NOKIA

Specifying receiver sensitivity for PR30

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Agenda

- Derivation of 25G PR30 receiver sensitivity specification, ONU
- Derivation of 25G PR30 receiver sensitivity specification, OLT
- Performance of 25G Ge/Si APD
- Conclusions
- Motion for 25G PR30 receiver sensitivity specification, ONU

Derivation of 25G PR30 receiver sensitivity specification, ONU

Supporters:

- David Li, Ligent
- Naruto Tanaka, Sumitomo
- Erick Yang, Macom
- Mark Heimbuch, Source Photonics
- Shawn Esser, Finisar
- John Johnson, Broadcom

25G penalty: APD receiver sensitivity vs. bit rate

Ref: Broadband Optical Access Networks, L. Kazovsky et. al. 2011

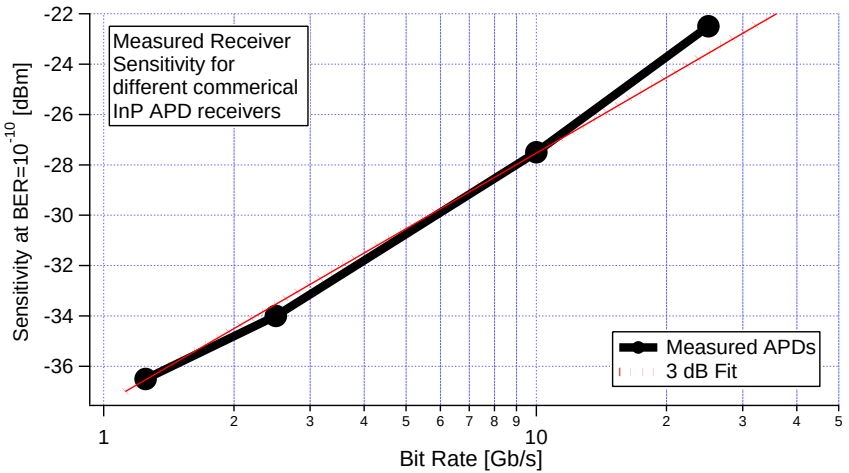
- SNR = signal power / noise power. SNR for APD:

$$\mathrm{SNR} = \frac{(MRP_{\mathrm{in}})^2}{2qFM^2(MRP_{\mathrm{in}} + I_d)\,\Delta f + 4k_BT\,\Delta f/R_L}.$$

- Assume (InP) APD is photocurrent shot noise limited:

  SNR = P_{in} / (2q F M^2 Δf) where

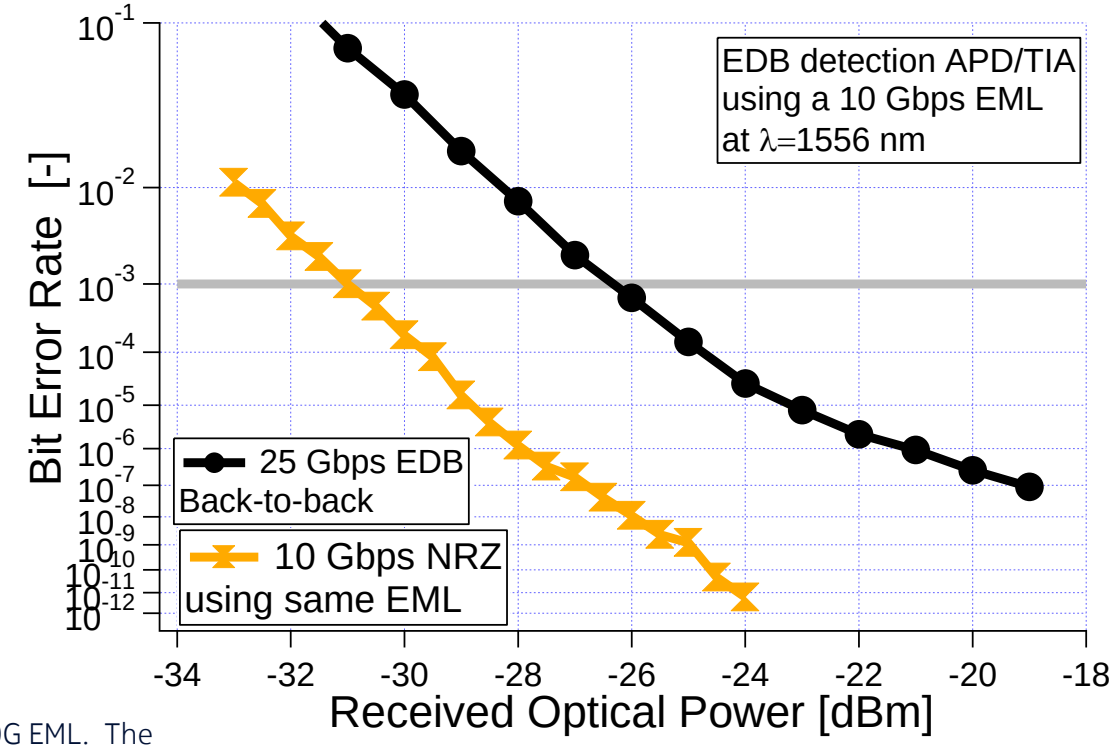
  - P_{in} is the average receiver optical power
  - Δf = receiver bandwidth
  - M = multiplication factor
  - F= excess noise factor



