Universität Rostock

Traditio et Innovatio

HOM coupler modelling for SPL

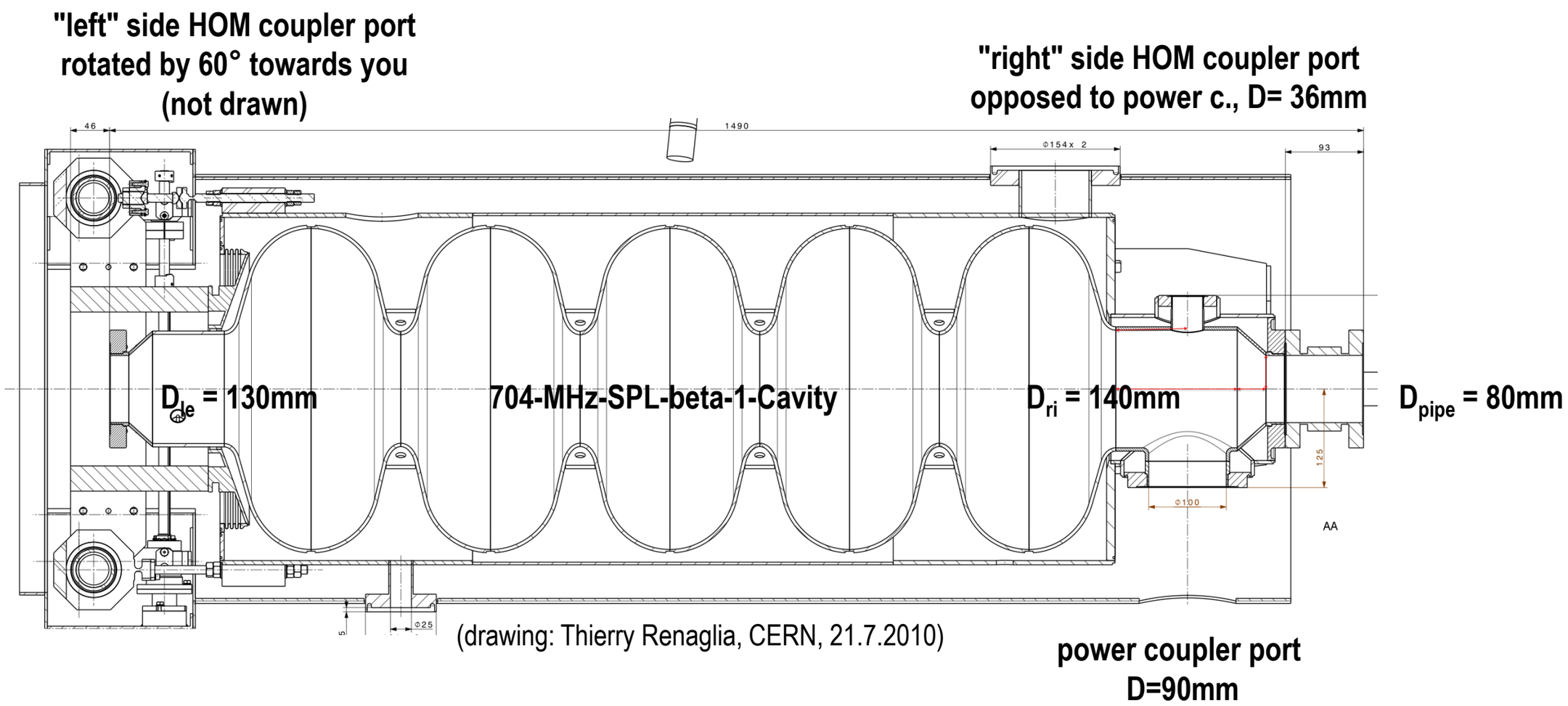
H.-W. Glock

Universität Rostock - Institut für Allgemeine Elektrotechnik

26.11.2010

5th SPL Collaboration Meeting, CERN, 25./26.11.2010

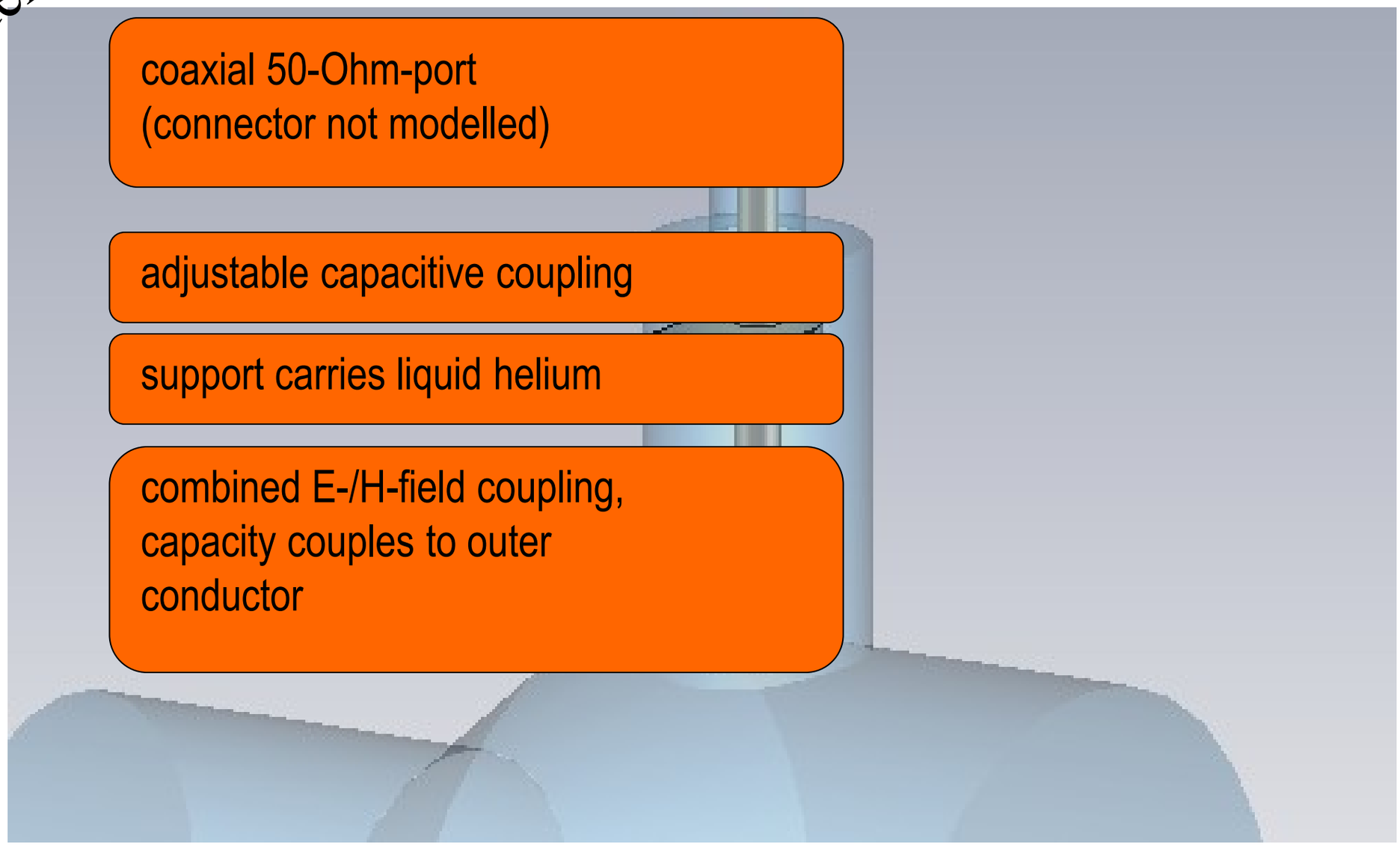
What we are talking about:



$Q_{secure} \leq 10^5$: HOM coupler not popular, but seem to be not to avoidable

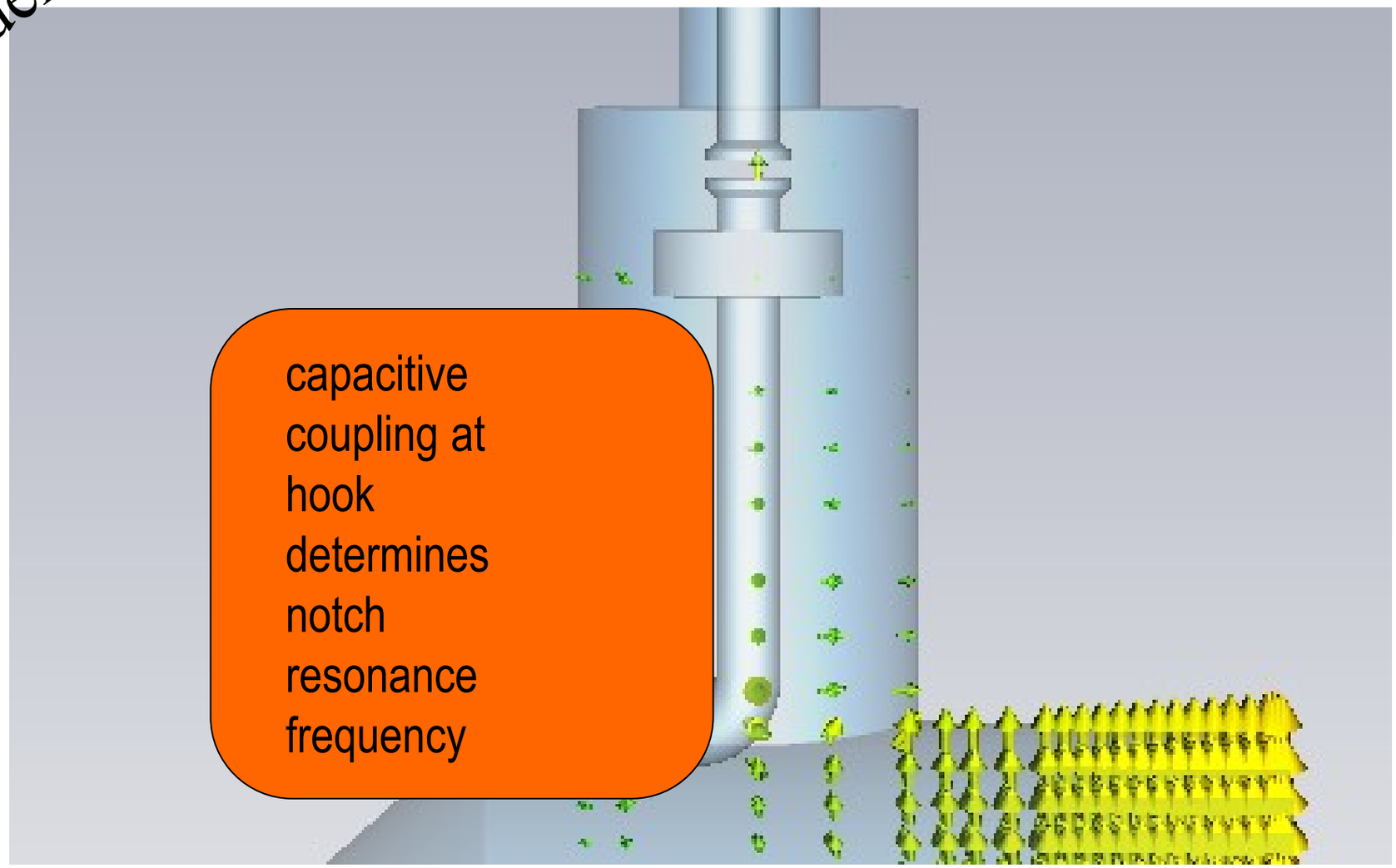
"Classical" LEP hook design as starting point (priv.com. WW)

