STUDIES OF MULTIPACTOR IN DIELECTRIC STRUCTURES

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Areas of cooperation with ANL-NRL-UMd programs

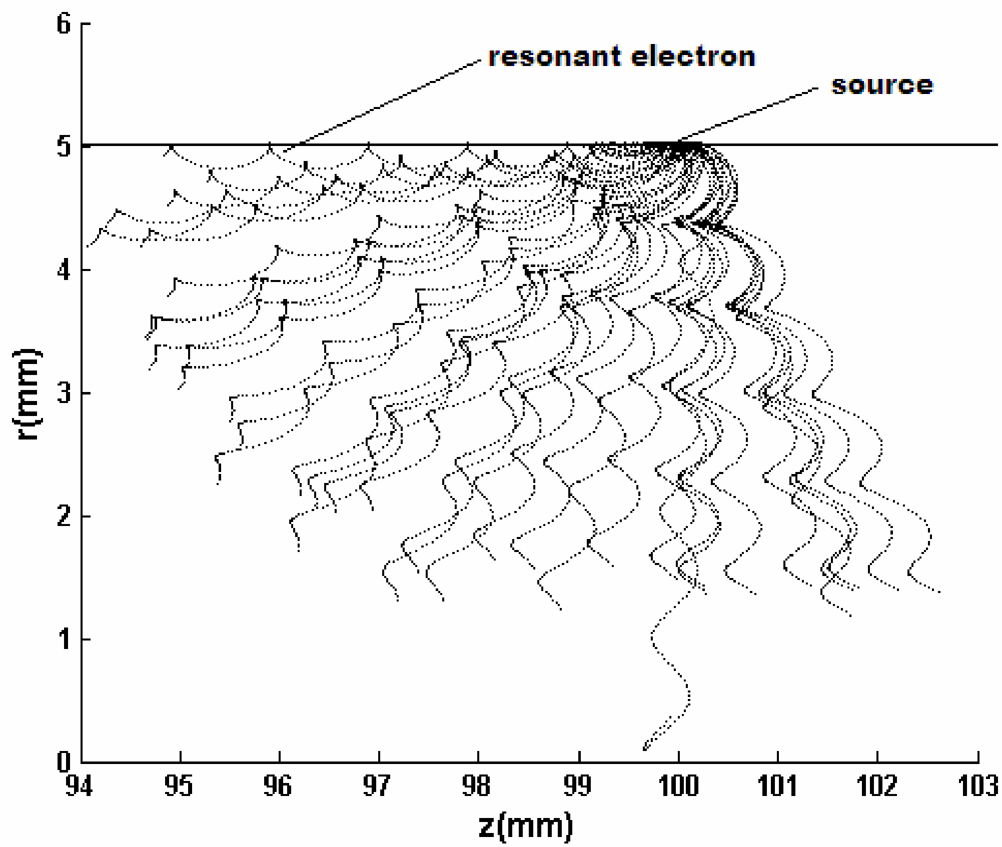
- 2D Multipactor model in OOPIC Pro
- Study dependence of multipactor on a/λ over 1-10mm beam channel size
- Diagnostics improvements for NRL tests
  - Rise time of multipactor (~1 ns)
  - Harmonic generation in multipactor discharge
  - Spectrum of emitted light
  - Dependence of spectrum and rise time on coatings
- Lab measurements of SEE coefficients for different ceramics
- Surface roughness and SEE

- Sustaining a multipactor discharge:
  - emitted electrons return to the dielectric-vacuum boundary and are resonantly captured
  - secondary electrons produced with yield >1
  - secondaries also resonantly captured.
  - As the discharge grows the electric field is modified by the contribution of the static space charge electric field, thus continuously changing the resonance condition.
- Analytic treatment challenging. Power and Gold model in qualitative agreement with the experimental results.

