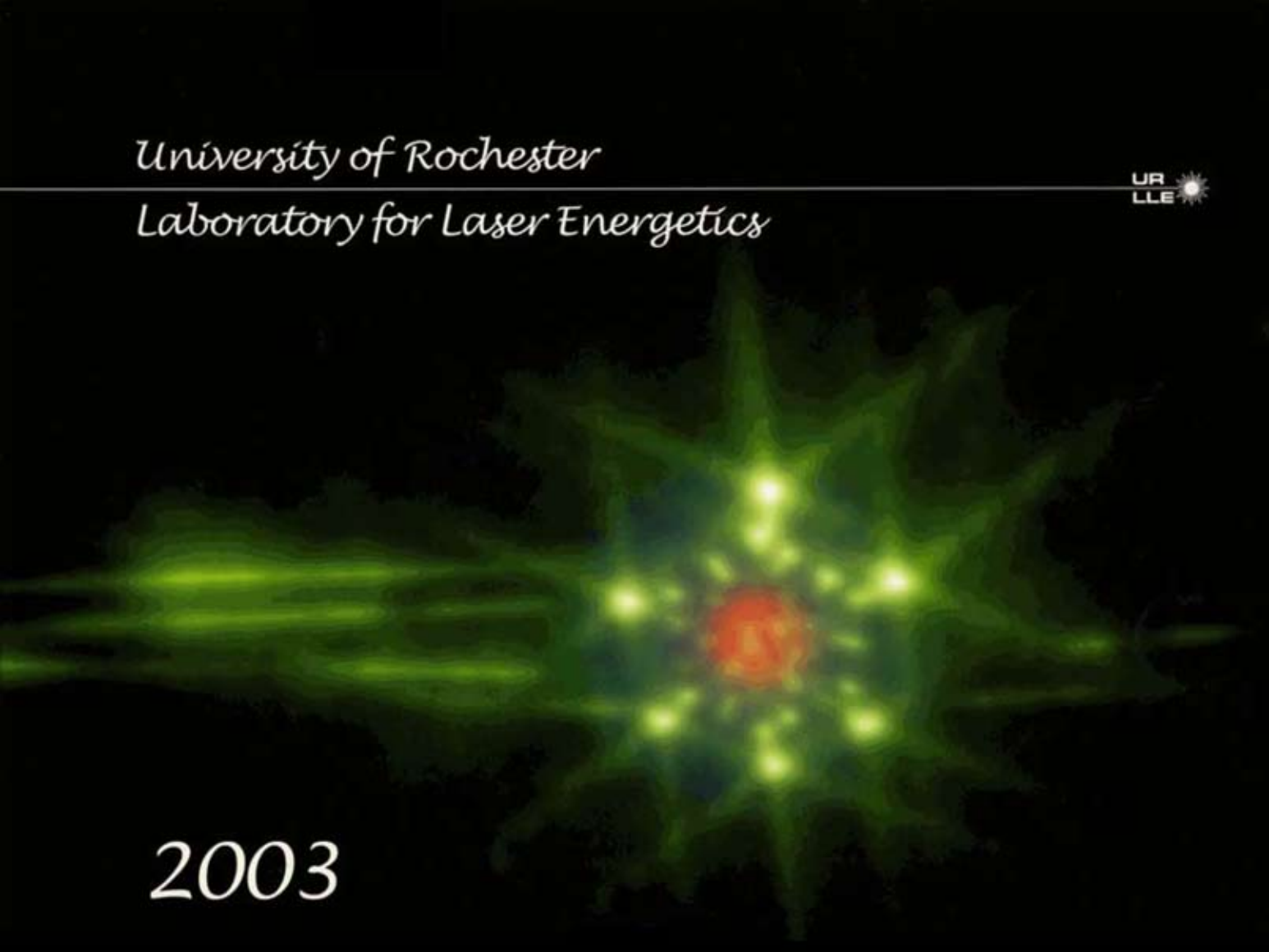
University of Rochester

Laboratory for Laser Energetics

UR LLE



2003

Mission Statement

The Laboratory for Laser Energetics (LLE) of the University of Rochester is a unique national resource for research and education in science and technology. The Rochester area has a history of innovation and provides a unique setting for LLE within a technologically sophisticated community. Established in 1970 as a center for the investigation of the interaction of intense radiation with matter, the Laboratory has the five-fold mission:

1. To conduct implosion experiments and basic physics experiments in support of the National Inertial Confinement Fusion (ICF) Program.
2. To develop new laser and materials technologies.
3. To provide graduate and undergraduate education in electro-optics, high-power lasers, high-energy-density physics, plasma physics, and nuclear fusion technology.
4. To operate the National Laser Users' Facility (NLUF).
5. To conduct research and development in advanced technology related to high-energy-density phenomena.

The 2003 LLE Calendar contains information on many of the Laboratory's programs as well as an account of some of its history.

We hope that you enjoy using your copy of the LLE Calendar and wish you a productive and fulfilling 2003.

COVER PHOTO: Scattered and refracted light image of a 60-beam implosion on the OMEGA laser system.

2003

JANUARY

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2004

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DECEMBER

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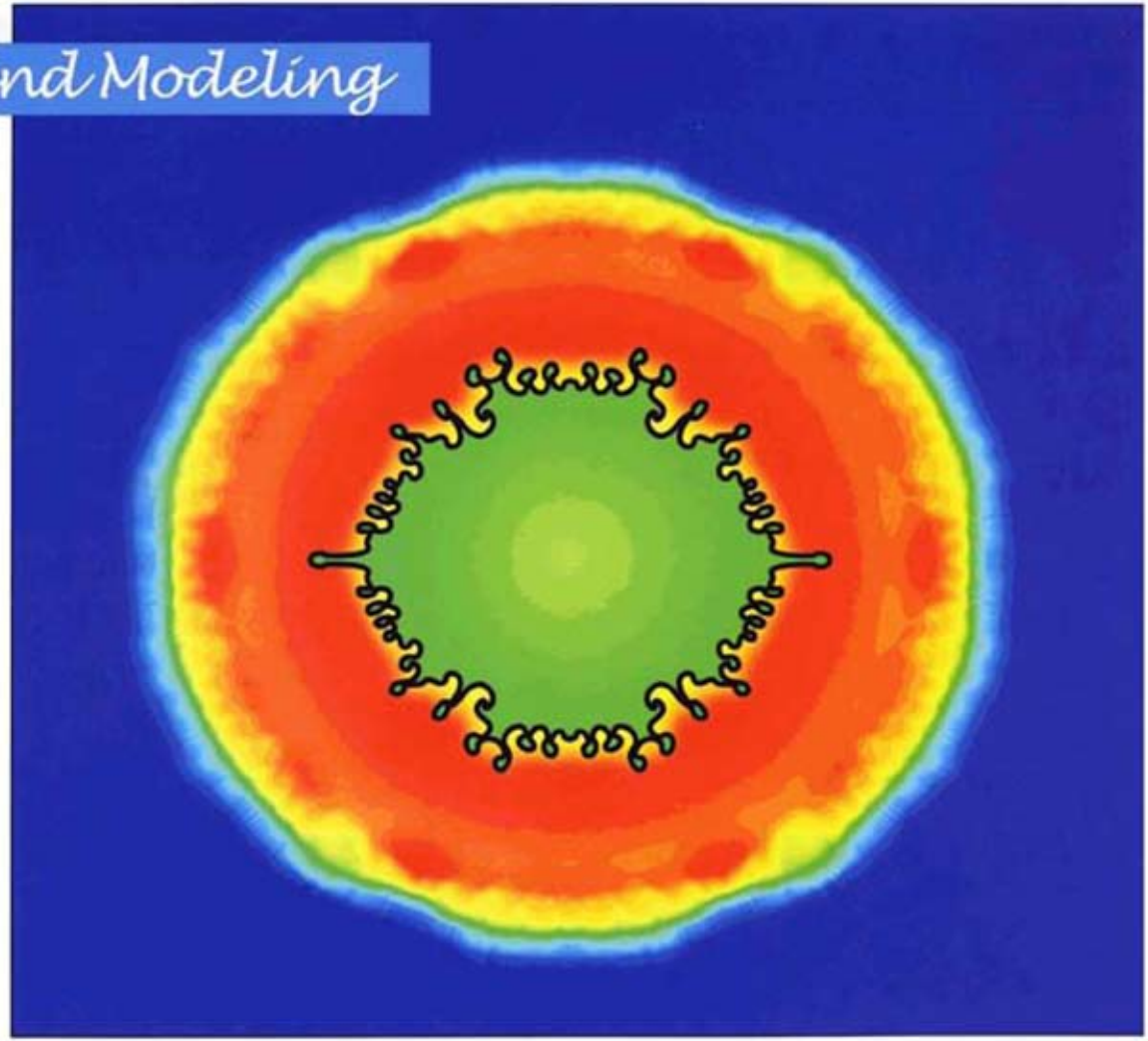
Theory and Modeling

