EM and Multipacting modeling for Crab Cavity development

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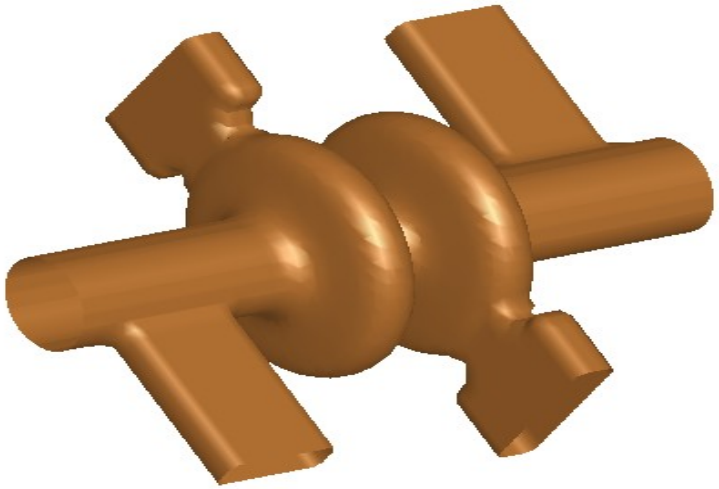

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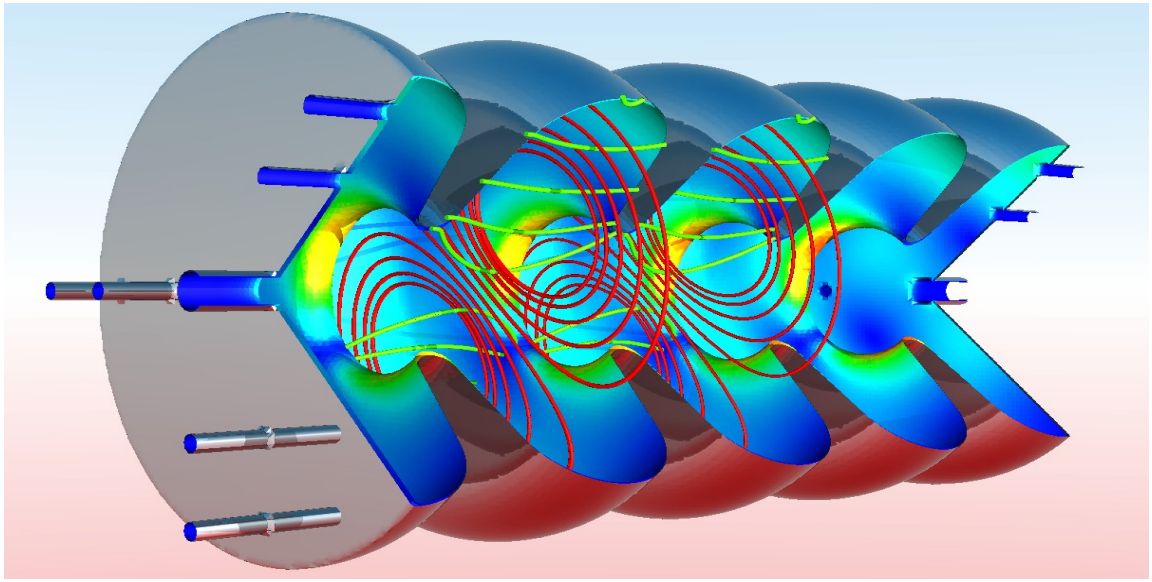
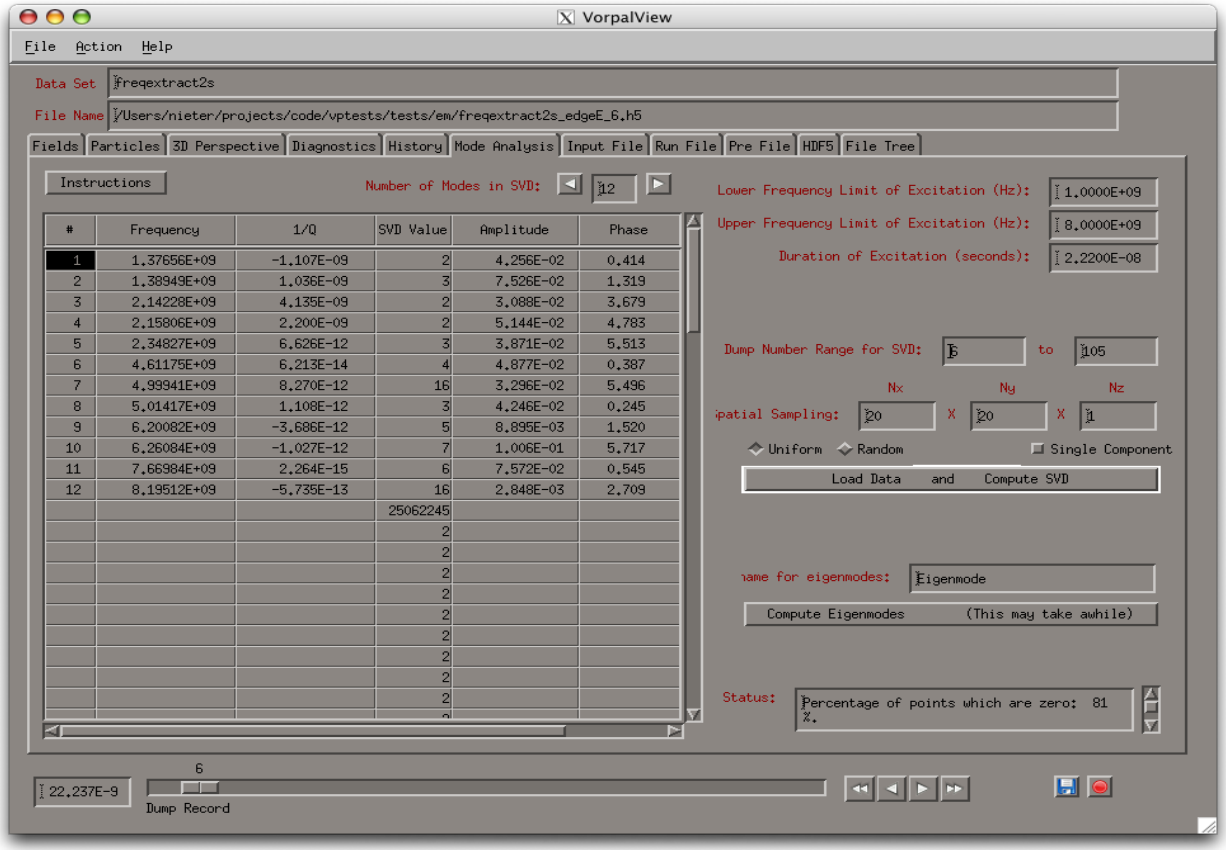
VORPAL is a powerful simulation tool for studying cavity multipacting

