EM and Multipacting modeling for Crab Cavity development

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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

- 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

• Zero mode that does not couple to the waveguides
Filter diagonalization compares favorably with results from Microwave Studio.

<table>
<thead>
<tr>
<th>Mode</th>
<th>VORPAL</th>
<th>Microwave Studio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undamped Zero mode</td>
<td>0.8031 GHz</td>
<td>0.8045 GHz</td>
</tr>
<tr>
<td>Undamped Pi mode</td>
<td>0.7983 GHz</td>
<td>0.8004 GHz</td>
</tr>
<tr>
<td>Damped Zero mode</td>
<td>0.7790 GHz</td>
<td>0.783 GHz</td>
</tr>
<tr>
<td>Damped Pi mode</td>
<td>0.7740 GHz</td>
<td>0.778 GHz</td>
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</tbody>
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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
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

- $E_{\text{peak}} \approx 10 \text{ MV/m}$
Preliminary simulations show possible multipacting in UK crab design

- $E_{\text{peak}} \approx 10 \text{ MV/m}$
- Movement towards equator implies soft barrier multipacting
Preliminary simulations show possible multipacting in UK crab design

- $E_{\text{peak}} \sim 10 \text{ MV/m}$
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