LLE is a unique national resource dedicated to research and education in all aspects of laser–matter interaction. A significant portion of LLE's research program involves theoretical multidimensional modeling and design of direct-drive laser fusion capsules. This photograph shows a 2-D contour plot of density in an imploded OMEGA capsule as simulated by the hydrodynamic code *DRACO*. The black line indicates the D_2-fuel/CH-shell interface.



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2003

January

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
29	31	31	1 New Year's Day University Holiday	2	3	4 Perihelion
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19	20 Martin Luther King, Jr. Day	21	22	23	24	25
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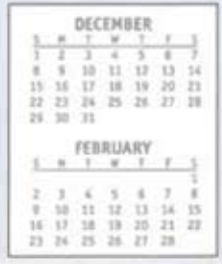
23 Years Ago

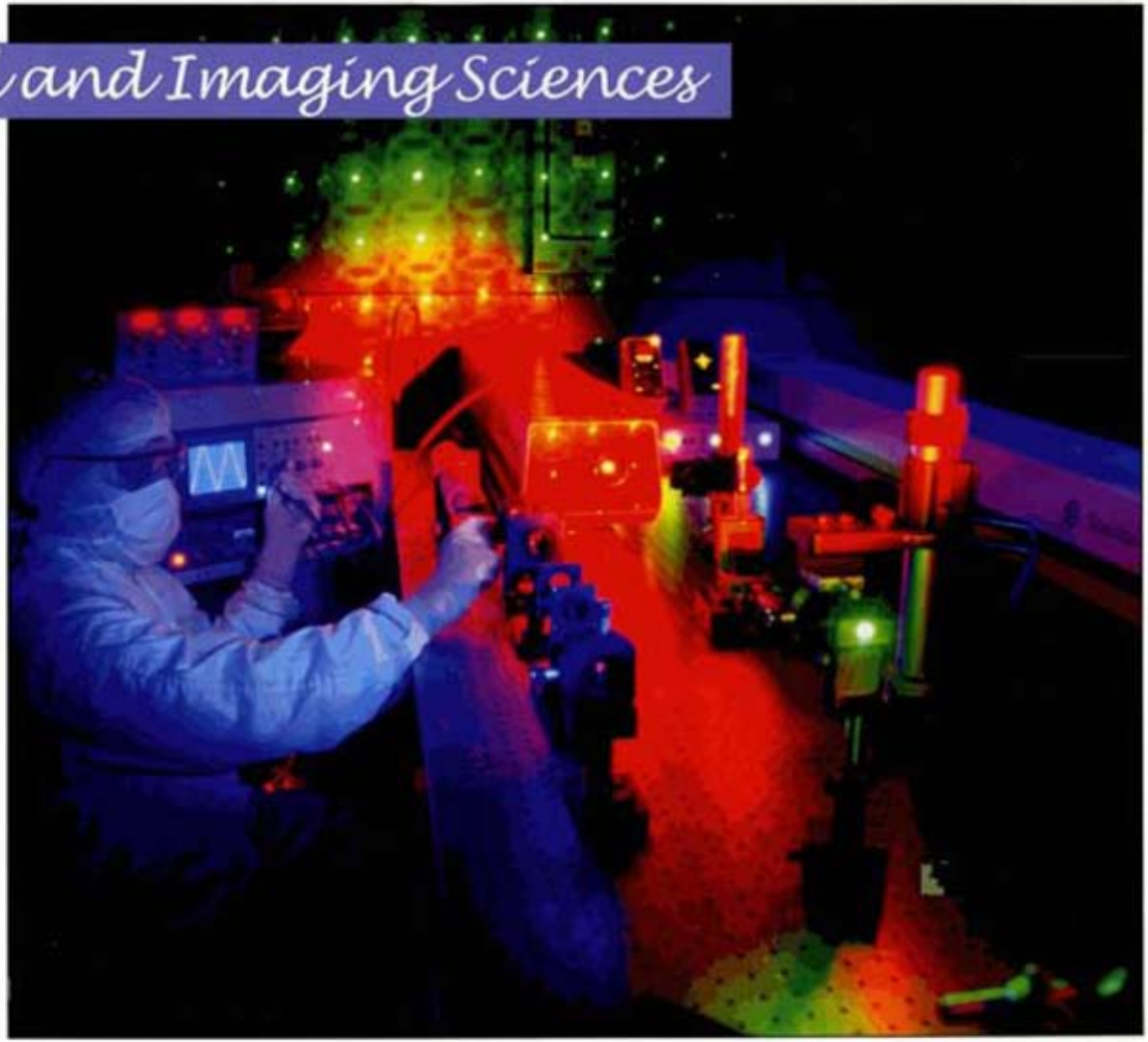
The 24-beam OMEGA Nd:glass laser was designed and constructed by LLE in collaboration with engineering staff from the Eastman Kodak Company. The original performance goals of OMEGA were to produce a short-pulse (~50–100 ps) peak power of 7.5 TW and a long-pulse (>300 ps) energy in excess of 1.2 kJ. The performance tests were concluded on 18 January 1980 and demonstrated short-pulse power of 12.2 TW (at 53 ps) and long-pulse energy (at 273 ps) of 1.76 kJ. Eventually the system was operated at longer pulses (~ 1 ns) with energy up to 4 kJ. The photograph shows an overhead view of the 24-beam OMEGA laser. The system was arranged in six clusters of four beams each.

Photo: Rare Books & Special Collections, University of Rochester Libraries



Optical and Imaging Sciences

LLE is engaged in a strong research and development program in Optical and Imaging Sciences including the development of diffractive optics such as distributed phase plates and gratings. This photograph shows Senior Research Engineer Terrance Kessler of the Optics and Imaging Sciences Group observing the details of an interference pattern that is generated by a holographic diffraction grating. High-efficiency gratings and phase plates, which are used to homogenize the beams of the OMEGA laser, are designed, developed, fabricated, and characterized at LLE.



