Analyzing network reliability up to 800G

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

1

Intro and recap

2

Bit Error Rate dependency

[redacted]

4

Distance

5

Temperature

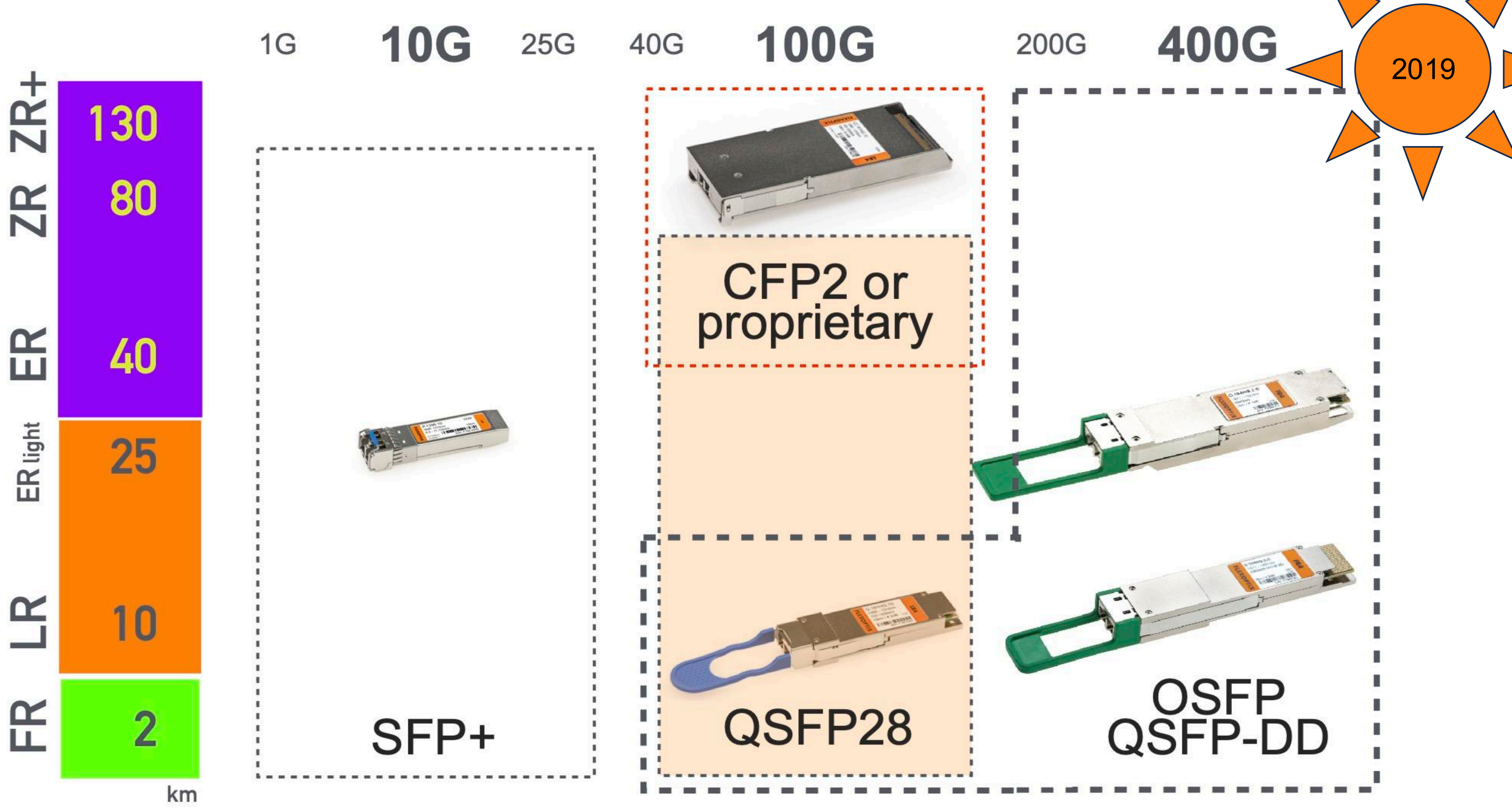
6

Live Demo

[redacted]

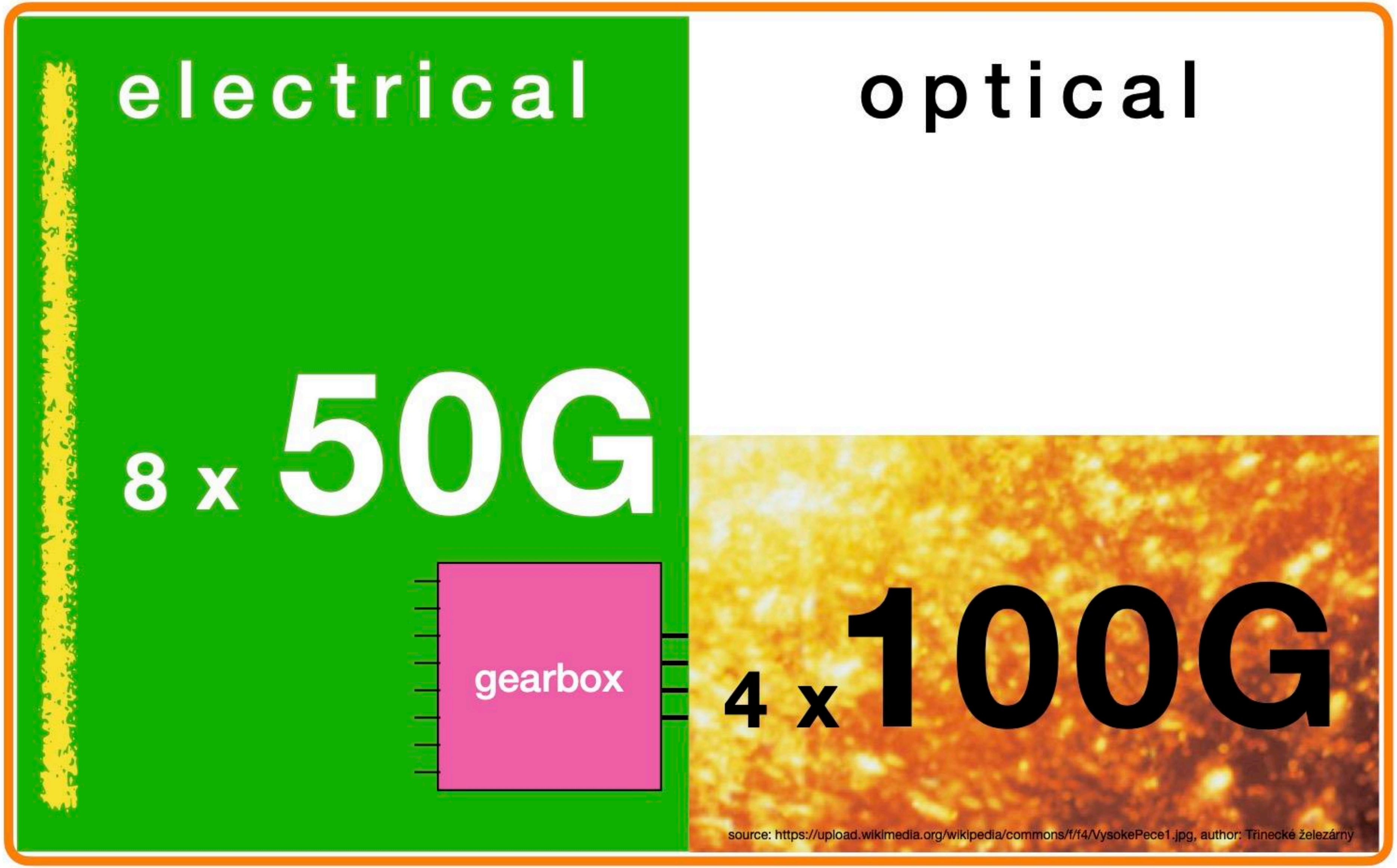
8

Take Away


1G
10G
25G
40G
100G
200G
400G
2019
ZR+
ZR
ER
ER light
LR
FR
130
80
40
25
10
2
km
CFP2 or proprietary
SFP+
QSFP28
OSFP
QSFP-DD

