MULTIPACTING ANALYSIS FOR THE SUPERCONDUCTING RF CAVITY HOM COUPLERS IN ESS

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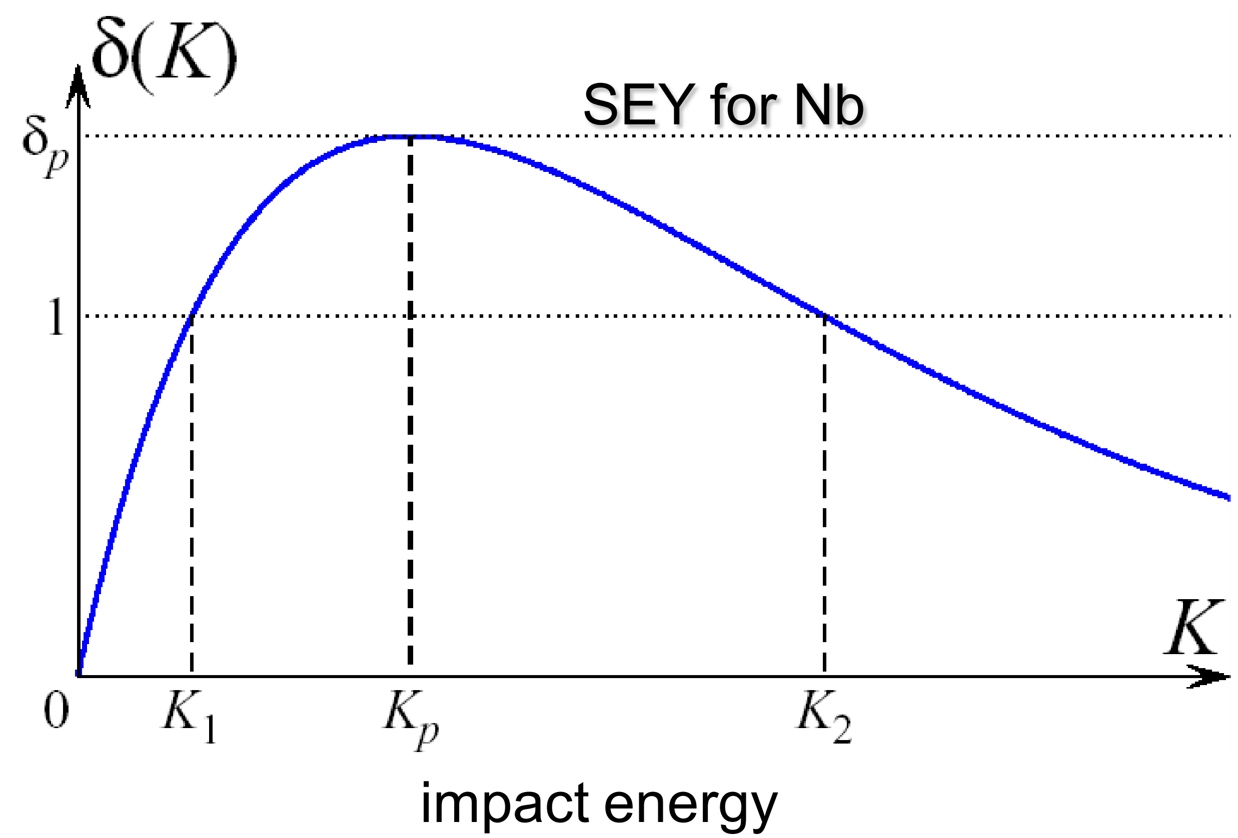
MULTIPACTING

Resonant process which lead to electron avalanche

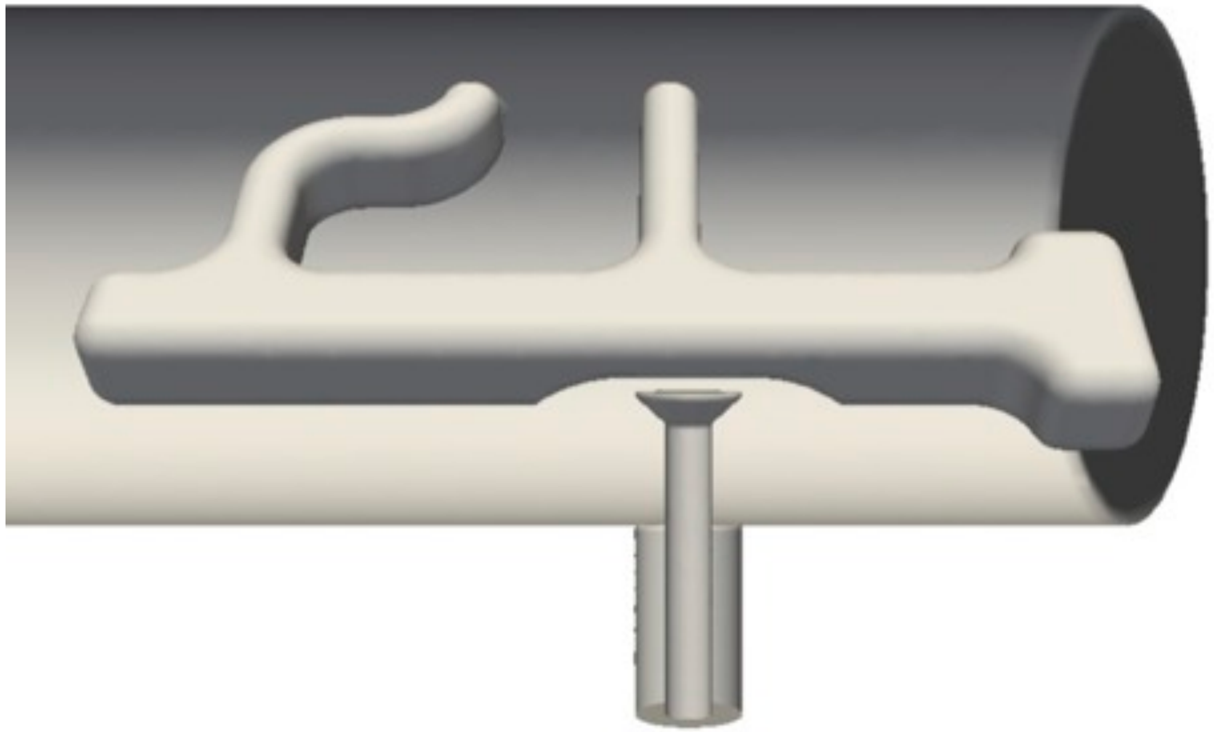
- Absorb RF power
- Heating effects



Electron impacts on surface

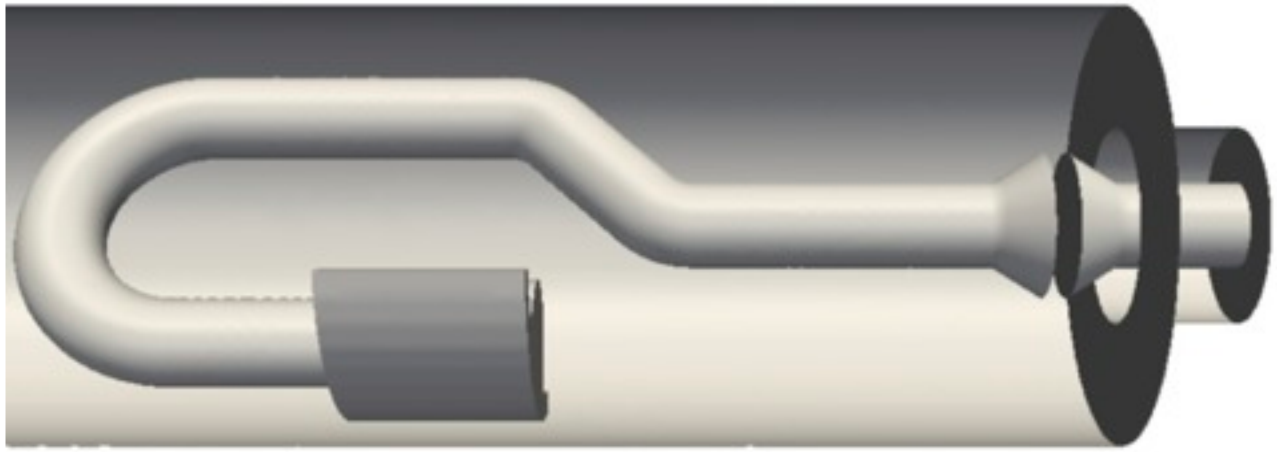
- if δ > 1, secondary e⁻ emitted
- **E** points towards surface

COUPLER DESIGNS



Courtesy of R. Calaga
Rescaled to 704MHz
Original design by J. Sekutowicz

HW Glock and
Rostock group



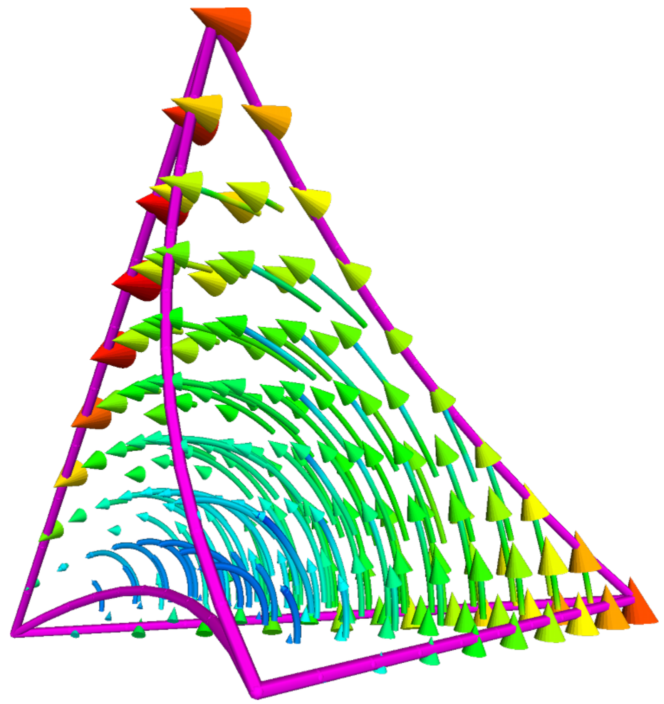
ACE3P

6 codes:

- **Omega3P** - Frequency domain
- T3P - Time domain
- S3P - S parameters
- **Track3P** - Multipacting/dark current
- PIC3P - Particle in cell
- TEM3P - Multi-physics code

Curved elements for conformal meshing in combination with **higher-order basis functions** provide **high field solution accuracy**

Quadratic curved tetrahedral element with high-order vector basic function



Courtesy of Advanced Computations Department, SLAC

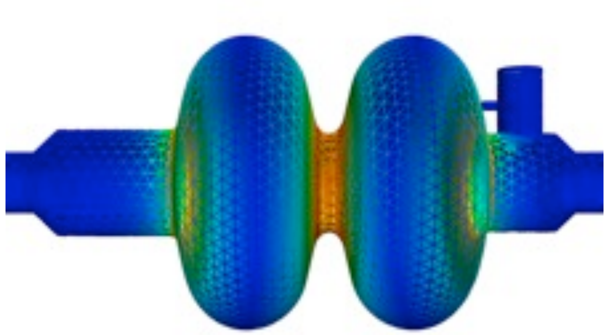
MP SIMULATION - ACE3P

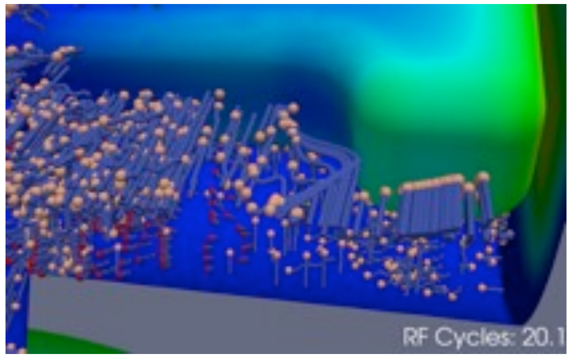
Generate Mesh

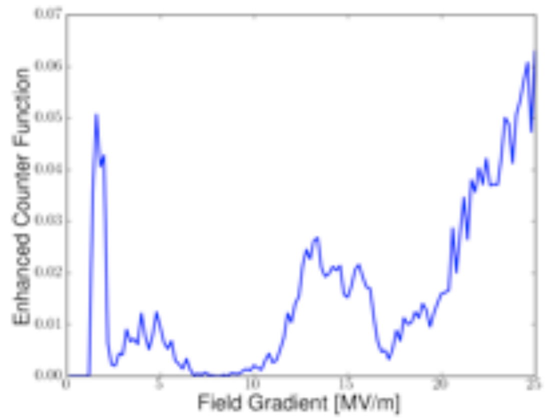
Find eigenmodes Omega3P