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2003

February

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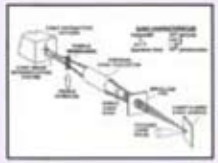

24 Years Ago

On 16 February 1979, the National Laser Users' Facility (NLUF) Steering Committee was convened to review the first 13 proposals submitted to use OMEGA as part of the NLUF program. The Committee recommended approval of up to 10 of these proposals for potential experiments on OMEGA. The figure above shows a schematic description of one of these experiments conducted during FY1980: nanosecond time-resolved x-ray-diffraction studies of biological systems proposed by James Forsyth of the University of Rochester/LLE.

JANUARY

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MARCH

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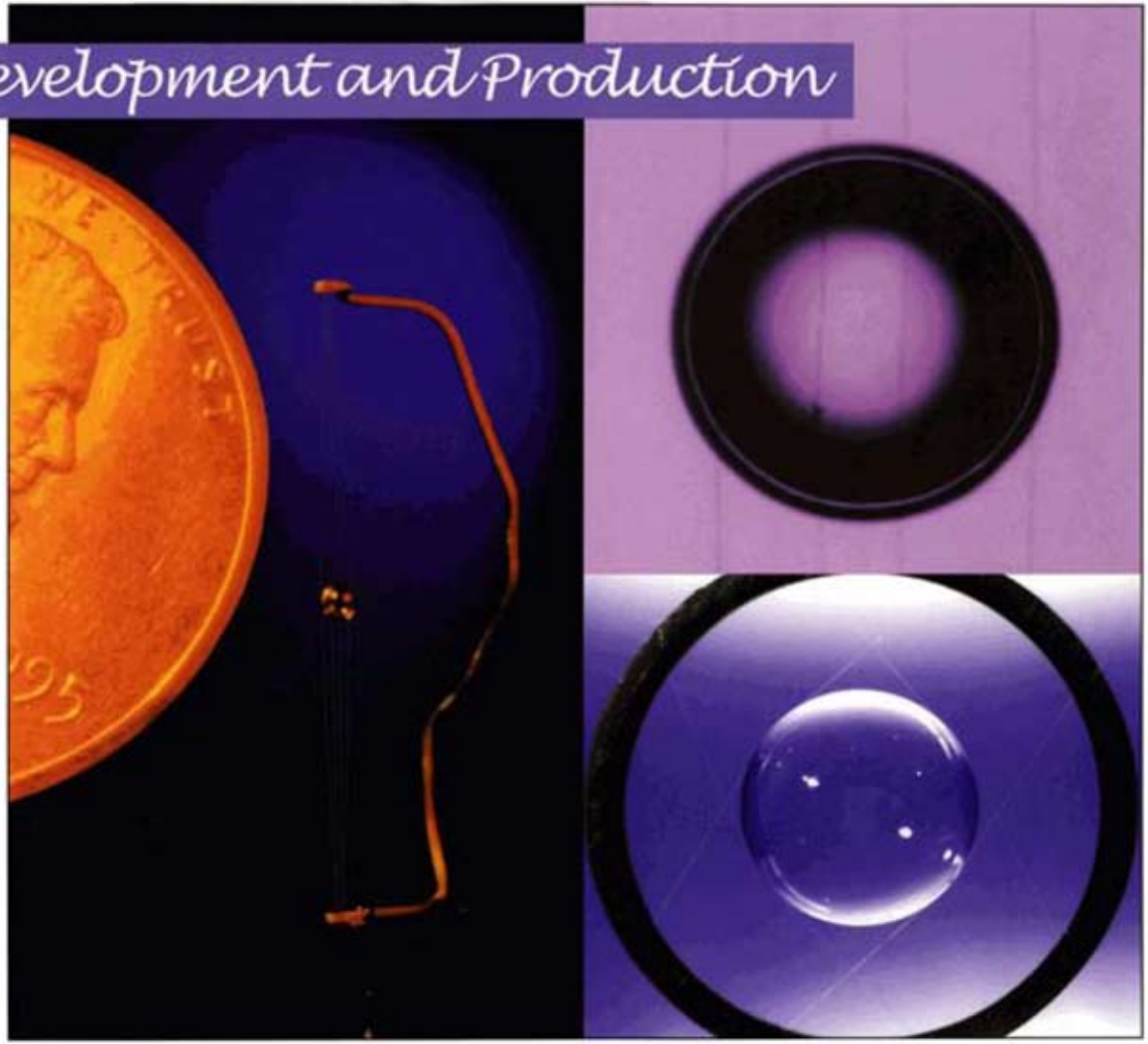
Target Development and Production

The LLE Target Fabrication Group has a broad range of capabilities in nano- and microfabrication technology and characterization and cryogenic-fuel-layer technology. The figures show (immediate right) an OMEGA-scale capsule mounted on a "C" mount compared to a penny; (top far right) a shadowgraph of a frozen-fuel-layer OMEGA capsule mounted on spider webs in a "C" mount; and (lower far right) a prototype NIF-scale (~4-mm-diameter) capsule mounted on spider webs in a ring mount designed for the National Ignition Facility geometry.



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2003

March

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16	17	18	19	20 Vernal Equinox	21	22
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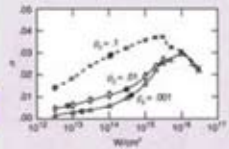

26 Years Ago

On 7 March 1977, the *Physical Review Letters* published a paper by R. L. McCrory of the Laboratory for Laser Energetics of the University of Rochester (currently Director, LLE) and R. L. Morse of the University of Arizona showing that the efficiency with which absorbed laser energy causes a given spherical implosion increases by a factor of 3 to 5 if the laser wavelength is decreased from the infrared wavelengths to the blue or near-ultraviolet. This finding was key in the thrust to develop high-efficiency frequency conversion for high-power Nd:glass fusion lasers. The illustration shows the scaling of hydrodynamic efficiency with laser intensity and critical density (ρ_c) (which scales inversely as the square of the laser wavelength).

