HOM Coupler Development for SPL

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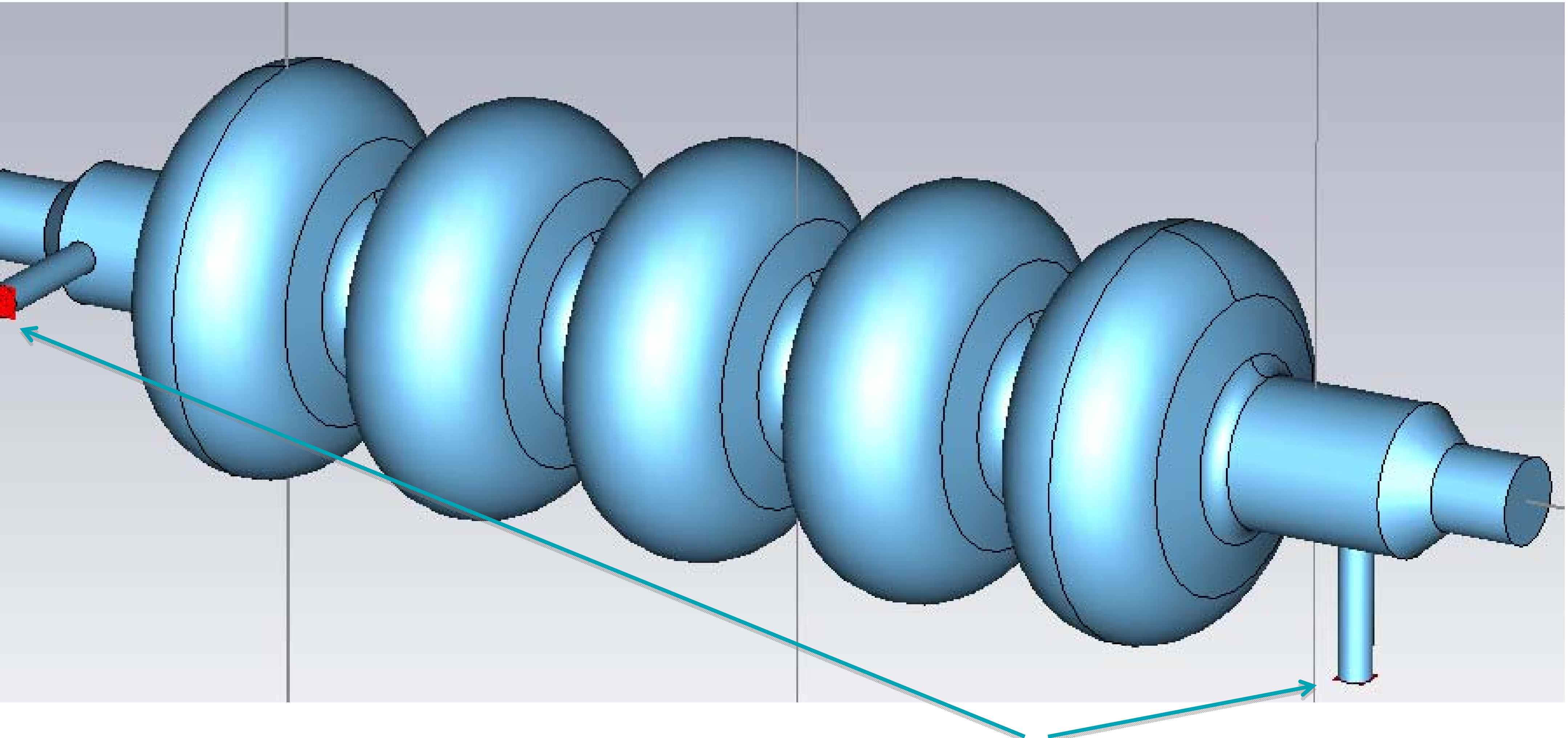
4th SPL Collaboration Meeting jointly with ESS
30.6.-2.7.2010 Lund

M coupler for SPL - β=1 cavity needed, better than ...

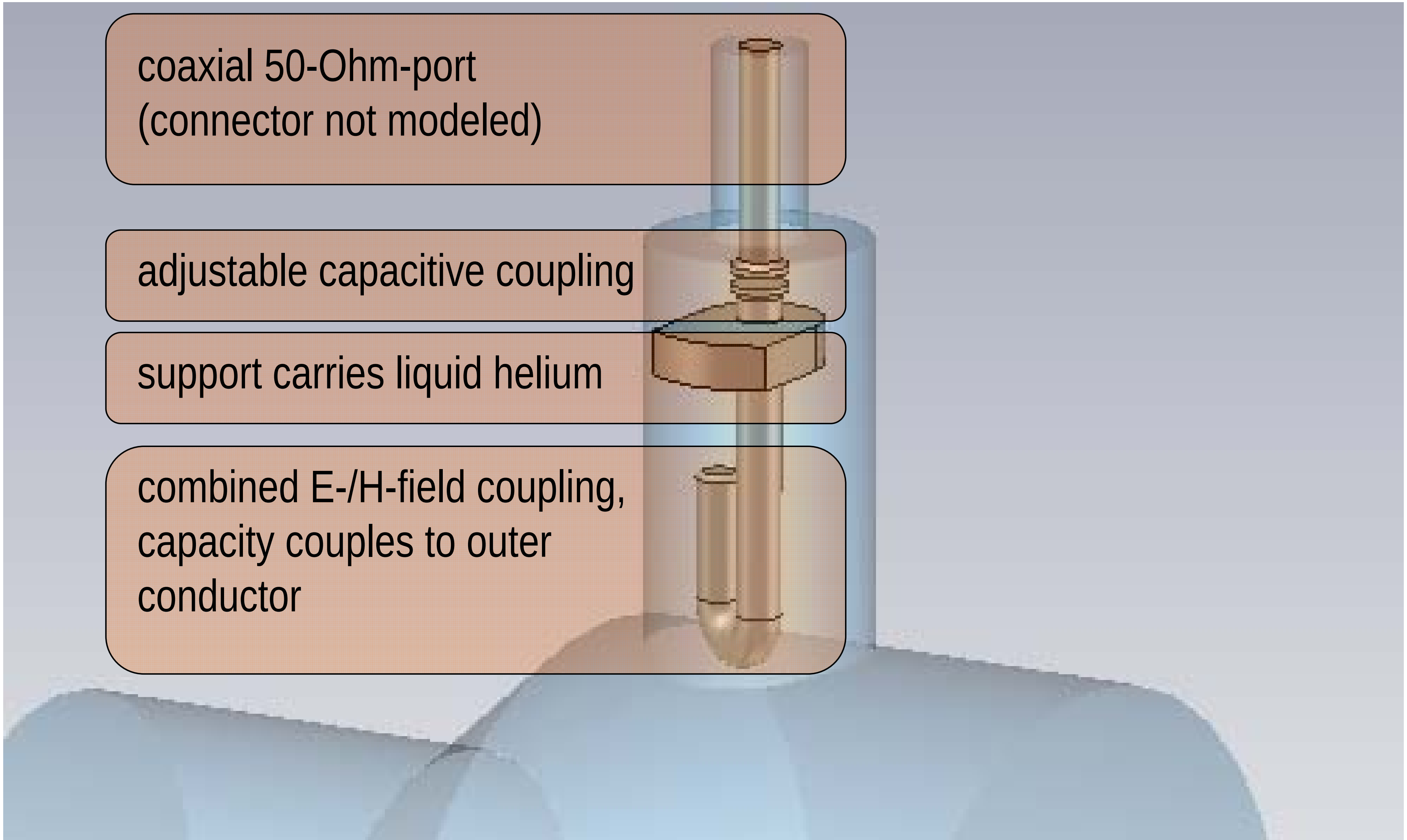


... coaxial couplers without fundamental mode filter

Given coupler design limitations

- Orientation and longitudinal position fixed (cavity construction efforts, space needed for tuner, ...)
- (Inner) diameter (max.) 36 mm
- Same design on both sides of the cavity
- (De)mountable, not welded