Track Particles through field Track3P

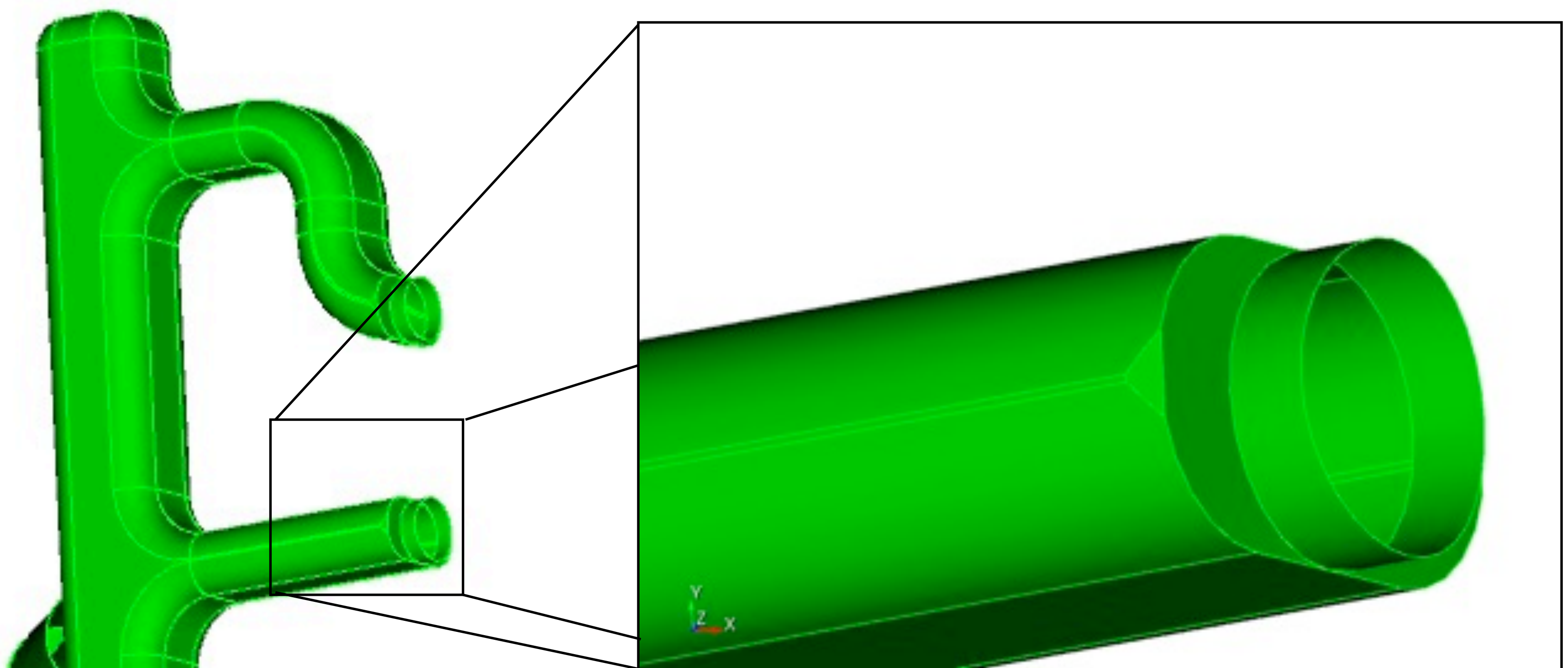
Postprocess find MP bands







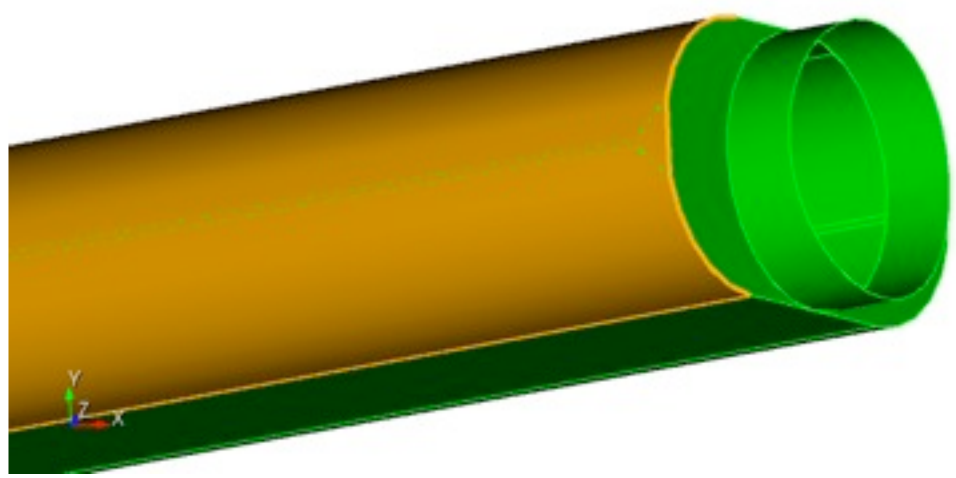
GEOMETRY CLEANUP



Small surfaces

↓

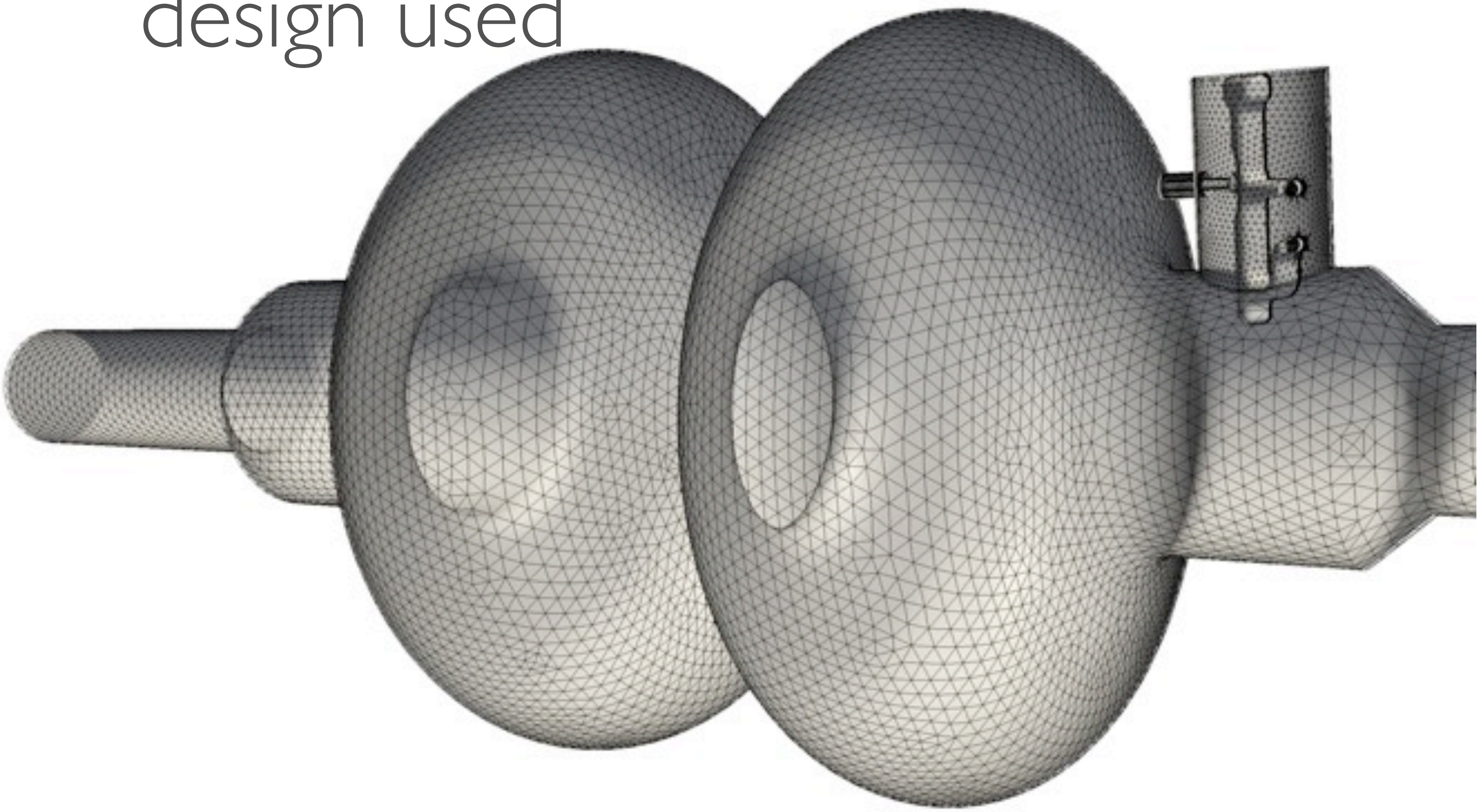
poor mesh quality



Create virtual surfaces

MESH GENERATION - CUBIT

CEA-SACLAY SPL
design used

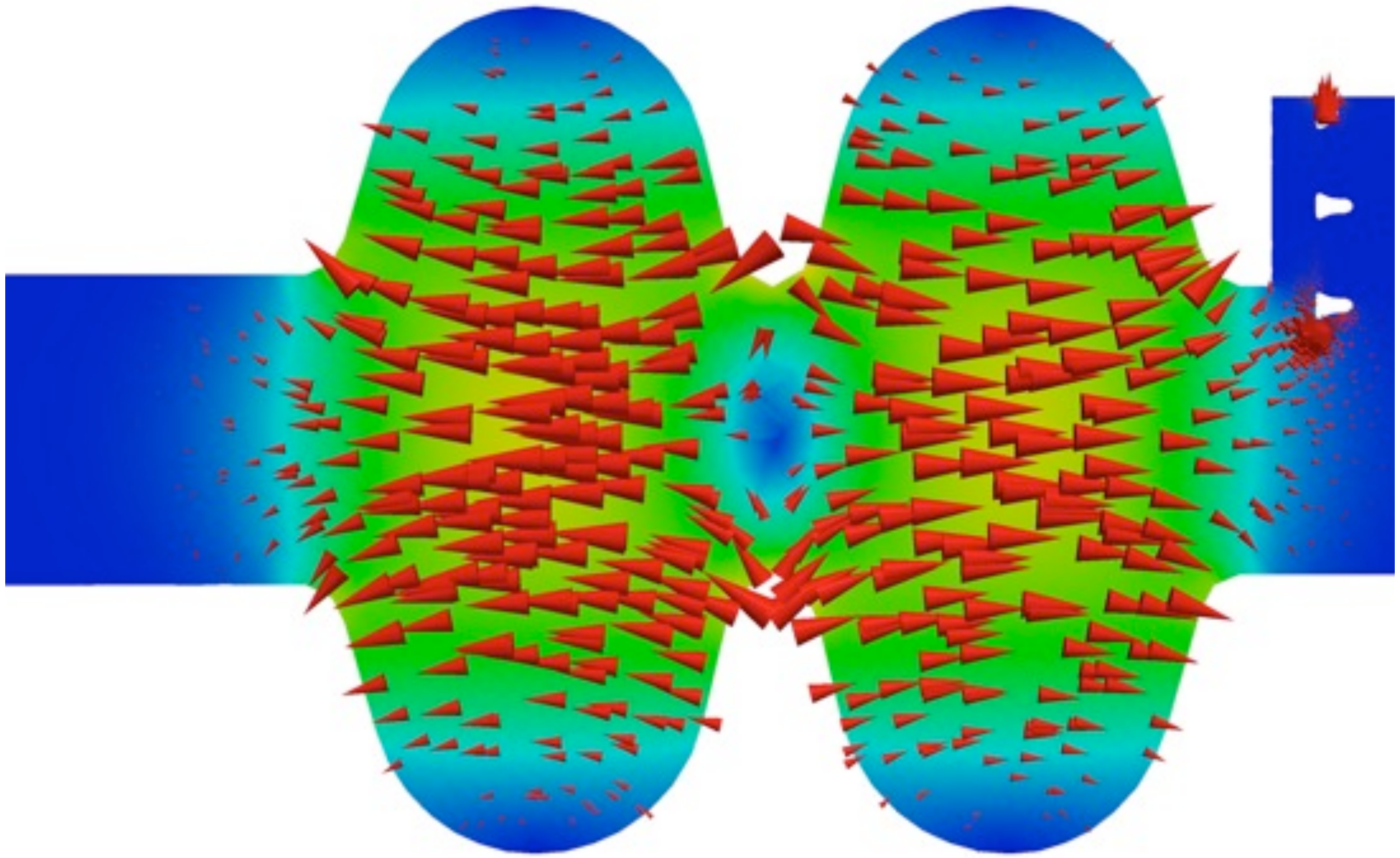


2 cells initially used
however
CPU time depends
on localised mesh
density not total

Kept 2 cells
for
consistency

OMEGA3P SIMULATION

Order p=2 used:
In each element, fields are expanded into 20 vector basis functions
(6 for p=1, 216 for p=6)



Tracking uses
π mode (704.42MHz)

