



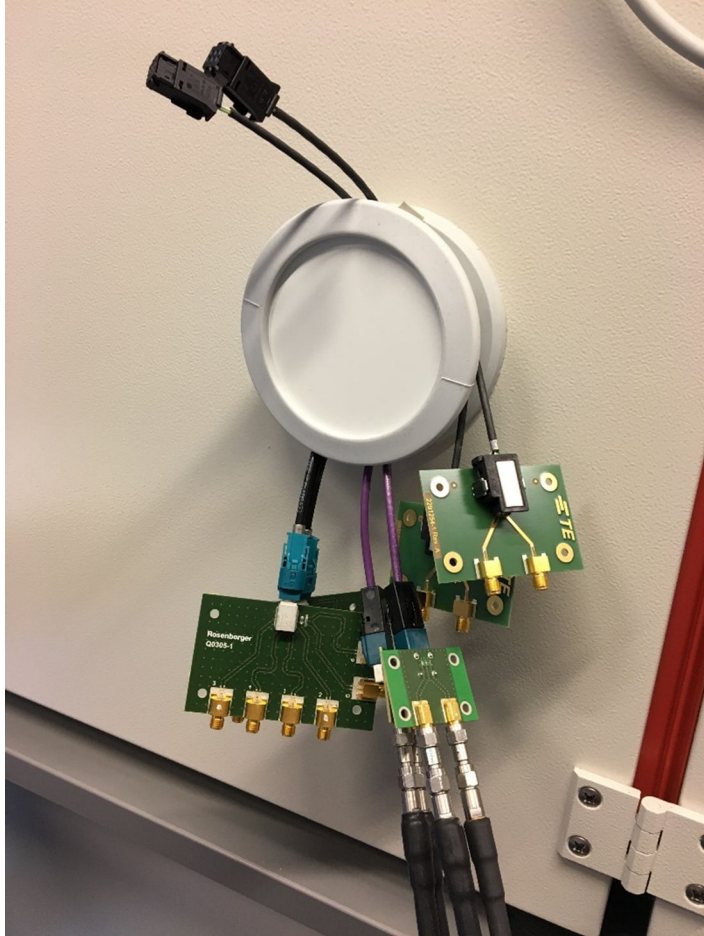
# **Temperature dependent cable characteristics and signaling implications**

