U.S. Department of Energy's
Office of Science

Fusion Energy Sciences Program

Fusion Energy Sciences Advisory
Committee Meeting

Office of Fusion Energy Sciences
Excellent Science
Attractive Energy

www.ofes.fusion.doe.gov

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

March 29, 2004

Topics

- Budget Update
- Goals and Milestones
- ITER
- NCSX Project
- IFE/HEDP Program
- FES FY 2004 Solicitations
- SC Strategic Plan
- FESAC Membership

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

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
- IFE science level, making transition to High Energy Density Physics program
- All other programs funded at about FY 2004 appropriations level

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

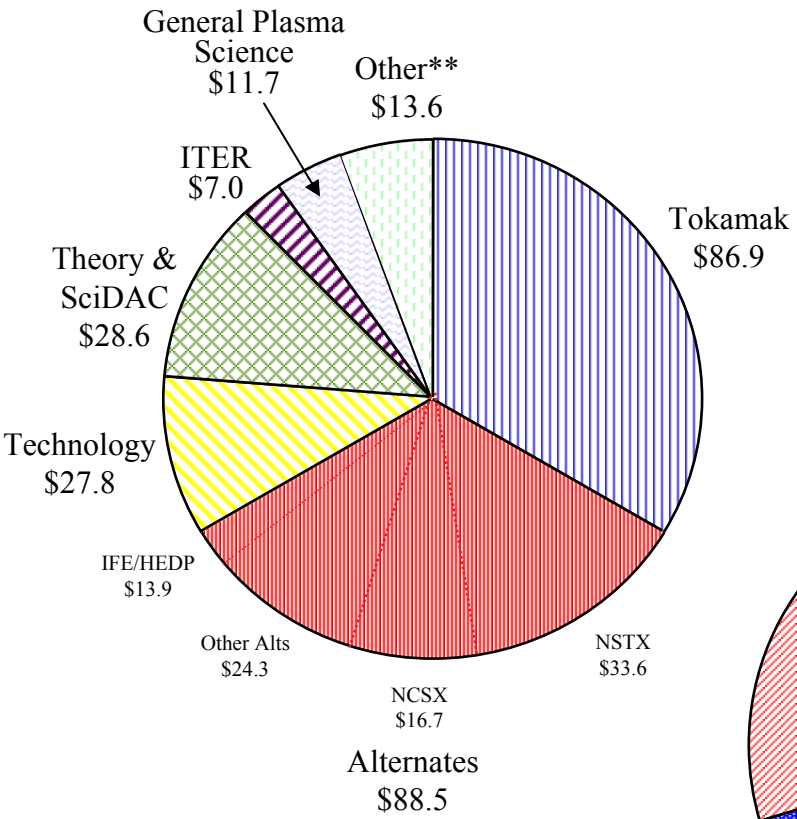
- ITER direct funding +$4 M
- Operation of facilities reduced from FY 2004 plan of 18 weeks each to 14 weeks each (-$3.2 M)
- NCSX kept at FY 2004 level instead of the planned $4.8 M increase
- Funding for ORNL move stretched out

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

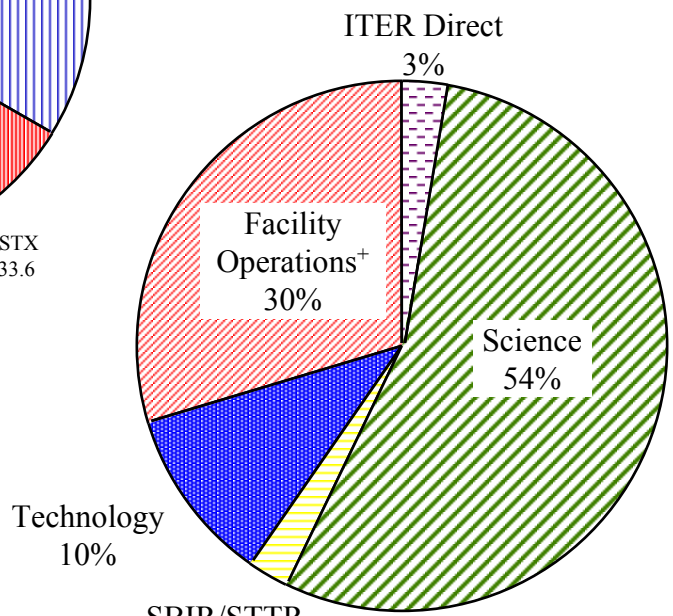
Fusion Energy Sciences Funding Distribution

