SWTEST

PROBE TODAY, FOR TOMORROW

2023 CONFERENCE

High Speed and Fine Pitch Phantom Technology

Advanced Solution for RF Test Over 53 Gbps and Fine Pitch at 70 µm

TECHNOPROBE

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MARVELL

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Introduction

- The probe card market closely follows the requests coming from the manufacturers of semiconductors, consequently the technological evolutions of the two fields are closely connected.
- Today, the manufacturers of semiconductors need to test fine pitch and high frequency devices.
- The probe card market attention is focused on manufacturing probe cards for KGD (known good die) testing of fine pitch and high frequency devices.
- Technoprobe designed and created an RF probe card that could meet the requirements and specifications demanded by Marvell.

Agenda

Topic	Customer request (challenges)	Technoprobe response	Data
RF	53 Gbps PAM4	Phantom technology which allows the integration of DC and RF in the probe head	1. Bandwidth (data rate and rise time) 2. RF measurements 3. Simulation vs. measurement 4. Customer eye diagram
Pitch	70 µm pitch	TPEG™ MEMS needles - T1 pointed	1. Force 2. Current Carrying Capacity (CCC) 3. Contact resistance 4. Scrub marks
Tester	Advantest Twinning	1. Mechanical: beam boss and cable guide 2. Electrical: Phantom technology and right angle, multi-coax cables	1. Beam boss example 2. Custom cable guide example

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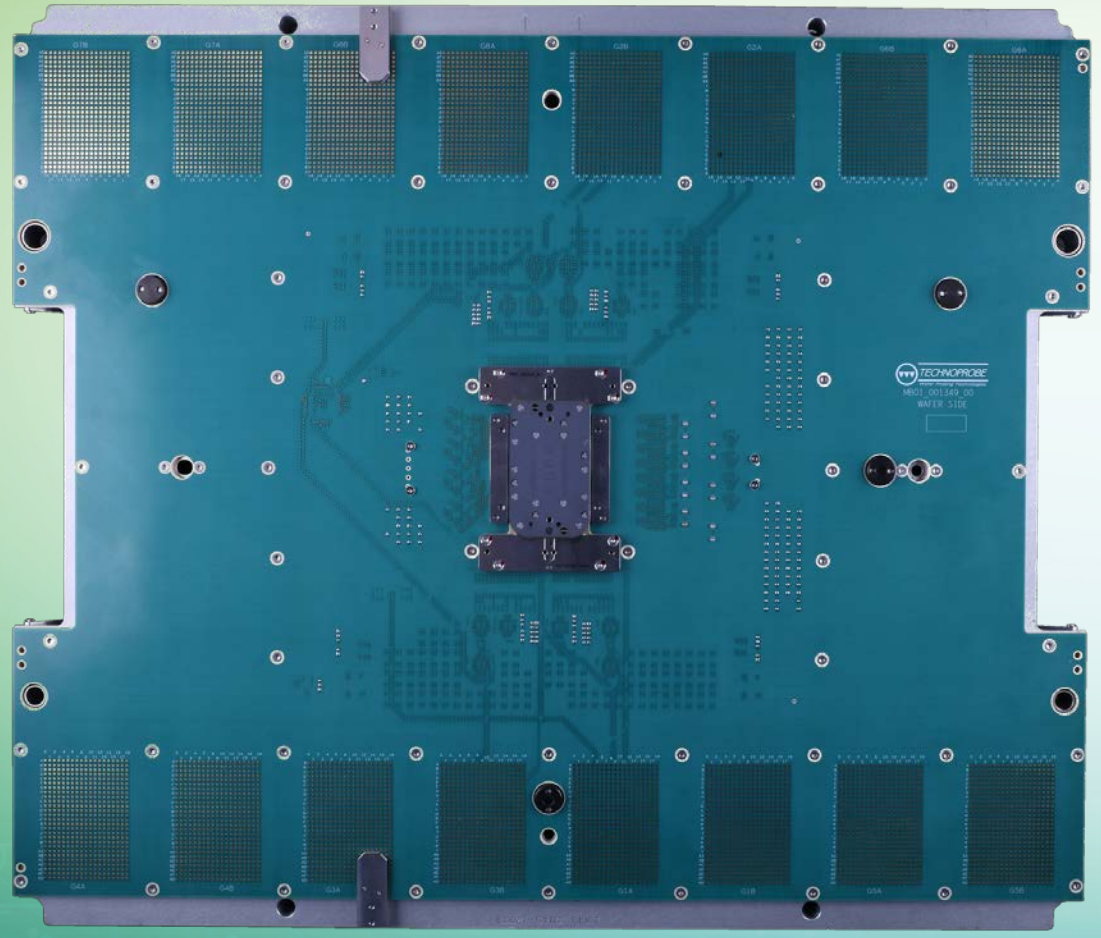
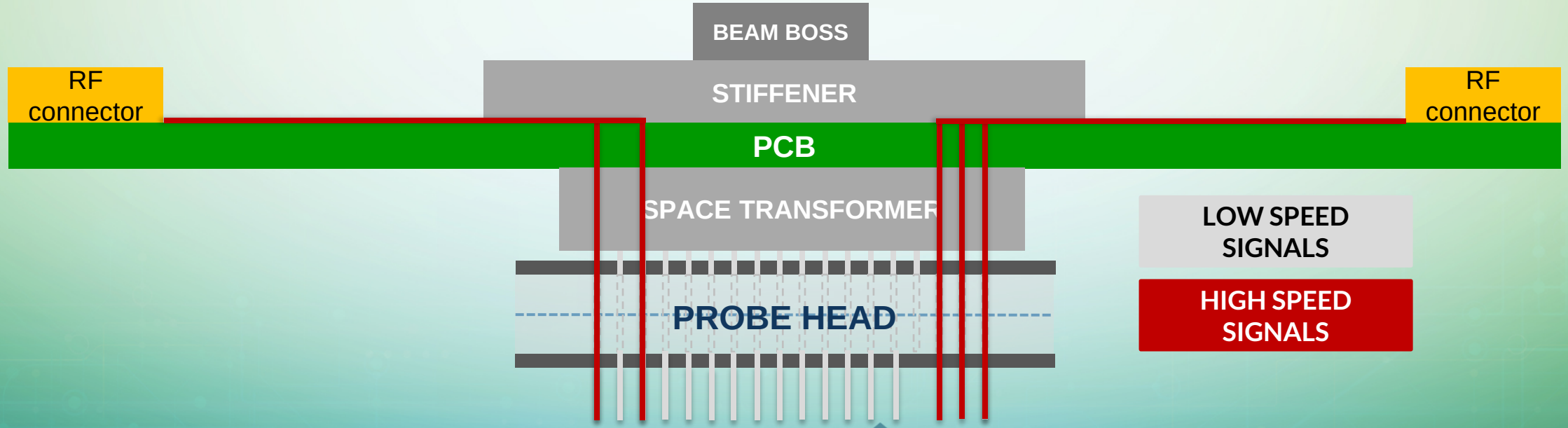
Phantom Technology
Probe Card– Wafer Side



- The Phantom probe cards has an architecture to address the RF probe card challenges:
  - Allow the integration of DC and RF in the probe head
  - Capable of probing larger arrays and multi-sites (x2 in this case)
  - Materials chosen to reach high temperatures (125°C)

