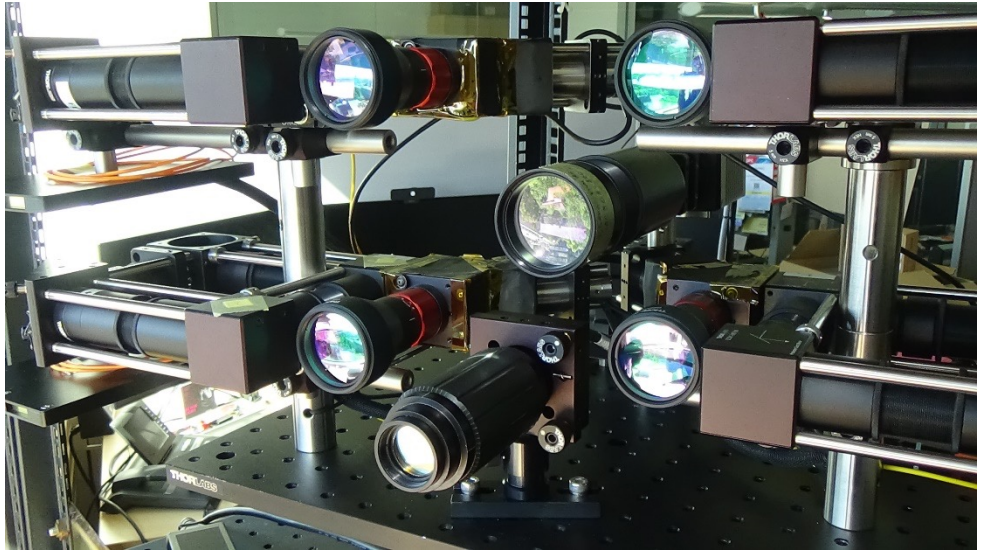
Real-Time 10 Gbit/s Digital Combining Over a 3 km Free-Space Optical Link With Multi-Aperture Receiver

P. Hanne, A. Arnould, N. Perlot, A. Johst, B. Bernhardt, M. Rothe, R. Freund



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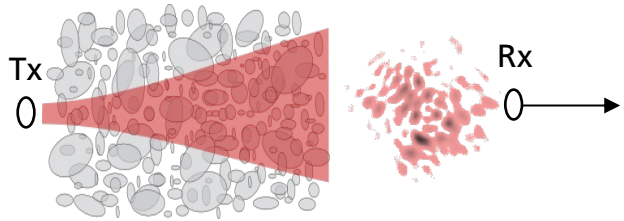
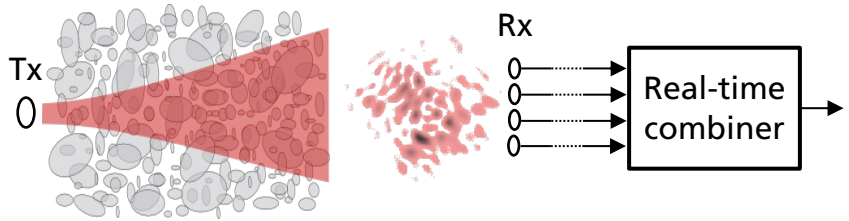
Atmospheric optical communications

Multi-aperture receiver and combining





- Atmospheric turbulence: power fades (milliseconds timescale)
- Bursts of bit errors

- One solution: Multi-aperture receiver and diversity combining
- In this work: **10 Gb/s digital real-time combining**