QSFP-DD and OSFP schema

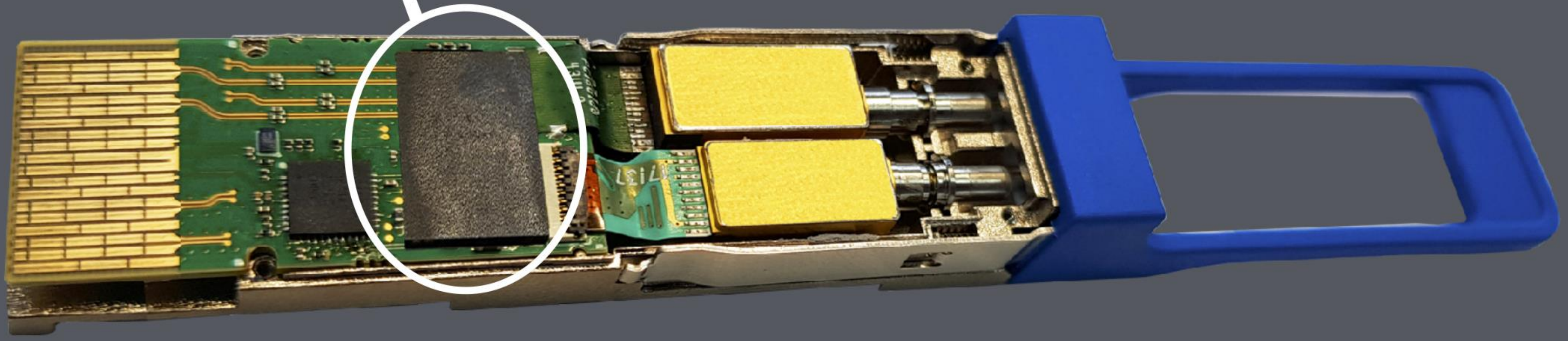
2019



2019

Digital**S**ignal**P**rocessor

+ FEC
+ BERT
+ OSNR
+ ...



Measuring Link Quality

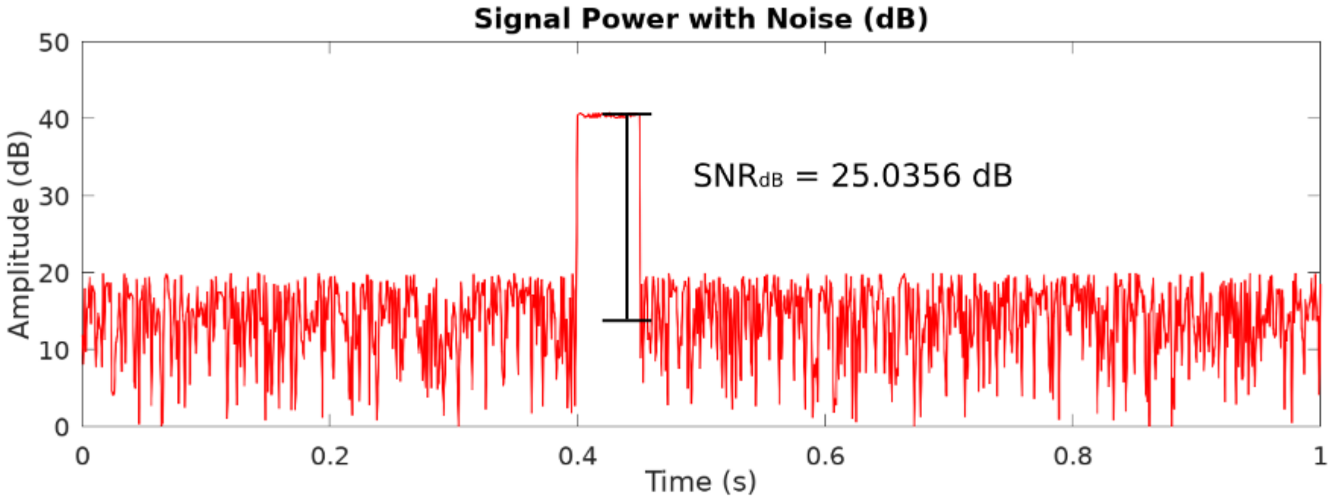
- **BER** = Bit Error Rate
- **SNR** = Signal-to-Noise-Ratio
- Convenience of using decibels for **small** and **large** values
- (e)SNR vs OSNR:

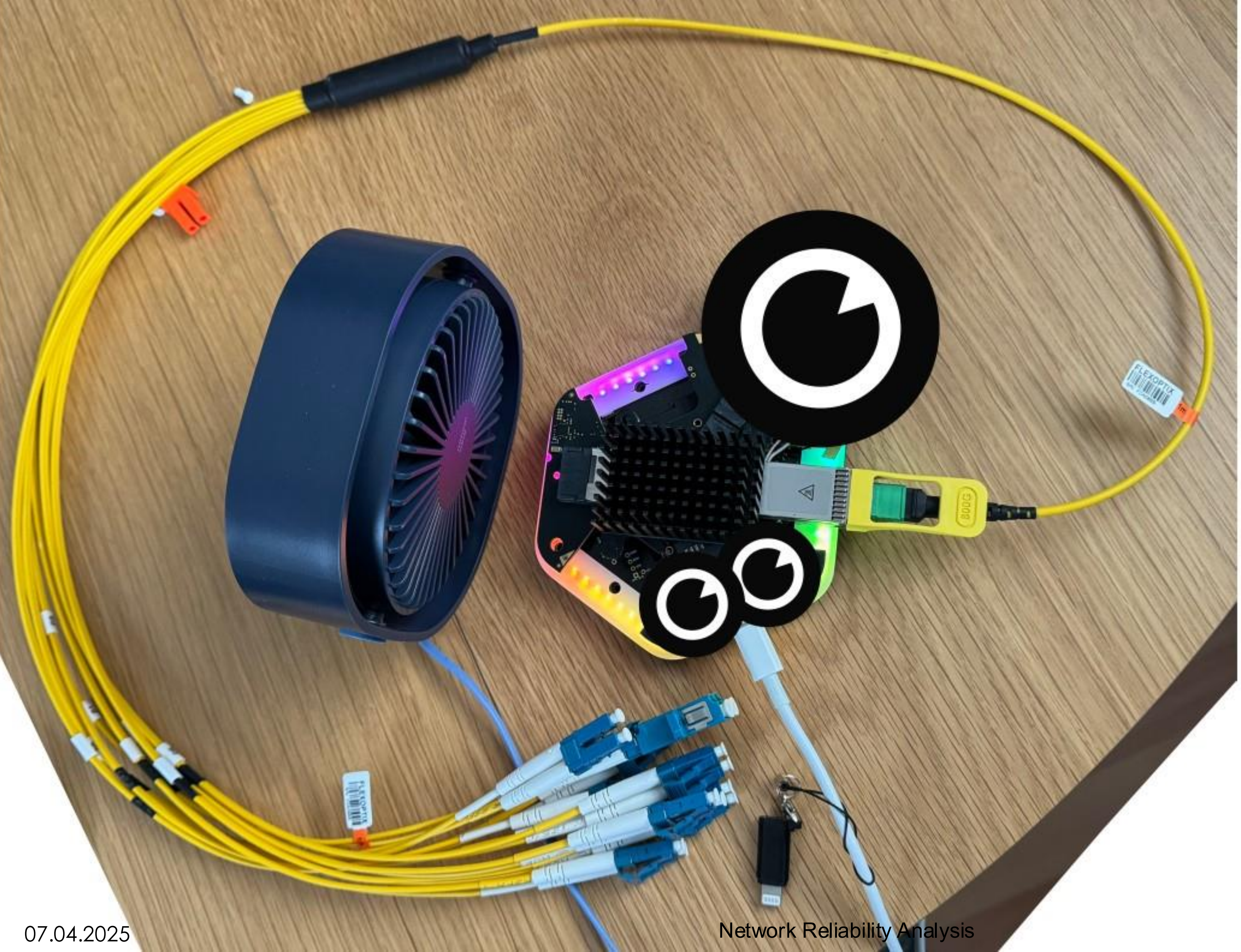
  electrical vs **optical**

Data POV

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

Communication POV





lab setup

FLEXBOX5 with 800G DD, heat sink and fan

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!

Shopping List:

1. The Transceiver

100G QSFP28 ER WITH DUAL CDR

40 km, λ1310 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

2. Fiber Cable (Drums)

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

3. Attenuators

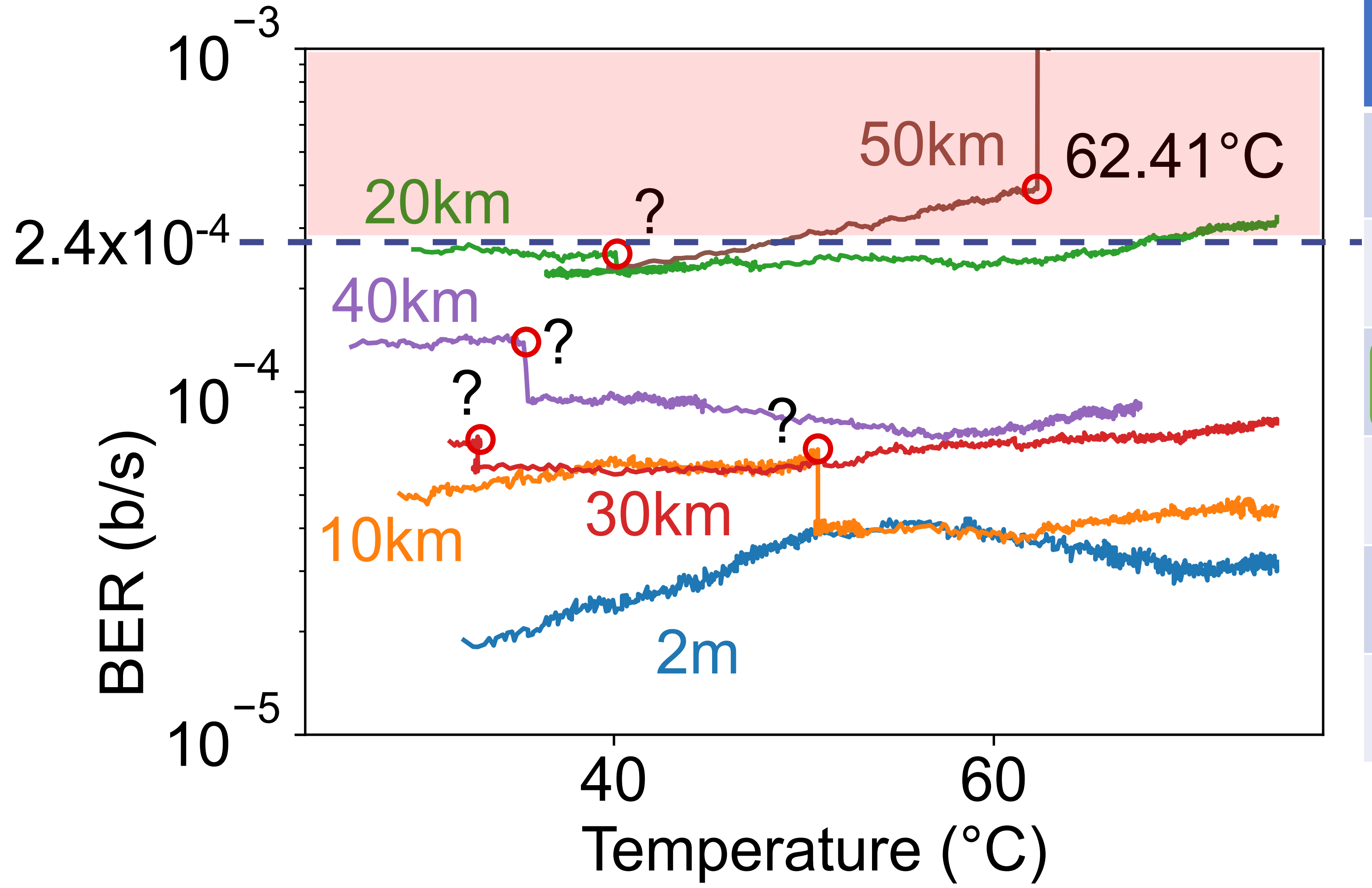
Q.13S1HG.40 attenuation calculation

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. 2.4x10-4

Source [11]

