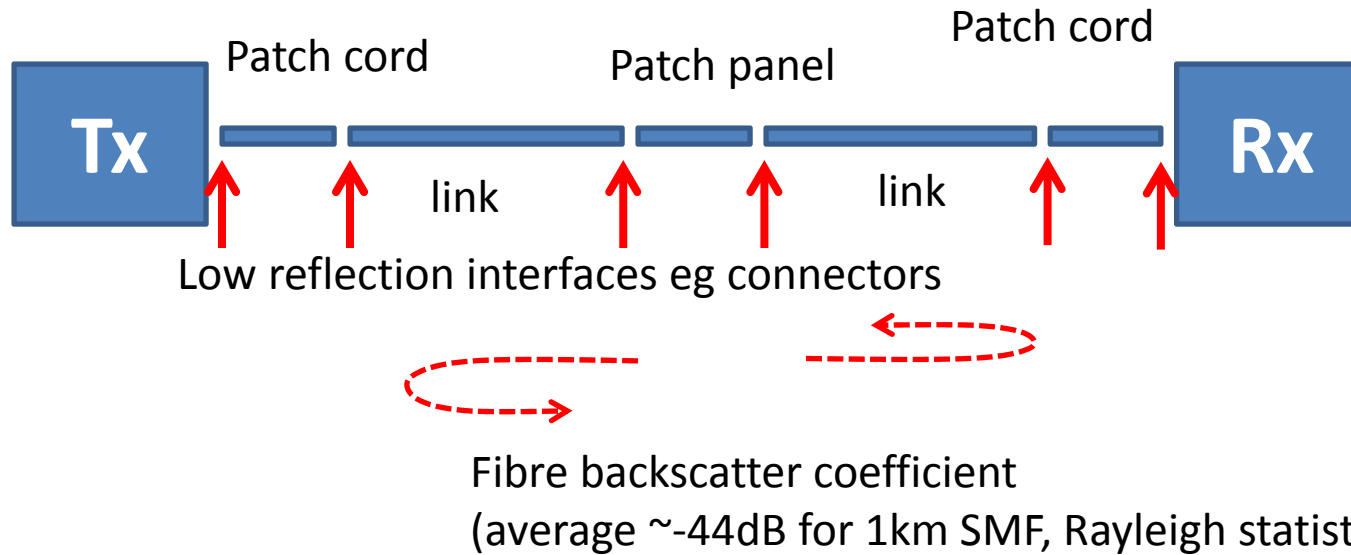


PAM-N, coherent interference and return loss specs

March 2012

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Link return loss



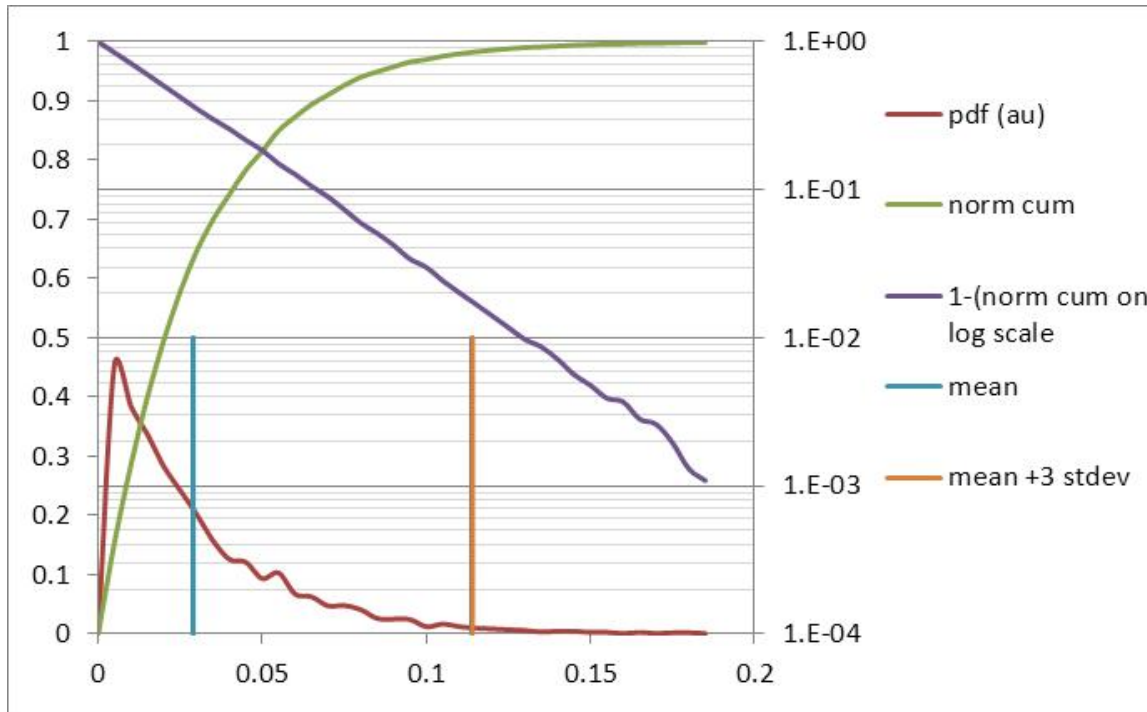
- Reflections along the link cause round trip optical 'echoes', leading to coherent interference for single wavelength sources.

- Round trip return loss, dB, = RL_{RT}
- Round trip reflection = $Rf_{RT} = 10^{(-RL_{RT}/10)}$

Return loss for PAM-N

- **Coherent interference: received power varies between $(1 \pm Rf_{RT}^{0.5})^2$**
 - Variation due to coherent interference is $\sim 4.Rf_{RT}^{0.5}$
- **The variation needs to be small compared to the OMA of a single level change.**
 - E.g. for PAM-8, OMA of single level $\sim 1/10^{\text{th}}$ of max Tx power (allowing a reasonable max ER), so for $4.Rf_{RT}^{0.5} < 1/100$
 - and so, $Rf_{RT} \sim 1/160000$, equivalent to -52dB, or 26dB RL each end of the cable.
- **For 2 connection interfaces at each end**, an added 6dB of RL margin is needed at each end (interference due to 2 equally reflective interfaces can quadruple reflected power):
 - **connections need to be below -32dB reflectance, ignoring fibre backscatter**
- **For 3 connector interfaces each end (eg. data centre environment)**, 9dB RL margin is needed at each end:
 - **connections need to specified to at least -36dB reflectance**
 - Further margin needed to allow for fibre backscatter.
 - Note: Backscatter of single mode fibre averages around -44dB for a 1km fibre. For single wavelength sources, the instantaneous backscatter can be much higher than this eg 4x for $\sim 1\%$ of the time .
- Round trip return loss effects should be considered carefully for multilevel modulation systems, and may place stringent demands on Tx, Rx, connector reflectance specifications. Consideration of backscatter in next 2 slides....