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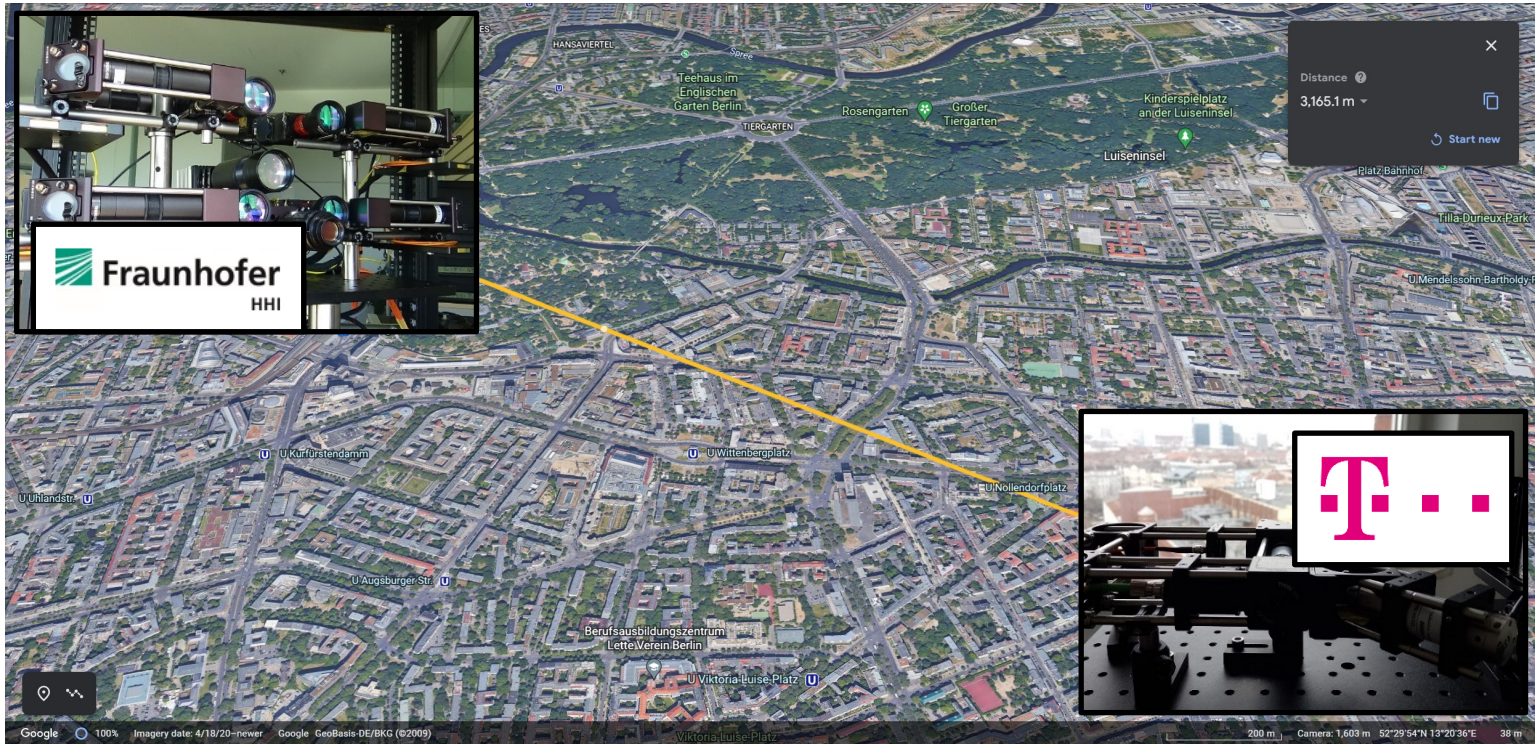
Experimental setup

3 km FSO link



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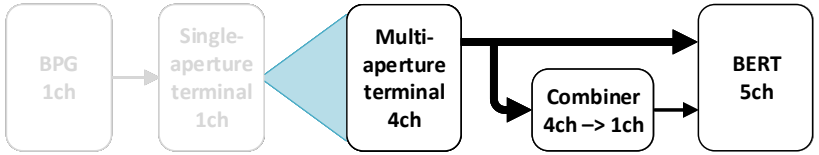
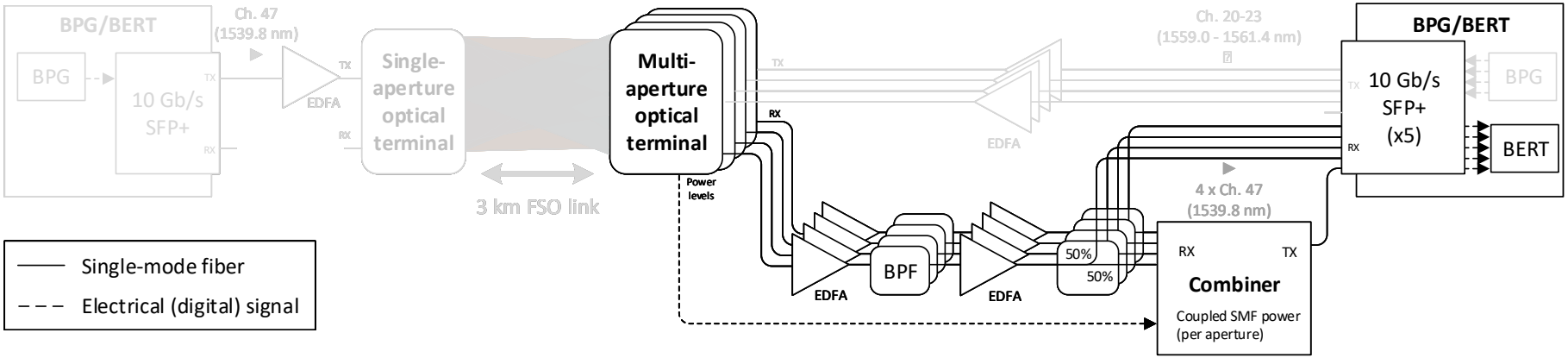
Experimental setup

