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2025 JLF Annual Report

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February 2026



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 Lawrence Livermore
National Laboratory

Jupiter Laser Facility

Annual Report

FY 2025

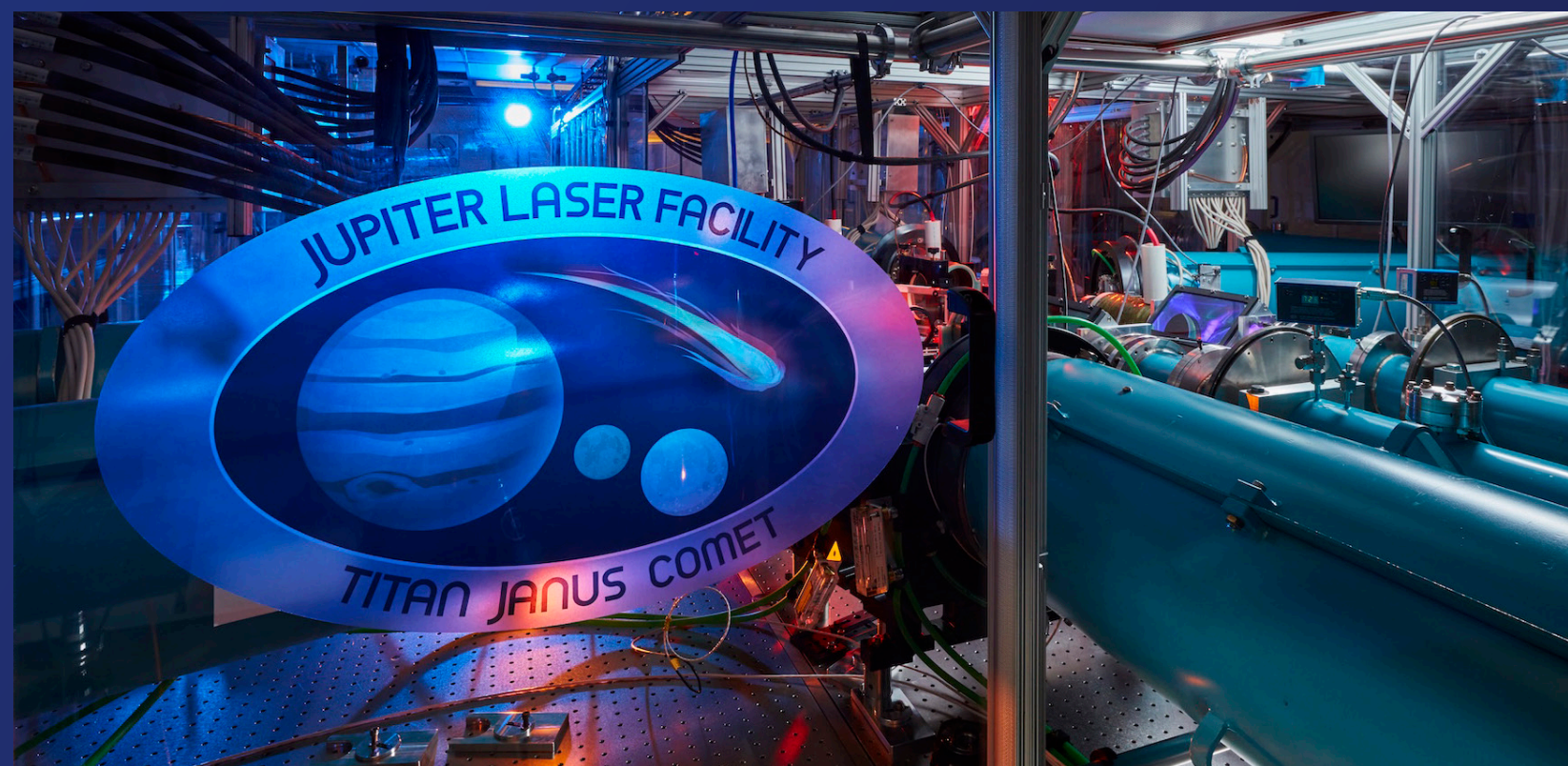


Table of Contents

Our Vision **2**

Welcome letter from JLF director **3**

Part 1: JLF Highlights **5**

 October 2024: JLF Director Félicie Albert elected vice chair of APS Division of Plasma Physics 6

 December 2024: JLF team visits LBNL as part of a LaserNetUS technical exchange 8

 February 2025: LLNL’s laser science on prominent display at NIF-JLF User Groups Meeting..... 13

 February 2025: Celebrating excellence with inaugural centers and institutes awards ceremony ... 15

 March 2025: LLNL laser experts shine at Laser Safety Conference 16

 March 2025: A brighter future for the Jupiter Laser Facility 17

 May 2025: LaserNetUS behind the scenes: the Jupiter Laser Facility 20

 May 2025: Big Ideas Lab podcast returns to shine a light on Jupiter Laser Facility..... 21

 June – July 2025: JLF represented at several conferences 23

 July 2025: Summer students explore opportunities at JLF 24

 July 2025: French Consul General visits LLNL and the Jupiter Laser Facility 25

 August 2025: JLF research and users honored with 2025 Director’s Institutional Awards 26

 September 2025: Novel probe captures every scene of a plasma movie all at once..... 27

 September 2025: HEDS fellow Patricia Cho probes cosmic mysteries 29

 September 2025: David Alessi named senior member of Optica 32

Part 2: JLF User Experiments **34**

 A systematic study of the effect of tamper materials on ablation depth and shock generation as a function of pulse duration: Determining why simulations don’t work for short pulses 35

 Investigating high-energy double pulse laser ablation in air for maximizing shocks in metallic targets 36

 Diffractive imaging of harmonically perturbed shock fronts..... 37

 Pump with Broadband Probe Experiments for Single-Shot Measurements of Plasma Conditions and Crossed-Beam Energy Transfer 38

 Speckles with a Twist: Towards Angular Momentum Smoothing in ICF..... 39

 Nanowire foam studies for photopumped x-ray backlighters 40

 Measurement of viscosity in CH-based plastics under diamond forming conditions 41

 Investigation, using short laser pulses, of fast shocks interacting with magnetic turbulence, and of the associated ion energization 42

 Ultrafast laser-driven x-pinches 43

 Laser-ion doping of semiconductors..... 44

 Dual Radiography using split beams at Titan 45

 Investigation of non-thermal electron collimation and optimization of energy for application to electron fast ignition 47

 Development of x-ray sources from high rep-rate solid targets 48

 Amplification of Ultrashort Pulses through Stimulated Raman Backscattering..... 49

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OUR VISION

To be the preeminent hands-on facility for addressing unique challenges and questions in high energy density, fusion energy, and laser science within the national and international ecosystem

Partner with academia, LaserNetUS, and the greater scientific community to develop new techniques and experimental platforms.

Advance the development of secondary sources of photons and particles for mission-relevant applications.

Serve as an experimental testbed for new laser, optical, target and diagnostic capabilities.

Recruit, train, and retain the next generation of researchers in the field, helping to build new collaborations along the way.

Welcome letter from JLF director



Dear JLF community,

I cannot believe I am now entering my third year as JLF director — time definitely flies when you are having fun! FY25 was another pivotal year for the Jupiter Laser Facility, marked by both scientific achievement and growing visibility for our community. Building on the successful reopening and refurbishment of the facility, we continued to demonstrate how JLF drives innovation in high energy density and fusion energy science, laser technology, and workforce development.

Across Janus, Titan, and COMET, users executed a diverse portfolio of experiments, from dynamic compression and opacity measurements to laser plasma interactions, laboratory astrophysics, and advanced diagnostics. These efforts are highlighted in this report, including the development of new probes that capture the time evolution of plasmas on a single shot, and diagnostics and platforms that are already impacting experiments at NIF and other large facilities. JLF continues to serve as both a testbed for new ideas and a bridge to larger scale campaigns.

FY25 also showcased the broader role of JLF within the Laboratory and the national HED science ecosystem. The NIF JLF User Groups Meeting in February brought nearly 180 participants to Livermore and highlighted the scientific progress made during JLF’s first full year of renewed operations. JLF research and users were recognized with Director’s Institutional Awards and Early and Mid Career awards, underscoring the quality and impact of the work performed here. Our team also contributed prominently to national conversations about laser safety, plasma physics, and inertial fusion energy through invited talks, conferences, and professional society leadership.

JLF’s integration with LaserNetUS deepened this year as well. We launched a new technical exchange program across LaserNetUS facilities and kicked it off with a JLF team visit to the BELLA Center at Lawrence Berkeley National Laboratory. These exchanges are strengthening operations, sharing best practices, and improving the user experience across the network. Filming for the LaserNetUS “Behind the Scenes” series and participation in the annual LaserNetUS meeting further increased the visibility of our facility and our users. At the same time, JLF continues to play a central role in ambitious new programs, such as the Big Aperture Thulium laser effort funded through one of the DOE Office of Science Microelectronics Science Research Centers, which will use JLF infrastructure to explore next generation high rep rate lasers for EUV and x-ray source development.

A core part of our mission remains training the next generation of scientists. In FY25, we welcomed another cohort of summer students, who joined experimental teams on Titan and presented their research at LLNL’s student poster symposium and national inertial fusion energy meetings. JLF users and early career scientists showcased their work at conferences across the country, highlighting experiments performed at the facility. These hands on experiences, and the mentoring provided by our staff and user teams, are central to JLF’s identity as a true user facility.

Finally, FY25 reinforced JLF's role as a focal point for partnerships and outreach. We hosted visits from international collaborators, science leaders, and we shared the story of the facility through venues such as the Big Ideas Lab podcast. These interactions help connect our work to a broader scientific and policy audience and open new pathways for collaboration.

As we look ahead, the combination of refurbished hardware, new capabilities like STILETTO and enhanced short pulse performance on Titan, strong partnerships across LLNL and LaserNetUS, and a growing user community positions JLF for an even more ambitious program in the coming years. I am deeply grateful to our technical and operations staff for their dedication, to our LLNL partners for their continued support, and to our users for bringing bold, creative ideas to the facility.

I look forward to more experiments, capabilities, partnerships, and groundbreaking science in the years to come!

With brightest regards,

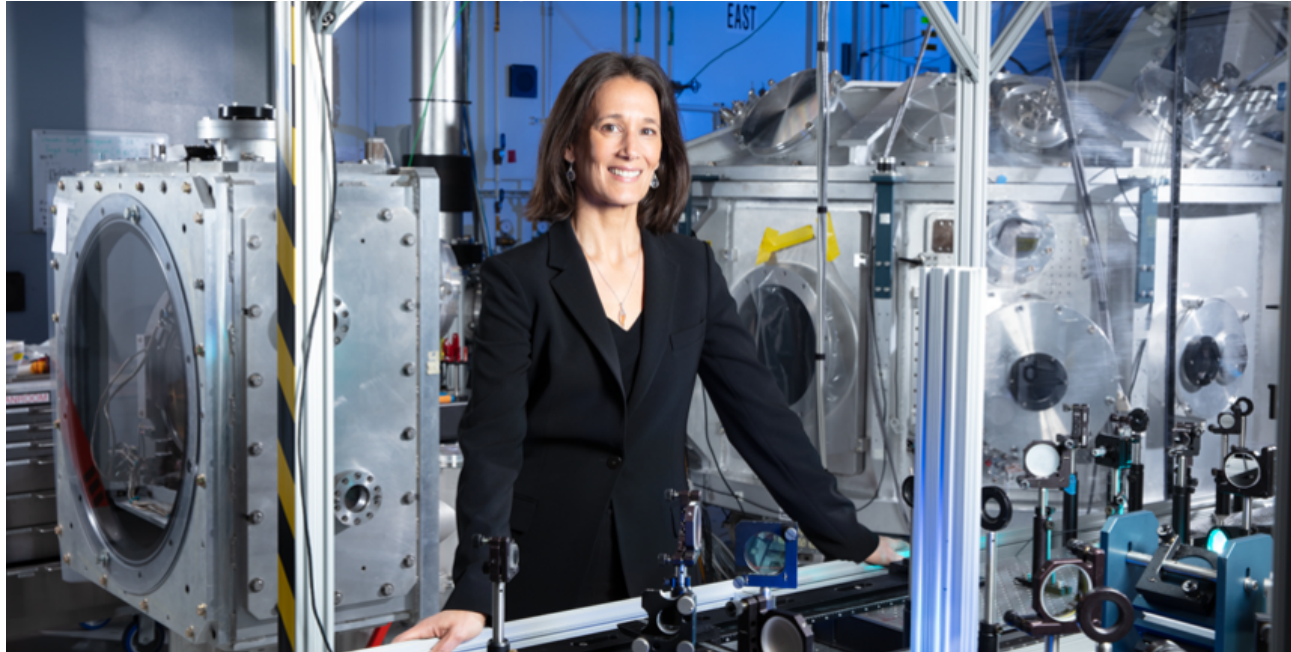
Félicie Albert

JLF Director

Part 1: JLF Highlights



October 2024: JLF Director Félicie Albert elected vice chair of APS Division of Plasma Physics



Félicie Albert, LLNL scientist and director of the Jupiter Laser Facility, will lead the American Physical Society Division of Plasma Physics Executive Committee through various leadership roles over the next four years.

[Lawrence Livermore National Laboratory](#) (LLNL) scientist and director of the [Jupiter Laser Facility](#) Félicie Albert has been elected to serve as vice chair of the [American Physical Society](#) (APS) [Division of Plasma Physics](#) (DPP) Executive Committee.

Established in 1959, the objective of DPP is the advancement and dissemination of the knowledge, understanding, and applications of plasmas — assemblages of charged particles of natural and laboratory origin.

In this four-year leadership commitment, Albert will serve as chair of the APS-DPP fellowship committee in the first year and then chair the program committee for the APS-DPP annual meeting in the second. In her third year of service, Albert will chair the division, where she will lead the APS-DPP executive committee in running the division, proposing new initiatives, and working with APS to ensure a vibrant and thriving plasma physics community. In her fourth year, she will serve as past chair of the division.

Albert first became a member of the APS and attended the meeting of the APS-DPP as an LLNL postdoctoral researcher in 2009. “There has never been a better time to be part of DPP,” said Albert. “Scientifically, we’ve seen so many breakthroughs in our field and are seeing the prospects of a clean energy source provided by fusion, both from magnetic and inertial confinement, become a reality. And plasmas are so much more! They have unparalleled breadth in temperature, density, and pressures, beat particle acceleration energy records, help us understand space and planets, devise new means of propulsion, and have the potential to revolutionize medical and industrial applications.”

As a member of the executive committee Albert’s goals will be threefold: working across sub-disciplines by reaching out to all members, encouraging cross fertilization and including all sub-disciplines when forming sub-committees; 2) continuing to build an open and welcoming community by ensuring every one of the division’s members can share their expertise, especially in awards and invited talks at the annual meeting; 3) promoting plasma physics to the greater public by placing emphasis on outreach to young audiences and communication with the public and the government.

In this role, Albert is excited to build an inclusive, diverse, and vibrant plasma physics community, bringing an increase in visibility to LLNL and developing new working relationships along the way.

December 2024: JLF team visits LBNL as part of a LaserNetUS technical exchange



The JLF technical team visited another LaserNetUS facility at the Lawrence Berkeley National Laboratory.

