Machine Configuration

NCSX Project Meeting

January 30-31, 2001

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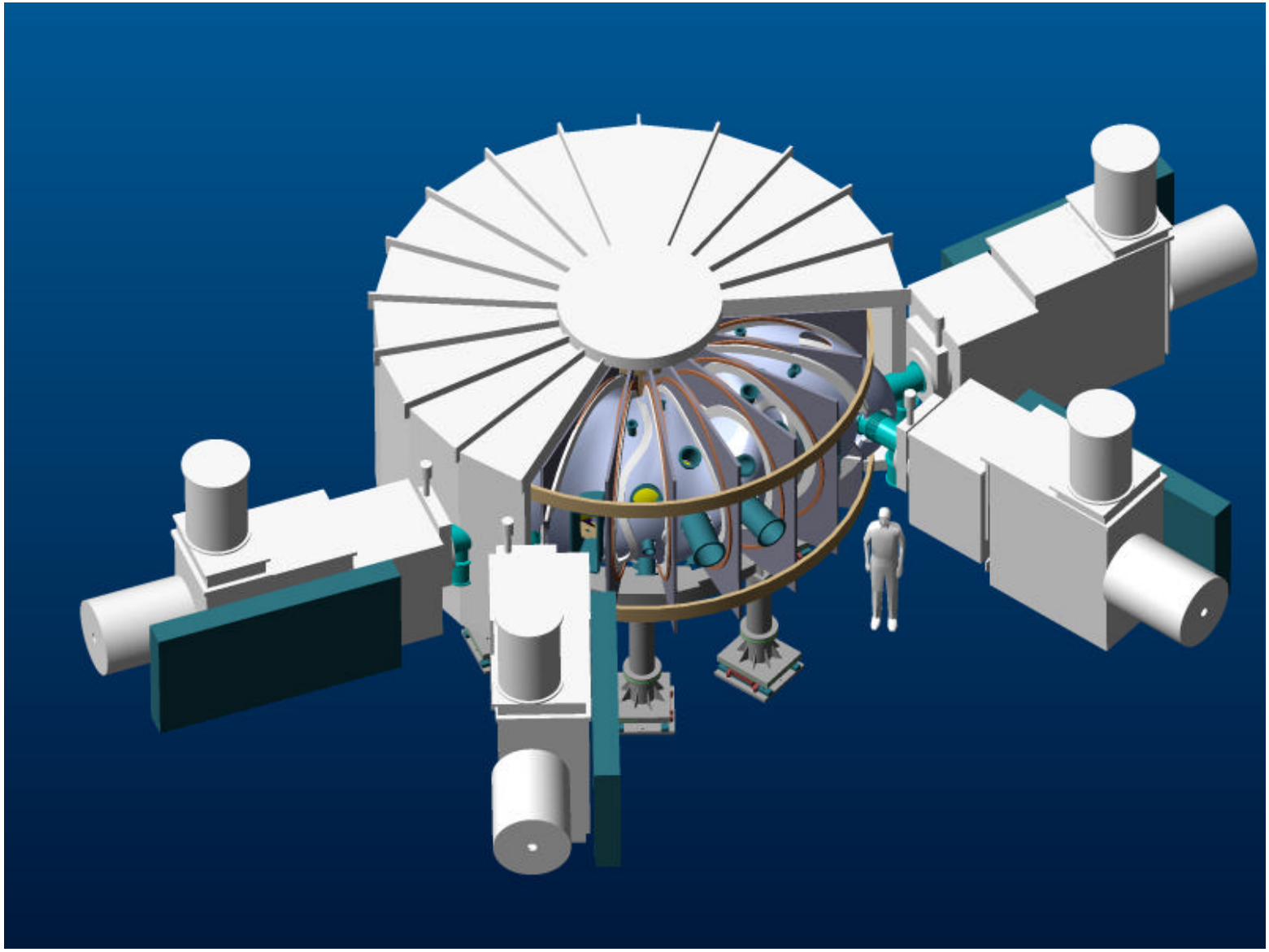
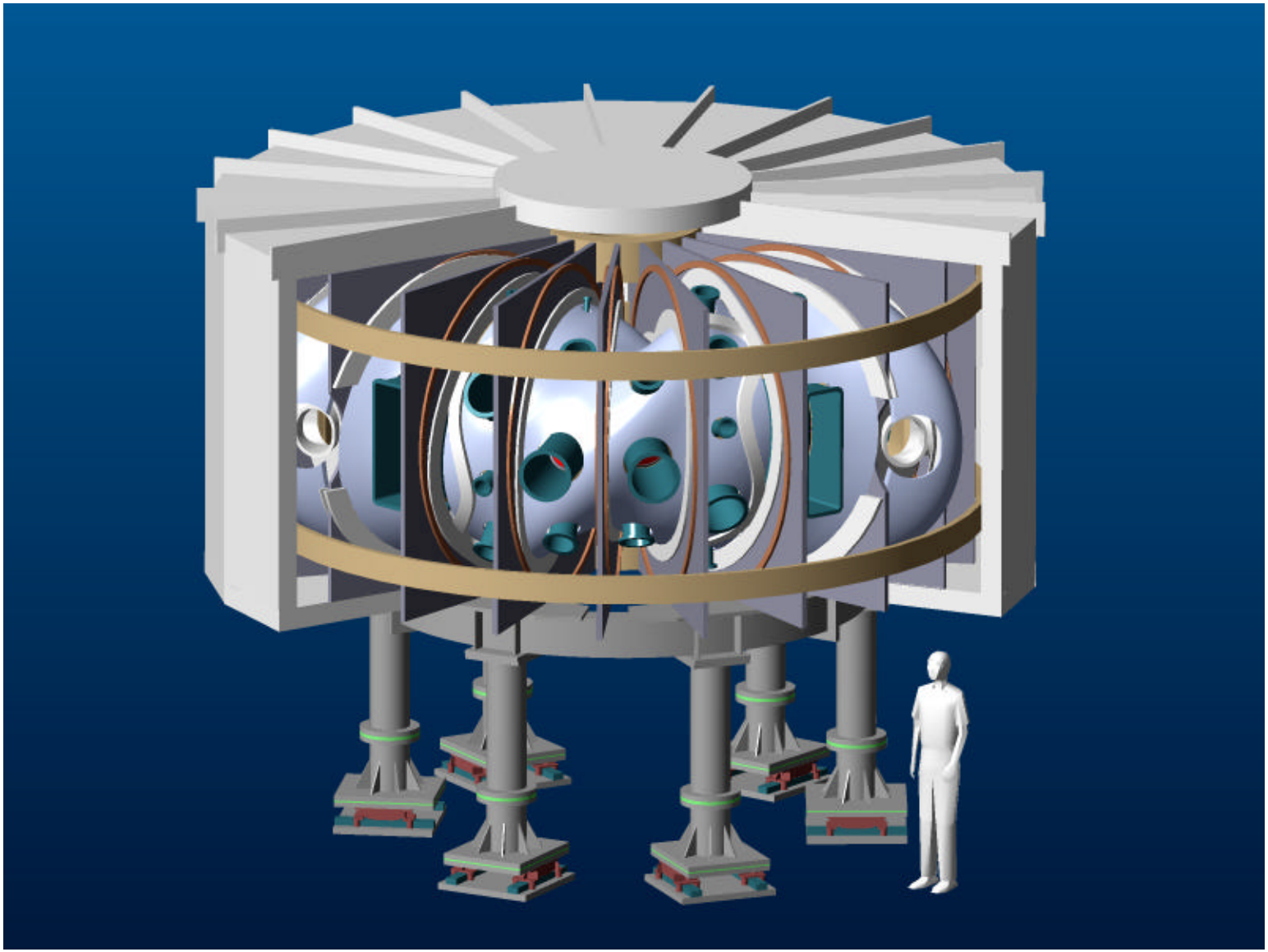
Introduction

- Since last project meeting, configuration has been updated to reflect several changes:
  - Scaling factors (0.82 geom, 0.85 field)
  - Incorporation of trim coils
  - PFC liner, vessel improvements
  - Modular coil winding form
- EM and structural analysis has also been updated

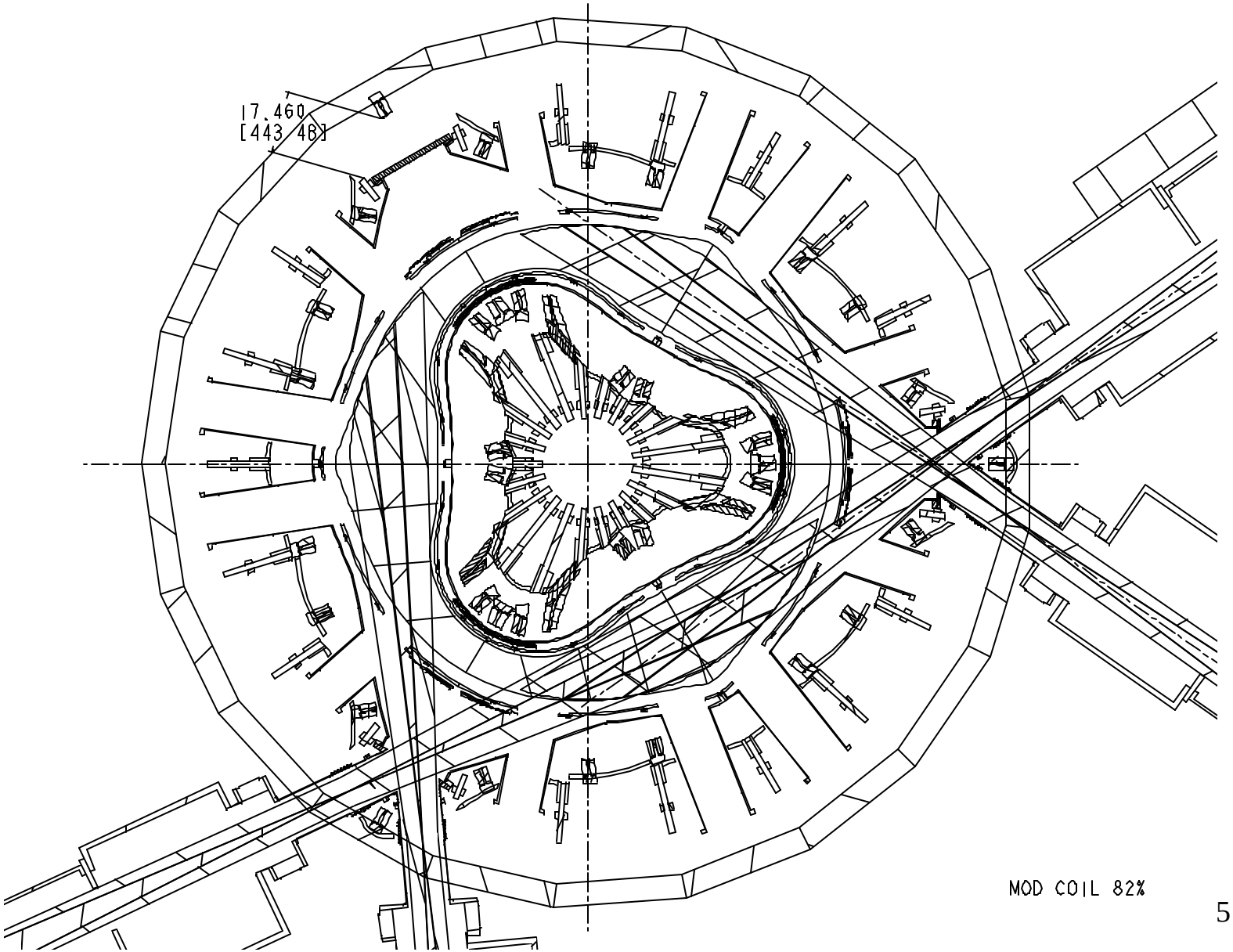
Machine Configuration



Machine Configuration

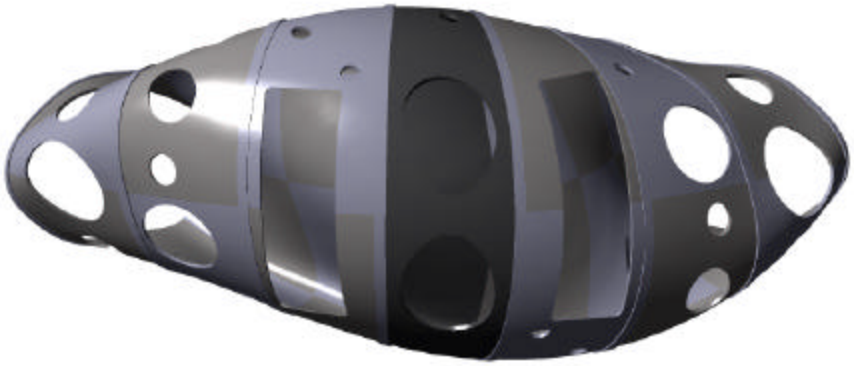


Plan Section View



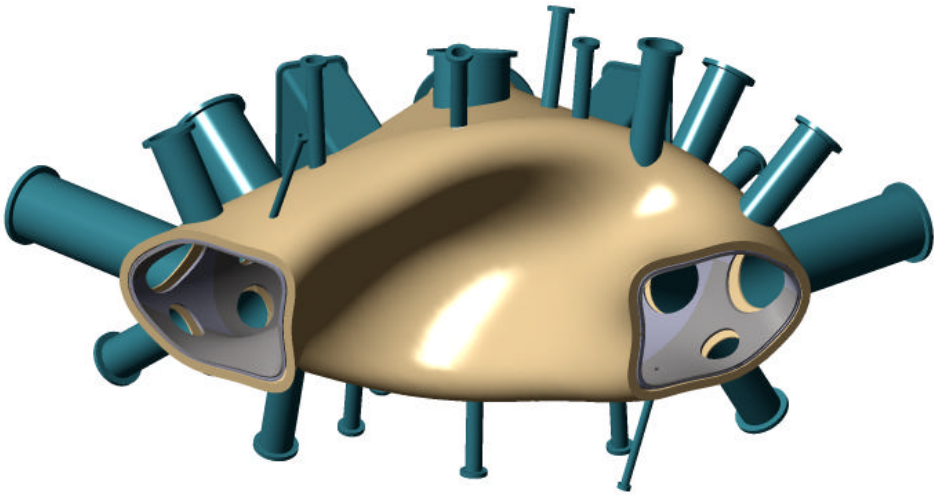
Plasma Facing Components

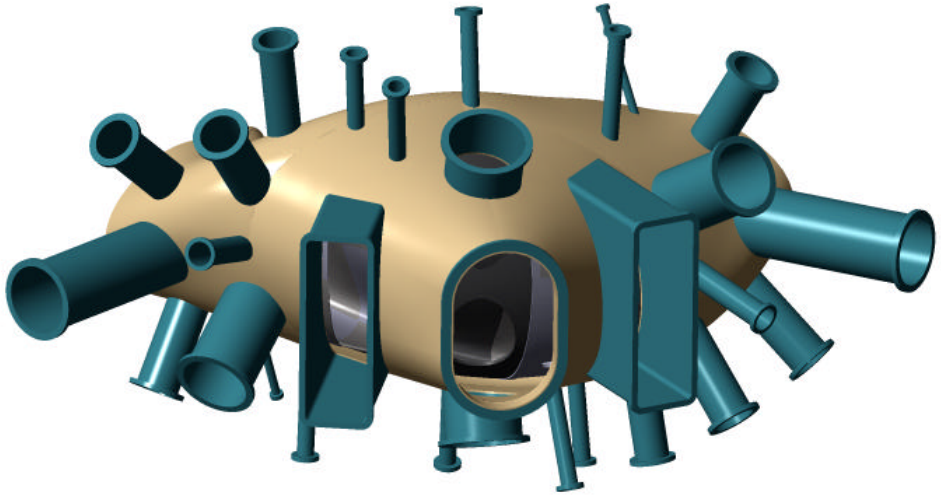
- Large, formed C/C panels attached to rib structure
- Maintain gap with plasma of 2-cm inboard, 10-cm outboard
- Space for sensors, mag loops, etc
- Bakeable to 350-C
- Accommodate 6-MW for 0.5-s
- Compatible with boronization, GDC
- Upgrade to full coverage, 12-MW for 1.7-s, divertor structure



