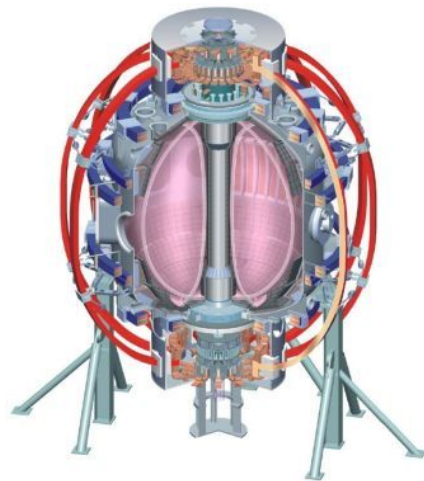


# NSTX Facility Achievements and Plans Toward 5 Year Plan Goals

Columbia U  
CompX  
General Atomics  
FIU  
INL  
Johns Hopkins U  
LANL  
LLNL  
Lodestar  
MIT  
Nova Photonics  
New York U  
ORNL  
PPPL  
Princeton U  
Purdue U  
SNL  
Think Tank, Inc.  
UC Davis  
UC Irvine  
UCLA  
UCSD  
U Colorado  
U Illinois  
U Maryland  
U Rochester  
U Washington  
U Wisconsin

**M. Ono**  
NSTX Project Director  
*For the NSTX Team*

**Midterm Review of Major MFE Facilities**  
Germantown, MD  
June 6, 2011



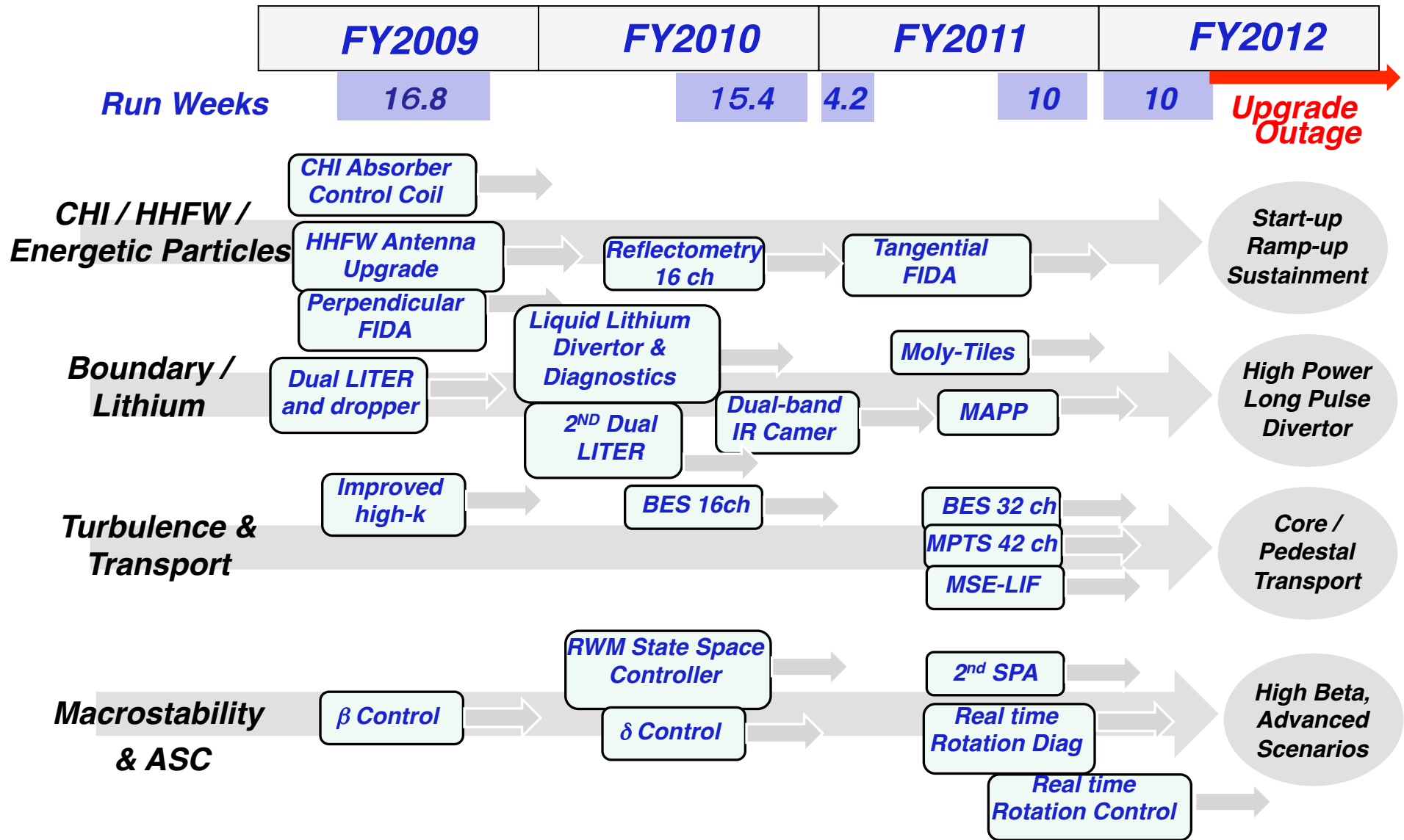
Culham Sci Ctr  
U St. Andrews  
York U  
Chubu U  
Fukui U  
Hiroshima U  
Hyogo U  
Kyoto U  
Kyushu U  
Kyushu Tokai U  
NIFS  
Niigata U  
U Tokyo  
JAEA  
Hebrew U  
Ioffe Inst  
RRC Kurchatov Inst  
TRINITI  
NFRI  
KAIST  
POSTECH  
ASIPP  
ENEA, Frascati  
CEA, Cadarache  
IPP, Jülich  
IPP,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

# Talk Outline

- **Facility overview**
- **Progress against the milestones and goals through annual budget planning process**
- **Summary of original proposed 5-Year Facility Plan**
- **Adaptation to technical or programmatic changes**
- **Mid-term facility status and accomplishments and plans and priorities for the remaining 2 years.**
- **Summary**
- **Supplemental slides:**
  - **Additional NSTX Upgrade Project information**
  - **ARRA funded activities**
  - **Successful lithium collaboration with EAST**

# NSTX 5 Year Base Facility Overview

## To Support NSTX Mission Elements and Upgrades



# Talk Outline

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# NSTX Facility Exceeded Operational Targets

## Facility Operated Safely for Ten Consecutive Years

- All facility and diagnostic milestones achieved on schedule in FY2009 and FY2010
- Achieved record number of total plasma shots and plasma shots per week for each of FY2009 and FY2010, and 4.2 run weeks operated thus far in FY2011.
- Introduction of lithium improved shots/week by ~ 50 % since the pre-lithium operations.

### NSTX Plasma Operation Statistics

Year	Run Week Milestone	Achieved Run Weeks	Achieved Shots	Achieved Shots/Week	Lithium Operations (%)
2011 start	14	4.2	839	199	~ 100
2010	15	15.4	2941	191	~ 100
2009	16	16.8	2750	163	92
2008	15	16.5	2570	156	46
2007	12	12.6	1890	150	69
2006	11	12.7	1615	127	0
2005	17	18.0	2221	124	0

NSTX received the State of New Jersey Commissioner of Labor and Workforce Development's 2010 Continued Excellence Award for working 10 consecutive years (2,011,666 hours) without an away from work lost time injury/illness case.

# All Facility Milestones in FY2009 and FY2010 Completed On or Ahead of Schedule

<b>FY2009</b>	<b>Description</b>	<b>Baseline</b>	<b>Actual</b>
F(09-1)	Operate NSTX Facility for 11 Experimental Run Weeks.	Sep 09	Aug 09
F(09-2)	Complete fabrication of the liquid lithium divertor target for particle pumping.	Sep 09	Sep 09
AF(09-1)	Operate NSTX Facility for 5 additional Experimental Run Weeks	Sep 09	Jul 09

<b>FY2010</b>	<b>Description</b>	<b>Baseline</b>	<b>Actual</b>
F(10-1)	Operate NSTX Facility for 14 Experimental Run Weeks.	Sep 10	Sep 10
F(10-2)	Commission the liquid lithium divertor target for particle pumping.	Sep 10	Apr 10
AF(10-1)	Operate NSTX Facility for 1 additional Experimental Run Weeks	May 10	May 10
AF(10-2)	Complete engineering design of facility upgrades including cost and schedule	Jun 10	Jun 10

<b>FY2011</b>	<b>Description</b>	<b>Baseline</b>	<b>Forecast</b>
F(11-1)	Operate NSTX Facility for 14 Experimental Run Weeks.	Sep 11	Sep 11
AF(11-1)	Complete commissioning of facility upgrades	Aug 11	Aug 11

## All Diagnostic Milestones in FY2009 and FY2010 Completed On or Ahead of Schedule

<b>FY2009</b>	<b>Description</b>	<b>Baseline</b>	<b>Actual</b>
D(09-1)	Upgrade the divertor bolometer to three views with 20 channels.	Sep 09	Apr 09
D(09-2)	Complete fabrication of the Beam Emission Spectroscopy system for transport studies.	Sep 09	Sep 09
AD(09-1)	Begin design diagnostic and facility upgrades	Aug 09	Aug 09

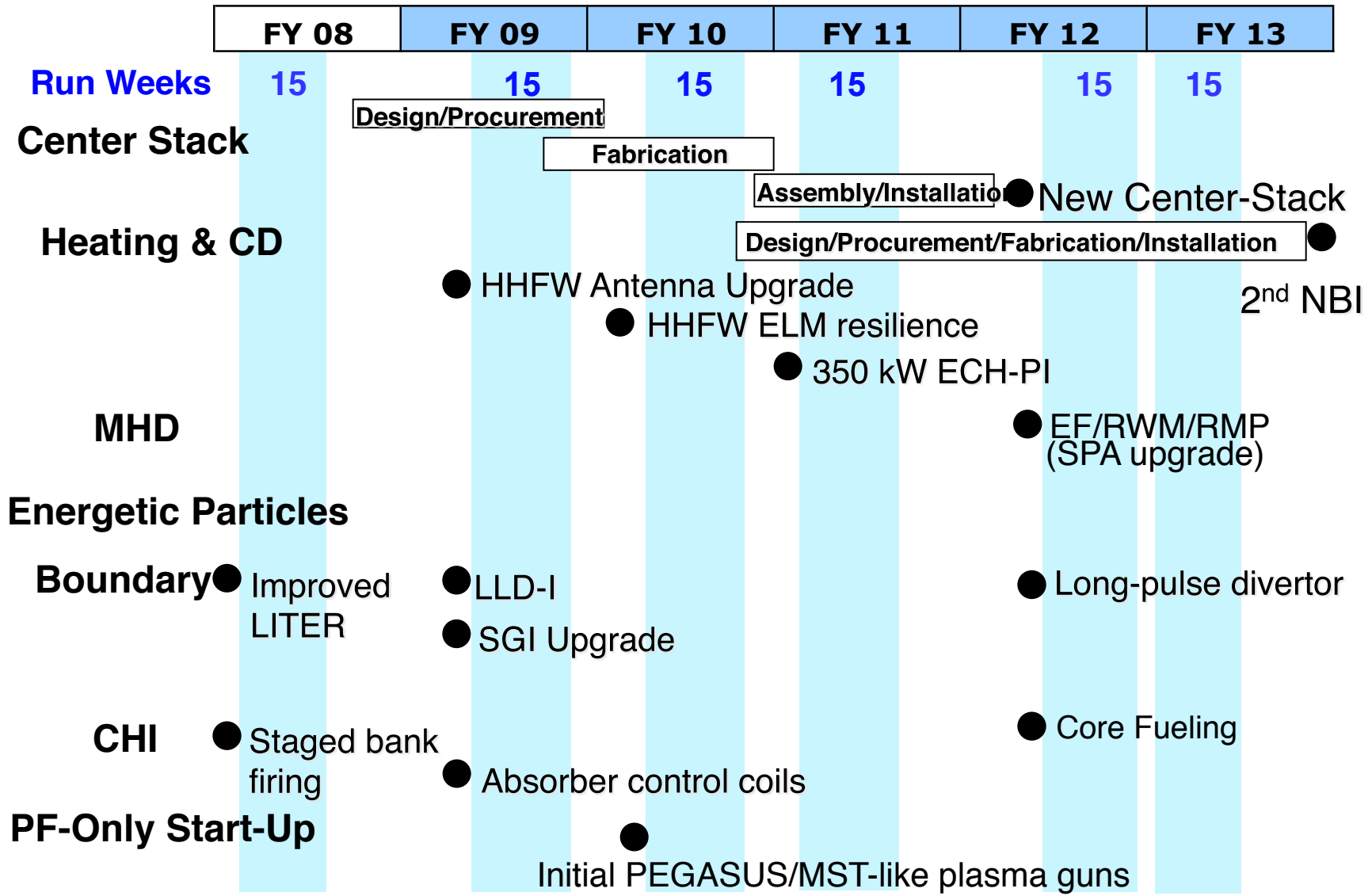
<b>FY2010</b>	<b>Description</b>	<b>Baseline</b>	<b>Actual</b>
D(10-1)	Commission the Beam Emission Spectroscopy system for transport studies	Sep 10	June 10
AD(10-1)	Complete key component procurements and begin assembly of plasma diagnostic upgrades	Sep 10	Sep 10

