

# Alien Crosstalk and Equiv AWGN Testing/models

**G. Zimmerman – SolarFlare Communications**

**Jose Tellado – Teranetics**

**Paul Kish – Belden CDT**

**Chris DiMinico – MC Communications**

**Terry Cobb - SYSTIMAX**

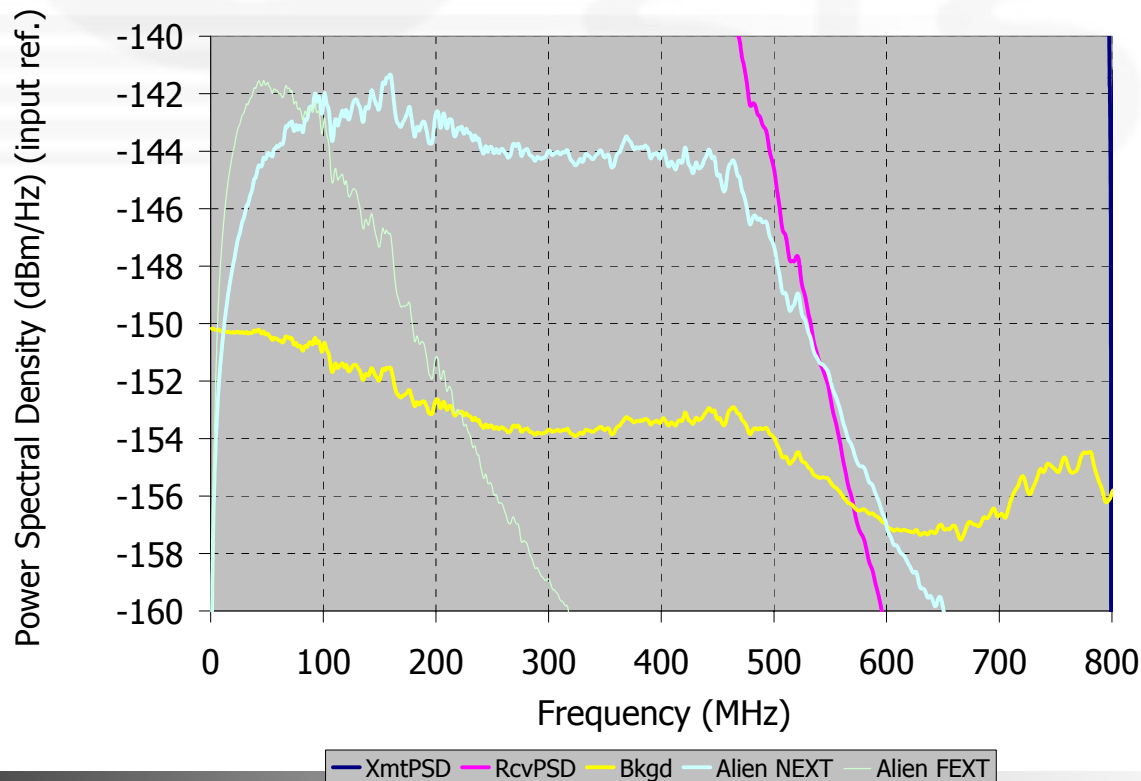
**IEEE P802.3an, 26-28 January 2005**

# Specifying the Channel

- 🚚 What is the Channel to be specified in IEEE?
  - 🚚 Transmission parameters and Coupling paths for the signal transmitted in a 10GBASE-T link (IL, RL, NEXT, FEXT)
  - 🚚 Noise environment in which that signal is to be received
- 🚚 Example Alien crosstalk noise spectra
  - 🚚 Addition of AFEXT on Models 1 & 2
- 🚚 Alien Crosstalk in mixed 1G/10G environments
  - 🚚 Implications for Power Backoff in Cat6
- 🚚 Conclusions on testing and specification

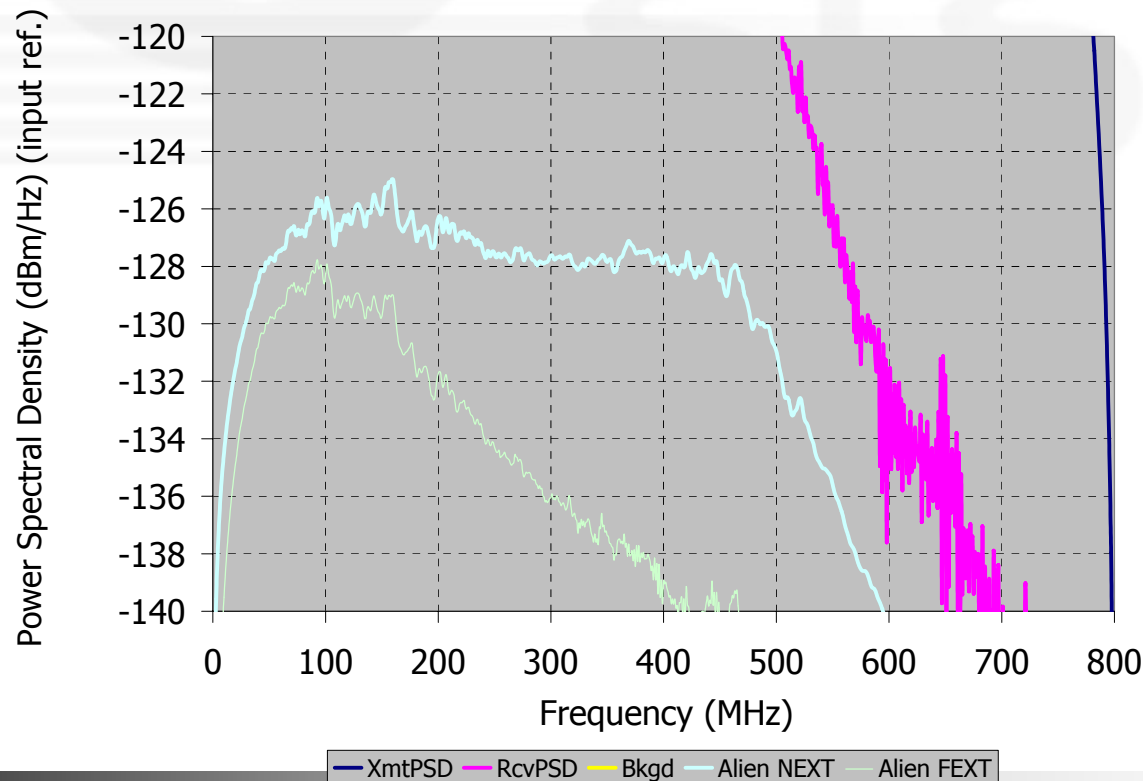
# Alien Crosstalk, 100m Model 1

- 5 dBm TX power, 60 dB PSANEXT loss min at 100 MHz
- 40 dB PSAELFEXT loss min at 100 MHz and 100m
- Average levels, 2.5 dB lower, shown