- FDTD electromagnetics coupled with Particle-in-Cell (PIC)
- Second order accurate boundary models
- Secondary electron physics (Furman/Pivi)
- Ability to track individual trajectories



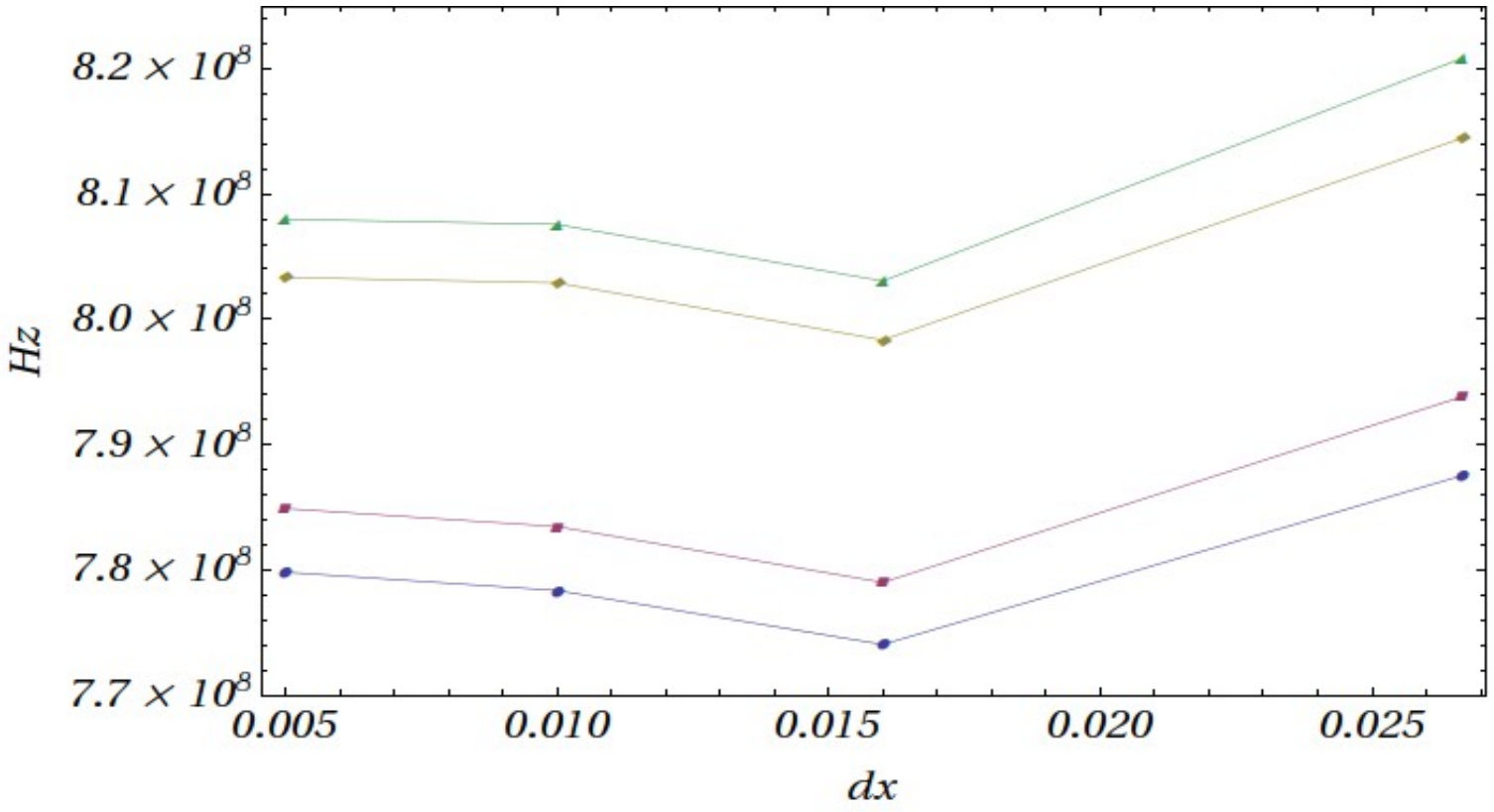
Filter diagonalization allows extraction of cavity frequencies and modes

- G.R. Werner, J.R. Cary, "Extracting degenerate modes and frequencies from time-domain simulations with filter-diagonalization", *Journal of Computational Physics*, Vol. 227, pp. 5200-5214, 2008
- Both frequencies and modes are found
- Deals with degeneracies



