Disruption Effects on FIRE PFCs

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Outline

- **Heat Loads**
- **Eddy and Halo Currents**
- **Future Plans**

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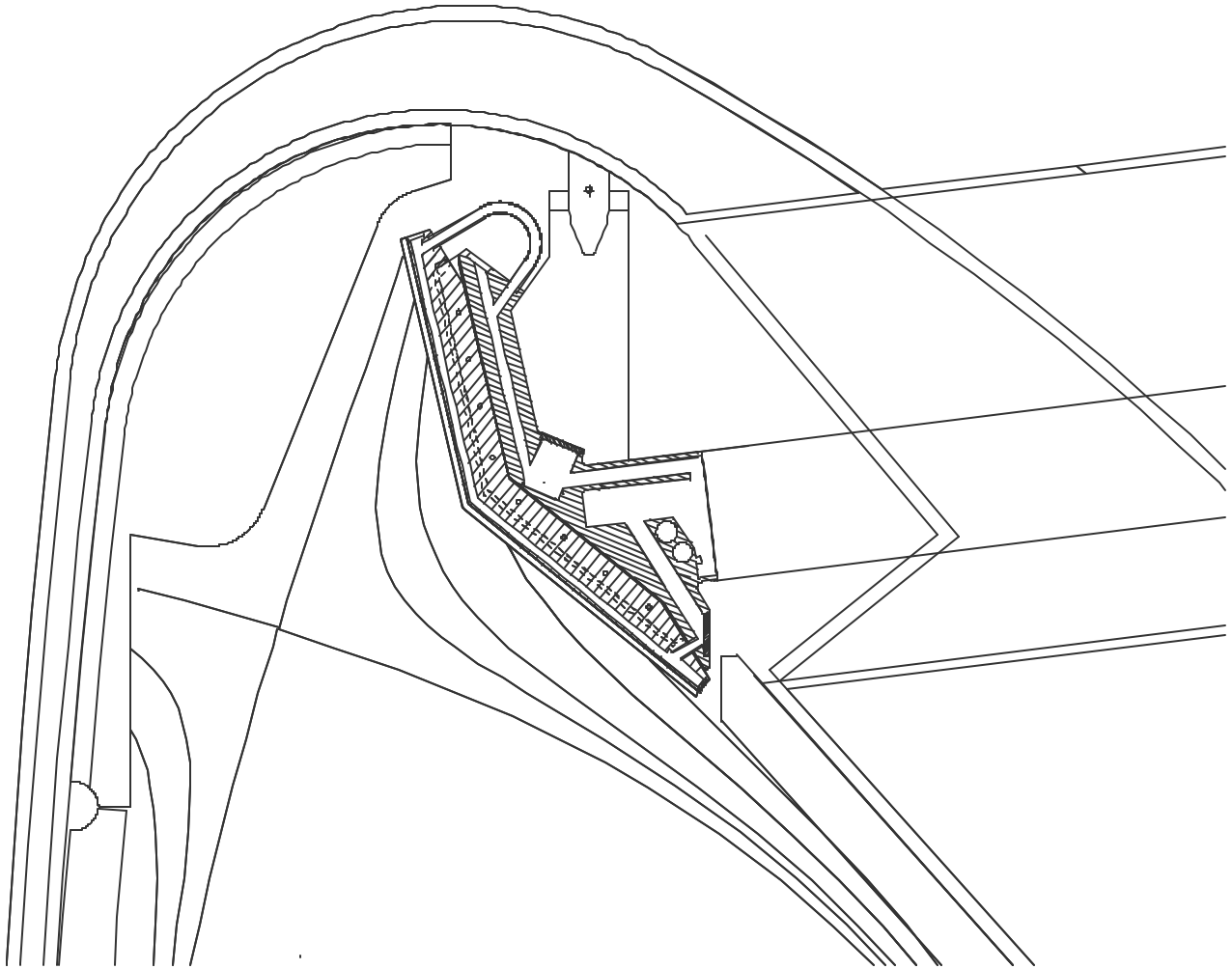
FIRE Divertor Design



