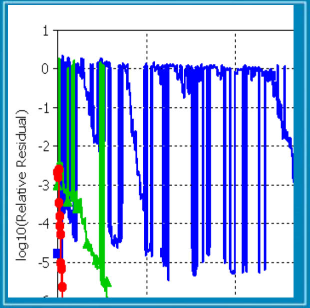
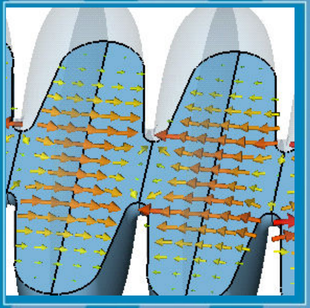
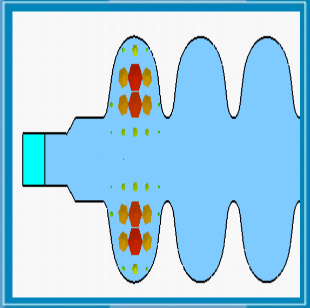
FAKULTÄT FÜR INFORMATIK
UND ELEKTROTECHNIK
UNIVERSITÄT ROSTOCK



Baseline HOM-Damping Considerations

Hans-Walter Glock

Rostock University, IEF, Institut für Allgemeine Elektrotechnik

3rd SPL-Meeting, CERN, 11.-13. November 2009

work is currently supported by BMBF

Path towards HOM-couplers?/absorbers?

funding / local project start: 1.10.09

today

Impression

Analysis

Conceptual decision

Construction

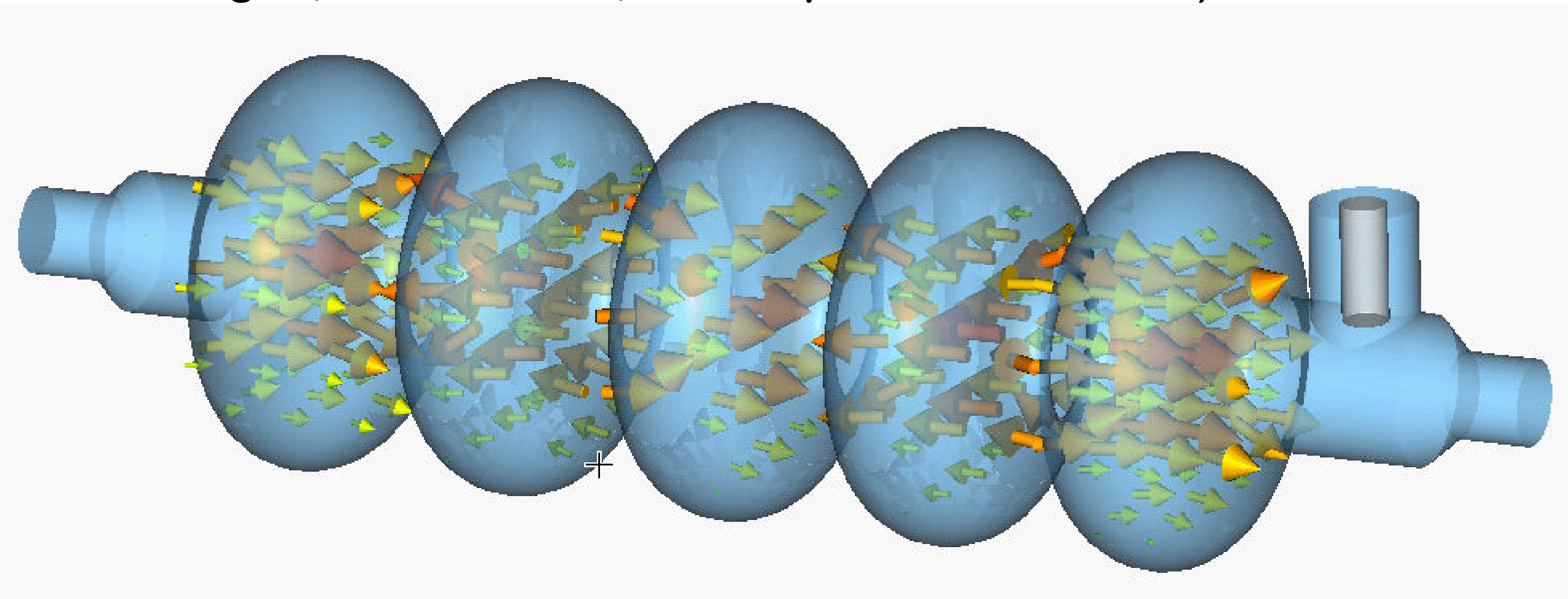
Most urgent:

- only absorption in bellows?
- dedicated absorber(s)?
- dedicated coupler(s)?

Impression/Analysis: Eigenmode spectrum

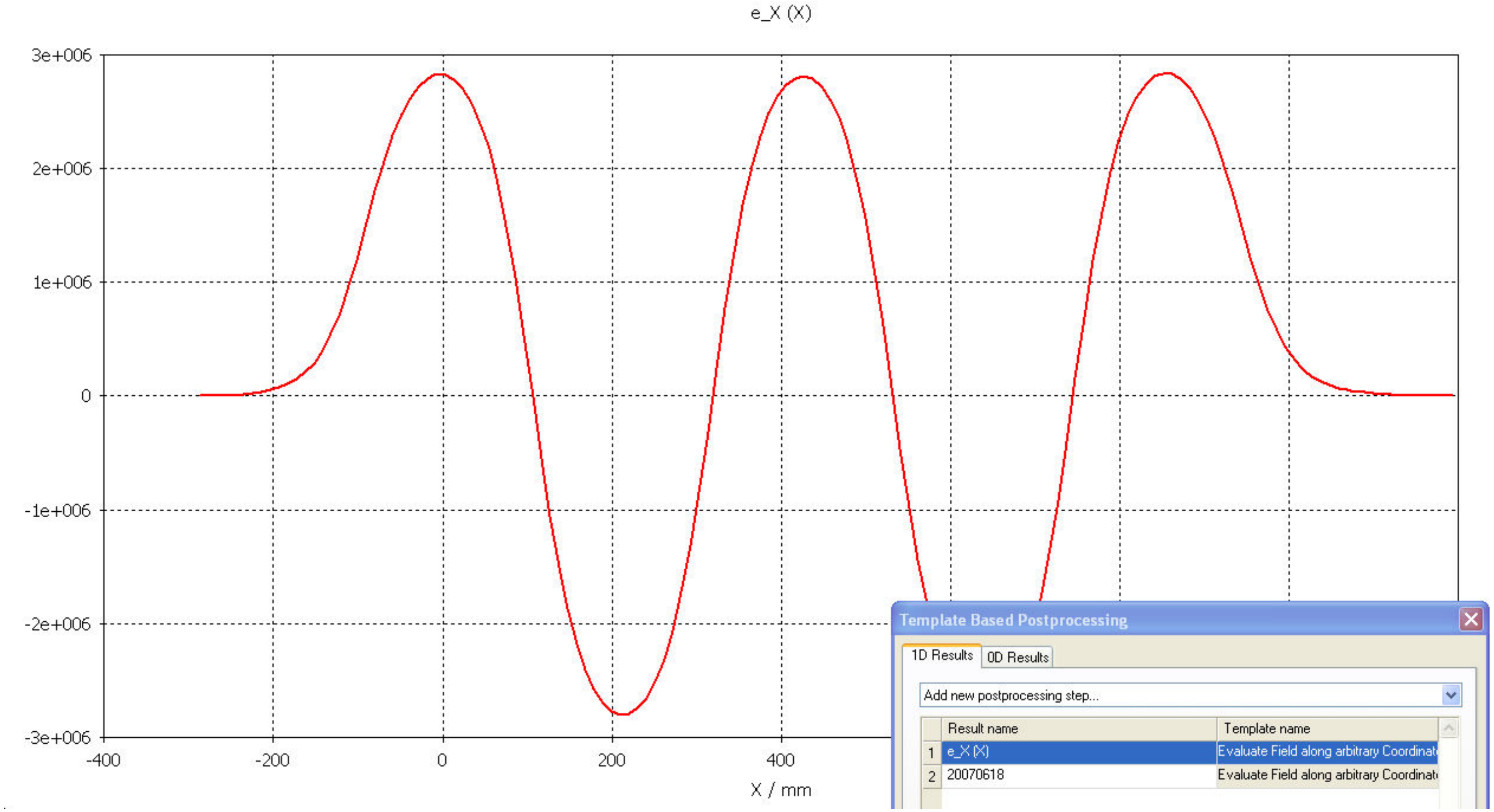
CST-MicrowaveStudio-Computation:

