WBS 14 - Helical Coils and Structure

23 February 1999

Design Parameters
- Saddle Coils
- Structure

Common Features

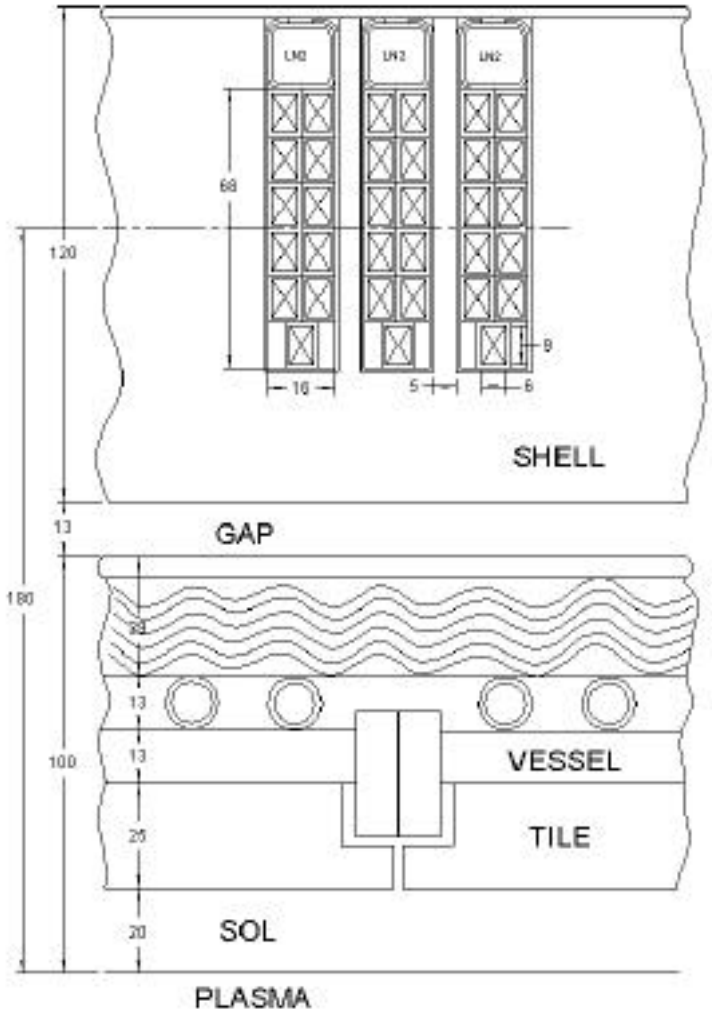
Design Options
- All Metal Wedges
- Metal Ribs with Cast Epoxy Fill
- Metal Shell with Cast Epoxy Fill

Issues

WBS 14 Design Parameters

Helical Coils

Plasma Configuration	C10 - 2T
Coil Configuration	SAD185-16
# Coils / Half Period	13
Dist from Plasma to Coil	18-cm
Current / Coil	84-kA
Min Coil C/L Spacing	23-mm
Nominal Coil Dimensions	18 x 70-mm
# Turns / Coil	10
Min Coil Bend Radius	8-mm
Shortest Coil Length (1-turn)	0.4-m
Longest Coil Length (1-turn)	16.7-m
Total Length of Conductor	4080-m
Total Weight of 78 Coils	6000-lb



WBS14 Design Parameters (cont'd)

Support Structure

Geometry:

- Inner surface conforms to vessel (R=1.5-m, a=0.45-m)

- Outer surface provides accurate (+/-.020") slots for coil winding

- Outer structure fits within PBX-M TF Coils

Temperature:

- Operating temperature = 80 - 300K

Electrical:

- Eddy current time constant < 10-ms

Strength:

- Withstand local EM pressures up to 3-ksi

Weight:

- Entire stellarator core < 50,000 lb

WBS14 Common Design Features

Helical Coils -

Braided Conductor	Ease of installation
Multiple Turns	Low current power supply, Minimize field errors
LN2 Cooling	Increase pulse length

Support Structure -

Segmented	Simplify VV fabrication, Minimize eddy currents
Exterior coils	Simplify coil installation

Other Desired Features -

Thermal exp like conductor	Minimize thermal stress
Good thermal conductivity	Simplify indirect cooling
Good machinability	Ease of slot fabrication

Support Structure Design Options

Option 1 - All Metal Wedges

- Structure consists of metal wedges arranged in a radial pattern
- Plates are attached to each other by bolts

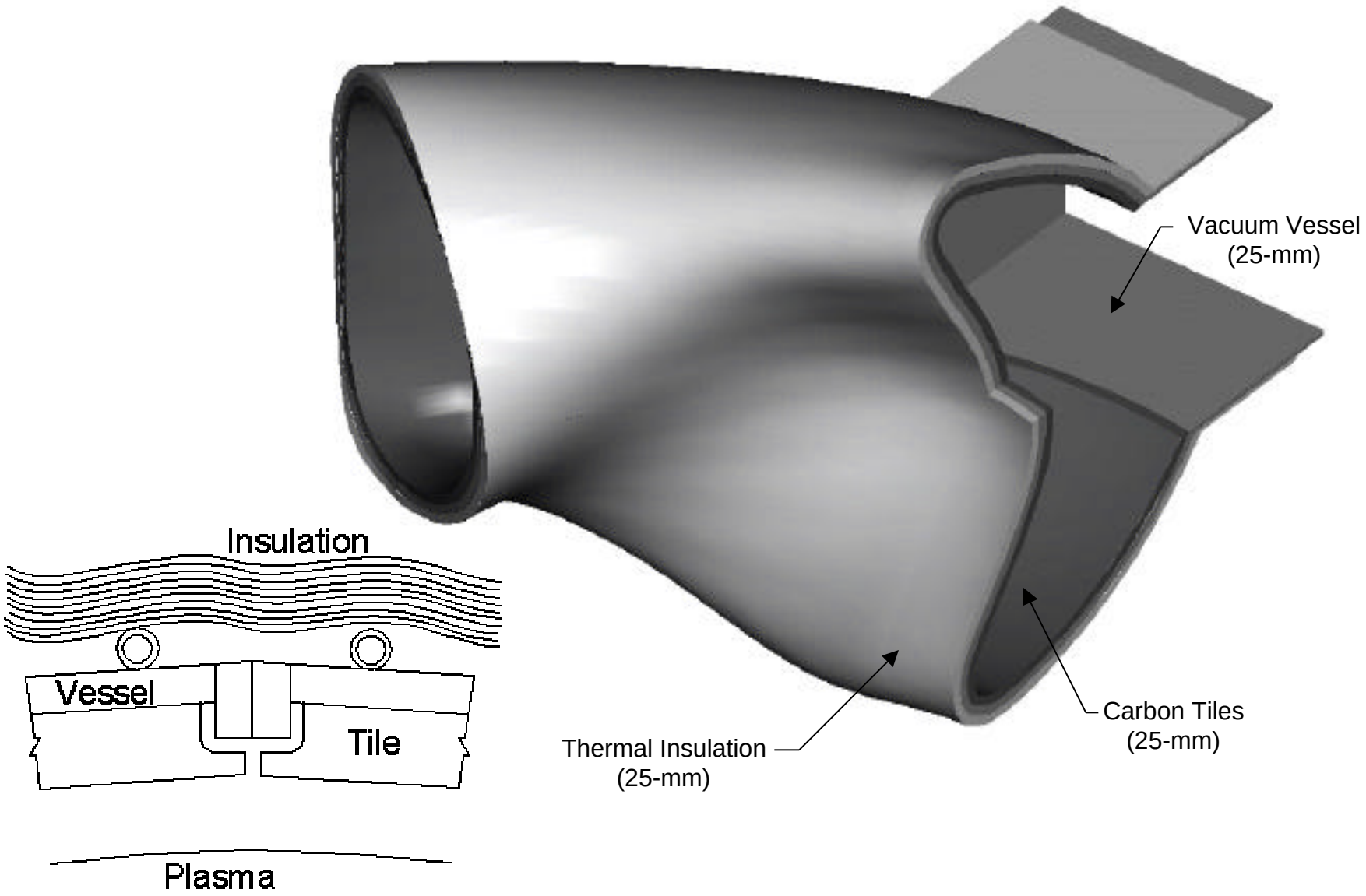
Option 2 - Ribs with Cast Epoxy Fill

- Structure consists of flat plates arranged in a radial pattern
- Cast epoxy fill between plates and in area of coil slots

