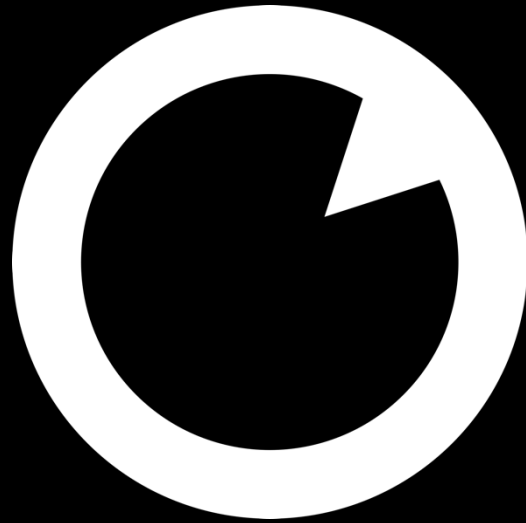
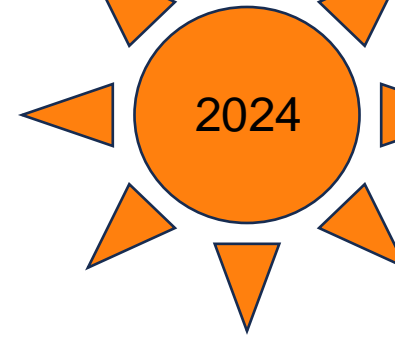


Analyzing network reliability up to 800G



Impact of SNR thresholds on BER for Coherent and
Non-Coherent transceivers



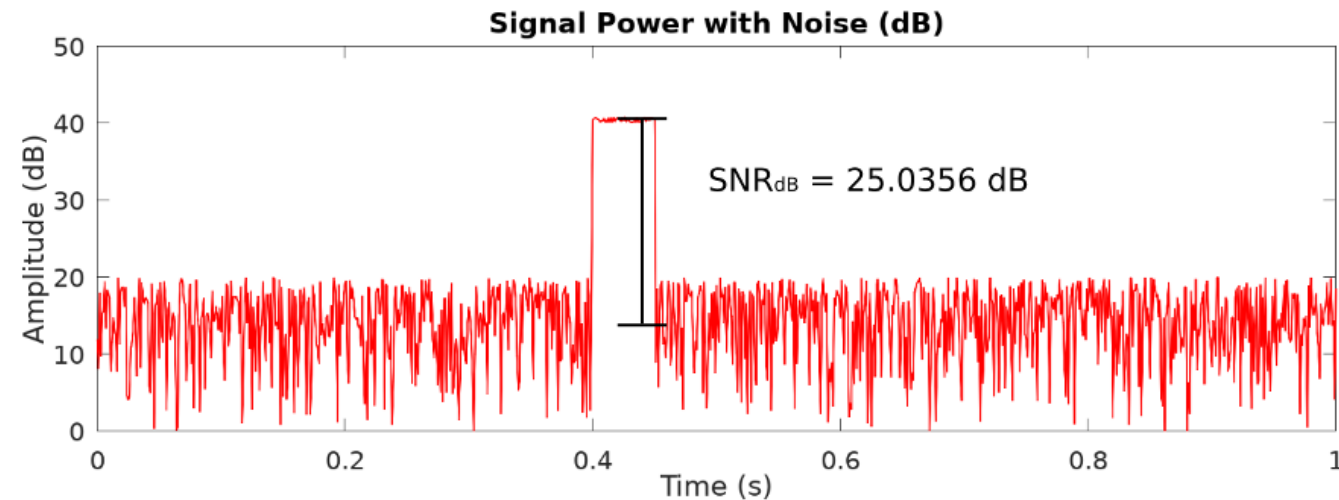
Measuring Link Quality

- **BER** = Bit Error Rate
- **SNR** = Signal-to-Noise-Ratio
- Convenience of using decibels for **small** and **large** values
- (e)SNR vs OSNR:
electrical vs optical

Data POV

$$\text{BER} = \frac{\text{Number of Erroneous Bits}}{\text{Total of Bits}}$$

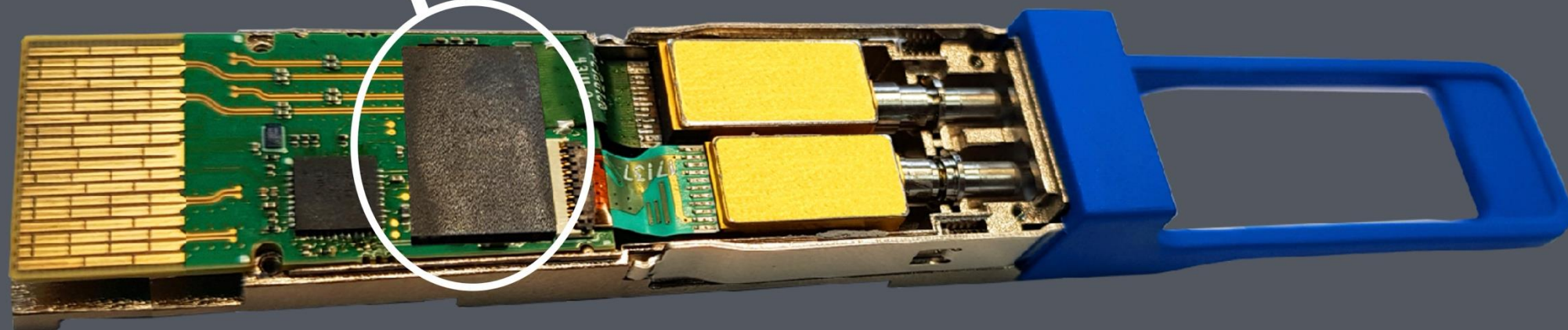
Communication POV

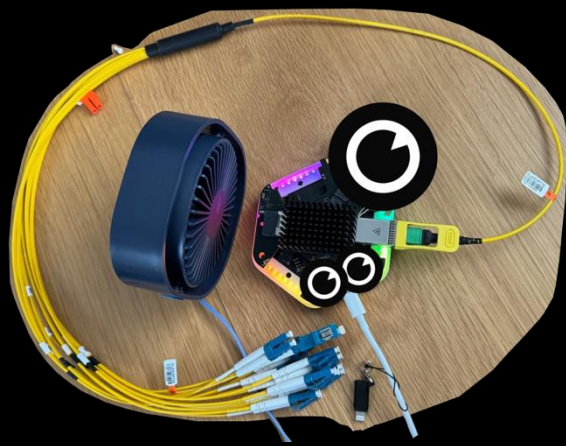


Digital Signal Processor

2019

- + FEC
- + BERT
- + OSNR
- + ...





DUTs* are

1. 100G QSFP28 Single Lambda DR 500m
2. 100G QSFP28 Single Lambda ER 40km
3. 400G QSFP-DD Coherent ZR low power
4. 400G QSFP-DD LR4 10km
5. 400G QSFP112 DR4 500m
6. 800G QSFP-DD DR8 500m

*Device Under Test

Watch for attenuation with short cables!

CAUTION: you may damage the photodiodes of long range transceivers!