- 3D
- no symmetry plane, ~200k meshpoints
- input coupler and beam pipes terminated by electric boundary
- fundamental mode found at 703.70 MHz (700 kHz below design: grid, discretization, but: keep effort reasonable)



Impression/Analysis: Eigenmode spectrum

Check for accelerating mode field flatness:



Mode spectrum

Mode	Frequency	|(Ax-x)/x|	Accuracy max(e)	div(e)	R/Q long (on axis Monop) / Ohm (5 mm off nonMon)	
1	0.592543115258	1.71e-015	3.75e-004	1.58e-007	im Koppler	
2	0.691657577029	1.27e-014	1.07e-003	5.75e-007	0.0016	fundMod PB
3	0.694912757203	2.35e-014	8.22e-003	5.52e-007	0.0431	
4	0.699011544865	2.78e-014	1.95e-003	7.10e-007	0.0159	V
5	0.702390091151	1.85e-014	1.01e-003	5.71e-007	0.1434	
6	0.703703699097	3.84e-014	1.47e-003	6.66e-007	560.05	Beschl. Mode
7	0.879265625014	1.42e-014	6.16e-004	8.70e-007	00	TE11
8	0.879272931869	2.68e-014	2.61e-003	9.22e-007	0.005	TE11
9	0.894030315009	3.60e-014	1.61e-003	9.54e-007	00	TE11
10	0.894141471434	2.00e-014	9.01e-004	1.11e-006	0.002	TE11
11	0.91569041556	1.35e-014	6.43e-004	7.54e-007	00	TE11
12	0.915936304869	2.33e-014	1.89e-003	9.73e-007	0.3555	TE11
13	0.940648830113	4.28e-014	6.29e-004	9.51e-007	00	TE11
14	0.940999795194	2.49e-014	2.04e-003	9.49e-007	0.683	TE11
15	0.966990966293	2.28e-014	5.27e-004	1.01e-006	00	TE11
16	0.967610905486	8.76e-014	1.44e-003	9.66e-007	0.221	TE11
17	0.979958550307	2.81e-014	9.31e-004	8.21e-007	00	TE11
18	0.980250416967	2.88e-014	5.80e-004	8.63e-007	0.026	TE11
19	1.00206515078	1.37e-014	3.30e-003	7.49e-007	00	TE11/TM11
20	1.00224277709	1.96e-014	6.83e-004	9.46e-007	0.233	TE11/TM11
21	1.01287853988	2.50e-014	3.95e-004	6.28e-007	00	TM11
22	1.01308225828	5.39e-014	4.42e-004	7.50e-007	0.432	TM11
23	1.01844715837	1.34e-014	8.35e-004	7.54e-007	00	TM11
24	1.01867181876	1.79e-014	7.95e-004	7.79e-007	0.097	TM11
25	1.02040974185	5.75e-014	7.82e-004	7.15e-007	00	TM11
26	1.02064636505	2.42e-014	7.83e-004	7.35e-007	0.004	TM11
27	1.24248660029	1.09e-013	8.10e-004	9.89e-007	00	TE21
28	1.24341752514	2.86e-013	2.92e-004	9.34e-007	0	TE21
29	1.24605780794	3.59e-013	6.35e-003	7.81e-007	00	TE21
30	1.24701464235	5.79e-013	3.40e-004	8.75e-007	0	TE21
31	1.25052316381	6.28e-013	1.23e-003	9.62e-007	00	TE21
32	1.25155351987	2.08e-013	3.21e-004	9.42e-007	0	TE21
33	1.25371664678	1.02e-012	2.26e-004	9.90e-007	00	TE21
34	1.25512418546	9.44e-013	5.47e-004	7.41e-007	0	TE21
35	1.25708970336	1.47e-012	2.06e-004	6.04e-007	00	Koppler
36	1.26192501951	3.30e-013	3.10e-004	6.97e-007	00	TE21

"00": 0 in range of numerical noise; "0" < 10^{-3} Ohm

Mode spectrum contd.

38		1.2896568133	3.56e-013	3.26e-004	9.30e-007	0.212	TM01
39		1.2998295428	5.21e-013	4.29e-004	9.23e-007	0.223	TM01
40	!!	1.31335849253	5.17e-013	2.93e-004	9.47e-007	10.827	TM01
41	k!	1.32468529329	2.30e-012	2.59e-004	8.65e-007	~25	TM01-hyb-Koppler
42	k!	1.32565553565	9.77e-013	3.42e-004	9.22e-007	~34	TM01-hyb-Koppler
43	!!	1.33129156269	6.68e-013	3.53e-004	8.80e-007	102.227	TM01
44		1.33426387184	2.50e-012	5.97e-004	6.86e-007	00	TM21
45		1.33512594751	4.63e-013	3.12e-004	7.07e-007	0	TM21
46		1.33664499694	6.16e-013	2.46e-004	6.02e-007	00	TM21
47		1.33752944698	6.43e-013	5.29e-004	6.47e-007	0	TM21
48		1.33990255418	9.95e-013	8.09e-004	6.29e-007	00	TM21
49		1.34052213662	5.62e-012	1.02e-003	7.21e-007	0	waist TE11
50		1.34081908229	6.56e-013	4.59e-004	6.51e-007	0	TM21
51		1.34289922003	2.21e-012	7.18e-004	6.19e-007	00	TM21
52		1.34304533896	1.35e-012	4.85e-004	8.60e-007	0.05	waist TE11
53		1.34382338732	6.78e-013	2.64e-004	6.89e-007	0.002	TM21
54		1.34464487144	e-012	4.45e-004	6.87e-007	00	TM21
55		1.34557074524			06e-007	.002	TM21

