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Jun Shan Wey is an Associate Fellow in Technology Standards Planning at Verizon. Her work focuses on industry standards ecosystem development for optical access and transport networks, representing Verizon in ITU-T SG15, FSAN, and ATIS. Along with serving as ITU-T SG15 Q2 Associate Rapporteur and WP1 Coordinator, she has held multiple Optical Fiber Communications (OFC) conference leadership roles and currently chairs the OFC Steering Committee. Shan is a Fellow of OPTICA, Senior Member of IEEE and received a B.S. from the National Chiao Tung University in Taiwan and Ph.D. from the University of Maryland, College Park, both in Electrical Engineering.

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Recent work in Working Party 1
Study Group 15

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Major themes of optical work in Working Party 1

Maintaining the existing optical access systems

- G-PON, XG(S)-PON, and 50G-PON
- OMCI and its extensions (e.g., WMCI)

Studying the future evolution of PON

- Very High Speed PON project

Finding and exploiting new applications of fiber networks

- FTTRoom, for true gigabit in-home networking
- FTTGrid, to better instrument and control power networks
- fgOTN-over-P2MP, to provide end-to-end circuit-based connectivity

The evolution of optical access systems

The industry has developed a whole series of PON systems

Each system employed a new technology to go faster

- A/B-PON: FP lasers and PIN detectors
- G-PON: DFB lasers and APDs
- XG-PON: Mandatory FEC, EML
- 50G-PON: DSP+LDPC, EML-SOA, SiGe APDs

The one thing that is truly constant is the fiber network

- G.652 fiber
- Passive optically split (~3.5 dB per stage of split)
- ~30 dB loss budget (29 dB regular, 32 dB premium, 35 dB super)
- ~20 km reach (40 km viewed as a stretch goal)
- Coexistent with existing PONs (But which ones?)

VHSP capacity objective

Based on inputs from major access service providers, the required information capacity of the VHSP system is ~200 Gb/s

- This is >4X the capacity of the previous 50G-PON system
- It anticipates that 100 Gb/s peak rates might be in the cards

FEC overhead is likely to stay around 20%

- This seems to balance a minimal optical speed penalty, coding gain, and complexity

Hence, we need a line speed of ~240 Gb/s

We note that these requirements are still subject to change

- Importantly, 100 Gb/s might be a fallback capacity if 200 Gb/s ends up being impractical

