POLITECNICO DI TORINO

BIDIRECTIONAL 4-PAM TO DOUBLE PER-FIBER CAPACITY IN 2-KM INTRA-DATACENTER LINKS

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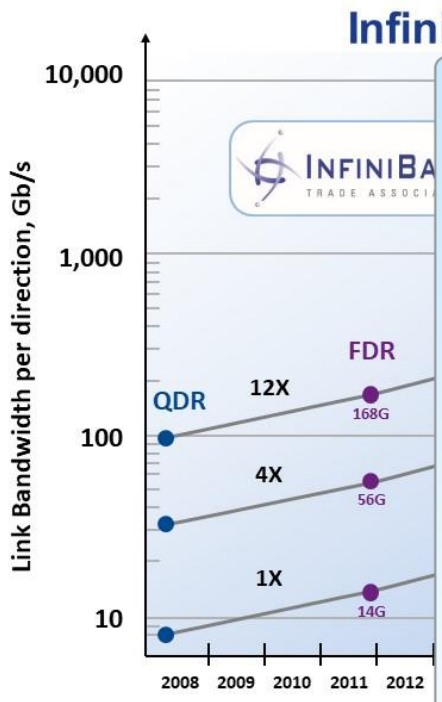
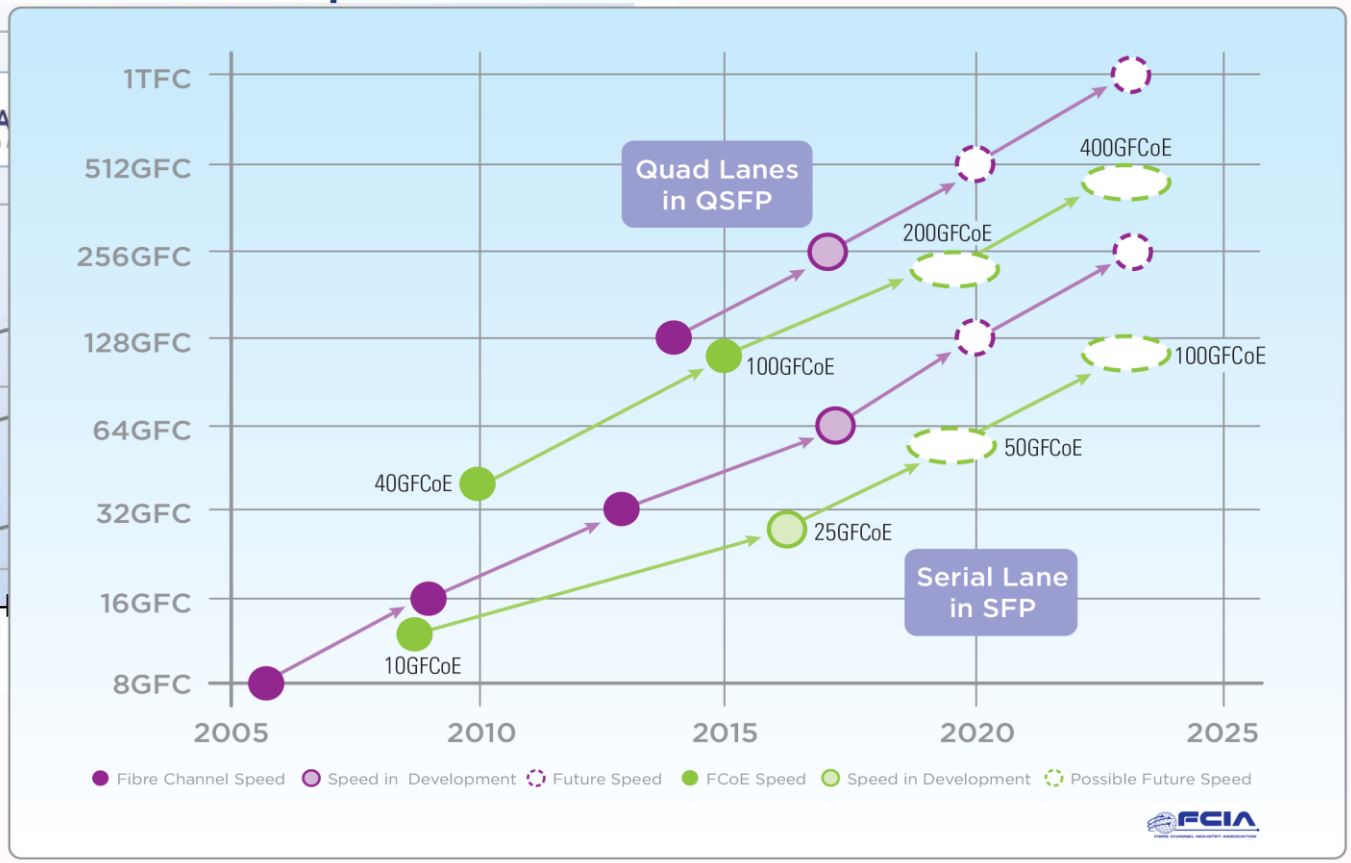
SPEED OF INTRA-DC INTERFACES