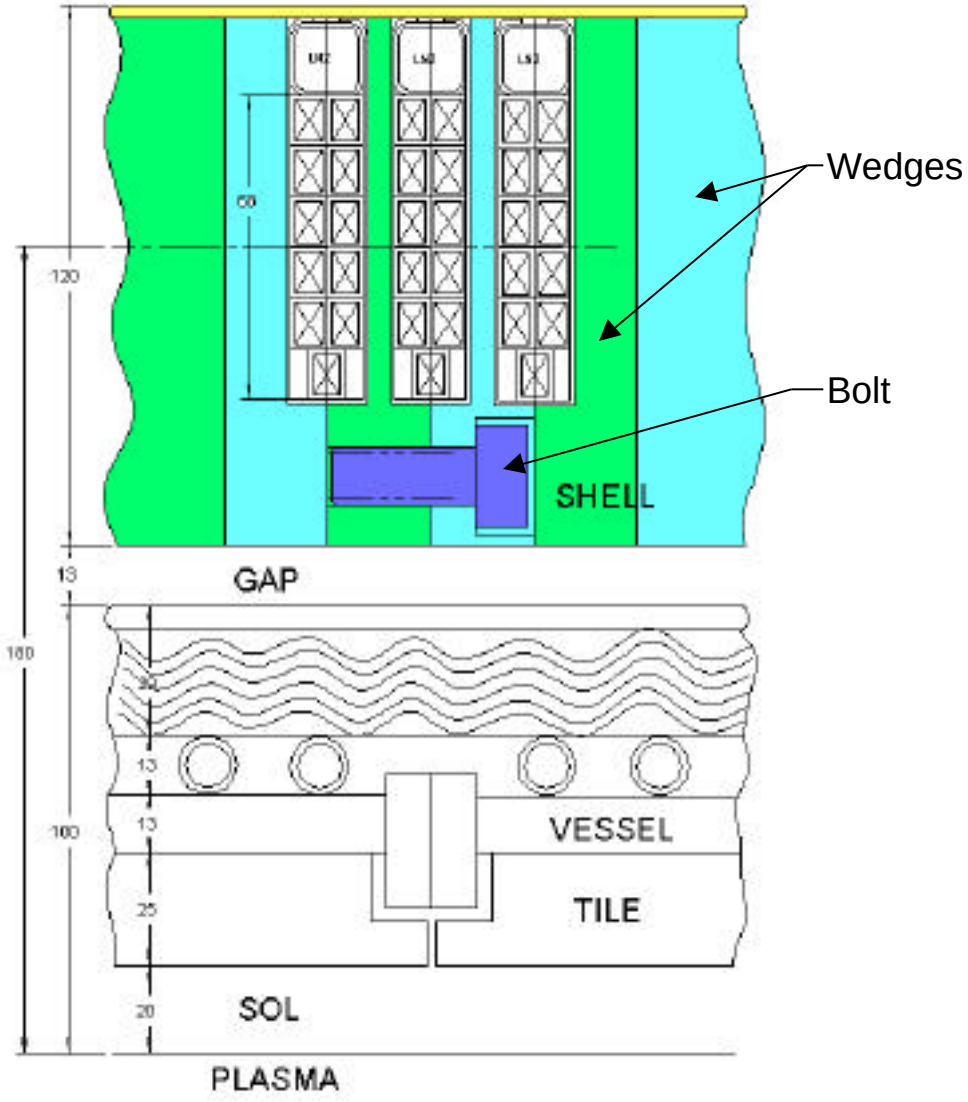
Option 3 - Shell with Cast Epoxy Fill

- Structure consists of an outer metal shell and inner cast epoxy shell
- The outer shell is removable to permit slot machining, coil winding