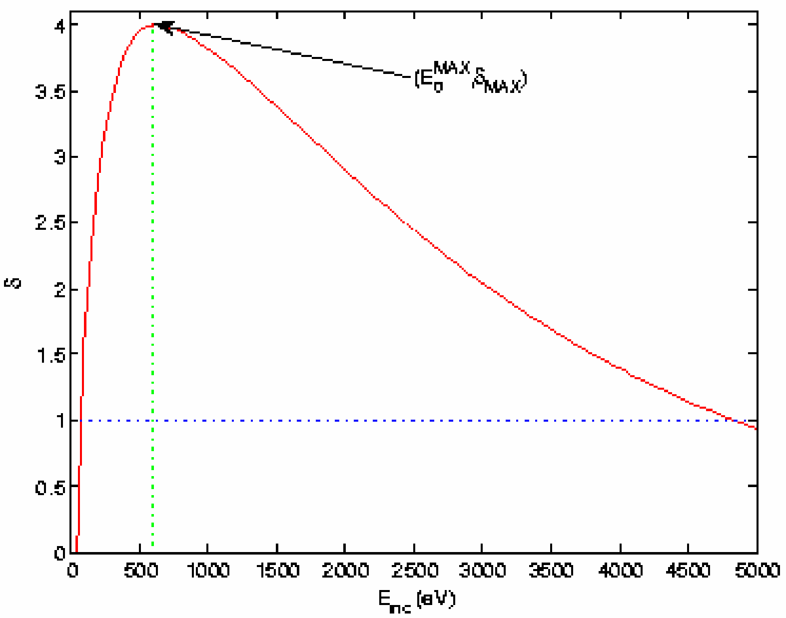
- Multipactor in PG is characterized by the ratio of the radial to axial electric fields at the dielectric-vacuum boundary $E_r/E_z=\pi a/\lambda_z$, where *a* is the radius of the beam channel and λ_z is the wavelength of the accelerating mode. The fraction of the incident power absorbed by the multipactor discharge is predicted by the model to scale as a^4.
- Reducing *a* is advantageous from the standpoint of multipactor (at the cost of making the transverse wakefields stronger and increasing the beam quality requirements).
- 25% difference in overall normalization attributed to the use of nominal SEY parameters for the structure materials.

Multipactor Simulations

- OOPIC Pro, 2½-D FDTD PIC code
- electrons originate at a field emission site at the dielectric-vacuum boundary
- Trajectories of low energy electrons emitted over 1 rf period in an 11.4 GHz structure.
- only one electron in this particular ensemble is resonantly captured by the TM_{01} accelerating mode
- these electrons (and their daughter electrons) are responsible for single surface multipactor.