The program leverages the cumulative capabilities of technical staff across the LaserNetUS network to achieve these critical objectives through hosting inter-facility site meetings. For the meetings, technical teams from different LaserNetUS facilities visit other LaserNetUS technical teams and tour their facilities and laser systems to exchange information, offer insights, and gain deeper knowledge across the organization. The primary goal is to broaden collective expertise throughout LaserNetUS and foster a collaborative environment that elevates operational standards.

As the inaugural organizer, the [Jupiter Laser Facility \(JLF\)](#) team from Lawrence Livermore National Laboratory (LLNL) played a pivotal role in bringing this exchange program concept to fruition. JLF instituted the first LaserNetUS technical exchange when the JLF technical team visited the [Berkeley Lab Laser Accelerator \(BELLA\) Center](#) at Lawrence Berkeley National Laboratory (LBNL) on December 18, 2024.

During the field trip, the JLF team toured two of BELLA's laser systems — the BELLA Petawatt and the BELLA Hundred Terawatt lasers. These in-person gatherings provided the JLF team an invaluable opportunity to sit down with the LBNL team to review and refine operational procedures, identify best practices, develop strategies for enhancing the experiences of experimental users and visitors, and assess ways to increase research productivity.

“It was great to see how another facility operates,” remarked Dr. Albert. “We looked at technical details common to both facilities, such as how we operate our vacuum systems. This exchange is a prime example of the potential benefits we can unlock by learning from each other.”



The JLF team takes a selfie in their PPE as they prepare to tour the LBNL BELLA laser systems.

Starting with local San Francisco Bay Area LaserNetUS labs, this activity is expected to extend to the entire network — currently, 13 members across North America and comprising 12 high-intensity laser facilities and one supporting facility — contingent upon available funding and productive outcomes from these initial exchanges. The overarching intent is to establish robust best practices that benefit the whole of LaserNetUS. With support from the U.S. Department of Energy (DOE) and the collaborative efforts of its technical teams, LaserNetUS continues its ongoing quest to achieve significant progress in laser operations and thereby foster a stronger and more capable network.

December 2024: LLNL selected to lead next gen extreme ultraviolet lithography research

Decades of cutting-edge laser, optics, and plasma physics research at [Lawrence Livermore National Laboratory](#) (LLNL) played a key role in the underlying science that the semiconductor industry uses to manufacture advanced microprocessors. These computer chips drive today’s astounding innovations in artificial intelligence, high-performance supercomputers, and smart phones.

Now a new research partnership led by LLNL aims to lay the groundwork for the next evolution of extreme ultraviolet (EUV) lithography, centered around a Lab-developed driver system dubbed the [Big Aperture Thulium \(BAT\) laser](#).

The team will participate in the Extreme Lithography & Materials Innovation Center (ELMIC), one of the centers selected for the Department of Energy (DOE) Office of Science’s [Microelectronics Science Research Centers](#) (MSRCs). [The DOE announced \\$179 million in funding for the three MSRCs](#), which were authorized as part of the bipartisan CHIPS and Science Act of 2022.

ELMIC aims to advance the basic science driving the integration of new materials and processes into future microelectronic systems. The LLNL-led project within this center is a four-year, \$12 million investigation specifically aimed at expanding the fundamental science around EUV generation and plasma-based particle sources. Other ELMIC projects will focus on key research areas such as plasma-based nanofabrication, 2D-material systems and extreme-scale memory.

The LLNL-led project will test the BAT laser’s ability to increase EUV source efficiency by about 10 times when compared with carbon dioxide (CO₂) lasers, the current industry standard. This could lead to a next generation “beyond EUV” lithography system producing chips that are smaller, more powerful and faster to manufacture while using less electricity.

“We have performed the theoretical plasma simulations and proof of concept laser demonstrations over the past five years that lay the foundations for this project,” said LLNL laser physicist Brendan Reagan. “Our work has already had quite an impact in the EUV lithography community, so now we’re excited to take this next step.”

Reagan and LLNL plasma physicist Jackson Williams are the project’s co-lead principal investigators. The project includes scientists from [SLAC National Accelerator Laboratory](#); [ASML San Diego](#); and the Advanced Research Center for Nanolithography ([ARCNL](#)), a public-private research center based in the Netherlands.

EUV lithography involves high-power lasers firing at tens of thousands of droplets of tin per second. The laser heats the droplets, each measuring about 30 millionths of a meter, to half a million degrees centigrade to produce a plasma that generates ultraviolet light with a wavelength of 13.5 nanometers.

Special multi-layer mirrors guide the light through plates called masks, which hold the intricate patterns of the integrated circuits for semiconductor wafers. The light projects the pattern onto a photoresist layer that is etched away to leave the integrated circuits on the chip.

The LLNL-led project will investigate the primary hypothesis that energy efficiency of existing EUV lithography sources for semiconductor production can be improved with technology developed for the novel petawatt-class BAT laser, which uses thulium-doped yttrium lithium fluoride as the gain medium through which the power and intensity of laser beams are increased.

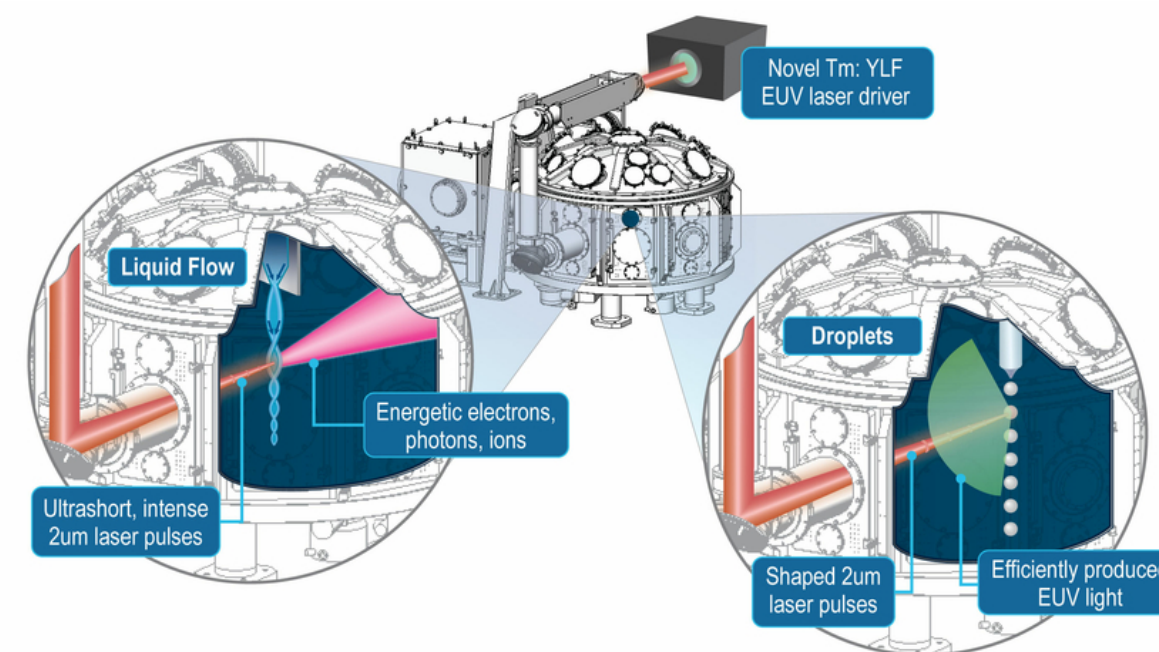
The unique central wavelength of thulium-doped yttrium lithium fluoride, lasing at about 2 microns, differs from all other intense lasers that operate at about or less than 1 micron or at 10 microns. The project will be the first exploration of joule-class laser-target coupling at 2 microns.

This builds on the [work](#) made possible by internal investments from LLNL’s [Laboratory Directed Research and Development](#) Program as well as externally funded support from the DOE Office of Science’s Office of High Energy Physics [Accelerator Stewardship Program](#), and the Defense Advanced Research Projects Agency.

The researchers plan to demonstrate pairing the compact high-rep-rate BAT laser with technologies that generate sources of EUV light using shaped nanosecond pulses and high-energy x-rays and particles using ultrashort sub-picosecond pulses.

“This project will establish the first high-power, high-repetition-rate, about 2-micron laser at LLNL,” Williams said. “The capabilities enabled by the BAT laser also will make a significant impact on the fields of high energy density physics and inertial fusion energy.”

Many of the experiments will be performed at the Jupiter Laser Facility.



The diagram shows high-repetition-rate laser bursts into LLNL’s Jupiter Laser Facility Titan target area (center), where the Big Aperture Thulium laser beams hit two target configurations: short-pulse irradiating liquid flow sheets for energetic particles (left) and long-pulse irradiating droplets for EUV generation and other experiments (right). (Illustration: Janelle Cataldo/LLNL)

Since its inception, the semiconductor industry has engaged in a constant race to make each generation of microprocessors smaller yet more powerful by packing as many integrated circuits and other features as possible into one chip. For the past several years, EUV lithography has taken the forefront because it uses EUV light to etch microscopic circuits as small as a few nanometers onto advanced chips and processors.

Reagan noted that the Lab has long pioneered the development of EUV lithography, including early spectroscopic studies that formed the foundation of plasma-based EUV sources.

A [1997 cooperative research project](#) involving LLNL, Sandia National Laboratories, and Lawrence Berkeley National Laboratory led to the development of the [Engineering Test Stand](#), the first prototype EUV exposure tool.

Furthermore, the Lab developed efficient multilayer optics that are instrumental in transporting and delivering the EUV light for lithography. Previously, LLNL [partnered with ASML](#) to exploit the Lab's extensive plasma simulation capabilities to optimize source efficiency.

Over the years, LLNL's extensive multidisciplinary research contributed to multilayer coating science and technology, optics metrology, light sources, lasers, high-performance computing and, notably, the historic achievement of [fusion ignition](#) at NIF in December 2022.

ASML, which makes the EUV lithography machines used by the biggest commercial producers of these chips, uses CO₂ pulsed lasers to drive the EUV light sources. But LLNL research over the past decade showed that newer diode-driven solid-state laser technology provides a promising path toward achieving higher power and greater overall efficiency for EUV lithography systems.

In addition to Reagan and Williams, key members of LLNL's multidisciplinary team include Félicie Albert, Leily Kiani, Emily Link, Thomas Spinka, Issa Tamer and Scott Wilks.

The project also includes Siegfried Glenzer, SLAC's high energy density division director and a former LLNL plasma physics group leader, Michael Purvis, ASML's lead EUV source research technologist and Oscar Versolato, head of the source department at ARCNL.

February 2025: LLNL's laser science on prominent display at NIF-JLF User Groups Meeting



This year's NIF and JLF User Groups Meeting highlighted the progress made to capitalize on and sustain the National Ignition Facility (NIF)'s capabilities, and the scientific advancements made in the Jupiter Laser Facility (JLF)'s first full year of operations following a major refurbishment.

The three-day joint conference, held from Feb. 11 to 13 in Livermore, drew about 180 attendees, including scientists and researchers from around the world who use the two renowned laser facilities at Lawrence Livermore National Laboratory (LLNL) to explore a broad range of fundamental discovery science.

In her welcoming address, LLNL Director Kim Budil said members of the two user groups have a "huge opportunity" this year to explain to a wider audience how LLNL and the nation's national laboratories play critical roles "not just in advancing the cause of science, but in demonstrating real leadership in these fields."

"You write papers, you give talks, you promote this important relationship between the broader scientific community and the national labs," Budil said. "This is a moment to tell our story and to build our constituency."

Jeff Wisoff, then-NIF & Photon Science principal associate director, explained how the annual conference delivers an important message of deterrence to the nation's potential adversaries, one of the Lab's main missions for the Department of Energy's National Nuclear Security Administration.

"Whether you know it or not, your presence is also a big part of our main mission, which is deterrence," Wisoff said. "By the world seeing the talent that is in this room and the papers you put out, they know that we're taking care of business."

The event is a joint meeting of the groups of scientists, researchers, professors and graduate and undergraduate students who propose and conduct Discovery Science experiments at NIF, the world's most energetic laser, and at JLF, an intermediate-scale user facility that offers three laser platforms—Janus, Titan, and COMET.

For JLF, 2024 marked the first full year of operations since a major four-year refurbishment of the facility was completed in late 2023, said JLF Director Félicie Albert. And the facility, which includes the fifth-highest energy laser in the U.S., celebrated the 50th anniversary of when its first laser, Janus, was installed.

“We’ve had so many things to be proud of in 2024,” Albert said.

February 2025: Celebrating excellence with inaugural centers and institutes awards ceremony



On Wednesday, Feb. 26, Lab members representing 18 centers and institutes gathered in the West Cafe for the inaugural Innovation and Achievement Awards Ceremony event, celebrating the outstanding contributions of those who have gone above and beyond in their respective programs.

The event was the brainchild of Data Science Institute (DSI) Director, Brian Giera, who shared: “After serving in my role for a year and a half, I realized how much scientific excellence is really borne by the people under the centers and institutes. [Their] incredible work is happening in the background, often without visibility. This ceremony is about making sure those efforts are recognized and celebrated.”

Several people, instrumental to the success of JLF, were recognized in the operational excellence and scientific innovation categories:

- Stephen Maricle ensured the success of the JLF through his technical expertise in laser beam alignment.
- Gaia Righi and Suzanne Ali maintained and upgraded the critical VISAR diagnostic tools at JLF.
- Shelby Conn revitalized communication strategies for the JLF, enhancing its visibility.
- Hoang Nguyen, Sean Tardif, Brad Hickman, James Nissen, and Candis Jackson (NIF Diffractive Optics Group) delivered critical, one-of-a-kind components for the JLF in record time.

March 2025: LLNL laser experts shine at Laser Safety Conference

Laser safety experts from Lawrence Livermore National Laboratory (LLNL) led several important sessions and presentations on the latest advances in laser technology and safety practices during the [2025 International Laser Safety Conference \(ILSC\)](#).

The biennial conference brought more than 200 experts to Orlando, Florida, from March 3 to 6 to discuss the safe use of lasers in the fields of academia, government, industry, medicine, and research and development.

The conference underscored LLNL's critical role in developing and safely applying cutting-edge laser technology.

“This gathering of experts from around the world is critical for promoting new regulations and fostering safe laser practices,” said conference general chair Jamie King, subject matter expert on laser safety for LLNL and the NIF and Photon Science (NIF&PS) directorate. “I was honored to be selected to serve in this role again.”

Félicie Albert, director of LLNL's [Jupiter Laser Facility](#), highlighted the facility's groundbreaking research exploring extreme states of matter found in space and deep within planets. Albert also joined an international panel of experts to discuss the role of global laser facilities in advancing scientific discovery.



Jupiter Laser Facility Director Félicie Albert presents at the 2025 ILSC conference. Credit: Jamie King

March 2025: A brighter future for the Jupiter Laser Facility



Since the 1970s, the Janus laser, now part of the Jupiter Laser Facility (JLF), has served as an experimental proving ground to Lawrence Livermore National Laboratory's (LLNL) laser and fusion programs and the broader high-energy-density and laser science communities.

Today, JLF is not only home to Janus — one of the world's few hands-on laser platforms producing kilojoules of energy — but also Titan, a unique laser platform that combines high-energy pulses with long and extremely short pulse lengths, and COMET: a high-repetition, standalone, compact multipulse terawatt laser system.