About BER max. $2.4x10^{-4}$ b/s

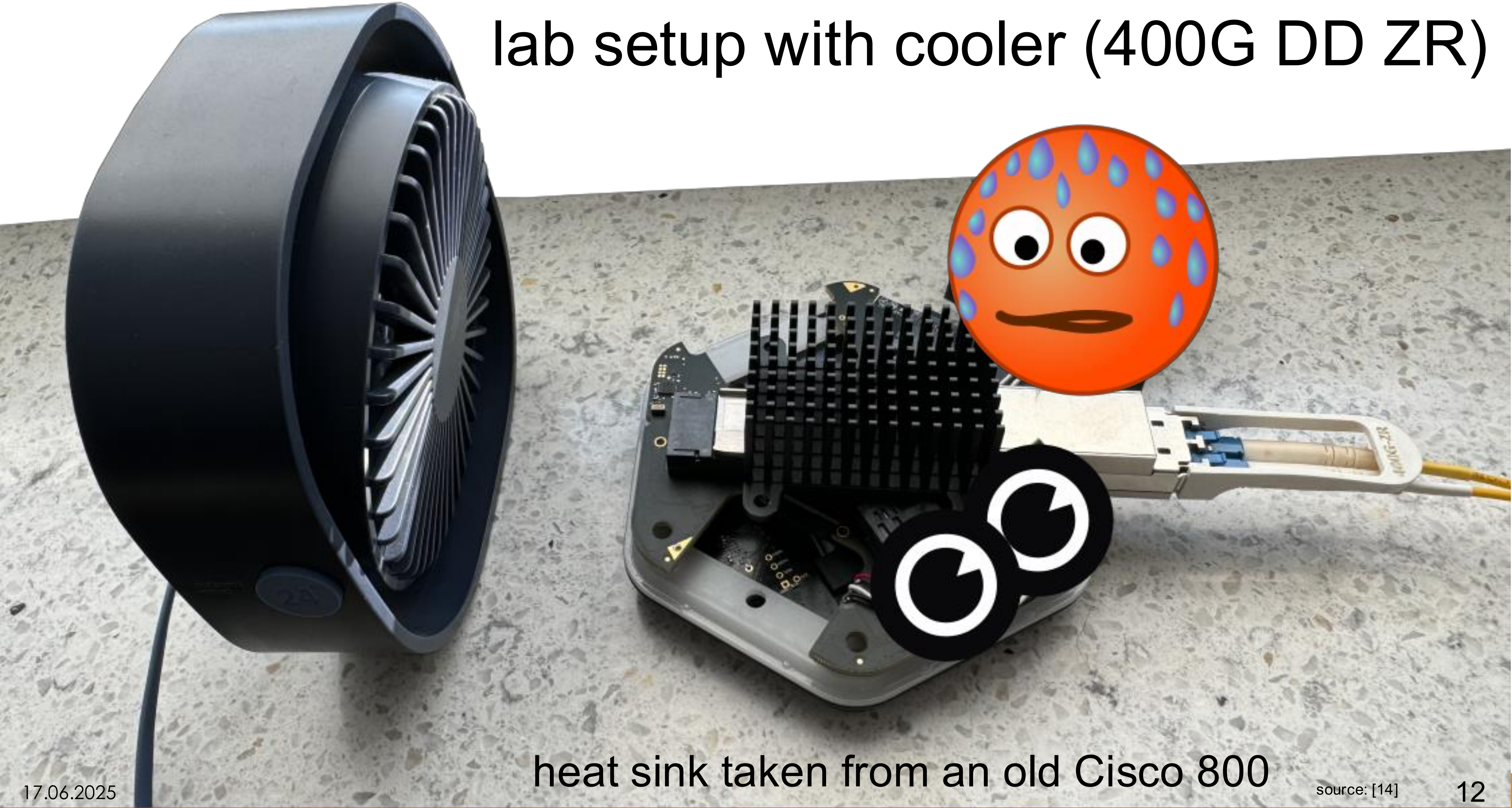
- PreFEC value

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

- Assume N_e = 100 errors, B = 100 Gbps and BER = $1.0x10^{-12}$ b/s
  - gating time ΔT is about 16 min
  - But with BER = $2.4x10^{-4}$ b/s you get ΔT = **4 µs** !

Source [8]

lab setup with cooler (400G DD ZR)