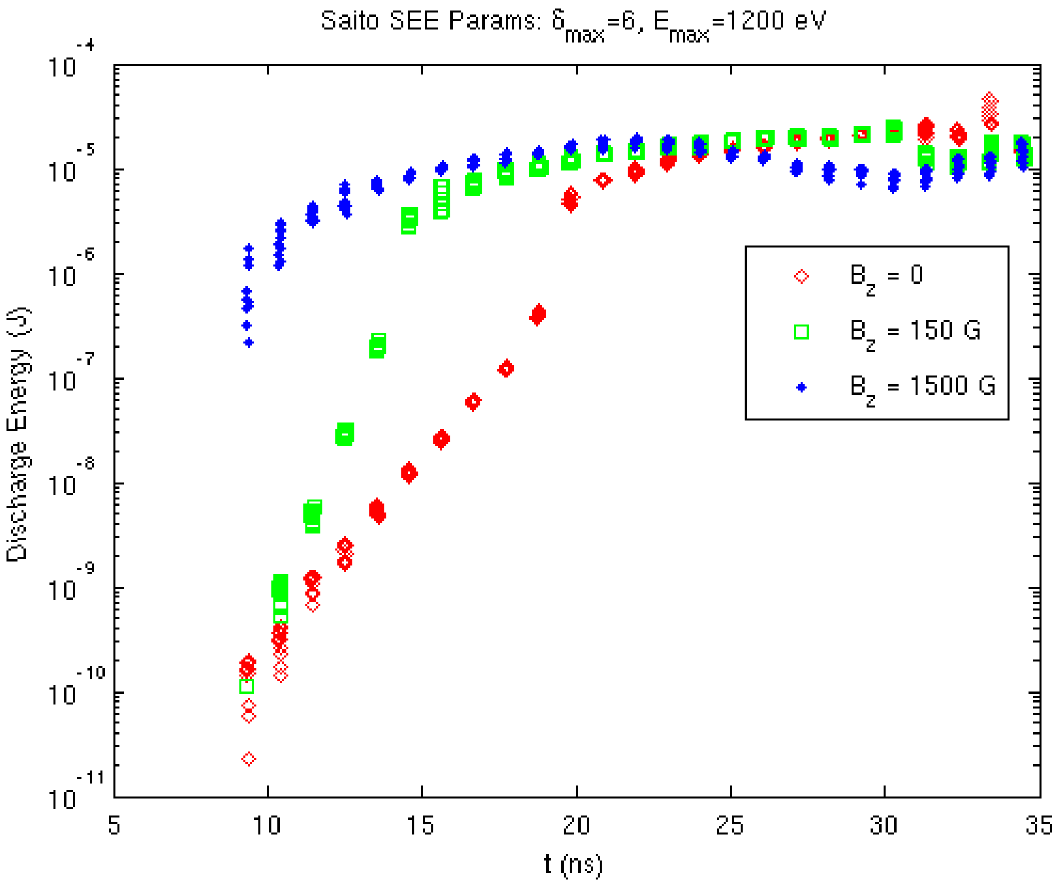


Vaughn Model



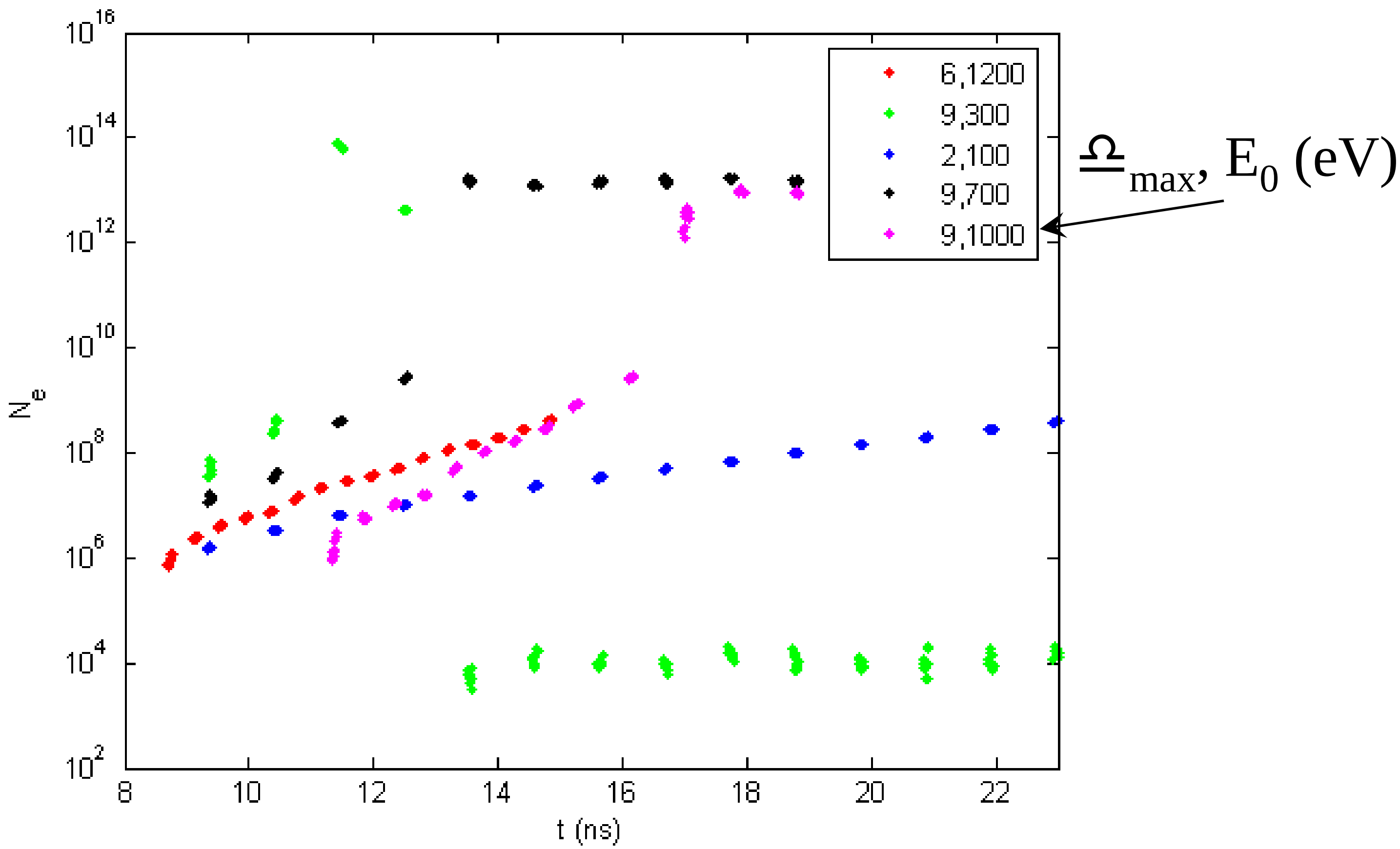
- Parameterization of secondary emission yield in terms of E_0^{MAX}, δ_{MAX},…
- For alumina, δ_{MAX} =1.5-9, E_0^{MAX} =350-1300.