Cavity is included in order to calculate field gradient

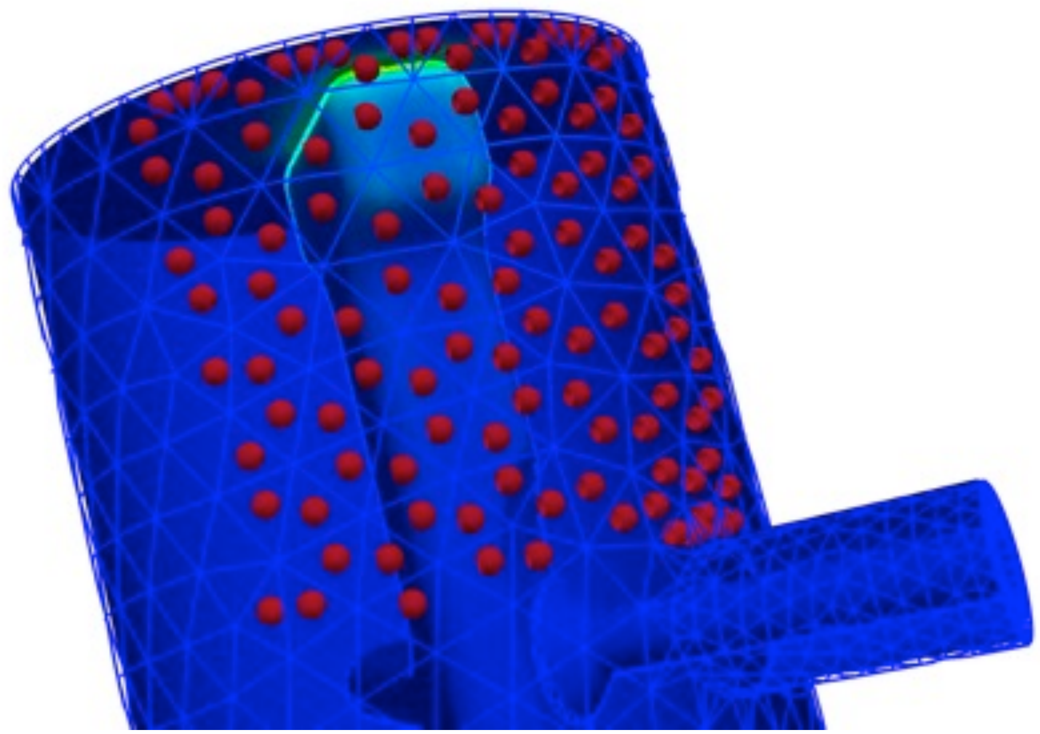
TRACK3P - SIMULATION

Define bounding box for emission

Particles emitted from centre of mesh elements within box

Occurs every 3.6° for 1 RF cycle

Particles tracked for a further 19 RF cycles



RE-EMISSION MODEL

Upon impact with a surface

If phase conditions correct

Particle re-emitted normal to surface at 2eV

Particle survives more than 4 impacts

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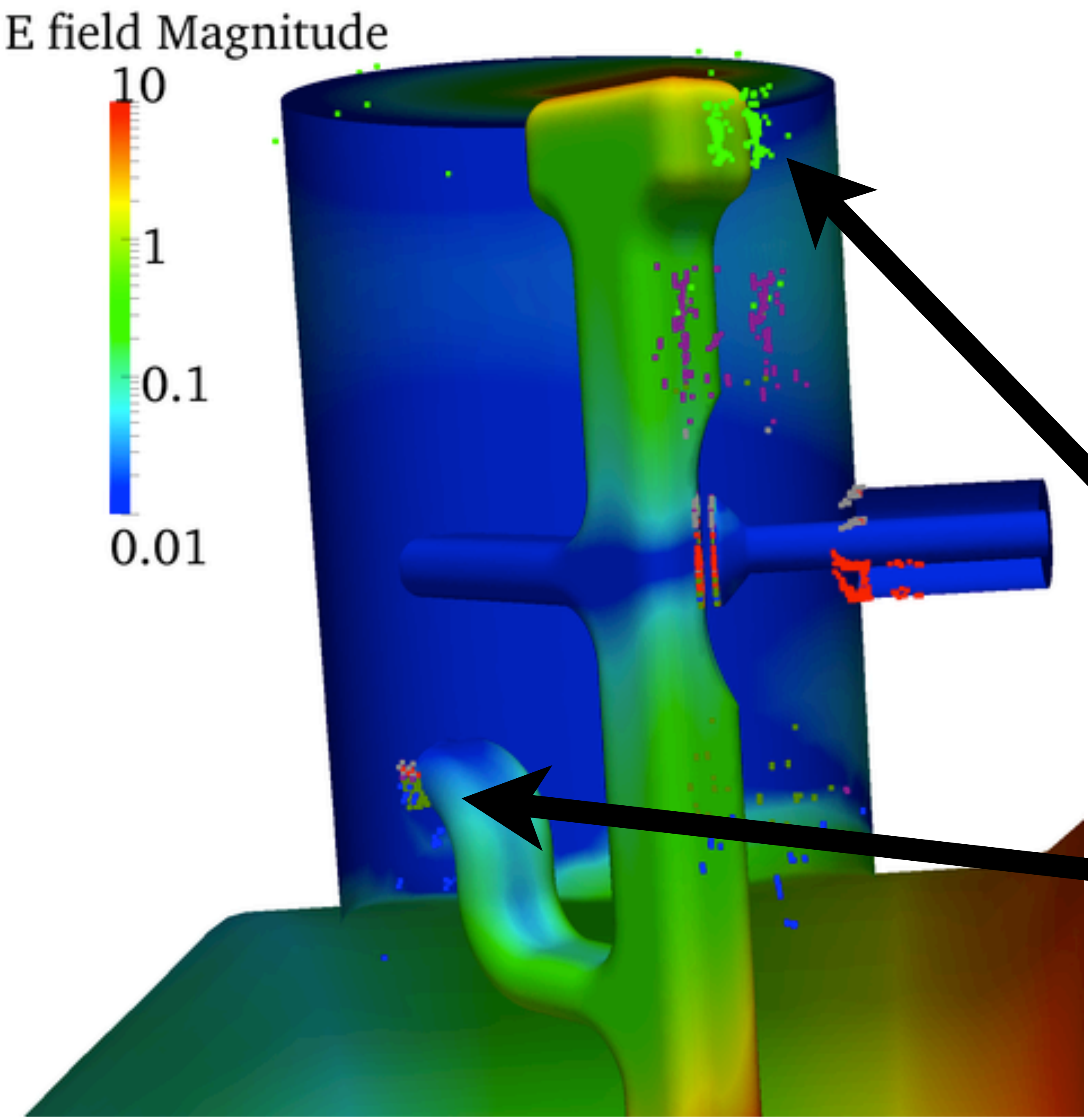
RESONANT

