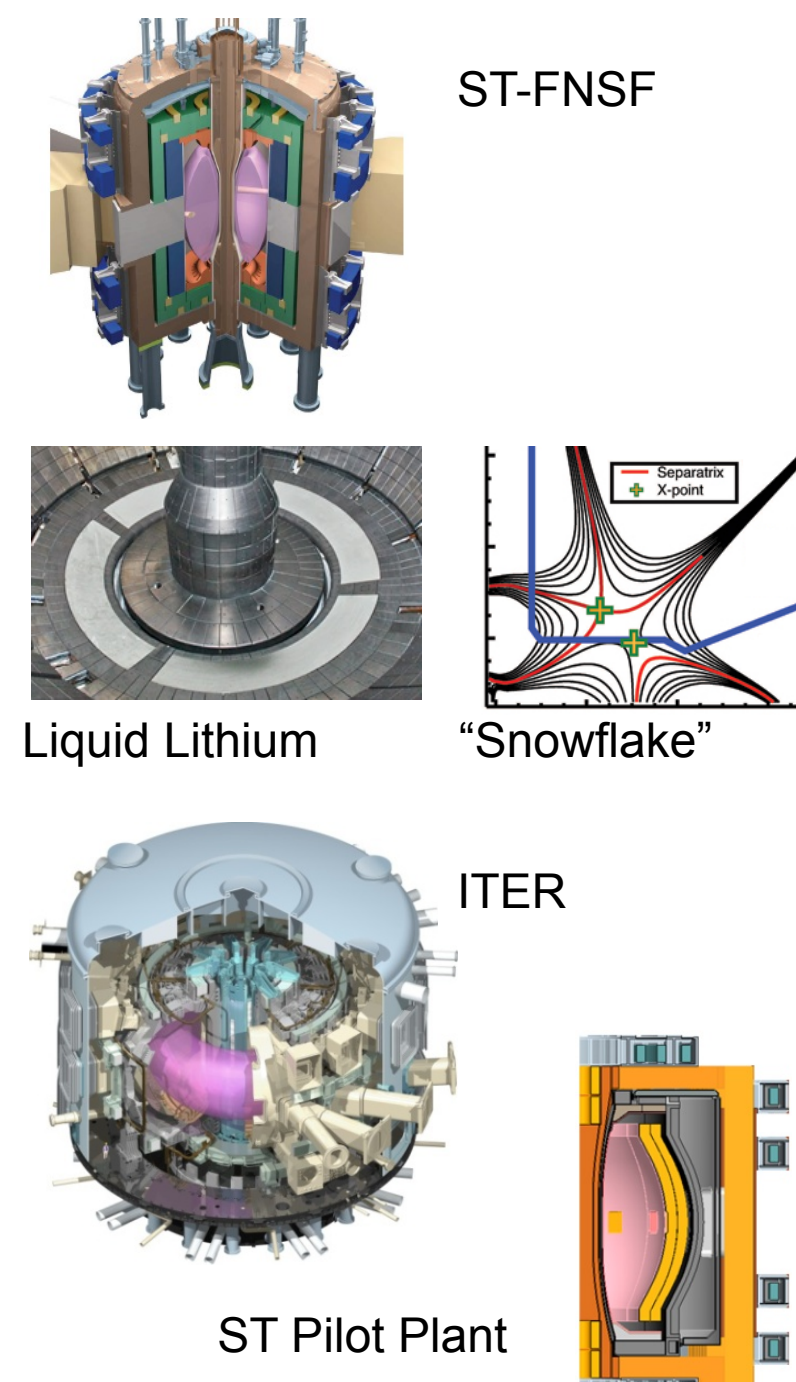
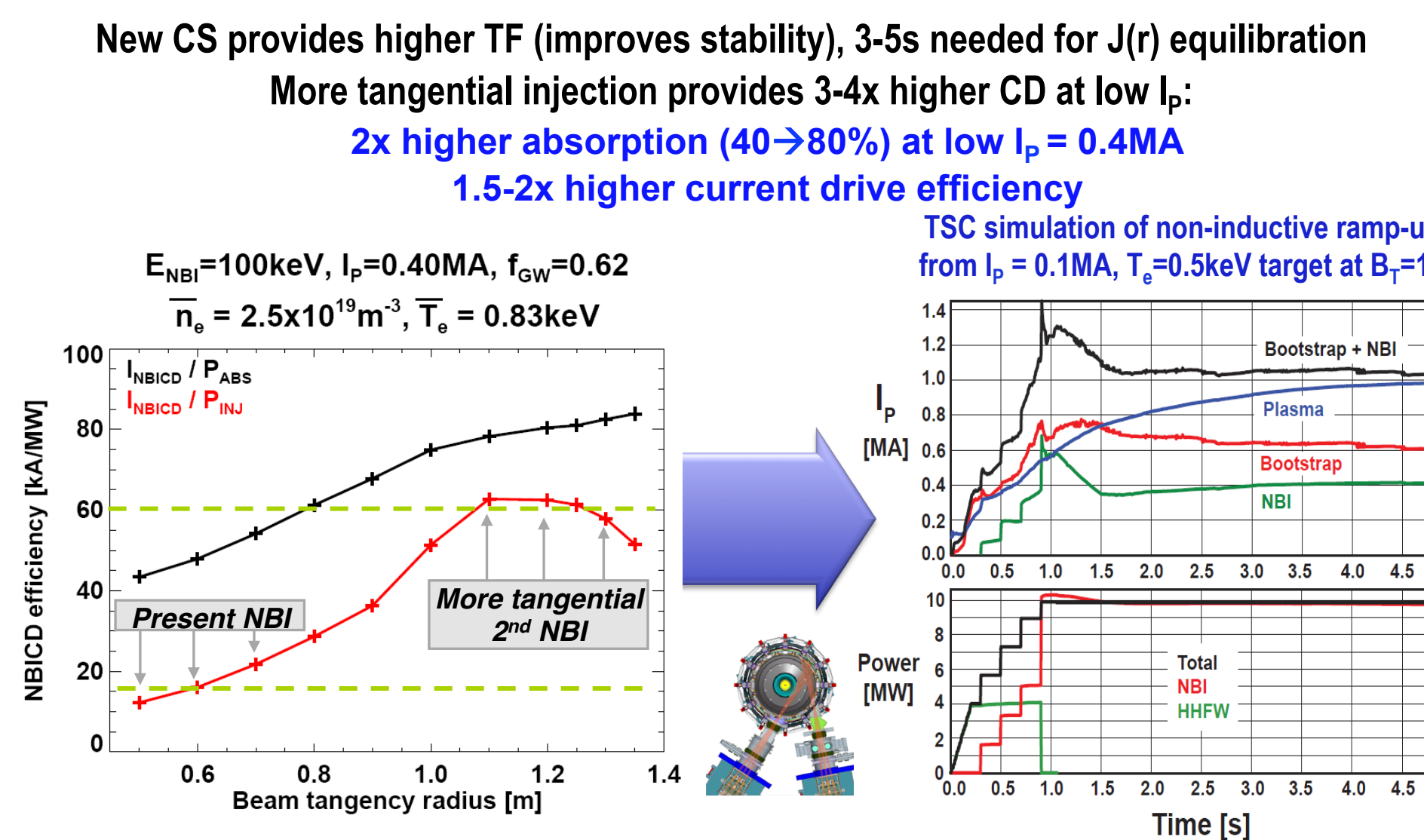