As one of the founding members of LaserNetUS — a constellation of laser facilities across North America — JLF is a prototype for the no-cost user facility model, operating on the idea that all researchers, regardless of their home institutions' laser capabilities, should have access to the brightest light available.

Former JLF director (now retired) Robert Cauble says, “My favorite part of my role was watching researchers and students come in and learn how to put experiments together, spending several weeks to set up, troubleshoot and acquire data. Seeing how driven they were to get results, thinking through the physics and technology in real time to reach a solution, was very rewarding.”

To meet the growing demands of its user community, JLF underwent a four-year-long modernization effort before resuming normal operations in 2024. In its first year back, the facility hosted 65 users from 20 institutions and supported 15 experiments — each experimental campaign spans approximately four weeks, allowing time for assembly, troubleshooting and data collection.

Thanks to the hands-on support of the JLF Operations Team and LLNL's Physical and Life Sciences and National Ignition Facility and Photon Science (NIF&PS) organizations, JLF made several hundred small

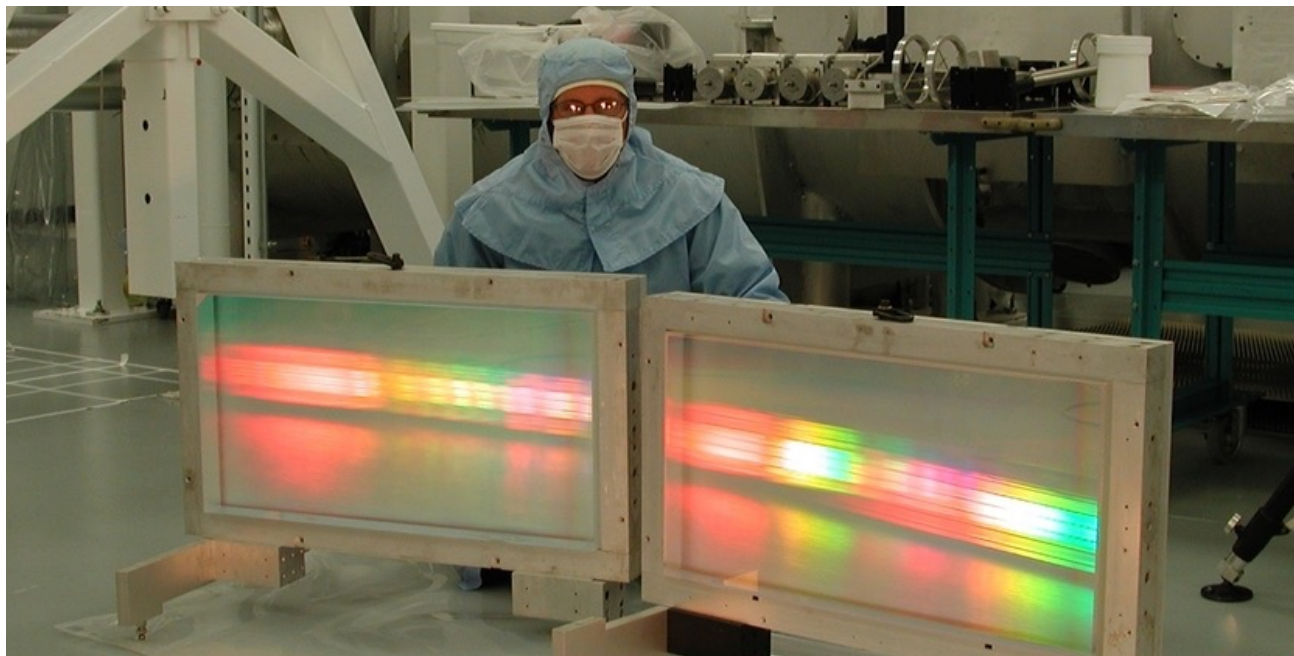
improvements and a number of large-scale renovations and new additions. Now, JLF offers enhanced energy and performance capabilities, higher shot rates and improved diagnostic instrumentation. In fact, many diagnostic tools currently used to capture valuable data from ignition experiments at NIF were originally developed at JLF, underscoring the synergistic and full-circle impact of this collaboration.

One new, notable addition to JLF is an advanced laser pulse-shaping technology known as STILETTO (Space-Time Induced Linearly Encoded Transcription for Temporal Optimization). STILETTO was coinvented by JLF and NIF&PS and made possible thanks to funding from LLNL's Laboratory Directed Research and Development program (21-ERD-034) and the Department of Energy's (DOE) Office of Fusion Energy Sciences (FES).

This new capability allows researchers to create highly customizable laser pulses with resolutions down to the picosecond (a trillionth of a second), generating over 1,000 independent temporal features (time-based attributes) over durations of up to 600 picoseconds. STILETTO's space-to-time mapping capabilities are analogous to a runner — in advance of their run — being able to precisely control and predict where their foot will land and with what intensity at each point in time. In a laser experiment, STILETTO can map where (spatially) and when (temporally) each feature of the laser pulse will occur.

With additional funding from the DOE's FES program, the facility was also able to add a third beamline in the laser bay dedicated to short-pulse operations in Titan. Now, with the dedicated short pulse and two long-pulse beamlines — one dedicated to Janus and the other switchable between Titan and Janus — the laser bay can shoot twice as often, more effectively serving simultaneous experiments in Titan and Janus.

The enhancements don't stop there, though. New, larger gratings were installed to improve the energy of Titan's short pulse by a factor of two (from 150 joules of energy to 300 joules), enabling close to a petawatt of power — about 1,000 times the capacity of the entire U.S. electrical grid — in 0.4 picoseconds.



The first-ever 80-centimeter gratings delivered to Titan in April 2005. (Photo courtesy of Rick Cross/LLNL)

For the user community, the new and improved facility will encourage researchers to stretch the realm of possibility and pursue novel experimental ideas at JLF.

Current JLF director Félicie Albert recounts just how vital JLF was to her early career at LLNL.

“One year, I prepared an experiment on Titan and all I got was noise with a hint of signal,” she said. “The next year, I asked the JLF team if I could install a new parabolic mirror in Titan with a longer focal length, which required changes to the target chamber. Thanks to the JLF team’s help, the experiment worked, and we got a good paper out of it. I love that part of JLF — how willing people are to help. It makes the long days of experiments worthwhile.”

More than ever before, JLF is ready to address unique challenges and questions in high-energy-density and laser science at an international scale, train the next generation of researchers, and support larger laser facilities like NIF.

May 2025: LaserNetUS behind the scenes: the Jupiter Laser Facility



In LaserNetUS’s fifth Behind the Scenes episode, Dr. Félicie Albert, Director of the Jupiter Laser Facility at Lawrence Livermore National Laboratory, shares insights from her global high-intensity laser research experience. From earning her PhD at École Polytechnique to conducting experiments at facilities worldwide, Dr. Albert illustrates how LaserNetUS is accelerating discovery by connecting students and researchers to cutting-edge laser technology.

Emphasizing LaserNetUS’s dedication to expanding the research landscape and collaboration within the network, this project features engaging mini videos spotlighting our users’ and facility points of contact’s (POC) experiences within LaserNetUS. Filming to produce this dynamic content for social media and presentations in FY25 wrapped at the 2024 LaserNetUS Meeting in Austin, TX.

May 2025: Big Ideas Lab podcast returns to shine a light on Jupiter Laser Facility



Since their invention in 1960, lasers have been a staple of science fiction. But beyond sci-fi, the technology is an essential, often overlooked, part of everyday life. From scanning barcodes to operating on eyes to recreating the conditions in the sun, laser applications range from mundane to life changing.

The Jupiter Laser Facility (JLF) at Lawrence Livermore National Laboratory (LLNL) has been a beacon in laser science for 50 years. The current episode of the Big Ideas Lab podcast takes a look at the facility — and the unique opportunities it offers. Listen on Apple and Spotify.

JLF was a predecessor of the National Ignition Facility (NIF). Many ideas and techniques used at NIF began at JLF, including fusion experiments and diagnostics.

As a user facility and a founding member of LaserNetUS, JLF allows researchers across the world to test their ideas. Anyone — from a graduate student with a crazy hypothesis to a senior physicist chasing their next big result — can apply to use these multi-million-dollar machines. And if accepted, they can fire the lasers themselves.

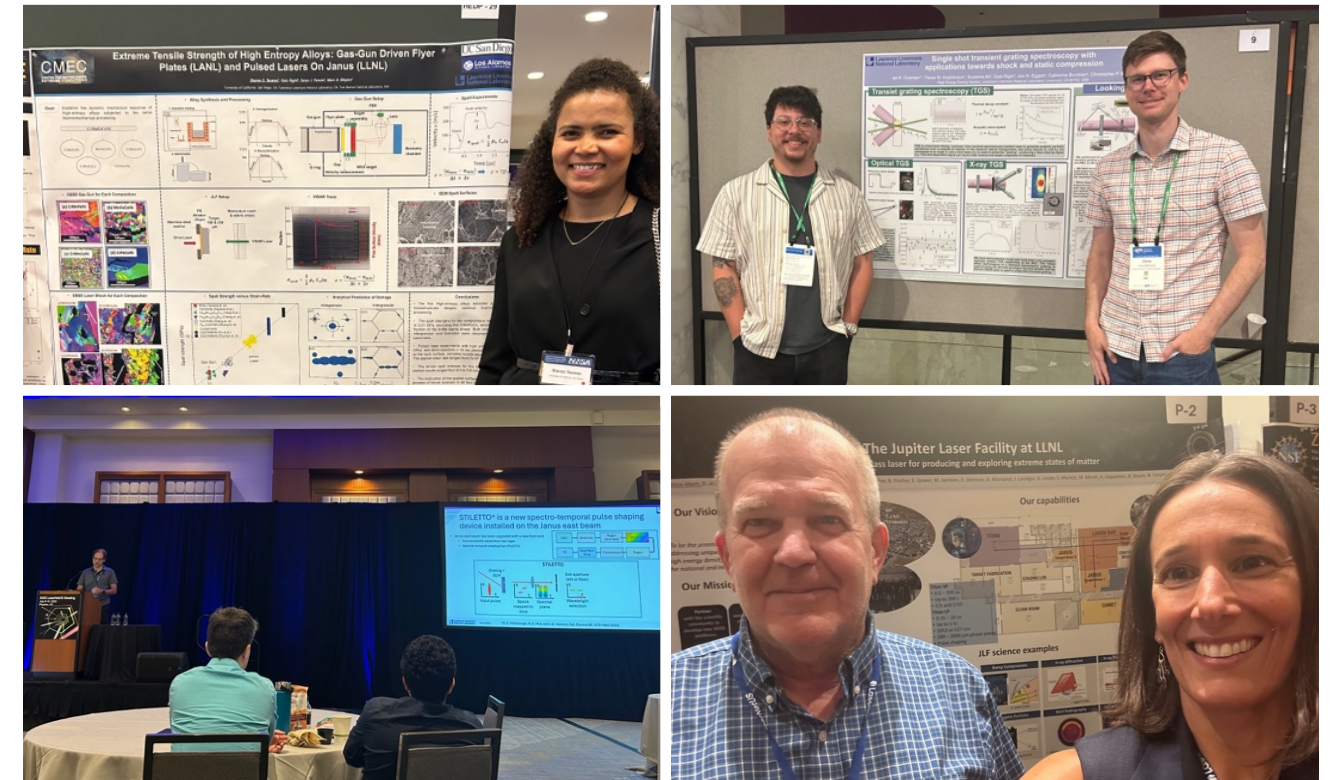
“We can support about 15 experiments every year. We have three different platforms. They have different characteristics, depending on what users want to do with them,” said JLF director Félicie Albert. “In 2024, we had 65 unique users. They come from other national labs, from academia, and from international institutions. We welcome everyone.”

LLNL postdoctoral fellow Liz Grace is one of those users. JLF is hands-on and open to trying new things. For her, that makes the facility a scientist’s dream.

“The data doesn’t come alive in the same way as if you took the data yourself. You know exactly where it came from, and you have a connection to the place and to the laser,” said Grace. “Creating that yourself is a very different feeling from being handed a data set.”

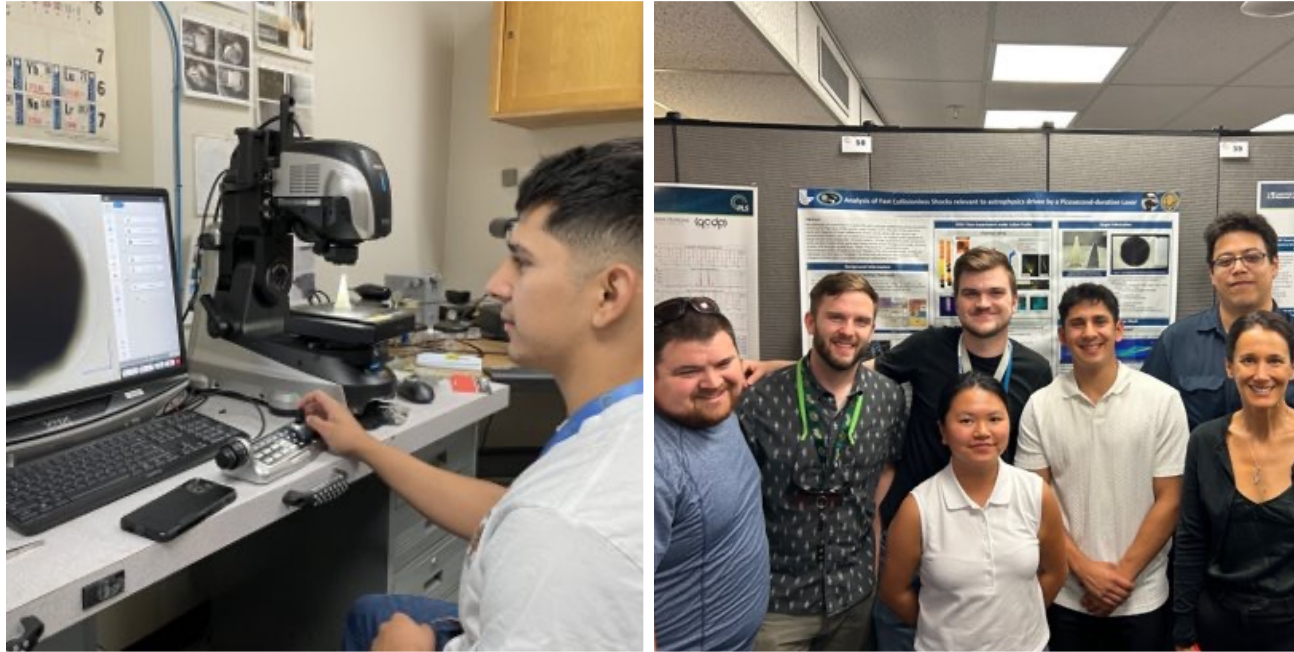
Tune into the Big Ideas Lab to learn how JLF has inspired and equipped Albert, Grace and many others to discover the next laser breakthrough.