Vacuum Vessel

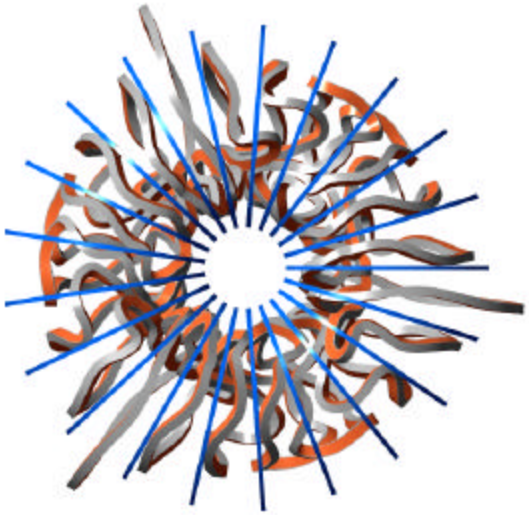
- Thin conformal structure
- Three large symmetric ports for heating systems
- Many smaller, symmetrically arranged ports for diagnostics
- External trace cooling/heating and layered insulation
- Low magnetic permeability
- Internal components mounted to vessel wall, vv supported by hanging from mod coils
- Provide access for heating systems, vacuum pumping, diagnostics, personnel

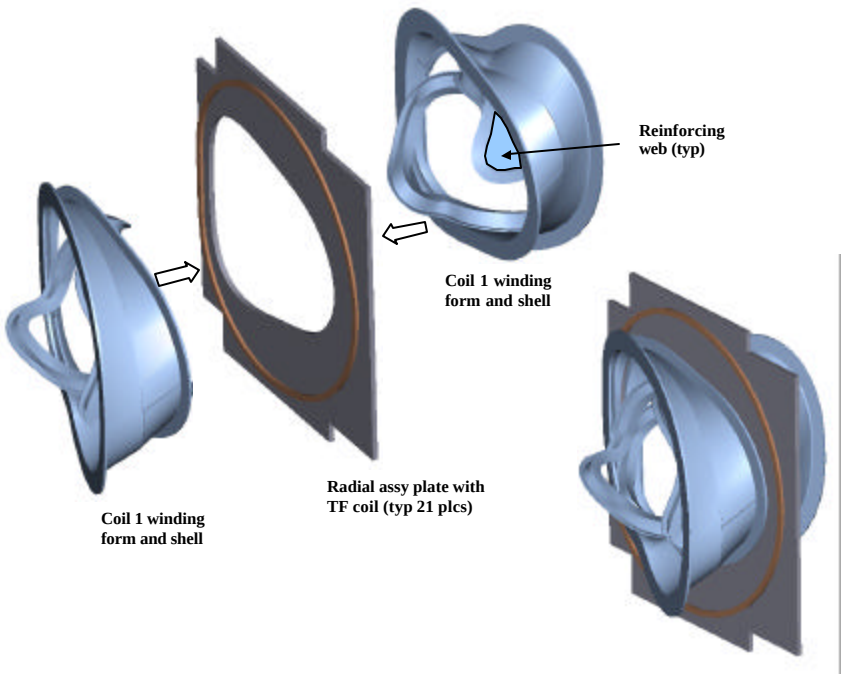




Toroidal Field Coils

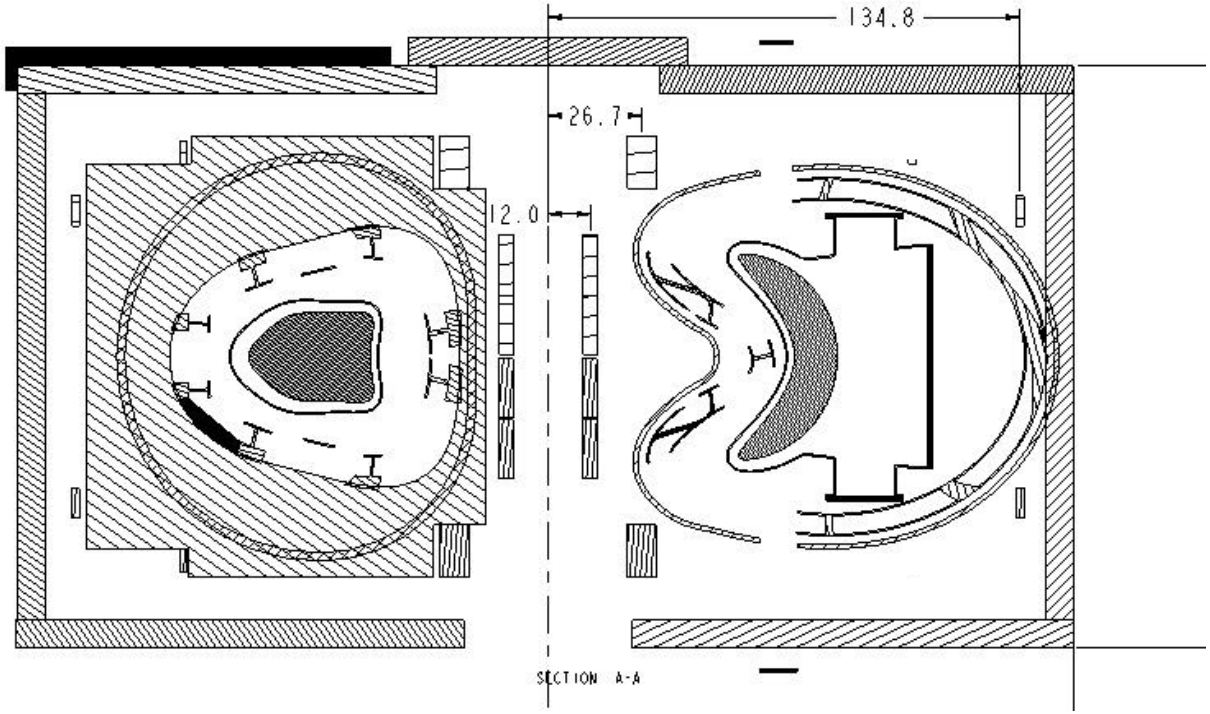
- Provide background toroidal field of +/- 0.25-T
- 21 coils, split and mounted on radial support plates
- 6 turns per coil, 3 on each side of plate
- Hollow copper conductor
- Operate at cryogenic temp





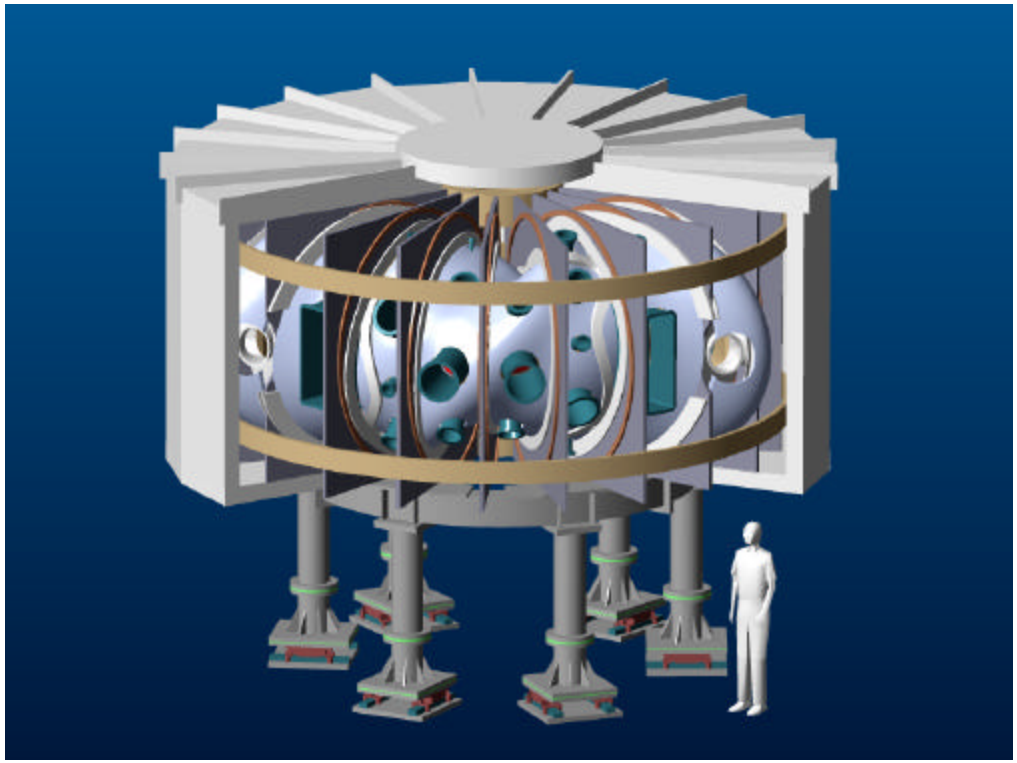
Poloidal Field Coils

- 5 pairs of PF coils required for equilibrium, OH and field shaping
- Minimize field errors
- OH supplies minimum of 1, goal of 3 V-s
- Located outside modular and TF coils
- Wound from hollow copper conductor, epoxy
- Operate at cryogenic temperature
- Free-standing between supports
- Separate leads for each coil



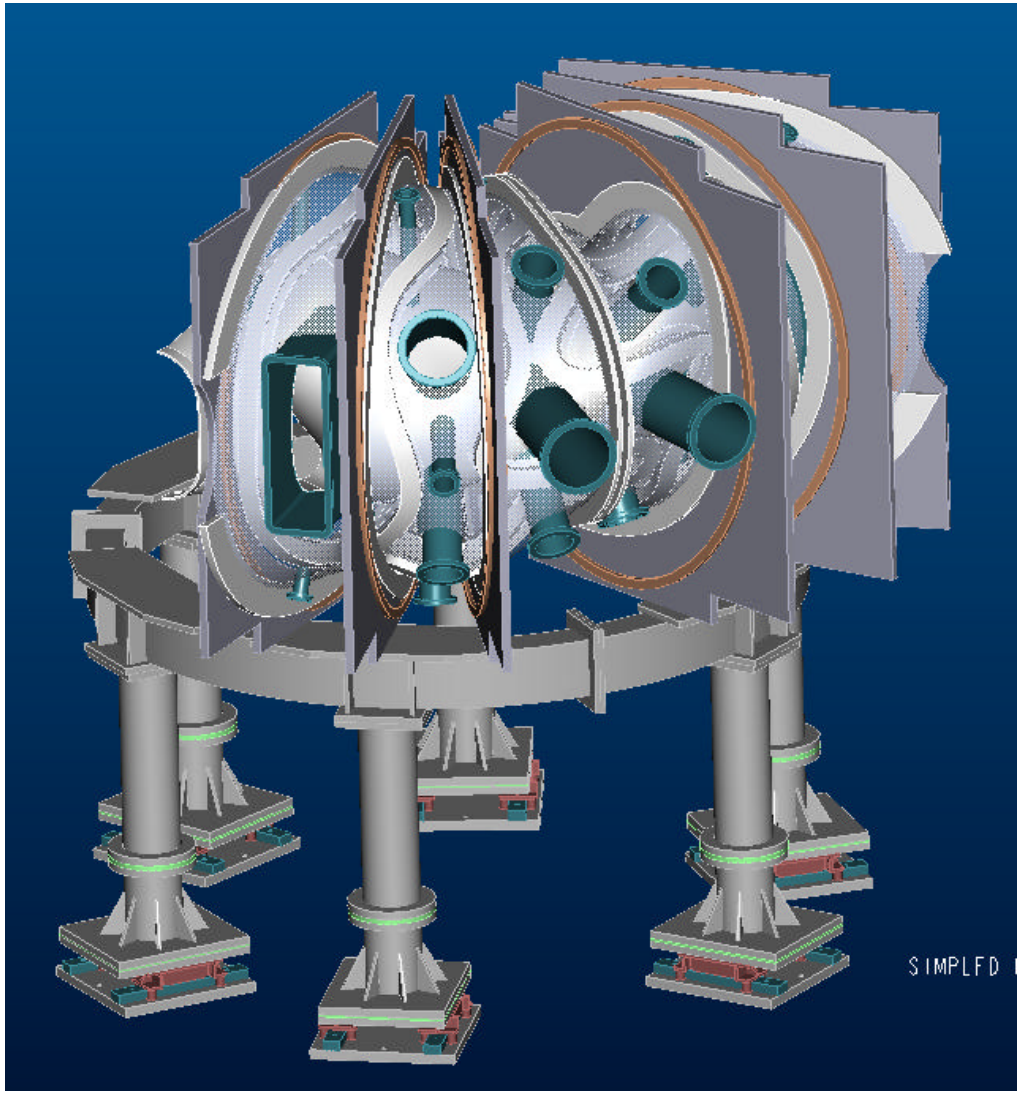
Cryostat

- Provide thermal insulation for cryo-cooled coils
- Slight positive pressure to prevent air ingress, condensation
- Access for maintenance, diagnostics, etc
- Frame and panel construction similar to FIRE design
- Gortiflex boots to seal between vessel port extensions and cryostat
- Forced air, heaters on exterior



