Update on Heating of the ARIES Divertor

Jake Blanchard
University of Wisconsin – Madison

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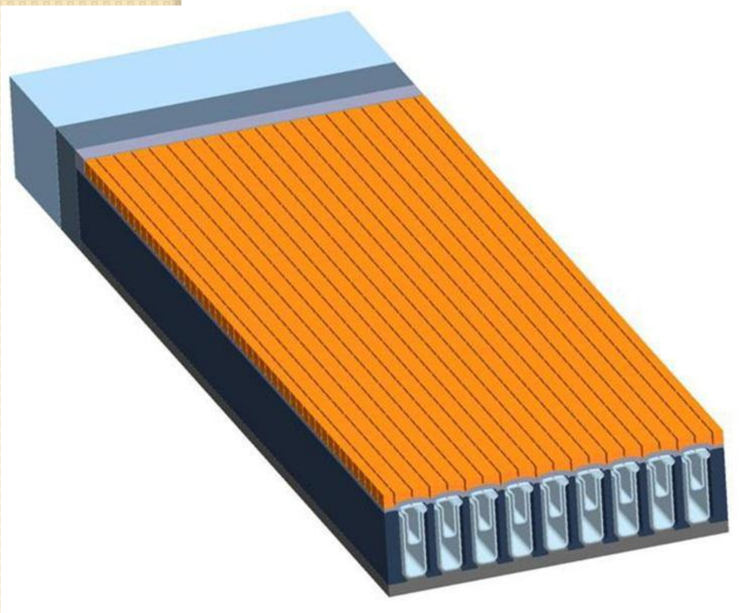
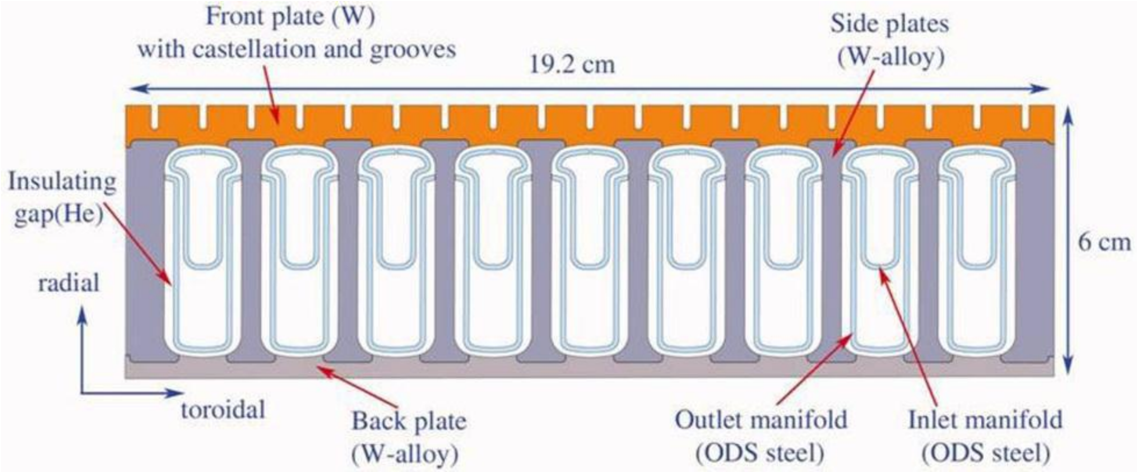
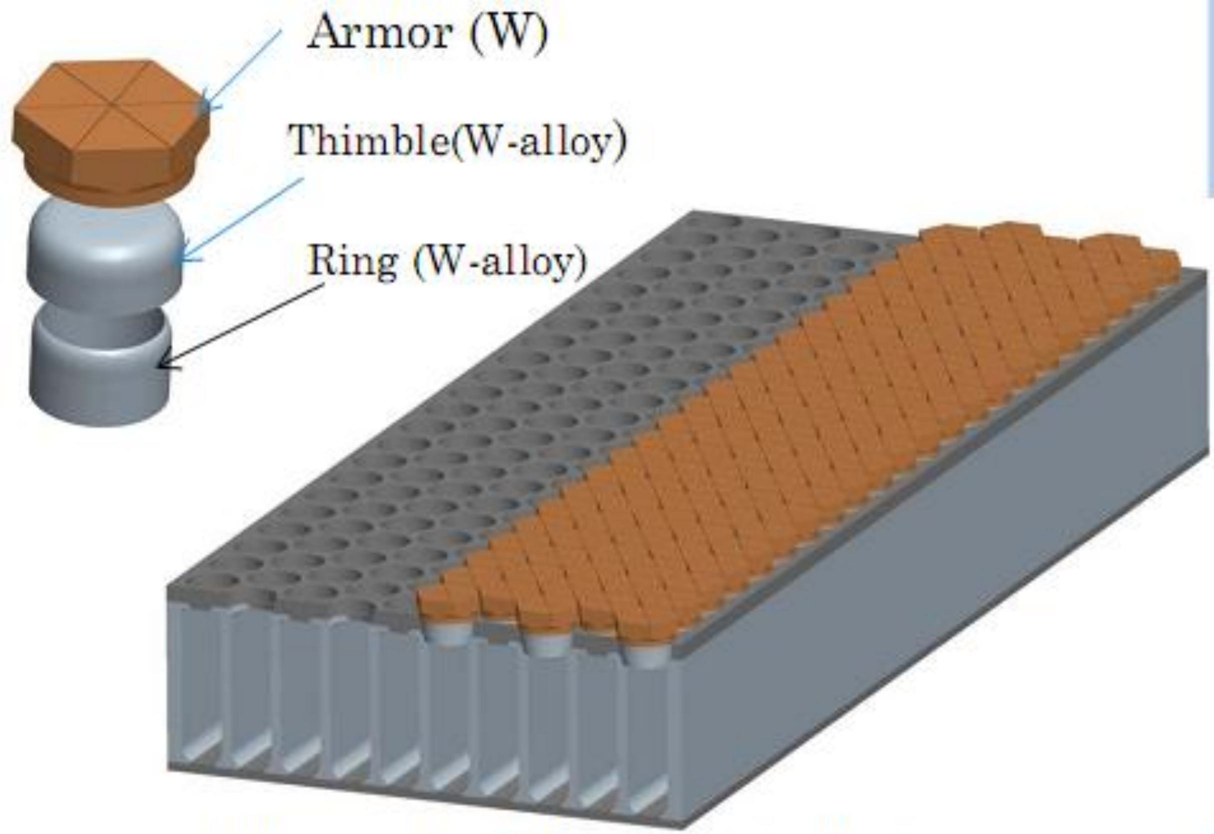
Consider Plate and Finger Designs

