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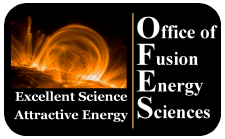
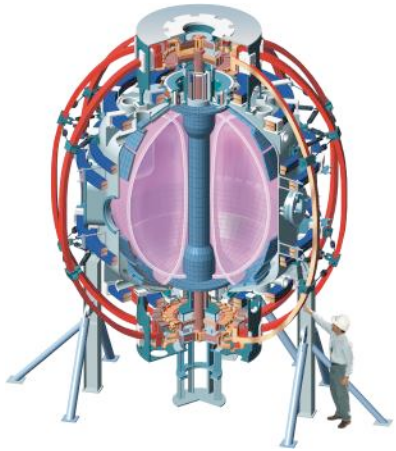


NSTX

NSTX Facility and Budget Plans – FY03-05

In Support of the NSTX Research Program

Masayuki Ono
Princeton Plasma Physics Laboratory
For the NSTX National Research Team

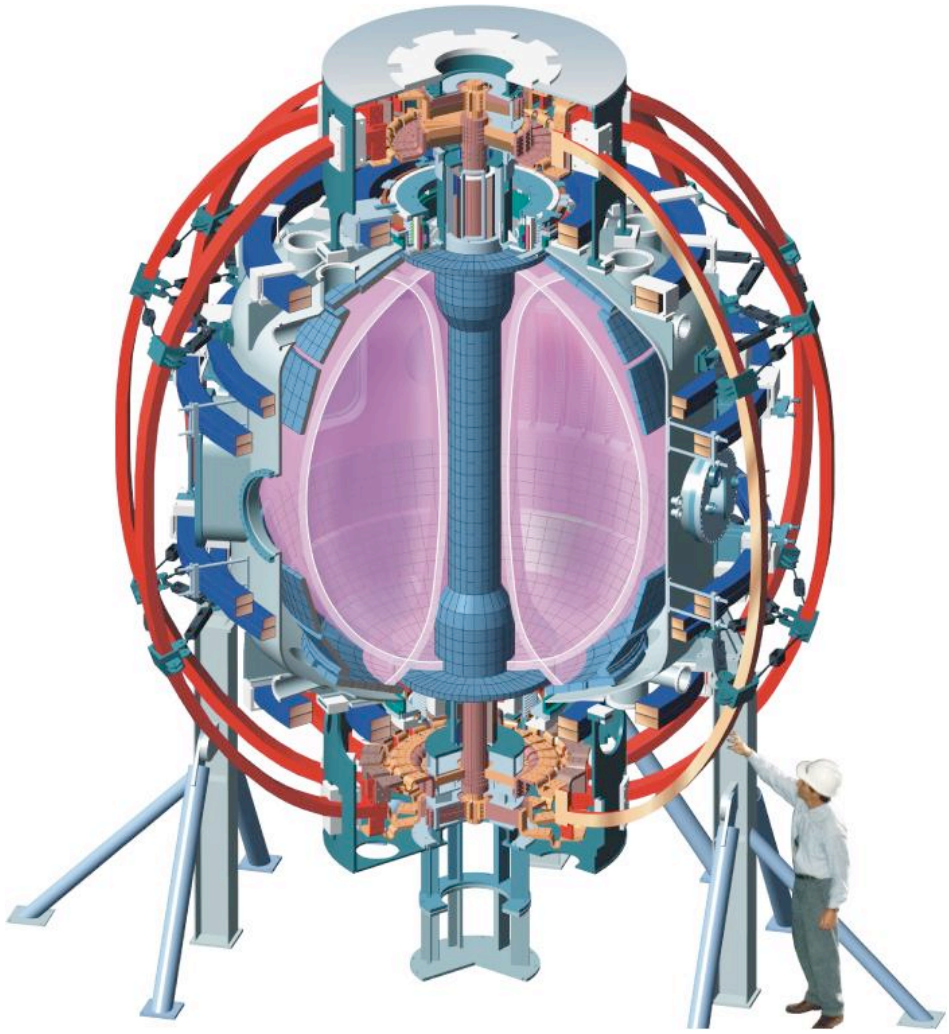


Budget Planning Meeting – FY 2005
Office of Fusion Energy Sciences
Department of Energy

