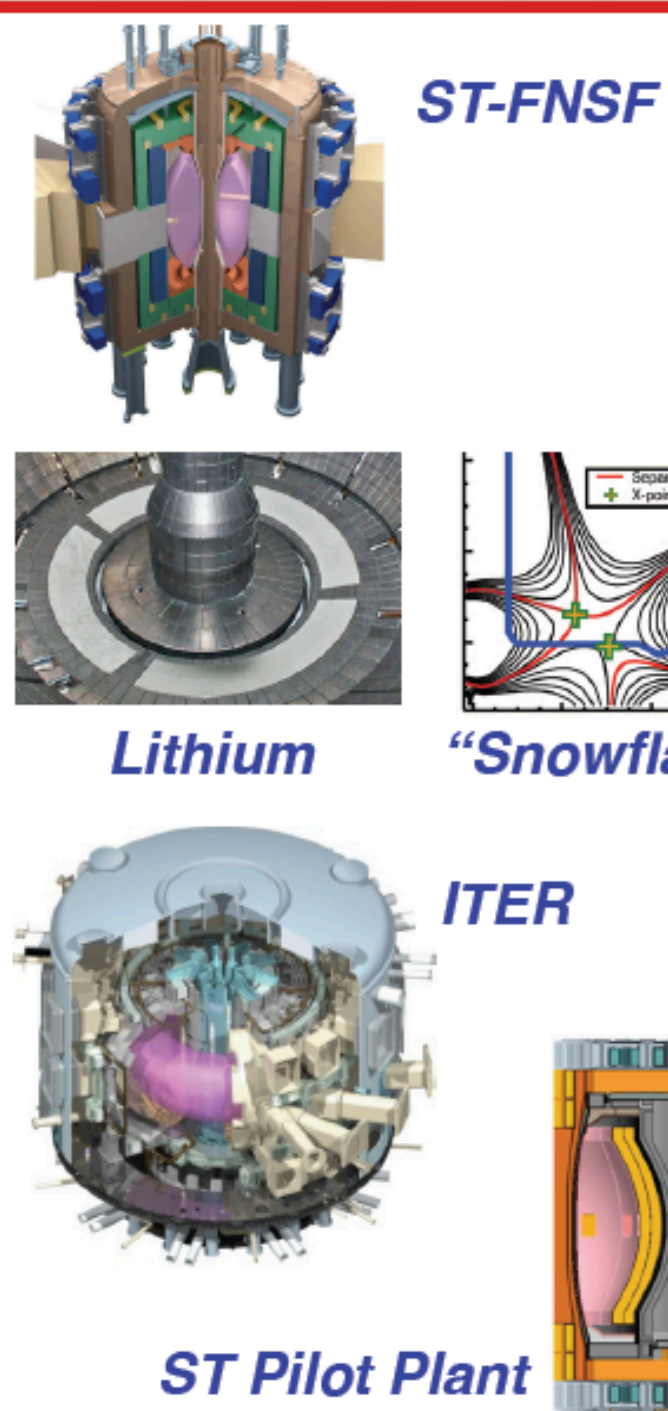
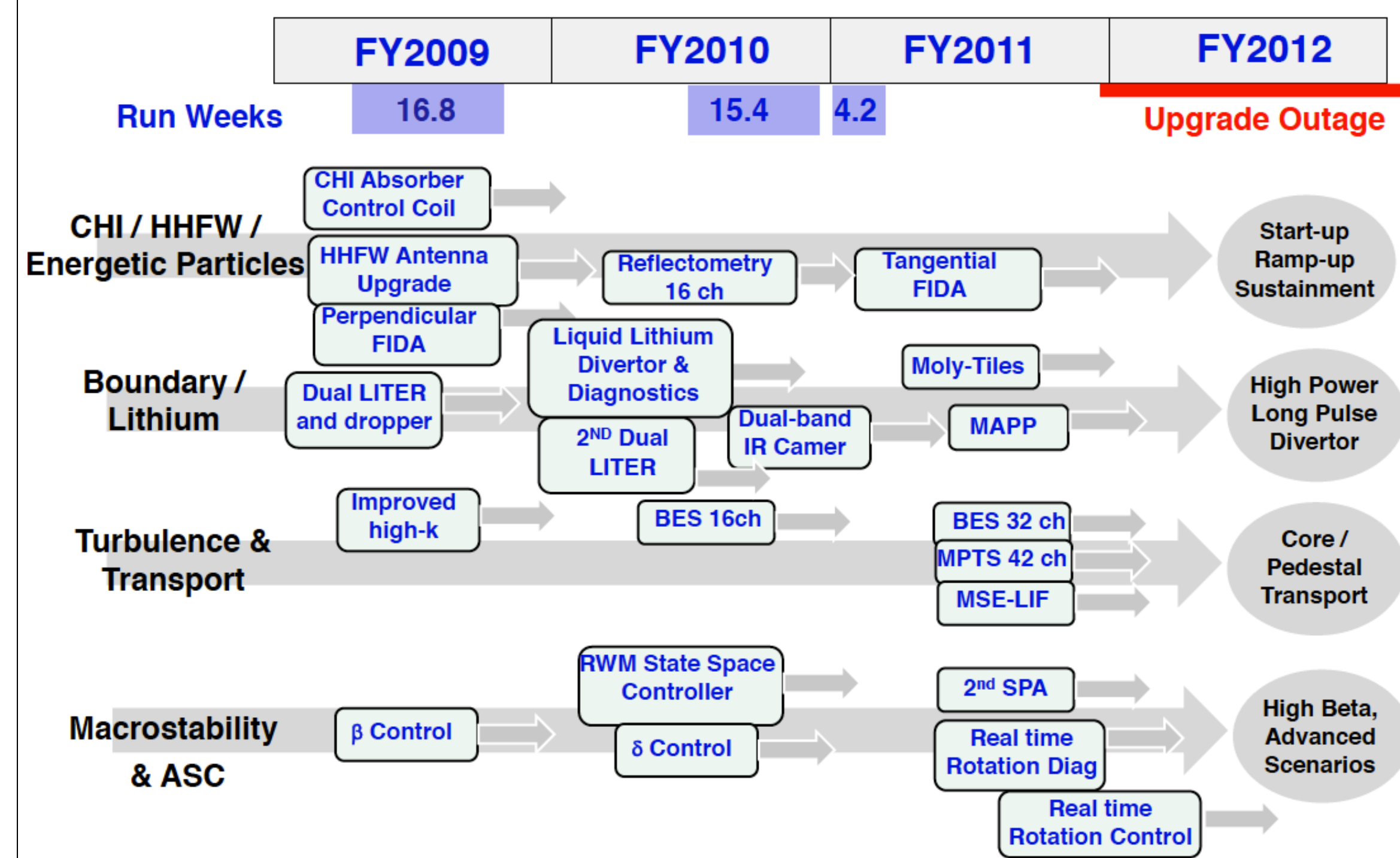