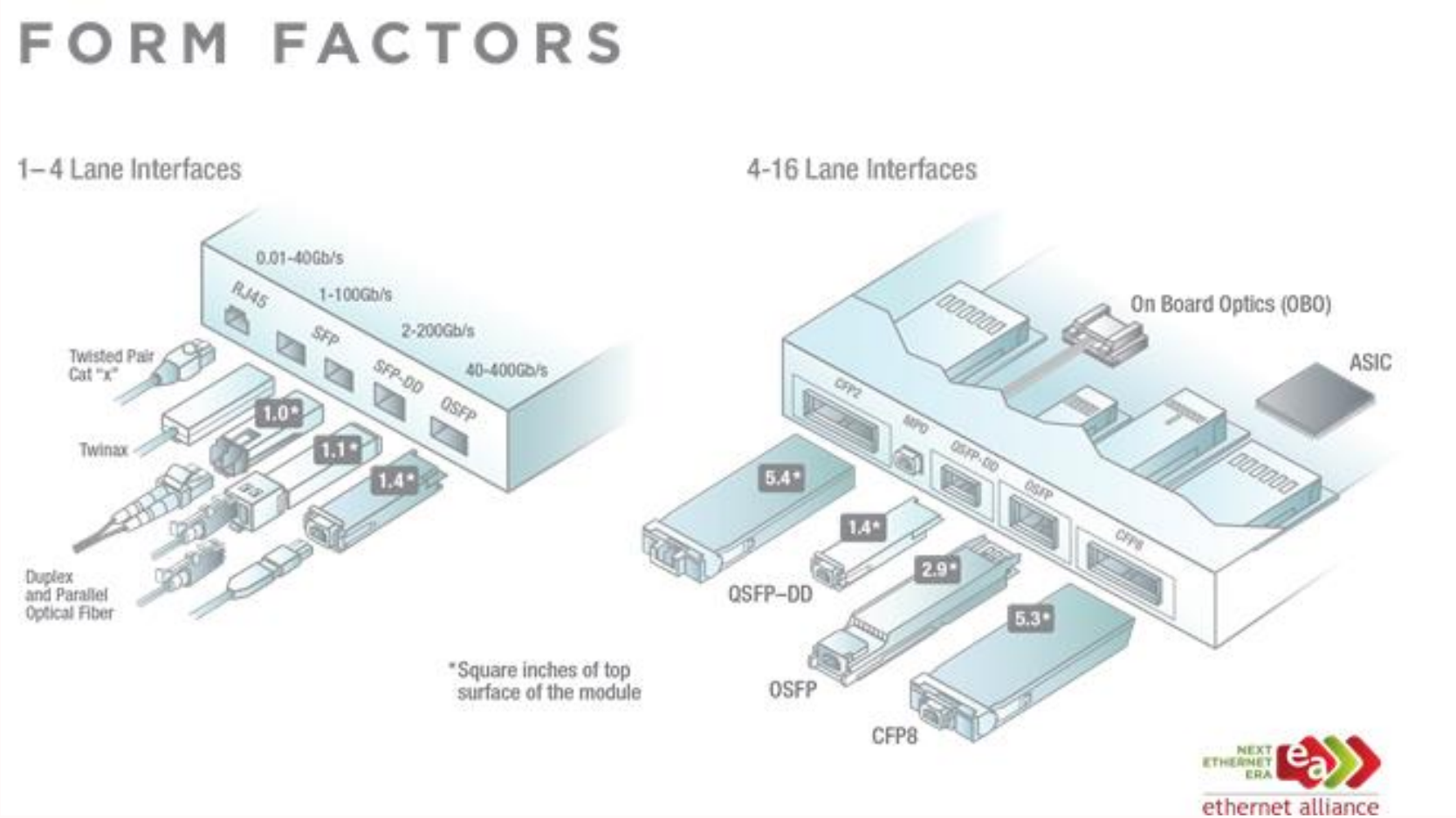
ETHERNET SPEEDS

Link Speed (b/s)





