NNSA Defense Programs
Inertial Confinement Fusion Ignition and High Yield Campaign

Presented by:
Dr. Christopher J. Keane
Acting Assistant Deputy Administrator for Inertial Confinement Fusion and the NIF Project

Presented at:
Fusion Power Associates
25th Anniversary Meeting
December 13, 2004
Outline

• National Nuclear Security Administration
• ICF Campaign and Stewardship overview
• NIF Use Plan – Defense Science Board review (Ignition 2010)
• Recent progress – NIF, OMEGA, Z, Nike
• University activities and High Energy Density Physics roadmapping
DEPARTMENT OF ENERGY

Federal Energy Regulatory Commission

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Departmental Representative to the DNFSB

* The Deputy Secretary also serves as the Chief Operating Officer

2 MAY 04
SSP Programs & Facilities
Provide Necessary Research Capabilities

Adv. Hydro Capability
(DARHT)

ICF Facilities
(NIF/OMEGA/Z)

Authority to
Use

Arming, Fuzing, Firing
HE Detonation
Implosion
Fission Burn
Boosted Burn
Radiation Flow
Implosion
Burn/Explosion
Effects

Stockpile Stewardship Campaigns
Advanced Computing

Component Manufacturing
(MESA)

(MSCI White)
ICF Campaign Strategic Goals

1. Achieve ignition in the laboratory and develop it as a scientific tool for stockpile stewardship
   • Provide thermonuclear burn capability for the SSP
   • Key integrated test for validation of integrated ASCI simulations

2. Execute high energy density physics experiments necessary to provide advanced assessment capabilities for stockpile stewardship
   • Support stockpile refurbishment and assessment
   • Address specific weapon issues, validate advanced ASCI simulations

3. Develop advanced technology capabilities that support the long-term needs of stockpile stewardship
   • Pursue promising advanced concepts (pulsed power fusion, “fast ignition”, petawatt lasers)

4. Maintain robust national program infrastructure and attract scientific talent to the Stockpile Stewardship Program
   • Support university programs and use of NIF, Omega, Z (~15% level)
ICF Campaign is a national effort

- Lawrence Livermore National Laboratory
  - *National Ignition Facility*
  - Glass laser technology development
  - Indirect drive ignition
  - Application of HED science to stockpile issues
  - Diode Pumped Solid State Laser

- Sandia National Laboratory
  - *Z/ZR pulsed power accelerator*
  - Physics of z-pinches and applications
  - Pulsed power technology development
  - High yield assessment

- Los Alamos National Laboratory
  - Trident glass laser
  - Indirect drive ignition
  - Application of HED science to stockpile issues

- University of Rochester / Laboratory for Laser Energetics
  - *Omega Upgrade glass laser*
  - Application of HED science to stockpile issues (with LLNL/LANL)
  - Direct drive physics assessment

- Naval Research Laboratory
  - Nike KrF laser
  - Use of smooth beams for physics
  - Direct drive target design
  - KrF laser technology development

- General Atomics
  - Target fabrication
  - Cryogenic technology target handling

- Academic Alliances Program
# ICF FY 2005 Budget

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<tr>
<th>Dollars in Millions</th>
<th>FY05 Request</th>
<th>FY05 Enacted</th>
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<td>69,437</td>
<td>(7,000)</td>
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<td>C10.9 NDP</td>
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<td>NIF 96-D-111 Const Total</td>
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<tr>
<td>Total NIF Project</td>
<td>243,700</td>
<td>225,700</td>
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<td>Total ICF Program</td>
<td>492,034</td>
<td>541,034</td>
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ICF FY 2005 Budget
(Summary of FY 2005 Congressional actions)

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- C10.1  Ignition activities reduced by $7M
- C10.3  $5M added for development of beryllium targets
- C10.4  $1M added to UNR for laser-magnetized plasma interaction studies
- C10.8  $25M added for development of high-average power lasers
- C10.8  $9M added for second shift operations on Z and Z Inertial Fusion Energy
- C10.9  NIF assembly, installation and activation activities reduced $18M
- C10.10 $28M added for Omega EP
- C10.10 $3M University of Texas; $2M University of Nevada, Reno; $1M for Z Petawatt Consortium
- RTBF  $13M added to Z Beamlet laser
The National Ignition Facility

First experiments occurred at NIF in 2004 and were a major success
NNSA has set Ignition 2010 as a major goal
Defense Science Board Task Force on NIF Activation and Early Use Plan

• Task force members:
  • Chair: Gen. Larry Welch (ret.) (IDA)
  • J. Foster (Technology Strategy/Alliances)
  • H. Grunder (ANL)
  • D. Hammer (Cornell)
  • T. Hardebeck (SAIC)
  • B. Press (LANL)
  • R. Wagner (LANL)
  • J. Dahlburg (NRL, Govt. advisor)
  • R. Bleach (OSD, Govt. advisor)
  • S. Stoner (OSD, Govt. advisor)
  • C. Keane (NNSA, Exec. Secretary)

Major findings of the DSB Task Force

- The NIF capability is a major component of the U.S. Stockpile Stewardship Program to assess and certify the future stockpile. NIF capabilities will also be a major contributor to advancing the science of astrophysics.

