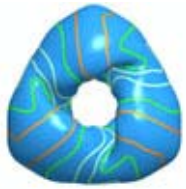
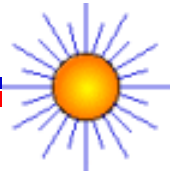
Update of the ARIES-CS Power Core Configuration and Maintenance





Presented by X.R. Wang

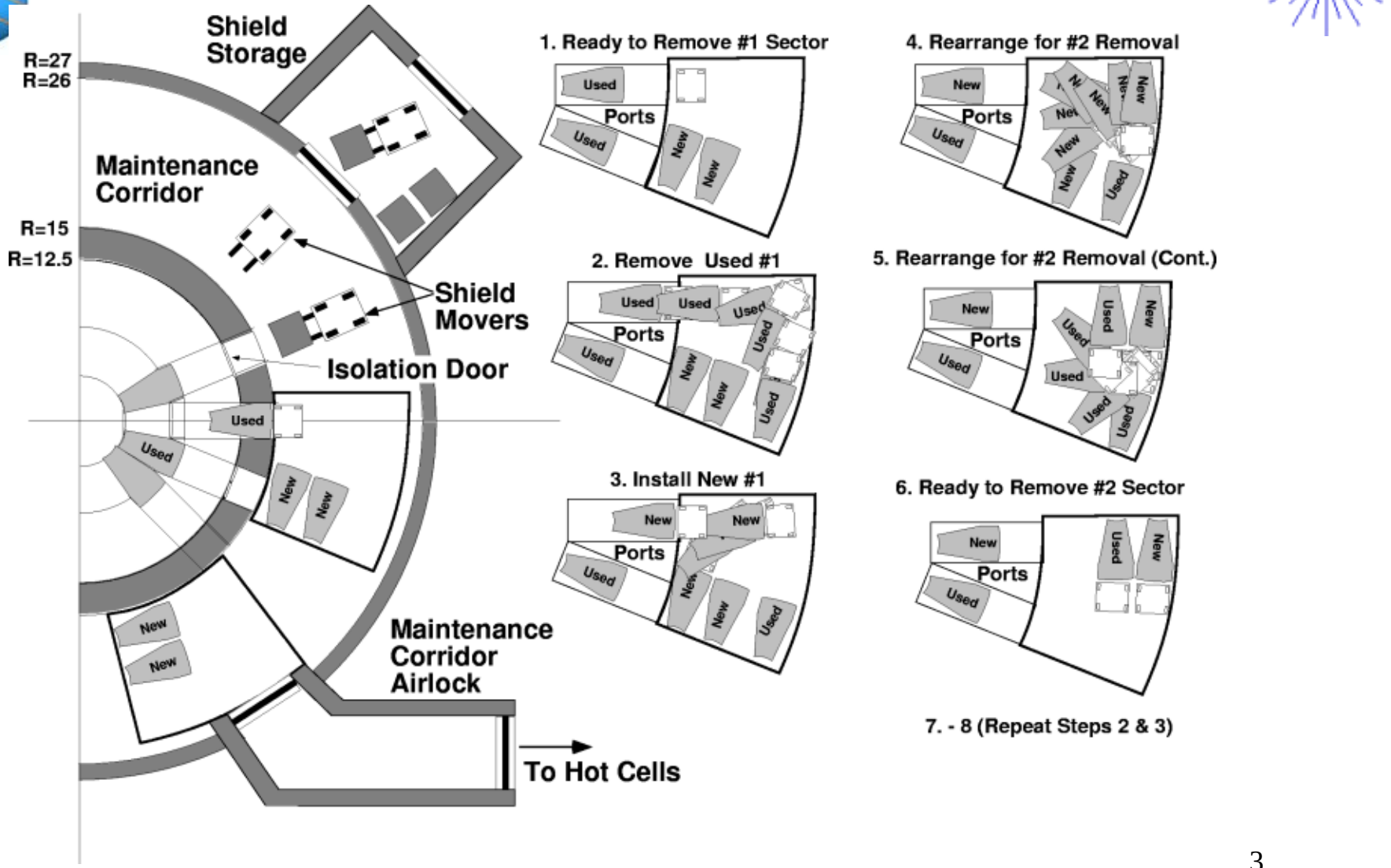
Contributors: S. Malang, A.R. Raffray
and the ARIES Team

ARIES Meeting
University of California, San Diego
November 4-5, 2004

Outline

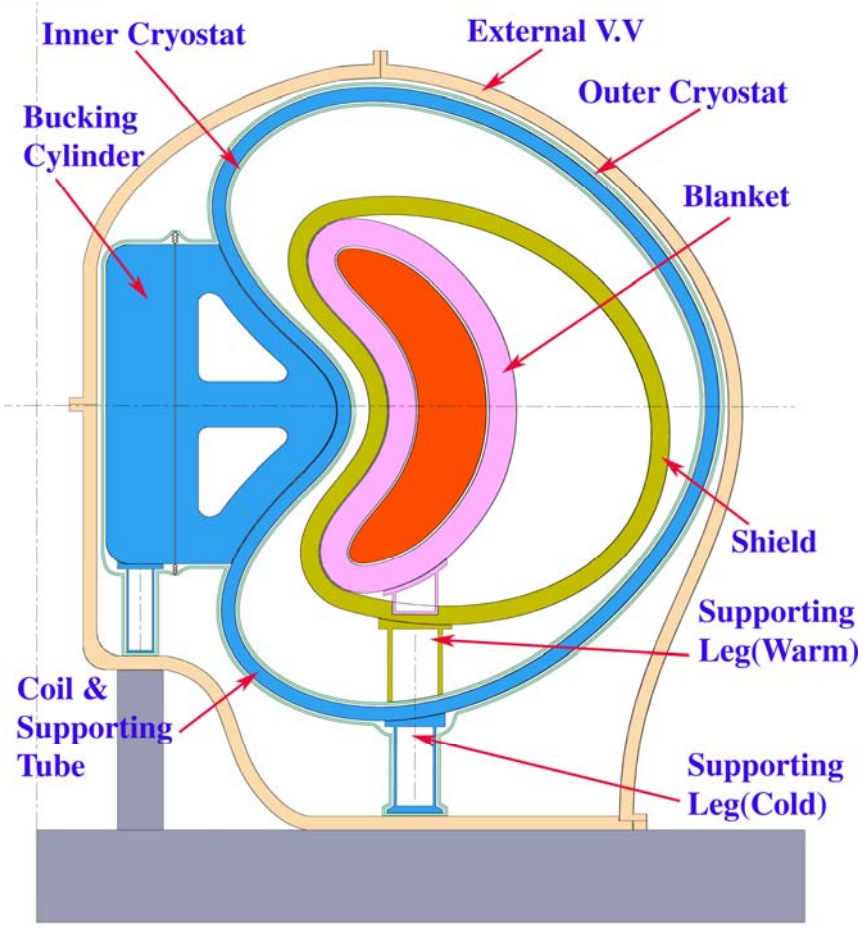
- ARIES-RS approach of containing the contamination during maintenance operation.
- Engineering details of external VV design.
- Approach to control the spread of radioactive particles for CS field-period based maintenance.
- Engineering details of internal VV and maintenance ports design.
- Approach to control the radioactivity for CS modular maintenance.

