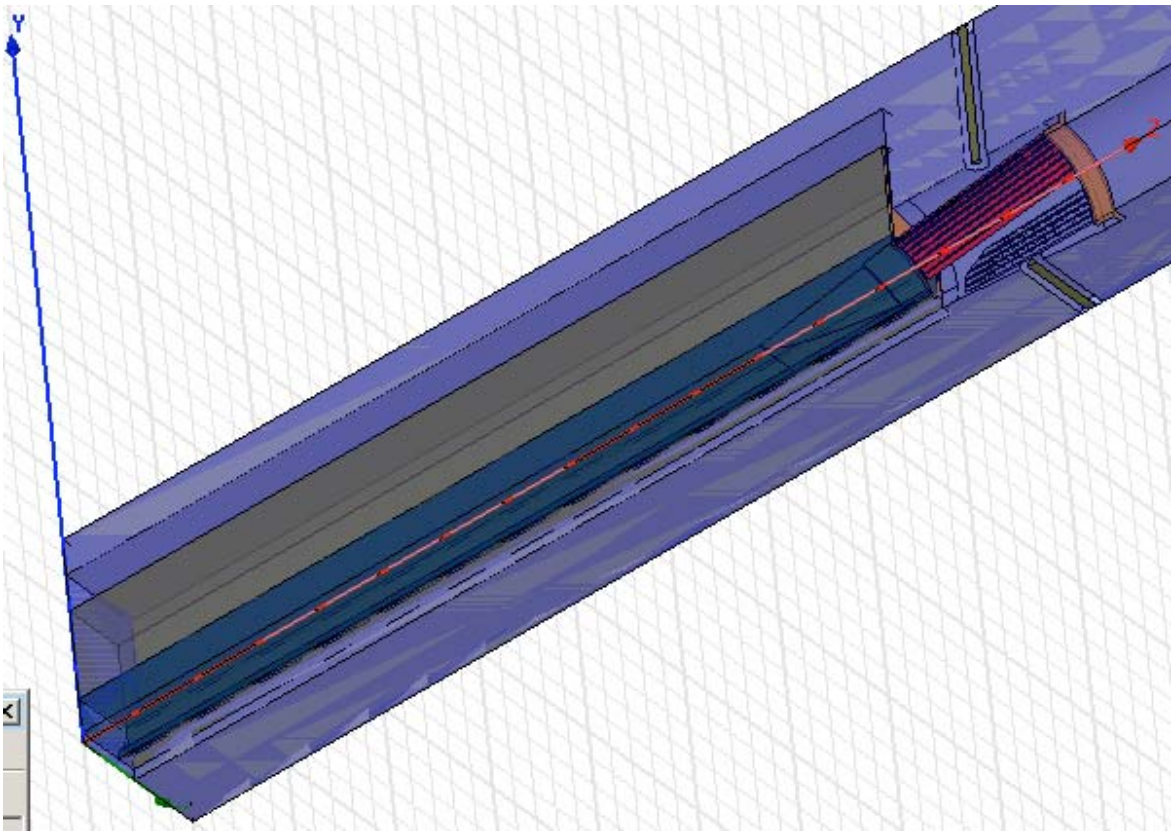
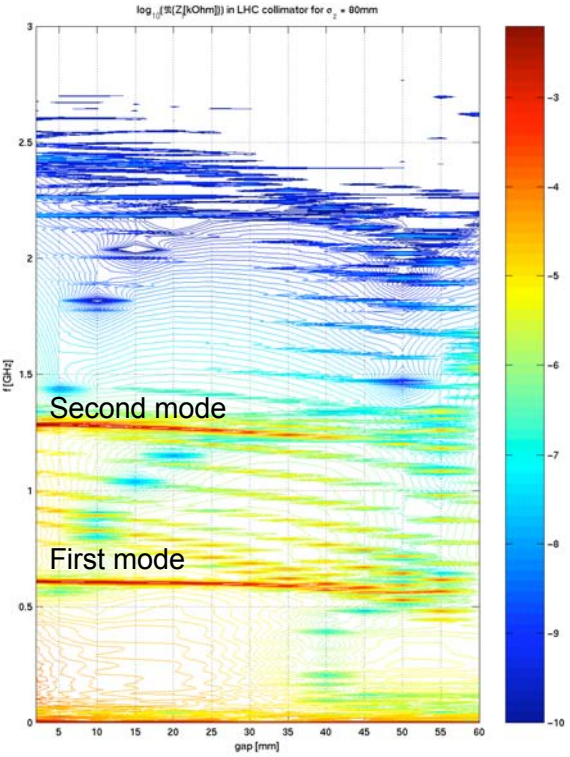
Simulation of trapped modes in LHC collimator

A.Grudiev

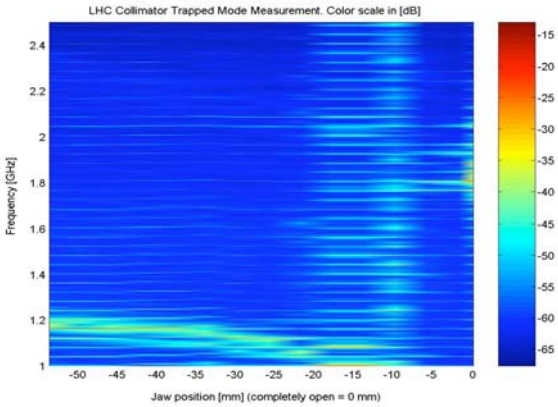
LHC collimator prototype geometry in HFSS