NSTX Upgrade Mission Elements

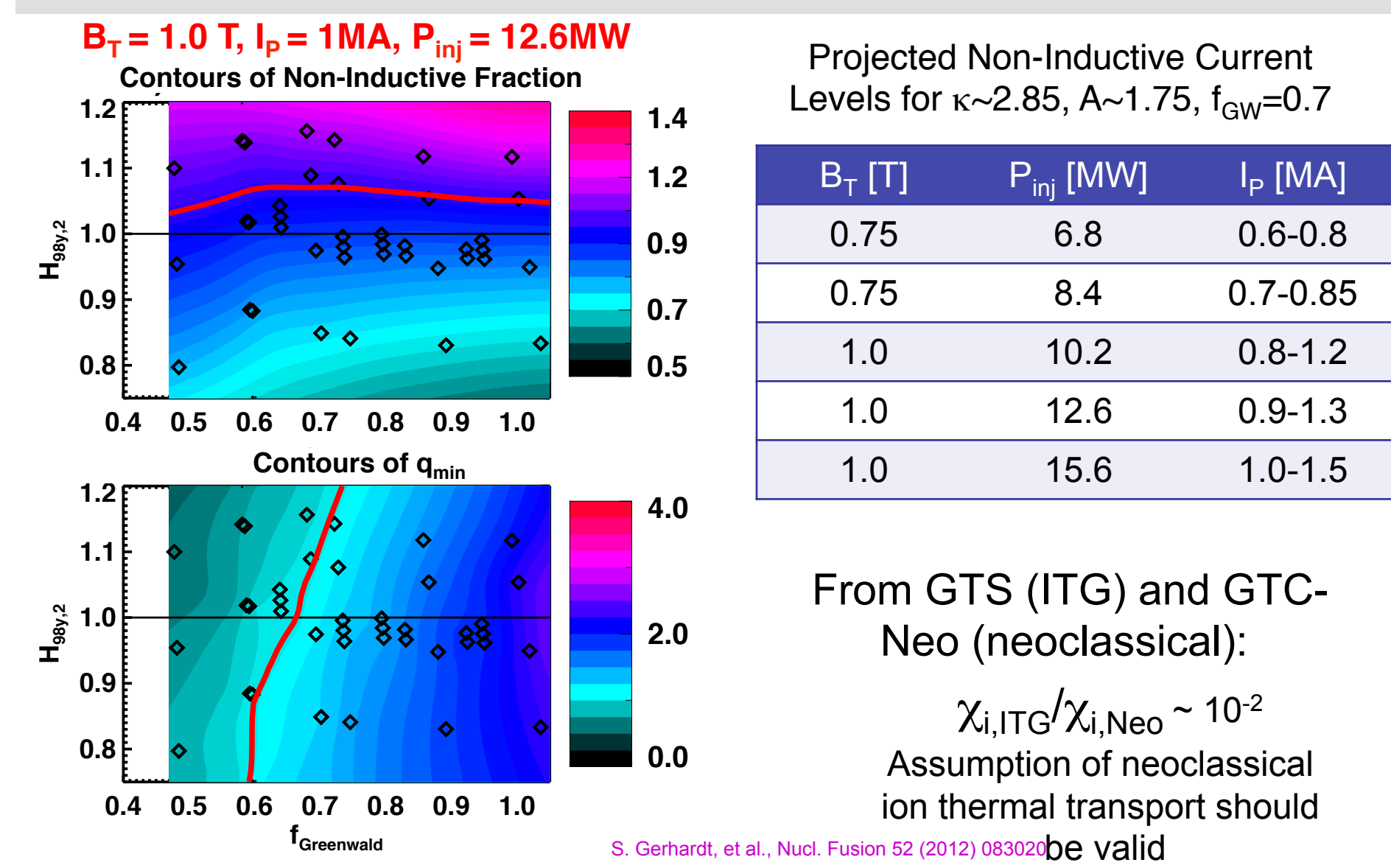
- Advance ST as candidate for Fusion Nuclear Science Facility (FNSF)
- Develop solutions for the plasma-material interface challenge
- Explore unique ST parameter regimes to advance predictive capability - for ITER and beyond
- Develop ST as fusion energy system



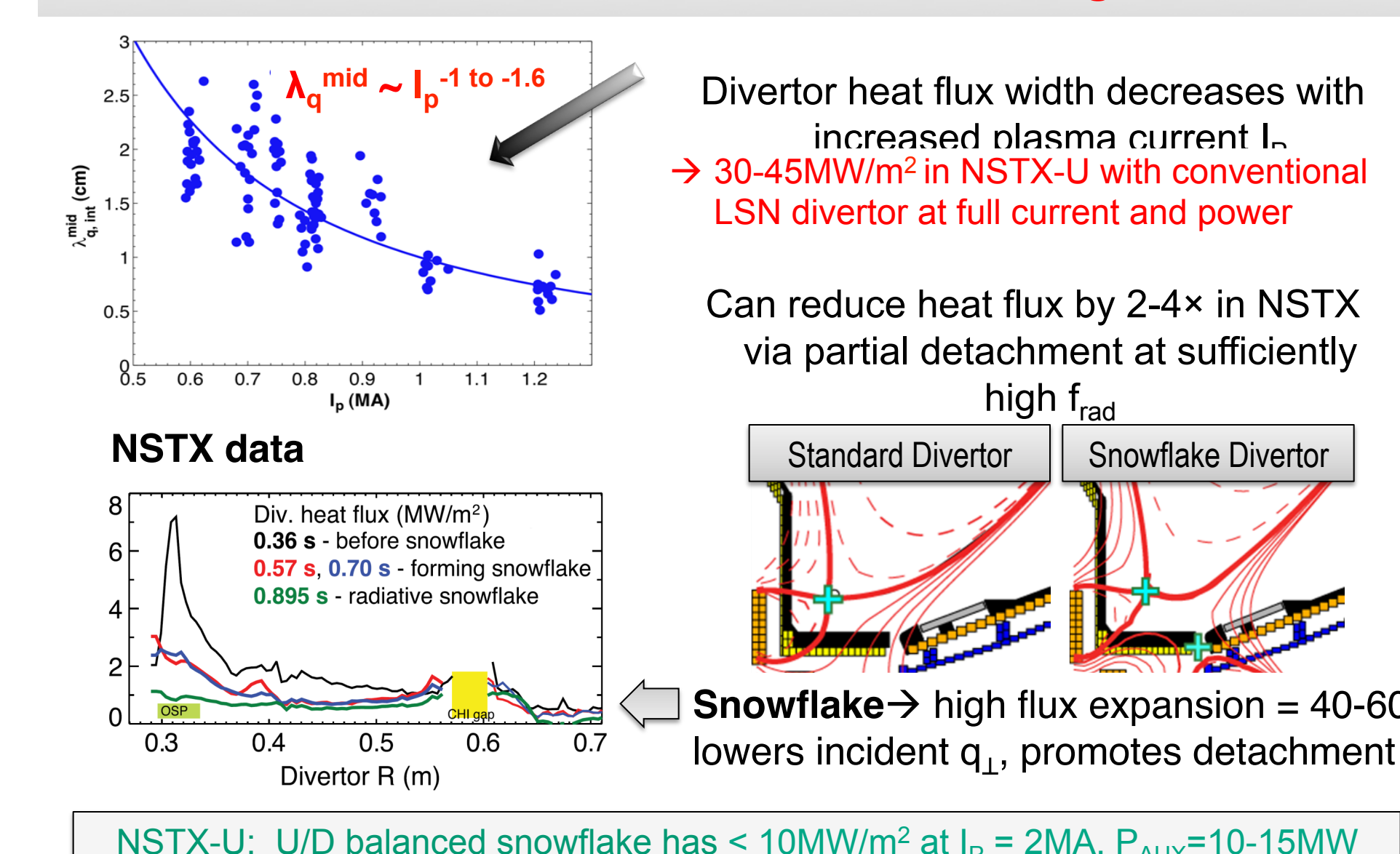
Non-inductive ramp-up from ~0.4MA to ~1MA projected to be possible with new centerstack (CS) + more tangential 2nd NBI