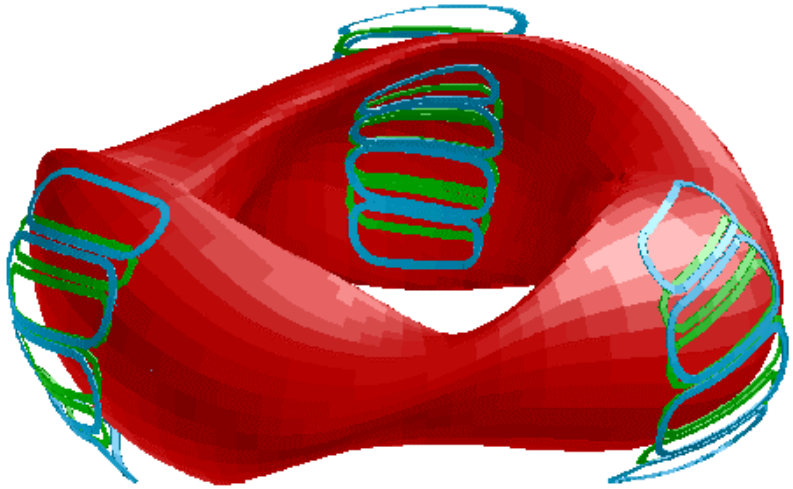
Machine Structure

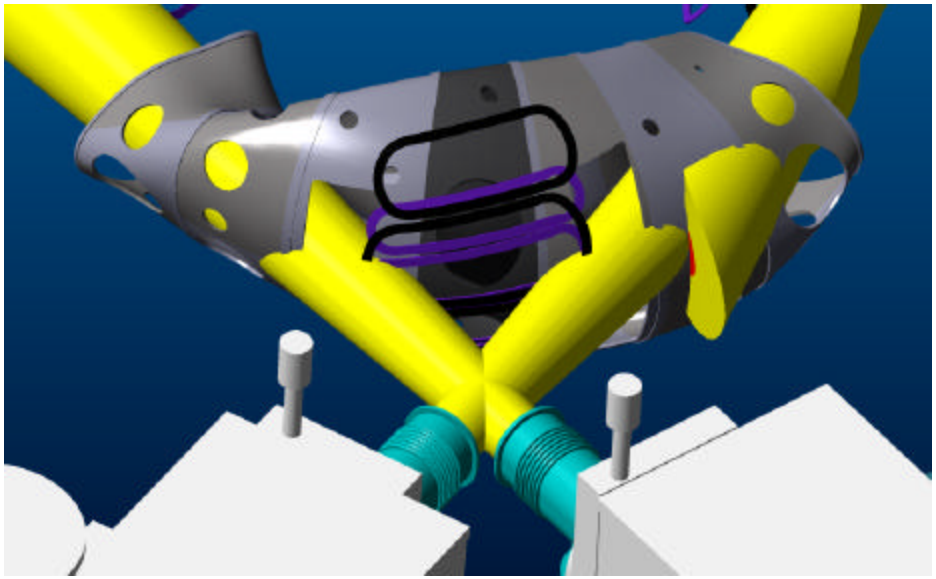
- Support stellarator core from foundation
- Provide thermal isolation, seismic restraint, leveling features
- Provide sufficient clearance for personnel access to bottom of cryostat/core
- Radial motion for assembly of field periods with joint at v=1/2 (bullet cross-section)



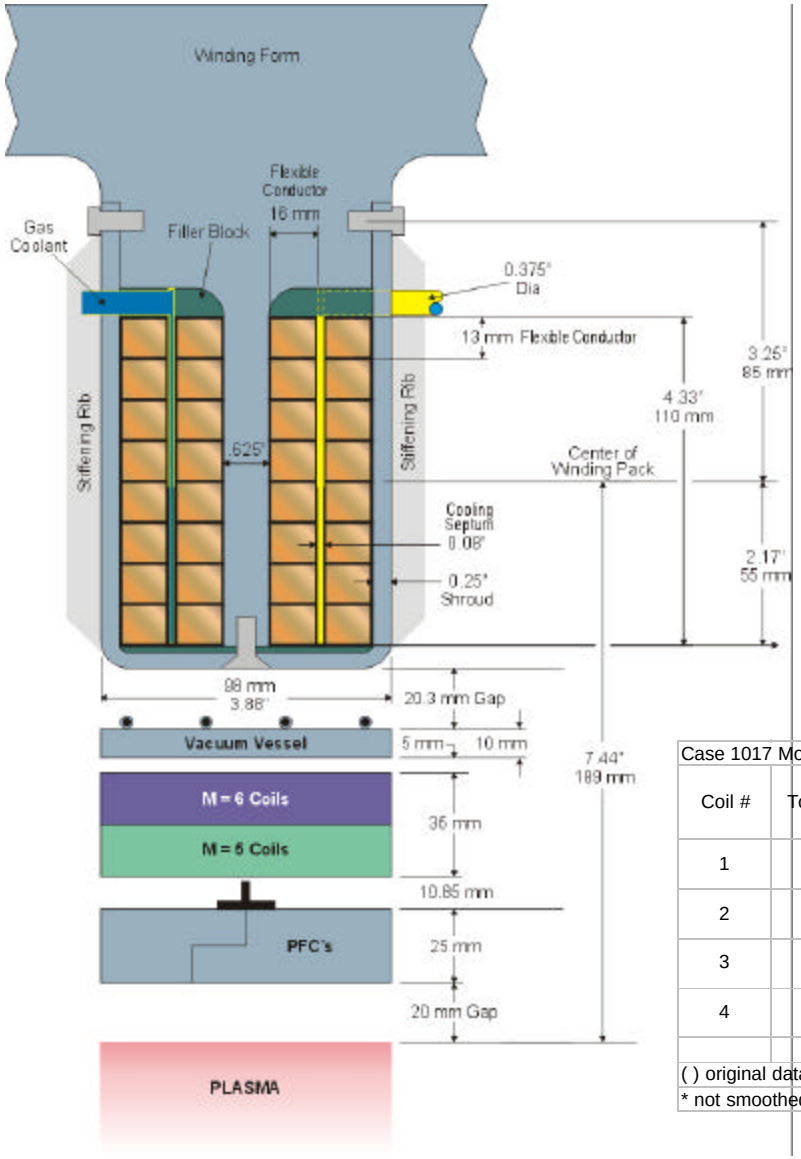
Trim Coils

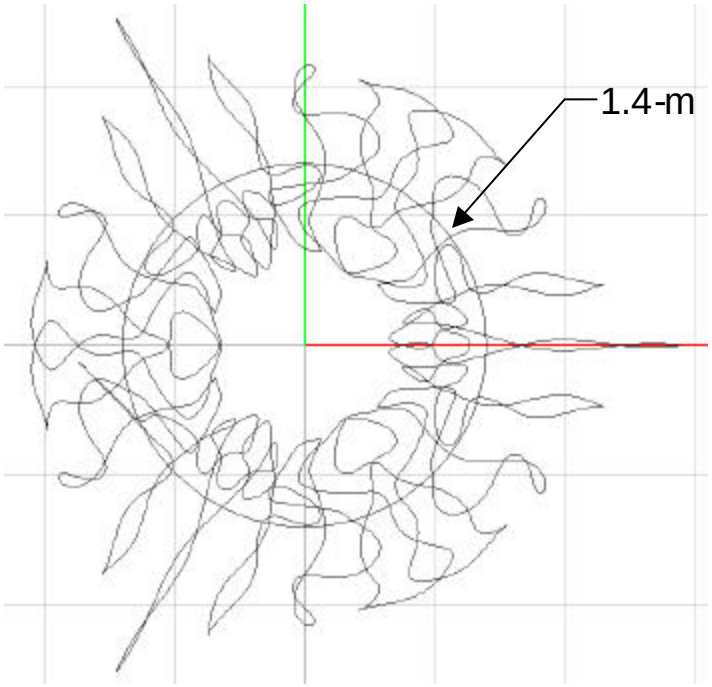
- Trim coil concept defined as window pane coils located inside vacuum vessel at “bean” section
- 12 coil assemblies of 4 coils each
- Coils must be “canned” for vacuum compatibility





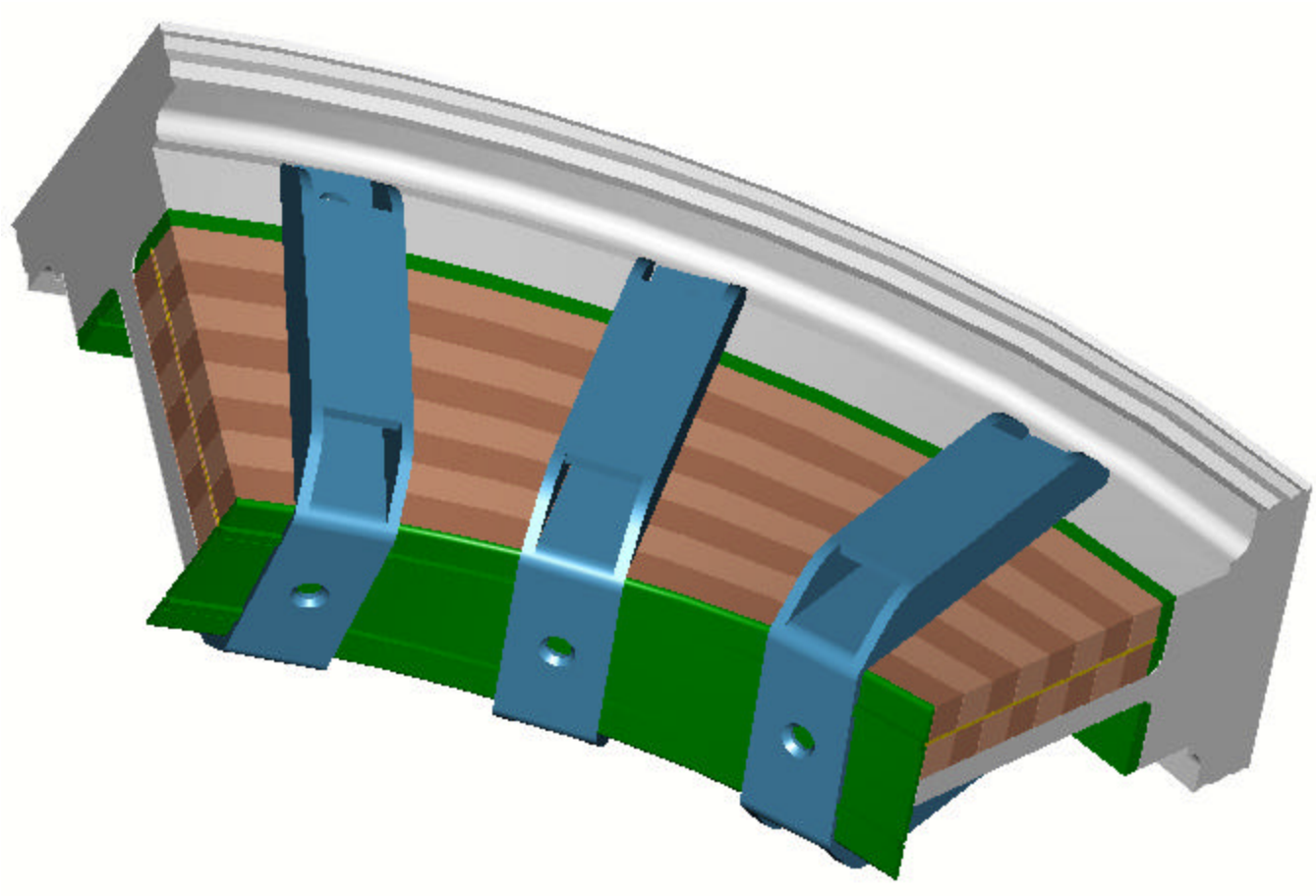
Modular Coils





Case 1017 Modular Coils, Geometry Factor = 0.82									
Coil #	Toroidal-V	Toroidal Angle (Deg)	Coil-Coil Min Dist (m)	Plasma Min Dist (m)	Plasma Max Dist (m)	Length (m)	Min Bend Radius (cm)	Nominal Xsec (cm)	Bounding Box w x h x d (m)
1	0.43	51.4286		0.246		6.088 (7.42)	8.0	10 x 16	1.5 x 1.3 x 0.90
2	0.29	34.2857	0.131 (0.157)	0.188		5.99 (7.30)	6.8	10 x 16	1.4 x 1.6 x 0.83
3	0.14	17.1429	0.124 (0.149)	0.188		6.545 (7.98)	7.2	10 x 16	1.7 x 1.9 x 0.71
4	0.00	0.0000	0.127 (0.150)	0.189		7.564 (9.22)	3.0*	10 x 16	2.1 x 2.0 x 0.56
( ) original data									
* not smoothed									