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# Overview

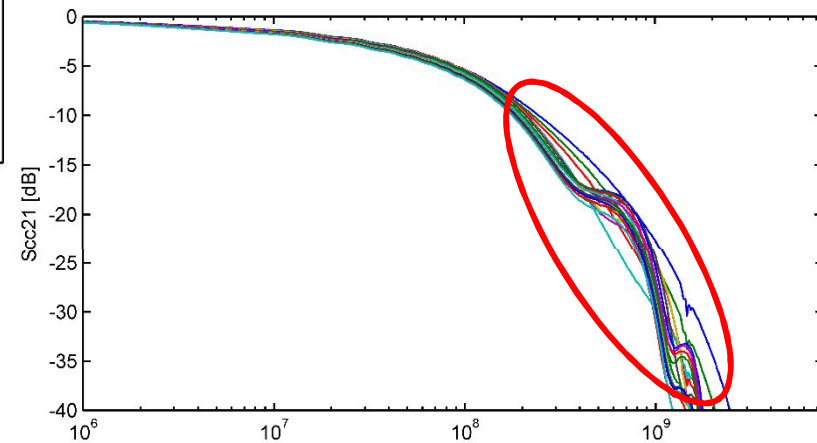
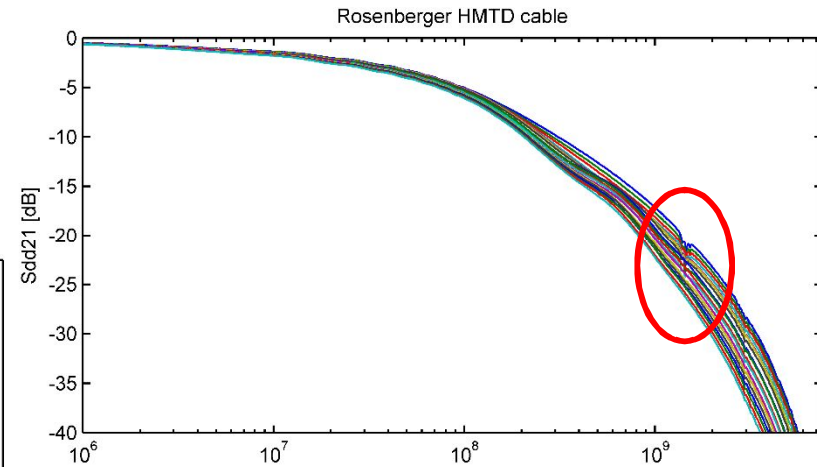
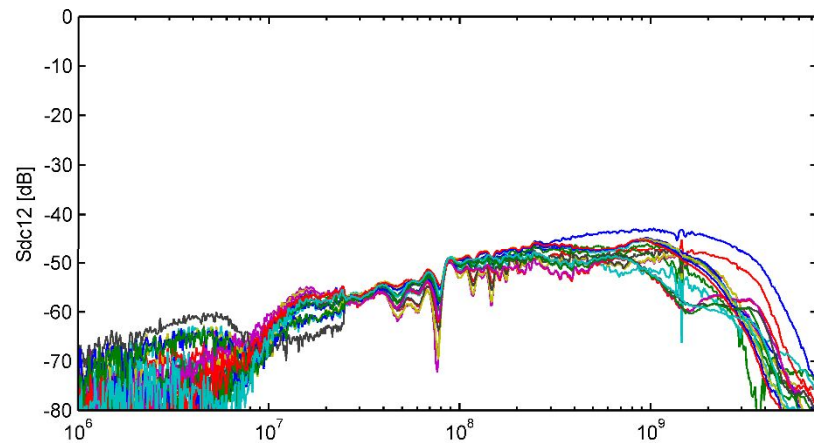
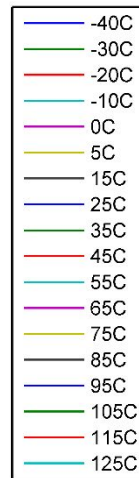
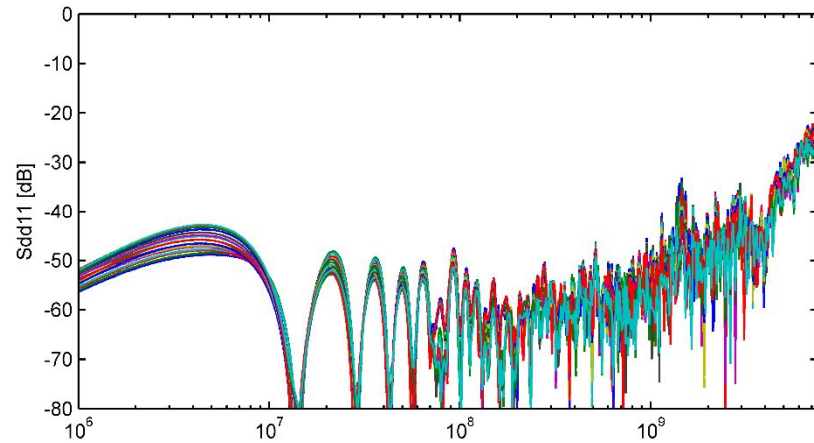
- ▶ Temperature characteristics of cables
  - Rosenberger H-MTD
- ▶ Perspective on link segment requirements
- ▶ Future work

