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

Petrasso, R.D., Ed.

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

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The OMEGA Laser Facility Users Group Workshop (April 29 through May 1, 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. 1). 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 at LULI or NIF); to provide an opportunity for students and post-doctoral fellows to present their research involving the OMEGA Facility in an interactive yet congenial atmosphere; and to provide LLE feedback from the users about ways to improve the facility and future experimental campaigns. The interactions that prevailed were spirited and lively, as can be seen in photographs shown in this article. The names and affiliations of the 152 members of the OMEGA Users Group can be found at (case sensitive) www.lle.rochester.edu/pub/OLUG/OLUGMEMBERS.pdf.

To set the tone for the workshop, the first two mornings were comprised of science and facility presentations. (The Workshop agenda is shown in the Appendix.) The facility talks proved especially useful for those not intimately familiar with the art and complexities of performing experiments at the OMEGA facility. The 6 overview science talks, given by leading world authorities, described the breadth and excitement of high-

energy-density science undertaken at the Omega Laser Facility, both present and future. The final overview talk concerned the role and importance of science to the 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>, the workshop website.

Thirty-two students and post-doctoral fellows, 27 of whom were supported by travel grants from NNSA, attended the workshop and presented 31 of the 48 contributed poster and oral presentations. Their content ranged from target fabrication to simulating important aspects of supernovae. Regardless of the subject, the presentations generated spirited discussions, probing questions, and friendly suggestions. In addition, 17 excellent contributed presentations were made by professional scientists and academics.

As discussed herein, 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. These findings were grouped into 5 areas: 60-beam OMEGA, OMEGA-EP, General User Issues, Information flow, and Broader Issues. These categories comprise a report given to Omega Facility management. The original report, and the management response, can be found in sections below and also at <http://ouw.lle.rochester.edu>. The management is currently using these recommendations as a guide for making decisions about Omega Laser Facility operations, priorities, and future changes.



Figure 1.

Attendees at the workshop. Over 100 researchers from around the world, from 29 universities and laboratories, participated. Workshop Reports and nearly all 62 Presentations can be found at <http://ouw.lle.rochester.edu>. Plans for the next OMEGA Users' Workshop 29-30 April 2010 are well underway, with significant financial support from NNSA already allocated for student/postdoc travel expenses.



Figure 2. Students and post-doctoral fellows at the workshop. Thirty two students and post-doctoral fellows attended, and made 31 presentations. Twenty seven received travel assistance from an NNSA grant. Equally important, the post-doctoral-student panel wrote an outstanding report (found in the last section of this document) on how to improve the OMEGA facility and on the generic issues that confront young researchers in high-energy-density science.

Another highlight of the workshop was the student/post-doctoral panel 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 contained in the last section of this article and also at <http://ouw.lle.rochester.edu>. Concise, coherent, and insightful, this report is well worth our careful attention.

Finally, one of the important decisions made at the workshop was the scheduling of the next one, which will be held at LLE on April 29 and 30, 2010. Meetings of the Users Group and interested members of the HED community are formulating plans for this next workshop and reviewing progress on the *Findings and Recommendations* of the first workshop. These meetings are taking place at both the IFSA Conference (8 September 2009) and the APS conference in Atlanta (3 November 2009).

The Presentations

A comprehensive series of 62 talks and posters were 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: on-going fast- and shock-ignition experiments; materials under extreme conditions at OMEGA and, in the near future, at the NIF; the critical role that simulations plays in designing and interpreting experiments; the physics connections between OMEGA 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 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 invited presentations, 48 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 (see <http://ouw.lle.rochester.edu>). In addition, work was presented on the opportunities for taking physics platforms developed at OMEGA to other facilities that were both larger (the NIF) and smaller (Jupiter, Trident, and LULI, as examples). The entire collection of presentations, both invited and contributed, formed much of the basis for spirited and lively discussions regarding the *Findings and Recommendations* for the OMEGA facilities and future capabilities, found in the next section.

The photographs in Figs. 3 – 21 provide a representative sampling of the workshop’s talks, interactions, and spirited ambiance. A much larger collection of photographs can be found at the workshop website.