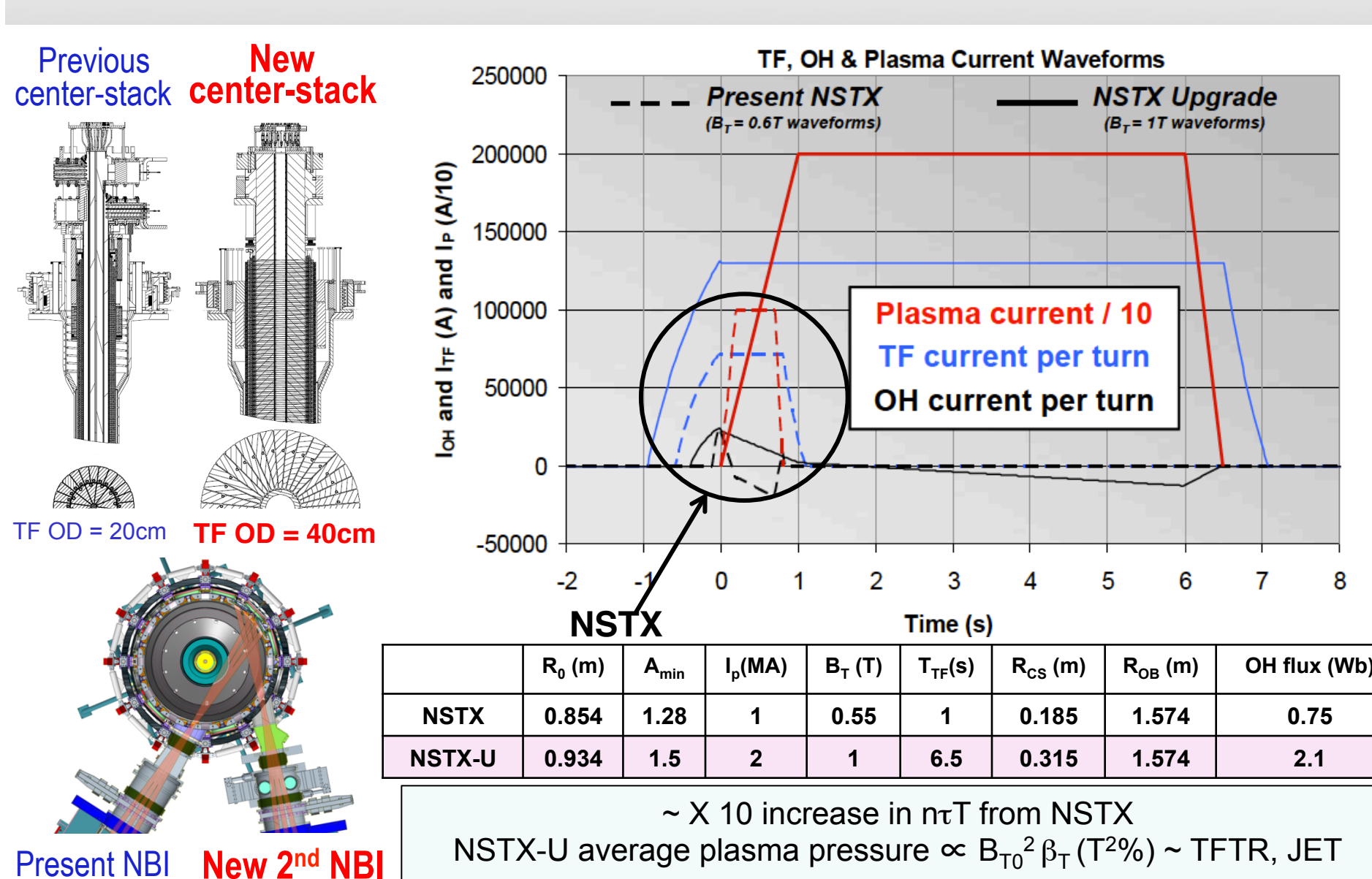
100% non-inductive operating points projected for a range of toroidal fields, densities, and confinement levels



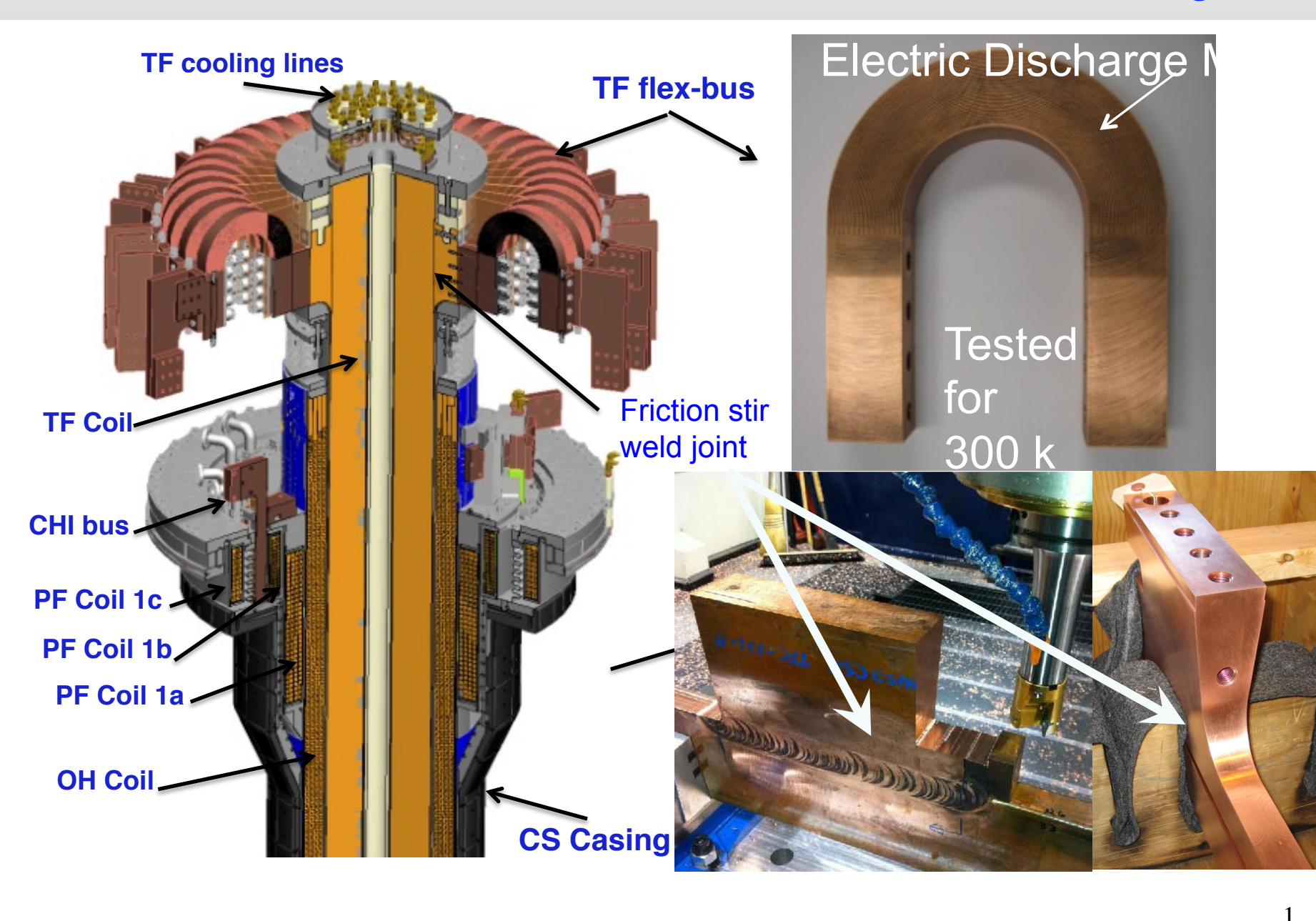
NSTX-U will investigate detachment and high-flux-expansion "snowflake" divertor for heat flux mitigation



