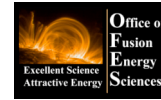


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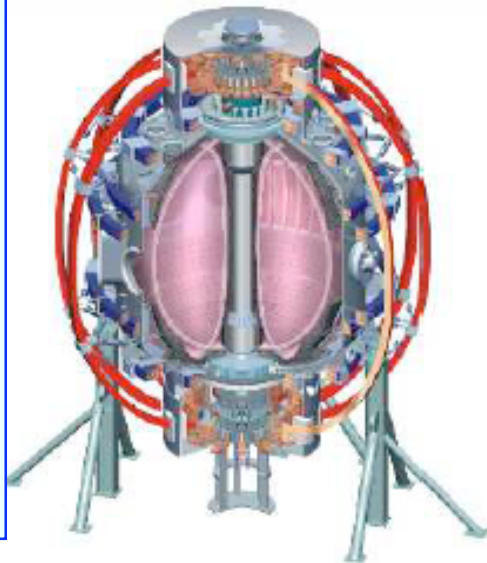
Facility and Diagnostic Plan, 5-Year Plan Preparation and NSTX/NCSX Relationship

Masa Ono

NSTX PAC 21st Meeting

January 17 - 19, 2007

College W&M
Colorado Sch Mines
Columbia U
Comp-X
General Atomics
INEL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Nova Photonics
New York U
Old Dominion U
ORNL
PPPL
PSI
Princeton U
SNL
Think Tank, Inc.
UC Davis
UC Irvine
UCLA
UCSD
U Colorado
U Maryland
U Rochester
U Washington
U Wisconsin



Culham Sci Ctr
U St. Andrews
York U
Chubu U
Fukui U
Hiroshima U
Hyogo U
Kyoto U
Kyushu U
Kyushu Tokai U
NIFS
Niigata U
U Tokyo
JAERI
Hebrew U
Ioffe Inst
RRC Kurchatov Inst
TRINITI
KBSI
KAIST
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep

NSTX Facility/Diagnostics in FY'06



- **DOE Joule Milestone - 11 run weeks**
Completed 12.66 run weeks with 1617 plasma discharges.
- **New research capabilities successfully implemented:**
 - **Lithium Evaporator for improved particle recycling control;**
 - **Feedback capability for EF/RWM coils powered by SPAs;**
 - **12 channels for MSE diagnostic to improve $j(r)$ determination;**
 - **Higher voltage operation of CHI for record current ~ 160 kA;**
 - **Dual remotely steerable, obliquely viewing 8-40 GHz EBW radiometers;**
 - **TF joints operated reliably up to 5.5 kG**
- **All the FY 06 Milestones were completed on or ahead of schedule.**

FY 2007 run scheduled to start in February with new capabilities

Successful DOE Midterm Review of Major MFE Facilities

September 21, 2006. OFES (5 Year Plan: FY 2004-2008)



- Met 28 out of 29 FEAs milestones in FY 04- 06 on or ahead of schedule.
- High facility operational availability achieved (~90%).
- Strong list of refereed publication with ~ 50 papers per year for FY 04-06.
- Contributed to ITPA and addressed important issues for CTF and ITER.

Received positive and helpful review feedback:

- "Significant progress has been made toward achieving the physics goals established three years ago in the NSTX 5-year plan. ... This work is at the forefront of confined plasma research, and is high in scientific merit."
- "Broadly speaking, the 5-year program is on schedule. Some areas are ahead of schedule, ... while some areas are delayed with good explanation."
- "The NSTX program has always been strongly coupled to the international and domestic spherical torus and tokamak programs, and through ITPA and USBPO activities, has increasingly contributed to the tokamak physics database for ITER."

