



Inertial Fusion in NNSA

Presented to:

**Fusion Power Associates
33rd Annual Meeting and Symposium
Washington, DC**

Presented by:

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ICF Program is critically important element of NNSA's Stockpile Stewardship Program (SSP)



Ensure that the Nation's nuclear weapon stockpile remains safe, secure, and effective without nuclear testing

- **Last underground test occurred more than 20 years ago (9/23/1992)**
- **Our confidence relies in part on computer models validated against experimental data**
- **ICF Program provides unique and extreme High Energy Density (HED) environments for model validation**

In October, *New York Times Letter to the Editor* from Tom D'Agostino (NNSA Administrator) & Parney Albright (LLNL Director) stated NIF's primary purpose is support of the weapons program.



ICF Program has 5 principal elements



- **Develop a robust burning plasma platform for the Predictive Capability Framework (PCF) of the SSP (Ignition is the first major step)**
- **Obtain fundamental physical properties of materials and plasmas in HED environments (in collaboration with Science Campaigns)**
- **Provide experimental data for computer model validation in the HED regime (in collaboration with the Advanced Scientific Computing Campaign)**
- **Develop and advance capabilities in HED Science**
- **Strengthen the HED community and grow the next generation of stewards**



Developing robust burning plasma platforms remains principal goal of the ICF Program



*Achieving ICF ignition is a Grand Scientific Challenge,
and we are closer to ICF ignition than we have ever been*

- **National Ignition Campaign**
 - ✓ **Successfully demonstrated exceptional laser performance on the NIF (power, energy, precision)**
 - ✓ **Developed and implemented an extraordinary suite of diagnostics**
 - ✓ **Achieved impressive capsule implosion conditions (see for reference the presentation by Moses at this symposium)**
 - ✓ **Completed 5 of 7 “key milestones” (significant alpha heating and ignition remain elusive)**
 - ✓ **Performed initial tests of point design with the laser pulse and target quality predicted to be sufficient for ignition**
 - ✓ **Continued to advance alternate ignition concepts**



Delay in achieving ignition required response to Congress and Path Forward plan



SEWD Appropriations Report for FY 2012 (112-164) & HASC Report for the FY 2013 NDAA (112-479) required report by 30 November 2012 detailing:

- **Scientific & technical barriers to achieving ignition**
- **Plan & schedule for reevaluating ignition program**
- **Best judgment of Administrator as to whether ignition can be achieved at NIF**
- **Impact on SSP of shifting ignition resources to life extension programs**



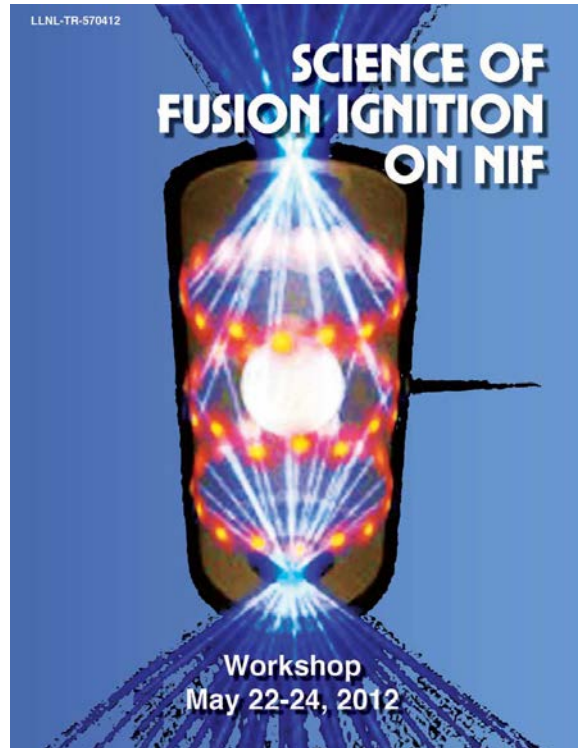
Approach to developing the Path Forward



- **Path Forward planning led by ICF Executives with Working Groups reporting to them**
- **ICF Executives = body comprised of 1 lead member from each ICF organization (LLNL, LANL, SNL, LLE, NRL, GA)**
- **Working Groups report to ICF Executives on topical issues:**
 - Indirect Drive
 - Polar Drive
 - Magnetically-Driven ICF
 - Diagnostics
 - Targets
- **ICF program planning continues with this structure**
- **ICF Executives delivered consensus Path Forward to NNSA**
- **NNSA preserved consensus document and added an NNSA Overview & Executive Summary**

