Straw-man power budget proposals for PMD tables

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Straw-man power budgets

- In order to generate first draft text for the NG-EPON PMD spec tables, this contribution summarizes the straw-man power budget assumptions used in laubach_3ca_04_0317.
  - It is fully expected that these numbers will be adjusted up or down as needed on the basis of ongoing contributions and comment resolution.
- Basic assumptions for construction of the power budgets:
  - All wavelengths in O-band with same specs for all 4 channels.
  - A wavelength plan with WDM coexistence (i.e., Plan A)
    - OLT combo module includes WDM coexistence filter losses of 0.5dB.
    - This would not be needed upstream for TDM coexistence (i.e., Plan B), but additional multi-rate sensitivity penalties might apply.
  - OLT and ONU mux(demux) insertion loss = 2.5(2.0)dB.
  - No enhanced FEC – will be considered later.
  - All ONUs without optical amplifiers for low cost.
  - PR20 OLTs without optical amplifiers for low cost.

Analysis boundary conditions

- OLT Cooled EML BOSA Pavg(max) = 5.5dBm.
  - Based on vendor survey [2] mean + 1 sigma. Includes diplexer loss, but not mux loss.
- ONU Cooled DML BOSA Pavg(max) = 8dBm
  - Based on vendor survey [2] mean + 1 sigma. Includes diplexer loss, but not mux loss.
- 20km TDP(max) = 1.5dB upstream [3] and downstream [4].
- ONU BOSA RX Sensitivity(max) = -24.2dBm
  - Based on analysis by Nokia [1], which is scaled from 10G-EPON ONU RX sensitivity.
  - In agreement with vendor data on 25G APDs with expected BOSA losses and margin
- OLT BOSA burst-mode RX Sensitivity(max) = -24dB
  - Based on analysis by Nokia [1]. This is scaled from 10G-EPON OLT RX sensitivity, so it should in theory include some burst-mode penalty.
- Resulting power budget gaps are to be resolved by a combination of:
  - Enhanced FEC gain
  - Improved optical component technology
  - Optical amplification at the OLT

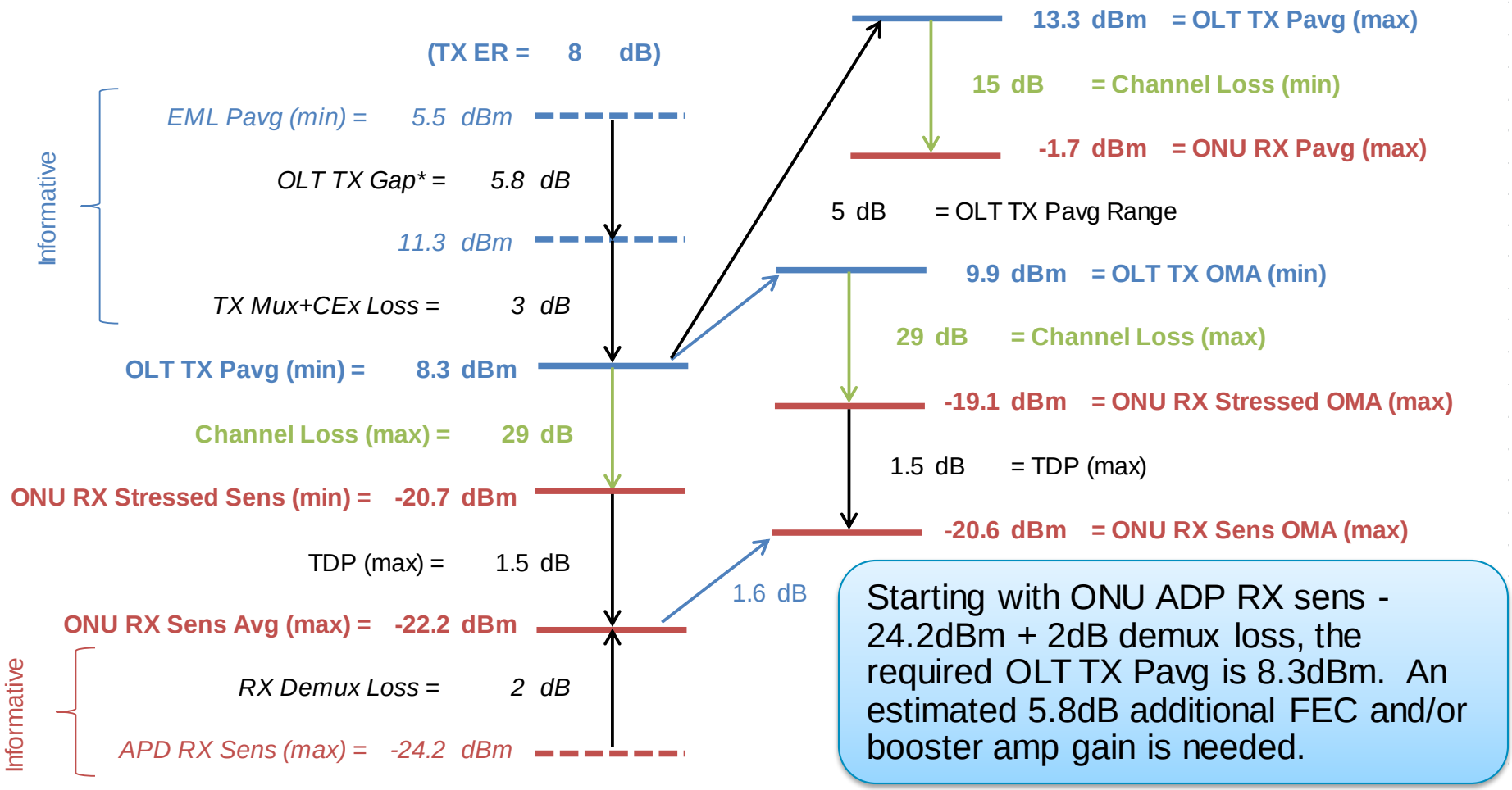
[1] harstead_3ca_4_0117

[2] harstead_3ca_1a_0716

[3] tanaka_3ca_1_0716

[4] umeda_3ca_3_0316

100G OLT and ONU: PR30 Downstream



* Gap to be closed by a combination of FEC gain, amplifier gain or improved component performance.