Tungsten HCFP(Helium-cooled Flat Plate) divertor





Finger Design



He-cooled W target plate

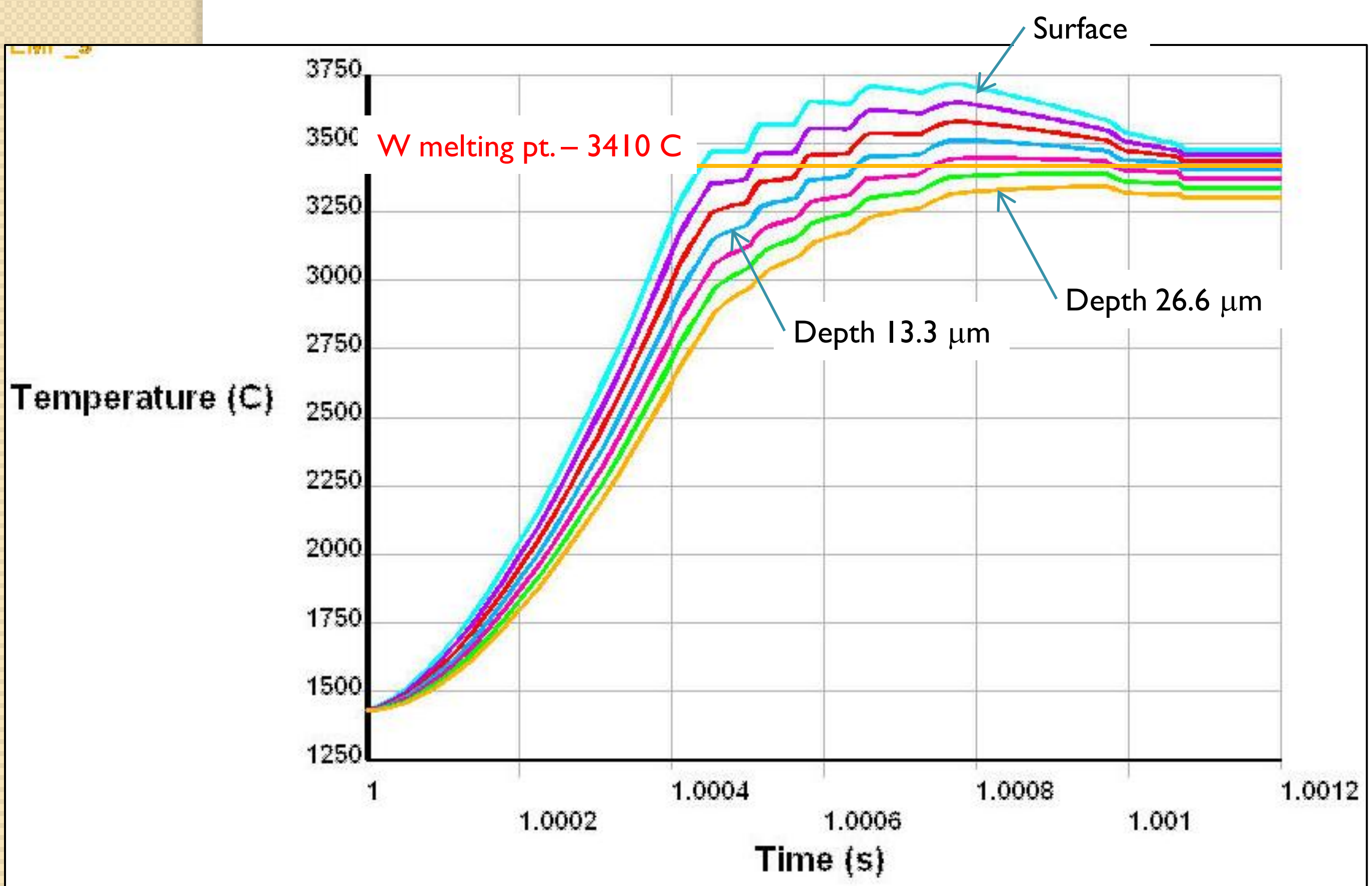
Goal

- There is still substantial uncertainty over expected heat fluxes during and between ELMS
- Approach is parametric, with ELM and inter-ELM heating treated separately
- Analysis here is strictly thermal, based on melting onset as our criterion
- Uncertainty in timescales, "spreading" during ELM, "tunneling" through high density divertor zone, etc.

Baseline ELM Paramters

