

# Bidirectional PAM-4 Experimental Proof-of-Concept to Double Capacity per Fiber in 2-km Data Center Links

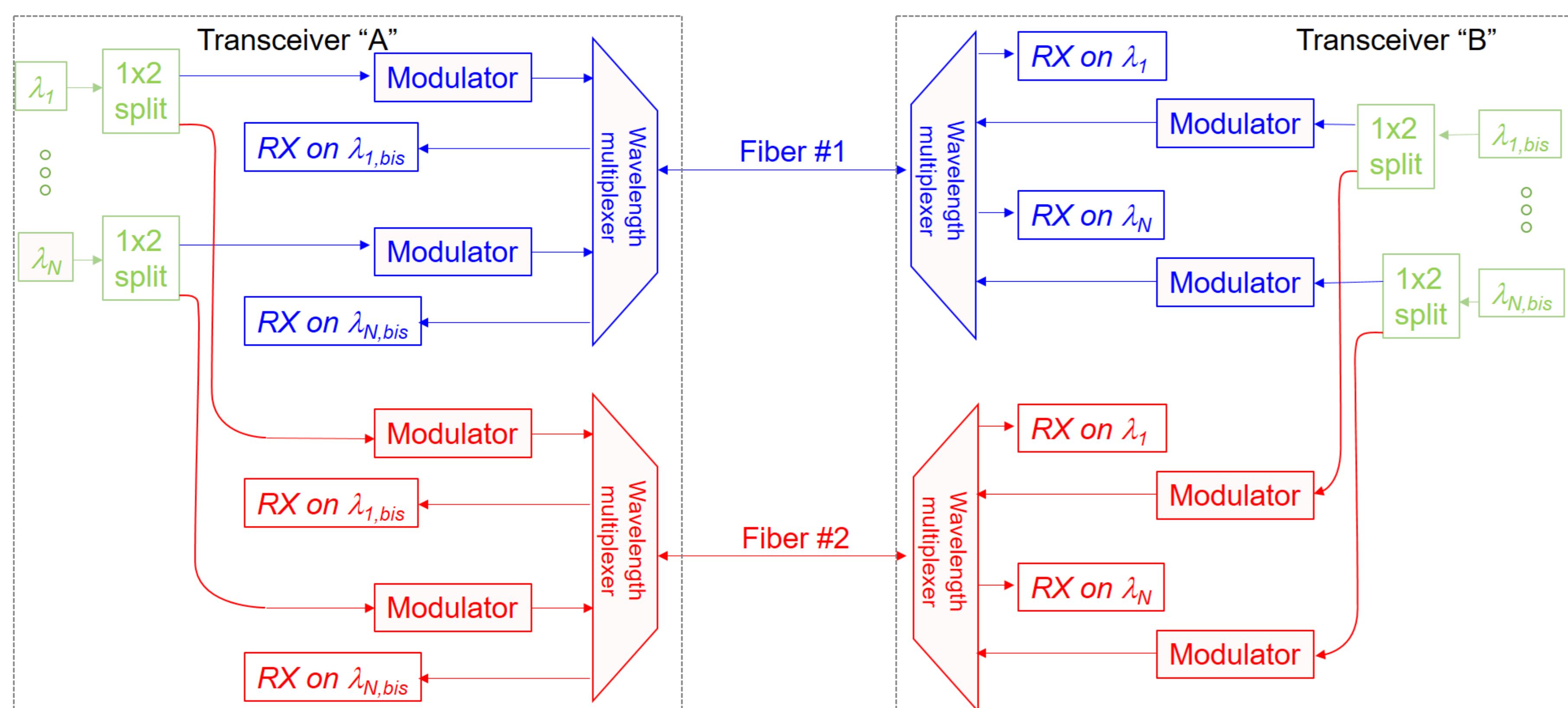
A. Nespola<sup>1</sup>, L. Bertignono<sup>2</sup>, D. Pileri<sup>2</sup>, F. Forghieri<sup>3</sup>, M. Mazzini<sup>3</sup> and R. Gaudino<sup>2</sup>

Istituto Superiore Mario Boella<sup>1</sup>, via P. C. Boggio 61, 10138 Torino – Italy [nespola@ismb.it](mailto:nespola@ismb.it)