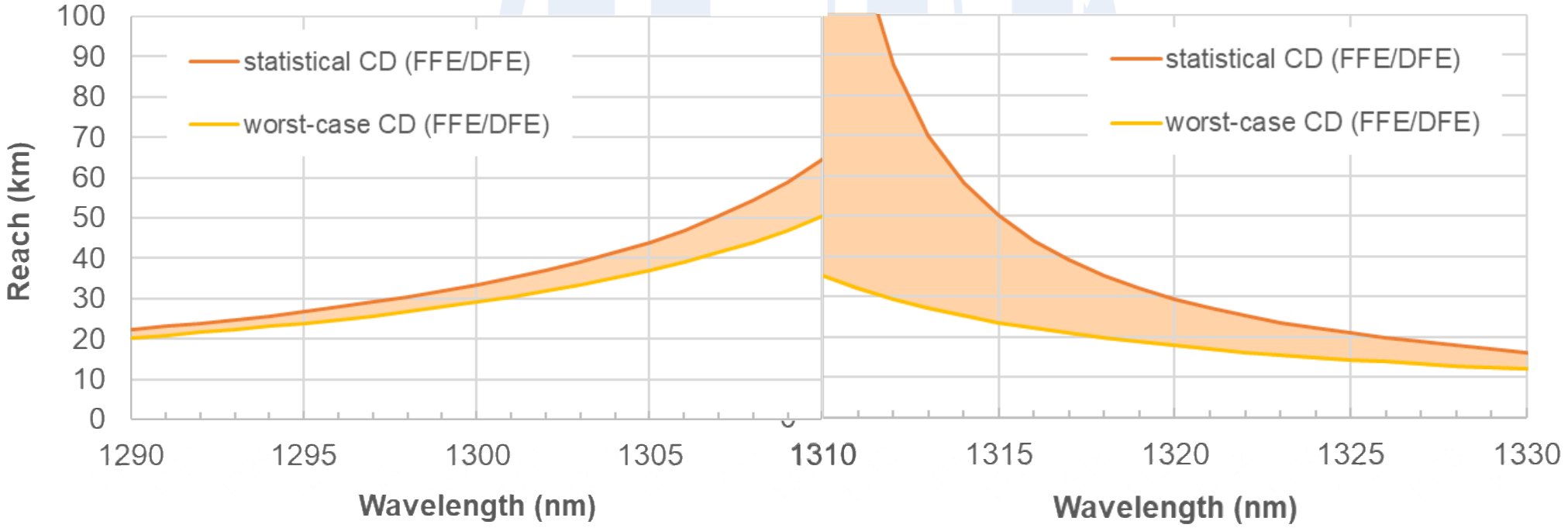
The limitation of IM-DD

All PONs to date have been IM-DD NRZ coded links

We are now approaching the limits of this tried-and-true design

The following graphs give the reach as a function of wavelength for 120 GBd transmission

