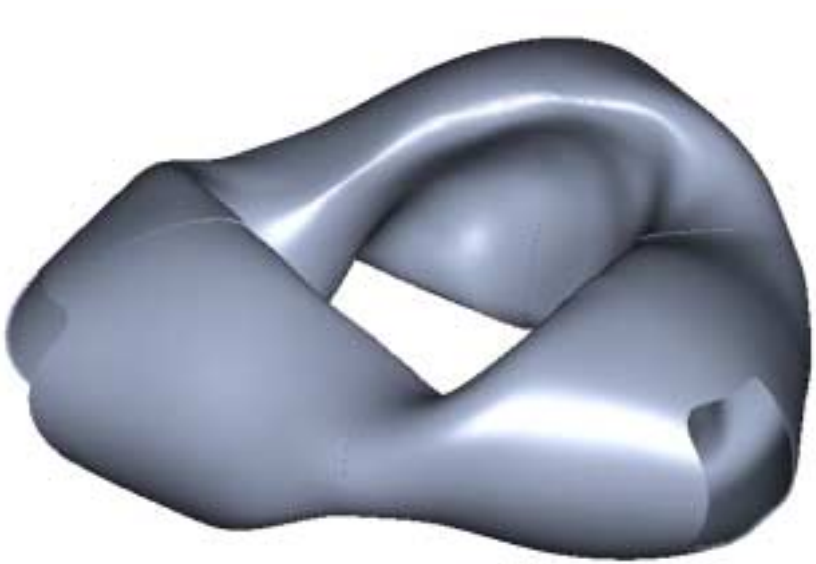
PFC requirements

- **Basic requirements**
  - **Carbon based**
  - **Provisions for adding (interface design included in research prep budget)**
    - **NBI armor**
    - **Trim coil armor**
    - **Inboard limiter / coverage**
    - **Divertor baffles and plates**
    - **Divertor "pumping"**
    - **Energetic ion loss armor**
  - **Make first plasma, field line mapping, ohmic operation**
  - **0.3 MW for 0.3 s**

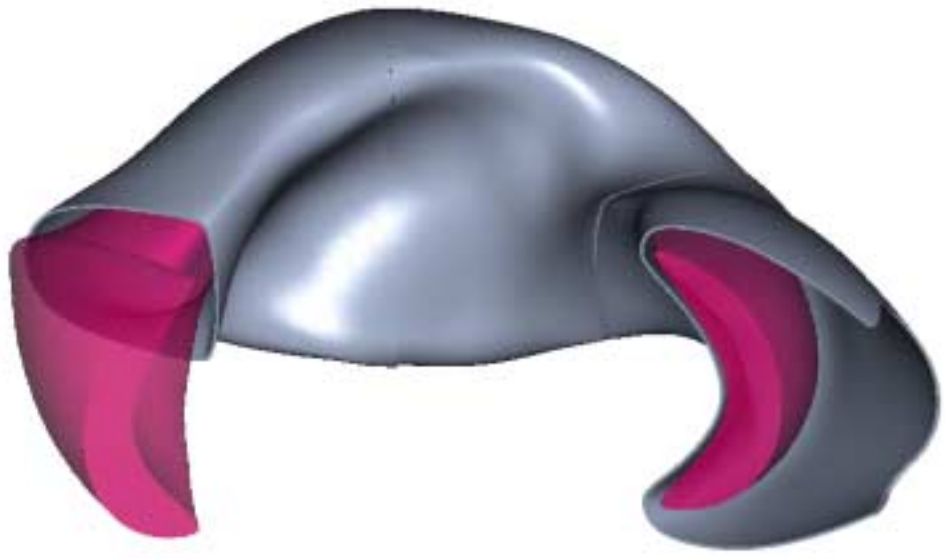
- **Upgrade requirements**
  - **Bakeable to 350C**
  - **> 60 % of power to divertor region, balance can be intercepted by walls**
  - **Provide penetrations, accommodate in-vessel diag. mounted on VV**
  - **Geometric tolerance of FW surface TBD, should be tune-able**
  - **Capability to bias the individual panels electrically up to 1kV**
  - **Full coverage of surfaces with carbon**
  - **12 MW for 1.2 s**

