

# Ultimate Frequency Limitations of Cobra Probe Contactors

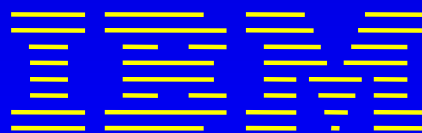
Raphael Robertazzi

*With Acknowledgement To*

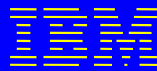
Christian Schuster

Petar Pepeljugoski

IBM Research

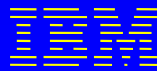


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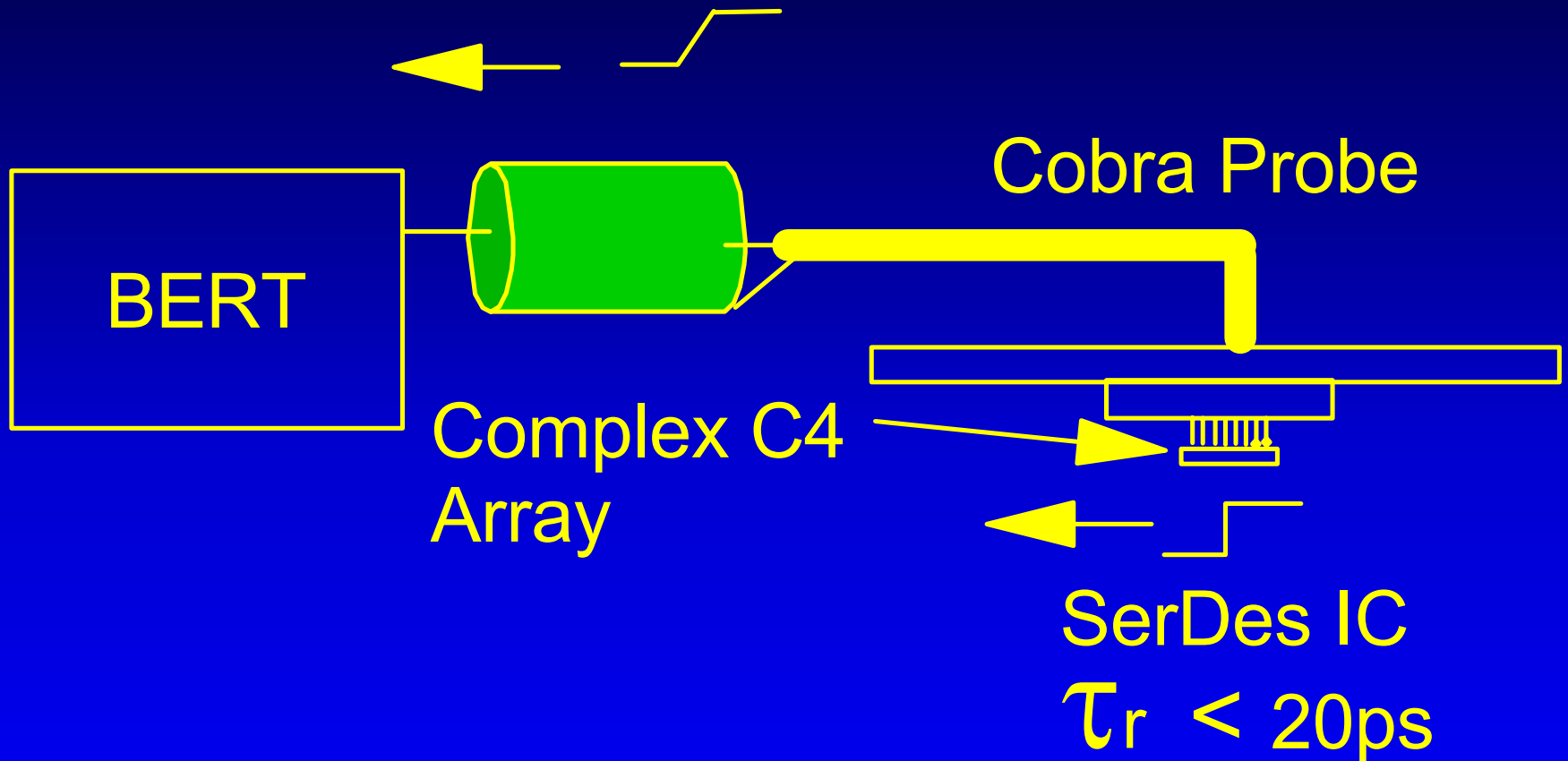


# Outline

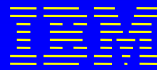
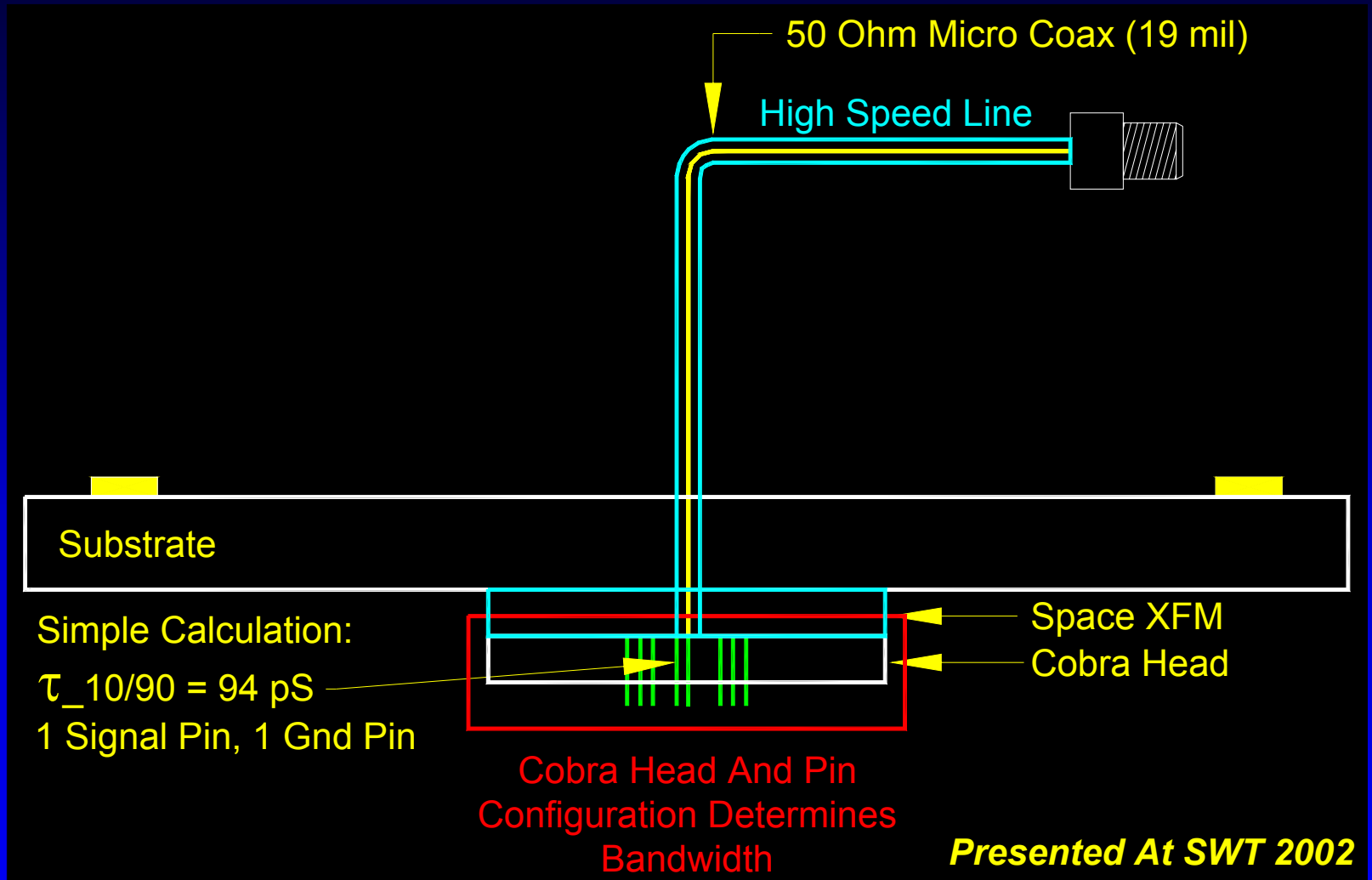
- Motivation: *What Is The Bandwidth Of A Cobra Probe Contactor?*
  - At Speed (10Gb/s And Higher) Test.
  - Inductance Of Power Connections.
- Impedance And Rise Time Calculations.
- Experiments.
  - Apparatus:
    - High Speed Space Transformer Using Micro-coaxial Cable (SWT 2002)
    - IBM Standard Cobra Head Contactor, 5 mil Probes.
  - Rise Time / Bandwidth Measurements.
  - Cross Talk Measurements.
- Conclusions.