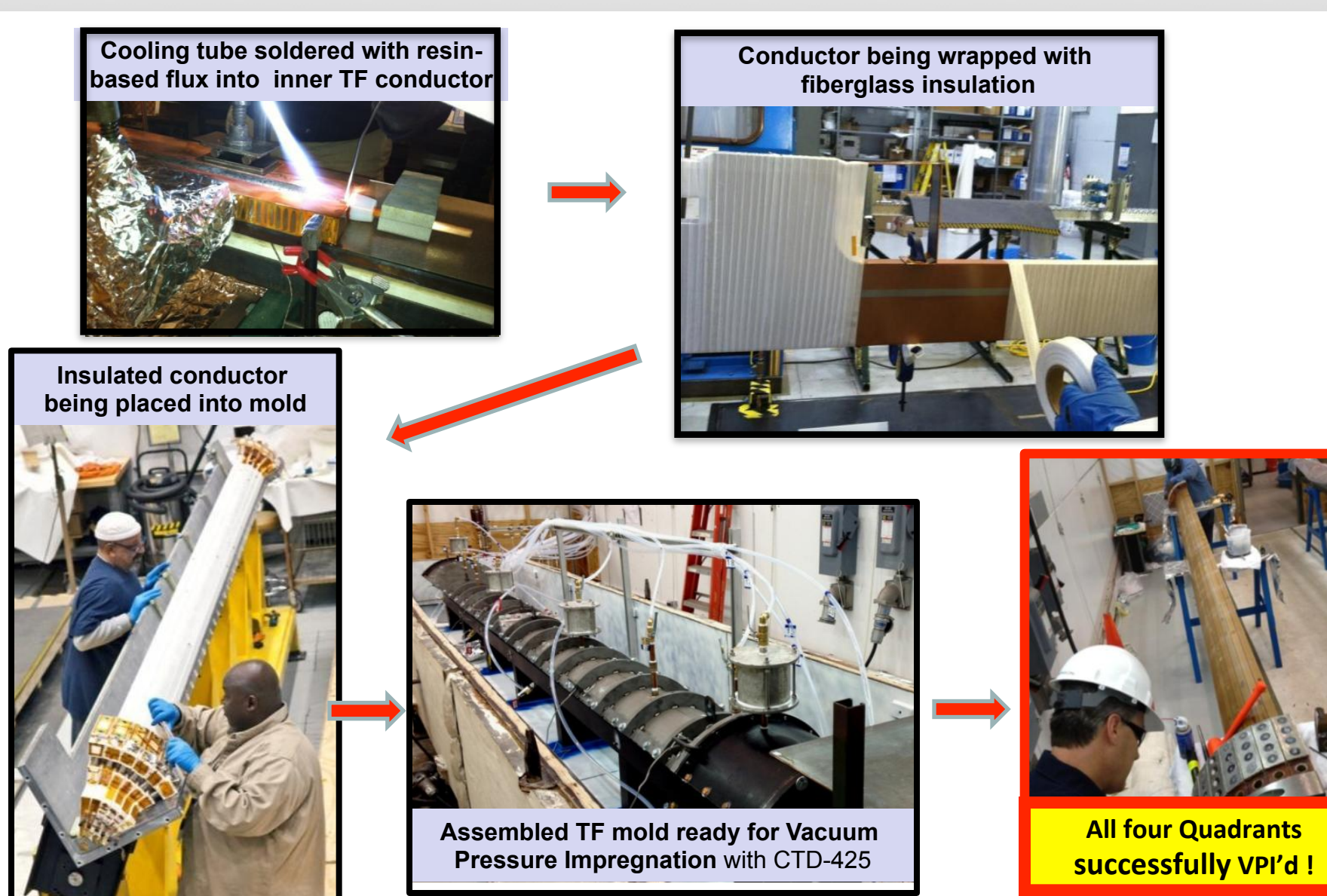
Substantial Increase in NSTX-U Device / Plasma Performance To provide data base to support ST-FNSF designs and ITER operations



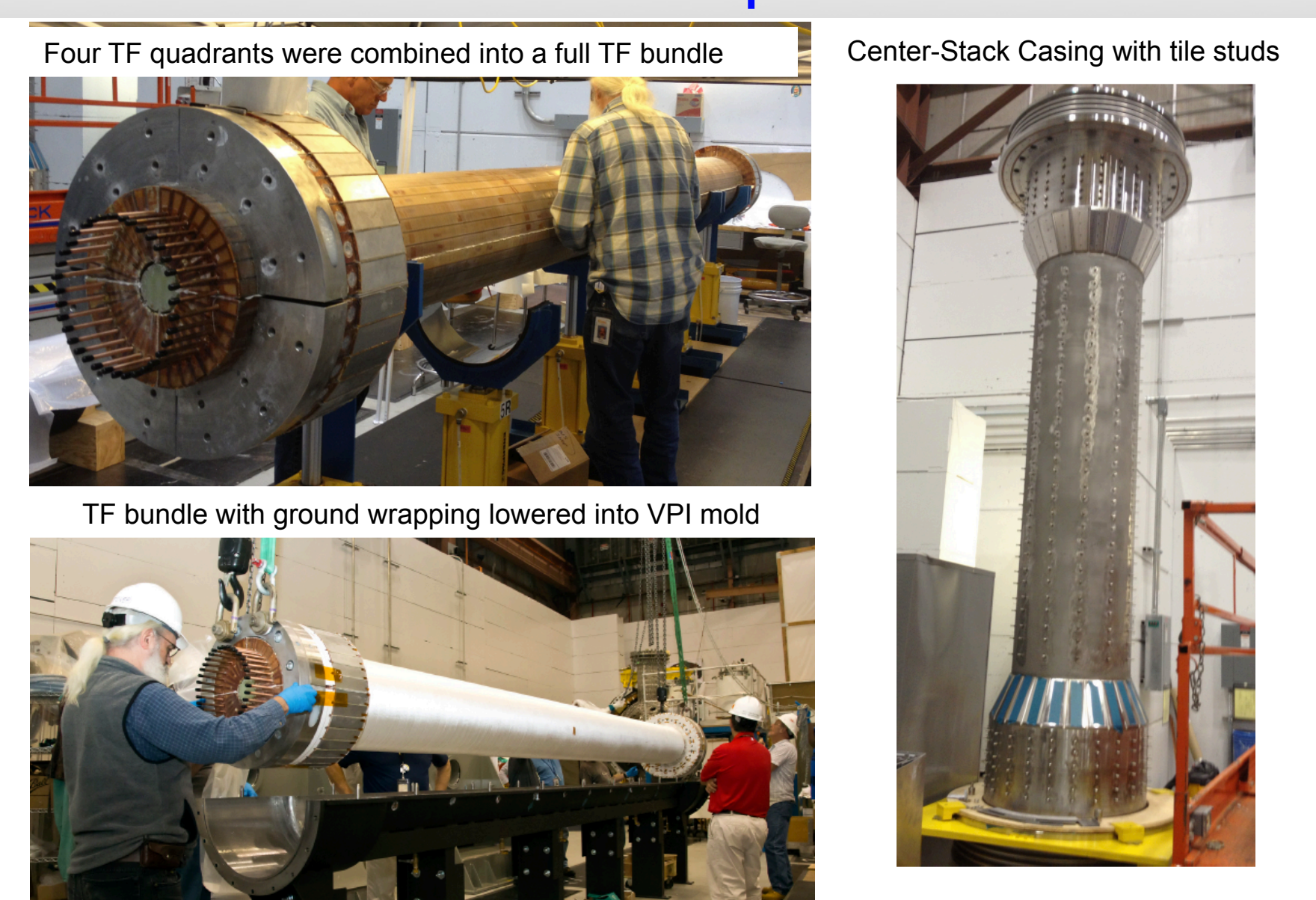
Improved Center-Stack Design to Handle Increased Forces Identical 36 TF Bars and Innovative Flex-Bus Design



Center Stack Fabrication & Assembly Proceeding Well Innovative manufacturing techniques developed