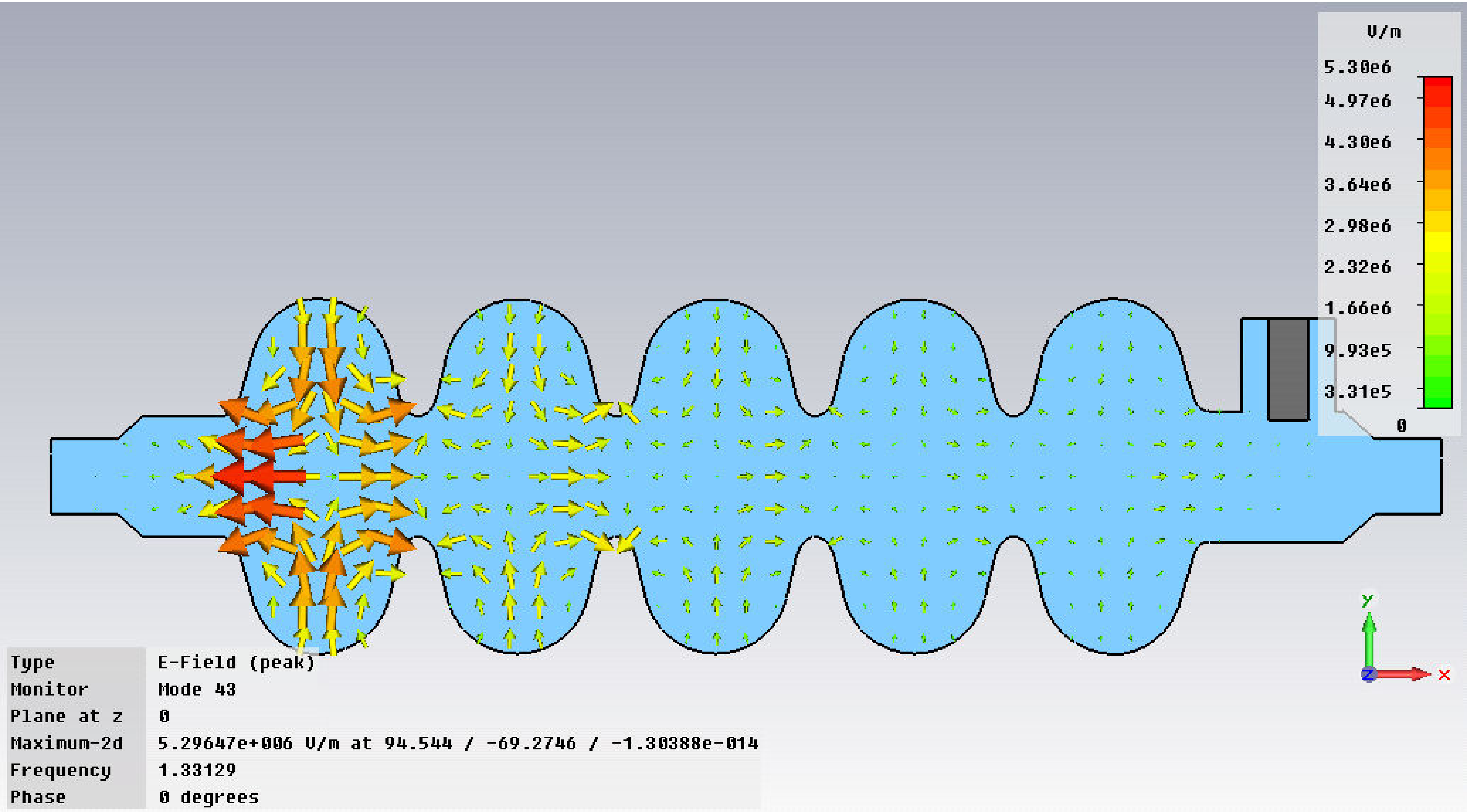
(R/Q)/Ω

	TM01
10.827	TM01
~25	TM01-hyb-Koppler
~34	TM01-hyb-Koppler
102.227	TM01
00	TM21

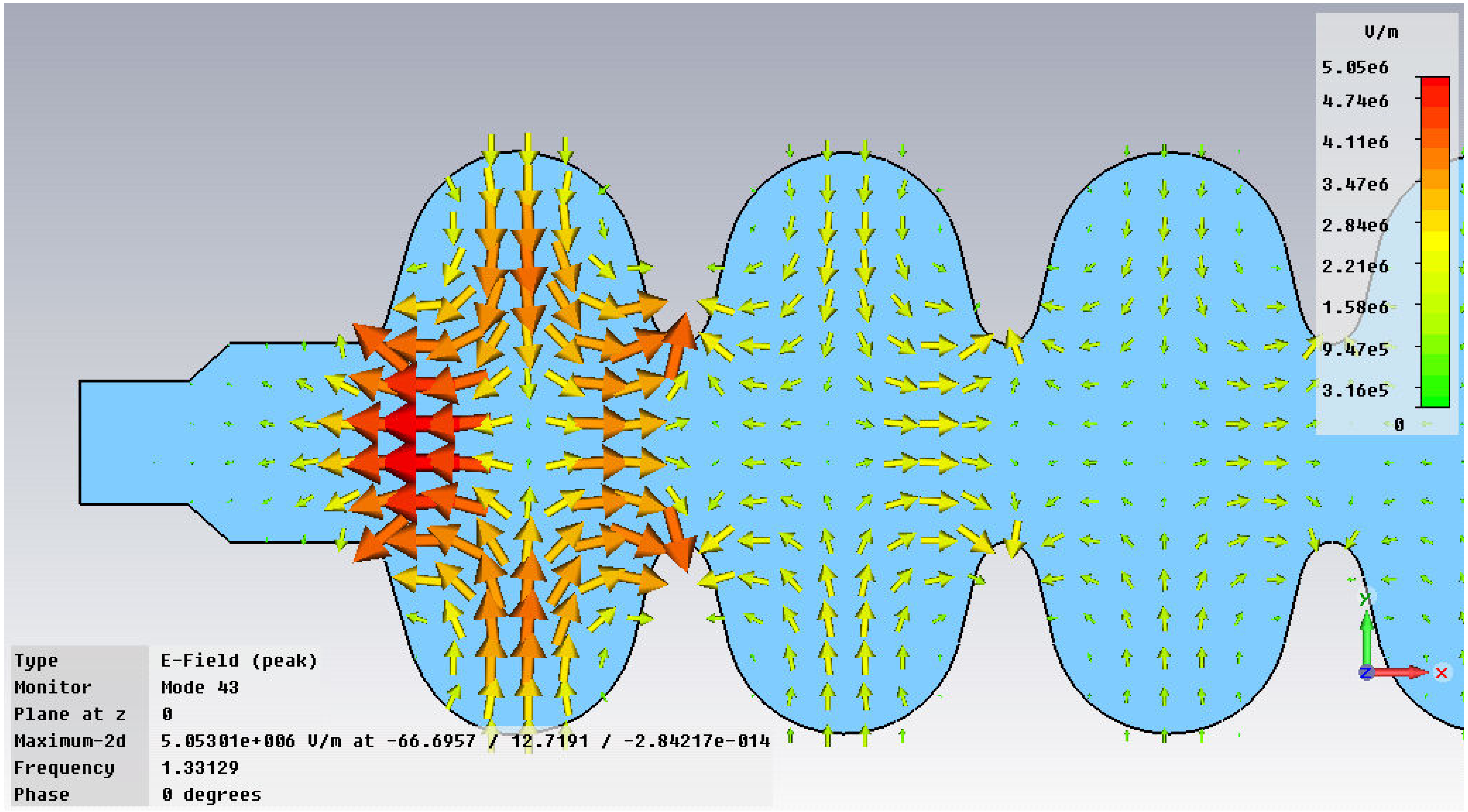
e of numerical noise; "0" < 10^{-3} Ohm

Are those the bad guys?