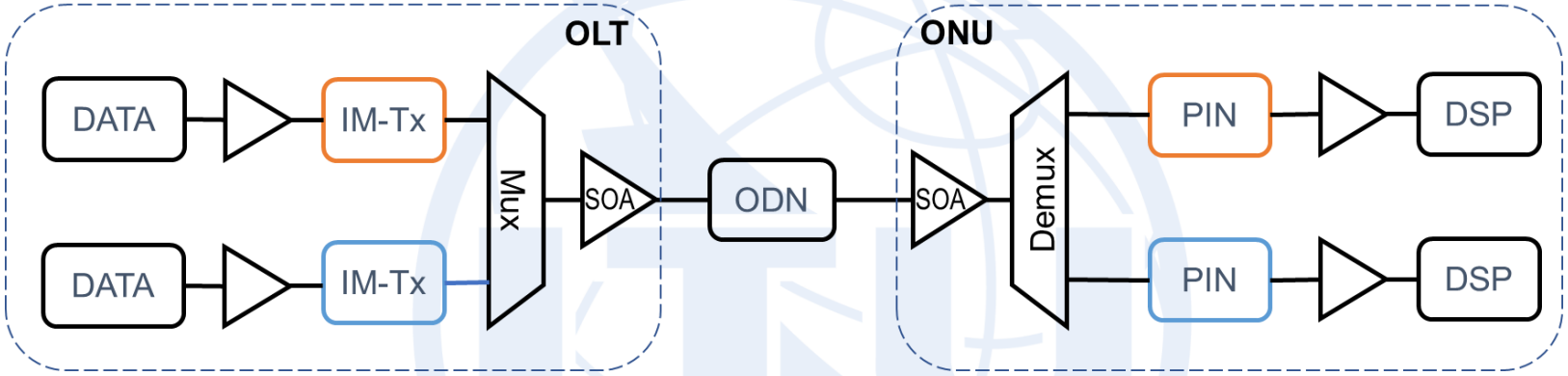
Lower limit assuming high ZDW fiber



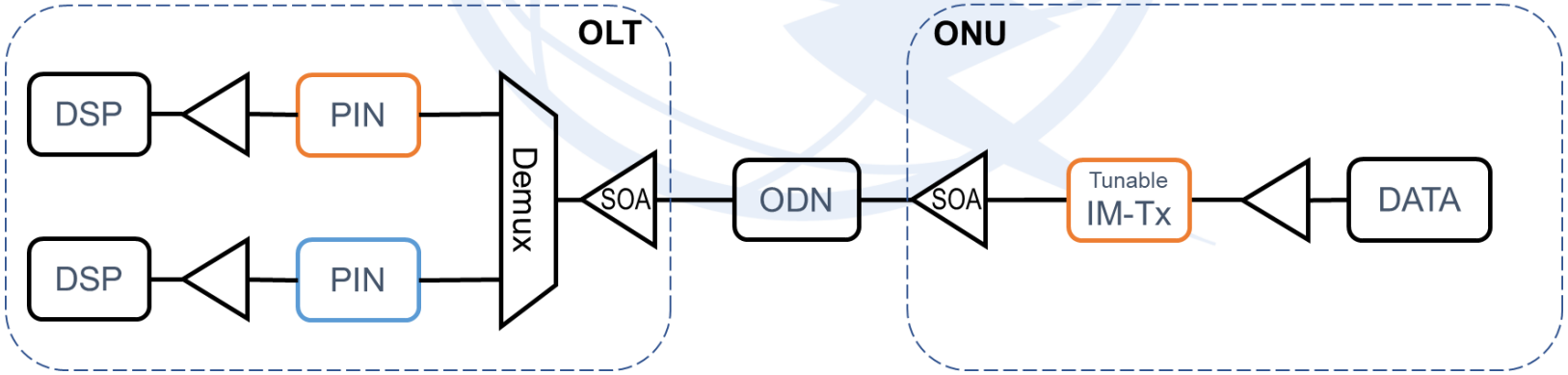
Higher limit assuming low ZDW fiber

Giving it both barrels: 200 Gb/s IM-DD

If IM-DD is limited to 100G, we can use two (much as Ethernet has used parallel optics to reach higher speeds)



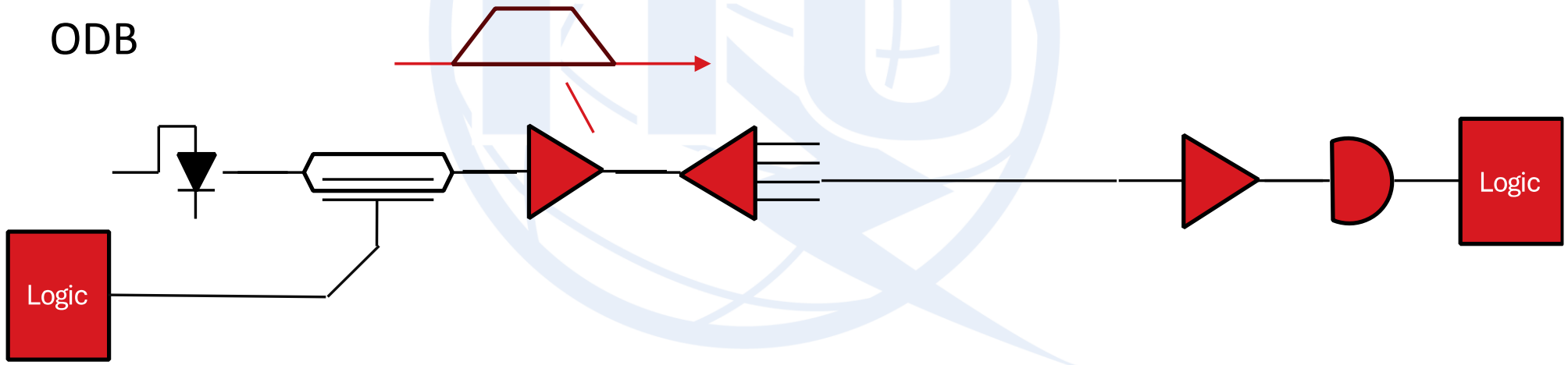
In the upstream, ONUs could have 1, 2, or tunable optics



