Updates of the ARIES-CS Power Core Configuration and Maintenance

UC San Diego

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ARIES Meeting

UW, Wisconsin

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Outline

- Answer Laila's question about neutrons streaming through He access tube.

  "Does redial space allow 25-30 cm of local shield?"

- Update layout of the non-uniform blanket module and revisit the steps for non-uniform blanket replacement

- Update and summarize DCLL blanket integration

20-30 cm Local Shield Needed to Protect VV/Magnet

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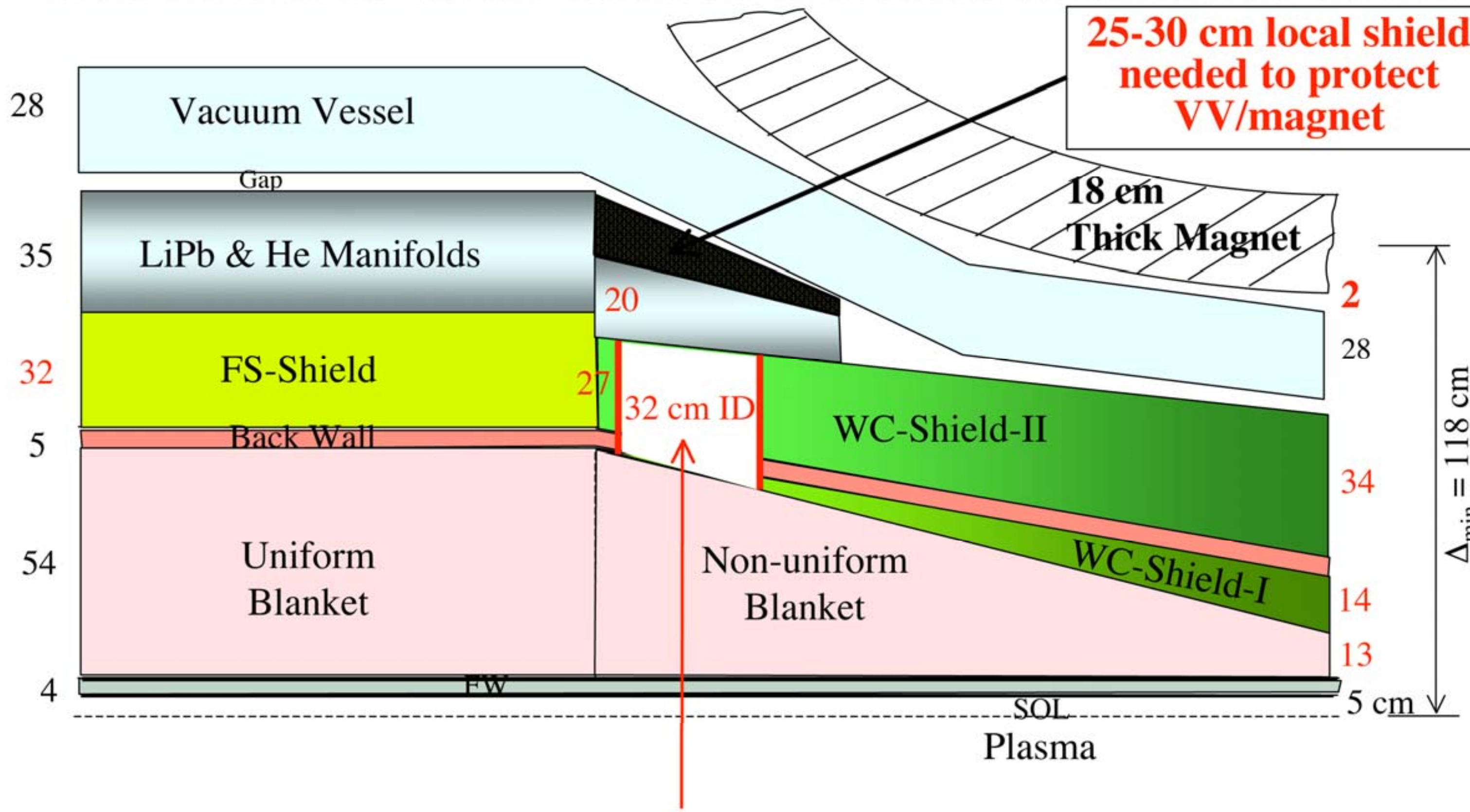
Xn Through He Access Tube

($R = 7$ m, peak $\Gamma = 5$ MW/m^2)



Most critical shielding space (not at Δ_{min})

Layout of the Blanket/Non-uniform Blanket/Shield Modules (Cross Section at 0º Degree)

