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25G upstream power budget

Ed Harstead, Nokia

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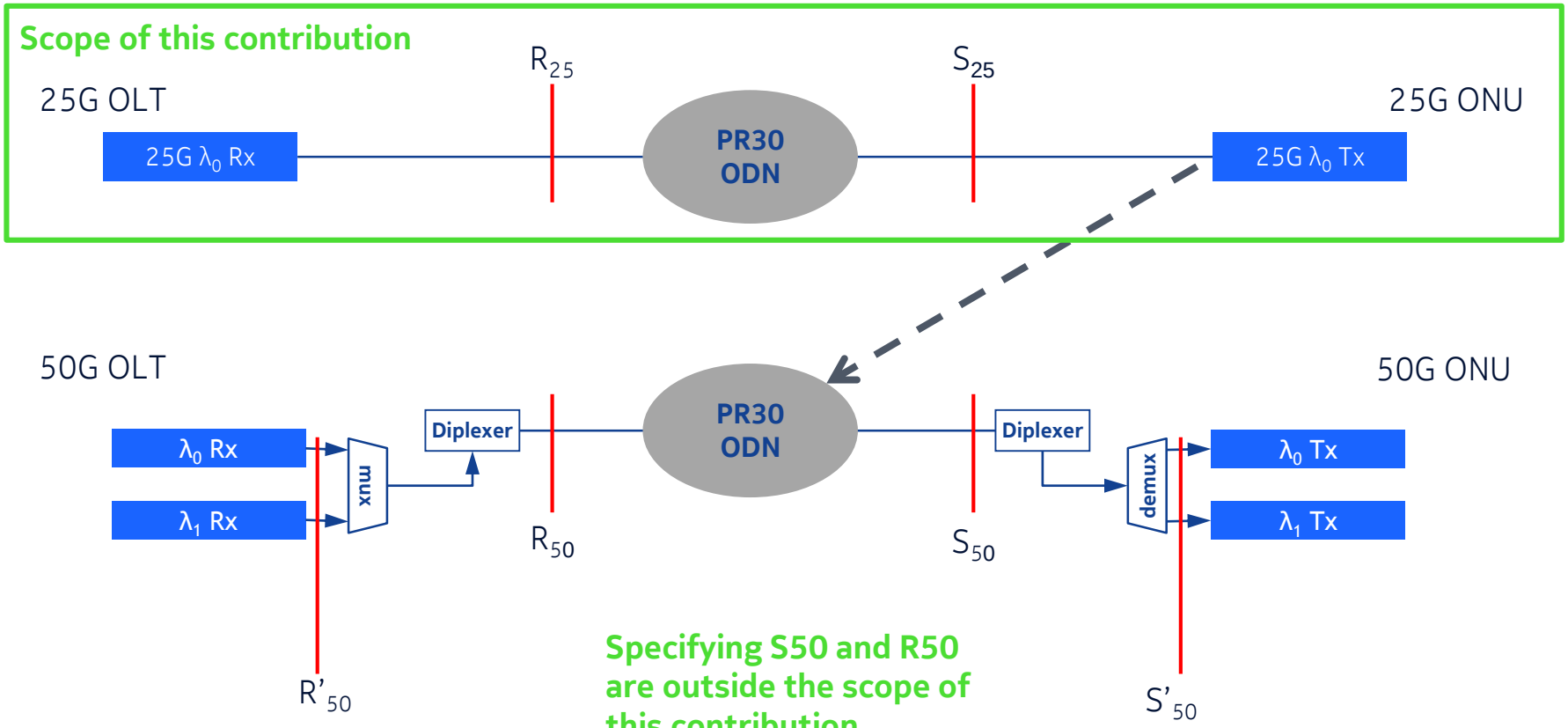
Supporters

- Barry Colella, Source Photonics
- Mark Heimbuch, Source Photonics
- John Johnson, Broadcom
- David Li, Hisense
- Hiroshi Miura, Mitsubishi
- Naoki Suzuki, Mitsubishi
- Daisuke Umeda, Sumitomo Electric

