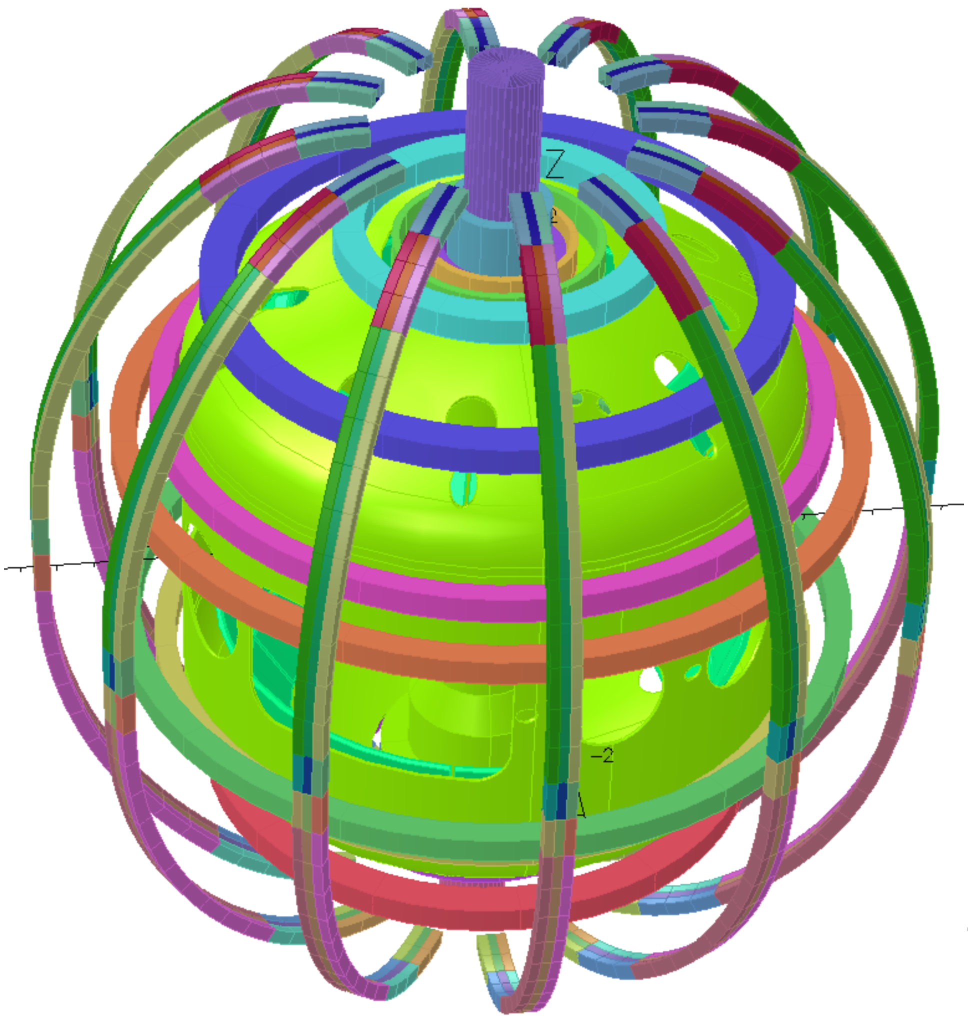
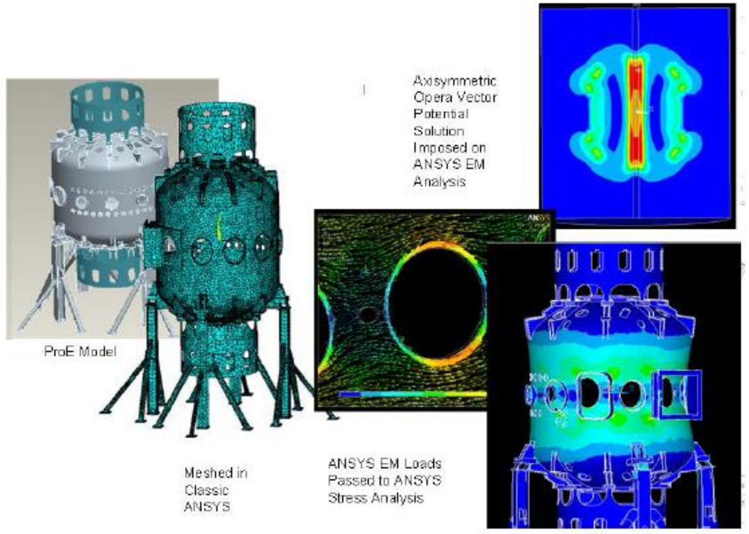
Disruption Analysis of PP, VV, and Components