Multipactor Discharge Evolution

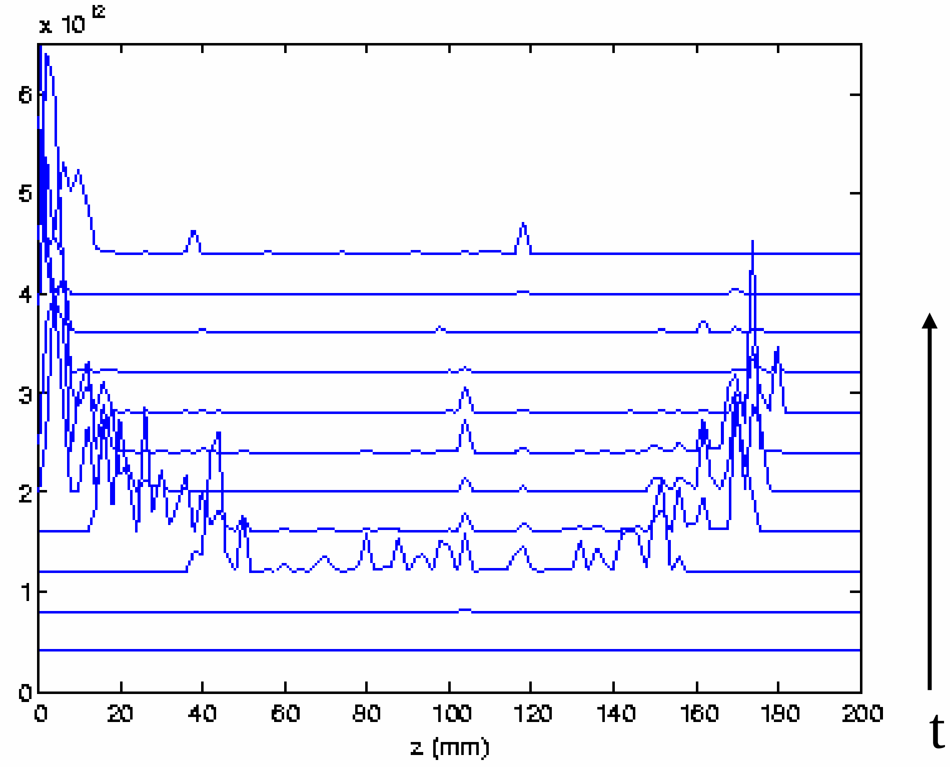


Multipactor Discharge Intensity

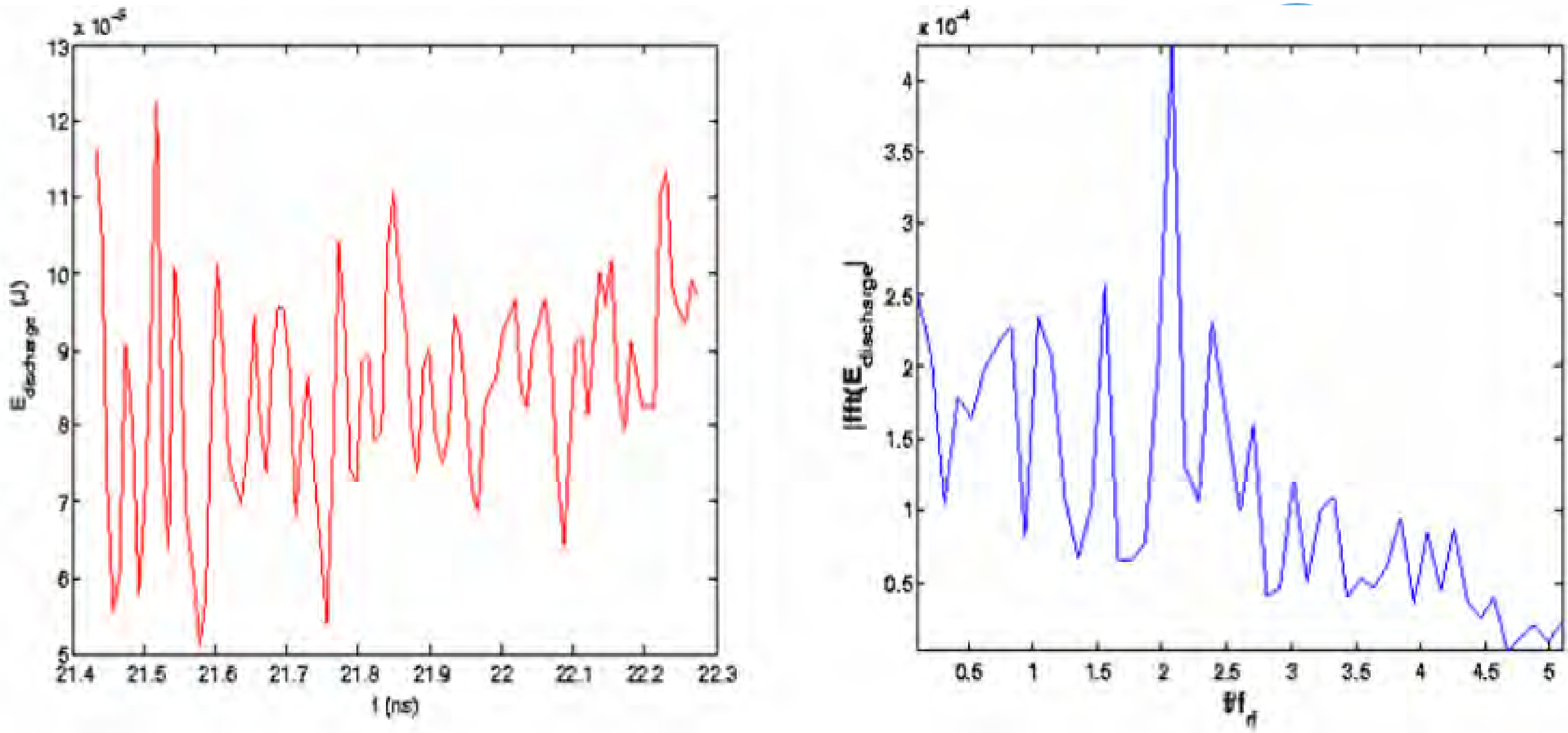
(P=1 MW, Vaughan Parameter Dependence)



