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DESIGNCON® 2024

WHERE THE CHIP MEETS THE BOARD

Conference
January 30 – February 1, 2024

Expo
January 31 – February 1, 2024

Santa Clara Convention Center

REALISTIC USE CASES FOR EDGE, ANGLED AND VERTICAL LAUNCH CONNECTORS UP TO 100 GHZ

Sandeep (Samtec)

Sandeep Sankararaman, Shawn Tucker,
Istvan Novak, Gustavo Blando (Samtec)

SPEAKER

Sandeep

Principal Engineer, Samtec

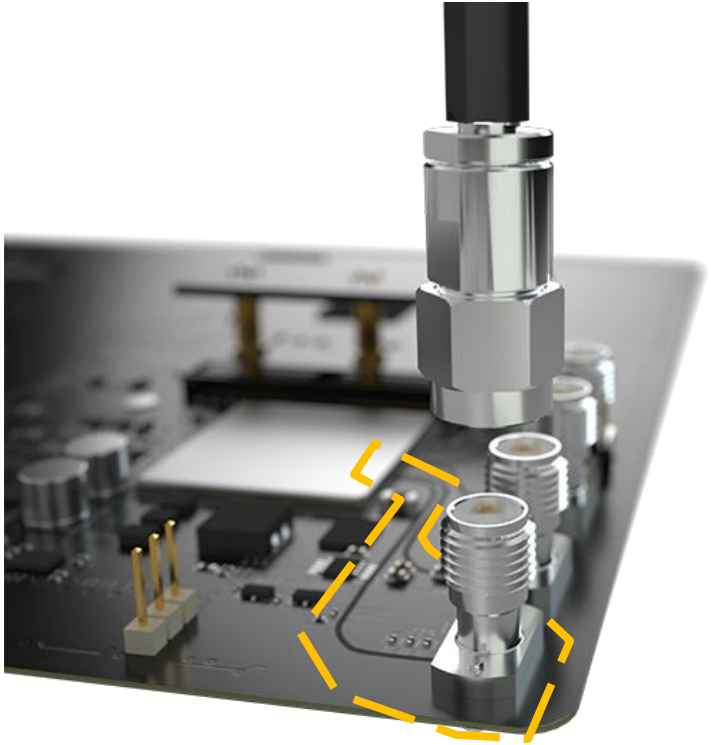
Sandeep@samtec.com | samtec.com

Sandeep has 20 years of experience in signal and power integrity for IC packages, PCBs, PCB connectors and connectors for cable assemblies.

WHAT'S THE OBJECTIVE?

Measure DUT transparently:

- Remove everything between test instrument and DUT



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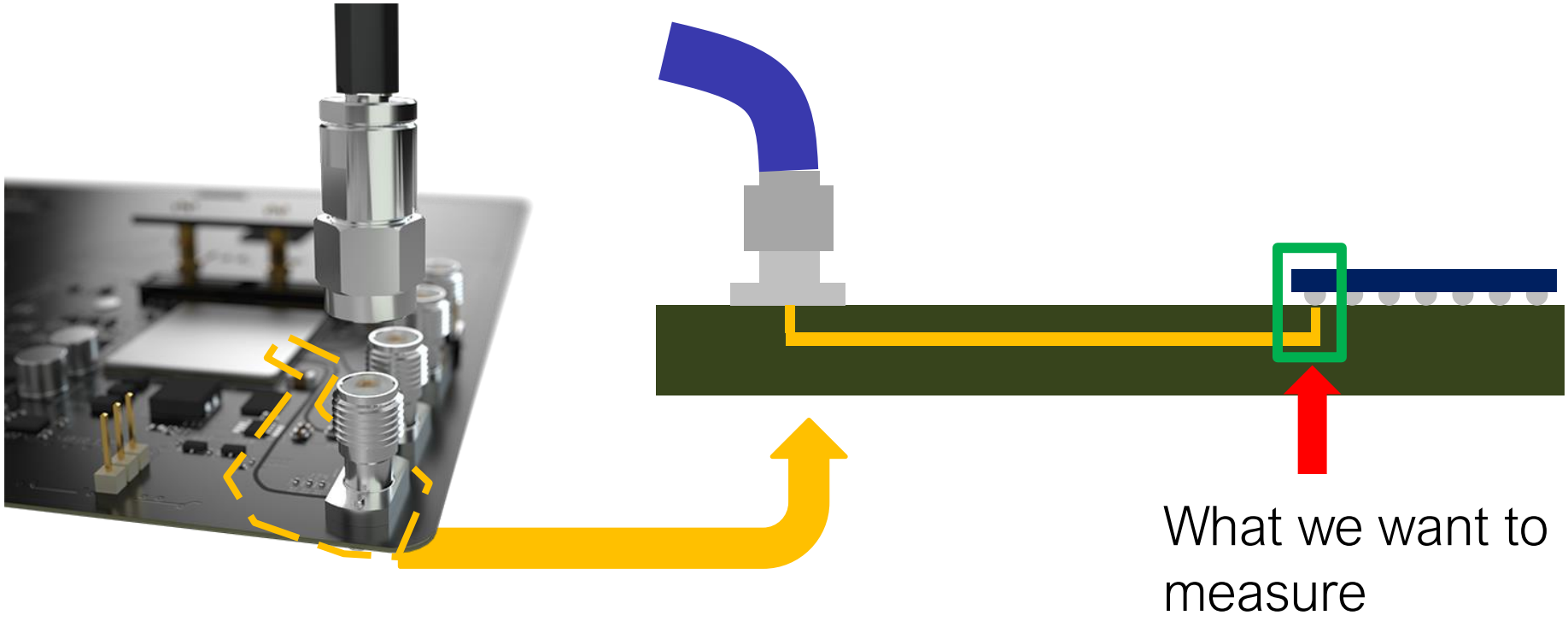

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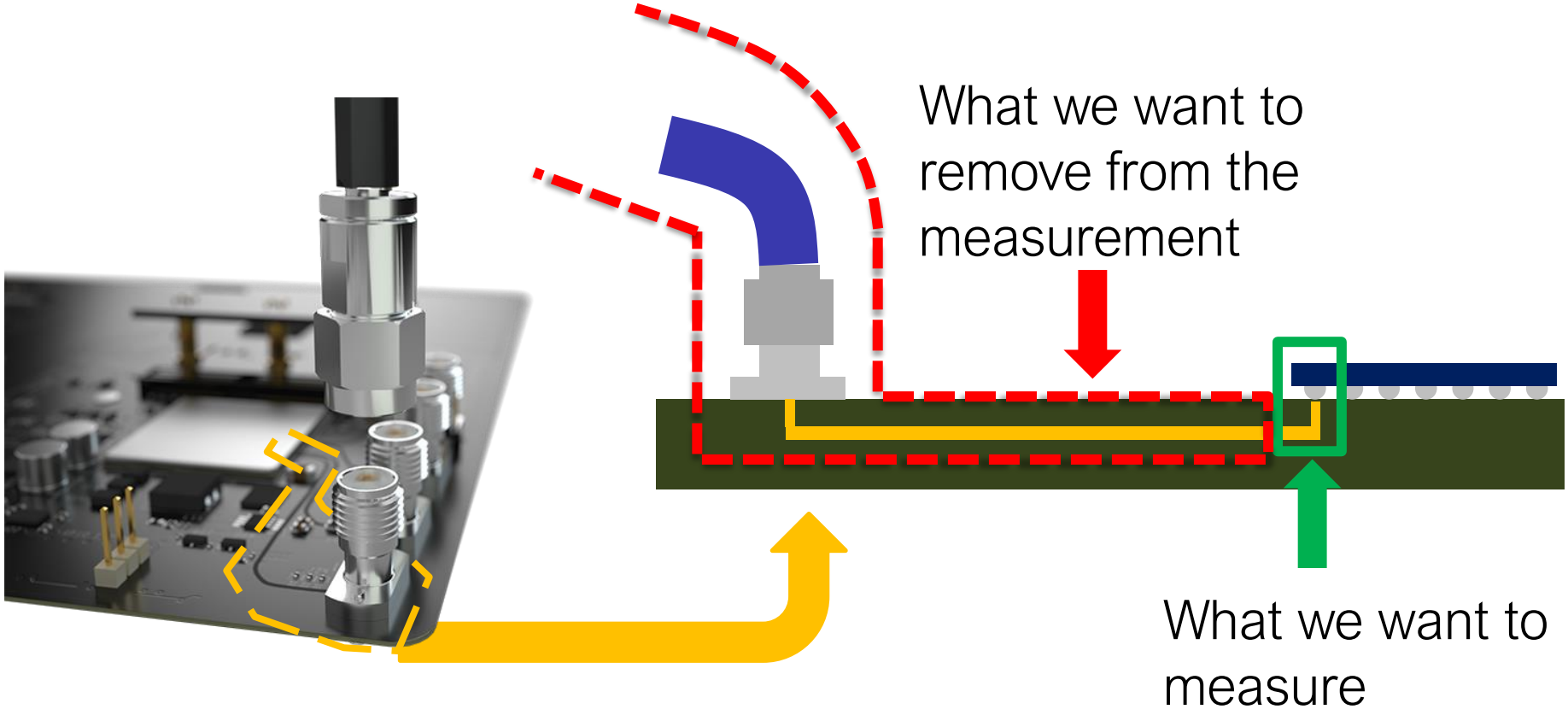
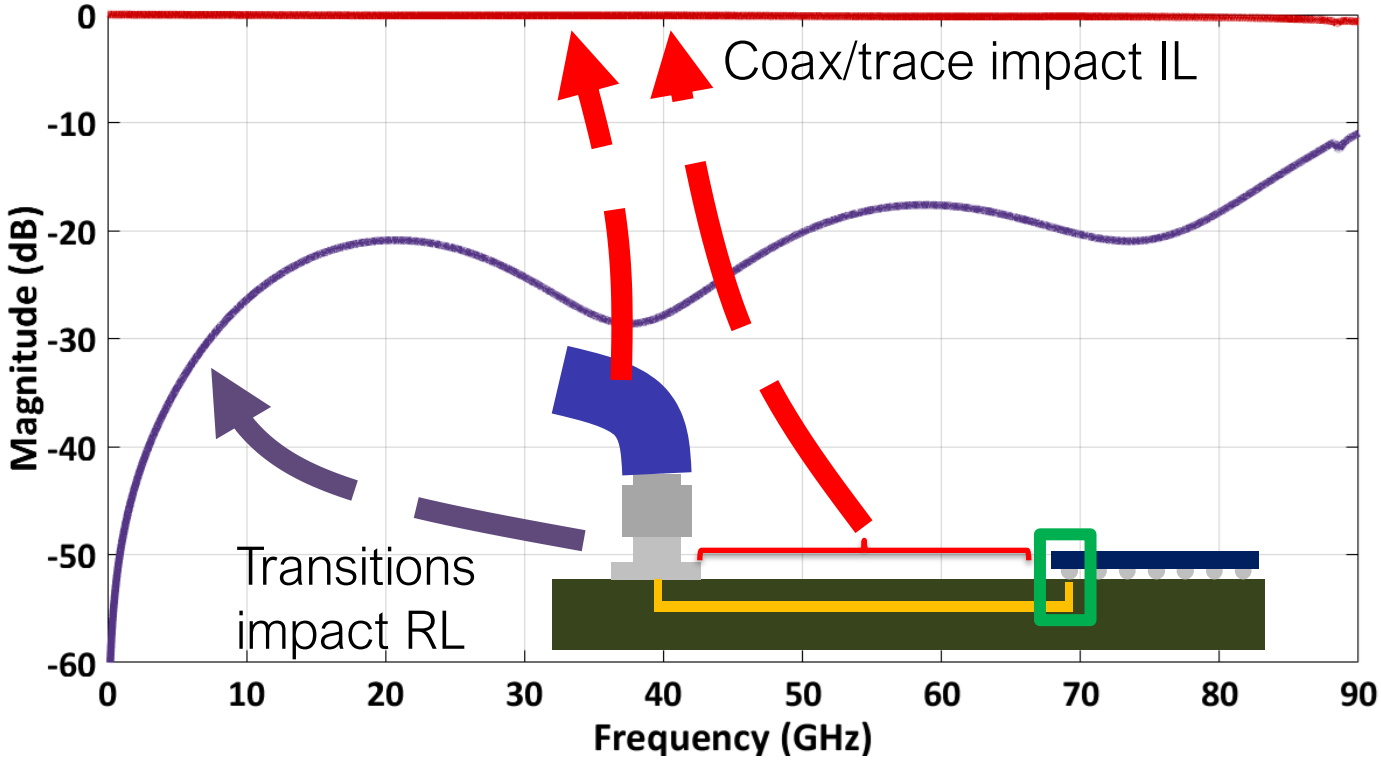
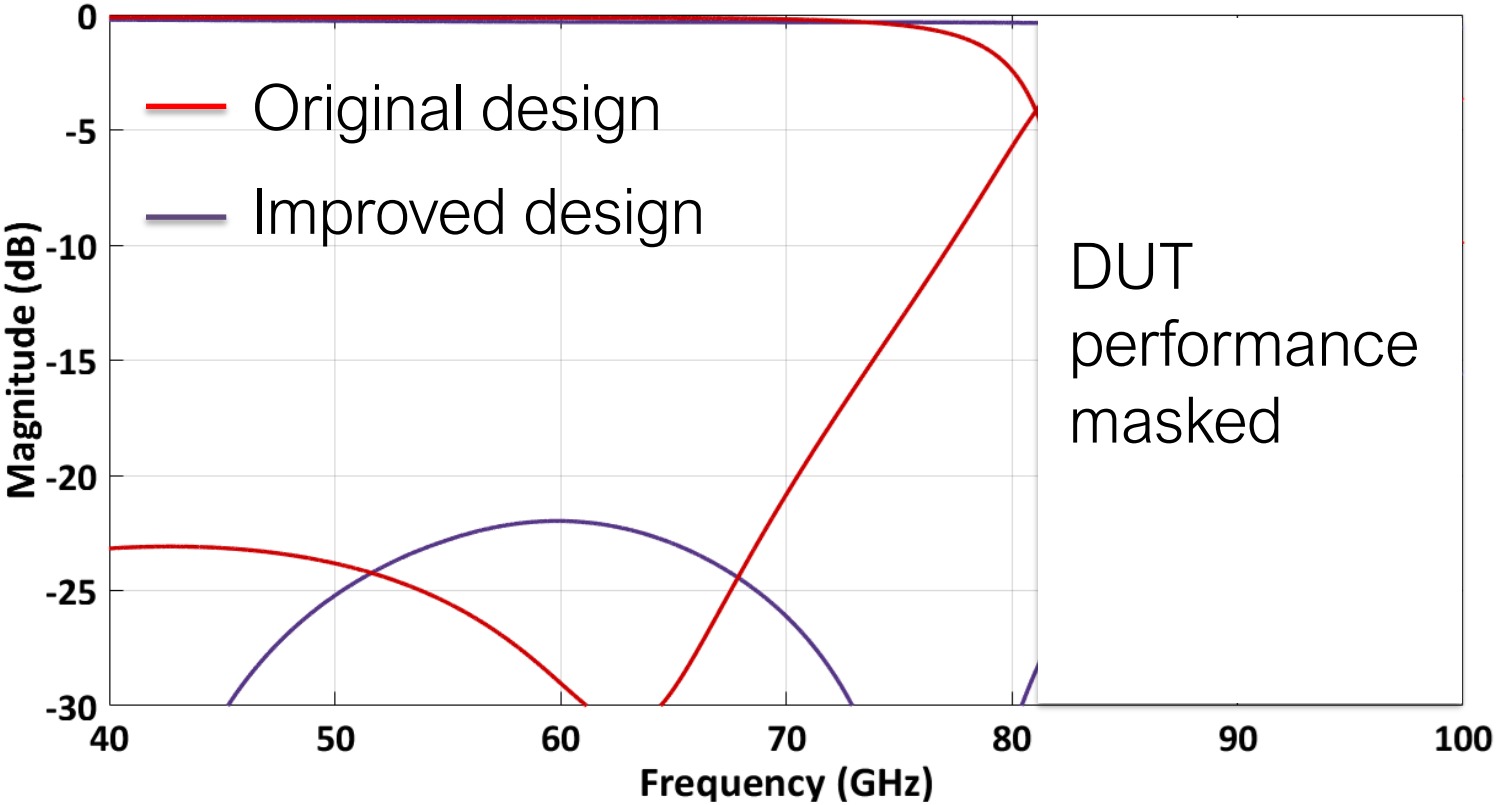


FIXTURE PERFORMANCE DETERMINANTS



MAKING FIXTURE TRANSPARENT



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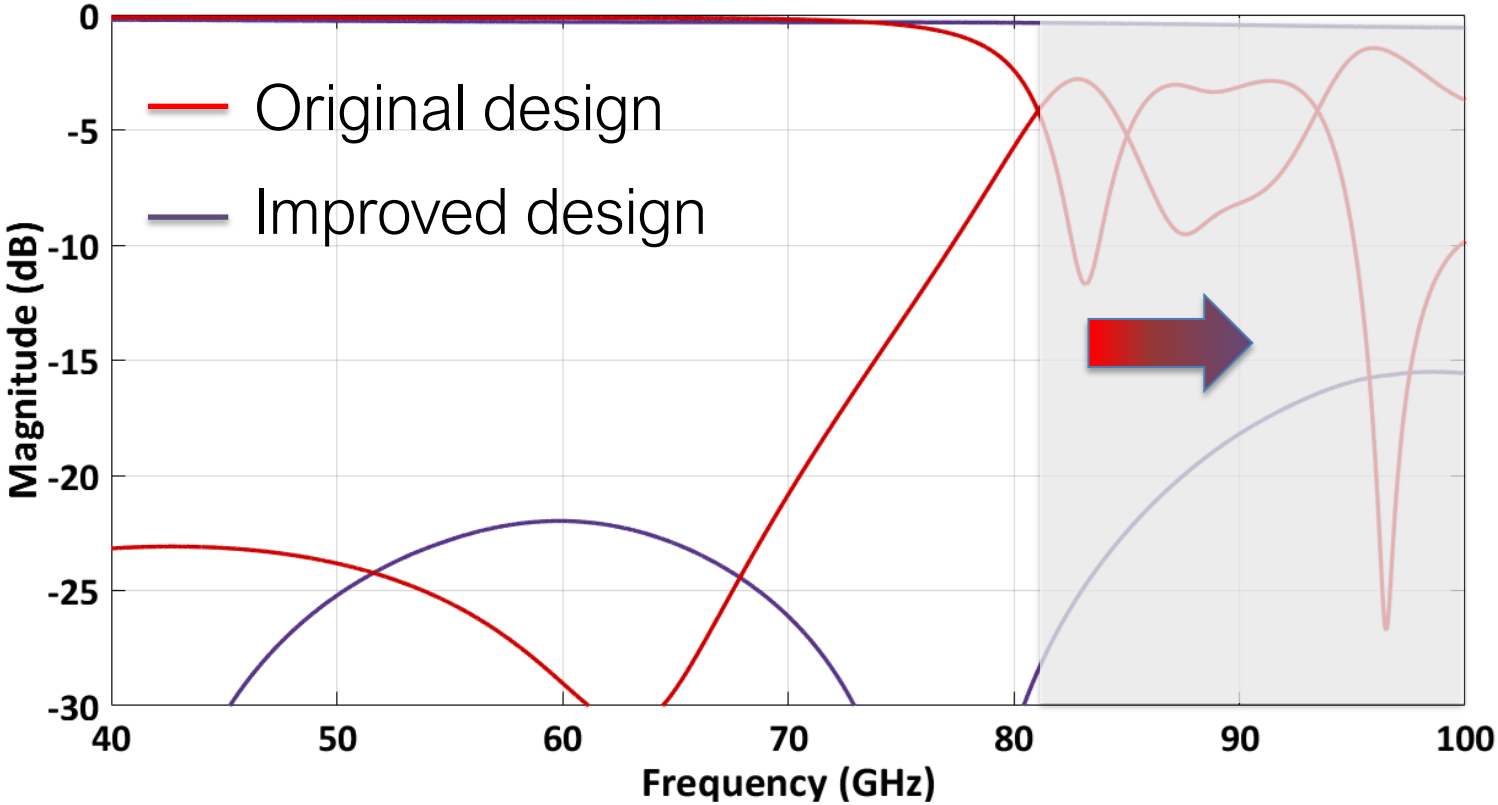