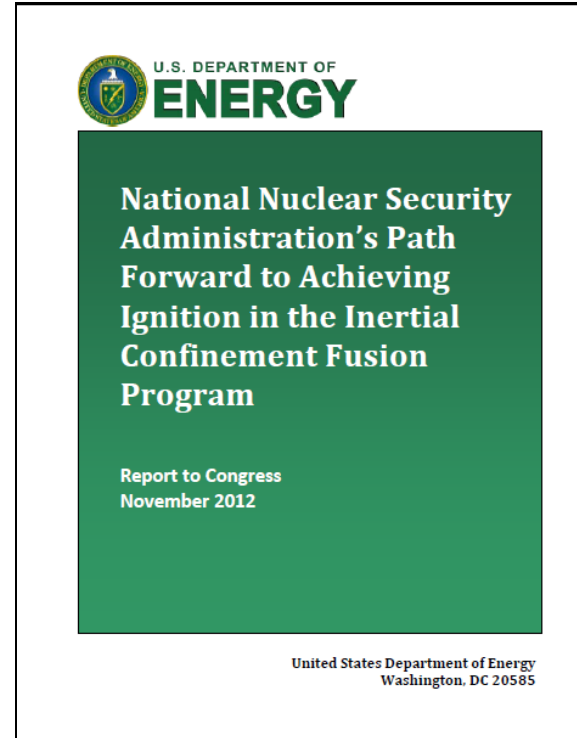


Path Forward provides consensus view from the National ICF Program leadership



May 2012

~120 scientists from around the world met to identify key missing understanding & path to resolve



November 2012

Consensus document submitted to Congress with proposed plan to resolve issues & achieve ignition



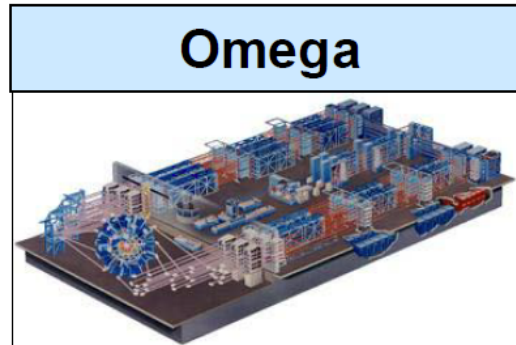
ICF facilities provide unprecedented environments for national security and fundamental science



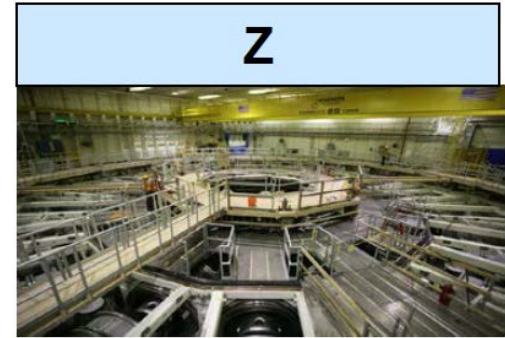
60% of the ICF Program budget is applied to facility operations at NIF, Z, and Omega



- Research on indirect drive ignition
- Laser plasma instabilities
- Hydrodynamic instabilities
- Radiation hydrodynamics
- Materials at extreme conditions



- Research on polar drive ignition
- Diagnostics development
- Open science platform
- Focused experiments on scientific issues for ICF
- Platform development for NIF experiments



- Research on magnetically-driven ICF
- Dynamic material properties – including Pu
- Radiation effects
- Radiation hydrodynamics
- Radiation transport



ICF Program supports academic research & health of the HED community

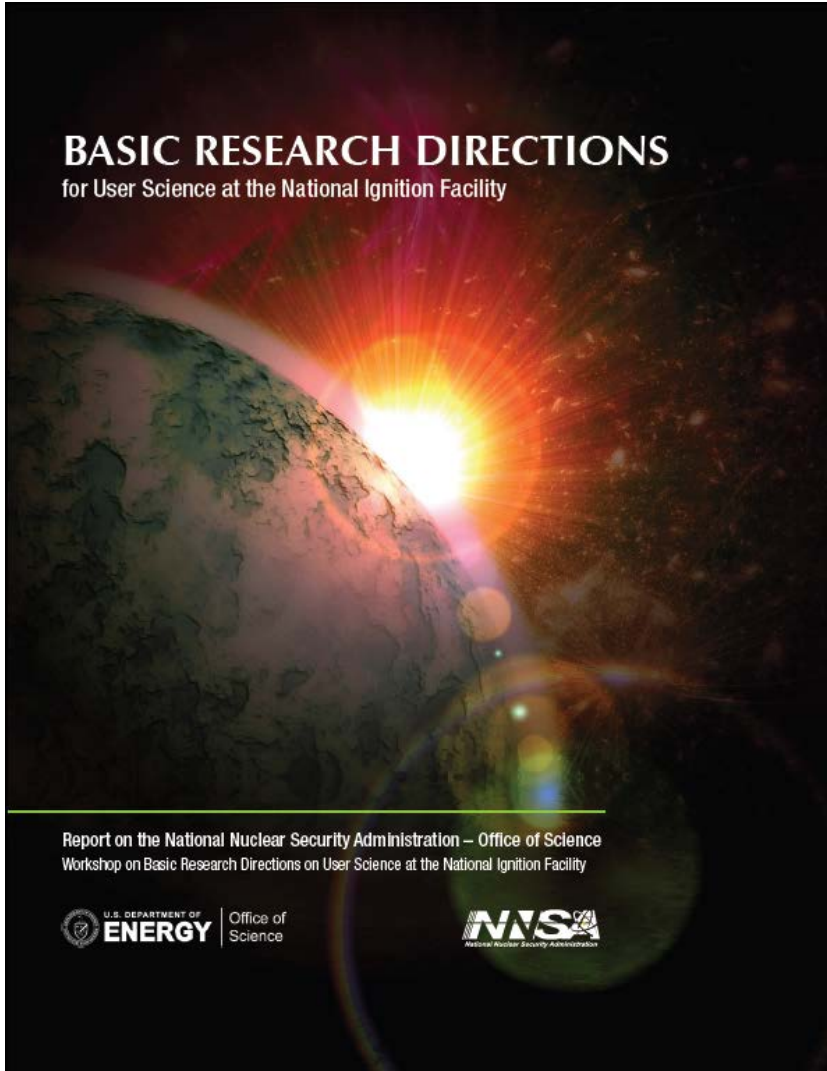


- Through the Joint Program in High Energy Density Laboratory Plasmas (JPHEdLP) and the Stockpile Stewardship Academic Alliances (SSAA), ICF funded \$12.2M in research in FY12
- A long term objective for our HED facilities is to dedicate up to 15% of experiments to fundamental science applications (Omega allocated 30% in FY12)
- When combined with the Science and ASC Campaigns, a total of \$40.7M from Stockpile Stewardship (NA-11) went to support these efforts*
- NIF, Z, and Omega are significantly oversubscribed, and there is no shortage of excellent proposals to consider

* Does not include cost of facility operations



NNSA/Office of Science collaboration in HED science makes NNSA facilities available to basic science users



- **Workshop Report on Basic Research Directions at the NIF**
- **Science of Fusion Ignition on NIF**
- **NIF/Jupiter Users Group meeting – Feb 10-13, 2013**
- **Omega Laser Users Group meeting – Apr 24-26, 2013**
- **5th Fundamental Science with Pulsed Power: Research Opportunities & User Meeting – Aug 11-14, 2013**
- **Selections made from the FY 2011 solicitations for the JPHEdLP and SSAA centers & contracts let**
- **Proposals for the FY 2012 JPHEdLP solicitation under review**
- **Selections for FY 2013-2014 NLUF solicitation completed**



ICF budget has been supported strongly by NNSA & Congress



FY 2012 FINAL		
MTE	Name	\$K
10.1	Ignition	109,888
10.2	Support of Other Stockpile Programs	0
10.3	Diagnostics, Cryogenics, & Experimental Support	85,654
10.4	Pulsed Power ICF	4,997
10.5	JPHEMLP	9,100
10.7	Facility Ops & Target Production	265,173
TOTAL		474,812

FY 2013 PBR/CR		
MTE	Name	\$K
10.1	Ignition	84,172
10.2	Support of Other Stockpile Programs	14,817
10.3	Diagnostics, Cryogenics, & Experimental Support	81,942
10.4	Pulsed Power ICF	6,044
10.5	JPHEMLP	8,334
10.7	Facility Ops & Target Production	264,691
TOTAL		460,000

But challenges ahead

- The resolution of the new blended rate at LLNL involves adding resources to RTBF funds. ICF Program funds will not increase due to this adjustment to give LLNL more flexibility.
- Fiscal Cliff



ICF budget justification relies on demonstrated relevance to current & future stockpile needs and continuous progress



- ICF facilities are providing data today that address long standing questions in the weapons program**
- ICF provides the only path to a laboratory burning plasma platform and, when achieved, will add a significant new tool for SSP**
- Significant progress continues to be made in understanding the physics and technology limiting the indirect drive approach to ignition**
- Alternate approaches to ignition are advancing and provide robustness to single point failure**
- The Path Forward describes a consensus plan for future activity**

In NNSA's opinion, ignition is the sine qua non for any Inertial Fusion Energy program



Summary



- **Ignition not yet achieved but remains principal goal of the ICF Program, and our understanding is increasing rapidly**
- **Alternate concepts to the mainline indirect drive approach are advancing**
- **HED facilities are operating well and are oversubscribed (by a lot)**
- **Vibrant HED community is recognized to be critical to the success of SSP**
- **ICF is an exciting grand challenge endeavor and remains a leading attractor for talent and the next generation of stewards**



BACKUP



NIC Key Milestones



	Short Description	NIC EP Rev 4.0 Approved Title	Due Date
1.	Facility approved for ignition shots	Complete contractor Readiness Assessment for High Yield	Q2 FY 2011
2.	Diagnostics available for ignition shots	Complete Operational Qualification of the First Set of NIC Ignition Diagnostics	Q2 FY 2011
3.	Systems, diagnostics, and experimental capabilities demonstrated	Begin First Integrated Ignition Experiments	Q4 FY 2011
4.	Preparing the fuel for ignition	Conduct first THD Tuning Experimental Campaign to Optimize Ignition Threshold Factor (ITF)	Q4 FY 2011
5.	Demonstrating that we can light the “match” – alpha heating	Conduct First DT Implosion Experimental Campaign to Demonstrate Limited Alpha Heating	Q3 FY 2012
6.	Completing the laser operations to give maximum headroom	Demonstrate 1.8 MJ Operations	Q2 FY 2012
7.	Demonstrating ignition (burn)	Conduct DT Implosion Experimental Campaign to Produce Gain of 1	Q4 FY 2012

Completed	Not completed
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ICF Budget



FY 2012 Final (\$K)	FY 2013 PBR (\$K)	FY 2013 CR (\$K)*
\$474, 812	\$460,000	\$447,647*
*Reduction reflects increased program taxes – from \$4,220 K to \$16,573 K		

Uncertainties Going Forward

- The resolution of the new blended rate at LLNL involves adding resources to RTBF funds. ICF Program funds will not increase due to this adjustment to give LLNL more flexibility.
- Fiscal Cliff



