



5G over Cat 6 and Cat 5e

IEEE 802.3 NGEABT

Ramin Farjad (rfarjad at aquantia com)

Amrik Bains (ambains at cisco com)

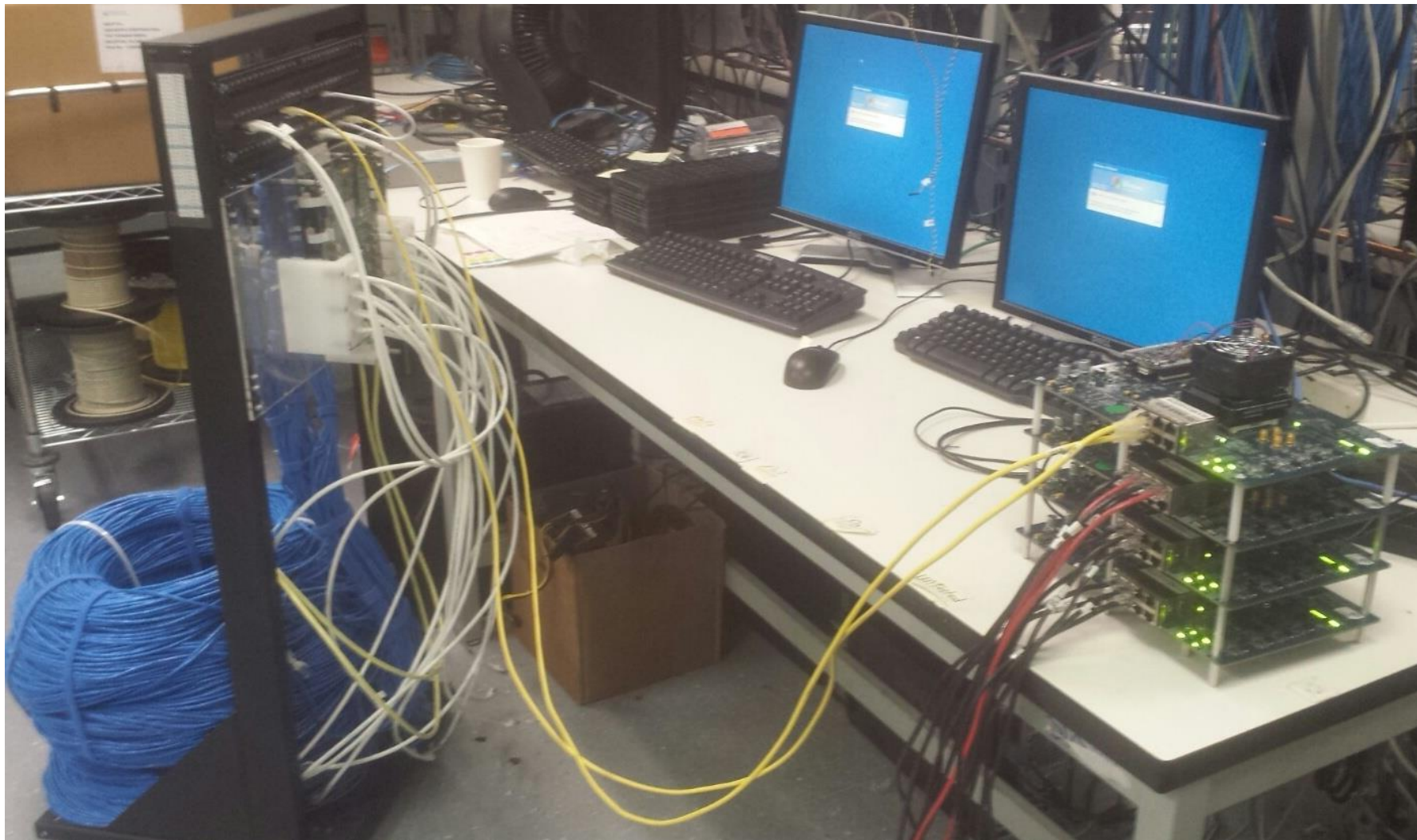
Background

- This deck presents the results of Phase 1 testing performed at PHY and System level for 5G over Cat6 and Cat 5e

Supporters

- David Chalupsky - Intel
- Clark Carty - Cisco
- Kamal Dalmia – Aquantia
- Peter Jones – Cisco
- Paul Langner – Aquantia
- Hossein Sedarat – Aquantia
- Ramin Shirani - Aquantia
- George Zimmerman – CME Consulting

- **PHY Test Setup: Cat5E Compliance Rack (Single Cable)**
 - Max length of Cat5e cable rack for 1GBASE-T testing: ~125m