Effective longitudinal impedance calculated using GdfidL (left) and measured with SPS beam (right)

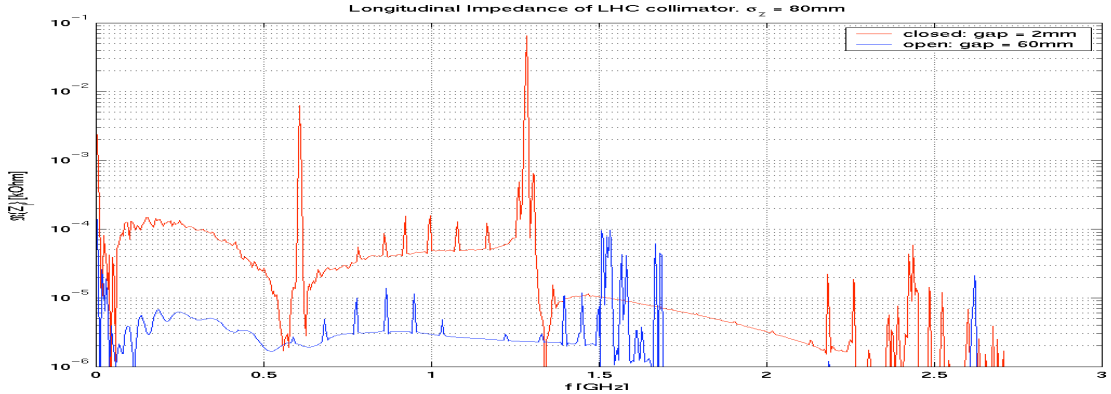


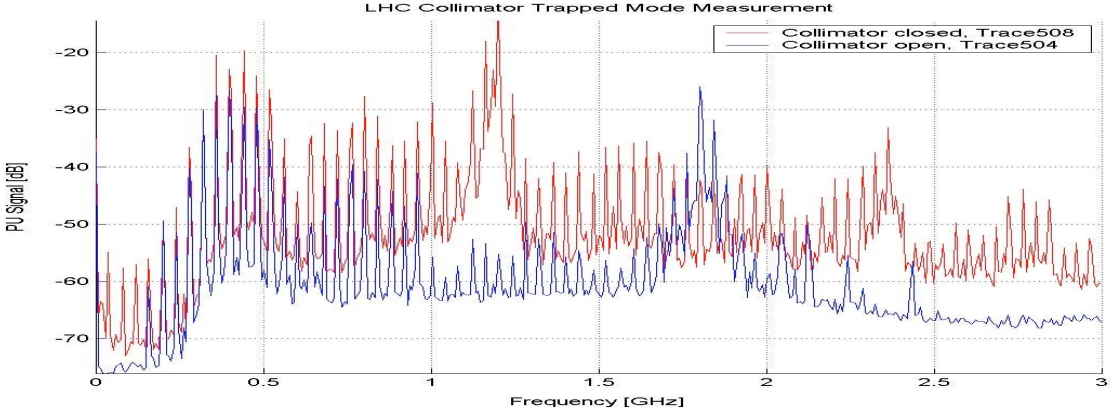
Measured by
F.Caspers and T. Kroyer



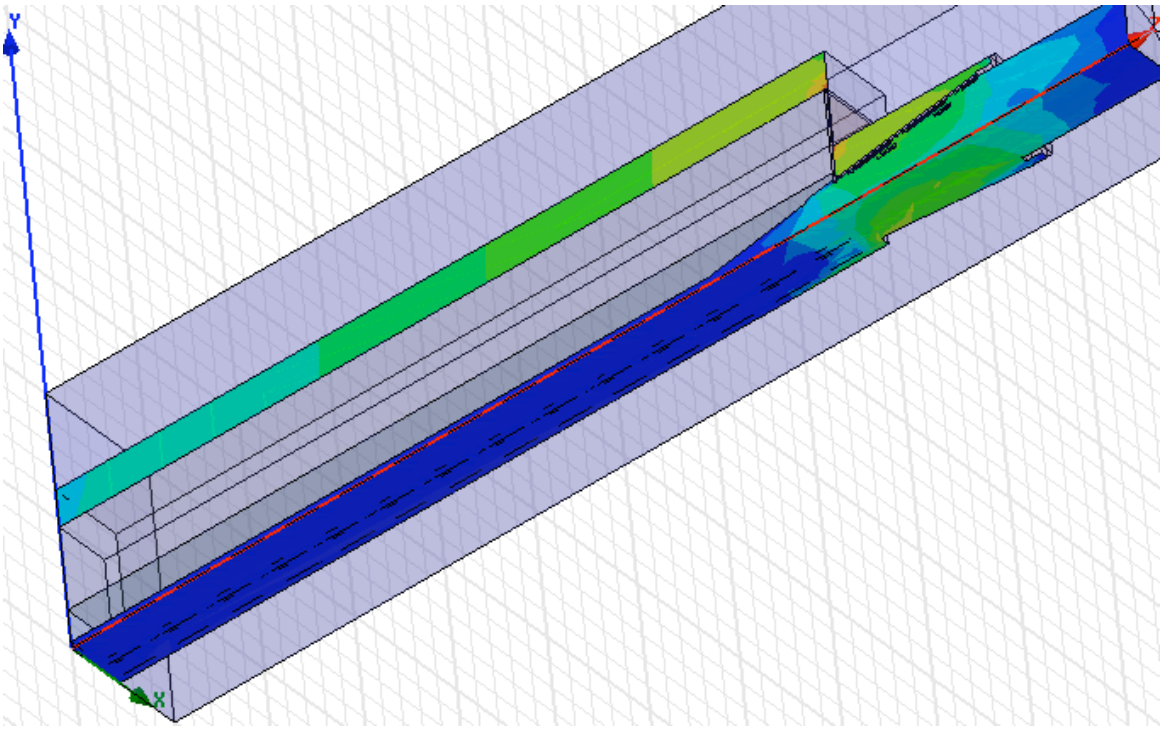
Gap varied from 6 to 60 mm

Effective longitudinal impedance calculated using GdfidL (left) and measured with SPS beam (right)