## NSTX Mission Elements

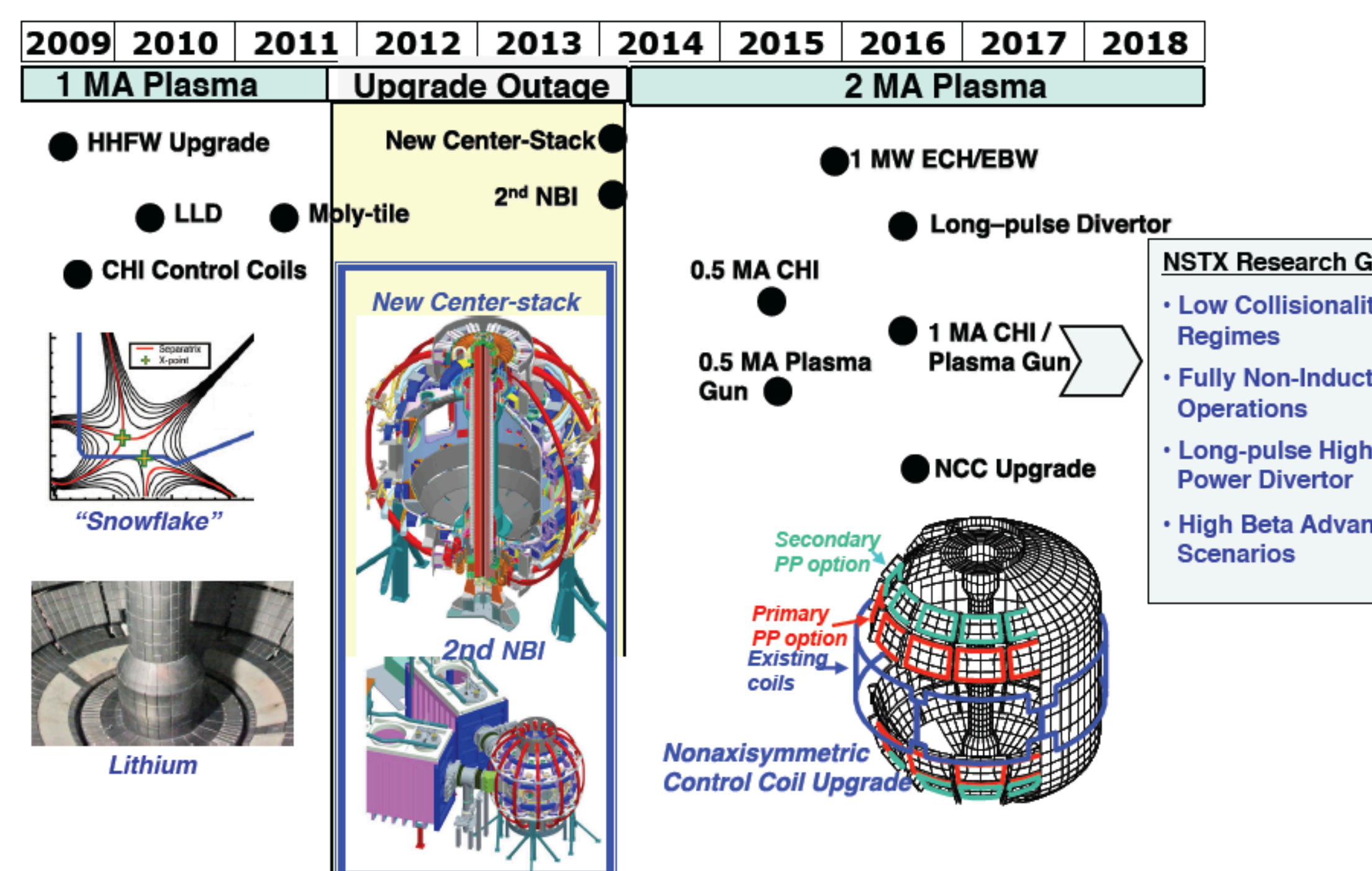
- Advance ST as candidate for Fusion Nuclear Science Facility (FNSF)
- Develop solutions for plasma-material interface