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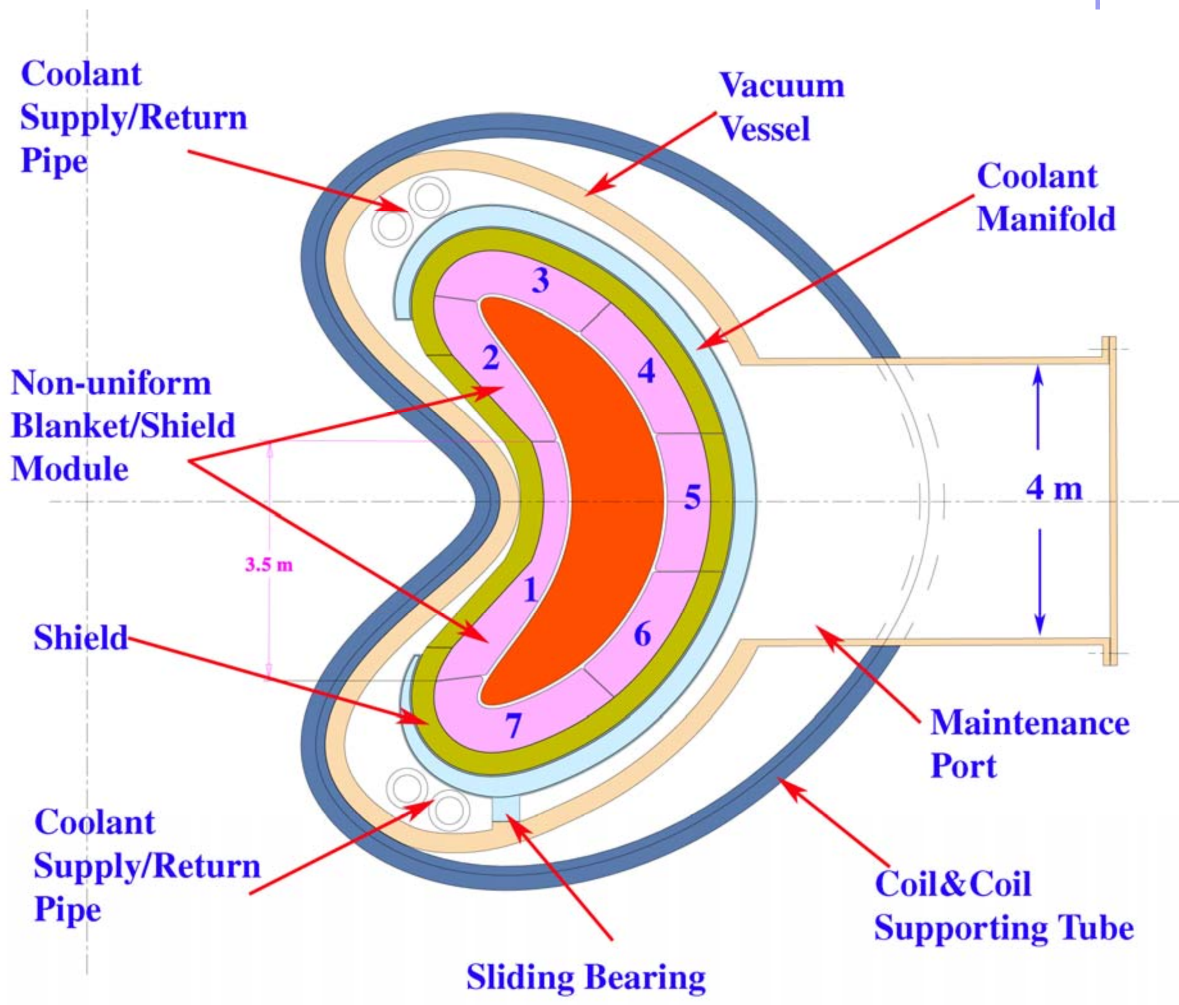
- There is no shield-only zone, and no manifold at the inboard region.
- There are two non-uniform blanket modules for the cross section at 0 degree.
- All the blanket modules will be fed from the bottom of the module except module #2.
- The blanket module #2 will be fed from top in order to gain space to place local shield and special design will be needed to drain PbLi during maintenance operation.



Layout of the Blanket/Non-uniform Blanket/Shield Modules (Cross Section at 15^o and 30^o Degree)

