Inertial Confinement Fusion Ignition and High Yield Campaign

Funding Profile by Subprogram

(dollars in thousands)

	FY 2009 Actual Appropriation	FY 2010 Current Appropriation	FY 2011 Request
Inertial Confinement Fusion Ignition and High Yield Campaign			
Ignition	100,535	106,734	109,506
NIF Diagnostics, Cryogenics, and Experimental Support	66,201	72,252	102,649
Pulsed Power Inertial Confinement Fusion	8,652	5,000	5,000
Joint Program in High Energy Density Laboratory Plasmas	3,053	4,000	4,000
Facility Operations and Target Production	203,282	269,929	260,393
NIF Assembly and Installation Program	55,192	0	0
Total, Inertial Confinement Fusion Ignition and High Yield Campaign	**436,915**	**457,915**	**481,548**

Outyear Funding Profile by Subprogram

(dollars in thousands)

	FY 2012	FY 2013	FY 2014	FY 2015
Inertial Confinement Fusion Ignition and High Yield Campaign				
Ignition	110,222	74,410	71,479	73,886
Support of Other Stockpile Programs	17,240	39,637	35,522	49,154
NIF Diagnostics, Cryogenics, and Experimental Support	74,104	83,878	82,921	76,117
Pulsed Power Inertial Confinement Fusion	5,000	5,000	5,000	5,000
Joint Program in High Energy Density Laboratory Plasmas	4,000	4,000	4,000	4,000
Facility Operations and Target Production	269,885	268,672	272,072	276,655
Total, Inertial Confinement Fusion Ignition and High Yield Campaign	**480,451**	**475,597**	**470,994**	**484,812**

Mission

The Inertial Confinement Fusion (ICF) Campaign provides an important component of the scientific and technical understanding required to assess the safety, security, and reliability of the Nation's nuclear weapons without nuclear testing. The program provides this capability through the development and use of advanced experimental tools, including state-of-the-art laser and pulsed power facilities. Science-based weapons assessments and certification requires that these advanced experimental tools have the capability to create and study matter under extreme conditions that approach the high-energy density (HED) environments found in a nuclear explosion.

Virtually all of the energy from a nuclear weapon is generated while in the high energy density (HED) state. High-energy density physics (HEDP) experiments on ICF facilities are required to validate the advanced theoretical models that are used to assess and certify the stockpile without nuclear testing. The National Ignition Facility (NIF) will extend HEDP experiments to include access to thermonuclear burn conditions in the laboratory, a unique and unprecedented scientific achievement.

The ICF Campaign, a vital component of the National Nuclear Security Administration's (NNSA) responsive infrastructure, supports NNSA's Stockpile Stewardship Program (SSP) through three strategic objectives:

- Achieve thermonuclear ignition in the laboratory and develop it as a routine scientific tool to support stockpile stewardship.
- Develop advanced capabilities including facilities, diagnostics, and experimental methods that can access the HED regimes of extreme temperature, pressure, and density required to assess the nuclear stockpile.
- Maintain the U.S. preeminence in HED science and support broader national science goals.

The importance of laboratory thermonuclear ignition to the national nuclear weapons program was one of the earliest motivations of the ICF program. A major focus of the ICF Campaign over the past decade has been the construction of the National Ignition Facility (NIF), which is required to achieve the principal program objective: to achieve thermonuclear ignition experiments in the laboratory. The NIF, located at the Lawrence Livermore National Laboratory (LLNL), is a 192 beam, high-energy, high-power laser system capable of delivering up to 1.8 megajoules of energy in a single pulse with a few nanoseconds duration. The NIF construction project was completed in March 2009 and provides NNSA extraordinary opportunities for significant scientific progress and discovery in the areas of thermonuclear ignition and matter under extreme HED conditions. Creating laboratory conditions of extreme densities and temperatures relevant to HED phenomena occurring in nuclear detonation is one of the most challenging requirements for science-based weapons certification.

