DIII–D NATIONAL PROGRAM BUDGETS

by
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FY05 Budget Planning Meeting
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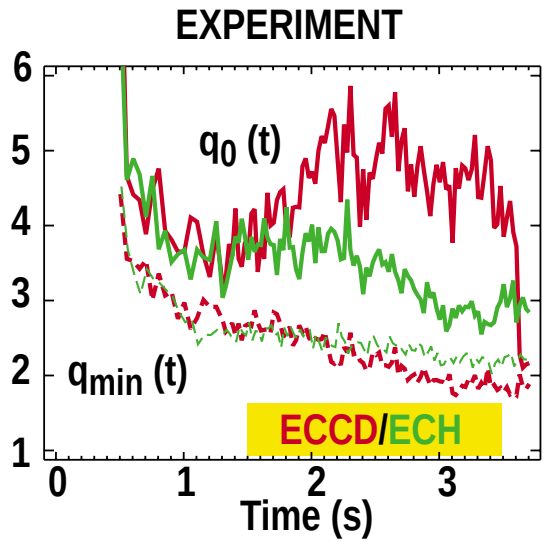
DIII–D
NATIONAL FUSION FACILITY
SAN DIEGO

GENERAL ATOMICS

050–03/RDS1/ci

THE DIII–D PROGRAM PRODUCED OUTSTANDING RESULTS IN 2002

- Research results reported in
  - 6 invited APS presentations
  - 17 IAEA presentations and papers
  - 1 invited EPS, and 14 contributed presentations; 15 papers
  - 3 invited PSI, and 14 contributed presentations; 17 papers
  - 2 invited HTPD, and 14 contributed presentations; 17 papers
- Clear demonstrations of current profile control using off-axis electron cyclotron current drive (ECCD)
- First experimental stabilization of the 2/1 neoclassical tearing mode using electron cyclotron current drive
- Understanding that the key physics of stabilization of the RWM is plasma rotation with respect to the mode



- Active feedback control of T_e [and indirectly J(r)] with ECH
- Successful disruption mitigation technique with real-time trigger of gas jet
- Geodesic acoustic mode branch of zonal flows identified in DIII–D plasmas
- Demonstrated isolated inner strike points in double-null divertor discharges – no ELMs, little particle and heat flux
- TAE mode number scales with $1/q^2$ consistent with theory in DIII–D/NSTX similarity experiments
- Identified the dependence of the density pedestal width on neutral penetration in both hydrogen and deuterium plasmas
- Plasma rotation observed in plasmas with no angular momentum input in C-Mod comparison experiments
- Staff played key leadership roles in the preparation and execution of the 2002 Snomass Fusion Energy Sciences Summer Study, a major step in moving ITER forward

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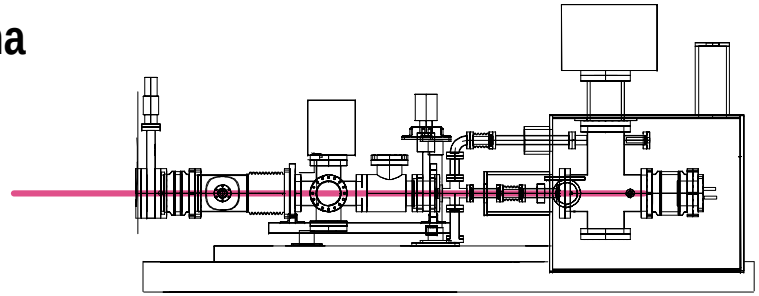
FY03 BUDGET SUPPORTS 13 RUN WEEKS AND CONTINUED PROGRESS ON KEY RESEARCH GOALS

Milestone 149: Proving the role of self-driven plasma current in instabilities at the plasma edge

- Lithium Beam diagnostic being commissioned

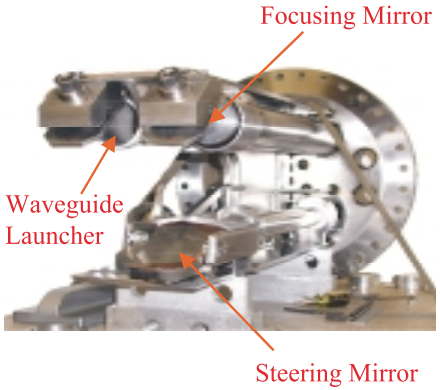


Milestone 150 Exploring plasmas beyond the frontier of conventional stability limits

- New I-coil system being commissioned

Milestone 151 Maintaining high performance by controlling plasma instabilities with microwaves

- NTM stabilization with ECCD



Many experiments in support of ITPA goals

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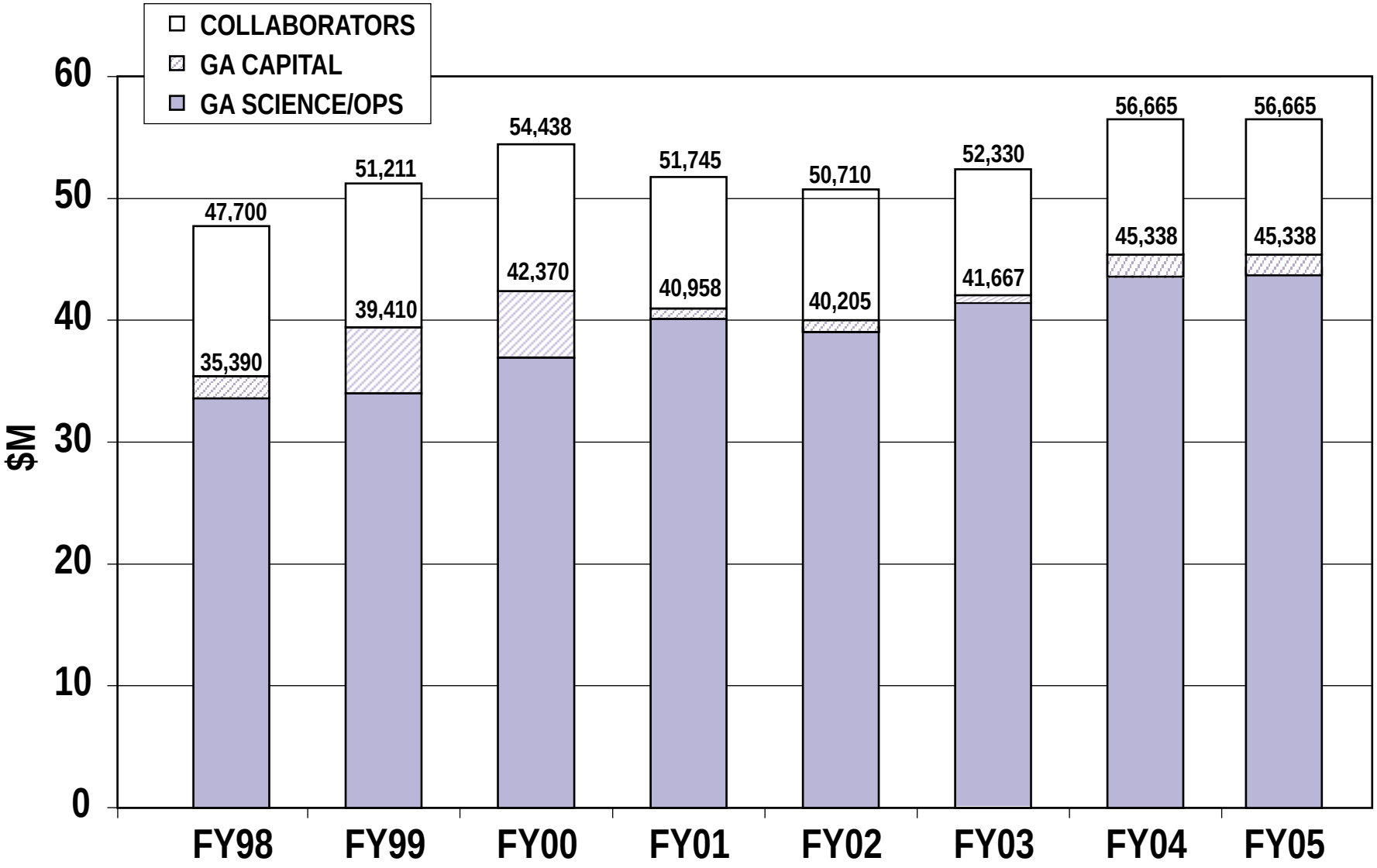
FY04 AND FY05 BUDGET INCREASES WILL ENABLE SIGNIFICANTLY INCREASED PROGRESS



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FY04 AND FY05 BUDGET INCREASE ENABLES

- Run time 13 → 21 weeks in FY04 (15 weeks FY05)
  - Increased research productivity
- Replacing 2-second Russian gyrotrons with long pulse CPI gyrotrons (GA) and 4th steerable launcher (PPPL)
  - Sustained AT performance by suppressing the main 2/1 NTM and controlling the current profile
- Neutral beam ion source refurbishment
- Support of new university turbulence diagnostics awarded in recent competition
- Resumption of fast wave operation
  - Electron heating and central q control

DIII–D NATIONAL FUSION PROGRAM

INSTITUTIONAL BUDGET DISTRIBUTION

FY03-05

($000)

	FY03	FY04	FY04(I)	FY05	FY05(I)
GA	**$41,667**	**$45,338**	**$7,716**	**$45,338**	**$13,671**
GA **	**$39,388**	**$42,290**	**$6,310**	**$42,888**	**$11,581**
COLLABORATION SUPPORT FROM GA CONTRACT	**$2,279**	**$3,048**	**$1,406**	**$2,450**	**$2,090**
UCLA	$582	$654		$605	
U. MARYLAND	$37	$36		$41	
U. IRVINE	$136	$100		$104	
COLUMBIA	$266				
OTHER GA COLLAB. SUBCONTRACTS	$75	$29		$31	
GA POST DOC PROGRAM			$366		$414
GA COLLAB. SUPPORT	$1,182	$2,229	$1,040	$1,669	$1,676
COLLABORATORS	**$10,663**	**$11,327**	**$1,380**	**$11,327**	**$3,000**
PPPL	$4,138	$4,438	$440	$4,438	$880
LLNL	$2,984	$2,993	$660	$2,993	$1,570
ORNL	$2,179	$2,263	$280	$2,263	$550
UCSD	$564	$560		$560	
U. TEXAS	$358	$374		$374	
COLUMBIA	*	$266		$266	
SNL	$160	$156		$156	
U. WISCONSIN	$153	$151		$151	
GEORGIA TECH	$127	$126		$126	
PROGRAM TOTAL	**$52,330**	**$56,665**	**$9,096**	**$56,665**	**$16,671**

* - COLUMBIA FUNDED FROM GA CONTRACT IN FY03.

** - INCLUDES CAPITAL EQUIPMENT

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DIII–D NATIONAL FUSION PROGRAM
INSTITUTIONAL STAFFING DISTRIBUTION
FY03-05
(FTE'S)

	ON-SITE FY03	FY03	FY04	FY04(I)	FY05	FY05(I)
GA CONTRACT SUPPORTED	**135.9**	**138.5**	**139.5**	**14.5**	**136.0**	**32.6**
GA	**129.4**	**129.4**	**132.4**	**14.5**	**125.5**	**32.6**
COLLABORATORS	**6.5**	**9.1**	**7.1**	**0.0**	**10.5**	**0.0**
UCLA	4.5	5.5	5.5		5.5	
U. MARYLAND	0.1	0.1	0.1		0.1	
U. IRVINE	0.8	1.2	1.2		1.2	
COLUMBIA	1.0	2.0				
OTHER GA COLLABORATOR SUBCONTRACTS	0.1	0.3	0.3		0.3	
COLLABORATORS	**26.6**	**41.3**	**42.4**	**4.1**	**41.2**	**6.5**
PPPL	5.5	10.7	11.9		11.2	
LLNL	9.1	12.7	11.3	3.0	10.8	3.5
ORNL	4.3	6.7	6.5	1.1	6.5	3.0
UCSD	3.7	3.7	3.7		3.7	
U. TEXAS	1.0	2.5	2.5		2.5	
COLUMBIA	*	*	2.0		2.0	
SNL	1.0	1.0	1.0		1.0	
U. WISCONSIN	1.0	3.0	2.5		2.5	
GEORGIA TECH	1.0	1.0	1.0		1.0	
TOTAL	**162.5**	**179.8**	**181.9**	**18.6**	**177.2**	**39.1**

* - COLUMBIA FUNDED FROM GA CONTRACT IN FY03.

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FY04 RESEARCH MILESTONES

- Milestone 152: Examining the role of particle flux on the structure of the edge transport barrier
- Milestone 153: Evaluating the physics basis for steady-state advanced tokamak operation
- Milestone 154: Assessing the operating space for tolerable edge localized modes in a next-step tokamak
- Milestone 155: Demonstrating the effectiveness of non-axisymmetric control coils inside the vacuum vessel for feedback stabilization of plasma instabilities

FY05 RESEARCH MILESTONES

- Milestone 156: Comparing poloidal dependence of edge turbulence measurements with edge turbulence predictions
- Milestone 157: Comparing initial high k turbulence measurements with code predictions
- Milestone 158: Controlling the spatial distribution of electrical current in tokamak plasmas (proposed for level I)
- Milestone 159: Characterizing erosion and re-deposition of carbon with implications for the tritium retention issue
- Milestone 160: Assessing control of the edge pedestal with stochastic boundary layers

IMPACT OF A 10% BUDGET CUT IN THE DIII–D NATIONAL FUSION PROGRAM IN FY05

The following actions would be taken in the order listed

1. Cancel Thomson refurbishment (GA)
2. Curtail fast wave support (PPPL, ORNL)
3. Stop construction of EC steerable launcher (PPPL)
4. Reduce run time from 15 to 8 weeks
5. Reduce LLNL support 1 FTE
   - LLNL faces choice of edge physics or AT (MSE)
6. Cancel replacement gyrotron procurement (GA)

- Total staff reduction

GA	7
PPPL	1
LLNL	1
ORNL	1
	10

- Revisit milestones 158 and 159

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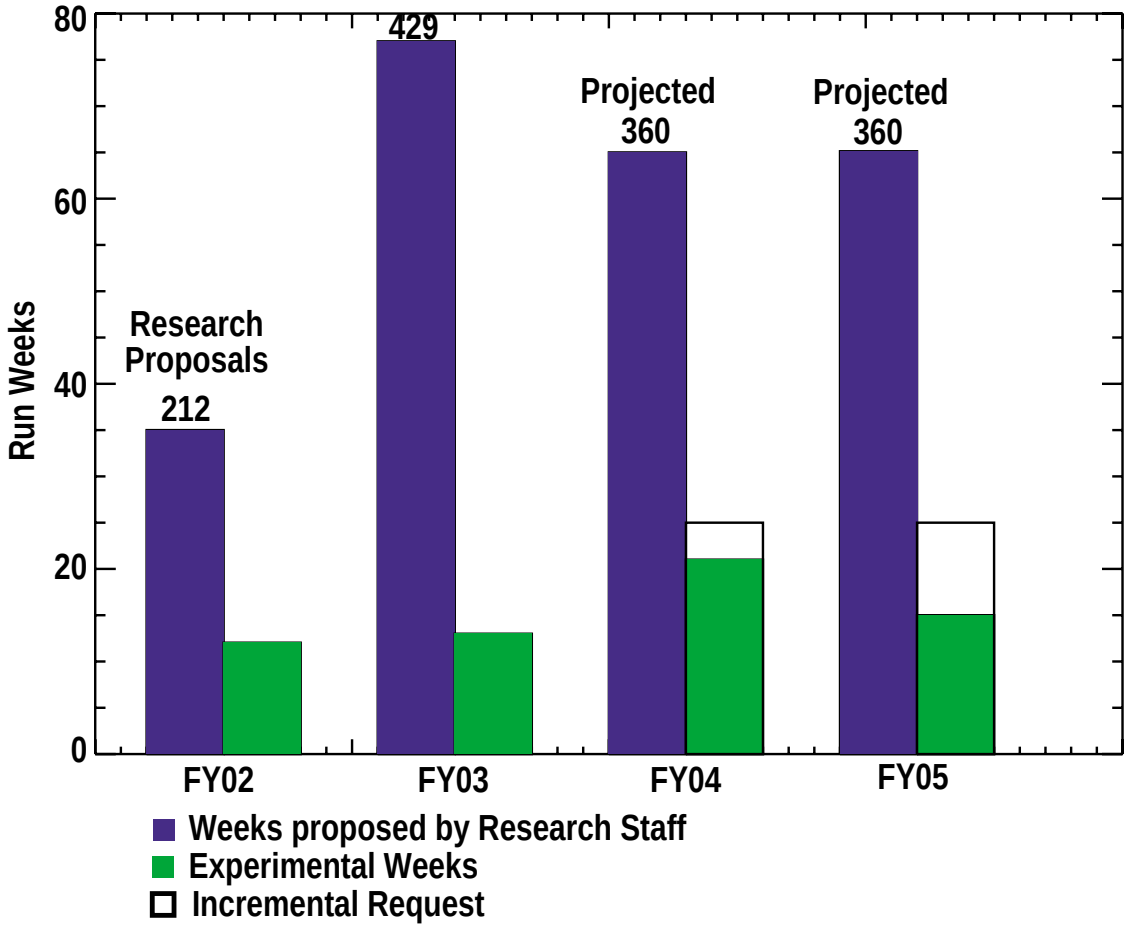
AN EXPLOSION OF RESEARCH PROPOSALS IN FY03



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DIII–D RECEIVED 429 RESEARCH PROPOSALS FOR CY03
FY03, 13 RUN WEEKS ⇒ 65 PROPOSALS CAN BE DONE

FOREIGN PROPOSALS

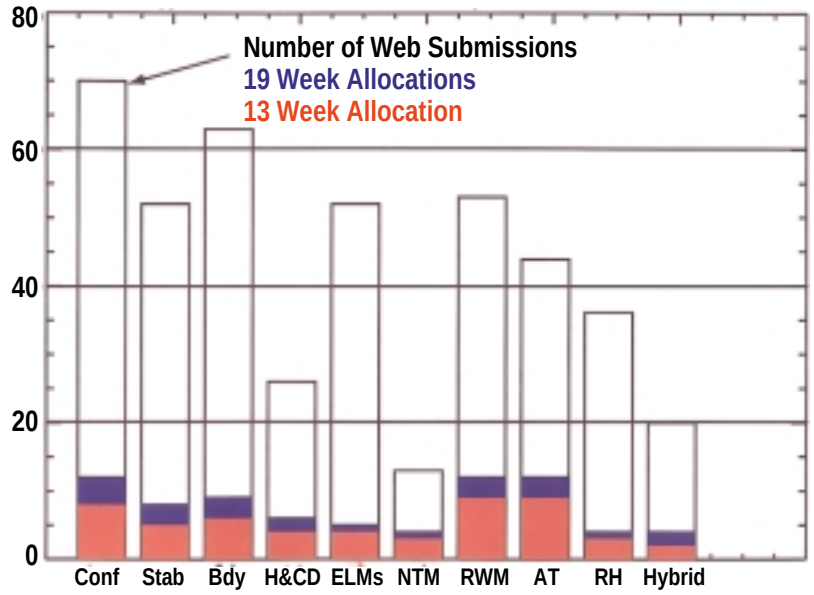
- Frascati 2
- Cadarache 2
- Ipp Germany 6
- JET 18
- Portugal 2
- Spain 2
- Italy 2
- Switzerland 3
- Netherlands 1
- Russia 5
- Japan (NIFS) 1
- Australia 2

Foreign total: 46

DOMESTIC PROPOSALS BY INSTITUTION

- Columbia 23
- FarTech 3
- GA 165
- Lehigh 3
- LLNL 36
- MIT 6
- ORNL 24
- PPPL 54
- RPI 1
- SNL 5
- UCI 3
- UCLA 13
- UCSD 20
- U. Texas 9
- U. Maryland 1
- U. New Mexico 1
- U. Wisconsin 6

Domestic total: 373



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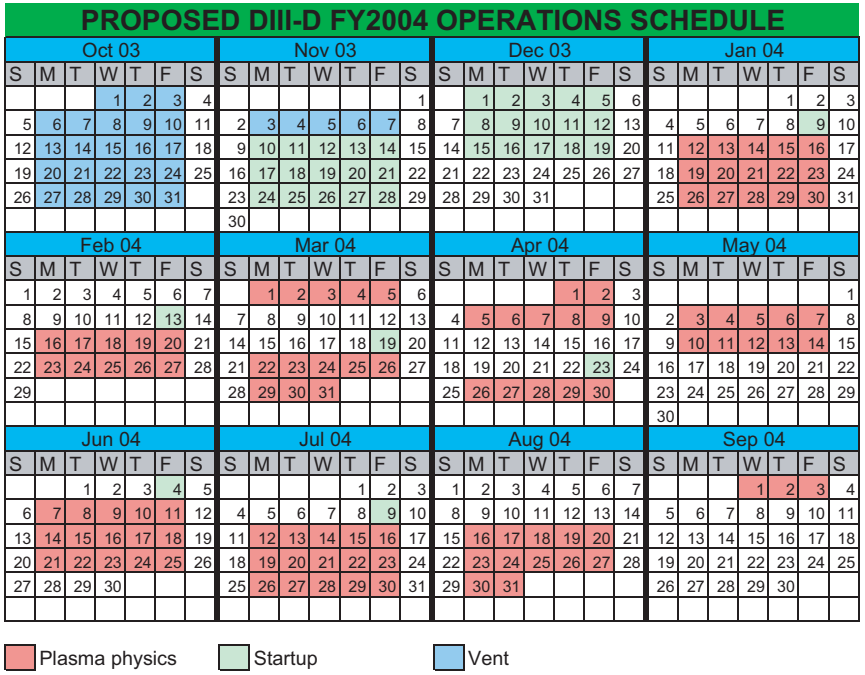
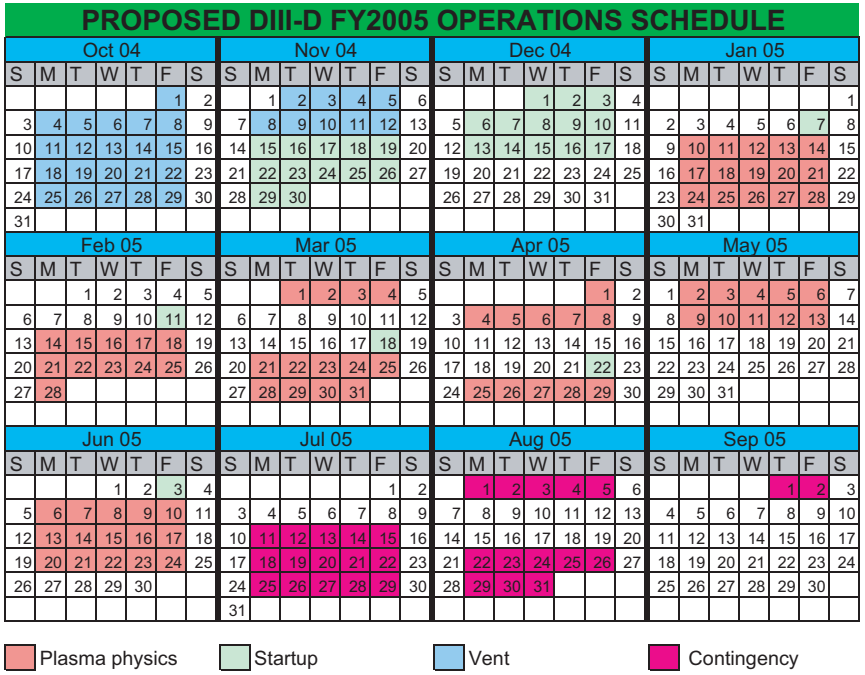
ITPA TOPICAL: PHYSICS GROUP PROPOSALS, NOVEMBER 2002

Proposal Title	Devices	FY2003 Experiment Time
β scaling of confinement in ELMy H–modes	All available devices, **DIII–D**, JET, NSTX, AUG, JT–60U	1 day
Improving the condition of global ELMy H–mode and pedestal databases	All available devices	
Development of hybrid scenario demonstration discharges	AUG, **DIII–D**, JET, JT–60U	2 days
Development of steady-state demonstration discharges	AUG, **DIII–D**, JET, JT–60U	~4
High-performance operation with $T_e \sim T_i$	AUG, **DIII–D**, JET, JT–60U	0 to 1
ITB operation with no external momentum input	AUG, C–Mod, DIII–D, JET, JT–60U	
Improved physics understanding of QDB/QH–mode operation	AUG, **DIII–D**, JET, JT–60U	3 days
Improved understanding of β-limits with ITB operation	AUG, **DIII–D**, JET, JT–60U, NSTX	2 to 3 days
Dimensionally similar ITB scaling experiments	AUG, JET	
Simulation and modeling support for T–10 turbulence studies	T–10	
Understanding of pedestal characteristics through dimensionless experiments	JET, JT–60U	
JET/DIII–D pedestal similarity studies	**DIII–D**, JET	1 day
Comparative MHD analysis and predictive modeling of Type 1 and Type II ELMy H–mode	AUG, JET, JT–60U	
Stability analysis with improved edge treatment	AUG, **DIII–D**, JT–60U	Study to be completed
Dimensionless identity experiments with JT–60U Type II ELMy H–modes in DIII–D	DIII–D, JT–60U	0 days
Impact of ELMs on the pedestal and SOL (effect of aspect ratio)	AUG, **DIII–D**, MAST, NSTX	0.5
Parameter similarity studies (L–H transition, EDA)	AUG, C–Mod, JET	
Parameter similarity studies Quiescent H–mode regimes	AUG, **DIII–D**, JET, JT–60U	0.5
Scaling of Type I ELM energy loss	**DIII–D**, JET, JT–60U and others	0.5
Tritium codeposition	AUG, C–Mod, **DIII–D**, JET, TEXTOR, Tore Supra	2 days
Parallel transport in the SOL	AUG, **DIII–D**, C–Mod, JET, JT–60U	1
Pressure and size scaling of gas jet penetration for deposition	AUG, C–Mod, **DIII–D**, JET, JT–60U	1 day
Joint experiments on resistive wall mode physics (lack of experiment time)	AUG, **DIII–D**, JET, NSTX	0.5
Joint experiments on neoclassical tearing modes (including error field effects)	AUG, **DIII–D**, JET	1 day
Neoclassical tearing mode physics — aspect ratio comparison	AUG, DIII–D, MAST, NSTX	0 day
Comparison of sawtooth control methods for neoclassical tearing mode suppression	AUG, **DIII–D**, JET	1 day
Error field sideband effects for ITER	**DIII–D**, JET	1 day
Preparation of ITER steady-state scenario	AUG, **DIII–D**, JET, JT–60U	~4 day
Preparation of ITER hybrid scenario	AUG, **DIII–D**, JET, JT–60	2 days

PROPOSED DIII–D FY04 AND FY05 OPERATION SCHEDULES

- 21 weeks in FY04
- 15 weeks in FY05 + 6 contingency weeks scheduled





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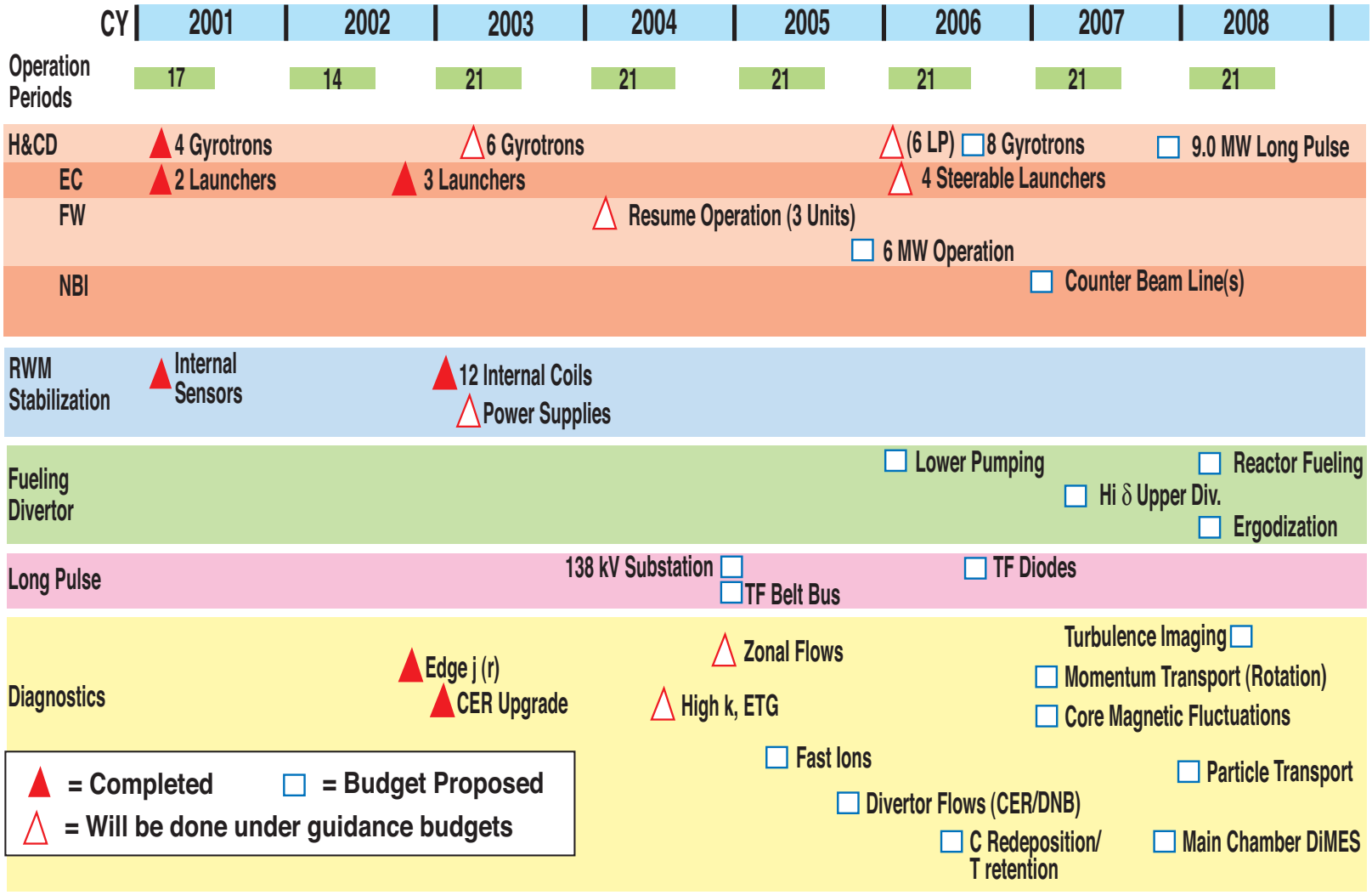
DIII–D NEEDS INCREASED FACILITY CAPABILITIES TO SIEZE THE OPPORTUNITIES FOR FY04–08



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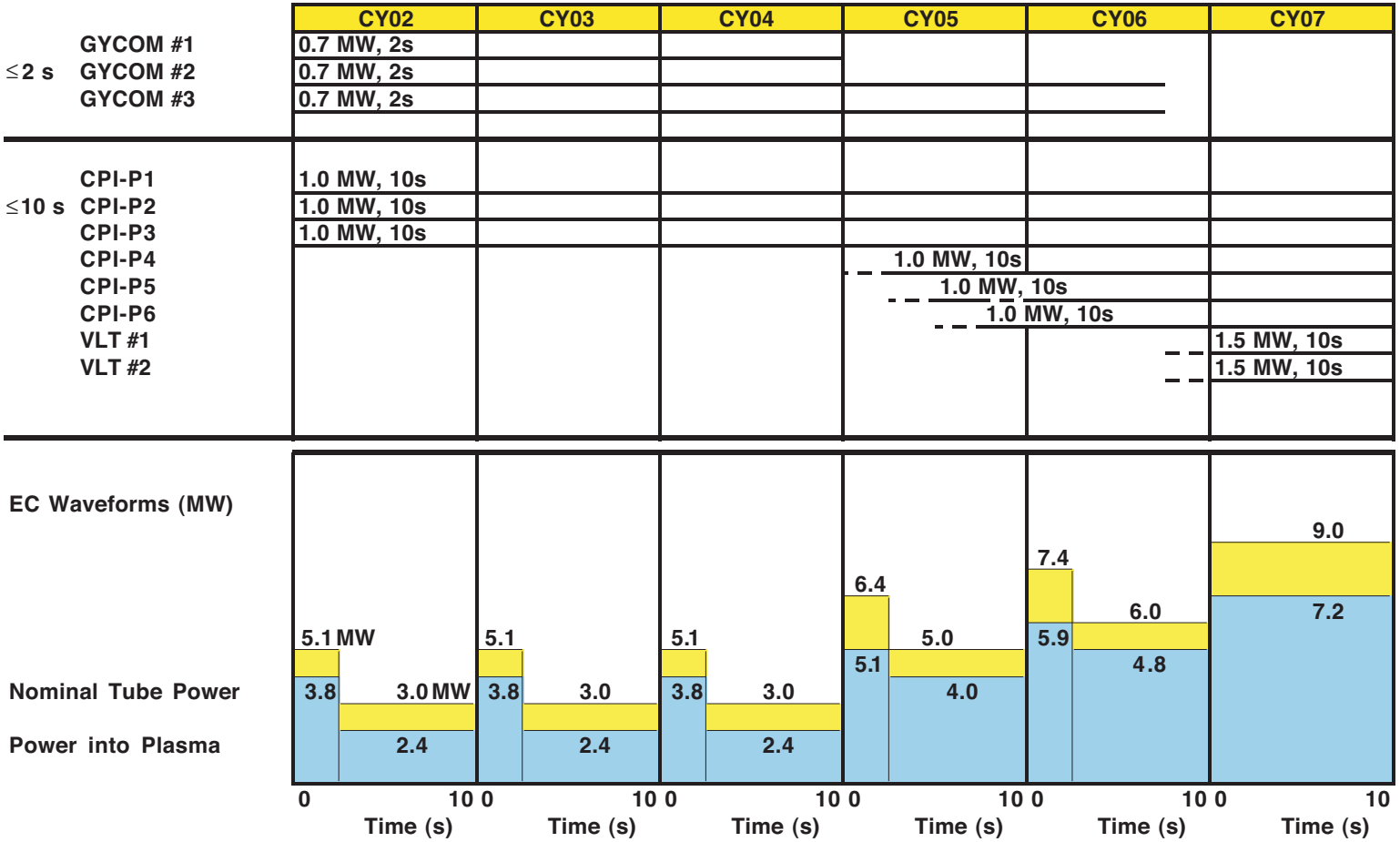
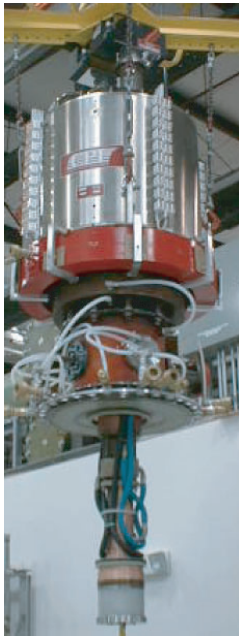
PROPOSED EC SCHEDULE





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SUMMARY OF INCREMENTAL BUDGET REQUESTS

	FY04		FY05	
Diagnostics		**$1631K**		**$3290K**
Divertor CER/DNB	GA	$512K	GA	$951K
			LLNL	$800K
Fast Elm Diagnostics	LLNL	$50K	LLNL	$50K
Tracer Pellets	GA	$65K	GA	$267K
Beam Ion Profile	GA-Irvine	$252K	GA-Irvine	$74K
Quartz Microbalances	GA	$211K	GA	$384K
Poloidal CER Upgrade	PPPL	$377K		
Reflectometer Upgrade	PPPL	$64K	PPPL	$364K
MDS Spectrometer	ORNL	$50K	ORNL	$50K
Pellet Injector Upgrade	ORNL	$50K	ORNL	$350K
EC Systems		**$391K**		**$4156K**
8 Gyrotron Ops	GA	$391K	GA	$3940K
Fast Scanning Launchers			PPPL	$216K
Resume Fast Wave Operation		**$393K**		**$649K**
ABB Tetrode Change			PPPL	$300K
Long Pulse Antenna	ORNL	$130K	ORNL	$50K
Transmission Lines	GA	$263K	GA	$299K
Prime Power / Infrastructure		**$4053K**		**$2023K**
138 kV Substation	GA	$1967K		
4160 to 48V Substation	GA		GA	$941K
Water System	GA	$300K		
Cryo Turbine	GA	$111K		
Helium Compressor			GA	$392K
Data / Computers	GA	$1090K	GA	$621K
ECH O+M	GA	$173K		
Power Systems	GA	$388K		
I-Coil Audio Amplifiers	GA	$24K	GA	$69K
Increase Operating Time		**$1109K**		**$2399K**
25 Weeks	GA (+4 weeks)	$1109K	GA (+10 weeks)	$2399K
Divertor and First Wall				**$2377K**
Pump HI δ DN			GA	$1626K
Thermal Upgrades			GA	$526K
Disruption Mitigation			GA	$225K
Ten Second Flattop at Full Field		**$490K**		**$767K**
TF Belt Bus	GA	$405K		
F-Coil Power Supplies	GA	$24K	GA	$214K
Data Systems	GA	$61K	GA	$553K
Totals		**$8067K**		**$15,259K**

† Does not include staff and postdoc increases of ~$1M.

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THE DIII–D PROGRAM MEETS THE CRITERIA FOR INVESTMENT

- **Quality**
  - Excellence (8 Excellence Prize winners and 50 APS Fellows)
  - Innovation in both science (AT) and technology (EC systems, Wall Stabilization coils)
  - Fundamental plasma science (Sheared E×B Flows, Stability research)
  - World leaders in AT research, wall stabilization, current profile control
- **Performance**
  - Cost-effective staged investments based upon proven results proposed
  - Technically credible pathways with breakthrough potential
- **Relevance**
  - Technical credibility (Building blocks of AT demonstrated)
  - Environmental attractiveness (Steady-state fusion systems)
  - Economic competitiveness (Higher power density systems)

WITH ADEQUATE RESOURCES, MAJOR FUSION OBJECTIVES ARE WITHIN OUR REACH

- **The guidance budget**
  - Substantially increases runtime
  - Assures the minimal level of long pulse EC power for the AT Program
  - Implements the university diagnostics for a major advance in transport understanding

- **The full support requested will**
  - Provide an advanced tokamak, steady-state basis before ITER operates
  - Enable the first phase of ITER to focus on advanced, long pulse modes, moving much of the currently envisioned phase 2 into phase 1
  - Clear the way for the carbon PFC solution in ITER and DEMO