ssical" LEP hook design as starting point



e design parameters

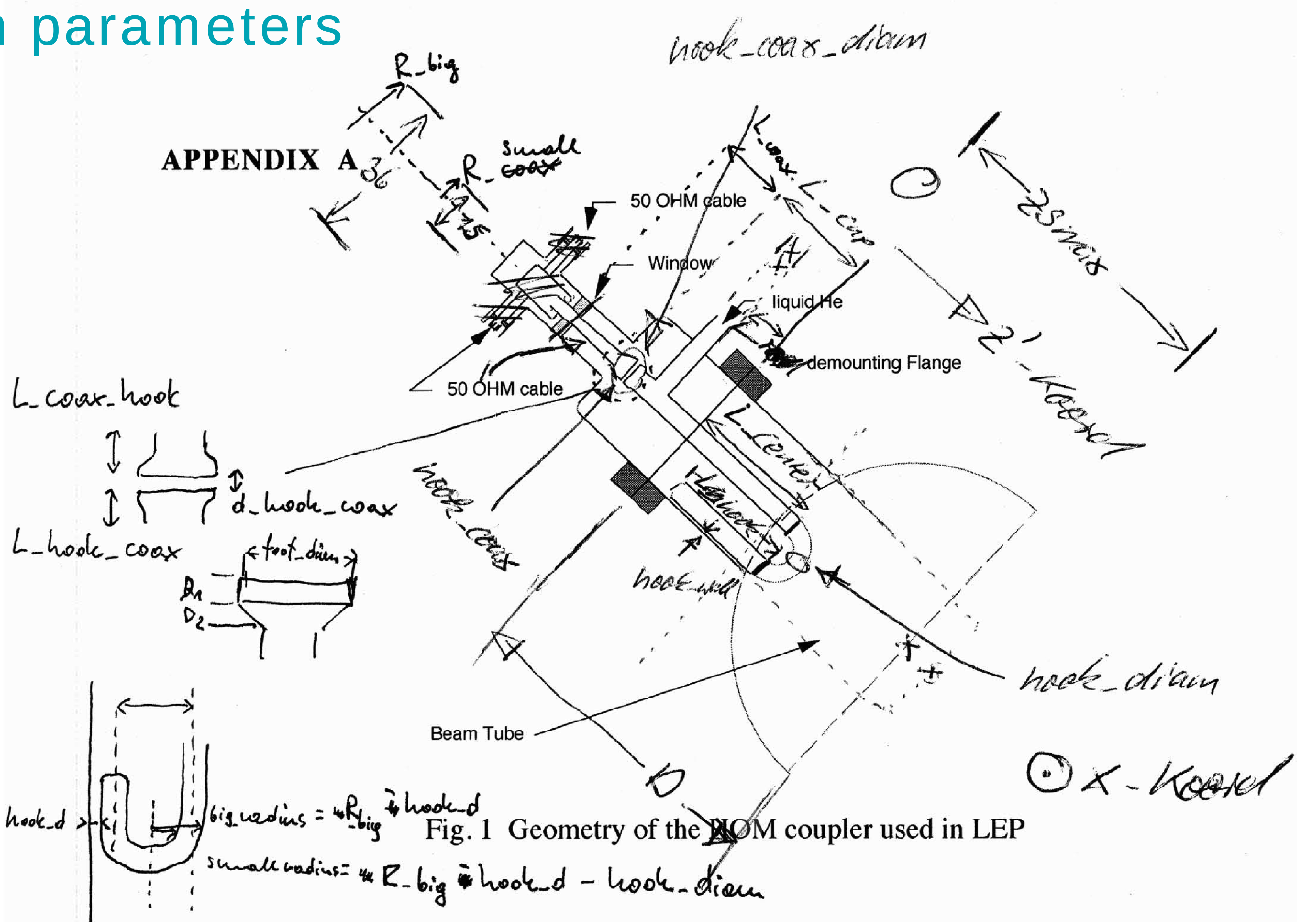
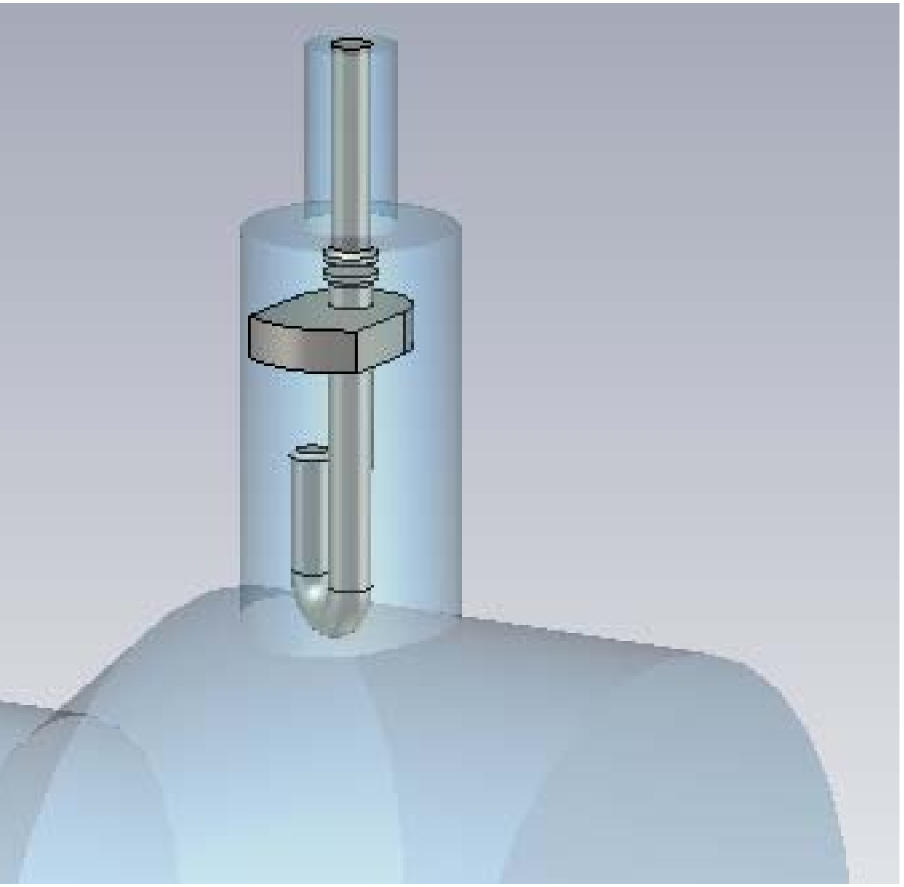


