Overview of the ITER Plasma Facing Components

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Blanket Variants and Plan to FDR

- There should be only 18 variants among the 440 Blanket Modules.
- However, there are more than 150 variants of Blanket Shield Modules (NBI, diagnostics, ELM coils, VS coils, …)
- Can be reduced to ~30 major variants
- Plan for design of BMs
- For CDR, 3 example modules (4,8,12) were presented.
- For PDR, design and analysis of 10 representative
  - modules (6, 4, 14, 8, 18 (NHF), 1, 12, 7, 2, 16) to
  - demonstrate that all key issues raised at CDR have been solved and that the design is on a firm basis for FDR.
- For FDR, design and analysis (to FDR level) of 26 main variants based on revised interfaces to demonstrate that the blanket is at a final design stage and that the design maturity allows to move to the procurement phase.
- Design split between procuring DAs (2 each for SB and FW panels) and IO

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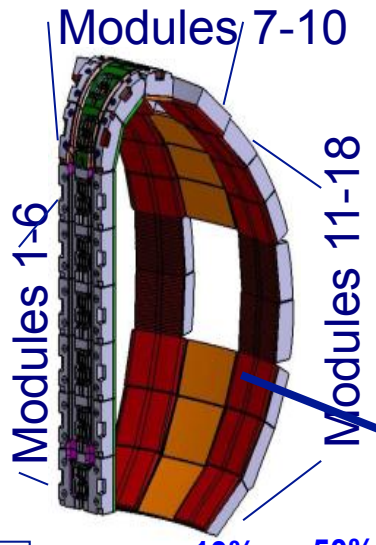
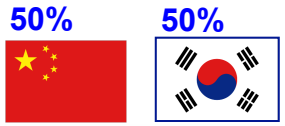
PFC Design Drivers

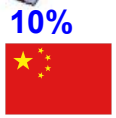
- Strong plasma interaction with the FW due to the power flow in the far scrape-off-layer due to large radial transport during ELMs
- Also heat flux during start-up and ramp-down (limiter like).
- Very accurate alignment of the FW relative to field lines is mandatory.
- All ITER disruptions have vertical motion
  - Major disruptions move slowly up/down during current decay.
  - Vertical Displacement Events move vertically prior to current decay (halo current flow)
  - Large net forces and large moments are generated (supports)
- Surviving disruptions requires:
  - Smaller modules (~1 m by ~1 m) Forces and Moments
  - Replaceable first wall (damage due to melting).
  - Toroidal fingers on FW (halo current)

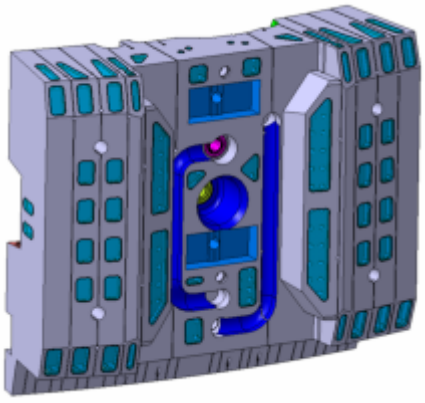
Blanket System



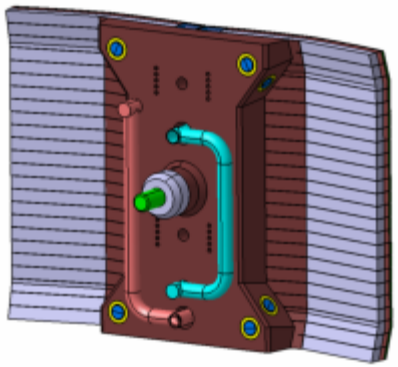
- The Blanket System consists of Blanket Modules (BM) comprising two major components:
  a plasma facing First Wall (FW) panel and a Shield Block (SB).
- It covers ~600 m^2





