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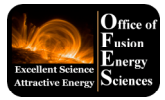

NSTX

Columbia U
Comp-X
General Atomics
INEL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Nova Photonics
NYU
ORNL
PPPL
PSI
SNL
UC Davis
UC Irvine
UCLA
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Ioffe Inst
TRINITI
KBSI
KAIST
ENEA, Frascati
CEA, Cadarache
IPP, Garching
IPP, Jülich
U Quebec

NSTX Scope, Costs, and Schedules

M. Ono

For the NSTX National Team

DOE Review of
NSTX Five-Year Research Program Proposal
June 30 – July 2, 2003

MAJOR FACILITY GOALS ACHIEVED ON SCHEDULE

Major NSTX Milestones	Planned	Achieved
Commence First Plasma[1]	Apr. 1999	Feb. 1999
Achieve 1 MA OH Discharges[2]	Sept. 2000	Dec. 1999
Commence CHI Operations	Sept. 2000	Sept. 2000
Commence HHFW Operations	Sept. 2000	Oct. 2000
Commence NBI Operations [3]	Oct. 2000	Sept. 2000
High β near no-wall limit (~25%)[4]	Sept. 2002	June 2001

[1] NSTX Construction (~$24M) completed on budget and schedule; received NJ Governor's safety award on the construction project.

[2] The plasma current capability further increased to 1.5 MA in June 2001.

[3] NBI construction project (~ $6M) completed on schedule and on budget.

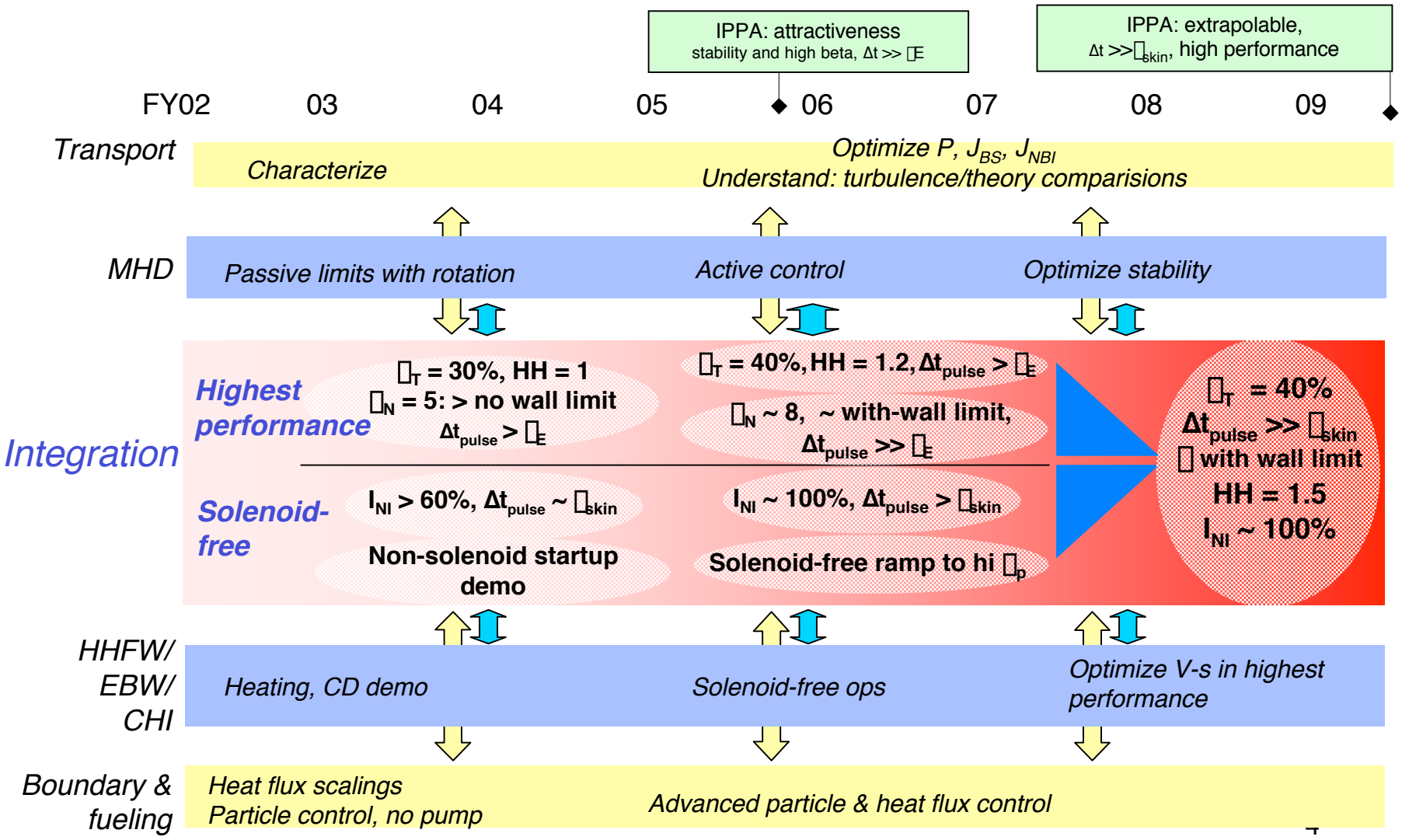
[4] Followed by the achievement of β_T ~ 35% in June 2002.

