LIU–SPS BD WG meeting

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Outline

Outline

Motivation

In the beginning, there was Impedance

The pumping port

- Used to connect vacuum pumps to the beam pipe
- Constitute abrupt change of geometric cross section

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Impedance

- Past shielding campaign to alleviate this
- Impedance of unshielded PP was presented previously [LIU–SPS BD WG 31.07.2014]

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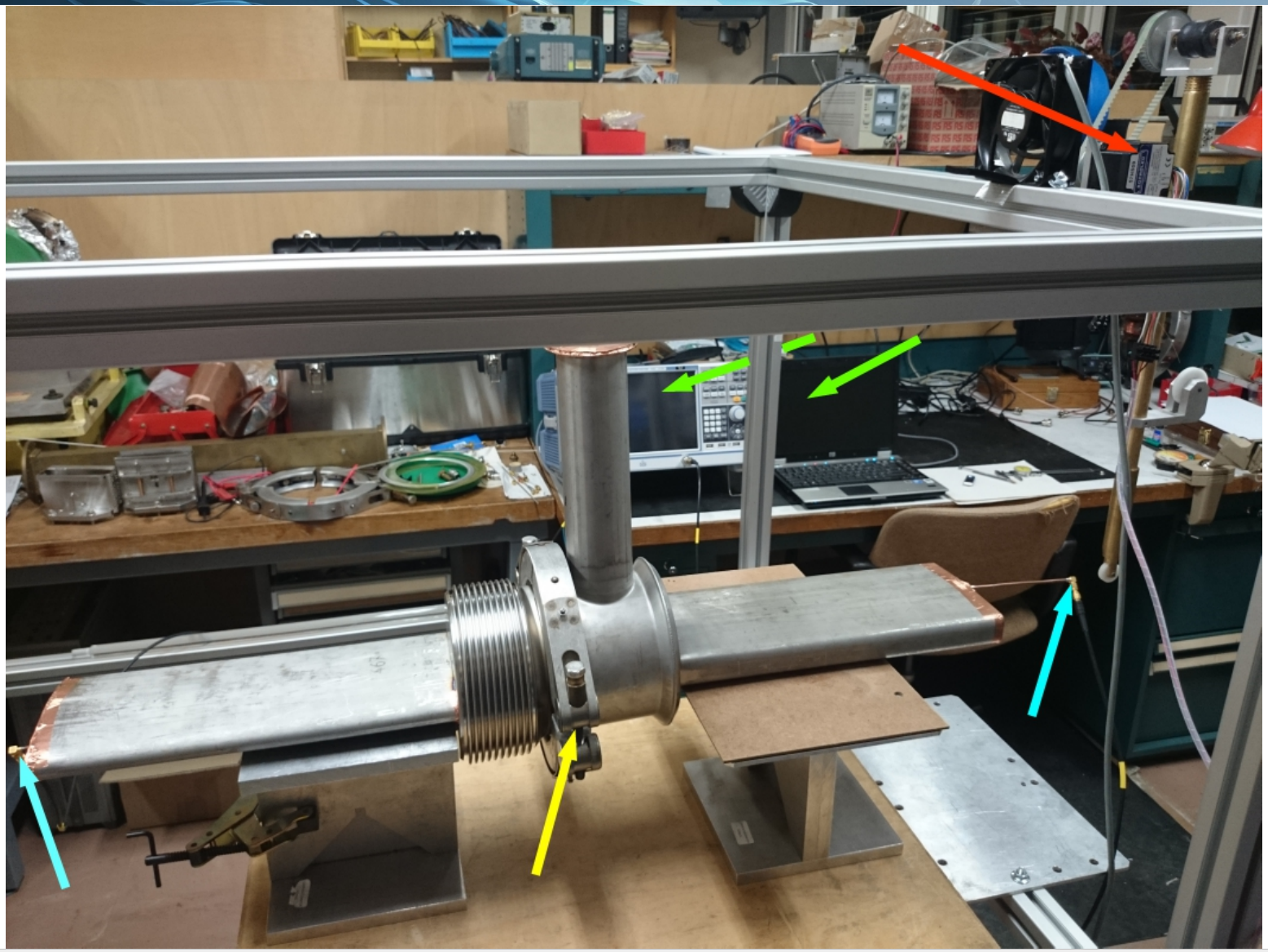
Next step:
Study impedance of Shielded pumping port

Device under test

The pumping port, exterior



Device under test

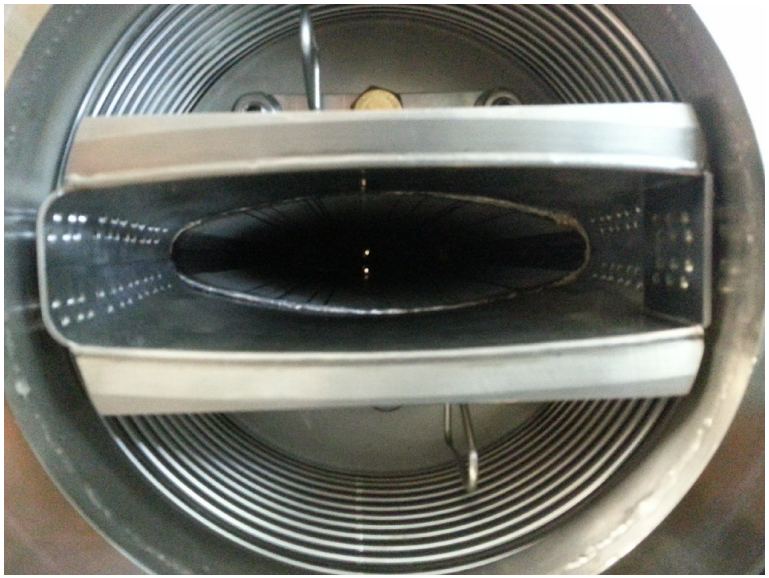
The pumping port, interior

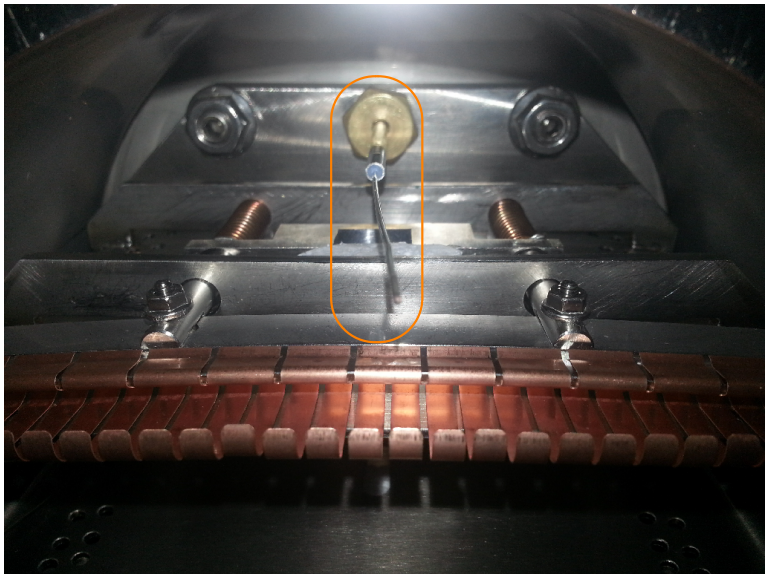
Deviation from the actual configuration

- In the tunnel the shields are mounted on spot welded bolts
- In the lab the shields are mounted on throughput bolts becaue:
  - Speed of construction/realization
  - Better coupler placement

