Titan Laser
Jupiter Laser Facility

Fusion Science Center Meeting
LLNL

Pravesh K. Patel
Aug 28-29, 2006
JLF is comprised of 5 lasers that serve the laboratory and academic user communities
The Titan laser was built to provide a capability for combined high energy SP and LP beam experiments.

Existing Janus Target Area (2x 1kJ LP beams)

New Titan Target Area

Laser Bay

Short-pulse: 300J in 400fs
Long-pulse: 1kJ in 3ns
Titan upgrade team

• Rick Cross  ENG  Project Engineer
• Dwight Price  PAT  JLF Operations manager
• Jim Bonlie  ENG  JLF Dep. Operations manager
• Glenn Huete  ENG  Mechanical
• John Caird  NIF  Laser design/Project manager
• Brent Stuart  NIF  OPCPA/Compressor design
• Al Erlandson  NIF  Laser design
• Jim Hunter  ENG  Laser operations
• Glenn Beer  ENG  Engineering design
• Carl Bruns  ENG  Facility/Mechanical
• Roger Van Maren  ENG  Experiments support
• Mike Saculla  ENG  Experiments support
• Maura Spragge  ENG  Facility
• Frank Esparza  ENG  Laser operations
• Dwight Heggies  ENG  Vacuum systems
• Doug Norman  ENG  Electrical
• David Cloyne  ENG  Systems support
• Jerry Britten  CMS  Compressor gratings
• Andrew Ng  PAT  Scientific Director
• Mark Eckart  PAT  Project manager
Titan laser architecture
We built a custom target chamber to accommodate flexible experimental configurations.
# FY06 Titan experiments schedule

<table>
<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
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<tbody>
<tr>
<td>Jan 09</td>
<td>Short-pulse commissioning</td>
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<tr>
<td>Jan 16</td>
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<tr>
<td>Feb 06</td>
<td>Janus 2-beam experiments</td>
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<td>Feb 13</td>
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<td>Feb 27</td>
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<td>Mar 06</td>
<td>X-ray radiography experiment</td>
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<td>Mar 13</td>
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<td>Mar 20</td>
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<td>Mar 27</td>
<td>Facility upgrade &amp; maintenance</td>
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<td>Apr 03</td>
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<td>Apr 17</td>
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<td>Apr 24</td>
<td>Proton generation/heating</td>
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<tr>
<td>May 01</td>
<td>experiment</td>
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<td>Jun 26</td>
<td>Facility upgrade</td>
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<td>Jul 03</td>
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<td>Jul 10</td>
<td>Short-pulse, long-pulse</td>
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<tr>
<td>Jul 17</td>
<td>commissioning</td>
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<td>Aug 07</td>
<td>ILSA experiment</td>
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<td>Aug 14</td>
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<td>Holiday shutdown</td>
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<td>Aug 28</td>
<td>ILSA experiment</td>
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<td>Sep 04</td>
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## Short-pulse Experiments

- **Prav Patel** PAT
- **Hye-Sook Park** NIF
- **Andy Mackinnon** NIF
- **Sebastien Le Pape** PAT
- **Andrew MacPhee** NIF
- **Ronnie Shepherd** PAT
- **Riccardo Tommasini** NIF
- **Hui Chen** PAT
- **Paul Neumayer** NIF
- **Daniel Hey** UC Davis (student)
- **Bingbing Zhang** UC Davis (student)
- **Kramer Akli** UC Davis (student)
- **Sophia Chen** UCSD (student)
- **Dustin Offermann** Ohio State (student)
- **Jeremy Jacox** MIT (student)
- **Leo Gizzi** Inst. Proc. C-Fisici, Italy
- **David Neely** RAL, UK
- **John Seely** NRL, Washington DC
- **Glenn Holland** NRL, Washington DC
- **Csilla Szabo** NIST, Gaithersburg MD
We have installed an extensive suite of diagnostics to characterise the laser pulse.

### Near-field

### Far-field

### Frog

### Spectrum

- Wavelength (nm)
- I (arb)
- 4.0 nm

### Pre-pulse

- Time (nsec)
- I (arb)
- Peak \( \times 10^{-8} \)
- Pre-pulse

### Energy

- Shot number
- Energy (J)
- Shot numbers: 0.5ps, 5ps, 10ps, 40ps, 120ps
- Energy values: 0, 50, 100, 150, 200, 250, 300

PKP 08.29.06 8
We have installed an extensive suite of diagnostics to characterise the laser pulse.
High dynamic range measurements of laser focal intensity distribution

Best focus is 4.9µm FWHM containing 14% of total laser energy
15µm diameter spot encircles 50% of total laser energy
We used XUV imaging to determine laser pointing and target alignment accuracy.

<table>
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<tr>
<th>150µm square foil target</th>
<th>20µm diameter wire target</th>
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Our laser and target alignment accuracy and laser pointing stability is better than 10µm.
We set up a $2\omega$ probe beam and interferometer to measure extent of pre-plasma.