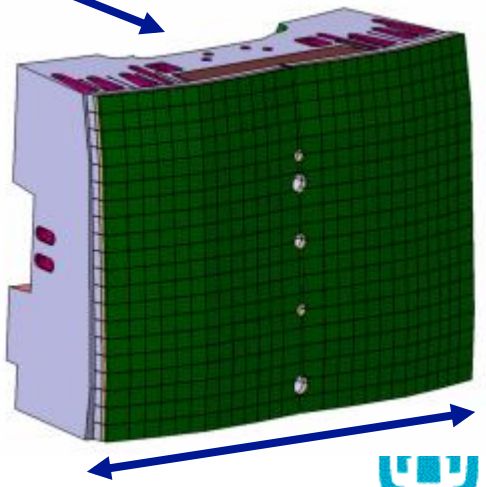


SB (semi-permanent)



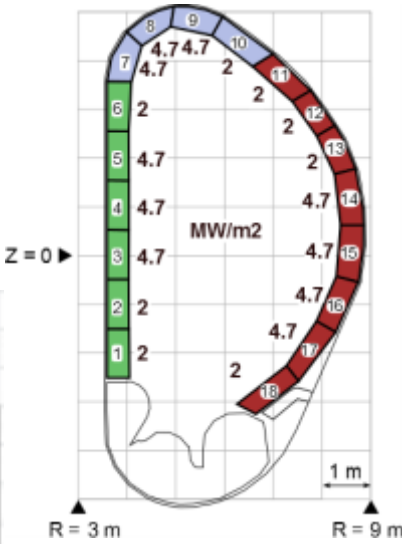
FW Panel (separable)

