Solid Breeder Blanket Design Concepts for HAPL

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Presentation Outline

- Two blanket designs are presented
  - A static solid ceramic breeder blanket design entirely cooled with He gas at 8 MPa
  - A moving bed solid ceramic breeder blanket design with the first wall cooled with He gas at 8 MPa and the solid breeder particles flowing under gravity through the reactor which are then transported to a heat exchanger for energy recovery.

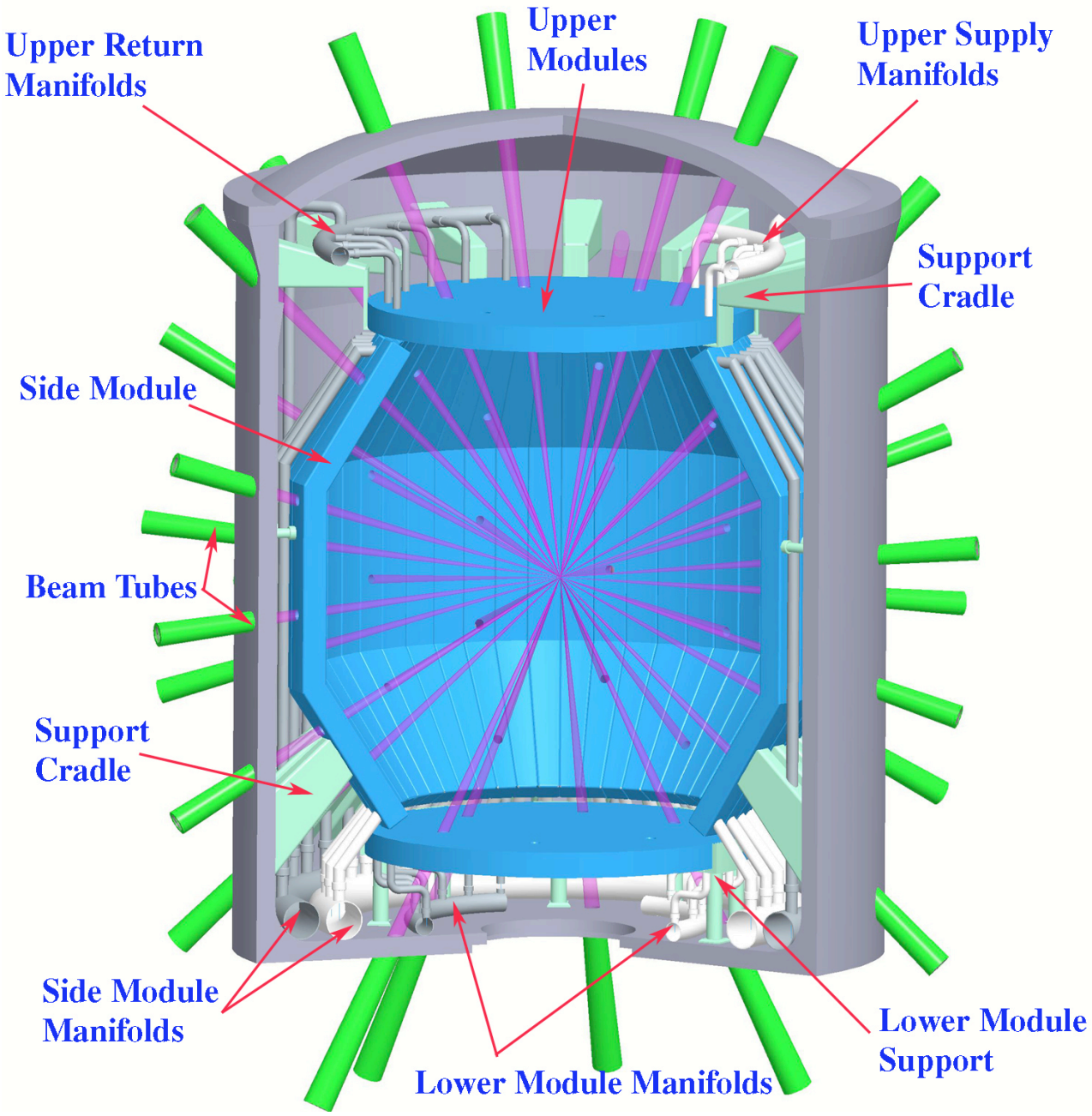
A Static Solid Breeder Blanket

- Solid breeder blanket options with Li4SiO4 and He as coolant have been mainly developed in Europe at FZK and have been considered for several designs including the EU-Demo and ARIES-CS.
- The structure is ferritic steel and the blanket is entirely cooled with He gas.
- The He gas, after cooling the FW, enters the breeding region which has plates of Be and solid breeder interspersed, and cools them before exiting the blanket and going to the heat exchanger.