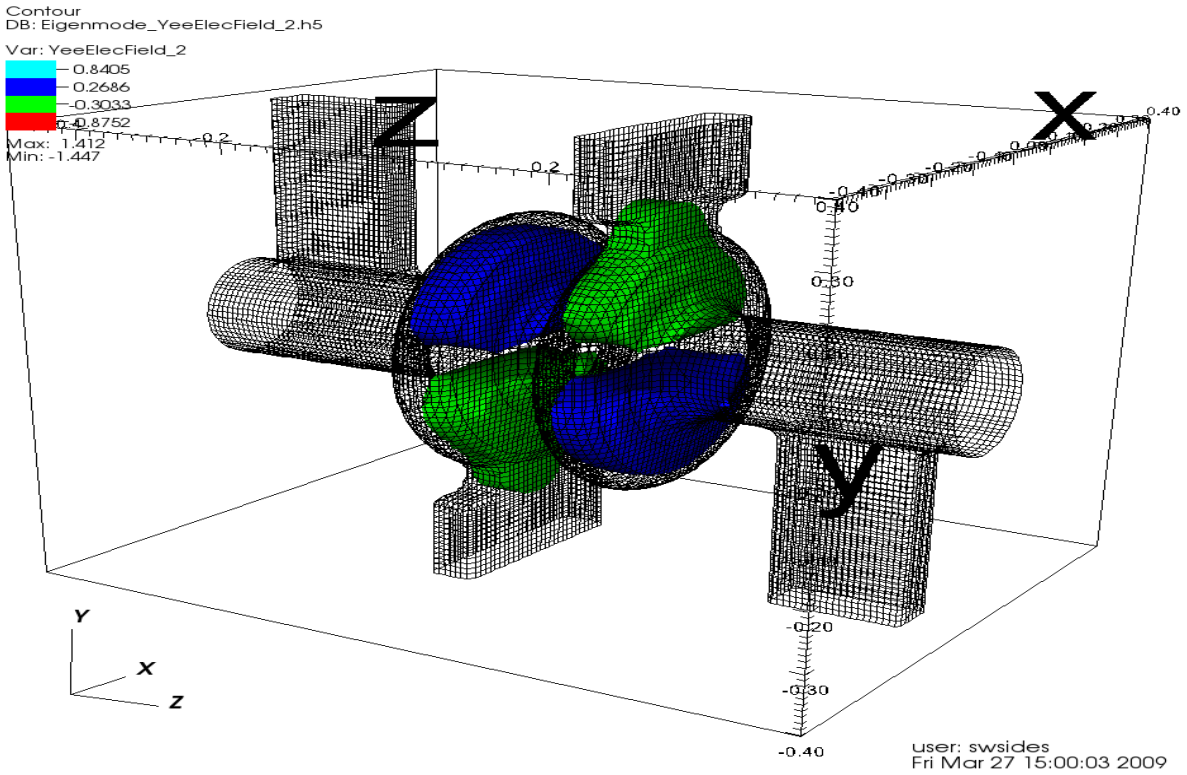
Filter diagonalization applied to UK crab cavity design finds all modes

- Gets separation between polarization states
- Gets separation between pi and zero modes



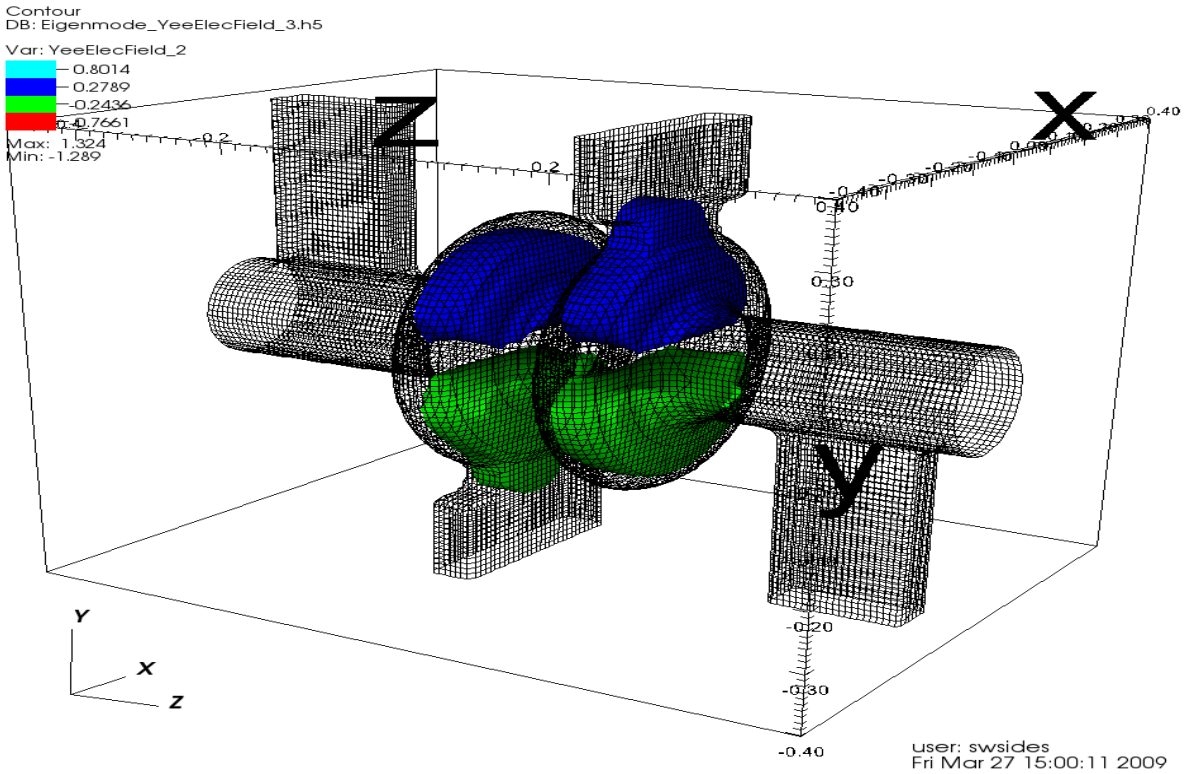
Filter diagonalization applied to Crab cavity design finds all modes