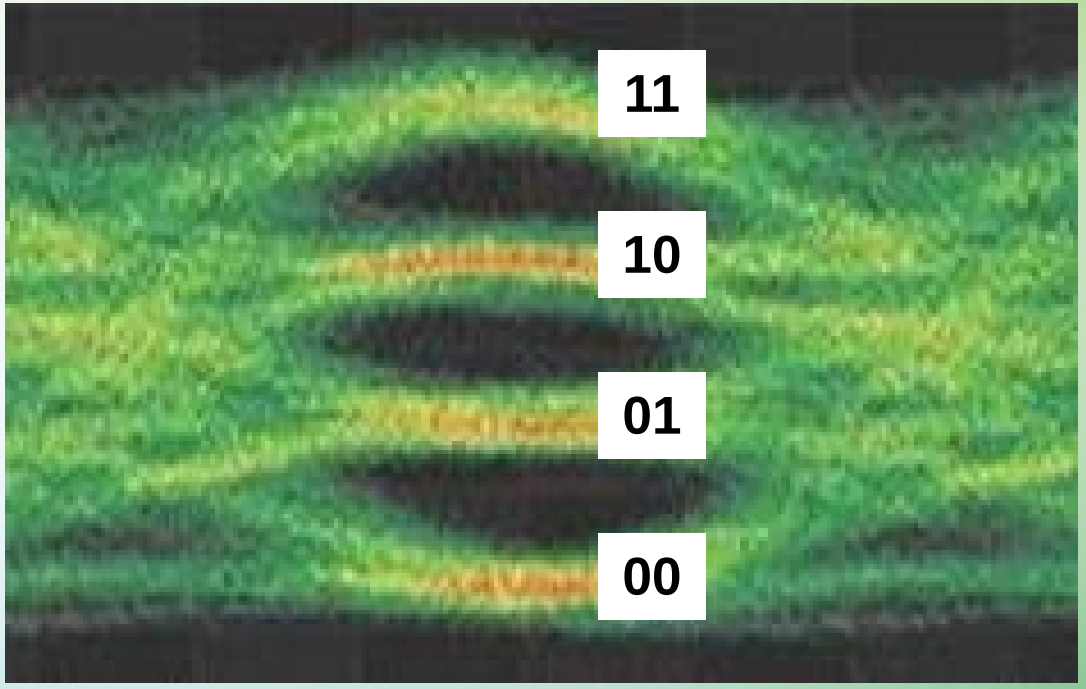
Phantom Technology
Probe Card– Cross section

- **Phantom probe head technology is a hybrid**
  - **Low speed signals, power and GND with TPEG™ vertical MEMS needles**
  - **High speed signals and GND with RF needles**



Gigabits to Gigabaud

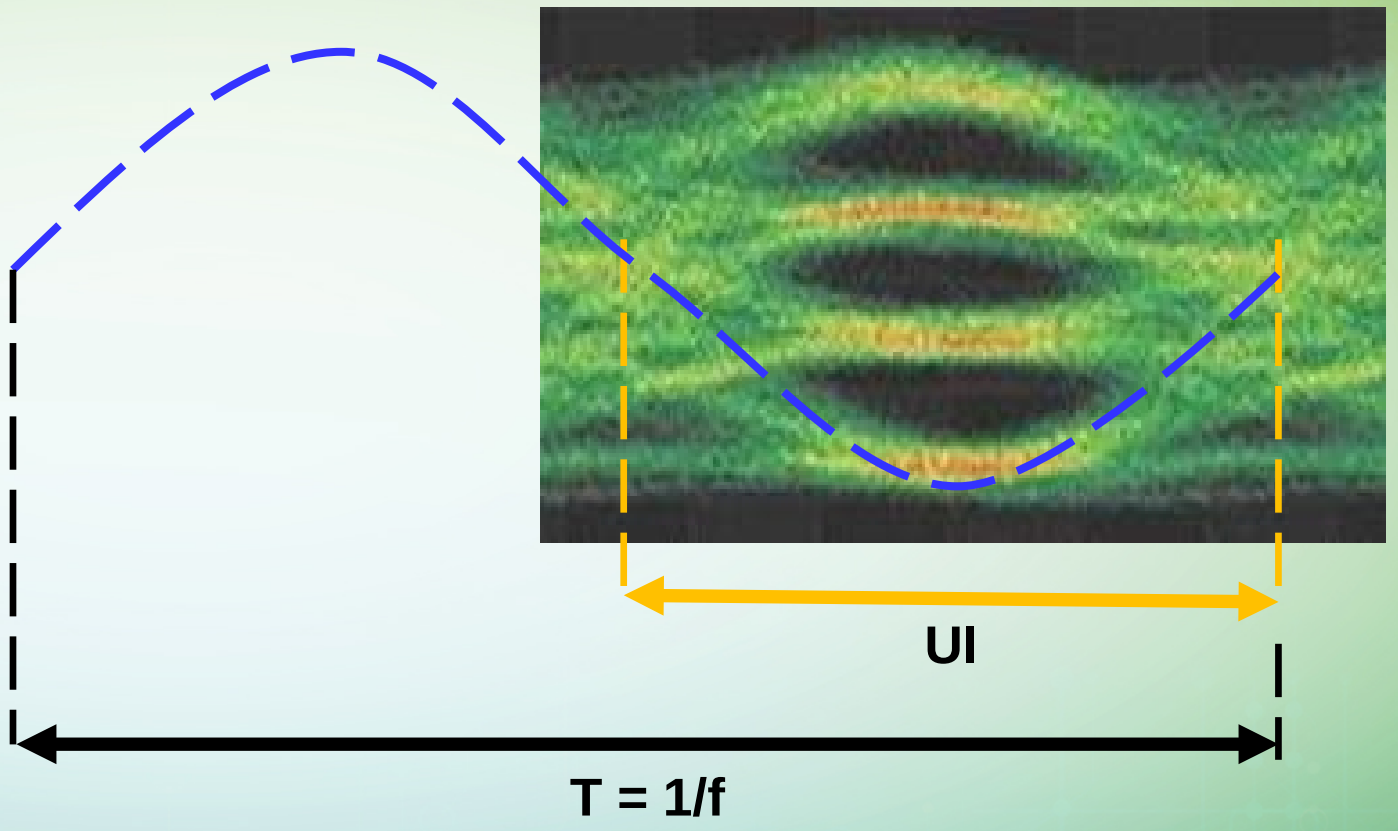
- The device is a 50 Gbps PAM-4 DSP
- PAM-4 means pulse amplitude modulation 4.
  - There are 4 voltage levels (pulse amplitude modulation)
  - Each voltage level (symbol) represents 2 bits of data
- The baud rate is the number of voltage changes (symbols) per second.
- 50 Gbps PAM4 is 25 GBd



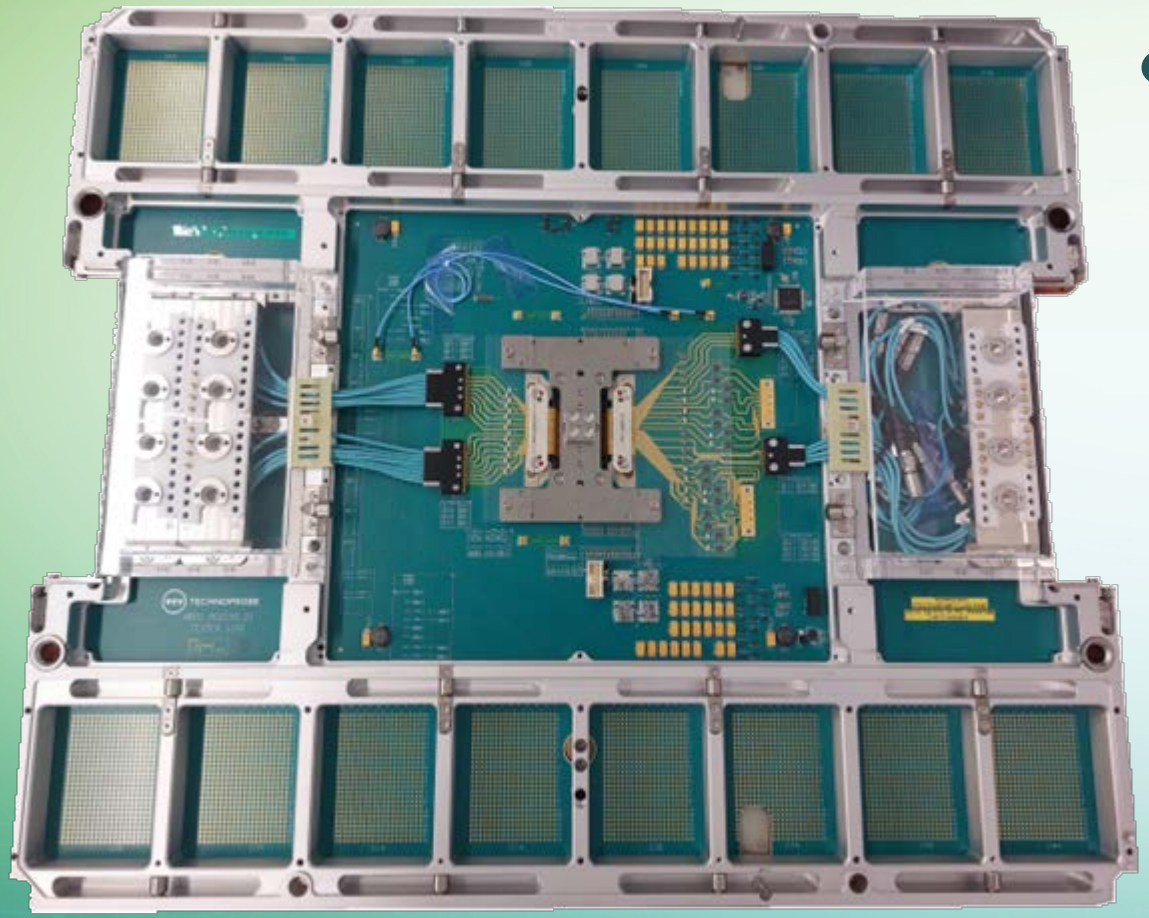
PAM4 Eye Diagram

Gigabaud to Gigahertz

- The device is a 50 Gbps PAM-4 DSP
- 50 Gbps PAM4 is 25 GBd
- The unit interval (UI) or symbol period is half as long as a sinusoidal wave period
- 25 GBd requires a frequency of at least 12.5 GHz



