

Education Summary

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Education/training is a primary technical mission for LLE. LLE is the only place where students can be trained at scale for careers in national security related to the science of Stockpile Stewardship. The education programs at LLE include a high school research program that exposes students to a professional environment where they work alongside scientists and engineers for a summer; undergraduate programs where students conduct research or work part-time with scientists and engineers often in the summer with some throughout an academic year (or longer) to understand how classroom education is applied to real world problems; graduate education where students are immersed in the science of high energy density (HED) physics and lasers to earn MS and Ph.D. degrees; and a new high school program for underrepresented minority students and their teachers in the local Rochester area. This report provides a summary of these activities in FY22.

Summer High School Research Program

Since 1989, LLE has held the annual Summer High School Research Program for Rochester-area high school students who have just completed their junior year. The eight-week program provides an exceptional opportunity for highly motivated students to experience scientific research in a professional environment. Sixteen students participated in the 2022 program (see p. 54). Four hundred and fifteen students from 55 high schools have participated in the program to date including 143 students who identify as female. Thirty-nine students have become Scholars in the prestigious Regeneration Science Talent Search based on the research projects they carried out at LLE. Many of the students progress to major in science-related disciplines at nationally recognized universities, and more than 100 have now received their doctoral degrees, which was a featured news article by the University of Rochester.¹

Broad Exposure to Science and Technology Student and Teacher Research Program

Started during FY20 by T. J. Kessler, the LLE Diversity Manager, the goal of the Broad Exposure to Science and Technology (BEST) initiative is to engage underrepresented high school students and their teachers from the Rochester City School District (RCSD) in various aspects of science and technology that support laser science and applications research at LLE. Two RCSD high school science and technology teachers and five high school students participated in this second year of LLE's BEST Program carried out at the RCSD's East High School over the six-week period during the summer of 2022 (see p. 57). A team of 20 LLE volunteers worked with the BEST students and teachers in a greater number of fields, including HED physics, magnetics, acoustics, theoretical physics, database management, graphic design, and the technology trades that support all research activities at LLE. The BEST participants visited LLE three times during the summer program to tour the OMEGA lasers, optical manufacturing facilities, and other support laboratories. The teachers and students of the BEST Program serve as ambassadors for outreach to other students at RCSD high schools, assisting in expanding the number of BEST candidates for the following year. Both an RCSD teacher and student from the 2021 BEST program participated in a visit by the director of the National Science Foundation to UR/LLE during the spring of 2022.

Undergraduate Student Program

Although LLE does not have a formal undergraduate student program, it has provided unique work-study opportunities for undergraduate research and co-op internships by involving undergraduate and community college students in its research activi-

ties. These students come from the University of Rochester, the Rochester Institute of Technology (RIT), the State University of New York (SUNY) at Geneseo, Cornell University, Monroe Community College, and other institutions. LLE scientists also host and mentor students participating in the Research Experience for Undergraduate Program funded by the National Science Foundation, and from 2022 the new Plasma and Fusion Undergraduate Research Opportunity (PFURO) Program funded by the Office of Fusion Energy Sciences. During FY22, 49 undergraduates including 17 co-op students and three PFURO students conducted research and work-study at LLE. To meet increased needs, LLE's undergraduate student program will be expanded into a formal program from FY23 and coordinated by a dedicated new program director.

Graduate Student Program

Graduate students use the Omega Laser Facility as well as other LLE facilities to conduct inertial confinement fusion (ICF) and high-energy-density–physics research to earn advanced degrees. These students make significant contributions to the LLE research output (e.g., they write a large fraction of the manuscripts published annually by LLE). Thirty-five UR faculty members across eight academic departments hold secondary appointments with LLE, increasing the breadth of leadership in science and technology. Sixteen scientists and research engineers at LLE hold secondary faculty appointments with the University in five different academic departments. The large number of faculty and LLE staff enable the Laboratory to pull together a new high-energy-density science (HEDS) curriculum and educate a large number of graduate students. More than 80 UR graduate students were involved in research at LLE in FY22 (see Table I), among which 67 students were directly funded by LLE via the NNSA-supported University of Rochester Frank Horton Fellowship Program. Their research includes theoretical and experimental plasma physics and fusion science, HED physics, x-ray and atomic physics, nuclear physics, material properties under extreme pressure, astrophysics, ultrafast optoelectronics, high-power laser development and applications, nonlinear optics, optical materials and optical fabrication technology, and target fabrication.