- Pi mode that couples to the waveguides



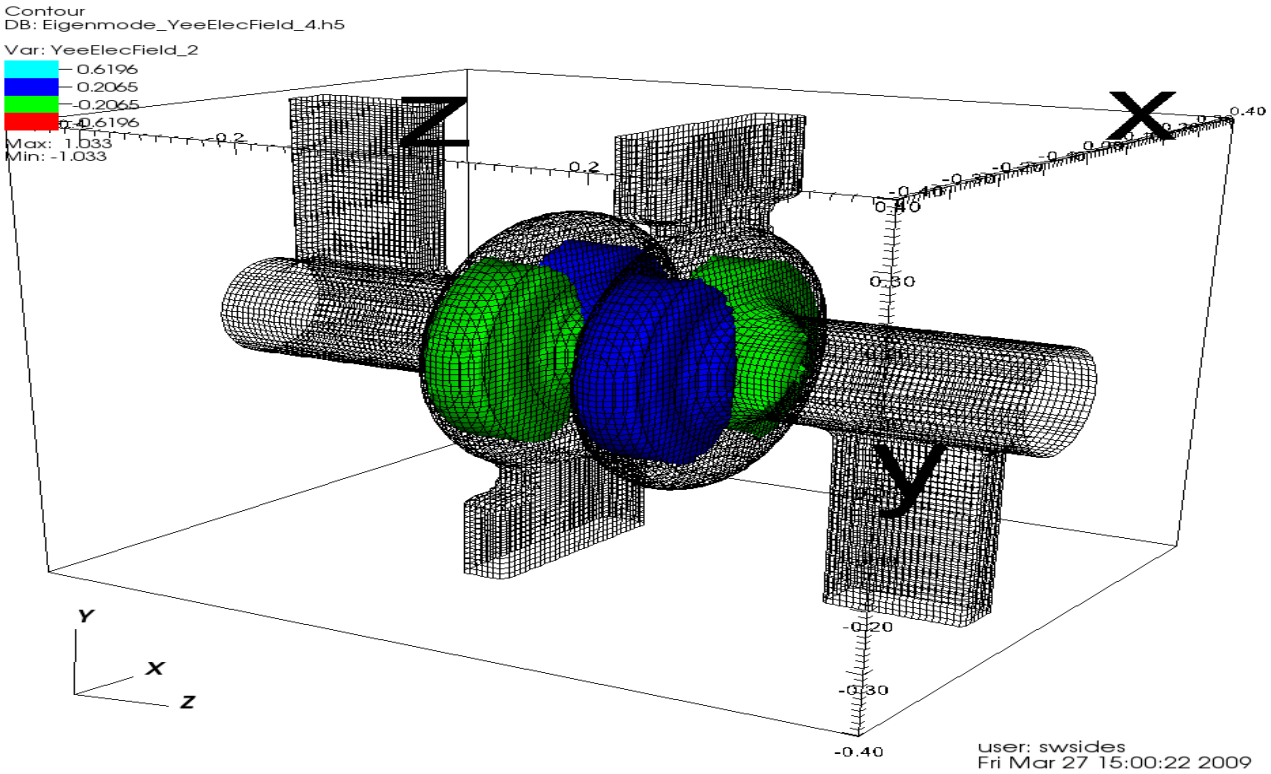
Filter diagonalization applied to Crab cavity design finds all modes