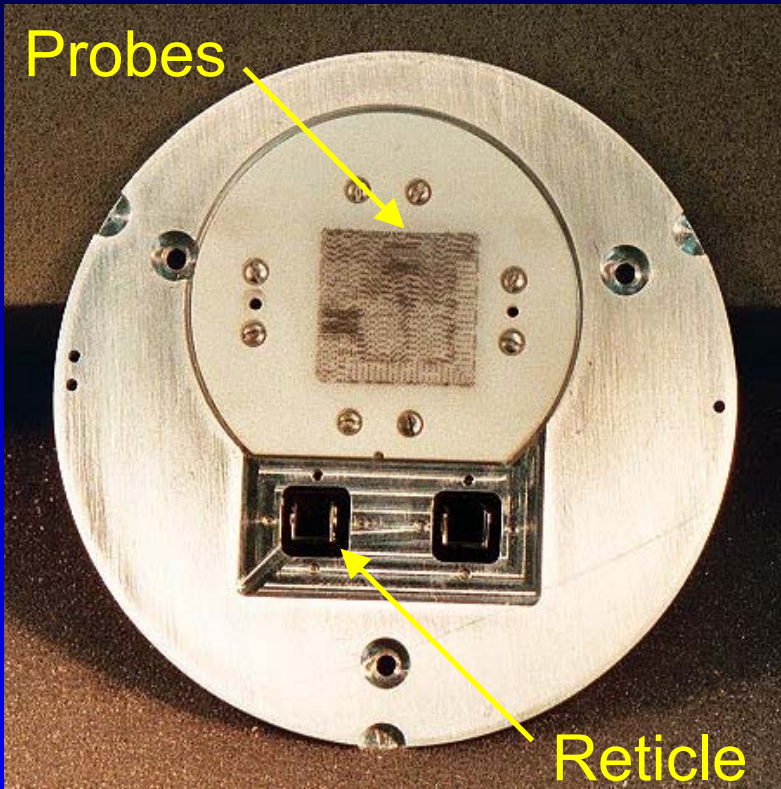
# Motivation: Wafer Level Test Of 10 Gb/s Serializer / Deserializer