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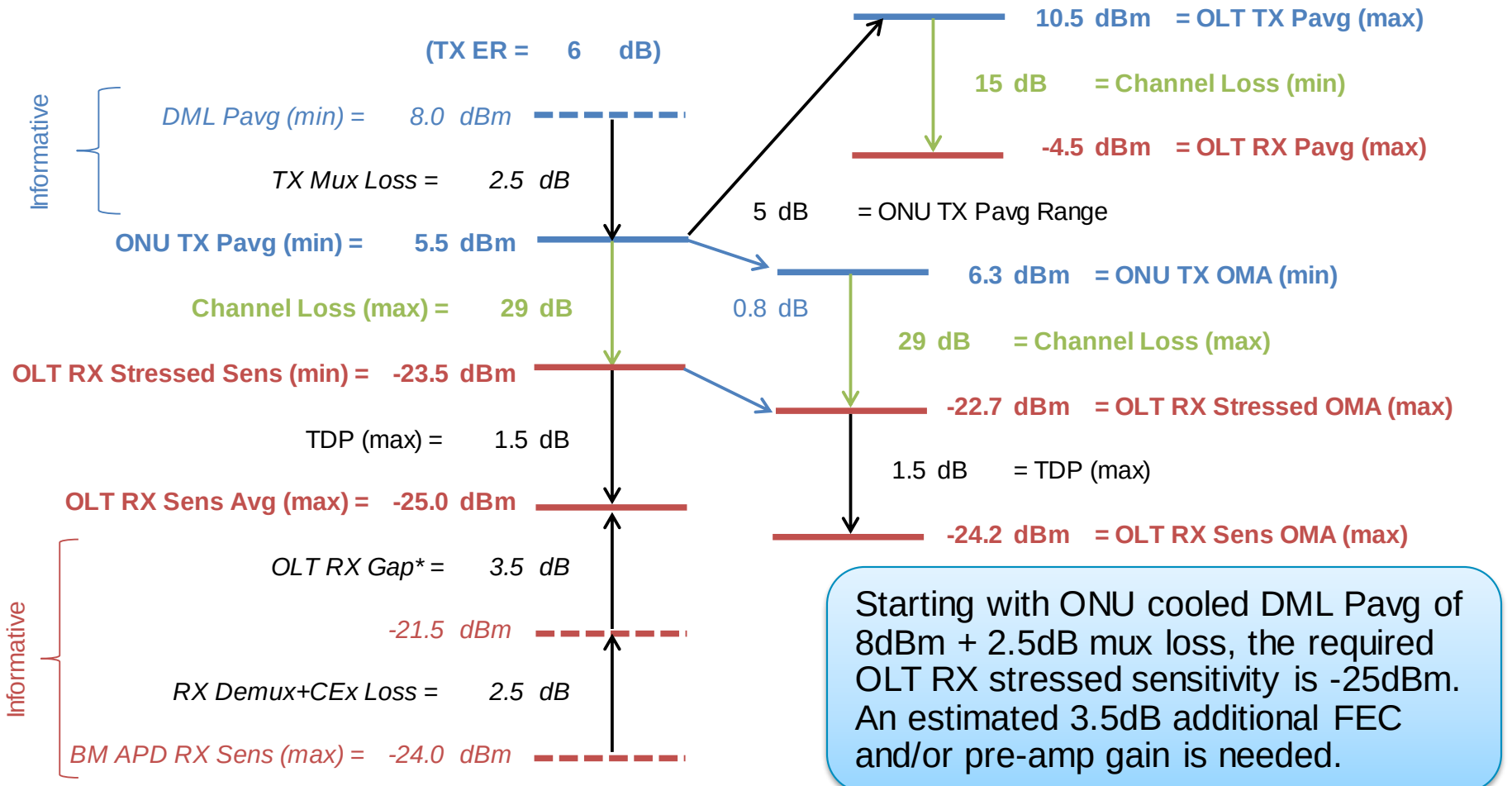
100G OLT and ONU: PR30 Upstream



Starting with ONU cooled DML Pavg of 8dBm + 2.5dB mux loss, the required OLT RX stressed sensitivity is -25dBm. An estimated 3.5dB additional FEC and/or pre-amp gain is needed.

* Gap to be closed by a combination of FEC gain, amplifier gain or improved component performance.

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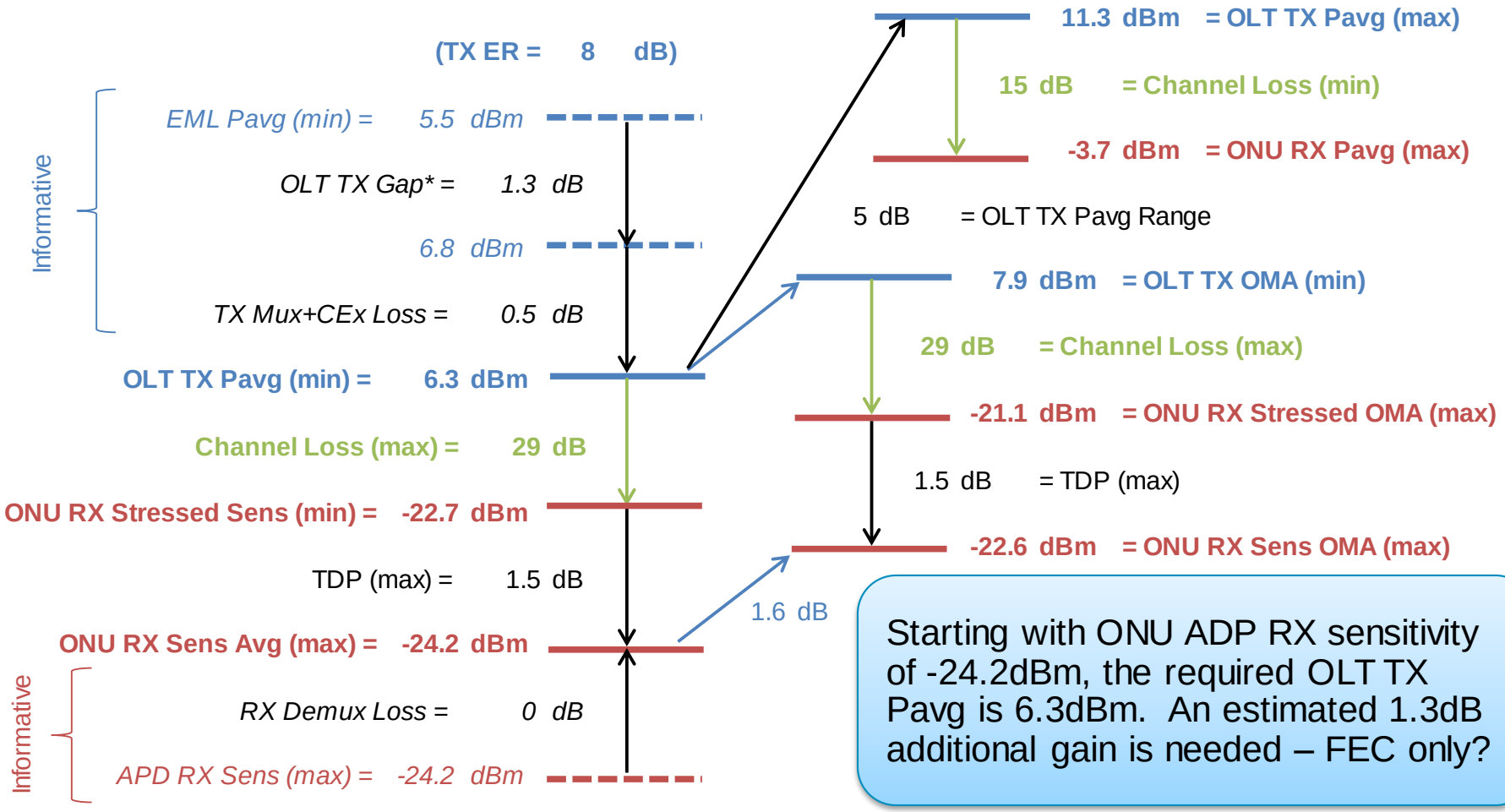
25G ONU and OLT considerations