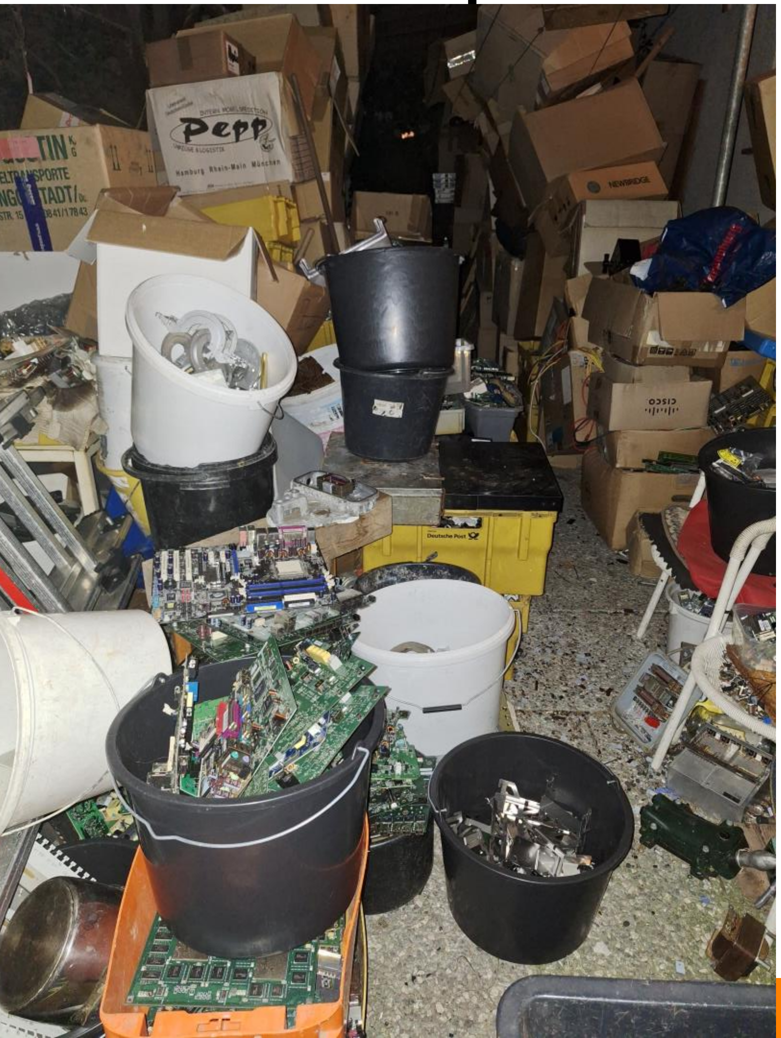


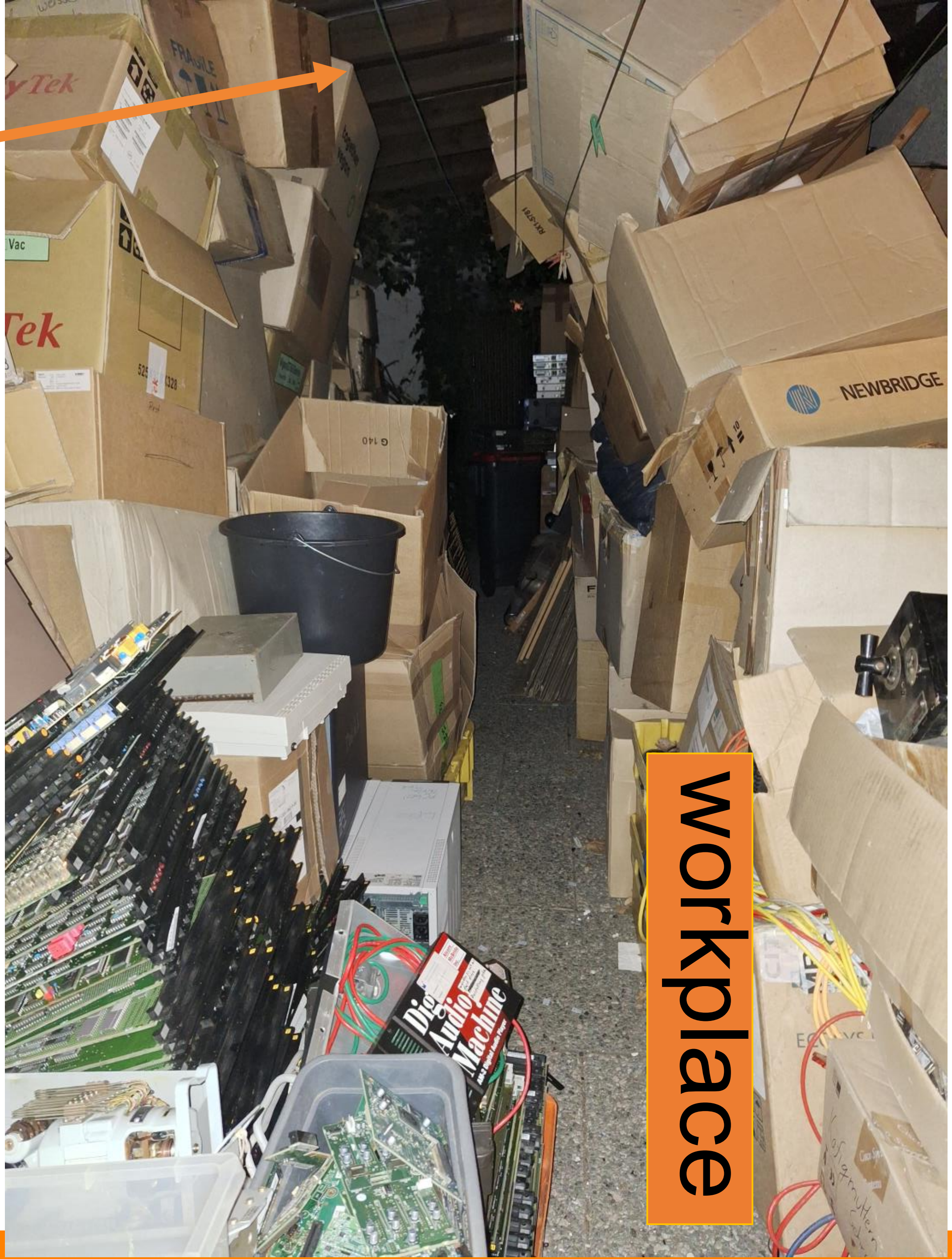
heat sink taken from an old Cisco 800

source: [14]

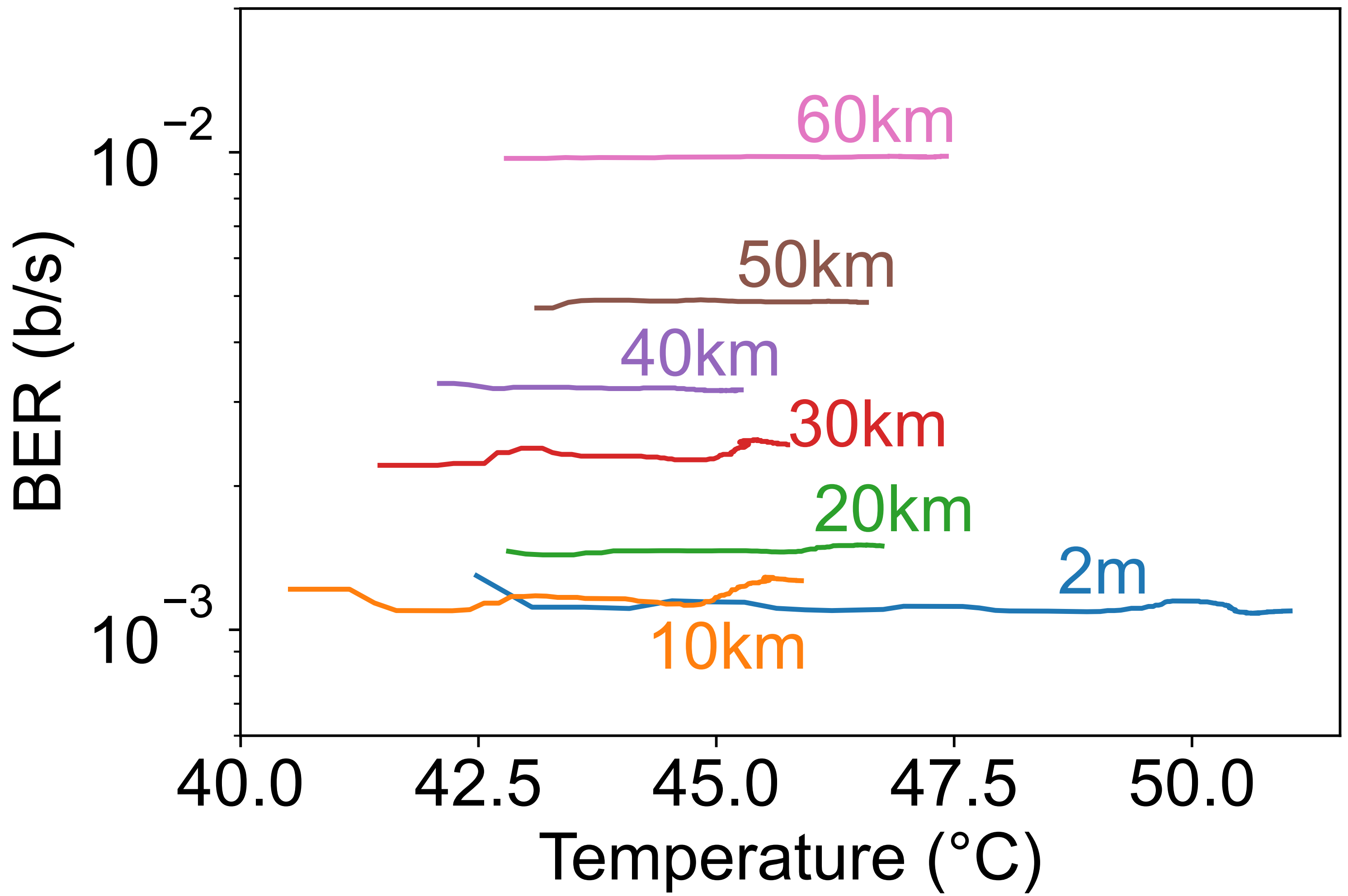
roof top

detailed separation





The coherent DD with cooling



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

Note: cFEC

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

Source [13]

