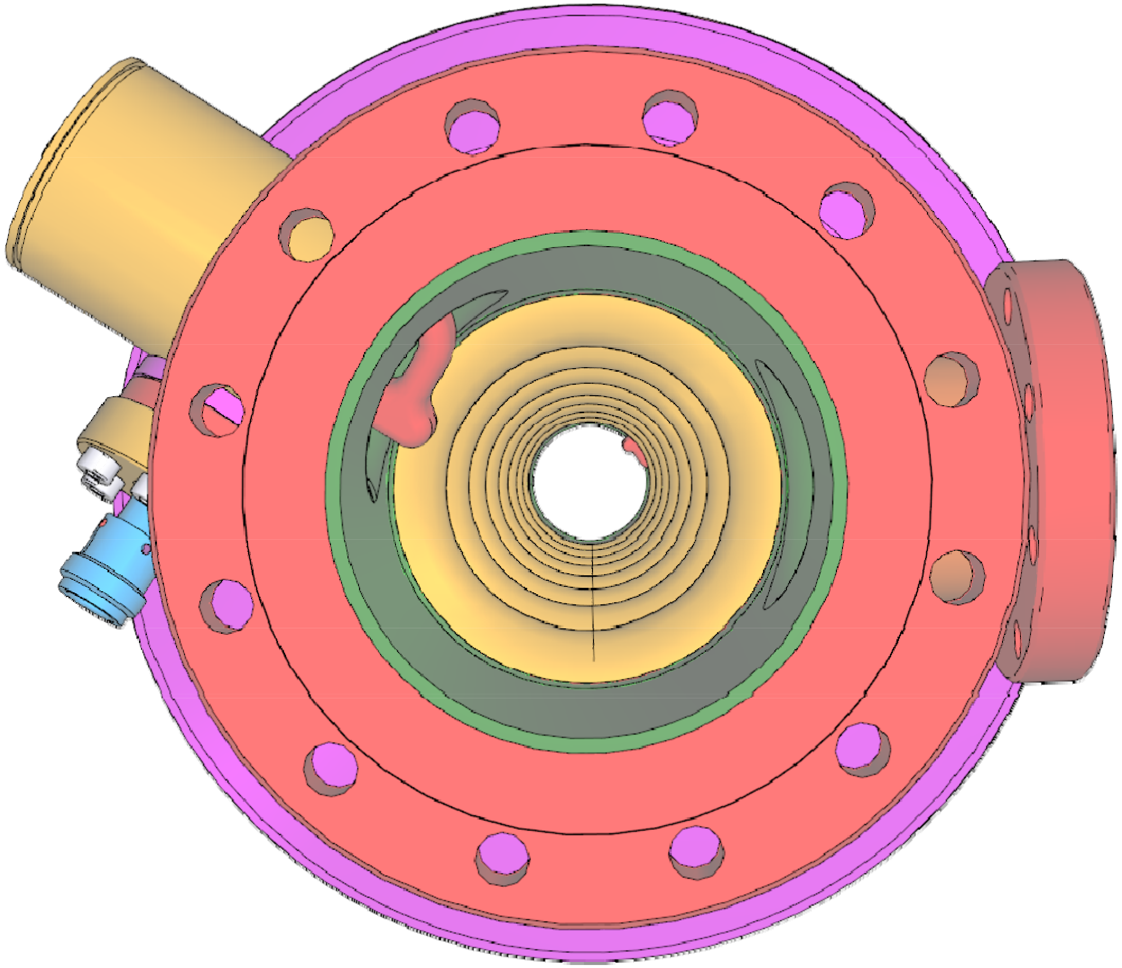
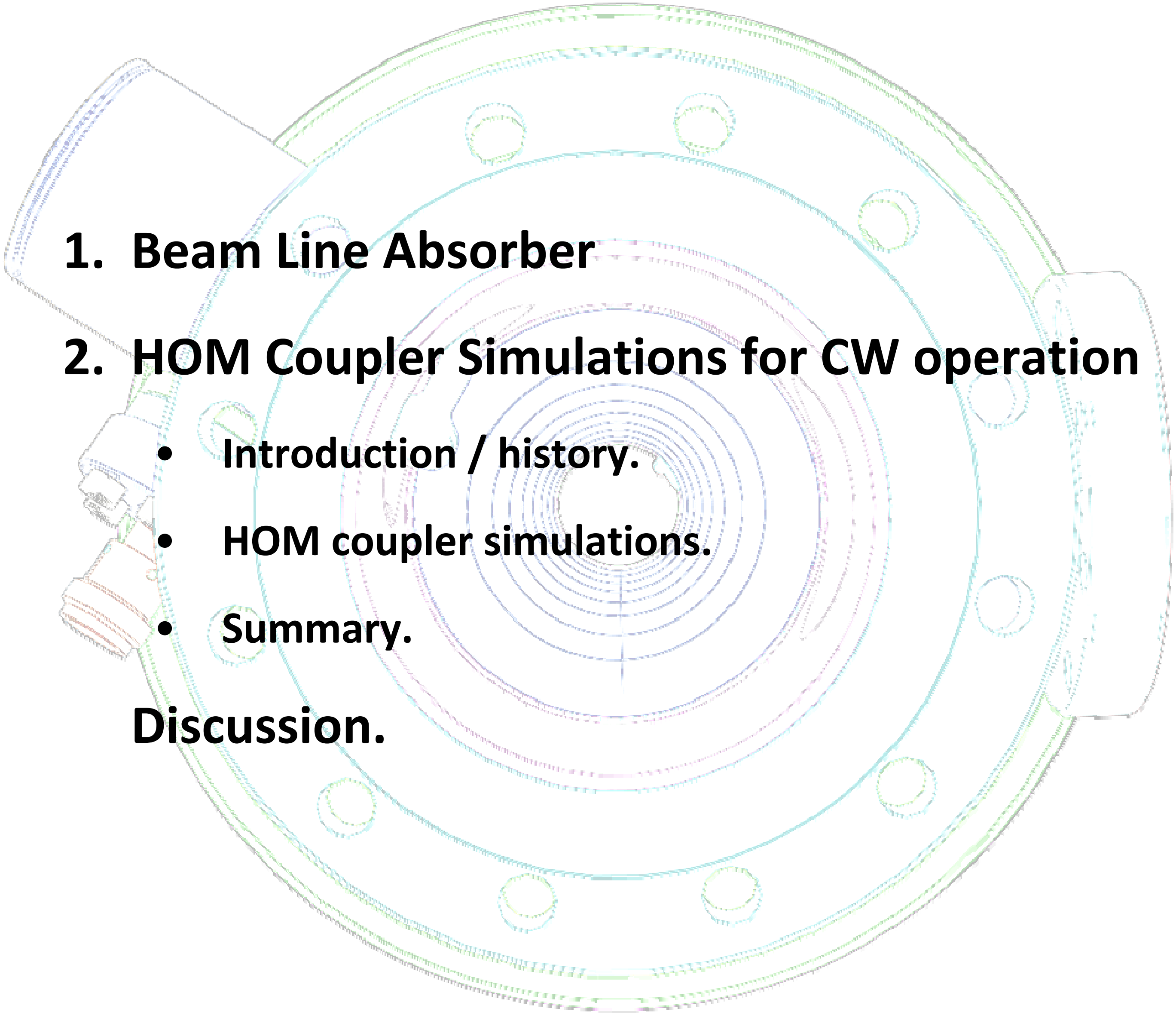
TTC topical meeting on CW SRF. Cornell University, June 12-14, 2013.

XFEL beamline loads and HOM coupler for CW

Denis Kostin, DESY



OUTLINE

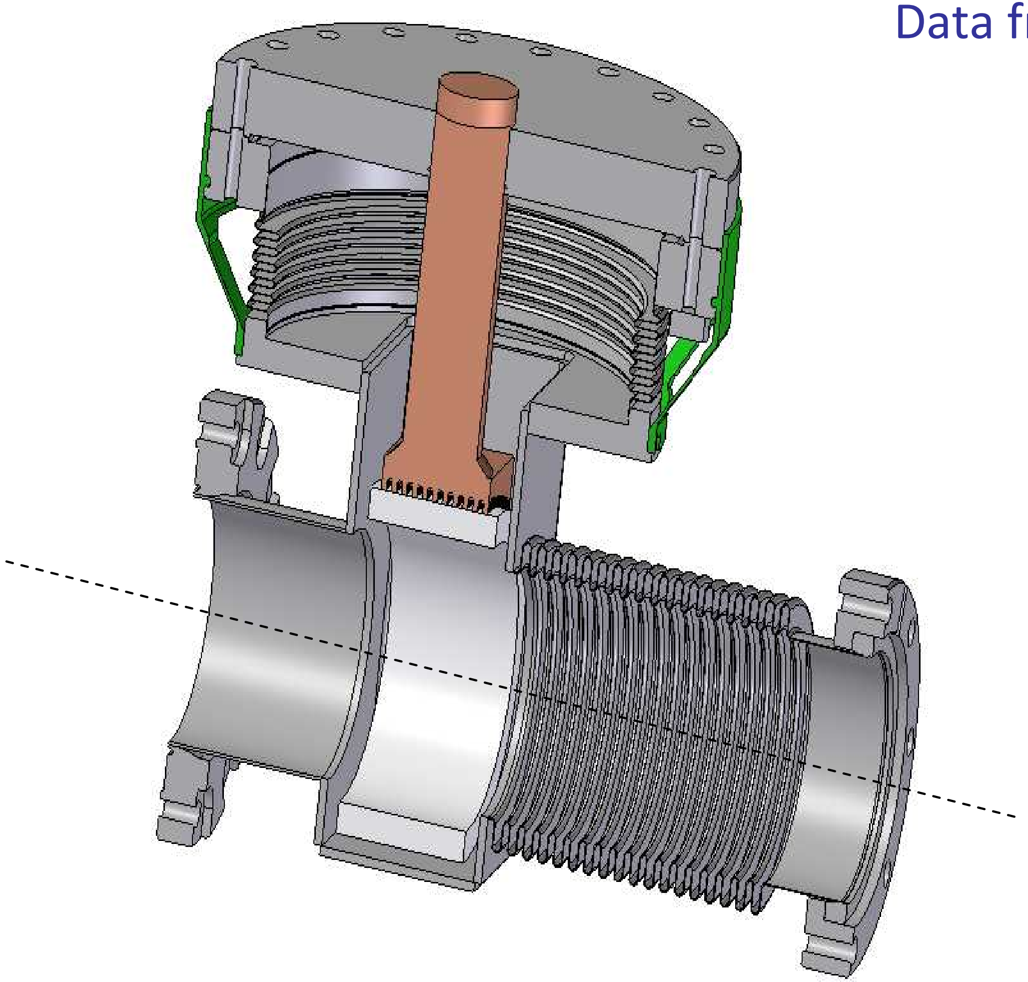


1. **Beam Line Absorber**
2. **HOM Coupler Simulations for CW operation**
   - **Introduction / history.**
   - **HOM coupler simulations.**
   - **Summary.**

Discussion.

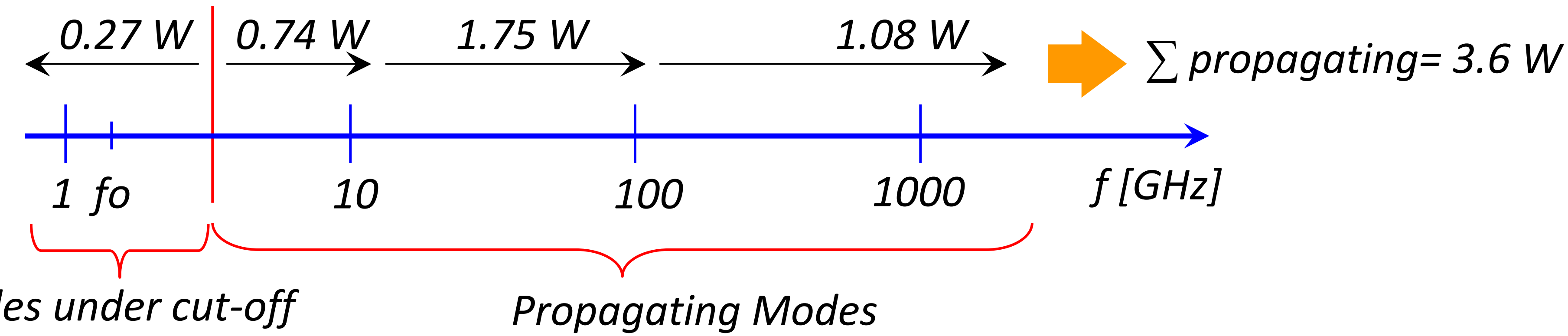
1. Beam Line Absorber

Data from Jacek Sekutowicz

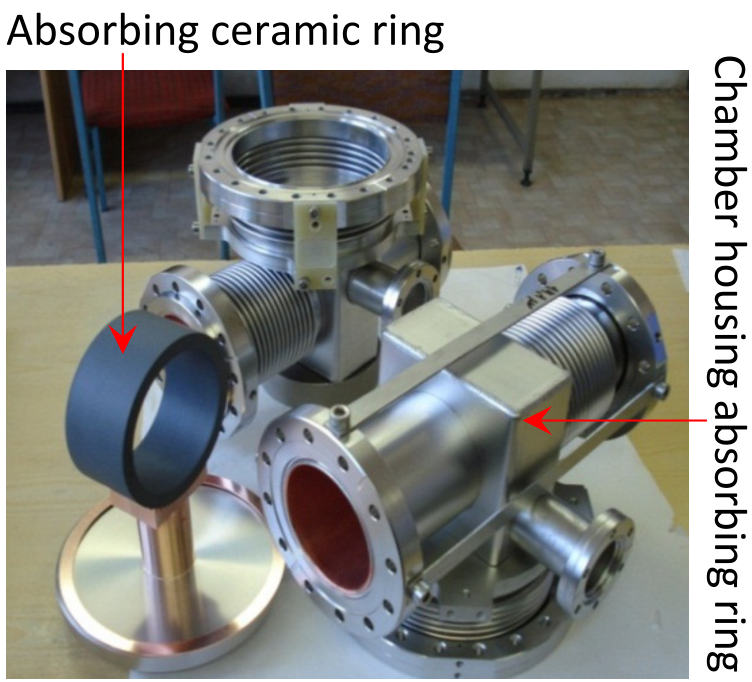


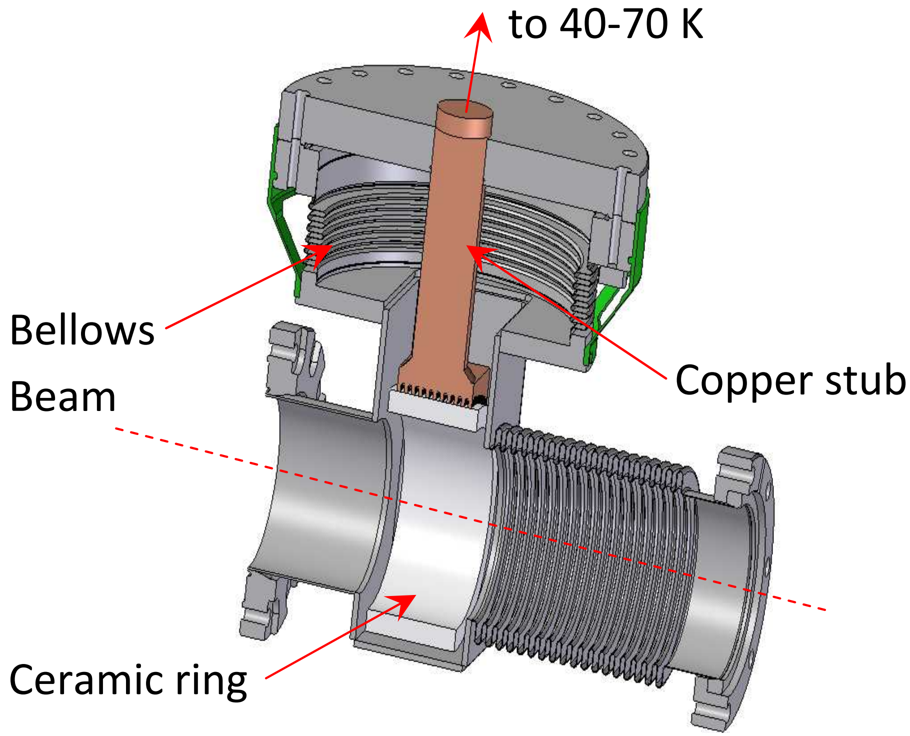
Beam Line Absorber Concept:

Nominal beam with 27000 short bunches will generate HOM power of 3.9 W/CM



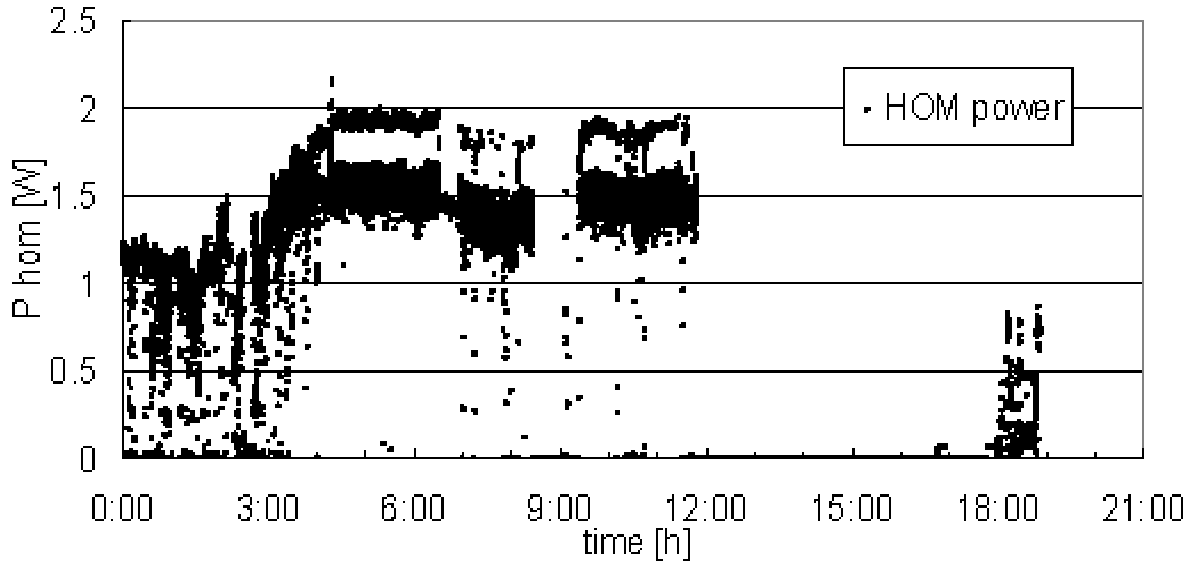
The XFEL beam line absorbers suppressing propagating modes have capacity of 100 W, which makes them suitable for large DF operations .

