The Jupiter Laser Facility – Update

Robert Cauble
JLF Director

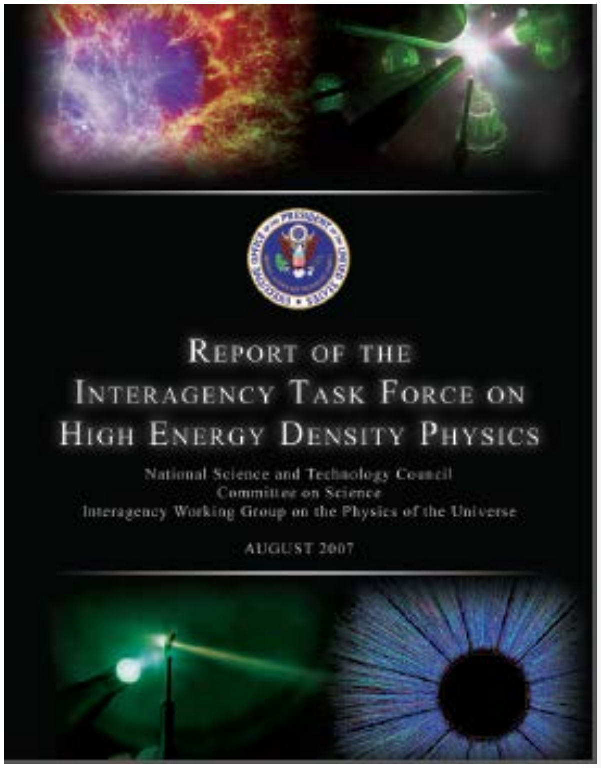
NIF/JLF User Group Meeting

February 9-11, 2015

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Security, LLC, Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

LLNL-PRES-788672

DOE-sponsored reports have made recommendations for research in High Energy-Density (HED) science



FUSION ENERGY SCIENCE ADVISORY COMMITTEE

Panel on High Energy Density Laboratory Plasmas

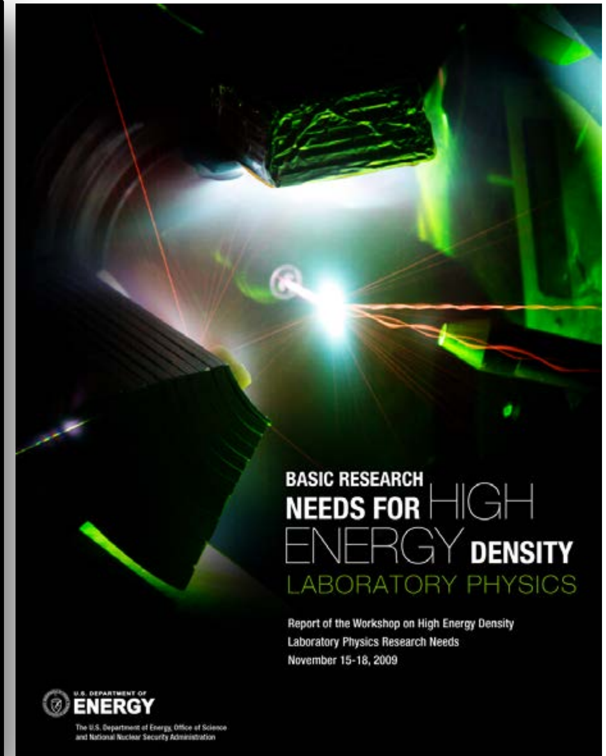
ADVANCING THE SCIENCE OF

HIGH ENERGY DENSITY LABORATORY PLASMAS

January 2009

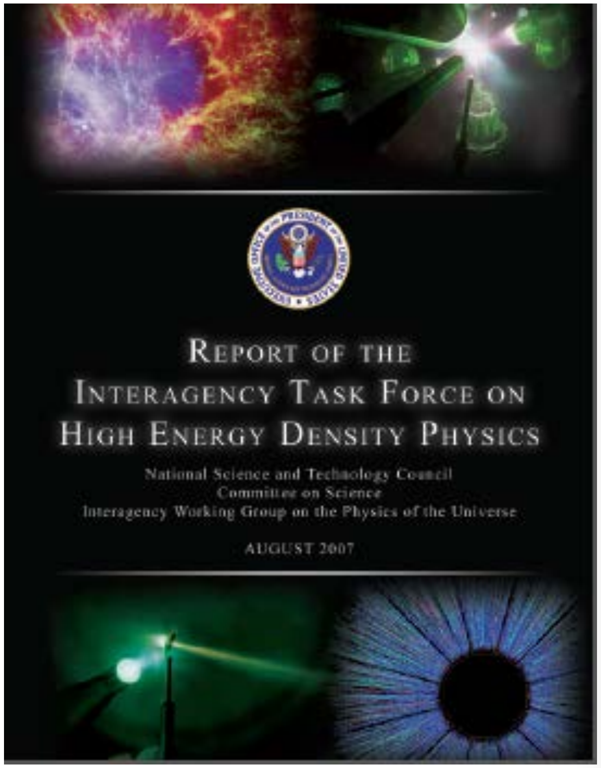
UNITED STATES DEPARTMENT OF ENERGY

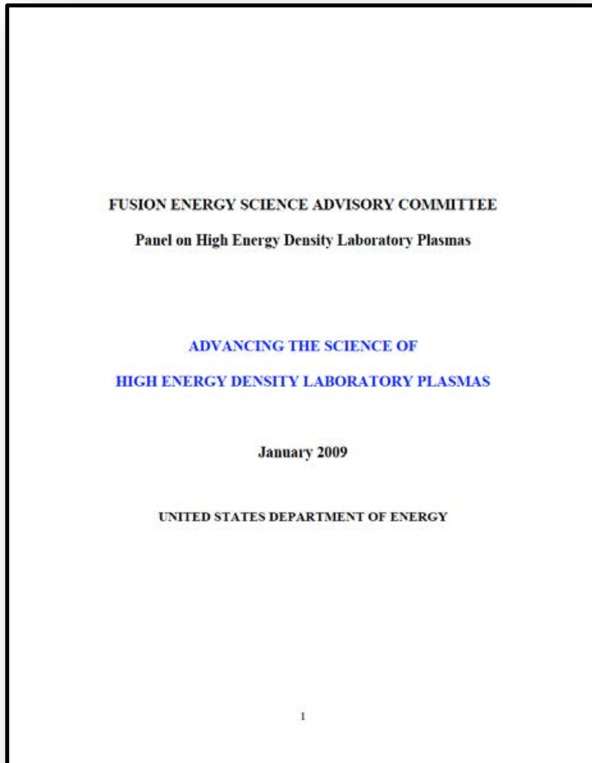
1



The reports all call for teaching HED science, broadening HED research, strengthening academic ties to DOE laboratories, and giving the broader community access to HED experimental facilities

DOE-sponsored reports have made recommendations for research in High Energy-Density (HED) science