Figure 3. Post-doctoral fellow Dr. Angelo Schiavi of Roma University discussed, on behalf of his European colleagues, the latest theoretical developments in fast ignition. Angelo delighted workshop attendees, not only with the clarity and depth of his presentation, but with his humorous and entertaining remarks! His presentation, and nearly all others, can be found at <http://ouw.lle.rochester.edu>.



Figure 4.
 Post-doctoral fellow Dr. Carolyn Kurantz makes decisive and unequivocal points about the subtleties and challenges of the Univ. Michigan lab-astro experiments she and colleagues have been implementing at OMEGA as part of their NLUF program, an effort led by Prof. Paul Drake. Carolyn is also a member of the Student-Post doc Panel, and Paul is a member of the Users Executive Committee.



Figure 6.
 Prof. Peter Norreys, of Rutherford-Appleton Laboratory, discussed the reasons that the testing and development of fast-ignition concepts on OMEGA are so critical for preparing for, and guiding, the European consortium fast-ignition experiments. Peter is an Executive Committee member of the OMEGA Users Group.

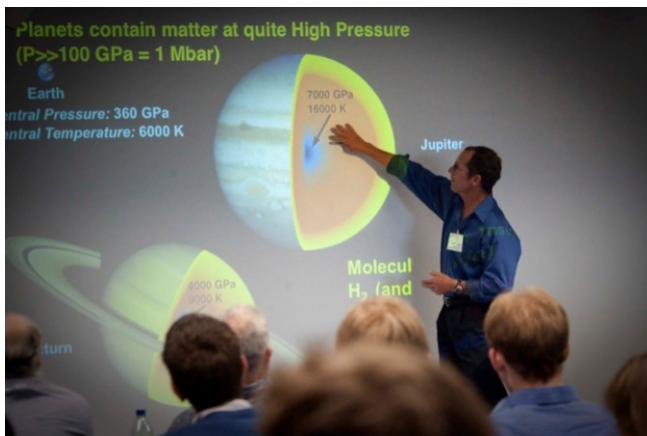


Figure 5.
 Probing the interiors of the planets through materials experiments at OMEGA, and soon at the NIF, was the focus of LLNL's Dr. Rip Collins. Here he describes how the inaccessible (planet interiors) becomes accessible through such laboratory experiments. Rip's animated description of the challenges of compressing a tofu-like material to densities of $\sim 100 \text{ g/cm}^3$ (five times the density of gold) led workshop attendees to give him the moniker of Dr. Tofu.



Figure 7.
 LLNL's post-doctoral fellow Dr. Ryan Rygg is chair of the student-postdoc panel that wrote an outstanding report on the challenges, and possible solutions, young researchers face in implementing experiments at OMEGA and other HED facilities. (See their report below and in ouw.lle.rochester.edu.) Ryan is a frequent experimenter at the OMEGA and Jupiter facilities, and he is collaborating with MIT researchers on nuclear diagnostics currently being implemented at the National Ignition Facility. Ryan is a member of Rip Collins' Shock/Materials Group (see Fig. 5) at LLNL.



Figure 8. During one of the frequent coffee breaks, LLE PhD student Maria Barrios (right) discusses her work and presentation on shock compressed materials with her former professor at Gettysburg College, Dr. Sharon Stephenson.



Figure 9. Post-doctoral fellow Dr. Louise Willingale of the Univ. of Michigan contemplates her response to a workshop attendee's query about aspects of her OMEGA-EP experiment involving proton emissions from the EP short-pulse beam interacting with a flat target. Louise is a member of the Student-Postdoc Panel.

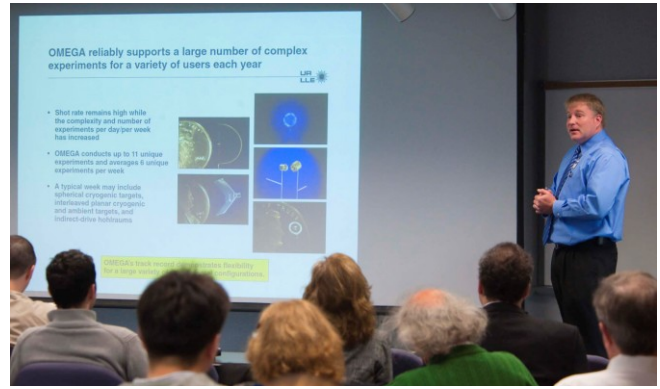


Figure 10. LLE's Senior engineer and manager Keith Thorp presented an overview of the planning, processes, and coordination needed to conduct a successful experiment at OMEGA. Such talks gave attendees the opportunity to meet with, and hear from, some of the key individuals responsible for operating and improving the facility. Keith is one of the many dedicated staff members involved in, and orchestrating, the day-to-day facility operations.

