Application of CST Microwave Studio for the Development of Mobile Communication Infrastructure RF Filters

Dr. Roland Rathgeber
Development of Filters and Combiners
KATHREIN-Werke KG, Rosenheim, Germany

KATHREIN

CST Microwave Studio ... Development of ... RF Filters: Overview

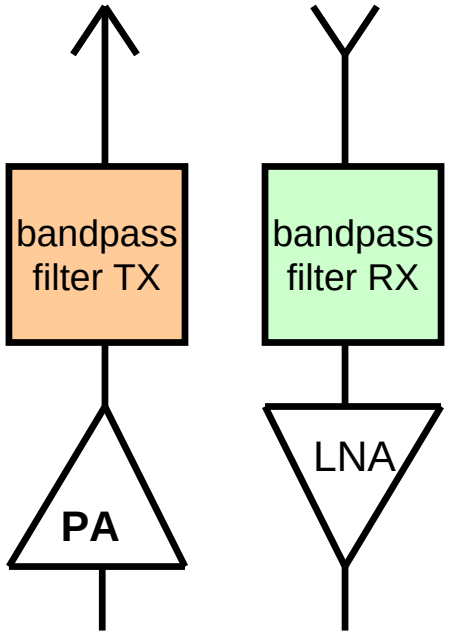
- **Introduction**
- **Filter Design Workflow:**
  - Single Resonator
  - Coupled Resonators
  - Capacitive Triplet
  - Inductive Triplet
  - Complete Filter
- **Conclusions**

Introduction: Base Station RF Frontend Filter - Example

Introduction: RF Front End Filters for Mobile Radio Base Stations

Low passband insertion loss - typically < 1 dB!

- ***Transmit (TX) - high power:***
  - High effort to generate RF power - not to be wasted in the filter!
  - Thermal management!
- ***Receive (RX) - low power:***
  - Reduce system noise figure!



Introduction

Choice of technologies:

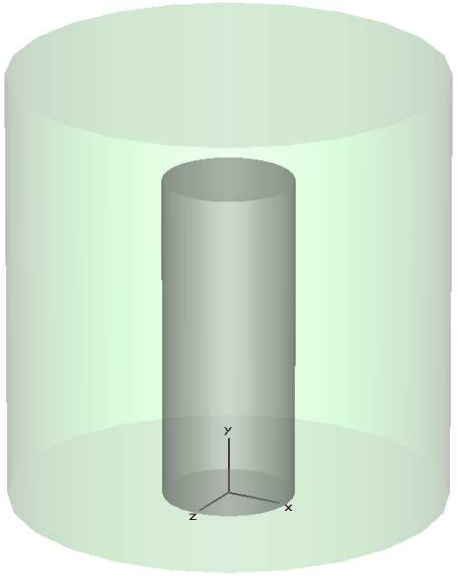
- *(Lumped element)*
- *...*

- Stripline
- Surface Acoustic Wave (SAW)
- **Coax combline**
- Ceramic
- ...

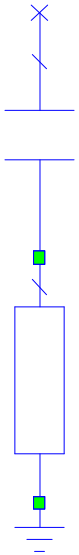
- *(Hollow waveguide)*

Single Resonator: Starting Point for Filter Development

3 D model:



Circuit model:



end capacity

transmission line

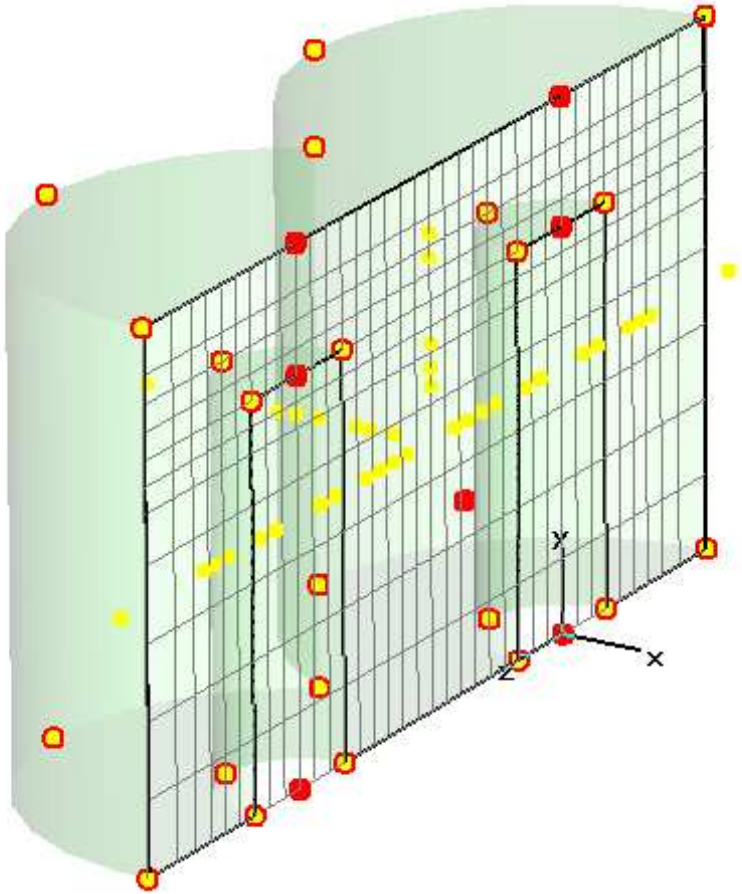
- **Inner conductor**
- **Air-filled cavity**
- (Outer conductor / housing not shown)

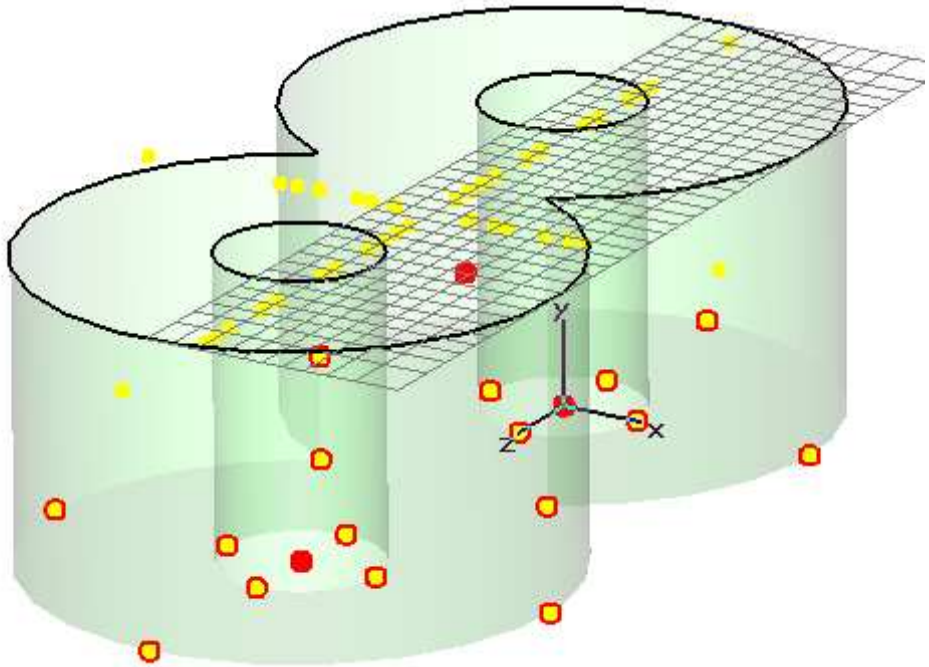
Relevant RF parameters:

--> Resonance frequency

--> Q factor

Coupled Resonators: Initial Mesh



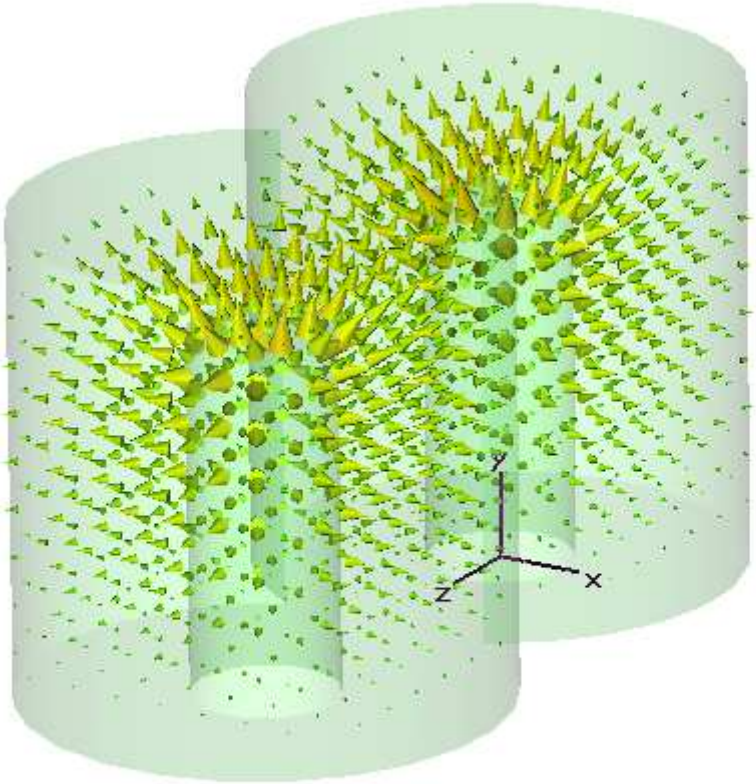


- 3960 *(10 x 11 x 36)* mesh cells
- *yz* symmetrie plane
- ´Perfect Boundary Approximation´ (PBA) used

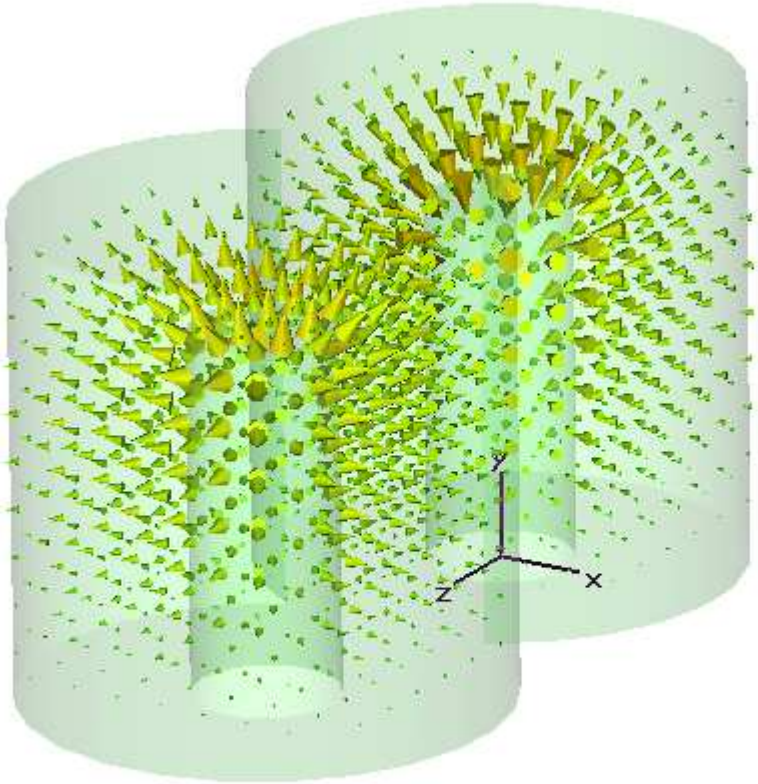
Coupled Resonators: Convergence

Mesh-cells	lower reso-nance (MHz)	upper reso-nance (MHz)	coupling band-width (MHz)	compu-tation time (min : s)	
3,960	**1911.89**	**1946.68**	**34.79**	**0:08**	***initial mesh***
9,828	1914.75	1950.38	35.63	0:15	
19,652	**1921.79**	**1958.11**	**36.32**	**0:32**	***used for field plots***
38,720	1922.30	1958.92	36.62	1:19	
63,648	1926.09	1963.01	36.92	2:49	
96,720	1926.27	1963.32	37.05	4:53	
138,720	1926.57	1963.68	37.11	8:57	