- Zero mode that couples to the waveguides



Filter diagonalization applied to Crab cavity design finds all modes

- Pi mode that does not couple to the waveguides



Filter diagonalization applied to Crab cavity design finds all modes

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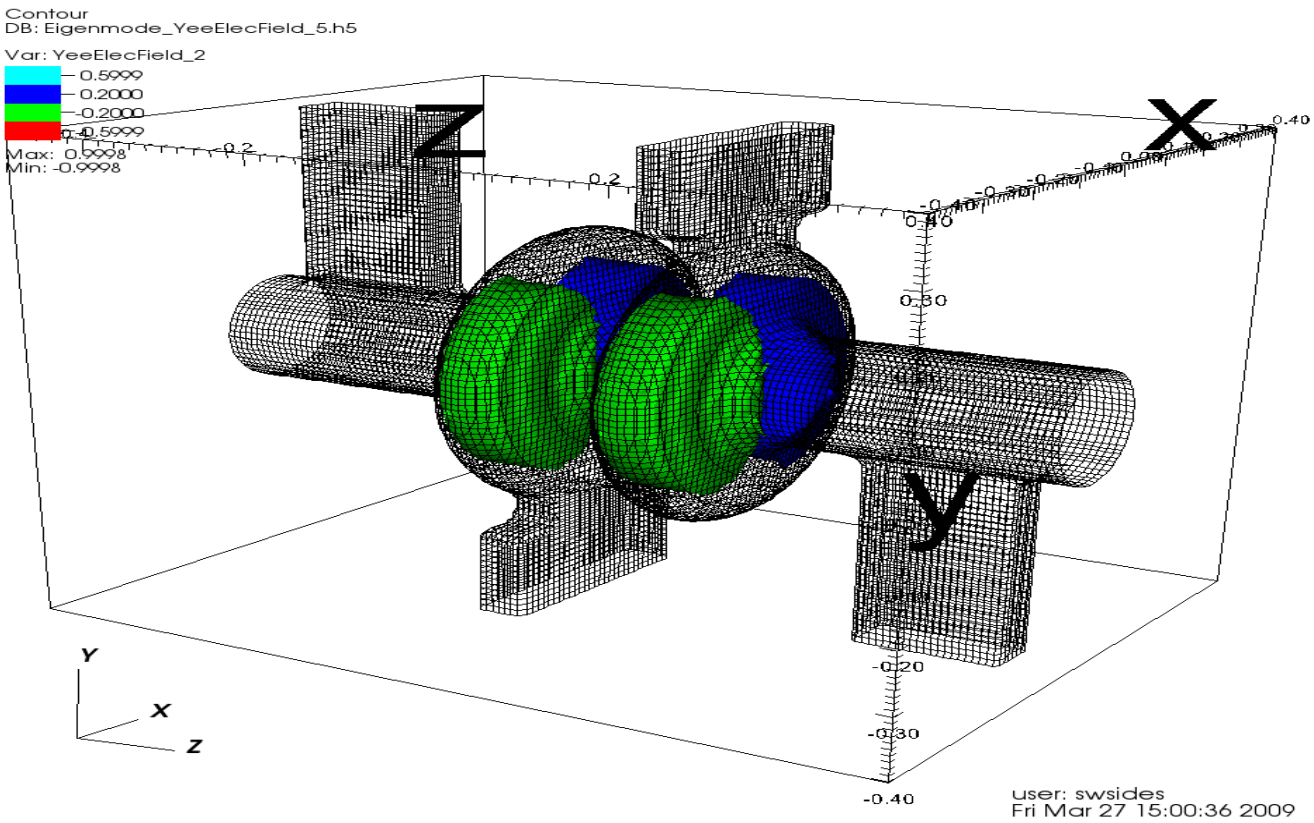
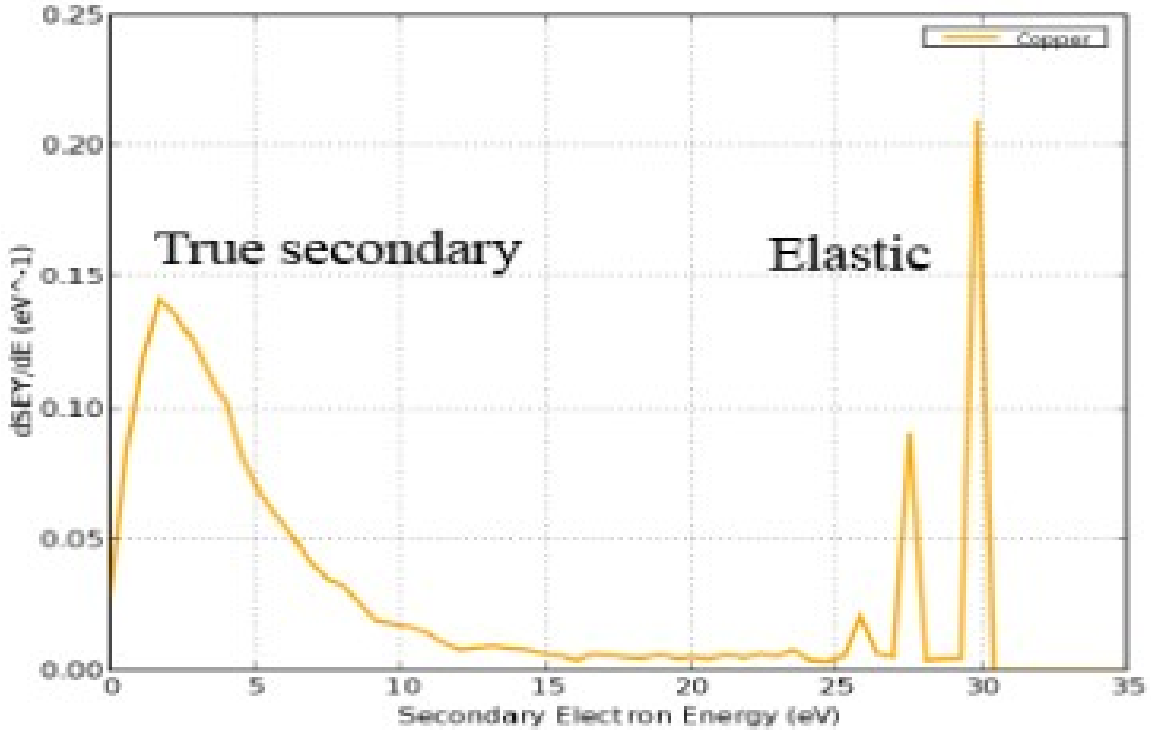


Filter diagonalization compares favorably with results from Microwave Studio

	VORPAL	Microwave Studio
Undamped Zero mode	0.8076 GHz	0.8045 GHz
Undamped Pi mode	0.8029 GHz	0.8004 GHz
Damped Zero mode	0.7834 GHz	0.783 GHz
Damped Pi mode	0.7783 GHz	0.778 GHz

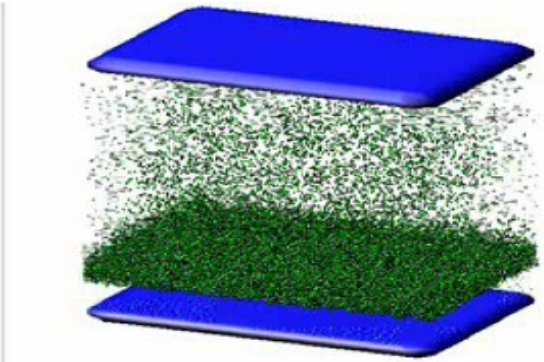
VORPAL's secondary electron emission models allow multipacting studies

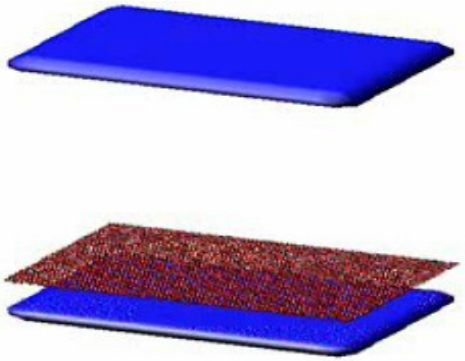
- Simple secondary emission – one secondary emitted at normal incidence
- Phenomenological model – true, diffuse and elastic secondaries
- M. A. Furman and M. Pivi, Phys. Rev. ST Accel. Beams 5, 124404 (2002)

