LAWRENCE LIVERMORE NATIONAL LABORATORY

2023

Jupiter Laser Facility

Strategic Plan

DISCOVERY SCIENCE &

Innovation in Action

The Jupiter Laser Facility (JLF) originated almost 50 years ago, during the early days of the LLNL laser programs. It became a user facility in 2008, joined the national LaserNetUS network in 2018, and has since been a magnet to attract young researchers into the field of high energy density (HED) science, address unique science questions, and develop new experimental platforms.

The convergence of several recent events, including achieving ignition at the National Ignition Facility, the growth of LaserNetUS and its community, the prospect of a national inertial fusion energy program, and the need to develop modern HED science platforms indicate strong needs for modernized mid-scale facilities such as JLF. As it is completing a 4-year long refurbishment period and will welcome users back in 2023, the facility is poised to address unique challenges and questions in high energy density and laser science within the national and international ecosystem.

This strategic plan outlines our approach to fulfilling JLF's mission to (1) develop new science, techniques, and platforms for programs and discovery science, in partnership with academia, LaserNetUS, and the greater community; (2) advance the development of secondary sources of photons and particles; (3) serve as a testbed for new laser, optical, target and diagnostic capabilities and (4) attract, train, and retain talent in HED and laser science and help build new collaborations.

—Félicie Albert
Deputy Director for Science and Technology, Jupiter Laser Facility

ACKNOWLEDGEMENTS

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CONTENTS

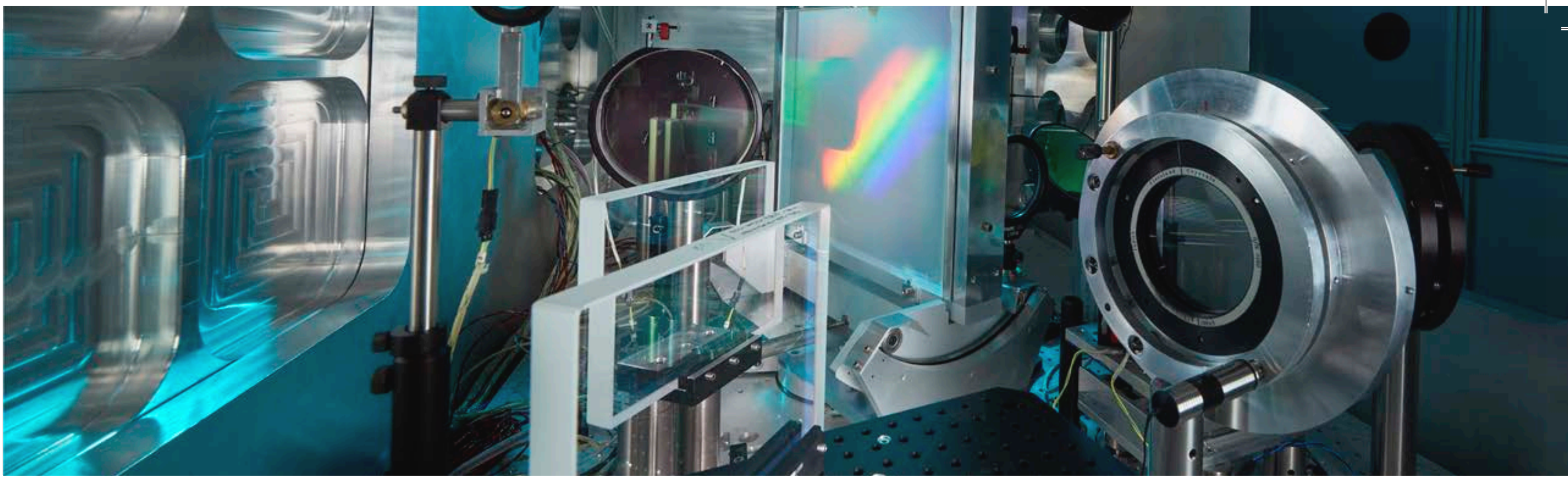
EXECUTIVE SUMMARY

JLF is an intermediate-scale, open laser facility dedicated to high-energy density science, with three operating laser systems and target areas: Titan, Janus, and COMET. JLF is the fifth highest energy laser in the United States. In scale and operation, JLF is similar to lasers at the Central Laser Facility at Rutherford-Appleton Laboratory in the U.K. and the Laboratoire pour l'Utilisation des Lasers Intenses (LULI) located at École Polytechnique in France. Access to JLF is obtained through an annual call for proposals, and a portion of the user time at JLF (50%) is now accessible through LaserNetUS. Over 100 PhDs have been granted that included thesis work at JLF, and the facility has been acknowledged in over 200 peer-reviewed publications.

JLF:

1. *Is the **preeminent hands-on facility to develop new science, techniques, and platforms** for programs and discovery science in HED science, in partnership with academia, LaserNetUS, and the greater community.*
2. ***Advances the development of secondary sources** of photons and particles as probes for national security, HED science, and industrial applications to enable innovation.*
3. *Serves as a **testbed for new laser, optical, target, and diagnostic capabilities,** and leverages efforts and capabilities across LLNL.*
4. ***Attracts, trains, and retains talent** in HED science and laser science and helps build new collaborations and partnerships for the vitality of the field.*

OUR VISION



Why JLF is important now

There is renewed momentum in the high intensity/high power laser community in the U.S. due to the convergence of several events indicating strong needs for new programs and facilities in this field.

- The 2018 National Academies of Sciences (NAS) report states that the U.S. has lost leadership in high intensity laser science/facilities.
- The 2018 Nobel Prize in Physics was awarded for Chirped Pulse Amplification, a technique used in most high intensity laser facilities (including JLF) today.
- LaserNetUS was established in 2018. JLF is one of the founding members of LaserNetUS, which now includes 10 facilities across North America. Of all the facilities, it is the only one that offers a combination of high energy (kJ), flexibility in beams/diagnostics configurations, and hands-on access.
- The December 5th, 2022 National Ignition Facility (NIF) results where researchers achieved ignition have reignited the prospect of a high-yield facility and the prospect of a national inertial fusion energy program, meaning intermediate-scale facilities like JLF can play a role in addressing the physics, diagnostics, and platform development involved in programs.
- JLF is aging, and the time is ripe to plan for a new, intermediate-scale open access facility at LLNL using state-of-the-art, high-repetition-rate technology for drivers, targets, and diagnostics. Currently, JLF is completing a four-year refurbishment period and will welcome back users in 2023. The facility is looking for user input and short-term/high-impact solutions.
- JLF will continue to be a magnet for talent into the LLNL workforce and serve as a steppingstone for programmatically relevant applications and missions.
- JLF plans to use the Livermore Valley Open Campus (LVOC) for a potential future facility to establish new academic, industrial, and programmatic partnerships within a multidisciplinary and innovative ecosystem.

JLF BY THE NUMBERS

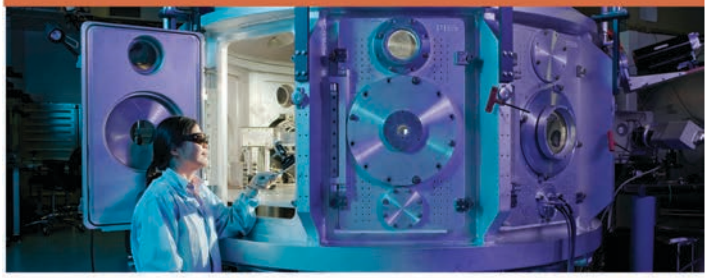
3 *operating laser systems/target areas*

5TH *highest energy research laser in the US—total of* ***2 kJ***

20-25% *of all JLF users are students*

95% *new scientists have remained in the HED field*

JANUS *built in* **1974**



USERS COME FROM

4 *LLNL Directorates*

63 *Universities*

24 *labs & non-academic institutions*

- Janus expanded to become JLF in 2006
- More than 100 PhDs have been granted that included thesis work at JLF, and several of these students have earned dissertation awards
- Acknowledged in over 200 peer-reviewed journal articles, including:
- More than 40 high-impact publications
- More than 75 long articles

OUR PLAN for the FUTURE

Vision for Future Facility

With renewed momentum in the high-intensity and high-power laser community in the U.S., the creation of LaserNetUS, the recent NIF results opening prospects of a future high-yield facility and a national inertial fusion energy program, and the need to recruit and retain a highly skilled workforce for NNSA and LLNL missions, JLF is in a unique position to expand its vision and mission. It will play a role in addressing some physics, diagnostics, and platform development.

Focus on High Energy Density Science

High Energy Density (HED) Science is the study of matter and energy under extreme conditions, such as condensed matter at densities found in the core of giant planets or hot plasmas typical of stellar interiors. This work demands integration of a range of disciplines, from atomic, plasma, nuclear, and condensed-matter physics to high-performance computing, diagnostics and instrumentation, materials science, and micro-fabrication. The HED domain is defined as energy densities exceeding 10^{11} joules per cubic meter or pressures exceeding 1 megabar, a unit of pressure equal to 1 million bars. Laboratory experiments involving HED conditions at higher temperatures are important to understanding the birth and death of stars and controlling fusion in the laboratory. Today, LLNL's existing and emerging HED facilities such as NIF are enabling researchers to recreate conditions at the cores of planets and stars and to test fundamental states and processes in stellar evolution.

Impact on Programs

Advances in HED science serve as a foundation for NNSA's Stockpile Stewardship Program (SSP) and are instrumental in efforts to control the fusion regime. While most experiments are performed at NNSA's three major HED science facilities (National Ignition Facility at LLNL, the Z facility at Sandia National Laboratories, and the OMEGA Laser Facility at the University of Rochester's Laboratory for Laser Energetics), JLF is poised to make unique contributions to the field of HED and high-intensity laser science. The JLF serves several functions that help address NNSA-identified enduring needs: supporting research, new techniques, and platforms relevant to HED science; promoting collaborations with research institutions and universities; and providing a stimulating and rewarding environment for young scientists to recruit and retain our next generation workforce. Through three laser platforms that offer researchers a range of capabilities to produce and explore states of matter under extreme conditions of high density, pressure, and temperature, JLF supports the development of novel platforms, techniques, diagnostics, and targets, and of our greatest asset: our workforce.

NEAR TERM

In the NEAR TERM, we will capitalize on the recently completed facility modernization to implement a series of impactful advances. This will augment capabilities, improve user experience, and impact our programs. This work will be done through stronger partnerships across the Laboratory (National Ignition Facility and Photon Science [NIF&PS]), Weapons and Complex Integration, Physical Life Sciences, Engineering, and in coordination with other facilities and programs, such as LaserNetUS and the National Diagnostics Working group.