Device under test

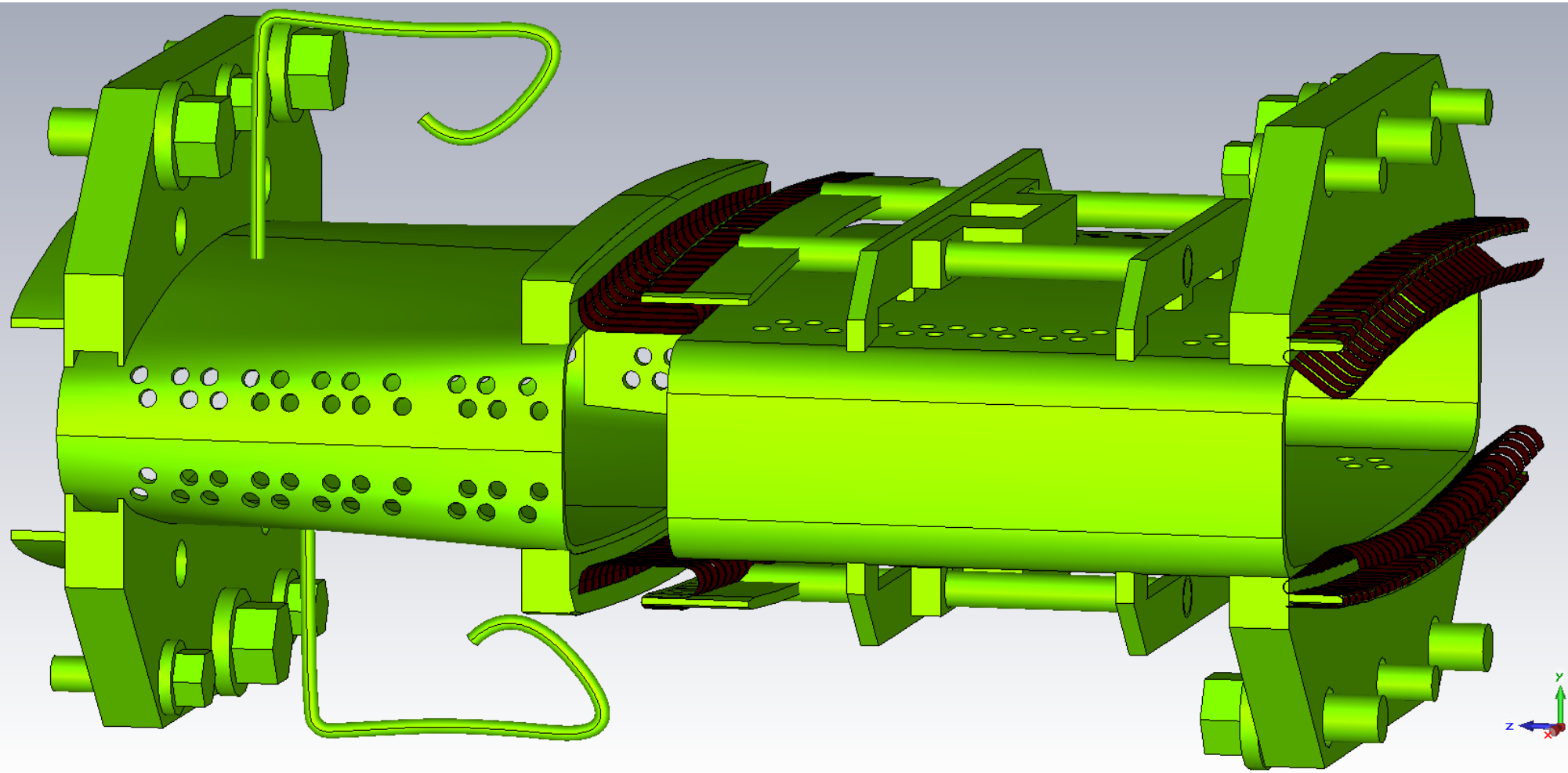
The pumping port, interior





Device under test

Shield model



Deviant cases

Misfits, undesirables and erroneous specimens

But, how could this happen?!

- Installation is difficult
- RF fingers can be askew
- Fingers can get stuck too far away from QF supports

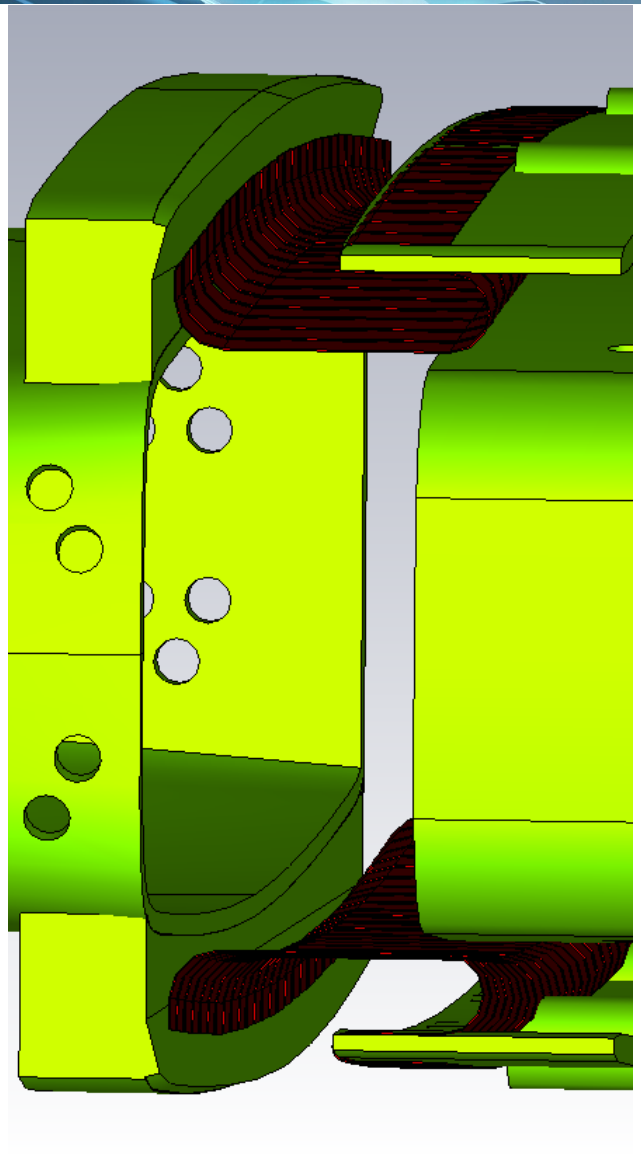
Conducted investigations

- Symmetric gaps
  (upper and lower fingers retracted the same length)
- Asymmetric gaps
  (upper and lower fingers retracted different lengths)
- Skewed fingers
  (one side of fingers do not touch QF supports)

Outline

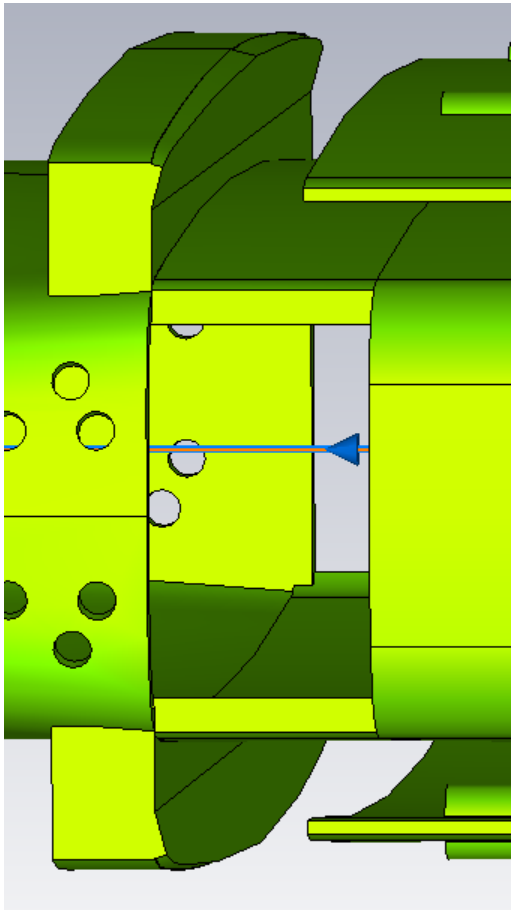
RF finger geometry and impact on results