- 10mJ light from OPCPA is recompressed and frequency doubled

120J tight focus on 25µm W foil

Pre-plasma at -25ps
Titan short-pulse: X-ray generation & radiography experiments

**X-ray single-hit CCD**

- 22 keV Ag K\(\alpha\)

**X-ray pinhole camera**

- 23 µm FWHM X-ray spot

**HOPG crystal spectrometer**

- Intensity (counts)
- Energy (keV)
- K\(\alpha\), Ly-\(\alpha\), K\(\beta\)

**Double crystal spectrometer**

- 10 µm lines
- 20 µm lines
- 30 µm lines
- 40 µm lines

**X-ray radiography**

- 20x20µm
- 100µm
- 20x20x100µm Ag wire
- 30µm thick Au resolution grid

PKP 08.29.06 13

H-S Park et al.
Titan short-pulse: Electron transport, proton generation, and isochoric heating

**Proton beam (RCF)**

- 3.6 MeV
- 6.4 MeV
- 11 MeV
- 14 MeV
- 17 MeV
- 20 MeV

**Electron spectra**

- 10 keV - 4 MeV

**XUV imagers**

- 500 µm diameter Cu disk

**XUV flat-field spectrometer**

- CV 4p-2s
- CVI 3p-2s
- CV 4d-2p
- CV 3p-2s
- CV 3d-2p
- CV 3s-2p
- CIV 3p-2s
- CIV 3d-2p
- CIV 3s-2p

**Interferometry**

- Proton beam
- 10 µm Al foil
- 650 ps time delay

**Streaked optical pyrometry**

PKP 08.29.06 14
Titan long-pulse arm is now operational enabling 2-beam combined SP-LP experiments
Titan long-pulse arm is now operational enabling 2-beam combined SP-LP experiments
First SP-LP experiment produced a radiograph of a shock front in SiO$_2$ using 17.5 keV K$_\alpha$ x-rays

Long pulse: ~250 J, 4 ns, 600 µm PZP
Short pulse: ~180 J, 40 ps, 300 µm defocus, 10 ns delay relative to long pulse

D. Hicks, S. LePape, D. Hey
Current ILSA experiment run by FSC is investigating hot electron transport in shock compressed plasmas

- A. Mackinnon (RI)  LLNL
- F. Beg (PI)  UCSD
- A. Macphee  LLNL
- S. Lepape  LLNL Postdoc
- J. Pasley  UCSD Postdoc
- M.S. Wei  UCSD Postdoc
- D. Hey  UC Davis SEGRF Student
- E. Shipton  UCSD URP Student
- S. Chen  UCSD Student Guest
- D. Offerman  Ohio State URP Student
- B. Bucker  UCSD Student Guest
- J. Jacox  MIT Summer Student
- R. Shepherd  LLNL
- L. Eberson  U. Maryland URP Student
- H. Nakamura  U. Osaka Student Guest
- R. Stephens  General Atomics
- W. Unites  LLNL
- M. Key  LLNL

CPA

200J @ 2ω, 200µm spot, 2ns

Targets

CRF Foam

5µm Au

5µm Cu

21µm Al

Targets

Image plate

Cu Kα imager

Ti Kα imager

X-ray radiography axis

VISAR

Long-pulse

HOPG

Cu Kα Single hit
Universities participate in both programmatic & institutional components of JLF User Program

- **Programmatic component**
  - High Energy Density Science (HEDS)
  - Inertial Confinement Fusion (ICF)
  - Fast Ignition Science (FIS)
  - Physical Data Research Program (PDRP)

- **Institutional component**
  - ILSA UEPP (University Education Partnerships Program)
  - ILSA UCDRD (University of California Directed R&D)
  - NNSA University Access to Intermediate Scale Laser Facilities
In FY06 academic collaborations at JLF included over 25 students and postdocs

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<tr>
<th>University</th>
<th>Name</th>
<th>Titan</th>
<th>Janus</th>
<th>Callisto</th>
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<tr>
<td>UC Davis</td>
<td>Hey Zhang</td>
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<td>Ross Tenjesdal</td>
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<td>UC San Diego</td>
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<tr>
<td>U. of Madrid, Spain</td>
<td>Casado</td>
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Collaborations can be initiated in three ways

- **Contact Andrew Ng, JLF Scientific Director**
  - General information on JLF User Program, Policies, Procedures
  - Technical information on JLF capabilities
  - Identification of potential LLNL collaborators

- **Work directly with an LLNL collaborator**
  - Joint development of collaborative project and proposal
  - Identification of a LLNL Responsible Individual as the administrative lead of the project

- **Contact Don Correll, ILSA Director**
  - Visit ILSA web site for funding opportunities, workshops, etc.
    - [http://ilsa.llnl.gov](http://ilsa.llnl.gov)