Updates on ARIES-ACT1 Power Core Configuration and System Integration

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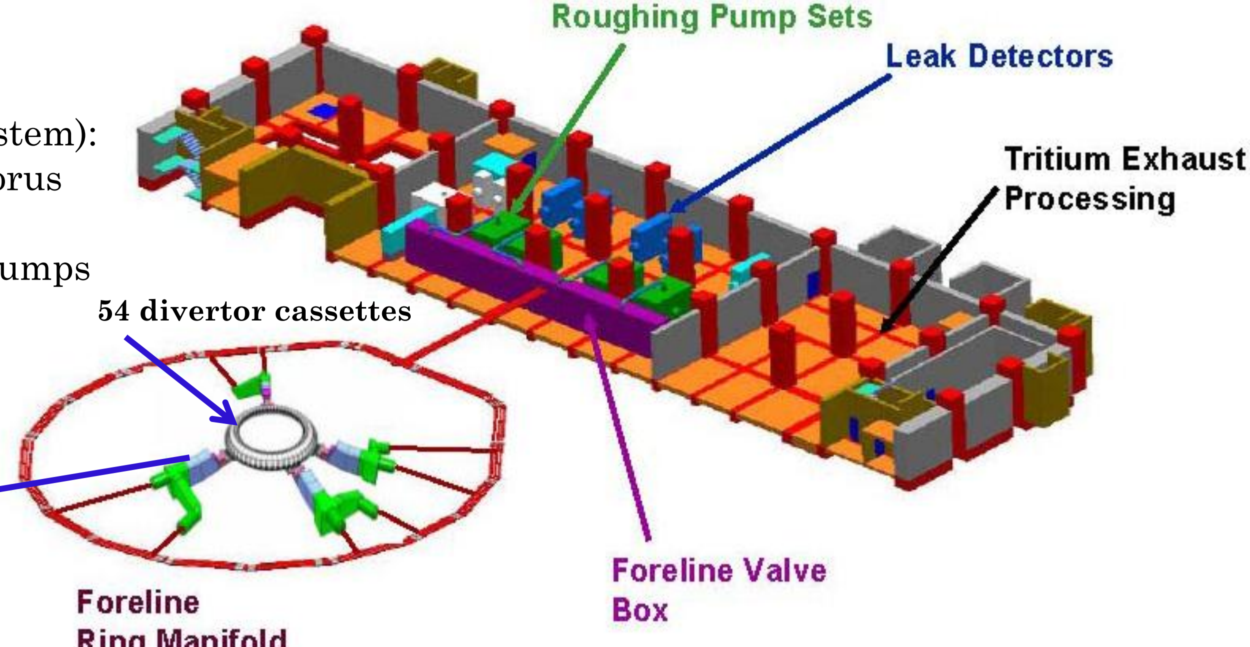
Tasks and Assignments from Last ARIES Project Meeting

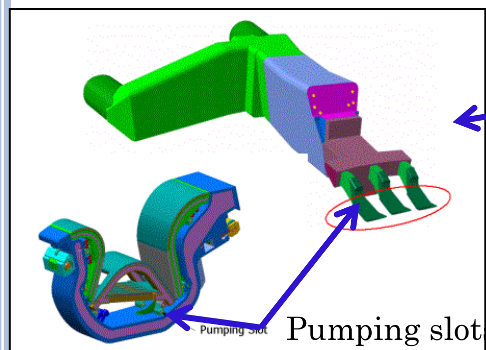
- ✓ Layout of the vacuum pumping ducts
- ✓ PF coil sets
- ✓ Shield blocks in the front of the port
- ✓ Integration of lower hybrid CD launcher into the ACT1 power core sector
- ✓ Integration of the LiPb manifolds
- ✓ Toroidal electrical connection of vertical stability shells

ITER Torus Pumping System

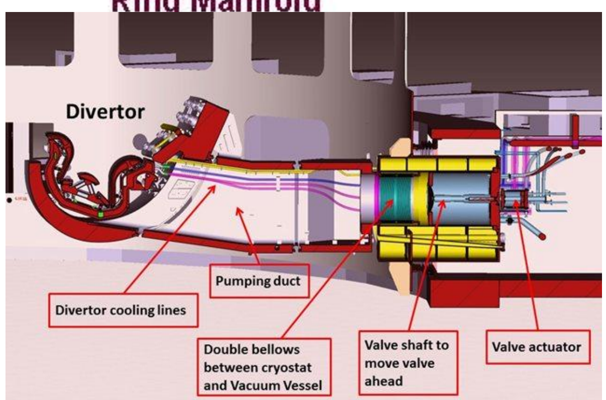
ITER has three high vacuum systems:

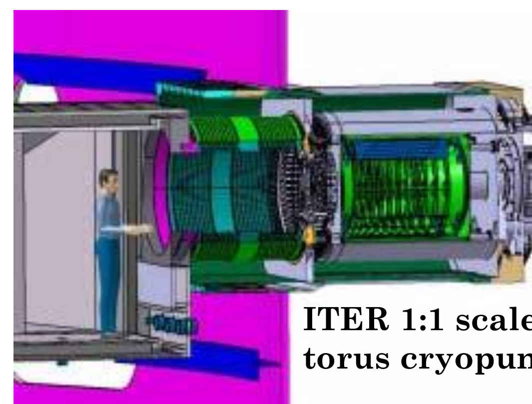
- Torus(primary vacuum system): 1350 m^3, 8 cryopumps, 4 torus pumping ducts
- Cryostat: 8400 m^3, 4 cryopumps
- NBI: 570 m^3, 2 cryopumps