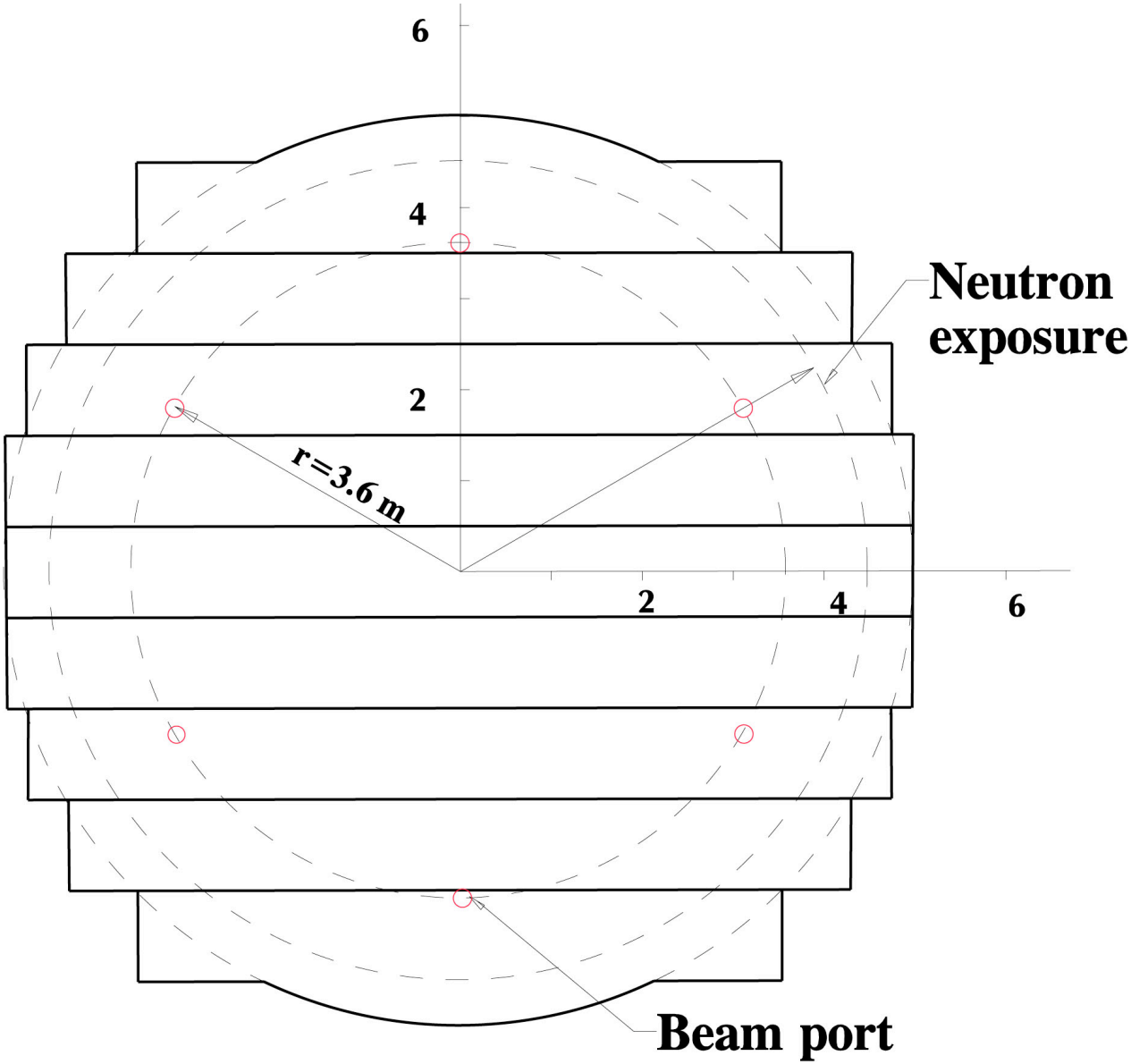
Static Solid Breeder Blanket Contd.

- The solid breeding material is either Li_4SiO_4 or Li_2TiO_3. Be is needed as a neutron multiplier.
- Beam port location and distribution is the same as in the earlier Li cooled blanket. Sixty beam ports are used.
- The laser beam tubes terminate at the vacuum chamber wall and from there the laser light travels to the target without tubes.
- There are 48 side blanket modules in the reactor with four beam ports in every fourth module.
- There is an upper and lower blanket with six beam ports in each.
- The chamber is equipped with a removable upper flange for maintenance of all the blanket components.
- The chamber is evacuated through the beam ports by pumps attached to the vacuum chamber. In addition, each beam tube will have a pumping station in the vicinity of the last mirror.

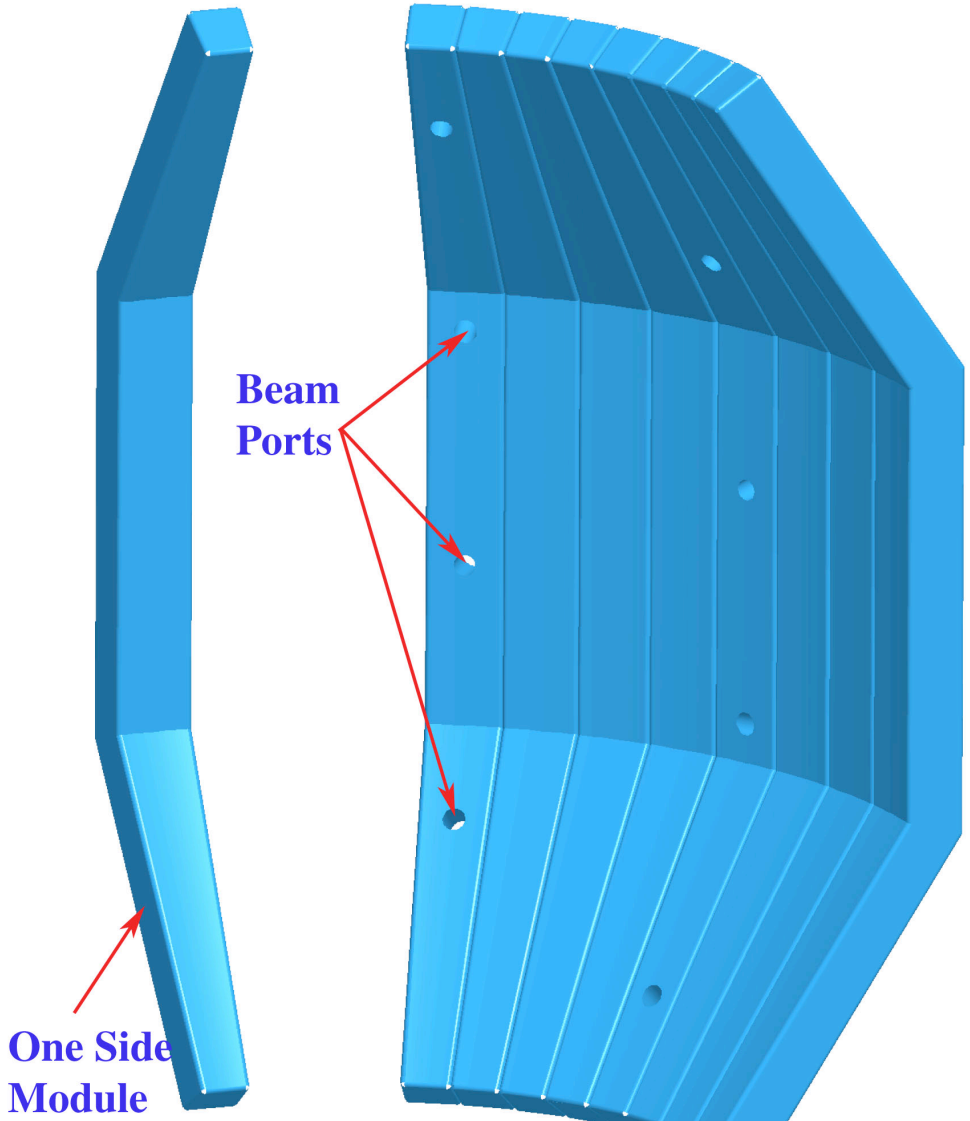
HAPL Chamber Shown with a Static Solid Breeder Blanket



