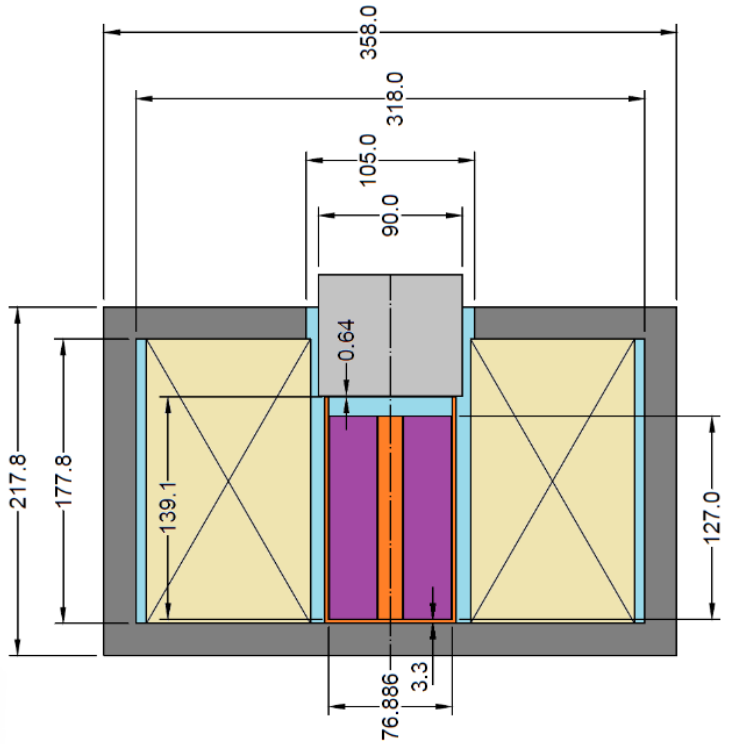
RF Losses in Layers of Glue between Garnet Blocks and Alumina Disks iteration #2

2-nd Harmonic Booster Cavity Meeting

Sept. 29, 2016

First attempt to evaluate the impact of layers of STYCAST 2850FT (Catalist 9) on the RF Properties of a Cavity

Aug. 2016



Typical properties of the glue mix at 1 MHz:

Permittivity	ε = 5.0
Loss tangent	tg(δ) = 0.03

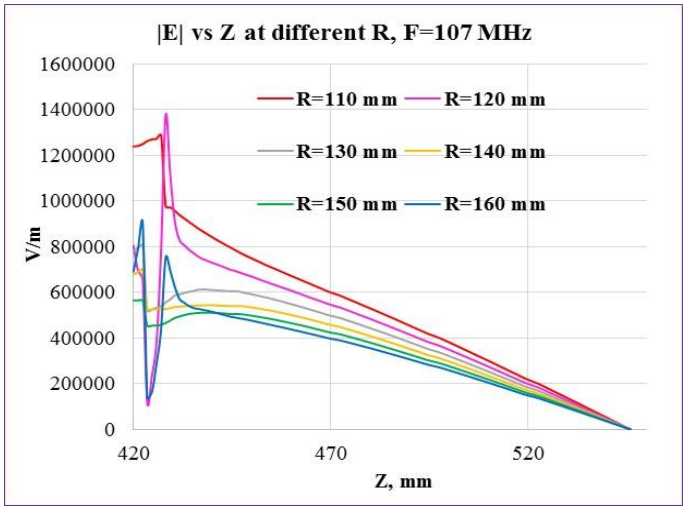
Interpretation of the measurement results pointed to a significantly higher values of the loss tangent: tg(δ) > 0.1

Reason of this discrepancy can be uncertainties of the measurement setup (symmetry and thicknesses) and of our knowledge of the material properties.

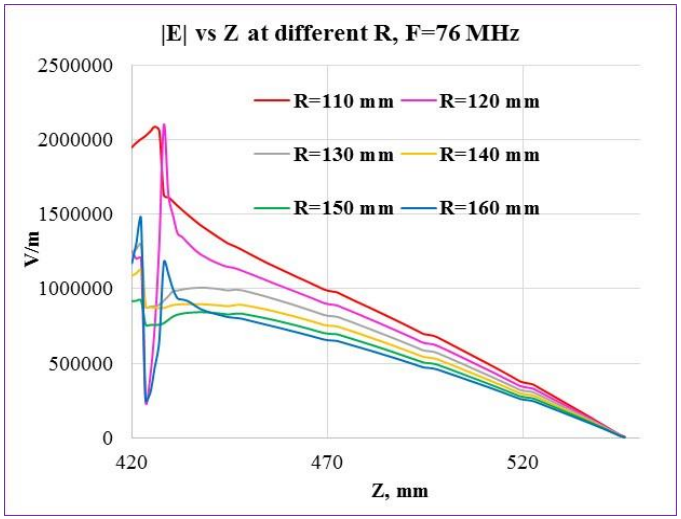
It was recommended to use a classical setup for measurement of RF properties.