LONG TERM

In the LONG TERM, we are exploring establishing a new facility, potentially within the Livermore Valley Open Campus (LVOC), to facilitate collaborative interactions with the HED science community and pave the way toward new partnerships with academia and industry within the multidisciplinary LVOC ecosystem. The facility would be integrated within LLNL's High Energy Density Science center mission and include office, meeting, and networking space. Within LVOC, the facility will also explore a three-pronged approach to (1) an open, peer-reviewed access user facility enabling discovery science and strong academic collaborations; (2) develop, leverage, support, and use new laser and optical science technology, diagnostics, and targets in partnership with NIF & PS and LLNL; and (3) support a new partnership and innovation culture for LLNL's missions, programs, and industrial applications.

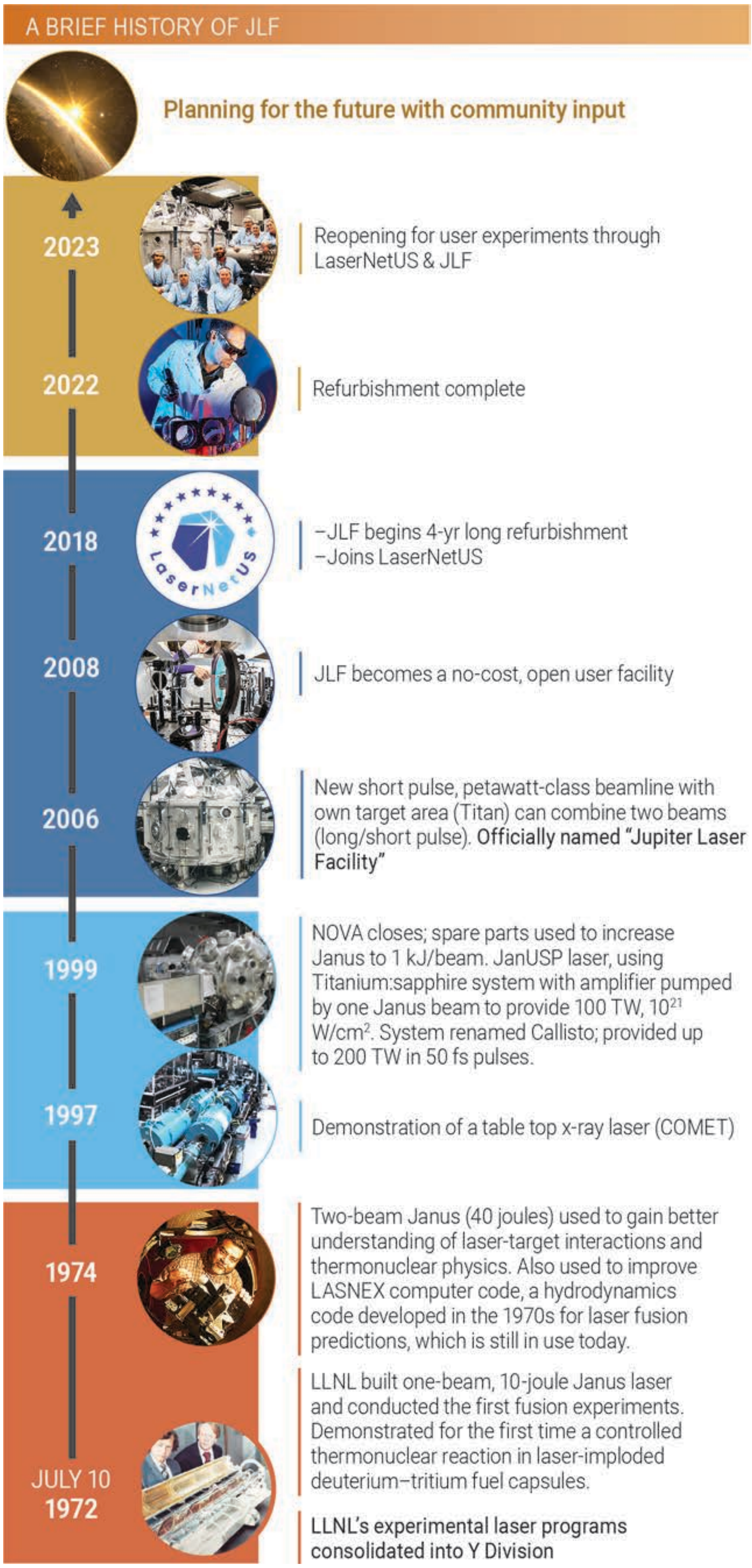


Figure 1. History of JLF.

JLF TODAY

JLF's uniqueness lies in its ability to provide simultaneously long, high-energy pulses to drive extreme states of matter with short, high-intensity pulses to drive secondary probes, while allowing users hands-on access and flexible configurations.

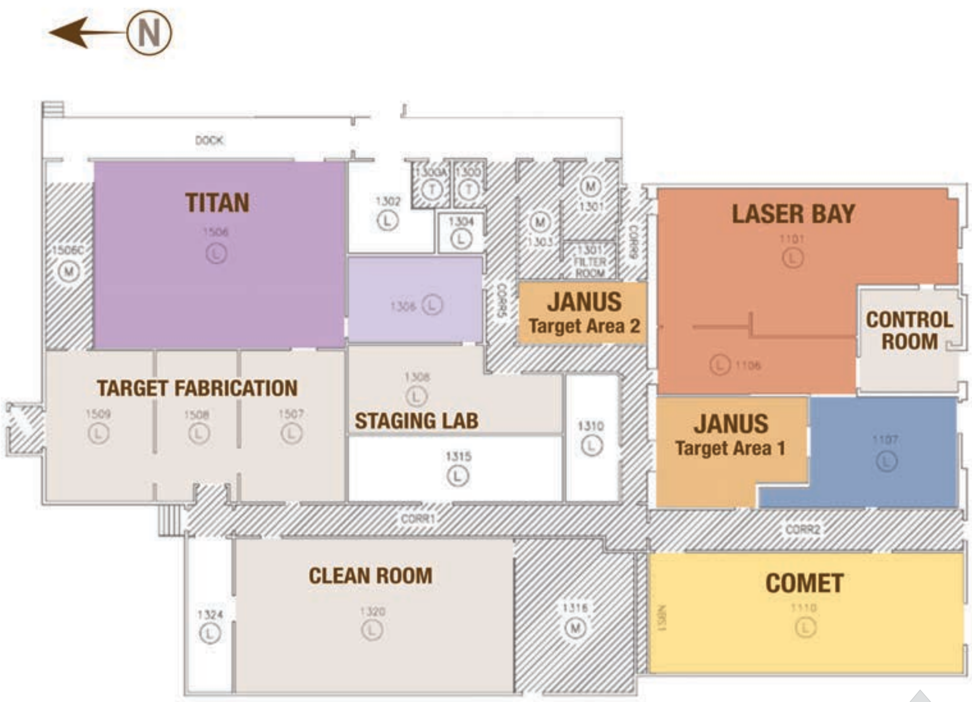
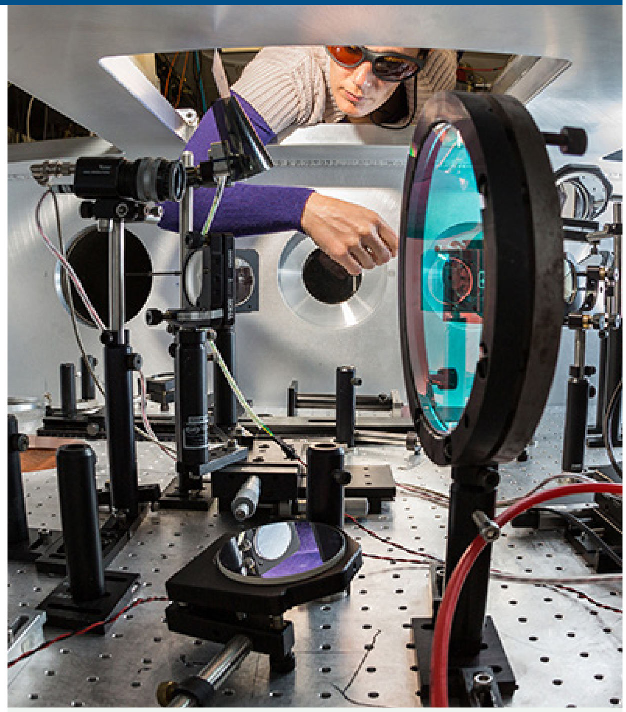


Figure 2. JLF Floorplan.

	Long-pulse (TA1 and Titan)		Short pulse (Titan)	COMET
Central wavelength (nm)	1053	527	1053	1053
Max energy on target (J)	1000	700	300	10
Energy stability	10 %	10 %	10 %	
Pulse duration on target	0.35 to 20 ns	0.35 to 20 ns	0.4 to 200 ps	0.5 ps
Pulse duration reliability	15 %	15 %	20 %	
Pulse shape	User defined	User defined	none	none
Temporal contrast	20:1			
Focal spot diameter (µm)	20	20	10 (f/3) or 29 (f/10)	6 (f/3 or f/6)
Phase plates	200-2000 µm	200-2000 µm	-	-
Prepulse level	$<10^{-3}$		$<10^{-7}$ (70dB power, <10mJ integrated)	
Timing accuracy	<100 ps			
Repetition rate	2/hour	2/hour	2/hour	15/hr

Table 1. JLF characteristics after refurbishment.



Characteristics

JLF supports multiple laser platforms: Titan, Janus TA1, Janus TA2, and COMET (the Europa laser annex is no longer operational). Titan's two-beam system is composed of a nanosecond, kilojoule long-pulse beam and a short-pulse beam with 1 to 10 ps pulses and energies up to 300 J, depending on pulse duration, and these beams can be used together or independently. JLF's Janus system has two independent beams, each of which can produce 1 kJ at 1.053 μm with pulse lengths from 1 to 20 ns. The system fires approximately every 30 minutes and offers frequency doubling, as well as a variety of pulse shapes. COMET's flexible configuration, which was designed primarily to generate laboratory x-rays, offers uncompressed pulse lengths from 500 ps to 6 ns, compressed pulses down to 0.5 ps, and beam energies up to 10 J.