	Large ELM	Large ELM*	Small ELM	Small ELM*
ΔW_{ELM} (MW)	24	24	5.9	5.9
A_{ELM} (m^2)	1.38	5.52	1.38	2.07
Energy to Divertor	50%	50%	80%	80%
Divertor Split	65%	65%	65%	65%
Applied ΔW_{ELM} (MW)	7.8	7.8	3.1	3.1
$\Delta t_{ELM,rise}$ (ms)	0.44	0.44	0.44	0.44
$\Delta t_{ELM,fall}$ (ms)	0.88	0.88	0.88	0.88
Avg ELM Flux (MW/m^2)	4280	1070	1720	1147
Inter ELM Flux (MW/m^2)	9.5	9.5	9.5	9.5

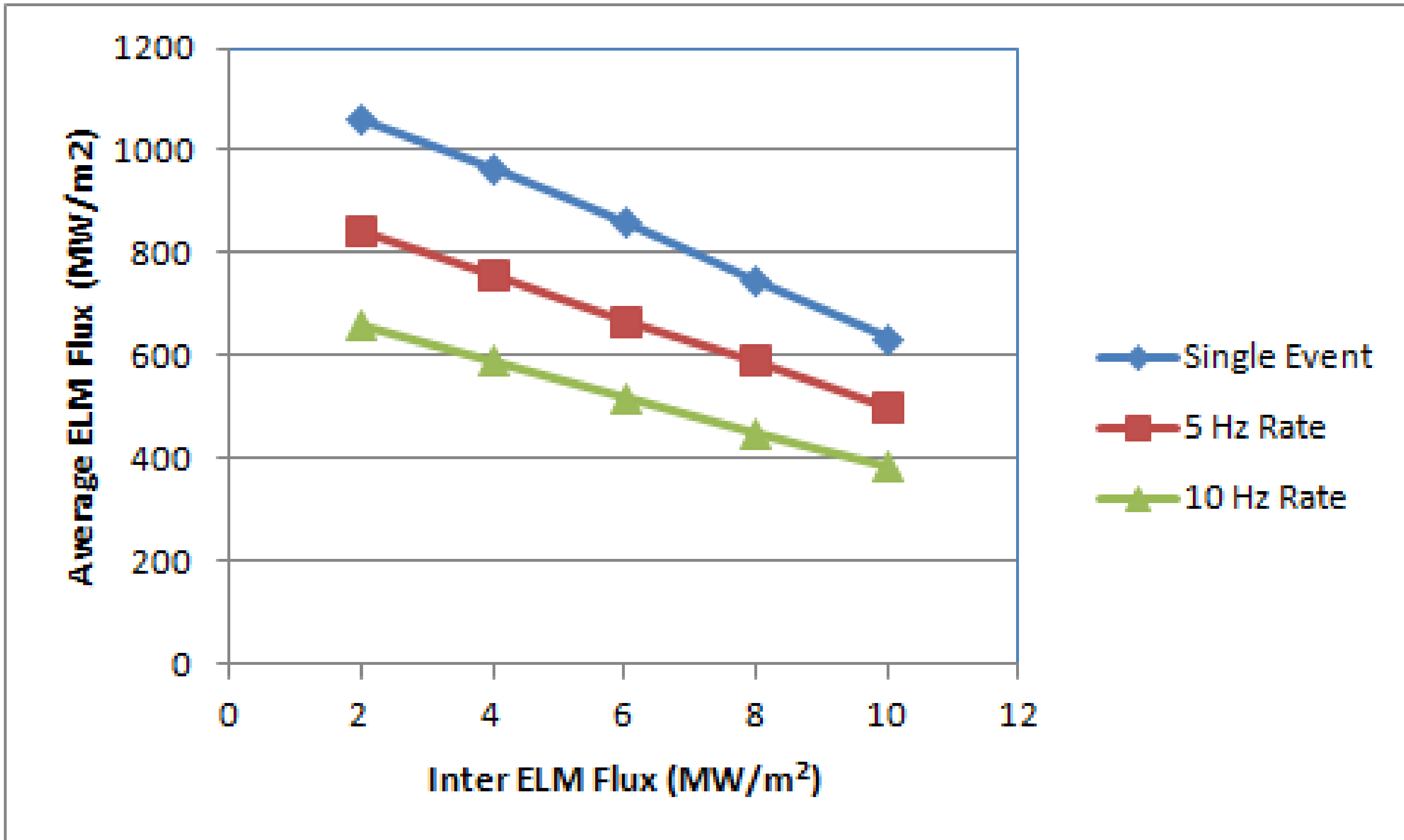
"Old Small ELM" Heating of Divertor Analysis indicated ~20μm Melt Depth