# Measurement set-up



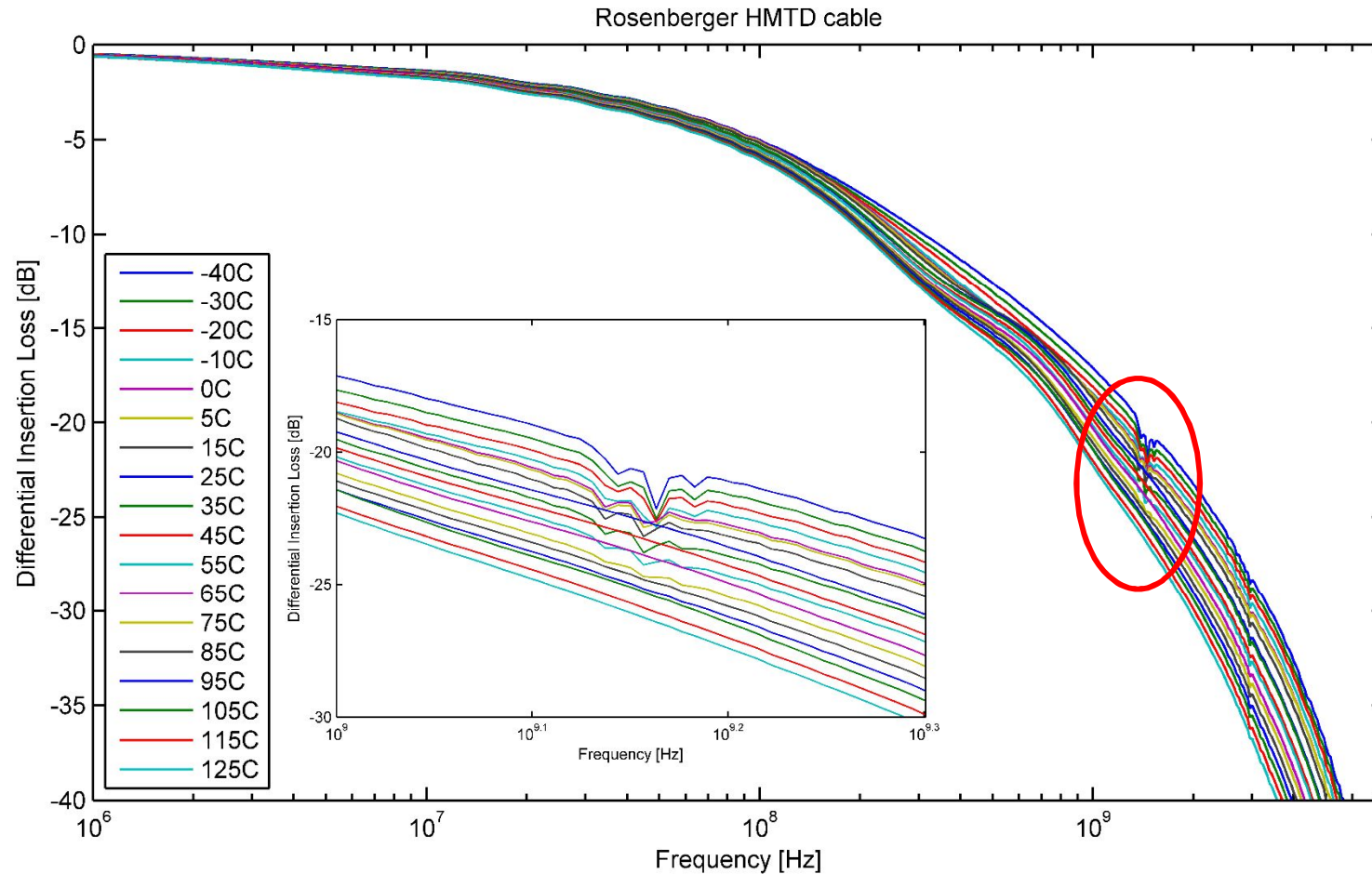
- ▶ Cable ends and fixtures outside the oven

# S-pars with parameter T



► Zoom into Sdd21 ...