Coupled Resonators: Lower and Upper Coupling Resonance



Type = E-Field (peak)
Monitor = Mode 1
Maximum-3d = 5.36709e+008 V/m
Frequency = 1921.8
Phase = 0 degrees

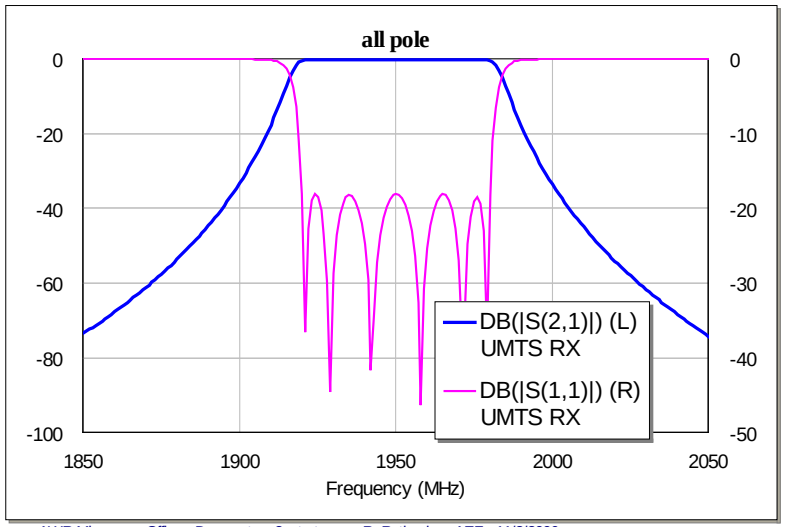


Type = E-Field (peak)
Monitor = Mode 2
Maximum-3d = 5.33324e+008 V/m
Frequency = 1958.12
Phase = 0 degrees

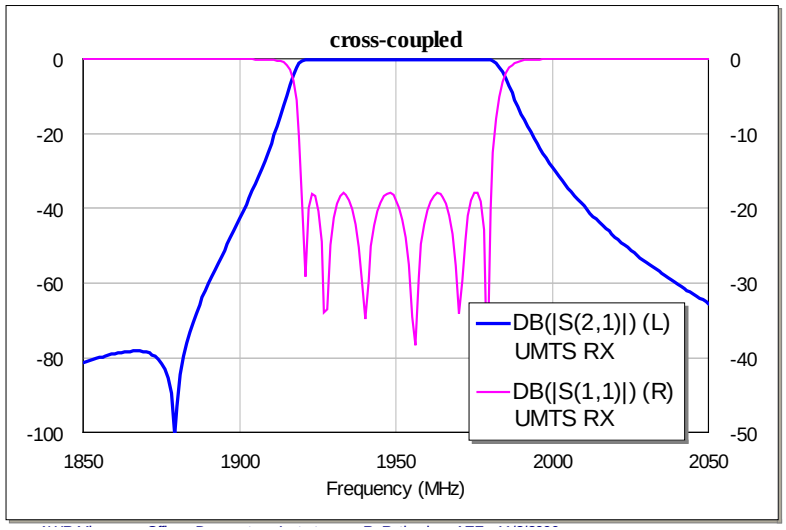
Capacitive Triplet: Basics

An additional capacitive coupling
from resonator #n to resonator #n+2 („capacitive triplet“) ...