- If increase Δf by 2, to maintain SNR must increase P_{in} by 2 = 3 dB
- Datasheet sensitivities confirm this (plotted in chart to right)
- For 10 Gb/s → 25 Gb/s APD: to maintain SNR must **increase P_{in} by 2.5 = 4 dB**
- That assumes M, R, F are maintained at 25G. That's a best case. It's safer to allocate some margin for reduced gain, responsivity, and noise performance at 25 Gb/s.
- For this we propose **25G APD performance margin =1 dB**, as can be seen as the approximate gap between the two lines at 25 Gb/s.

25G penalty: electro duobinary detection

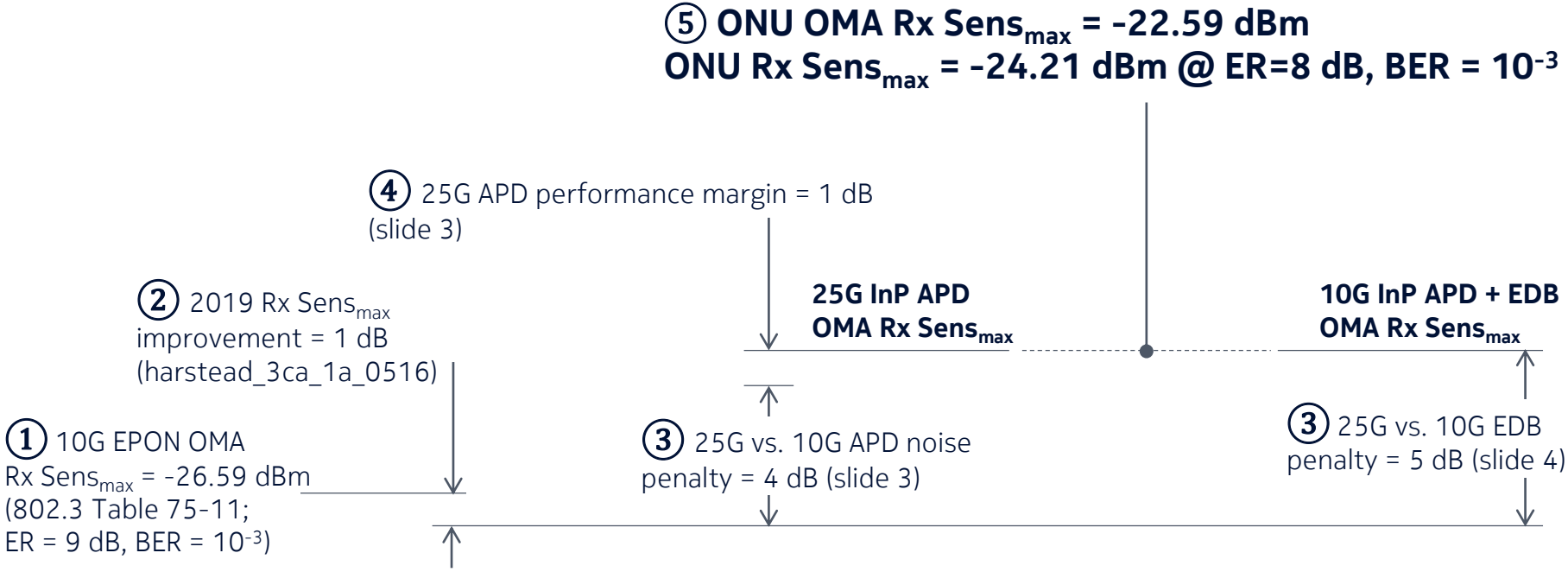
- Electro duobinary detection as described in houtsma_3ca_1_0516.pdf
- For the same 10G APD, a 5 dB penalty for 25 Gb/s duobinary detection vs. 10 Gb/s NRZ detection at 10^{-3} BER has been measured.



