Status of the US National Inertial Fusion Program

Presentation to the Fusion Energy Sciences Advisory Committee Meeting

by:
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Director, Office of Inertial Confinement Fusion

March 1, 2006

The US Inertial Fusion Program has 3 principal components

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- The first ignition experiment on the National Ignition Facility in 2010
- Pulsed Power fusion experiments with the goal of high yield
- High energy density experiments related to the “Fast Ignition” concept for ICF

NNSA has a vigorous program of Activity in ICF

- **The next 10 years will offer major new opportunities for inertial fusion and high energy density physics**
  - NIF 81% complete, first ignition experiments planned for 2010
  - Ignition confidence increasing (direct and indirect drive)
  - Strong progress in pulsed power fusion- fuel and symmetry conditions
  - Petawatt lasers open new programmatic and scientific opportunities
  - Important new scientific capabilities coming in FY2007- OMEGA EP, refurbished Z, Z-Beamlet PW

- **High energy density physics is recognized as an important and emerging scientific field**
  - NAS, OSTP reports
  - Interagency working group

- **University activities continue to play an important role**
  - Recent SSAA solicitation- awards nearly complete
  - User group for high energy density physics (HEDSUP)

The National Ignition Facility is 85 % complete

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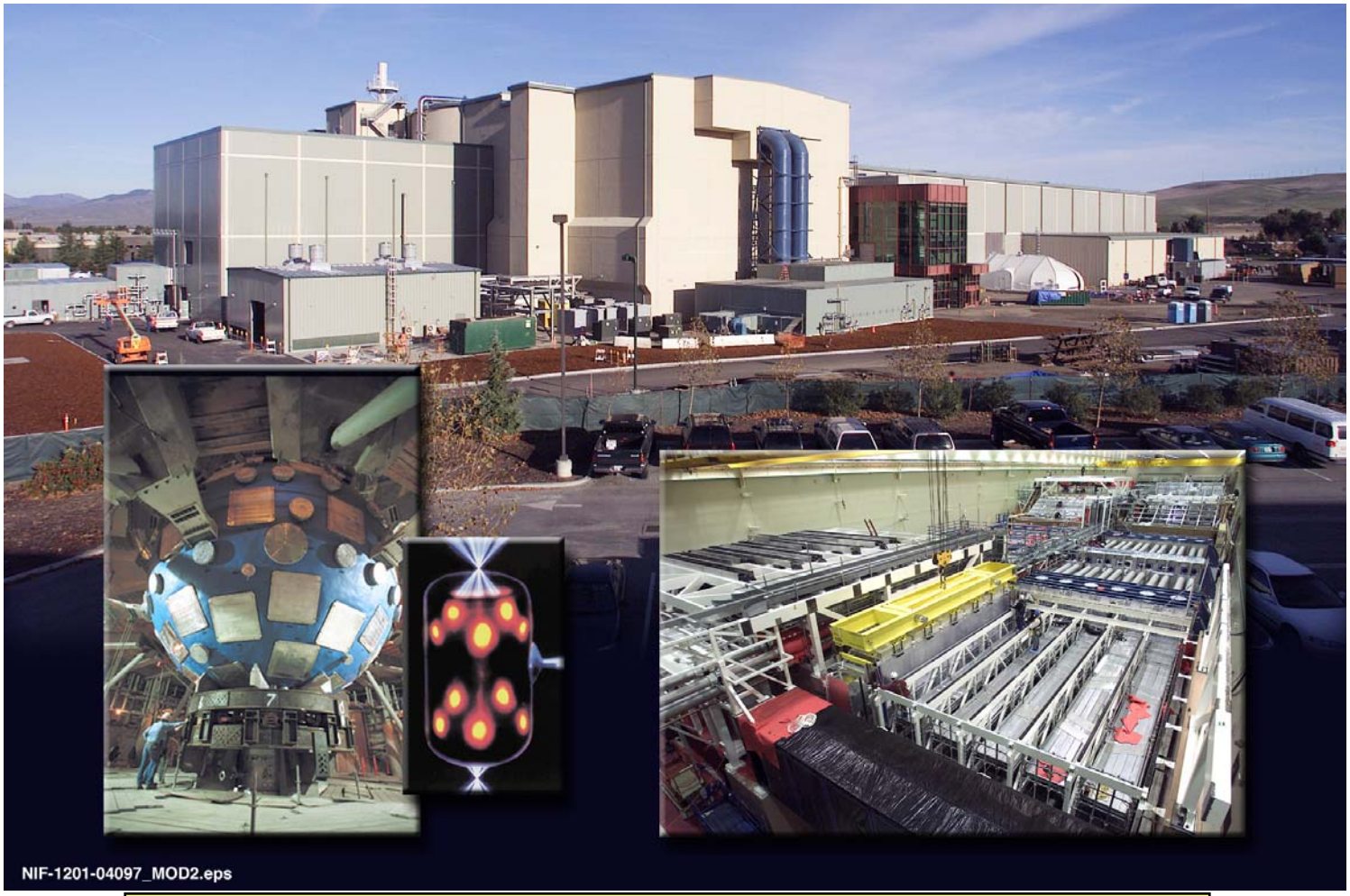
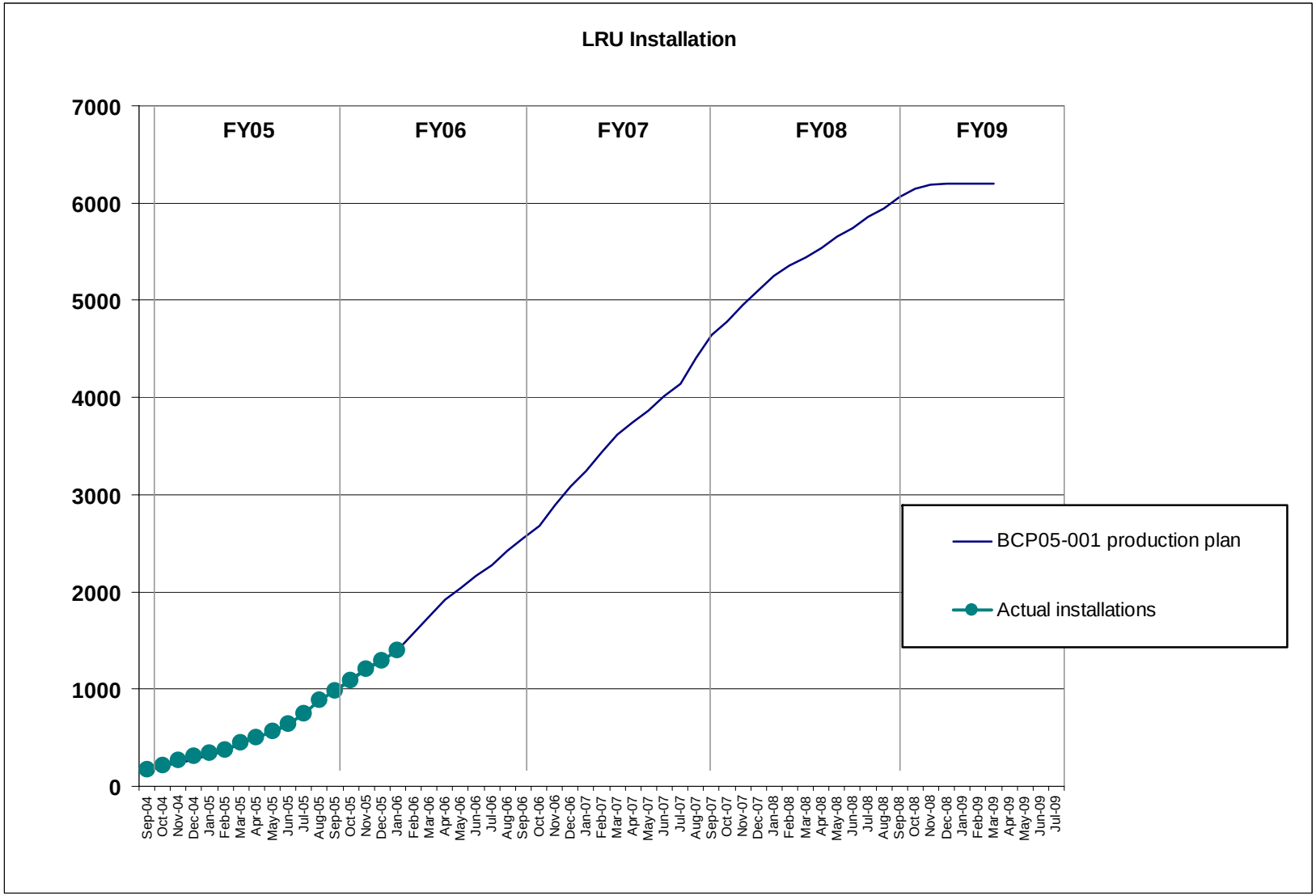