... will create a transmission zero below the passband

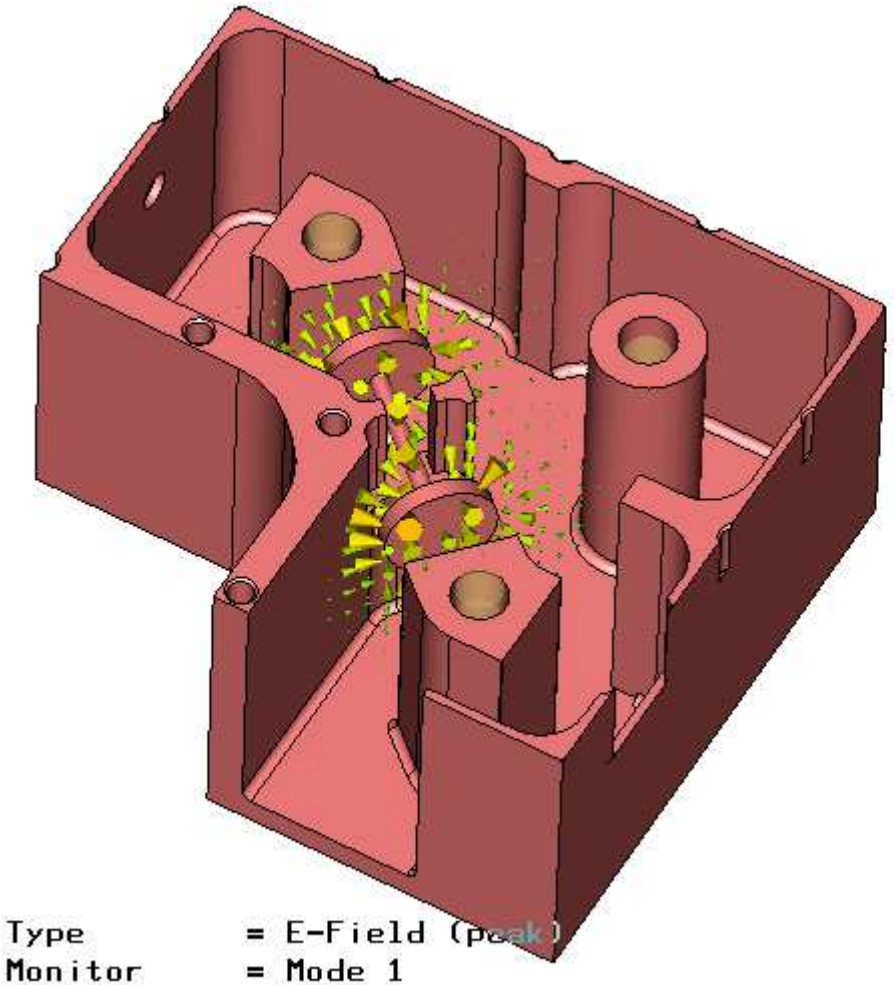


6-resonator bandpass filter, all-pole type



6-resonator bandpass filter, transmission zero below passband

Capacitive Triplet: Static Mode E-Field

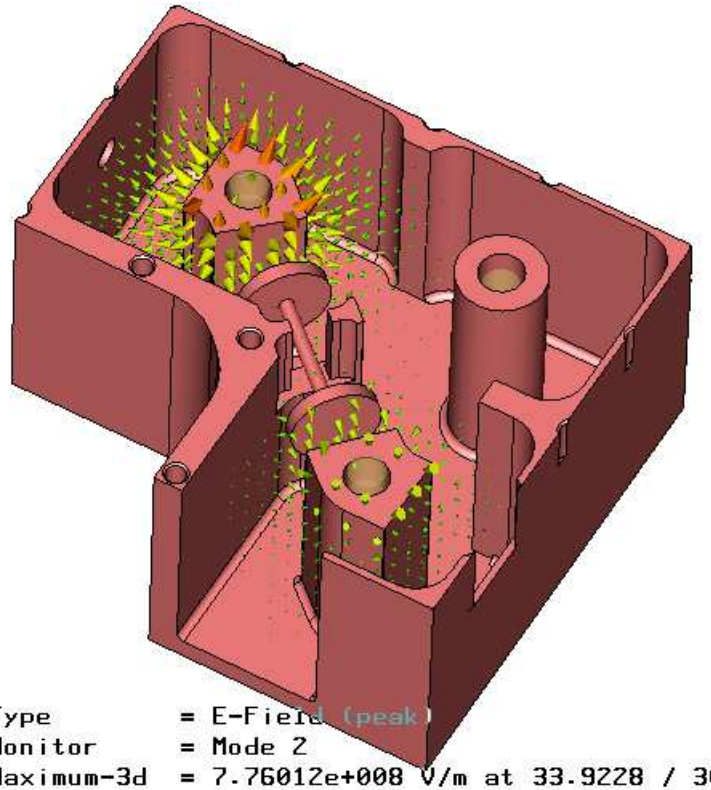


Type = E-Field (peak)
Monitor = Mode 1
Maximum-3d = 9.7852e+008 V/m at 42.797 / 26.2375 / -81
Frequency = 0