PFC envelope maximized inside vessel

- **PFC envelope is pushed out to vessel wall to provide maximum plasma shape flexibility**
- **Divertor envelope is still evolving, but baffles for neutral particle control must be accommodated**



PFC envelope

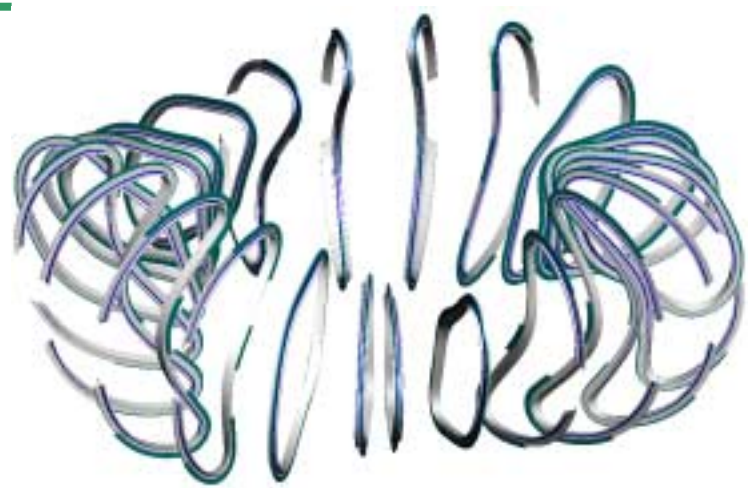


PFC envelope with plasma

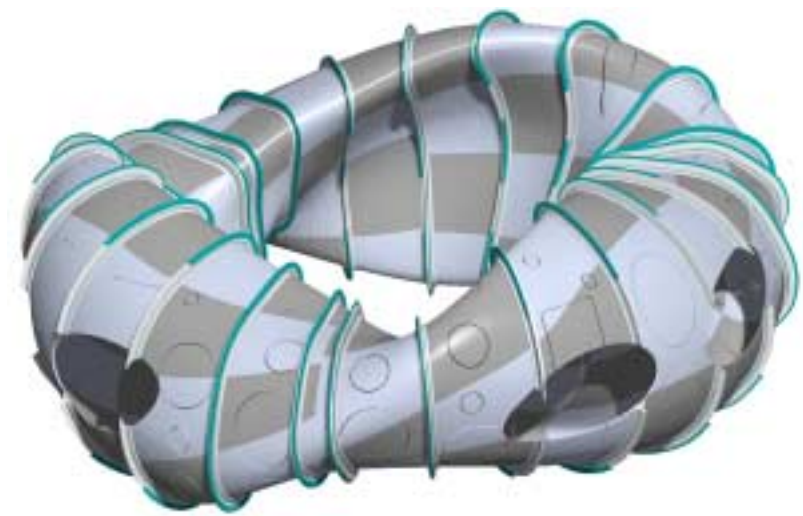
PFC design concept

- **Staged implementation planned**
  - **Initial coverage with carbon tiles mounted on vessel assembly flanges to form array of poloidal limiters**
  - **Panels for NB armor and divertor region will also be provided after NBI installed**
- **Full coverage provided by mounting molded carbon fiber composite (CFC) panels on poloidal ribs**
  - **Panel size based on advice from BFG aerospace (~ 60 cm square, 1 cm thick)**
- **Ribs are separately cooled / heated with He gas for bakeout (350C) and normal operation**
- **Ribs are registered toroidally to VV but allowed to grow radially and vertically**