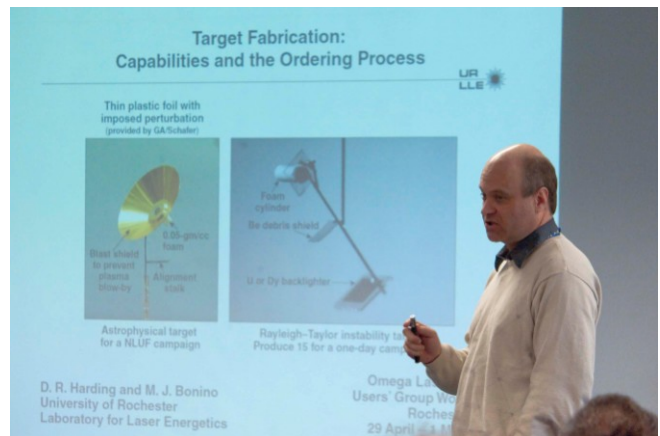


Figure 11. Targets are a critical part of any experiment. Here LLE's Dr. David Harding describes the range and complexity of targets that are designed and then meticulously assembled and characterized prior to their fielding. Each step in the process requires excruciating attention to detail and design, often requiring many interactions between the experimenter and the target-manufacturing team. Most targets are manufactured at General Atomics (GA), and 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're sure is shared by Dave.



Figure 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 that attended the workshop.

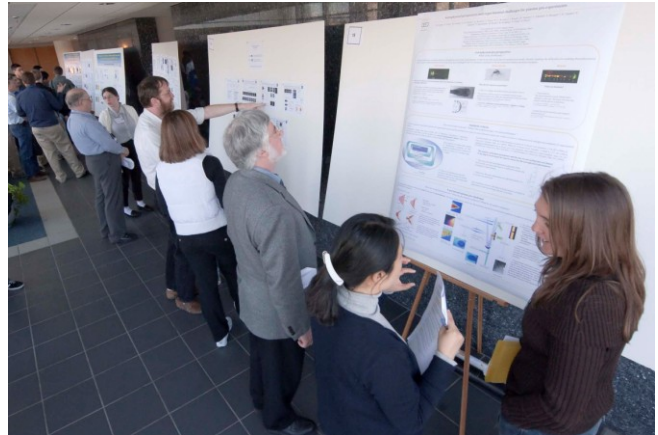


Figure 14.
The 62 workshop presentations, of which several are shown here during the poster session, covered a wide spectrum of cutting-edge high-energy-density science relevant to OMEGA, NIF, and other HED facilities. Nearly all presentations in their entirety can be found at <http://ouw.lle.rochester.edu>.



Figure 13.
Spirited and lively discussions often ensued in poster and workshop breakout sessions, with the results ending up in the *Reports of Recommendations and Findings* (<http://ouw.lle.rochester.edu>). Many of these "findings" are currently being implemented by the OMEGA management, and discussions between them and the Users Executive Committee continue on a bi-monthly basis.



Figure 15.
Here PhD student Teresa Bartel of the Univ. of San Diego discusses her OMEGA-EP experiments with LLE's theoretical physicist Dr. Steve Craxton. Teresa'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. Too low a proton conversion efficiency would preclude such an impulsive heating scheme for fast ignition. Teresa is a member of Prof. Farhat Beg's group at the Univ. of San Diego.

