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Cavity parameters used in CST, preliminary results with blocking capacitor and more thermal analyses

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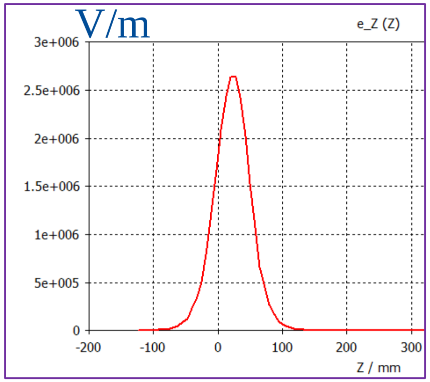
2nd Harmonic cavity Meeting

1/VII-2015

Definitions in CST



$P_{rms} = V_{rms}^2/R \Rightarrow R_s = V_{rms}^2/P_{rms} = V_{peak}^2/2P_{rms} = Veff^2/2P_{thermal} = R_{gennady}/2$

What are V_{eff}, P, R_{sh} in CST?

Voltage V_{eff}: CST integrates the electric field along the given voltage integration path (cavity axes typically). By definition V_{eff} takes into account time flight factor, but currently β = 1 is assumed (β - particle relative velocity).

Thermal losses P:

Result: Thermal Losses

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Loss calculation settings:

  Default conductivity for PEC surfaces: 5.800000e+007   S/m
  Consider surface losses on boundaries: *** none ***

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Computed 2 thermal loss distributions.

 1: Filename   : loss (#0001)_1(1)
    Solver     : Frequency Domain: S-Parameter [1(1)]
    Frequency  : 76.55 MHz
    Grid       : Tet
    Field Type: Dynamic Loss density
    Loss Type  : Electric Volume Loss
    Total Loss: 3.870068e-001 W

 2: Filename   : surface loss int (#0001)_1(1)
    Solver     : Frequency Domain: S-Parameter [1(1)]
    Frequency  : 76.55 MHz
    Grid       : Tet
    Field Type: Surface Loss Density
    Loss Type  : Surface Loss
    Total Loss: 1.048295e-001 W
```

FD solver -> Thermal solver

Result: Heat Flow Values

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Heat Flow [temperaturesource1]:                              -1.949943e-001 W
Heat Flow [temperaturesource2]:                               2.881760e+000 W
Heat Flow [temperaturesource3]:                               0.000000e+000 W
Heat Flow [thermalloss0: El. Volume Loss Distribution]:       3.870204e-001 W (rms) (imported:
Heat Flow [thermalloss0: Surface Loss Distribution]:          1.025462e-001 W (rms) (imported:


Total Heat Flow:  3.176333e+000 W (rms) =  6.352665e+000 W (peak)

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External power scaling factors:
- thermalloss0:    1.000000e+000
External power sum considered:  4.895666e-001 W (rms) =  9.791332e-001 W (peak)
```

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External power scaling factors:
- thermalloss2:    6.504000e+003
External power sum considered:  3.184784e+003 W (rms) =  6.369569e+003 W (peak)
```

Shunt impedance: $R_{sh} = V_{eff}^2/P$

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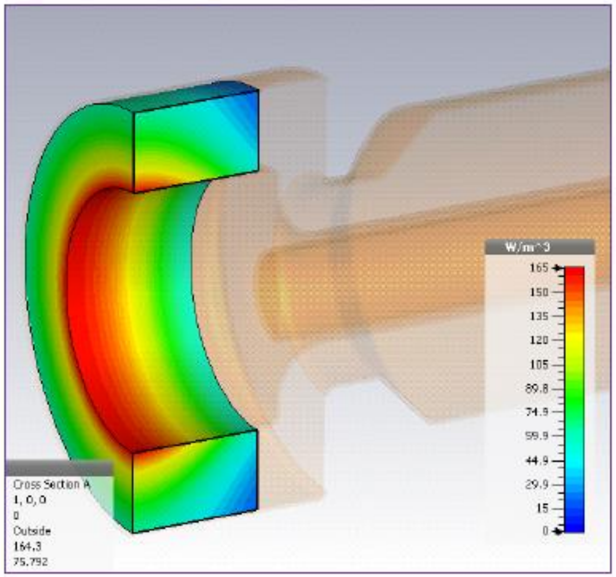
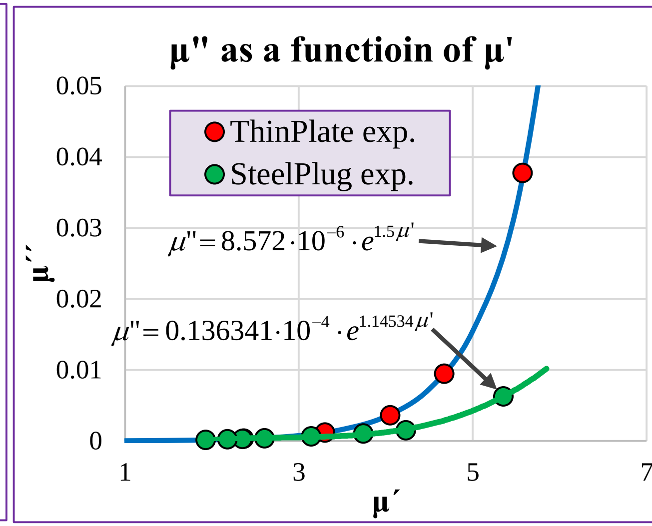
FD, EM and trans. model with garnet with averaged μ´ & μ´´

Garnet with fixed parameters μ´=3.5, $\tan\delta_e$ = 0.0001 and $\tan\delta_m$ = 0.000467. Equivalent to transmission model



<u>Tianhuan Luo, ThinPlate data</u>
F = 75.503 MHz
For V_peak = 100 KV:
P_ferrite_e = 8.11 kW
P_ferrite_m = 63.25 kW
P_ferrite = 71.36 kW
P_copper = 9.14 kW
