Loss Expectations for Elements in the 400G Copper Channel

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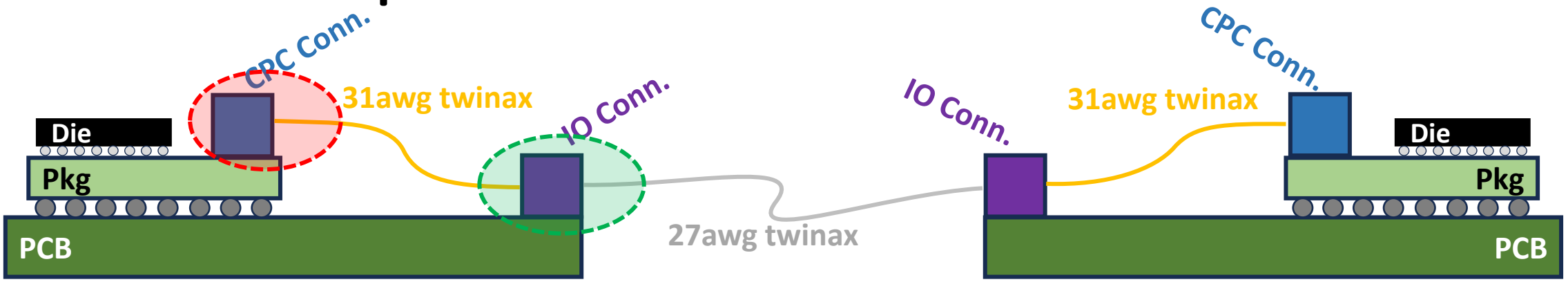
Contributors

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Agenda

- There have been several presentations starting to propose candidate channel loss specifications, e.g.
  - M. Li, E. Frlan (oif2026.461.02)
  - M. Li, K. Lusted (oif2026.229.00)
  - H. Cirit (cirit_400GPL_01_2609)
- To facilitate that discussion and future loss apportionment, we want to present our current and best-guess-future loss estimates of key components (CPC, twinax, IO)
- Compare how current component loss values stack up against full link samples measurements
- Extrapolate channel loss for various length configurations
- Everything here is in the context of Z_0=85ohm