June – July 2025: JLF represented at several conferences



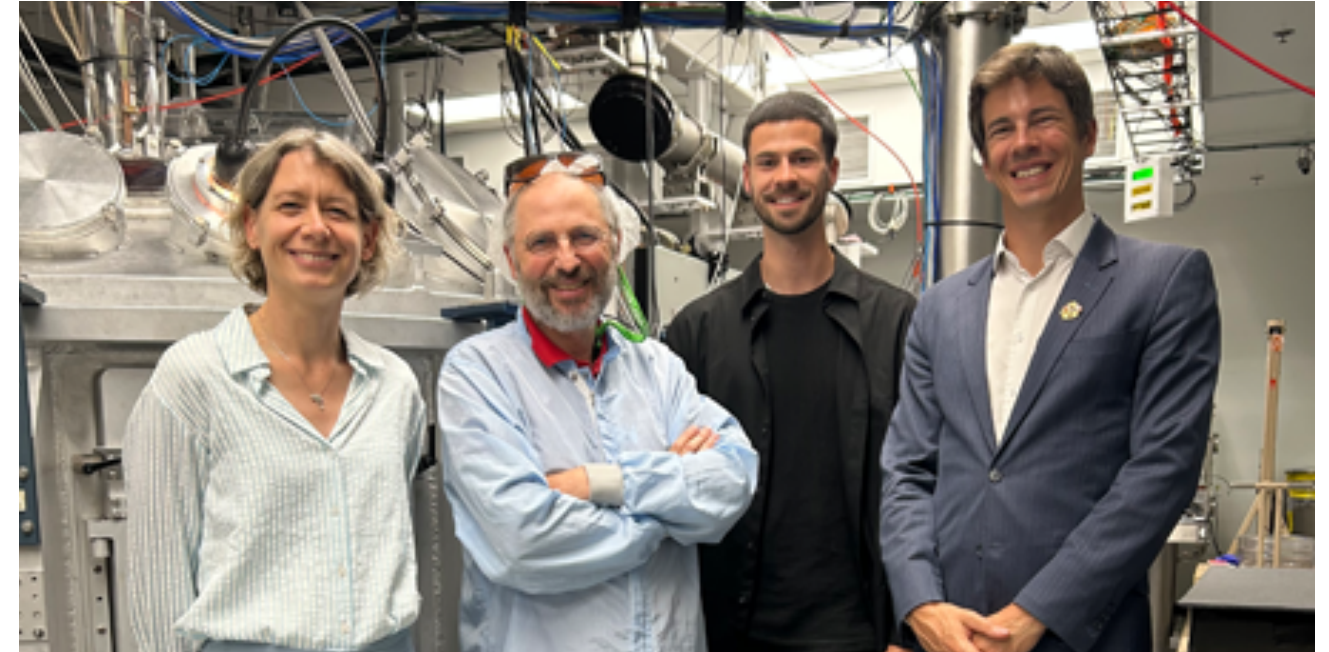
With users back in full swing at JLF, many of them presented at various conferences over the year. Pictured here are graduate student Sheron Tavares (UCSD, Janus) at the annual NNSA Stewardship Science Academic Program symposium, Ian Ocampo, and Chris McGuire (LLNL, Janus) at the APS Science of Compression in Condensed Matter conference, Andrew Longman (LLNL, Janus) at the annual LaserNetUS meeting, and JLF operations manager Brent Stuart with JLF director Félicie Albert in front of the JLF Capabilities poster at the annual LaserNetUS meeting.

July 2025: Summer students explore opportunities at JLF



Over the summer, JLF welcomed another cohort of summer students. This year, Ming Lu Chen and Jayden Menchaca, both undergraduate students from the University of California, Merced, did a summer internship at the facility and participated in a Titan experiment. There, they got to align and build targets, set up diagnostics, and analyze data. At the end of their internship, they presented their research during the annual LLNL student poster symposium and were able to attend the IFE-SURE symposium in Washington D.C., where they met with other students participating in the national Inertial Fusion Energy Program (IFE-STAR) funded by the DOE office of Fusion Energy Sciences.

July 2025: French Consul General visits LLNL and the Jupiter Laser Facility



On July 1, Florian Cardinaux, Consul General of France in San Francisco, visited LLNL for a day of high-level discussions and facility tours focused on scientific collaboration and technological innovation.

These tours included a visit to LLNL's Jupiter Laser Facility (JLF), where a team of researchers from France's École Polytechnique is currently conducting experiments on laboratory astrophysics as part of the LaserNetUS network.

"I received most of my training in optics and lasers in France and went on to pursue a postdoc and career at LLNL, so this visit was really meaningful to me," said JLF director Félicie Albert. "Discussing the breadth and depth of what we do at LLNL was very energizing, and after today I envision many new possibilities for collaborations and exchange."

Cardinaux and his colleagues also were briefed on LLNL's quantum computing research by Kristi Beck, director of the Livermore Center for Quantum Science.

August 2025: JLF research and users honored with 2025 Director's Institutional Awards

The annual Director's Institutional Awards recognize outstanding team and individual contributions to the Lab in the following areas: [team science](#), [operations](#), [science and technology](#), [publications](#), and [early and mid-career recognition](#). A [ceremony held on August 12](#) honored award recipients and celebrated their outstanding achievements. Recipients who have done research at JLF are:

Suzanne Ali (Early and Mid-Career Recognition Program)

Suzanne joined the Laboratory as a graduate student in 2010 while she was earning her Ph.D. in physical chemistry from the University of California, Berkeley. She was then part of what was previously called the Lawrence Graduate Scholar Program, where she expanded her research experience in the Jupiter Laser Facility, working on diagnostic development for dynamic compression experiments. Since then, her research at LLNL has primarily focused on precision measurements of material properties under extreme conditions with involvement across inertial confinement fusion, high-energy-density science, and Global Security.

Now, as both a program lead and campaign lead, she derives inspiration from Livermore's dually supportive and scientifically rigorous environment. She is honored to be an EMCR award recipient and looks forward to continuing to manage projects while advancing her technical work.

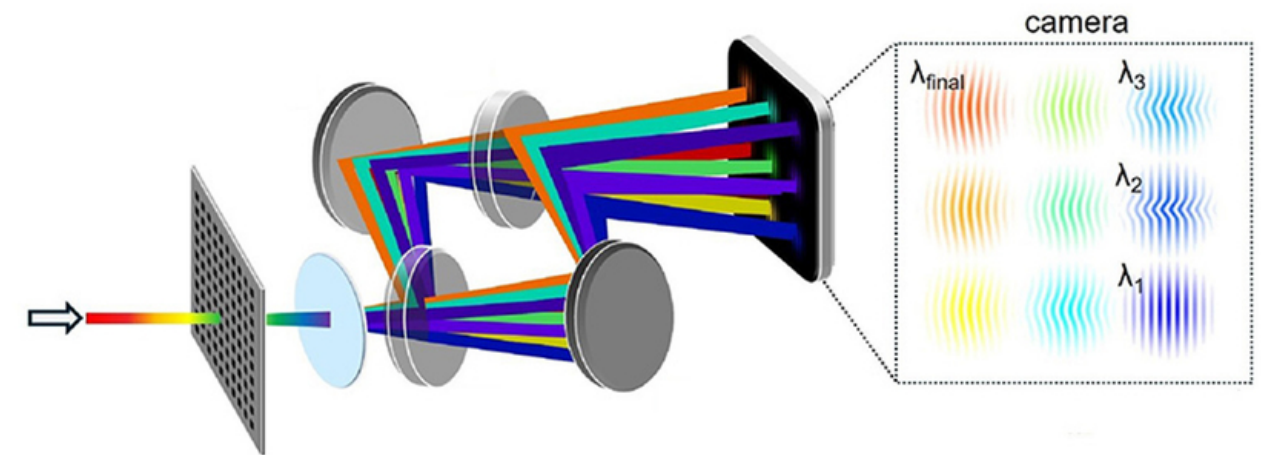
"The need to discover and understand is the biggest thing," Suzanne said. "I derive a lot of value from just being able to dig in and investigate hard problems. The other big component is the knowledge that my work has real-world impact in both stockpile science and global security."

Isabella Pagano (Excellence in Publication Award – Student)

For her publication titled "Source Size of X-rays from Self-Modulated Laser Wakefield Accelerators"

Journal: *Physics of Plasmas*

September 2025: Novel probe captures every scene of a plasma movie all at once



Plasma, ionized gas and the fourth state of matter, makes up over 99 percent of the ordinary matter in the universe. Understanding its properties is critical for developing fusion energy sources, modeling astrophysical objects like stars, and improving manufacturing techniques for semiconductors in modern cell phones.

But watching and determining what happens inside high-density plasmas is difficult. Events can unfold in trillionths of a second and behave in complex, unpredictable ways.

In a study published in *Optica*, researchers at Lawrence Livermore National Laboratory (LLNL) developed a new diagnostic that captures plasma evolution in time and space with a single laser shot. This breakthrough creates plasma movies with 100 billion frames per second, illuminating ultrafast dynamics that were previously impossible to observe. The research was performed at JLF by using the COMET laser.

"In most high-energy, high-intensity laser experiments currently, we take a single image per laser shot," said LLNL scientist and lead author Liz Grace. "However, these plasmas are unstable and unpredictable, and small changes can have butterfly effects that impact the subsequent evolution. It's important to capture as much information at once as possible."

Each laser shot through a plasma is slightly different, so stitching that information together across different discrete shots can be a large source of error. In contrast, the new diagnostic, called Single-shot Advanced Plasma Probe Holographic Reconstruction, or SAPPHIRE, captures everything in one go.

To accomplish this, the team uses a special laser pulse with what is called a "chirp." This means that the laser pulse and the colors contained within it are stretched out in time. For example, in the negative chirp used in this work, bluer light with shorter wavelengths races through first, followed later by redder light with longer wavelengths.

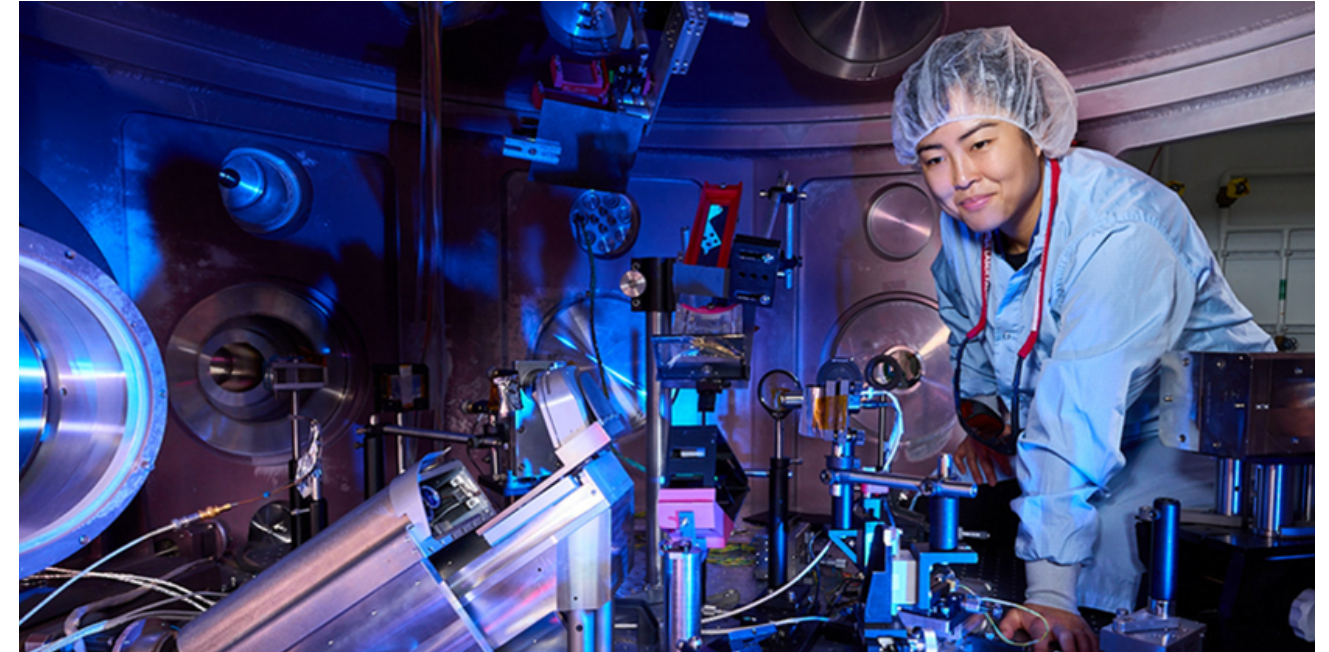
The upper half of the laser beam passes through the plasma, where it refracts and warps, while the lower half does not. On the other end of the plasma, the SAPPHIRE diagnostic separates those two beam halves, then recombines them to create a unique interference pattern for each wavelength of light — and therefore each timestamp.

With a bit of math, that interference pattern can be transformed into a map of electron density in the plasma, providing the researchers with an exquisitely detailed movie of how the plasma changes with time.

The authors tested SAPPHIRE on helium-nitrogen gas jets, but Grace said the diagnostic can be applied to measure time dependent underdense (translucent to the laser) plasma profiles created in pulsed power, waveguides, plasma optics, laser-based particle accelerators and more.

“I personally would love to see this diagnostic applied to fusion energy environments, including Z-pinch plasmas,” she said. “In the paper, we provided a very thorough instruction manual of how to build your own, and I’m looking forward to seeing what people can come up with.”

September 2025: HEDS fellow Patricia Cho probes cosmic mysteries



The High Energy Density Science (HEDS) Center fellowship at Lawrence Livermore National Laboratory (LLNL) encourages postdoctoral scientists to expand their horizons and pursue new research possibilities related to the study of matter and energy under extreme conditions.

For HEDS Center fellow and experimental physicist Patricia Cho, the fellowship has allowed her to branch out from her Ph.D. work, exploring new areas of laboratory astrophysics, and introducing new experimental approaches into her collection of work. The Jupiter Laser Facility has been one of the key LLNL resources to help her succeed.

Iron in the cosmos

While earning her Ph.D. in astronomy from the University of Texas at Austin, Cho sought to answer the research question: Why do high amounts of iron appear in the accretion disks that swirl around black holes?

An accretion disk is a flat, spinning disk of gas, dust and other material that forms around a massive object, like a black hole. When modeling black hole accretion disks, in order to replicate experimental observations, more iron has to be put into the model than expected.

“One thing that’s so weird about this,” Cho explained, “is that we’re talking about seeing an overabundance of iron in two massively different black hole populations: stellar mass and supermassive black holes.”

Not only are stellar mass black holes extremely small compared to supermassive black holes, but their formation mechanisms are vastly different.

“A stellar mass black hole is thought to form from the direct collapse of a star’s core, while supermassive black holes are believed to grow over time through the mergers of smaller black holes and other massive objects,” said Cho.

So why do researchers see a systematic trend of iron overabundance in both types of systems? To investigate this question, Cho conducted experiments at Sandia National Laboratories’ Z machine to determine whether these black hole accretion disks actually contain a lot of iron by reproducing in a laboratory setting what she was seeing in the model.

This introduction into the world of laboratory astrophysics at Sandia eventually led her to Livermore in 2024, where she would continue her cosmic-related research under the HEDS fellowship — but this time tackling a different fundamental question about the universe.

Finding the solar convection zone

“My research is now focused on questions about opacity — basically, how transparent or opaque plasmas are in astrophysical contexts, and how that influences the way radiation interacts with matter,” said Cho. “Understanding opacity is crucial because it helps us build accurate models of how stars and galaxies form and evolve. The answers we find can influence our understanding of the age and development of the universe, and ultimately, our place within it.”