Communication chain





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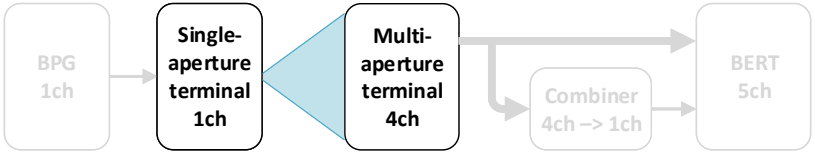
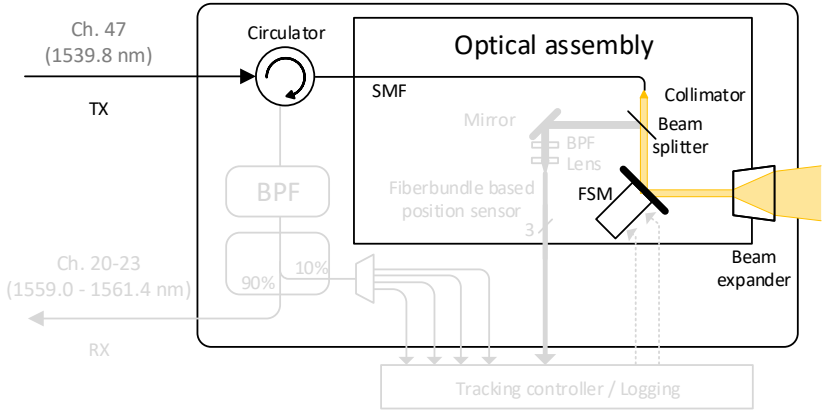
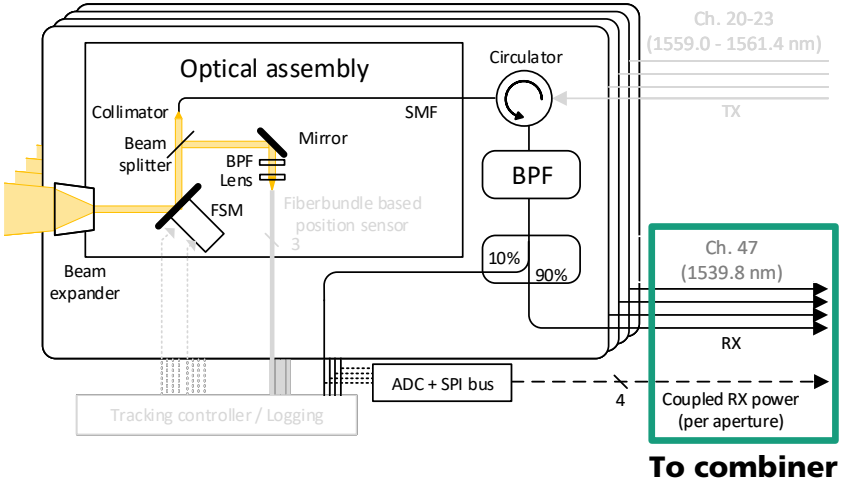
Experimental setup

Optical terminals







- TX: 10 Gbit/s signal from SMF to FSO
- RX: 4 diversity optical signals from FSO to SMF