NIF concentrates 1.8 Mega Joules of energy into a mm^3 size target through the use of advanced laser technology

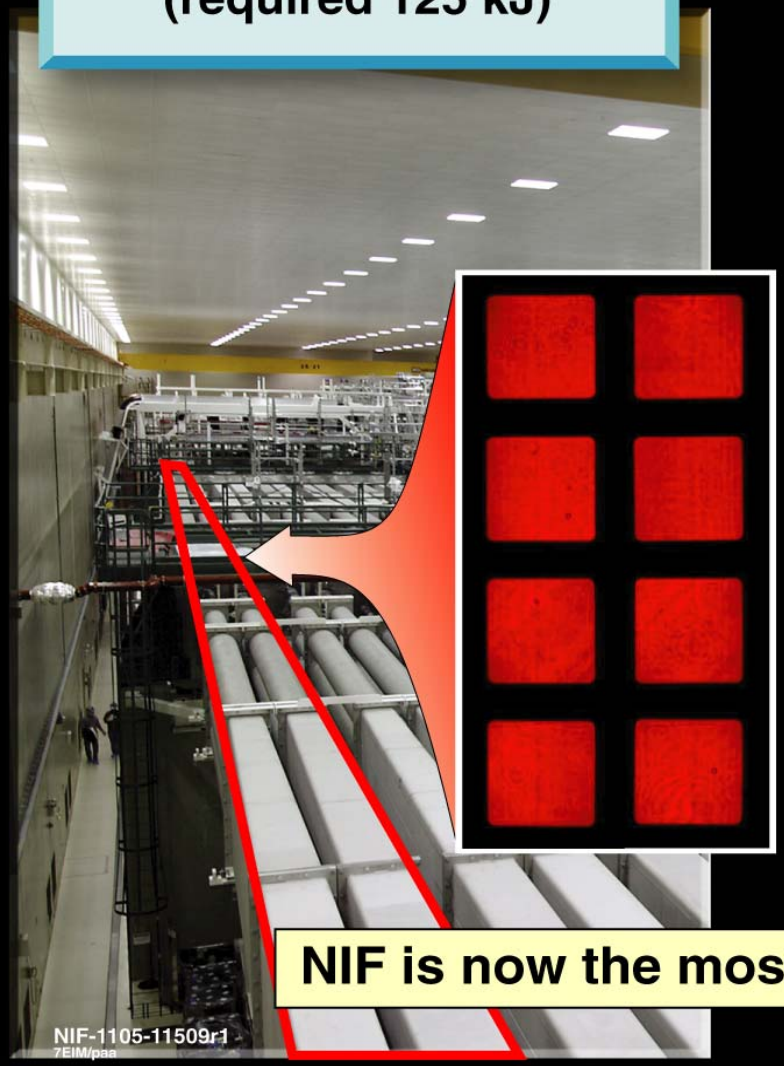
A tangible demonstration of progress is the insertion rate of modular units - LRUs



1st Bundle
Operated at
152 kJ
(required 125 kJ)

NATIONAL
IGNITION
FACILITY

1,600 of 6200 LRUs
Installed on schedule



NIF is now the most energetic pulsed laser

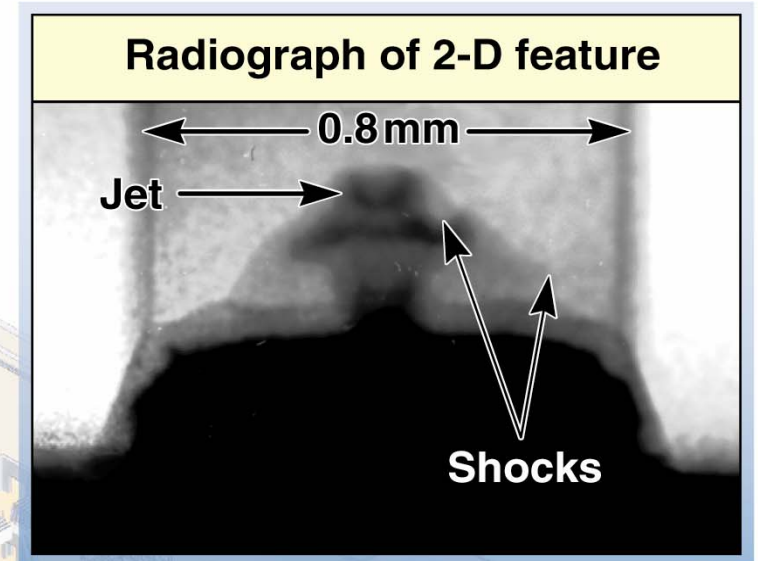
NIF-1105-11509r1
7EIM/paa

NIF has executed over 400 experiments

National Nuclear Security Administration

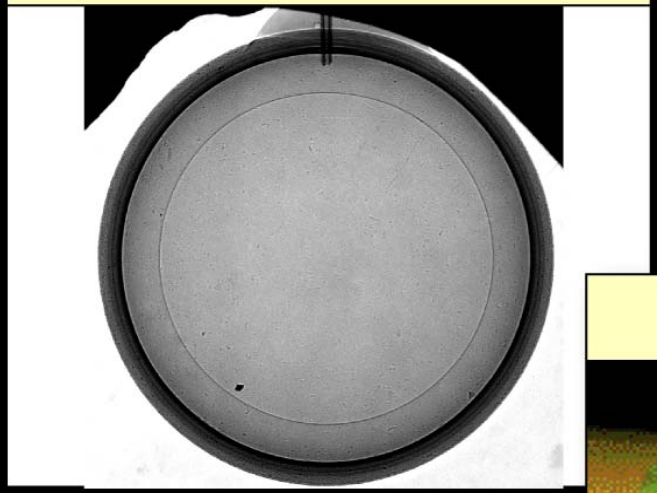
Hydrodynamic experiment: (FY 2004)

- Challenges our 2- and 3-D code capabilities
- Demonstrates our ability to do complex experiments on NIF
- Uses sophisticated target, diagnostic, and laser alignment providing great accuracy and reproducibility



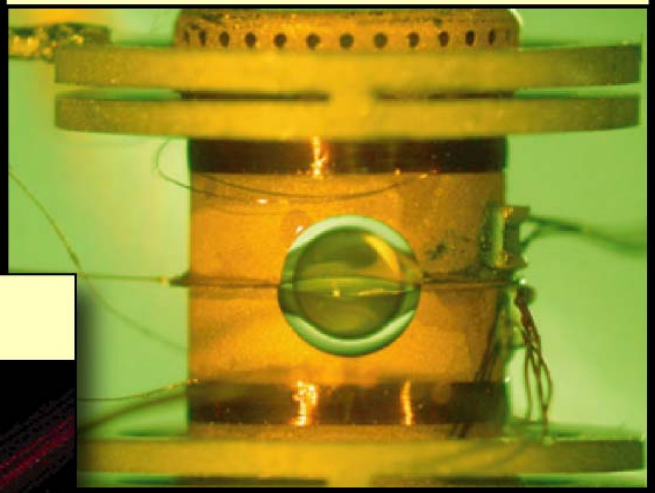
Full single beam performance has been demonstrated