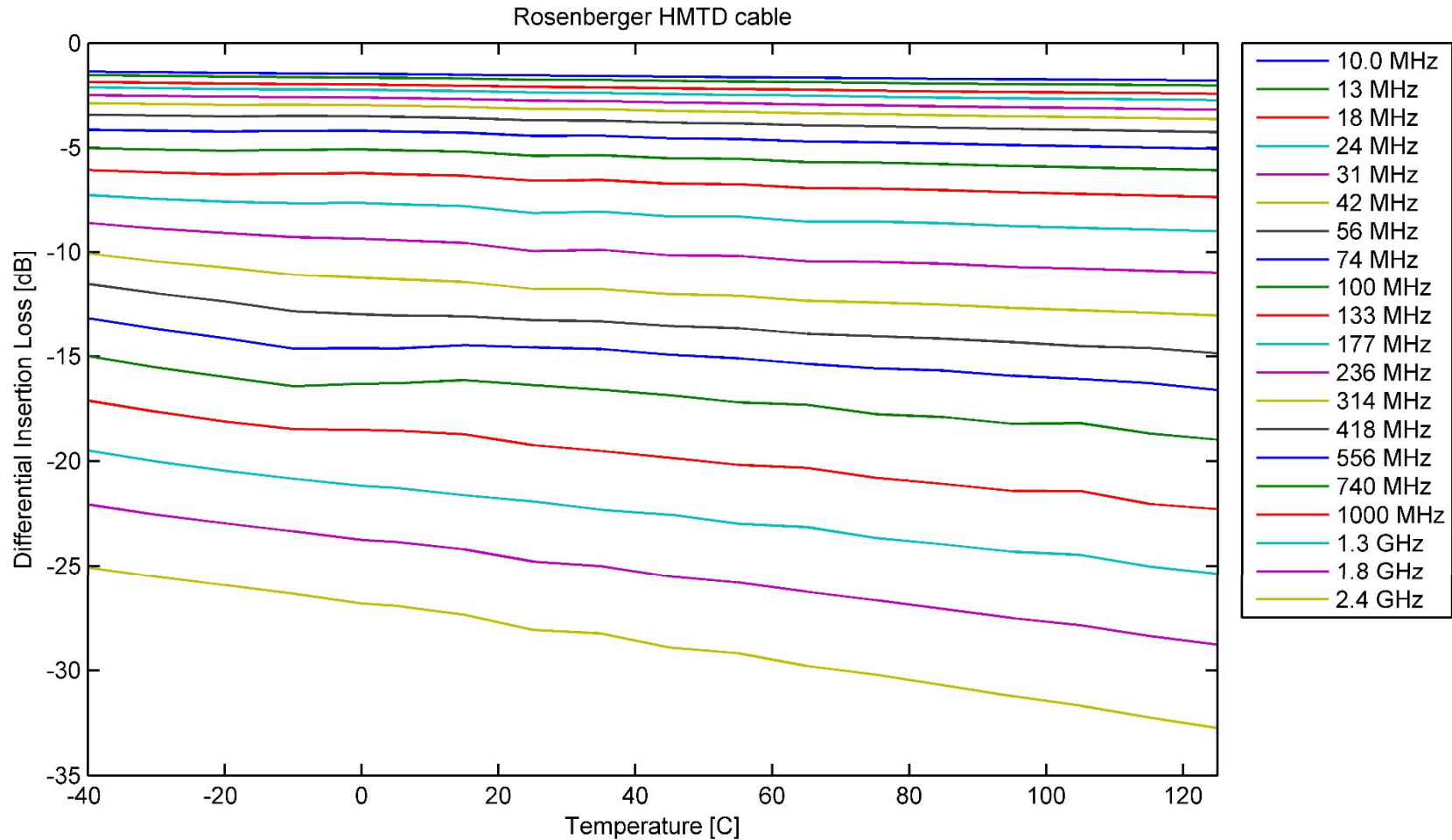
# Sdd12 for multiple Temps



- ▶ Substantial loss variability over temperature  $f > 100$  MHz
- ▶ Small dips beyond 1 GHz: changing with temperature

