

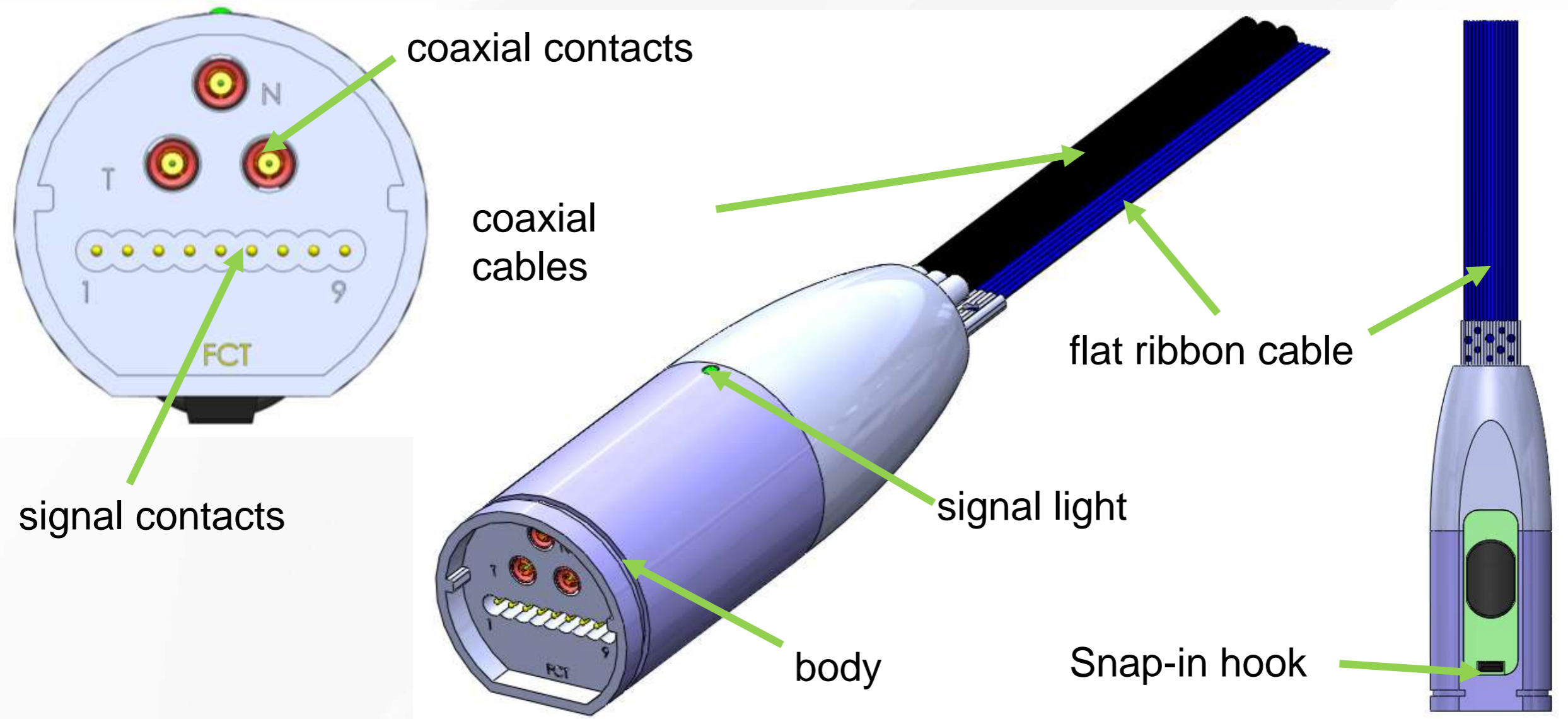
Application of Simulation Tools in the Design and Construction of Connector Systems

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Agenda

- Insight into the construction process of a medical connector for close-proximity to patient application by means of mechanical, electrical and injection mould technique simulation
 - requirements
 - mechanical and injection mould simulations
 - electrical simulations
- Examples of further product developments

Simulated components at the connector development stage



Product requirements for the medical connector

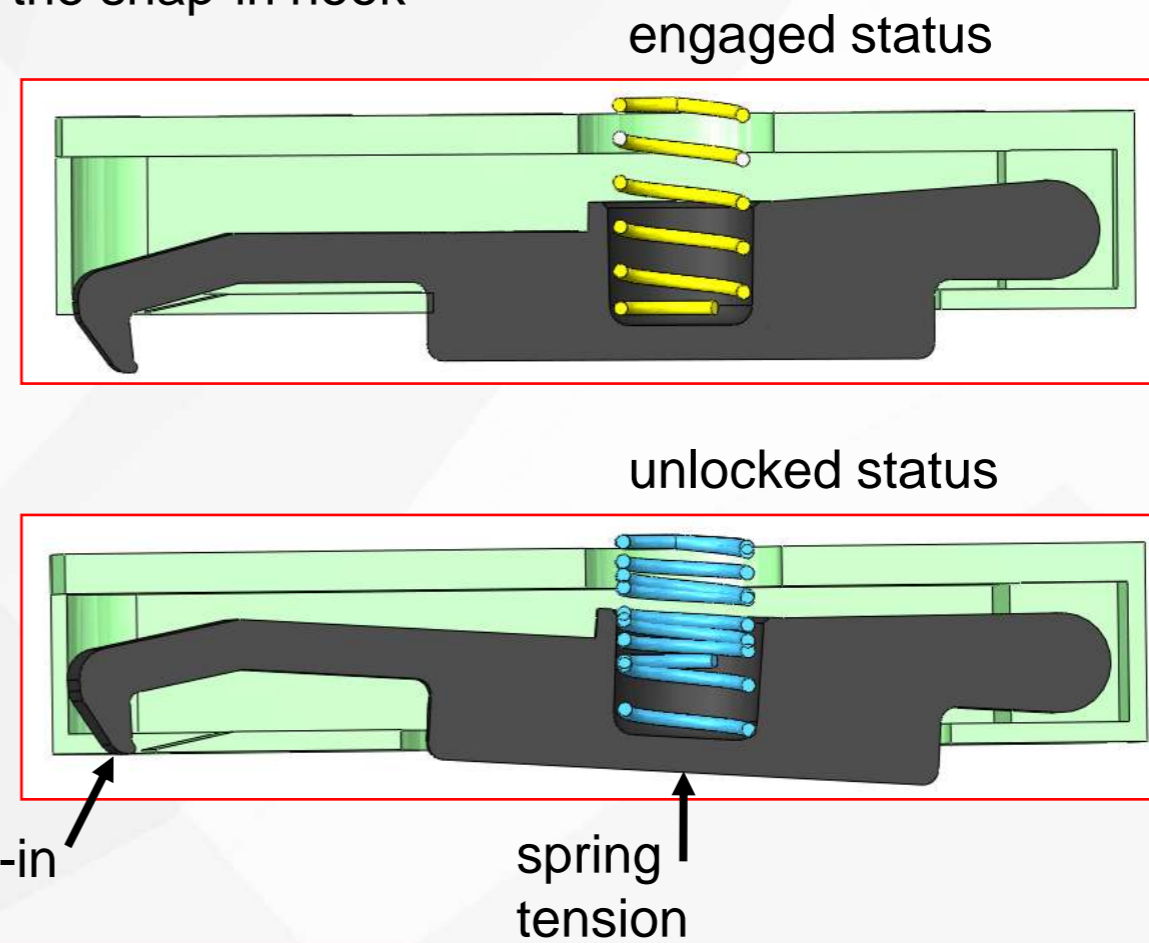
- Mechanically stable snap-in hook during latching and unlocking
- Force of the snap-in hook on the microswitch $> 10\text{N}$
- High mechanical resistance and stability
- Resistance to signal interference
- Good coaxial contact VSWR-results
- Low insertion forces

Agenda

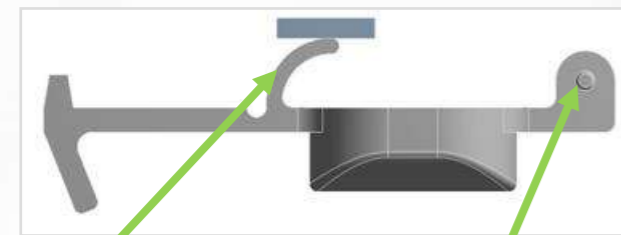
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Simulation of Snap-in Hook load during unlocking

- The snap-in hook should be designed to be elastic .
- Unlock by pulling back the snap-in latch → leads to spring tension
- Spring tension loads the snap-in hook.
- Aim: No critical mechanical load is required for the snap-in hook

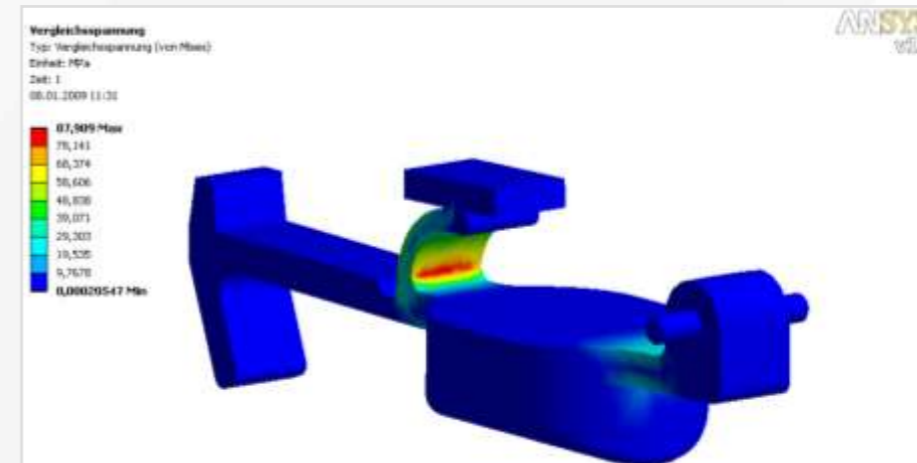
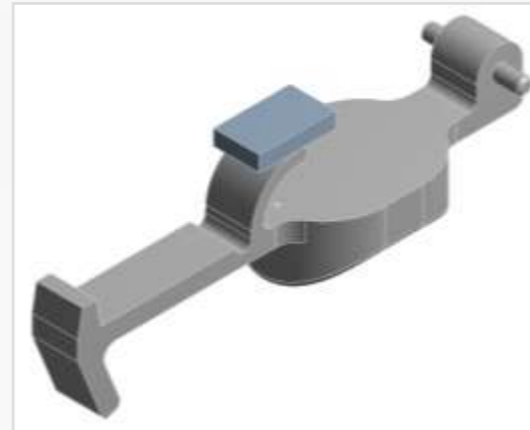
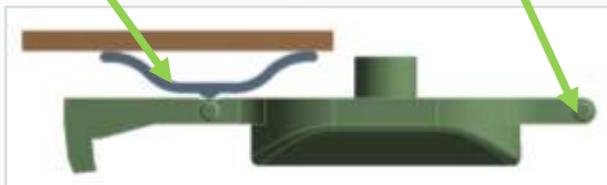


Simulation of mechanical tension in the Snap-in Hook through elasticity

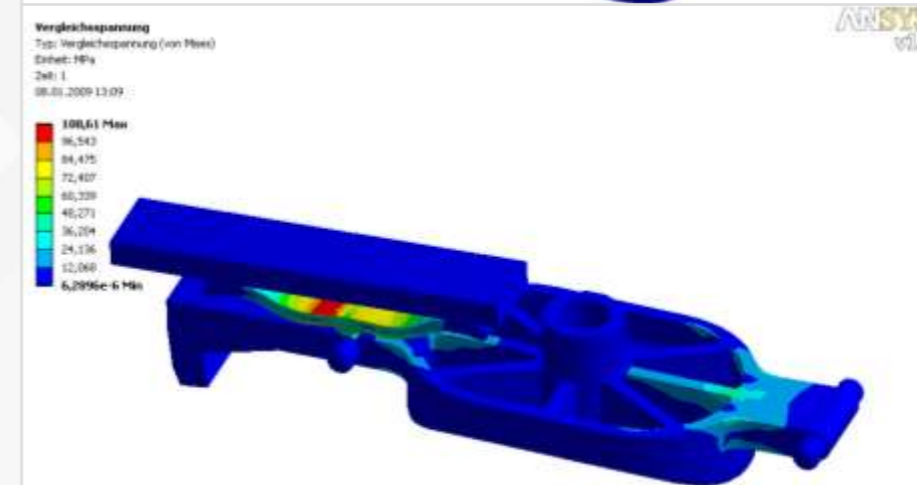
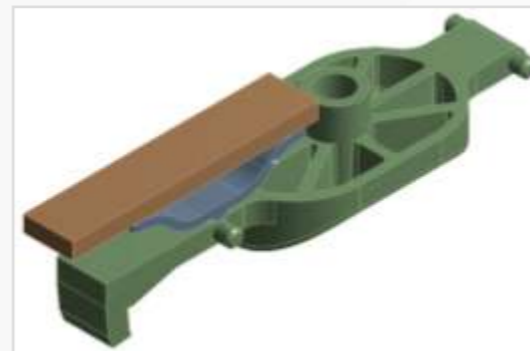


spring shackle

axis



concept 1



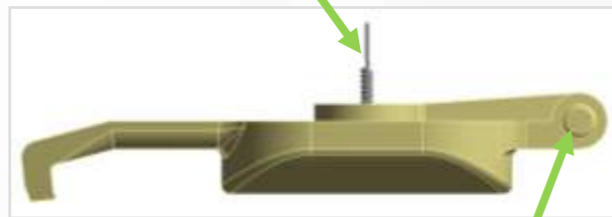
concept 2

Concepts 1 and 2 with plastic-spring shackle:

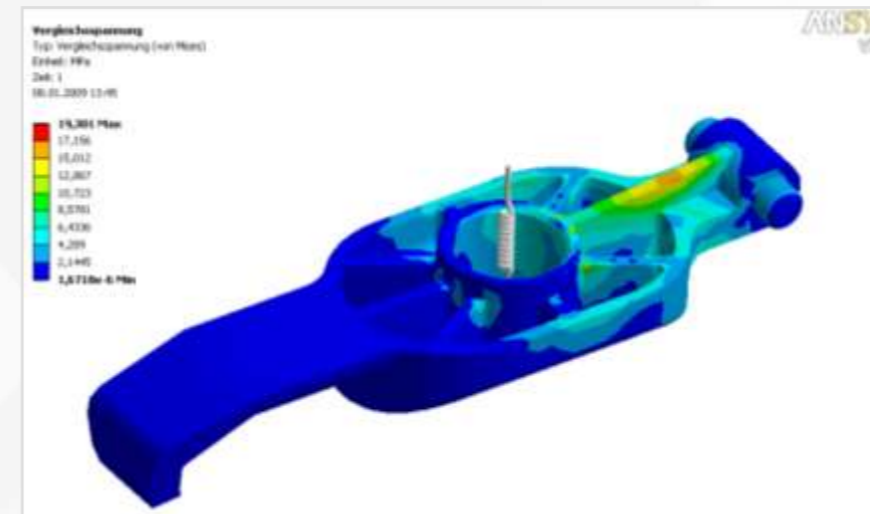
- tension in a critical range
- concept alteration to the flat spring

Final concept with steel spring: → tension in non-critical range

steel spring
(symbolic demonstration)



axis



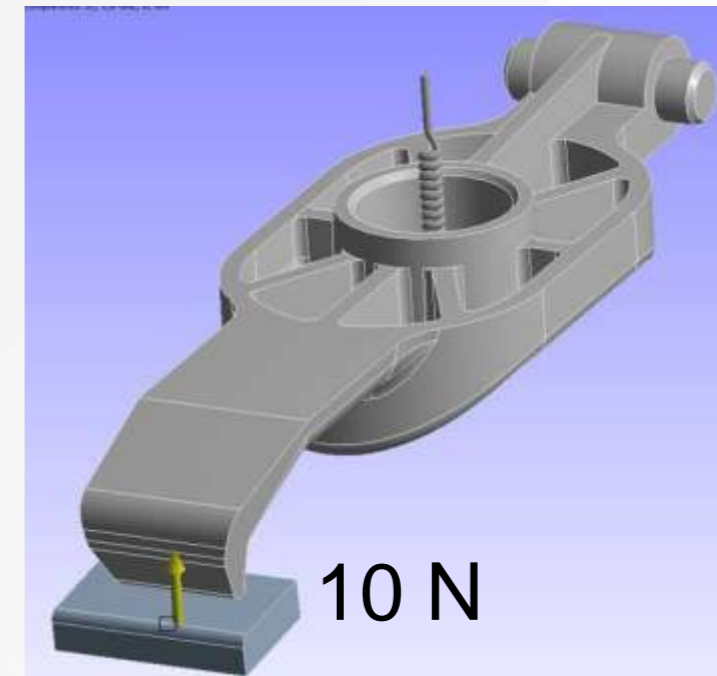
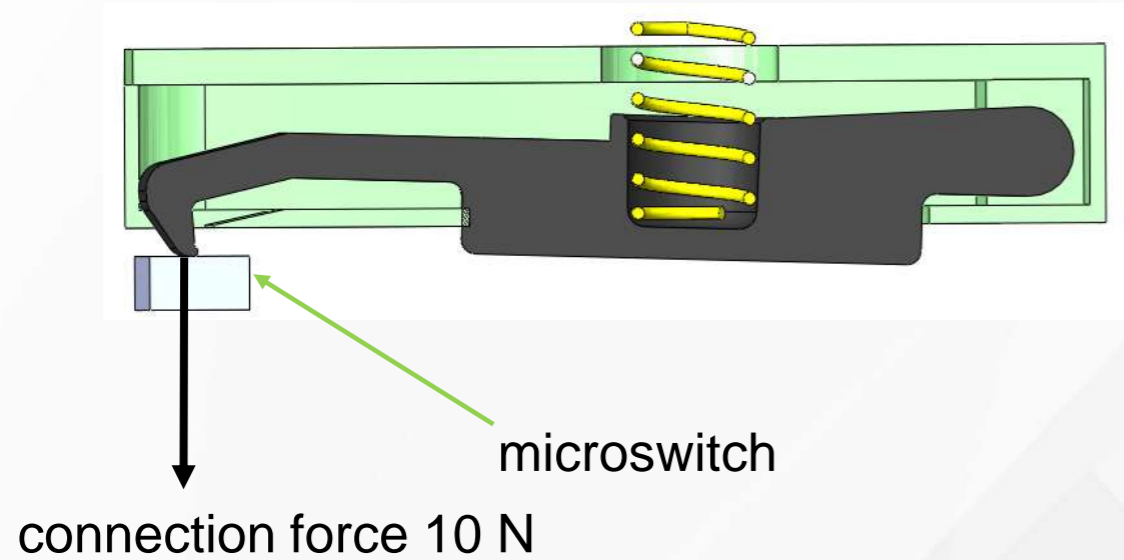
final concept

Conclusion:

from concept 1 → final concept

peak tension reduced by 78 % from about 88 MPa to 19 MPa.

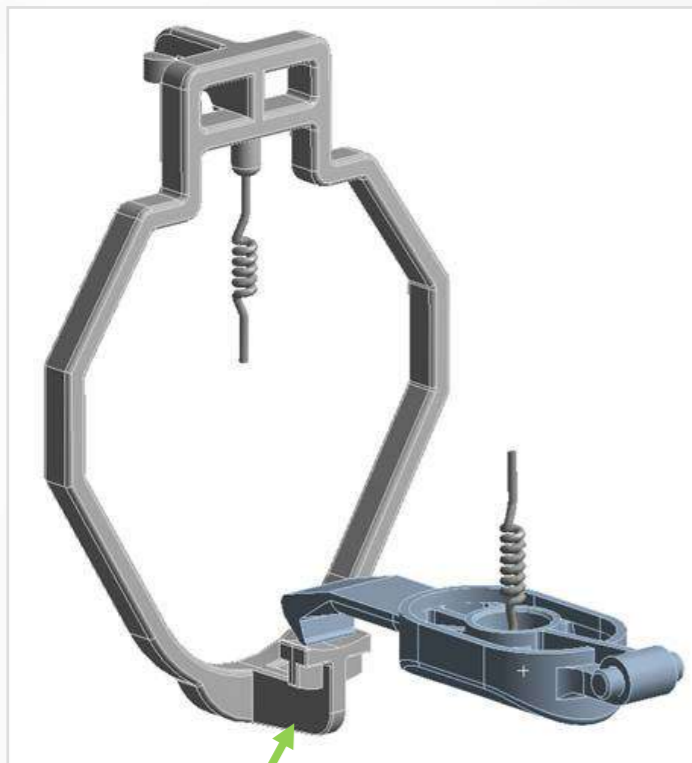
Requirements for the Snap-in Hook:
connection of microswitch after latching .
 $\geq 10\text{N}$ connection force.



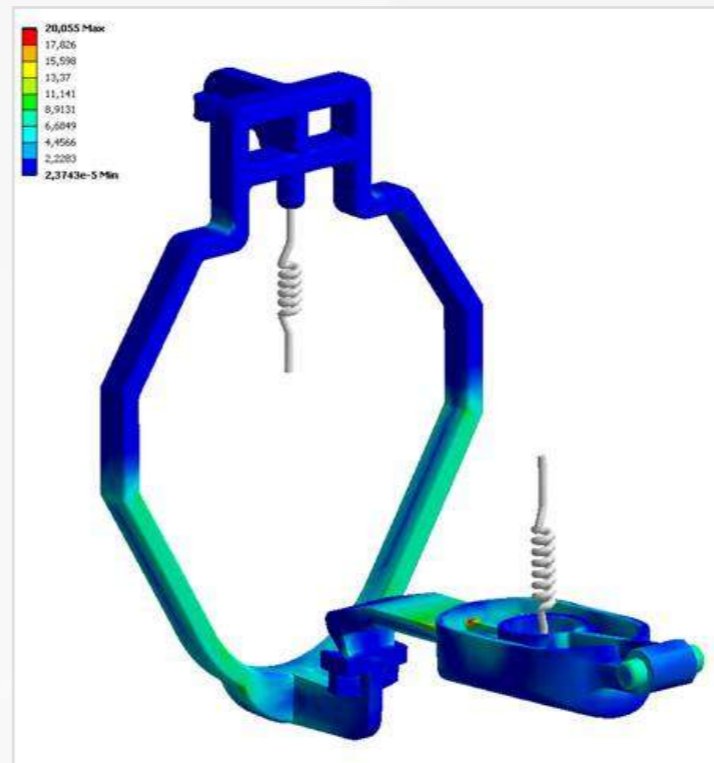
load on the Snap-in Hook

Simulation result:

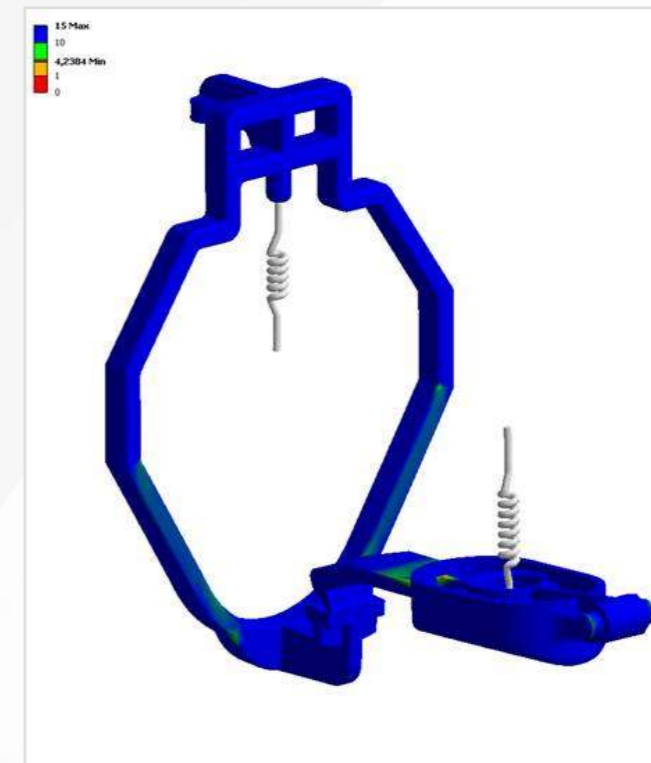
→ behavior when using the microswitch:



microswitch



max. tension 20,1 MPa



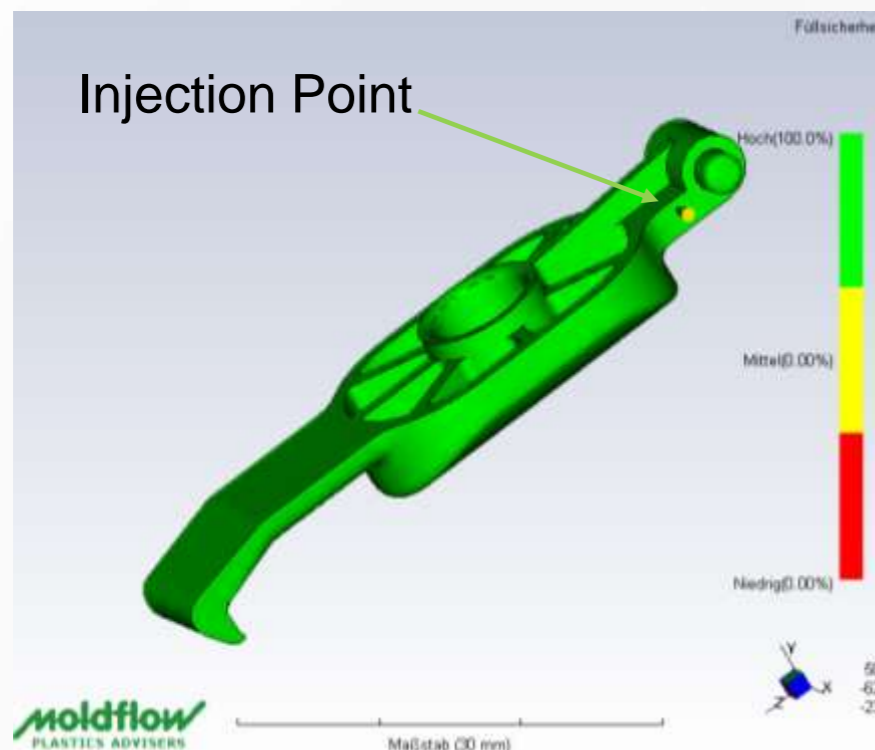
safety factor (SF)
Min. SF = 4,2 (> 1)