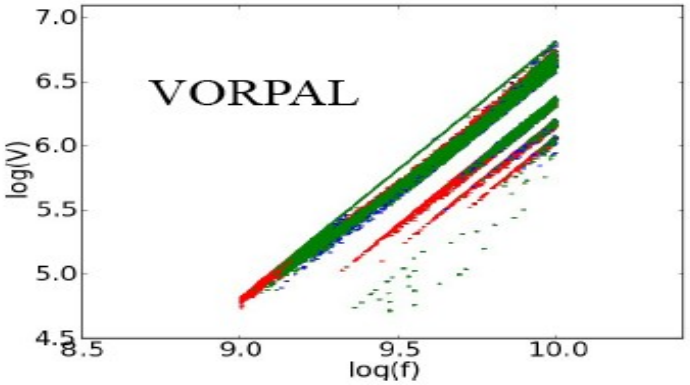


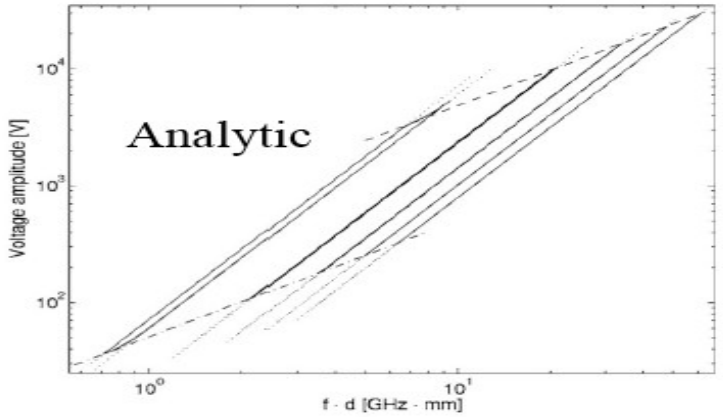
VORPAL has been benchmarked against analytical multipacting results