In FY22, LLE directly funded graduate/undergraduate research with twelve external academic partners including SUNY Geneseo, RIT, the University of Delaware, Massachusetts Institute of Technology's Plasma Science and Fusion Center, the University of Michigan, the University of Nebraska-Lincoln, the University of Nevada at Reno, Stony Brook University, the University of California at Los Angeles, the University of Alberta, Imperial College London, and Oxford University. These programs involved 22 undergraduate students including 20 from SUNY Geneseo, 19 graduate students, six postdoctoral researchers, eight scientists and research staff, and 17 faculty members.

In addition, LLE has significantly facilitated the education and training of several hundred students and postdoctoral researchers in the HEDP and ICF science areas from other universities through their participation in the National Laser Users' Facility, Laboratory Basic Science, LaserNetUS, and collaborations with LLE and DOE national laboratories. More than 70 graduate students (including 16 mentioned above) from 28 universities (see Table I in the **External Users' Program**, p. 80) and over 40 postdoctoral researchers were involved in these external user-led research projects with experiments conducted at the Omega Laser Facility in FY22.

Sixteen graduate students, including nine from the University of Rochester and seven from other academic institutions have successfully completed their thesis research and obtained Ph.D. degrees in calendar year 2022. Table II lists their name, university, and current employer. Seven of them (44% of the total), including three from UR, joined the NNSA laboratories, five stayed within academia, and four work in the private sector.

1. L. Valich, University of Rochester, Laser Lab Springboards 100-Plus High Schoolers to Doctoral Degrees, Accessed 3 July 2023, <https://www.rochester.edu/newscenter/laser-lab-springboards-100-plus-high-schoolers-to-doctoral-degrees-517662/>.

Table I: More than 80 graduate students, including 67 LLE-funded UR Frank Horton Fellows (marked by *), conducted research at LLE during FY22.

Student Name	Department	Faculty Advisor	LLE Advisor (if different)	Research Area	Notes
N. Acharya*	ME	J. Shang	D. N. Polsin	Viscosity Measurements in High-Energy-Density Fluids	New Horton Fellow
M. Adams	PA	P.-A. Gourdain/ P. Tzeferacos		Elucidation of Magnetic-Field Generation via Laser-Target Illumination in the Magnetohydrodynamic Framework	Former Horton Fellow; graduated in 2022
M. V. Ambat*	ME	D. H. Froula	J. L. Shaw	First-Light Laser Wakefield Acceleration Experiments on MTW-OPAL	
A. Anand*	PA	J. Carroll-Nellenback		The Role of Exoplanetary Magnetic Fields in Atmospheric Evolution and Habitability	
A. Armstrong*	PA	P. Tzeferacos		Radiative, High-Energy-Density Magnetized Turbulence: Charting the Uncharted Plasma Regimes of Fluctuation Dynamo	
B. Arnold*	PA	S. X. Hu		Developing a Finite-Element Discrete-Variable-Representation-Based Real-Space Density-Function-Theory Code for High-Energy-Density Physics	New Horton Fellow
J. Baltazar*	ME	S. P. Regan	R. C. Shah	Inertial Confinement Fusion Implosion Physics	
Z. Barfield*	PA	D. H. Froula		Heat Transport in High Magnetic Fields	
D. T. Bishel*	PA	G. W. Collins/ J. R. Rygg	P. M. Nilson	X-Ray Spectroscopy of Hot Dense Matter: Plasma Screening of Atomic Orbitals at Atomic Pressures	
G. Bruhaug*	ME	G. W. Collins/ J. R. Rygg	H. G. Rinderknecht/ M. S. Wei	Short-Pulse Laser-Generated Probes for High-Energy-Density Experiments	
S. Cao*	ME	C. Ren	R. Betti	Predicting Hot Electrons for Inertial Confinement Fusion	
D. Chakraborty	ECE	R. Sobolewski		Optics and Imaging	
G. Chen	ECE	R. Sobolewski		Novel Terahertz Sources and Terahertz Time-Domain Spectroscopy: Characterization of Novel Materials	
J. Cheng	MS	R. Sobolewski		Terahertz and Optical Pump-Probe Spectroscopy	
D. A. Chin	PA	G. W. Collins/ J. R. Rygg	P. M. Nilson	X-Ray Absorption Spectroscopy for the Study of Materials Under Extreme Conditions	NNSA Stockpile Stewardship Graduate Fellow (a former Horton Fellow)

Table I: More than 80 graduate students, including 67 LLE-funded UR Frank Horton Fellows (marked by *), conducted research at LLE during FY22 (continued).