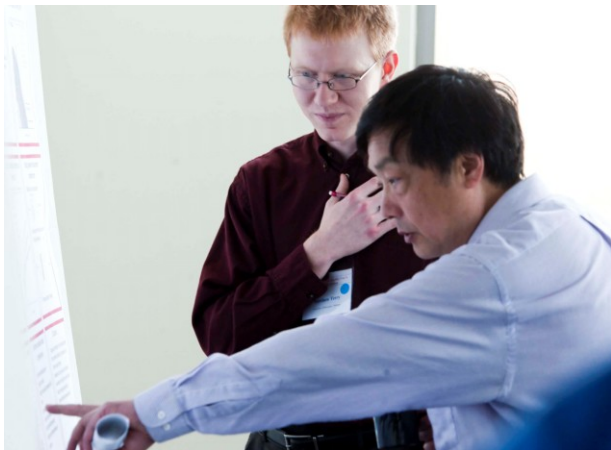


Figure 16. Theoretical PhD student Matt Terry of Univ. of Wisconsin, Madison, listens intently to the query of experimentalist Dr. Chikang Li of MIT regarding Matt's work on the stopping power of energetic particles in dense hot plasmas. Such problems, while of basic interest to HED physics, are of special relevance to ICF where, for example, the stopping and energy deposition of alphas is crucial to the ignition instability. Matt discussed several theoretical stopping models, and the differences between them. Could such differences, sometimes small, have subtle but non-trivial consequences on ignition criteria, making it either easier or harder to achieve ignition at the National Ignition Facility?



Figure 18. In a light moment, the Omega Users Executive and Student/Postdoc Committees discuss details and assignments for writing the *Findings and Recommendations* of our workshop. The two committee reports and the initial management response can be found at <http://ouw.ile.rochester.edu> and in this document. As noted in these reports, the process of improving the OMEGA facility is an on-going activity involving bi-monthly meetings between the Executive Committee members and the 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 OMEGA Users workshop (29-30 April 2010). An important finding of both committees was the excellence with which the OMEGA facility is run, offering exciting opportunities to the Users to perform world-class experiments.



Figure 17. At his poster about the measurements of fields associated with Rayleigh-Taylor (RT) instabilities, MIT PhD student Mario Manuel talks with theoretical physicist Dr. Serge Bouget of CEA, France. Mario'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 work with workers from a broad range of fields and experience within the world-wide high-energy density physics community.



Figure 19. The French came in full force to the workshop, bringing a dashing but friendly contingent with exciting ideas and zest! Vive La France!



Figure 20.

A workshop banquet at the Univ. of Rochester Faculty club offered an enjoyable evening for all workshop attendees. Next year's workshop, 29-30 April 2010, will have another attractive venue for the banquet, presenting yet again an opportunity for renewing old acquaintances and making of new friends and colleagues.



Figure 21.

Here our European colleagues share a light moment at the workshop banquet with, we are quietly told, a toast to The Queen! Come join us at the next years OMEGA Users' Workshop, 29-30 April 2010. It will prove to be both stimulating and memorable!

Findings and Recommendations of 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

Marilyn Schneider, Lawrence Livermore National Laboratory

This report includes the following subsections:

- I. Introduction
- II. OMEGA (60-Beams)
- III. OMEGA EP
- IV. General User Issues
- V. Information Flow
- VI. Broader Issues

I. Introduction

Extensive discussions occurred during the workshop, in both formal and informal settings, regarding (1) ways in which the Omega Facility could be more effective in utilizing existing resources and (2) new capabilities or technologies that would be highly desirable from the OMEGA Users' (i.e., OLUG) point of view. Before turning to particulars, it is important to stress that there was a resounding response by the workshop attendees that the Omega Facility was extremely well run and that the team that operates OMEGA is both highly dedicated and very skilled. To them and the facility, we want to first and foremost express our deep gratitude.

Two workshop reports were written. The first was by the OLUG Executive Committee and was a best attempt to summarize the view of all workshop attendees (some 110 professional scientists and engineers, academics, students, and postdocs from 4 countries). Its findings were grouped into the following five areas: 60-beam OMEGA; OMEGA EP; General Users' Issues; Informational Flow; and Broader Issues. The second report, which follows the LLE response to this report, below, was written by the Student/Postdoc Panel and its findings and recommendations strongly reflect the point-of-view of students, postdocs, and, in general, new users at OMEGA. Concise, coherent, and insightful, the student/postdoc report is deserving of our careful attention.