- Both simple and phenomenological model reproduce multipacting bands



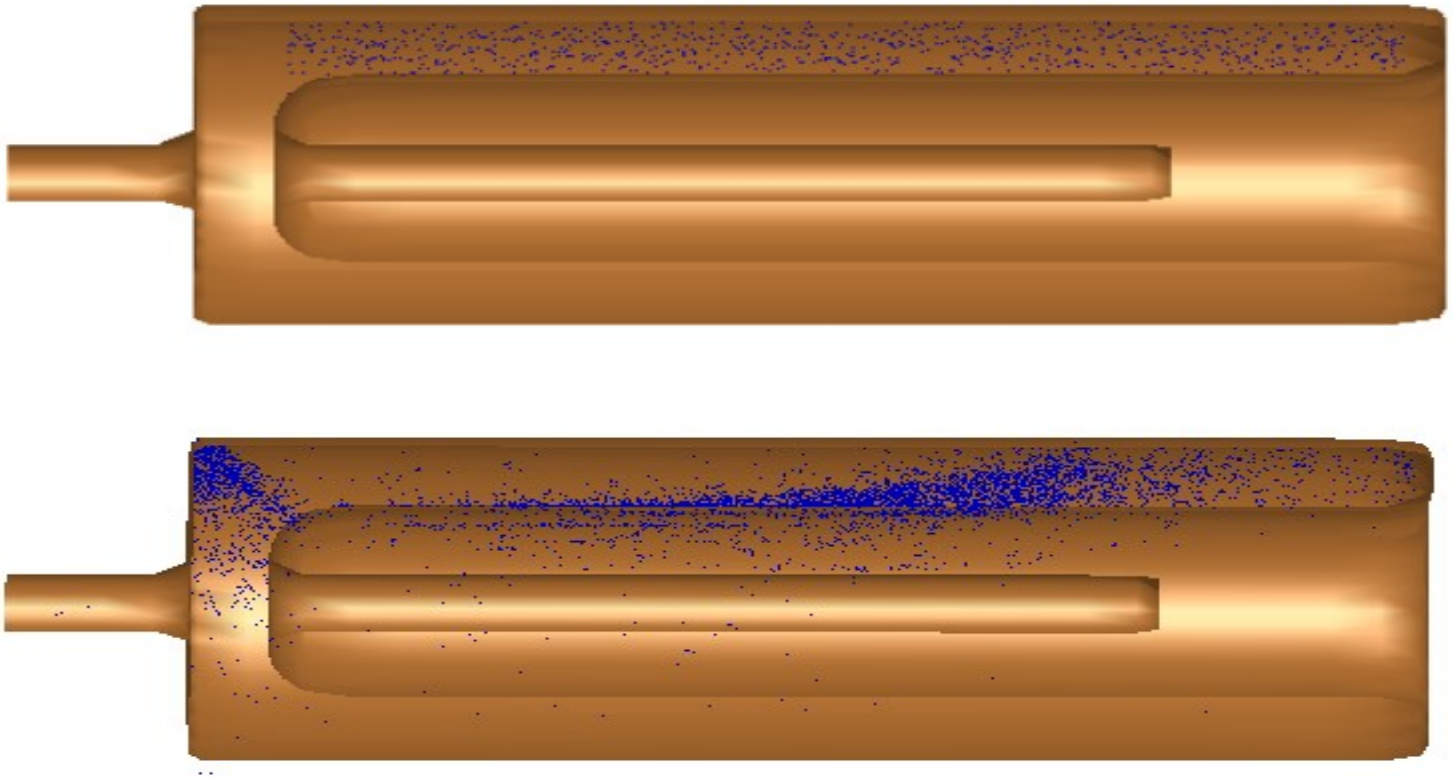






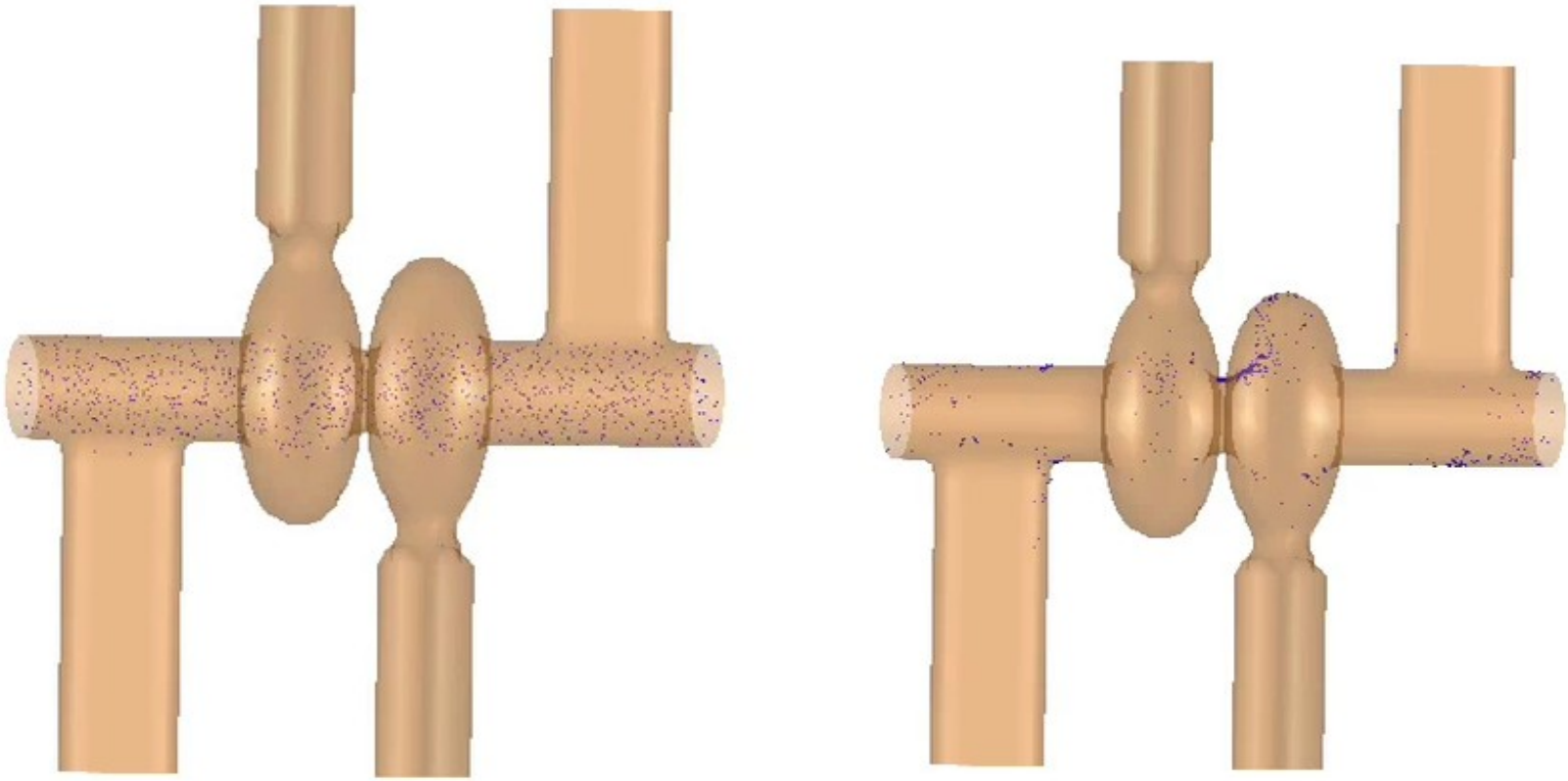
VORPAL simulations can be used to identify potential multipacting

- Multipacting occurring in BNL quarter wave cavity



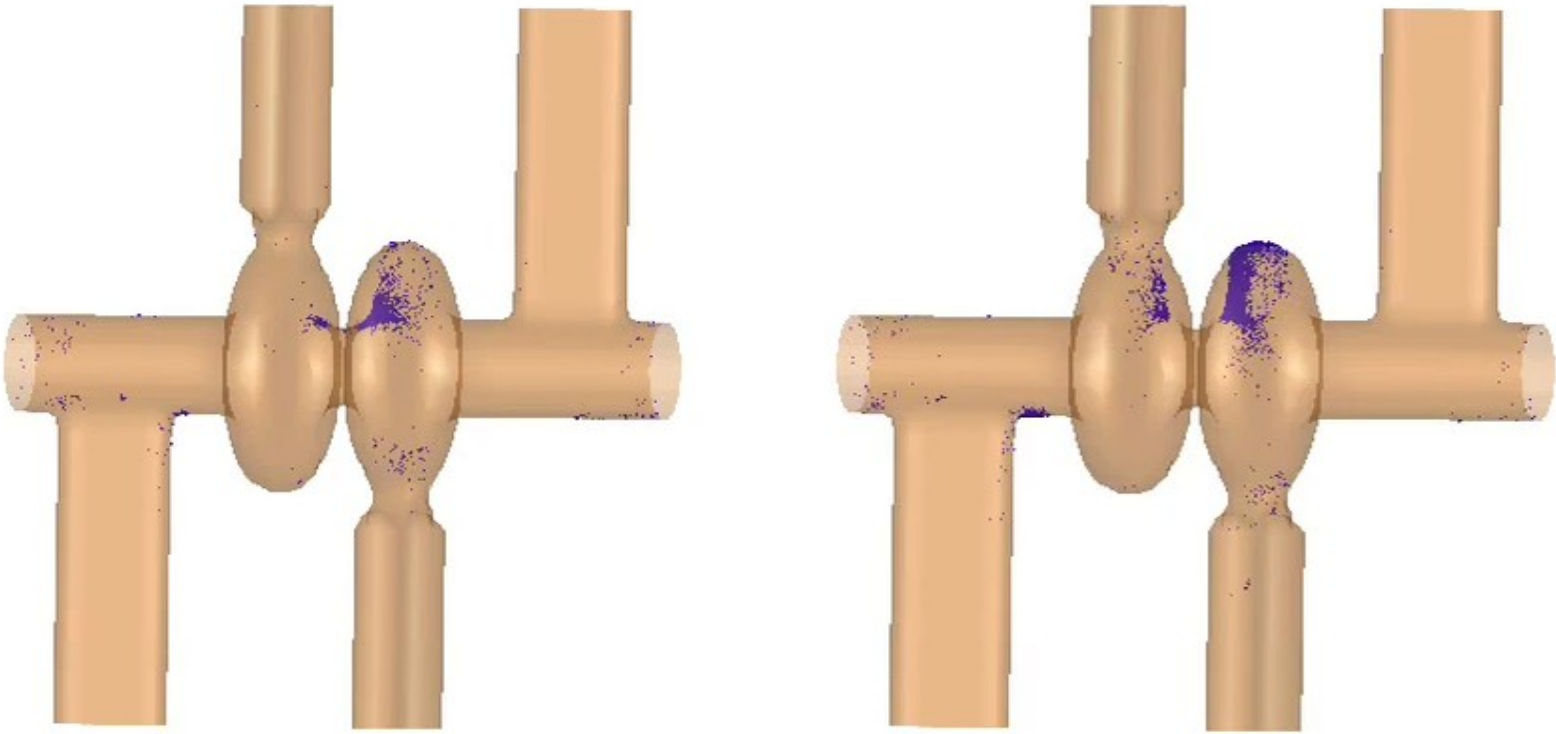
Preliminary simulations show possible multipacting in UK crab design

