Further considerations of 400GBASE-ZR 75GHz black link transfer functions and baseline specs proposal

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IEEE P802.3cw Optical Crosstalk Ad-hoc

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Motivation

- Recent Contributions have recognized the need to honor ‘black link’ methodology to develop specs for both 802.3ct and 802.3cw
  https://www.ieee802.org/3/cw/public/adhoc/20_1202/dambrosia_3cw_201202.pdf

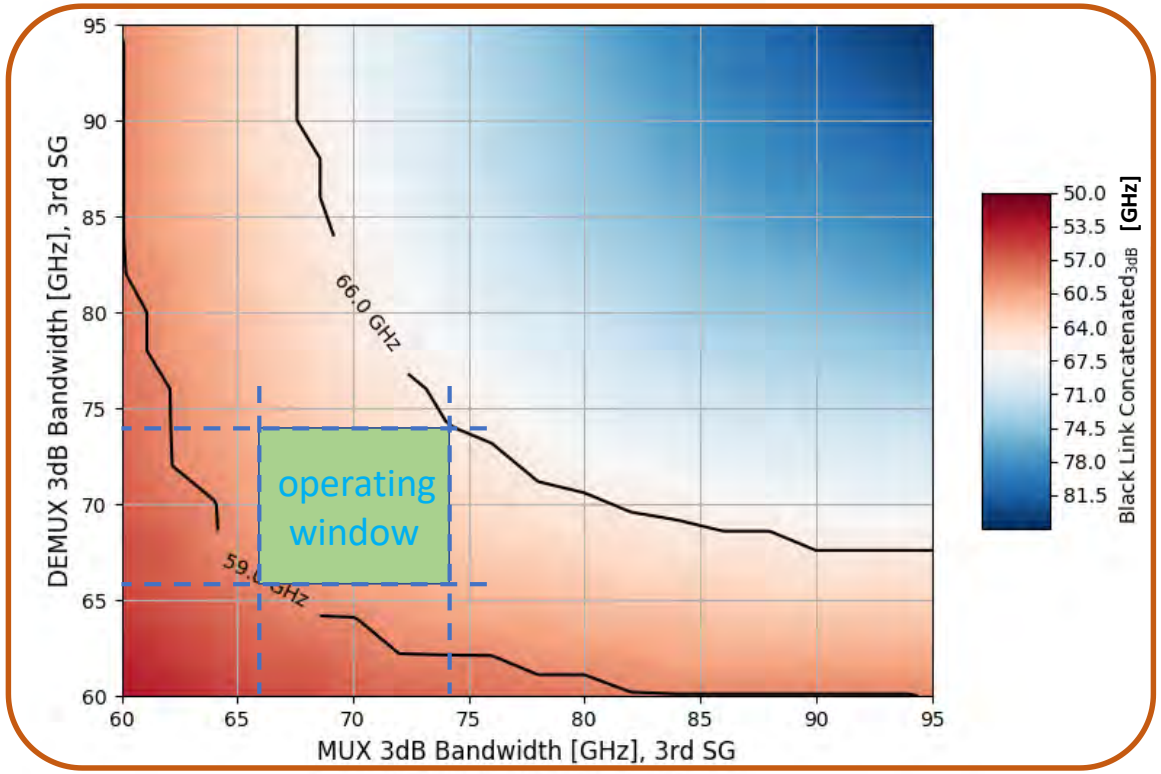
- Transfer functions of black link are being established
  https://www.ieee802.org/3/cw/public/adhoc/21_0201/zhang_3cw_01_210201.pdf
  https://www.ieee802.org/3/cw/public/adhoc/21_0201/maniloff_3cw_01a_210201.pdf

- This work attempts to further the operating window approach from zhang_3cw_01_210201 of deriving a set of transfer functions for the black link and how that relates to the Tx side of the specification.