March 18-19, 2003
Gaithersburg, Maryland

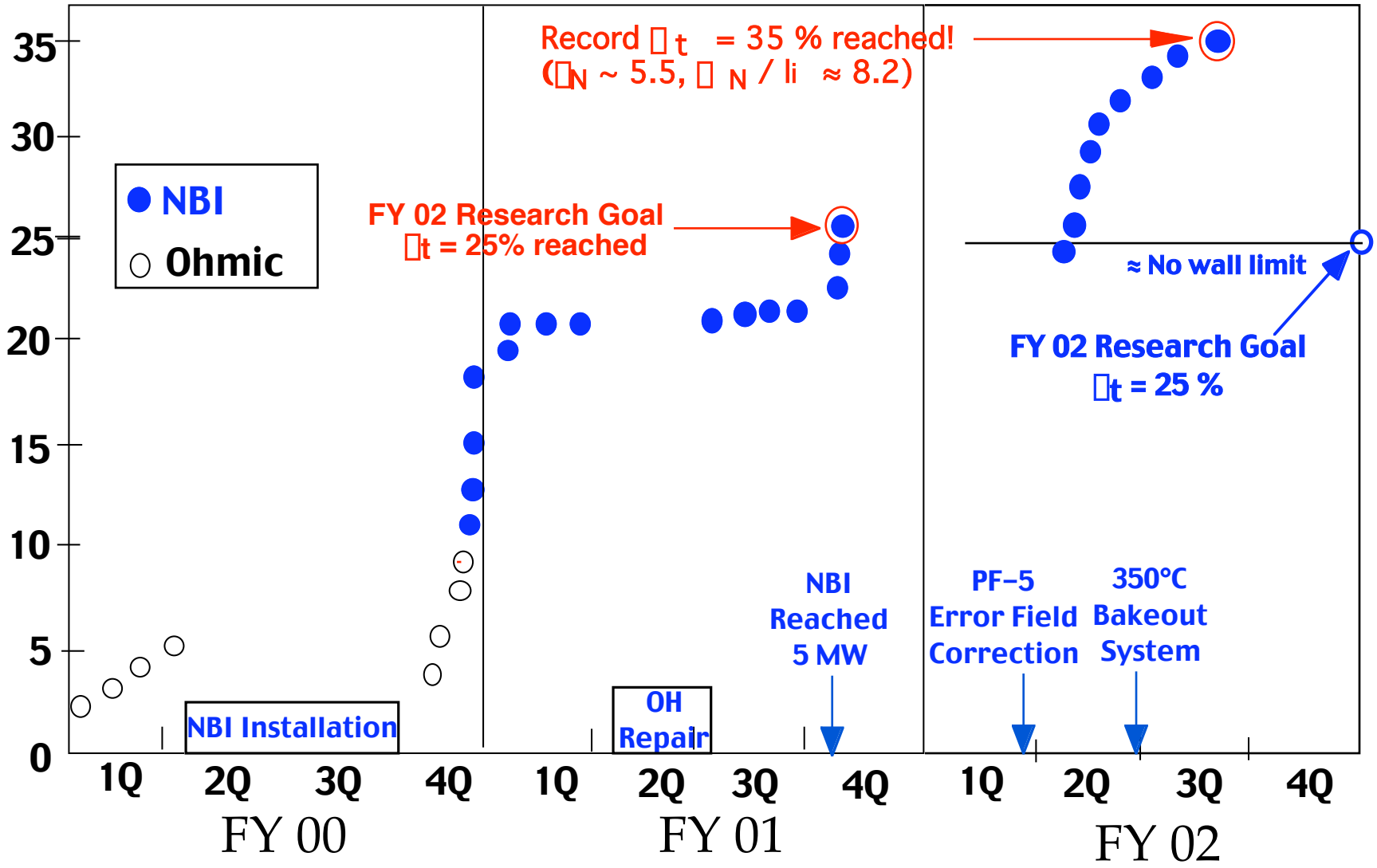
Columbia U
Comp-X
GA
INEL
JHU
LANL
LLNL
Lodestar
MIT
Nova Photonics
NYU
ORNL
PPPL
PSI
SNL
UC Davis
UC Irvine
UCLA
UCSD
U Maryland
U New Mexico
U Wash
U Wisc
UKAEA Fusion
Hiroshima U
HIST
Kyushu Tokai U
Niigata U
Tsukuba U
U Tokyo
Ioffe Inst
TRINITI
KBSI
KAIST
ENEA, Frascati

