OLUG. There are currently no plans to provide a crystal imager for OMEGA.

3. OMEGA EP

(a) Phase plates with 1-mm spot size are essential to a number of users.

LLE Response: Two phase plates will be available starting in FY10. Four more substrates are on order and will be made into phase plates by FY11.

(b) SSD will also matter for a number of possible experiments.

LLE Response: SSD is not planned for OMEGA EP except on the NIF PAM (in mid-FY10), which will be able to feed Beam 3. Implementing SSD on additional beamlines would require significant resources.

(c) OLUG strongly endorses adding a simultaneous SOP to ASBO.

LLE Response: SOP cabinet location and beam path are part of the OMEGA EP ASBO design package. LLE believes that it has identified a streak camera for the SOP and, if available, will install it on OMEGA EP later in FY09 or early in FY10.

(d) Pulse-shaping equivalent to NIF capability will help a number of users (100 ps to 30 ns).

LLE Response: Current architecture does not support >10-ns operation. LLE is evaluating possible strategies to provide this capability as well as shorter pulses. Operating with individual beam-pulse durations greater than 10 ns will, however, require a significant redesign of the front end in addition to significant resources.

(e) Spherical crystal imaging would be very helpful.

LLE Response: A crystal-imager project has been proposed by LLE for OMEGA EP but has been deferred until FY10. LLE is reviewing the requirements and benefits, but there are concerns that with the high energy of the OMEGA EP beams, significant target heating could shift the K-shell lines out of the imager-wavelength acceptance band. Any suggestions for system requirements are welcome from OLUG. There are currently no plans to provide a crystal imager for OMEGA

(f) Low-energy probe beams would be helpful:

- 1ω chirped pulse via an air compressor to allow for adjustment;
- 2ω or 3ω would be better;
- up to 1 J would provide an x-ray option.

LLE Response: A fourth-harmonic probe is in development. It will provide a 10-ps (nonchirped) pulse of 20 mJ to 100 mJ at 263 nm. LLE's goal is to have the system installed in FY10, including light-collection optics that would allow for Schlieren imaging and grid refractometry. It will be on a fixed path in the plane, perpendicular to the backlighter direction, 60° from vertical.

(g) A record of experience with EMP versus the type of experiment, laser intensity, and diagnostics should be made available to users.

LLE Response: EMP signatures are currently collected on each short-pulse shot on OMEGA and OMEGA EP. Diagnostic EMI-related diagnostic failures are logged by the shot crew when encountered. We will organize and make this information available to users in the near future.

(h) Organized penalty and conflict information would be useful, e.g., blast shield.

LLE Response: LLE will organize and distribute this package shortly. It will also become available on the web site.

4. General User Issues

(a) Earlier assessment of conflicts or problems in the setup; e.g., it would be beneficial to have access to Scheduling Committee outputs six months in advance. Users also want to know what operational delays may be introduced by the initial plan.

LLE Response: Omega management staff are available for advance planning at the request of any user. Campaign proposals can be submitted at any time in advance of the two-month required date. Users can request an early evaluation of their proposal, although this will not include potential conflicts with other experiments the same week. Users should make this request to J. M. Soures.

(b) The need to establish a link to scientists/engineers/technicians as mentors (as C. Sorce does for LLNL).

LLE Response: LLE agrees with the need for this enhanced liaison function and will support to the limit of our resources. Specific requests are generally supported. Requests for links to LLE staff should be directed to J. M. Soures.

(c) Zero interframe timing for x-ray framing cameras would

- be a standard operating procedure each day
- be readily available on the web
- arrange calibration and testing as a dedicated instrument maintenance block of time

LLE Response: These operations currently occur as part of routine operations. We will make this information more readily available to the users in the near future through the web site. Calibration and testing where required for data analysis should be included in experiment planning.

(d) LLE should host wikis for areas of user interest, e.g., x-ray Thomson scattering, x-ray framing cameras, etc.

LLE Response: LLE could host a blog forum for users to discuss the status of operational diagnostics. Diagnostic status information is currently available on the web site. LLE will explore options that allow user dialogue.

(e) It is important to continue to use Be.

LLE Response: LLE expects to continue to support the use of Be at the Omega Facility. We are evaluating current regulations.

(f) Improved links to more information in SRF's and other material, especially for each diagnostic, including brief description, contact people, RSI or other reference, procedures, etc.