2. Fiber Cable (Drums)



10 + 20km G.652.D
@1310nm ≤ 0.35 dB/km

Shopping List:

1. The Transceiver

100G QSFP28 ER WITH DUAL CDR

40 km, $\lambda 1310$ nm, LC-Duplex, Singlemode

Q.13S1HG.40
QSFP28
ER



- ✓ Universal QSFP28 Transceiver
- ✓ Use FLEXBOX to configure to almost any vendor
- ✓ For 100GBASE-ER Ethernet links
- ✓ Integrated Clock-Data-Recovery (CDR)
- ✓ PAM4 modulated signal
- ✓ Supported Data Rates: 106.25 Gbit/s
- ✓ Up to 40 km via Singlemode OS2
- ✓ LC-Duplex Connector

3. Attenuators



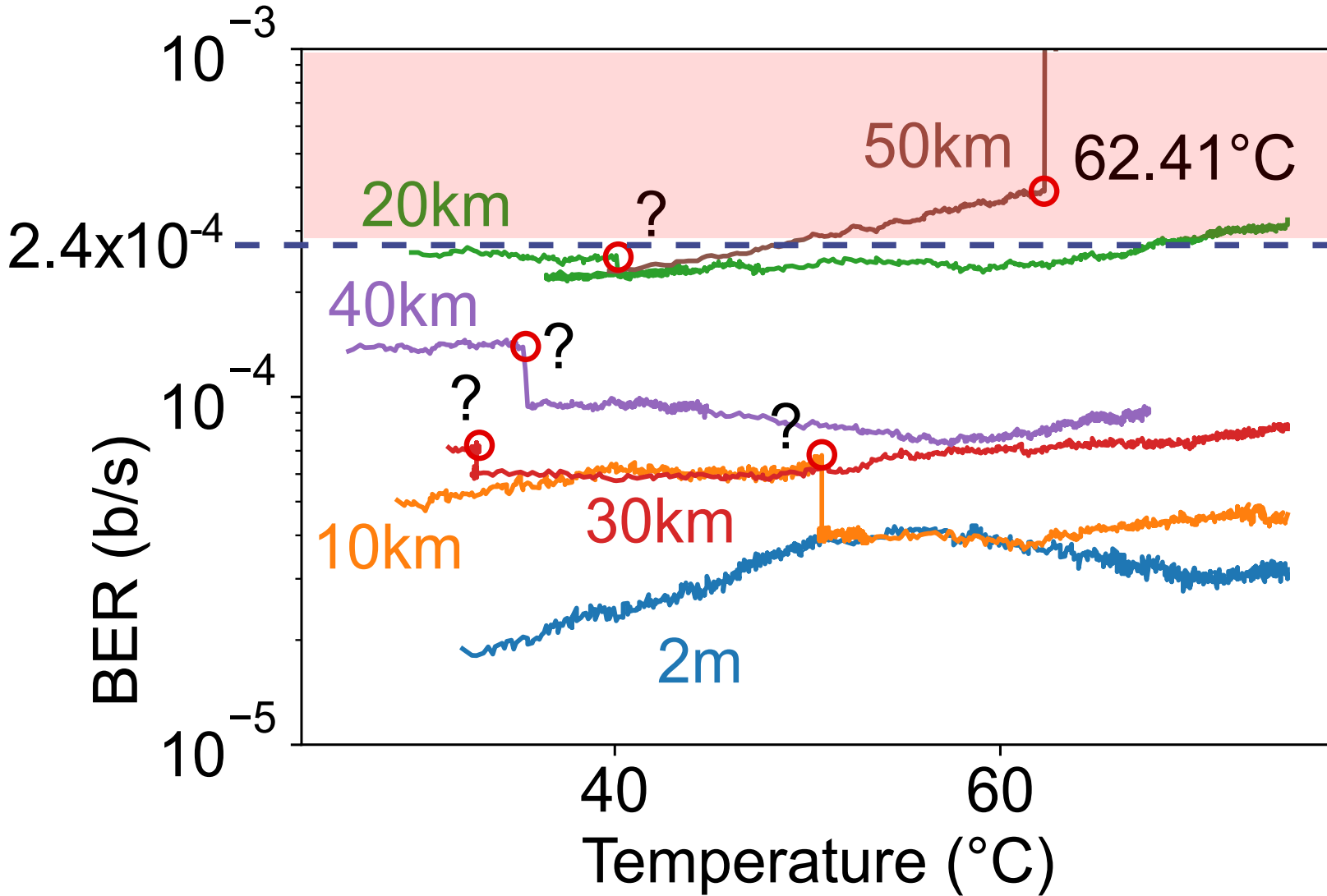
Q.13S1HG.40 attenuation calculation

fiber length + attenuator	cable (0.35 dB/km)	used attenuator
2 meter	about 0 dB	11 dB
10 km	3.5 dB	11 dB
20 km	7 dB	11 dB
30 km	10.5 dB	5 dB
40 km	14 dB	2 dB
50 km	17.5 dB	2 dB

TRANSMIT MIN/MAX PER LANE	4.5 dBm / 7.9 dBm
RECEIVER MIN/MAX PER LANE	-14 dBm / -3 dBm (overload) @100G
WAVELENGTH TX (TYPICAL)	1310 nm
WAVELENGTH TX (RANGE)	1308.1 - 1310.2 nm
WAVELENGTH RX (TYPICAL)	1310 nm

At least **11dB** attenuation is required to ensured safety

100G BER on attenuation



fiber length + attenuator	TX Power (dBm)	RX Power (dBm)
2 m 11 dB	+ 4.8	- 7.1
10 km 11 dB	+ 4.8	- 10.0
20 km 11 dB	+ 4.8	- 13.4
30 km 5 dB	+ 4.8	- 11.9
40 km 2 dB	+ 4.8	- 11.1
50 km 2 dB	+ 4.8	- 14.6

Q.13S1HG.40

IEEE 802.3db BER range : max. 2.4×10^{-4}

Source [11]