NSTX Facility Capability Steadily Improved

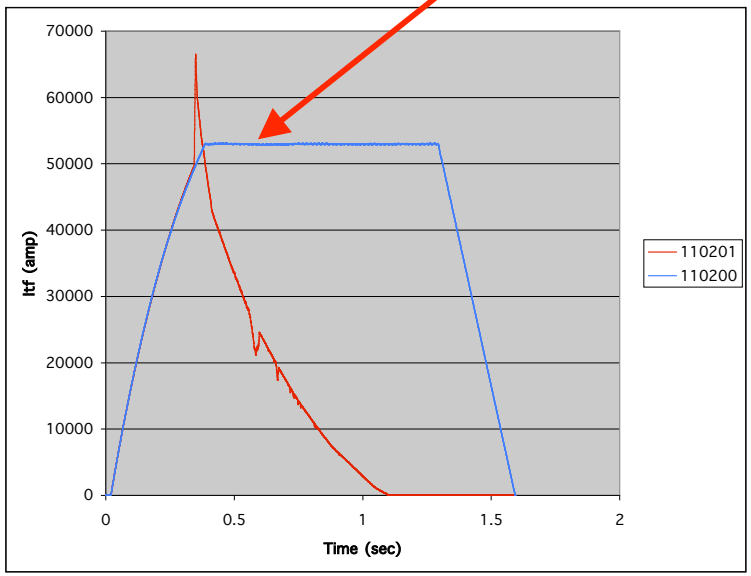


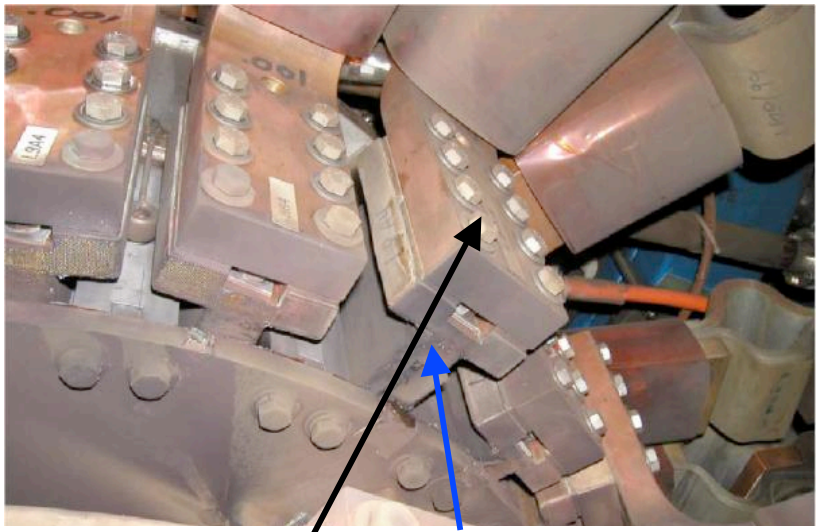
Capabilities	
PFC bakeout	***350°C***
Gas fueling	***HFS/LFS***
Aspect ratio	1.27
Elongation	2.5
Triangularity	***0.8***
Plasma Current	1.5MA
Toroidal Field	***0.6T***
NBI ***(100kV)***	***7 MW***
HHFW (30MHz)	6 MW
- full antenna phase control	
Pulse Length	***1s***
Reduced PF error field	