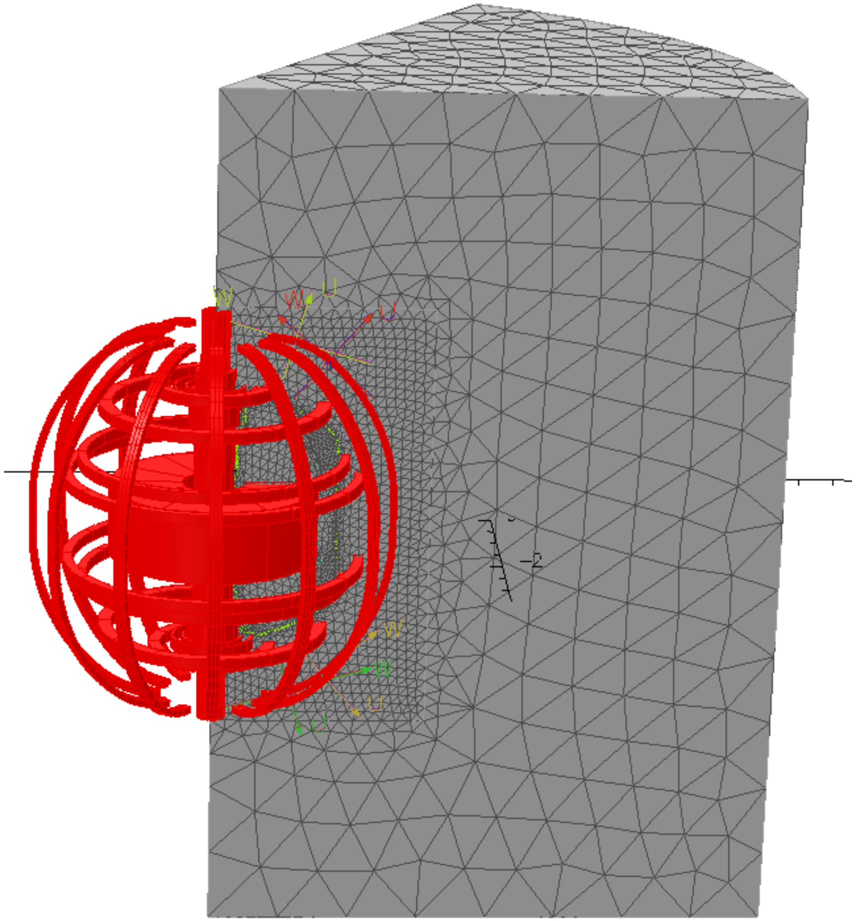


Goal:
To benchmark Titus EMAG model with transient magnetic field vector potentials imported from Hatcher's 2D Opera Analysis

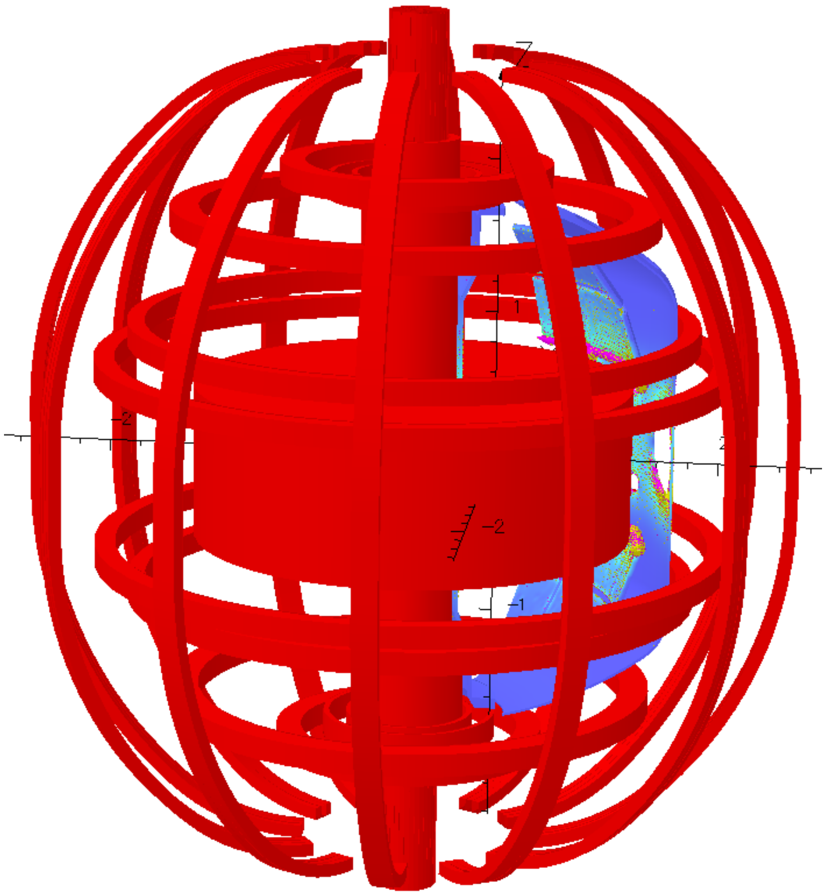


Large bending of PPs are directly caused by the eddy current during plasma disruption