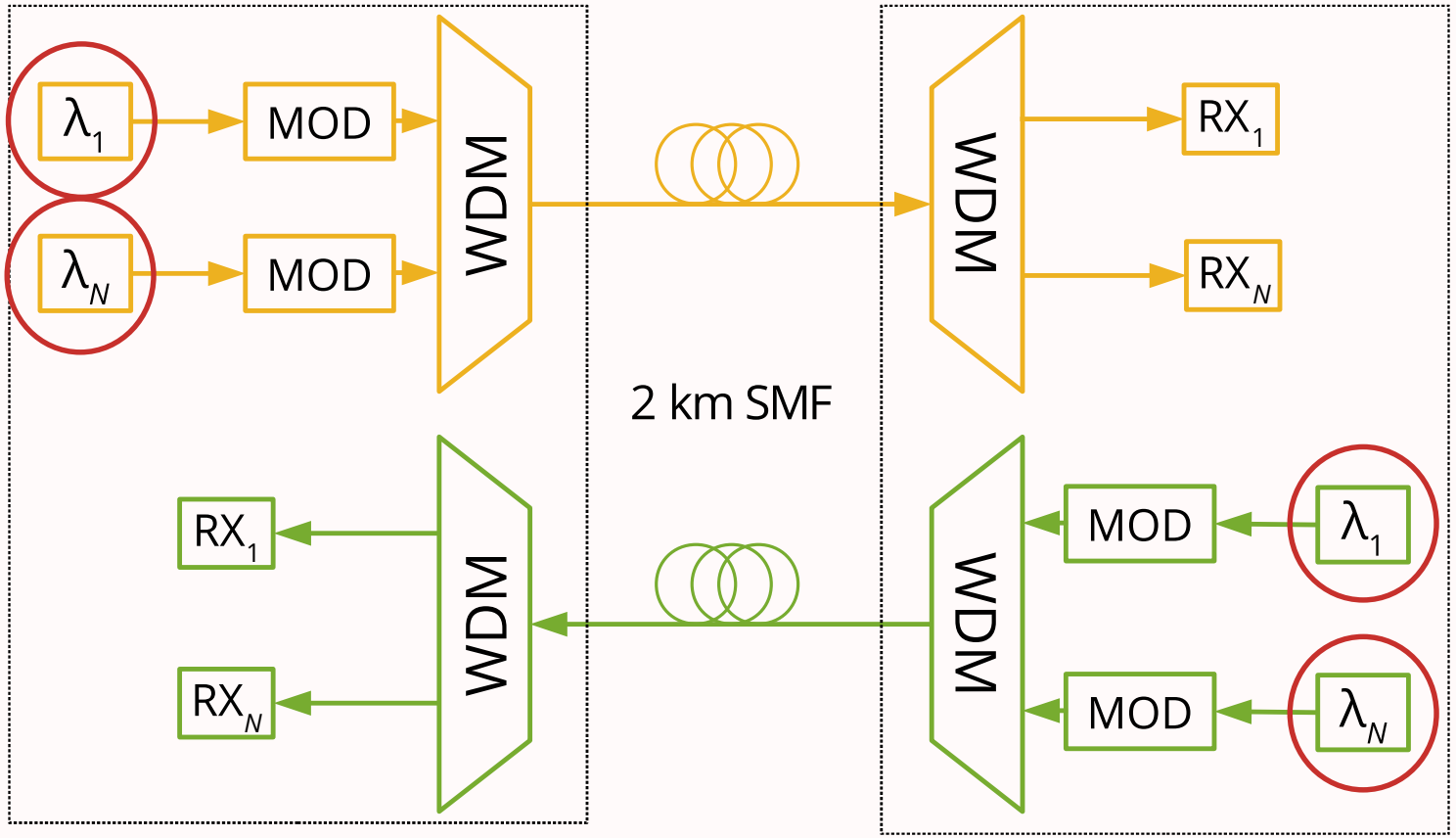
FORM FACTORS



REQUIREMENTS FOR FUTURE INTRA-DC LINKS

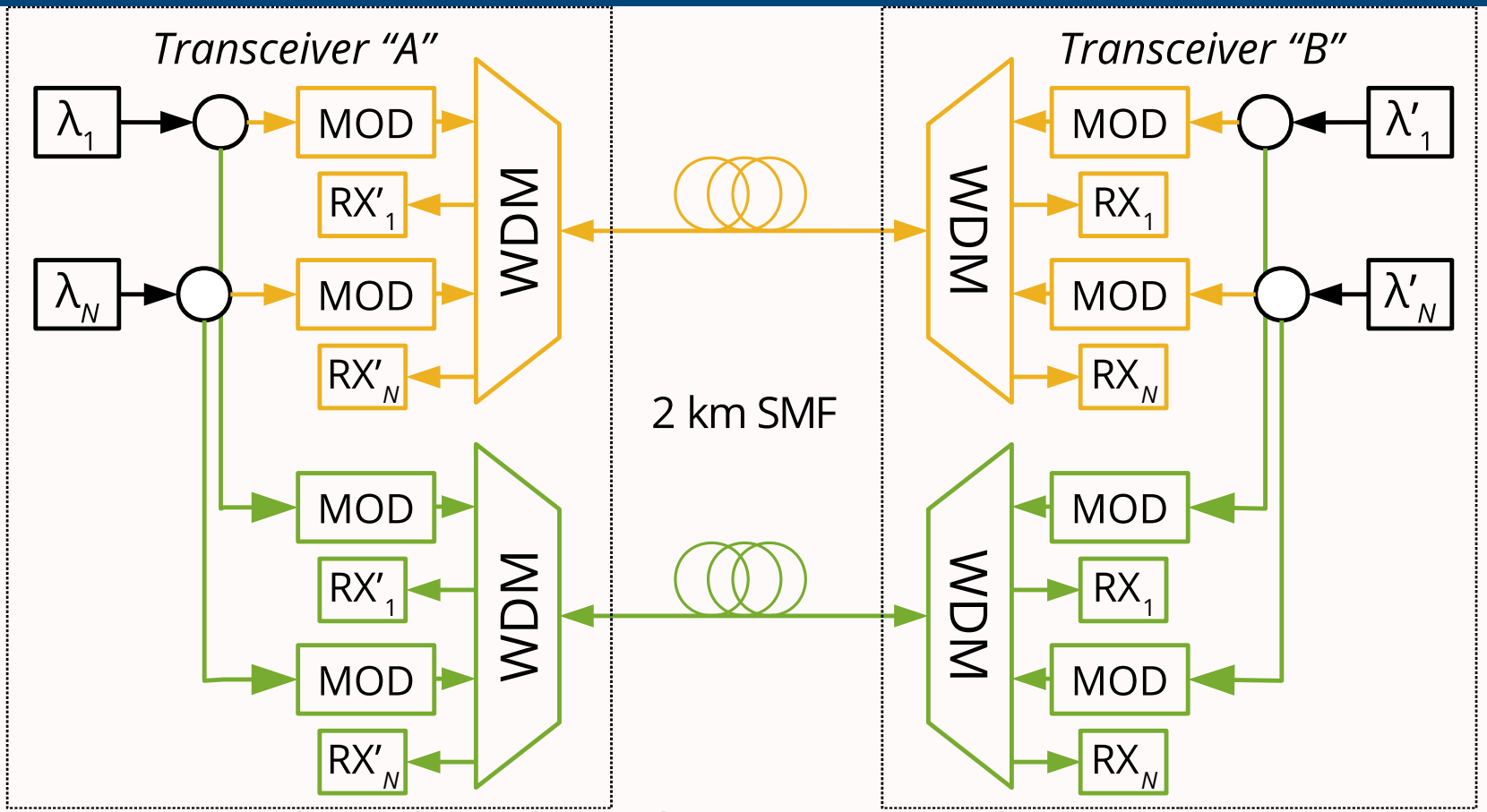
- Speed
- Cost
- Size
- Power consumption