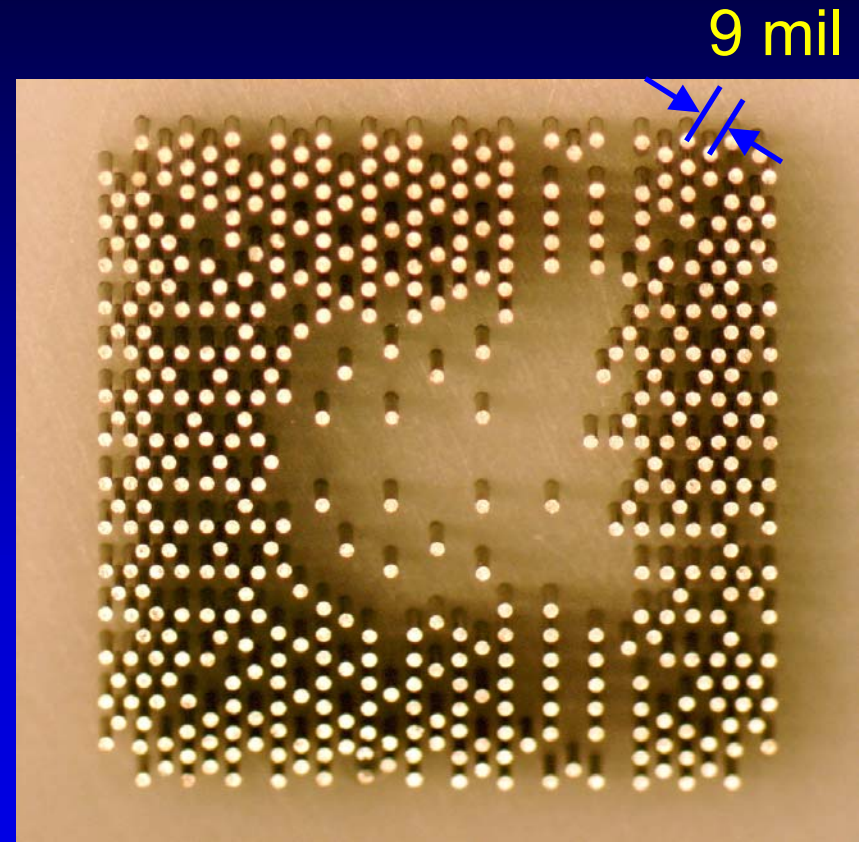
# High Performance Cobra Probe Card



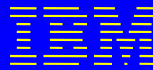
# Cobra Head Contactor



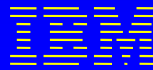
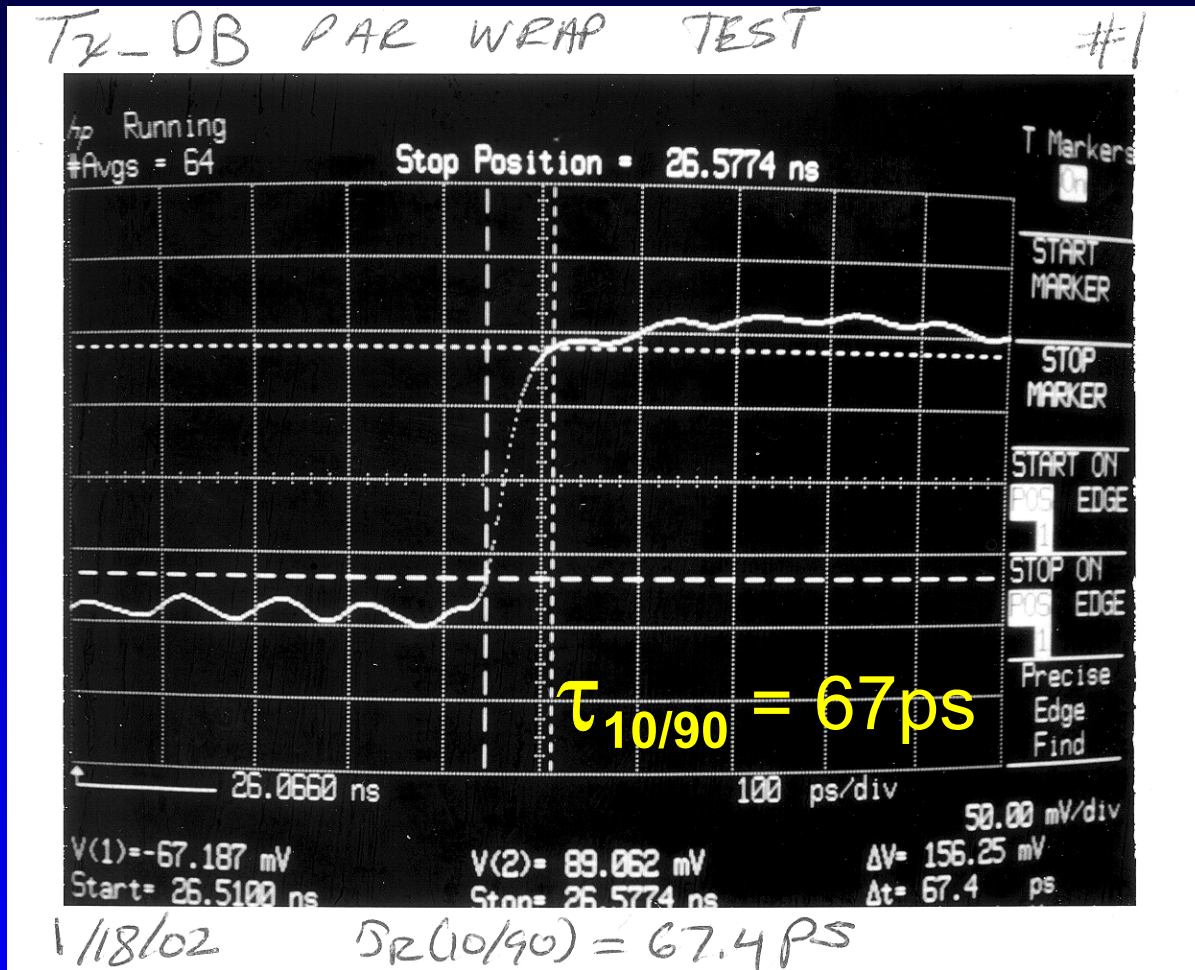
Cobra Head, Wafer Side



SerDes Probe Set



# SerDes Output Data (1 Signal / 1 Gnd)

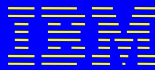


# Results Of SerDes Test

- Full Functionality At Wafer Level At Full Speed Of 10 Gb/s.
- Rise Time Less than Computed From Simple Model Of Cobra Head.

