Channel Model Correlation Update and Trends

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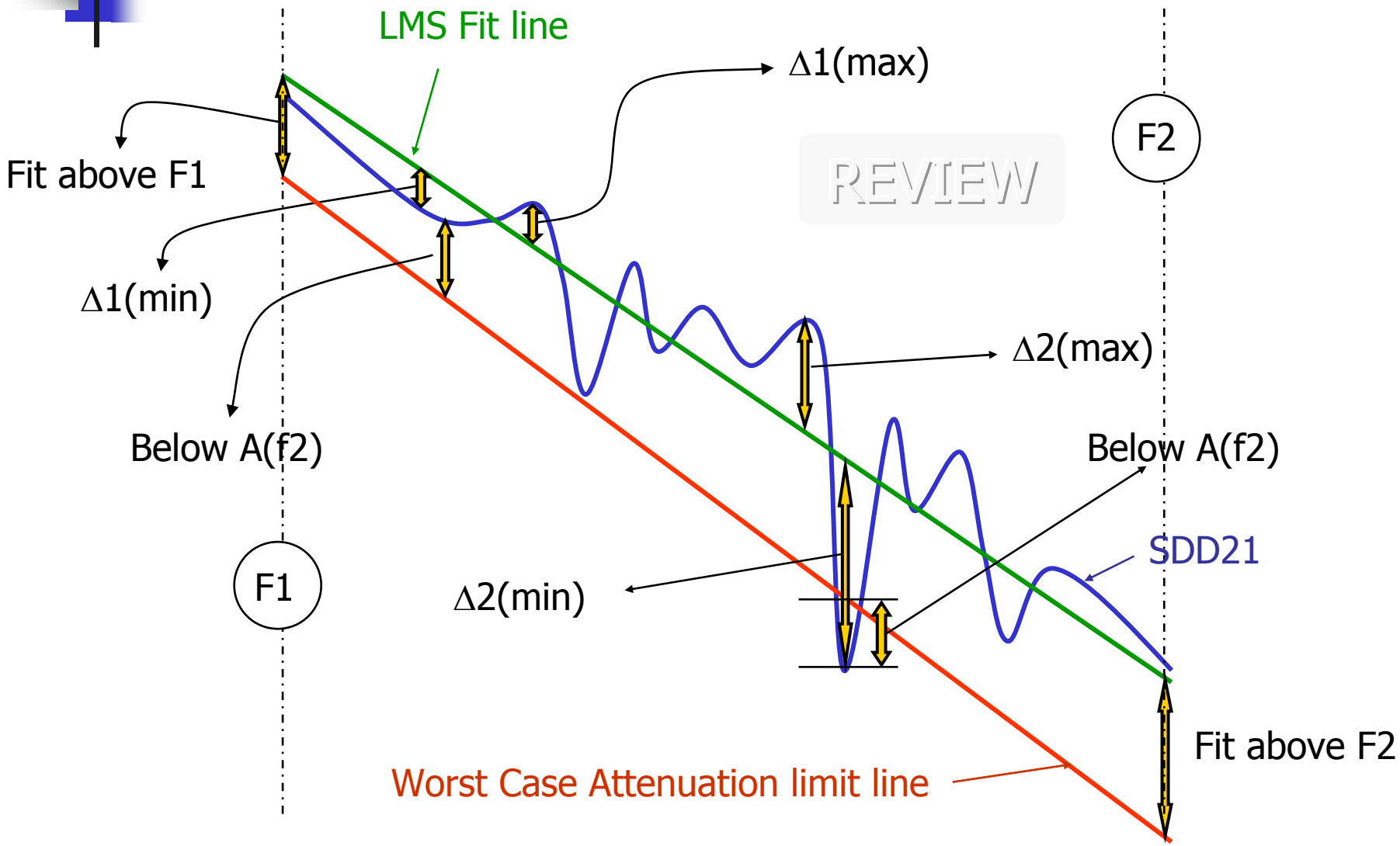
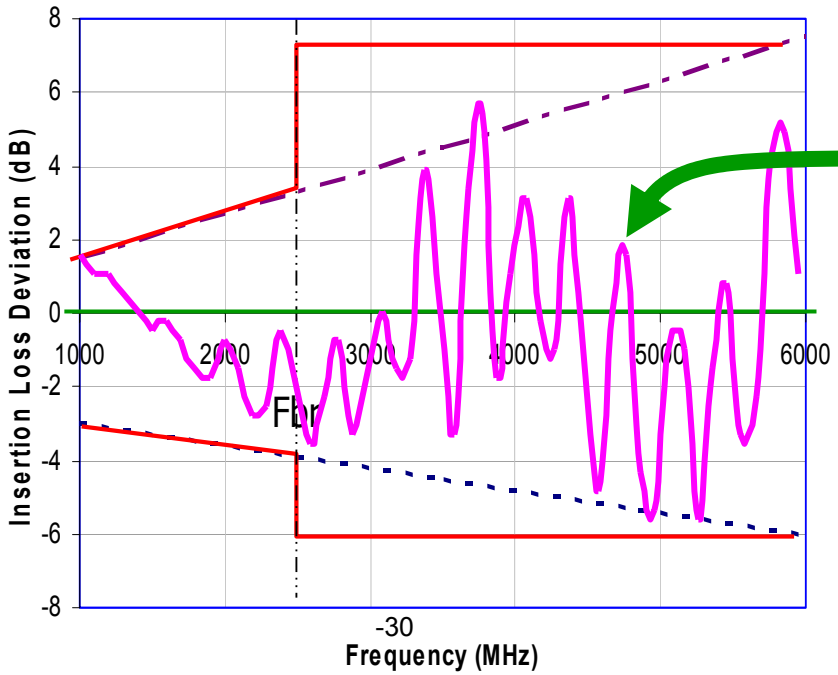
Supporter: John D'Ambrosia, Tyco
May, 2005

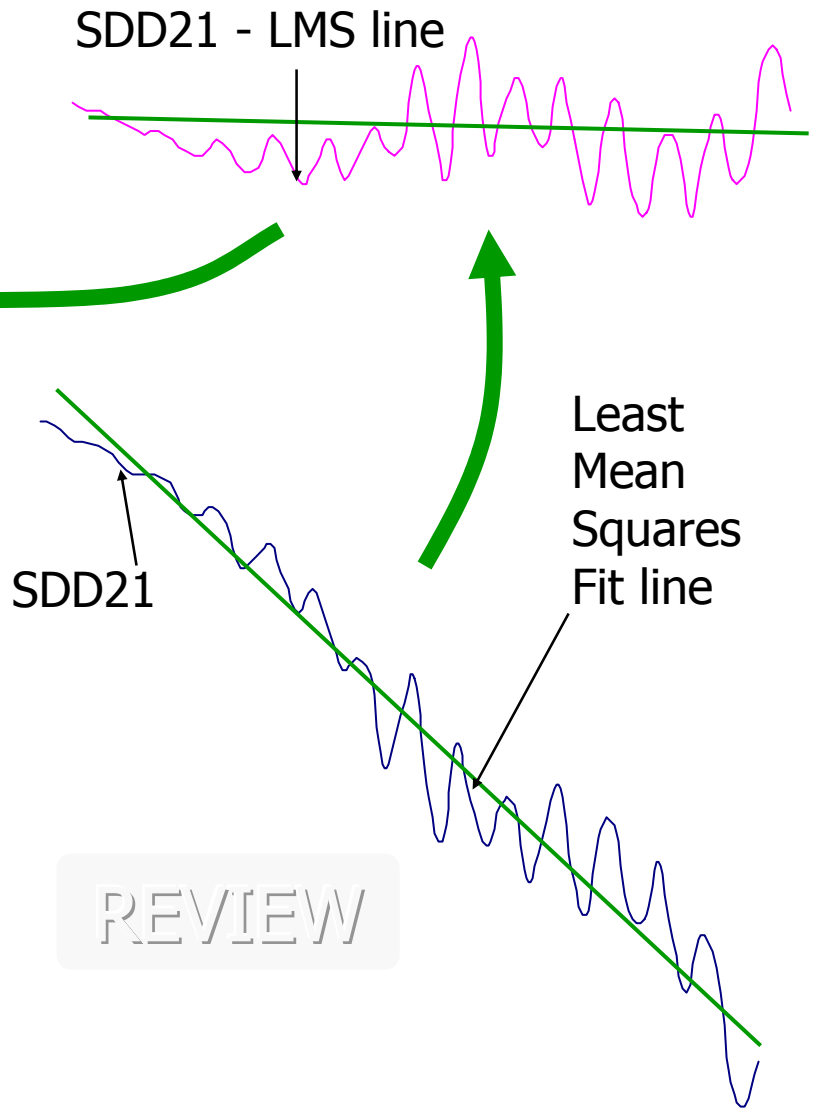
AC Parameters Analyzed: Terminology



REVIEW

AC parameters limit Suggestion





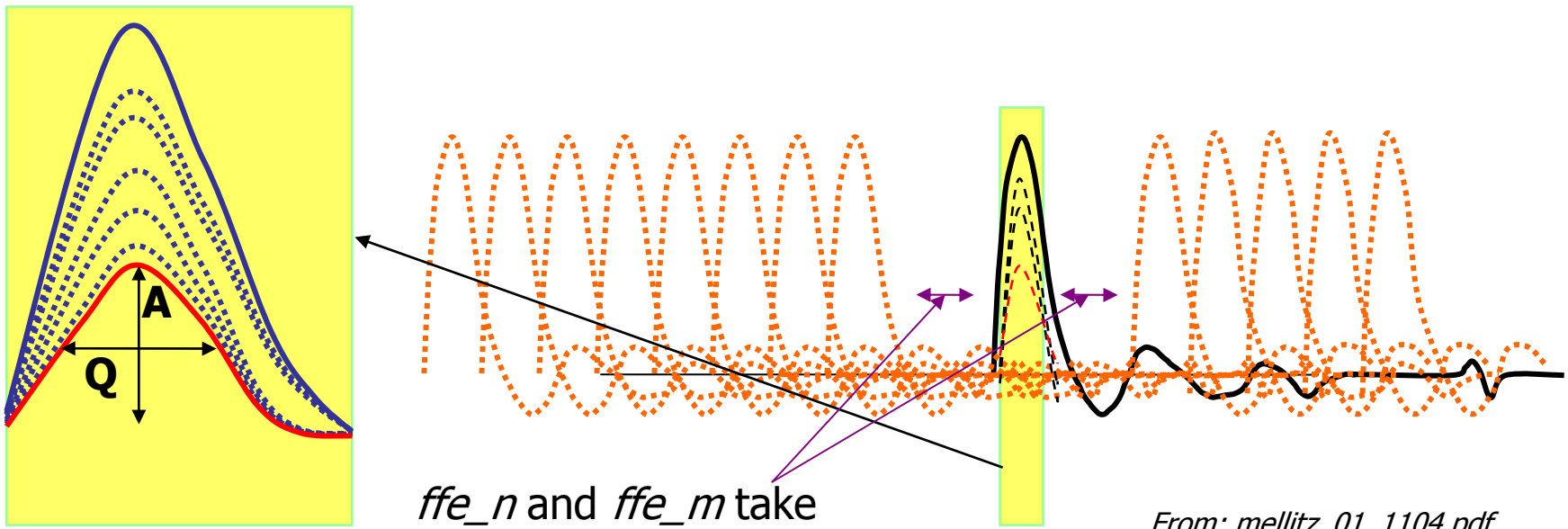
REVIEW

Time domain parameter analyzed

$$Xtest(t) = pulse21(t) - \sum_{k=ffe\_n}^{\infty} | pulse21(t - k*UI) | - \sum_{k=-ffe\_m}^{-\infty} | pulse21(t - k*UI) |$$

$$- \sqrt{\sum_{i=1}^{n} xtkf_i (\sum_{k=-\infty}^{\infty} | xtk_i (t - k*UI) |)^2}$$

REVIEW



ffe_n and *ffe_m* take care of this region

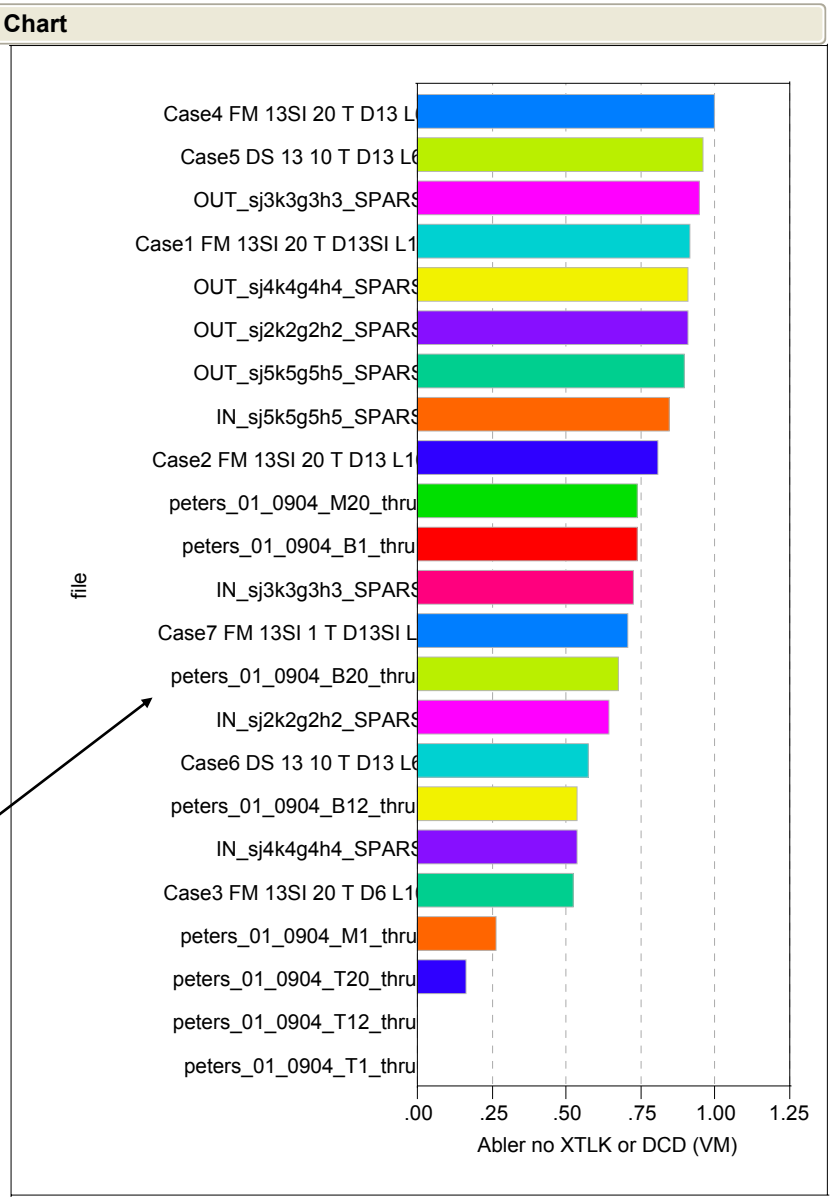
From: mellitz_01_1104.pdf

Procedure

- Cascade all channels (on web) with cap-like model for tx and rx
  - We need resolution here
    - Do we base the spec on the s4p's or s4p's cascaded with package models?
    - If so the words need to go in the spec.
- Create ordered set of channels based on each parameter.
- "Data mine" for results
- Call for Straw Polls

Abler Voltage Margin (no xtk no DCD)

- Peters 0904 T12 and T1 worst
  - T20 and M1 next worst
- Peters 0305 not included