Impact on Programs and LLNL Workforce

Historically, the Janus laser has led to pioneering achievements for the ICF and x-ray laser programs in the 1970s and 1980s, notably to demonstrate for the first time the thermonuclear reaction in laser-imploded deuterium–tritium fuel capsules. Starting in 1974, researchers used the two-beam Janus laser to gain a better understanding of laser–plasma physics and thermonuclear physics. It was also used to improve the LASNEX computer code, a hydrodynamics code developed in the 1970s for laser fusion predictions that is still in use today. Early on, the Janus laser also spurred the development of many important diagnostic techniques, including a method for obtaining a high-resolution image of an imploded target and measuring its temperature, which led to better-characterized experiments.

Several techniques, platforms, science, and diagnostics were initially developed at JLF and went on to be implemented at NIF:

- Diagnostic development for NIF including a dilation x-ray imager at COMET and diagnostic images of ICF implosions at NIF with 10-ps resolution;
- X-ray Thomson scattering that measures electron and ion temperatures of hot dense plasmas, now also at NIF and OMEGA;
- 2D Velocity Interferometer System for Any Reflector (VISAR);
- Proton isochoric heating;
- Positron and pair plasmas;
- Laser wakefield acceleration; and
- Development of sources of MeV radiography in support of stockpile stewardship applications.

"JLF played an essential role in my career growth. I did my postdoc work at JLF which led to 3 papers in Phys. Rev. Lett. The hands-on experience and access to the state-of-the-art lasers provided by JLF have been benefiting students and early-career scientists for generations"

—Yuan Ping (Group leader in PLS and Program Group Lead for Advanced Capability Development within High Energy Density Science in the Weapon Physics and Design (WPD) Program)

"JLF is an amazing facility for students, post docs, and new research scientists to get hand on experience executing HED experiments"

—Steven Ross (Optical Diagnostics group leader in NIF)

"The Jupiter laser facility has always been a great place to do experiments. It is small enough to get hands on experience in HED science and a great place to try new things"

—Andy Mackinnon (JHEDS leader and HED S&T Section leader)

"JLF is the ideal place to bring new ideas to test and develop; eventually some of them can be carried over to large lasers like Omega and NIF which can further their impact to science and application"

—Hui Chen (Physicist)

"The JLF is a great facility for researchers to design and build up experiments to assist in our understanding of plasma physics phenomena observed throughout the universe. This environment fosters the development of new diagnostics and encourages researchers at all stages of their careers to test their own experimental hypotheses. There are a limited number of facilities of this scale where researchers can be hands-on and they are incredibly important in the training of students and expanding our understanding of many different research areas"

—Elie Tubman (LLNL Postdoc)

"JLF is where I learned to do experimental high-energy-density plasma physics, without this opportunity and training I may not be where I am today. Even now as a designer it provided me with invaluable learning and experience"

—Annie Kritcher (Lead designer on ICF Hybrid-E campaign)

Impact on Scientific Community

JLF offers a unique versatility of tools and resources to the scientific research community. In addition to offering a platform for independent R&D across a wide variety of HED science laser experiments, JLF also provides facility access to a range of HED science experimental users. Experiments at JLF provide a steppingstone to research at NIF and OMEGA, and JLF has served as an ideal facility to train, recruit, and retain young HED scientists.

JLF users come from 63 universities, 24 laboratories, and non-academic institutions. Typically, 20-25% of users are students. More than 100 PhDs have been granted that included thesis work at JLF, and several of these students have earned dissertation awards, with 95% of them remaining in the field. More than half of experimentalists at NIF under the NIF Discovery Science Program have used JLF in the past.

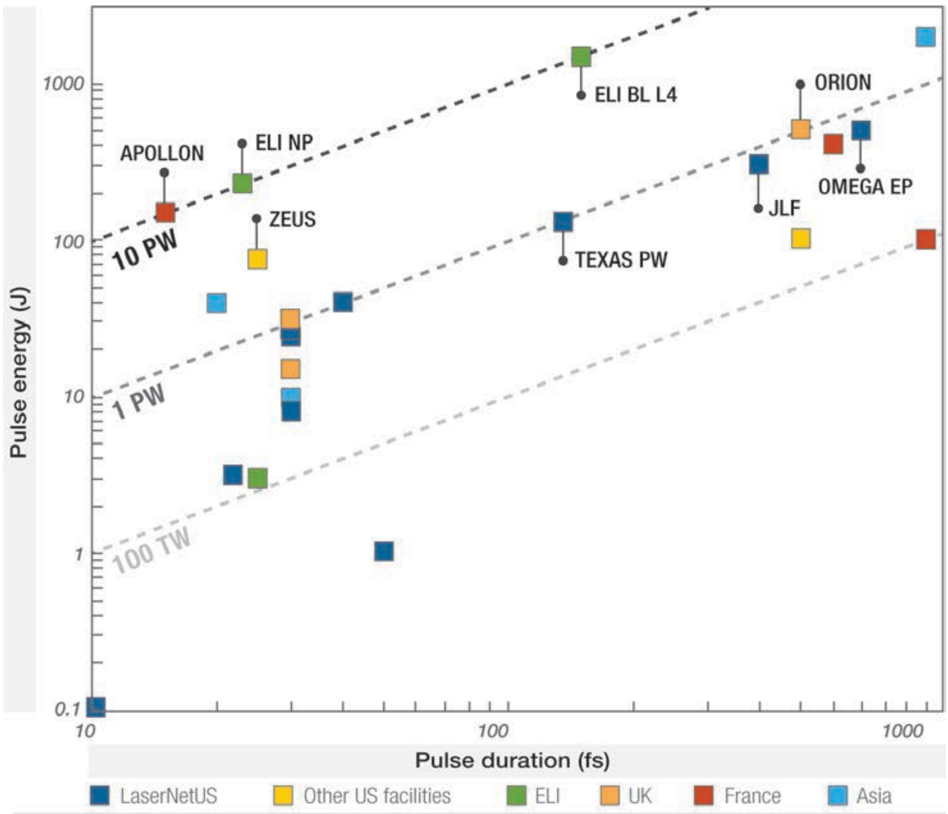


Figure 3. Pulse energy vs. duration of a few notable high intensity laser facilities.

Table 2. JLF offers unique capabilities within LaserNetUS and the international user community.

USA				
Facility/ Institution	**Laser**	**Noteworthy/Uniqueness**	**Status**	**Mission**
JLF – LLNL	Titan	Kilojoule-class laser facility, combination of short and long pulse with hands on access	Current	User facility LaserNetUS
	Janus		Current	
	COMET		Current	
MEC – SLAC	25 TW	Coupled to x-ray free electron laser	Current	User facility LaserNetUS
	Compression		Current	
	MEC - U (SP)		2027	
ALLS – INRS	150 TW	On demand secondary x-ray sources for radiography and imaging applications	Current	User facility LaserNetUS
	Infrared		Current	
Scarlet – OSU	300 TW	High repetition rate targetry (liquid crystals) and diagnostics	Current	User facility LaserNetUS
	10 TW		Current	
ELL – UNL	Diocles	High energy x-ray beams synchronized with petawatt pulses	Current	User facility LaserNetUS
	Archimedes 10 TW		Current	
ALEPH – CSU	ALEPH 800	High Intensity laser pulses at high repetition rate	Current	User facility LaserNetUS
	ALEPH 400		Current	
BELLA – LBNL	PW	Multiple femtosecond, petawatt class beams with shaped pulses at repetition rate	Current	User facility LaserNetUS. Nominally funded through HEP for staged LWFA
	HTW primary		Current	
	HTW second		Current	
CHEDS – UT	TPW	High energy and multi petawatt synchronized pulses	Current	User facility LaserNetUS
OMEGA EP – LLE	Long Pulse (up to 4 beams)	High energy (several kJ) beams with precision control, flexible configuration, and extensive suite of diagnostics	Current	User facility LaserNetUS + NLUF + LBS. Funded by NNSA cooperative agreement
	Short pulse (up to 2 beams)		Current	
	EP OPAL	Multi-PW beams	Planned	User facility
IFAST – UCF	OPCPA	Long wavelengths	Current	User facility LaserNetUS
	FOPA		Current	
	CPA		Current	
Focused Energy	T-Star (Long Pulse, up to 4 beams)	Private fusion company	Planned	IFE Fast Ignition + possible LaserNetUS facility
			Planned	
	T-Star (Short pulse, up to 4 beams)		Planned	
			Planned	
U Michigan – CUOS	ZEUS	Highest peak power in U.S.	Current	NSF User facility
SNL – Z	Petawatt	Coupled to pulsed power driver	Current	Stockpile Stewardship NNSA. Backlighter for Z
	Beamlet		Current	

JLF Science Focus

To achieve success in High Energy Density and High Intensity Laser Science, several scientific and thematic areas must be integrated. JLF, with its unique strengths, abilities, and versatility, is one of the top laser facilities to address these big science questions. Some of the key scientific and thematic areas JLF contributes to include the following:

Hydrodynamics and materials: This area focuses on understanding the properties of condensed matter under dynamic compression, including the thermodynamic response, the stress and strain behavior, instabilities, and kinetics to advance our knowledge of planetary science and astrophysics, as well as improving predictive capabilities for weapons effects.

Opacity, warm dense matter, and transport: Key to our understanding of stars, planetary interiors, and laboratory fusion experiments are energy flow through dense matter and its influence on fundamental material properties such as temperature, pressure, and ionization.

Laser-plasma interactions: Parametric instabilities govern the energetics in laser-plasma interactions (LPI), significantly affecting instability growth, saturation, and energy coupling to the plasma. Controlling and manipulating LPI will increase abilities to create an extended range of HED conditions to realize the full potential of laser-driven inertial fusion platforms but also explore a new class of plasma-based optical components and techniques for the next generation of ultra-high intensity/power lasers.

Particle acceleration, secondary sources, and applications: High intensity lasers are now able to drive unique and compact sources of both fields and particles like electrons and ions for use in radiography, light sources, and electric/magnetic field generation. This field is rapidly moving from understanding the underlying physics to a new class of applications relevant to HED science but many other societal, industrial, and defense applications.

High field physics: As peak laser intensity continues to increase, laser–plasma interaction studies enter a new regime where the physics of relativistic plasmas is strongly affected by strong-field quantum electrodynamics (QED) processes, including hard photon emission and electron–positron (e+e-) pair production.

Nuclear physics and photonics: The study of nuclear photonics allows the investigation of nuclear reactions using laser technology. Applications range from fundamental understanding of our universe (Big Bang nucleosynthesis) to understanding fusion reactions for ICF/IFE applications, to industrial and national security applications with the interrogation of nuclear materials with high energy photon and particle sources.

Diagnostic development: Diagnostics are a keystone of successful HED science experiments. Their precision, resolution, efficiency, and reliability are essential to make quality measurements for providing enough observables and benchmarking codes. JLF serves both as a diagnostic development testbed for larger facilities but can also augment its own suite of diagnostics for improved scientific output.

SCIENCE FOCUS AREA:

HYDRODYNAMICS AND MATERIALS

Understanding the properties of condensed matter under dynamic compression, including the thermodynamic response (equation of state and phase), the stress and strain behavior (strength and viscosity), instabilities (turbulence, mix, and ejecta), and the kinetics, is necessary for advancing both our knowledge of planetary science and astrophysics, as well as improving predictive capabilities for weapons effects. The JLF has a highly productive and well-established track record for advancing basic science and diagnostic development for dynamic compression. One example is dynamic diffraction, developed on Janus in the 1980s, then reproduced on Nova in the 1990s, and now at the National Ignition Facility.

Science Questions

Developing a true predictive capability for dynamic material response under HED conditions requires decoupling the many degenerate contributions to the measured material response in our experiments. As both our diagnostics and experimental platforms become more complex, this decoupling is increasingly feasible. JLF plays a vital role in this process, both as a development location for complex new diagnostics and techniques, as well as a source of data.

How We Can Answer these Questions

We must provide a flexible and reliable facility where students and early career scientists can accumulate hands-on experience developing, building, and running HED experiments. New techniques and diagnostics developed at this facility will expand our understanding of phase transition kinetics, strength, and equation of state; mixing and ejecta; and turbulence in astrophysical settings. With the addition of classified capabilities, we can rapidly extend those new techniques to address the most important programmatic problem. In addition, the scientifically rewarding projects will help educate and prepare the next generation of scientists for stockpile stewardship and facilitate staff retention.

What JLF Needs

In the short term, JLF needs to maintain the current flexible facility setup, which is important for developing novel techniques and diagnostics and providing reliable pulse shaping, beam spatial shaping, and high long pulse power (>500 J at 527 nm). More specifically, this will allow for novel diagnostic developments, including the new holographic VISAR methods for viscosity measurement and time resolved radiography for Rayleigh-Taylor (RT)/Richtmyer-Meshkov instability and ejecta studies, and improvements on existing methods, such as simultaneous diffraction and VISAR and target heating/cooling capability for EOS studies. Additionally, JLF could better support and more rapidly bring new developments to the NNSA's programmatic efforts with the ability to conduct classified/hazardous materials experiments.

In the long term, the inclusion of a long-pulse NIF quad at JLF would extend the range of reachable conditions, allowing for more work to be completed at JLF instead of requiring a move to larger facilities. In combination with diagnostic developments in radiography (high resolution gated radiography), this would extend the range of ramp compression to 10 Mbar, provide more flexibility in x-ray sources, allow JLF to investigate high Mach number blast waves and jets relevant to astrophysical settings, and explore classical RT unstable interface evolution approaching a transition to turbulence.

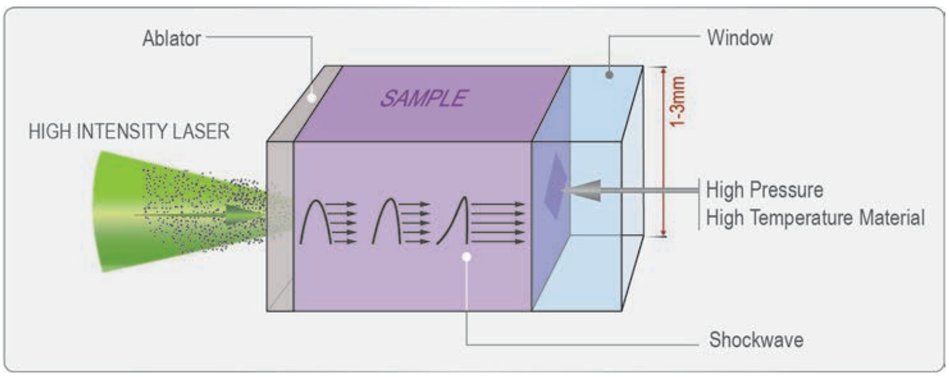


Figure 4. JLF lasers can drive shock compression experiments.

Key Partnerships

Both internal and external partnerships are important for this focus area.

- Internal partnerships with the programs (WCI, GS, NIF) to build on existing knowledge and programmatic priorities.
- External partnerships with academia to bring new ideas and train and motivate students and post-docs.

GOALS

NEAR-TERM

- Flexible facility setup
- Reliable beam and pulse shaping
- High long pulse power
- Diagnostic upgrades
- Classified/hazardous work

NEAR-TERM IMPACT

- New viscosity/strength measurements
- Instability/ejecta studies
- Improve existing methods and apply to programmatically important materials
- Bring new developments more rapidly to the programs

LONG-TERM

- NIF-quad equivalent capability

LONG-TERM IMPACT

- Extend range of reachable conditions
- More work done at JLF before moving to oversubscribed large facilities
- Ramp compression to 10 Mbar
- Brighter and higher energy x-ray sources
- Access to more astrophysically relevant conditions

SCIENCE FOCUS AREA:

OPACITY, WARM DENSE MATTER, AND TRANSPORT

Energy flow through dense matter and its influence on fundamental material properties such as temperature, pressure, and ionization are key to our understanding of stars, planetary interiors, and laboratory fusion experiments. Accurate modeling is only possible with simulations benchmarked closely to experiments. The huge array of materials and conditions of interest to academia, industry, and the stockpile stewardship mission necessitate a flexible and well-equipped research facility with deep specialist knowledge upon which to draw. JLF is uniquely positioned within the laser facility ecosystem to provide these capabilities and exploit the wealth of data available.

Science Questions

Delving into a better understanding of dense matter requires addressing questions around opacity, plasma, and thermal equilibrium. Related to opacity, this focus area seeks to answer questions around how strong magnetic fields influence x-ray opacity (e.g., in the atmosphere of white dwarf stars). JLF seeks to understand the cross-sections and stopping powers for nuclear excitations in dense plasma, how dopants influence the ionization balance of plasma, to accurately determine the internal temperature distribution of plasma, and how fast electrons and ions thermally equilibrate.

How We Can Answer these Questions

JLF has led the way in answering these questions by combining flexible diagnostic, target, and laser configurations with sufficient energy to access high temperatures and densities. Well-maintained laser and target diagnostics, easy hands-on user access, and a strong local expert support group ensures that each shot delivers as much high-quality data as possible. Other systems (e.g., Advanced Laser for Extreme Photonics [ALEPH]) have shown value in firing at higher repetition rates, and JLF will need to improve data handling and increase automation, without sacrificing laser energy or reliability, to operate under those conditions.

What JLF Needs

In the short term, JLF should focus on higher quality and quantity of data to benchmark codes. To achieve this goal, investing now in enabling infrastructure to achieve "shot-on-demand" rep-rate as technology matures is one key factor. Reliable automated data handling and archiving, including a user portal for access control (c.f., NIF, LCLS, LLE archives) and a larger quantity of and better calibrated "standard" facility diagnostics are also important to JLF's short-term goals.

In the longer term, JLF should aim to access higher temperatures and densities relevant to programmatic objectives, as well as fundamental HED and astrophysics.

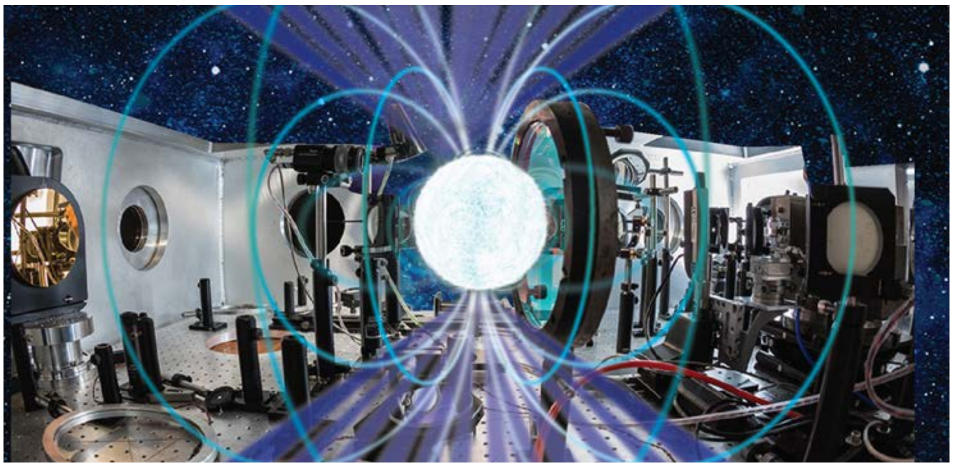


Figure 5. JLF can help measure opacities relevant to magnetized white dwarf atmospheres.

GOALS

NEAR-TERM

- Data and laser performance archiving and access
- Increase repetition rate
- Standard calibrated diagnostics
- Routine beam spot and contrast optimization
- Improve automation through machine learning and modeling

NEAR-TERM IMPACT

- Higher quality and quantity of data to benchmark codes

LONG-TERM

- Resourced to maintain quality through facility lifetime
- Classified operations
- Multiple short and long pulse beams at rep rate
- Spatiotemporal pulse shaping and smoothing for all beams

LONG-TERM IMPACT

- Access to higher temperatures and densities relevant to programs and fundamental HED and astrophysics

Toward this end, JLF needs multiple well-characterized short- (100-1000 fs) and long-pulse (100-1000 ps) laser beams capable of delivering ~1 kJ/beam, switchable frequency doubled short pulse for high contrast, and short- and long-pulse shaping capabilities.

Key Partnerships

Internally, building partnerships and identifying common goals (e.g., common physics questions for NIF and WCI) will be crucial. Externally, academia will remain a source of ideas, recruits, and expertise. Industry interested in applications, such as non-destructive evaluation (NDE) source development.

- **Internal:** Expanding internal user base (e.g., Global Security)
- **External:** Exchange of capabilities with national and international partners.