Assumption: Fully Assembled Vacuum Vessel



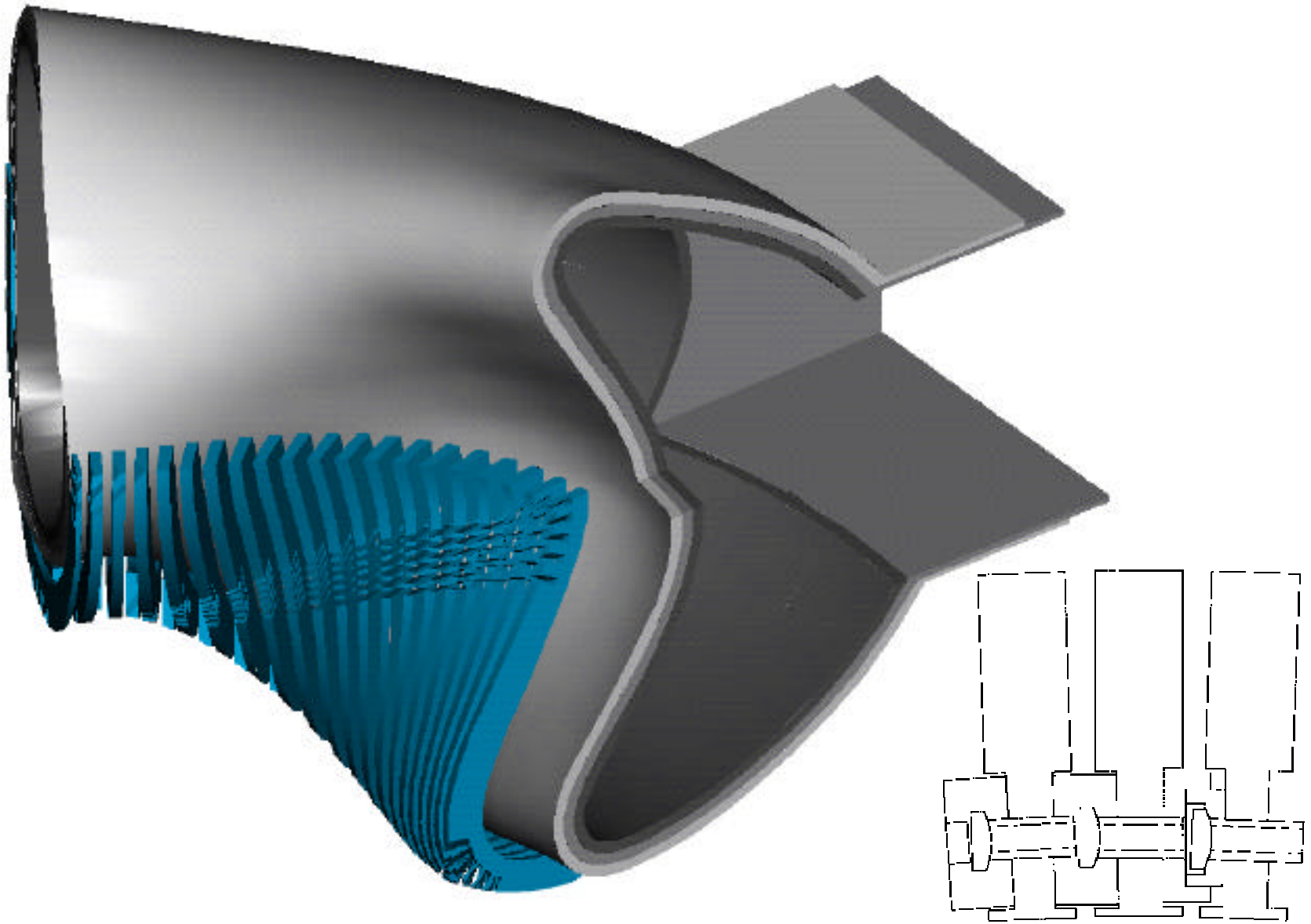
Option 1 - All Metal Wedges



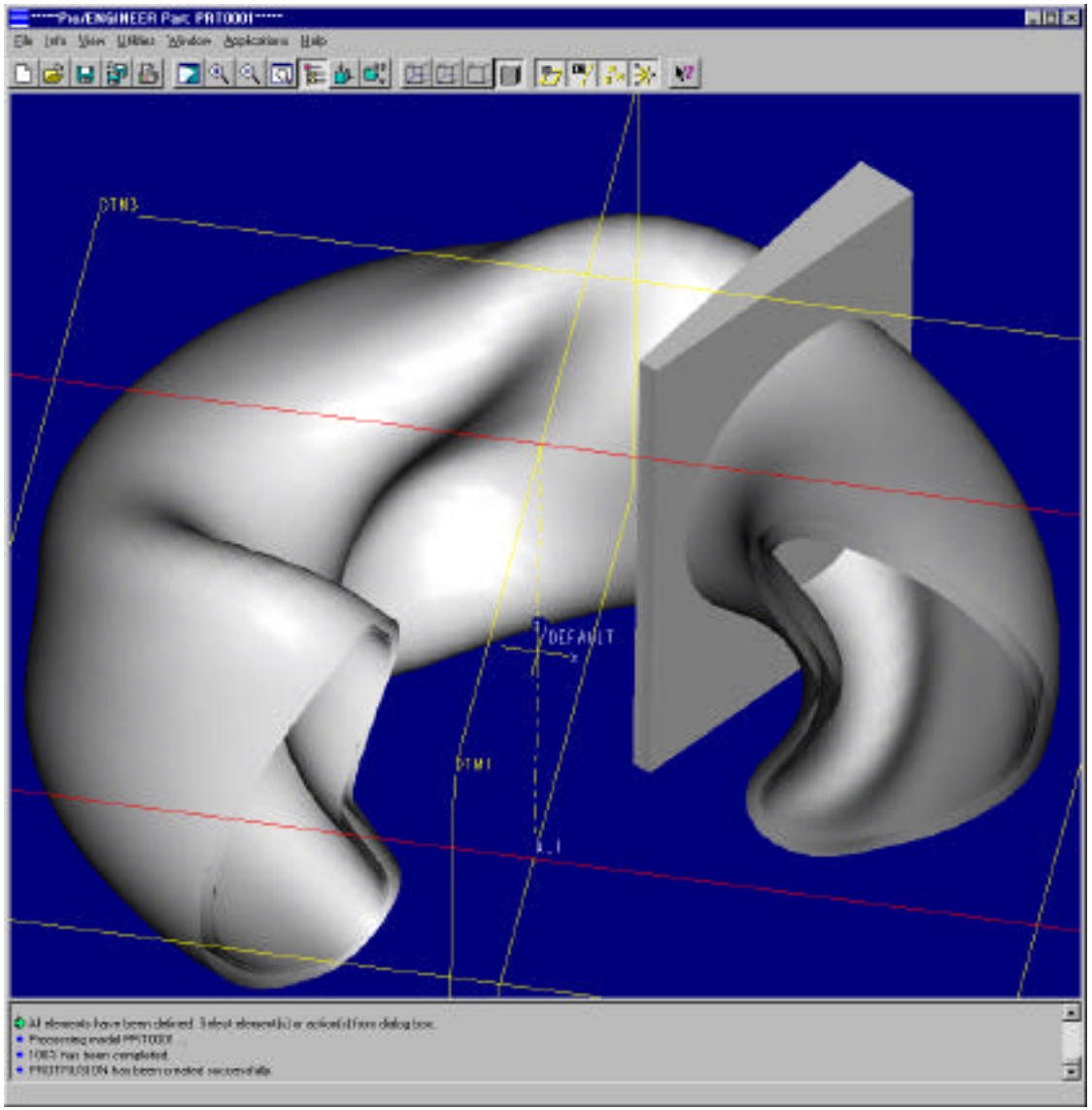
Parameters:

- Wedge -shaped radial plates
- 3-deg Sector (25-75 mm thk)
- 40 Patterns, 240 plates total
- Sheet insulation between wedges
- Bolted joints (allows pre-assem)
- Last wedge must be welded

Similar to old concept - Flat Radial Plates



Similar to old concept - Radial Wedges (7.5-deg)



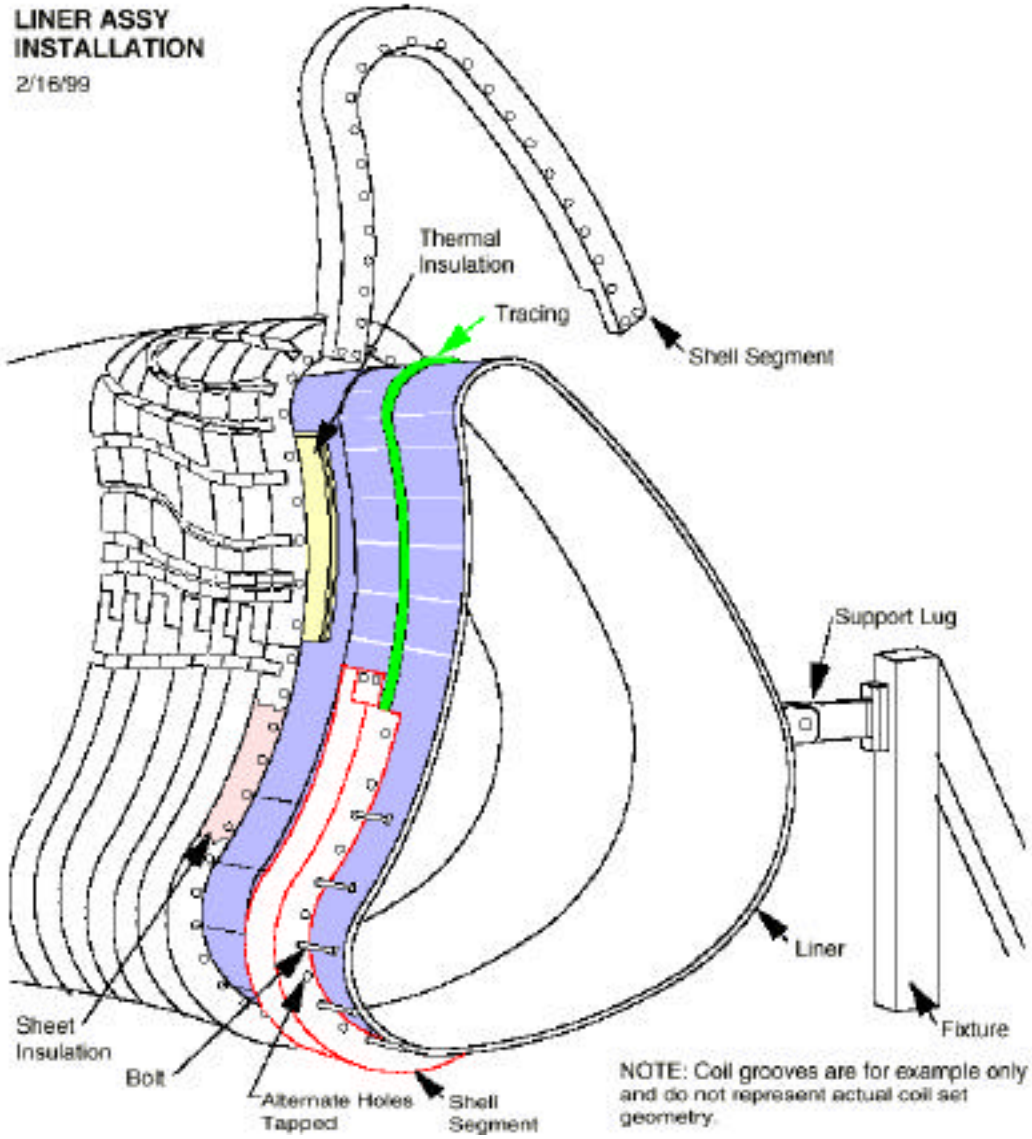
Option 1 - All Metal Wedges

Liner Structure

- Vacuum tight
- Atmospheric pressure
- All welded
- Traced cooling/heating
- Developed from flat plate
- Supported by coil structure
- Radial lugs for therm exp