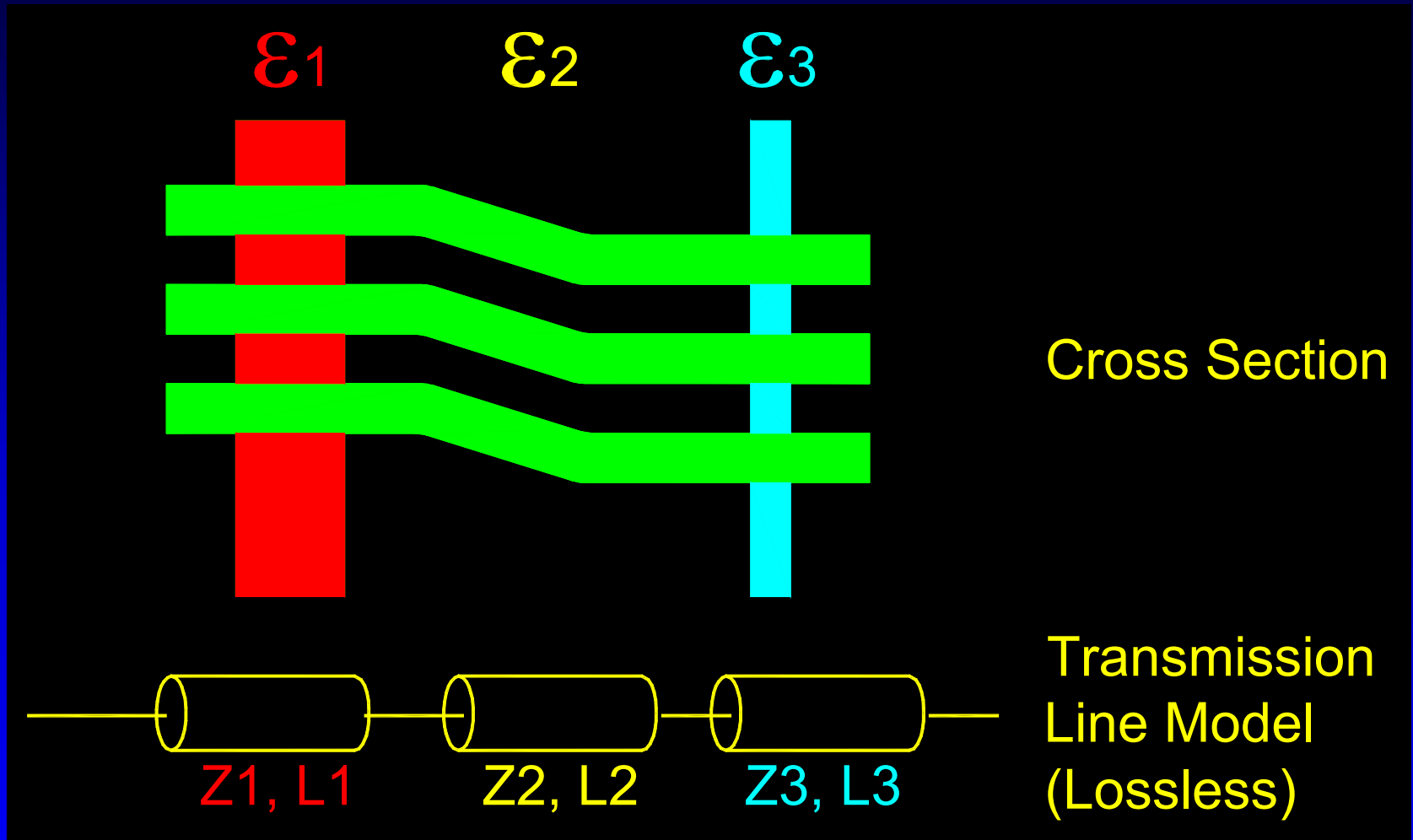


More Complex E-M Model Required To Predict Frequency Response Of Test Head



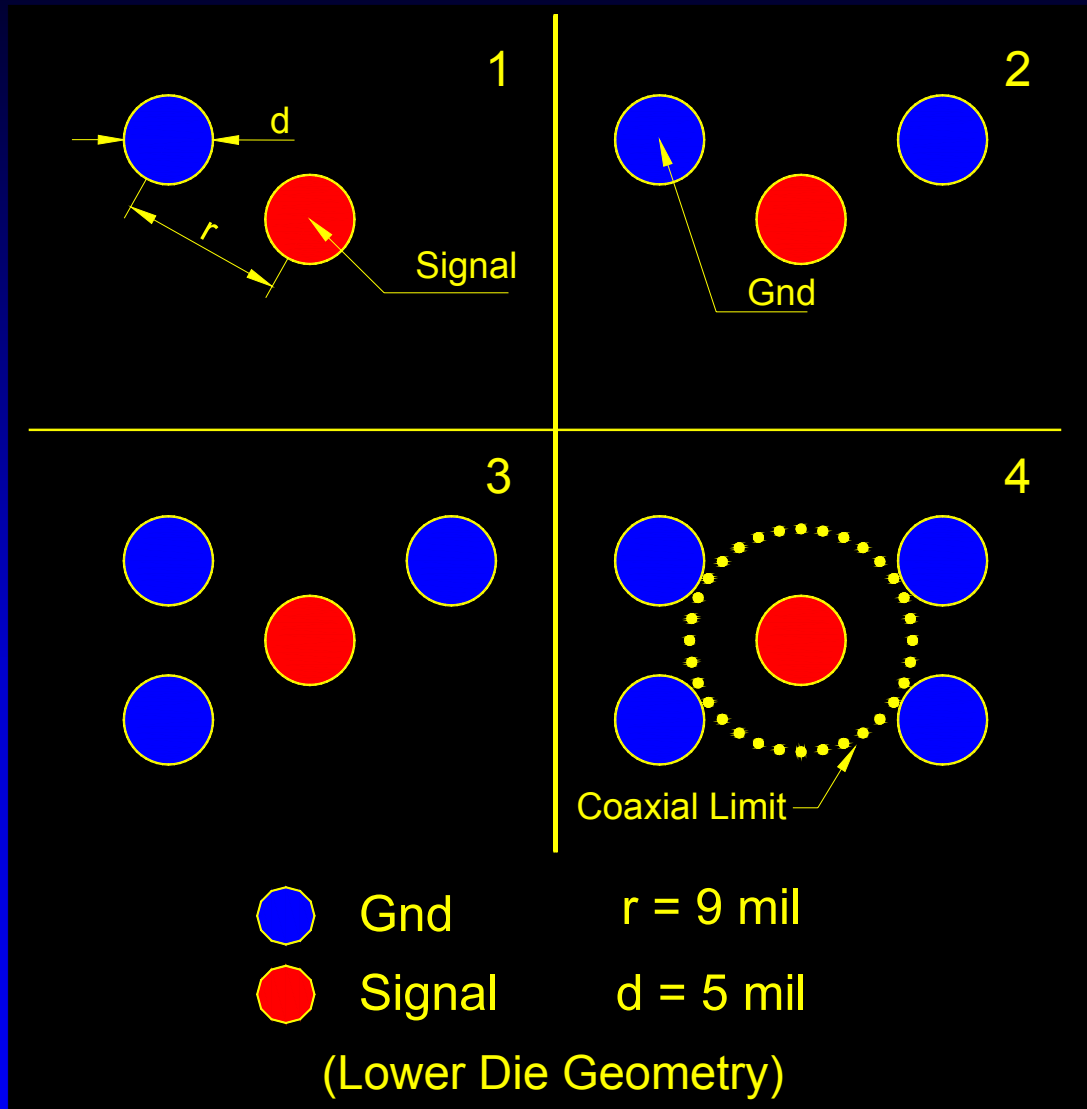


# Cobra Head Electrical Model

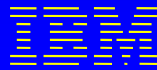
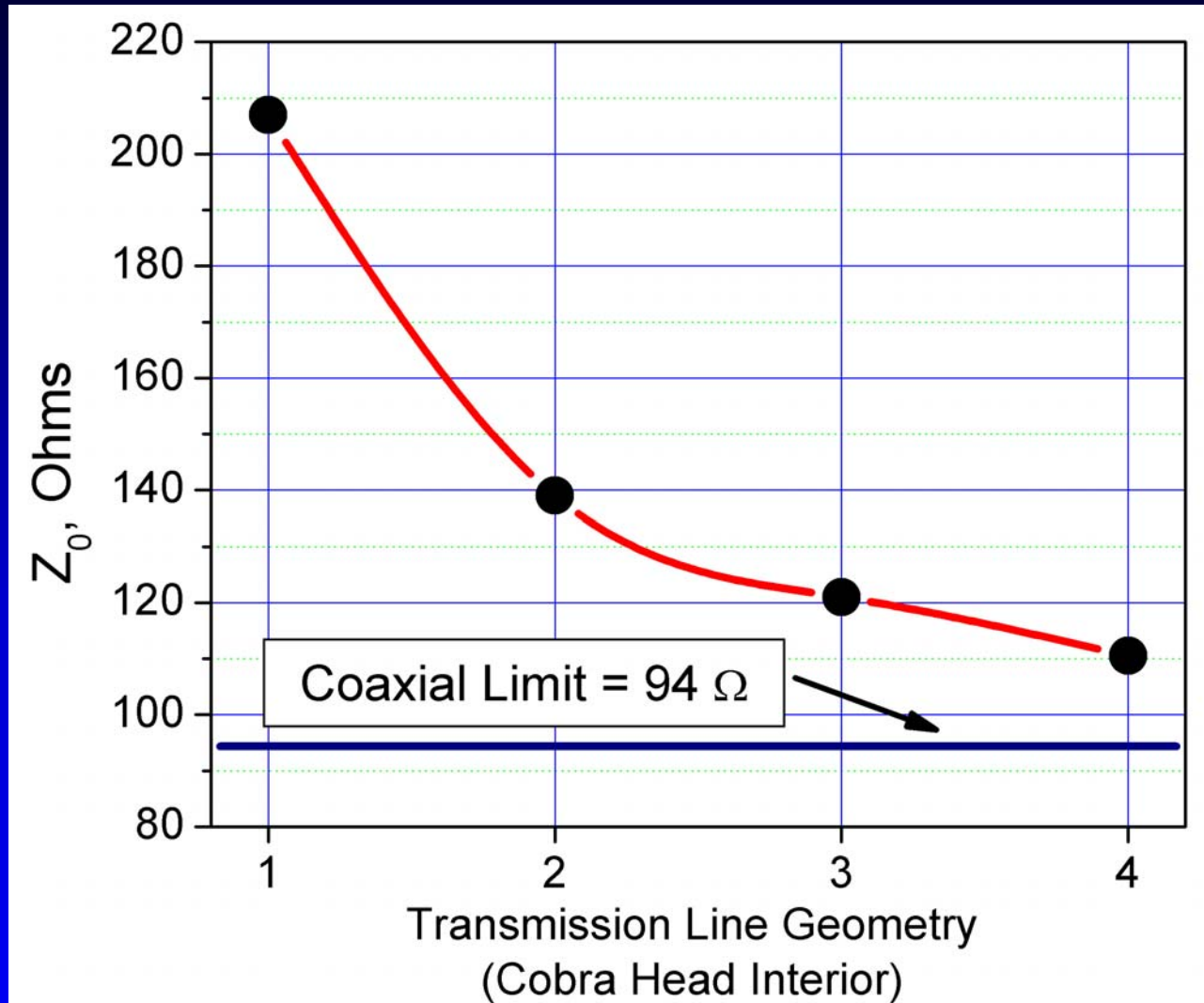