LLE Response: Improved documentation including an Equipment Qualification Package will be linked shortly via SRF web pages.

(g) Provide dedicated laboratory space for visiting groups:

- enable a user to make preparations without conflicts
- computer linkages in this laboratory or wherever preparations occur

LLE Response: Dedicated "side-lab" space is currently available in LLE rooms 175, 177, 182, and 6000 (OMEGA EP diagnostic workshop). Additional transient space is available upon request. Ethernet is available but must be pre-arranged. Note that space is limited.

(h) Comments on after-shot feedback process:

Quality is not entirely satisfying. The overall sense is that 20%, give or take, of the feedback is too hurried or pressured to be accurate. Issues like data quality are often not immediately clear.

- add "Shot Cycle Assessment" line to feedback form.

LLE Response:

- *The Experiment Effectiveness Assessment Form (EEAF) is used for tactical evaluation during shots by the shot crew. Best-effort feedback is the objective. Longer-term issues that take time to sort out should be included in the Experimental Critique one to two weeks after the campaign. If the information changes after the initial experimental critique is submitted, the user is encouraged to submit a revised critique.*

- *Users can review shot-cycle information, including cause and length of delays in real time on "OMEGA Availability" on the Operations web site. LLE is considering adding a "Comment" area for shot-cycle assessment to the EEAF.*

5. Information Flow

(a) Detailed information flow is a challenge, especially when strong internal connections are lacking, despite the fantastic job OMEGA is doing.

LLE Response: LLE is working on a presentation and table showing users how to use the database system to find specific shot-planning and analysis information.

(b) Put an "X-ray Framing Camera Status" and a "Streak Camera Status" page on the web for user access. Coordination and information flow for framing-camera flat fields and signal levels would also be very useful—to improve user planning (see wikis).

LLE Response: LLE could host a blog forum for users to discuss status of operational diagnostics. Diagnostic status information is currently available on the web site. LLE will explore options that allow user dialogue.

(c) Implement a search capability to enable all users to find out who has used or is planning to use specific diagnostics or other capabilities (including SRF's and PI's).

LLE Response: LLE will implement a "Recent Use" history database of each diagnostic that will be available to users.

(d) Implement automatic notification of diagnostic status during run up toward shots using this particular diagnostic.

LLE Response: Automated link to blog could be implemented. The best way to get this information, however, is for the users to read the Diagnostic Status page.

(e) There is a need for more information relating to changes in policy about DT fill, although, in general, users report good communication about policy changes.

LLE Response: Formal announcements of policy changes will be distributed via the Scheduling Committee. The committee meets biweekly (could the OLUG mailing list be used to distribute regular notices of changes in facility policy to users?).

(f) OMEGA EP information

- need focus, energy, and regular timing of update
- need to know, ASAP, focus ability versus energy through blast shields in OMEGA EP
- need to know, ASAP, contrast on OMEGA EP
- need to know status of TIM updates

LLE Response: LLE is actively developing the diagnostics to address these items. We want to make them available ASAP, subject to finite development time and resources. The LLE System Science staff believes that providing accurate information is extremely important and will release information only when they are confident that it is correct. They are actively working on these issues.

- Focus and energy operating envelope will be further explored in the coming months.
- Blast-shield use impact is being analyzed and will be disseminated when available.
- A high-contrast diagnostic is being deployed as a high priority.
- Initial capability is expected in FY09.
- TIM-10 and TIM-11 will be completed in Q4 FY09; TIM-15 is expected in Q1 FY10. Information will be posted on the Omega Laser Facility web page.

(g) Regular updates on phase-plate inventories and availability (both OMEGA and OMEGA EP) would be beneficial.

LLE Response: They will be selectable with far-field information on the SRF interface as soon as they are available. Much of this information already exists online in the DPP database.

6. Broader Issues

OLUG recommends consideration of the following issues:

(a) The absence of explicit support for diagnostic development in universities has an increasingly adverse effect on hands-on training in an area of increasingly formal facility operations.

(b) The availability of small facilities as staging grounds for hands-on training, diagnostics, and experiment development is a concern.

(c) OLUG encourages a HIPER/US workshop to promote joint and complementary research on HEDP physics.

LLE Response: These issues are beyond LLE's control, but LLE will work with NNSA to address them.