When reading these two reports, one is struck by the fact that they have many common issues, especially those relating to information flow and to the process of preparing for and executing science campaigns in the OMEGA environment. This commonality is, in part, due to the challenging complexity, especially from the point of view of new users, of the facility and its operations, even though there are myriad tools at the Omega Facility to help navigate through this process. Indeed, as will be obvious even in the different sections of the Executive Committee report itself, these same themes, aside from the technologically specific recommendations of those sections, were oft repeated. Since the management response was written to address the issues that were raised *strictly* on the last day of the workshop (1 May 2009), and because the sections of the Executive Report, as was the management response, were written several days after the workshop, there is a slight mismatch between issues of the formal Executive Report (contained herein in Sections II – VI) and the Management Response. In part because of this, but more

importantly due to the complexity of some of the issues involved and the need to iterate back and forth from recommendations to what is actually achievable from the management point of view, this Report must necessarily be considered a work in progress. To that end, we continue to meet bi-monthly with the OMEGA management to discuss what can be realistically achieved, and progress towards, 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 Users workshop (29-30 April 2010).

II. OMEGA (60-Beams)

In the course of our working-group discussions, the users developed a list of desired improvements enabling better use of the OMEGA 60-beam Facility. The list that follows is in order of priority, reflecting both the degree of resonance across the users and the degree of importance to specific subgroups of users.

1. **Delay and conflict information:** A web page providing the top 15 or so typical delays generated by decisions about how to construct an experimental day. Examples would include the delays associated with repointing beams or with moving a framing camera. This is of value to help users better develop their initial plans for shot days.
2. **More options for driving the 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. Indeed, we recognize that it is a tall order. The minimum functionality is the ability to use the SSD driver on one leg while using another driver on the other two legs. (A way to achieve this might include enabling the backlighter to drive on any two legs.) Also, having the capability of operating SSD and main drivers simultaneously is potentially quite important to x-ray Thomson-scattering experiments, an emerging area where much greater activity can be anticipated.
3. **More static x-ray PHC's:** These diagnostics are rarely, if ever, critically important but are of value in assessing whether an experiment went as intended. Their number has dropped over recent years and it would be helpful to see a few cameras re-activated.
4. **More SG8 or similar phase plates:** This would be specifically useful when users share shot days. Whether SG8's are in fact the right choice or how this integrates with phase plates for OMEGA EP was not addressed. Most users would agree that having some phase plates for OMEGA EP is far more important than having additional ones for OMEGA 60.
5. **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 would not rank it above other ways to spend the necessary funds. The users would strongly encourage support for any

effort by a major laboratory to implement this diagnostic.

III. OMEGA EP

1. **Beam Smoothing:** The use of Distributed Phase Plates (DPP's) significantly improves the spatial uniformity of irradiation in the focus of high-power laser beams. Their use has been shown to 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 the 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.

In addition, 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 at the OMEGA EP Facility 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 2-D SSD studies to be implemented for the user community.

2. **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 NIF (100 ps to 30 ns) are explored by management so that an assessment of priorities can be made at the next OLUG meeting.

3. **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 are explored by management so that an assessment of priorities can be made at the next OLUG meeting.

4. **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 financial year.

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

5. **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 enable any 2-D ambiguity that arises at velocity discontinuities to be resolved. The working group agreed that the addition of passive Streaked Optical Pyrometry (SOP) channels would be a valuable addition. They would allow the lower radiation temperatures and shock pressures to be measured. *OLUG recommends the simultaneous provision of SOP with the ASBO diagnostic suite.*

6. **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 provision of Ti, Cu, and higher-Z K_{α} imaging spectrometers.

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

7. **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 is made available to facility users of instruments and detectors that have suffered from EMP and radiological noise damage so that mitigation strategies can be undertaken when planning experiments.

8. **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 be made available to facility users of known delays so that facility users are more aware of the costs of decisions.

IV. General User Issues

A number of issues were discussed that are common to users of both OMEGA and OMEGA EP. 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*:

1. A number of users have indicated that it would be important to have 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. For example, the connection between changes in laser pulse energy, shape, 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. Along the same lines, 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?

In this connection, the idea was proposed of having the option of starting the discussion process of the detailed experimental proposal for the shots with relevant personnel in the facility several months ahead of time.

At the moment, this is currently done as the result of the submission of the detailed experimental proposal two months ahead of the planned time. The 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.