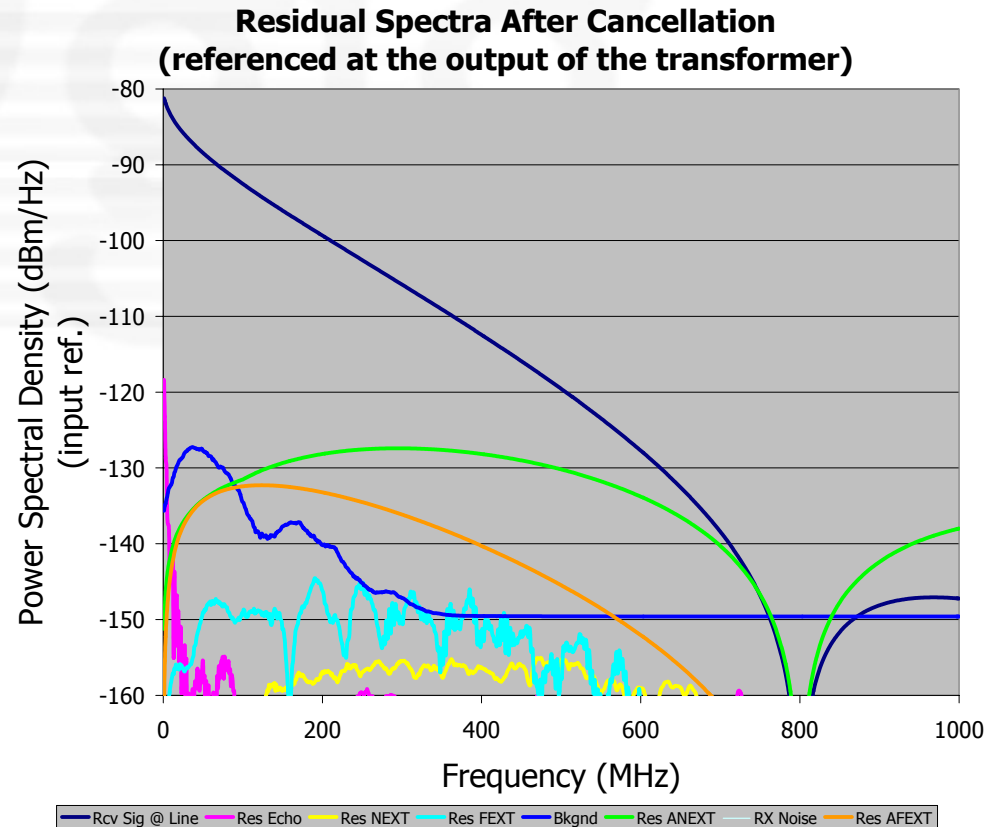
# Alien Background, 55m Model 2

- 🚗 5 dBm TX power, 47 dB PSANEXT loss min at 100 MHz
- 🚗 33 dB PSAELFEXT loss min at 100 MHz and 100m (55m=35.6 dB)
- 🚗 Average levels, 2.5 dB lower, shown
  - 🚗 Results are scaled for 55m Cat 6 line



# Model 2: 55m Cat 6, Mixed Xtalk




- Half 10G, Half 1000BASE-T Disturbers
- 1000 BASE-T crosstalk based on data-center measurements
  - Scaled to represent PSANEXT/PSAFEXT specs under discussion
- 10GBASE-T Crosstalk
  - Scaled -1.8 dB for half-fill
  - 5 dBm TX power



# Limitations on Power Backoff

- 🔌 1000BASE-T source limits power backoff
- 🔌 PSANEXT of the max level transmitter must be tolerated
  - 🔌 PSAFEXT level from 10GBASE-T is allowed to be backed off
- 🔌 On Cat 6, greater than 4 dB power reduction at 55m makes system vulnerable to 1000BASE-T ANEXT
- 🔌 No specific proposal at this time

# AWGN Levels for Channel Specification

-  5 dBm TX Power
-  Actual PSANEXT/PSAFEXT variation across frequency is  $< 4$  dBpp
-  500 MHz broadband sources readily available

Channel	PSANEXT loss (100 MHz min)	PSAELFEXT loss (100MHz min, 100m)	Margin for DSQ system	Equivalent AWGN at MDI
Model 1 (Cat 6aug, Class F IL, 100m)	60 dB	40 dB	4.51 dB	-138.9 dBm/Hz
Model 1 (Cat 6aug, Class F IL, 100m)	61 dB	39 dB	4.76 dB	-139.2 dBm/Hz
Model 1 (Cat 6aug, Class F IL, 100m)	62 dB	38 dB	5.30 dB	-139.8 dBm/Hz
Model 2 (Cat6, 55m)	47 dB	30 dB	3.21 dB	-125.5 dBm/Hz
Model 2 (Cat6, 55m)	47 dB	33 dB	4.06 dB	-126.3 dBm/Hz

# Additional PSAFEXT Results: Assumptions

- ❏ Draft 1.2, DSQ128+LDPC(1723,2048) at 800MHz
- ❏ Channel Model 1 and Model 2
  - ❏ Both cases include PSANEXT
- ❏ Residual Impairments:
  - ❏ -140 dBm/Hz AWGN
    - ❏ Models cable AWGN, residual Echo, NEXT, FEXT, analog ...
- ❏ PSAFEXT modeled by the equation
  - ❏  $PSAFEXT(f,L) = X - 20 \cdot \log_{10}(f/100) - 10 \cdot \log_{10}(L/100) + IL(f,L)$
  - ❏ Where f is frequency in MHz and L is length in meters and X is the PSAELFEXT 100MHz constant
- ❏ SNR margin computed from Salz Equation with impairments listed above
  - ❏ Salz analysis assumes ideal rx filter, linearity, sampling and equalizer



