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A Methodology to Obtain OSNR Penalty vs Optical Inter-Channel Crosstalk

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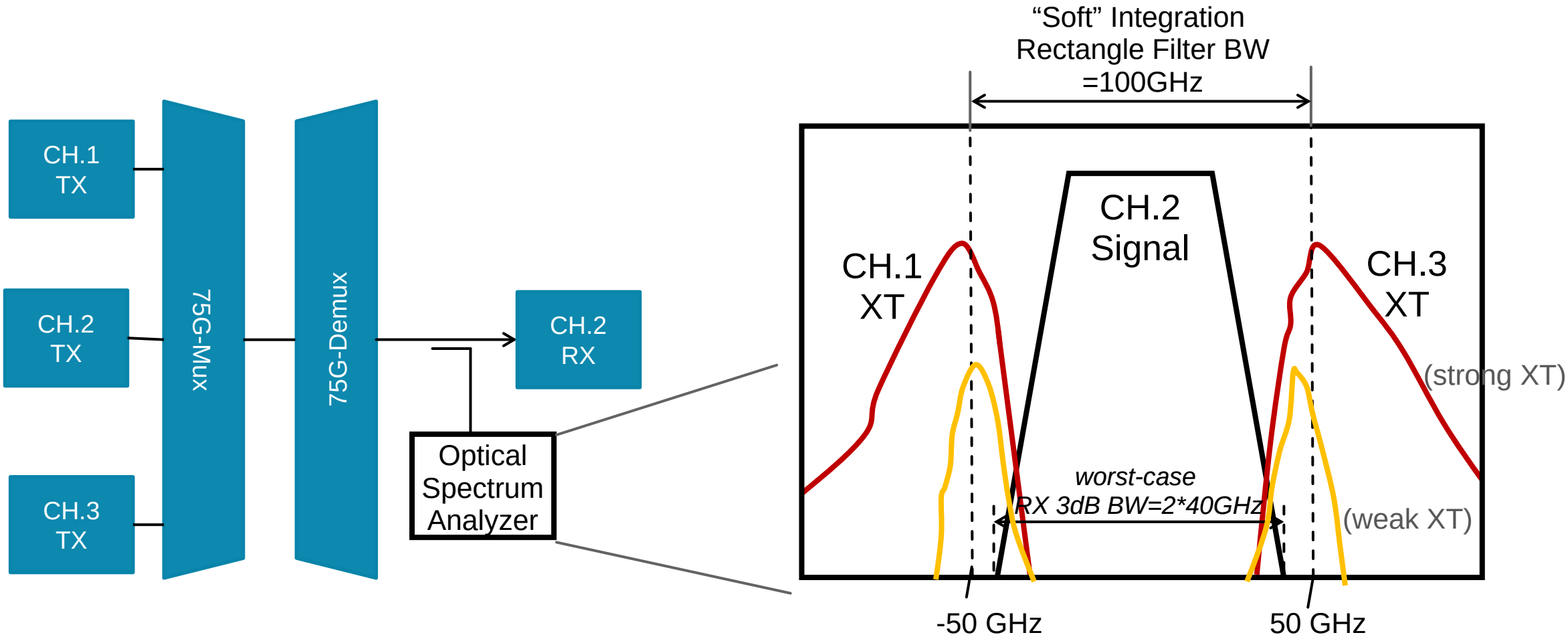
Introduction

- **Inter-channel crosstalk was proposed as a black link parameter (way_3cw_01a_200423)**
  - The crosstalk power integration filter was arbitrarily chosen to be 75GHz
  - The crosstalk was assumed to be flat
- **Inter-channel crosstalk was calculated for different MUX/DEMUX filter shapes and a pulse-shaped TX spectrum (maniloff_3cw_01_200528), but not directly related to rOSNR penalty**
  - Calculated electrical domain crosstalk NSR to map to rOSNR penalty
- **In this contribution, we propose a general methodology to relate rOSNR penalty to inter-channel crosstalk** *(=adjacent-channel crosstalk in coherent systems)*
  - Define worst-case receiver bandwidth and DSP parameters
  - Increase the crosstalk via laser/mux/demux frequency drifts and scaling mux/demux bandwidths
  - Worst-case optical power imbalance among wavelengths
  - Define a “soft” integration filter after DEMUX to calculate optical crosstalk to signal ratio