- The preceding 100G power budgets include mux and demux losses that are equally applicable to 50G OLT and ONUs.
  - A single set of specs can be used for 50G and 100G PMDs.
- The case of 25G OLTs and ONUs demands additional consideration since cost optimized 25G-EPON may be critical to early deployments.
  - Without mux and demux losses, amplifiers may be avoided and lower power and lower cost lasers may be used.
  - 25G OLTs only need to operate with 25G ONUs.
    - Lack of TX mux loss enables use of EML TX without booster SOA.
    - Lack of RX demux loss enables use of APD RX without pre-amp SOA.
  - 25G ONUs must be able to operate with all OLT generations.
    - ONU TX must have sufficient power to overcome 100G OLT demux loss.
    - ONU RX must be able to handle higher TX power from 100G OLT.
- For these reasons, it makes business sense to define separate specs for 25G OLT and ONUs with 25G upstream.

25G OLT and ONU: PR30 Downstream



* Gap to be closed by a combination of FEC gain, amplifier gain or improved component performance.

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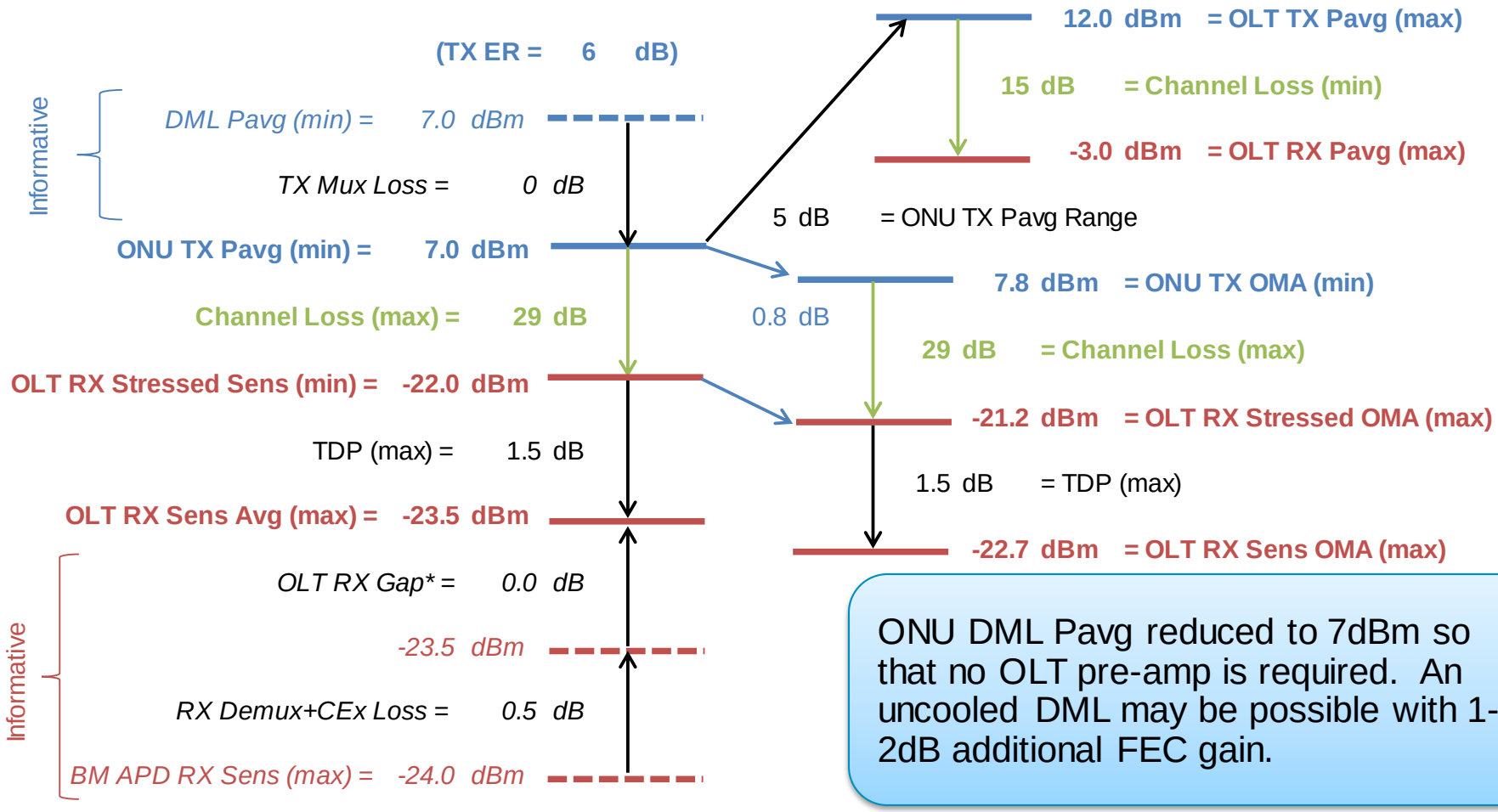
25G OLT and ONU: PR30 Upstream



ONU DML Pavg reduced to 7dBm so that no OLT pre-amp is required. An uncooled DML may be possible with 1-2dB additional FEC gain.

* Gap to be closed by a combination of FEC gain, amplifier gain or improved component performance.

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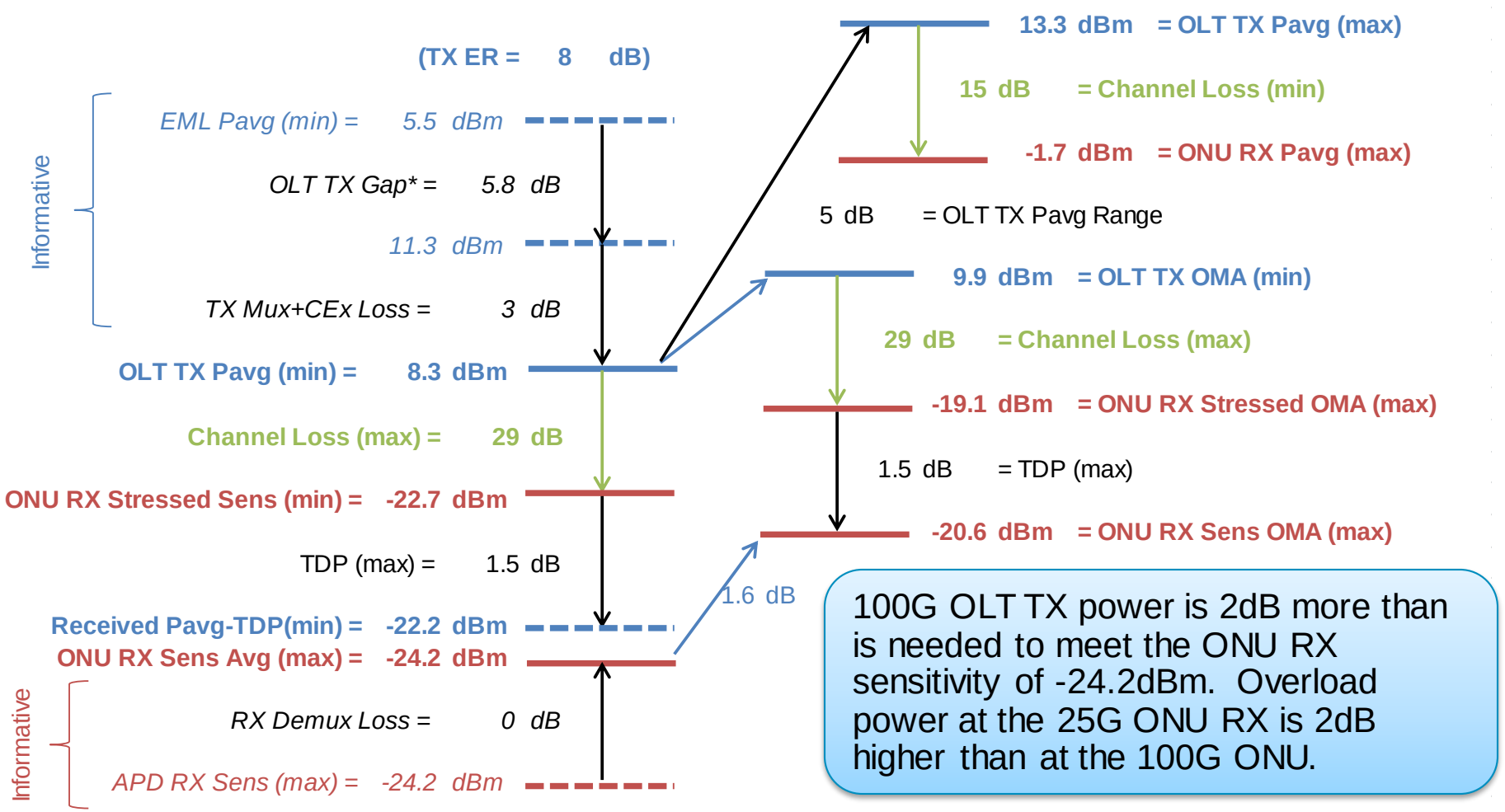
100G OLT and 25G ONU: PR30 Downstream



* Gap to be closed by a combination of FEC gain, amplifier gain or improved component performance.

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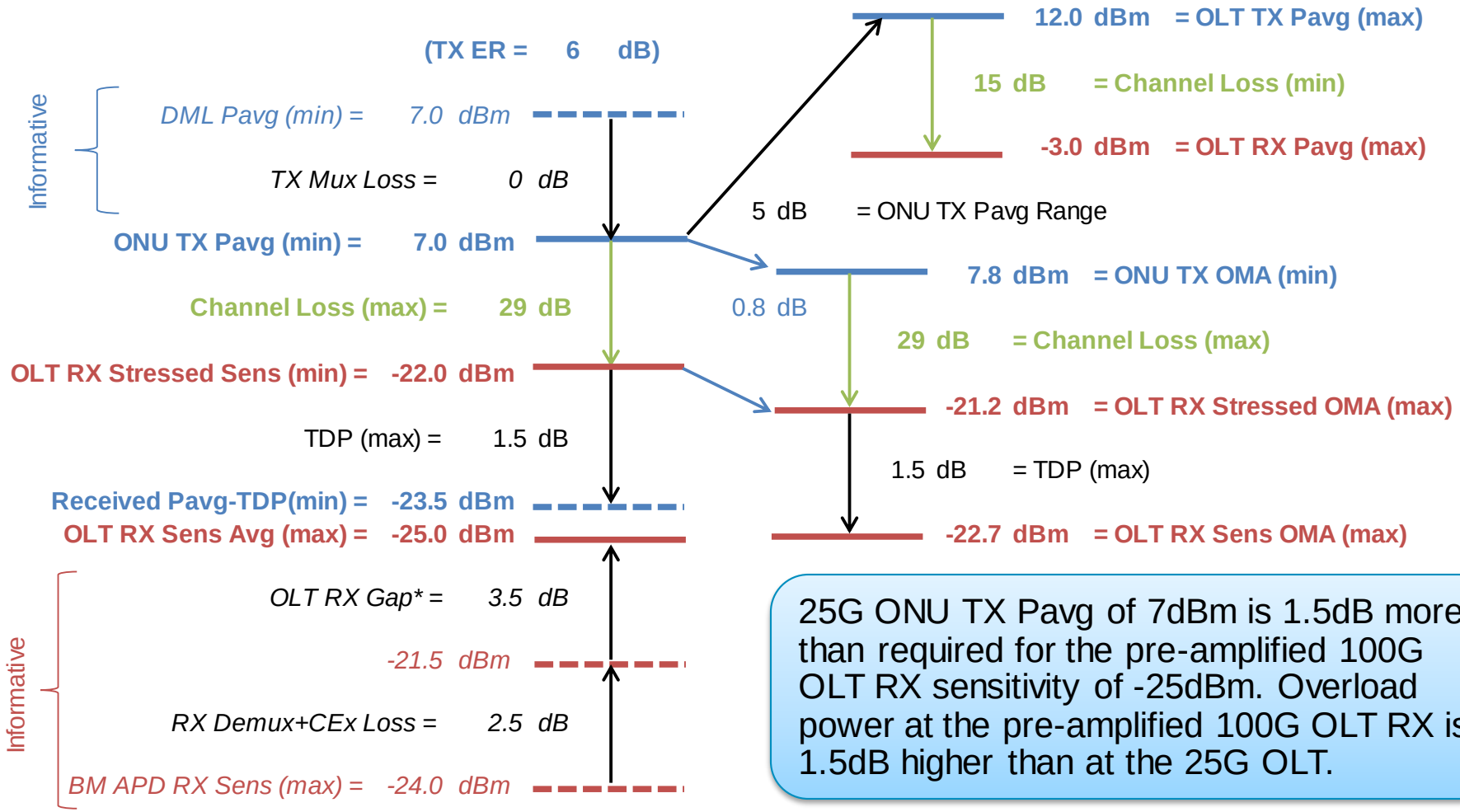
100G OLT and 25G ONU: PR30 Upstream



25G ONU TX Pavg of 7dBm is 1.5dB more than required for the pre-amplified 100G OLT RX sensitivity of -25dBm. Overload power at the pre-amplified 100G OLT RX is 1.5dB higher than at the 25G OLT.