Rapid Progress On High Beta Research

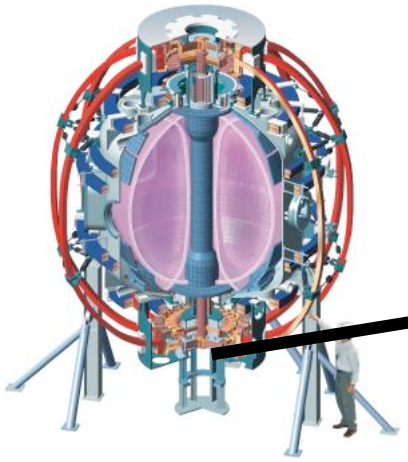


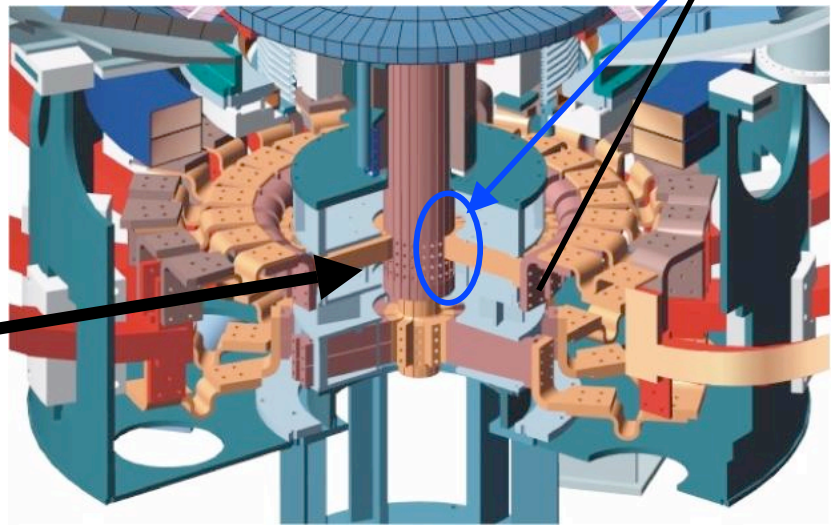
TF Fault Occurred on February 14, 2003





A TF "flags" joint separated.





Fortunately:
- No serious collateral damages occurred.
- TF bundle lifted out of machine without breaking high vacuum allowing important post diagnostic calibrations.

Lesson learned and move on

o A joint design weakness uncovered by this incident and through detailed analyses. (loss of contact pressure, ambiguous load path, fatigue factor - joint failed in its 5th year of operation ~10,000 cycles.)

o Improved joint with sufficient margin being designed including mock-up fatigue tests of 50,000 cycles.

o TF Joint Final Design Review (inviting participants from C-MOD, MAST, DIII-D, PEGASUS, and FFOC) to be held in April.

o Once the design is complete, the fabrication is relatively rapid.

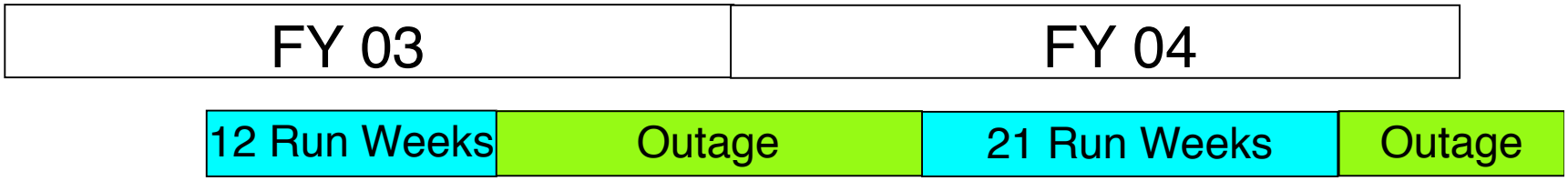
oThe TF bundle fabrication can be funded within the operation budget.

o Significant long term benefits with good joint design:

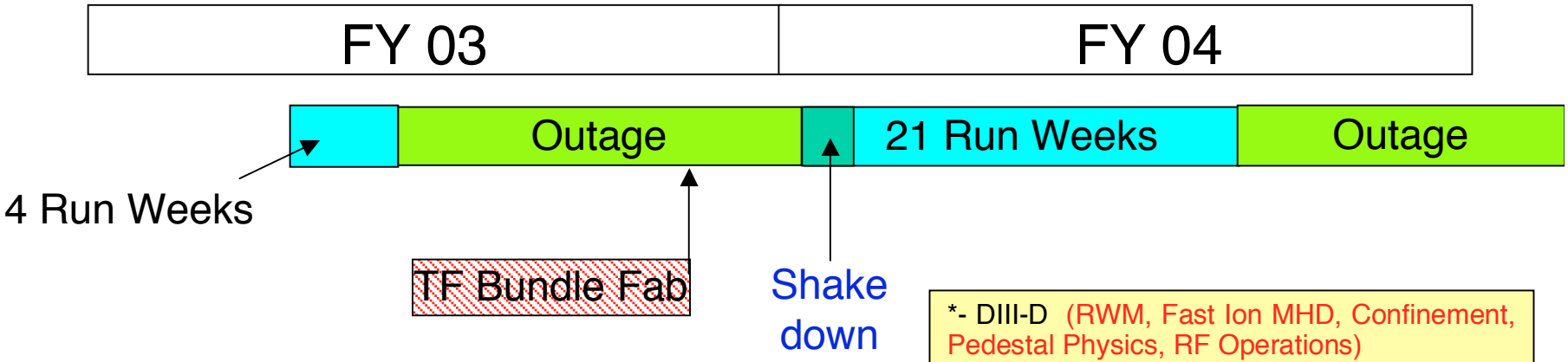
- Improve long term operational reliability
- Achieve routine operations up to full parameters
- Reduce future maintenance and repair liabilities