TM01-Mode, 1.331 GHz, high R/Q – Mode: E-Field

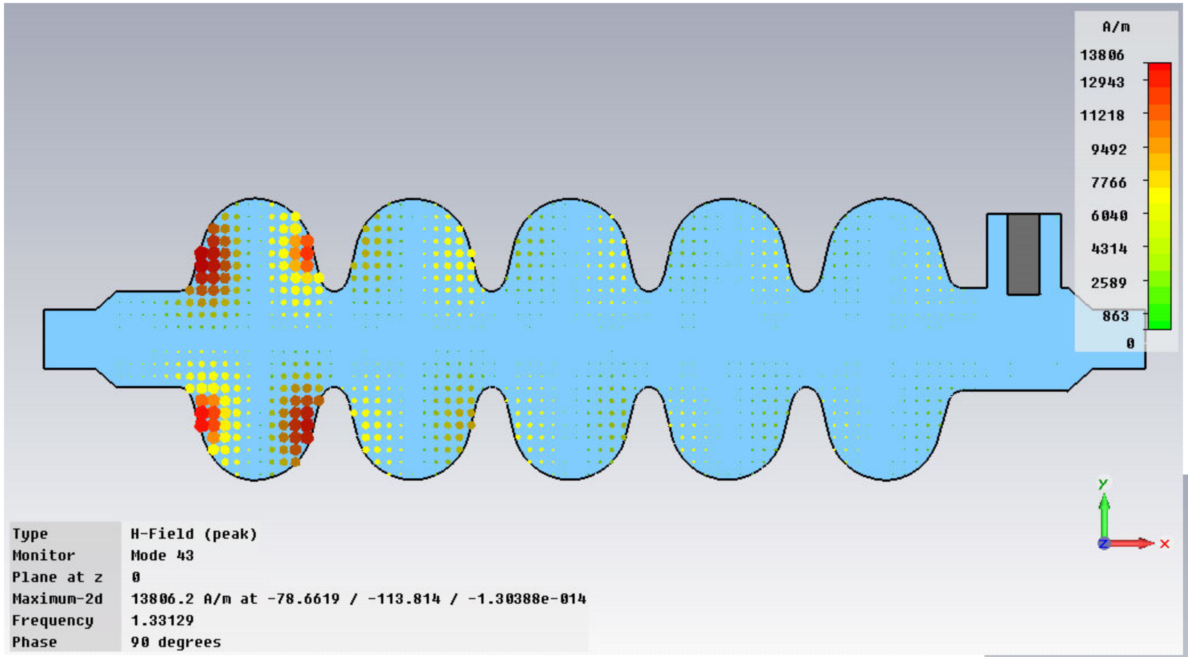


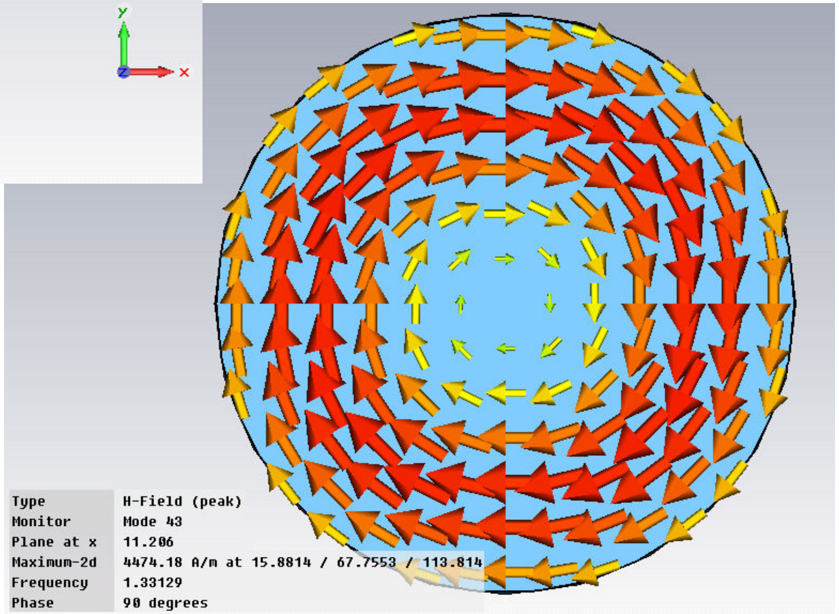
TM01-Mode, 1.331 GHz, high R/Q – Mode: E-Field

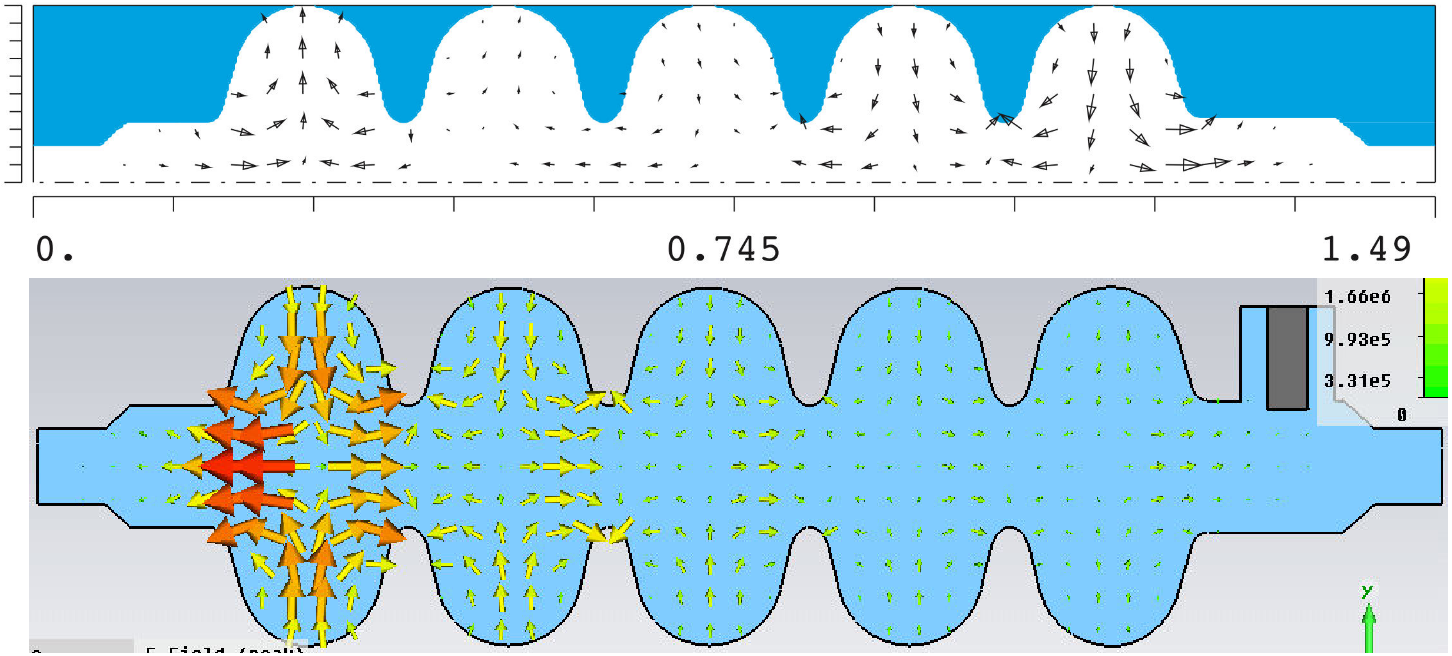


Evanescent fields since far below TM01-cut off in 40mm-beam pipe radius (~2.80 GHz)

TM01-Mode, 1.331 GHz, high R/Q – Mode: H-Field







2D => no coupler **=>|**

|=> different long. distribution

Different mesh/discretization **=>|**

=> Damping through input coupler ??

