Preliminary Designs of Background Coils for NCSX

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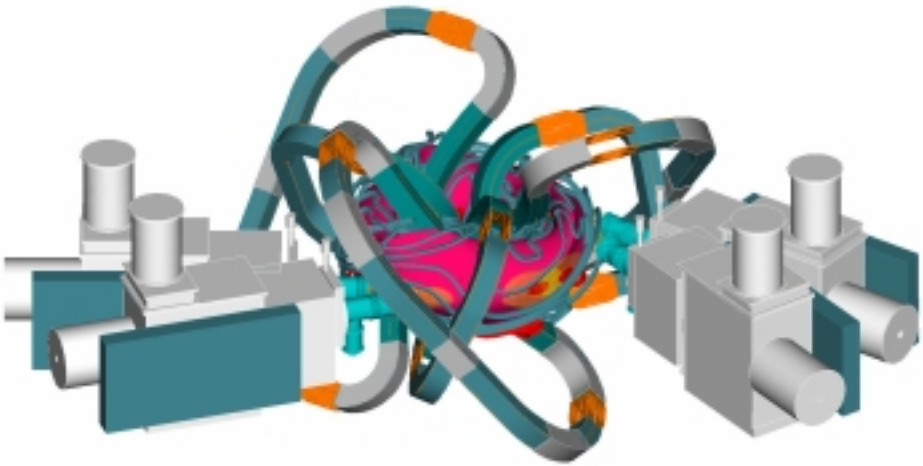
Introduction

- Alternative designs are considered for NCSX which are not constrained by the use of PBX-M.
- The goal of this study is to provide physics engineering, and cost comparisons to the PBX-M option.

Two Machine Configurations with Significantly Different Background Field Coils are Being Studied to Permit Comparision of “Demountable” vs. “Wind in Place” Coil Costs