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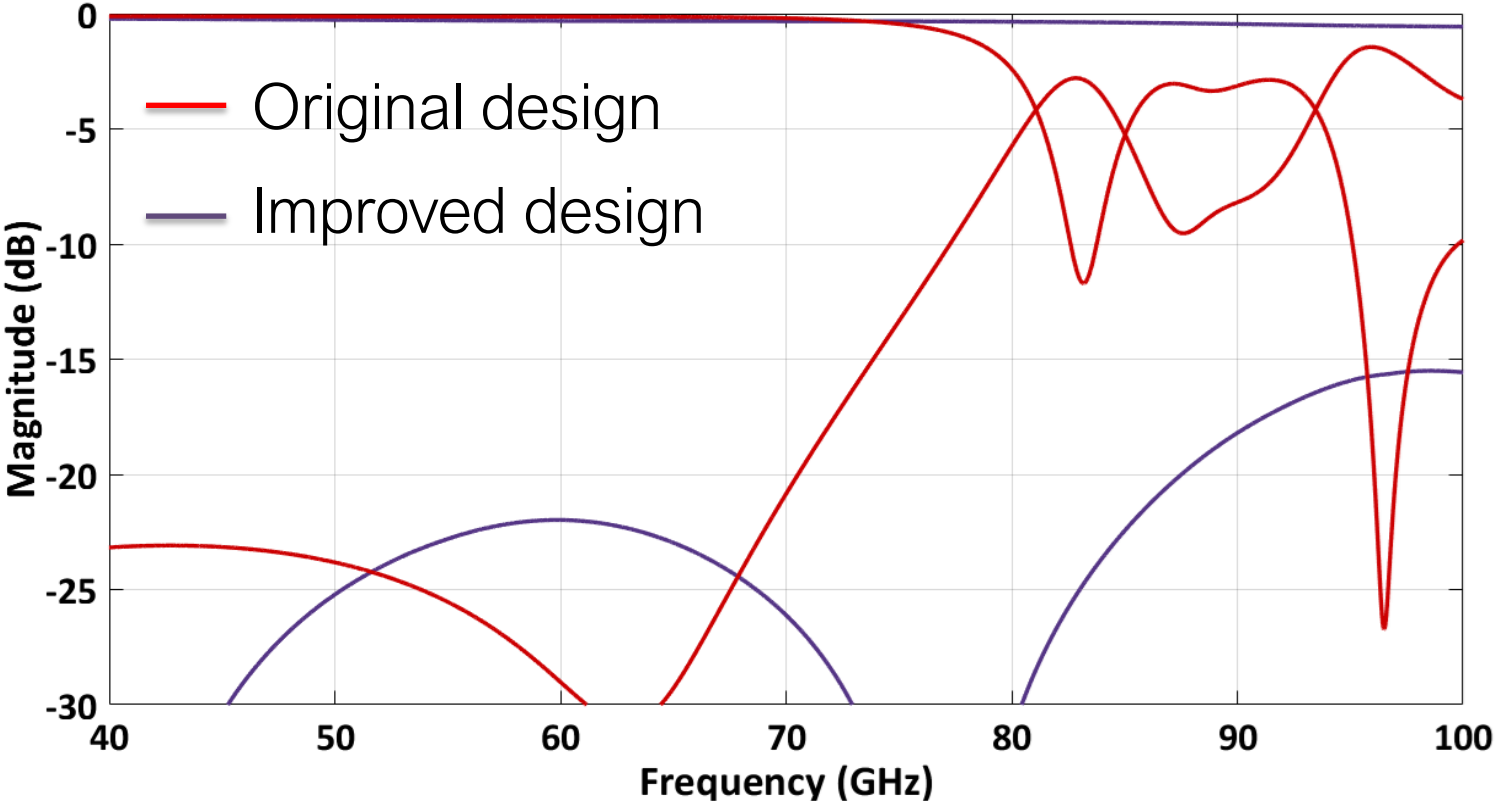


MAKING FIXTURE TRANSPARENT

Reduce IL:

- Move as close to DUT as possible
- Reduce losses as much as possible

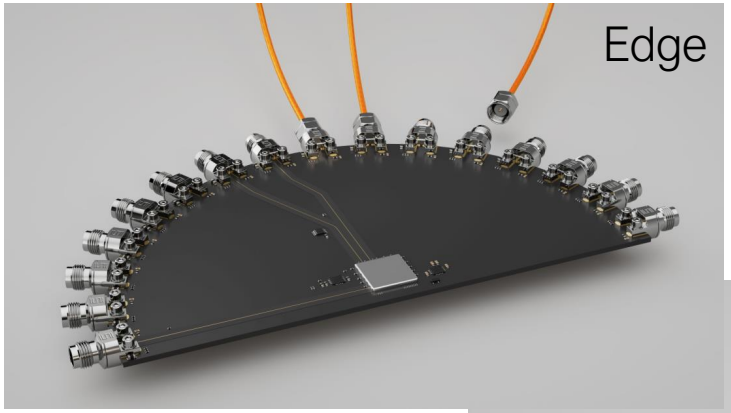
Reduce RL:

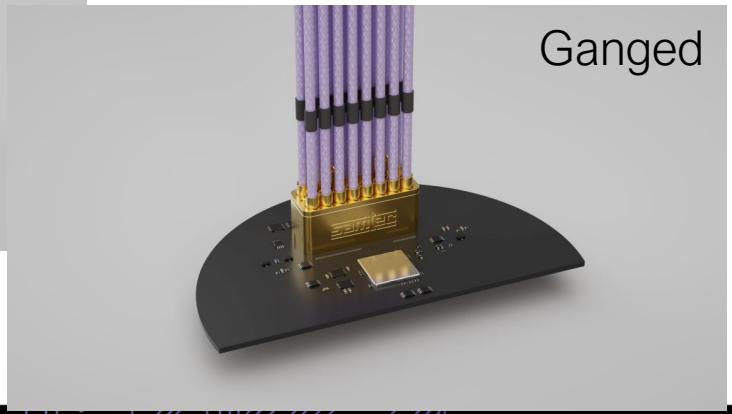
- Minimize transitions
- Impedance match transitions
- Avoid higher order modes

How do these apply to test setups with:

- Edge
- Vertical/Angled
- Ganged connectors

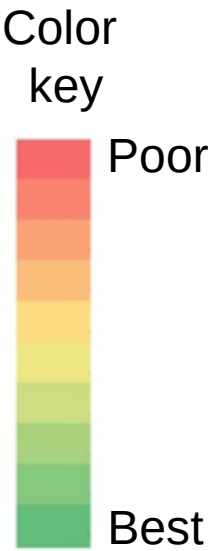
CASES TO CONSIDER



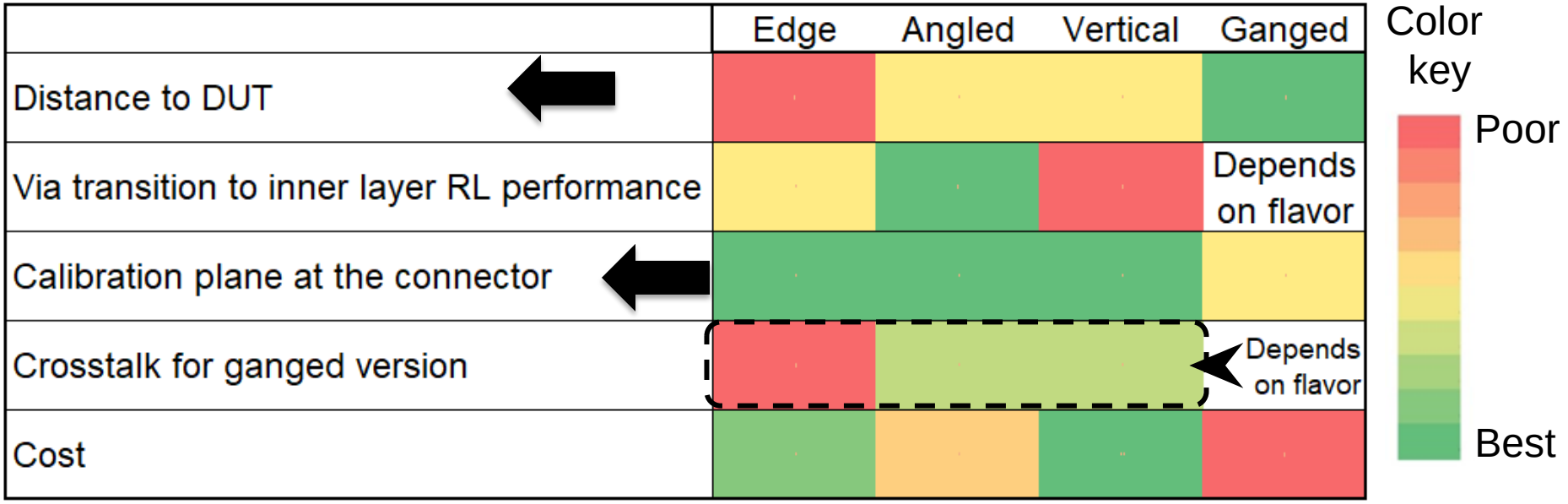


SPOILER ALERT – COMPARISON TABLE

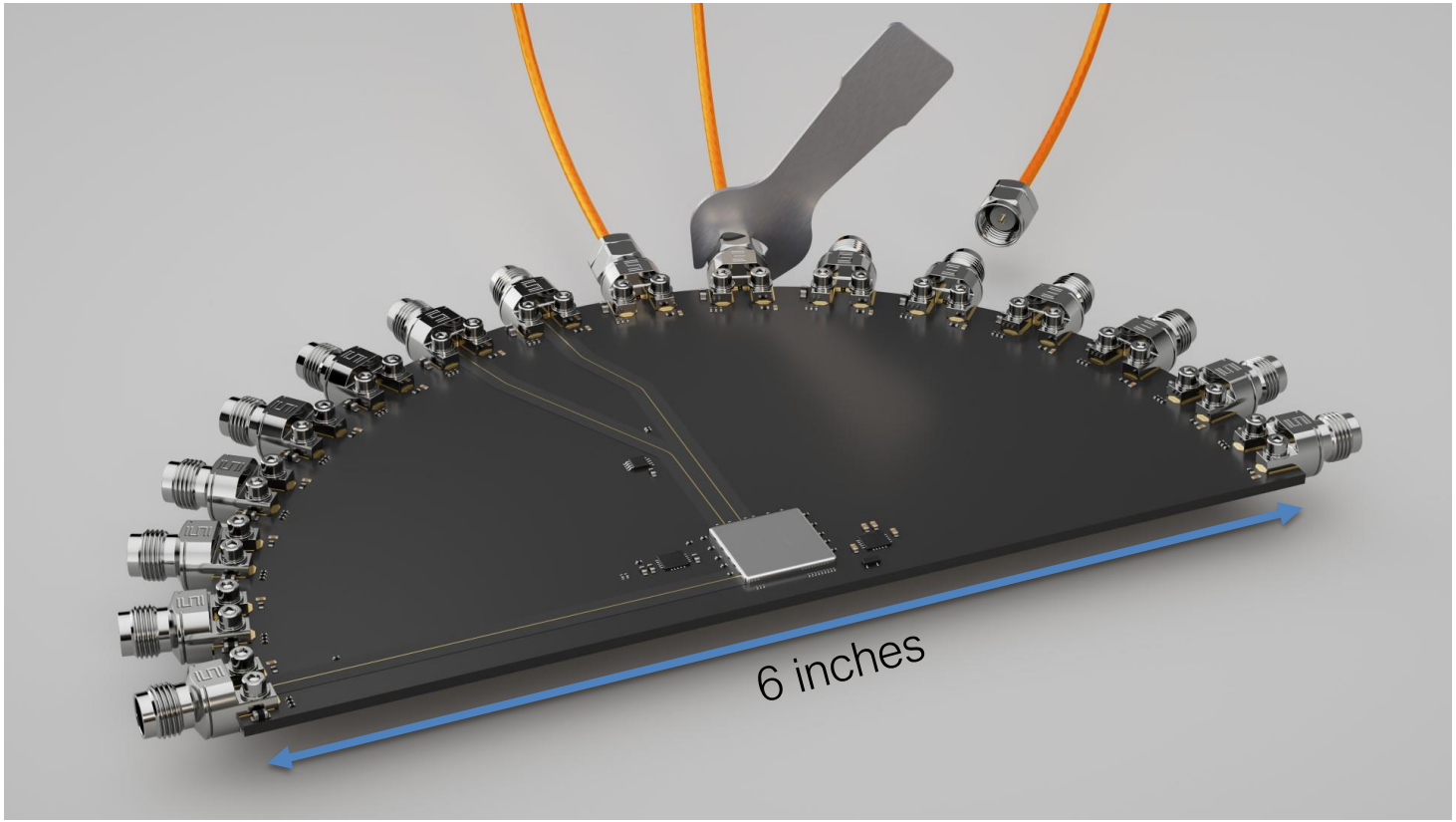
	Edge	Angled	Vertical	Ganged
Distance to DUT				
Via transition to inner layer RL performance				Depends on flavor
Calibration plane at the connector				
Crosstalk for ganged version				Depends on flavor
Cost				



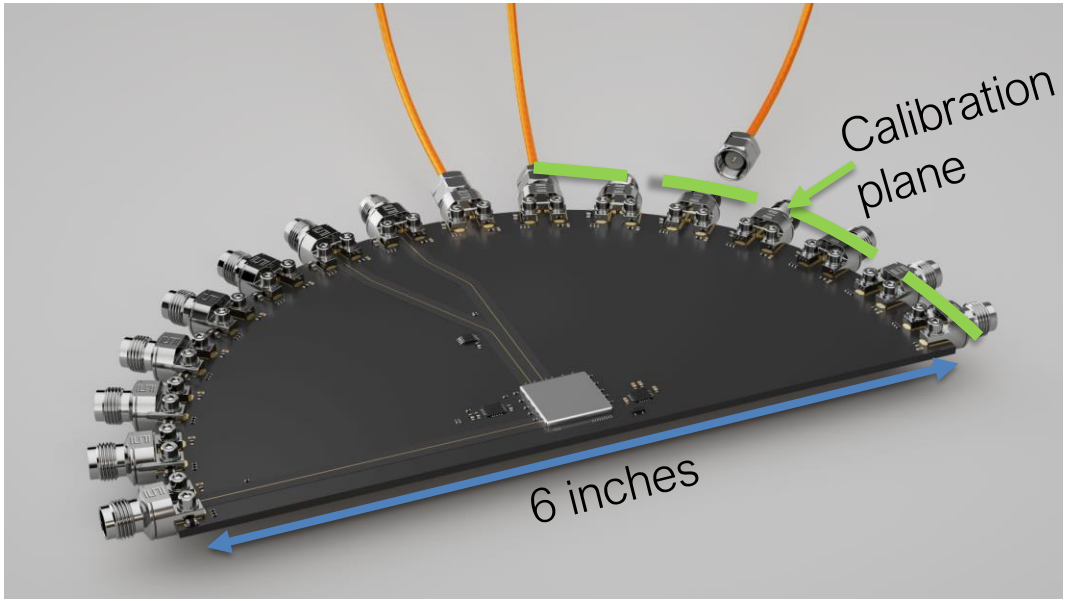
IL KNOBS


Edge
Angled
Vertical
Ganged
Distance to DUT
Via transition to inner layer RL performance
Depends on flavor
Calibration plane at the connector
Crosstalk for ganged version
Depends on flavor
Cost
Color key
Poor
Best

SENSE OF SCALE: EDGE CONNECTORS



SENSE OF SCALE: EDGE CONNECTORS

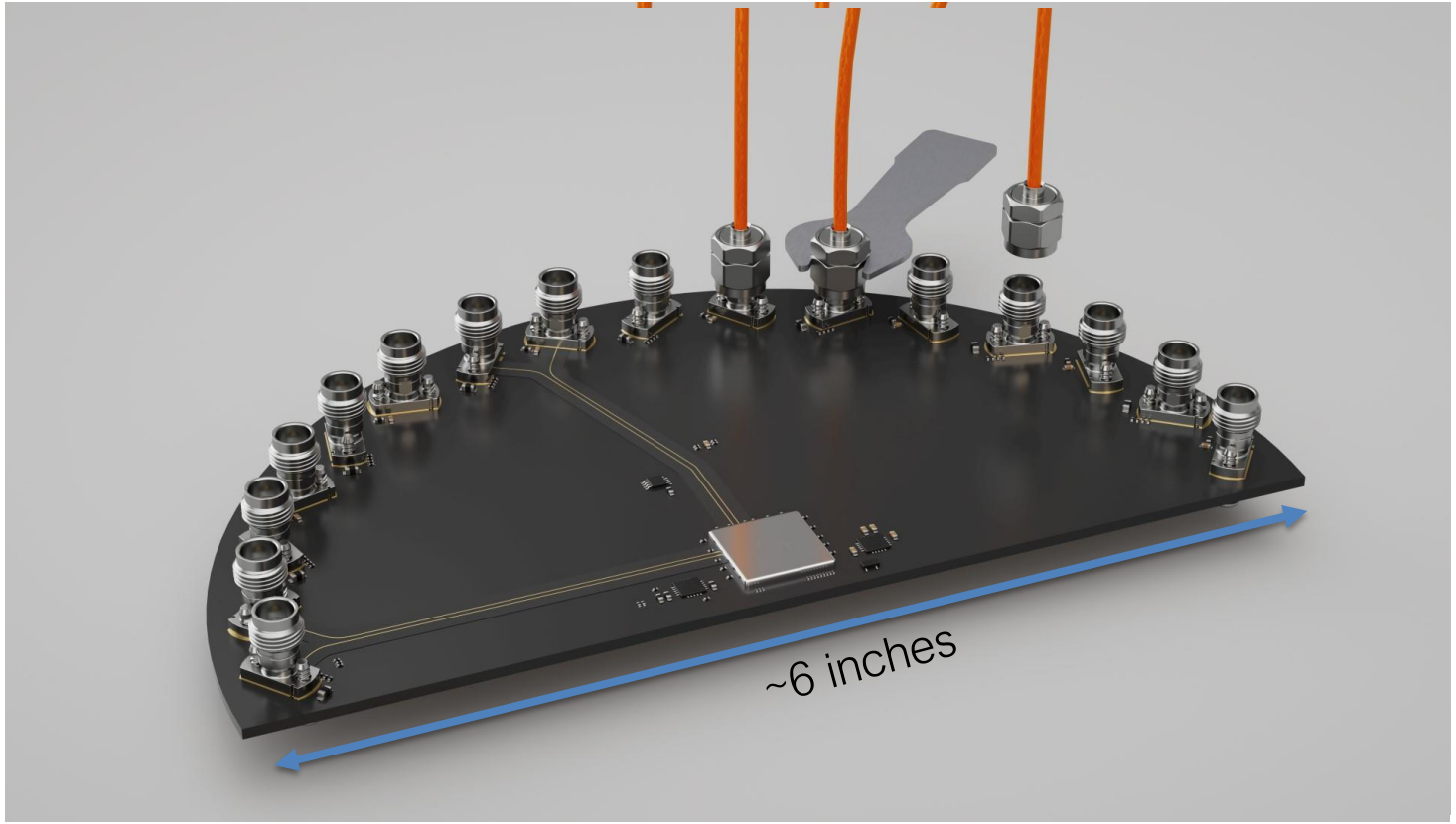


Everything up to edge connector is removed by calibration.

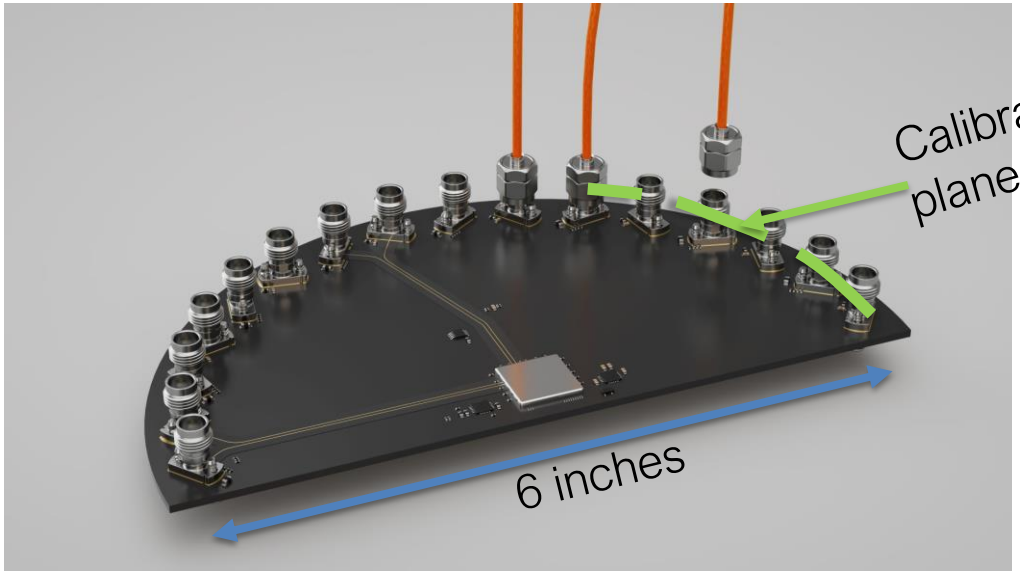
Still to be de-embedded:

- Edge connector launch
- Approx. 3in. trace

SENSE OF SCALE: VERTICAL ARRANGEMENT 1



SENSE OF SCALE: VERTICAL ARRANGEMENT 1

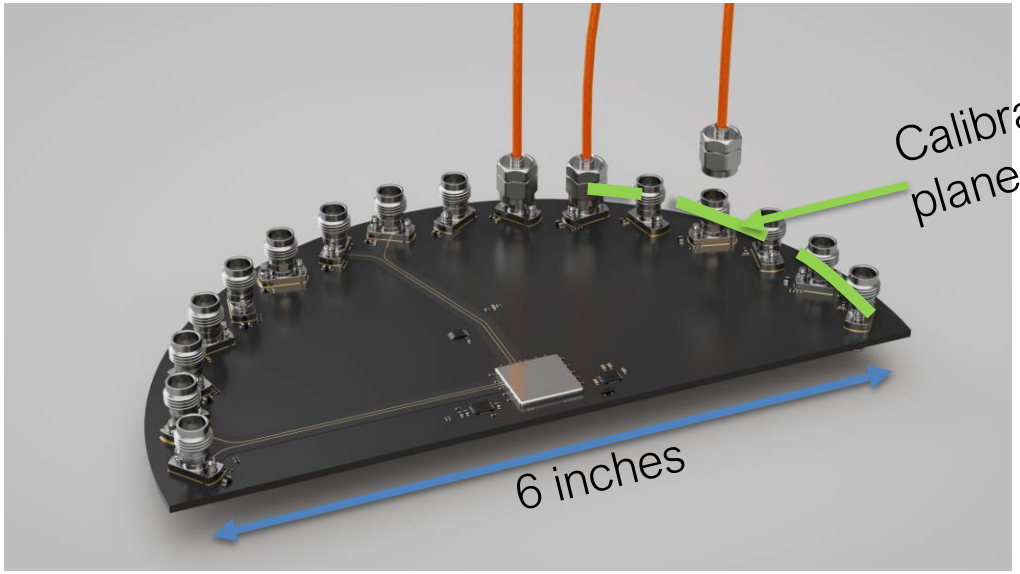


Everything up to vertical connector is removed by calibration.