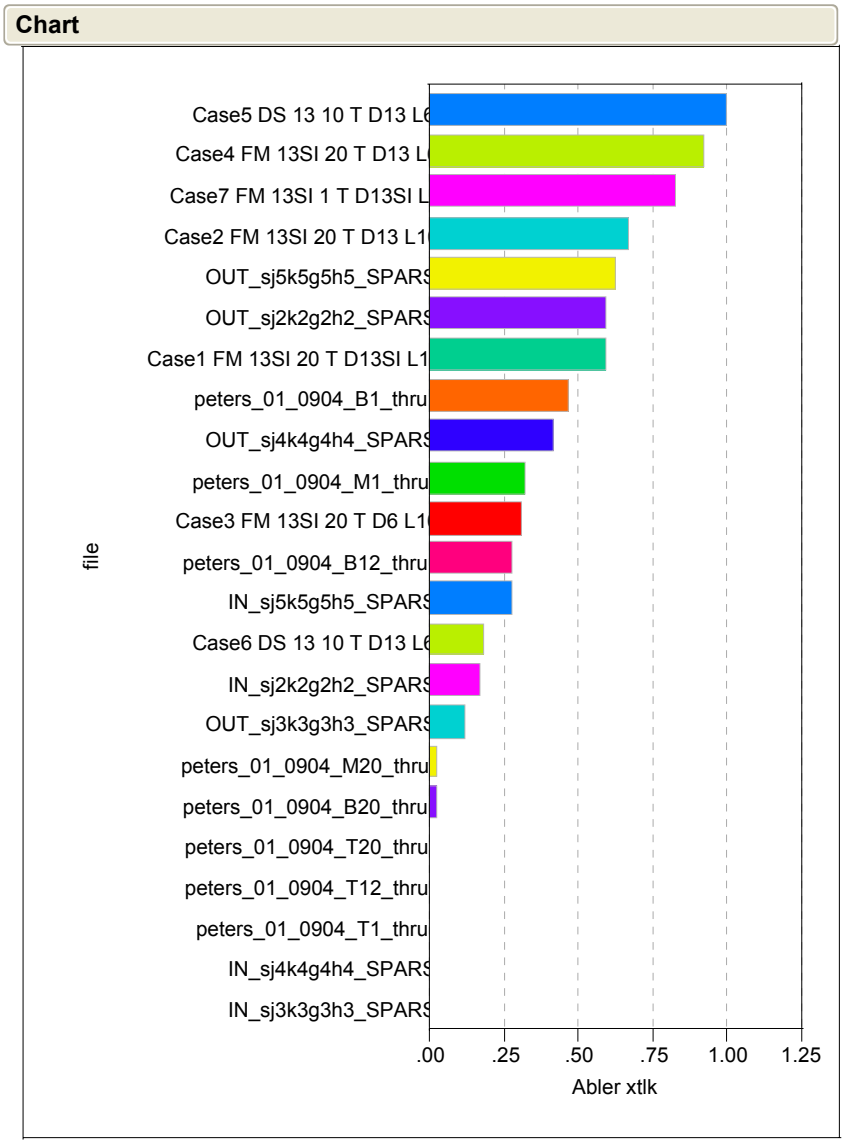


Names of channels at

http://www.ieee802.org/3/ap/public/channel_model/index.html

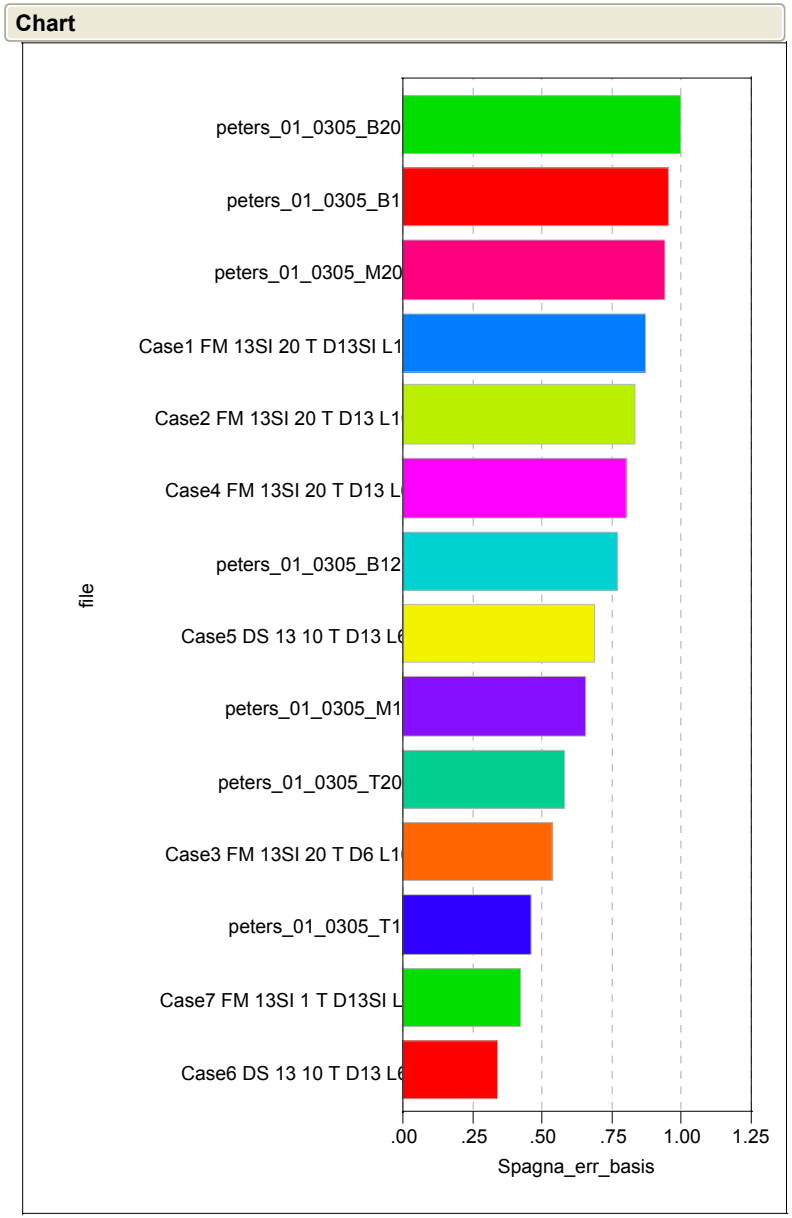
Abler Voltage Margin (xtlk)

- Peters 0904 Top and IN j4 and j3 worst
- Peters 0305 not included

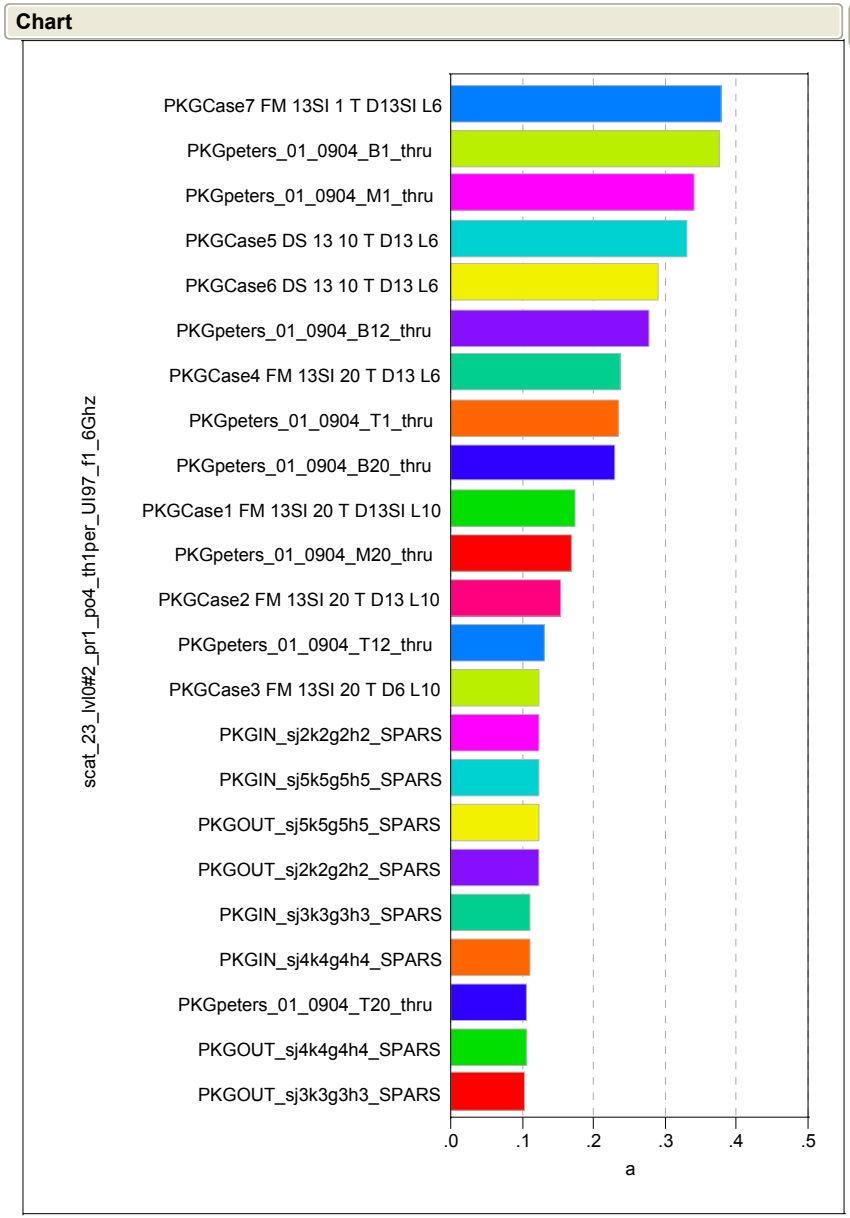


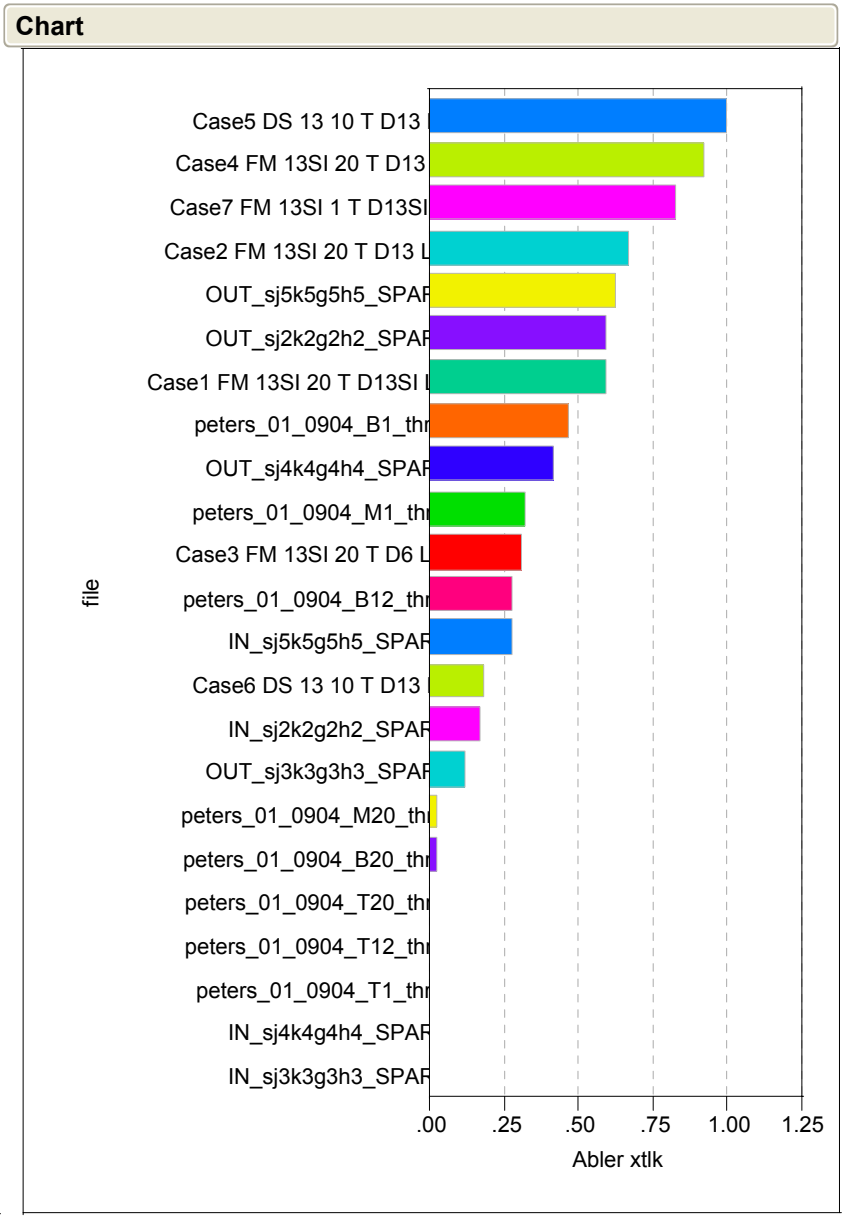
Spagna RMS error analysis (FF3/DFE5)

- Larger value is more costly to implement
- Only Peter 0305 and Tyco channels done.
- Abler data suggests Case 3 has one of the worst margins.
  - RMS error suggest that case 3 is not to bad.