Phantom Technology
Probe Card–Tester Side



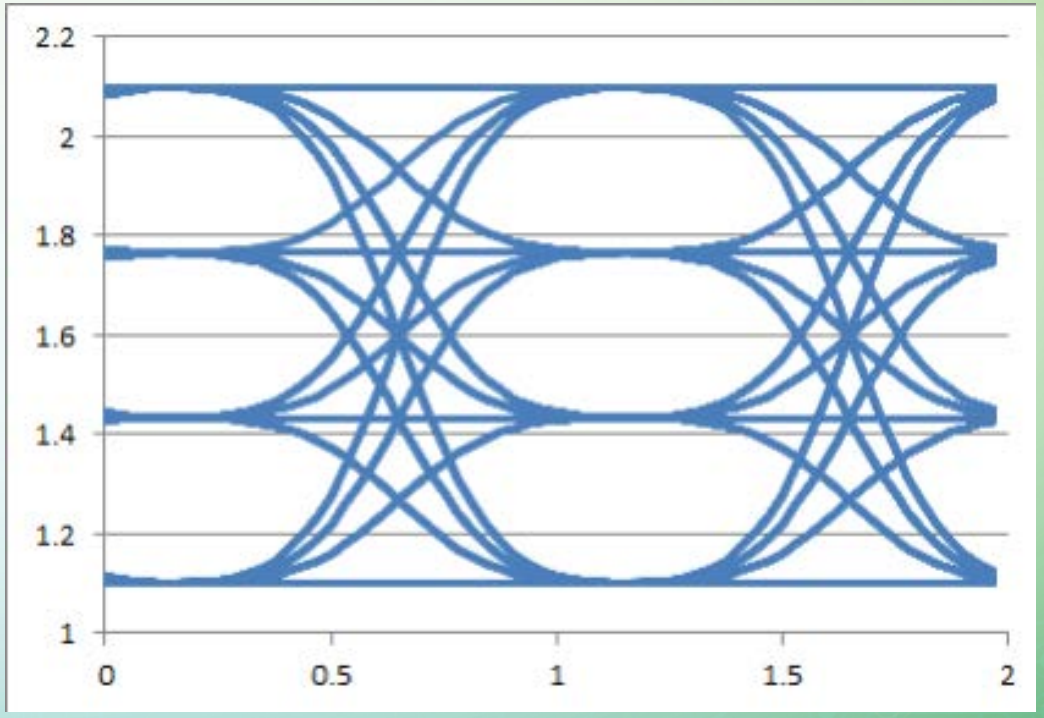
- Technoprobe performs 3D EM simulation for every new project
  - Use the Phantom probe head technology to route the 53 Gbps signals between the DUT and the MultiLane instruments.
  - Right angle, multi-coax cables with SMPM blind mate connectors for signal fidelity, signal density, blind mate, and limited height.
  - Custom brackets to route cables to the MultiLane instruments without interfering in the direct docking

Bandwidth Based on Rise Time

- Consider a 26.5625 GBd data rate
- The unit interval (UI) is 37.7 ps
- A rise time that is half the UI would be 18.8 ps
- A common simplification is that the

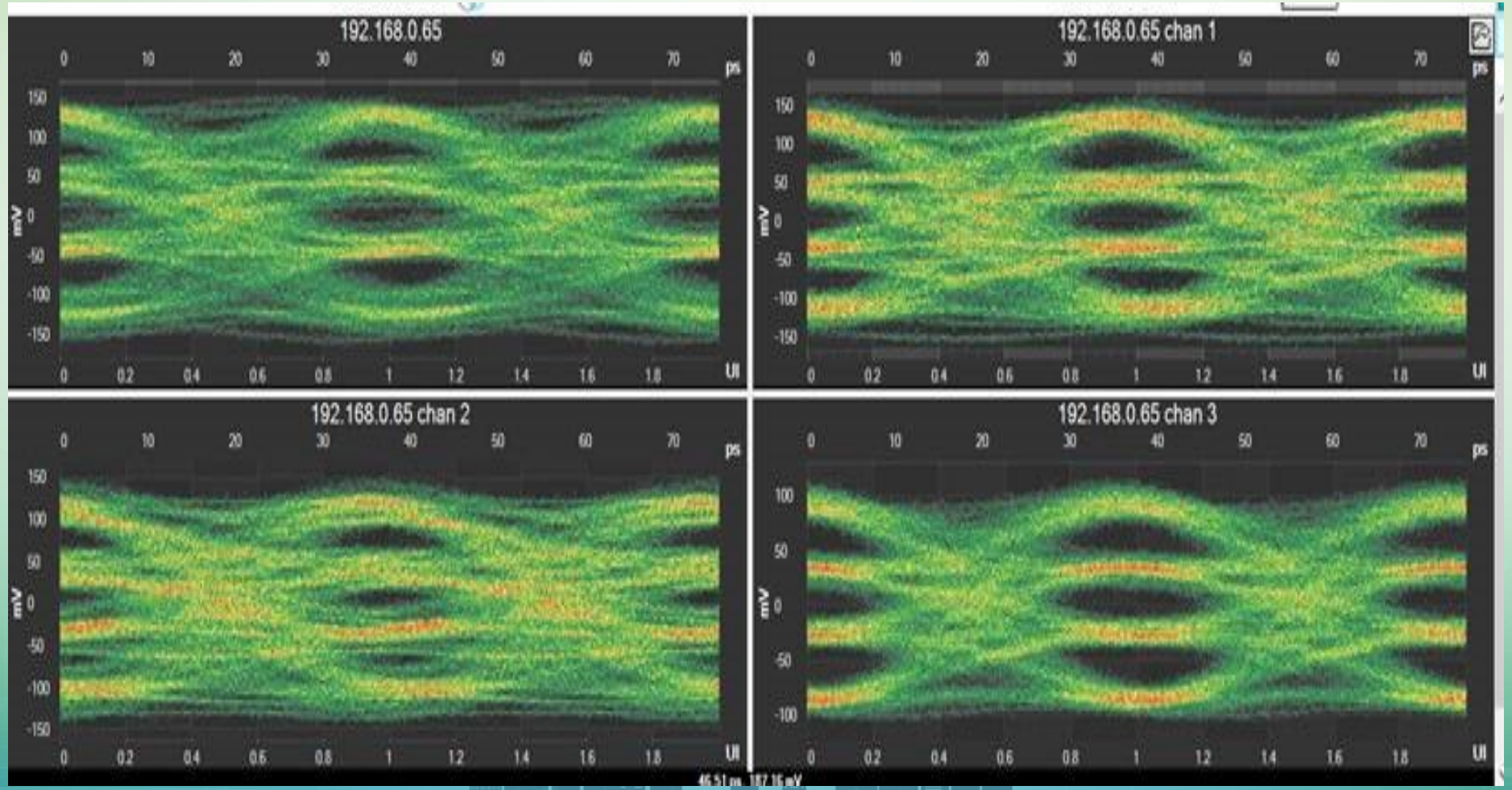
$$BW = 0.35 / RT_{10\text{-}90}$$

- For a 10-90% rise time of 18.8 ps, the minimum frequency bandwidth would be 18.5 GHz.