Opera 3D Model – Transient ELEKTRA Solver

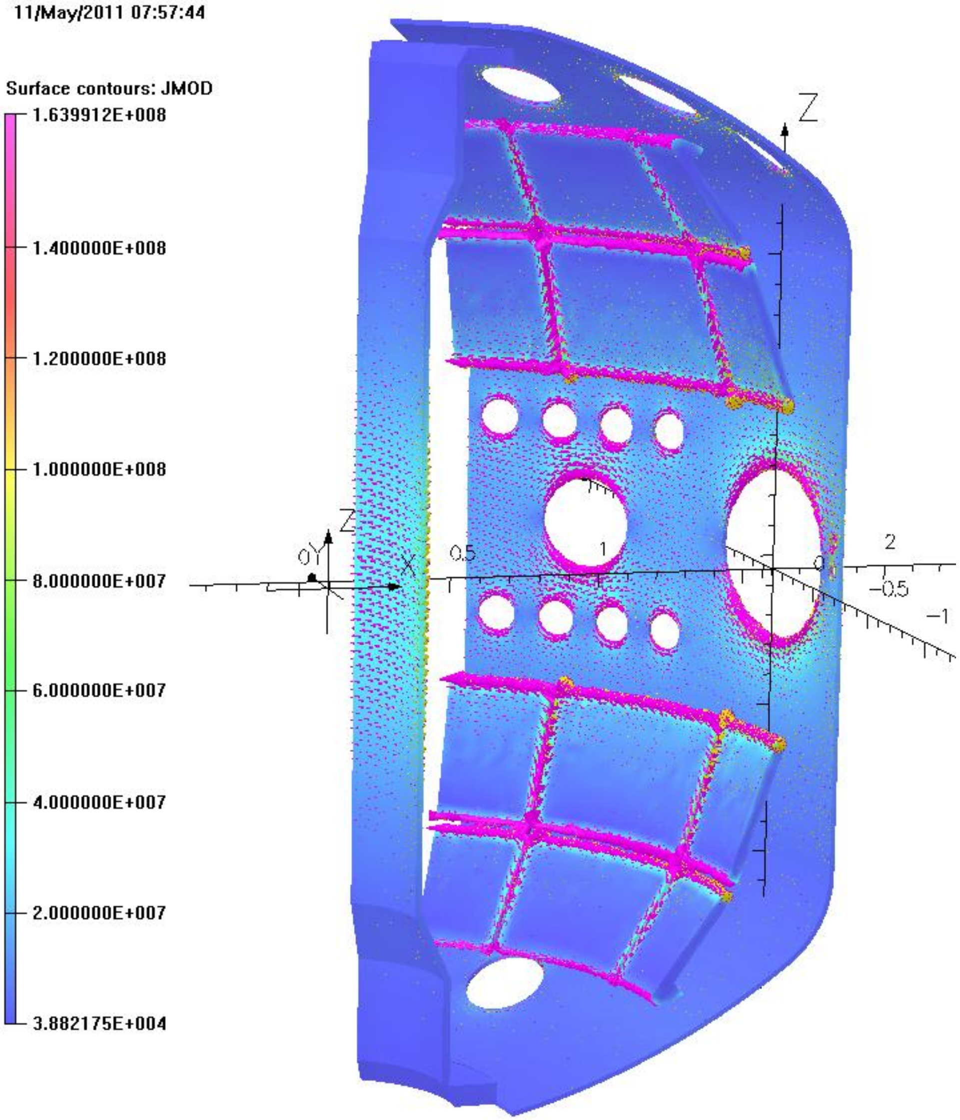


Fast mid-plane centered disruption 2 MA/ms
Back ground field OH, TF and PF coils (#79)

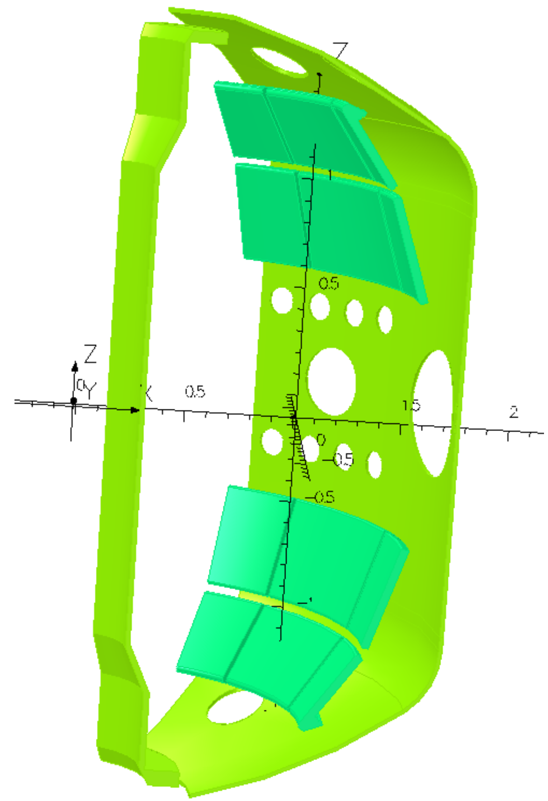


Square shape plasma (same cross section area as circular shape)