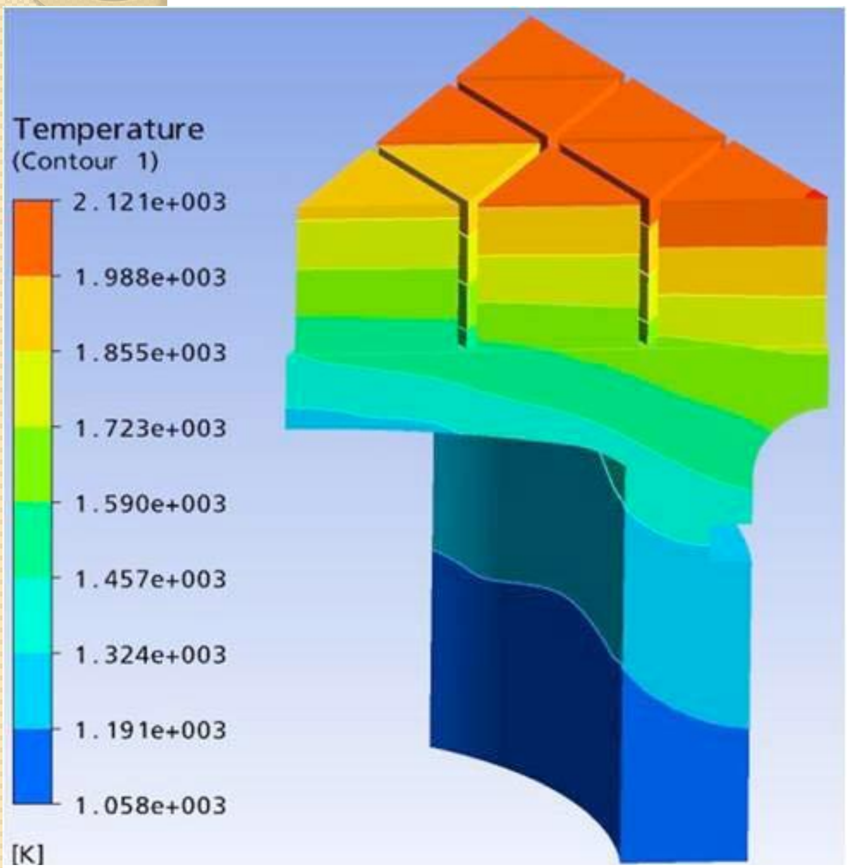
ΔW_{ELM} (MW)	6.0
A_{ELM} (m^2)	1.44
Energy to Divertor	50%
Divertor Split	65%
Applied ΔW_{ELM} (MW)	2.0
$\Delta t_{ELM,rise}$ (ms)	0.4
$\Delta t_{ELM,rise}$ (ms)	0.8
Avg ELM Flux (MW/m^2)	1130
Inter ELM Flux (MW/m^2)	6.7