ARIES-RS Approach of Employing Large Transfer Flasks



M. Tillack, S. Malang, L Waganer et. al., and the ARIES Team "Configuration and Engineering Design for ARIES-RS Tokamak Power Plant" *Fusion Eng & Des*.,38(1997)

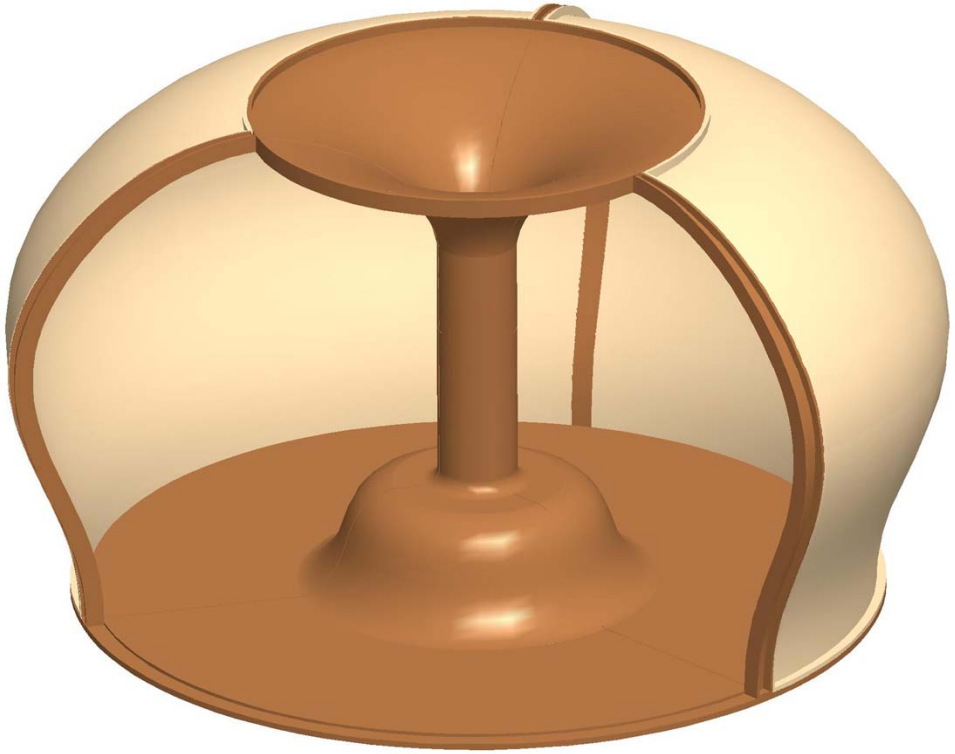
Characteristics of External VV Based on Field-Period Maintenance Scheme



Cross-section at 0 degree

- External VV design will be adopted, and each field-period consists of three segments.
- Replacement of entire field period requires opening of the VV over a field period.
- For a blanket replacement, an entire field period compose of cryostat, coils and coil supporting tube, and blanket unit is withdrawn in radial direction.

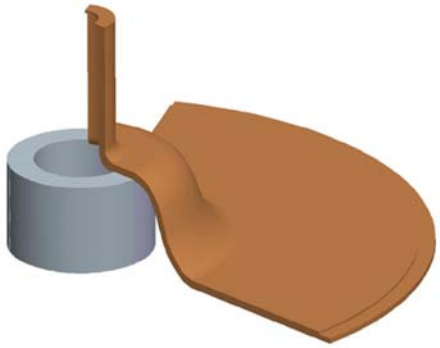
External VV Assembly



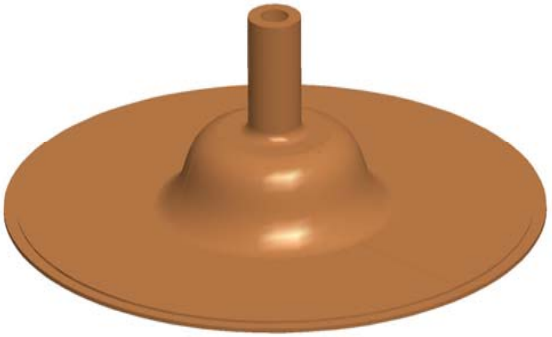
Cutaway of the External VV Assembly

- The vacuum vessel is a three-period structure.
- Uniform shape and size in toroidal direction is considered. This design will result in a simple geometry, and easy to assembly and fabricate.
- The skeleton parts of VV (brown color) will be jointed together by welding.
- The three VV doors will be joined together at bolted joints.
- No structural re-welding will be needed during maintenance.