P_total = 80.5 kW
The Omega3P EM simulation agrees well with Gennady's results.



tanδ_m	4.67e-4	2.06e-4	
R_sh, kΩ	128	230	CST EM
P , kW	78	43.5	
R_sh, kΩ	124	205	Omega3P
P , kW	80.5	48.7	
R_sh, kΩ	78.5	152	Transmit. model
P , kW	127.4	65.8	

For garnet with fixed parameters FD solver and EM solver (CST and Omega3P) deliver close results.

For f=76 MHz μ´=3.5 => SteelPlug tanδ = 0.000206 (or tanδ = 0.0002145 from Tan's approximation)

Recalculating Tianhuan Luo results with SteelPlug tanδ = 0.000206
P_total=8.11+9.14+71.36*206/467=48.72 kW
Rsh = 100^2/48.72 = 205 kΩ

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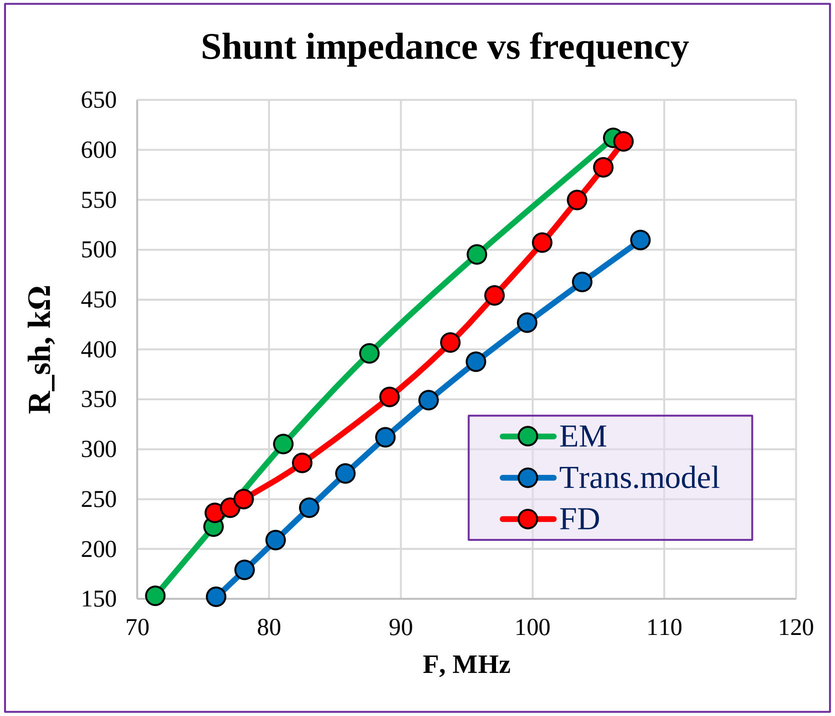
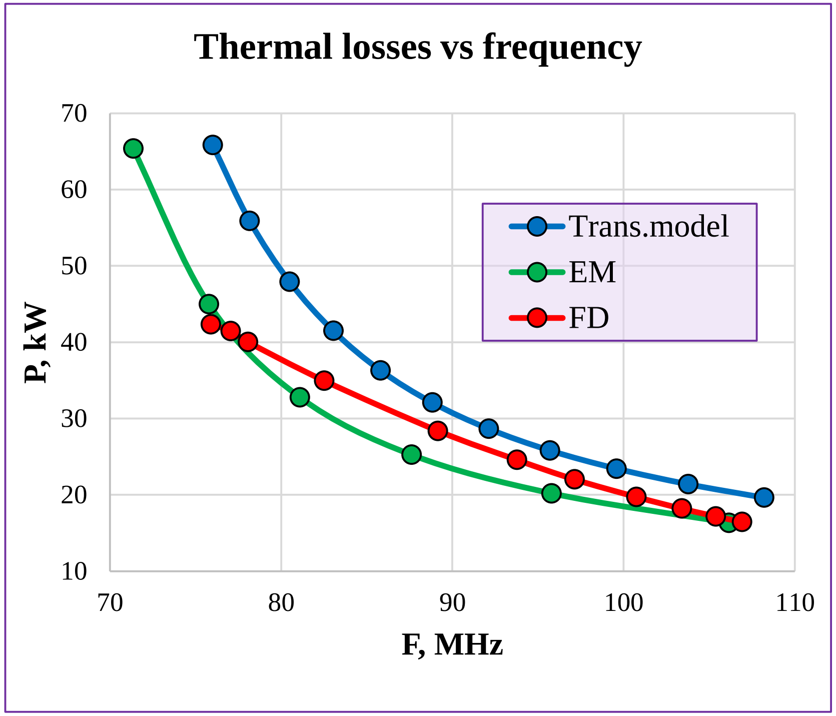
Uniform garnet vs non-linear garnet