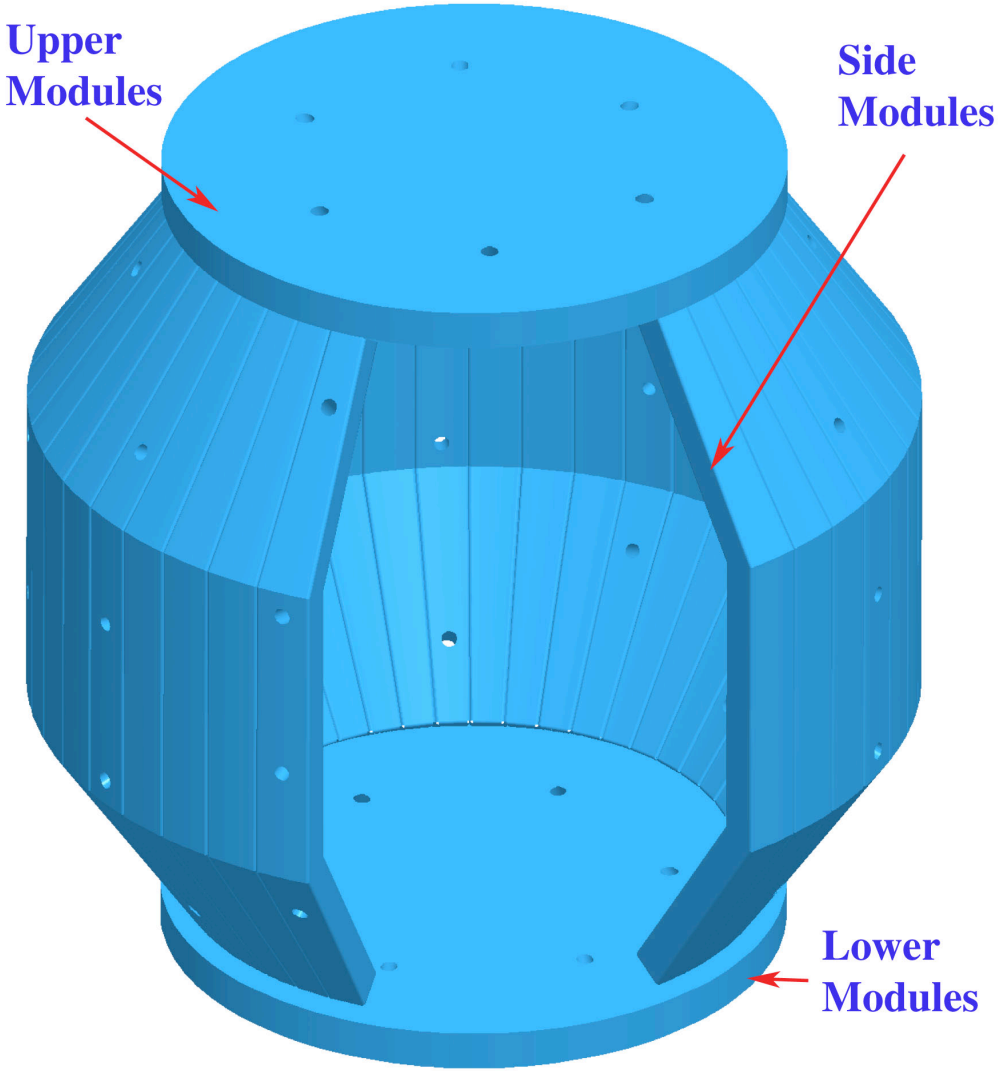
Top View of a Lower/Upper Blanket



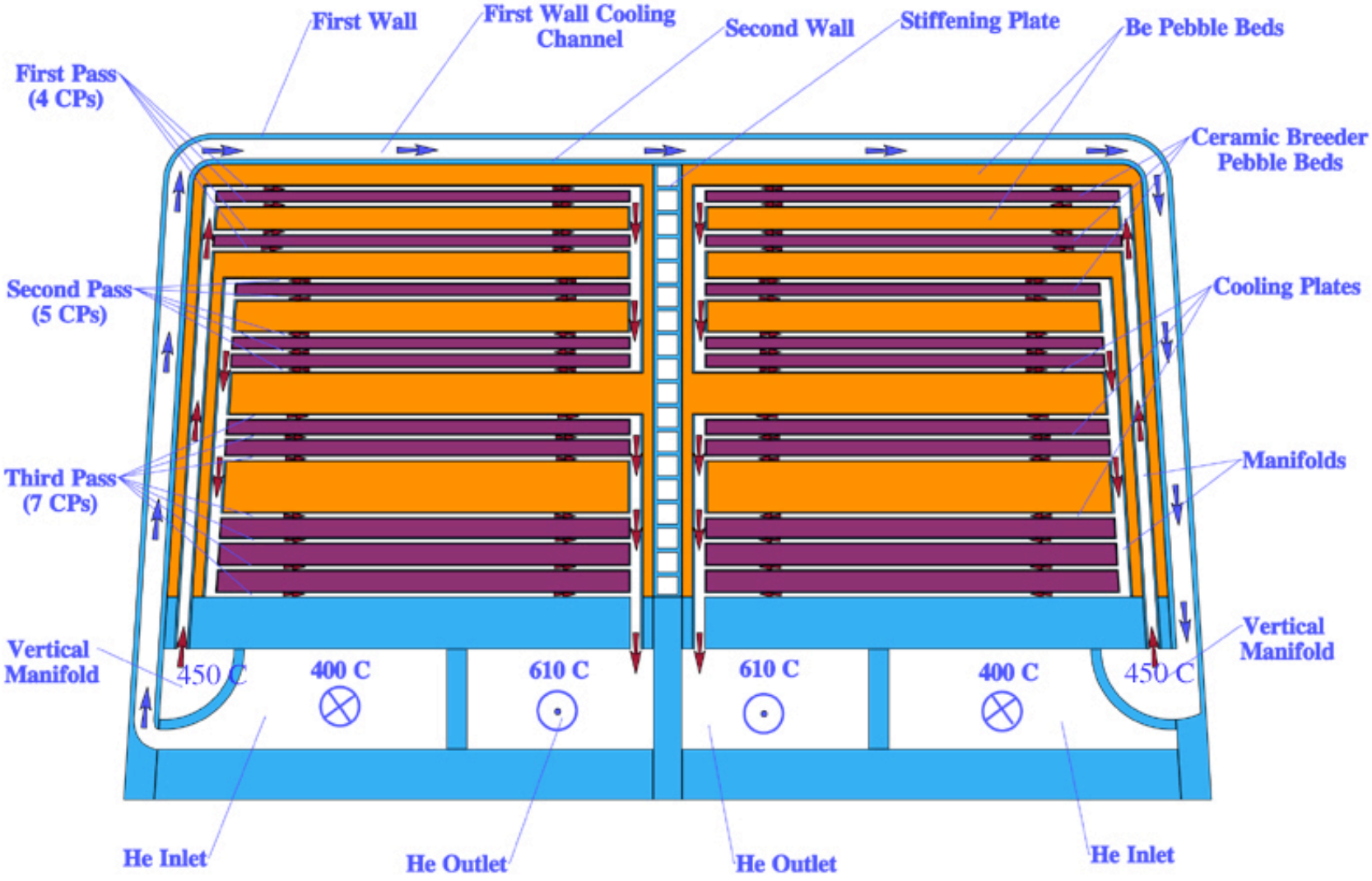