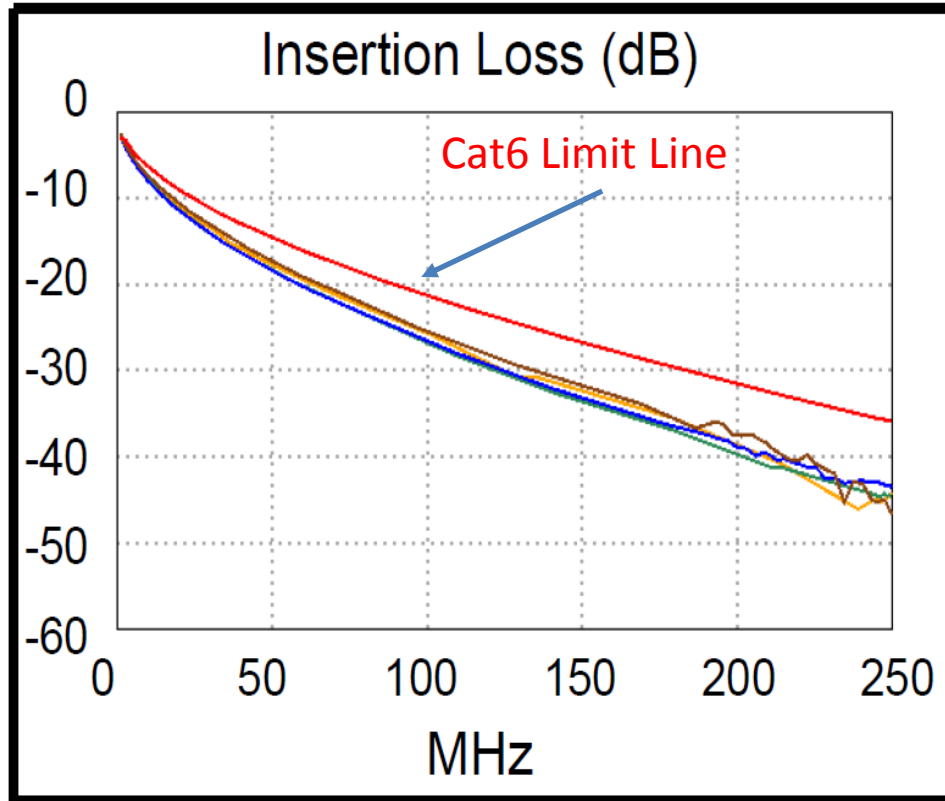
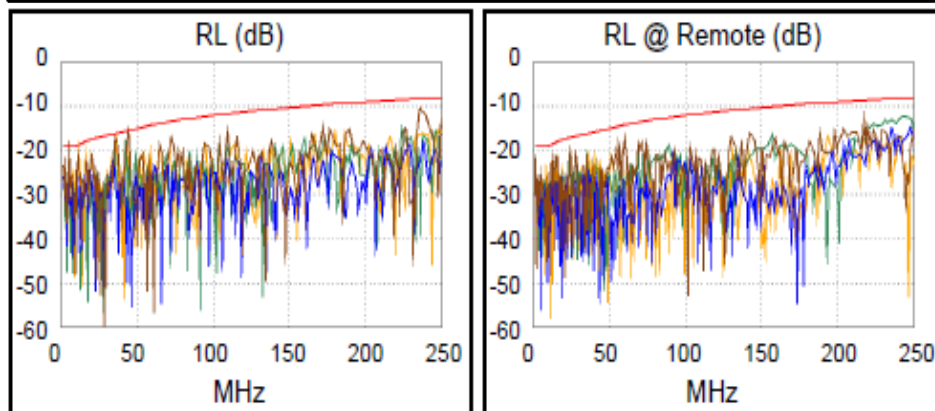


- **Cat5E 125m Single Cable Measurements:**

- Cable IL = 27.3dB@100MHz → IL Margin to Cat5E Limit= **-3.4dB**
- Cable IL = 45.3dB@250MHz → IL Margin to Cat6 Limit= **-9.3dB**
- Error free operation with BER<1E-12

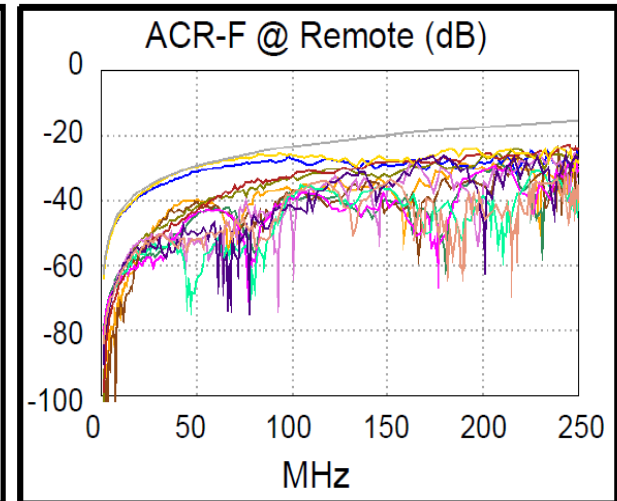
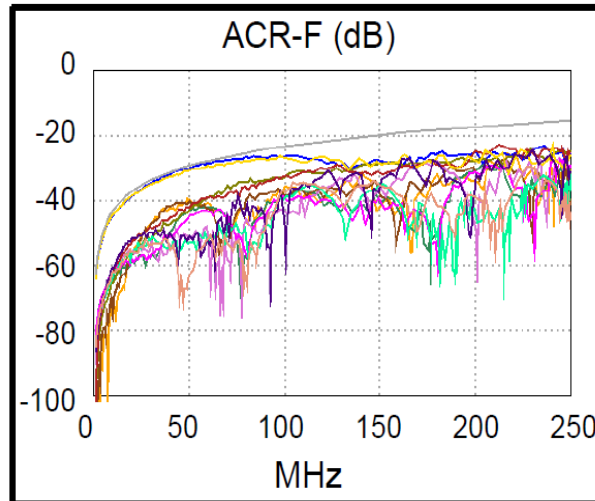
Length (m), Limit 100.0	[Pair 78]	125.4 F
Prop. Delay (ns), Limit 555	[Pair 45]	641 F
Delay Skew (ns), Limit 50	[Pair 45]	35
Resistance (ohms)	[Pair 45]	23.9

Insertion Loss Margin (dB)	[Pair 12]	-13.3 F
Frequency (MHz)	[Pair 12]	240.5
Limit (dB)	[Pair 12]	35.1