Findings and Recommendations of the Student/Postdoctoral Panel

OLUG Student/Postdoctoral Panel:

Ryan Rygg, Chair, Lawrence Livermore National Laboratory
Dan Casey, Massachusetts Institute of Technology
Carolyn Kuranz, University of Michigan
Hiroshi Sawada, University of California–San Diego
Louise Willingale, University of Michigan

A variety of topics were raised during the student/postdoctoral/new-user panel session at the OLUG meeting. Although the chance to perform experiments on OMEGA is a wonderful opportunity for students and postdocs, a number of issues are of particular concern for new users, especially those who are not members of groups with strong ties to LLE. In an effort to increase the effectiveness of experiments performed by students, postdocs, and other new users, the major areas of discussion are summarized below.

1. Information for New Users

Copious information about many aspects of OMEGA is available on the LLE web site. Navigating the web site to find relevant documents can be overwhelming for external users, however, partly because the information for external OMEGA users is intermingled with the much greater volume of information provided specifically for facility staff.

New users would benefit from a concise and easy-to-find overview of the location and purpose of relevant documents and resources. For example, the NLUF Users' Guide is a particularly useful resource, yet it is not well known by all external users and, in particular, would be hard to identify as a useful document for those new users not funded by NLUF.

Many also expressed a desire for readily accessible descriptions of available diagnostics. The current "Help" links from the SRF diagnostic pages are too cryptic to be very useful for inexperienced users, and the NLUF Users' Guide's diagnostics section is sometimes too far removed from the terse SRF labels to make it possible to evaluate which diagnostics are appropriate for a given experiment. It was proposed that a Diagnostic Summary page be provided (perhaps in parallel or perhaps merged with the Diagnostic Status page) that includes the diagnostic acronym, a two- to three-sentence description of its use and limitations, operational procedures, a link to relevant RSI papers, and examples of calibration or experimental data, if available. Links to this Diagnostic Description Summary page directly from the SRF form or SRF diagnostic Help page would also be useful.

In addition to a resource diagnostic summary, other information suggested as valuable on a *new users' summary page* includes concise (as compared to the 227-page NLUF Users' Guide) descriptions of the laser system's capabilities; tools to aid in experimental planning, such as delays incurred by laser or diagnostic-configuration changes; and a list of whom to contact with questions regarding various topics.

2. Engineering Liaison for External Users

One recommendation that was echoed in later sessions was to designate an engineering liaison for external users. OMEGA users are widely spread both nationally and internationally, and it is impractical for each group to have a representative at LLE for the weeks and months prior to a shot day to prepare and interface the experiment with the facility. These external users could share a designated representative who is familiar with the facility, knows of whom to ask which question, can perform some of the legwork in the weeks prior to shot day, and is up to date on the latest news/issues that may affect the experiment. The suggested archetype for this liaison is the role that C. Sorce currently performs for the national labs. In summary, students and postdocs would greatly benefit from contact with a designated junior technical staff member or liaison who could answer numerous questions.

3. Availability of Smaller Facilities

Finally, many expressed concerns regarding the continued availability of smaller-scale experimental facilities. Smaller-scale facilities provide a practical means of testing new diag-

nostics and experimental ideas prior to their implementation on OMEGA. In addition, they offer an opportunity for hands-on experience to students and postdocs in a relatively low stakes environment, where the cost of mistakes—an essential element of experience gain—is lessened.

Given OMEGA's limited experimental time and to help ascertain whether OMEGA is the proper facility, a list could be supplied of alternative smaller-scale experimental facilities for potential use for diagnostic and experimental development. Suggestions were also made to include the proposal process and deadlines, if any, for each facility in addition to the name, location, and description.

Conclusions and Future Workshops

This first OLUG workshop, with over 100 attendees, was the beginning 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 facility. OLUG Executive Committee members and facility management have been meeting on a bimonthly basis to assess progress, compatible with facility resources and impact, toward the implementation of the *Findings and Recommendations*. Progress will be reported on at a satellite meeting at the Atlanta APS Meeting (3 November 2009) and at the next OLUG Workshop.

The next Omega Lasers Users Group Workshop will be held at LLE on 28 April–1 May 2010. Significant financial support from NNSA has already been procured to help defray the cost of student and postdoc travel.

ACKNOWLEDGMENT

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This updated review was compiled and edited by R. D. Petrasso (petrasso@psfc.mit.edu) of MIT's Plasma Science and Fusion Center with critical input and contributions by Workshop attendees, the Executive and Student/Postdoctoral Workshop Committees, and LLE management.