Modular Coil – Curved Section



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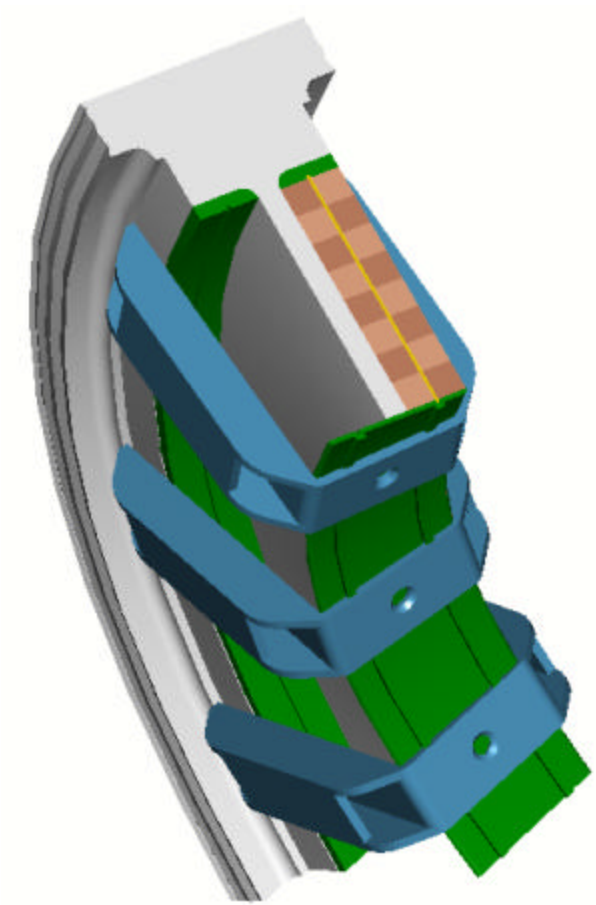
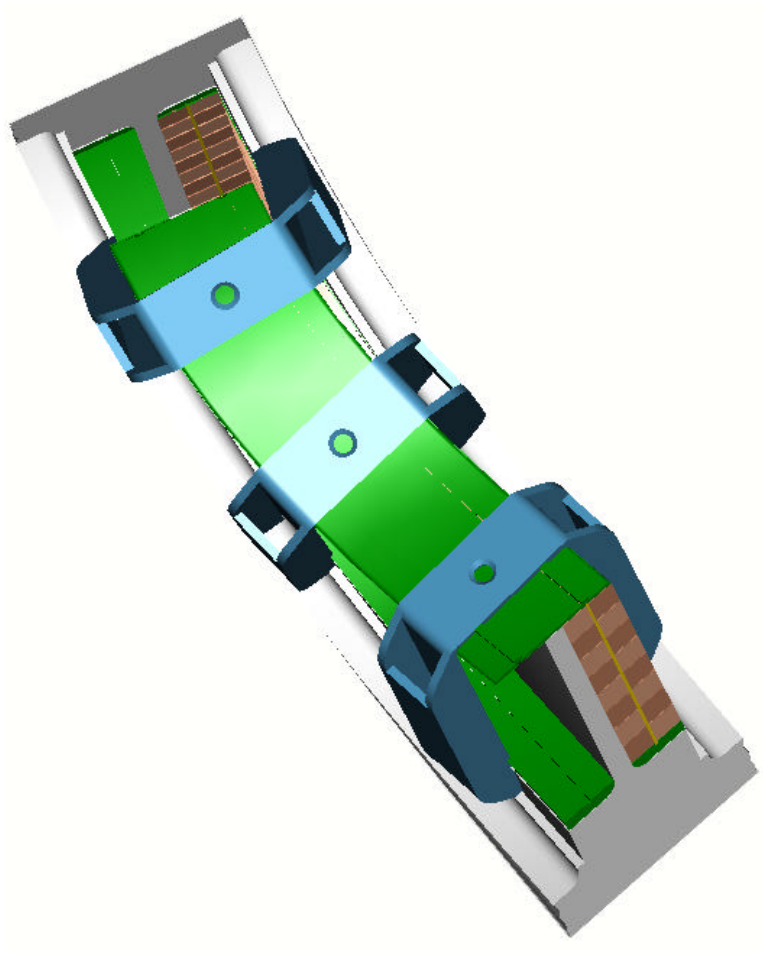
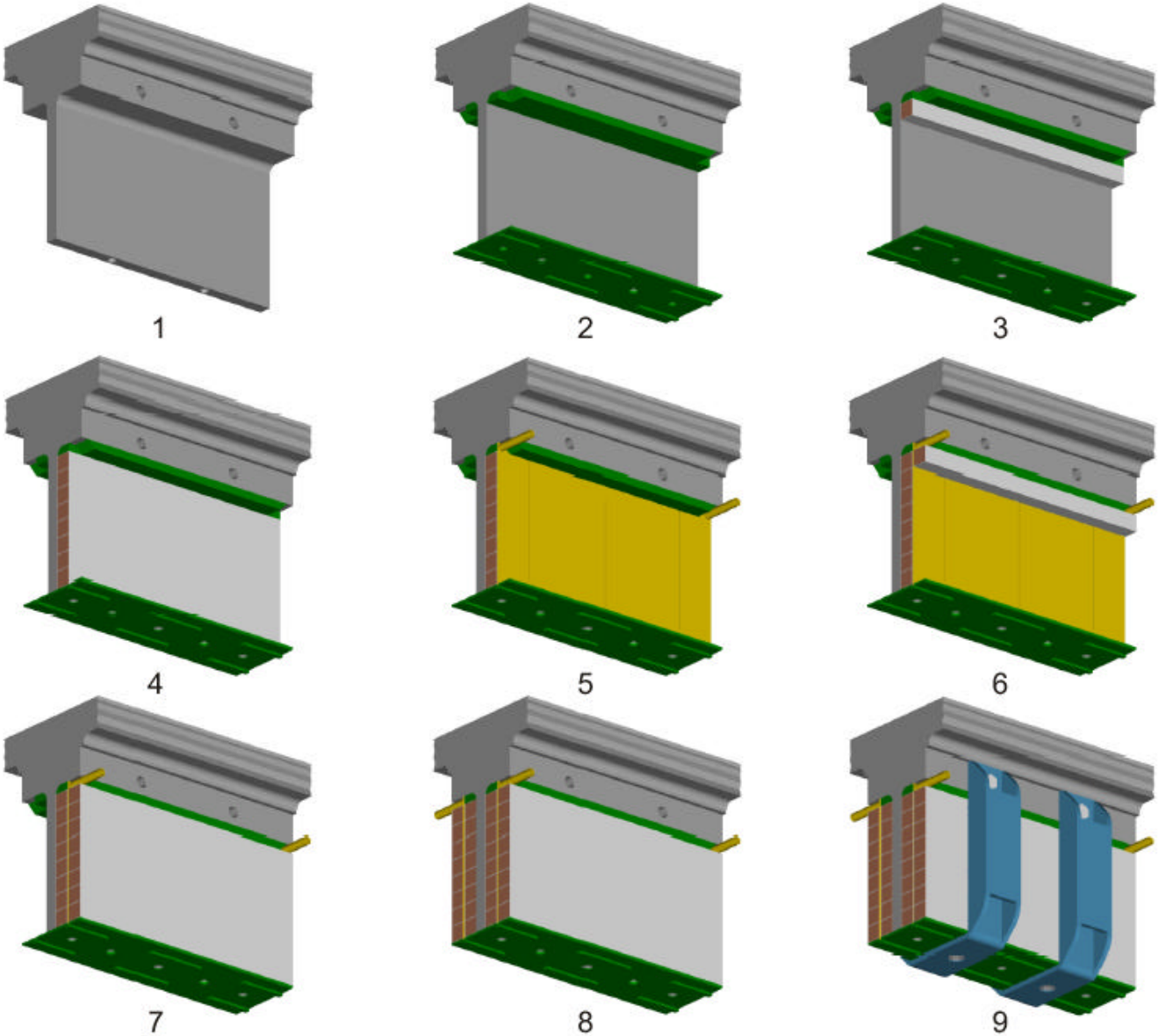
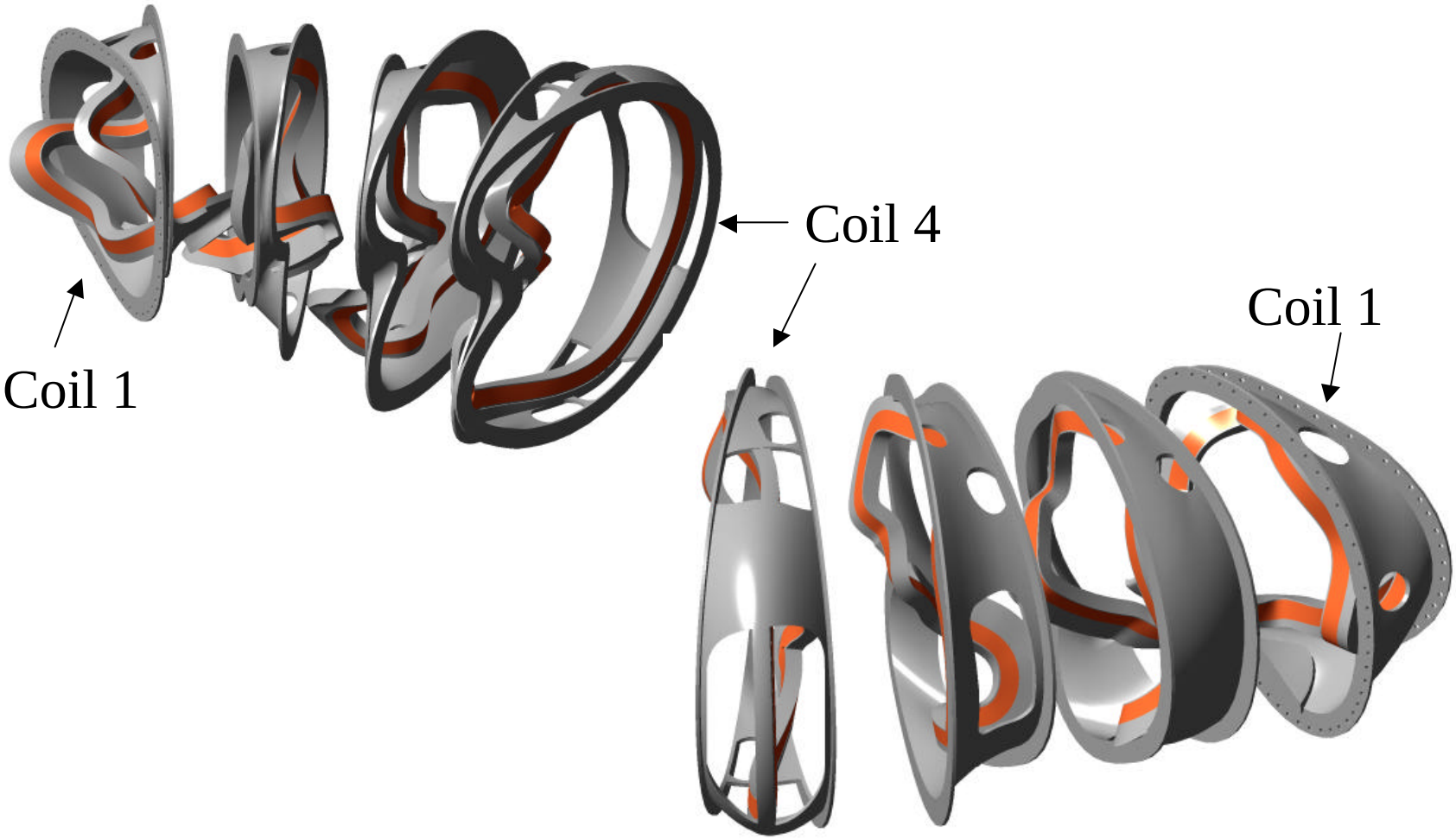