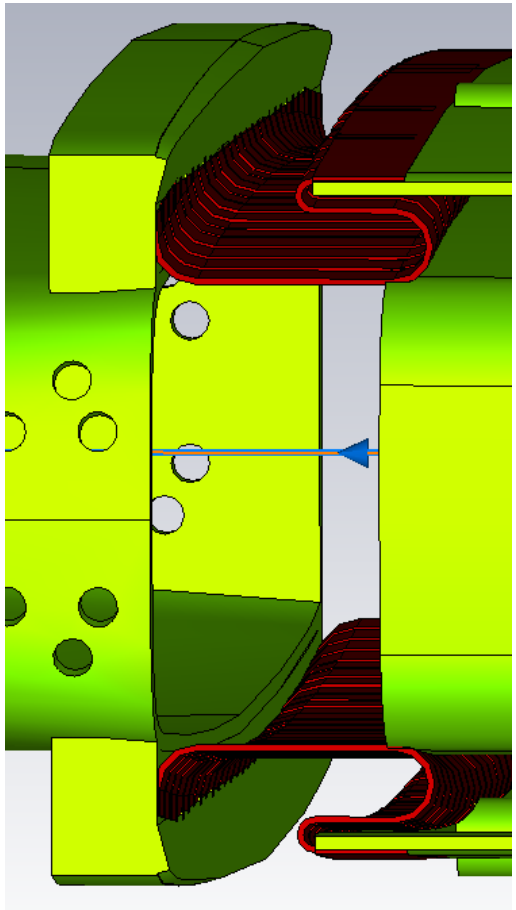
Actual geometry

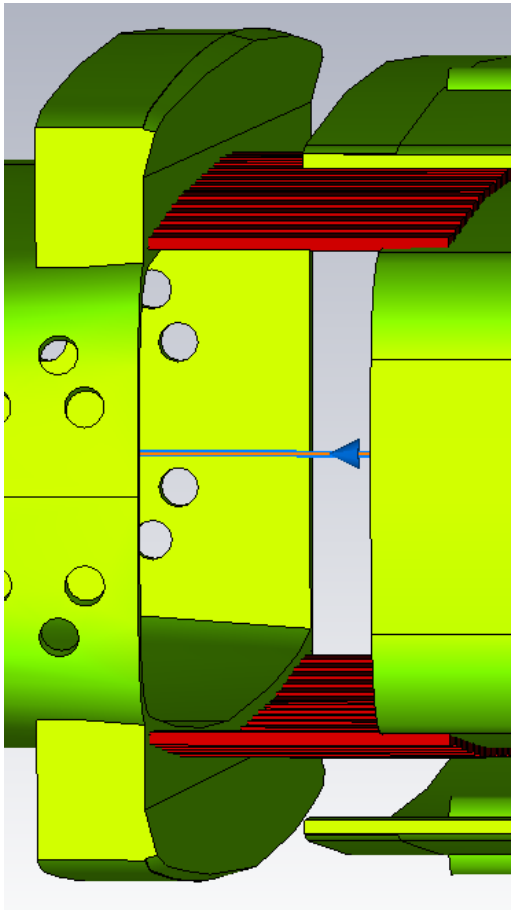


RF finger geometry and impact on results

Three approximate geometries

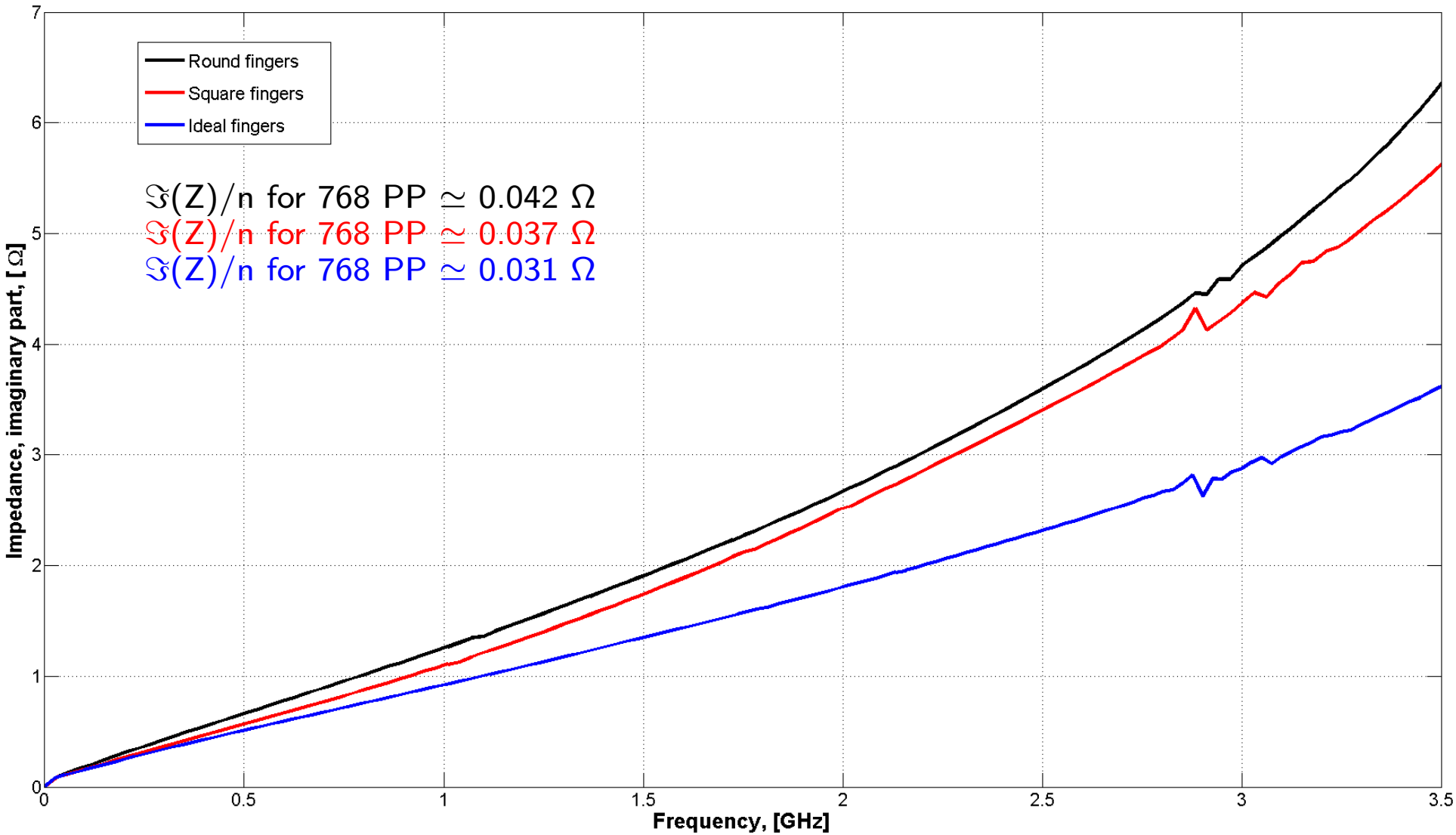






RF finger geometry and impact on results

Resulting impedance from the three approximations



RF finger geometry and impact on results

Resulting impedance from the three approximations

Computational time

Similarity between Round and Square allows for simulations to be run with square fingers to save computational time

