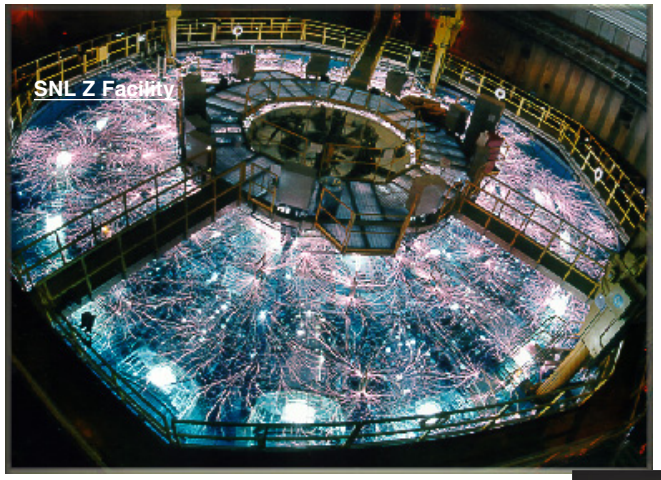
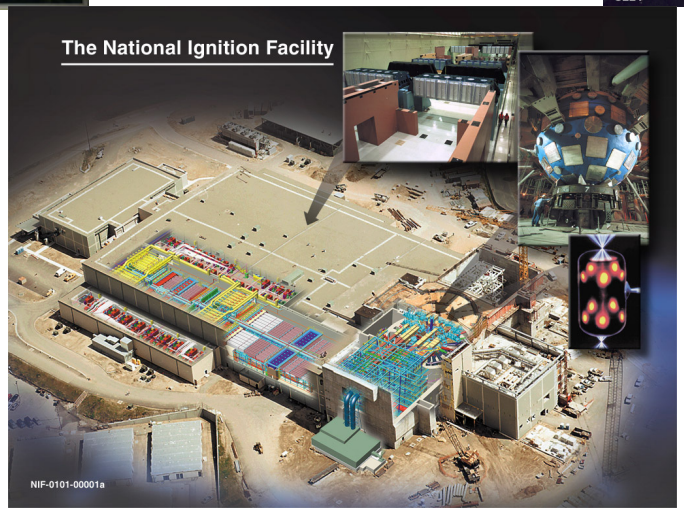
NNSA Defense Programs

Inertial Confinement Fusion Ignition and High Yield Campaign



National Nuclear Security Administration



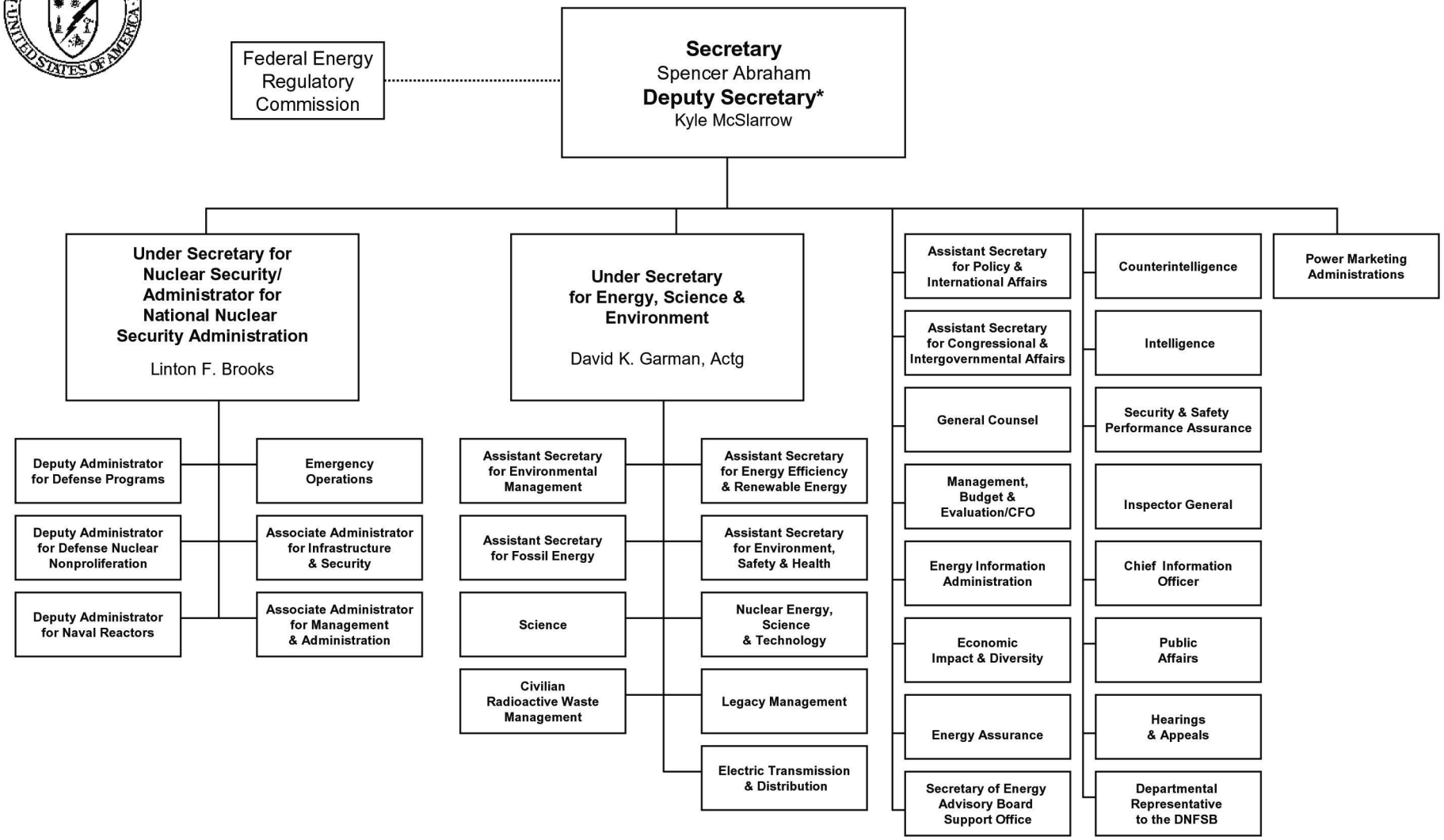
Presented by:
Dr. Christopher J. Keane
Acting Assistant Deputy Administrator for
Inertial Confinement Fusion and the NIF Project