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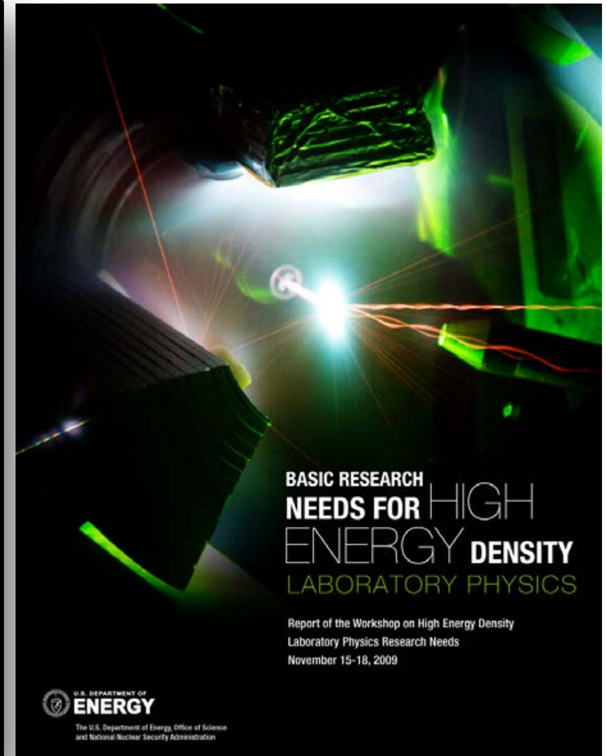
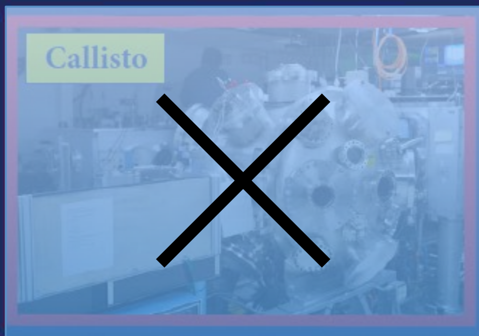
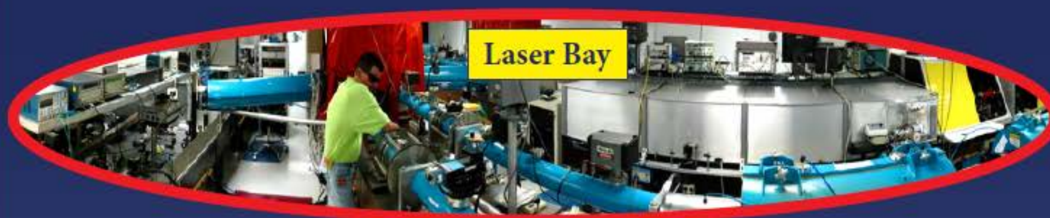


The reports all call for teaching HED science, *broadening HED research, strengthening academic ties to DOE laboratories, and giving the broader community access to HED experimental facilities*

Access is difficult when the facilities are "privately held" or have astounding capabilities but are expensive

Jupiter Laser Facility





Expanding High Energy-Density Science

Jupiter is a multi-platform intermediate-scale facility for HED science

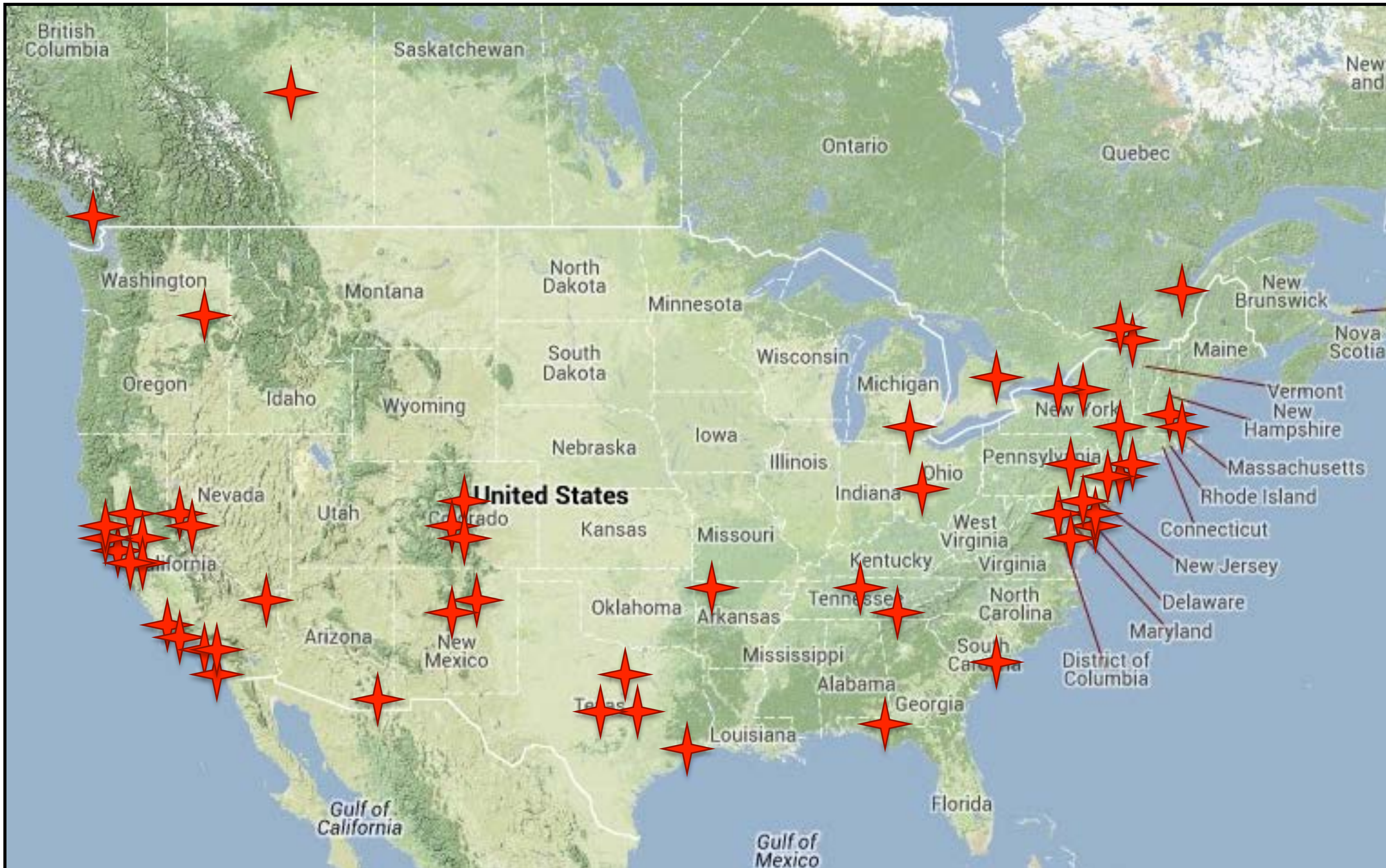
Mission

- Expand the frontiers of high energy-density laboratory science
- Support high energy-density science at LLNL in multiple programs
- Support, collaborate with, and expand the broader HED physics community
- Help train and recruit future scientific workforce