Scope: 25G EPON, upstream direction, PR30 loss budget



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Methodology

- Derive the 25G OLT receiver sensitivity specification from state-of-the-art 10G PON OLT receivers
  - 10G PON optics have been/are being tested by the market to meet requirements for low cost
  - The specifications already include margins for burst mode, yield, temperature and end-of-life.
- Deriving a specification from measurements of 25G APDs in continuous mode is problematic:
  - Small sample size measurements do not include the margins, in particular burst mode penalty
- Propose to use the same derivation method as for 25G ONU sensitivity in harstead_3ca_4_0117
- As a baseline, propose: **-29 dBm** @10 Gb/s, 1e-3 BER and ER=6. This is state-of-the-art for InP APDs.
  - Aggressive but achievable 10G specification to relax 25G ONU launch power, while
  - Having a viable path to an APD implementation (with no SOA preamp).
- Relax 25G DML ER from 6 dB to 5 dB per harstead_3ca_3_0917

10G PR30 OLT module sensitivity measurements in liu_3ca_1_1117

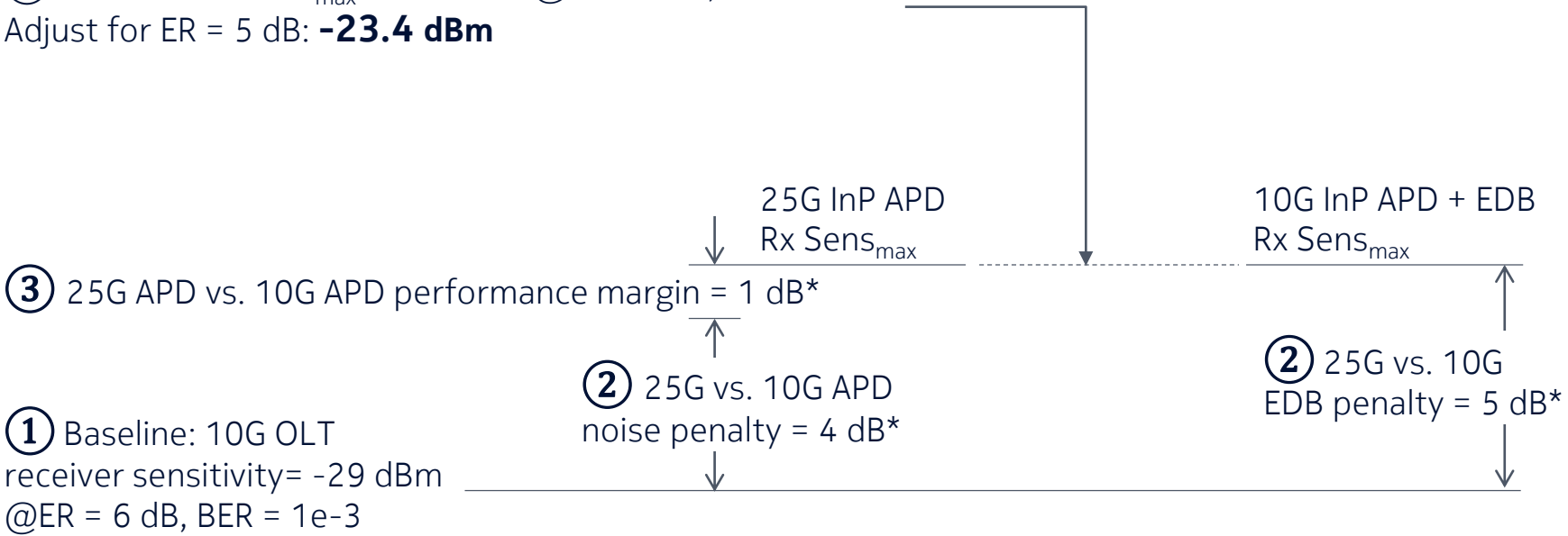
10G PR30 OLT module sensitivity measurements in liu_3ca_1_1117														
mean			-31.39				-30.15				-31.30			-29.57
sigma			0.54				0.51				0.50			0.48
mean+3sigma			-29.77				-28.61				-29.80			-28.14
	vendor	temp	sensitivity		vendor	temp	sensitivity		vendor	temp	sensitivity		vendor	temp	sensitivity
	A	25	-31.26		B	25	-29.61		A	65	-30.95		B	65	-29.32
	A	25	-31.29		B	25	-30.16		A	65	-30.88		B	65	-29.87
	A	25	-31.46		B	25	-31.03		A	65	-31.65		B	65	-30.34
	A	25	-31.26		B	25	-30.32		A	65	-30.95		B	65	-29.53
	A	25	-30.96		B	25	-30.1		A	65	-30.95		B	65	-29.51
	A	25	-31.64		B	25	-29.48		A	65	-31.53		B	65	-28.79
	A	25	-32.69		B	25	-30.35		A	65	-32.18		B	65	-29.66
	A	25	-30.62												
	A	25	-31.45												
	A	25	-31.22												
temp = 65 C															