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



* The Deputy Secretary also serves as the Chief Operating Officer

2 MAY 04

Deputy Administrator
Dr. Everet H. Beckner
Principal Assistant Deputy Administrator for Military Application
Brigadier General Ronald J. Haeckel, USAF
NA-10

National Nuclear Security Administration

Assistant Deputy Administrator for Research, Development and Simulation
Dr. David H. Crandall
Deputy for Technical Direction
Joseph J. Maguire
NA-11

- **Office of Defense Science** — Director: James Van Fleet — **NA-113**
- **Office of Advanced Simulation & Computing** — Director: Dr. Dimitri F. Kusnezov — **NA-114**
- **Office of Stockpile Assessments & Certification** — Acting Director: Dr. Kevin C. Greenaugh — **NA-115**
- **Office of Institutional & Joint Programs** — Acting Director: Michael E. Long — **NA-116**
- **Office of Facilities Management & ES&H Support** — Director: Michael A. Thompson — **NA-117**
- **Office of Pit Projects** — Director: Dr. Jerry M. Freedman — **NA-118**

Acting Assistant Deputy Administrator for Military Application and Stockpile Operations
Martin Schoenbauer
Deputy Assistant Deputy Administrator
Antonio Tavares
NA-12

- **Office of Nuclear Weapon Surety and Quality** — Director: Colonel Greg Boyette , USAF — **NA-121**
- **Office of Nuclear Weapons Stockpile** — Acting Director: Joseph Gazda — **NA-122**
- **Office of Stockpile Technology** — Director: Roger Lewis — **NA-123**
- **Office of Operations and Construction Management** — Director: Xavier Ascanio — **NA-124**

Assistant Deputy Administrator for Program Integration
Thomas P. D'Agostino
NA-13

- **Office of Strategic Planning and Analysis** — Director: Patrick J. Higgins, Jr. — **NA-131**
- **Office of Planning, Budgeting, and Integration** — Director: Terry D. Bearce — **NA-133**

Assistant Deputy Administrator for Secure Transportation*
Steve Hafner
Office of Headquarters Liaison Director
Michael A. Connor
NA-15

- **Office of Mission Operations** — Manager*: Mike Flynn — **NA-151**
- **Office of Support** — Manager*: Richard H. Richey — **NA-152**

Acting Asst. Deputy Administrator for Inertial Confinement Fusion and National Ignition Facility Project
Dr. Christopher J. Keane
NA-16

- **Office of Inertial Confinement Fusion** — Acting Director: Dr. Richard K. Thorpe — **NA-161**
- **Office of the NIF Project** — Acting Director: Scott L. Samuelson — **NA-162**

* = stationed in Albuquerque

SSP Programs & Facilities Provide Necessary Research Capabilities

National Nuclear Security Administration

Adv. Hydro Capability

(DARHT)

ICF Facilities
(NIF/OMEGA/Z)

Authority to Use

Arming, Fuzing, Firing

HE Detonation

Implosion

Fission Burn

Boosted Burn

Radiation Flow

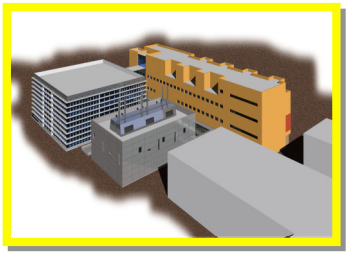
Implosion

Burn/Explosion

Effects

Militarily Effective Yield

Stockpile Stewardship Campaigns
Advanced Computing



Component Manufacturing
(MESA)

(ASCI 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

National Nuclear Security Administration

Dollars in Millions	FY05 Request	FY05 Enacted	FY05 Delta
C10.1 Ignition	76,437	69,437	(7,000)
C10.2 Support of Other Stockpile Programs	38,987	38,987	0
C10.3 NIF EST	44,023	49,023	5,000
C10.4 Pulsed Power ICF	10,080	11,080	1,000
C10.5 University Grants/Other Support	7,776	7,776	0
C10.6 NIF OPC	0	0	0
C10.7 Facility Ops & Target Production	63,056	63,056	0
C10.8 Inertial Fusion Energy Technology	0	34,000	34,000
C10.10 High-Energy Petawatt Laser Dev	7,975	41,975	34,000
Total ICF Base Program	248,334	315,334	67,000
C10.9 NDP	113,700	95,700	(18,000)
NIF 96-D-111 Const Total	130,000	130,000	0
Total NIF Project	243,700	225,700	(18,000)
Total ICF Program	492,034	541,034	49,000