Cryopumps, pump ducts and divertor cassette

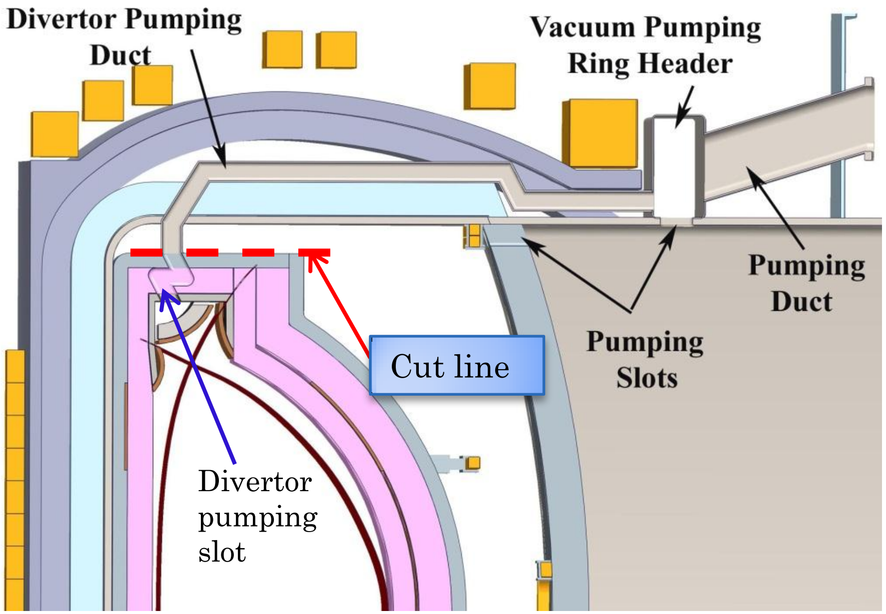




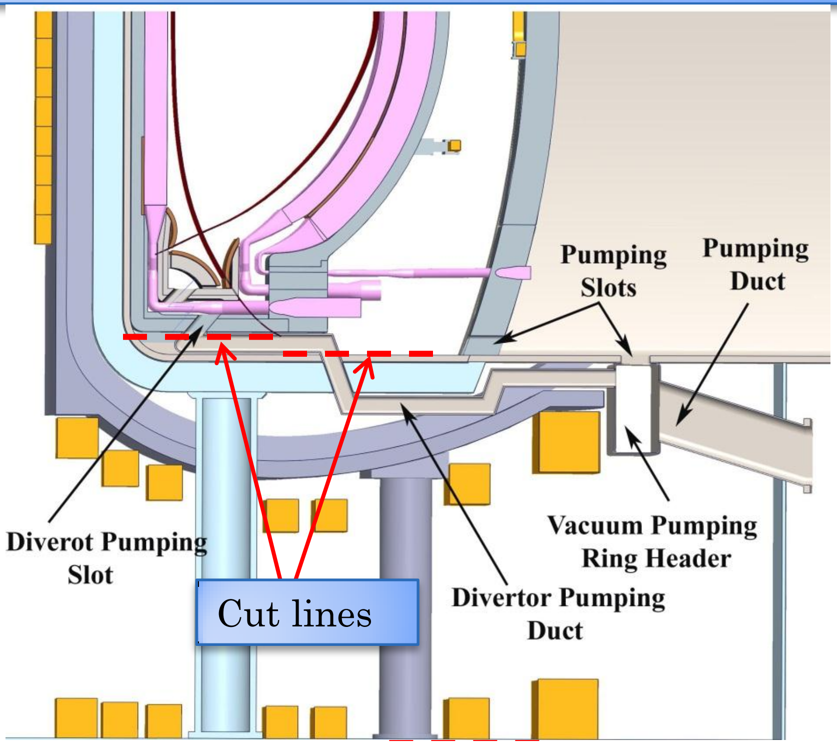
ITER 1:1 scale prototype torus cryopump

Cartoon (not to scale) of the torus pumping system showing the cryopumps and divertor ring and foreline manifold connection to the roughing pumps.

Layout of the ACT1 Vacuum Pumping Ducts (Option 1)