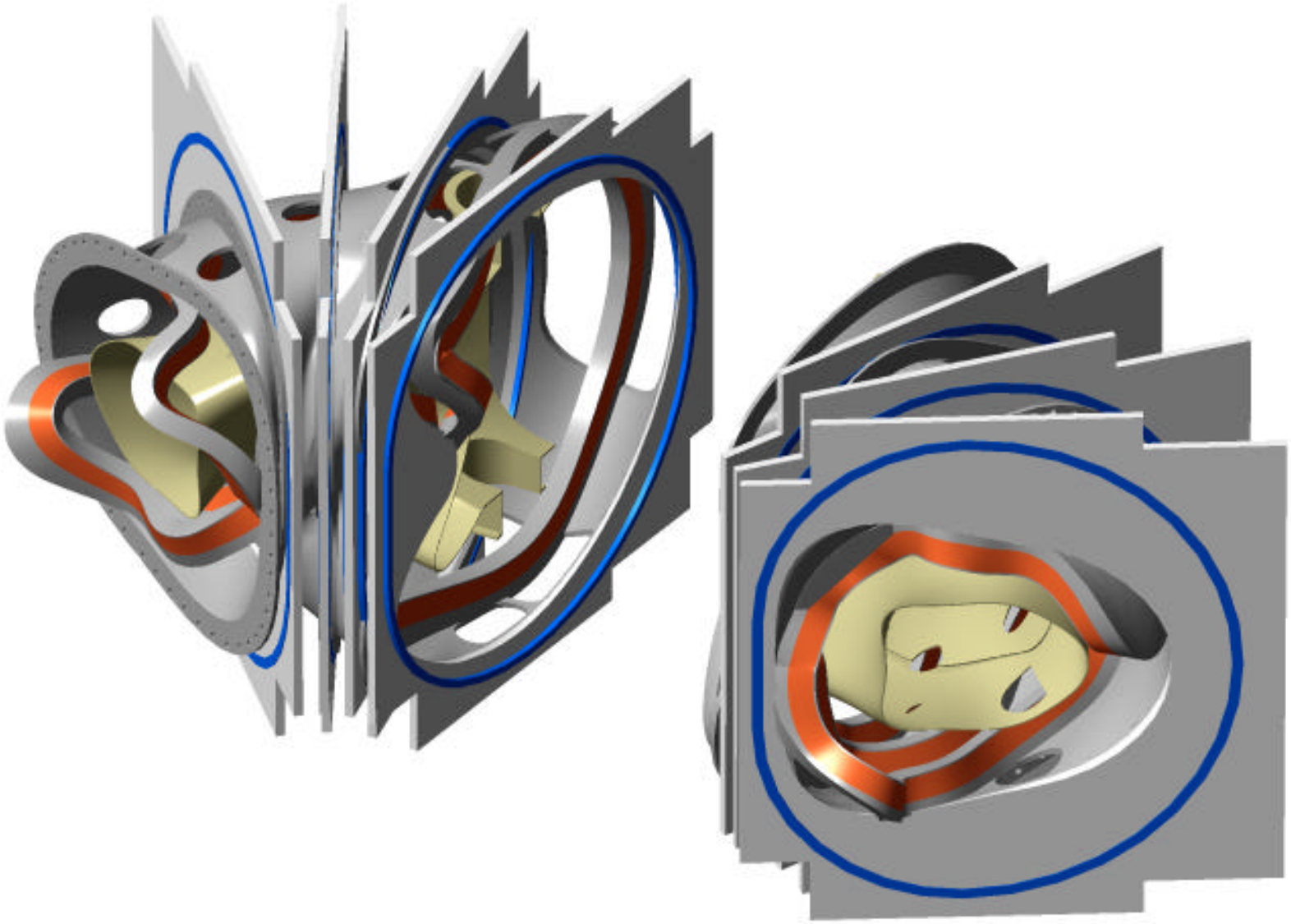
Coil Winding Process



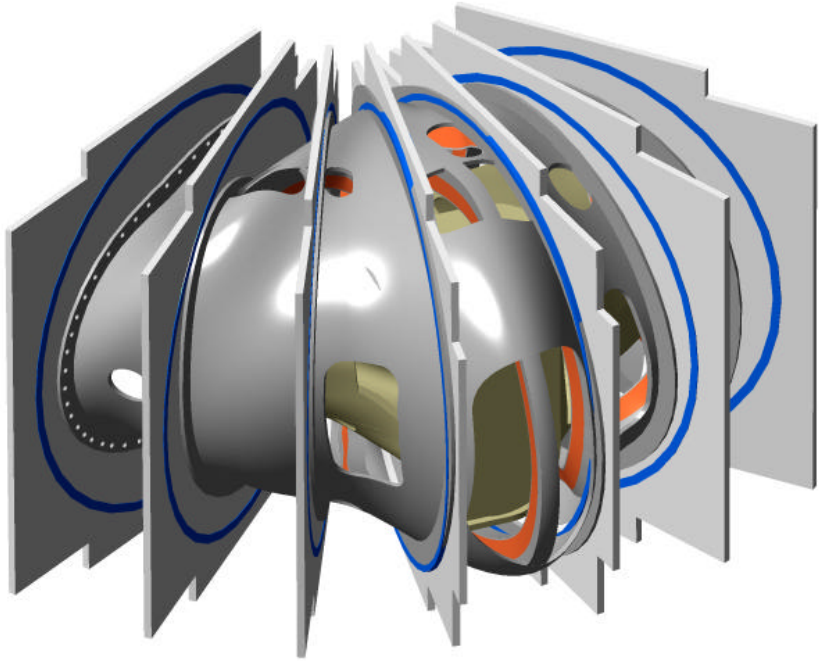
Coil Winding Form and Structure



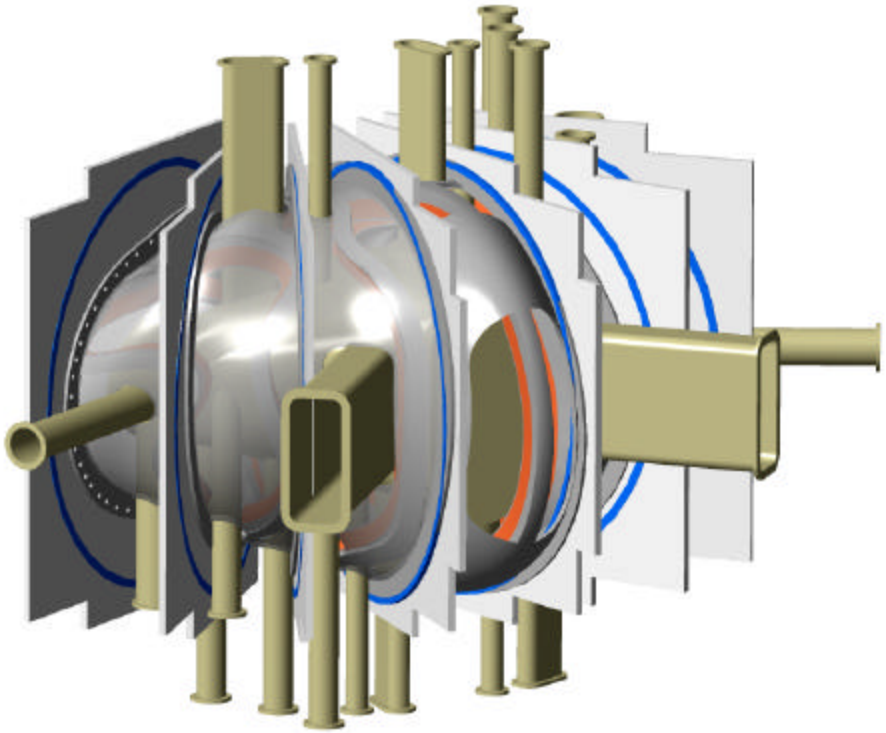
Half Field Period Subassembly



Field Period Subassembly

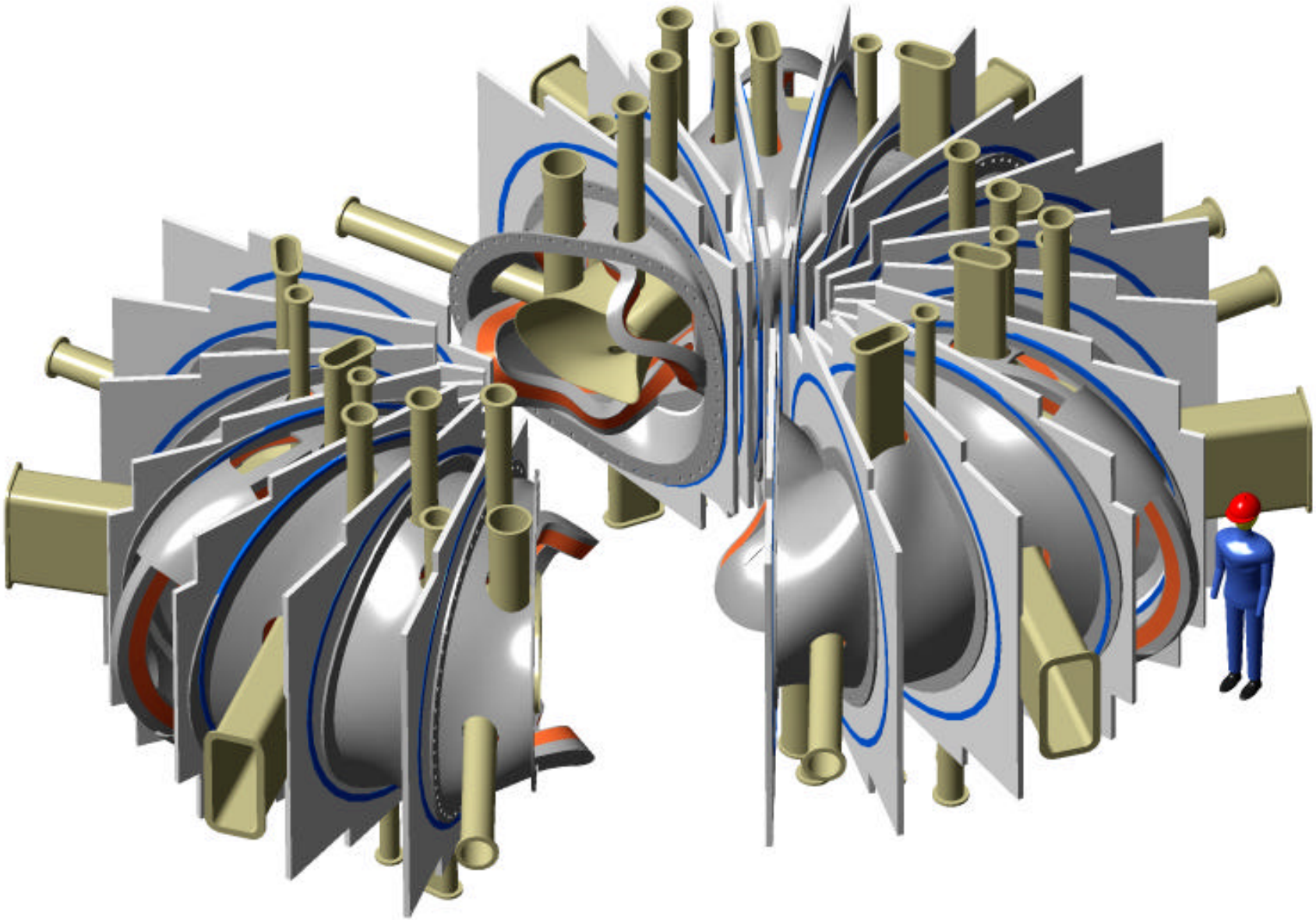


Before Attaching Vessel Port Extensions

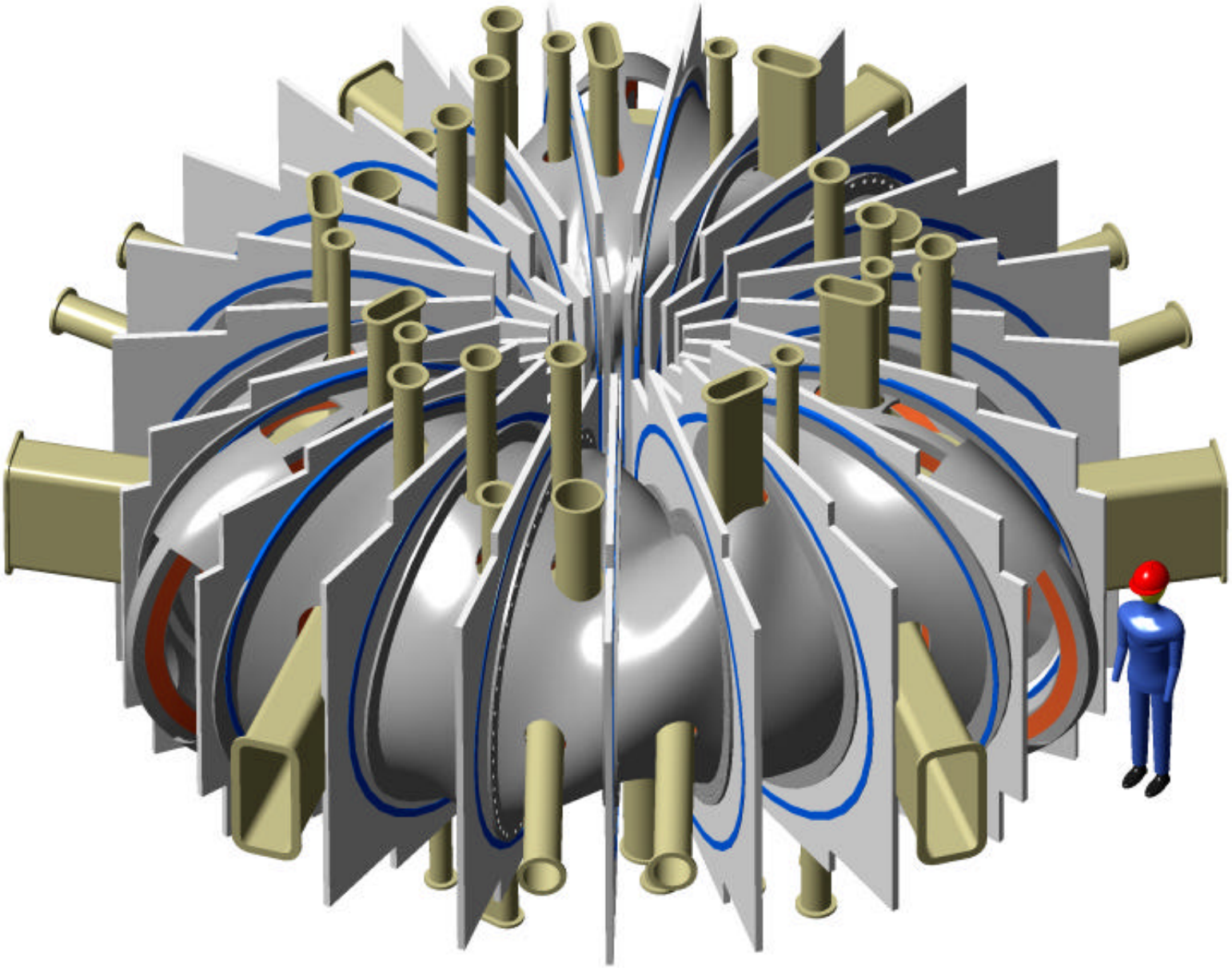


After Attaching Port Extensions

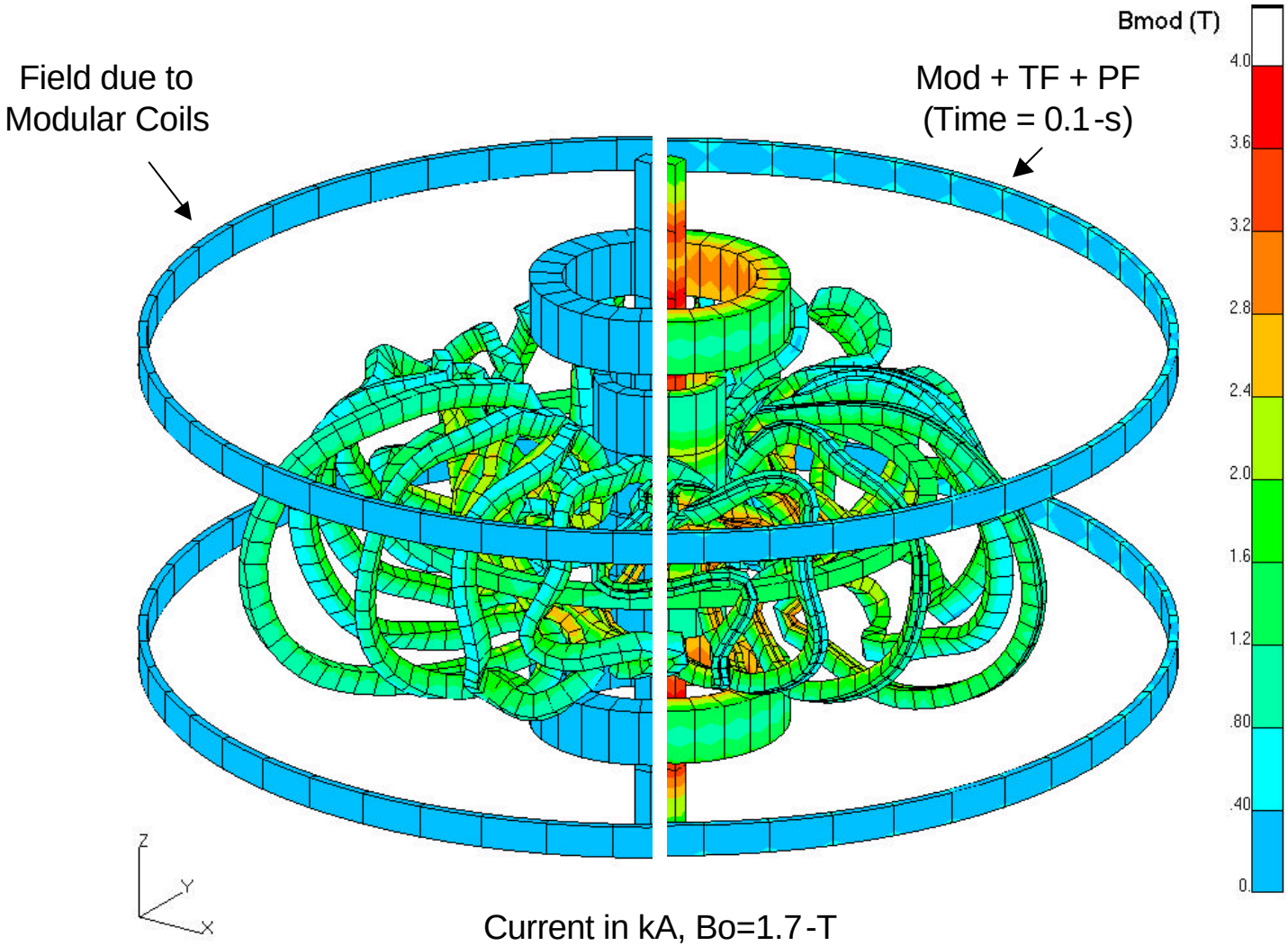
Assembly of 3 Field Periods



Modular Coil Assembly



EM Analysis with TF/PF Coils



Current in kA, Bo=1.7-T

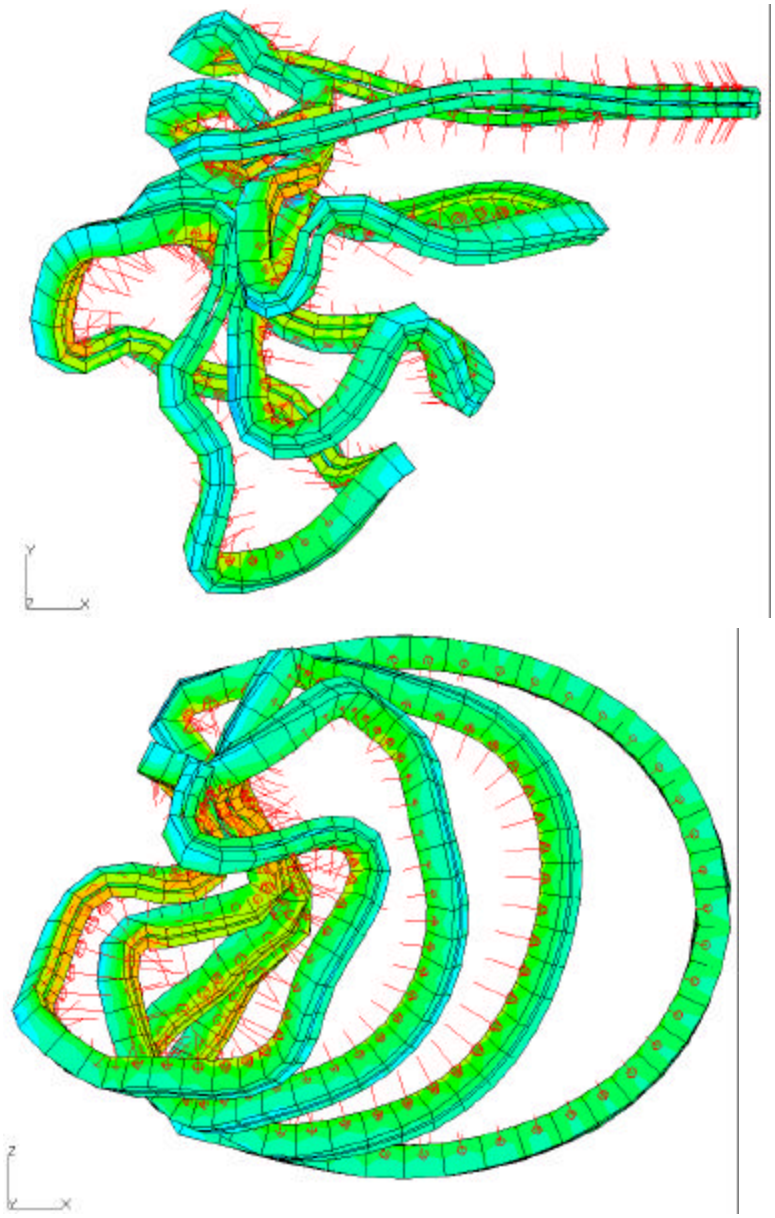
Time	M1	M2	M3	M4	PF1	PF2	Not used	PF3	Not used	Not used	PF4	TF	Plasma
-1.8	0	0	0	0	0	0	0	0	0	0	0	0	0
-1.5	0	0	0	0	-159	159	0	276	0	0	-28	-9	0
0	-635	-594	-614	-649	-954	957	0	1658	0	0	-166	-56	0