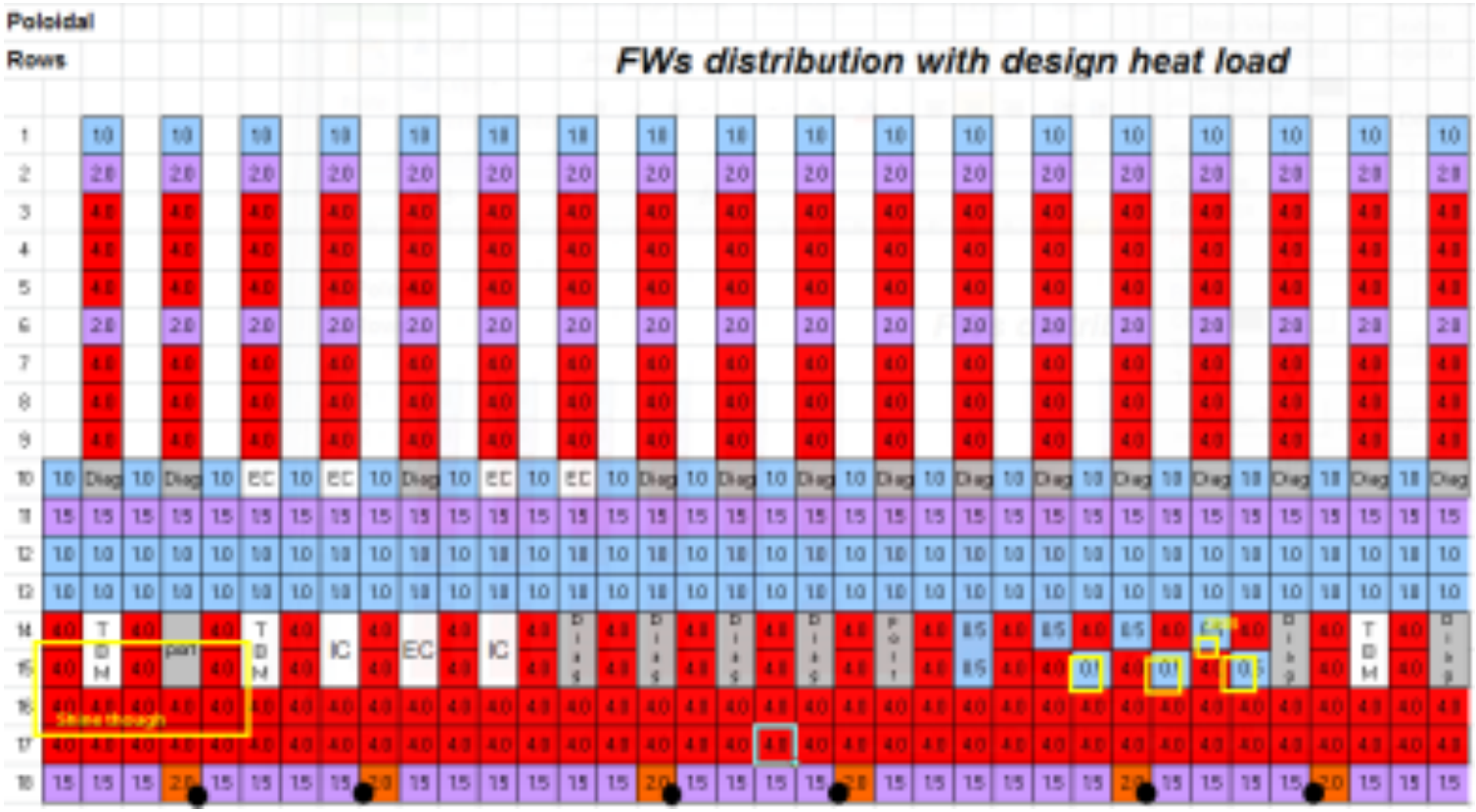
Blanket Module



First Wall Panels: Design Heat Flux

- No change in FW shaping since PDR
- 218 Normal heat flux panels (2 MW/m^2) → EU
- 222 Enhanced heat flux panels (4.7 MW/m^2) → RF, CN





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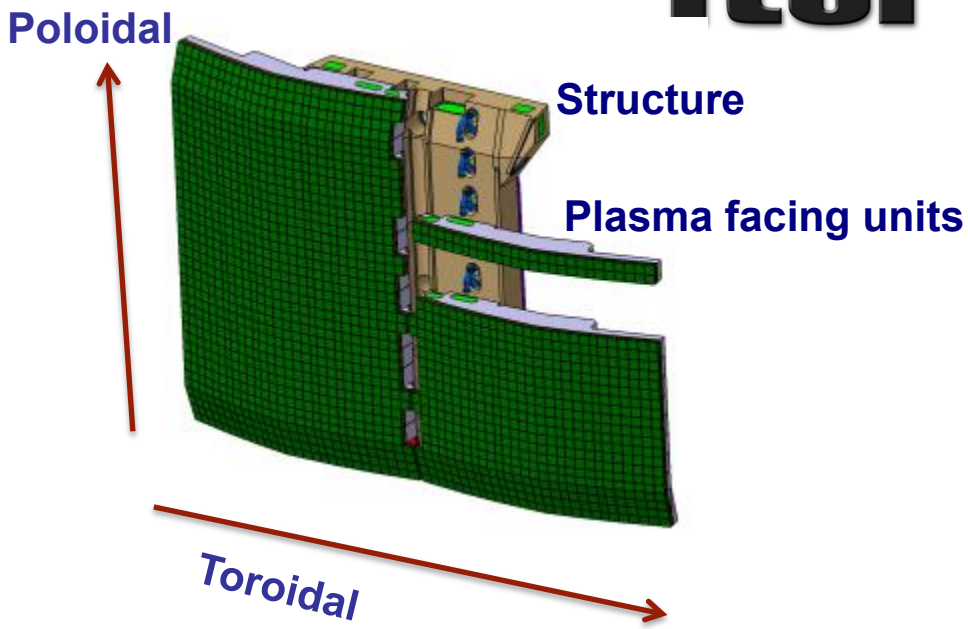
Design of First Wall Panel

- PFC units are "fingers"
- Shaped
- Oriented toroidally
- Attached to a poloidal beam
- Overhanging



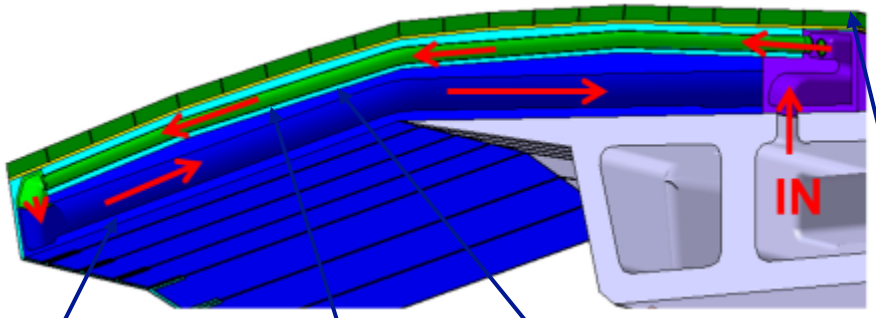
FW04 with some fingers removed

- Beam is structural 'backbone' to FW panel
- Centralizes all FW interface to Shield block (central bolt, compression pads, water connections, electrical straps)
- Serves as manifold distributing water to fingers

