Numerical Calculations of Field Enhancements due to Small Grooves

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X-band Accelerator Structure Design and Test Program
@SLAC, USA
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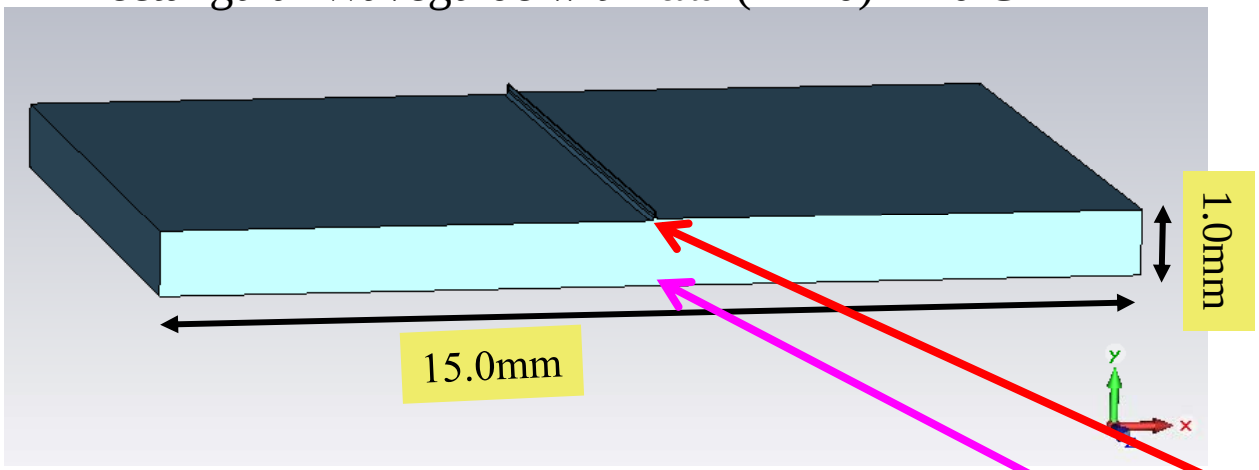
Computation of RF Fields by CST-MWS

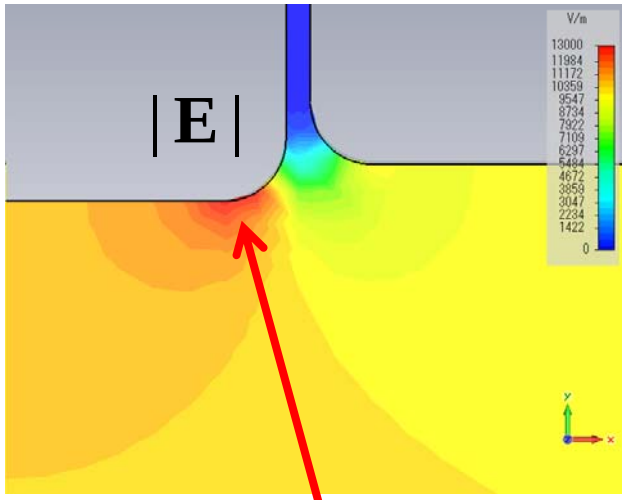
(v2011.02)

~ *Geometry and Definition* ~

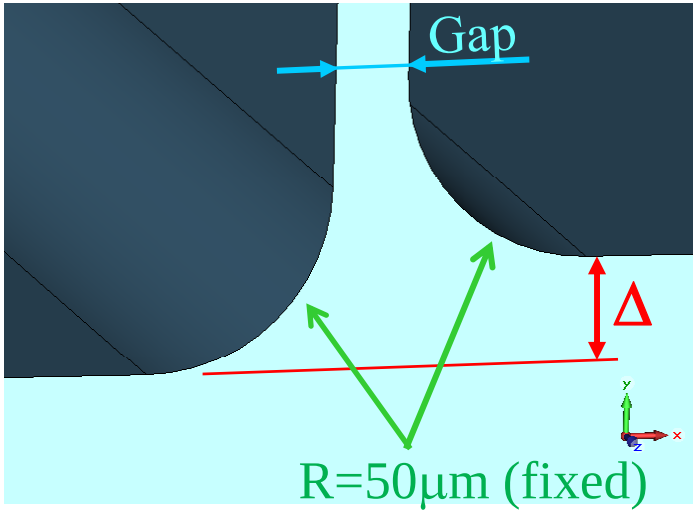
Rectangular Waveguide with f_{cutoff}(TE10) = 10 GHz



e.g. Gap=20μm, Δ=30μm



3 Parameters to Describe the Groove



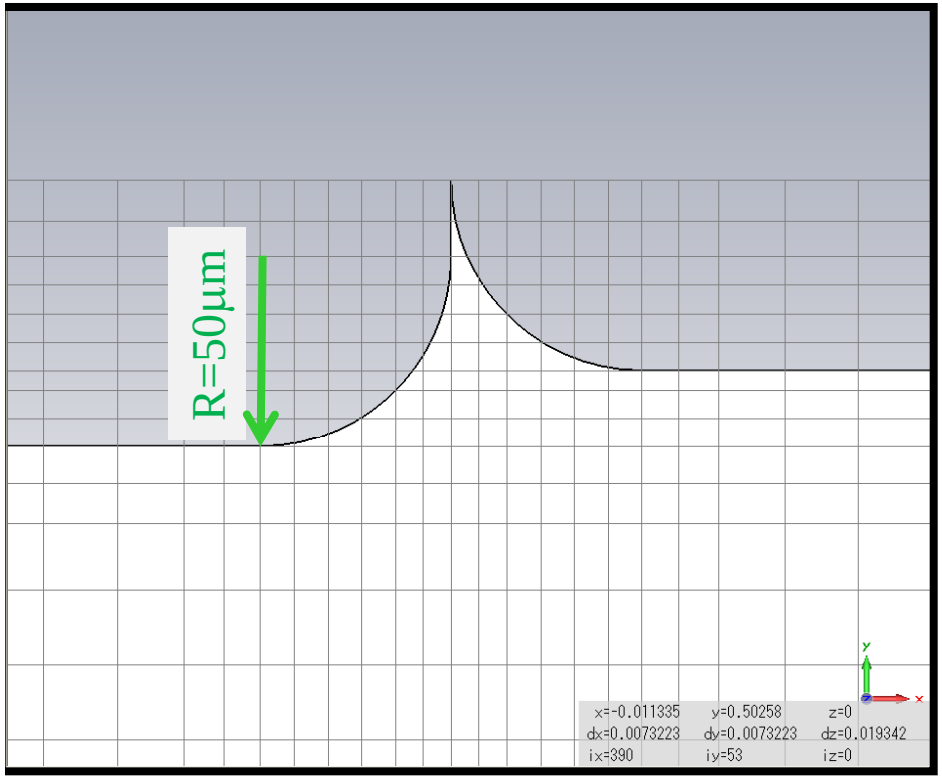
Enhancement Factor $\cong \frac{E_{max}}{E_{ref}}$

Simulating:
- Chamfer of the Quadrants
- etc.