<b>FY2011</b>	<b>Description</b>	<b>Baseline</b>	<b>Forecast</b>
D(11-1)	Complete the commissioning of a real-time plasma rotation diagnostic system	Sep 11	Sep 11
AD(11-1)	Complete commissioning of diagnostic upgrades	Aug 11	Aug 11

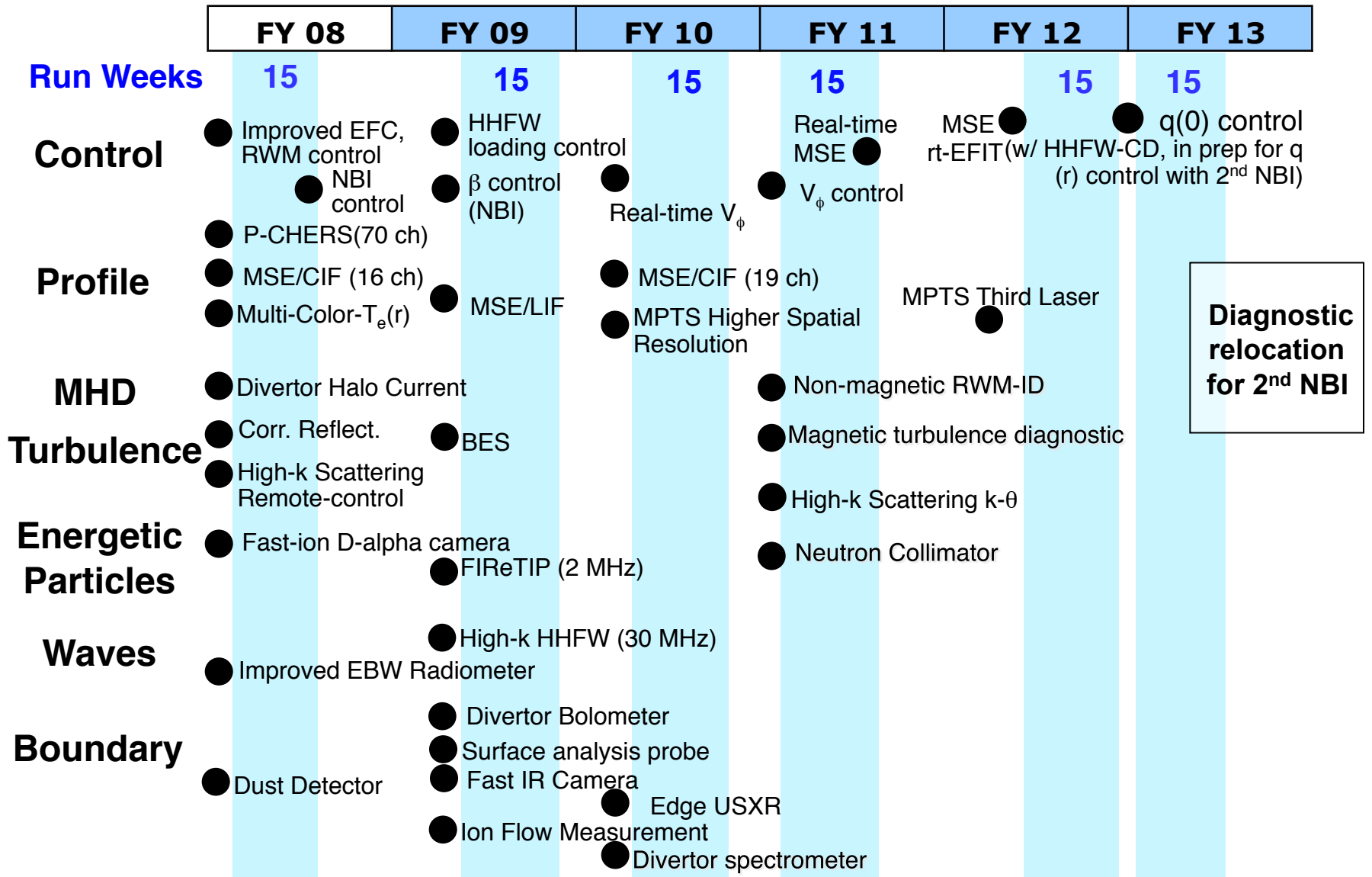
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# Original NSTX 5 Year Facility Upgrade Base Plan



# Original NSTX 5 Year Control / Diag. Upgrade Base Plan



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# Longer Term Facility Upgrade Plan Evolved Since 2008

## Drivers were ReNeW, FNSF, PMI, ITER, and NSTX Upgrade Project

- **NSTX Upgrade Project Initiated:**
  - **Upgrading NSTX with New Center-Stack and 2<sup>nd</sup> NBI doubling  $B_T$  heating/CD power and  $I_p$  would help achieve lower collisionality and fully non-inductive operations which would narrow gaps identified by FESAC TAP.**
  - **NSTX Upgrade Project team formed and being managed under the DOE Order 413.3A.**
    - Upgrade new center-stack and 2<sup>nd</sup> NBI as one project and one outage
    - Comprehensive up front engineering designs and R&Ds for all key components
- **ReNeW and FESAC TAP processes identified important R&D issues in PMI for FNSF and ITER.**
  - Increased emphasis toward boundary physics particularly LLD and associated diagnostics.
- **With the Upgrade Project and PMI emphases, some high cost upgrades such as ECH were postponed.**

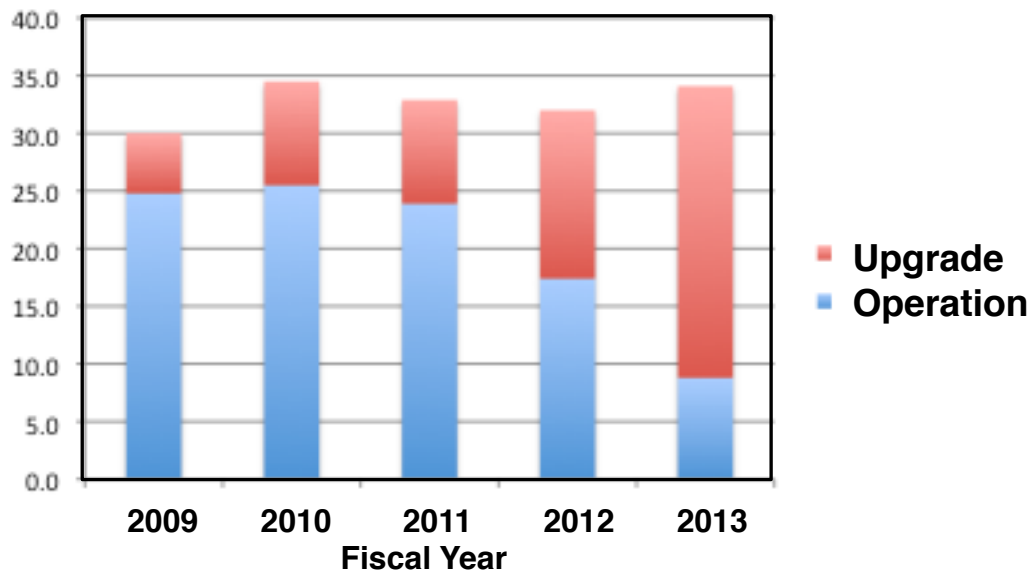
# Annual Budget for 5 Year Base Plan vs. Actual/Guidance

## NSTX Upgrade Project Funded Largely From the NSTX Facility Fund

Fiscal Year	5 Year Proposal	Actual/ Guidance	ARRA Increment
2009	\$46.2	\$45.1	\$8.1
2010	\$47.1	\$46.9	
2011	\$48.6	\$46.6	
2012	\$50.0	\$49.8	
2013	\$51.5	\$52.9	

- ARRA funding significantly enhanced facility and science capability
- Collaboration budget ~ \$6 M / year awarded based on a peer reviewed DOE grant solicitation process.