A first step beyond IM-DD: Optical Duobinary

ODB has been the darling of the research lab

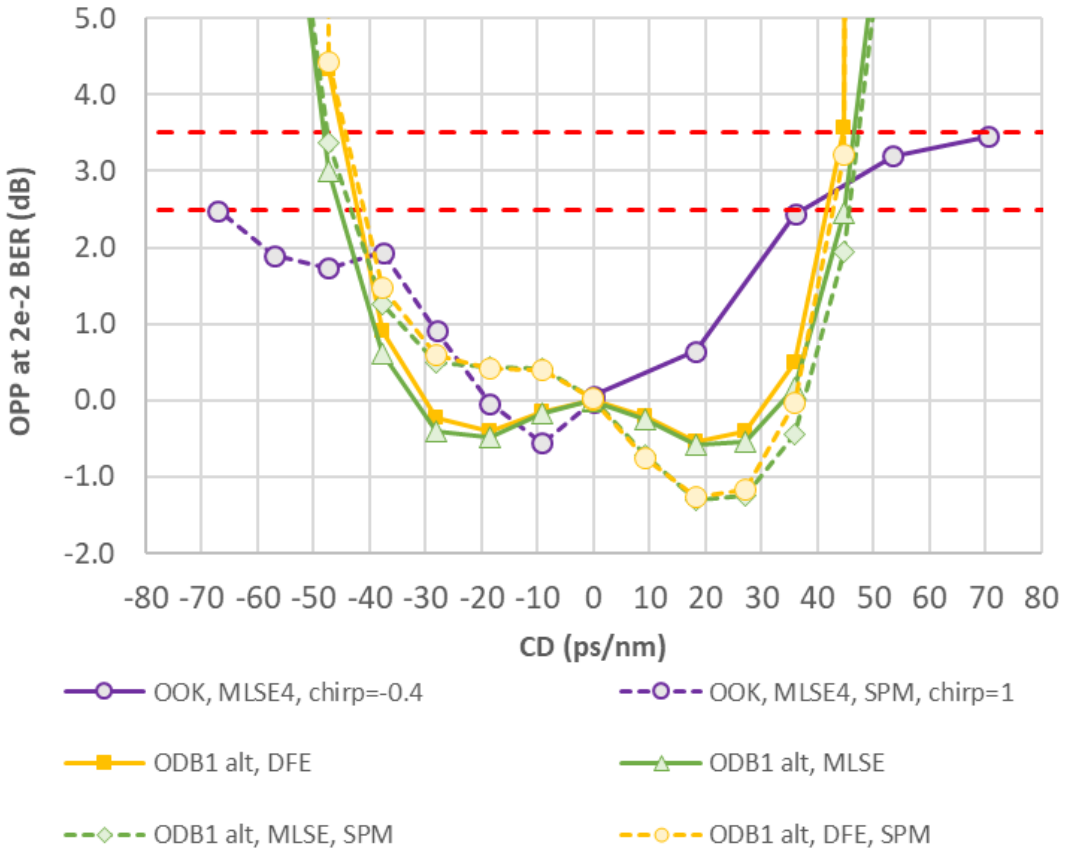
- Uses a fancy transmitter, but the receiver is quite simple – good for PON downstream
- Suppressed carrier also yields much better nonlinear performance
- Gives double the rate for any given dispersion