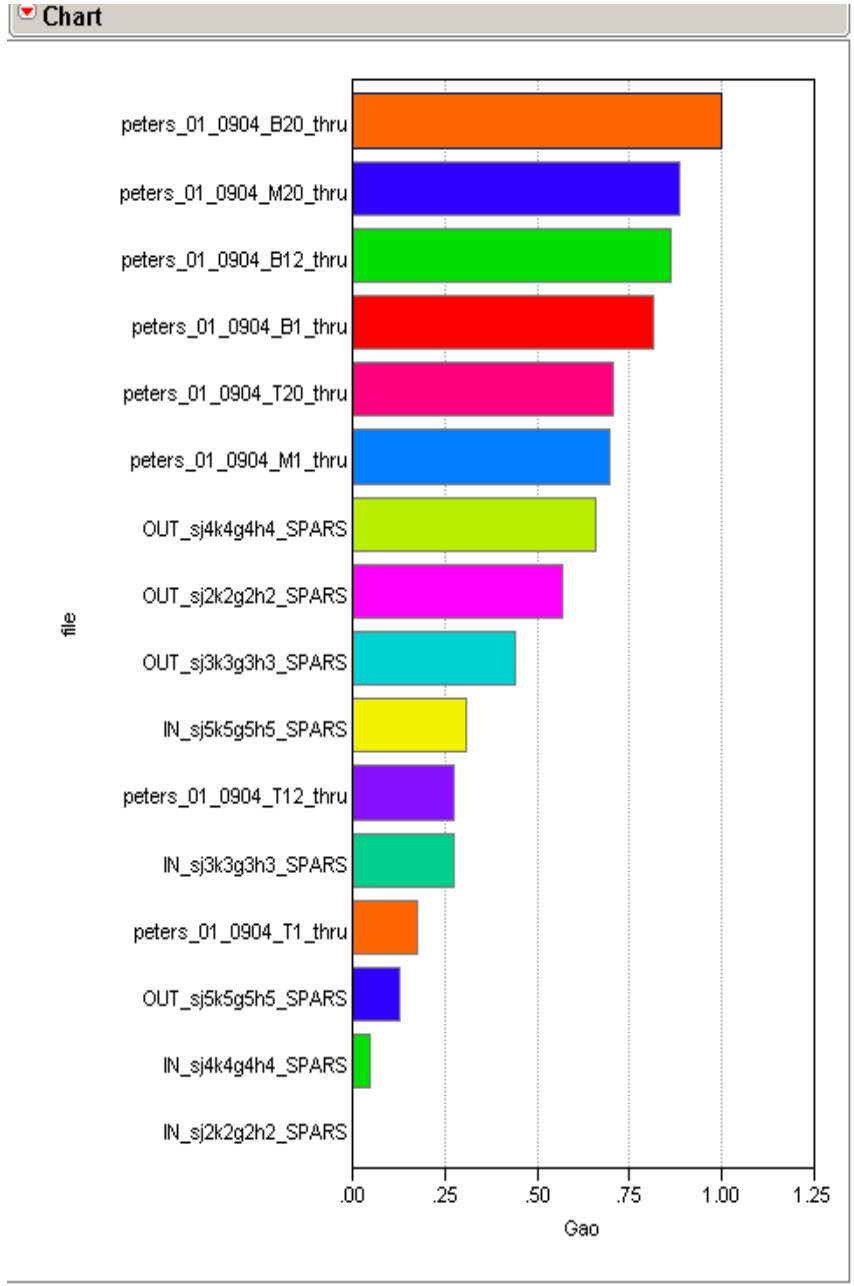
Abler w/xtlk and A w/xtlk





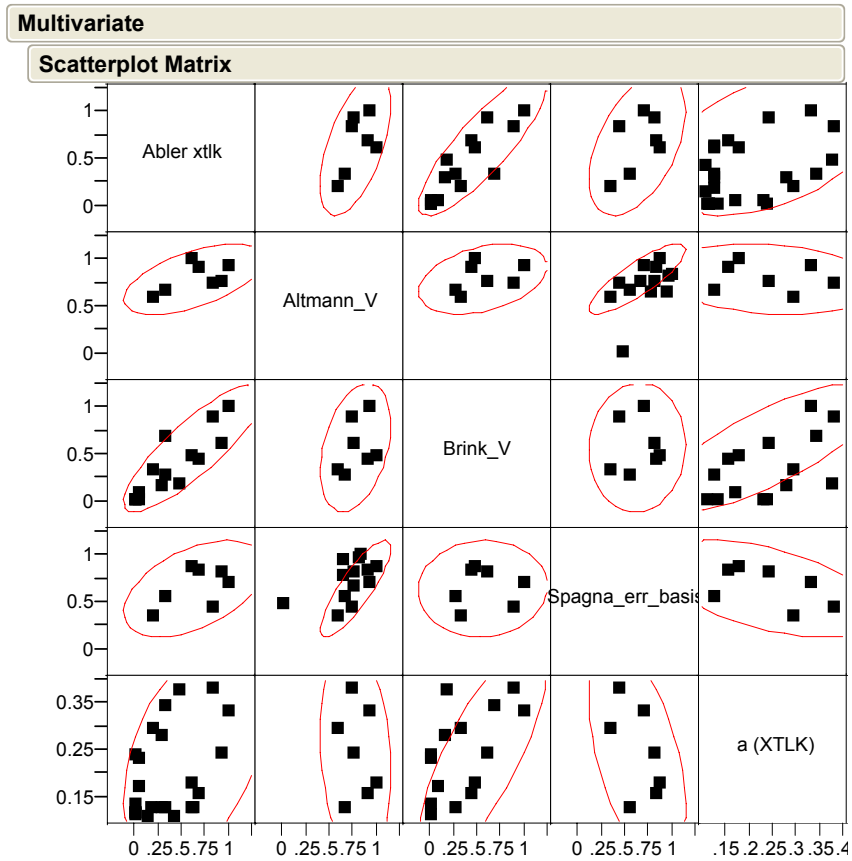
Gao w/o XTL

- In j4 and j2 are the toughest channels.
- B20 is the best



Correlation Between Xtlk results

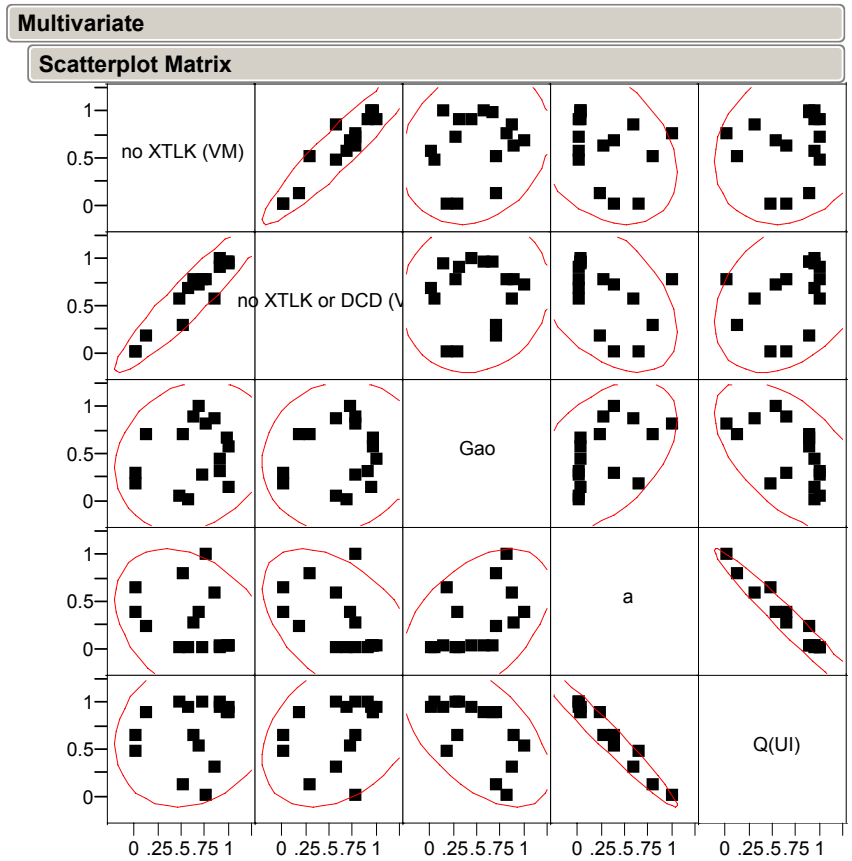
- All result normalized and scaled to 0 to 1.
- Loose correlation between Brink and Abler
- Loose correlation between Spagna and Altmann



The better the correlation, the closer the ellipse gets to a 45 degree line

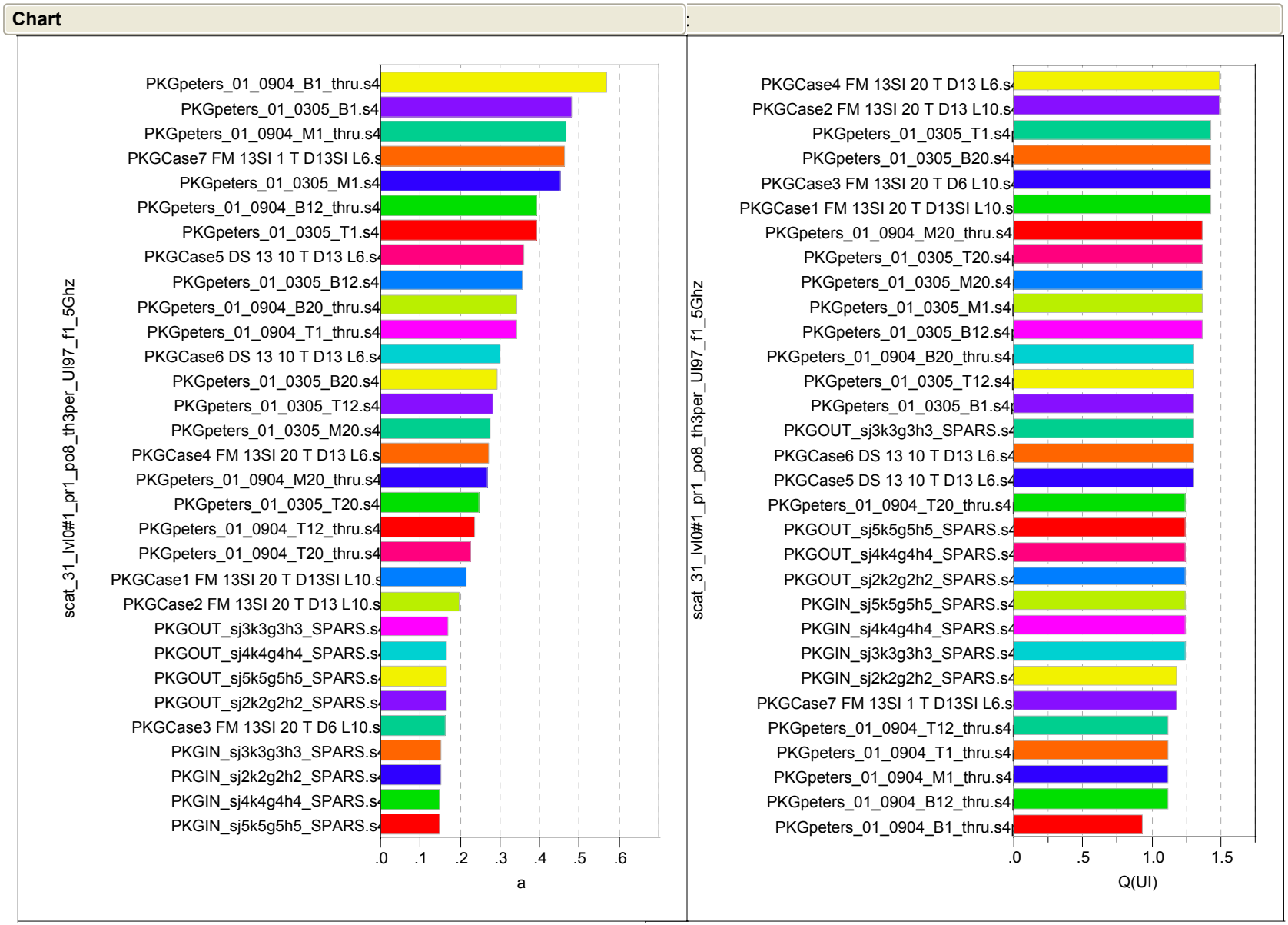
Correlation Between no Xtlk results

- Strong correlation between Abler w/wo DCD
- Strong correlation between A and Q
- Poor correlation between A,Q and Abler and Gao
- Question: What is good enough for a standard.
  - Abler and Gao agree T1 is low on the list



The better there correlation, the closer the ellipse gets to a 45 degree line

A and Q



Chart
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PKGpeters_01_0305_B1.s4
PKGpeters_01_0904_M1_thru.s4
PKGCase7 FM 13SI 1 T D13SI L6.s
PKGpeters_01_0305_M1.s4
PKGpeters_01_0904_B12_thru.s4
PKGpeters_01_0305_T1.s4
PKGCase5 DS 13 10 T D13 L6.s
PKGpeters_01_0305_B12.s4
PKGpeters_01_0904_B20_thru.s4
PKGpeters_01_0904_T1_thru.s4
PKGCase6 DS 13 10 T D13 L6.s
PKGpeters_01_0305_B20.s4
PKGpeters_01_0305_T12.s4
PKGpeters_01_0305_M20.s4
PKGCase4 FM 13SI 20 T D13 L6.s
PKGpeters_01_0904_M20_thru.s4
PKGpeters_01_0305_T20.s4
PKGpeters_01_0904_T12_thru.s4
PKGpeters_01_0904_T20_thru.s4
PKGCase1 FM 13SI 20 T D13SI L10.s
PKGCase2 FM 13SI 20 T D13 L10.s
PKGOUT_sj3k3g3h3_SPARS.s
PKGOUT_sj4k4g4h4_SPARS.s
PKGOUT_sj5k5g5h5_SPARS.s
PKGOUT_sj2k2g2h2_SPARS.s
PKGCase3 FM 13SI 20 T D6 L10.s
PKGIN_sj3k3g3h3_SPARS.s
PKGIN_sj2k2g2h2_SPARS.s
PKGIN_sj4k4g4h4_SPARS.s
PKGIN_sj5k5g5h5_SPARS.s
.0 .1 .2 .3 .4 .5 .6
a
scat_31_lvl0#1_pr1_po8_th3per_UI97_f1_5Ghz
PKGCase4 FM 13SI 20 T D13 L6.s
PKGCase2 FM 13SI 20 T D13 L10.s
PKGpeters_01_0305_T1.s4
PKGpeters_01_0305_B20.s4
PKGCase3 FM 13SI 20 T D6 L10.s
PKGCase1 FM 13SI 20 T D13SI L10.s
PKGpeters_01_0904_M20_thru.s4
PKGpeters_01_0305_T20.s4
PKGpeters_01_0305_M20.s4
PKGpeters_01_0305_M1.s4
PKGpeters_01_0305_B12.s4
PKGpeters_01_0904_B20_thru.s4
PKGpeters_01_0305_T12.s4
PKGpeters_01_0305_B1.s4
PKGOUT_sj3k3g3h3_SPARS.s
PKGCase6 DS 13 10 T D13 L6.s
PKGCase5 DS 13 10 T D13 L6.s
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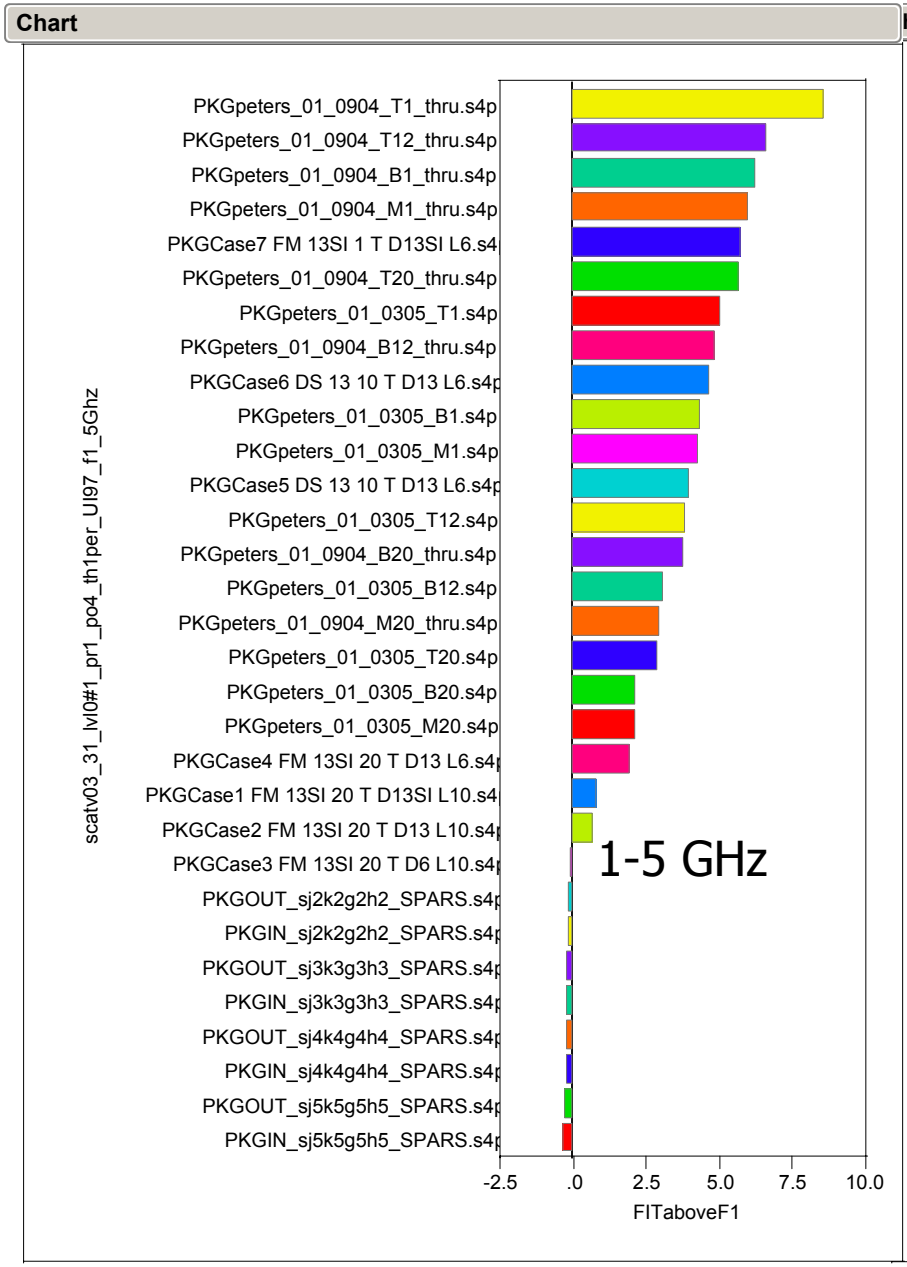
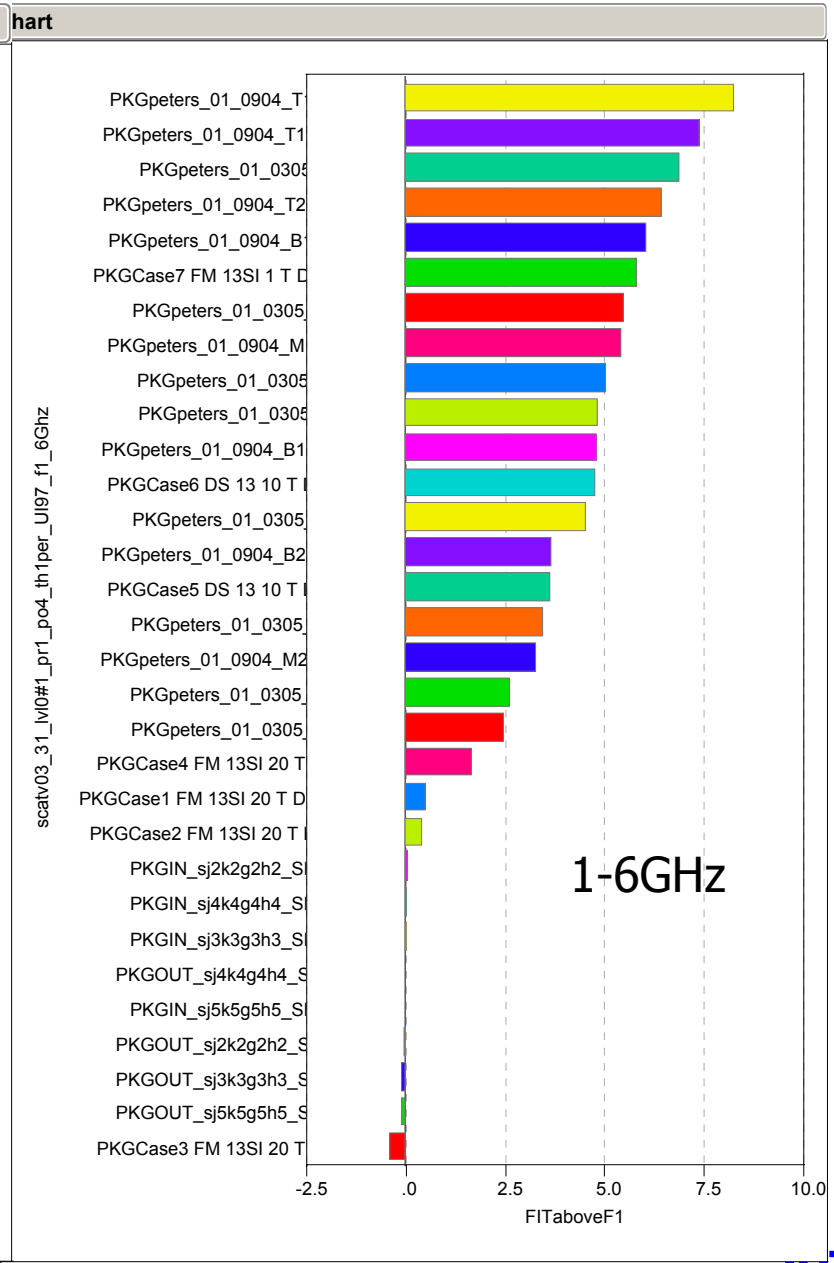
PKGIN_sj3k3g3h3_SPARS.s
PKGIN_sj2k2g2h2_SPARS.s
PKGCase7 FM 13SI 1 T D13SI L6.s
PKGpeters_01_0904_T12_thru.s4
PKGpeters_01_0904_T1_thru.s4
PKGpeters_01_0904_M1_thru.s4
PKGpeters_01_0904_B12_thru.s4
PKGpeters_01_0904_B1_thru.s4
.0 .5 1.0 1.5
Q(UI)