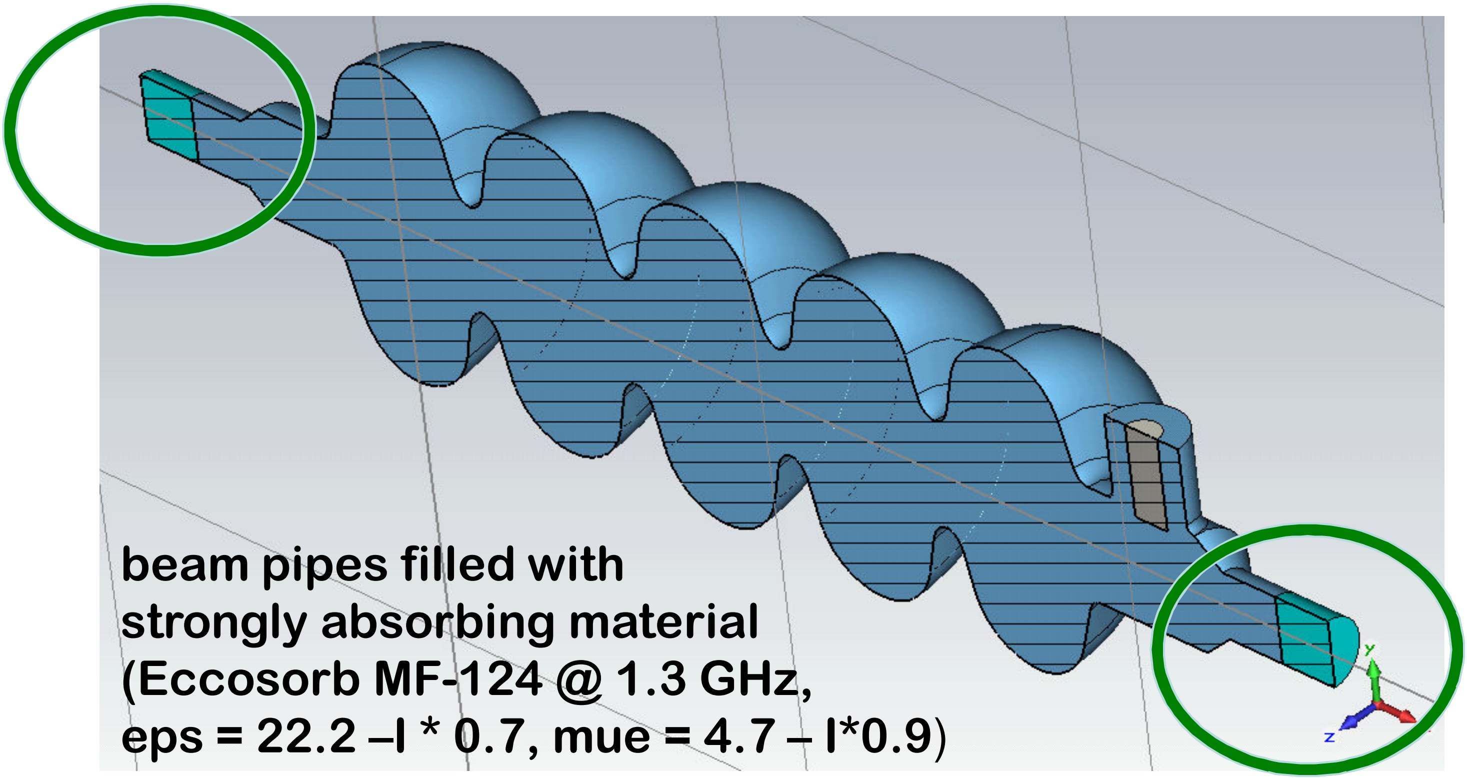
MWS – MAFIA 2D Comparison: R/Q

Mode		Frequency/GHz	R/Q long (on axis) / Ohm		f (MAFIA 2D)	R/Q
			3D cst – MicrowaveStudio ©		**2D cst – MAFIA ©**	
~~1~~		~~0.592543115258~~	~~im Koppler~~			
2		0.691657577029	0.0016	TM01 fu.	0.6912639	0.04
3		0.694912757203	0.0431	TM01 fu.	0.6945495	0.327
4		0.699011544865	0.0159	TM01 fu.	0.6986902	2.122
5		0.702390091151	0.1434	TM01 fu.	0.7021096	55.28
6		0.703703699097	560.05	TM01 acc.	0.7033651	511.13
.						
.						
.						
38		1.2896568133	0.212	TM01	1.291917	0.055
39		1.2998295428	0.223	TM01	1.302472	1.318
40	!!	1.31335849253	10.827	TM01	1.317096	1.903
~~41~~	~~k!~~	~~1.32468529329~~	~~~25~~	~~TM01 hyb Koppler~~		
~~42~~	~~k!~~	~~1.32565553565~~	~~~34~~	~~TM01 hyb Koppler~~		
43	!!	1.33129156269	102.227	TM01	1.328853	44.51

Both simulations show high R/Q, though with different values.

Approach: Strong absorption at waveguide ports ...

