SWTEST 2021 CONFERENCE

PROBE TODAY, FOR TOMORROW

30TH ANNIVERSARY

# Millimeter-Wave Signal Integrity in a Dense Device-Interface Board Environment

TERADYNE


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# 5G/FR2 ATE components create difficult challenges

- **Issues:**
  - Excess insertion losses, Small Geometry and Impedance Sensitivity
  - Large Pin-counts for both mmWave and SERDES (Mixed in one chip)
    - MIMO ***dramatically*** increases mmWave and HS-Digital connections
  - mmWave signal conditioning components can experience
    - Large temperature excursions
    - Cross-talk and EMI

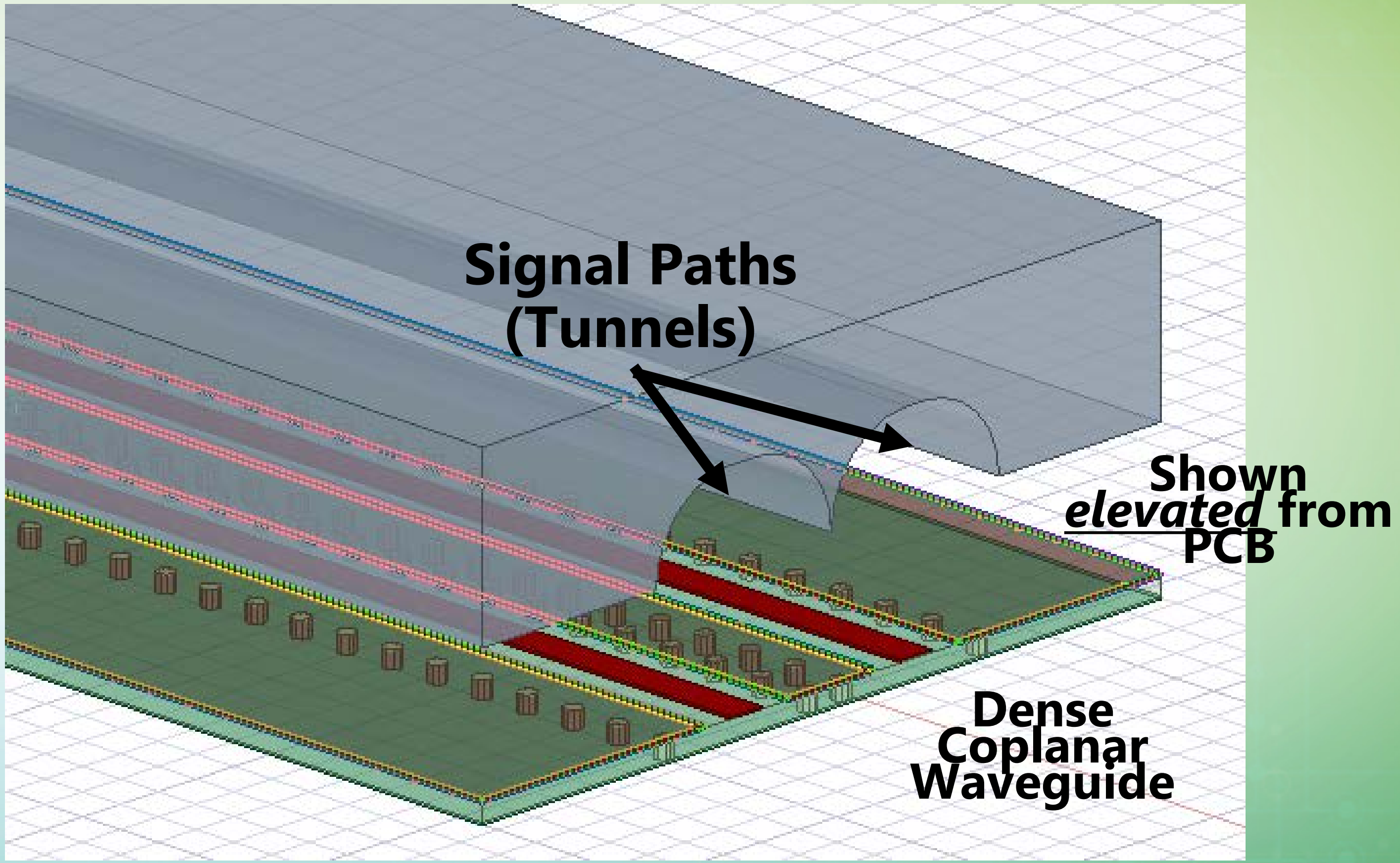
- **Socket/Handler constraints**
  - Critical Height restrictions
  - Smaller PCB paths experience defects due to flexure and delamination
  - Alteration of impedance values (CPW or Microstrip)

# Objectives

- **Performance**
  - **Reduce insertion loss** without increasing cost
  - **Introduce new interconnection methods** that incorporate mmWave frequencies
  - **Increase Pin-connection density** while avoiding connection crosstalk
  - **Resolve measurement problems** introduced by higher frequencies
- **Increased design flexibility**
  - **Avoid new Fab methods/materials** which increase cost and time
  - **Avoid DIB re-spins** due to defects or design errors
  - **Provide re-use** of expensive mmWave DIBs

# Method 1 – DIB Shield > Understanding

- **Ultra-thin solid metal shield for all surface connections**
  - **Corrosion-free durable alloy**
  - **Paths customized for each DIB**
  - **Soldered or mechanical attachment**
  - **0.9 to 2 Millimeter thickness Compatible with Handler clearance**