# Possible Contact Geometries



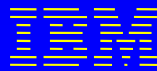
# Air Dielectric Impedance Calculation



# Impedance In Different Regions Of The Cobra Head

## Z0 vs. Geometry And $\epsilon$

Configuration	1	2	3	4	
$\epsilon$	1	207	139	121	111
	4.3	100	67	58	54
	6	85	57	49	45



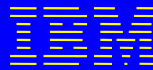
# Impedance, Capacitance And Inductance Summary

Z<sub>0</sub>, L, And C vs. Geometry For  $\epsilon = 1$

Configuration *	1	2	3	4
Z <sub>0</sub> From 2D Calculation $\Omega$	207.0	139.0	120.8	110.5
Z <sub>0</sub> From Approximation $\Omega$	206.8	n/a	n/a	n/a
Capacitance (F/m)	1.611E-11	2.401E-11	2.762E-11	3.019E-11
Inductance (H/m)	6.907E-7	4.635E-7	4.028E-7	3.686E-7

\* Inside Cobra Head

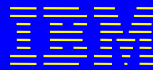
*C. Schuster, IBM Research*



# Simulated Rise Times

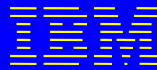
10% - 90% Rise Time vs. Geometry (50  $\Omega$  Load)

Configuration	1	2	3	4
$\tau$ (ps)	69	35	34	33

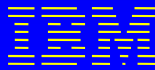
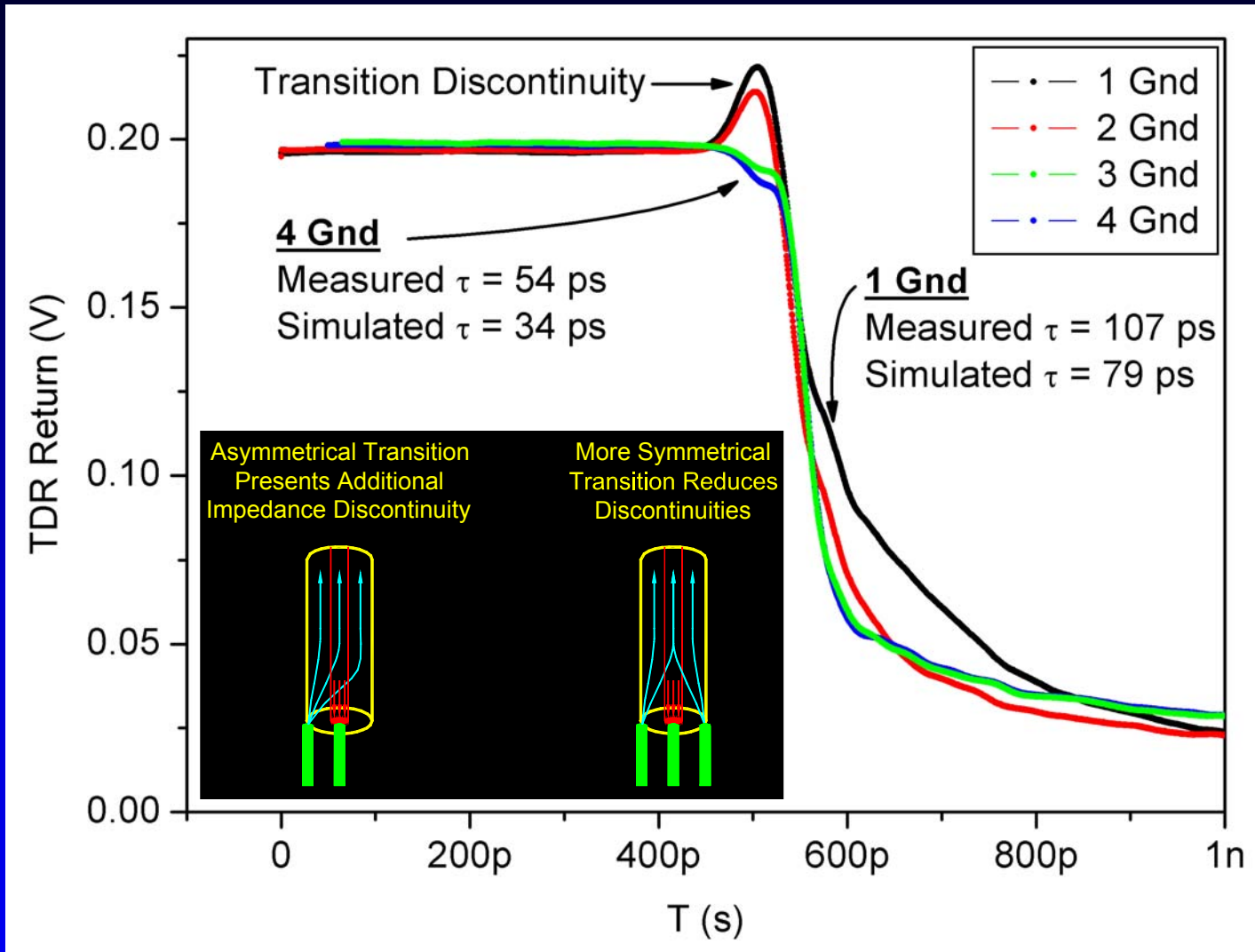


# Cobra Head Electrical Characterization (Single And Multi-Ground)

- TDR Into Short (Gold Ground Plane).
- Through Measurements Using CPW Connection Of Two Probe Sets.
  - TDT.
  - S21.
  - 12.5 Gb/s Eye Diagram,  $2^7-1$  PRBS.
- Cross talk.