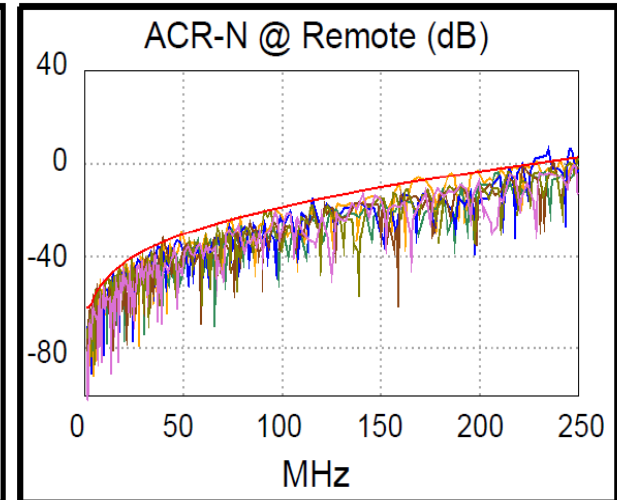
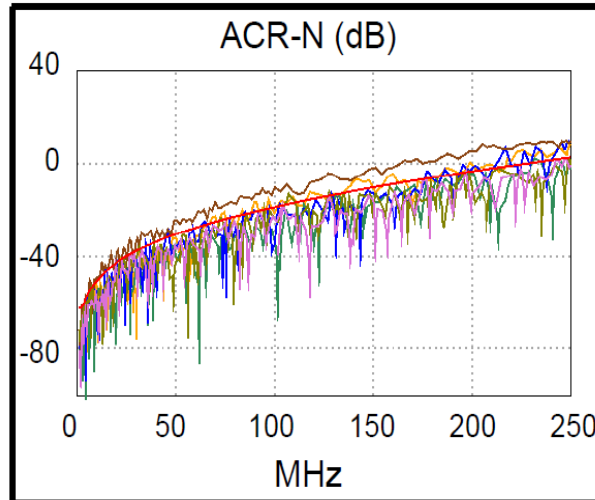


- **Single 125m Cat5E: Attenuation to Crosstalk Ratio (ACR)**
 - Versus Cat6 Crosstalk Limit Lines

• **IL to FEXT Ratio** →
Marginal to Limit line



• **IL to NEXT Ratio** →
Violating Limit Line

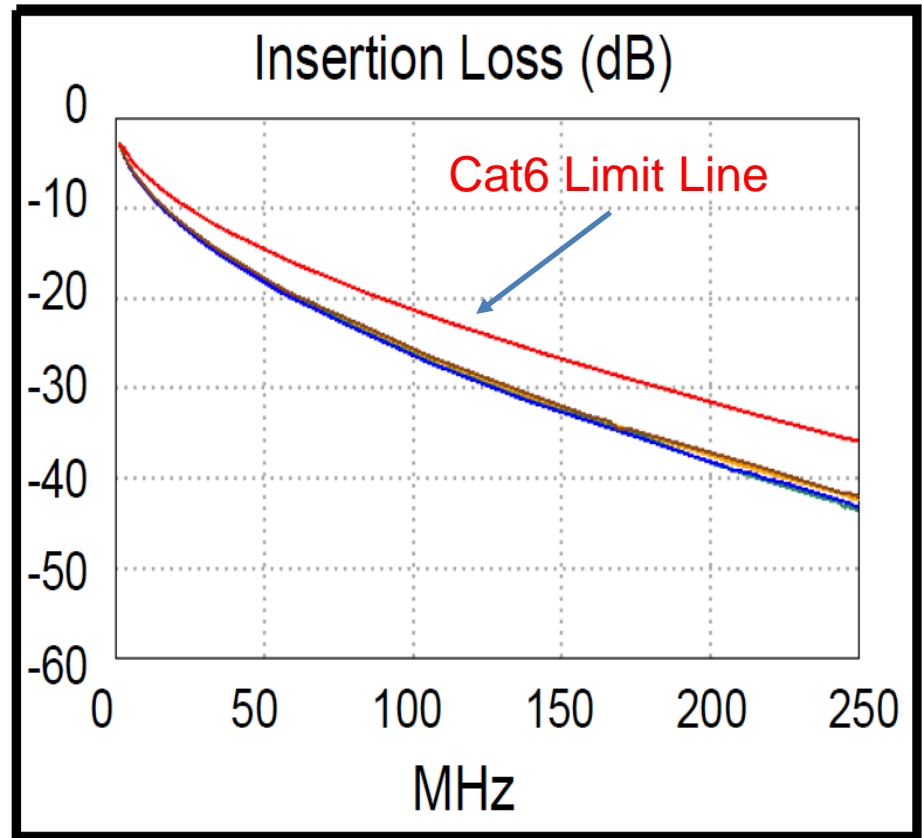
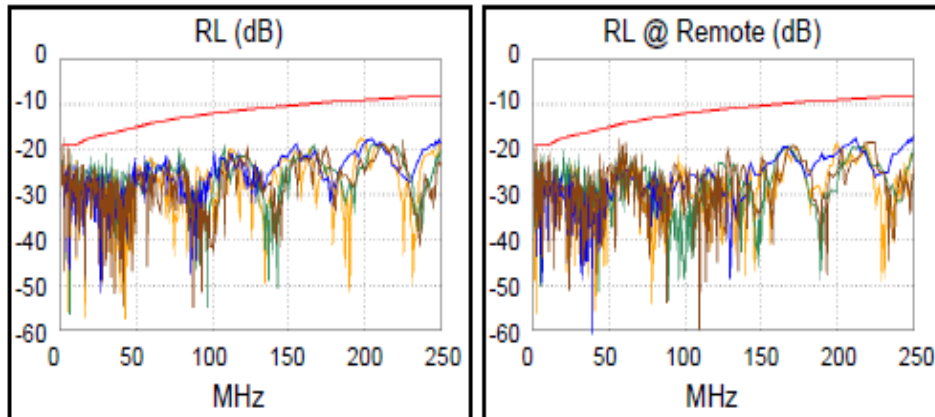


- **Cat6 ~135m Single Cable Measurements**

- Cable IL = 43.8dB @250MHz → IL Margin to Cat6 Limit=-7.8dB
- Error free operation with BER<1E-12

