NSTX CSU
Upgrade Overview

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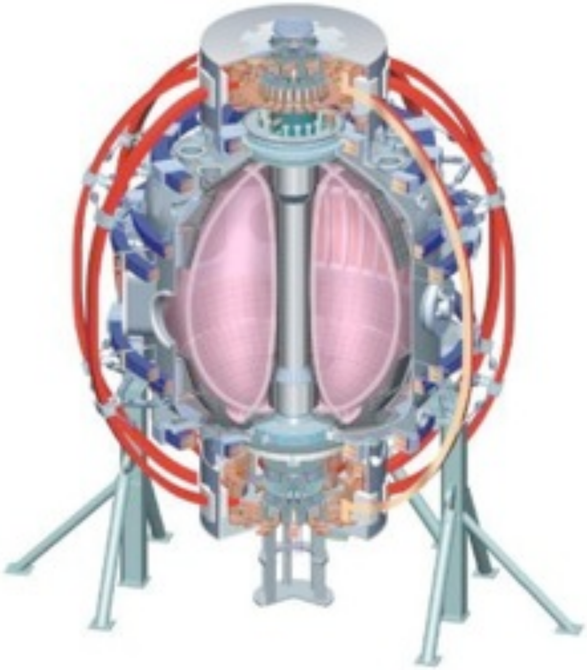
NSTX Upgrade Project
Conceptual Design Review
LSB, B318
October 28-29, 2009



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Outline

- Introduction
- Scope
  - – Central Core Mods
  - – Structural Improvements
  - – Electrical System Upgrades & Auxiliary Systems
- Peer Review Results
- Major Milestones
- Cost Estimates
- Risk
- Summary

Introduction

- Purpose
  - To expand the NSTX operational space and thereby the physics basis for the next-step ST facilities
  - To achieve higher levels of performance and pulse duration
- Requirements Summary