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Heat Loads

- **Thermal Quench Phase**
  - **33 MJ stored thermal energy**
  - **Loss time 0.2 ms**
  - **Heated area in the divertor**
    - » **Inner - 9.35 l_E m²**
    - » **Outer - 10.9 l_E m²**
  - **Energy Scrape-off length 1.8-2.3 cm (from Tom Rognlein's edge modeling)**
  - **Angle of incidence: outer - 30º and inner - 90º**
  - **Ratio of heated length before to during disruption: 1 to 3**
  - **In/out ratio: 1/2**
  - **Toroidal peaking: 2:1**

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Heat Loads - Thermal Quench

- **Energy deposition on the divertor plates**
  - **Inner: 8.5 to 21.8 MJ/m^2 or 42.5 to 109 GW/m^2**
  - **Outer: 7.3 to 18.7 MJ/m^2 or 36.5 to 93.5 GW/m^2**
- **These heat fluxes will cause the tungsten surface to melt in about 50 ns after the start of the disruption**
- **Ahmed Hassanein is modeling the effects of evaporated W on the surface heat loads and calculating the re-radiated heat loads on near-by surfaces (results in April)**

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Heat Loads

- **Magnetic Stored Energy loss**
  - **Stored magnetic energy 35 MJ**
  - **Energy loss time: 6 ms**
  - **Toroidal peaking: 2:1**
  - **Energy deposition on the first wall**
    - » **Average: 0.5 MJ/m^2**
    - » **Peak: 0.75 MJ/m^2**
  - **Heat flux to the first wall (max): 126 MW/m^2**
  - **If all of this energy is applied to melting Be, the thickness of the melted layer is 0.14 mm. This will be reduced by conduction and radiation. This level of melting is very modest and no problem.**

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Halo Currents

- **Taking either a peaked distribution or an uniform gives the same halo current in the worst location.**
- **For 16 divertor modules the maximum halo current is 200 kA.**
- **Module size**
  - **Inner poloidal length: 0.58 m** **current path: 0.14 m**
  - **Outer poloidal length: 0.68 m** **current path: 0.41 m**
- **The force exerted on a module is**
  - **Inner: 0.3 MN**
  - **Outer: 0.77 MN**
- **These values are about 50% of those used before.**

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Eddy Currents

- Current decay rate: 3 MA/ms
- Current decay duration: 2.2 ms for 6.5 MA
- B field makes a shallow angle with the outer divertor
- Average B on outer divertor is 0.5 Tesla
- Flux cutting the plate is 0.23 Webers
- Flux change is -104.5 Webers/s
- The estimated resistance of the plate is 18 mW
- The L/R time is about 0.04 s
- The peak induced current is about 300 kA inductively