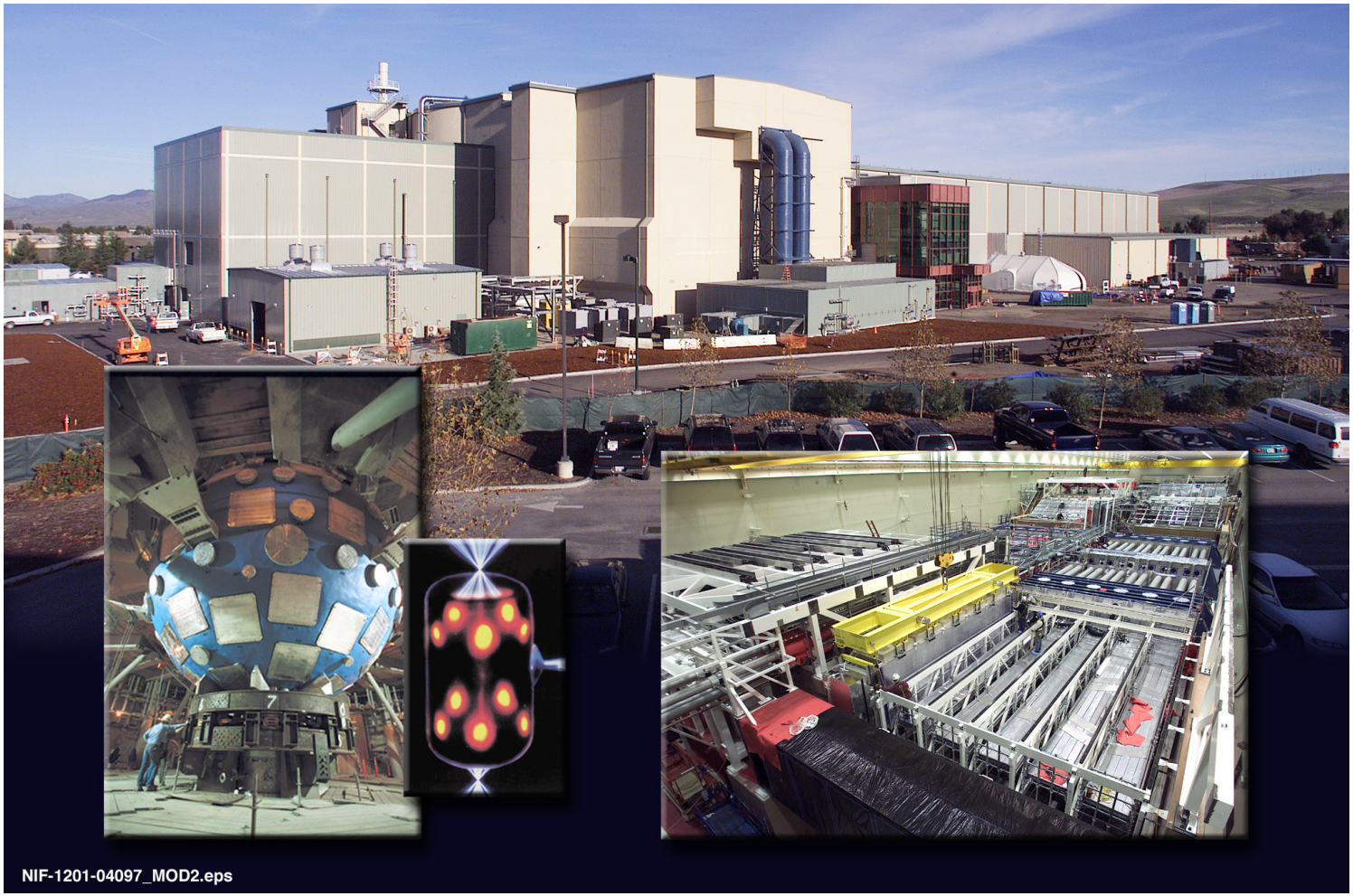
ICF FY 2005 Budget

(Summary of FY 2005 Congressional actions)

Congressional Actions	FY05 Request	FY05 Enacted	FY05 Delta
C10.1 Ignition	76,437	69,437	(7,000)
C10.3 NIF EST	44,023	49,023	5,000
C10.4 Pulsed Power ICF	10,080	11,080	1,000
C10.8 Inertial Fusion Energy Technology	0	34,000	34,000
C10.9 NDP	113,700	95,700	(18,000)
C10.10 High-Energy Petawatt Laser Dev	7,975	41,975	34,000