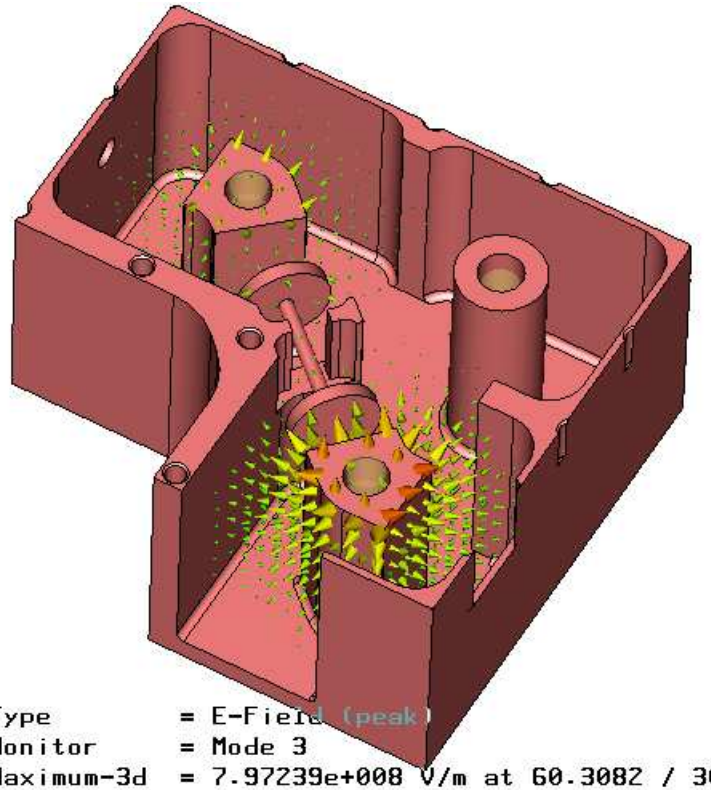
- ***Mode 1 @ 0 MHz:***
  unwanted ´static´ mode!
- **Mode 2 @ 1734 MHz:**
  first coupling resonance
- **Mode 3 @ 1795 MHz:**
  second coupling resonance

KATHREIN

Capacitive Triplet: (Cross-) Coupling Resonances, E-Fields



Type = E-Field (peak)
Monitor = Mode 2
Maximum-3d = 7.76012e+008 V/m at 33.9228 / 30.5 / -97.4698
Frequency = 1733.59
Phase = 0 degrees