Simulation of injection Molding process by means of moldflow

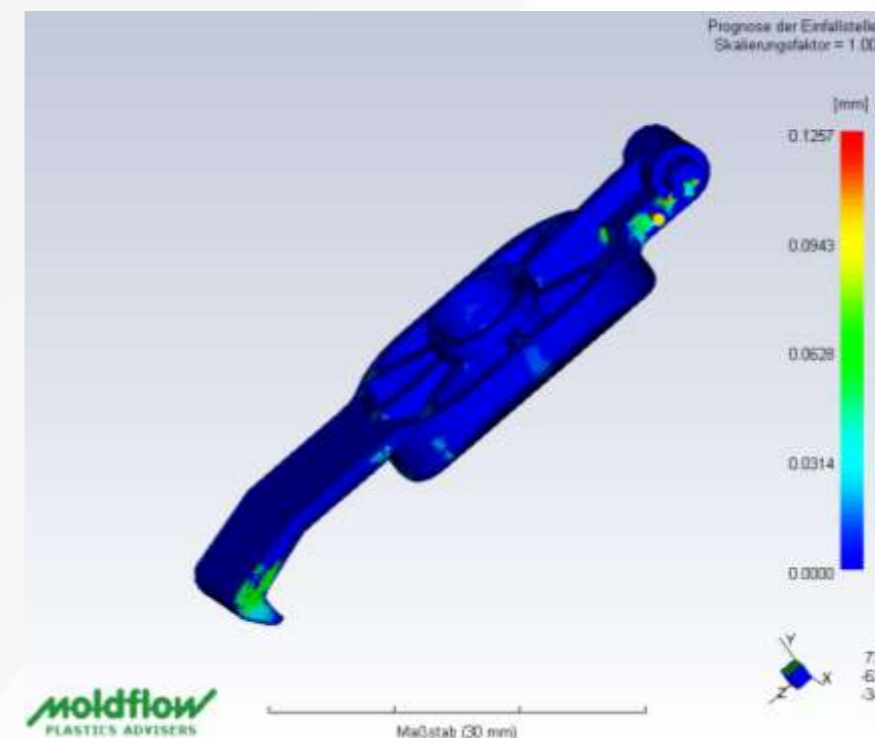
Simulation result

Question: Snap-in Hook – Is the final concept feasible?

- Injection Molding is technically feasible
- Good ductility and priming reliability
- Few pockmarks owing to corrugated design

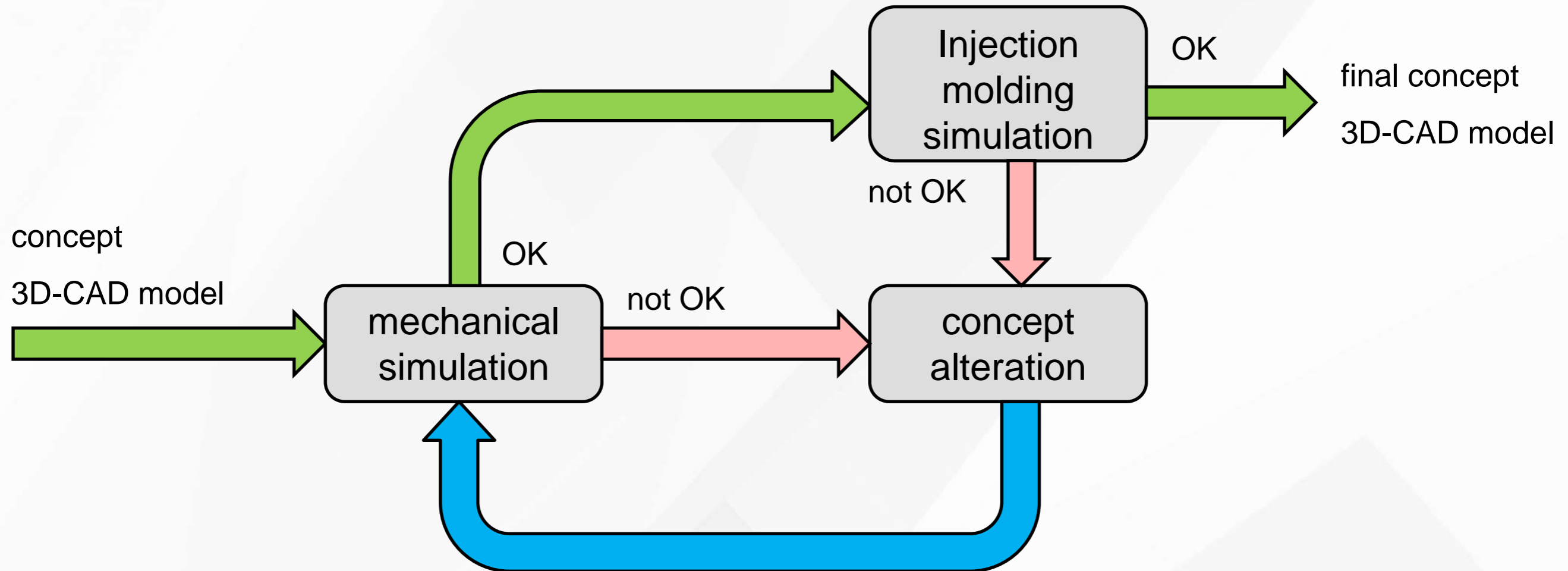


priming reliability



forecast of pockmarks

The simulation process represents an enclosed circuit.



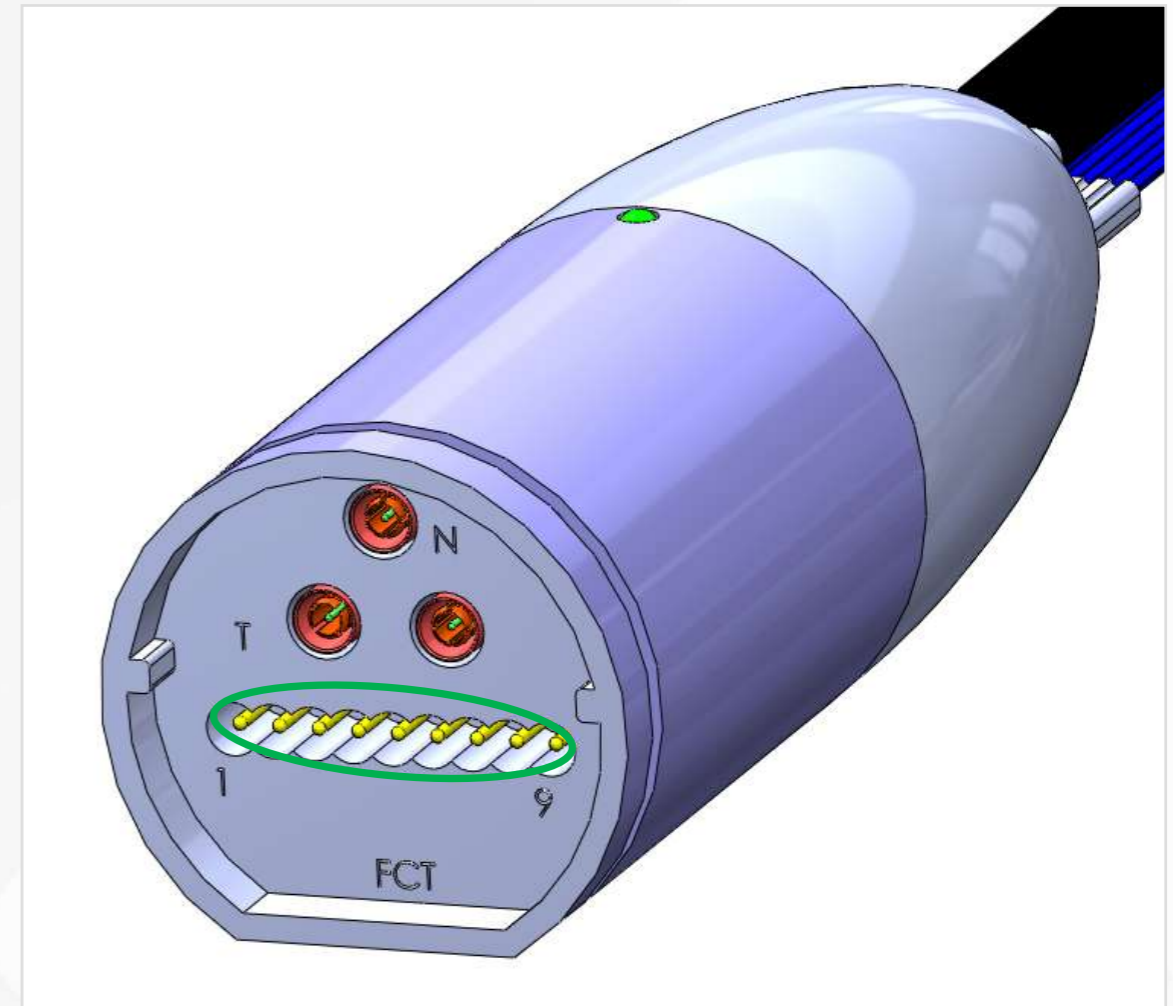
Requirement ergonomical connecting behavior

→ Aim: Low contact mating force

Question: Mating force dependency ?

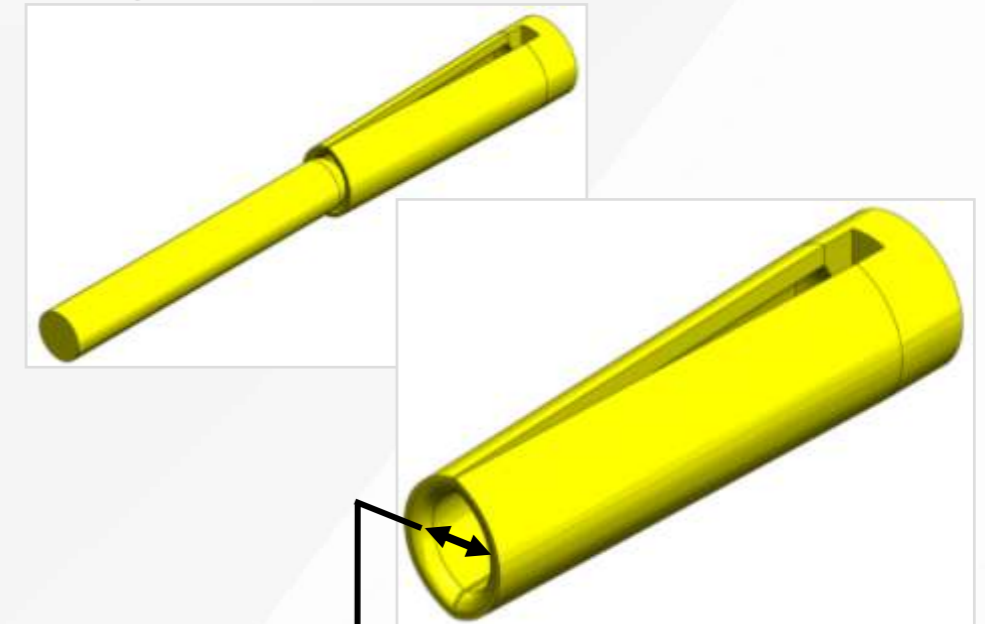
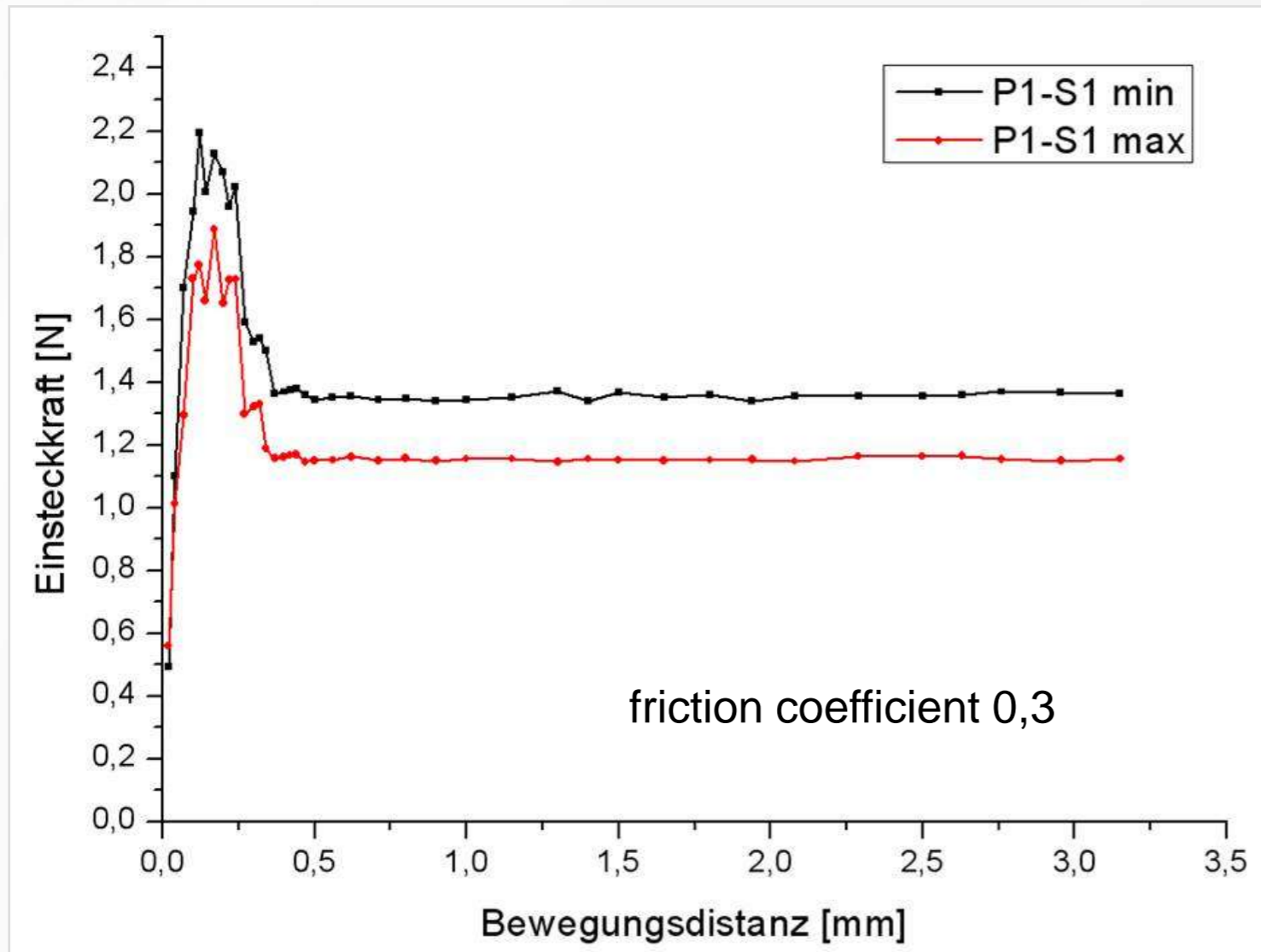
→ of the socket geometry

→ of the friction coefficient



Observation of force gradient with tulip shape-geometry

- during insertion
- with different clearance spacing



Pin/socket-clearance spacing
 P1-S1 min. 0,79 mm
 P1-S1 max. 0,81 mm

Simulation result:

→ Reduction of the mating force by 0,2 N when the clearance space is increased by 20 μm .