Evolution of the Discharge at the Dielectric-Vacuum Boundary



(Plot separation ~ 2 ns)

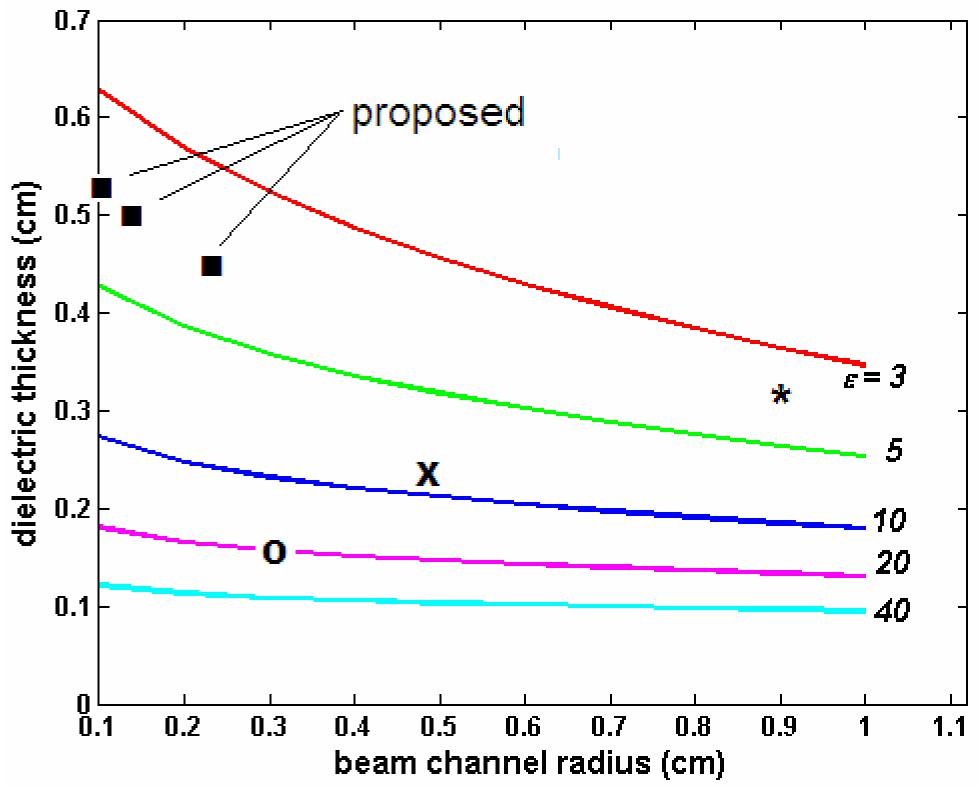


Total multipactor discharge energy (l) and Fourier spectrum (r). Harmonics generated by the discharge (like the peak in the spectrum at 2 $f_{rf.}$) are a possible diagnostic of multipactor evolution.