Other advanced HED experimental capabilities within the ICF Campaign include the pulsed power Z-machine at the Sandia National Laboratories (SNL) and the OMEGA Laser Facility at the University of Rochester's Laboratory for Laser Energetics (LLE). Both facilities have recently undergone significant improvements. The Z-machine was refurbished and upgraded to provide more shot capacity and higher current. The new performance levels of the Z-machine are required for important weapons materials measurements. At LLE, a high-energy, short pulse capability was added to the existing 60 beam, 30 kilojoule OMEGA laser system. The OMEGA Extended Performance (EP) can produce high energy x-rays which are required for the advanced radiography capability needed in many weapons physics experiments. The combined capability is referred to as the OMEGA Laser Facility.

The National Ignition Campaign (NIC) is a multi-site integrated effort which focuses on achieving thermonuclear burn in the laboratory. Through FY 2012, the entire effort in Ignition and NIF Diagnostic Development subprograms is devoted to the NIC and about 75 percent of Facility Operations and Target Production. This includes all ignition experimental activity at NIF and the preparatory activity at OMEGA and ignition target development and fabrication. The partners in the NIC include LLNL, LLE, Los Alamos National Laboratory (LANL), SNL, and General Atomics (GA). The NIC has two primary objectives: (1) Perform the first ignition experimental campaign on the NIF beginning in FY 2010, and; (2) Transition the NIF from project completion to routine facility operations by the end of FY 2012.

Because of the importance of the NIC and its specific focused goal of ignition, NNSA designated it as an Enhanced Management Program requiring adherence to a rigorous set of project management standards including a formal execution plan. The execution plan describes the multi-year NIC scope, schedule, and budget baseline. Reporting on a large number of milestones, earned value reporting, and a formal change control process are among the management tools used to track progress against the NIC baseline. The NIC Execution Plan was submitted to Congress in late FY 2005 and progress reports on the status of the NIC technical programs to achieve ignition are provided to Congress quarterly.

A new JASON review of NIC was conducted in 2009 to assess progress since its previous review in 2005 and to evaluate preparations for the first ignition experiments in FY 2010. The 2009 review concluded that impressive, steady progress has been made but substantial scientific and technical challenges remain.

Early experimental work at NIF will continue to focus on assessing uncertainties in the physics understanding of ignition and adjusting or "tuning" the important parameters (e.g., laser beam pointing) to achieve the best set of ignition conditions. Early experiments will provide information such as: the coupling efficiency of the laser energy to the target; the timing of the shocks used to compress and heat the fuel; and the ablation rate and symmetry of the capsule as the implosion proceeds. The first ignition campaign began in late FY 2010 and will be followed by two additional campaigns (in FY 2011 and early FY 2012) that will vary the important parameters and obtain data to validate physics models in the burning plasma regime. This will further the understanding of ignition and allow a reproducible ignition platform to be optimized for SSP applications.

The ICF program is now utilizing experience acquired in the initial phase of NIF operation to constantly refine its plan for the FY 2011 and FY 2012 campaigns and the logistics required to implement those campaigns. The ICF program is planning for a very intense unprecedented level of campaign activity in FY 2011. Rapid reconfiguration of the laser in response to the results of tuning experiments will present a challenging operational task. This combined with the continuing installation and upgrade of diagnostics indicates the need for some increase in manpower.

For the SSP, ignition and thermonuclear burn will allow routine access to physical regimes hitherto unavailable in the laboratory. In addition, the demonstration of thermonuclear ignition will be of major importance for the Department of Energy's (DOE) energy and fundamental science missions.

Benefits

Within the ICF Campaign, there are 6 subprograms, each of which makes a unique contribution to Government Performance and Results Act (GPRA) Unit Program Number 29.

- The Ignition subprogram includes advanced theoretical modeling, systems engineering, target and experiment design, and experiments on ICF facilities.

- The Support of Other Stockpile Programs subprogram develops experimental capabilities in the HED regime and applies these tools and methodologies to resolve important stockpile questions. This is a vital area of collaboration between the ICF and Science Campaigns.

- The NIF Diagnostics, Cryogenics, and Experimental Support subprogram supports specialized technologies needed for the first ignition experiments and for the execution of other HED experiments on the NIF. Efforts include the design, development, and engineering of a complex array of diagnostic and measurement systems. This subprogram also includes design and construction of the NIF cryogenic target system.