NSTX FACILITY OPERATED ~ 90% AVAILABILITY

	FY 00	FY 01	FY 02	FY 03	FY 04 - 08
Run weeks planned	15	15	12	12	21
Run weeks achieved	15	~16	13	4	
Hours of operations	600	640	520	160	840
Average shots/week	104	116	118	80	

- High operational availability (~90%) maintained while ramping up the facility and diagnostic capability (and sophistication.)
- While the TF joint failure was an unfortunate event, the newly designed TF joint should significantly improve operational reliability needed to achieve the five year plan - 21 run weeks per year.
- Total FY 00-03 run weeks achieved 48 weeks compared with the planned 54 weeks.
- ISM (Integrated Safety Management) culture emphasized; N.J. Governor's safety awards in 2001 and 2002.
- Cost of a spare OH solenoid budgeted in FY 04-05.

NSTX Planned Facility/Diagnostic Upgrades Support the Exciting Research Program for FY 04 - 08



Diagnostic and Facility Upgrades are Proposed to Support Research Plan

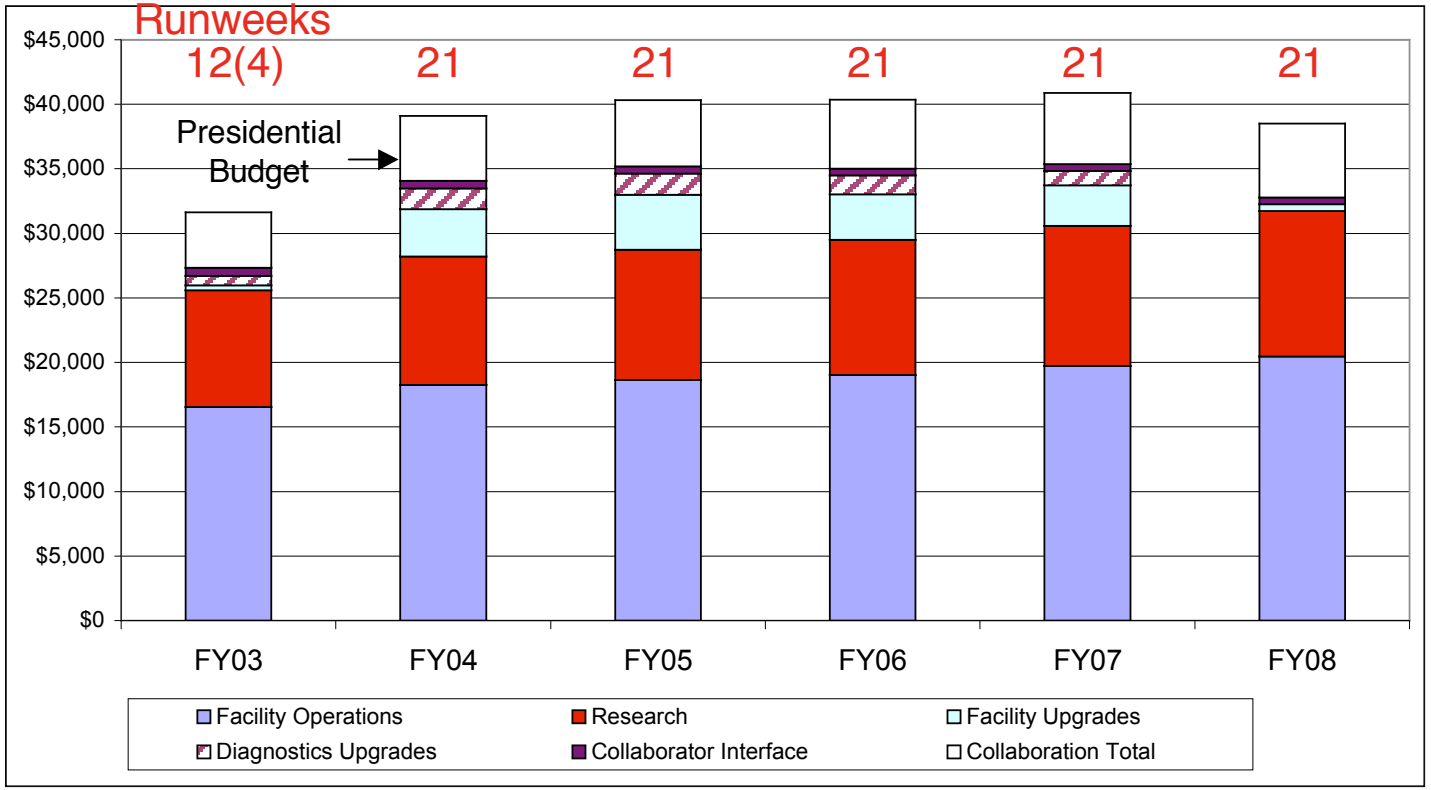
Diagnostics	Facility