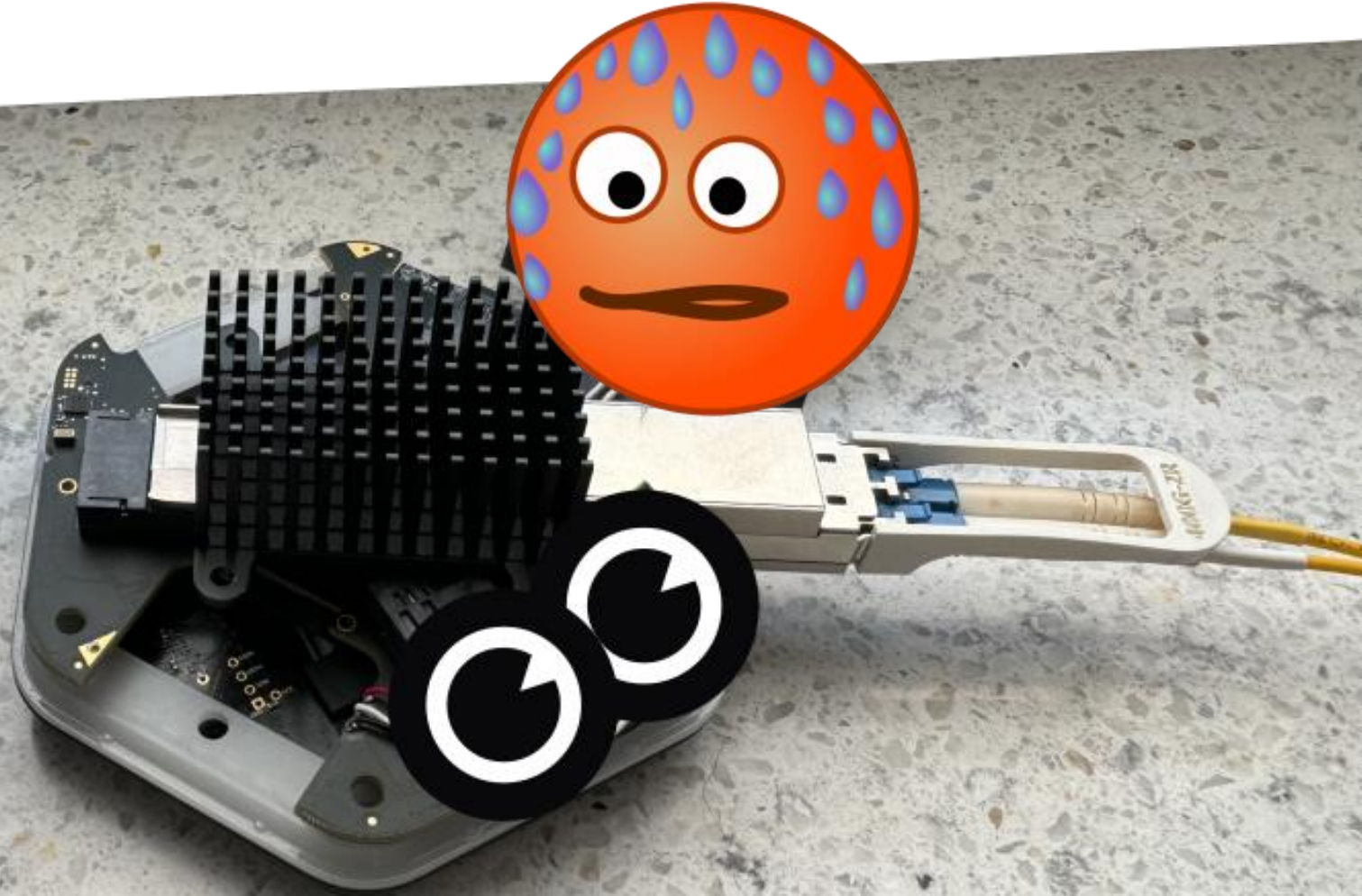
About BER max. 2.4×10^{-4} b/s

- PreFEC value

$$BER = \frac{N_e}{B \Delta T}$$

- Assume $N_e = 100$ errors, $B = 100$ Gbps and $BER = 1.0 \times 10^{-12}$ b/s
 - gating time ΔT is about 16 min
 - But with $BER = 2.4 \times 10^{-4}$ b/s you get $\Delta T = \underline{\underline{4 \mu s}}$!

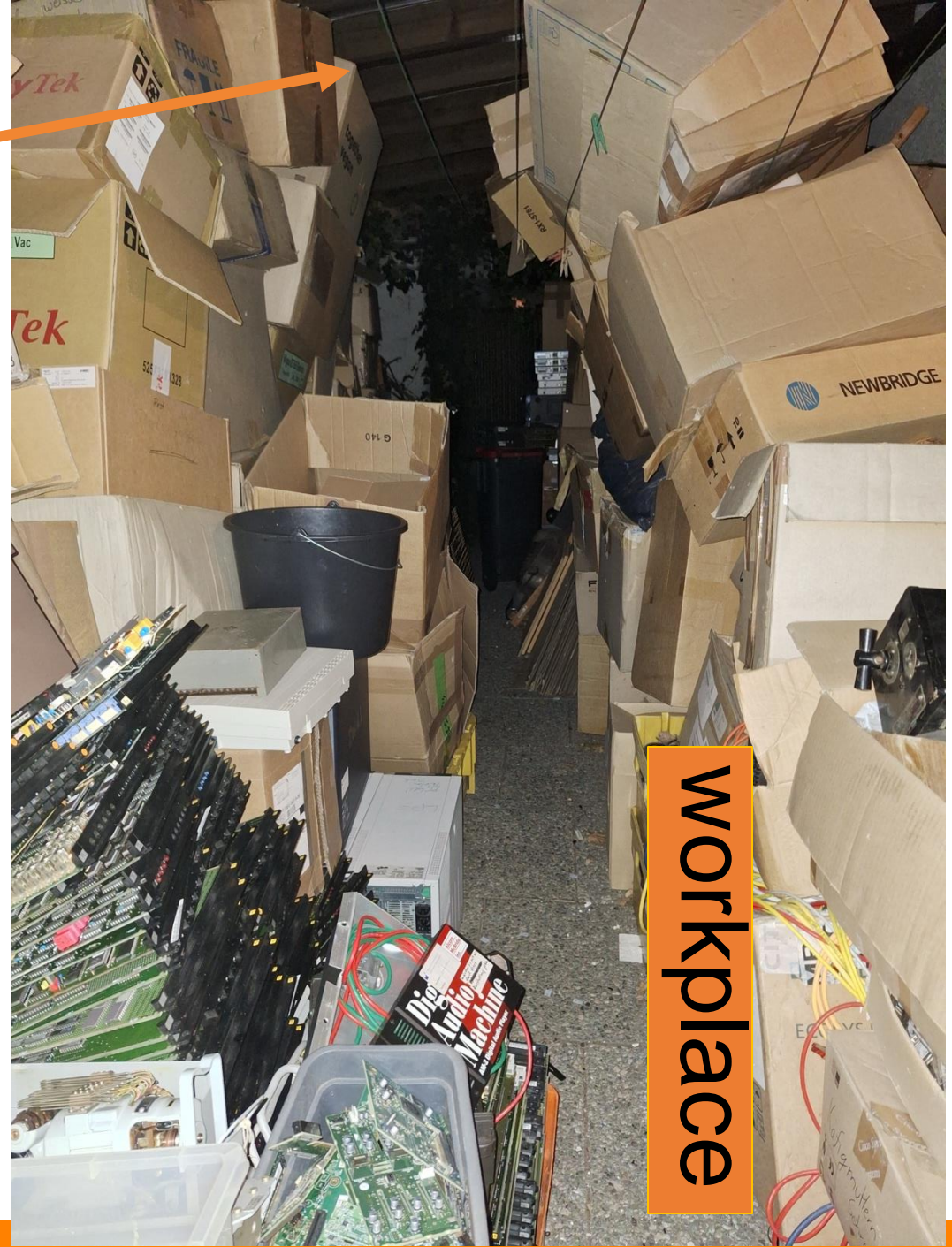
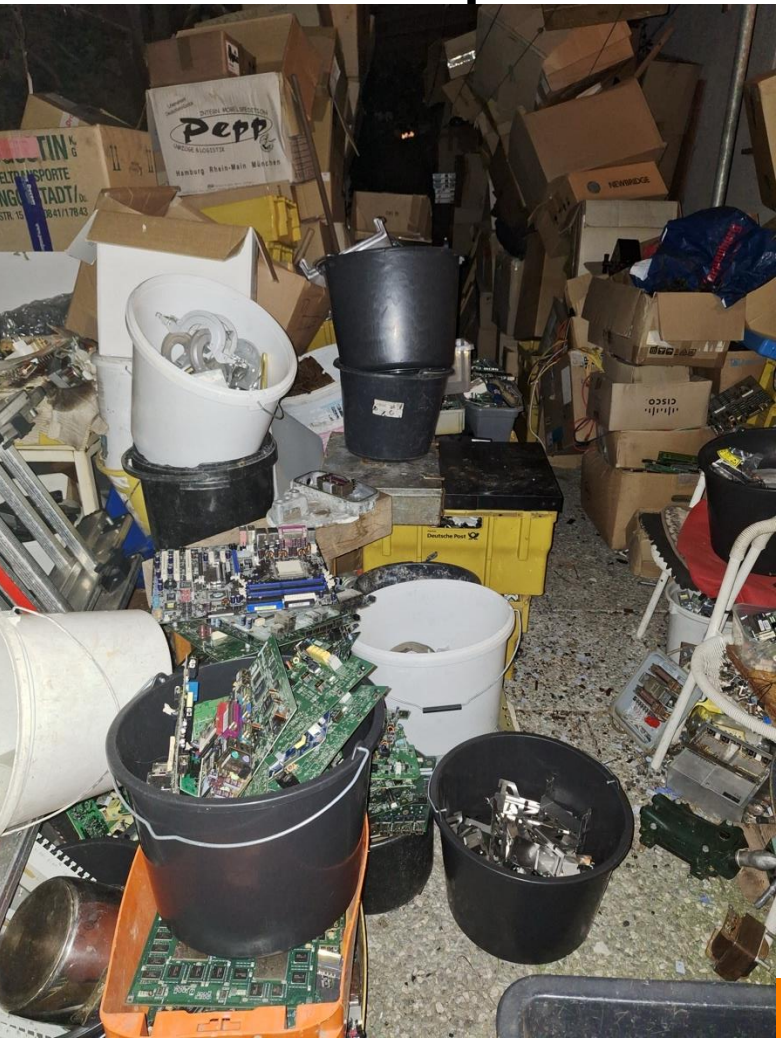
lab setup with cooler (400G DD ZR)