Student Name	Department	Faculty Advisor	LLE Advisor (if different)	Research Area	Notes
K. Churnetski*	ME	S. P. Regan	W. Theobald	Three-Dimensional Hot-Spot X-Ray Emission Reconstruction for Mitigation of Low-Mode Asymmetries on OMEGA	
C. Danly	ME	R. Betti		Spatial Measurements of Ion Temperatures of Inertial Confinement Fusion Hot Spots	Technical Advisor: V. Geppert-Kleinrath (LANL)
R. Dent*	CHE	A. Shestopalov	S. G. Demos	Next-Generation Gratings for High-Power Lasers	
J. D'Souza*	PA	P.-A. Gourdain	S. Zhang	Large-Scale High-Energy-Density Simulations with <i>ab initio</i> Quality	New Horton Fellow
R. Ejaz*	ME	R. Betti		Understanding the Physics of Areal-Density Degradation in Direct-Drive OMEGA Implosions Through Dedicated Experiments and Statistical Modeling	
I. N. Erez*	PA	P.-A. Gourdain		Achieving High Magnetization with Cylindrically Converging Plasma Flows	New Horton Fellow
M. Evans*	PA	P.-A. Gourdain		The Study of Warm Dense Matter Generated by Pulsed-Power Generators	
P. Farmakis*	ME	R. Betti	R. Betti/ P. Tzeferacos	Three-Dimensional Reconstruction of the Compressed Core in OMEGA Direct-Drive Implosions	
P. Franke*	PA	D. H. Froula		Measuring the Dynamics of Electron Plasma Waves with Thomson Scattering	Graduated in 2022
J. García-Figueroa	CHE	D. R. Harding		Electron Cyclotron Resonance Microwave Chemical Vapor Deposition Method and Its Influence over the Properties of Vapor-Deposited Hydrocarbon Films	Former Horton, graduated in 2022
K. Garriga	OPT	X. C. Zhang		Terahertz Research	
M. Ghosh*	CHE	D. McCamant	S. Zhang	Chemistry of Planetary Materials Under Extreme Pressure and Temperature Conditions	
M. K. Ginnane*	ME	G. W. Collins/ J. R. Rygg		Compressibility, Structure, and Melting of Platinum to 500 GPa	
X. Gong*	ME	G. W. Collins/ J. R. Rygg		Structure and Electronic Properties of Sodium and Potassium at High Pressure	

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Student Name	Department	Faculty Advisor	LLE Advisor (if different)	Research Area	Notes
R. Goshadze*	ME	Y. Gao	V. V. Karasiev	Deep Neural Network for Learning Noninteractive Free-Energy Density Functional to Enhance Density Functional Theory-Based Simulations Relevant to High-Energy-Density Physics	New Horton Fellow
S. Gupta*	OPT	P. S. Carney/ J. M. Zavislan	M. D. Wittman	Quantitative Confocal Phase Imaging for the Inspection of Target Capsules	
H. Hasson*	PA	P.-A. Gourdain		Understanding the Transition from Accretion Flows to Magnetized Turbulent Jets Using Pulsed-Power Drivers	New Horton Fellow
S. K. Harter	EES	M. Nakajima	D. N. Polsin	Planetary Science	
B. J. Henderson*	PA	G. W. Collins/ J. R. Rygg		Hugoniot Measurements of Silicon and Radiance Transition in Shocked Silica Aerogel	
J. Hinz*	PA	S. Rajeev	V. V. Karasiev	Developing Accurate Free-Energy Density Functionals via Machine Learning for Warm-Dense-Matter Simulations	
R. Holcomb*	OPT	J. Bromage		Machine-Learning Control of High-Average-Power Lasers for Ultrafast Applications	
M. F. Huff*	PA	G. W. Collins/ J. R. Rygg		The Equation of State of Shocked Iron and Bridgmanite	
G. W. Jenkins*	OPT	J. Bromage		Divided-Pulse Coherent Combination for Scaling High-Power Nonlinear Processes	Graduated in 2022
M. Jeske*	CHE	D. R. Harding		Engineering Resins for Two-Photon Polymerization	
R. Jia*	CHE	A. Shestopalov	S. G. Demos	Effects of Organic Monolayer Coatings on Optical Substrates	
A. Kish*	PA	A. B. Sefkow		Algorithms for Long-Time-Scale Plasma Simulation	
S. Kostick*	ME	W. Theobald	M. J. Rosenberg	Laser-Energy Coupling in Direct-Drive Experiments at the National Ignition Facility and Omega	New Horton Fellow
K. Kotorashvili*	PA	E. G. Blackman		Magnetic-Field Generation, Mass Transport, and Spin Evolution in Hydrogen Burning Stars and White Dwarfs	
A. LaPierre	CH	G. W. Collins/ J. R. Rygg		Development of Raman Spectroscopy for Dynamic Compression Experiments on OMEGA	