Still to be de-embedded:

- Vertical connector launch
- Approx. 3in. trace

SENSE OF SCALE: VERTICAL ARRANGEMENT 1



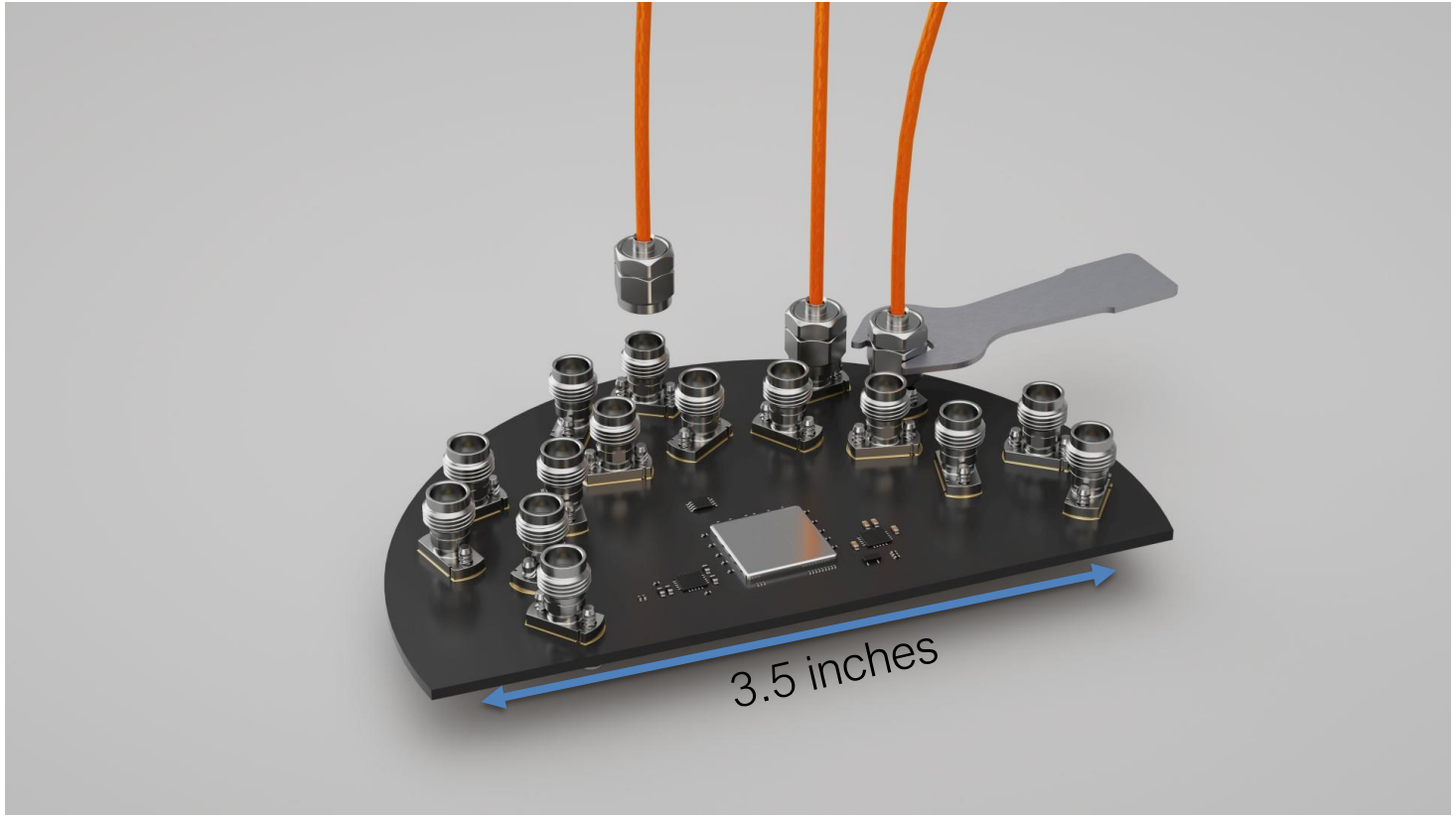
Everything up to vertical connector is removed by calibration.

Still to be de-embedded:

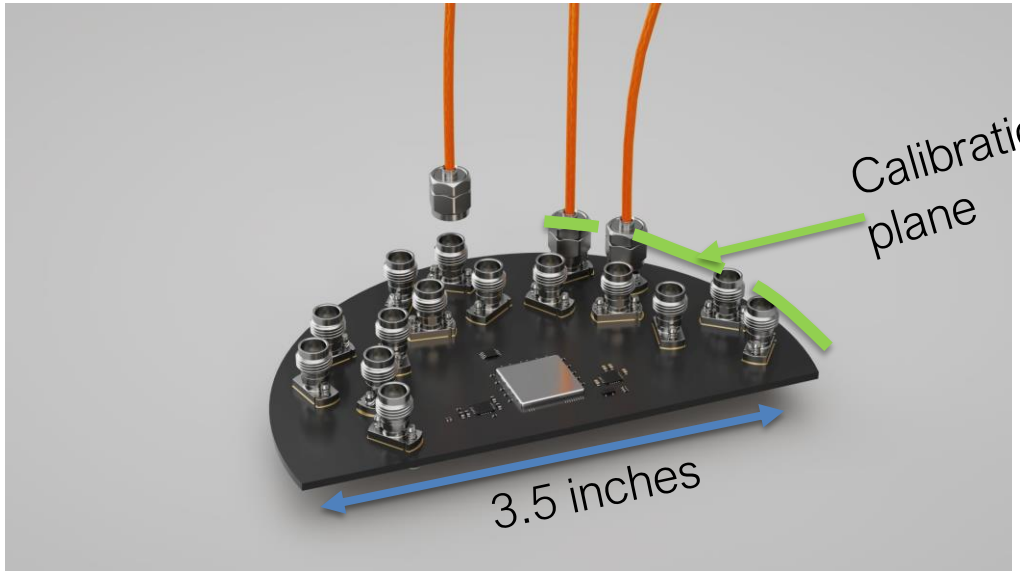
- Vertical connector launch

Takeaway:
Not very different from edge connector case

SENSE OF SCALE: VERTICAL ARRANGEMENT 2



SENSE OF SCALE: VERTICAL ARRANGEMENT 2

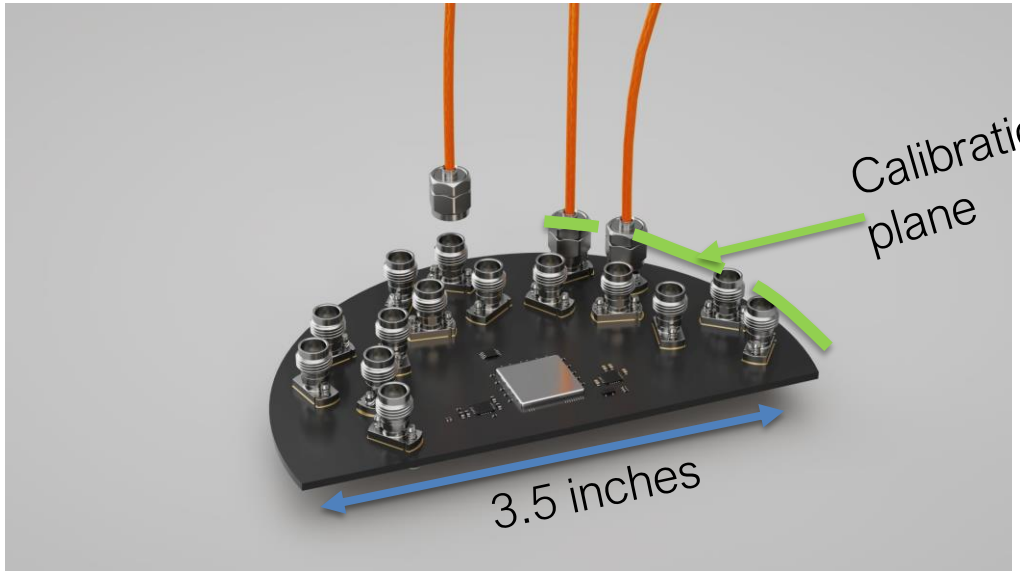


Everything up to vertical connector is removed by calibration.

Still to be de-embedded:

- Vertical connector launch
- Approx. 1.75in. trace

SENSE OF SCALE: VERTICAL ARRANGEMENT 2



Everything up to vertical connector is removed by calibration.

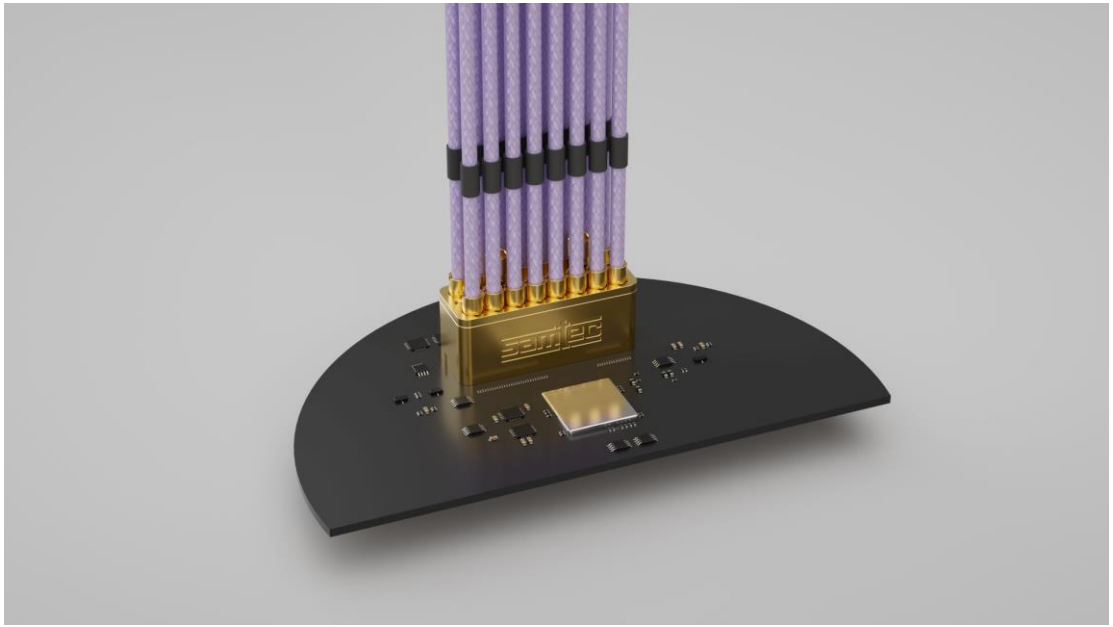
Still to be de-embedded:

- Vertical connector launch

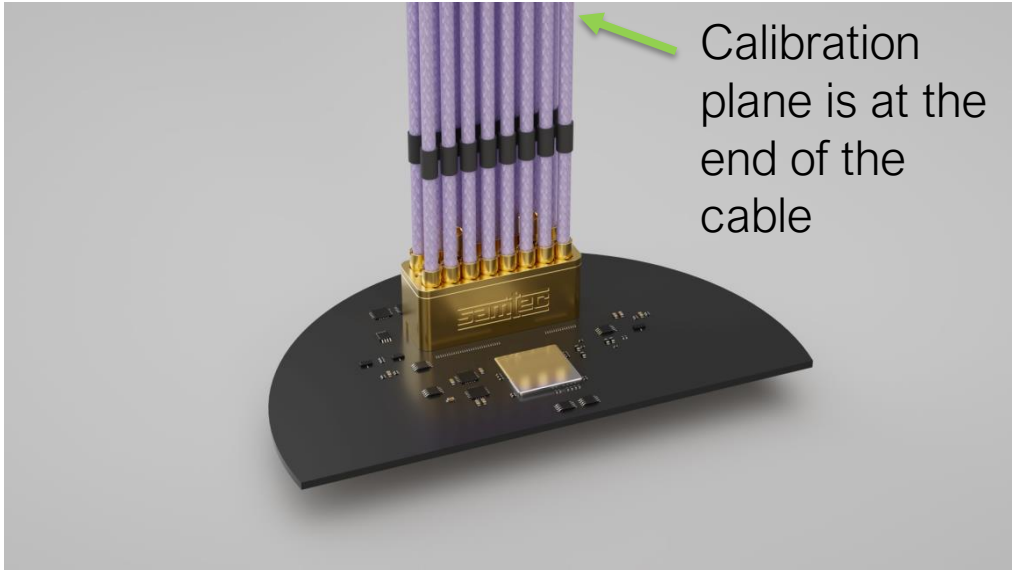
…in. trace

Takeaway: VLCs can move closer, but length matching is harder

SENSE OF SCALE: GANGED CONNECTOR



SENSE OF SCALE: VERTICAL ARRANGEMENT 2



Placed very close to DUT.

Density of connections allows very short trace lengths. All traces can escape similarly

Still to be de-embedded:

- Few inches of cable
- Connector launch

PHYSICAL DISTANCE TO DEEMBED

Case	Distance
Edge connectors	3” PCB trace
Vertical/angled	>1.25” PCB trace
Ganged connector	4” of cable

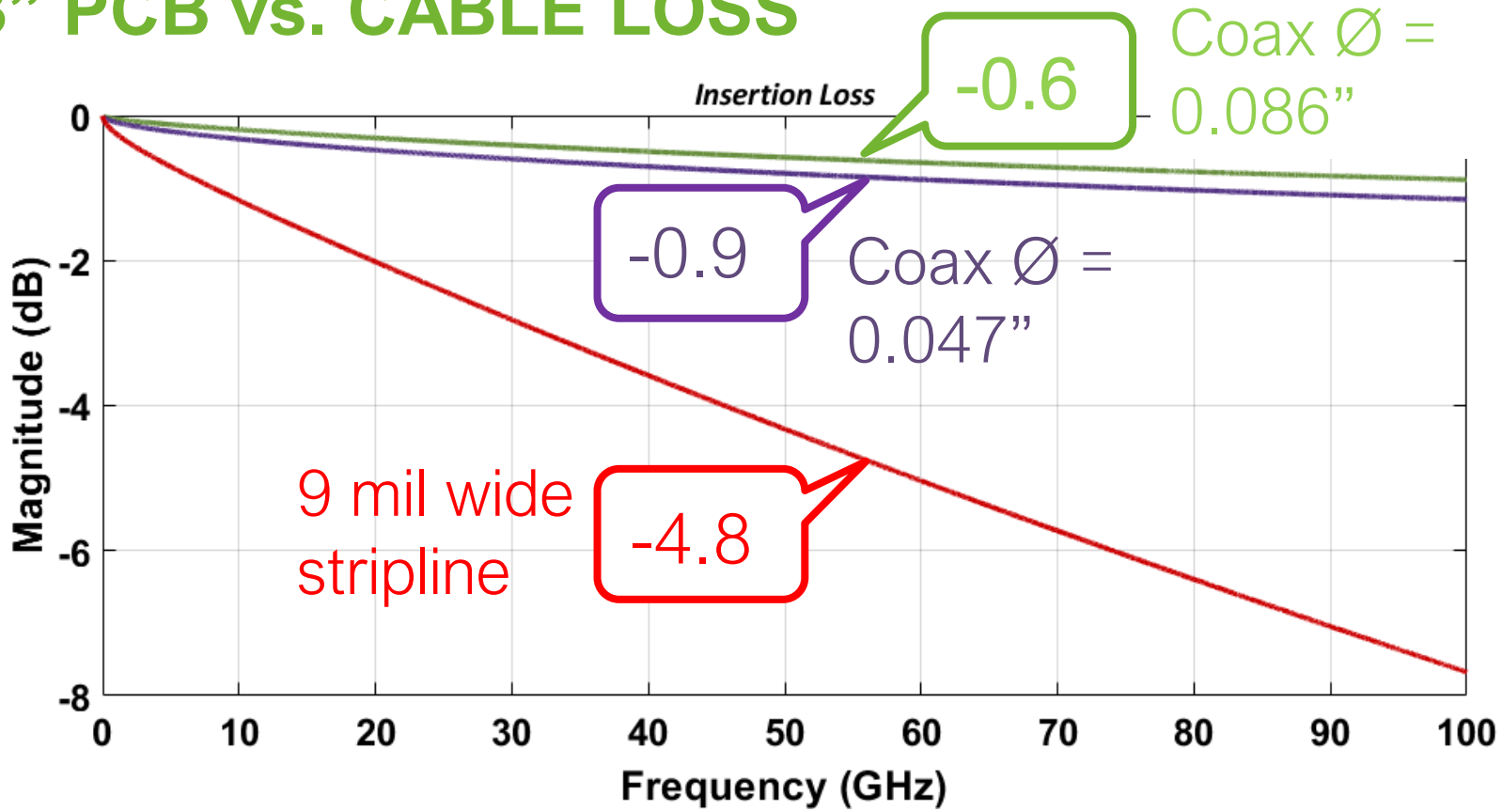
PHYSICAL DISTANCE TO DEEMBED

Case	Distance
Edge connectors	3” PCB trace
Vertical/angled	>1.25” PCB trace
Ganged connector	4” of cable

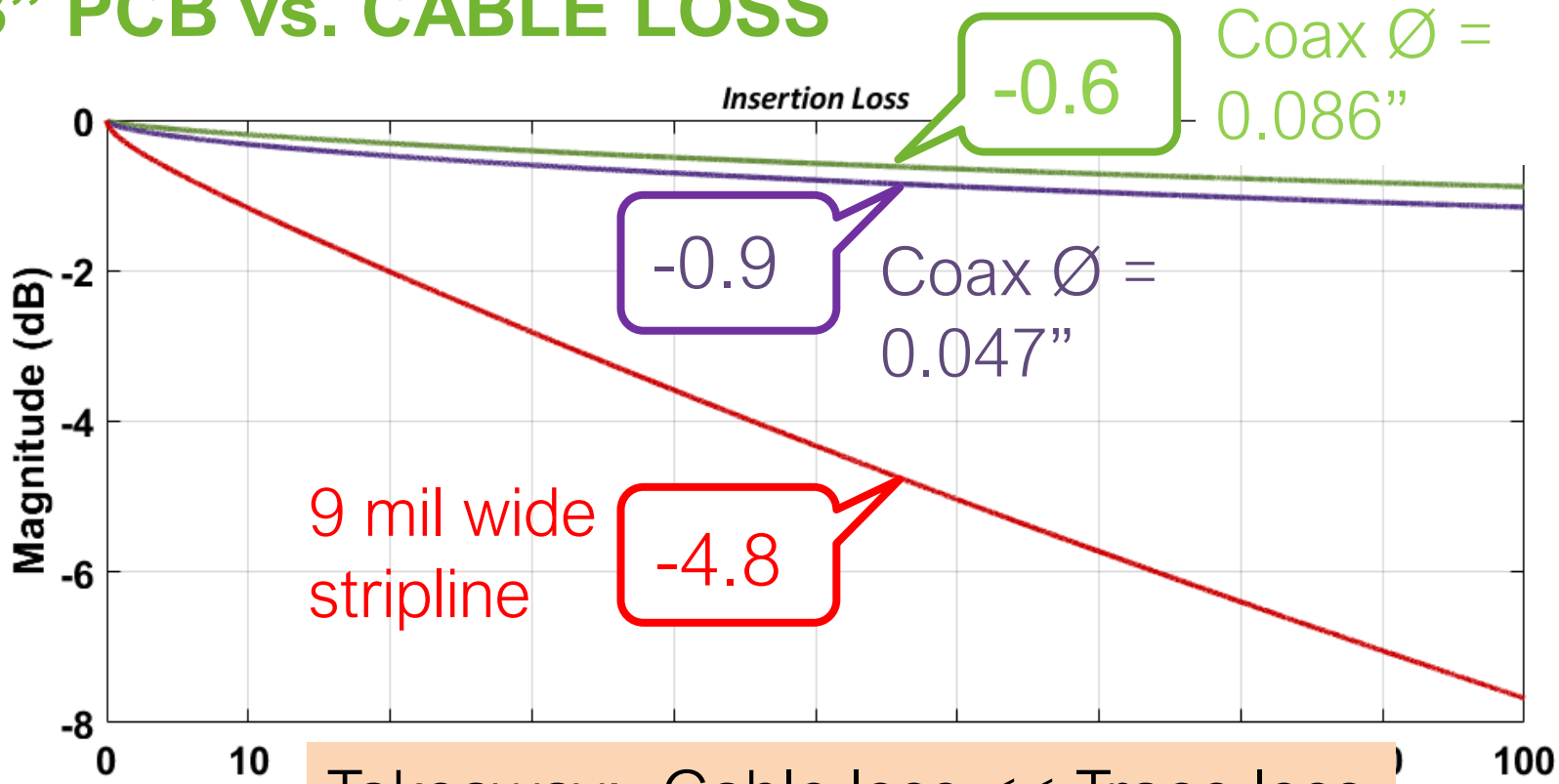
Which is worse?