Poloidal ribs

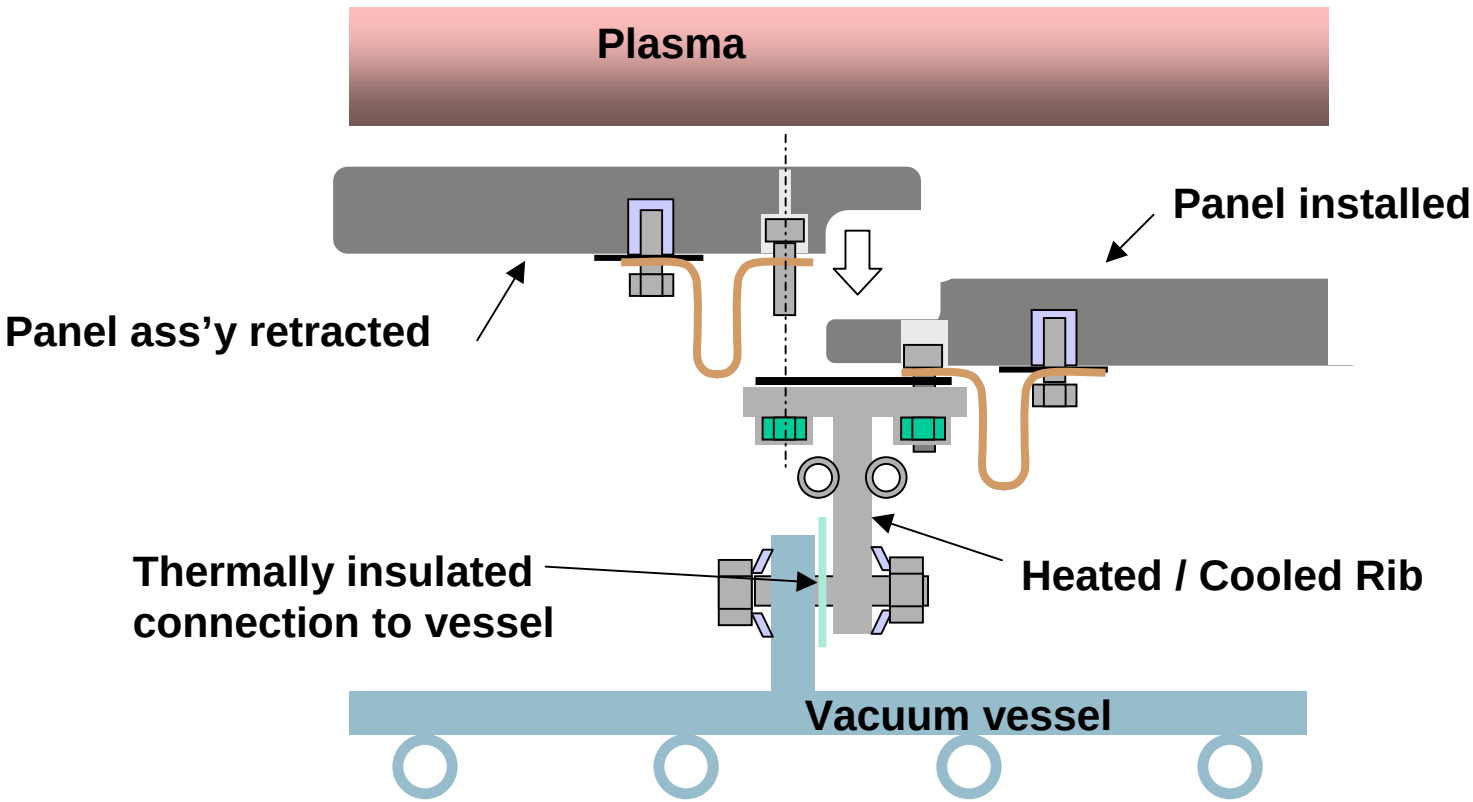


CFC panels mounted on poloidal ribs



PFC panel / rib detail

- **Details for one concept for panel attachment developed with BFG Aerospace**



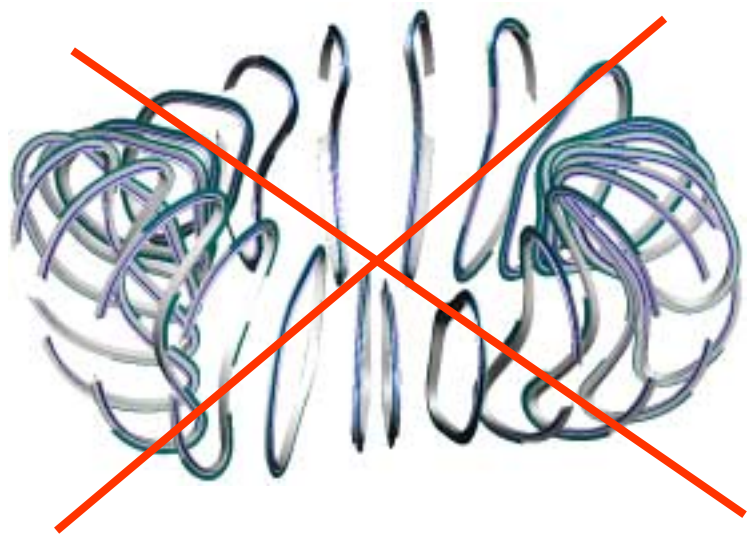
PFC implementation plan

Project Phase and PFC Stage:	Heating:	Poloidal limiters (at bullet symmetry planes)	Full CFC panel coverage, (including support ribs w/coolant tracing, CFC panels)	Divertor	
				Divertor baffles	Active Divertor pumping
I,II,III OHMIC	Ohmic 0.3 MW, 0.3 s	x			
IV Aux htg.	3 MW NBI, 0.3 s	x	x		
V High Beta	6 MW NBI + 6 MW RF, 0.3 s	x	x	x	
VI Long pulse	6 MW NBI + 6 MW RF, 1.2 s	x	x	x	x