A and Q Limiting cases

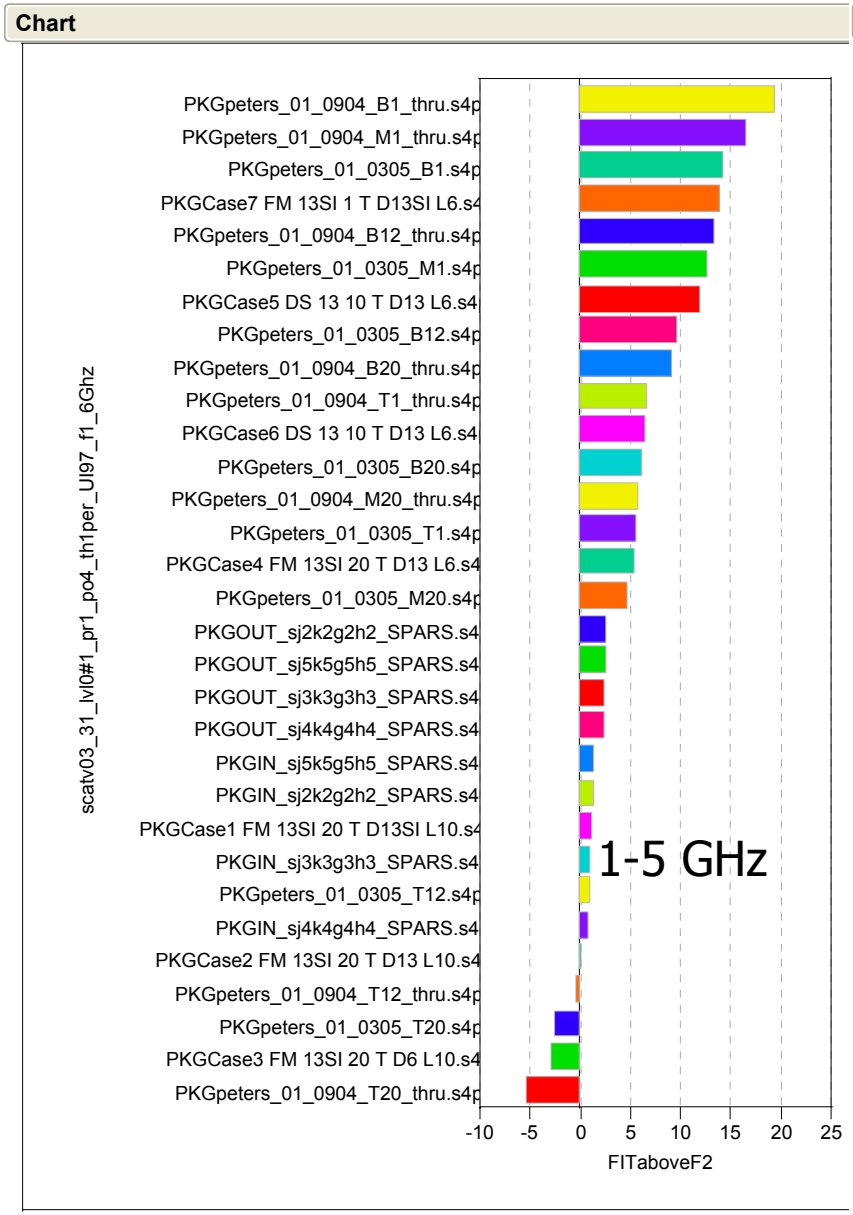
- All Molex channels and Tyco case 3 have smallest A's
- Hard to draw conclusion about Q