Modeling Additional Heat Deposition

Electric field in the tuner corresponding to V = 100 kV accelerating voltage at **107 MHz**



Electric field in the tuner corresponding to V = 100 kV accelerating voltage at **75 MHz**

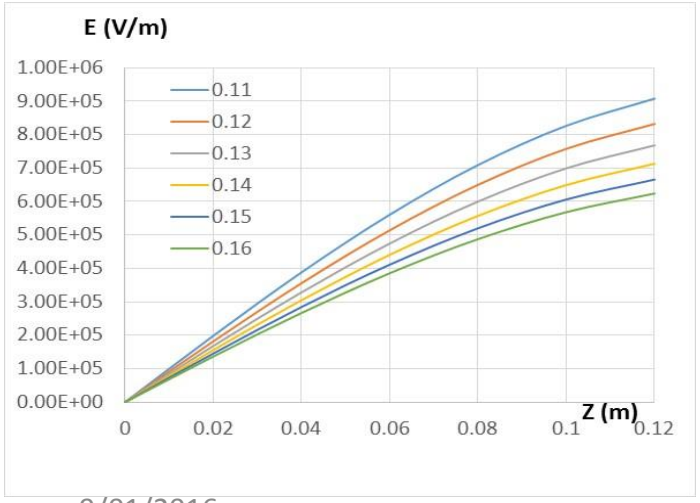


Assumptions:

ε = 5
t = 0.1 mm
tg(δ) = 0.1
Rep. rate – 15 Hz

Parameterization of the electric field in the tuner (Z0 = 0.15 m):

$E(r,z)\ [V/m] = 1\cdot10^6\cdot r_{in}/r\cdot\sin(2\pi\cdot z/z0)$



$E(r,z)\ [V/m] = 1.7\cdot10^6\cdot r_{in}/r\cdot\sin(2\pi\cdot z/z0)$

Volumetric power loss:

$p\ [W/m^3] = 1/2\cdot\omega\cdot\varepsilon\varepsilon_0\cdot tg(\delta)\cdot E^2$

Surface power loss:

$p_S\ [W/m^2] = 1/2\cdot t\cdot\omega\cdot\varepsilon\varepsilon_0\cdot tg(\delta)\cdot E^2$

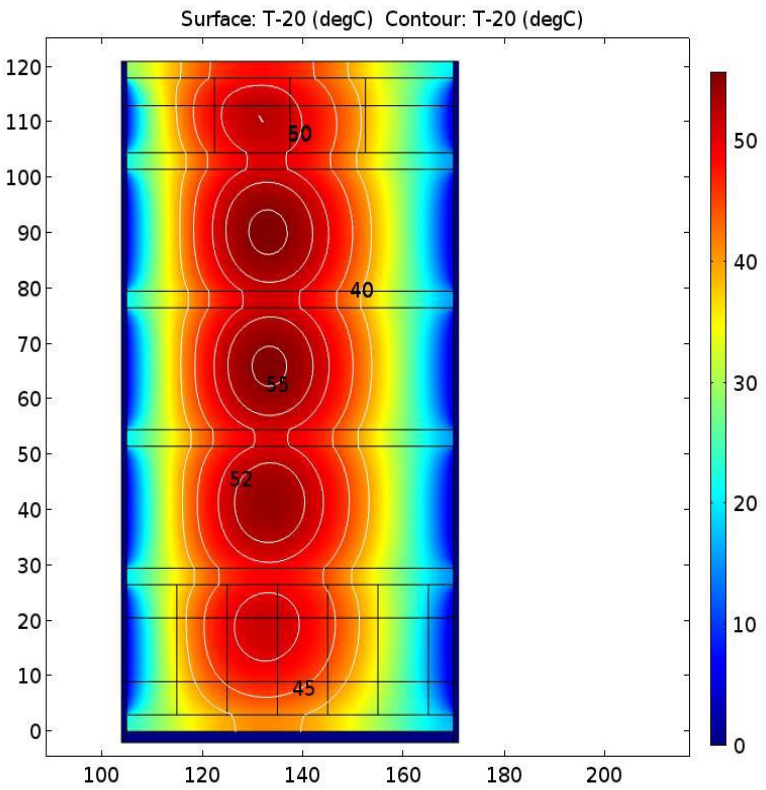
$f = 107\ MHz \rightarrow p_S = 1.5\cdot10^{-7}\cdot E^2$