MHD – EBW radiometer, fast ΔT_e – MSE/CIF, LIF polarimeter [Nova] **Transport & Turbulence** – High & low-k Δ-wave scattering [UCLA, UCD] – Δ-wave imaging reflectometer [UCD] – GPI – Planar LIF edge fluctuations [C-Mod, DIII-D, Nova, PSI, SBIR] **Edge & Divertor** – Divertor laser Thomson scattering **Astrophysics & Diagnostic Development** – X-ray imaging crystal spectrometer [LLNL, Chandra, C-mod, KSTAR, Adv. Diagnostics Program]	**Very High Δ** – Ex-vessel field and mode control coils [CU] – Modification of PF1A (k=2.6, Δ=0.6) – Active mode control systems [CU] **CD, MHD, Integrated Scenarios** – EBW (1Δ 4 MW source power) [VLT, MIT, ORNL] **Startup** – EBW – CHI absorber control coils – Outboard PF-only induction **Particle & Edge Plasma Control** – Cryopumps – Lithium pellets, coating, flowing surface module [VLT-PFC, CDX-U]

BUDGET ESTIMATE ASSUMPTIONS

- 21 weeks per year operations estimated are based on past operational experiences.
- The proposed 5 year budget is ~ 10 % above the FY 04 presidential level for both PPPL and collaborators; relatively flat for future years.
- Upgrade cost is estimated bottom-up where possible, with contingency based on experience.
- Avoided strong front loading of upgrades:
  - implementations timed to match the program plan.
  - consistent with personnel availability