Fig. 1 Geometry of the HOM coupler used in LEP

ree design parameters

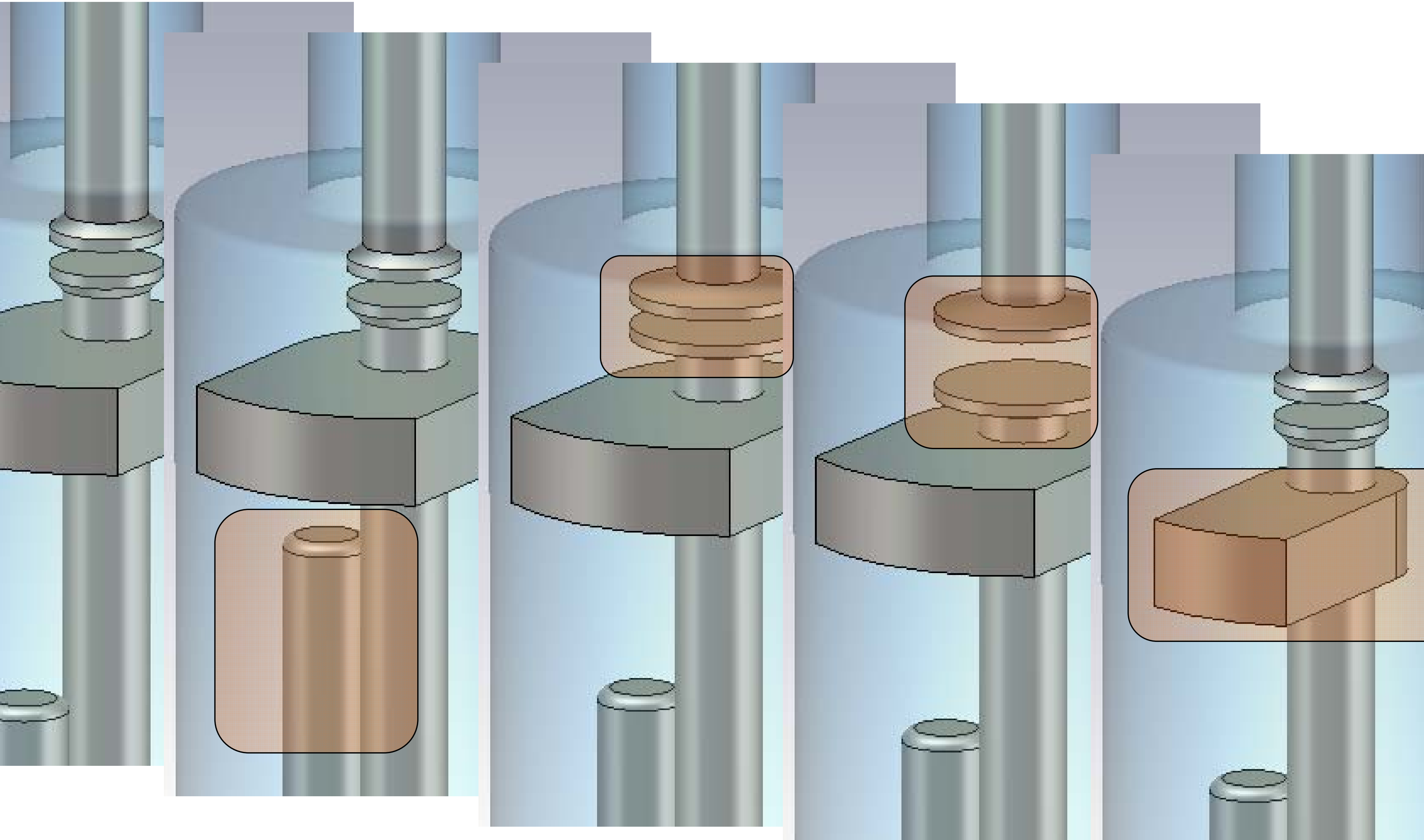
electrodynamical CAE

~ 20 adjustable parameters

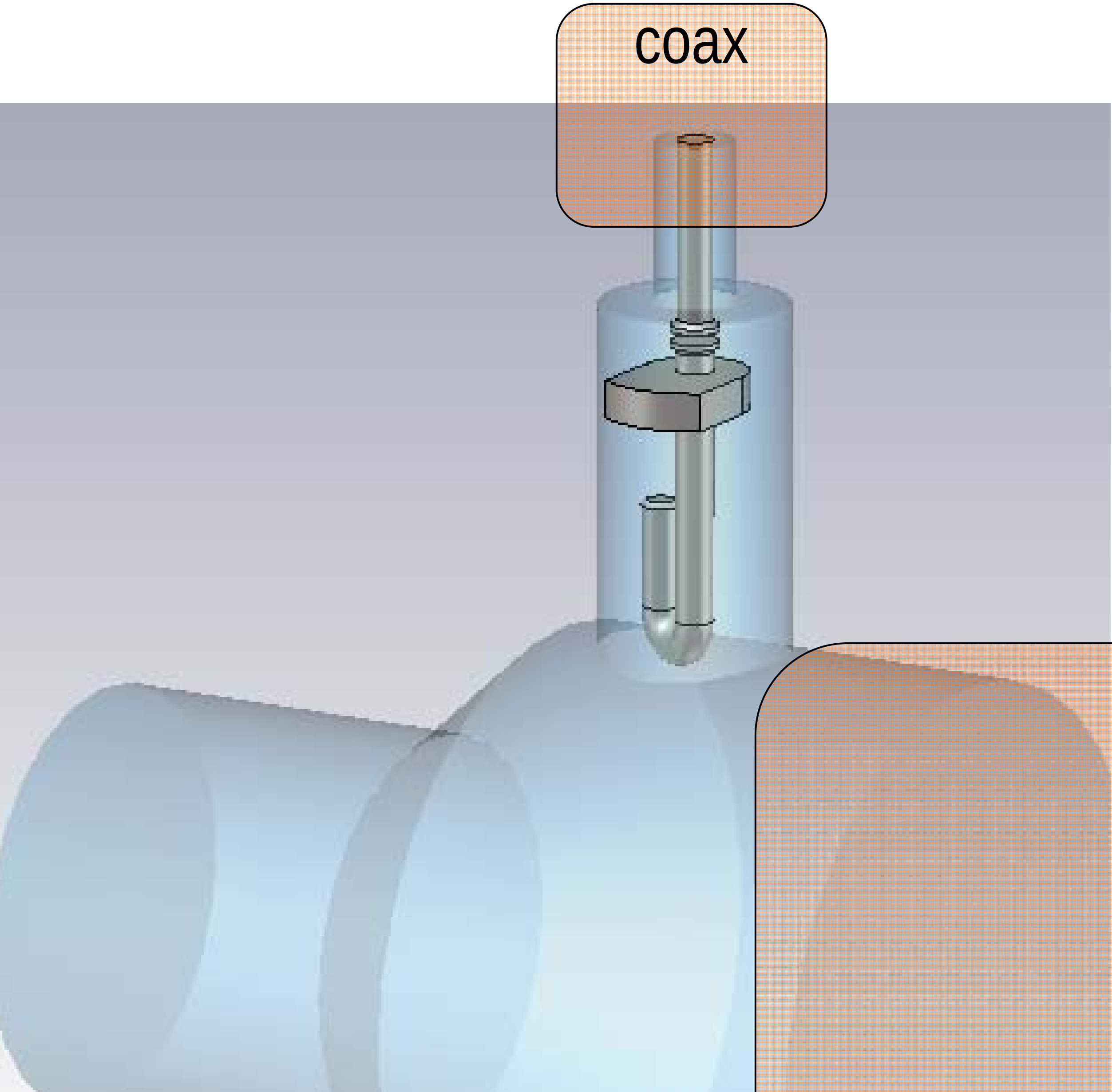


Name	Value	Description	Type
D	100	beam axis - flange	Leng
D_HOM	10	! long. dist. HOMC - beam pipe taper	Leng
L_center	30	coupler hook center length straight part	Leng
L_coax	30	coupler cup end - coax end	Leng
L_cup	30	flange - coupler cup end	Leng
L_hook	34	coupler hook peripheral straight part leng	Leng
L_rod	10	flange-rod spacing	Leng
R_big	36/2	coupler rf radius	Leng
R_small	15/2	coax outer rf radius	Leng
Rotangle	60	! rotation angle of hook	None
X_position	0	not modify	Leng
Z_position	0	not modify	Leng
coax_diam	6.5152134	coax inner diameter (50 ohm 15 mm out)	Leng
d_hook_coax	2	!! distance capacity hook - coax !!	Leng
foot_cone_thick	1	hoot foot taper length	Leng
foot_diam	9	!! diameter capacity hook - coax !!	Leng
foot_thick	1	hook foot length	Leng
hook_d	2	!! distance hook-wall !!	Leng
hook_diam	7	coupler hook cylindrical diameter	Leng
r_lp1	65	! radius large beam pipe	Leng
r_lp2	40	! radius small beam pipe	Leng
rod_base	20	width of rod base	Leng
rod_thick	7	rod thickness	Leng
xlen_lc	28	! length beam pipe cone	Leng

ree design parameters – examples



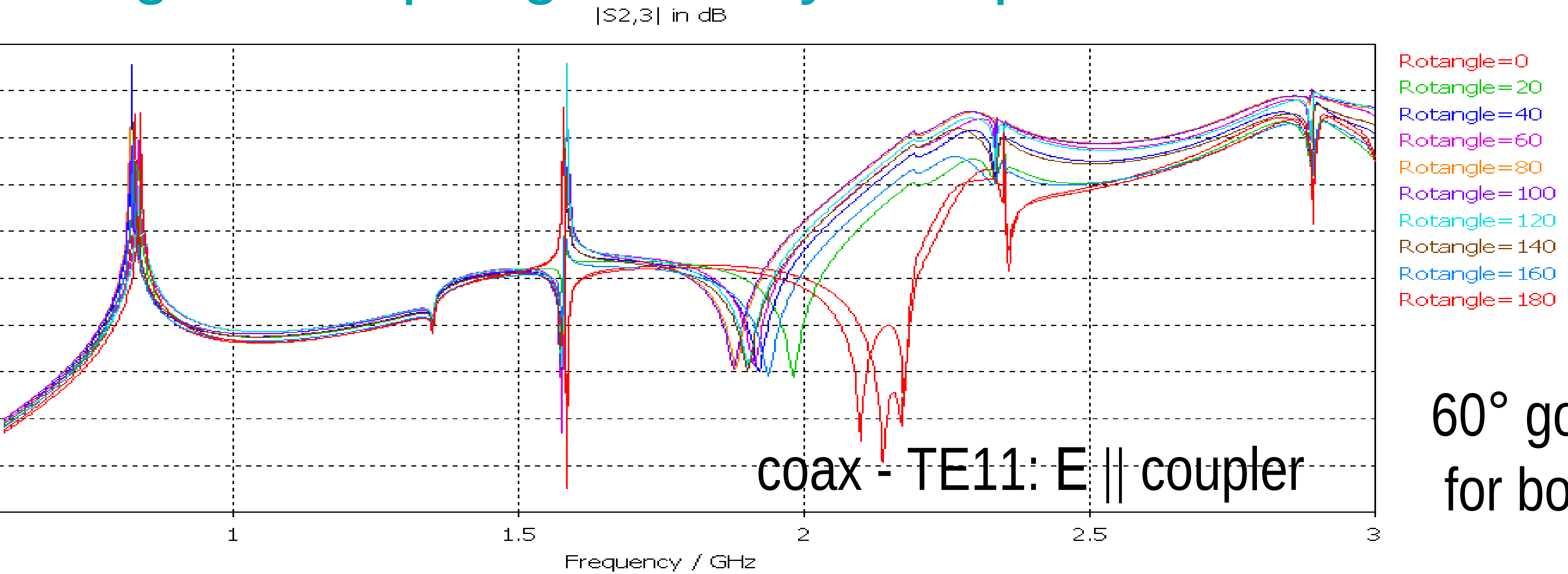
aveguide-Coax-Transmission used to assess coupling



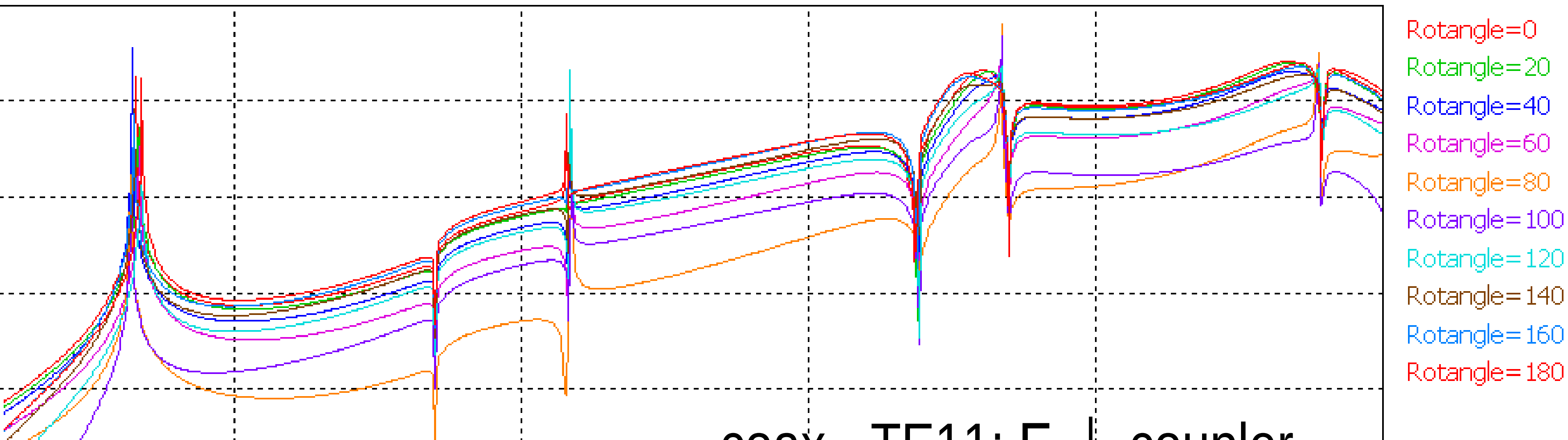
waveguide connection to cavity:

- TE_{11} – horizontal
- TE_{11} – vertical
- TM_{01} (esp. f_{acc} !)
- TE_{21} – pol. 1
- TE_{21} – pol. 2