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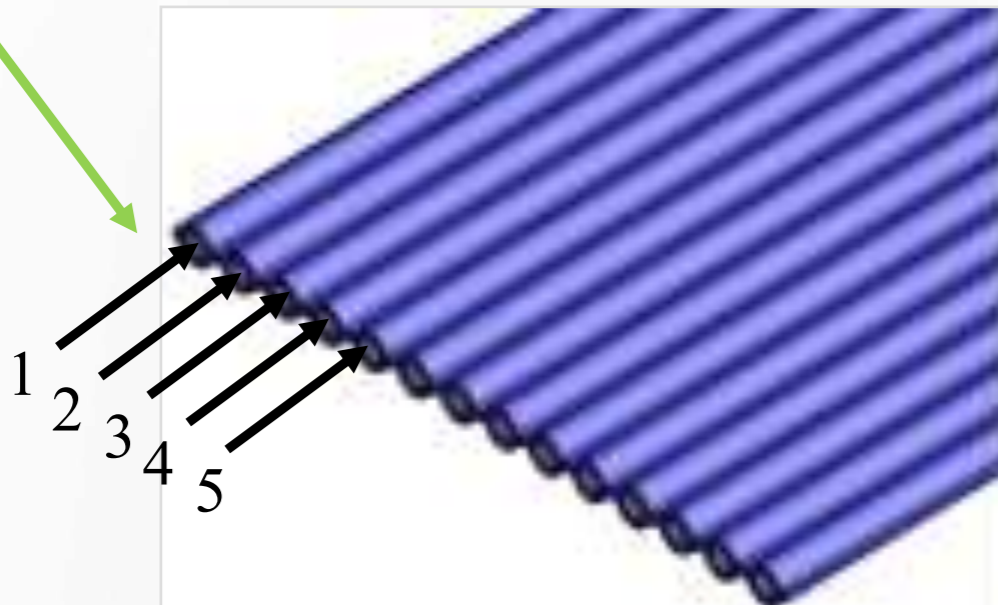
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Crosstalk behavior of the flat ribbon cable with and without shielding:

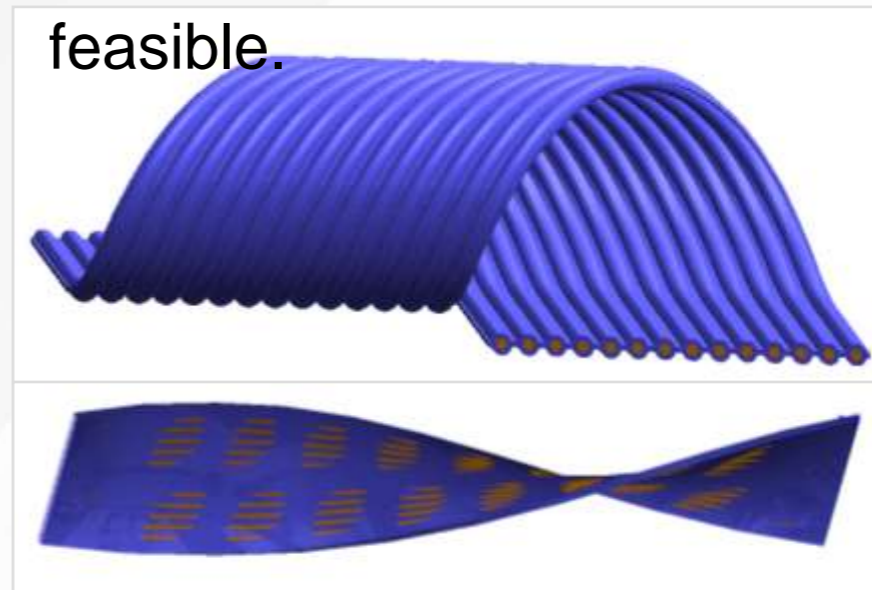


Questions:

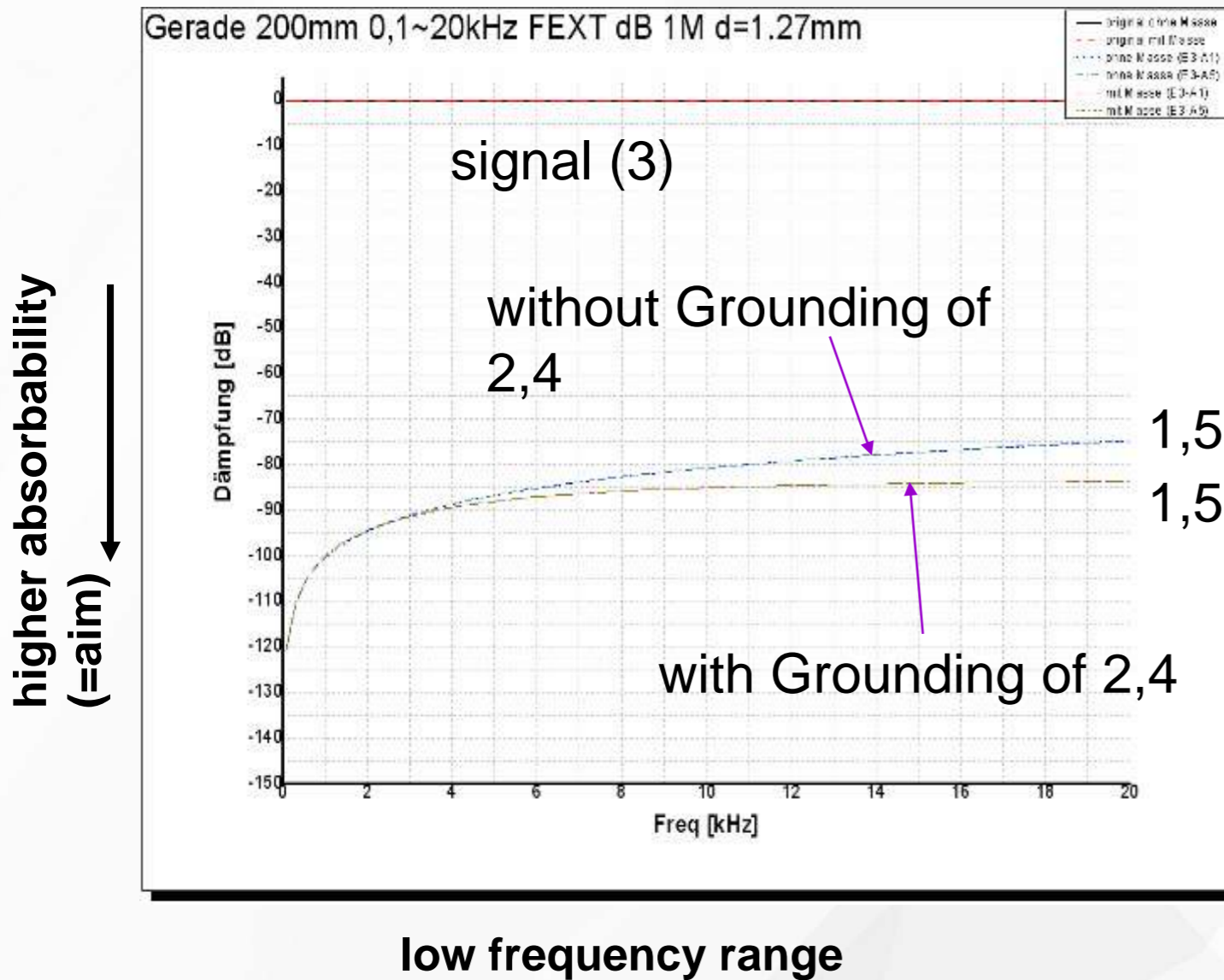
- Crosstalk behavior of cable 3 and cables 1 and 5 ?
- Influence of the cables 2 and 4 without/with Grounding ?
- behavior in low and high frequency range ?



simulation of a twisted flat ribbon cable is also feasible.



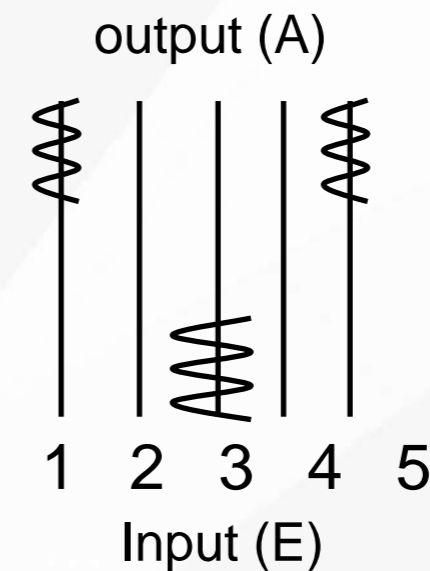
Results for the low frequency range



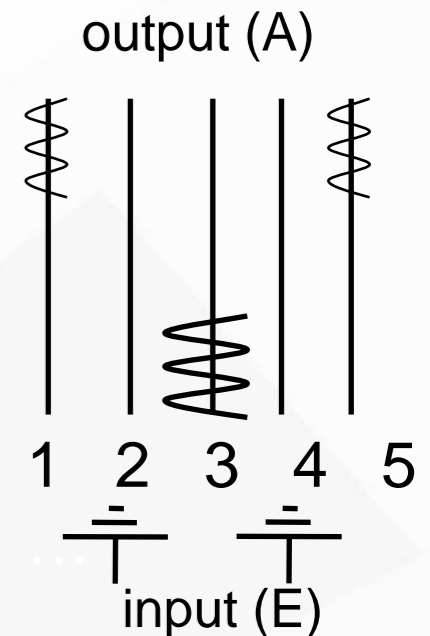
Conclusion:

In the low frequency range up to 4 kHz Grounding is not required.