Worst-case Assumptions

- Middle channel optical power 4dB lower than neighbors
- No pulse shaping, TX OSR=1, RX OSR=1.2
- Laser frequency drifts up to +/-1.8GHz
- Local Oscillator Offset (LOO)= 1.8GHz (for [+1.8 0 -1.8] laser drifts)
- Mux/Demux frequency drifts up to +/-4GHz
- RX 3dB bandwidth (including ADC) = 30, 35, and 40GHz, with a trapezoidal filter shape
- TX 3dB bandwidth 30GHz RRC α=0.3, 0.4, and a realistic shape
- rOSNR baseline starts at 26dB @ pre-FEC BER=1.25e-2
- Inter-channel crosstalk (XT) is increased by laser/mux/demux frequency drifts and scaling the mux/demux bandwidth from 1 to 1.15

Integration Filter for Measuring XT/Signal Power



100GHz rectangular integration filter can capture the signal and adjacent-interference (ACI) power seen by a RX whose BW is as wide as 40GHz. 100GHz is also not too wide to capture ACI power that the receiver does not see.

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Reference Receiver (PIN+TIA+ADC)

- **30GHz RX**

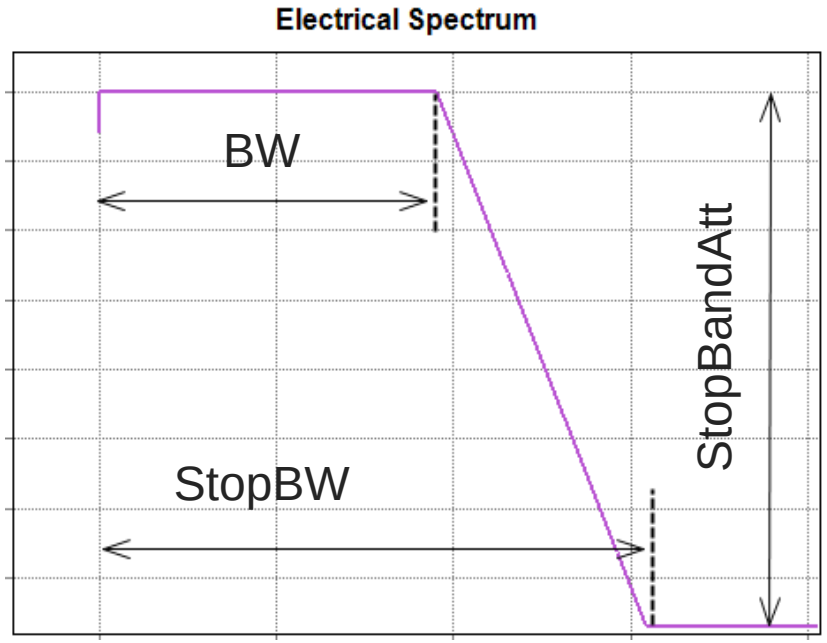
  BW= 28.6 GHz
  StopBW= 46.4 GHz
  StopBandAtt= 38.5 dB