NHF First Wall

Normal Heat Flux Finger:

- q" = 2 MW/m^2
- Steel Cooling Pipes
- HIP'ing fabrication
- Maximum tile size ~50 x 50 mm
- Be 10 mm thick

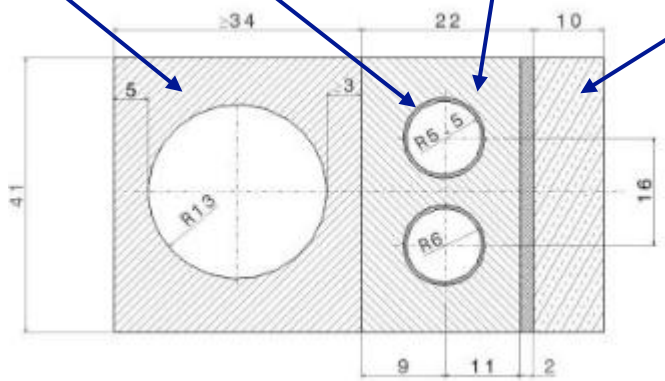


SS Back Plate

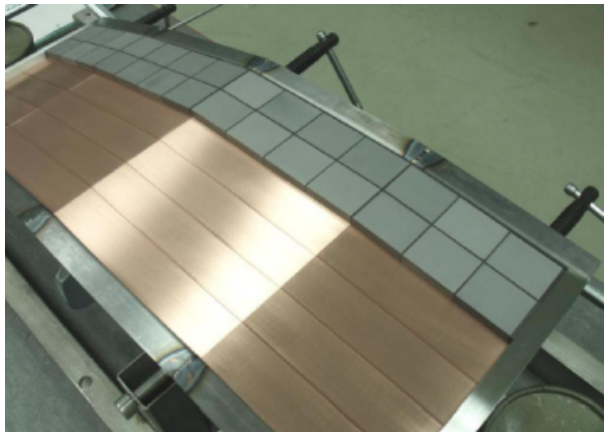
SS Pipes

CuCrZr Alloy

Be tiles



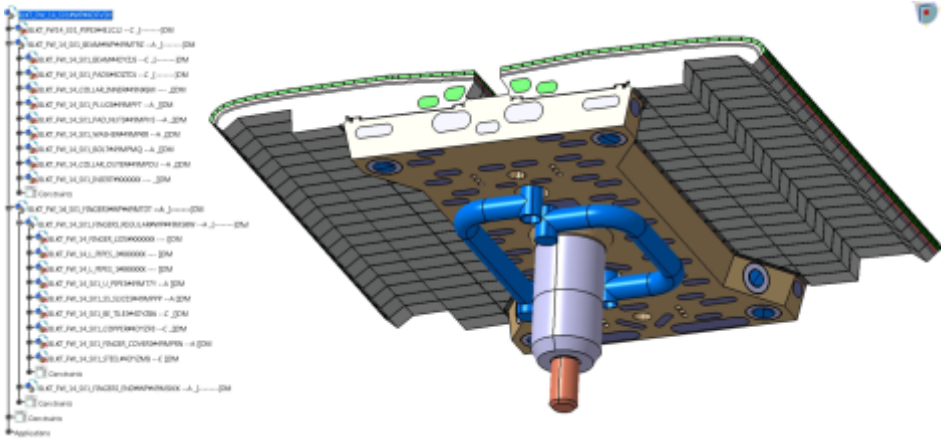
Normal Heat Flux Semi-Prototype



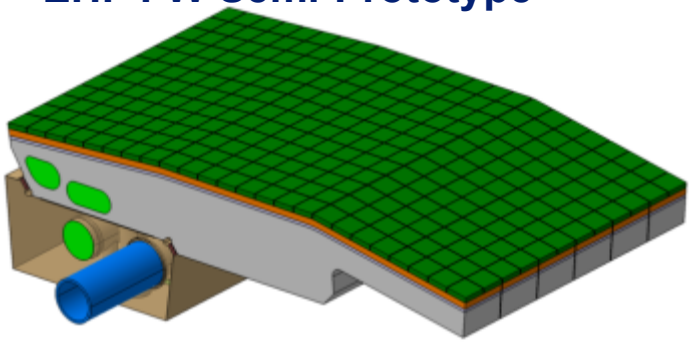
EHF First Wall

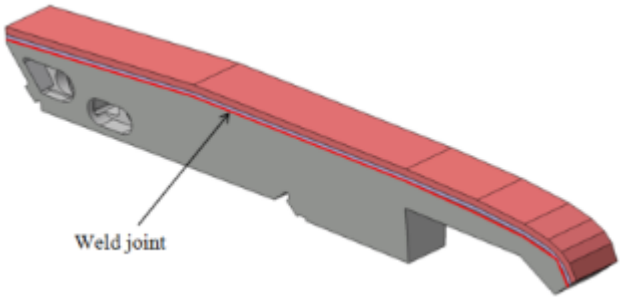
Enhanced Heat Flux Finger:

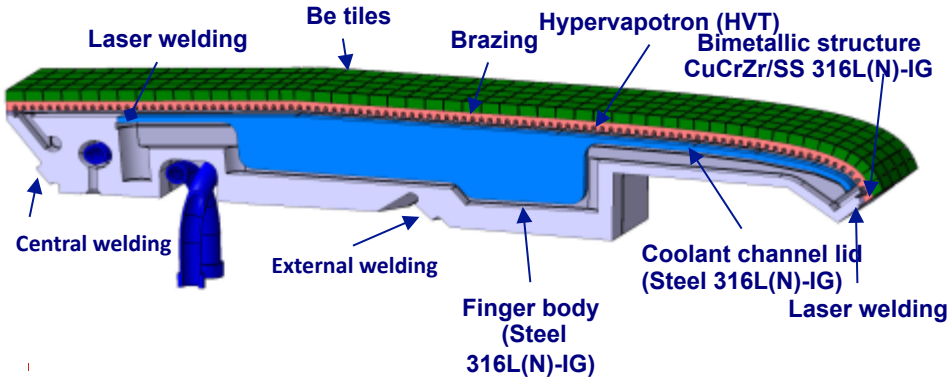
- q” = 4.7 MW/m^2
- Hypervapotron
- Explosion bonding (SS/CuCrZr) + brazing (Be/CuCrZr)
- Maximum tile size 12 x 12 mm
- Be 8 mm thick