FY 07 Facility Enhancements



- **Higher temperature bakeout of divertor tile to improve plasma performance and to prepare for lithium**
 - Lower divertor tiles to 350°C and upper tiles to 300°C
- **Improved restraint of OH-TF coils to reduce n=1 error field**
 - Spacers installed
- **Higher pressure for supersonic gas injector to improve fueling for H-mode (LLNL)**
- **Faster lithium evaporation ~ x10 with improved aiming to lower divertor plates (pending FDR)**
 - Evaporation between/during shots in normal cycles
 - Shields installed to protect MPTS and high-k windows
- **Higher voltage for higher current CHI (U Washington)**
 - Upgrading charging power supply
 - Improved voltage monitoring
 - Dynamo edge probe (UCSD)
- **Faster processors for real-time plasma control system to replace obsolete components (GA)**
 - Aiming to be ready to operate in parallel by end of FY07 run

FY 07 Diagnostic Enhancements



- Poloidal CHERS (27 ch) for transport physics
- MSE 12 → 16 channels for improved $j(r)$ resolution (Nova)
- Transmission grating x-ray spectrometer viewing across NBI for impurity transport (JHU)
- FIDA (Fast Ion D_α measurement) - a few fast, band-pass-filtered channels for the local fast-ion density (late in the run) (UC Irvine)
- FReTIP 4 → 6 channels (500 kHz) for improved spatial resolution (UC Davis)
- New collection mirror for high-k scattering system
- Correlation reflectometer, fixed freq. reflectometer (3 → 6 ch), profile reflectometer (25 → 10 μ s) and high-k backscattering (late in the run) (UCLA)
- Improved high-frequency Mirnov coil system for energetic particle modes and segmented Rogowski coil for disruption study
- Wider-angle view and gas-puffing for EBW radiometers for H-mode coupling
- 3 RF probes to measure surface waves during HHFW heating
- Additional divertor filterscope fast channels (24-32 total) (ORNL)
- Hypervelocity dust/particle injector (HDI) (pending chit resolution) (LANL)