Cho’s opacity research is driven by a disagreement between two different methods (helioseismic measurements and stellar structure models) used to identify where the boundary of the solar convection zone is; that is, the boundary inside the Sun that initiates a change in the way energy moves.

Below this boundary, energy is transported mainly by radiation, so photons are bouncing around and gradually making their way out from the core. Within this region, the material is relatively stable and doesn’t move much. But above this boundary, the material becomes unstable to convection, so instead of just photons carrying energy, the hot plasma itself starts to move and churn.

The problem is that helioseismology, which uses the vibrations of the Sun to pinpoint this boundary, says the base of the convection zone is at one radius, while the stellar structure models, which rely heavily on opacity calculations, predict a different radius.

Currently, Cho is conducting experiments at LLNL’s National Ignition Facility (NIF) to help theorists confirm the accuracy of the opacity measurements and reconcile the differences between these two approaches.

While pressing forward with her opacity experiments at NIF, she has also begun working on experiments with more direct, terrestrial applications — work that she says could have a real impact on humanity.

Opening new doors

Cho’s latest research effort started earlier this year when she became curious about what others were working on at the Laboratory. After knocking on a few doors and connecting with other researchers, she discovered that one of her colleagues was researching electron fast ignition (EFI), an alternative fusion energy concept, and was connected to an experimental campaign in Paris at the APOLLON laser facility.

While working on this campaign, Cho helped field five core diagnostics used to collect data. One of the diagnostics she worked on was called a titanium K alpha imager.

“It is used to look at the back portion of the target to visualize the localization of the hot spot and tell us how well the electrons are being collimated [focused] onto the back surface of the target,” Cho explained. “Because that’s the whole idea: to collimate the electron beam and produce hotter conditions that could hopefully lead to ignition.”

Back at Livermore, Cho is continuing to work with colleagues on similar EFI experiments at LLNL’s Jupiter Laser Facility (JLF), where she is using JLF’s Titan laser to refine their experimental platform.

“I feel very fortunate that I don’t feel like there are many boundaries to the things that I can pursue if I’m interested in them; like this EFI experiment, I’ve been having so much fun with it,” said Cho. “The underlying physics is so new to me and super exciting; and it’s a combination of the fact that I have the HEDS fellowship and the fact that Livermore is so supportive of providing postdocs with career development opportunities that I am able to explore these new things.”

September 2025: David Alessi named senior member of Optica



Lawrence Livermore National Laboratory (LLNL) physicist David Alessi has been named a senior member of [Optica](#), an international society dedicated to promoting the generation, application, archiving, and dissemination of knowledge in the field of optics and photonics.

Alessi, the chief laser scientist for the [Advanced Radiographic Capability](#) (ARC) within LLNL's National Ignition Facility (NIF), received the status in recognition of his contributions to optics research and service to the optics community.

"I am honored to receive this recognition from Optica," Alessi said. "I am grateful for the opportunities at LLNL to perform world-leading research with so many talented and team-focused individuals here."

"Impact is one of Optica's core values," said Optica President Jim Kafka, "and I am incredibly pleased to recognize our new class of senior members who have made such an impact on our field."

Founded in 1916, Optica is the leading organization for scientists, engineers, business professionals, students, and others interested in the science of light. Senior membership status recognizes members with more than 10 years of significant experience and professional accomplishments or service in their fields.

Alessi, who received his B.S., M.S., and Ph.D. degrees in electrical engineering from Colorado State University, Fort Collins, has more than 20 years of experience in laser and plasma physics R&D.

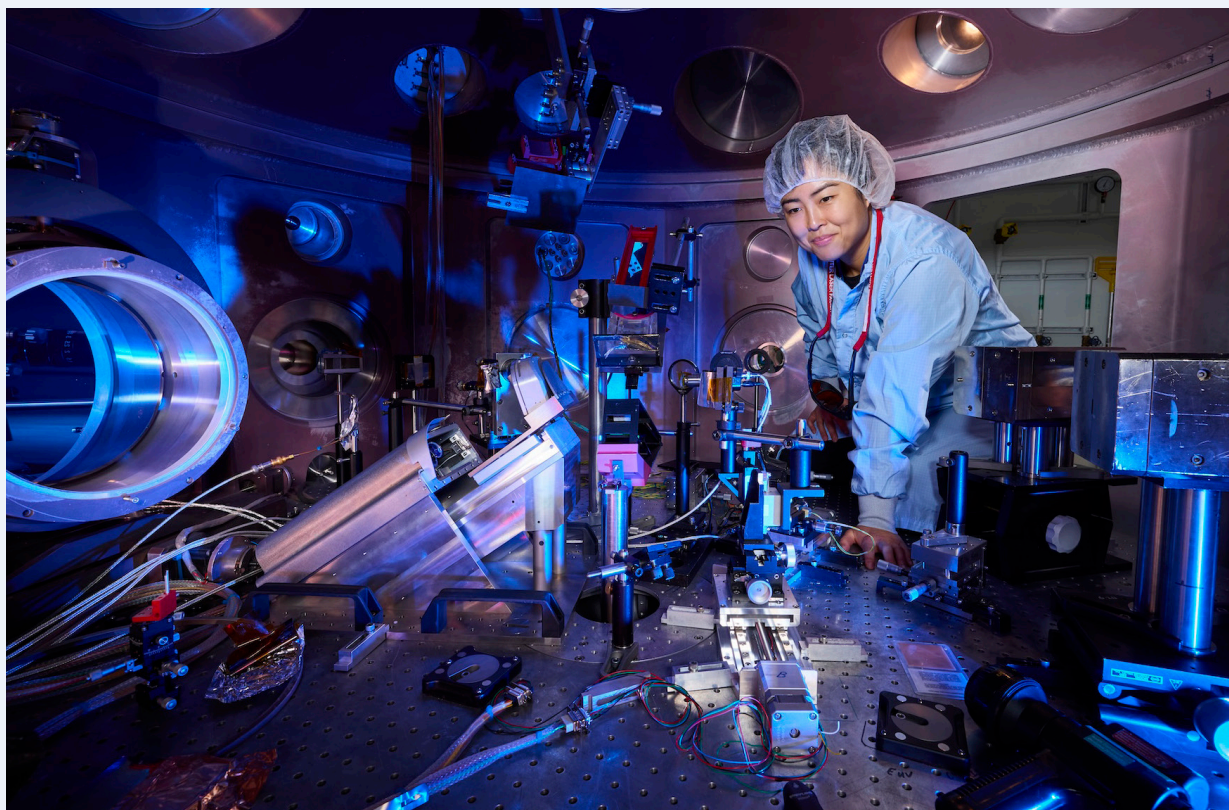
He was a Lawrence Fellowship finalist and came to LLNL as a postdoc in 2011, then joined the staff as a laser physicist in 2014. Since May 2018, he has served as chief laser scientist and integrated project team lead for ARC, the world's highest-energy short-pulse laser.

Alessi has led multiple projects within the NIF and Photon Science directorate, including various upgrades to ARC, the development of new pulse compressor [diffraction grating technologies](#), the proof-of-concept demonstration of subsystems for the [HAPLS laser](#), and the development of an advanced [short-pulse laser-damage test station](#).

He currently also provides laser science support to LLNL's [Jupiter Laser Facility](#), where he has participated in experiments generating high-energy protons, electrons, x-rays, and [betatron radiation](#). He is co-author of 46 peer-review journal papers, holds three patents, and his work has been included in 150 conference presentations.

Optica has more than 18,500 members from 175 countries and works to promote the science of light and the advanced technologies made possible by optics and photonics.

Part 2: JLF User Experiments



A systematic study of the effect of tamper materials on ablation depth and shock generation as a function of pulse duration: Determining why simulations don't work for short pulses

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We performed experiments to investigate the response of tamped ablators to a range of direct drive laser pulses generated at Janus, spanning intensity (10^9 - 10^{12} W/cm²), pulse duration (350 ps – 10 ns), wavelength (fundamental and 2nd harmonic), ablator material (Al and Ti) and tamper material (sapphire, fused silica, LiF, and bare metal). For diagnostics, we used line VISAR to obtain pressure/density, and SOP/ultrafast interferometry for ablation plume thermal emission and density, respectively. More than 130 shots were performed spanning the parameter space. This work aims to elucidate mechanisms responsible for enhancement of pressure with tamped ablation and the limitations of pressure enhancement as a function of intensity, pulse duration and wavelength. For tamped ablation, sub-nanosecond pulses at 10^{11} W/cm² are known to obtain pressures well into the 10s of GPa, whereas longer pulses (in the 10 ns range) typically obtain <10 GPa pressure due to nonlinear absorption in the tamper material. The plasma plume diagnostics (SOP and interferometry) of this experiment obtain information about energy deposited in the tamper, which limits pressure in the ablator. Based on our initial data survey, we expect to publish three papers: 1) variation of pressure and correlation with tamper absorption vs. intensity for a single pulse duration (5 ns) and wavelength (2nd harmonic), 2) variation of pressure and plume density vs. pulse intensity and duration for bare metal ablators, and 3) variation of pressure vs. intensity and pulse duration for tamped ablators. The first of these papers is nearly done – currently we are finishing data analysis and modelling. We observe a correlation between absorption in the tamper and reduction of pressure at the ablator and good agreement between simulations of plume dynamics and observed plasma density. Based on the quality of the data and the strength of correlations, these experiments suggest a useful relationship between the upstream plasma properties and the loss of pressure at the ablation plane.

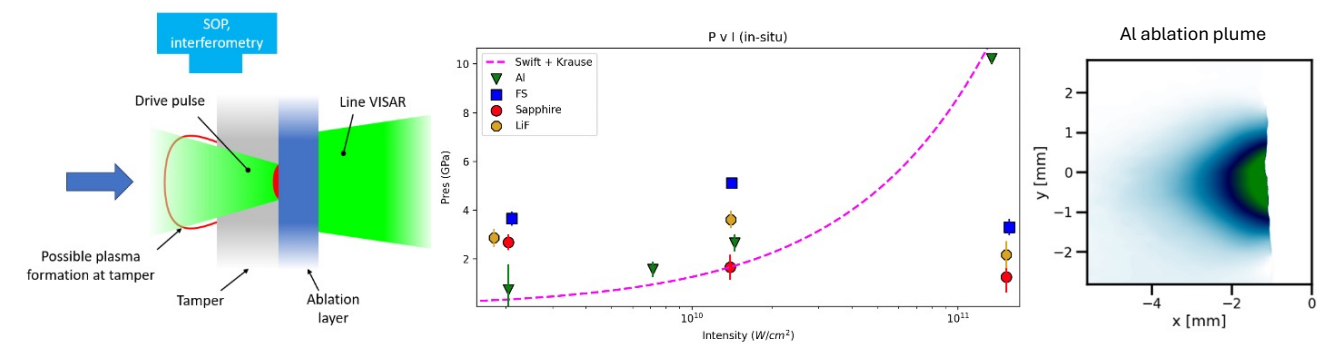


Figure 1 (left) Schematic of the experiment. For low intensity, all drive energy arrives at the tamper/ablator interface, where tamper confinement of the expanding plasma enhances the pressure in the ablator compared to bare Al. At higher intensity, nonlinear absorption at the upstream side of the tamper absorbs pump light reducing the fraction of energy delivered to the ablator and the pressure. (center) Pressure as a function of intensity delivered to the ablator and the pressure from tamped ablation is less than found in ablation from bare metal. (right) A contour plot of free electron density as a function of position in the ablation plume for bare Al. This measurement enables an estimate of absorbed energy, which can be used to estimate the reduction of pressure in the ablator for intensity above 10^{10} W/cm².

Investigating high-energy double pulse laser ablation in air for maximizing shocks in metallic targets

J. Crowhurst, J. Wolfe, S. Ly, C. Perreault, J. Lee, J. Zaug, W. Keller
Lawrence Livermore National Laboratory

We have shown¹ that for laser pulses of energy order 10 millijoules and durations of several nanoseconds, the strength of the shock that is driven into a solid target in air is enhanced if the energy is delivered in the form of two discrete pulses rather than a single pulse of the same total energy. The primary aim of this campaign was to investigate if this enhancement still occurs when drive energies are increased up to ~100 J, (i.e. by at least 3 orders of magnitude), while keeping fluence on target (~10-100 J cm⁻²), and other parameters such as pulse length (5 – 20 ns), and inter-pulse delay, Δt (~1-100 μs), comparable. Experimental diagnostics were photon Doppler velocimetry and fast video (5 Mfps). Samples were also inspected visually, after they had been shot, for signs of spall and other types of damage. We found that indeed shock strength was enhanced by 2-3x, and by 5x in some cases, compared with a single pulse. We also found that in some targets (thin aluminum, and a much thicker ceramic), spall could not

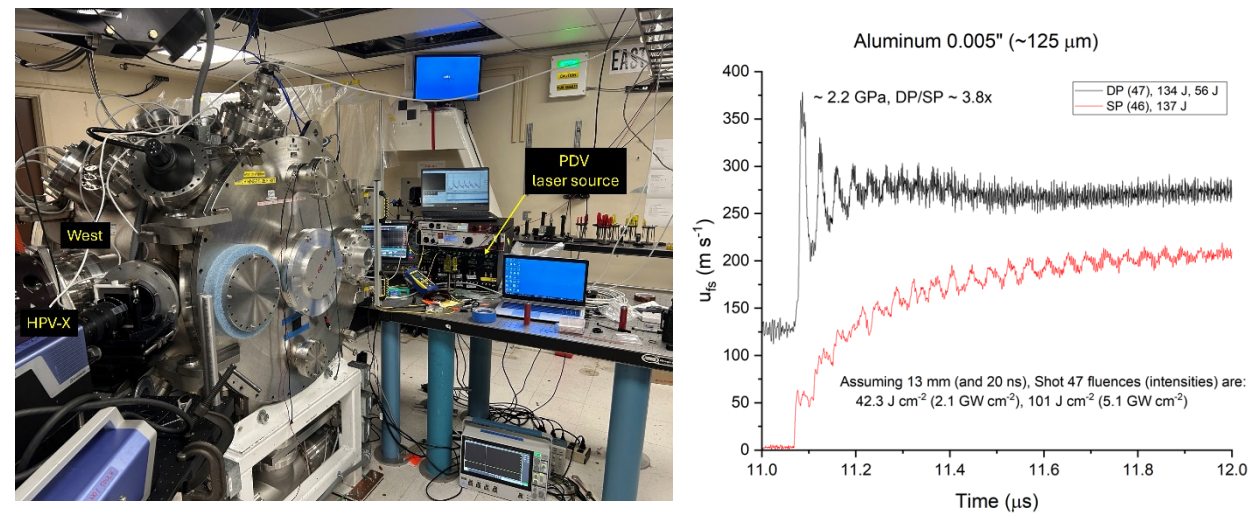


Figure 1 **Left**: Target Area 1 of the Janus platform (JLF) showing the target chamber and some of the apparatus we used for our campaign. **Right**: PDV traces for a single pulse drive (red, “SP”) and the corresponding double pulse drive (black, “DP”). Δt was 10 μs. Other experimental parameters are indicated.

be achieved with one pulse but was clearly achieved using two pulses. These experiments were carried out at the Jupiter Laser Facility (LLNL) using the Janus platform (“Target Area 1” shown in Figure 2). Conveniently for this work, Janus provides two separate beams, named “East” and “West”, that can be independently timed. Thus, we did not need to bring in a second laser. The East beam was used as the “Preconditioner” (i.e. the pulse that arrives first and produces a rarefied region in the vicinity of the sample surface¹), and the West was used as the “Drive” (i.e. the pulse that produced the relevant shock). Shots were carried out over 17 working days between 16th September to 8th October 2024. Two additional days of setup time were provided. 141 shots were carried out over the course of the campaign (an average of about 8 shots a day).