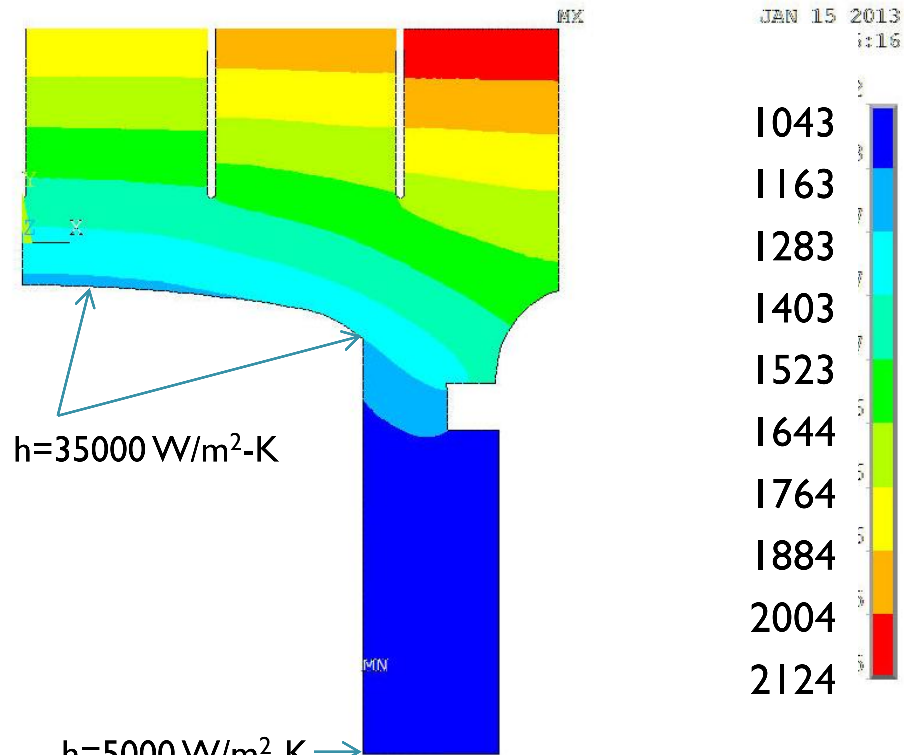
Parametrics – Plate Design

Combination of Inter-ELM and ELM fluxes that will just cause melting (quasi-steady state)



Simplified Finger Thermal Model for ELMs

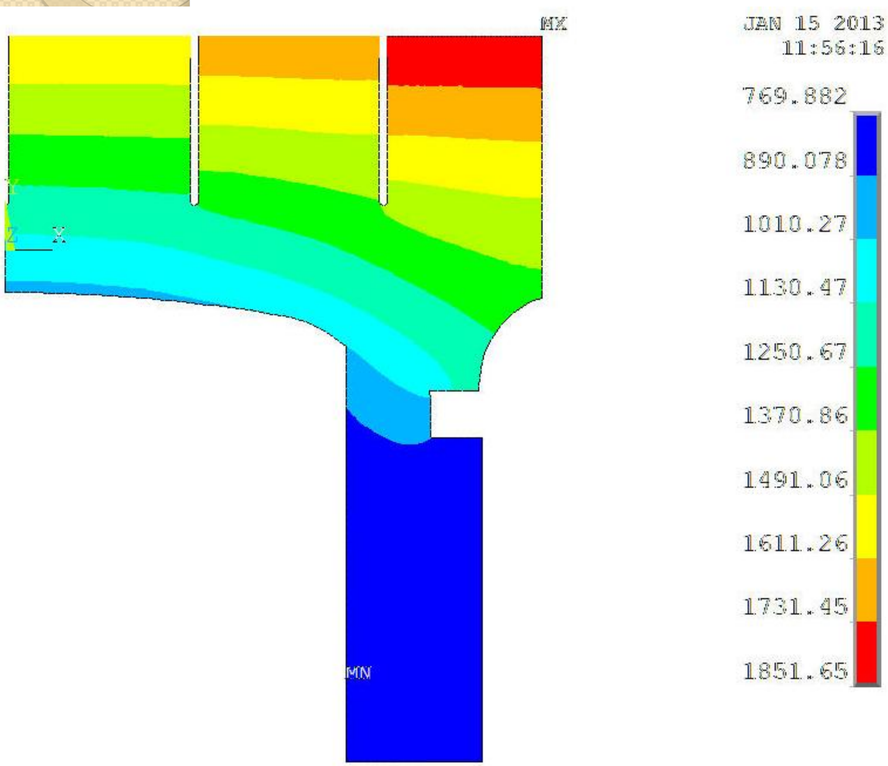


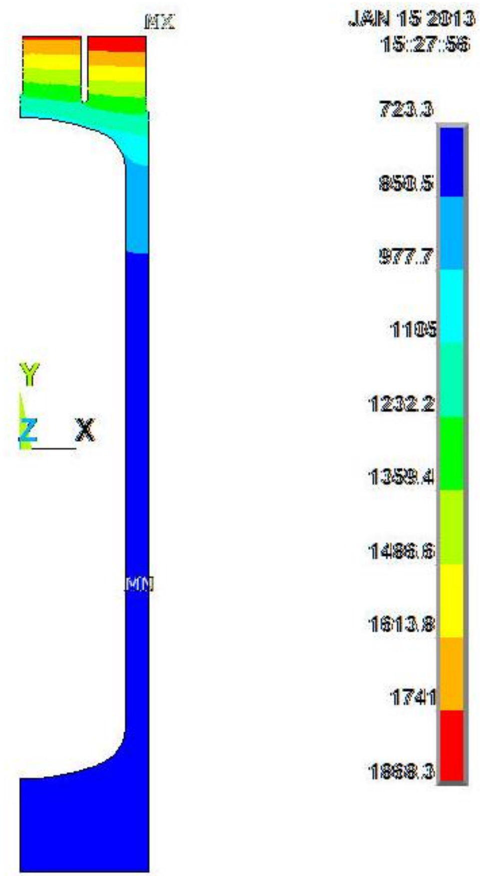


Recent US Activities on Advanced He-Cooled W-Alloy Divertor Concepts for Fusion Power Plants
M. S. Tillacka,1, A.R. Raffraya,2, X. R. Wanga, S. Malangb, S. Abdel-Khalikc, M. Yodac, and D. Youchisond