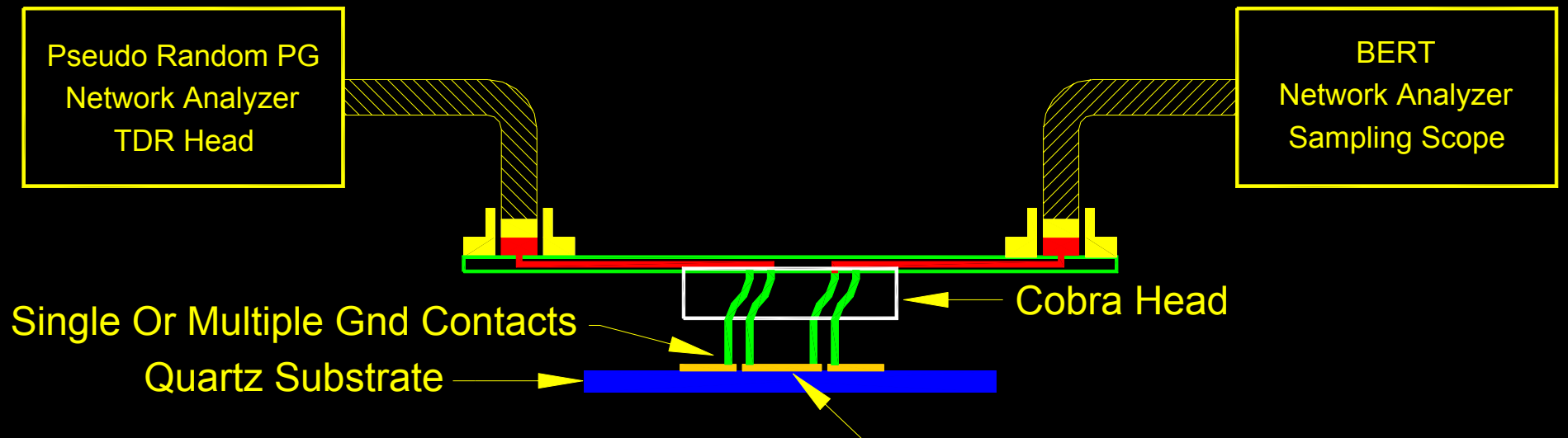


# TDR Into Short

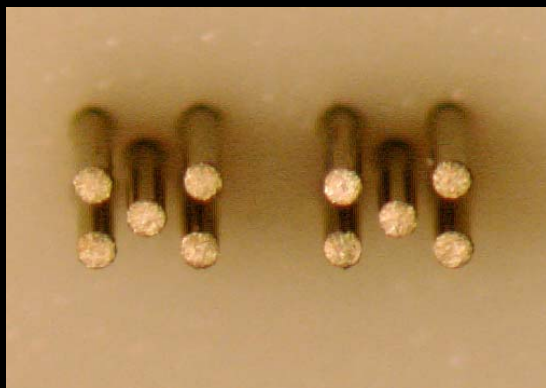




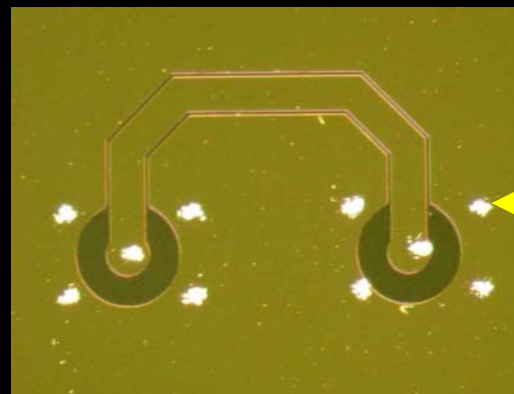
# Experimental Set Up For TDT And S21



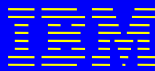
4 Gnd Probe Set



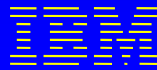
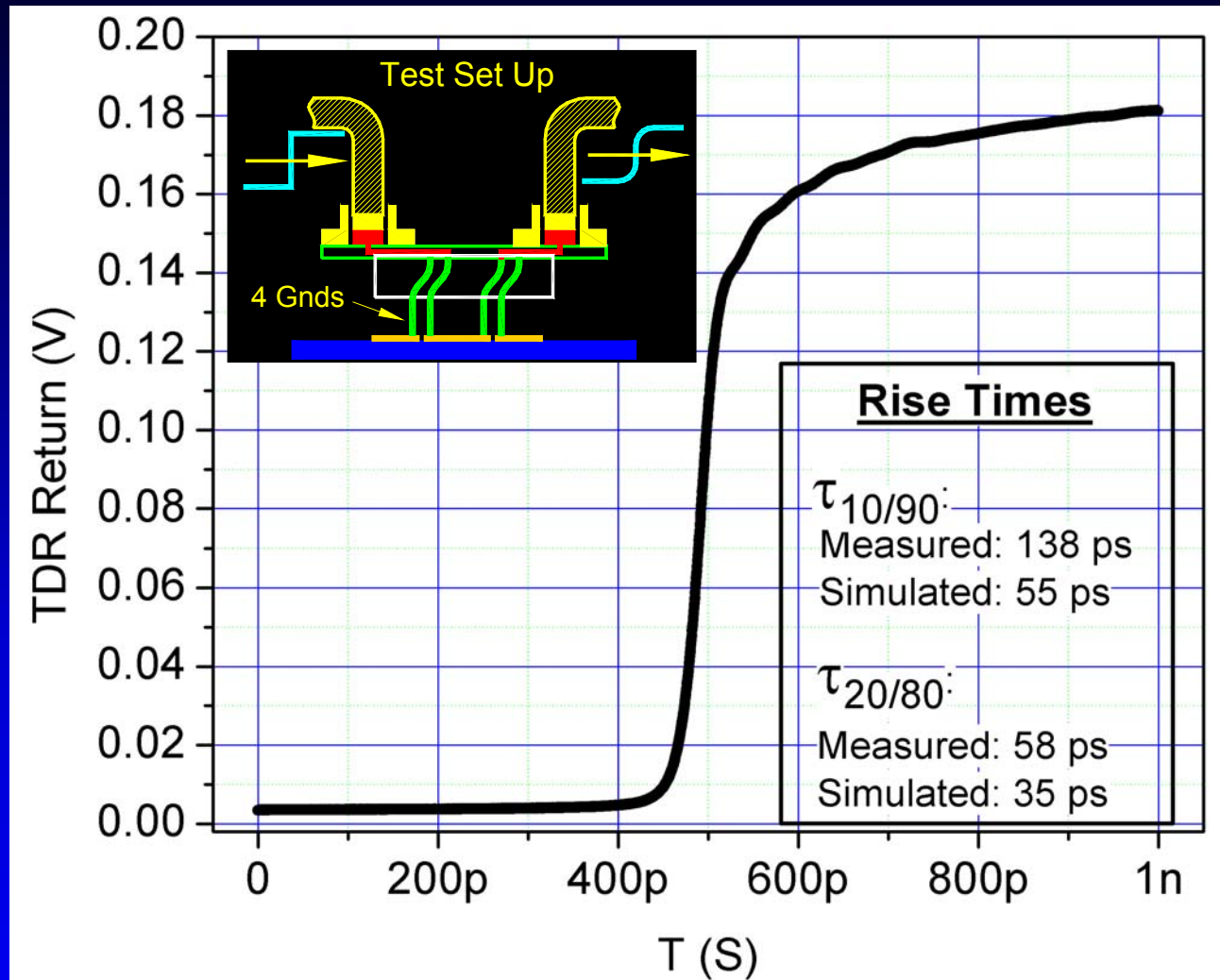
Top View Of CPW



