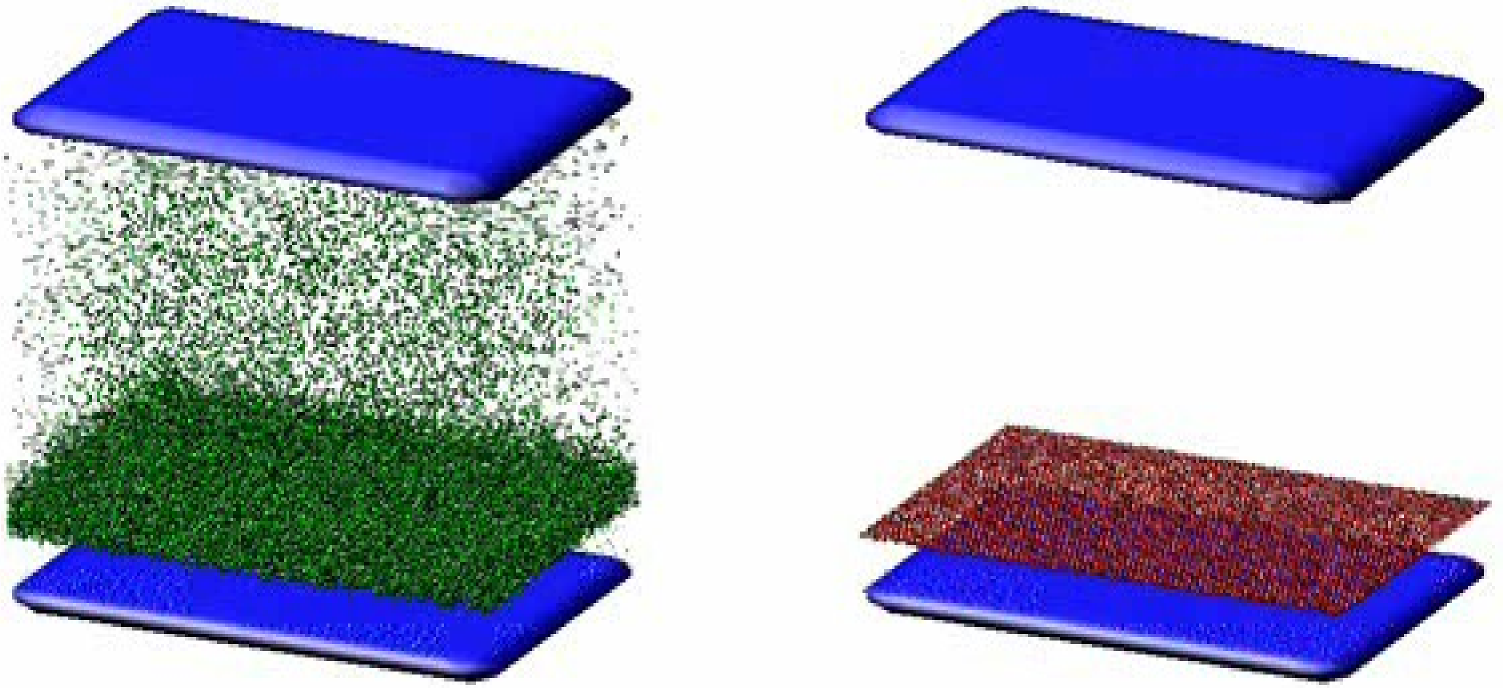
Multipacting models for NP and HEP applications



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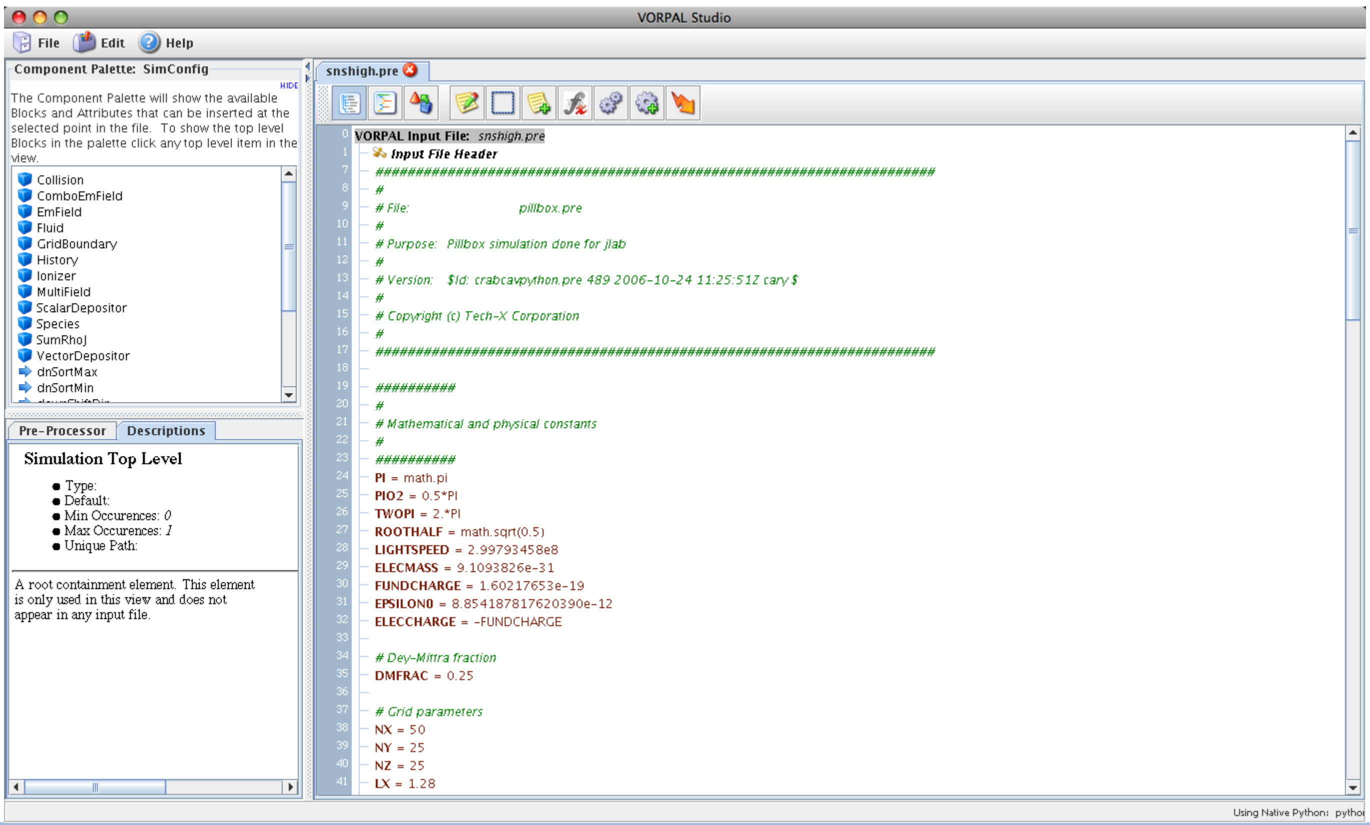
Funded by DoE NP under the SBIR grant DE-FG02-05ER84172

