Status of the Power Core Configuration Based on Modular Maintenance

Presented by X.R. Wang

Contributors: S. Malang, A.R. Raffray
and the ARIES Team

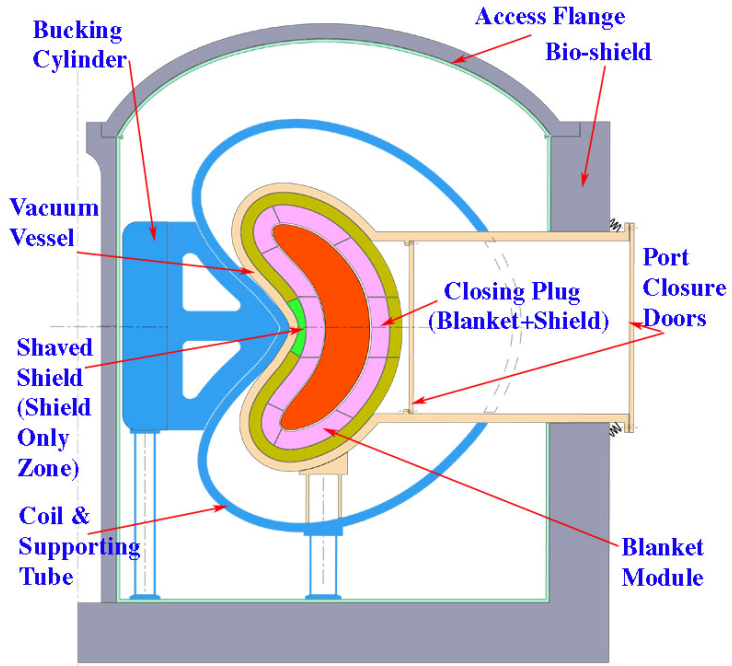
ARIES Meeting
University of Wisconsin, Madison
June 14-15, 2005

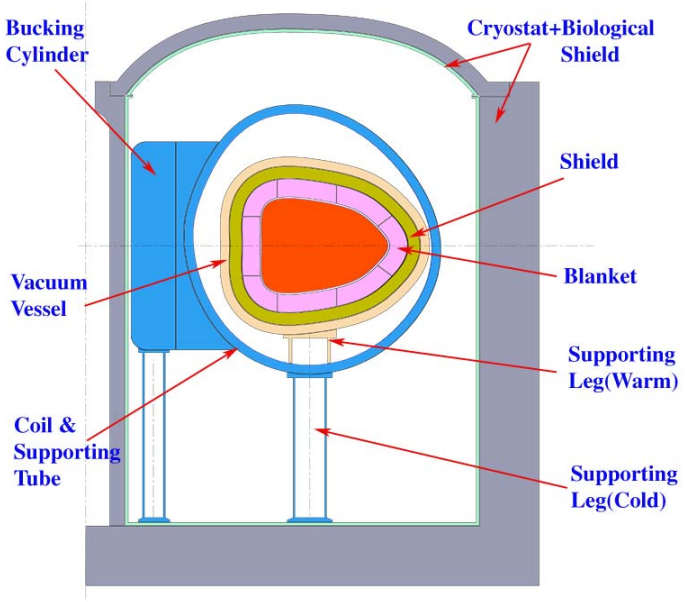
What is new?

- Start 3D CAD modelling of ARIES-CS power core components.
  - -bucking cylinder
  - -coils&coil structure tube
  - -internal vacuum vessel
  - -manifold
  - -hot shield
  - -FW&blanket
  - -building

- Check and analysis space issue of the power core components and assemblies.
  - -interference/clearance calculations
  - -volume calculations

Power Core Configuration Based on Modular Maintenance Approach

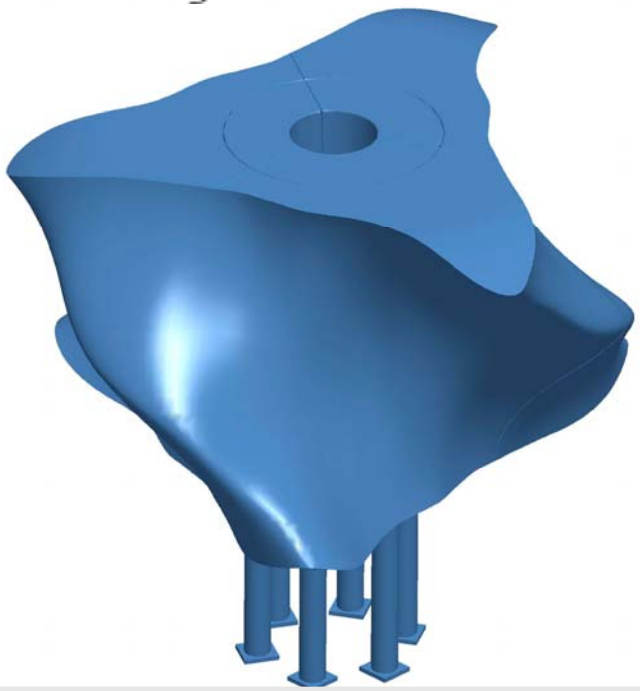


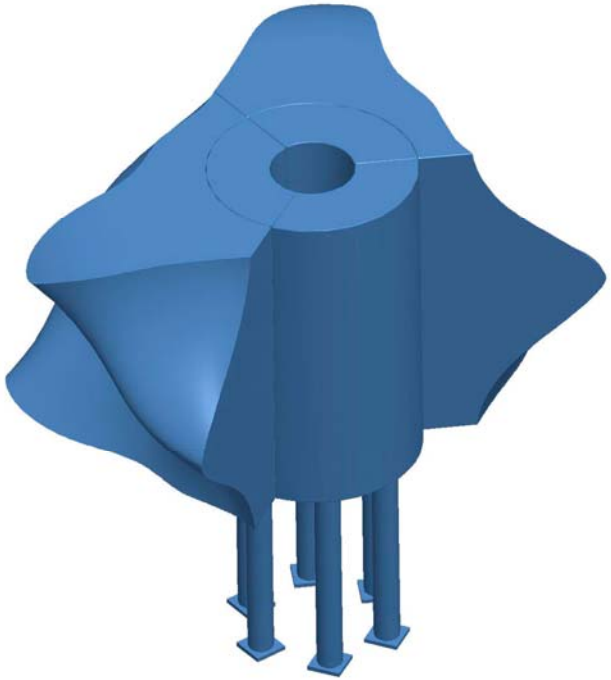


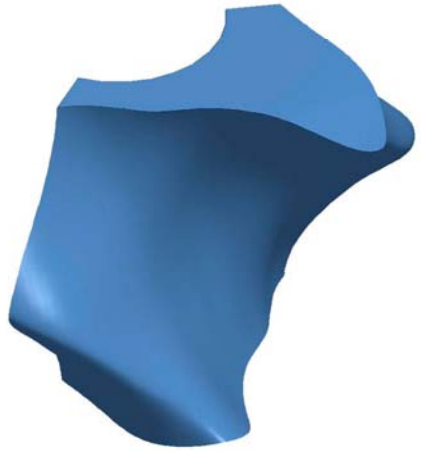
Major design features:

- VV must fit into the modular coils with their structure support.
- Breeding blanket and shielding modules have to be attached to a shell constituted by the shield and the manifold regions. This shell is supported by the VV.
- Coolant supply/return pipes are placed inside of VV to reduce penetrations through VV.
- All out-of-plane forces are reacted inside the field period, and the centering forces are reacted by a strong bucking cylinder in the center of the torus.
- For thermal insulation, the entire coil system has to be enclosed in a common cryostat.
- No disassembling and re-welding of VV are required for blanket replacement.

Assembly of Bucking Cylinder



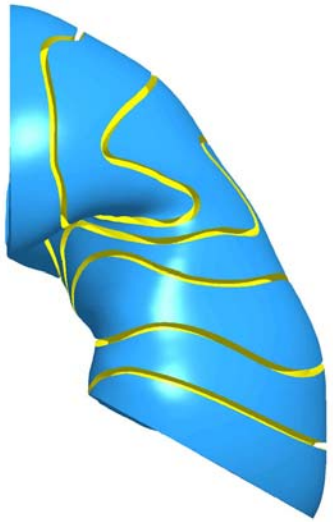


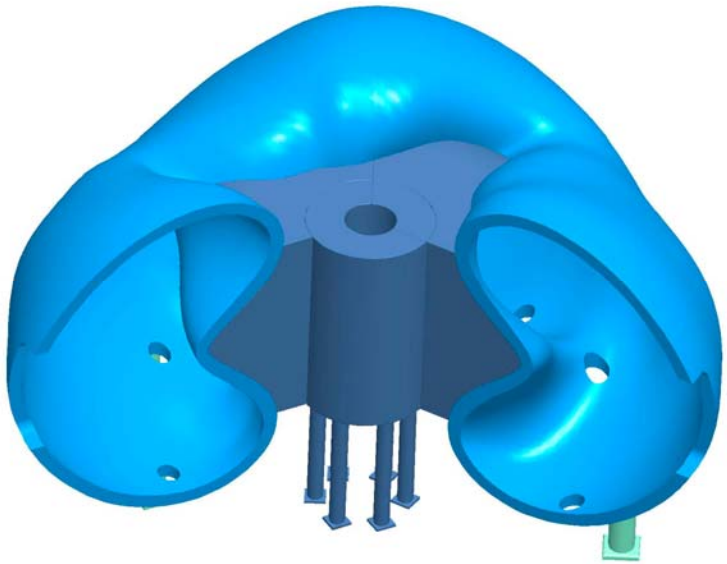


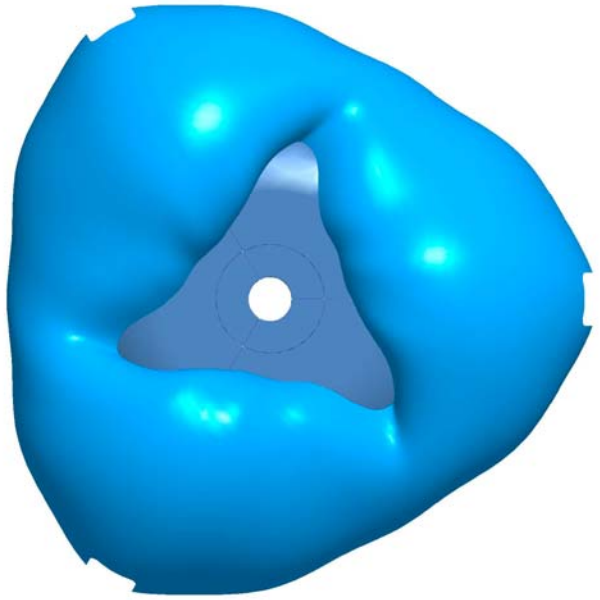
- Geometry of the bucking cylinder is very complex.
- The outer surface of the bucking cylinder is generated by using partial surfaces of coil supporting tube as a boundary, and it is well matched with the outer surface coil supporting tube.
- The bucking cylinder parts (cold structure) will be supported by cold legs, and the weight will be transferred to foundation(ground base).