EHF FW Semi-Prototype

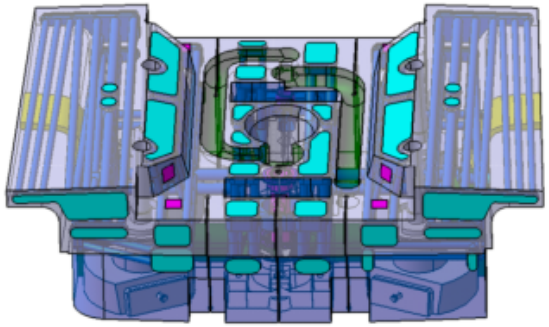




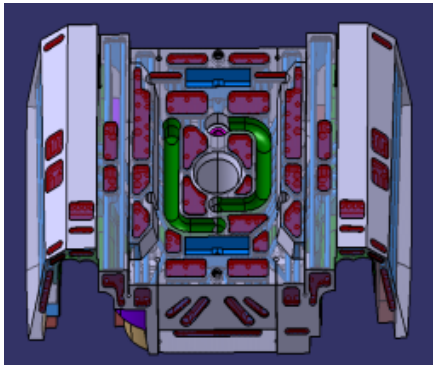


Shield Block Design

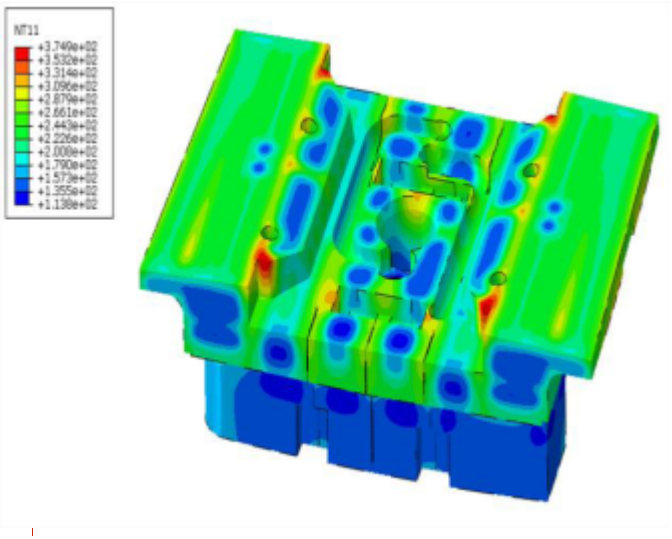
SB12

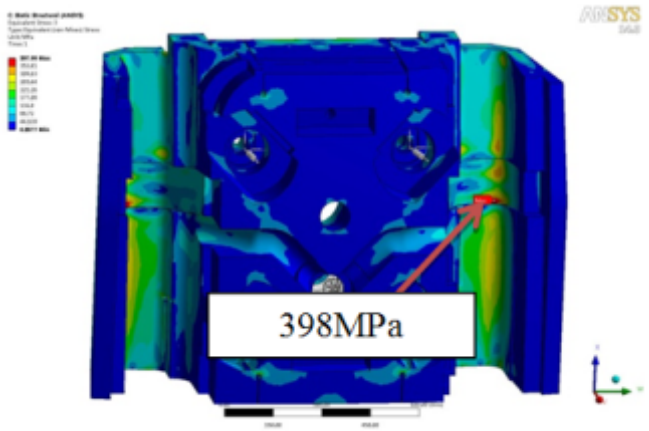


SB14



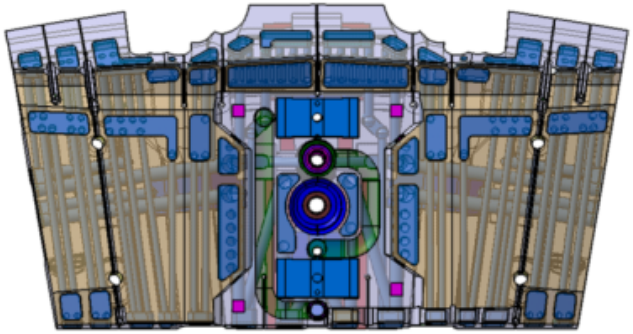
- Slits to reduce EM loads and minimize thermal expansion and bowing
- Poloidal coolant arrangement.
- Cooling holes are optimized for water/SS ratio (improving nuclear shielding).
- Cut-outs at the back to accommodate many interfaces (Manifold, Attachment, In-Vessel Coils)
  - SB geometry at each toroidal row is very different + many variants