Center Stack Is Coming Together TF Bundle is completed



NSTX Upgrade Project Progress Overview

R. Strykowski, E. Perry, T. Stevenson, L. Dudek, S. Langish, T. Egebo, M. Williams and the NSTXU Project Team

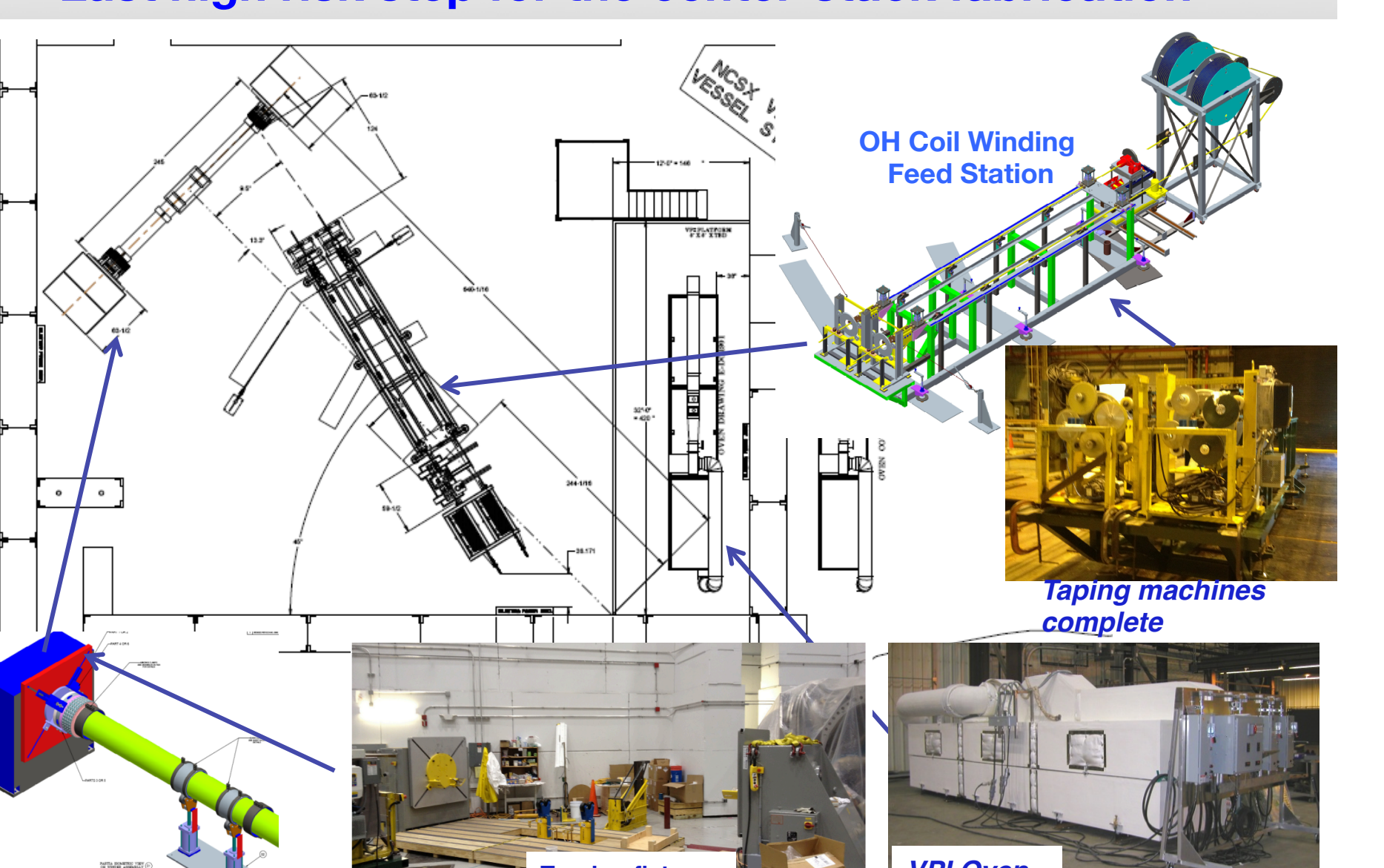
- New Center Stack Project Scope
- Inner TF bundle
 - TF Flex bus
 - OH coil
 - Inner PF coils
- Center stack
- Enhance outer TF supports
 - Enhance PF supports
 - Reinforce umbrella structure
 - New umbrella lids
- Structure
- Power systems
 - I&C, Services, Coil protection
- Ancillary Sys
- 2nd NBI Project Scope
- Decontaminate TFTR beamline
 - Refurbish for reuse
 - Relocate pump duct, 22 racks and numerous diagnostics to make room in the NSTX Test Cell
 - Install new port on vacuum vessel to accommodate NB2
 - Move NB2 to the NSTX Test Cell
 - Install power, water, cryo and controls



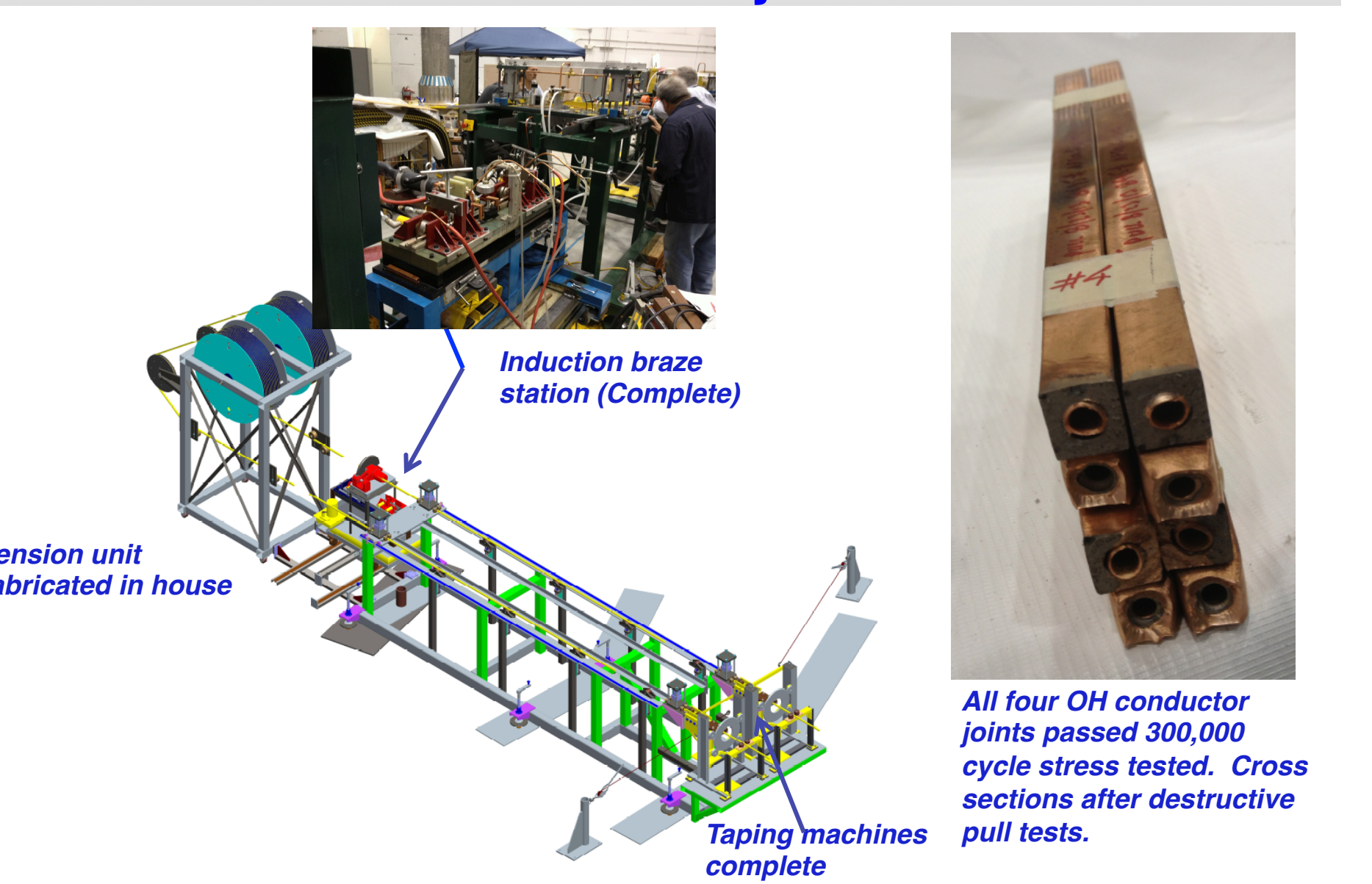
Aquapour for the TF-OH Gap Maintenance 1 mm gap is maintained utilizing water soluble aquapour