# PSAELFEXT SNR Margin for Model 1

Models 100m of Cat6Aug

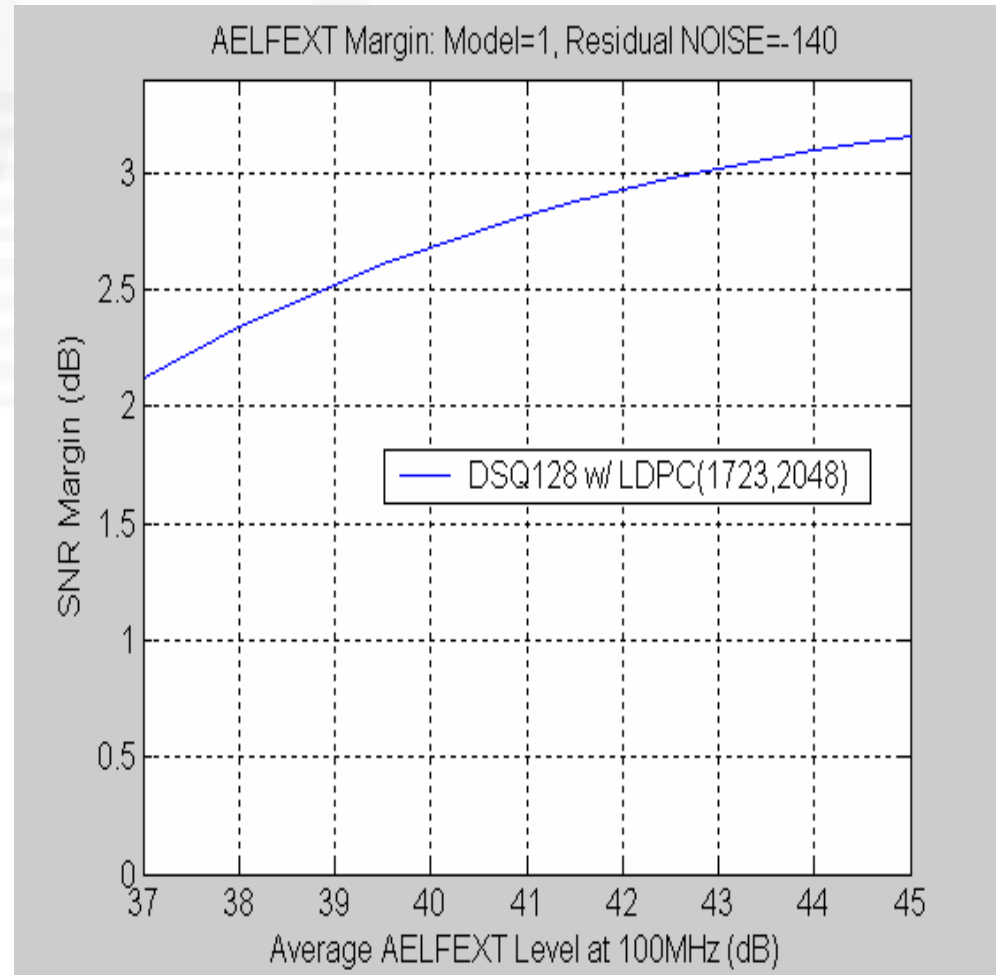
SNR margin vs average PSAELFEXT level

No PSAELFEXT, Margin = 3.4dB

X=45, Margin = 3.2 dB

X=40, Margin = 2.7 dB

X=37, Margin = 2.1 dB



# Tradeoff of PSAELFEXT and PSANEXT

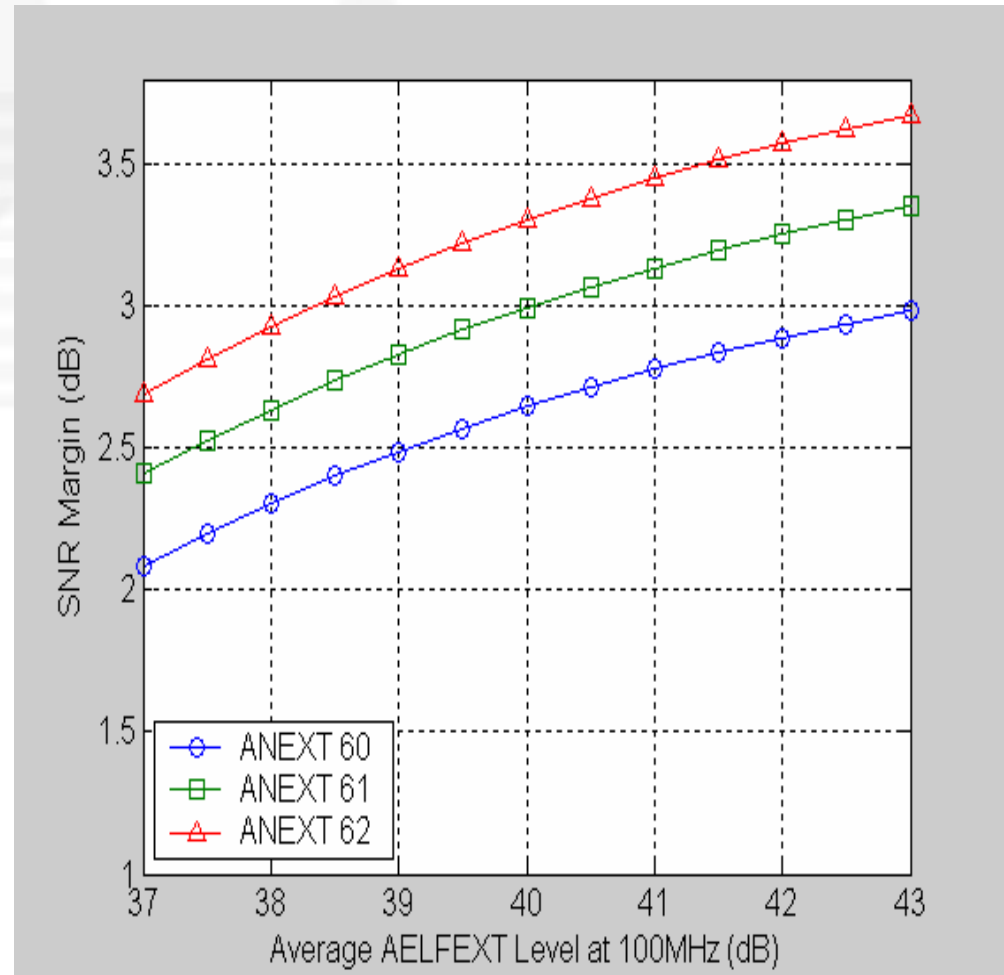
PSAFEXT level can be increased at the expense of lower PSANEXT