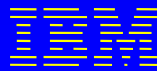
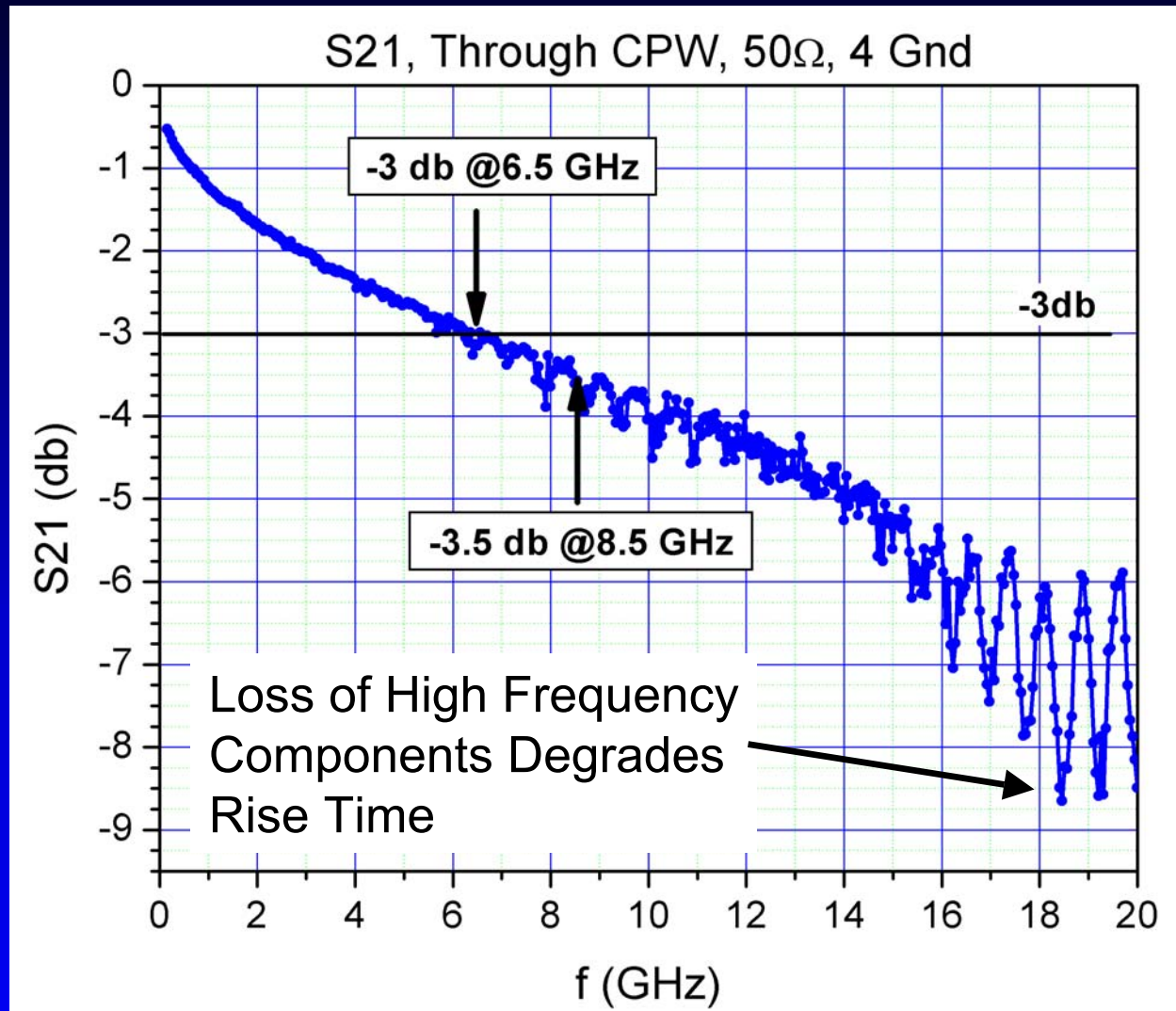
Probe Contact Mark