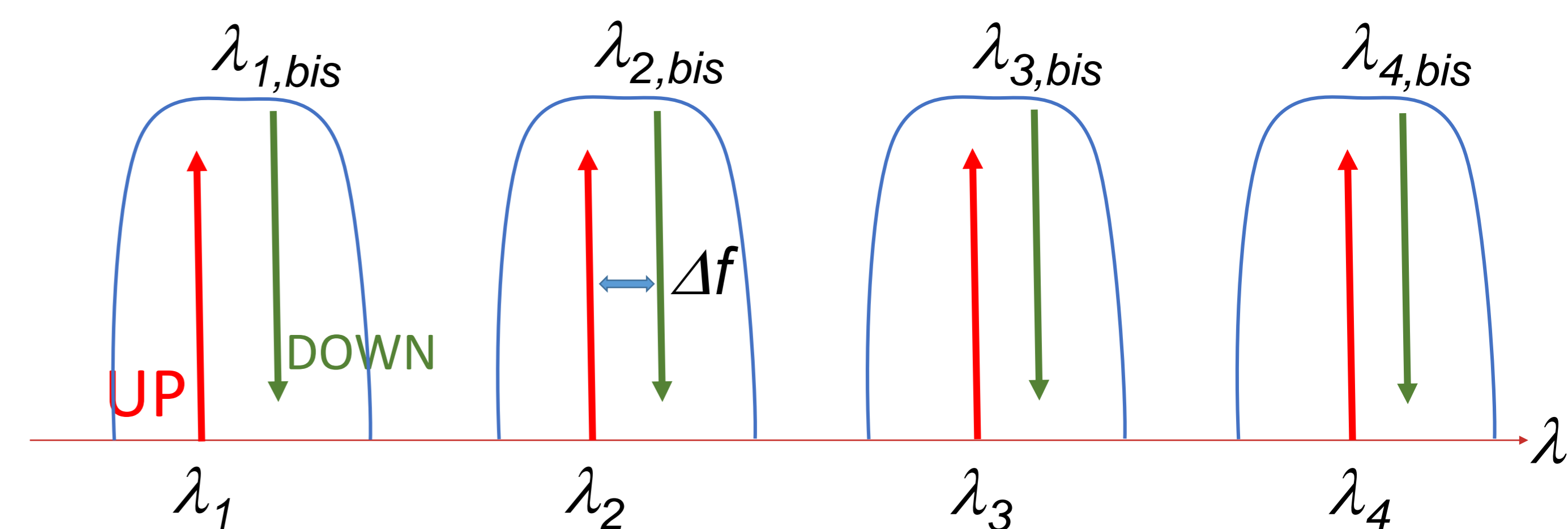
Politecnico di Torino<sup>2</sup>, C. so Duca degli Abruzzi 61, 10129 Torino – Italy, [luca.bertignono@polito.it](mailto:luca.bertignono@polito.it); [gaudino@polito.it](mailto:gaudino@polito.it)

Cisco Photonics Italy srl<sup>3</sup> 20871 Vimercate (MB) – Italy [forghie@cisco.com](mailto:forghie@cisco.com)

**Abstract:** We propose the use of bidirectional transmission to double the effective capacity over (each available) fiber in short-reach (2km) data-center links using direct-detection PAM-4. In particular, we experimentally show the conditions under which spurious reflections give a limited power penalty.