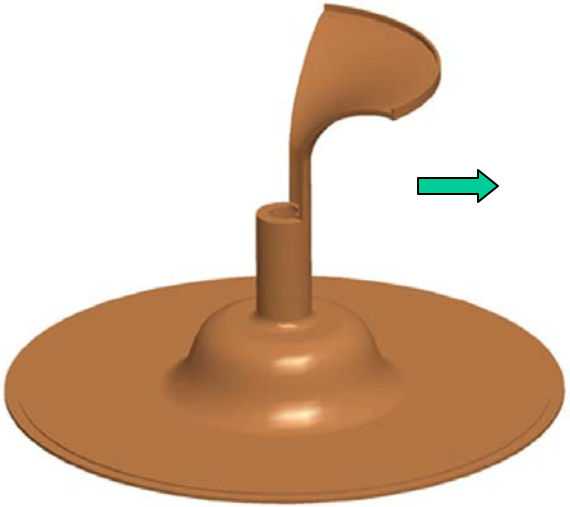
Vacuum Vessel Assembly Sequence



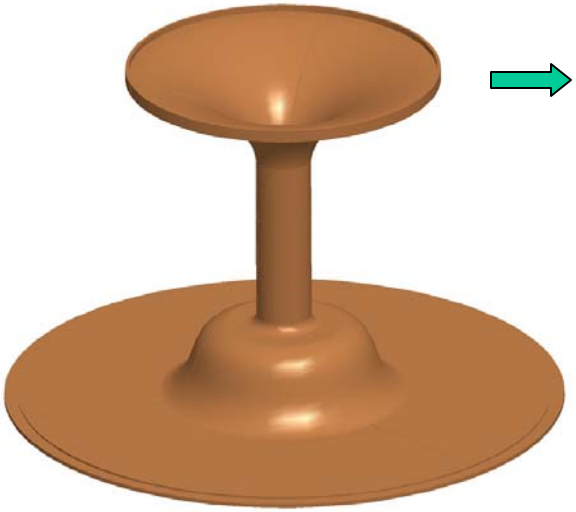
Position the bottom part



Weld other bottom parts

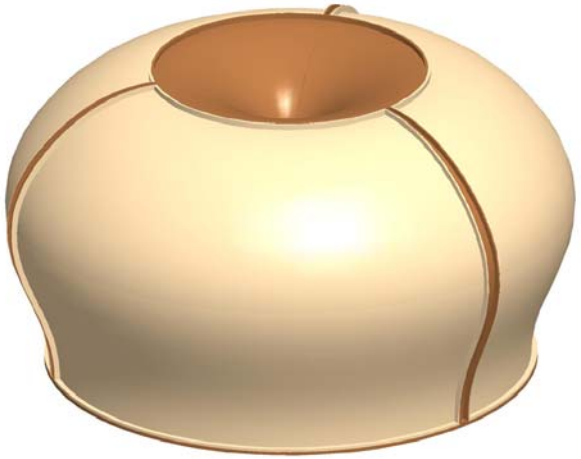


Add/weld the top part



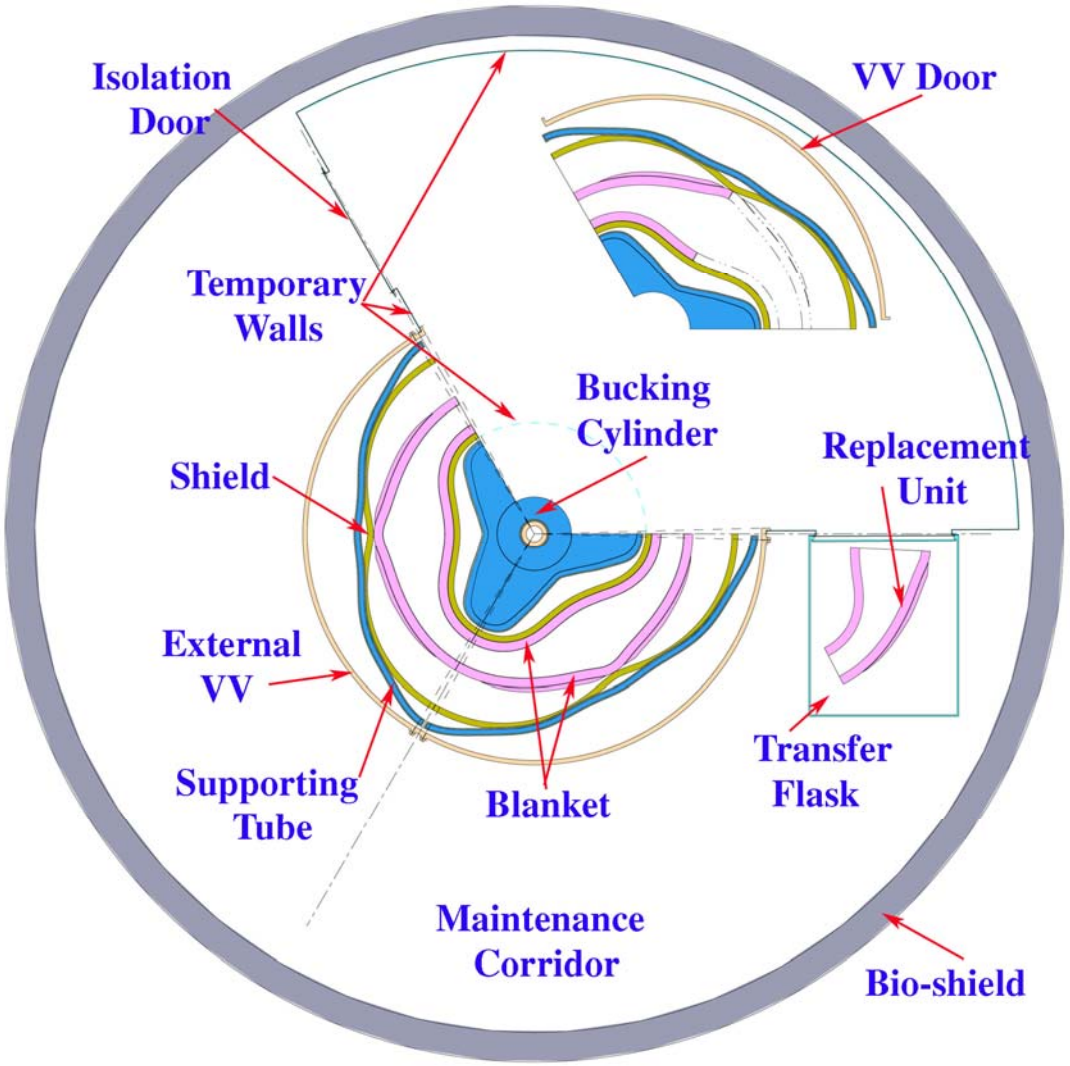
Add/weld other top parts

Add the side flanges



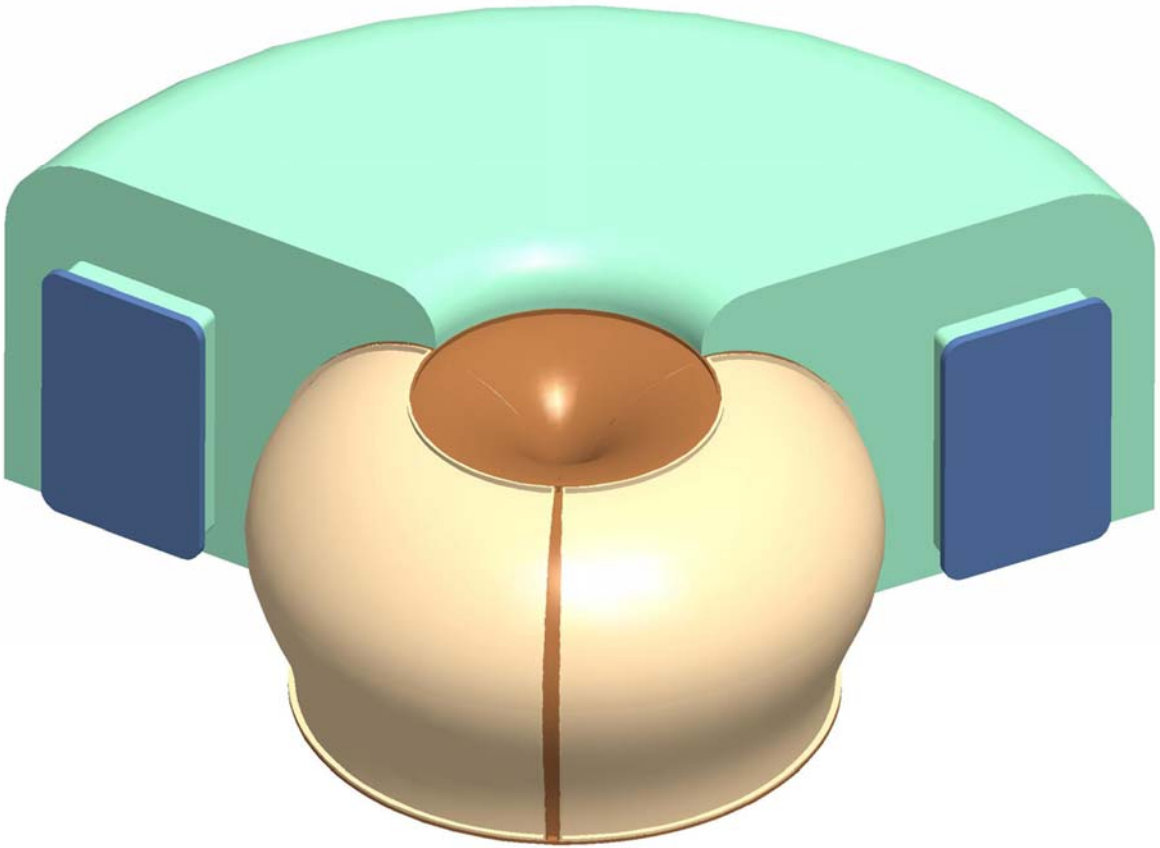
Add three doors and bolt together

Proposed Solution for Controlling the Spread of Radioactive Particles



- A temporary tent will be attached to the VV side flanges and top flange to avoid the plasma chamber or the used components to expose to the building atmosphere.
- Large flasks will be attached to the outer flanges of the tent prior to opening the tent and flask doors.
- The replacement unit will be removed into the flask and transferred to hot cell.

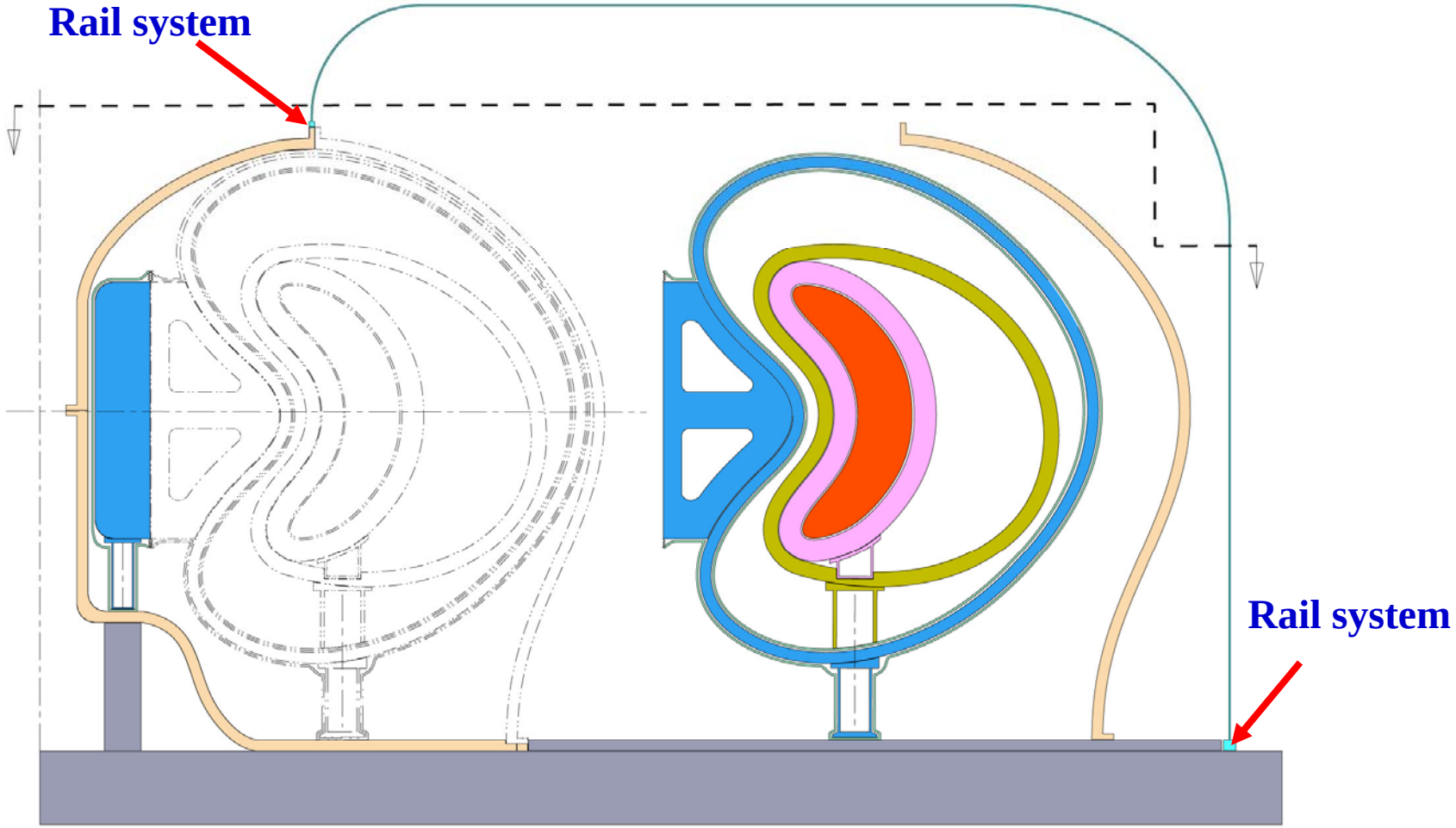
Layout of the Temporary Tent for Controlling the Spread of Radioactive Particles