- The Pulsed Power Inertial Confinement Fusion subprogram supports the assessment of Z-pinches for achieving fusion ignition and high yield, developing diagnostics for use at NIF, Z, and other HEDP facilities, and provides for materials measurements for ICF target design.

- The Joint Program in High Energy Density Laboratory Plasmas (HEDLP) subprogram funds joint activities with the Office of Science to steward the study of laboratory HED plasma physics. Both the HED physics activities within the Stockpile Stewardship Academic Alliances and the National Laser User Facility (NLUF) program at LLE, previously funded under the University Grants/Other ICF Support budget category, are now funded within the Joint Program. The NNSA portion of the joint program is funded via both the ICF and the Science Campaigns.

- The Facility Operations and Target Production subprogram supports experimental operations at NIF, OMEGA, and Z, as well as activities in target research, development, and fabrication.

In concert with the Science Campaign, the ICF Campaign provides experimental data required to validate weapons-relevant physics models that form the basis of weapons simulation design codes. These codes along with the advanced, high-performance computing platforms developed within the Advanced Simulation and Computing (ASC) Campaign are used within the SSP for the required annual assessment and certification of the U.S. nuclear stockpile. Coordination of the efforts of the Science, ICF, and ASC Campaigns is achieved, in part, through the Predictive Capability Framework (PCF) planning to prioritize and schedule major activities. The data, analysis methodologies, models and simulation codes developed by the Defense Programs' science effort also lend confidence to and support the analysis performed to meet Directed Stockpile Work (DSW) commitments. These commitments include understanding the impact of aging weapons systems, closing Significant Findings Investigations (SFIs) identified from surveillance or other sources, and certifying refurbished devices resulting from life extension programs (LEPs).

In addition to supporting NNSA's national security mission, ICF capabilities also serve DOE's missions to develop advanced energy systems (Office of Fusion Energy Sciences) and to further our understanding of fundamental science (Office of Basic Energy Sciences).

Annual Performance Results and Targets

(R = Results; T = Target)

Performance Indicators	FY 2006 Results	FY 2007 Results	FY 2008 Results	FY 2009 Results	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Endpoint Target
Secretarial Goal: Security: Reduce nuclear dangers and environmental risks **GPRA Unit Program Number:** 29, Inertial Confinement Fusion Ignition and High Yield Campaign											
Demonstrate Ignition at National Ignition Facility: Cumulative percentage of progress towards demonstrating ignition (simulating fusion conditions in a nuclear explosion) at the National Ignition Facility (NIF) to increase confidence in modeling nuclear weapons performance. (Long-term Outcome)	R: 71% T: 73%	R: 80% T: 80%	R : 86% T: 86%	R: 93% T: 93%	T: 100%	N/A	N/A	N/A	N/A	N/A	By 2010, complete first attempt to demonstrate ignition on the NIF.
National Ignition Facility (NIF) Construction: Cumulative percentage of construction completed on the 192-laser beam NIF. (Long-term Output)	R: 88% T: 87%	R: 94% T: 94%	R : 99% T: 98%	R: 100% T: 100%	N/A	N/A	N/A	N/A	N/A	N/A	By 2009, complete NIF construction.
National Ignition Facility (NIF) Equipment Fabricated: Cumulative percentage of equipment fabricated to support ignition experiments at NIF. (Long-term Output)	R: 45% T: 45%	R: 63% T: 63%	R : 82% T: 82%	R: 95% T: 95%	T: 100%	N/A	N/A	N/A	N/A	N/A	By 2010, complete fabrication of cryogenics and diagnostics equipment to support ignition experiments on the NIF.
Stockpile Stewardship Experiments at ICF Facilities: Annual number of days available to conduct stockpile stewardship experiments, totaled for all ICF facilities. (Annual Output)[a]	R: 691 T: 400	R: 403 T: 270	R : 558 T: 240	R: 500 T: 200	N/A	N/A	N/A	N/A	N/A	N/A	By 2009, increase ICF facility availability to 200 total days per year.

[a] Fluctuations in numbers resulted from termination of Nike Operations at NRL in 2009, refurbishment of ZR at SNL in 2007 (no shots), and availability of NIF beginning in 2010. The goal to increase ICF facilities availability to 200 was achieved in FY 2009.