NSTX Schedule

Original Plan



Revised Plan



- The outage is accelerated by three months.
- New plan allows FY 04 extended outage.
- Increase collaborations.*

*- DIII-D (RWM, Fast Ion MHD, Confinement, Pedestal Physics, RF Operations)

- C-Mod (X-ray spectroscopy, Edge and Micro Turbulences, RF Operations, MSE)

- MAST (EBW, Boundary Physics, Confinement Scaling)

- Support ITER costing

MHD Mode Stabilization

Opportunity Areas are Resonant Field and RWM Controls.

Plasma Operations	FY 03	FY 04	FY 05

MHD Diagnostics

- Wall-mode sensors
- Fast X-ray cameras (Frascati, JHU, PSI)
- Ultra-soft x-ray arrays (JHU)
- Fast MHD sensor
- Improved magnetics and EFIT (Columbia)
- Real time EFIT (GA)

• β_p ~ 0.9, V_{loop}~0.2 at 1 MA single null
• $\beta_N \approx 7$ and $\beta_P \approx 2.5$ during ramp down
• 1 MA with half-swing

Resonant Field Control

- Error Field Reduction
- Preliminary Resonant Field Control System (Columbia)
- Optimized Resonant Field Control System (Columbia)

• β_T ~ 15% higher than FY 02
• Locked mode occurrence reduced

Confinement and Transport

Exciting Opportunities For Advanced Fluctuation Diagnostics

Plasma Operations	FY 03	FY 04	FY 05

Profile Diagnostics

- T_i , V_ϕ , Vpol(edge) with high precision.

- 51 Channel Toroidal CHERS
- Edge Rotation Spectrometer
- 4 Channel FIReTIP(UCD)
- Poloidal CHERS
- Extra 10 Channels MPTS
- Third laser MPTS
- 7 Channel FIReTIP(UCD)

Energetic Patricles

- Fast Ion Loss Probe

Fluctuation Diagnostics

- Intriguing fluctuation data obtained

- Low k Reflectometer (UCLA)
- Gas-puff Imaging (LANL, PSI)
- Reciprocating probe (UCSD)
- Install Prototype High k Microwave Scattering
- Install Low k Imaging Reflectometer

Non-Inductive CD Systems

Enhancement Opportunity areas are EBW and CHI

Plasma Operations	FY 03	FY 04	FY 05

HHFW (6MW)
ORNL/VLT
GA,UCSD,
MIT

- HHFW Feed Improvement
- Plasma Feed-back phase control
- HHFW Antenna Upgrade

- Decision Point
- Base

• Power improved to 5 MW from 3.5 MW in FY02

- 4 Channel MSE/CIF (Nova) → 10 Channel MSE/CIF (Nova)
- MSE / LIF (Nova)

EBW -E / -CD

- EBWE / Edge $n_e(r)$
- Optimized EBWE Antenna (ORNL)

1 MW High Power EBWCD Tube Development (Collaboration with MIT/ORNL/VLT)

CHI (I_T = 0.5 MA)
U. Washington
GA,LANL

- New CHI Absorber Insulator Fabrication (U. Washington)
- Absorber field null control (U. Washington)
- Dynamo-head For helicity transport (UCSD)

• Absorber arcs reduced.