0.1	-635	-594	-614	-649	-954	957	0	1658	0	0	-166	-56	0

EM Force Vectors

- TF, PF fields at time = 0.1-s increase net radial force significantly

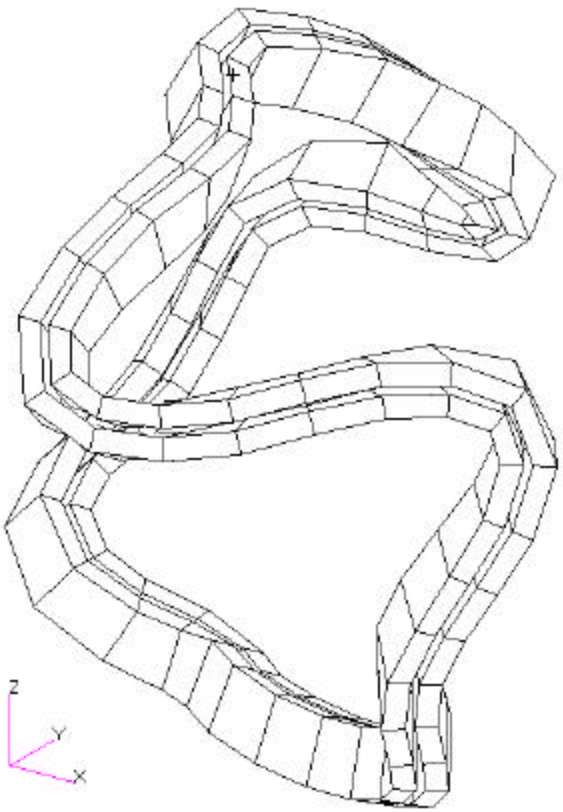
Coil Net Force in kN:

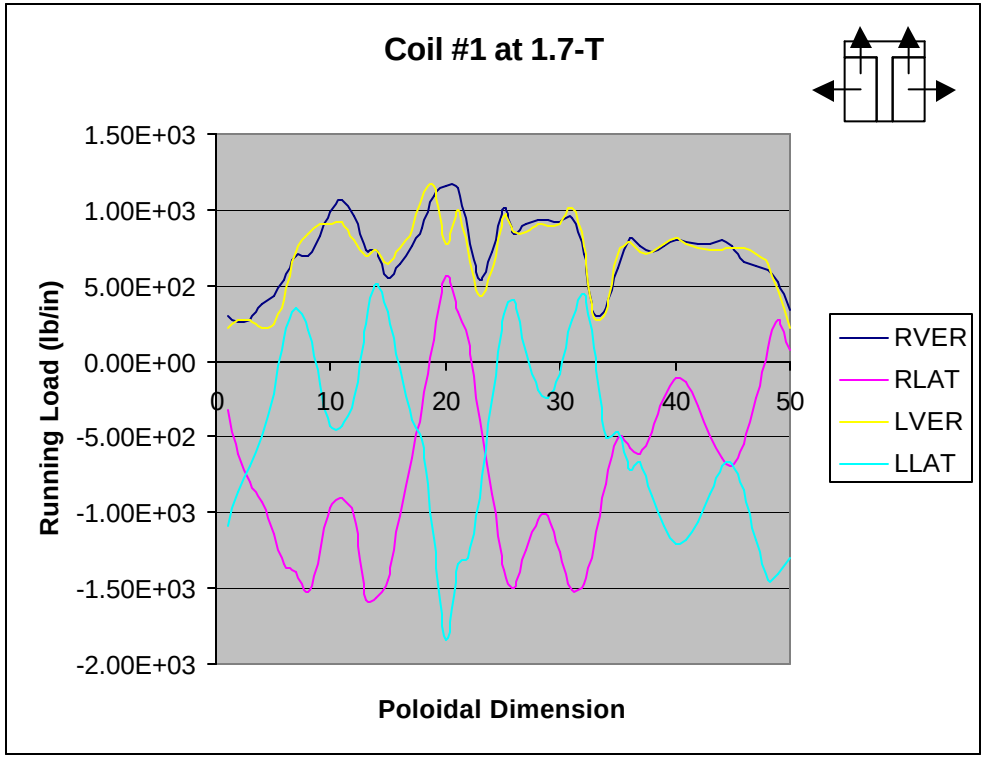
	Mods Only		Mods + TF + PF	
	FR	FZ	FR	FZ
1	-78	169	-216	169
2	-401	170	-485	176
3	-260	-17	-299	7
4	-318	0.8	-392	1



Coil #1 Force Components

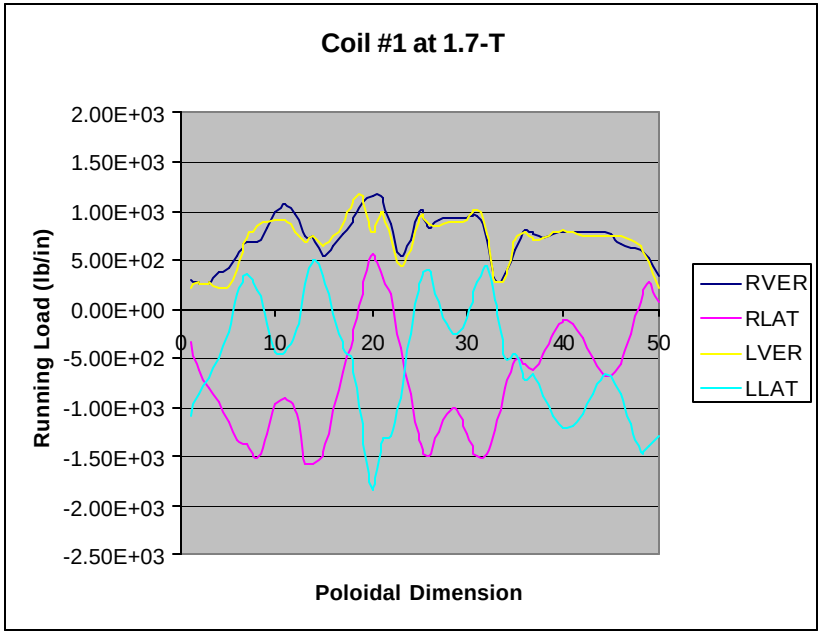
- Coil #1 has max upward load of ~1200-lb/in, max lateral load of ~1800-lb/in
- Maximum lateral load away from web is ~500-lb/in

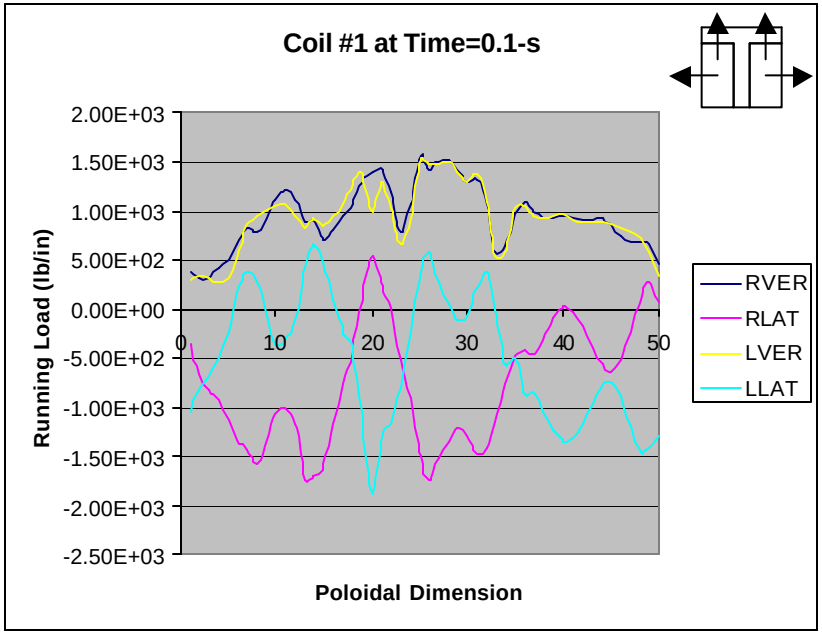




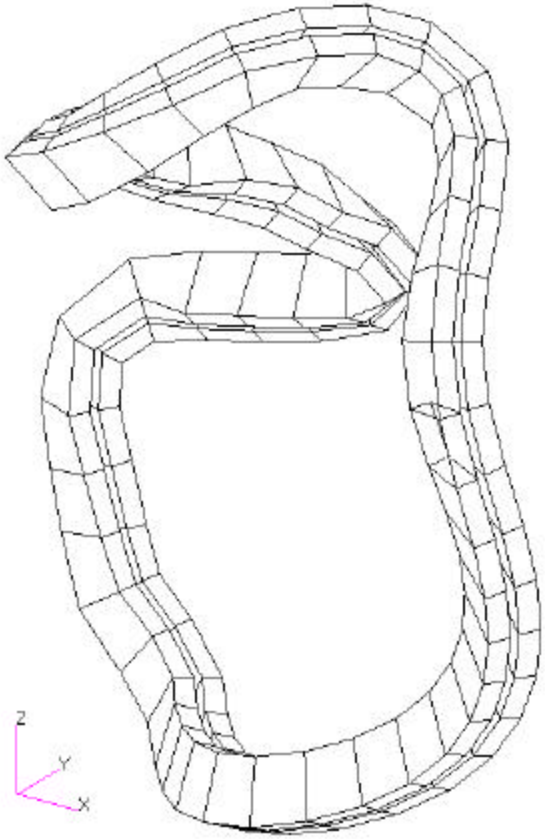
Coil #1 Force Components

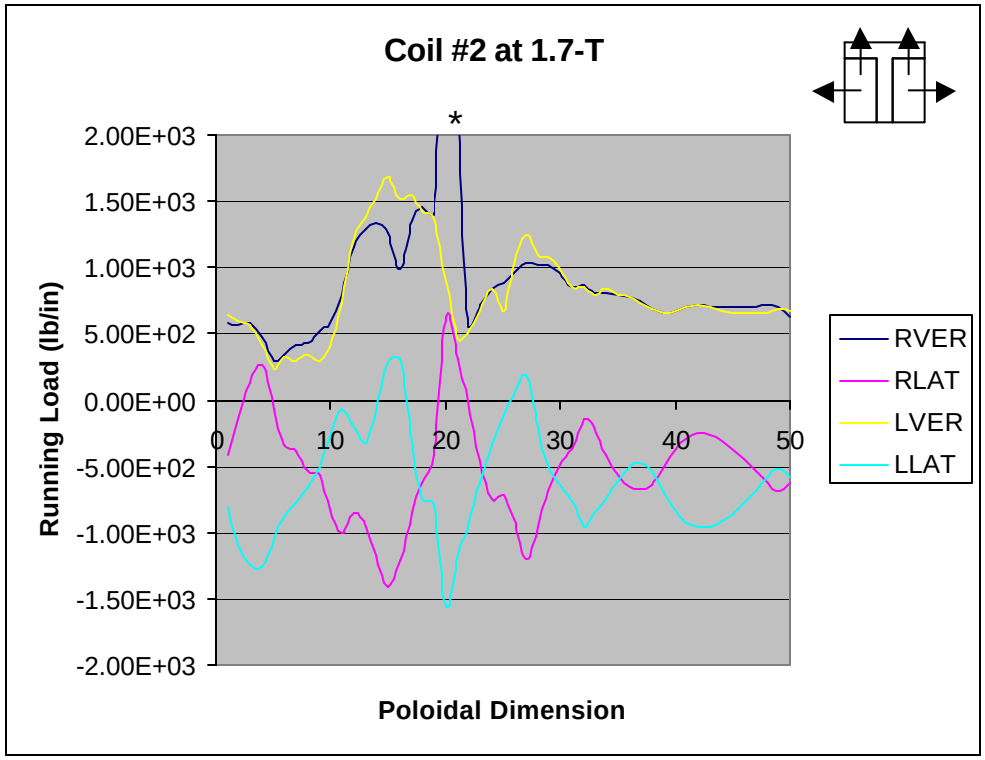
- With TF/PF coils added, upward load is increased to ~1500-lb/in