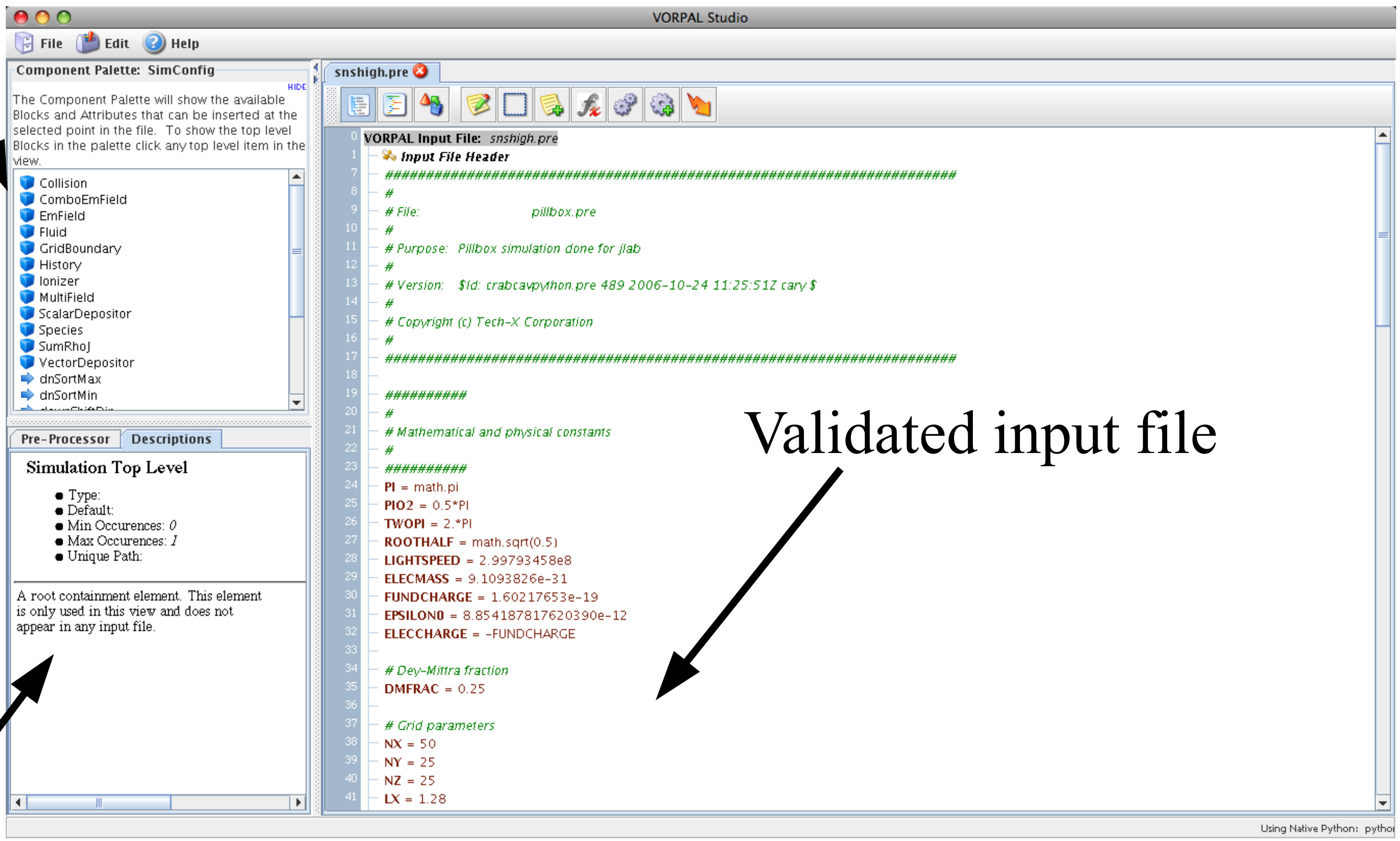
New features of VORPAL improve multipacting simulations

- VORPAL Studio (interactive tool for constructing input files)
- SUPERFISH geometry import
- Particle tracking
- Improved force calculation at conformal boundaries



VORPAL Studio is an interactive tool for constructing input files

Drag-and-Drop input file blocks (Fields, Particles, etc)

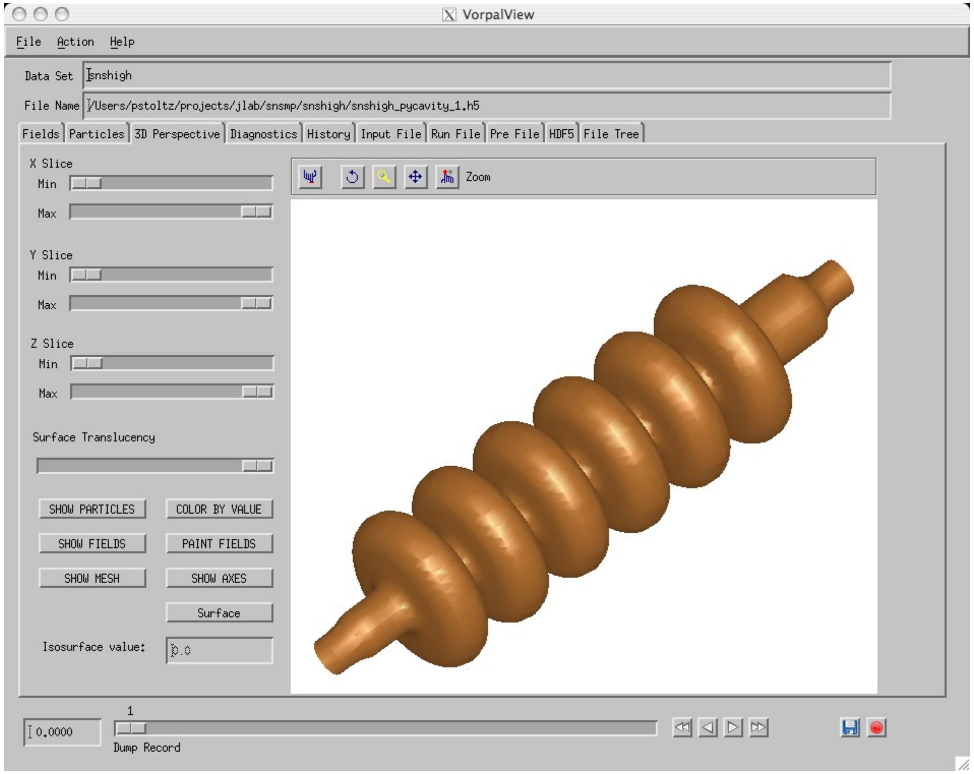


Validated input file

Interactive help (on-line VORPAL manual)

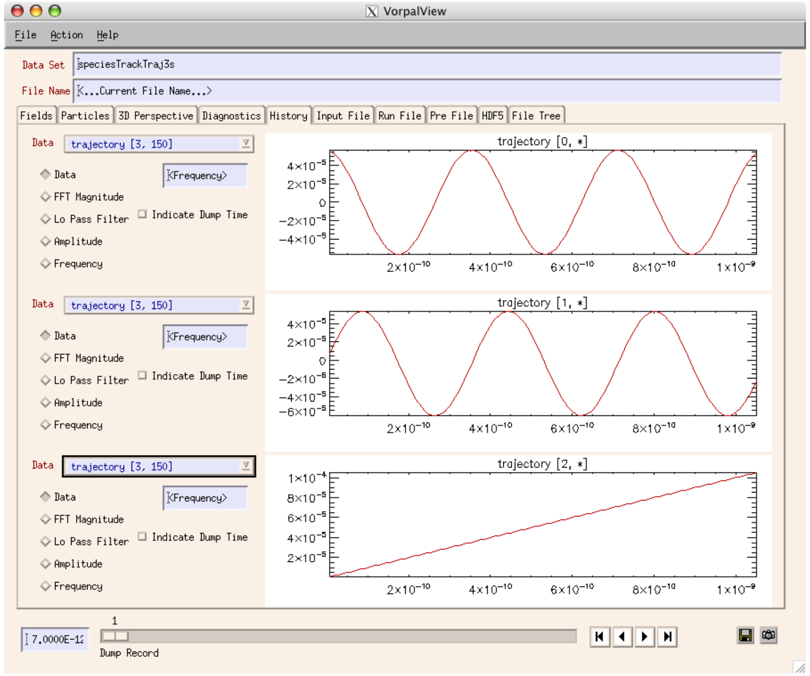
Users can now import SUPERFISH geometry directly

- VORPAL supports nearly all SUPERFISH geometry constructs (every one we've seen used)
- Users can start from SUPERFISH (2D) and add non-axisymmetric features (3D) with union operations



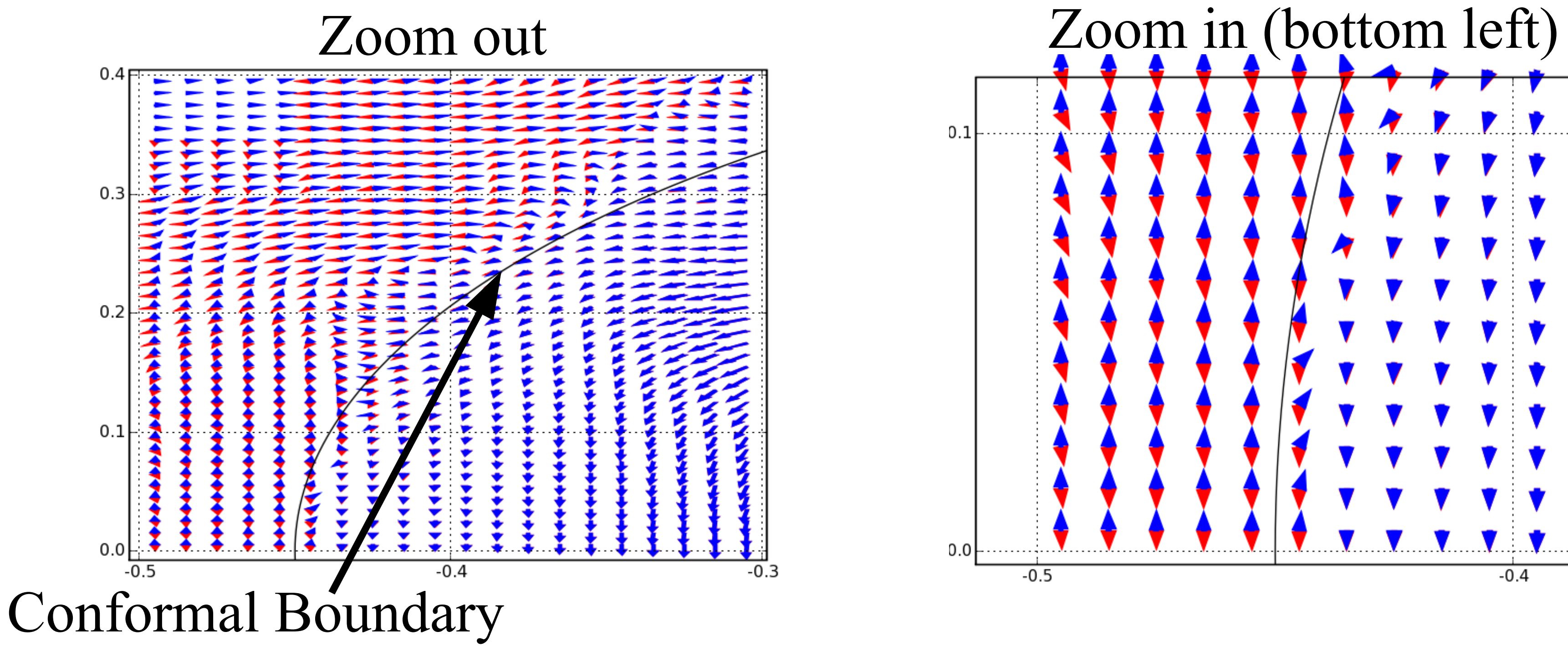
Users can track individual particle trajectories to help diagnose multipacting