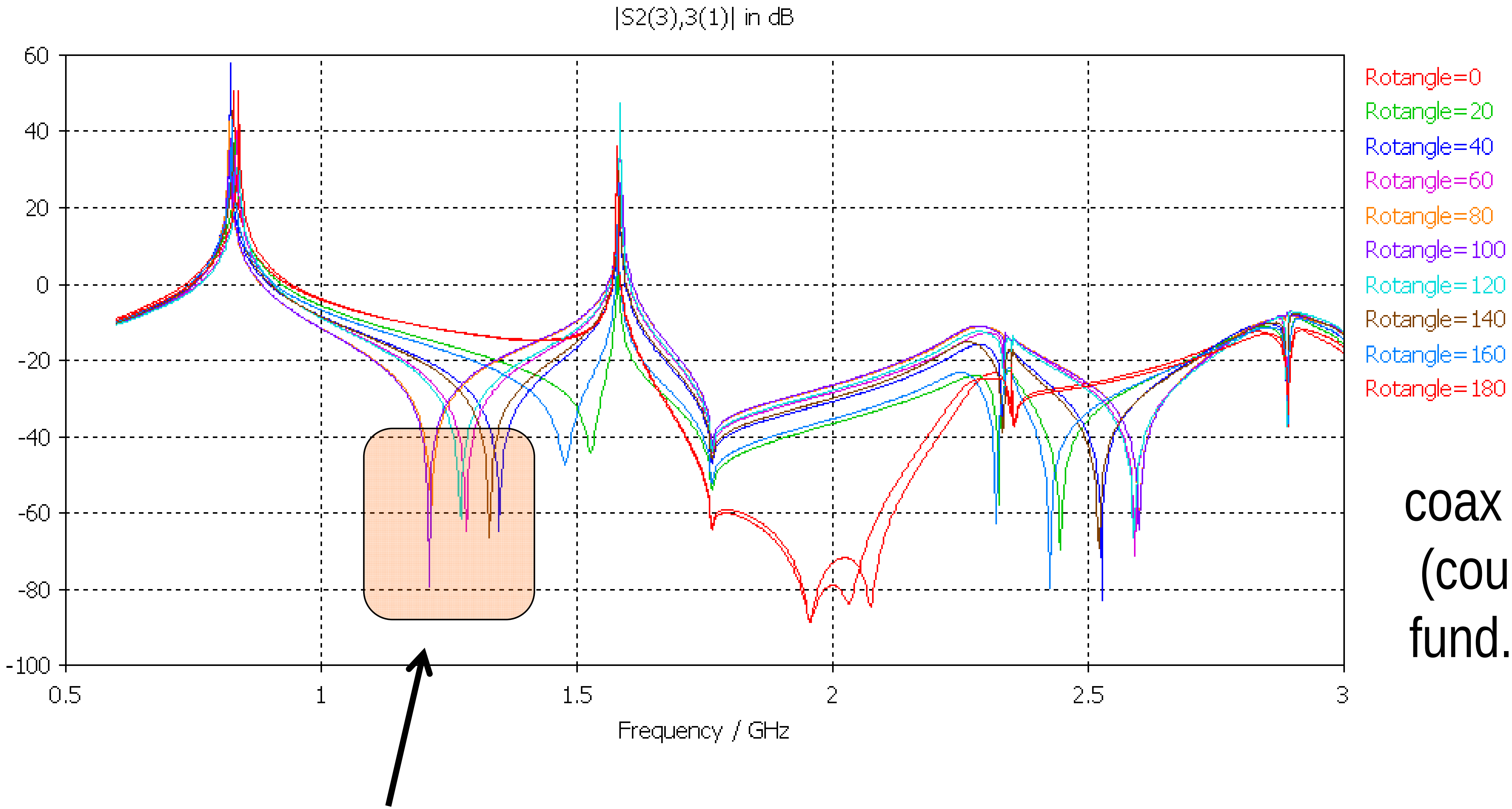
aveguide-Coax-Transmission used to assess coupling – e.g. example geometry - dependence on hook rotatio



60° good compron
for both polarizatic



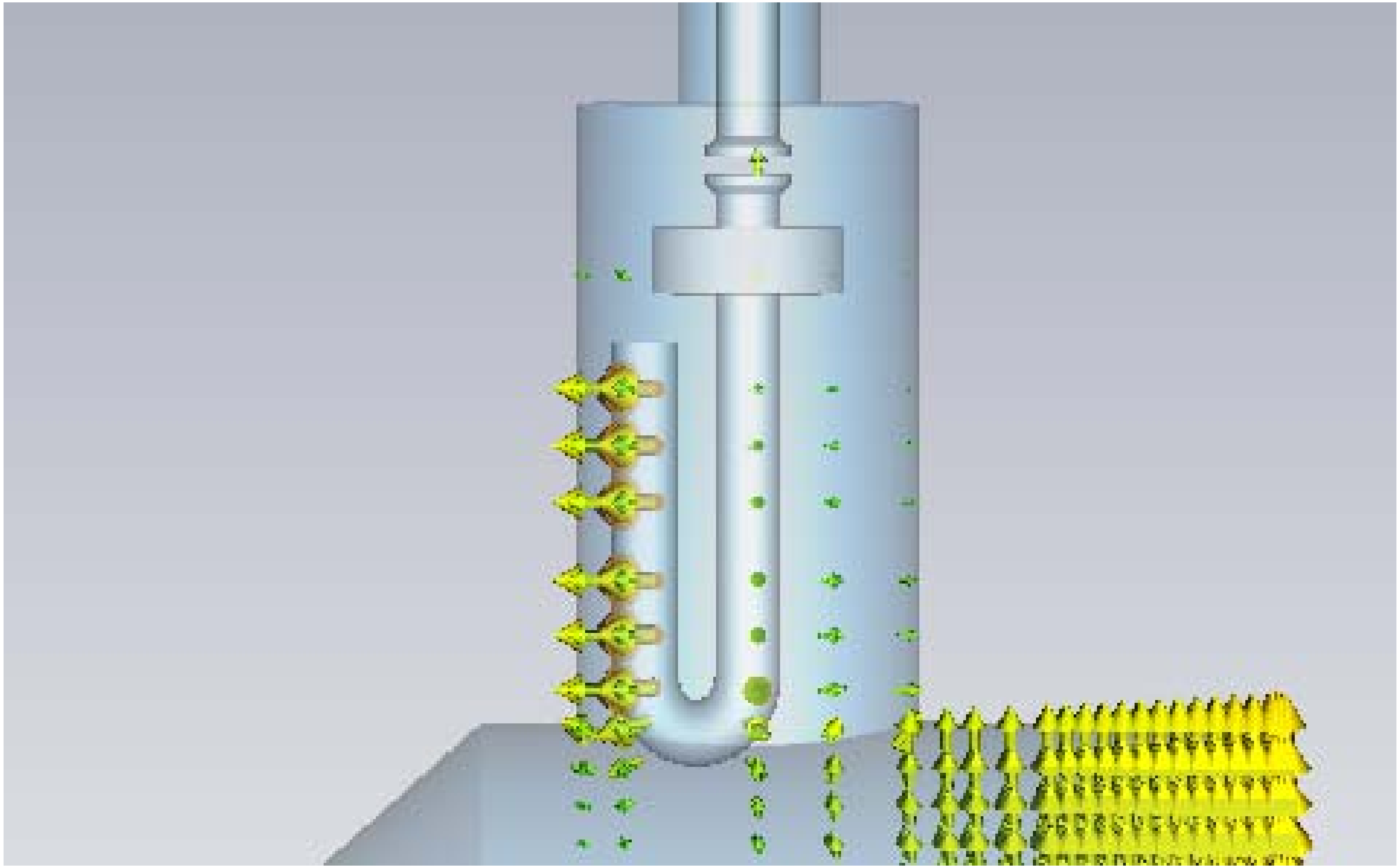
ndamental mode rejection –
e.g. example geometry - dependence on hook rotatio



coax - TM0
(couples t
fund. mode

minimum of transmission occurs, but not at 704 MHz – to be tuned !

ld distributions give hints for design – e.g. example geometry – E-field geometry @ 704 MH