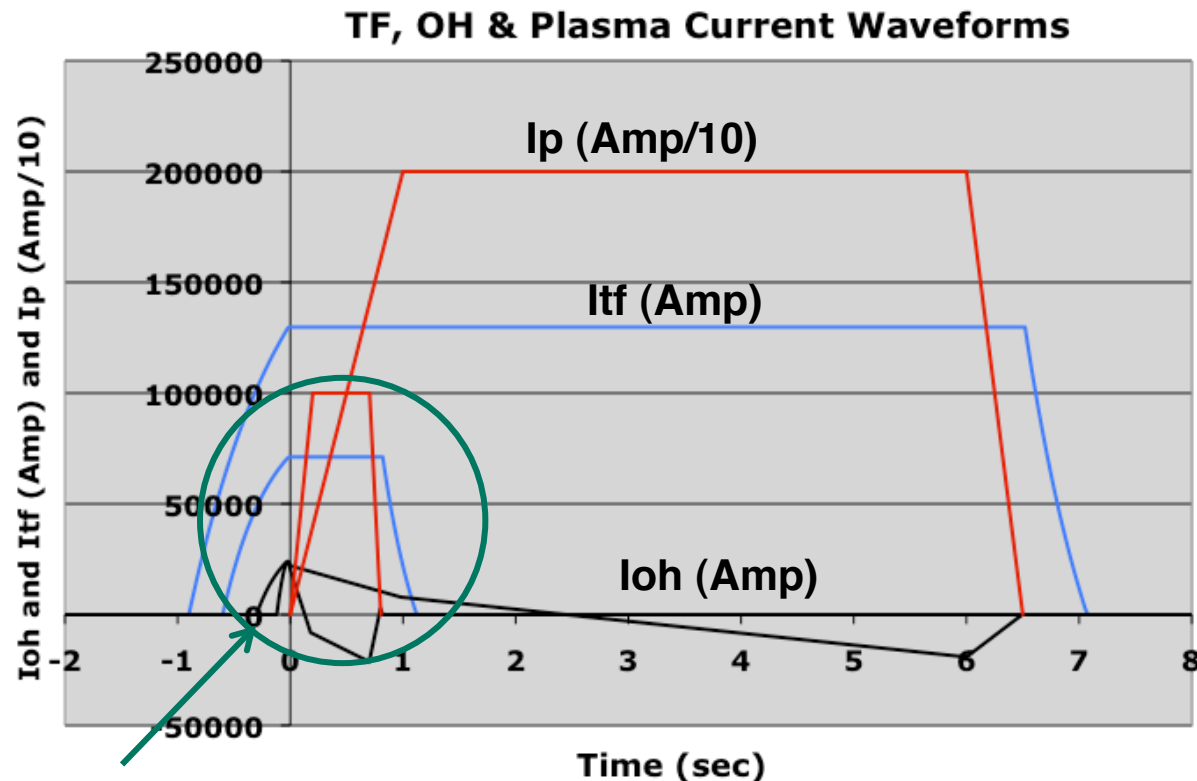
\$M NSTX Facility Budget Overview



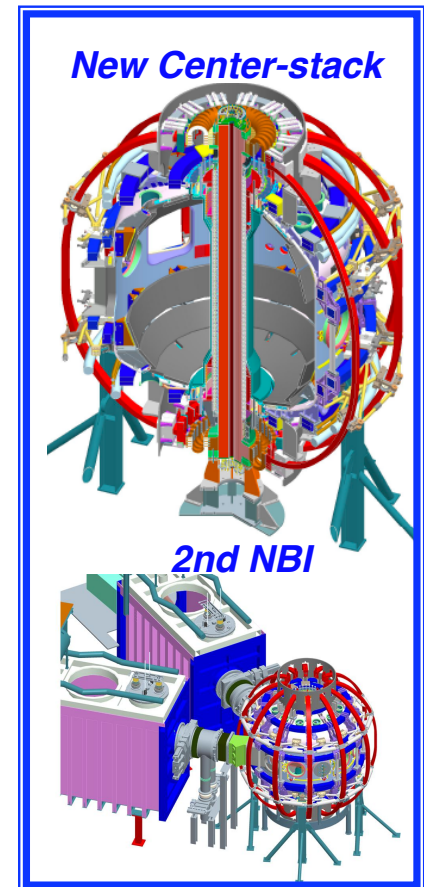
- Total facility budget is relatively flat over the five year period.
- The Upgrade Project construction is largely funded from the facility budget by the ramp-down of the facility operation budget after FY 2011.

# Upgrades for Low Collisionality, Non-Inductive Operations

## Higher $B_T$ and $I_p$ narrows gaps to FNSF identified by FESAC TAP



Present NSTX

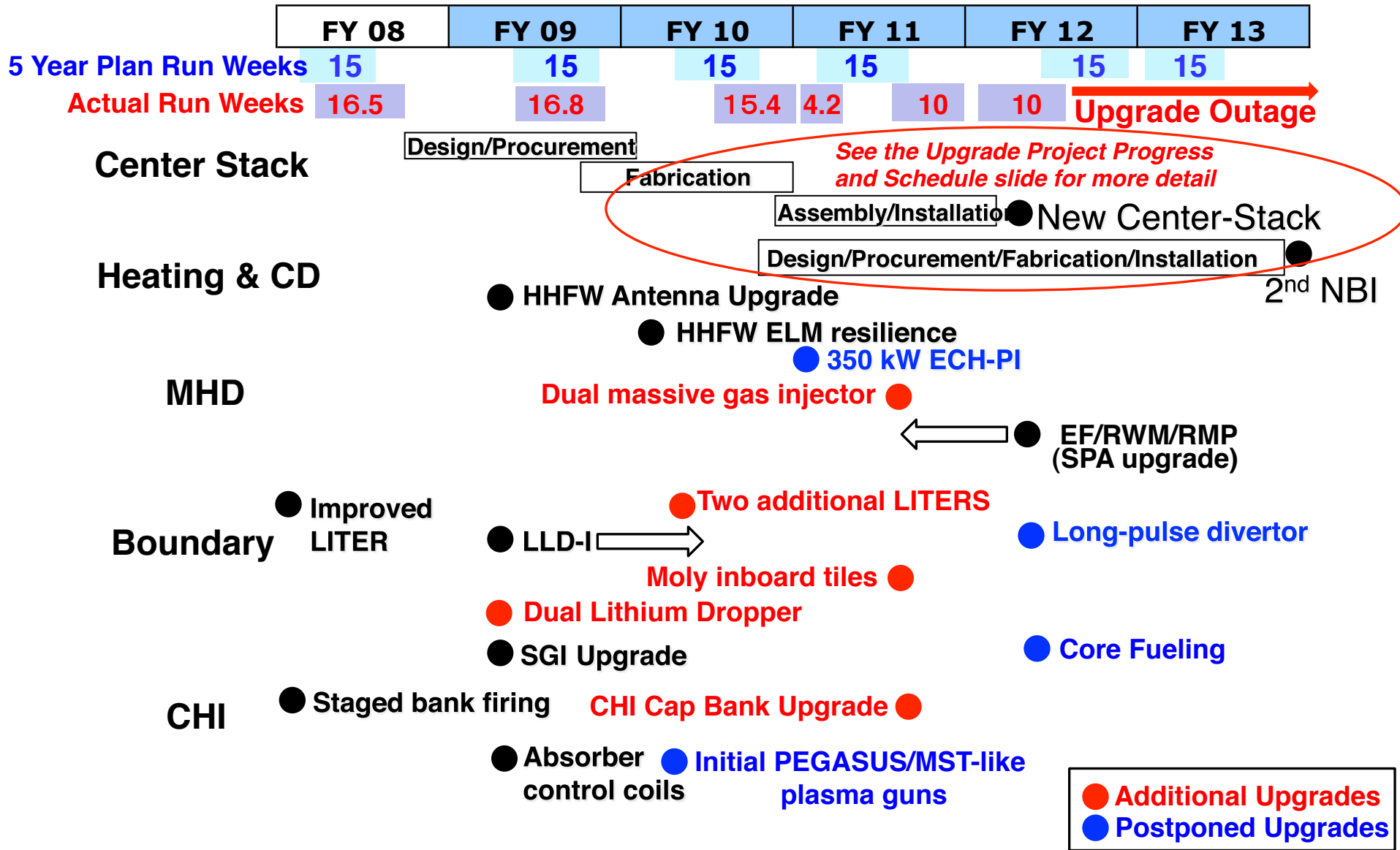


Relative performance of  
Upgraded NSTX vs. Base:

NBI power increased 2 x  
 Available OH flux increased 3x, 3-5x longer flat-top  
 $I_p$  increased 2x,  $B_T$  increased 2x at same major radius  
 Plasma stored energy increased up to 4x (0.25 → 1MJ)

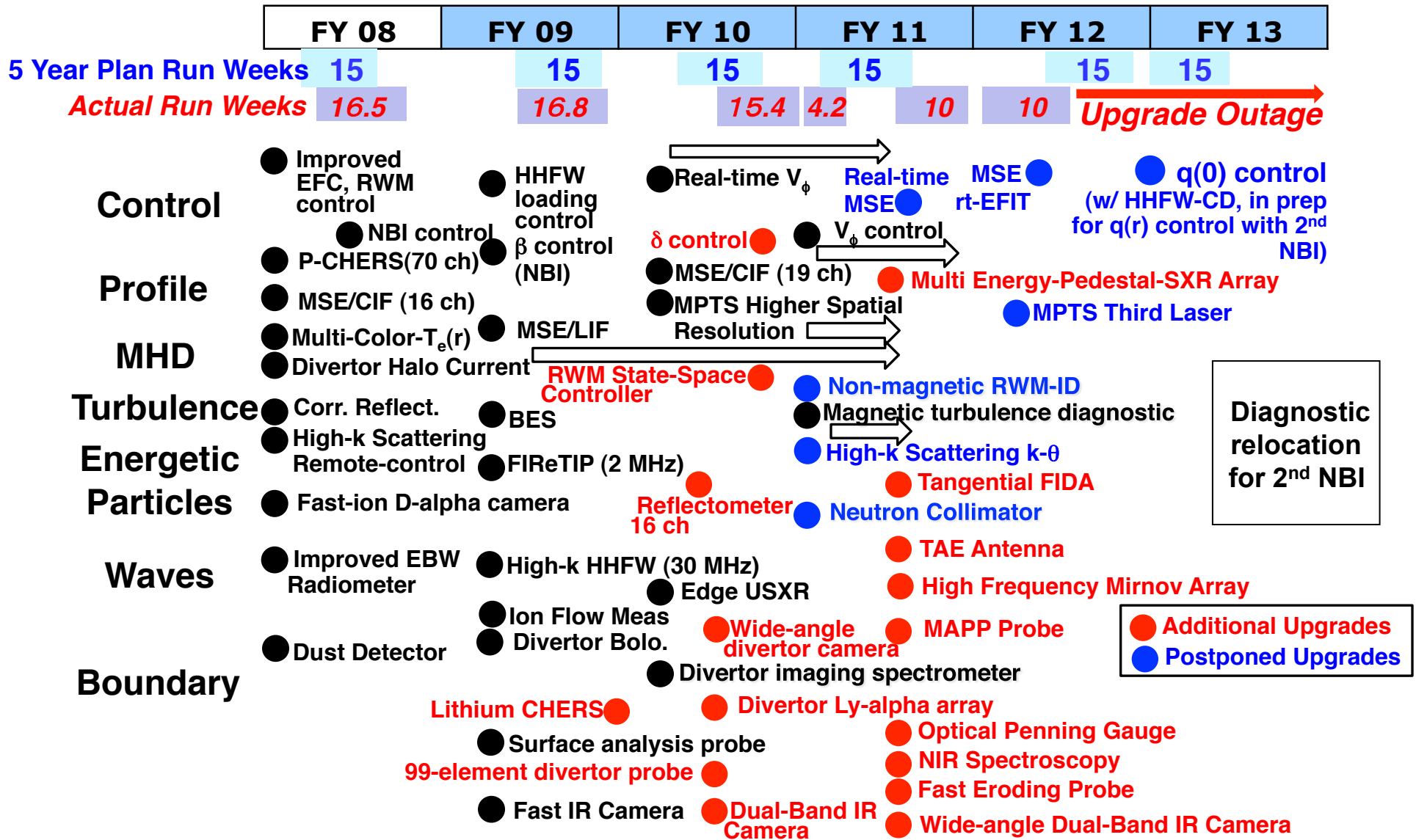
# Facility Upgrade Activity Comparison with 5 Year Plan

## Facility Plan Evolved Due to Technical and Programmatic Changes



# Diagnostic Upgrade Activity Comparison with 5 Year Plan

## Diagnostic Plan Evolved Due to Technical and Programmatic Changes



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# Strong Publications and Conference Participations

## Growing Number of Highly Capable Young Researchers

	Refereed Publication	PRLs	APS Invited	IAEA Papers
2008			6	20
2009	45	6	5	
2010	63	5	10	25
2011	*52	5		

*\* Includes 18 submitted manuscripts*

- Half of the publications and invited talks were led by collaborators
- 8 of 16 PRLs published in 2009-2011 were led by students and junior research