Project cost: **Program cost:**

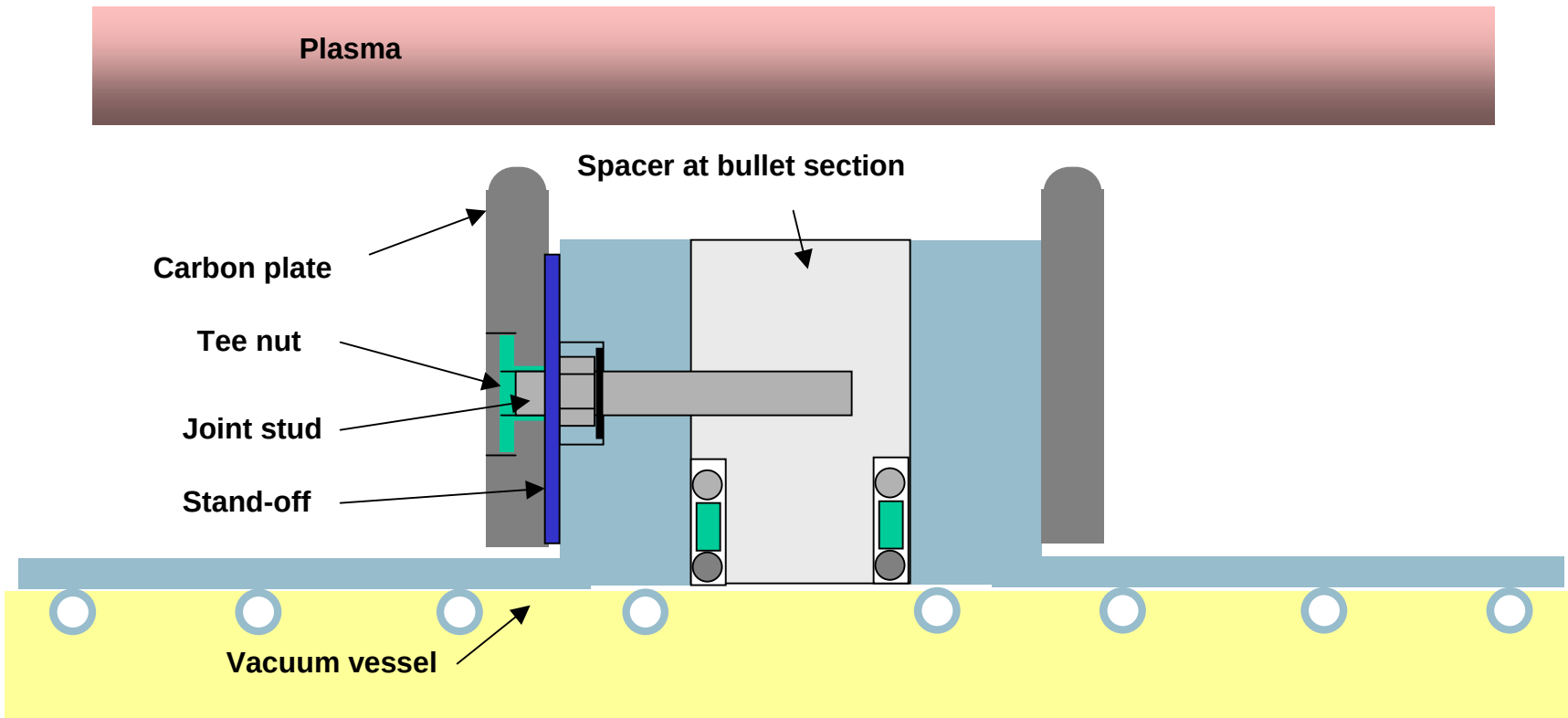
PFC implementation: Phases I, II, III

- **NO Rib structure with cooling/heating lines**
- **Carbon (e.g. Poco, ATJ) tiles *mounted directly to VV***
- **Carbon limiters are installed only at v=1/2 (bullet) cross section, but are semi-continuous poloidally**



PFC simple limiter detail

- **Details for flat carbon plates at either side of bullet shaped section (vessel field joint)**