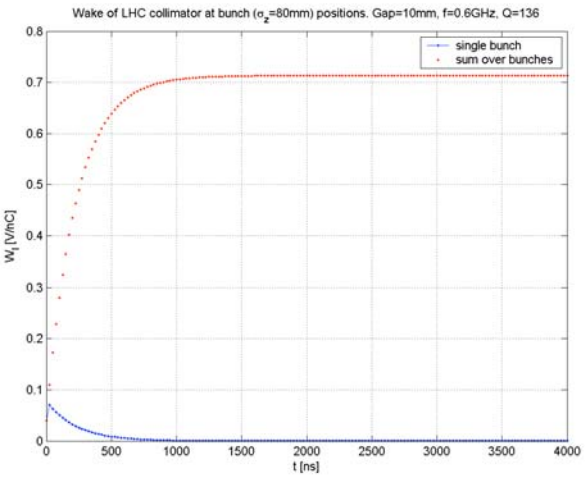




Electric field of the first m=0 mode in log scale (gap=10mm)



First bunch (blue) and total wake (red) along the train for the first m=0 mode



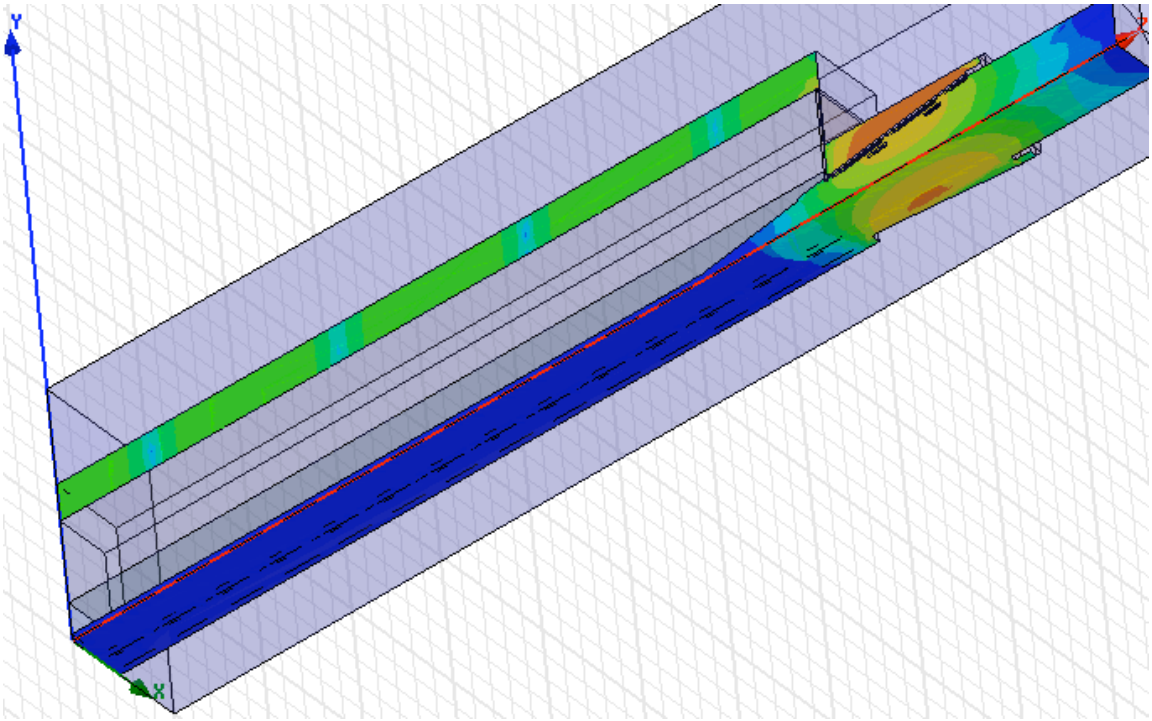
f=0.6GHz
(15th-harmonic of bunch frequency)
Q=136
r/Q = 0.1 Ohm (accelerator impedance)
k = 0.13 V/nC (loss factor)