- Advance toroidal confinement physics for ITER and beyond
- Develop ST as fusion energy system



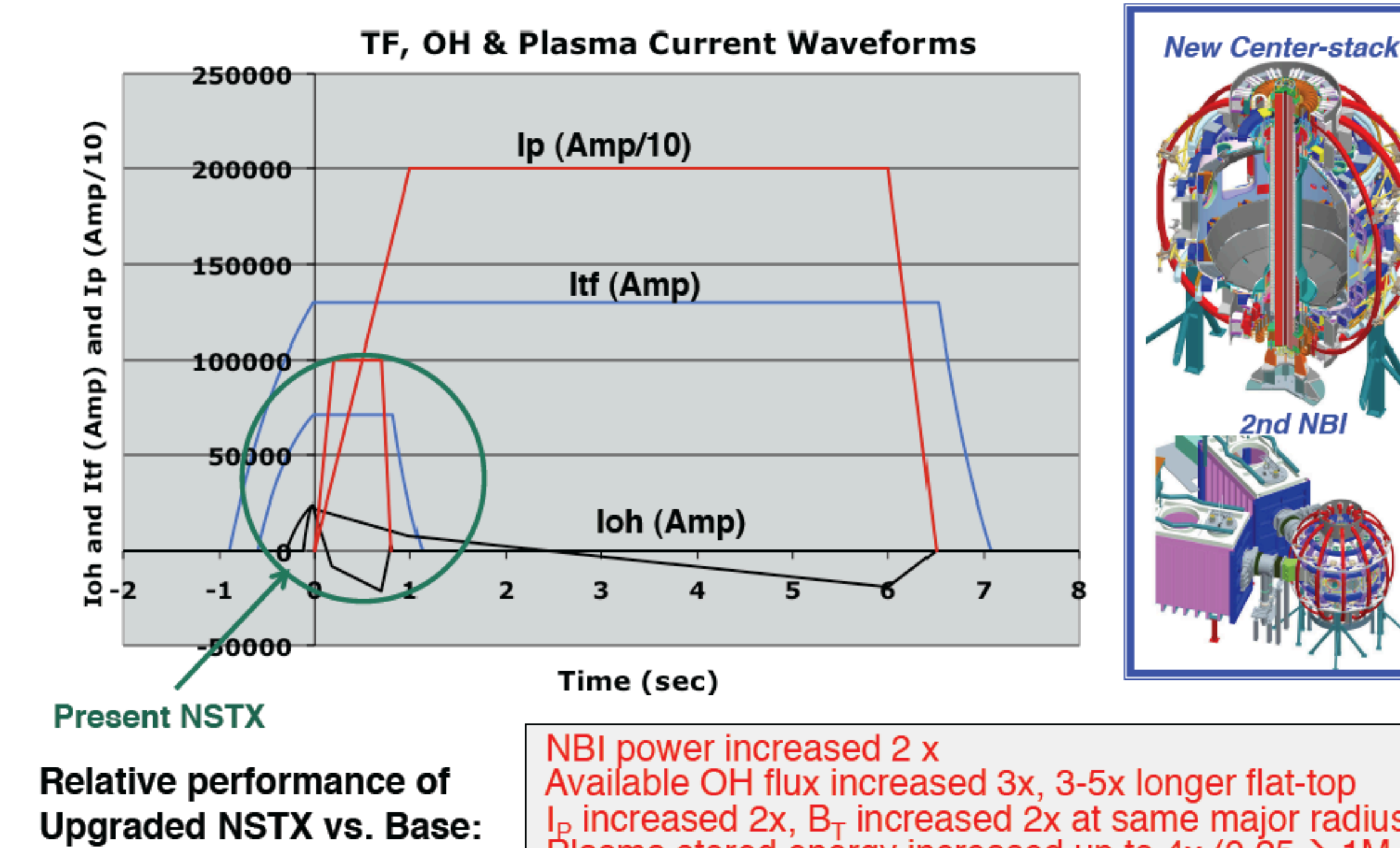
## NSTX Facility Overview To Support NSTX Mission Elements and Upgrades