... in order to get lowest Q-limit without immediate need to model bellows

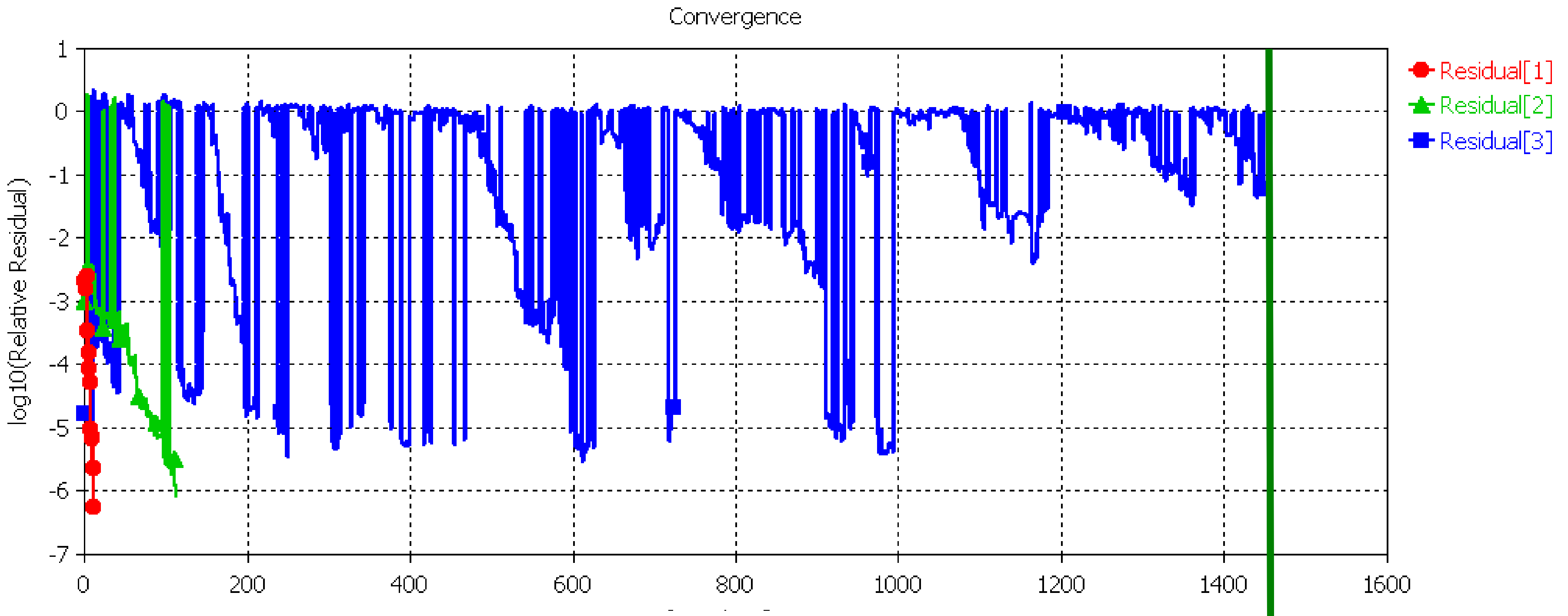


Since evanescent fields, direct complex eigenmode computation preferred ==> Jacobi-Davidson-Solver

Complex Jacobi-Davidson-Solver

... very useful for direct computation of complex eigenfrequency = Resonance frequency + Q-value.

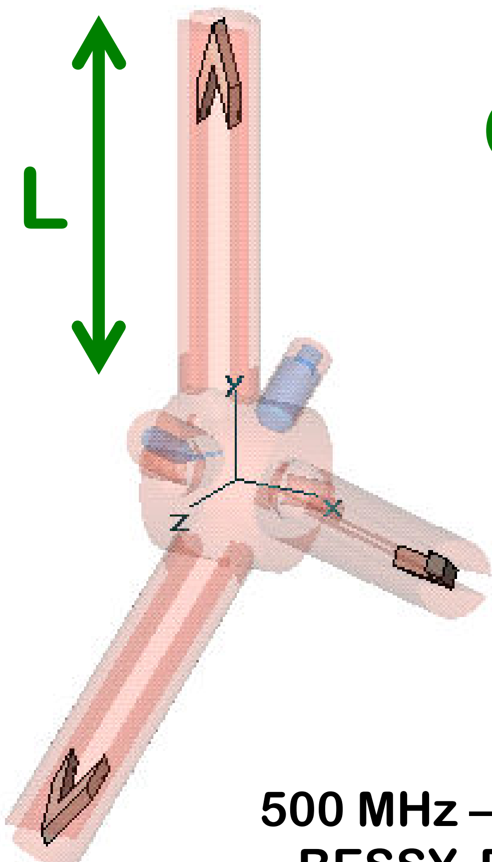
But :

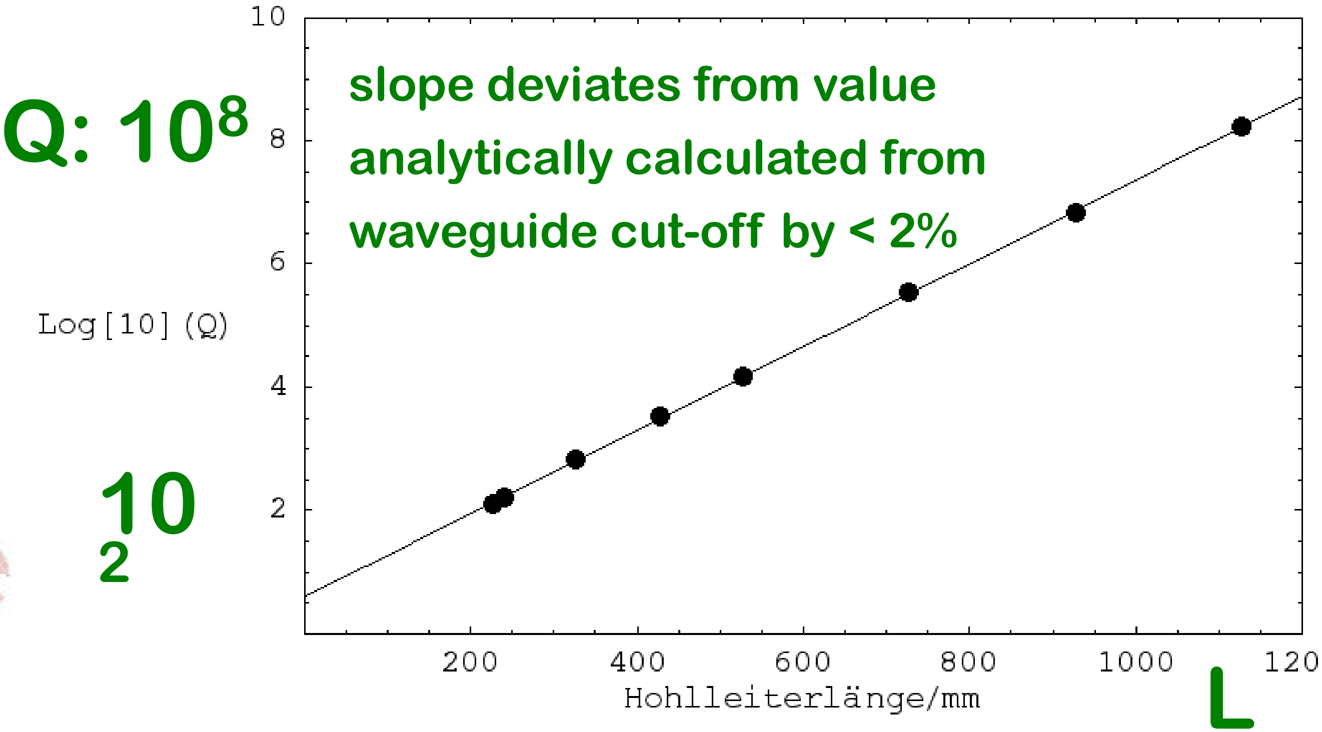


some modes: no or poor convergence, e.g: 59 h for 90 tsd meshcells on 3 GHz cpu

Complex Jacobi-Davidson-Solver II

Why using such a capricious tool? – If it works, it works !