Cryogenic System

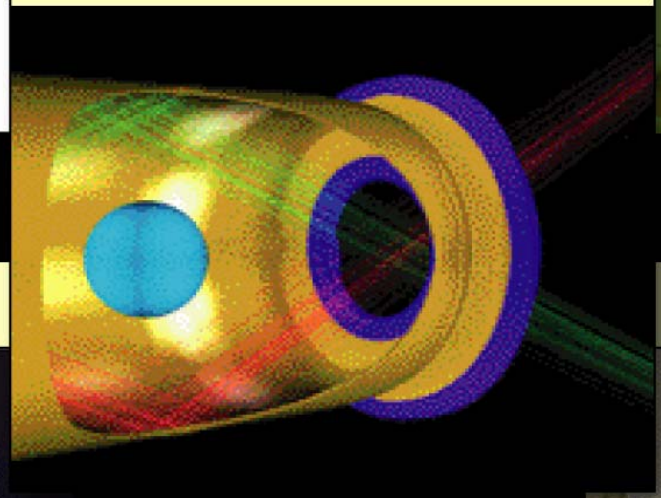


NIC

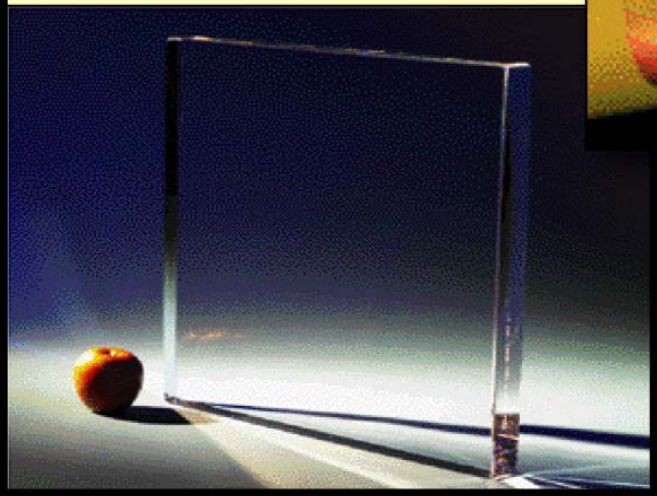
Target Fabrication



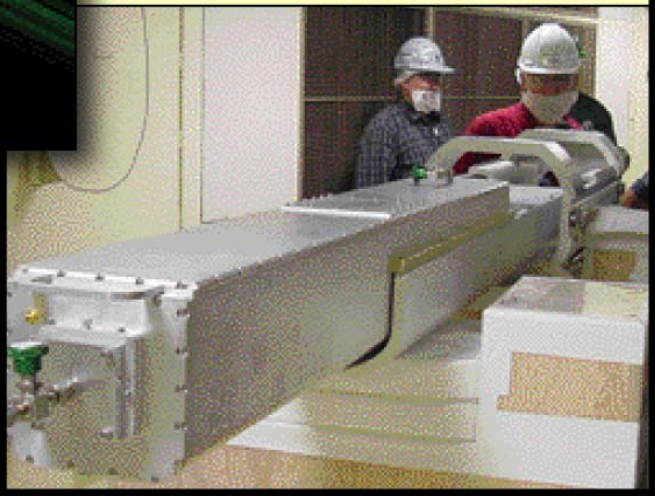
Target Design



User Optics



Diagnostics



NIF-1105-11560
15EIM/cds

P9895

The “phase space” over which NIF targets are expected to ignite has expanded

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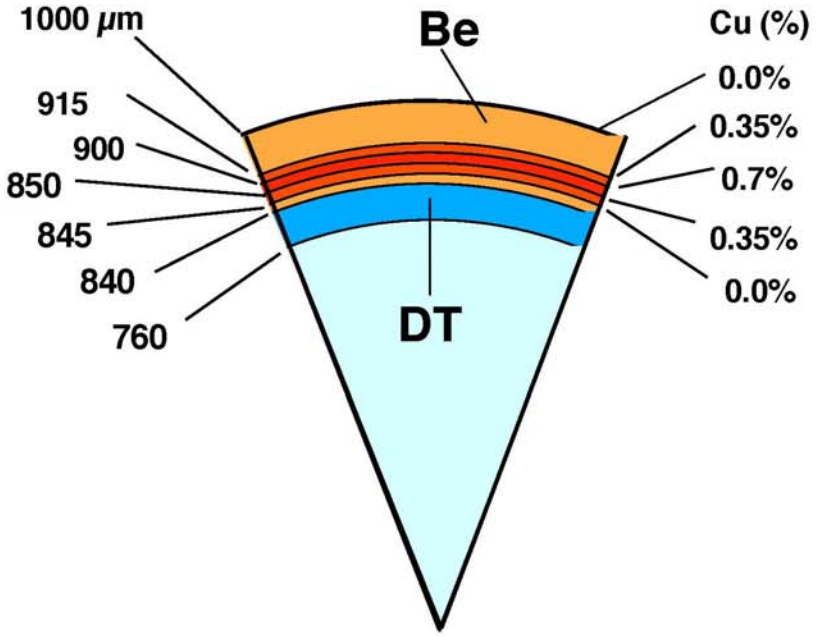
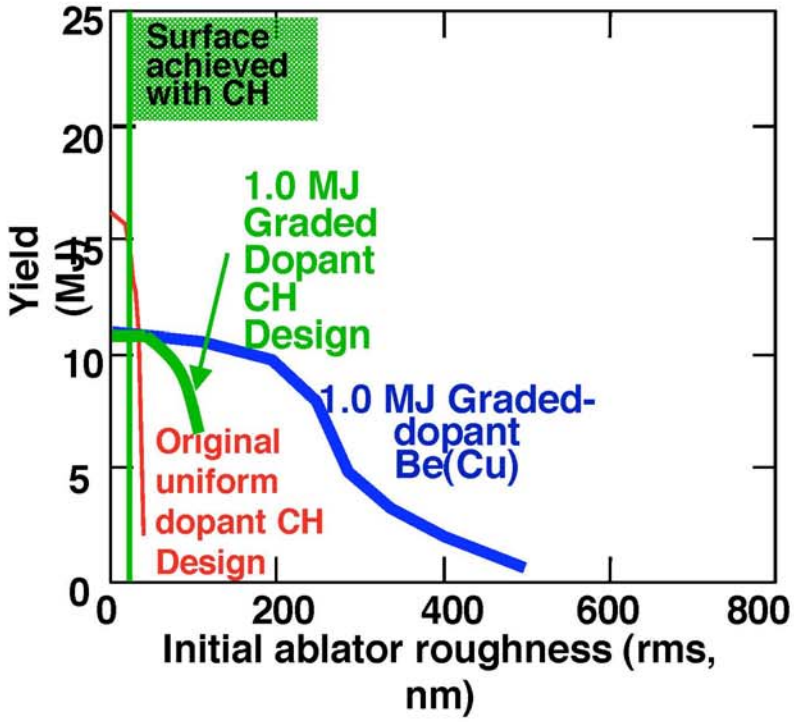
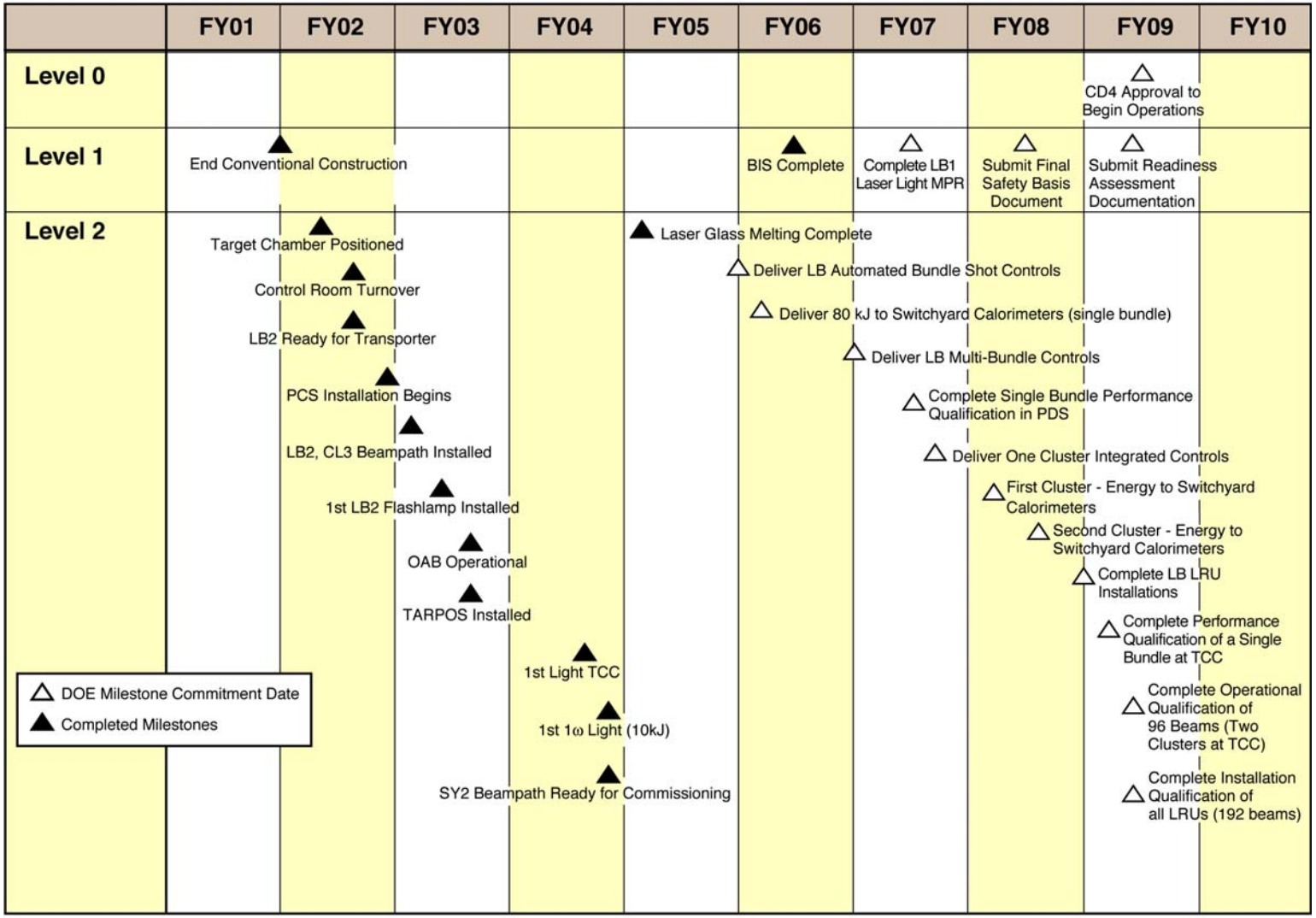
300 eV design:





Be is also about 2x more tolerant to ice roughness

The revised NIF Project baseline completes in Q2FY2009 and supports Ignition 2010



NIF-0402-04478_r12.ai
052605/cc

A national ignition plan has been signed by the sites and NNSA

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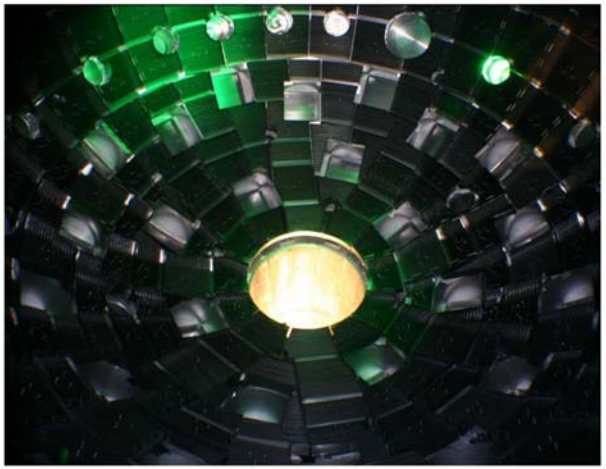
National Ignition Campaign Execution Plan

June 2005

National Nuclear Security Administration

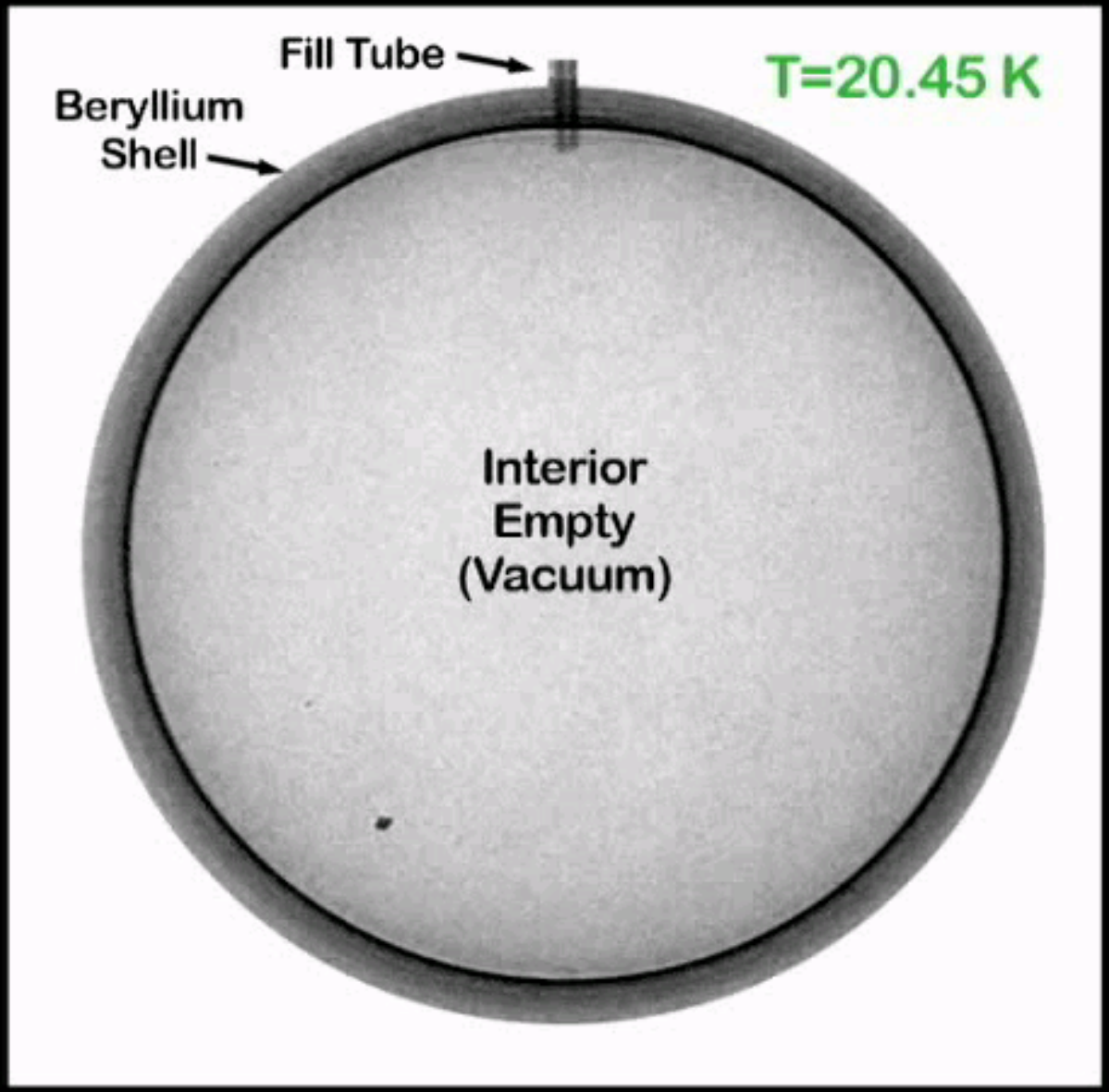


Los Alamos NATIONAL LABORATORY · GENERAL ATOMICS · UR LLE

	FY05	FY06	FY07	FY08	FY09	FY10	FY11
Level 0	National Ignition Campaign			Begin first integrated ignition experiments △			
Level 1	National Ignition Campaign			Ready for 1 MJ operations △ Begin FY10 target performance experiments △		Ready for 1.8 MJ operations △	
Level 2	National Ignition Campaign			Complete hazardous materials MPR △ Complete tritium/neutron production MPR △		Complete first ignition experiments MPR △	
	Systems Engineering			△ Facility requirements for FY10 ignition experiments under CM Complete laser performance and facility impacts review △		Complete LPOM power balance calibration △	
	Target Physics	△ Place ignition point design under CM		△ Begin hohlraum energetics experiments with smoothed beams on OMEGA △ Specify laser irradiance requirements		△ Complete Title II design review for FY10 ignition target △ Validate convergent shock timing on OMEGA	Complete FY10 target performance experiments △

	FY05	FY06	FY07	FY08	FY09	FY10	FY11
Level 2	Integrated Target Systems	△ Complete cryogenic Title I design △ Demonstrate scientific prototype capsules		△ Demonstrate scientific prototype capsules with fill tubes △ Complete cryogenic Title II design	△ Demonstrate engineering prototype ignition target △ Demonstrate engineering prototype target layering △ Qualify cryogenic target production	△ Complete IQ of cryogenic sys*	
	Diagnostics	△ Place ignition diagnostics requirements under CM		△ Complete initial target illumination characterization diagnostics Complete full target illumination characterization diagnostics △ Complete diagnostics for FY10 target performance experiments △		Complete ignition implosion diagnostics △	
	User Optics	△ Begin PS crystal growth		△ Begin CPP imprinting △ Begin DDS production		△ Comp. user optics for FY10 exps.	
	Personnel and Environmental Protection Systems			△ Complete PEPS Title I design	△ Complete PEPS Title II design Complete PEPS IQ for tritium operations* △	Complete PEPS IQ for first ignition experiments* △	

△ DOE Milestone Commitment Date
*Installation Qualification (IQ): Systems are installed, aligned, and under computer control (if required).
Some titles have been abbreviated for this chart, full titles are contained in Appendix E, Table E-1.