Table I: More than 80 graduate students, including 67 LLE-funded UR Frank Horton Fellows (marked by *), conducted research at LLE during FY22 (continued).

Student Name	Department	Faculty Advisor	LLE Advisor (if different)	Research Area	Notes
M. Lavell*	ME	A. B. Sefkow		The Development of Hybrid Fluid-Kinetic Numerical Models for Simulating Fusion-Relevant Plasmas	
L. S. Leal*	PA	R. Betti	A. V. Maximov	Simulations and Studies of Inertial Confinement Fusion Relevant Laser-Generated Plasmas in External Magnetic Fields	Graduated in 2022
A. Lees*	ME	R. Betti		Understanding the Fusion Yield Dependencies in OMEGA Implosions Using Statistical Modeling	
Y. Liu*	OPT	B. E. Kruschwitz		Development of an Electro-Optical-Based Ultraviolet Pulse Measurement System	
R. Markwick*	PA	A. Frank		Laboratory Astrophysics Studies of Colliding Radiative Magnetized Flows	New Horton Fellow
J. Martinez	ME	S. P. Regan	C. J. Forrest	Measurements of the Scattered Neutron Energy Spectrum from OMEGA Cryogenic Implosions	
T. Mason	CHE	R. B. Spielman		Pulsed-Power Technology	
M. M. McKie*	PA	D. H. Froula	J. L. Shaw	Wave Breaking of Electron Plasma Waves as it Applies to Hot-Electron Generation and Laser-Plasma Amplifiers	
B. McLellan*	PA	P. Tzeferacos	S. X. Hu/ S. Zhang	A Theoretical Study of Structural Transformations, Hydrodynamic Motion, and Optical Properties of Crystals and Amorphous High-Energy-Density Materials	
K. R. McMillen*	PA	D. H. Froula	J. L. Shaw	Filamentation of Picosecond Pulses Through Underdense Plasmas	
S. C. Miller*	ME	V. N. Goncharov		Hydrodynamic Instabilities of Inertial Confinement Fusion Implosions	Graduated in 2022
K. Moczulski*	ME	P. Tzeferacos		Characterization of Magnetized Turbulence and Fluctuation Dynamo Through <i>FLASH</i> Simulations and OMEGA Experiments	
K. L. Nguyen*	PA	J. P. Palastro		Nonlinear Saturation of Cross-Beam Energy Transfer	
K. A. Nichols*	PA	S. X. Hu		<i>Ab initio</i> Investigations of Nonlocal Electron and Ion Transport in High-Energy-Density Plasmas	
S. F. Nwabunwanne*	ECE	W. R. Donaldson		Design, Fabrication, and Characterization of AlGaIn-Based Ultrafast Metal-Semiconductor-Metal Photodiodes	