- Previously, electrons in VORPAL were indistinguishable
- New feature allow tracking of individual particles
- Emerging capability: variable weight particles to track multipacting without an exponential increase in particles



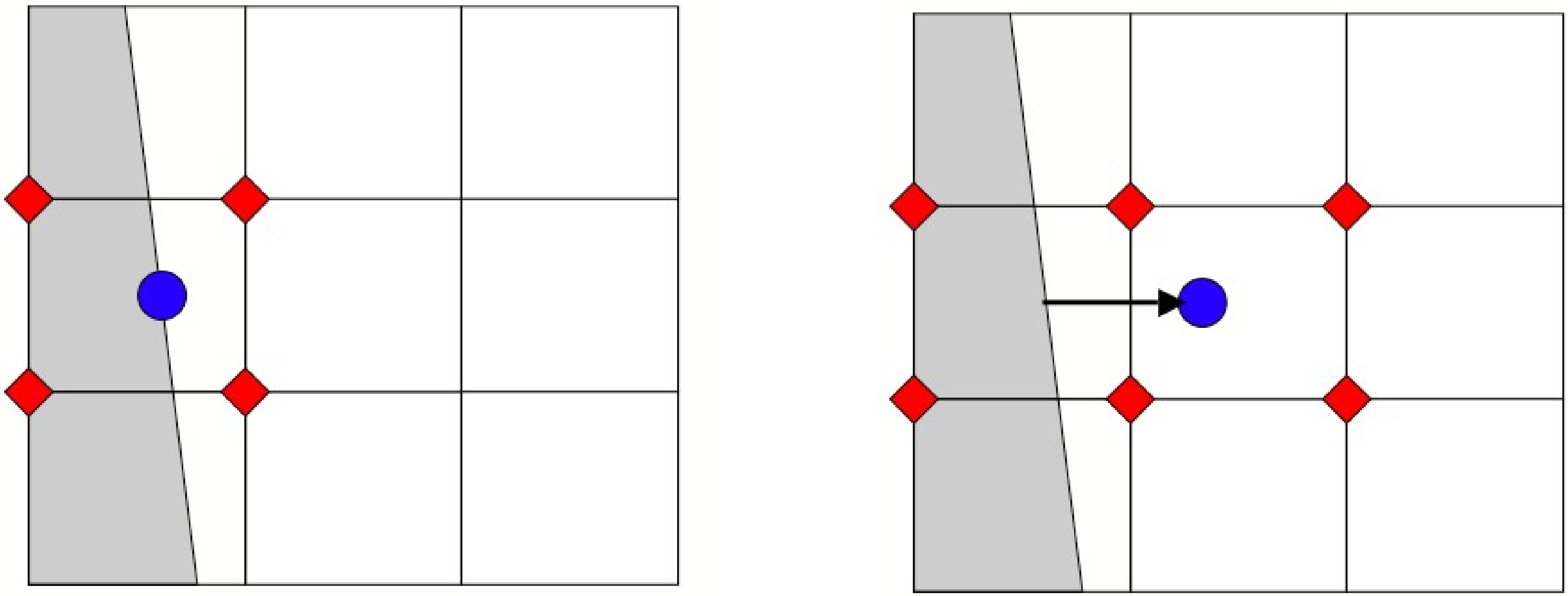
New interpolation algorithms give more accurate forces near the walls

- **Previously, the interpolation algorithm in VORPAL interpolated from the grid corners (did not necessarily mean zero tangent field at the boundary)**
- **New interpolation enforces zero tangent field at the boundary**



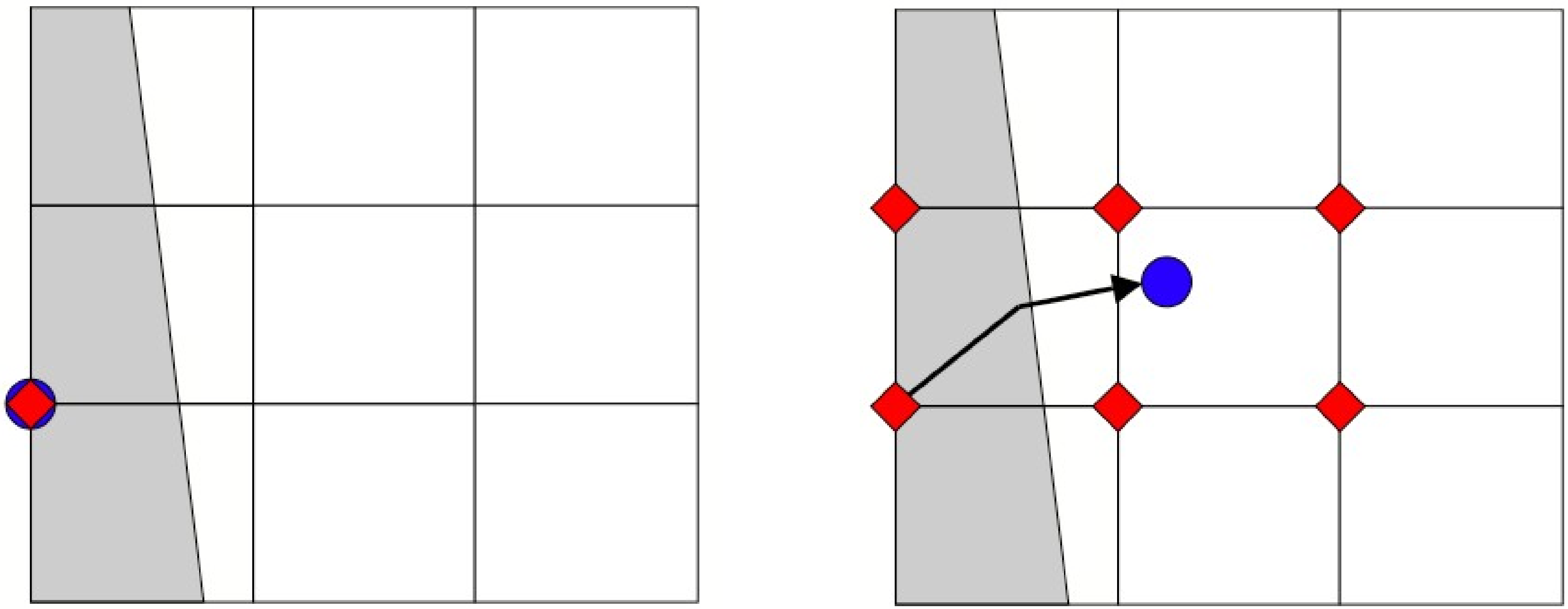
Red = old algorithm, Blue = new algorithm

Accurate multipacting simulations require accurate (charge-conserving) particle emission