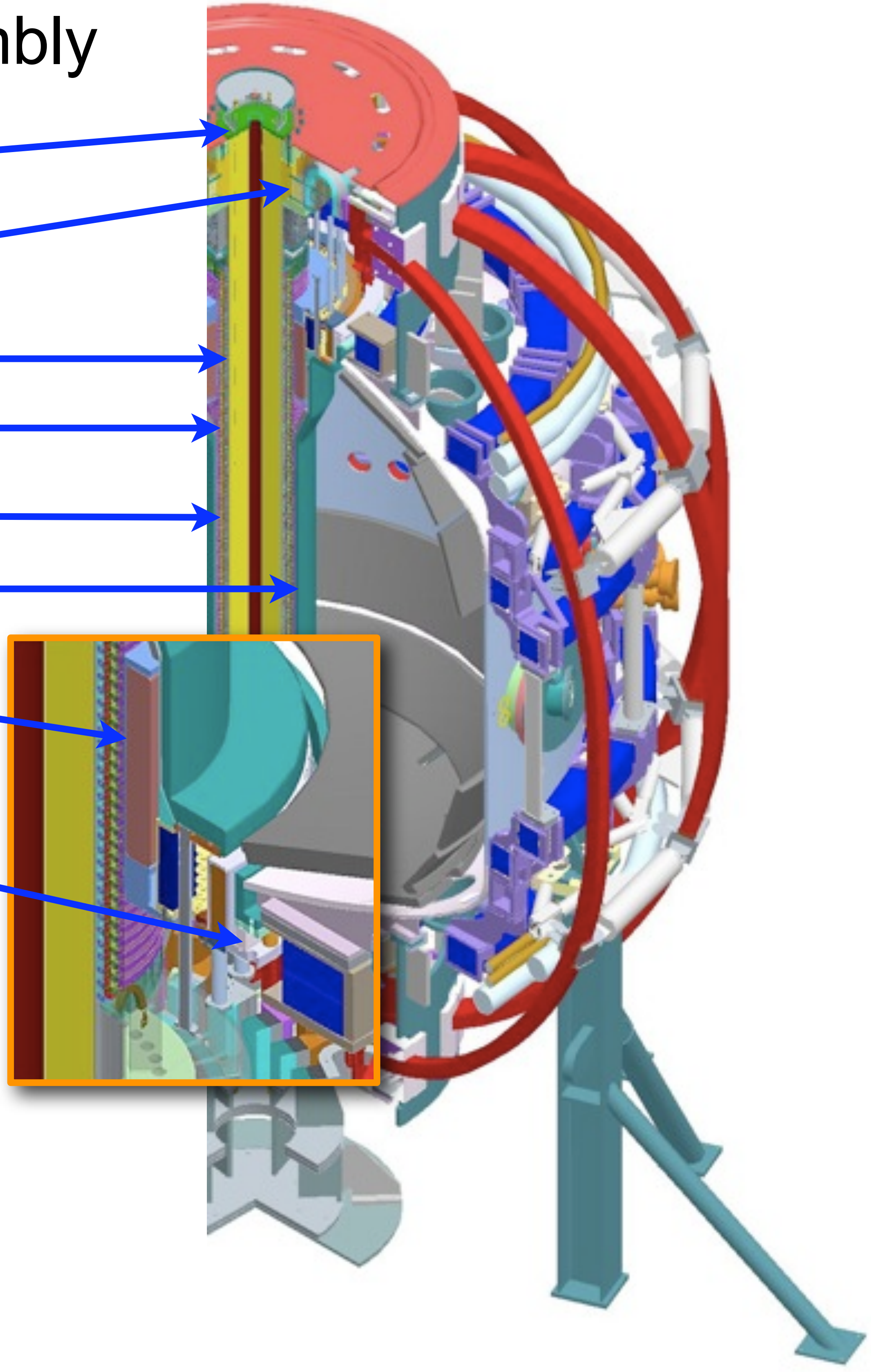
	NSTX	NSTX-CSU
Plasma Major Radius [m]	0.8540	0.9344
Aspect Ratio	1.266	1.500
Plasma Current, I_P [MA]	1.0	2.0
Toroidal Field B_t [T]	0.6	1.0
Pulse Length, T_{pulse} [s]	0.5	5.0
Rep Rate $T_{repetition}$ [s]	600	2400
Center Stack Radius $R_{centerstack}$ [m]	0.1849	0.3148
Antenna Rad, $R_{antenna}$ [m]	1.5740	1.5740

NSTX Upgrades Scope

- Changes to the Central Core (Chrzanowski / Titus / Willard):
  - Toroidal Field (TF) inner leg bundle including flags, hubs, and flexible connectors
  - Ohmic Heating (OH) coil
  - Poloidal Field (PF) coils PF1A Upper, PF1A Lower, and PF1B
  - Microtherm thermal insulation
  - Center Stack Casing (CSC)
  - Plasma Facing Components (PFC) associated with CSC including the Inboard Divertor (IBD)
  - TF, OH, PF1A Upper (PF1AU), PF1A Lower (PF1AL), and PF1B Lower (PF1BL) coil electrical leads
  - CS and Supply piping for heating and cooling of CSC and IBD
- Structural Improvements (Dudek / Titus)
  - TF outer leg supports
  - PF coil supports
  - Pedestal which supports Center Stack Assembly from floor
  - Vacuum vessel if required (VV)
- Electrical Systems (Ramakrishnan)
  - Power Systems
  - CS Bakeout system
  - I&C systems
- Center Stack Diagnostics Sensors
- Auxiliary Systems
  - Cooling water system mods
  - CS and Supply piping for inboard gas injection