X inches of trace/X+ inches of cable?

3” PCB vs. CABLE LOSS



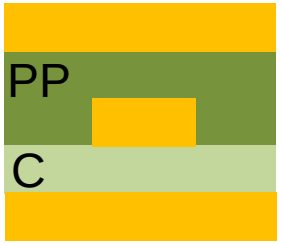
3” PCB vs. CABLE LOSS



Takeaway: Cable loss << Trace loss

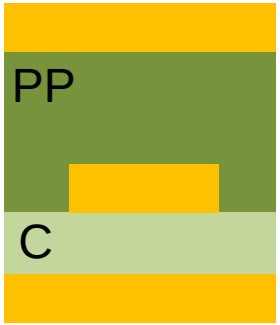
WHEN SIGNIFICANT TRACE LENGTH IS NEEDED

GEN 1



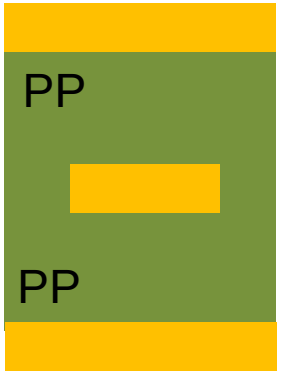
5mil line;
6mil uVia

GEN 2



8mil line;
6mil uVia

GEN 3



~8mil line;
4mil uVia

WHEN SIGNIFICANT TRACE LENGTH IS NEEDED

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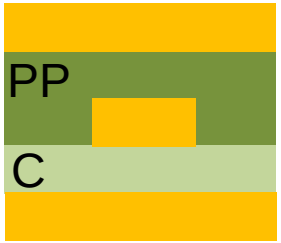
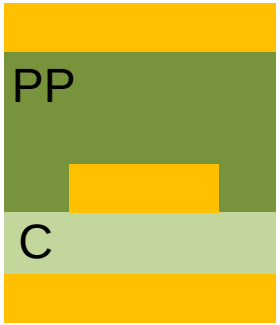


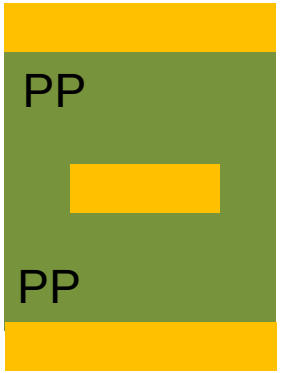
5mil line;
6mil uVia

GEN 2



8mil line;
6mil uVia

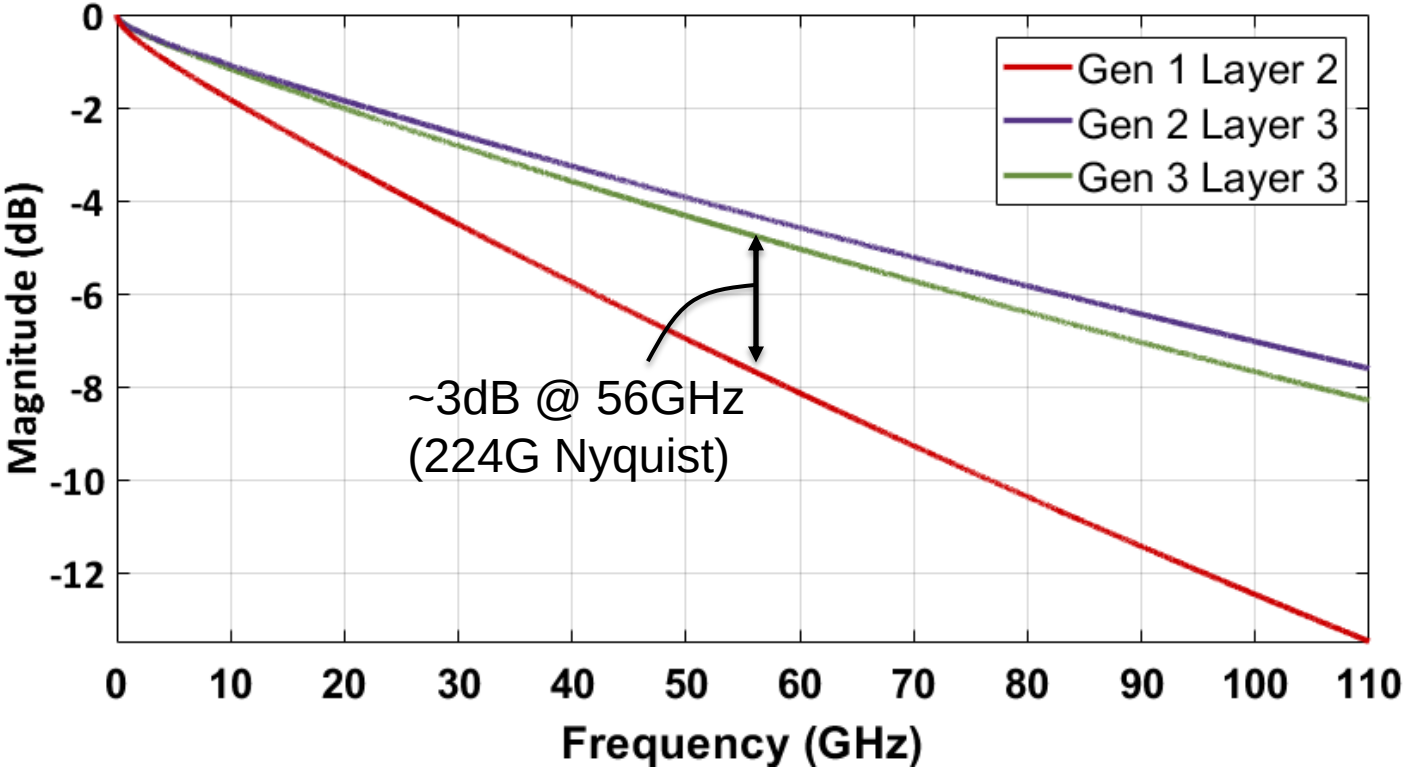
GEN 3



~8mil line;
4mil uVia

Takeaway: Shoot for widest trace with narrowest via

PCB STACKUP LOSS COMPARISON – 3 INCH



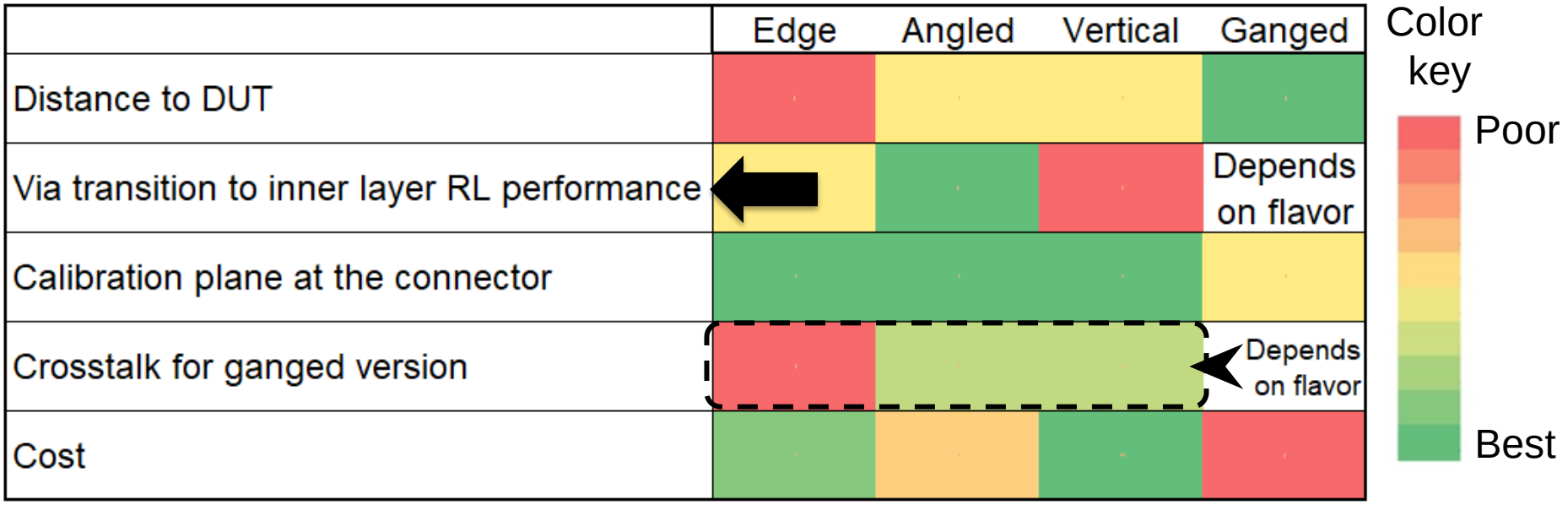
SECTION TAKEAWAYS

Cover most distance to DUT with low loss cable

Where trace is needed, use low loss diel, widest line possible with narrow via

Ganged vertical /edge connectors can be very beneficial

RL KNOBS


Edge
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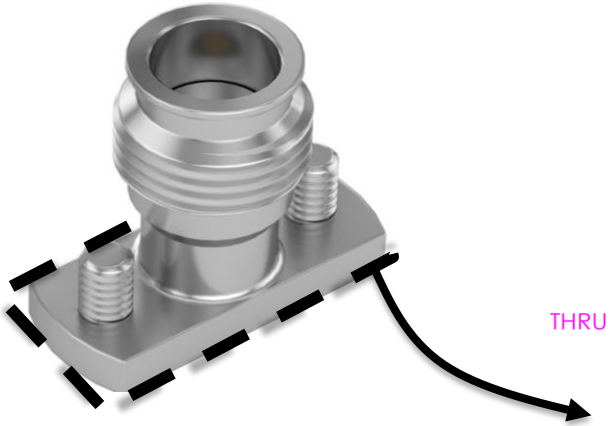
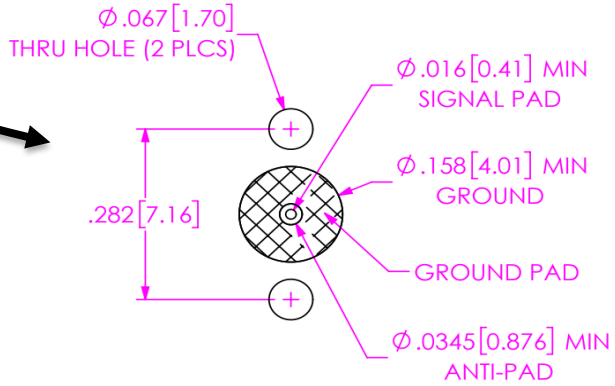
Distance to DUT
Via transition to inner layer RL performance
Depends on flavor
Calibration plane at the connector
Crosstalk for ganged version
Depends on flavor
Cost
Color key
Poor
Best

RL PERSPECTIVE: FOOTPRINT vs. LAUNCH

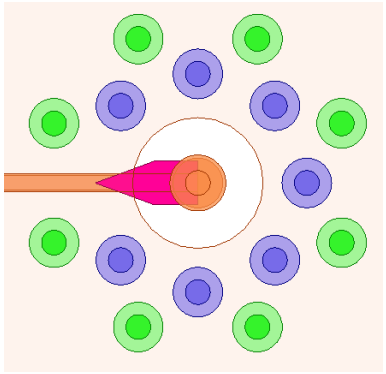


Compression mount VLC

Footprint from datasheet

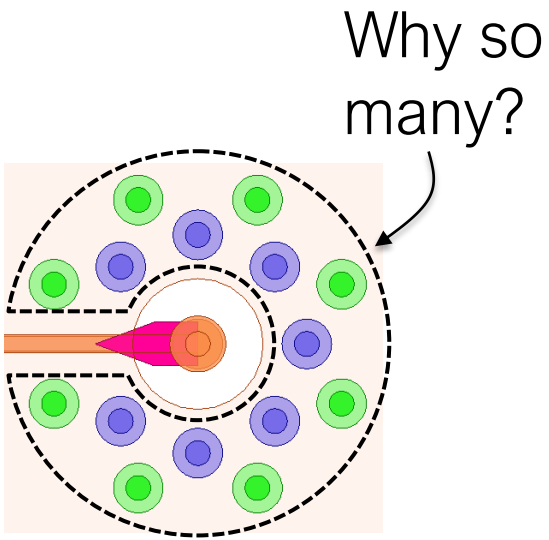


RECOMMENDED PCB LAYOUT
(SEE NOTE 2)



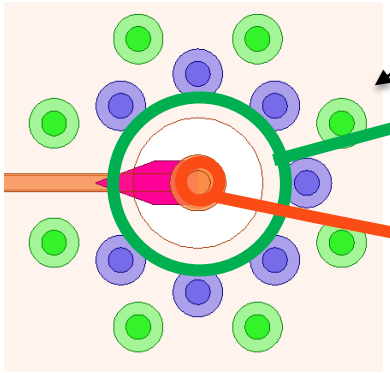
Electrically tuned signal launch

LAUNCH CONSIDERATIONS: VIA COUNT



LAUNCH CONSIDERATION A: VIA COUNT

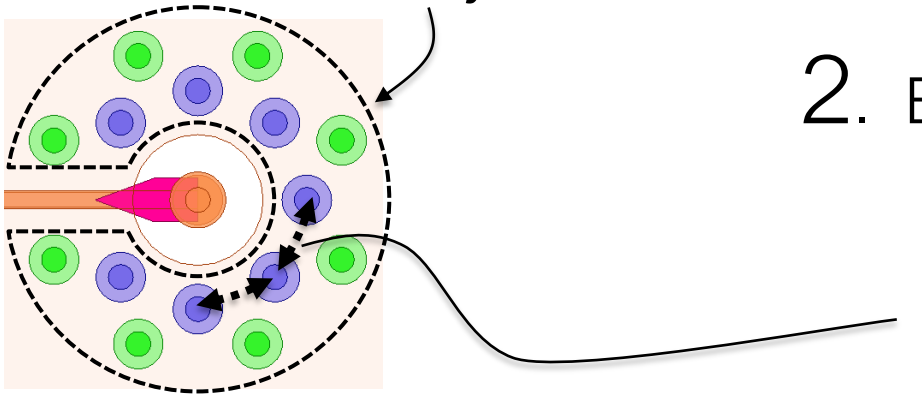
Why so many?



1. Good Z_0 control:

$$Z_0 = 138 \frac{\log_{10}\left(\frac{D_{GND}}{D_V}\right)}{\sqrt{\varepsilon_R}}$$