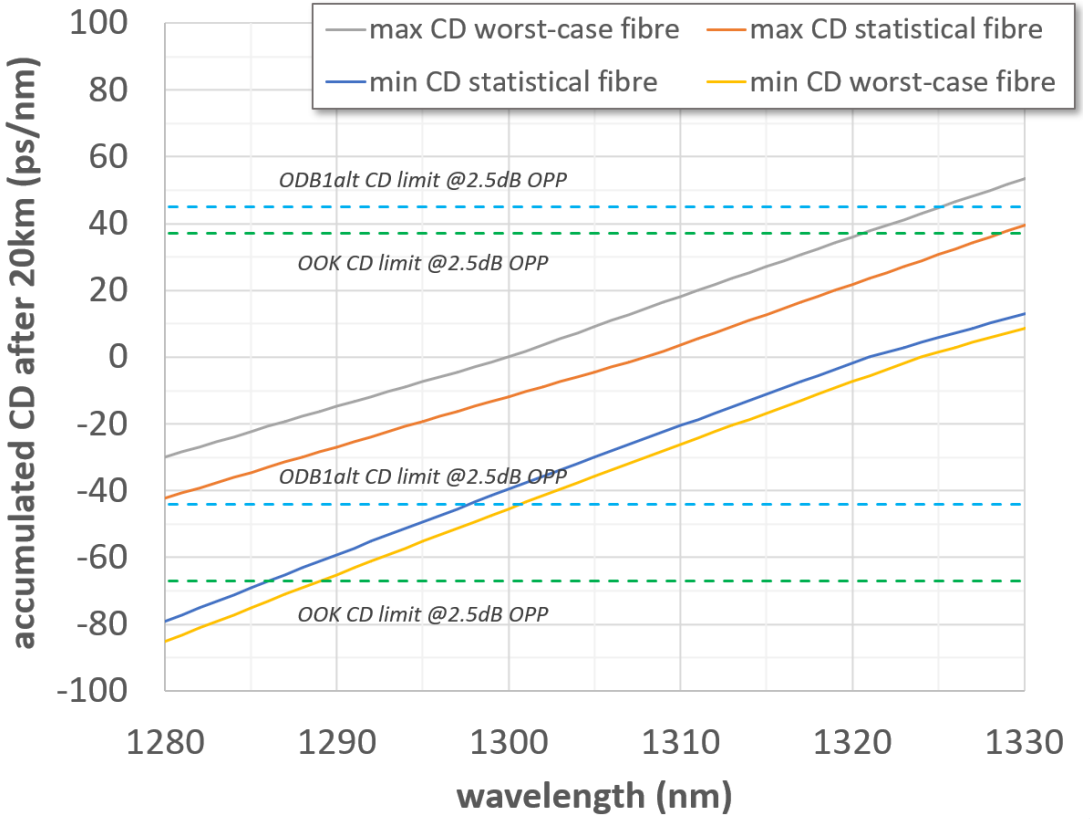


ODB and chirp-controlled NRZ