Boundary Physics

Exciting Enhancement Opportunity in Core Fueling and Boundary Physics

NSTX

Plasma Operations	FY 03	FY 04	FY 05

Wall Conditioning
(Gas/plasma Boronization, Between-shot GDC)

Li/Boron Pellet Injector

- Decision Point
- Base
- Incremental

Power/Particle Control

Divertor IR Camera (ORNL)

Fast IR Camera (ORNL)

• Dramatic divertor heat load spreading for high □

Advanced Power and Particle Handling Decision Point (Divertor Cryo Panel)

AEUV Spectrometer

Divertor Thomson Scattering

Fueling

In-board gas injectors

Supersonic Gas injector

Pellet injector in "suitcase" (ORNL)

• Easier H-mode access confirmed

NSTX Facility Utilization

Facility Plasma Operations Availability

	FY 02	FY 03	FY 04	FY 05
# of run weeks planned	12	12	21	21
# of run weeks achieved	13*	4**		
# of hours	520	160	840	840

* 90% overall facility availability achieved in FY 02

** The facility operation was interrupted due to the TF fault problem in Feb. 2003.

Participating Research Personnel

	PPPL	non-PPPL
Researchers	42	70***
Post Doc.	3	7
Grad. Students	5	5
Undergrad. Students	3	5

*** Including 15 overseas collaborating researchers from countries Japan, Russia, Korea, UK, Ukraine, and Canada in FY 03

NSTX Budget Summary ($M)

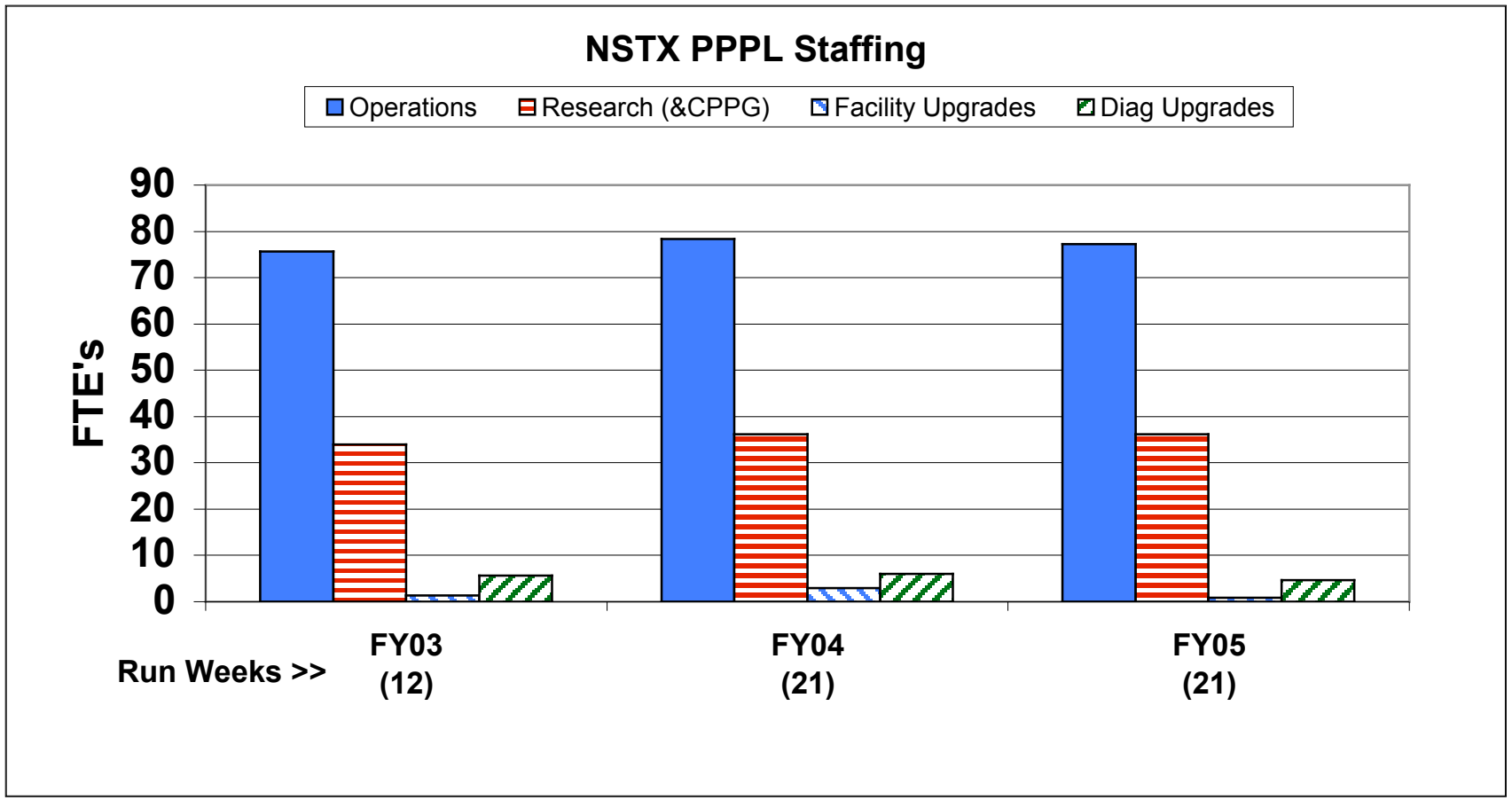
Facilities Run weeks	FY03 12(4)	FY04 21	FY04 11	FY04	FY05 21	FY05 8	FY05
	Base	Base	10% cut	Incr.	Base	10% cut	Incr.
Facility Operation	$15.44	$16.95	$15.93		$17.21	$15.90	
CHI Absorber							
Error Field Coils	$0.30	$0.25	$0.25		$0.25	$0.25	
Other Upgrades		$0.50		$0.54			$1.49
Facilities Total	**$15.74**	**$17.70**	**$16.18**	**$0.54**	**$17.46**	**$16.15**	**$1.49**