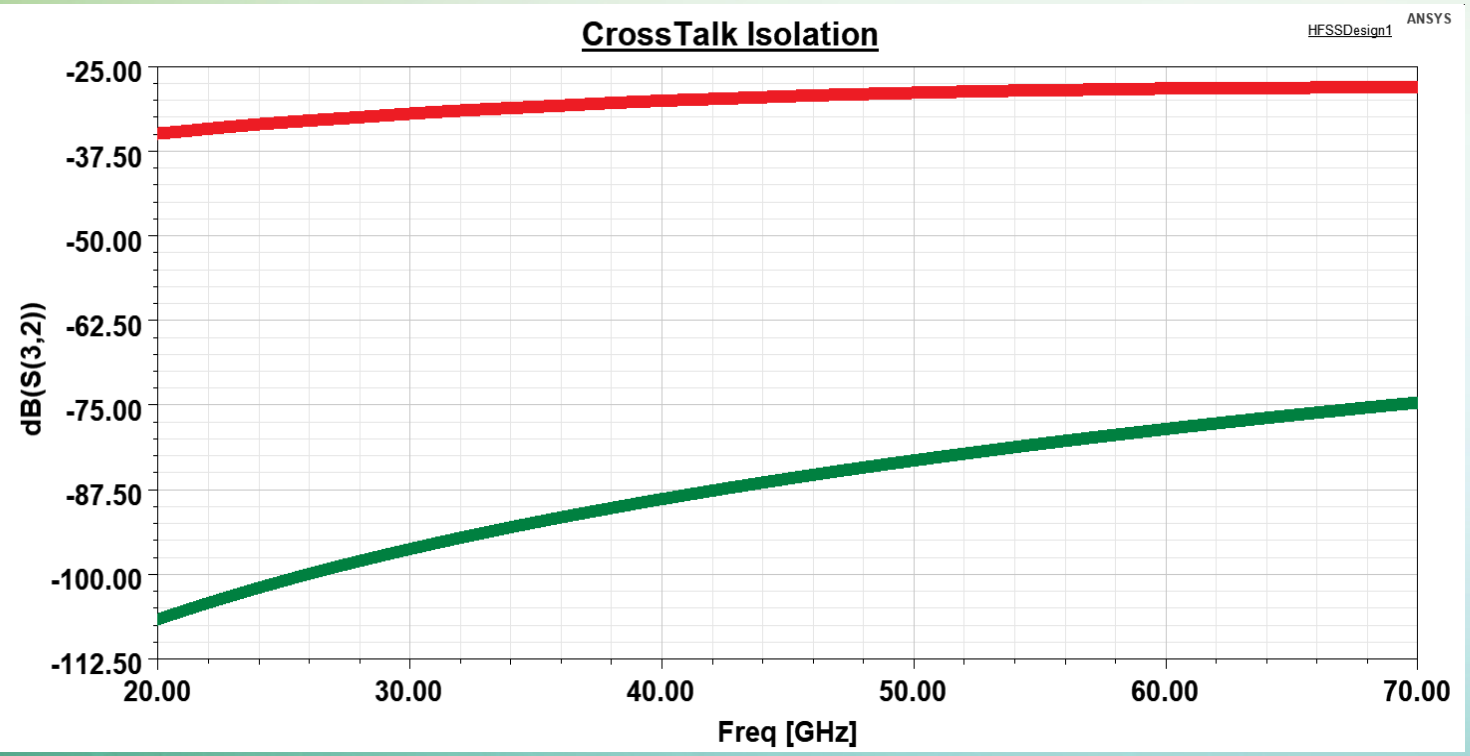


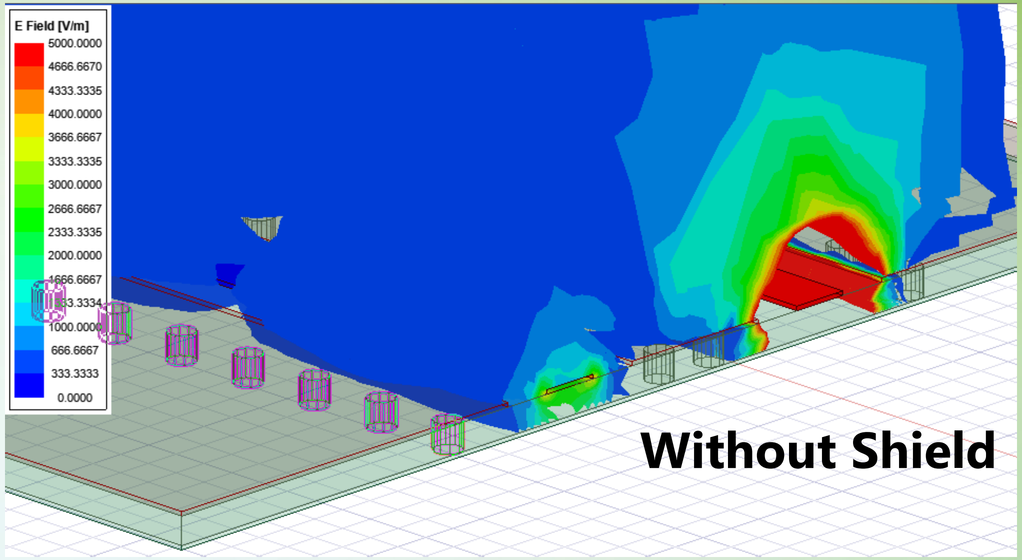


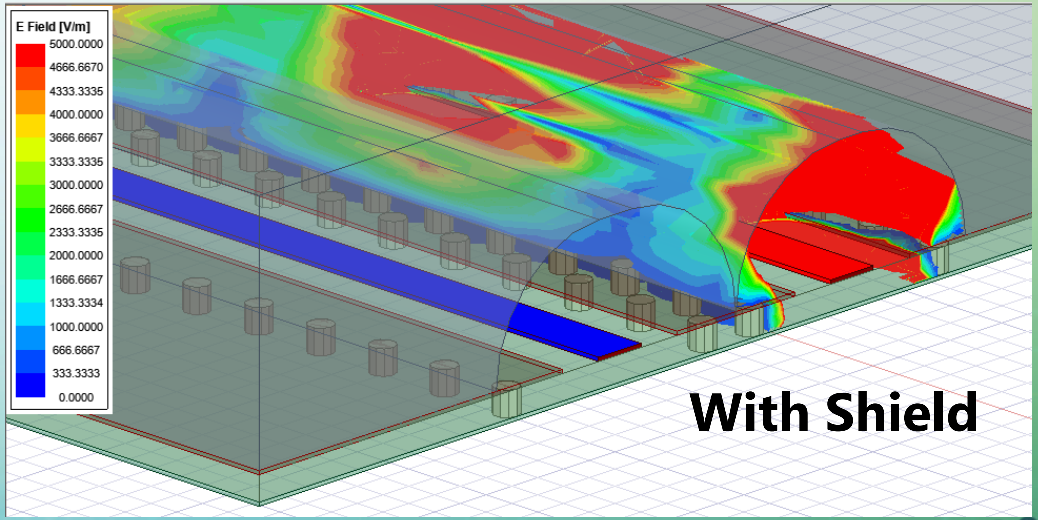
**Inventor: Luis Valiente**
**Senior RF and mmWave Interface Designer**

# Method 1 – DIB Shield > Improve Path Isolation

- **With DIB Shield, Cross-talk improved >55 dB**