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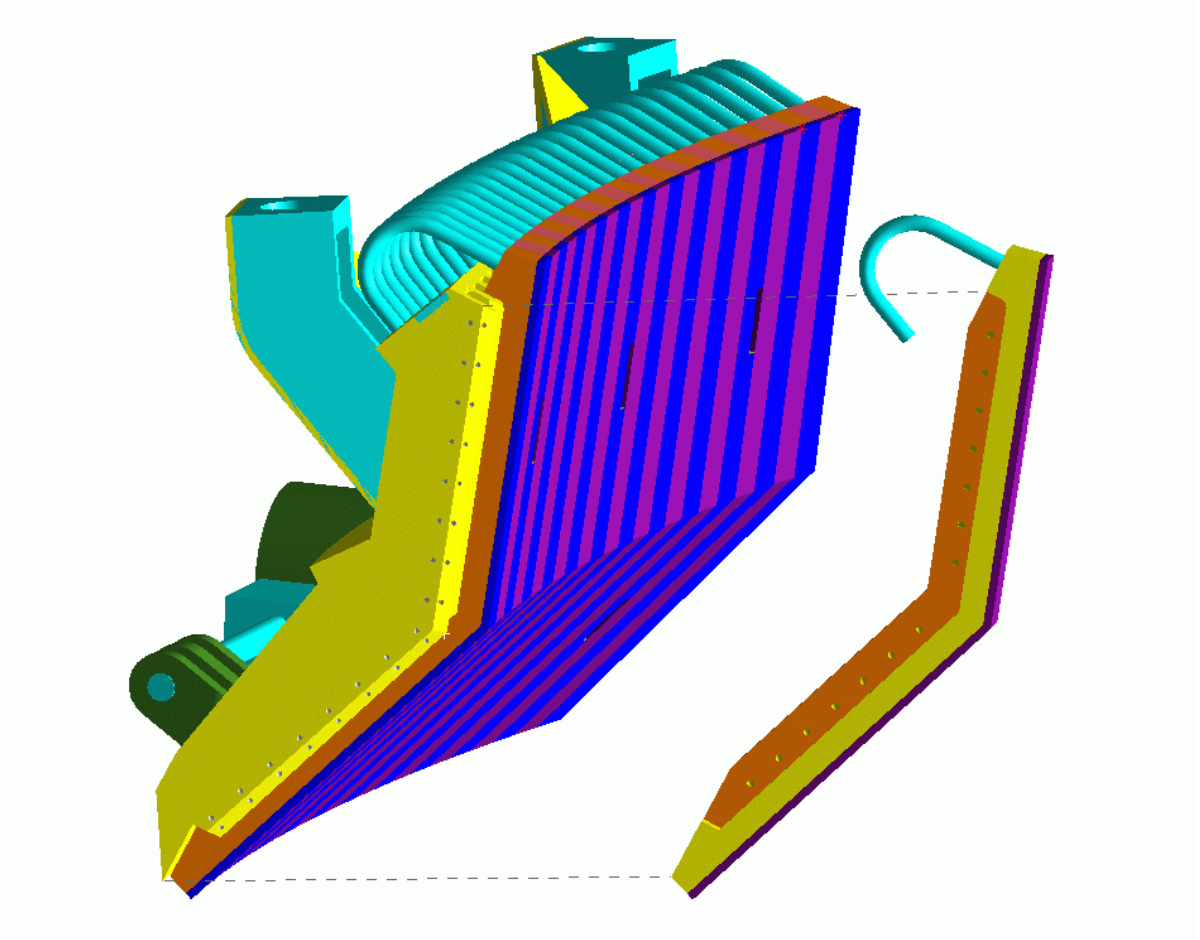
Outer Divertor Module