strong capacitive coupling between "hook" and outer conductor =>

Status and plan

Description of fully parameterized coupler geometry available

Many (~20) degrees of freedom to be taken into consideration

Primary design criterion: notch filter to be tuned for fundamental mode freque

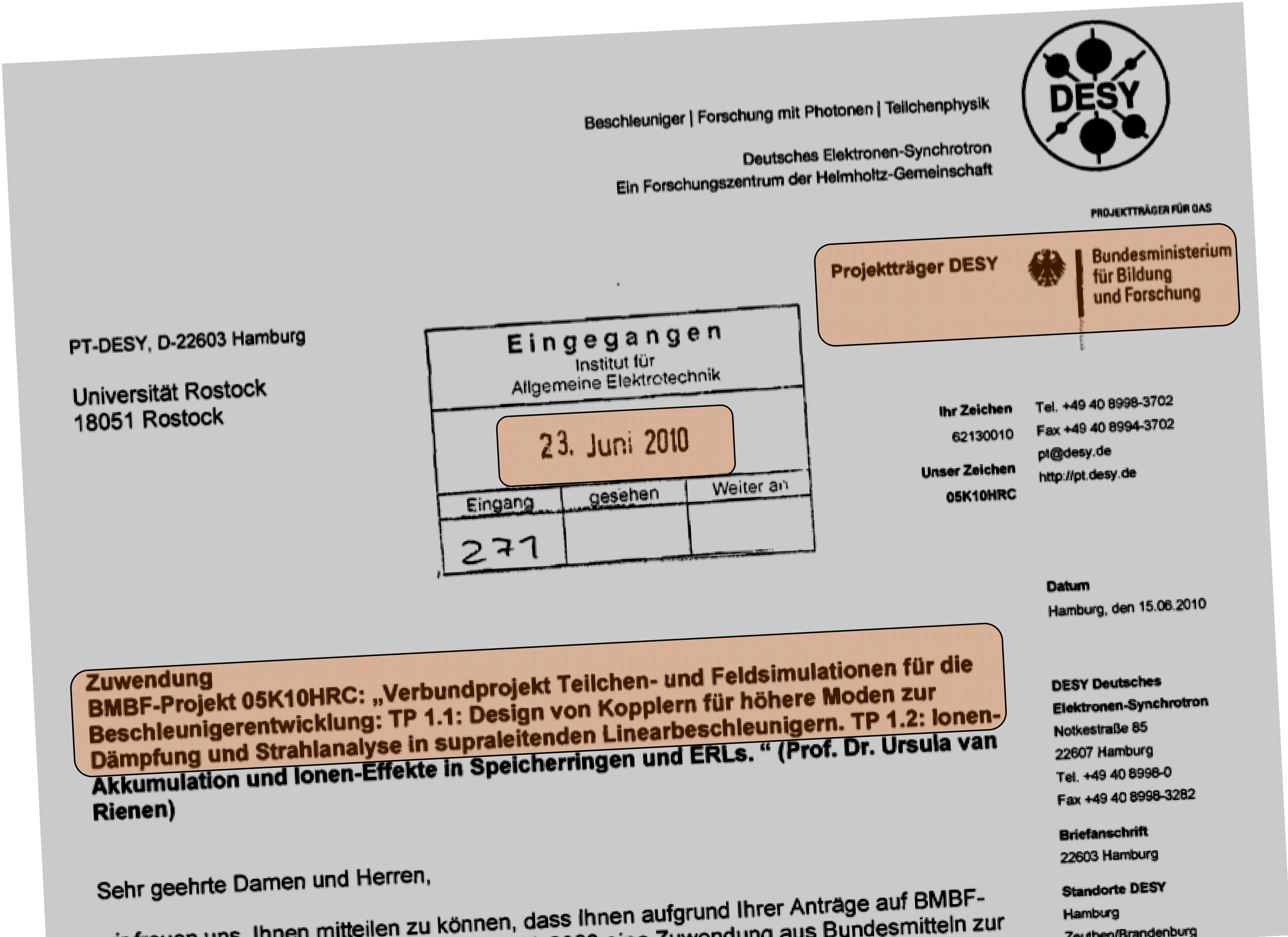
Combination with cavity (as done for coaxial couplers), Q-determination with pole fi
algorithm

Further optimization according polarization sensitivity (mainly TE11, TM11) ...

... Current density / loss density ...

... and further constructive aspects (cooling, manufacturing)

ne news regarding ESS and University of Rostock:



Beschleuniger | Forschung mit Photonen | Teilchenphysik

Deutsches Elektronen-Synchrotron
Ein Forschungszentrum der Helmholtz-Gemeinschaft

DESY

PROJEKTTRÄGER FÜR DAS

Projektträger DESY | Bundesministerium für Bildung und Forschung

PT-DESY, D-22603 Hamburg

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Eingegangen
Institut für
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23. Juni 2010

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271		

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Zuwendung
BMBF-Projekt 05K10HRC: „Verbundprojekt Teilchen- und Feldsimulationen für die Beschleunigerentwicklung: TP 1.1: Design von Kopplern für höhere Moden zur Dämpfung und Strahlanalyse in supraleitenden Linearbeschleunigern. TP 1.2: Ionen-Akkumulation und Ionen-Effekte in Speicherringen und ERLs. " (Prof. Dr. Ursula van Rienen)

Sehr geehrte Damen und Herren,

...freuen uns, Ihnen mitteilen zu können, dass Ihnen aufgrund Ihrer Anträge auf BMBF-... eine Zuwendung aus Bundesmitteln zur

ERN-SPL*-Study, EUCARD**, DoHRo*** @ Rostock

CERN-SPL:*

HOM damping design for CERN-SPL-Study

*EUCARD** – WP 10.5.3:*

HOM distribution and geometrical dependencies (FLASH-1.3, FLASH-3.9, XFEL(?)) needed for HOM coupler signal based beam analysis

*DoHRo*** – HOM:*

-WP 1: HOM damping design for BERLINPRO

-WP 2: HOM damping design for ESS – high energy part of p-linac

-WP 3: Simplified electronics for HOM coupler signal based beam analysis

RN-SPL: "Design of HOM-Damping for CERN-SPL“; funded by German Federal Ministry of Research+Education, Project: 05H09

JCARD: EU FP7 Research Infrastructure Grant No. 227579

ERN-SPL*-Study, EUCARD**, DoHRo*** @ Rostock

taff (% of FTE):	Funding:
Prof. Dr. Ursula van Rienen (~ 5%) Dr. Dirk Hecht (administrative; now ~ 5%) Dipl.-Ing. Thomas Flisgen (80% EUCARD**, 20% teaching)	Rostock University
Dr. Hans-Walter Glock	50% CERN-SPL* 25% EUCARD** 25% DoHRo***
Dipl.-Ing. Mirjana Ivanovska (50%, on pregnancy leave till Oct`10) Dipl.-Phys. Tomasz Galek (100%, Oct.`09 - Jan.`10, 50% July`10 – Dez`10) N.N.-PhD: (50%)	CERN-SPL*
N.N.-PhD: (50%) Dr. Carsten Potratz (100%, from July`10)	DoHRo***

RN-SPL: "Design of HOM-Damping for CERN-SPL"; funded by German Federal Ministry of Research+Education, Project: 05H09

JCARD: EU FP7 Research Infrastructure Grant No. 227579

Thank you for your attention.

litional stuff:

olver overview
SC principle
ole identification
-determination for coaxial couplers

Methods for S-Parameter-Calculation (updated)

nsient Solver xahedral Grid

- oadband computation of S-arameters via FFT.
- eak coupling between thogonal modes in rotational mmetric structures.

- any time steps are needed to ach steady state due to large me constants.
- Parameters do not show the otch effect of HOM coupler in reasonable manner.

Frequency Solver Hexahedral Grid

- Appropriate for structures with high quality factors.
- Weak coupling between orthogonal modes in rotational symmetric structures.

- Long computational time, because each S-Matrix has to be computed for every frequency sample.
- Very dense mesh is needed for HOM coupler.

Frequency Solver Tetrahedral Grid

- Appropriate for structures with high quality factors.
- Less number of unknowns is needed to describe HOM coupler
- Fast solver available for tetrahedral grids.

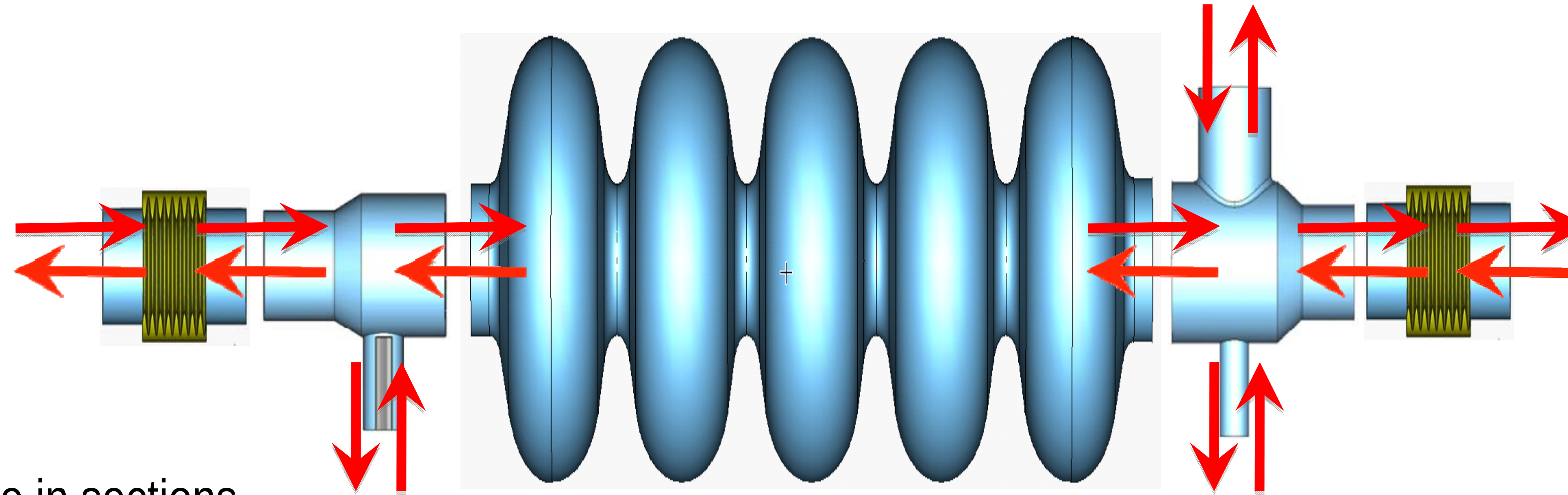
- Strong artificial coupling between orthogonal modes in rotational symmetric structures (e.g. cavity), due to non symmetric grid.