Cross-section above middle plane



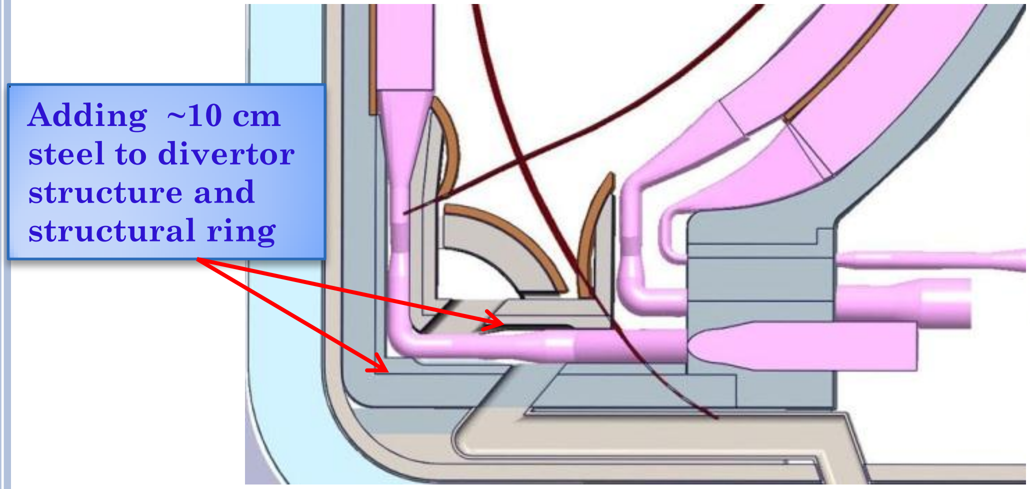
Cross-section below middle plane

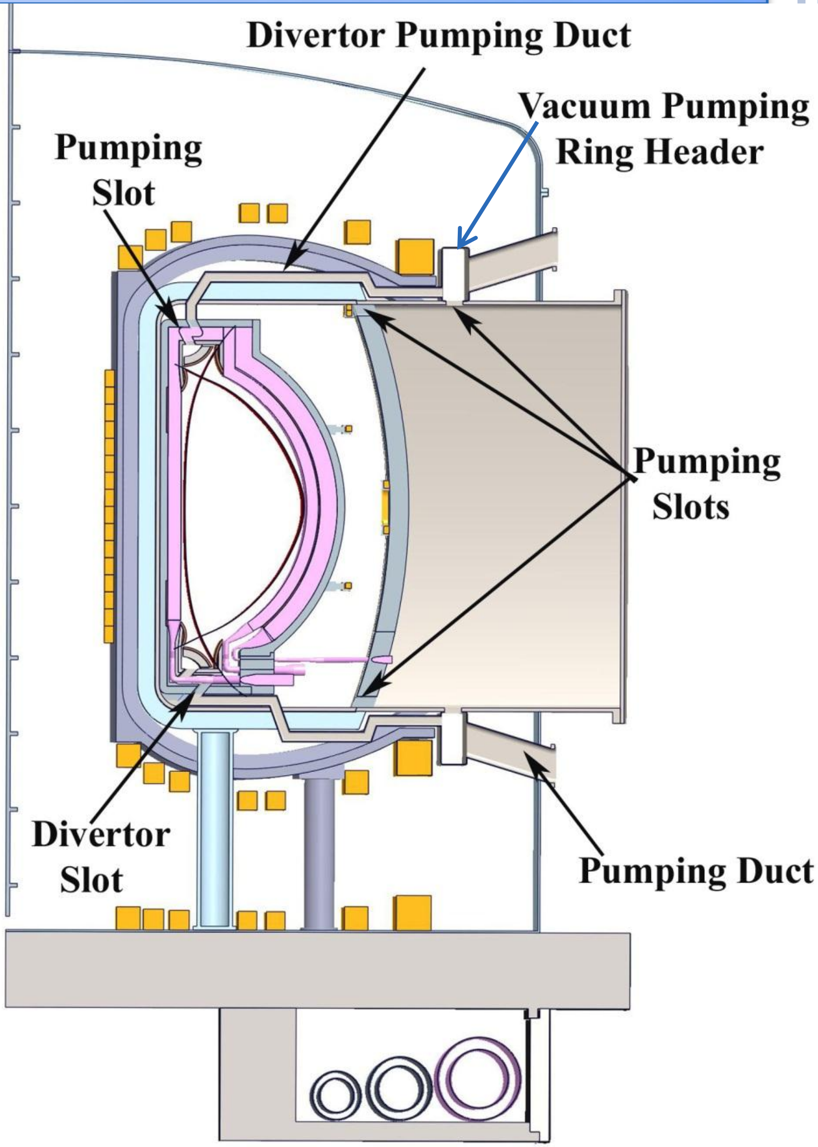
- The ACT1 vacuum pumping system consists of 32 divertor pumping ducts, 2 vacuum pumping ring headers and 8 cryo-pumps located at the outside of cryostat (the same numbers as the ITER).
- The dimensions of vacuum pumping ducts:
  - ✓ 32 Divertor pumping ducts: 0.48 m (tor.) x 0.25 m (rad.)
  - ✓ 2 Pumping ring headers: 1.2 m (pol.) x 0.7 m (rad.)
  - ✓ 8 pumping ducts: 0.9 m (pol..) x 1.4 m (pol.)

- The divertor pumping ducts between the bottom plate of the structural ring and the VV need to be cut and removed for installation of rail system and sector maintenance.

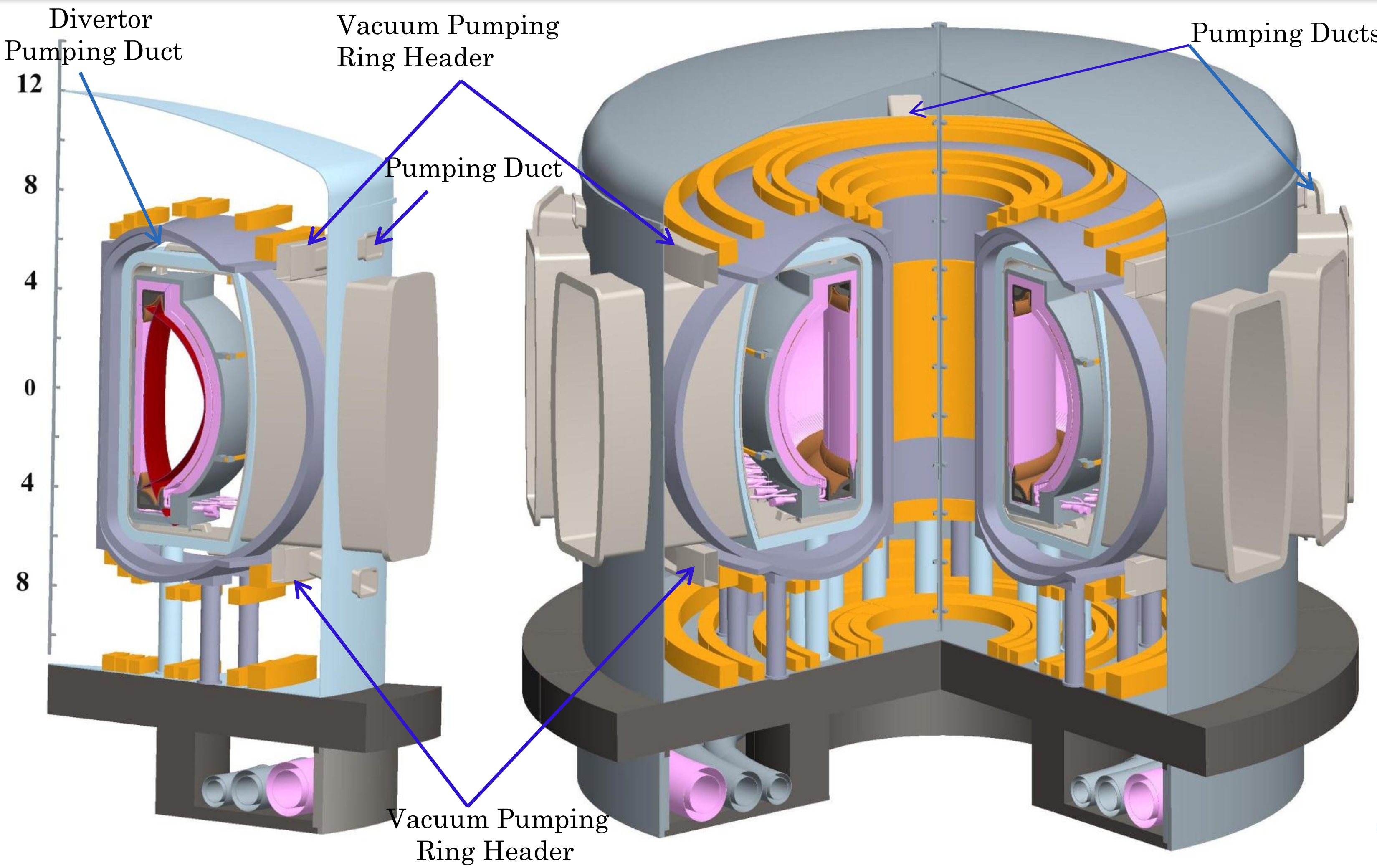
Updates on the ARIES-ACT1 Overall Power Core Configuration