Coil Structure

- Tapered radial plates
- Segments bolt to each other
- Assembled around liner
- Coil slots machined before or after assembly



Option 1 - All Metal Wedges

Fabrication / Assembly Sequence

Fabrication

Procure tapered plates
Cut inner / outer shape
Cut into poloidal segments
Reassemble poloidal segments
Drill holes / attachment features
Machine undersized coil slots

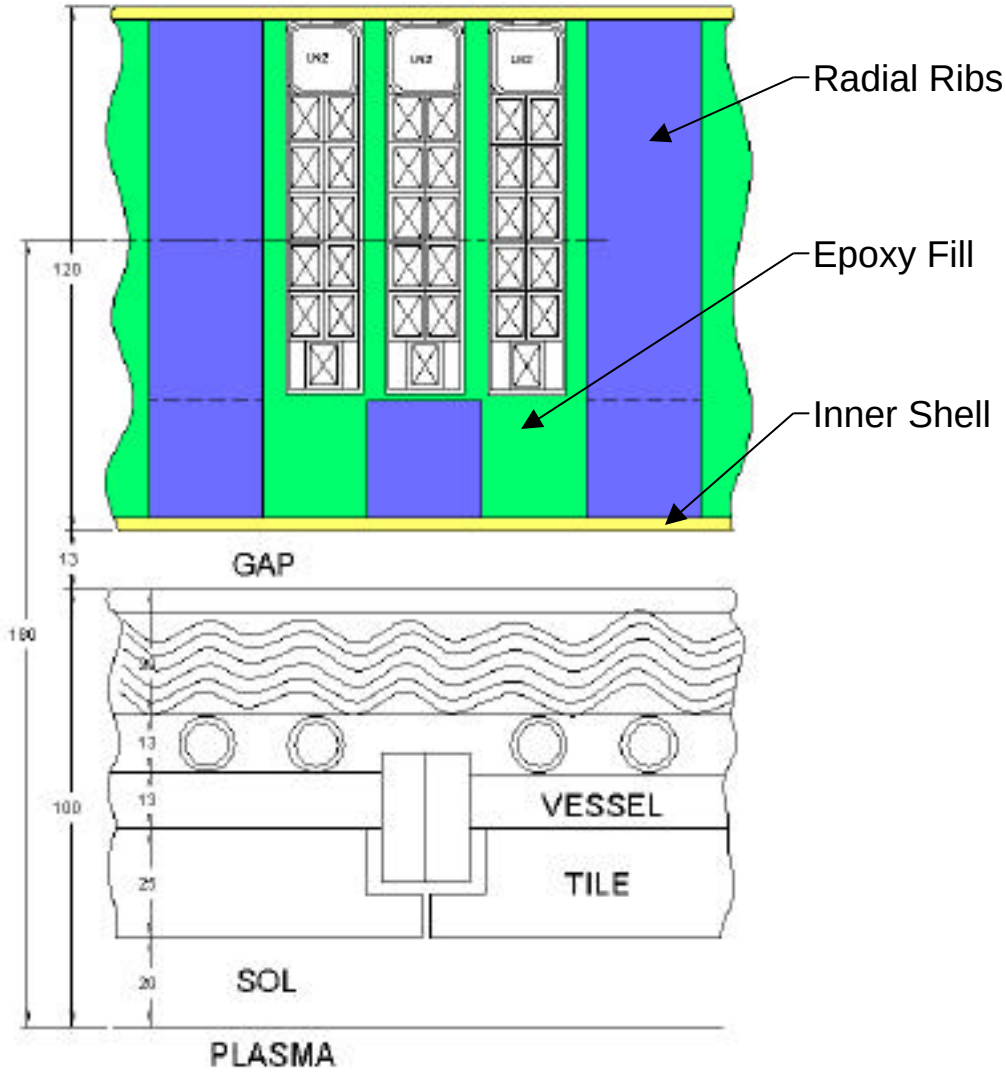
Pre-assembly

Position wedges on fixture
Install insulating shims
Bolt / pin wedges together
Perform coil slot final machining
Disassemble structure

Final Assembly

Reassemble around vacuum vessel
Prepare for coil installation

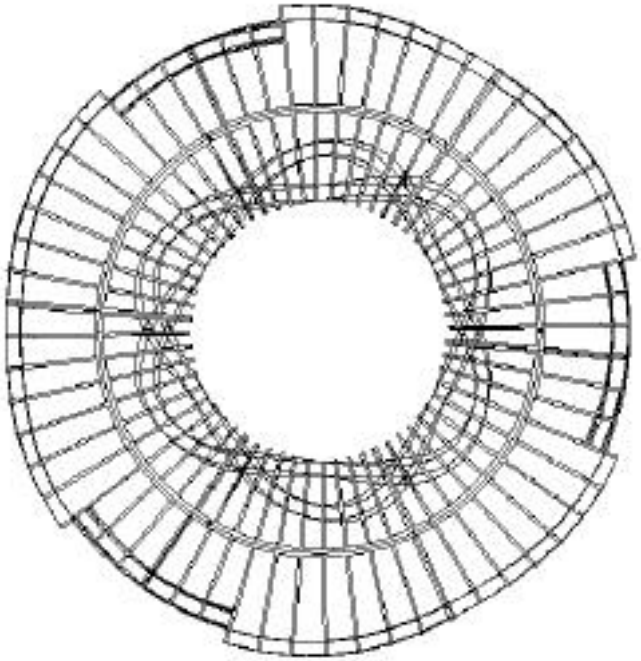
Option 2 - Metal Ribs / Cast Epoxy Fill



Parameters:

- Flat radial plates (25-mm thk)
- 20 Patterns, 120 plates total
- 18 Sub-assemblies
- Inner shell for epoxy fill