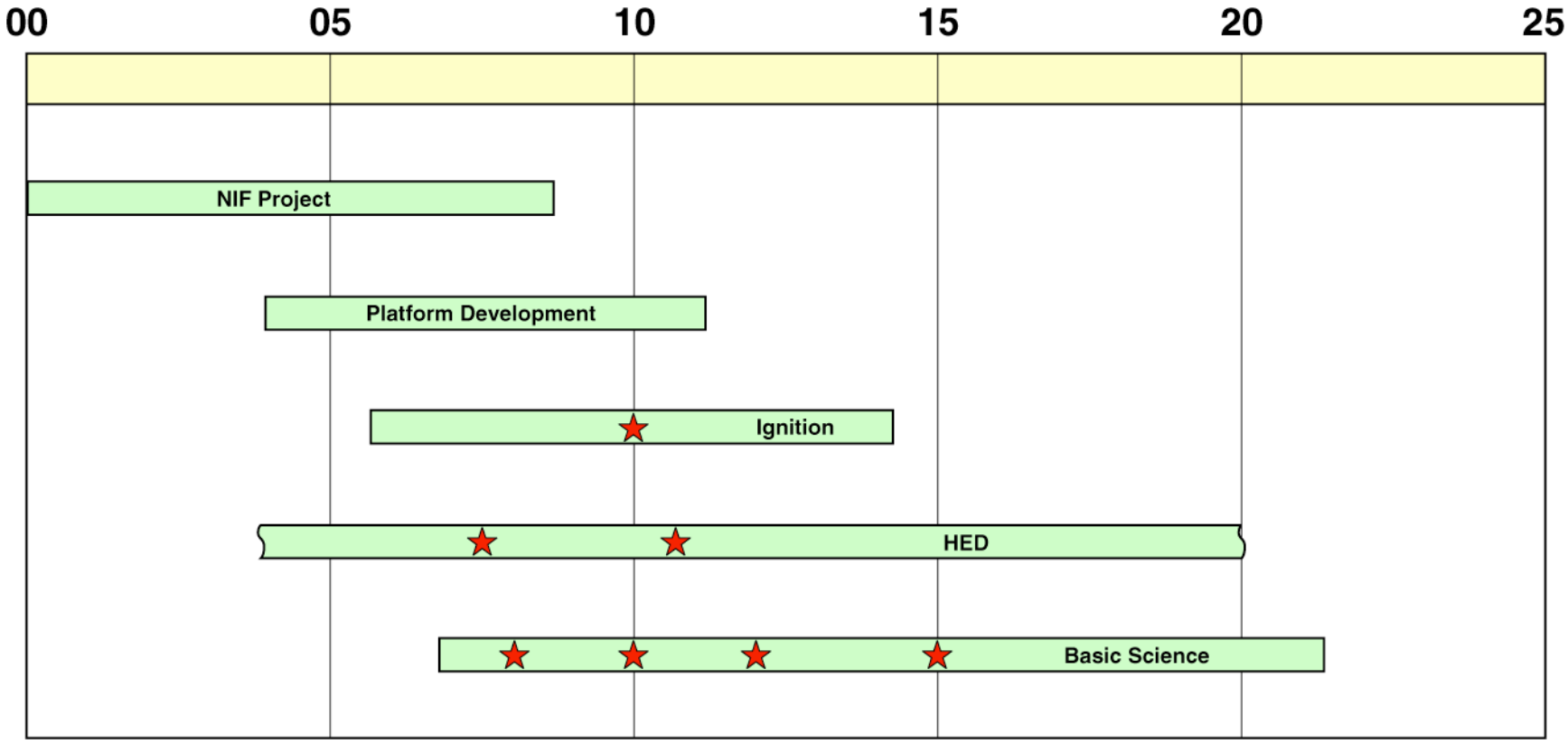
- C10.1 Ignition activities reduced by $7M
- C10.3 $5M added for development of beryllium targets
- C10.4 $1M added to UNR for laser-magnetized plasma interaction studies
- C10.8 $25M added for development of high-average power lasers
- C10.8 $9M added for second shift operations on Z and Z Inertial 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

NIF Activation and Early Use Plan- Defense Science Board Review



NNSA has set Ignition 2010 as a major goal

Defense Science Board Task Force on NIF Activation and Early Use Plan

National Nuclear Security Administration

- **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)

- **Report issued - http://www.acq.osd.mil/dsb/reports**

Major findings of the DSB Task Force

National Nuclear Security Administration

- 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.

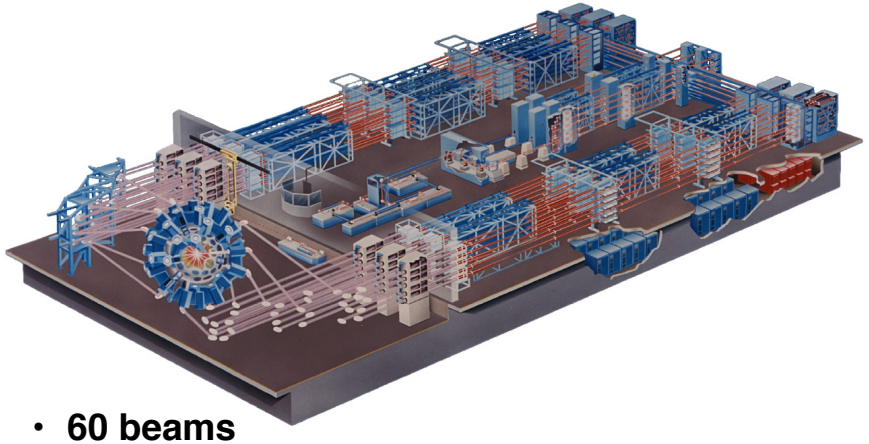
- Ignition on NIF is a “breakthrough” capability. With it we can begin to probe weapon phenomena associated with thermonuclear burn and **thus address the most important remaining question in weapon physics.**

- 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.