- **35GHz RX**

  BW= 33.4 GHz
  StopBW= 54.1 GHz
  StopBandAtt= 38.5 dB

- **40GHz RX**

  BW= 38.2 GHz
  StopBW= 61.9 GHz
  StopBandAtt= 38.5 dB



StopBW / BW= 1.62

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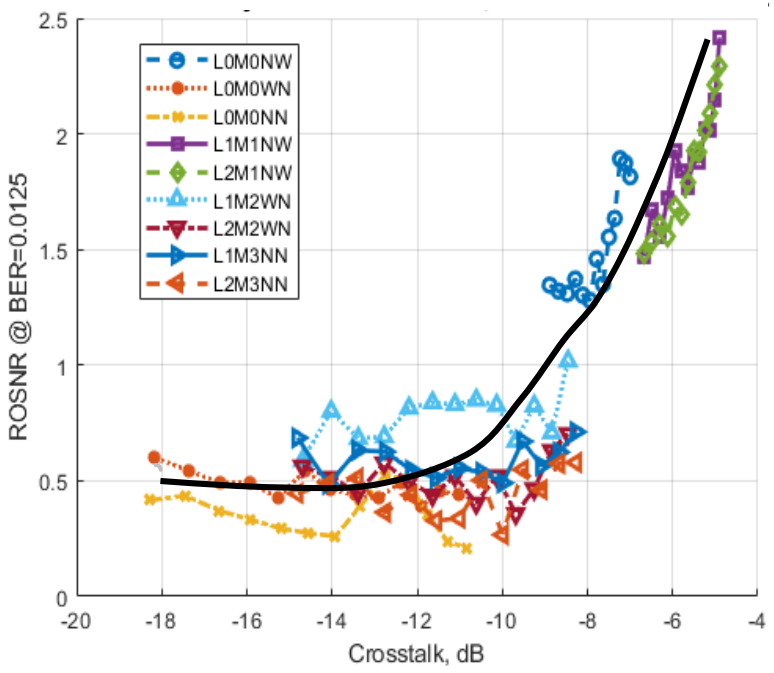
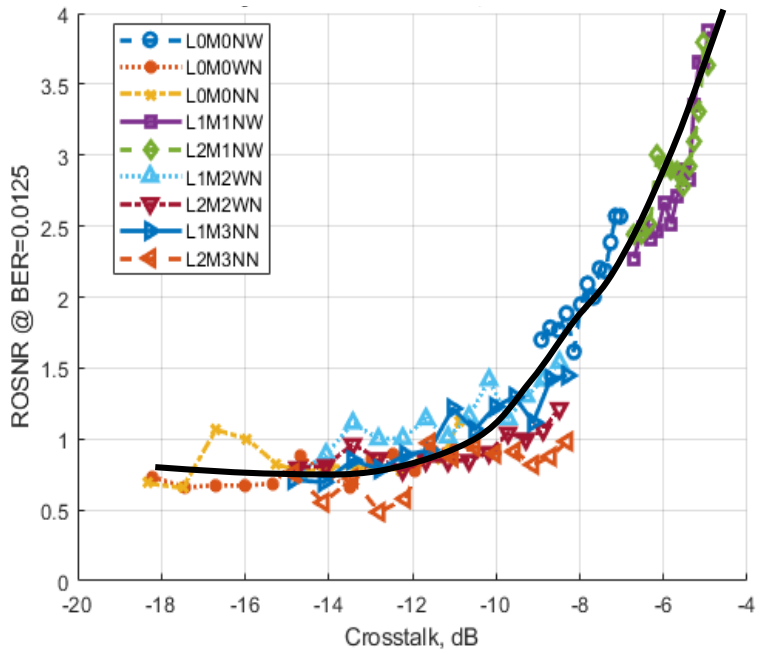
rOSNR Penalty @ BER=1.25e-2 vs Optical Crosstalk

3 RX BW and various combinations of MUX/DEMUX filter shape /bandwidths and laser/mux/demux frequency shifts [rectangle integration filter BW=100GHz]

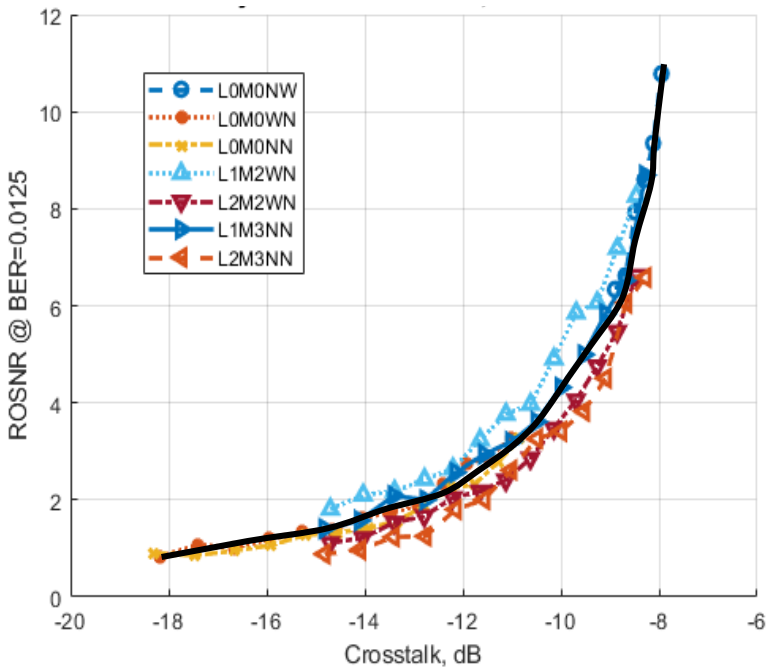
RX BW= 30GHz



RX BW= 35GHz



RX BW= 40GHz



Laser Drifts (GHz) [Ch1, Ch2, Ch3, LO]
L0: [0, 0, 0, -1.8]
L1: [1.8, -1.8, -1.8, 0.0]
L2: [1.8, 0.0, -1.8, -1.8]