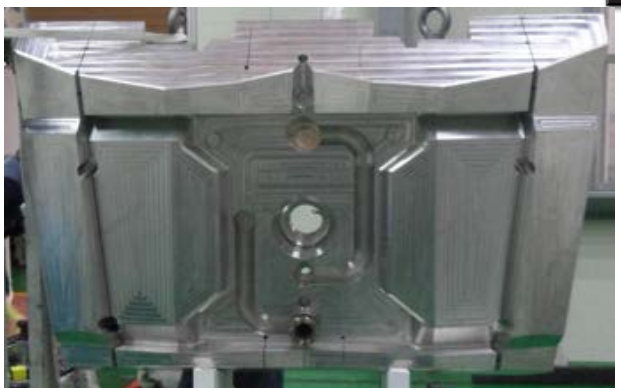




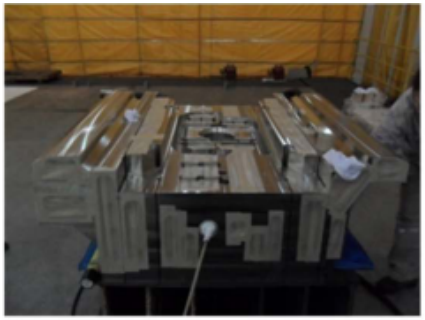
Shield Block Full-Scale Prototypes

KODA: SB08





CNDA: SB14



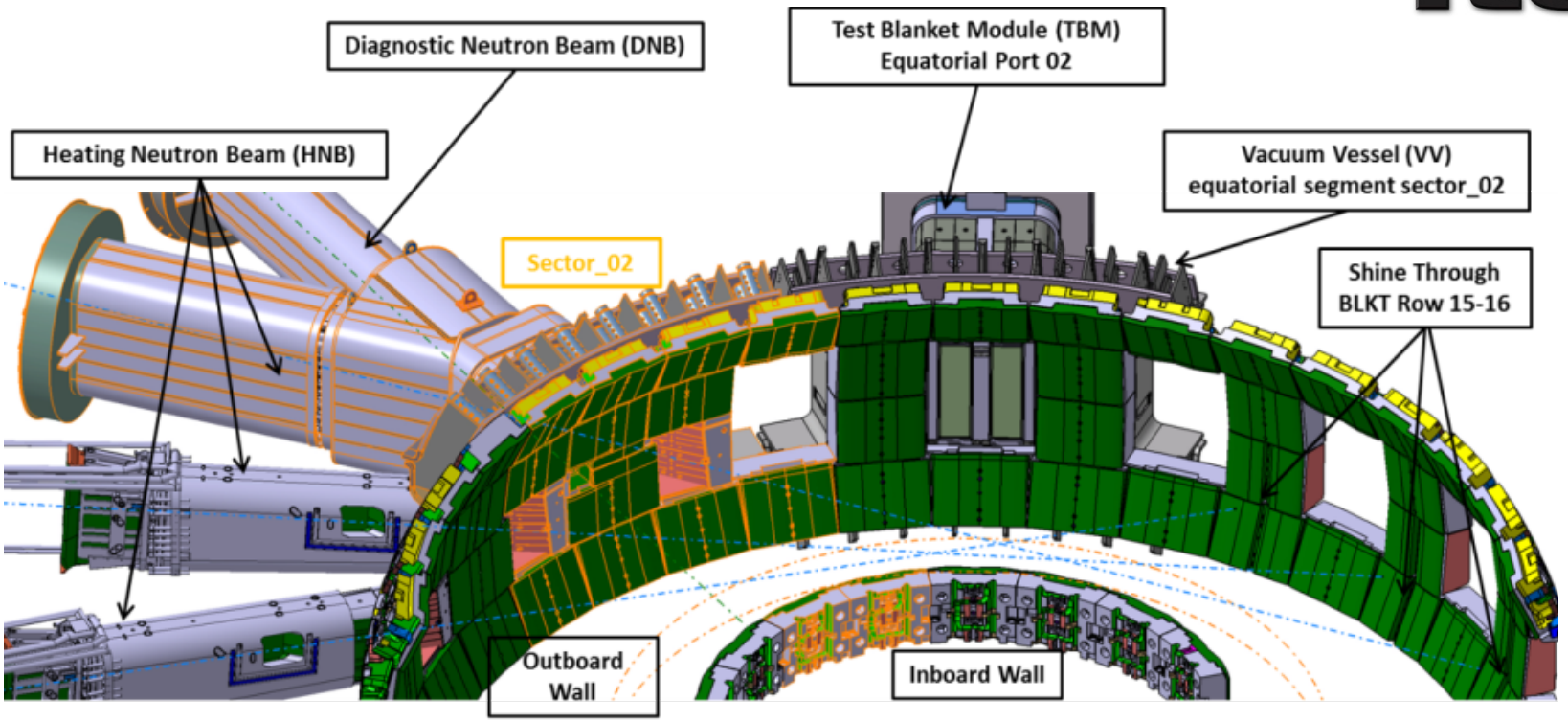
Set-up

Tack welding

Cover welding

- **Basic fabrication method from either a single or multiple-forged steel blocks and includes drilling of holes, welding of cover plates of water headers, and final machining of the interfaces.**