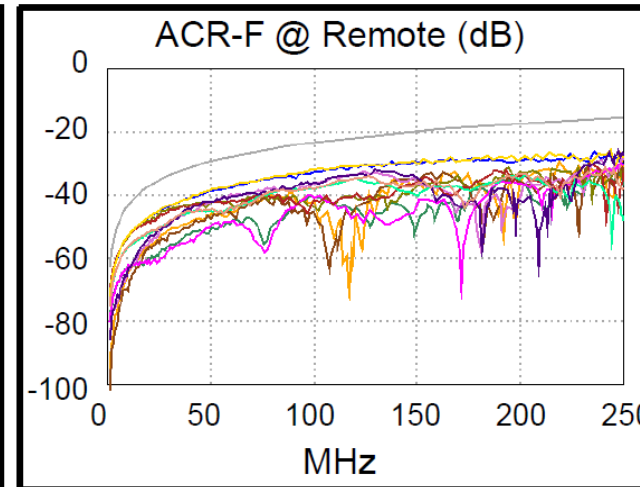
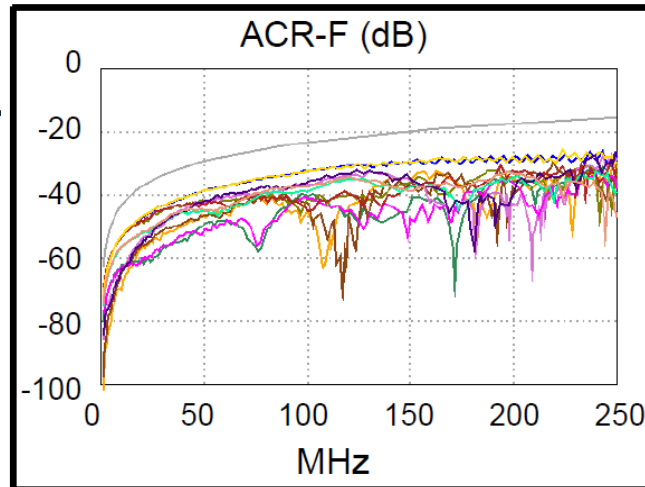
Length (m), Limit 100.0	[Pair 78]	136.9F
Prop. Delay (ns), Limit 555	[Pair 45]	696F
Delay Skew (ns), Limit 50	[Pair 45]	34
Resistance (ohms)	[Pair 45]	23.2

Insertion Loss Margin (dB)	[Pair 36]	-7.8F
Frequency (MHz)	[Pair 36]	245.0
Limit (dB)	[Pair 36]	35.5

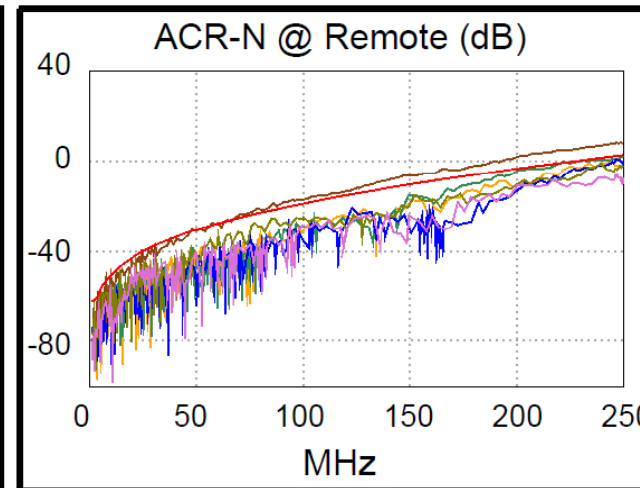
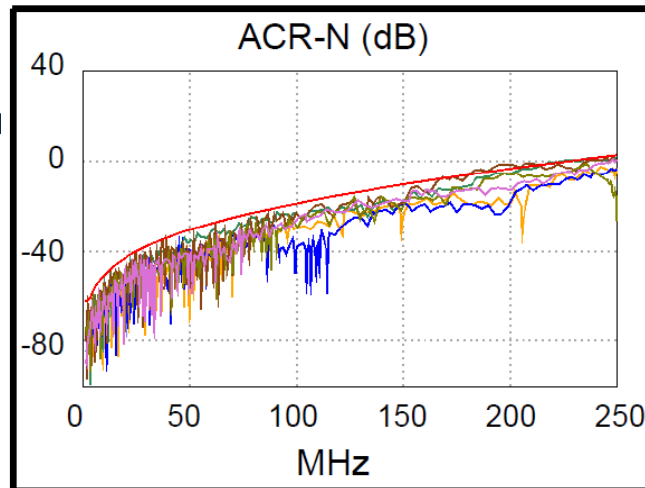


- **Single 135m Cat6: Attenuation to Crosstalk Ratio (ACR)**
 - Versus Cat6 Crosstalk Limit Lines

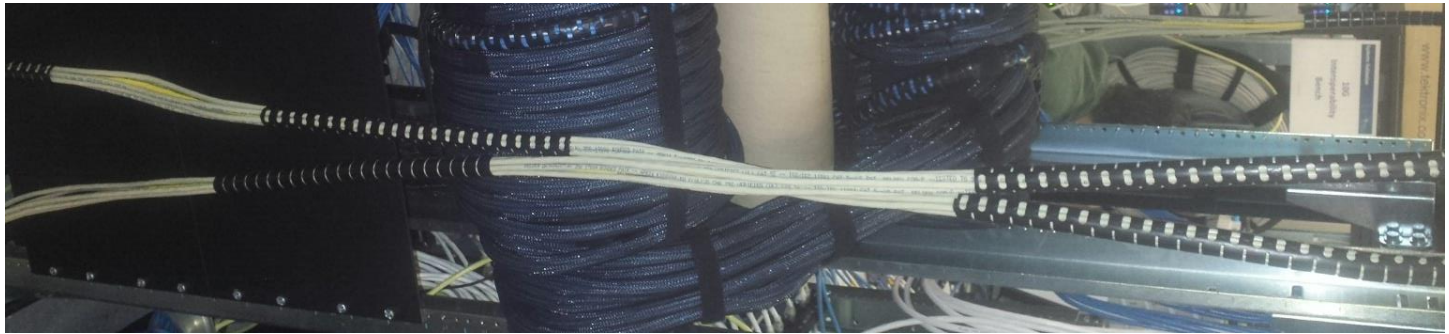
• **IL to FEXT Ratio** →
Good Margin to Limit



• **IL to NEXT Ratio** →
Violating Limit Line



- **100m Cat5E (6around1) Cable Setup**
- **A realistic implementation of WAP application in commercial buildings:**
 - **10m (bundled): Strapped every 1ft**