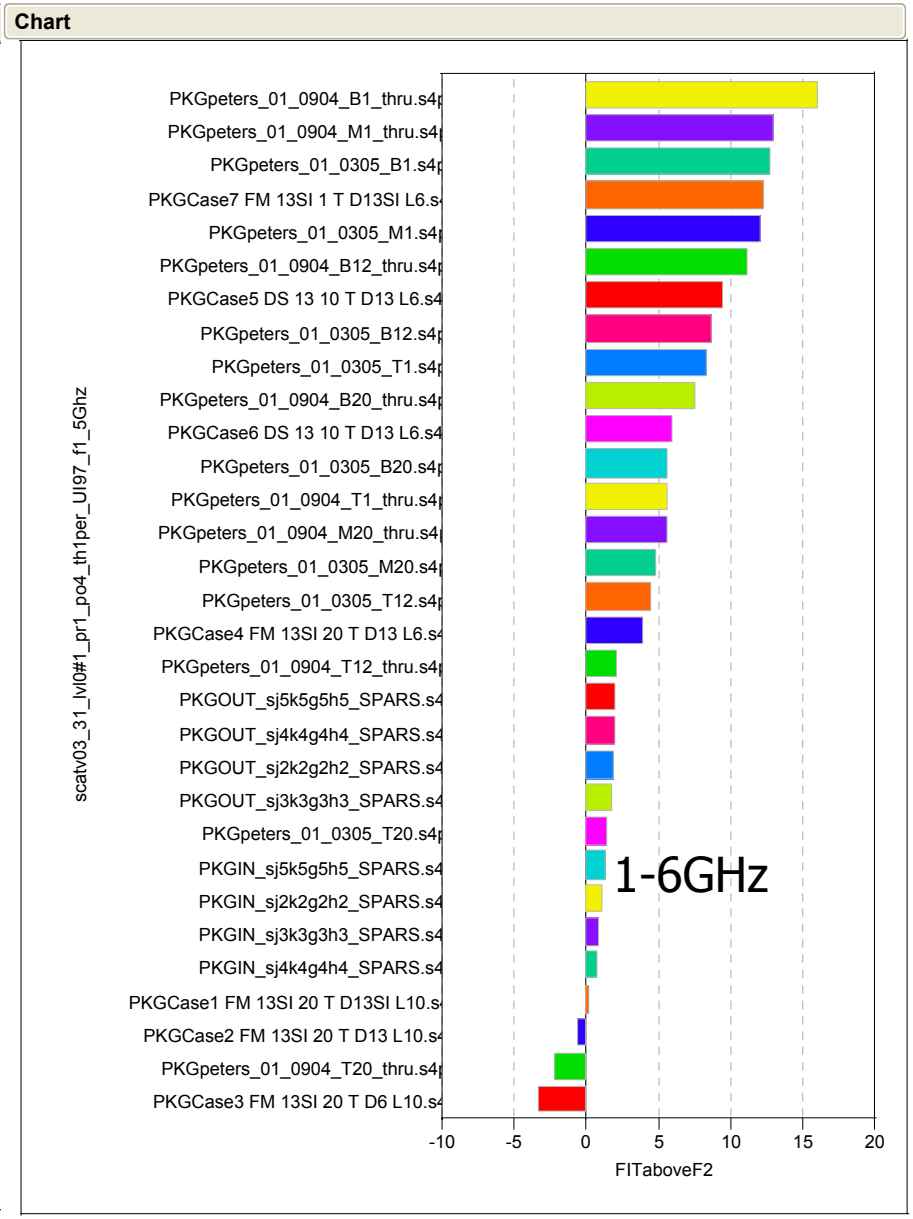
Fit line above Attenuation at F1





Fit line above Attenuation at F2

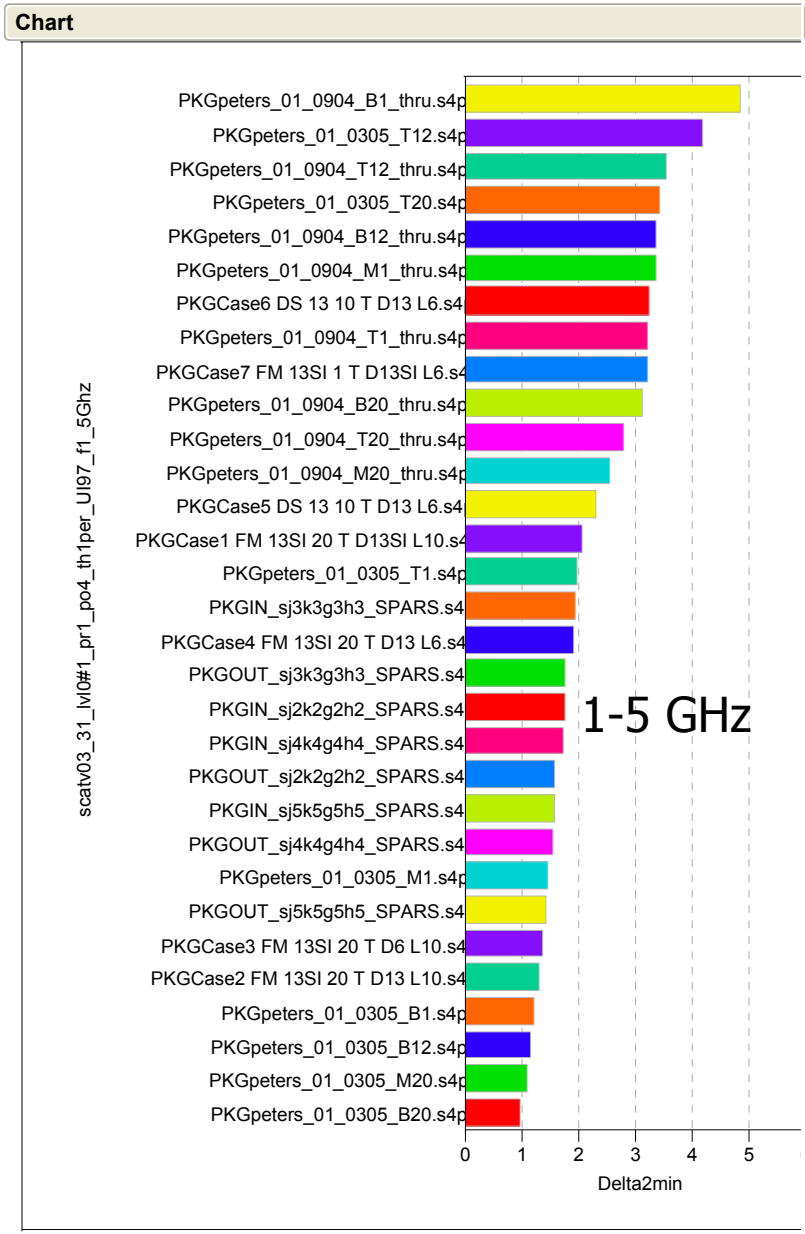


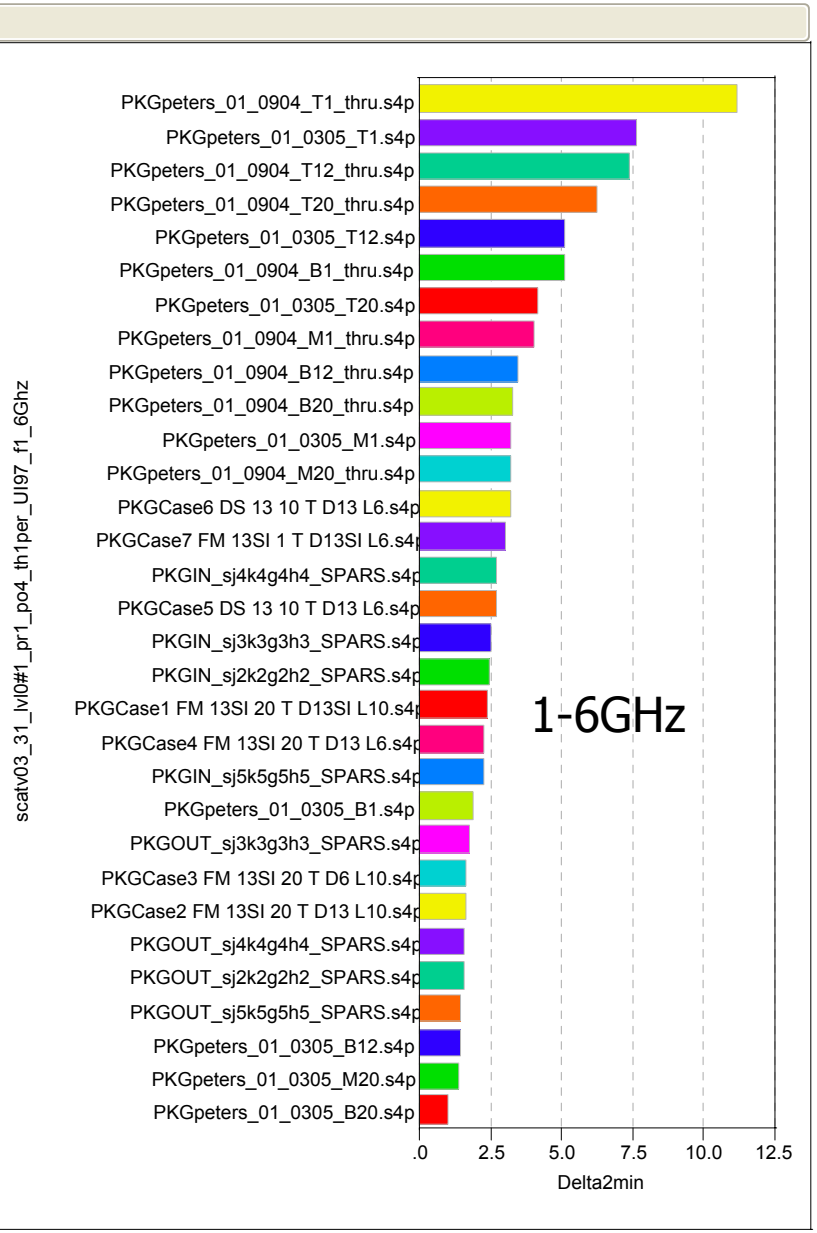


LMS fit line exceeds attenuation lines

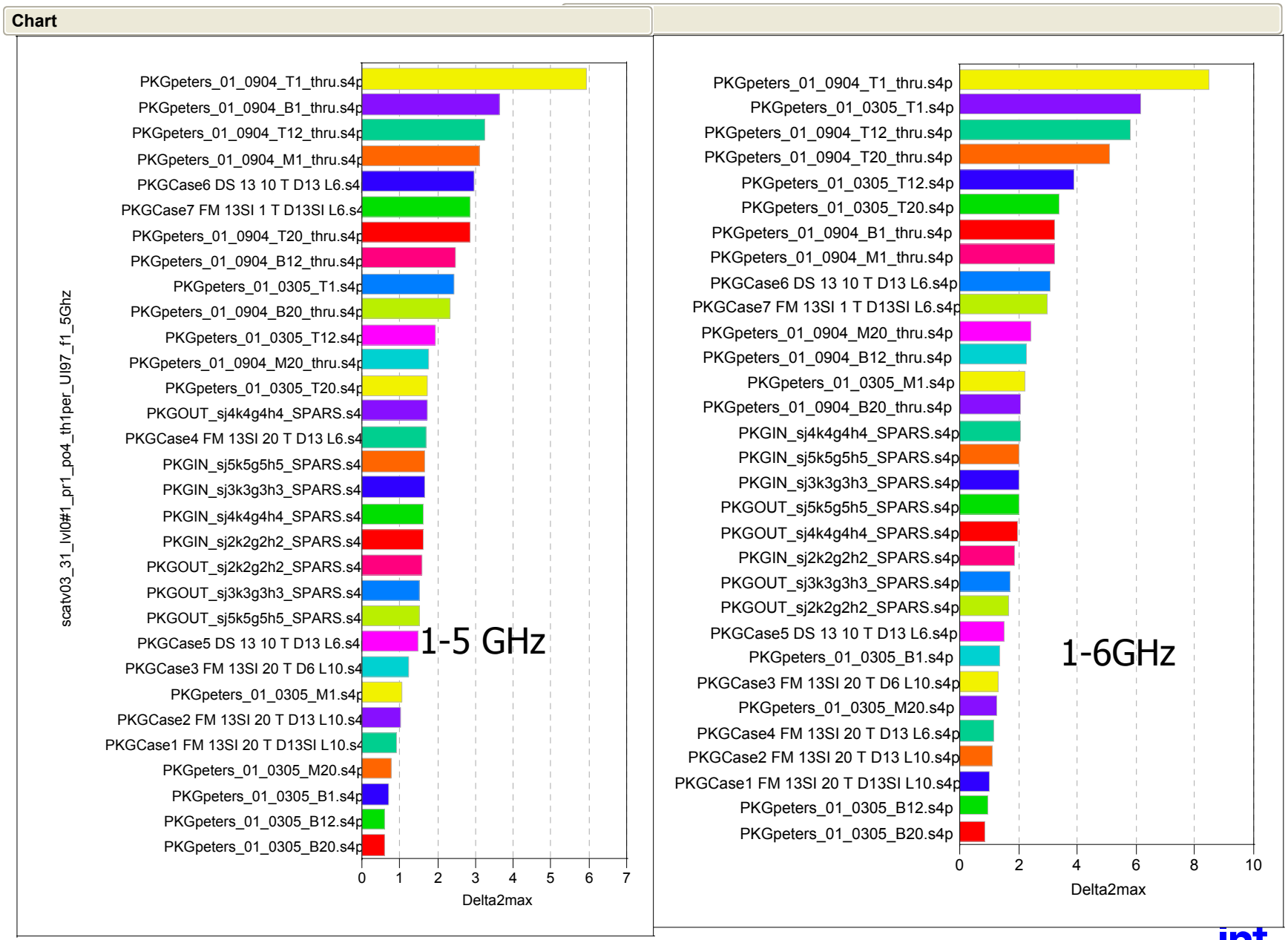
- Fails LMS line at F2
  - F1=1Ghz, F2=5Ghz
    - Peters_01_0904_t12
    - Peters_01_0305_t20
    - Tyco Case3
    - Peters_01_0904_t20
  - F1=1Ghz, F2=6GHz
    - Peters_01_0904_t20
    - Tyco Case3
    - Tyco Case 2
- Fails LMS line at F1
  - F1=1Ghz, F2=5Ghz
    - All Molex channels (408 m2)
    - Tyco Case 3
  - F1=1Ghz, F2=6Ghz
    - Molex outj2,outj3,outj5, inj5
    - Case 3

Δ_2(min) occurs between 2.5 GHz and F1

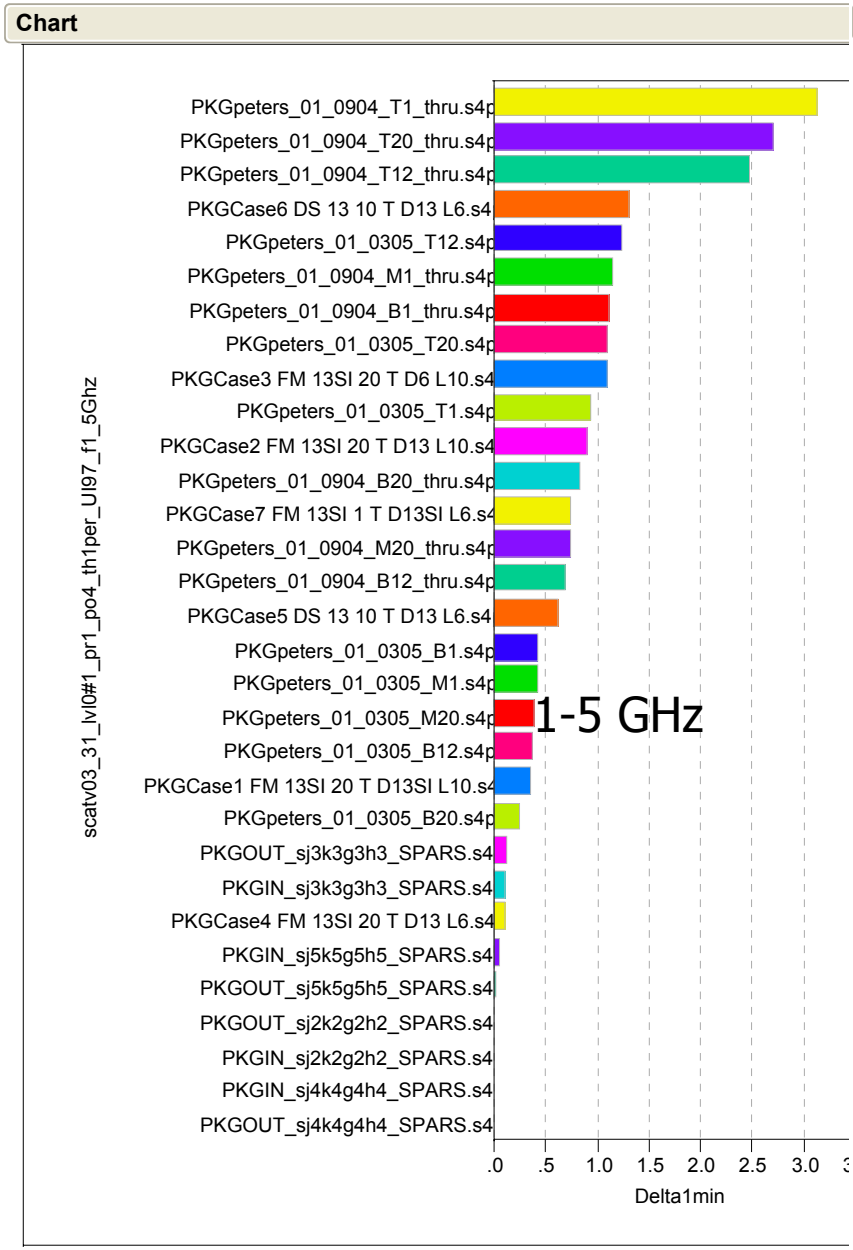




Δ_2(max) occurs between 2 GHz and F1



$\Delta_1(min)$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PKGpeters_01_0904_T1_thru.s4p
PKGpeters_01_0904_T20_thru.s4p
PKGpeters_01_0904_T12_thru.s4p
PKGCase6 DS 13 10 T D13 L6.s4
PKGpeters_01_0305_T12.s4p
PKGpeters_01_0904_M1_thru.s4p
PKGpeters_01_0904_B1_thru.s4p
PKGpeters_01_0305_T20.s4p
PKGCase3 FM 13SI 20 T D6 L10.s4
PKGpeters_01_0305_T1.s4p
PKGCase2 FM 13SI 20 T D13 L10.s4
PKGpeters_01_0904_B20_thru.s4p
PKGCase7 FM 13SI 1 T D13SI L6.s4
PKGpeters_01_0904_M20_thru.s4p
PKGpeters_01_0904_B12_thru.s4p
PKGCase5 DS 13 10 T D13 L6.s4
PKGpeters_01_0305_B1.s4p
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PKGOUT_sj2k2g2h2_SPARS.s4
PKGIN_sj2k2g2h2_SPARS.s4
PKGIN_sj4k4g4h4_SPARS.s4
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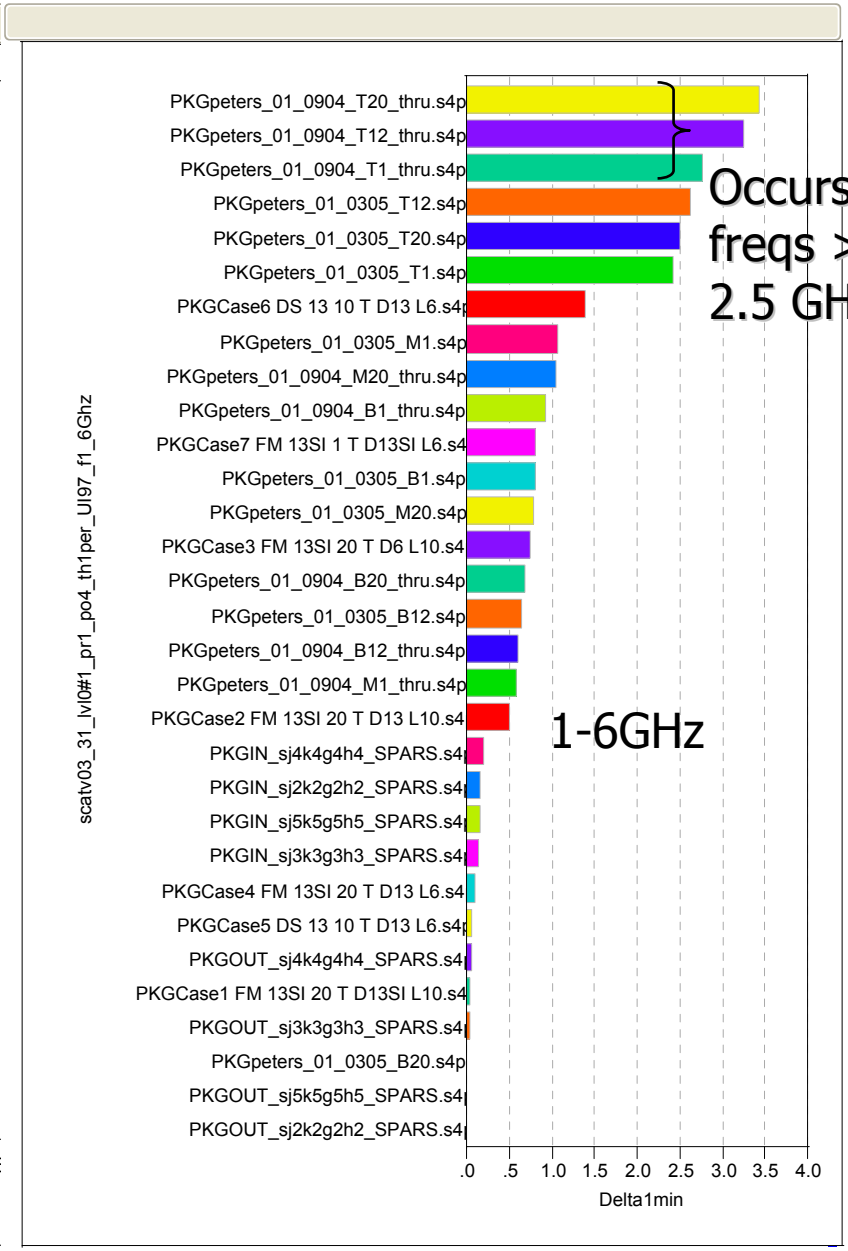
1-5 GHz
.0 .5 1.0 1.5 2.0 2.5 3.0
Delta1min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PKGpeters_01_0904_T12_thru.s4p
PKGpeters_01_0904_T1_thru.s4p
PKGpeters_01_0305_T12.s4p
PKGpeters_01_0305_T20.s4p
PKGpeters_01_0305_T1.s4p
PKGCase6 DS 13 10 T D13 L6.s4
PKGpeters_01_0305_M1.s4p
PKGpeters_01_0904_M20_thru.s4p
PKGpeters_01_0904_B1_thru.s4p
PKGCase7 FM 13SI 1 T D13SI L6.s4
PKGpeters_01_0305_B1.s4p
PKGpeters_01_0305_M20.s4p
PKGCase3 FM 13SI 20 T D6 L10.s4
PKGpeters_01_0904_B20_thru.s4p
PKGpeters_01_0305_B12.s4p
PKGpeters_01_0904_B12_thru.s4p
PKGpeters_01_0904_M1_thru.s4p
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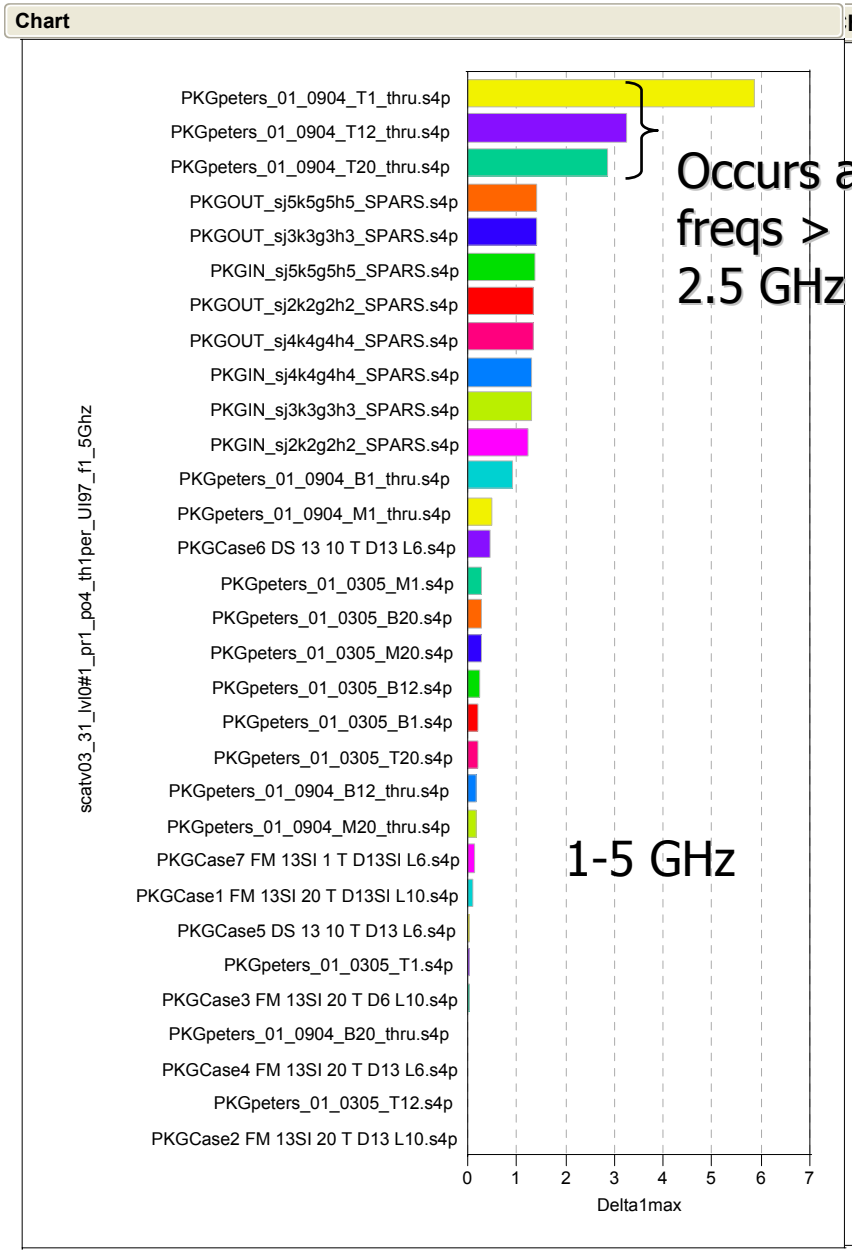
PKGIN_sj2k2g2h2_SPARS.s4
PKGIN_sj5k5g5h5_SPARS.s4
PKGIN_sj3k3g3h3_SPARS.s4
PKGCase4 FM 13SI 20 T D13 L6.s4
PKGCase5 DS 13 10 T D13 L6.s4
PKGOUT_sj4k4g4h4_SPARS.s4
PKGCase1 FM 13SI 20 T D13SI L10.s4
PKGOUT_sj3k3g3h3_SPARS.s4
PKGpeters_01_0305_B20.s4p
PKGOUT_sj5k5g5h5_SPARS.s4
PKGOUT_sj2k2g2h2_SPARS.s4
Occurs at freqs > 2.5 GHz
1-6GHz
.0 .5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
Delta1min