Side Modules Showing Beam Ports



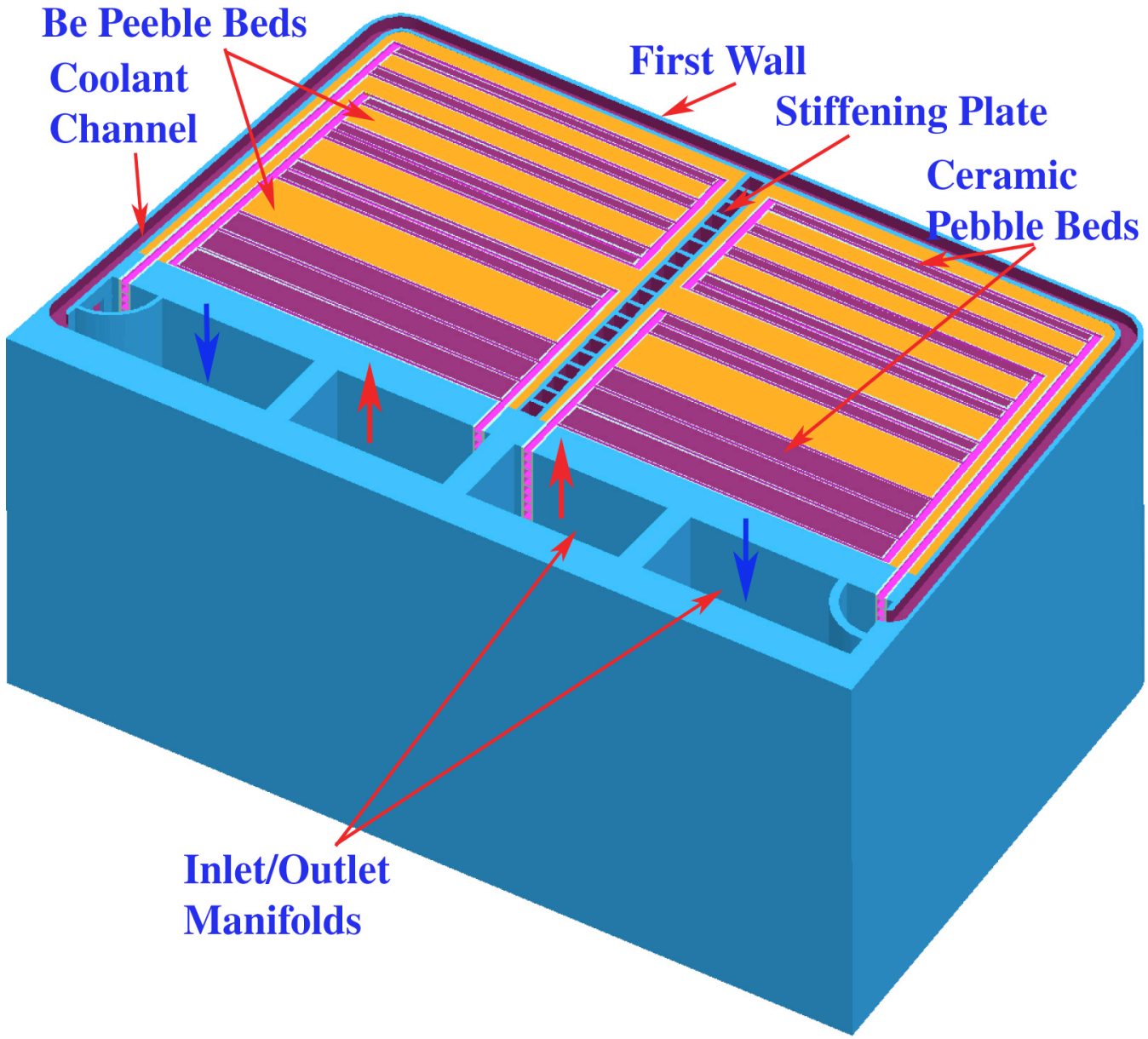
Side Blanket Module Grouping Shown with an Upper and Lower Blanket