Option 2 - Metal Ribs / Cast Epoxy Fill



TOP VIEW

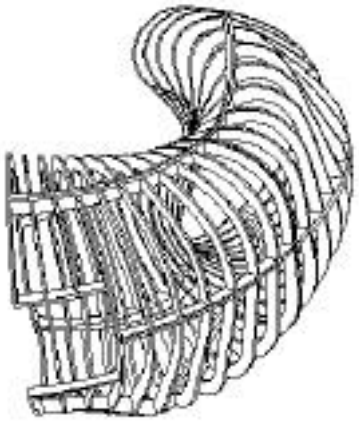
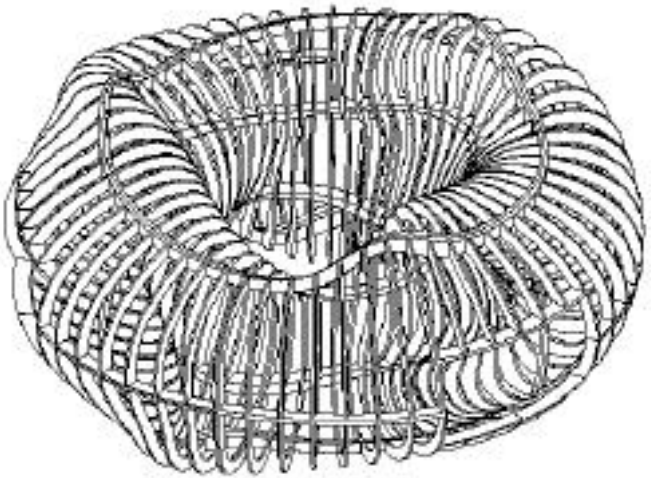
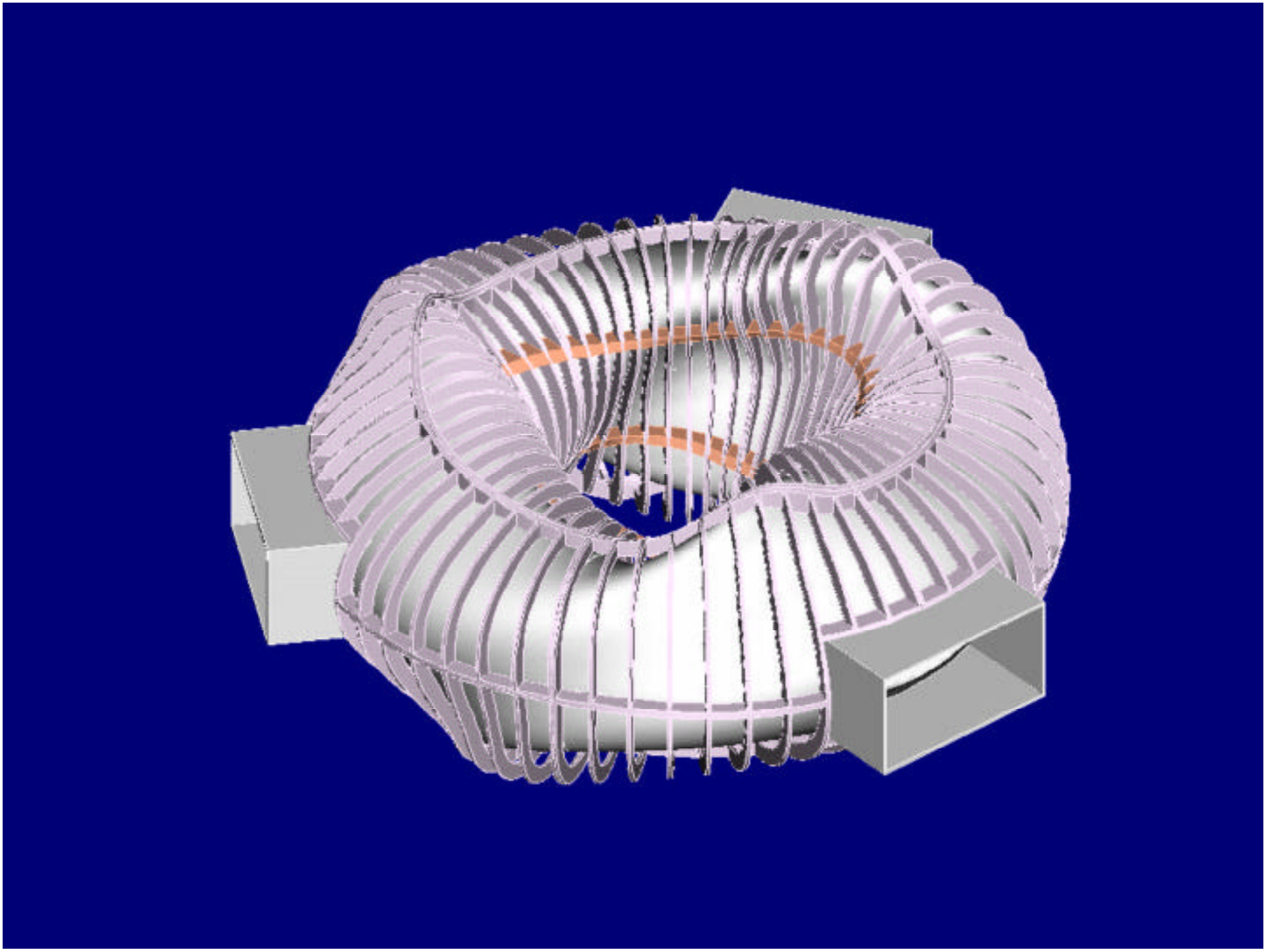
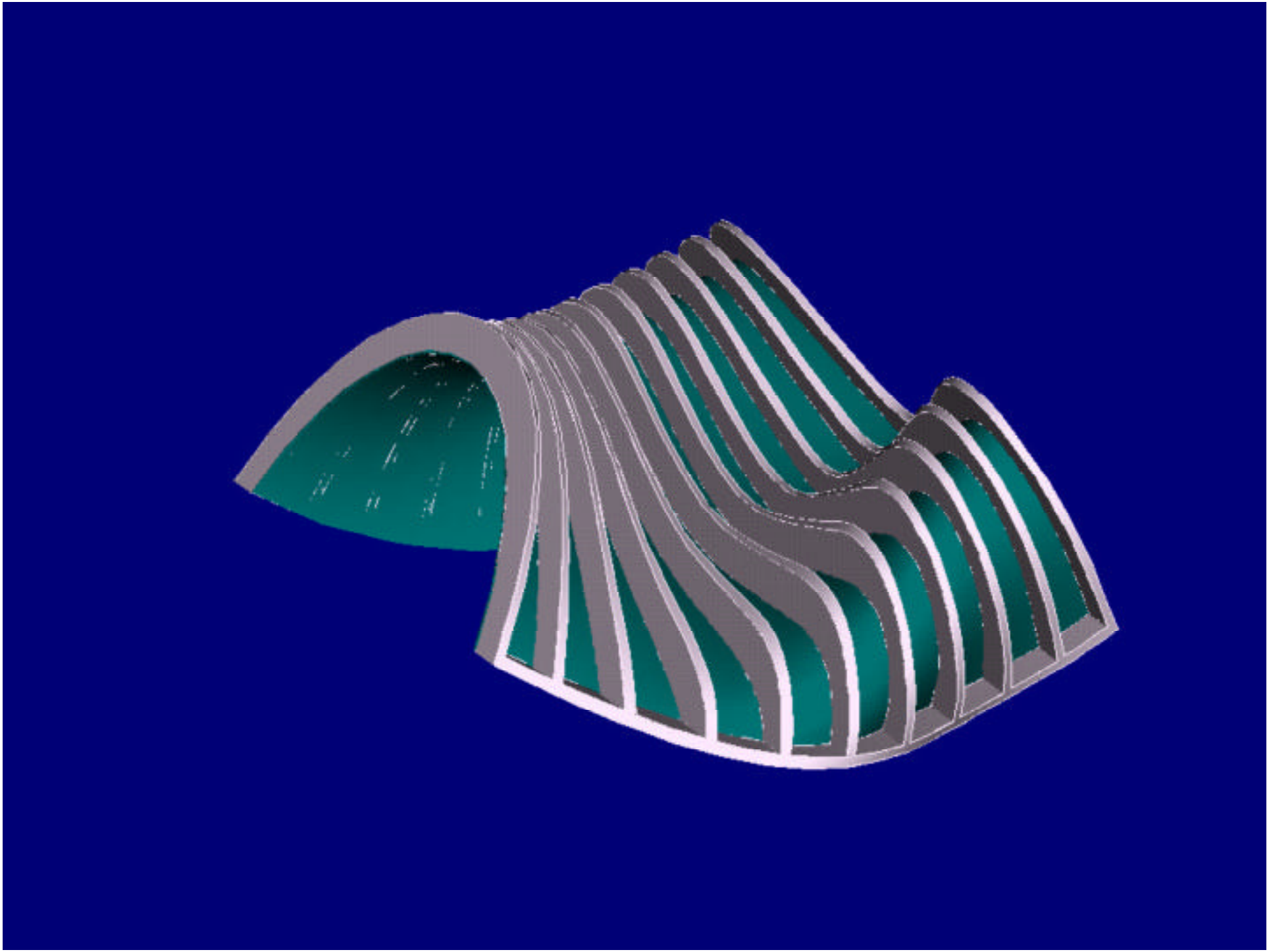