reminder



E-field geometry @ 704 MHz

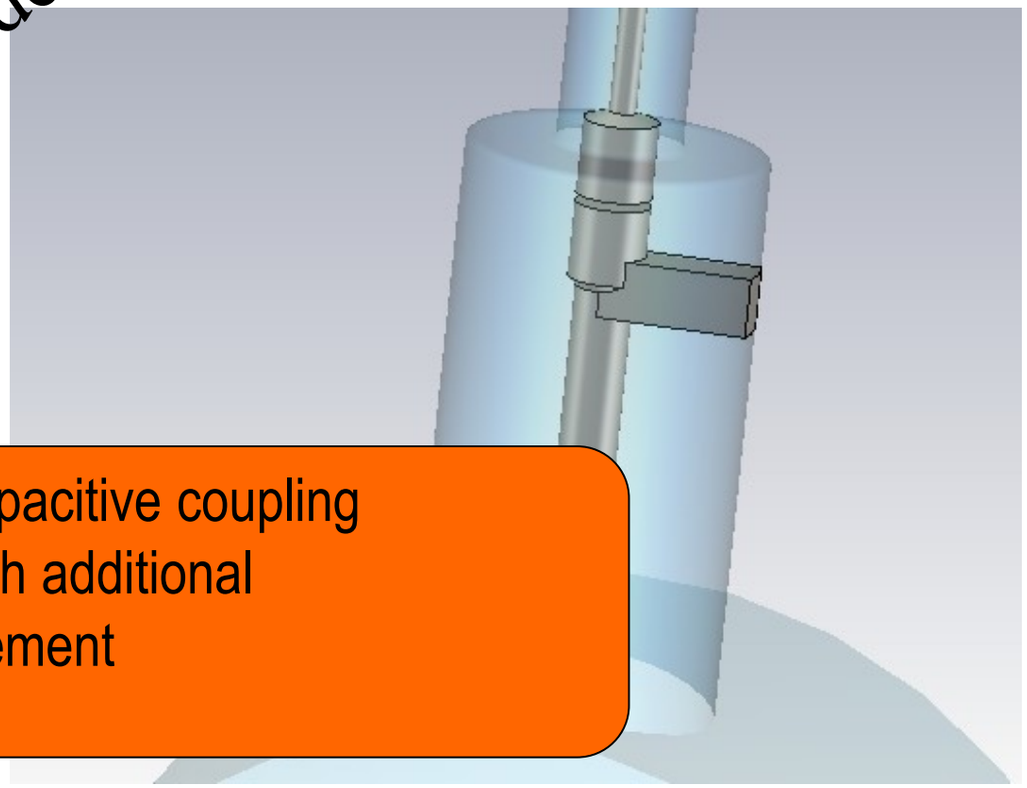
reminder



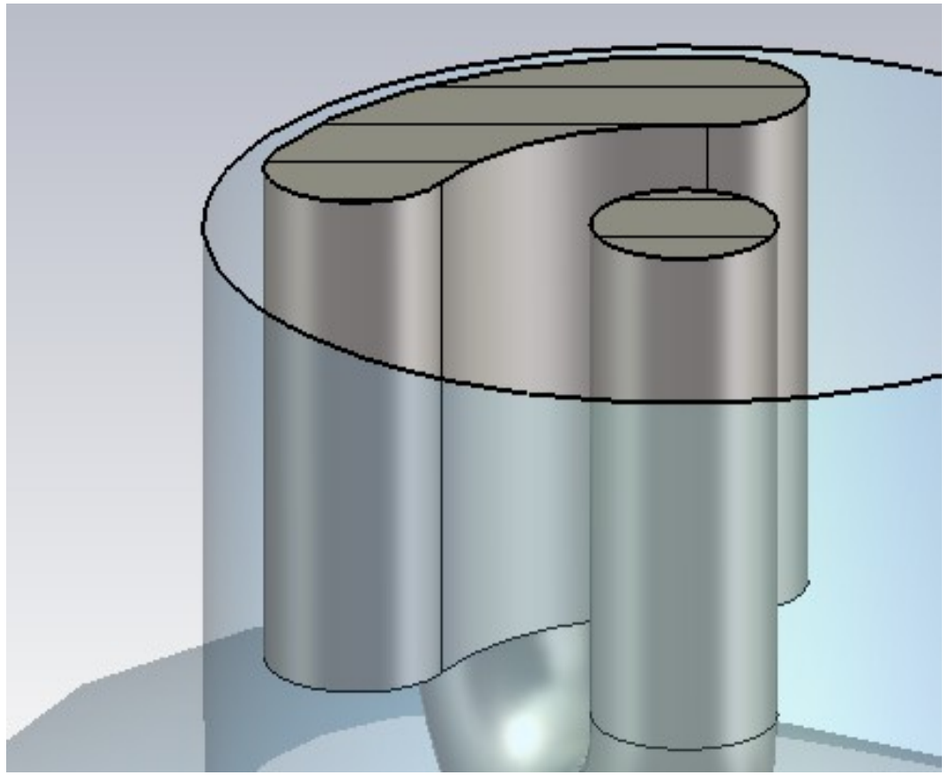
strong capacitive coupling between "hook" and outer conductor