heat sink taken from an old Cisco 800

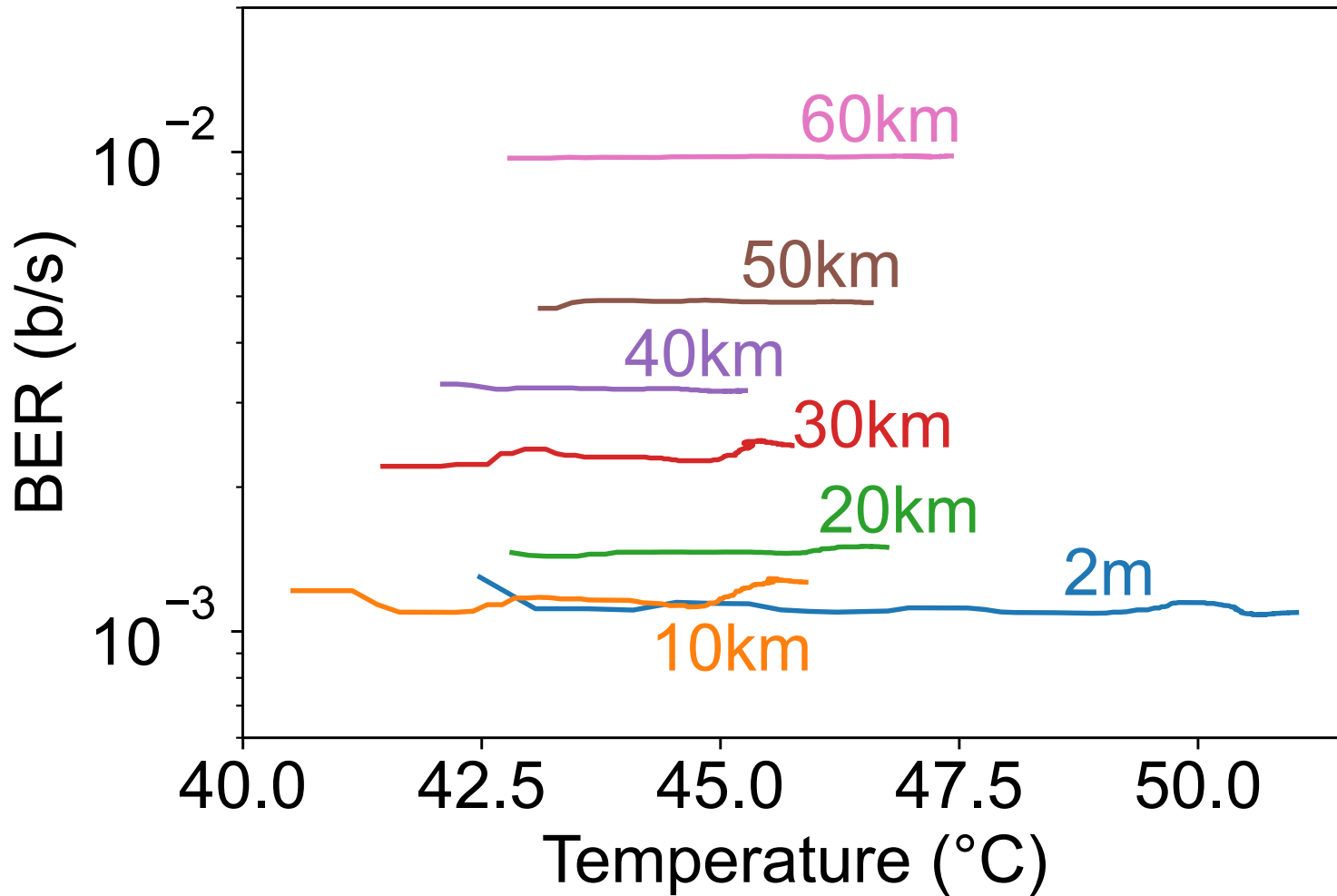
roof top

detailed separation



workplace

The coherent DD with cooling



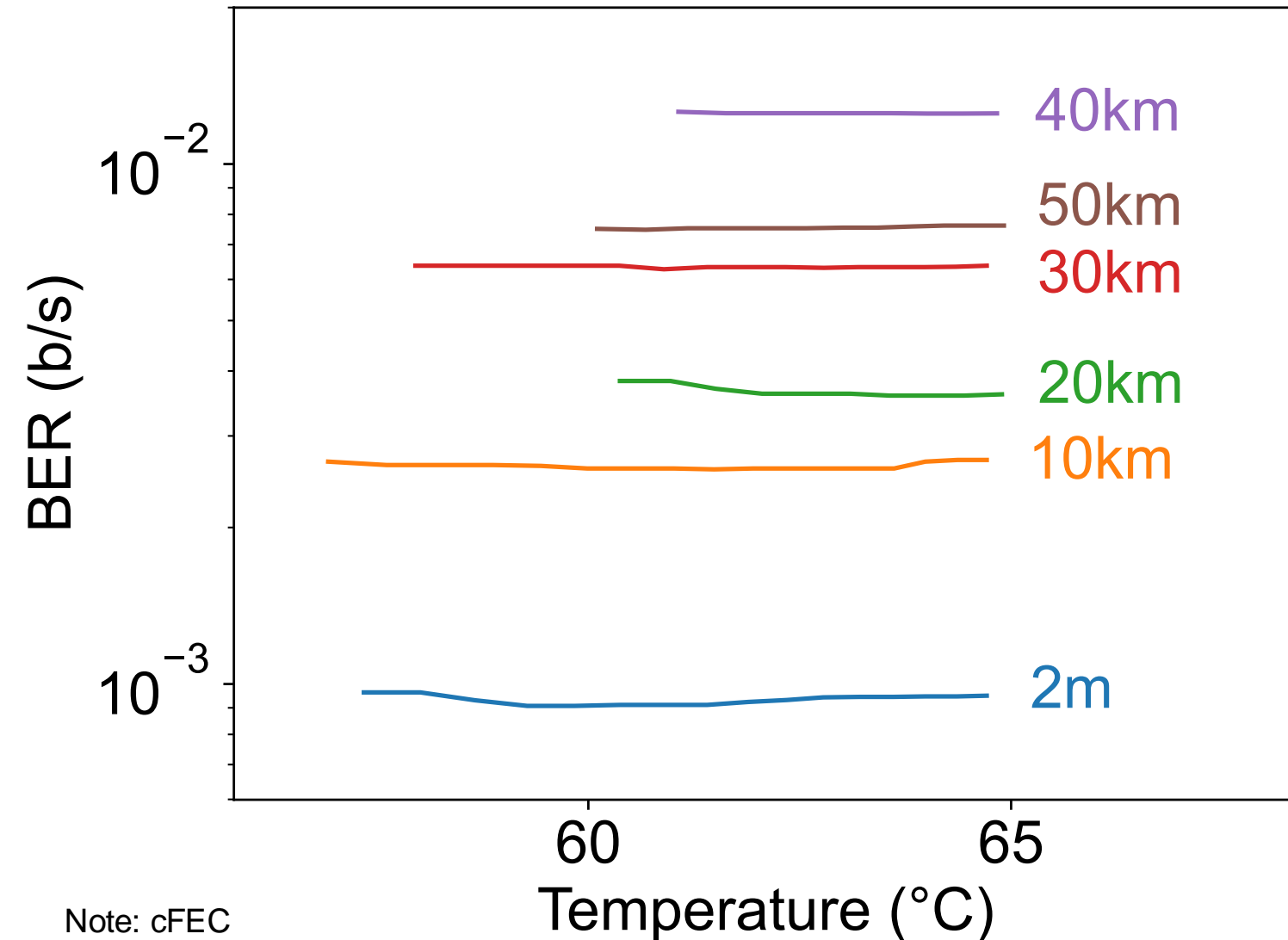
Note: cFEC

Fiber Length	TX Power (dBm)	RX Power (dBm)
2 m	-10.0	-10.2
10 km	-10.0	-11.7
20 km	-10.0	-13.1
30 km	-10.0	-14.9
40 km	-10.0	-16.7
50 km	-10.0	-18.5
60 km	-10.0	-20.9