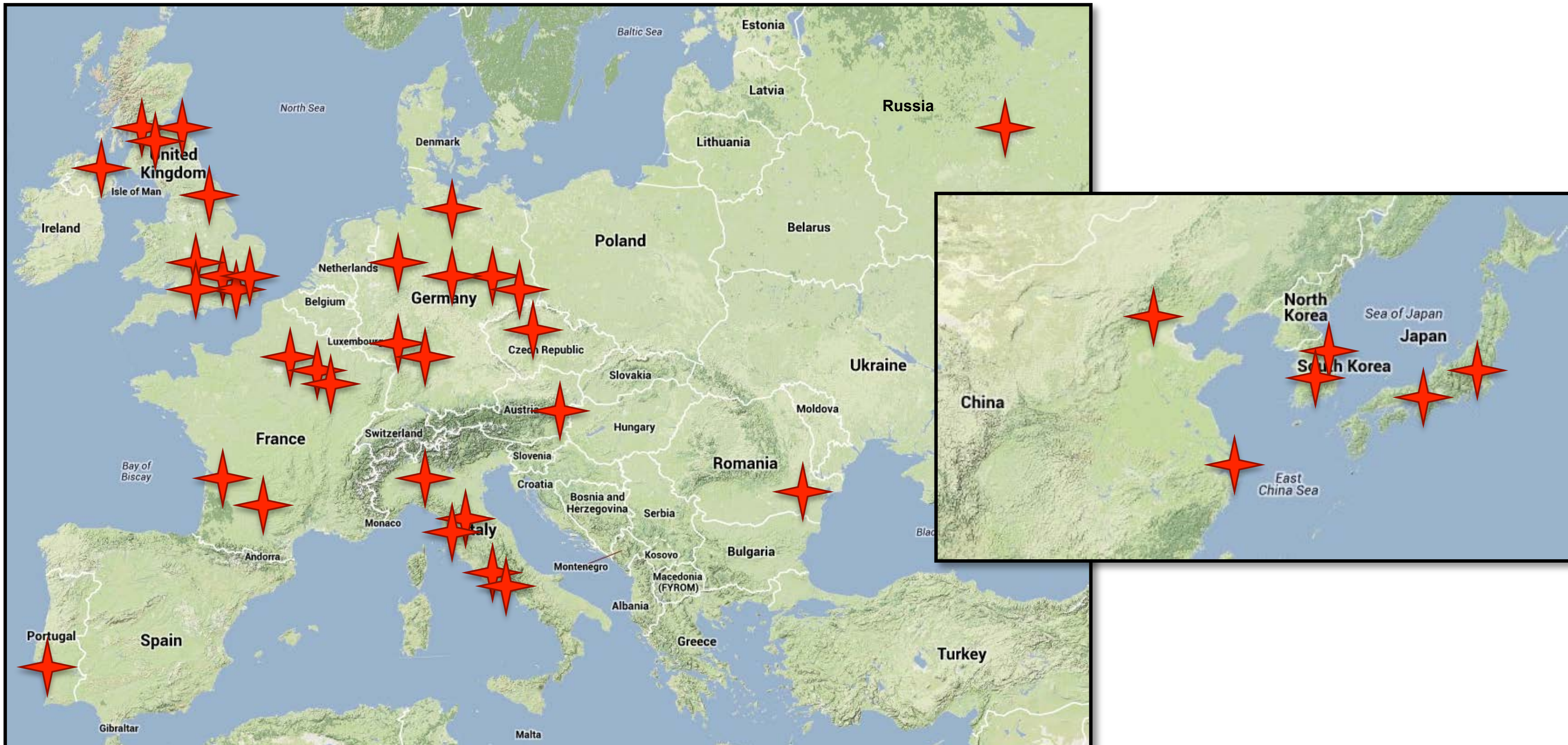
Approach

- Office-of-Science-style user facility at which laser time is provided free-of charge and apportioned through an open, competitive peer-review process
- On a scale that provides significantly more laboratory access and greater flexibility than large-scale laser facilities
- With a variety of platforms capable of front-rank HED science for different classes of experiments
- And the infrastructure to safely support multiple users with a range of experience levels

Jupiter users come from academic institutions and laboratories in the US and Canada,



as well as in Europe and Asia



A number of organizations involved in HED science have active JLF users

LLNL

Engineering
NIF
PLS
WCI

Cal Tech
Colorado St
Columbia
Florida A&M
Harvard
MIT
Merchant Marine Acad
Ohio State
Princeton
Rice
South Carolina State
Stanford
Texas A&M
U Arizona
U Arkansas
UC-Berkeley
UC-Davis
UCLA
UC-San Diego
UC-Santa Barbara
U Colorado
U Dallas
U Maryland
U Michigan
U Nevada Las Vegas
U Nevada Reno
U Pennsylvania
U Rochester
U South
U Texas
Vanderbilt
Villanova
Washington State
West Point

Academy Science Czech
Chinese Academy of Sciences
Ecole Polytechnique
Gwangju IST
Heinrich-Heine U
Imperial College
INRS - Montreal
IST Lisbon
Leibnitz U
McGill U
Nat Inst Nucl Phys Italy
Osaka U
Queen's U Belfast
Russian Academy of Sciences
Shanghai Jiao Tong U
Tech U Darmstadt
Tech U Dresden
U Alberta
U Bordeaux/CELIA
U British Columbia
U Edinburgh
U Glasgow
U Jena
U Milano
U Oxford
U Paris
U Paris-Sud
U Pisa
U Quebec
U Rome
U Strathclyde
U Toronto
U York
Vienna U Tech

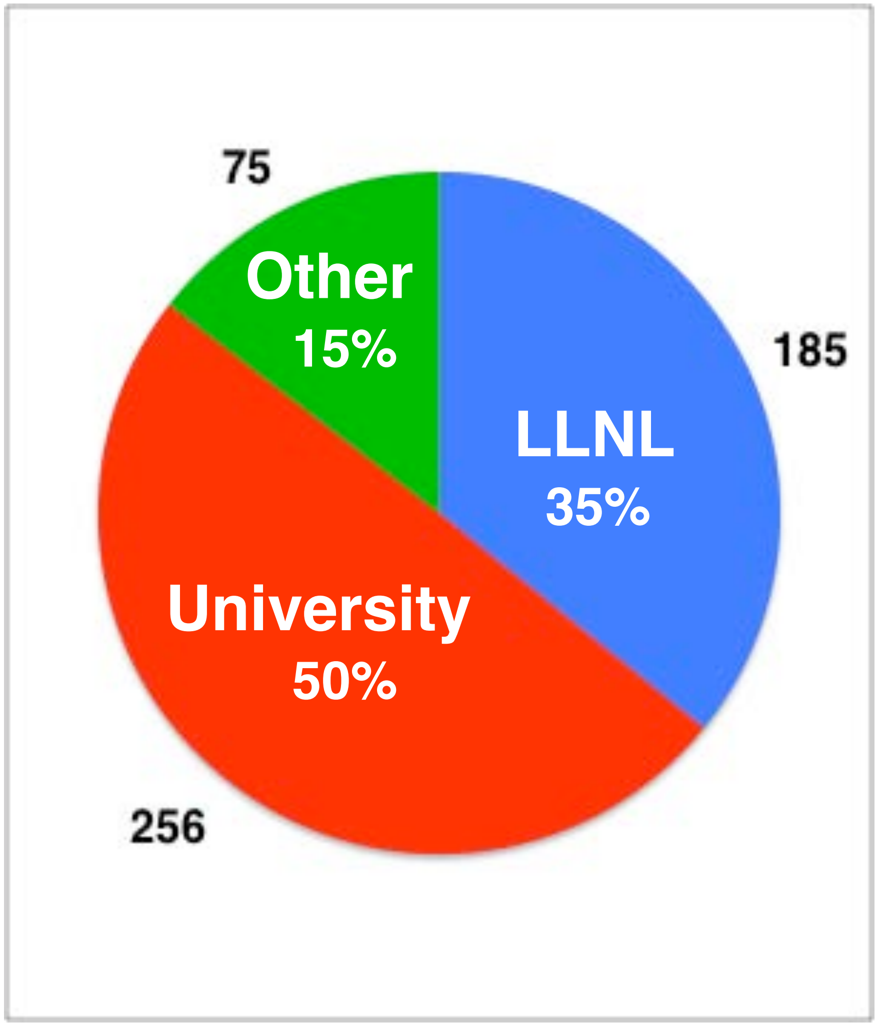
Other Institutes

ARFL
Carnegie Inst
DTRA
Ecopulse
EMC
GA
LANL
LBNL
LLE
NIST
NRL
NSTec
NTF
SLAC

AWE
CEA
CNR/Pisa
DESY
GSI
LNCMI Toulouse
JAEA Japan
KAERI Korea
Kentech
RAL
Rom Inst Phys & NE