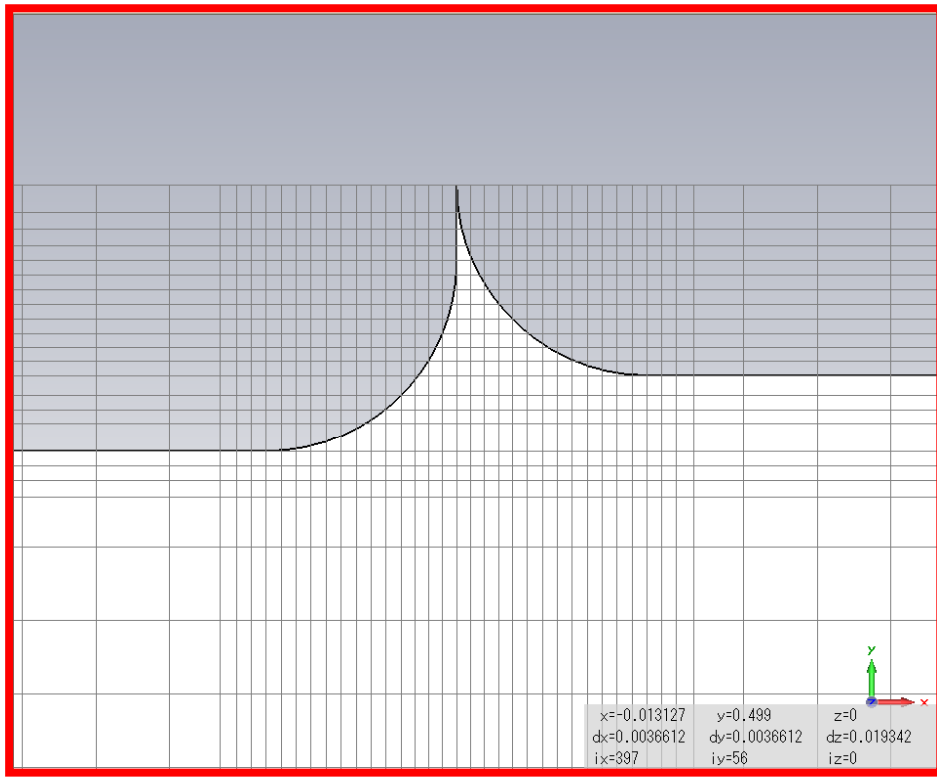
Meshing Parameters and Mesh-Size Dependence

FDSolver.Method "Hexahedral Mesh"
Mesh.MeshType "PBA" ‘(Perfect Boundary Approx.)
Mesh.LinesPerWavelength “300"
Mesh.AutomeshRefineAtPecLines "True", “**RAPL**"
FDSolver.AccuracyHex "1e-6"

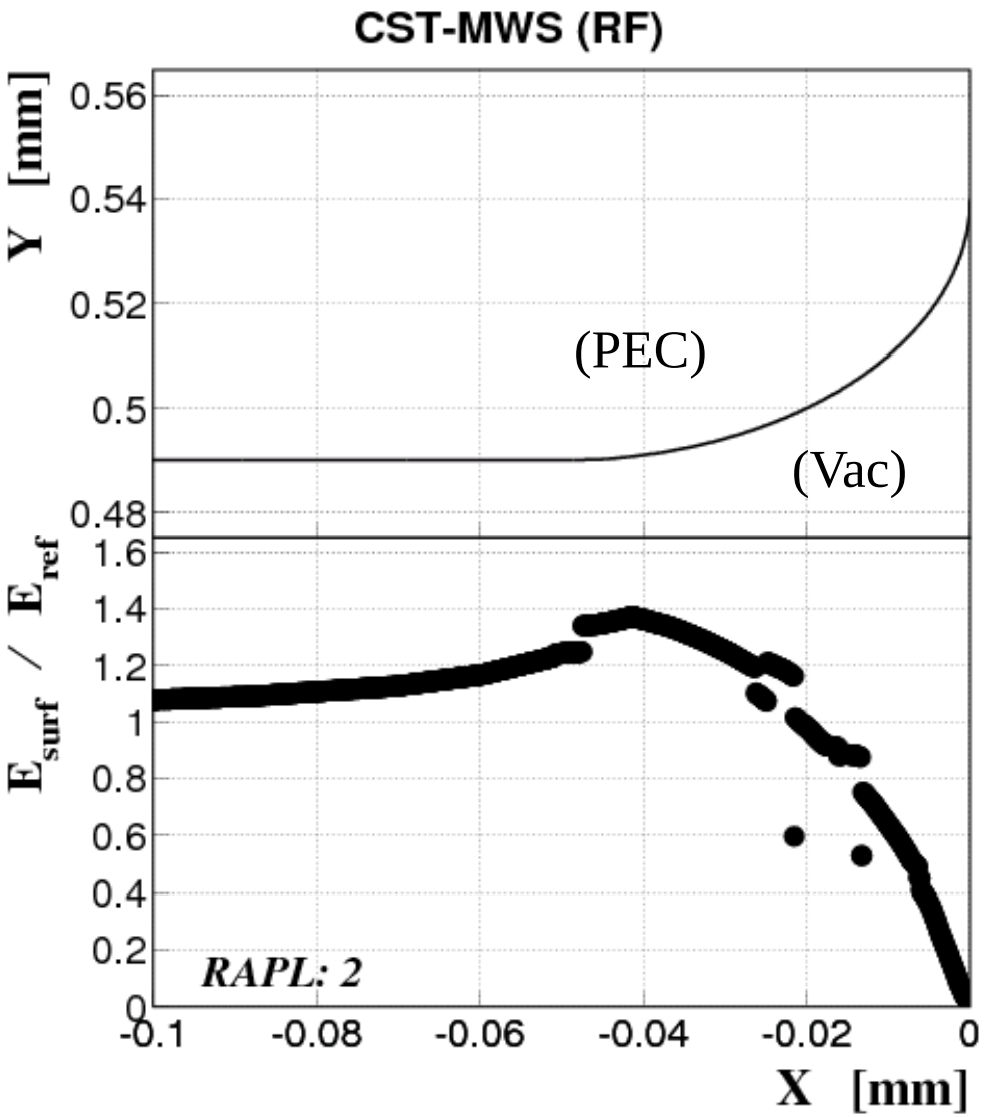
RAPL=2 (default)



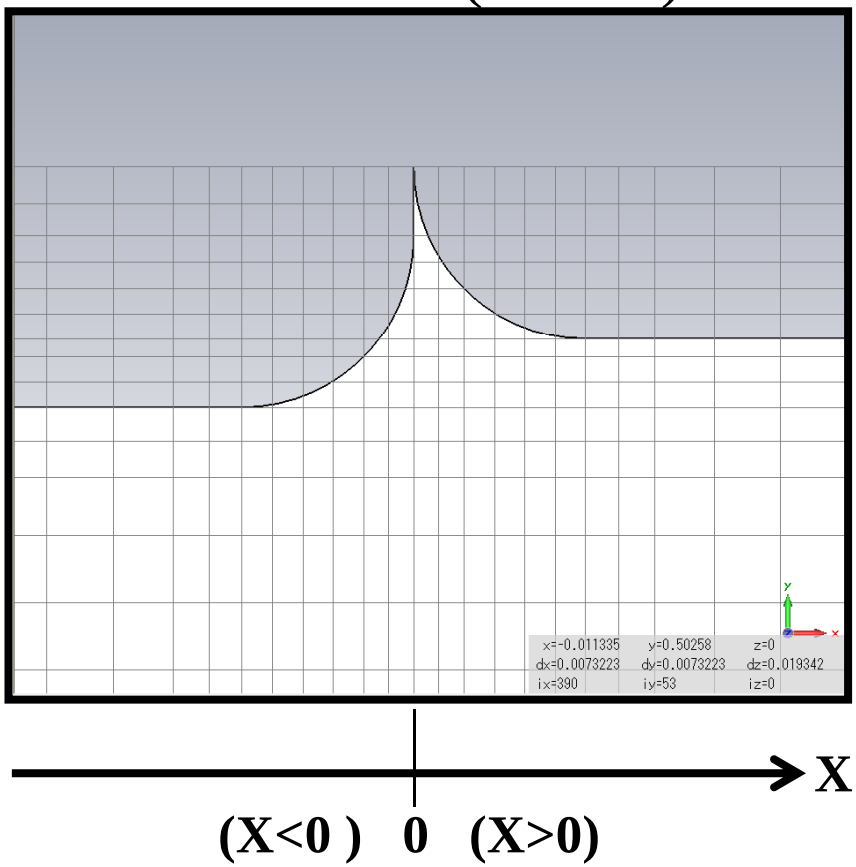
RAPL=5

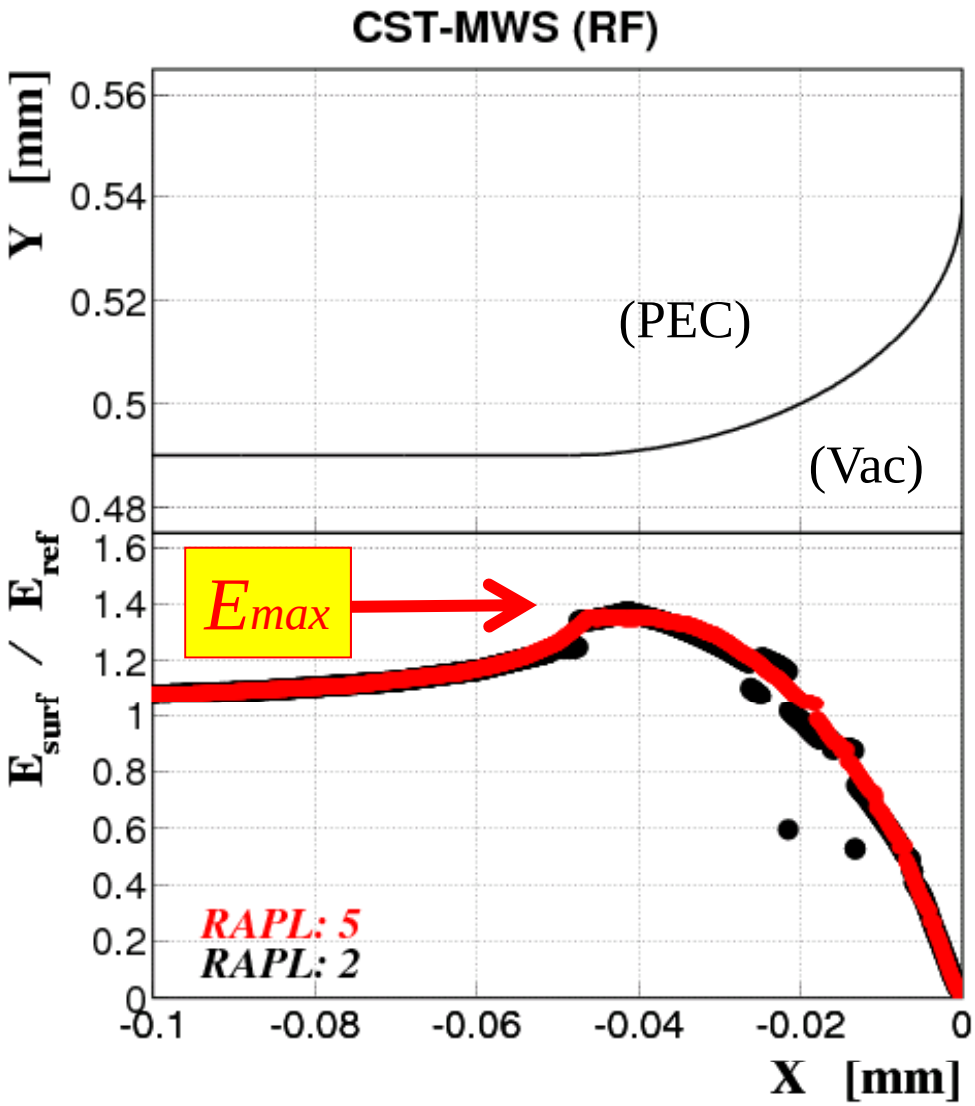


Using a function: “GetFieldVectorSurface()”
→ Better field interpolation scheme on PEC surfaces

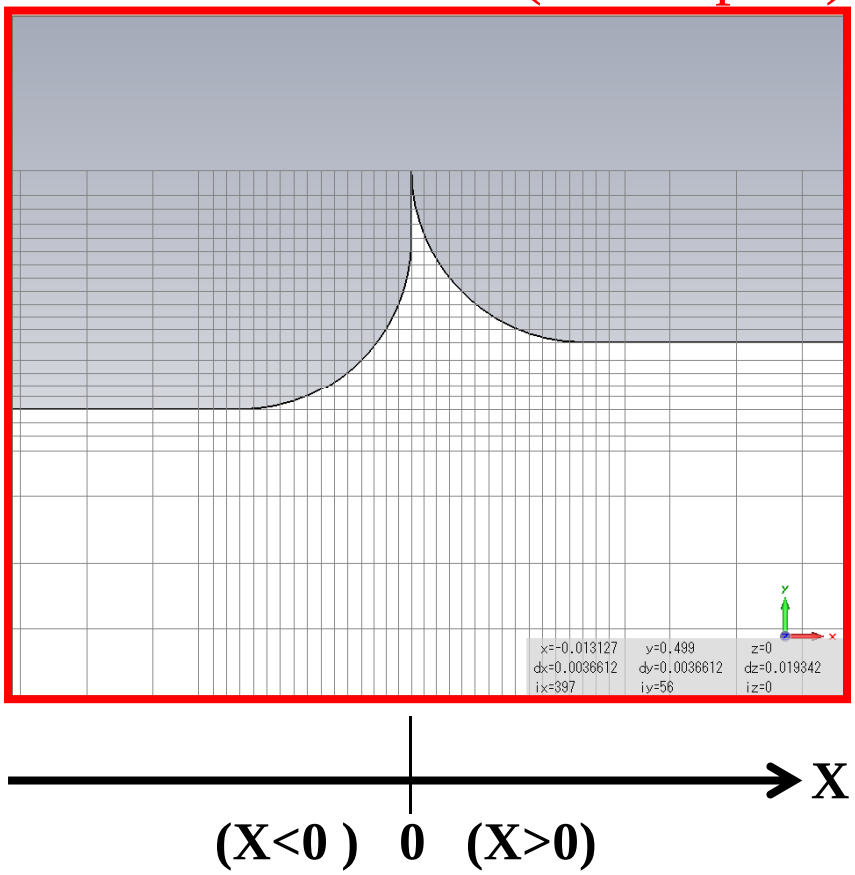


RAPL=2 (default)

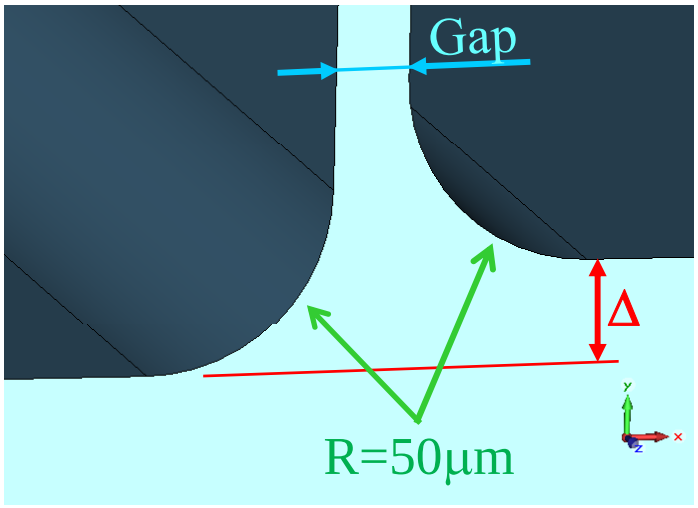


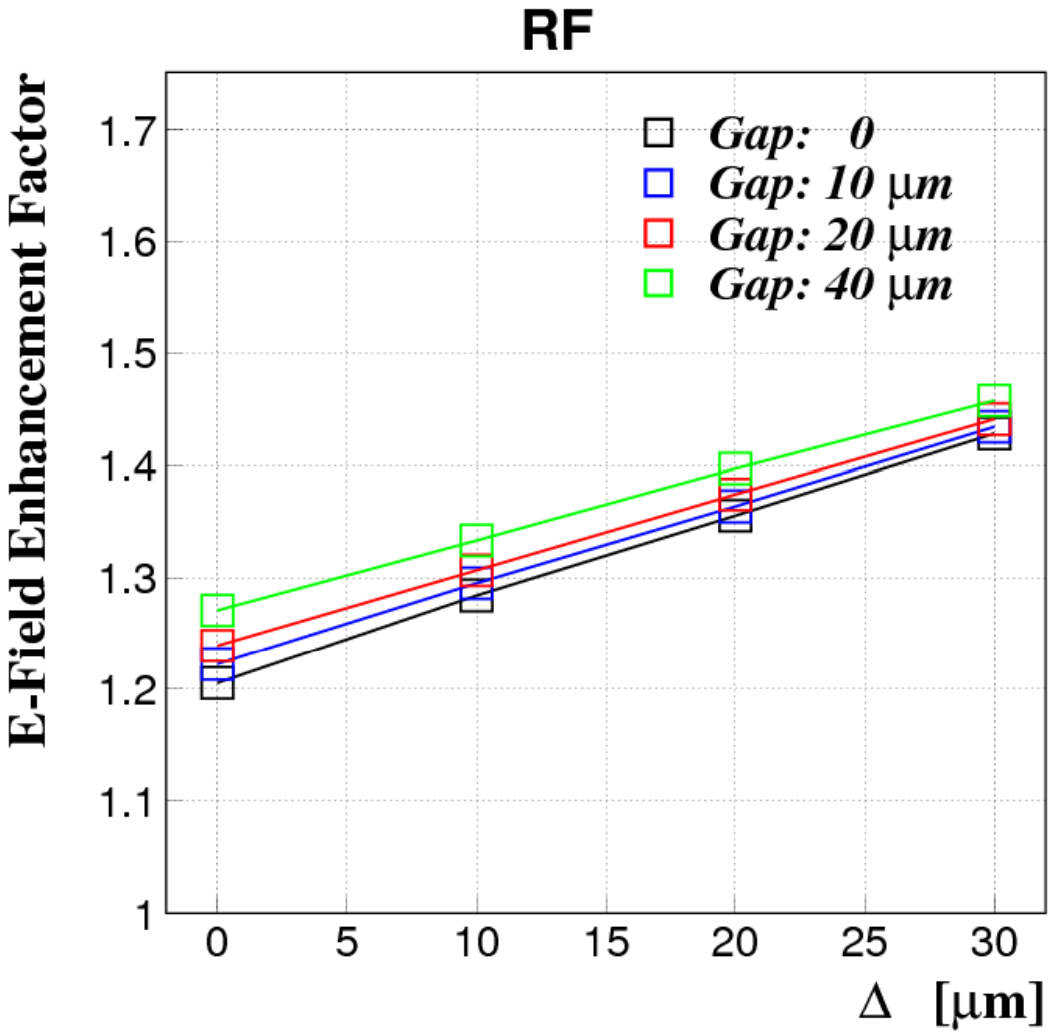


RAPL=5(→Adopted)

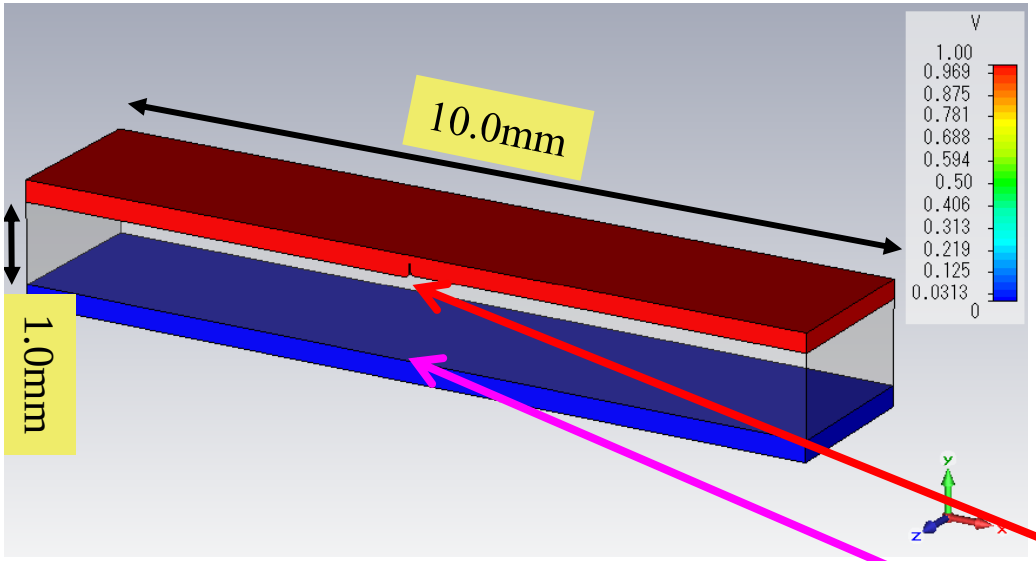


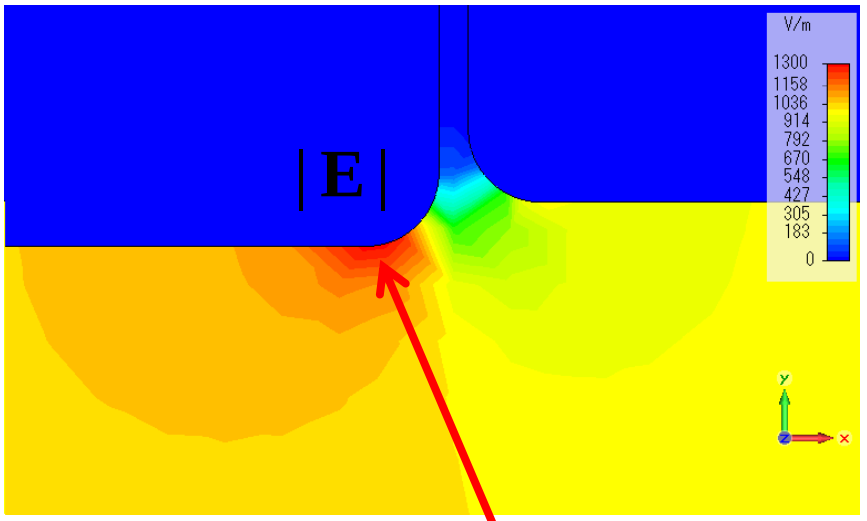
Results


Gap
Δ
R=50μm

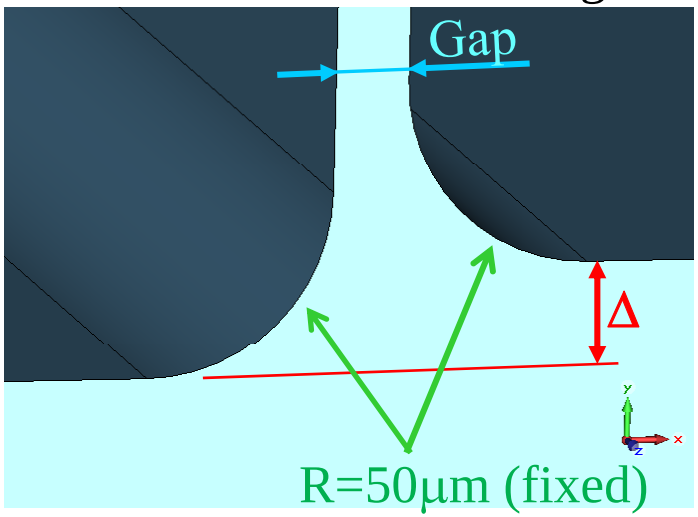

RF
E-Field Enhancement Factor
Gap: 0
Gap: 10 μm
Gap: 20 μm
Gap: 40 μm
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0
5
10
15
20
25
30
Δ [μm]

Check the Results(1): E-Static Fields by CST-EMS (v2011.02)





3 Parameters to describe the groove

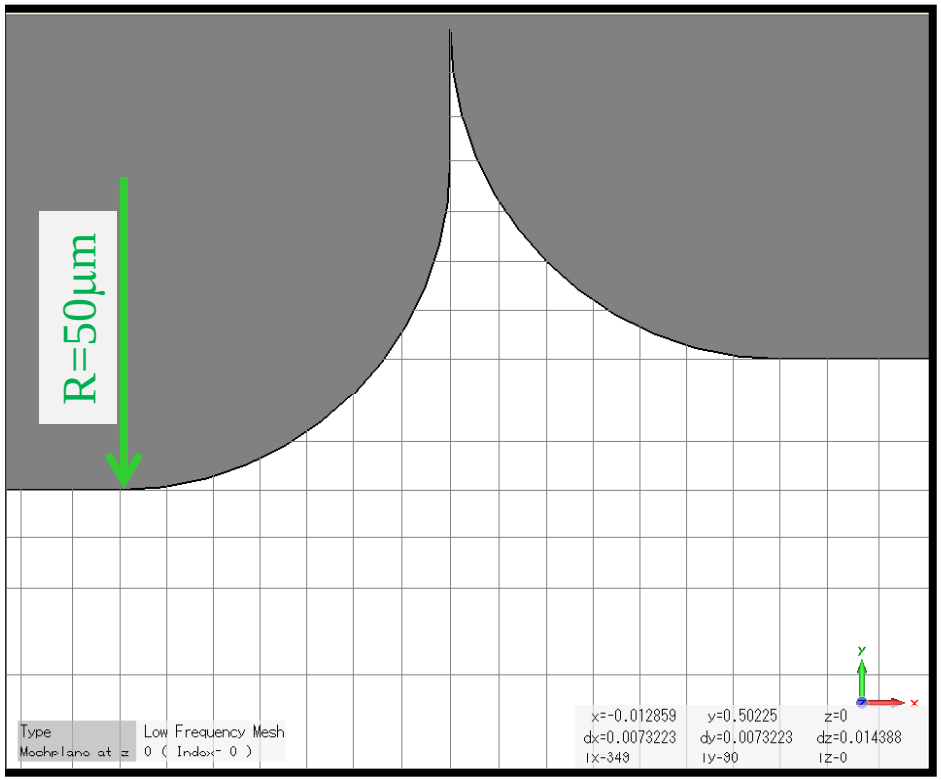


$$\text{Enhancement Factor} \cong \frac{E_{max}}{E_{ref}}$$

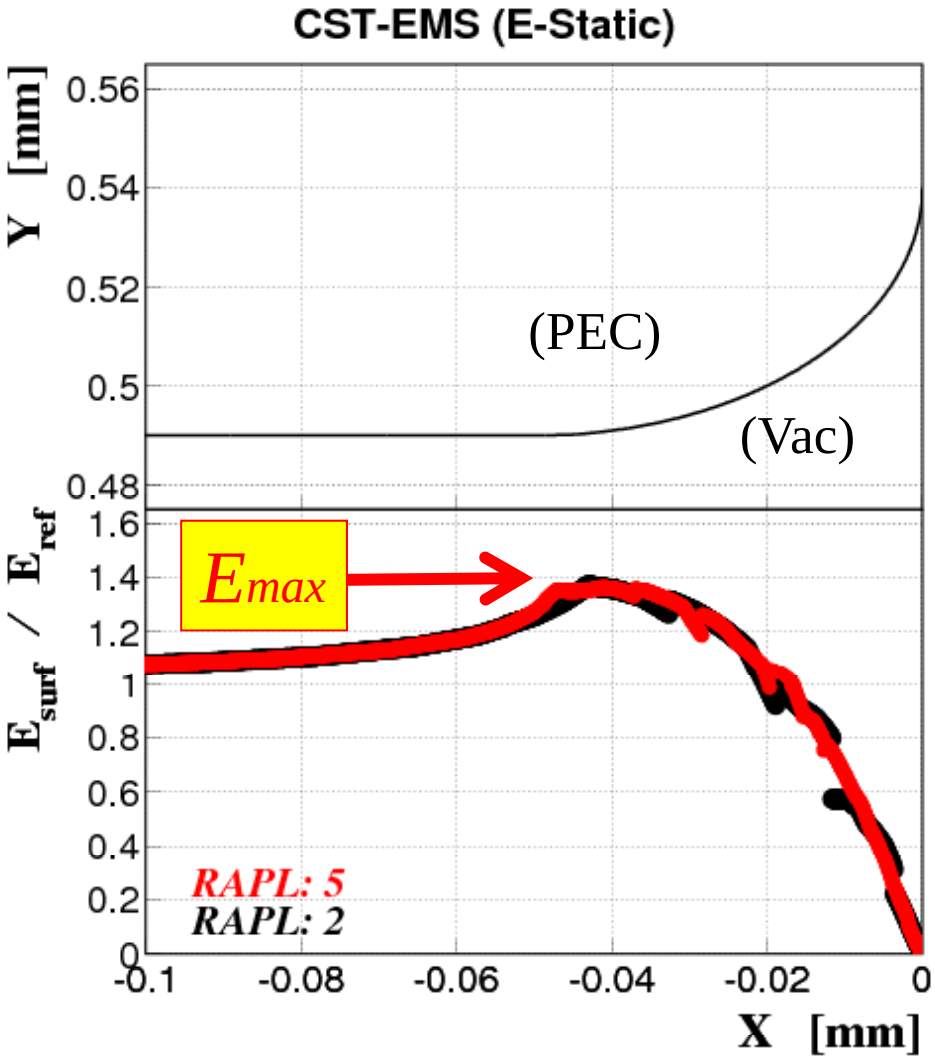
Meshing Parameters and Mesh-Size Dependence