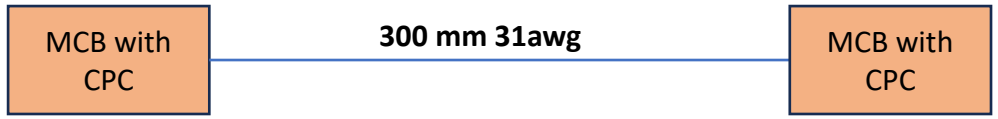
Isolated Components To Be Considered



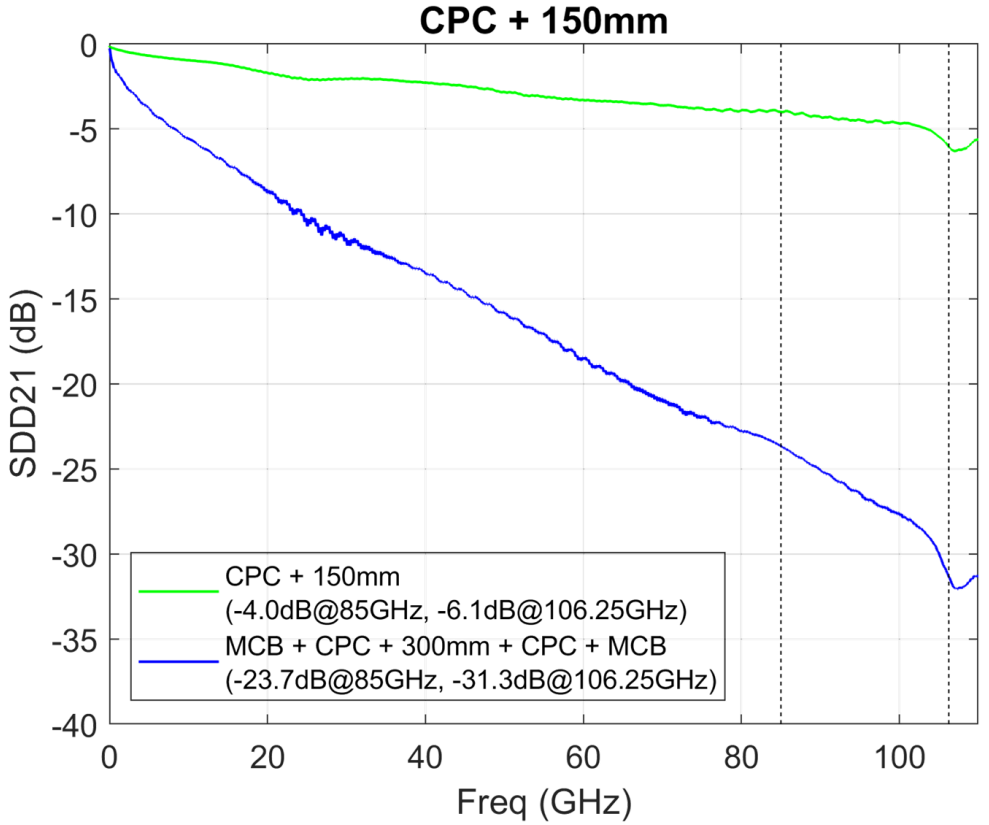
- CPC + 150mm twinax
- 90mm 31awg + VR-VH IO Conn + 260mm 27awg
  - The CPC & VR-VH IO connectors have twinax as part of them because isolated measurements need some amount of twinax for handling purposes
  - These are not easily deembedded due to termination consistency (especially at shorter lengths)
- 1m 31awg internal twinax (scalable)
- 1m 27awg external twinax (scalable)
- We'll then mix-and-match to construct LR channels of arbitrary length

CPC + 150mm 31awg Internal Twinax

- Deembedded loss (–) is for:
  - CPC connector (i.e. L2 via, footprint, elastomer, connector)
  - 150mm 31awg twinax
- Original raw measurement (–) was of:



  - Traces on MCB were deembedded
  - Deembedded response was then “symmetrically halved” and the left-half portion is what is plotted



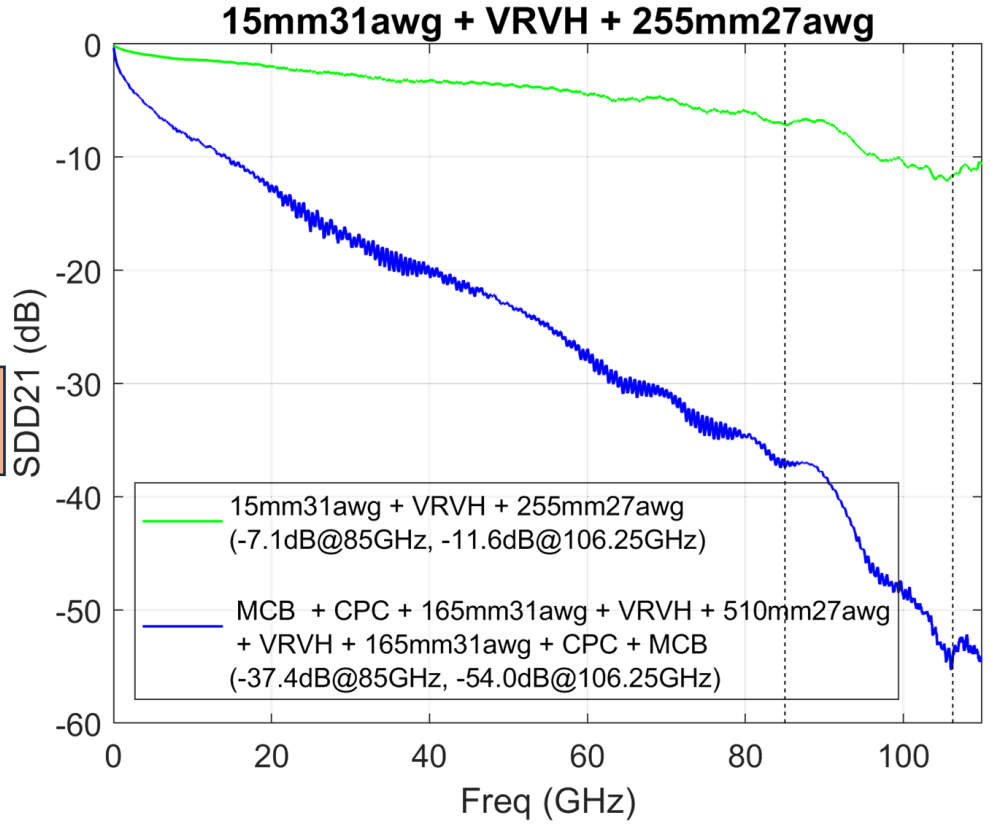
Frequency (GHz)	Current Loss (dB)	Future Projected Loss (dB)
85	4.0	4.1
106.25 (limit of VNA)	6.1	5.0