Assembly of Coils&Coil Tube and Bucking Cylinder

UC SanDiego



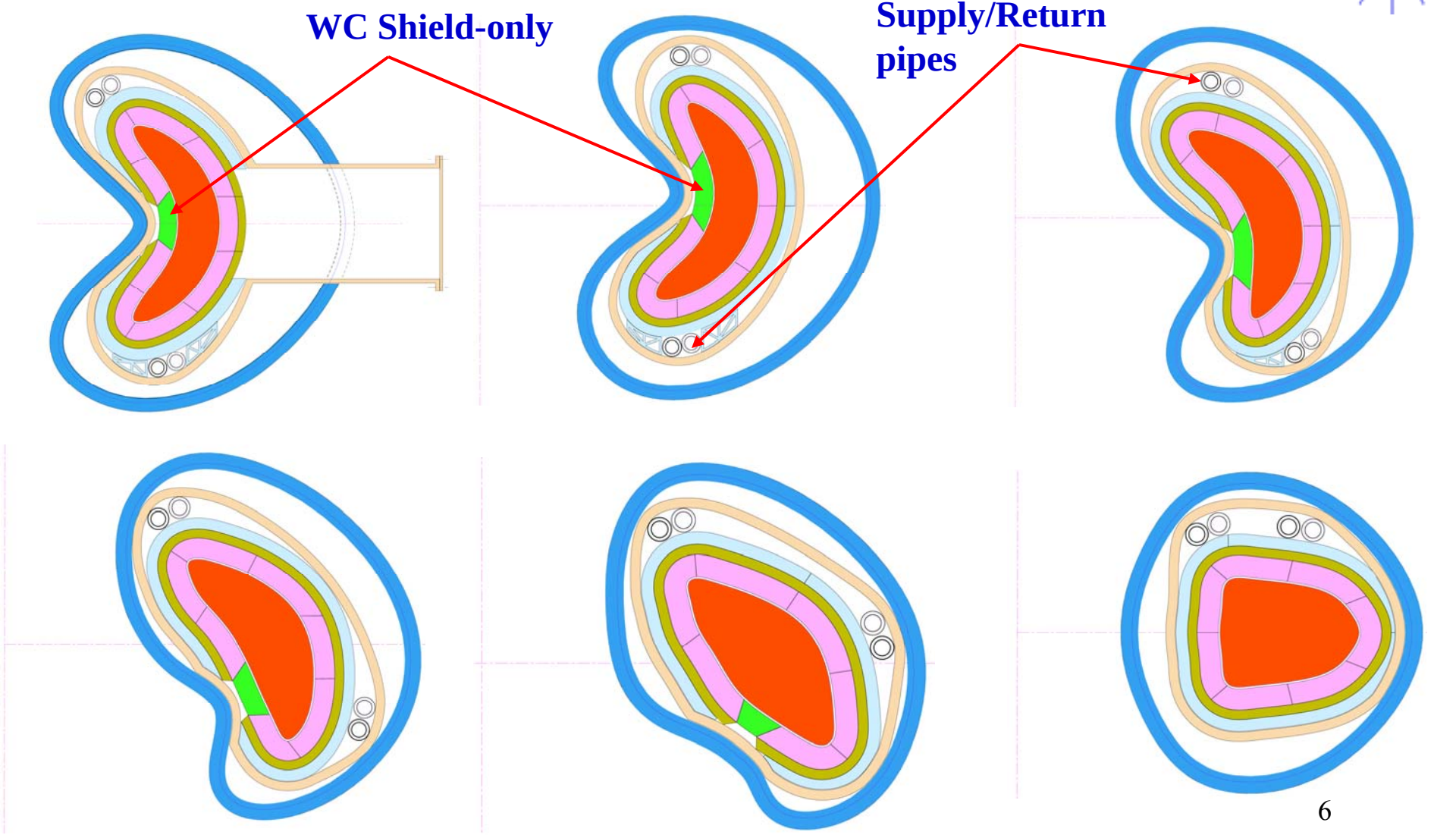




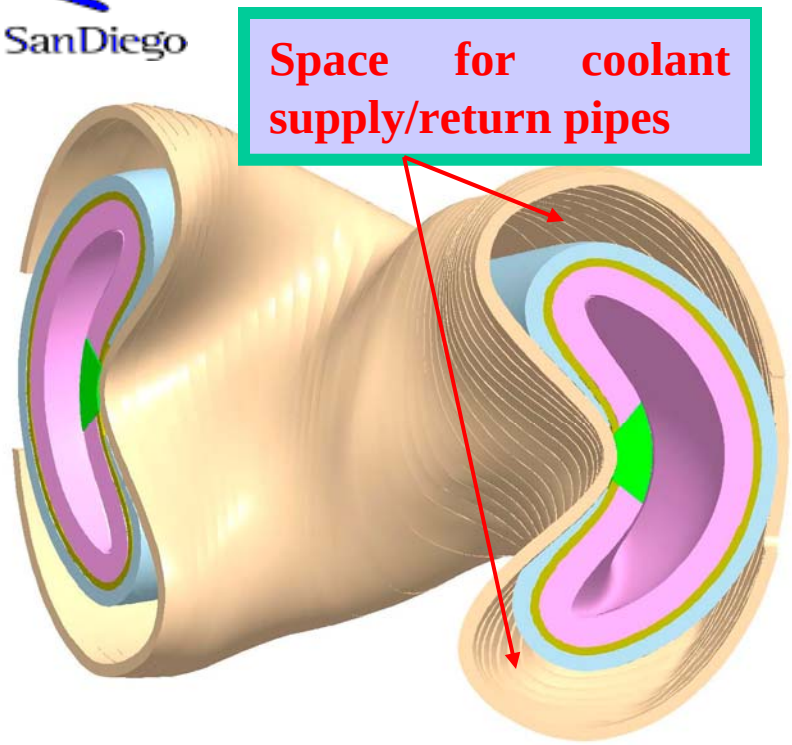
Design Features

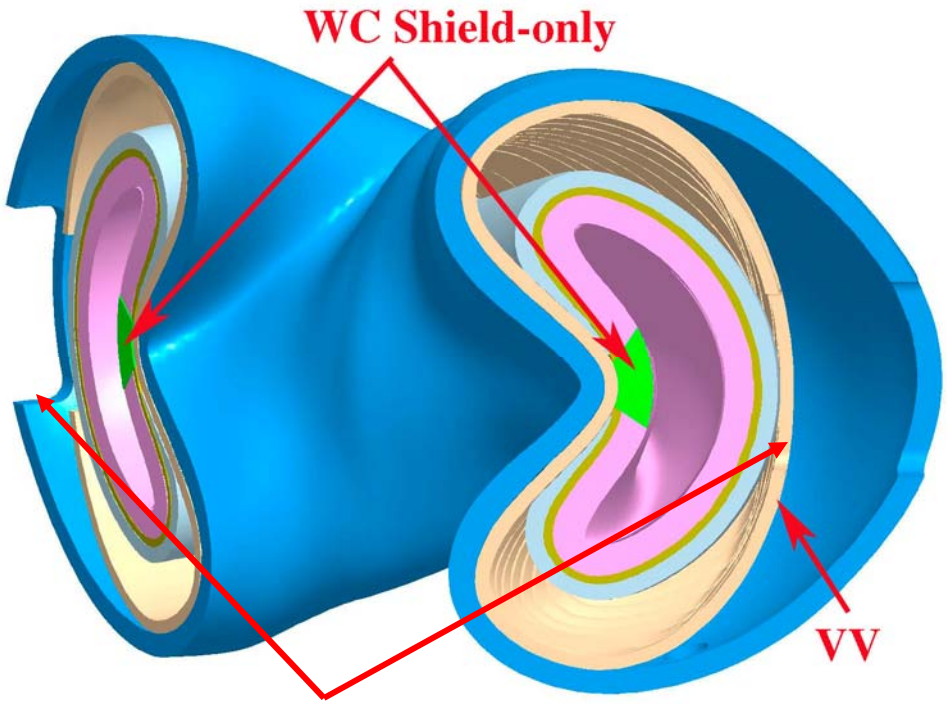
- Coil supporting tube is composed of inter coil structure, coil cases and winding pack. The tube is subdivided into three parts, one part per period.
- The bucking cylinder is placed into the center of coil tube to react the large centering forces.
- The entire coil system has to be enclosed in a common cryostat.

Define of the Internal Vacuum Vessel



Internal Vacuum Vessel



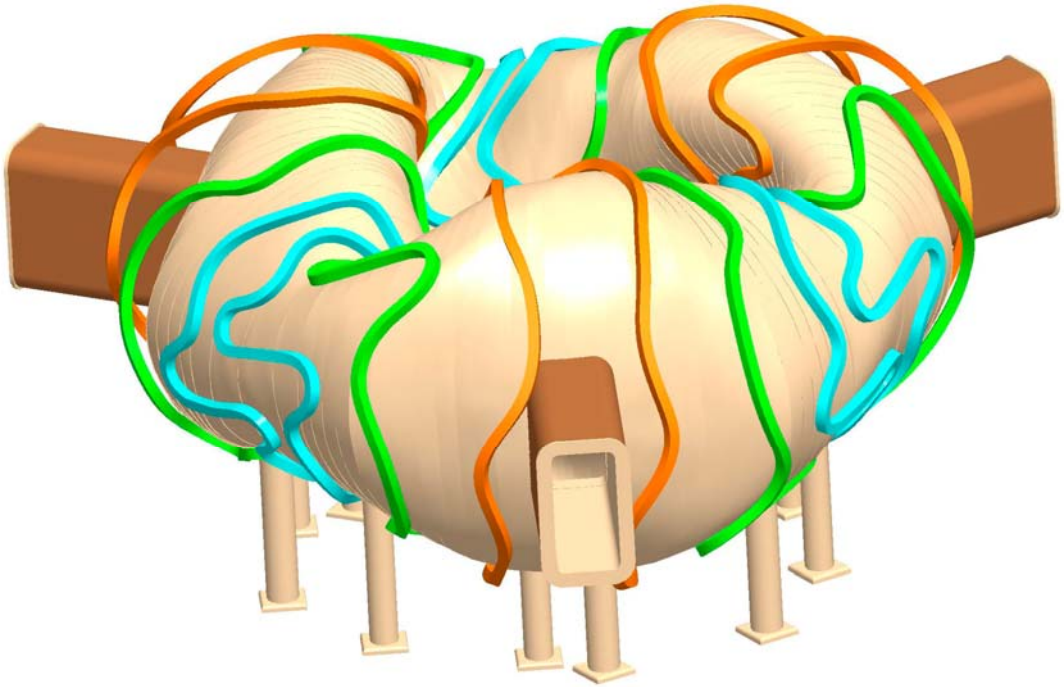


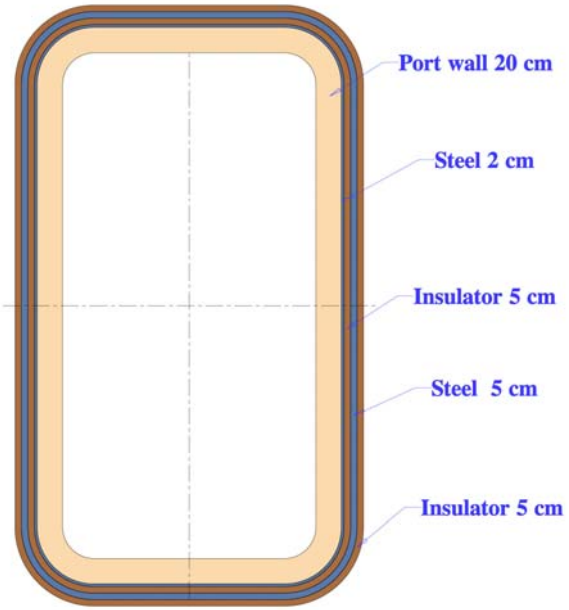
VV & Coil tube cuts for maintenance port

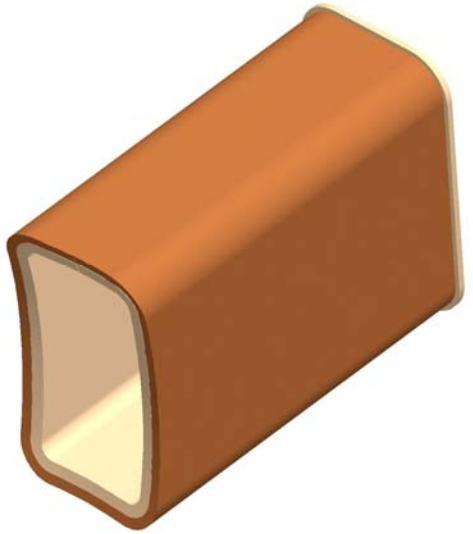
Vacuum Vessel Design considerations:

- VV must fit into the modular coils with their structure support.
- The space inside the VV must be sufficient for breeding blanket and shield modules and manifold.
- No disassembling and re-welding of VV are required for blanket replacement.

Maintenance Ports Arranged Between Modular Coils at 0°, 120° and 240°







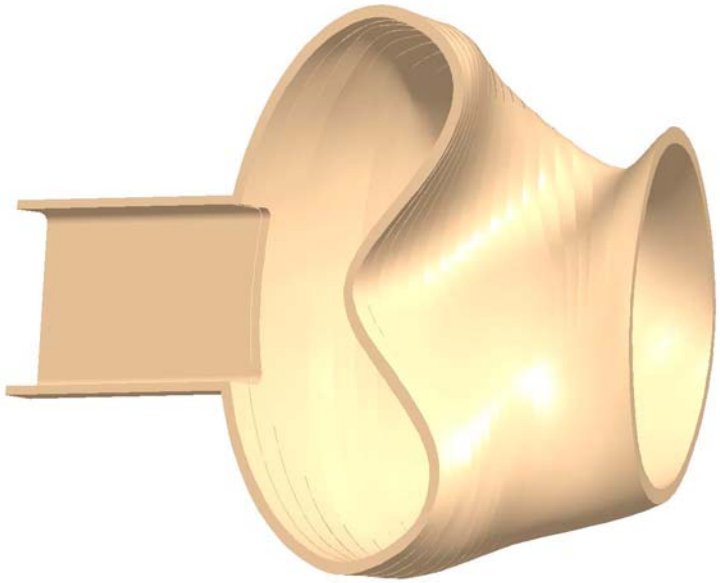
Rectangular port shape: 2m x 4m

(*Assuming 1 or 2 ports for each field-period)

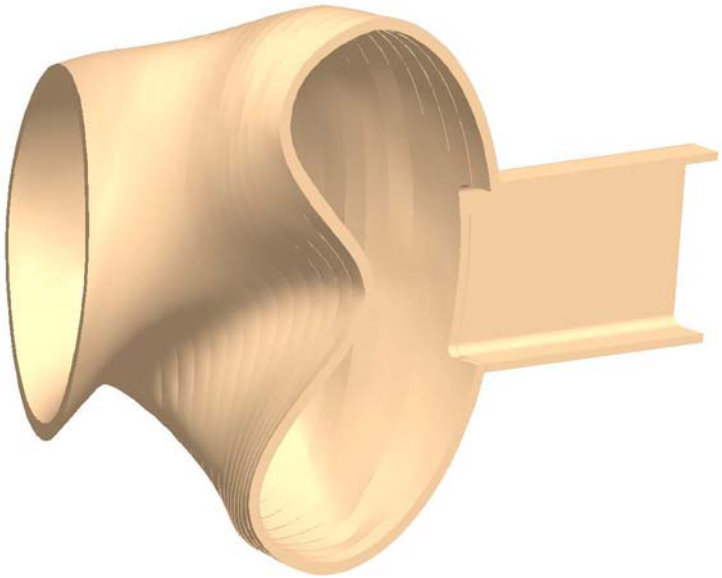
Vacuum Vessel Assembly Sequence

UC San Diego

60-120° segment



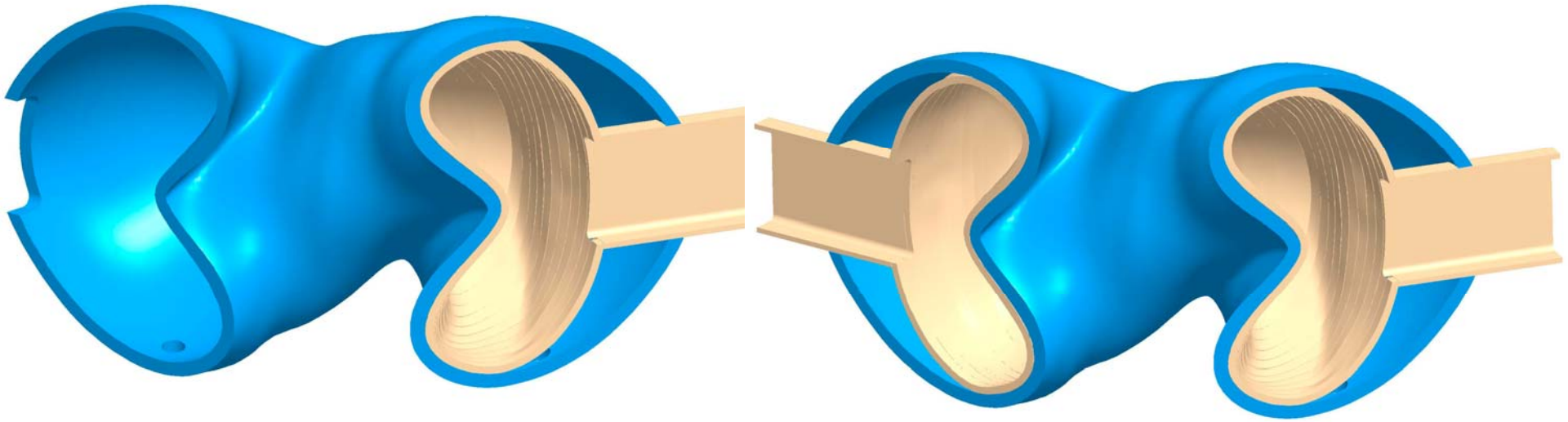
0-60° segment



- VV is assembled by six segments, and two segments for each field-period are mirror symmetric.
- Considering the twofold mirror symmetry, there is only one shape per field-period.
- The port can be subdivided into two halves and welded to the VV segment to avoid at 0 degree cross section welds behind coils.

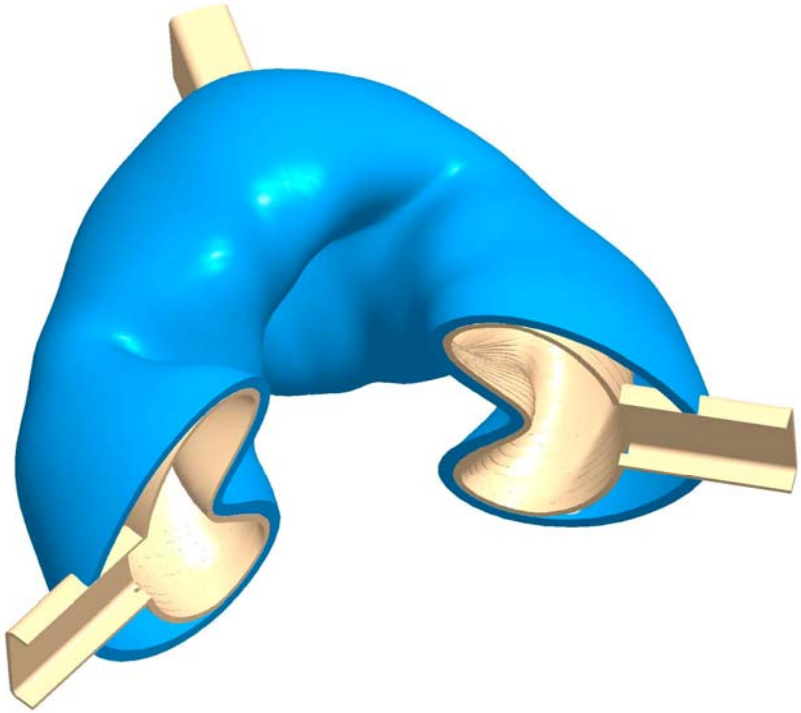
Vacuum Vessel Assembly Sequence(1)