- The distinction between “ignition” and “weapons physics” is not valid or useful and should be removed.

- Ignition on NIF is a “breakthrough” capability. With it we can begin to probe weapon phenomena associated with thermonuclear burn and thus address the most important remaining question in weapon physics.

- The Task Force believes the NIF Activation and Early Use Plan, in its current stage of development, is being competently executed and provides the best approach to achieving ignition on the planned schedule.

- Additional detail and planning are needed in the area of risk mitigation for ignition. (Note: formation of federal advisory committee for ICF recommended)

- There is a need to transition from the intense central management required to build NIF to a collaborative approach appropriate for implementing an integrated national program.
The OMEGA laser produces > 1400 target shots/year

- 60 beams
- >30 kJ UV on target
- 1%-2% irradiation nonuniformity
- Flexible pulse shaping
- Short shot cycle (1 h)

A record number of shots was executed in FY 2004
OMEGA Extended Performance (EP) Project

- Add two high-energy petawatt lasers for advanced backlighting and fast-ignition experiments
- $67M total estimated cost, 5 year schedule ($33M appropriated through FY04)
- University of Rochester to provide new $20M building, State of New York to fund $2M target chamber
- CD-3 (Start Construction) approved May 2004

<table>
<thead>
<tr>
<th></th>
<th>Pulse duration</th>
<th>Pulse Energy</th>
<th>Power</th>
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<tbody>
<tr>
<td>Petawatt beams</td>
<td>$10^{-10}$-$10^{-12}$ sec</td>
<td>2500 joules</td>
<td>25 Terawatt-2.5 Petawatt</td>
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<tr>
<td>Long pulse beams</td>
<td>$10^{-8}$-$10^{-9}$ sec</td>
<td>6000 joules</td>
<td>0.6 Terawatt-6 Terawatt</td>
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</table>
Direct drive could achieve ignition while the NIF is in the x-ray-drive configuration.
Nike is examining issues central to defining the physics requirements for direct drive ICF

Example: thin high-Z layers substantially reduce the effects of laser non-uniformity

CH target (single beam “foot”)

CH with 120 nm Pd (single beam “foot”)
The Z Refurbishment Project will enable z-pinch implosions to produce over 2.5 MJ and 300 TW of x rays.

- ZR facility refurbishment in progress
- $61.7M total estimated cost, 4-5 year schedule
- Funded through Readiness in Technical Base and Facilities (RTBF)
- CD-3 approved 9/04

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<tr>
<th>FY02</th>
<th>FY03</th>
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<th>FY05</th>
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<td><img src="image1" alt="Machine Architecture Development" /></td>
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<td><img src="image3" alt="Power Flow, Infrastructure Design/Fab" /></td>
<td><img src="image4" alt="SATPro on Z20" /></td>
<td><img src="image5" alt="Production Design/Fab" /></td>
<td><img src="image6" alt="Hardware Installation in Z" /></td>
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**Notes:**
- CD0: CD1
- CD2: CD3
- CD4

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The Z-Beamlet laser is being upgraded to provide a 2-4 kJ, 1-10 psec short pulse laser for high energy radiography and fast ignitor experiments on Sandia’s Z facility beginning in 2007.

A stand alone 50 J, 0.5 - 10 psec prototype laser system will begin operation in 2005.
Natl. Academy reports state ICF/High Energy Density Physics is an exciting and rapidly evolving field

“Frontiers in High Energy Density Physics” (R. Davidson et al.)

“...research opportunities in this crosscutting area of physics are of the highest intellectual caliber and are fully deserving of the consideration of support by the leading funding agencies of the physical sciences.”

“Connecting Quarks with the Cosmos: Eleven Science Questions for the New Century” (M. Turner et al.)

“Discern the physical principles that govern extreme astrophysical environments through the laboratory study of high energy density physics. The Committee recommends that the agencies cooperate in bringing together the different scientific communities that can foster this rapidly developing field.”

University activities are supported via the Stockpile Stewardship Academic Alliances Program (SSAA)

- NNSA has expanded initial HEDP component in SSAA in response to National Academy Reports
  - From $3M to $4M/yr for grants, 1 new center of excellence
- Planning for an annual SSAA solicitation.
  - Typical grant is for 3 years. (Annual performance evaluation)
  - Approx. one-third of all grants competed each year. (~ $3 M/year)
  - Periodic solicitation for Centers of Excellence (multiple years)
- Fellowship program (under consideration)

Watch DOE electronic solicitation web page: http://e-center.doe.gov
Browse financial assistance opportunities
Summary- major points

• ICF Program continues to make strong technical progress
  • First experiments conducted at NIF
  • Ignition outlook promising
  • First thermonuclear neutrons at Z
• DSB report affirms value of NIF and Ignition to weapons mission
• Ignition 2010 is a major goal –this will require sustained focus and enhanced management discipline
• NAS recognizes High-Energy-Density Physics as an important emerging scientific field