Eddy Current Centered Disruption – 60 Degree Model



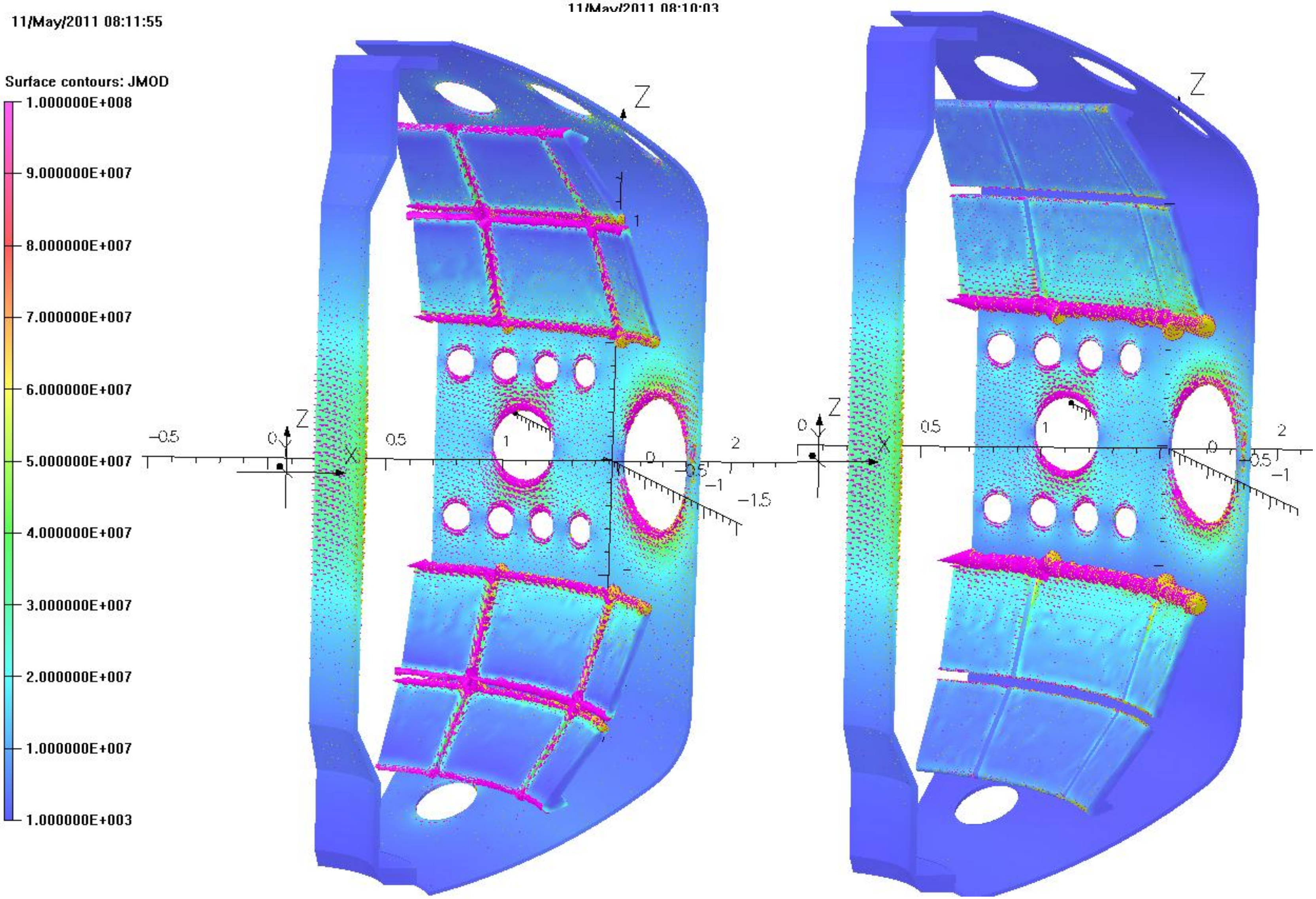
With gap between PPs – at end of disruption



Electrical conductivity

Passive Plate	**5.97x10^{7} (Copper)**
Gap between PP	**1.35x10^{6} (SS)**
VV	**1.35x10^{6} (SS)**
CS Casing	**1.35x10^{6} (SS)**