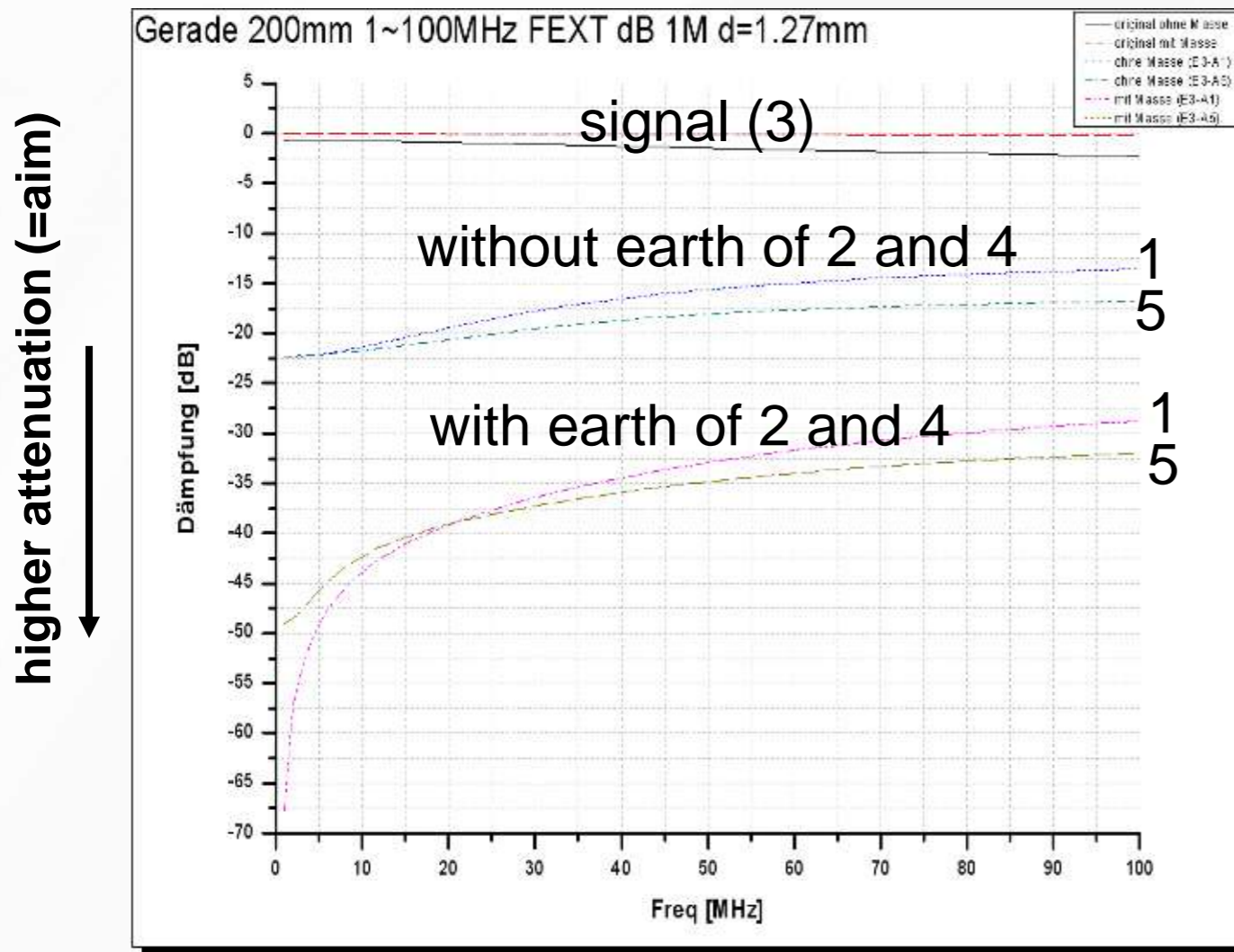
2 and 4
without Grd/grd



2 and 4
with Grd/grd



Results for the high frequency range



higher attenuation (=aim)

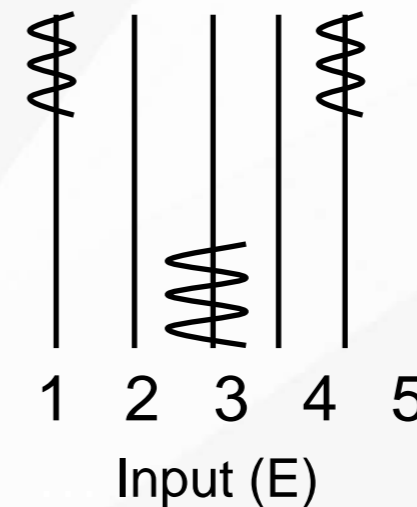
Higher frequency range

Conclusion:

In the higher frequency range the earth accounts for an increase in attenuation of ca. 15-20 dB.

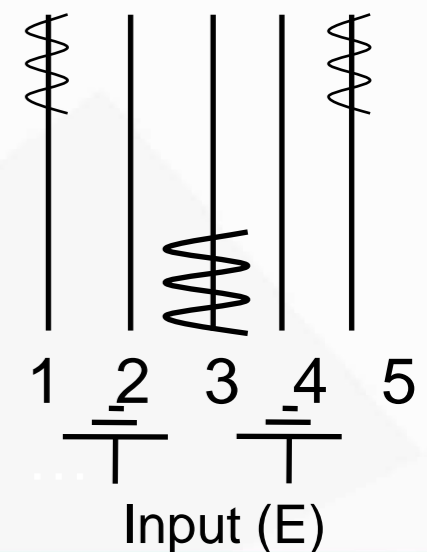
2 and 4
without
grounding/mass

output (A)

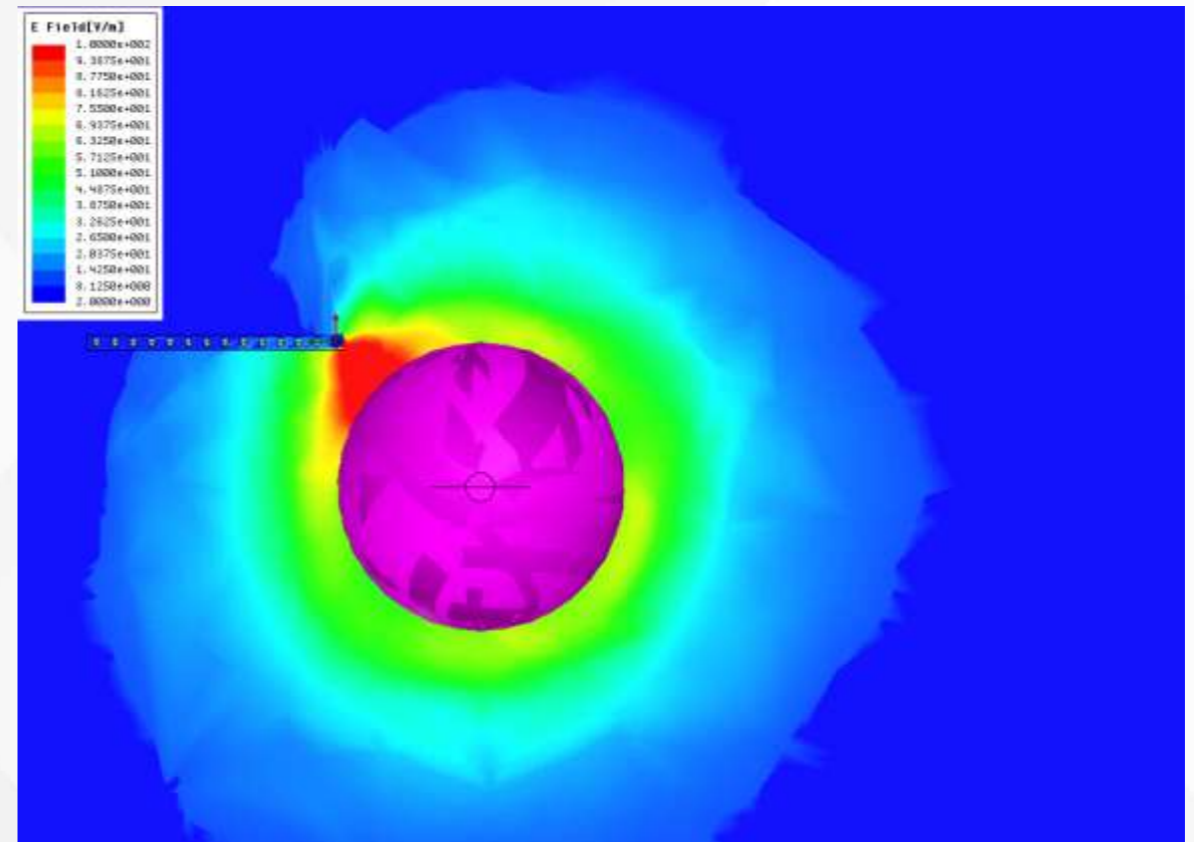
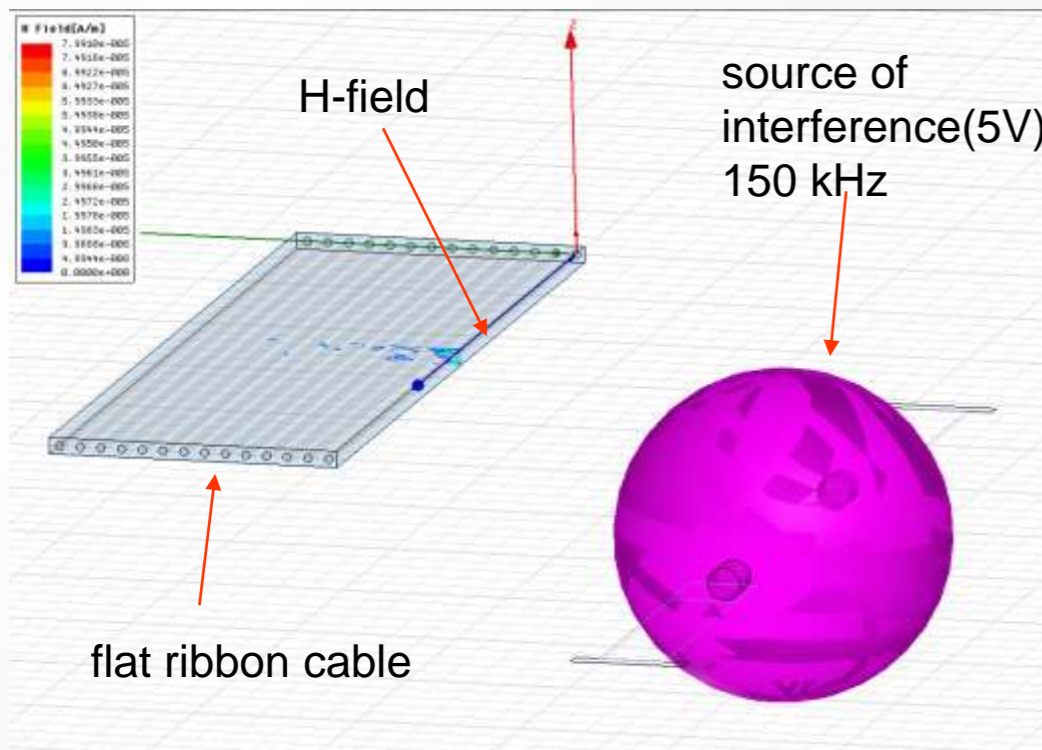


2 and 4
with
grounding/mass

output (A)

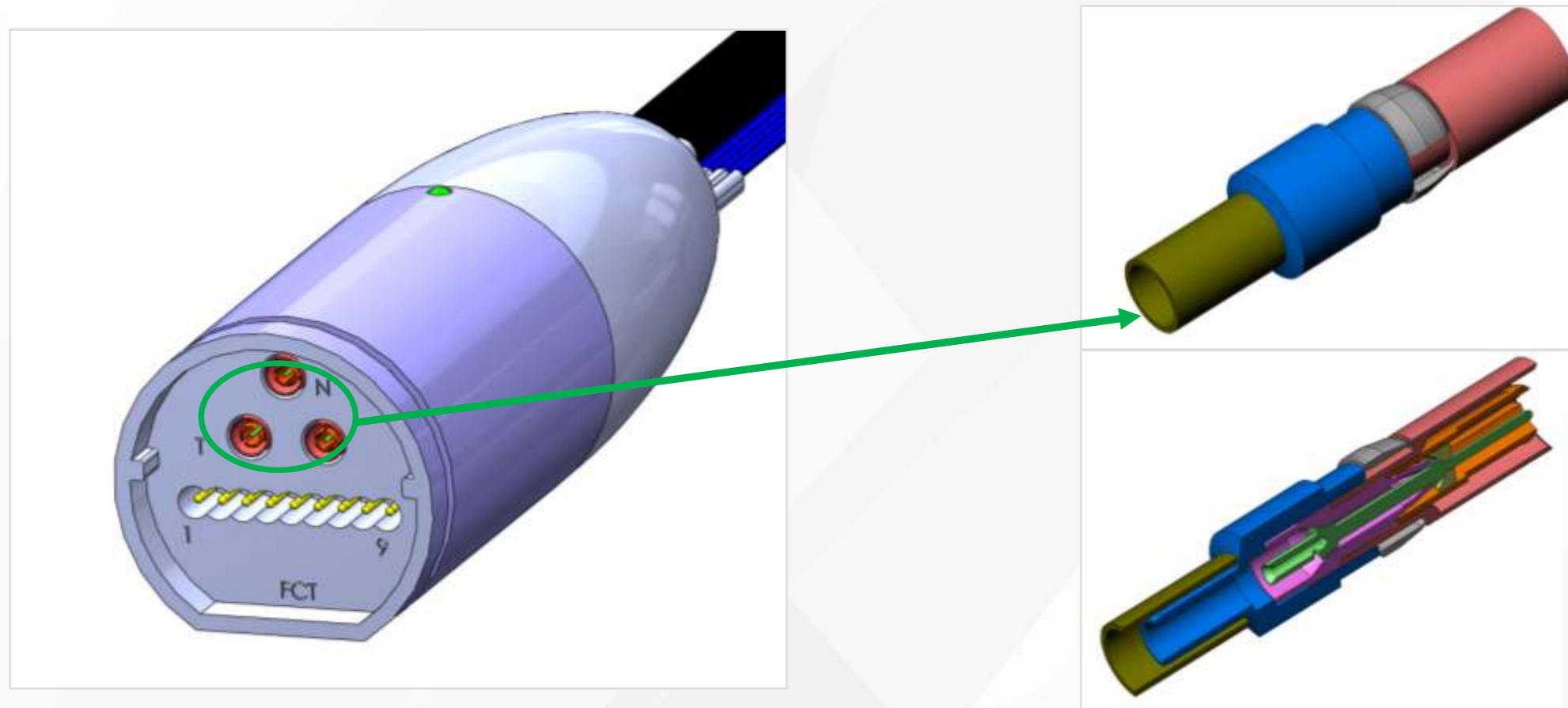


Effects of a 5V source of interference, with a frequency of 150 kHz, on the flat ribbon cable.