Surface heat flux	**10 MW/m^2**
Volumetric heat generation	**17.5 MW/m^3**
He inlet temperature	**600 C**
He base pressure	**10 MPa**

Plate and Finger Concepts Under Identical Thermal Loading (Steady State)





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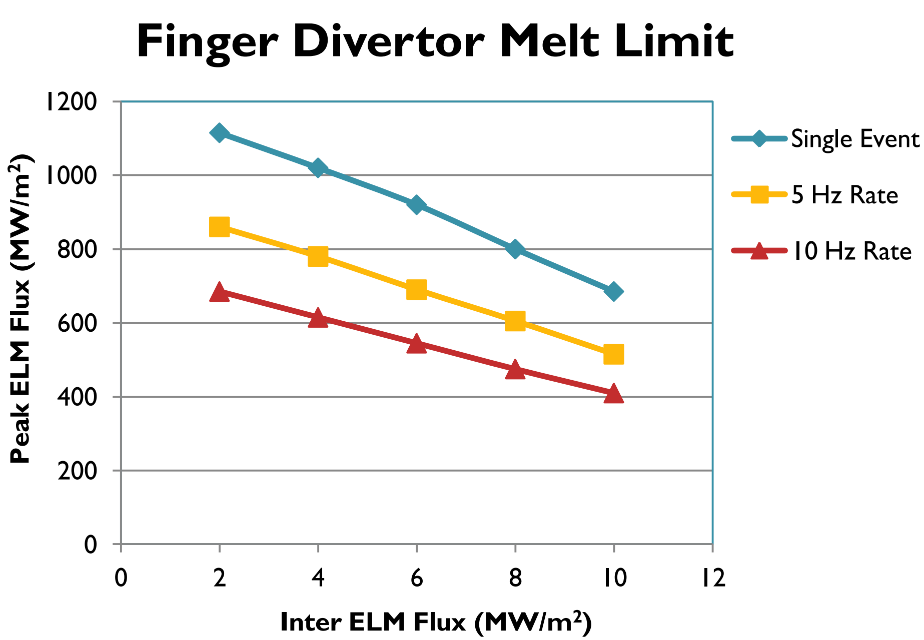
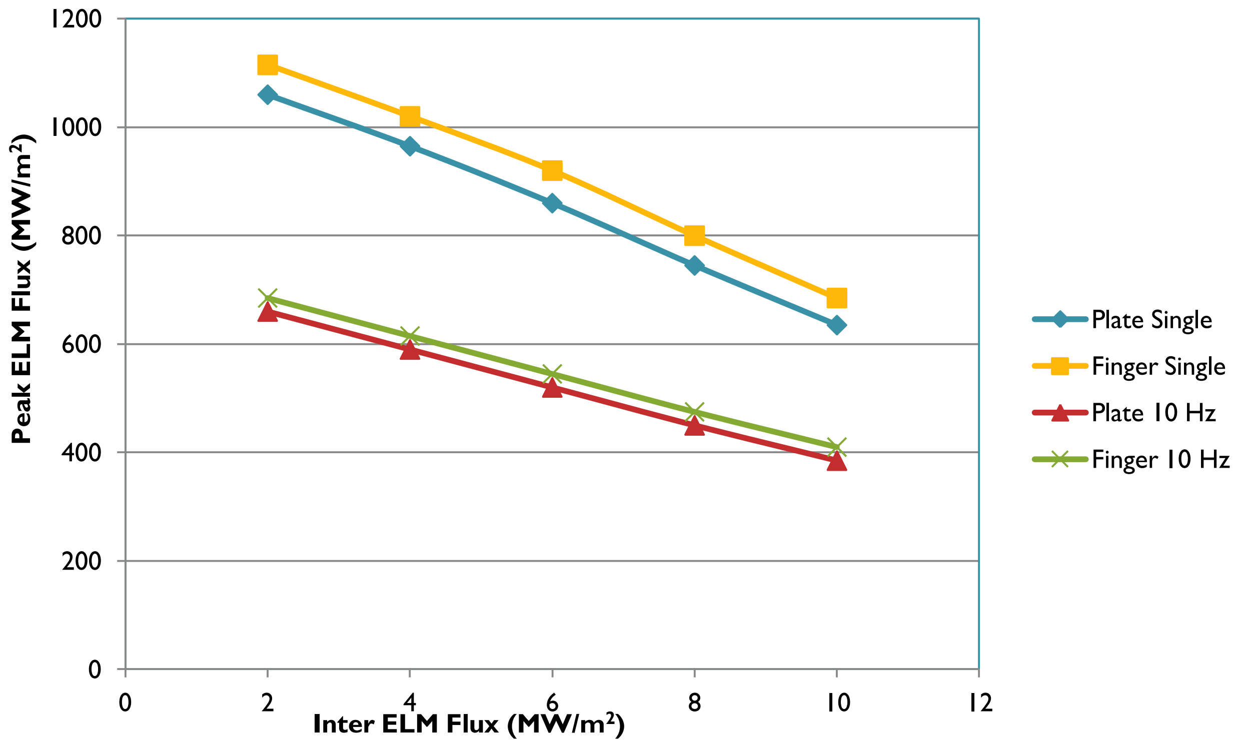
Parametrics – Finger Design