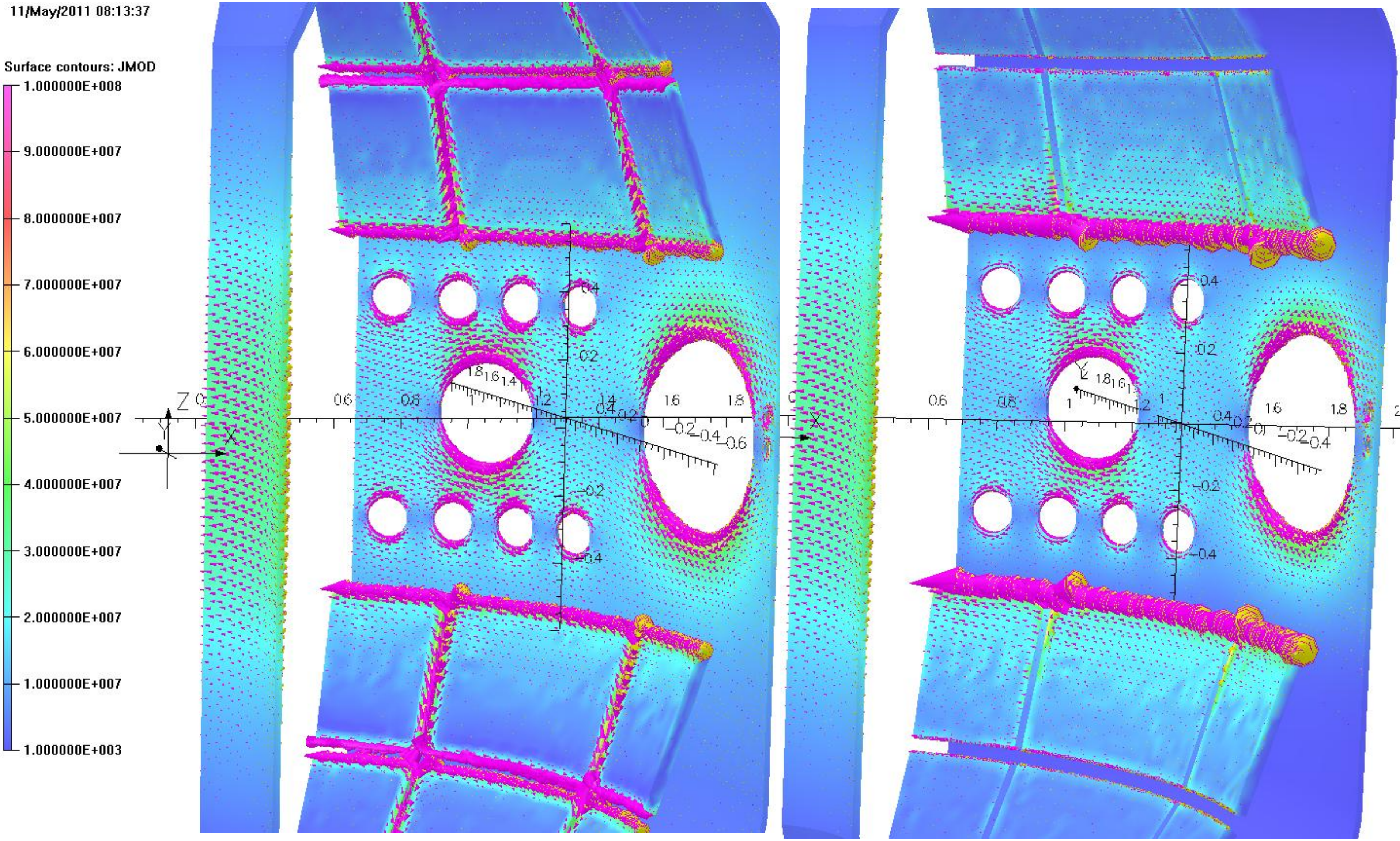
Eddy Current Centered Disruption – 60 Degree Model