### NSTX Research Team Membership:

- Team consists of 58 PPPL researchers and 195 non-PPPL researchers
- Growing number of young researchers : 23 post-docs (up from 11 in 2008, 2 ARRA, 2 ORISE Fellows), and 24 students



# NSTX Researchers Received Community Recognitions

## Strong collaborator contributions

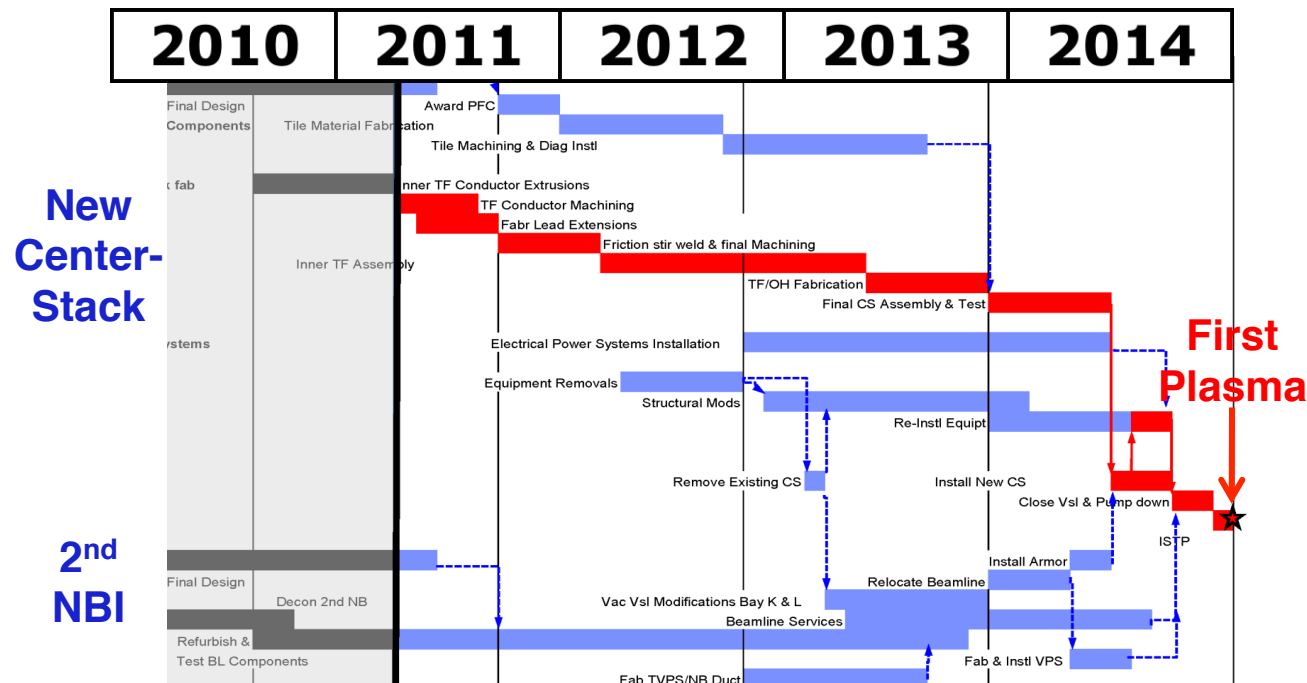
- Stefan Gerhardt (PPPL) and Joshua Breslau (PPPL) received 2009 US DOE **Presidential Early Career Awards**.
- V. Soukhanovskii (LLNL), J.P. Allain (Purdue U), and J-K Park (PPPL) received **2010 DOE OS Early Career Awards**.
- S. Sabbagh (Columbia University) was honored at IAEA (Daejeon, Korea) for his **2009 Nuclear Fusion Paper Award**.
- E. Fredrickson (2008-PPPL), R. Maingi (2009-ORNL), J. Menard (2010-PPPL) and S. Sabbagh (2010-Columbia University) were elected **APS-DPP Fellows**.
- J-K Park (PPPL) received the 2010 Marshall N. Rosenbluth **Outstanding Doctoral Thesis Award**.
- J-K Park received the 2011 **Outstanding Young Researcher Award (OYRA)** from Association of Korean Physicists in America (AKPA)

# Upgrades Provide Major Step Toward Future Fusion Systems

## Access to low collisionality and fully non-inductive operations

	NSTX	NSTX Upgrade	Fusion Nuclear Science Facility
Aspect Ratio = $R_0 / a$	$\geq 1.3$	$\geq 1.5$	$\geq 1.5$
Plasma Current (MA)	1	2	4 $\rightarrow$ 10
Toroidal Field (T)	0.5	1	2-3
P/R, P/S (MW/m,m <sup>2</sup> )	10, 0.2*	20, 0.4*	30 $\rightarrow$ 60, 0.6 $\rightarrow$ 1.2

\* Includes 4MW of high-harmonic fast-wave (HHFW) heating power

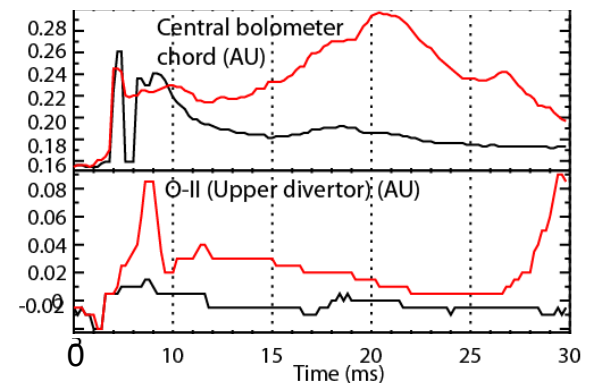
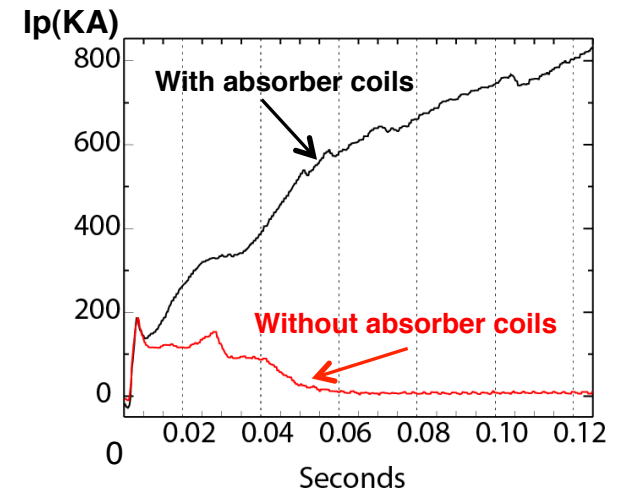
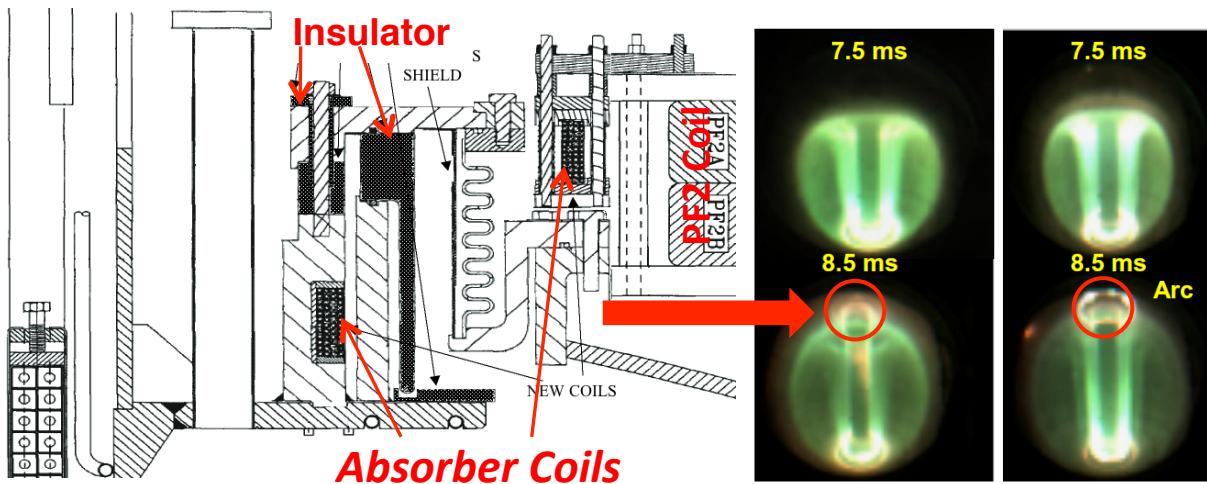


### Upgrade Project Status

- CD-0 (Mission Needs) Approved - February 2009
- CD-1 (Conceptual Design) Approved - April 2010
- CD-2 (Preliminary Design) Approved - December 2010  
Project Baselined
- CD-3 (Final Design) Target - January 2012 (Start of construction)
- CD-4 (Project Completion) Target - September 2014 (Planned Finish)

# Successful Solenoid-free Start-up for FNSF

## Demonstrated Flux Saving, Lower Density, Lower Inductance Start-Up



Low Z impurity reduction during CHI efficiently produced OH compatible plasmas ( $I_{tor} \sim 100 \times I_{inj}$ )

- Avoidance of absorber arcs by control coils energized in 2009
- Lithium coating of lower divertor to reduce impurity
- LLD (lithium on moly surface) acted as anode in 2010 to further reduce impurity

U. Wash.

### 2011-2013 Plans

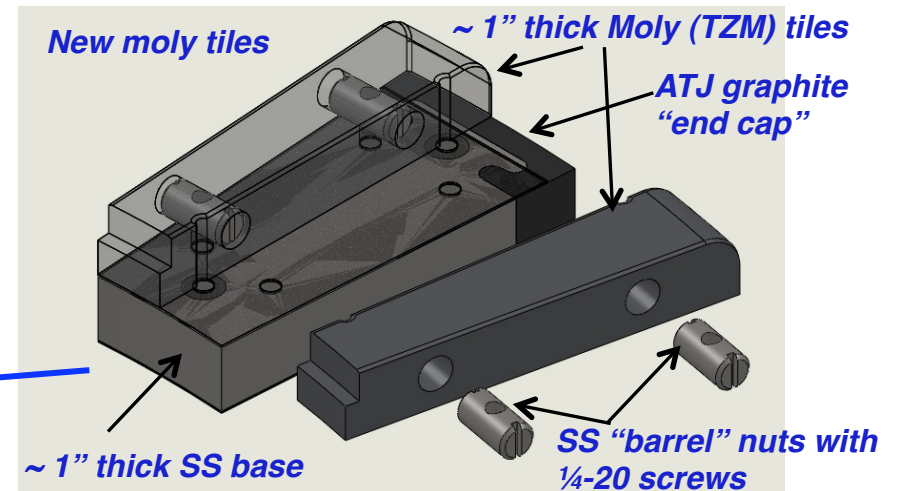
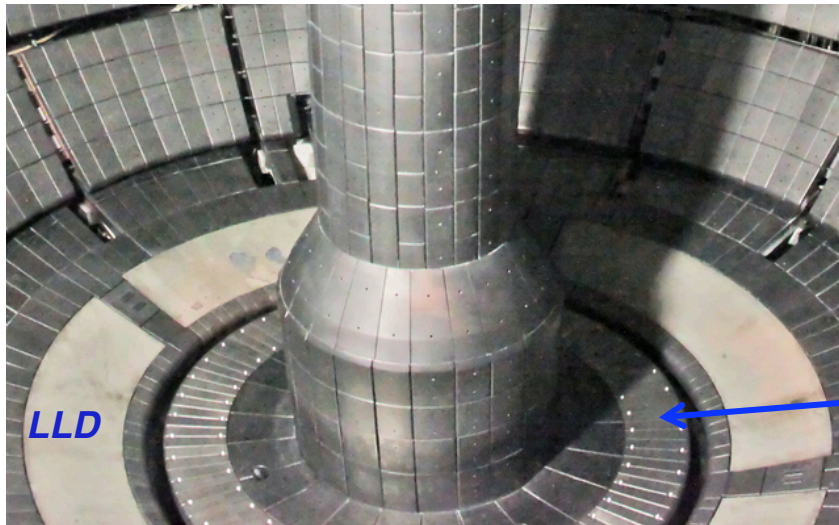
- Molybdenum cathode with lithium coating for higher CHI current  $\sim 0.5$  MA
- CHI + HHFW scenarios with higher  $T_e$
- Provide low-inductance target for stability and pulse-length optimization for AT
- PEGASUS collaboration will emphasize post-upgrade high current gun injection R&D