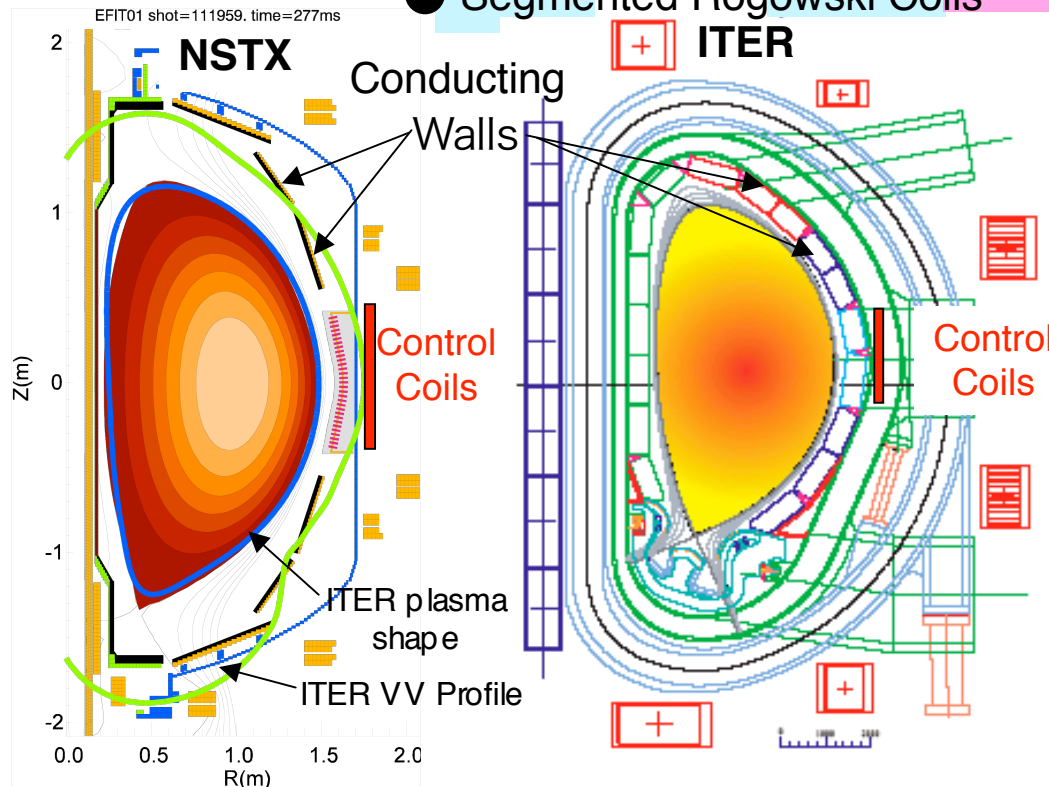
MHD

NSTX Well Positioned for Cutting-Edge EF/RWM Research



	FY 07	FY 08	FY 09
Run Weeks			
Base / Request*			
EF/RWM	10-11	12	12
Disruptions		8	8
	<ul style="list-style-type: none"> ● EF/RWM Feedback (Columbia) ● PCS Processor Upgrade (GA) ● β_N feedback 	<ul style="list-style-type: none"> ● β_N feedback 	<ul style="list-style-type: none"> ● V_ϕ feedback (Request)