LAUNCH CONSIDERATION A: VIA COUNT

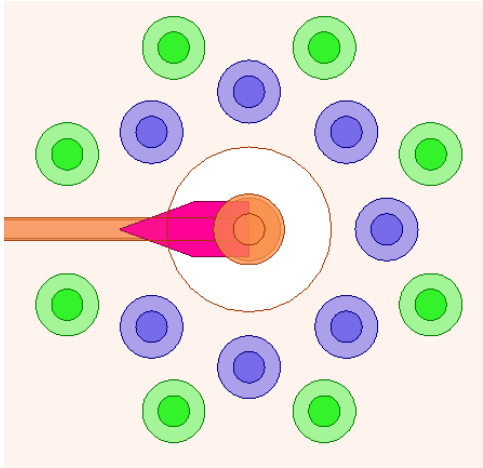


1. Good Z_0 control.

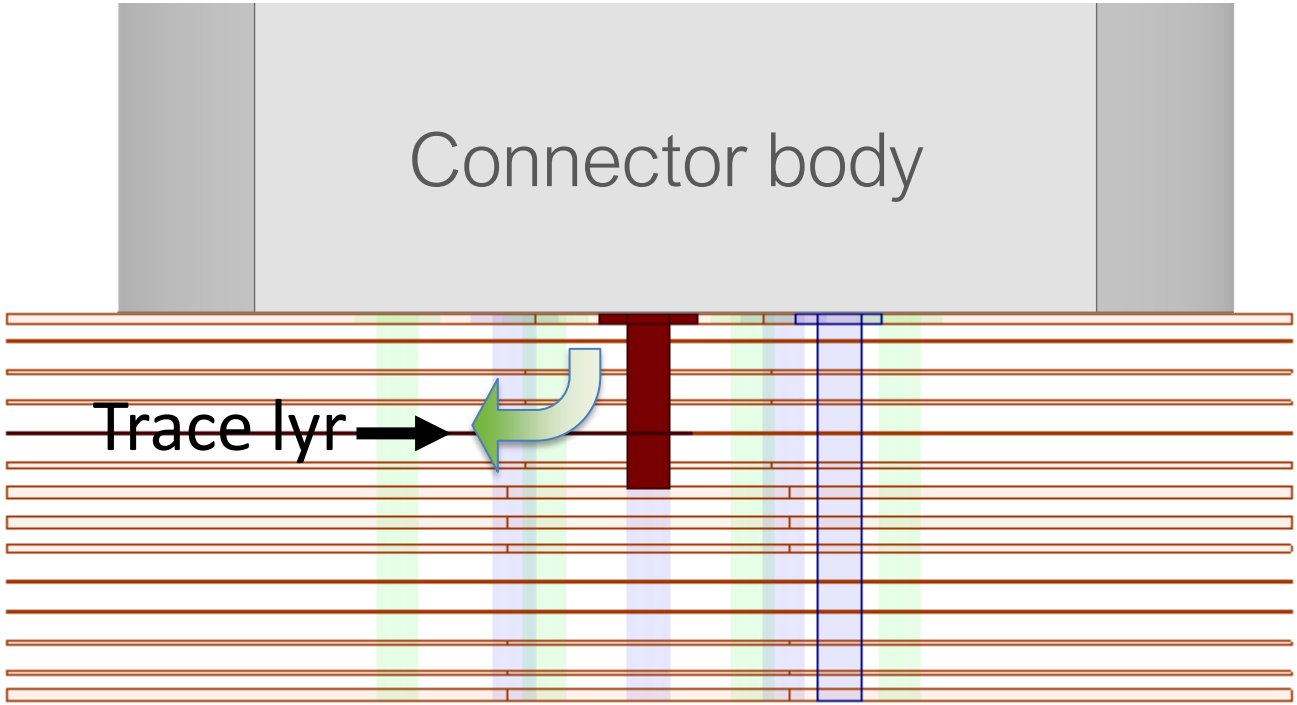
2. Energy escape

LAUNCH CONSIDERATION B: ENERGY FLOW

Top View

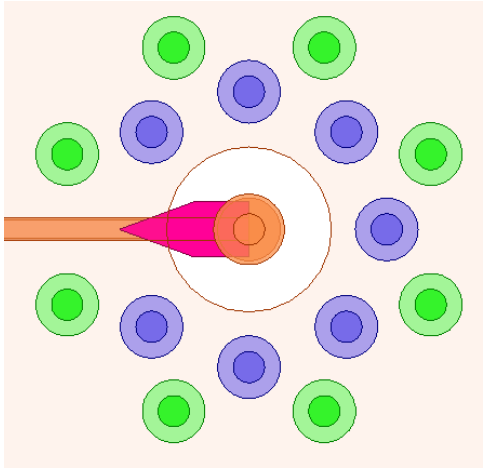


Side View

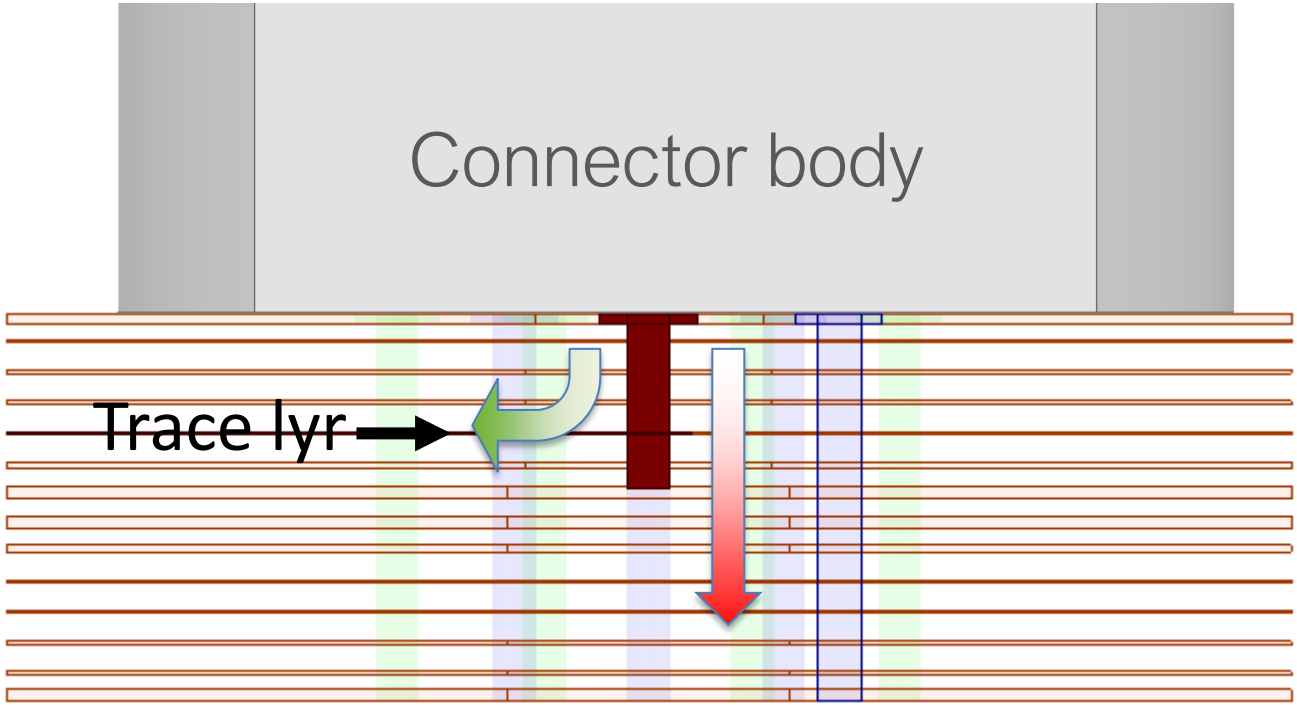


LAUNCH CONSIDERATION B: ENERGY FLOW

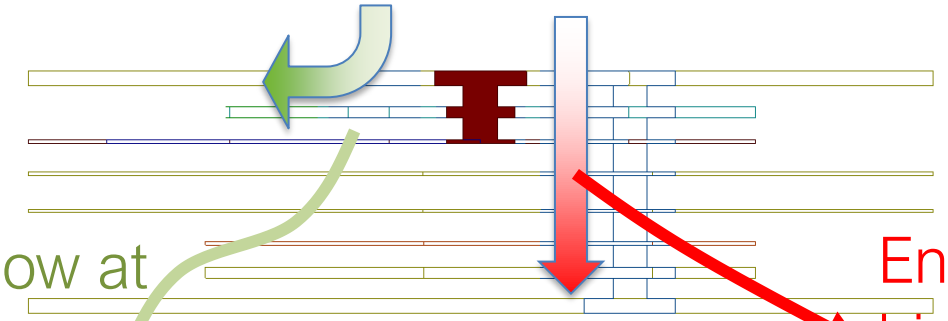
Top View



Side View

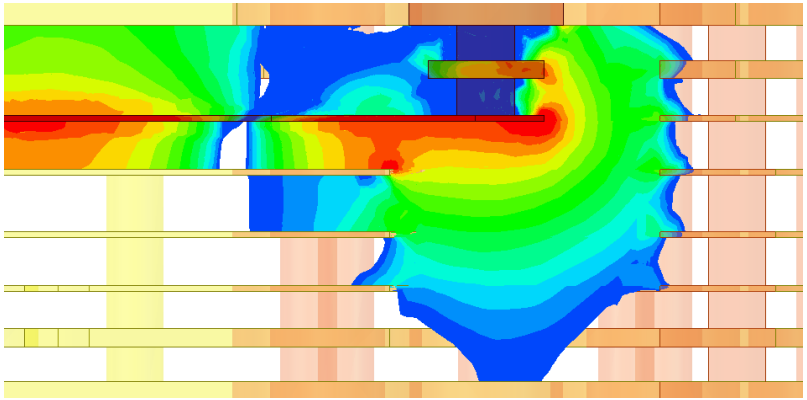


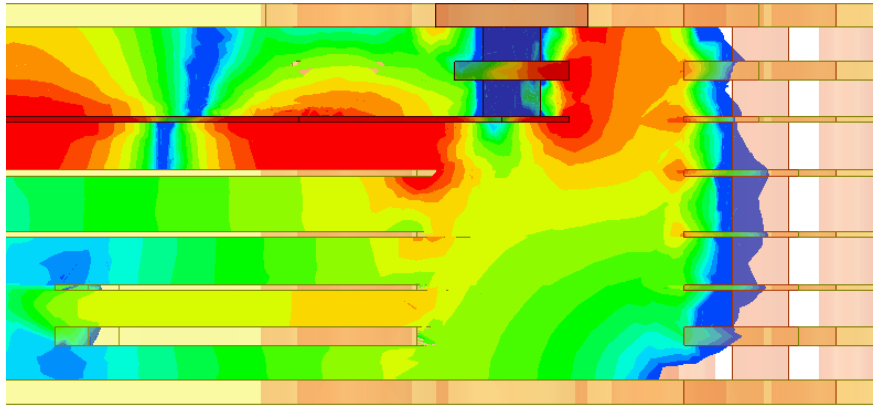
LAUNCH CONSIDERATION B: ENERGY FLOW



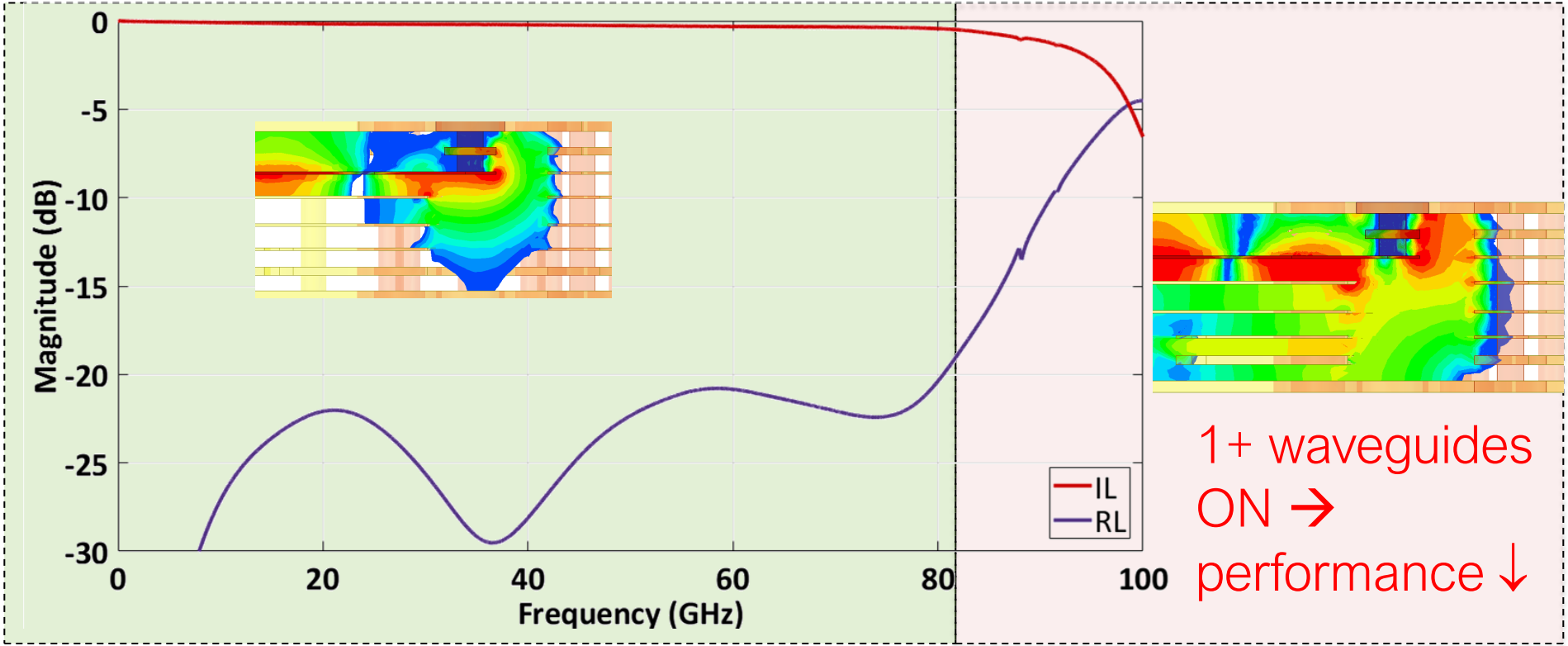
Energy flow at lower freq.

Energy flow at higher freq.

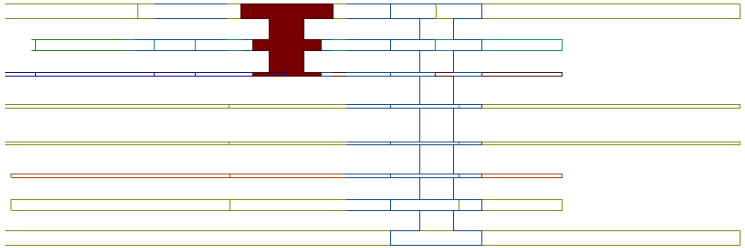




LAUNCH CONSIDERATION B: ENERGY FLOW

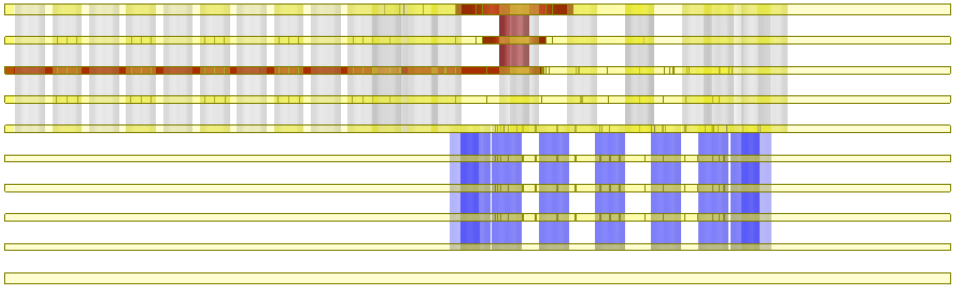


LAUNCH CONSIDERATION: REGIONS



PCB only has thru vias for GND

This PCB has stacked + staggered GNDs



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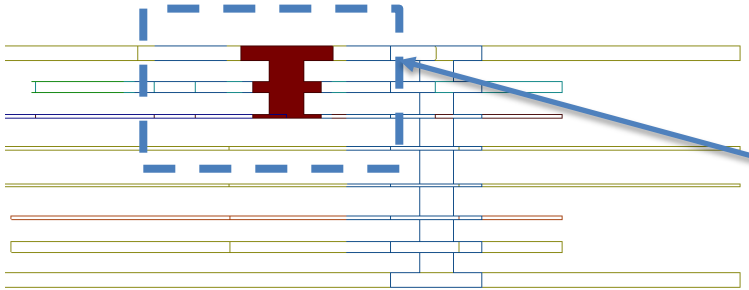
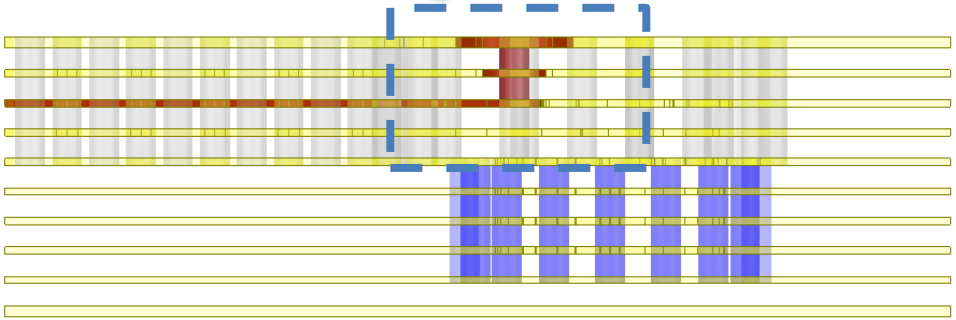
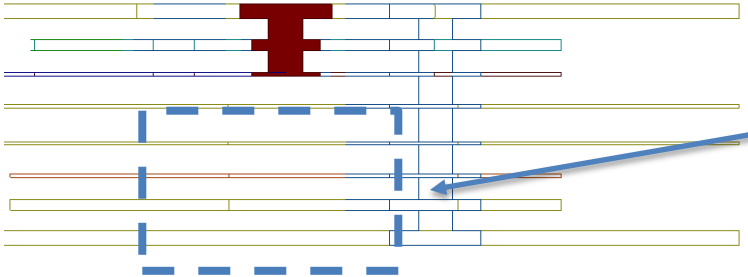


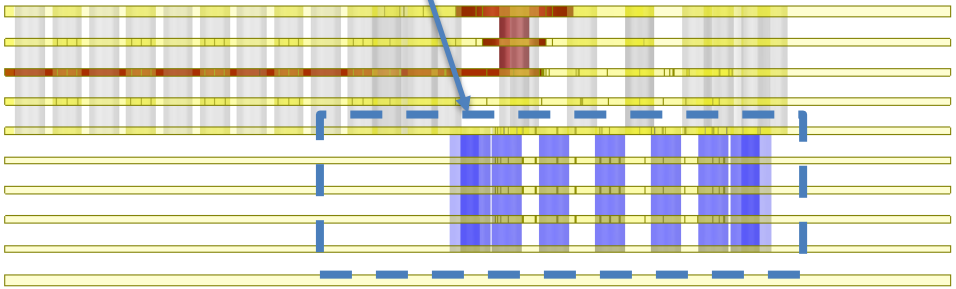
Treated like coax



LAUNCH CONSIDERATION: REGIONS

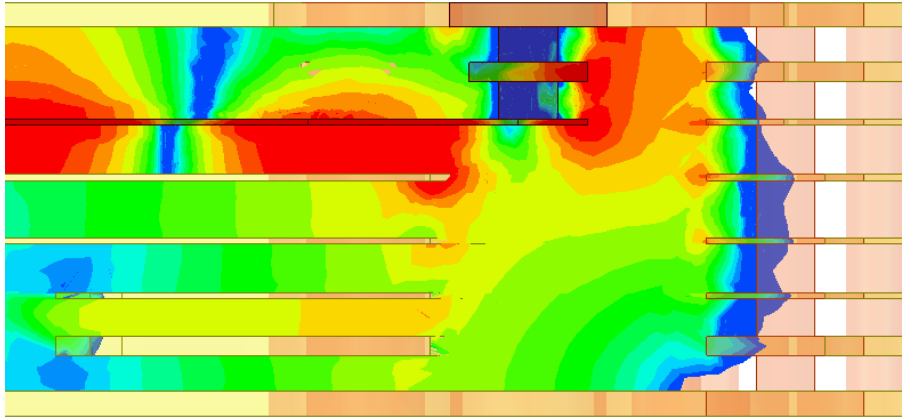


Caution: Waveguides!

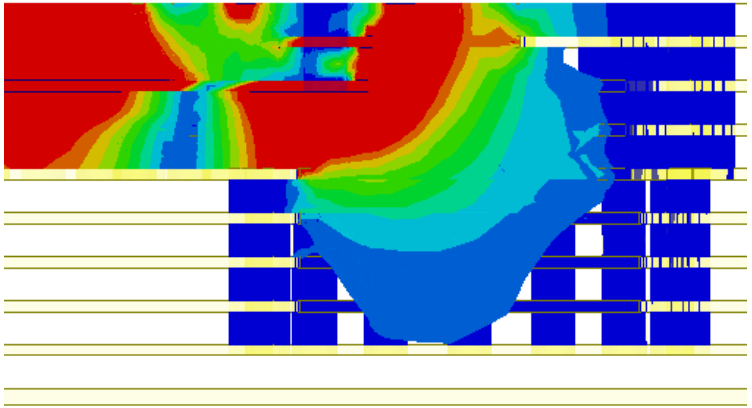


LAUNCH CONSIDERATION: REGIONS

E. field @ 95 GHz



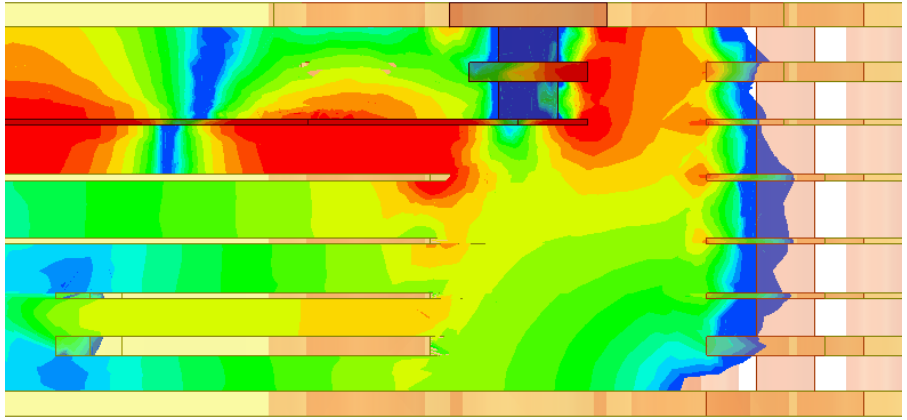
E. field @ 100 GHz



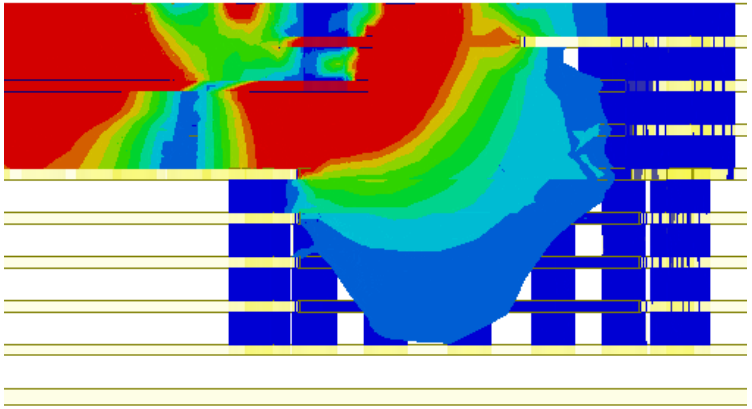
Adjusting GNDs above/below launch ***independently*** limits unwanted energy propagation