- Modified layout of the vacuum pumping ducts
- Redefined PF coil sets (iterating with Chuck)
- Integrated inboard and outboard blanket manifolds to the power core, and an extra steel plates (8-10 cm) added to the divertor structure and structural ring for shielding.
- Modified the shield blocks thickness from 22 cm to 47 cm
- Redeined the cryostat and the coolant ring headers under ground





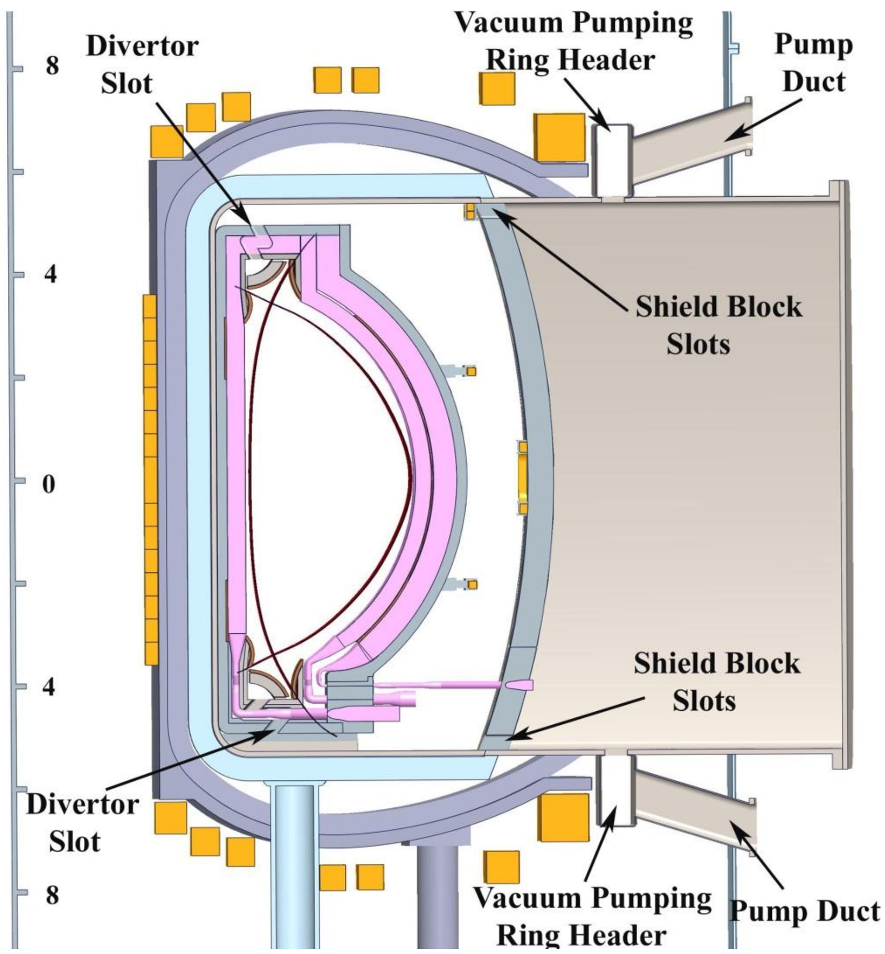
Updates of the ARIES-ACT1 Overall Power Core Configuration



- ✓ 2 vacuum pumping ring headers located at top and bottom of the port
- ✓ 16 x2 divertor pumping ducts connecting to the pumping ring headers
- ✓ 8 vacuum pumping ducts (4 at the top and 4 at the bottom), and 8 cryopumps.

Layout of the ACT1 Vacuum Pumping Ducts (Option 2: ARIES-AT Pumping Approach)

- No divertor pumping ducts.
- No needs for cutting and removing the divertor pumping ducts during maintenance.