Uniform garnet – transition model and CST eigenmode solver
Non-linear garnet – CST frequency domain with external bias





Losses in copper and dielectric losses:

- Frequency domain solver with uniform garnet - 16.6 kW
- Eigenmode solver with uniform garnet - 16.7 kW
- Frequency domain with non-linear garnet at 106 MHz - 16.4 kW
- Transition model at 106 MHz - 20 kW

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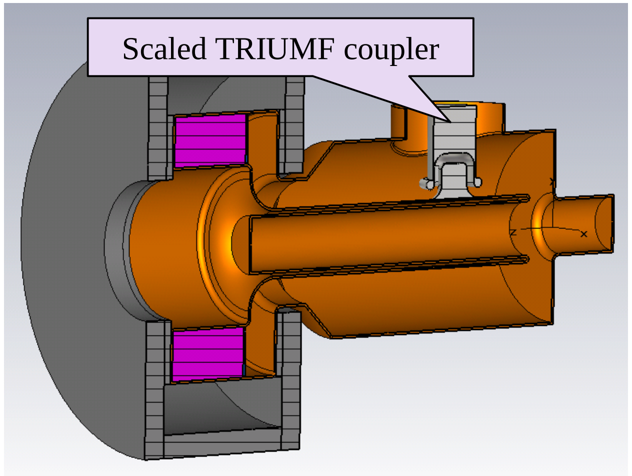
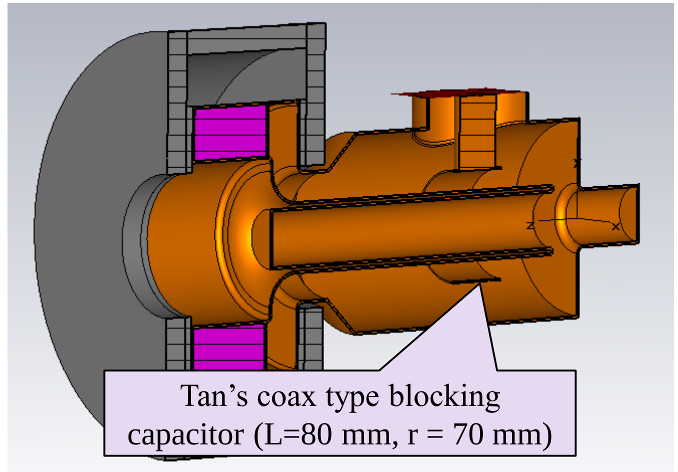
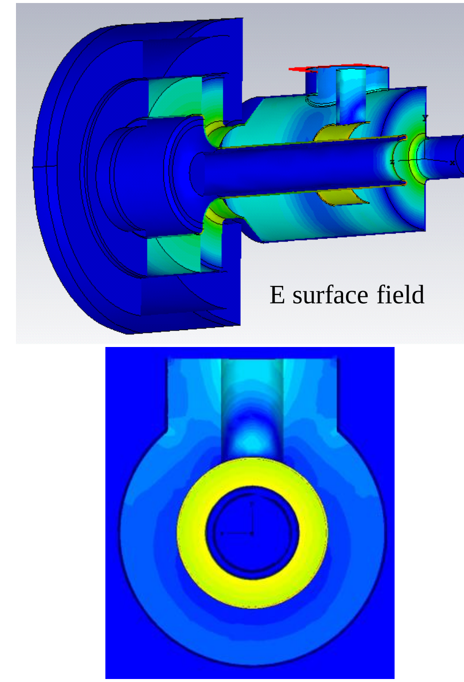
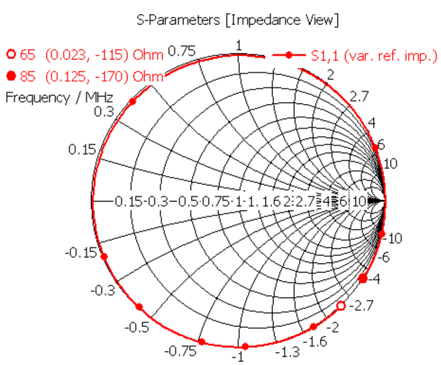
Power coupler or blocking capacitor

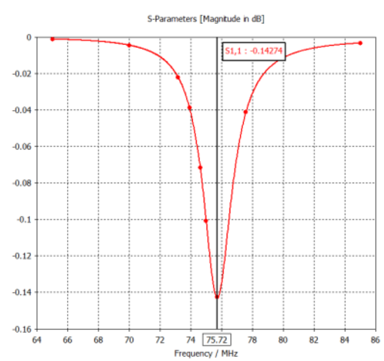


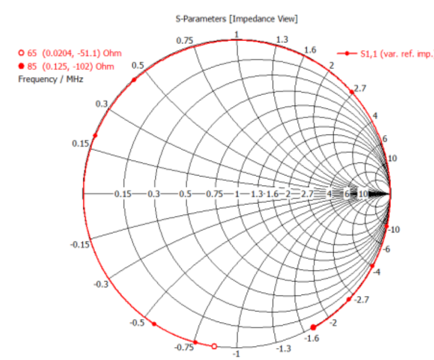