Fast Resonant Solver Hexahedral Grid

- Appropriate both for structures high quality factors and couple set-ups.
- Weak coupling between orthog modes in rotational symmetric structures.
- Really fast

- Significant violation of unitarity matrices below cut-off

ncatenation procedure based on scattering operties: Coupled S-Parameter Computation = CSC

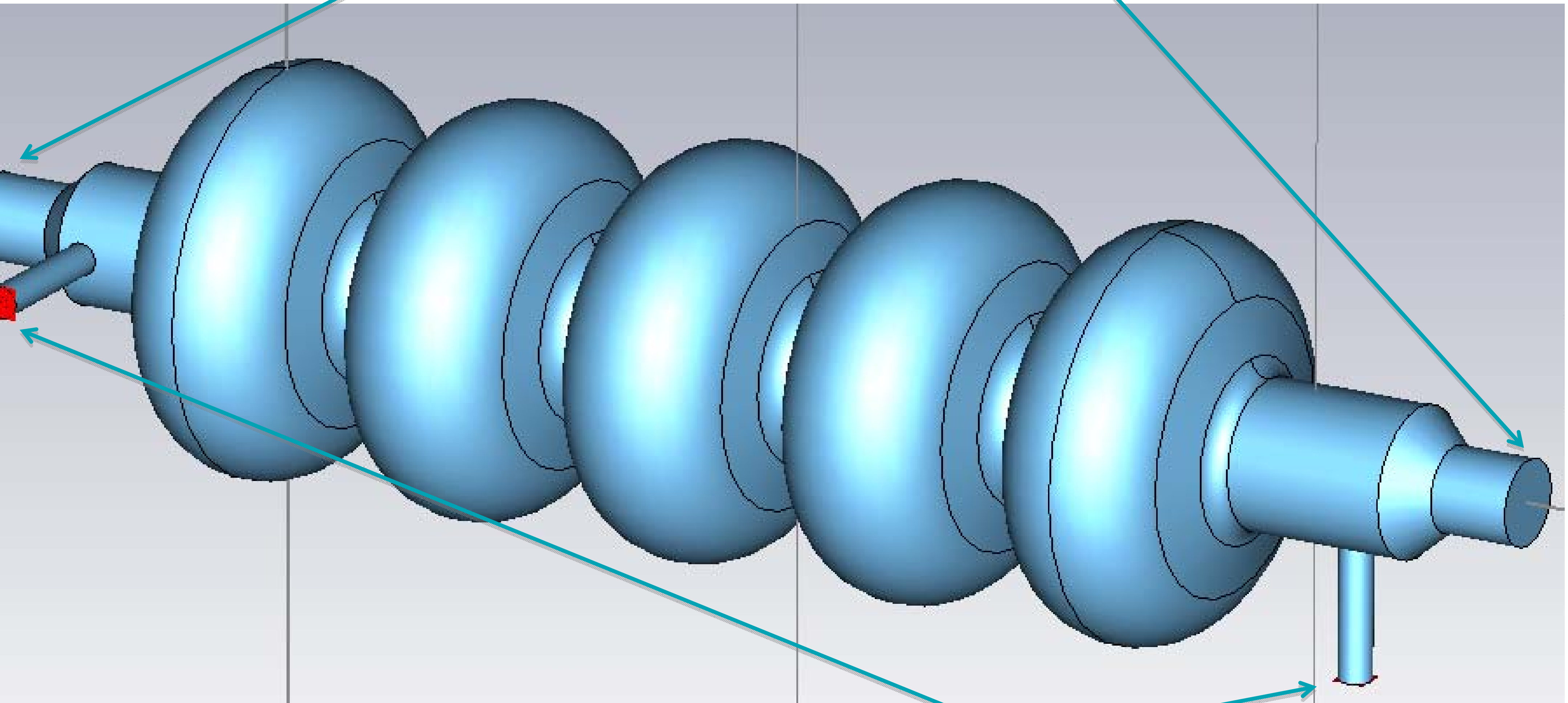


- Split structure in sections
- Compute scattering (S-) parameters of all sections individually with appropriate solvers
- Compute overall S-parameters as function of f with special algorithm*, applicable to any structure topology and mode number
- Derive loaded Q-values from S-parameter spectra

*: e.g.: H.-W. Glock, K. Rothemund, U. van Rienen: "CSC – A System for Coupled S-Parameter Calculations", TESLA Report

…-β=1-cavity:
…M-Q_{load} from full setup computation of coax-coax-transmissi…

80 mm diameter shortened beam pipes

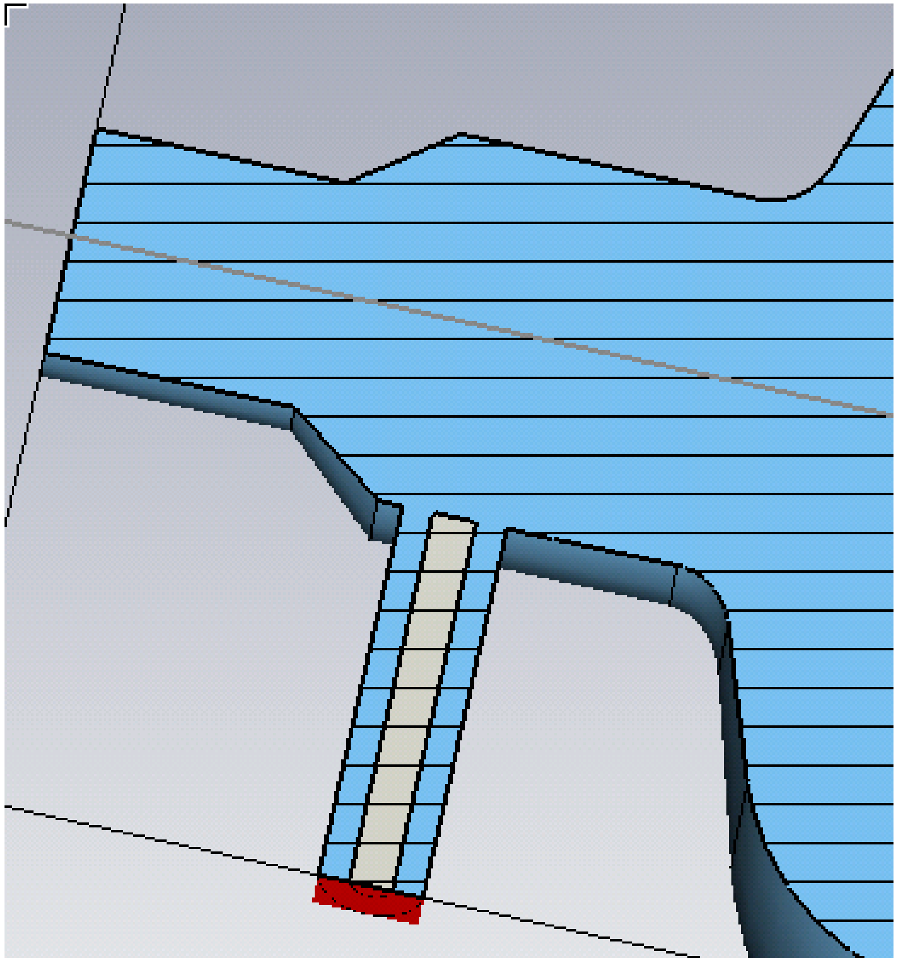


following Nov'09 SPL Meeting proposal: 30 mm diameter coaxial couplers

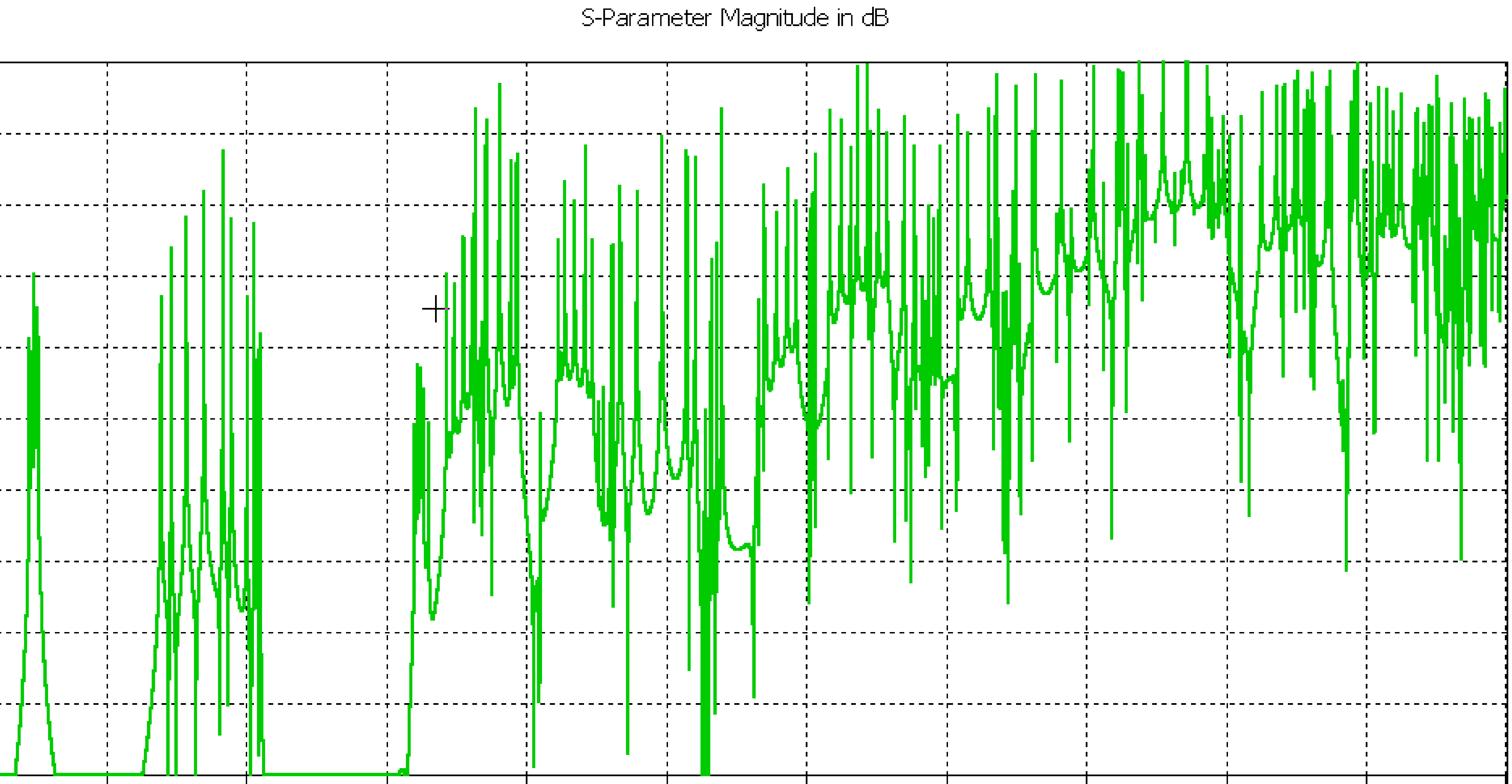
ax with antenna tip depth = 0:

to avoid extreme Q-values

scaling in a second step using coupler section's S-parameters in order to reach design fundamental mode Q