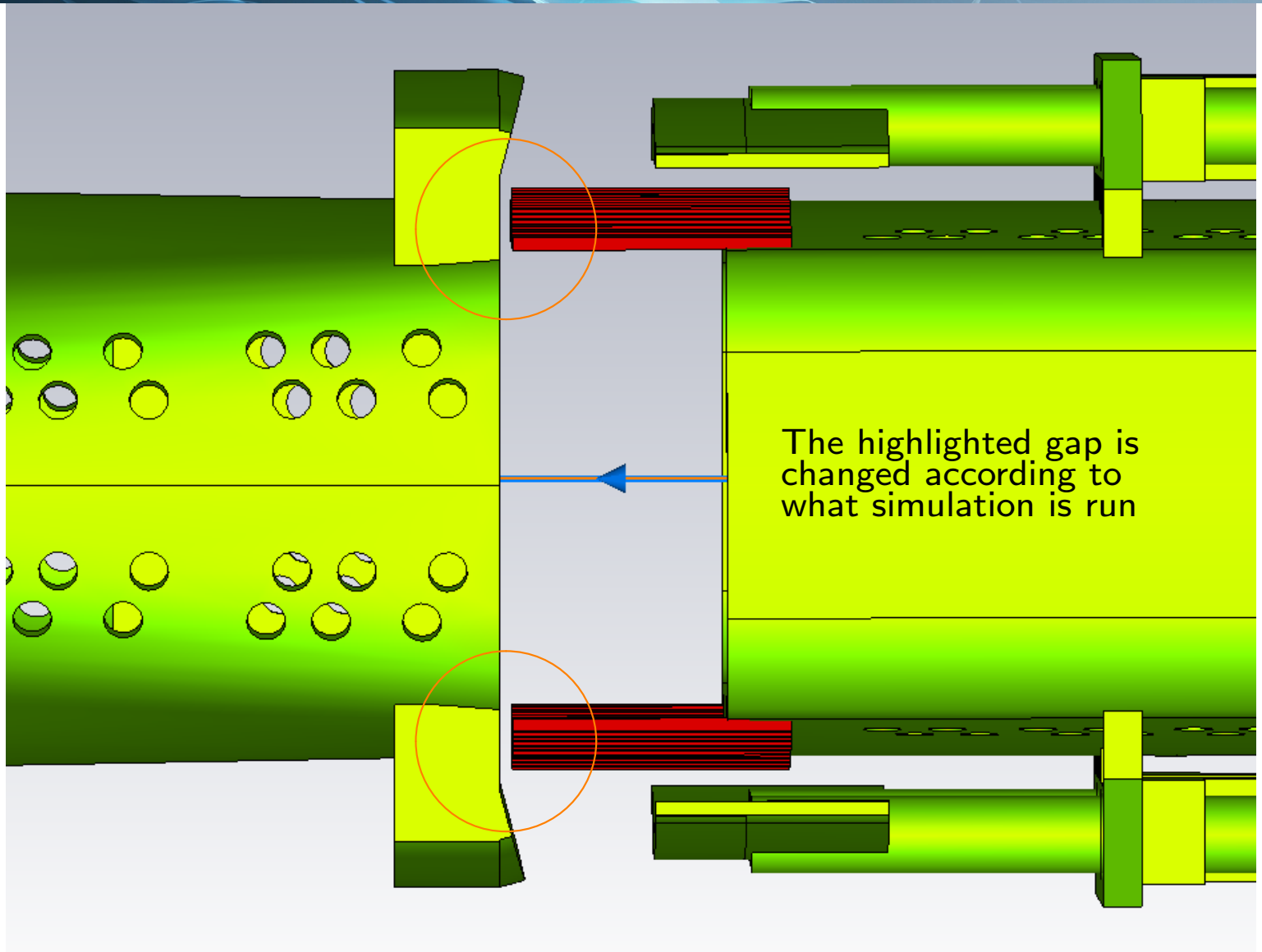
Well placed fingers

Well placed fingers give only a very small contribution to the $\Im(Z)/n$

Outline

No RF contact

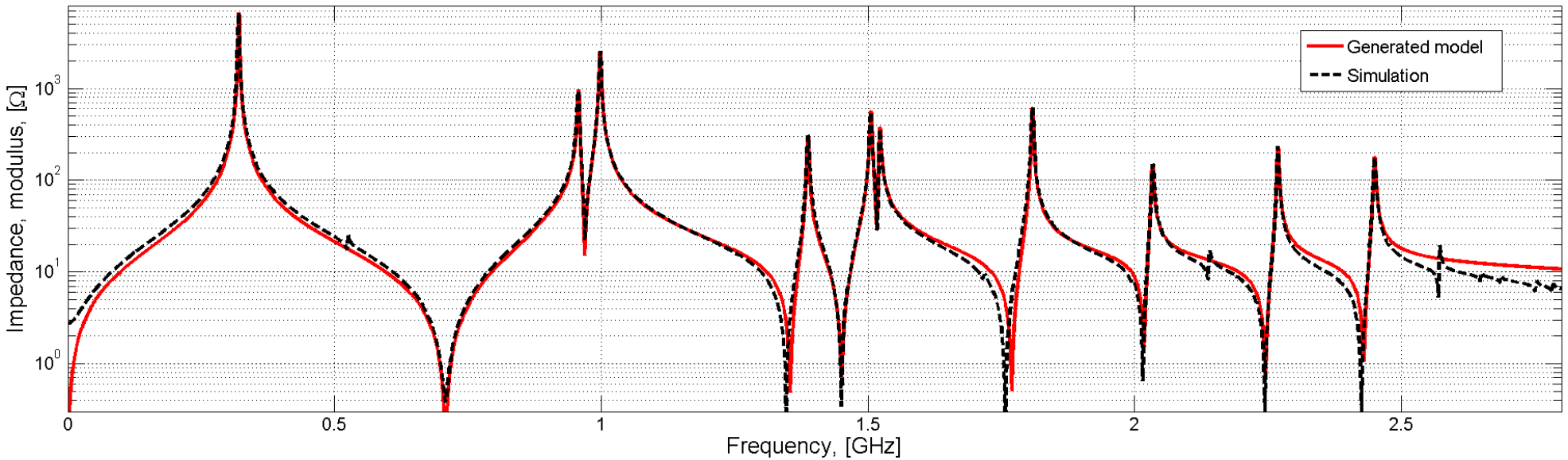
Uniform gap



No RF contact — #1

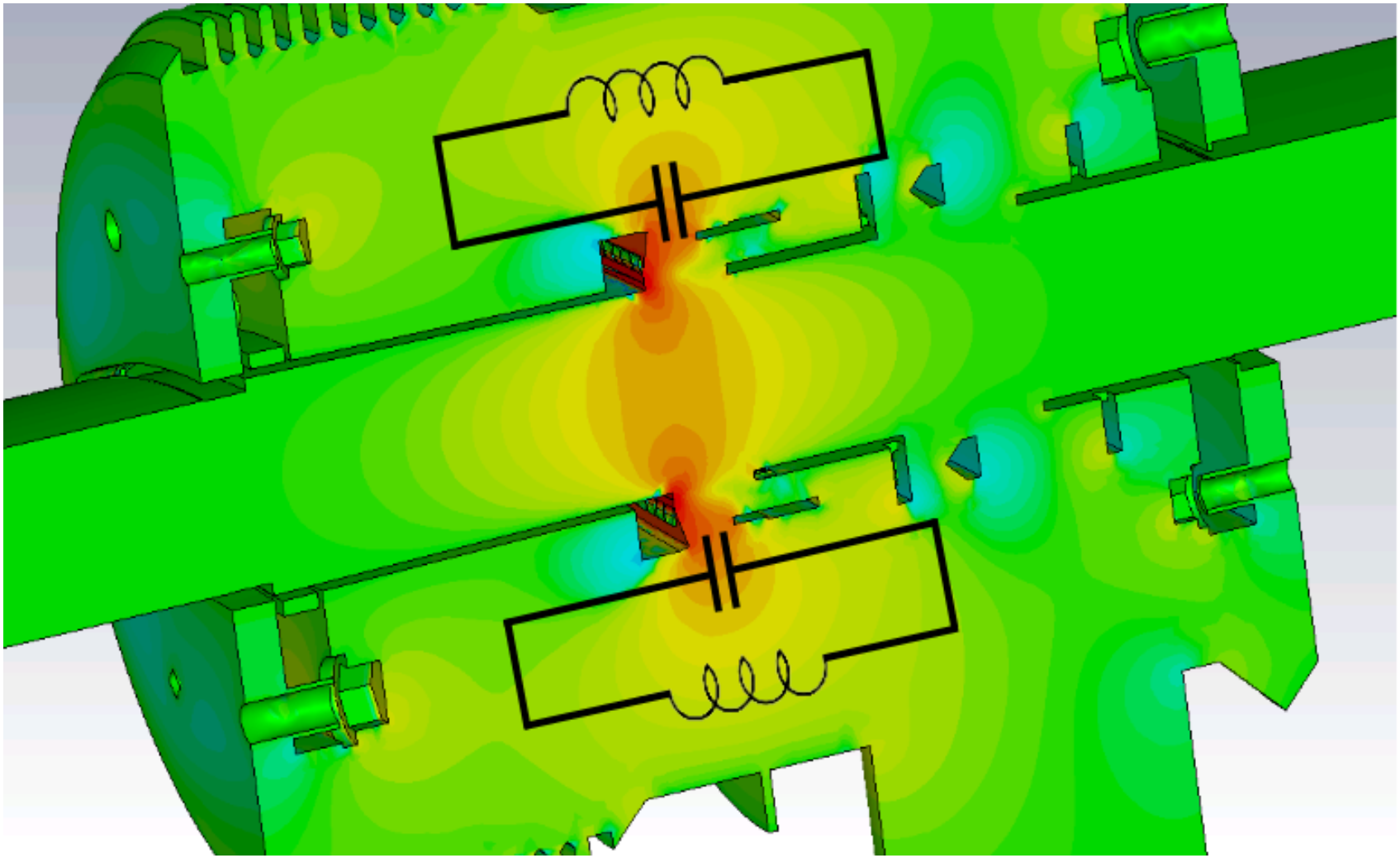
1 mm uniform gap

SimType	f [GHz]	Z [kΩ]	Q [U]	R/Q [Ω]
Wake	0.320	7.5	260	28.85
EigenMode	0.317	6.526	229.2	28.46
Wake	0.957 / 0.998	0.954 / 2.528	400 / 400	2.38 / 6.32
EigenMode	1.003	2.785	340	8.21
Wake	1.387	0.308	600	0.51
Wake	1.506 / 1.522	0.560 / 0.360	550 / 550	1.02 / 0.65
Wake	1.808	0.614	850	0.72
Wake	2.033	0.149	650	0.23
Wake	2.268	0.233	900	0.26
Wake	2.450	0.179	800	0.22