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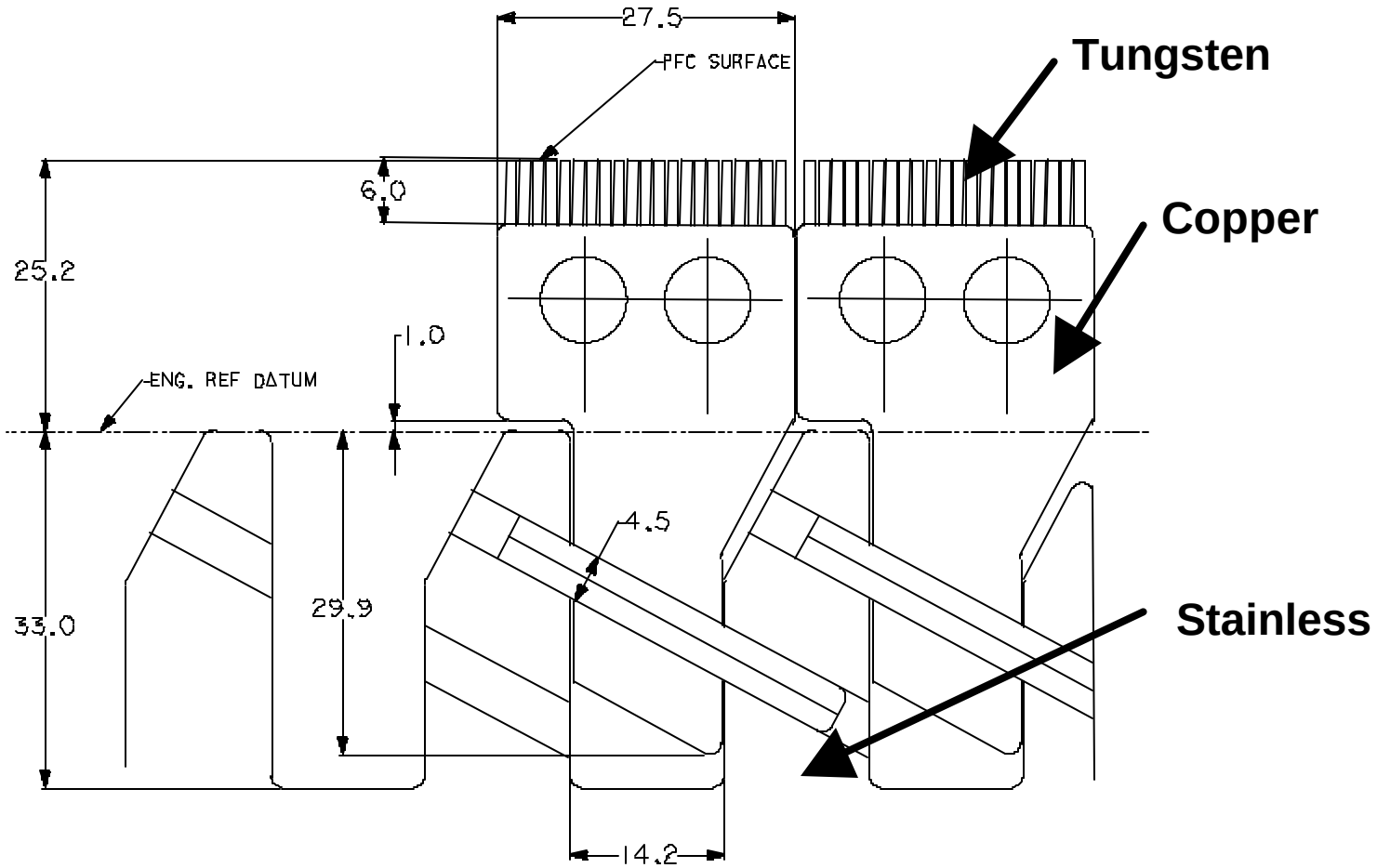
Divertor Module Construction



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Eddy Currents

- **Average B on inner divertor is 2.1 Tesla**
- **Flux cutting the plate is 0.43 Webers**
- **Flux change is -200 Webers/s**
- **The estimated resistance of the plate is 11 mW**
- **The L/R time is about 0.023 s**
- **The peak induced current is about 750 kA inductively**

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Eddy Currents

- The force on the edge of an outer plate is about 1.9 MN
- The force on the edge of an inner plate is about 2.8 MN
- This is a 2.5 times the halo load for the outer and 8.5 times the inner halo load
- Mitigating factors
  - The copper surface is not continuous
  - The stainless steel backing will need to be slotted
  - The convoluted path will add resistance

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Eddy Currents

- There is also a loop formed between the legs of the outer divertor supports
- This loop is slightly smaller than the loop on the surface and it is all stainless steel
- The loop resistance is about .17 mW and the L/R time is about 3 ms (resistive effects will limit the current).
- This loop can be broken by insulating one of the legs (easy to do).