General schematic

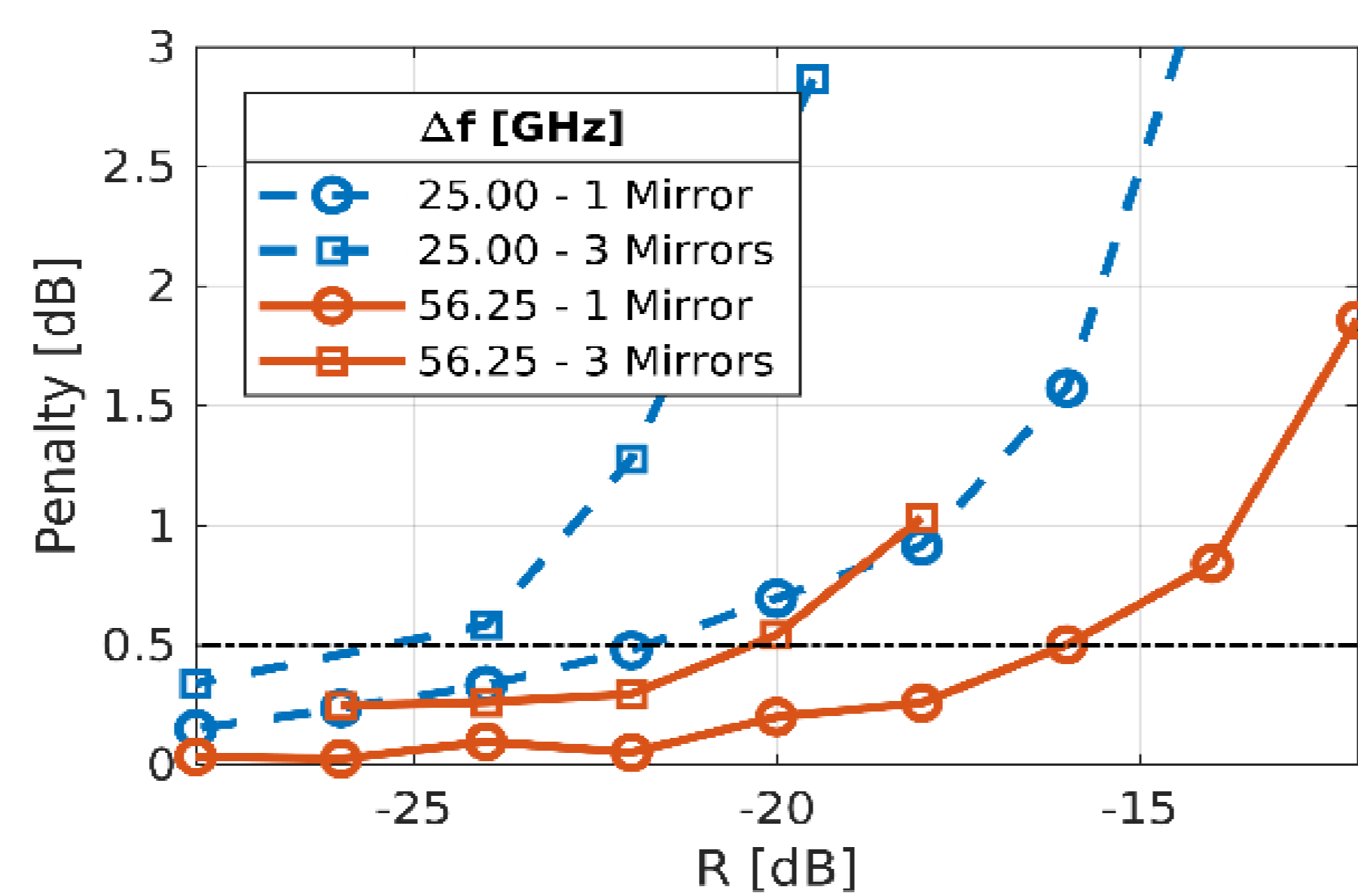