400GBASE-FR8 STANDARD



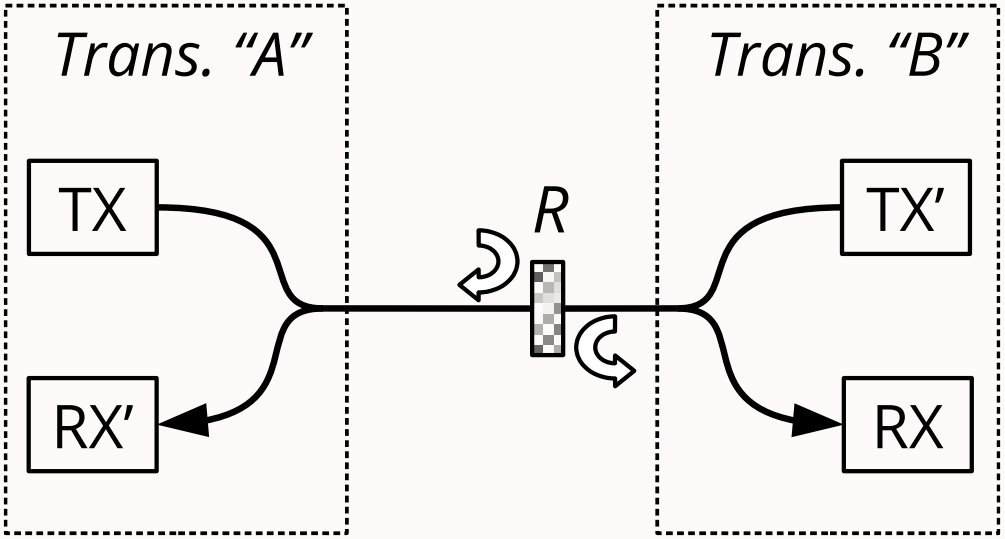
- 8 WDM channels, 800 GHz spacing
- 50 Gbit/s per channel
- Two transceivers, duplex SMF cable
  - *How to reduce power consumption?*

PROPOSED ARCHITECTURE

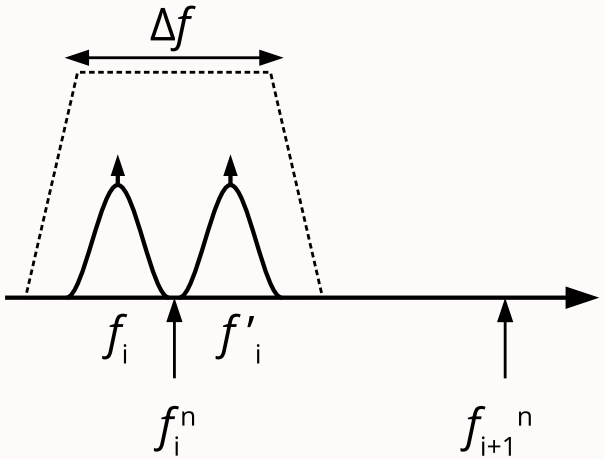


- Lasers are shared inside each transceiver (like MPO)
  - Duplex cable used simultaneously in both directions, like in PONs
- **Double** *per-laser* capacity
  - Unavoidable link-budget loss due to 3-dB splitters