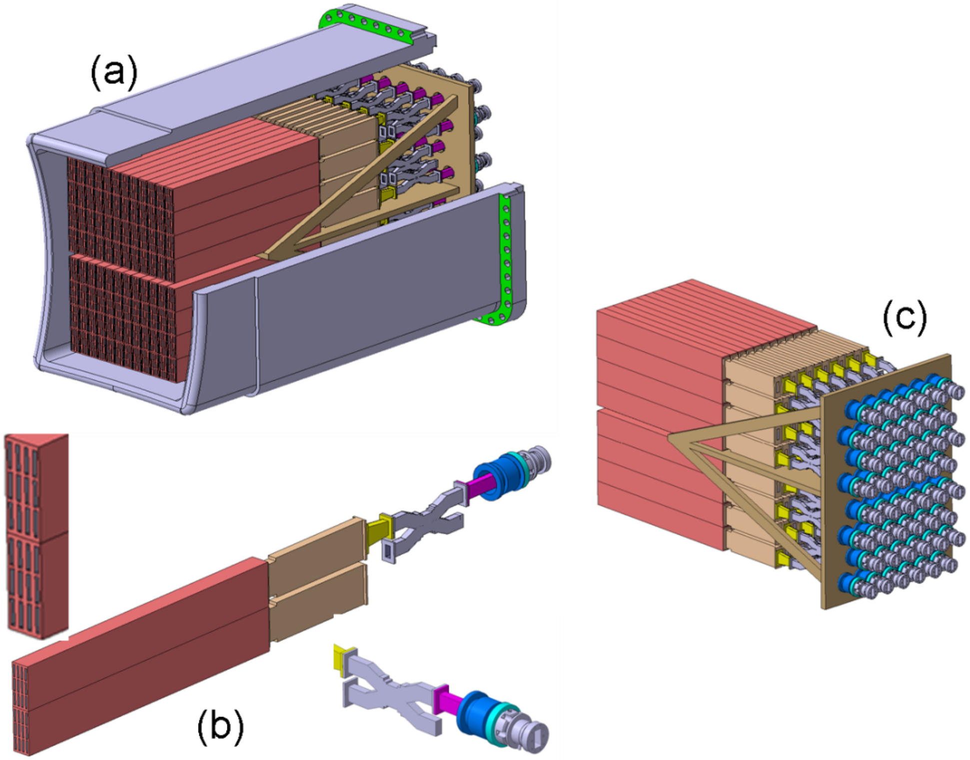


ITER Lower Hybrid Current Drive Launcher

- The ITER LH system is designed to deliver a power of 20 MW at 5 GHz using a single port.

- The power density in the waveguide is 33 MW/m^2.

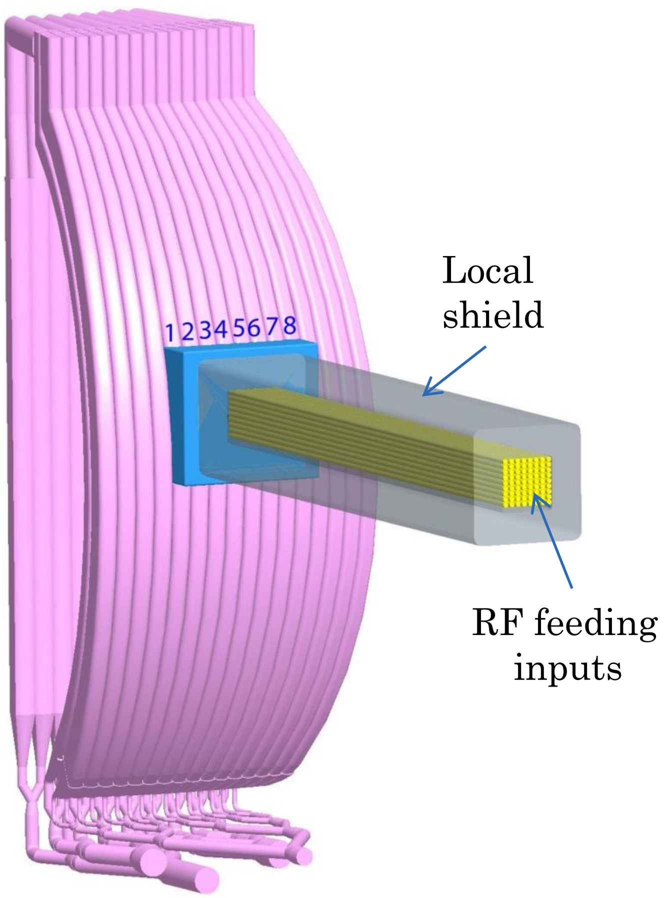
- Overall dimensions on facing plasma side (FW): 1.5 m(toroidal) x 1.9 m (poloidal).



(a) ITER LH launcher, 48 modules
(b) 1 module with 24 active WGs
(c) 48 RF windows

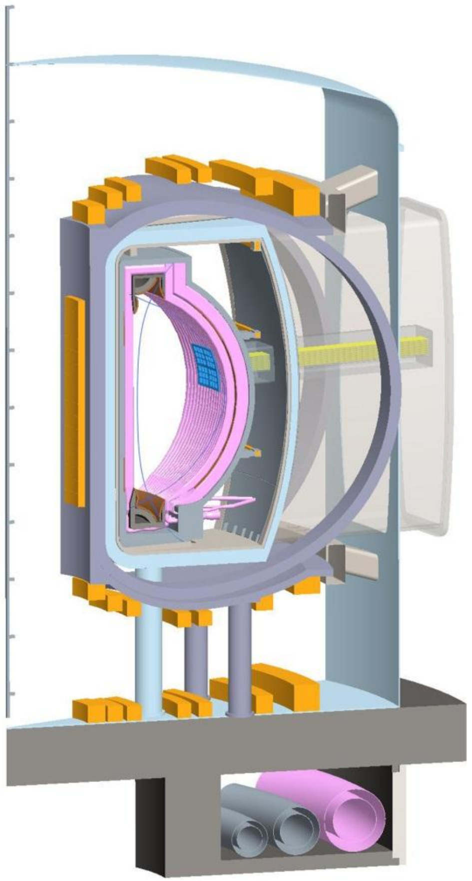
Opening of the Outboard Blankets for the Launcher System

- The toroidal width of the OB-I sector at the mid-plane is ~3.2 m, composed of 16 modules with ~0.2 m for each blanket module.
- The opening of the sector for installation of the CD launcher system:
  - ✓ Toroidal width: 1.6 m (in order to cover 8 of 16 outboard blanket modules)
  - ✓ Poloidal length: 1.9 m
- ITER LH launcher with dimensions of 1.5 m (toroidal) x 1.9 m (poloidal). Adding a 5 cm steel to the frame on two side will make the launcher system well matching the ACT1 blankets.