EStaticSolver.Method "Hexahedral Mesh"
Mesh.MeshType "PBA" ‘(Perfect Boundary Approx.)
Mesh. MinimumStepNumber “100"
Mesh.AutomeshRefineAtPecLines "True", “**RAPL**"
EStaticSolver.Accuracy "1e-9"

RAPL=2(default)



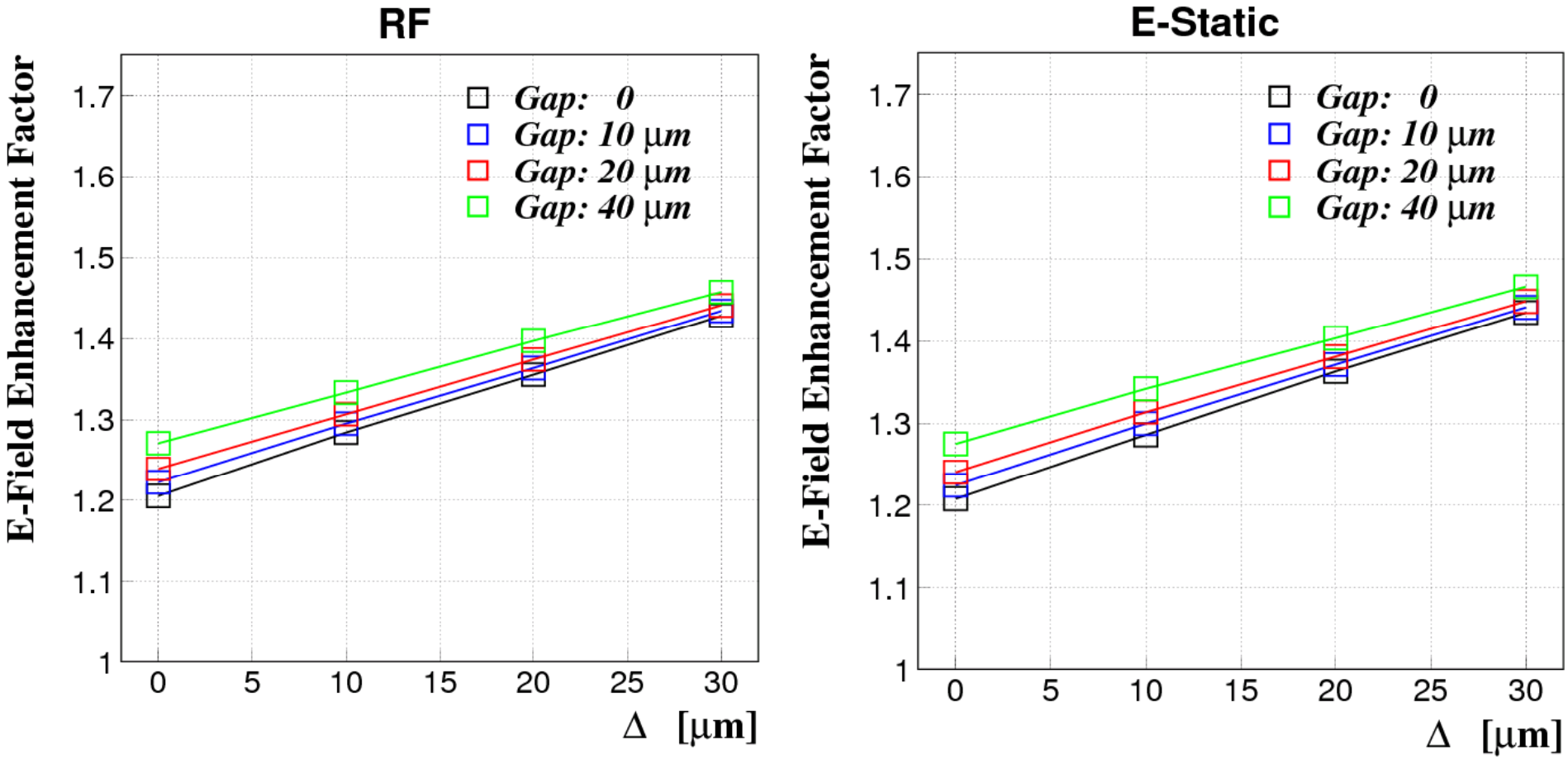
RAPL=5



RAPL=5(→Adopted)

Comparison of the Results

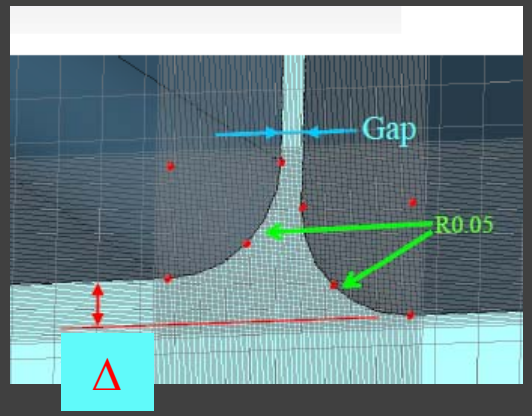
~Cross-Check of the Computations~

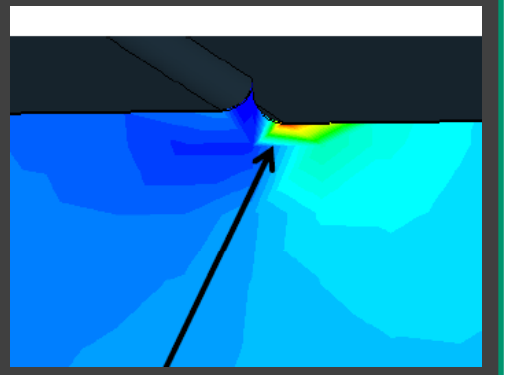


Good Agreements as expected

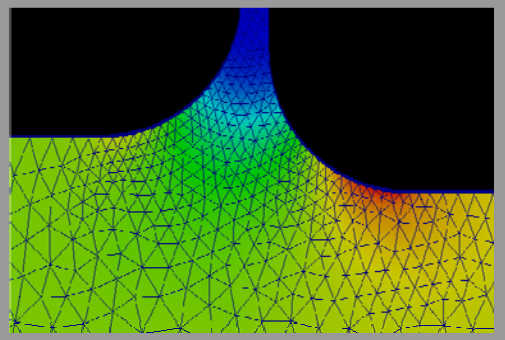
Check the Results(2):
Simulation using Omega3P (by Zenghai Li)