Number of active JLF users continues to increase

JLF now has 516 users, up from 489 last year



Most PhD students stay in the HED community; many stay at LLNL

PhD Student	School	Grad Year	Employment
Matthew Allen	UC – Berkeley	2004	Staff Sandia/ABQ; 2007 intern House DHS Committee
Tommy Ao	U British Columbia	2004	Staff Sandia/ABQ
Jim King	UC – Davis	2006	Ohio State, sited at LLNL
Kramer Akli	UC – Davis	2006	Staff GA; 2010 Ohio State U
Gillis Dyer	U Texas – Austin	2007	Staff U Texas - Austin
Jorge Filevich	Colorado State	2007	Postdoc Colorado State; 2010 Industry
Alessandra Ravasio	Ecole Polytechnique	2007	Research staff CNRS
Dan Hey	UC – Davis	2007	Postdoc LLNL/NIF; 2010 Industry
Dustin Offerman	Ohio State U	2008	Postdoc LANL; 2012 consultant
Andrew Higgenbotham	Oxford	2009	Lecturer Oxford; Prof U York
Despina Milathianaki	U Texas – Austin	2009	Postdoc LLNL; 2011 Staff SLAC
Benjamin Barbrel	Ecole Polytechnique	2009	Staff CEA, sited at SLAC
Stewart McWilliams	UC – Berkeley	2009	Staff Carnegie Inst Washington
Sophia Chen	UC – San Diego	2009	Postdoc LLNL; 2011 NSF Postdoc
Cliff Chen	MIT	2009	Staff LLNL
Andrea Kritcher	UC – Berkeley	2009	Lawrence Fellow; Staff LLNL
Joe Ralph	UC – Los Angeles	2009	Staff LLNL/NIF
Tammy Ma	UC – San Diego	2010	Staff LLNL/NIF
Steven Ross	UC - San Diego	2010	Staff LLNL/NIF
Art Pak	UC – Los Angeles	2010	Staff LLNL/NIF
Nathan Kugland	UC – Los Angeles	2010	Postdoc LLNL/NIF; 2013 Industry
Tony Link	Ohio State U	2010	Staff LLNL
Dylan Spaulding	UC - Berkeley	2010	Postdoc CEA; 2012 Postdoc Harvard
Tyan-lin Wang	UC – Los Angeles	2010	Industry
Andrew Collette	UC – Los Angeles	2010	Postdoc U Colorado
Frederic Perez	Ecole Polytechnique	2011	Postdoc LLNL/PLS
Erik Shipton	UC - San Diego	2011	Staff General Atomics
Alexander Pelka	Tech U Darmstadt	2011	Postdoc LULI; Staff European XFEL
Ana Manic	Ecole Polytechnique	2011	Asst Professor U Nis, Serbia
Teresa Bartel	UC - San Diego	2011	Industry
Alex James	UC - San Diego	2011	Postdoc Princeton
Brad Pollock	UC - San Diego	2012	Lawrence Fellow LLNL/NIF
Drew Higginson	UC - San Diego	2012	Postdoc Ecole Polytechnique
Toshinori Yabuuchi	UC - San Diego	2012	Asst Professor Osaka U
Paul Davis	UC - Berkeley	2012	Postdoc UCB; FY14 Congressional Fellow
Matthew Suggit	Oxford	2012	Postdoc Oxford
Kelly Cone	UC - Davis	2012	Industry
Katerina Falk	Oxford	2012	Postdoc LANL; Staff ELI
Vladimir Ovchinnikov	Ohio State U	2012	Postdoc Voronezh U, Russia
Tony Visco	U Michigan	2012	Industry
Richard Kraus	Harvard	2013	Lawrence Fellow, Staff LLNL
Maxence Gauthier	Ecole Polytechnique	2013	Postdoc SLAC
Emma McBride	U Edinburgh	2013	Postdoc DESY
Andrew Krygier	Ohio State U	2013	Postdoc Ohio State, Ecole Polytechnique
Ian Bush	U York	2013	Postdoc Imperial College London
David Turnbull	Princeton	2013	Postdoc LLNL/NIF
Elijah Kemp	Ohio State U	2013	Postdoc LLNL/PLS
Dominik Kraus	TU Darmstadt	2013	Postdoc UC Berkeley
Franklin Dollar	U Michigan	2013	Postdoc U Colorado/JILA
Amadou Nourou	Ecole Polytechnique	2013	Lecturer U Abdou Moumouni, Niger
Sam Feldman	U Texas – Austin	2013	Industry
Colin Brown	Imperial College	2013	Staff AWE
Chirstine Krauland	U Michigan	2014	Postdoc UCSD
Orlando Ciracosta	Oxford	2014	Postdoc Oxford
Wenchao Yan	CAS	2014	Postdoc U Nebraska
Michael Purvis	Colorado State	2014	Postdoc Colorado State
Adrien Deneoud	Ecole Polytechnique	2014	Postdoc CEA
Bruno Albertazzi	Ecole Polytechnique	2014	Researcher Osaka U
Gabriele Hoffmeister	TU Darmstadt	2014	*Postdoc GSI*
Pierre-Marie Leguay	U Bordeaux	2014	*Postdoc U Bordeaux*
Gabriele Mogli	Oxford	2014	Industry
Carlos Di Stefano	U Michigan	2014	Undecided
Brad Westover	UC - San Diego	2014	Finishing

- **FY12: 95 student users of JLF**
- **FY13: 117 student users of JLF**
- **FY14: 130 student users of JLF**
- **FY14: 137 student users of JLF**

- **10 PhDs awarded to JLF student users in 2014**

Selected 2014 publications

PNAS

Concurrence of monoenergetic electron beams and bright X-rays from an evolving laser-plasma bubble

Wenchao Yan[a], Liming Chen[a,1], Dazhang Li[b], Lu Zhang[a], Nasr A. M. Hafz[c], James Dunn[d], Yong Ma[a], Kai Huang[a], Luning Su[a], Min Chen[c], Zhengming Sheng[c,e], and Jie Zhang[c,1]

[a]Beijing National Laboratory for Condensed Matter Physics, Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China; [b]Institute of High Energy Physics, Chinese Academy of Sciences, Beijing 100049, China; [c]Key Laboratory for Laser Plasmas (Ministry of Education), Department of Physics and Astronomy, Shanghai Jiao Tong University, Shanghai 200240, China; [d]Lawrence Livermore National Laboratory, CA 94550; and [e]Scottish Universities Physics Alliance, Department of Physics, University of Strathclyde, Glasgow G4 0NG, United Kingdom

Contributed by Jie Zhang, March 6, 2014 (sent for review October 20, 2013)

Desktop laser plasma acceleration has proven to be able to generate gigaelectronvolt-level quasi-monoenergetic electron beams. Moreover, such electron beams can oscillate transversely (wiggling motion) in the laser-produced plasma bubble/channel and emit collimated ultrashort X-ray flashes known as betatron radiation with photon energy ranging from kiloelectronvolts to megaelectronvolts. This implies that usually one cannot obtain bright betatron X-rays and high-quality electron beams with low emittance and small energy spread simultaneously in the same accelerating wave bucket. Here, we report the first (to our knowledge) experimental observation of two distinct electron bunches in a single laser shot, one featured with quasi-monoenergetic spectrum and another with continuous spectrum along with large emittance. The latter is able to generate high-flux betatron X-rays. Such is observed only when the laser self-guiding is extended over 4 mm at a fixed plasma density (4×10^{18} cm^{-3}). Numerical simulation reveals that two bunches of electrons are injected at different stages due to the bubble evolution. The first bunch is injected at the beginning to form a stable quasi-monoenergetic electron beam, whereas the second one is injected later due to the oscillation of the bubble size as a result of the change of the laser spot size during the propagation. Due to the inherent temporal synchronization, this unique electron–photon source can be ideal for pump–probe applications with femtosecond time resolution.