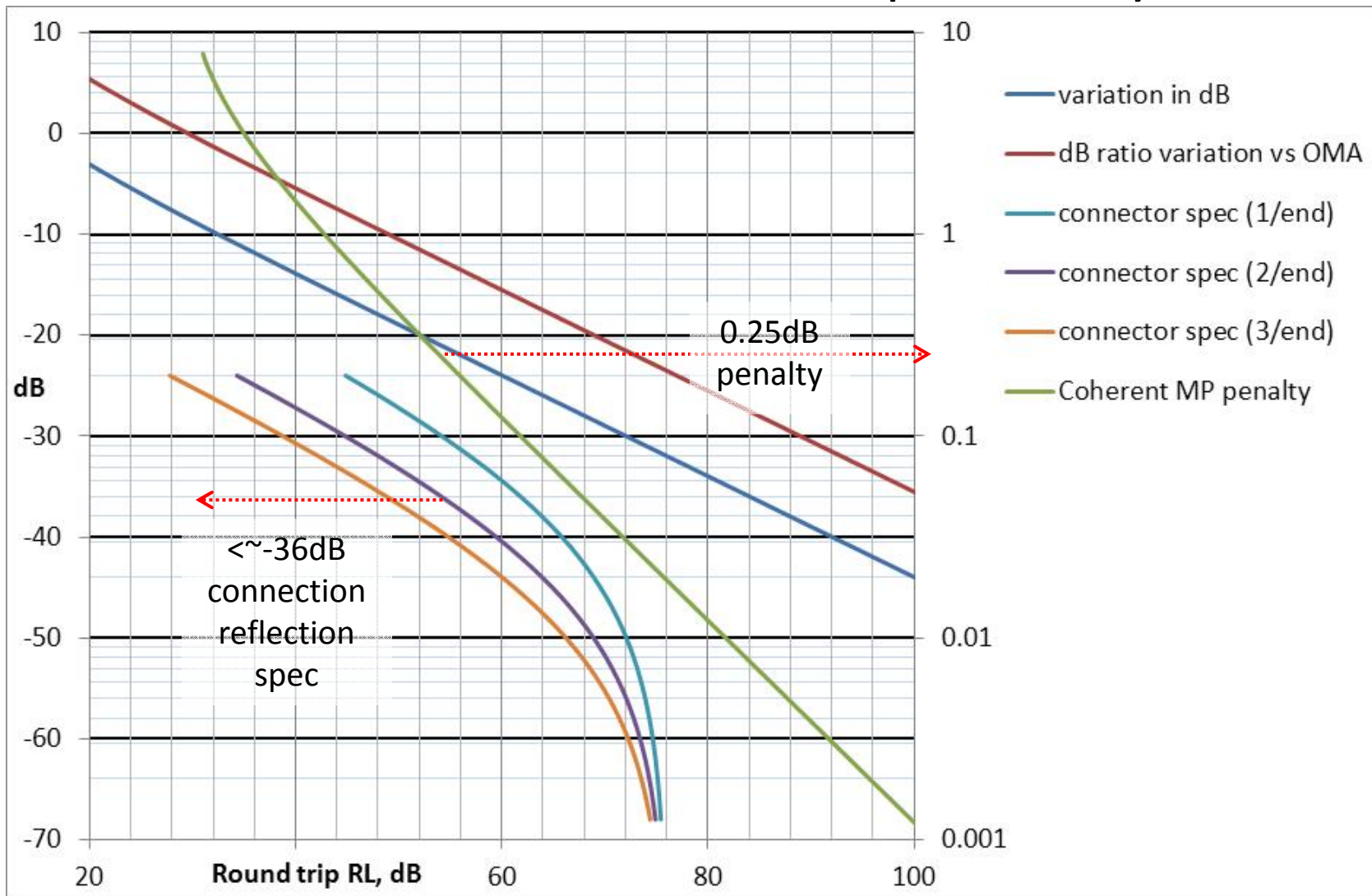
Backscatter statistics



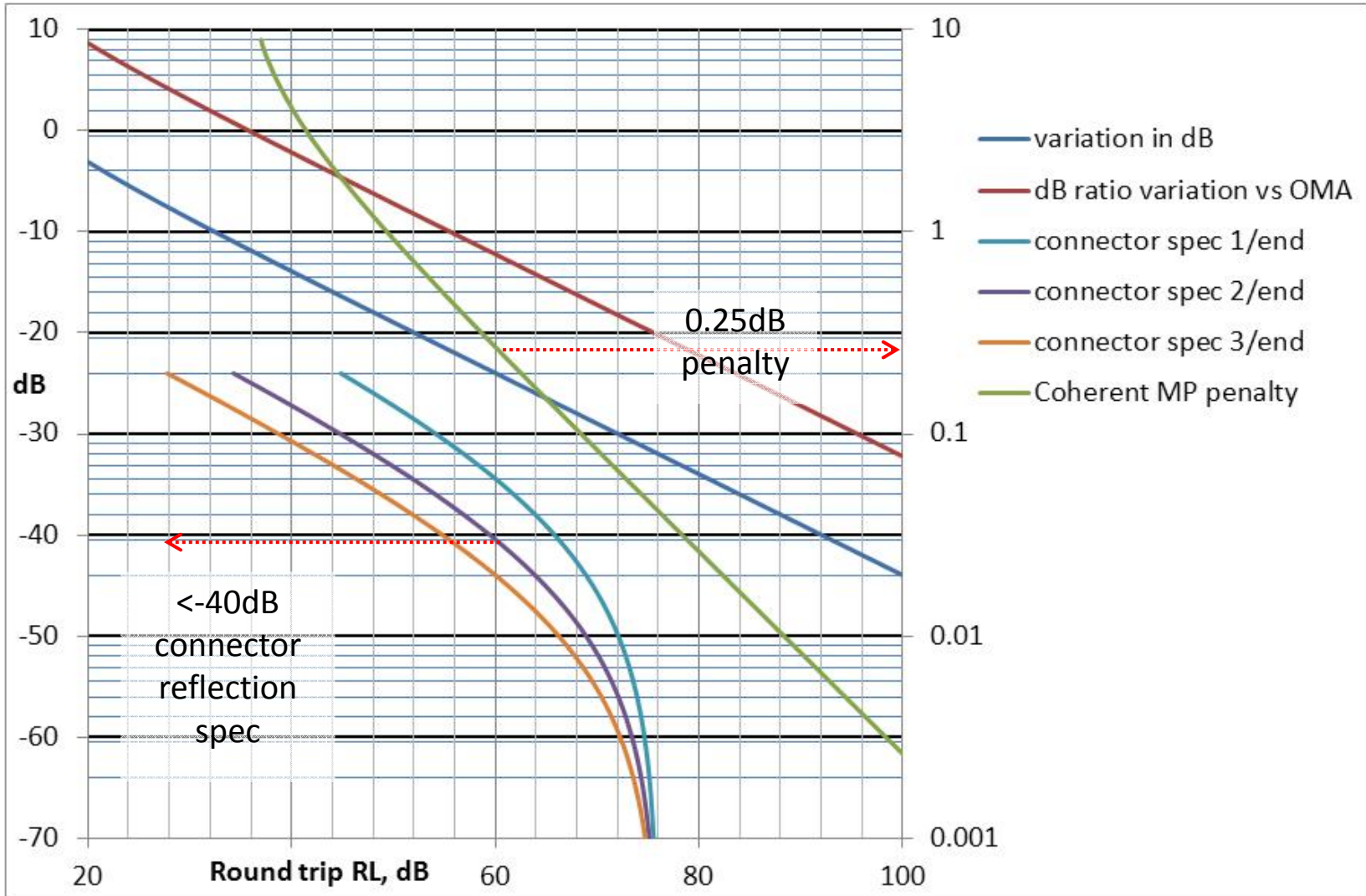
- Backscatter has Rayleigh p.d.f.
 - typically slowly time varying due to thermal and mechanical changes to fibre)
 - backscatter induced penalties affect outages, not just average error rates.
- Standard deviation = mean
- Backscatter is 3x average ~5% of time, 4x average ~1% of time

Further reading (for example): “Statistics of Rayleigh backscatter from a single-mode optical fibre“, Healey, P.; Electronics Letters, Volume: 21, Issue: 6, 1985, Page(s): 226 – 228.

Coherent multipath with PAM 8, 2, 4, 6 connections per link, backscatter at $\sim 1\%$ probability



Coherent multipath with PAM 16, 2, 4, 6 connectors per link, backscatter at ~1% probability



Thanks !