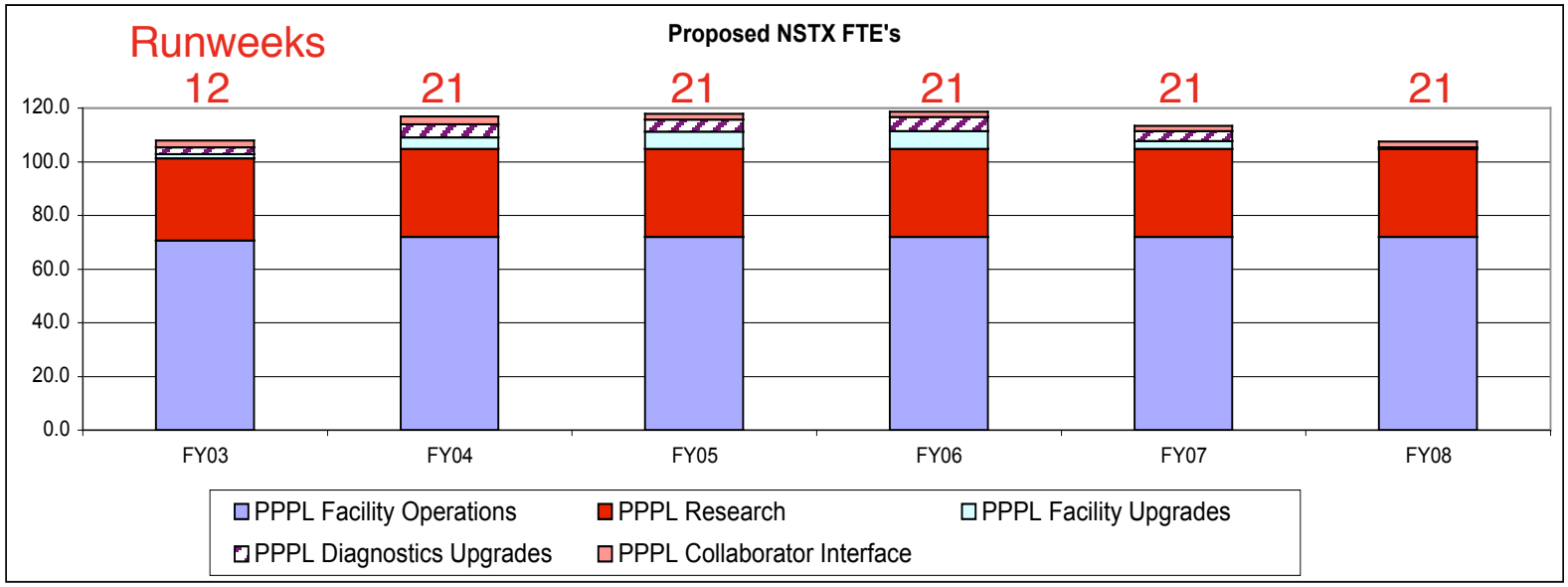
We made some tough choices.

FY 03 - FY 08 NSTX BUDGET OVERVIEW



	FY03	FY04	FY05	FY06	FY07	FY08
Facility Operations	$16,539	$18,264	$18,645	$19,024	$19,728	$20,458
Research	$9,034	$9,947	$10,091	$10,465	$10,852	$11,289
Facility Upgrades	$388	$3,650	$4,250	$3,550	$3,150	$500
Diagnostics Upgrades	$739	$1,628	$1,636	$1,453	$1,110	
Collaborator Interface	$619	$579	$559	$525	$526	$527
Collaboration Total	$4,300	$5,032	$5,142	$5,332	$5,530	$5,734
TOTAL	**$31,619**	**$39,101**	**$40,324**	**$40,348**	**$40,896**	**$38,508**

FY 03 - FY 08 NSTX PPPL FTE OVERVIEW



	FY03	FY04	FY05	FY06	FY07	FY08
PPPL Facility Operations	70.6	72.0	72.0	72.0	72.0	72.0
PPPL Research	30.7	32.7	32.7	32.7	32.7	32.7
PPPL Facility Upgrades	1.5	4.3	6.5	6.7	3.0	0.7
PPPL Diagnostics Upgrades	2.5	4.9	4.4	5.2	3.6	
PPPL Collaborator Interface	2.7	3.0	2.3	2.1	2.1	2.1
TOTAL	**108.0**	**116.9**	**117.9**	**118.7**	**113.4**	**107.4**

- The NSTX PPPL staff level is relatively flat at 110.

PPPL FACILITY OPERATIONS BUDGET

FACILITY OPERATIONS : 21 run weeks per year

	FY04	FY05	FY06	FY07	FY08
Torus Systems	$304	$310	$322	$334	$346
NBI	$3,101	$3,155	$3,273	$3,395	$3,522
Machine Operations	$3,150	$3,204	$3,324	$3,448	$3,577
FCPC	$1,413	$1,404	$1,457	$1,511	$1,568
MG/AC Power	$1,026	$1,046	$1,085	$1,126	$1,168
Data Acquisition	$1,010	$1,028	$1,067	$1,107	$1,148
Central I&C	$785	$799	$828	$859	$892
Plasma Control	$446	$455	$472	$489	$508
Energy	$1,107	$1,148	$1,191	$1,236	$1,282
Construction Support	$1,107	$1,124	$1,166	$1,209	$1,255
RF Operations	$1,691	$1,722	$1,786	$1,853	$1,922
Diagnostic Operations	$1,527	$1,555	$1,613	$1,673	$1,736
Spares	$200	$200	$200	$200	$200
OH Spare	$200	$300			
ERWM Allocations	$1,196	$1,196	$1,240	$1,286	$1,333
Total	$18,264	$18,645	$19,024	$19,728	$20,458

- Essentially inflation adjusted flat budget.
- Budgeted for spare OH solenoid.
- Anticipated savings from NCSX parallel operation in FY 08 not included.