For $\sigma_z = 80mm$
Max. single bunch energy loss:
0.7V/nC x 16nC = 11V

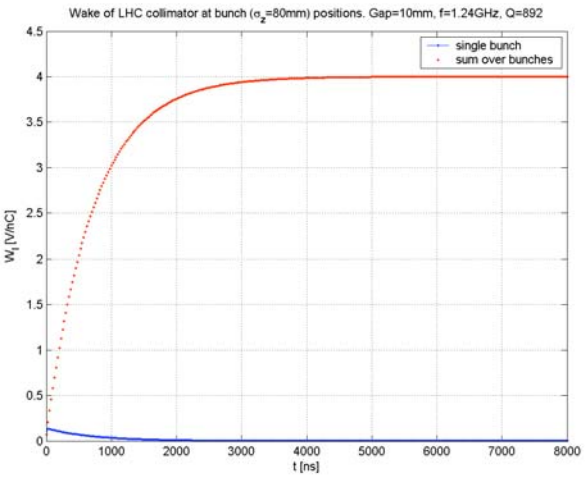
Total energy loss per train (2808 bunches):
dE = 0.5 mJ

Dissipated power: dE x frev = 6 W

Electric field of the second m=0 mode in log scale (gap=10mm)



First bunch (blue) and total wake (red) along the train for the second m=0 mode



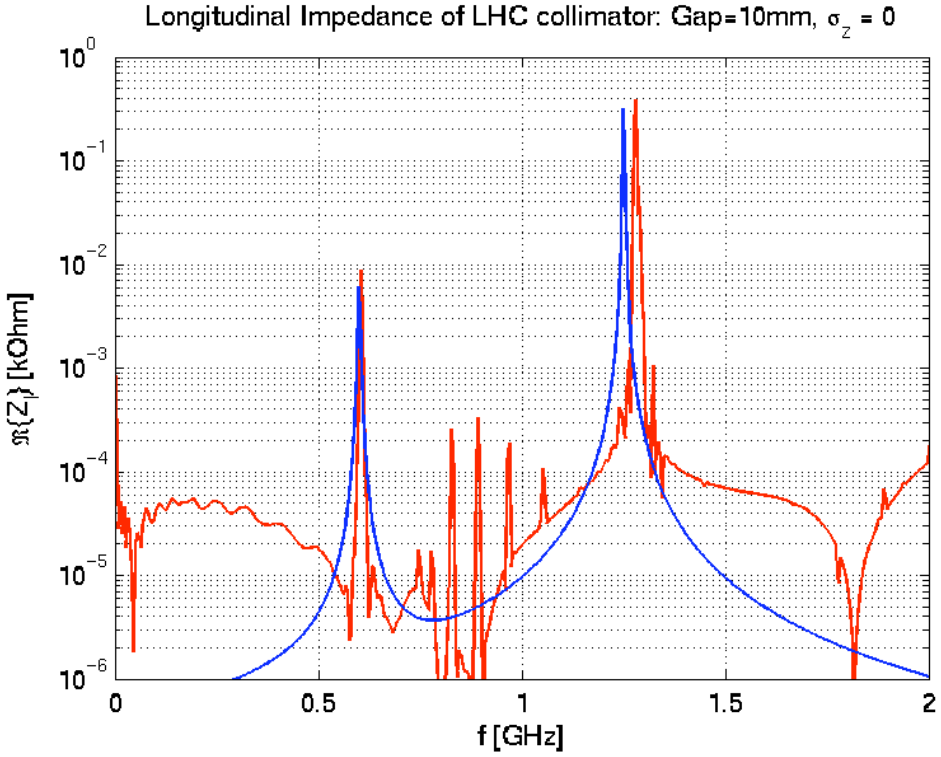
f=1.24GHz
(31st-harmonic of bunch frequency)
Q=892
r/Q = 2.67 Ohm (accelerator impedance)
k = 5.2 V/nC (loss factor)

For $\sigma_z = 80mm$
Max. single bunch energy loss:
4V/nC x 16nC = 64V

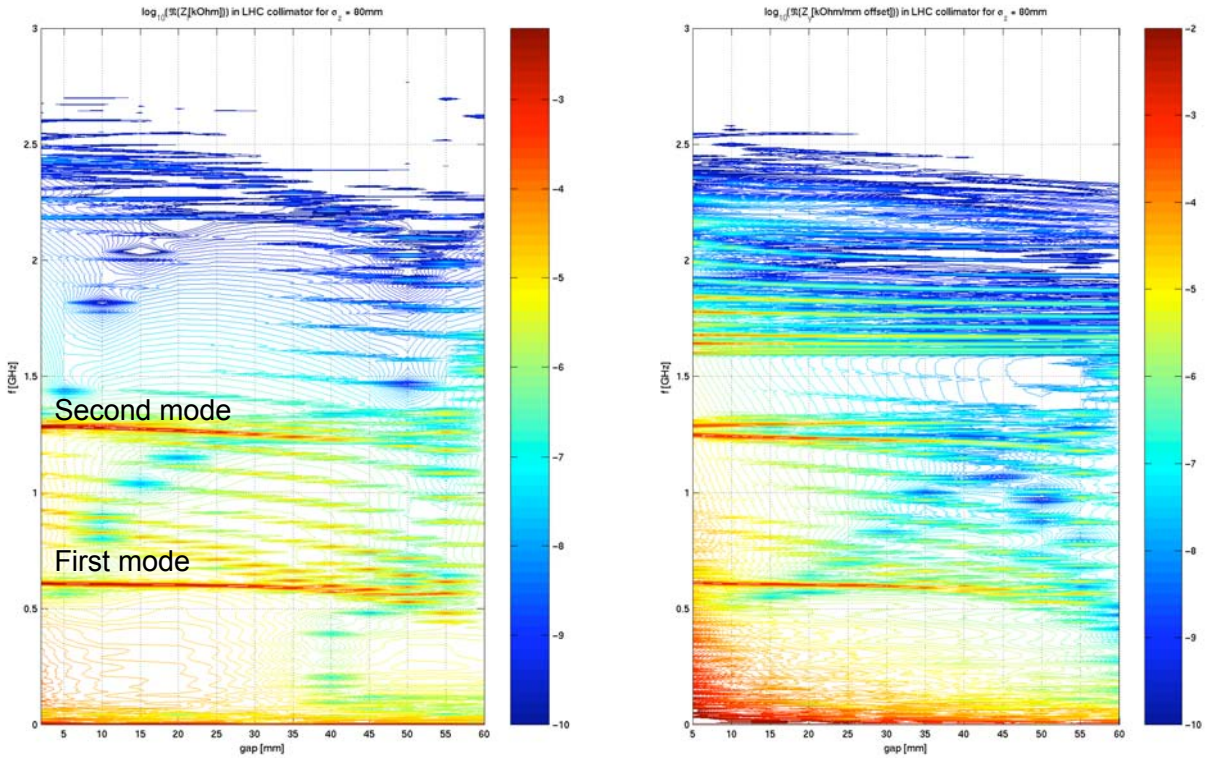
Total energy loss per train:
dE = 2.8 mJ
Total dissipated power per collimator:
dE x frev = **32 W**
12.3% is dissipated in rf fingers: **4 W**