SCIENCE FOCUS AREA:

LASER PLASMA INTERACTIONS

JLF keeps LLNL at the forefront of laser and plasma research, and helps retain critical expertise. It is the ideal test bed for new concepts in plasma photonics and magnetized HED plasma. Furthermore, the theory to manipulate high intensity beams was first demonstrated at JLF. It has had a major impact in validating LPI modeling through enhanced diagnostic fielding flexibility and higher repetition rate with respect to the larger facilities such as the NIF and OMEGA. Newer platforms will continue to explore previously unassessed HED regimes of high-power LPI. Next-generation magnetically assisted ignition and x-ray source generation platforms on NIF would benefit from focused-physics experiments at JLF with larger B-fields.

Science Questions

JLF could spearhead the next generation of LPI control/predictability. Improving LPI mitigation at different laser frequencies is crucial to widen the ICF design parameter space. JLF can investigate a prototype for a plasma-based chirped pulse amplification (CPA), and plasma-based efficient high-damage threshold “optics.” JLF has previously demonstrated magnetized transport platforms for studying LPI and thermal/B-field transport in Magnetized HED plasmas. Finally, exploration of optimized laser and plasma conditions for maximizing magnetized, LPI-driven hot-electron generation of interest multi-keV x-ray production could help develop of next-generation sources on the NIF. Focused physics experiments will help identify and isolate relevant phenomena and validate LPI, MHD and radiation transport models.

How We Can Answer these Questions

JLF already contributes to significant advancement on LPI mitigation. The Space-Time Induced Linearly Encoded Transcription for Temporal Optimization (STILETTO) system, which mitigates LPI via amplitude modulation, is a unique capability. JLF allows unmatched control over laser intensity, wavelength, and phase of the beam on a picosecond timescale as required to compare advanced beam smoothing techniques. The facility’s flexibility regarding laser geometry, number of beams, and targets has room to improve. Additional beams and more flexible geometries would be useful to assemble parts of a CPA architecture. Externally generated magnetic fields with strengths of up to ~20 T have previously been demonstrated at JLF, but higher fields will make plasmas more relevant for next-generation magnetically assisted ignition and x-ray source platforms.

What JLF Needs

Adding two beams (0.5 ps, 5 J) and access to larger B-fields (50 T) would expand the scope of research. Such field strengths may be generated with single-use coils and the recently built “Vulcan” pulsed power system for JLF, but they have not yet been integrated into the facility for use. LLNL could boost JLF’s status by adding readily available laser and plasma diagnostics such as Thomson scattering, backscatter, and x-ray power diagnostics. These diagnostics would allow a more thorough characterization of the on-shot laser drive, coupling, and resulting plasma conditions, which are essential to improving our understanding of LPI and transport behavior. Diagnostic support teams from LLNL and NIF would increase JLF’s potential users and foster outside collaboration with LLNL teams.

Figure 6. JLF can help test plasma gratings concepts

GOALS

NEAR-TERM
- Two additional beams (0.5 ps, 5 J)
- Pulse shaping
- Wavelength tuning
- STILETTO Integration
- More readily available LPI diagnostics

NEAR-TERM IMPACT
- Advanced LPI control and predictability
- Thermal, laser, and magnetic field transport studies
- Code validation

LONG-TERM
- One long kj-class pulse and several short (fs-ps) pulses with flexible crossing angles
- Magnetized plasmas with > 50 T fields

LONG-TERM IMPACT
- Use plasma photonics for high impact applications (CPA)
- Beam combiner for SBS amplification

Key Partnerships

Hosting external collaborators at JLF is a fantastic recruiting tool for LLNL as well as great advertisement of LLNL expertise to the broader community. Past and future achievements are the result of multiple partnerships between UC Berkeley, Stanford, University of Michigan, U.S. Naval Research Laboratory (NRL), Defense Threat Reduction Agency (DTRA), Los Alamos National Laboratory (LANL), Laboratory for Laser Energetics (LLE), National Ignition Facility (NIF), and JLF. Contribution from the NIF program is also valuable to making JLF relevant to assist inertial confinement fusion (ICF), inertial fusion energy (IFE), and survivability efforts.

SCIENCE FOCUS AREA:

PARTICLE ACCELERATION, SECONDARY SOURCES, & APPLICATIONS

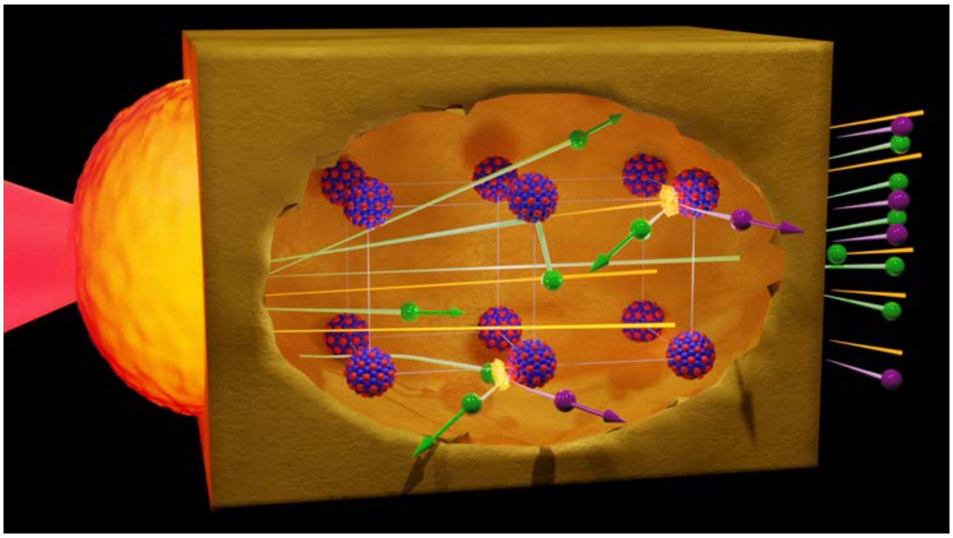
High intensity lasers such as JLF are now able to drive unique and compact sources of both fields and particles like electrons and ions for use in radiography, light sources, and electric/magnetic field generation. At LLNL, key mission areas include the use of backlighters and radiography, which necessitate the use of laser-driven secondary sources and particle acceleration. Laser-driven sources provide a flexible, multimodal approach that enables scientists to develop a better understanding of materials science, from dynamic processes and changes to the impacts of aging and other characteristics of high-density materials. JLF houses Titan, which is able to access energies and fluxes of particles that few other facilities can. Expanding upon JLF's capabilities can strengthen its value-add to the scientific research community. JLF is co-located with other accelerator, diagnostic, and target fabrication facilities at LLNL that could provide the facility with additional resources.

Science Questions

While the physics of secondary source generation has been well explored, thanks to an integrated experimental and modeling approach, source improvements need to be made for relevant societal and mission applications, including medicine and biology, industry, national security, condensed matter science, and high energy density science. To increase x-ray, neutron, and other secondary source brightness we need to improve electron and ion energies, divergence, and flux for efficient conversion to these sources. Generating high static fields for exploring high field physics, particle acceleration, guiding, and magnetized HED are at the forefront of current research efforts.

How We Can Answer these Questions

JLF's Titan is one of the few high intensity lasers in the world combining high energy (>100 J), a sub-picosecond pulse length, and flexibility in setting up beams and target configurations. It is a unique platform to develop and optimize new source generation mechanisms. The combination of long and short pulse beams is also ideal to investigate HED matter with these sources. However, JLF lacks the repetition rate and automation necessary to optimize sources, as well as detailed laser diagnostics on each shot. It also lacks ultrashort pulse duration (200 fs or less) necessary to attain certain regimes of particle acceleration. Exquisite control of key parameters (contrast to levels better than 10^{12}, polarization, spatial mode, sub-ps pulse shaping), coupled with the addition of external magnetic fields and facility-provided targetry would improve our ability to develop and use novel sources.



GOALS

NEAR-TERM
- Better control of short laser pulses (shape, intensity, polarization, contrast)
- Better beam quality and focusing
- Invest in target & special optics capabilities

NEAR-TERM IMPACT
- X-ray and particle sources with greater precision
- New regimes with exquisite laser control

LONG-TERM
- High rep rate capability and diagnostics
- Active feedback for precision control
- Co-location of short (ps/fs) and long (ns) pulses and magnetic drive

LONG-TERM IMPACT
- Precision sources
- Probing of unexplored HED regimes

What JLF Needs

To optimize and develop new sources, JLF needs to invest in new target and beam configurations, as well as in dedicated target fabrication capability and personnel. In the long term, adding an ultrashort pulse (<200 fs) pulse capability with sufficient energy (>500 J) would allow access to yet unexplored regimes. New regimes could also be investigated with specific equipment (circular polarizers, plasma mirror system, Basler pulse shaping, pulsed power for B field generation, deformable mirror control, spiral phase optics and a permanent gas jet system).

Key Partnerships

- Radiography (NIF-ARC, WCI, GS, Engineering, Industry, IFE)
- Particle Acceleration (PLS, academia, DOE- HEP, IFE)
- High fields (NIF, LPI, WCI, academia, National labs, IFE)

Figure 7. JLF enables acceleration of electrons, positrons and ions and high energy x-ray production.

SCIENCE FOCUS AREA:
HIGH FIELD PHYSICS

Relativistic pair plasma jets are present in several astrophysical processes, such as gamma-ray-bursts (GRBs) and neutron star magnetospheres. JLF was the first place where a substantial laser-generated pair jet was created, and the facility can be used to optimize pair jet energy and density. Intensity, energy, and beam quality upgrades to JLF will allow for optimization of the pair jet energy and density that will help shed light on this important laboratory astrophysical process. These upgrades will also allow new and exciting experiments that will help constrain nonperturbative field theories like Strong-Field Quantum Electrodynamics (SFQED). For example, at low laser intensity, electrons scatter via linear Compton scattering, becoming nonlinear as the laser intensity increases. At even higher intensity, the scattered photon creates electron-positron pairs: matter and antimatter created in vacuum out of photon energy. At yet higher intensity, even the pair creation becomes nonlinear. JLF will facilitate the exploration of this chain of processes that will help constrain nonperturbative field theories, which in other forms describe nuclear matter and quantum gravity.