* Gap to be closed by a combination of FEC gain, amplifier gain or improved component performance.

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Summary of OLT PMDs

	25GBASE-PR30-D	50GBASE-PR30-D 100GBASE-PR30-D	25GBASE-PR20-D	50GBASE-PR20-D 100GBASE-PR20-D	Unit
OLT TRANSMIT					
TX Pavg(min)	6.3	8.3	3.3	3.3	dBm
TX OMA(min)	7.9	9.9	4.9	4.9	dBm
DS Power Gap	1.3	5.8	0	0.8	dB
OLT RECEIVE					
RX Pavg Sens(max)	-23.5	-25	-21.5	-21.5	dBm
RX OMA Sens(max)	-22.7	-24.2	-20.7	-20.7	dBm
US Power Gap	0	3.5	0	0	dB

Biggest gap is TX Pavg for 50G and 100G OLTs, 5.8dB. It will be difficult to achieve 11.3dBm before the mux using single-channel SOAs without significant additional FEC gain.

It should be possible to achieve 3.5dB pre-amp gain using SOA pre-amps for 50G and 100G OLT RX, but will be easier with additional (burst mode) FEC gain.

Other power gaps less than 1.5dB are within range to be closed by additional FEC gain alone.

Summary of ONU PMDs

ONU TRANSMIT	25GBASE-PR30-U 50/25GBASE-PR30-U 100/25GBASE-PR30-U	50GBASE-PR30-U 100/50GBASE-PR30-U 100GBASE-PR30-U	ALL PR20-U	Unit
TX Pavg(min)	7	5.5	4	dBm
TX OMA(min)	7.8	6.3	4.8	dBm

ONU RECEIVE	25GBASE-PR30-U	50/25GBASE-PR30-U 50GBASE-PR30-U 100/25GBASE-PR30-U 100/50GBASE-PR30-U 100GBASE-PR30-U	ALL PR20-U	Unit
RX Pavg Sens(max)	-24.2	-22.2	-22.2	dBm
RX OMA Sens(max)	-22.6	-20.6	-20.6	dBm

The most difficult ONUs to realize will be the 50/50G, 100/50G and 100/100G PR30 ONUs which require cooled DMLs with 8dBm output power. This requirement should be relaxed with additional (burst mode) FEC gain if possible.

Conclusions

- In order to generate first draft text for the NG-EPON PMD spec tables, this contribution summarizes the straw-man power budget assumptions used in laubach_3ca_04_0317.
- There are gaps in some power budgets due to the expected limitations of optical components that must be closed by additional FEC gain, optical amplifier gain or improvements in component technology.
- Despite the limitations, it will be beneficial for the task force to have populated (as opposed to empty) tables in the baseline text that can be used as the starting point for future contributions and comments.

Thank You!

Appendix: PR20 power budgets

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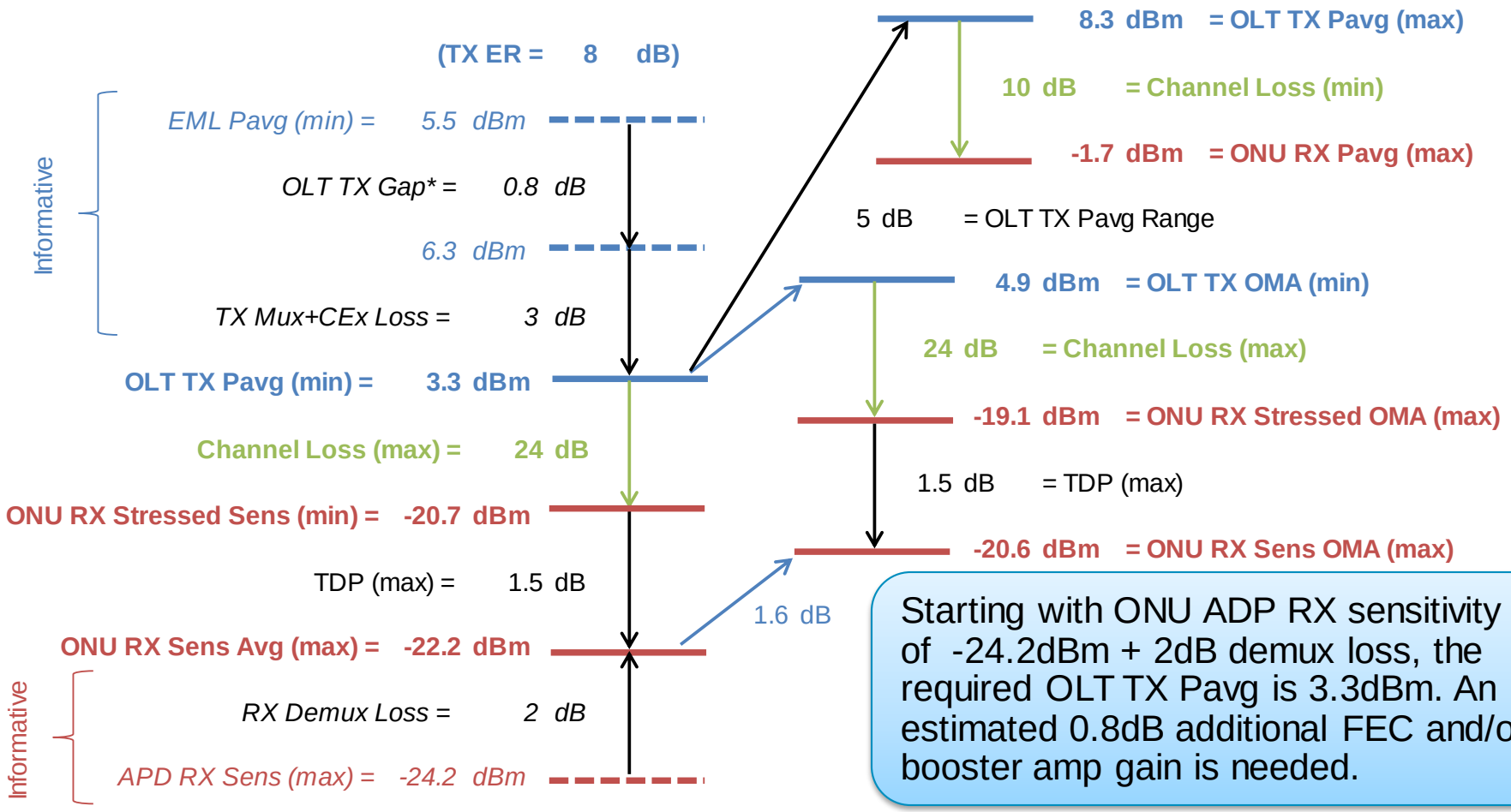
100GBASE-PR20 downstream



Starting with ONU ADP RX sensitivity of -24.2dBm + 2dB demux loss, the required OLT TX Pavg is 3.3dBm. An estimated 0.8dB additional FEC and/or booster amp gain is needed.