1. J. C. Crowhurst, S. Ly, B. Koroglu, W. J. Keller, Using double pulse laser ablation in air to enhance the strength of laser-driven shocks. Opt. Express 32, 7053–7063 (2024).

Diffraction imaging of harmonically perturbed shock fronts

T.M. Hutchinson, A. Marsh, L. Grace, G. Righi, C. McGuire, Y.J. Kim, E. Reichel, T. Brendel
Lawrence Livermore National Laboratory

In this experiment, we made considerable progress towards a multi-frame 2D-visar diagnostic at TA-1 for shock physics applications. The diagnostic enables (among other things) quantitative measurement of the attenuation of harmonic perturbations to a shock as it propagates. Analytic predictions for this attenuation vs shock propagation length depend on the shocked matter viscosity. Consequently, this diagnostic enables viscosity estimates for matter at high pressure, including for common rocky planet constituents at relevant conditions. We collected data over 30+ shots with > 800J at 2ω using SiO₂ samples, and demonstrated that a 5+ frame 2D-visar is realistic. However, unanticipated errors in target design precluded collection of a full decay curve, so we gathered a large set of improvements to the design and data analysis is underway.

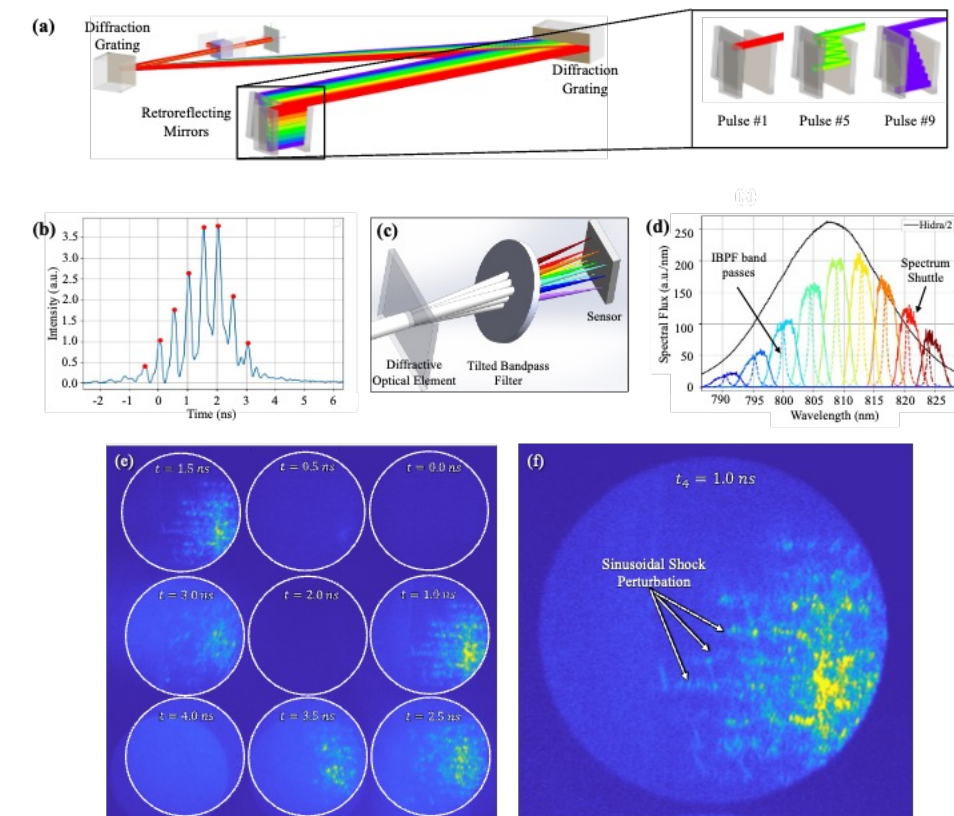


Figure 1. (a) Design overview of hardware for generation of a sequence of chromatically dispersed pulses via a broadband femtosecond pulse a stretcher, and a resonating cavity (b) Experimental diode recording showing daughter pulses separated by 500 ps (c) after passing through a pair of matched interferometers (as typical 2D visar) daughter pulses are chromatically demultiplexed onto a single camera sensor using a diffractive optical element (DOE) and tilted bandpass filter (d) Design for spectral throughput of Hydra (black line) prior to IBPF (solid lines) and after the IBPF (dashed lines) (e) Experimental image showing nine 2D VISAR images of a reflecting shock in fused silica at 250 GPa with 500 ps separation between images. The central frame is dark due to an improperly specified DOE (f) Expanded frame demonstrating the reflective shock front is modulated by a sinusoidal perturbation. 2D VISAR fringes are ~7 pixels in wavelength with k-vector along the diagonal from top left to bottom right.

Pump with Broadband Probe Experiments for Single-Shot Measurements of Plasma Conditions and Crossed-Beam Energy Transfer

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¹Lawrence Livermore National Laboratory, Livermore, CA, 94550

By utilizing crossed-beam energy transfer (CBET) between a strong pump and a broadband probe beam, it is possible to map the CBET gain spectrum in a single shot. This approach enables time-resolved measurements of key plasma properties including electron density, temperature, and flow velocity with signal levels up to nine orders of magnitude stronger than Thomson scattering.

Using the Janus laser and STILETTO, a newly developed temporal-spectral pulse-shaping technique, we have experimentally measured the CBET gain curve for the first time. Successful measurement of the gain spectrum requires a probe beam that is both spectrally broadband, centered on the pump wavelength, and temporally incoherent over hundreds of picoseconds. These otherwise conflicting laser requirements are uniquely enabled by the STILETTO platform.

With this technique, we have demonstrated high-precision measurements of plasma parameters while independently scanning pump energy, plasma density, and plasma temperature^{1,2,3,4}. Owing to its exceptional signal-to-noise ratio and single-shot capability, this novel diagnostic is now being developed as a potential platform for measuring plasma conditions on the National Ignition Facility (NIF).

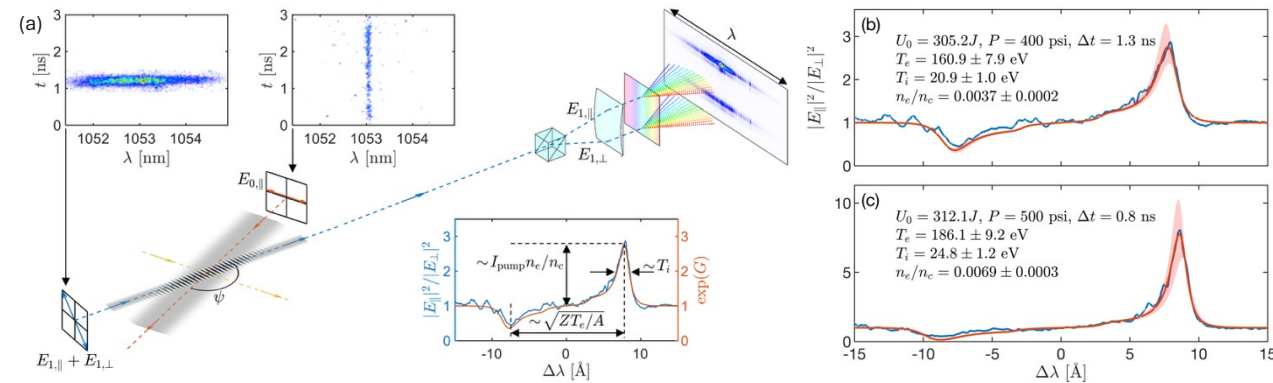


Figure 1.

(a) Schematic of the experimental setup for implementing a broadband probe on Janus/TA1. The west pump beam (red; 300 J, 3 ns, 1053 nm) crosses the east probe beam (blue; 5 mJ, 165 ps, 1053 nm, 4 nm bandwidth) in a CH₄ plasma. A high-resolution spectrometer analyzes the transmitted probe spectrum, which is imprinted with plasma-induced CBET gain features, enabling high-precision extraction of the plasma temperature, density, and flow velocity.

(b,c) Representative single-shot CBET gain spectra measured at different pump-probe time delays and gas-jet backing pressures.

1. A. Longman *et al.*, Physical Review Letters 135, 175103 (2025).
2. A. Longman *et al.*, Invited Talk, Anomalous Absorption Conference, Sedona, AZ (2025).
3. A. Longman *et al.*, Invited Talk, LasernetUS Users Meeting, Pheonix, AZ (2025).
4. A. Longman *et al.*, Invited Talk, American Physical Society Division of Plasma Physics, Longbeach, CA (2025).

Speckles with a Twist: Towards Angular Momentum Smoothing in ICF

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Introducing angular momentum into a laser wavefront offers a promising new approach to laser speckle smoothing, which is critical for mitigating detrimental laser-plasma instabilities in inertial confinement fusion (ICF). Leveraging the flexibility of the Janus laser system and LLNL's in-house optics manufacturing capabilities, we have developed and tested high-power spiral phase plates at the 300-J level in TA1, producing the highest-energy orbital angular momentum (OAM) focal spots demonstrated to date.

Preliminary experiments imaged and characterized speckle fields in three-dimensional space, revealing net rotation along the propagation direction for OAM modes with topological charges ranging from $L = 8$ to $L = 8$, both with and without continuous phase plates (CPPs). These beams were subsequently employed in several laser-plasma interaction experiments, including crossed-beam energy transfer using a broadband probe¹, as well as backward and forward stimulated Brillouin scattering (SBS). Initial results indicate a modest reduction in backscatter with increasing topological charge, contrary to prior expectations, likely attributable to the increased Rayleigh range of the mode-converted beams. These trends indicate that pure OAM beams result in similar amounts of SBS backscatter as those without OAM. This trend may be broken however using two different OAM modes with two different wavelengths².

A follow-up campaign is planned for 2026, in which we will detune crossing, speckled OAM beams to introduce controlled temporal rotation of the beam and speckle pattern, enabling a systematic study of OAM-driven speckle dynamics and their impact on laser-plasma interactions.

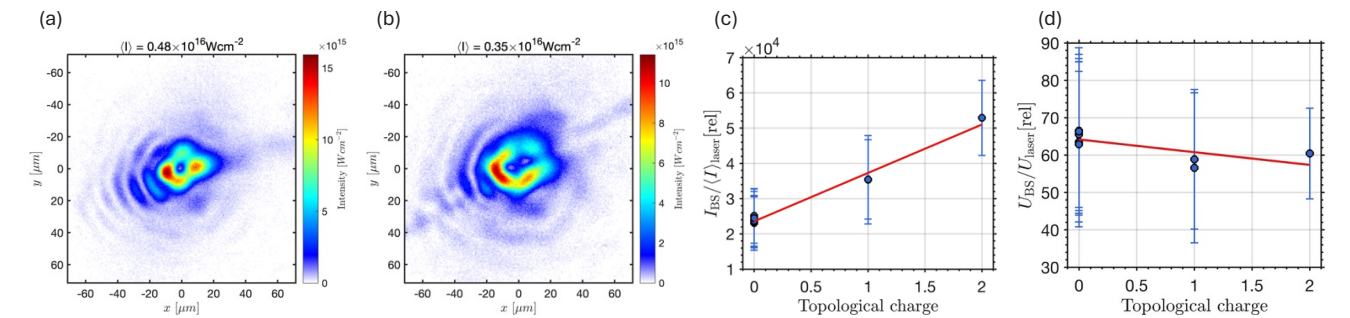


Figure 1.

Far-field images of the Janus focal spot and intensities assuming 300J in 3ns at focus for (a) $L = 1$, and (b) $L = 2$ OAM beams. (c) Backscattered intensity at 1053nm normalized to the intensity weighted laser intensity as a function of topological charge. Previous theories indicated that this should be a flat trend. (d) Backscattered laser energy relative to the incident laser energy as a function of topological charge. Previous theories predicted this to be a strongly decreasing trend.

1. A. Longman *et al.*, Physical Review Letters 135, 175103 (2025).
2. A. Longman *et al.*, Submitted to Nature Photonics (2025), arXiv:2508.05943

Nanowire foam studies for photopumped x-ray backlighters

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¹General Atomics

²University of Michigan

Using the Janus laser 2nd harmonic in the TA1 setup, we conducted a study of laser propagation in nanowire foams. Nanowire foams have been shown previously to give high efficiency thermal X-ray emission for nanosecond scale laser drive¹. The targets were chosen to be 10 mg/cc foam composed of Cu nanowires, which are expected to have a volume-averaged free electron density nearly equal to the critical density for 2 ω drive in the experiment. Understanding laser propagation in the framework of such a foam, as it is ionized, driven, and heated, is key to attaining desirable X-ray qualities for backlighting applications.

In total, 49 full-energy target shots were executed, with pulse duration of 1, 2, or 3ns and three focal spot sizes (using phase plates), spanning intensity of $2 \times 10^{13} - 3 \times 10^{14}$ W/cm². The target was 600, 1200, or 1800 μ m long. The primary diagnostics were two channels of Streaked Optical Pyrometry observing the target rear surface, three X-ray spectrometers, and an X-ray pinhole camera.

Optical emission (excluding laser transmission) from the target rear was observed via SOP to peak after the end of the laser pulse in all cases, and the brightness and temporal history were strongly dependent on the experiment parameters. Numerous Cu X-ray lines were observed, primarily He-like. The dependence upon line brightnesses as a function of laser and target conditions is ongoing. Side-on X-ray pinhole camera images exhibited extended emission regions up to 600 μ m for a 600 μ m long target and as long as 1200 μ m for an 1800 μ m long target. Target images and an example X-ray pinhole image are shown in Fig. 1.

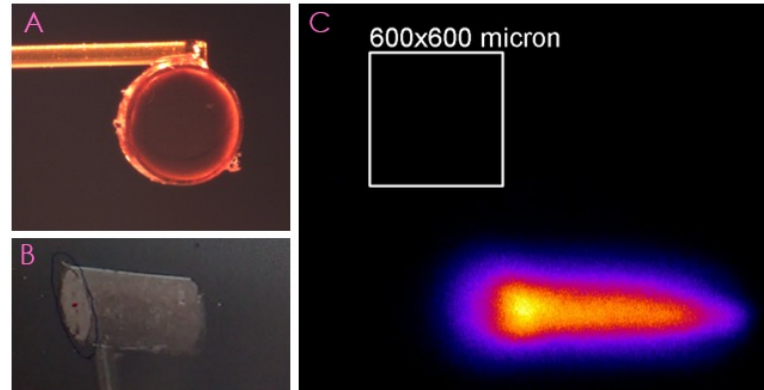


Figure 1

A) face-on image of a mounted target with polyimide tube and Cu nanowire foam filling. B) alignment station capture of a target side-on. C) X-ray pinhole camera showing extended emission (laser irradiation from the left). White box for scale. Note, subfigures are from 3 different targets.

1. M. J. May, et al. "Thermal energy transport in laser-driven high x-ray conversion efficiency metallic silver nanowire foams." *Physical Review E* **111**, 015201 (2025).