GOALS

NEAR-TERM
- High Energy Titan (300-1000 J) and reliability in parameters
- High Power (>10^{20} W/cm^2)

NEAR-TERM IMPACT
- Quantification of QED-relevant effects
- Robust secondary sources of particles

LONG-TERM
- High repetition rate and precision diagnostics to achieve good statistics
- 2-μm multi PW laser beams at rep rate
- Two short PW pulse beams minimum

LONG-TERM IMPACT
- High quality GeV electron beams to reduce measurement uncertainty
- Probing of unexplored astrophysical regimes

Science Questions

Studying pair plasma jets helps answer the question of what particle acceleration mechanisms are at play in astrophysical observations of objects like gamma ray bursts (GRBs). Laser created pair plasma jets are also unique systems that may shed light on the question of why our universe has matter-antimatter asymmetry. As the laser intensity approaches the ultra-relativistic regime, experiments with these lasers will help bridge the gap between perturbative and nonperturbative field theories and help lay the groundwork for advances in fundamental physics.

How We Can Answer these Questions

JLF offers unique flexibility and access, but it has limited laser energy and number of beams for laboratory astrophysics experiments. JLF cannot currently address science questions in this area better than other existing, constructing, or proposed laser systems such as Gemini, Vulcan, ELI, ZEUS, EP-OPAL. All these systems include studying strong-field QED as one of their important goals. However, an upgraded JLF will be uniquely poised if it incorporates 2-μm laser beam(s) at high power, energy, and rep rate. Other laser systems use 1-μm lasers or frequency convert the beams to higher harmonics. High power systems at 10-μm wavelength also exist, but no system has 2-μm light that is bright enough for strong-field QED experiments. The wavelength scaling is an unstudied aspect, which may generate surprises for the community.

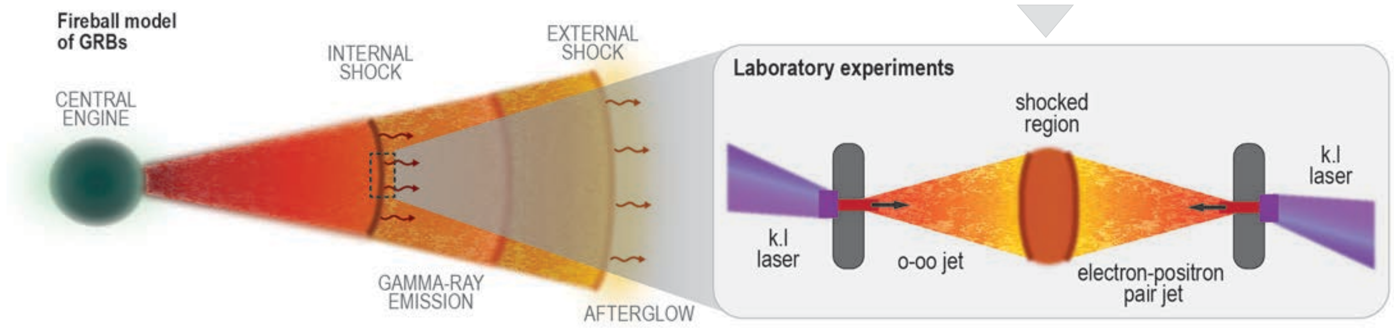
What JLF Needs

JLF should be the flagship facility that has high energy (300 J–1000 J) at high power (10^{20}–10^{23} W/cm^2), with a minimum of two beams. For unique studies, at least one beam should be 2-μm wavelength. Beam 1 for laser wakefield acceleration (LWFA) should possess the following parameters: I > 10^{19} W/cm^2, and 40 fs, 10 J at rep rate. Beam 2's parameters for high intensity interaction should be: ~ 2-5 PW (large a_0 ~ 100) at 2-μm wavelength. High quality electron and laser beams, coupled with high rep rate and precision diagnostics for particles and photons will enable good statistics and reduce measurement uncertainty.

Key Partnerships

Development of a laser wakefield acceleration (LWFA) arm would benefit radiography applications for LLNL missions and programs and studies on high energy electron beam stopping power. External collaborators (academia and international) are key partners in this effort.

Figure 8. JLF experiments could test the fireball model of gamma-ray bursts in the laboratory.



SCIENCE FOCUS AREA:

NUCLEAR PHYSICS AND PHOTONICS

The field of nuclear photonics, whereby nuclear reactions can be induced using laser technology, informs many real-world applications. These range from a fundamental understanding of our universe (Big Bang nucleosynthesis) and understanding fusion reactions for ICF/IFE applications, to industrial and national security applications with the interrogation of nuclear materials with high energy photon and particle sources. JLF's high intensity lasers make it possible to generate ionizing radiation and induce nuclear reactions at lower laser energies and higher rep rates than those pursued for several decades in laser-driven ICF. Furthermore, JLF provides a lower footprint in terms of size and cost than conventional accelerator-based sources.

Science Questions

JLF's capabilities make it a useful and unique resource for nuclear physics and photonics research. Key questions to answer at JLF include cross-section measurements relevant to nuclear astrophysics and nucleosynthesis. JLF can also address questions around fission and fusion, specifically the study of short-lived, exotic isotopes that are fission byproducts, as well as probing the branching ratio of deuterium-tritium reactions to understand key issues in fusion and plasma science. Additional questions include the production of neutron sources for novel applications; the production of bright gamma-ray sources for detection of special nuclear materials, photofission, and nuclear isomer production; and the need to bridge the gap between current laser-based neutron sources and reactor/spallation sources are also key for researchers at JLF.

How We Can Answer these Questions

JLF has more energy, more flexibility, and multiple beams compared to mid-scale university facilities. The long pulse can be used to generate environment and the short pulses for active probing (using secondary sources). In particular, Titan provides a unique platform to develop secondary sources of particles and high energy photons for nuclear studies. While JLF does not have the energy level of a larger scale facility (NIF, OMEGA) and configuration for implosions, it is flexible, can do several shots in one day, and provides a unique test bed for physics and platform development. Calibration of nuclear diagnostics and the development of neutron and gamma ray source capabilities would enable nuclear photonics applications and progress at JLF.

What JLF Needs

Further updates and upgrades to JLF could enable the facility to fuel continued progress in the field. The ability to handle tritium and uranium would allow JLF to study relevant reaction cross-sections, while upgraded infrastructure would support nuclear activation measurements. Joule-class, short-pulse lasers at high repetition rates (kHz) would allow MeV photon generation and fast neutron production. High-energy lasers with higher rep rates (100-300 J, 10 Hz) could provide single-pulse particle fluxes suitable for diagnosing transient phenomena and generating intense bursts of thermal and epithermal neutrons. High-energy, kJ-class single-shot systems (shot per minute to 1 Hz) would provide the highest pulsed particle yield to drive prompt nuclear reactions or for neutron spectroscopy.

Key Partnerships

- ICF and IFE efforts
- Academic access to JLF
- National Diagnostic Program + LaserNetUS to provide/ test suite of nuclear/particle diagnostics
- National security (DHS, DARPA) for national security applications

GOALS

NEAR-TERM

- Explore tritium, uranium capability
- Develop neutron sources with current capabilities
- Bring Titan to 300 J at shortest pulse duration
- Field magnetic recoil spectrometer and nuclear activation measurement capability

NEAR-TERM IMPACT

- Study nuclear reactions to understand key issues in fusion and plasma science

LONG-TERM

- Three types of lasers: Joule class, kHz, 100's joule, 10 Hz, kJ-class, shot/min
- Dedicated suite of diagnostics
- Handling of certain nuclear materials

LONG-TERM IMPACT

- Production of a broad set of neutron sources for mission-relevant applications
- Bright gamma-ray sources for detection of special nuclear materials, photo-fission, isomer production

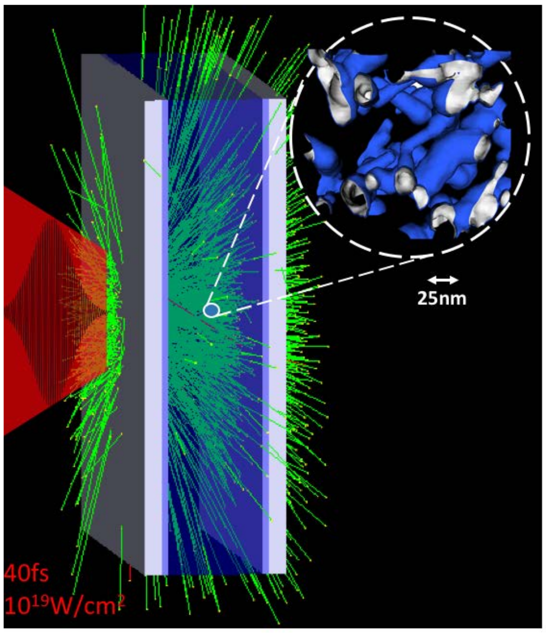


Figure 9. JLF can test DD fusion reaction to produce high flux neutron sources in CD foam targets irradiated by relativistic laser pulses.

SCIENCE FOCUS AREA:

DIAGNOSTIC DEVELOPMENT AND CALIBRATION

Diagnostics are a keystone of successful HED science experiments. There are numerous examples of successful diagnostic development or testing at JLF with transfer to other facilities such as NIF, OMEGA, and ORION to address key questions in HED science. The national diagnostic working group consists of technical experts and has been tasked by NNSA to identify and prioritize the development of transformational diagnostics to support HED facilities. With the creation of LaserNetUS and its coordinated diagnostic development and sharing, JLF has the potential to be part of a new national ecosystem and serve as a testbed for new methods and high repetition rate systems. JLF's flexibility makes it possible to field outside diagnostics and diagnostic setups.

Science Questions

The wealth of diagnostics that has been and will continue to be developed at JLF is poised to address science questions of all the focus areas presented in this plan. Success stories include the development pulse dilation systems (DIXI, now at NIF), fast-gated x-ray framing cameras (SLOS, now at NIF), 2D VISAR (now also used at OMEGA), x-ray streak cameras, particle spectrometers, laser diagnostics (SpecFROG for OMEGA EP), crystal x-ray spectrometers, dynamic diffraction platforms (PXRDO), pulsed magnetic fields, and sample recovery techniques.