Performance Indicators	FY 2006 Results	FY 2007 Results	FY 2008 Results	FY 2009 Results	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Endpoint Target
Z Facility Experiments: Annual average hours per experiment required by the operational crew to prepare the Z facility for an experiment. (Efficiency)	R: 10.3[a] T: 11	R: 0 T:11	R : 10.59 T: 11	R: 8.17 T: 9.5	N/A	N/A	N/A	N/A	N/A	N/A	By 2009, reduce the operational crew preparation time per Z facility experiment to 9.5 hours. (2004 Baseline equivalent of 11 hours/experiment).[a]
Nuclear Explosive Package Assessment: Cumulative percentage of progress in replacing key empirical parameters in the nuclear explosive package assessment with first principles physics models assessed by validation with experiment. (Long-term Outcome)[b]	N/A	N/A	N/A	N/A	T : 60%	T: 63%	T: 66%	T:69%	T:72%	T:75%	By 2020, use modern physics models in assessment calculations to replace the major empirical parameters affecting energy balance, boost initial conditions, amount of boost, secondary performance, and weapons output. (Share with Science Campaign.)
Predictive Capability for Nuclear Weapons Performance: Cumulative percentage of progress towards achievement of key extreme experimental condition of matter needed for predictive capability for nuclear weapons performance. (Long-term Outcome)[c]	N/A	N/A	N/A	N/A	T : 35%	T: 55%	T: 75%	T: 85%	T: 90%	T: 100%	By 2015, achieve greater than unity value of the average of the ratio of achieved conditions to needed conditions. (Share with Science Campaign)
Cost Reduction: Cumulative percentage of operating cost reduction from 2009, adjusted for inflation, utility costs, and laboratory indirect costs, all ICF facilities combined. (Efficiency)[c]	N/A	N/A	N/A	N/A	T : 1%	T: 2%	T: 3%	T: 4%	T: 5%	T: 6%	By 2019, achieve a 10% cost reduction in combined ICF facilities.

[a] Additional radiation safety procedures required revision of annual and endpoint targets by +2 hours in 2006. Facility did not operate in 2007 due to major refurbishment.

[b] Joint Performance Indicator with Science Campaign developed during 2008 OMB PART Review.

[c] New efficiency measure developed during OMB PART Review in 2008.

Performance Indicators	FY 2006 Results	FY 2007 Results	FY 2008 Results	FY 2009 Results	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Endpoint Target
High Particle and Radiation Environments: Annual percentage of shots/experimental implosions in which the facility and diagnostics meet the minimum requirements for obtaining data in high particle and radiation environments. (Annual Output)[a]	N/A	N/A	N/A	N/A	T: 30%	T: 40%	T: 50%	T: 60%	T: 70%	T: 72%	By 2017, 95% of the shots conducted annually will meet the minimum data requirements.
Z-Materials: Annual percentage of data points that are provided by experimental capabilities meeting the requirements of model development for measuring properties of high-Z materials under weapons-relevant conditions. (Annual Output)[c]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	T: 30%	T: 45%	T: 60%	By 2016, 100% of the data points for high-Z material will meet the model development requirements.
Fusion Ignition Shots: Annual percentage of fusion ignition shots that are provided by experimental capabilities meeting the yield and yield variation requirements consistent with weapons physics models and uncertainty analyses. (Annual Output)[a]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	T: 50%	T: 70%	T: 80%	By 2015, 80% of the shots will meet the yield and yield variation requirements.
Experimental Capabilities: Annual percentage of data points that are provided by experimental capabilities meeting the model development and validation requirements to understand degradation of ignition yield due to hydrodynamics effects. (Annual Output)[a]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	T: 30%	T: 40%	By 2017, 100% of the data points will meet the model development and validation requirements.

[a] New Performance Indicator developed during OMB PART Review in 2008.

FY 2009 Accomplishments
National Ignition Campaign

- Precise measurement of power balance on eight NIF beams at Target Chamber Center showed that the NIF meets the power balance requirements for ignition pulse shapes.
- Ninety-six continuous phase plates that shape the beam spot for optimal illumination of the ignition target were installed.
- The Ignition Target Alignment System was installed and commissioned.