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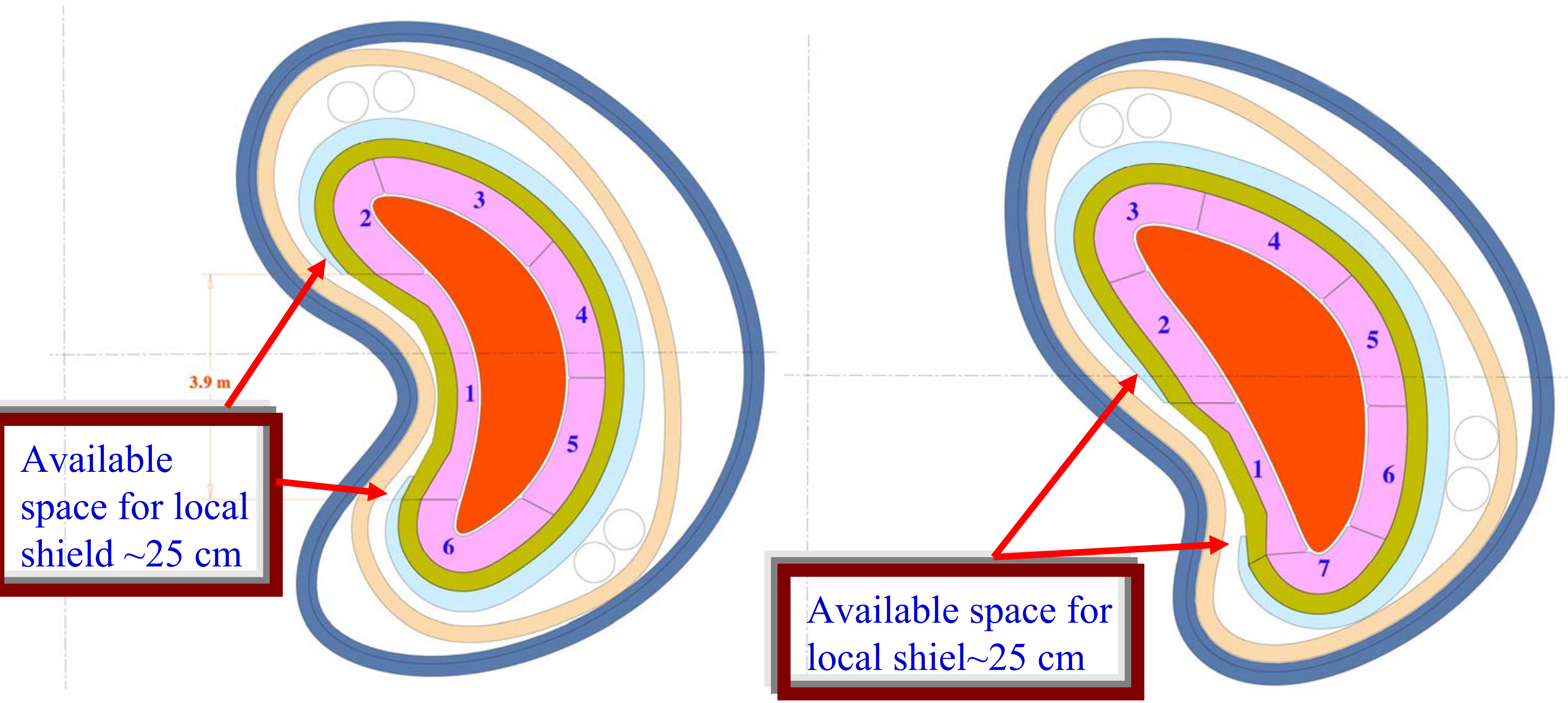

➢To increase the space, the height of nou-uniform blanket module has to be extended, but has to be lower than height of maintenance port.

Layout of the Blanket/Non-uniform Blanket/Shield Modules (Cross Section at 45º and 60º Degree)

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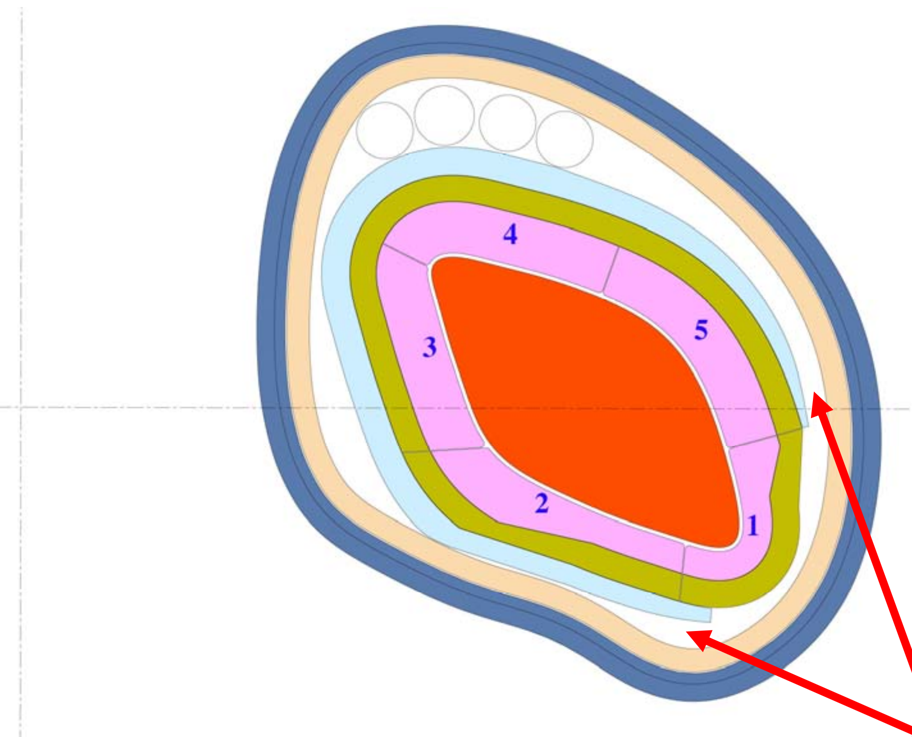
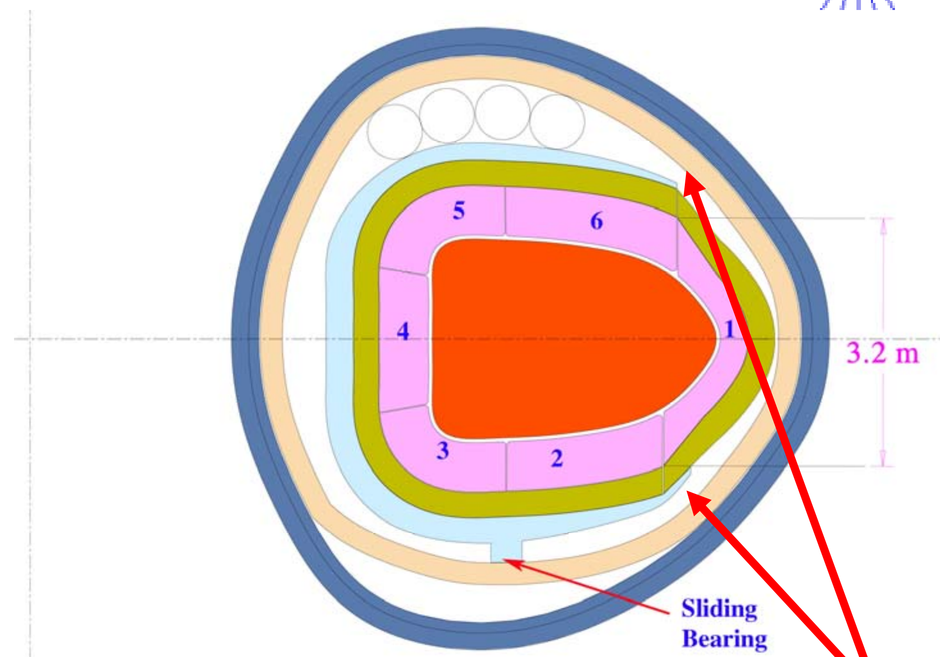