U. Wis.

# Increased Boundary Physics Emphasis for PMI and FNSF

## Liquid Lithium Covered Moly Surfaces Reduced Carbon Influx

Split-top Moly on SS tile satisfies design requirements



### LLD Status:

- Plasma heating effectively raised the LLD surface temperature to ~ 200 - 250 °C.
- No significant LLD surface damage nor moly influx observed with direct divertor strike point
- LLD plates cleaned and reinstalled with some mechanical support enhancements

### Molybdenum tiles now on inboard divertor

- Replace the second row tiles with 1" moly tiles
- All 48 tiles are moly including three diagnostic tiles
- Lithium coating with LITER ~ 2 x outer LLD rate
- Plasma heating can liquify lithium surfaces

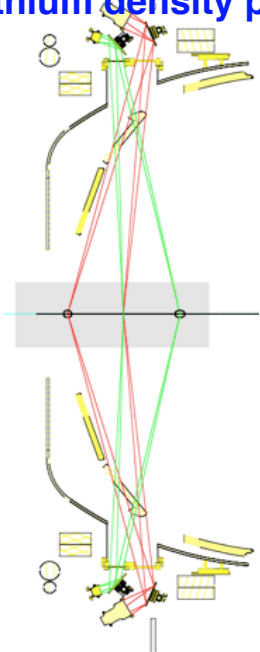
- Developing attractive solutions for post-upgrade long-pulse power & particle handling PFCs/divertor are high priority boundary physics task for FY2013.
- Decision in 2012 and conceptual design in 2013 for moly-tile and divertor upgrades.



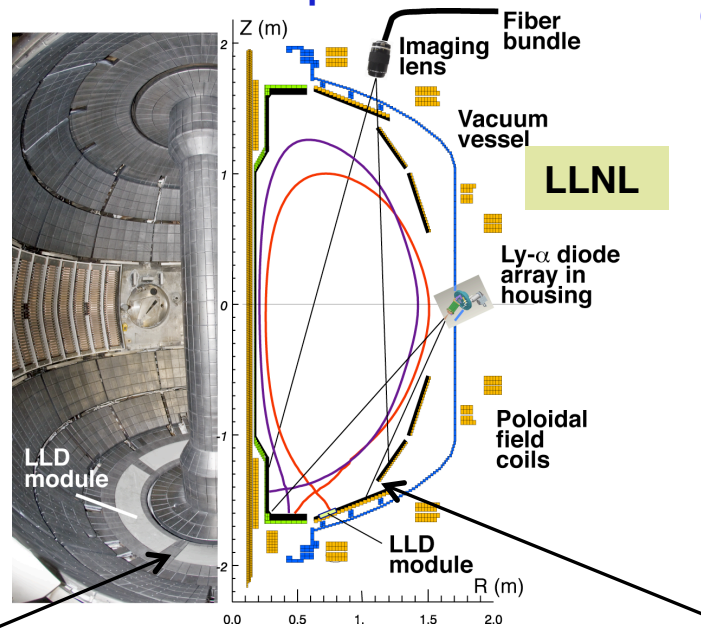
# Enhanced Diagnostics for LLD and Boundary Physics

## Reflecting PAC Recommendation - Multi-Institutional Contributions

**Lithium CHERS**  
Lithium density profile

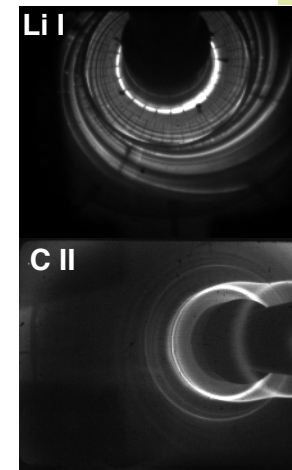


**Divertor Imaging Spectrometer**

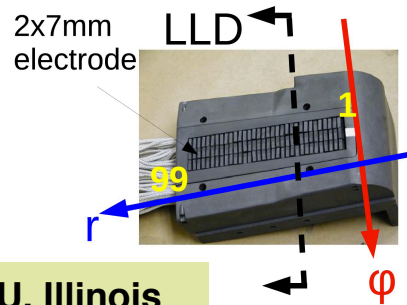


**Two fast 2D visible and IR cameras with full divertor coverage**

LLNL, ORNL

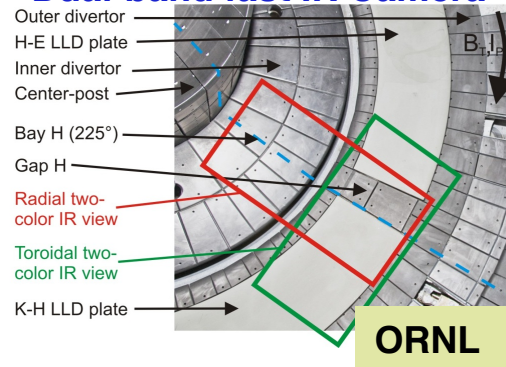


**Dense Langmuir Probe Array**



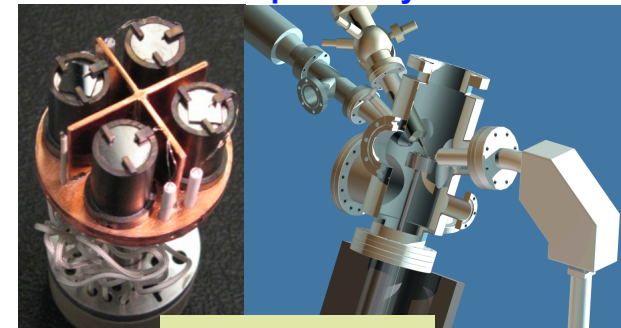
U. Illinois

**Dual-band fast IR Camera**



ORNL

**PMI Probe / to be replaced by MAPP Probe**



Purdue U.

# **NSTX Leads a Growing World Lithium Program** **(NSTX, LTX, FT-U, T11M, T-10, TJ-II, EAST, HT-7, RFX, KTM)**

**NSTX Goal: To investigate effectiveness of lithium for divertor heat and particle control while enhancing plasma performance.**

**NSTX lithium research interacts broadly and benefitted from the PPPL and outside research groups:**

- **Utilized the TFTR and the CDX-U lithium experiences.**
- **Synergy with on-going LTX research activities.**
- **Growing and highly productive lithium collaboration with EAST.**
- **Liquid lithium research collaboration with Penn State.**
- **Emerging collaboration with Princeton University on lithium surface interactions.**

**2<sup>nd</sup> Lithium Symposium held at PPPL on April 27 – 29, 2011**

**Over 50 presentations from 10 magnetic fusion confinement facilities**

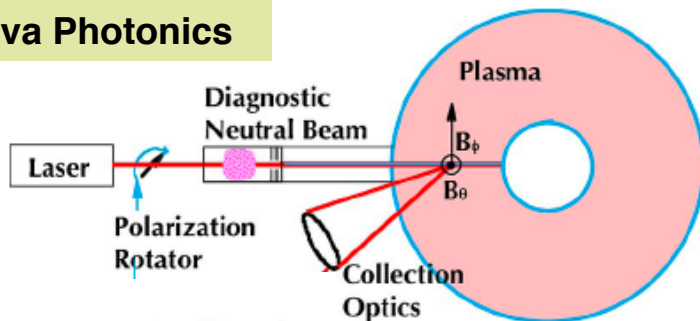
- **Multi-machine observations show robustness of lithium results**
- **NSTX lithium dropper contributed to H-mode / Long-Pulse EAST Operation**
- **Promising high heat flux capable liquid lithium divertor concepts emerging.**

**Please visit <http://isla2011.pppl.gov/index.html>!**

# Enhanced Pedestal / Profile Diagnostics for Pedestal and Core Transport Joint Research Targets

## MSE-LIF to Measure $E_r(r)$ , $B(r)$

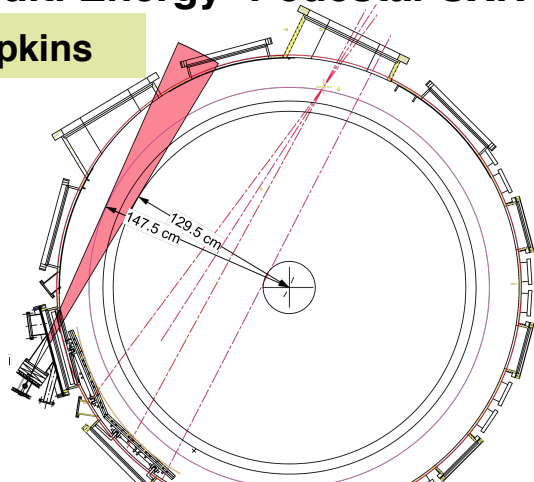
Nova Photonics



10 channels to be available in FY 2011.  
Additional channels in FY 2012

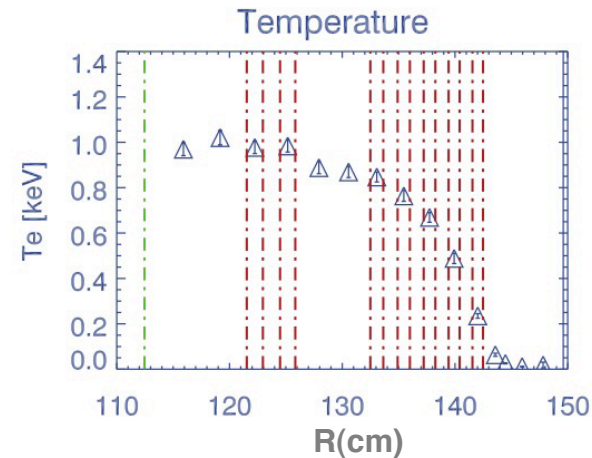
## Multi Energy -Pedestal-SXR

Johns Hopkins



20 channel in the edge region with  
~ 1 cm resolution

Additional 12 MPTS channels enhance pedestal resolution to ~ 1 cm, also improve core ITB diagnosis