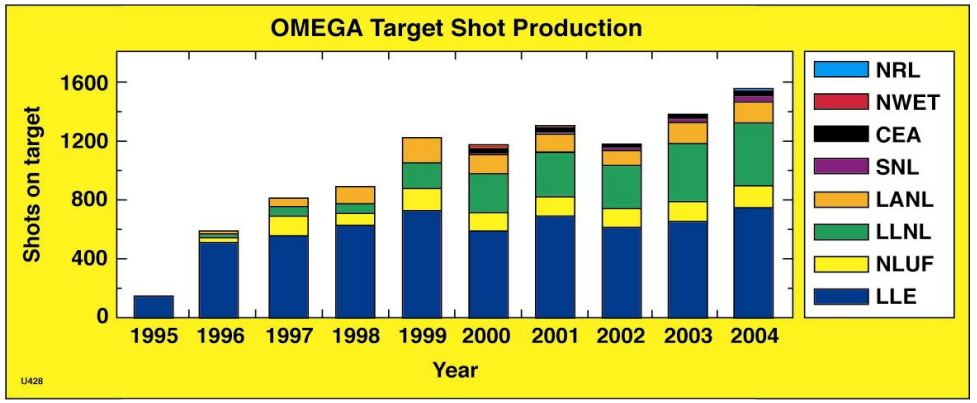
- Additional detail and planning are needed in the area of risk mitigation for ignition. (*Note: formation of federal advisory committee for ICF recommended)*

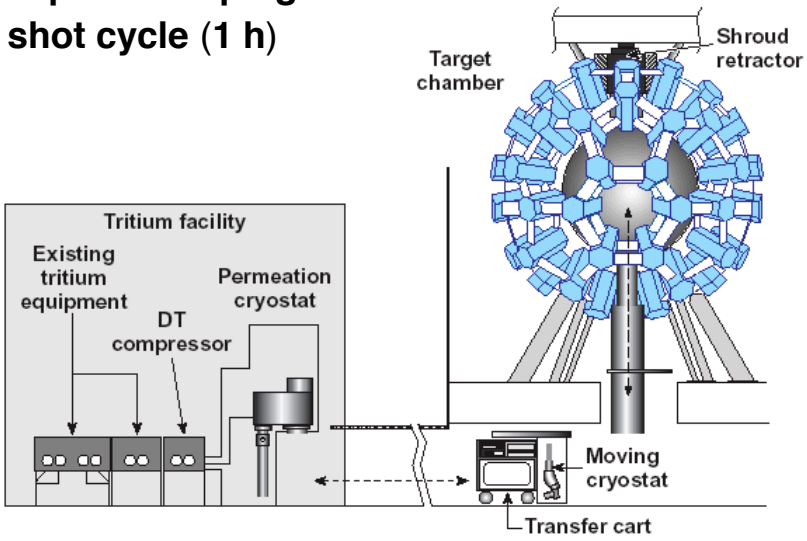
- There is a need to transition from the intense central management required to build NIF to a collaborative approach appropriate for implementing an integrated national program.

The OMEGA laser produces > 1400 target shots/year



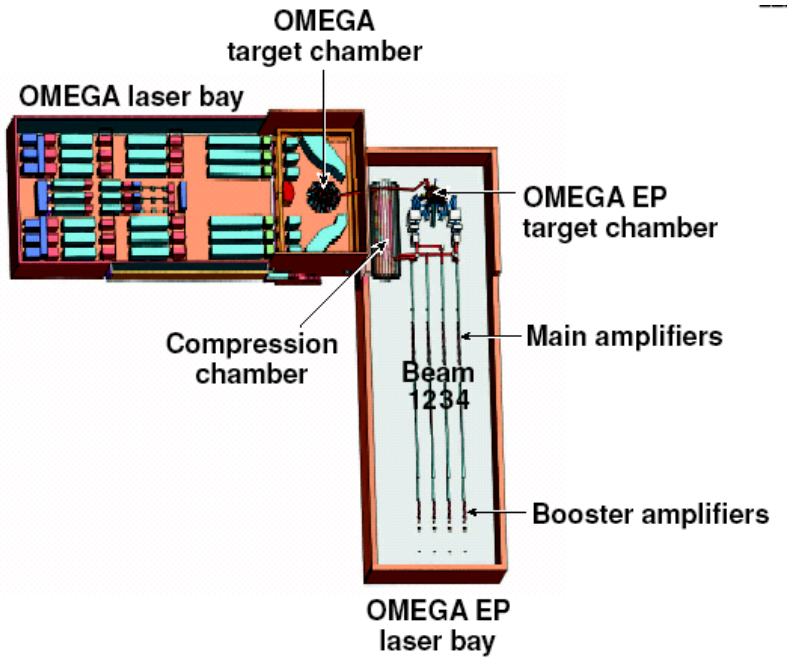
- 60 beams
- >30 kJ UV on target
- 1%-2% irradiation nonuniformity
- Flexible pulse shaping
- Short shot cycle (1 h)





A record number of shots was executed in FY 2004

OMEGA Extended Performance (EP) Project



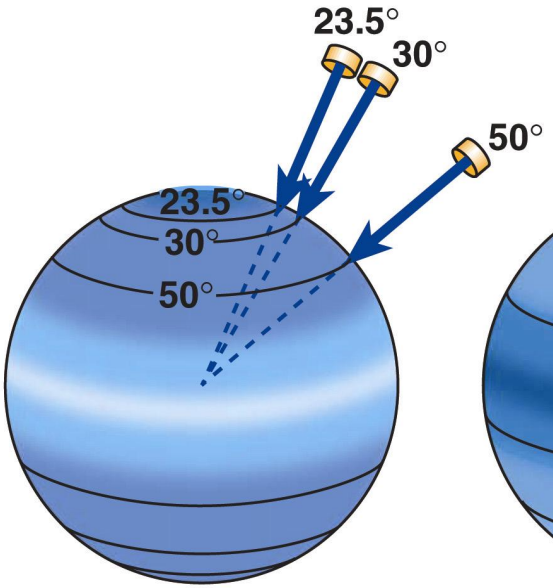
- Add two high-energy petawatt lasers for advanced backlighting and fast-ignition experiments
- $67M total estimated cost, 5 year schedule ($33M appropriated through FY04)
- University of Rochester to provide new $20M building, State of New York to fund $2M target chamber
- CD-3 (Start Construction)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