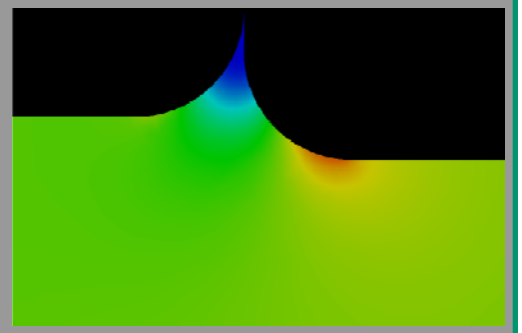
CST-MWS (T. Abe) (update)		
Gap (micron)	Δ (micron)	Emax / Enominal
0	0	1.21
0	20	1.36
10	20	1.37

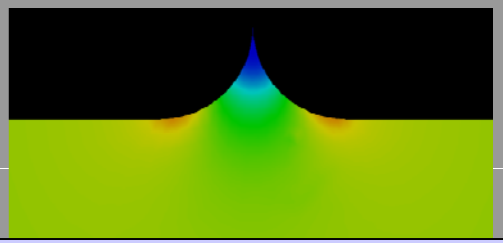


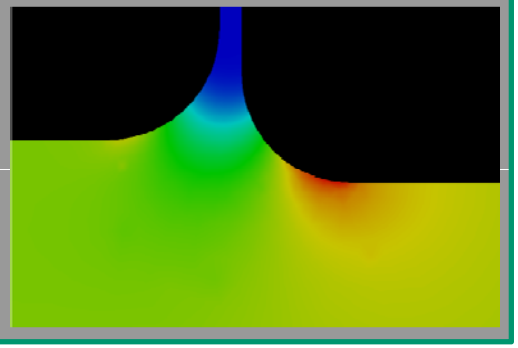


SLAC Omega3P (Z. Li)		
Gap (micron)	Δ (micron)	Emax / Enominal
0	0	1.23
0	20	1.40
10	20	1.44