No RF contact — #1

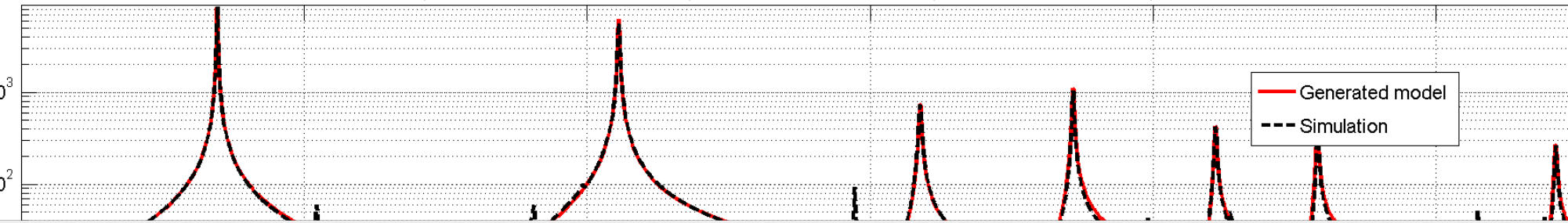
1 mm uniform gap — Field from EigenMode



No RF contact — #2

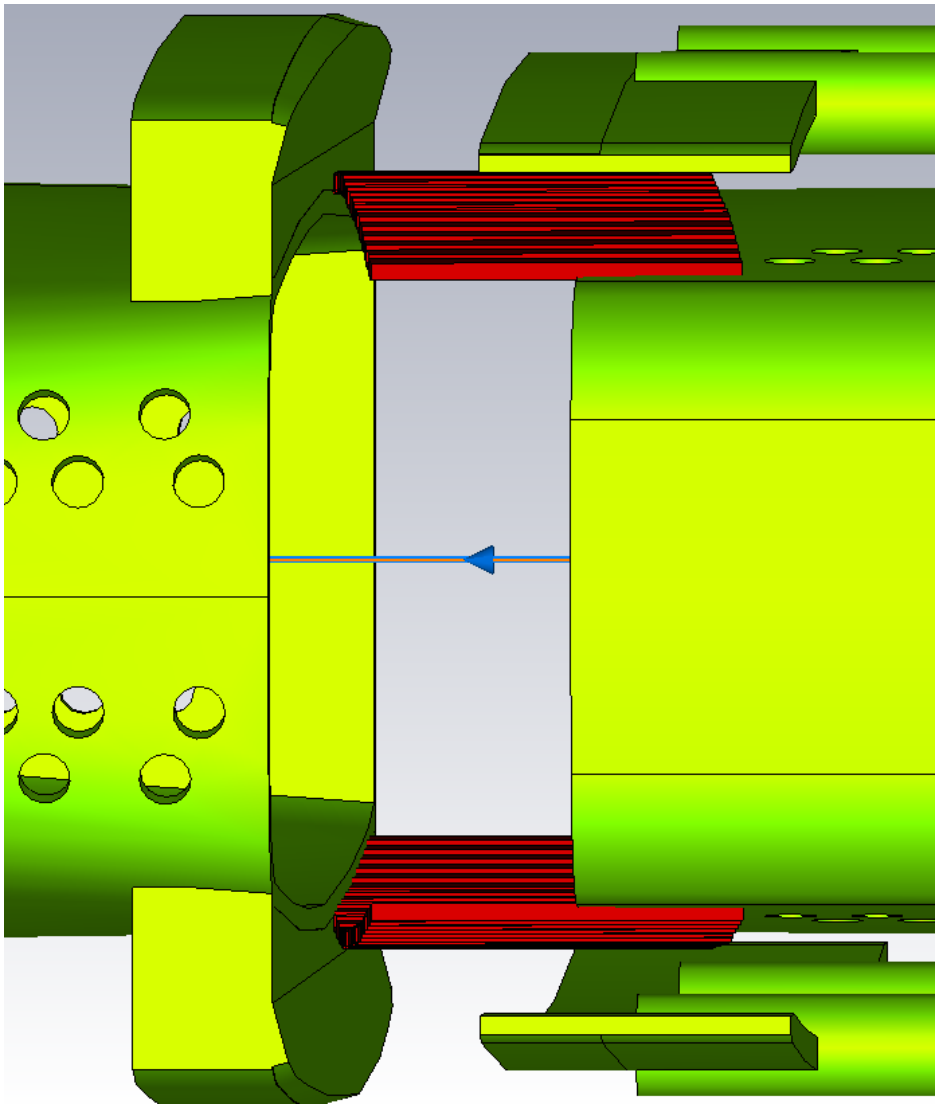
2 mm uniform gap

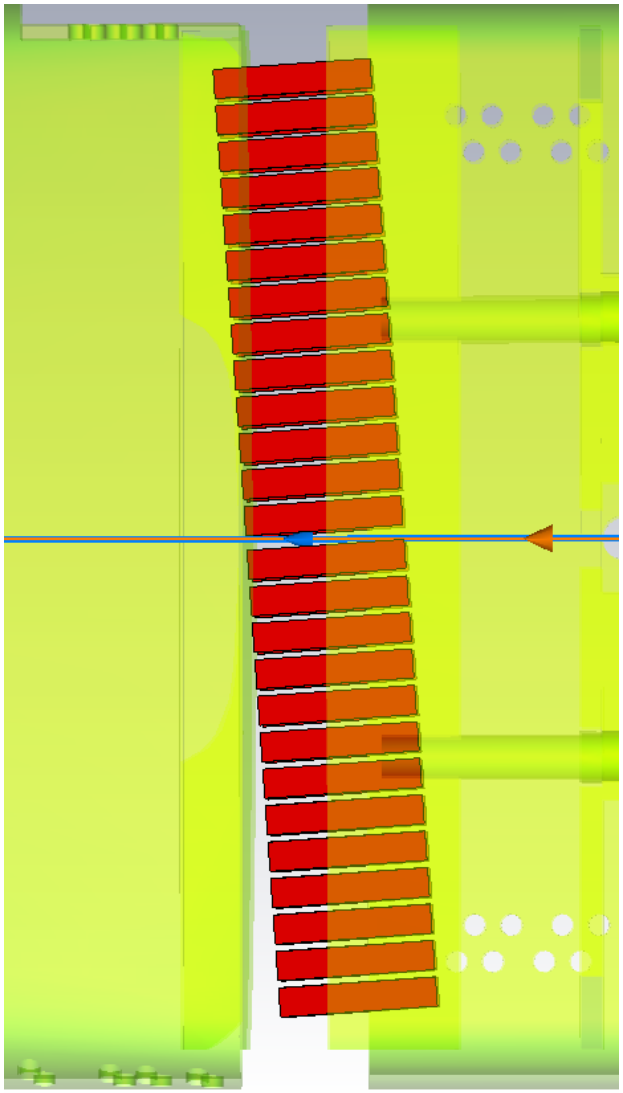
SimType	f [GHz]	Z [kΩ]	Q [U]	R/Q [Ω]
Wake	0.347	8.55	270	31
EigenMode	0.348	8.715	270	32.2
Wake	1.055	6.2	525	12
EigenMode	1.036	4.467	407	11
Wake	1.588	0.75	500	1.5
Wake	1.859	1.12	750	1.5
Wake	2.11	0.43	700	0.6
Wake	2.291	0.448	800	0.5
Wake	2.711	0.27	750	0.3



Some RF contact

Fingers askew

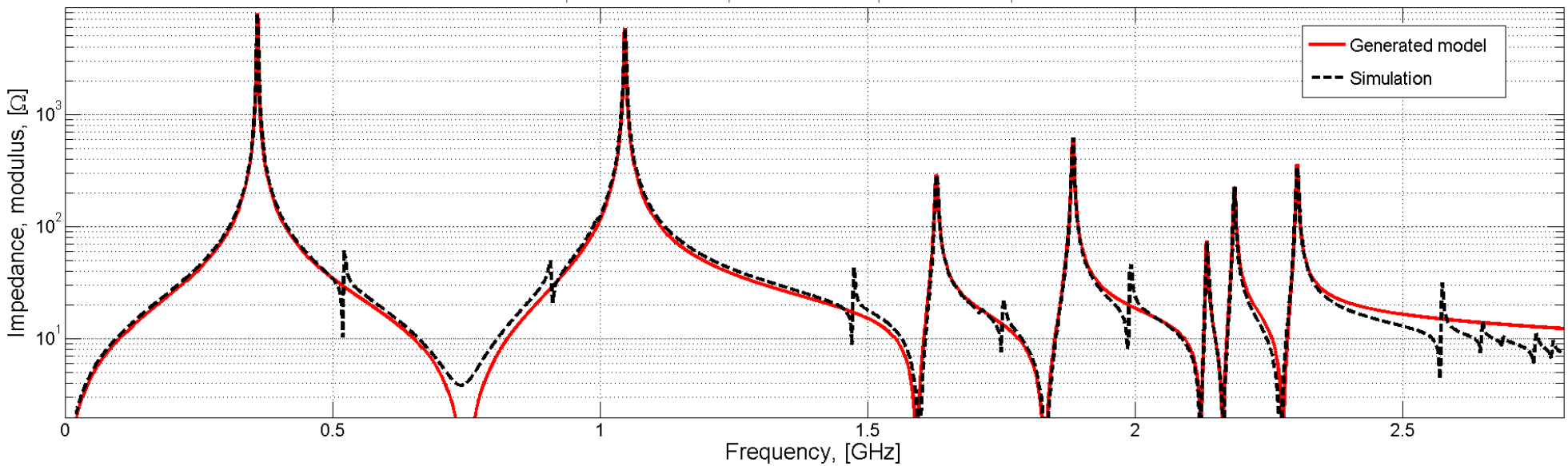




Some RF contact

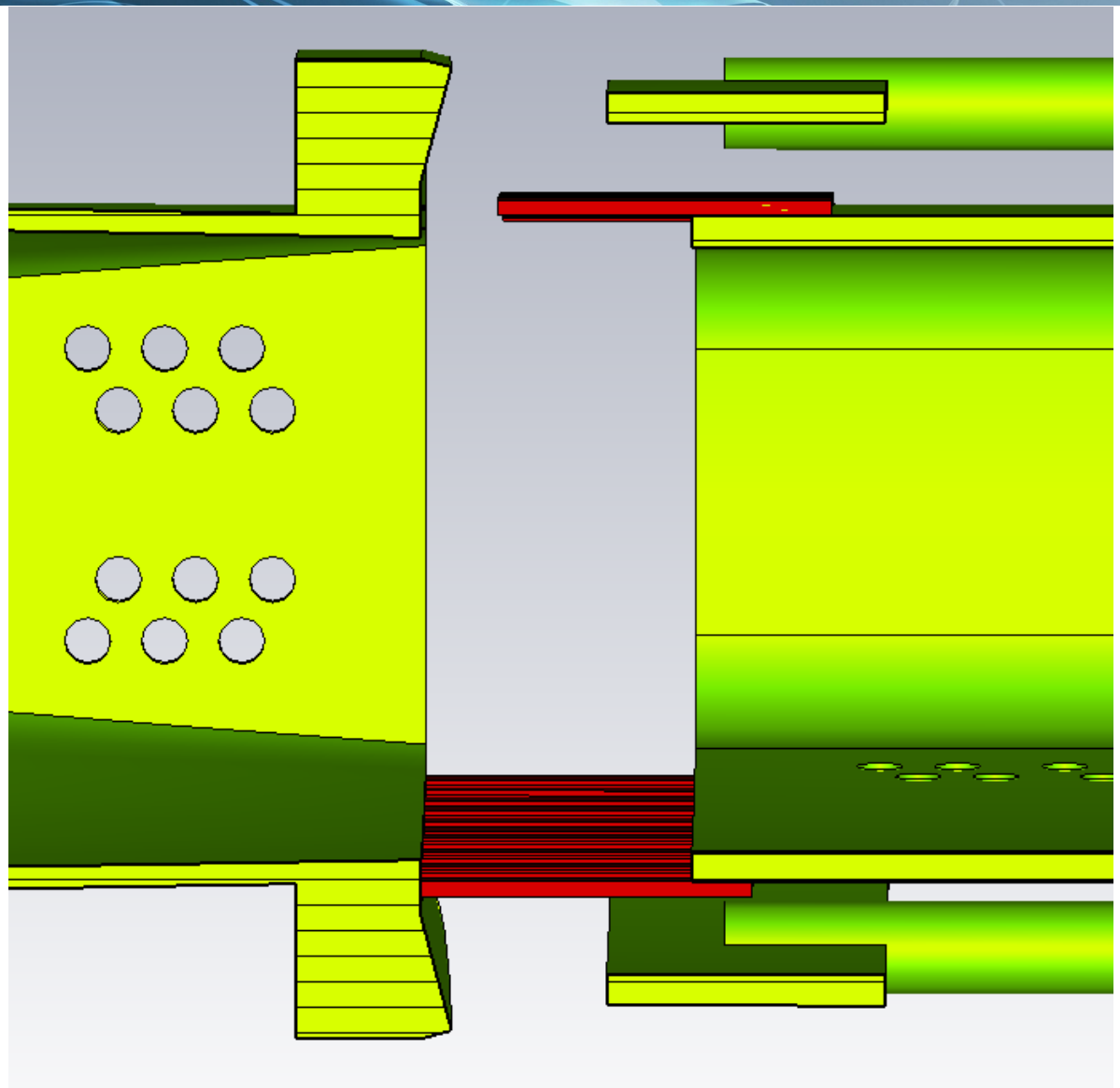
Fingers askew

SimType	f [GHz]	Z [kΩ]	Q [U]	R/Q [Ω]
Wake	0.360	7.97	280	28.45
EigenMode	0.357	7.75	250	31.15
Wake	1.046	5.90	520	11.35
EigenMode	1.029	4.615	405	10.9
Wake	1.628	0.289	400	0.72
Wake	1.883	0.623	680	0.92
Wake	2.133	0.074	800	0.09
Wake	2.185	0.225	700	0.32
Wake	2.302	0.36	800	0.45