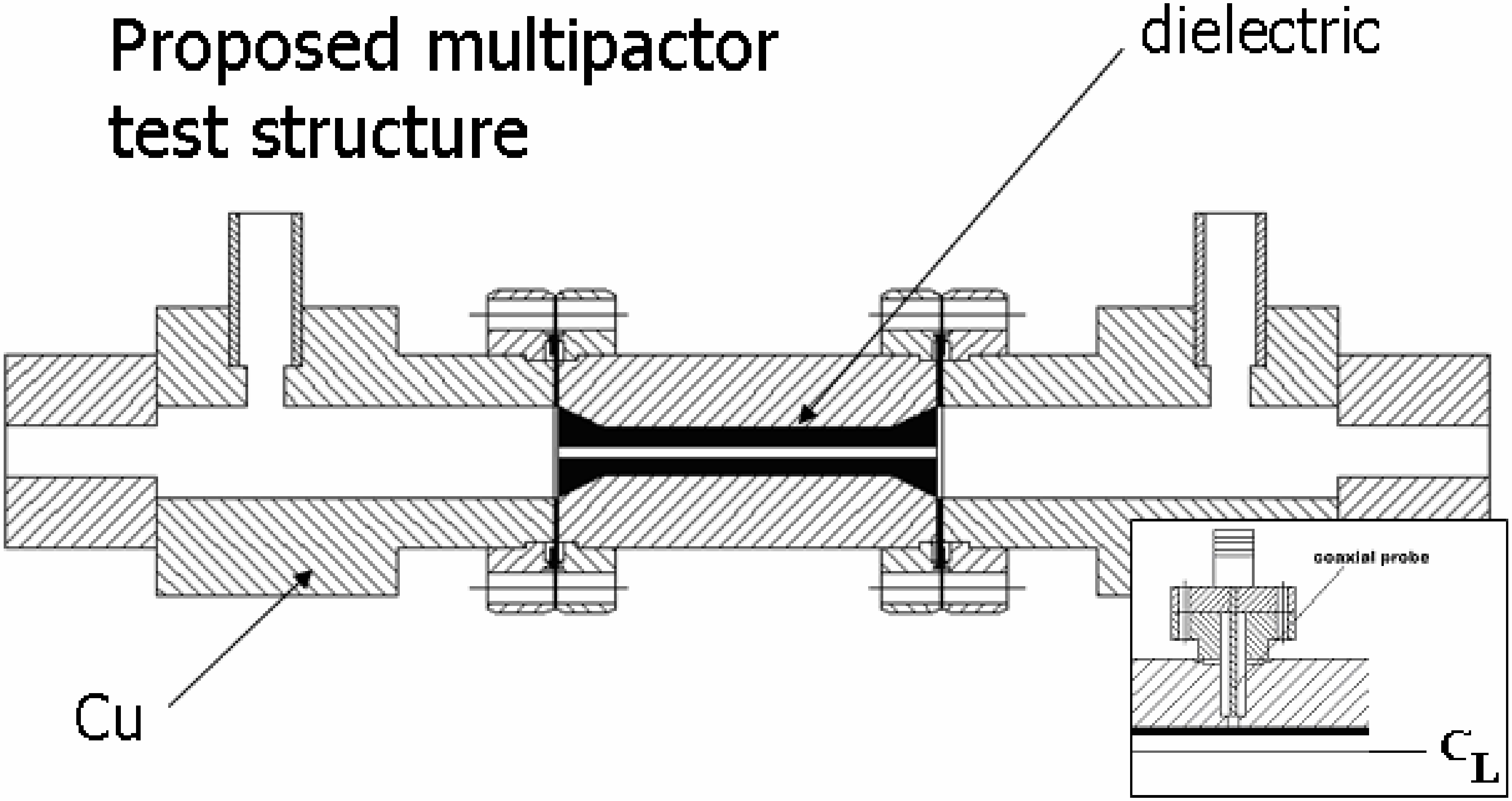
X-Band Multipactor Test Structures

Wall thickness vs channel radius *a* and permittivity ε for fixed frequency.

Plan to study multipactor for 3 new structures of different beam channel radius.



Proposed multipactor test structure



Proposed Experiments

- Study the dependence of multipactor on structure geometry, dielectric material, and rf field strength and pulse length. Design, construct, and test 3 new DLAs of different geometries. The tests will be conducted at the NRL X-band magnicon facility and will provide complementary data to the three devices already measured by ANL/NRL.
- Improved instrumentation for high power multipactor experiments (moving beyond power loss measurements).
- Augment existing diagnostics with field probes (harmonics), optical diagnostics to study multipactor time development and spectrum.
- Studies of multipactor suppression emphasizing approaches based on optimization of device geometry (beam channel radius) and rf power ramp profile. Possibility of "jumping" over the resonant energy range for multipactor by rapidly increasing the rf power to the DLA.