Fill Tube
T=20.45 K
Beryllium
Shell
Interior
Empty
(Vacuum)

Direct drive (uniform and "polar") is also being developed for NIF

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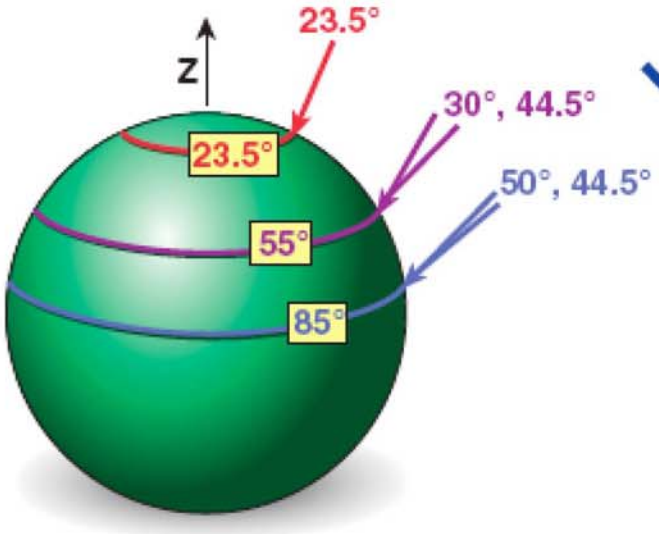
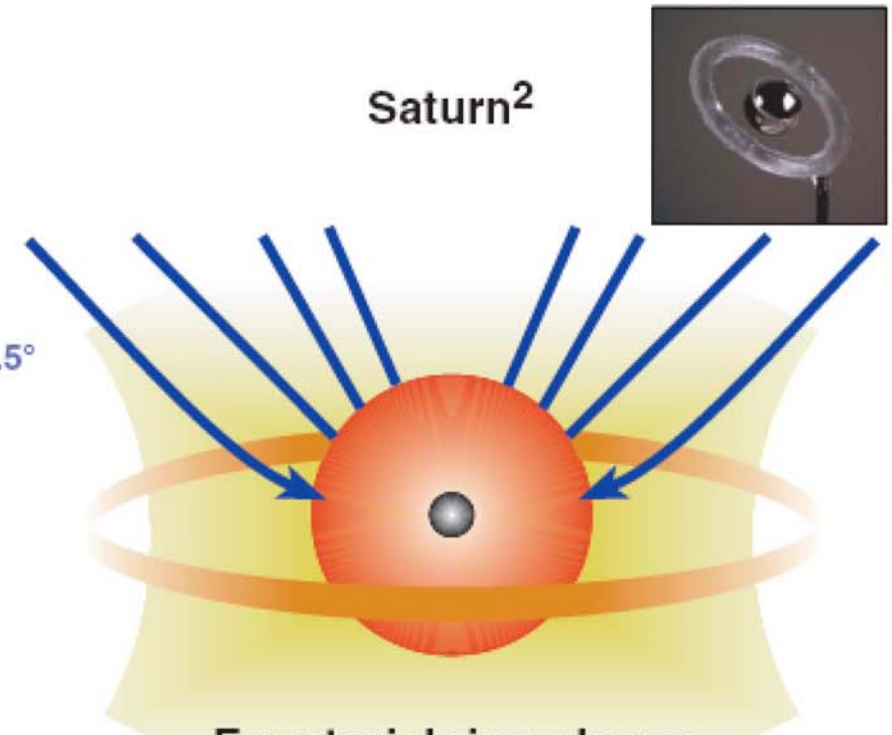
Standard PDD[1]



NIF x-ray drive beams
are re-pointed towards equator.

Saturn[2]



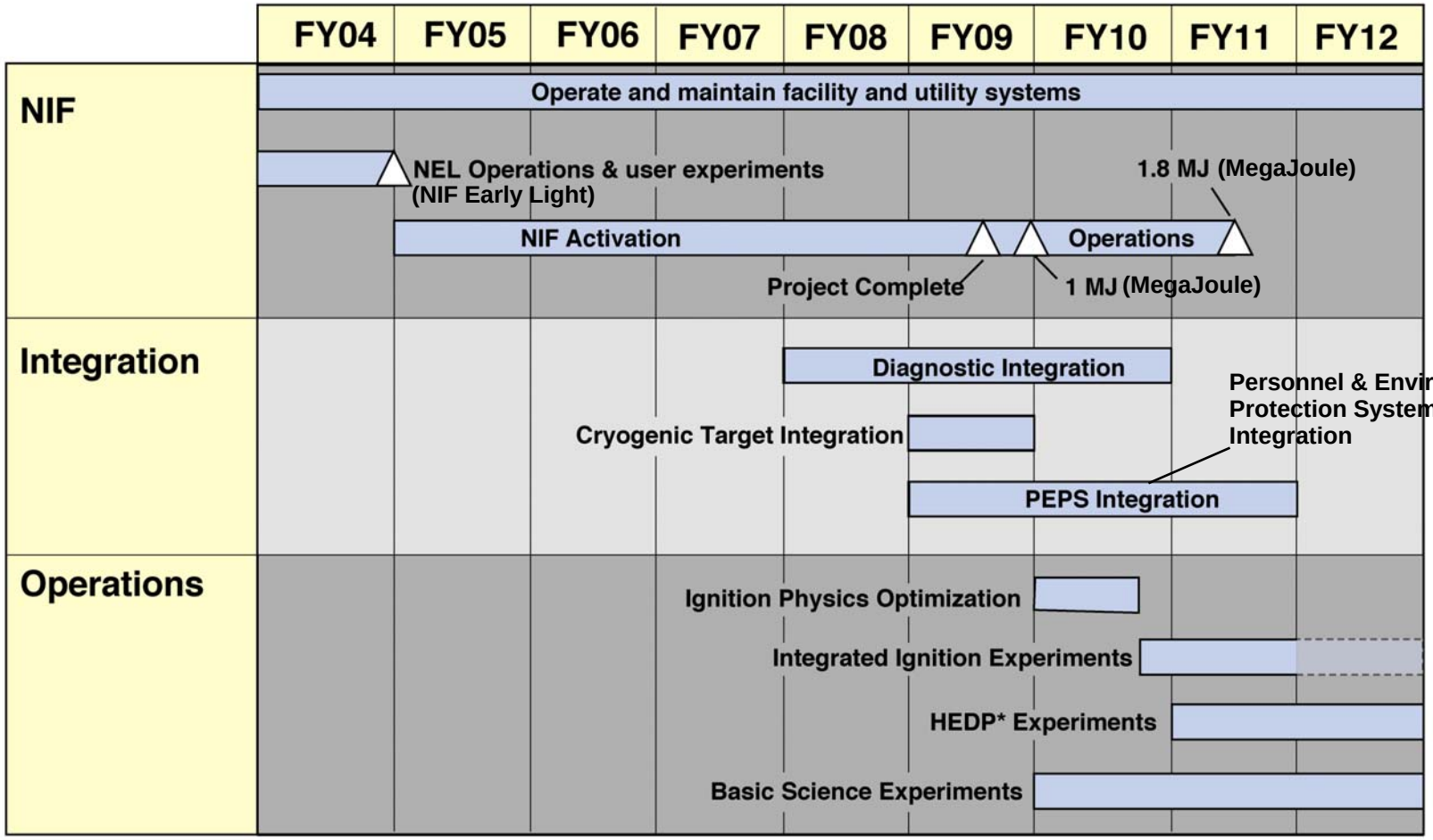
Equatorial ring plasma
deflects oblique rays onto equator.

PDD target performance is being validated on OMEGA.

[1]S. Skupsky *et al.*, Phys. Plasmas 11, 2763 (2004).
[2]R. S. Craxton *et al.*, Phys. Plasmas to be published (2005).

TC6920

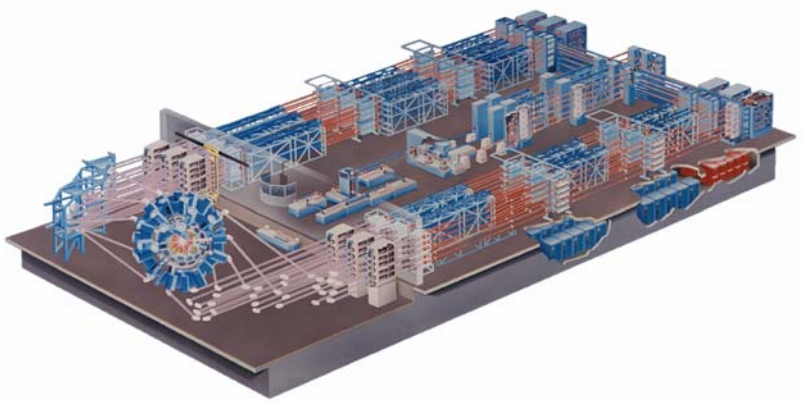
The plan for use of NIF calls for first ignition experiments in FY2010