SNR margin vs average PSAELFEXT level

PSANEXT<sub>pk</sub>=60,  
PSAELFEXT<sub>ave</sub>=42,  
Margin=2.8dB

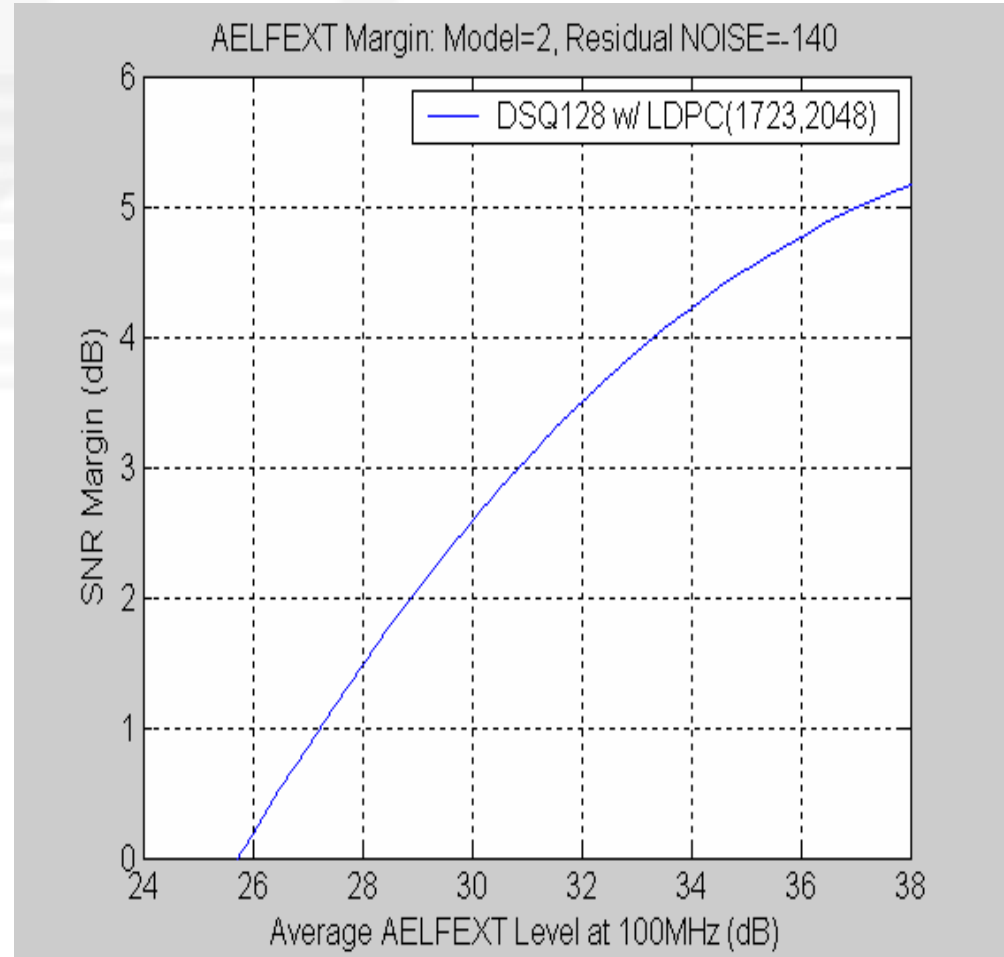
PSANEXT<sub>pk</sub>=61,  
PSAELFEXT<sub>ave</sub>=41,  
Margin=3.1dB

PSANEXT<sub>pk</sub>=62,  
PSAELFEXT<sub>ave</sub>=40,  
Margin=3.3dB



# PSAELFEXT SNR Margin for Model 2

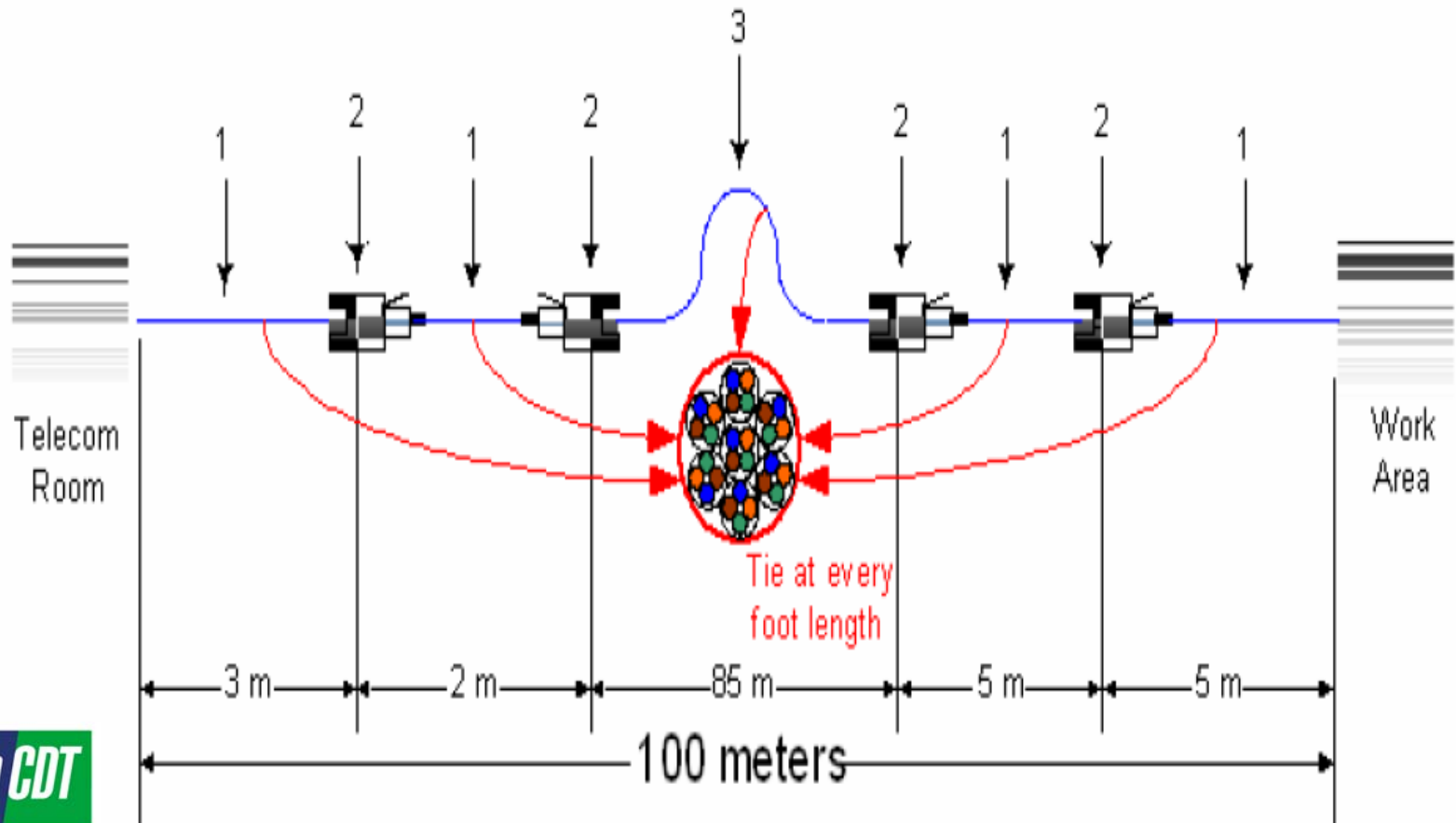
- Models 55m of Cat 6
- SNR margin vs average PSAELFEXT level
  - No PSAELFEXT, Margin = 5.9dB
  - X=35, Margin = 4.5 dB
  - X=33, Margin = 3.9 dB
  - X=30, Margin = 2.6 dB
  - X=25, *No Margin*