Δ_1(max)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PKGpeters_01_0904_T12_thru.s4p
PKGpeters_01_0904_T20_thru.s4p
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PKGpeters_01_0904_B1_thru.s4p
PKGpeters_01_0904_M1_thru.s4p
PKGCase6 DS 13 10 T D13 L6.s4p
PKGpeters_01_0305_M1.s4p
PKGpeters_01_0305_B20.s4p
PKGpeters_01_0305_M20.s4p
PKGpeters_01_0305_B12.s4p
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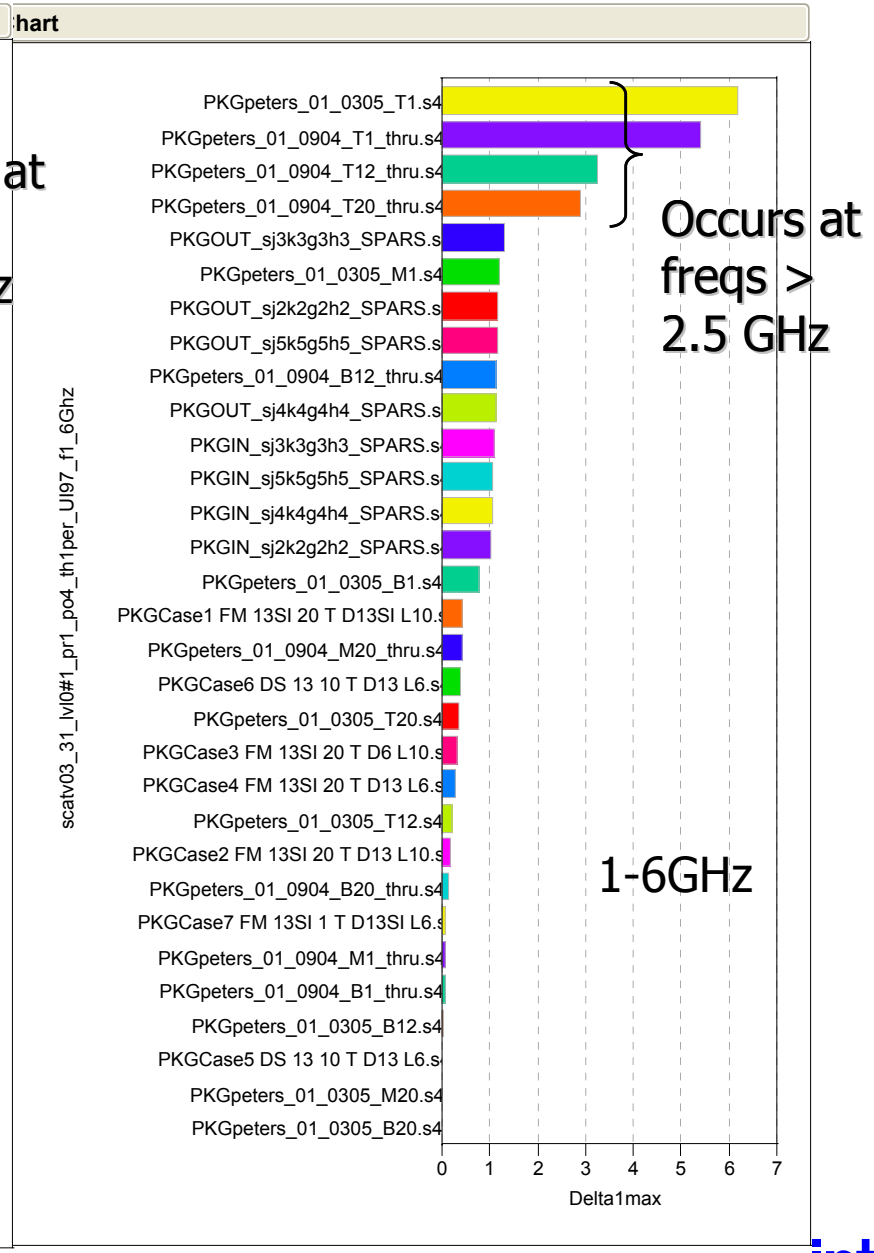
PKGpeters_01_0904_B12_thru.s4p
PKGpeters_01_0904_M20_thru.s4p
PKGCase7 FM 13SI 1 T D13SI L6.s4p
PKGCase1 FM 13SI 20 T D13SI L10.s4p
PKGCase5 DS 13 10 T D13 L6.s4p
PKGpeters_01_0305_T1.s4p
PKGCase3 FM 13SI 20 T D6 L10.s4p
PKGpeters_01_0904_B20_thru.s4p
PKGCase4 FM 13SI 20 T D13 L6.s4p
PKGpeters_01_0305_T12.s4p
PKGCase2 FM 13SI 20 T D13 L10.s4p
scatv03_31_lvl0#1_pr1_po4_th1per_UI97_f1_5Ghz
0 1 2 3 4 5 6 7
Delta1max
Occurs at freqs > 2.5 GHz
1-5 GHz


hart
PKGpeters_01_0305_T1.s4
PKGpeters_01_0904_T1_thru.s4
PKGpeters_01_0904_T12_thru.s4
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PKGpeters_01_0305_M1.s4
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PKGOUT_sj4k4g4h4_SPARS.s
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PKGCase1 FM 13SI 20 T D13SI L10.s
PKGpeters_01_0904_M20_thru.s4
PKGCase6 DS 13 10 T D13 L6.s
PKGpeters_01_0305_T20.s4
PKGCase3 FM 13SI 20 T D6 L10.s
PKGCase4 FM 13SI 20 T D13 L6.s
PKGpeters_01_0305_T12.s4
PKGCase2 FM 13SI 20 T D13 L10.s
PKGpeters_01_0904_B20_thru.s4
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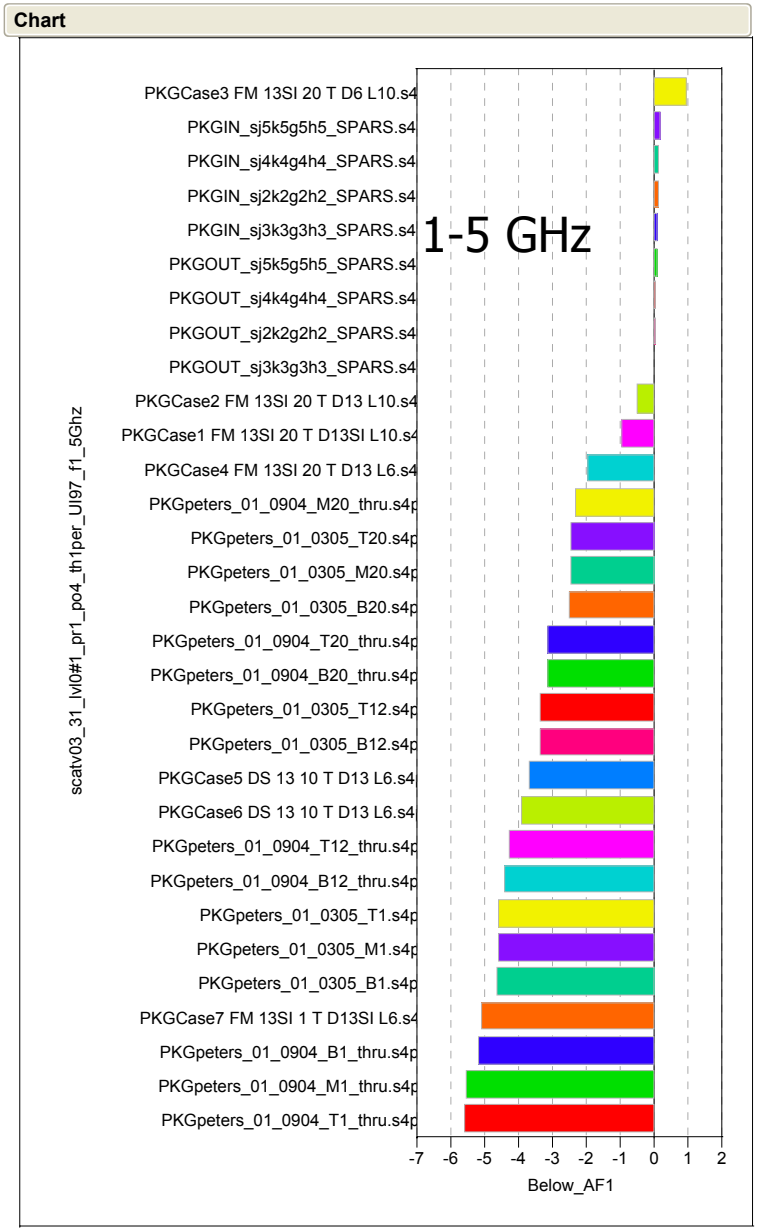
PKGpeters_01_0904_M1_thru.s4
PKGpeters_01_0904_B1_thru.s4
PKGpeters_01_0305_B12.s4
PKGCase5 DS 13 10 T D13 L6.s
PKGpeters_01_0305_M20.s4
PKGpeters_01_0305_B20.s4
scatv03_31_lvl0#1_pr1_po4_th1per_UI97_f1_6Ghz
0 1 2 3 4 5 6 7
Delta1max
Occurs at freqs > 2.5 GHz
1-6GHz

Below AF1: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1-5 GHz
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PKGOUT_sj5k5g5h5_SPARS.s4
PKGOUT_sj4k4g4h4_SPARS.s4
PKGOUT_sj2k2g2h2_SPARS.s4
PKGOUT_sj3k3g3h3_SPARS.s4
PKGCase2 FM 13SI 20 T D13 L10.s4
PKGCase1 FM 13SI 20 T D13SI L10.s4
PKGCase4 FM 13SI 20 T D13 L6.s4
PKGpeters_01_0904_M20_thru.s4p
PKGpeters_01_0305_T20.s4p
PKGpeters_01_0305_M20.s4p
PKGpeters_01_0305_B20.s4p
PKGpeters_01_0904_T20_thru.s4p
PKGpeters_01_0904_B20_thru.s4p
PKGpeters_01_0305_T12.s4p
PKGpeters_01_0305_B12.s4p
PKGCase5 DS 13 10 T D13 L6.s4
PKGCase6 DS 13 10 T D13 L6.s4
PKGpeters_01_0904_T12_thru.s4p
PKGpeters_01_0904_B12_thru.s4p
PKGpeters_01_0305_T1.s4p
PKGpeters_01_0305_M1.s4p
PKGpeters_01_0305_B1.s4p
PKGCase7 FM 13SI 1 T D13SI L6.s4
PKGpeters_01_0904_B1_thru.s4p
PKGpeters_01_0904_M1_thru.s4p
PKGpeters_01_0904_T1_thru.s4p
-7 -6 -5 -4 -3 -2 -1 0 1 2
Below_AF1