Synchrotron light sources are powerful in generating bright X-rays for a wide range of applications in basic science, medicine, and industry (1). However, these machines are usually large in size and expensive for construction and maintenance and are thus unaffordable to many would-be users. With the advent of tabletop ultrashort and ultraintense lasers, laser plasma acceleration (LPA) proposed by Tajima and Dawson (2) has demonstrated its great potential as a compact accelerator and X-ray source. Significant progress in LPA was made in the last decade (3–11): Well-collimated (approximately millirad) quasi-monoenergetic electron beams were first observed in 2004, and the electron energy above gigaelectronvolts over centimeter-scale acceleration lengths were demonstrated in several laboratories in the last few years.

While accelerating longitudinally in the laser wakefield, the electron beams also oscillate transversally (wiggling motion) due to the transverse structure of the wakefield, which emits well-collimated betatron X-rays (12–14). Among several mechanisms to generate X-ray radiation from laser–plasma interactions (15–20), betatron radiation is straightforward and able to deliver larger X-ray photon fluxes per shot [$\sim 10^8$ phs/shot (21)] and higher photon energies [up to gamma rays (22)]. The betatron oscillation frequency is given by $\omega_\beta = \omega_p(2\gamma)^{-1/2}$, where ω_p is the plasma frequency and γ is the Lorentz factor of the accelerated electron beam. For large-amplitude betatron oscillations (i.e., a few micrometers in size), the resulting broadband spectrum extends up to the critical frequency of $\omega_c \sim 2\gamma^2\omega_\beta$, after which it drops exponentially. The radiation is emitted in the forward direction within a cone angle $\theta \sim K/\gamma$, where K is the strength parameter of the plasma wiggler given by $K = 2\pi(\gamma r_0)/\lambda_b = 1.33 \times 10^{-10}\gamma^{1/2}n_e^{1/2}[\mathrm{cm}^{-3}]r_0[\mu\mathrm{m}]$, and λ_b is the betatron wavelength. The average photon number with mean energy $\hbar\omega_c$ emitted by an electron is given by $N_x = 5.6 \times 10^{-3} N_\beta K$, where N_β is the number of oscillation periods. Many experiments (11, 21–25) have been carried out to enhance the radiation flux, for example, to increase the electron charge, the electron energy, the oscillation amplitude r_0, and oscillation period N_β through extending the acceleration length. However, these experiments have shown that the improvement of the betatron X-ray flux is generally accompanied by a loss of electron beam quality. For example, as mentioned above, because $N_x \propto r_0$, the increasing of r_0 is considered an efficient way to enhance the X-ray flux, but this results in a larger electron emittance and energy spread.

Results

In this paper, we demonstrate the simultaneous generation of quasi-monoenergetic electron beams and collimated high flux X-ray sources from multiple injections in self-injected laser wakefield acceleration on a 100-TW laser system using 1-cm-long helium gas jet. Two sequentially injected bunches of electrons are observed in experiment, where the first bunch forms a quasi-monoenergetic spectrum around 0.46 GeV with <9% energy spread and the second bunch contains more electrons but forms a broad spectrum with highest energy up to 1.4 GeV. Such energy is beyond the energy gain estimated by the usual dephasing limit (12). A betatron X-ray flash, which had 4.5×10^8 photons per

Significance

Desktop laser plasma acceleration is able to generate monoenergetic electron beams, and such electron beams can oscillate in the plasma bubble, which results in the collimated X-rays with ability of femtosecond temporal resolution. However, high-flux X-ray emission and high-quality electron beams have not been obtained simultaneously because high-yield X-ray emission is usually produced at the cost of electron beam qualities. By stimulating double injections into a plasma bubble, we report our experimental observation in which both a monoenergetic electron beam at the gigaelectronvolt level and ultraintense hard X-rays with peak brightness higher than the third generation of synchrotrons. Due to the inherent temporal synchronization, this unique electron–photon source can be ideal for "single-shot" pump–probe applications at femtosecond and nanometer scales.

Author contributions: L.C., N.A.M.H., and J.Z. designed research; W.Y., L.C., D.L., L.Z., N.A.M.H., J.D., and L.S. performed research; Y.M., K.H., M.C., and Z.S. contributed new reagents/analytic tools; W.Y., L.C., D.L., Y.M., and K.H. analyzed data; and W.Y., L.C., N.A.M.H., and Z.S. wrote the paper.

The authors declare no conflict of interest.

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PHYSICS

www.pnas.org/cgi/doi/10.1073/pnas.1404336111

PNAS | April 22, 2014 | vol. 111 | no. 16 | 5825–5830

PRL 113, 116404 (2014) PHYSICAL REVIEW LETTERS week ending 12 SEPTEMBER 2014

Metallization of Warm Dense SiO_2 Studied by XANES Spectroscopy

A. Denoeud,[1,*] A. Benuzzi-Mounaix,[1,3] A. Ravasio,[1,3] F. Dorchies,[2] P. M. Leguay,[2] J. Gaudin,[2] F. Guyot,[5] E. Brambrink,[1] M. Koenig,[1] S. Le Pape,[6] and S. Mazevet[3,4]

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[2]*Centre Lasers Intenses et Applications (CELIA), CNRS, CEA, Université Bordeaux 1, 33405 Talence, France*
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[4]*Département de Physique Théorique et Appliquée, CEA, 91680 Bruyère-le-Chatel, France*
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(Received 21 February 2014; published 12 September 2014)

We investigate the evolution of the electronic structure of fused silica in a dense plasma regime using time-resolved x-ray absorption spectroscopy. We use a nanosecond (ns) laser beam to generate a strong uniform shock wave in the sample and a picosecond (ps) pulse to produce a broadband x-ray source near the Si K edge. By varying the delay between the two laser beams and the intensity of the ns beam, we explore a large thermodynamical domain with densities varying from 1 to 5 g/cm^3 and temperatures up to 5 eV. In contrast to normal conditions where silica is a well-known insulator with a wide band gap of 8.9 eV, we find that shocked silica exhibits a pseudogap as a semimetal throughout this thermodynamical domain. This is in quantitative agreement with density functional theory predictions performed using the generalized gradient approximation.

DOI: 10.1103/PhysRevLett.113.116404 PACS numbers: 71.30.+h, 31.15.ae, 52.25.Os, 52.50.Lp

Understanding the behavior of matter under extreme conditions of density and temperature is a major issue for various fields of physics, such as the design of new materials, inertial confinement fusion, or the modeling of planetary interiors [1–3]. Planetary science is witnessing a revolution with the discoveries of hundreds of planets orbiting nearby stars . Characterizing such astrophysical objects requires the physical properties of key constituents at multi-Mbar pressures and few-eV temperatures [4,5].

It is thus necessary to establish their equations of state and to identify structural changes, phase transitions, metallization, and dissociation processes at planetary interior conditions. The relevant thermodynamical conditions largely extend beyond those anticipated for the solar system planets and require expanding our knowledge of the physical properties at more extreme conditions. It currently presents a challenge for high-pressure physics, as such conditions are not directly accessible experimentally.