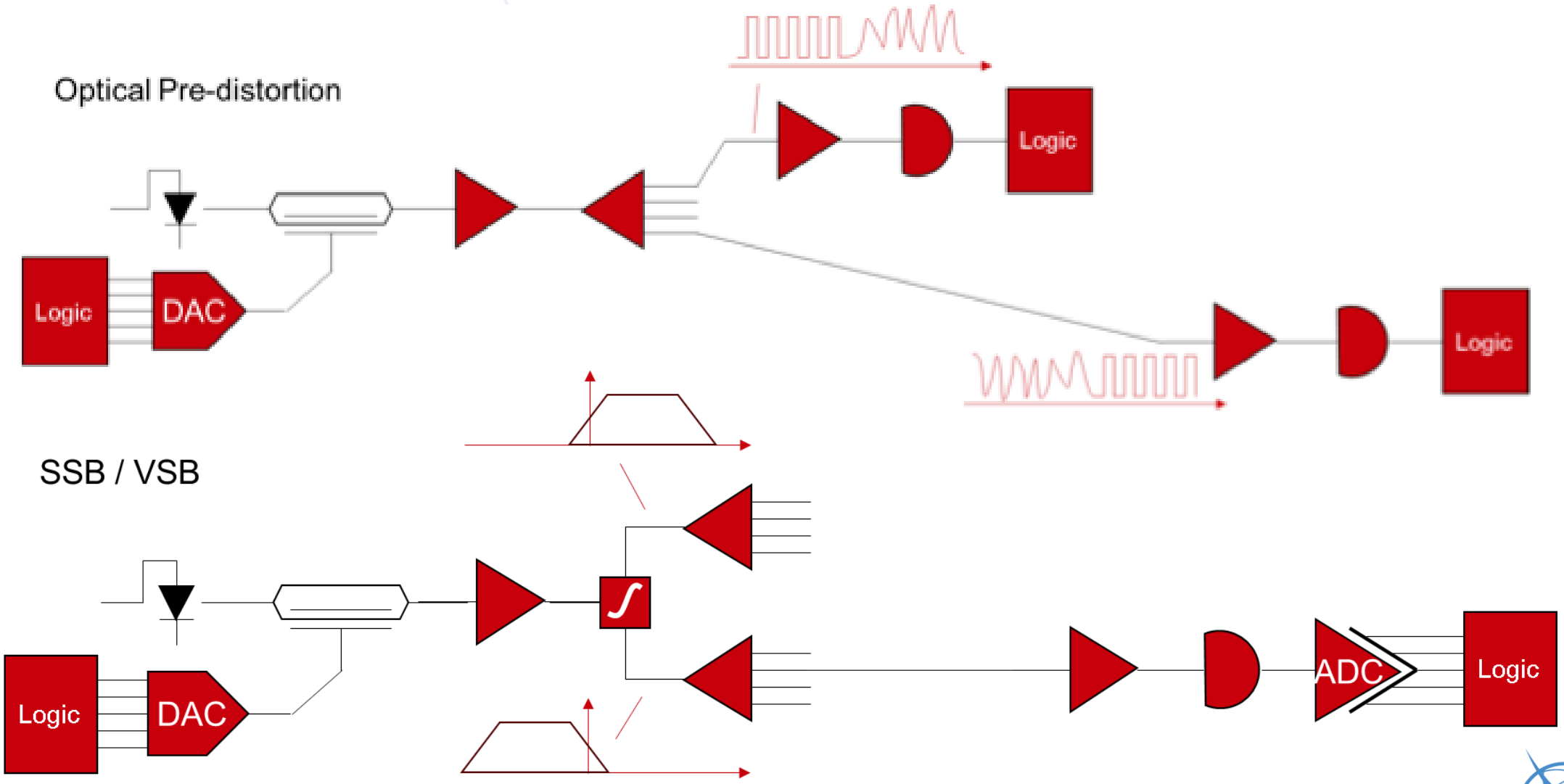
As expected, ODB has a wider dispersion tolerance range