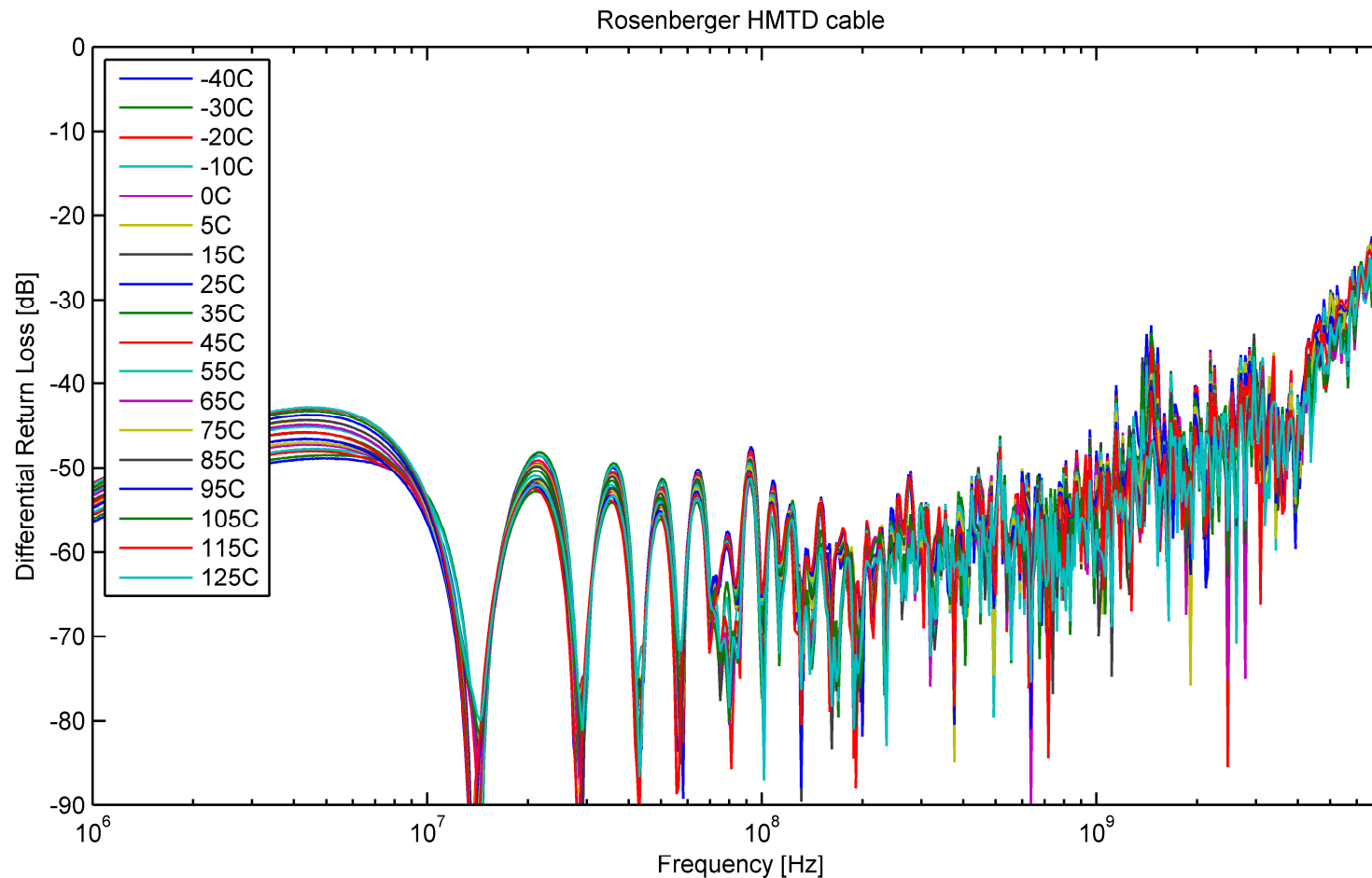


# Sdd21 = f(Temp)



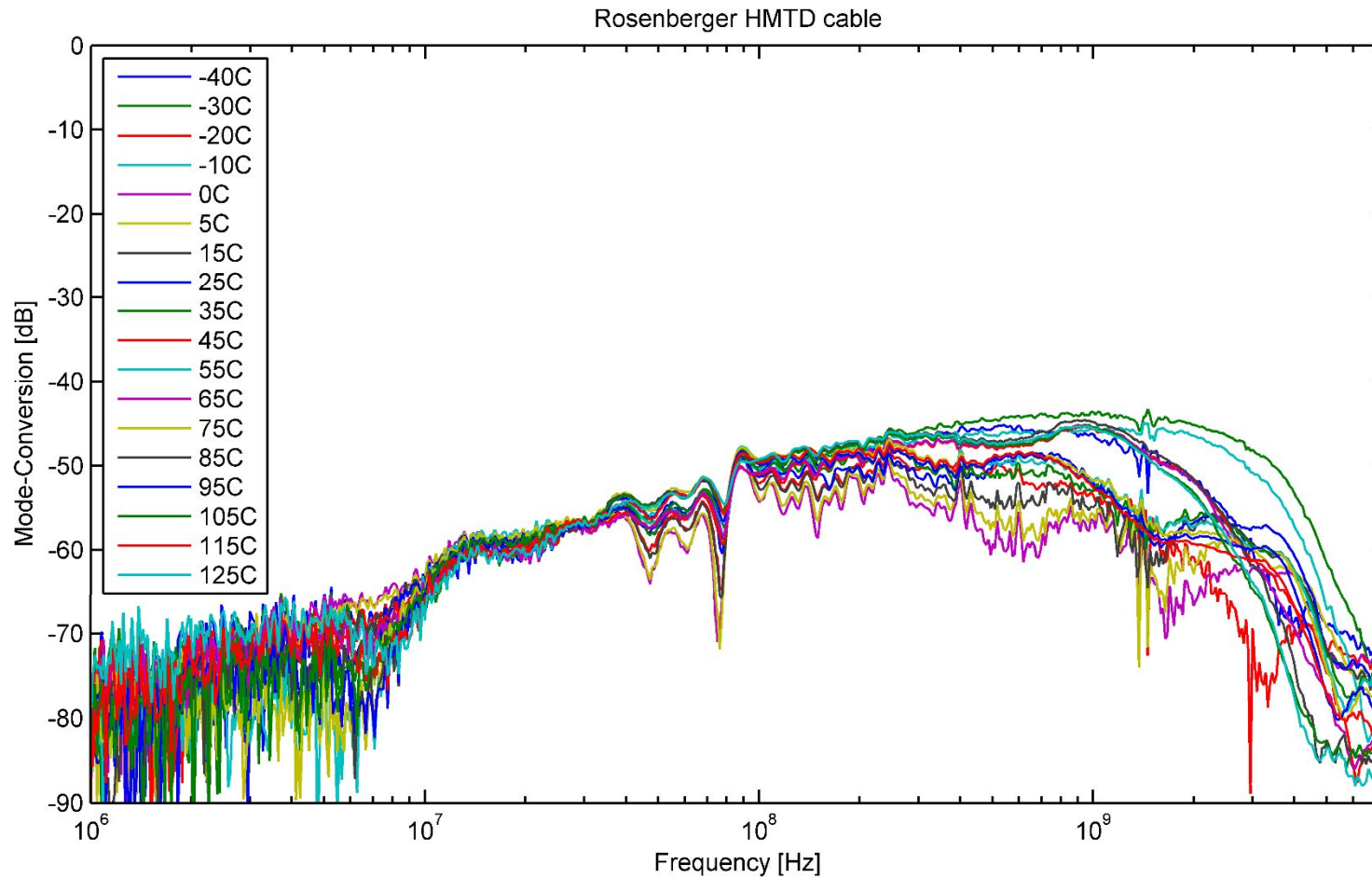
► Slope  $\sim 0.03\text{dB}/^\circ\text{C}$  @ 1GHz and  $\sim 0.047\text{dB}/^\circ\text{C}$  @ 2.4GHz

# Sdd11 for multiple Temps



- ▶ Worst at high temperature, but generally very good!