- E_{peak} ~10 MV/m



Preliminary simulations show possible multipacting in UK crab design

- E_{peak} ~10 MV/m
- Movement towards equator implies soft barrier multipacting



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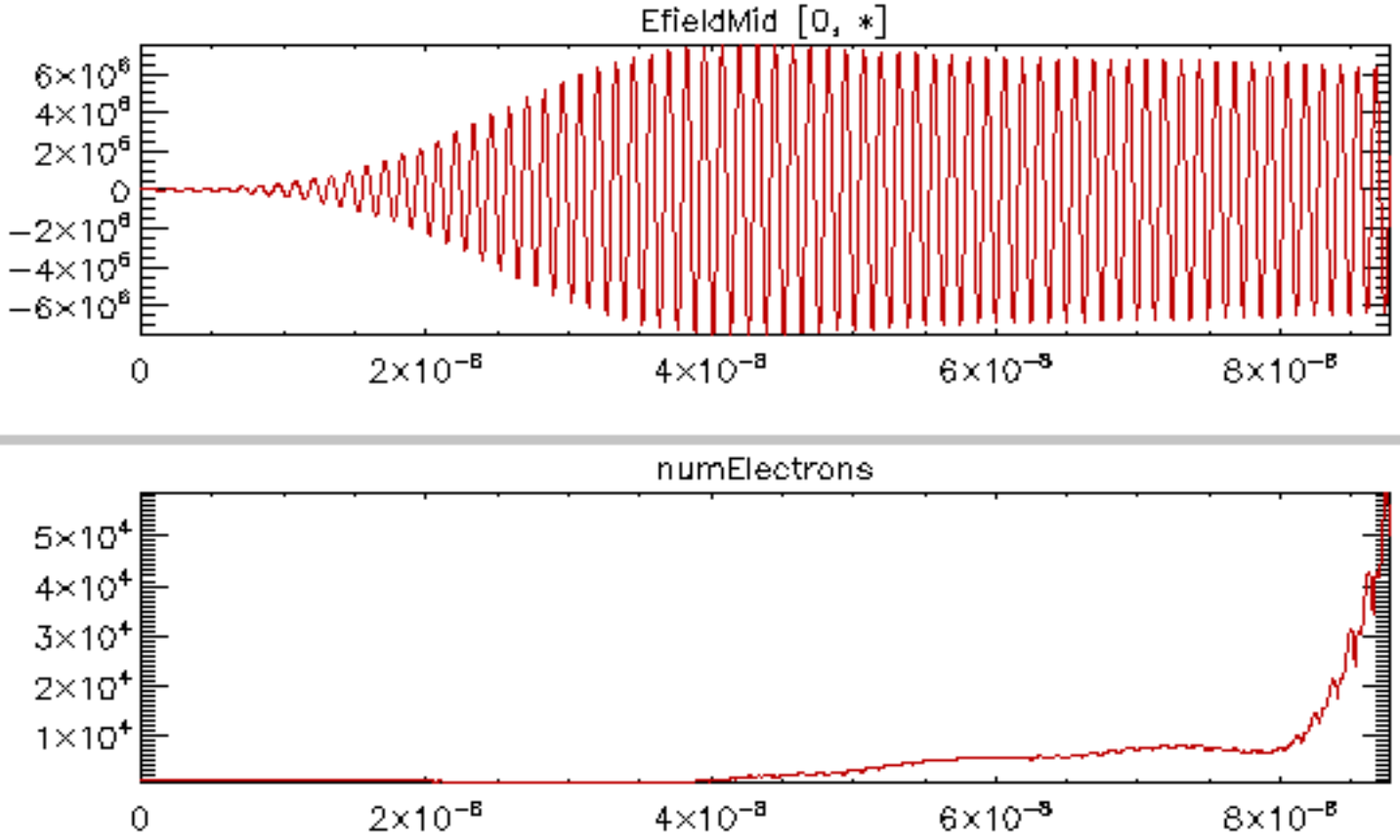

Further simulations needed to clarify the nature of the multipacting

- With full secondary model simulations become very slow
- Once sites of multipacting are identified we can look at individual trajectories
- Identifying whether multipacting produces soft or hard barriers can be done with scans over power

Simulation studies of UK crab cavity design will continue

- J. Smith will be running simulations with VORPAL
- Runs will include benchmarking with other tracking codes
- Simulation results will help guide cavity design