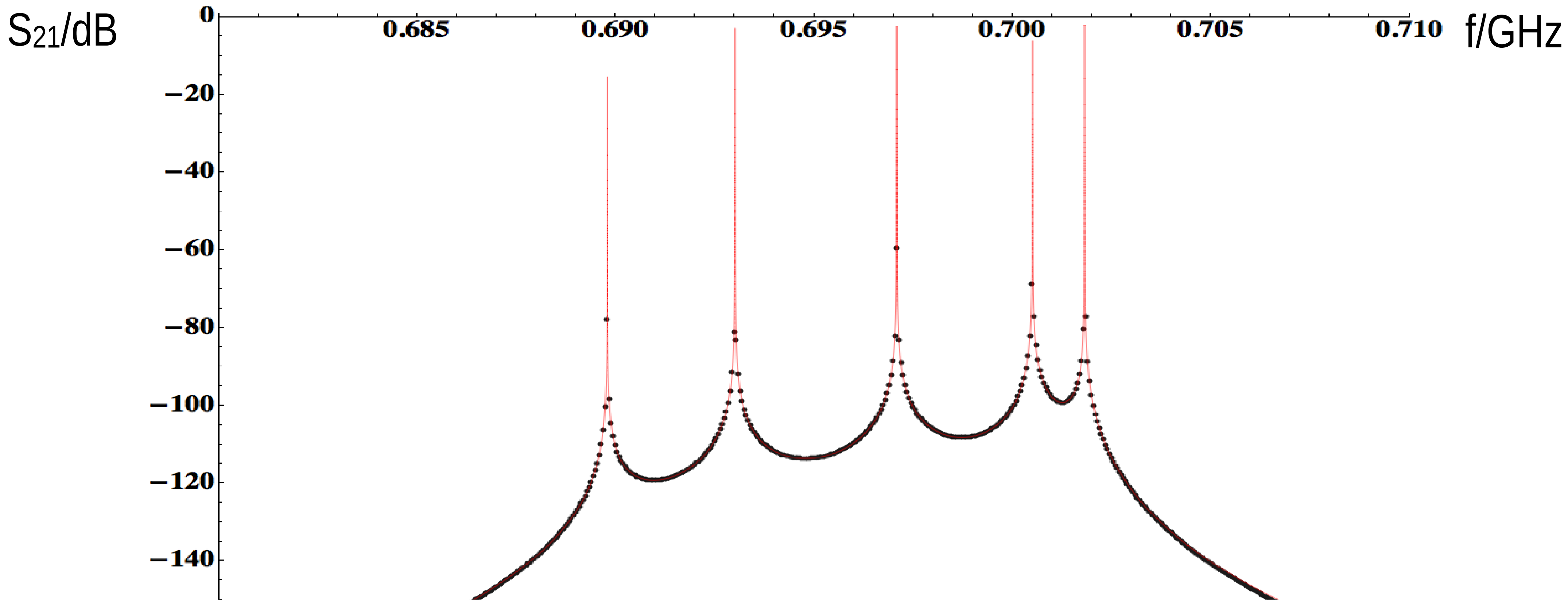


Entire transmission spectrum 0.65 – 2.80 GHz:
- more than 400 resonances with wide Q-range



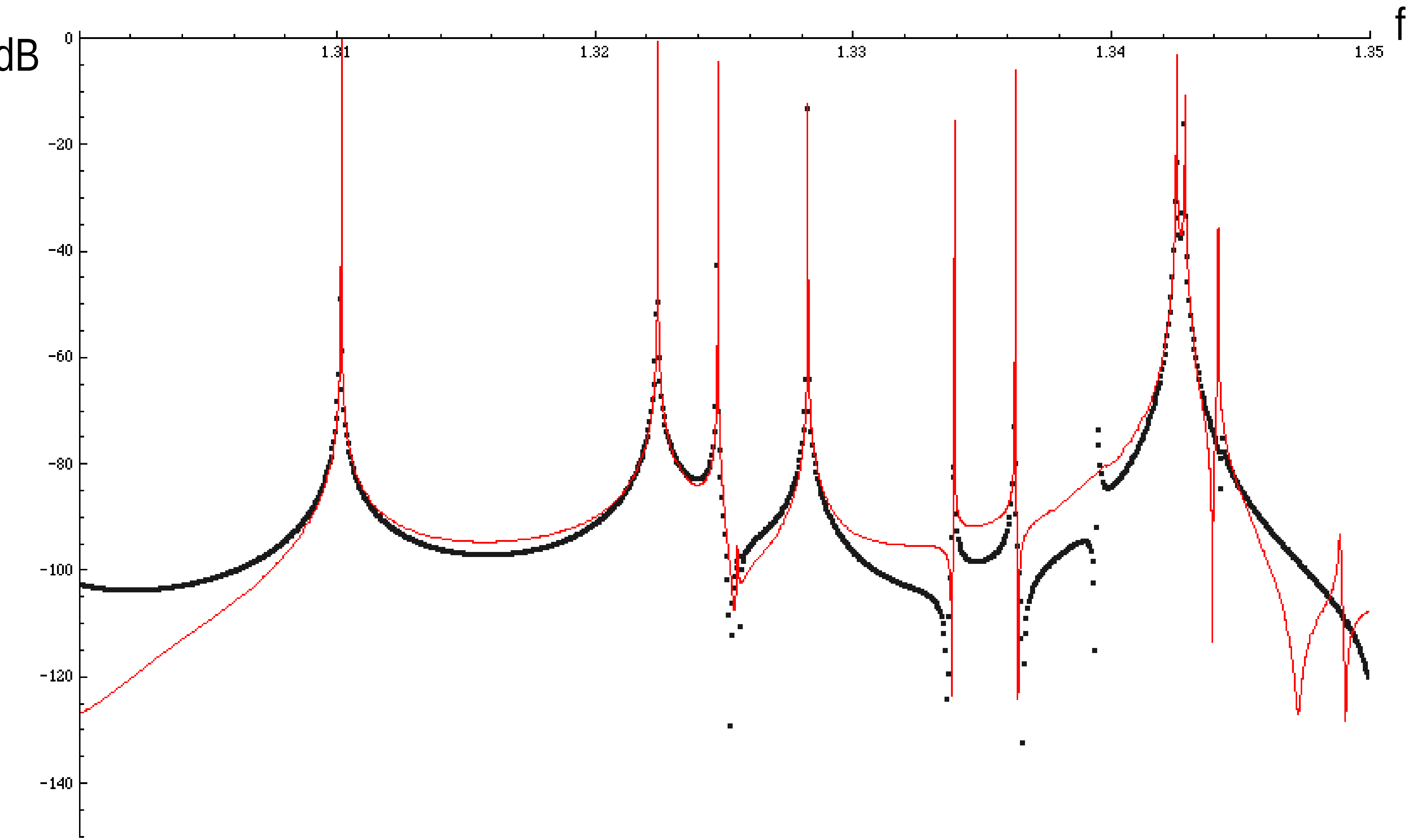
ing Pole-fitting algorithm* to determine loaded Q's

$$S_{21}(f)=\sum_k \frac{a_k}{2\pi i f - p_k} \qquad Q_k = -\frac{\mathrm{Im}\{p_k\}}{2\,\mathrm{Re}\{p_k\}}$$



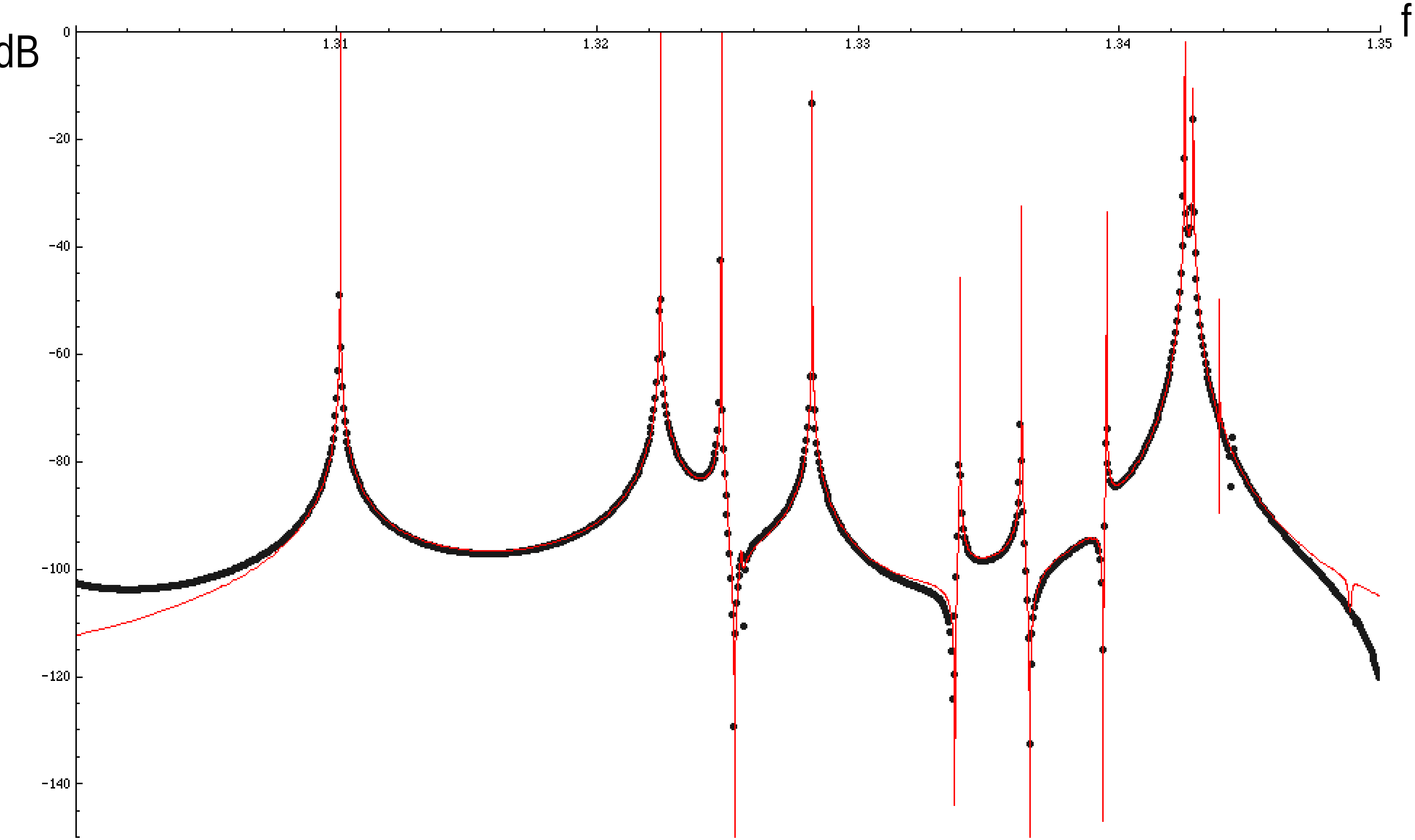
fundamental mode passband - dots: cstStudio© computation - line: fit result