MAIN ISSUE: BACK-REFLECTIONS



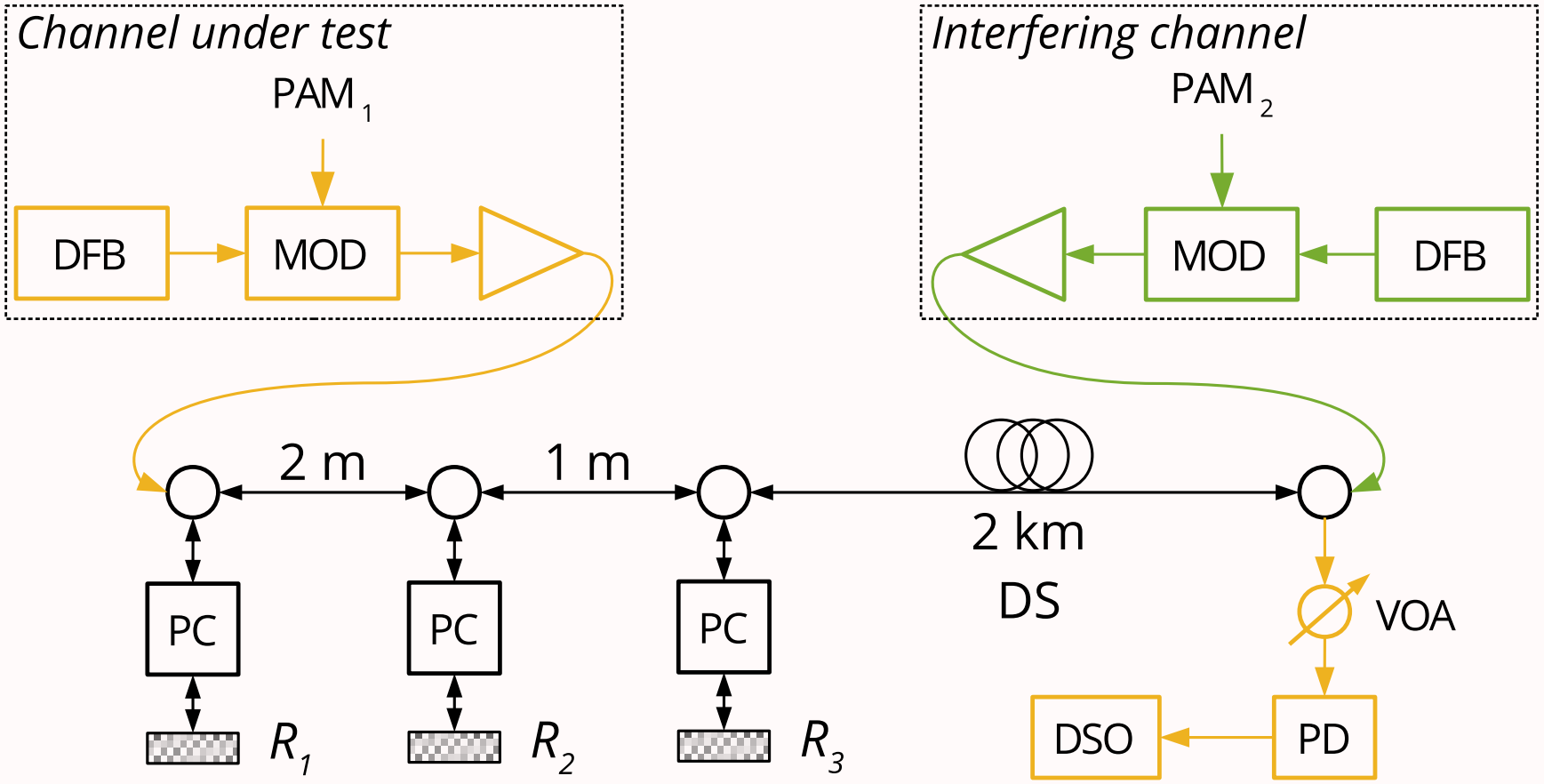
- Back-reflections cause coherent crosstalk
- PONs use completely different wavelength (in O- and C-bands)
- Proposal: *slight* detuning, staying in the same WDM channel