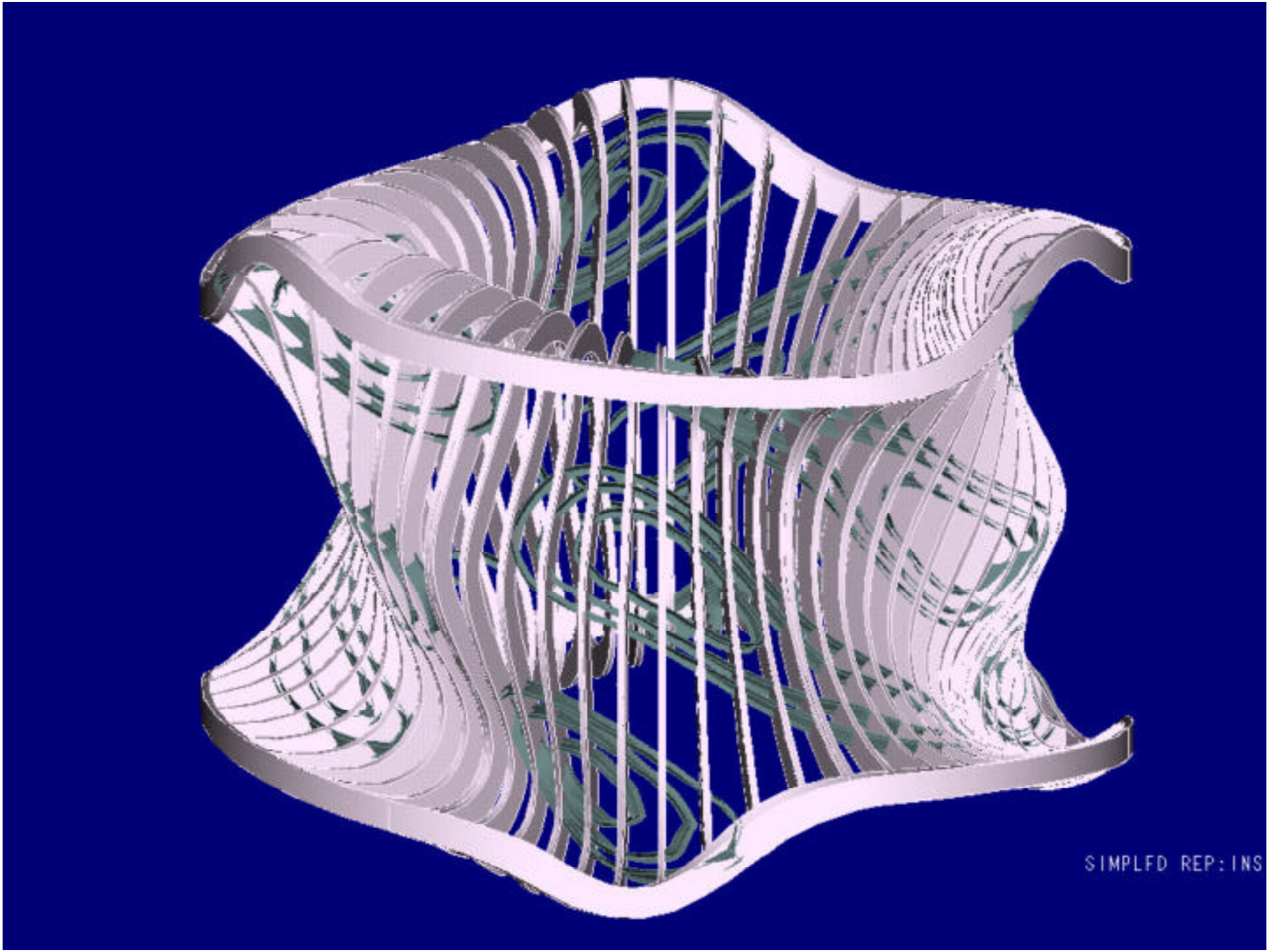
PLATE STRUCTURE
ONE PERIOD

EXPLODED VIEW








SIMPLFD REP:INS

Option 2 - Metal Ribs / Cast Epoxy Fill

Fabrication / Assembly Sequence

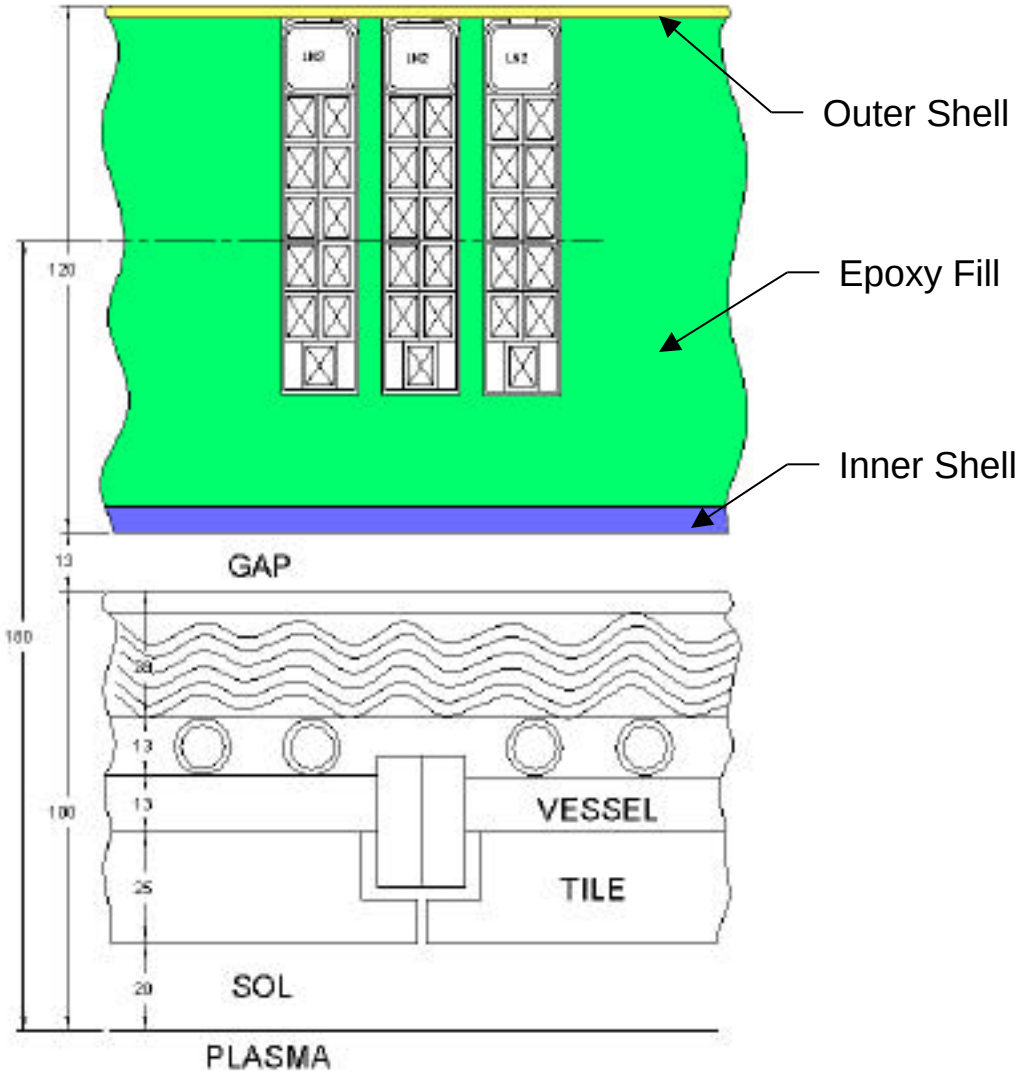
Fabrication

Procure flat plates
Cut inner / outer shape
Cut into poloidal segments
Reassemble poloidal segments
Machine undersized coil slots
Weld into sub-assemblies
Install inner shell form

Assembly

Position sub-assemblies around vessel
Bolt / pin / weld sub-assemblies together
Cast epoxy / glass fill
Perform coil slot final machining
Prepare for coil installation

Option 3 - Metal Shell / Cast Epoxy Fill



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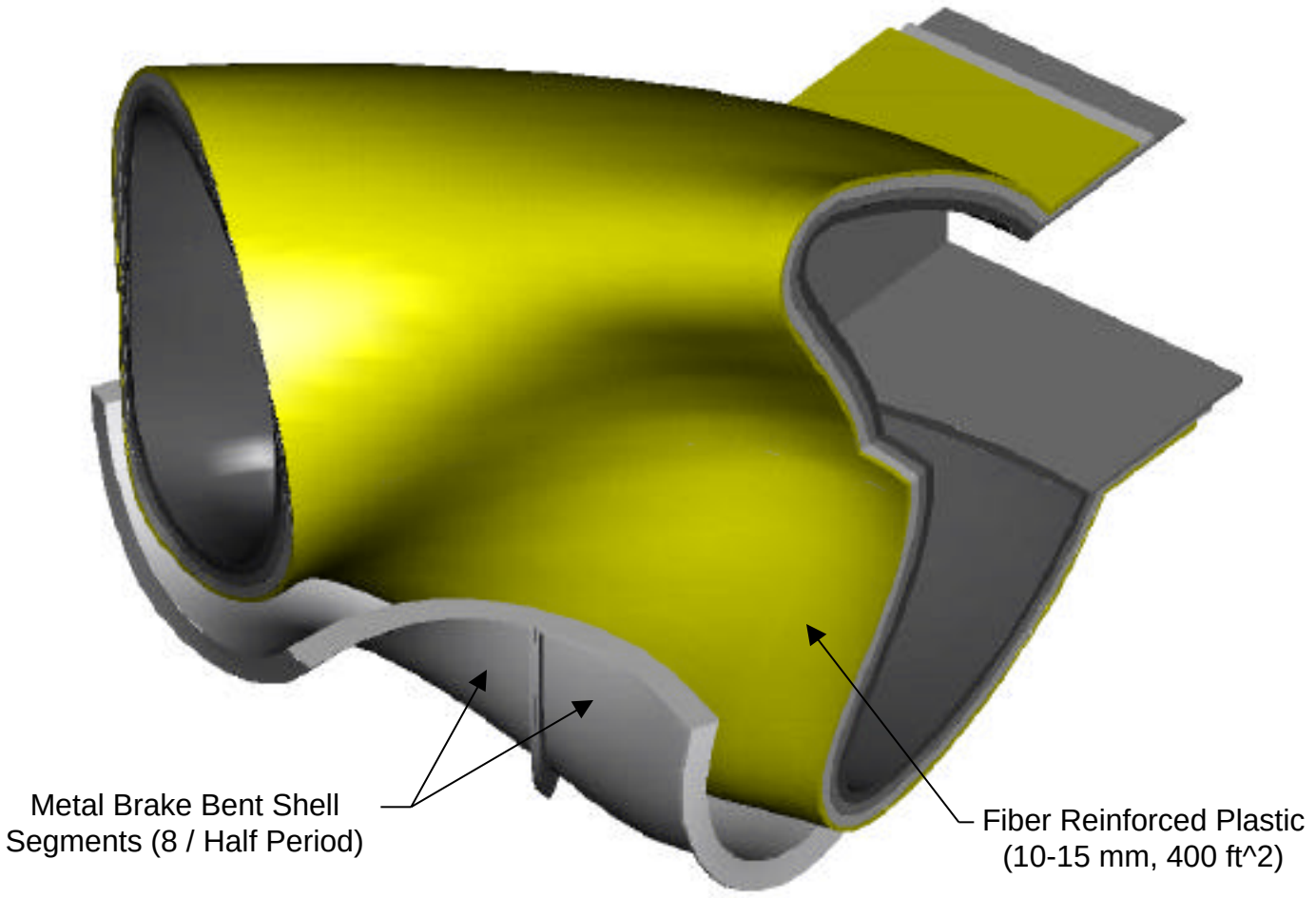

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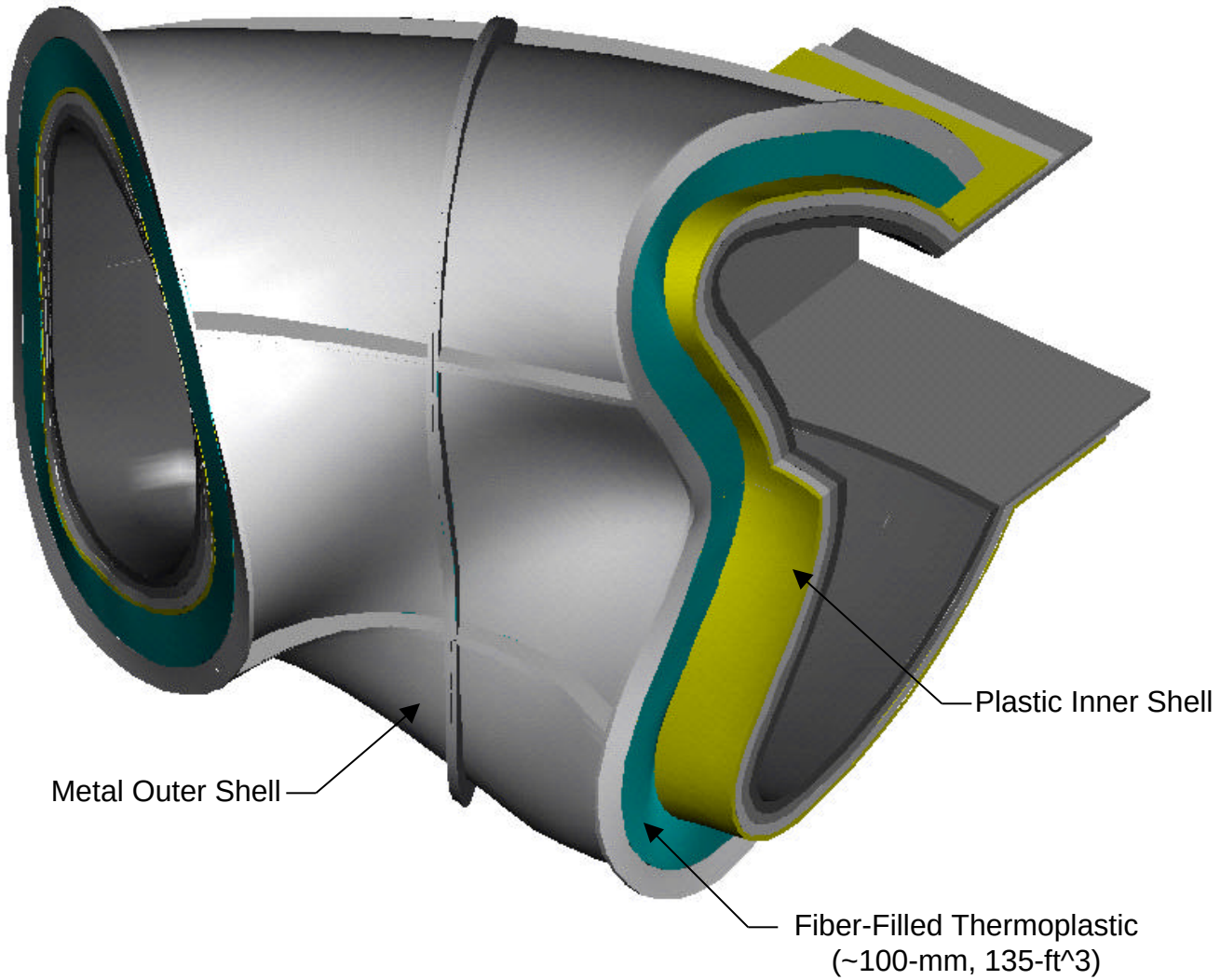

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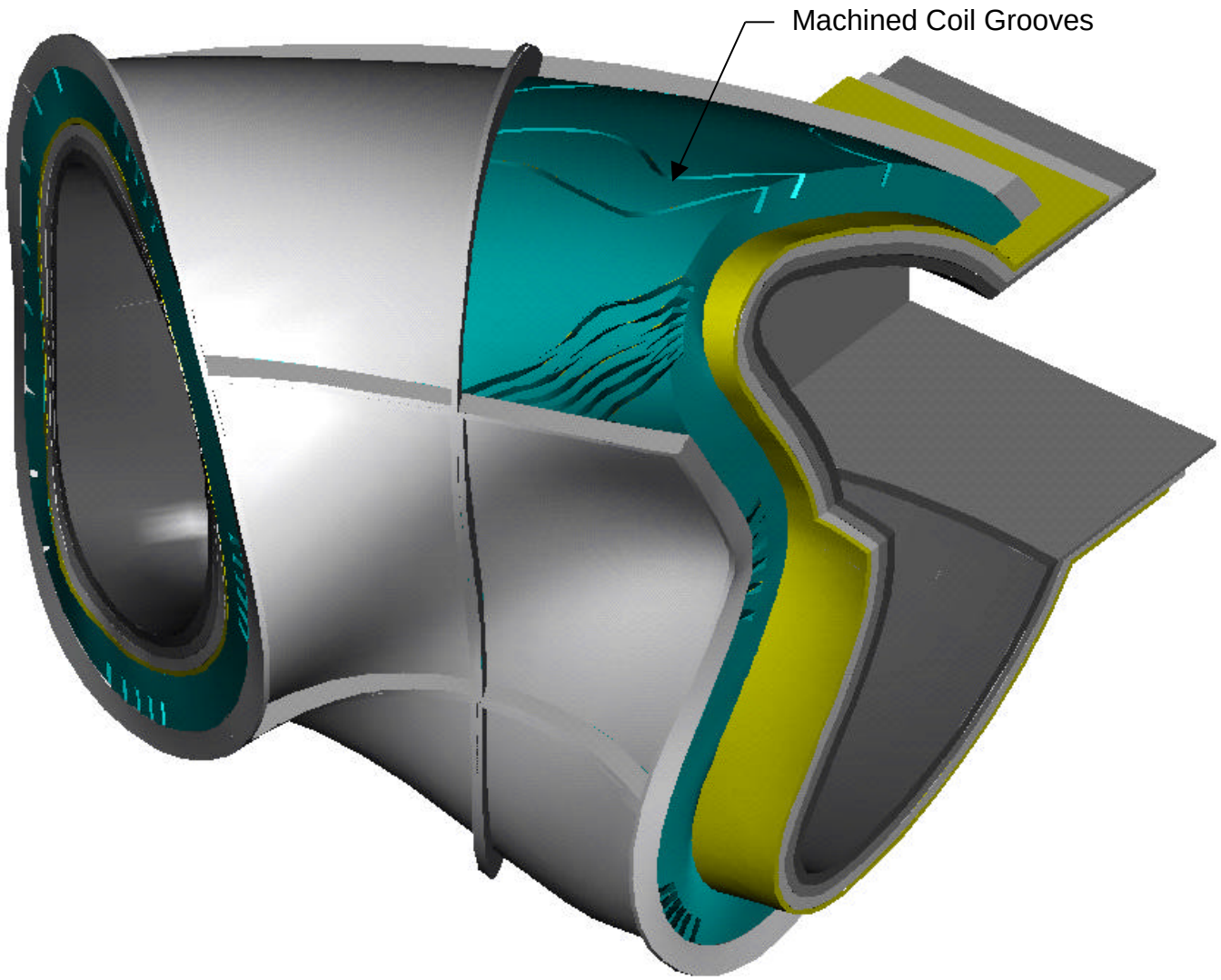
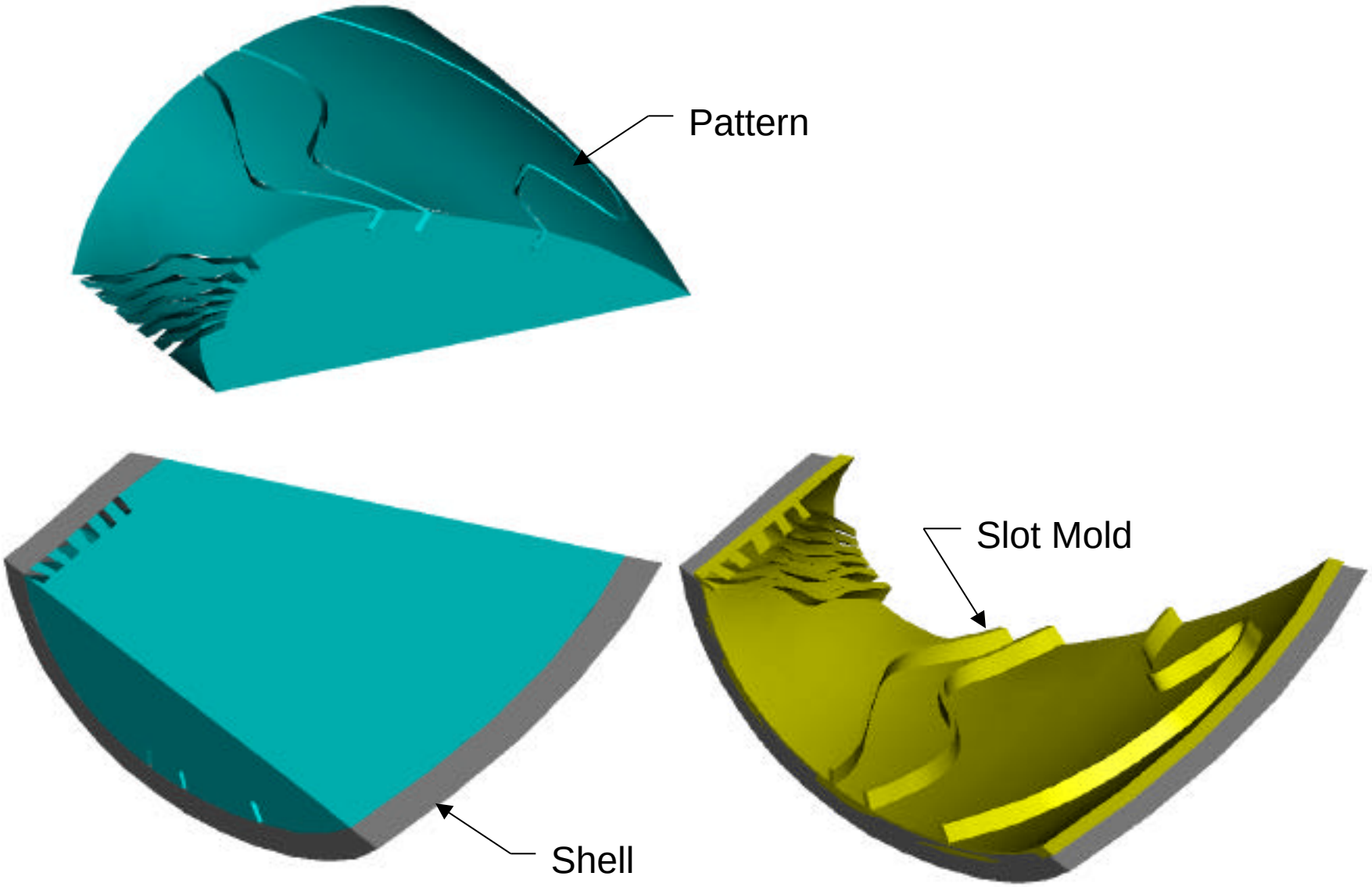


Option 3 - Winding Form with Slot Mold



Option 3 - Metal Shell / Cast Epoxy Fill

Fabrication / Assembly Sequence

Fabrication

Procure flat plates
Cut flanges and developed shapes
Brake bend shell segments
Weld into sub-assemblies

Assembly

Install inner shell form around vessel
Position outer shell around form
Cast epoxy fill between shells
Perform coil slot final machining
Prepare for coil installation

Design Option Evaluation and Issues

Option 1 - All Metal Wedges

- Thermal expansion compatible with conductor
- Good mechanical properties
- Most conventional; requires less R&D

Issues:

- Cost/availability of tapered plate
- Installing last wedge
- Weight of stellarator core

Option 2 - Metal Ribs / Cast Epoxy Fill

- Uses fewer plates; plates are flat
- Easy to machine coil slots

Issues:

- Thermal expansion differences
- Strength unknown
- Casting process (filling, curing)
- Significant R&D required

Design Option Evaluation and Issues (cont'd)

Option 3 - Metal Shell / Cast Epoxy Fill

- Brake-bent shell same as vessel
- Less assembly labor
- Easy to machine coil slots

Issues:

- Thermal expansion differences
- Strength unknown
- Casting Process (filling, curing)