FEBRUARY

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APRIL

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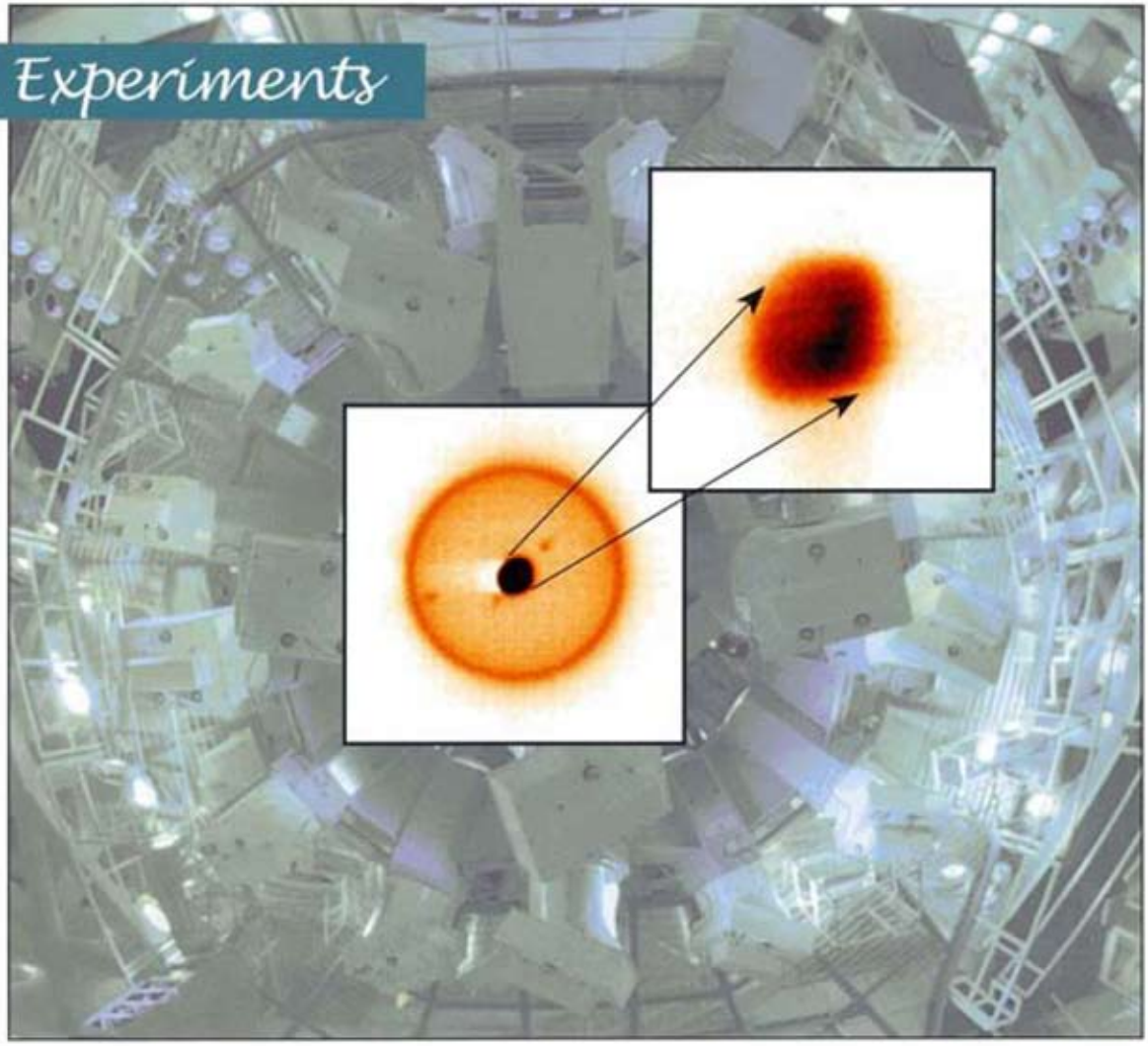
OMEGA Experiments

X-ray imaging of implosions is one of many diagnostic techniques used by the OMEGA Experiments Group to conduct inertial fusion experiments. The center of this photograph shows a time-integrated 2- to 6-keV x-ray image of a cryogenic deuterium-filled capsule implosion. The outer ring corresponds to the original diameter (~ 0.9 mm) of the target and the compressed core has a diameter of ~ 0.1 mm. To the right of the central image is a 4- to 7-keV x-ray image of the core taken with an x-ray microscope.



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April

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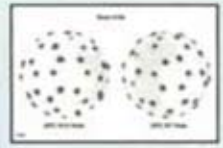
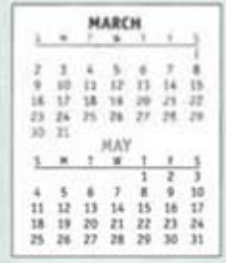


8 Years Ago

On 19 April 1995 the first 60-beam target test shot was taken on OMEGA. This shot initiated a two-week period during which the formal performance verification tests of the 60-beam OMEGA were conducted. The performance requirements included 60-beam energy on target of up to 30 kJ for a five-shot series taken at a repetition rate of one shot per hour. During these performance tests, OMEGA exceeded all its specifications, delivering in excess of 32 kJ per shot on target for a series of five sequential shots taken at a rate of one shot per hour. The photo shows x-ray imaging data from a pointing target (a 4-mm-diameter Au-coated sphere) with all 60 beams on target.



Diagnostic Support and Development

LLE has developed a comprehensive plasma and laser diagnostic capability for inertial fusion and high-energy-density physics experiments. Measurement of the laser pulse shape for each of the 60 beams with high bandwidth (~10 GHz) and dynamic range is required to assure adequate power balance and control of the pulse shape. Six LLE-developed streak cameras are used to measure the pulse shape of all 60 OMEGA beams. The photograph shows William Donaldson (Sr. Scientist) reviewing the processed pulse shape data from 30 beams from a cluster of three streak cameras mounted on the wall.

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May

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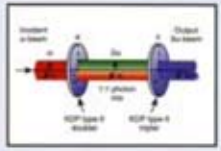
25	26 Memorial Day University Holiday	27	28	29	30	31



23 Years Ago

On 1 May 1980, a patent application was filed for a frequency-tripling technique invented by R. S. Craxton of the University of Rochester, LLE (U.S. patent 4,346,314 issued 24 August 1982). This so-called polarization mismatch technique is illustrated schematically in the sketch above. The technique was first demonstrated experimentally on the Glass Development Laser (GDL) system at LLE; two papers on the subject were published in *Optics Communications* in September 1980. This frequency-tripling technique rapidly became a means of choice to significantly enhance the effectiveness of existing and soon-to-be-built high-power Nd-glass laser systems including OMEGA, Nova, OMEGA Upgrade, GEKKO, LIL, LMJ, and the NIF.

APRIL

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JUNE

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Optical Manufacturing

A key factor for the success of LLE is its location in an area with a strong optical science and technology base and infrastructure. The photograph shows Senior Technical Associate Gary Mitchell testing a mirror coated by the LLE Optical Manufacturing Group (OMAN) for the Z-beamlet laser at the Sandia National Laboratory. OMAN is responsible for all OMEGA optics and, additionally, is providing high-energy damage coatings for the National Ignition Facility (NIF) polarizers and mirrors and assembling the NIF deformable mirrors.

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June

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
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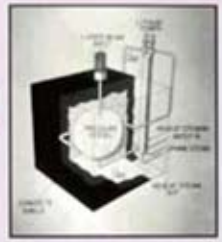
8	9	10	11	12	13	14
15	16	17	18	19	20 LLE Golf Tournament Shadow Lake	21 Summer Solstice
22 33rd Anomalous Absorption Conference - Lake Placid, NY	23	24	25	26	27	28
29	30	1	2	3	4	5



32 Years Ago

On June 1971, almost one year after the formal establishment of the Laboratory for Laser Energetics at the University of Rochester, an article entitled "Fusion by Laser" appeared in the *Scientific American* authored by Moshe J. Lubin (LLE Director at that time) and Arthur P. Fraas of the Oak Ridge National Laboratory. The summary for this article states: "Experiments indicate that energy-releasing fusion reactions can be initiated and to some extent controlled without a confining magnetic field by focusing a powerfu laser on a frozen pellet of fuel." The sketch shows a conceptual laser-fusio reactor discussed in this article.