	Vendor A	Vendor B
mean	-31.30	-29.57
sigma	0.50	0.48
mean+3sigma	-29.80	-28.14

C-temp mean+3 sigma is about -29 dBm. Does not include aging margin.

Derivation of 25G PR30 OLT receiver sensitivity specification
Not including FEC improvement

④ 25G OLT Rx $Sens_{max}$ = -24 dBm @ ER=6 dB , BER = 10^{-3}
Adjust for ER = 5 dB: **-23.4 dBm**



*Similar derivation method as for 25G ONU sensitivity in harstead_3ca_4_0117

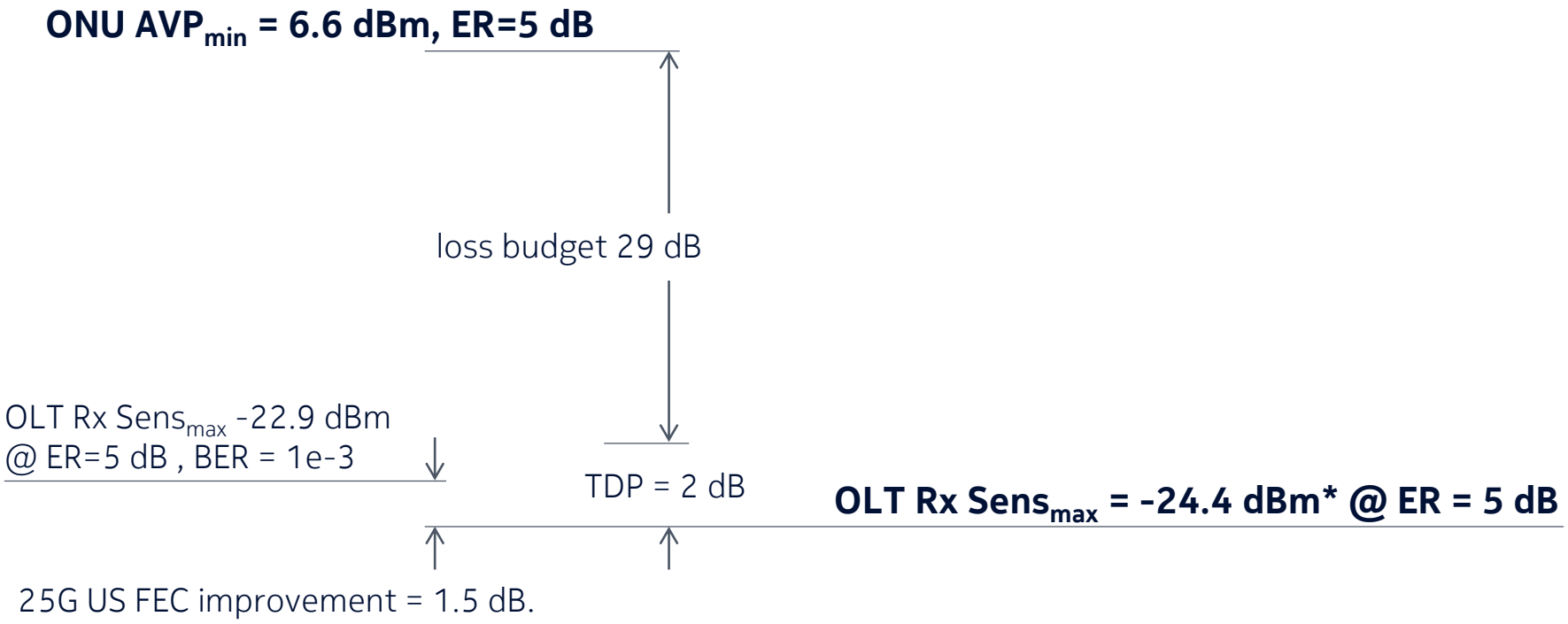
Additional sources of risk/loss

- There may be some risk associated with translating 10G APD performance to 25G APD performance.
- There will be somewhat greater risk of meeting spec at I-temp (required for remote OLTs) vs. C-temp.
  - The APD sensitivity difference is about 0.3 dB from 10G experience (D. Umeda).
- There will likely be a market need for combo modules.
  - Additional filtering can add 0.5-1 dB insertion loss (D. Umeda)
- **To mitigate the above, propose to add an extra 0.5 dB of margin: -22.9 dBm @1e-3 BER, ER= 5 dB.**
- Further risk mitigation:
  - Ge/Si APD per pan_3ca_1_0317.
  - SOA preamp (last resort, hopefully only necessary for initial deployments, at most)

TDP and FEC improvement

- For upstream 25G DML TDP, assume 2 dB per tanaka_3ca_1_1116
- 25G US FEC improvement = 1.5 dB, per powell_3ca_1a_0118 (via laubach_3ca_1b_0118: GE model, with interleaver, precoder on, minimum value).

25G upstream loss budget, PR30



*BER = 1e-2 nominally

Check proposed specification for 25G ONU DML

- Per vendor survey harstead_3ca_3_0917

cooled DML	number	mean	σ
AVPmin (dBm)	6	6.5	0.5
ER (dB)	6	5.2	1.0

uncooled DML	number	mean	σ
AVPmin (dBm)	5	4.7	1.0
ER (dB)	5	4.6	0.7

ONU AVP_{min} = 6.6 dBm, ER=5 dB is confirmed to be feasible for cooled DMLs.

ONU AVP_{min} = 6.6 dBm, ER=5 dB may be feasible during the life of 25G PON with future improvements in technology.

Notes:
- "number" = number of responses
- "mean" = the average value of the responses. When a vendor gave a range for a value, the midpoint of that range was used.
- "σ" = the standard deviation of the responses.