	Pulse duration	Pulse Energy	Power
Petawatt beams	**10^{-10}-10^{-12} sec**	**2500 joules**	**25 Terawatt-2.5 Petawatt**
Long pulse beams	**10^{-8}-10^{-9} sec**	**6000 joules**	**0.6 Terawatt-6 Terawatt**

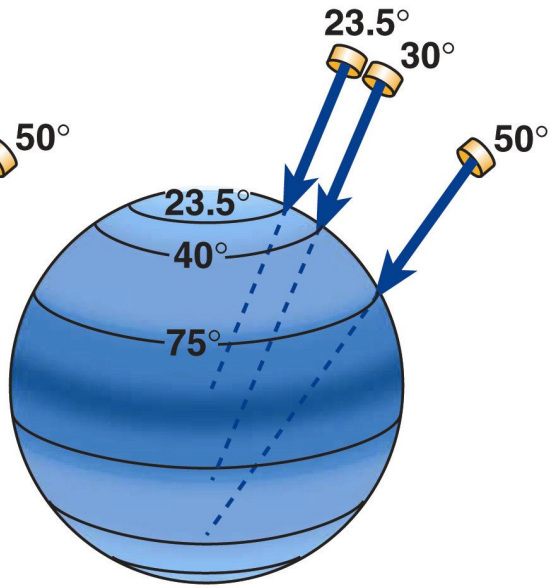
Direct drive could achieve ignition while the NIF is in the x-ray-drive configuration

National Nuclear Security Administration

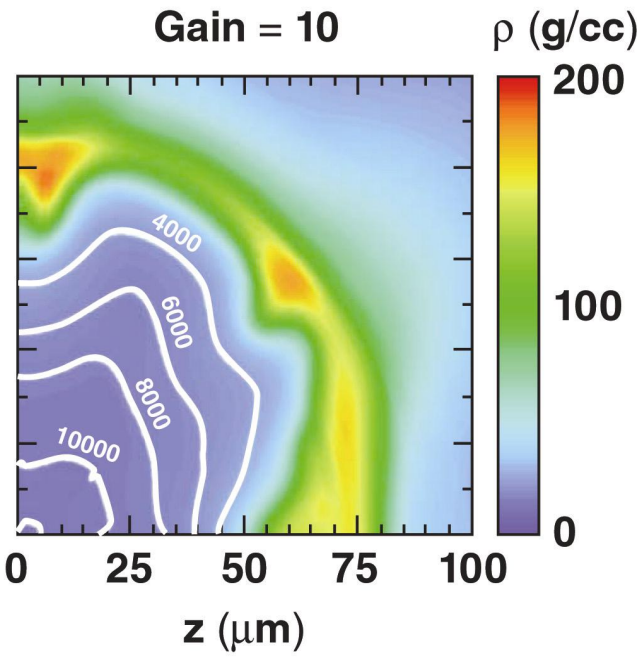
Standard pointing with x-ray-drive configuration



Repointing for PDD



2-D hydrodynamic simulations

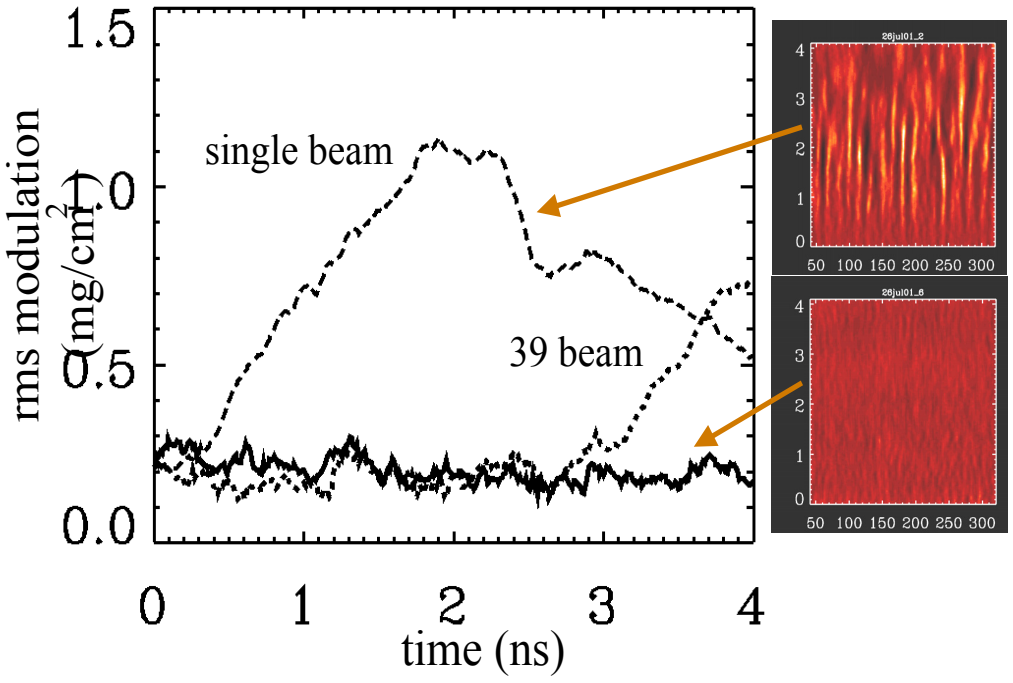


Higher gain results are being obtained with a higher velocity target design.