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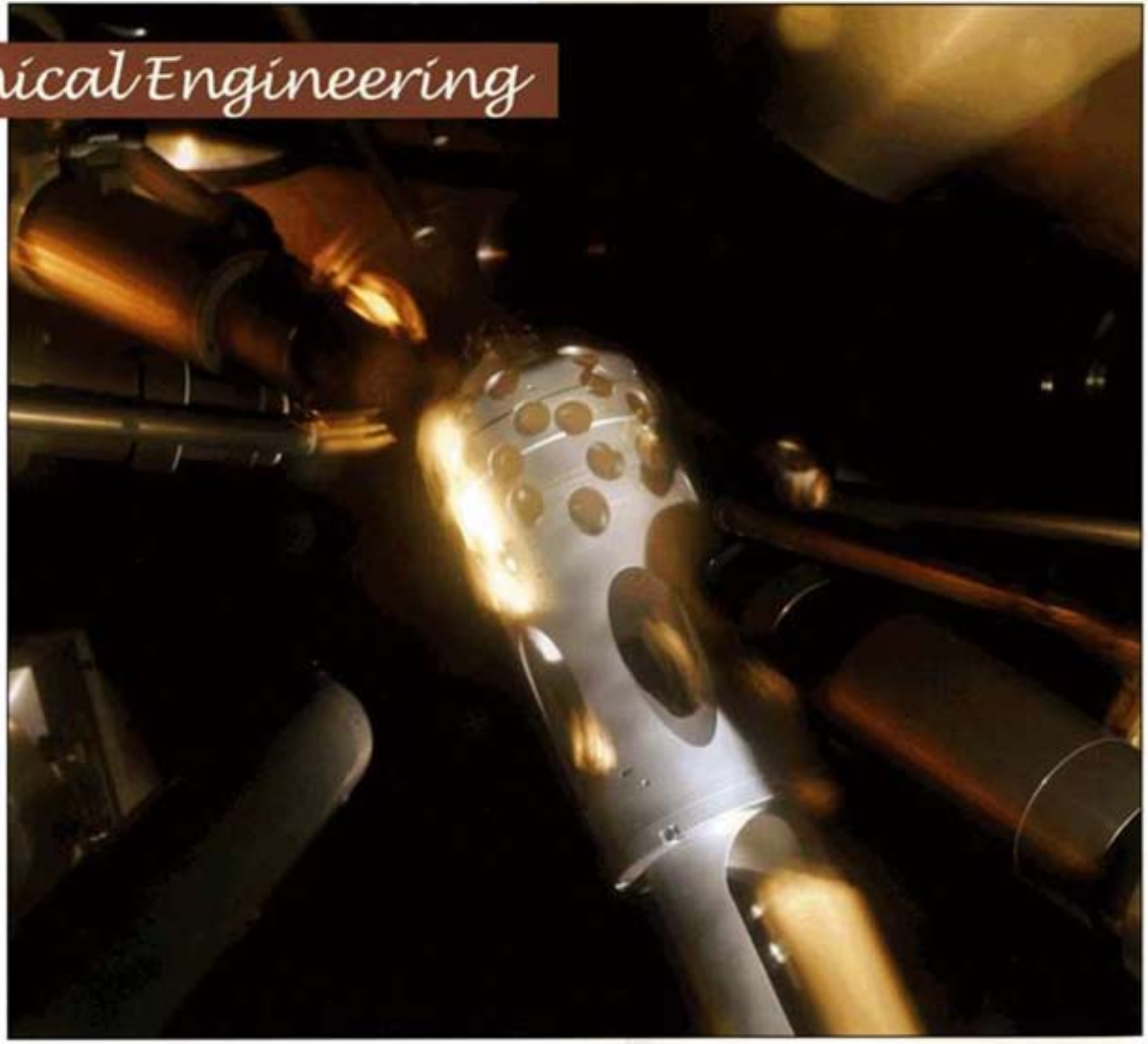
Mechanical Engineering

LLE's Mechanical Engineering Group is integrated into all major laboratory projects. One such project is the OMEGA Transport Instrument System (OTIS), which consists of a precision-fabricated glass sphere located inside a precision mechanical fixture. Precise (~ 0.1%) beam transport measurements can be routinely made when this system is located in the center of the OMEGA target chamber. Continuous-wave UV laser light is transported through the UV optical portion of each beamline, focused onto the surface of the sphere, and retroreflected back through the beamline to a power ratiometer. This photograph shows the OTIS system inside the OMEGA target chamber.



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July

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6	7	8	9	10	11	12
13	14	15	16	17	18 LLE Golf Tournament Deerfield	19
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28 Years Ago

On 11 July 1975, the New York State Legislature passed a supplemental appropriation for 1975 that contained an appropriation for $7.5 million as an interest-free loan to the University of Rochester to support the construction of a building to be used for the Laser Fusion Feasibility Project. This building currently houses the OMEGA laser facility and many of the associated laboratories and offices. The above sketch shows the proposed Laser-Energy Center.

Photo: Rare Books & Special Collections, University of Rochester Libraries

JUNE

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AUGUST

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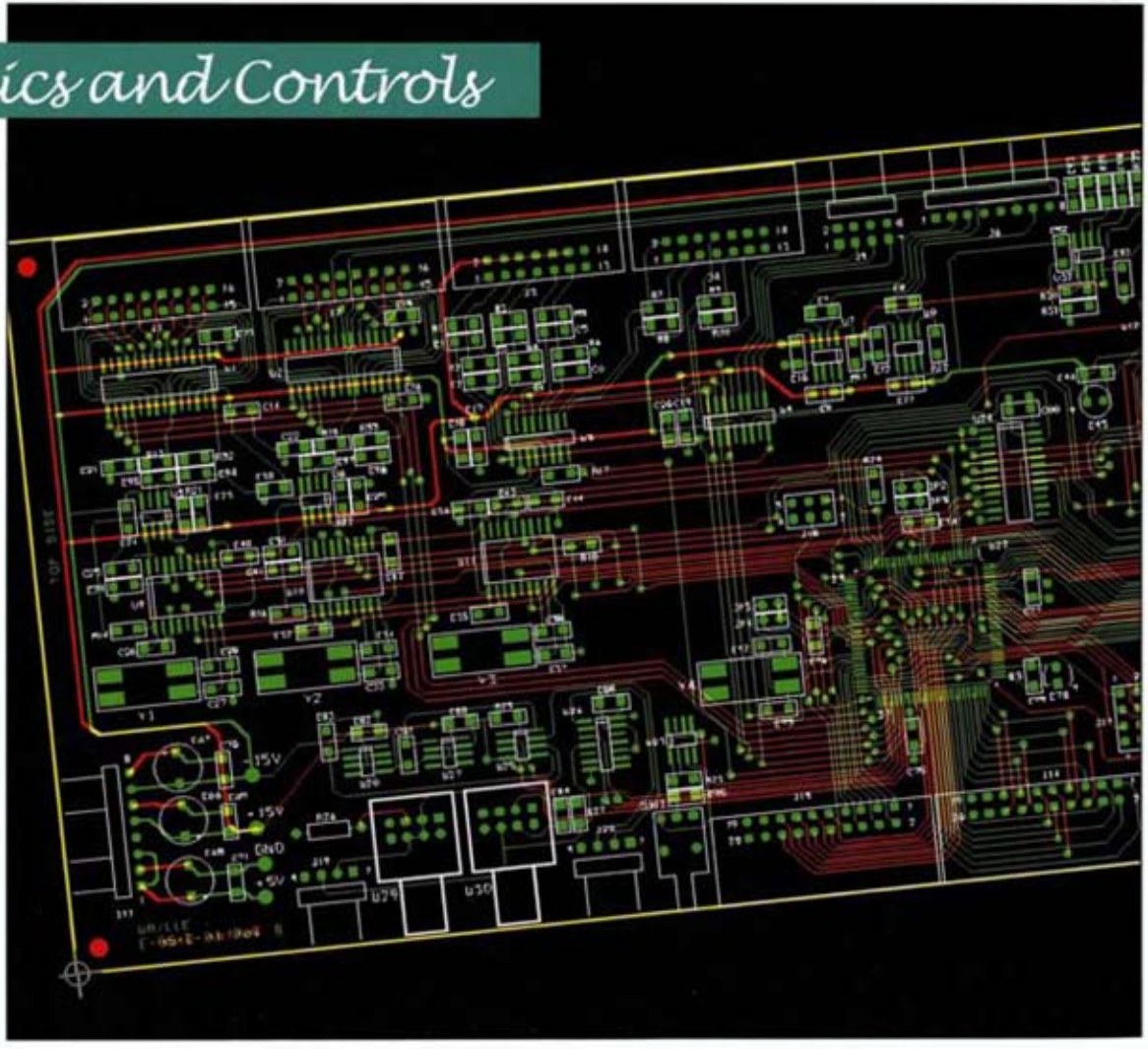
Electronics and Controls