OIF BER Range:
 1.5×10^{-4} to 1.3×10^{-2}

Source [13]

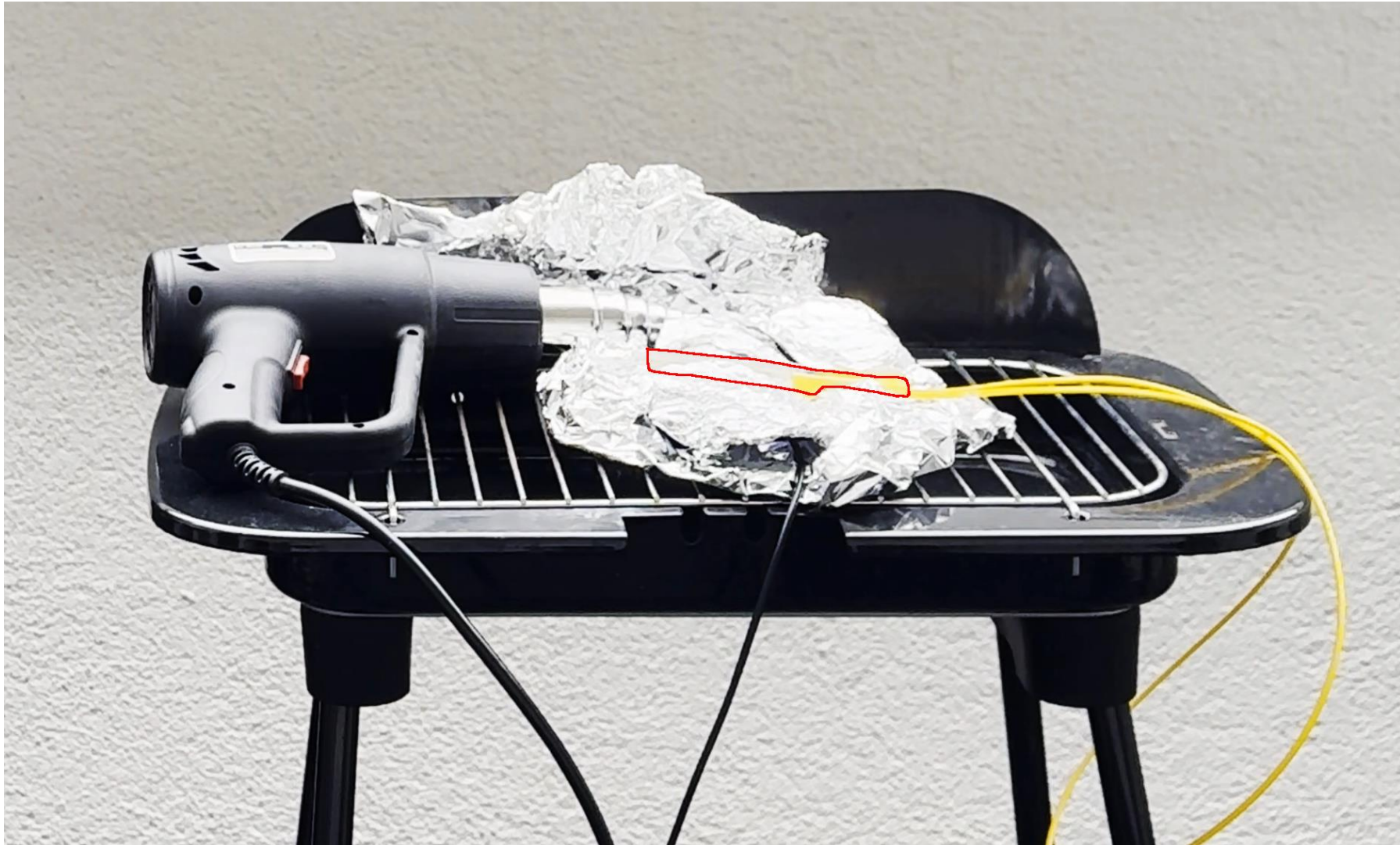
The coherent DD without cooling



Fiber Length	TX Power (dBm)	RX Power (dBm)
2 m	-10.0	-9.2
10 km	-10.0	-11.6
20 km	-10.0	-13.3
30 km	-10.0	-15.0
40 km	-10.0	-16.7
50 km	-10.0	-18.6

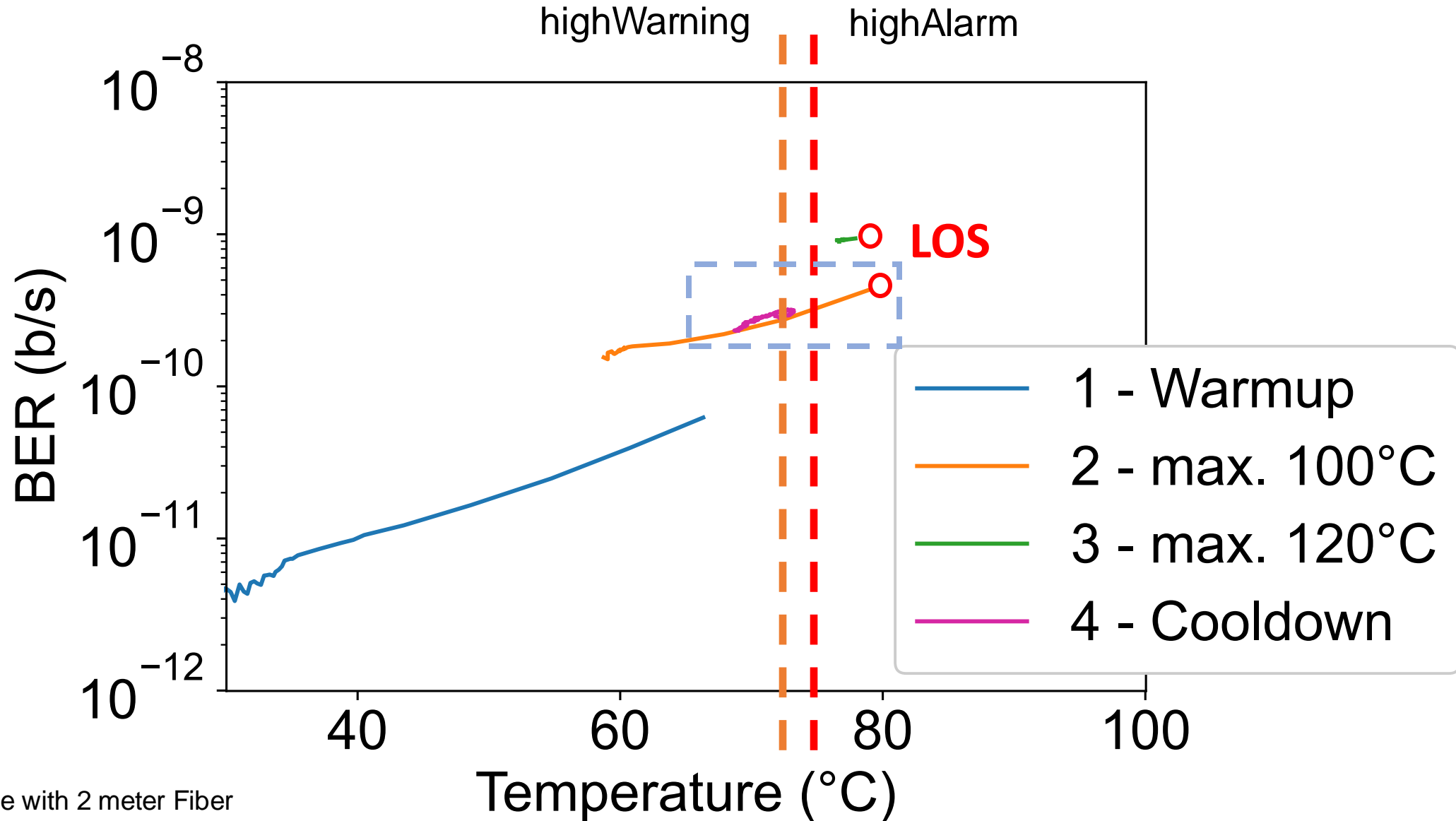
OIF BER Range:
 1.5×10^{-4} to 1.3×10^{-2}

What if we go over the specs, up to $\sim 120^{\circ}\text{C}$?