15mm 31awg + VR-VH IO Conn + 255mm 27awg

- Deembedded loss (–) is for:
  - 15mm 31awg twinax
  - VR-VH IO connector
  - 255mm 27awg twinax
- Original raw measurement (–) was of:



  - DUT on previous slide was used to deembed the MCB/CPC/31awg-twinax
  - Deembedded response was then “symmetrically halved” and the left-half portion is what is plotted

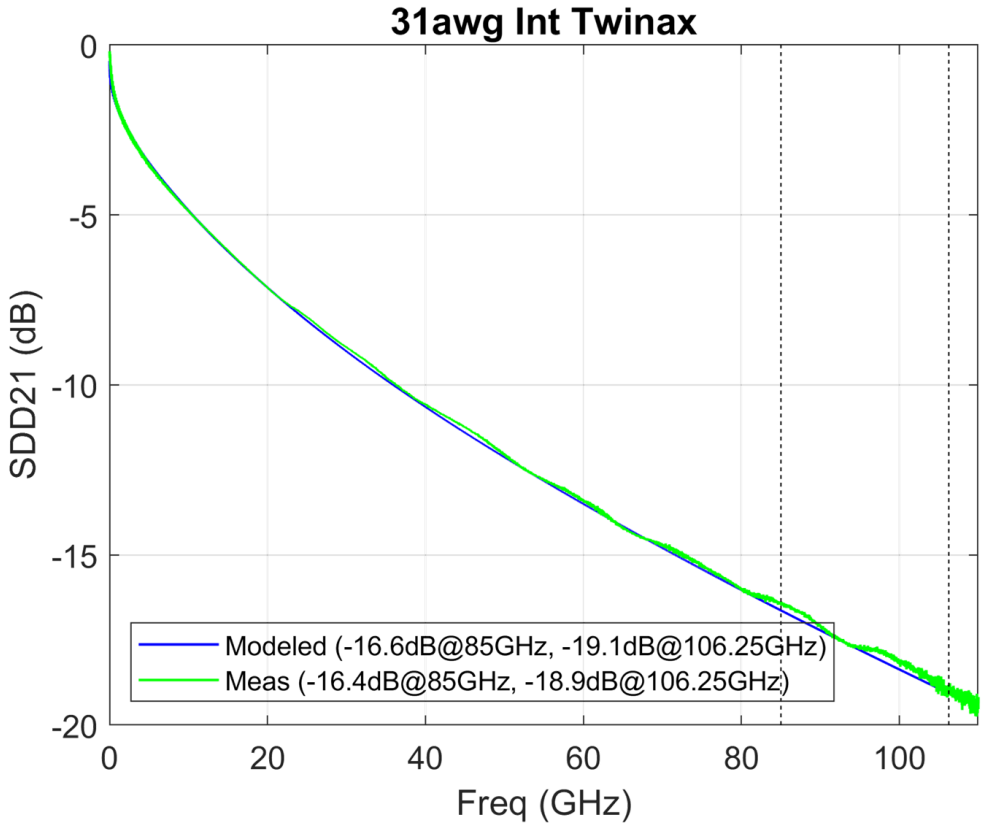


Frequency (GHz)	Current Loss (dB)	Future Projected Loss (dB)
85	7.1	6
106.25 (limit of VNA)	11.6	8