  **Note: dual-Via stitched between lines**
  **Crosstalk is free-space coupling**

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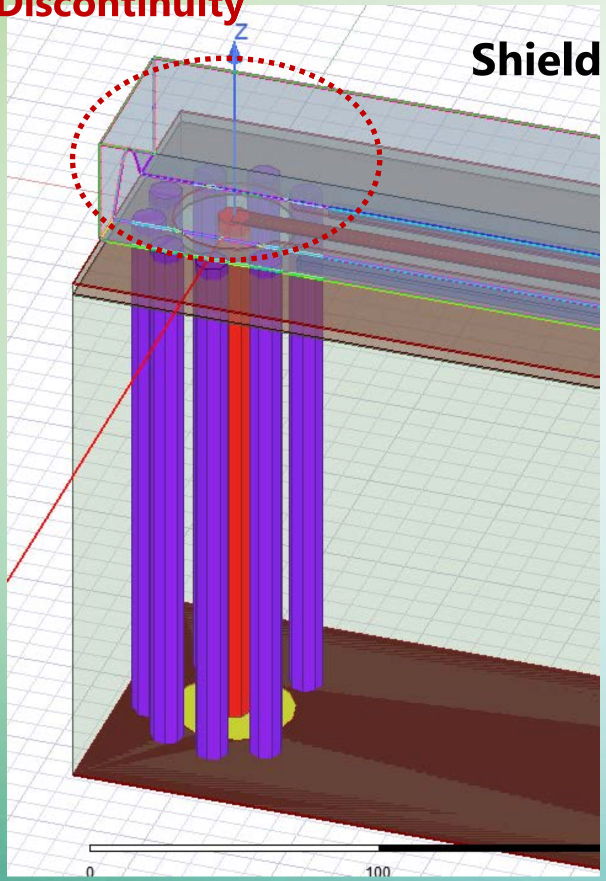
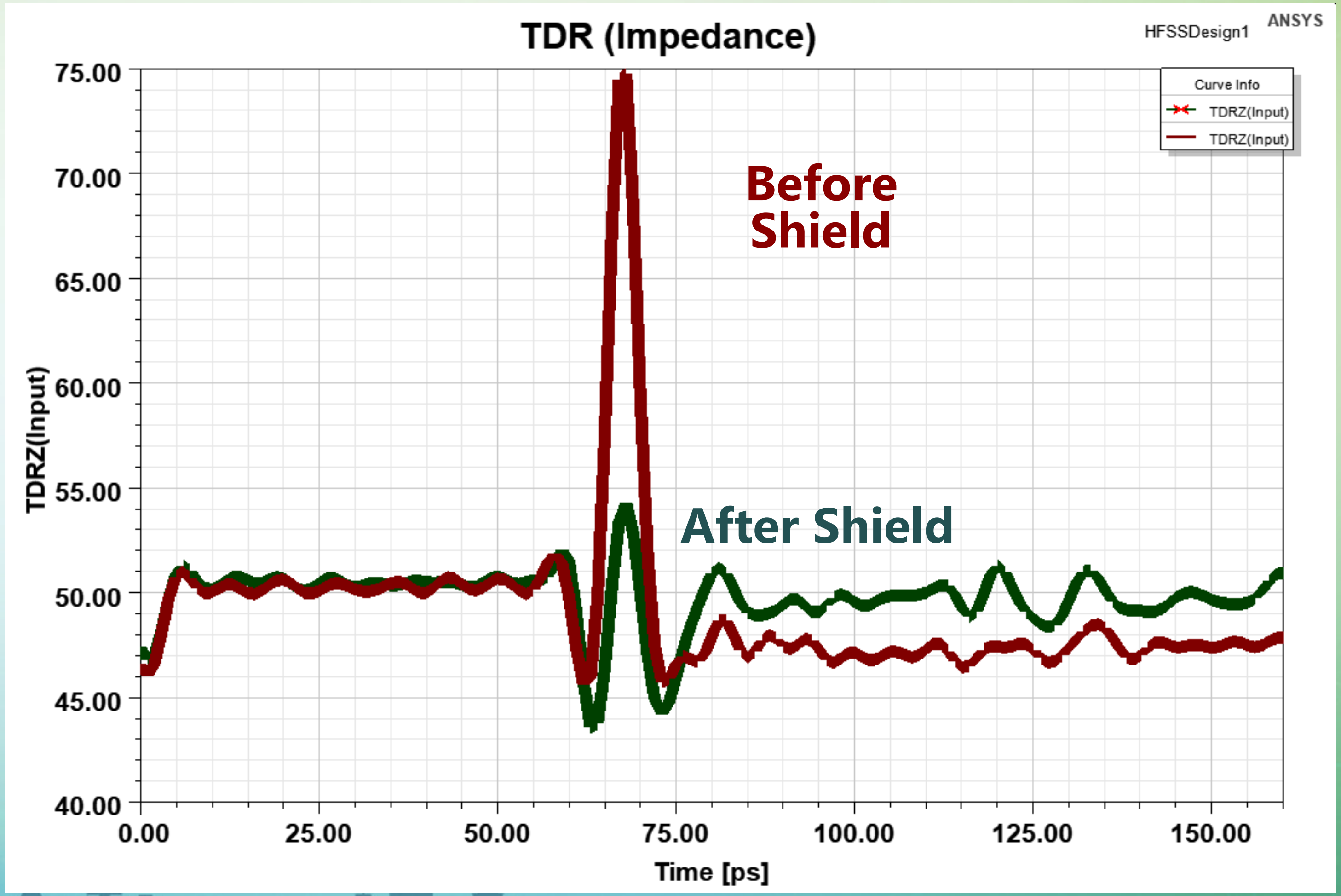
# Method 1 – DIB Shield > Improve Impedance