GOAL OF THIS WORK

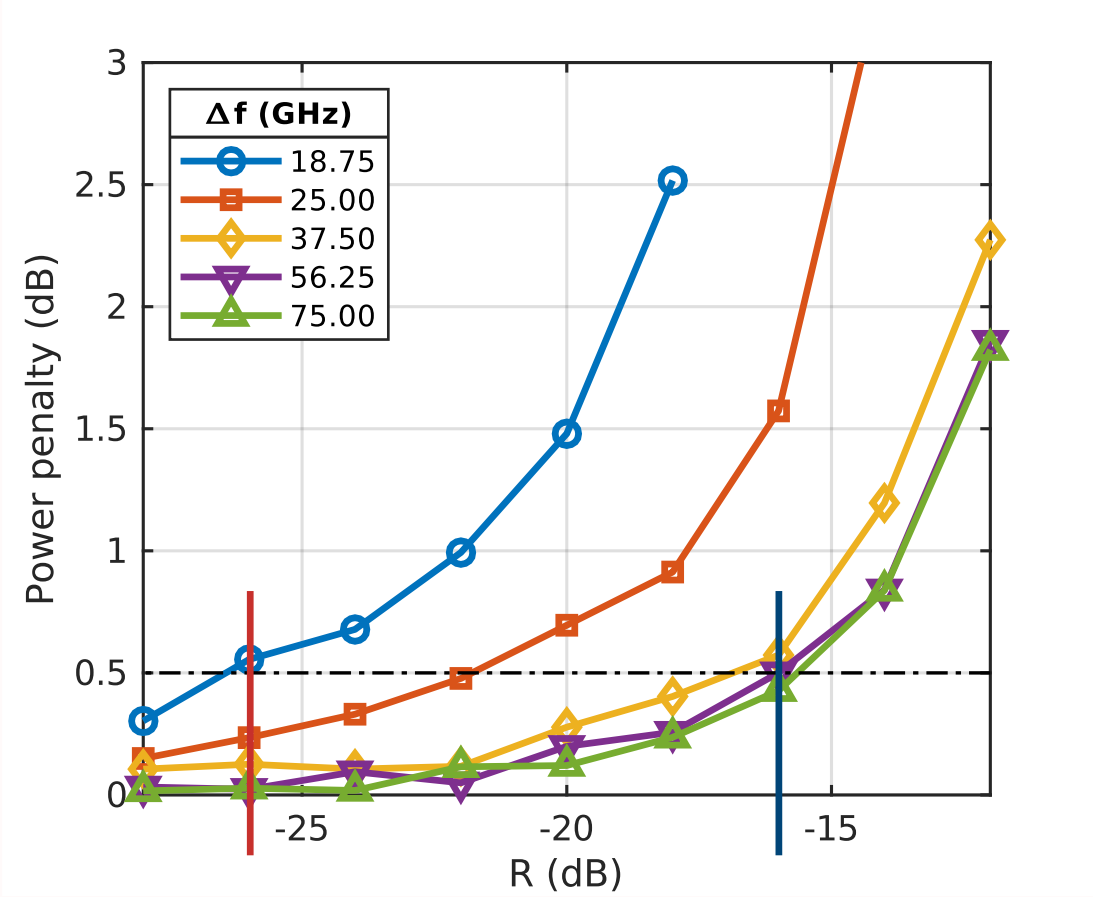
- **Back-reflection penalty** as a function of **laser frequency separation** for 2-km PAM-4 links
- Demonstrate that a *small* separation is sufficient to keep penalty *low* (<0.5 dB) for "standard" reflections
  - For instance, legacy TIA-568 LC connectors have a maximum back-reflection of -26 dB

EXPERIMENTAL SETUP



- 1550-nm transmission using DS fiber to emulate 1310-nm
- 53 GBaud or 28 GBaud PAM-4
- BER threshold: 2×10^{-4} (KP4 FEC)