Available space for local shield ~25 cm

Available space for local shield ~25 cm

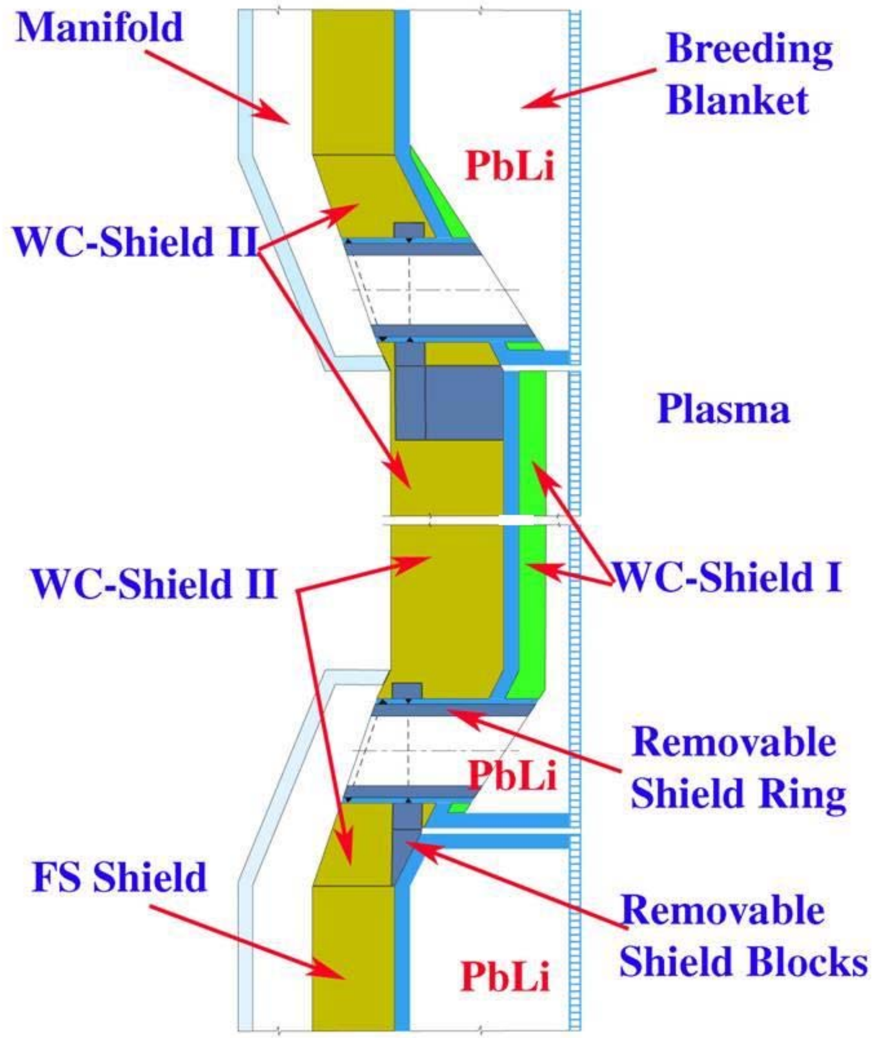
Layout of the Non-uniform Blank and Coolant Access Pipe

➢Like regular breeding blanket modules, the welds are protected by removable shielding ring inside of the tube.