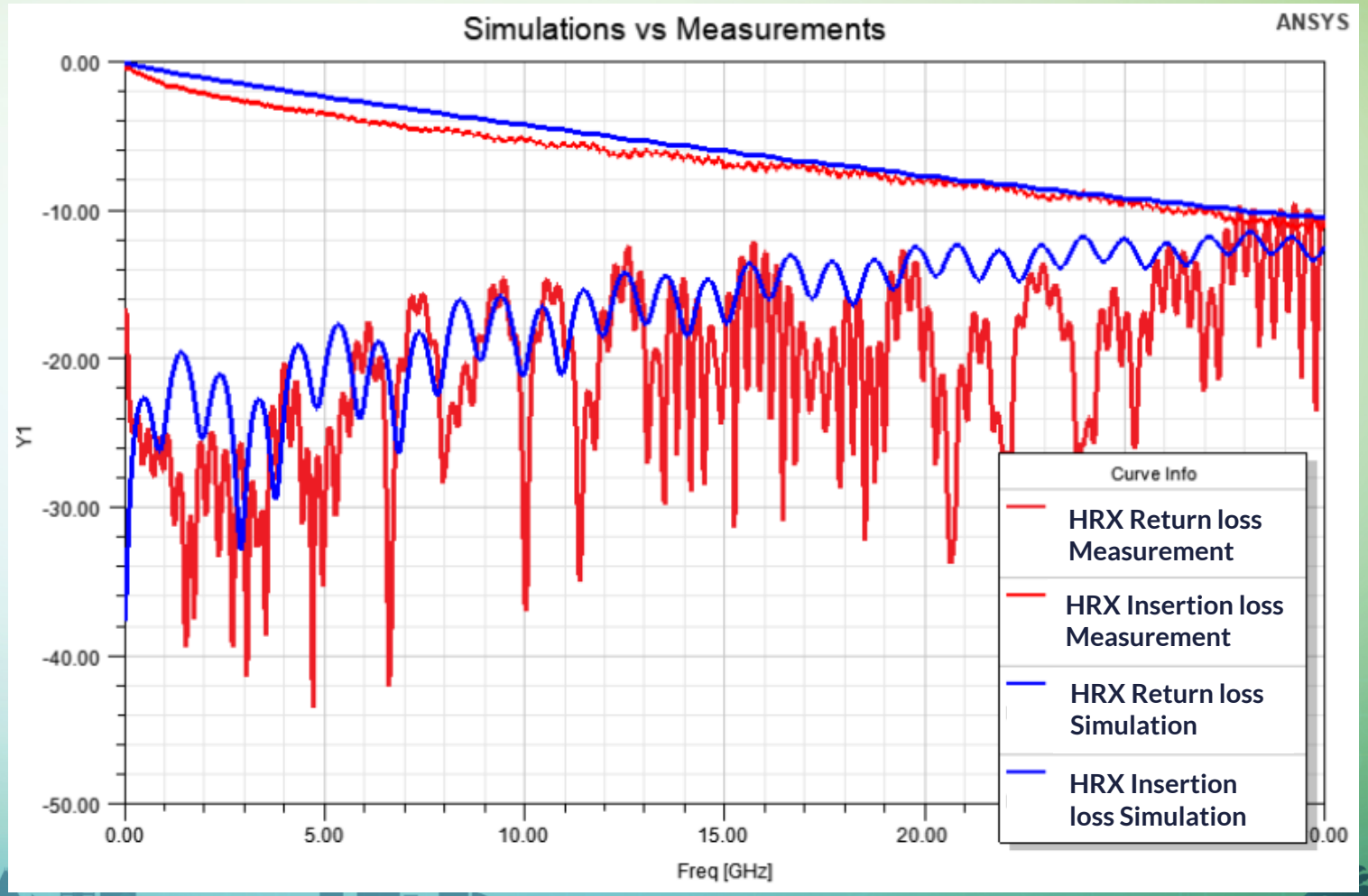
PAM4 26.5625 Gigabaud Eye Diagram

- Single-ended, 4 channel output seen from DSO in the V93000



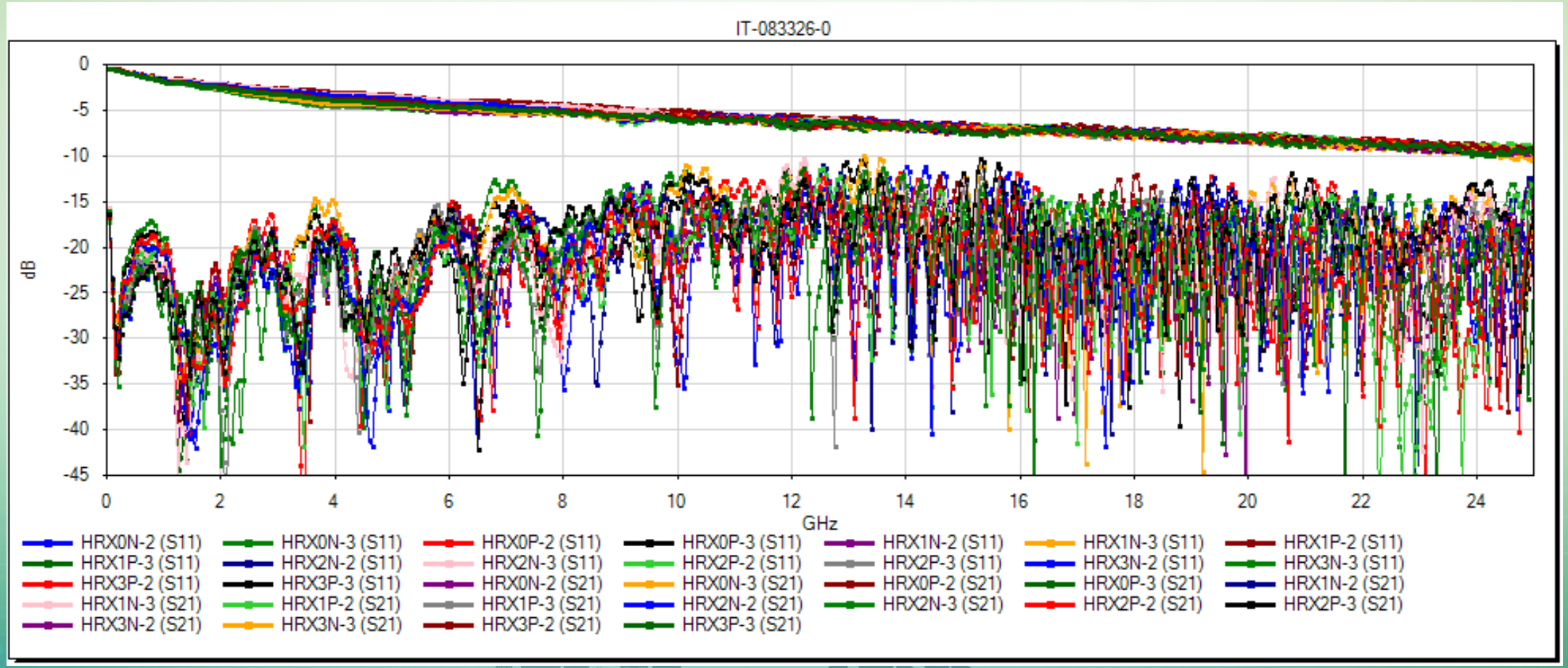
Phantom Technology
Full Path Simulations

- Technoprobe performs 3D EM simulation for every new project
  - Simulation with different configurations of needles
  - Choice of the correct configuration
  - Full path simulation
  - Comparison between full path simulations and measurements