Cross-Section of a Static Solid Breeder Side Module



3D Cad Drawing of a Static Solid Breeder Blanket



Cross-Section Showing a Beam Port in a Module

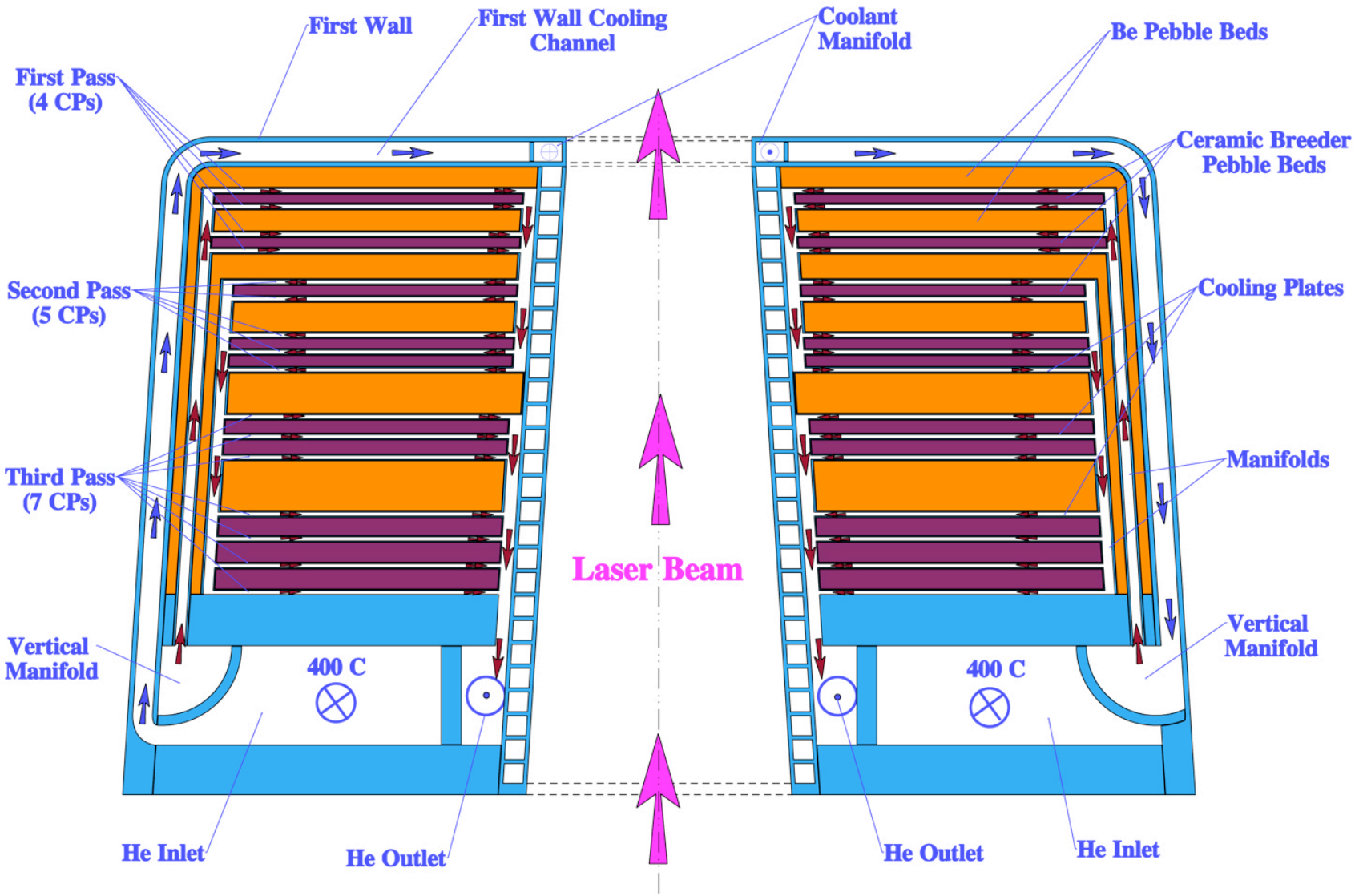
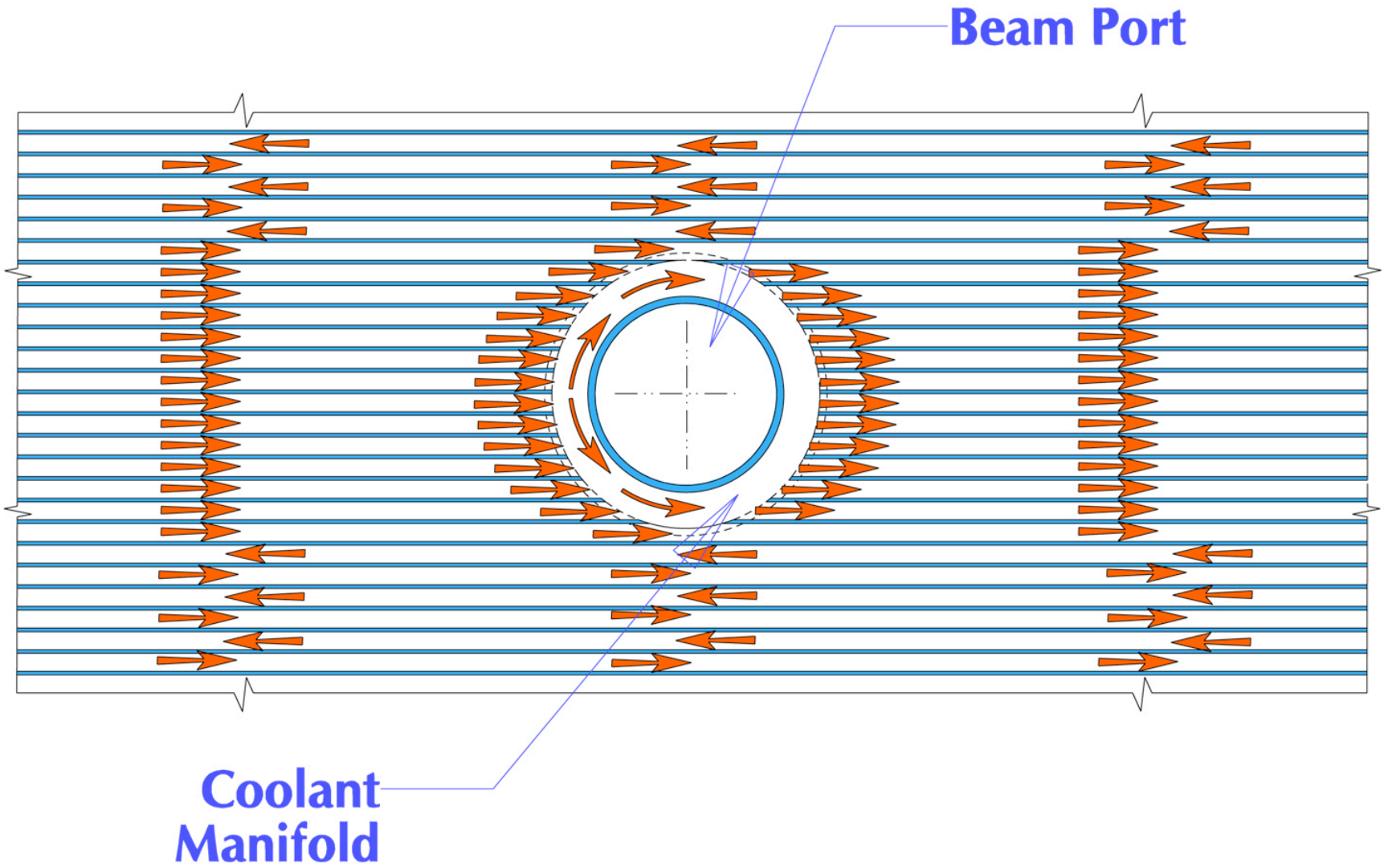