Pure hook not tunable for 704 MHz => Modification of hook end in order to adjust fundamental mode notch filter

reminder

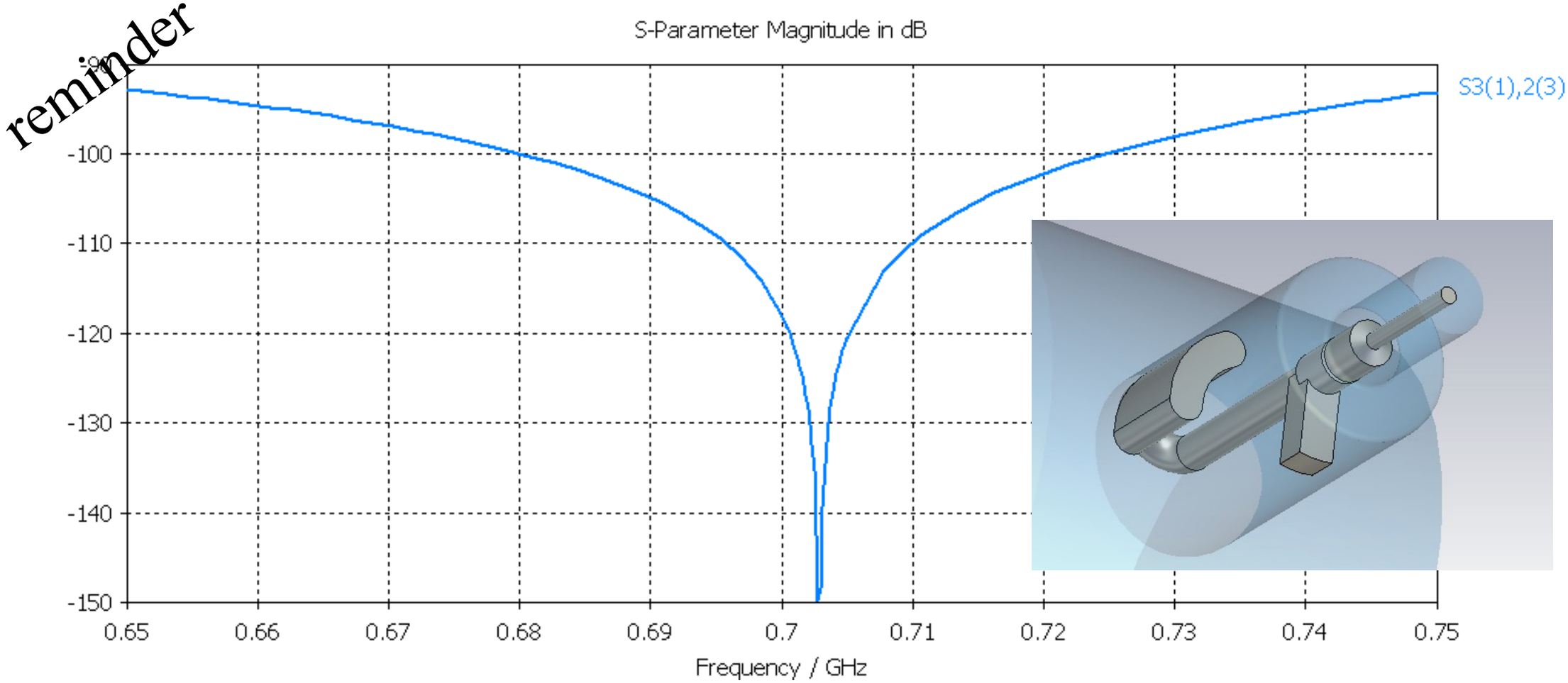


enlarge capacitive coupling
at hook with additional
surface element



Waveguide(TM_0)–Coax–Transmission blocked @ fundamental mode frequency => Tuning ok

reminder

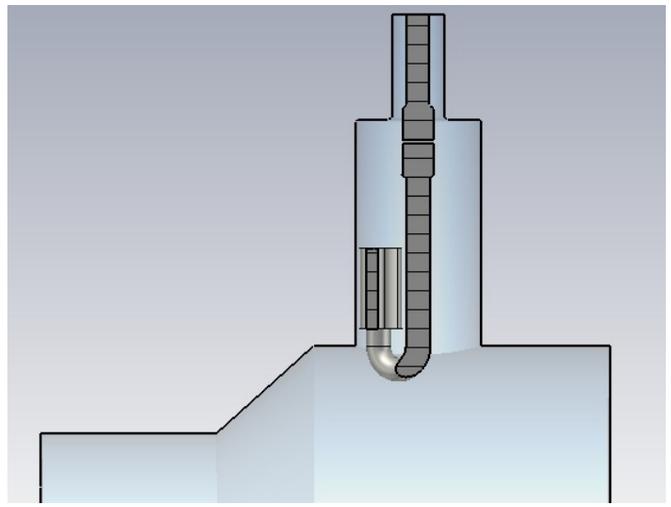


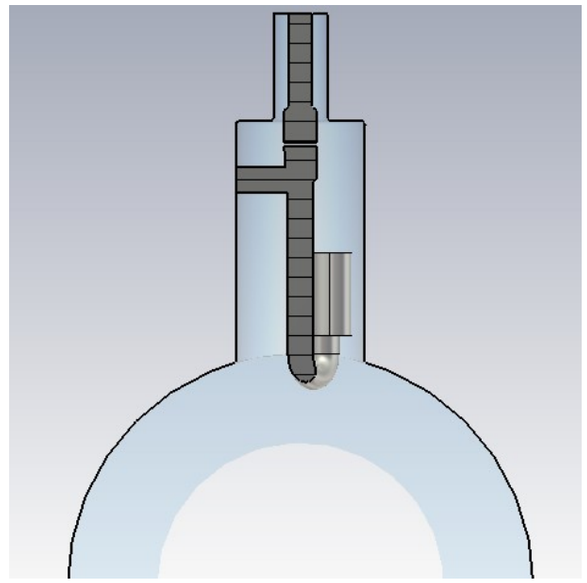
Some geometrical details

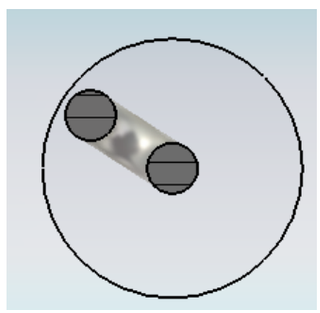
Penetration depth of the antenna/loop in the beam pipe could be increased, but:
- risc of dark current heating,
- impedance

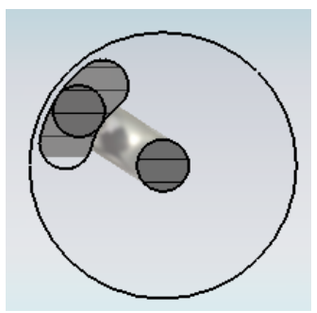
Mechanical stability, esp. against oscillations, may be an issue.