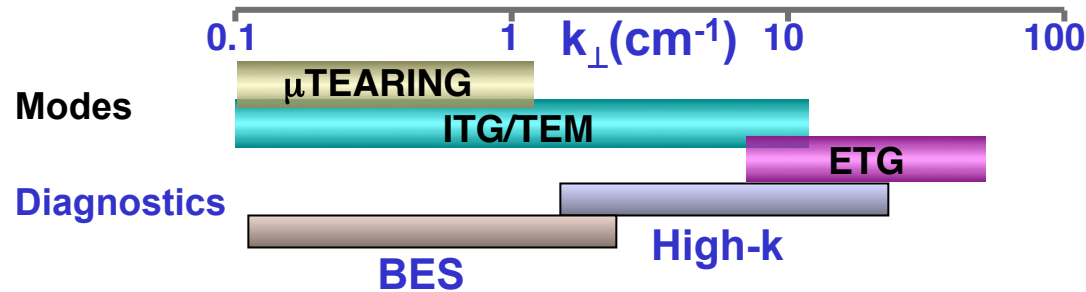


- NSTX profile diagnostic set is quite comprehensive providing nearly all of the plasma profile information.
- All of the profile diagnostics are at mid-plane, naturally suited for rapid analyses
- In FY 2013, MPTS will be re-aimed to accommodate the upgraded center-stack



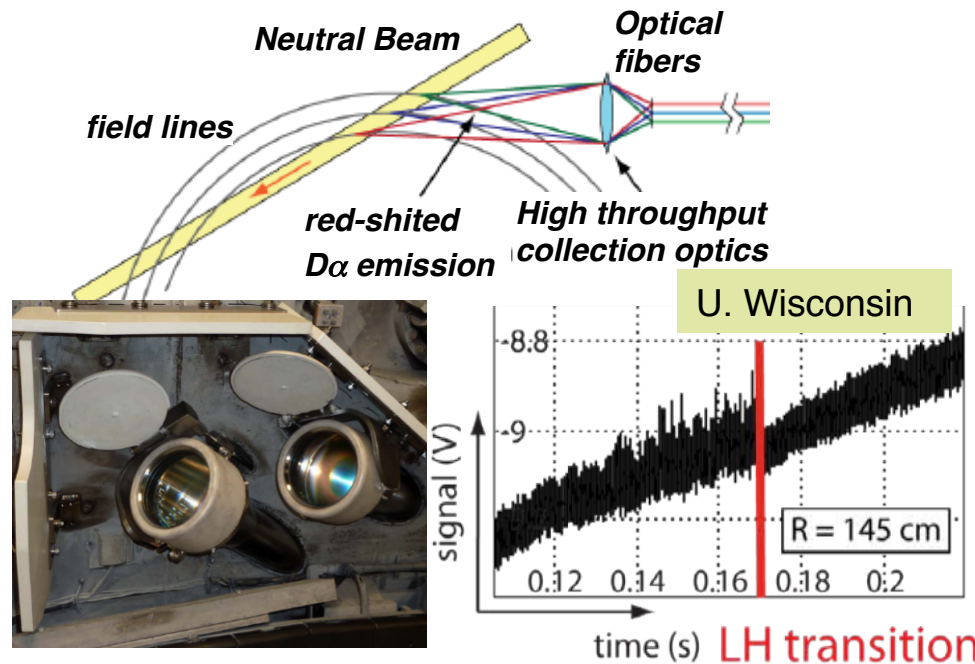
# Wide-k Range Turbulence Diagnostics

Increase and Understand H-mode Confinement at Lower  $n_e, v^*$



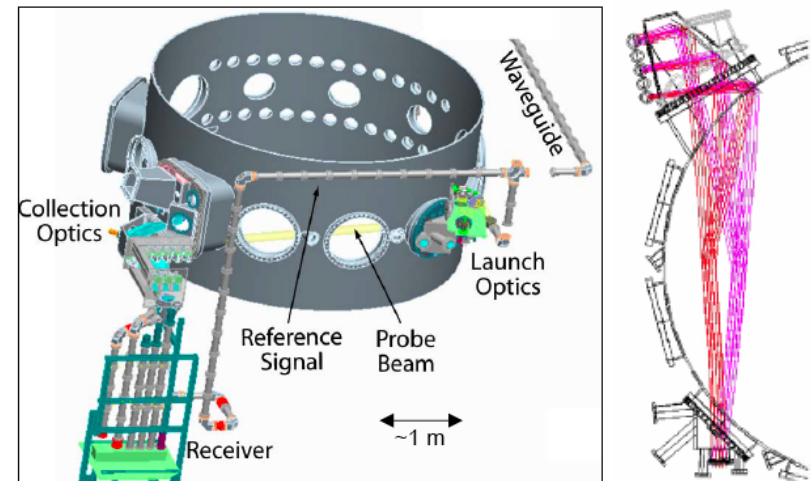
## Beam Emission Spectroscopy for ion-gyro-scale turbulence

- BES was implemented in FY2010 with 16 ch to measure lower k turbulence..



## High-k Tangential Scattering for electron-gyro-scale turbulence

- High-k scattering has been the workhorse for the NSTX turbulence/transport studies.



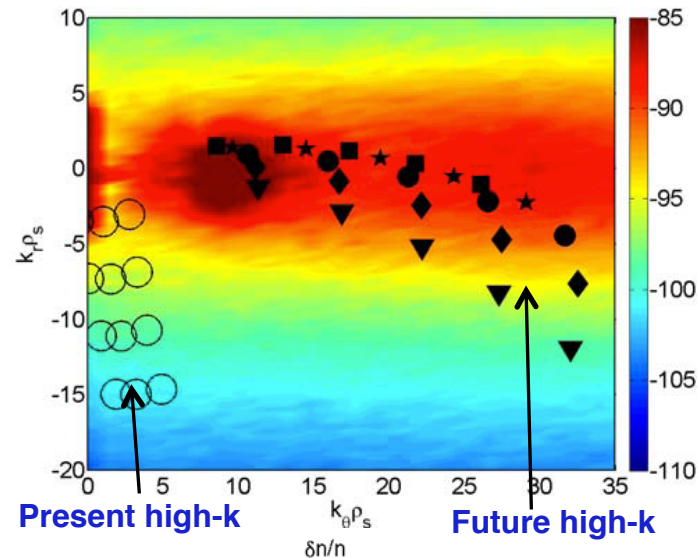
- Remote capability implemented in FY 2009.
- Solid-state source upgrade in FY 2010 greatly improved stability and reliability

UCD

# Wide-k Range Turbulence Diagnostics

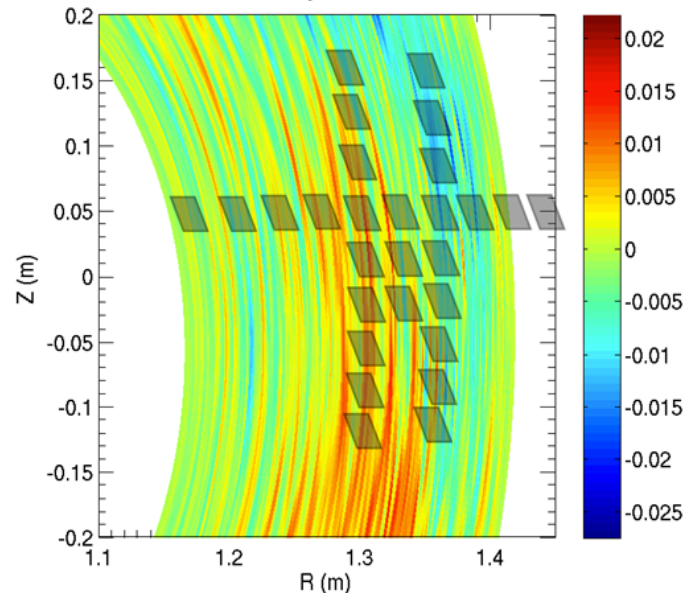
## Improvements to be Implemented in FY2012-2013

- **High-k Upgrade:** Current high- $k_r$  scattering system will be removed to install the 2<sup>nd</sup>NB during upgrade.
  - Design of a new high- $k$  scattering system is in progress and will be completed during FY13 and FY14



*$k$  space coverage for the present and future high- $k$  scattering systems with ETG  $k$  spectrum (non-linear GYRO, NSTX L-mode)*

- **BES System:** 32 ch in FY 2011. Extensive comparison between measurements and micro-instability calculations including GYRO, GTS, GS2, GTC-NEO.
  - Use synthetic diagnostics to compare simulated and measured fluctuating quantities and their spectral characteristics



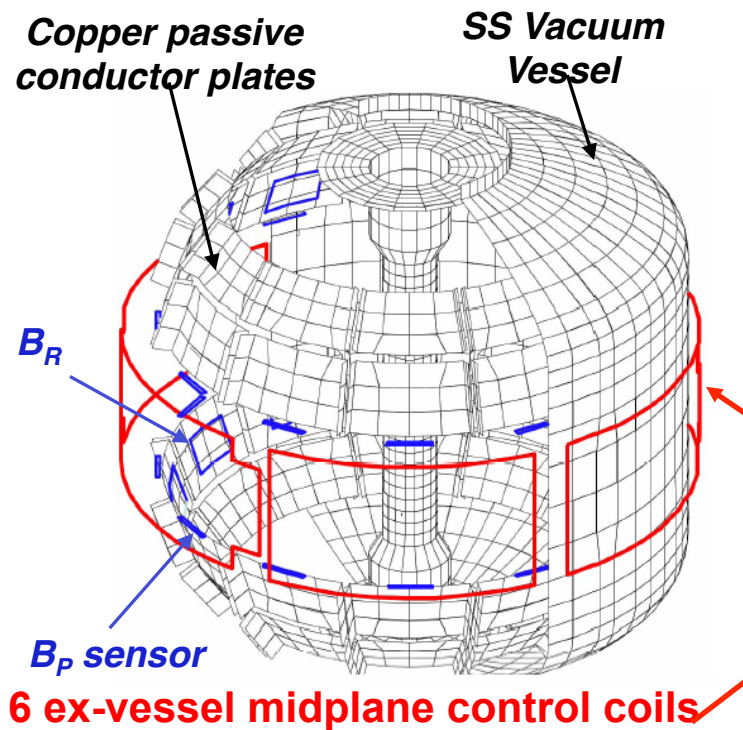
*BES views with micro-tearing density fluctuations (nonlinear GYRO NSTX H-mode)*

# Macrostability and Advanced Plasma Control

## Sustain $\beta_N$ and Understand MHD Behavior Near Ideal Limit

Advanced RWM state space controller demonstrated in FY2010

Columbia U



2nd Switching Power Amplifier (SPA) to enable all six EFC/RWM coils for control of  $n = 1, 2, 3$  simultaneously in FY2011 (installed)

- RWM spectrum dependence
- Rotation and beta effects on NTMs
- Response to 3D fields for EFC, ELM and Neoclassical Toroidal Viscosity physics
- Disruption physics

Real Time Rotation Diagnostic Status: Real-time measurement of toroidal rotation velocity at 4 spatial locations in plasma.

- Commission diagnostic in FY2011.
- Use in real time control system in FY 2012.