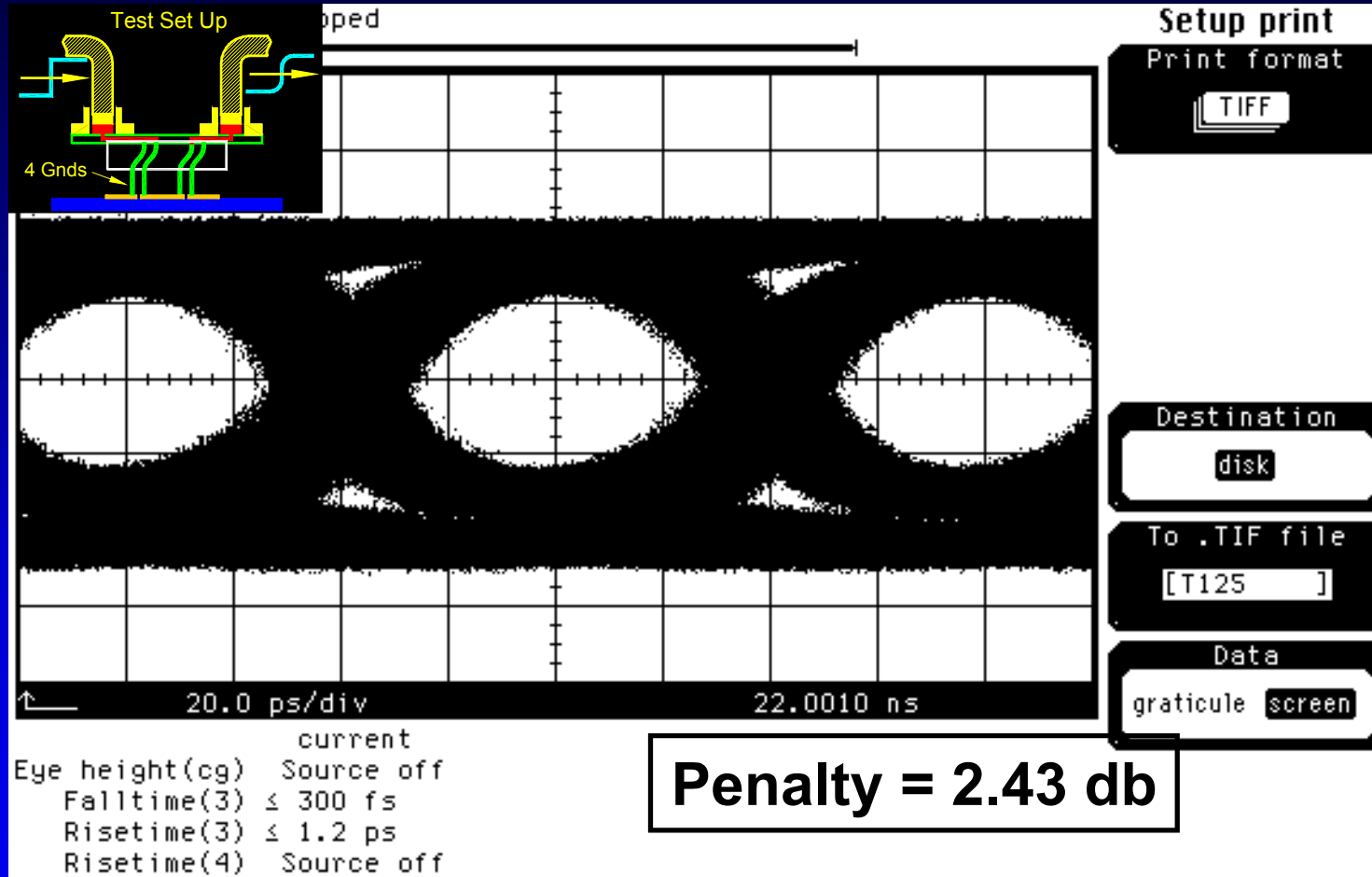
# TDT Through CPW, 4 Gnd / 3 Gnd



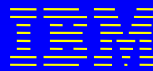
# S21 Through CPW, 4 Gnd / 3 Gnd



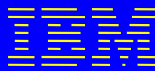
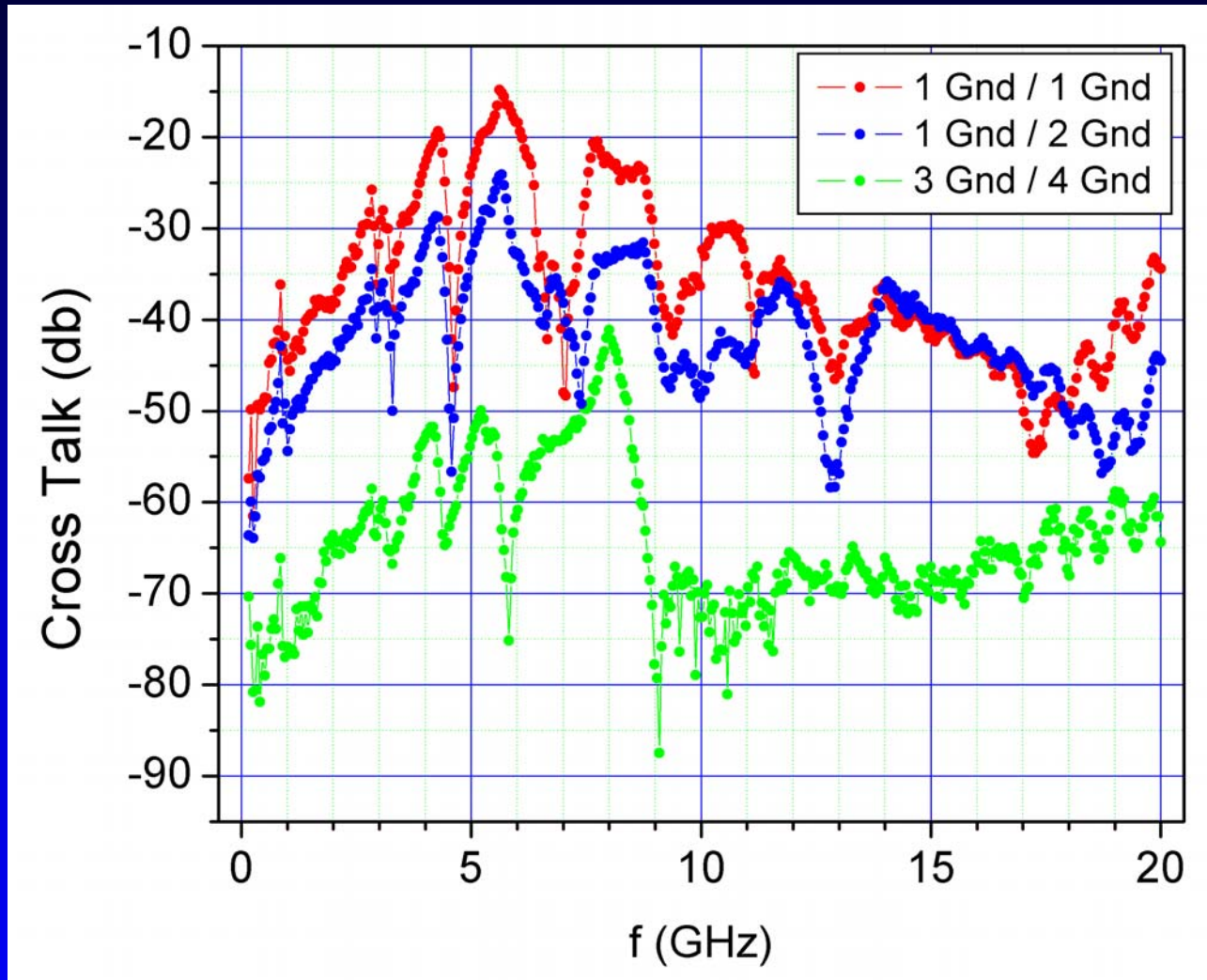
# 12.5 Gb/s Eye Diagram, 4 Gnd / 3 Gnd



*Petar Pepeljugoski, IBM Research*



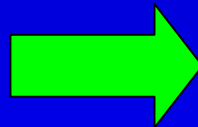
# Cross Talk Comparison



# Conclusion

- Demonstrated That A Conventional Cobra Probe Contactor When Used With A New High Performance Space Transformer Is Capable Of >12.5 Gb/s Test At Wafer Level With ISI Loss Penalty of 2.4 dB.
  - Connection To Chip Used Non-optimal Ground Configuration.
- Higher Speeds Possible With Optimized (4 Gnd) Connection To IC.
- Estimate Of Upper Speed Limit Based On TDR Data:

$$\tau_{10/90} = 56 \text{ ps}$$



$$18 \text{ Gb/s (1 Bit / } \tau \text{)}$$