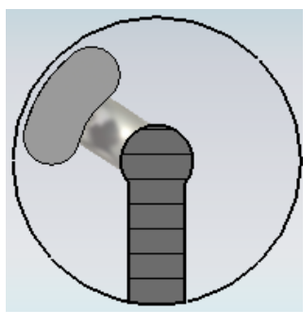
But: LHC cavs. use similar concept (courtesy W.W.)

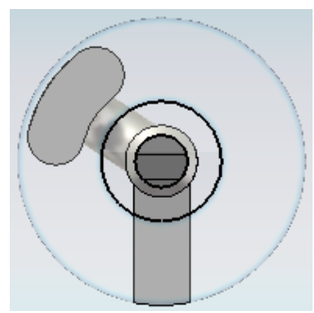






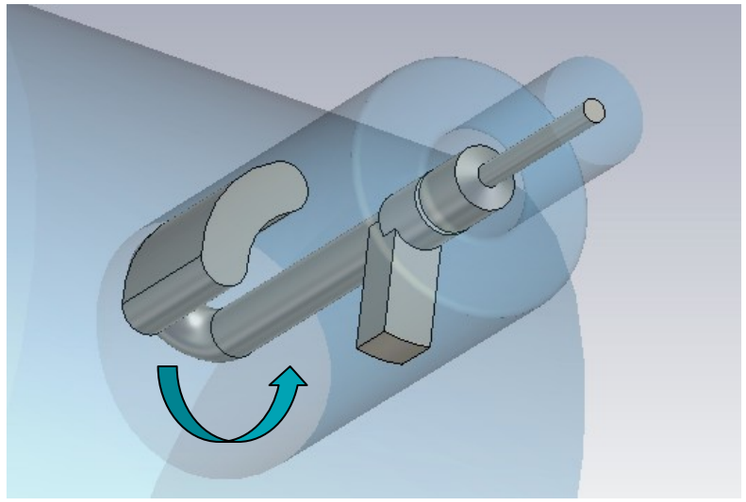






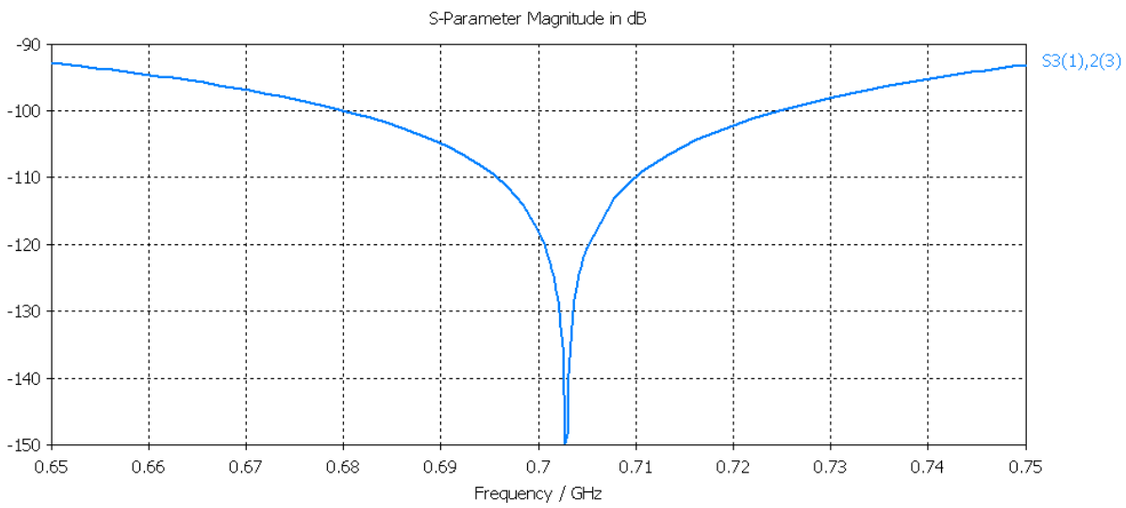
Remarks about fundamental mode notch filter:

1.) Tuning rather sensitive both against capacity surface AND rotation angle (~5 MHz/Degree⇔ 30 dB/Degree)



2.) => notch filter understood as combination of resonance AND "directional coupler"-effect: certain E-H-correlation causes cancelation

3.) This demands for external re-tuning capability after mounting (e.g. rotation)