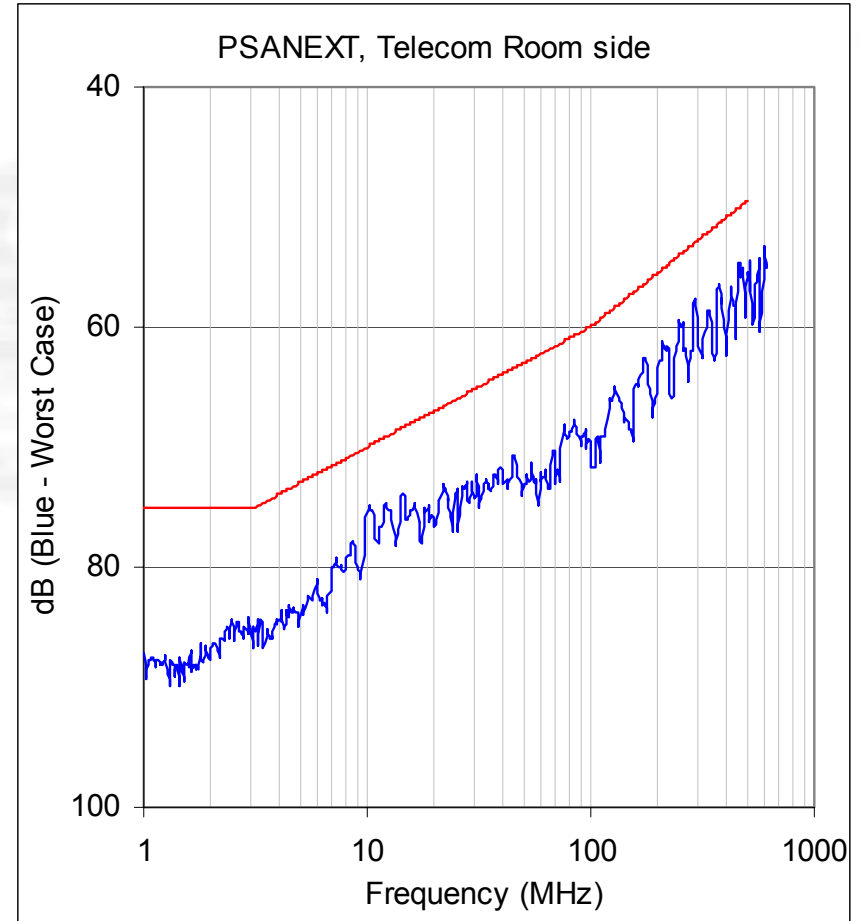
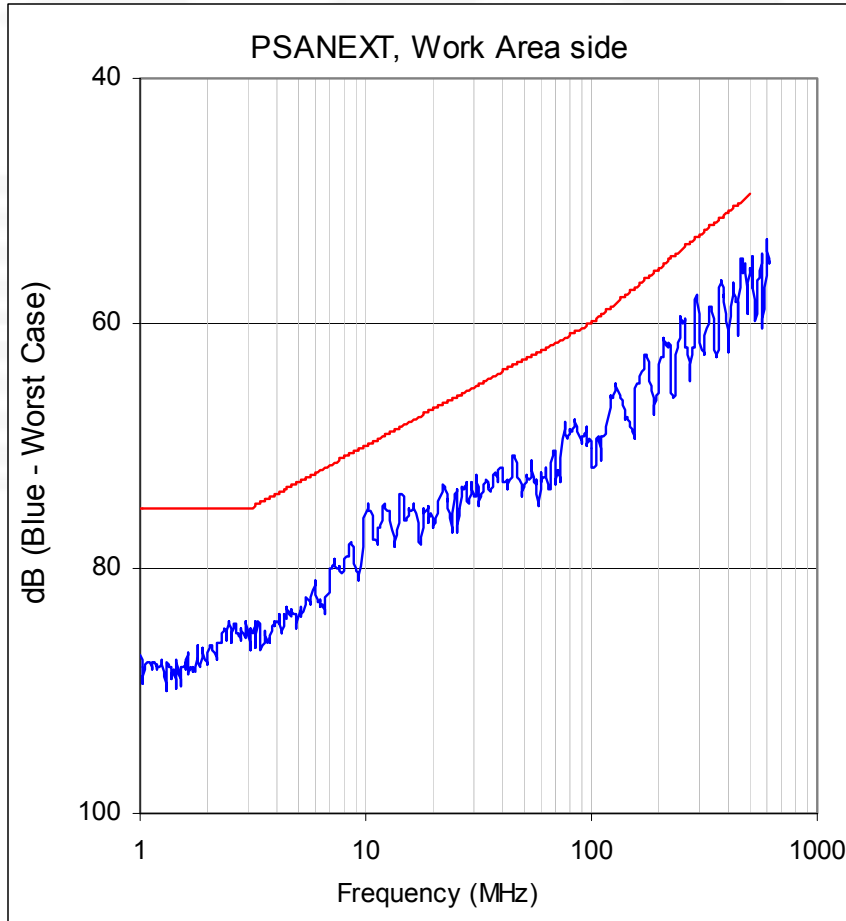
# Channel Configuration: Measurement Data