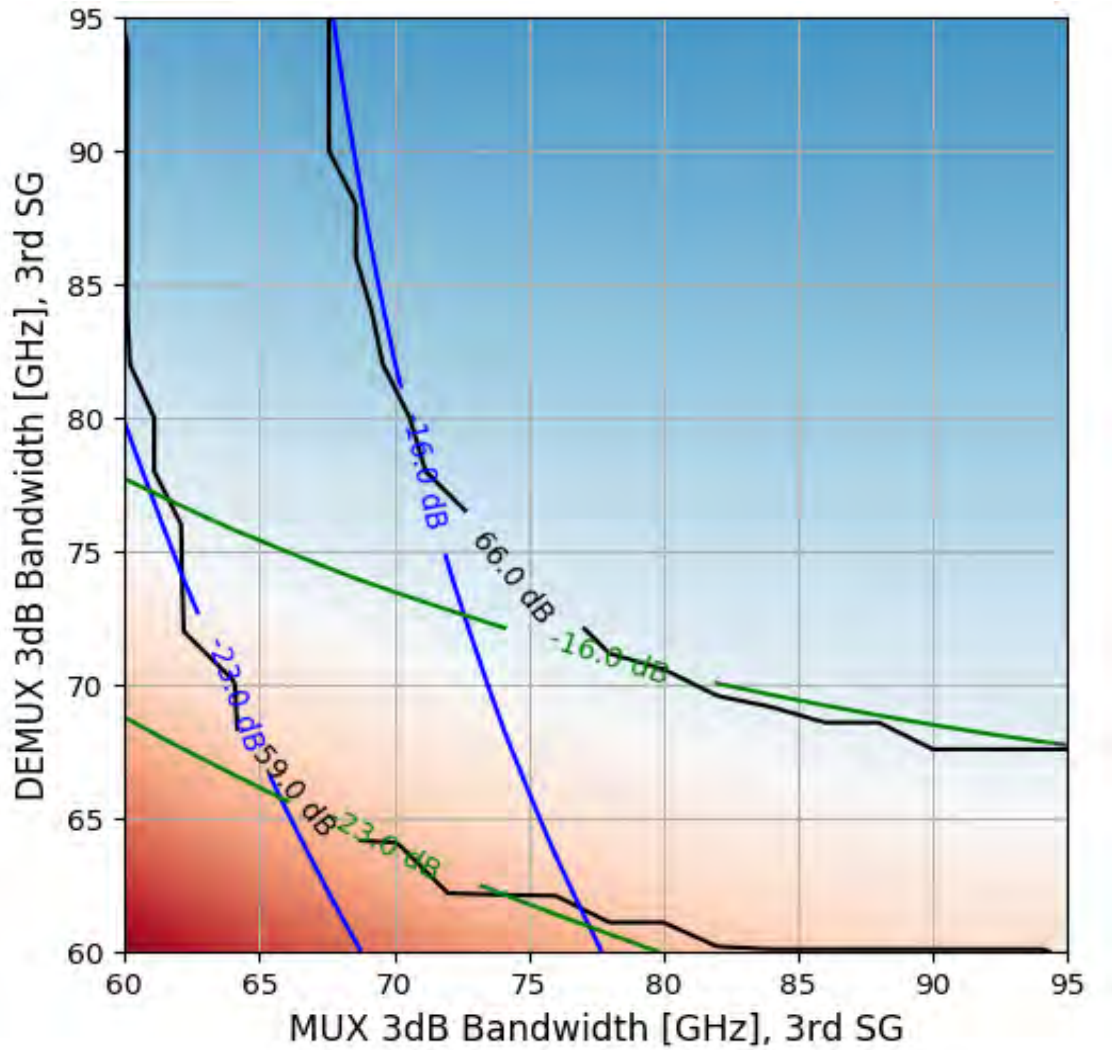
- Goal is to ensure robustness of link design conformance and ease of black link qualification, as well as Tx design conformance for ease of qualification and flexibility in design implementation.

Recap zhang_3cw_01_210201

Mux/Demux operating window



A set of Black link transfer functions



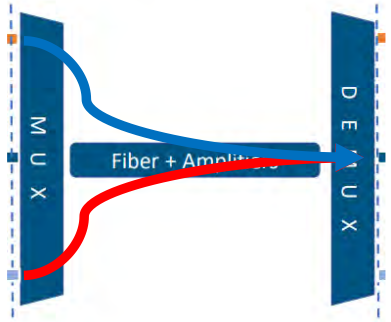
The issue with using only a single input and single output (SISO) concatenated black link transfer functio on the channel 'N' input/output ports was shown in slide 13 of zhang_cw_01b_201116.