Special Modules – Neutral Beam Injector Area

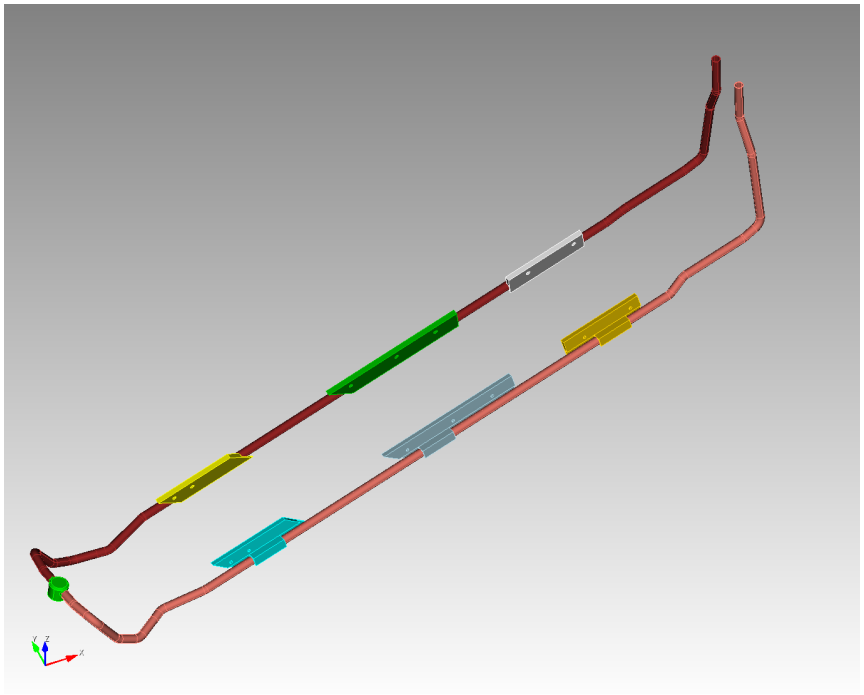


- The NB region with the neutron bean injection ports create a particular geometry challenge for the blanket design
- Special modules have been developed to accommodate this as well as the other design constraints
- The NB shine-through also needs to be accommodated by the impacted Blanket Modules

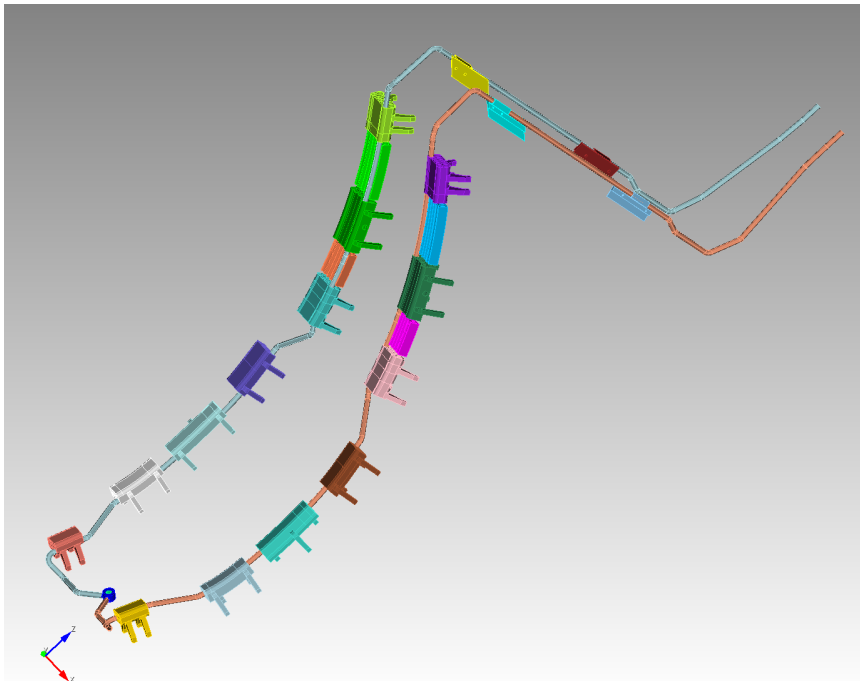
FDR Outcome

- Only 5 category 1 chits were generated at the FDR (all dealt with management issues)
- Three were about 25 category 2 chits that were concerning design or analysis issues (all are being addressed by the IO team).
- There were less than 20 category 3 chits (all minor issues and mostly answered by now).
- The coolant manifold FDR is scheduled for Spring 2014.
- Design and analysis on the major variants not covered by FDR (NBI area mostly) is ongoing with completion planned for Fall 2013.
- Minor variants are being analyzed as the interfaces are settled within the constraints of the overall blanket design.

Examples of Typical Blanket Manifolds



BM09 shortest inner manifold



BM16 Typical Outer Manifold