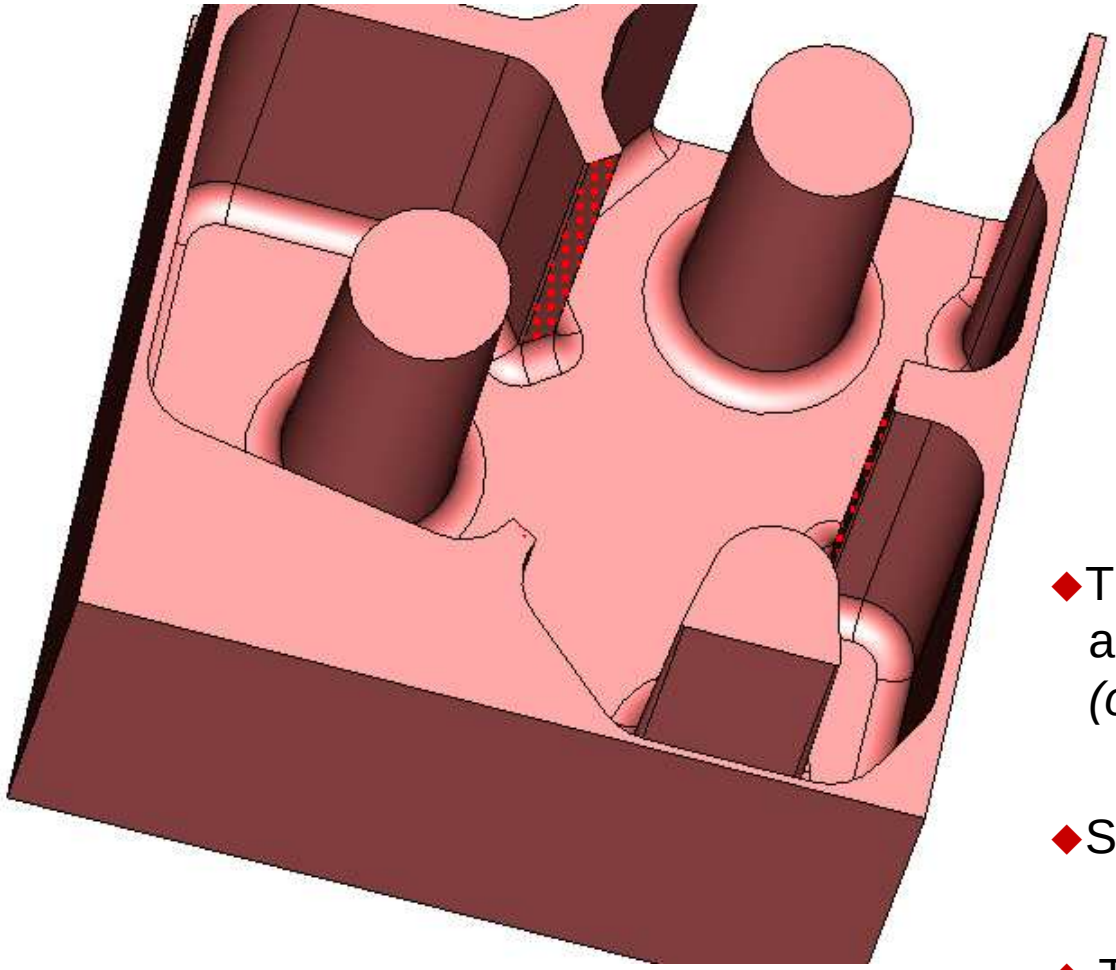


Type = E-Field (peak)
Monitor = Mode 3
Maximum-3d = 7.97239e+008 V/m at 60.3082 / 30.5 / -7
Frequency = 1795.4
Phase = 0 degrees

- **Mode 2 @ 1734 MHz:**
  first coupling resonance

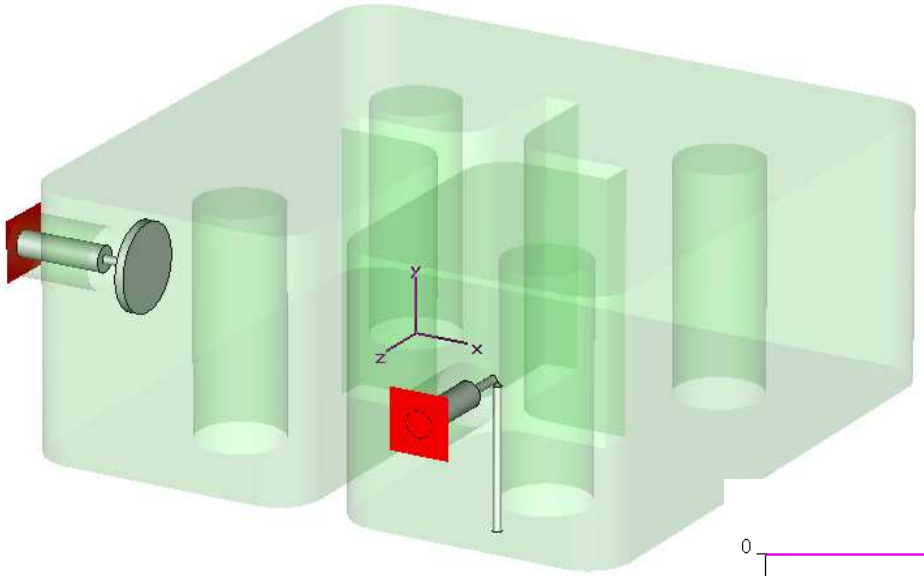
- **Mode 3 @ 1795 MHz:**
  second coupling resonance