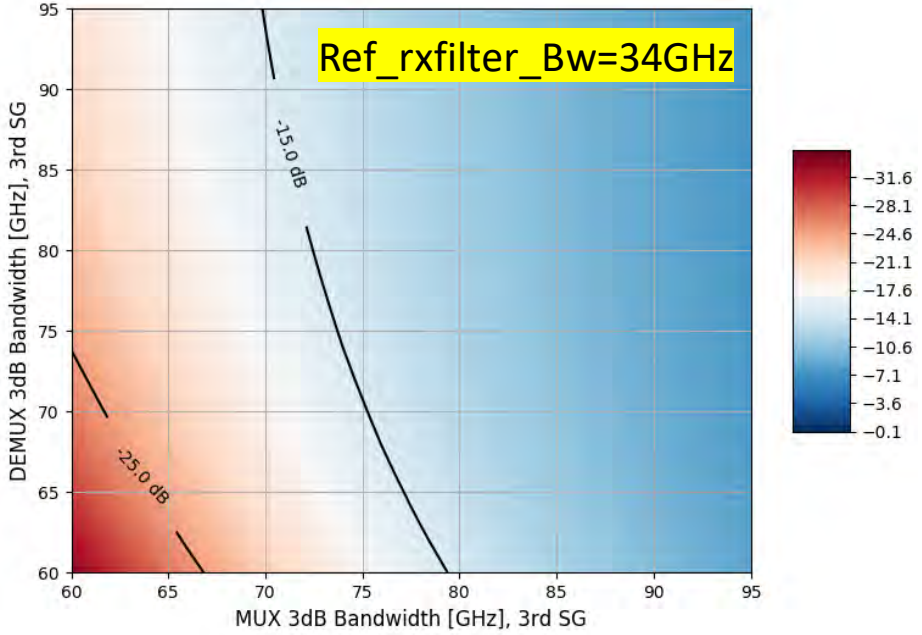
Using proposed min/max (d)mux 3dB BWs from slide 23 of zhang_cw_01b_201116, we show here a contour with concatenated 3dB BWs. Bounded by min concatenated 59GHz and max 66GHz, one could s the operating window using the SISO approach is prohibitively larger than the individual filter 3dB specs.

This drives the needs of additional parameters for black link transfer function to bound the operating space.

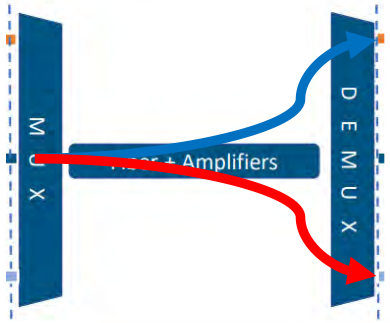
Two Types of Crosstalk Transfers

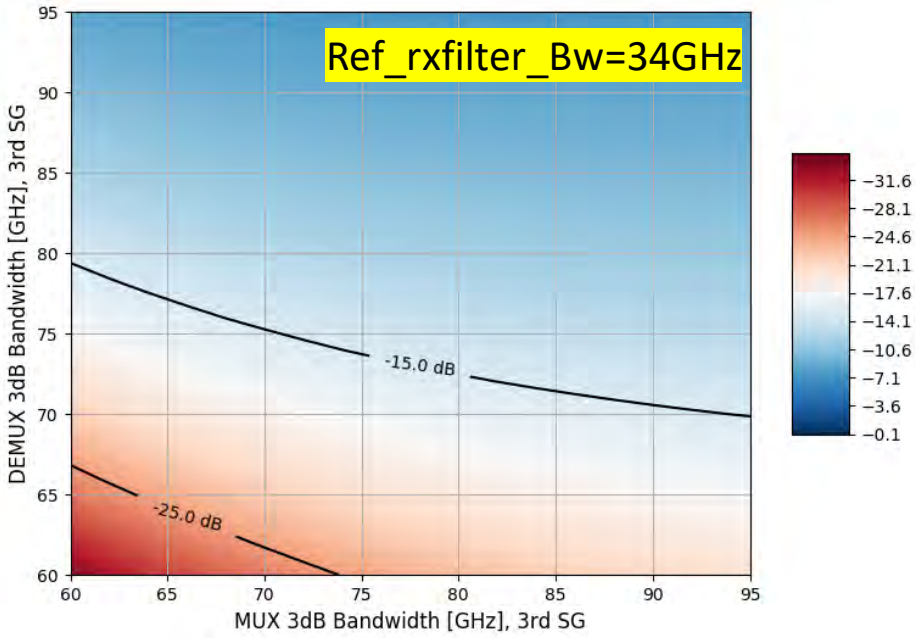
Type I:
Adjacent Mux ports to Center Demux port