FY 2005 Congressional
$264.1M



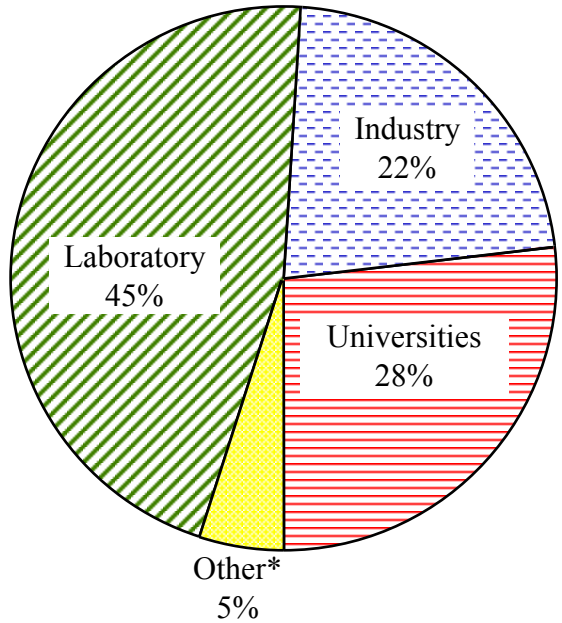
**SBIR/STTR
GPP/GPE
ORNL Move
Reserve
Environmental Monitoring

Functions



+Includes NCSX Project

Institution Types



*NSF/NIST/NAS/AF/
Undesignated funds

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%

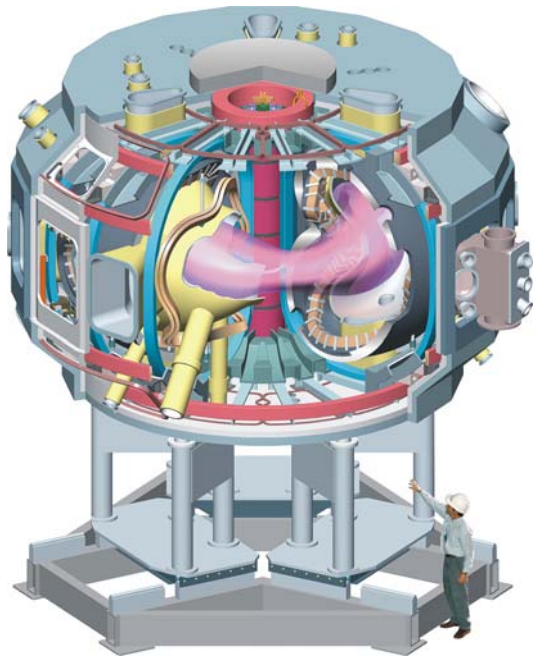
NCSX FY 2004 and FY 2005 Targets

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.



NCSX

OFFICE OF SCIENCE

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 22)	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 22)	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.	Complete (as of March 24)	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 22)	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 22)	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.	

OFFICE OF SCIENCE

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 22). 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 22). 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 22). 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

OFFICE OF SCIENCE

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 ?) 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 22) C-Mod on track (as of March 22) NSTX on track (as of March 22)	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) Yes for C-Mod 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.	