$f = 75\ MHz \rightarrow p_S = 1.0\cdot10^{-7}\cdot E^2$

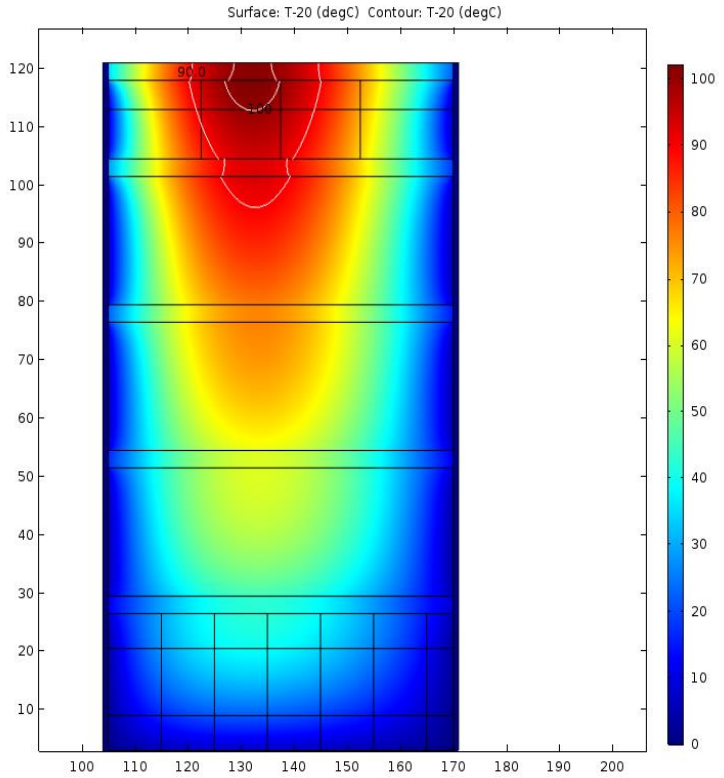
Average $p_s = 2\cdot10^4\cdot(r_{in}/r)^2\cdot\sin^2(2\pi\cdot z/z0)$ $[W/m^2]$

Impact on the Temperature Distribution in the Tuner

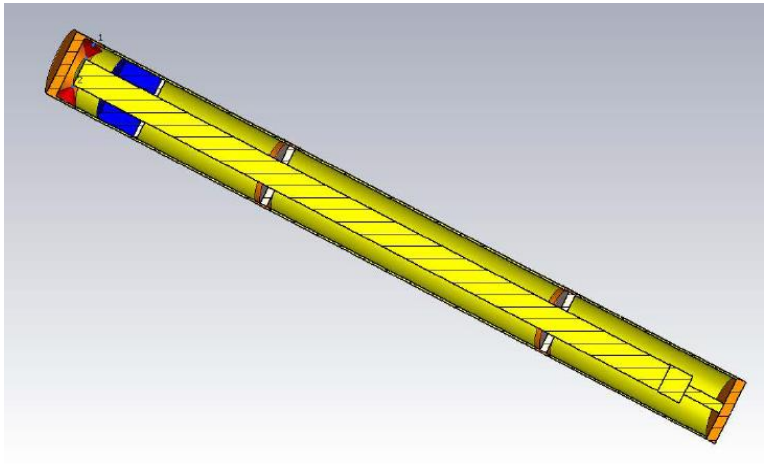
No glue

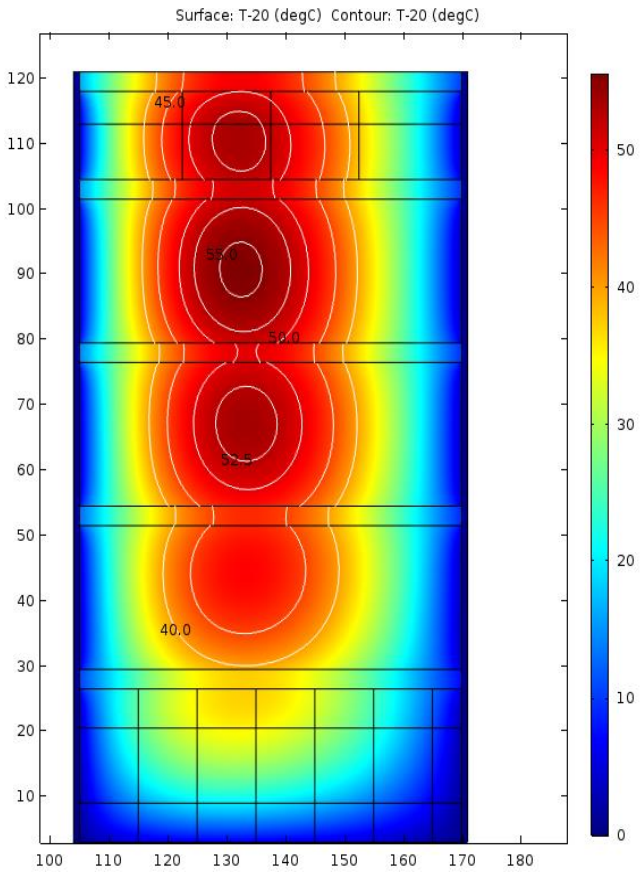


0.1 mm layer of glue



Updated results for the loss tangent





Measure Q with no epoxy

Q(meas) =1628, Q(sim) = 2342

Adjust resistive losses in simulation until Q(sim) ~ Q(meas)

Measure Q with epoxy. Do a back-of-the-envelope calculation:

tanδ =0.017

Put epoxy in simulation using calculated **tanδ = 0.017**

Q(meas) = 235, Q(sim)=230

Evaluate sensitivity. If tanδ = 0.03 in sim, Q(sim) = 138

Used two approaches for adjusting resistive losses: uniform and at joints only

Used two different gaps in data and sim → same results

Large gap: 3.8”, small gap ~0.5”

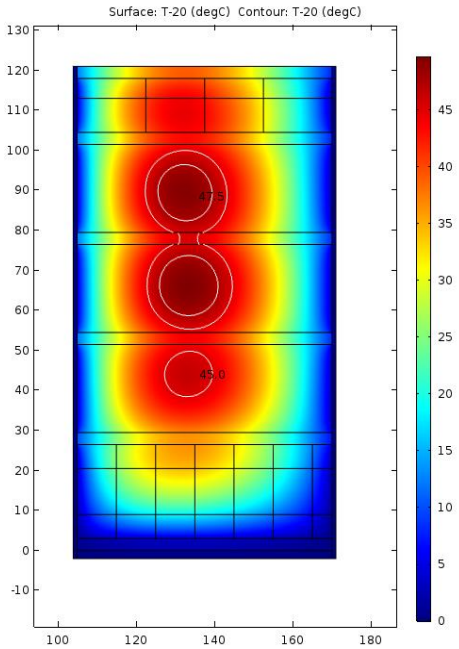
Just to be consistent

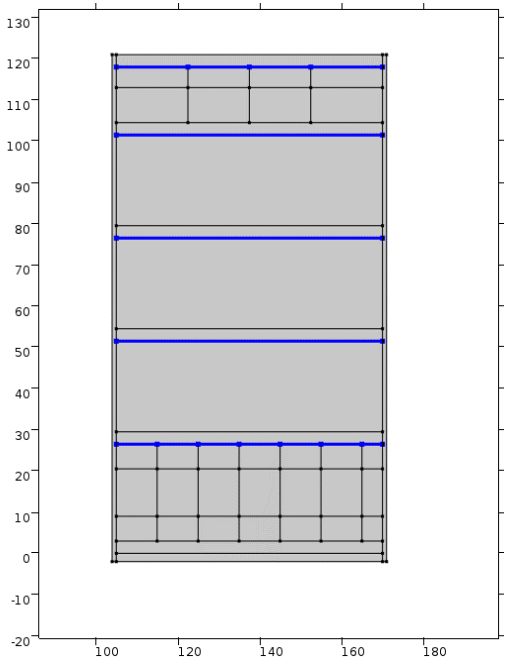
t = 0.1 mm
No loss in the glue.
No air gaps.