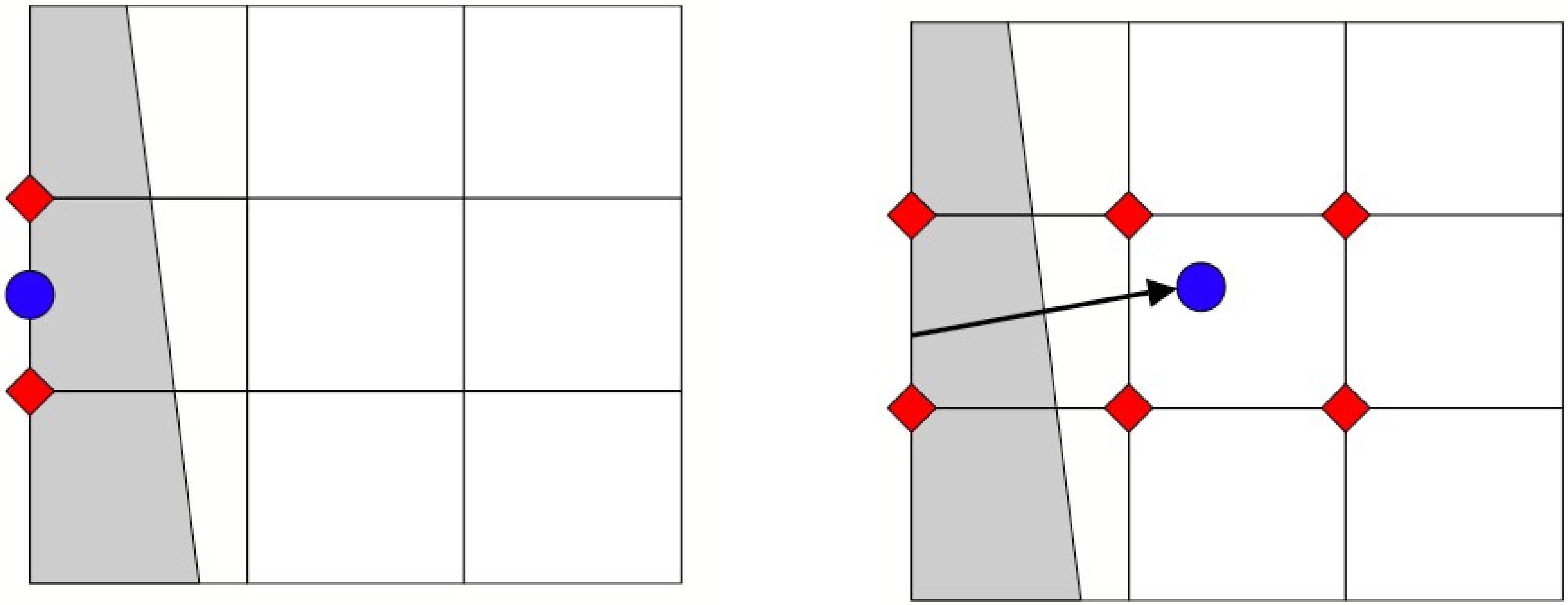
Obvious approach doesn't work with cut cells (it leaves behind unphysical charge)

Accurate multipacting simulations require accurate (charge-conserving) particle emission



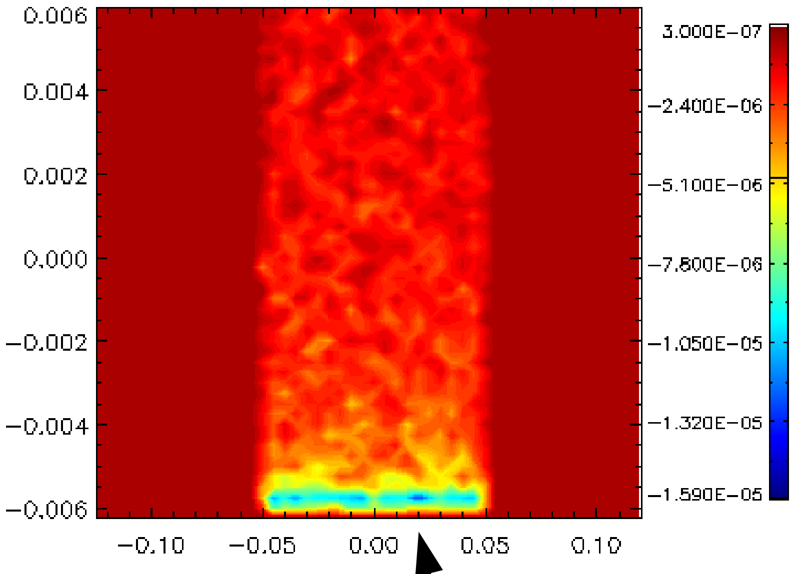
Next most obvious approach works, but can be noisy and troublesome to implement

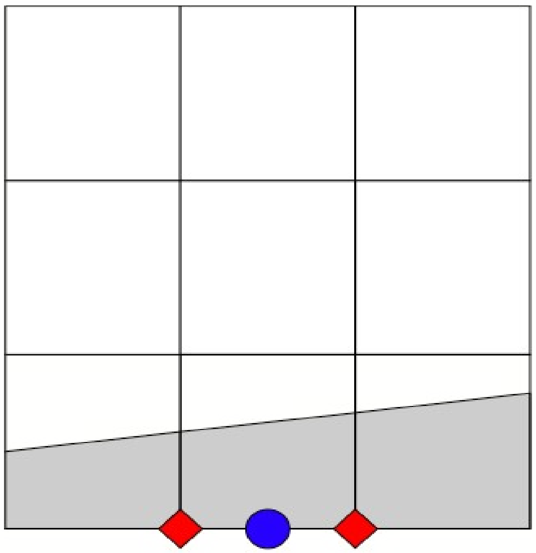
Accurate multipacting simulations require accurate (charge-conserving) particle emission



A less noisy approach is to move in new electrons from the nearest point on the side in the conductor

To verify the new algorithm works, we tested with planar (but cut cell) emission

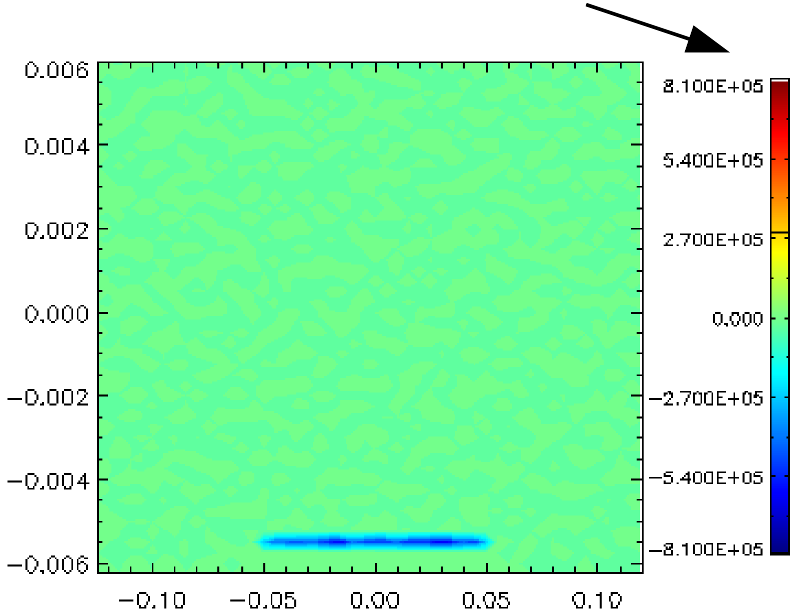




Correct algorithm should show no buildup of field on emission surface

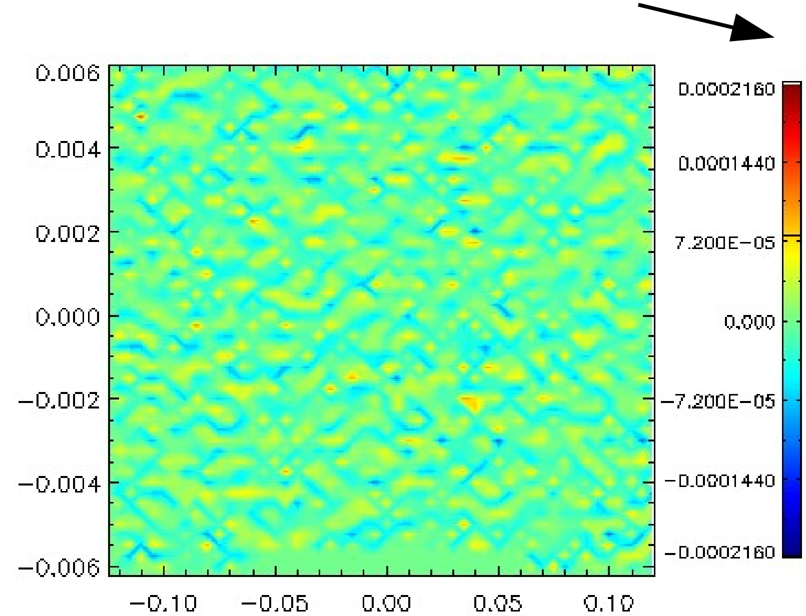
Emission from conducting edge improves charge conservation