1-2” air gap between plates

Gap filled with weld between plates

Eddy Current Centered Disruption – 60 Degree Model



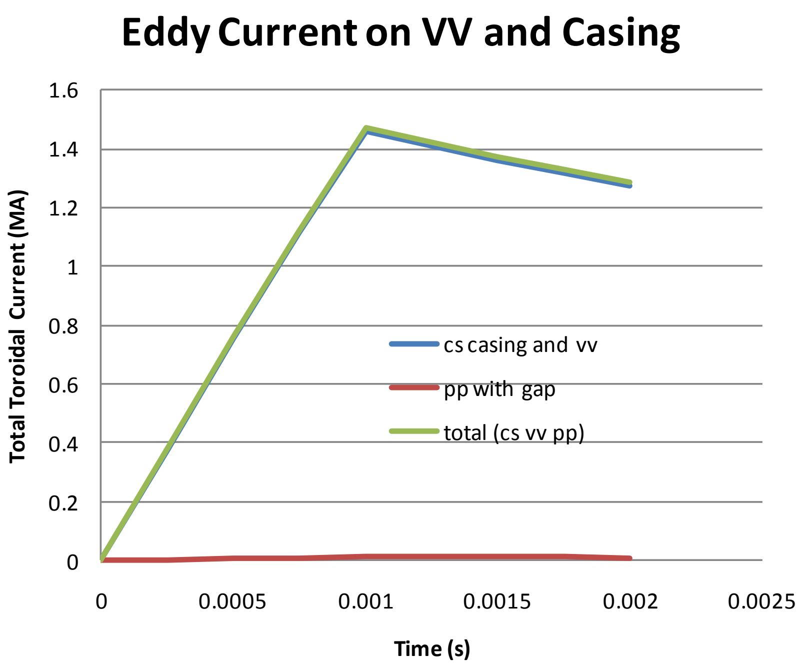
Eddy current at end of disruption

Disruption Analysis of PPs

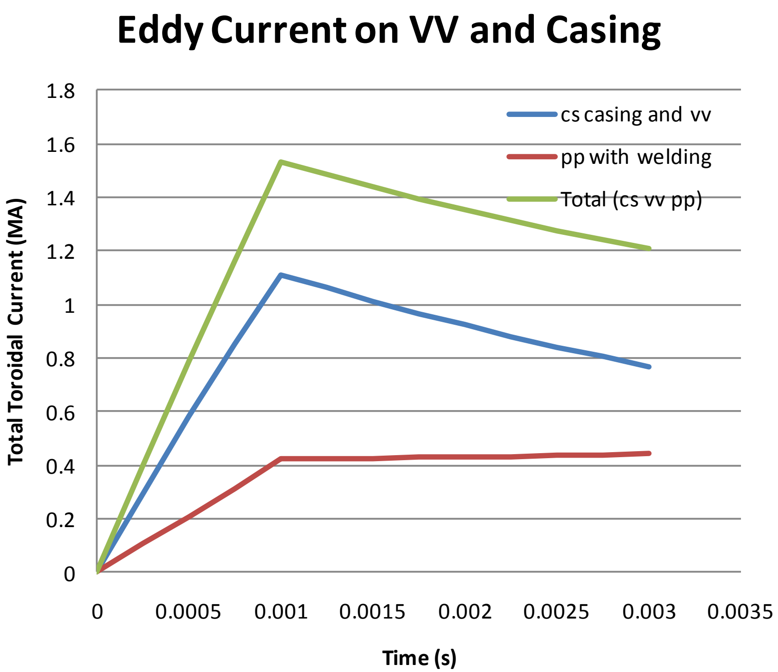
- 3D Opera model with square shape plasma (same J as circular shape)
- Background field from OH, TF, PF coils
- Centered mid-plane disruption
  - Fast disruption (2 MA/ms)
  - Eddy current in PPs, VV, CS-Casing
- Results

Comparison of total induced current (%)