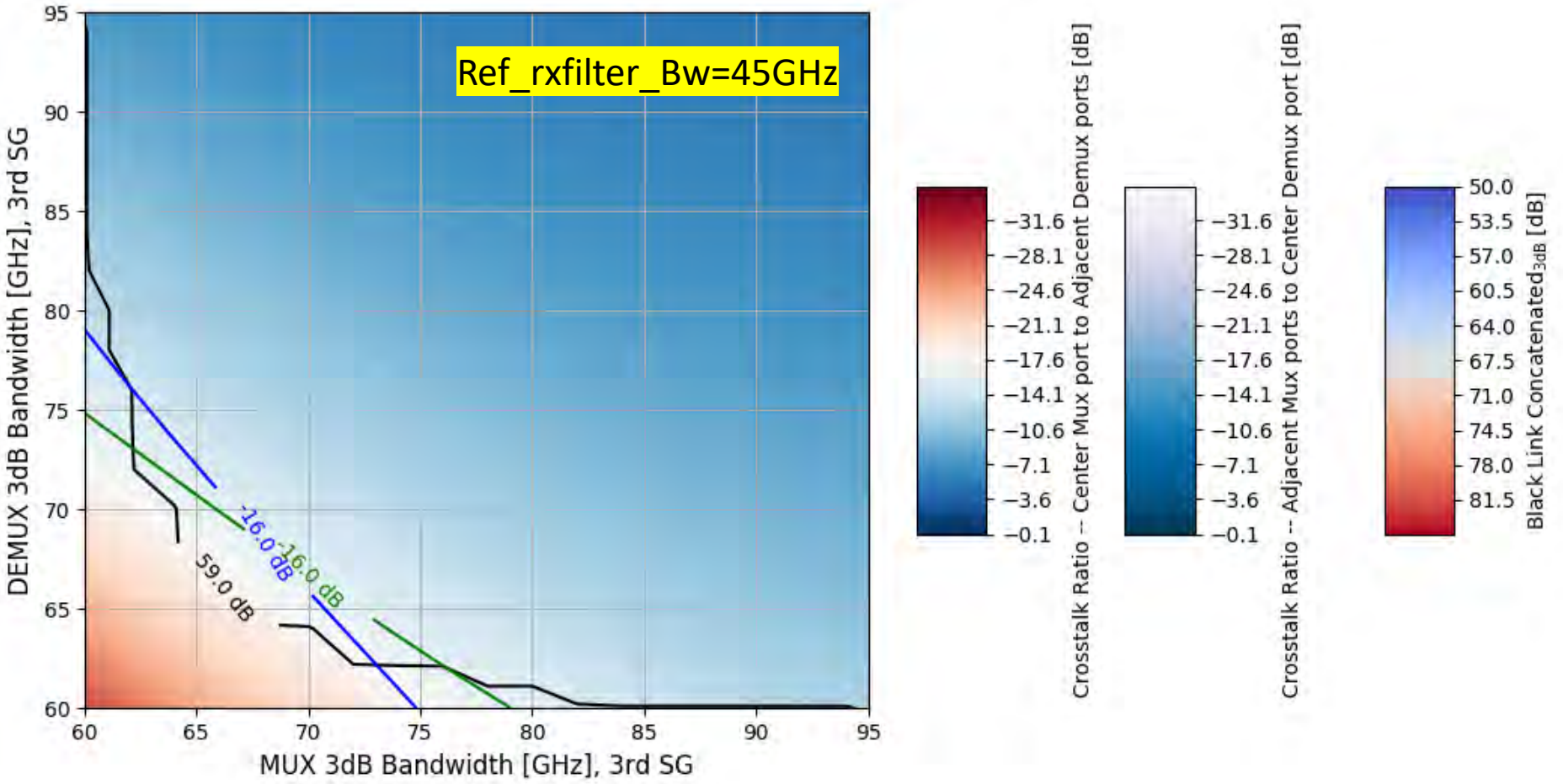


Type II:
Center Mux port to Adjacent Demux ports





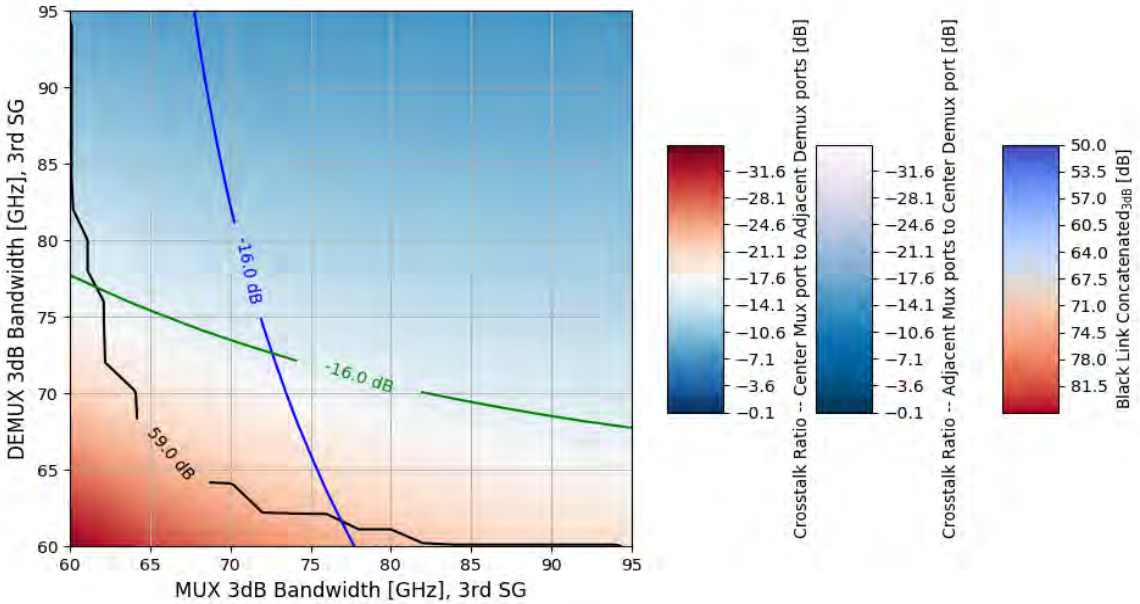
Without a (tight) Reference Receiver Definition



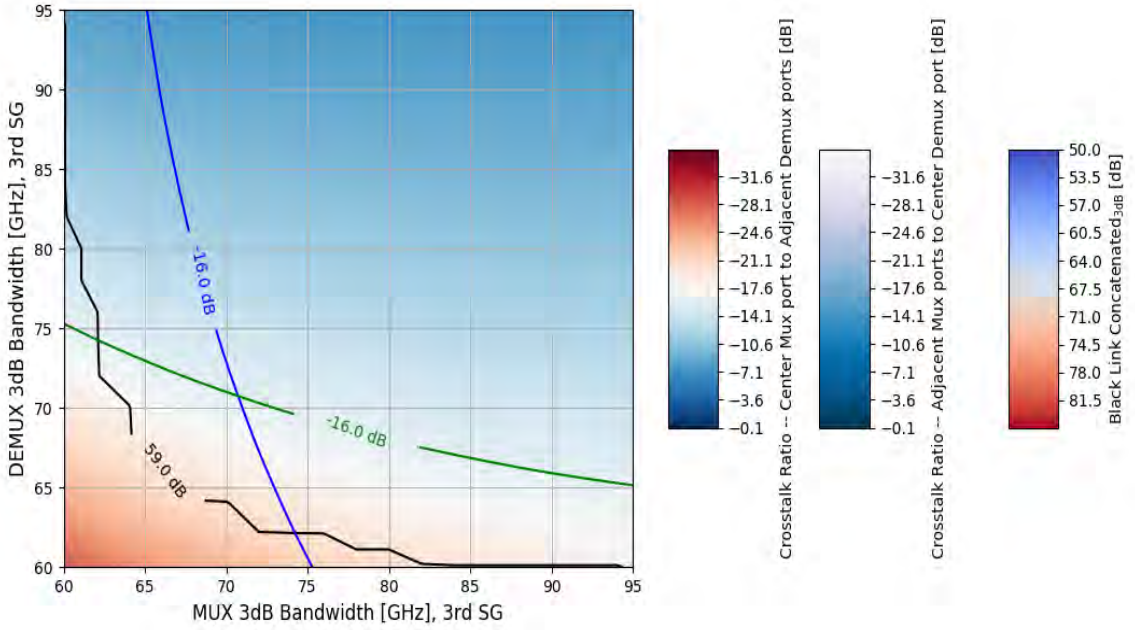
- If the reference receiver 3dB bandwidth is set to 45GHz (same 5th order Butterworth), the operating window is noticeably shrunk, revealing the importance of ref Rx definition when computing the two types of crosstalk transfer functions.