*Note: Request is 10% enhancement over the base

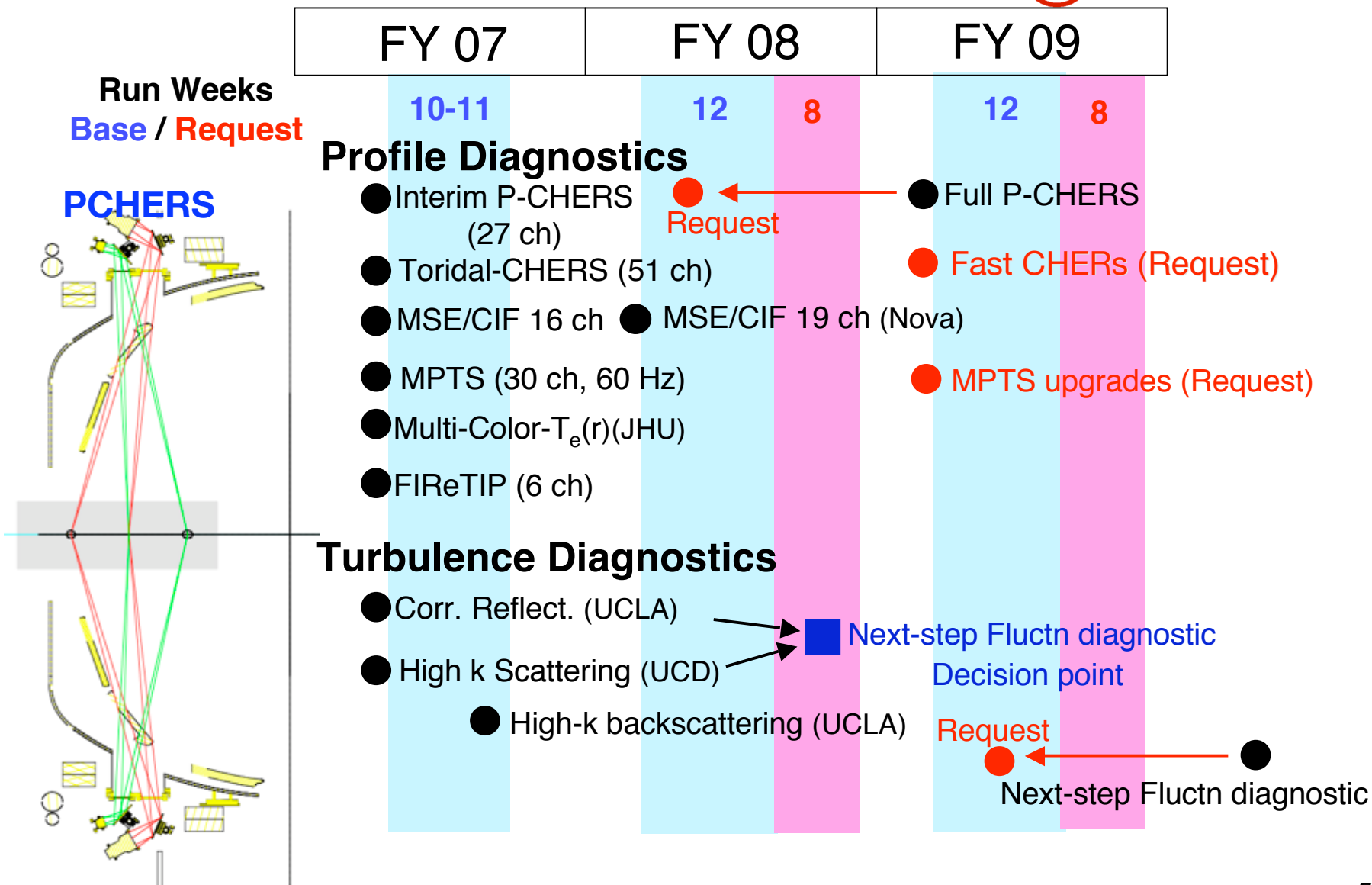


Advanced Plasma Control:

- EF/RWM feedback control successfully implemented in FY 06 experiments.
- PCS Processor Upgrade will provide faster feedback control x 3-10 in FY 08.
- Real-time diagnostic data processing:
 - β_N feedback in FY 08
 - V_ϕ feedback in FY 09

Transport and Turbulence

High Priorities are Poloidal CHERS and High-k Scattering



Boundary Physics

High Priority to test Liquid Lithium Divertor Target in 2009

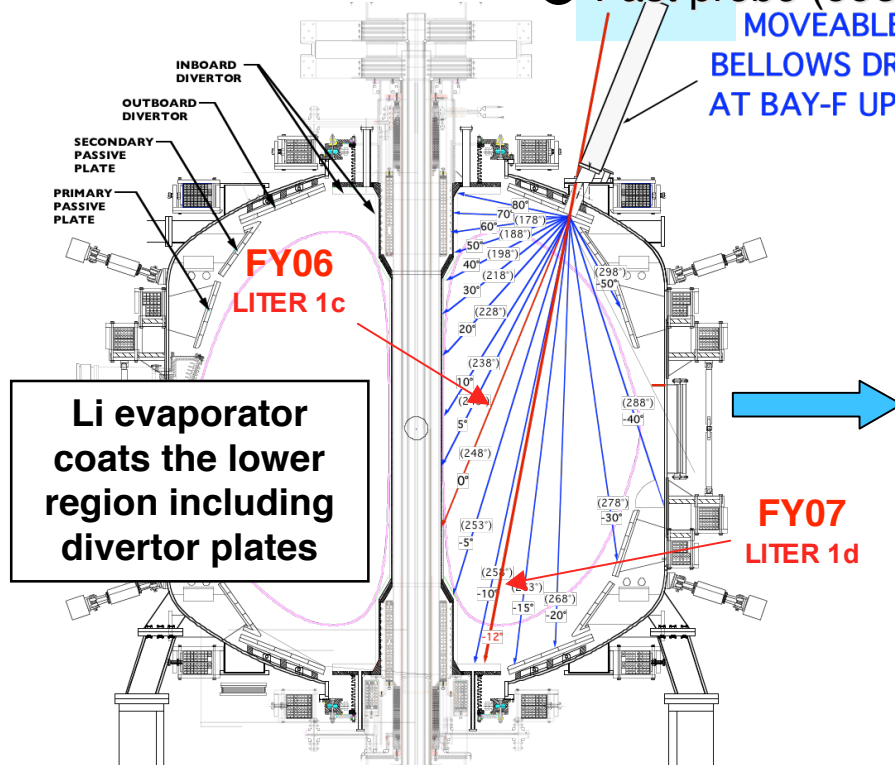


	FY 07	FY 08	FY 09
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Run Weeks
Base / Request

- | Run Weeks | FY 07 | FY 08 | FY 09 |
|-----------|-------|-------|-------|
| Base | 10-11 | 12 | 12 |
| Request | 8 | 8 | 8 |
- Improved (x10) Li Evaporator
 - Pellet/Dust Injector (LANL)
 - SSGI (LLNL)
 - Filterscope (~ 30 ch, ORNL)
 - Fast probe (UCSD)
 - Fast IR Camera (Request)
 - Divertor Diagnostics (Request)
 - Liquid Lithium Divertor Target (proposed pending review)