2. Another point of common concern that was brought up at the workshop is that of calibrating and characterizing diagnostics available on OMEGA and OMEGA EP. In this connection, flat fielding of streak and framing cameras is a typical example that is relevant to many users but certainly not the only one; however, it is a good case for illustration. 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. Yet, the information they produce in this regard is potentially useful to many users. The idea was discussed at the workshop that 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 did not tax the shots dedicated to a given science campaign; i.e., if it did 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. On one hand, 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. On the other hand, 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 the discussions at the workshop that there is strong consensus among users in that characterization and calibration of diagnostics available on OMEGA and OMEGA EP is an important point affecting many users and that it is a critical issue that must be addressed.

3. Evaluating and assessing the Omega Facility performance and the experimental campaign was another important topic of discussion. This is an important issue since it provides an opportunity for users to convey feedback and comments to the Omega Facility. Current procedures on OMEGA include an Effectiveness Assessment form that must be returned by the PI to the Shot Director after each shot, and an Experimental Critique sheet that is submitted during the week after 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.

However, a thorough overall assessment of the experimental campaign including, in particular, the quality and quantity of the data recorded and how well were the science goals 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 website accessible by users (via login and password) indicating the current status of OMEGA and OMEGA EP diagnostics.

4. Better and more-complete information about the instruments and diagnostics available on OMEGA and OMEGA EP are needed.

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

5. The role that Chuck Sorce plays in LLNL experimental campaigns as a 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 at the workshop that it would be useful to have a similar resource person to perform that task for all experimental campaigns.

6. OLUG recommends the continued use of Be in OMEGA and OMEGA EP shots.
7. OLUG recommends additional office space for (outside) users be allocated when they are visiting and preparing for their shots.
8. OLUG recommends that space be provided on the OMEGA website 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.

V. Information Flow

This topic involves better communications with Omega Facility users. Generally, the communication between LLE and users is conducted very well; however, the amount of information required for a successful campaign on OMEGA is very large. The suggestions below represent the distilled recommendations of the Users Group

to improve communications, *which is especially important for those who have no internal connection with LLE or are new users.*

1. 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 (couple of sentences), 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 as the laboratory staff is 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 also 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 of this exercise is to enable *ride-along* testing of a user's diagnostic. Perhaps more often than not, such a ride-along would not be reasonable. Occasionally, however, such multiplexing of experiments may increase the overall productivity of the Omega/Omega EP Facility. As examples, the

"neutron days" often conducted by Vladimir Glebov attract a host of users with various TIM diagnostics that benefit from testing. Another example is the pointing shots conducted for LLE cryo shots. 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 be an increase in productivity.

2. 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 practicable, 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.

3. Miscellaneous

Similar updates are desirable for other OMEGA systems

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

VI. Broader Issues

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

There is also a concern about the availability of small facilities as staging grounds for hands-on training, diagnostics, and experiment development. Again, students and postdocs are significantly impacted by this circumstance. Although OLUG recognizes that the concern expressed in these two paragraphs are really outside the purview of the Omega facility, it is an issue that does impact the researchers, especially younger ones who come to LLE to perform experiments.

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 between 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 Recommendations and Findings

This report includes the following sections:

- I. Introduction
- II. OMEGA (60 beams)
- III. OMEGA EP
- IV. General User Issues
- V. Information Flow
- VI. Broader Issues

I. Introduction

LLE Management responded to the Omega Laser Facility Users' Group Recommendations listed in the last section. The response reproduced below was written on 1 May 2009. Since then, on-going progress and updates have occurred, and will be reported at the Atlanta APS Meeting (3 Nov 2009) and at the next Users workshop (29-30 April 2010).

II. OMEGA (60 beams)

1. Penalty and conflict information would help: e.g., pointing, framing camera moves, phase plates, etc.
LLE Response: The LLE website will be modified to make it easier to find this type of information.
2. Desirable to be able to drive any legs from any driver—becomes 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.
3. Need more static x-ray pinhole cameras
LLE Response: OMEGA H8 camera now operational. LLE will evaluate TC port allocation for possible addition of fixed PHC's. It may be possible to deploy two or three decommissioned units.
4. Spherical crystal imaging (diagnostic) would be nice.
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.