Integration of the LH CD Launcher in the ARIES-ACT1 Sector

Launcher assembly

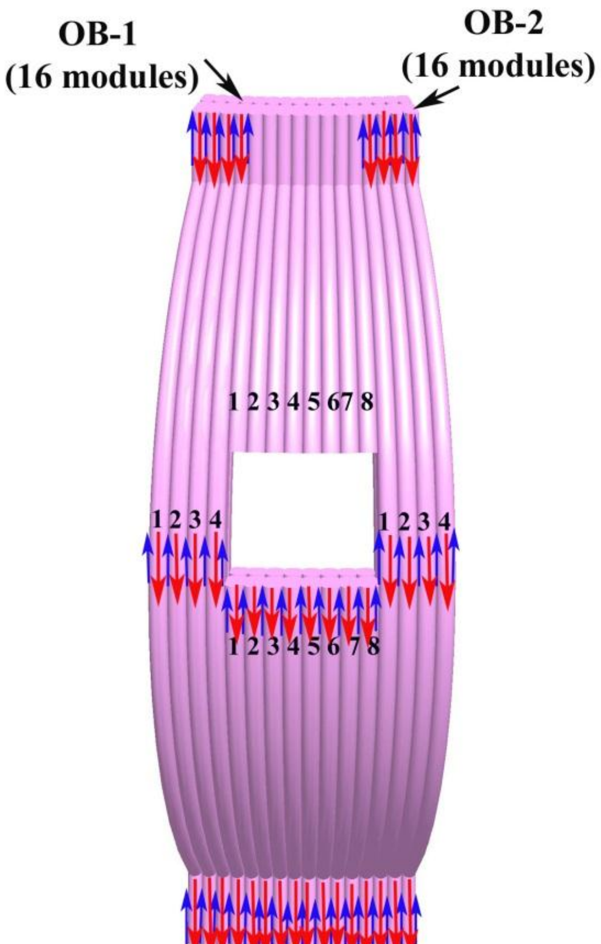


ACT1 power core with integration of the launcher

- Two LH CD launchers are integrated into the ACT1 power core (at 11.25 and 191.25 toroidal degree)
- All the RF feeding inputs will connect to the RF generator locating the outside of bio-shield.
- A local shield (roughly ~50 cm thick) must be placed around the RF feeds.

Cooling Scheme for the Sectors with LH Launcher Installed

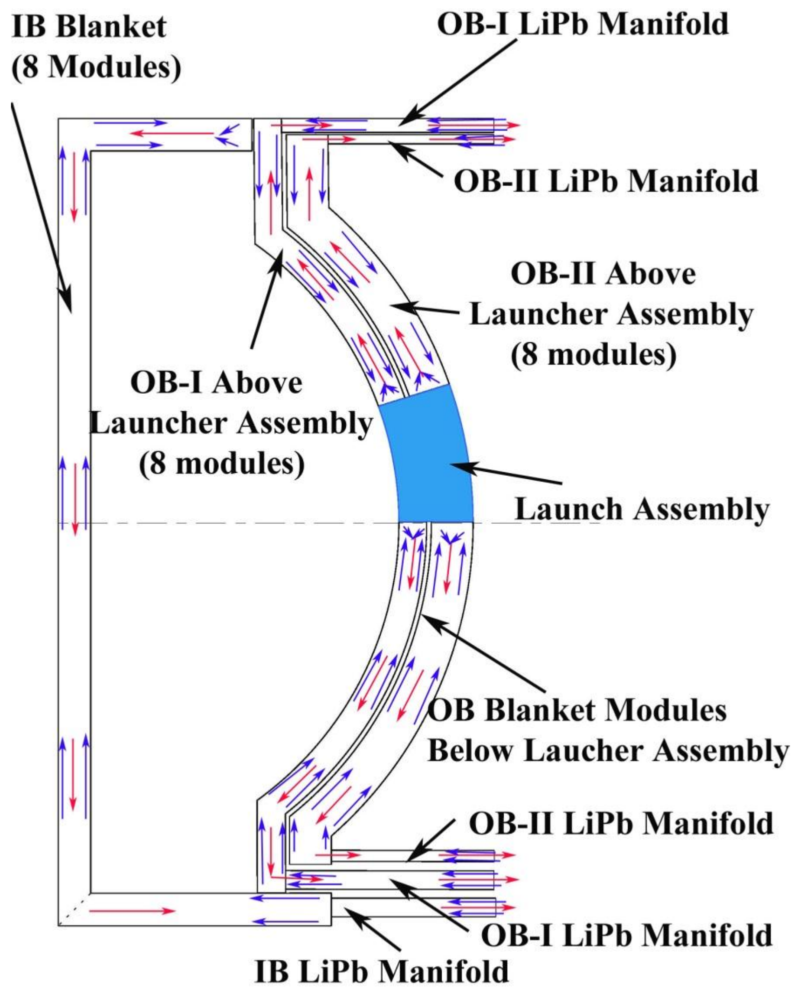
- The temperature rise in the different modules will be made identical to the coolant in the "normal" modules by adjusting the flow rate corresponding to the heat generated in the modules.
- In the outer 16 modules (8 OB-I and 8 OB-II modules) at the two sides of the launcher, the flow rate is identical to the flow rates in the normal sectors.
- In the lower halve of the blanket modules (8 OB-I and 8 OB-II modules), the flow rate is reduced to ~50% of the normal flow rate in a normal module.
- The Li-Pb coolant will be fed by the bottom manifolds, flow up to the mid-plane, then make U-bend, and flow into the center duct to the bottom manifolds.
- How will the upper halve of the blanket modules (total of 16) be cooled?



Connecting to OB-1&OB-2 LiPb manifold
(32 LiPb channels)

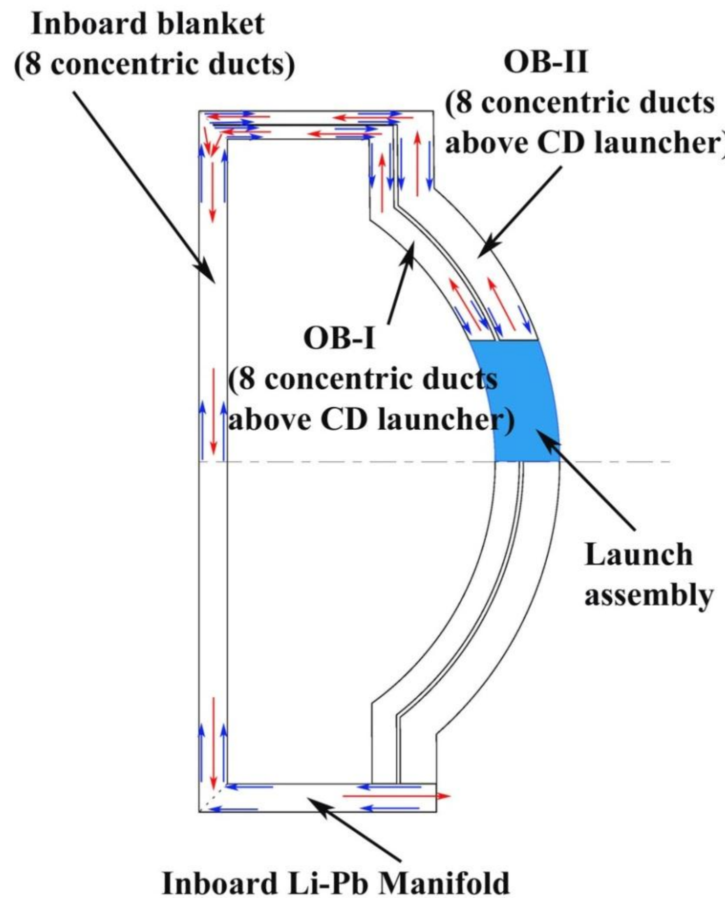
Cooling Scheme of Blanket Modules Above the Launcher Assembly (Option 1)