In this context, current planetary models rely almost exclusively on physical properties obtained using first principles simulations based on density functional theory (DFT) predictions [6–9]. This approach has known limitations such as band gap underestimation, underbinding, or overbinding of molecular bounds that all potentially affect the predictions at extreme conditions [10]. It is thus important to validate the basic underlying mechanisms occurring for key planetary constituents as pressure and temperature both increase.

Among these constituents, complex silicates [i.e., $(Mg,Fe)SiO_3$ and $(Mg,Fe)_2SiO_4$] and the products of their dissociation (SiO_2, MgO) are of major interest. Their metallization and dissociation as pressure and temperature increase are a central issue for the modeling of terrestrial planets or the cores of giant and icy giant planets [11–14]. These two effects influence strongly the equation of state (EOS) and the evolution of the associated transport properties. To increase our confidence in the predictions at planetary interior conditions, we present here an experimental investigation of the metallization of silica in pressure and temperature.

Silica is an insulator with a large band gap of 8.9 eV at normal density-temperature conditions [15]. It turns metallic as density and temperature both increase. This was recently investigated using laser shock experiments by performing reflectivity, temperature, and shock velocity measurements along the principal Hugoniot [16,17]. These studies suggested a connection between the loss of correlation between the Si and O atoms, the closing of the band gap, and the increase in reflectivity.

To go beyond such indirect measurements, we present here an experimental and theoretical study of the properties of fused silica at Mbar pressures using time-resolved X-ray Absorption Near Edge Spectroscopy (XANES). We show that shocked silica is not an insulator with a closing band gap as pressure and temperature increase but exhibits a pseudogap and should thus be considered as a semimetal [18].

The experiment was performed both on the LULI2000 laser facility at the Laboratoire Pour l'Utilisation des Lasers Intenses at the Ecole Polytechnique and on the TITAN laser of the Jupiter Laser Facility at the Lawrence Livermore

0031-9007/14/113(11)/116404(5) 116404-1

Selected 2014 publications

PHYSICS OF PLASMAS **21**, 082702 (2014)

Electron temperature and density characterization using L-shell spectroscopy of laser irradiated buried iron layer targets

M. Shahzad,[1] G. J. Tallents,[1] A. B. Steel,[2] L. Hobbs,[3] D. J. Hoarty,[3] and J. Dunn[2,a)]
[1]*York Plasma Institute, The University of York, York YO10 5DQ, United Kingdom*
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(Received 1 May 2014; accepted 23 July 2014; published online 5 August 2014)

Uniform high density plasmas of different materials with properties relevant to the interior of stars and to inertial fusion can be created by laser irradiation of targets containing a buried layer of the material. Buried layer targets also enable the diagnosis of hot and thermal electron, x-ray and ion heating of targets. In this paper, L-emission spectroscopy from an iron layer (thickness 77 nm) encased in an otherwise plastic target (of thickness 240 nm–1.36 μm on the laser side) is irradiated by 0.53 μm wavelength, 2 ps duration laser pulses at irradiances of 10^{17}–10^{18} Wcm^{-2}. The relative iron L-emission from Li-like Fe XXIV to Ne-like Fe XVII is used to diagnose the plasma conditions of temperature and density in the iron layer. As the upper quantum states of the L-emission lines are in local thermodynamic equilibrium, line intensity ratios depend on both electron temperature and density, which—we show—enables the simultaneous measurement of both electron temperature and density by considering several line intensity ratios. We also show that hot electron target heating and the value of thermal flux limited heat conduction can be evaluated from the relative intensity of iron lines. © *2014 AIP Publishing LLC*. [http://dx.doi.org/10.1063/1.4892263]

APPLIED PHYSICS LETTERS **105**, 161110 (2014)

Diagnosis of bubble evolution in laser-wakefield acceleration via angular distributions of betatron x-rays

Y. Ma,[1] L. M. Chen,[1,a)] N. A. M. Hafz,[2] D. Z. Li,[3] K. Huang,[1] W. C. Yan,[1] J. Dunn,[4] Z. M. Sheng,[2,5] and J. Zhang[2]
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(Received 7 September 2014; accepted 12 October 2014; published online 23 October 2014)

We present an indirect method to diagnose the electron beam behaviors and bubble dynamic evolution in a laser-wakefield accelerator. Four kinds of typical bubble dynamic evolution and, hence, electron beam behaviors observed in Particle-In-Cell simulations are identified correspondingly by simultaneous measurement of distinct angular distributions of the betatron radiation and electron beam energy spectra in experiment. The reconstruction of the bubble evolution may shed light on finding an effective way to better generate high-quality electron beams and enhanced betatron X-rays. © *2014 AIP Publishing LLC*. [http://dx.doi.org/10.1063/1.4900412]

PHYSICS OF PLASMAS **21**, 056701 (2014)

Summary of recent experiments on focusing of target-normal-sheath-accelerated proton beam with a stack of conducting foils[a)]

P. A. Ni,[1,2,b)] N. Alexander,[3] J. J. Barnard,[4] and S. M. Lund[4]
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(Received 23 November 2013; accepted 3 February 2014; published online 22 April 2014)

We present a summary of recent experiments on focusing of laser target-normal-sheath-accelerated (TNSA) proton beam with a stack of thin conducting foils. The experiments were performed using the Phelix laser (GSI-Darmstadt) and the Titan laser, Lawrence Livermore National Laboratory. The phenomena consistent with self-collimation (or weak self-focusing) of TNSA protons were experimentally observed for the first time at the Phelix laser user facility, in a specially engineered structure ("lens") consisting of a stack of 300 thin aluminum foils separated by 50 μm vacuum gaps. Follow up experiments using the Titan laser obtained results consistent with the collimation/focusing observed in the initial experiments using the Phelix. The Titan experiments employed improved, 25 μm- and 50 μm-gap targets and the new fine mesh diagnostic. All the experiments were carried out in a "passive environment," i.e., no external fields were applied, and no neutralization plasma or injection of secondary charged particles was imposed. A plausible interpretation of the observed phenomena is that the combination of magnetic self-pinch forces generated by the beam current together with the simultaneous reduction of the repulsive electrostatic forces due to the conducting foils inhibits radial expansion of the beam. © *2014 AIP Publishing LLC*. [http://dx.doi.org/10.1063/1.4872217]

PHYSICS OF PLASMAS **22**, 013110 (2015)

On specular reflectivity measurements in high and low-contrast relativistic laser-plasma interactions

G. E. Kemp,[1,2,a)] A. Link,[1] Y. Ping,[1] H. S. McLean,[1] P. K. Patel,[1] R. R. Freeman,[2] D. W. Schumacher,[2] H. F. Tiedje,[3] Y. Y. Tsui,[3] R. Ramis,[4] and R. Fedosejevs[3]
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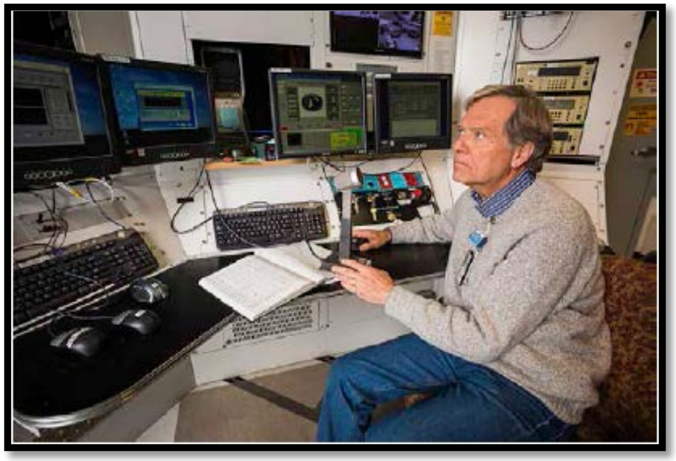
(Received 7 October 2014; accepted 5 January 2015; published online 14 January 2015)