* Gap to be closed by a combination of FEC gain, amplifier gain or improved component performance.

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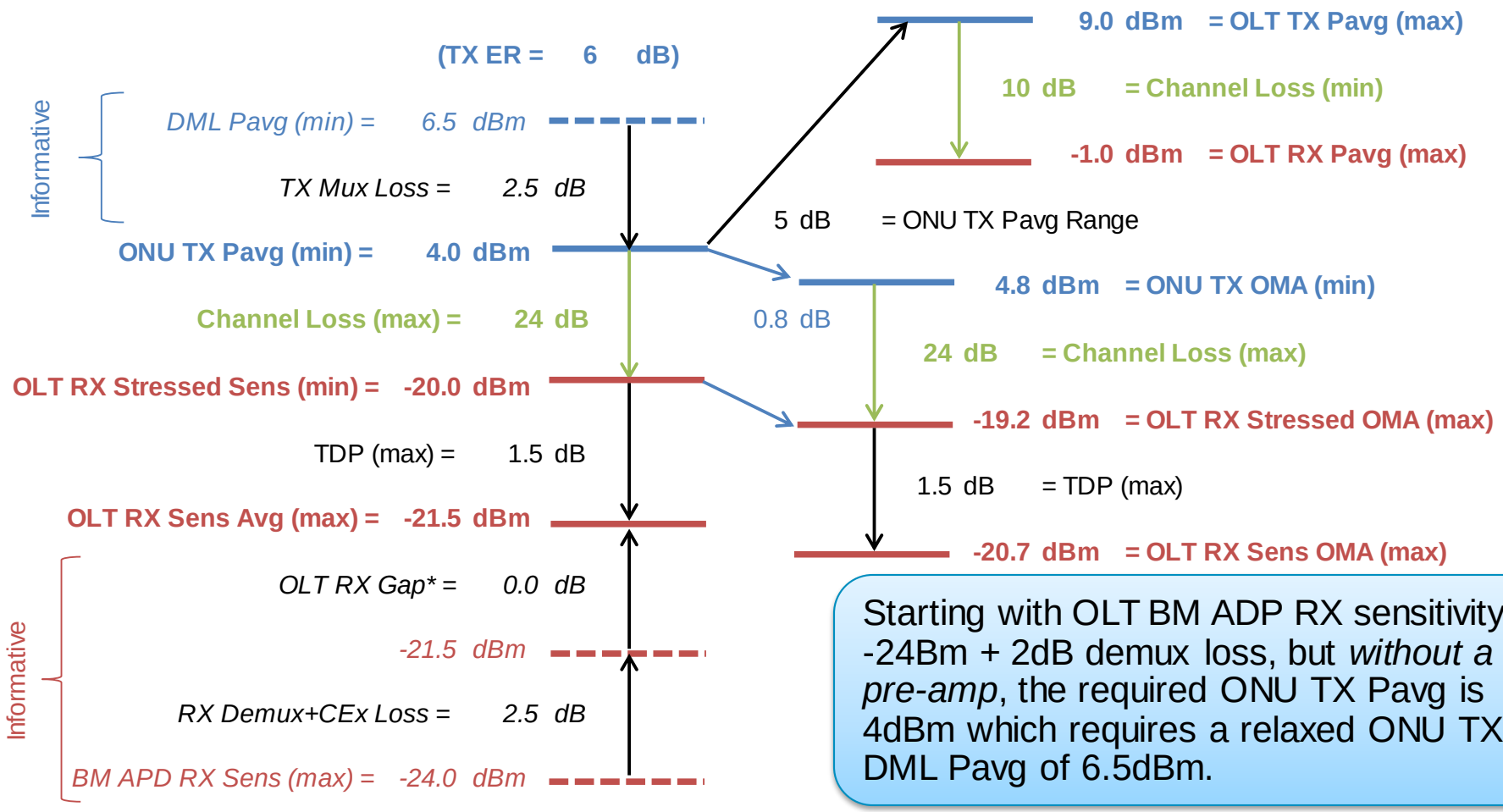
100GBASE-PR20 upstream



Starting with OLT BM ADP RX sensitivity -24Bm + 2dB demux loss, but *without a pre-amp*, the required ONU TX Pavg is 4dBm which requires a relaxed ONU TX DML Pavg of 6.5dBm.

* Gap to be closed by a combination of FEC gain, amplifier gain or improved component performance.

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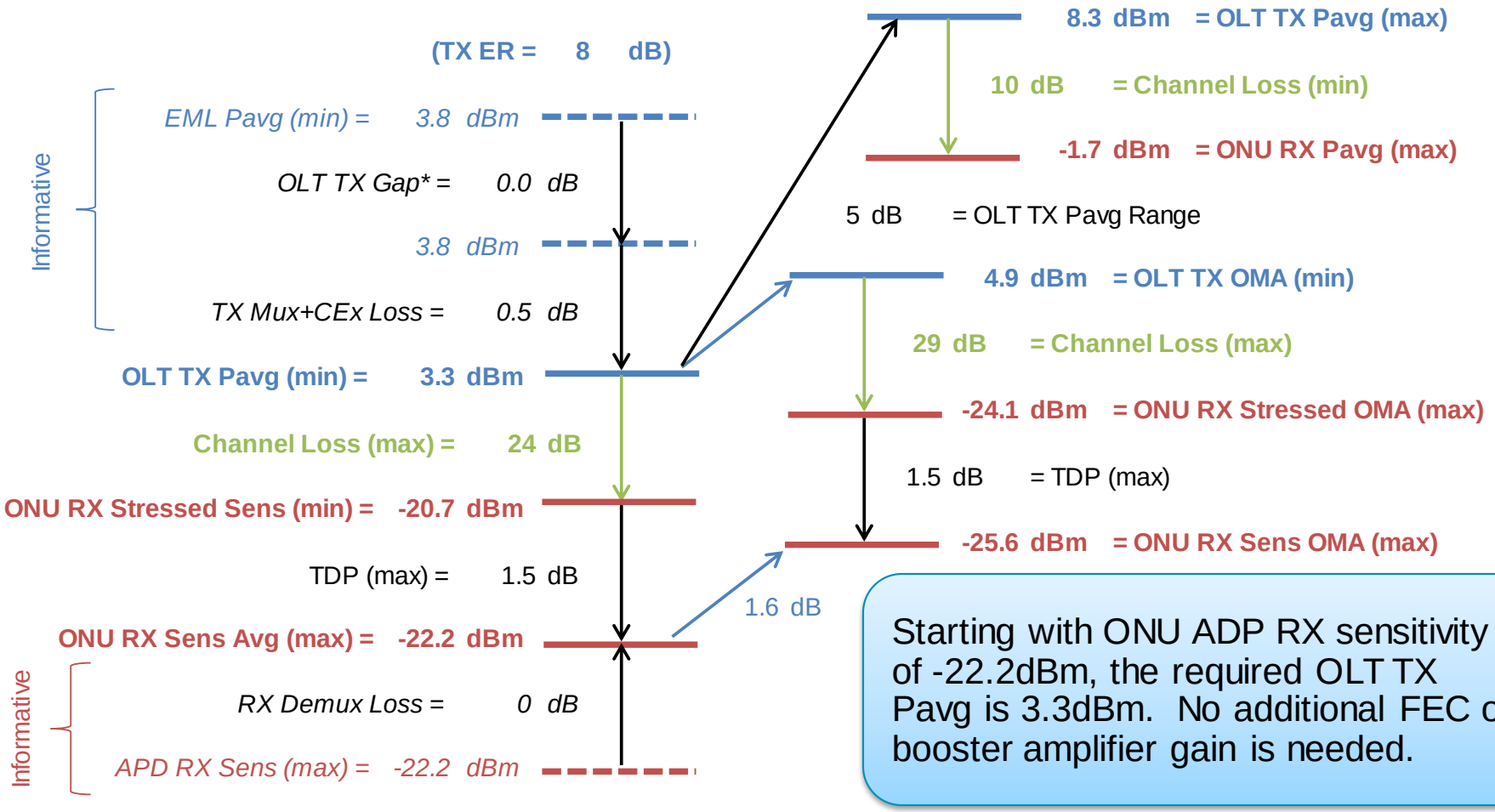
25G OLT and ONU: PR20 Downstream