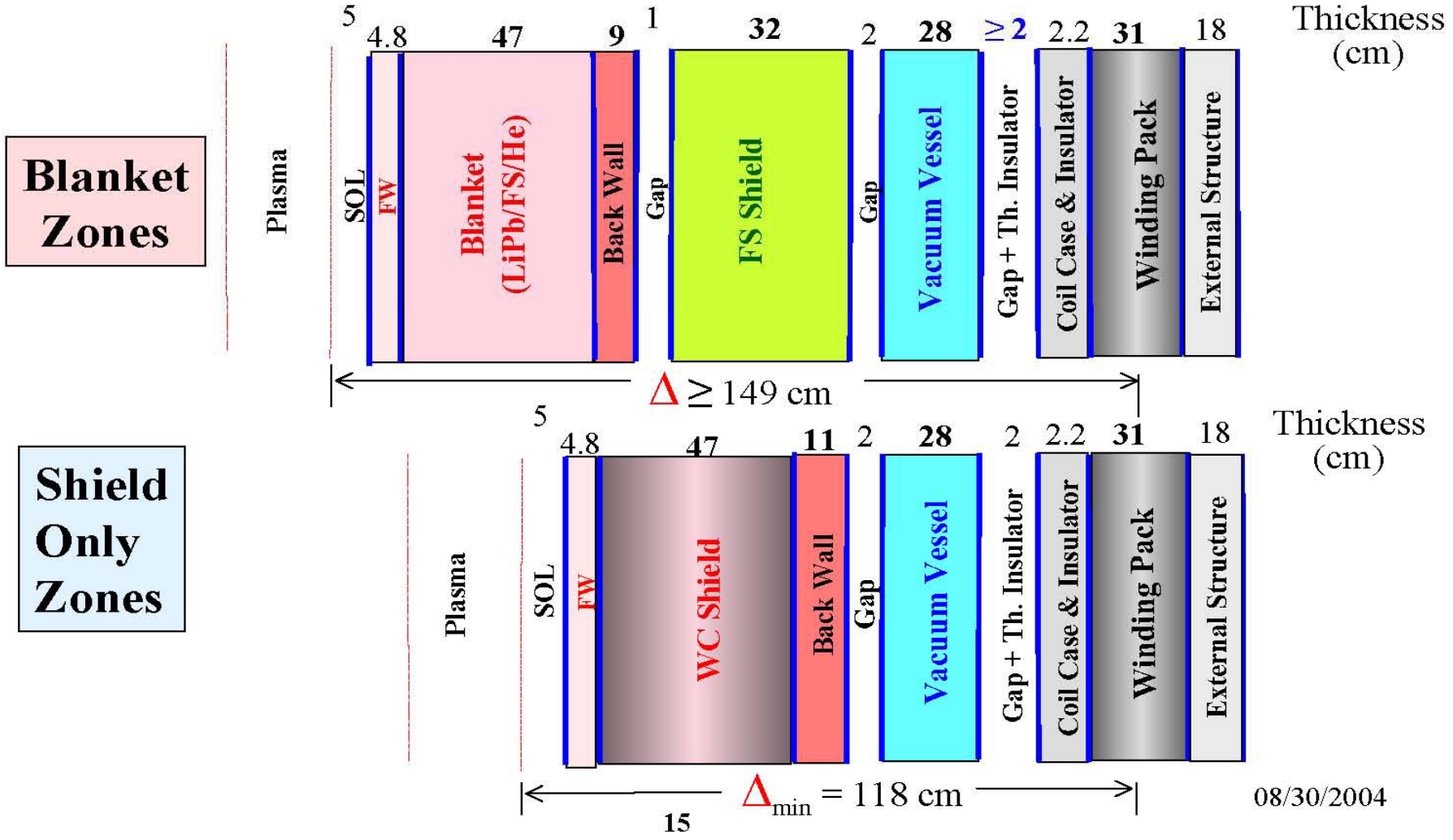
Major Features:

- The tent can be moved around from one field-period position to another by the installed rail systems.
- Inside the tent, a negative pressure would be maintained, therefore, perfect seals would not be depended.
- It is easy to clean the tent after maintenance operation.