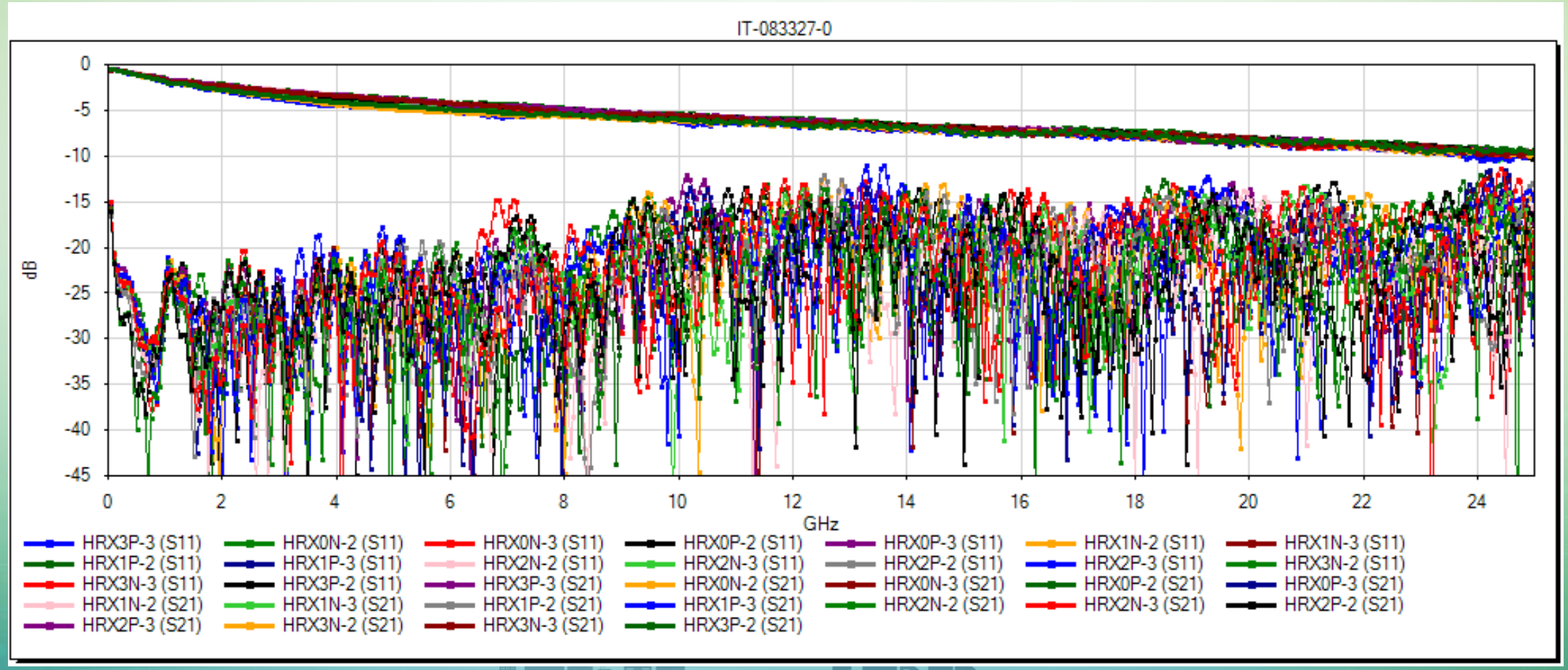
Full Path S-parameters

- Probe head ID #26: 2 sites, 4 differential inputs each



Full Path S-parameters

- Probe head ID #27: 2 sites, 4 differential inputs each



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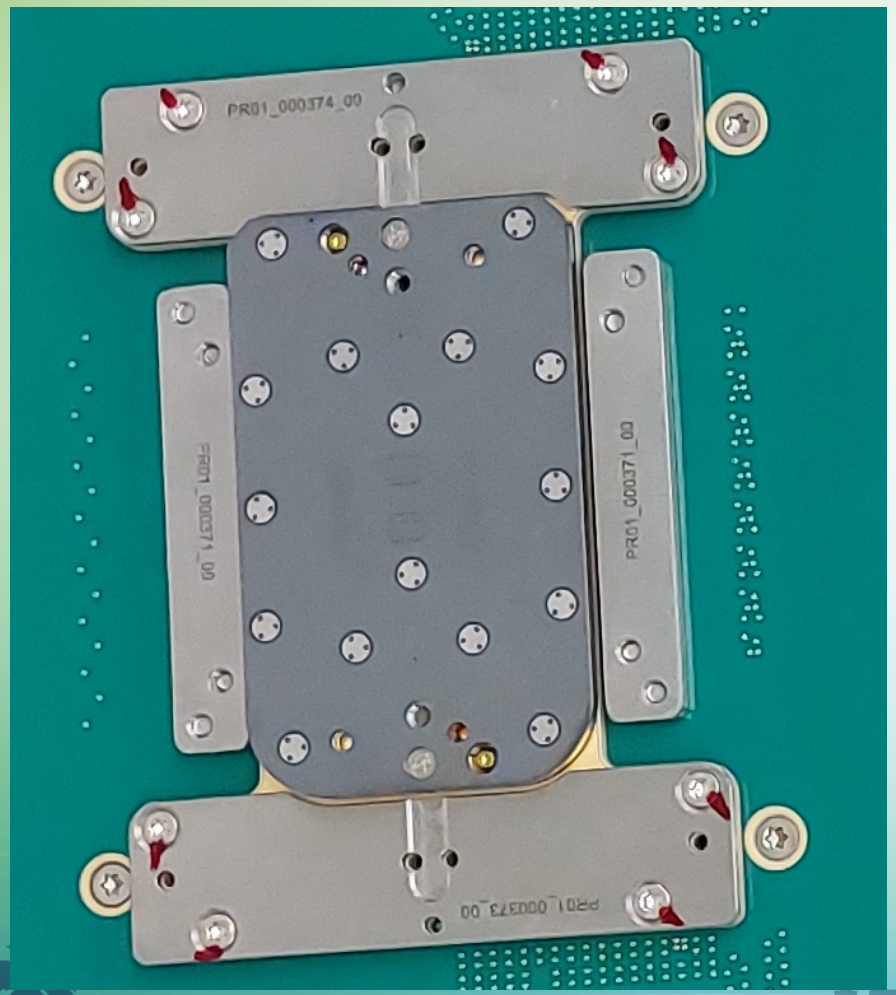
Phantom Technology