Note: 20RF cycles means cannot resolve trajectories higher than 5th order

CALAGA DESIGN

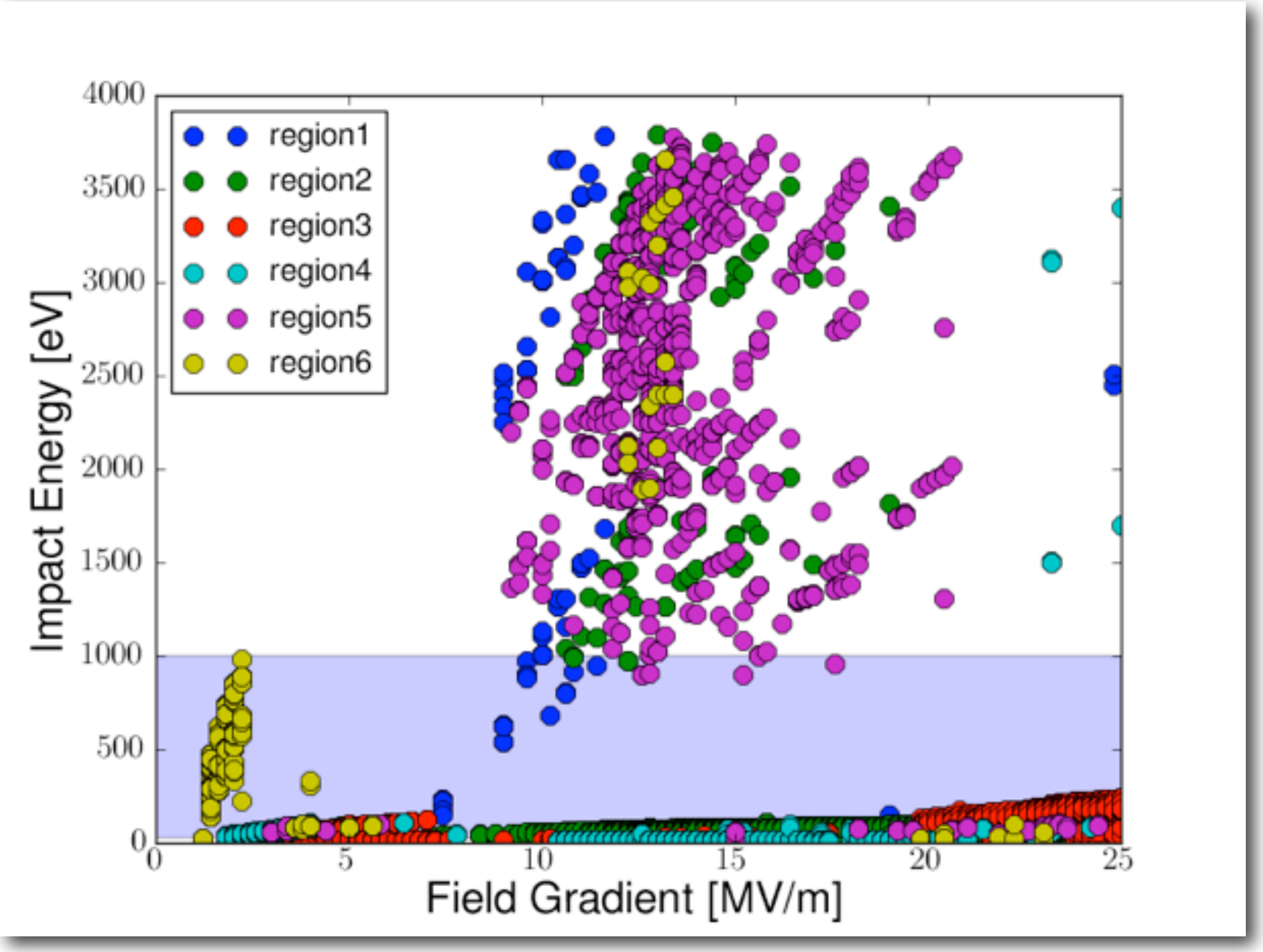


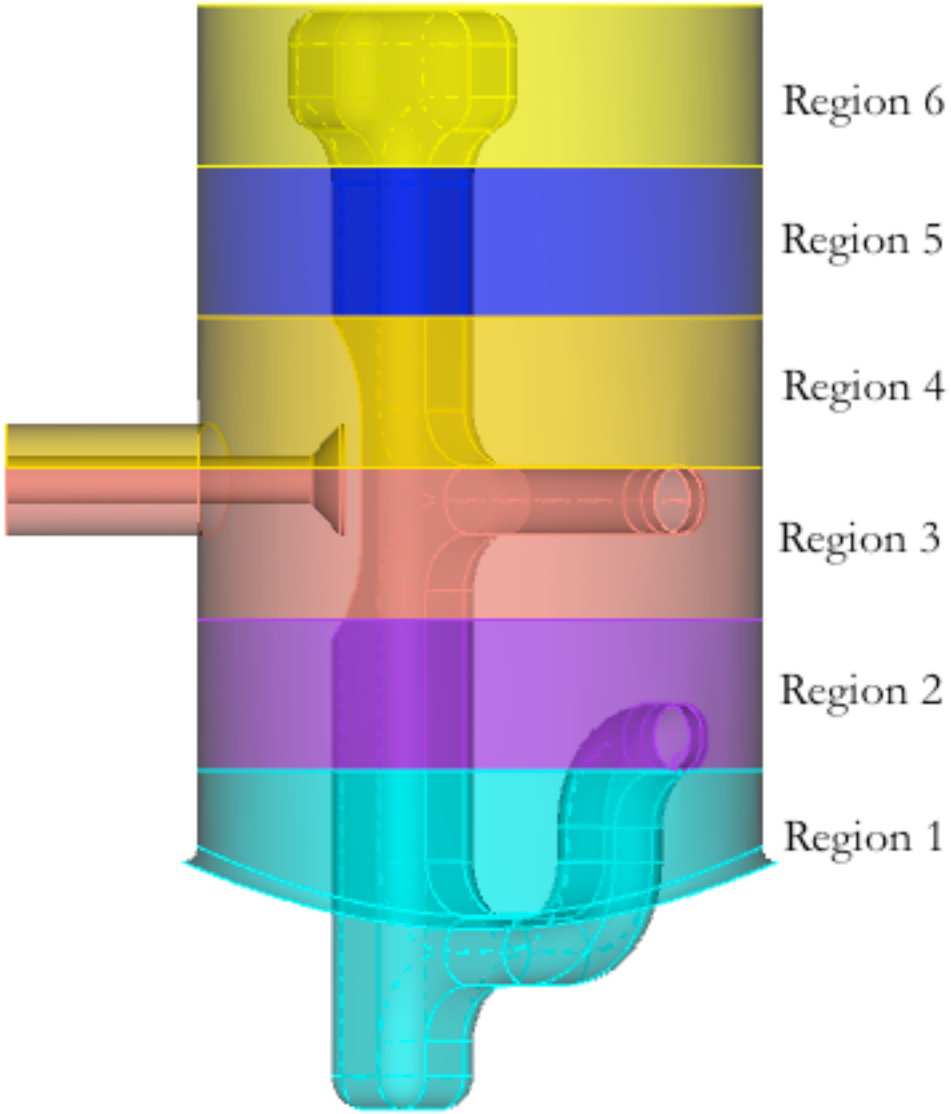
~1000 particles emitted every 3.6°

~100,000 tracked

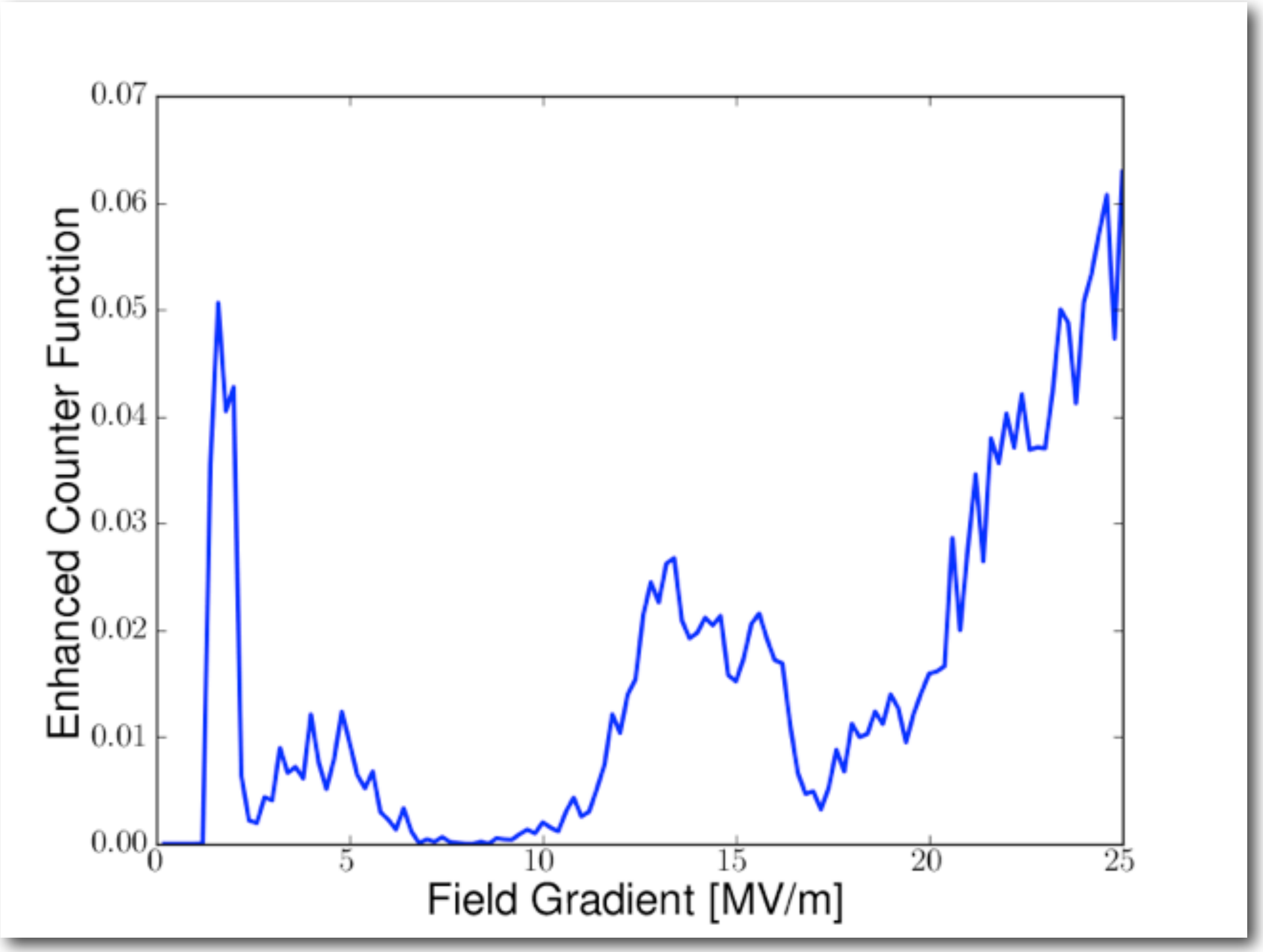
Strongest resonances

IMPACT VS GRADIENT