Elevation View of Showing the Tent and Its Rail Systems

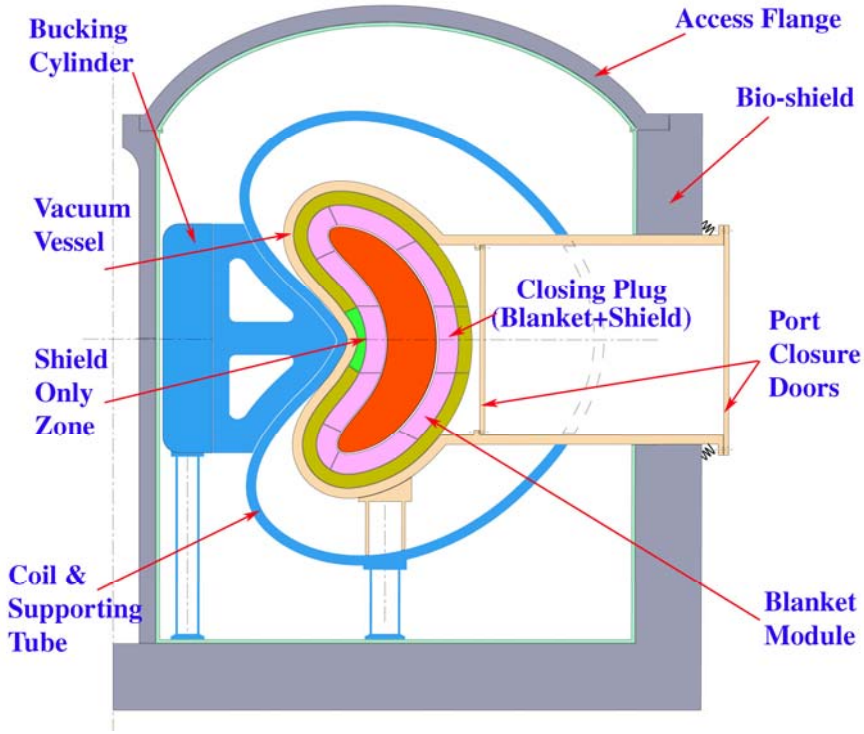


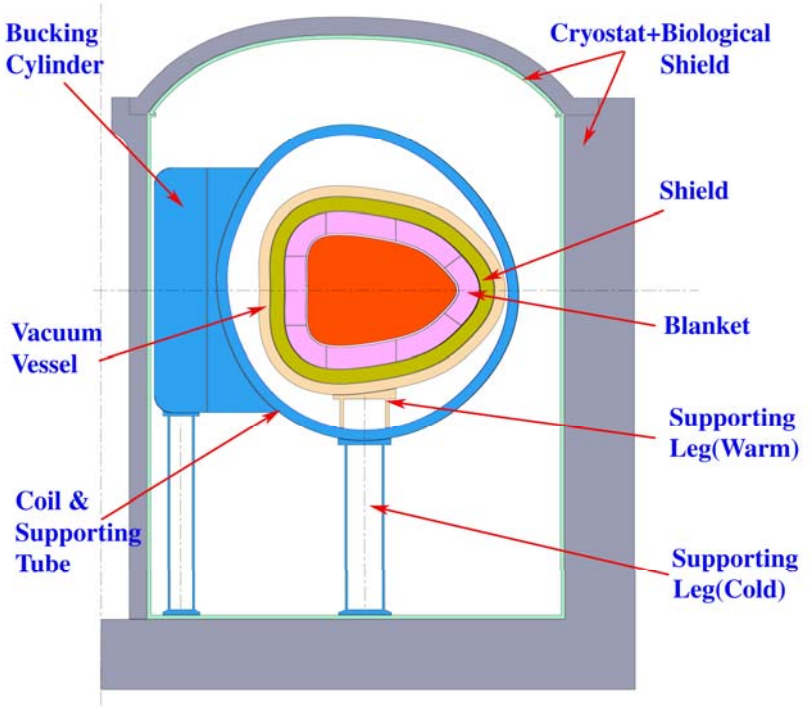
LiPb/FS/He Radial Build
(Water-Cooled **Internal** VV)



*** Presented by Laila at the ARIES Meeting**

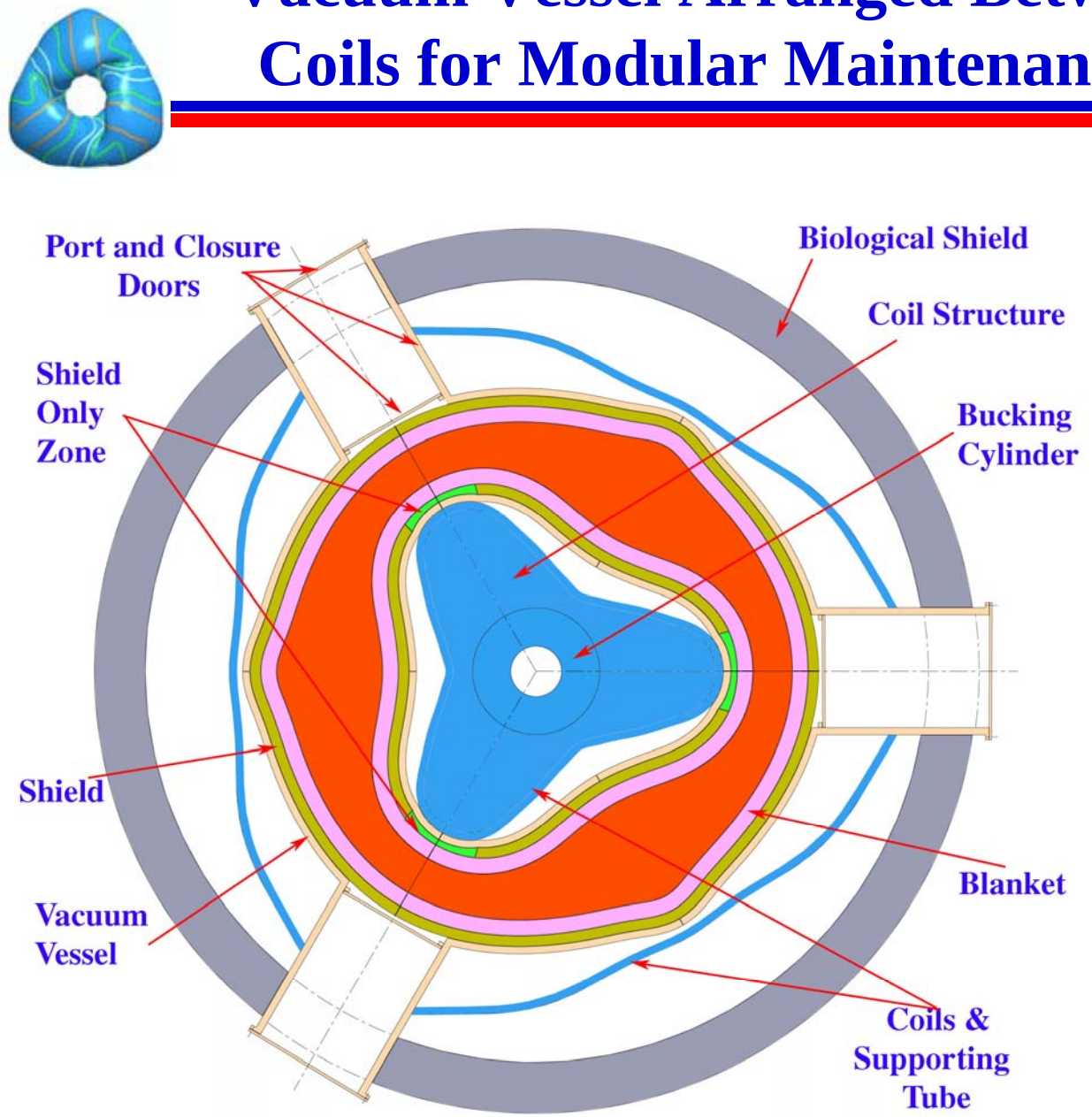
Vacuum Vessel Arranged Between Shield and Coils for Modular Maintenance





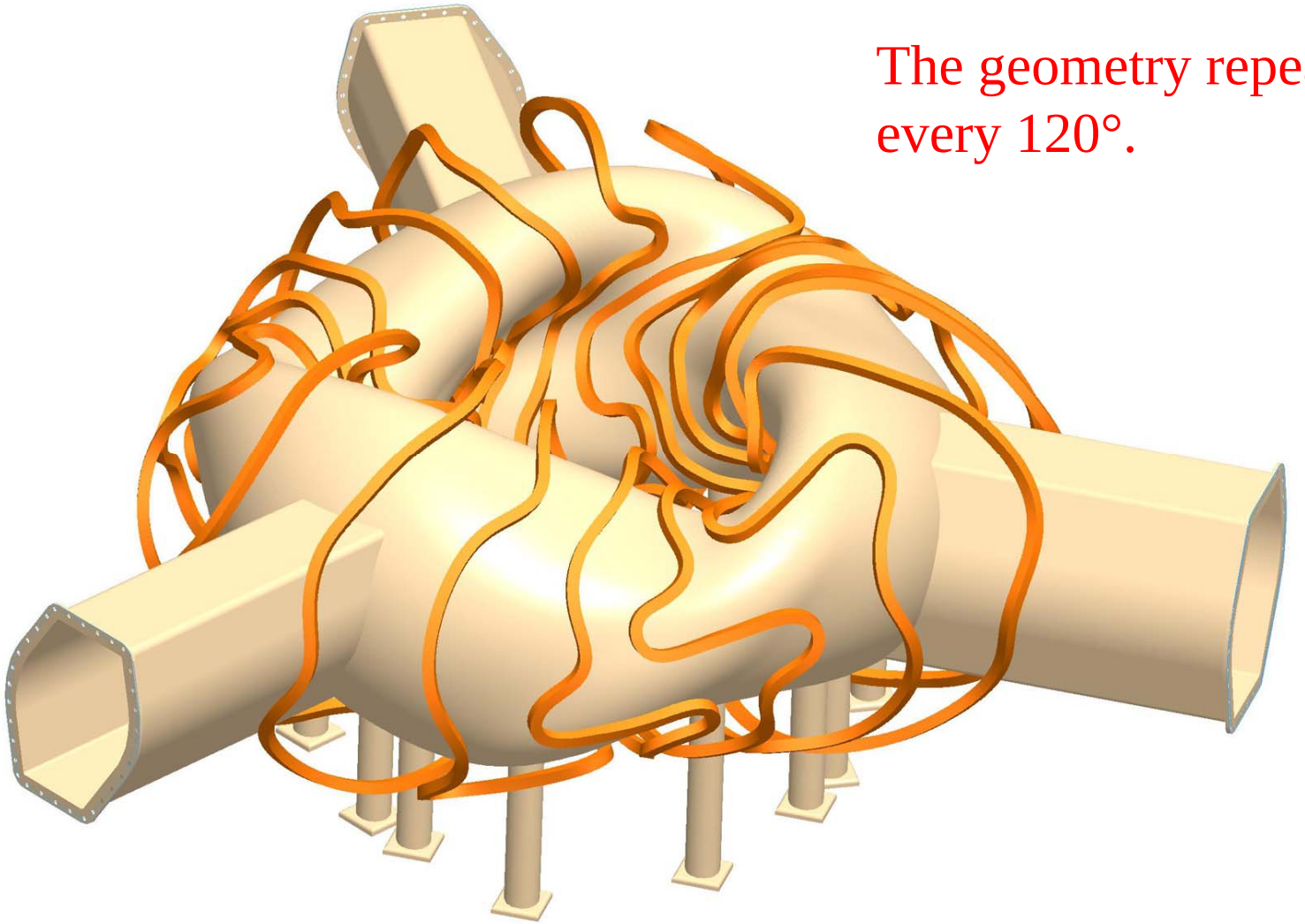
- VV is a complex (non-uniform size and shape), three-period structures nestled inside the coils.
- VV serves as an additional shield for protecting the coils.
- No disassembling and re-welding of VV are required for blanket replacement.
- Minimum distance between FW and inner surface of the coils is 100 cm (100 cm=120(min. distance)-5(SOL)-5(coil case)-10(half winding pack)).
- ***The shield-only-zone design has to be used in these regions where there are no enough space.***