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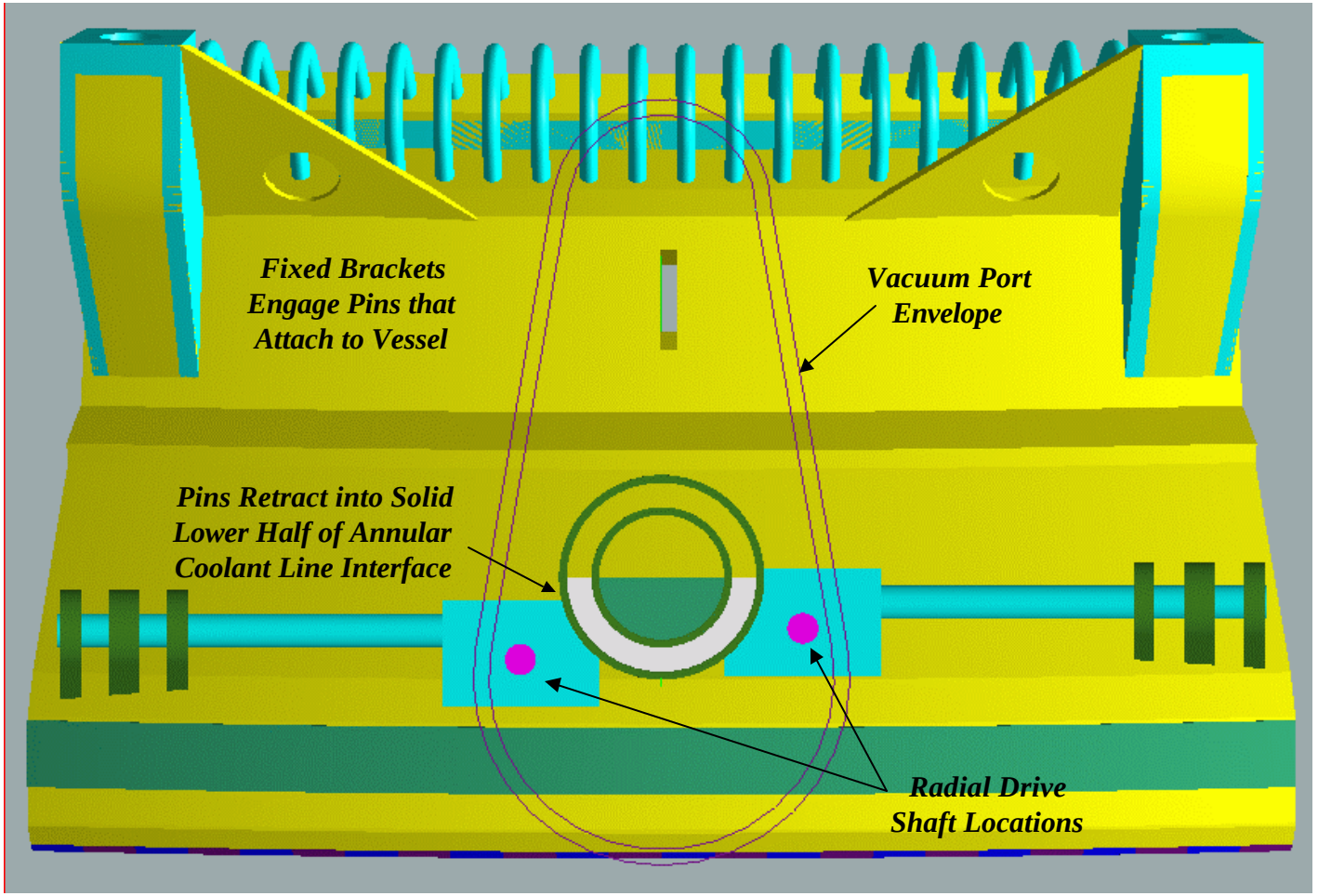
Outer Divertor Module



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Other Work In Progress

- **Tom Rognlein is trying to find a detached solution for the outer divertor (adding Be and Ne impurities) Due April**
- **Chandu Baxi is starting on thermal analysis of the baffle.**
- **Boeing is under contract as of 3/7/2000. They will be starting analysis of the eddy current induced stresses next week.**

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