Status of ITER – Remaining Issues

1. Site Selection Pending

Rokkasho, Japan

Cadarache, France, EU

Parallel Activities to Prepare the US to Act Following Site Selection

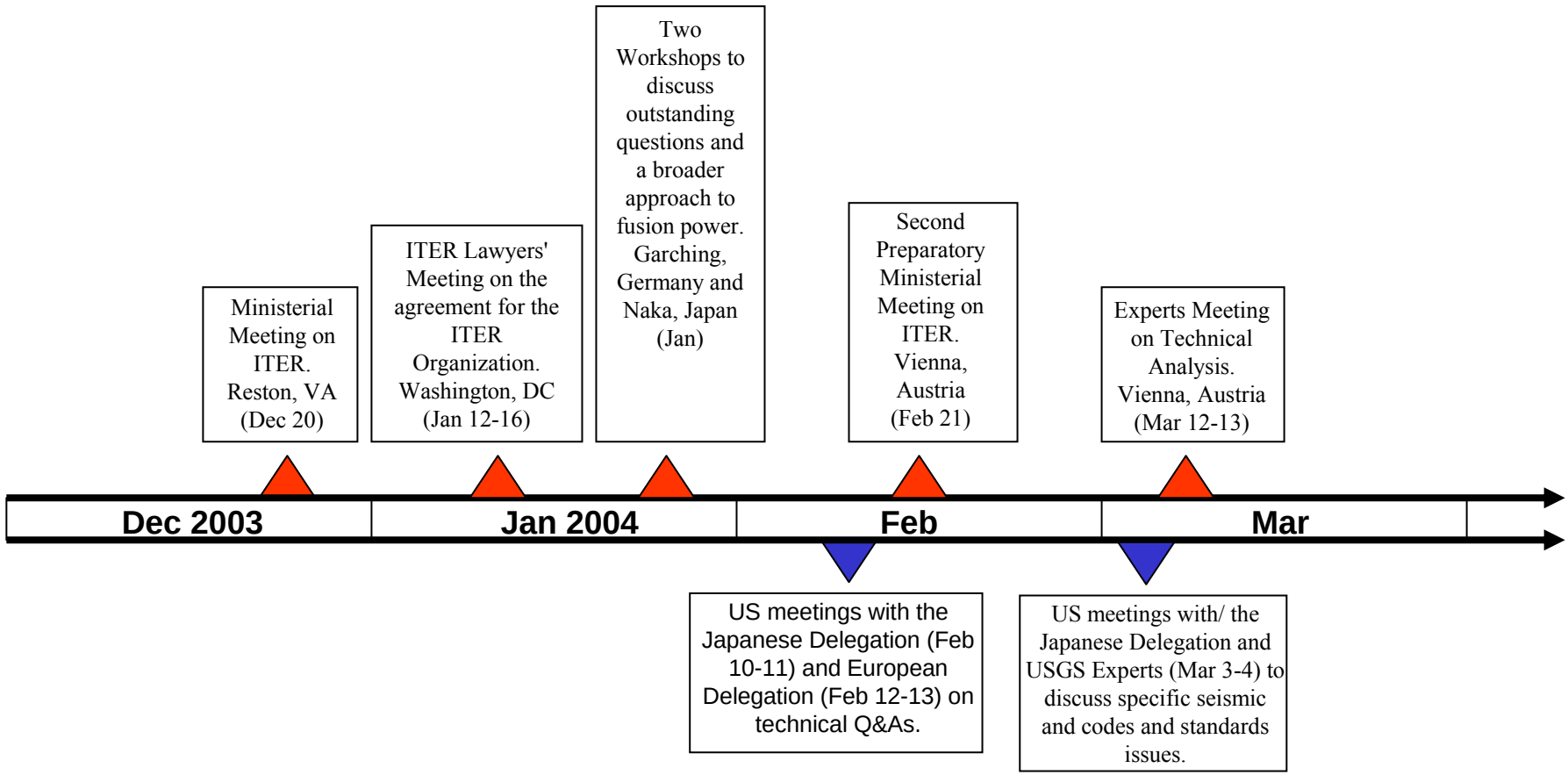
2. Agreement Text Pending – legalities and interpretations
3. Key Personnel – Secondees, US ITER Project Office, ITER Organization
4. OFES Program and Community Preparation for ITER
5. Licensing – responsibility of host site
6. Funding – executing FY 04, defending FY05, and planning FY06
7. Construction Start – 2006?