Diagnostic installation

- Other activity focused on installing and commissioning diagnostics and other equipment required for the first NIC experiments, including: Dante soft x-ray spectrometer, FFLEX hard x-ray spectrometer, Full Aperture Backscatter System (FABS), and the Near Backscatter Imager (NBI). The first of a suite of Neutron Time-of-Flight (NTOF) detectors that will measure the neutron yield, bang time[a], and down-scattered neutron spectrum, was installed on the NIF target chamber.

Preliminary NIC experiments

- The initial NIC experiments on the NIF focused on measuring the temperature in a hohlraum similar to the one that will be used to drive ignition targets. Initial tests of hohlraum performance have yielded drive temperatures greater than 300 electron volts which demonstrates extremely encouraging progress toward ignition requirements.

Ignition Diagnostic Development

- On the OMEGA Laser Facility at LLE, cryogenic implosion experiments produced the highest neutron yields to date in these implosions. The first short pulse x-ray radiograph of an imploding cryogenic deuterium target was obtained. Radiographic images showed the evolution of the shell compression near peak burn along with the core self emission which provides important validation of some diagnostic methods that will be applied in actual ignition experiments at NIF.
- A Magnetic Recoil Spectrometer (MRS), developed through collaboration between the Massachusetts Institute of Technology (MIT) and LLE, measured the down-scattered neutron spectrum from the implosion of a cryogenic deuterium-tritium (DT) target on OMEGA. The down-scattered neutron spectrum is used to determine the compressed fuel's areal density.
- LANL scientists fielded a gamma ray detector on OMEGA that will be used to measure the time of fusion burn on the NIF. A liquid scintillator based neutron time-of-flight detector demonstrated detection of the down-scattered neutron signal without residual afterglow from the primary neutron signal from a cryogenic DT target implosion on OMEGA. This validates the use of NTOF detectors for down-scattered neutron measurements on the NIF. The technique that will be used on NIF for convergent shock timing was validated on OMEGA.

Target Development and Production

- The cryogenic ignition target production capability was fully qualified, demonstrating high precision targets meeting the point design specifications in quantities consistent with the experimental

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[a] Bang time, a term commonly used within the ICF community, is generally defined as the time interval from the beginning of the driver generated pulse to the time of maximum neutron generation.

schedule. Cryogenic layers meeting ignition requirements were formed using a cryogenic mixture of hydrogen and tritium.

Ignition Planning and Review

- A JASON review of the NIC was conducted in January 2009. The review provided an assessment of the progress of the NIC and its readiness to perform the crucial ignition experiments in FY 2010. The review concluded that impressive, steady progress has been made but suggested that substantial scientific and technical challenges remain.

NIF Project

- The NIF was completed in accordance with its approved baseline on March 27, 2009. All Project Completion Criteria have been met.
- The NIF performed a 192-beamline shot in March, 2009 that produced a record 1.1 megajoules of ultraviolet (3ω) light. Target shots in July 2009 delivered more than 600 kilojoules (kJ) (3ω) to hohlraum targets similar to those that will be used in the first ignition experiments.

OMEGA Laser Facility

- A multi-institutional team captured a radiograph of a shock wave propagating in a solid Aluminum target. The shock wave was generated by one of OMEGA EP's long pulse ultraviolet beams and the x-ray source was generated by a high energy short pulse delivered by a second OMEGA EP beamline interacting with a Samarium target.
- The first OMEGA Laser Facility User's Group Workshop was held at LLE with 100 scientists from twenty-nine universities and laboratories, 4 countries, and NNSA attending. The workshop facilitated communication among the users and with the facility and provided feedback on ways to improve operations and capabilities for users. This workshop was an important component of the ICF Program's plan to evolve all its facilities into national user capabilities.
- As of the third quarter of FY 2009, the OMEGA Laser Facility performed 1,140 target shots with high availability and effectiveness. Users included scientists from LANL, LLE, LLNL, SNL and various universities, as well as the Atomic Weapons Establishment (United Kingdom) and Commissariat a L'energie atomique, CEA (France).