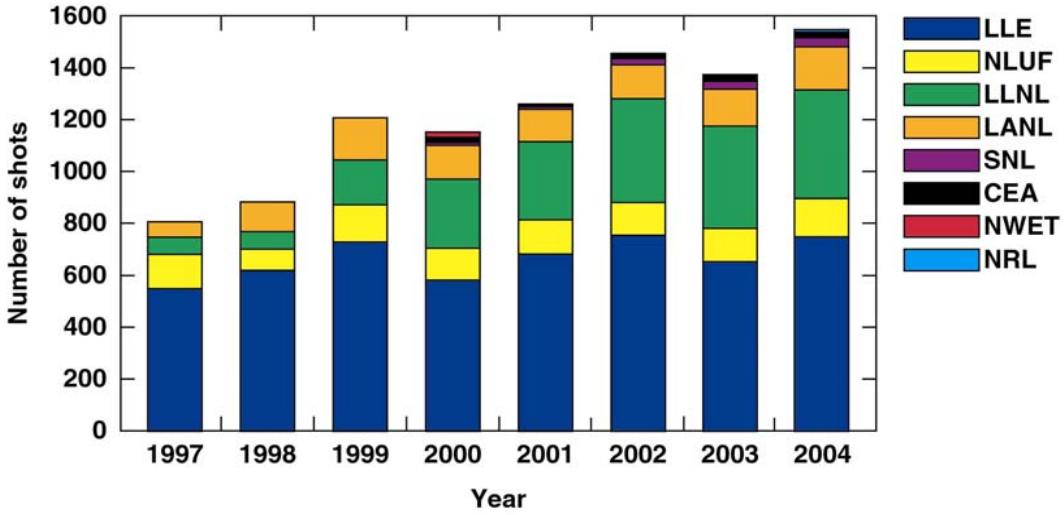


* Weapons physics experiments in support of Stockpile Stewardship

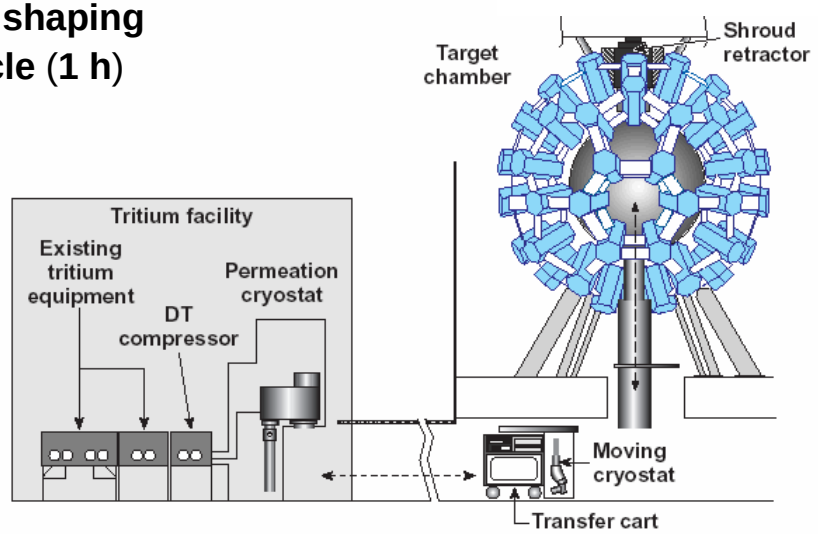
NIF-0505-10826r5
04BM/cc

OMEGA continues to be the principal experimental laser facility in the United States (World)



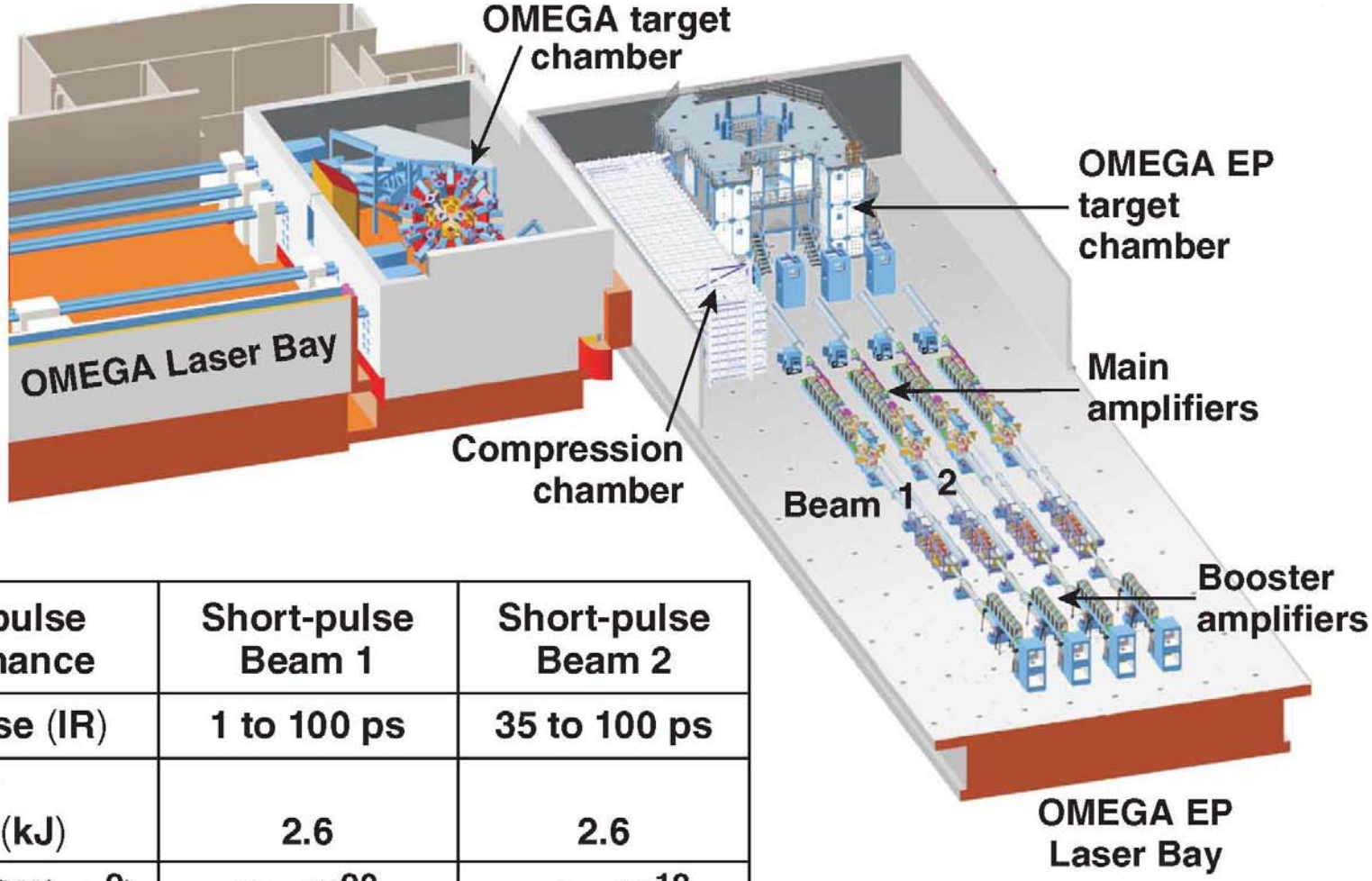


- 60 beams
- >30 kJ UV on target
- 1%-2% irradiation nonuniformity
- Flexible pulse shaping
- Short shot cycle (1 h)



OMEGA is being upgraded with“petawatt” capabilities (OMEGA EP)

The OMEGA EP laser beams will be located next to the existing OMEGA facility



Short-pulse performance	Short-pulse Beam 1	Short-pulse Beam 2
Short pulse (IR)	1 to 100 ps	35 to 100 ps
IR energy on-target (kJ)	2.6	2.6
Intensity (W/cm^2)	6×10^{20}	$\sim 4 \times 10^{18}$
Focusing	> 80% in 20 μm	> 80% in 40 μm