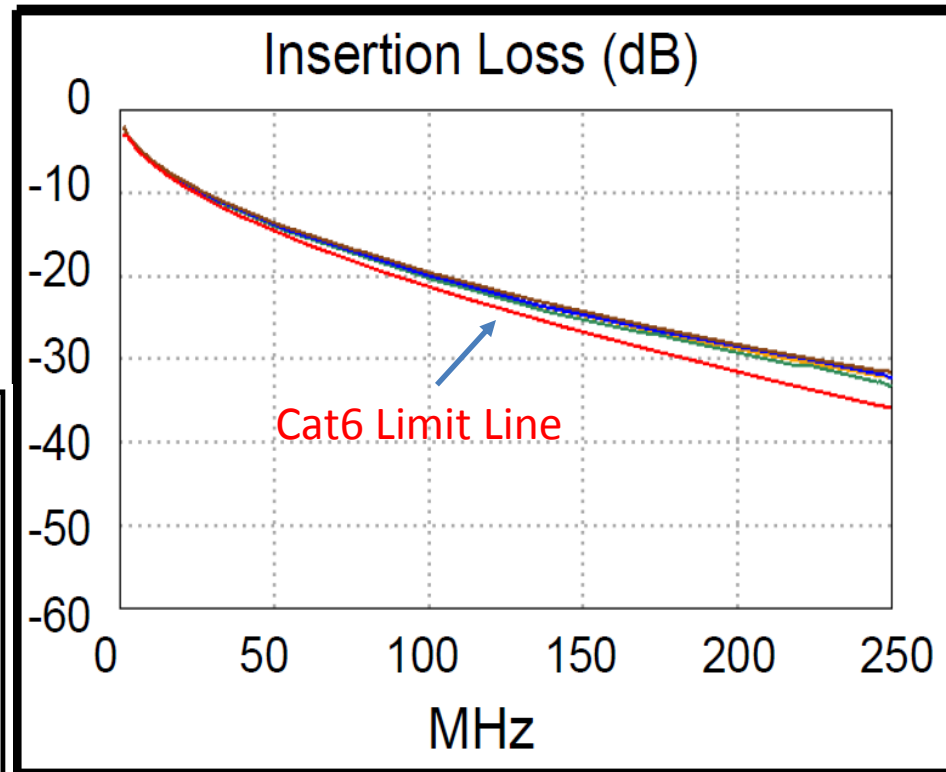
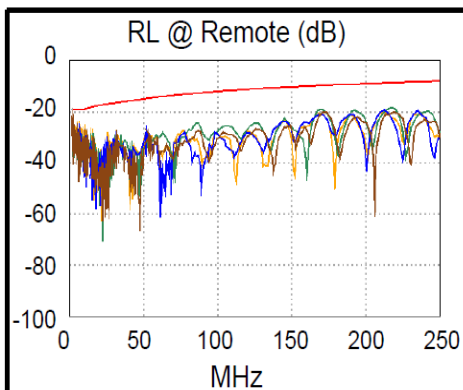
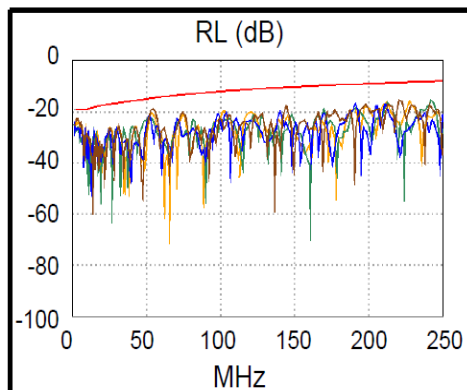
- **90m (unbundled)**



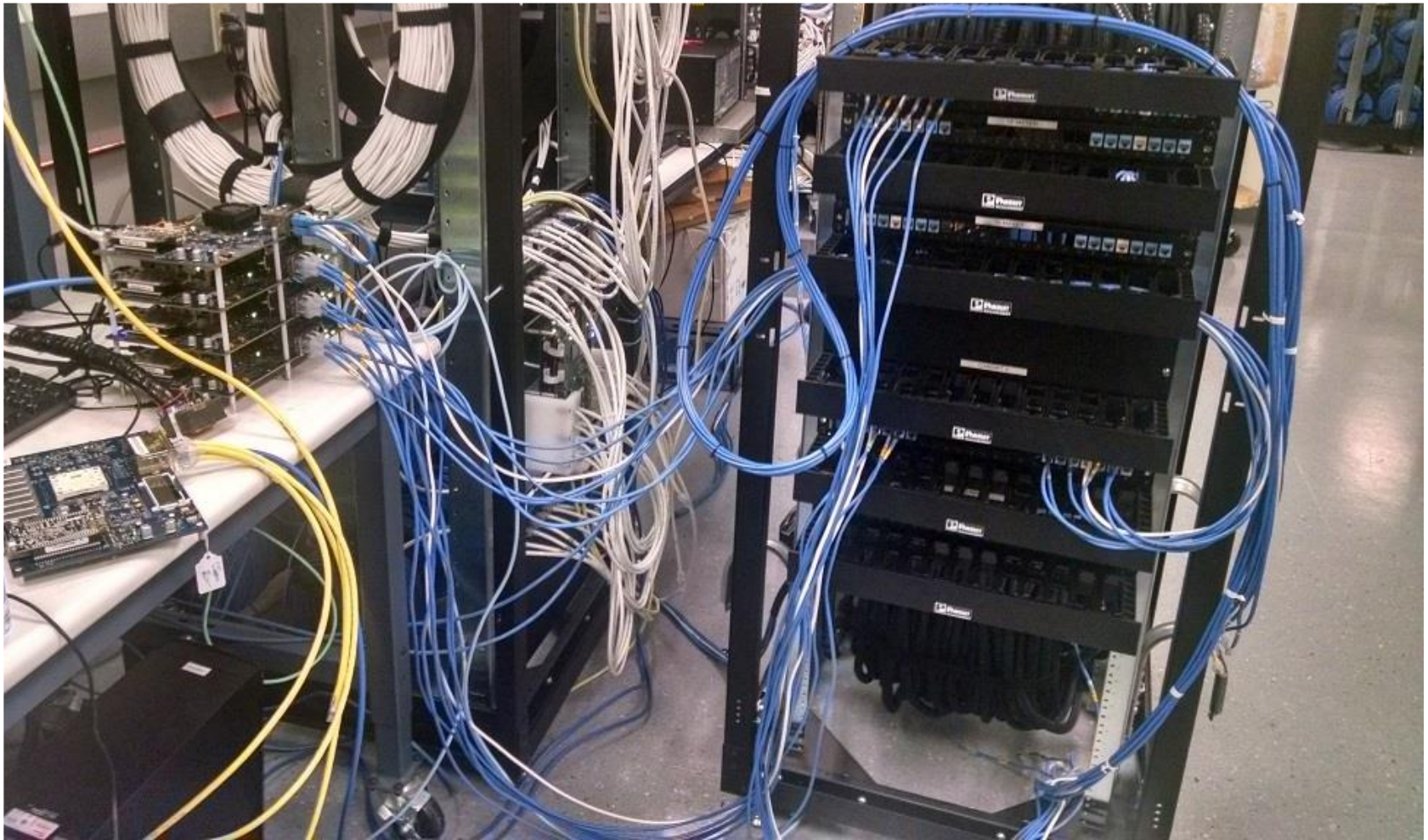
- Cat5E 100m 6around1 Measurements:
 - Cable IL = 20.5dB@100MHz & 33.4dB@250MHz
 - Error free operation with BER<1E-12