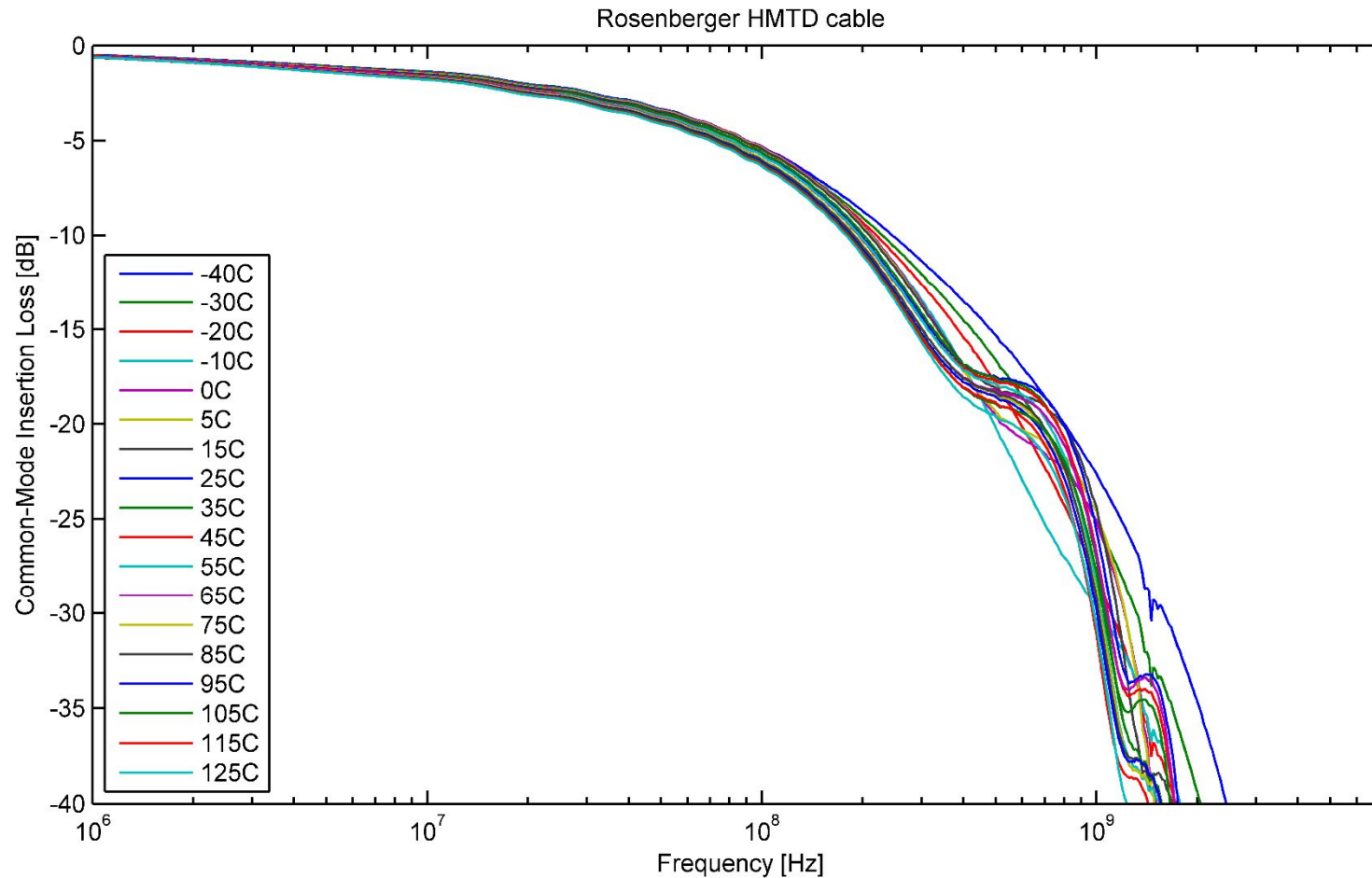
# Sdc12 for multiple Temps



► Fairly stable level



# Scc12 for multiple Temps



- ▶ Temperature-dependent 'resonance' >200MHz

# Status

- ▶ Currently limited set of bulk cable options available
  - Can we expect more materials?
- ▶ How much innovative progress can be expected from cable manufacturers?
  - Where is the physical limit?

# Assessment towards 10Gbps

- ▶ If usable BW is only 1GHz, feasibility of 10Gbps over single-pair is endangered
  - Would imply  $\geq 5$ -bits/symbol (including some coding)
  - Too sensitive to interference (noise margin)
- ▶ Previous analysis for expected interference levels shows that probably 3-bits/symbol is about maximum
  - Unless shielding isolation is expected to be improved
  - Stories that shielding attenuation actually degrade over time too
- ▶ Recommend to ensure that IL requirement for 15m link segment achieves smooth roll-off up to 3GHz
- ▶ Recommend to ensure that IL for a 15m link segment at 2GHz does not exceed 23dB
  - Power efficiency of transceivers will matter too

# Future work

- ▶ Humidity impact analysis
- ▶ TE has shown cable data in September last year:  
DiBiaso\_3ch\_01a\_0917.pdf
  - No temperature data shared yet
  - Would be interesting to see temperature behavior too

# Conclusions

- ▶ Cable shows some insertion loss 'resonance' beyond 1GHz
- ▶ Data suggests that characteristics change permanently at high temperature
- ▶ Desire to ensure sufficiently large BW to enable single-pair 10Gbps
- ▶ Need more cable measurements for dependence of characteristic on environmental conditions