Science							
PPPL Research	$8.28	$9.30	$8.34		$9.44	$8.40	
Upgrade Diag.	$1.00	$1.00	$0.58	$0.40	$1.20	$0.55	$1.05
Colla. Diag. Interf.	$0.62	$0.70	$0.56	$0.10	$0.60	$0.56	$0.10
Collaborations	$4.30	$4.77	$4.30	$0.27	$4.77	$4.30	$0.27
Science Total	**$14.2**	**$15.77**	**$13.78**	**$0.77**	**$16.01**	**$13.81**	**$1.42**

ERWM	**$1.68**	**$1.71**	**$1.71**		**$1.71**	**$1.71**	
Grand Total	**$31.62***	**$35.18**	**$31.67**	**$1.31**	**$35.18**	**$31.67**	**$2.91**

*Note: FY03 Base includes ~ $1.2M Carryover from FY2002.

NSTX PPPL Personnel Staffing



- Overall PPPL staff reduced by 79 in FY 2003.
- Some reductions in FY 04 and 05.
- Without D&D, reduced flexibility to reassign technical staff within PPPL.

Incremental Funding For FY 04 - 05 Can Greatly Enhance NSTX Science Output

- Improve facility capability:
  - Implement deuterium pellet injector (FY 04)
  - Start 1 MW EBW 15 GHz tube development (FY 05)
  - Divertor cryo-pumping particle control system (FY 05)
- Improve Diagnostic capability:
  - Fast infrared camera for boundary physics (FY 04)
  - Divertor MPTS (FY 05)
- Improve facility reliability and availability
  - Spare parts and preventive maintenance.

Consequences of 10% Budget Cut In FY 04

- Significant reduction in runtime (from 21 to 11 weeks)
- Research progress slowed by almost 50%.
- NSTX staff reduction of ~ 13% or ~ 15 FTE
  - Could result in further terminations due to severance cost
- Non-labor reduction of ~ 50%
  - Diagnostic components, spare parts, energy, travel, *etc.*
- Critical facility and diagnostic upgrades will be deferred.
  - HHFW antenna upgrade and CHI absorber null field coil power supply
  - Poloidal CHERS, Thomson scattering upgrades, Divertor Bolometer.
- Similar impact on all collaborations.

FY 05 impacted more severely due to inflation.

Summary

- FY 02 was a very productive year (one more run week than planned and 90% overall plasma availability.)
- FY02- 03 campaign produced very exciting results.
  - Record beta values achieved.

    $\beta_T \approx 35\%$, $\beta_N = 6$, $\beta_N / l_i = 10$, $\beta_{pol} > 1$.
  - High beta and high confinement ($\beta_N H_{89P} \approx 15$) sustained for τ-pulse > τ-skin or 8 τ_E ($V_{loop} \sim 0.1V$).
  - Good progress on RWM, no wall beta limit exceeded by 30% and sustained for many resistive wall time through plasma rotation.
- FY 04-05 base budget allows significant increase in the run weeks from FY02- 03, crucial for making timely progress.
  - Improved TF will improve facility reliability and availability.
  - Physics capability rapidly ramping up to support exciting program.
  - Far more experimental proposals than run time available.

NSTX program is oriented to FESAC goals.