LAUNCH CONSIDERATION: REGIONS

E. field @ 95 GHz

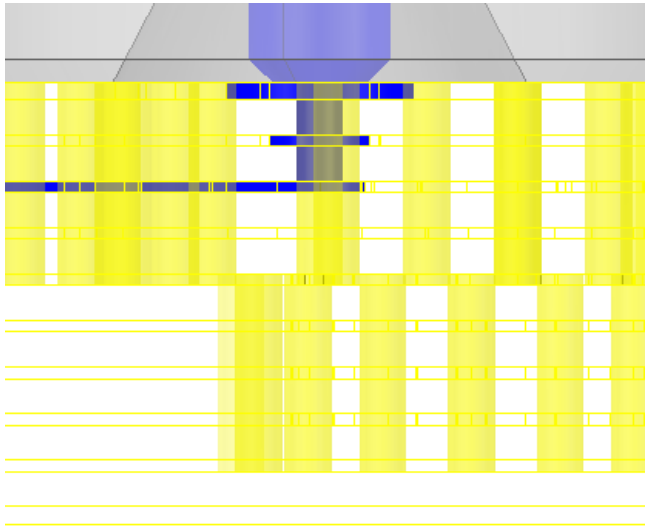


E. field @ 100 GHz

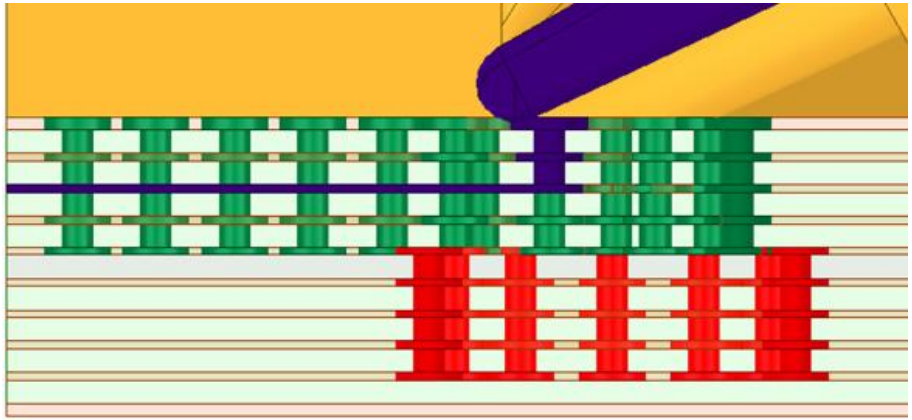


Takeaway: Independent GNDs below launch
→ better performance

VERTICAL VS. ANGLED LAUNCHES

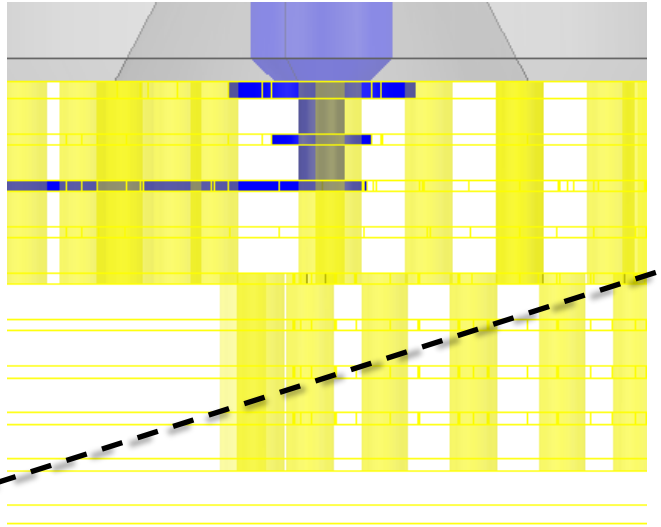


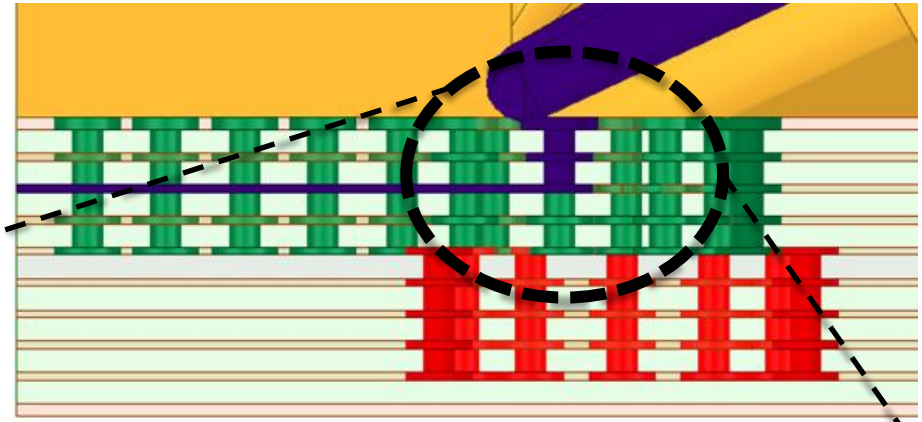
Vertical connector
tip + PCB launch



Angled connector
tip + PCB launch

VERTICAL VS. ANGLED LAUNCHES

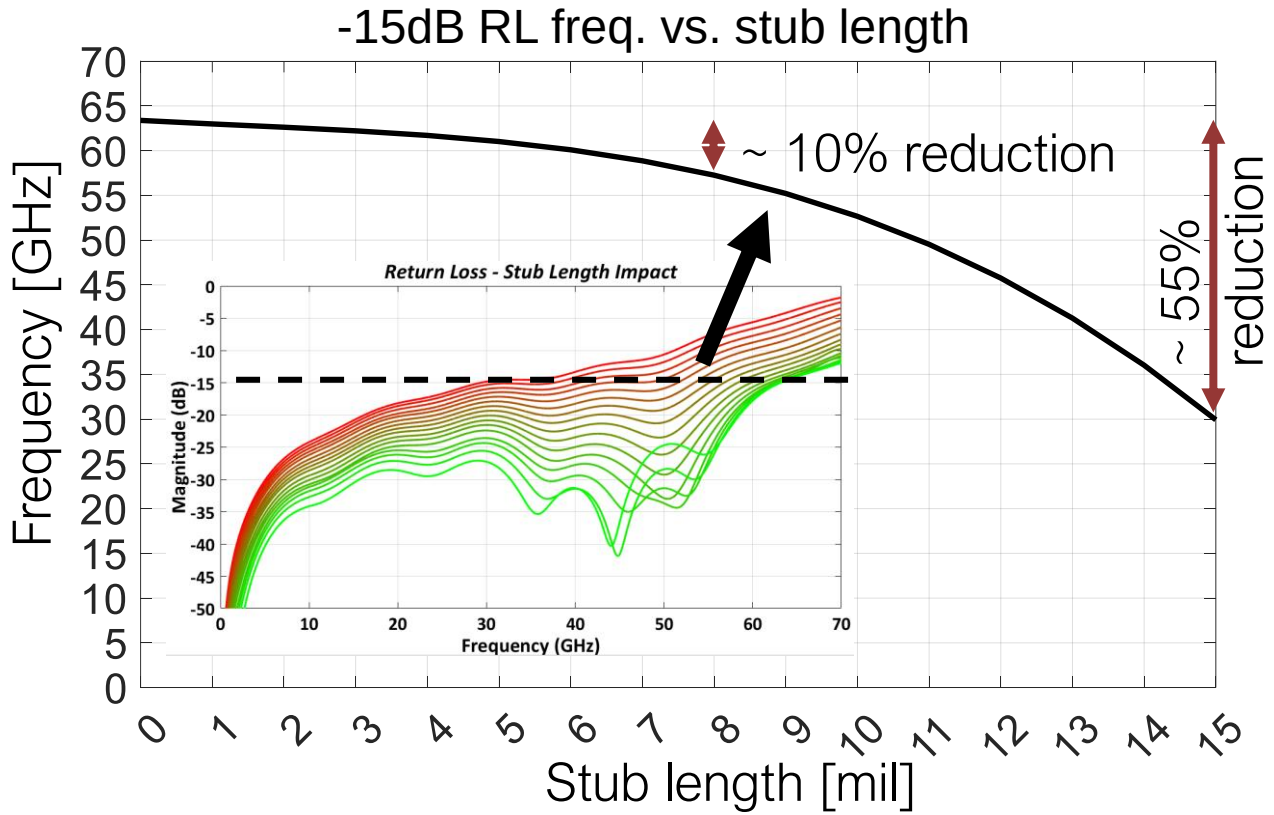




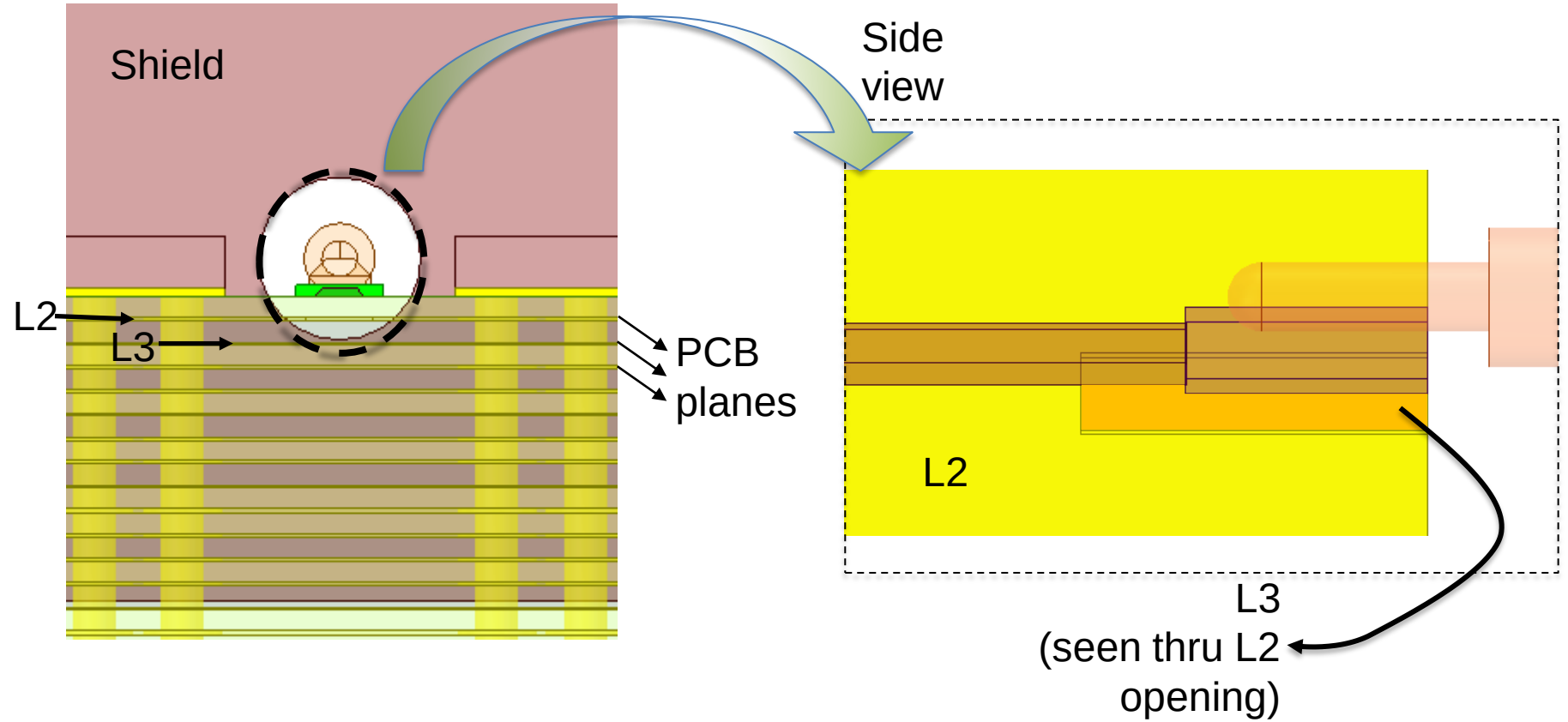
Smaller landing pad → Smaller coax section → Higher BW

BACKDRILLING CONSIDERATIONS

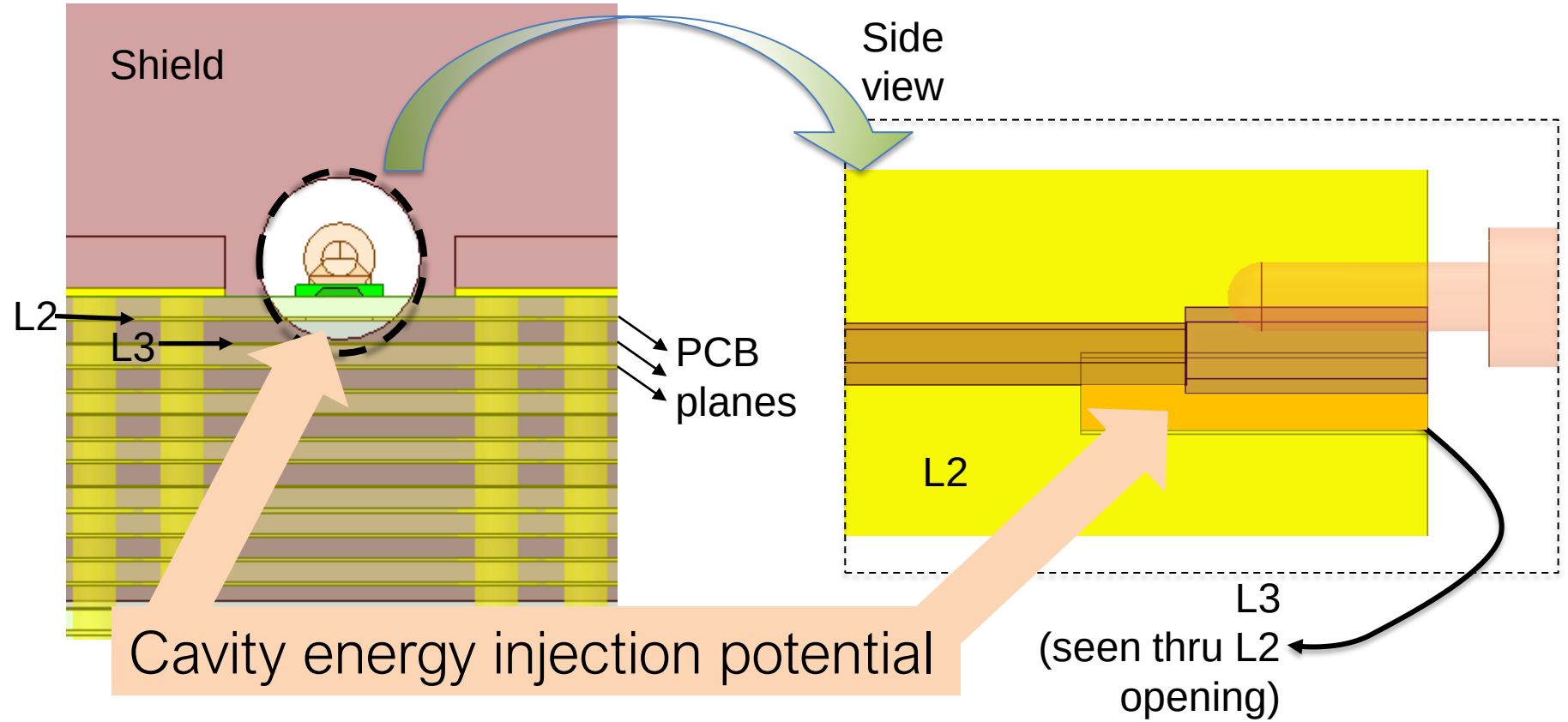
Back Drill



EDGE LAUNCH CONSIDERATIONS



EDGE LAUNCH CONSIDERATIONS



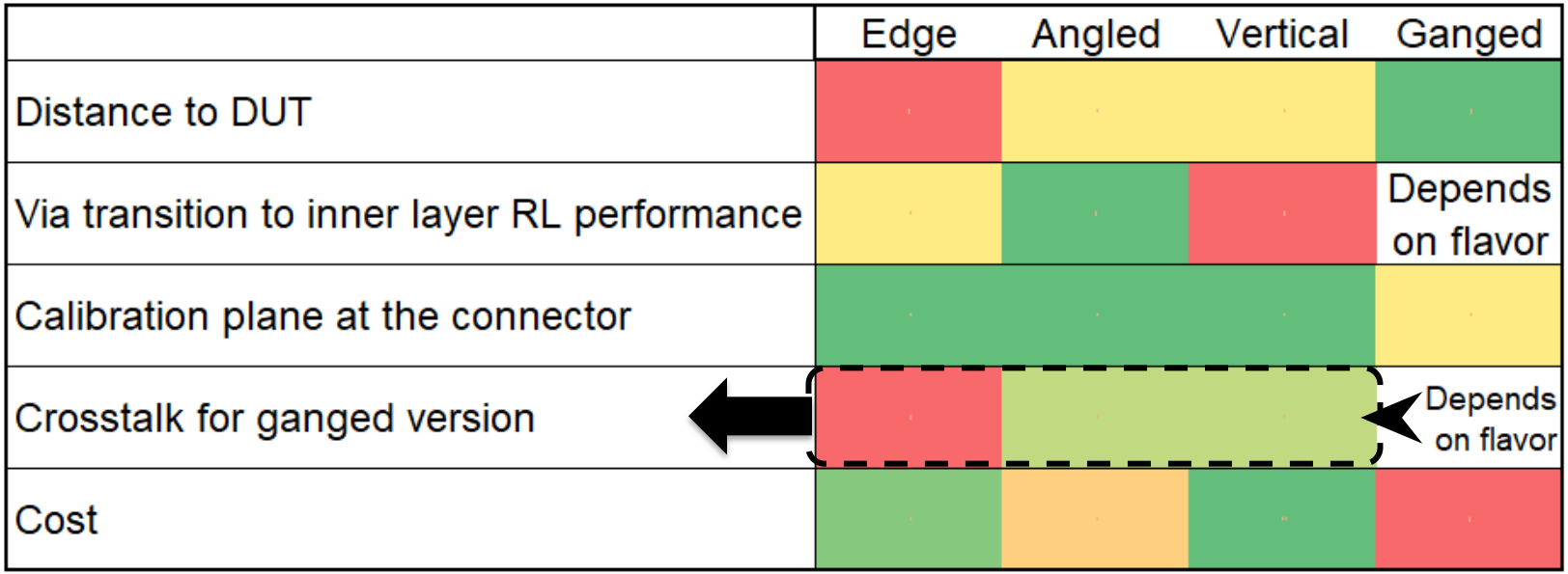
SECTION TAKEAWAYS

Every wideband connector launch can produce modes that limit performance

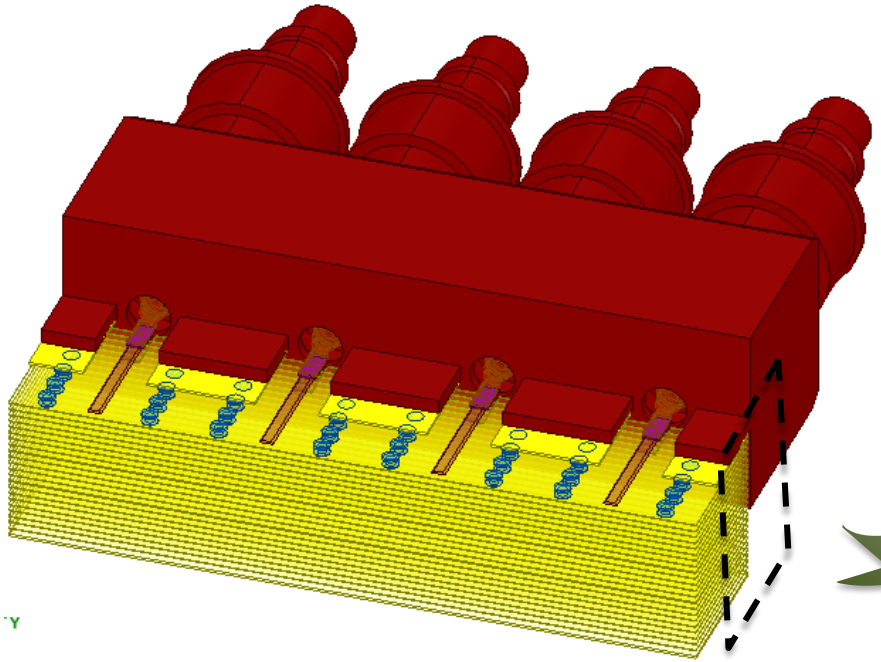
Balancing launch cavity size between Z_0 control; mode control is key