➢The removable shielding blocks are made of WC, and they are lifetime components.

➢Cutting/Rewelding the access tube to disconnect the module is similar to the approach of the regular blanket.

➢Reweldability of manifold will be assessed by UW.



(Not Scaled)

Non-uniform Blanket Modules Will Be Removed Sequentially

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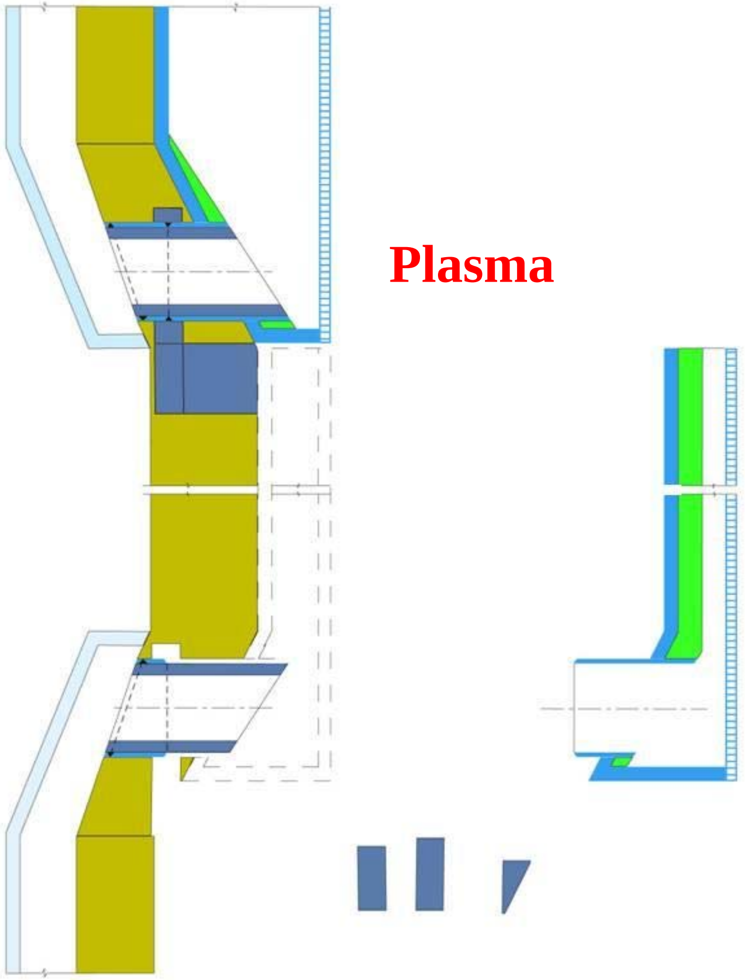
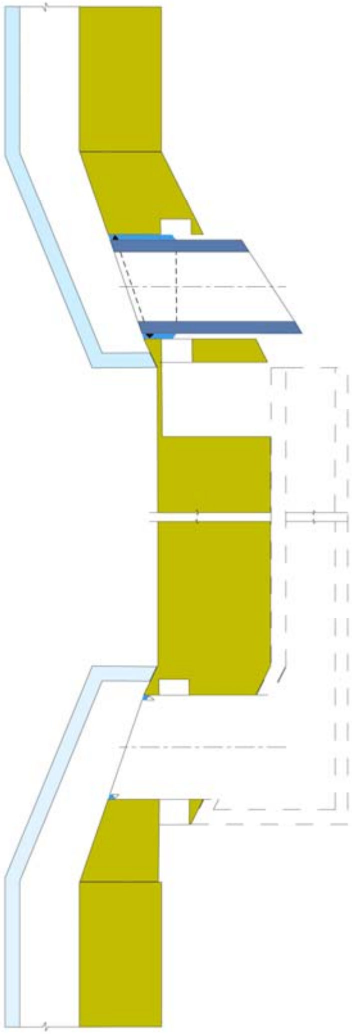
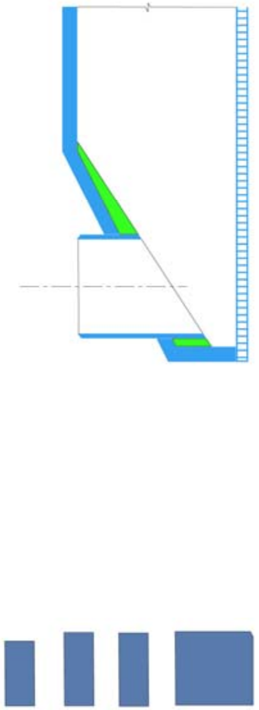
- Assume the neighboring blanket module at the bottom being removed;
- Remove three shield blocks first;
- Make the first cut near the special module with the tools from plasma side;
- Remove the special module out;
- Remove the shield ring inside the access tube out;
- Cut the second cut with in-boor tools, and remove the partial access tube out.



Non-uniform Blanket Modules Will Be Removed Sequentially (Cont.)





Tilt the Coolant Access Pipe Away Would Possibly Make the Cut/Rewelding More Difficulty

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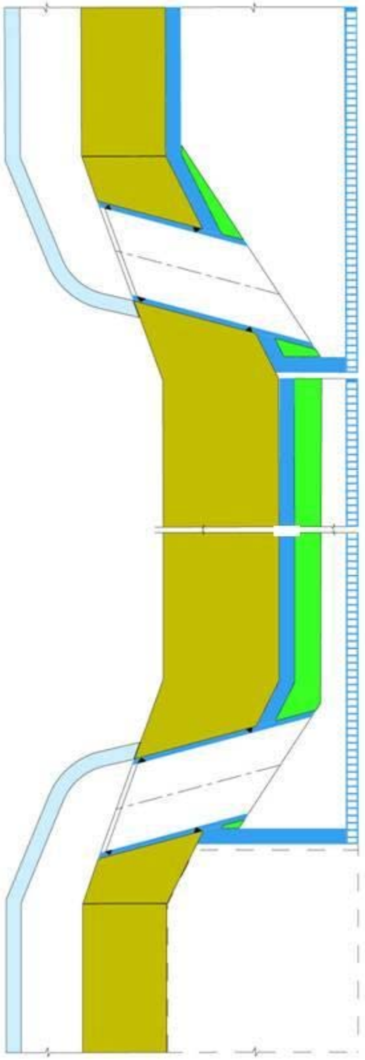
- It is difficult to make the cut/rewelding along an ellipse orbit with orbital tools.
- Tilt the access coolant pipe away from or towards Δmin would not gain the space between the manifold and VV.



DCLL Blanket Integration

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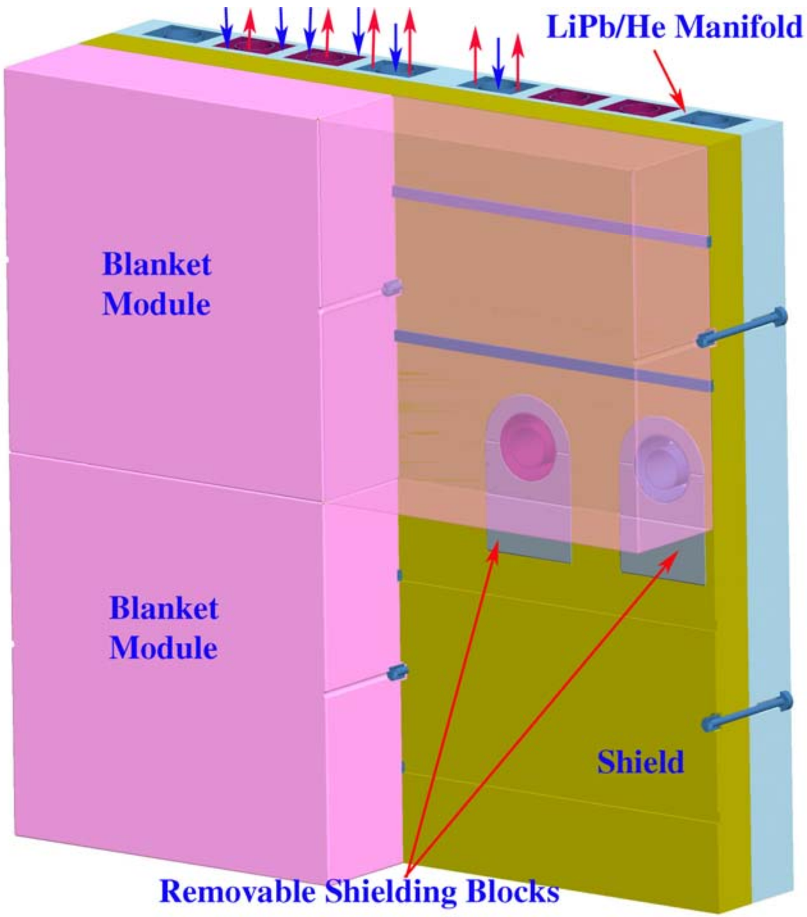
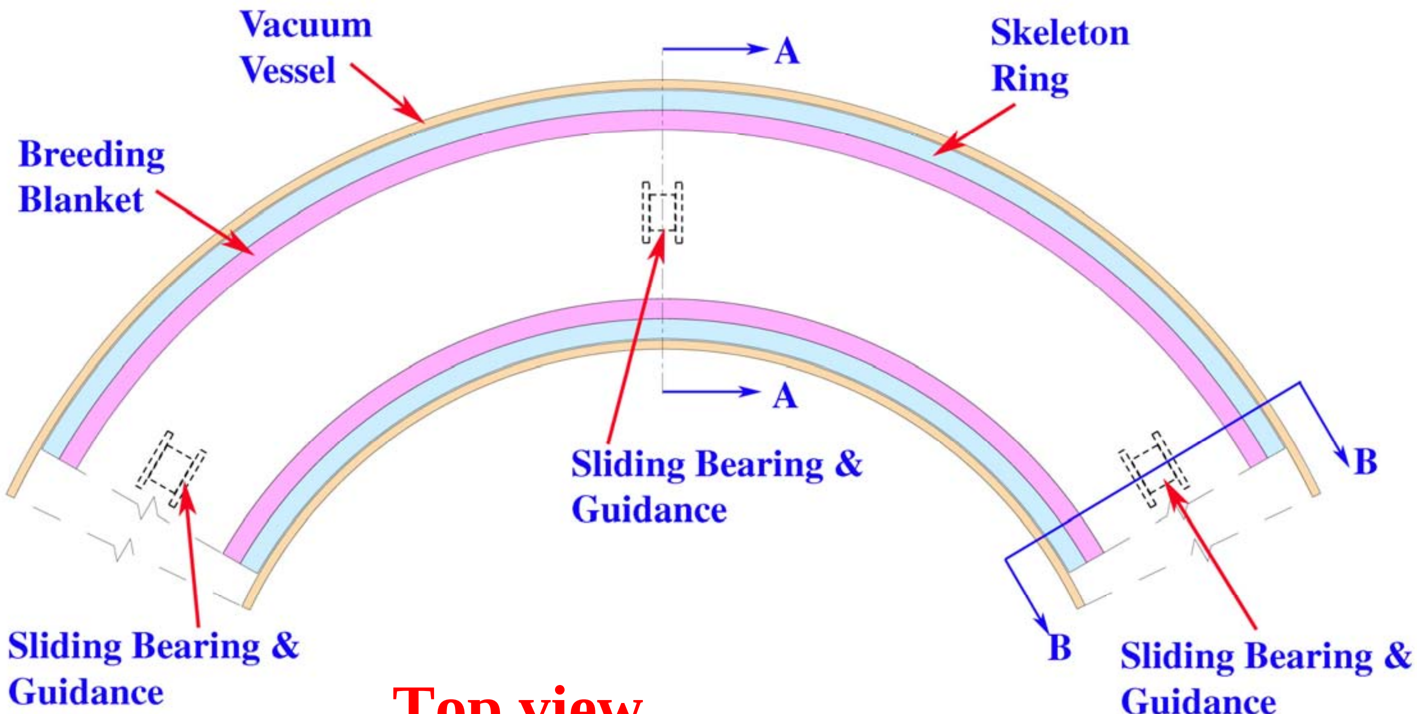
- The basic idea is to design a “hot” power core with skeleton rings continuous in the poloidal direction, but subdivided in toroidal direction into segments, and on which the blanket modules are attached.
- The skeleton rings are composed of a shield and poloidal manifold region, operated at nearly uniform temperature in order to minimize differential thermal expansions and thermal stresses.
- How would the “hot power core” be supported from bottom considering the VV and coil system as “cold” component?



Connecting into Supporting



Top view

➢Sliding bearings between skeleton ring and VV are arranged at the bottom of the VV.

➢ The weight of the “hot power core” per field-period will be supported by 3 cold legs attached to the VV.

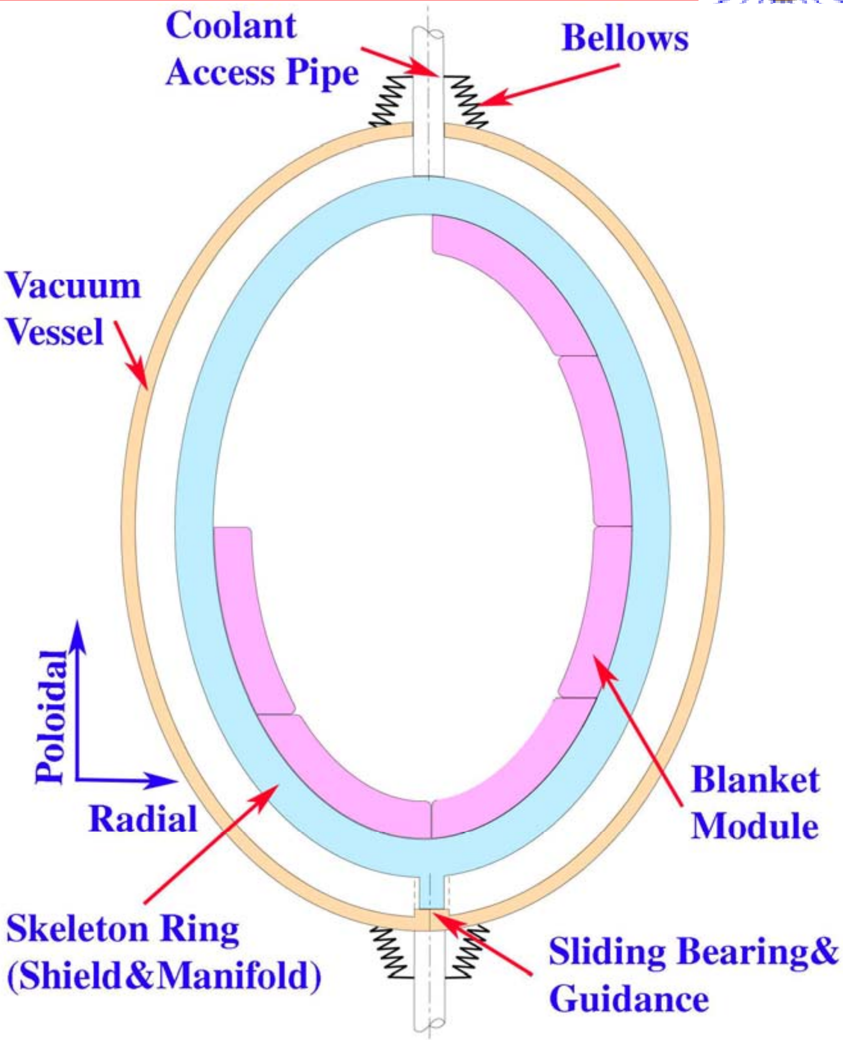
A-A Cross Section: Sliding Bearing for Hot Skeleton Ring

- Concentric coolant pipes are placed at the top and bottom to connect the skeleton ring with the external primary loops and penetrate the VV.

- With the radial guidance of the sliding bearings installed at the bottom of VV, the hot core at the location of AA is allowed for a radial movement only.

- The movement will be small since the sliding bearings in cross section BB allow only differential expansion in toroidal direction. Therefore, any movement of the coolant access pipes relatively to the VV will be very small (fix point)

- Based on assumption of 10 cm height of the bearing, the heat losses per field-period is very small, ~50 KW.



A-A Cross Section

B-B Cross Section: Sliding Bearing for Hot Skeleton Ring (Cont.)

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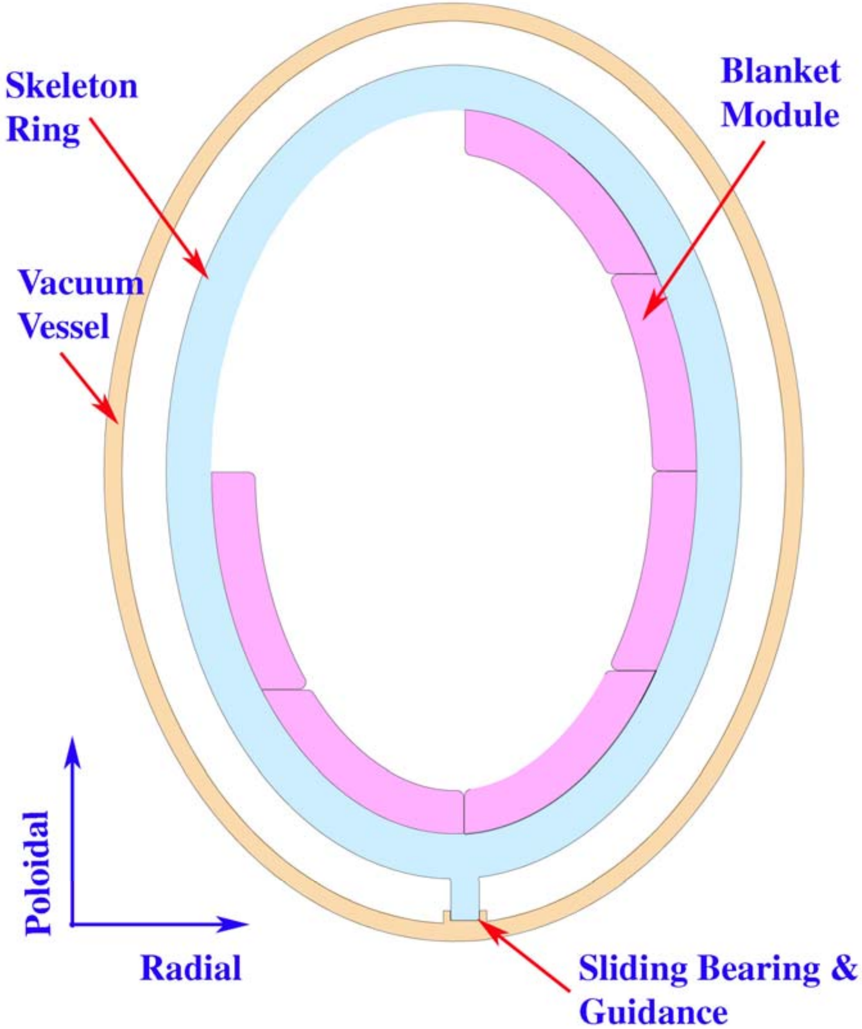
- With the toroidal guidance installed at the bottom of VV, the hot core is allowed for toroidal movement at the both ends.

- The movement will be in the order of 2 cm if there is only one skeleton ring per field-period and a temperature difference of ~250 °C between skeleton ring(~450 °C) and VV(~200 °C)



B-B Cross Section

Summary

- Based on CAD analysis for the case of R=7.0 m, it is possible to add ~25 cm local shield between manifold and VV at the location of the coolant access pipes to protect the VV and magnet.

- It is obvious that increasing the major radial from 7.0 m to 7.5~8.0 m will increase the space for placing local shield.

- The blanket modules will be attached to a skeleton ring of nearly uniform temperature (hot power core). This skeleton ring is supported through the VV by sliding bearings, located at the bottom of the VV, and allowing differential thermal expansion between these two components.

- Coolant access pipes connecting the external primary loop with the hot power core penetrate the VV close to the geometrical fix point, minimizing relative movements between these two components.