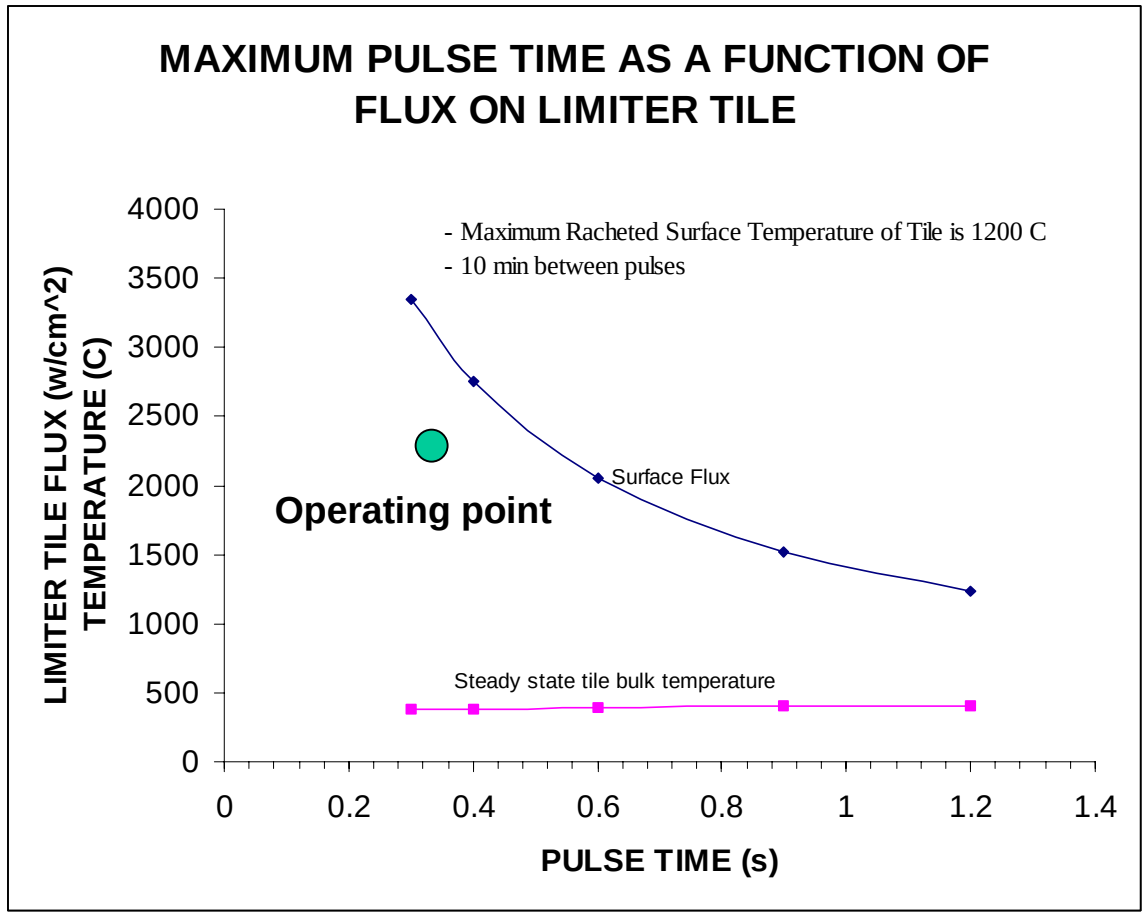
Heat loads on limiter

- **Assume:**
  - **1 cm e-folding of particle energy**
  - **0.3 MW per pulse**
  - **6 toroidal locations to remove heat**
  - **Poloidal peaking factor of 20**

- **Max flux = 2275 W/cm^2**