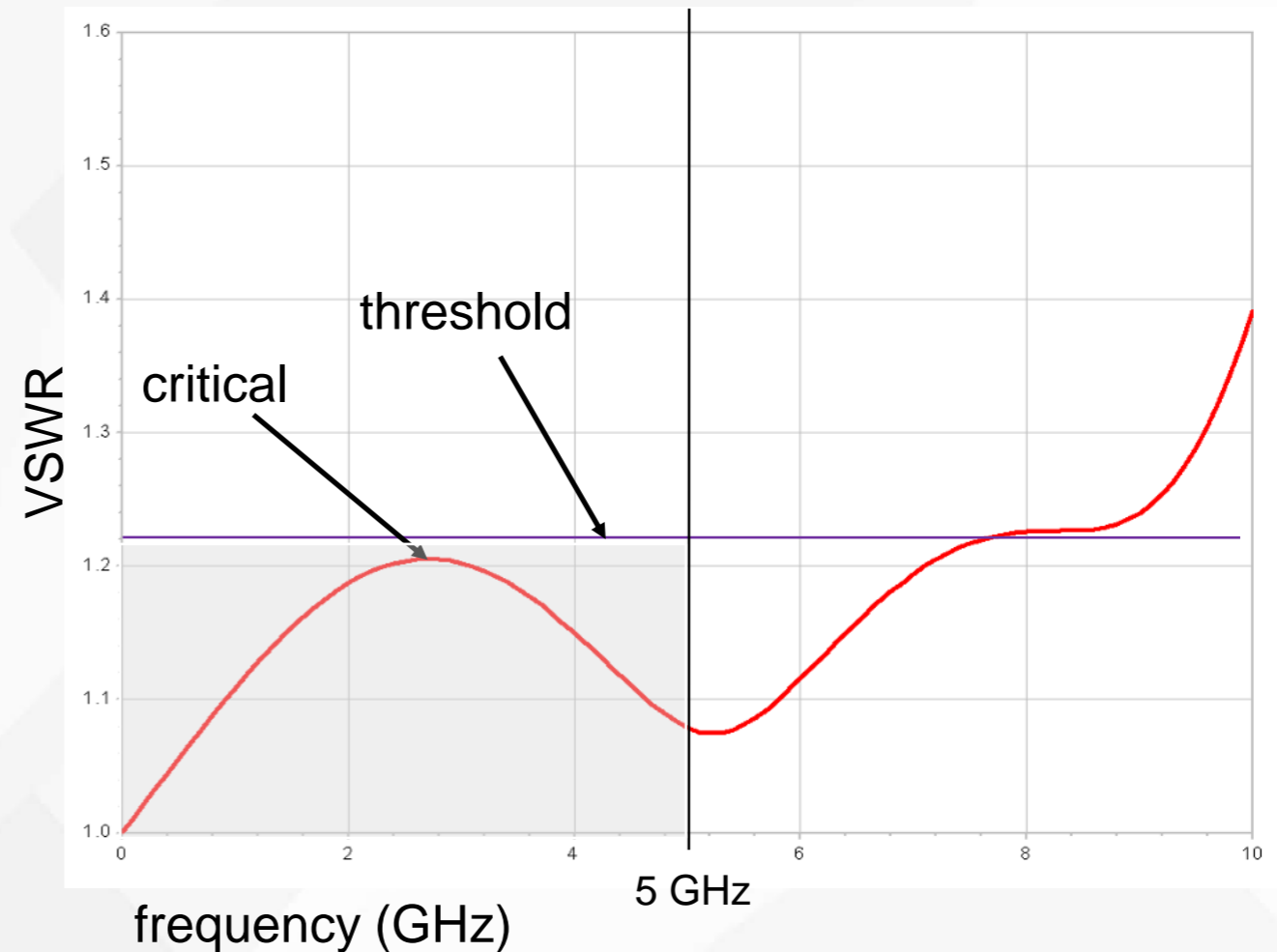
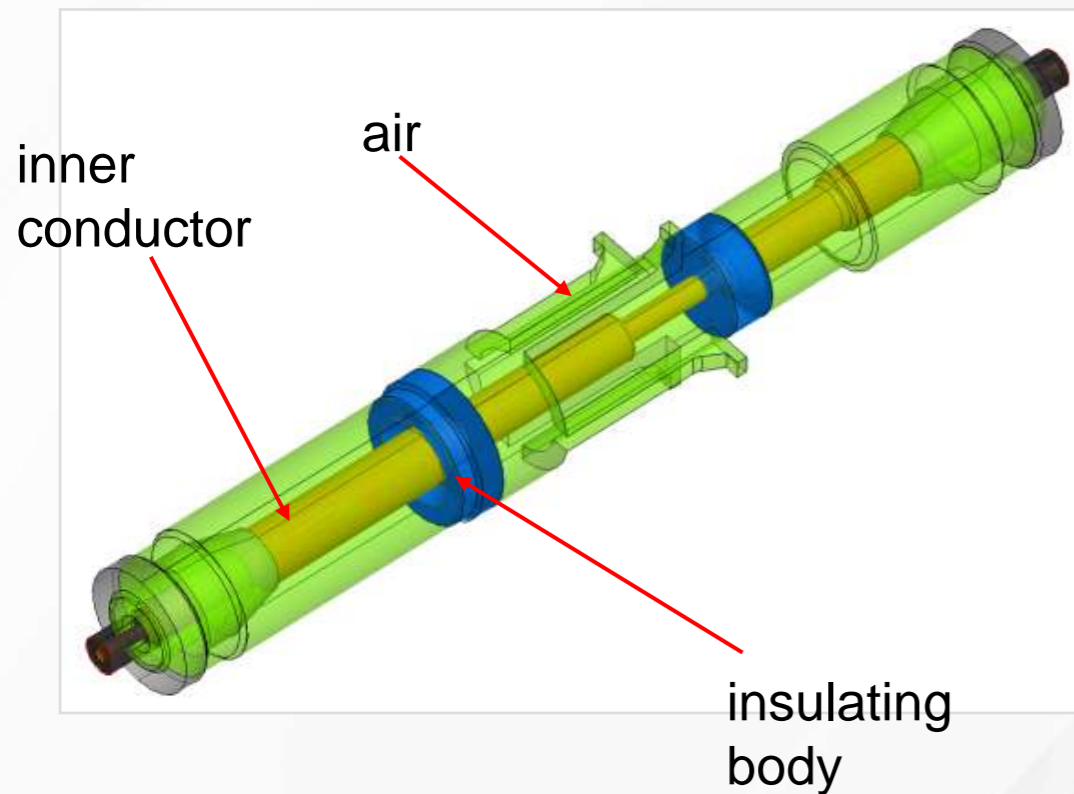


Simulation of VSWR-value for the coaxial contact.

Aim → improvement of the signal transmission quality



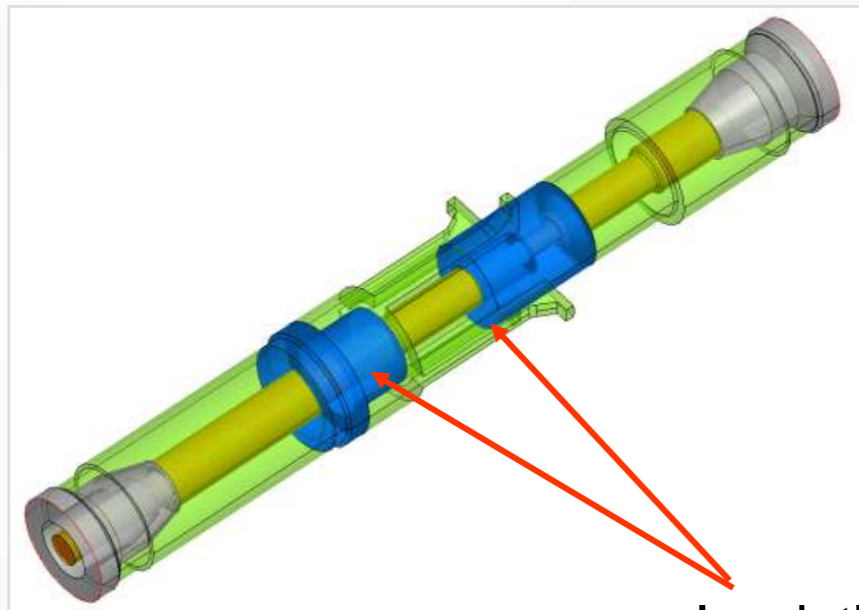
Problem: At 2,8 GHz the VSWR-threshold is almost broken.
Aim: In the range 0-5 GHz → Improvement of the VSWR-values.



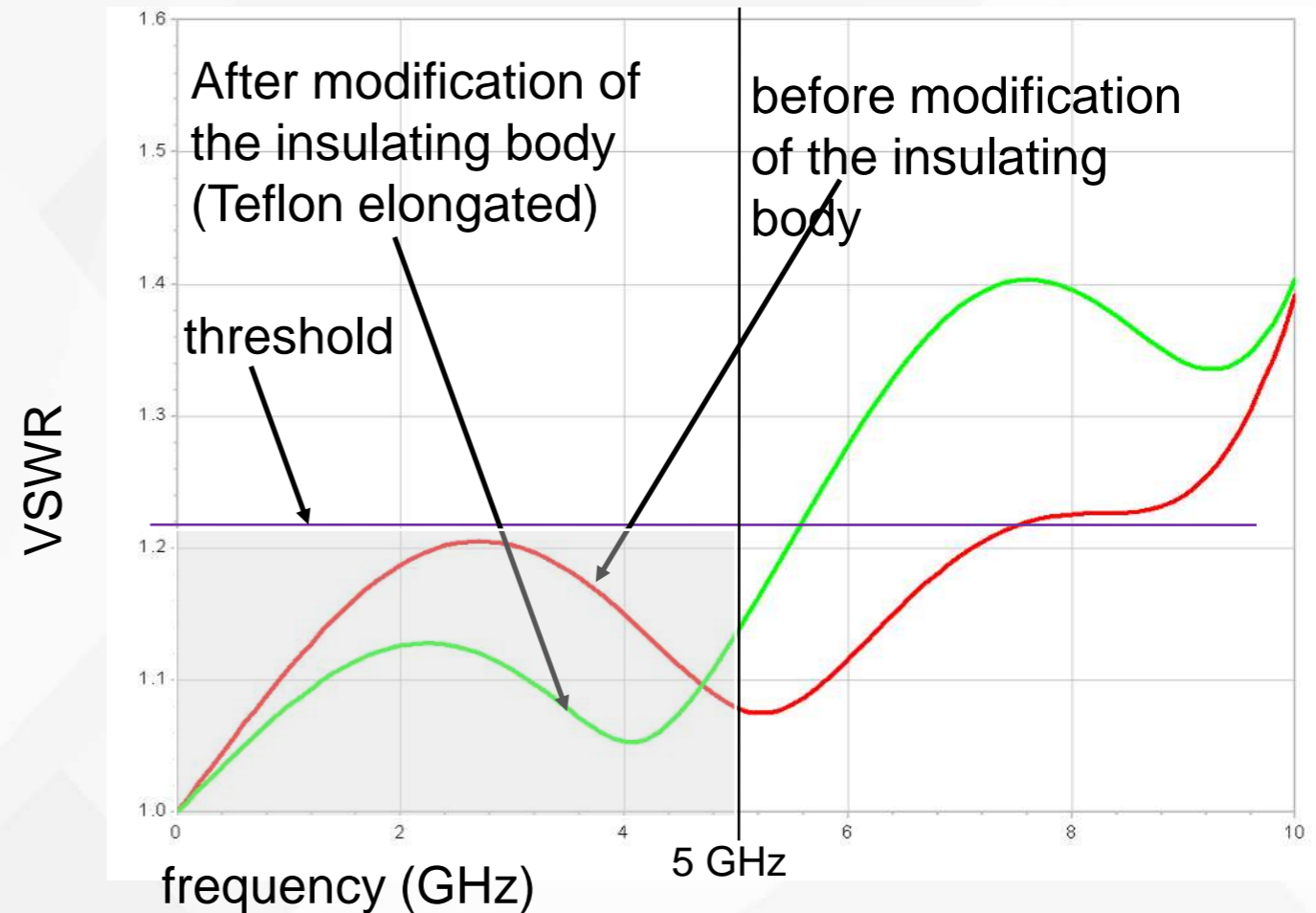
VSWR-curve before the geometry-improvement

Modified Insulating body

→ VSWR-value improves in the range 0-5 GHz



Insulating body elongated



VSWR-curve comparison before and after the geometry-improvement

Summary of the medical connector simulation results:

- **Snap-in Hook design**
 - mechanically stable and injection molding technically feasible
 - load transmission of 10N on the microswitch guaranteed.
- **Flat ribbon cable crosstalk behavior**
 - Grounding improves attenuation by 15-20dB in the higher frequency range.
 - no fundamental influence by Grounding in the low frequency range.
- **Coaxial contact signal quality**
 - VSWR-optimisation by reconfiguration of the insulating body geometry.
- **Insertion force-behavior**
 - Through specific optimisation of the socket geometry the insertion force can be reduced.