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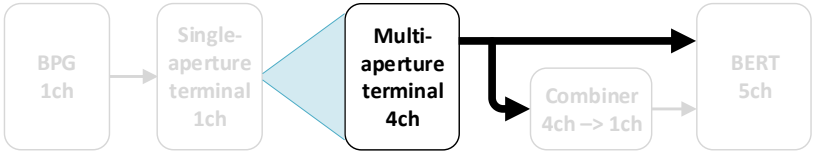
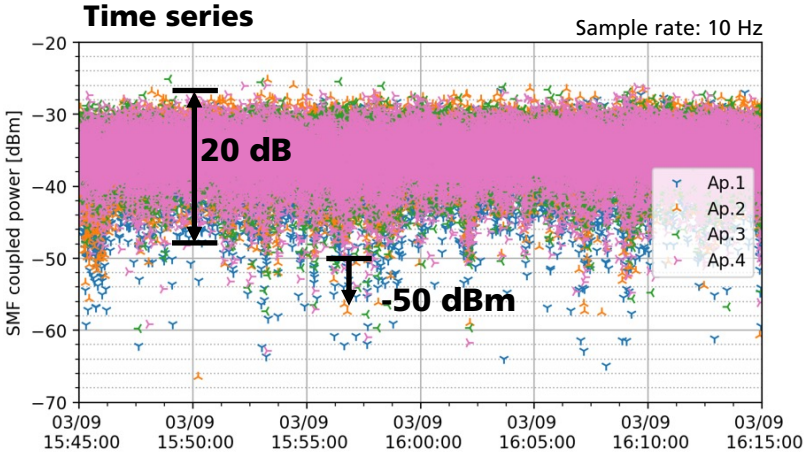
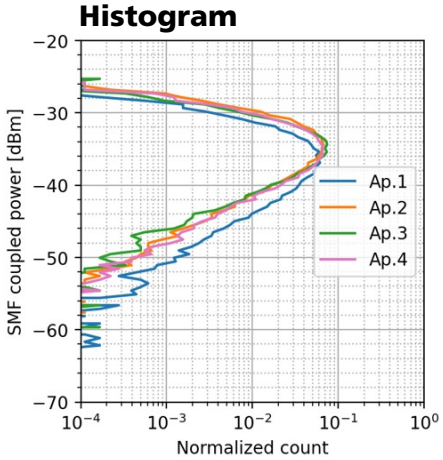
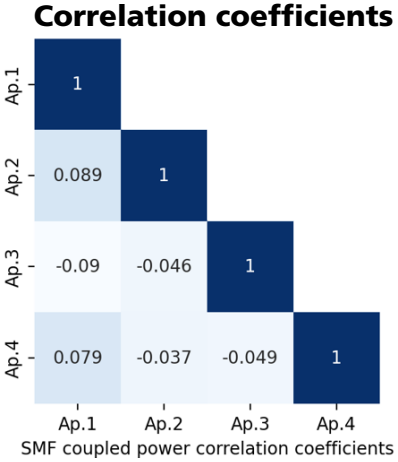
Experimental setup

Received optical power









SMF coupled power levels of individual apertures (Ap.)

- >20 dB range, strong fades with optical power < -50 dBm
- Power values of time series uncorrelated