MOVEABLE
BELLOWS DRIVE
AT BAY-F UPPER

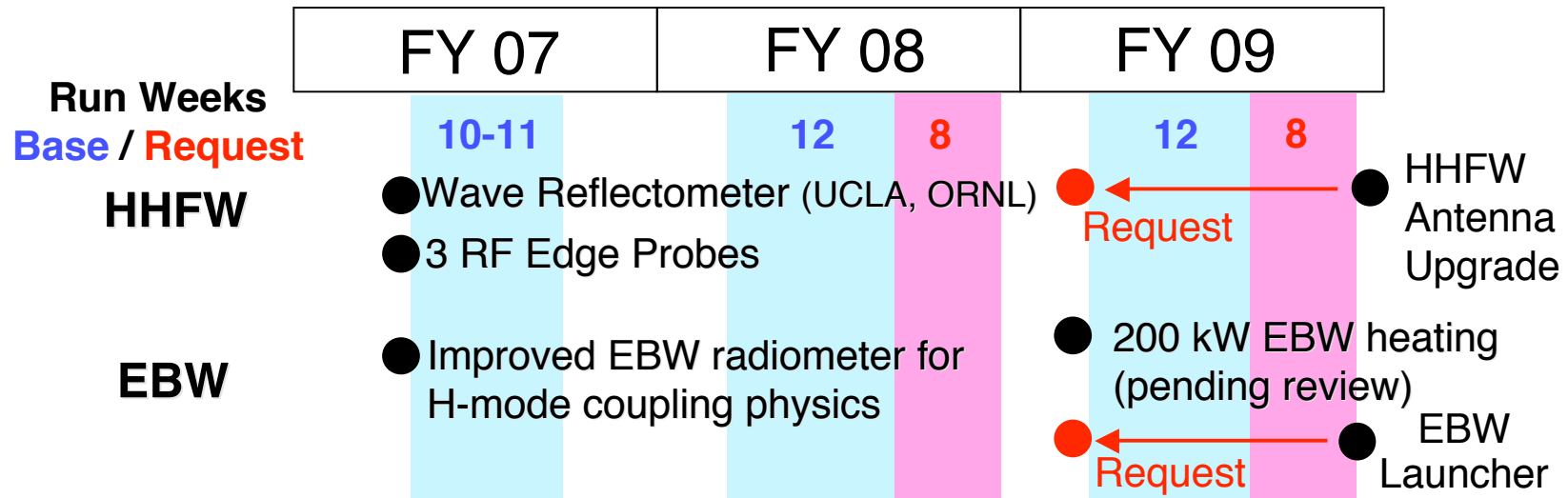


Proposed Liquid Lithium Divertor Target:

- Lithium evaporator produced improved confinement and some density control
- Surface reaction however limits effectiveness of solid lithium for longer pulses planned
- Liquid lithium needed to maintain fresh lithium surface for continued pumping
- Heated saturated mesh is a leading candidate
- Proposed to design in FY 07, fabricate in FY 08, and install for the FY 09 run

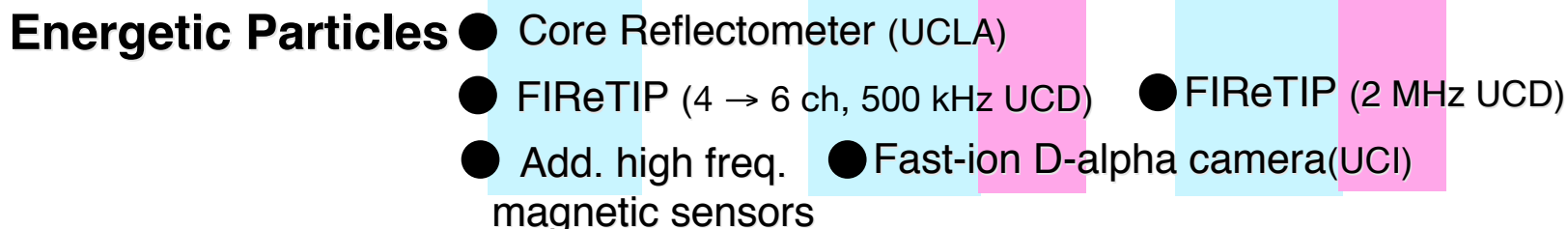
Waves and Energetic Particles

High priority to implement 200 kW EBW/ECH system



New Direction: Proposed to implement 100 – 200 kW (15.3, 28 GHz) EBW/ECH system utilizing existing ORNL and PPPL equipment