$E \sim 10^5$



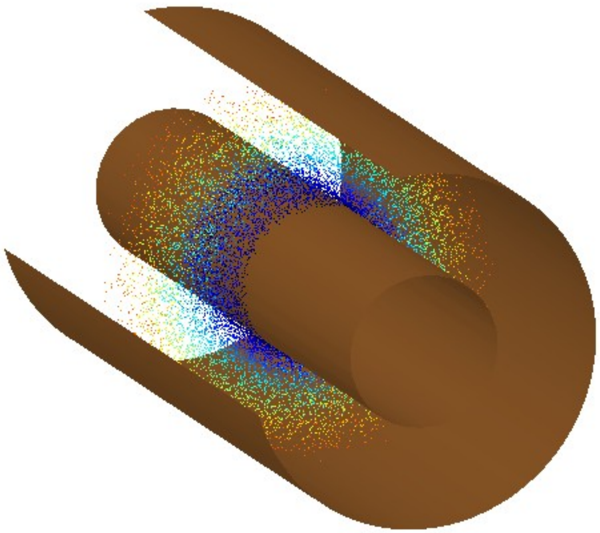
Old algorithm

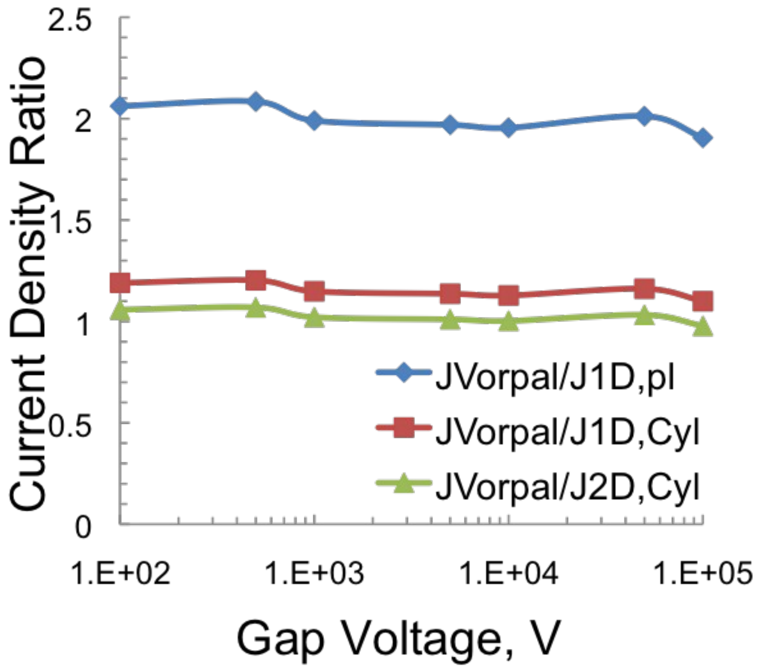
$E \sim 10^{-4}$



New algorithm

We successfully verified these emission algorithms even for high current (space charge limited) emission



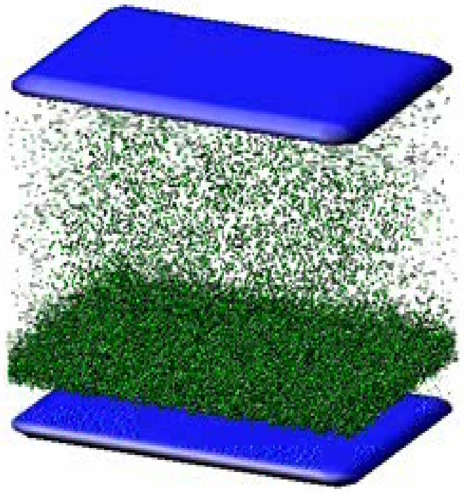


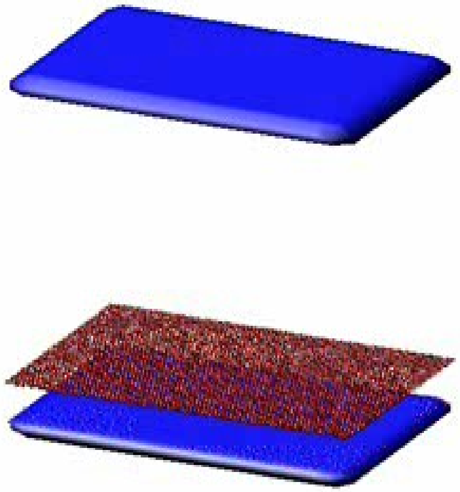
New emission algorithm correctly reproduces analytic results for maximum current in a coaxial geometry

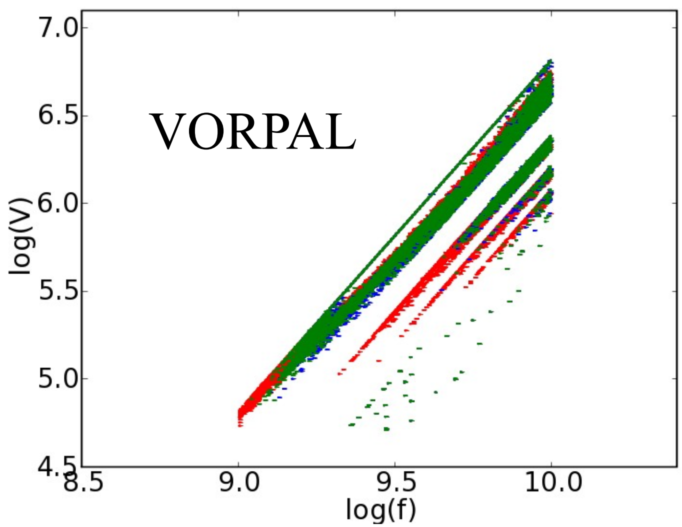
Next we would like to verify multipacting behavior against known results