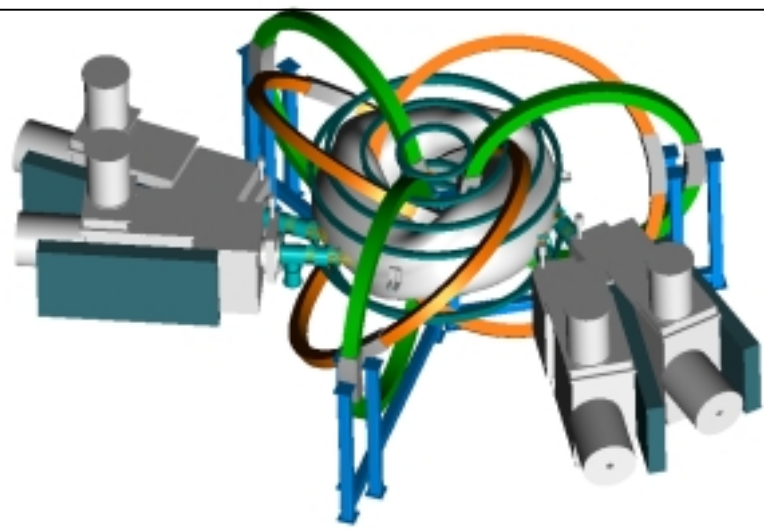


The Tilted Coil Option

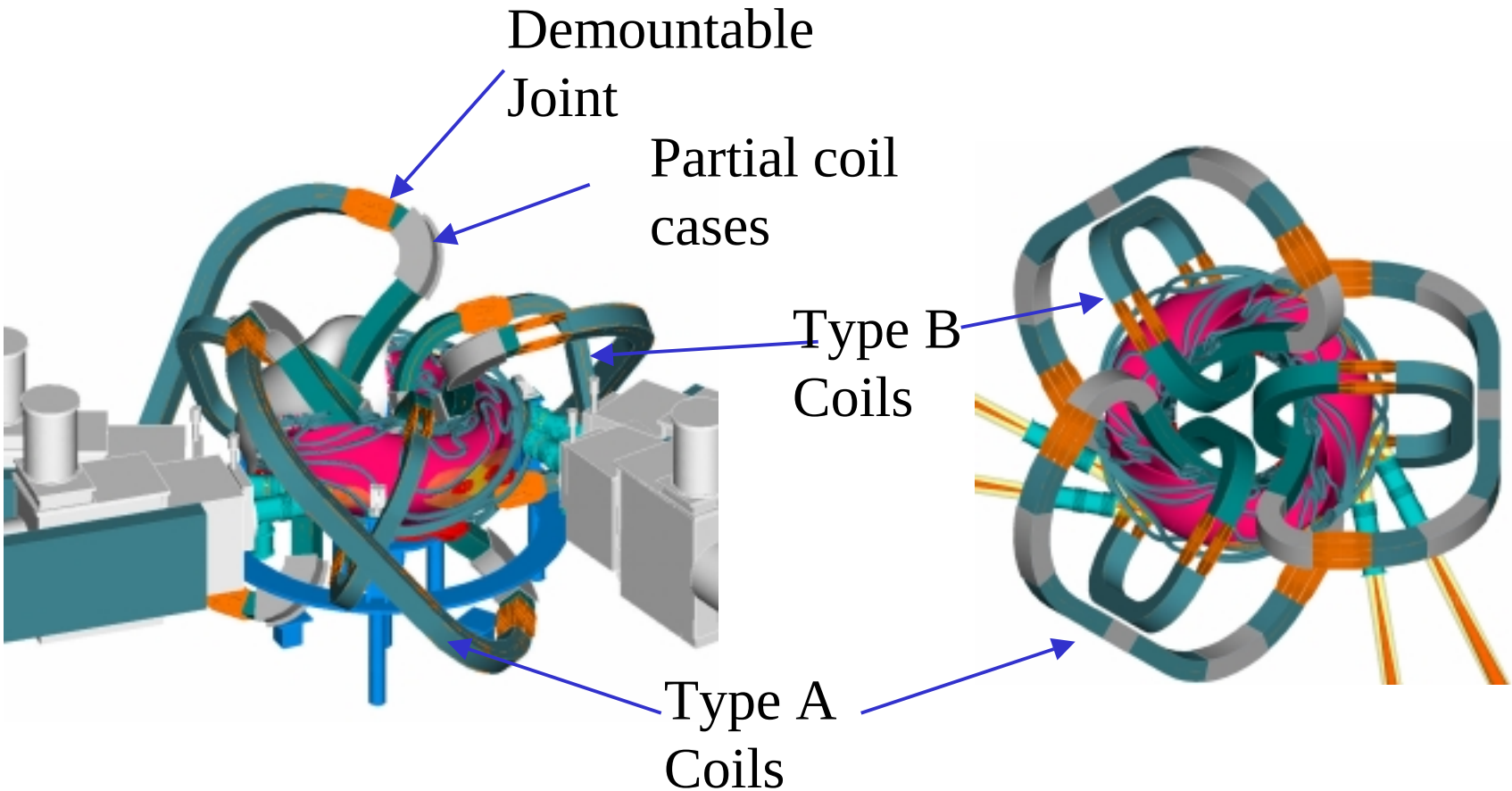
- General coil shape & concave inner legs favors forming (vs. winding) with demountable joints.
- Most of the work so far has been on this design.

The l=3 Option

- Circular shape can be wound in place. Demountable coils are also possible.
- Work is just getting underway.