M0: *zero mux/demux shift*
M1~M3:
Up to +/-4GHz mux/demux shift

MUX/DMUX
N: 75GHz 3rd-order Gaussian
W: 3dB BW ≈ 1.2 x 75GHz *3rd-order Gaussian BW*

For each receiver bandwidth, all results converge to a common curve

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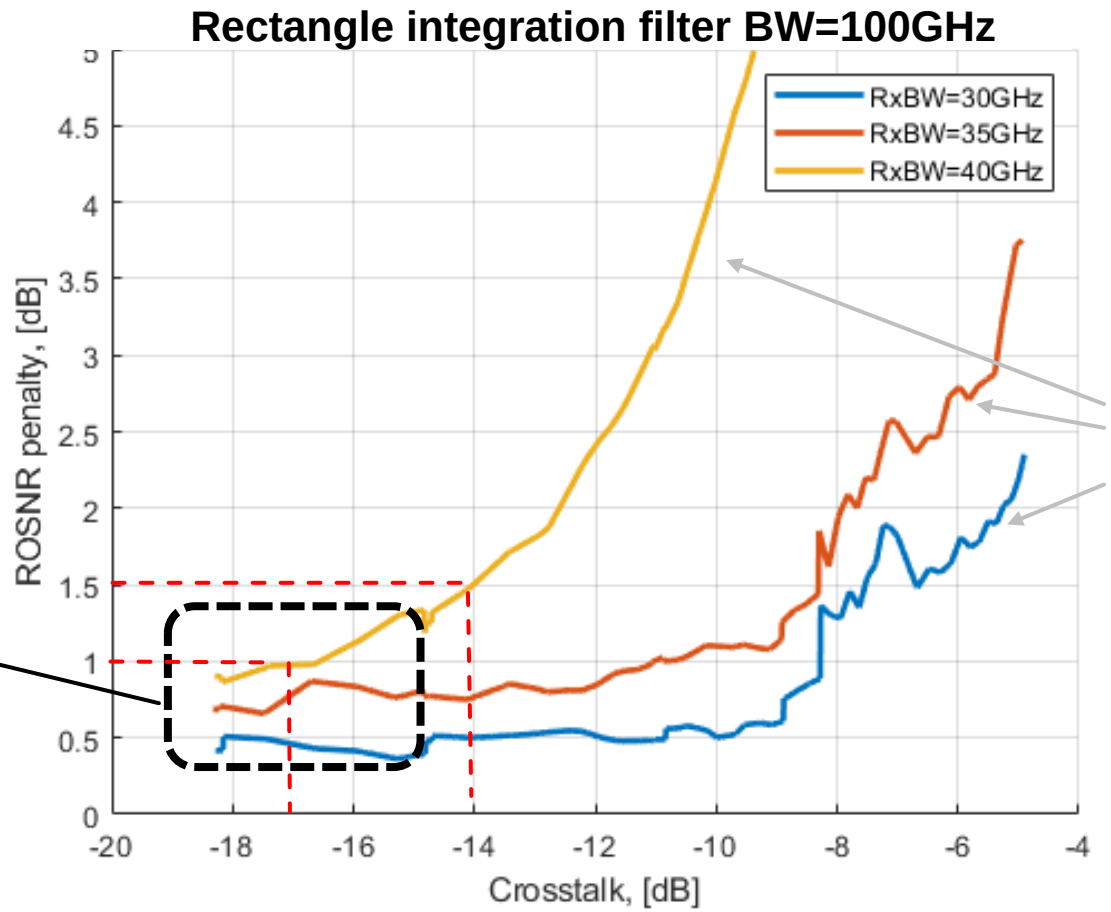
Worst-Case rOSNR Penalty vs Optical Crosstalk

When using DEMUX with 75GHz 3rd-order Gaussian filter shape, the rOSNR penalty difference is < 1dB. Good for interoperability despite different receiver bandwidths.