Z Facility

- Full capability of the refurbished Z-machine has been demonstrated; for example the maximum current was increased from 18 to 26 mega-amperes. The refurbishment of Z has improved shot-to-shot reproducibility (within +/- 0.5 percent for the current pulse shape), provided more precise current shaping, and a longer, variable pulse length. The operation of Z has been demonstrated at the rate consistent with 220 shots per year.
- Advanced ICF pulsed power concepts have been tested in experiments that produced significant neutron yields[a]. Isentropic compression experiments at Z have been used to measure the equation-of-state of beryllium (Be) and diamond in parameter ranges required by ICF target design and have also been used to demonstrate magnetic drive pressures of 6 megabar (Mbar). Magnetically

accelerated flyer plates have been used to perform equation-of-state studies in sapphire to pressures of 20.7 Mbar.

- SNL, in collaboration with LANL, completed an important Stockpile Stewardship experiment on the refurbished Z-machine obtaining pressure-density data for tantalum at pressures up to 4 Mbar. The refurbished Z also provided data on the strength of beryllium, an important material used in both ICF capsules and other defense applications. The melt phase of diamond was studied with accuracies of one percent.

Other ICF Accomplishments:

- The Naval Research Laboratory (NRL) demonstrated operation of the Electra electron beam amplifier at 90,000 shots continuous operation for 2.5 Hz and 50,000 shots at 5 Hz. The total shots with Electra have now exceeded 1 million. Electra is an important prototype for the pump of a laser that could be used in an Inertial Fusion Energy (IFE) Experiment.
- LLNL operated the front-end laser on their diode-pumped, solid-state Mercury laser system in an autonomous mode (computer-controlled and diagnosed) for over 15 million shots.

Joint Program in High Energy Density Laboratory Plasmas (HEDLP)

- In FY 2008, the joint program issued a solicitation that supports academic and national laboratory research in HEDP. Over 135 proposals were received indicating a strong interest in the field. In FY 2009, 24 proposals were selected for initial funding.

Major Outyear Priorities and Assumptions

The outyear requirements for the ICF Campaign total $1,911,854,000 for FY 2012 through FY 2015. The achievement of ignition and thermonuclear burn and its application to the major unresolved issue in weapons physics will remain the highest priority within the ICF Campaign. Once NIC has successfully achieved ignition and thermonuclear burn in the laboratory subsequent experiments will be designed to provide a reproducible ignition platform that can be exploited by the SSP to address important weapons physics questions.

After the completion of NIC at the end of FY 2012, NIF will be capable of supporting routine operations for ignition and other HED experiments in support of SSP. Capabilities will include: certified data systems supporting experimental operations; optics and targets management systems; target production capability for the baseline ignition platform and some HED targets for SSP experiments; a second operational cryogenic target positioner; an initial set of radiation-hardened diagnostics; and a third set of continuous phase plates. In FY 2013 and beyond, the ICF Program will pursue an increasingly broader range of HED experiments (both ignition and non-ignition) required by the weapons certification process. This will include work in materials dynamics, plutonium equation-of-state and constitutive properties, hydrodynamics, x-ray opacities, and understanding the boost process. Pursuit of this agenda of vital weapons deliverables will require an increasingly sophisticated array of diagnostics, including a variety of measurement systems that can operate in the ignition or near-ignition environment. This in turn will require major investment to be shared by ICF, the Science Campaign, and other parts of the weapons community.

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[a] The neutrons are a product of fusion, thus the number of neutrons produced serves as an index of efficiency of fusion.

The ICF Campaign will continue to provide some funding for the operations of its HED physics capabilities (facilities and technical expertise) to support emerging and future needs of the NNSA's national security mission. These needs may include advanced ignition concepts (such as fast ignition or various forms of direct drive) or other HED capabilities. This modest commitment to the basic science of HED may expand in response to various priorities, such as energy initiatives. Following the achievement of thermonuclear ignition, the Department anticipates that the relative importance of these potential missions and the role of the various ICF Campaign program elements and facilities supporting these missions will be reevaluated and modified to meet national needs and priorities.