## NSTX Upgrade Outage Started Due to TF Fault, Upgrade was Accelerated by ~6 Months



## Upgrade Substantial Increases $B_T$ , $I_p$ , $\tau_{pulse}$ , $P_{NBI}$ Higher $B_T$ and $I_p$ narrows gaps to Fusion Neutron Science Facility



## New Upgrades Implemented in 2011

### 2nd SPA Successfully Installed and Commissioned Sustain $\beta_N$ and Understand MHD Behavior Near Ideal Limit

2nd 3-channel Switching Power Amplifier (SPA) commissioned in July 2011 powers independent currents in six EFC/RWM coils for simultaneous control of  $n = 1, 2, 3$  field harmonics

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

### Molybdenum Tiles Installed for In-Board Divertor Liquid Lithium Covered Molybdenum Surfaces Reduced Carbon Influx

Molybdenum tiles manufactured and installed on inboard divertor in April 2011

- Supported by ARRA funding
- Replace 48 second row tiles with 1" thick molybdenum tiles
- Three tiles contain diagnostics
- Lithium coating with LITER ~ 2 x outer LLD rate
- Plasma heating can liquify lithium on surface

## NSTX TF Fault Occurred on July 20, 2011 TF Bundle Operated for 7+ years for 20,000 shots

- TF bundle short occurred ~ 2 feet from the bottom in a relatively low mechanical stress area.
- TF bundle dissection and analyses showed no sign of fatigue.
- Zinc chloride based flux used for cooling water tube soldering was the cause of insulation failure.