Note: These 25G EDB results are with a 10G EML. The penalty is expected to be slightly lower if a 25G EML is used.

Derivation of 25G PR30 receiver sensitivity specification, ONU

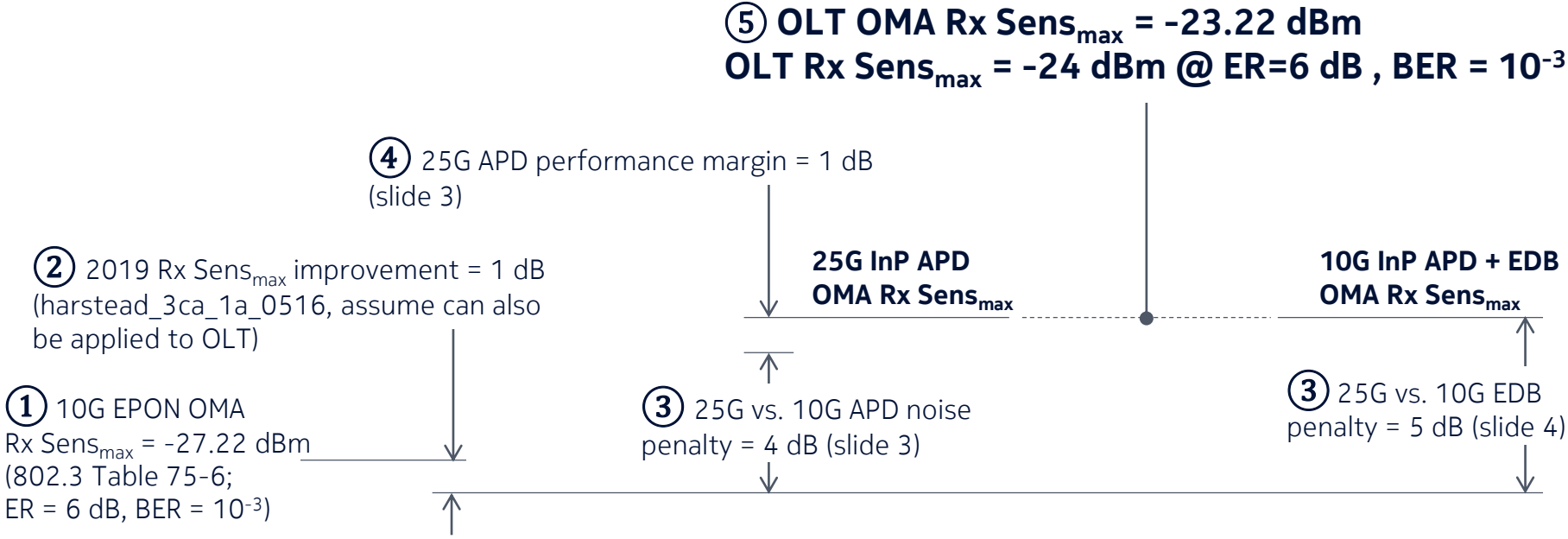
- Assume: OLT EML, with ER=8 dB per harstead_3ca_1a_0516
- Assume no FEC improvement over 10G EPON
- Assume no additional diplexer loss compared to 10G EPON (wavelength plan dependent)



Derivation of 25G PR30 receiver sensitivity specification, OLT

Derivation of 25G PR30 receiver sensitivity specification, OLT

- Assume: ONU DML, with ER=6 dB per harstead_3ca_1a_0516.
- Assume no FEC improvement over 10G EPON
- With adjustment to the OMA method, a spec could be written that would also allow for an EML with lower power and higher ER (risk mitigation).