G5546q

OMEGA EP construction

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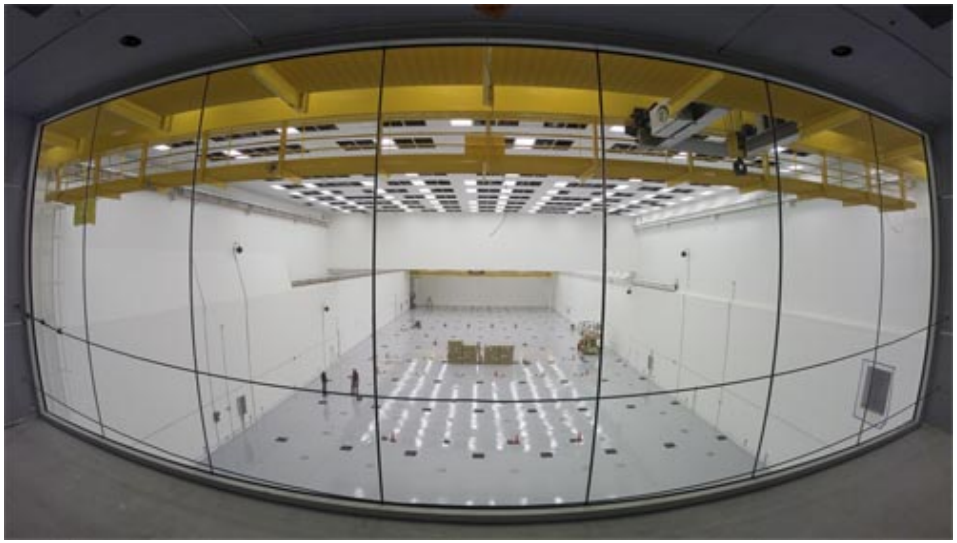
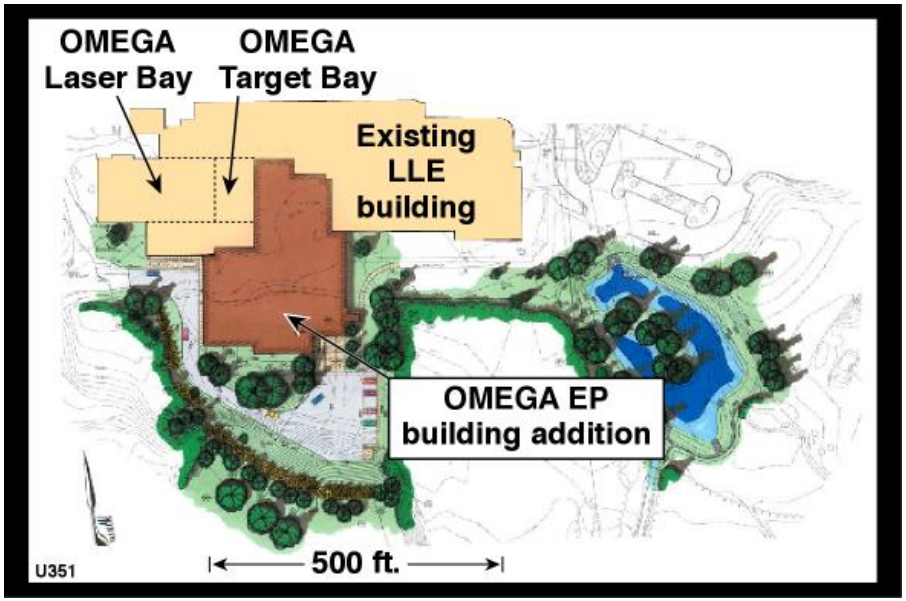
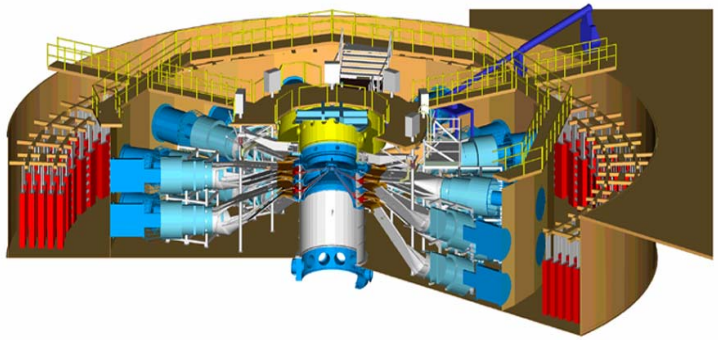




ZR and Z Beamlet- petawatt are important additions to program capability



- The ZR project is upgrading the performance of Z
  - 18 MA to 26 MA
  - 2x increase in diagnostic access
  - 2x shot rate capability

- The Z-Petawatt project is upgrading the capability of Z-Beamlet
  - 2 TW to 1 PW
  - backlighter hν 9 - 25 keV
  - integrated FI experiments on ZR

- The ZR and Z-Petawatt facilities will begin operations in 2007.

High resolution x-ray backlighting is an important new diagnostic now in routine use on Z

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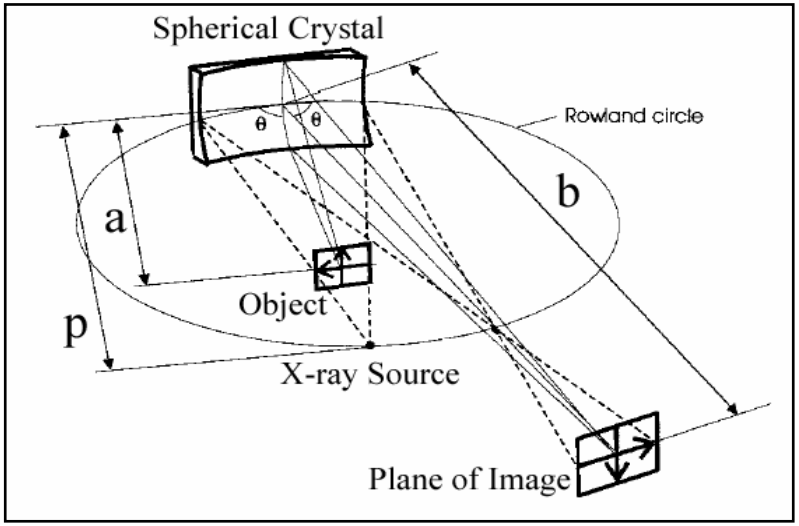
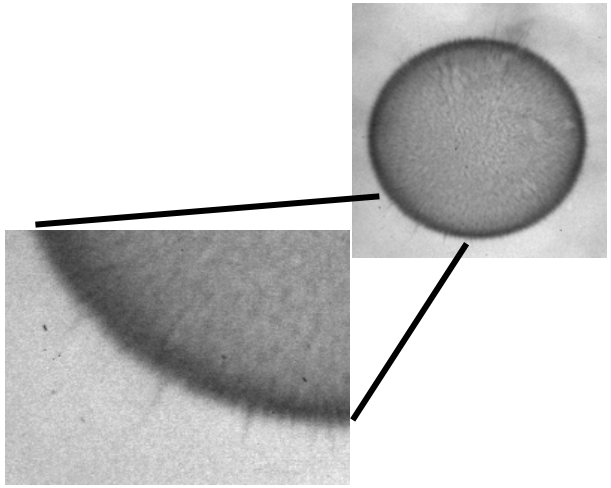
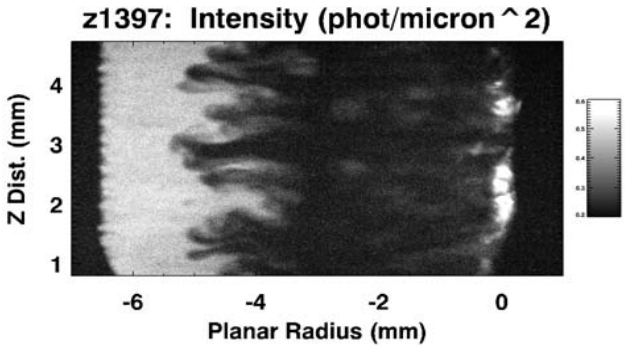
X-ray backlighting using a bent crystal imaging detector system



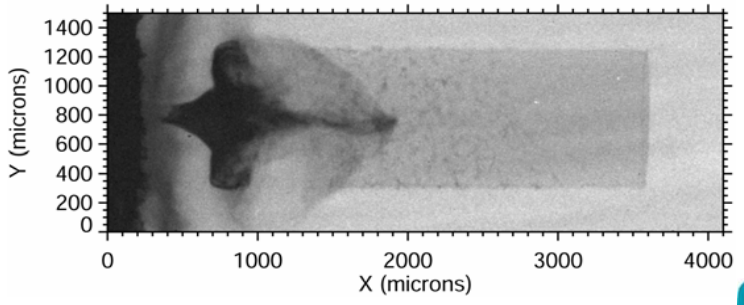
3.2 mm dia. capsule radiograph (C_r = 1.7)



Z-pinch implosion



Complex hydrodynamics

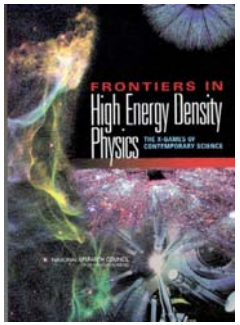


Sandia National Laboratories

Recent National Academy of Sciences reports have stressed importance of high energy density physics

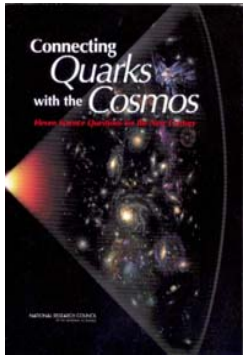
National Nuclear Security Administration

- **"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.)**

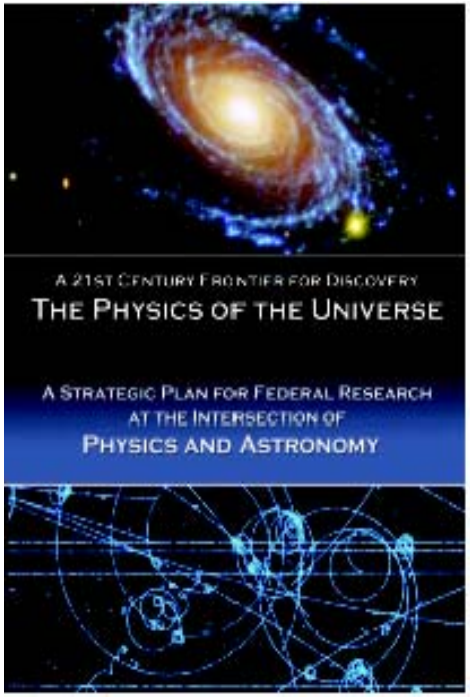


"Discern the physical principles that govern extreme astrophysical environments through the laboratory study of high energy density physics. The Committee recommends that the agencies cooperate in bringing together the different scientific communities that can foster this rapidly developing field."