Average values of the three RX BW data from last slide

If rOSNR penalty=1 or 1.5dB, max inter-channel xtalk = -17 or -14dB when using 100GHz rectangle integration filter

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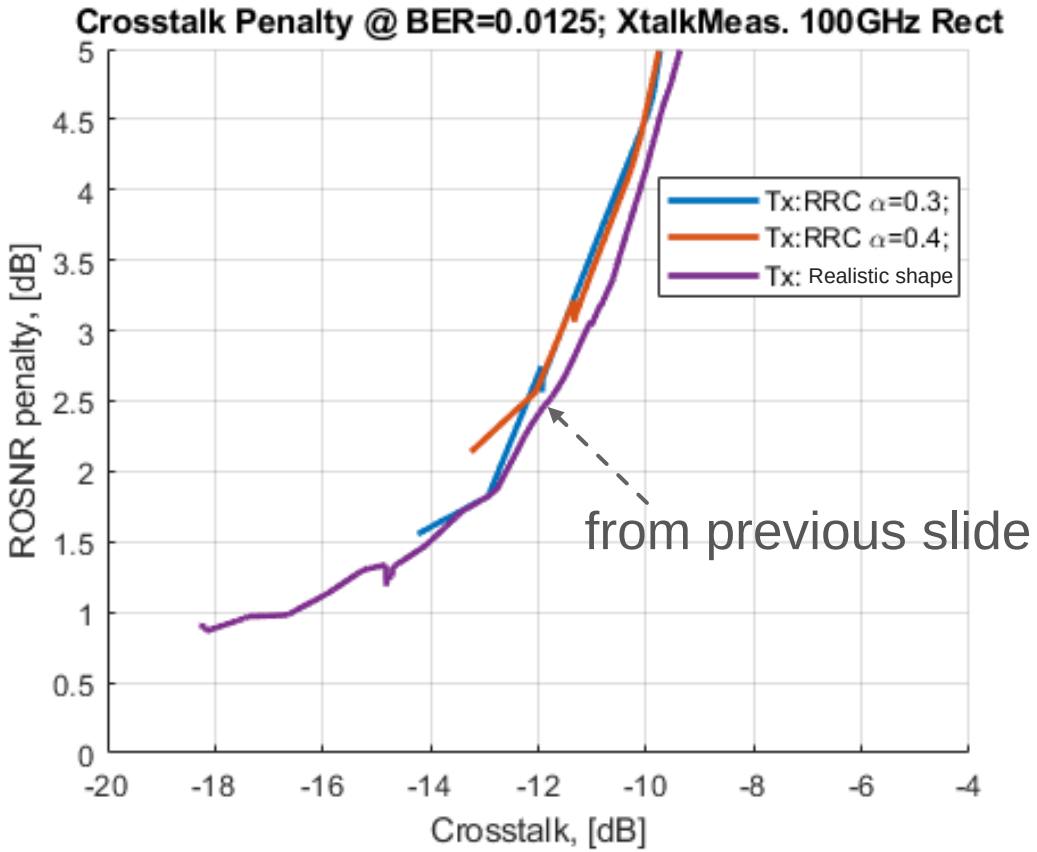
Effects of TX Optical Spectral Shape (RX BW=40GHz)



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OSNR Penalty vs Inter-Channel Crosstalk

- **A methodology is proposed to obtain OSNR penalty vs inter-channel crosstalk based on:**
  - *RX BW=40GHz with a trapezoidal shape; TX OSR=1, RX OSR=1.2, LOO=1.8GHz, TX output power 4dB lower than neighbors*
  - *TX BW modeled by RRC α = 0.3, 0.4, and a realistic shape*
  - *Increase crosstalk via laser/mux/demux frequency drifts and scaling the mux/demux bandwidths*
  - *Define a soft integration rectangle filter with a 100GHz bandwidth to calculate optical crosstalk to signal power ratio*
- **Observations**
  - *DEMUX with a 75GHz third-order Gaussian filter shape (see maniloff_3cw_01_200528, with manufacturing variation) is necessary to maximize 400ZR transceiver inter-operability*
  - *MUX with a 75GHz third-order Gaussian filter shape (see maniloff_3cw_01_200528, with manufacturing variation) could alleviate TX bandwidth constraint*
  - *MUX/DEMUX with a 75GHz third-order Gaussian filter shape causes least interference with 400ZR transceiver design*
  - *More simulations can be carried out with respect to reference transmitter and receiver spectral shapes and see the impact on rOSNR vs inter-channel crosstalk results*