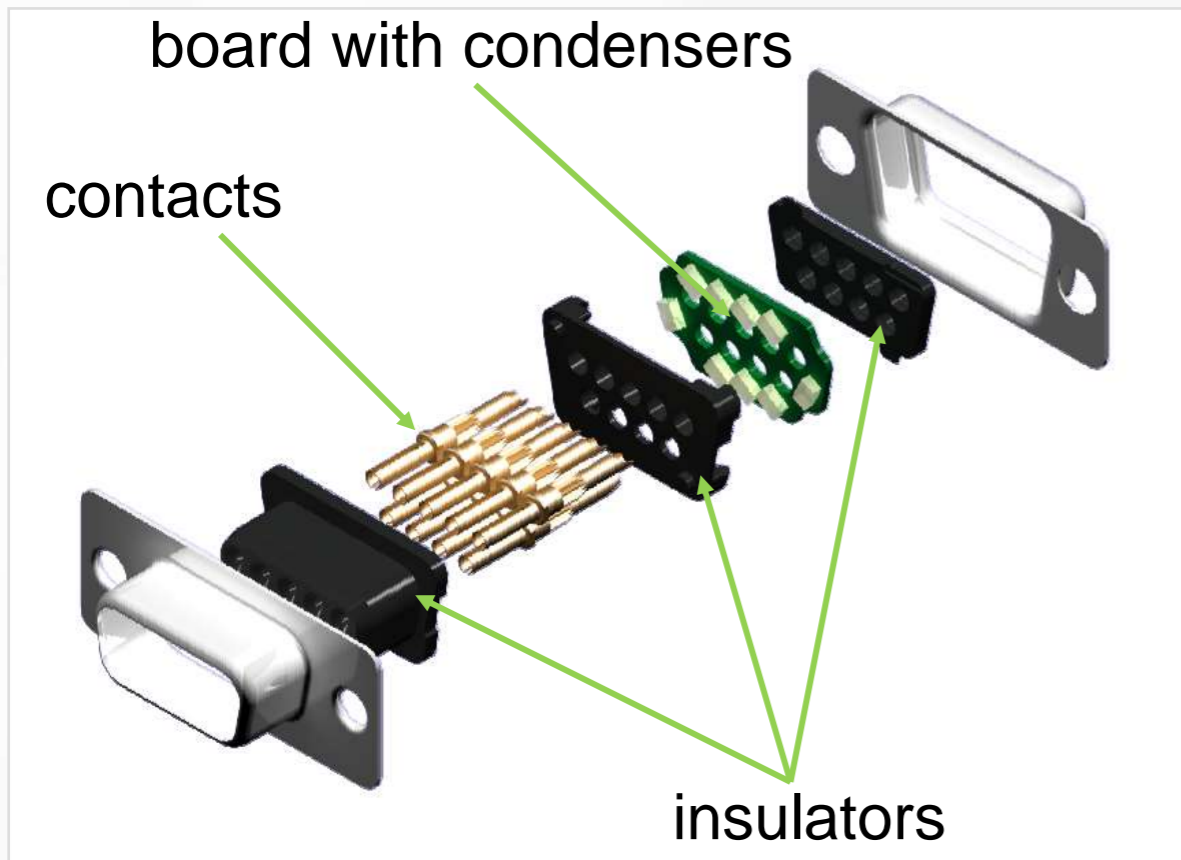
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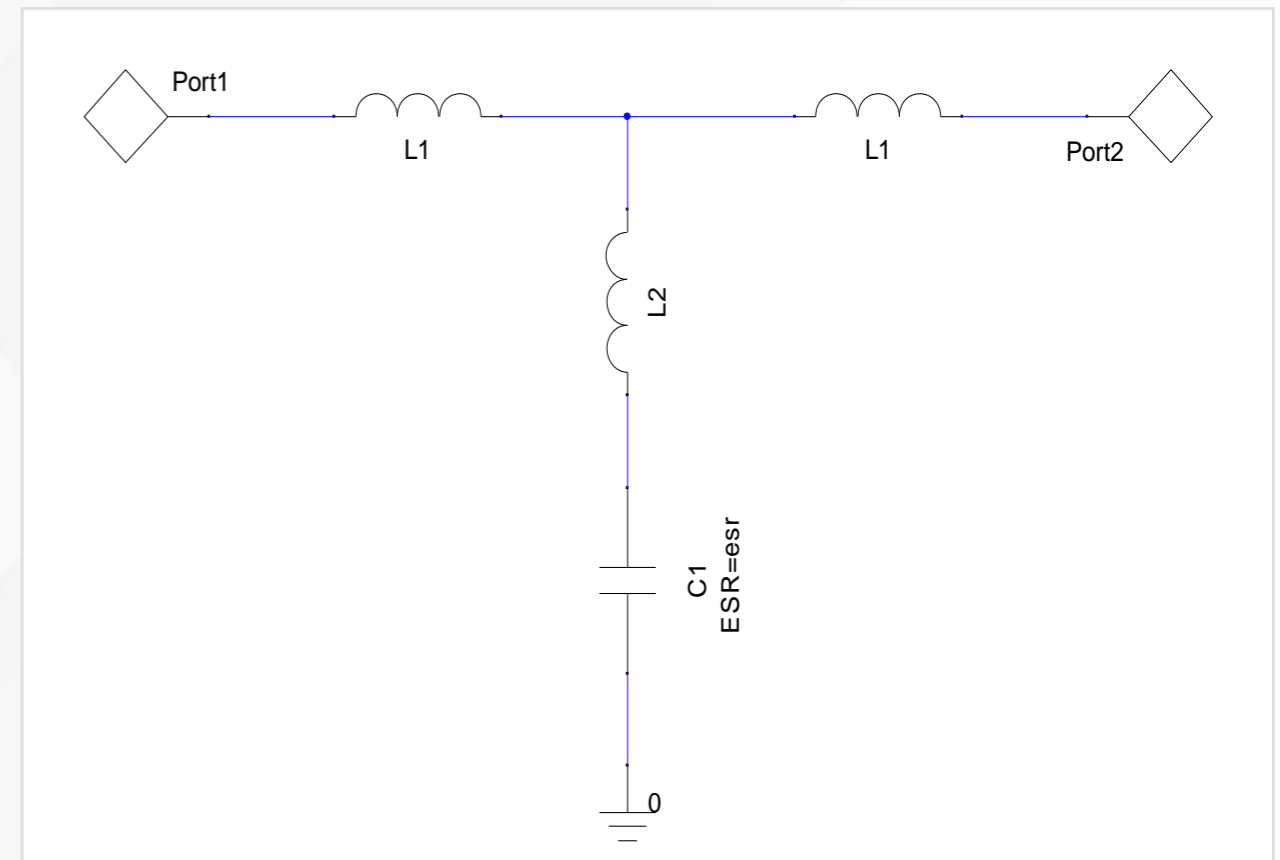
Further examples of other simulation capabilities

- filter characteristics
- shield attenuations

Detection of the filter characteristics



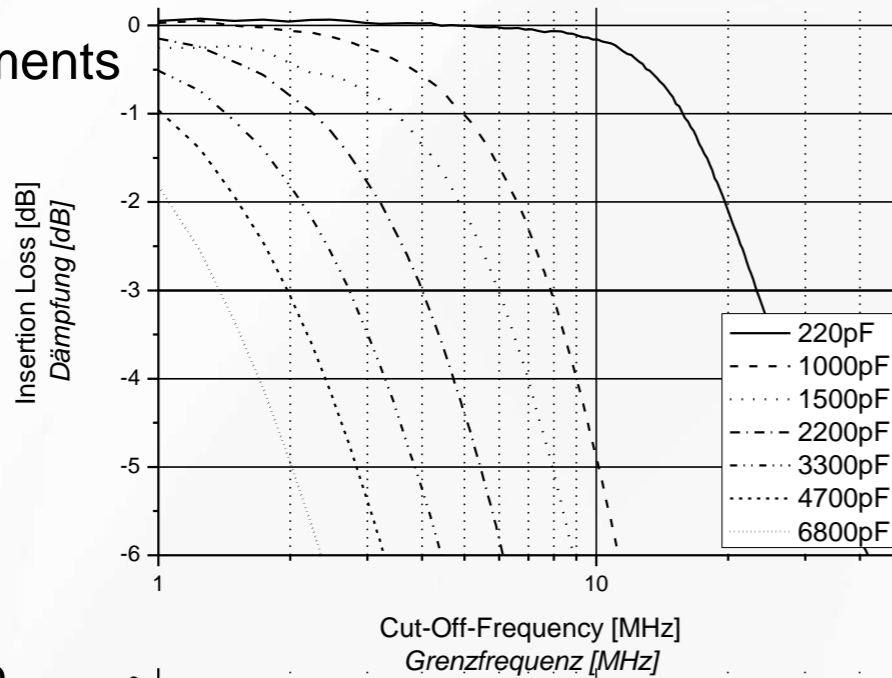
Assembly of a filter connector



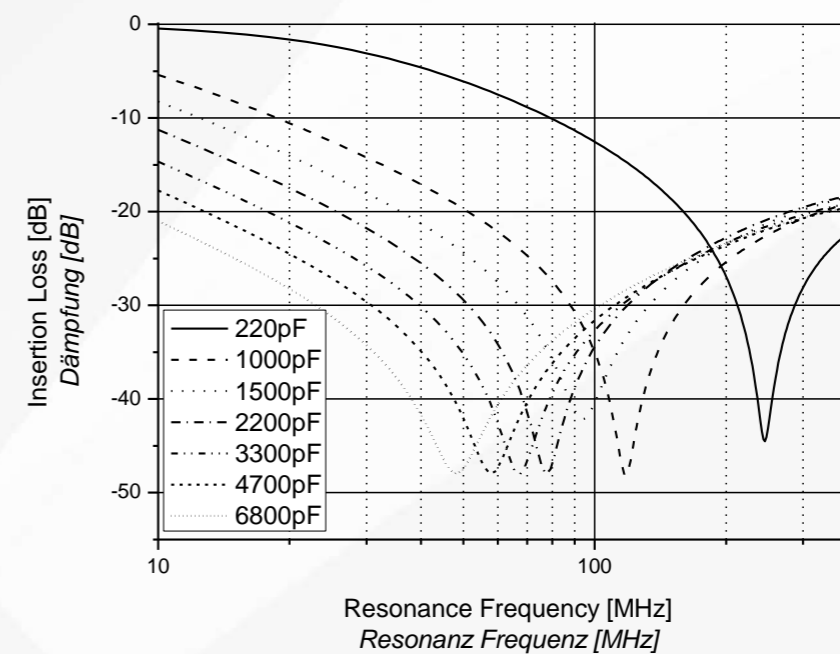
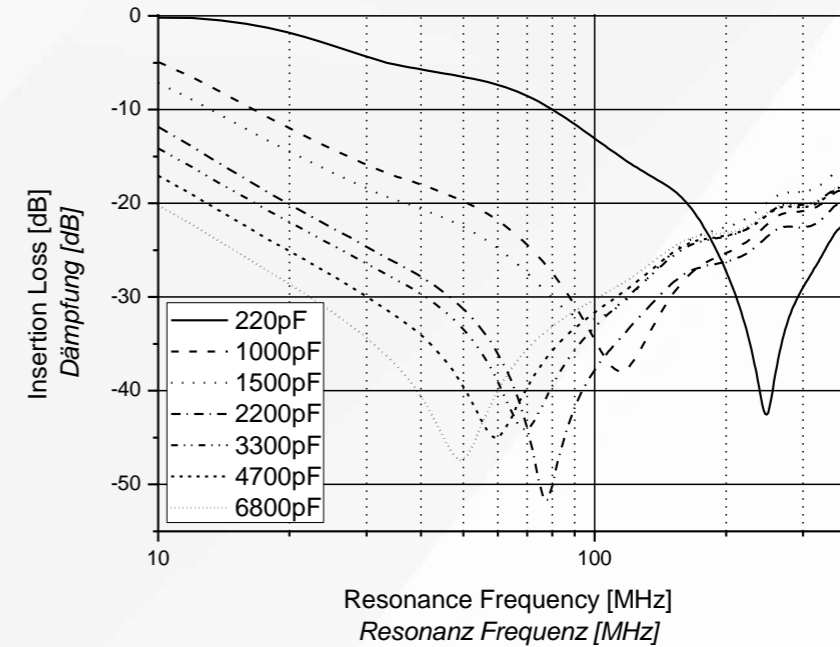
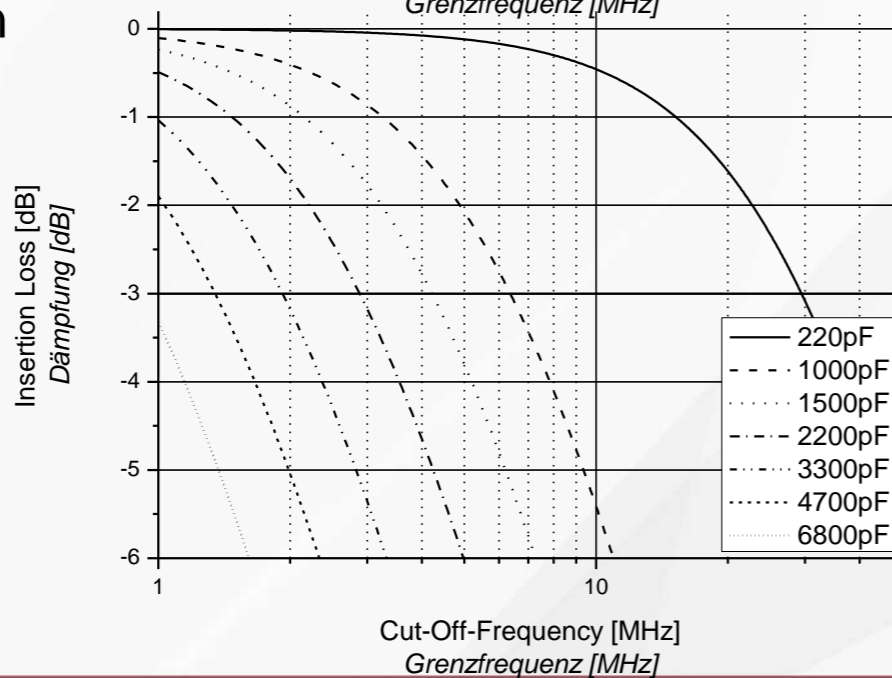
Circuitry plan