Measurement of viscosity in CH-based plastics under diamond forming conditions

Gaia Righi¹, Na'im Kalantar², Yong-Jae Kim¹, Trevor Hutchinson¹, Suzanne Ali¹, Nitish Acharya³, Jessica Shang², Hussein Aluie², Hye-Sook Park¹

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The viscosity of CH-based plastics was investigated using the measurement of a decaying perturbed shock front. In transparent materials, the formation of a reflecting shock can be tracked using velocimetry techniques and if a perturbation is placed in the path of the shock wave, the wave will pick up the pattern as it travels through the sample. A known perturbation amplitude is machined into the target such that when the shock traverses it, the amplitude decay can be tracked and related to viscosity (Fig. 1a). This experiment was conducted in Janus TA1, for its ability to deliver a two long-pulse (up to 20 ns) high energy (up to 500 J) drive lasers coupled with velocimetry diagnostic (VISAR). We conducted a total of 46 shots throughout the 4-week beamtime to study both the optical and viscous properties of the commonly used epoxy, Stycast 1266. Reflecting shocks in this material were seen ~ 3 Mbar and show clear fluctuations in intensity, corresponding to the design ripple wavelength (Fig. 1b). Streaked optical pyrometry (SOP) was also fielded successfully and also clearly shows the rippled pattern (Fig. 1c). Detailed data analysis is ongoing, with support from hydrodynamic simulations. Additionally, these results will be presented at upcoming conferences with a planned conference proceedings publication.

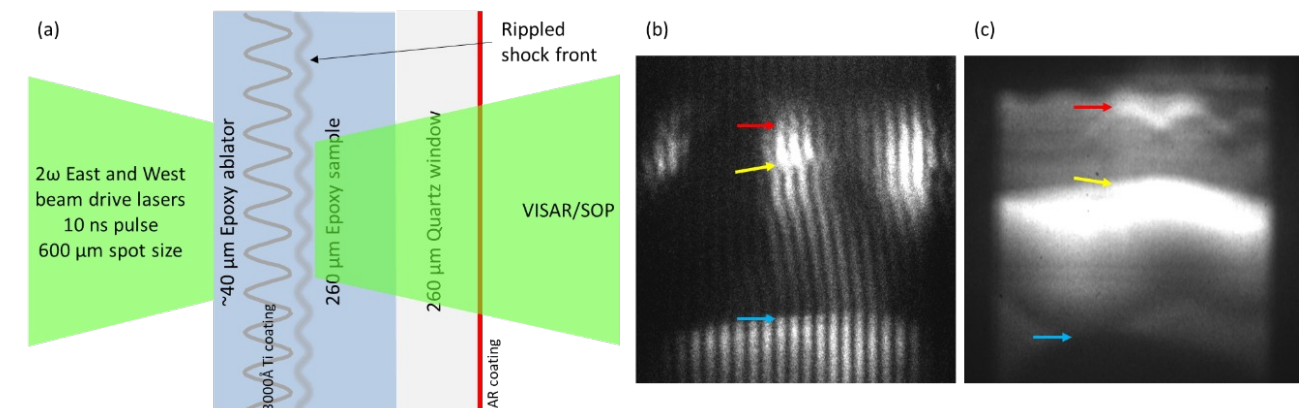


Figure 1

(a) Experimental set-up showing 527 nm drive laser driving a rippled target. VISAR measures the velocity of the rippled shock front, which becomes reflective at high pressure and SOP measures thermal emission. (b) VISAR leg A and (c) SOP data showing evolution of the rippled shock in the epoxy. Red arrow depicts formation of strong reflecting shock, yellow arrow depicts shock breakout into quartz window, and blue arrow shows free surface breakout.

Investigation, using short laser pulses, of fast shocks interacting with magnetic turbulence, and of the associated ion energization

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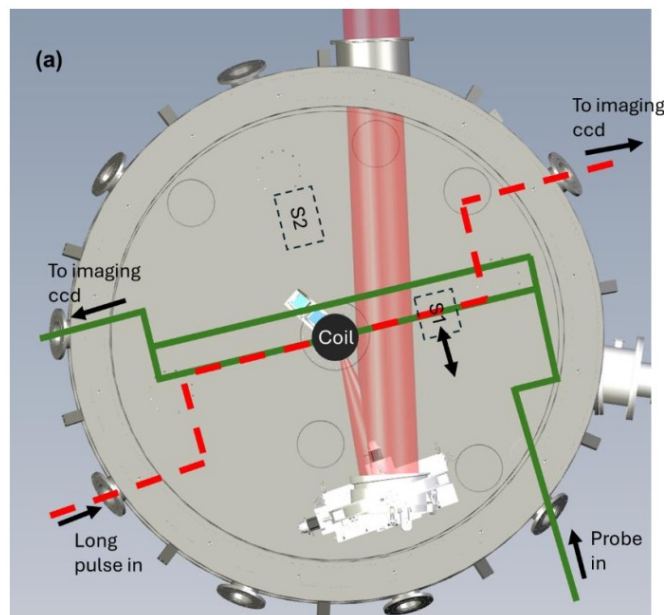
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The experiment was performed at TITAN and had as goal to study cosmic-ray (CR) energization by fast magnetized shocks. Up to now, astrophysically-relevant shocks could be produced in the laboratory, but using long-pulse lasers, e.g. NIF, Vulcan or LULI2000, and accelerated particles could be measured and processes deciphered, but the energization was limited to proton energies of the order of a few tens of keV.

With this experiment, we aimed at generating much faster shocks than before, through the use of the intense and energetic short-pulse of TITAN. The concept was to use this beam in the ps to tens of ps regime, i.e. long enough to allow a shock to form and propagate, but also not too long so that its intensity stays high and that the shock could be produced at high velocity. The shock was formed by having the TITAN beam interact with a very plastic foil, which was exploded, such that a stream of high velocity ions would be generated. These ions were made to propagate in a low-density H₂ gas jet that was externally magnetized, such that the magnetic field-associated dissipation helps the formation of the shock.

We performed 118 shots with varying magnetic fields in the values of (0, 10, 20) Tesla and target thicknesses (0.5, 0.9, 1.5) μm. The schematic of the experiments is shown in Fig. 1. We characterized the shock using two sets of diagnostics: (1) an optical interferometer allowed to evidence the formation of the shock in the gas and its evolution. (2) Thomson scattering allowed us to evaluate the plasma temperature and evidence the heating associated with the shock formation. Additionally, two Thomson parabola spectrometers, positioned along and perpendicular to the laser axis, recorded the accelerated particles.



Remarkably, the spectrometer perpendicular to the beam, and along the axis of the magnetic field, recorded energy-bunched protons accelerated by the shock, at energies extending into the multi-MeV energy domain. Further analysis will let us characterize the shock velocity as well as its amplitude as a function of time, which we can then use to compare different models of CR energization to match our proton spectrum measurements.

Figure 1

Schematic diagram of the experimental setup, using both the short and long pulses of Titan, plus the short-pulse probe beam. S1 and S2 are electron/ion spectrometers.

Ultrafast laser-driven x-pinch

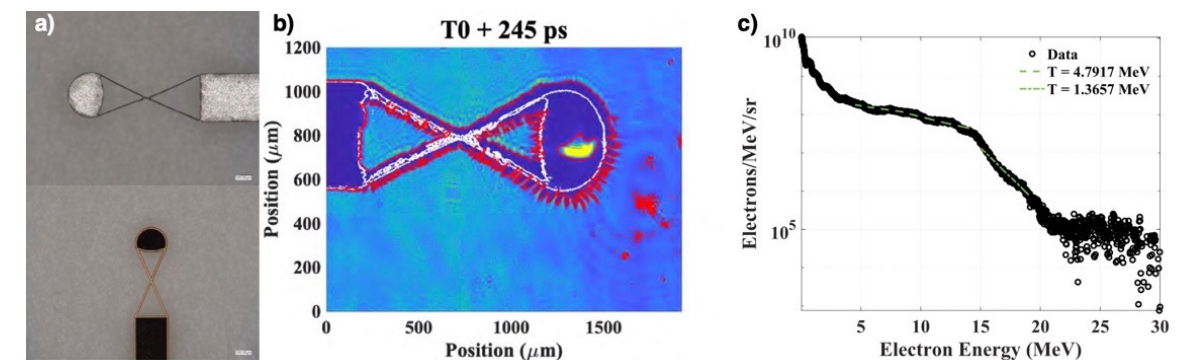
P. I. H. J. LeFevre¹ with P. T. Campbell¹, M. J.-E. Manuel², R. D. McBride¹, and C. C. Kuranz¹

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This report describes a recent experiment at the Titan laser to develop laser-driven x-pinch. The experiments at Titan use laser-produced return currents to drive metal targets with crossed wire features to produce a prompt x-pinch. Titan is the ideal facility to develop this x-ray source because the high energy per pulse is beneficial for driving the pinch. X-pinch is a current-driven device that concentrates the magnetic pressure at the crossing point of the “x” [1]. This leads to short duration source with a small spatial extent. Pulsed-power experiments in high-energy-density plasmas use x-pinch for high-resolution radiography, absorption spectroscopy, and diffraction studies [2-4]. These sources are not typically used in laser experiments due to timing jitter, lack of collocated facilities, and debris concerns. Additionally, the repetition rate of a traditional x-pinch is currently a few per day, which makes it impractical to use at high-repetition rate laser facilities.

The laser-driven x-pinch experiments on Titan, conducted in March of 2025, used the 1 short-pulse beam at best compression and the f/3 parabola to reach the largest intensities and drive the largest peak current in the target. The targets were made of either copper or aluminum foil, shown in Fig. 1 a, with an oval feature for the laser to hit. An “x” structure supports this oval as a return current path to ground and acts as an x-pinch. The laser is incident at a 45-degree angle to the surface normal of the target. There were 40 high energy laser shots during the campaign.

The measurements in these experiments were optical shadowgraphy, X-ray pinhole imaging, and particle spectrometry. Optical shadowgraphy measurements used the optical probe beam at 2ω to allow probing of higher densities and to avoid the scattered 1ω light at the target. The particle spectrometer capture protons and electrons showing temperatures of a few MeV for both particle types. University of Michigan undergraduate student Ingrid Rhind analyzed the X-ray images and proton spectra. Figure 1 b and c show the results of analyzed data for each of the measurements. The shadowgraphy measurement in Fig. 1b shows the condition of the x-pinch 245 ps after the laser pulse along with contours of the plasma at 245 ps and the pre-shot image to illustrate the instability growth on the wires. This may be the electrothermal instability, but this is still under investigation. Figure 1c shows an electron spectrum from an x-pinch target with a two-temperature fit due to the presence of two distinct slopes in the data.



Talk at LaserNetUS 2025; Poster at APS DPP 2025; Poster at University of Michigan summer undergraduate research experience symposium; paper in preparation

[1] S. A. Pikuz et al. Plasma Physics Reports, 2015, Vol. 41, No. 4, pp. 291–342

[2] S. A. Pikuz et al. Rev. Sci. Instrum. 68, 740–744 (1997)

[3] J. Strucka et al. Matter Radiat. Extremes 7, 016901 (2022)

[4] J. Read et al. Rev. Sci. Instrum. 95, 023508 (2024)

Laser-ion doping of semiconductors

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We conducted an experiment at the Jupiter Laser Facility (JLF) using the Titan laser platform to explore the effects of intense ion pulses on materials. The scientific goal of this experiment was to investigate the potential for laser-plasma acceleration to create novel materials phases, including superconducting and qubit-forming materials. Specifically, we aimed to use intense pulses of protons and heavy ions to excite and heat materials, leading to the formation of a superconducting phase in diamond and novel color centers in semiconductors. Our motivation for this experiment was to gain access to the dynamics of radiation effects with short ion pulses, drive materials to high temperatures and pressures, and stabilize interesting new materials phases. We successfully executed 42 high-power shots with an average energy of ~130 J and small variation in energy.

Our results show that diamond can be turned into a superconductor by ion implantation using intense pulses of boron ions from laser acceleration, with transition temperatures (Tc) ranging from ~0.1 to 0.5 K. Additionally, we observed the formation of novel color centers in semiconductors, which are qubit candidates for applications in quantum networking and quantum sensing. These findings open new opportunities for the formation of tunable superconductors and provide insights into materials far from equilibrium. A manuscript detailing these results is in preparation. We plan to further explore and refine this process in a future experiment, aiming to reach higher Tc's, understand the tuning range of Tc with various dopants and materials, and explore the formation of novel spin-photon qubit candidates. This work has the potential to establish a new direction for the application of unique tools from high energy density science to manufacturing, microelectronics, and quantum information science.

The work is supported by the U.S. Department of Energy Office of Science, Office of Fusion Energy Sciences, under Contract No. DEAC02-05CH11231.

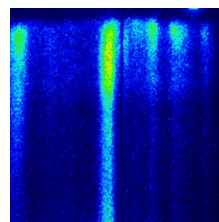


Figure 1

Streak camera image from the light emission of a secondary target that got exposed to laser-ion accelerated ions.

1. Kaushalya Jhuria, Amanda Hebert, Jhon Lawrence Bulosan, Jai Ceraso, Kian Leonard, Jacob Romeo, Wei Liu, Thomas Schenkel, Arun Persaud, APS-DPP (poster "Advanced Diagnostics of Laser-Ion Doping for Quantum Materials and Qubit Synthesis", (2025)

Dual Radiography using split beams at Titan

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Laser-driven MeV radiography is a promising application for HED science that is maturing rapidly. Demonstrations of highly efficient, high-flux, high-energy, and high-resolution x-ray beams, as well as the resulting radiographs, are becoming more commonplace [1,2,3,4]. However, additional capabilities are desirable, such as multi-time and multi-axis sources that enable radiography to better constrain dynamically evolving systems.

At Titan, we conducted an experiment to demonstrate a split-beam geometry and obtain two simultaneous radiographs. The split-beam geometry at Titan refers to placing a mirror inside the chamber that splits the beam into two, with each half of the Titan beam focused by its own parabola. We refer to the beam that does not reflect off the splitting mirror, and the parabola it uses, as the primary". The beam that reflects off the splitting mirror, and its parabola, is referred to as the secondary". Each beam had dedicated focal-spot monitors for alignment. A single tungsten plate was used, which acted as the target for both the primary and secondary beams.

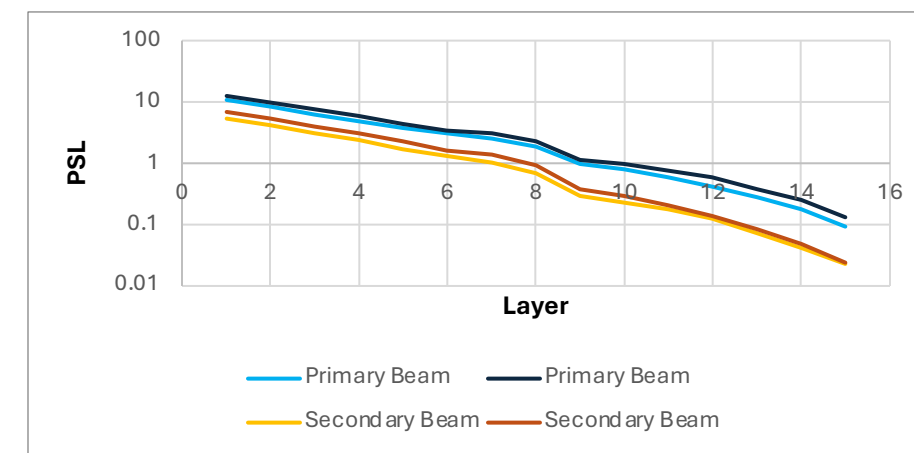


Figure 1: BMXS data from Primary and secondary only shots

Before performing radiography, the primary and secondary x-ray sources were characterized individually using two BMDXs [5], one positioned on the laser axis for each beam. Figure 1 shows the measured PSL from primary-only and secondary-only shots. The secondary x-ray source is approximately twice as bright as the primary x-ray source. We postulate that this difference is due to the quality of the primary focal spot compared to that of the secondary focal spot.