Detailed Justification

	(dollars in thousands)		
	FY 2009	FY 2010	FY 2011
Ignition	**100,535**	**106,734**	**109,506**

This subprogram is the central focus of the effort to produce thermonuclear fusion in the laboratory and to utilize ignition to address key weapons issues. The effort performs detailed theoretical designs (in both 2 and 3 dimensions) of the complete performance of ignition targets. Ignition target design is part of a very close coupling of ICF with the Advanced Simulation and Computing Campaign (ASC) and the Science Campaign. In close collaboration with the Science Campaign, this subprogram also includes experimental design, the development of specific, experimental methods focused on achieving ignition and systems engineering improvements.

Regardless of the specific status of ignition, FY 2011 will present a very demanding agenda of work in the ignition effort. Results from the first ignition attempts in 2010 will be analyzed in detail, and the intensive process of tuning laser and target parameters for optimum performance will continue. There will also be a need for continual reevaluation of the diagnostic measurement systems, including possible plans for upgrades, re-calibration, and other adjustments.

The first ignition campaign (spanning FY 2010 to FY 2011) will attempt to compress, implode, and ignite a layered DT capsule with a ~1.3 megajoule energy pulse from the NIF.

An important component of work in ignition will be continual support experiments at OMEGA. Crucial operations such as re-calibration, tuning, and adjustment of diagnostics and experimental techniques will occur there.

This ignition subprogram will also closely collaborate with the Science Campaign effort to perform vital HED (non-ignition) weapons physics experiments on the NIF and OMEGA in FY 2011.

NIF Diagnostics, Cryogenics and Experimental Support	**66,201**	**72,252**	**102,649**

This subprogram supports specialized technologies needed for the first ignition experiments and for the execution of other HED experiments on the NIF. This effort includes the design, development, and engineering of a complex array of diagnostic and measurement systems. These systems provide the vital data generated in ignition experiments and include the associated information technology subsystems needed for data acquisition, storage, retrieval, visualization, and analysis. The data generated will be utilized to tune the ignition process and to provide key information required by the weapons SSP.

The intensive activity in ignition during FY 2011 will be mirrored in a very active period of installation, calibration, and utilization of the diagnostic systems. Coordination of this activity with ignition target experiments will represent a major logistics and systems planning effort. Additionally, a

	(dollars in thousands)		
	FY 2009	FY 2010	FY 2011

significant portion of the effort in this subprogram during FY 2011 will be in the design of experiments, and diagnostics aimed at utilizing ignition conditions to answer specific Weapons Program SSP questions.

The NIF Diagnostics, Cryogenics and Experimental Support subprogram also includes design and construction of the NIF cryogenic target system. This very complex experimental system is required to produce a precise frozen layer of DT nuclear fuel on the inner wall of an ignition capsule. This layer is required for ignition to occur.

Other activities performed in the Experimental Support subprogram include: (1) the development and activation of optical systems required to produce the optical spatial beam smoothing needed in ignition experiments and subsequent campaigns; (2) integration and experimental commissioning of the NIF target area; and (3) installation and qualification of both the tritium handling system and the personnel and environmental protection systems.

Pulsed Power Inertial Confinement Fusion	**8,652**	**5,000**	**5,000**

This subprogram funds computational target design, experiments, and experimental infrastructure to assess pulsed power as a means to achieve thermonuclear fusion in the laboratory. The program also advances the science and technology of megajoule-class pulsed power systems to improve efficiency, reliability, precision and repetition rate, and to reduce costs. In addition, experiments in pulsed power advance fundamental research in high-energy-density plasmas, laboratory astrophysics, and planetary science. In FY 2011, activities will focus on utilizing the new diagnostics (neutron and x-ray imaging) to demonstrate consistent fusion conditions that can be utilized in variety of applications.

Joint Program in High Energy Density Laboratory Plasmas	**3,053**	**4,000**	**4,000**

High Energy Density Laboratory Plasmas (HEDLP) is a joint program with the Office of Science to support basic high energy density physics research. This subprogram provides support for external users at the University of Rochester OMEGA facility as well as a joint solicitation for HEDLP research to be performed at universities and DOE laboratories. For FY 2011, NNSA will contribute funding from the ICF and Science Campaigns.