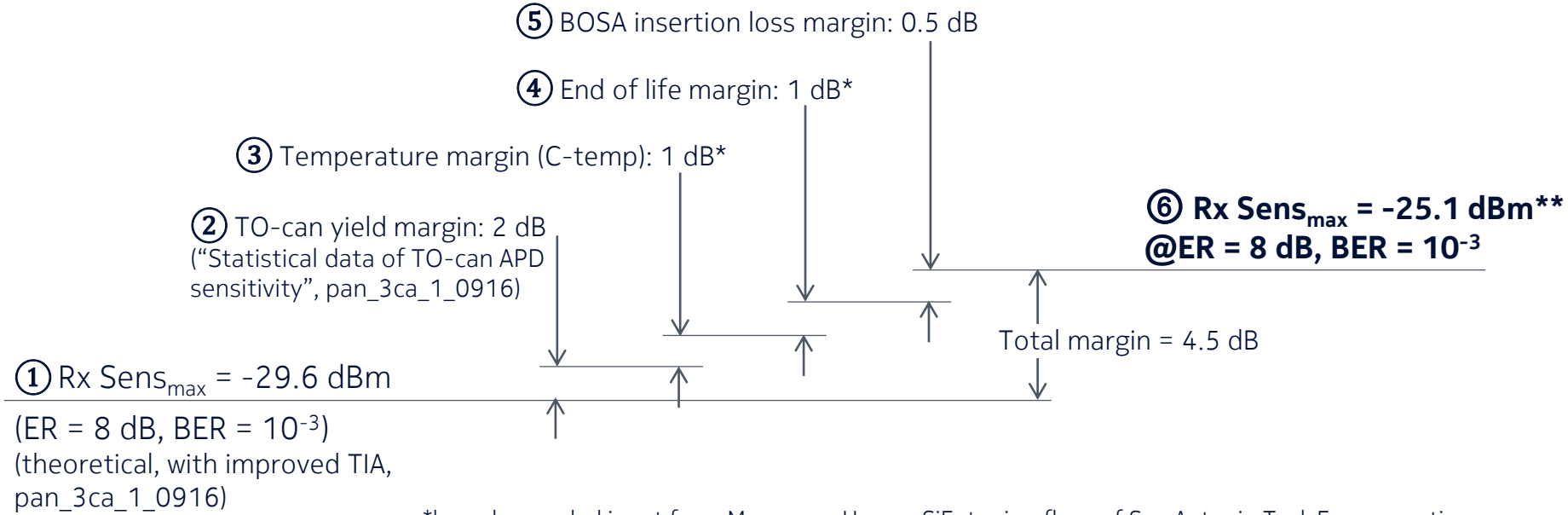


Vendor feedback

- Consensus on OLT specification not achieved
- Some specific feedback:
  - Re: ② 2019 Rx $Sens_{max}$ improvement = 1 dB (harstead_3ca_1a_0516, assume can also be applied to OLT)
    - Not clear that OLT APD receivers have/will experience as much improvement as ONU APD receivers. There may not have been as much margin originally allocated to the OLT side.
  - We may want to push the OLT receiver spec harder to allow for lower power lasers in 25/25 ONUs.

Performance of 25G Ge/Si APD

Ge/Si APD may offer improved performance at 25G



*based on verbal input from Mengyuan Huang, SiFotonics, floor of San Antonio Task Force meeting
**Not inconsistent with sample measurement in tanaka_3ca_1_1116: -26.62 dBm @ ER = 8.3 dB, BER = 10^{-3}

The Ge/Si APD, based on theoretical sensitivity and assumed margins, might deliver ~1 dB improvement

25G PR30 receiver sensitivity specification: Ge/Si APD

- The 25G Ge/Si APD may offer improved performance, but it's not clear how much improvement in mass volume/high yield production, and over temperature and end of life.
- There is only one vendor currently offering this technology
- Therefore the lower risk route is to specify receiver sensitivity based on InP APDs for 25G EPON, if we can make the PR30 power budget to work with InP APDs and without optical amplification
- The performance of Ge/Si APDs can still help in overcoming demux losses in 50G and 100G EPON.
  - For example, specify more aggressive 100G receiver performance
  - 100G OLTs and ONUs will come to market later, giving more time for maturation of Ge/Si APDs and more vendor offerings
  - In addition, InP APDs might see some further improvement in time

Conclusions

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- PR30 receiver sensitivity (rounded to nearest 0.1 dBm) and receiver sensitivity OMA specifications for 25G EPON are proposed:

	Receiver sensitivity (max, BER= 10^{-3}) (dBm)	Extinction ratio (dB)	Receiver sensitivity OMA (max, BER= 10^{-3}) (dBm)
ONU	-24.2	8	-22.58
OLT	-24	6	-23.22

- These are baseline values that would be adjusted, if required, for deltas with respect to 10G EPON
  - improved FEC
  - higher diplexer loss due to smaller DS/US gap (ONU only)
- These values may be used as starting points to derive 50G and 100G ONU and OLT receiver sensitivities, before accounting for filter insertion losses. Ge/Si APD performance may help overcome those losses.
- Ge/Si APDs have promise for improved performance, but at this time there is risk associated with developing 25G EPON specifications dependent on that performance.

Motion

The ONU receiver sensitivity specification proposed in harstead_3ca_x_0117, page 14, -24.2 dBm at BER= 10^{-3} and ER=6 dB, shall be adopted as a baseline. The final specification would be adjusted, if required, for these two possible deltas with respect to 10G EPON:

- improved FEC
- higher diplexer loss due to smaller DS/US gap

Moved:

Seconded:

For:

Against:

Abstain: