U.S. Department of Energy's

# Office of Science

# Fusion Energy Sciences Program

## Budget Planning Meeting

**Dr. N. Anne Davies**
Associate Director
for Fusion Energy Sciences

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www.ofes.fusion.doe.gov

U.S. Department of Energy

Office of Science

# The Office of Science FY05 Budget Request

(dollars in thousands)

| | FY 2003 Comparable Approp. | FY 2004 Comparable Approp. | FY 2005 President's Request | FY 2005 Request vs. FY 2004 Appropriation | |
|---|---|---|---|---|---|
| **Science** | | | | | |
| Basic Energy Sciences | 1,001,941 | 1,010,591 | 1,063,530 | +52,939 | +5.2% |
| Advanced Scientific Computing Research | 163,185 | 202,292 | 204,340 | +2,048 | +1.0% |
| Biological & Environmental Research | 494,360 | 641,454 | 501,590 | -139,864 | -21.8% |
| *Congressionally-directed projects* | *(51,927)* | *(140,762)* | *(——)* | *(-140,762)* | *(-100.0%)* |
| *Core Biological and Environmental Research* | *(442,433)* | *(500,692)* | *(501,590)* | *(+898)* | *(+0.2%)* |
| High Energy Physics | 702,038 | 733,631 | 737,380 | +3,749 | +0.5% |
| Nuclear Physics | 370,655 | 389,623 | 401,040 | +11,417 | +2.9% |
| Fusion Energy Sciences | 240,695 | 262,555 | 264,110 | +1,555 | +0.6% |
| Science Laboratories Infrastructure | 45,109 | 54,280 | 29,090 | -25,190 | -46.4% |
| Science Program Direction | 137,425 | 152,581 | 155,268 | +2,687 | +1.8% |
| Workforce Development for Scientists & Teachers | 5,392 | 6,432 | 7,660 | +1,228 | +19.1% |
| Small Business Innovation Research/Technology Transfer | 100,172 | —— | —— | —— | —— |
| Safeguards and Security | 61,272 | 56,730 | 67,710 | +10,980 | +19.4% |
| Subtotal, Science | 3,322,244 | 3,510,169 | 3,431,718 | -78,451 | -2.2% |
| Use of prior year balances | —— | -10,000 | —— | +10,000 | +100.0% |
| **Total, Science** | **3,322,244** | **3,500,169** | **3,431,718[a]** | **-68,451** | **-2.0%** |
| *Total, excluding Congressionally-directed projects* | *(3,270,317)* | *(3,359,407)* | *(3,431,718)* | *(+72,311)* | *(+2.2%)* |

[a] *Note, when compared to the FY 2004 request (comparable), the FY 2005 request increases $104,885,000 (3.2%).*

# *FY 2005 Fusion Energy Sciences President's Budget Request*

| | FY 2003 Actual | FY 2004 Approp. | FY 2005 Cong. |
|---|---|---|---|
| Science | 136.2 | 143.9 | 144.0 |
| Facility Operations | 66.2 | 84.5 | 85.5 |
| Technology | 38.3 | 27.4 | 27.8 |
| SBIR/STTR | 6.2 | 6.8 | 6.8 |
| *OFES Total* | *246.9* | *262.6* | *264.1* |
| | | | |
| DIII-D | 51.9 | 56.0 | 54.0 |
| C-Mod | 19.2 | 22.2 | 21.5 |
| NSTX | 30.1 | 34.7 | 33.6 |
| NCSX | 11.7 | 16.7 | 16.7 |
| IFE/HEDP | 17.0 | 15.1 | 13.9 |

# Fusion Energy Sciences Long Term Goals

1. Predictive Capability for Burning Plasma

   Develop a predictive capability for key aspects of burning plasmas using advances in theory and simulation benchmarked against a comprehensive experimental database of stability, transport, wave-particle interaction, and edge effects.

2. Configuration Optimization

   Demonstrate enhanced fundamental understanding of magnetic confinement and improved basis for future burning plasma experiments through research on magnetic confinement configuration optimization.

3. Inertial Fusion Energy and High Energy Density Physics

   Develop the fundamental understanding and predictability of high energy density plasmas.

# FY 2004 and FY 2005 Targets

- Average achieved operational time of major national fusion facilities as a percentage of total planned operational time is greater than 90%

- Cost-weighted mean percent variance from established cost and schedule baselines for major construction, upgrade, or equipment procurement projects kept to less than 10%

# NCSX FY 2004 and FY 2005 Targets

FY 2004 Target Milestone:

Established, in February 2004, the performance baseline (i.e. cost, schedule and technical scope) of the National Compact Stellarator Experiment (NCSX). The Total Estimated Cost for NCSX is $86.3M with completion in May 2008.

FY 2005 Target Milestone:

Begin NCSX fabrication (i.e. Critical Decision 3) and award, through a competitive process, production contracts for the NCSX Modular Coil Winding Forms and Vacuum Vessel.

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| PSPG/TARGETS - ABBREVIATED | FY 2004 PSPG/TARGETS | Quarter 1 | Quarter 1 Status - On Track or Comment | Quarter 2 | Quarter 2 Results - "Yes/No" and Comment | Quarter 3 | Quarter 3 Status - OnTrack or Comment | Quarter 4 | Quarter 4 Status - On Track or Comment |
|---|---|---|---|---|---|---|---|---|---|
| SC6-1a Conduct feedback control experiments in DIII-D | Conduct feedback control experiments in DIII-D with the new internal control coils to reach plasma operating conditions beyond the limits that can be achieved without the stabilizing effect of a nearby conducting wall. (EO/GA) | Evaluate initial operation with internal coil and sensors for RWM stabilization and compare to models. Develop new experimental proposals. | Completed (as of Dec 18) | Conduct initial experiments aimed at increasing beta with new internal coils (error field reduction and active feedback). | On track (as of March 15) | Perform analysis of initial high beta experiments and compare with models. Conduct additional feedback optimization experiments. Evaluate advantages of internal coils. | On track (as of June 30) | Evaluate plasma response with optimal feedback. Perform experiments to optimize beta above the no wall limit with existing bandwidth of actuators. Evaluate bandwidth limitations of actuators. | |
| SC6-1b Compare energy confinement, H-mode thresholds, and divertor particle dynamics in Alcator C-Mod discharges | Compare energy confinement, H-mode thresholds, and divertor particle dynamics in single-null, double-null, and inner-wall-limited discharges in Alcator C-Mod, establishing limits of divertor power handling for advanced tokamak plasma regimes and requirements for advanced divertors for planned burning plasma tokamaks. (RD/MIT) | Assess neutral particle dynamics in single-null, double-null, and inner-wall-limited discharges. | Completed (as of Dec 24) | Assess energy confinement in double-null discharges. | On track (as of March 15) | Explore H-mode threshold for double-null discharges. | On track (as of June 30) | Assess divertor power handling for densities and powers typical of AT regimes. | |
| SC6-1c Include electron dynamics in turbulent transport simulations | Include electron dynamics in turbulent transport simulations and compare the results with experimental results from both U.S. and foreign tokamaks to benchmark the simulation code. (CB/LLNL) | SUMMIT code protypes of electron physics benchmarked against GYRO. GS2 comparison to JET results. | Completed (as of Dec 24) | Profiles from Electromagnetic GYRO simulations with kinetic electrons will be compared with D3D experimental data. | On track (as of March 15) | GTC Kinetic electrons via electrostatic hybrid model, linear TEM benchmark with FULL and GT3D, nonlinear TEM mode simulations. | On track | SUMMIT code with full physics production version is compared to GS2. | |
| SC6-1d Expand experiments on stabilization of Neoclassical Tearing Mode instabilities in DIII-D | Expand the experiments on stabilization of Neoclassical Tearing Mode instabilities with increased electron cyclotron heating power in DIII-D and compare the results with computational models to benchmark the theories. (EO/GA) | Evaluate new feedback for Shafranov shift. | Completed (as of Dec 18) | Execute experiments to increase beta with NTM stabilization. Complete analysis of high beta discharges. Evaluate need for additional stabilization optimization experiments. | On track (as of March 15) | Compare analyzed experimental results with computational models. | | Improve NTM feedback stabilization for more routine utilization. | |
| SC6-1e Complete design of advanced ICRF antenna for C-Mod | Complete detailed design of an advanced, high-power, load tolerant, ion cyclotron radio frequency antenna for C-Mod. (TV/MIT&ORNL) | Evaluate four-strap prototype antenna performance in non-symmetric heating mode. | Completed (as of Dec 15) | Evaluate fixed, passive tuning elements. | On track (as of March 15) | Complete thermal analysis of preliminary design. | | Complete design for advanced four-strap antenna. | |
| SC6-2a Assess confinement and stability in NSTX | Assess confinement and stability in NSTX by characterizing high confinement regimes with edge barriers and by obtaining initial results on the avoidance or suppression of plasma pressure limiting modes in high-pressure plasmas. (SE/PPPL) | Install additional in-vessel magnetic sensors to measure modes that may limit plasma pressure. | Completed (as of Nov 17) | Begin experimental research operations. | Completed (as of Jan 20) | Characterize the benefits of the spherical torus configuration and plasma rotation on the avoidance or suppression of pressure limiting modes. | On track (as of June 30) | Characterize the dependence of electron and ion thermal diffusivities on variations in plasma parameters at high pressure in high confinement regimes. | |

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| PSPG/TARGETS - ABBREVIATED | FY 2004 PSPG/TARGETS | Quarter 1 | Quarter 1 Status - On Track or Comment | Quarter 2 | Quarter 2 Results - "Yes/No" and Comment | Quarter 3 | Quarter 3 Status - OnTrack or Comment | Quarter 4 | Quarter 4 Status - On Track or Comment |
|---|---|---|---|---|---|---|---|---|---|
| SC6-2b Carry out experiments in support of heavy ion beam inertial fusion | Integrate elements of initial plasma neutralized beam focus and carry out initial experiments in support of heavy ion beam inertial fusion. (FT/LBNL) | Report on measurements of transport through 4 magnetic quadrupoles. Include measurements of beam aberrations and haloes. | Completed (as of Dec 16) | Report on measurements of neutralized transport. Include details of beam phase space at the entrance to the neutralization section, and in-situ characterization of the plasma sources. | On track (as of March 8). Energy scan measurement was repeated with a 1-cm aperture. Data on halos and beam profiles are being analyzed. | Report on beamline test results of the nonintercepting ion beam diagnostic with electron beam deflection. | On track | Compare experimental results with theory and report on the comparisons. | |
| SC6-2c Carry out full voltage beamlet acceleration for heavy ion beam inertial fusion | Carry out full voltage beamlet acceleration and determine beamlet characteristic (multibeamlet source configured in FY 2003) for heavy ion beam inertial fusion. (FT/LBNL) | Determine the characteristics of high current density multibeamlets produced and transported under full voltage gradient on STS-100. | Completed (as of Dec 16) | Complete engineering drawings for the merging beamlet experiment to be installed on STS-500 and report on the final design. | On track (as of March 8). An alternate physics design for the merging-beamlet experiment which reduces the cost. | Complete fabrication of electrodes, insulators, and initial diagnostics equipment for the merging beamlet experiment. | | Demonstrate acceleration of high current density multibeamlets on STS-500 and report on the experimental results. | |
| SC6-2d Complete first phase of irradiation testing of fusion materials in U.S. fission reactors | Under a cost-shared collaborative program with Japan for irradiation testing of fusion materials in U.S. fission reactors, complete first phase of testing to evaluate the effects of neutron bombardment on the microstructural evolution, and property changes of candidate fusion materials. (SB/ORNL) | Initiate fusion materials irradiation testing in HFIR high flux region with goal of accumulating by FY 2005 neutron fluences of ~10 to 40 dpa in a variety of advanced steel specimens. | Completed (as of Dec 15) | Complete design, assembly, and installation of 2nd and 3rd increment of irradiation capsules in HFIR with goal neutron fluence accumulation of up to ~20 and 50 dpa, respectively. | First part of goal (2nd irradiation capsule) is on track (as of March 15). Second part of goal (3rd irradiation capsule) is delayed by 3 months to 6/04 because of HFIR restart schedule slippage due to unplanned outages (NOTE: delay has allowed adding a 4th irradiation capsule to increase productivity of HFIR irradiations). | Complete first phase of irradiation testing by extracting specimens that have reached neutron fluence accumulation of up to 10 dpa. | Will be delayed by about 1 month to 7/04 because of HFIR restart schedule slippage due to unplanned outages | Begin post-irradiation examinations of extracted 10 dpa specimens to determine microstructural evolution and property changes, and compare results to modeling predictions. | May be delayed by about 1 month to end of 10/04 because of HFIR restart schedule slippage due to unplanned outages |

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| PSPG/TARGETS - ABBREVIATED | FY 2004 PSPG/TARGETS | Quarter 1 | Quarter 1 Status - On Track or Comment | Quarter 2 | Quarter 2 Results - "Yes/No" and Comment | Quarter 3 | Quarter 3 Status - OnTrack or Comment | Quarter 4 | Quarter 4 Status - On Track or Comment |
|---|---|---|---|---|---|---|---|---|---|
| SC7-6a Deviation in Weeks of Major Facilities | Keep deviations in weeks of operation for each major facility within 10 percent of the scheduled weeks. (EO/GA; RD/MIT; SE/PPPL) | Achieve level of facility operation consistent with base line plans and meeting total operating weeks for the FY 2004. | DIII-D completed (as of ?)<br>C-Mod completed (as of Dec 24) | Achieve level of facility operation consistent with base line plans and meeting total operating weeks for the FY 2004. | DIII-D on track (as of March 15)<br>C-Mod on track (as of March 15)<br>NSTX on track (as of March 15) | Achieve level of facility operation consistent with base line plans and meeting total operating weeks for the FY 2004. | Yes for DIII-D (as of June 30)<br>Yes for C-Mod<br>No for NSTX | Achieve facility total operating weeks as planned for FY 2004: DIIID, 18 weeks: C-Mod, 18 weeks: NSTX, 18 weeks. | |
| SC7-6b National Compact Stellarator Experiment (NCSX) Final Design | Complete the Final Design of the National Compact Stellarator Experiment and begin fabrication. (GN/PPPL&ORNL) | Authorize prototype fabrication - modular coil winding forms and vacuum vessel. | Completed (as of Oct 27) | Initiate winding process on a 3D surface and assess implications for design and fabrication. | Completed (as of Feb 6) | First prototype modular coil winding form casting produced for machining. | Review delayed until 1st Quarter of FY 2004 (as of June 30) | CD-3 readiness: complete preparations for CD-3 determination. | |

# *Summary of Fusion Energy Sciences FY 2005 Program*

**ITER**

- Direct Funding of $7M: $1M for procurement of S/C Wire; $6M in reserve awaiting selection of organization to host U.S. Project Office and other decisions
- Total of $38 M in resources from throughout the program will support preparation for U.S. tasks

**Science** ($150.8 M, +$0.1 M)

- +$1 M for MST
- Focus SciDAC on burning plasma physics
- NCSX research in support of construction level
- All other programs funded at about FY 2004 appropriations level

**Facilities Operations** ($85.5M, +$1 M)

- ITER direct funding +$4 M
- Operation of facilities reduced from FY 2004 plan of 18 weeks each to 14 weeks each (-$3.2 M)
- NCSX kept at FY 2004 level instead of the planned $4.8 M increase
- Funding for ORNL move stretched out

**Enabling R&D** ($27.8M, $+$0.4 M)

- Fusion Technologies closed out in FY 2004, some parts moved to Plasma Technologies
- FIRE program wrapped up with Physics Validation Review in FY 2004

# *NCSX Project*

- Evolution of design and response to design reviews raised project cost to $83M

- New definition of project completion and new funding profile result in cost and schedule impact

Total project cost $86.3 M, for project completion in FY 2008

| | FY 2003 | FY 2004 | FY 2005 | FY 2006 | FY 2007 | FY 2008 |
|---|---|---|---|---|---|---|
| New Profile | 7,897 | 15,921 | 15,921 | 22,100 | 19,400 | 5,100 |
| Previous Profile | 7,897 | 15,921 | 20,397 | 17,800 | 11,485 | |

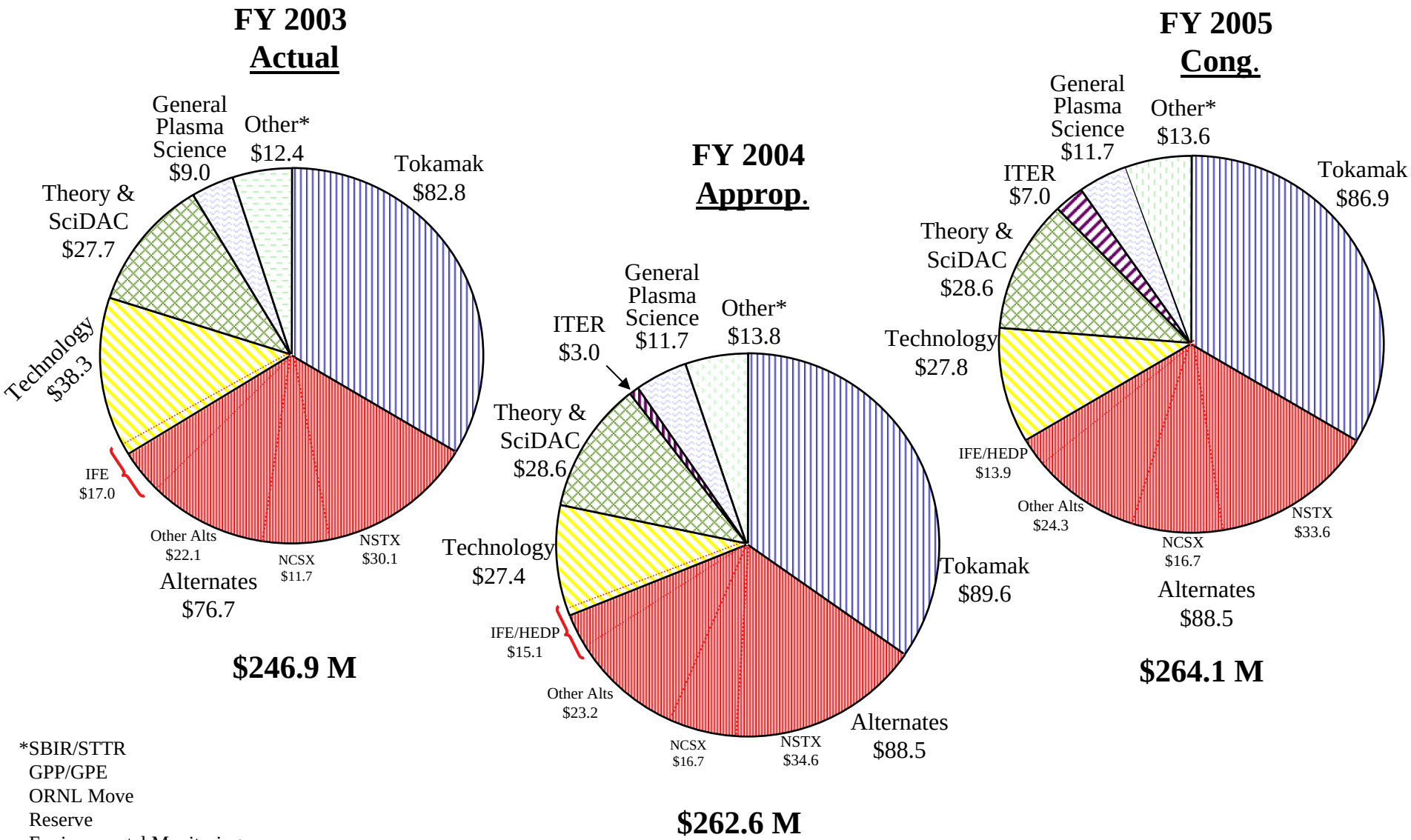
($69 M – 83 M; completion FY 2007)

# *Fusion Program Resources in Preparation for ITER*

| Elements | FY 2004 Approp. | FY 2005 Cong. |
|---|---|---|
| Fusion Plasma Theory and Computation (SciDAC) | $1,000,000 | $3,000,000 |
| DIII-D Experimental Program | 3,000,000 | 10,000,000 |
| Alcator C-Mod Experimental Program | 1,000,000 | 5,000,000 |
| ITER Preparations | 3,000,000 | 7,000,000 |
| Plasma Technology | 0 | 13,000,000 |
| *Total* | *$8,000,000* | *$38,000,000* |

# *Fusion Energy Sciences Budget*

($ in Millions)

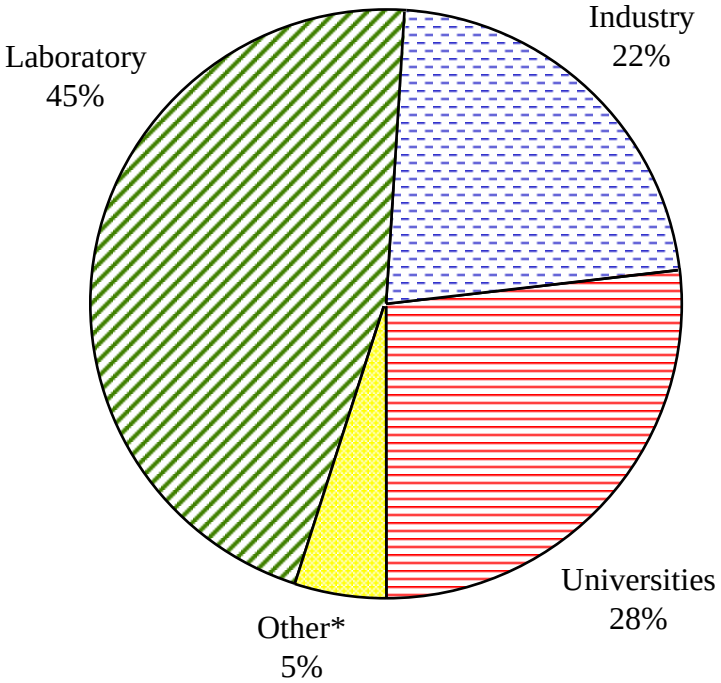



*SBIR/STTR
GPP/GPE
ORNL Move
Reserve
Environmental Monitoring

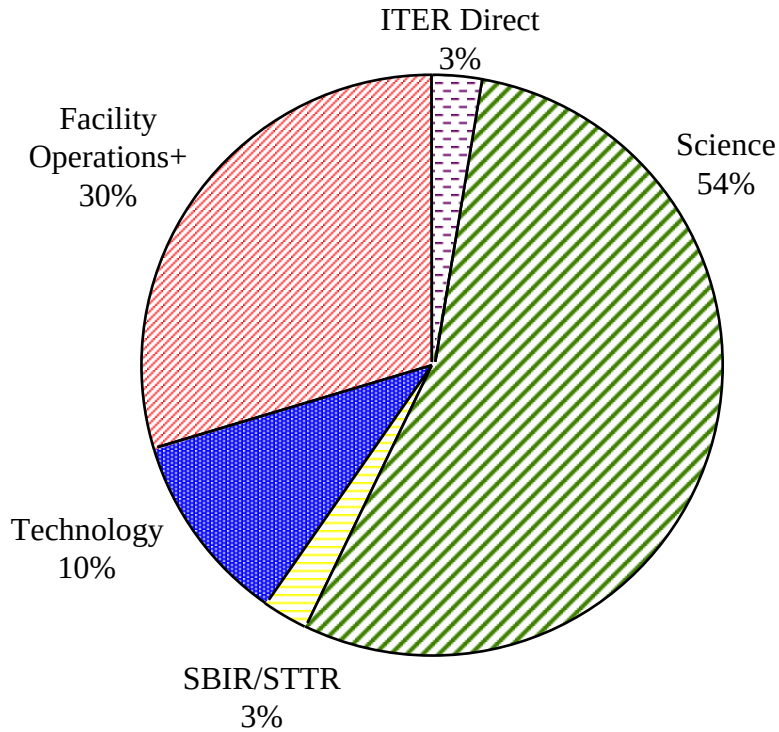
# *Fusion Energy Sciences Funding Distribution*

FY 2005 Congressional
$264.1M

## Institution Types




## Functions




*NSF/NIST/NAS/AF/Undesignated funds

+Includes NCSX Project

# *Fusion Energy Sciences University Funding*

($ in Millions)

| | FY 2003 Actual | FY 2004 Appropriations | FY 2005 Congressional |
|---|---|---|---|
| Massachusetts Institute of Technology | 22.8 | 26.9 | 26.9 |
| Other Universities | 46.5 | 47.7 | 47.6 |
| ***Total University*** | ***69.4*** | ***74.6*** | ***74.5*** |
| | | | |
| By Subprogram | | | |
| Science | 46.3 | 51.0 | 50.1 |
| Facility Operations | 10.8 | 13.8 | 13.6 |
| Technology | 12.3 | 9.8 | 10.8 |
| ***Total University*** | ***69.4*** | ***74.6*** | ***74.5*** |