Some RF contact

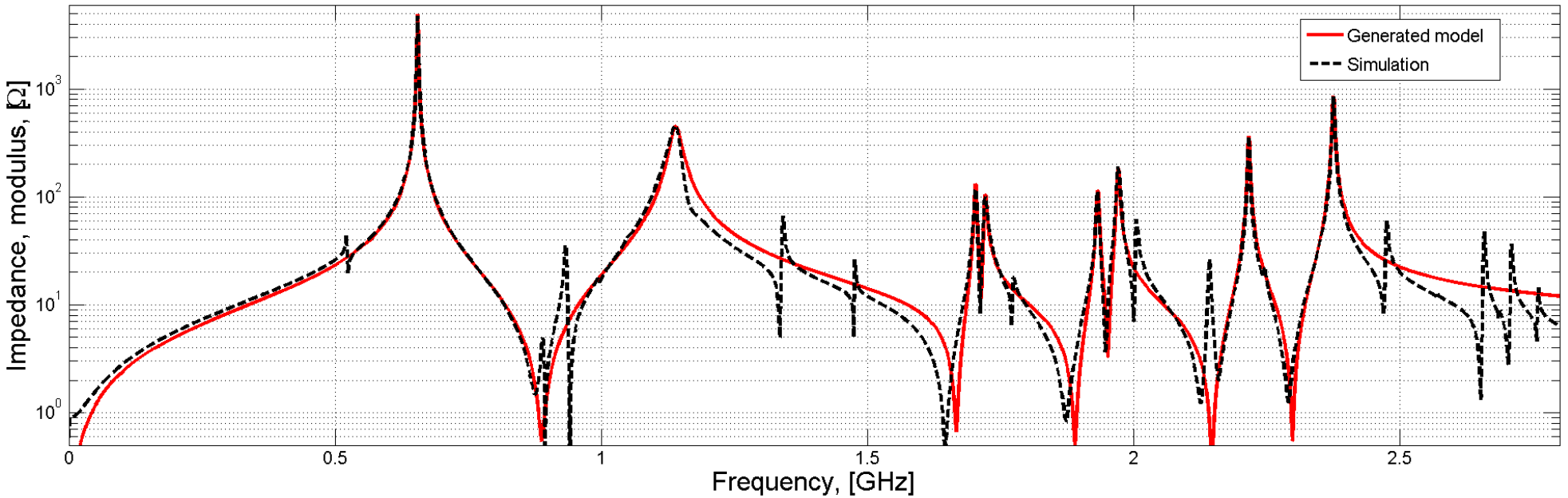
Upper fingers not touching



Some RF contact

Upper fingers not touching

SimType	f [GHz]	Z [kΩ]	Q [U]	R/Q [Ω]
Wake	0.655	4.9	485	10.1
Wake	1.140	0.45	50	9
Wake	1.703	0.13	500	0.26
Wake	1.721	0.1	400	0.25
Wake	1.933	0.114	500	0.22
Wake	2.216	0.365	750	0.58
Wake	2.375	0.865	750	1.15



Outline

Introduction to measurements

General notes regarding challenges and correctness

Challenges

- Low Q's
- Relatively low R/Q's

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Very challenging measurements

- A lot of work has gone into improving the setup, measurement parameters and the post processing of results
- Resonances with $R/Q < 1$ have not been measured, as they, in any case, have very small impedance
- The focus has been on the first two modes (around 0.350–0.400 and 1.000 GHz)

Introduction to measurements

Early conclusion

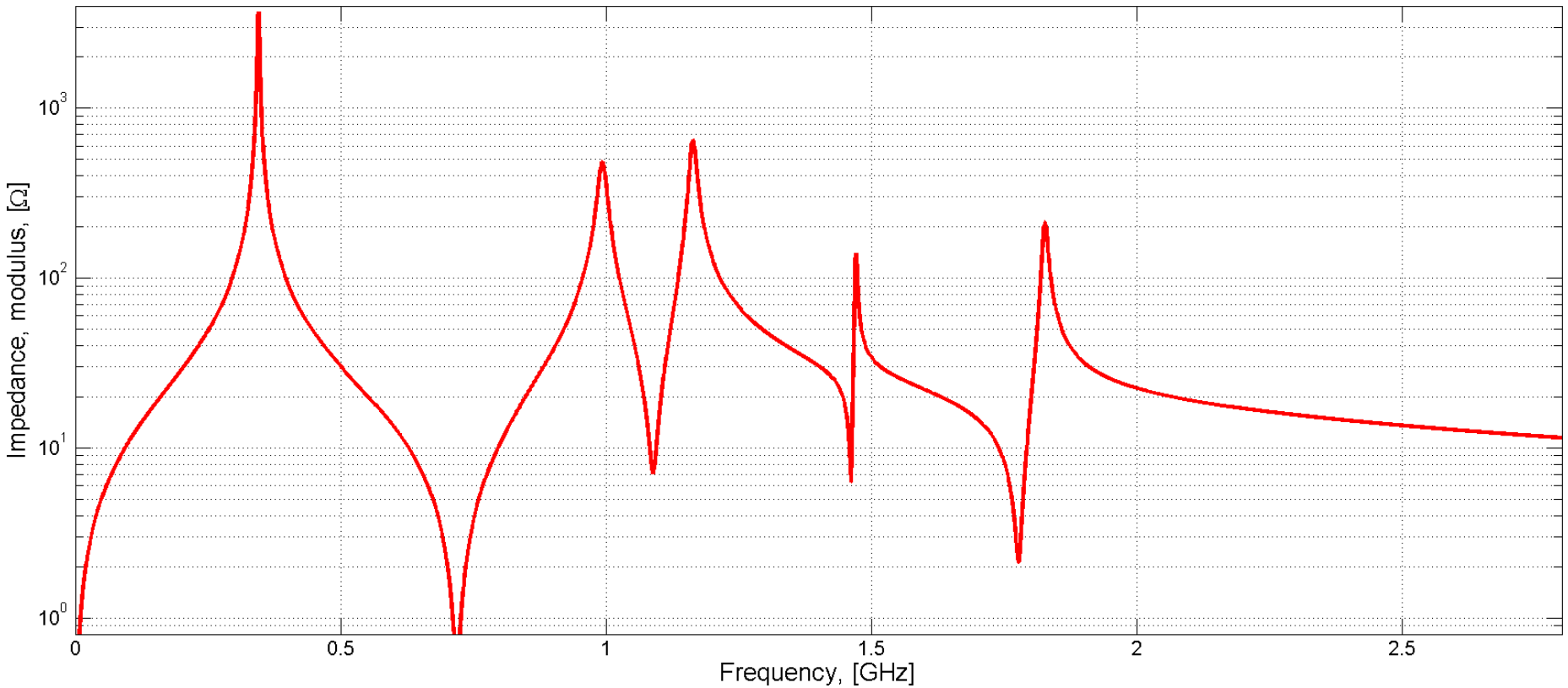
Important remark regarding the results

- Results for the low frequency mode (around 350–400 MHz) are all bullet proof
- Results for higher frequency modes suffer from uncertainties
  - Partially identified these uncertainties
  - Hopefully solved during next week

Uniform gap

Unknown gap length (1–5 mm) — beadpull measurements

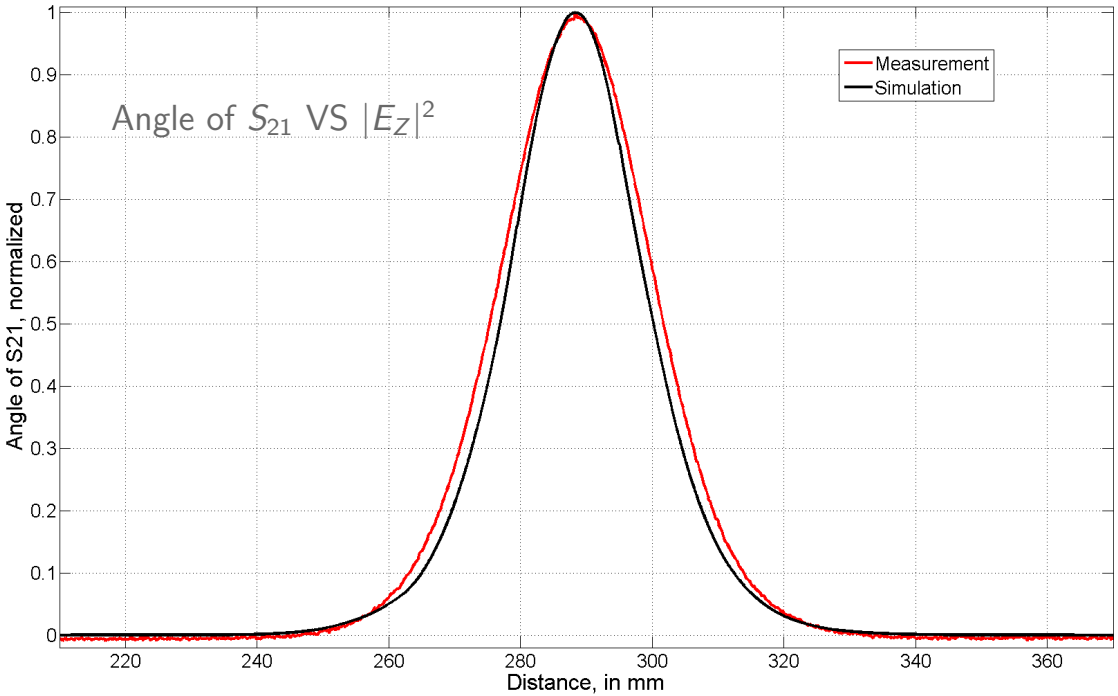
f [GHz]	Z [kΩ]	Q_L [U]	R/Q [Ω]
0.345	3.7	125	**29.6 ±5%**
0.993	0.481	65	7.4 ±30%
1.163	0.650	100	6.5 ±30%
1.470	0.133	405	0.33 ±100%
1.826	0.211	192	1.1 ±70%

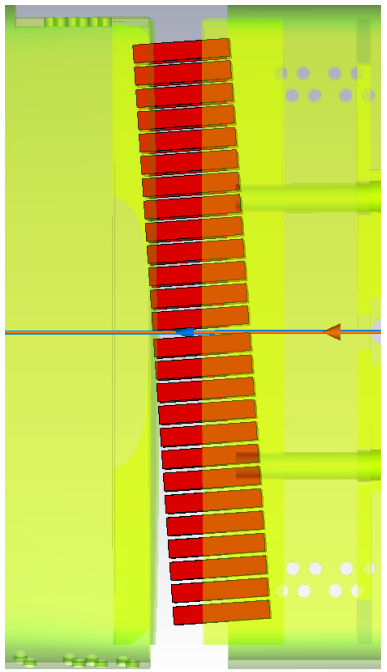


Skewed fingers

Unknown angle

DataType*	f [GHz]	Z [kΩ]	Q [U]	R/Q [Ω]
EigenMode	0.357	7.75	250	31.15
Wake	0.360	8.1	280	29
Meas	0.42	1.11	43	25.8
EigenMode	1.029	4.615	405	10.9
Wake	1.046	6.2	520	12
Meas	0.973	0.94	100	9.4