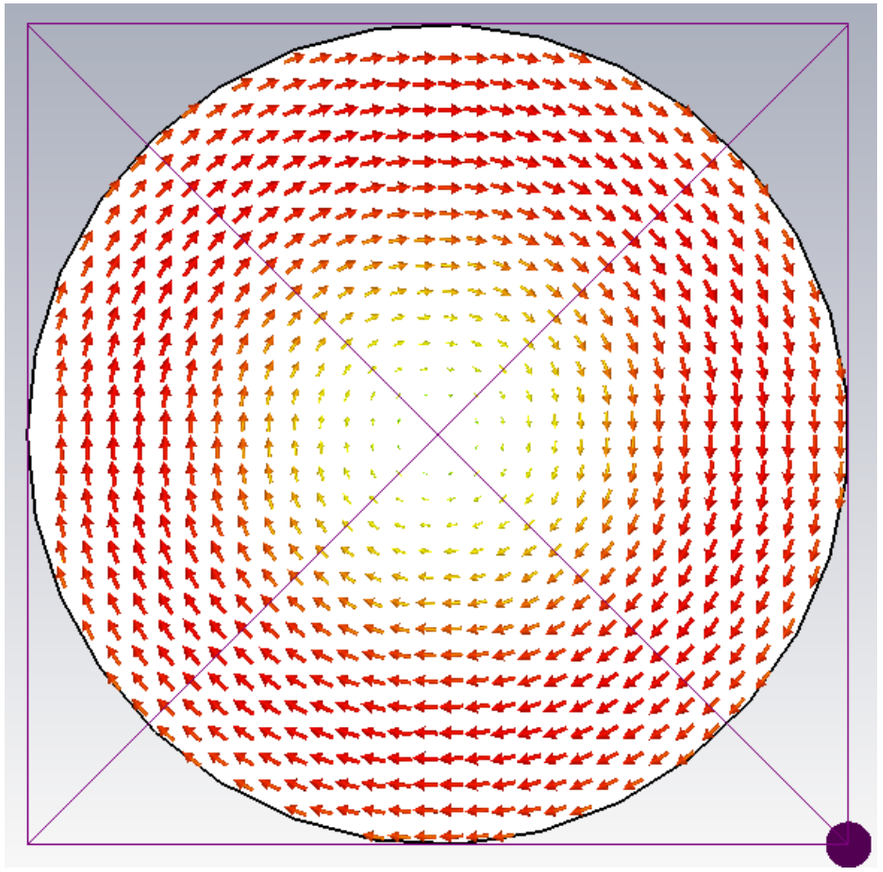


Why looking for a single S-parameter during tuning?:

Fundamental mode is of TM_0-type (no dependence on angle around axis).

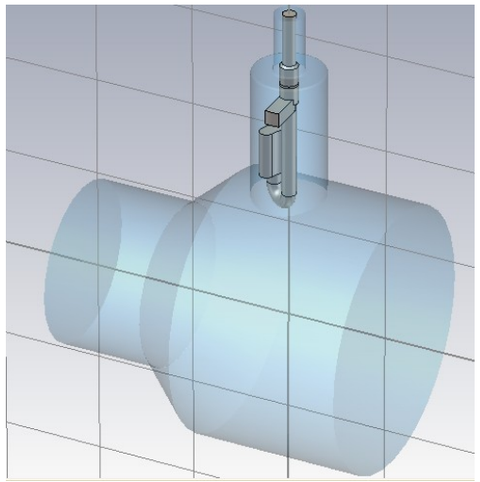
Thus it directly couples only to TM_{01}, TM_{02}, ... waveguide modes, all below cut-off @ 704 MHz.

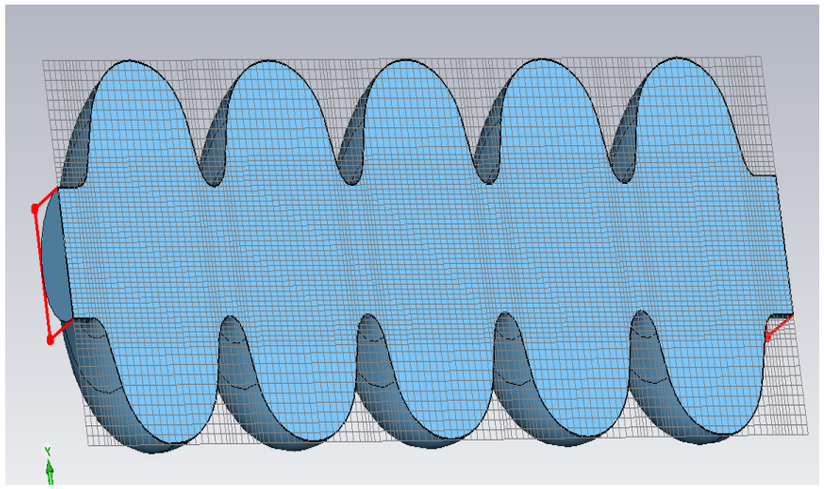
Neglecting all higher types than TM_{01} causes very small error but significantly reduces numerical effort.

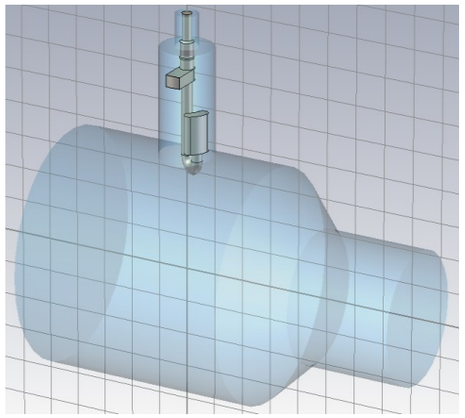


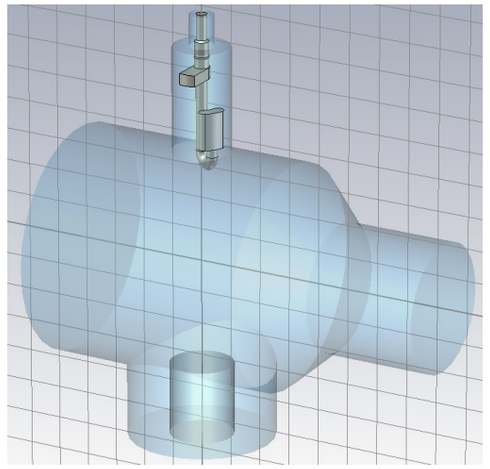
TM01-Mode H-field

Q-ext computations based on:



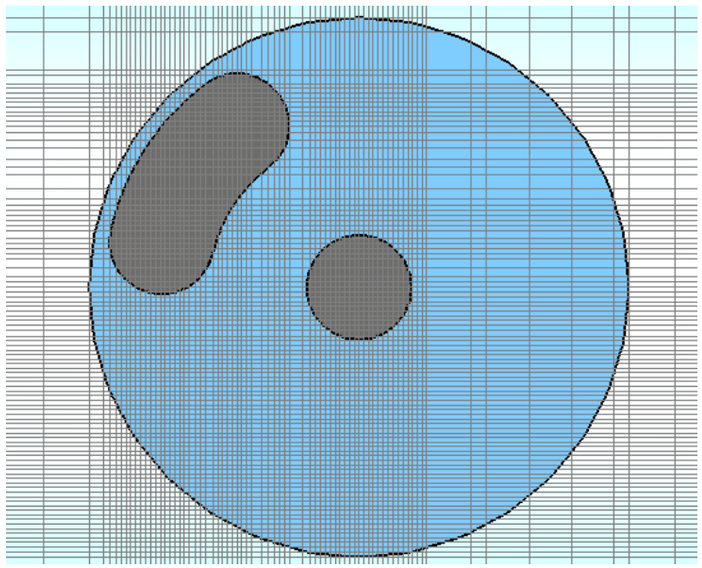


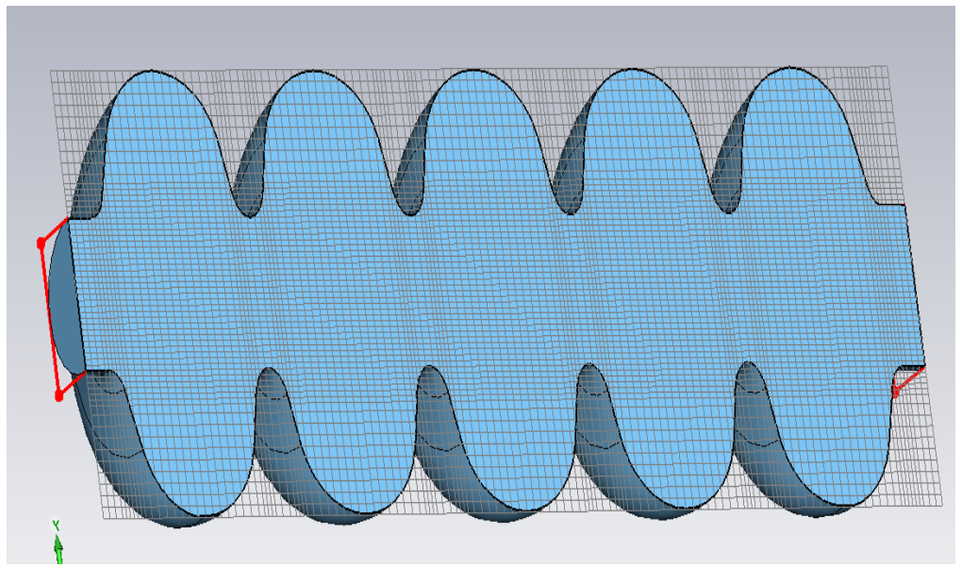




- CSC-coupling of 8 modes in D=130mm/140mm-coupler-cavity-connections (TE11,TM01, TE21,TM11,TE01)
- right coupler both w/o power coupler (90mm coax, 50 Ohm, penetration depth freely chosen)
- D=80mm beam pipes left open (but most below cut-off)

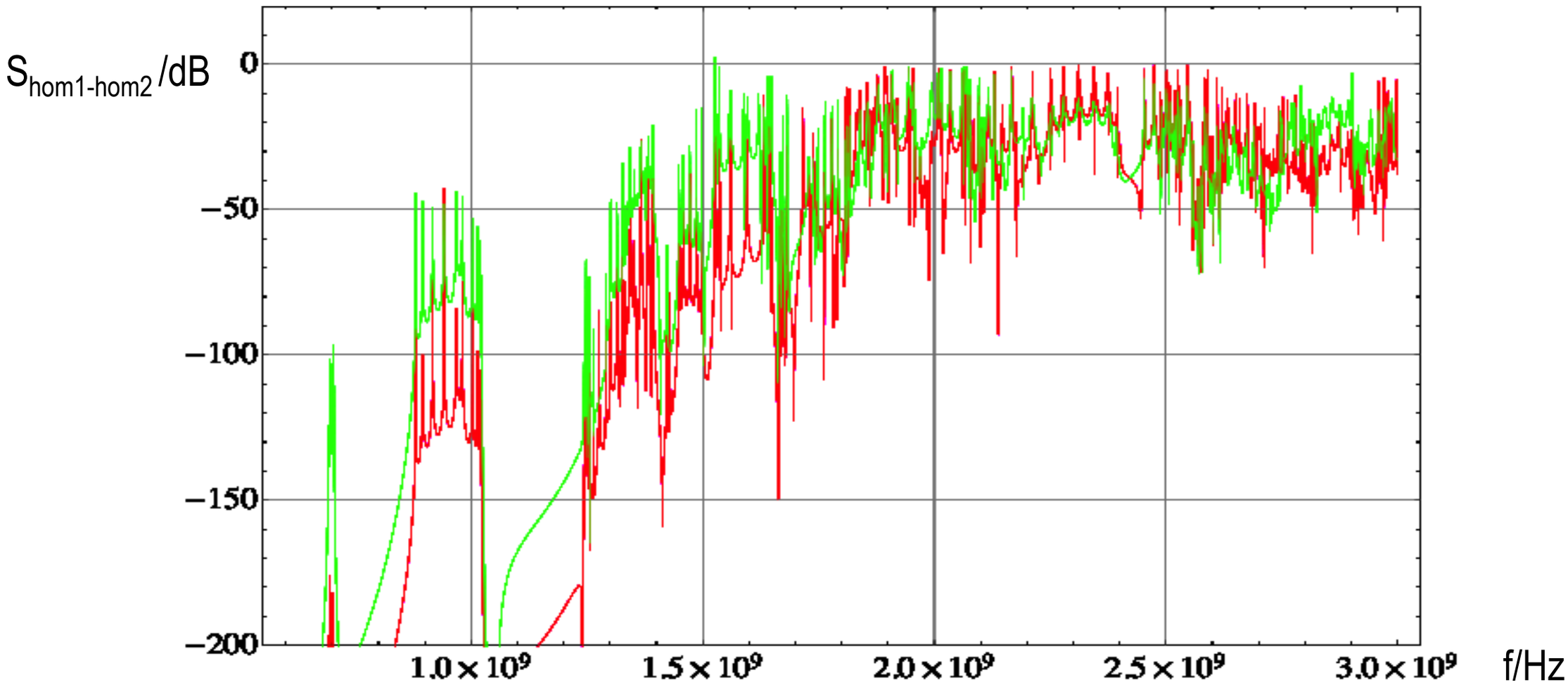
Scattering parameter computation:





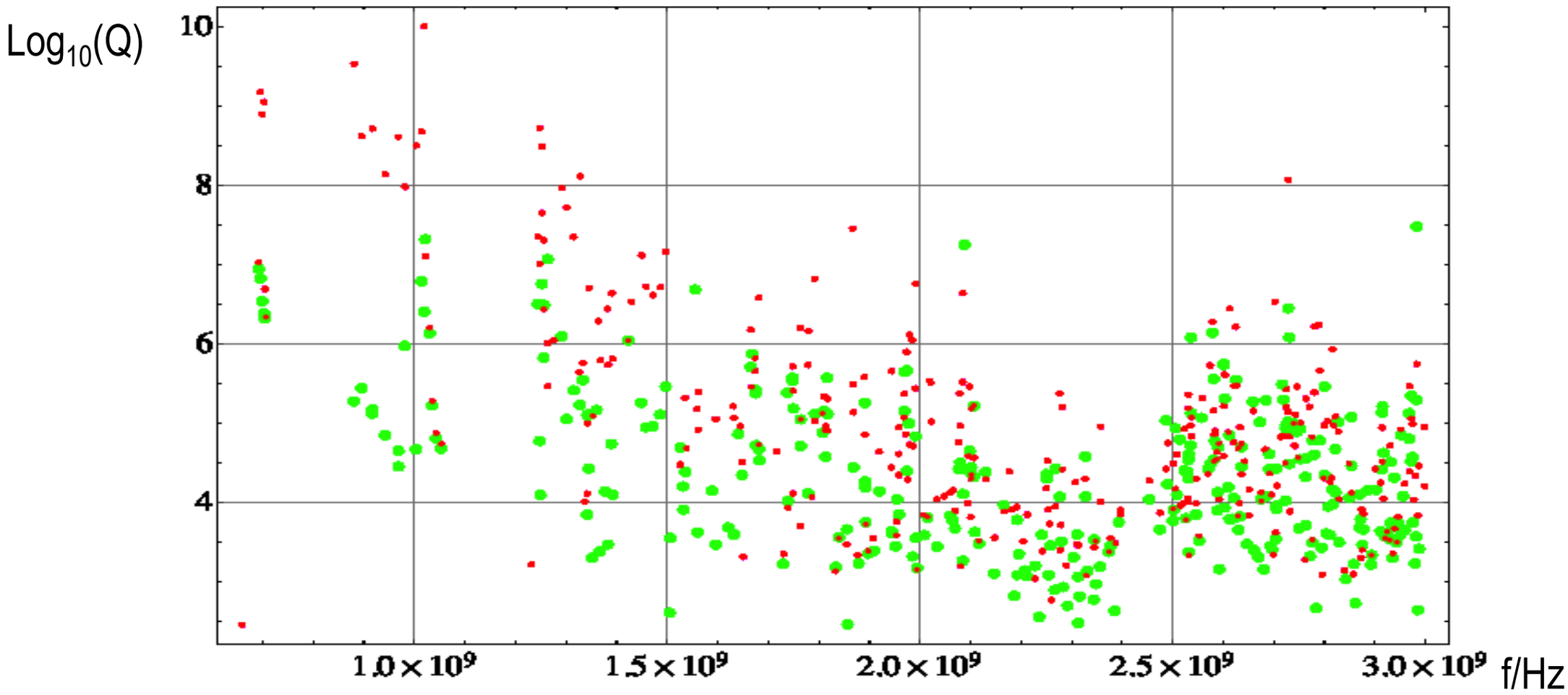
- Using "Fast-Resonant"-Solver of CST MicrowaveStudio© (ver. 2010-7)
- taking S-parameter from multimodal Z-matrix using analytical waveguide impedance expressions (most secure way)
- typical computation time: ~several hours; therefore during optimization use of tetrahedral grid, applied to few frequency points (=> ~fraction of hours/configuration)

This (cst-computation, csc-concatenation) gives HOM1-HOM2 transmission:



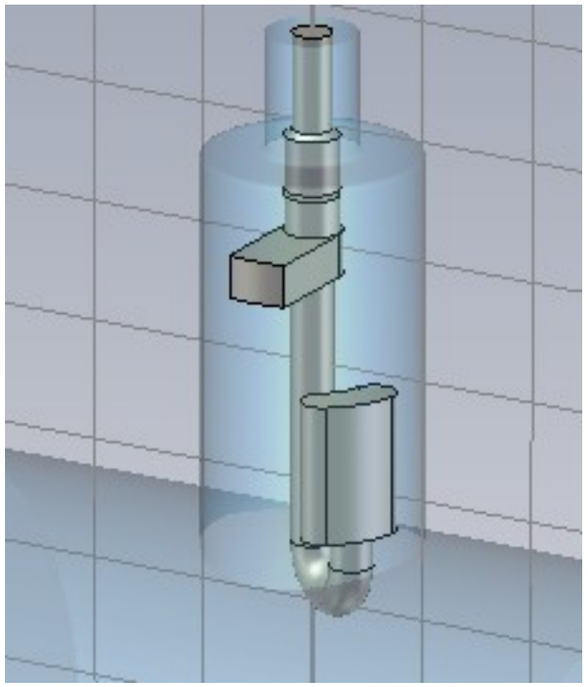
- red: HOM coupler only, green with matched power coupler
- presence of power coupler lifts transmission level and seem to decrease Qs

Put this in resonance-fit-algorithm in order to determine Qs:



- red: HOM coupler only, green with matched power coupler
- main power coupler helps significantly below 2 GHz; still Qs > 10^6 found

Conclusion



- tuning successful, but: sensitive setup, 180° rotation seem to hinder "directional coupler"- effect
- Q values w/o main power coupler computed, closer to 10^5, but not reached