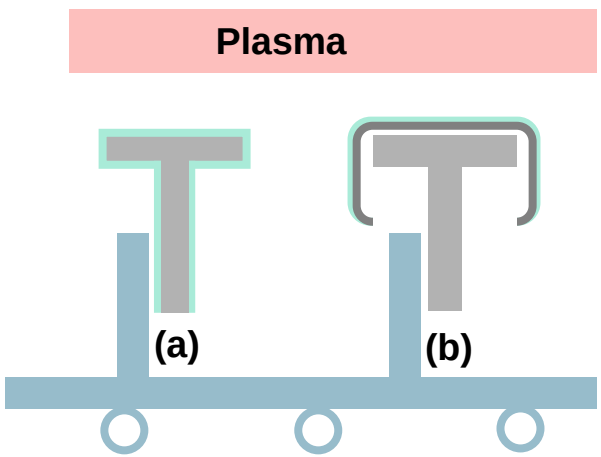
Heat flux limit on isolated limiter tile

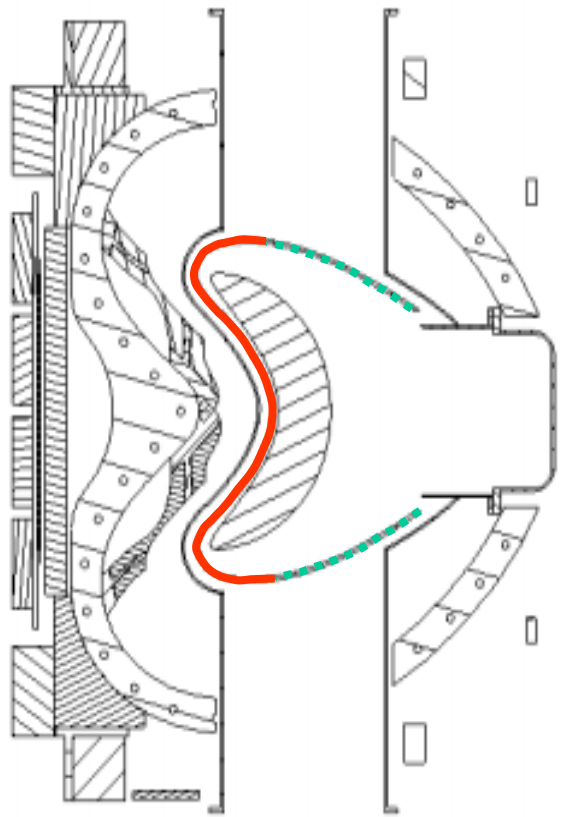
- **1-D calculation**
- **Ratcheting limit assumes radiation cooling only**
- **10 minute cool-down between pulses**
- **1200 C max temperature**