D. Schulte has calculated a mode at 1.15GHz with 110W of total dissipated power

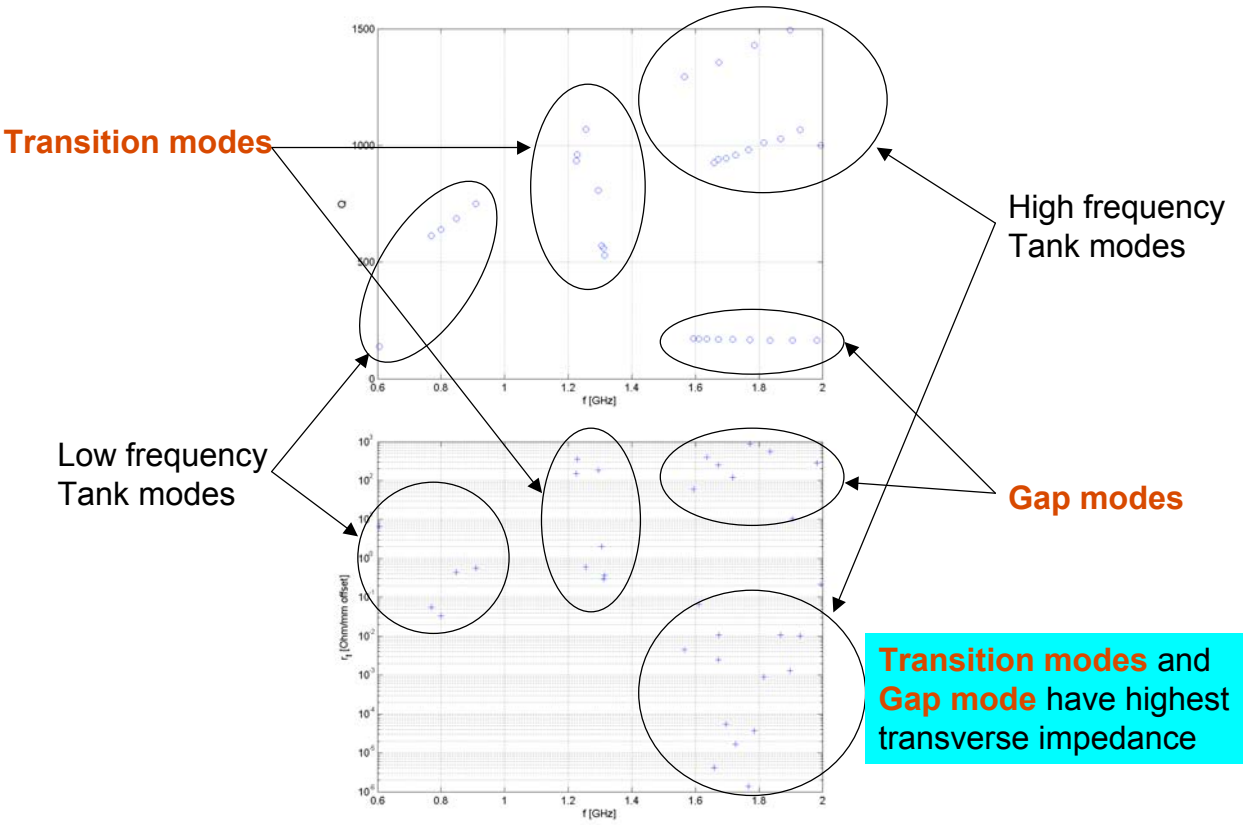
Longitudinal impedance calculated using Gdfidl (red) and reconstructed from HFSS (blue)



Effective longitudinal (left) and transverse (right) impedance calculated by GdfidL