- **Shield becomes part of Impedance Matching**
  - **Example: Abrupt Right-Angle connection between Coax-Via and Surface CPW**

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# Method 2 – Resonant Coupled Stripline (RCS) > Issues

- **Coupling from Via to Stripline is difficult**
  - Drill-stubs create antenna radiators at mmWave Frequencies
  - Resulting in Crosstalk and Impedance Problems
  - Back-drilling works poorly or not at all

- **Yet, mixing CPW *and* Stripline is desirable to increase density**
  - Pin density and location makes interleaving these lines advantageous

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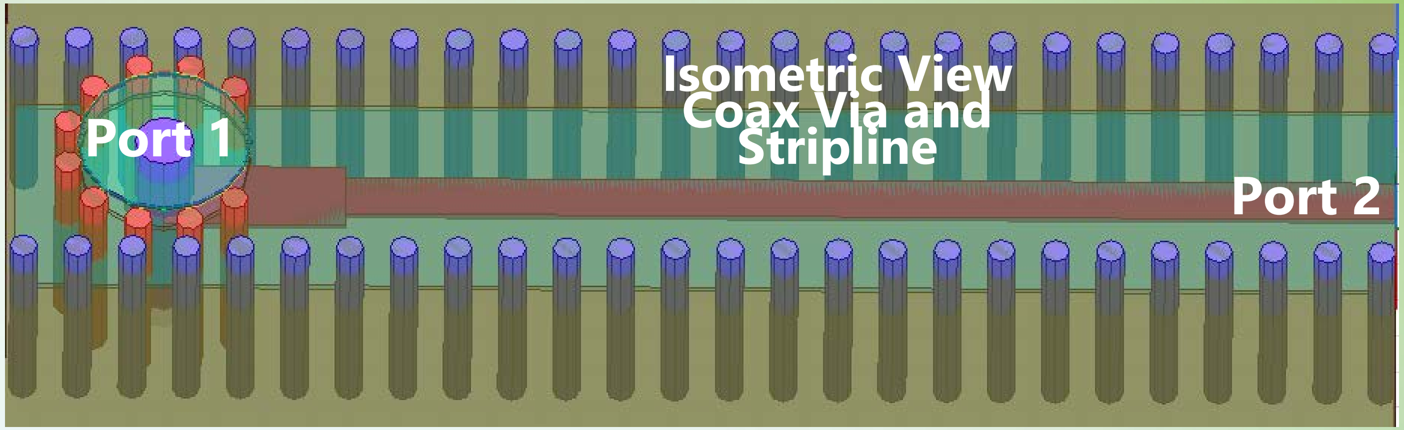
mmWave Applications Specialist

# <u>Method 2</u> – Resonant Coupled Stripline (RCS) > Understanding

- **DIBs are thick, leverage this!**
  - RCS uses the principle of $\lambda/4$ Stub Resonator
  - The RCS Via is terminated with a Shorted Stub.
  - Energy at the desired frequency is coupled <u>only</u> to the transmission line.
- **The weakness is a Limited Bandwidth**
  - However, RCS BW is much larger than defined 5G/FR2 Spans
- **Teradyne has developed a DC-Connectivity Compatible Version**

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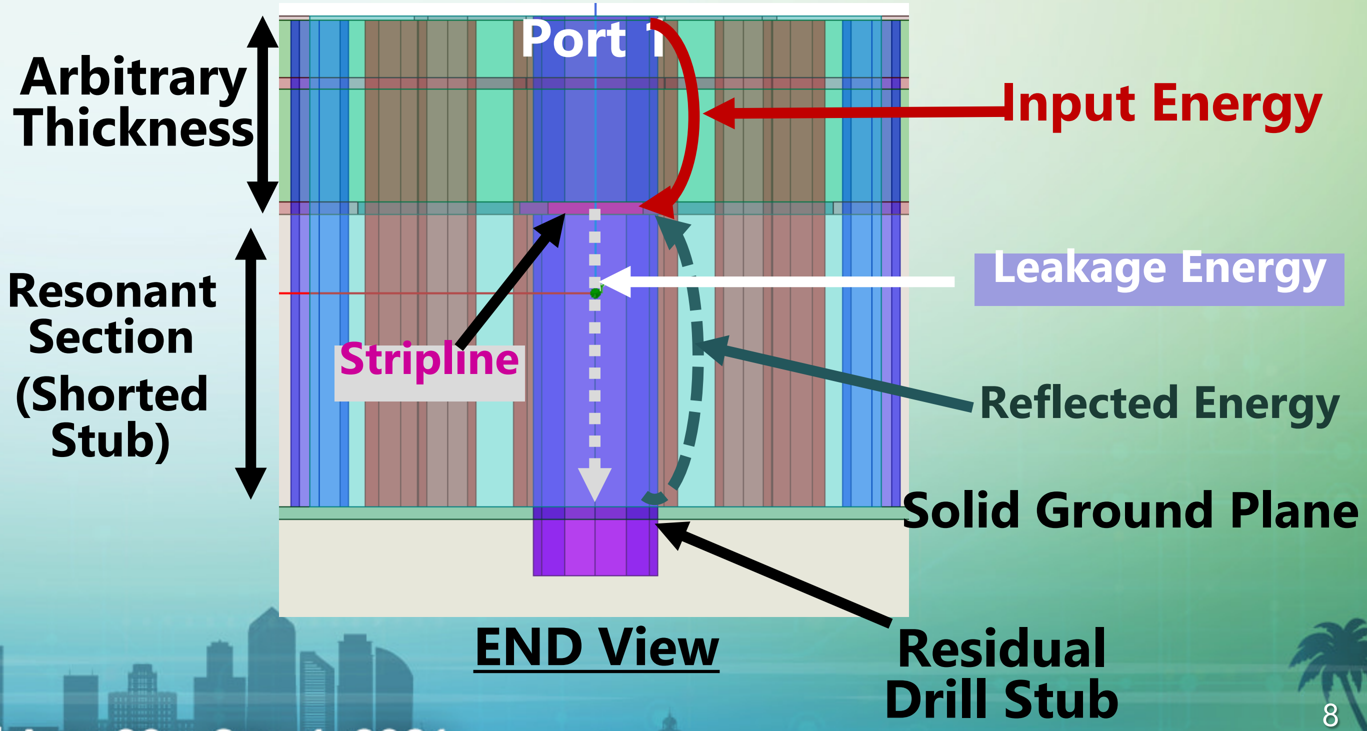