The Electronics and Controls Group is integrated with the other engineering disciplines of LLE and provides a broad spectrum of capabilities. This group is responsible for electronics and controls systems for such diverse applications as high-speed streak cameras, cryogenic target handling systems, high-vacuum systems, and a variety of high-power lasers. The computer-generated drawing on the right shows the layout of a "next generation" streak camera control board with four copper layers. LLE leads in the design and implementation of ultrahigh-speed optical and x-ray streak cameras.



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2003

August

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
27	28	29	30	31	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15 LLE Golf Tournament Bristol Harbour	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

17 Years Ago

In August 1986, the featured article of *Scientific American* was titled "Progress in Laser Fusion" by R. Stephen Craxton, Robert L. McCrory, and John M. Soures, all of the University of Rochester's Laboratory for Laser Energetics. The article discussed the considerable progress made in laser fusion since the ability to convert infrared lasers to the ultraviolet was demonstrated at LLE in 1979. The authors concluded that electric power generation using short-wavelength lasers would be feasible with lasers generating between 1.6 and 10 MJ per pulse with a fusion energy release 100 times larger than the input laser energy.

JULY

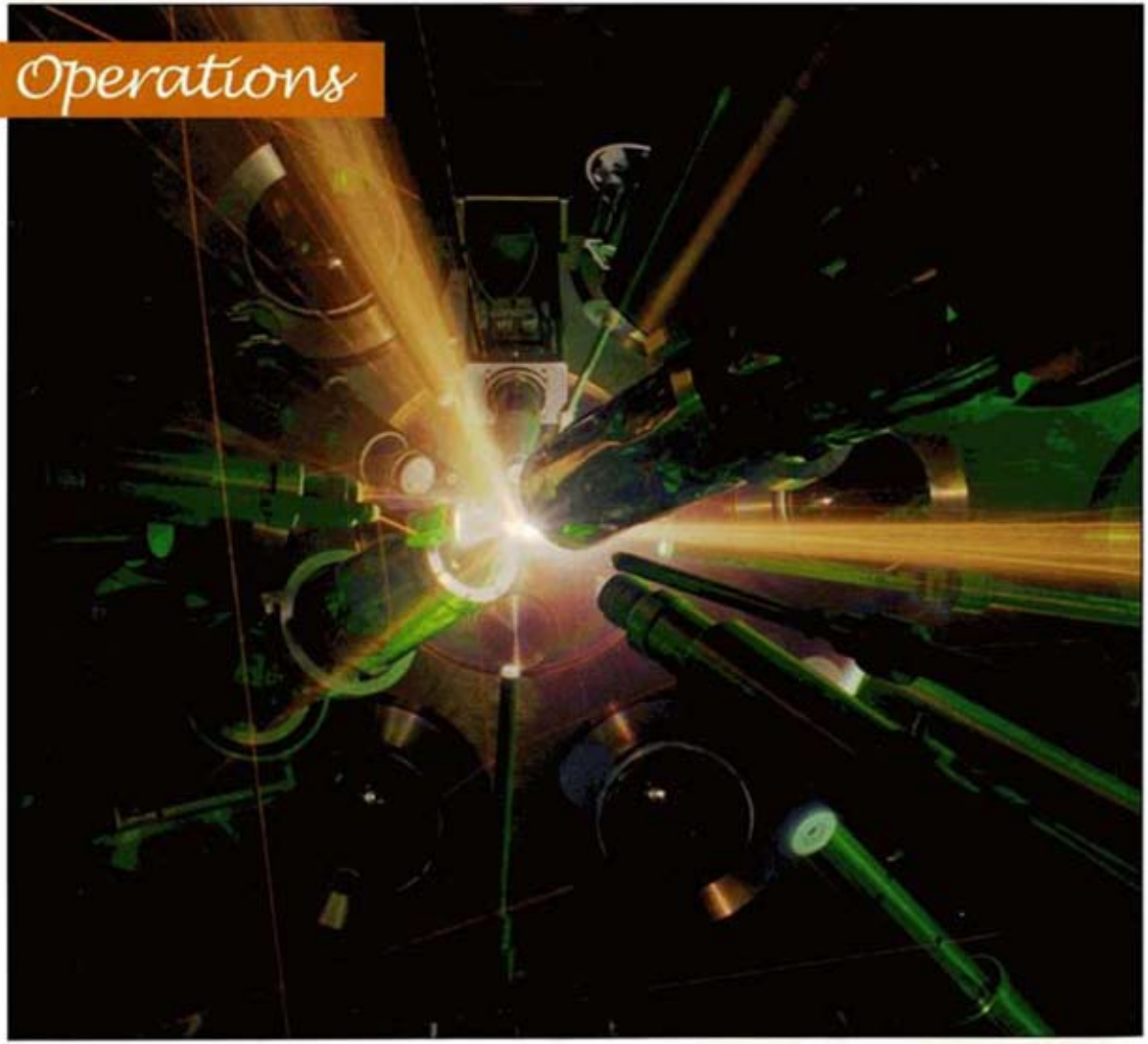
S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

SEPTEMBER

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

OMEGA Operations

The OMEGA Operations Group provides operational support for all aspects of the facility from front-end laser sources to experimental diagnostics. OMEGA produces nearly 1400 target shots per year for a wide variety of experiments. External groups under the National Laser Users' Facility (NLUF) and from national laboratories carry out nearly half of these experiments. This photograph of the inside of the OMEGA chamber was shot during an NLUF experiment carried out by a collaborative team led by the University of California, Davis, to study the response of materials to rapid heating using x-ray diffraction as a probe.



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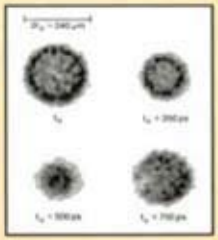
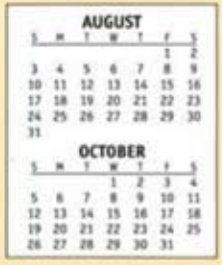
September

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
31	1 Labor Day University Holiday	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23 Autumnal Equinox	24	25	26	27
28	29	30	1	2	3	4