* Gap to be closed by a combination of FEC gain, amplifier gain or improved component performance.

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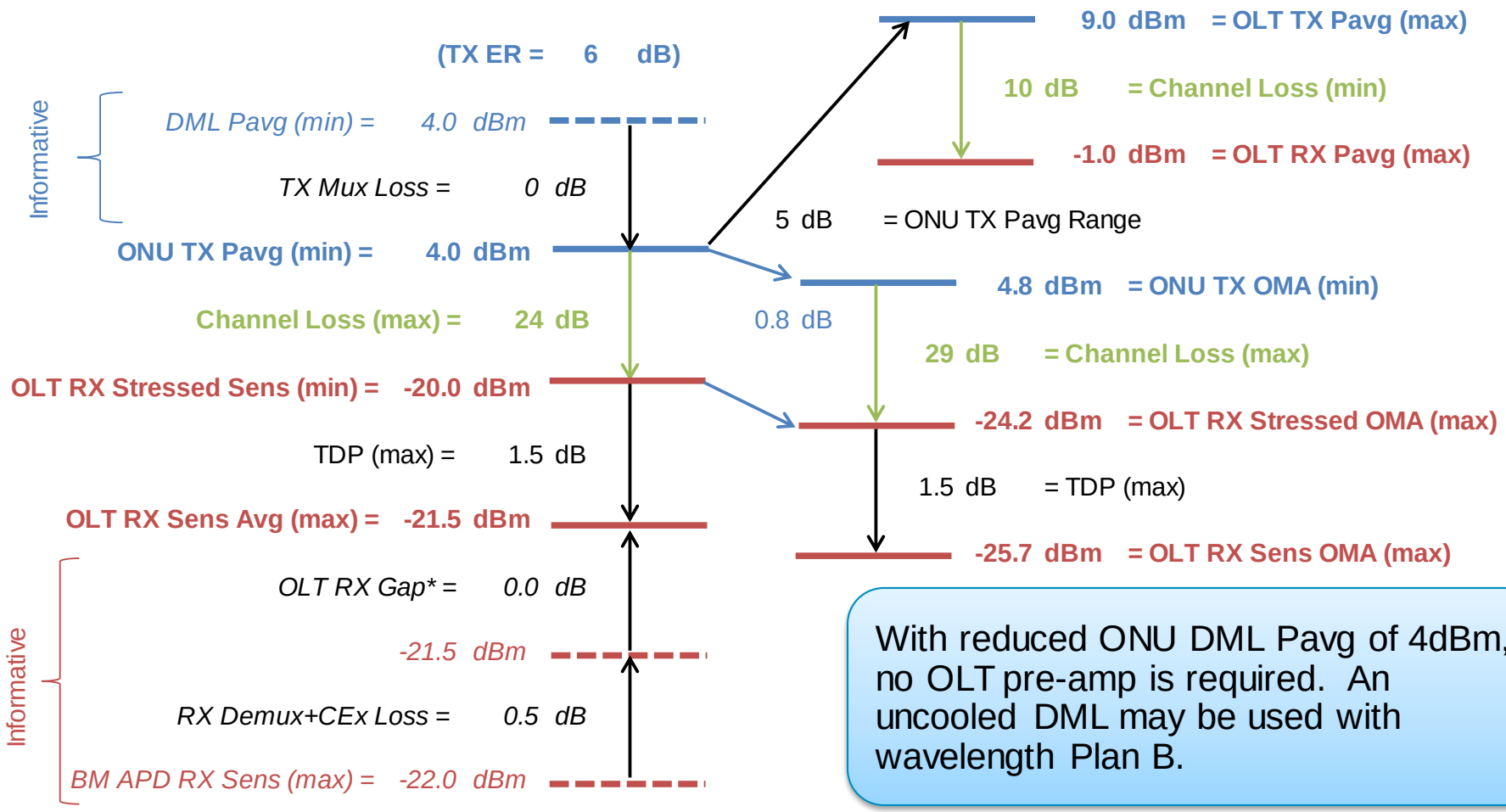
25G OLT and ONU: PR20 Upstream



With reduced ONU DML Pavg of 4dBm, no OLT pre-amp is required. An uncooled DML may be used with wavelength Plan B.

* Gap to be closed by a combination of FEC gain, amplifier gain or improved component performance.