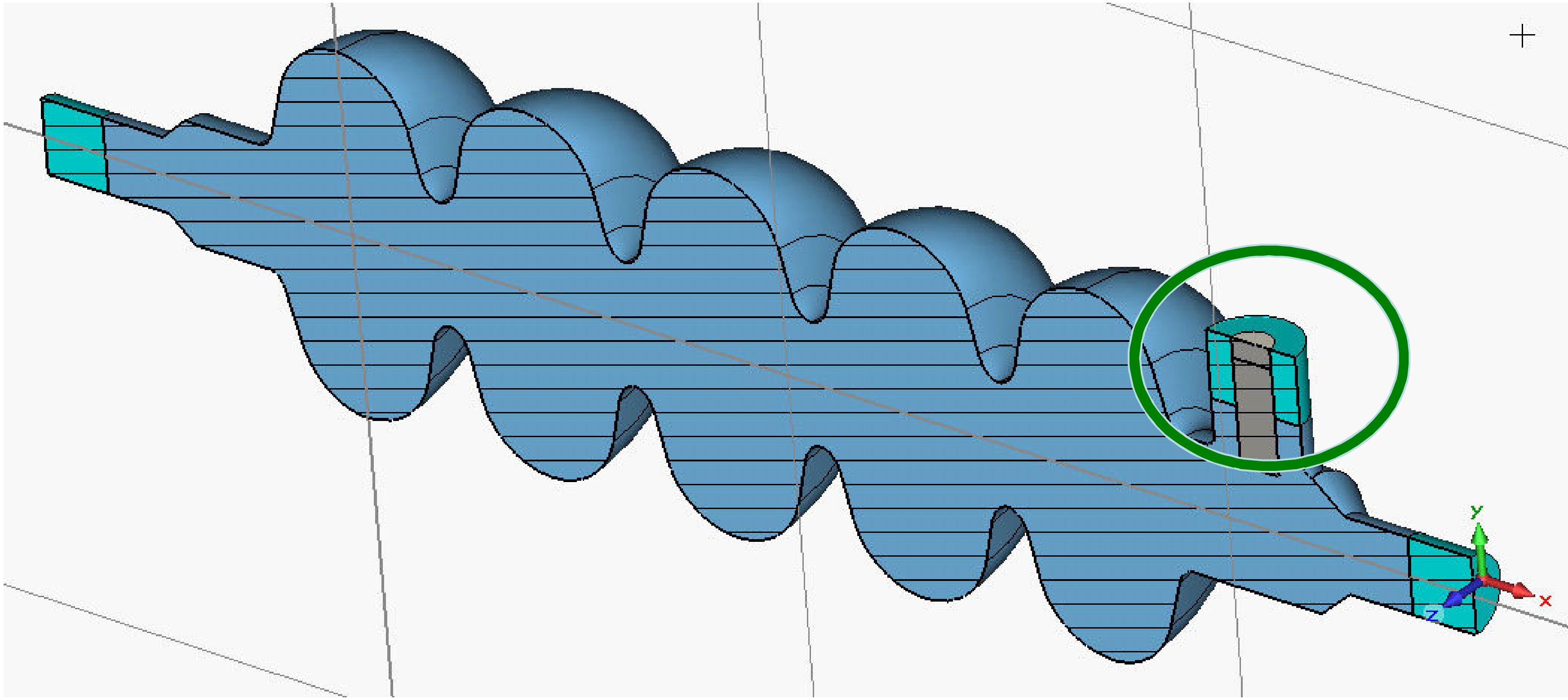




500 MHz – NC –"EU-Cavity"
BESSY, Berlin et. sev. al.

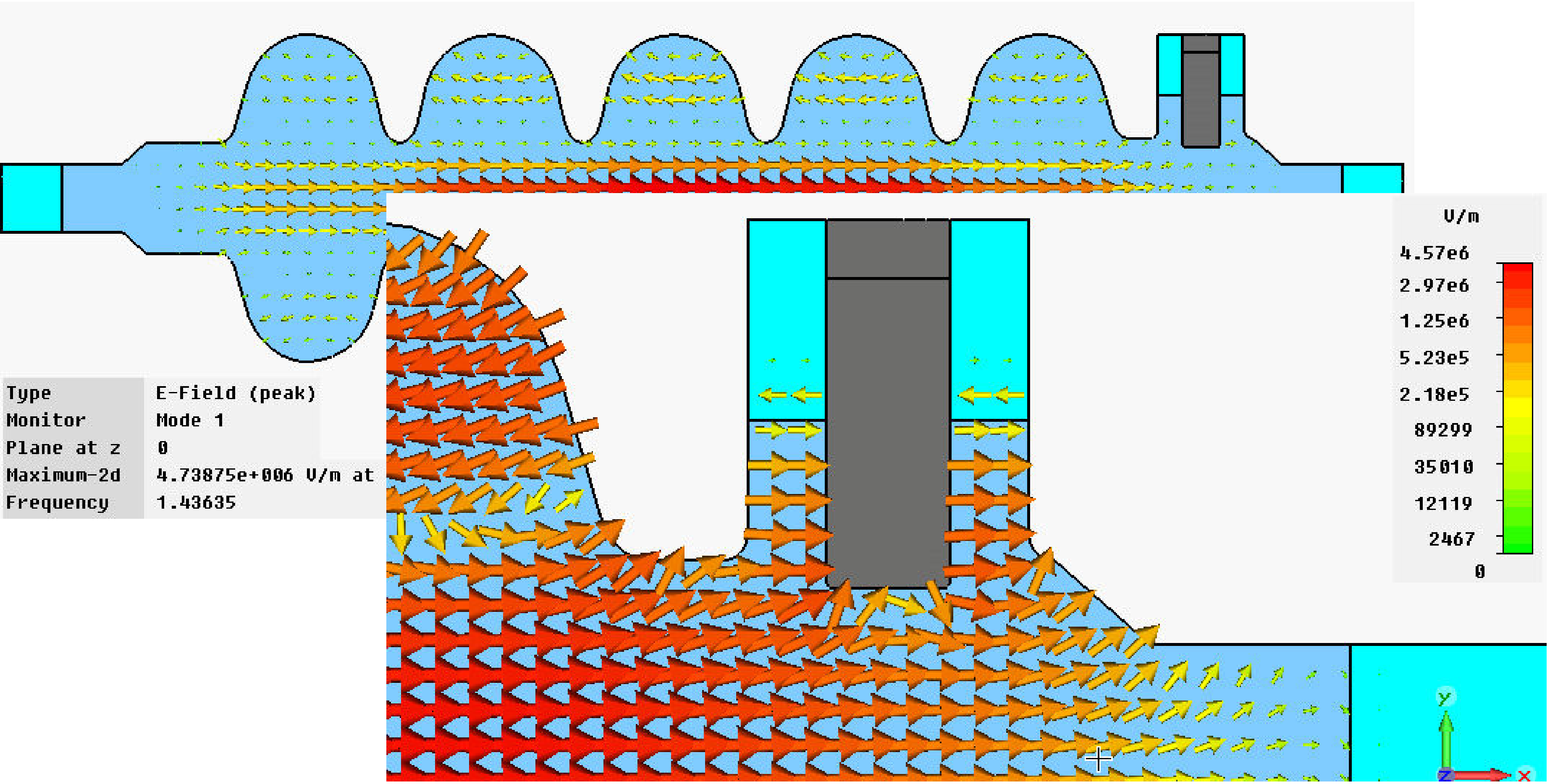
Approach: Strong absorption at waveguide ports ...