Interestingly, NRZ with chirp control and MLSE can do the same

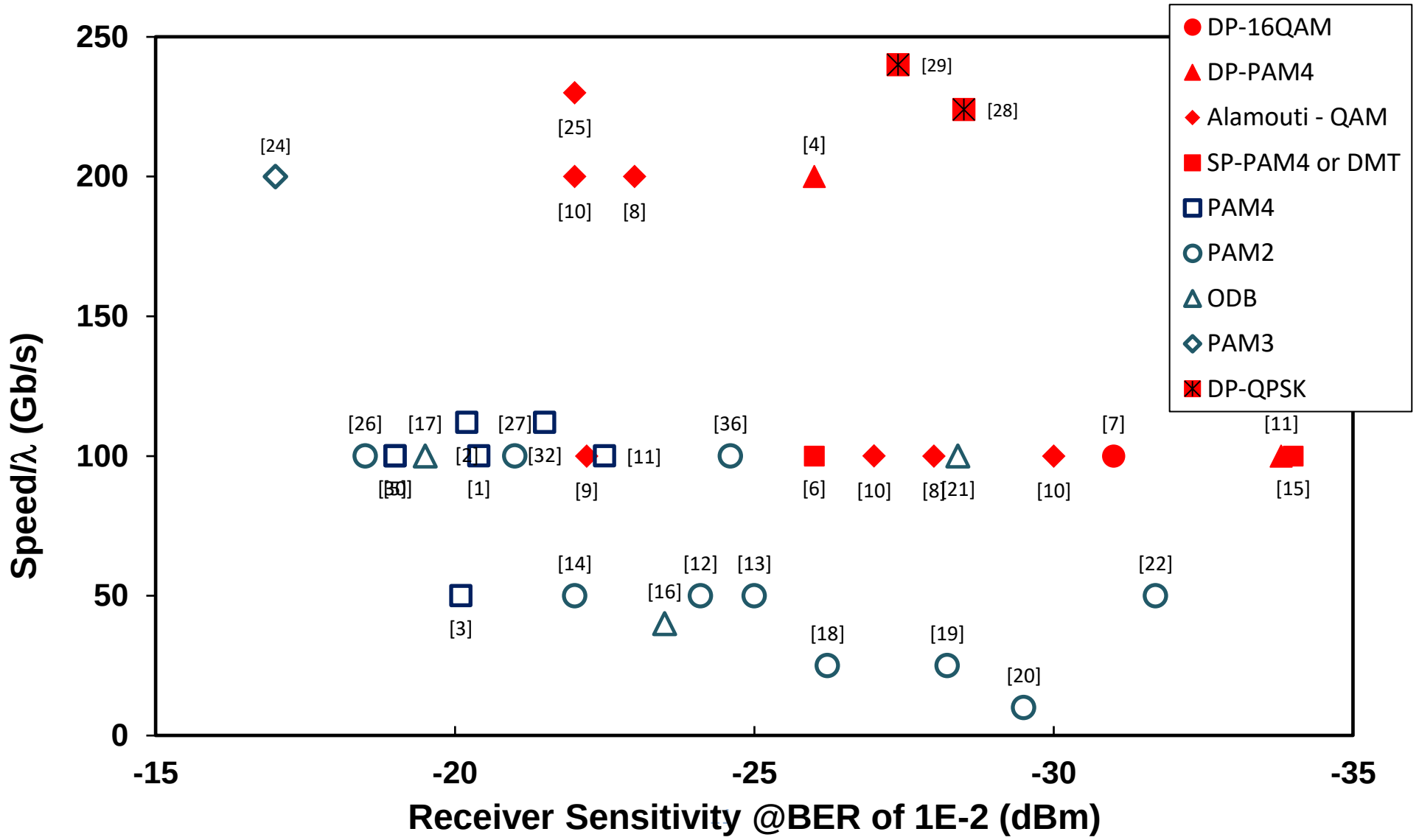




Kind of coherent



Sensitivity as a function of speed



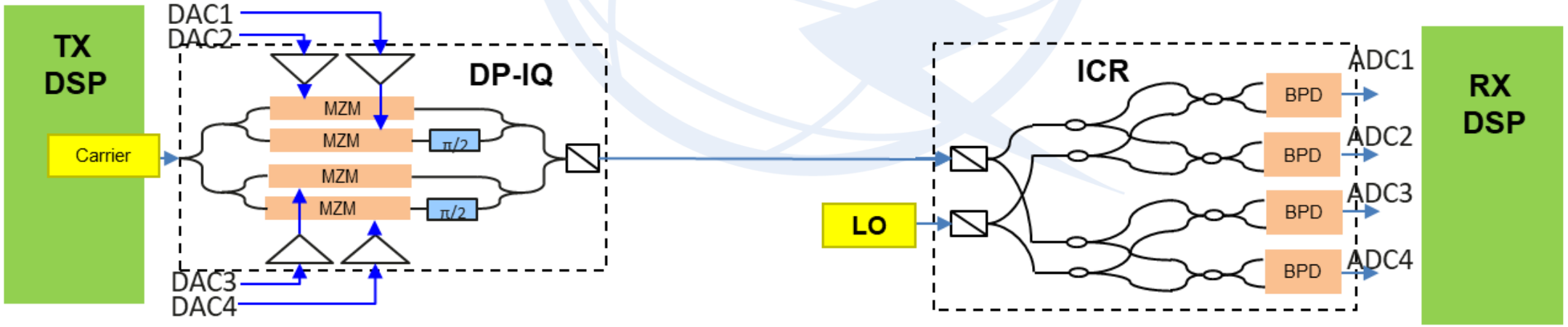
Fully coherent: many possibilities

At the physical layer, either side can implement

- Fully coherent (2 polarizations x 2 quadratures)
- Half coherent (1 pol x 2 quadratures, or 2 pol x 1 quad)
- Low-cost coherent (1 pol x 1 quad)