e-fitting algorithm: "Old" version



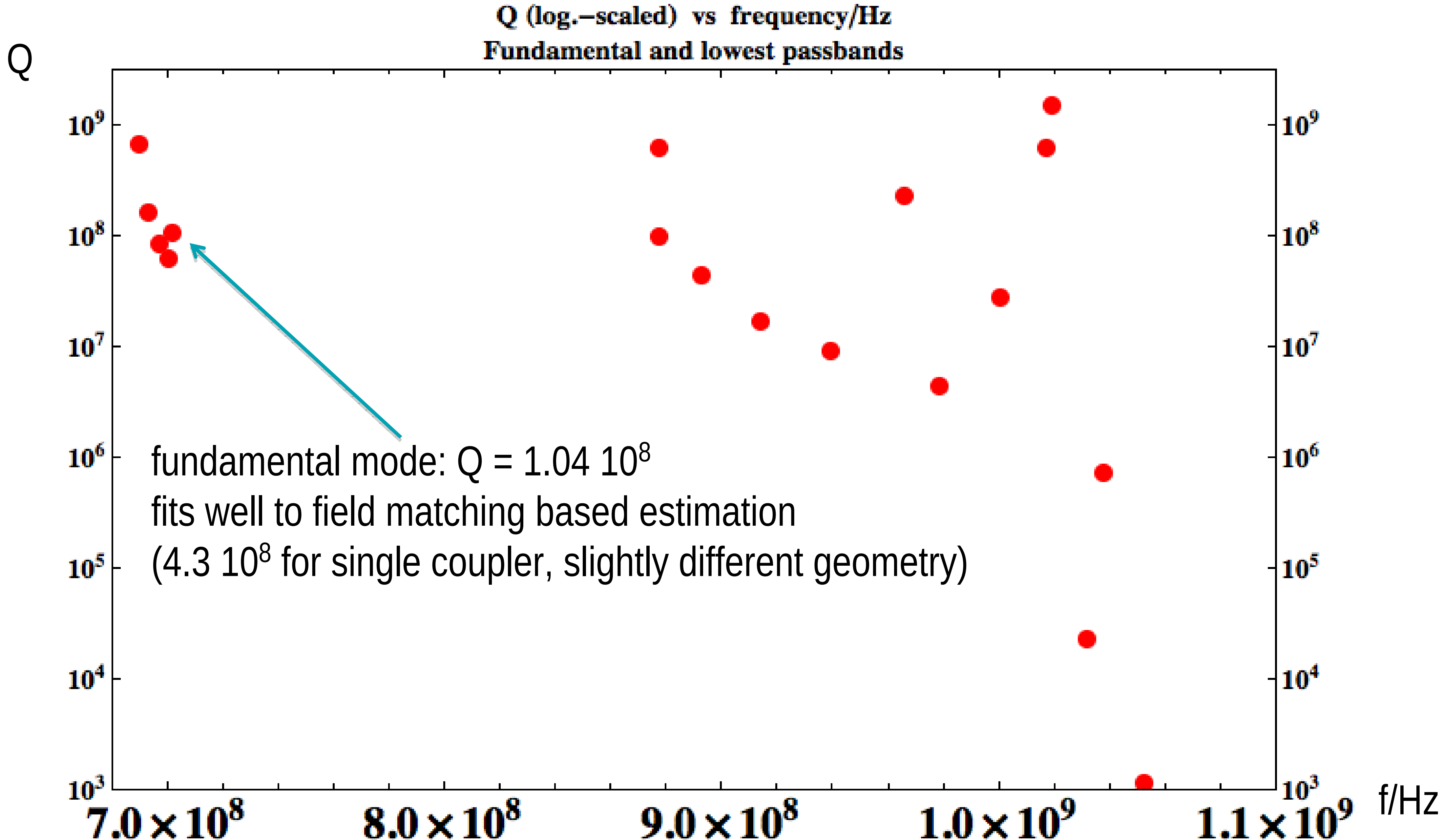
"Old" algorithm (see reference)

proved pole-fitting algorithm

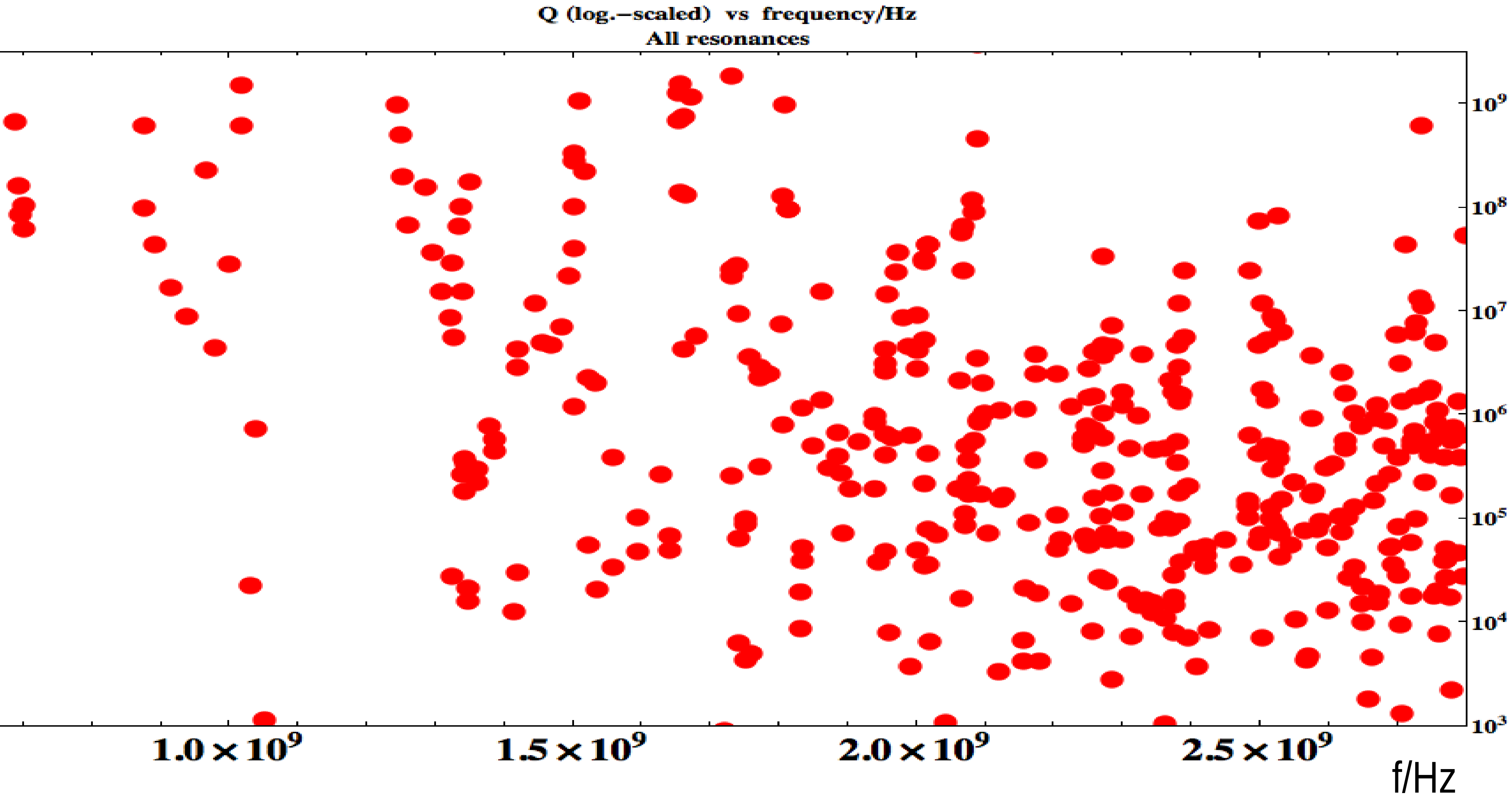


Improved algorithm - corrects for higher order contributions, but still not working in any case

-value of lowest modes for 0 mm antenna depth:



-value spectrum for 0 mm antenna depth:



Several HOM modes with Q values as high or above fundamental mode
(holds also for reduced coupling)