III. OMEGA EP

1. 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.
2. SSD will also matter for a number of possible experiments.
LLE Response: SSD is not planned for OMEGA EP except on the NIF PAM, which will be able to feed Beam 3 in mid-FY10. Implementing SSD on additional beamlines would require significant resources.
3. Strongly endorse adding 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.
4. 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. Evaluating possible strategies to provide this capability as well as shorter pulses. However, operating with individual beam pulse durations greater than 10 ns will require a significant redesign of the front end and significant resources.
5. Spherical crystal imaging would be very helpful.
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
6. Low-energy probe beams would be helpful including
 - 1 ω chirped pulse via an air compressor to allow adjustment
 - 2 ω or 3 ω 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 to 100 mJ at 263 nm. LLE's goal is to have the system installed in FY10 including light-collection optics that would allow Schlieren imaging and grid refractometry. It will be on a fixed path in the plane perpendicular to the backlighter direction, 60° from vertical.*
7. Must somehow develop a record of experience with EMP versus type of experiment, laser intensity,

diagnostics.

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.

8. Organized penalty and conflict information would be helpful, e.g., blast shield.

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

IV. General User Issues

1. Earlier assessment of conflicts or problems in the setup; e.g., more access to Scheduling Committee outputs but being able to get this six months in advance would be great. Want to also 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 John Soures.

2. Establish a link to scientists/engineers/technicians as mentors...(as Chuck 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 John Soures.

3. Zero interframe timing for x-ray framing cameras would be
 - A standard operating procedure each day
 - 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 website. Calibration and testing where required for data analysis should be included in experiment planning.

4. 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 status of operational diagnostics. Diagnostic status information is currently available on the web site. LLE will explore options that allow user dialogue.

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

6. Improved links to more information in SRF's and other material, especially for each diagnostic. Include: brief description, contact people, RSI or other reference, procedures, etc.

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

7. Provide dedicated laboratory space for visiting groups:
 - Enable preparations without conflicts.
 - Computer linkages in this laboratory or wherever preparations occur.

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

8. 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 clear for a while.

- 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.*

V. Information Flow

1. A challenge, especially when not having strong internal connections, despite the fantastic job OMEGA is doing.

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

2. Put an x-ray framing camera and streak camera status page up on the web for all 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 Reponse: 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.

3. 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.

4. Implement automatic notification of diagnostic status during run up toward shots that use this particular diagnostic.

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

5. There was a problem with information flow 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 bi-weekly (could the OLUG mailing list be used to distribute regular notices of changes in facility policy to users?).

6. 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
- Status of TIM updates needed.

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. Item

- *Focus and energy operating envelope is being 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. News web page.*
- *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 Facility*

7. Need regular updates on phase-plate inventories and availability (both OMEGA and OMEGA EP).
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.

VI. Broader Issues

OLUG recommends consideration of the following three issues:

1. 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.
2. Concern about availability of small facilities as staging grounds for hands-on training, diagnostics, and experiment development.
3. Proceed with 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 at San Diego

Louise Willingale, University of Michigan

This report includes the following sections:

- I. Information for new users
- II. Engineering liaison for external users
- III. Availability of smaller facilities

A variety of topics was raised during the student/postdoc/new-user panel session at the OMEGA Laser Users' Group meeting. Although the chance to perform experiments on OMEGA is a wonderful opportunity for students and postdocs, there are a number of issues that 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.

I. Information for new users

Copious information about many aspects of the Omega Laser Facility is available on the LLE website.

However, navigating the website to find relevant documents for external users can be overwhelming, partly because the information for external OMEGA users is intermingled with the much greater volume of information provided specifically for Omega 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 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.

Beside a resource summary and 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 capabilities; tools to aid in experimental planning, such as delays incurred by laser or diagnostic configuration changes; and a list of who to contact with questions about various topics.

II. Engineering liaison for external users

One recommendation that was echoed in later sessions was to create 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 OMEGA facility. However, these external users could share a designated representative who is familiar with the facility, knows who 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 Chuck Sorce currently performs for the national labs. Thus, students and postdocs would benefit from contact with a junior technical staff member who could answer numerous simple questions.

III. 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 diagnostics 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. In addition to the name, location, and description, suggestions were also made to include the proposal process and deadlines, if any, for each facility.

Conclusions and Future Workshops

This first OLUG workshop, with over 100 attendees, was only 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 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 Atlanta APS Meeting (3 November 2009), and at the next Users Workshop.

The next OMEGA Users Workshop will be held at LLE on April 29 and 30, 2010, 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. Come join us!

Acknowledgments

For capturing the ambiance and spirit of the workshop through his lens, we thank Eugene Kowaluk. We thank Irina Cashen, Sarah Frasier, Kathie Freson, Jenny Hamson, Karen Kiselycznyk, Katie Leyer, Jody Mayer, Lisa Stanzel, Jean Steve, and Jennifer Taylor for their gracious help and assistance. To NNSA, we gratefully acknowledge the financial assistance for student/postdoc travel expenses. We also gratefully acknowledge the University Of Rochester Fusion Science Center which co-sponsors the OMEGA Users Group Workshop.

Appendix: Agenda of the OMEGA Users' Group Workshop, April 29 – May 1, 2009

Wednesday, 29 April 2009

7:15	Registration (East entrance to LLE)	
7:45-8:30	Continental breakfast	
	General Session: Seminar Room	
8:30-8:35	Welcome	Robert L. McCrory, Jr.
8:35-8:45	Workshop objectives, agenda, working groups, announcements	Richard Petrasso
8:45-9:15	OMEGA/OMEGA EP Facility: Status and Performance	Sam Morse
9:15-9:45	Engineering Support and Qualification Process for Interfacing New Experiments	Greg Pien
9:45-10:15	Diagnostics Status for OMEGA/OMEGA EP	Craig Sangster
10:15-10:30	Break	
10:30-11:00	Status of OMEGA EP, an Experimentalist's perspective	Christian Stoeckl
11:00-11:30	Status of integrated Fast- and Shock-Ignition Experiments on OMEGA/OMEGA EP	Wolfgang Theobald
11:30-12:00	Laboratory Astrophysics at OMEGA/OMEGA EP	Paul Drake
12:00-12:30	Materials under extreme conditions at OMEGA, OMEGA EP, and the NIF	Rip Collins
12:30-12:40	Entire Workshop Photo; Student-Postdoc photo	
12:40-1:30	Lunch...box lunches; OMEGA and OMEGA EP Tours	
1:30-3:45	First Poster Session: Posters 1–18	
3:45-4:00	Break	
4:00-6:15	Second Poster Session: Posters 1–18	

Thursday, 30 April 2009

7:45-8:30	Continental breakfast	
8:30-9:00	Laser Properties: Pulse shaping, pulse duration(s), phase plates...	Keith Thorp
9:00-9:30	Targets	David Harding, Mark Bonino, Brian Vermillion
9:30-10:00	The Role of Simulation on Design and Analysis of OMEGA Experiments	Roberto Mancini
10:00-10:30	Basic Science Connections between OMEGA/OMEGA EP and HiPER Risk Reduction	Peter Norreys
10:30-10:45	Break	
10:45-11:55	Student/postdoc/new-user Forum Testament of issues, experiences, recommendations for the Workshop and Workshop Report (to continue this discussion during the working groups)	
11:55-12:00	Discussion of working groups/goals/charge	
12:00-1:00	Lunch; tour of OMEGA and OMEGA EP	
	Working Group 1:(Seminar Room) ICF, Fast and Advanced ignition, Diagnostics	Expeditors: R. Mancini, P. Norreys, J. Knauer
	Working Group 2:(Coliseum) Materials, Shocks, Warm-Dense-Matter, X-ray Generation, LabAstro,	Expeditors: P. Drake, J. Cobble, M. Schneider, H. Baldis
1:00-3:30	Working Group Sessions I and II	
1:00-2:30	Contributed Oral presentations	
3:30-3:45	Break	
3:45-6:00	Working group session	
7:00-10:30	No Host Reception and Dinner at the UR Faculty Club	

Friday, 1 May 2009

7:45-8:30	Continental breakfast	
	General Session: Seminar Room	
8:30-9:30	Basic HED Science is Important to NNSA	Christopher Deeney
9:30-11:30	Executive session	
11:30-12:00	Initial Presentation and discussion of workshop findings and recommendations to LLE Management and NNSA	
12:30-2:00	Lunch and adieus.....Tours of OMEGA and OMEGA EP	
2:00-2:30	OLUG Executive Council meeting; review report writing and schedule	