Length (m), Limit 100.0	[Pair 78]	100.5
Prop. Delay (ns), Limit 555	[Pair 36]	495
Delay Skew (ns), Limit 50	[Pair 36]	9
Resistance (ohms)	[Pair 45]	18.2

Insertion Loss Margin (dB)	[Pair 36]	2.6
Frequency (MHz)	[Pair 36]	250.0
Limit (dB)	[Pair 36]	35.9



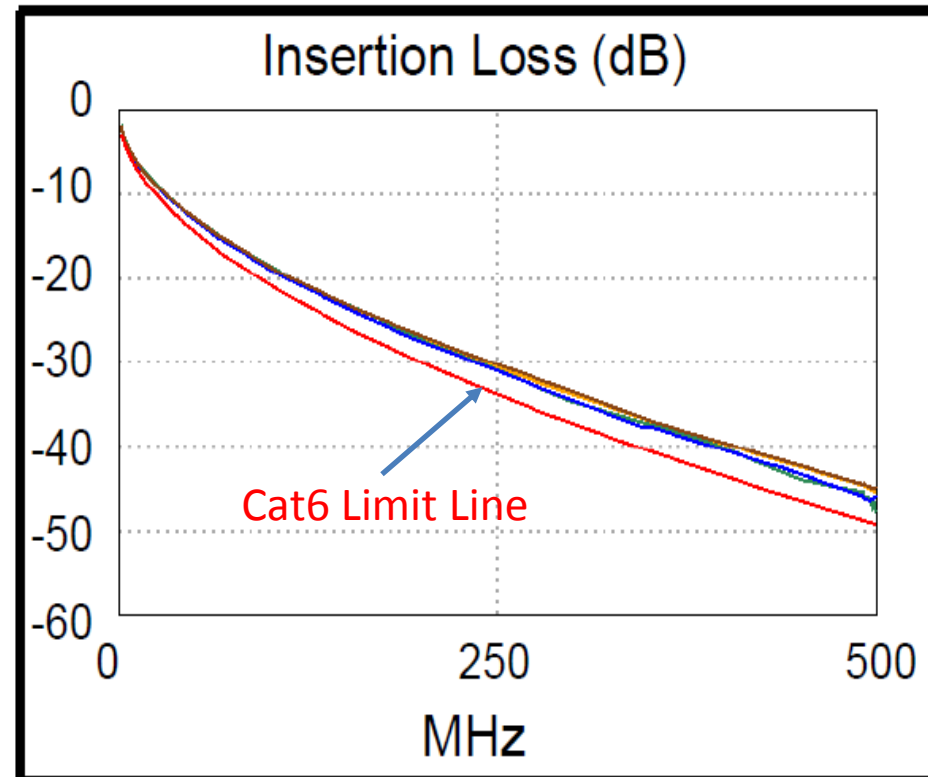
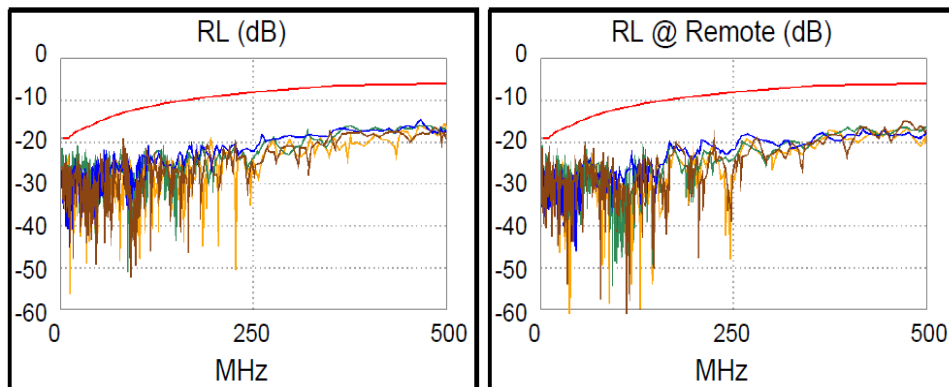
- **PHY Test Setup: Cat6 6around1 Cable Rack**
 - 100m 6around1= 96m (bundled) + 4m (unbundled)



- Cat6 100m 6around1 Measurements:
 - Cable IL = 31.8dB@250MHz
 - Error free operation with $BER < 1E-12$