Stackable microvia constructions allow much higher performance

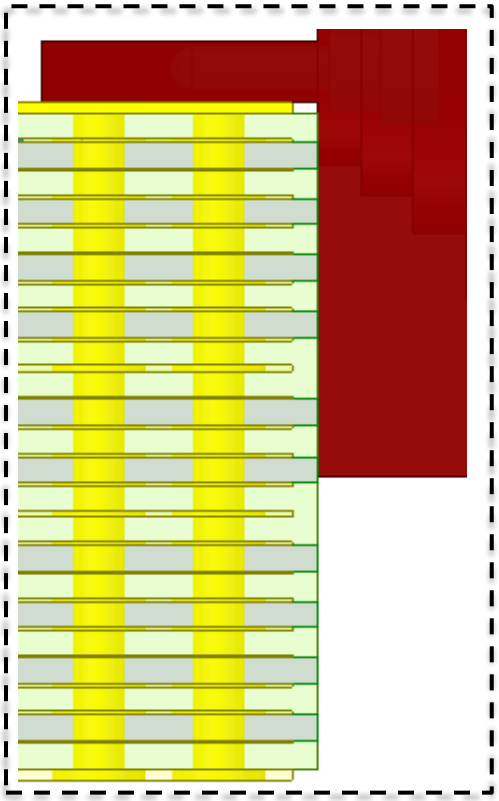
CROSSTALK CONTROL



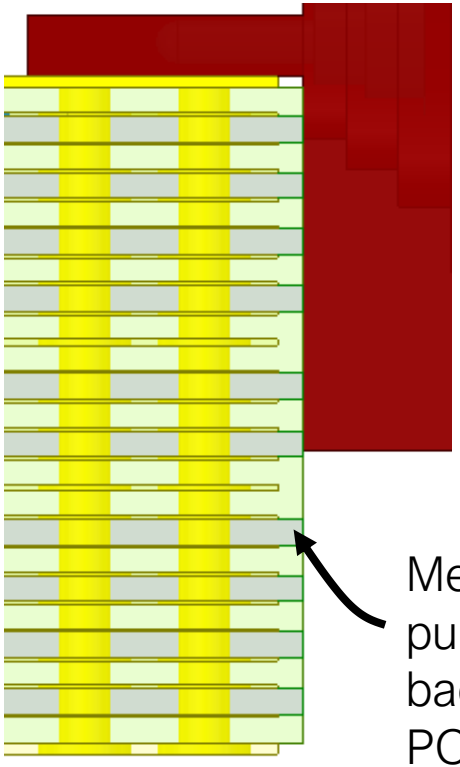
GANGED EDGE CONNECTORS



Side
view

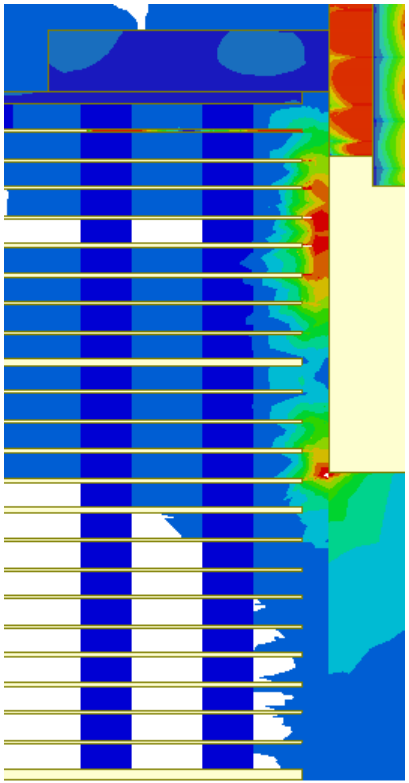


GANGED EDGE CONNECTORS

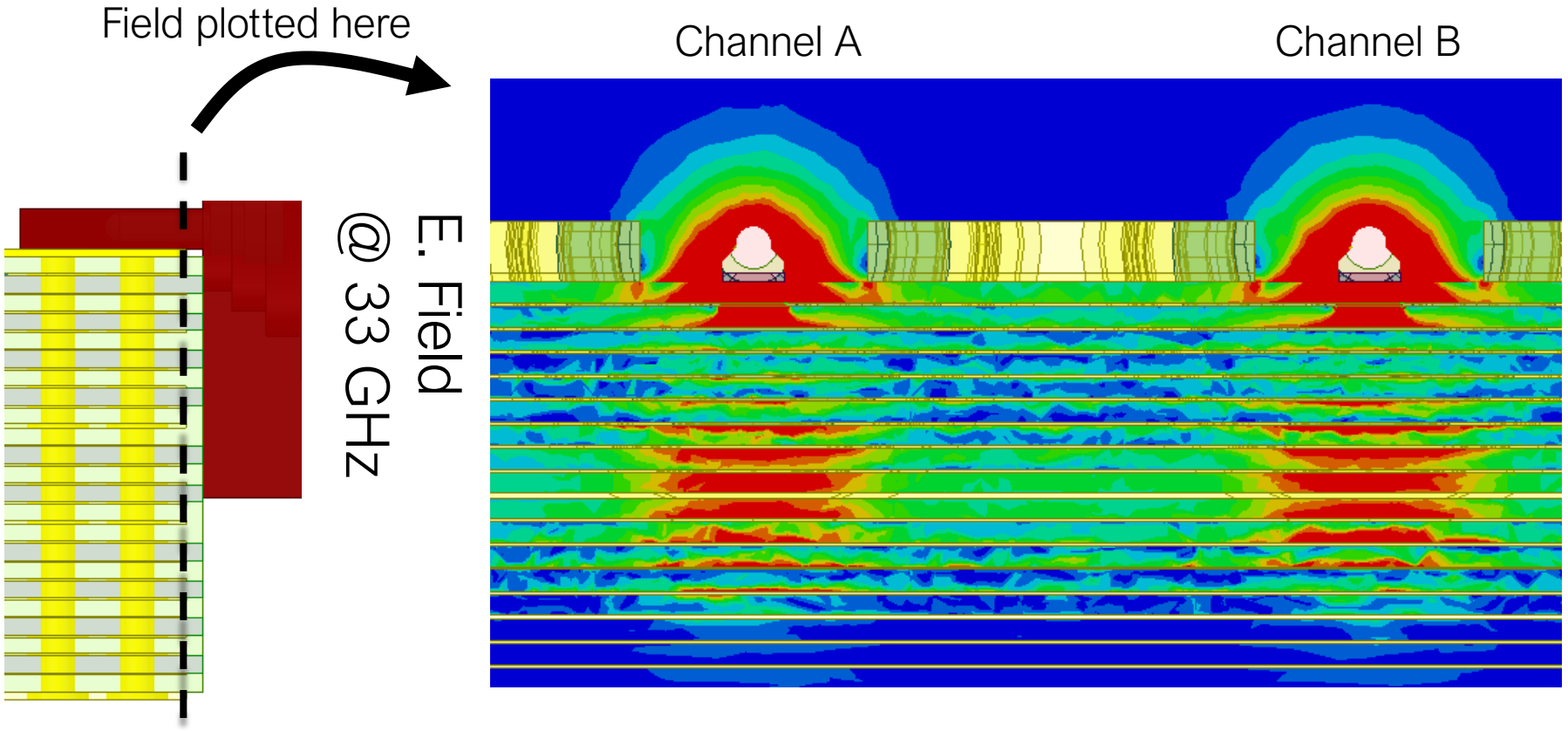


Metal pulled back from PCB edge

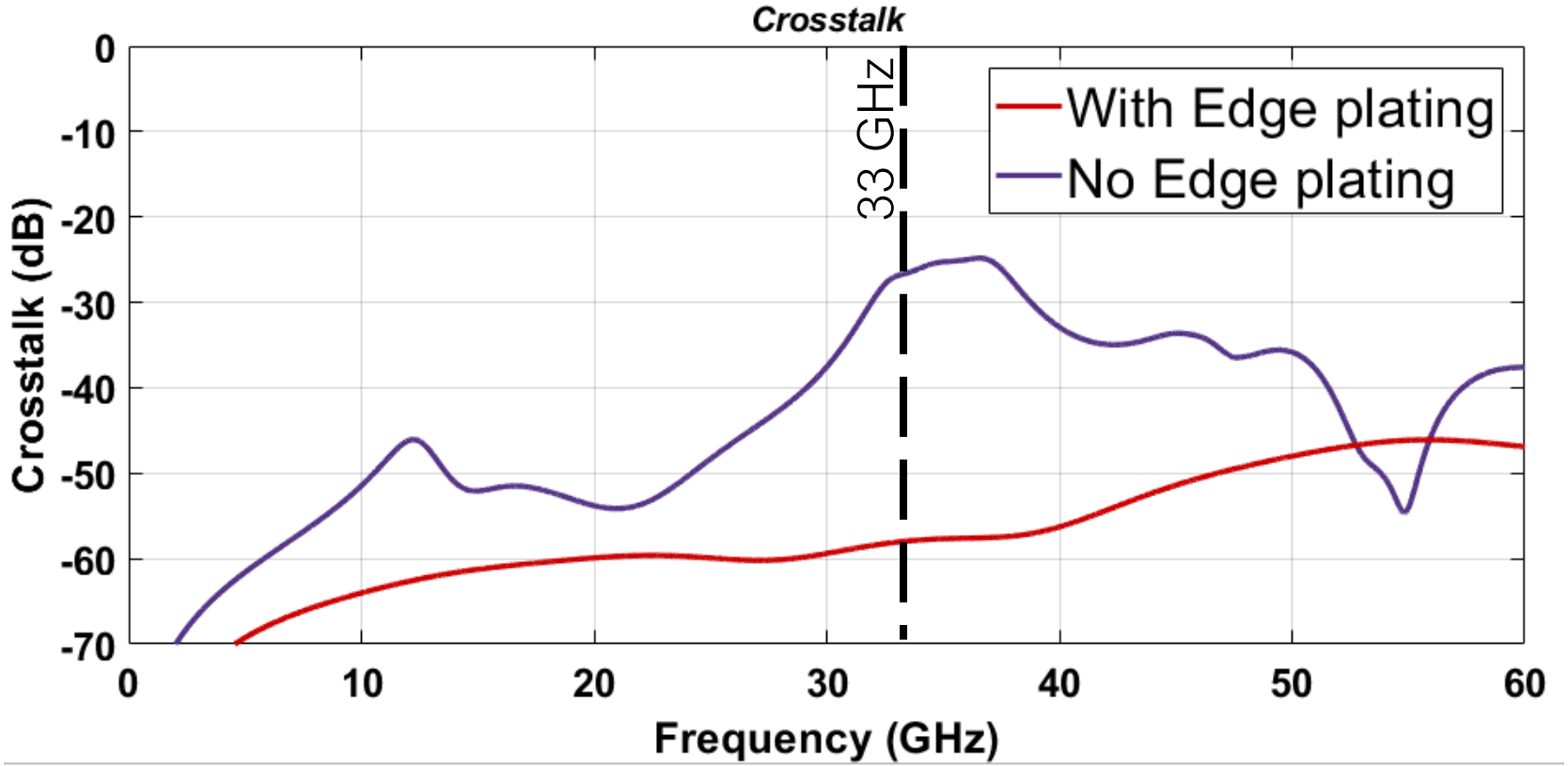
E. Field @ 33 GHz



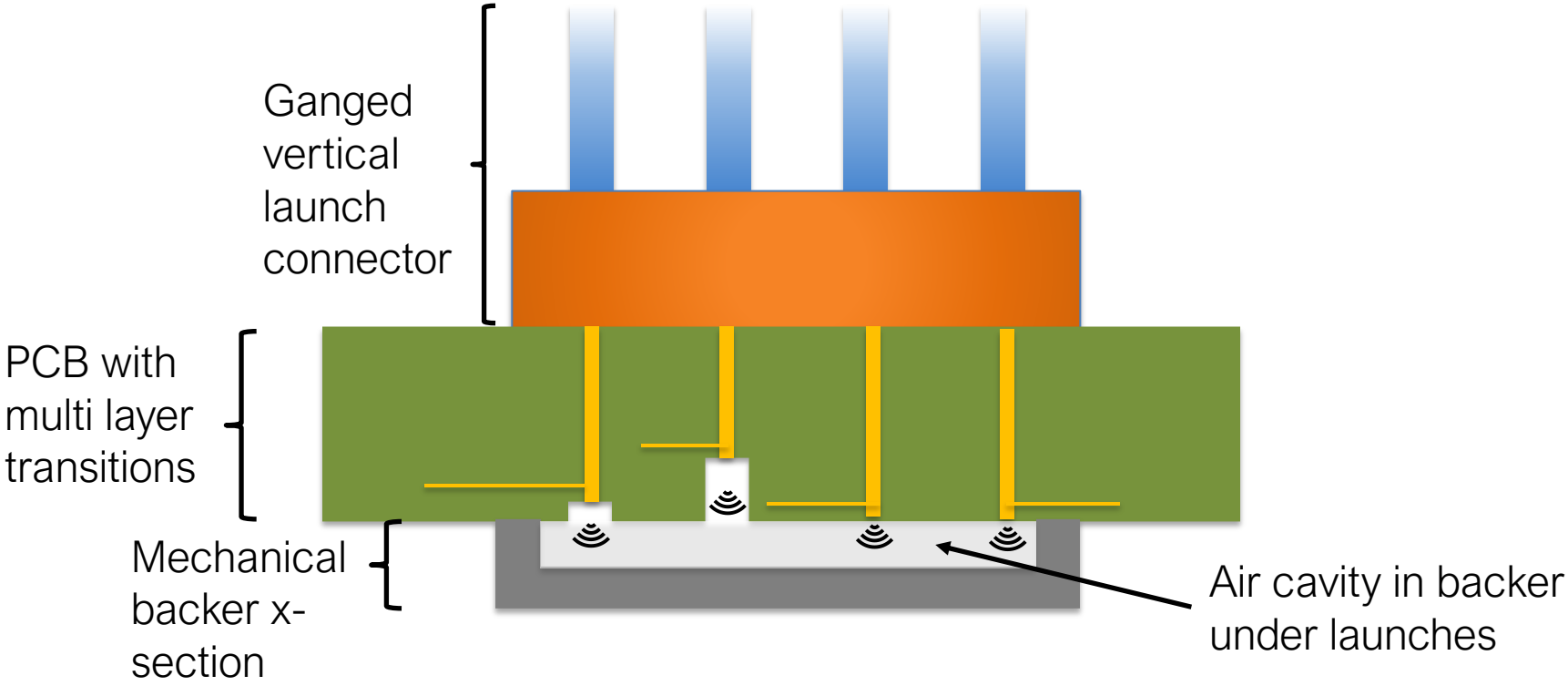
GANGED EDGE CONNECTORS



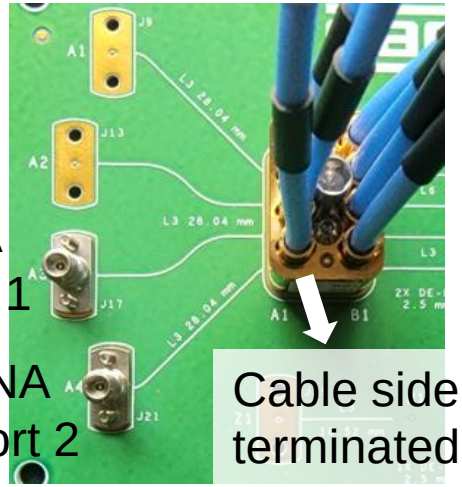
GANGED EDGE CONNECTORS - XTALK

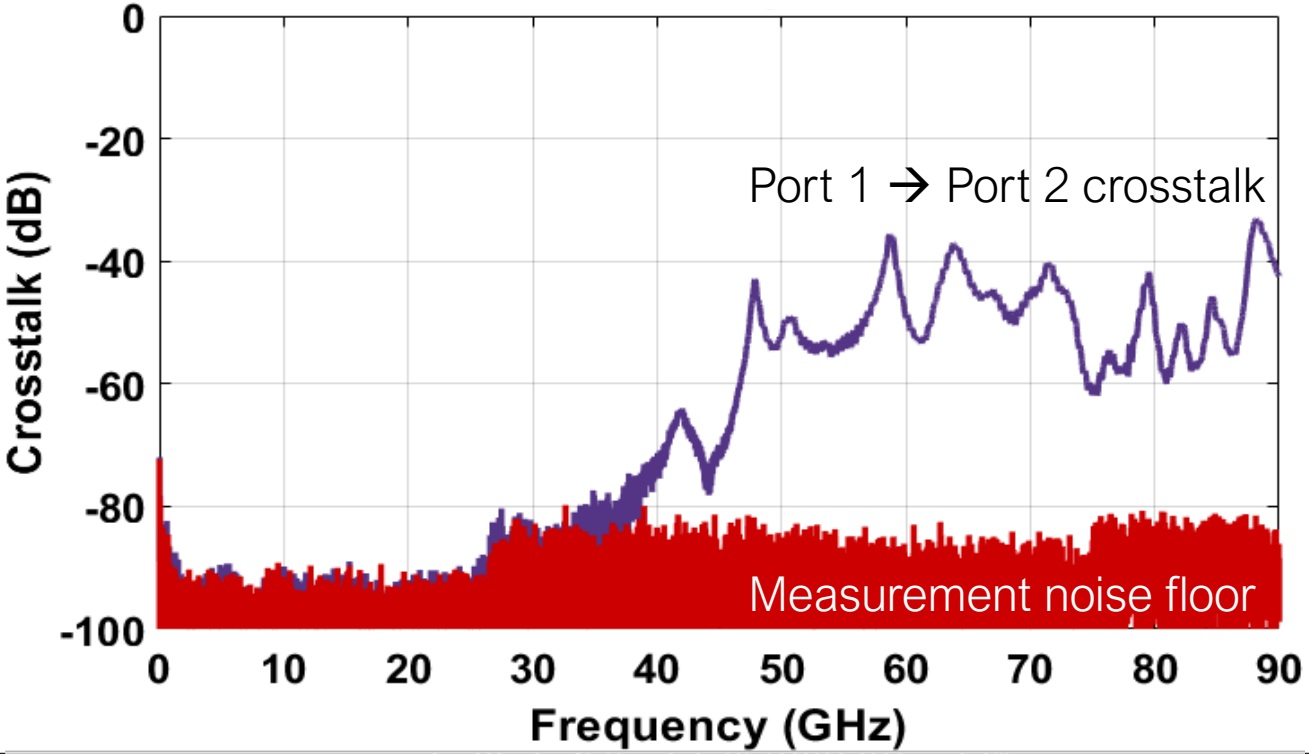


GANGED VERTICAL CONNECTORS - XTALK

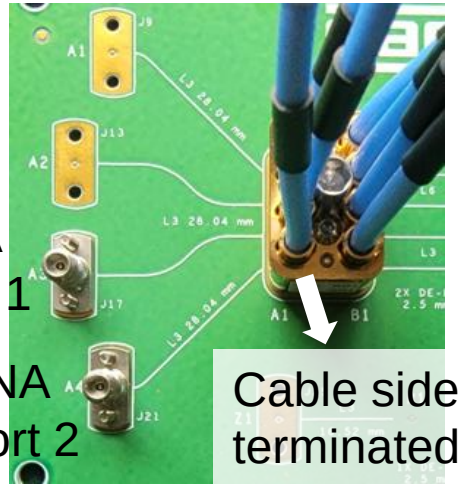


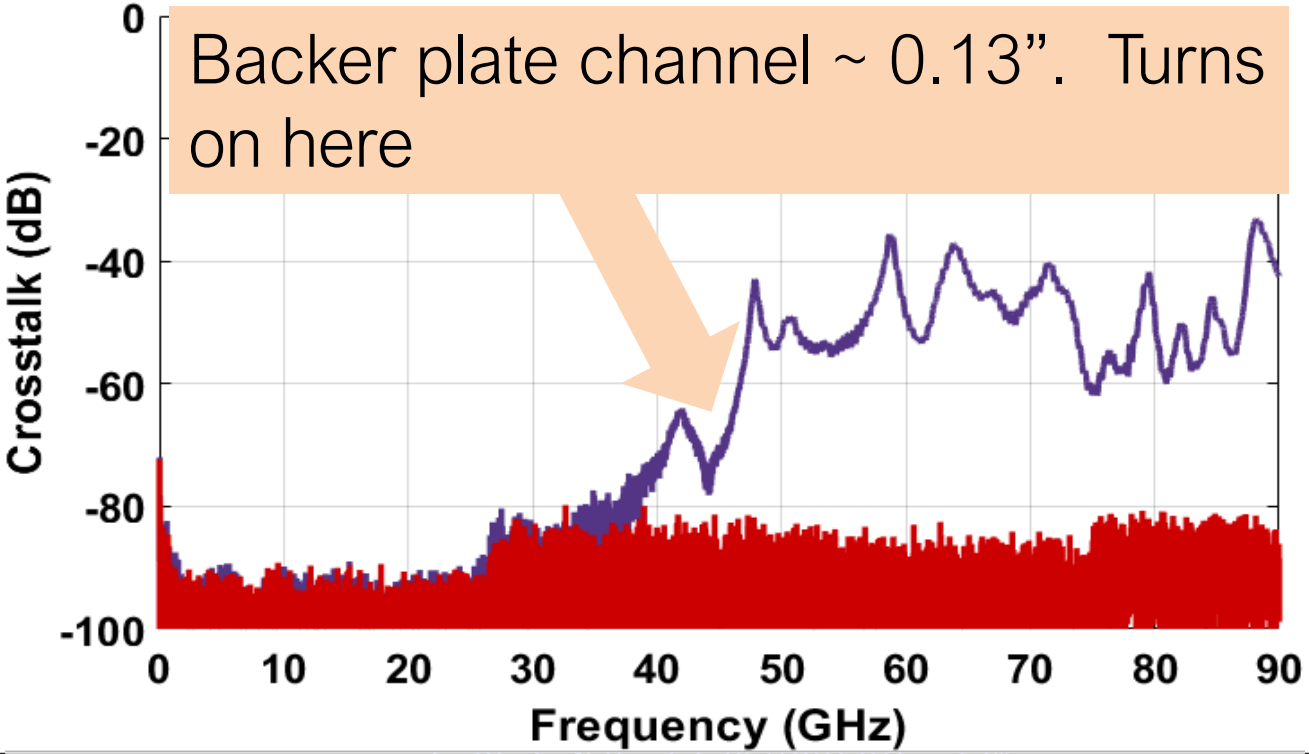
GANGED VERTICAL CONNECTORS – MECH BACKER XTALK