... and at input coupler



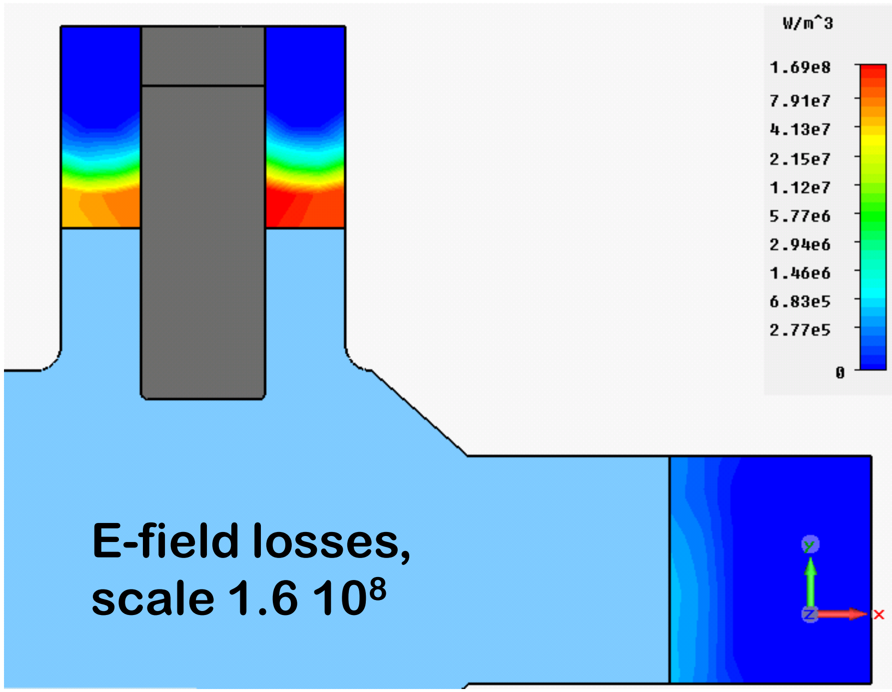
coaxial TEM coupler line: either Jacobi-Davidson or classical Kroll-procedure [SLAC-Pub 5345, Sept. 90] for Q_{ext}-determination

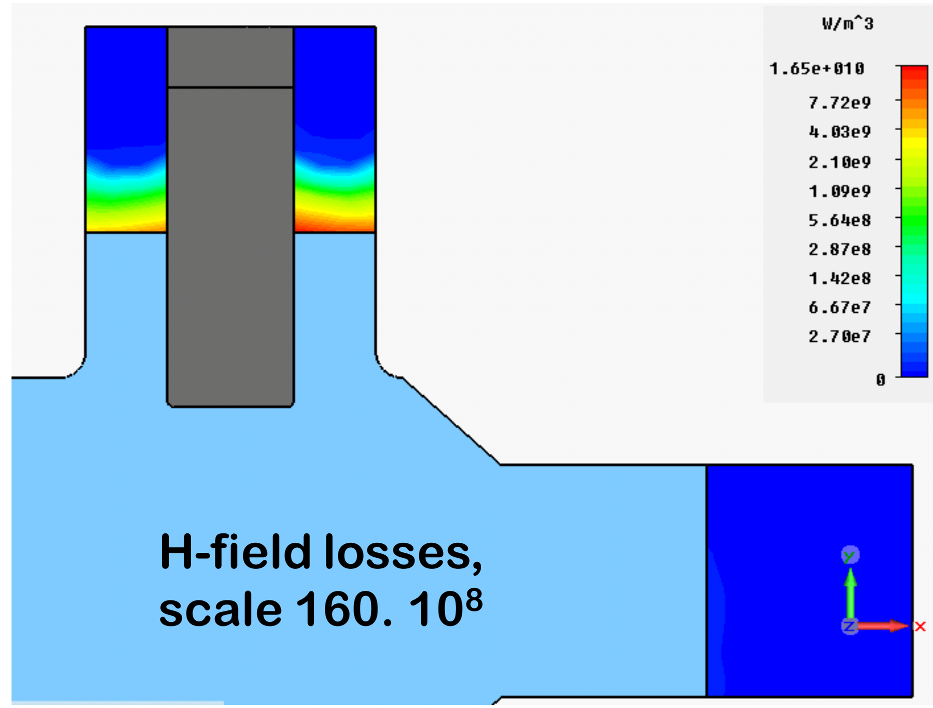
Example: TM02, 1.436 GHz, successful convergence:



Non-TEM field in the coupler area, but which absorption?

Example: TM02, 1.436 GHz, successful convergence:





Computed Q_{ext}: 16500; losses almost completely in the input coupler

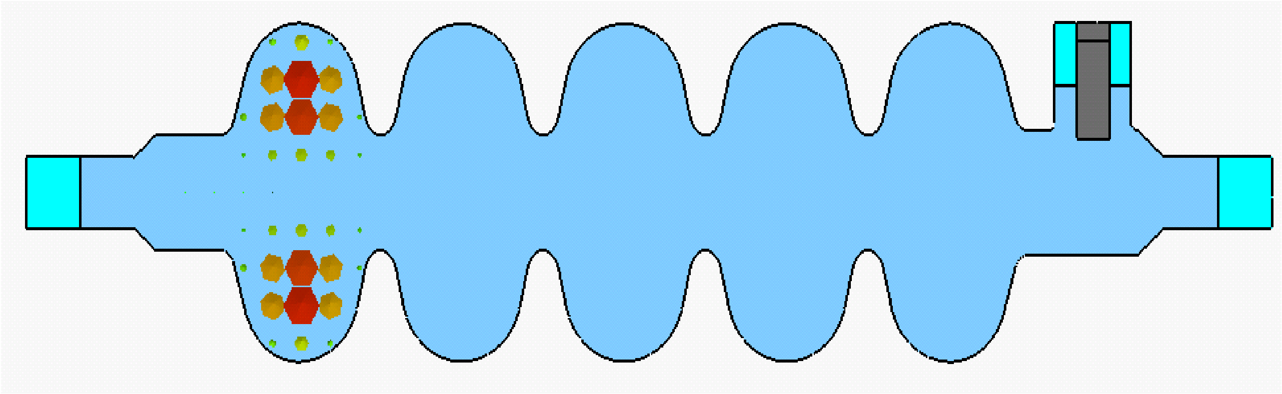
Like a conclusion

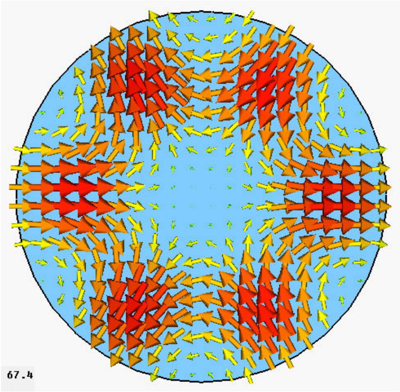
- Some high R/Q-modes with poor absorption in beam pipes very likely (2 independent programs and discretizations)

- Main coupler to be considered as significant HOM-power sink (which limits 2D calculations)

- But what about wrong polarisations?

- Or something similar to this (TE31, 1.507 GHz, R/Q small) AND high R/Q:





Like an outlook