Length (m), Limit 100.0	[Pair 78]	101.4
Prop. Delay (ns), Limit 555	[Pair 45]	520
Delay Skew (ns), Limit 50	[Pair 45]	24
Resistance (ohms)	[Pair 78]	16.8

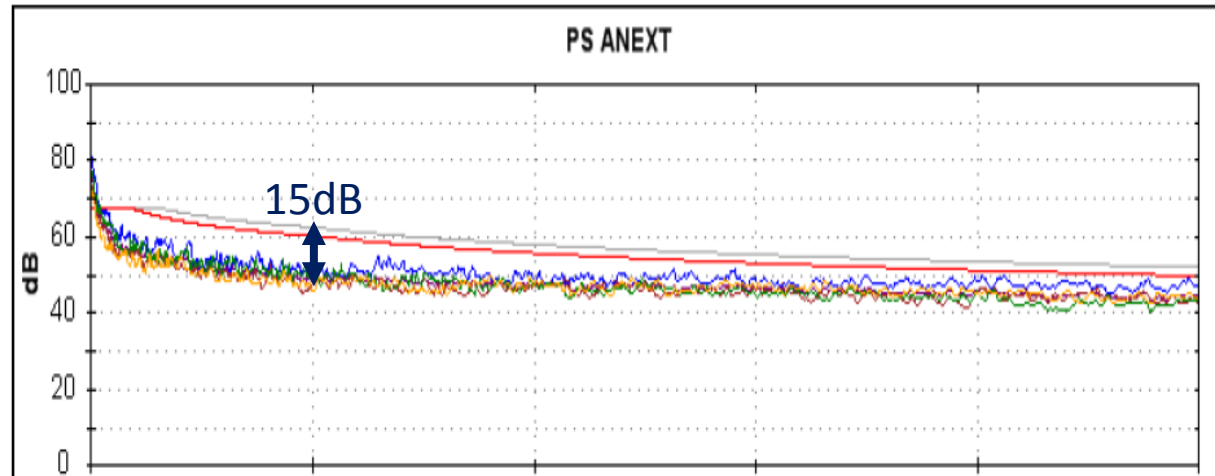
Insertion Loss Margin (dB)	[Pair 36]	1.5
Frequency (MHz)	[Pair 36]	500.0
Limit (dB)	[Pair 36]	49.3



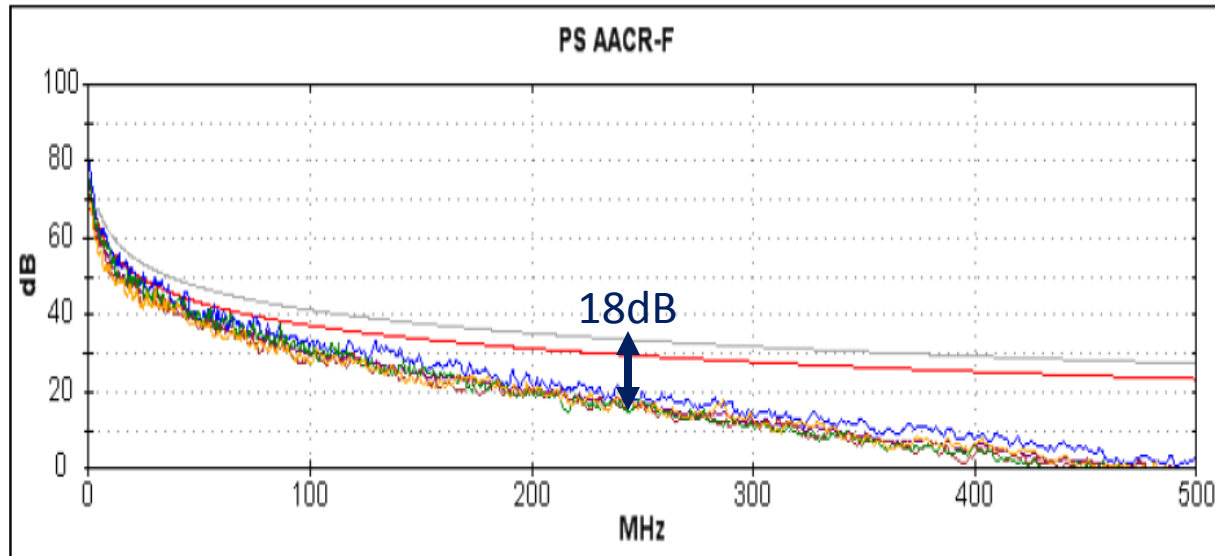
Next Generation Enterprise BASE-T Access

- Alien Crosstalk for Cat6 100m 6around1 under test
 - Versus 10GBASE-T Alien Crosstalk Limit Lines

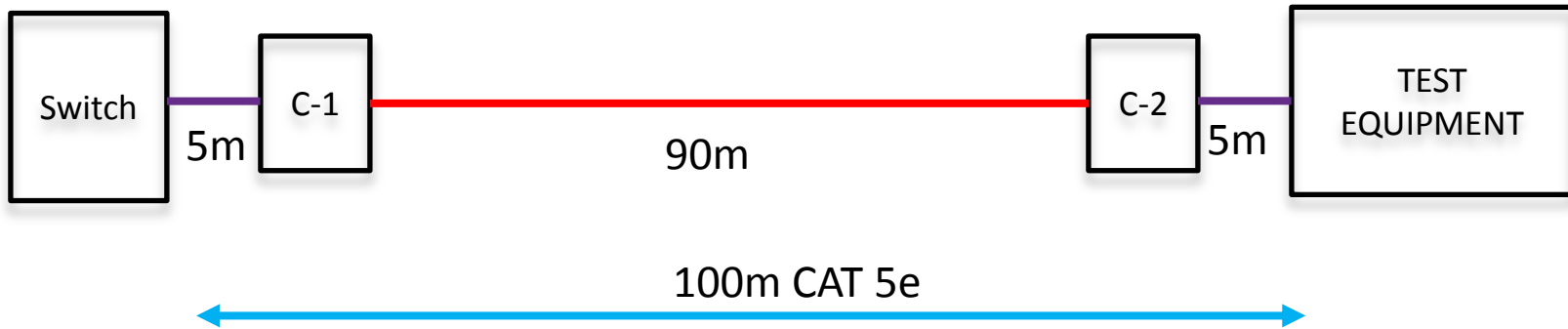
• **ANEXT Loss →**
~15dB > 10G limit line