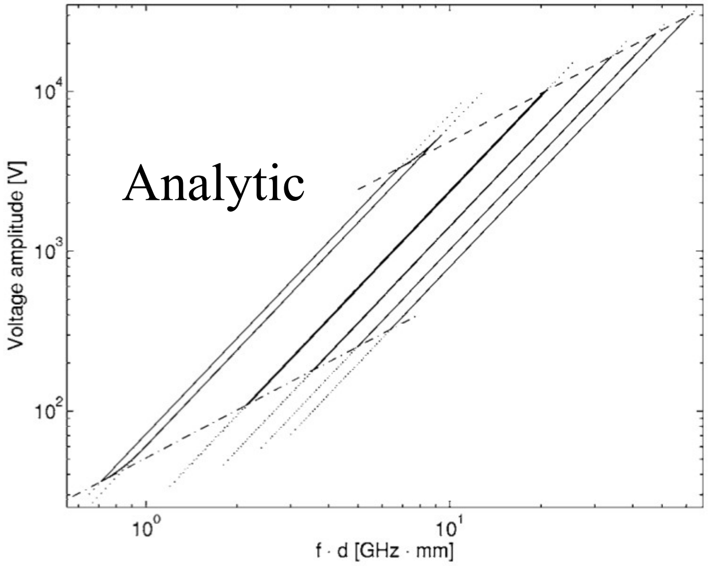
Show movie

First benchmark: we get expected results for planar multipacting

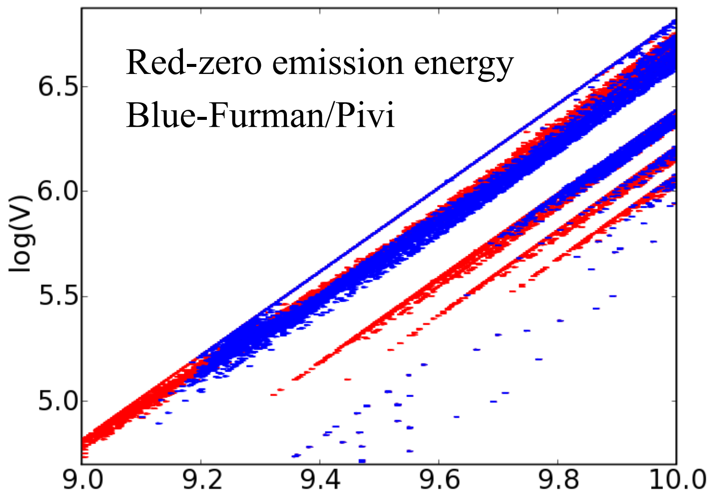


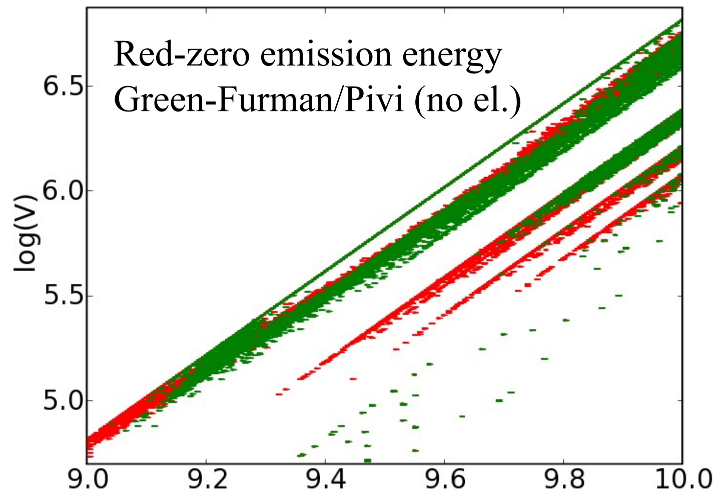


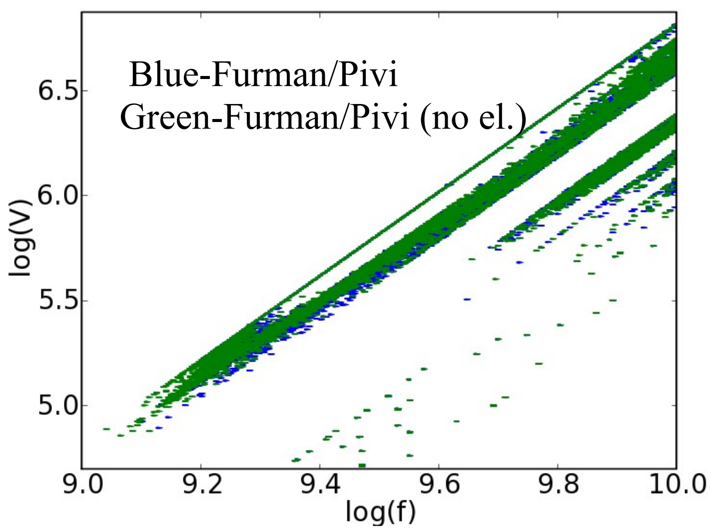


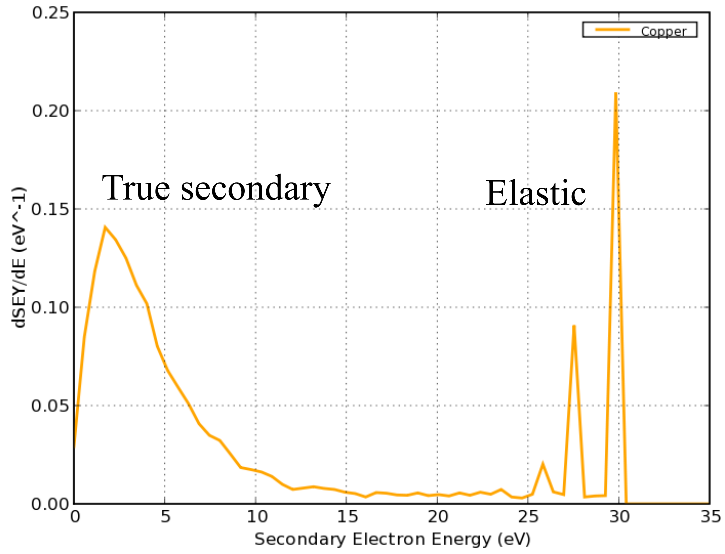


We tested the effects of realistic energy emission spectrum on planar benchmark

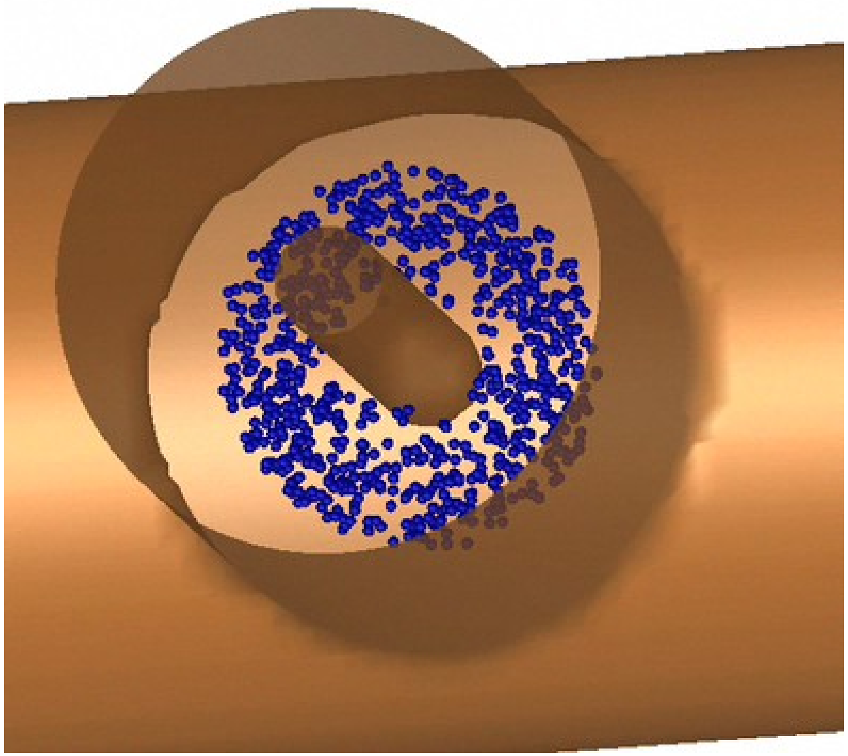


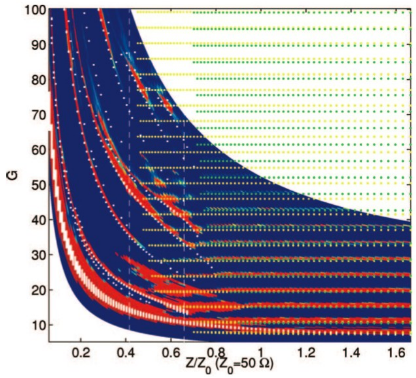




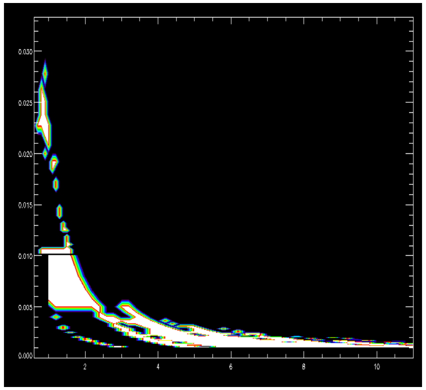


Final benchmark: we get expected results for cylindrical multipacting





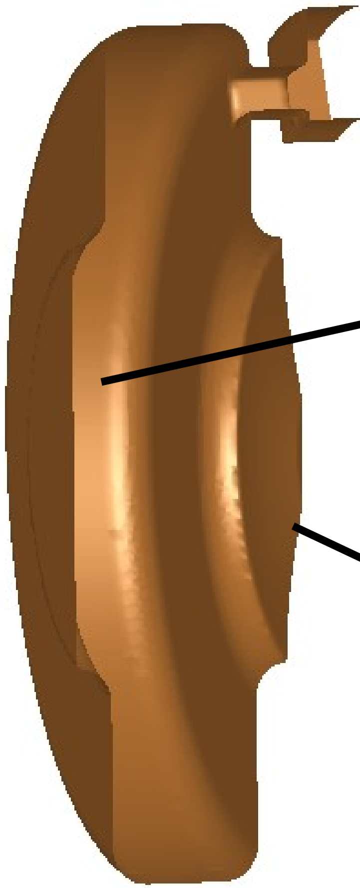
Previous work*

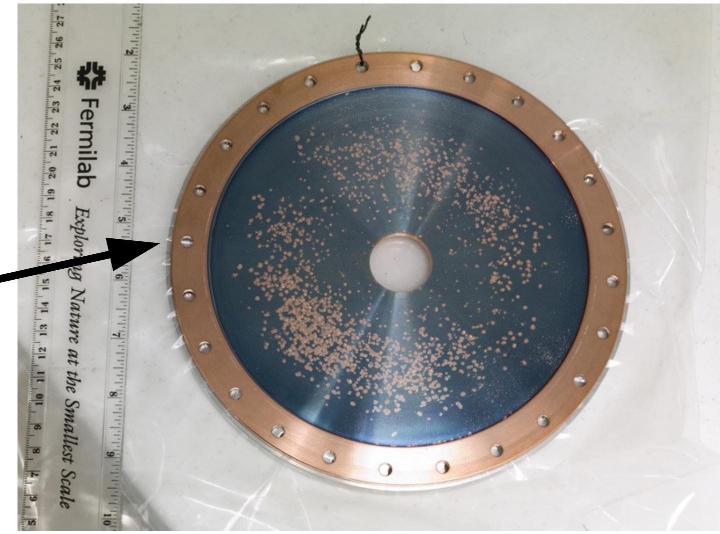


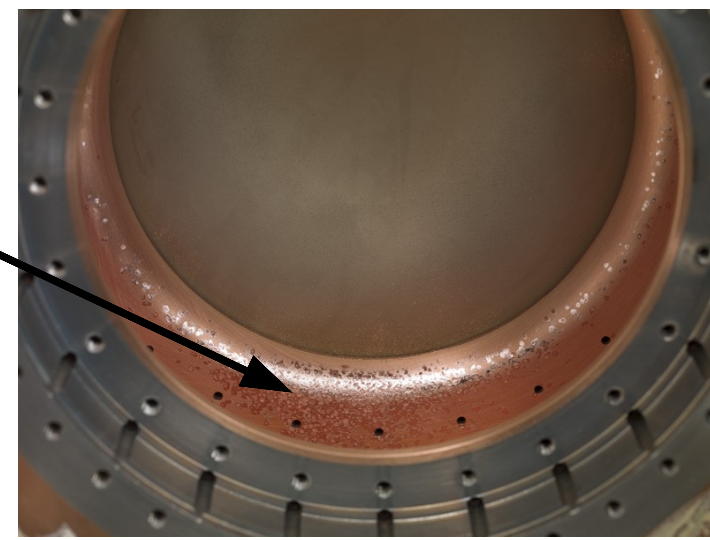
VORPAL

*Semenov, PHYSICS OF PLASMAS **14**, 033509 ?2007?

Motivation: muon collider community would like to understand mechanisms for breakdown in 805MHz structures

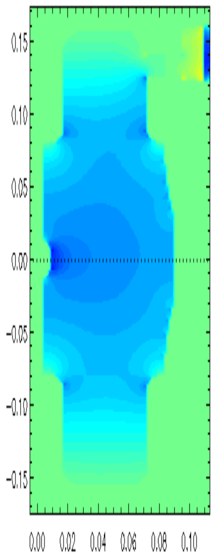


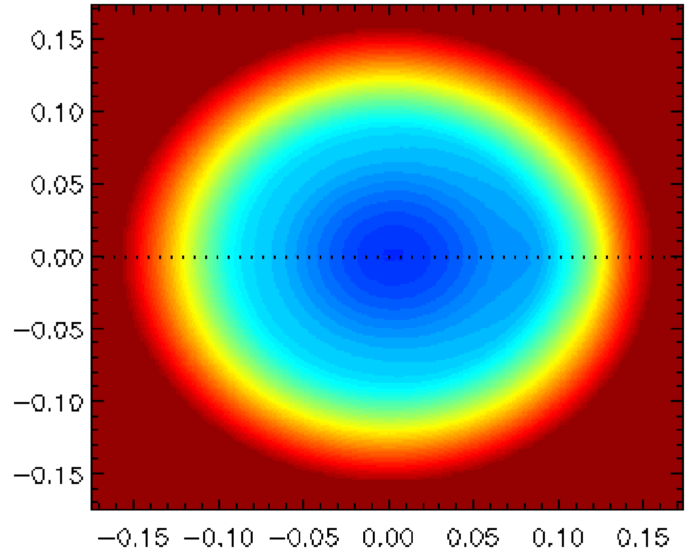