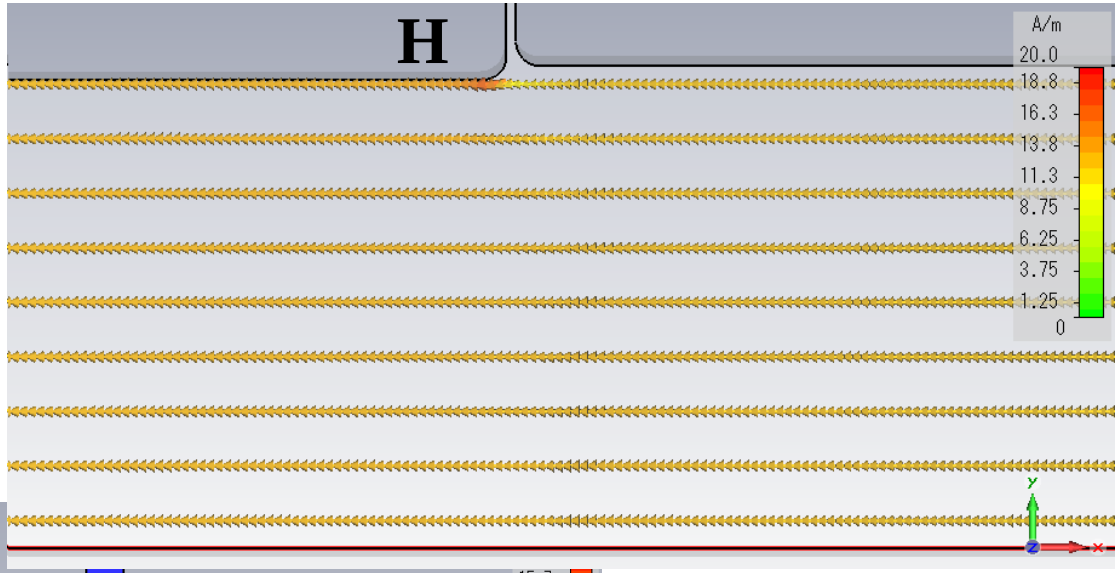


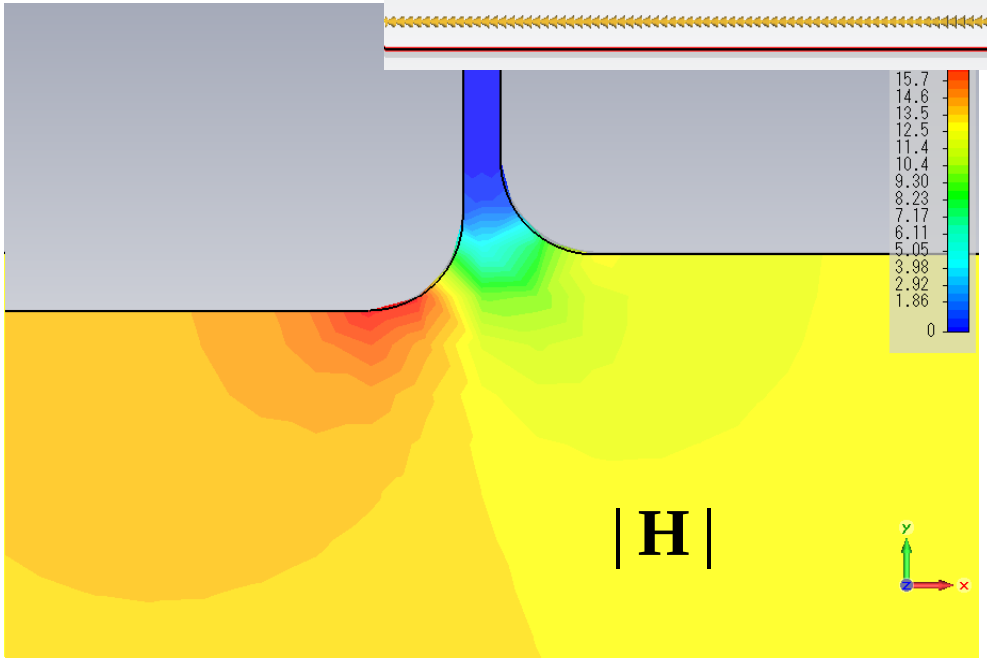
Fairly Good Agreements

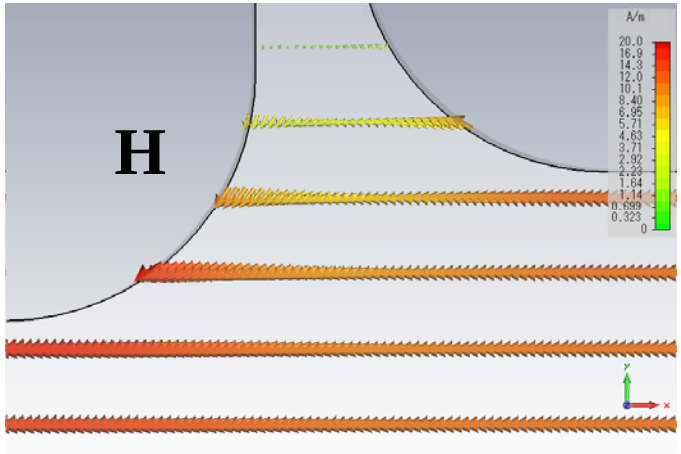
Magnetic Field Enhancement

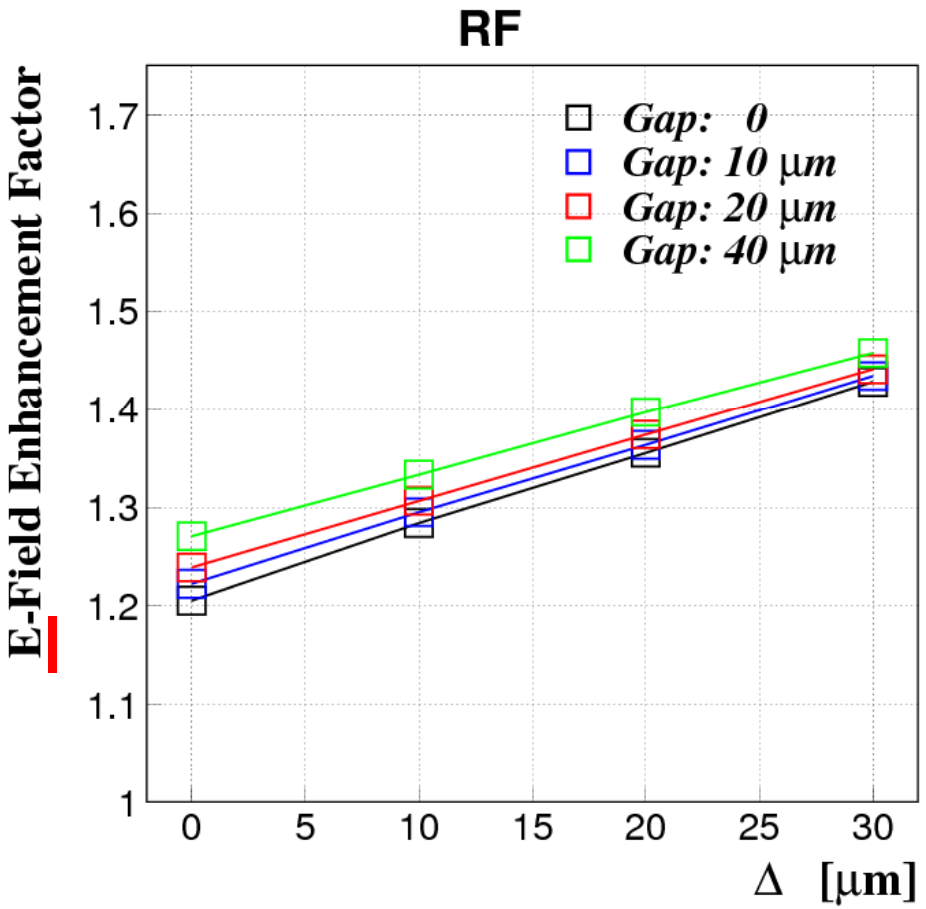
e.g. R=50μm, Gap=20μm, Δ=30μm

TE10-like Mode





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Gap: 10 μm
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1.7
1.6
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1.4
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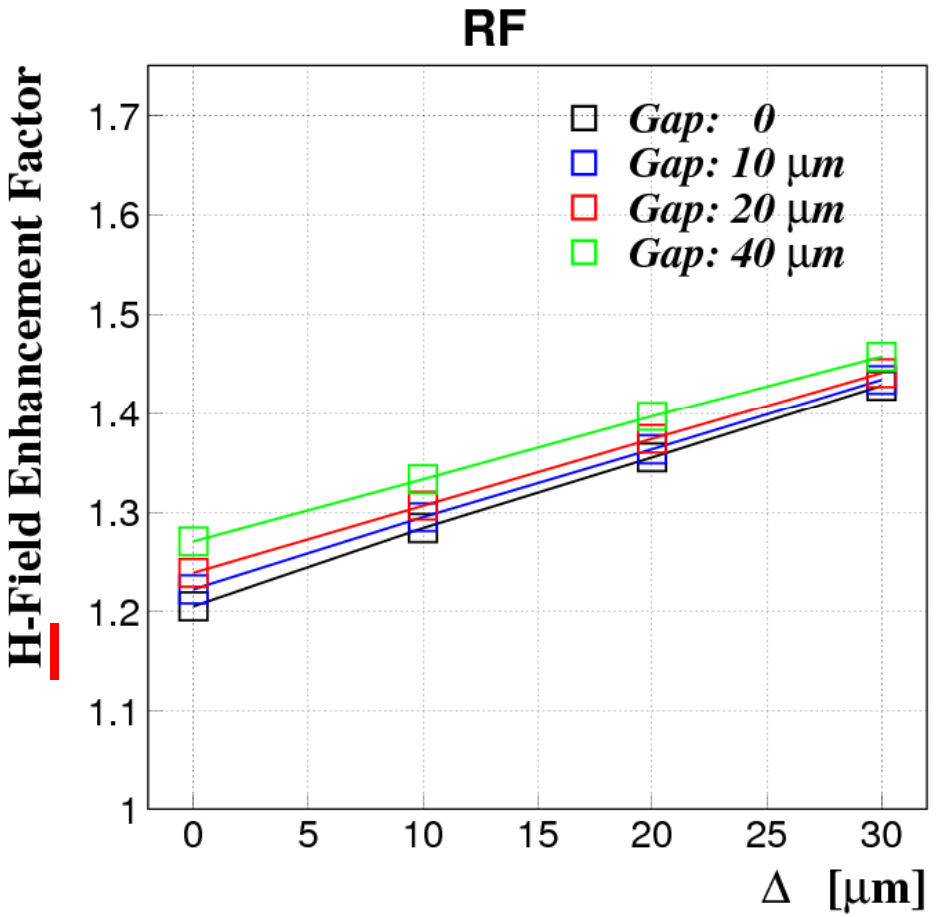
1.2
1.1
1
0
5
10
15
20
25
30
Δ [μm]


RF
H-Field Enhancement Factor
Gap: 0
Gap: 10 μm
Gap: 20 μm
Gap: 40 μm
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0
5
10
15
20
25
30
Δ [μm]

Conclusions

- **Field enhancements due to small grooves with round chamfers have been computed by using CST-MWS/EMS.**
  - At least 20% enhancement for R=50μm round chamfers.
  - Increases to 40% enhancement
    as the Δ size increases to 25μm.

- **More simulation studies to be done**
  - Conductor surfaces damaged by BD/discharge
  - What kind of shapes makes large field enhancements?