Dissection of shorted region

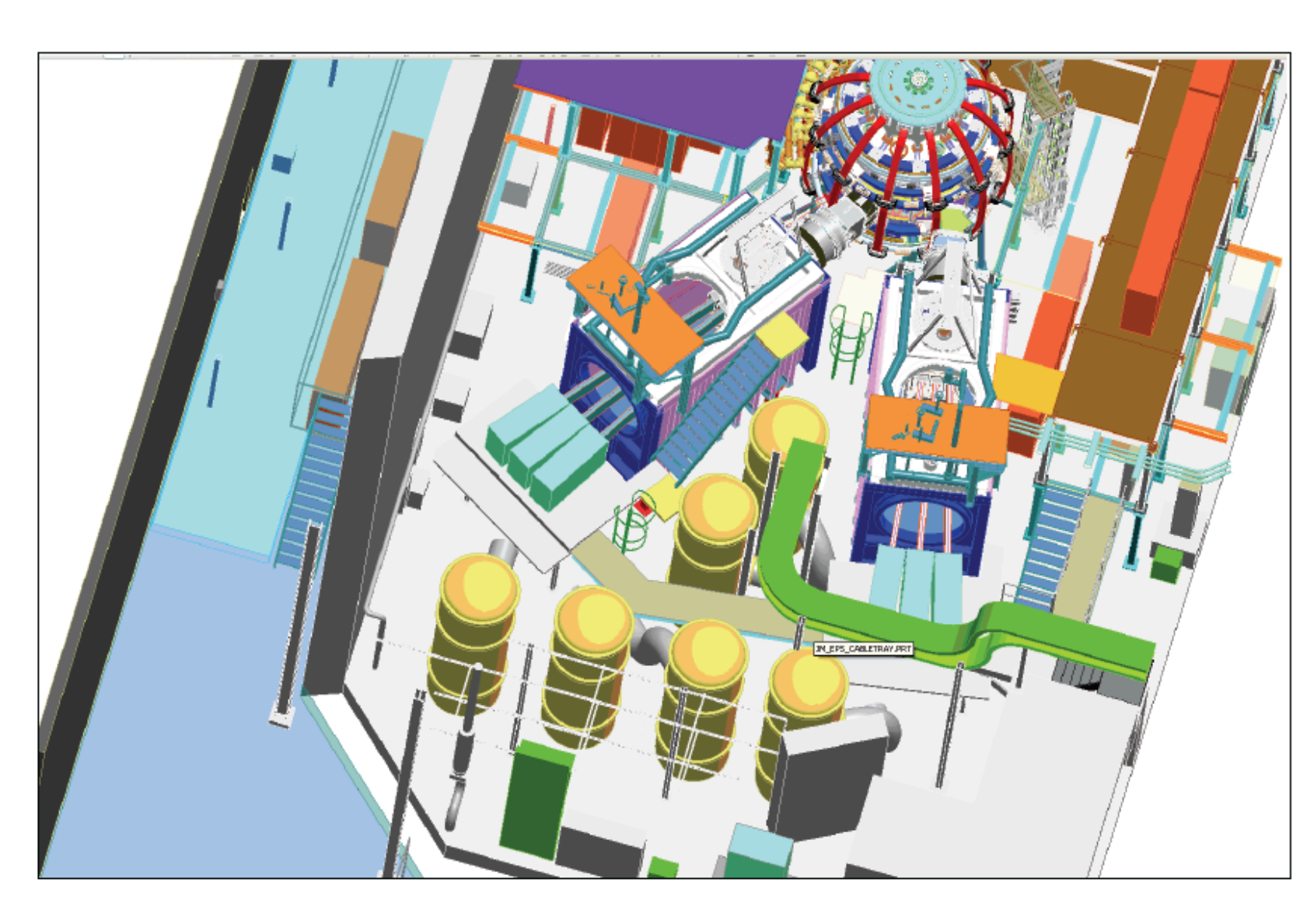
TF Upgrade to use "Rosin" flux and change the procedures for removing the flux residues

## Center Stack Upgrade and Related Enhancement: Detailed Design, Analyses, and R&D Are Now Well Advanced

Center Stack Upgrade and Related Enhancement: Detailed Design, Analyses, and R&D Are Now Well Advanced

- Since B and J increase x 2, the E&M forces increase x 4
- Upper TF/OH Ends
- Lower TF/OH Ends
- Inner TF Flex Bus Joint
- Inner TF Conductor Fabrication-1

## NSTX-U Test Cell General Arrangement Drawing



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

2nd NBI requires relocation of a TFTR NBI system to NSTX and relocation of NSTX diagnostics from Bay K to Bay L

- Decontamination of 2nd Beam line Successfully Completed in 2010
- Reassembly of the 2nd Beam line has started
- Bay L CHERS, MPTS, & others
- Bay K-J weldment installed for NBI BL2

## Real Time Velocity Diagnostics Developed Important Tool for Advanced Plasma Control

A Real-Time Velocity (RTV) diagnostic will be incorporated into the plasma control system for feedback control of the plasma rotation profile using the NBI and non-resonant magnetic braking as the actuators

- Based on active charge-exchange recombination spectroscopy (CHERS)
- Measures at six radial locations and a sampling rate of 5 kHz.
- Uses two toroidally separated views to distinguish the heating NB view from the background (intrinsic) contribution.
- Installed and commissioned on NSTX in July 2011

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

Additional 12 channels enhance resolution in pedestal to ~1 cm and improve diagnosis of ITB in plasma core