PFC implementation: Phase IV

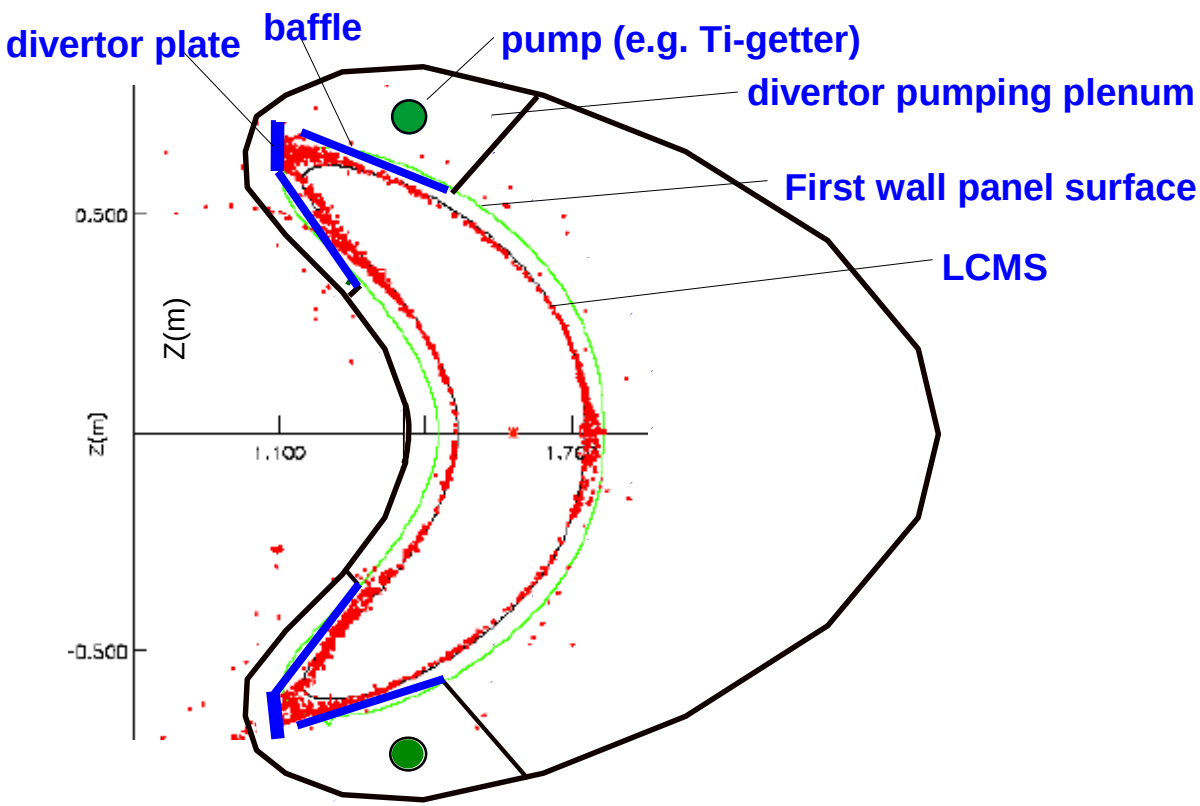
- **Rib structure with cooling/heating line**
- **Panel coverage from upper divertor to lower divertor on inboard side**
- **Panel coverage for NBI armor on outboard side**
- **Exposed ribs protected with low Z coating:**
  - **a) B4C spray coating**
  - **b) Sheet metal covers with B4C coating**





PFC implementation: Phases V,VI

- **Phase V, divertor baffles**
- **Phase VI, with active pump**



- **Panel coverage everywhere?**

Ref. Peter Mioduszewski.