Massive Gas Injectors for mid-plane / private flux injection installed

U. Wash.

Conceptual Design for advanced control coils and real time control system in FY2013

- MHD: 3D coil physics design for RWM/RMP/TM/EFC/NTV/TAE
- Control: Model/plan for real-time-MSE for NBI J-profile control

Columbia U, GA,  
ORNL, Nova

# Energetic Particle Capability for $\alpha$ -Physics and NBI CD

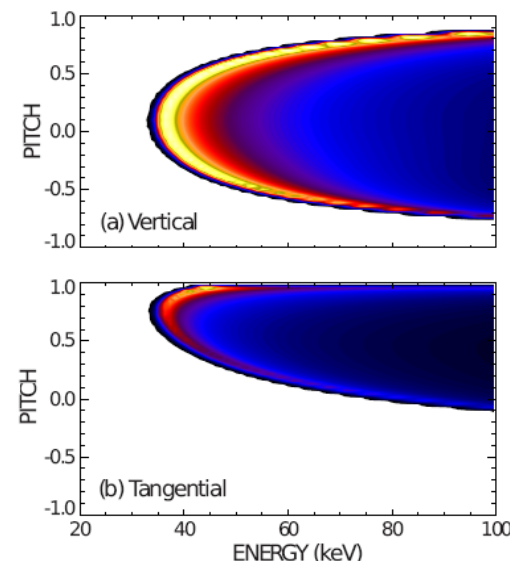
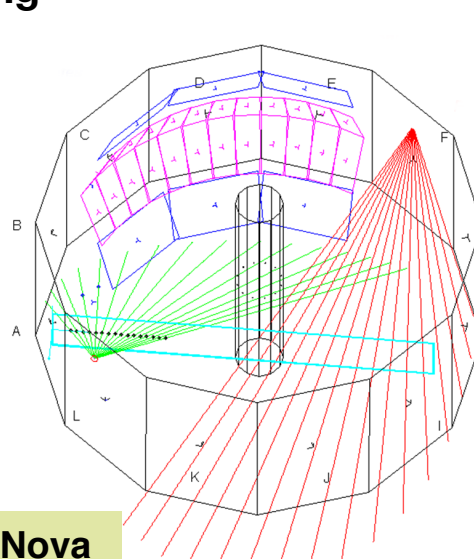
## Quantitative measurements facilitating theory/modeling validation

### Fast Ion D-Alpha Diagnostic Providing Crucial Energetic Particle Data

- p-FIDA in 2009 provided valuable initial energetic particle profile inf.
- t-FIDA upgrade was implemented in 2011 readied for the plasma operations.
- FIDA complemented by Scanning NPAs, solid-state NPA, sFLIP, and neutron diagnostics, MSE-LIF

UC Irvine, Nova

### Tangential FIDA Views



### A suite of energetic particle induced mode diagnostics is now available

- Soft X-ray Array, Multi-channel wave reflectometer, BES, FReTIP, 2.8 MHz Mirnov array for n/m mode structure
- A prototype TAE-frequency antenna installed

JHU, UCLA, U. Wis., UCD

### FY 2011- 2013 Energetic Particle Activities

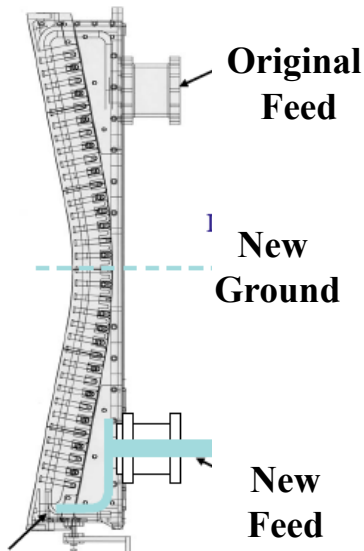
- Integration of new energetic particle physics diagnostics – tFIDA, BES, MSE-LIF, TAE antenna, improved Mirnov array in FY2011 - 2012.
- An assessment in FY 2013 for the post upgrade operations



# HHFW Heating/CD for Current Ramp-Up and Maintenance

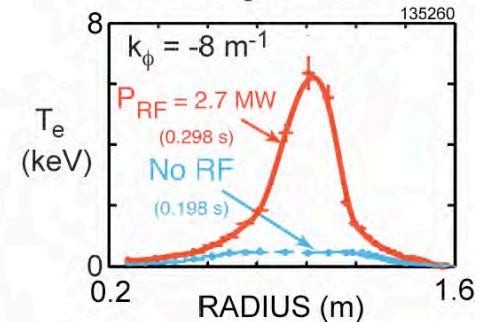
## HHFW Heating Efficiency Improved with Antenna Upgrades

### Double Feed Antenna modification (2009)

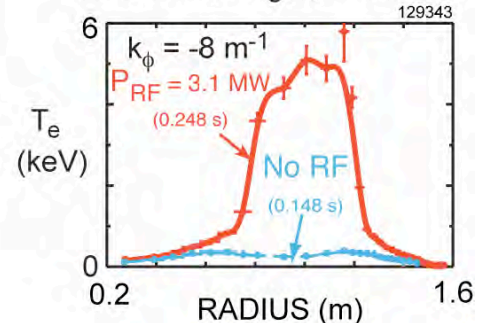


Resulted in improved electron heating in both helium and deuterium

Helium:  $T_e(0) = 6.2$  keV



Deuterium:  $T_e(0) = 5.2$  keV



- Maximum radiation at mid-plane
- Power capability should increase by a factor of 2

ORNL

- FY 2010 Sustained HHFW H-mode at low current  $\sim 300$  kA with  $T_{e0} \sim 3$  keV
- FY 2011 HHFW heating and current drive for start-up at low current
- FY 2012 HHFW + CHI for solenoid-free start up
- FY 2013 Conceptual design for antenna enhancement

# **NSTX is Making Excellent Progress on Its Five Year Plan**

## **Operation and Upgrades Effectively Support NSTX Research Plan**

- All the FY 2009 - 2010 milestones completed on or ahead of schedule with high research productivity supported by excellent facility operations.
- Facility / diagnostic capability greatly improved supporting the 5 Year Plan in all key science areas.
- NSTX research team highly productive in terms of honors, publications and invited talks at major conferences.
- NSTX facility operations and upgrades adapted effectively to technical or programmatic changes.
- Effective mid-term facility plans and priorities were developed for the remaining 2 years support of the 5 Year Plan.
- NSTX Upgrade Project implemented at high priority in the Five Year Plan.
  - The Upgrade Project is funded largely from the base NSTX facility operation budget.
  - Excellent progress to date with CD-2 approval (project baselined) in Dec. 2010 and the project completion in FY 2014

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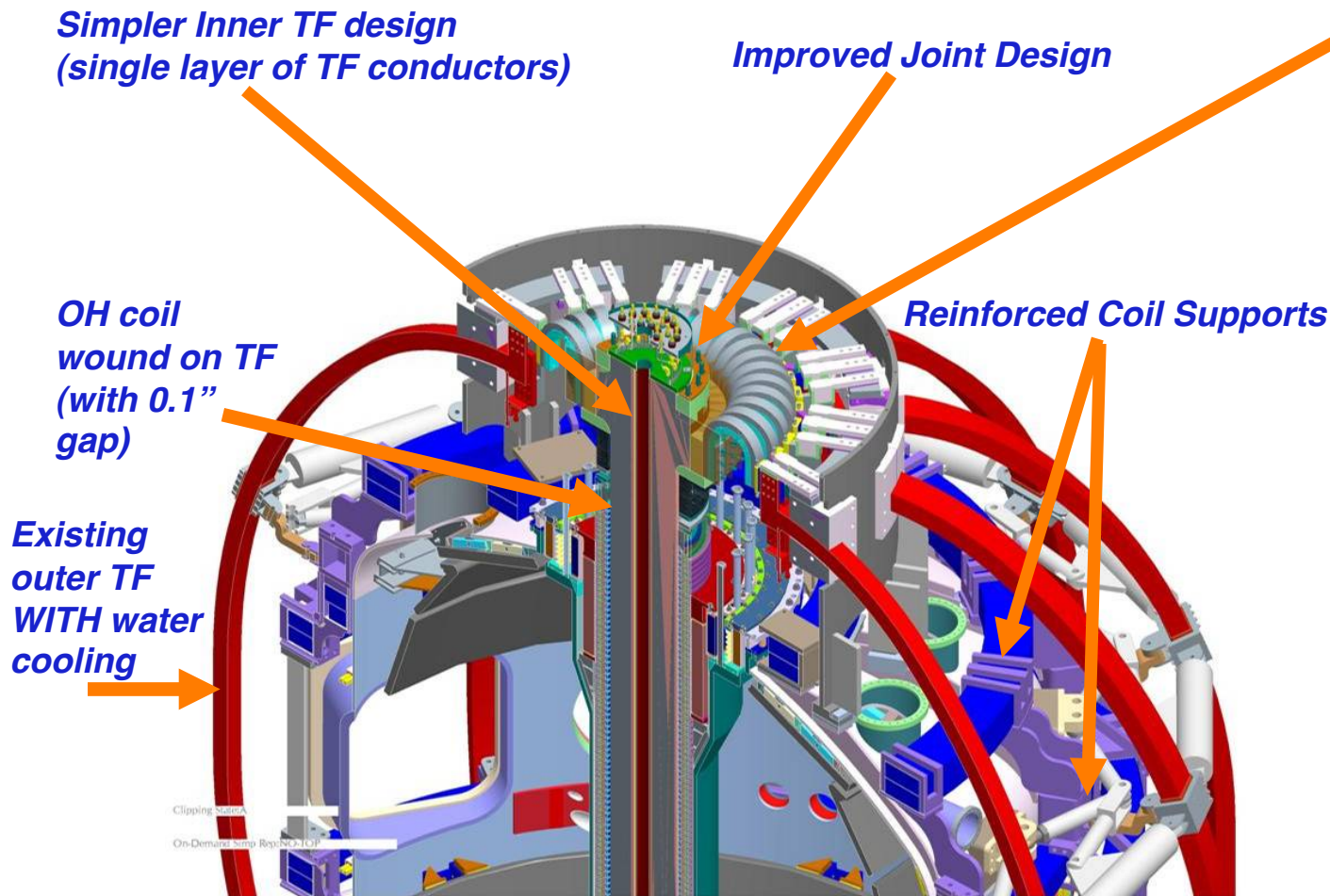
# Supplemental Slides



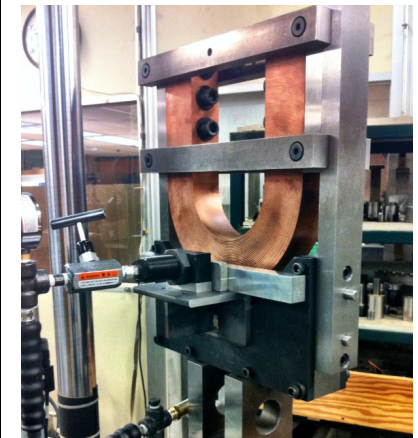
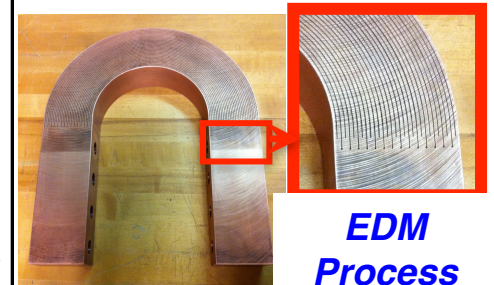
# Center Stack Upgrade and Related Enhancements

Detailed Design, Analyses, and R&D Are Now Well Advanced

Since  $B$  and  $J$  increase  $\times 2$ , the E&M forces increase  $\times 4$



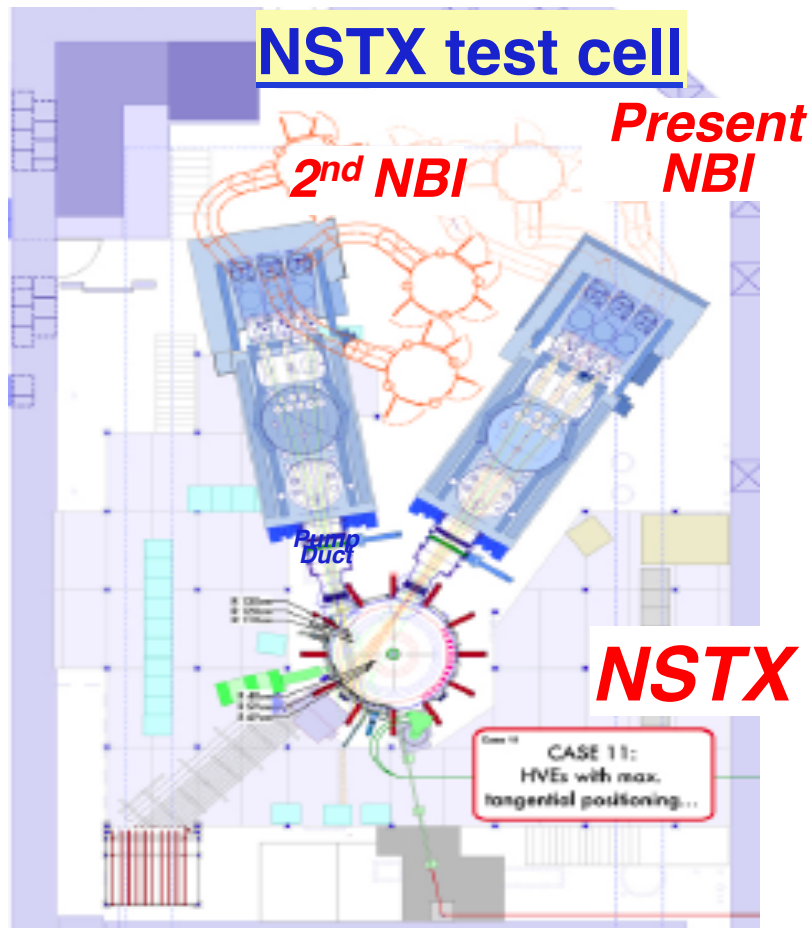
## TF Flex Strap R&D



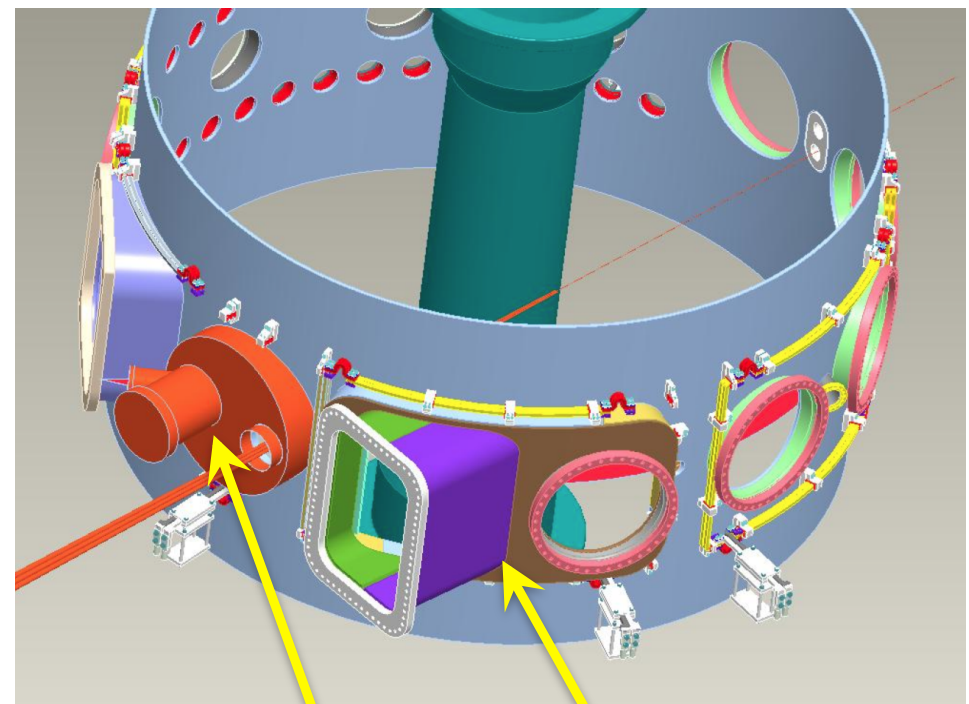
**Successfully Tested to 300,000 cycles**

# 2<sup>nd</sup> NBI requires relocation of a TFTR NBI system to NSTX and relocation of NSTX diagnostics from Bay K to Bay L

- Decontamination of 2<sup>nd</sup> Beam line Successfully Completed in 2010
- Reassembly of the 2<sup>nd</sup> Beam line has started



## Bay L Diagnostics & Bay K Weldment



*Bay L CHERS, MPTS, & others*

*Bay K-J weldment installed for NBI BL2*

# Diagnostic Systems Growing with Strong Collaboration Contributions

## MHD/Magnetics/Reconstruction

Magnetics for *equilibrium reconstruction*  
Halo current detectors  
High-n and high-frequency Mirnov arrays  
Locked-mode detectors  
RWM sensors (n = 1, 2, and 3)

## Profile Diagnostics

MPTS (42 ch, 60 Hz) (*re-aim*)  
T-CHERS:  $T_i(R)$ ,  $V_\phi(r)$ ,  $n_C(R)$ ,  $n_{Li}(R)$ , (51 ch)  
P-CHERS:  $V_\theta(r)$  (71 ch)  
*MSE-CIF (15 ch)*  
*MSE-LIF (10 ch in FY 11, up to 24 ch in FY 12)*  
*FIReTIP interferometer (6 ch) (UCI, TBD)*  
Midplane tangential bolometer array (16 ch)

## Turbulence/Modes Diagnostics

*Tangential microwave high-k scattering (upgrade)*  
*Beam Emission Spectroscopy (24 ch)*  
*Microwave reflectometers*  
*Ultra-soft x-ray arrays – multi-color*  
*Fast X-ray tangential camera (500kHz) (relocate)*

## Energetic Particle Diagnostics

Neutral particle analyzer (2D scanning) (*remove*)  
*Solid-State neutral particle analyzer (enhance)*  
Fast lost-ion probe (energy/pitch angle resolving)  
Neutron measurements  
*Fast Ion  $D_\alpha$  profile measurement (perp + tang)*

## Edge Divertor Physics

*Gas-puff Imaging (500kHz)*  
*Fixed Langmuir probes*  
High density Langmuir probe array  
Edge Rotation Diagnostics ( $T_i$ ,  $V_\phi$ ,  $V_{pol}$ )  
*1-D CCD  $H_\alpha$  cameras (divertor, midplane)*  
*2-D divertor fast visible camera*  
Divertor bolometer (20ch)  
*IR cameras (30Hz) (3)*  
*Fast IR camera (two color)*  
Tile temperature thermocouple array  
Dust detector  
Edge Deposition Monitors  
*Scrape-off layer reflectometer*  
*Edge neutral pressure gauges*  
*Plasma-Material Interactions Probe*  
*Divertor Imaging Spectrometer*  
*Lyman Alpha ( $Ly_\alpha$ ) Diode Array*

## Plasma Monitoring

Fast visible cameras  
Visible bremsstrahlung radiometer  
Visible and UV survey spectrometers  
*VUV transmission grating spectrometer*  
*Visible filterscopes (hydrogen & impurity lines)*  
*Wall coupon analysis*  
*X-ray crystal spectrometer (astrophysics)*  
*(Collaboration contributions) (Post upgrade changes)*

# ARRA Funding Greatly Enhanced Research Capability

## Significantly Increases NSTX Science Output

### Enhanced operation of Major Fusion Facilities in FY09 and FY10

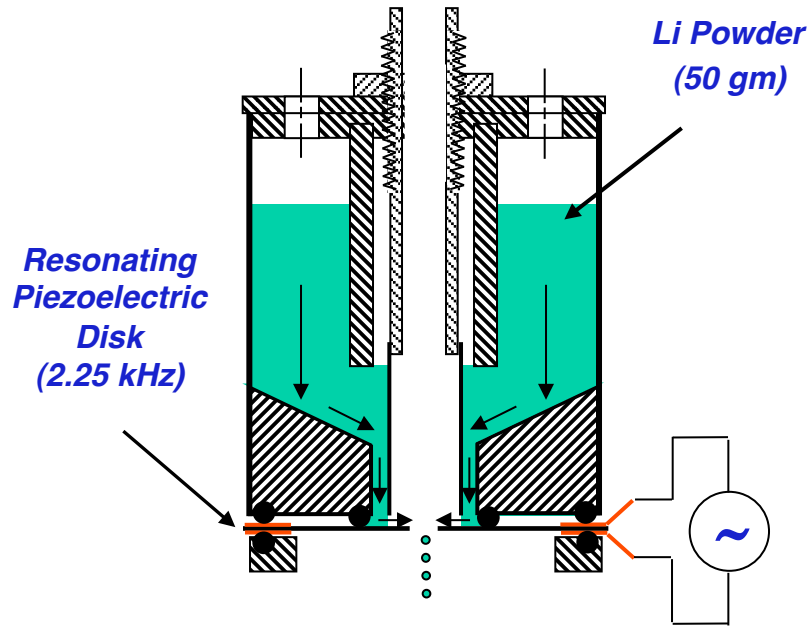
- 5 extra run weeks in FY 09 and one extra in FY 10 enabled the NSTX researchers to conduct high priority fusion plasma experiments.

### Diagnostics and Facility Upgrades in FY 09 - 11:

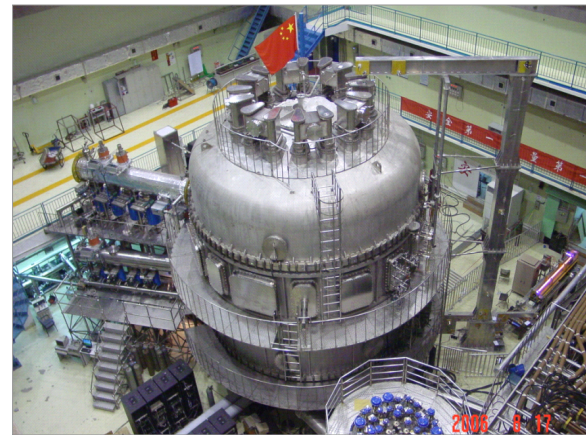
- Extra 12 channels for the multi-pulse Thomson scattering system for improved H-mode pedestal and plasma edge spatial resolution to support the FY 11 joint research milestone.
- Motional Stark Effect Laser Fluorescence advanced diagnostic system for internal magnetic and electric field measurements will be also installed which can also provide important data for the FY 11 joint research milestone.
- Enhancement to the lithium liquid divertor target capability for improved divertor pumping to control edge collisionality for the FY 11 joint research milestone. Two Lithium Evaporators, LLD diagnostics and in-board molybdenum tiles.
- Post Doctoral Fellows to support the enhanced research capabilities.
- 2nd switching power amplifier system for improved error field/resistive wall mode/resonant magnetic perturbation spectra to control the edge error field for the FY 11 joint research milestone.



# NSTX Lithium Dropper Helped To Achieve H-modes on EAST MHD Suppressed and Impurities Reduced by Active Li Powder Injection



Exp. Advanced Superconducting Tokamak



Missions: To achieve steady-state high-performance plasma and study related physics and technologies

*Li injection during long plasma operation in EAST*