Remaining Issue #1

Status of ITER – Site Selection

Timeline of Major Activities Related to ITER Host Sites Negotiations

(Rokkasho, Japan and Cadarache, France, EU)



Denotes meetings where all six ITER parties were present.

Denotes meetings where the US met with another ITER party.

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*

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 is now $86.3 million, 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	

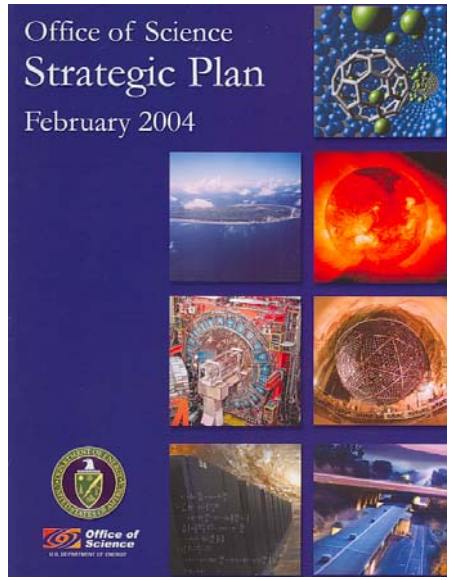
($69 M – 83 M; completion FY 2007)

Evolution of IFE/HEDP Program

Office	Current Program	Future Program
SC	o Heavy Ion Accelerator Physics o Target Physics (modeling) o Fast Ignition o Chamber, Target Fabrication, System Studies	o Focus on science issues o Close out technology research o Develop High Energy Density Physics roadmap with DP, NSF
DP	o High Average Power Laser Program o Z for IFE	

Office of Science Strategic Plan

- Published February 2004; electronic version available at www.sc.doe.gov/



- Fusion "Broad Goals"
  - Demonstrate with burning plasma fusion's scientific/technological feasibility
  - Develop fundamental understanding for predictive capabilities
  - Determine most promising approaches and configurations for energy
  - Develop new materials, components and technologies for energy
- Success Indicators (www.science.doe.gov/measures)
  - Progress in developing benchmarked predictive capability for burning plasma
  - Progress in demonstrating enhanced understanding of magnetic confinement and in improving basis for designing future burning plasma experiments through research on confinement configuration optimization
  - Progress in developing predictability of high-energy density physics including energy applications
- "Facilities for the Future of Science: A Twenty-Year Outlook" is a companion document identifying ITER as the first priority facility for the Office of Science

Fusion Energy – The Moral Imperative

- Current world energy usage is not environmentally sustainable
- The potential role of fusion in alleviating poverty is a powerful social good which needs to be explored
- Our legacy for future generations is **clean**, **safe** energy
- All scenarios indicate that energy sustainability is attainable only by a **mix** of policies, plans, technologies, and funding
- Fusion energy is not the **only** solution but should be **part** of a solution

Fusion Energy Sciences Program
FY 2004 Solicitations

Program	Decisions Complete
Fusion Science Centers	April
Junior Faculty Development	May
SciDAC	June
Theory Program	August
Innovative Confinement Concepts	August
ITER Project Office	TBD

FESAC Membership

- Terms of all members expire in November. Please e-mail Al Opdenaker with your expression of willingness to continue to serve or desire to step down

- We are seeking from the community at large, names of possible new FESAC members to serve November 2004-November 2006. Please send your suggestions along with a brief set of information on why the person suggested would be a good candidate for membership to Al Opdenaker

albert.opdenaker@science.doe.gov