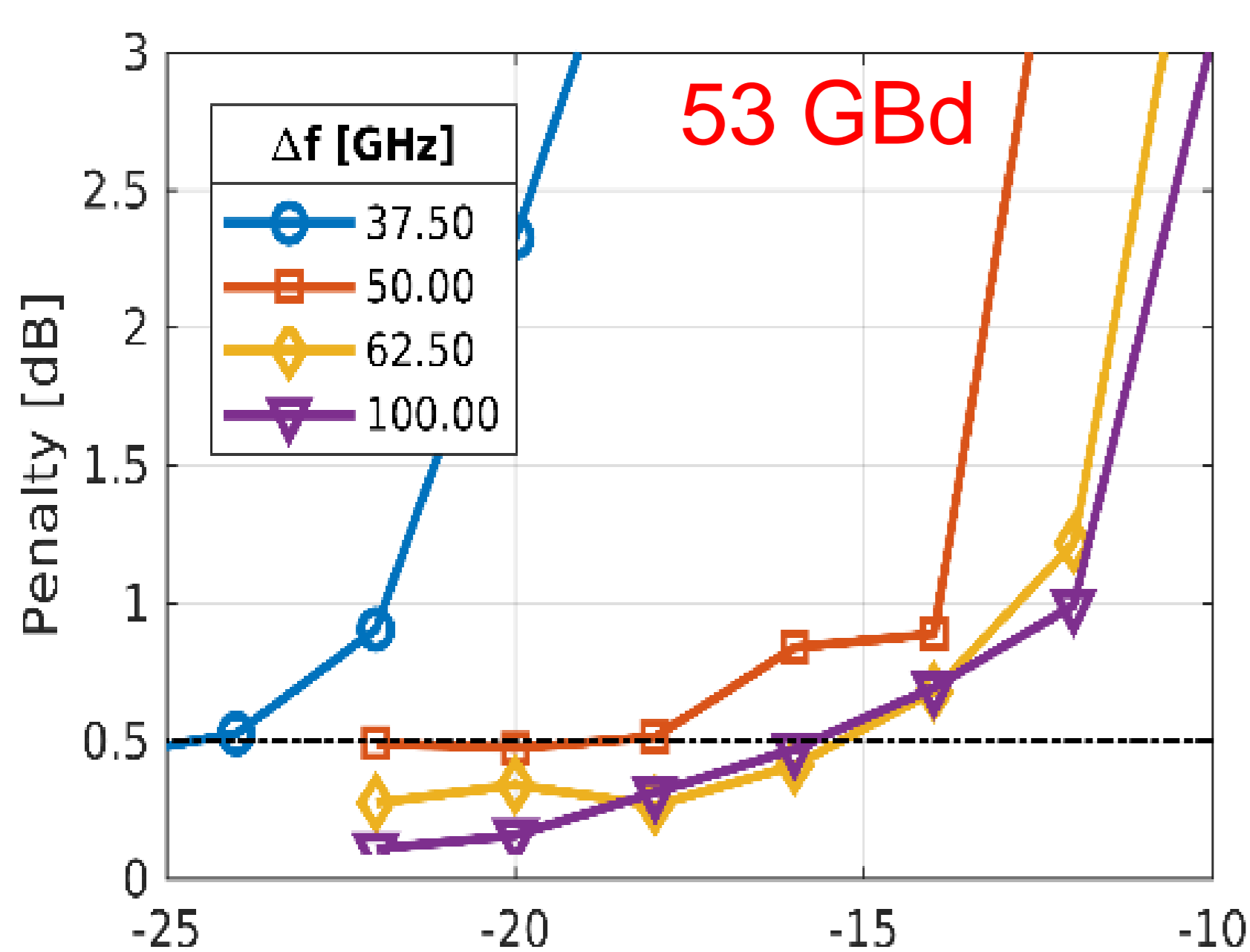
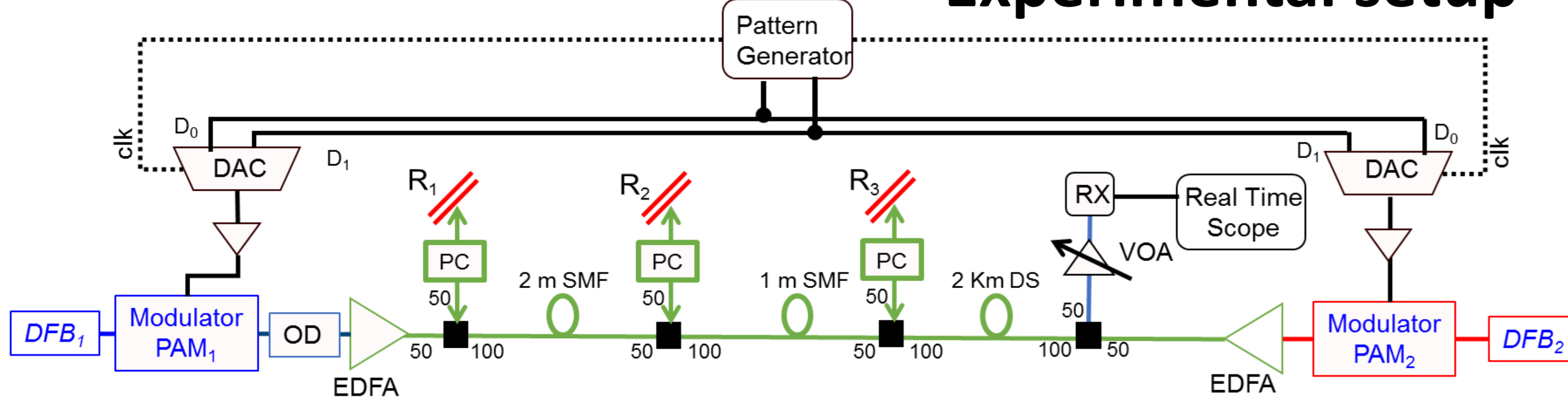