31awg Internal Twinax

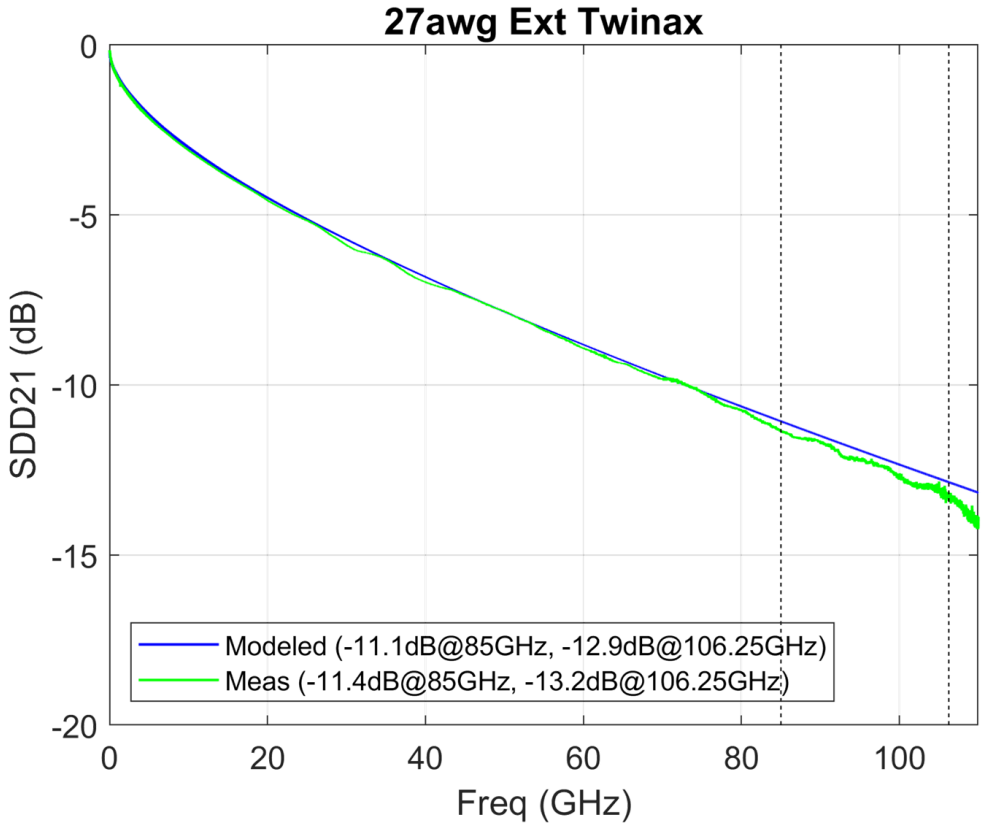
- Loss shown for 1m 31awg twinax
- Measurement already closely matches simulation
  - Do not anticipate further significant improvement

Frequency (GHz)	Current Loss (dB)	Future Projected Loss (dB)
85	16.4	16.6
106.25 (limit of VNA)	18.9	19.1



27awg External Twinax

- Measurements are good but impaired by the 27awg bulk cable test fixtures
  - We expect that actual cable loss is closer than shown to the model



Frequency (GHz)	Current Loss (dB)	Future Projected Loss (dB)
85	11.4	11.1
106.25 (limit of VNA)	13.2	12.9