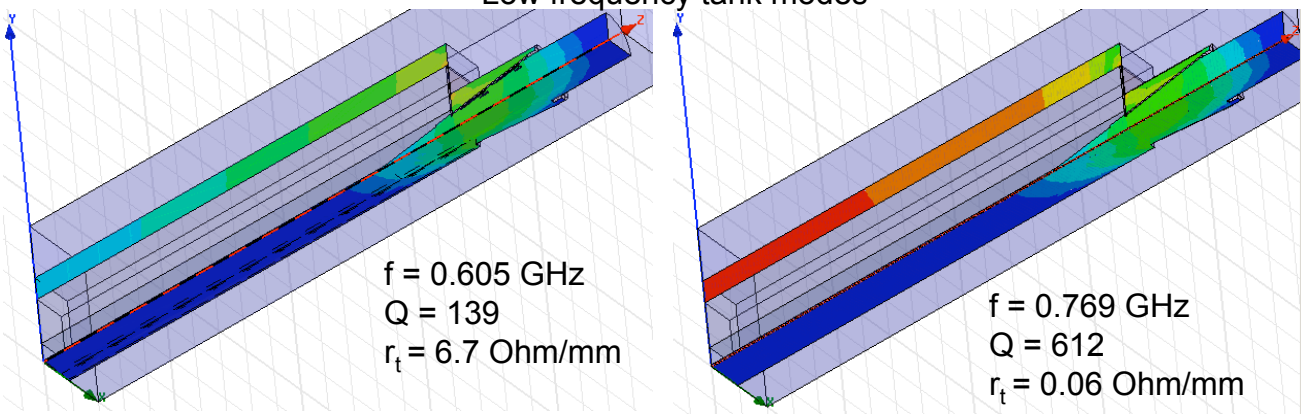


Q-factor and transverse impedance of trapped modes

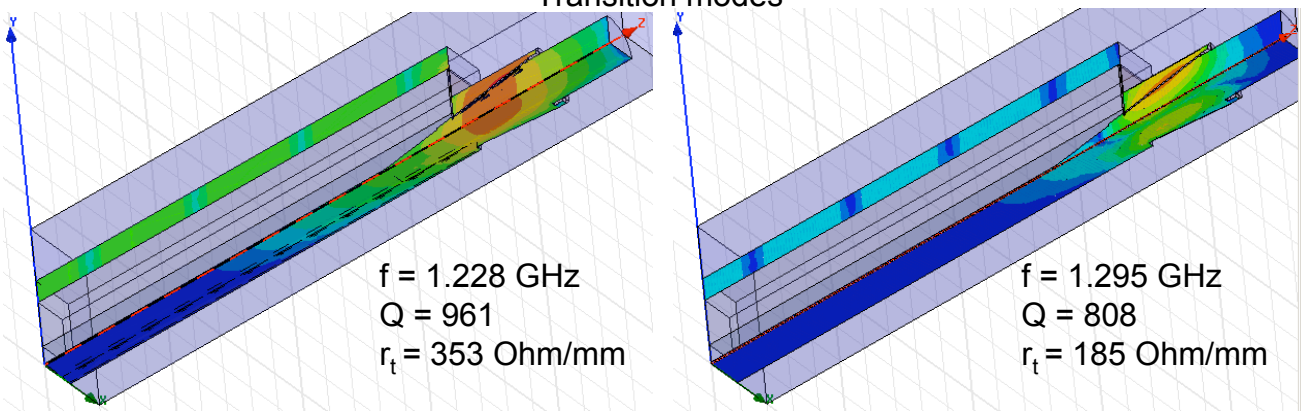


Electric field distribution of some trapped modes (m=1)

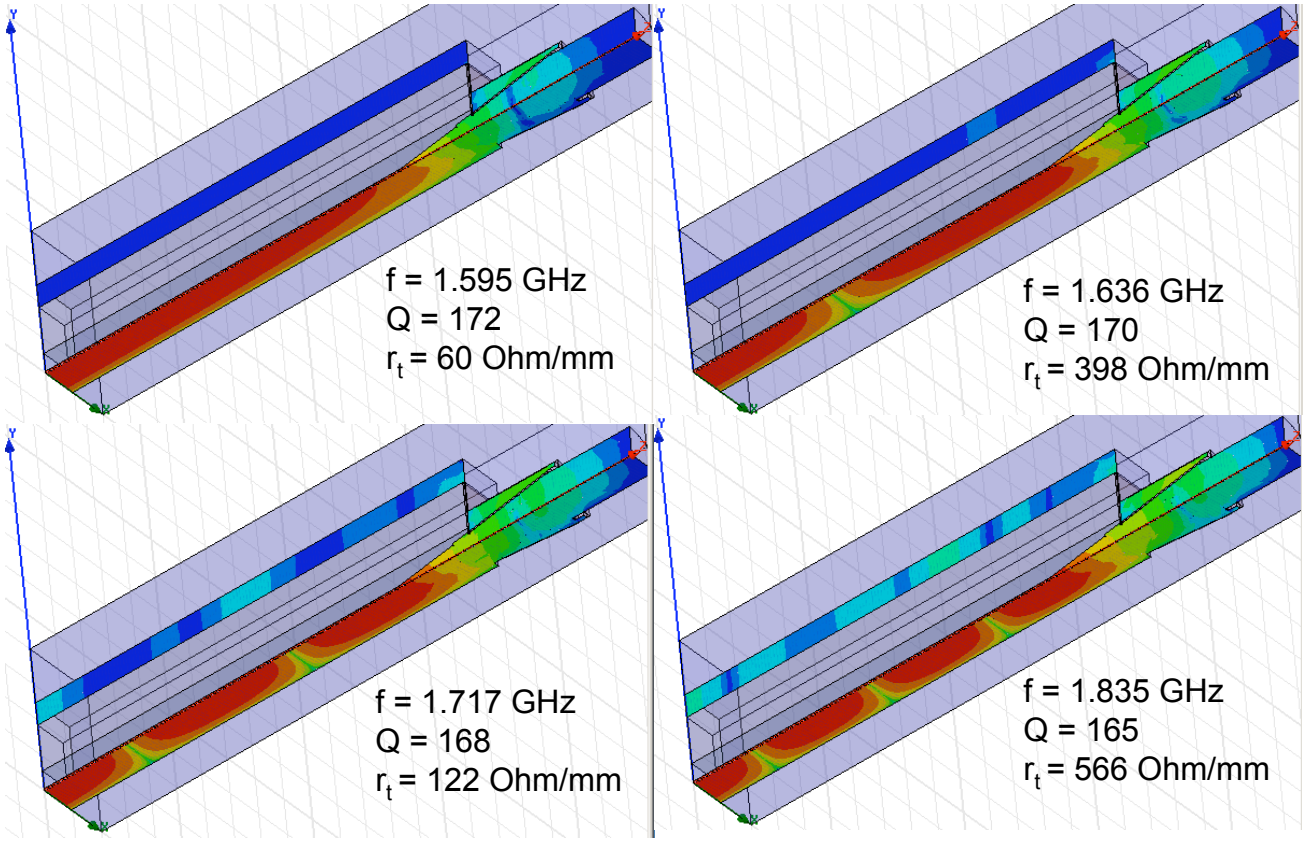
Low frequency tank modes



Transition modes



Electric field distribution of gap modes (m=1)



Electric field distribution of high frequency tank modes (m=1)

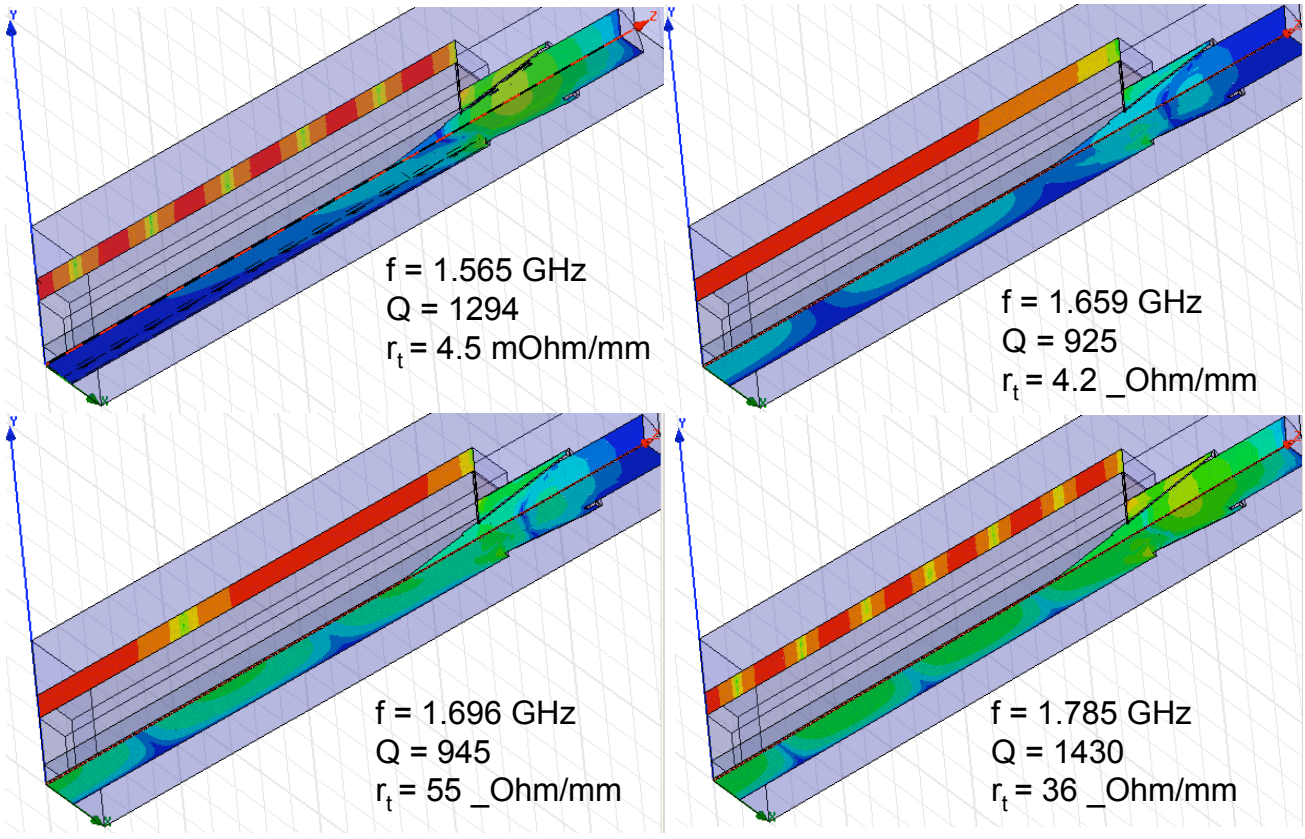


Table of transverse mode parameters: gap = 5mm

- f[GHz] Q r_t/Q[Ohm/mm^2] r_t[Ohm/mm^2] k_t[V/nC/mm^2] r_t/Q[Ohm/mm] r_t[Ohm/mm] k_t[V/nC/mm] k_t(Fy)[V/nC/mm]

- **0.605 139 6.105e-004 8.486e-002 5.802e-004 4.815e-002 6.693e+000 4.576e-002 4.507e-002** 0.769 612 1.467e-006 8.976e-004 1.772e-006 9.100e-005 5.570e-002 1.099e-004 1.078e-004 0.799 639 8.823e-007 5.638e-004 1.107e-006 5.269e-005 3.367e-002 6.613e-005 6.769e-005 0.848 687 1.135e-005 7.798e-003 1.512e-005 6.387e-004 4.388e-001 8.508e-004 8.432e-004 0.909 751 1.449e-005 1.088e-002 2.068e-005 7.604e-004 5.710e-001 1.086e-003 1.074e-003 **1.226 934 4.174e-003 3.898e+000 8.037e-003 1.624e-001 1.517e+002 3.128e-001 3.154e-001 1.228 961 9.441e-003 9.072e+000 1.821e-002 3.668e-001 3.525e+002 7.076e-001 7.040e-001** 1.255 1070 1.473e-005 1.576e-002 2.904e-005 5.601e-004 5.993e-001 1.104e-003 1.072e-003 **1.295 808 6.198e-003 5.008e+000 1.261e-002 2.283e-001 1.845e+002 4.645e-001 4.513e-001 1.306 570 9.626e-005 5.487e-002 1.975e-004 3.517e-003 2.005e+000 7.214e-003 6.707e-003** 1.312 560 1.452e-005 8.134e-003 2.993e-005 5.282e-004 2.958e-001 1.089e-003 1.178e-003 1.315 530 1.910e-005 1.012e-002 3.944e-005 6.929e-004 3.672e-001 1.431e-003 1.255e-003 1.565 1294 1.143e-007 1.480e-004 2.811e-007 3.486e-006 4.511e-003 8.570e-006 9.109e-006 **1.595 172 1.158e-002 1.991e+000 2.901e-002 3.463e-001 5.957e+001 8.677e-001 8.508e-001** 1.611 171 1.288e-005 2.203e-003 3.259e-005 3.817e-004 6.526e-002 9.656e-004 1.628e-003 **1.636 170 8.031e-002 1.365e+001 2.064e-001 2.342e+000 3.982e+002 6.019e+000 5.867e+000** 1.659 925 1.585e-010 1.466e-007 4.130e-010 4.558e-009 4.216e-006 1.188e-008 1.182e-008 **1.672 169 5.269e-002 8.905e+000 1.384e-001 1.504e+000 2.541e+002 3.949e+000 3.924e+000** 1.673 940 9.243e-008 8.688e-005 2.429e-007 2.636e-006 2.478e-003 6.927e-006 6.866e-006 1.674 1356 2.806e-007 3.805e-004 7.379e-007 7.998e-006 1.085e-002 2.103e-005 2.075e-005 1.696 945 2.062e-009 1.948e-006 5.492e-009 5.800e-008 5.481e-005 1.545e-007 1.470e-007 **1.717 168 2.603e-002 4.374e+000 7.021e-002 7.234e-001 1.215e+002 1.951e+000 1.872e+000** 1.727 958 6.217e-010 5.956e-007 1.687e-009 1.718e-008 1.646e-005 4.660e-008 6.611e-008 1.767 981 5.264e-011 5.164e-008 1.461e-010 1.421e-009 1.394e-006 3.945e-009 4.446e-009 **1.772 167 1.948e-001 3.253e+001 5.422e-001 5.245e+000 8.759e+002 1.460e+001 1.429e+001** 1.785 1430 9.523e-010 1.362e-006 2.670e-009 2.546e-008 3.640e-005 7.138e-008 1.497e-007 1.815 1012 3.334e-008 3.374e-005 9.506e-008 8.765e-007 8.870e-004 2.499e-006 2.525e-006 **1.835 165 1.318e-001 2.175e+001 3.800e-001 3.428e+000 5.656e+002 9.881e+000 9.742e+000** 1.868 1028 4.096e-007 4.210e-004 1.202e-006 1.046e-005 1.075e-002 3.070e-005 3.003e-005 1.898 1494 3.463e-008 5.173e-005 1.032e-007 8.705e-007 1.300e-003 2.595e-006 2.913e-006 **1.906 164 2.506e-003 4.109e-001 7.502e-003 6.272e-002 1.029e+001 1.878e-001 1.866e-001** 1.930 1067 3.838e-007 4.095e-004 1.164e-006 9.489e-006 1.012e-002 2.877e-005 2.992e-005 **1.983 164 7.304e-002 1.198e+001 2.275e-001 1.757e+000 2.882e+002 5.474e+000 5.509e+000** 1.995 1000 8.990e-006 8.990e-003 2.817e-005 2.150e-004 2.150e-001 6.738e-004 7.114e-004