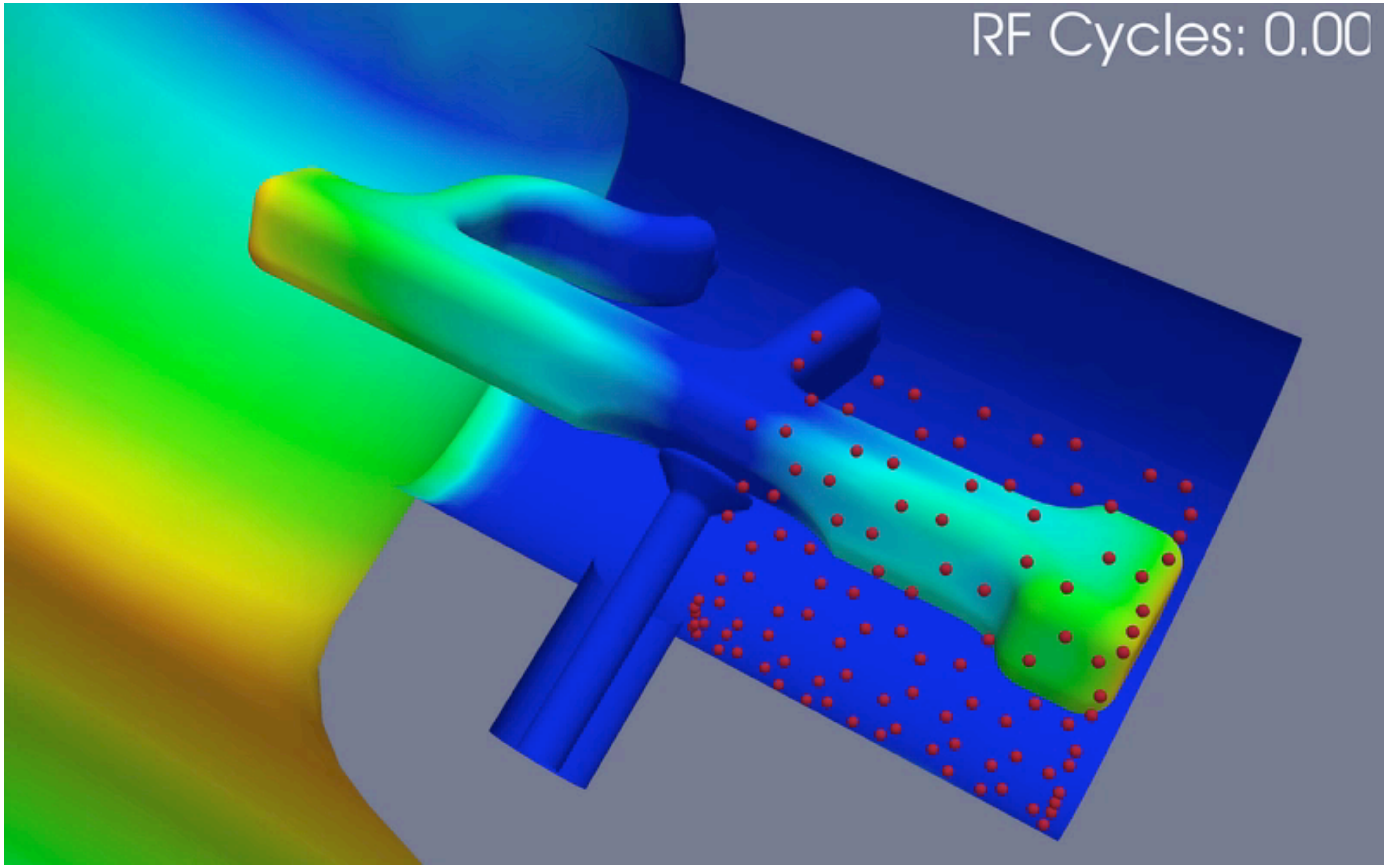
ENHANCED COUNTER



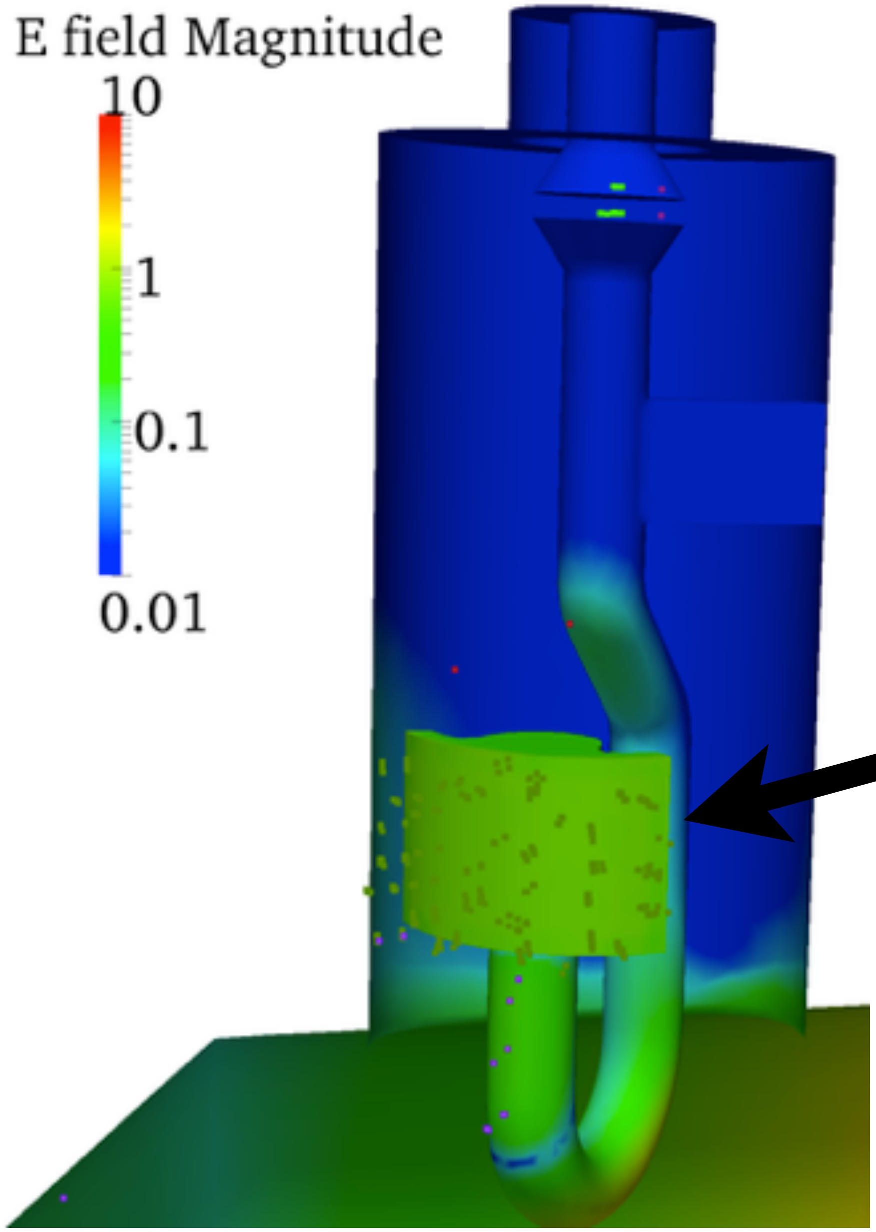
$$\sum_i SEY_i$$

Normalised by total initial charge

1.6MV/M



ROSTOCK DESIGN

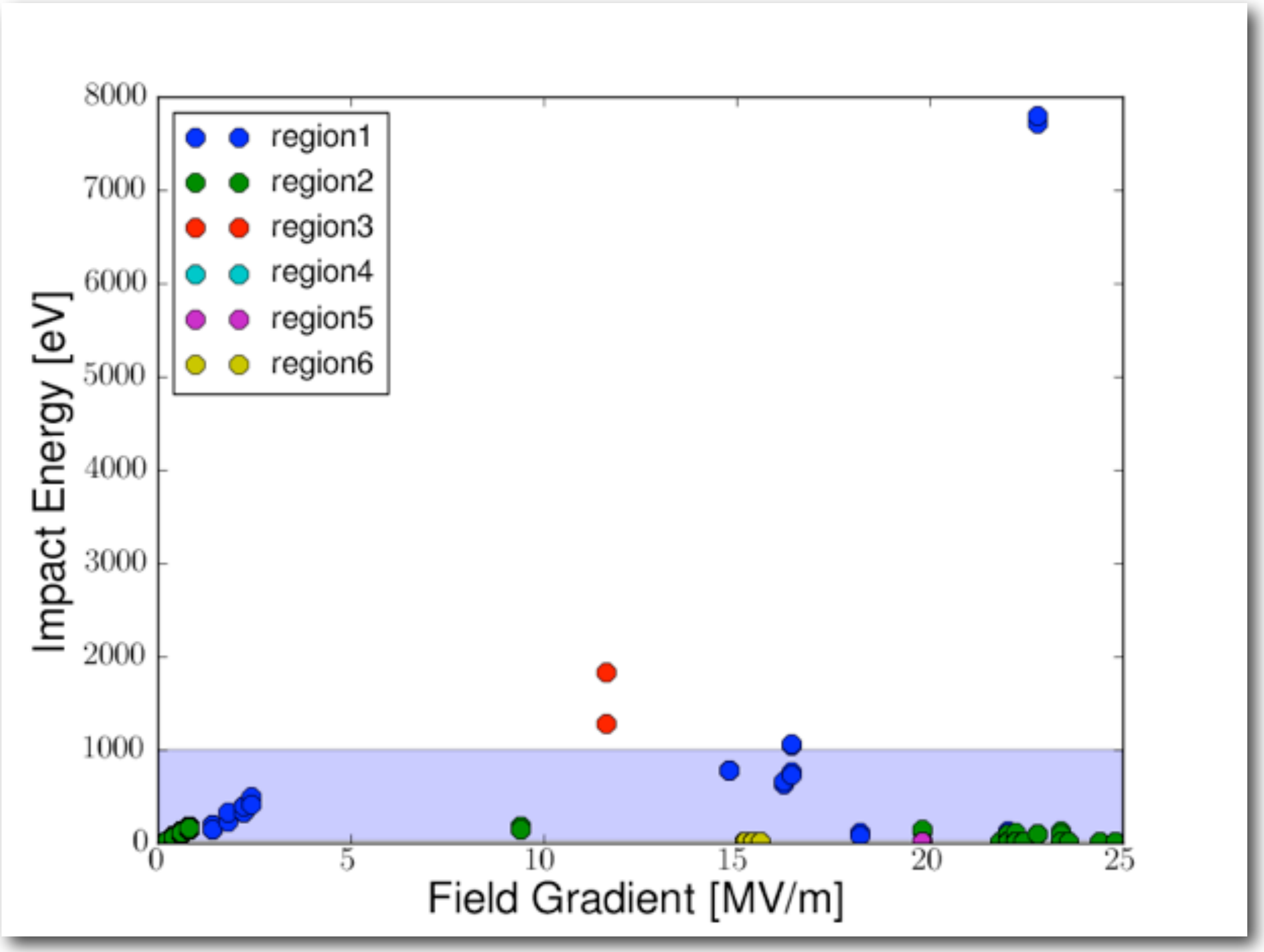


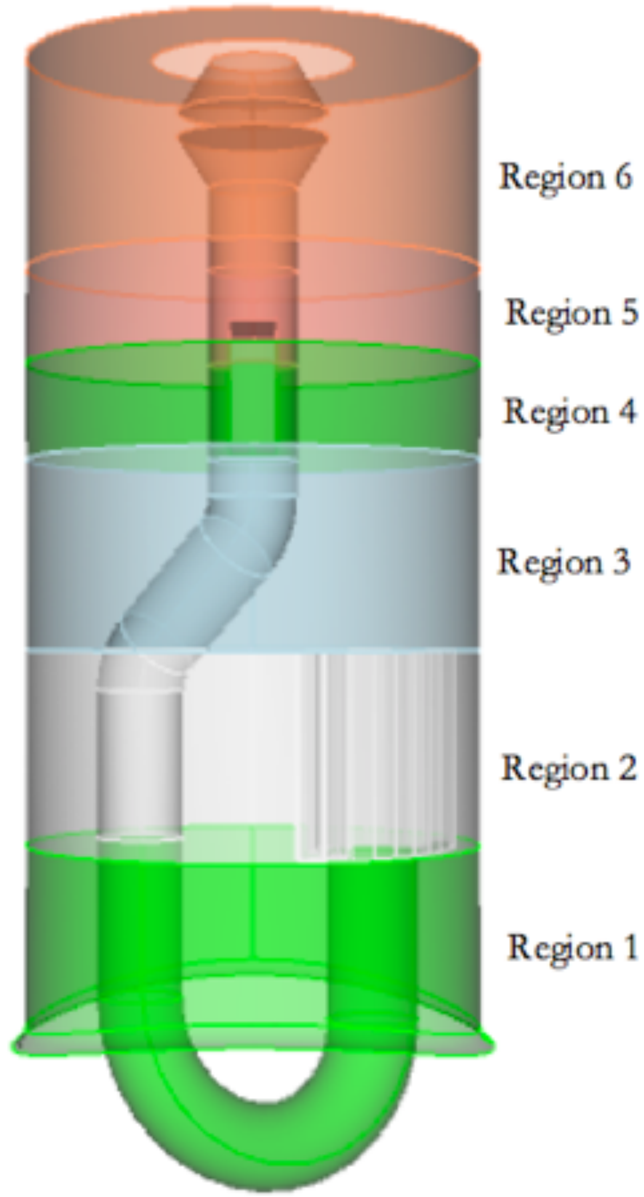
Again ~100,000 particles tracked overall