Facility Operations and Target Production	**203,282**	**269,929**	**260,393**

This subprogram supports operations of ICF facilities including NIF, OMEGA, and Z, in a safe and secure manner. It also supports target and sample fabrication, including the very sophisticated targets required for ignition. As mentioned in the descriptions of the Ignition and the NIF Diagnostics, Cryogenics and Experimental Support subprograms, FY 2011 will be dominated by intense activity in the pursuit of ignition and its development for specific weapons applications. Coordination of ignition experiments, diagnostic installation and upgrades, and continued refinement of the laser itself will be a major challenge.

	(dollars in thousands)		
	FY 2009	FY 2010	FY 2011

More than 300 shots are being planned on the NIF in FY 2011, and there will be a continuing strong requirement for SSP work on the OMEGA and Z facilities. Accomplishment of the full agenda of weapons SSP deliverables is possible only with these 3 facilities working in concert.

Other activities carried out in the Facilities Operations and Target Production subprogram include: (1) support for shot directors and operational staff; (2) engineering sustainment; and (3) support staff for the final optics inspections system and its associated optics conditioning, initiation and mitigation processes to increase the lifetime of optics exposed to ultraviolet light.

	FY 2009	FY 2010	FY 2011
NIF Assembly and Installation Program	**55,192**	**0**	**0**

This funding element supported the activities associated with integration, planning, assembly, installation, and activation of the NIF. The NIF Assembly and Installation Program also provided the staffing, training, and procedures for the NIF operations; work essential to deliver a facility ready for transition from construction project to fully capable experimental facility. Following project completion in FY 2009, this effort was transferred to the Facility Operations and Target Production subprogram in FY 2010.

	FY 2009	FY 2010	FY 2011
Total, Inertial Confinement Fusion Ignition and High Yield Campaign	**436,915**	**457,915**	**481,548**

Explanation of Funding Changes

	FY 2011 vs. FY 2010 ($000)
Ignition Funding supports the intense increase in ignition activity involving real-time experimental data analysis theoretical interpretation. There will be a significant increase in design activity related to the upgrade of diagnostics as ignition is approached.	**+2,772**
NIF Diagnostics, Cryogenics, and Experimental Support Supports the significant increase in experimental activity as data at or near ignition is produced. The increase in resources is essential for re-calibrating, refining, and upgrading diagnostic systems that are exposed to an increasingly severe flux of gamma rays and neutrons. Also supports the final refinements of the cryogenic system as the first ice layered targets are imploded and finally, the increase supports logistic activity associated with installation, calibration, and utilization of the diagnostic systems all in coordination with an intense period of ignition experimentation. Additionally, the funding increase supports the initiation of a dedicated effort in ignition-based weapons physics experiments. The majority of resources will be devoted to the design of diagnostics that are capable of functioning in the harsh (radiation and particle) environment created by igniting plasmas. This effort will provide direct coupling between the ignition effort and other portions of the Weapons Program.	**+30,397**
Facility Operations and Target Production In FY 2011, the request reduces operations in weapons physics at Omega and Z while maintaining ignition experiments.	**-9,536**
Total Funding Change, Inertial Confinement Fusion Ignition and High Yield Campaign	**+23,633**

Capital Operating Expenses and Construction Summary

Capital Operating Expenses[a]

(dollars in thousands)

	FY 2009	FY 2010	FY 2011
General Plant Projects	400	409	418
Capital Equipment	12,218	12,487	12,762
Total, Capital Operating Expenses	**12,618**	**12,896**	**13,180**

Outyear Capital Operating Expenses

(dollars in thousands)

	FY 2012	FY 2013	FY 2014	FY 2015
General Plant Projects	427	436	446	456
Capital Equipment	13,043	13,330	13,623	13,923
Total, Capital Operating Expenses	**13,470**	**13,766**	**14,069**	**14,379**

[a] Funds are appropriated for Operations and Maintenance, which includes operating expenses, capital equipment and general plant projects. The program no longer budgets separately for capital equipment and general plant projects. FY 2010 and FY 2011 funding shown reflects estimates based on actual FY 2009 obligations.