Motion

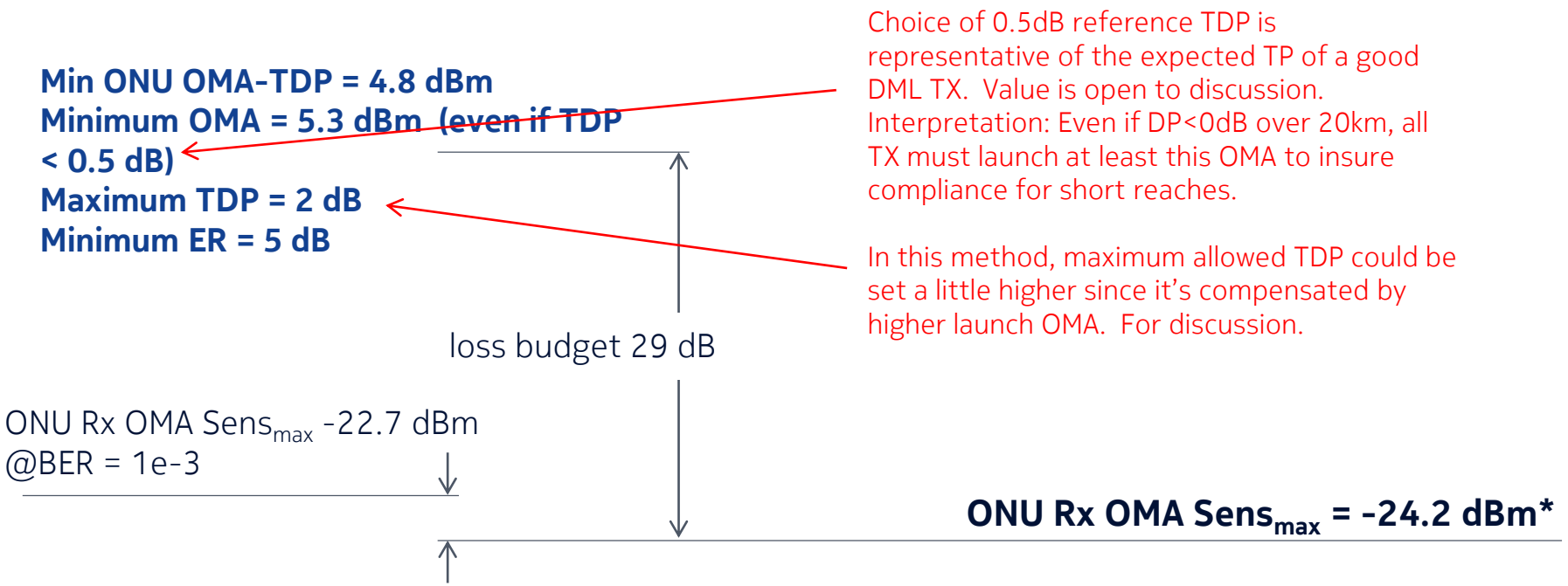
The 25G-EPON PR30 specifications proposed in harstead_3ca_2_0318 page 6
- 25G OLT receiver sensitivity: -24.4 dBm at BER= 1e-2 and ER=5 dB
- 25G ONU transmitter: AVPmin = 6.6 dBm and ER min = 5 dB

shall be adopted.

- Moved: Ed Harstead
- Seconded:

- For:
- Against:
- Abstain:

Example: Converting to OMA and OMA minus TDP (John Johnson)



Choice of 0.5dB reference TDP is representative of the expected TP of a good DML TX. Value is open to discussion. Interpretation: Even if DP<0dB over 20km, all TX must launch at least this OMA to insure compliance for short reaches.

In this method, maximum allowed TDP could be set a little higher since it's compensated by higher launch OMA. For discussion.

*BER = 1e-2 nominally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Backup

Reason to avoid a 25G specification that will never be realizable with APD

- The 100G Ethernet ER4 (40 km) receiver specification was initially based on a PIN+SOA.
- Ever since, they have been working to correct this mistake, with APD-friendly ER4f/ER4lite and now 4WDM MSA.

18 October 2016 Chris Cole, Finisar

100G 10km, 20km & 40km 4x25G NRZ WDM Optical Specifications Proposal, Draft 04

Specification	10km WDM4-10 w/ FEC 100G LR4 loss	20km WDM4-20 w/ FEC	40km WDM4-40 w/ FEC
Rate ± 100 ppm Gb/s	25.78125	25.78125	25.78125
Reach km (RX type)	10 (PIN)	20 (PIN)	40 (APD)

- The cost of the SOA+PIN will depend on volumes, and it's now unlikely to have any significant volume from 100G Ethernet. Therefore it is likely to be high cost.
- The SOA+PIN will have significantly higher power dissipation than the APD. This will degrade OLT port density
- **Therefore a 25G OLT specification requiring SOA+PIN will be a liability for 25G EPON market success**