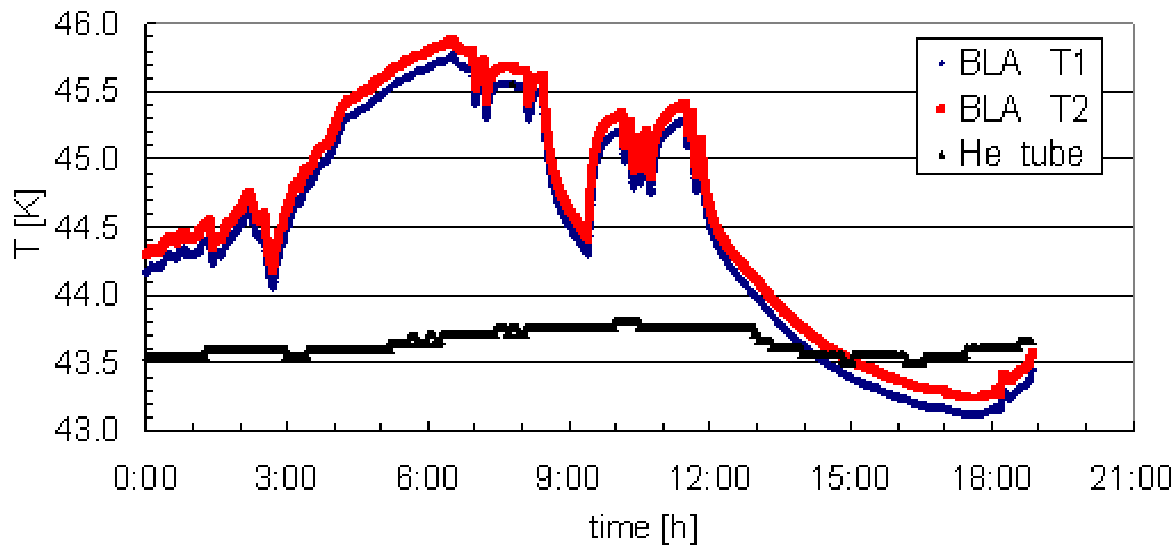




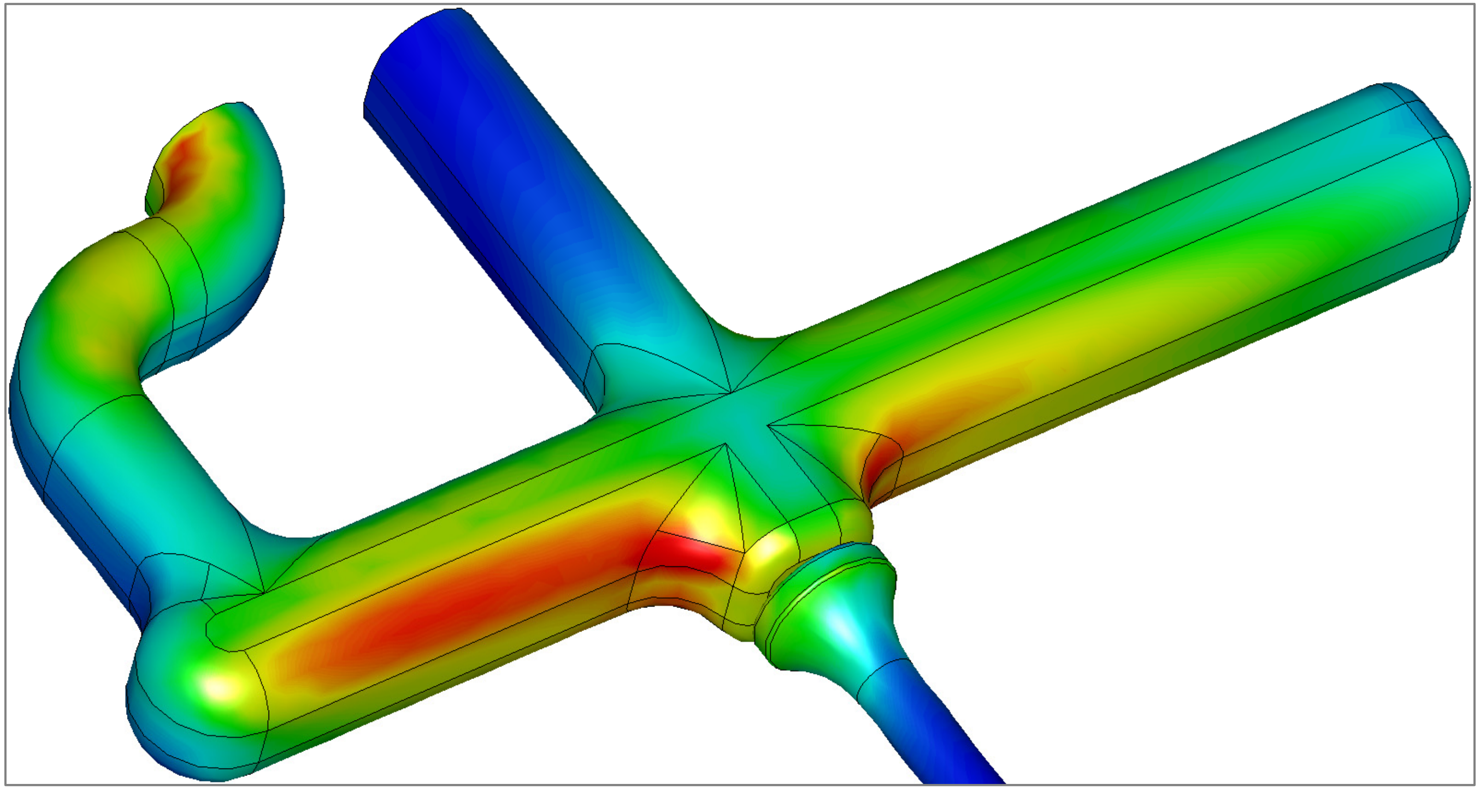
Beam Line Absorber Test:

The total deposited HOM power by the nominal XFEL beam will be 3.9 W/CM, if no synchronous excitation will take place. A big fraction (~85%) of the propagating HOM power will be dissipated in the beam line absorbers (BLA). BLA's will be installed in all interconnections, and at the beginning and end of all linac subsections. The absorption of microwaves takes place in the ceramic ring attached to the brazed copper stub. The stub transfers the dissipated energy to the 40-70 K cryostat shield via an external thermal connection. In the absorber design we took into account a possible upgrade of the XFEL facility to higher average brilliance by operating it with more bunches. For this case, the BLA power capacity has been specified to 100 W, which will allow for acceleration of up to one million nominal bunches/s. The prototype of the BLA was tested at FLASH twice in 2008 and 2009. The second test was conducted with much more stable linac operation than the first one. The charge/bunch was up to 3.2 nC and the bunch length was ~1.5 mm. The FLASH linac could be operated with 800 bunches/pulse. An example of the HOM power induced in the cryomodule closest to the BLA and the temperatures measured by thermometers attached to the stub and to the cooling tube are shown in the figure on the right. In the run (4-8 am) presented here, the numerically estimated power absorbed by the BLA was 255 mW. The maximum observed temperature rise of 2.5 K indicated absorption of 325 mW, which was higher by 27% than the computed value.



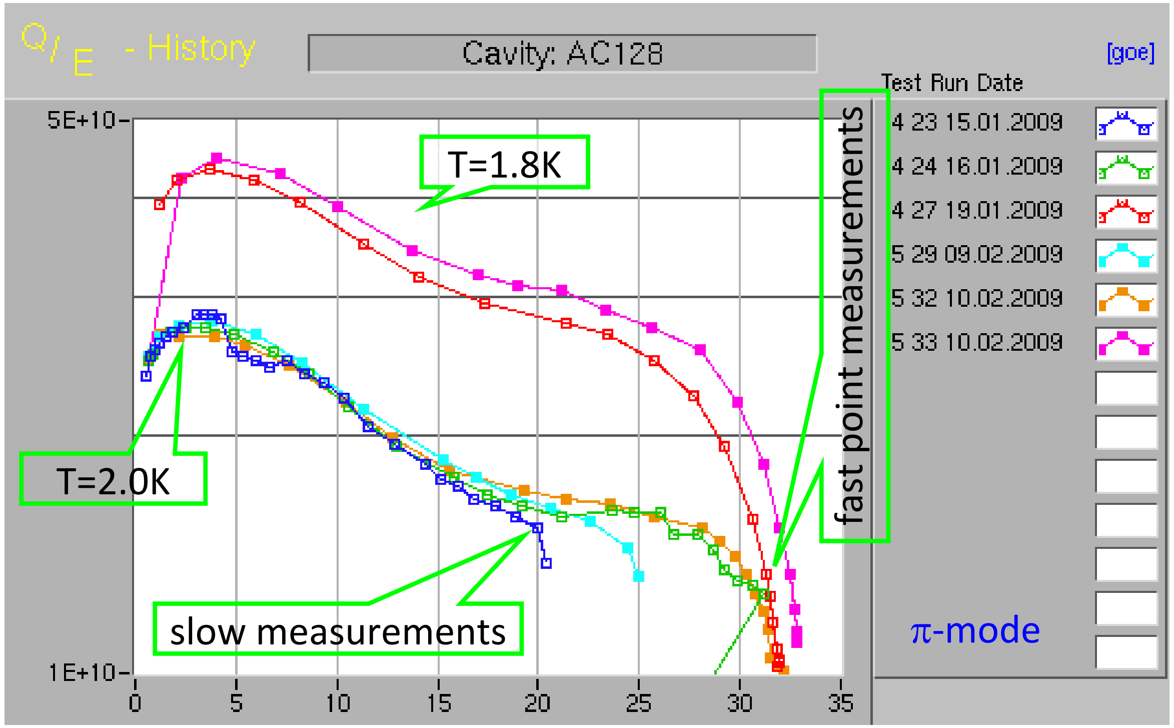


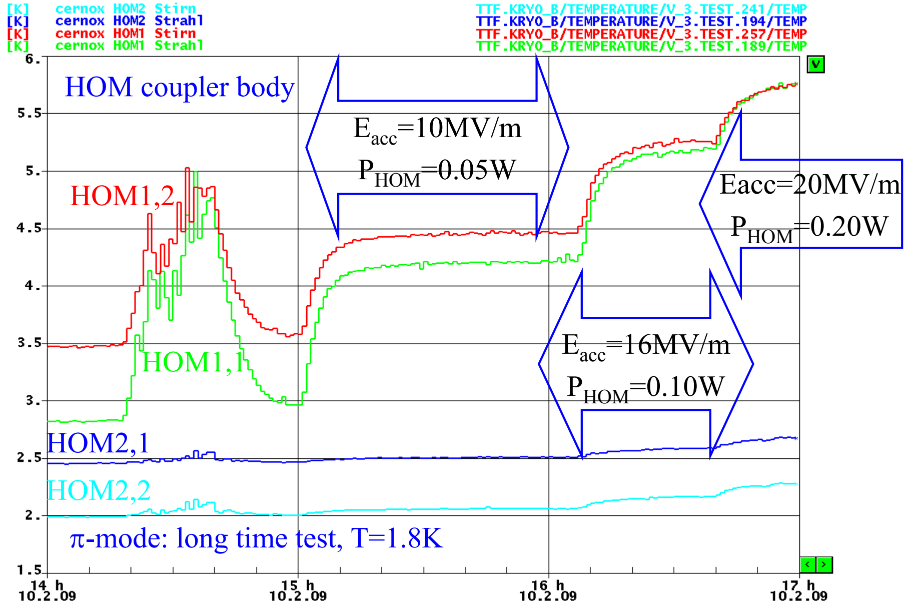
2. HOM Coupler Simulations for CW operation

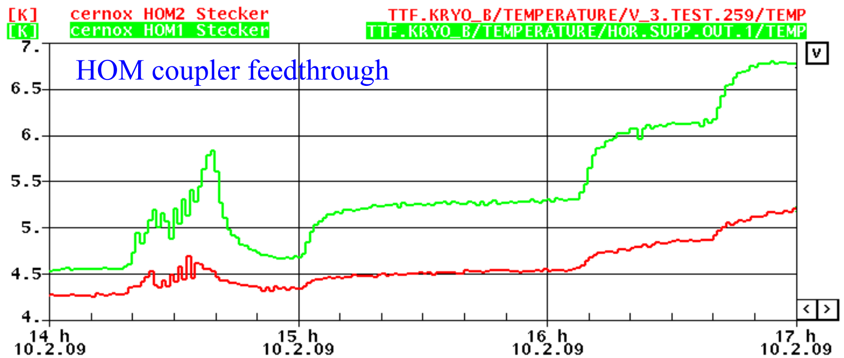


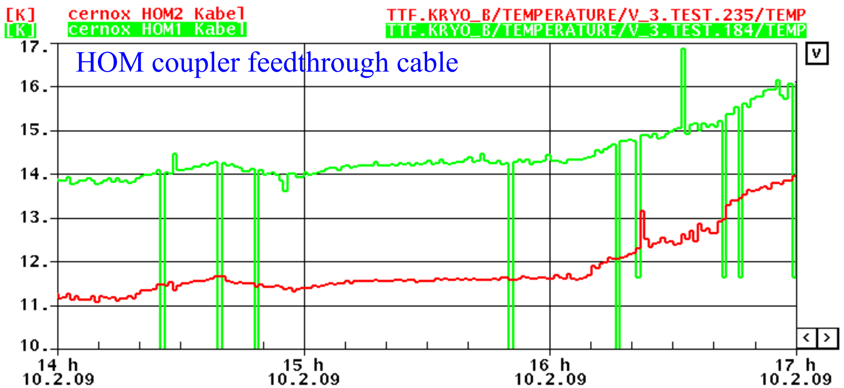
HISTORY:

CW test on cavity AC128 in the horizontal cryostat









Heat load from HOM couplers / HOM couplers temperature increase

D.Kostin, at.al, **TESLA Type 9-Cell Cavities Continuous Wave Tests**, SRF2009

Simulations:

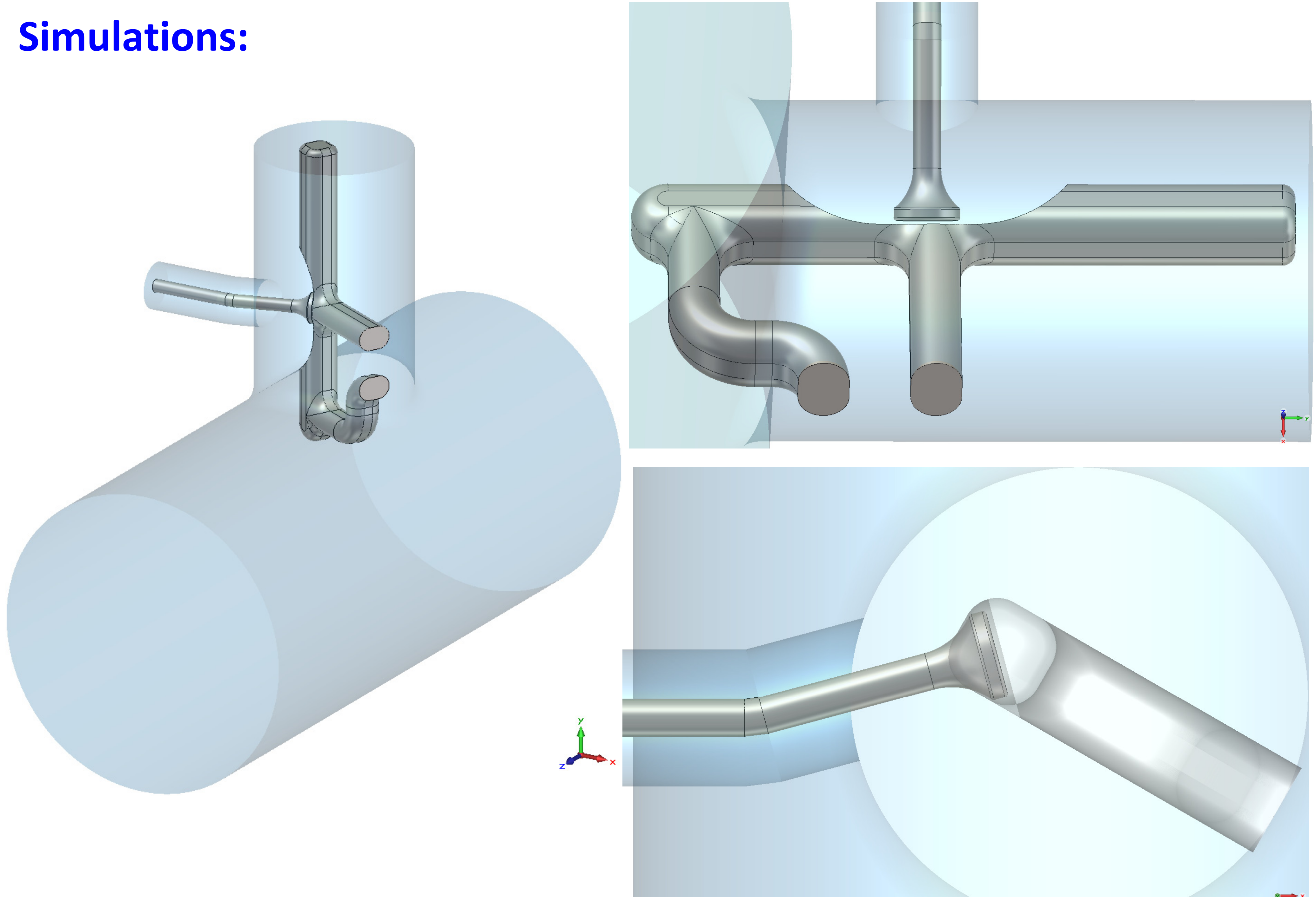


Figure 1: standard HOM coupler

Simulations:

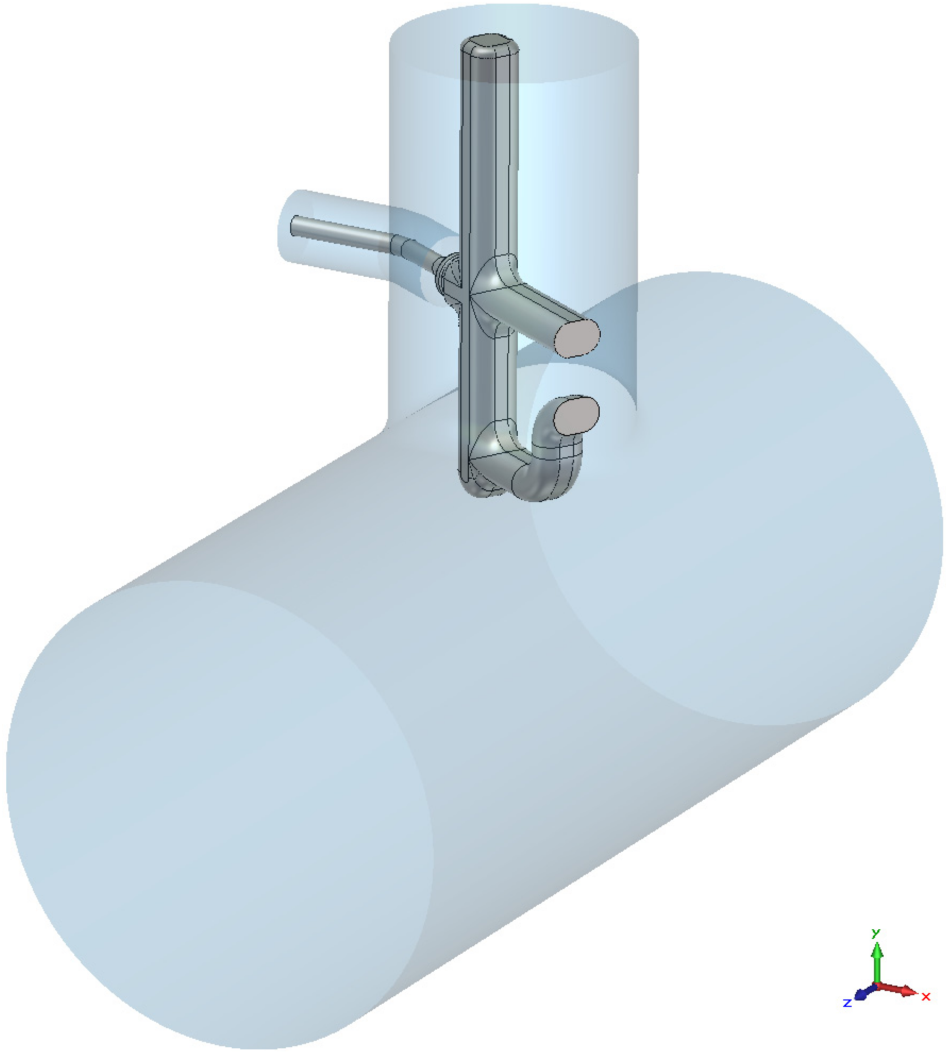
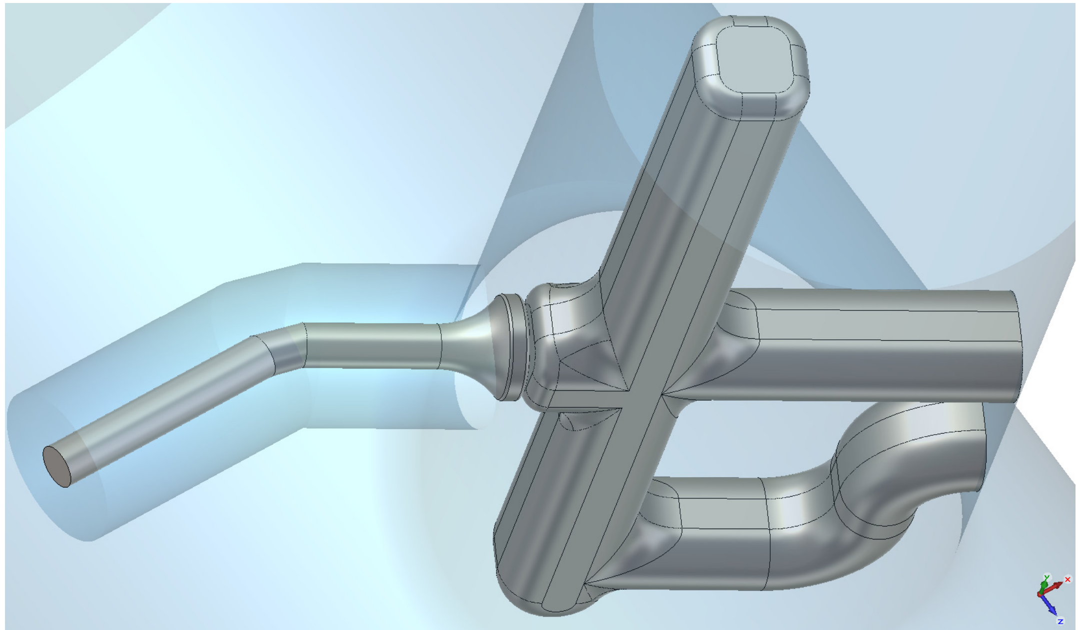
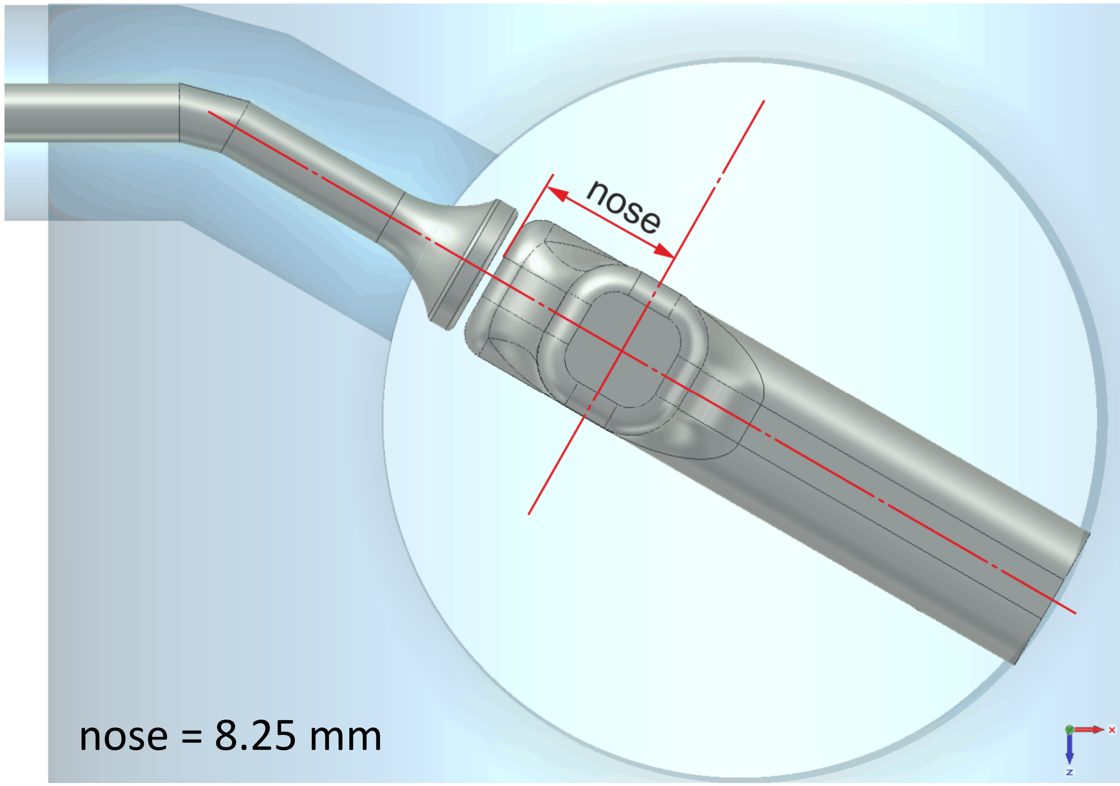
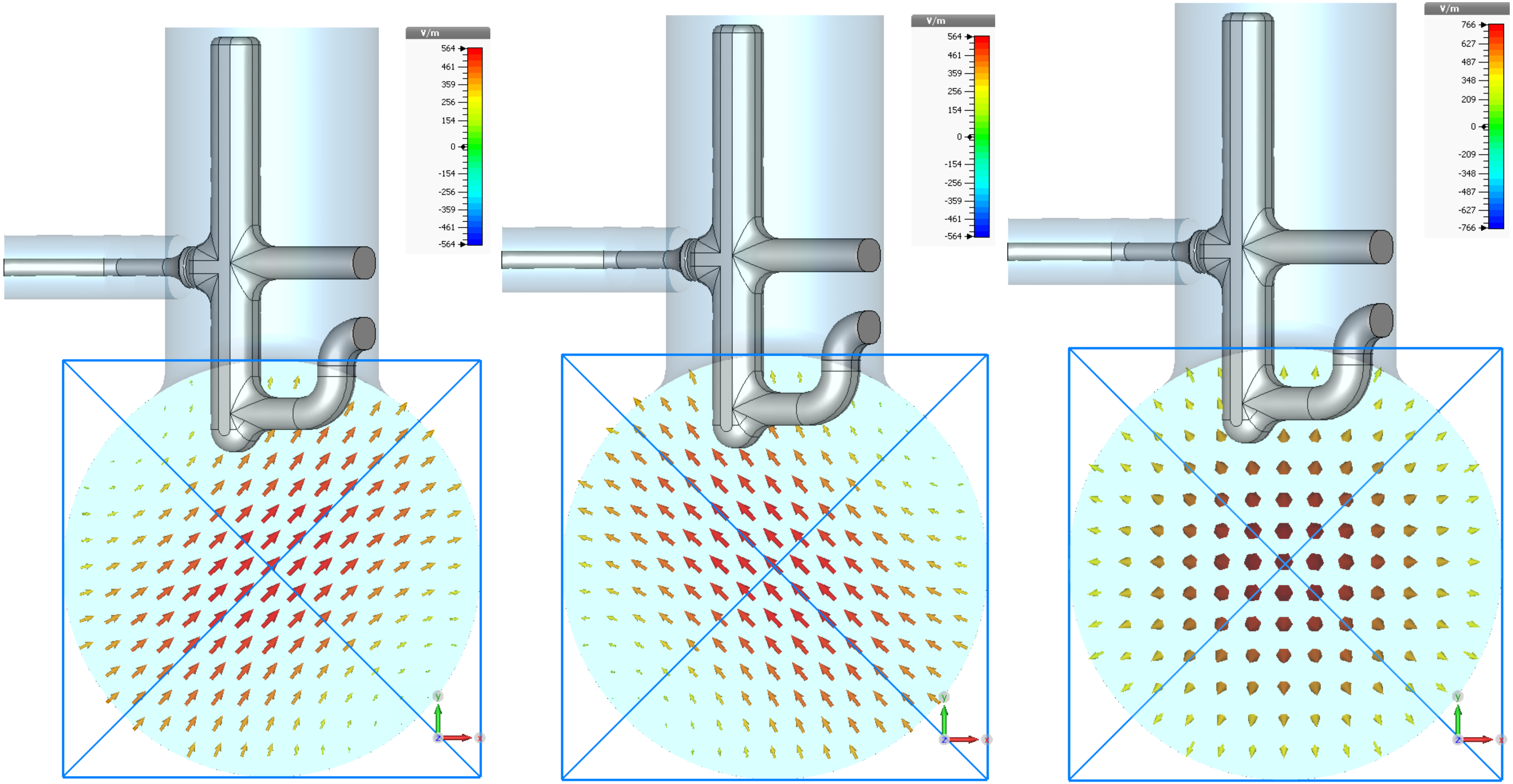


Figure 2: new HOM coupler





Simulations:



1. dipole (polarization 1) 2. dipole (polarization 2) 3. monopole

Figure 3: input port (tube) modes

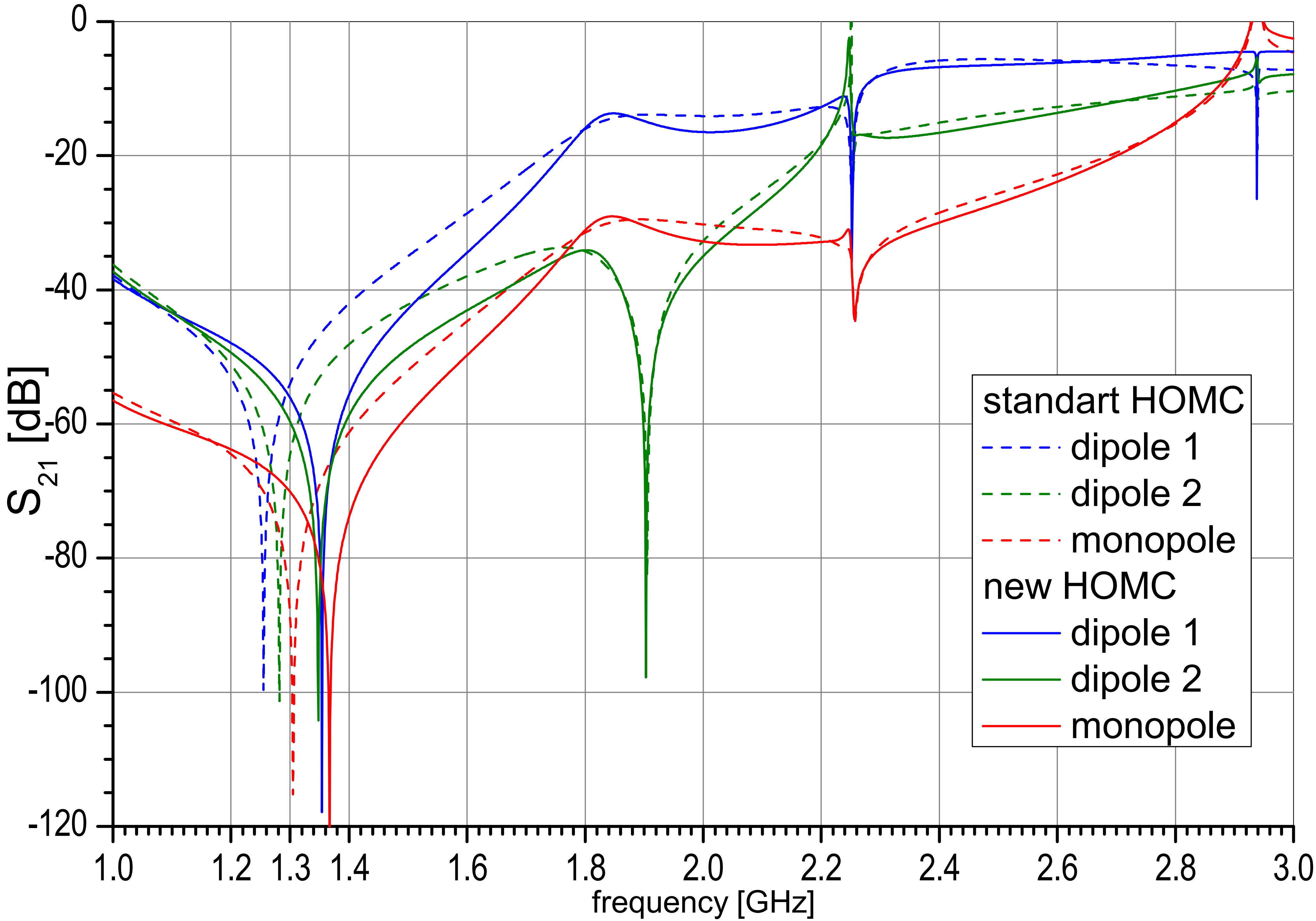


Figure 4: S_{21} comparison

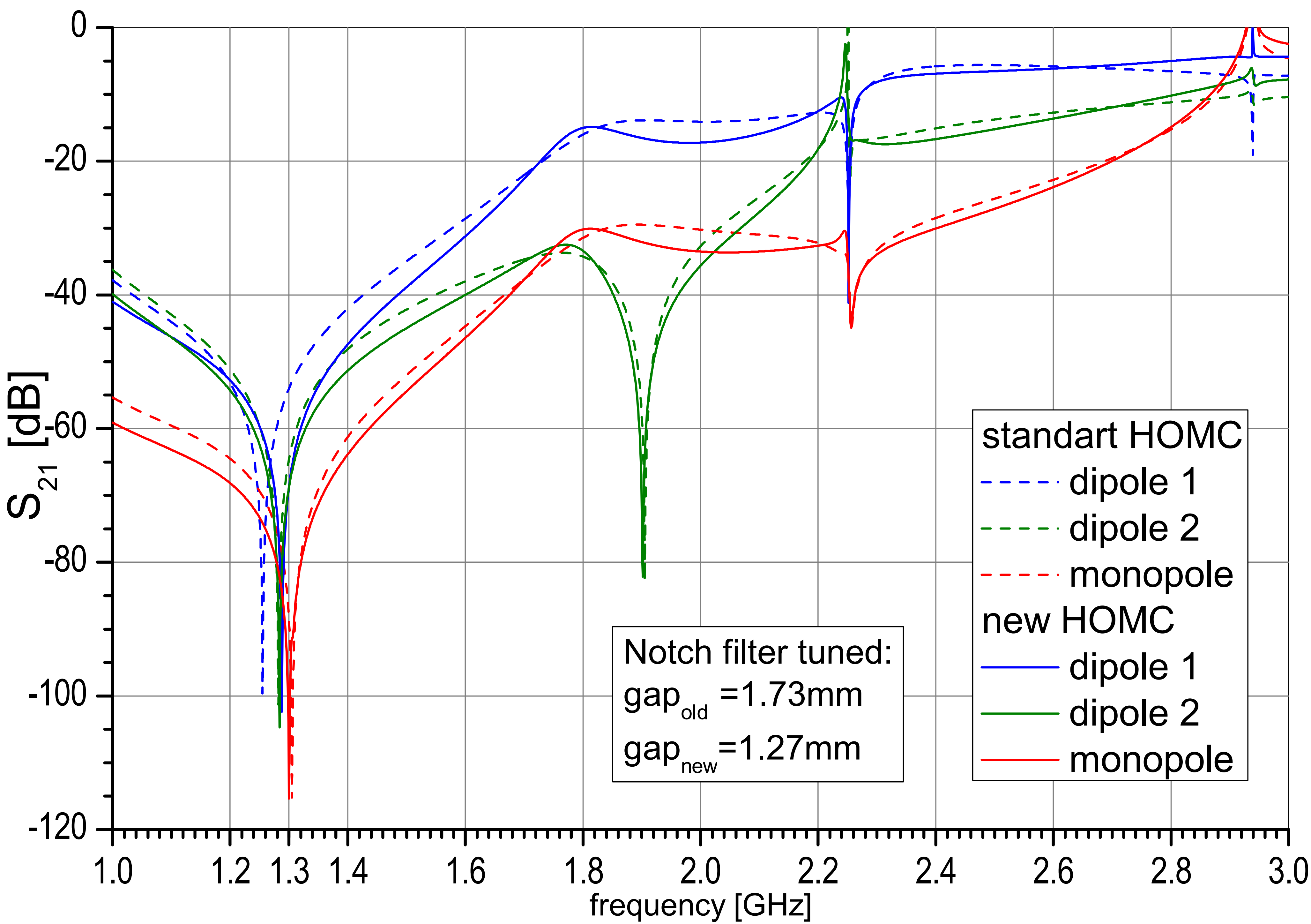
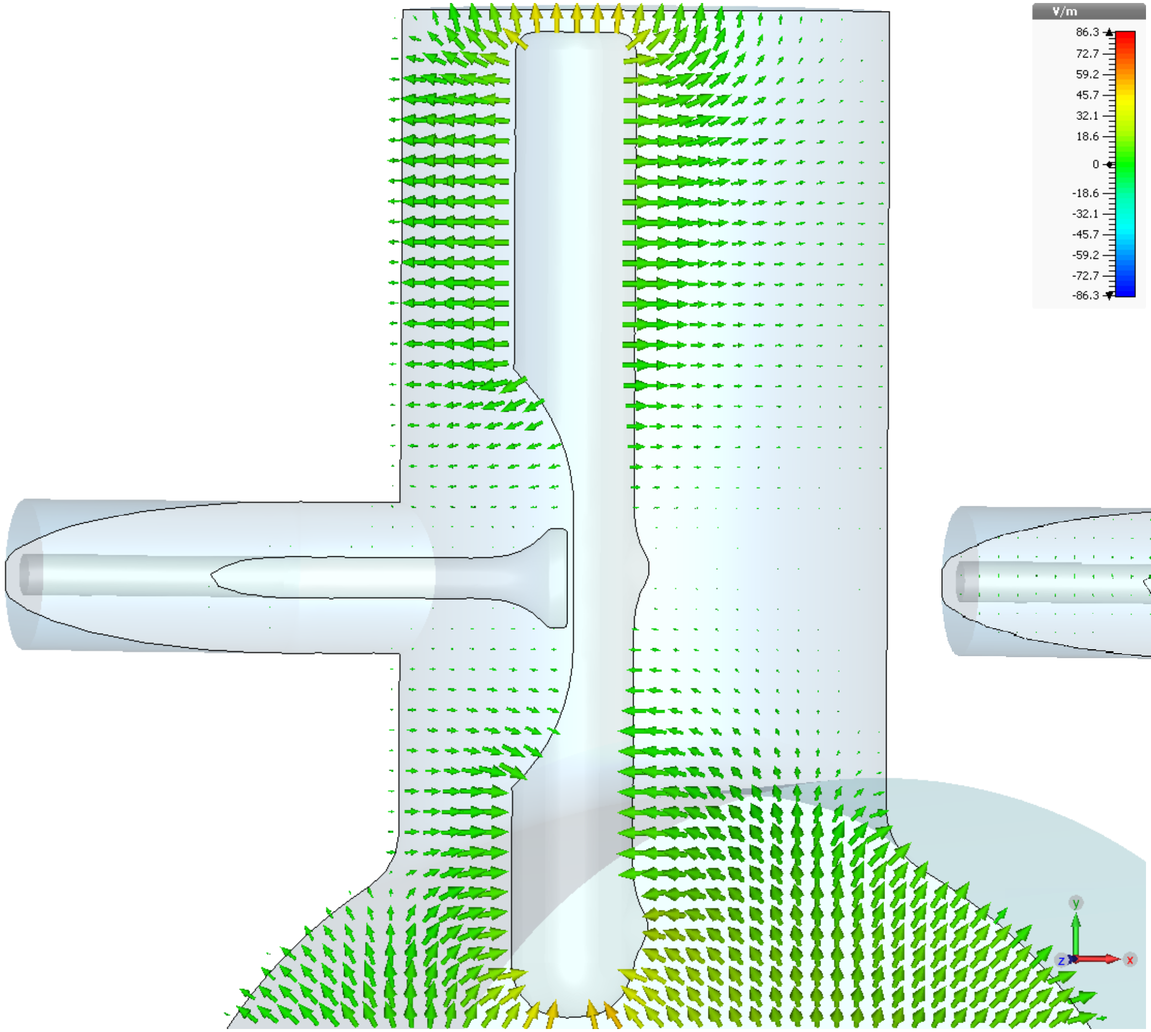
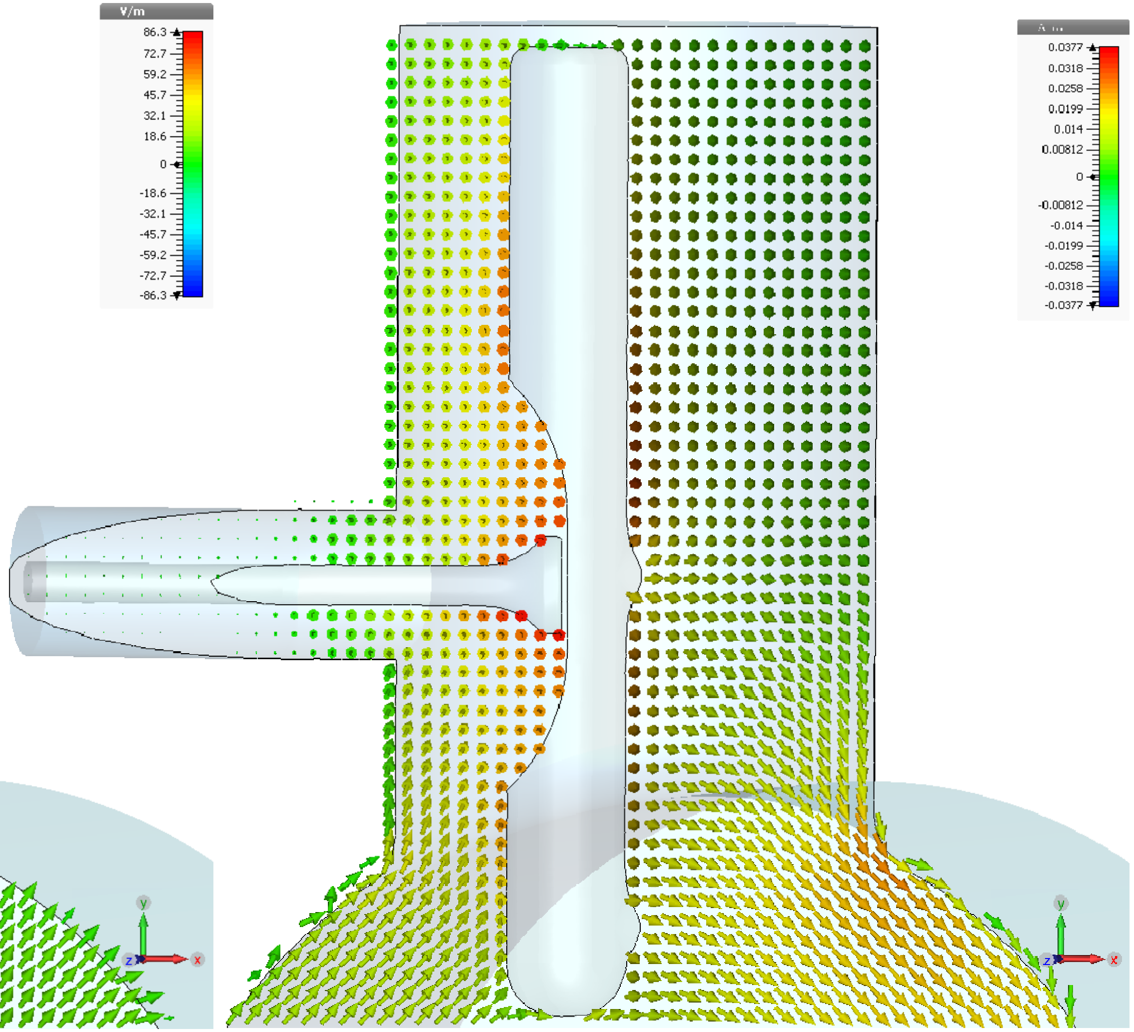


Figure 5: S_{21} comparison: tuned notch filter

Simulations:



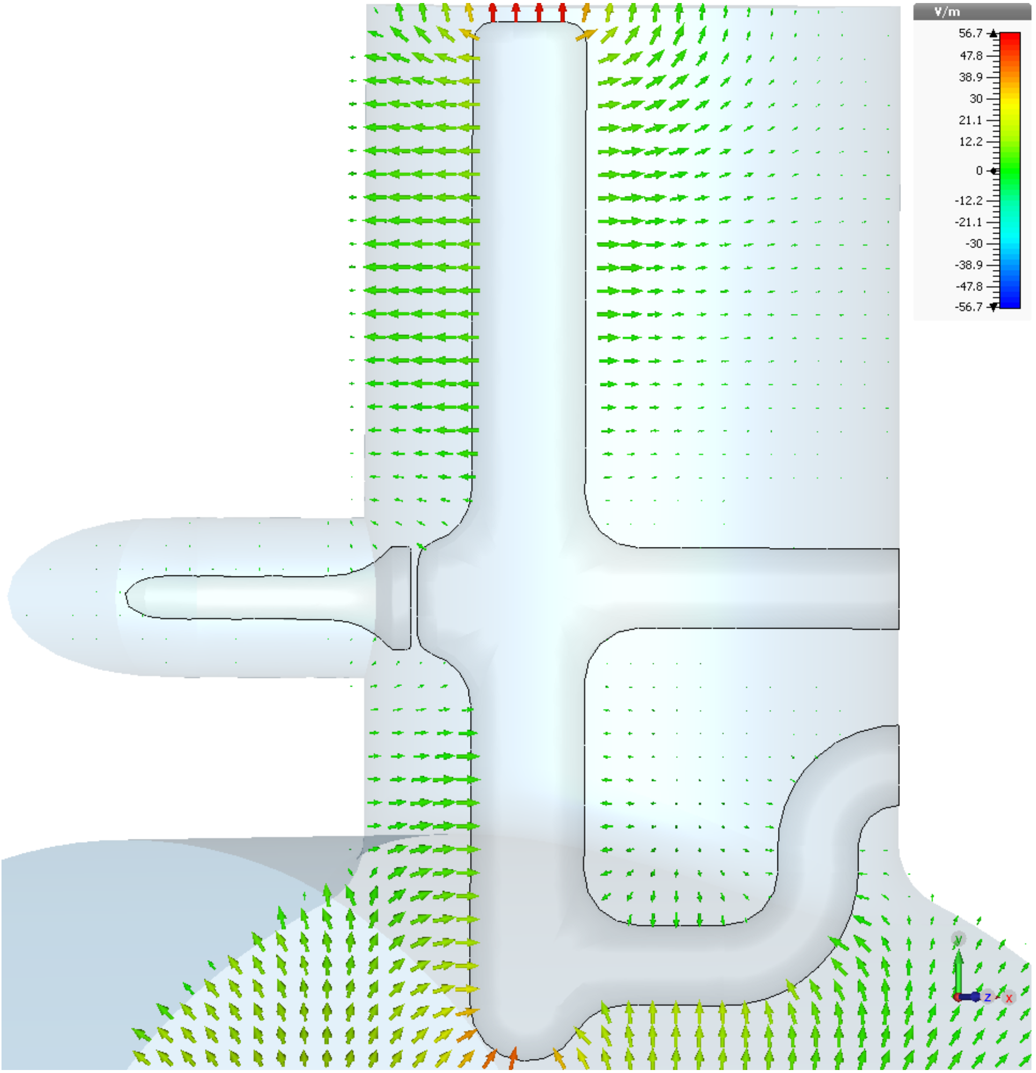
E-field (1 W input tube power)



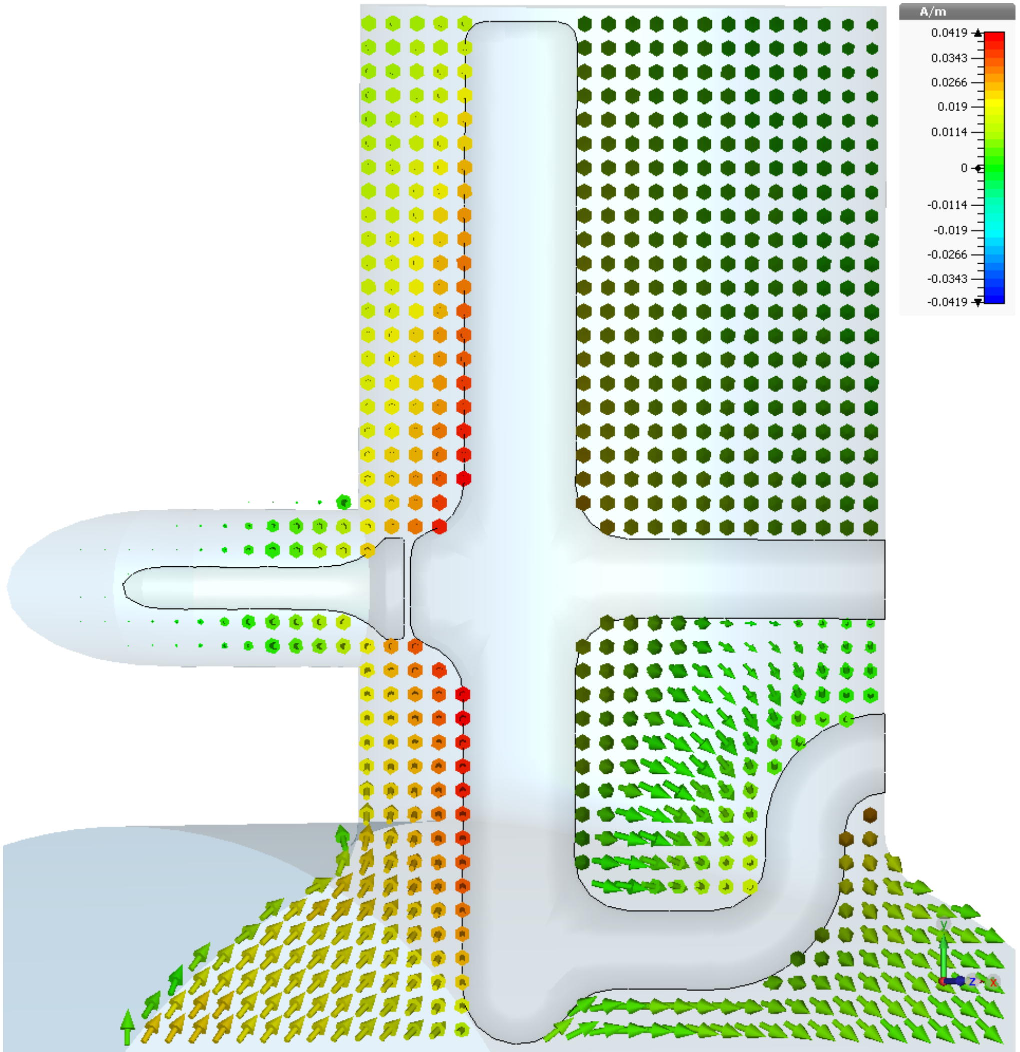
H-field (1 W input tube power)

Figure 6: standard HOM coupler E/H fields at 1.3 GHz, monopole mode

Simulations:



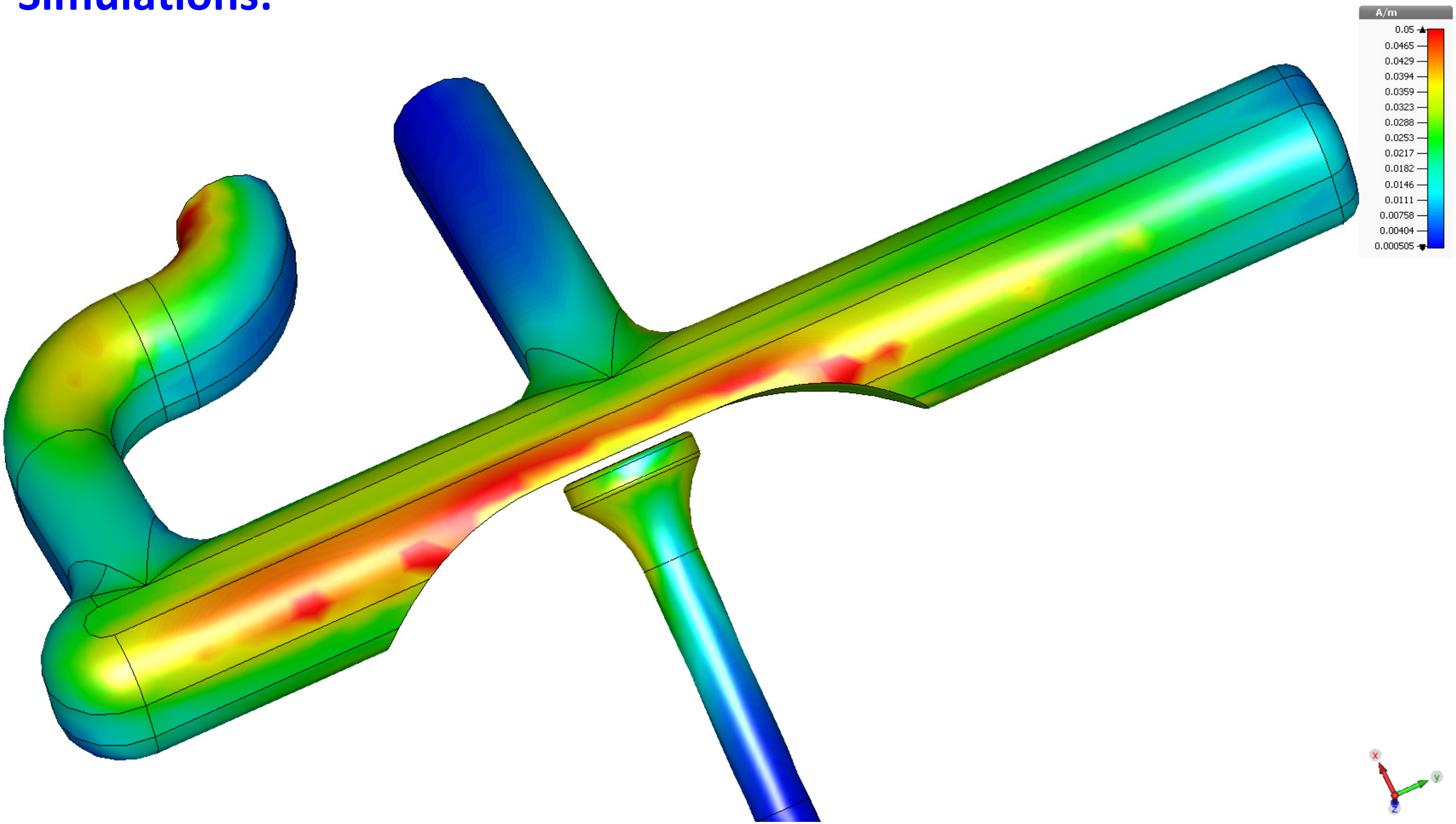
E-field (1 W input tube power)



H-field (1 W input tube power)

Figure 7: new HOM coupler E/H fields at 1.3 GHz, monopole mode

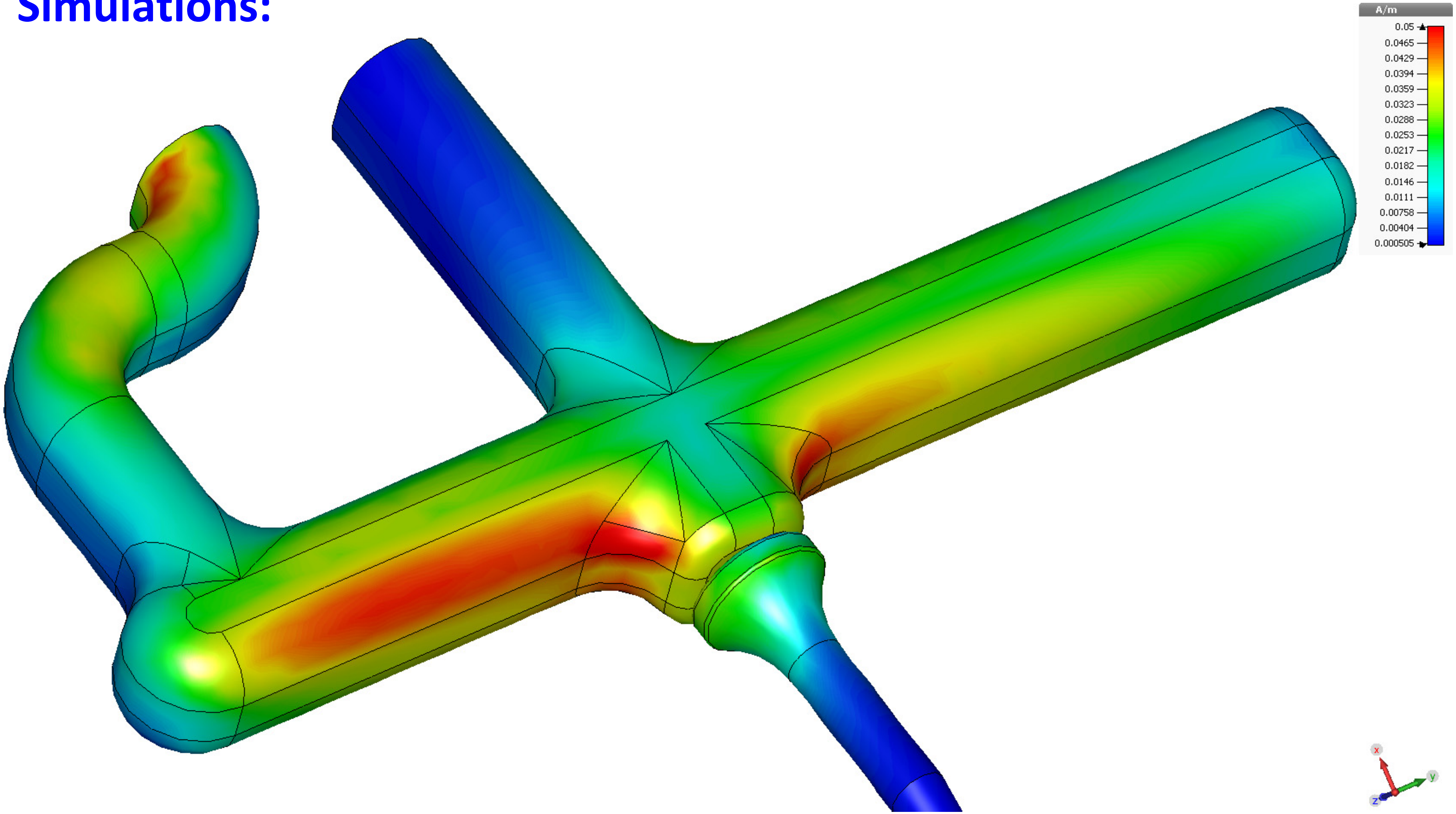
Simulations:



plot max. 0.05 A/m with 1 W input tube power

Figure 8: standard HOMC: magnetic field amplitude near loop/feed surfaces

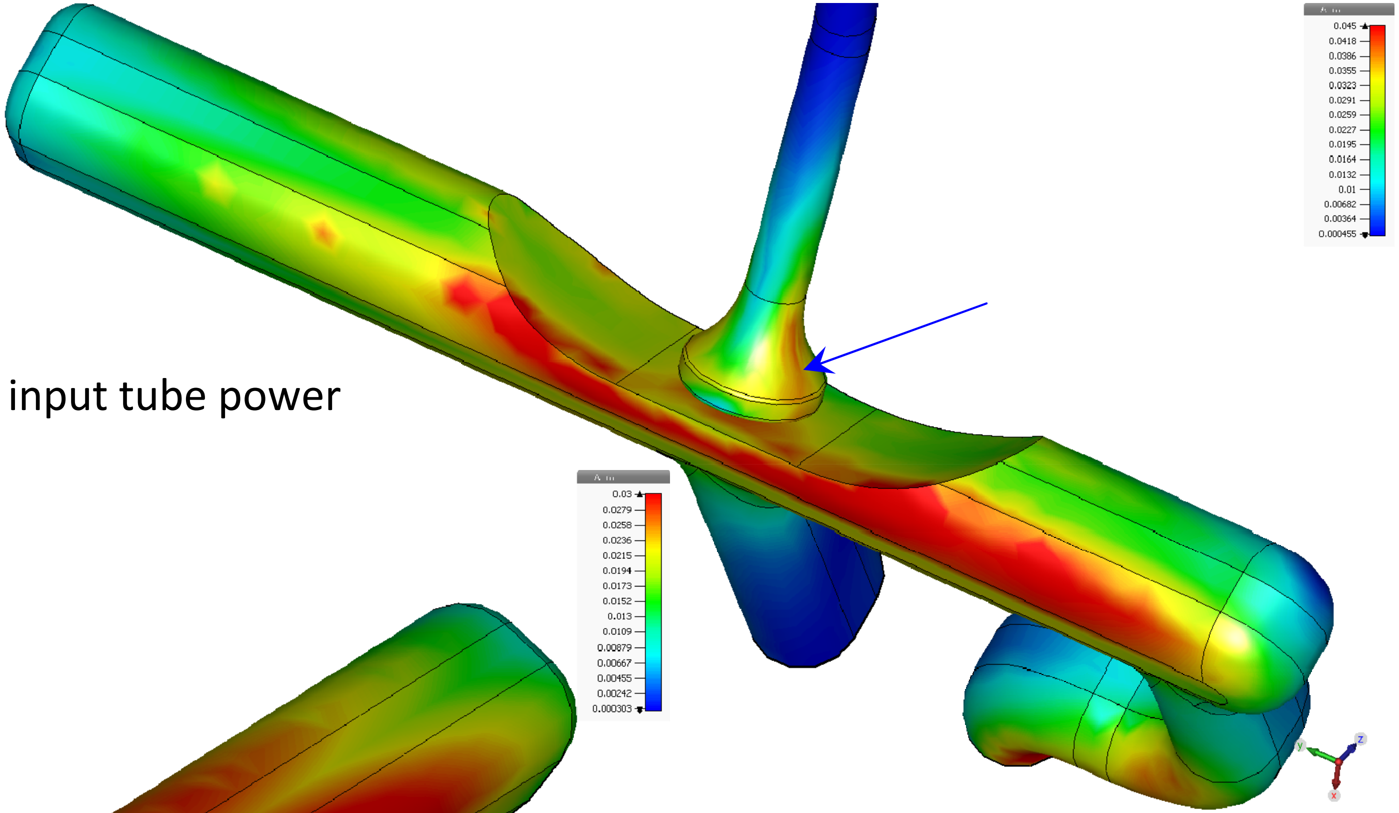
Simulations:



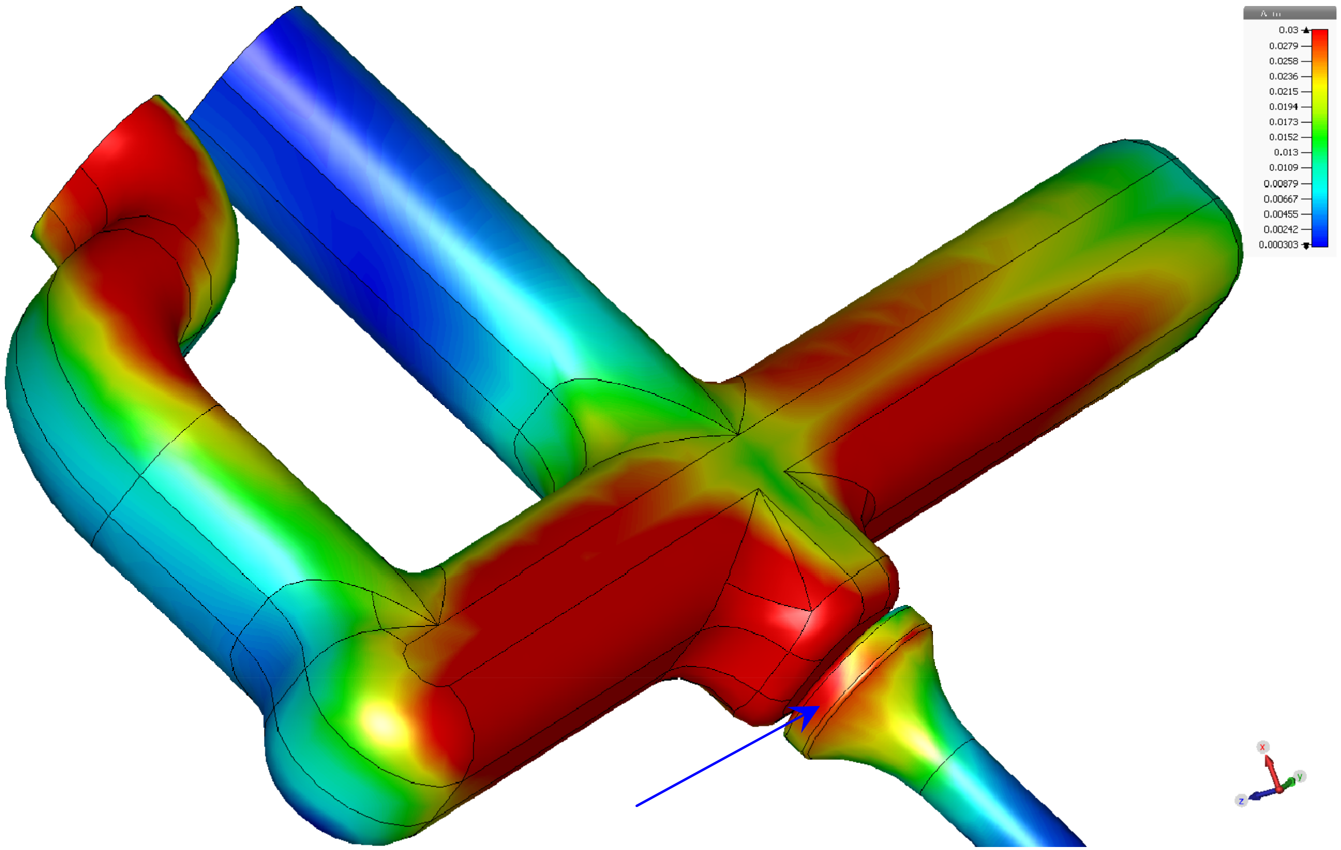
plot max. 0.05 A/m with 1 W input tube power

Figure 9: new HOMC: magnetic field amplitude near loop/feed surfaces

Simulations:



plot max. 0.045 A/m with 1 W input tube power



plot max. 0.03 A/m with 1 W input tube power

Figure 10: magnetic field amplitude distributions near loop/feed surfaces compared

Simulations:

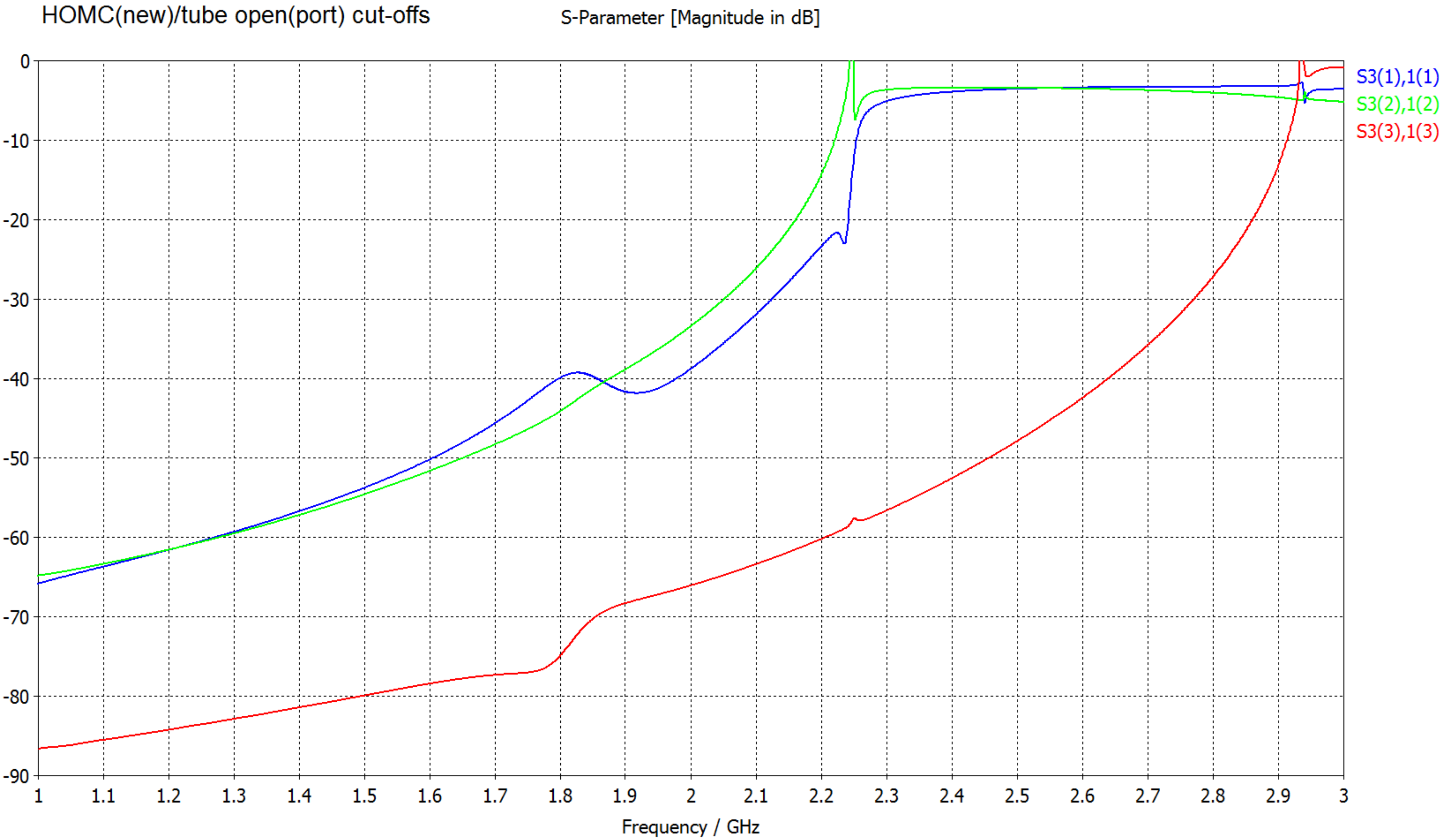
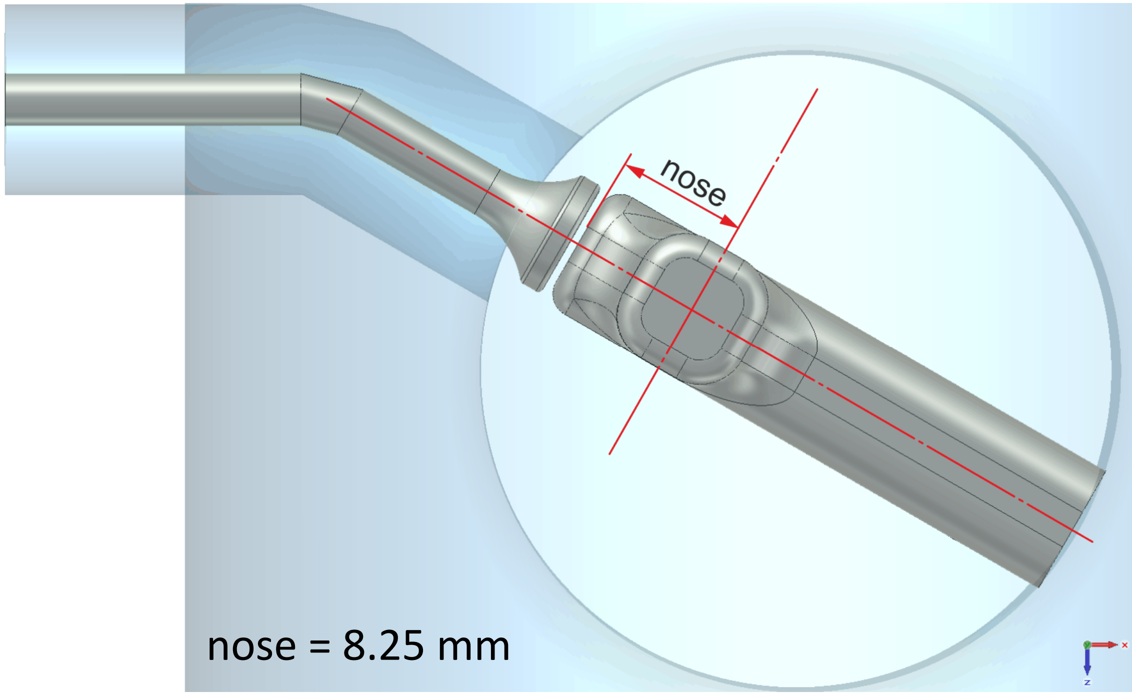


Figure 11: $S_{31}(f)$: cut-off references for the tube



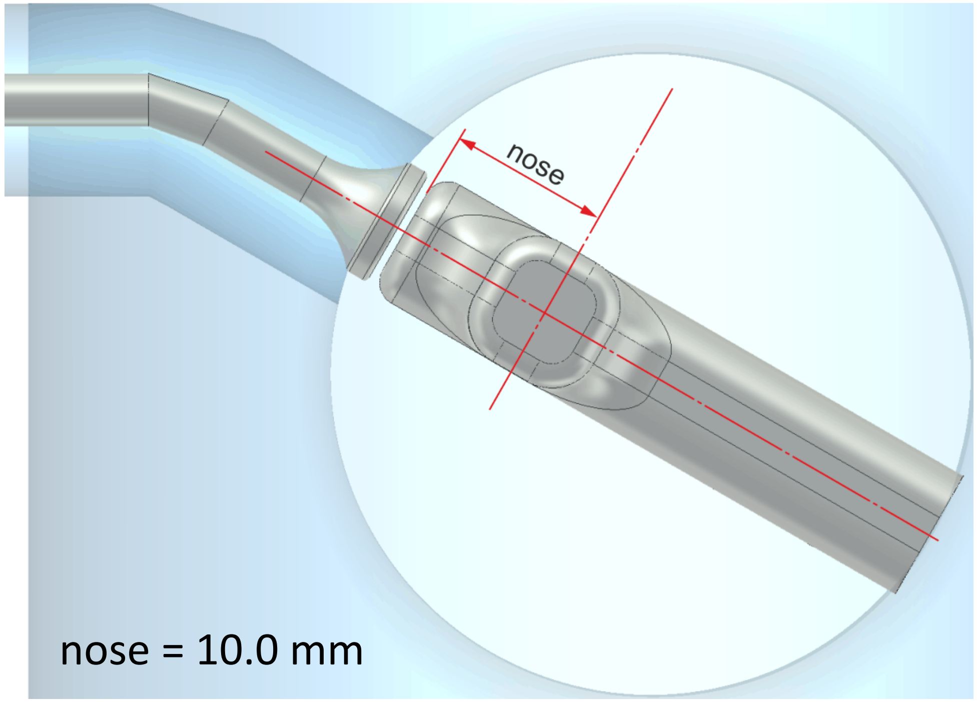


Figure 12: New HOMC geometry change: nose length.

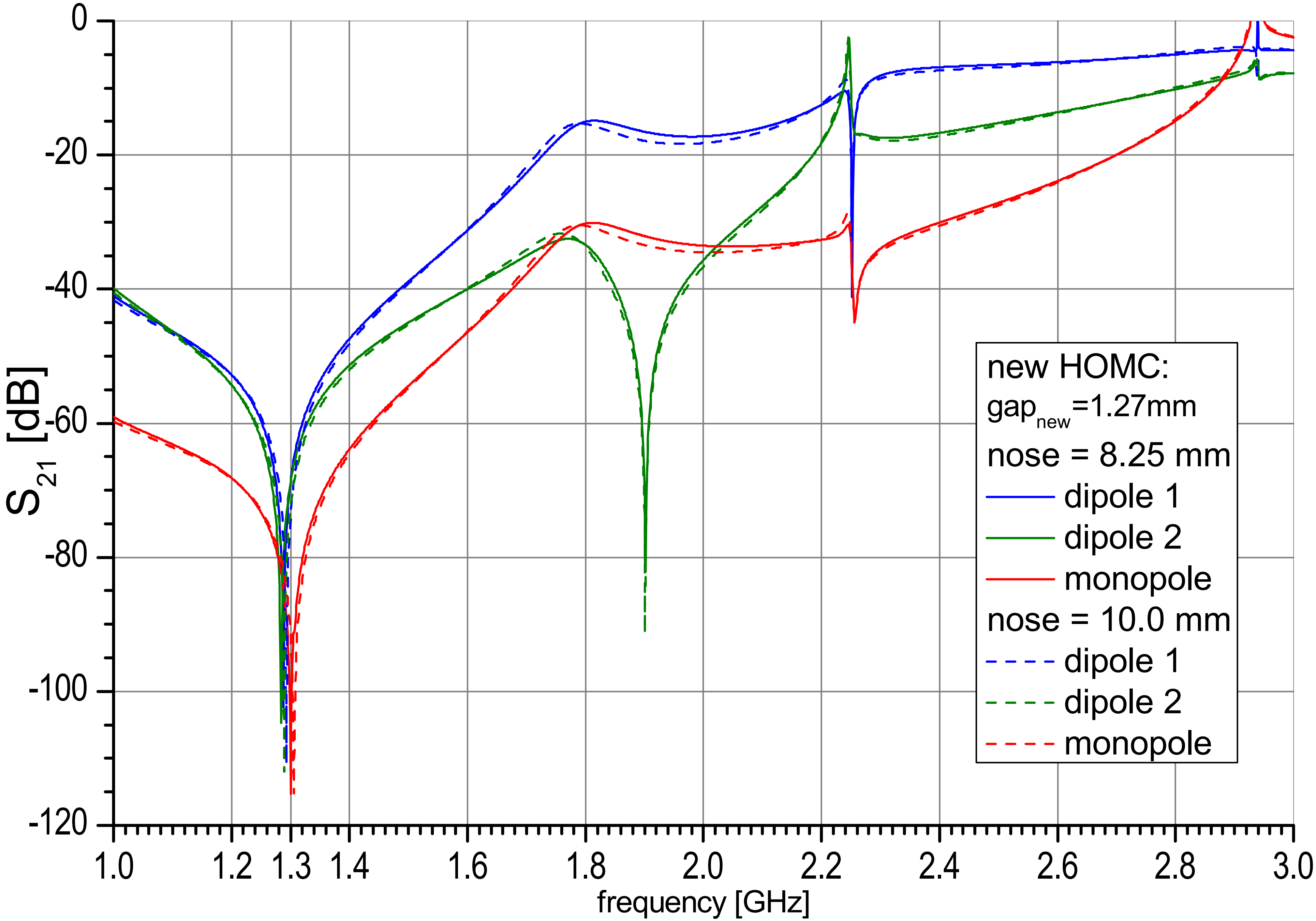


Figure 13: New HOMC geometry change: nose length. $S_{21}(f)$.