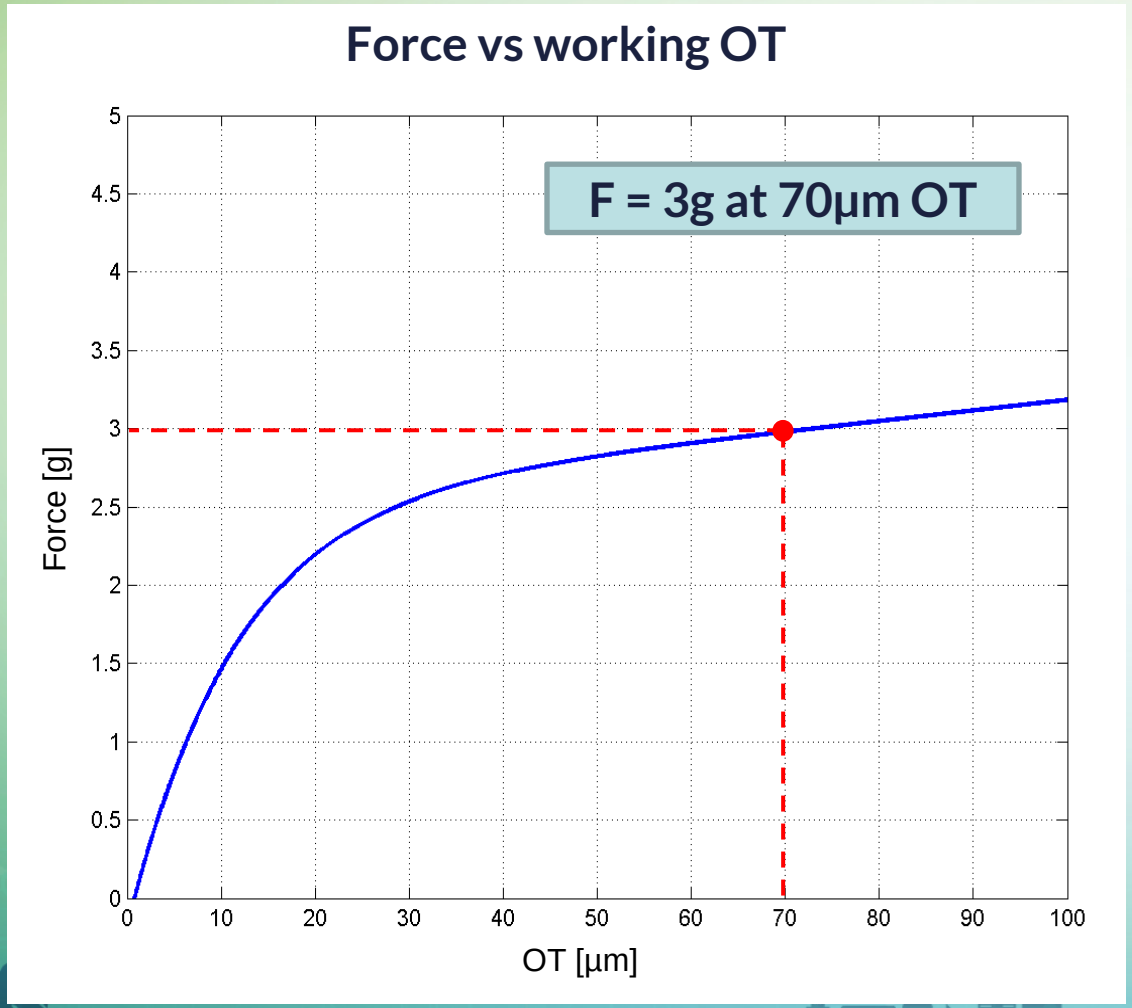
TPEG™ MEMS Needles - T1 Pointed

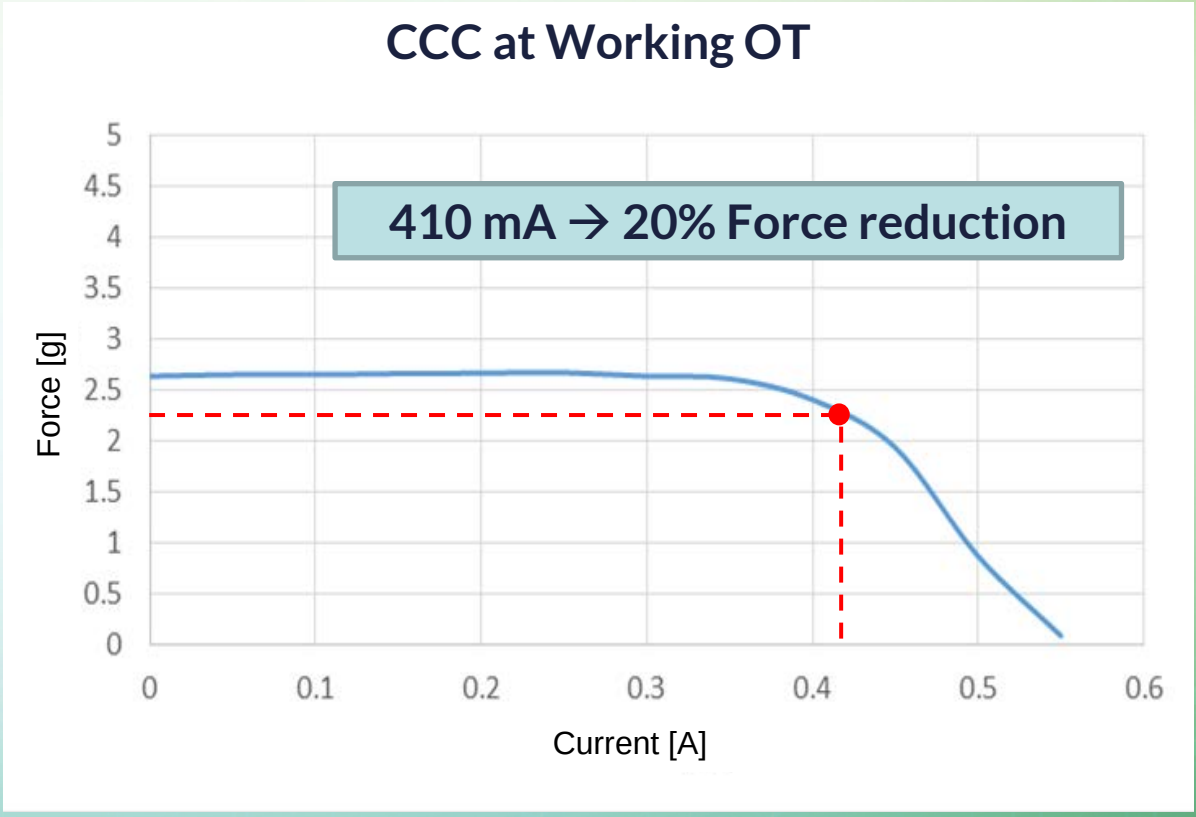


	PARAMETER	Phantom Needle Technology
Low and high-speed signals	Min pitch	• 70 µm line array configuration • 80 µm full array configuration
	Needle tip diameter	10 ± 4 µm
	Force (at 70 µm OT)	3 g
	X, Y alignment accuracy	12 µm
	Contact resistance	<2.7 ohm
	DC Window	20 µm
	Max pin count	> 20.000 pins
Low-speed signals	DC resistance	0.3 ohm
	Current Carrying Capacity	410 mA

TPEG™ MEMS needles - T1 Pointed

Force and current carrying capacity (CCC)