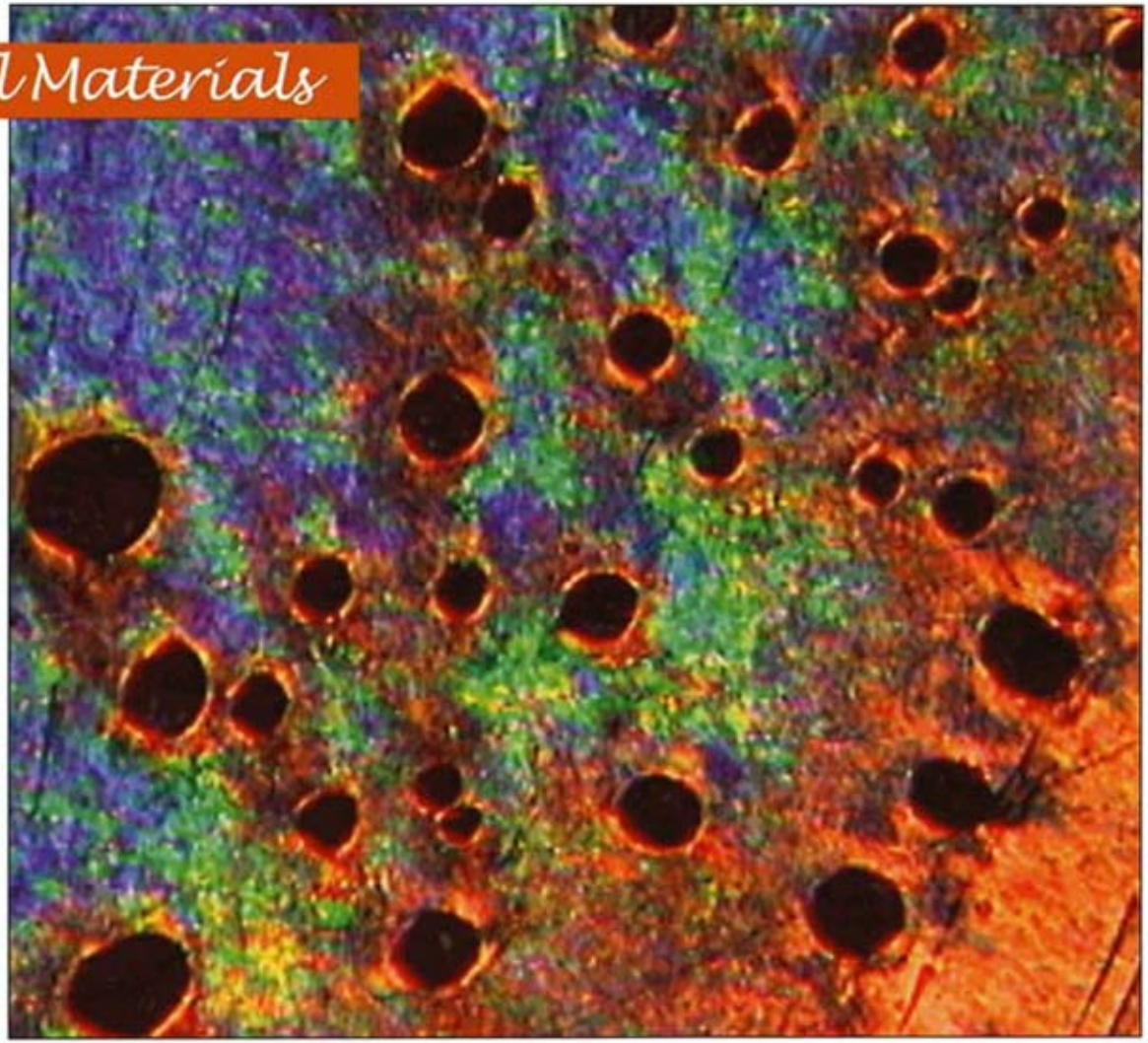
15 Years Ago

The September 1988 issue of *Nature* included a paper entitled "Laser Driven Implosion of Thermonuclear Fuel to 20 to 40 gcm^{-3}" by R. L. McCrory *et al.* This paper described direct-drive implosion experiments using cryogenic-DT-fuel-layer capsules conducted on the OMEGA laser that achieved compressed fuel densities in the range of 100 to 200 times liquid-DT-fuel density, the highest DT density achieved at that time in laser fusion experiments. This high-density demonstration experiment was a major condition to obtain DOE approval for the upgrade of the OMEGA laser to 60-beam, 30-kJ, UV operation.



Optical Materials

The Laboratory for Laser Energetics (LLE) conducts a strong program in the research and development of optical materials. This work includes the development of liquid-crystal optical materials with applications in high-energy laser systems. Shown here is a cholesteric (or chiral nematic) liquid crystal viewed at 100x magnification under crossed polarizers. The brilliant colors are due to reflected circularly polarized light.



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2003

October

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
28	29	30	1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27 APS Conference Albuquerque, NM	28	29	30	31	1

25 Years Ago

U. S. Congressman Frank Horton (above) fired the first shot on Zeta, a laser comprising the first six beams of OMEGA on 17 October 1978. The shot generated more than 300 million neutrons and climaxed the morning of what University President Robert L. Sproull called "a great day in the life of this University." It was witnessed by approximately 200 guests from government, industry, and academia.

Photo: Rare Books & Special Collections, University of Rochester Libraries

SEPTEMBER

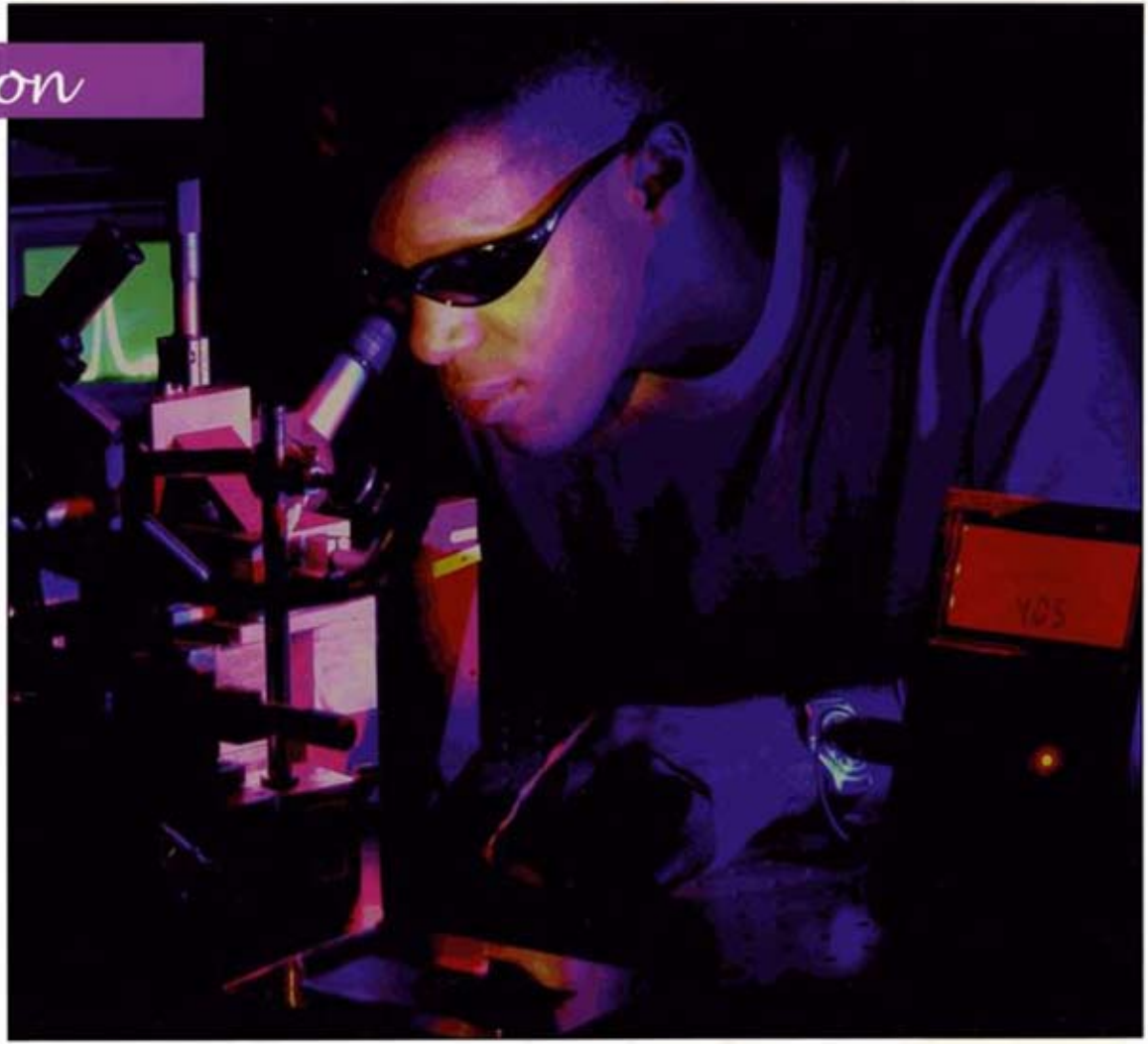
S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