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Student Name	Department	Faculty Advisor	LLE Advisor (if different)	Research Area	Notes
H. Pantell*	PA	G. W. Collins/ J. R. Rygg		Thermodynamic and Mass Transport Properties of Planetary Materials at Extreme Conditions	
S. Paramanick*	PA	E. G. Blackman		Multiscale Study of Supersonic Plasma Wind Interacting with a Magnetized Earth-Like Planet	New Horton Fellow
H. Pasan*	PA	R. Dias	G. W. Collins	Novel Hydrogen Rich Materials at High-Energy-Density Conditions: Route to “Hot” Superconductivity	
D. Patel*	ME	R. Betti		High- and Mid-Mode Number Stability of OMEGA Cryogenic Implosions	
R. Paul*	ME	S. X. Hu		High-Pressure Phase Diagram of Ramp-Compressed Materials	Graduated in 2022
D. Ramsey*	PA	J. P. Palastro		Electron Dynamics and Radiation Generation in a Flying Focus	
J. Ruby*	CH	W. U. Schroeder	W. T. Shmayda	Effects of Surfaces on Superpermeation	
A. Sexton*	ME.	A. B. Sefkow		Advanced Graphics Processing Units Algorithms for Simulations of Inertial Confinement Fusion and High-Energy-Density Physics	New Horton Fellow
M. Signor*	PA	G. W. Collins/ J. R. Rygg		Using X-Ray Spectroscopy to Study Material Properties at High Energy Densities	New Horton Fellow
T. T. Simpson*	PA	J. P. Palastro		A Flying Focus Driven by Self Focusing	
E. Smith*	PA	G. W. Collins/ J. R. Rygg		Understanding Materials Assembled to Extreme States via Laser-Driven Implosions Using Bayesian Inference	
Z. K. Sprowal*	PA	G. W. Collins/ J. R. Rygg		Off-Hugoniot Studies in Hydrogen and Hydrocarbons	
R. Swertfeger*	OPT	J. Bromage		High-Power Ultrafast Amplifiers Using Cryogenically Cooled, Diode-Pumped Fluoride Crystals	New Horton Fellow
A. Syeda	ME	J. Shang/ H. Aluie		Particle Tracking with X-Ray Radiography in Shock-Driven Flows and Viscometry Using Shocked Particles	
G. Tabak*	PA	G. W. Collins/ J. R. Rygg		Experimental Investigation of Warm Dense Matter	
M. VanDusen-Gross*	PA	H. G. Rinderknecht		Electron and Gamma Signatures of Relativistically Transparent Magnetic Filament Experiments	

Table I: More than 80 graduate students including 67 LLE-funded UR Frank Horton Fellows (marked by *) conducted research at LLE during FY22 (continued).

Student Name	Department	Faculty Advisor	LLE Advisor (if different)	Research Area	Notes
M. Wang*	CHE	D. R. Harding		Using Two-Photon Polymerization to “Write” Millimeter-Size Structures with Micron Resolution	
C. A. Williams*	PA	R. Betti		High-Yield Cryogenic Implosions on OMEGA	
J. Young*	PA	P.-A. Gourdain		Laser-Triggered X Pinches	
J. Zhang	OPT	G. Agrawal	W. R. Donaldson	Slow Light in Photonic Crystal Fiber	
Y. Zhang*	ME	J. R. Davies		Kinetic Study of Magnetized Collisionless Shock Formation and Particle Acceleration	

ME: Mechanical Engineering

PA: Physics and Astronomy

CH: Chemistry

CHE: Chemical Engineering

OPT: Institute of Optics

ECE: Electrical and Computer Engineering

EES: Earth and Environmental Sciences

MS: Material Science

Table II: Sixteen students successfully defended their Ph.D. theses in calendar year 2022.

Name	Ph.D. Institution	Current Position, Employer
M. Adams	University of Rochester	Postdoc, Sandia National Laboratories
G. Chen	University of Rochester	System Engineer, KLA
P. Franke	University of Rochester	Scientist, Tau Systems Inc.
J. García-Figueroa	University of Rochester	Postdoc, Johns Hopkins University
B. J. Henderson	University of Rochester	Specialist in Optical Design, L3Harris Technologies
G. Jenkins	University of Rochester	Senior Optical Design Engineer, ASML
L. S. Leal	University of Rochester	Postdoc, Lawrence Livermore National Laboratory (LLNL)
S. Miller	University of Rochester	Assistant Scientist, LLE
R. Paul	University of Rochester	Postdoc, LLNL
M. Khan	University of York	Postdoc, University of York
D. Kim	Princeton University	Postdoc, Carnegie Institute of Science
G. Righi	University of California, San Diego	Postdoc, LLNL
B. Russell	University of Michigan	Postdoc, University of Michigan
R. Simpson	Massachusetts Institute of Technology (MIT)	Lawrence Fellow, LLNL
G. Sutcliffe	MIT	Postdoc at MIT, to join LLNL (HEDS Center Postdoc Fellow)
R. Vandervort	University of Michigan	Postdoc, Los Alamos National Laboratory