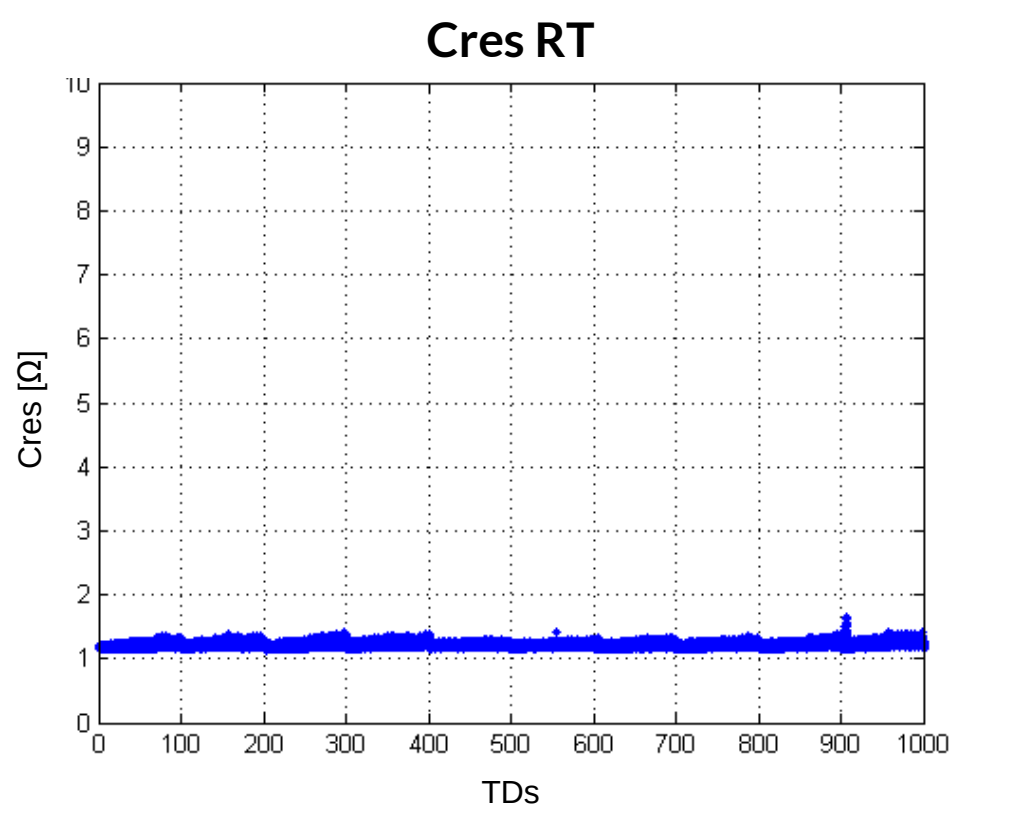


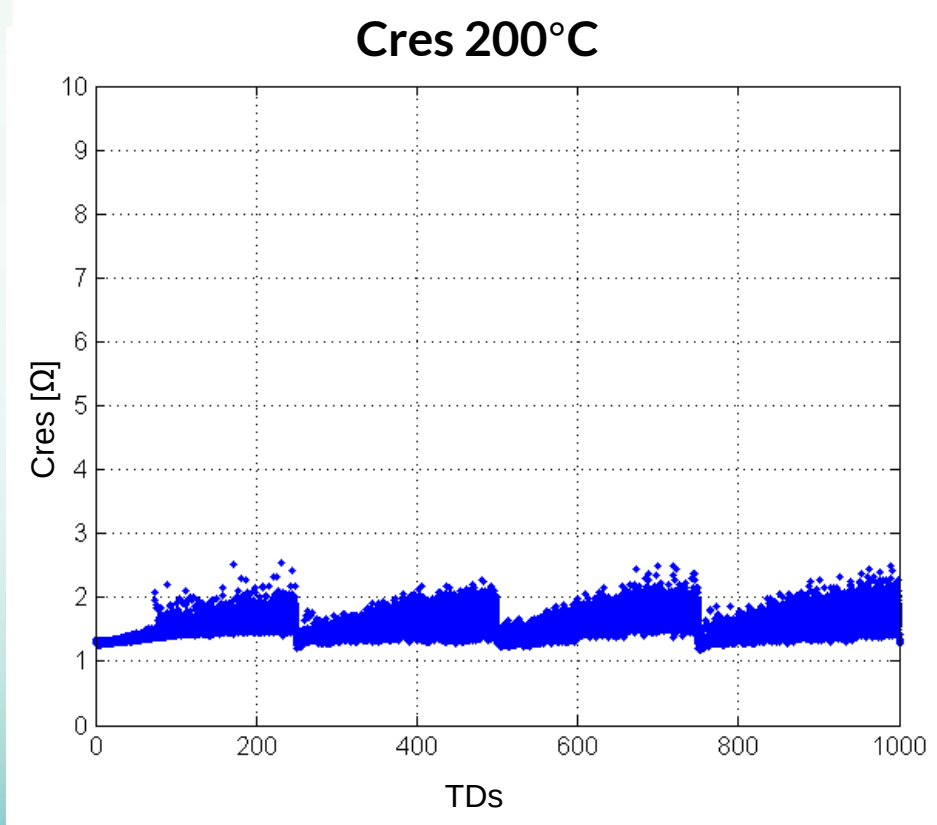


TPEG™ MEMS needles - T1 Pointed

Contact Resistance

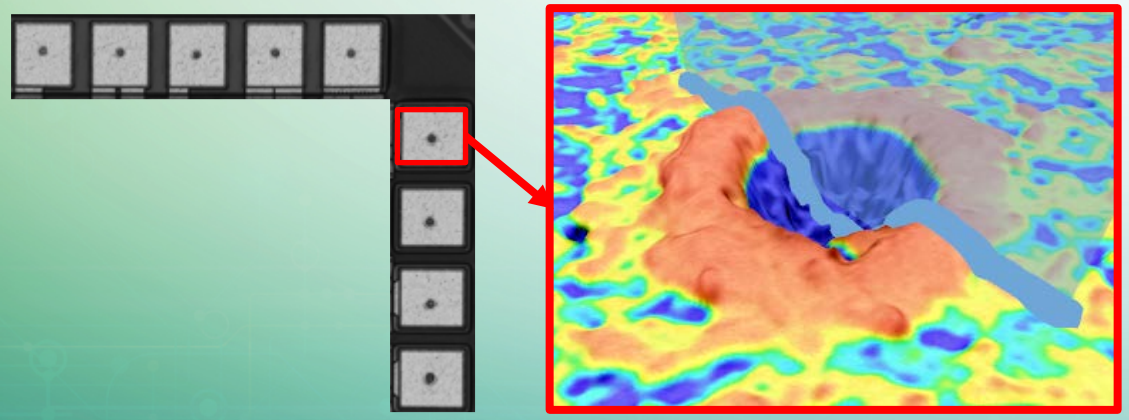
- Contact resistance on a blank aluminum wafer at 70 μm OT

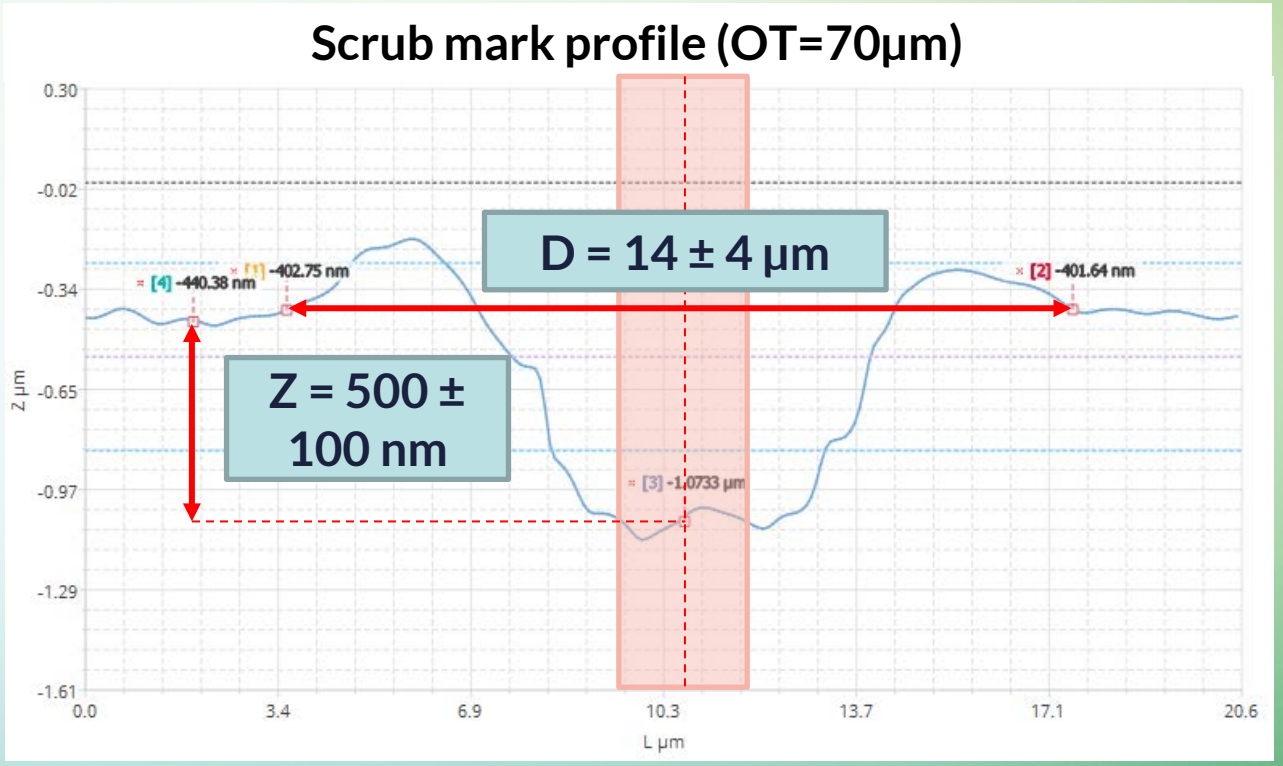




TPEG™ vertical MEMS needles and RF needles
Scrub Marks

- **Scrub mark OT=70µm**
  - Needle tip diameter is 10 ± 4 µm
  - 60 x 66 µm pads
  - Diameter scrub mark is 14 ± 4 µm
  - Depth scrub mark is 500 ± 100 nm
  - Uniform scrub marks