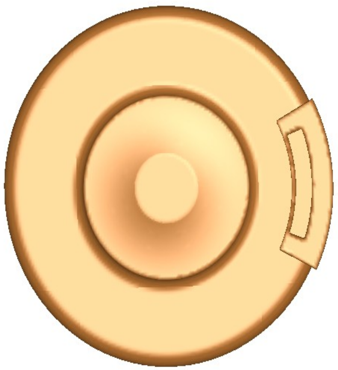


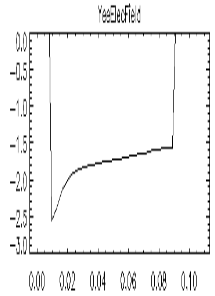
Higher-order modes (note assymetry)?
Effects of coupler?

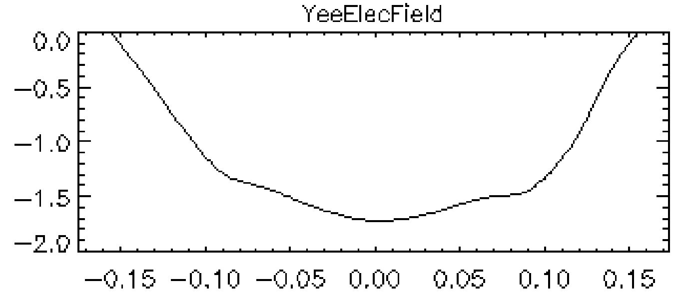
We are benchmarking VORPAL field results with MAFIA (so far agreement is good)





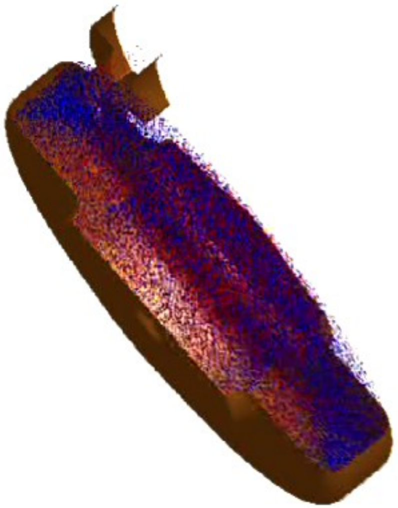




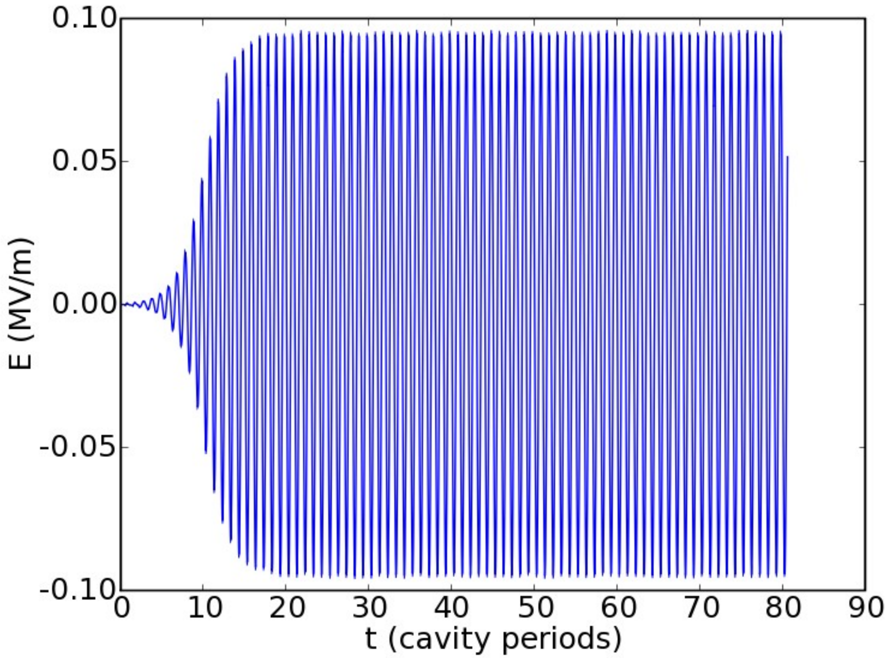


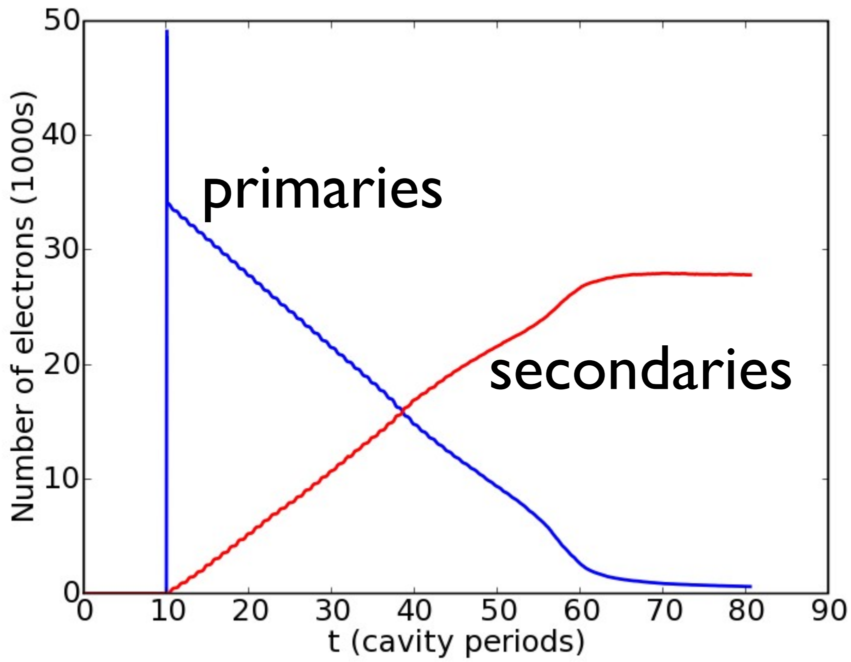
Our recipe for multipacting: let seed electrons create secondaries, watch for growth

•Our recipe for studying multipacting:
–Slowly ring up cavity (we ring up over roughly 20 periods)
–Seed a low level of electrons uniformly (seed electrons are blue)
–Allow seed electrons to create secondary electrons (secondaries are red)
–Allow seconaries to create further seconda
–Run for many rf periods (we ran for roughl
100 periods)
–Look for growth in number of secondaries



Multipacting alone is not self-sustaining in the button cavity...