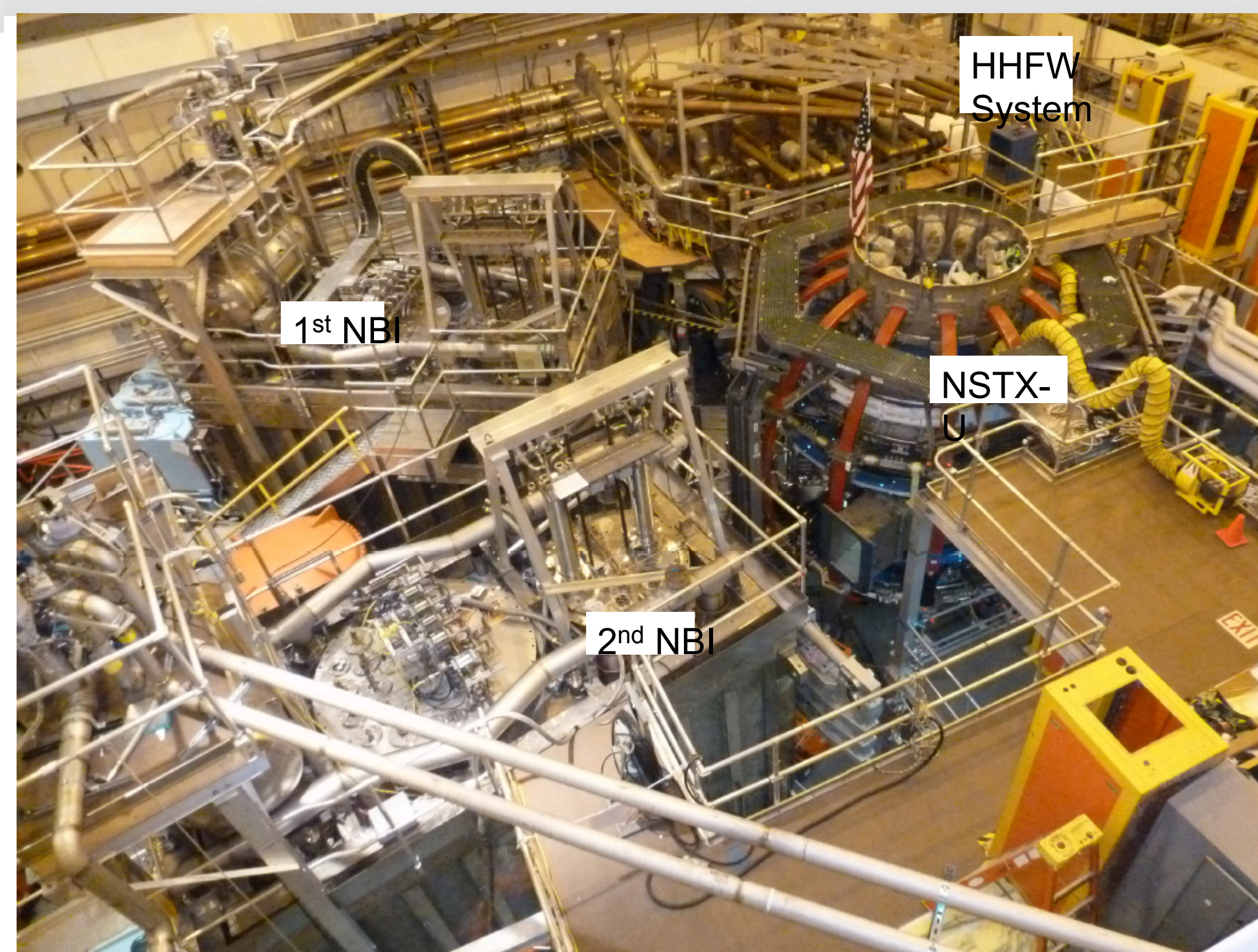
NSTX-U OH Coil Winding Station Last high risk step for the center-stack fabrication



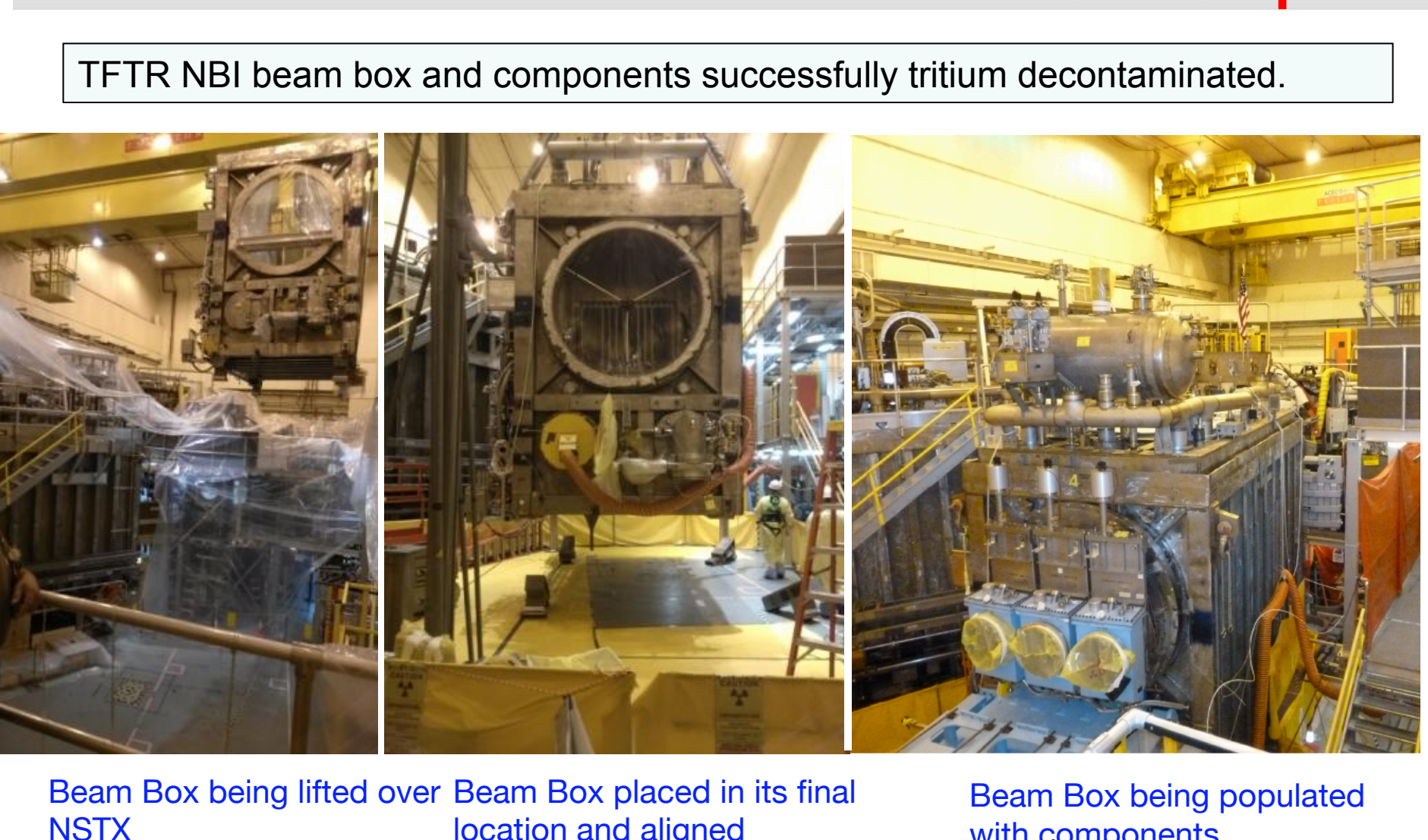
OH Conductor Induction Braze R&D Completed 2 x 3 x 4 = 24 induction braze joints must be made