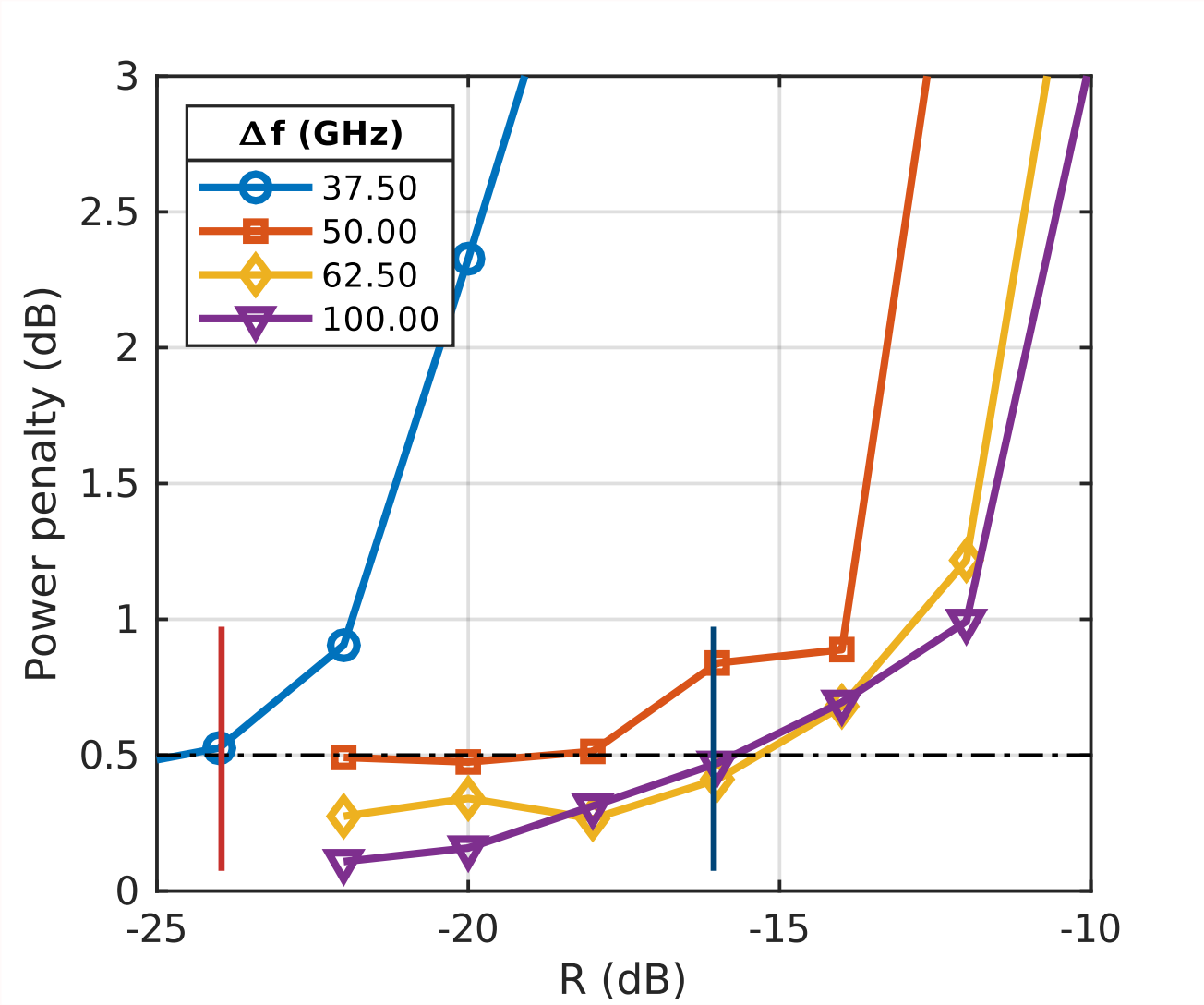
SINGLE REFLECTION RESULTS – 28 GBAUD



KEY TAKE AWAY

- Rule of thumb: **$\Delta f > R_s$**
- Feasible in the LAN-WDM grid (800-GHz spacing)