• **AFEXT Loss-IL →**
~18dB > 10G limit line



- System Test Setups



Test completed: IEEE802.3 Figure 40A-2

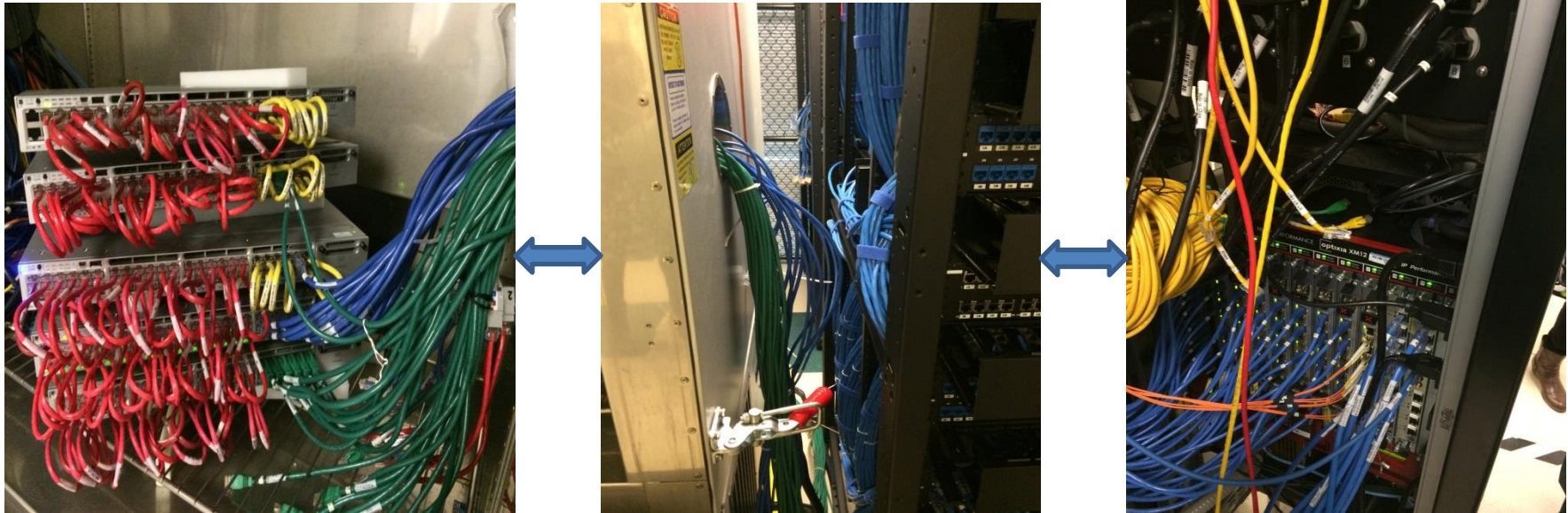
- Phase 1: IEEE 1000BASE-T configuration

Test Conditions

- Voltage/Temperature
 - Voltage: Nominal, +2.5% and -2.5%
 - Temperature (System Ambient): -5C, 25C and 55C
- 30W and 60W PoE
- Various Single Cable

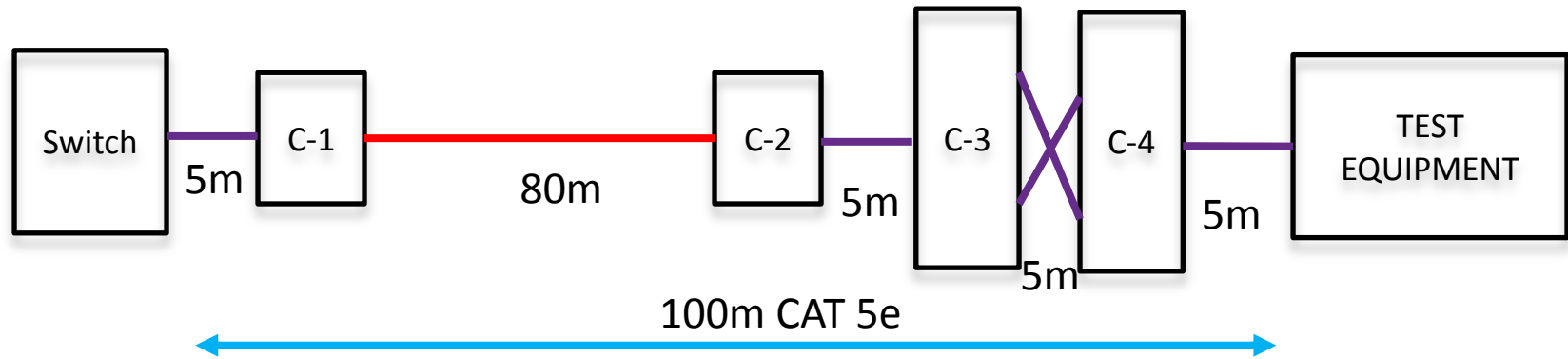
System Measured Results

- Multiple Test using various single Cat 5e cables
- 9 hours test while temperature /voltage cycling
- Various packet size from 64Bytes to 10KBytes



- BER performance $< 1.0 \times 10^{-12}$

Test Setup: Next Step - Phase 2



Test pending: IEEE802.3 Figure 40A-1

- Phase 2 Test underway with 6-around-1 with same assumptions as 10G alien-crosstalk consideration for Cat 5e and Cat 6 at 5G. Result should be available before March Plenary

Summary

- Current simulations and measurement show that 5G over Cat 5e is doable under certain configurations
- Our recommendation is that NGEABT to further investigate use cases and specify channel specification for 5G over Cat 5e and Cat 6 operation

THANK YOU!