Radiography was performed on a 3D-printed titanium object. Due to the size of the object, its distance from the sources, and the separation between the two interactions, there is a significant region of overlap at the radiography plane. The radiography geometry and the radiograph captured on the image plate are shown in Fig.2(b) and Fig.2(c), respectively. The left side of the radiograph corresponds to the primary beam, which again appears brighter than the secondary beam in the image. The reduction in clarity on the left-hand side of the image is due to parallax, since the object is close to the source.

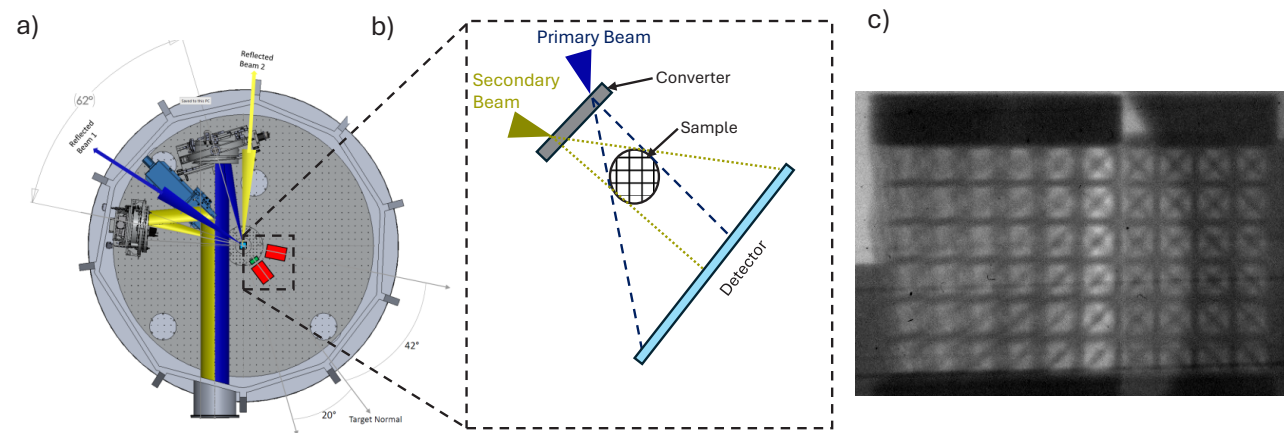


Figure 2: a) A top down drawing of the Titan target chamber showing the split beam geometry. Blue beam is referred to as the primary beam and the yellow and the secondary. b) The two beams interact with the same converter target creating a point source of x-rays. Due to the proximity of the sources, the radiographed object has a region of overlap. c) A dual radiograph of a 3D printed object with 200µm trusses with the ‘primary’ radiograph on the left and the ‘secondary’ radiograph on the right. Parallax effects obscure the features on the primary radiograph.

These first split beam radiography results at Titan demonstrate that two simultaneous MeV x ray sources can be generated and used to image a common object. With further optimization of focal spot quality and geometry, this approach could enable routine multi time, multi axis radiography of dynamically evolving HED systems.

1. C. Courtois et al., Physics of Plasmas 18, 023101 (2011).
2. S. M. Kerr et al., Physics of Plasmas 30, 013101 (2023).
3. A. S. Bogale et al., Physical Review Research 7, 023169 (2025).
4. D. R. Rusby et al., Physics of Plasmas 32, 123102 (2025).
5. C. D. Chen et al., Review of Scientific Instruments 79, 10E305 (2008).

Investigation of non-thermal electron collimation and optimization of energy for application to electron fast ignition

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This experiment was carried out at Titan, utilizing the 130J, 0.5ps short pulse laser to study resistive collimation of electrons in cylindrical coaxial targets with a copper core and an aluminum doped plastic cladding. The two materials have a resistivity gradient at the interface which produces strong self-generated magnetic fields that push electrons towards the core. The resistively collimated electrons are useful for electron fast ignition as a beam of charged particles to inject into a fusion hot spot. The primary goal of this experiment was to infer resistivity gradients by measuring the temperature in the coaxial targets and using this to benchmark resistivity models in EFI codes. The campaign acquired 73 high power shots, and we measured highly repeatable x-ray emission spectra to constrain temperatures and escaping electron energy distributions to constrain electron collimation. Preliminary results from the experimental campaign were presented at the 67th Annual Meeting of the APS Division of Plasma Physics^{1,2}.

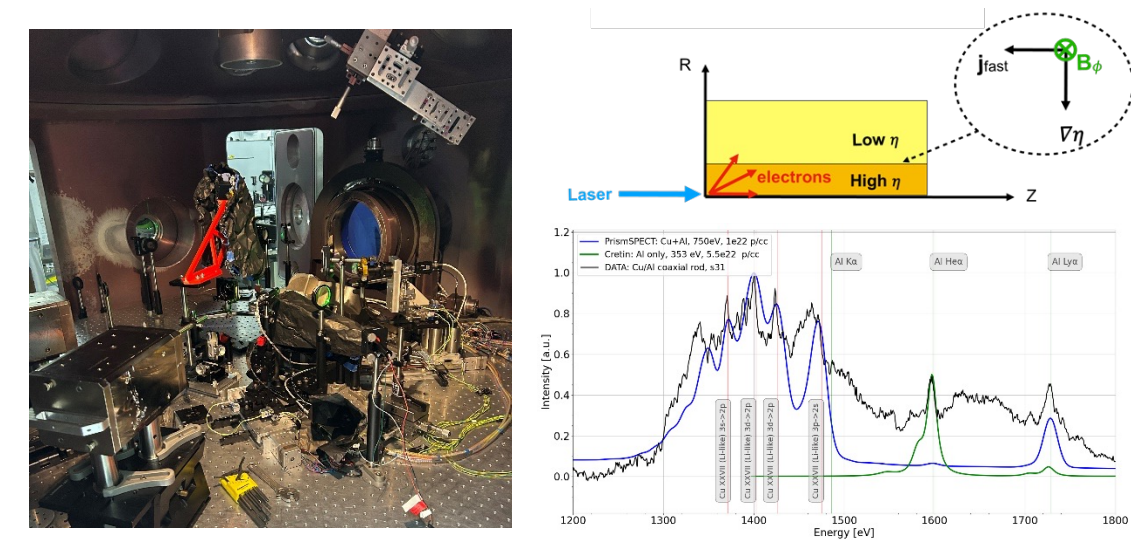


Figure 1. **Left:** Titan target chamber with campaign diagnostics installed. **Right top:** Resistive collimation concept sketch, electrons are pushed to regions of higher resistivity due to azimuthal self-generated magnetic fields. **Right bottom:** X-ray spectra showing Cu *L-shell* emission from hot core region and Al *K-shell* emission from cooler cladding region. Simulated spectra from collisional radiative model for preliminary comparison.

1. S. Yunus et al., Experimental study of short pulse laser generated electron collimation for EFI using resistive focusing, 67th Annual Meeting of the APS Division of Plasma Physics, Long Beach CA (2025)
2. R. B. Morgan et al., Oxygen Emission Measurements Using a Double Crystal von Hamos Spectrometer for Electron Collimation Experiments, 67th Annual Meeting of the APS Division of Plasma Physics, Long Beach CA (2025)

Development of x-ray sources from high rep-rate solid targets

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The COMET experiment supported efforts to develop a laser-driven, high energy, high resolution x-ray source for computed tomography (CT). The experiment goal was to increase readiness of high rep-rate sources from solid targets, characterize a radiography detection system, and perform an initial integration with a CT software system in support of LDRD 25-ERD-010. A secondary goal was to collect x-ray generation data for code benchmarking over a range of pulse durations and target thicknesses, at a low laser intensity to complement the high intensity dataset from the CSU ALEPH laser. COMET was chosen for its accessibility, flexibility, and relatively high repetition rate of 1 shot per 5 minutes.

The experimental goals were accomplished with a range of success. After the primary Scitech target tape drive was found to not be functional a secondary solid target platform was fielded using a vertical flag geometry, allowing 6-7 shots under vacuum. This was used to perform contact radiography of test objects and collect data on a HERIE Ta stack diagnostic, as recorded on image plate and an imaging system with a LYSO scintillator, large mirror and Andor camera (Fig. 1). Overall, 24 shots were taken on two target types (100 μm thick Cu, ~450 μm thick Ta), giving a good dataset of COMET source performance. Lastly, the 5 Hz beam was used to pre-condition the target, drilling holes and increasing x-ray output. This experiment helped lay the groundwork for a subsequent successful experiment at the CSU ALEPH laser.

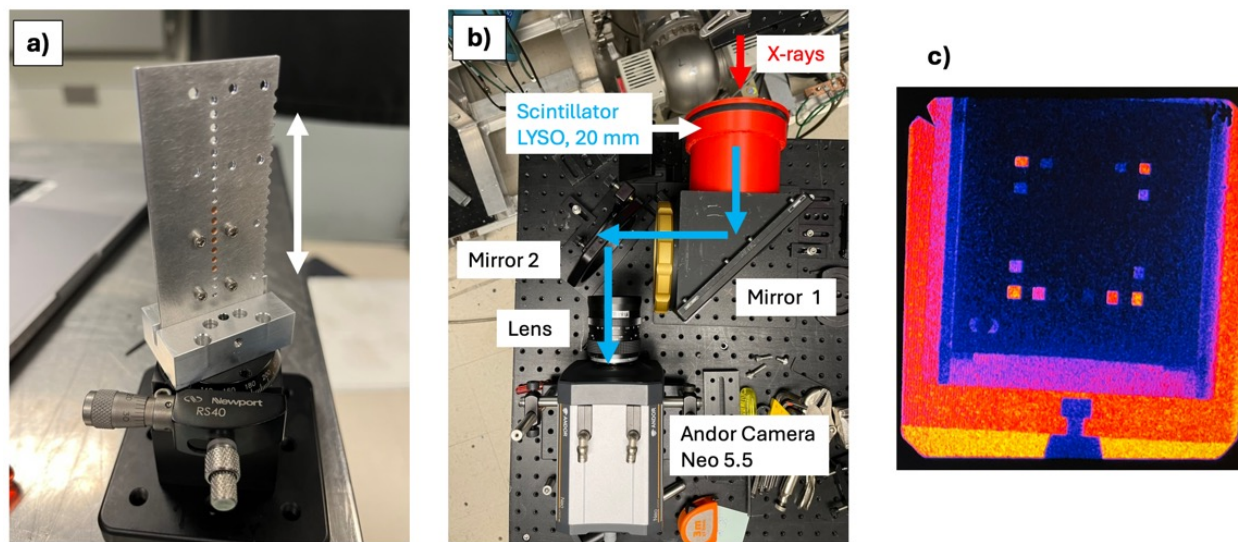


Figure 1

(a) Vertical target holder with 100 μm copper foil. A motorized vertical translation stage allowed 6 – 7 shots per vacuum cycle. (b) Imaging system configuration. (c) Example of HERIE Ta step data from a ~400 μm thick Ta foil, with pre-conditioning (image plate).

Amplification of Ultrashort Pulses through Stimulated Raman Backscattering

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The short summary covered in this report is a continuation of results we achieved in 2024. In 2024 we reached our original project goal of “demonstrating the feasibility of increasing the output energy in ultra-short laser pulses by over 100 times via the Stimulated Raman Backscattering (SRBS) technique”. With an input SRBS pulse energy measured of ~ 330uJ (slightly lower than the best pulse energy of ~ 500 uJ), the amplified SPBS pulse is ~ 30 – 40 mJ, breaking the maximum energy limit of a few millijoule, and narrowly reaching our project goal of amplifying the output energy in ultra-short laser pulses by over 100 times.

To further investigate the capacity of the SRBS scheme, based on our 2024 results, we optimized our experimental setup to improve the nonideal plasma conditions, and characterized the SRBS pulse before and after the amplification in both the temporal domain and in the spectral domain. Using an autocorrelator combined with a spectrometer and using a FROG (provided by JLF). We tested and compared different devices in measuring the SRBS pulse. These studies enabled us to establish a practical direction for reaching the extreme light regime.

Figure 1 shows the SRBS pulse spectra and pulse width measured by spectrometer, autocorrelator and FROG.

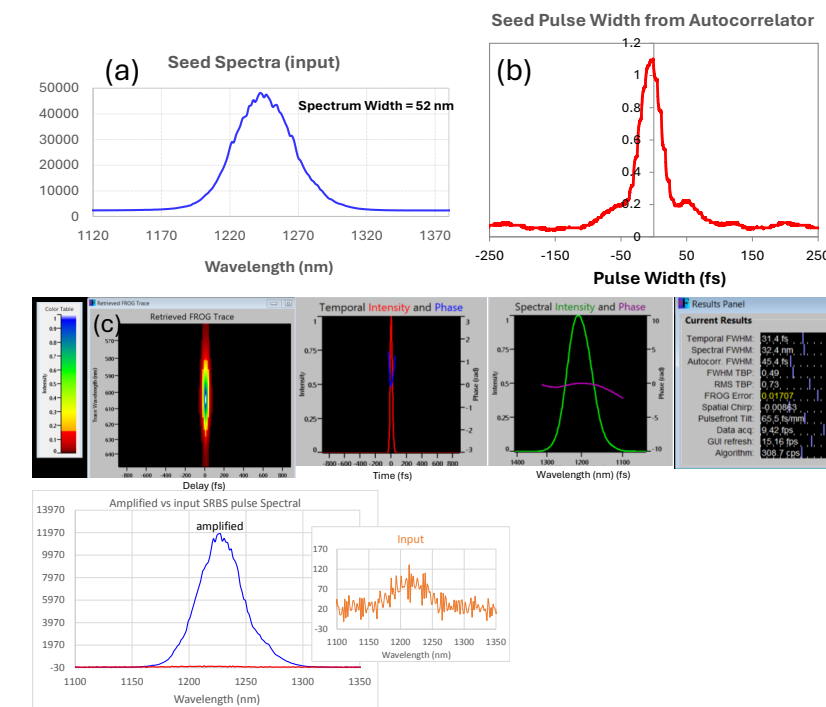


Figure 1

Measured SRBS pulse spectra and pulse width, (a) and (b) the input SRBS pulse spectra with spectra width of 52nm and pulse width measured by an autocorrelator of 45fs; (c) the input SRBS pulse spectra and pulse width measured by a FROG (data measurement provided by Austin Linder of JLF); (d) the amplified vs. the input SRBS pulse measured by a gated spectrometer. The amplified SRBS pulse width is estimated as ~49fs, based on a Transform-limited Gaussian pulse. This Transform-limited Gaussian pulse estimation is consistent with (a) and (b), where based on 52nm bandwidth centered at 1250nm in (a), the pulse width is estimated as ~44fs, consistent with 45fs pulse width measured in (b) and in (c).