Toroidal Current (%)	Titus	Zhai
VV+CS Casing	72%	75%
PPPs+SPPs	24%	25%

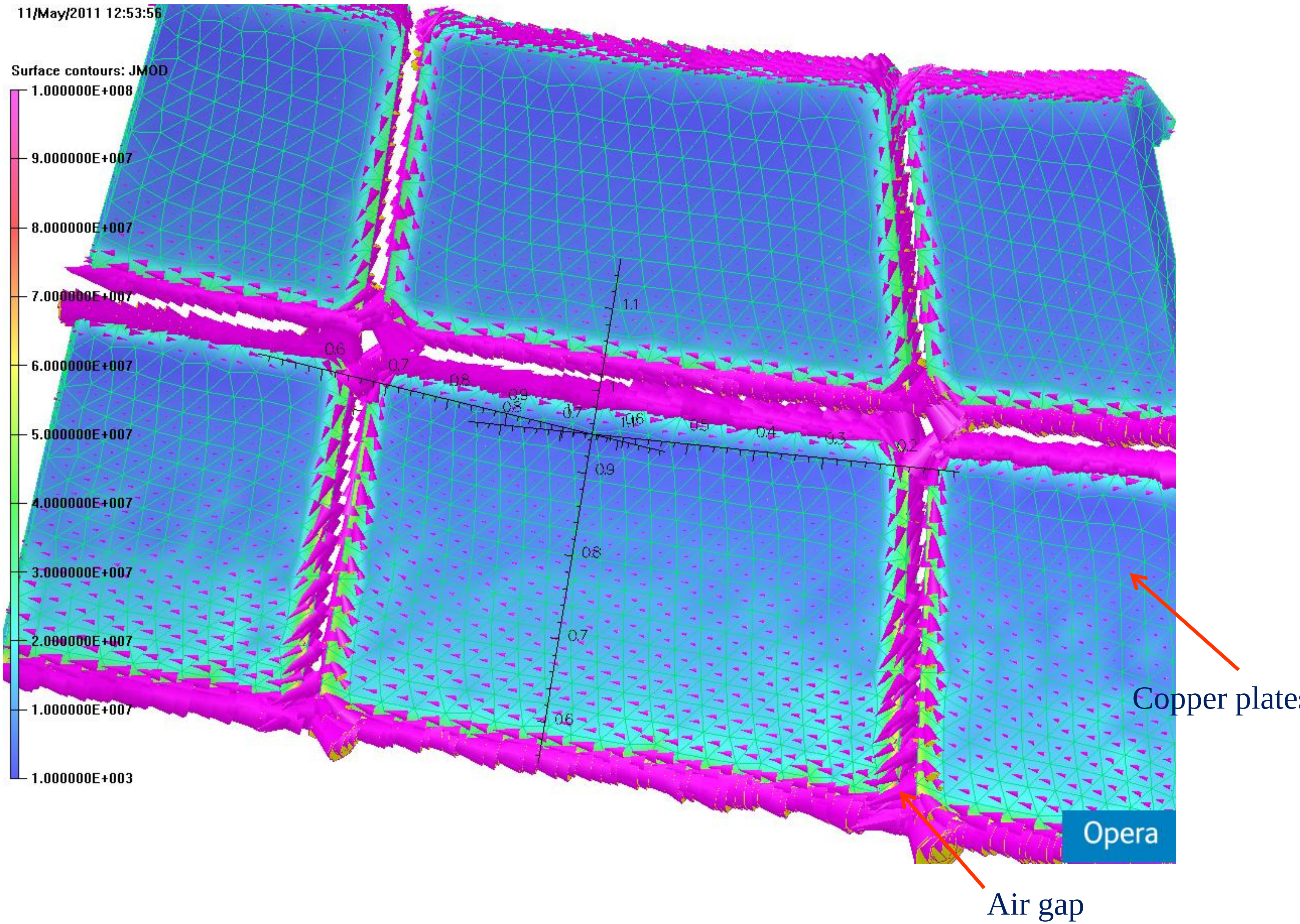


1-2” air gap between PPs

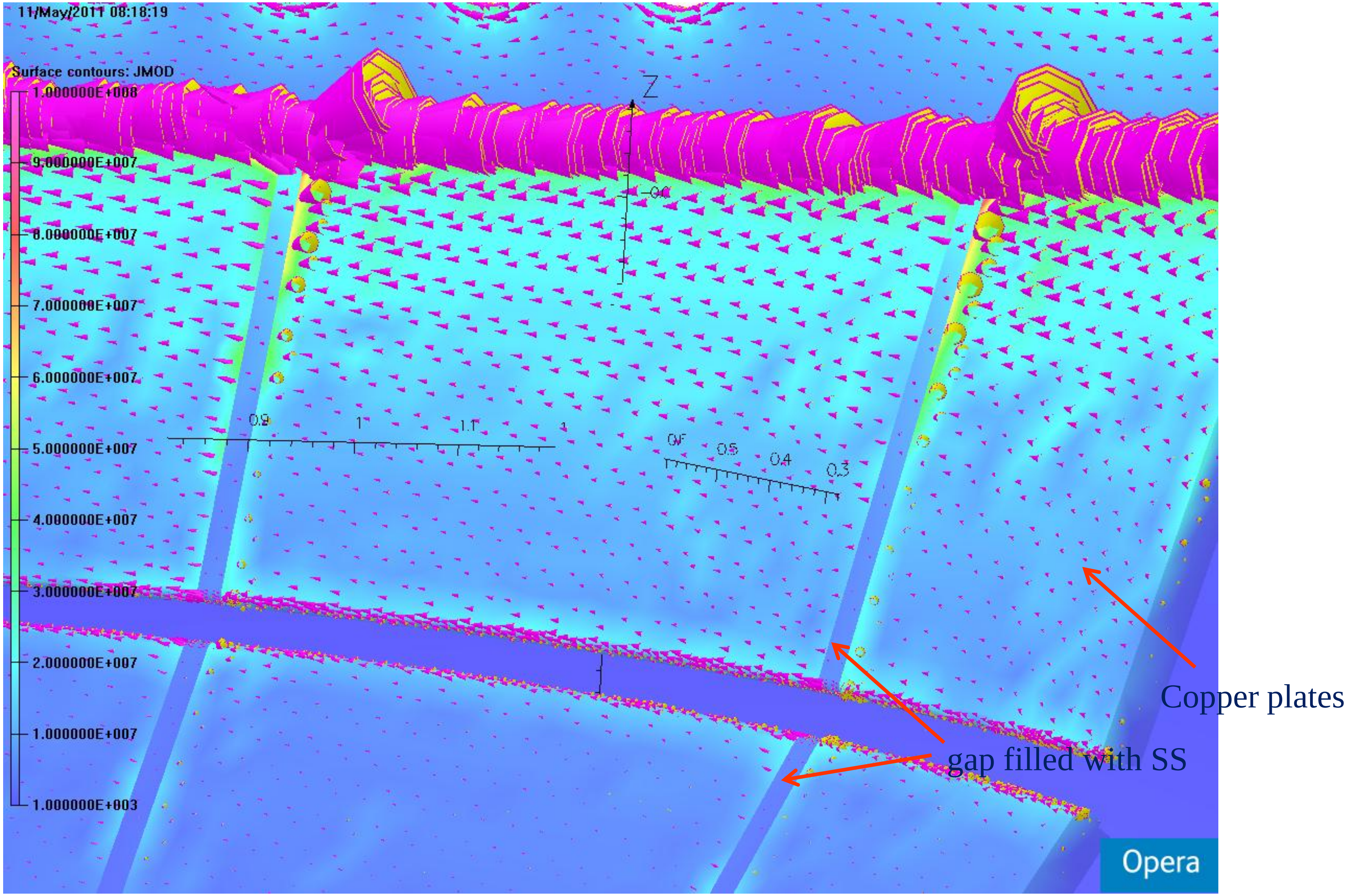


Gap filled with SS (change loops in PPs)