Vacuum Vessel Arranged Between Shield and Coils for Modular Maintenance(Plane view)



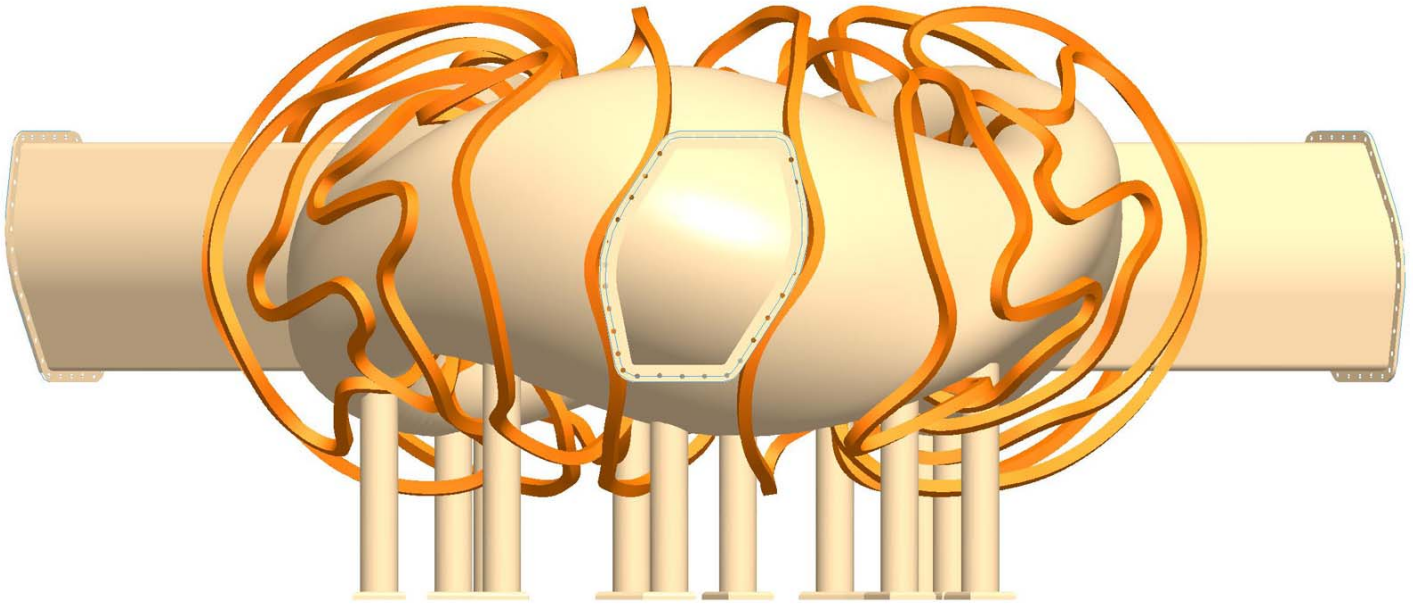
- The optimum locations for these ports are the 0°, 120°, and 240° cross-sections (assuming one port per field period).
- The ports have to bridge the space between VV and bio-shield. Bellows at the connections between port and cryostat allow for differential thermal expansion.
- In order to maintain the containment of tritium, there should be two doors of the port, one at the VV and one at the outside of the cryostat.

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



The geometry repeats every 120°.

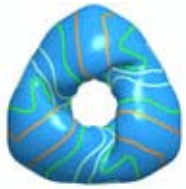
Front View of Showing the Maintenance Port



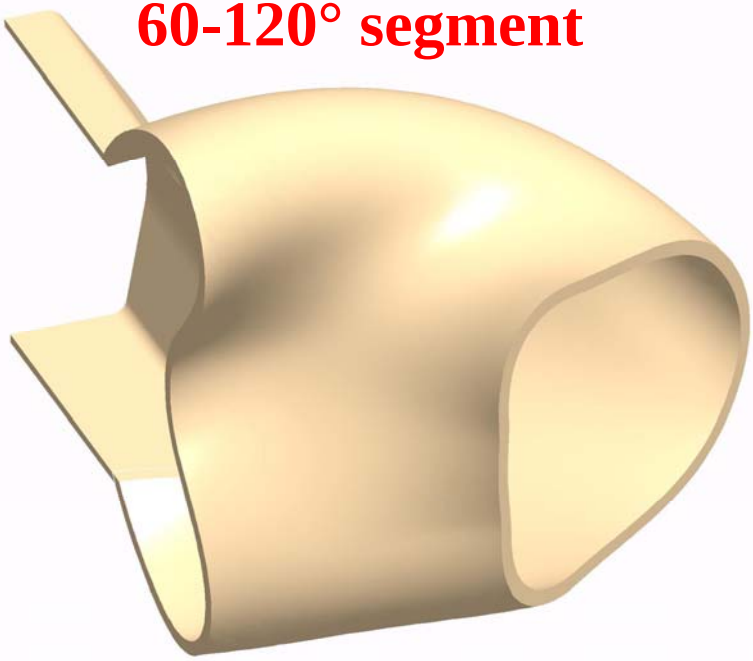
- The shape of the maintenance port is followed to the coil edges. This enables the maximum height and width of the ports and the articulated boom for module handling.

Horizontal length at top:	***2.7 m***
Horizontal length at middle:	***4.5 m***
Horizontal length at bottom:	***2.5 m***
Vertical length:	***5.8 m***