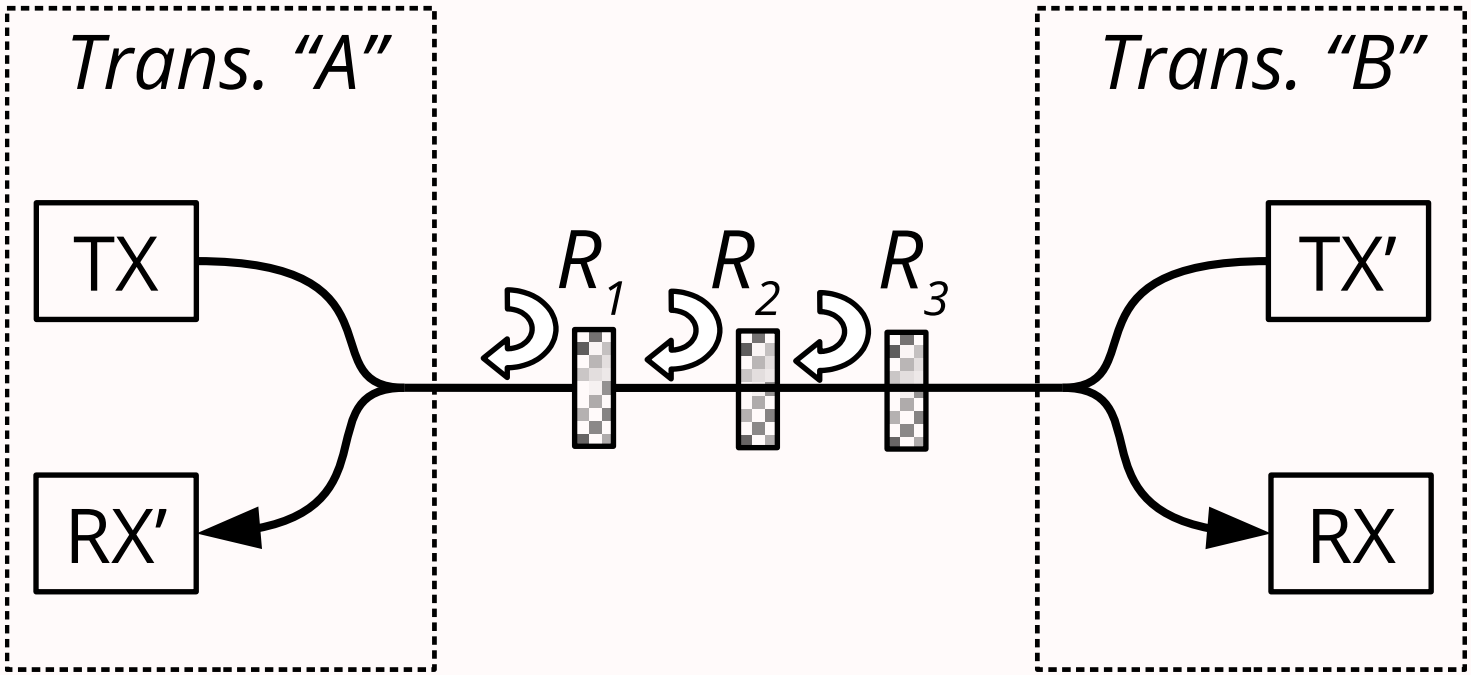
SINGLE REFLECTION RESULTS – 53 GBAUD



KEY TAKE AWAY

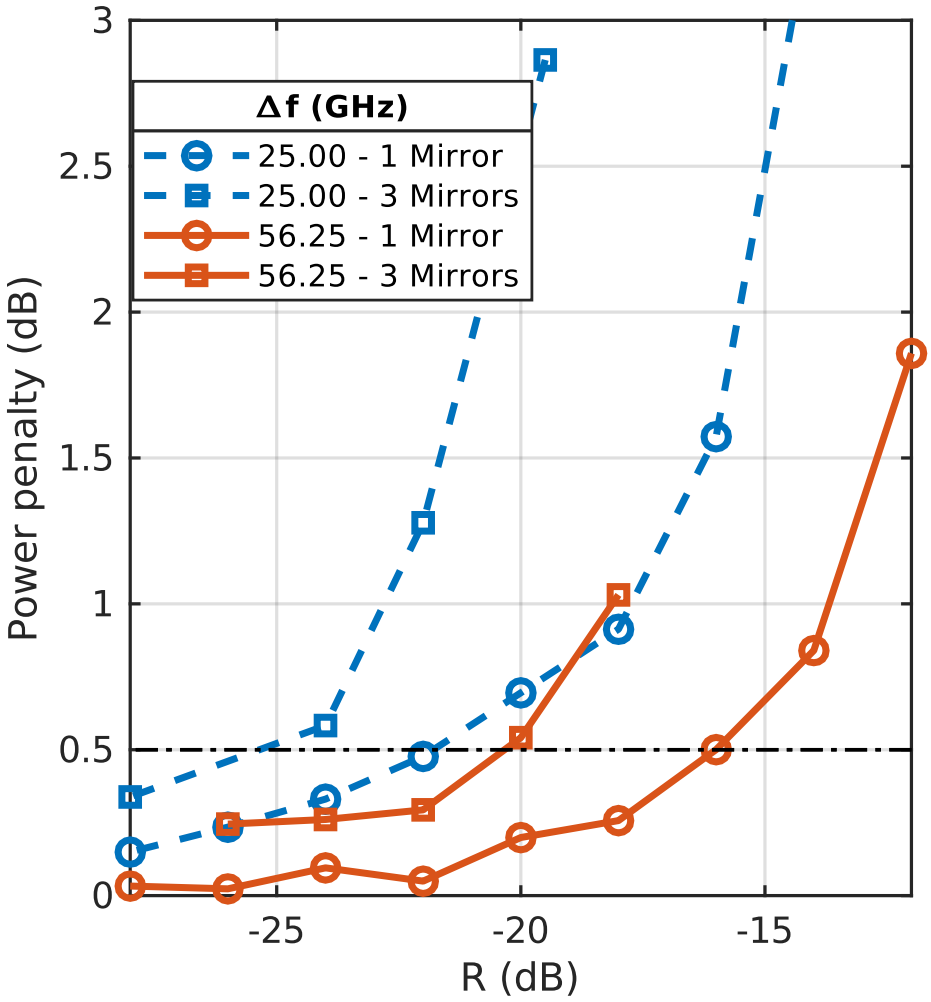
- Rule of thumb: **$\Delta f > R_s$**

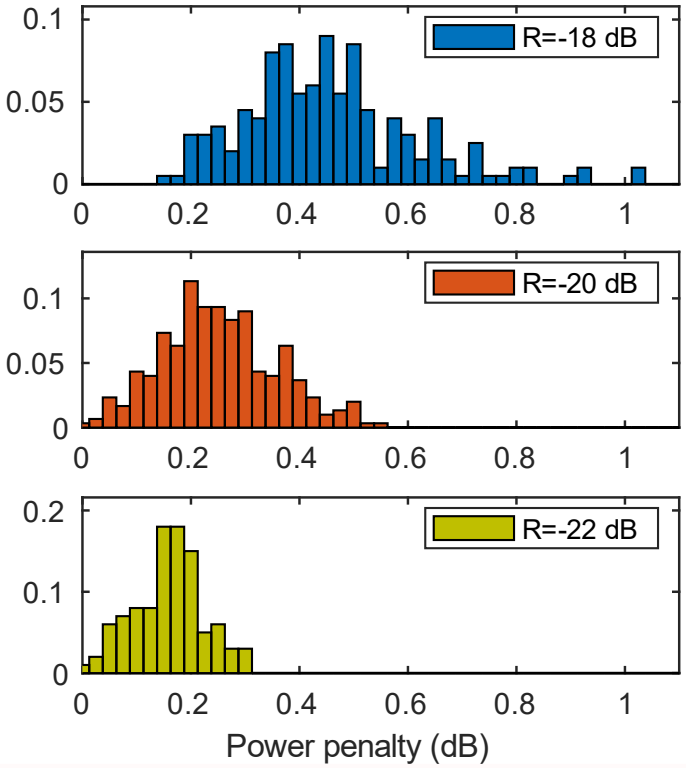
MULTIPLE REFLECTIONS



$$P_{\text{refl}} \propto \left| R_1 e^{j\phi_1} + R_2 e^{j\phi_2} + R_3 e^{j\phi_3} \right|^2$$

THREE REFLECTIONS RESULTS – 28 GBAUD





- Multiple-reflection penalty is random
  - Worst-case over 100 measurements
- **Rule of thumb: $\Delta f > 2R_s$**

KEY TAKE AWAY

CONCLUSIONS

- A **bi-directional** architecture can potentially double *per-laser* capacity over standard duplex SMF cables
  - Main cost is extra loss due to 3-dB splitters

- Back-reflection penalties can be *avoided* if lasers in one transceiver are *slightly* detuned
  - Rule of thumb: $\mathbf{\Delta f > 2R_s}$
  - Keeps same nominal channel in WDM grid

THANK YOU FOR YOUR ATTENTION!

Acknowledgements:

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  http://www.photonext.polito.it/

- The work was partially sponsored by Cisco Photonics

Slides available *soon* on https://www.optcom.polito.it/talks