How We Can Answer these Questions

It will be important for JLF to set up a diagnostic working group that can also interface with the NNSA National Diagnostic Working Group and LaserNetUS to enable:

- Technology transfer and a pool of common diagnostics
- Focused efforts and lessons learned
- Setting of priorities for joint diagnostics
- Technical reviews, including reviewing requests as part of the proposals

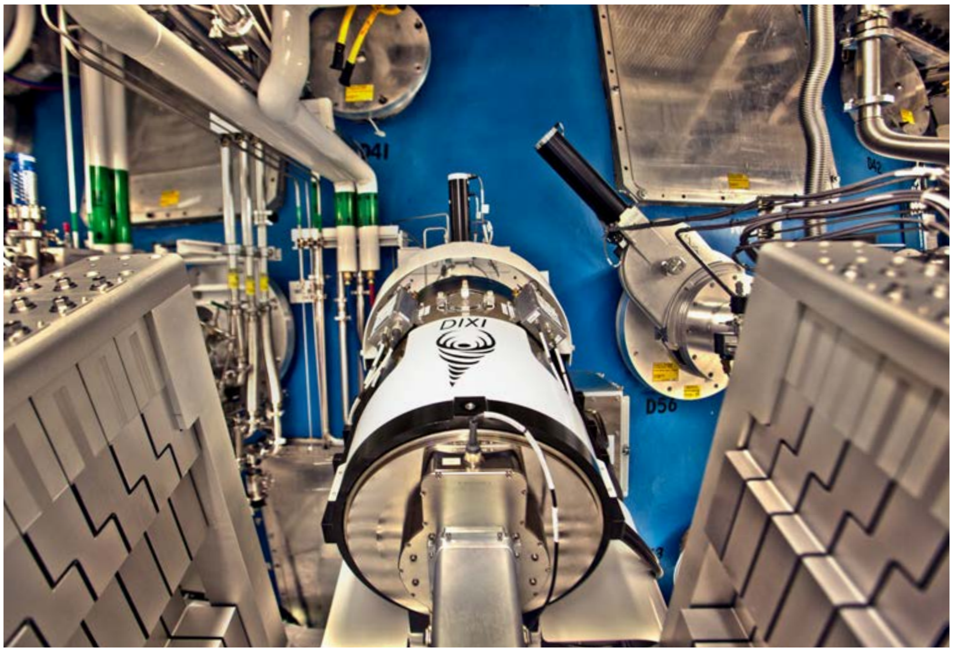


Figure 10. JLF serves as a testbed for new NIF diagnostic development.

GOALS

NEAR-TERM
- Build up a dedicated diagnostic suite for high-demand diagnostics
- Revive offline testing laser capabilities

NEAR-TERM IMPACT
- JLF will be flagship facility for development and testing of diagnostics to be implemented at NIF and OMEGA
- Easier access to standard diagnostics for JLF and LaserNetUS users

LONG-TERM
- High repetition rate diagnostic capability
- Active diagnostics development

LONG-TERM IMPACT
- JLF part of a national diagnostic ecosystem
- Testbed for new methods and high repetition rate systems and experiments

What JLF Needs

JLF needs to build additional diagnostics for those in high demand and keep them available at JLF for easy access (e.g., Thomson parabola, EPPS, etc.). The facility would also benefit from a JLF-dedicated suite of diagnostics with proper, up-to-date documentation, including calibration, user manuals, and diagnostic points of contact, as well as a dedicated offline testing laser capability (20ps to ~150ps, ~200nm, rep rate ~2Hz, few mJ – 100mJ in UV, similar to [Europa 150 fs/1 J in red (100-200 mJ doubled)]. In the long term, JLF will be a place for active diagnostics development and testing and support high repetition rate capability.

Key Partnerships

- NIF, TASE, EBIT
- LaserNetUS; LLE (OMEGA, OMEGA EP), LANL, Princeton, SNL, GA, SLAC, MEC, AWE/ORION (U.K.), CLF (U.K.)

THE DREAM JLF of the Future

While in **the near term** we will capitalize on the recently completed facility modernization to implement a series of impactful advances, **in the long term,** we are exploring establishing a new facility, ideally within the Livermore Valley Open Campus (LVOC), to facilitate collaborative interactions with the HED science community and pave the way toward new partnerships with academia and industry within the multi-disciplinary LVOC ecosystem.

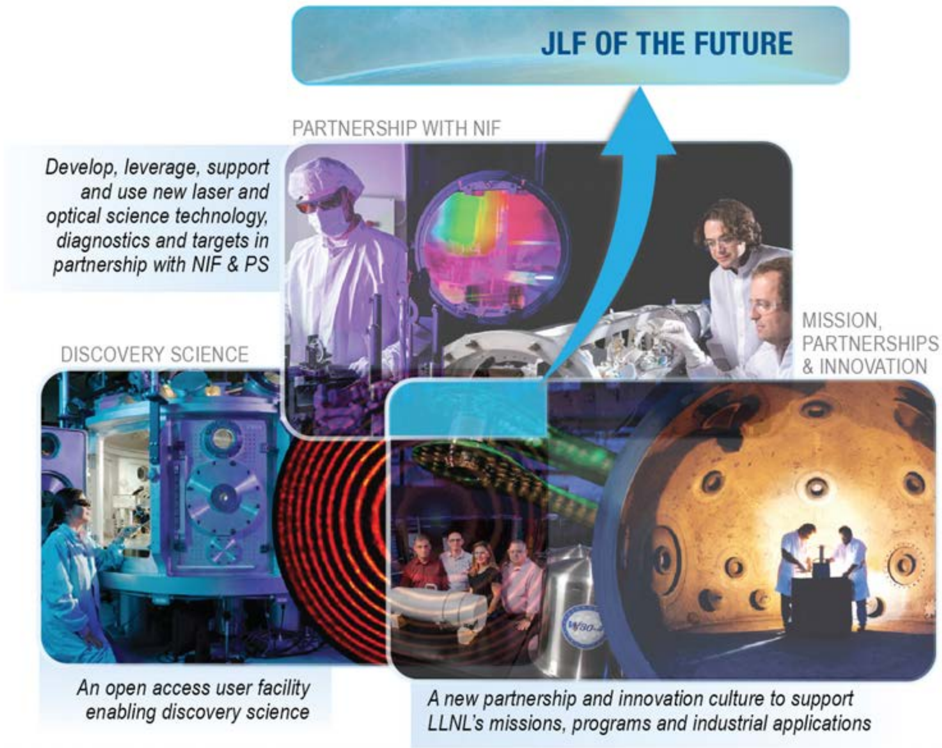
Mission and Governance of Future new Facility

Through three main thrusts, the new facility will contribute to LLNL's culture of innovation and partnership to support shared missions:

- Provide an open, peer-reviewed access user facility enabling discovery science and platform development in the multi-disciplinary LVOC ecosystem.
- Develop, leverage, support, and use new laser and optical science technology, diagnostics, and targets in partnership with NIF & PS and LLNL relevant programs.
- Foster a new partnership and innovation culture to support LLNL's missions, programs, and industrial applications.

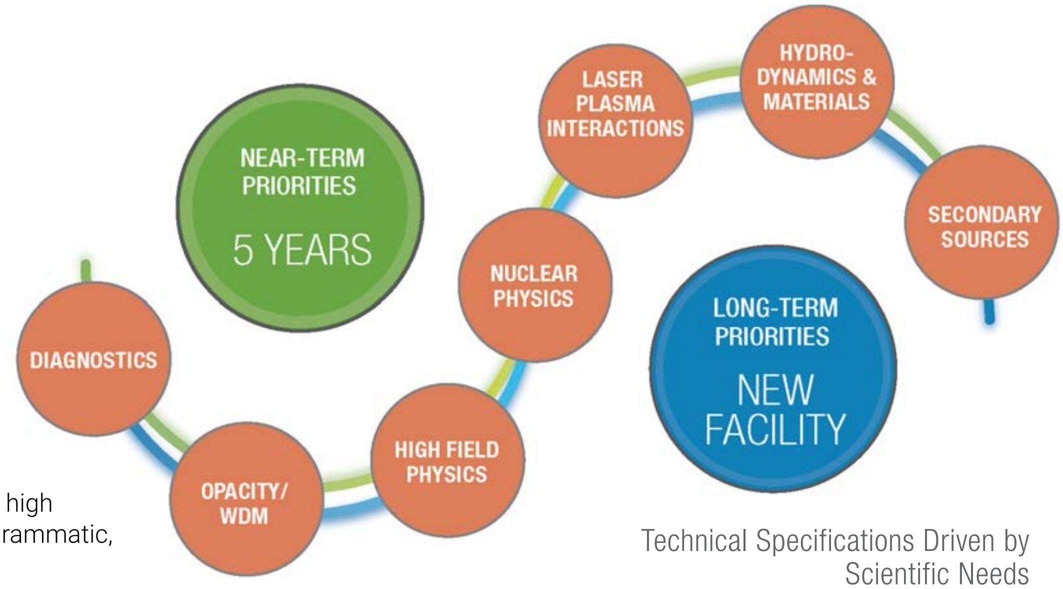
Impacts to LLNL Programs

JLF will continue to advance scientific understanding, innovation, and discovery with experimental capabilities in high-energy-density and laser science and will contribute to NNSA's core mission of maintaining a safe, secure, and reliable stockpile. The facility will support defense and energy programs across NNSA, DOE, and multiple federal agencies. A new facility at LVOC will be an ideal venue to spin-in breakthrough technologies from the private sector and apply them to projects in NNSA and DOE mission areas. The facility will aim to be open for international collaborators, academia, the private sector, and other national laboratories. Physical proximity provides opportunities to leverage new partnerships within the LVOC ecosystem to support our missions.



Attributes of Future New Facility

- **Encouraging partnerships:** the embedded facility harnesses multi-disciplinary areas and risk-taking to develop new techniques.
- **Flexibility and agility:** multiple beams and target areas at high repetition rate with accessibility to a broad parameter space.
- **Secondary sources:** particles and high energy photons for scientific, programmatic, and industrial applications.