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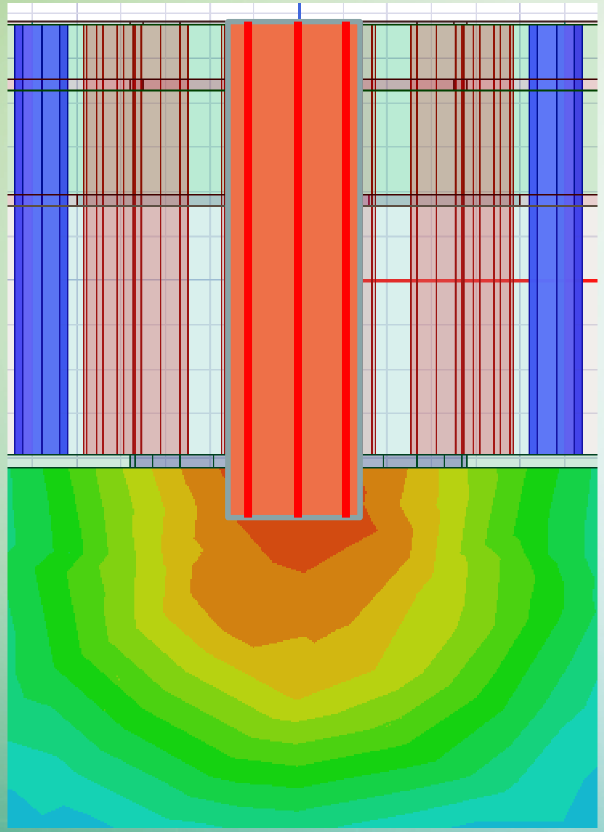
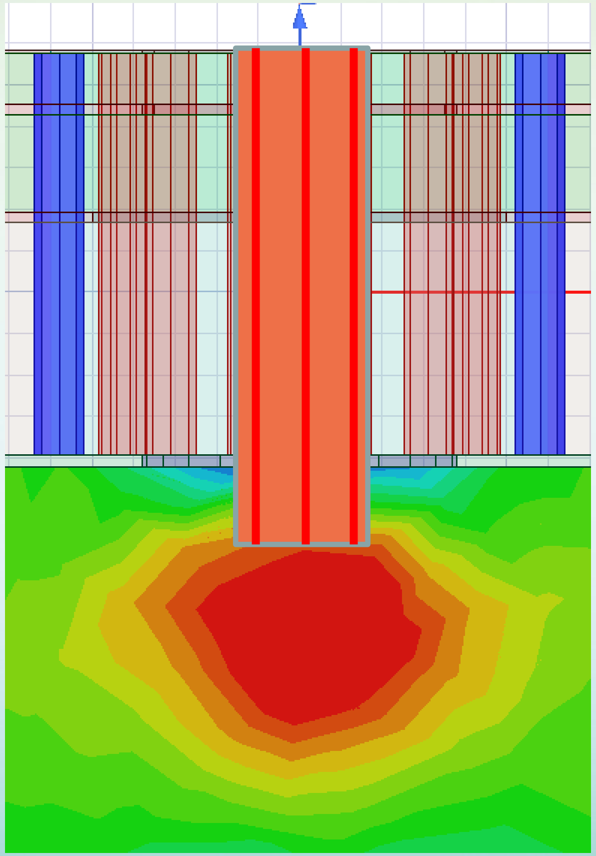
# Method 2 – Resonant Coupled Stripline (RCS) > Stub Radiation

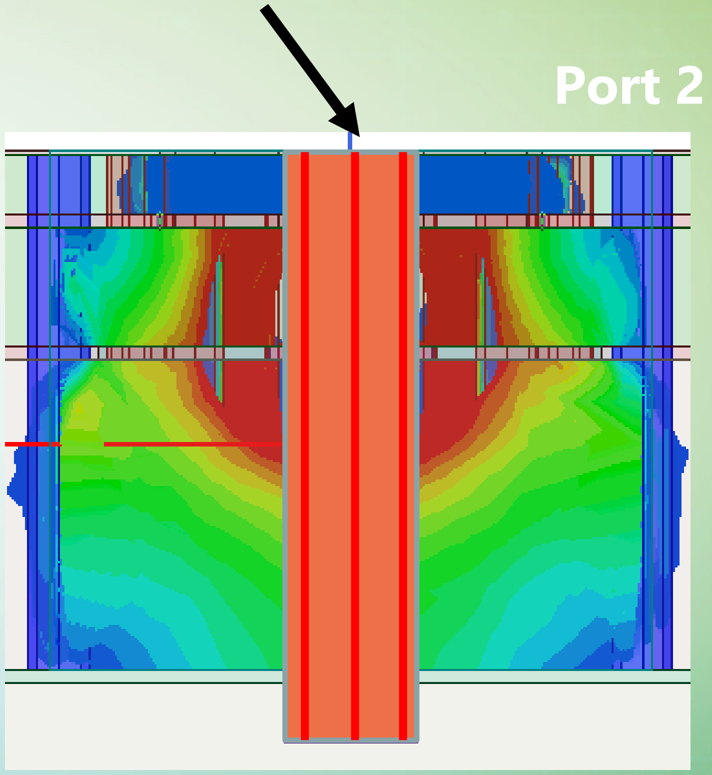
- **Drill-Stub radiating into Dielectric through Anti-Via Clearance**