## SAMPLE DESCRIPTION:

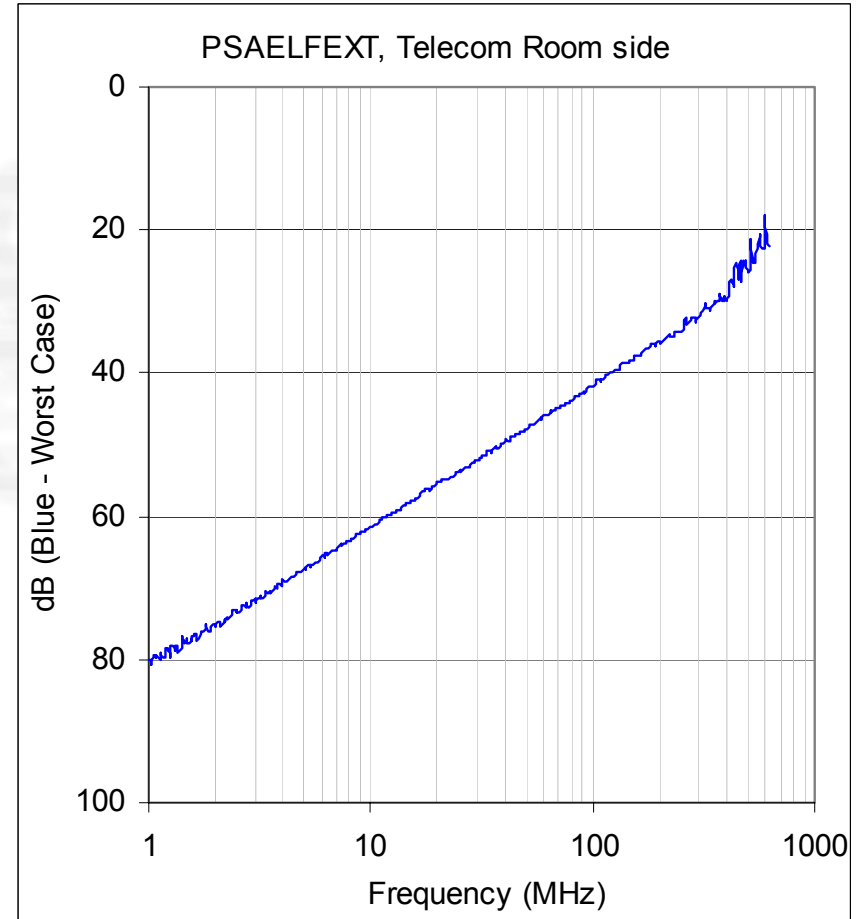
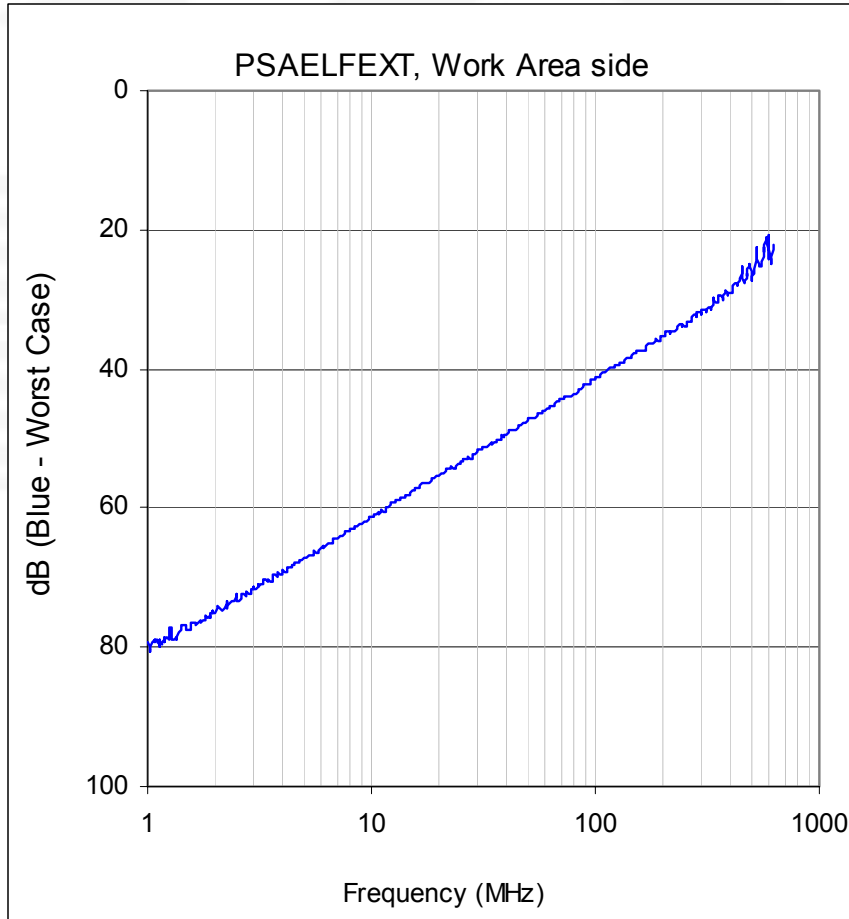
Channel Configuration (4 Connector)