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

Note: example with 2 meter Fiber

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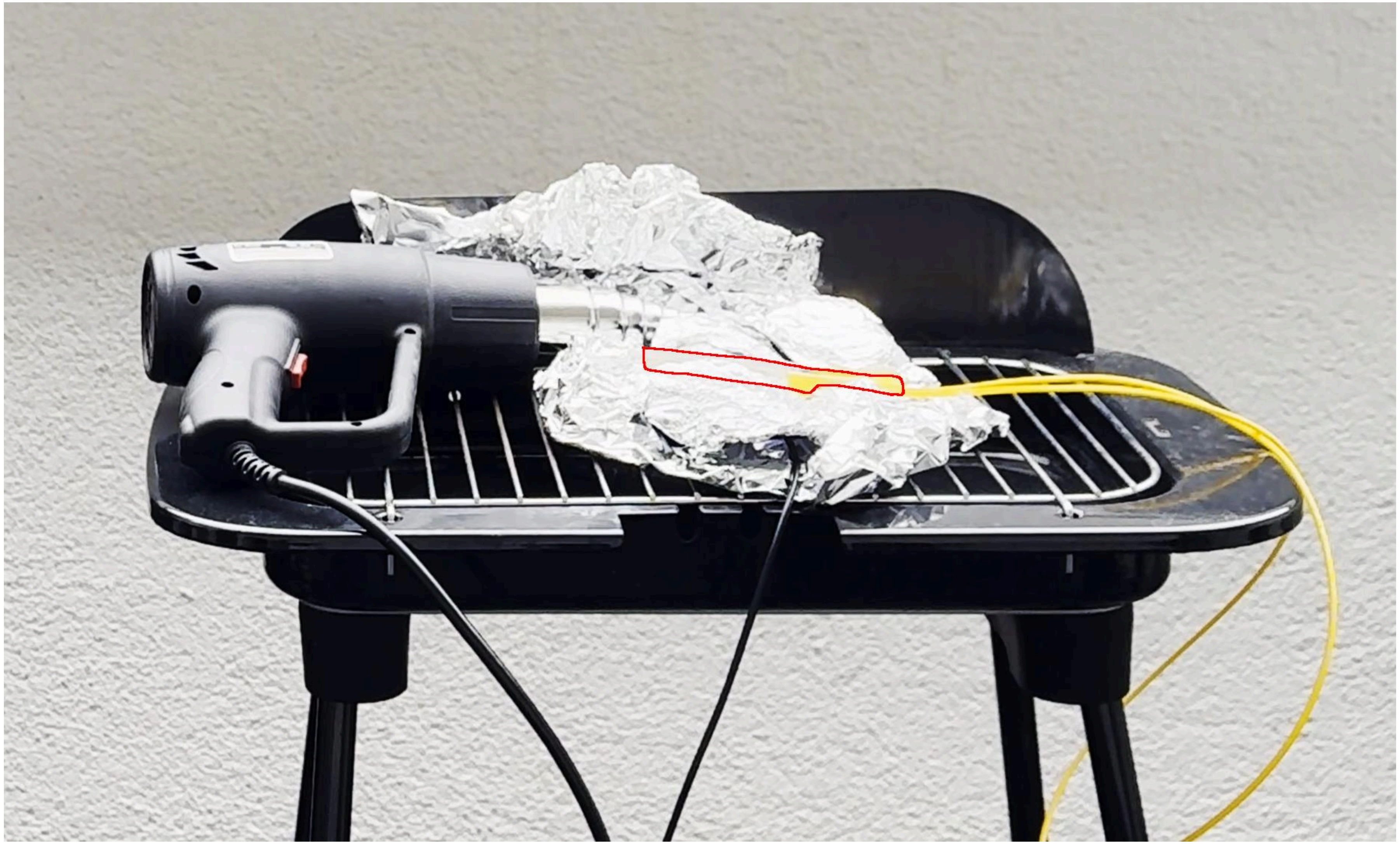

Note: example with 2 meter Fiber. Q.13S1HG.05

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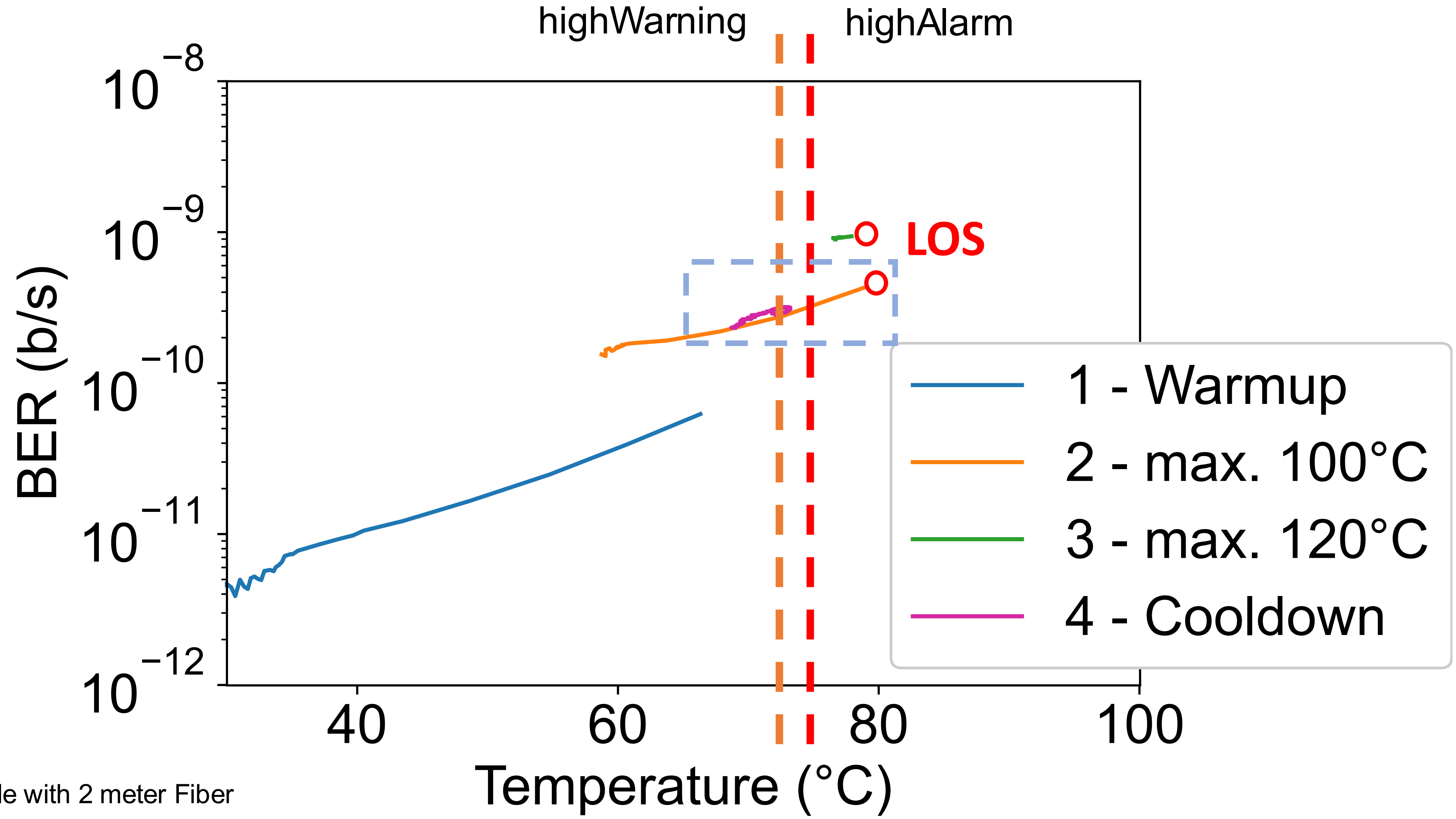
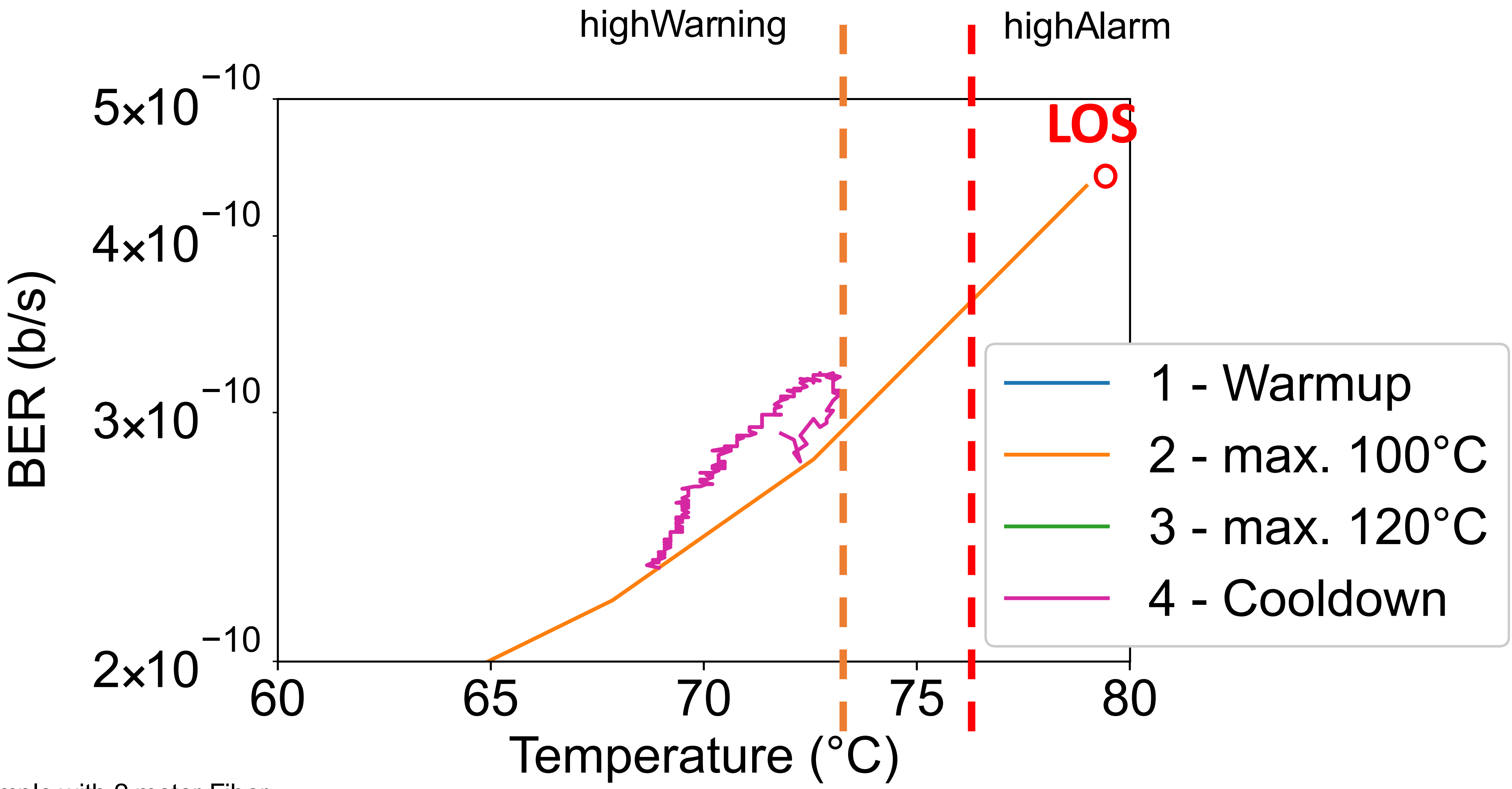