Figure Showing FW Coolant Routing Around a Beam Port



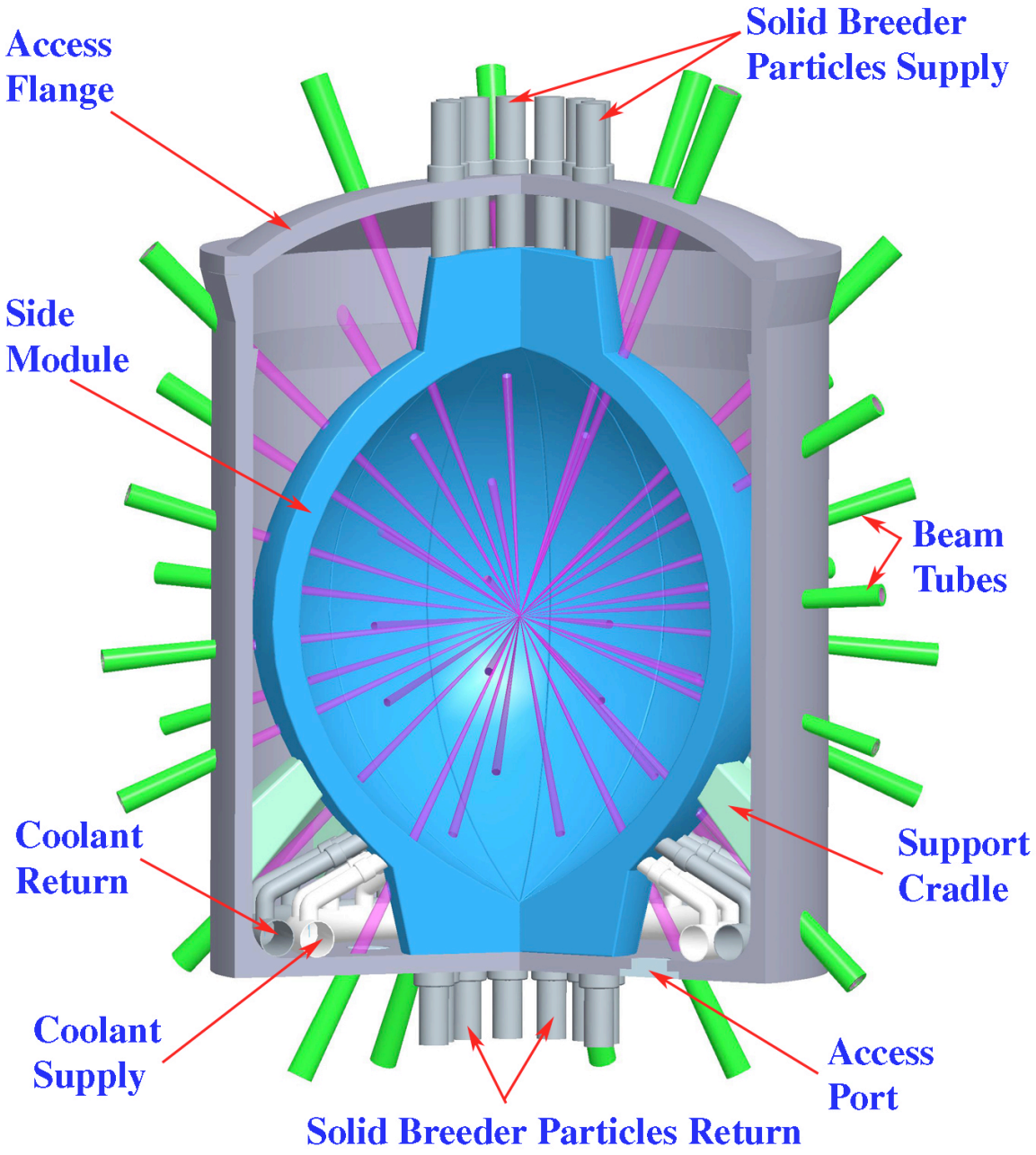
A Moving Bed Ceramic Solid Breeder Blanket

- A moving bed using solid ceramic breeder material particulates is presented as an alternate option in this blanked design series.
- The breeding material is admitted at the top of the blanket and flows by gravity to the bottom where it exits and is transported to a heat exchanger. Fluidized beds are used to transport the material outside the reactor.
- The FW is He gas cooled the same way as in the static solid breeder with counter-current tubes at the FW.
- Be rods are integrated into radial struts which provide reinforcing of the FW against a He gas leak. The rods are encased in FS tubes and are cooled with He gas flowing through holes in the middle and on the outer surfaces

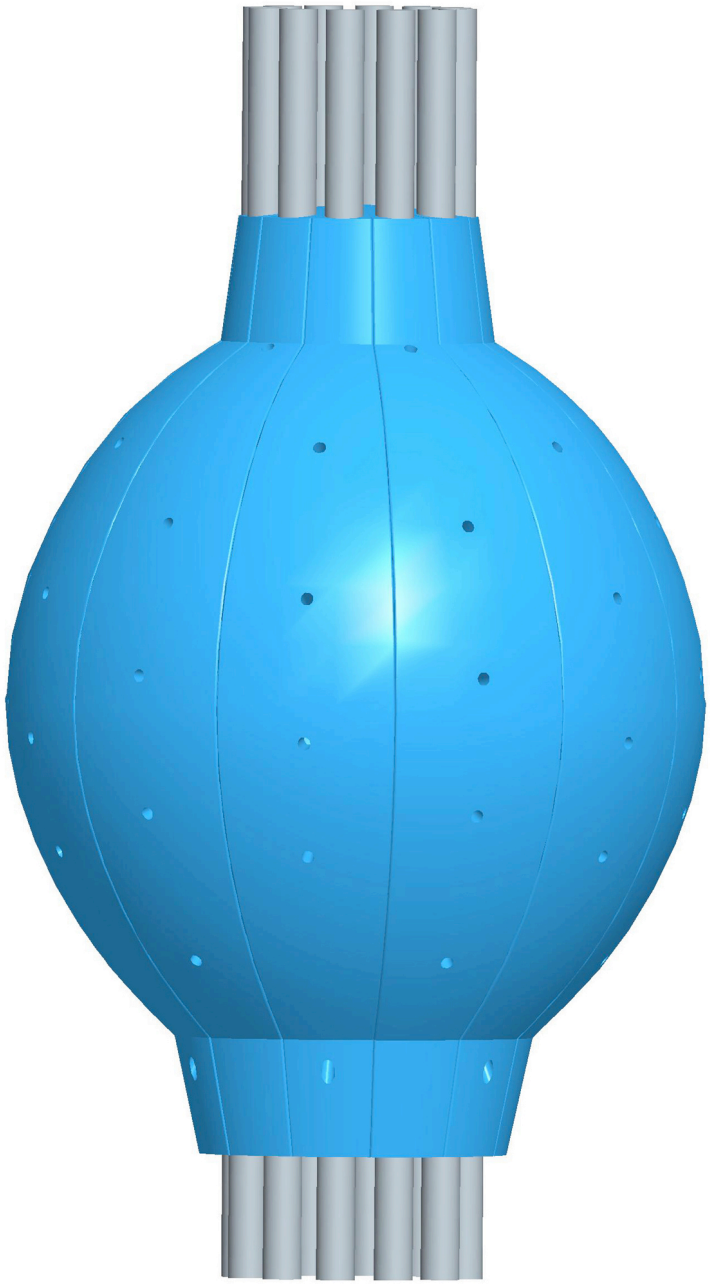
A Moving Bed Ceramic Solid Breeder Blanket Contd.