Majority of impacts between wall and capacitive plate

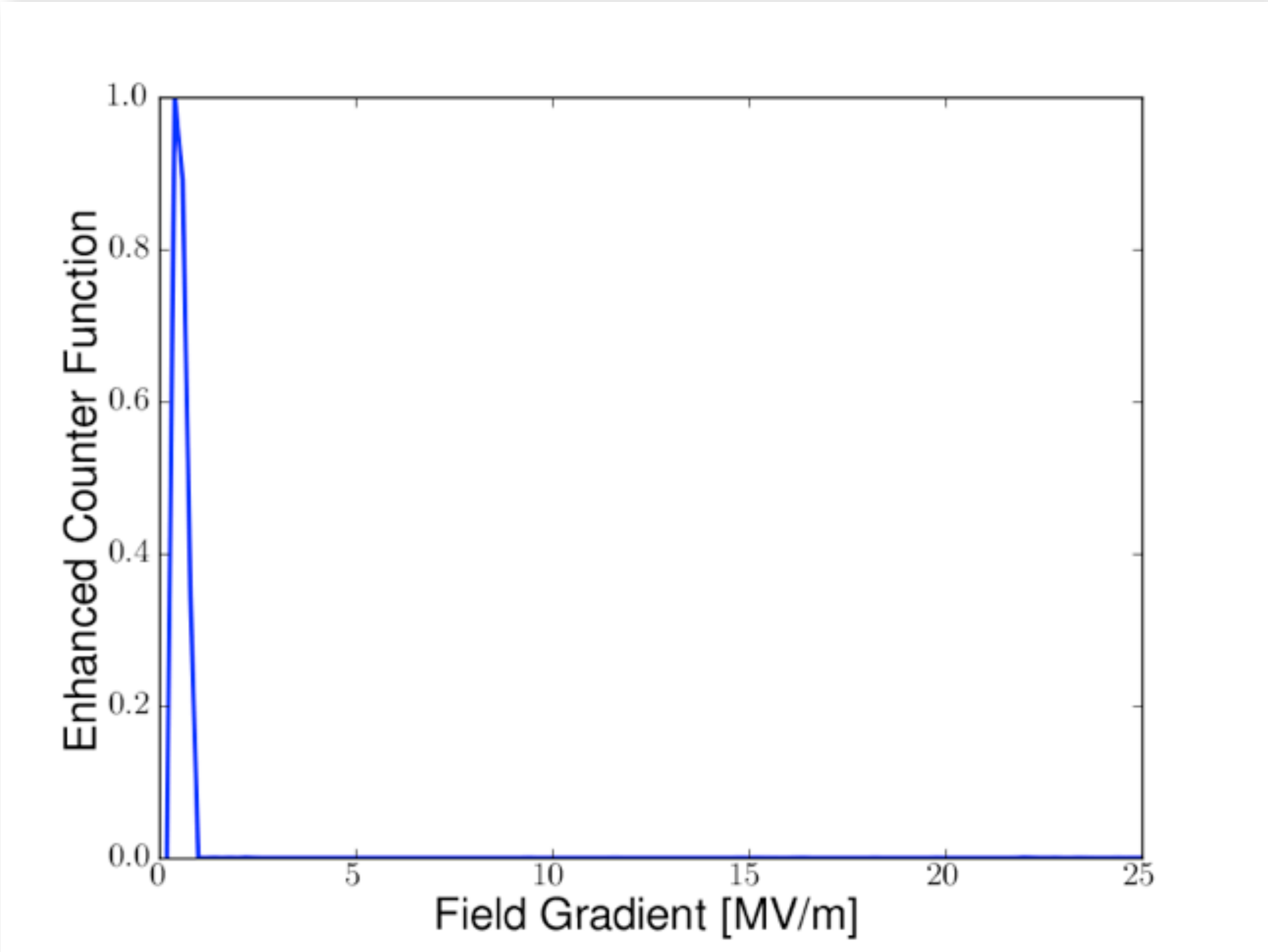
Small activity elsewhere

IMPACT VS GRADIENT





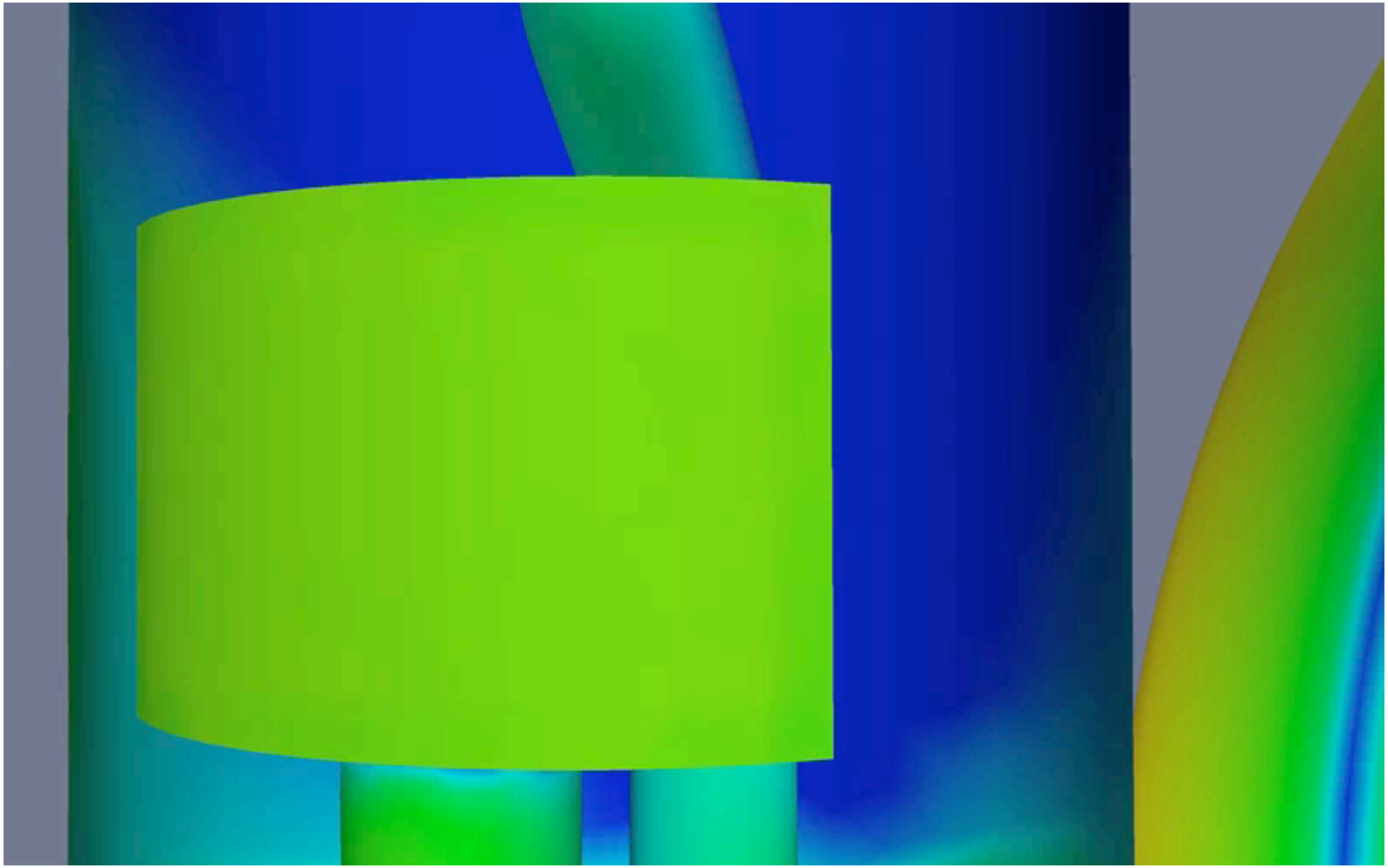
ENHANCED COUNTER



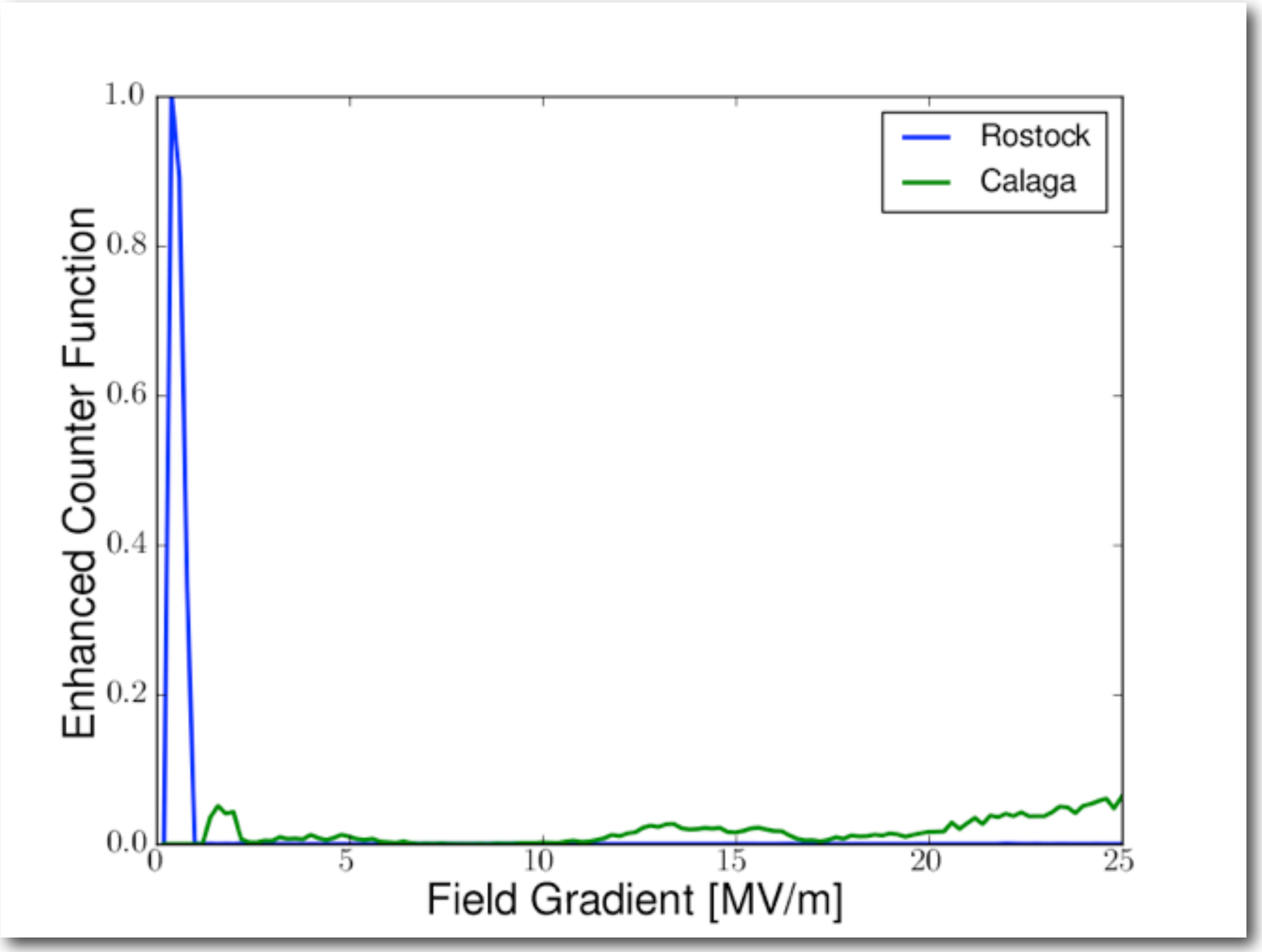
One very strong band

2 point between wall and capacitive plate

0.4MV/M



COMPARISON



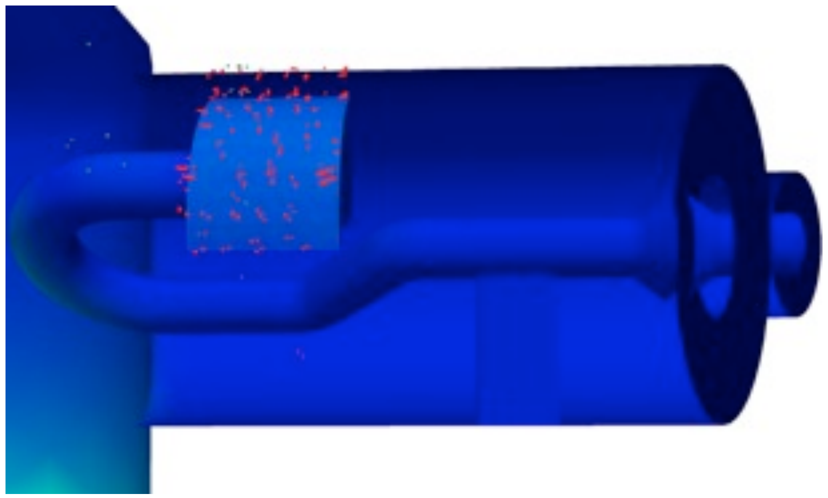
Rostock

One strong but narrow band

Calaga

lower but extends across a broader range of gradients

IMPROVEMENTS

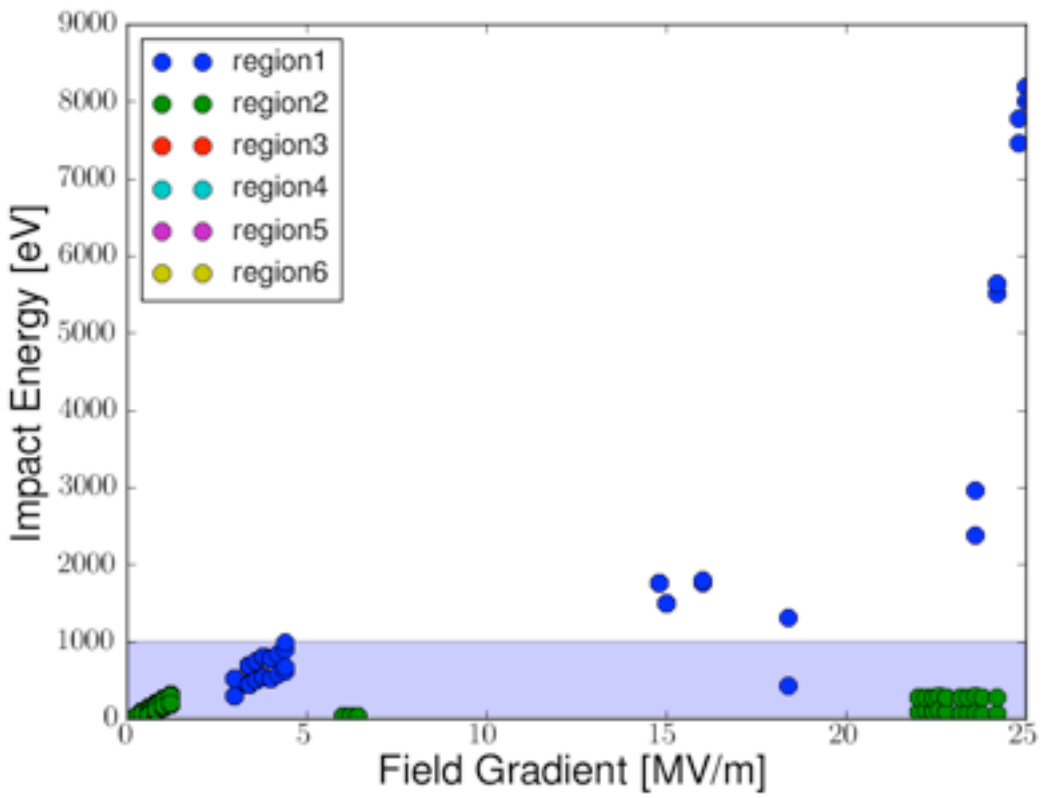


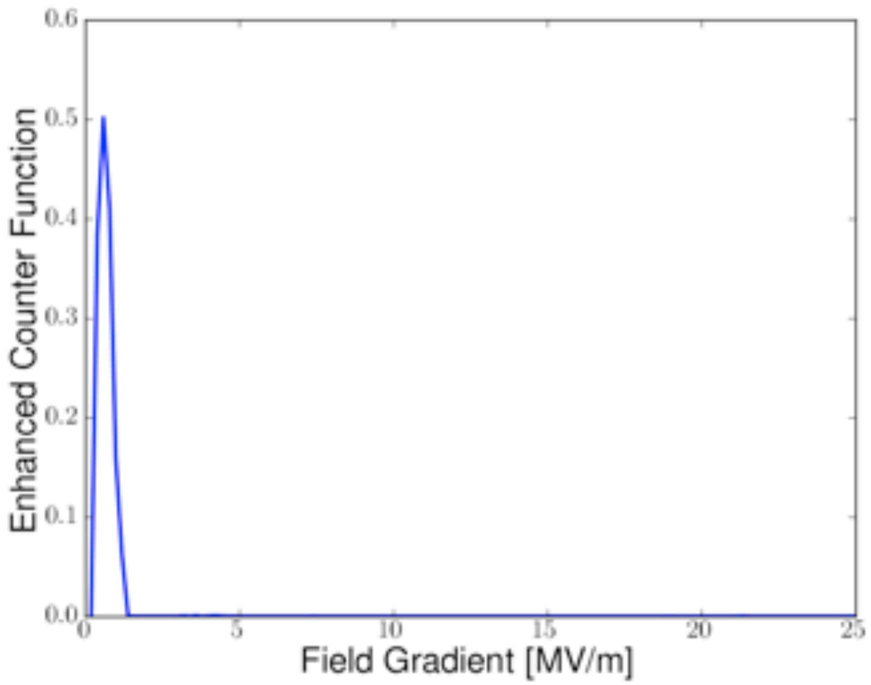
Dimension changes

Reduction in MP strength

Concentrate the electrons in one line on the element

Hope for conditioning along that line





OPEN QUESTIONS

Can we know if a barrier can be processed?

Is normalising the counter by initial charge the best way to compare the two designs?

Is tracking for 20 RF cycles (5th order resolution) sufficient?

CONCLUSIONS

Calaga design

Appears to be safest design so far ...

Plans for modification to reduce MP activity

Rostock design

One strong band is the main worry

If we could be sure it could be processed, then the initial conclusion may reverse