Results in the high frequency range

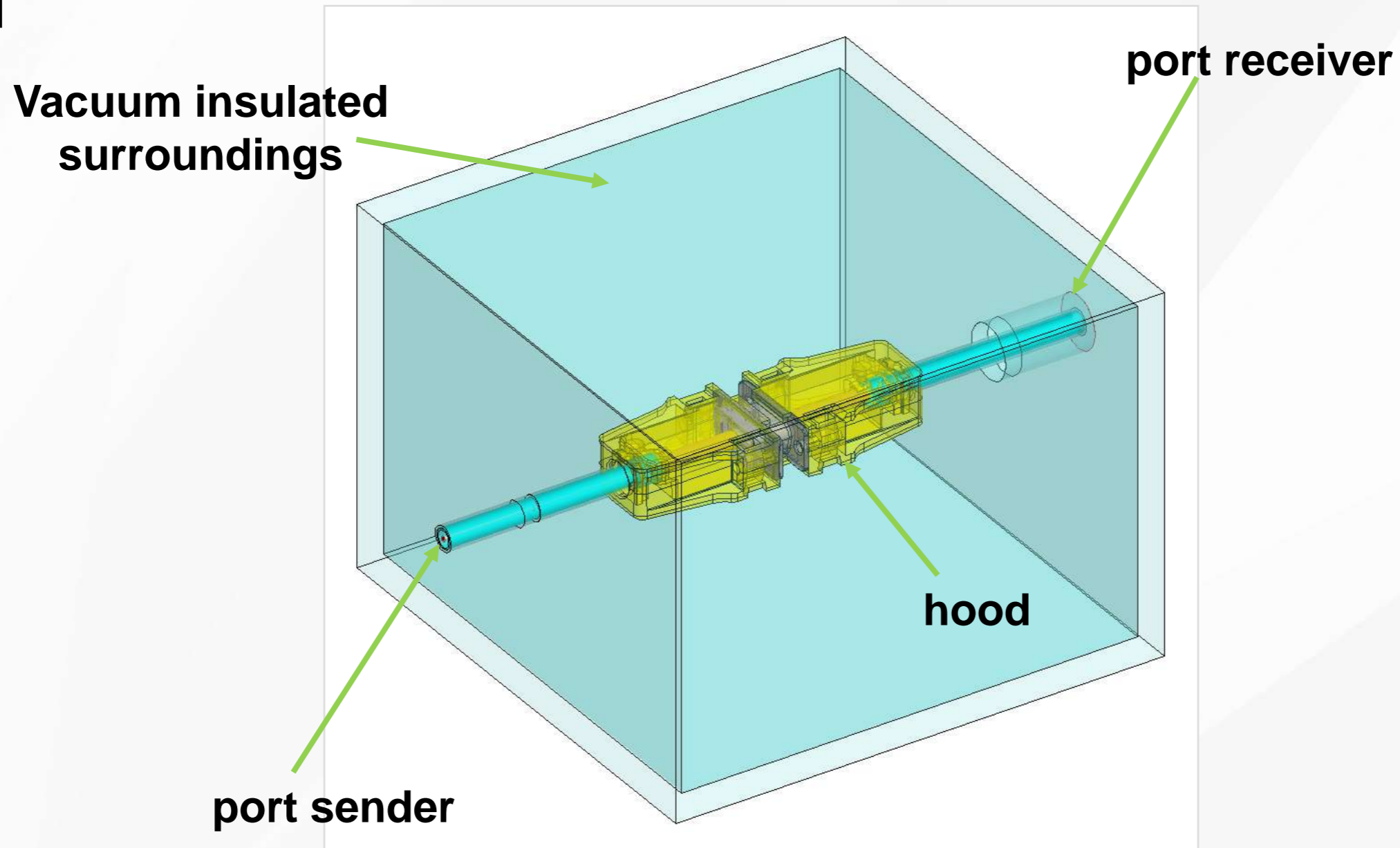
measurements



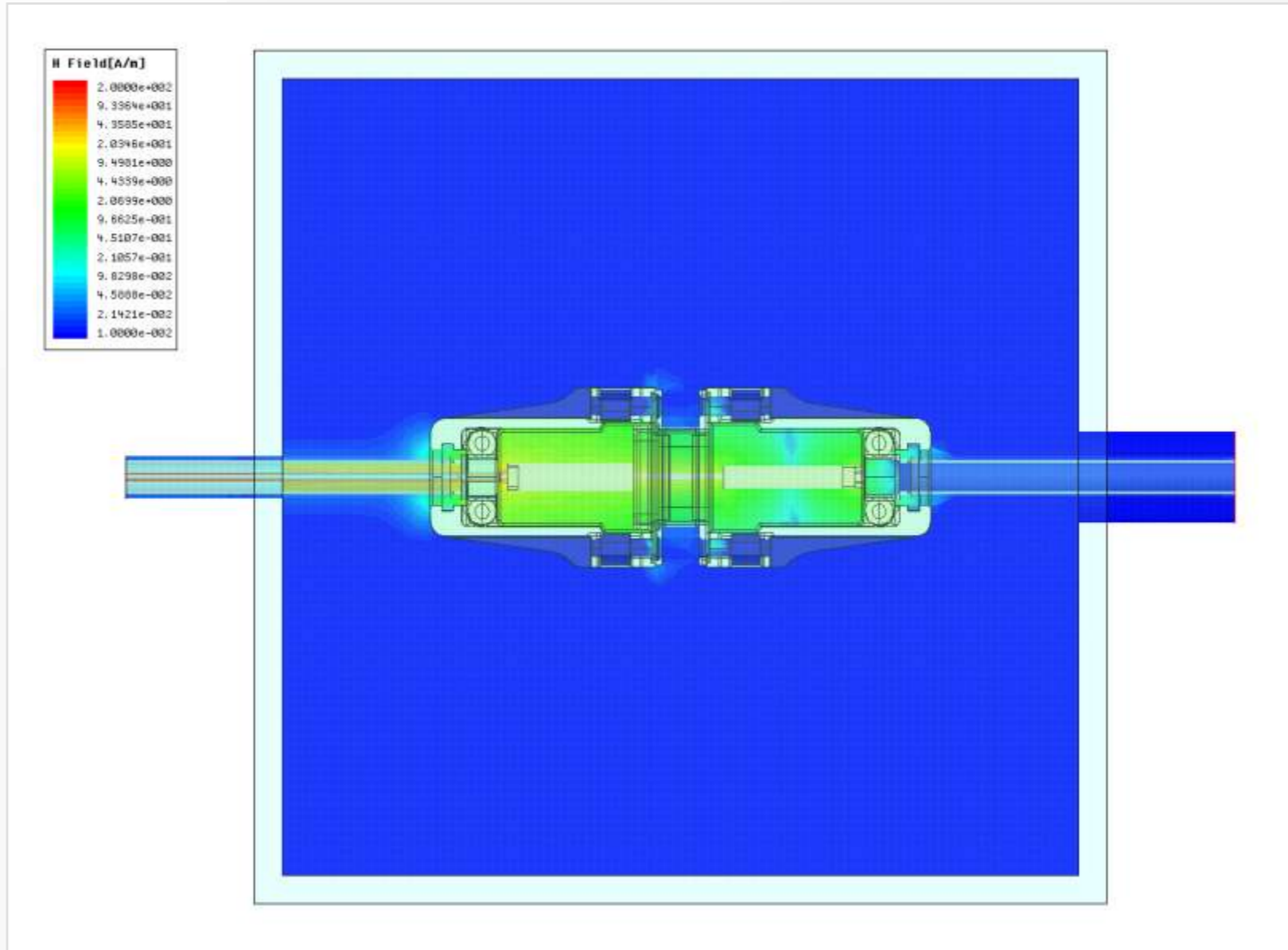
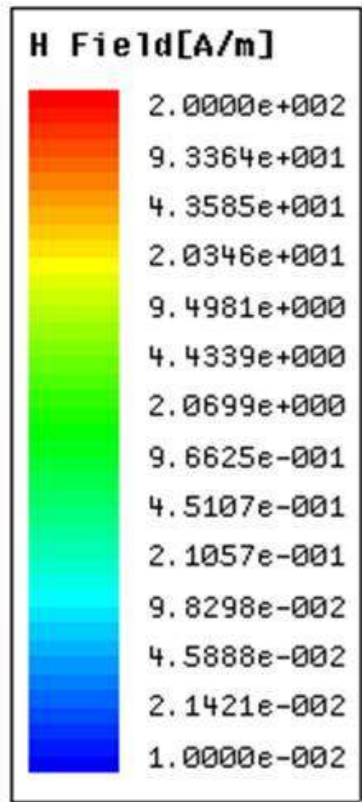
simulation



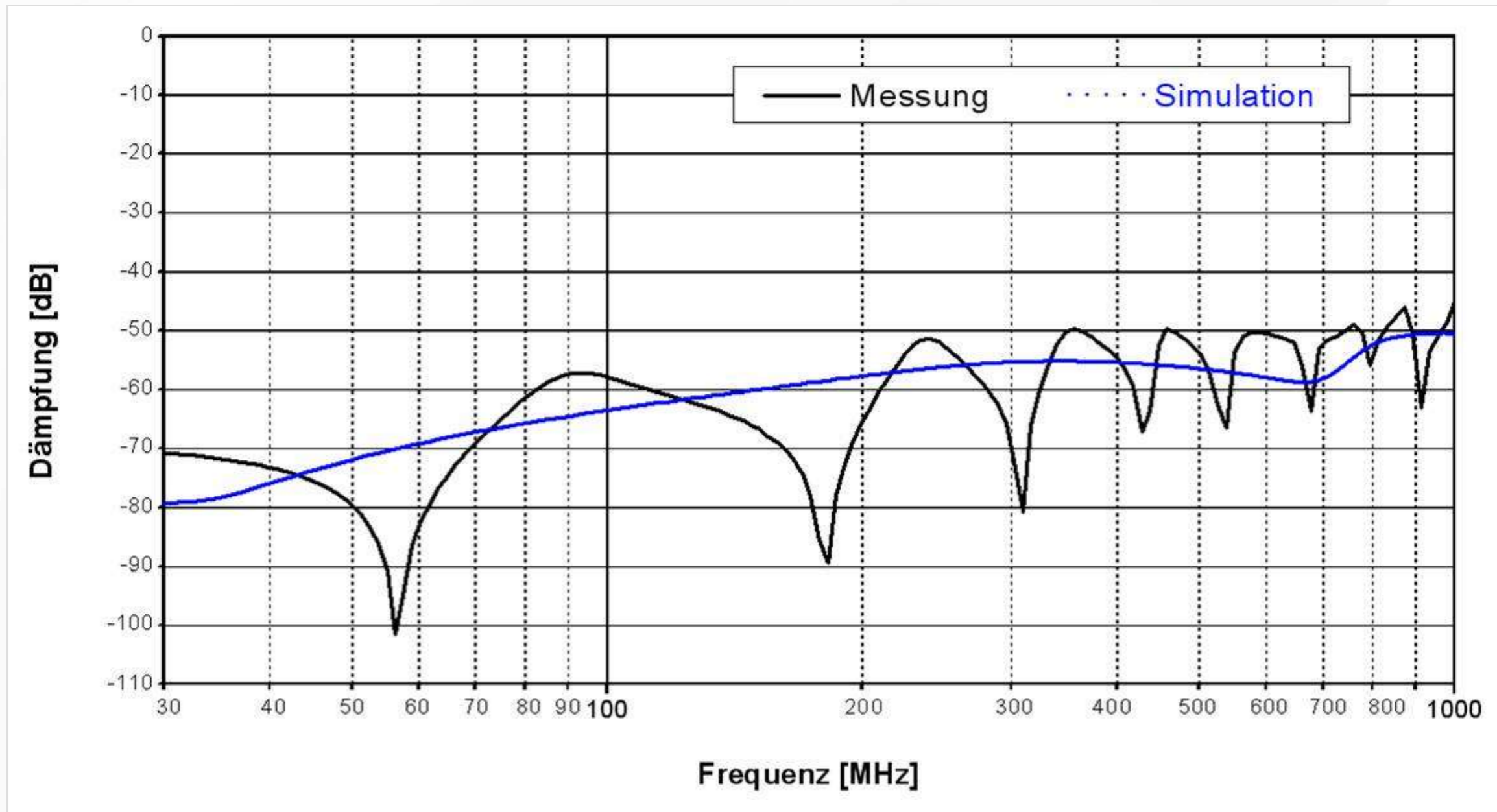
Shielding attenuation of a metal hood



Result: H-field



Result: Shielding attenuation



Simulation before mass production and the manufacture of samples has the following advantages:

- ✓ Cost effective due to the reduced manufacture and testing of samples
- ✓ Time saving due to the fast recognition of mechanical and electrical behavior
- ✓ Improved quality due to the early detection of potential errors and design optimisation
- ✓ Improved risk assessment and fast evaluation of feasibility
- ✓ Increased know-how due to an accumulation of knowledge regarding the effects on and characteristics of component parts.

**Thank you for your
attention!**

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