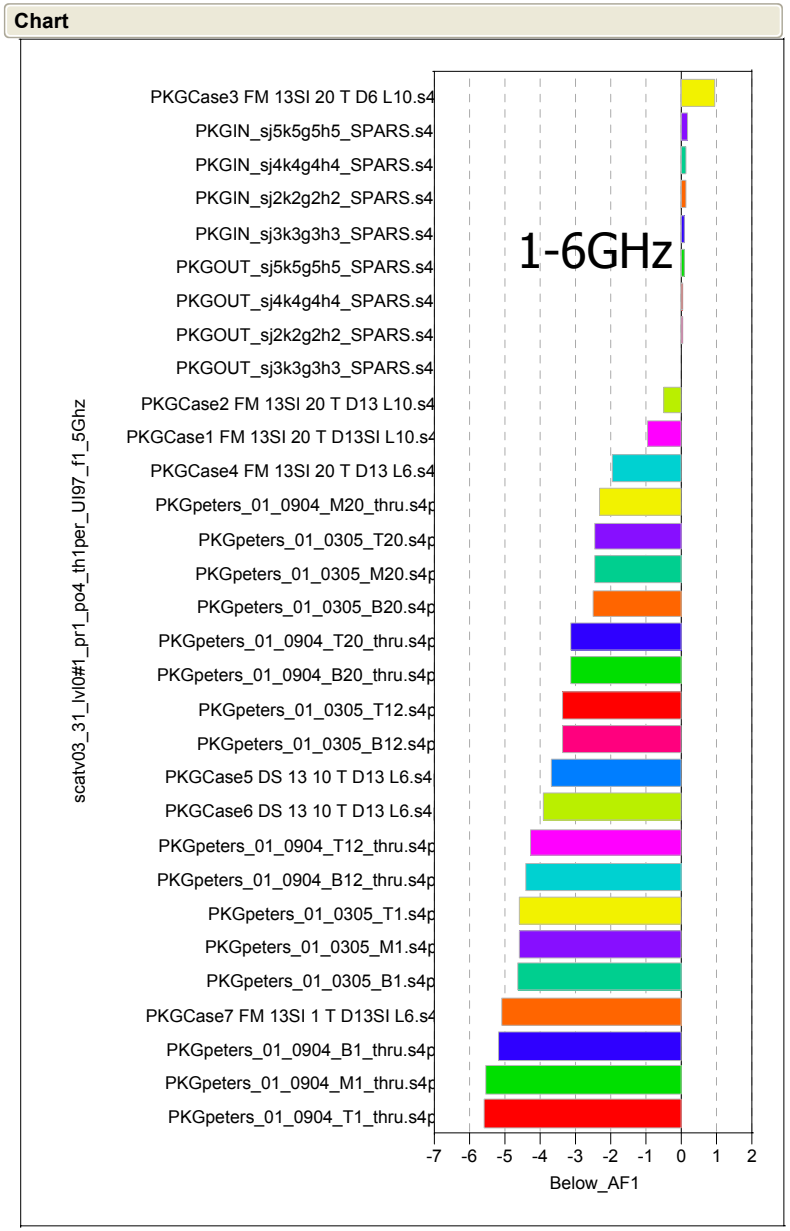
Chart
1-6GHz
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PKGCase2 FM 13SI 20 T D13 L10.s4
PKGCase1 FM 13SI 20 T D13SI L10.s4
PKGCase4 FM 13SI 20 T D13 L6.s4
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PKGpeters_01_0305_T20.s4p
PKGpeters_01_0305_M20.s4p
PKGpeters_01_0305_B20.s4p
PKGpeters_01_0904_T20_thru.s4p
PKGpeters_01_0904_B20_thru.s4p
PKGpeters_01_0305_T12.s4p
PKGpeters_01_0305_B12.s4p
PKGCase5 DS 13 10 T D13 L6.s4
PKGCase6 DS 13 10 T D13 L6.s4
PKGpeters_01_0904_T12_thru.s4p
PKGpeters_01_0904_B12_thru.s4p
PKGpeters_01_0305_T1.s4p
PKGpeters_01_0305_M1.s4p
PKGpeters_01_0305_B1.s4p
PKGCase7 FM 13SI 1 T D13SI L6.s4
PKGpeters_01_0904_B1_thru.s4p
PKGpeters_01_0904_M1_thru.s4p
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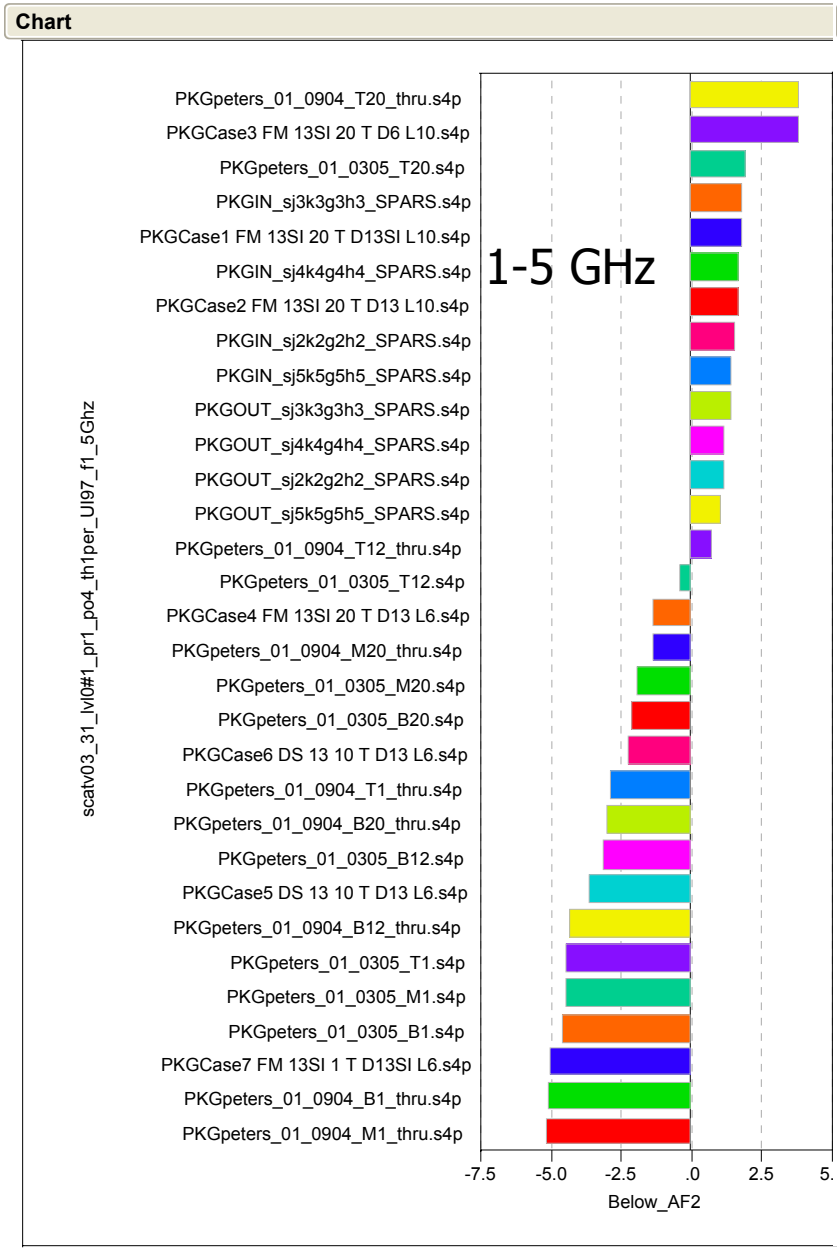
-7 -6 -5 -4 -3 -2 -1 0 1 2
Below_AF1

Below F2: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PKGpeters_01_0305_T20.s4p
PKGIN_sj3k3g3h3_SPARS.s4p
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PKGIN_sj4k4g4h4_SPARS.s4p
PKGCase2 FM 13SI 20 T D13 L10.s4p
PKGIN_sj2k2g2h2_SPARS.s4p
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PKGOUT_sj3k3g3h3_SPARS.s4p
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PKGOUT_sj2k2g2h2_SPARS.s4p
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PKGpeters_01_0305_T12.s4p
PKGCase4 FM 13SI 20 T D13 L6.s4p
PKGpeters_01_0904_M20_thru.s4p
PKGpeters_01_0305_M20.s4p
PKGpeters_01_0305_B20.s4p
PKGCase6 DS 13 10 T D13 L6.s4p
PKGpeters_01_0904_T1_thru.s4p
PKGpeters_01_0904_B20_thru.s4p
PKGpeters_01_0305_B12.s4p
PKGCase5 DS 13 10 T D13 L6.s4p
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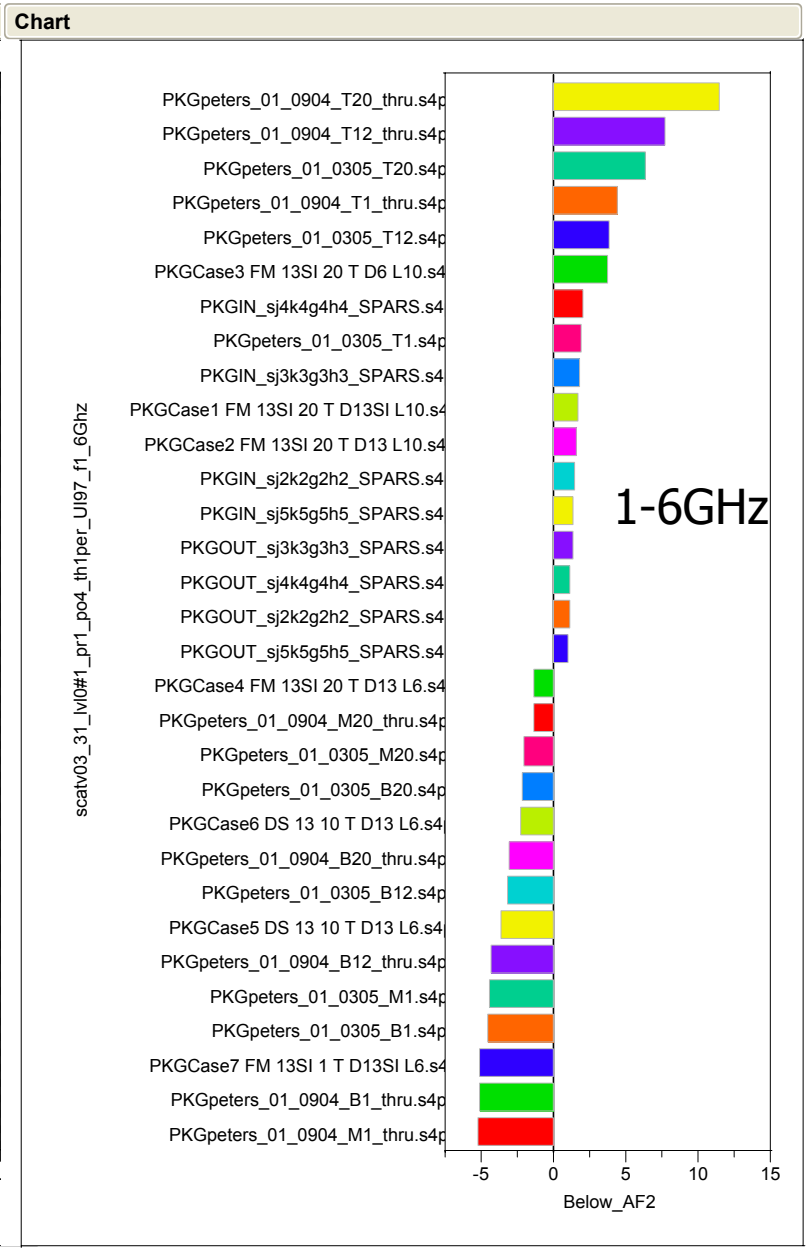
PKGpeters_01_0305_T1.s4p
PKGpeters_01_0305_M1.s4p
PKGpeters_01_0305_B1.s4p
PKGCase7 FM 13SI 1 T D13SI L6.s4p
PKGpeters_01_0904_B1_thru.s4p
PKGpeters_01_0904_M1_thru.s4p
1-5 GHz
-7.5
-5.0
-2.5
.0
2.5
5.
Below_AF2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PKGpeters_01_0305_T20.s4p
PKGpeters_01_0904_T1_thru.s4p
PKGpeters_01_0305_T12.s4p
PKGCase3 FM 13SI 20 T D6 L10.s4
PKGIN_sj4k4g4h4_SPARS.s4
PKGpeters_01_0305_T1.s4p
PKGIN_sj3k3g3h3_SPARS.s4
PKGCase1 FM 13SI 20 T D13SI L10.s4
PKGCase2 FM 13SI 20 T D13 L10.s4
PKGIN_sj2k2g2h2_SPARS.s4
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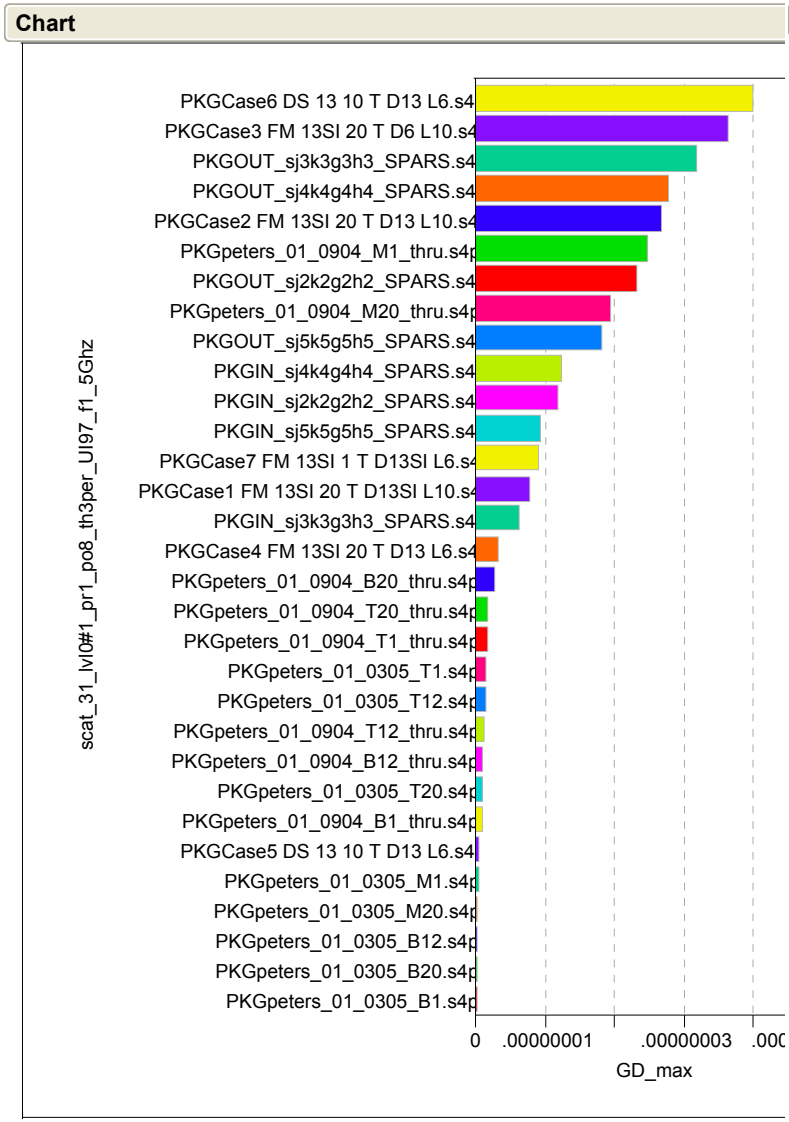
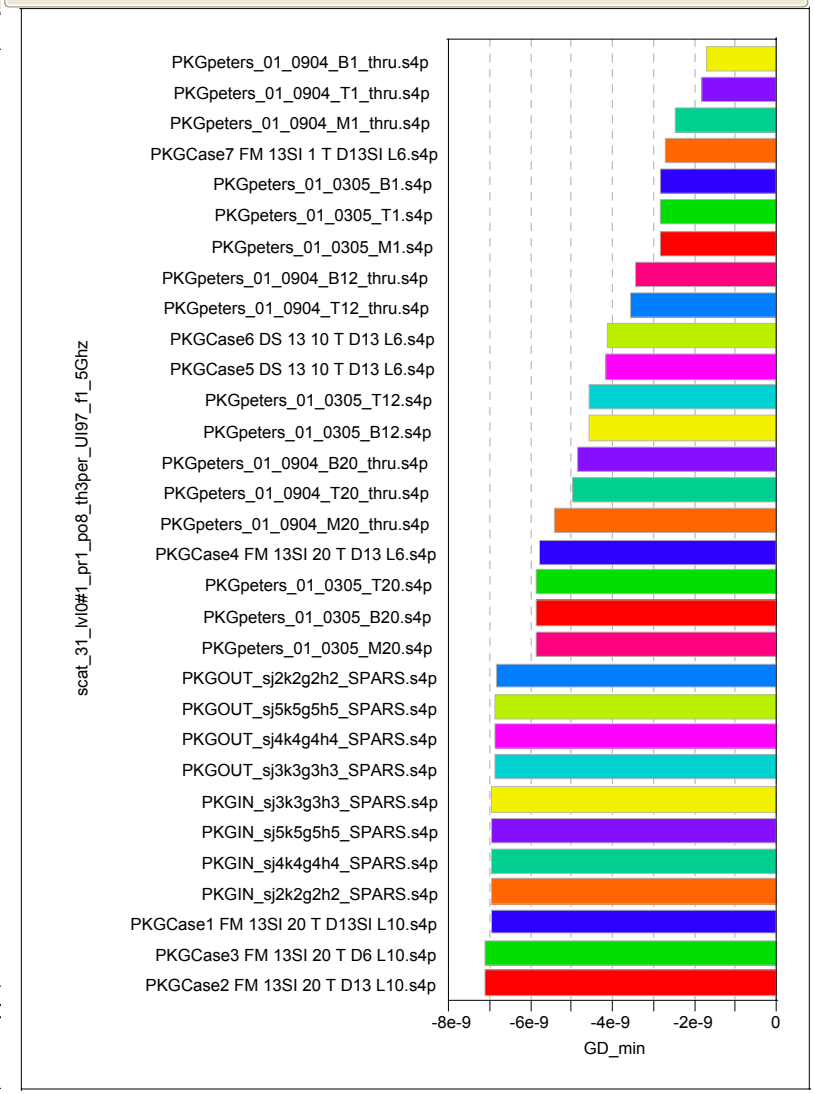
PKGOUT_sj2k2g2h2_SPARS.s4
PKGOUT_sj5k5g5h5_SPARS.s4
PKGCase4 FM 13SI 20 T D13 L6.s4
PKGpeters_01_0904_M20_thru.s4p
PKGpeters_01_0305_M20.s4p
PKGpeters_01_0305_B20.s4p
PKGCase6 DS 13 10 T D13 L6.s4
PKGpeters_01_0904_B20_thru.s4p
PKGpeters_01_0305_B12.s4p
PKGCase5 DS 13 10 T D13 L6.s4
PKGpeters_01_0904_B12_thru.s4p
PKGpeters_01_0305_M1.s4p
PKGpeters_01_0305_B1.s4p
PKGCase7 FM 13SI 1 T D13SI L6.s4
PKGpeters_01_0904_B1_thru.s4p
PKGpeters_01_0904_M1_thru.s4p
1-6GHz
-5
0
5
10
15
Below_AF2

Other parameters max/min Group Delay





AC Parameter Result overview

- Peters 0904 T1 has consistently worst Δ's
  - Except Δ2(min)
- Below AF1
  - Molex channel are on LMS fit line
  - Tyco case 3 is below LMS fit line
- Below AF2
  - Peter 0904 T20 is worst
  - This parameter can realistically enable more channels.
- The freq where Δ2's occurs at is normally less than F2 and does not seem to have a pattern where it occurs.