# Power Sum Alien NEXT

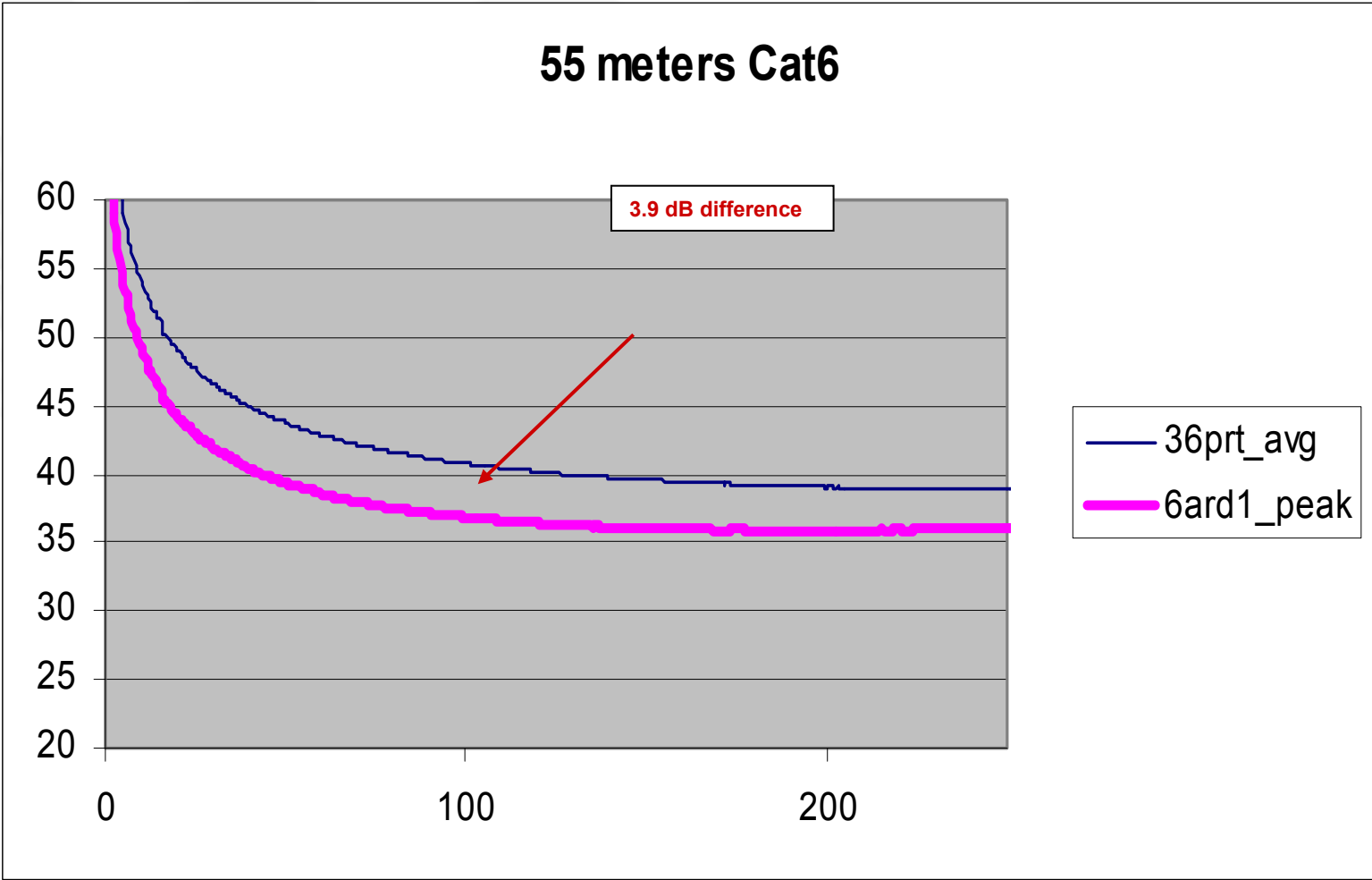


# Power Sum Alien ELFEXT



Note: Noise floor limitations above 400 MHz

Comparing PSFEXT 36 port average to the 6 around 1 peak



# 10GBASE-T PSAELFEXT



## PSAELFEXT

Channel	PSAELFEXT loss (dB) (100 MHz min)	Average PSAELFEXT across four pairs @ 100MHz (dB)	PSAELFEXT Correction (dB) -length correction -scale correction	Analysis Models (dB)
Model 1 (Class F, Augmented 6, IL 100m)	37	4		41 (100 m)
Model 2 (Cat6, 55m)	31 (55 m)	4	2.6	37.6 (55 m)
Model 3 (Class E, 100 m)	37 (100 m)	4		41 (100 m)



# 10GBASE-T PSANEXT

Channel	PSANEXT loss (100 MHz min) (dB)	Difference between Peak and Average across four pairs (dB)	Average PSANEXT across four pairs @ 100MHz (dB)	Analysis Models (dB)
Model 1 (Class F ,Augmented 6, IL 100m)	60	2.5	1	63.5
Model 2 (Cat6, 55m)	47	2.5	1	50.5
Model 3 (Class E, 100 m)	62	2.5	1	65.5

# AWGN Levels for Channel Specification



5 dBm TX Power






Actual PSANEXT/PSAFEXT variation across frequency is  $< 4$  dBpp



500 MHz broadband sources readily available

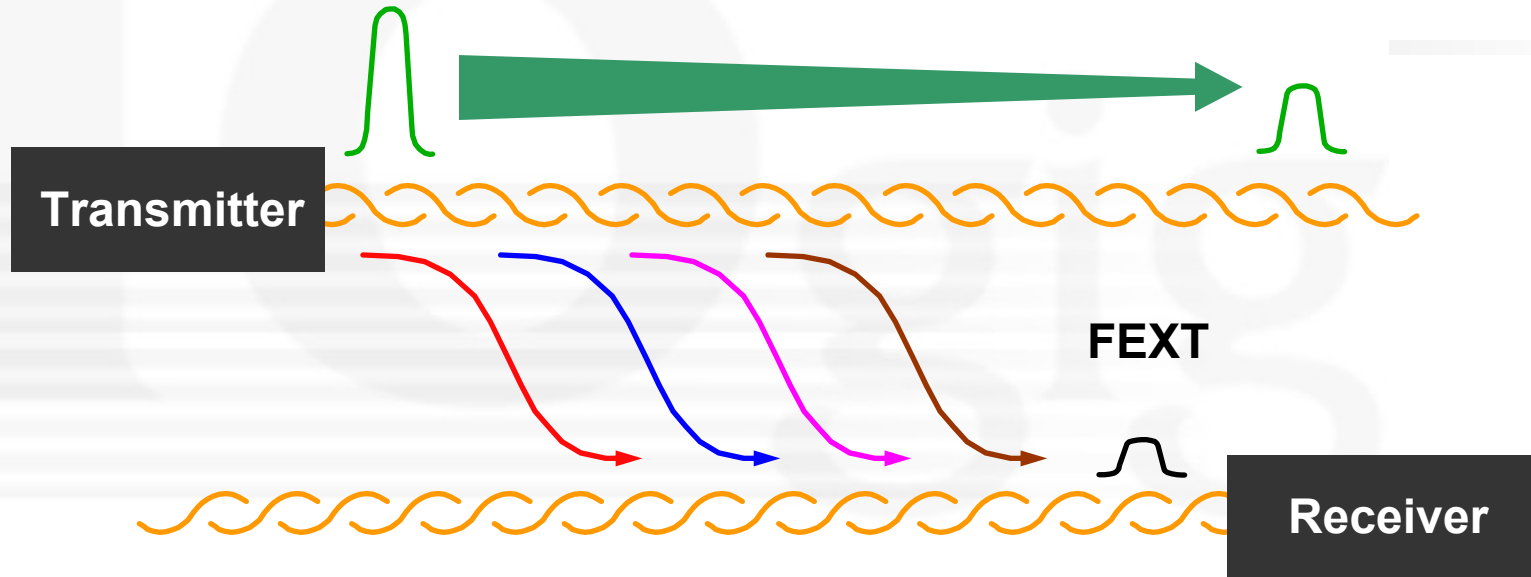
Channel	PSANEXT loss (100 MHz avg)	PSAELFEXT loss (100MHz avg, 100m)	Margin for DSQ system	Equivalent AWGN at MDI
Model 1 (Cat 6aug, Class F IL, 100m)	63.5	41	4.9 dB	-139.4 dbm/Hz
Model 2 (Cat6, 55m)	50.5	37.6 (55 m)	4.59 dB	-126.9 dbm/Hz
Model 3 (Cat6, 100m)	65.5	41 (100 m)	4.4 dB	-140.9 dbm/Hz