Note: example with 2 meter Fiber. Q.13S1HG.05

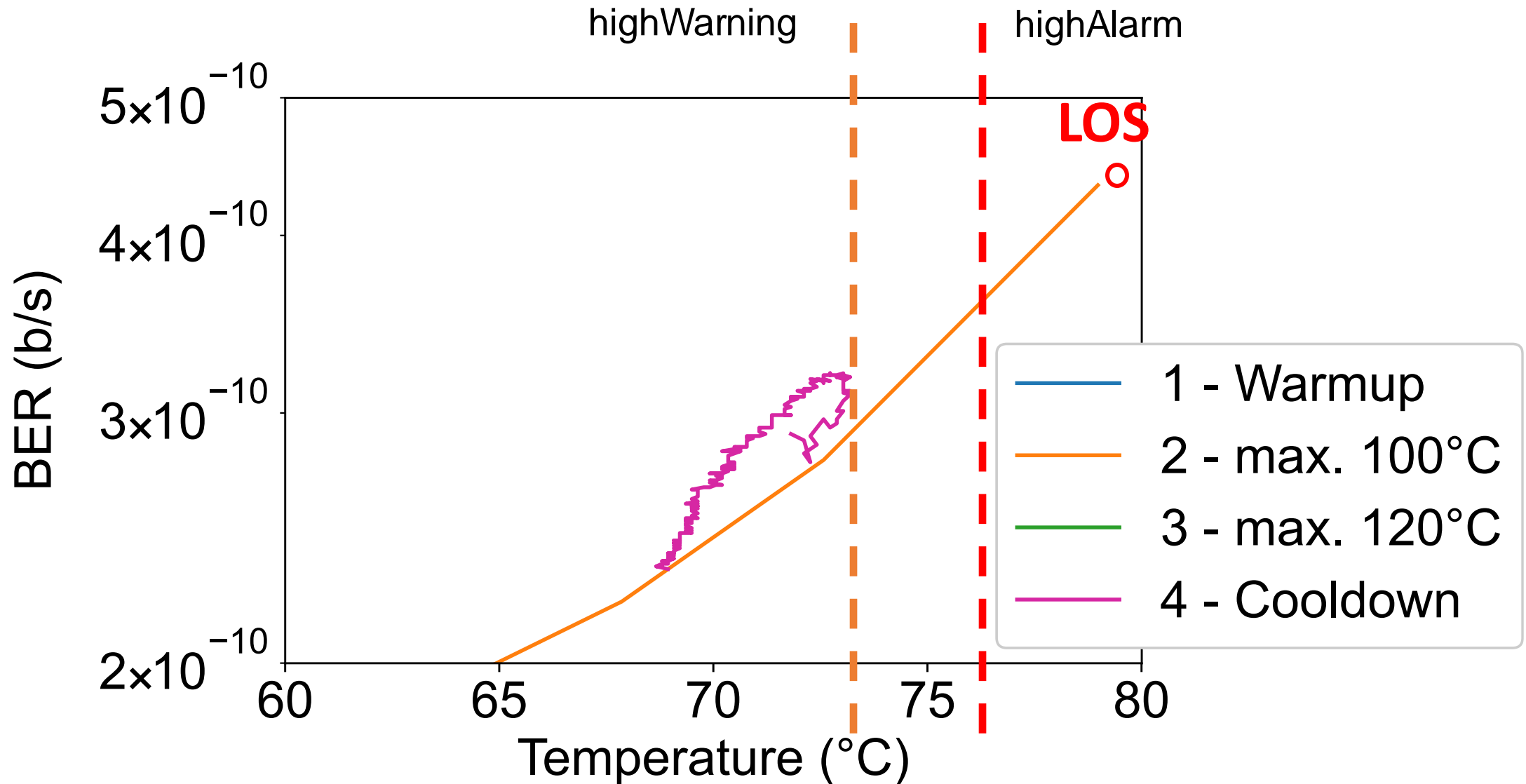
What if we go over the specs, up to ~120°C ?



Note: example with 2 meter Fiber

source: [15]

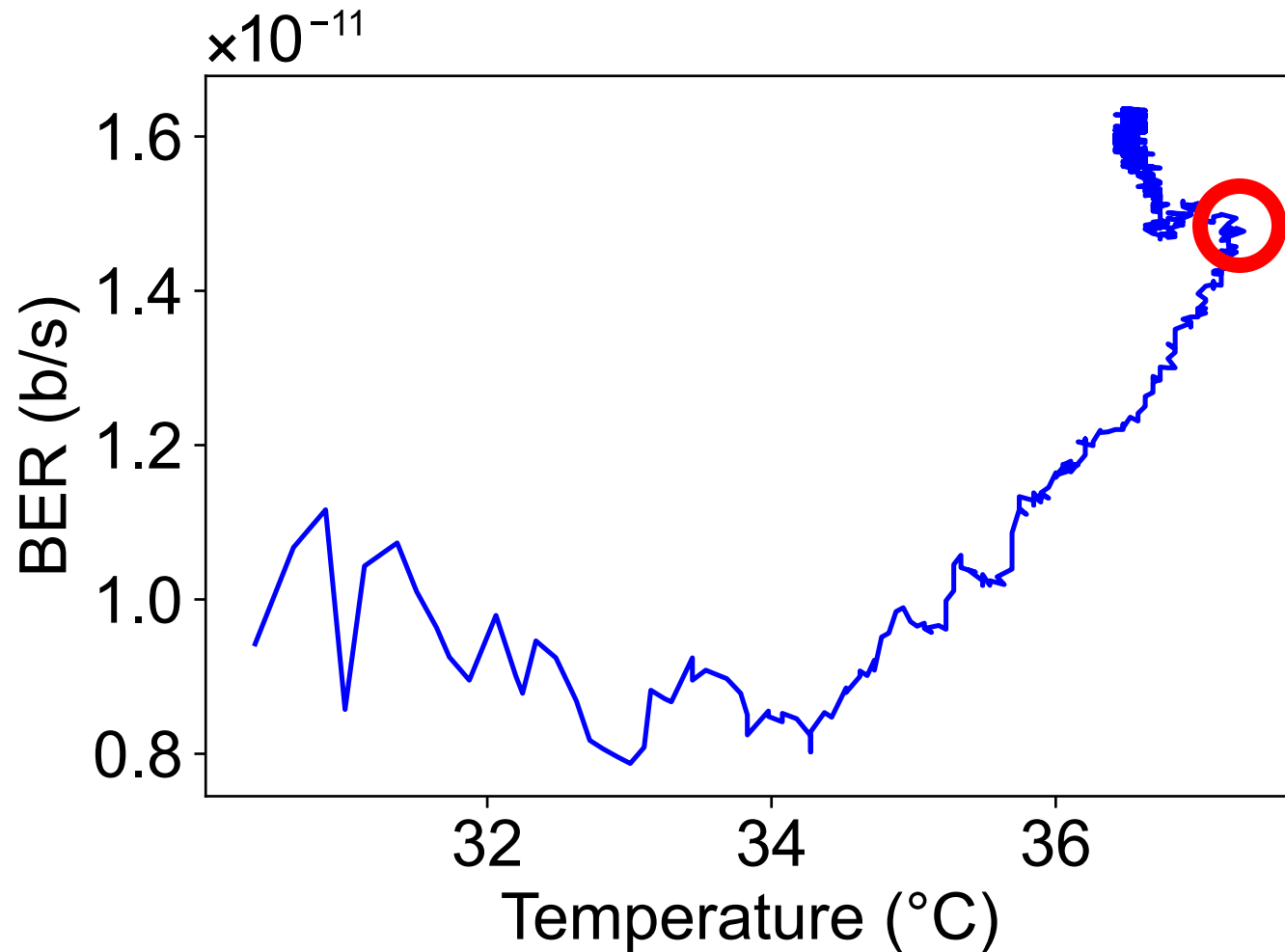
What if we go over the specs, up to ~120°C ?