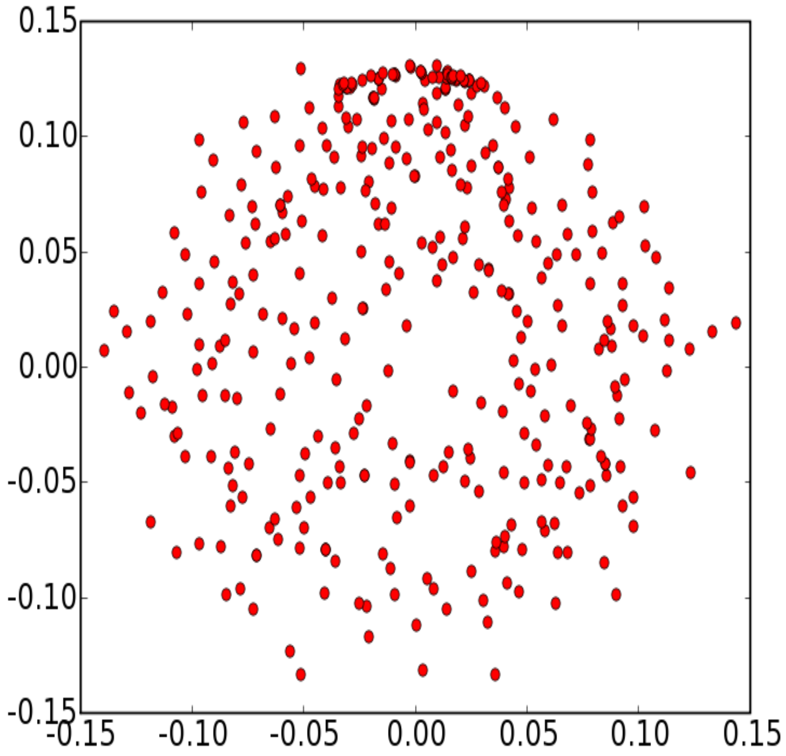


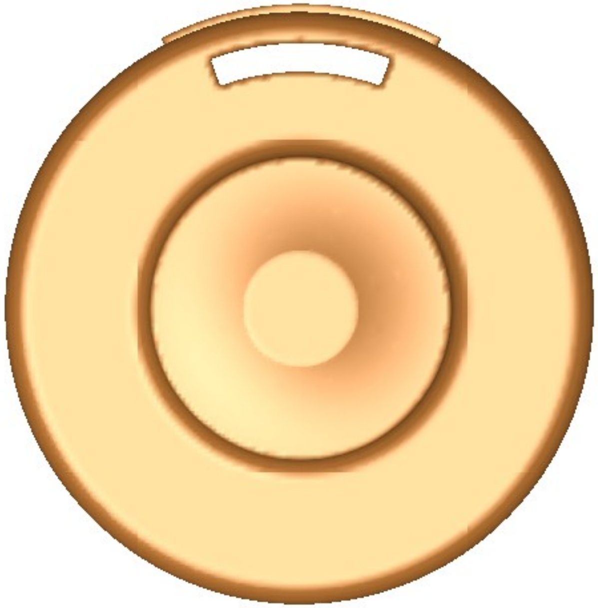


In the presence of multipacting, fields maintain their structure and number of secondaries levels off...so multipacting is not a problem by itself (maybe with gas ionization, etc, it would be...but that's breakdown)

Electron impact does give hints of problems

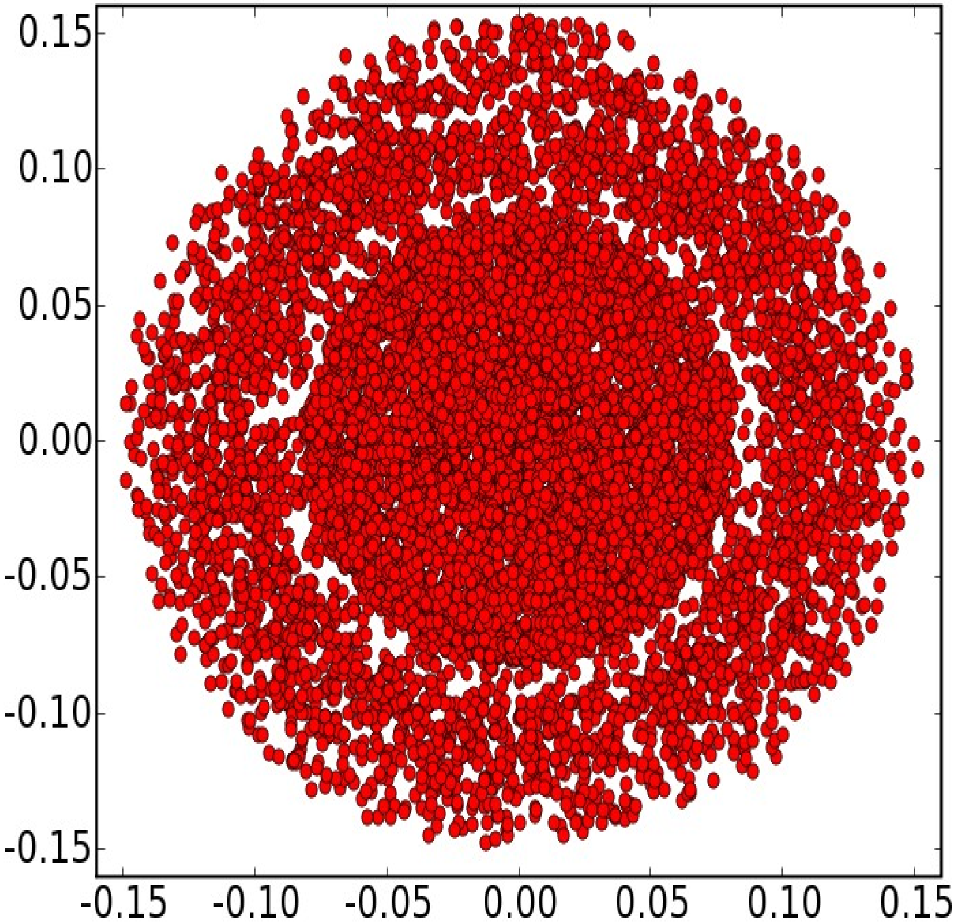
t =15 ns

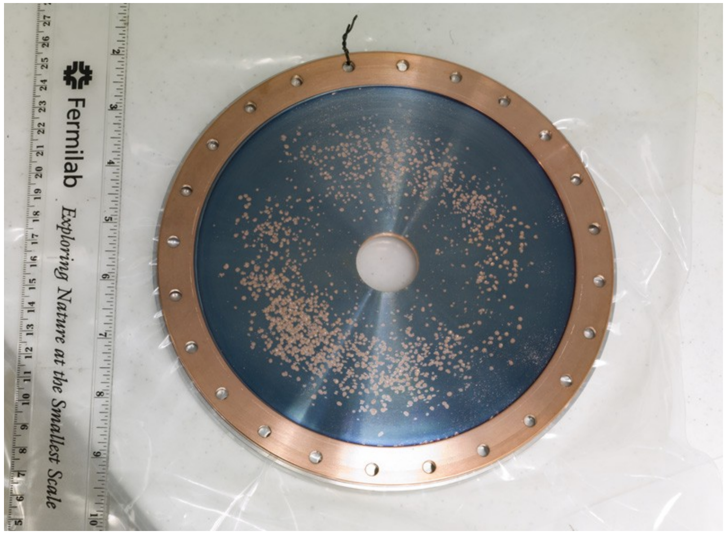




Electron impact does give hints of problems

t =35 ns





Show movie