Technical Specifications Driven by Scientific Needs

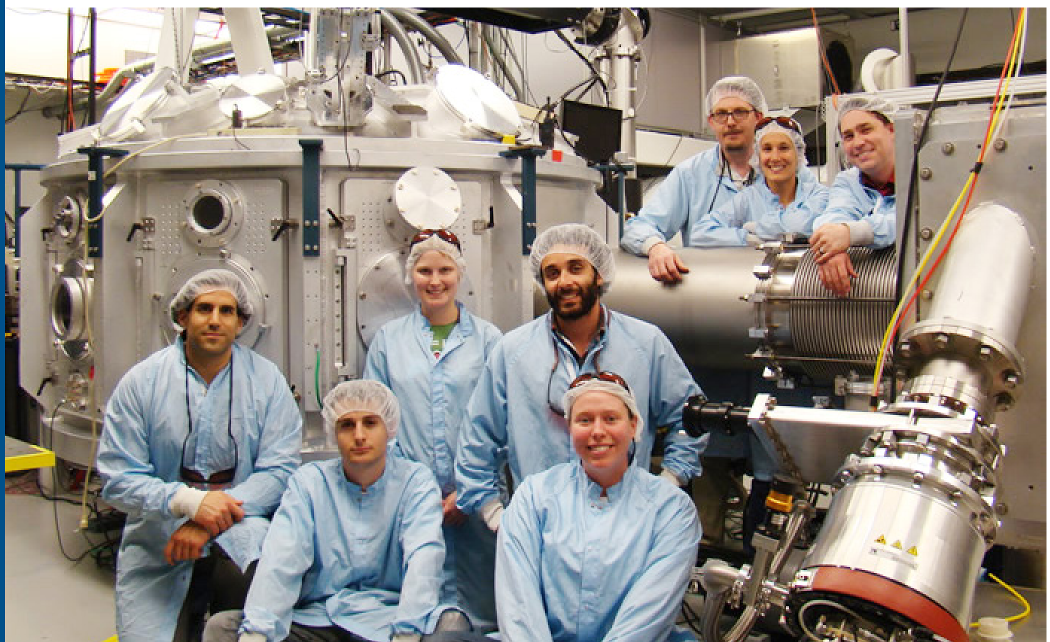
	Near-Term	Long-Term
Diagnostics	– Build up a dedicated diagnostic suite for high-demand diagnostics – Revive offline testing laser capabilities	– High repetition rate diagnostic capability – Active diagnostics development
Opacity/ WDM	– Data and laser performance archiving and access – Increase repetition rate – Standard calibrated diagnostics – Routine beam spot and contrast optimization – Improve automation through machine learning & modeling	– Resourced to maintain quality through facility lifetime – Classified operations – Multiple short and long pulse beams at rep rate – Spatiotemporal pulse shaping and smoothing for all beams
High field physics	– High Energy Titan (300-1000 J) and reliability in parameters – High Power (>10^{20} W/cm^2)	– High repetition rate and precision diagnostics to achieve good statistics – 2-μm multi PW laser beams at rep rate – Two short PW pulse beams minimum
Nuclear physics	– Explore tritium, uranium capability – Develop neutron sources with current capabilities – Bring Titan to 300 J at shortest pulse duration – Field magnetic recoil spectrometer and nuclear activation measurement capability	– Three types of lasers: Joule class, kHz, 100's joule, 10 Hz, kJ-class, shot/min – Dedicated suite of diagnostics – Handling of certain nuclear materials
Laser Plasma Interactions	– Two additional beams (0.5 ps, 5 J) – Pulse shaping – Wavelength tuning – STILETTO Integration – More readily available LPI diagnostics	– One long kj-class pulse and several short (fs-ps) pulses with flexible crossing angles – Magnetized plasmas with > 50 T fields
Hydro-dynamics & materials	– Flexible facility setup – Reliable beam and pulse shaping – High long pulse power – Diagnostic upgrades – Classified/hazardous work	– NIF-quad equivalent capability
Secondary sources	– Better control of short laser pulses (shape, intensity, polarization, contrast) – Better beam quality and focusing – Invest in target & special optics capabilities	– High rep rate capability and diagnostics – Active feedback for precision control – Co-location of short (ps/fs) and long (ns) pulses and magnetic drive

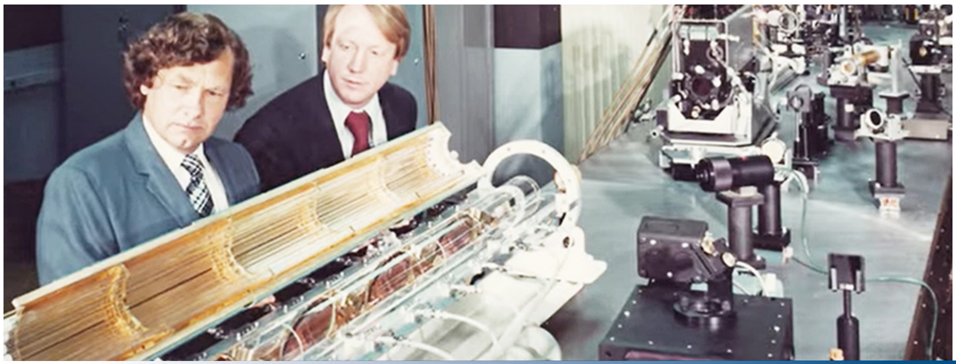
WORKFORCE

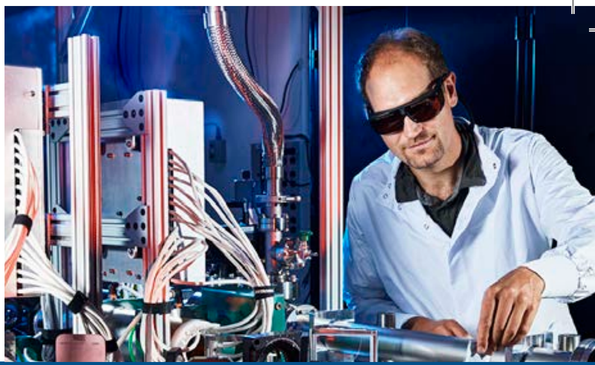
LLNL's central objective, **Mission & Program Delivery,** relies on workforce excellence, with attention to **Workforce Development**—hiring, developing, and retaining exceptional staff in an institution that offers career-long learning. By providing an environment for executing breakthrough, impactful, and rewarding S&T projects, JLF helps attract, train, and retain a skilled and vibrant workforce in high-energy-density and laser science to support the NNSA Stockpile Stewardship Program. Key areas that JLF attracts include experimental HED and ICF scientists, diagnostics engineers, and laser, mechanical, and electrical technicians. All these workers are needed not only in JLF, but also in LLNL's ICF and HED science for nuclear deterrence. JLF will contribute to workforce excellence and staff retention by providing a supporting environment for our staff and collaborators aligned with LLNL workforce goals.

PARTNERSHIPS

Partnerships provide necessary support to mission delivery, and through a deep network of partnerships and collaborations, we can both respond to today's urgent needs and anticipate the challenges of tomorrow. Through effective partnerships, JLF's unique capabilities will combine with those of internal and external collaborators to enhance the facility, and in turn, contribute to the Laboratory's success. Our strategic planning group has identified key internal and external strategic partnerships for JLF that will have mutual benefit and impact.







Key Partner	Benefit & Impact
NIF and Photon Science	Implement state of the art capabilities developed at NIF (eg., STILETTO, VBL) and use JLF for advancing NIF's objectives (laser damage testing, testbed for new laser technology development and ideas)
Diagnostic Development and Calibration (TASE)	Calibrate and test diagnostics for larger platforms (NIF, OMEGA), augment JLF suite of diagnostics
PLS, Engineering, Computing	Develop capabilities and workforce
Target fabrication capabilities	State-of-the-art targets for JLF experiments, testing of new target materials, capabilities
Onsite accelerators and facilities	Sharing of equipment, additional calibration capabilities
WCI Programs (ICF, survivability, HED)	Development of new platforms and techniques; better alignment of JLF with LLNL's priorities
High Energy Density Science center	Outreach, education, and workforce pipeline in HED science
Other LLNL centers and institutes	Partnership on specific areas (eg., AI3, NCI, Data Science Institute, CASC)
LVOC	Multidisciplinary ecosystem to encourage innovation, enhances LLNL scientific vitality, closer ties with UC through use of UCLCC
LaserNetUS	National ecosystem, access to broad user base, sharing or resources (e.g., diagnostics)
NNSA National diagnostic working group	Provide recommendation for new diagnostics
National IFE program	Use JLF to test focused IFE ideas, attract new users, workforce pipeline
Academia	Research and innovation, new ideas, diverse workforce pipelines, highly skilled technical staff in key areas, continuous learning opportunities
Industry	Development of new applications, Spin-out/Spin-in, projects of mutual interest
Other national labs	Mission delivery for NNSA partners, sharing of resources
Similar facilities (CLF, LULI)	Sharing of best practices
International collaborations	Maintain JLF at the forefront of international laser user facilities, expand knowledge, user base and LLNL reach

ACRONYMS

ARC	Advanced Radiographic Capability
AWE	Atomic Weapons Establishment
CASC	Center for Applied Scientific Computing
CLF	Central Laser Facility
DARPA	Defense Advanced Research Projects Agency
DHS	Department of Homeland Security
DIXI	Dilation X-ray imager
DOE	Department of Energy
DTRA	Defense Threat Reduction Agency
EBIT	Electron Beam Ion Trap
ELI	Extreme Light Infrastructure
EOS	Equation of State
EP	Extended Performance
EPPS	Electron positron proton spectrometer
FROG	Frequency Resolved Optical Gating
GA	General Atomics
GRBs	Gamma Ray Bursts
GS	Global Security
HED	High Energy Density
HEP	High Energy Physics
ICF	Inertial Confinement Fusion
IFE	Inertial Fusion Energy
JLF	Jupiter Laser Facility
KJ	Kilojoules
LANL	Los Alamos National Laboratory
LBS	Laboratory Basic Science
LCLS	Linac Coherent Light Source
LLE	Laboratory for Laser Energetics
LLNL	Lawrence Livermore National Laboratory
LPI	Laser Plasma Interactions
LULI	Laboratoire pour L'Utilisation des Lasers Intenses
LVOC	Livermore Valley Open Campus
LWFA	Laser wakefield acceleration
MEC	Matter under Extreme Conditions
NAS	National Academies of Sciences
NCI	Non destructive characterization institute
NDE	Non-destructive Evaluation
NIF	National Ignition Facility
NLUF	National Laser User Facility
NNSA	National Nuclear Security Administration
NRL	U.S. Naval Research Laboratory
OPAL	optical parametric amplifier line
PLS	Physical Life Sciences
PS	Photon Science
QED	Quantum Electrodynamics
RT	Rayleigh Taylor
S&T	Science & Technology
SFQED	Strong-Field Quantum Electrodynamics
SLOS	Single Line of Sight
SNL	Sandia National Laboratories
SSP	Stockpile Stewardship Program
STILETTO	Space-Time Induced Linearly Encoded Transcription for Temporal Optimization
TASE	Target Area Science & Engineering
UC	University of California
UCLCC	University of California Livermore Collaboration Center
VBL	Virtual BeamLine
VISAR	Velocity Interferometer System for Any Reflector
WCI	Weapons and Complex Integration
WDM	Warm dense matter
WPD	Weapon Physics and Design
ZEUS	Zettawatt-Equivalent Ultrashort pulse laser System

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