Eddy Current Distribution on PP during Mid-Plane Disruption



Eddy Current Distribution on PP during Mid-Plane Disruption

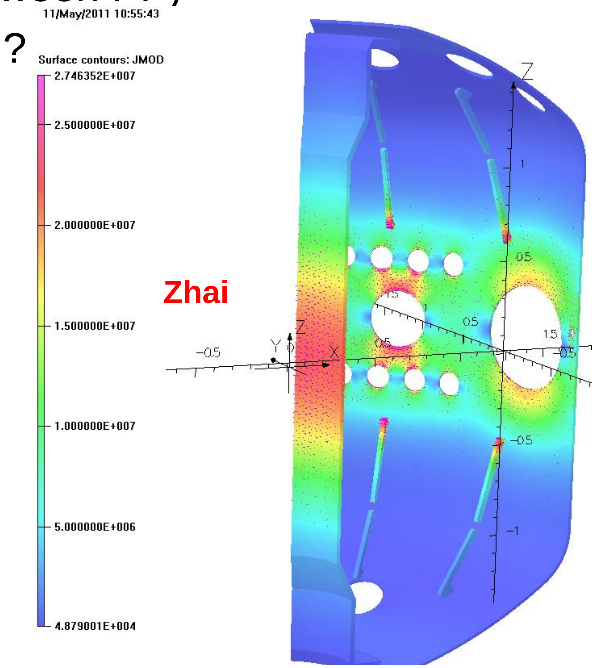


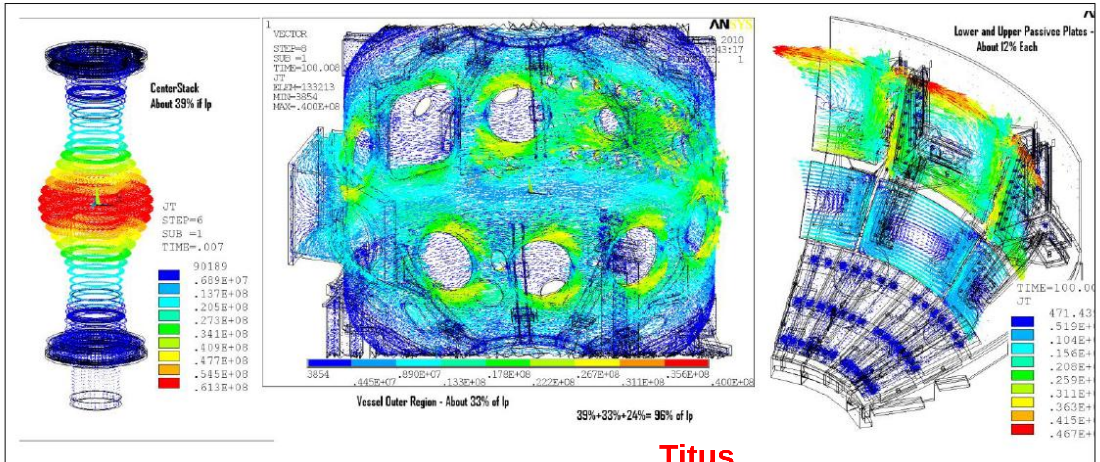
Disruption Analysis of PP, VV, and Components

- Discussion
  - Max background field used in Pete's model
  - Vector potential from 2D continuous model (no gaps between PP)
  - Induced current from 2D model should in same direction?

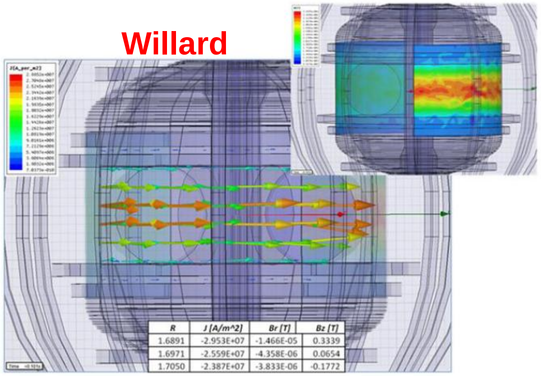
Comparison of peak current density

Current Density (A/m²)	Titus	Willard	Zhai
VV (x10⁶)	26.7~30	29.53	~27.5





Inventory of Currents in the Passive Structures



Maxwell 3D vs Opera 2D VV Wall Eddy Current and B Field Results

From Tom Willards Wed meeting Presentation Aug 2010

Figure 9.2.2-7 Maxwell and OPERA Mid-Plane Disruption Current Densities

Disruption Analysis of PP, VV, and Components

- Opera Model – R. Hatcher
  - Max background field from PF and OH coils; no TF coils
  - Mesh in radial direction to capture skin effect (skin depth?)
  - Electrical conductivity
    - Passive plates
    - VV and CS casing – from measurement (SS?)
  - Time varying vector potential solution (r*A? electrical scalar potential?)
- Opera Vector Potential input to 3D ANSYS model – P. Titus
  - ELEKTRA combination of total and reduced vector potentials
    - Total vector potential $\nabla \times \frac{1}{\mu} \nabla \times \mathbf{A} = -\sigma(\frac{\partial \mathbf{A}}{\partial t} + \nabla V)$
    - Reduced vector potential $\nabla \times \frac{1}{\mu} \nabla \times \mathbf{A_R} = 0$
    - Electrical scalar potential $\nabla \bullet \sigma(\nabla V + \frac{\partial \mathbf{A}}{\partial t}) = 0$

Disruption Analysis of PP, VV, and Components

- Recommendation
  - Design electrical conducting path to reduce eddy current gradient in PPs to reduced eddy induced bending effect?