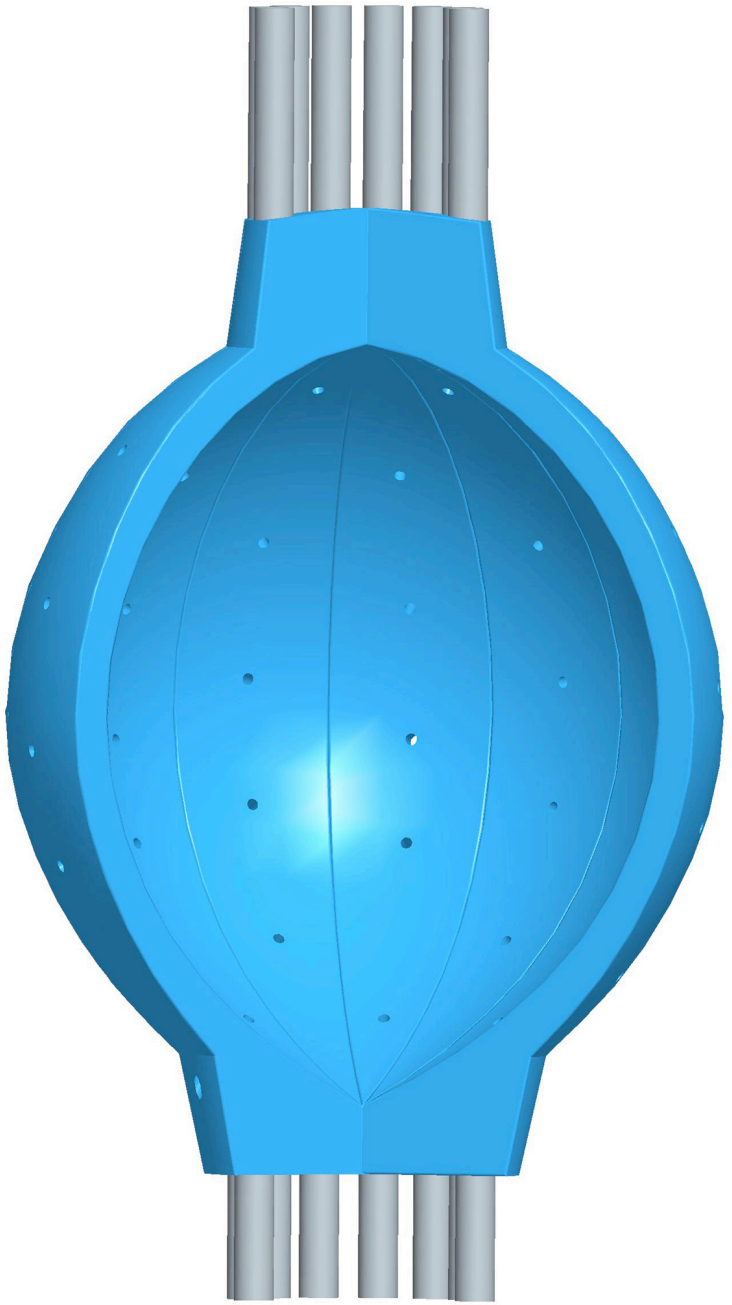
- The blanket modules are continuous top to bottom and there is no need for separate upper and lower blankets.
- There will be 12 or 24 blanket modules in the reactor
- Laser beam distribution is the same as previously. In the case of 12 modules, each module will have 6 beam ports. In the case of 24 modules, every other module will have six beam ports.
- The typical average velocity of the particles is ~ .06 m/s taking about 6.5-8 min. to traverse the length of the blanket.
- Tritium residence in Li_2TiO_3 at 730^{o} C is between 1.5- 5.5 minutes. Over this period, and before going to a heat exchanger, the T_2 will diffuse into the fluidizing carrier gas (He) and can be collected on distillation columns.