TC6631

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

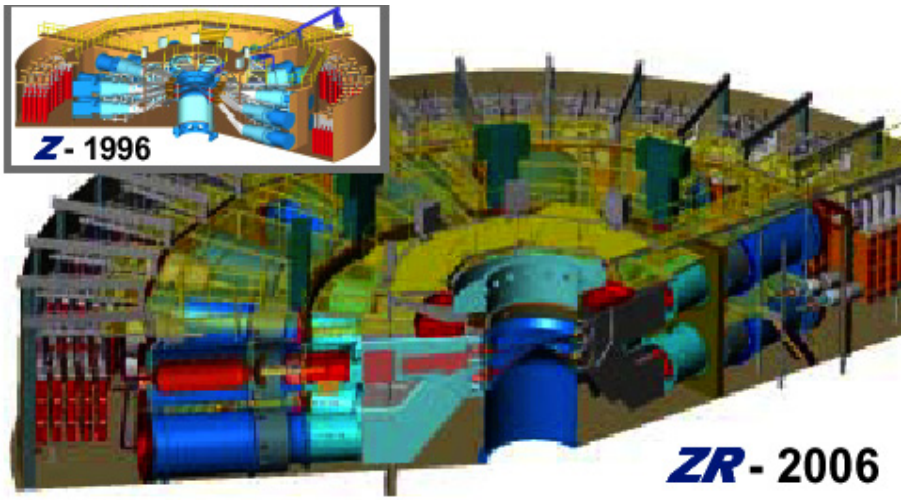


CH target
(single beam "foot")

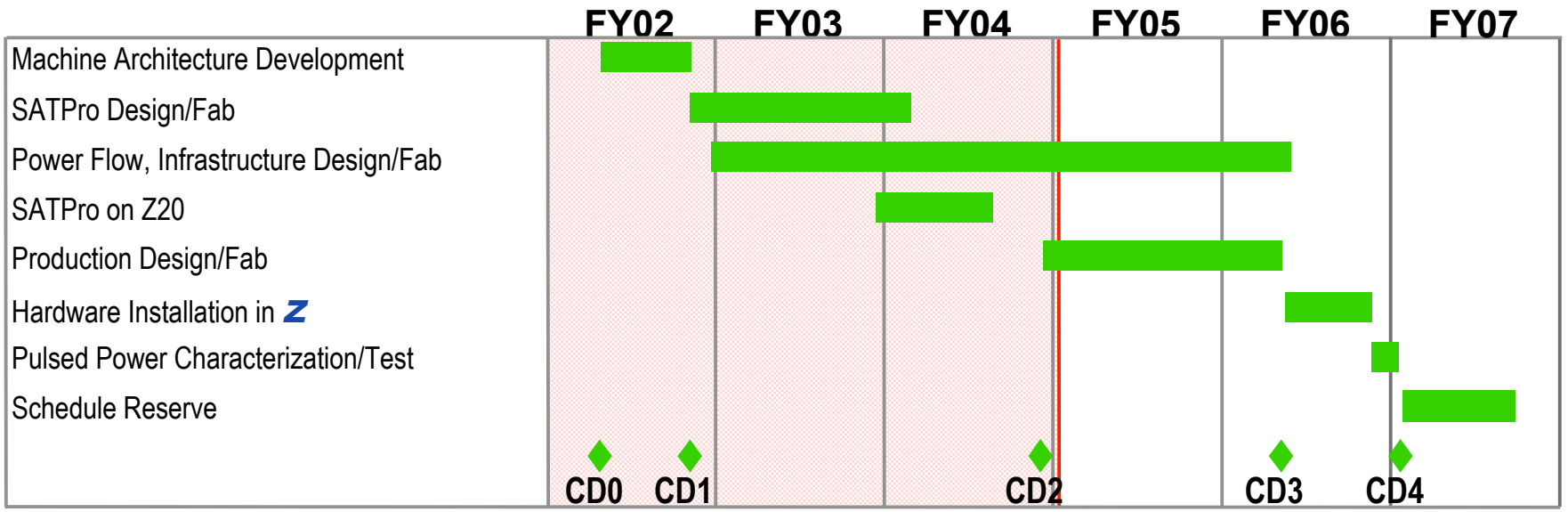
CH with 120 nm Pd
(single beam 'foot')

The Z Refurbishment Project will enable z-pinch implosions to produce over 2.5 MJ and 300 TW of x rays

National Nuclear Security Administration



- 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



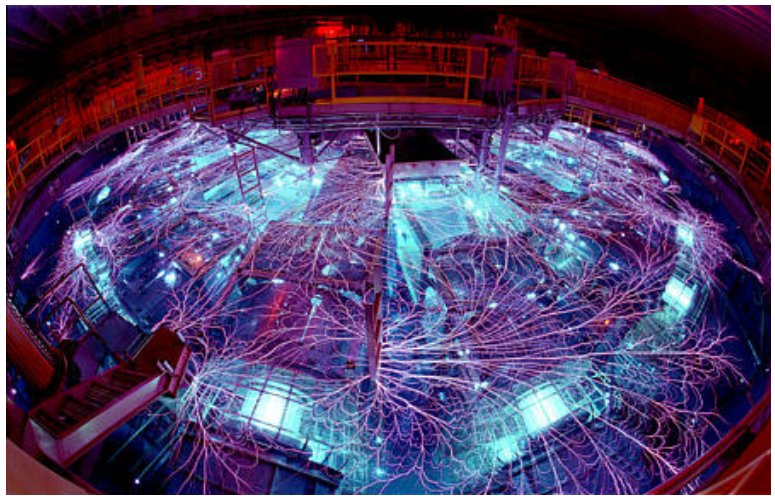
Z-Beamlet laser is being upgraded to provide a high energy PW laser for SNL's Z facility