Polychromator assembly

- Twelve additional channels for the multi-pulse Thomson scattering (MPTS) system were installed and commissioned in July, 2011.
- Calibration was performed in situ by employing Rayleigh and Raman scattering of the light from the MPTS laser system by nitrogen and argon introduced into the vacuum vessel

## Engineering Analyses of TF Fault

- The NSTX Toroidal Field (TF) Bundle failed on July 20, 2011
- An autopsy of the failed bundle was performed and presented to EIR
- From these examinations we conclude:
  - The fault originated between Turns 14 & 30 and spread to 13.
  - The "autopsy" and photomicrographs indicated no physical damage to the insulation between turns. Insulation looks good!
  - Although there were voids at the cusps, no evidence of electrical "treeing" or breakdown was observed.
  - The hardness measurements showed no significant evidence of overstress or fatigue.
  - The reason for the initial low megger resistance in some bars was pinpointed in two locations.
  - The SEM and Auger analyses confirmed the presence of elements from the solder flux.
  - A literature search pointed to other instances of insulation failures due to similar fluxes.
- Based on these findings, we conclude that flux contamination of the insulation led to the fault. The EIR committee agreed.
- The majority of the EIR recommendations are being addressed by a solder consultant

## Analysis showed accelerating upgrade maximizes run time and scientific productivity over next 5 years (2011-15)

Option:	Pre-Upgrade Ops	Post-Upgrade Ops	Total Ops
Base plan	8 months	12 months	20 months
Rebuild TF	7 months	2 months	9 months
Upgrade	0	19 months	19 months

	FY2011	FY2012	FY2013	FY2014	FY2015
Base	OPS	Outage (30 mos.)	OPS	OPS	OPS
Rebuild	TF Rebuild	OPS	Outage (30 mos.)	Outage (30 mos.)	OPS
Upgrade	Outage (30 mos.)	Outage (30 mos.)	Outage (30 mos.)	Outage (30 mos.)	OPS

Collaborations, data analysis / publications, next-step ST study

## Centerstack R&D - TF Flex Connector

Centerstack R&D - TF Flex Connector

- Successfully tested to 300,000 full stroke cycles
- Design Requirement = 60,000 cycles
- Setup for OH Coil Winding
- Roll it into NTC, Fly it over, Fit it back together, Align it, Burn it all up, Pump down...

## OH/TF Manufacturing Area (Ref: NSTX-PLAN-MFG-1300-00)

OH/TF Manufacturing Area (Ref: NSTX-PLAN-MFG-1300-00)

- The Inner TF/OH fabrication will occur at PPPL in the CS High Bay area (Former NCSX Test Cell)
- Crane capacity (45 T), environmental control and adequate work space

## MSE-LIF Installed for Enhanced Pedestal / Profile Diagnostics Installed and Commissioned on NSTX in August 2011

The Motional Stark Effect measurement based on Laser Induced Fluorescence (MSE-LIF) diagnostic will provide measurements of the field line pitch angle profile without requiring injection of the heating neutral beam.

MSE-LIF provides unique capabilities

- Measure RF-driven current without the heating neutral beam.
- Measure total magnetic field in plasma to reconstruct total plasma pressure.
- Together with MSE-CIF, yield radial electric field profile

## t-FIDA upgrade was implemented in 2011 Energetic Particle Capability for $\alpha$ -Physics and NBI CD

Fast Ion D-Alpha Diagnostic Providing Crucial Energetic Particle Data

Tangential FIDA Views

- A new tangential Fast-Ion Deuterium-Alpha (t-FIDA) diagnostic, with a view mostly tangential to the B field, has been built, installed and commissioned in FY 2011
- Complements the vertical FIDA, as it measured fast ions parallel to B, particularly valuable for non-inductive current drive research in the NSTX Upgrade.
- The observation geometry with both active and background views has been aligned to an accuracy < 5 mm at the measurement location.

## NSTX-U NBI - Refurbish Ion Sources

NSTX-U NBI - Refurbish Ion Sources

- Because BL1 did not support full 2011-2012 operations, BL1 sources are still viable and have been stored in place.
- Therefore, our three spares may be used for upgrade.
- Savings to project of approximately \$900k.

## BL Refurbishment: Ion Dump and Calorimeter - in progress

BL Refurbishment: Ion Dump and Calorimeter - in progress

- Ion Dump Replacement
- Calorimeter Upgrade