**Radiation at 30GHz**



**Radiation at 40GHz**




**RCS Structure**
**No Radiation**

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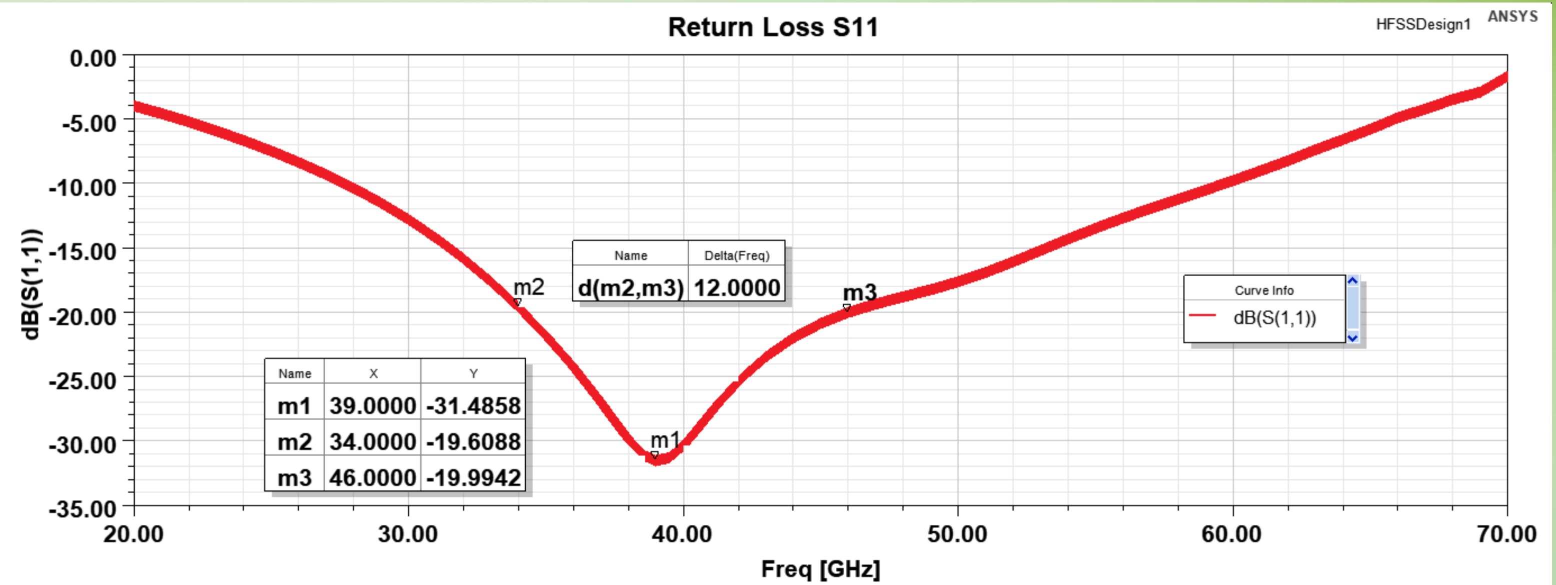
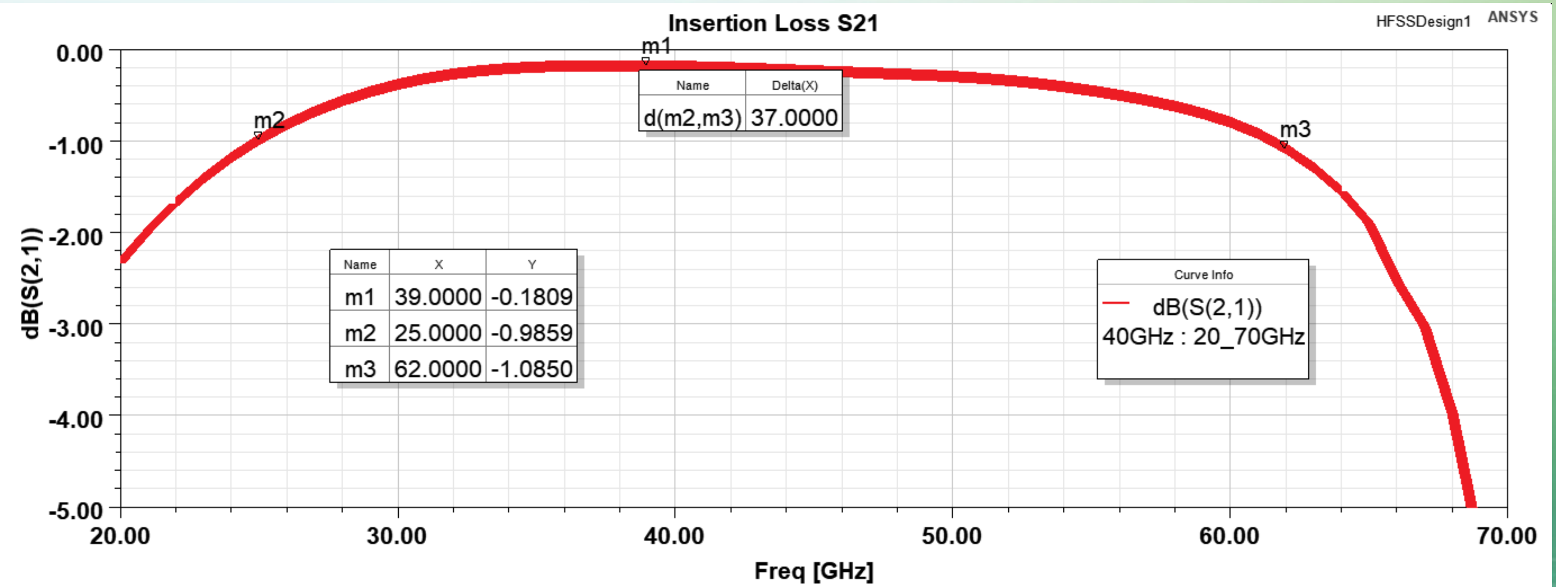
**mmWave Applications Specialist**