- There are 16 blanket modules above the launcher and they will be cooled from top LiPb manifolds.
- It requires to adjust the mass flow rate of the blanket modules to maintain the same coolant temperature rise as the normal blanket modules.
- It also requires 2 LiPb manifolds at the top to feed the coolant.
- The blanket modules including the FW cooling channels do not need to be re-designed.

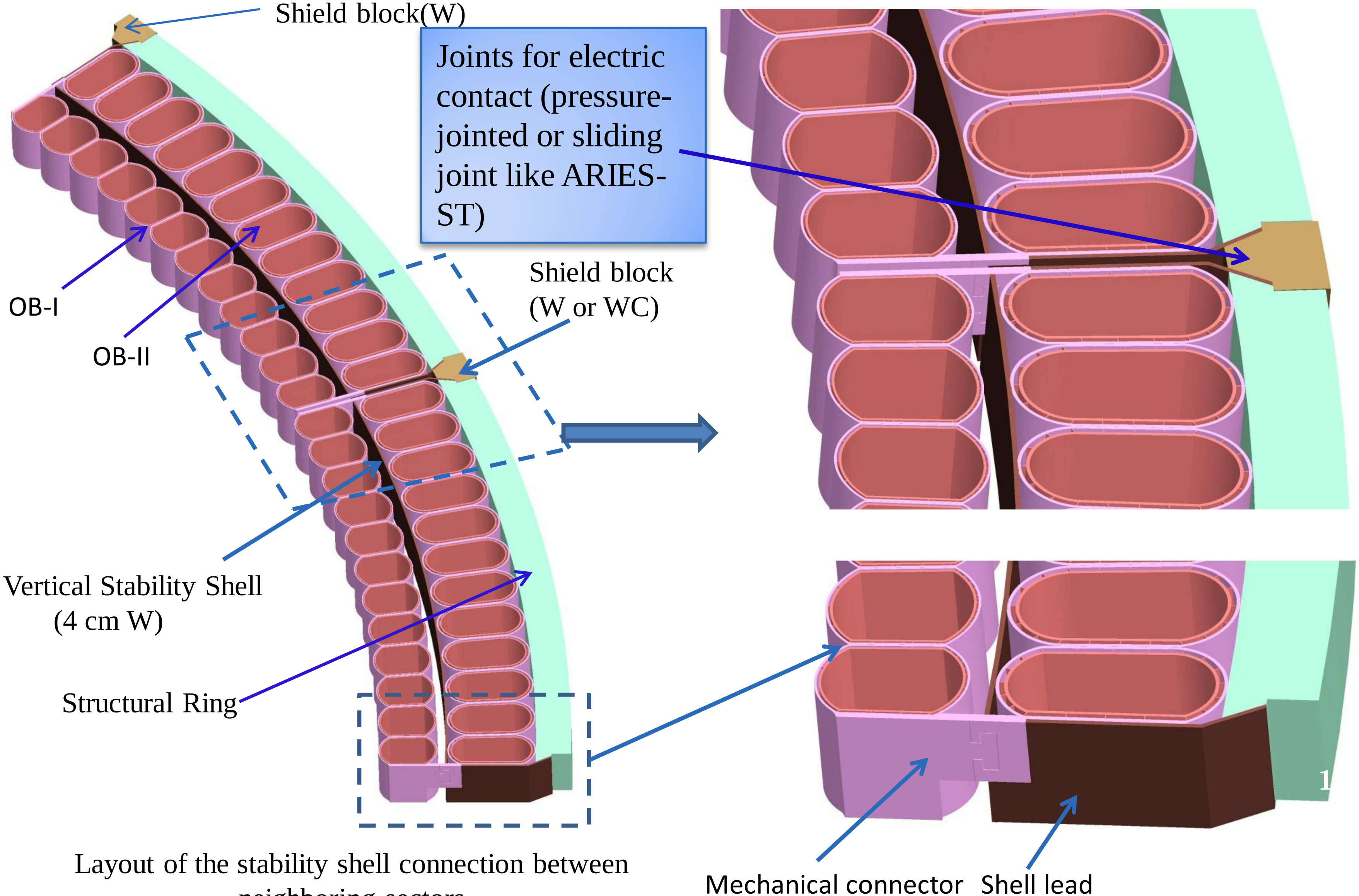


Cooling Scheme of Blanket Modules Above and the Launcher Assembly (Option 2)

- The 16 blanket modules above the launcher will be cooled from top with the coolant flow of the IB blanket.
- This requires the coolant splitting and connecting between IB and OB blankets at the top and it must be possible to separate the IB and OB blanket segments in the hot cell by cutting these connectors (no detailed design)
- The total thermal power of the normal IB/OB sector, Q_{IB}=~20 MW, Q_{OB}=~66 MW and the thermal power of 16 OB blanket modules above the launcher is ~25% of the normal OB.
- The total power of the IB blankets of a sector with launcher will be increased to Q_L=~36.5 MW, and the flow rate for the IB blanket sector and 16 OB blanket modules above the launcher has to be increased by ~80%.
- The inboard blanket modules need to be re-designed for FW temperature control.