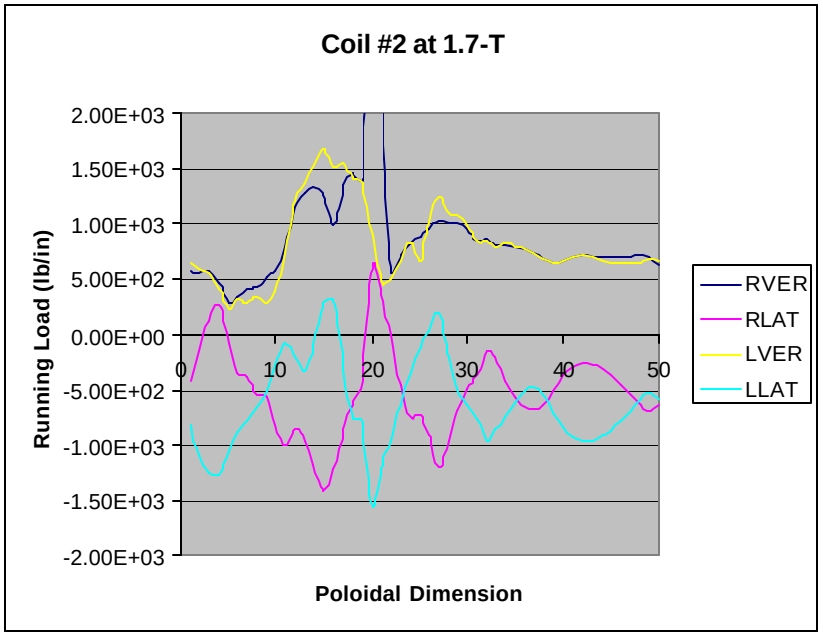
Coil #2, Mods Only

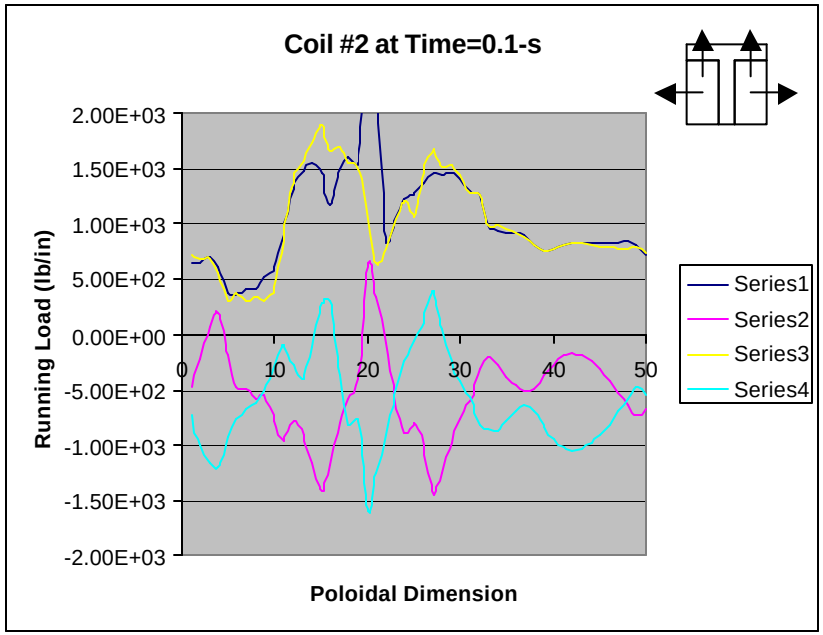




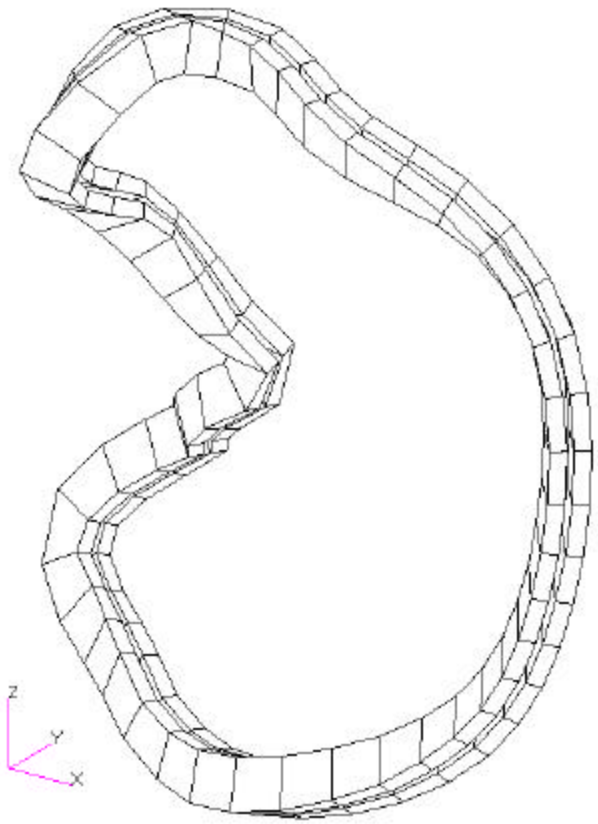
* Error- spike due to elem overlap

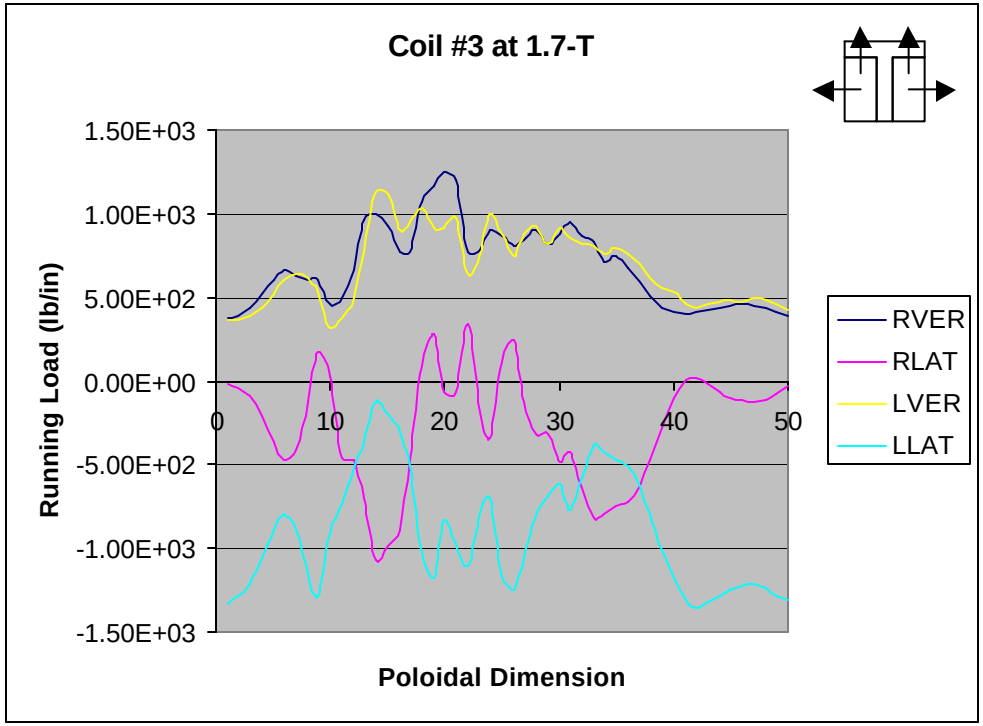
Coil #2, Mods + TF/PF



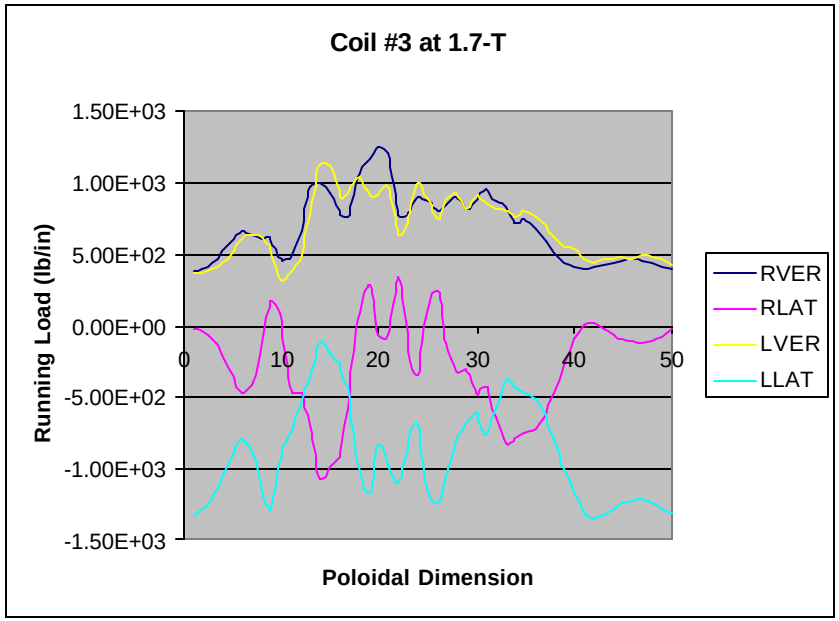


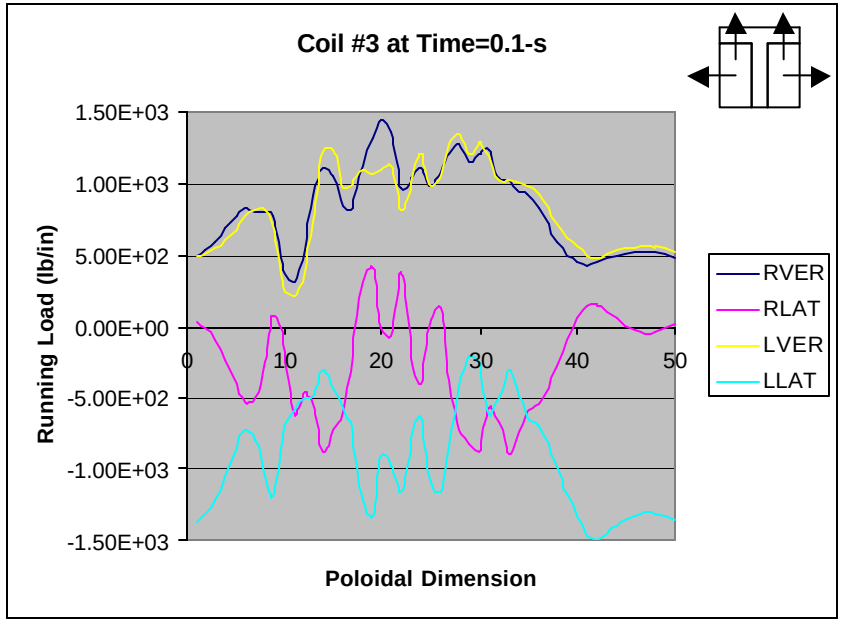
Coil #3, Mods Only



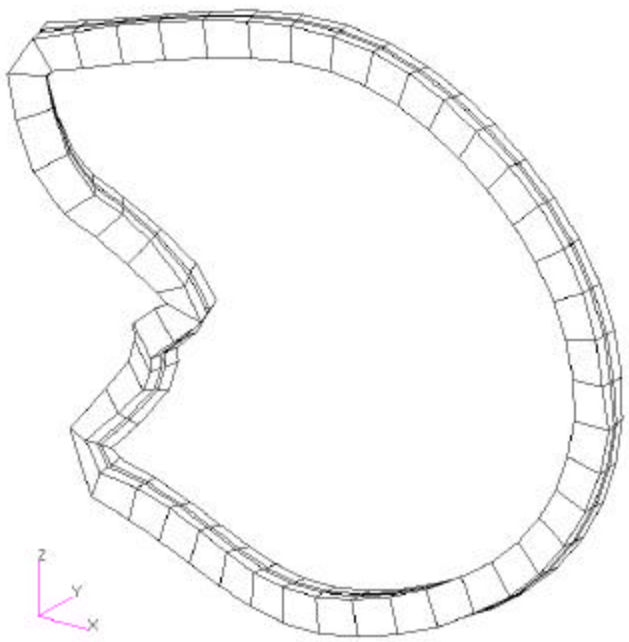


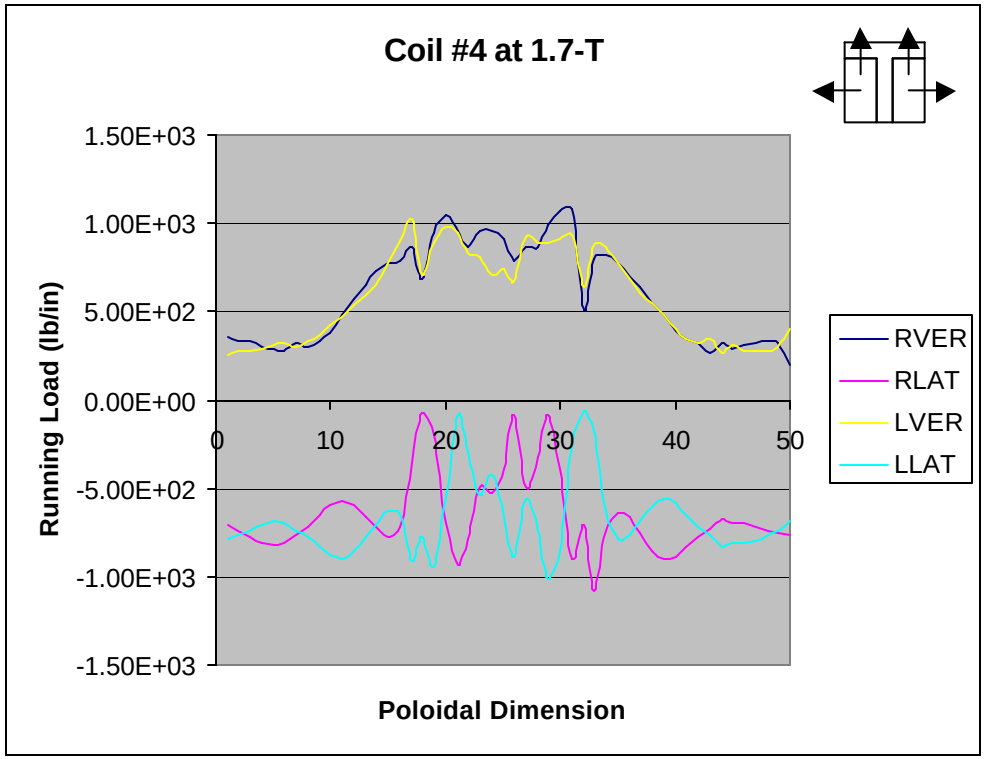
Coil #3, Mods + TF/PF



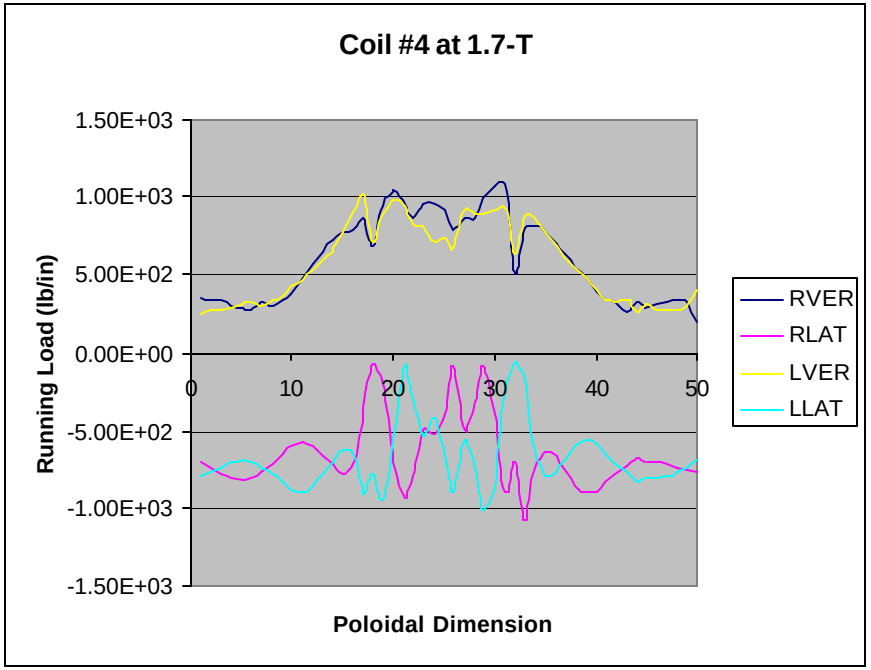


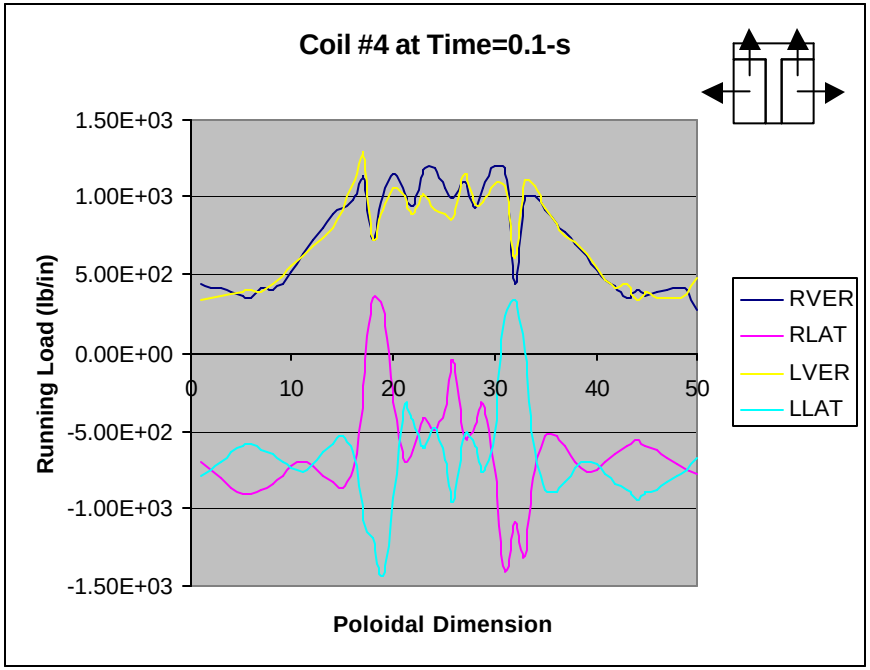
Coil #4, Mods Only





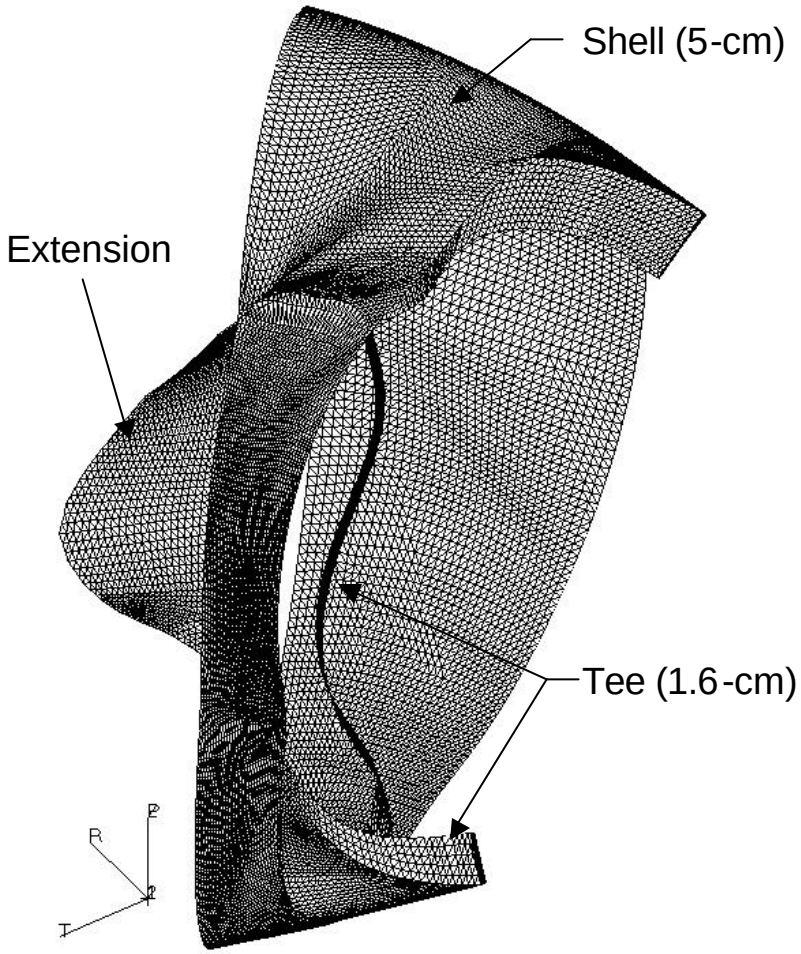
Coil #4, Mods + TF/PF