# Method 2 – Resonant Coupled Stripline (RCS) > Performance at 39GHz

- **Excellent Insertion Loss**
  - As all energy is retained, insertion loss is very low.
  - 39GHz 1dB Span is 37GGz
- **Good Return Loss**
  - 39GHz 20dB R/L span is 12 GHz
  - At one desired frequency R/L is excellent.
- **The weakness is a Limited Bandwidth**
  - However, BW is much larger than defined 5G/FR2 Spans

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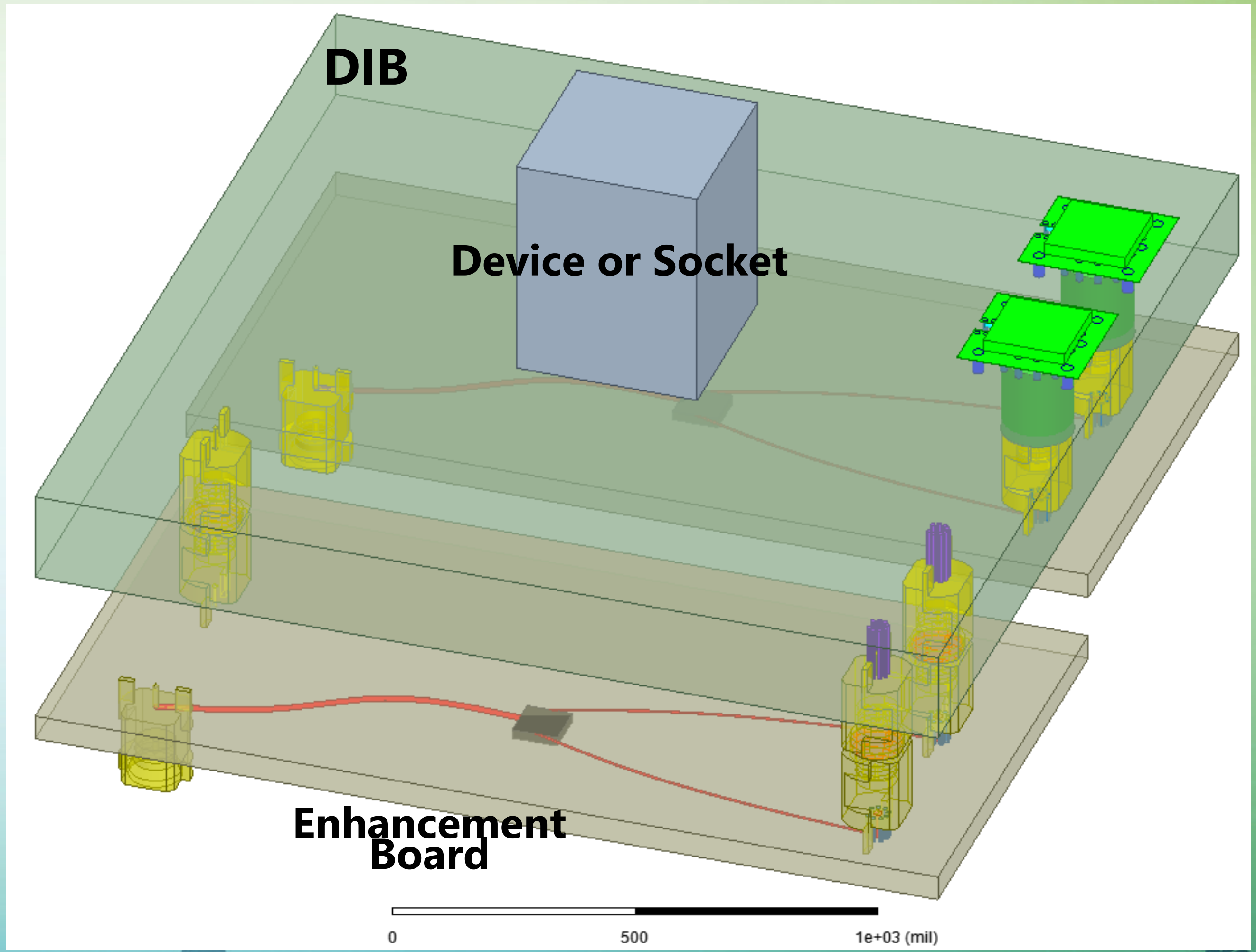
# Method 3 – Modular Applications > Issues

- **mmWave components operate better on Alumina or soft-board PCB materials**
  - Incompatible with DIB Construction and Handler impacts
- **Best performing components starting to come only in BGA Packages**
- **Large number of cables is expensive and degrades performance**
- **Updating/Altering Test Capability can require full DIB Re-Spin, very expensive**