National Nuclear Security Administration

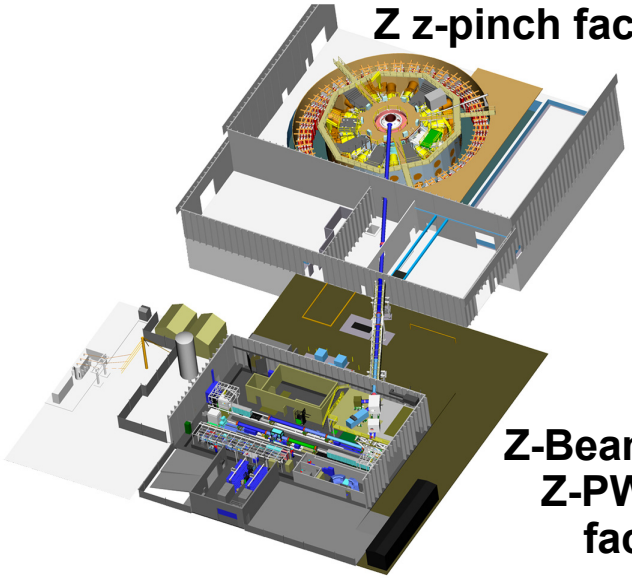
- The Z-Beamlet laser is being upgraded to provide a 2-4 kJ, 1-10 psec short pulse laser for high energy radiography and fast ignitor experiments on Sandia's Z facility beginning in 2007.

- A stand alone 50 J, 0.5 - 10 psec prototype laser system will begin operation in 2005.

Z multimegajoule z-pinch facility

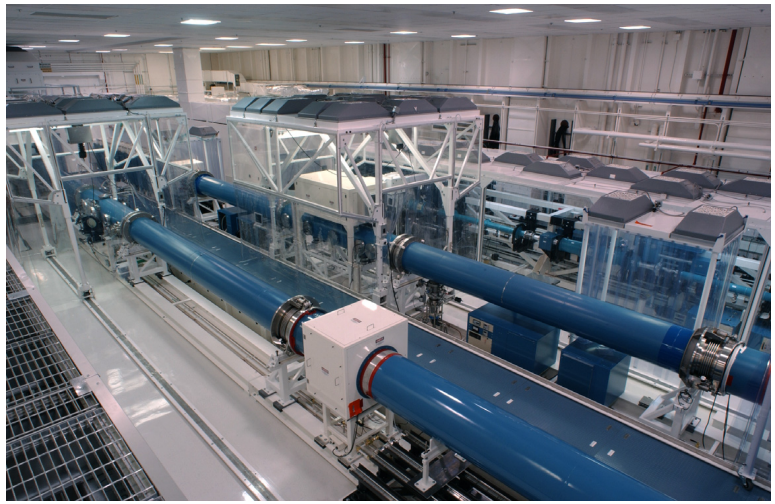


Z z-pinch facility



Z-Beamlet and Z-PW laser facility

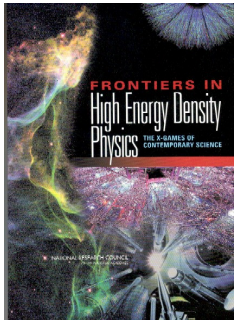
Z-Beamlet multikilojoule laser facility



Natl. Academy reports state ICF/High Energy Density Physics is an exciting and rapidly evolving field

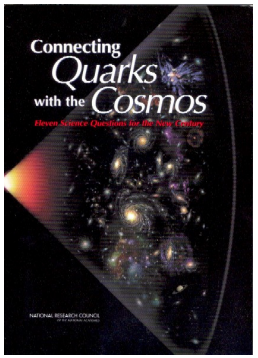
National Nuclear Security Administration

"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."

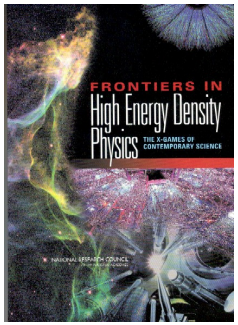
"Connecting Quarks with the Cosmos: Eleven Science Questions for the New Century" (M. Turner et al.)



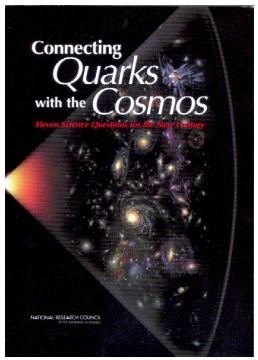
"Discern the physical principles that govern extreme astrophysical environments through the laboratory study of high energy density physics. The Committee recommends that the agencies cooperate in bringing together the different scientific communities that can foster this rapidly developing field."

Implementation document: **"A 21st Century Frontier of Discovery: The Physics of the Universe - A Strategic Plan for Federal Research at the Intersection of Physics and Astronomy" issued February 2004**

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