ICF FY 2012 Site Funding



Targets

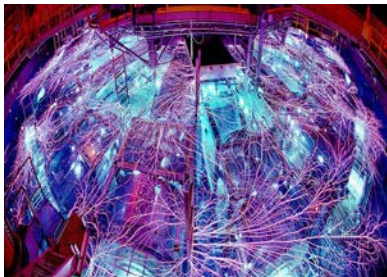


LANL

NRL

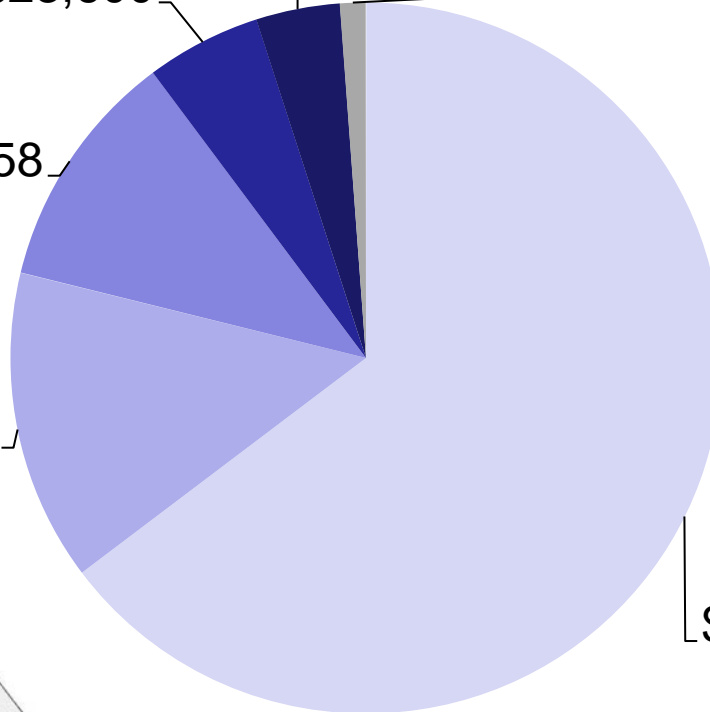


\$23,600 \$17,187 \$5,335



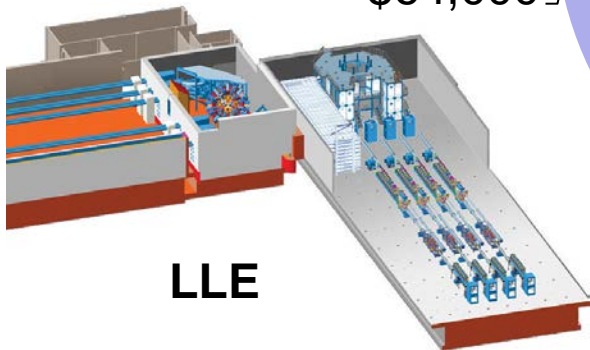
SNL

\$49,458



\$292,472

LLNL



LLE

\$64,000



ICF FY 2013 PBR/CR Site Funding



Targets



\$25,000/\$25,000

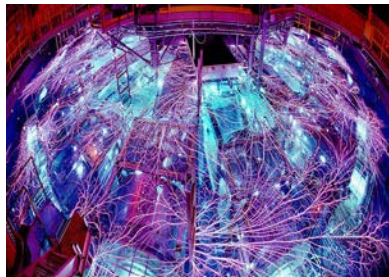


LANL

\$16,500/\$15,956

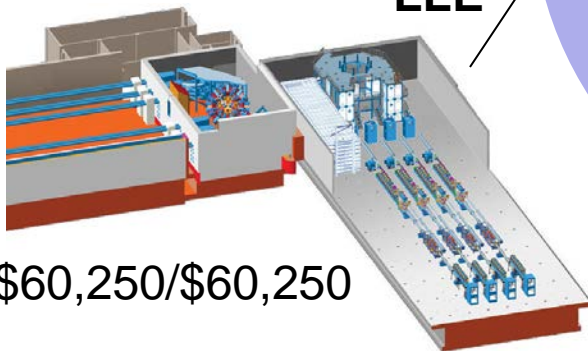
NRL

\$5,000/\$4,865



SNL

\$55,000/\$53,078



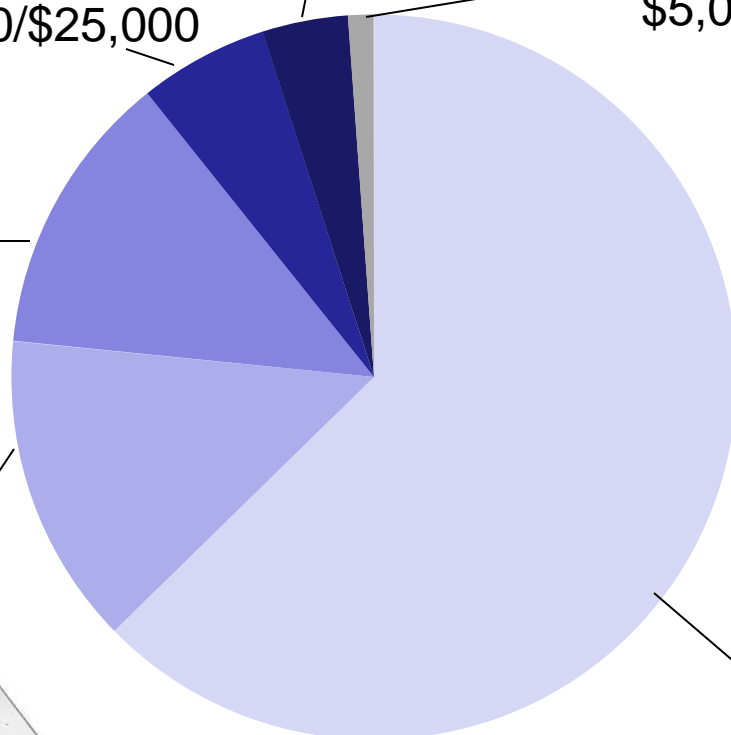
LLE

\$60,250/\$60,250



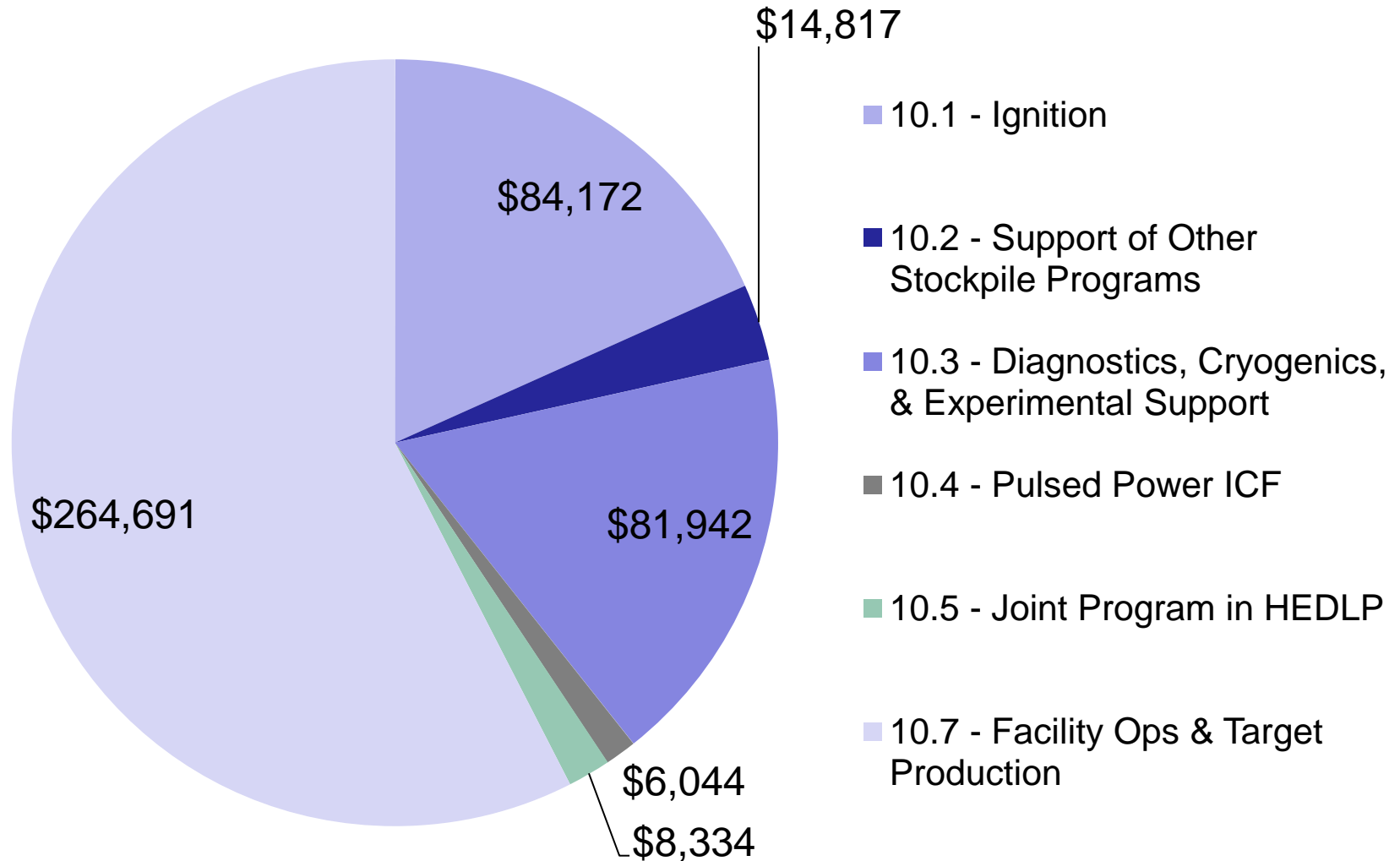
LLNL

\$271,750/\$262,214





ICF FY 2013 Budget by MTE





ICF in the Press



- “A Step Forward for Fusion” (*Science NOW*, 18 Sep 2012, <http://news.sciencemag.org/sciencenow/2012/09/a-step-forward-for-fusion.html>) implies that MagLIF concept on Z is near scientific breakthrough.
- “Ignition Switch” (*Nature*, Vol. 491, Issue 7423, 7 Nov 2012) article implies that mission of NIF changing from fusion energy to nuclear weapons due to failure to achieve ignition.
- “Laser lab shifts focus to warheads” (*Nature*, Vol. 491, Issue 7423, 7 Nov 2012) implies same as above
- “*Nature* contradicts key officials concerning National Ignition Facility’s original mission” editorial in *Physics Today* (8 Nov 2012) accuses the ICF Program of “unrealism”, “bluster”, and “hubris”.
- Etc...

The ICF community must be careful to not overpromise or confuse