Inductive Triplet

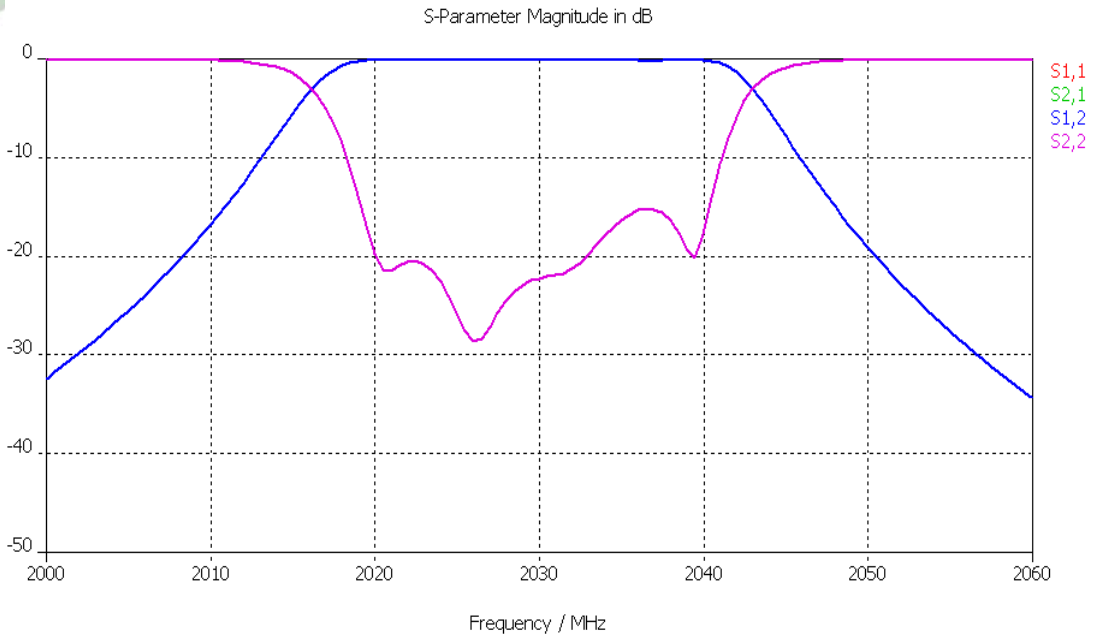


- Three couplings,
  all of the same type
  (opening in side wall)
- Strong interaction
- Three-parameter optimization

Complete Filter: Model, Results



4-resonator bandpass filter



Complete Filter: Computation Time

Year 2003:

- 1 GHz computer clockrate
- „Old“ computer architecture
- CST Transient Solver
  (AR-Filter not used)

==> 56 hours calculation time!

Year 2007:

- 3.2 GHz computer clockrate
- Improved computer architecture (bus, cache, ...)
- „Resonant Fast S-Parameter“ Solver

==> 9 min 30 s calculation time!

KATHREIN

Conclusions

- **Applications of CST Microwave Studio in the design process of coaxial combline bandpass filters**
- **Application-specific problems**
- **Recent improvements in the CST software**

Thank you for your attention!