Impact of Filter Frequency Offsets

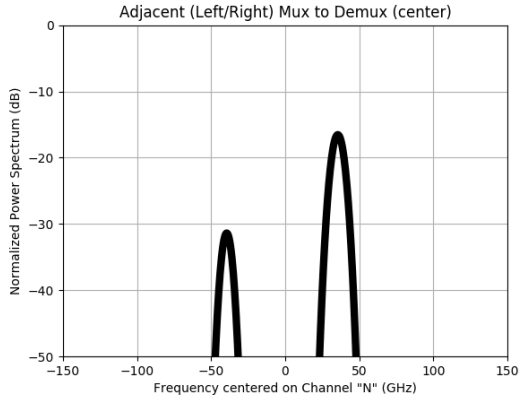
left_awg_offset =0 GHz, right_awg_offset =0 GHz



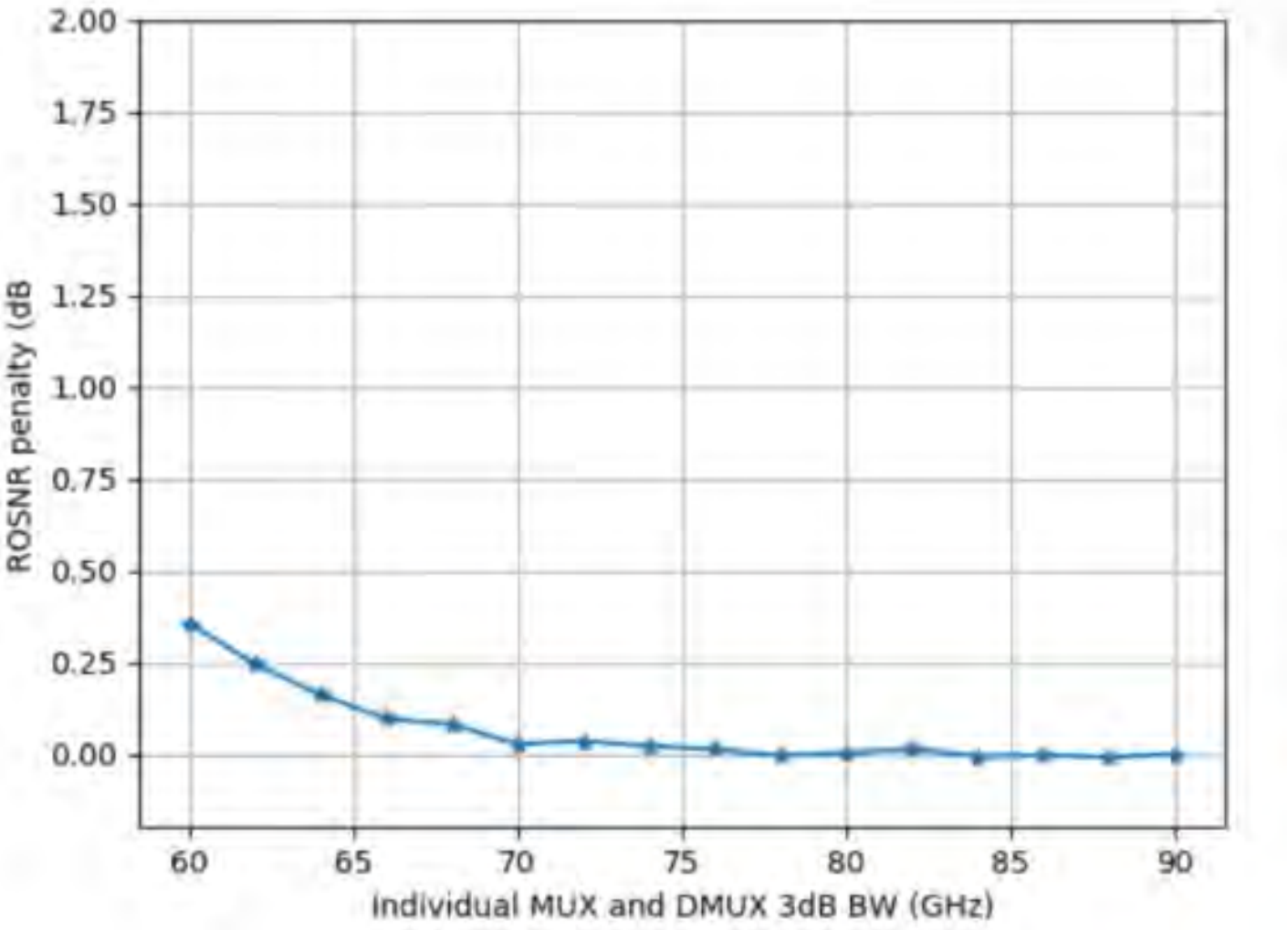
left_awg_offset =4 GHz, right_awg_offset =4 GHz



- Left and Right Mux filters are both shifted towards blue by 4GHz, whereas the center Demux is kept unshifted w.r.t. its grid.
- Larger frequency offsets result in reduced operating window, as compared with the baseline.



A Look at the Filtering Penalty



- Experimental data collected with 400ZR single channel traversing through programmable optical filter emulating a concatenated Mux and Demux transfer function.
- Worst case frequency offsets (+/-4GHz) are also emulated.
- For an allocation of a quarter of a dB ROSNR penalty, individual 3dB BW of 62GHz can be tolerated.
- Therefore, 66GHz lower bound specifications for Mux/Demux are proposed originally.

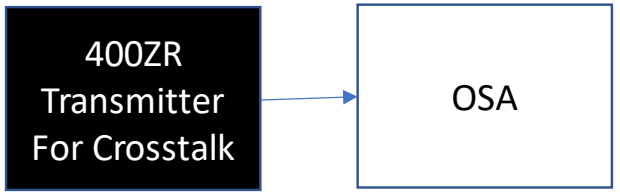
Earlier Proposed 75GHz Compliance Proposal

- See 2020 Nov Plenary P802.3cw contribution:

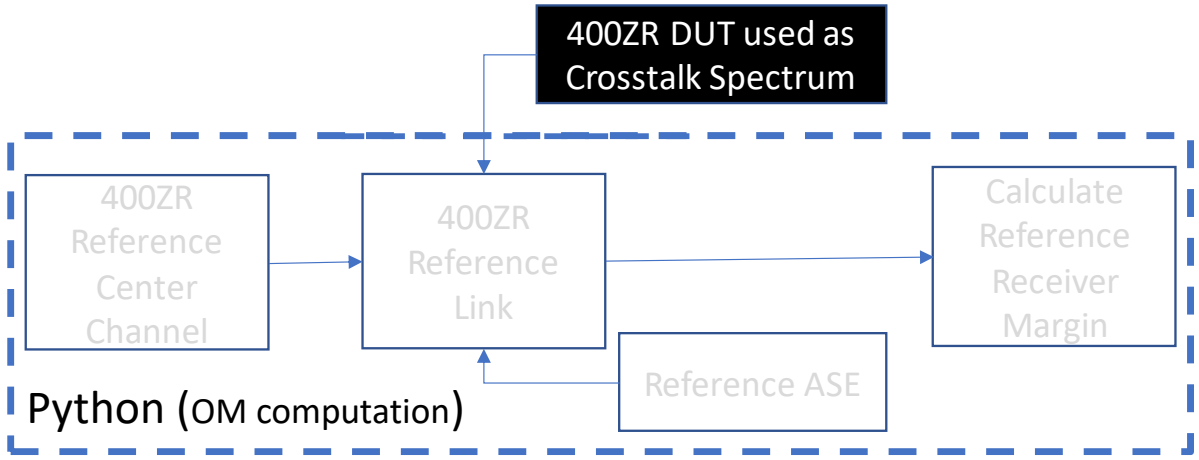
[400GBASE-ZR 75GHz specification framework and compliance methodology proposal]

Optimal Eq SNR metric	• A **rigorous** metric that is backed by **digital communication theory** accounts for **arbitrary** signal and noise/crosstalk spectral shapes
Link Compliance Mask	• Defines the **transfer function** requirements for the optical mux and demux components
TX Crosstalk Compliance	• Calculates **a figure of merit** which ensures a compliant TX **does not cause more crosstalk** than the RX compliance test setup
RX Compliance	• Defines a **worst-case setup** specifying the **minimum performance** required from a compliant receiver

Measurement Setup



Tx Operating Margin Computation

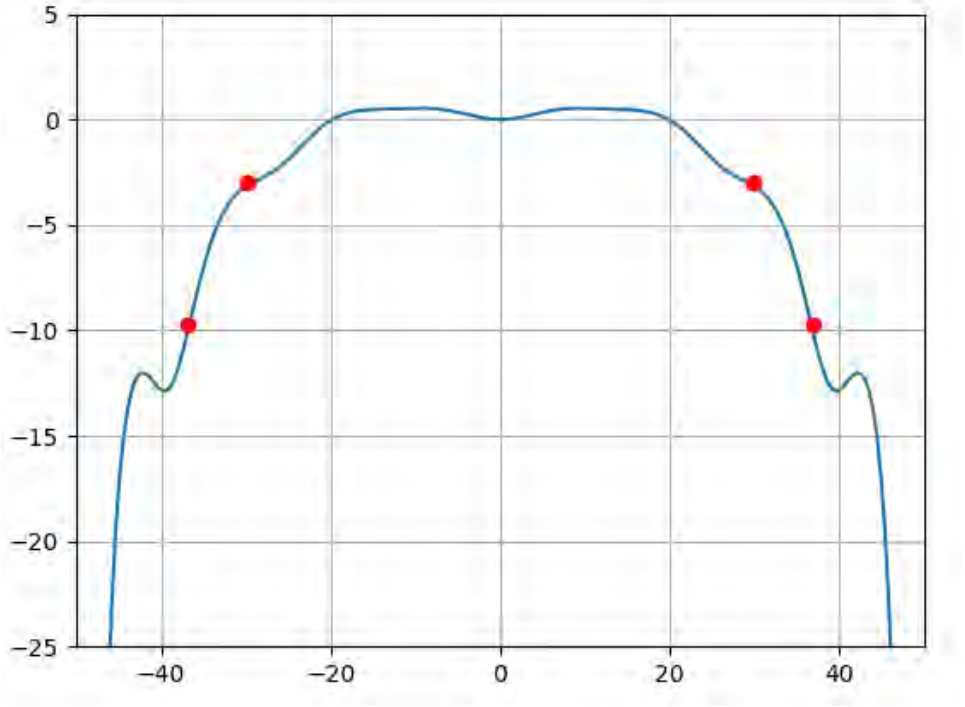


Comparison of two standing proposals on TX

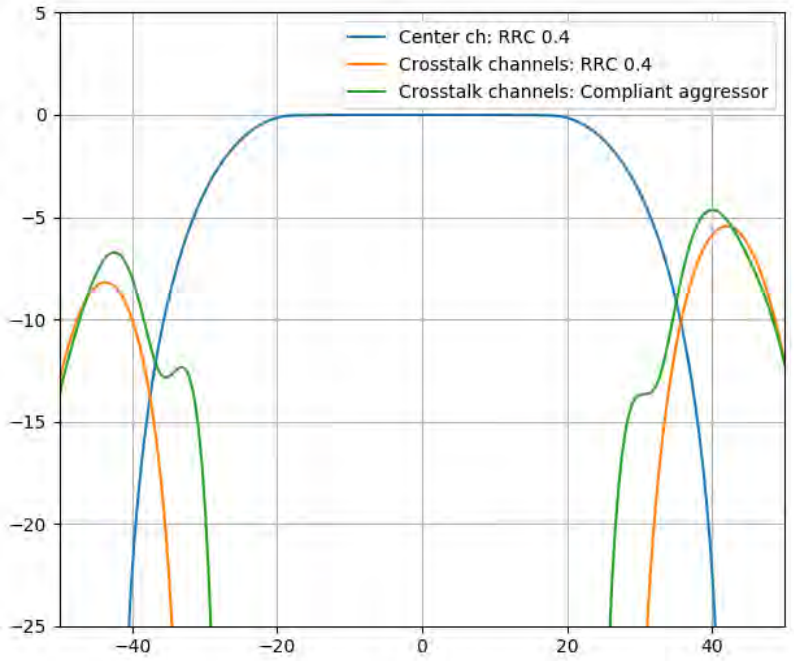
	zhang_3cw_01b_201116 **TX OM (operating margin)**	way_cw_01b_201116 **TX Spectral Masks**
Simplicity	1 spec	4+ specs [cost adder]
Technical soundness	Rigorous metric Support arbitrary spectrum [Ensure flexibility in design]	Lack of supporting data
Use of a Receiver	A well-defined reference receiver for direct perf correlation	A poor-man OSA
To Rx compliance	Direct linkage to Rx to ensure end-to-end interop	Isolated Tx and Rx specs
Interop insurance	Yes	No

Meeting Tx mask, but could fail interop

Example Tx spectrum



Crosstalk Spectral



The example Tx spectrum complies with the -3dB and -10dB Tx mask proposed in way_cw_01b_201116. However, the resulting crosstalk spectrum is much pronounced which could fail the system interoperability.

Summary

- MIMO (multiple input multiple output) treatment of the black link transfer function is a must, and two types of crosstalk transfer together with through transfer are identified and analyzed.
- This will generate a new set of black link parameters
  - Need to further examine their compliance methodology
  - Need to check their impact to modeling (could generate confusion before the new set of parameters are stable)
- Revisited Nov. Plenary contribution on 75GHz compliance and spec proposal and reaffirmed the benefit of Tx operating margin OM metric (as opposed to Tx spectral mask)