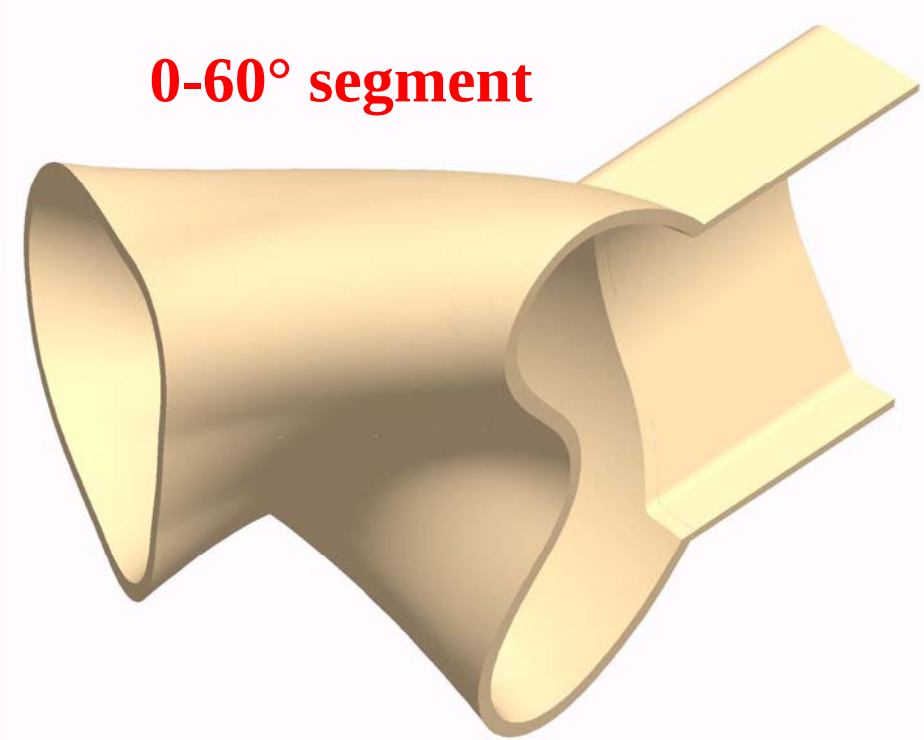
Vacuum Vessel Segments



60-120° segment

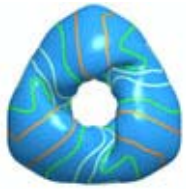


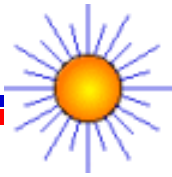
0-60° segment



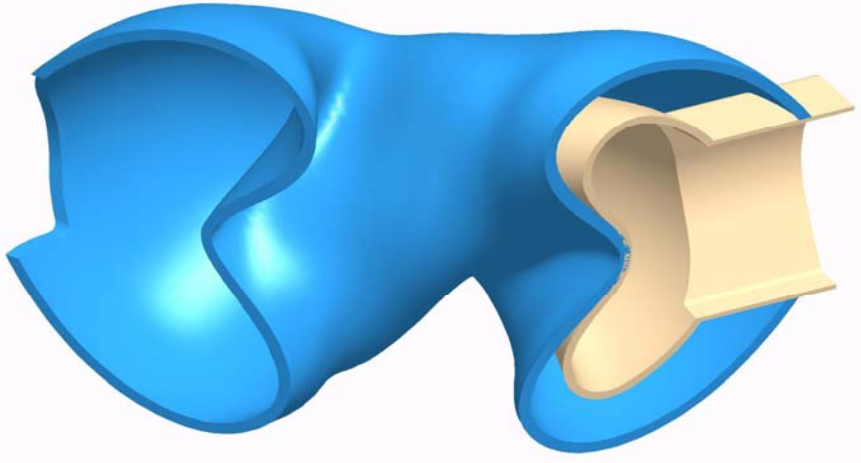
- VV is assembled by six segments, and two segments for each field-period.
- Considering the twofold mirror symmetry, there is only one shape per field-period.
- The port can be subdivided into two halves and welded to the VV segment to avoid at 0 degree cross section welds behind coils.

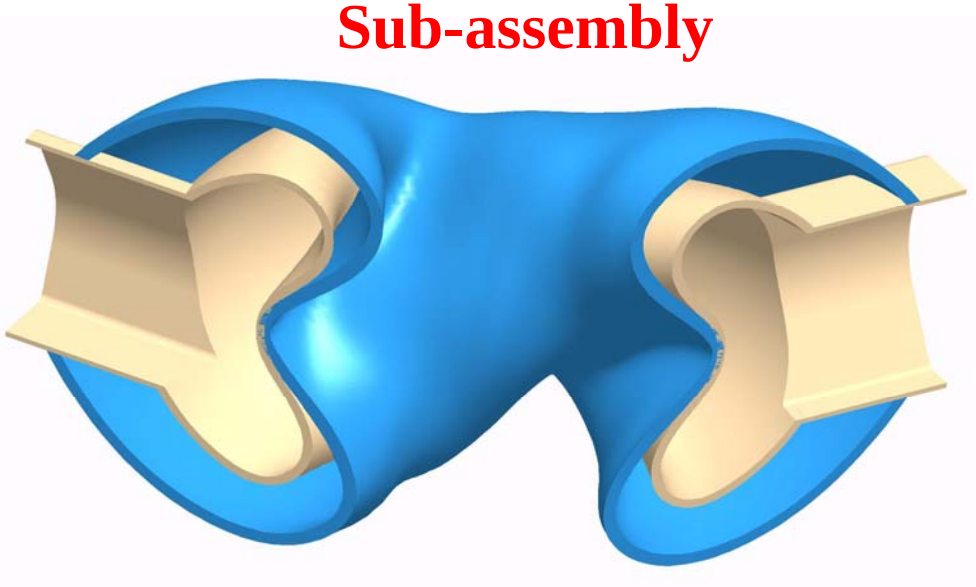
Vacuum Vessel Assembly Sequence(1)





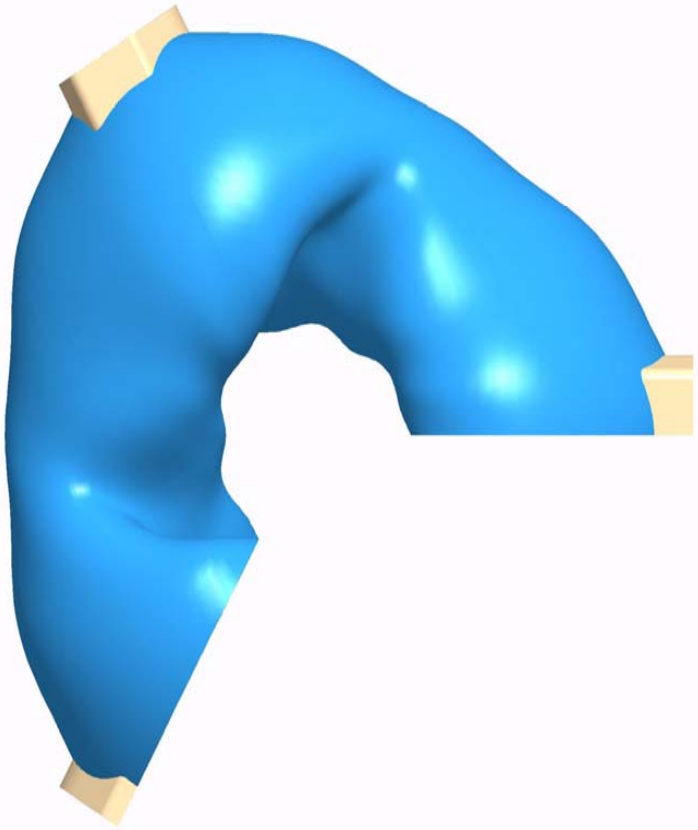
VV and Coils Sub-assembly

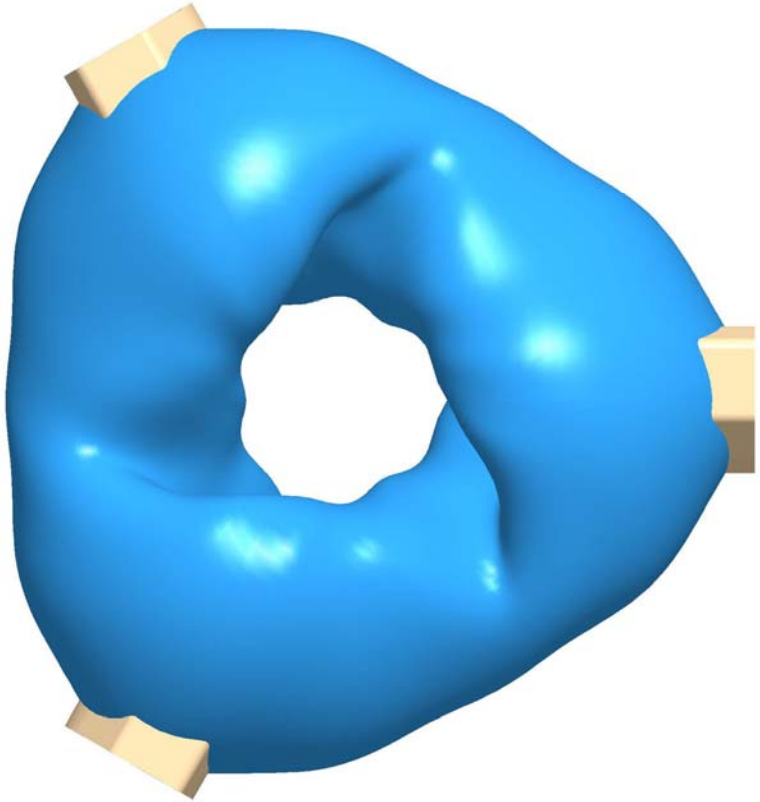




- Position the coil supporting tube of the field-period.
- Slide one VV segment into the coil supporting tube of the field period in toroidal direction from one end.
- Install another VV segment by sliding it into the coils supporting tube from another end, then weld the two segments from inside at 60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

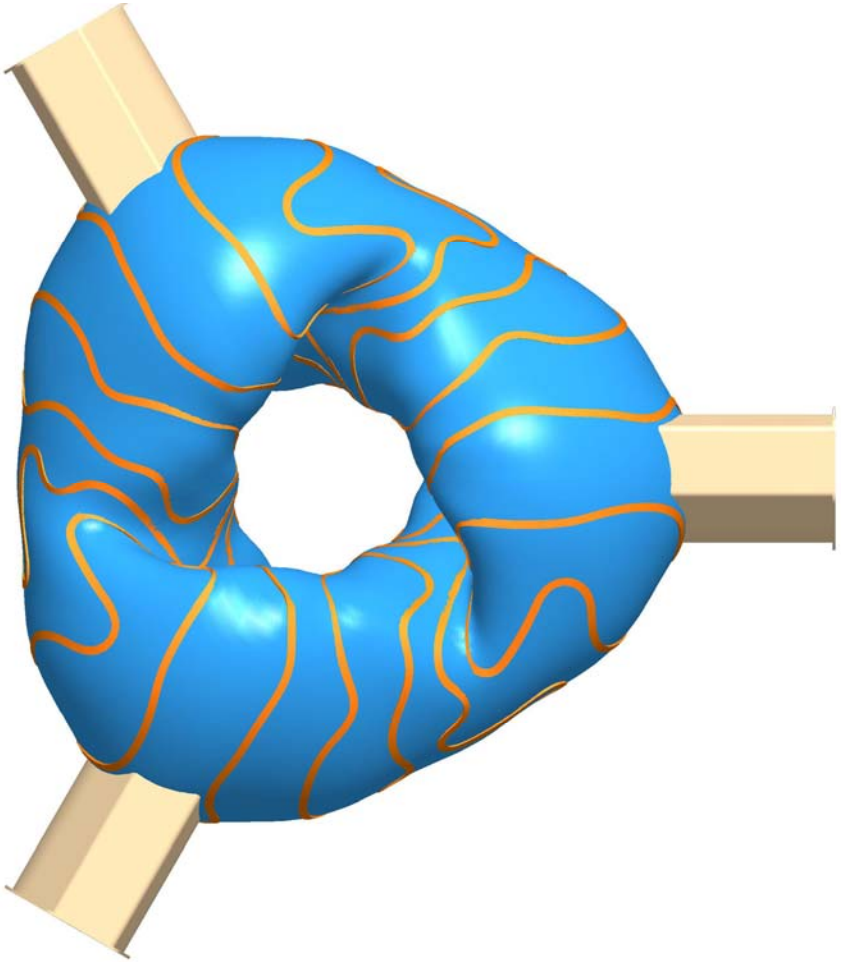
Vacuum Vessel Assembly Sequence(2)





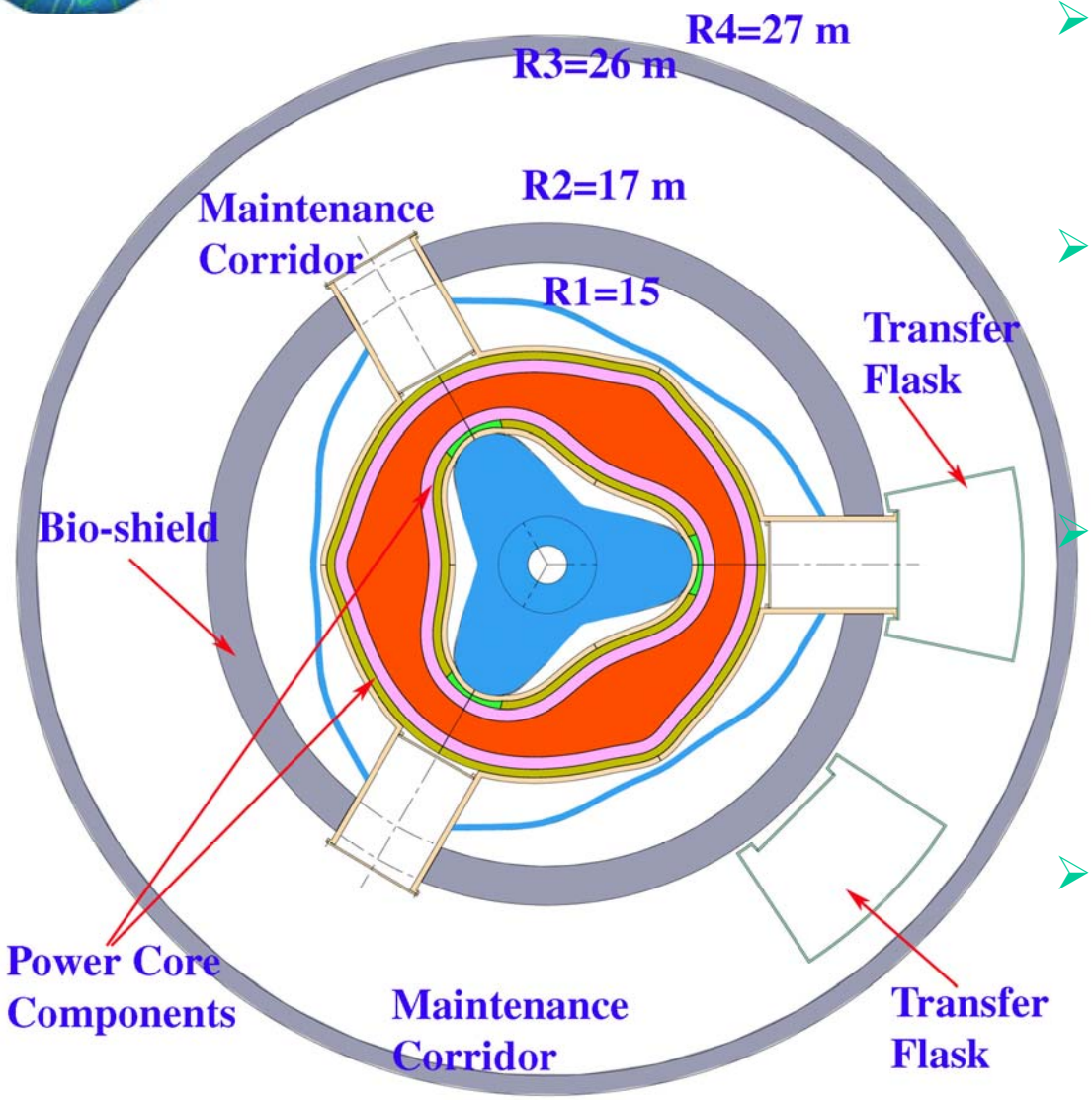
- Position and install two VV and coils sub-assembly, and joint together at 0, 120, and 240 degree by welding.

Vacuum Vessel Assembly Sequence(3)



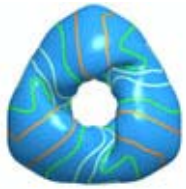
- Add and install the VV port extensions.

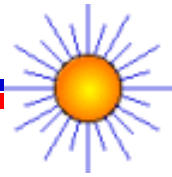
Approach of the Controlling Radioactivity Based on Modular Maintenance



- ARIES-RS approach of controlling radioactivity will be adopted in the CS modular maintenance.
- A large transfer flask will be attached to the outer flange of a maintenance port prior to opening the door of the port.
- After a bio-shield door removed and stored, both doors will be opened , then the used blanket modules can then be moved into the flask and be transferred to hot cell.
- All handling of the power core must be performed with remote control.

Summary





- The external vacuum vessel with uniform shape and size is designed for the configuration based on the field-period maintenance approach.
- A temporary tent is designed to contain the radioactivity during the maintenance operation for the field-period maintenance.
- The internal vacuum vessel is arranged between shield and coils, and the shape and size is non-uniform for modular maintenance.
- Transfer flask(ARIES-RS approach) is employed for controlling the the radioactivity for the modular maintenance.