Note: example with 2 meter Fiber

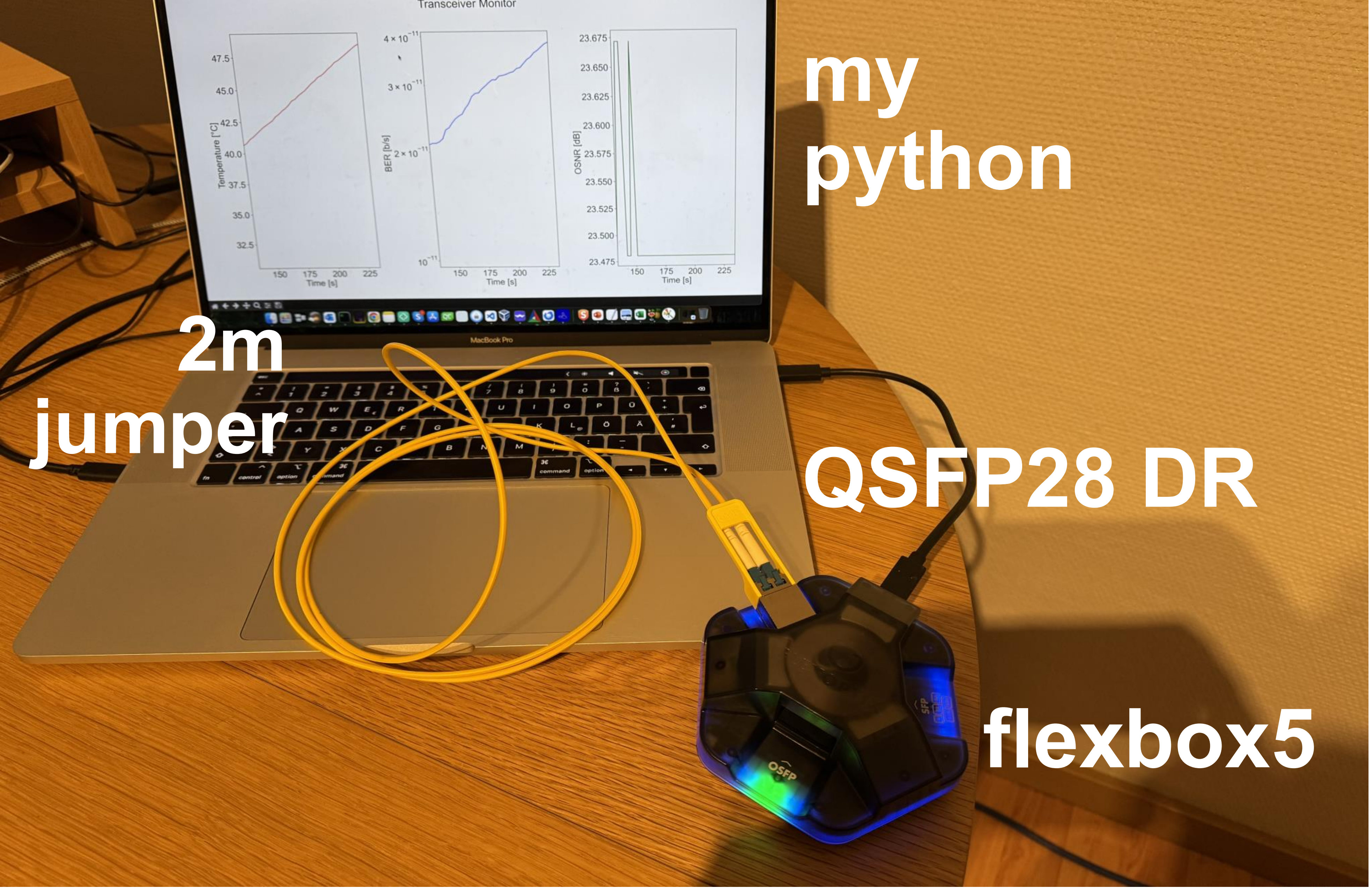
source: [15]