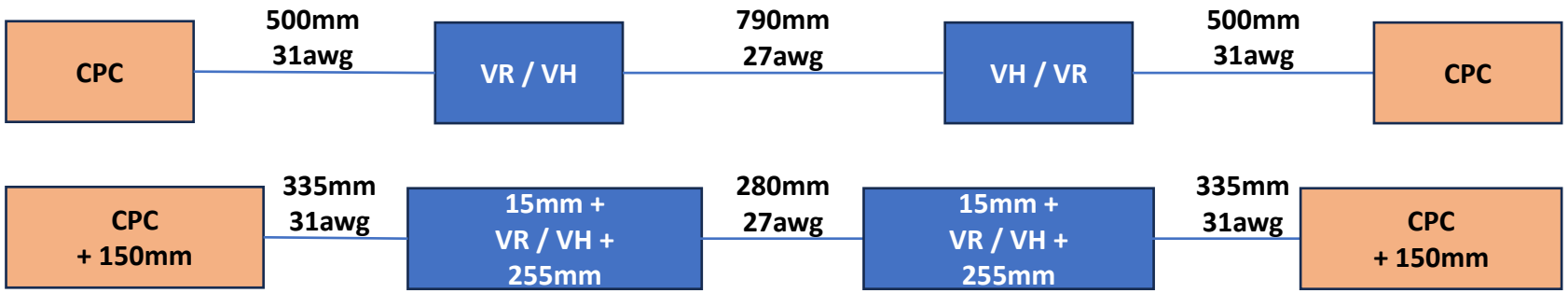
Itemized Loss Menu

Component	IL (dB) @85GHz	IL (dB) @106.25GHz
CPC + 150mm 31awg twinax	4.1	5
90mm 31awg twinax + VR-VH IO + 260mm 27awg twinax	6	8
1m 31awg internal twinax	16.6	19.1
1m 27awg external twinax	11.1	12.9

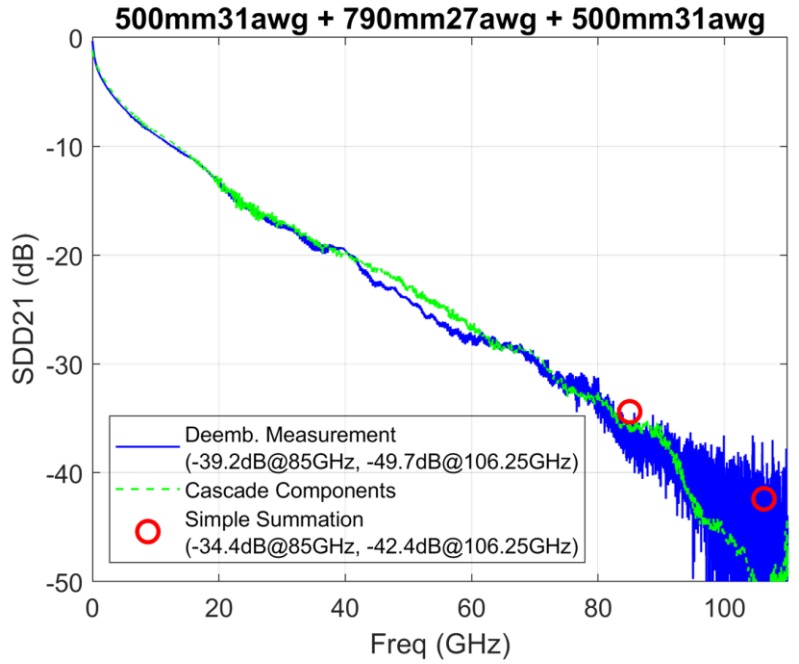
- This is only meant to be a ballpark estimate to give a 10,000 foot view of what our total channel loss will look like (especially for the 1m BP target)
  - Clearly, effects like reflections between components, mode conversions, etc are being omitted

Sanity Check 1:

- Conceptual:
- Building from our pieces:

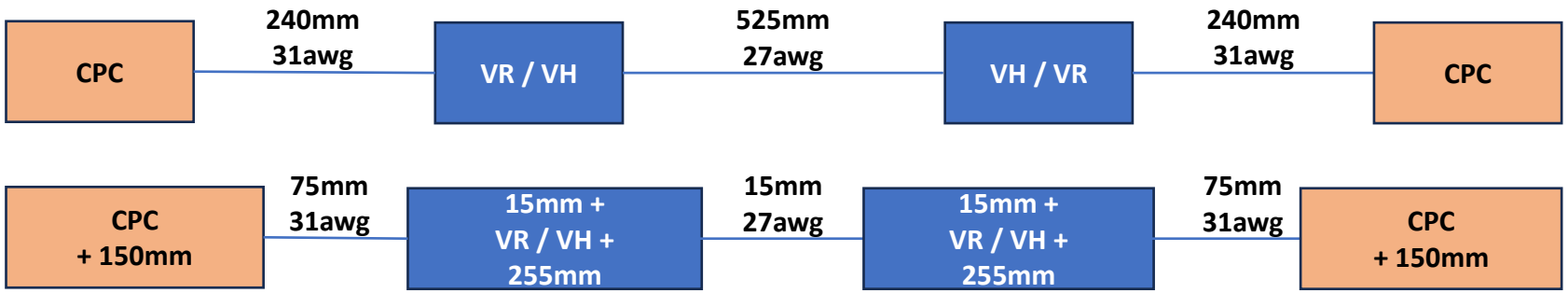


Approach	85GHz Loss	106.25GHz Loss
Measured Loss (MCB Deemb; —)	39.2 dB	49.7 dB
Summation of Components (o)	34.4 dB	42.4 dB

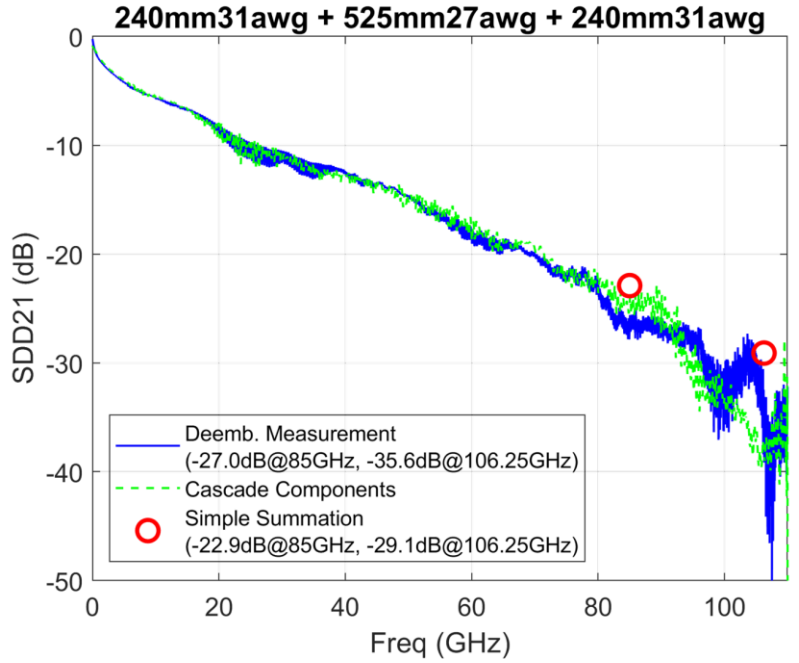


Sanity Check 2:

- Conceptual:
- Building from our pieces:

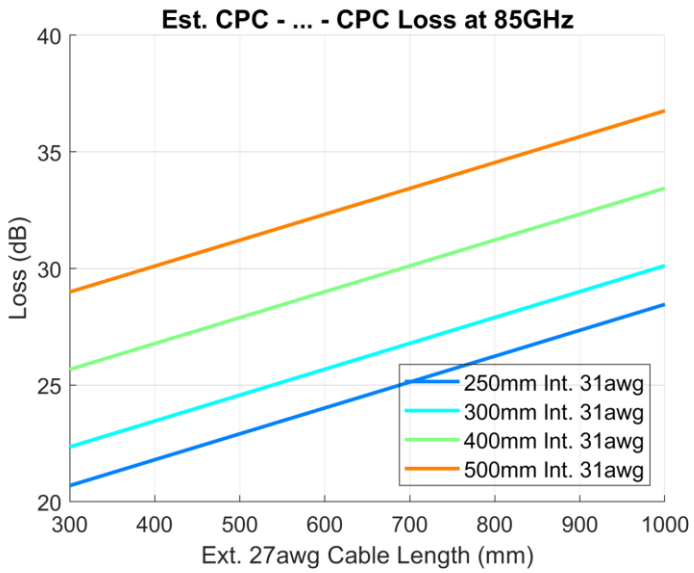


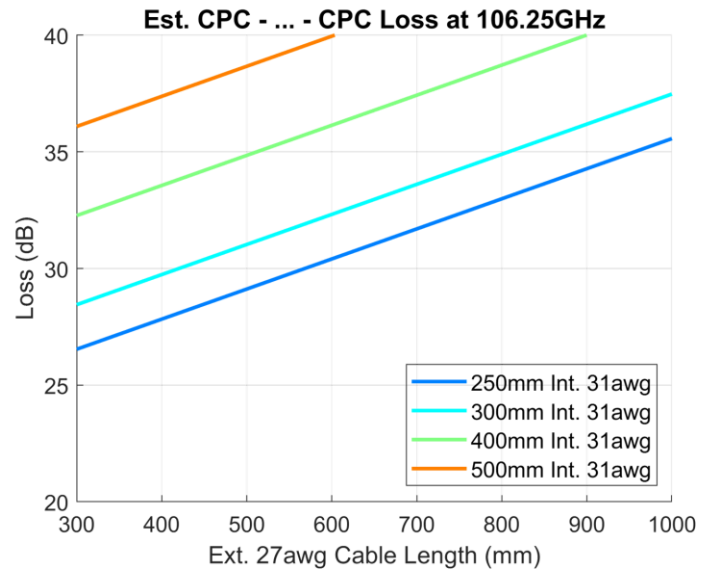
Approach	85GHz Loss	106.25GHz Loss
Measured Loss (MCB Deemb; —)	27.0 dB	35.6 dB
Summation of Components (o)	22.9 dB	29.1 dB



Extrapolation to Wider Array of Cases

- Using the menu of loss components, below plot the CPC-…-CPC channel loss for various length configurations
  - Listed internal 31awg lengths have 2 such segments (one on each side)





- If the CPC-…-CPC portion of the channel is held to **mid/upper-20dB's**, then it will be challenging to get to a 1m cable BP or DAC with PAM-6
  - PAM-4 will be quite challenging
- This portion of the channel probably needs a bigger slice of the loss budget than mid-20dB, especially for PAM-4

Summary

- Showed where we are on component loss values and our best estimate at how much we expect to improve it
- Used these elements to provide a quick dirty estimate of total CPC-…-CPC loss
- We hear whisper numbers of mid/high-20s of dB, but that will be risky to realize with 1m BP/DAC
  - We would hope substrate losses can be further reduced and DSP improvements would afford more loss to the copper channel

Thank You!

References

1. M. Li, E. Frlan, “Architecture and Methodology Considerations for Developing CEI-448G-VSR/LR-PAM4/PAM6 Specifications”, OIF, oif2026.461.02, 2026.
2. M. Li, K. Lusted, “Path Forward for Developing CEI-448G-VSR/LR Specifications”, OIF, oif2026.229.00, 2026.
3. H. Cirit, “Scaling the Rack: Electrical Interconnect for Hypersaler Compute Demands”, IEEE P802.3dv, cirit_400GPL_01_2609, 2026.