RESEARCH BUDGET

PPPL RESEARCH	FY04	FY05	FY06	FY07	FY08
International Collaborations	$285	$233	$242	$250	$260
Physics Analysis	$3,608	$3,686	$3,822	$3,964	$4,110
Theory	$622	$636	$659	$684	$709
Research Operations	$4,955	$5,059	$5,246	$5,441	$5,642
ERWM-Allocations	$478	$477	$495	$513	$532
Total	$9,947	$10,091	$10,465	$10,852	$11,253

Collaboration Research	FY04	FY05	FY06	FY07	FY08
Collaboration interface support	$579	$559	$525	$526	$527
Collaboration	$5,032	$5,142	$5,332	$5,530	$5,734

- **Collaborations research contributes strongly to diagnostics.**
- **EBW upgrade collaboration opportunities not included.**

FACILITY UPGRADES BUDGET

FACILITY UPGRADES	FY04	FY05	FY06	FY07	FY08	TOTAL
Heating and Current Drive						
EBW (PPPL)	$530	$600	$500	$220	$100	**$1,950**
EBW (Collaboration/industry)*	$700	$1,800	$2,150	$2,300		**$6,950**
HHFW Antenna Upgrade*	$100	$200				**$300**
High Beta Access						**$0**
RWM Coil System	$500	$300	$500			**$1,300**
PF 1A Upgrade	$270	$250				**$520**
OH-Solenoid-Free Start-up						**$0**
CHI Pwr Supplies	$100					**$100**
Outer PF Start-Up	$350					**$350**
Power and Particle Handling						**$0**
Cryo-Panel	$300	$200				**$500**
Stabilizing Plate Modification	$700	$500				**$1,200**
Lithium Coating*	$100	$100	$100			**$300**
Liquid Lithium Module*				$130	$400	**$530**
Divertor PFC Upgrade*			$100	$300		**$400**
Pellet Injector*		$200	$100			**$300**
Compact Toroid Injector		$100	$100	$200		**$400**
Total	**$3,650**	**$4,250**	**$3,550**	**$3,150**	**$500**	**$15,100**

* In collaboration with VLT

4 MW EBW UPGRADE BUDGET

In collaboration with ORNL, MIT, GA, VLT, Industry

- **EBW System: 4 x 1 MW tube at 15 GHz to deliver 3 MW in plasma**
- **EBW tube developed in collaboration with VLT/MIT/Industry**
- **Cost effective with existing NBI 120 keV power supply and utilities at PPPL**
- **1 MW tube capability to be available in FY 06**
- **Significant collaboration/industry opportunities**

EBW System Budget ($k)

	FY 04 PPPL	Coll/ Indust	FY 05 PPPL	Coll/ Indust	FY 06 PPPL	Coll/ Indust	FY 07 PPPL	Coll/ Indust	FY 08 PPPL	Coll/ Indust	Total Cost
EBW Facility	530		600		500		220		100		1950
Solid State Regulator				800		800					1600
I MW Tube R&D		700		700							1400
Production tubes						750		1500			2250
											0
Launcher,waveguide, etc.				300		600		800			1700
											0
TOTAL	530	700	600	1800	500	2150	220	2300	100	0	8900

- Total budget $ 8,900k
  - PPPL $1,950k
  - Collaboration/industry $6,950k
- VLT role (~ $400k) is crucial for the tube development.