Note: example with 2 meter Fiber

source: [15]

At constant temperature how much does time influence BER?

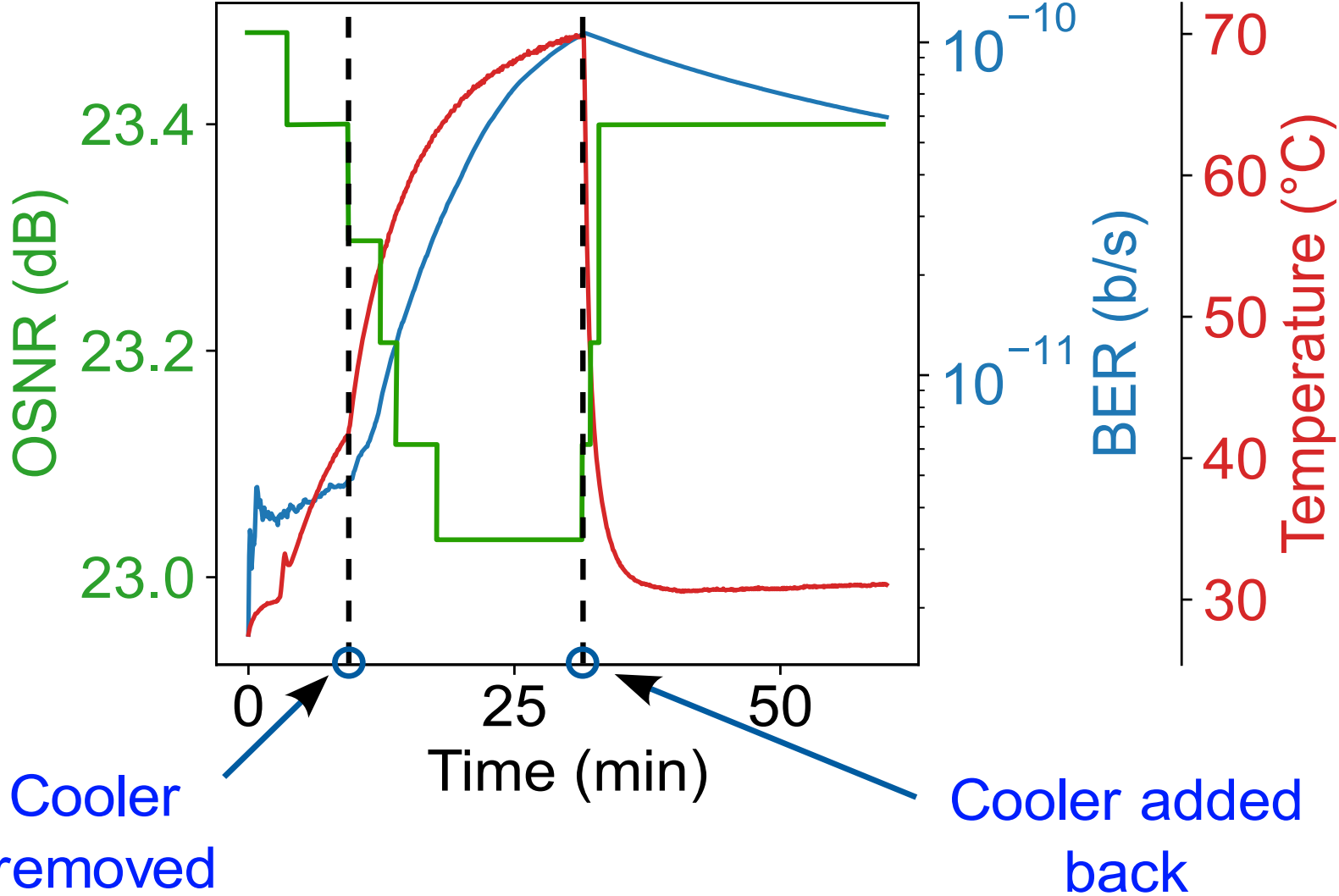


37.0 $^{\circ}\text{C}$
were
reached
after 4 min.

Example with Q.13S1HG.05, 2m
cable and a fan with heat sink
constantly cooling.
1 hour of BER measured.

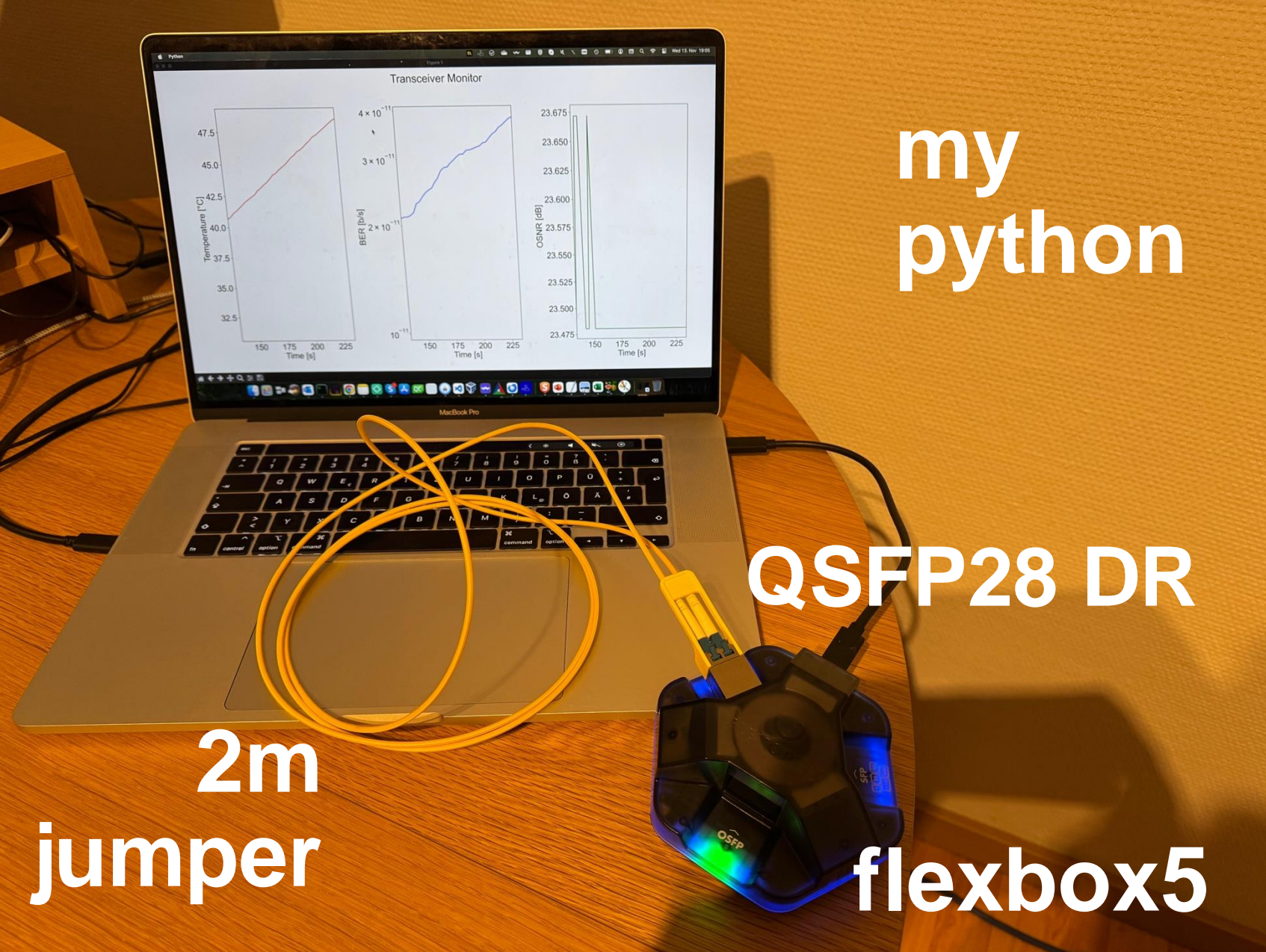
Note: PostFEC values (KP4 FEC)

Initial BER recoverable?



after recovering
10 times worse!