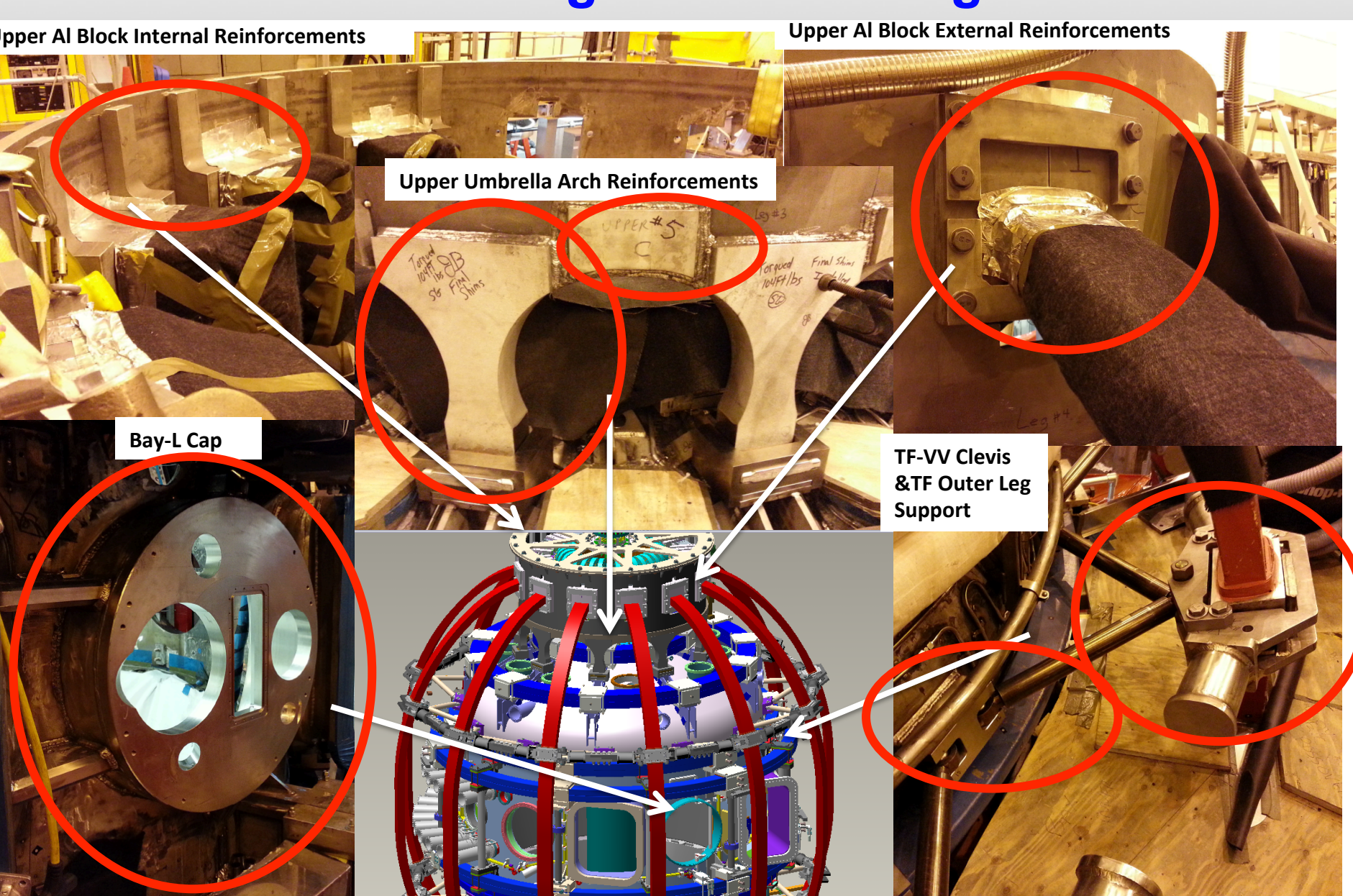
Aerial View of the NSTX-U Test Cell (Nov. 2013)



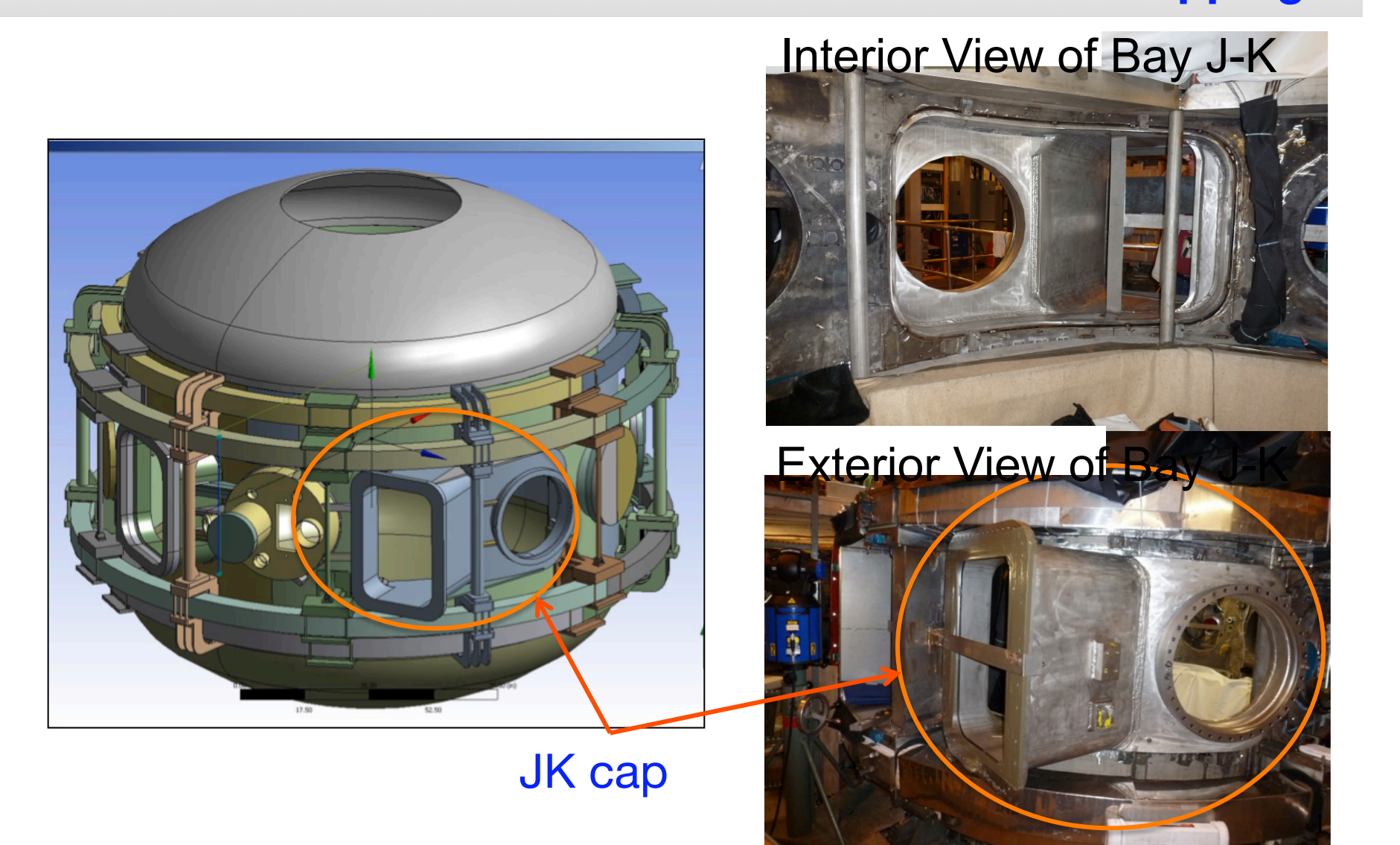
Relocation of the 2nd NBI beam line box from the TFTR test cell into the NSTX-U Test Cell Complete.