Simulations:

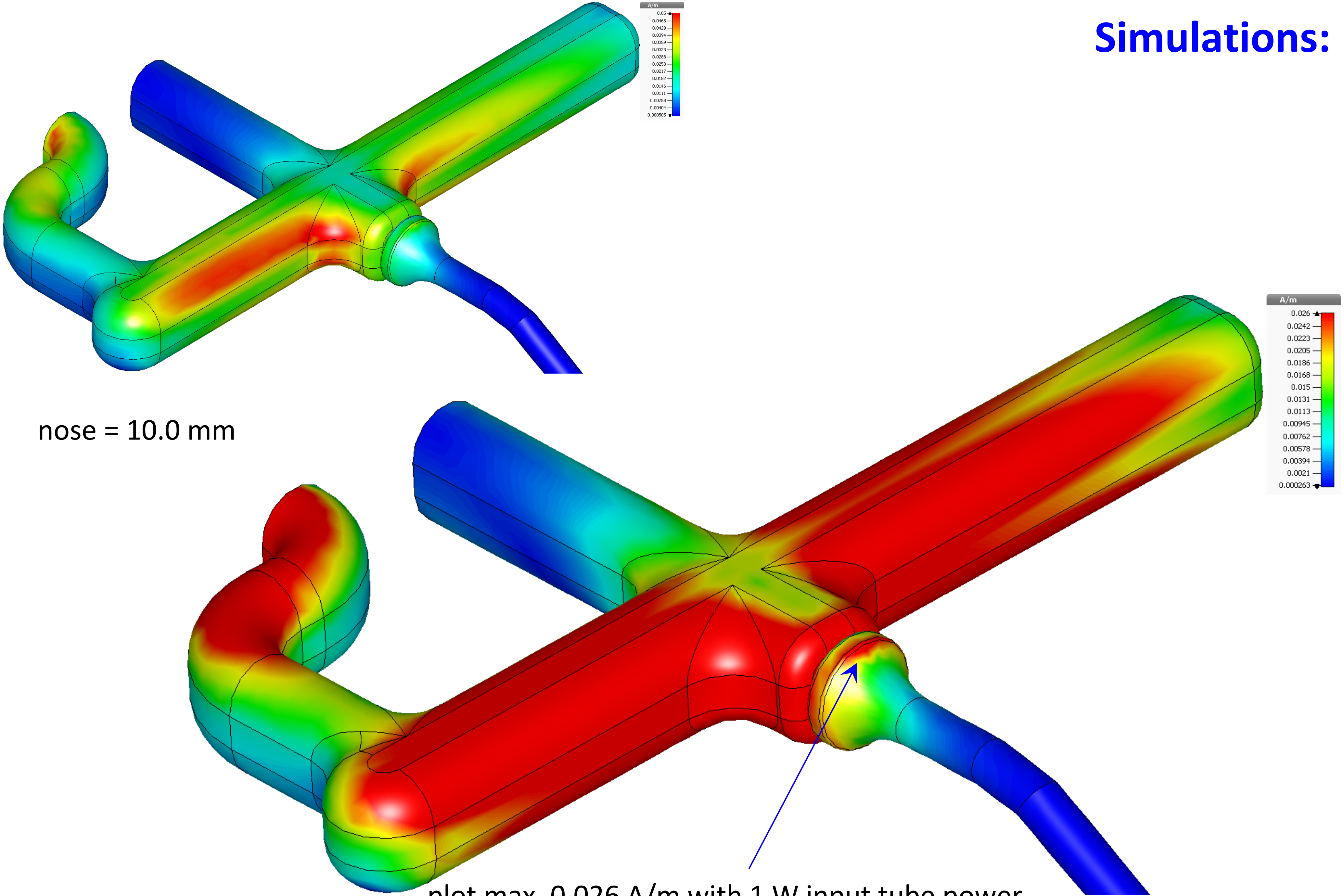
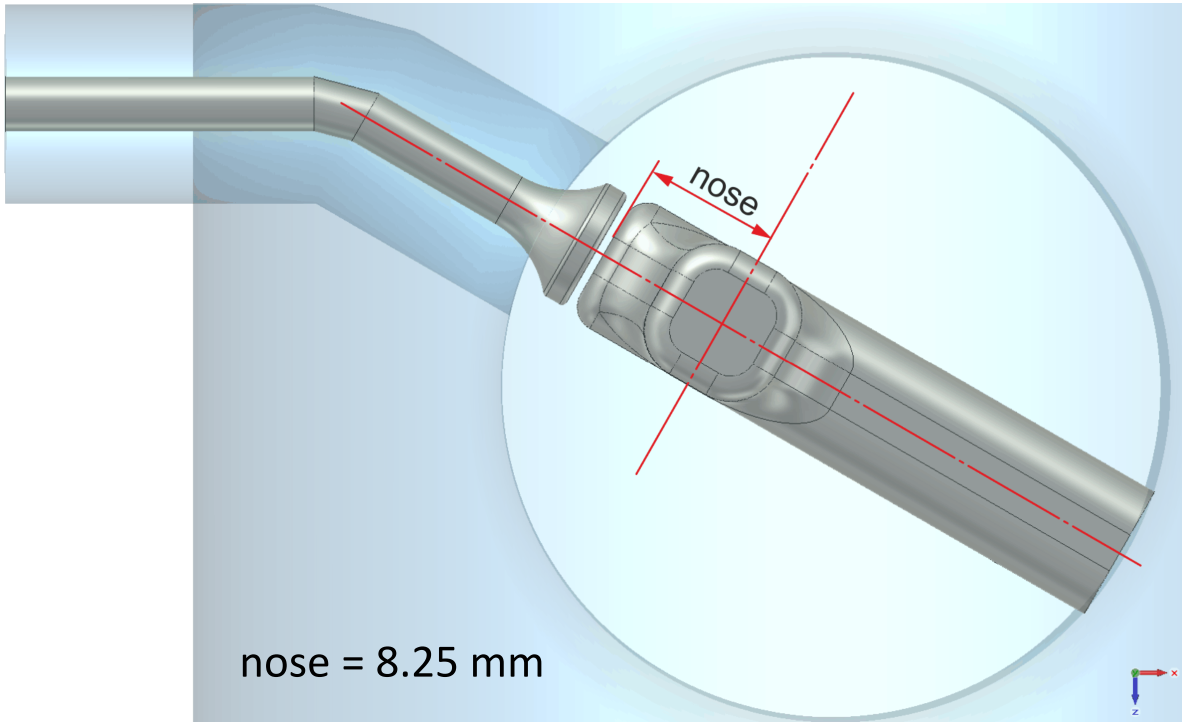


Figure 14: New HOMC geometry change: feedthrough antenna magnetic field.



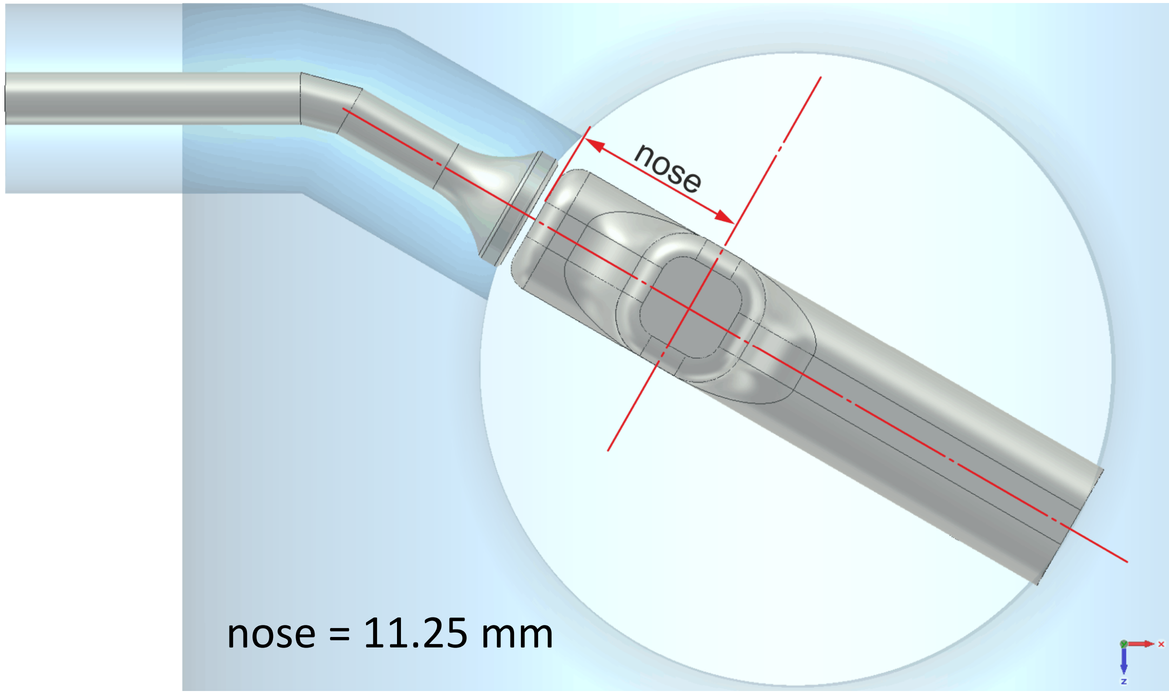


Figure 15: New HOMC geometry change: nose length.

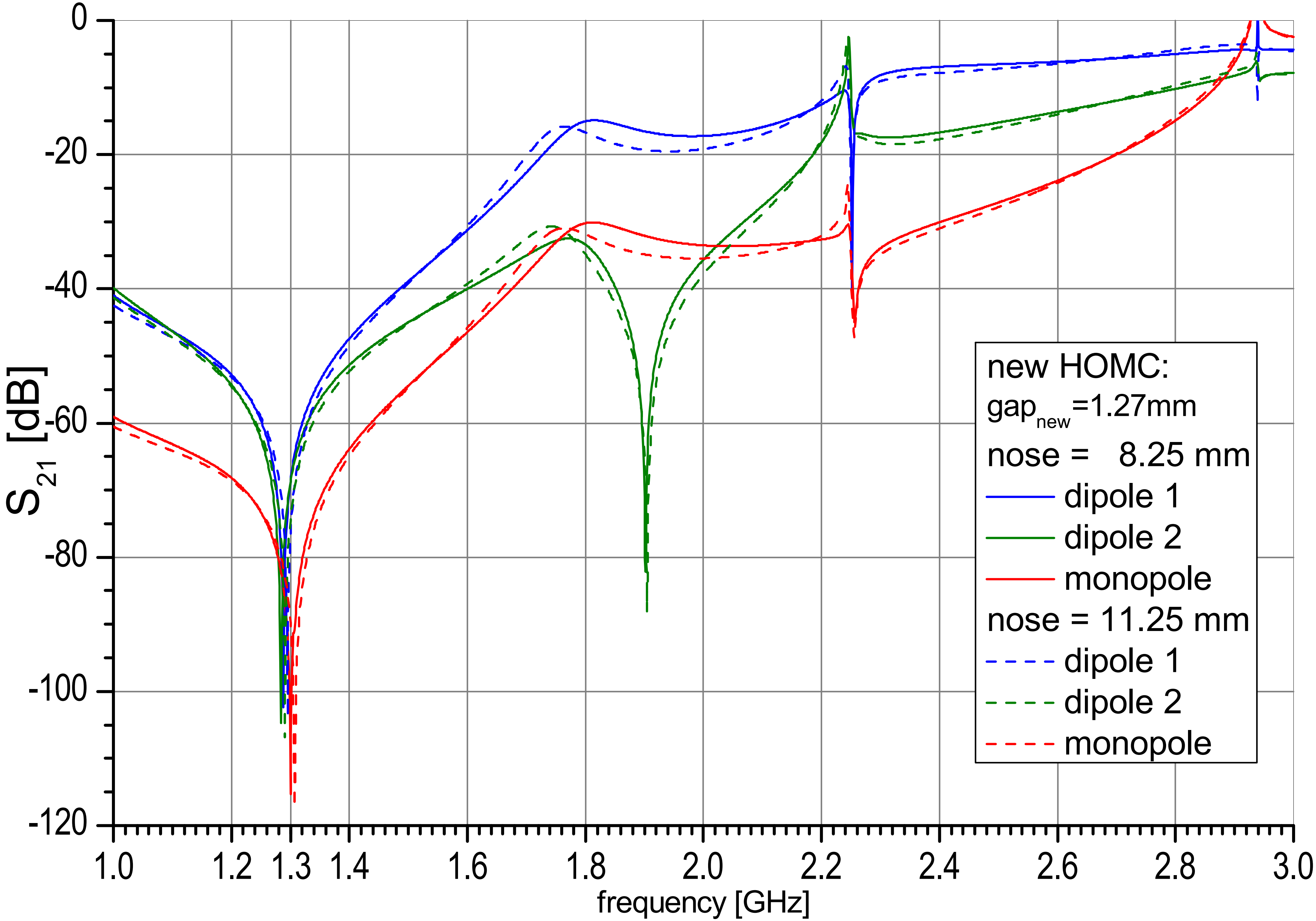
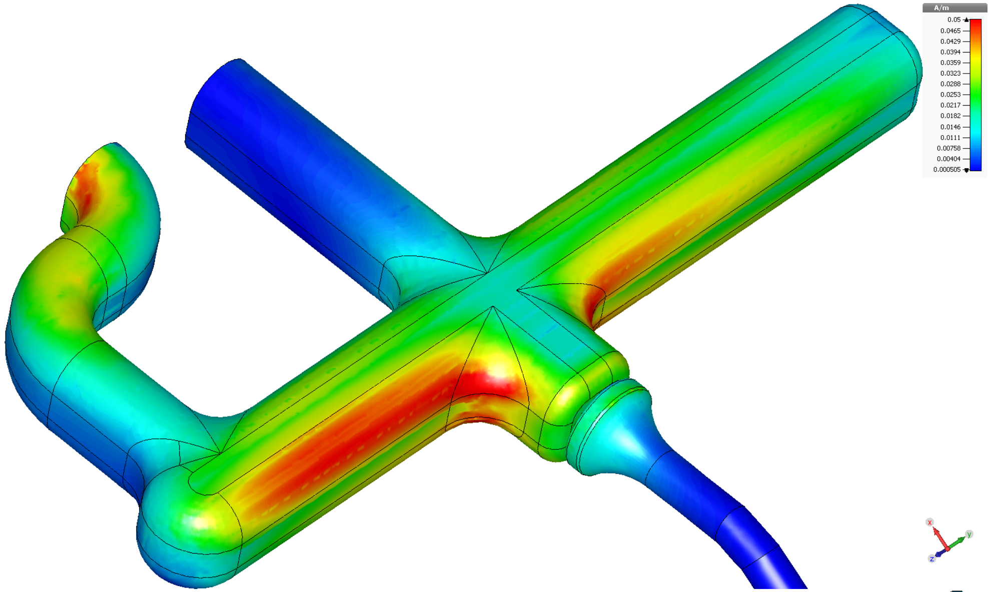
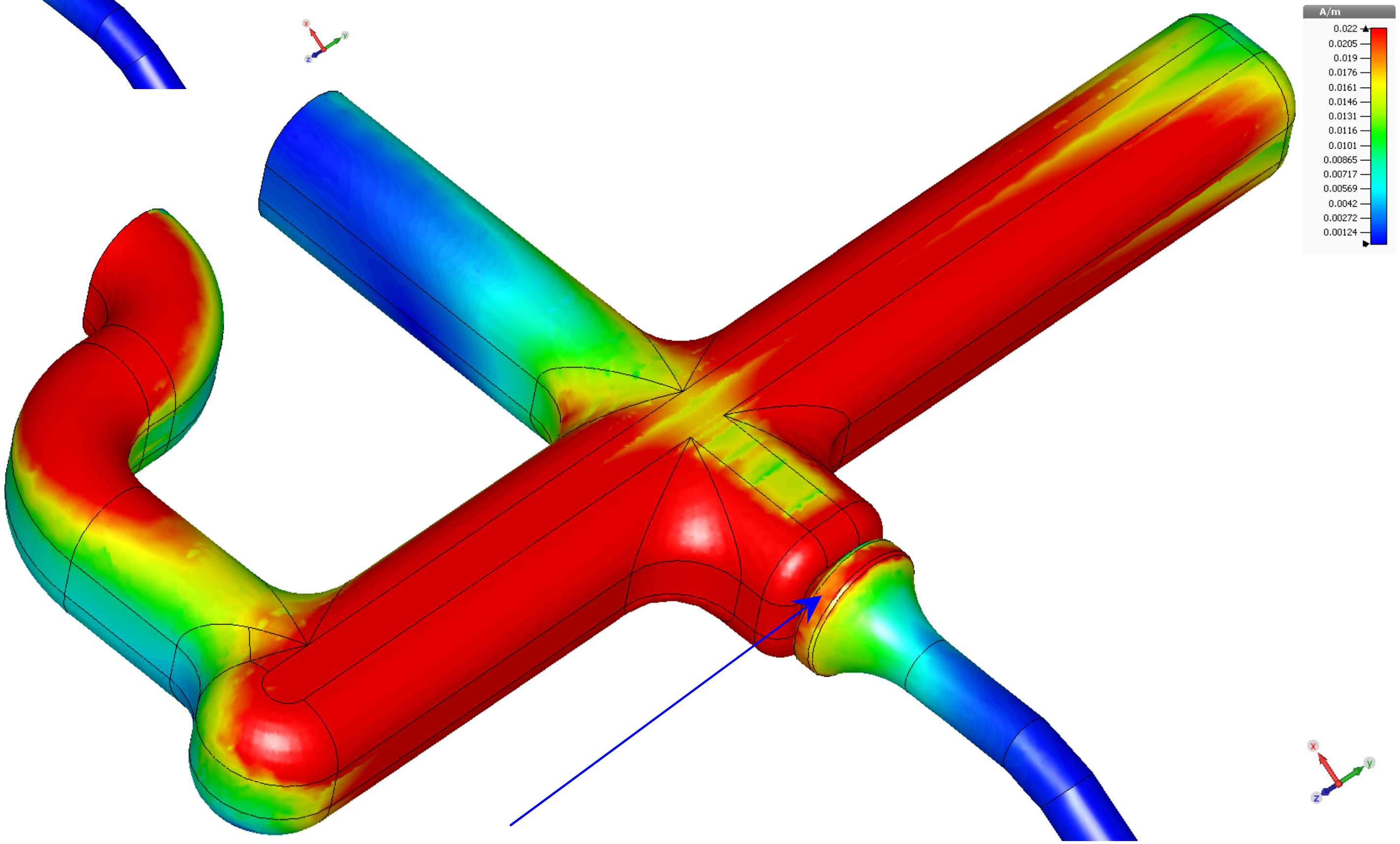


Figure 16: New HOMC geometry change: nose length. S_{21}(f).