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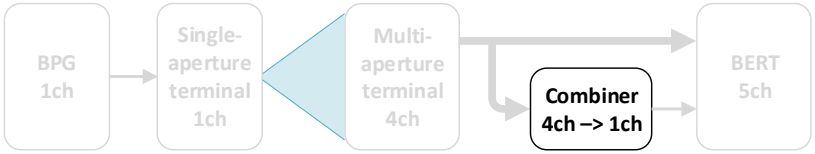
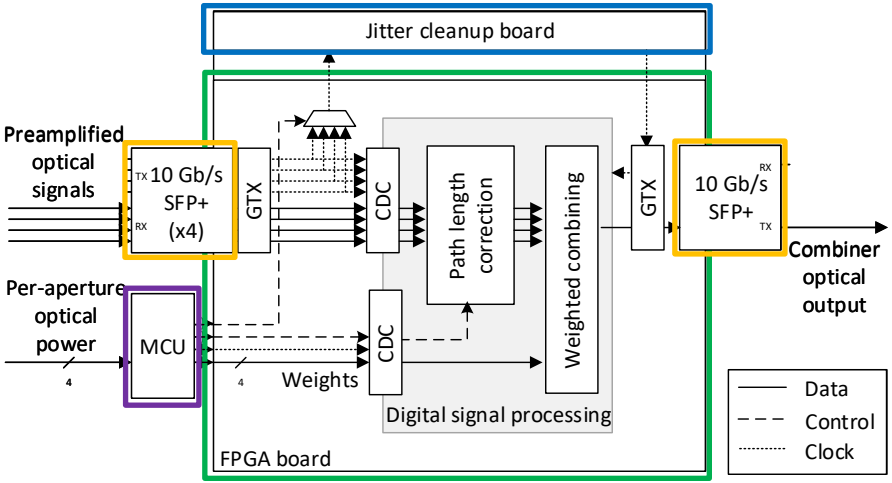
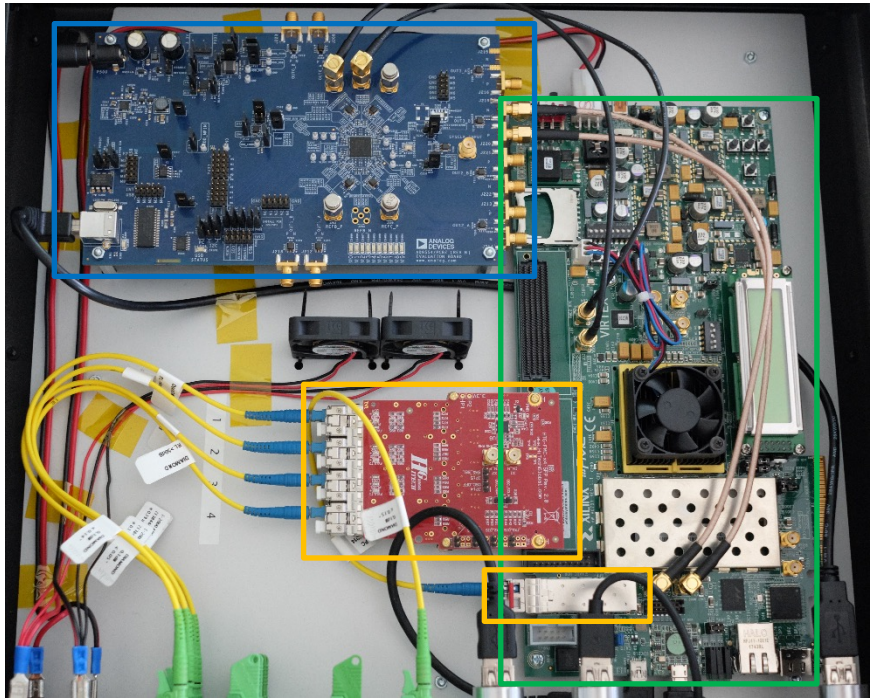
Real-time combiner

Architecture







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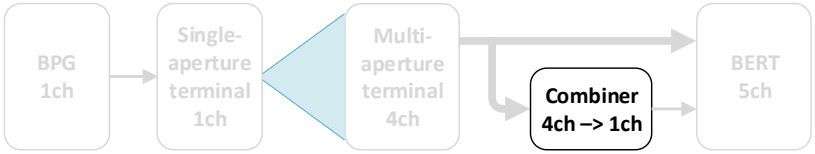
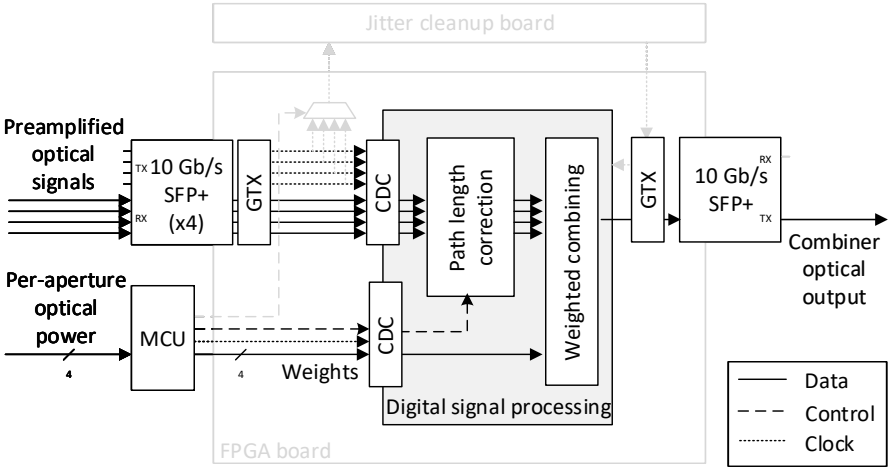
Real-time combiner