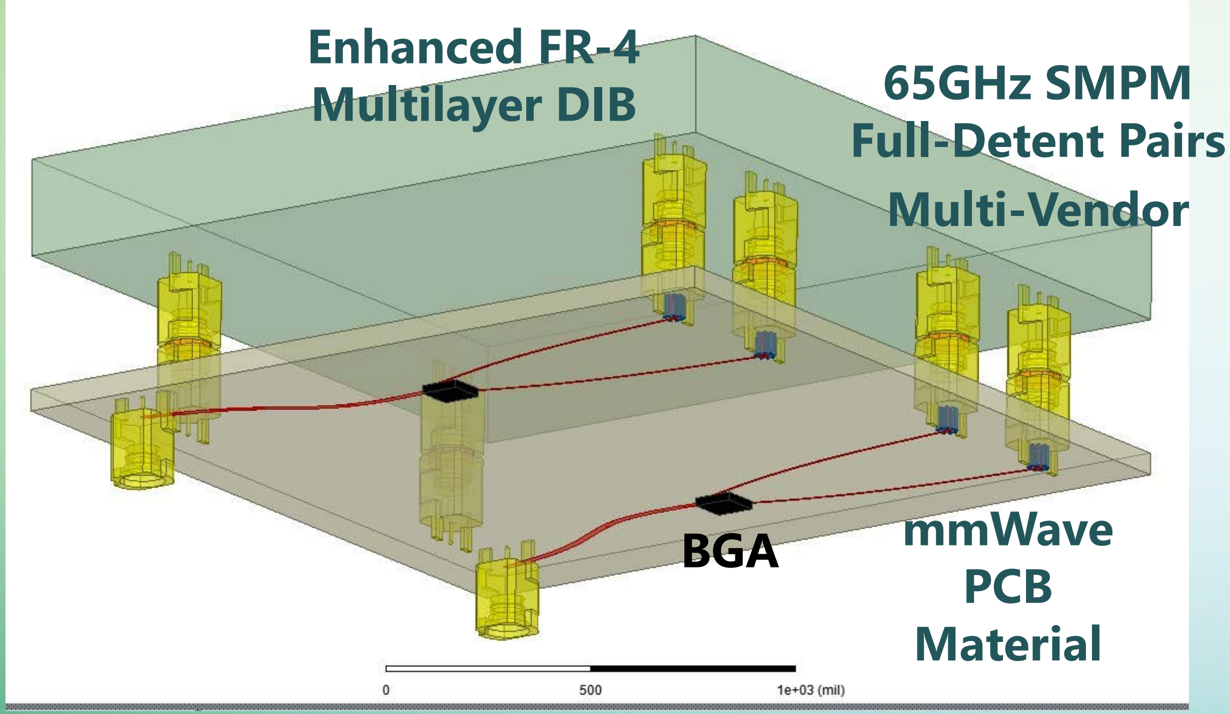
# Method 3 – Modular Applications > Understanding

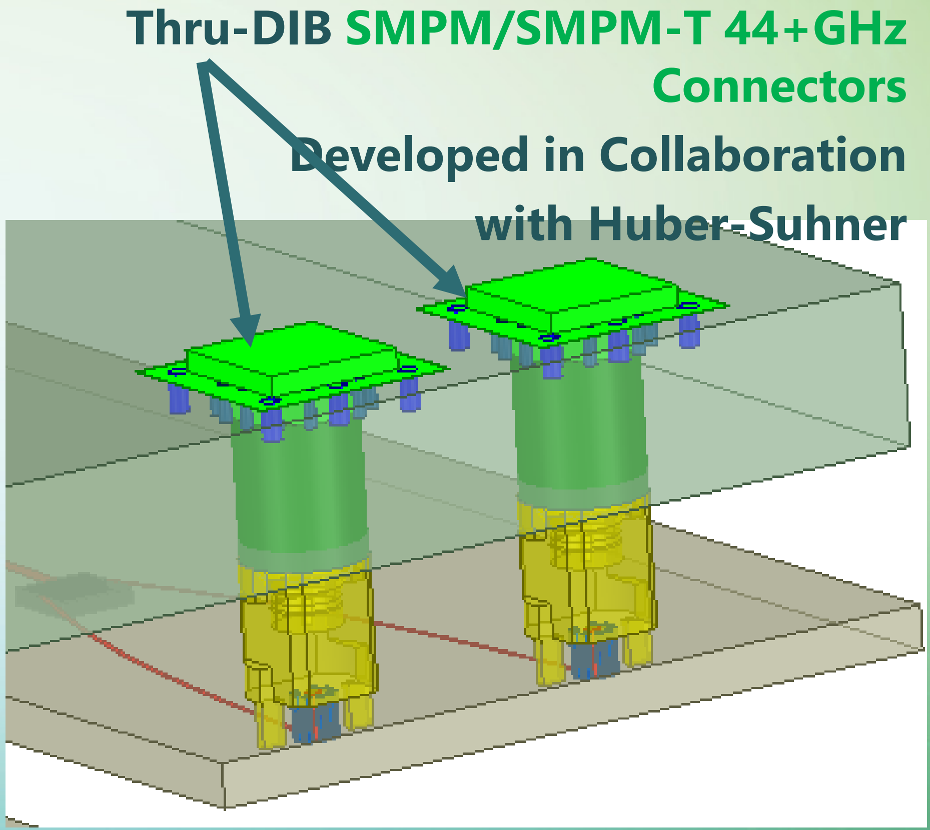
- **Modular Enhancement Boards compatible with mmWave Interconnections and Devices**
- **Mount directly to the Tester side of the DIB**
- **Eliminate excess cable loss, excess impedance mismatch and cable expenses**
- **Application Devices:**
  - Multiplexers
  - Noise Figure LNA Boosters
  - Gain/Power Boosters
  - Sensing Directional Couplers



# Method 3 – Modular Applications > Understanding

- **Connect through Coaxial Vias or to Through-DIB SMPM-Detent connections**



# Continuing Work and Conclusion

- We are continuing to develop new Transmission Line methods, Calibration methods and Enhancement apparatus.
- Thank you for your attention and please ask questions if you wish.
  Or contact me after the Conference.