- Test EBW heating
- Heat CHI start-up plasma to ~100 eV enabling HHFW heating and CD
- Assist PF-only start-up research



Solenoid-Free Start-Up

Build upon the Success of Transient CHI



	FY 07	FY 08	FY 09
Run Weeks Base / Request	10-11	12 / 8	12 / 8
	<ul style="list-style-type: none">● Improved power supply & voltage monitor● Dynamo edge probe (UCSD)	<ul style="list-style-type: none">● Increased voltage	<ul style="list-style-type: none">● 200 kW ECH (pending review)● Plasma injector (under discussion)

- **Coaxial Helicity Injection** (U. Washington)
 - CHI performance rapidly increases with applied voltage (60 → 160 kA with 1.5 → 1.7 kV)
 - Improve transient voltage monitor and power supply to increase voltage toward 2 kV in FY 07 - 08
- **Outer-PF-only start-up** (Tokyo Univ., KAIST, ORNL, Univ. Wisconsin)
 - 2009: Test PF-only start-up with improved preionization
200 kW ECH and PEGASUS plasma injector (under discussion)

NSTX Budget Summary (\$M)



	FY 07	FY 08		FY 09	
Budget cases	Base	Base	Request	Base	Request
Run Weeks	10 to 11	12	20	12	20
Facility Ops	18.0	18.7	19.8	19.3	20.4
Facility Upgrades	0.6	1.0	2.0	1.0	2.0
Facility Total	18.6	19.7	21.8	20.3	22.4
PPPL Research	9.6	10.1	10.4	10.4	10.7
Diag Upgrades	0.7	0.6	1.3	0.6	1.3
Coll Diag Interf	0.7	0.6	0.7	0.6	0.7
Collaborations	5.0	5.2	5.7	5.4	5.9
Science Total	16.0	16.5	18.1	17.0	18.6
NSTX Total	34.6	36.2	39.9	37.3	41.0

- FY 07 budget ~ \$ 0.4 M less than the FWP budget for 12 run weeks.
- 12 run week base cases in FY 08 and 09 include minimal upgrades.
- Requested ~10% budget increase allows ~ 66% increase in facility utilization and acceleration of high priority facility and diagnostic upgrades.

Modest Budget Enhancement (~ 10%) Significantly Increases Science Output



- Significantly increases facility utilization
 - 66 % increase in run weeks (from 12 to 20)
- Accelerates key facility/diagnostic upgrades by one year:
 - HHFW antenna upgrade for FY 09 run
 - EBW launcher for FY 09 run
 - Full P-CHERS for FY 08 run
 - Divertor diagnostics in FY 08 - 09
 - Next-step turbulence diagnostic to be commissioned in FY 09
 - Fast CHERS in FY 09
- Improves facility reliability and availability
 - Better preventive maintenance and
 - Provide critical spare parts