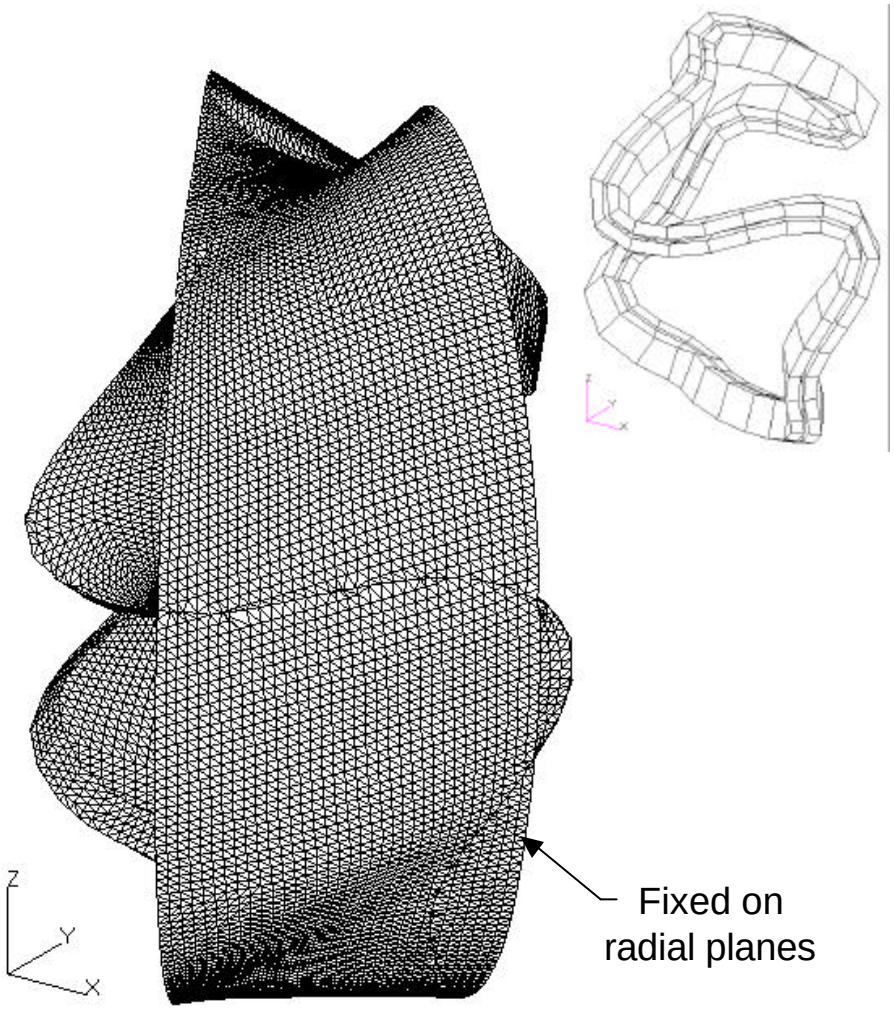




Structural Model of Coil #1

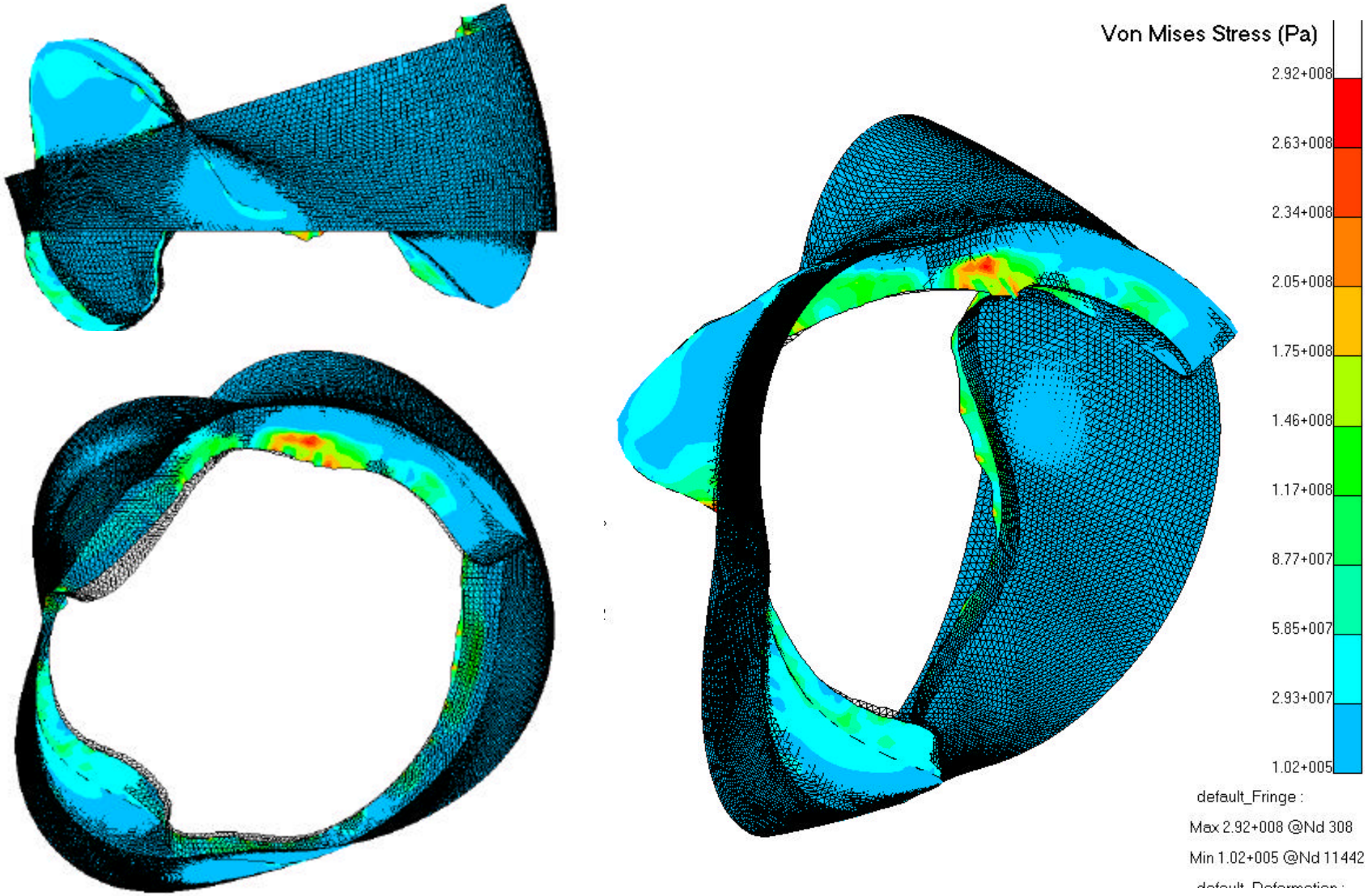
- ANSYS plate element model with MAGFOR loads applied at winding center (end of tee)





VM Stress Results

- Max displ = 0.4-mm, max stress = 292-Mpa (~130% YS)
- Modeling decisions tended to increase stress (shell shape, depth of tee, total load applied to web)



Summary / Conclusions

- Configuration as defined by INTRALINK database is much improved
- Minor revisions needed for PFCs, modular coils, support structure
- Interference checking in progress
- Stress analysis confirms basic coil structure sizing