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



Note: example with 2 meter Fiber

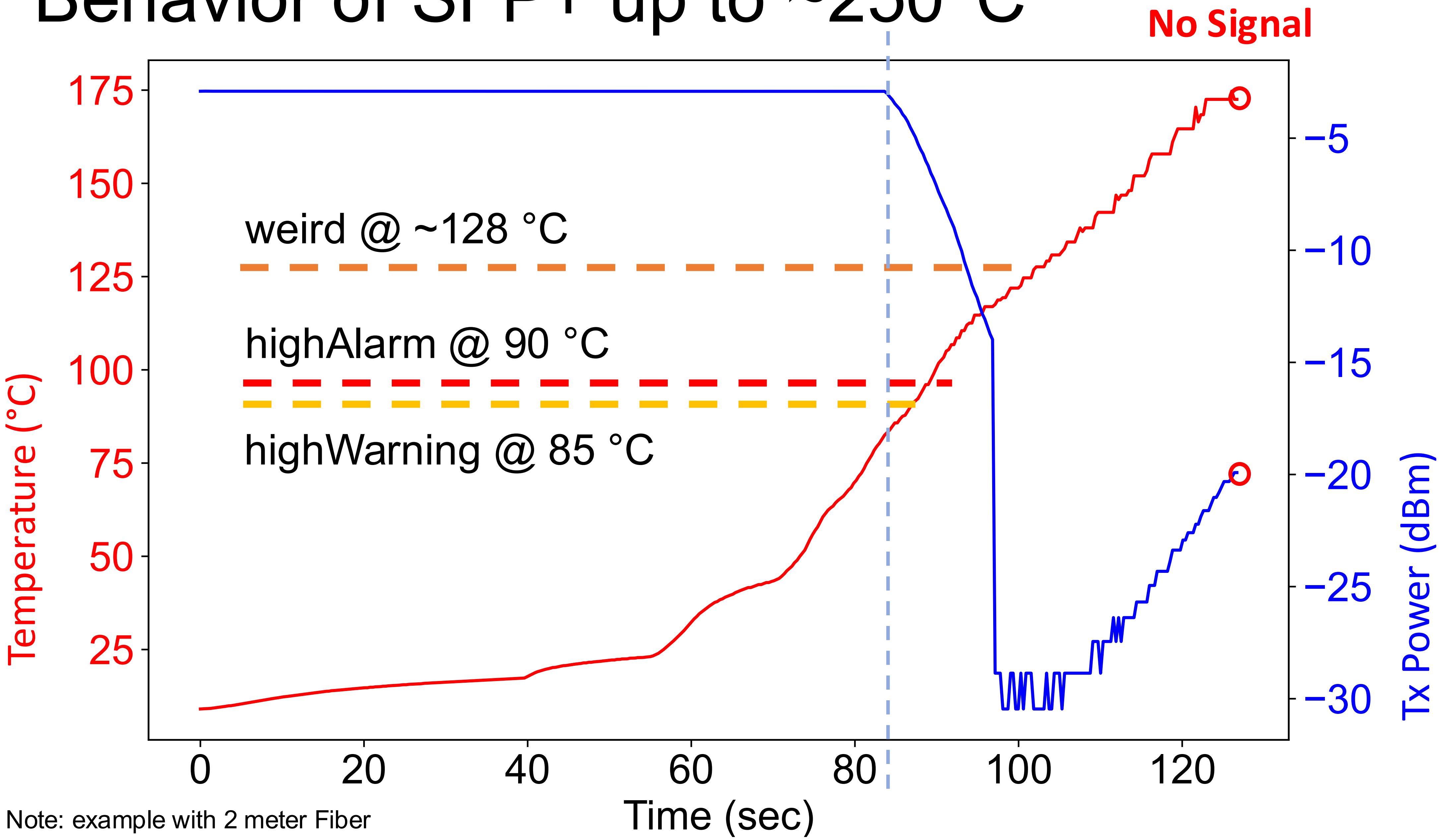
source: [15]

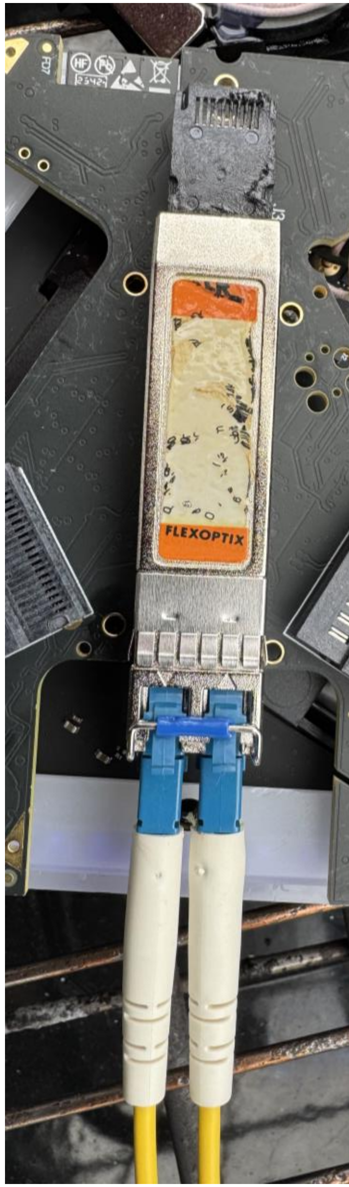


live demo

Video Link: https://cloud.flexoptix.net/index.php/s/X2zKs7WtSfPagay

Behavior of SFP+ up to ~250°C





Note: example with 2 meter Fiber

take aways

- BER on Direct Detection Transceiver (DDT, grey transceivers) depends on both temperature and fiber length
- BER is rolling average value, not an instant 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 <u>changes</u>, 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.

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

take aways

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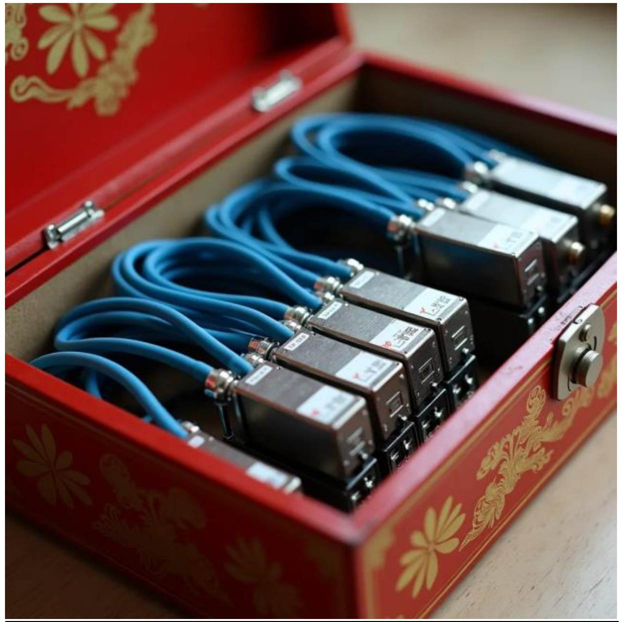

FLUX AI: ”Chinese restaurant take away box filled with tranceivers” !!!

FLEXOPTIX

Thank you

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