Draft Plan for Developing the Next 5 Year Plan FY2009 - 2013

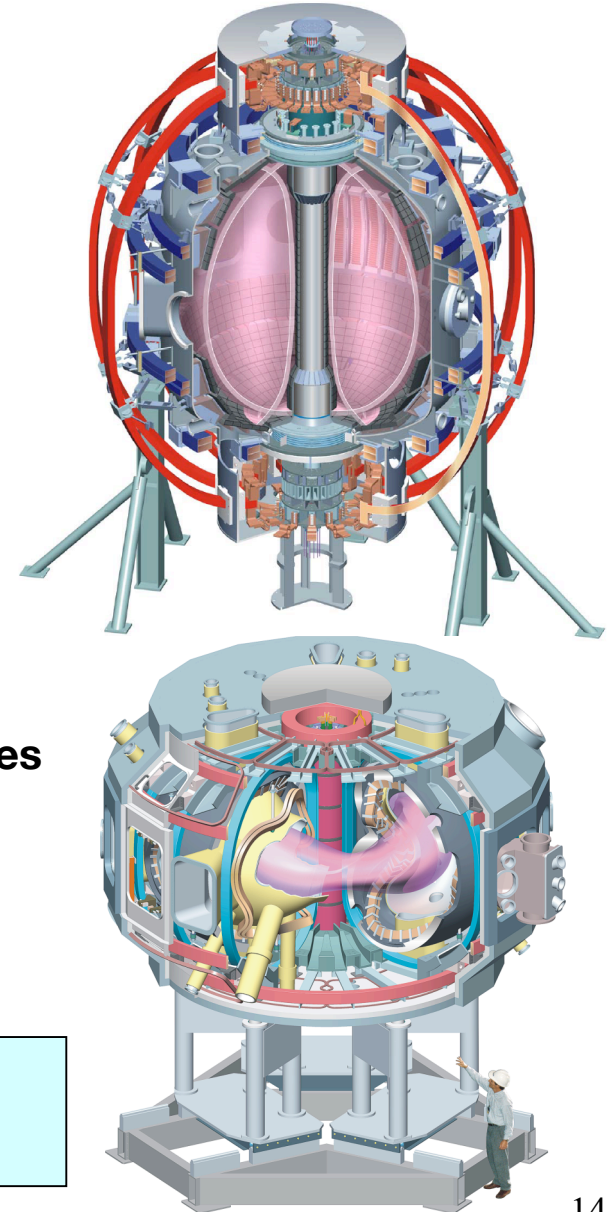


~ Dec. 20, 2006	Initial brainstorming on key research opportunities for the next 5 years
Jan. 15, 2007	Input from theory community for theory/modeling support
Feb. 2007	Mini-meetings to identify key research opportunities
March 2007	Develop preliminary upgrade cost estimates (manager's estimates)
April 2007	Develop draft plan for key approaches in support of opportunities
April 2007	Develop and review outline for the draft plan
April 2007	Team meeting to review approaches and opportunities
July 2007	Initial draft plan ready
August 2007	Team discussion of the initial draft plan
Sept. 17-19, 2007	Tokamak Planning Workshop at MIT
Jan. 2008	NSTX PAC reviews the draft plan
Feb. 2008	Final draft plan ready for review by the team
April 1, 2008	Final plan (document) ready
1 wk before review	Final presentation material ready
~ May 2008 (TBD)	New 5 Year Plan Review meeting

Joint Operations of NSTX and NCSX Envisioned

- NCSX first plasma planned in FY 09 with field mapping
- NCSX outage in FY 10 for upgrades
- NCSX physics experiments with NBI planned to start in FY 11
- Under flat budget, plan is to start alternate year operation in FY 11:
 - Shared use of resources (e.g. power supplies, computers, some diagnostics)
 - Operation team moves from one device to the other
 - Researchers will generally participate in both facilities
 - Cut overhead associated with outages (typically ~ 3 months) by ~1/2
 - Off-line facility to implement major upgrades

Details of joint operations to be developed as part of the next NSTX 5-year plan



Exciting Opportunities and Challenges

Optimized Plans Developed for FY 2007 - 2009



- **Productive FY2006 run completed, July, 2006**
- **Successful mid-term DOE review, Sept. 2006**
- **FY 2007 run planned from February through June**
- **Exciting new capabilities proposed for FY 2007-2009**
 - 200 kW EBW/ECH (Waves, Solenoid-free Start-up)
 - Liquid lithium divertor target (Boundary)
 - New faster processors for plasma control system (MHD)
 - Poloidal CHERS (T&T)
 - Increased MSE channels (T&T and MHD)
 - D-alpha fast ion diagnostics (Energetic particles)
- **~10% increase in budget greatly enhances science output**
 - Increase runtime by 66%
 - Accelerate key upgrades (HHFW, divertor diagnostics, MPTS)

• **NSTX will be formulating the next 5 year plan: 2009- 2013**

• **NSTX-NCSX Joint Operations Discussions Started:**
- Two advanced physics facilities at PPPL starting 2009