Using both experiment and 2D3V particle-in-cell (PIC) simulations, we describe the use of specular reflectivity measurements to study relativistic ($I\lambda^2 > 10^{18}$ W/cm$^2\cdot\mu$m^2) laser-plasma interactions for both high and low-contrast 527 *n*m laser pulses on initially solid density aluminum targets. In the context of hot-electron generation, studies typically rely on diagnostics which, more-often-than-not, represent *indirect* processes driven by fast electrons transiting through solid density materials. Specular reflectivity measurements, however, can provide a *direct* measure of the interaction that is highly sensitive to how the EM fields and plasma profiles, critical input parameters for modeling of hot-electron generation, evolve near the interaction region. While the fields of interest occur near the relativistic critical electron density, experimental reflectivity measurements are obtained centimeters away from the interaction region, well after diffraction has fully manifested itself. Using a combination of PIC simulations with experimentally inspired conditions and an analytic, non-paraxial, pulse propagation algorithm, we calculate reflected pulse properties, both near and far from the interaction region, and compare with specular reflectivity measurements. The experiment results and PIC simulations demonstrate that specular reflectivity measurements are an extremely sensitive qualitative, and partially quantitative, indicator of initial laser/target conditions, ionization effects, and other details of intense laser-matter interactions. The techniques described can provide strong constraints on many systems of importance in ultra-intense laser interactions with matter. © *2015 AIP Publishing LLC*. [http://dx.doi.org/10.1063/1.4906053]

Staff changes – on the minus side



John Caird
Control

Jim Bonlie
Operations Manager

Gary Freeze
Mech Tech

Staff changes – on the plus side

Brent Stuart
Manager

Rick Cross
Elect/Mech Engineer

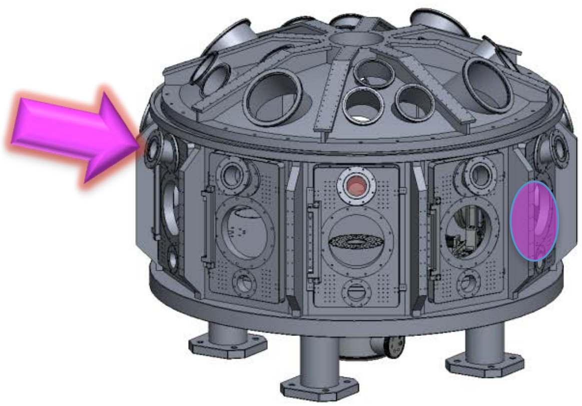
Kris Chubb
Computer Scientist

LLNL has permitted JLF to invest in new and improved capablities

- **New timing system**
  - Greenfield master unit with fiber coupled delay generators throughout JLF
  - 12-ps-rms jitter, compared with 400 ps for old SRS boxes
  - Switch to new system scheduled for week of 3/30/15
- **Kentech drivers for 50-mm Pockels cells**
  - Faster rise time, better prepulse extinction
  - Solid-state electronics rather than thyratron switching
- **OPCPA pump laser**
  - Diode-pumped Nd:YAG heads replace lamp-pumped Nd:YLF
  - Eliminates phase-conjugate cell
  - Old lamp-pumped heads can be used to increase Janus E&W alignment beam energy
  - Switch to new heads scheduled for week of 4/6/15
- **Diagnostics**
  - GigE camera network (with a few cameras to start) for shot-time diagnostics
  - Data acquisition hardware to standardize reading of shot-time energy meters
  - Forward and backward beam diagnostic at 34° mirror between β and γ disk amplifiers

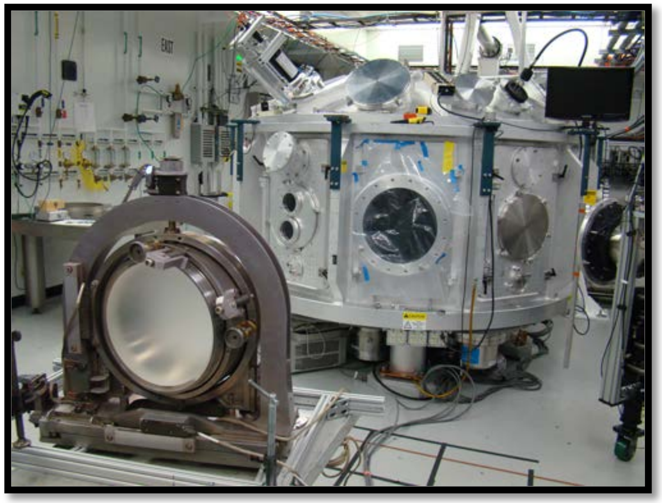
Next month we will implement the first f/10 experiment on Titan short-pulse beam

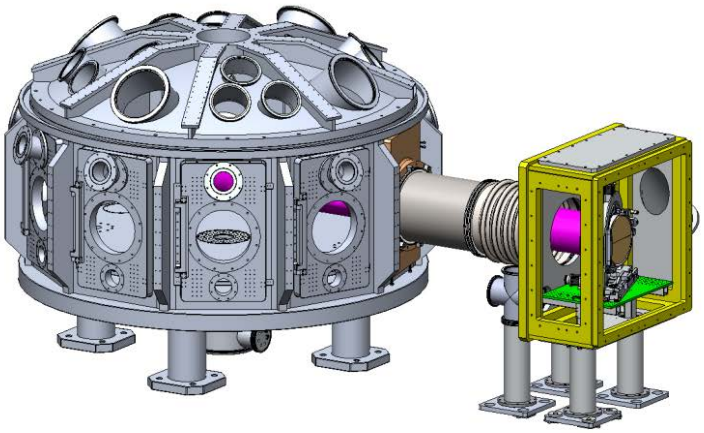
Titan normally uses an 1-m focal length f/3 final optic - OAP - that resides in the chamber



We are installing a 3-m focal length f/10 final optic geared mainly to particle acceleration experiments

Next month we will implement the first f/10 experiment on Titan





We are installing a 3-m focal length f/10 final optic geared mainly to particle acceleration experiments

We are offering a green ps beam in Titan in order to improve pulse contrast

- The ps beam in Titan is normally 1ω with a contrast of 10^{-5}
- Three years ago we "borrowed" 2ω optics from the decommissioned HELEN laser at AWE for use in an AWE experiment requiring better contrast
  - sub-aperture so not full energy
  - contrast of about 10^{-8}
- That and a couple of follow-on experiments terminally damaged the optics, especially the final focusing off-axis parabola (OAP)
- We bought and coated a new green, full-aperture OAP
  - we don't have full aperture doubling crystal, intermediate optics, and spares, so still can't run at full energy
- But a majority Titan proposals requested green

Some clean up (30 years worth) has been going on

Comments from last year

- Excellent staff
- Good training for students
- Good place to develop diagnostics
- Exceptional flexibility

Recommendations by JLUG

First and most important, stabilization of the Facility

- Better reliability and performance
- Better reproducibility – reduce energy and timing fluctuations
- Decreased downtime – inventory of spare parts
- Increase in staff – to assist experimentalists

The investment in JLF by the Director has allowed us to start addressing these issues

Recommendations by JLUG

Facility improvements

- Better laser diagnostics
- Better long-pulse shaping
- Increase in energy for Janus, Titan, and 2ω probe beams – new regimes
- Ability to split long-pulse beams – flexibility
- Second short-pulse beam in Titan – revitalize experiments
  - increase energy and delay in split SP Titan beam
- Consider implementing Optical Science Laser (OSL)