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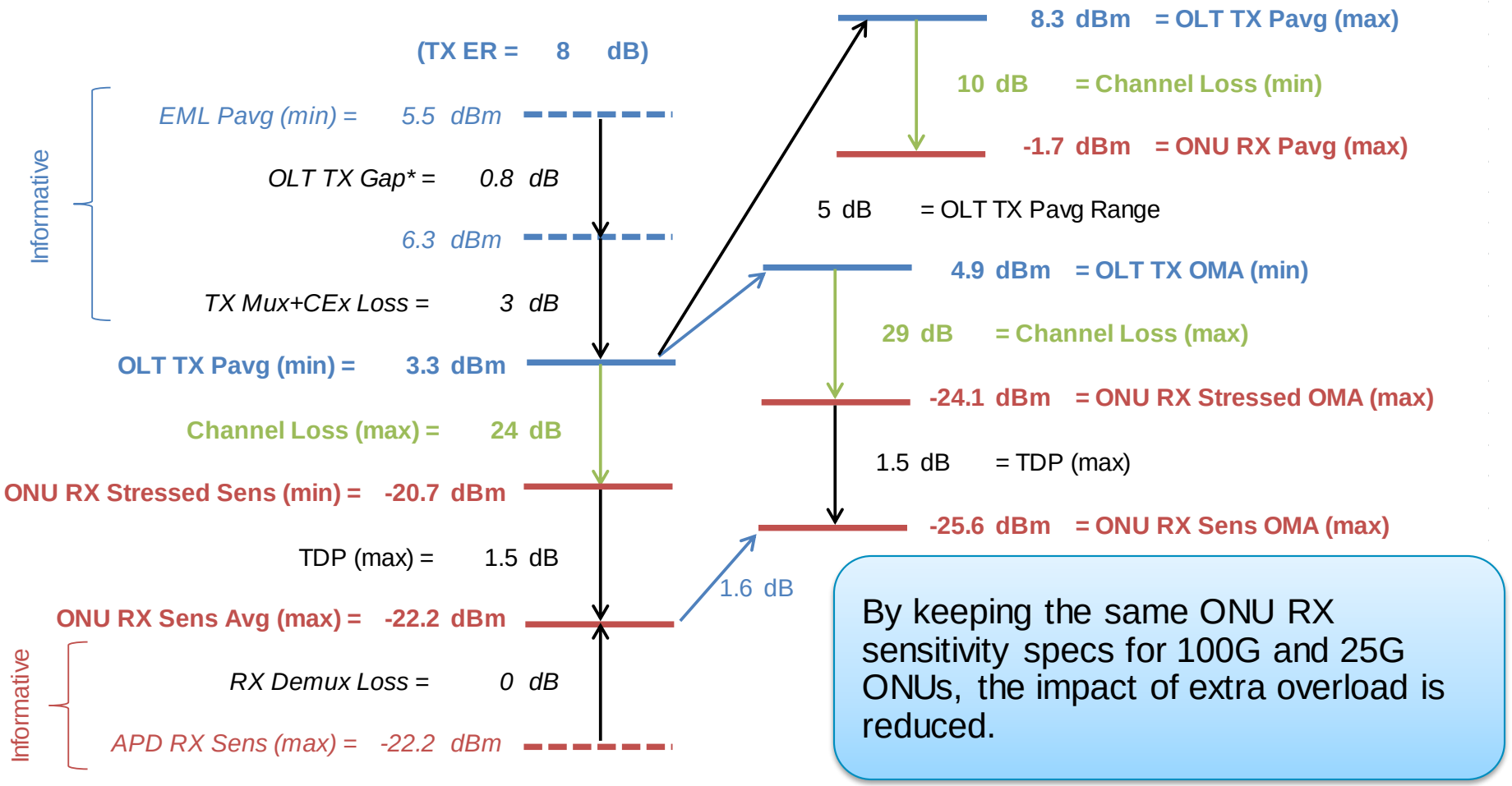
100G OLT and 25G ONU: PR20 Downstream



By keeping the same ONU RX sensitivity specs for 100G and 25G ONUs, the impact of extra overload is reduced.

* Gap to be closed by a combination of FEC gain, amplifier gain or improved component performance.

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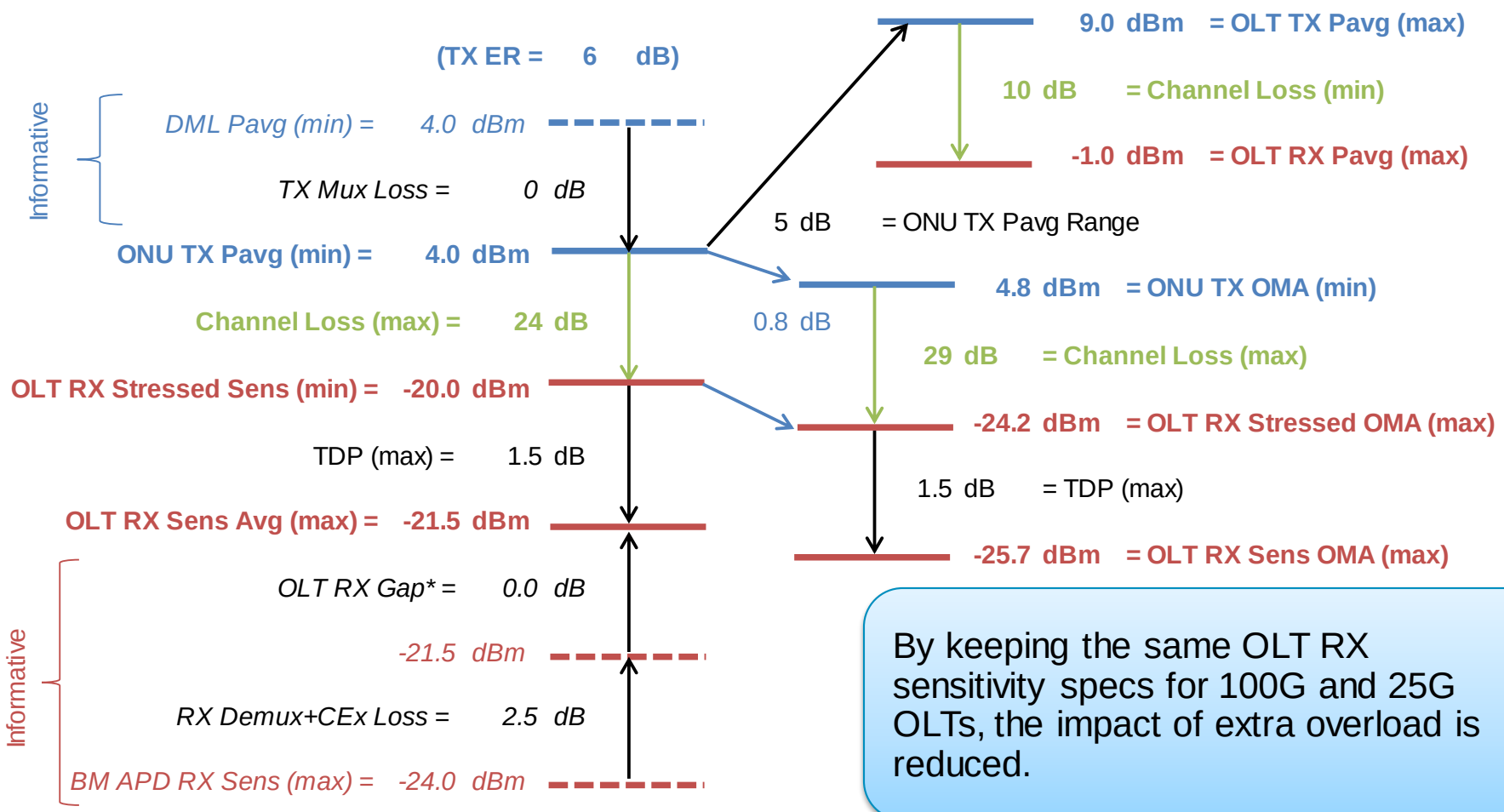
100G OLT and 25G ONU: PR20 Upstream



By keeping the same OLT RX sensitivity specs for 100G and 25G OLTs, the impact of extra overload is reduced.

* Gap to be closed by a combination of FEC gain, amplifier gain or improved component performance.

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