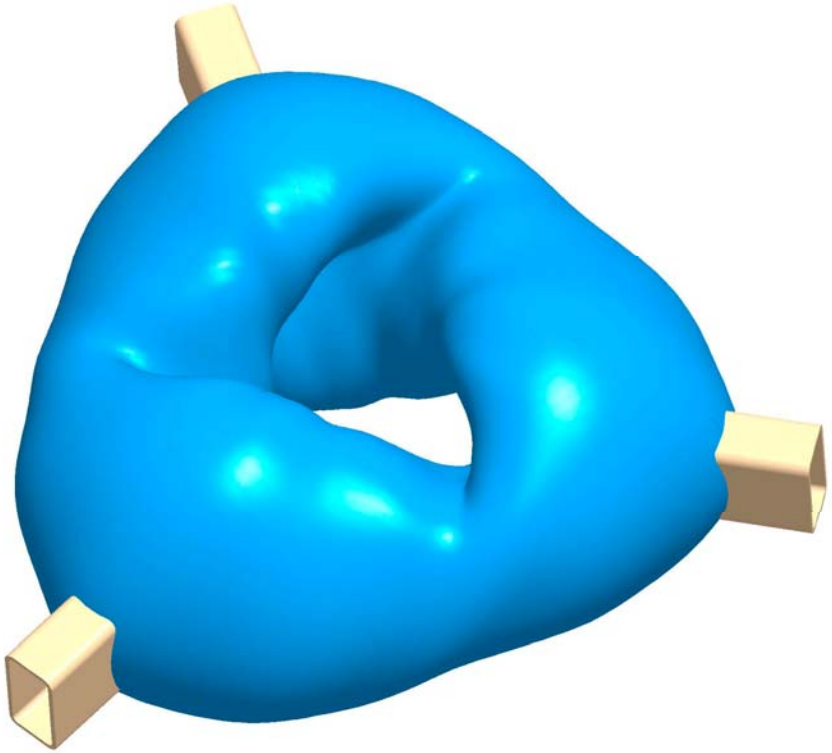
VV and Coils Sub-assembly



- Position the coil supporting tube of the field-period.
- Slide one VV segment into the coil supporting tube of the field period in toroidal direction from one end.
- Install another VV segment by sliding it into the coils supporting tube from another end, then weld the two segments from inside at 60 degree .

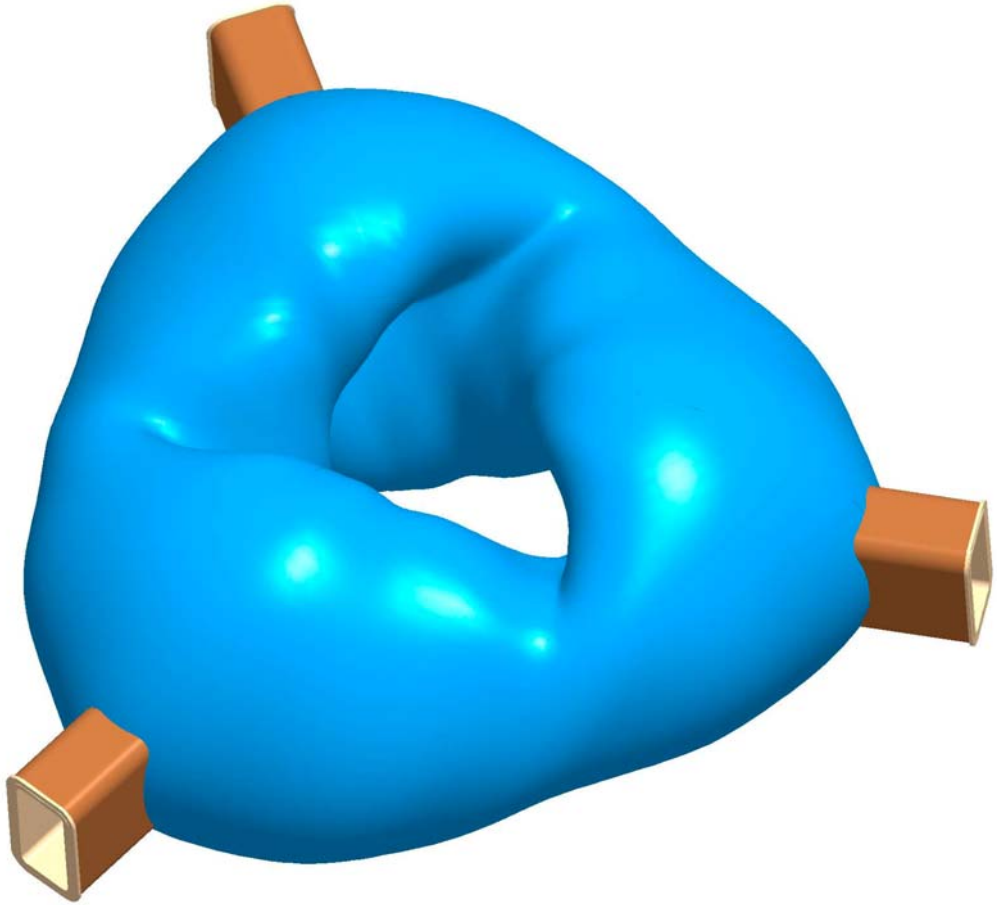
Vacuum Vessel Assembly Sequence(2)





- Position and install two VV and coils sub-assembly, and joint together the VV at 0, 120, and 240 degree by welding.

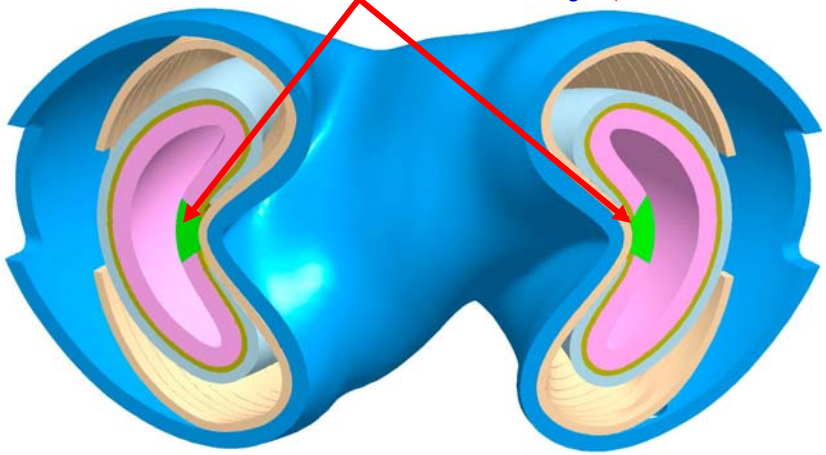
Vacuum Vessel Assembly Sequence(3)



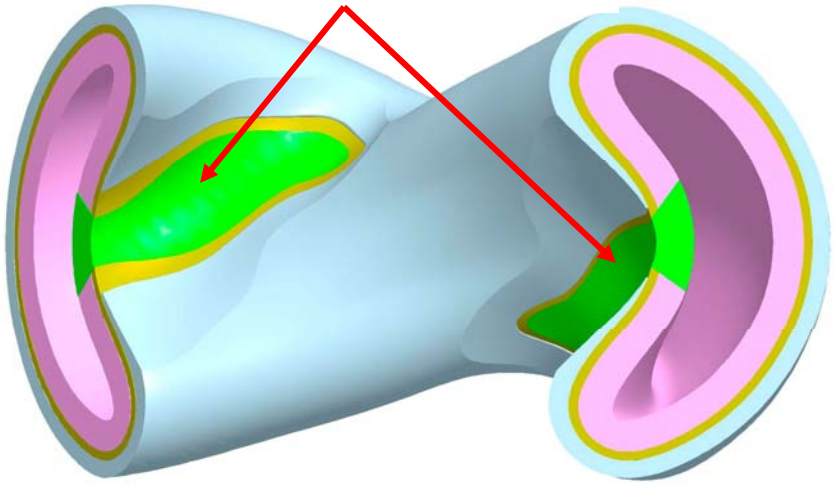
- Add and install the VV port extensions, insulators and flanges.

Analysis Interferences/Clearances Between VV and Blanket/Shield/Manifold

WC Shield-only (Δmin=119 cm)



WC Shield-only

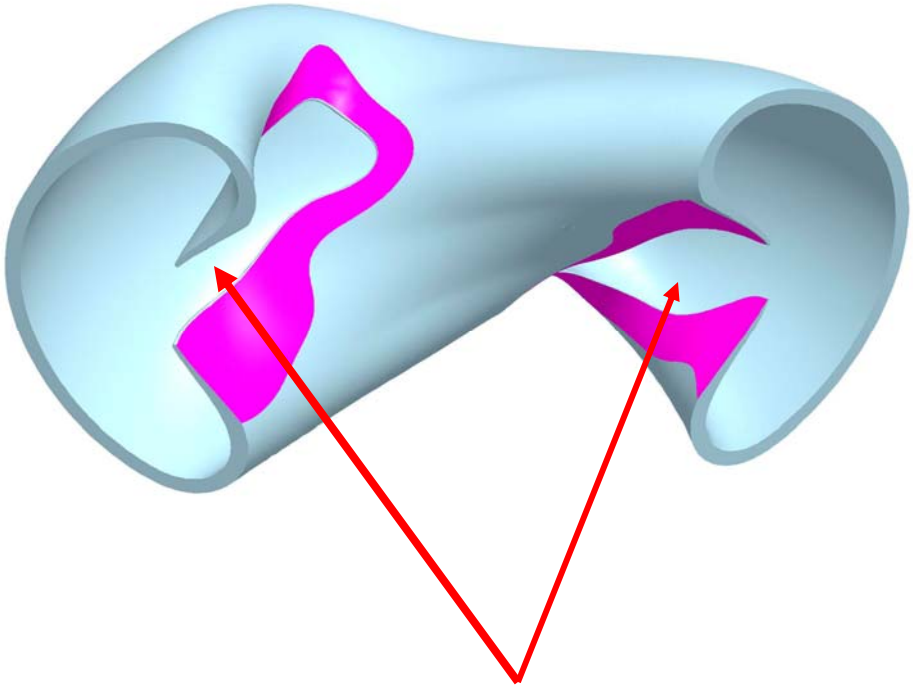


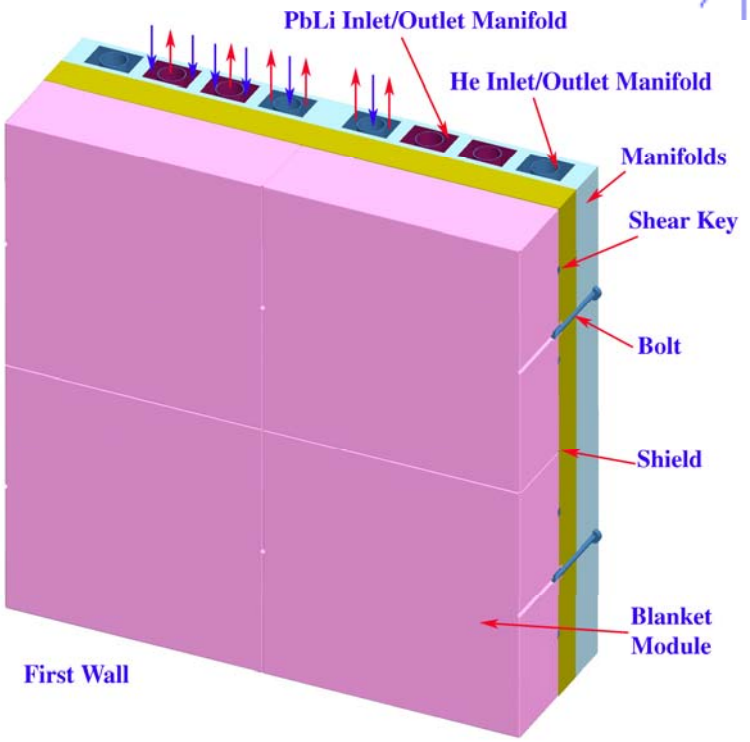
FW&Blanket:	63 cm
FS Shield :	28 cm
Vacuum vessel:	28 cm
Manifold:	35 cm

(***Laila, "Radial Build and Composition for LiPb/FS/He System", March 22, 2005***)

- There is no sufficient space in a few locations to fit into the combination blanket, shield and manifold. The WC Shield-only module will be installed in this region.
- It may need ~5 to 10 cm space to place manifold for feeding helium coolant to the WC Shield-only module.
- Breeding blanket and shielding modules have to be attached to a shell constituted by the shield and the manifold regions. This shell is supported by the VV. (***structure should be added between manifold and VV at the bottom, not shown in drawing***).

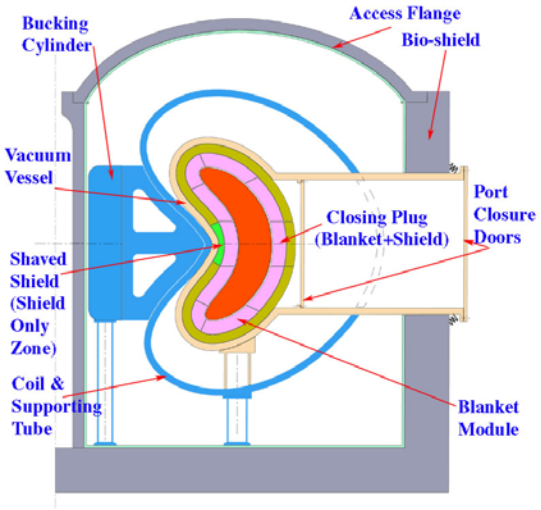
Isometric View of Showing the Area Where Needs 5-10 cm for Manifold

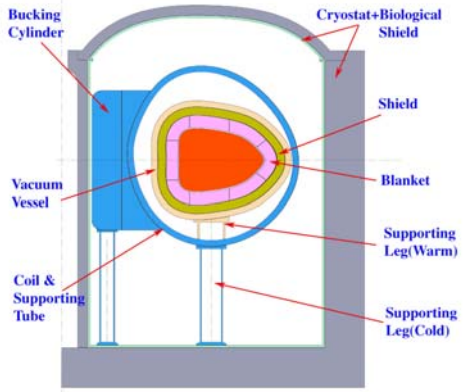


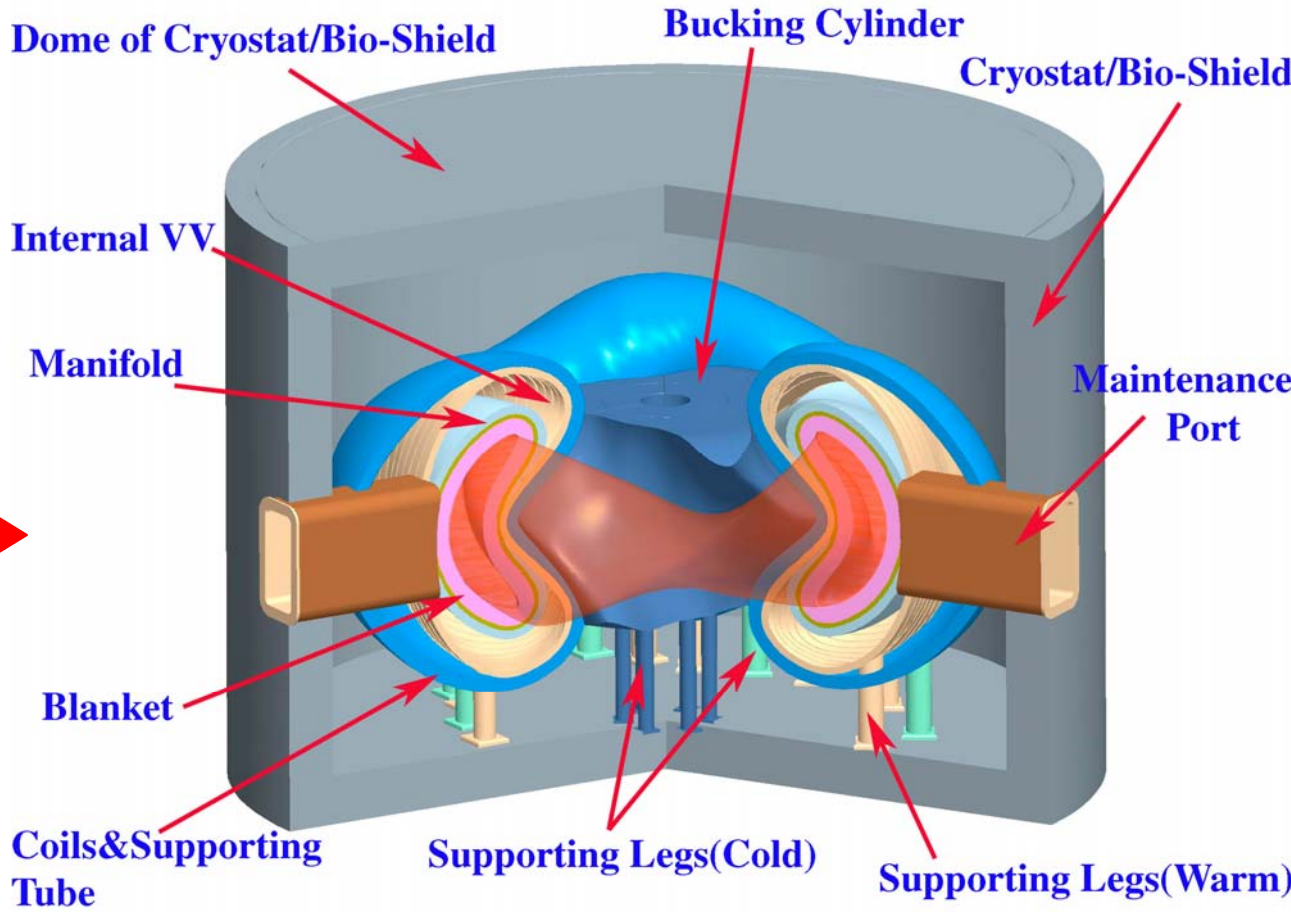


The manifold was cut to fit into inside VV. 5 ~10 cm space will be needed to place a thin manifold to feed Helium to WC-Shield-Only module.

Overall Power Core Configuration







Geometry of the biological shield is modified to a simple column with a top dome.

Volumes of the Power Core Components

UC San Diego

Component	Volume(100% dense), m^3
Plasma	556.5
Bucking cylinder	535.1
Coil system(supporting tube+winding pack)	950.2
Vacuum vessel (Ports+insulators)	532.2
Blanket	585.9
Shield	191.4
Manifold	359.1
Bio-Shield	8043.3

Summary

- 3D CAD modeling for CS power core components based on modular maintenance has been started in order to locate and analysis the space issue.
- Clearances/Interferences have been checked and analyzed between pair of sub-assemblies and pair of parts.
- The WC Shield-only modules will be installed in few locations where there is no sufficient space for the combination blanket, shield and manifolds, and 5~10 cm more space is needed to place manifold for cooling the WC Shield-only modules.