# Proposals

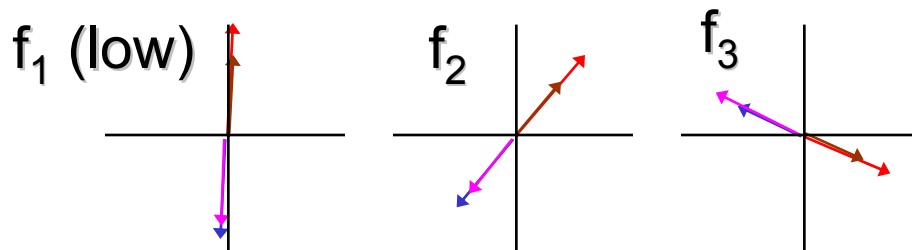
-  Proposal 1: Specify PSANEXT/PSAELFEXT averaging across pairs in channel model for Models 1, 2, 3 as specified on slides 15, 16, 17.
-  Proposal 2: Specify PSAELFEXT 100m, 100MHz intercepts, length and IL scaling as in slides 15, 16, 17.
-  Proposal 3: Liaise these values to the appropriate cabling standards groups as channel requirements for 10GBASE-T.

**BACKUP**

# Far-End Crosstalk (ELFEXT or AELFEXT)

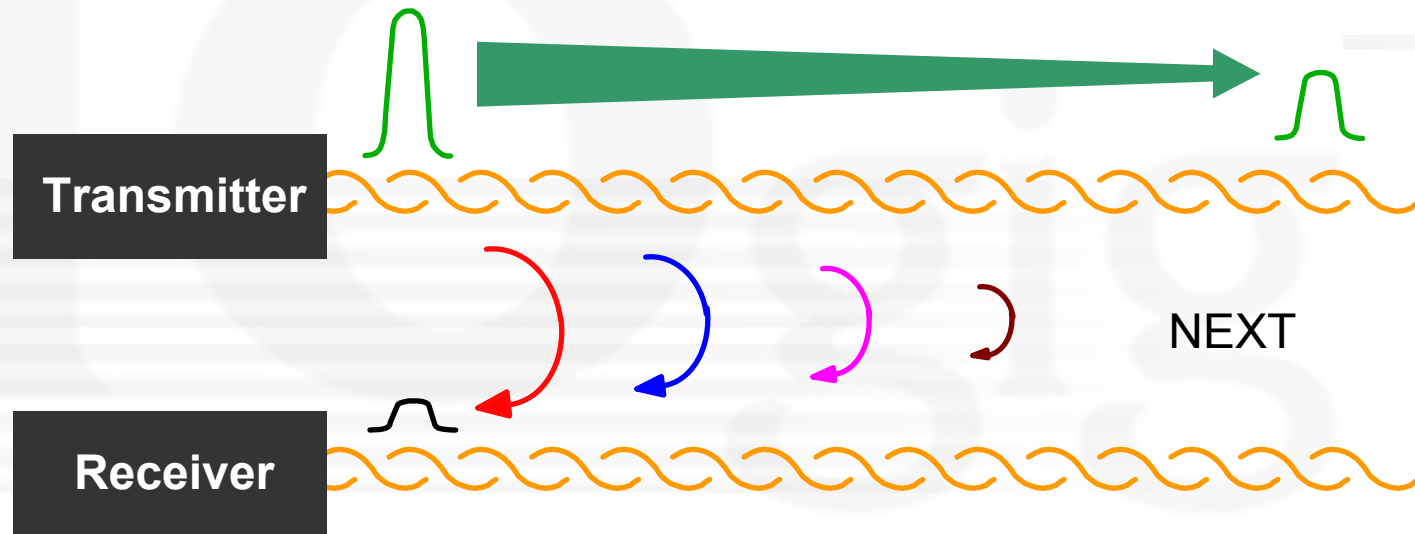


$$\text{ELFEXT} = C_1 * e^{-j\beta l} + C_2 * e^{-j\beta l} + C_3 * e^{-j\beta l} + C_4 * e^{-j\beta l} \quad \leftarrow \text{phase is the same for all}$$

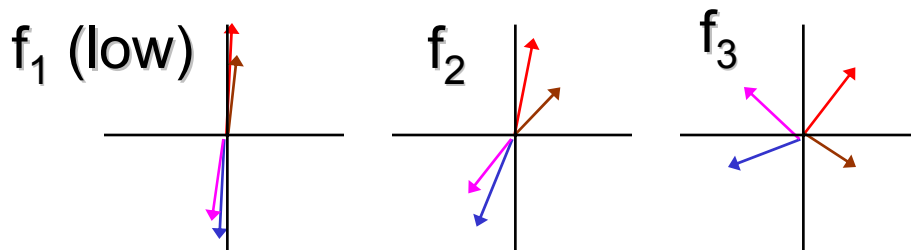


- Vectors always aligned so magnitude of sum of vectors is constant (no ripple with frequency, 20 dB/dec slope).
- Worst case will vary a lot from sample to sample based on whether vectors happen to luckily sum to zero or not (4 dB worst pair vs avg pair)

# Near-End Crosstalk (NEXT or ANEXT)



$$\text{NEXT} = C_1 * e^{-\alpha l_1} * e^{-j\beta l_1} + C_2 * e^{-\alpha l_2} * e^{-j\beta l_2} + C_3 * e^{-\alpha l_3} * e^{-j\beta l_3} + C_4 * e^{-\alpha l_4} * e^{-j\beta l_4}$$



- Sum of vectors varies over frequency resulting in ripple (2.5 dB peak vs avg).
- Worst case will occur since peaks will largely align at some frequency.
- Sample-to-sample variation is small since statistics will yield peaking (1 dB worst pair vs avg pair).