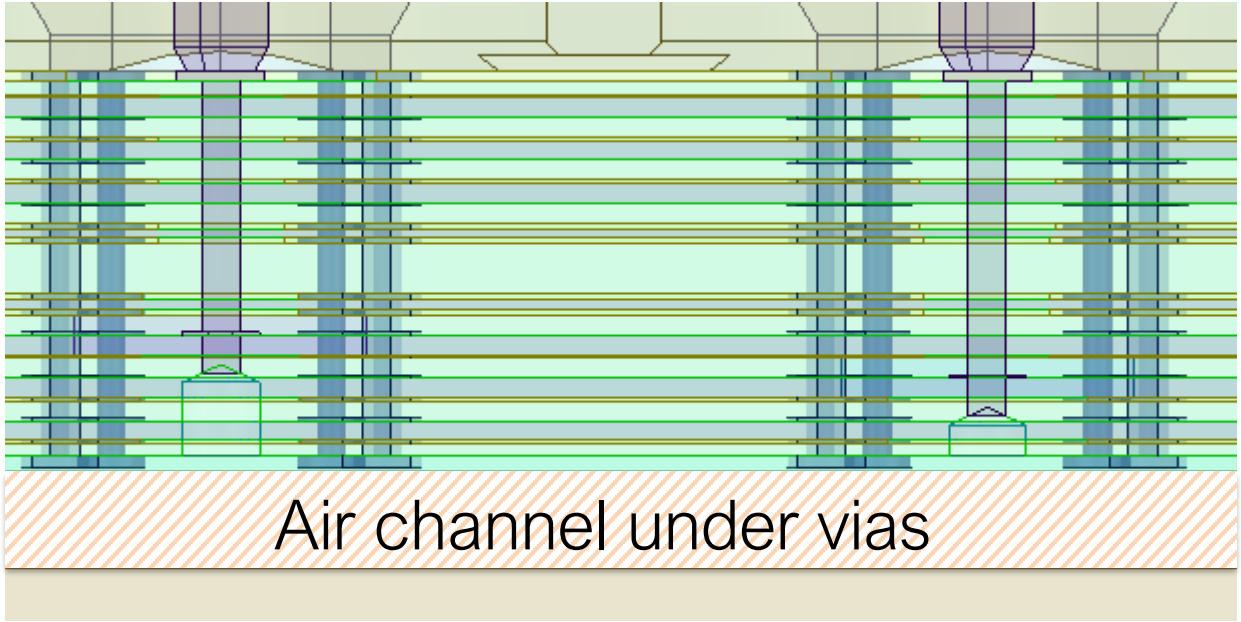


GANGED VERTICAL CONNECTORS – MECH BACKER XTALK



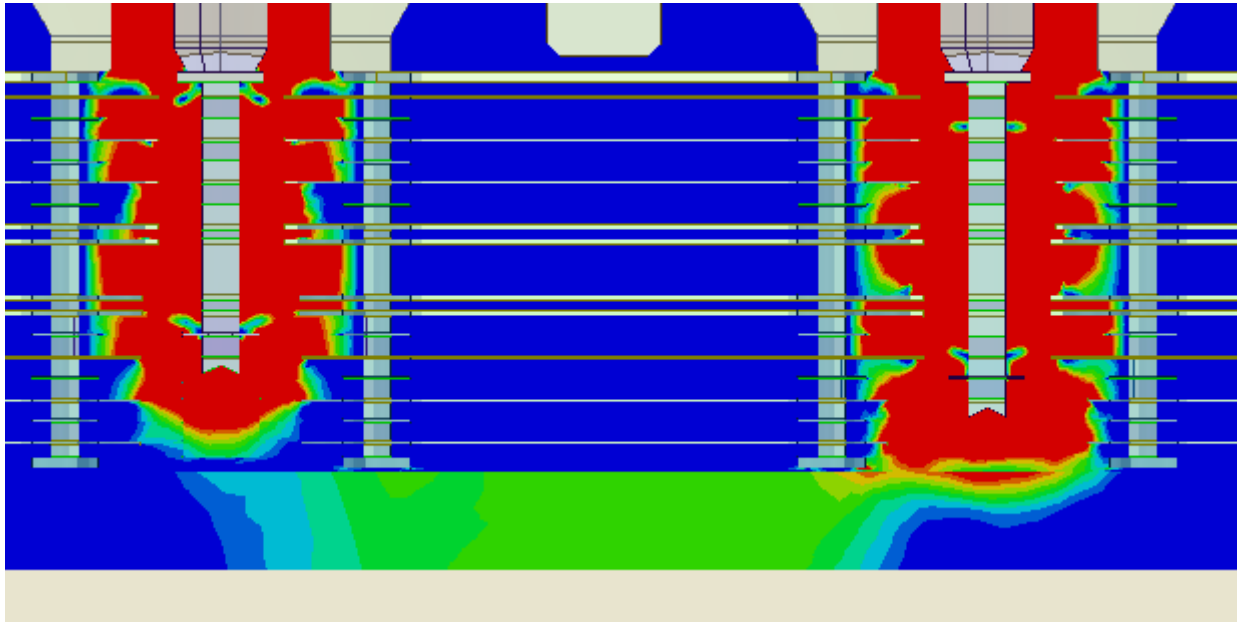


BACKSIDE XTALK



BACKSIDE XTALK

E. Field
@ 56 GHz
(224G Nyquist)



BACKSIDE XTALK

E. Field
@ 56 GHz
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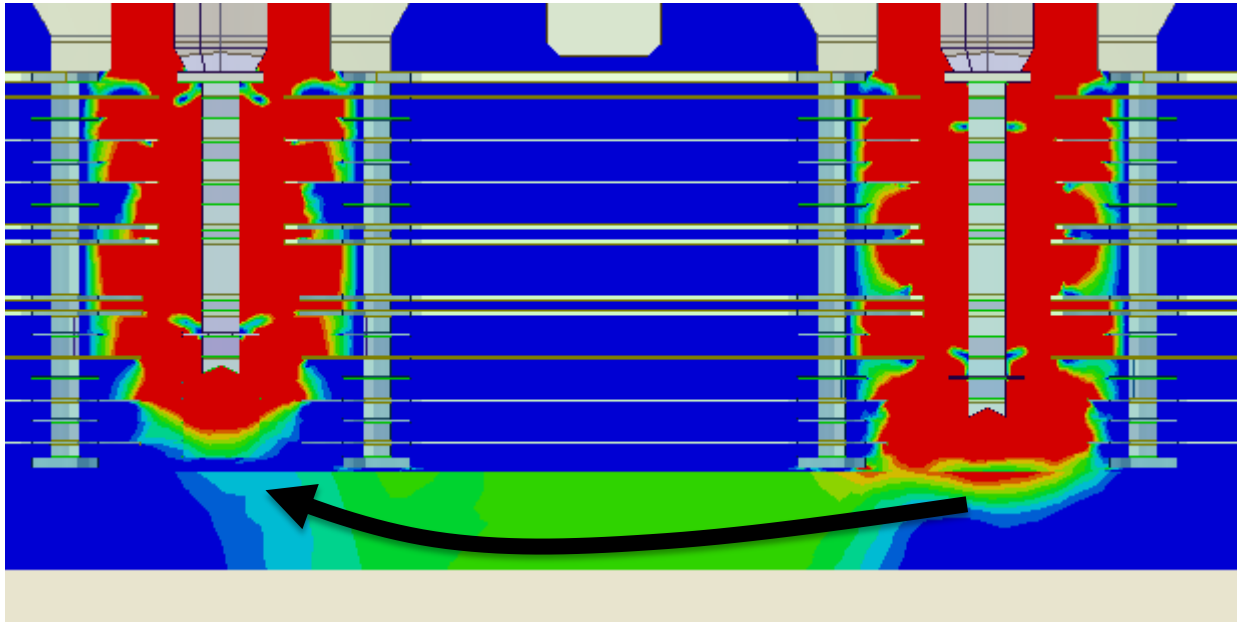


SECTION TAKEAWAYS

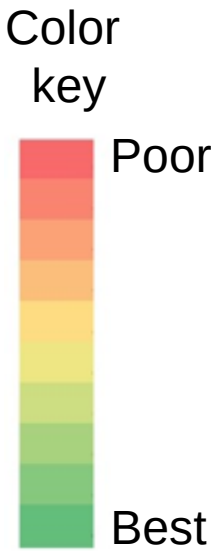
Lots of opportunities to create unintended waveguides!

Edge plating a must for edge connectors at high frequencies

Mechanical support structures can worsen crosstalk

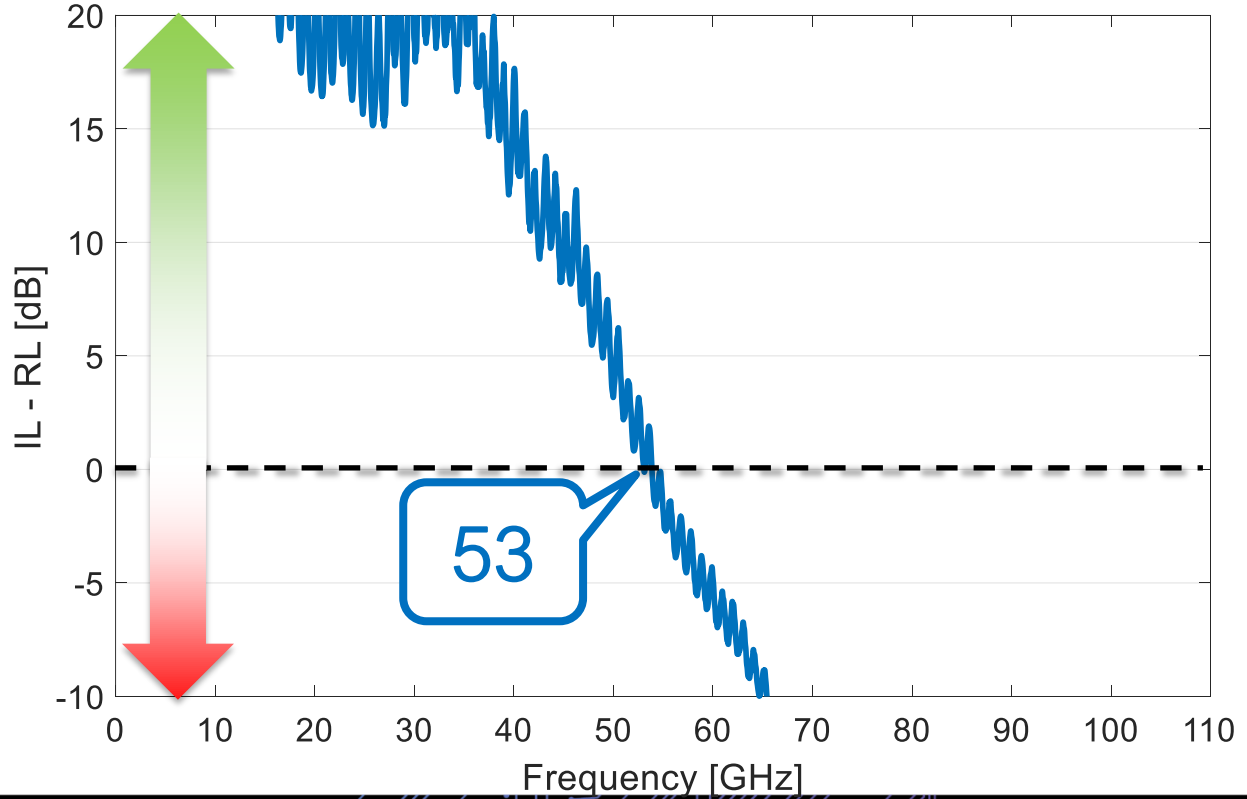
PUTTING ALL TOGETHER

	Edge	Angled	Vertical	Ganged
Distance to DUT				
Via transition to inner layer RL performance				Depends on flavor
Calibration plane at the connector				
Crosstalk for ganged version				Depends on flavor
Cost				



DE-EMBEDDING BANDWIDTH

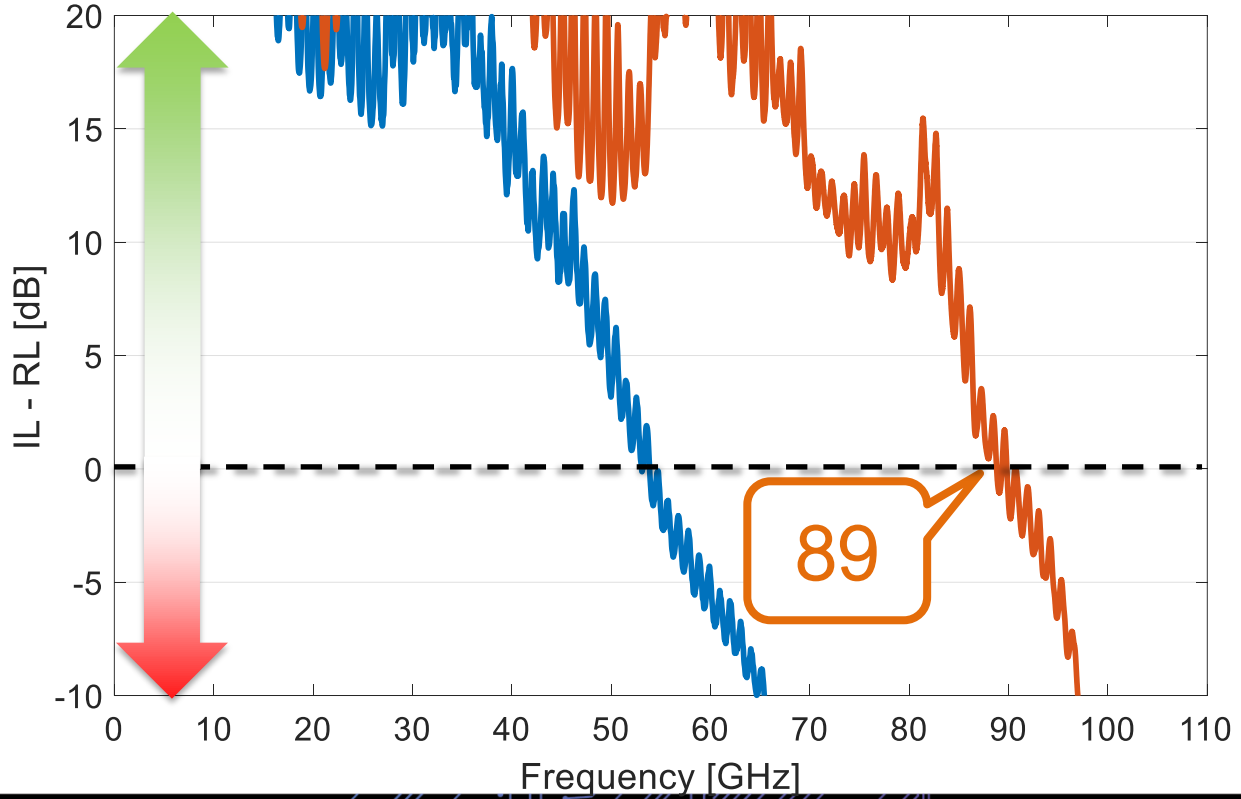
Gen 1 design:



DE-EMBEDDING BANDWIDTH

Gen 2 design:

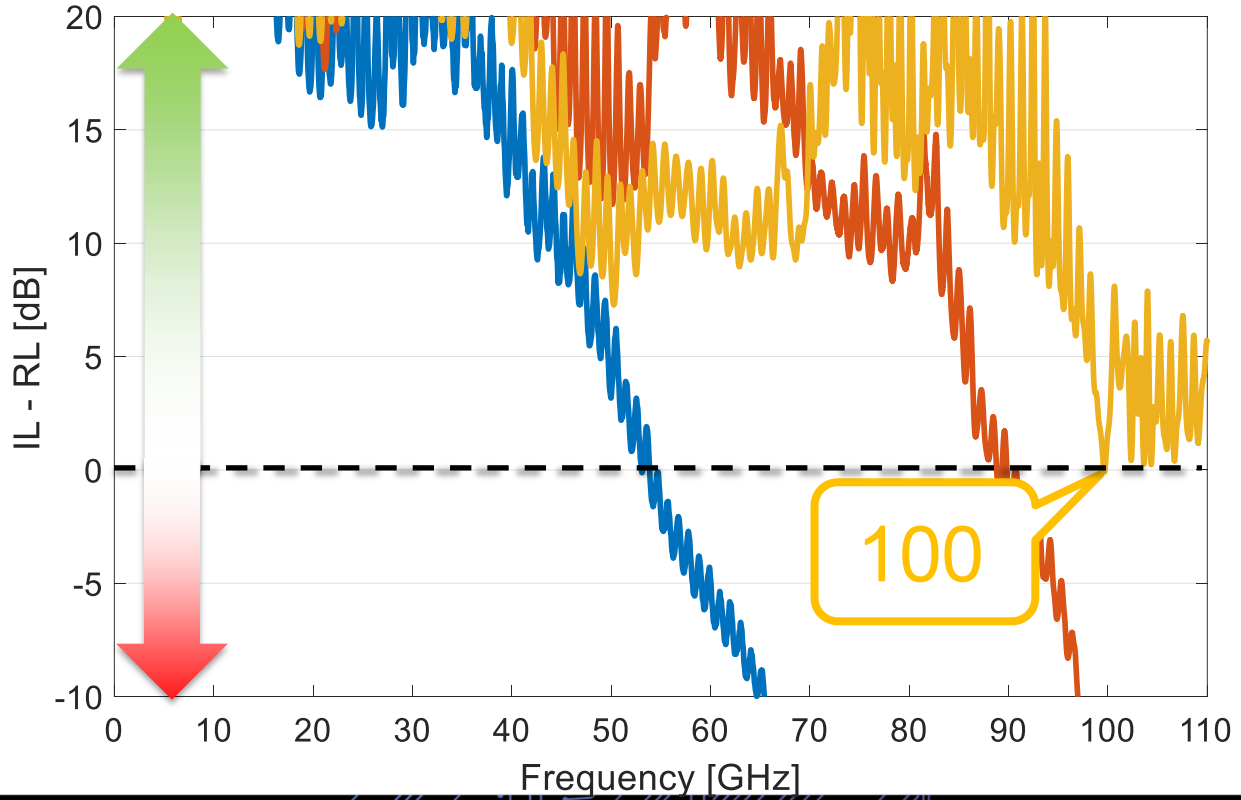
Lower IL; similar RL



DE-EMBEDDING BANDWIDTH

Gen 3 design:

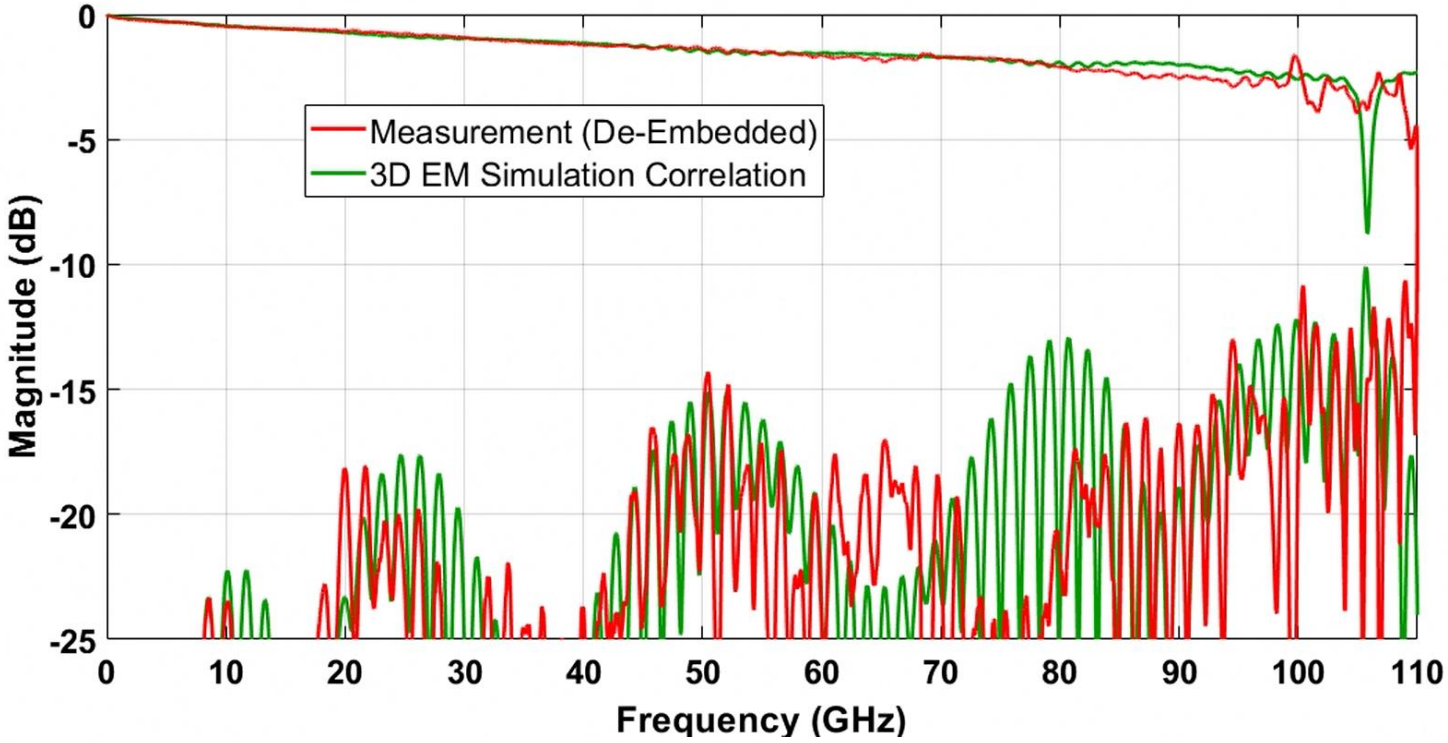
Similar IL; better RL



RUBBER MEETS THE ROAD

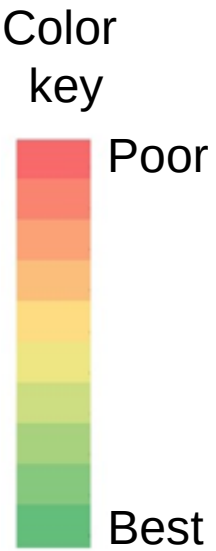
DUT:
Ganged VLC
with 3” coax

Fixture:
1mm VLC +
1.3” trace



CONCLUSION

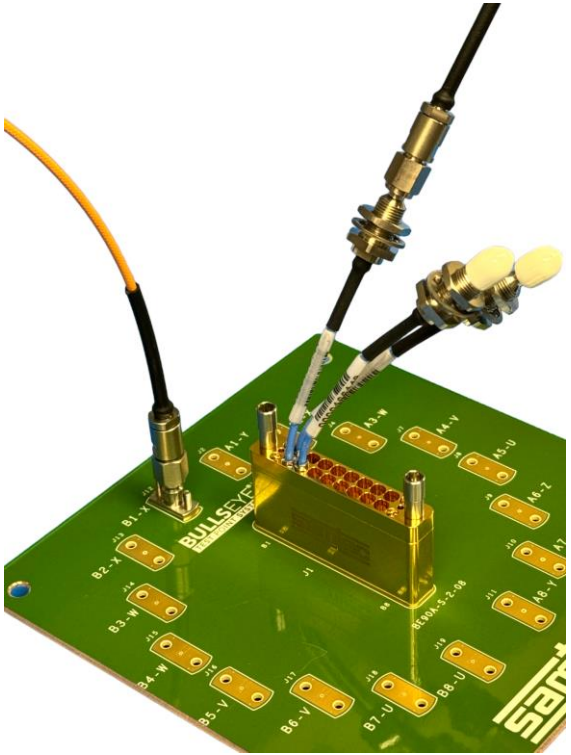
	Edge	Angled	Vertical	Ganged
Distance to DUT				
Via transition to inner layer RL performance				Depends on flavor
Calibration plane at the connector				
Crosstalk for ganged version				Depends on flavor
Cost				



MORE INFORMATION

- Live demo at Samtec booth 939
- **Further background:** PCB Stackup & Launch Optimization in High-speed PCB Designs, DesignCon 2022

  https://blog.samtec.com/post/wideband-rf-launch-literally-everything-you-need-to-know/



Thank you!

QUESTIONS?