HAPL Chamber with Moving Bed Ceramic Breeder Blanket

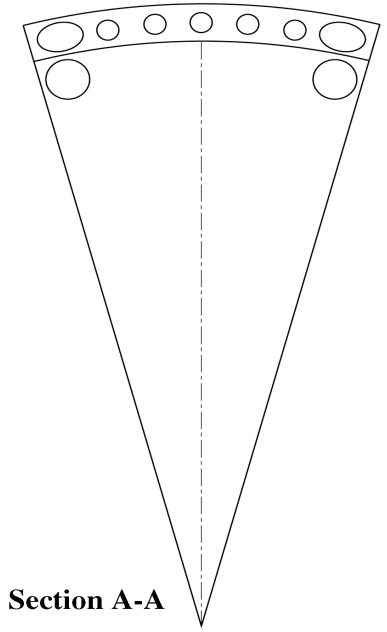


Assembled Moving Bed Ceramic Breeder Blanket Modules

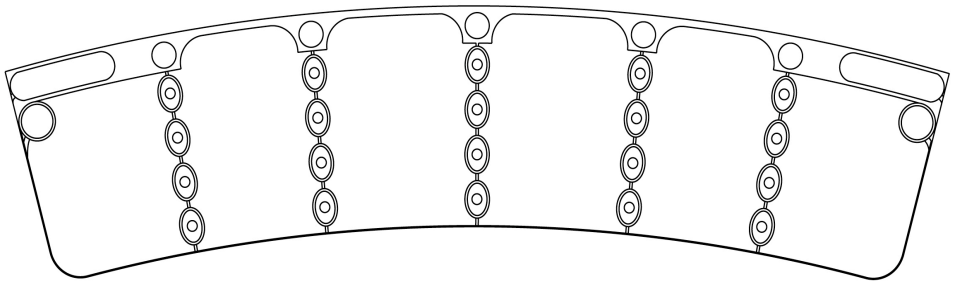




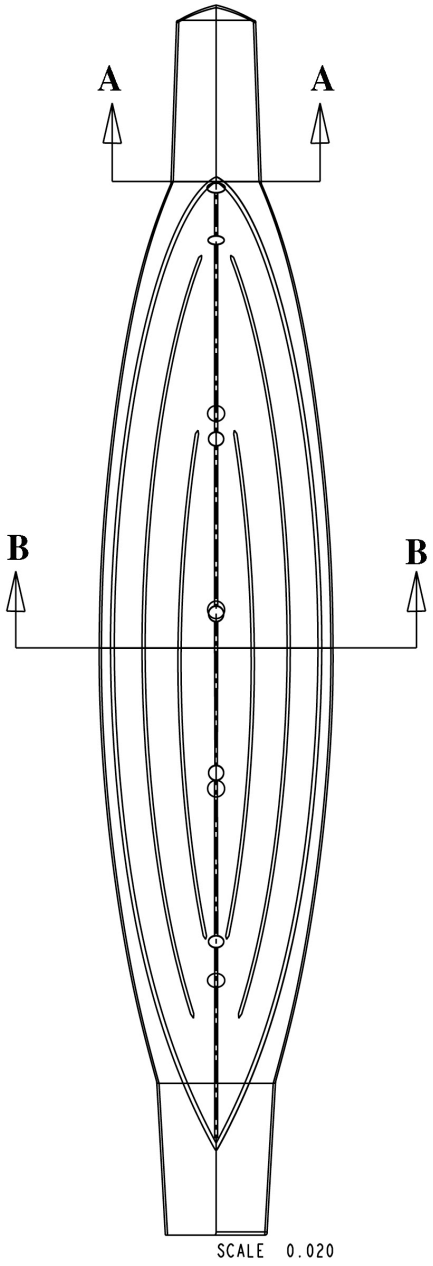
View of a Module of the Moving Bed Ceramic Blanket



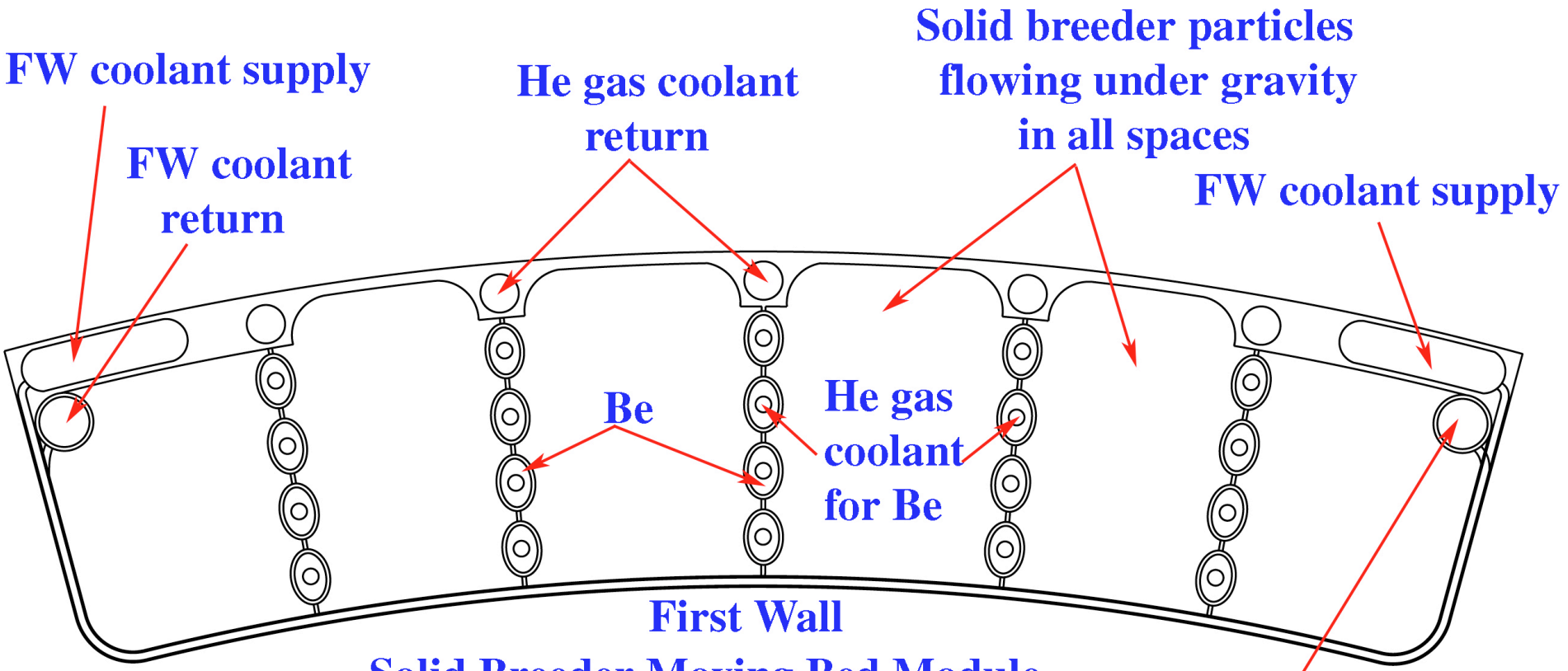
Section A-A



Section B-B



Cross-Section of Moving Bed Ceramic Breeder Module at Mid-Plane



Summary and Conclusions on Ceramic Breeder Blankets

- Two different design options of ceramic breeder blanket have been presented, one with static breeder panels and one with moving bed ceramic particles.
- Ceramic breeder blankets tend to be more complex than self cooled liquid metal breeders:
  - Require high pressure He gas cooling of the structure. Static breeder blankets have potential problems with hot spots, T_2 recovery and Li depletion.
  - Moving bed ceramic breeders alleviate some of these problems but require large moving bed systems outside the reactor for handling the ceramic particles and extracting their energy in heat exchangers.
- Both designs can be coupled to a Brayton cycle whose efficiency would need to be optimized