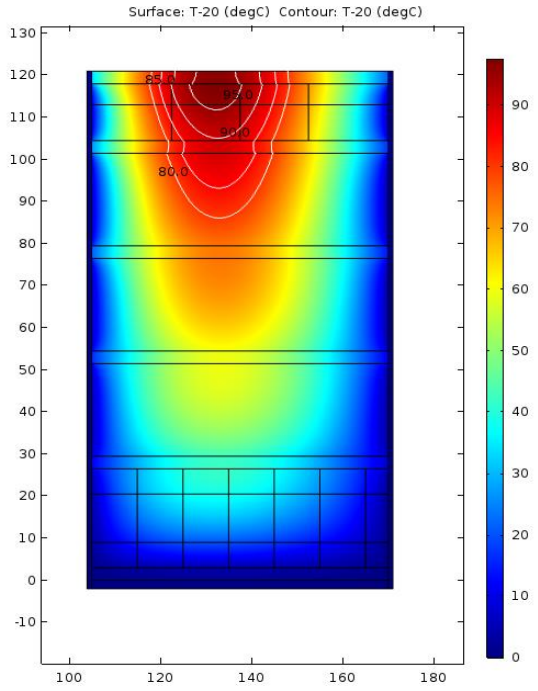
One half of the gaps

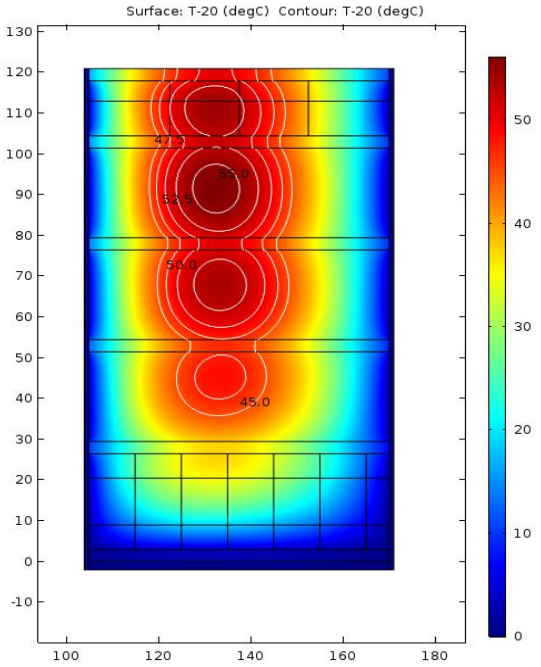
tg(δ) = 0.1

tg(δ) = 0.02

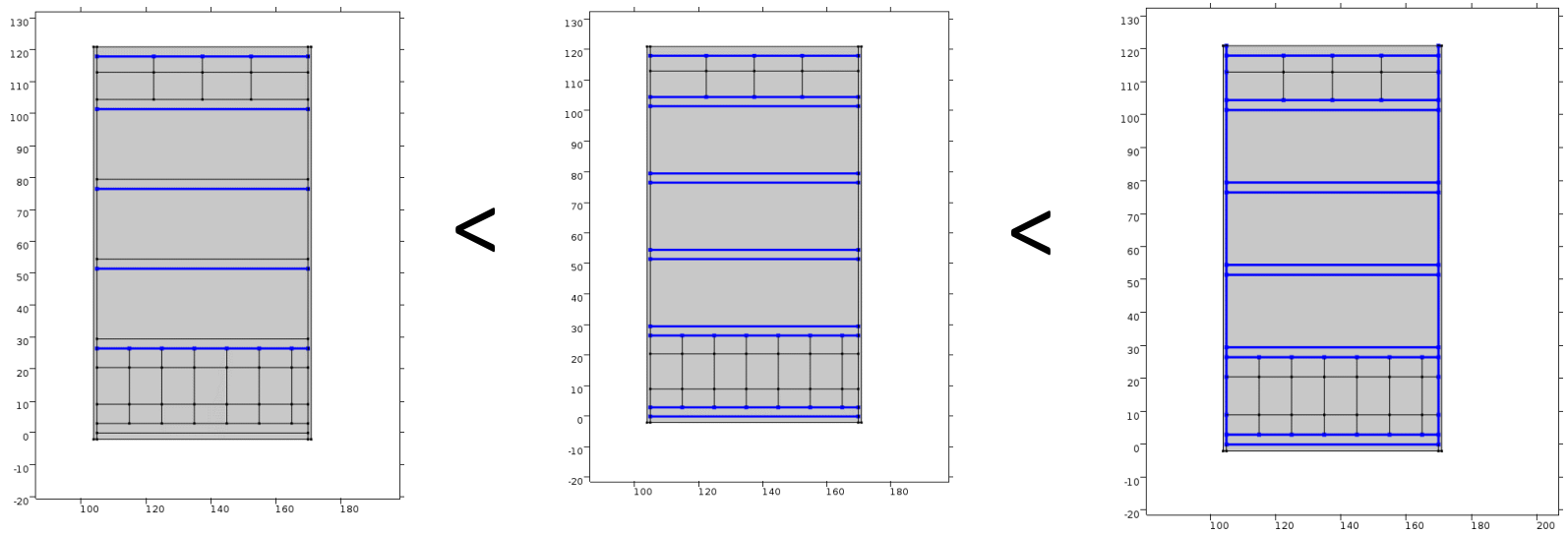


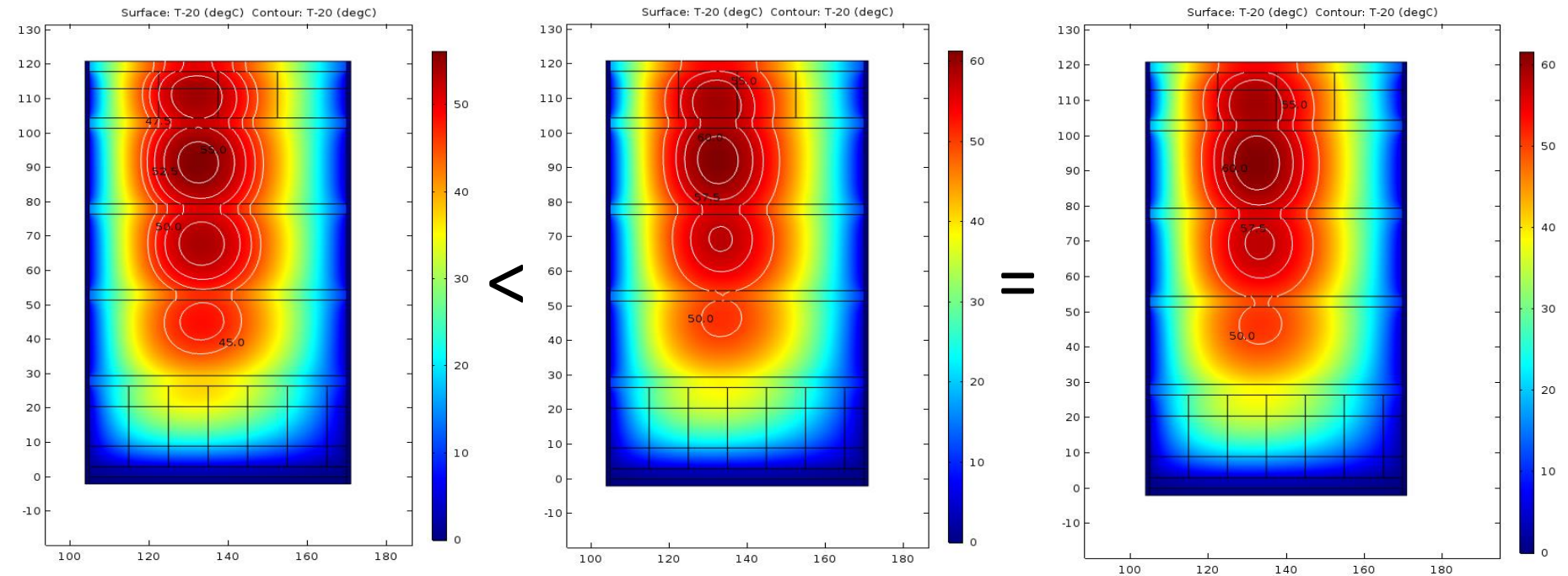






tg(δ) = 0.02




Surface: T-20 (degC) Contour: T-20 (degC)
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Conclusion

Classical setup for measurement of RF properties was used to measure the loss factor of the epoxy. Obtained loss tangent of ~0.017 compares well with the data provided by different manufacturers.

“Old” modeling results took into account only half of the gaps filled with epoxy. Adding more layers, although changes the temperature distribution, but modestly.

Power loss in the radial layers of epoxy does not noticeably change the temperature field.