4-signal weighted combining





Clocking

- Requires one clock domain for processing and sending data
- One recovered clock –> reference

Processing

- Data transferred to DSP clock domain
- Time synchronization of data streams
- Weighted combining

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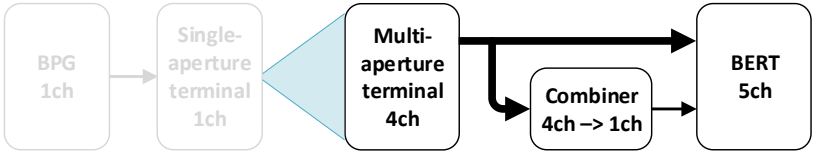
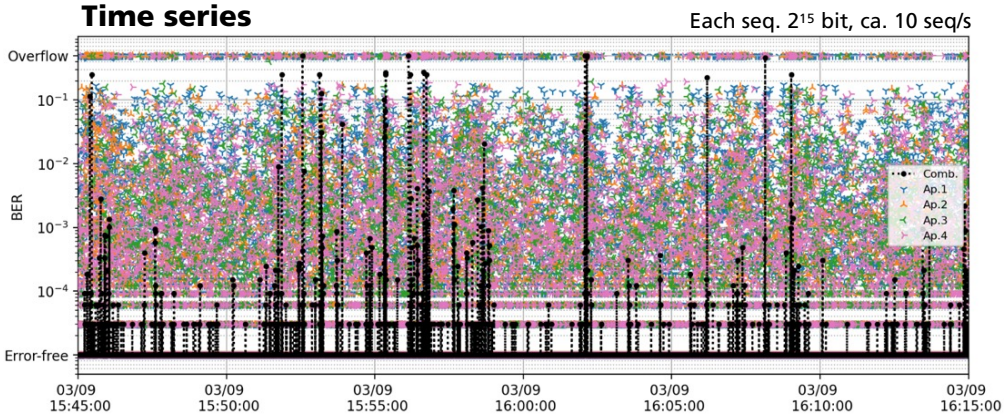
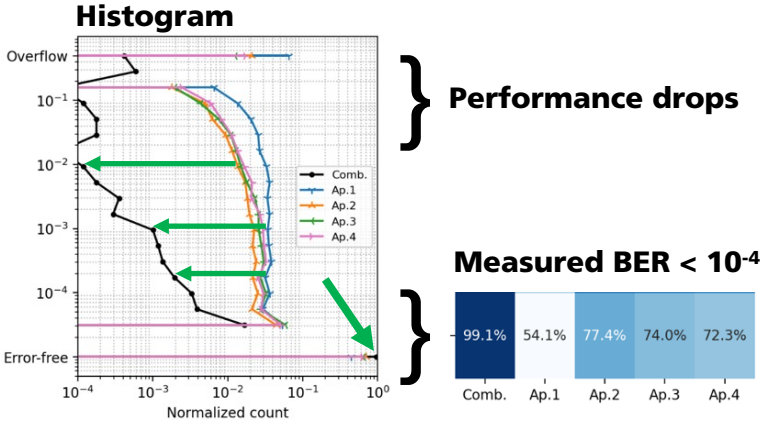
Real-time combiner

Performance







BER improvement compared to signals of individual apertures

- Combiner distribution shifted to less counts region
- Still few drops in combiner performance
- **99%** of combined signal **BER ≤ 10^{-4}**

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Conclusions

- Multi-aperture to compensate fades
- FPGA combiner for real-time weighted combining of diversity signals
  - 10 Gb/s with SFP+
  - Tested over 3 km FSO link
  - Tests showed significant improvement of BER distributions
- Next steps: long-term tests, combining on bidirectional data transmission

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