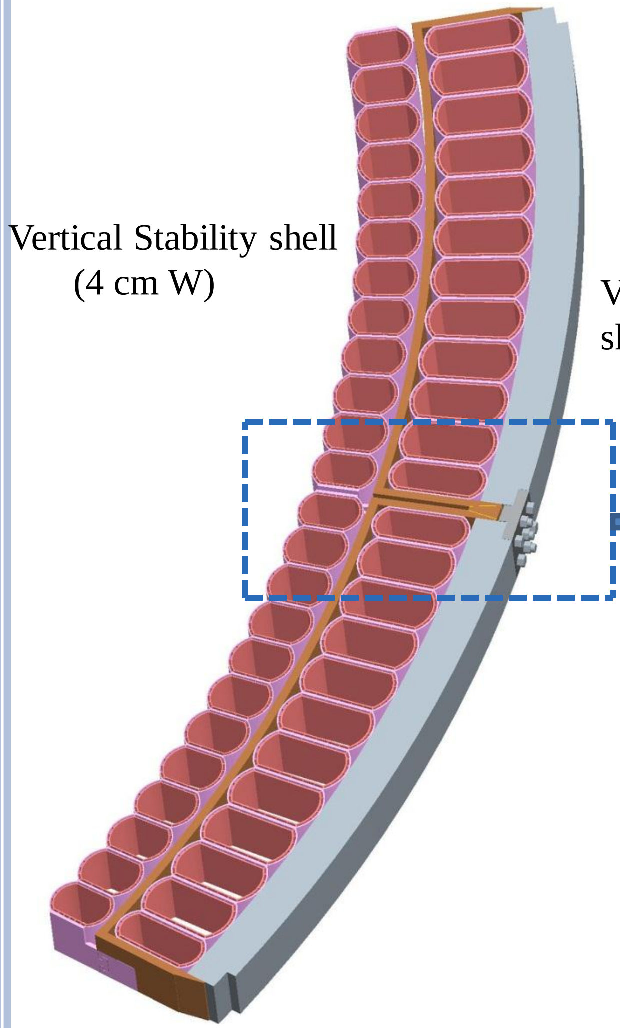


Toroidal Electrical Connections of the Vertical Stability Shells (presented in 1/23/2012 at ARIES Meeting)

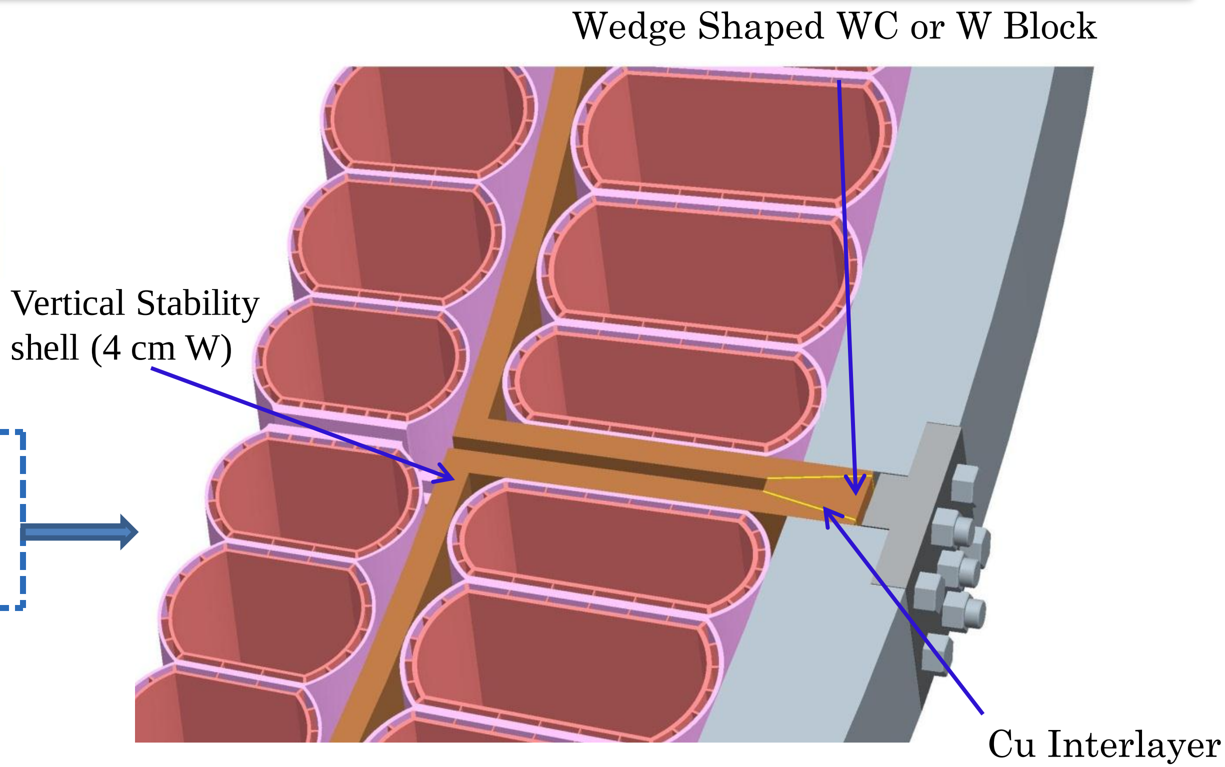


Layout of the stability shell connection between neighboring sectors

Toroidal Electrical Connections of the Vertical Stability Shells (Adding details)



Layout of the stability shell connection between neighboring sectors



- Inserting a wedge-shaped conducting block into the gap
- Applying mechanically high contact pressure to ensure sufficiently high electrical conductance by strong screws at the backside of the structural ring.
- Using W or WC as material for wedge-shaped block in order to combine high electric conductance, allowing high temperature operation, and excellent neutron shielding to minimize gap streaming.

Summery

- ARIES-ACT1 power core configuration has been updated, including
  - ✓ New PF coil sets
  - ✓ Layout of vacuum pumping ducts
  - ✓ Launcher system
  - ✓ LiPb manifolds (Christina)

- All CAD figures on the ARIES Web site will be updated soon.