Changes to Central Core

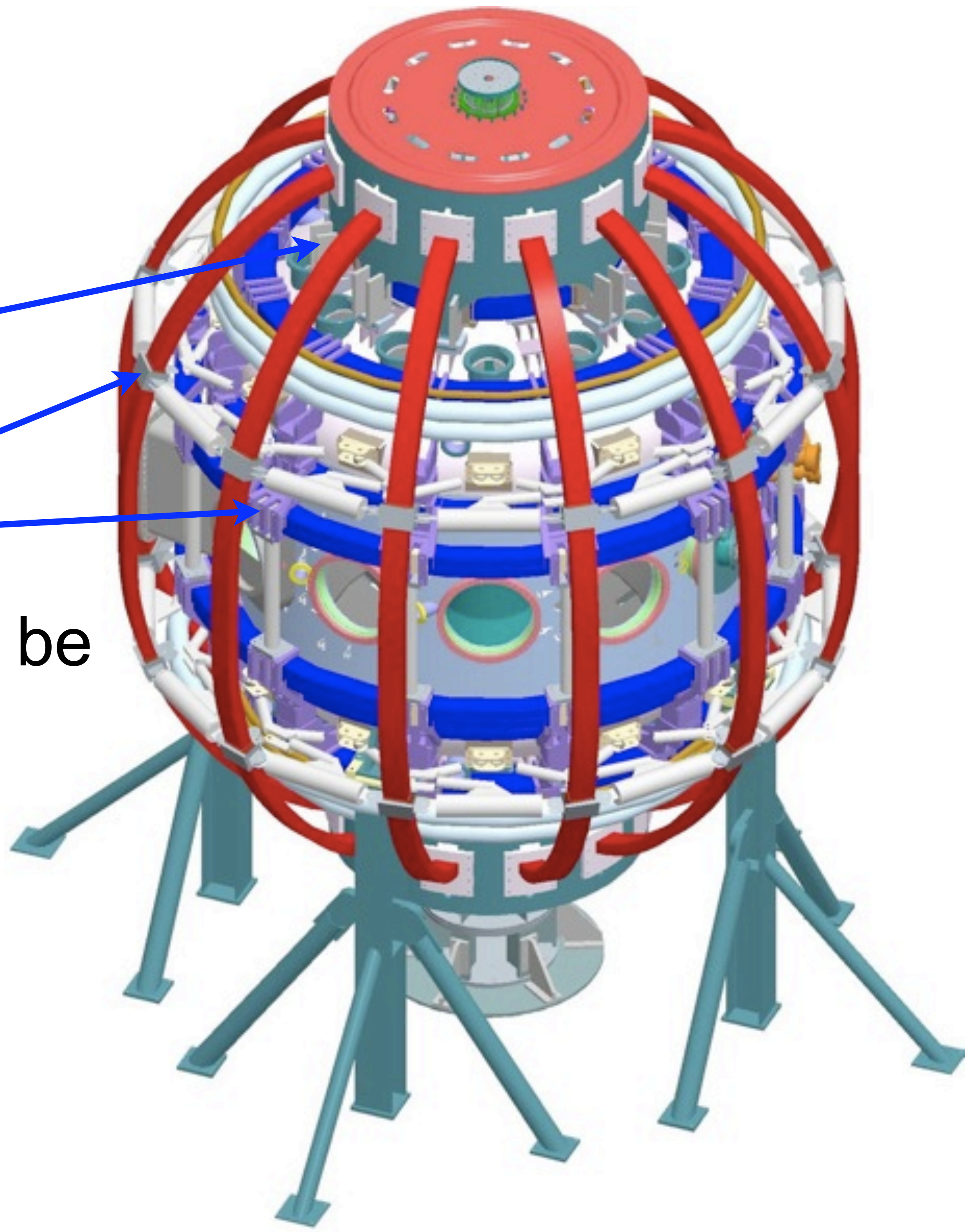
- Design, Build and Install New CS Assembly including (Chrzanowski / Titus / Willard):
  - New TF Hub Assembly
  - New TF Stub and Flex Assemblies
  - New Inner TF Bundle
  - New Ohmic Heating Coil
  - New Inconel Casing & Insulation
  - New PFC Tiles
  - New Poloidal Field 1a, b & c Coils
  - New Ceramic Break