Example with Q.13S1HG.05 and PostFEC values.



my
python

The
Demo

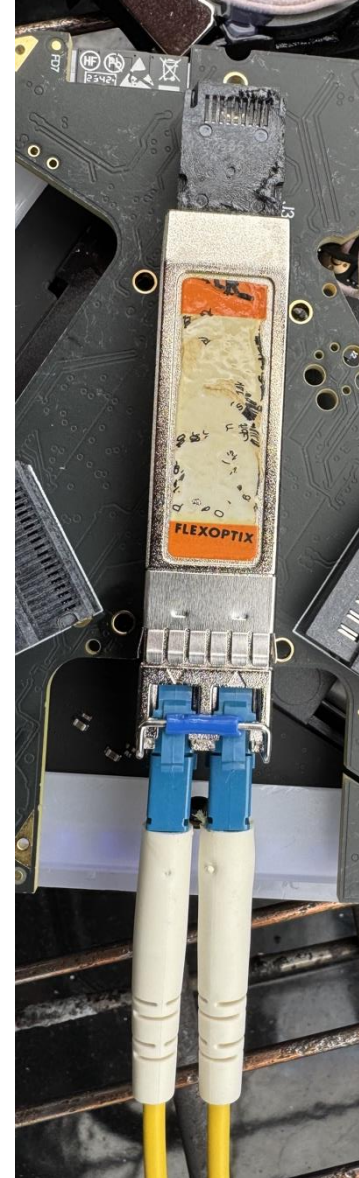
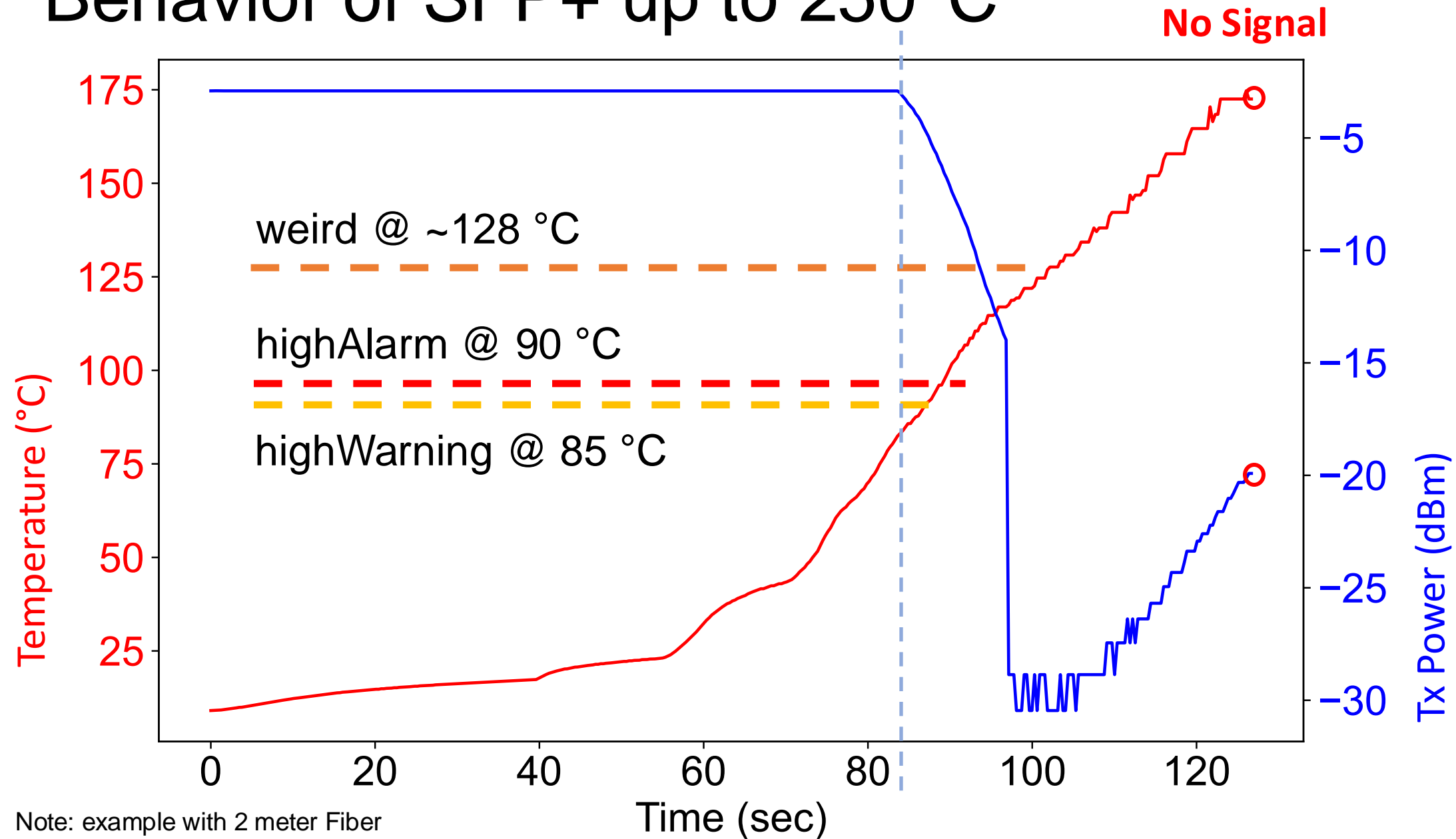
QSFP28 DR

2m
jumper

flexbox5

Video URL: <https://cloud.flexoptix.net/index.php/s/p9N8ePMoXwDGoBj>

Behavior of SFP+ up to 250°C



- BER on Direct Detection Transceiver (DDT, grey transceivers) depends on both temperature and fiber length
- BER is rolling average value, not a currently taken snapshot
- There isn't so much margin above high Alarm Temperature and LOS
- Coherent Transceivers benefit more from the properties of light, but also require a DSP with more features for proper signal recovery
- Coherent Transceivers BER do not bother with temperatures changes, mainly on fiber length
- The specified BER values are defined in IEEE802.3df for such devices in general. for DDT: when your BER is fine OSNR won't be your enemy.

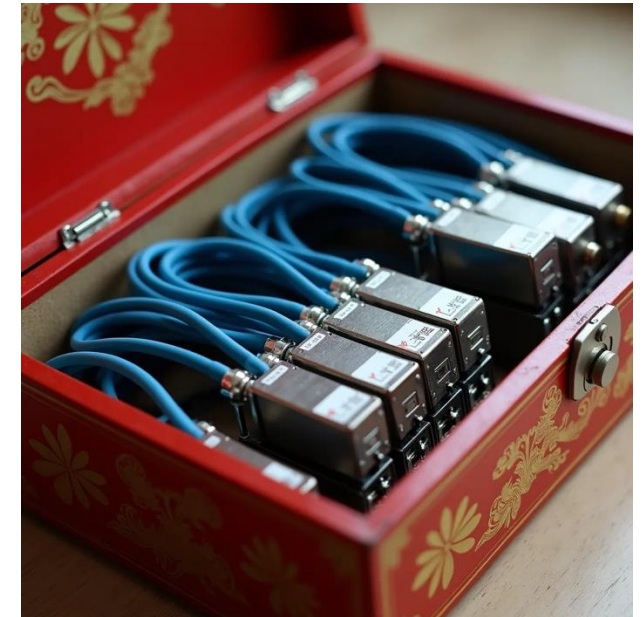
take aways



FLUX AI: "Chinese take away box from a restaurant filled with noodles" !!!

- BER on Direct Detection Transceiver (DDT, grey transceivers) depends on both temperature and fiber length
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take aways



FLUX AI: "Chinese restaurant take away box filled with transceivers" !!!

Thank you



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