Proposed frequency allocation

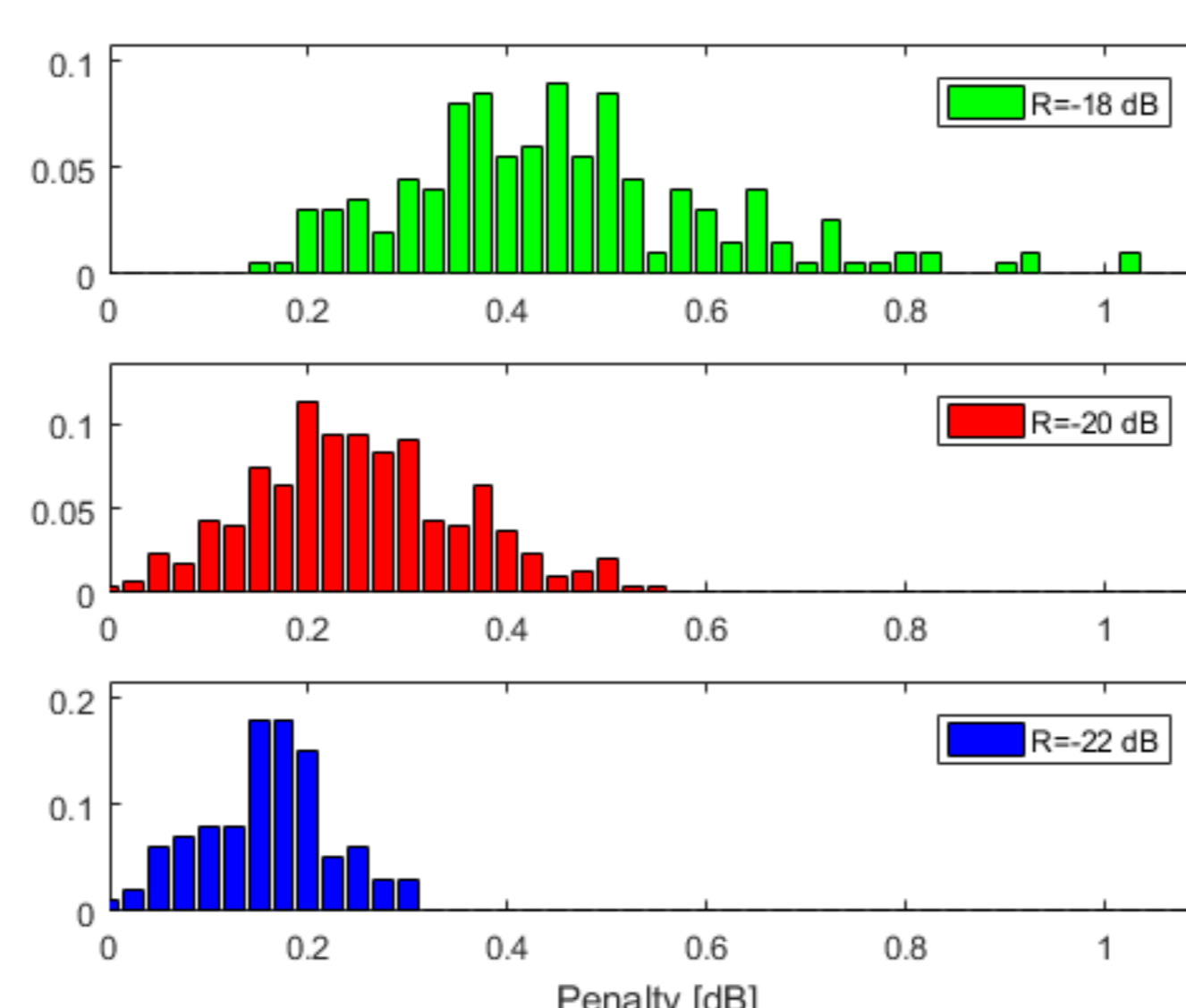
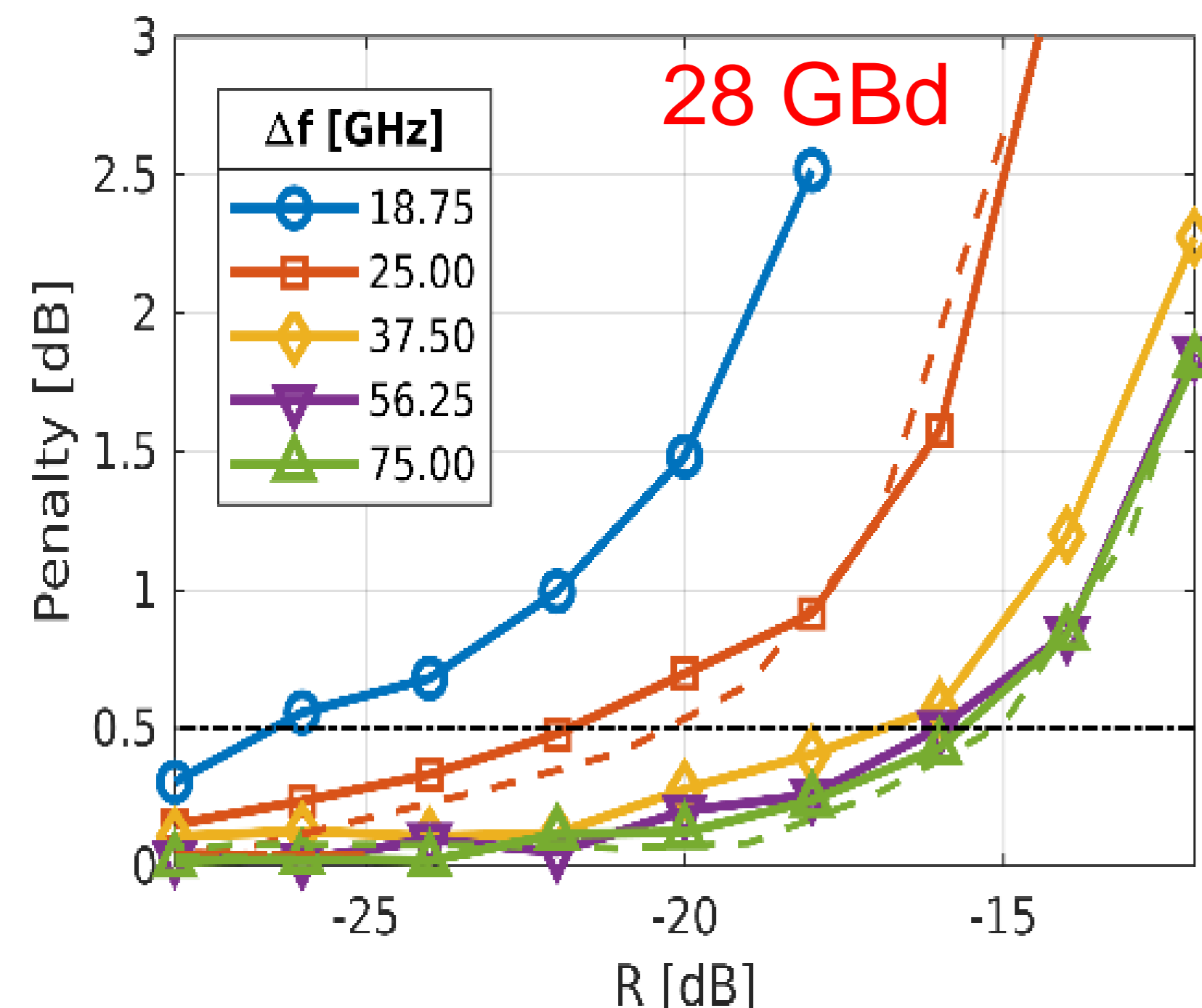
Modulation Format	PAM-4
Net bit rate	50 or 100 Gbps
Gross baud rate	28 or 53 GBd
Target BER (KP4 FEC)	$2 \cdot 10^{-4}$
TX: EML DFB	2 MHz linewidth
RX:	PIN receiver

Experimental parameters

Experimental setup



Power penalty vs. Reflection for one and three reflection points, at 28 GBd and for different spectral separation  $\Delta f$ .



Histograms of the measured penalty for repeated BER measurements for three different reflection values and three reflections. Parameters: 28 GBd,  $\Delta f=56$  GHz.

Penalty vs. Reflection for a single reflector, at 53 GBd (a) and 28 GBd (up), for different spectral separation  $\Delta f$ . We also superimposed with dashed line the results of numerical simulations in Matlab

## Conclusions

We have experimentally demonstrated that high baud rate (28 GBd and 53 GBd), short distance (2Km) PAM-4 transmission can be made bidirectional on each single fiber, thus doubling system capacity, with less than 0.5 dB power penalty, provided that:

- 1) The spectral separation  $\Delta f$  between the two lasers is greater than twice of the baud rate.
- 2) Individual reflection points generate reflections smaller than  $R=-20$  dB.

The only issue to implement the proposed scheme will be developing a suitable servo-mechanism to keep the spectral separation of the lasers always above twice the baud rate. At 53 GBd this would mean a tuning range of the lasers of less than 1 nm in O-Band, which can be also split between the two interfering lasers. This requirement is well within the thermal tuning range of currently used lasers for the short-reach market segments.