At the TC layer, the system can employ

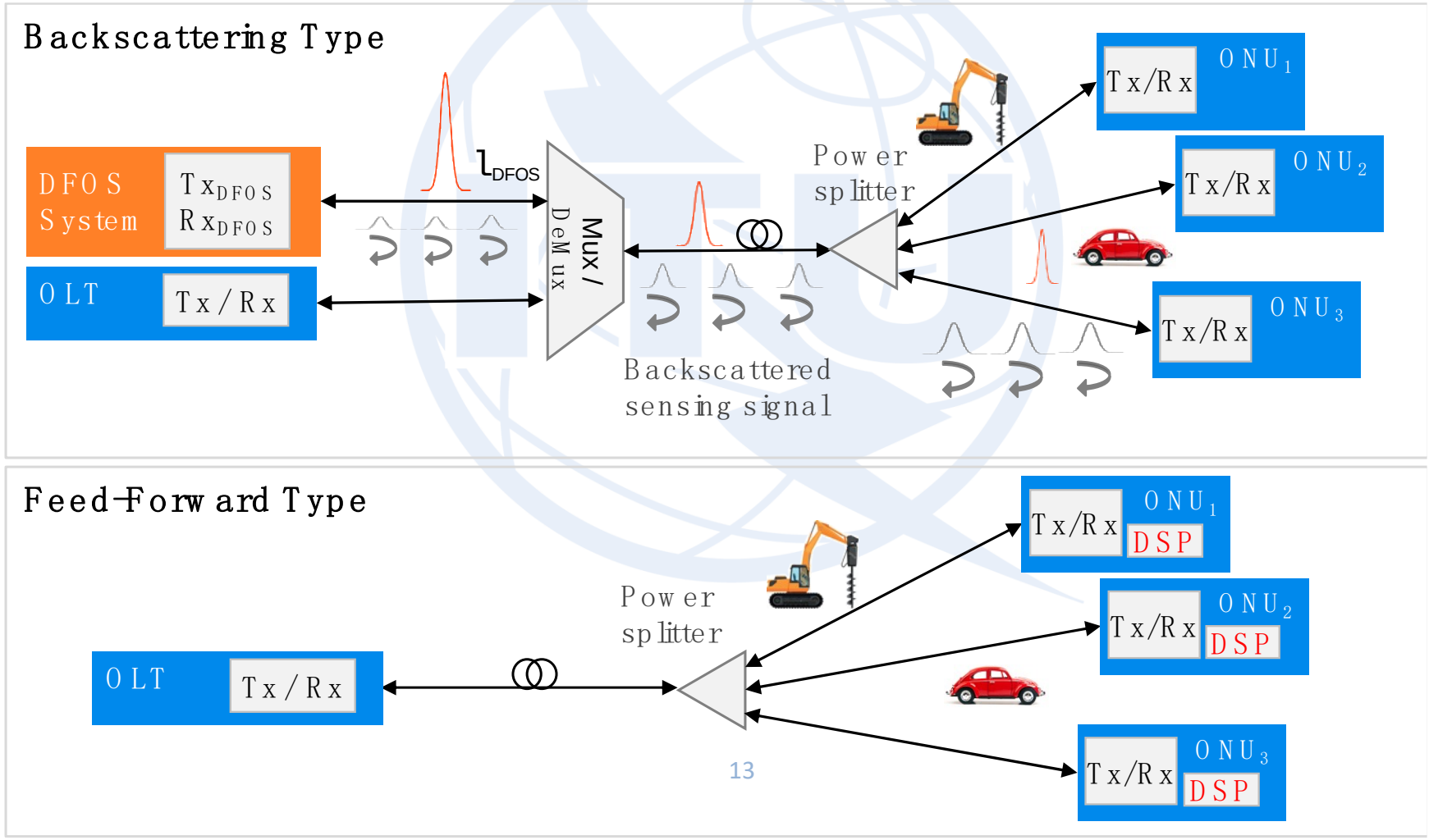
- TDM: Best DBA
- FDM: Lowest latency
- OFDM: Fine BW granularity
- Hybrid schemes: TFDM and TWDM



Distributed Fibre Optic Sensing (DFOS) in access networks

Two types of sensing technology: backscattering, feed-forward

Two use cases: deployed fibre infrastructure OAM, providing Sensing-as-a-Service



Conclusions

VHSP is a long-range project, aiming to make an initial survey of the technical requirements and possibilities for a very high speed PON

Roughly speaking, we're looking for a 250 Gb/s line-rate system that runs over the existing legacy fiber network, coexisting with XG- and 50G-PON

IM-DD is reaching its limits, so a major focus of the project is to better understand this issue, and see if we can get one more play out of this

- All things being equal, IM-DD should be a lower cost solution
- Operators might consider 2x100G systems, if it enables low cost

Coherent is the technically safe option, but there are many variants there, and the economic outlook for all of those is unclear at this time

- It is easy to imagine datacenter coherent might suddenly drop in cost
- We've seen history of PON driven by sudden moves in optics pricing

Distributed Fibre Optic Sensing brings a paradigm shift of how optical fibre network can be utilized

- It can enhance optical network OAM by proactively monitoring and preventing potential damages
- Deployed fibre infrastructure is transformed into an intelligent sensing network, actively monitoring environments beyond passive data transmission

Thank you !

Questions?