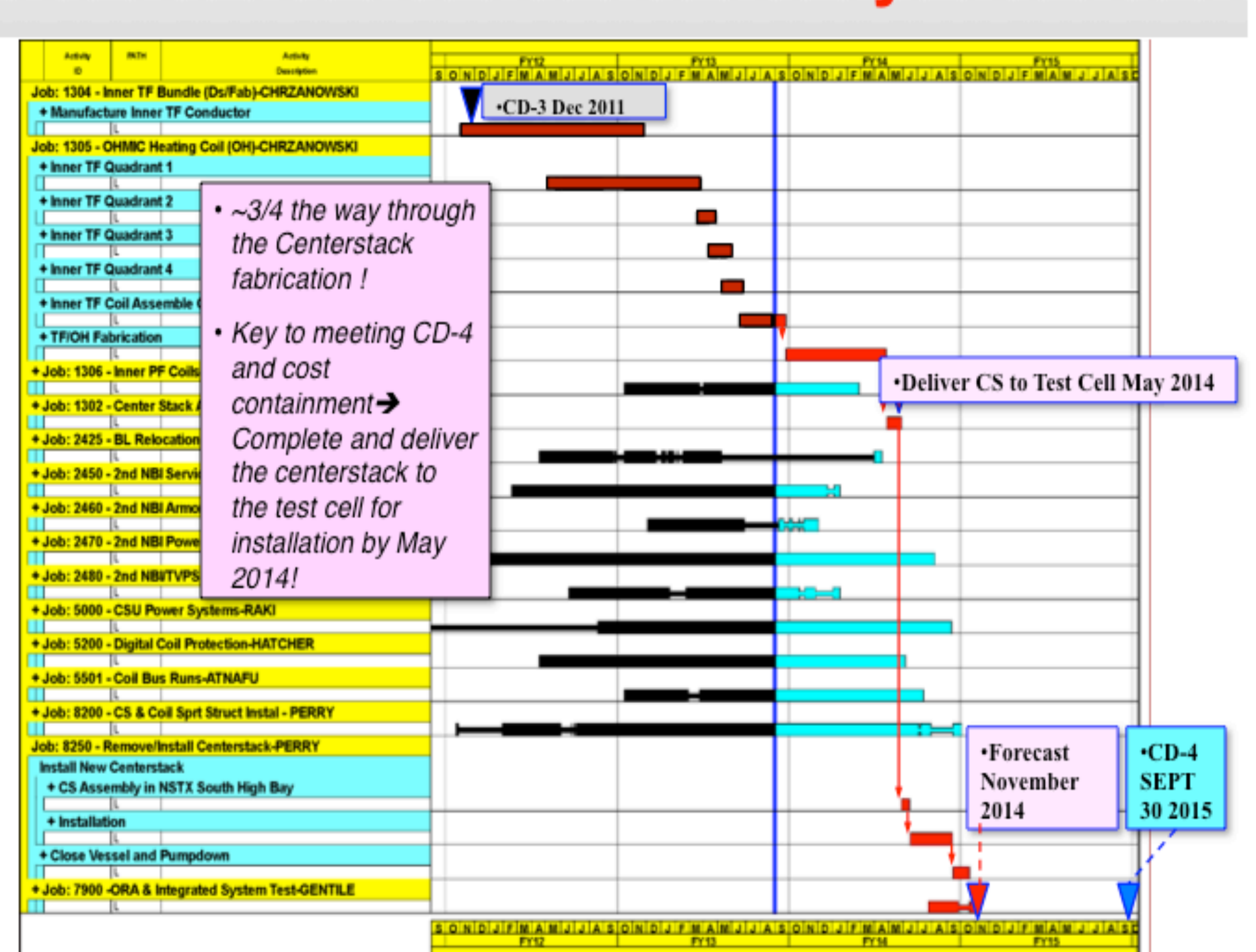
Support Structural and Vacuum Vessel Upgrades Must handle 4 x higher electromagnetic loads



Highly Tangential 2nd NBI Enabled by JK-Cap Outer Wall Radius Moved Outward to Avoid Beam Clipping



Schedule on track for early finish



NSTX-U diagnostics to be installed during first 2 years Half of NSTX-U Diagnostics Are Led by Collaborators

MHD/Magnetics/Reconstruction Magnetics for equilibrium reconstruction Halo current detectors High-n and high-frequency Mirnov arrays Locked-mode detectors RWM sensors Profile Diagnostics MPTS (42 ch, 60 Hz) T-CHERS: T ₁ (R), V ₁ (R), n ₁ (R), n ₂ (R), (51 ch) P-CHERS: V ₁ (R) (71 ch) MSE-CH (18 ch) MSE-LIF (20 ch) ME-SXR (40 ch) Midplane tangential bolometer array (16 ch) Turbulence/Modes Diagnostics Poloidal FIR high-k scattering Beam Emission Spectroscopy (48 ch) Microwave Reflectometer Microwave Polarimeter Ultra-soft x-ray arrays - multi-color Energetic Particle Diagnostics Fast ion D ₂ profile measurement (perp + tang) Solid-State neutral particle analyzer Fast lost-ion probe (energy/pitch angle resolving) Neutron measurements New capability, Enhanced capability	Edge Divertor Physics Gas-puff imaging (500kHz) Langmuir probe array Edge Rotation Diagnostics (T ₁ , V ₁ , V ₂) 1-D CCD H ₂ cameras (divertor, midplane) 2-D divertor fast visible camera Metal foil divertor bolometer AXUV-based Divertor Bolometer IR cameras (30Hz) (3) Fast IR camera (two color) Tile temperature thermocouple array Divertor fast eroding thermocouple Dust detector Edge Deposition Monitors Scrape-off layer reflectometer Edge neutral pressure gauges Material Analysis and Particle Probe Divertor VUV Spectrometer Plasma Monitoring FIR interferometer Fast visible cameras Visible bremsstrahlung radiometer Visible and UV survey spectrometers VUV transmission grating spectrometer Visible filterscopes (hydrogen & impurity lines) Wall coupon analysis
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Formulating Strategy Toward Full NSTX-U Parameters After CD-4, the plasma operation could enter quickly into new regimes

	NSTX (Max.)	Year 1 NSTX-U Operations (2015)	Year 2 NSTX-U Operations (2016)	Year 3 NSTX-U Operations (2017)	Ultimate Goal
I_p [MA]	1.2	~1.6	2.0	2.0	2.0
B_T [T]	0.55	~0.8	1.0	1.0	1.0
Allowed TF I ² [MA ² s]	7.3	80	120	160	160
I_p Flat-Top at max. allowed I ² , and B_T [s]	~0.4	~3.5	~3	5	5

- 1st year goal: operating points with forces up to 1/2 the way between NSTX and NSTX-U, 1/2 the design-point heating of any coil
Will permit up to ~5 second operation at $B_T=0.65$
- 2nd year goal: Full field and current, but still limiting the coil heating
Will revisit year 2 parameters once year 1 data has been accumulated
- 3rd year goal: Full capability

Facility and Diagnostic Enhancements to support the exciting 5 year research plan