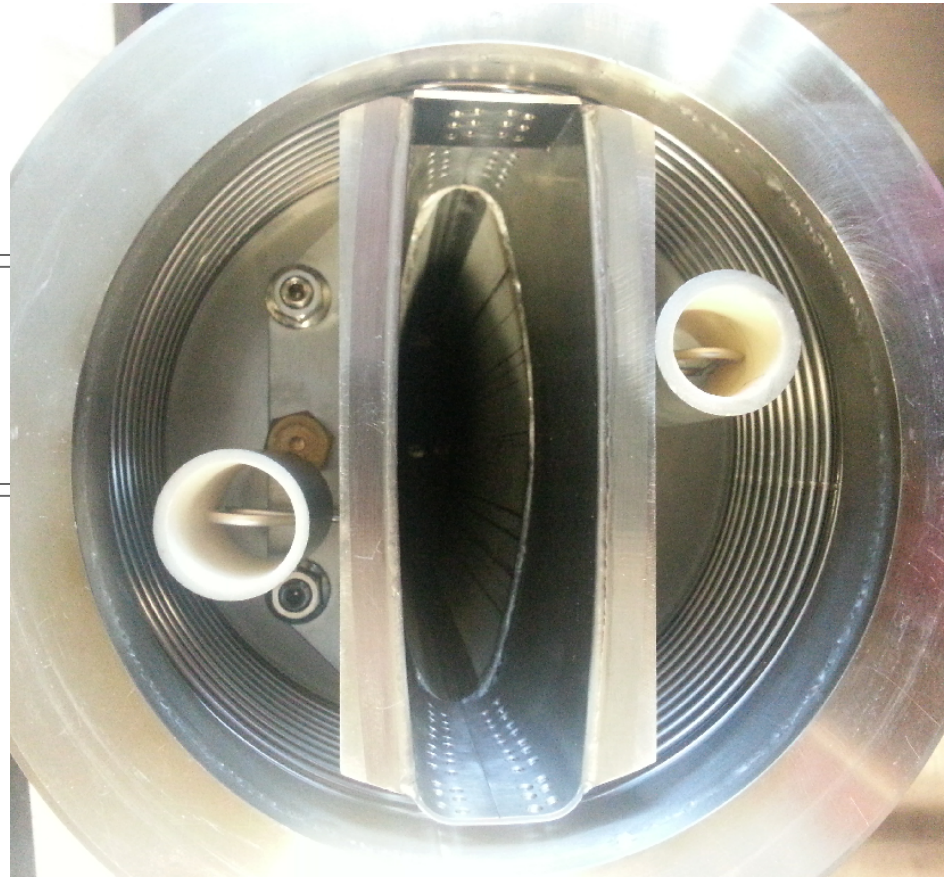
*

Simulation results from slide 20

Damping resistors

Measuring new Q's, uniform gap $\simeq$5mm

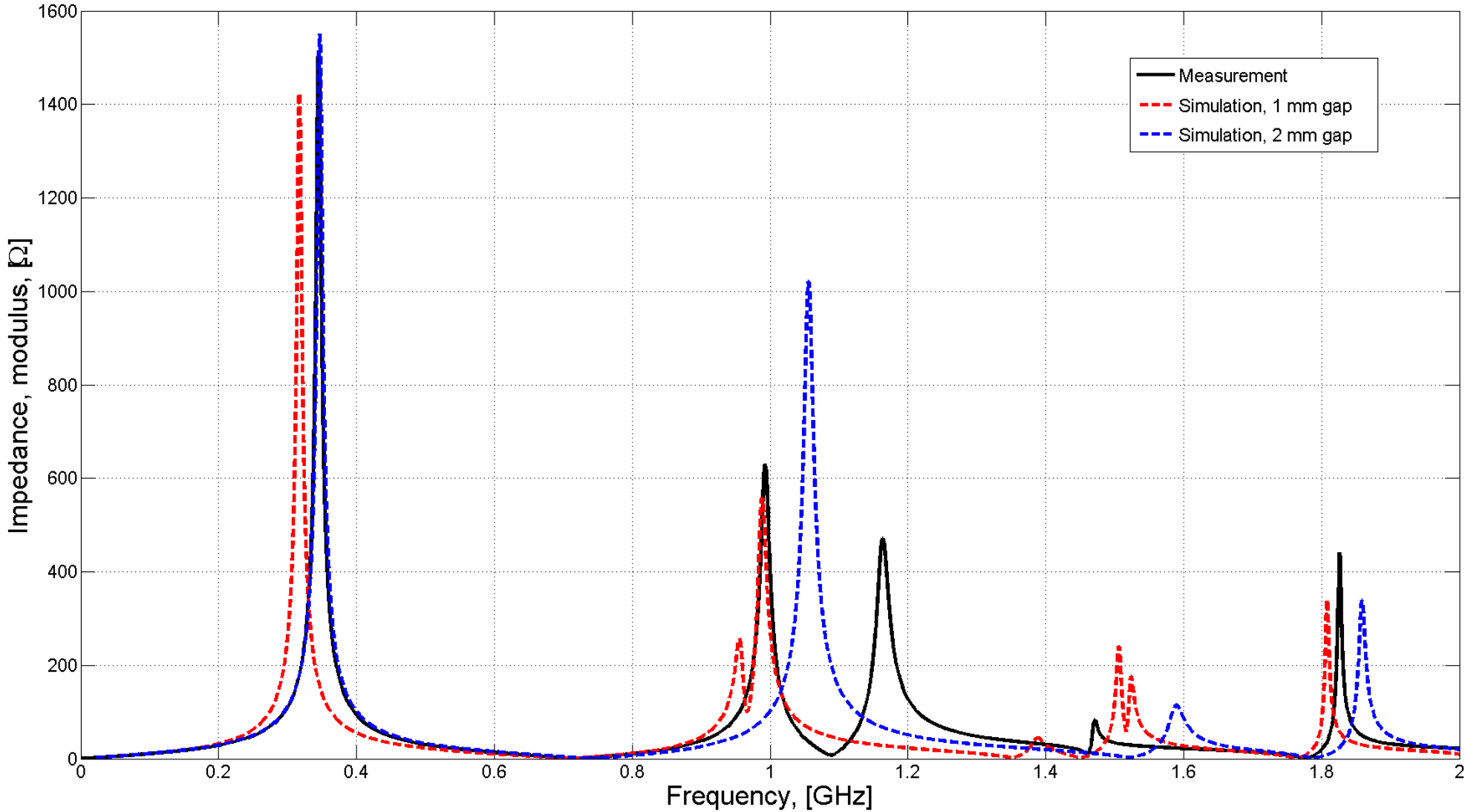
# DampRes	f [GHz]	Q [U]
1 DampRes Long type	0.382	76
	1.016	113
	1.134	107
2 DampRes Long type	0.381	51
	1.014	85
	1.137	72



Outline

Comparing simulations and measurements

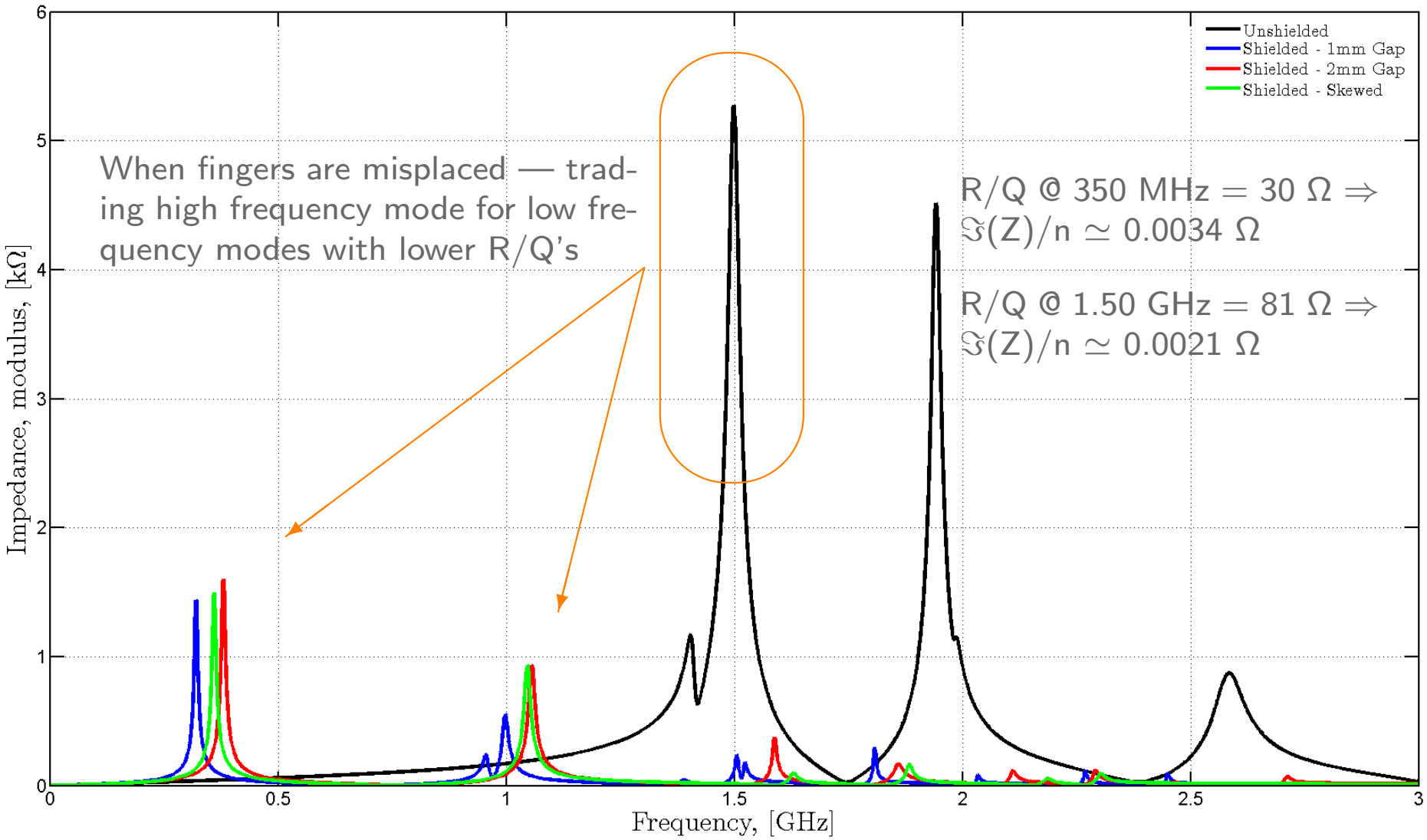
Construct impedance model for damped pumping ports



