Considerations for 400GBASE-ZR 75GHz Black Link Transfer Functions

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IEEE P802.3cw Optical Crosstalk Ad-hoc

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Motivation

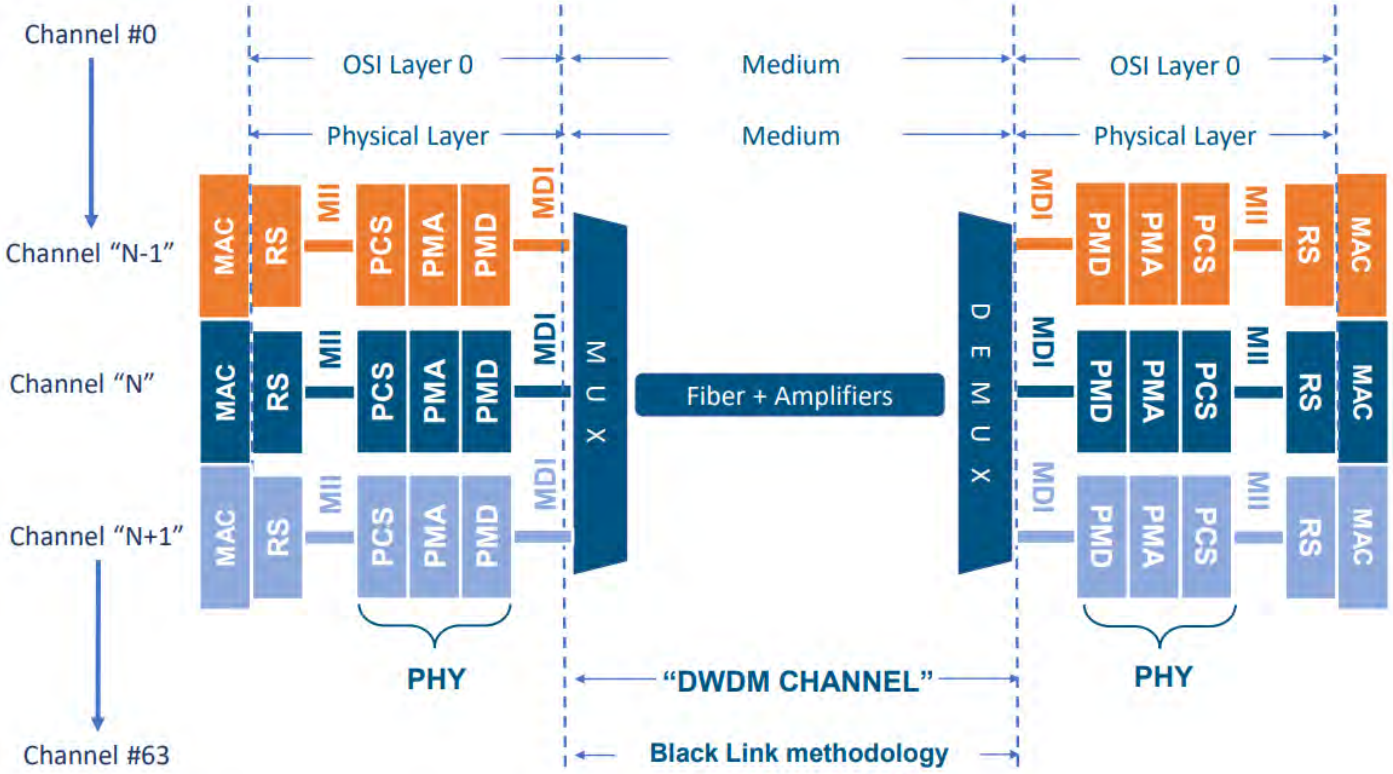
- Recent Contributions have recognized the need to honor ‘black link’ methodology to develop specs for both 802.3ct and 802.3cw
  https://www.ieee802.org/3/cw/public/adhoc/20_1202/dambrosia_3cw_201202.pdf

- Transfer functions of black link needs to be established
  https://www.ieee802.org/3/cw/public/adhoc/20_1209/maniloff_3cw_01_201209.pdf

- This work attempts to provide a systematic approach of deriving a set of transfer functions for the black link and examines the new set of parameters from a black link operating window perspective.

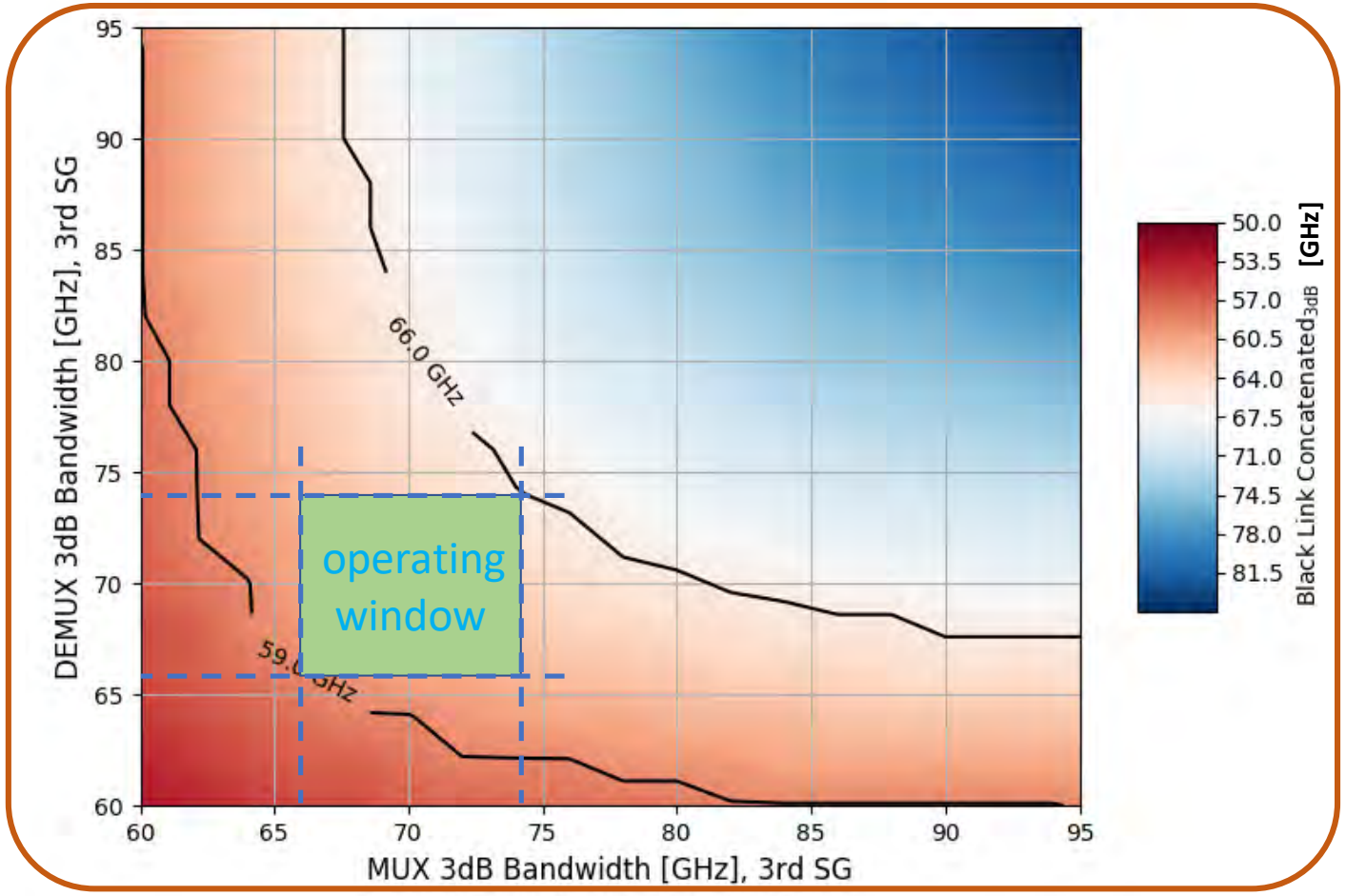
- Goal is to ensure robustness of link design conformance and ease of black link qualification for any new parameters proposed.

Black Link Methodology

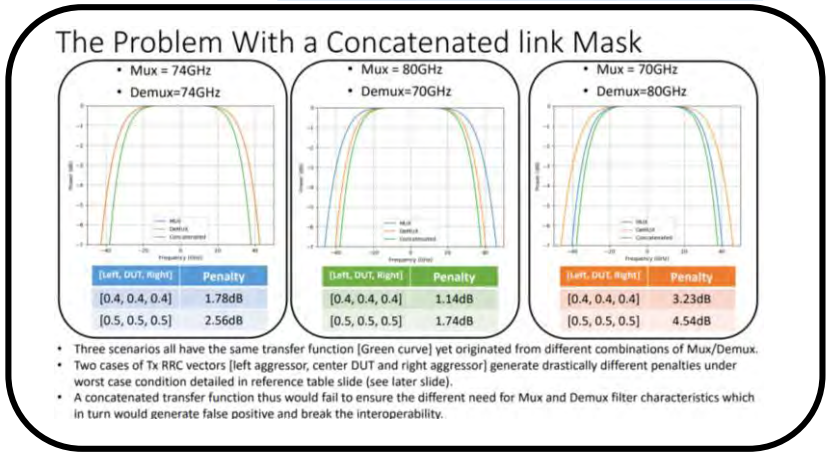


https://www.ieee802.org/3/cw/public/adhoc/20_1202/dambrosia_3cw_201202.pdf

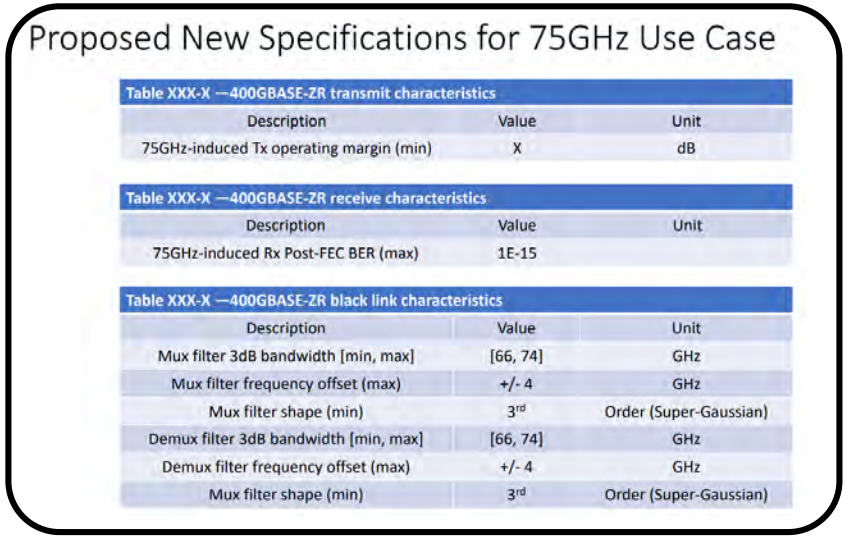
Network Filters -- Operating Window



Slide # 13 of [zhang_3cw_01b_201116]



Slide # 23 of [zhang_3cw_01b_201116]



- The issue with using only a single input and single output (SISO) concatenated black link transfer function 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 see 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.

Adjacent Mux ports to center Demux port

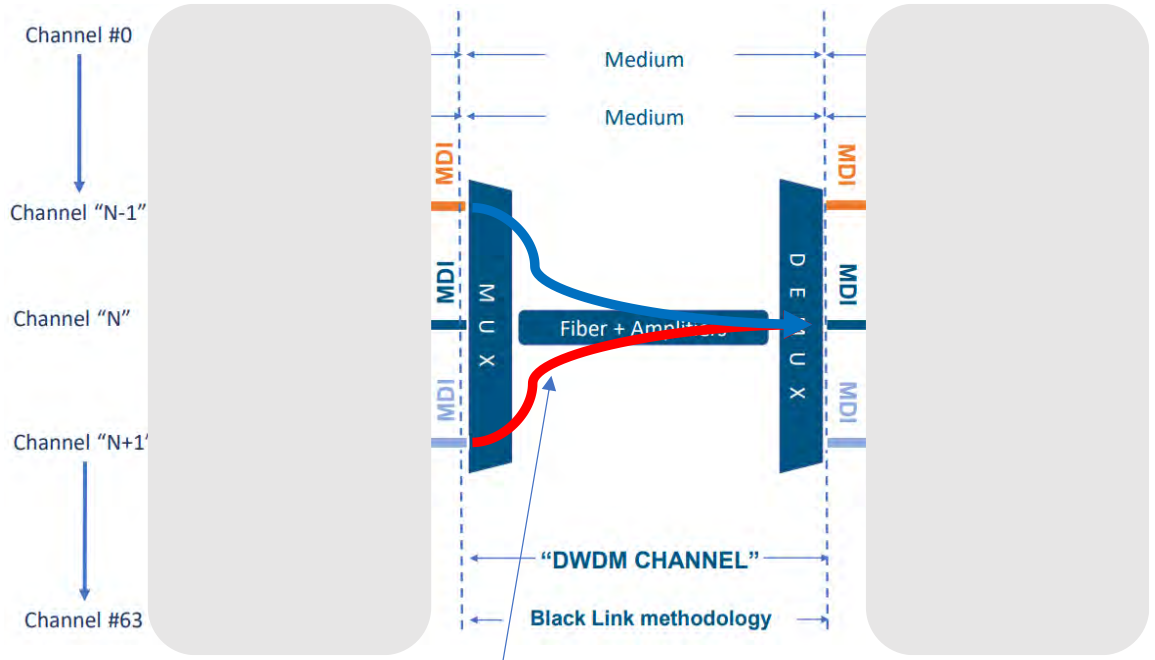
Stimulus

DWDM Link

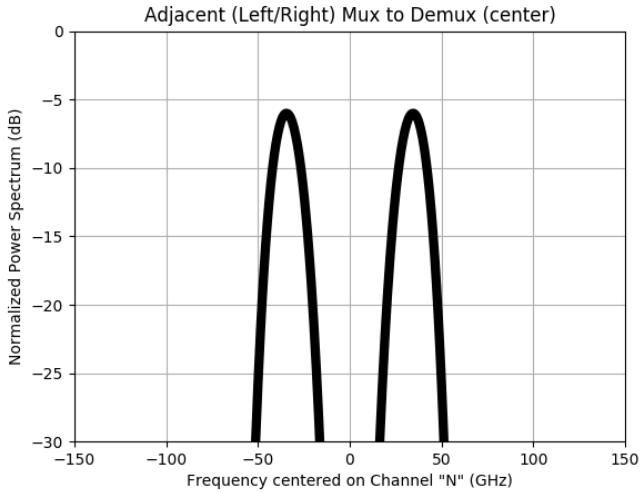
Response

Broadband ASE

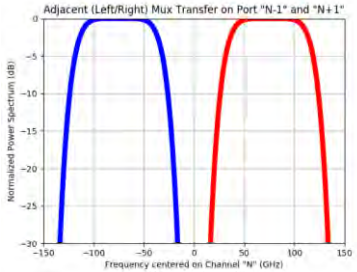
Broadband ASE



Optical Crosstalk Transfer



Illustrative Example: MUX = 80GHz, DEMUX =70GHz



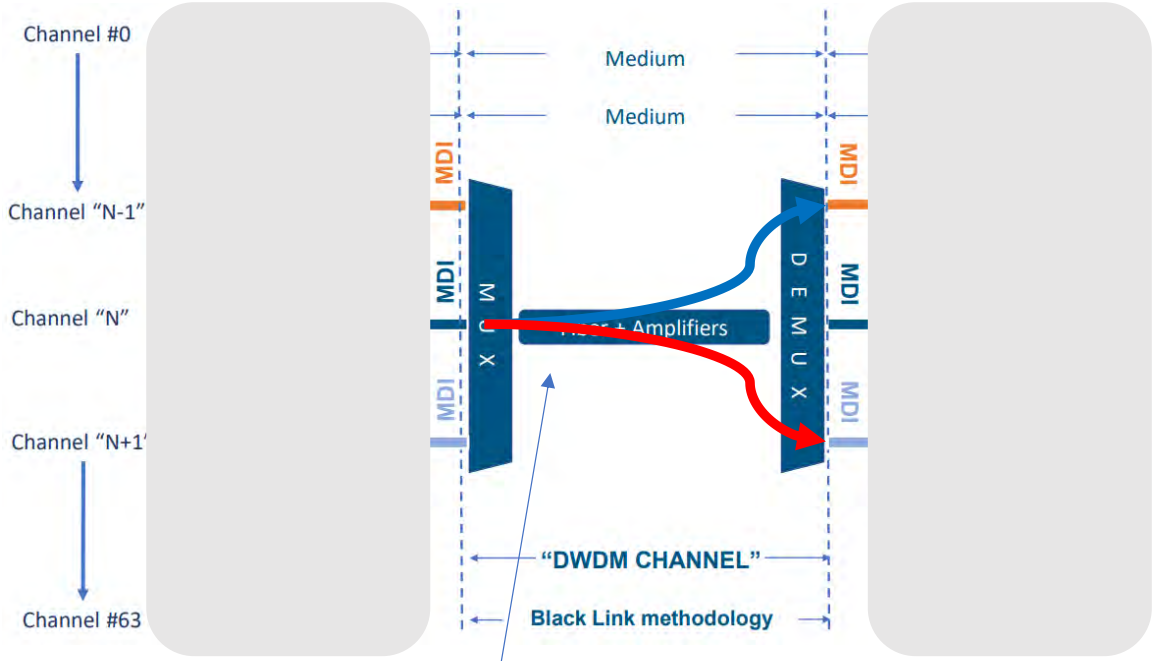
Center Mux ports to adjacent Demux ports

Stimulus

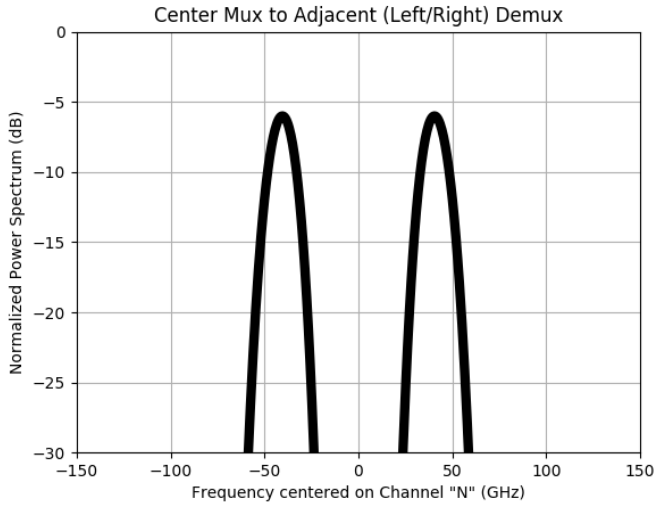
DWDM Link

Response

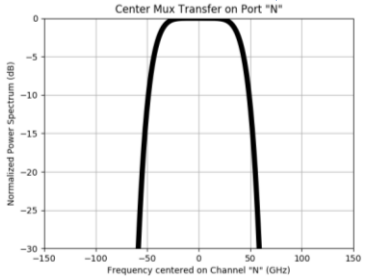
Broadband ASE



Optical Crosstalk Transfer

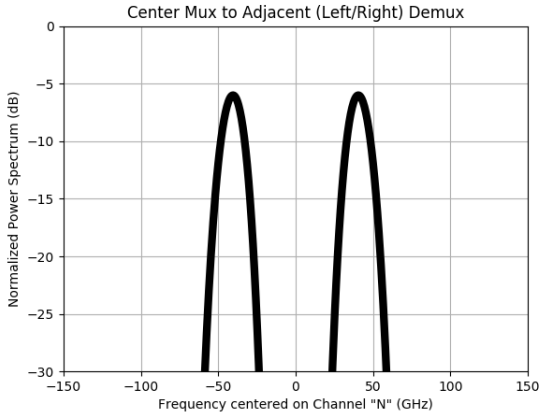


Illustrative Example: MUX = 80GHz, DEMUX =70GHz

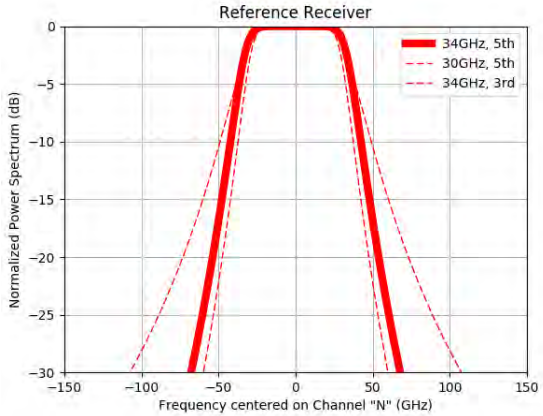


Reference receiver consideration

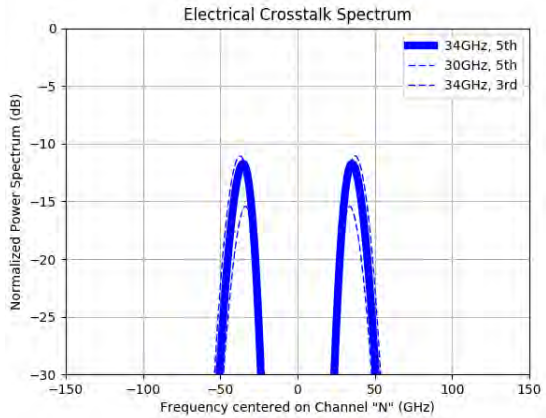
Optical Crosstalk Transfer



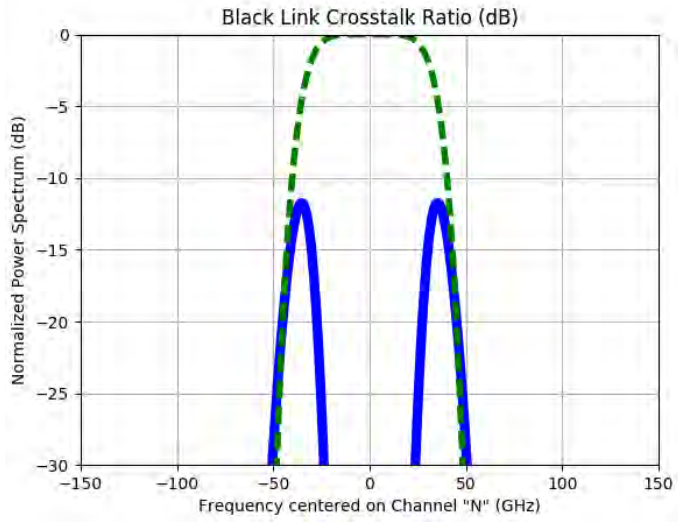
Reference Receiver



Electrical Crosstalk Transfer



Compute *Crosstalk Ratio*



$$Black\_Link\_CenterM2AdjD = abs(H_{MUX})^2 * abs(H_{DMUX\_LEFT})^2 + abs(H_{MUX})^2 * abs(H_{DMUX\_RIGHT})^2$$

H_{RX} = **Butterworth_filter**(*ref_rx_bandwidth, ref_rx_order*)

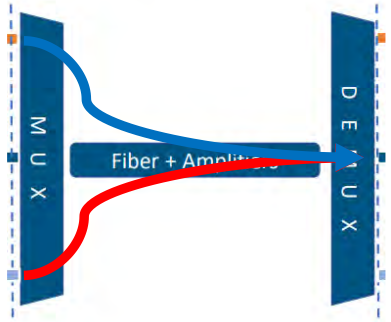
$$Black\_Link\_Concatenated = abs(H_{MUX})^2 * abs(H_{DMUX})^2$$

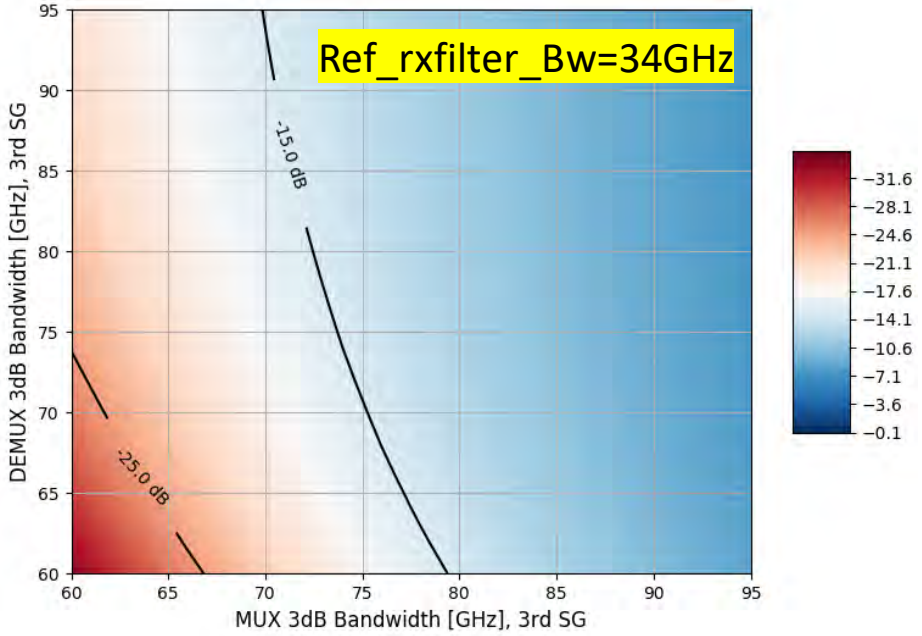
$$\textbf{Crosstalk Ratio (dB)} = 10 * log10\left\{\frac{\int_{-f}^{+f} [\ Black\_Link\_CenterM2AdjD\ * abs(H_{RX})^2]}{\int_{-f}^{+f} Black\_Link\_Concatenated}\right\}$$

Compute Two Types of **Crosstalk Ratio**

Type I:

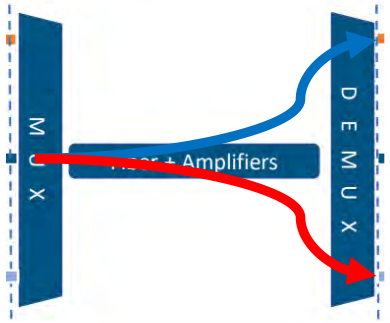
Adjacent Mux ports to Center Demux port

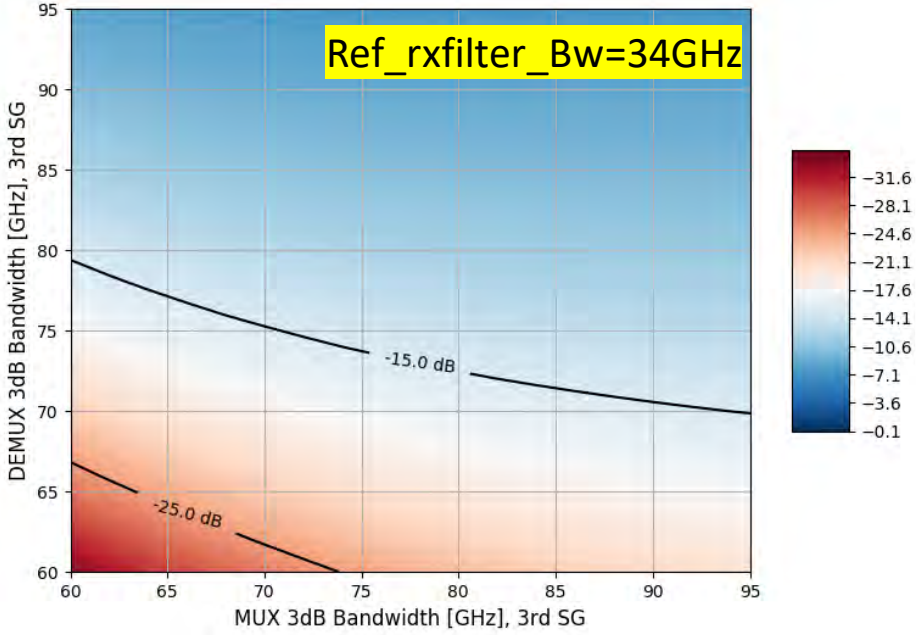




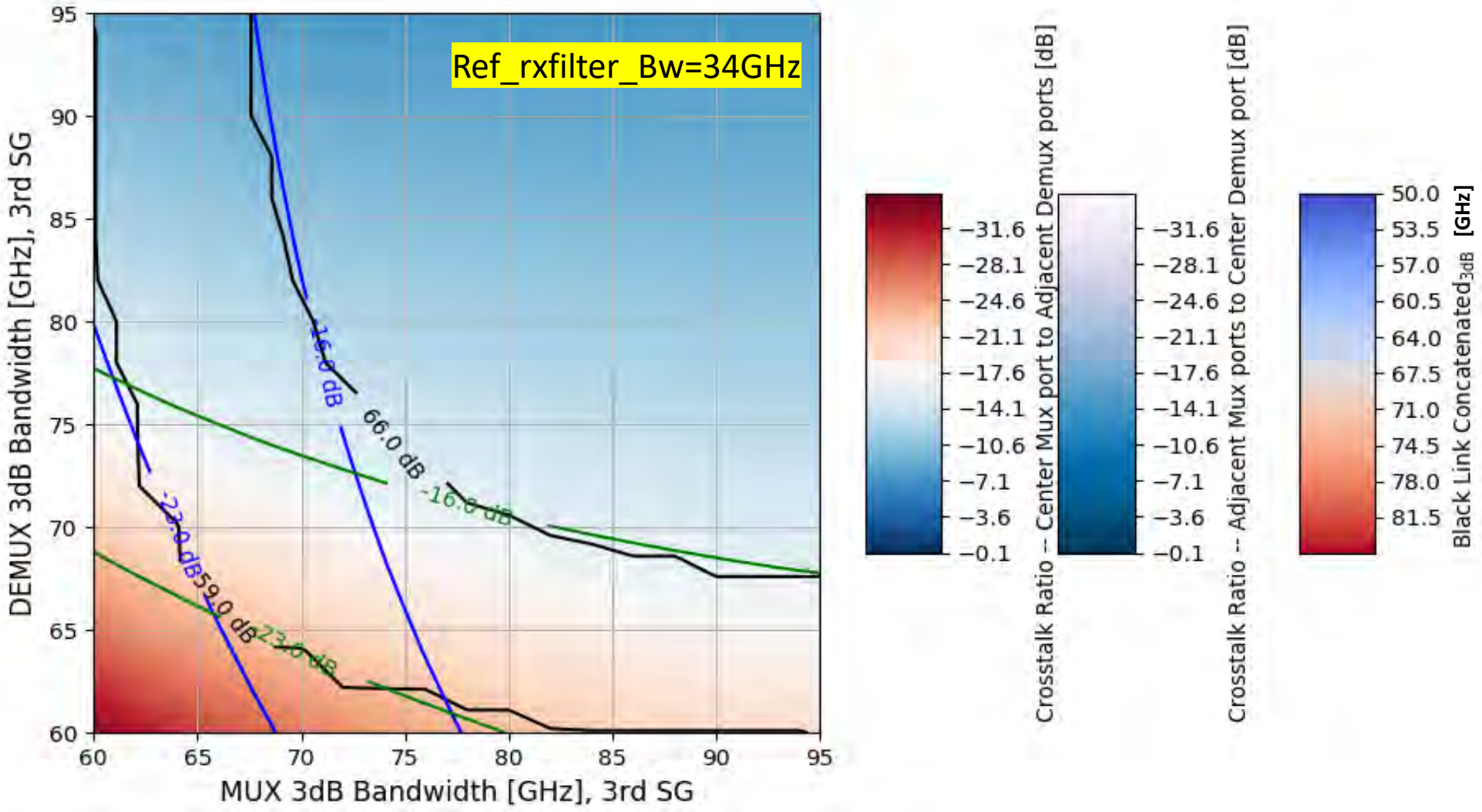
Type II:

Center Mux port to Adjacent Demux ports





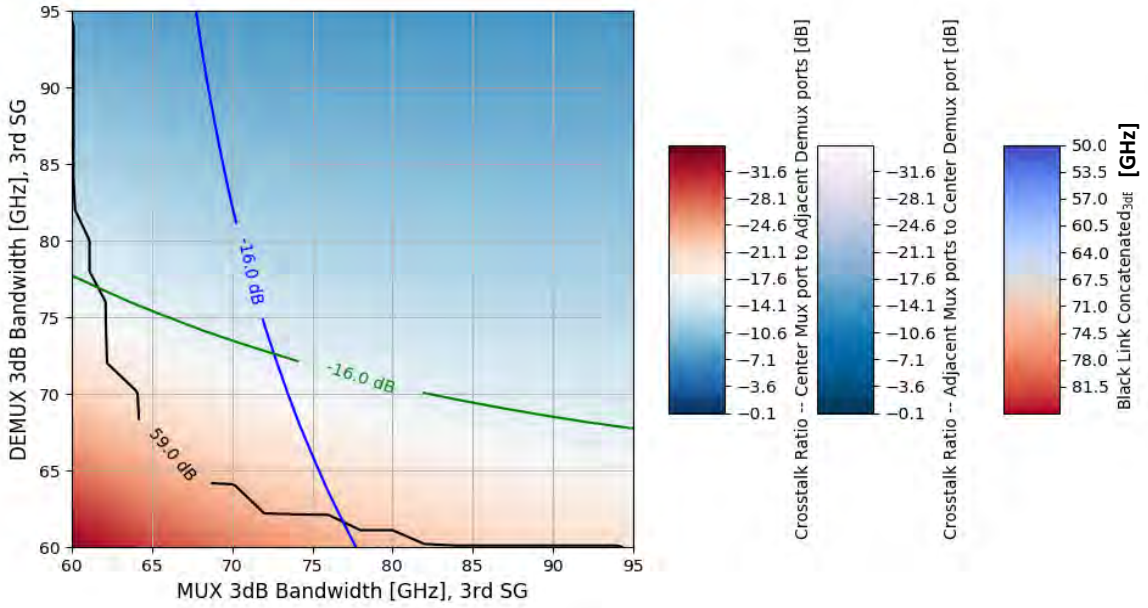
Putting the contours all together – Baseline [Left, Center, Right]



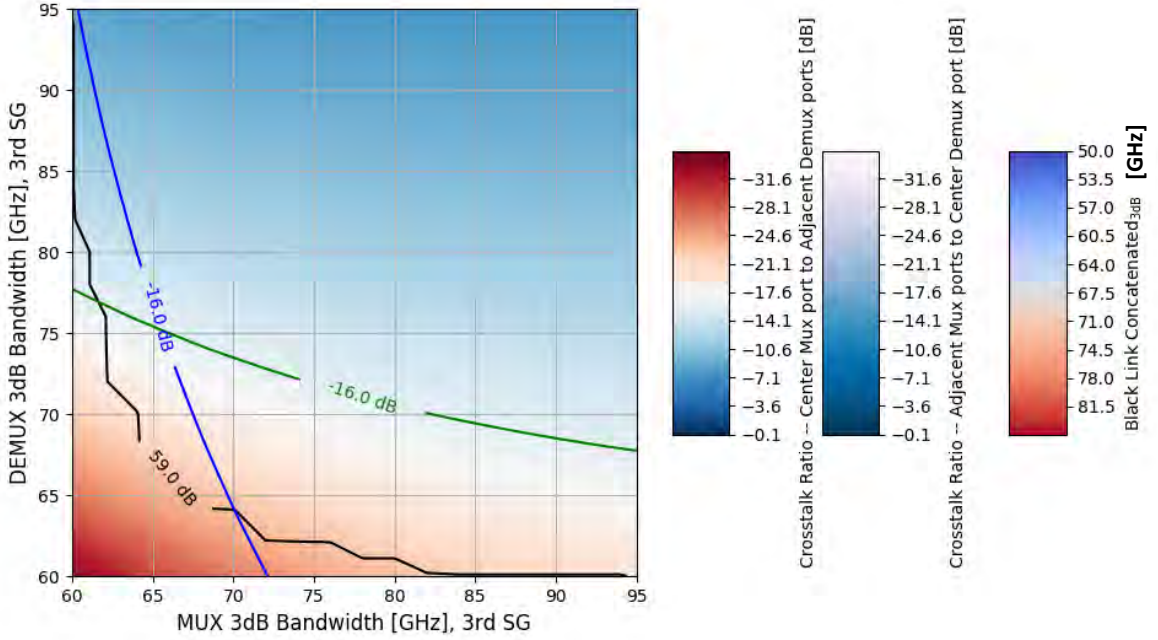
- The through concatenated transfer function (**black**) with the two types of cross transfer crosstalk ratio (green and blue) could serve as bounds for overall **operating window**.

Impact of Filter Insertion Loss Deviation

MUX Insertion Loss Deviation (port to port) = 0dB



MUX Insertion Loss Deviation (port to port) = 4dB



- This port-to-port insertion loss deviation (ILD) is to be distinguished with power imbalance from the transmitter channels.
- Higher ILD case results in reduced operating window, as compared to the baseline.

Summary

- MIMO (multiple input multiple output) treatment of the black link transfer function is a must, as opposed to SISO (single input single output) analysis.
- This will generate a new set of black link parameters
  - Need to examine their compliance methodology
  - Need to check their impact to modeling (could generate confusion before the new set of parameters are stable)
- Operating window for allowable Mux/Demux spaces should be served as governing criterion when examining new black link parameter proposals.