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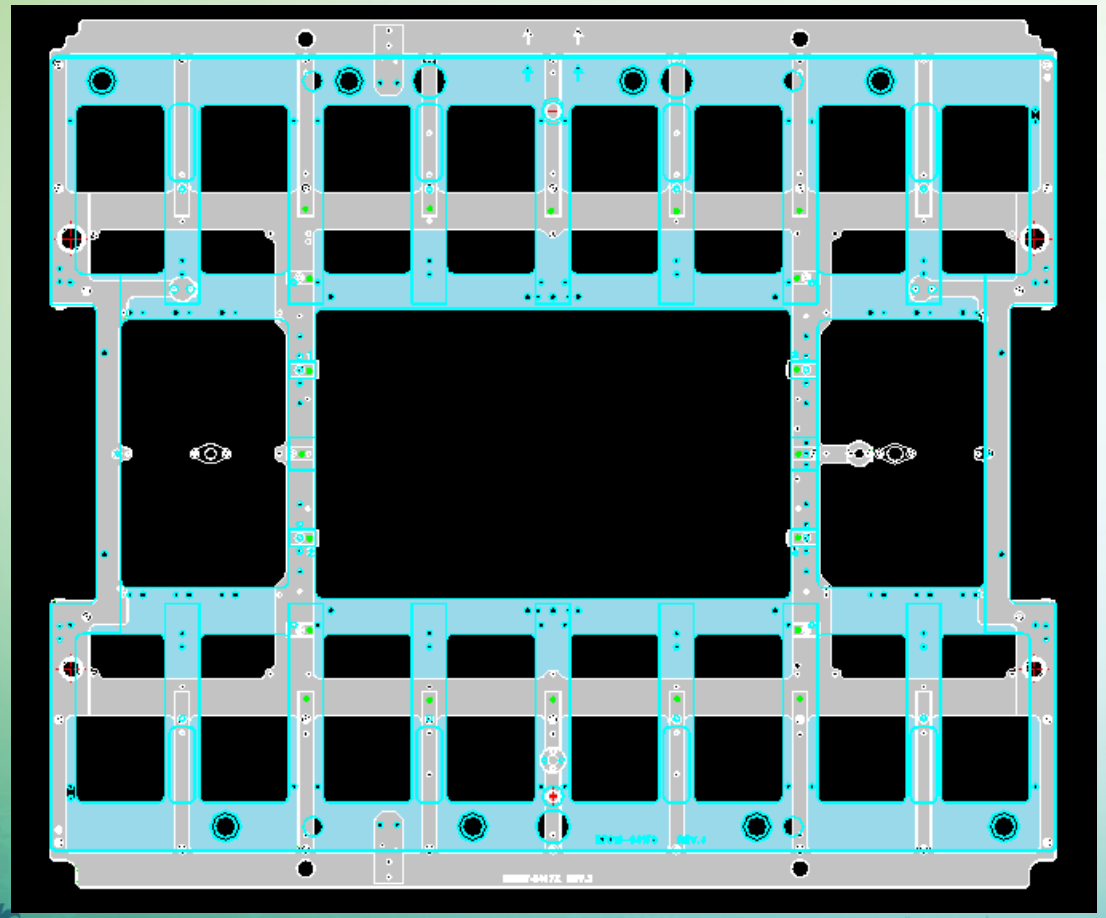
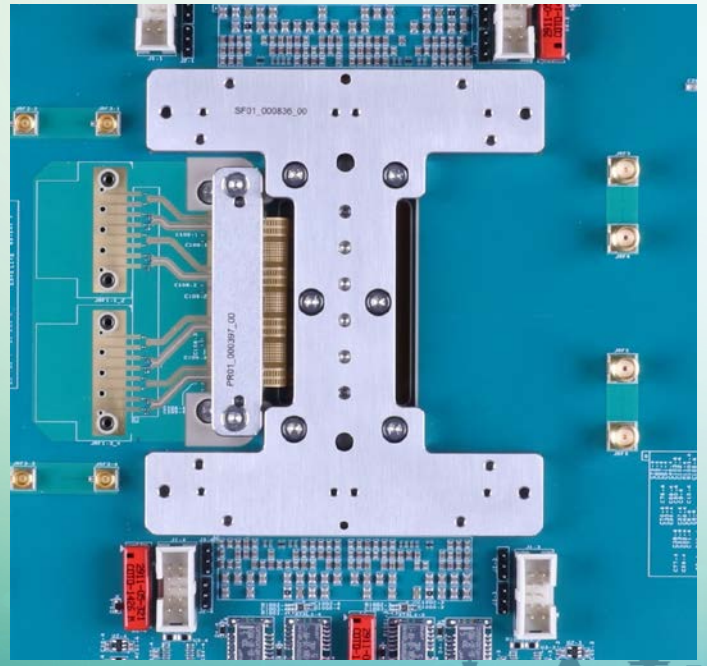
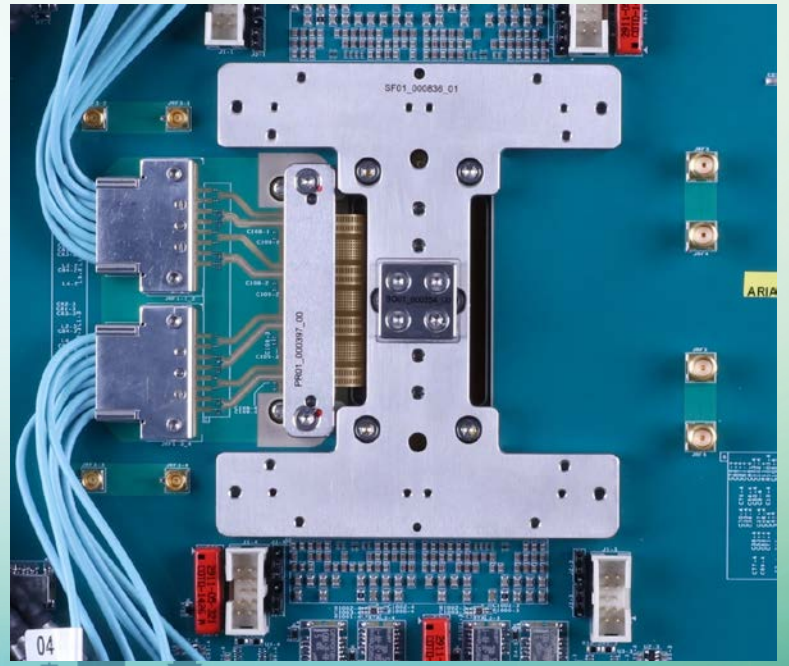


- V93000 twinning solution
  - The application space in the twinning version is more than 100 mm wider. It makes the interface to the bridge beam even more important
  - Custom brackets to route cables to the MultiLane instruments without interfering in the direct docking

Beam Boss for V93000 Direct-Probe™

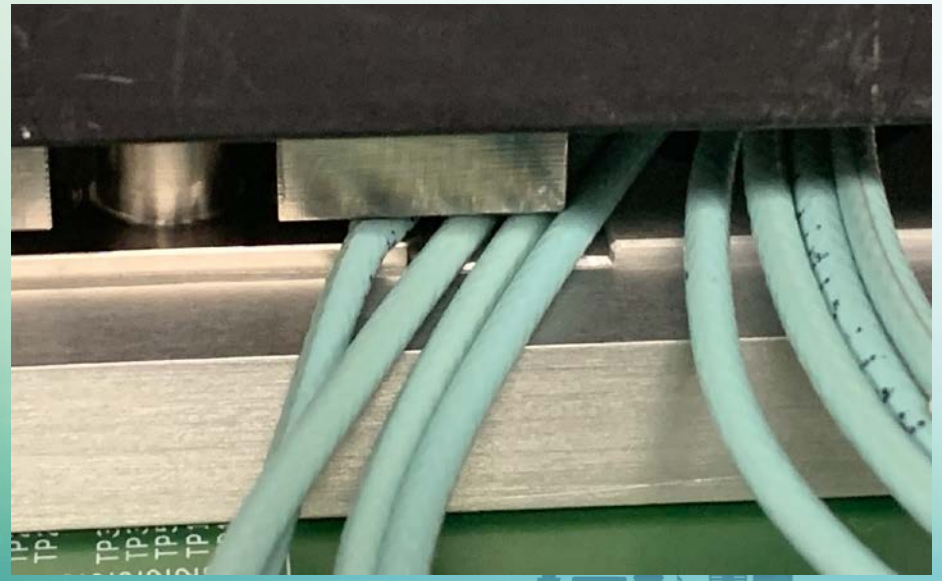
- The importance of beam boss
  - A beam boss is a protruding feature on the probe head stiffener to contact the bridge beam in the V93k direct dock applications. It transfers the probing force through the probe head to the bridge beam, and then, to the prober head plate instead of into the PCB and stiffener.

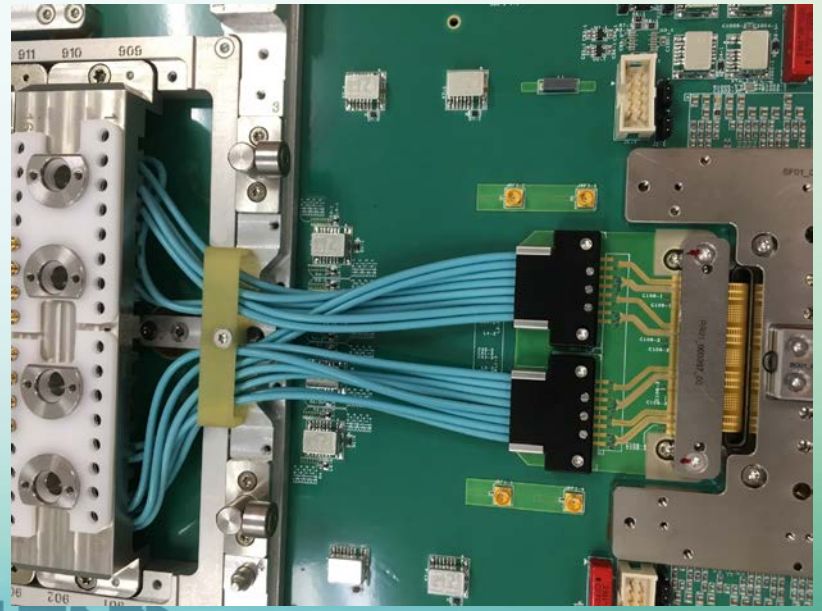




Cable Guides for V93000 Direct-Probe™

- **Custom bracket to safely route cables**
  - **There is a problem that prevents using the default Advantest cable guide**
  - It is easy for the cables to get pinched between the bridge beam and stiffener
  - Technoprobe designed a custom bracket to route cables **to the MultiLane instruments without interfering in the direct docking**





Summary

- The probe card market evolves to match the semiconductor device test requirements for KGD
  - Finer pitch
  - Higher frequencies
  - Multi-DUT
- Technoprobe's Phantom probe card evolved to meet the requirements from Marvell for dual-site probe card for 53 Gbps PAM4 testing on 70 µm pitch pads in a V93k with the Twinning interface