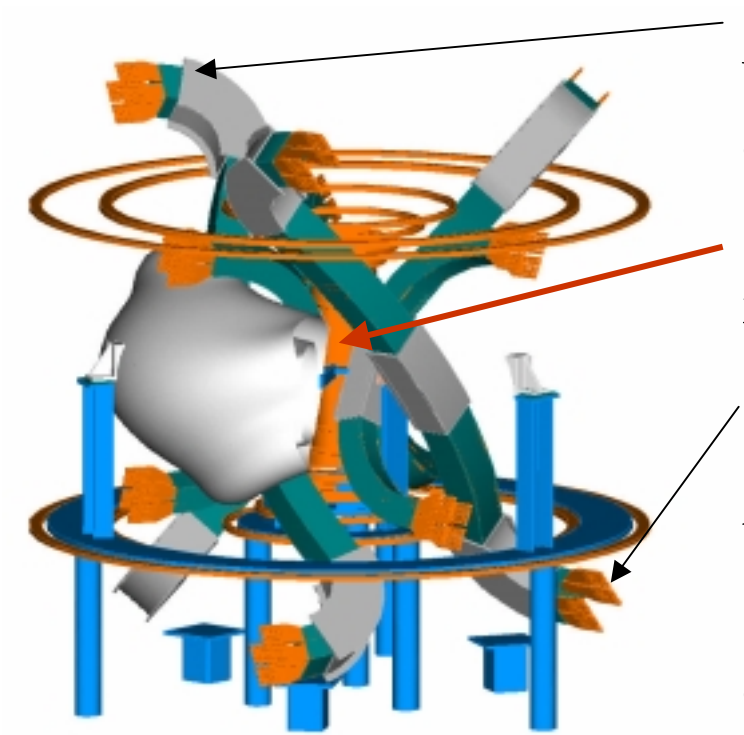
NCSX Tilted TF Coil Overview



Elevation View

Top View

General Arrangement of Options Using Background Field Coils



- The outer OH & PF coils are located in the bore of the TF coils above and below the core.
- The central portion of the OH coil is located in the open center of the TF legs.
- In the tilted design (shown), the TF coils are split top & bottom to permit them to be threaded through the NCSX core.
- In the wound design (not shown), the TF coils will be wound in place around the core assembly on flanged “bobbins” which will be rotated.

Preliminary Tilted Coil Parameters

Parameter	Type A	Type B
No. Coils	3	3
MAt/ Coil	2.778	1.989
Turns /coil	20	20
Turns arrangement	2 layers of 10 turns	2 layers of 10 turns
Nom. Cu Size	0.75 x 5.6”	0.75 x 5.6”
Coil current	139 kA	99.5 kA
Current Density	33 kA / sq. in.	23.7 kA / sq. in.
Coil weight, lbs.	16000	8900

Tilted TF Coil Design Choices

Present Design:

- Copper radially oriented, bent the “hard way” for stiffness.
- DIIID type finger joints with shear bolts. Good experience base.
- *Structural arrangement still evolving. Likely features:*
  - Partial coil cases
  - Support via pins at mid plane

Optional Design:

- Layer wound (toroidally oriented) copper. Forms easier.
- Lap joints with insulated through bolts. May be easier to machine.
- Choice will depend heavily on vendor preference.

The l=3 TF Design

- Work just getting underway.
- Tentative design features:
  - Split flanged “bobbins” that will be installed around the core.
  - Two coil types: Type A requires 2.69 MAt/coil; type B requires 2 MAt/coil.
  - Coil current will be kept to ~40 kA to keep conductor small (~1sq. In.) so it can be wound in place.
  - Bobbins will be rotated to form tensioned, b-stage insulated conductor.
  - Coils will be heated and cured in place.

Conclusions

- ***From the engineering point of view, it is possible to develop a machine arrangement which uses background coils of either type in conjunction with conformal coils.***
- ***There are significant tradeoffs to be considered in choosing between the "wind in place" and "demountable" designs.***
  - *Cost. Wound in place likely to be less costly.*
  - *Schedule. Wound in place requires serial operations; may take longer.*
  - *Machine Maintenance & Upgrades: Demountable design can be taken apart in the event of a core failure or upgrade; wind in place coils would have to be cut off and replaced.*
  - *Reliability. Not clear which is better. The wound coil is simpler, but will have many more turns and connections. Winding in place may not be as well controlled as a factory environment.*
- ***A higher aspect ratio is desired.*** Original plan to locate the central OH solenoid between the inner legs of the Type A and B TF coils was abandoned.
  - This would have resulted in short central solenoid and flux leakage.
  - Present plan is to locate the solenoid in the central open region between the A and B coils. Small bore diameter results in ~1.5 V-s limit

Still More Conclusions!

- *The coil support design is tough and will require clever engineering to contend with the unusual machine geometry, unusual force orientations, and be low in cost with reasonable assembly.* Tom Brown will present more details of the structure and assembly later.
- *Cost comparisons to the PBX-M baseline are being developed and will be discussed by Brad Nelson.*

Future Plans

- Support structure and integration with conformal coils has to be completed.
- The configuration needs to be optimized to provide the best performance and flexibility, good experimental access, and low cost.
- Costing studies will track these activities and be performed parallel.