- R&D Activities to support above work
  - TF electrical joint testing
  - OH braze joint testing
  - Stir Welding Tests

Structural Improvements Required

- Design Build and Install (Mangra / Dudek / Titus):
  - Reinforcement to existing coil structures to handle higher magnetic loads
    - Umbrella Structure
    - Outer TF Legs & Vacuum Vessel
    - Outer PF Coil
- Vacuum Vessel reinforcement may be necessary in localized areas (eg Passive Plate supports)



Electrical System Upgrades & Diagnostics

- Power Feed Upgrades (Ramakrishnan)
  - Upgrade TF power supply to support full field capability of ~1T. (At ~1T, ~2.5s flattop every 20 min and up to ~5 s every 40 min)
    - Existing cables will be reconnected for TF use. Thus there will be a total of 8 cables per pole for TF.
- Replace Centerstack Diagnostics
  - Rogowski Coils
  - Mirnov Coils
  - Flux Loops
  - Langmuir Probes
  - Thermocouples

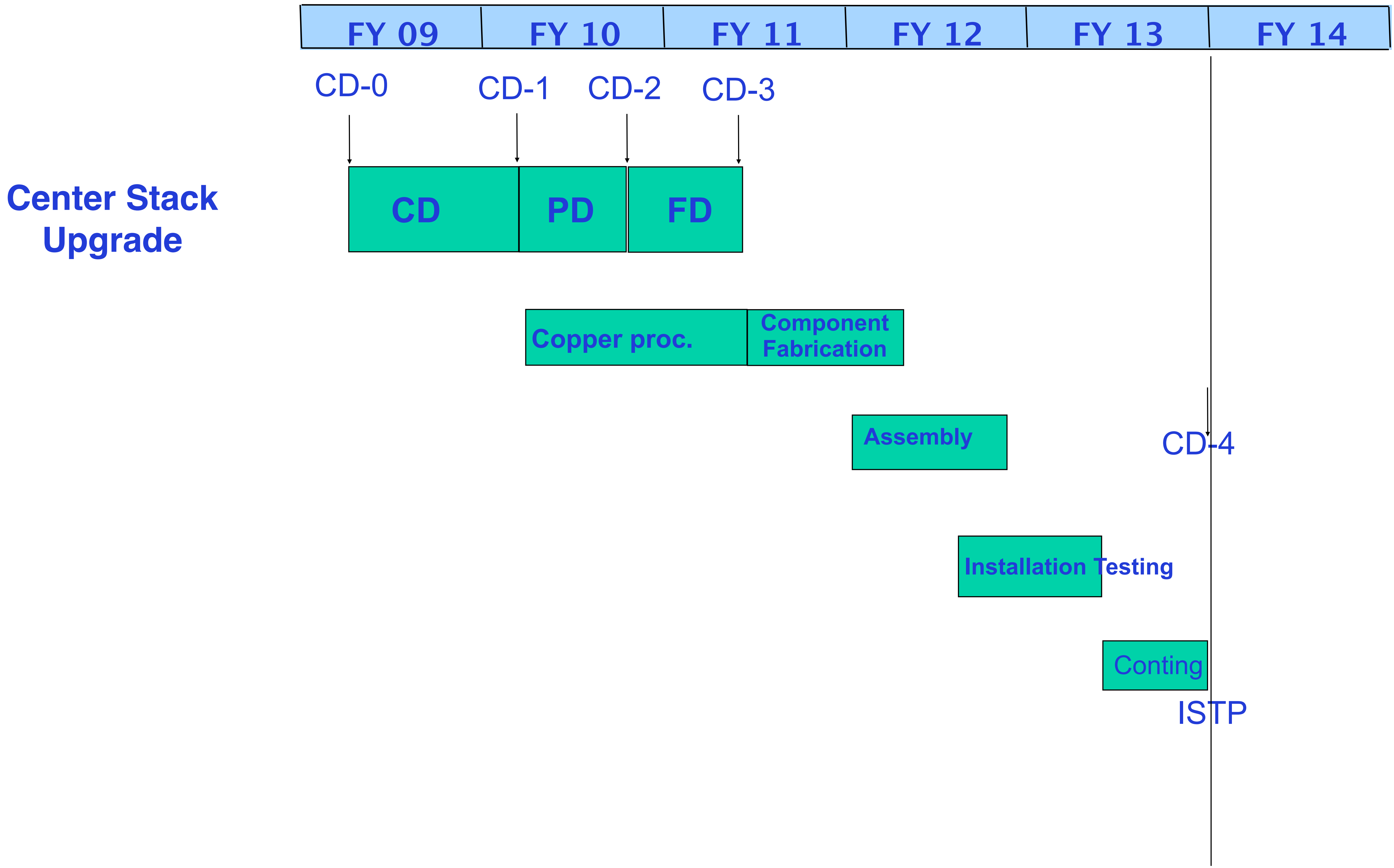
Auxiliary Systems

- Gas Injection Systems
  - Relocate existing center stack gas injection system to the new center stack
- Coil Cooling water modifications
  - Increase in cooling water pressure by upgrading the pump for the OH coil to provide 600 psig (up from 400 psig)
  - Upgrade the existing cooling water system to cool the outer TF coil legs separately from the inner

Peer Review

- A peer review of this design was held in mid August
- The reviewers included engineers from outside the lab
- Presentations included technical details on the analysis and the design concept
- At this review 40 Chits were generated and have been dispositioned
  - Most of the chits were written in the area of analysis recommendations and TF Inner to outer joint design (Willard)
  - Project has responded to these chits and the closeout is being tracked
  - There were no “show stoppers”

Major Milestones for Center Stack Upgrade