Plasma Diagnostic Plan: Strong Collaboration Contributions

Upgrade	Institution	Research Areas of Interest							Development/Deployment				
		MHD	Transport	HHFW	EBW	CHI	Boundary	Integr'n	FY03	FY04	FY05	FY06	FY07
Additional magnetics	PPPL/Columbia	√		√		√	√	√	■	■	■	■	■
CHERS upgrade	PPPL	√	√	√	√	√	√	√	■				
Imaging x-ray crystal*	PPPL		√						■				
EBW antenna with local limiter*	PPPL				√				■				
Fast lost-ion probe	PPPL	√	√						■				
MSE/CIF (10ch / 19ch)	NOVA	√	√	√	√	√		√	■	■			
Additional x-ray cameras*	JHU/PSI	√				√		√	■	■			
FIReTIP upgrades	UC Davis	√	√	√	√	√	√	√	■	■			
Line-filtered cameras	PPPL/ORNL		√				√		■		■		
Tangential microwave scattering	PPPL/UC Davis		√						▒	■			
MPTS (30ch / 90Hz / 40ch)	PPPL	√	√	√	√	√	√	√		■	■	■	
Fast reciprocating probe	UCSD	√	√	√	√		√			■			
Horiz. divertor bolometer	PPPL						√	√		■			
Microwave backscattering	UCLA	√	√							■			
Edge Doppler upgrade	PPPL	√	√	√	√	√	√	√		■			
Deposition monitors	PPPL						√			■			■
Poloidal CHERS	PPPL	√	√					√		▒	■		
MSE/LIF*	NOVA	√	√	√	√	√		√		▒	■		
Planar LIF visualization*	NOVA/PSI	√	√				√			▒	■		
Neutron collimator	PPPL		√							▒	■		
Langmuir probe upgrades	PPPL/ORNL						√			▒	■	■	
Divertor visible spectrometer	PPPL						√				■		
Fast IR camera	PPPL/ORNL					√	√				■		
Vertical divertor bolometer	PPPL						√	√			■		
Imaging reflectometer	PPPL/ UC Davis	√	√								▒	■	
Helium-jet spectroscopy	PPPL						√	√			▒	■	
Divertor reciprocating probe	UCSD						√				▒	■	
Charged fusion product det'r	PPPL	√	√									■	
Divertor Thomson scattering	PPPL						√	√				▒	■
Divertor UV spectrometer	PPPL						√						■
Energy extract analyzer	PPPL						√						■

* Innovative Diagnostic Initiatives

PPPL DIAGNOSTIC UPGRADES
CRUCIAL ELEMENTS OF 5 YEAR RESEARCH PLAN

DIAGNOSTIC UPGRADES	FY04	FY05	FY06	FY07	FY08	TOTAL
Boundary Physics Diagnostics						
CS&Divertor Probe Arrays		$90	$54	$36		$180
Divertor Bolometers	$105	$165				$270
IR and Filtered Cameras	$126	$54		$54		$234
Divertor/Edge Spectroscopy		$350	$150	$150		$650
Divertor Thomson Scattering			$340	$400		$740
Gridded Energy Analyzer			$125	$125		$250
Deposition Monitor	$75					$75
Profile Diagnostics						
MPTS Upgrades	$350	$200	$350			$900
Edge Rotation Upgrade	$160					$160
Poloidal CHERS	$250	$250				$500
Energetic Particle Diagnostics						
Neutron Collimator	$100	$240				$340
Charged Fus Prod Detect			$130			$130
Transport / turbulence diagnostics						
Tangential Scattering for high k	$342					$342
Impurity Injector				$225		$225
Imaging Reflectometry		$167	$184			$351
MHD						
Additional Fast Magnetics & DAS	$120	$120	$120	$120		$480
Total	$1,628	$1,636	$1,453	$1,110		$5,827

The NSTX 5-Year Plan is an Exciting and Cost-Effective Element of the U.S. Fusion Energy Science Program

Quality and Relevance are High

- Research facility and integrated national research team are both world class
- Forefront scientific results and innovative plans in all key areas:
  - Stability, Transport, Startup and Sustainment, Boundary, Integrated Scenarios
- Plans are directly aligned with FESAC IPPA goals
- Collaboration across a broad frontier:
  - ICC's, Tokamaks, Astrophysics, Fusion Technology
- Contributes to ITPA
- Providing scientific basis for attractive CTF and Demo

Facility Operation and Upgrades are Cost Effective

- Three NJ Governor's Safety Awards
- 90% availability, average of 112 shots per operational week since FY 01
  - Thorough plan to fix TF joints and avoid future losses of run time
- Innovative facility and diagnostic upgrades support each area of research
  - PPPL NSTX upgrade costs average 10.5% of total budget over five year period
- Total proposed yearly budget about 10% above FY2004 President's request