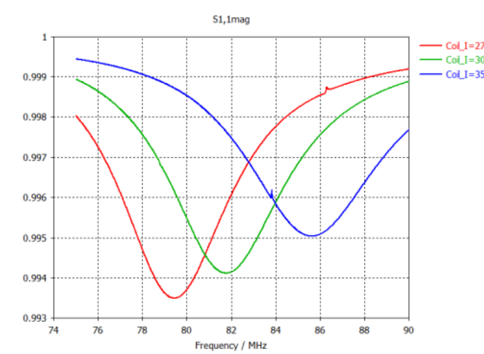


Capacitance (10pF from trans. model)) is not convenient and sufficient requirement for designing. It is not even clear what is its definition in the 3D model.



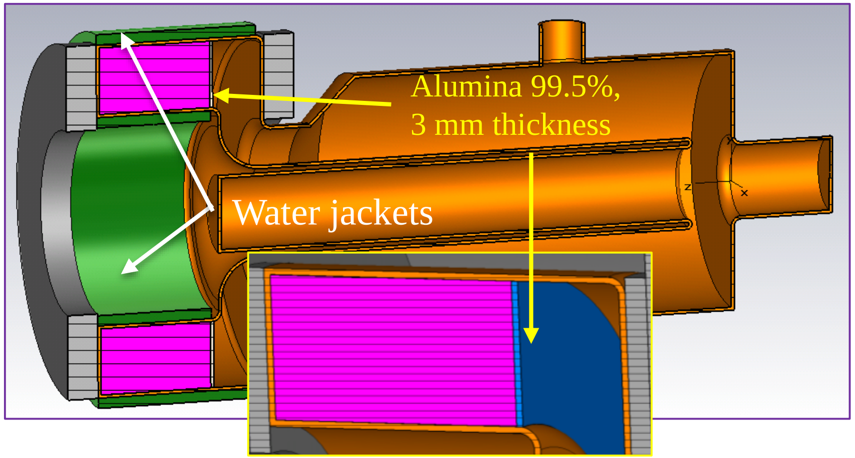


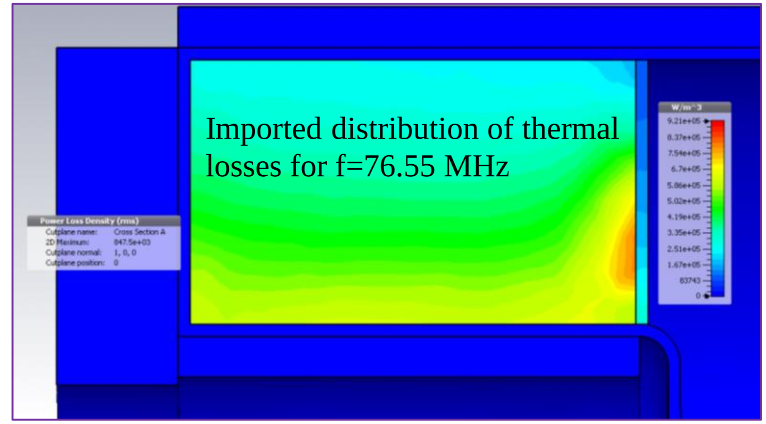




Both are overcoupled. For higher frequency the reflection is increasing.

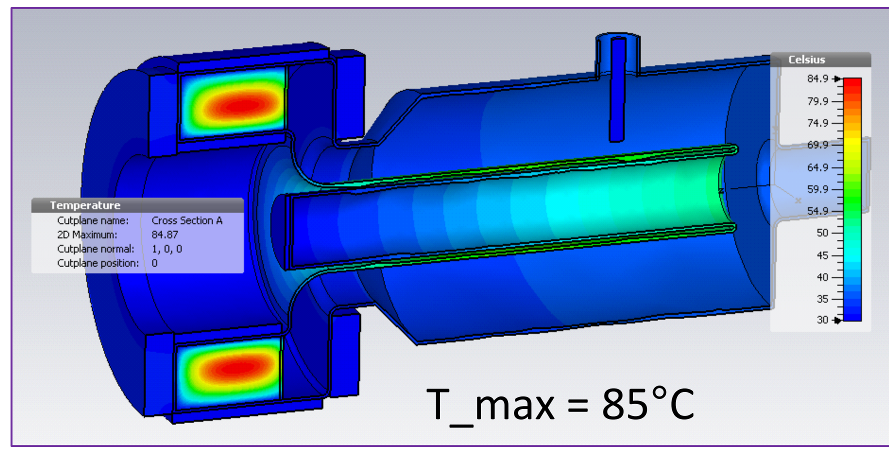
Thermal analyses with alumina cooling disk





Thermal conductivity
Al_2O_3 - 30 W/K/m
Al800 - 3.5 W/K/m

Simulation with thermal losses of P=3.2 kW and cooling water temperature of 30 °C, old ramp.



Temperature distribution

Additional alumina disks will reduce T_max

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