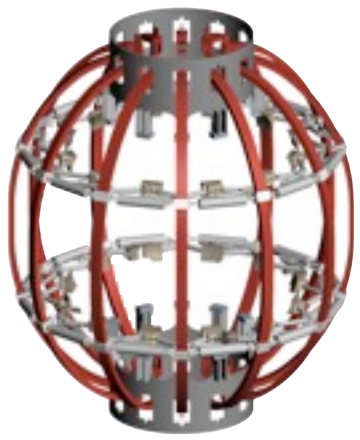


Cost Estimates

- Cost estimates were generated by the Job Managers with input from engineers closest to the work
- Estimates are conservative
- Depending on the work estimated, they are based on
  - Previous NSTX construction
  - Quotes from Vendors or suppliers
  - Engineering Judgement
  - Published cost data (eg RS Means)
- Additional detail to be presented by R. Strykowsky

Centerstack Upgrade Risks at CD-0

- Risk: The ability to find a cost effective TF Joint that works at higher fields.
  - The selected design has been verified through analysis to be far superior to the existing design for current capacity and liftoff (Willard presentation)
- Risk: Little room to re-enforce outer TF Legs and Umbrella Structure to handle higher loads.
  - The original concept of a diamond brace has evolved to a “radius rod concept”
  - Uses space utilized by existing support to transfer the loads back to the VV



Centerstack Upgrade Risks at CD-1

- The latest Risk Registry now has 34 risks identified
  - Vendor Performance (9)
  - Coil Fabrication (8)
  - Installation Difficulty (7)
  - Design error (4)
  - Analysis (3)
  - Other (3)
- Risk: OTF and PF Support Installation Difficulty
  - Design is being tailored to improve installation
    - Modular
    - Utilize space occupied by existing supports
  - Careful planning
    - Coordinate carefully with NB upgrade
    - Methodical removal of existing equipment

Summary

- The upgrade requirements are challenging but a conservative conceptual design is being presented
- The design is well defined and is ready to proceed to the preliminary design level
- The upgraded TF joint, which was problematic with the original design, has evolved into a robust design with major improvement in margin
- The cost estimates are based on the conservative design which is being presented