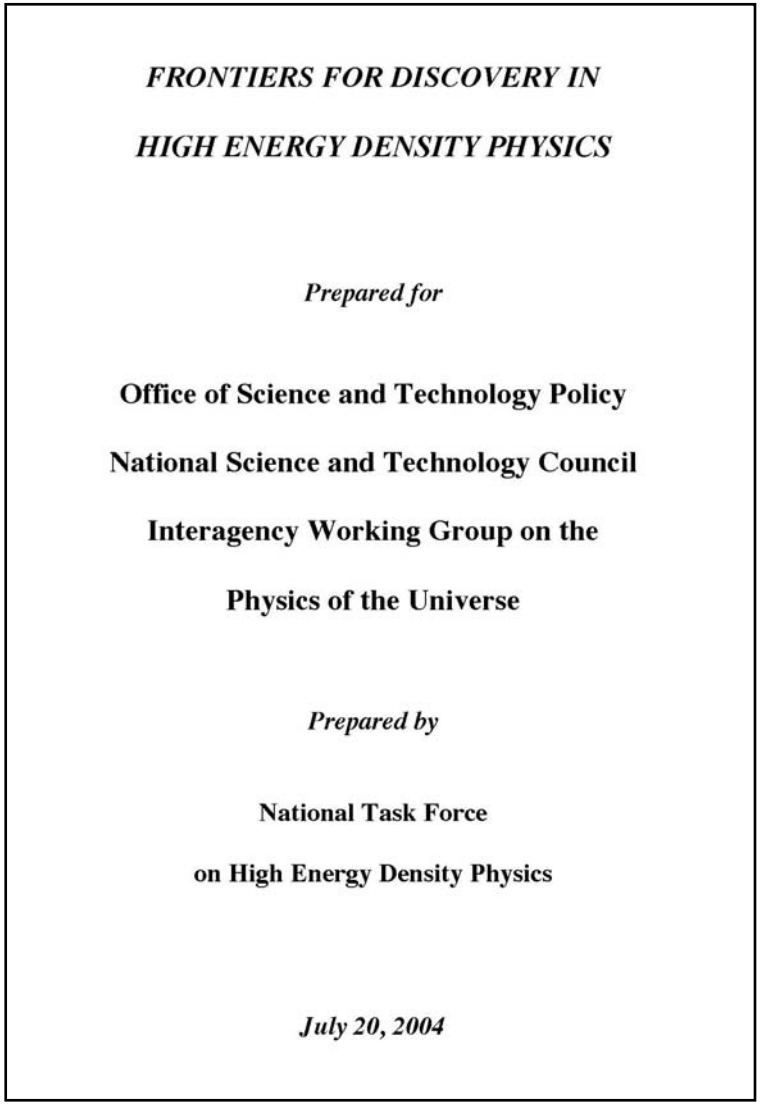
Interagency Working Group on the Physics of the Universe (OSTP, DOE/SC, DOE/NNSA, NSF, NASA)

National Nuclear Security Administration

"HEDP is an emerging field that provides crucial measurements that are relevant to interpreting astrophysical observations of the universe. The field has great promise that should be better coordinated across the various Federal agencies to capitalize on the emerging opportunities."



Interagency group chartered a team to develop an HEDP "roadmap"



FRONTIERS FOR DISCOVERY IN

HIGH ENERGY DENSITY PHYSICS

Prepared for

Office of Science and Technology Policy

National Science and Technology Council

Interagency Working Group on the

Physics of the Universe

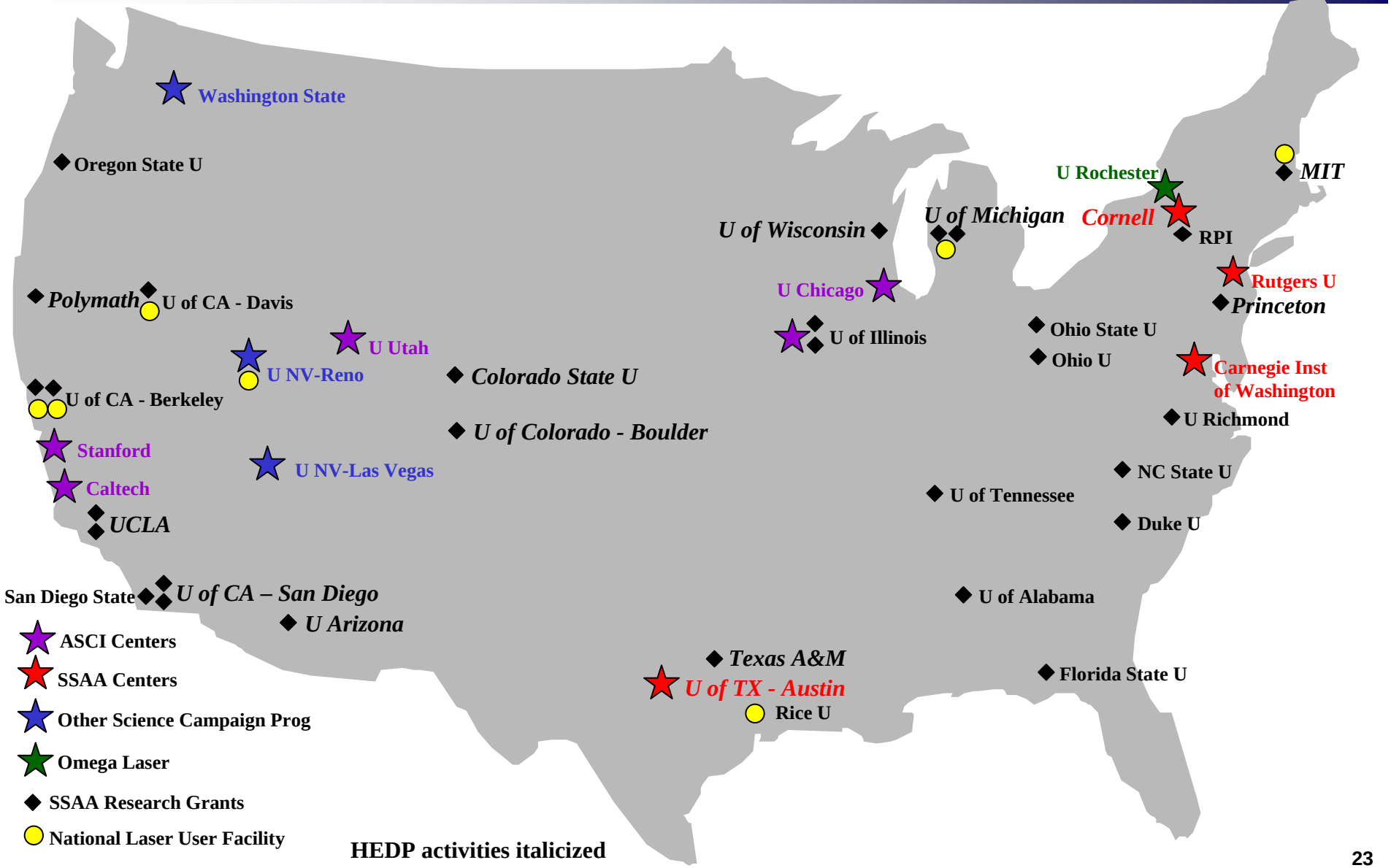
Prepared by

National Task Force

on High Energy Density Physics

July 20, 2004

Academic Alliances



HEDP activities italicized

Conclusions

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