Combination of Inter-ELM and ELM fluxes that will just cause melting (quasi-steady state)



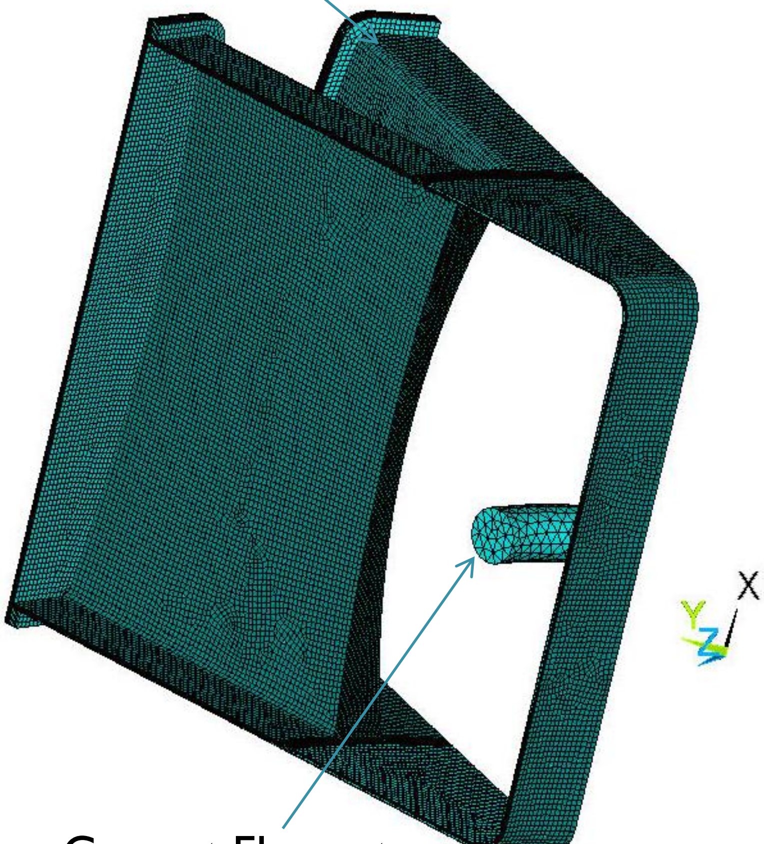
Finger vs. Plate

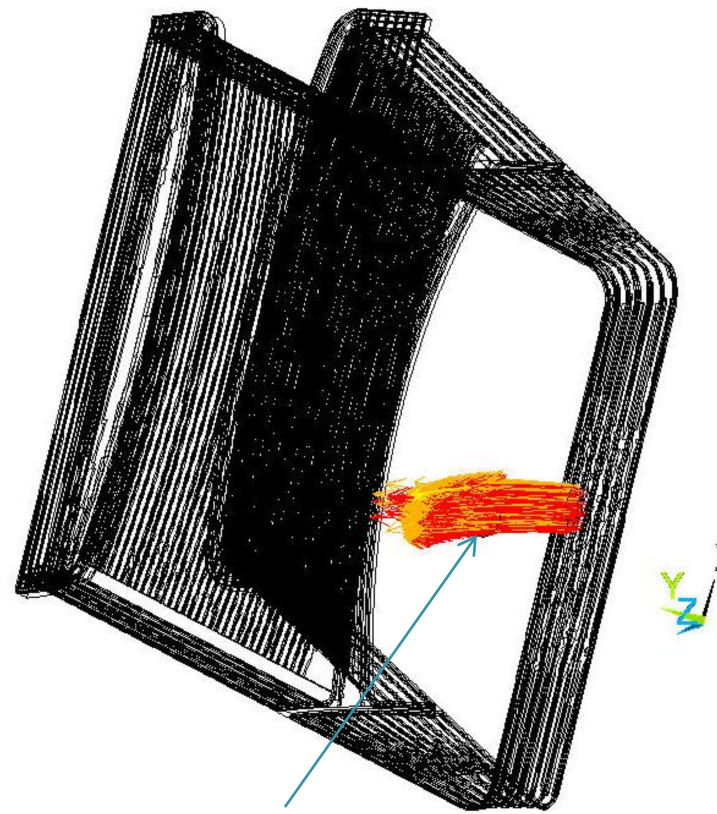


Vacuum Vessel (Disruption)

- Model from UCSD imported for E&M
- Plasma will be line source
- Current will ramp down linearly
- No other structures considered
  - Blanket
  - First wall
  - Stabilizing structures
  - Etc.