Simulations:



nose = 11.25 mm



plot max. 0.022 A/m with 1 W input tube power

Figure 17: New HOMC geometry change: feedthrough antenna magnetic field.

Simulations:

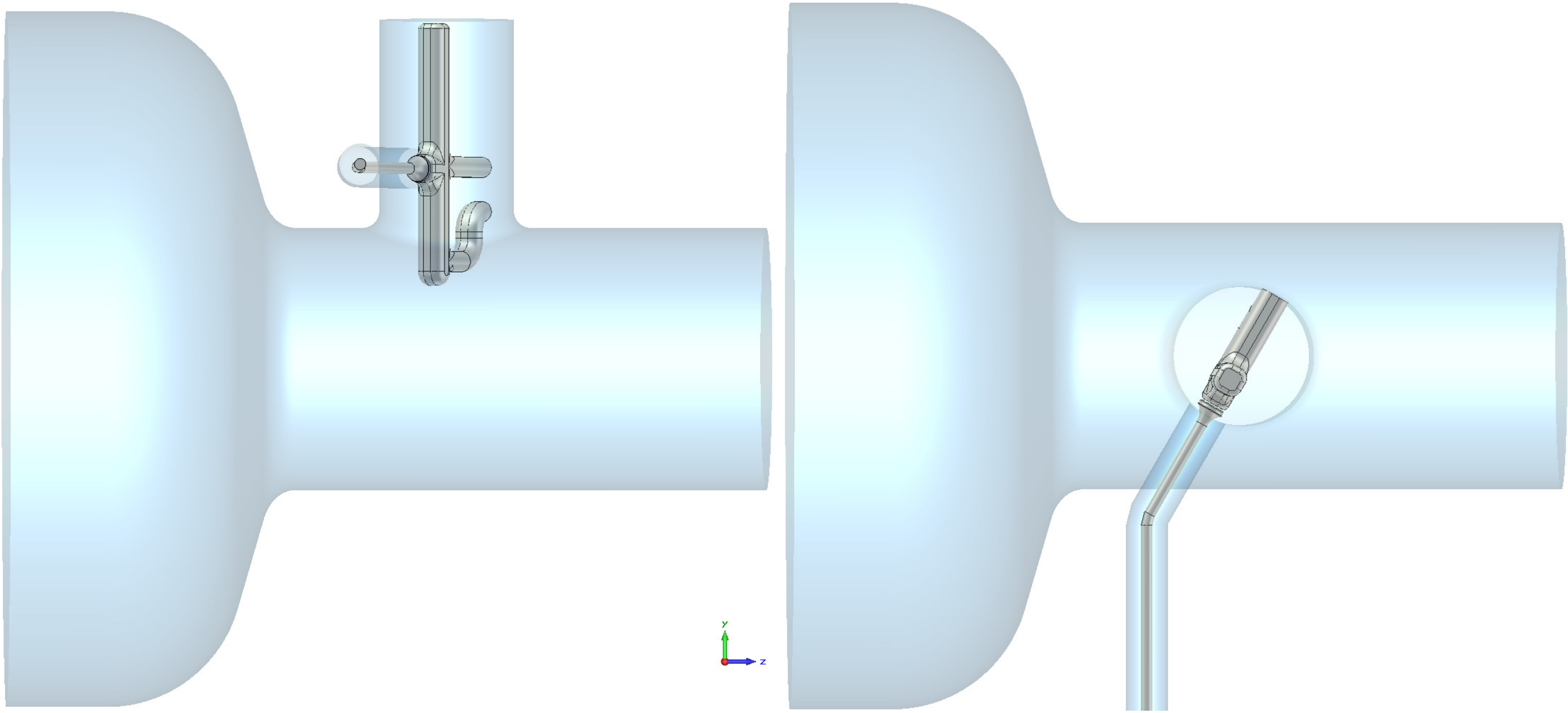
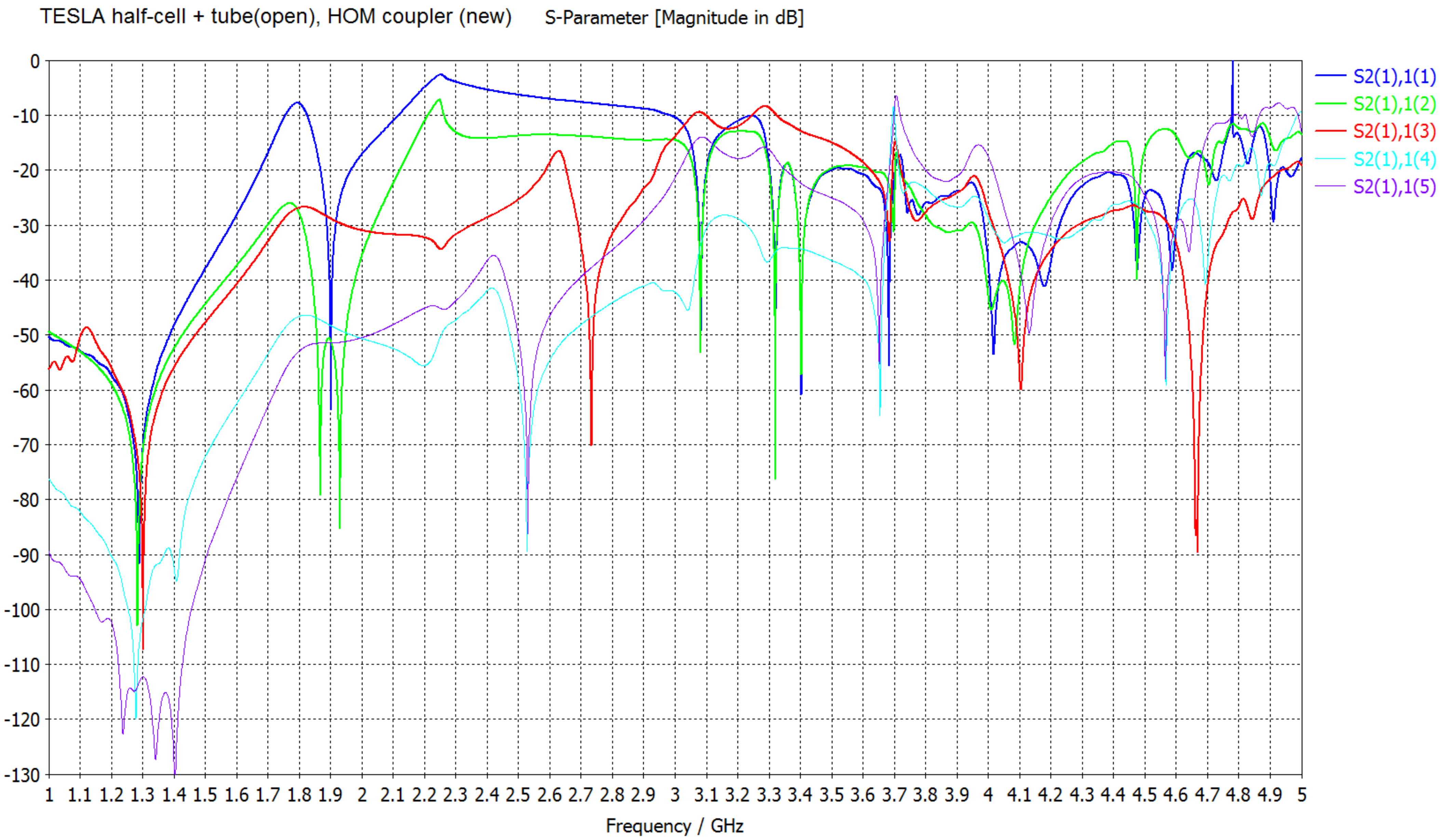


Figure 18: New HOMC geometry simulation with a half cell.

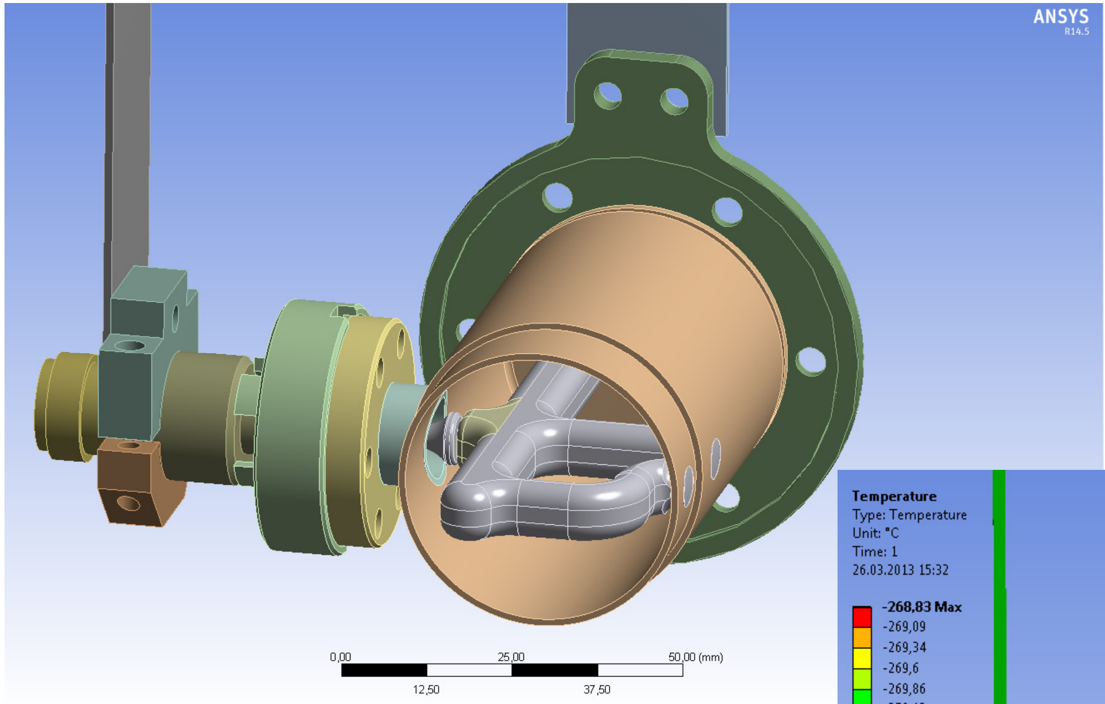
Simulations:



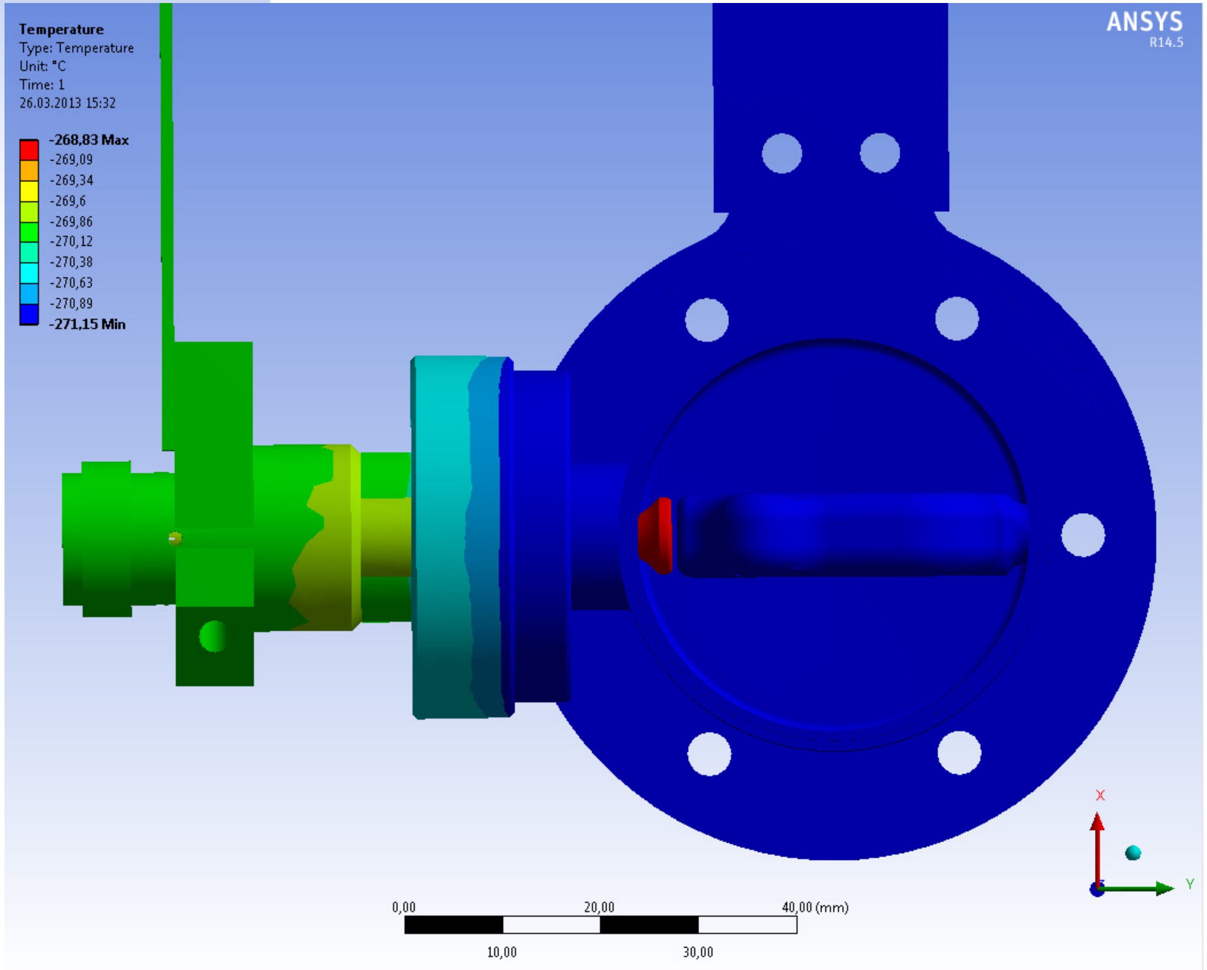
mode 1,2 dipole; mode 3 monopole; mode 4,5 quadrupole.

Figure 19: New HOMC geometry simulation with a half cell: S21(f).

Simulations:



HOMC antenna thermal load: 20mW



Geometry change from old design does not change the heat conduction/flow, new design ais aimed to decrease of the heat load at the HOMC antenna.

Figure 20: ANSYS thermal simulations.

SUMMARY

1. HOM coupler for the TESLA type cavity was simulated with the beam tube using the CST MWS T solver. Standard (old) and new coupler types were simulated (fig.1 and 2). Simulation was done with monopole and dipole modes, dipole mode polarization angle was chosen to be 45 degrees, set in the cavity by the main input coupler (fig.3).

2. S_{21}(f) comparison in range of 1..3 GHz shows rather small difference between the transmission of the standard and new designs (fig.4 and 5). Notch filter was adjusted for the new design with a new gap value of 1.27 mm with a sensitivity of 0.165 GHz/mm. Notch filter gap change was done by changing the HOMC body length.

3. Electromagnetic fields calculated for the monopole mode (3) at 1.3 GHz (fig.6 and 7). HOMC loop and feedthrough antenna surface magnetic (H) field amplitude distributions (fig.8 and 9) comparison (fig.10) yields the feedthrough antenna tip peak H-field ratio old/new of 0.045/0.030 = 1.5 ([A/m] with 1W input tube power). Thus, the HOMC antenna tip was shifted to lower H-field region in the new design.

4. Increasing the coupler loop protrusion (nose) length in the new design from 8.25 to 10 and 11.25 mm (fig.12, 15) slightly changes the transmission (fig.13, 16) and magnetic field distribution (fig.14, 17), so the old/new ratio is 0.045/0.026 = 1.7 for nose length of 10 mm and 0.045/0.022 = 2.0 for 11.25 mm (but with less transmission, fig.16).

5. Simulation with a half-cell (fig.18) was done with additional quadrupole modes (4,5) in wide frequency band 1..5 GHz (fig.19).