Outline

Effect of shielding when misplaced

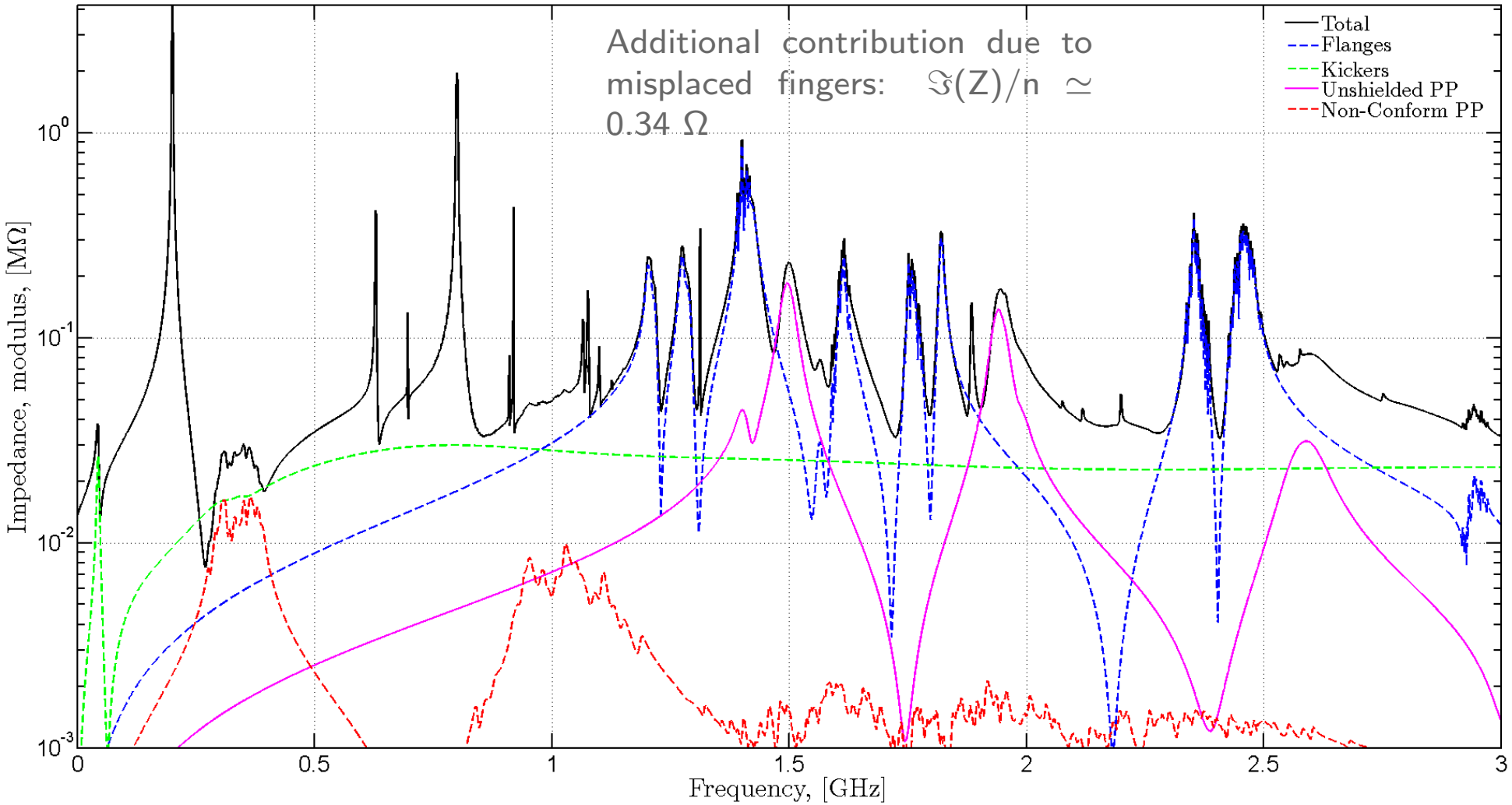
Comparing empty pumping port with erroneously shielded



Outline

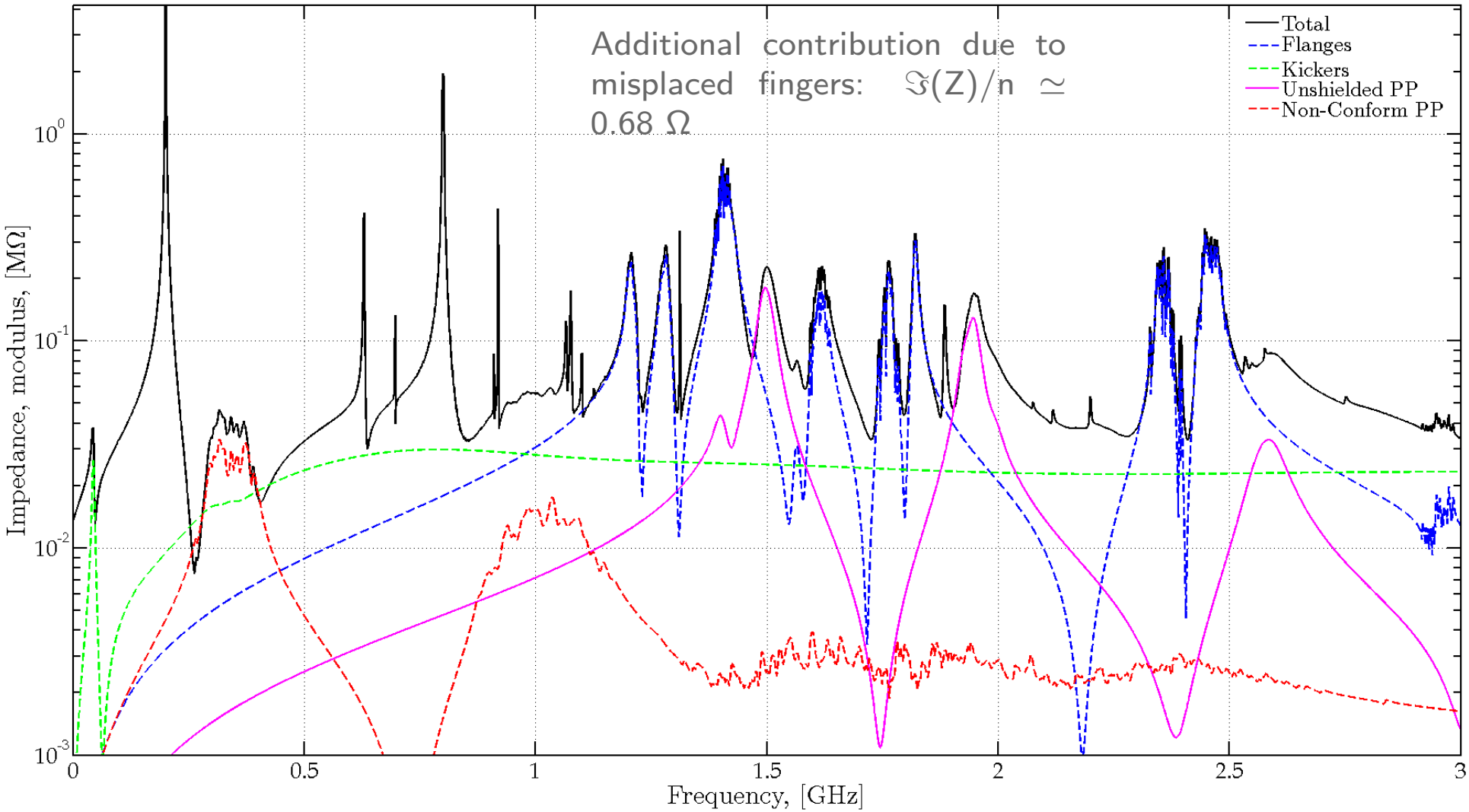
Complete longitudinal impedance model

Assuming 5% of PP's with gap, 5% of PP's with skewed fingers



Complete longitudinal impedance model

Assuning 10% of PP's with gap, 10% of PP's with skewed fingers



Outline

Summary

- When the shields are working as intended, the longitudinal impedance is negligible, however there is some, very small, contribution to the $\Im(Z)/n$
- Several likely deviations from the intended positioning of the fingers have been studied
  - Simulations and measurements are in good agreement
  - Low frequency modes (350–400 MHz), for several cases, have been found and characterised accurately
  - Higher frequency modes (> 1 GHz) have also been found and characterised, however some difficulties have arisen and will be studied further

Conclusions

- Correctly placed shields are 'impedanceless'
- Misplaced fingers can be worse than the unshielded case
- The misplacement percentage is unknown
  - This percentage cannot be very big
  - It may be possible to estimate the percentage based on the synchrotron frequency shift measured before and after the shielding campaign?
  - X–ray imaging can be used to check the position of the fingers
  - 10–20% gives reasonable contribution to the $\Im(Z)/n$