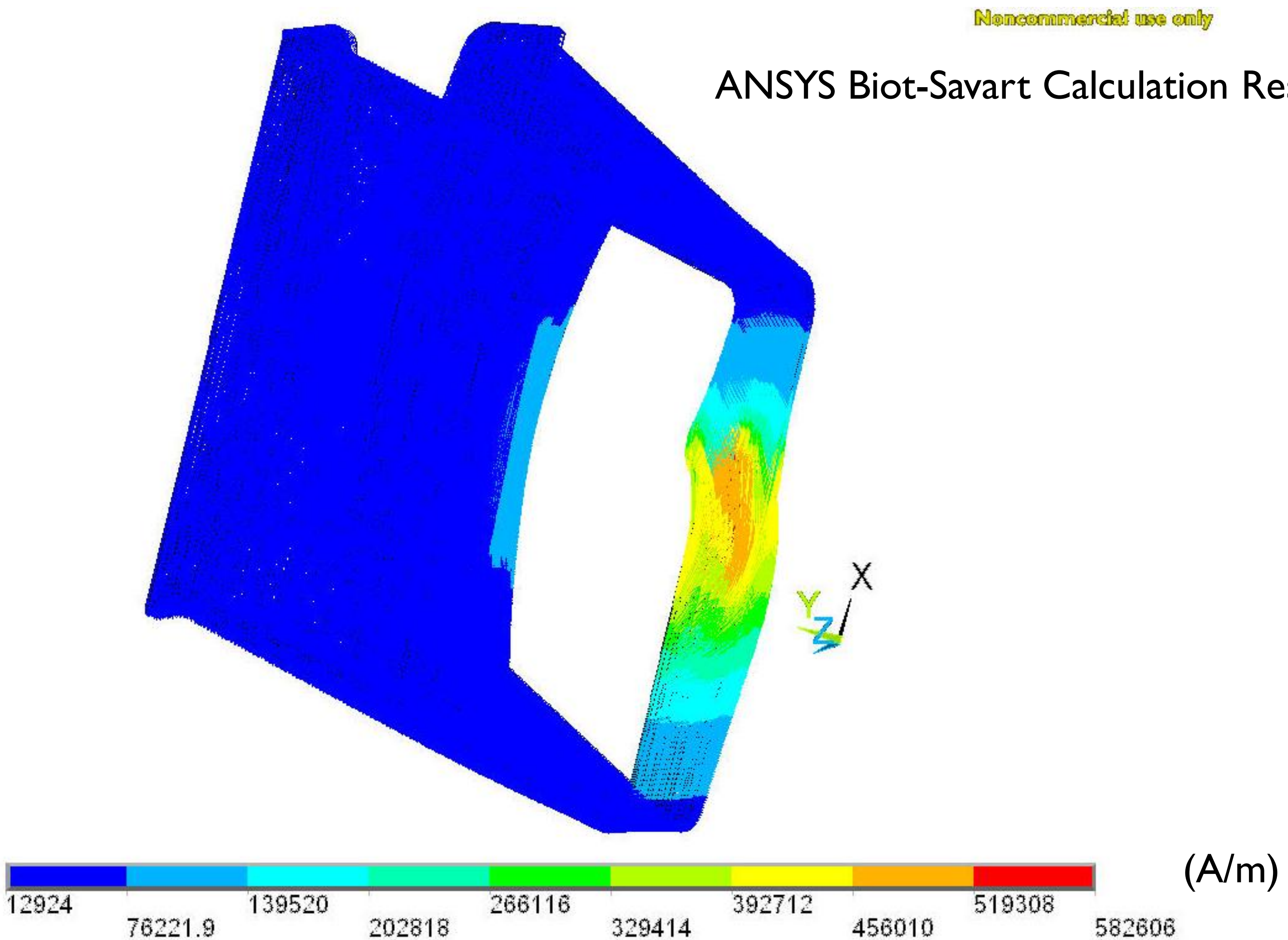
ANSYS Vacuum Vessel Model with Plasma Current Elements





Magnetic Field in Vacuum Vessel From Plasma

ANSYS Biot-Savart Calculation Results



Conclusions

- We don't see a substantial difference between finger and plate concepts when ELMS are accounted for
- We have imported the UCSD CAD model of the VV into ANSYS
  - Goal is to calculate induced currents and forces do to linear current decay (no plasma motion)