Recommendations by JLUG

Communication of information

- Continuity between campaigns
- Create a JLF User Guide
- Updated info on website
- Electronic shot form *a la* Omega
- Create JLF Science Advisory Board to direct research and improvements

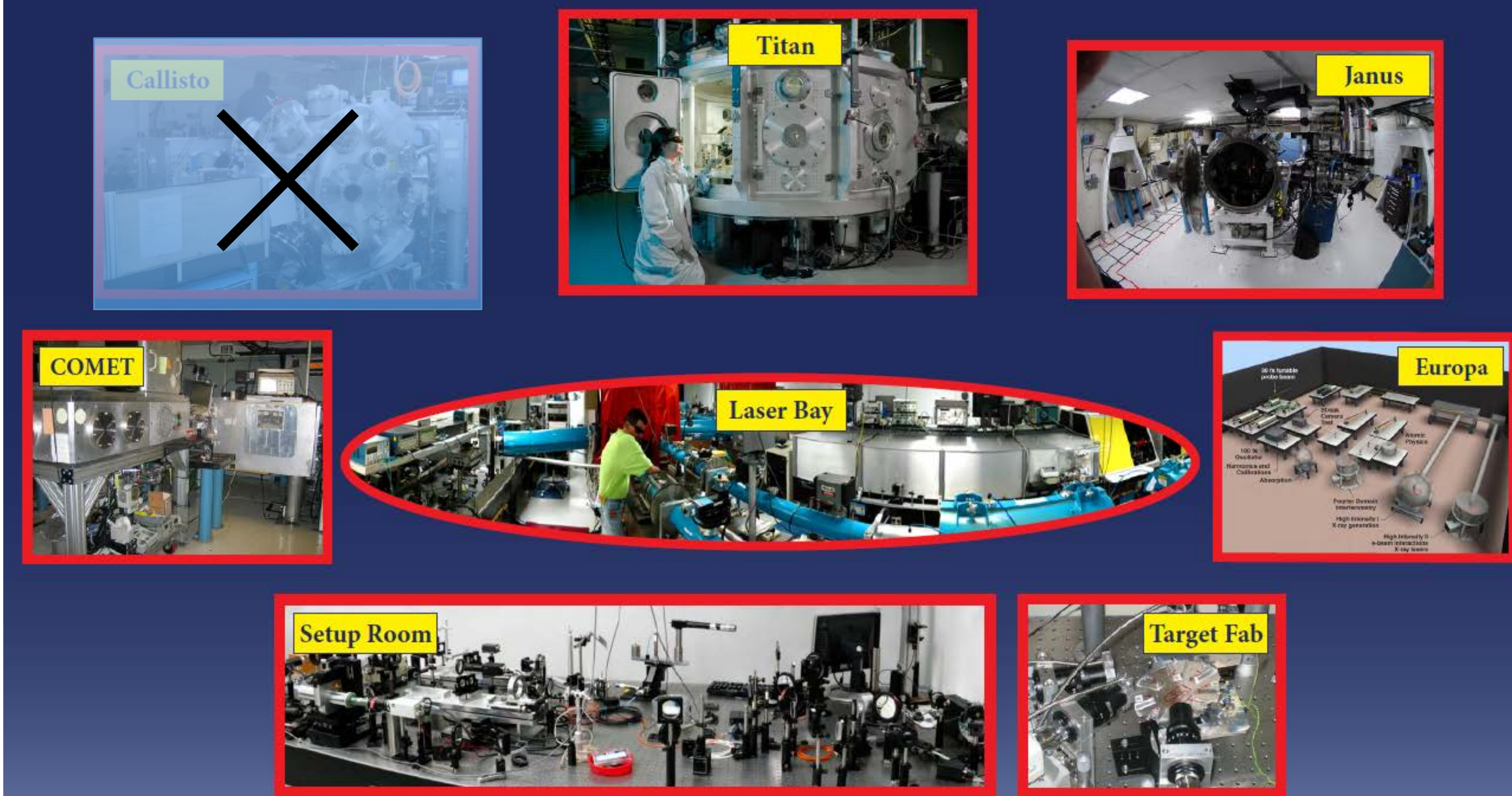
Future of JLF

- **We've made a start toward stabilizing JLF. To continue LLNL has to develop an institutional strategy for "lasers." NIF the Facility and NIF the Directorate will naturally lead this; JLF must be part of it.**
- **The strategy will take some time to develop**
- **JLF is a key access point for HED research at LLNL. The future needs of JLF are defined by the users. The UG should assemble a prioritized document of need to be submitted to whomever leads the strategy effort – so it's not just me talking. Be as specific as you can.**

  - reasons for JLF to exist beyond the Mission Criteria (or emphasizing them)
  - improved predictability, reproducibility, performance: what level required
  - improved contrast in Titan: what level and why
  - fs capability
  - need for dual SP beams in Titan; desirable but expensive
  - is there a case for operating OSL in a JLF-like model?

We can count on NIF to help, to see JLF as supporting NIF, LLNL, DOE and the broader scientific community

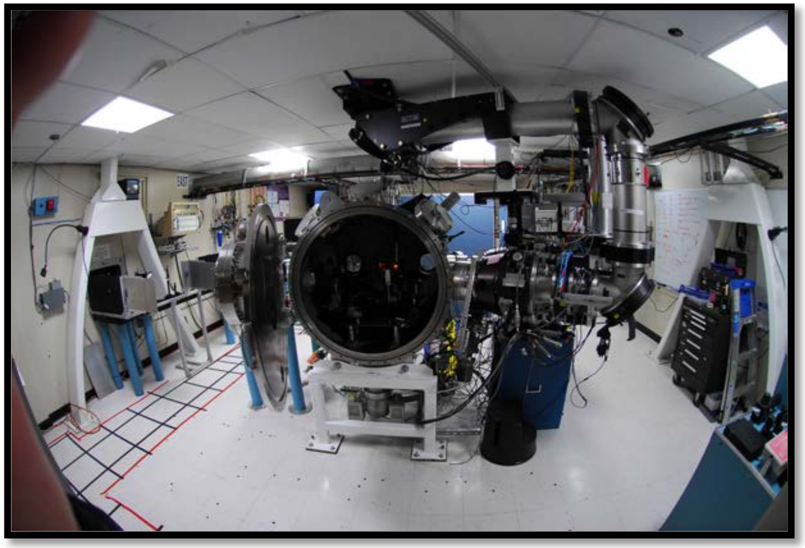
Jupiter Laser Facility



Expanding High Energy-Density Science

CY2015 experiments will investigate a number of HED areas - Janus

- Characterizing B-fields: measure B as well as ρ,T via Thomson scattering
- Plasma photonics: manipulating polarization with plasma; better understand cross-beam mixing
- Melting/vaporization during planet formation, shocking Mg-silicates and Mg-oxides
- Material strength and viscous plastic flow of Fe at high strain rates
- Effect of microstructure on strength of meteoric materials
- Strength and elastic effects in NIF ablator materials
- Phase changes in shocked potassium via SWORD reflectivity diagnostic developed on JLF
- Broadband CARS of shocked samples: diagnostic for structural changes



CY2015 experiments will investigate a number of HED areas - Titan

- Relativistic magnetic reconnection in colliding plasmas
- Radiation and particle production in astrophysical shocks
- Control of hot electron transport using induced magnetic fields
- Highly collimated electron acceleration/x-ray production from laser-solid interactions
- Ultra-HED matter using nanostructured targets
- Proton acceleration using a cryogenic hydrogen jet target
- 100+ MeV ions using electrostatic shocks
- X-rays from self-modulated wakefield-accelerated electrons

The End