NOVEMBER

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

Education

Education at the post-graduate, graduate, under-graduate, and high-school level is a very high priority for LLE. In the photograph graduate student Carlo Williams operates an electro-optic sampling system. This system is capable of measuring subpicosecond transients and was developed, demonstrated, and patented by LLE as part of a graduate student thesis research project in 1982 (U.S. Patent 4,446,425 by J. A. Valdmanis and G. Mourou).



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2003

November

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
26	27	28	29	30	31	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27 Thanksgiving University Holiday	28 University Holiday	29
30						

26 Years Ago

To verify the ability of the original 24-beam OMEGA laser to reach its specified performance level, a one-beam prototype system, GDL (glass development laser), was built in the "new" LLE building in 1977. By 8 November 1977, GDL was producing peak power levels in excess of 0.5 TW per beam in short pulses. The accompanying photo shows the GDL laser as it was originally configured for this performance testing. The GDL laser continued to operate for a variety of experiments including the first demonstration of high-efficiency frequency tripling, the first comprehensive series of 0.35-μm laser-matter interaction experiments, and the first series of NLUF experiments.

OCTOBER

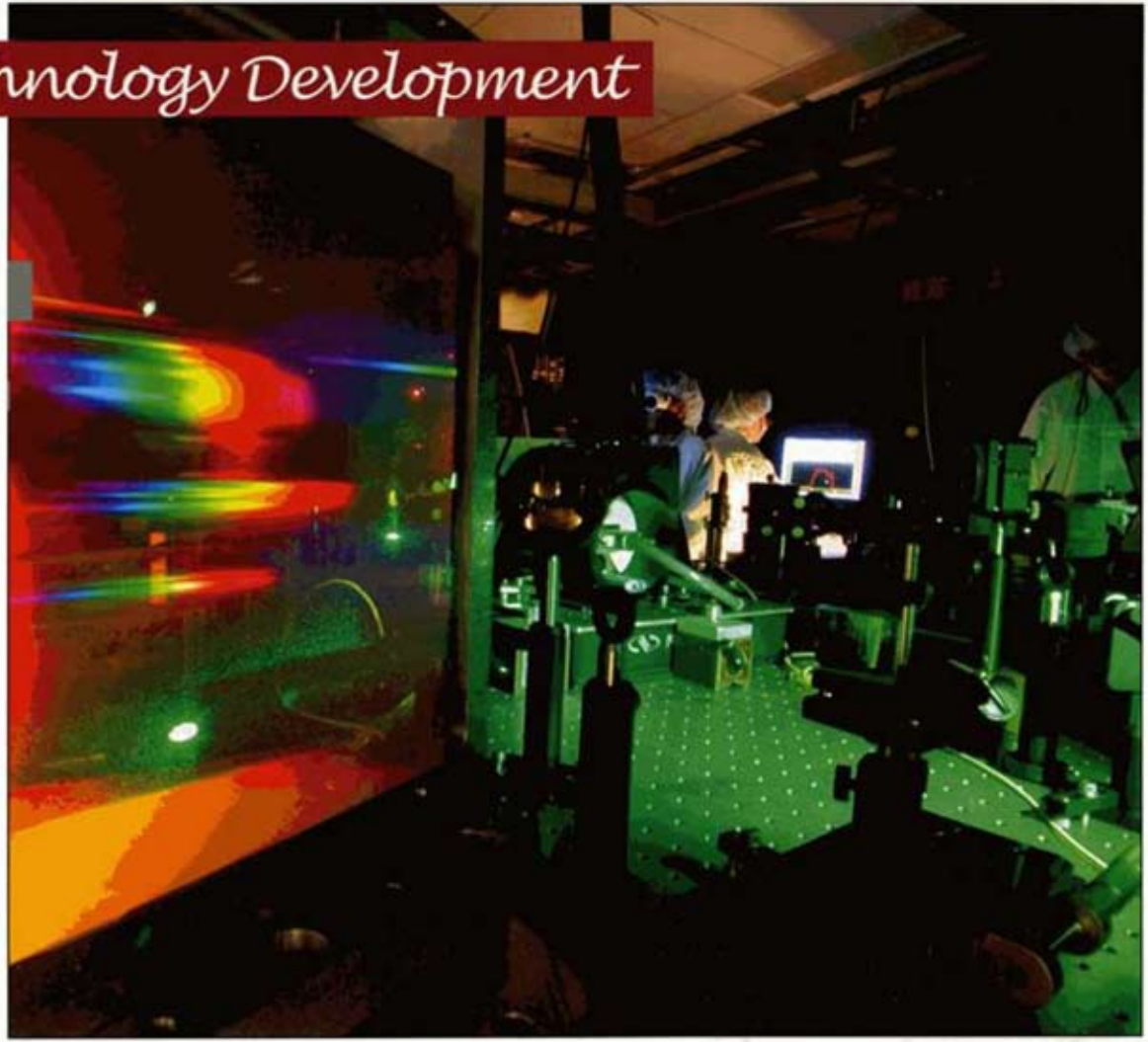
S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

DECEMBER

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

Laser Technology Development

The LLE Laser Technology Development Group is responsible for inventing solutions to solve challenging laser problems. One such example is shown in this photograph: Optical Parametric Chirped Pulse Amplification (OPCPA). The OPCPA uses a nonlinear crystal (LBO) pumped by the frequency-doubled output of a Nd:YLF laser to amplify (by ~ ten million times) the pulse-stretched output of an ~200-fs laser pulse. This system will serve as the injection laser for a future laser facility currently in design at LLE.



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2003 December

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
30	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22 Winter Solstice	23	24	25 Christmas University Holiday	26	27
28	29	30	31			

11 Years Ago

At 5:09 pm on 18 December 1992, the last target shot was fired on the original 24-beam OMEGA laser. Operations of OMEGA, which had been operated in various configurations including 6-beam and 24-beam infrared and 24-beam ultraviolet and had been fired approximately 25,000 times since its first shot in 1978, were suspended on this date to support the upgrade of OMEGA to a 60-beam, 30-kJ, UV laser. OMEGA was successfully upgraded on schedule and within budget and met or exceeded all its specifications.

The above photograph shows the OMEGA Laser Bay during the demolition phase of the OMEGA Upgrade project.

NOVEMBER

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

JANUARY

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

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