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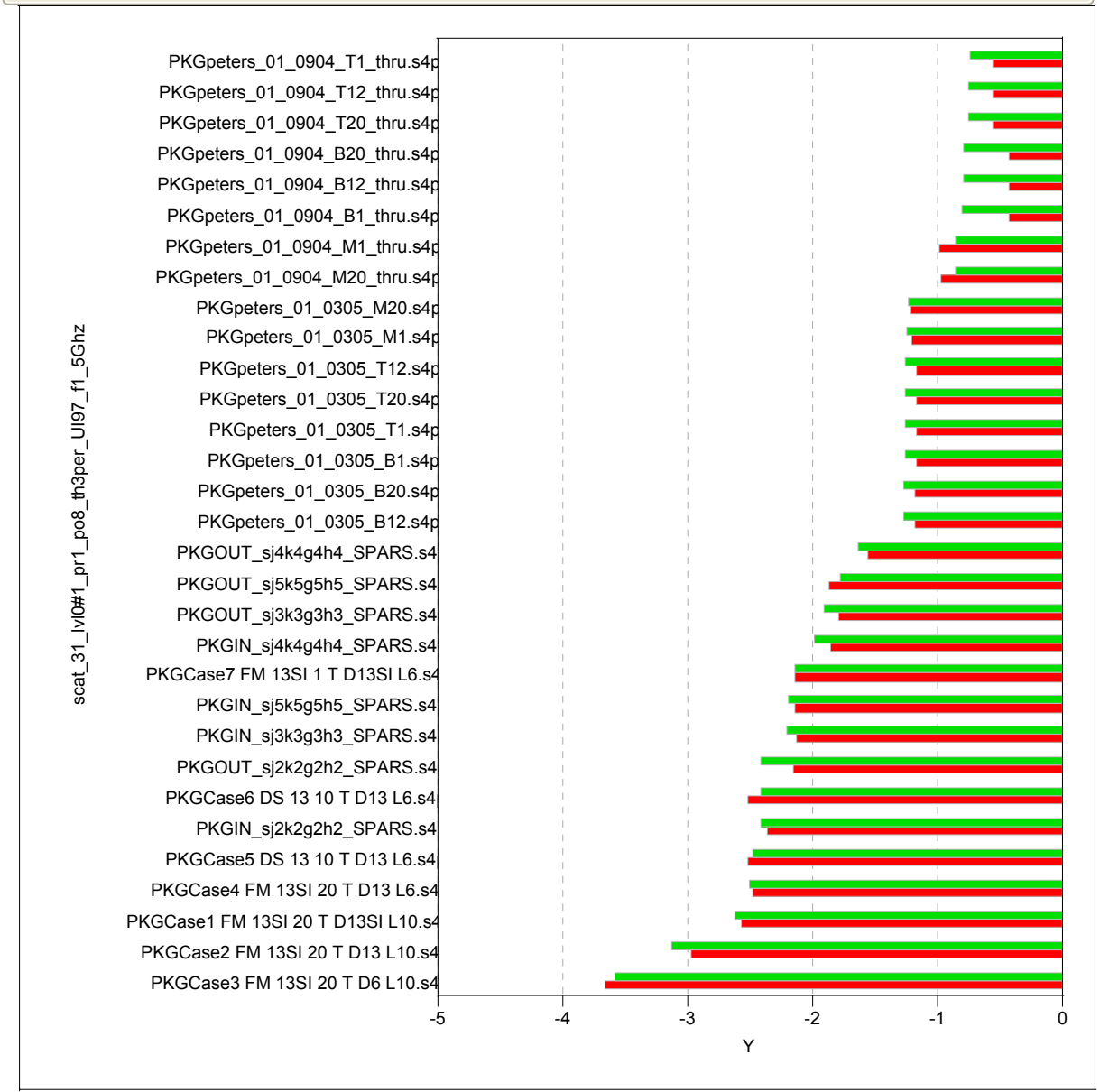
SDD11 and SDD22 max

Chart

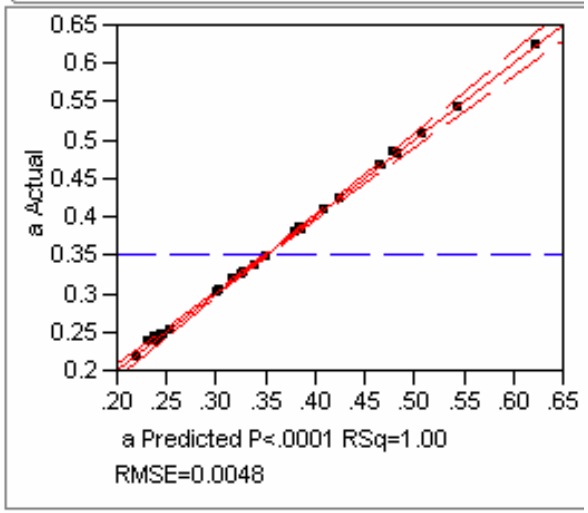
Overlay Chart



AC parameters fit to "A"

Response a

Actual by Predicted Plot



Summary of Fit

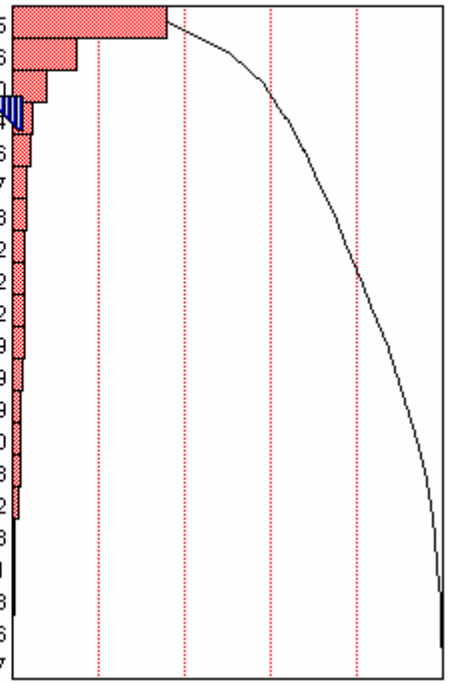
R-square is the portion of variation attributed to the mc
1. Root Mean Squared Error "RMSE" estimates the star
residual.

RSquare	0.999414
RSquare Adj	0.998047
Root Mean Square Error	0.004775
Mean of Response	0.350319
Observations (or Sum Wgts)	31

Pareto Plot of Transformed Estimates

Absolute effect sizes from high to low, and how they add up.

Term	Orthog Estimate
Below_AF1	-0.0923425
Delta2max	-0.0387356
Delta2min	0.0208530
Delta1max	0.0122384
(Below_AF1+2.42741)*(Delta1max-1.07749)	0.0109826
(Below_AF2-0.20405)*(Delta1max-1.07749)	-0.0090137
(Delta1max-1.07749)*(Delta1max-1.07749)	-0.0084703
(Delta2max-3.6764)*(Delta1min-0.93368)	-0.0081912
(Delta2min-3.37919)*(Delta2min-3.37919)	-0.0079892
(Below_AF1+2.42741)*(Below_AF1+2.42741)	0.0076772
(Delta2max-3.6764)*(Delta2max-3.6764)	0.0075689
(Delta2max-3.6764)*(Delta1max-1.07749)	-0.0065329
Below_AF2	-0.0059269
(Below_AF2-0.20405)*(Below_AF1+2.42741)	0.0053100
(Below_AF2-0.20405)*(Below_AF2-0.20405)	0.0048378
(Below_AF2-0.20405)*(Delta1min-0.93368)	-0.0042332
(Below_AF1+2.42741)*(Delta2min-3.37919)	0.0019533
(Below_AF1+2.42741)*(Delta2max-3.6764)	-0.0016701
(Below_AF2-0.20405)*(Delta2min-3.37919)	0.0015263
(Delta1min-0.93368)*(Delta1min-0.93368)	0.0011416
(Below_AF2-0.20405)*(Delta2max-3.6764)	-0.0000187



Great fit!

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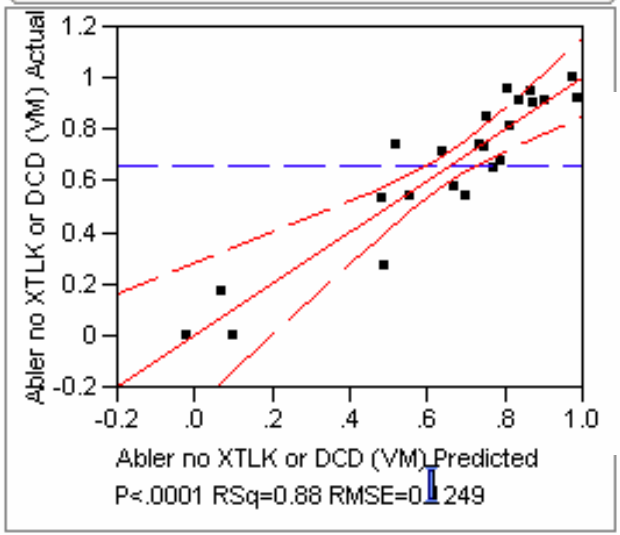
AC to Abler Voltage Margin, no Xtl, no DCD

Whole Model

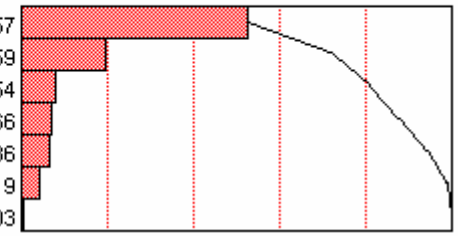
Actual by Predicted Plot



Pareto Plot of Transformed Estimates

Absolute effect sizes from high to low, and how they add up.

Term	Orthog Estimate
Delta1min	-0.2477957
(Below_AF1+2.06399)*(Below_AF1+2.06399)	-0.0920759
Delta2max	-0.0391154
Delta1max	-0.0328866
Below_AF1	0.0317136
Delta2min	-0.0204619
Below_AF2	-0.0036503



Summary of Fit

R-square is the portion of variation attributed to the model, between 0 and 1. Root Mean Squared Error "RMSE" estimates the standard deviation of th residual.

RSquare	0.879051
RSquare Adj	0.822608
Root Mean Square Error	0.124889
Mean of Response	0.656087
Observations (or Sum Wgts)	23

Got warning: ill condition experiment

Poor fit

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Do time parameters fit/correlate to AC parameters?

- AC parameters fit well to A
- AC parameter do not fit well to system analysis (w/out Xtlk)
  - Maybe not enough data
  - I.e. all the channel were not done

Performance Correlation

- Agreement on worst channel between the all the Abler and ac params.
- Only 65% correlation agreement on grading other channels.
  - Potential reasons:
    - DFE and FFE are not passive functions
    - Numerical implementations can vary
    - Numerical error could be significant compare to the results.
- A and Q are not correlated to channel performance
  - A and Q do fit a complex function of AC parameters

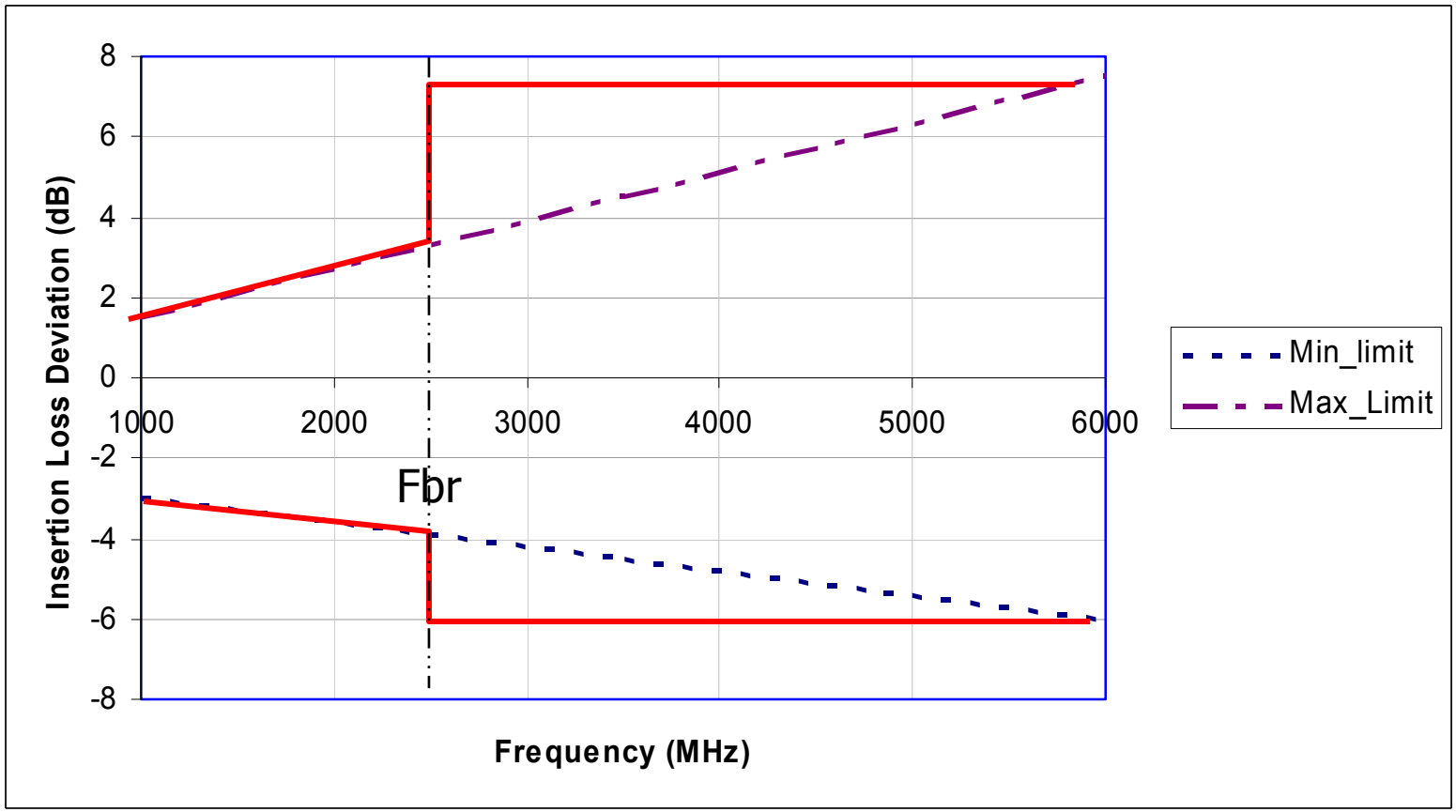
Drawing "lines in the sand"

- Wait until June meeting to so we can gain performance consensus
- Use that consensus to draw "the lines in the sand"

Parameter	Value	Units
fmin	0.05	GHz
fmax	15	GHz
b1	2.25E-0.5	
b2	1.20E-10	
b3	3.50E-20	
b4	–1.25E-30	
f1	1	GHz
f2	6	GHz
IL1	A(f1)-TBD	dB
IL2	A(f1)-TBD	dB
mHF	40	dB/decade
Δ1(min)	TBD	dB
Δ1(max)	TBD	dB
Δ2(min)	TBD	dB
Δ2(max)	TBD	dB
Fbr	TBD	GHz

Straw Poll 1

- Change AC limit graph to have the form as follows:



Straw Poll 2

- Given
  - Tx is observable
  - Channel parameters are observable
  - Rx is only observable for BER
  - At least some folks think most channel are workable in the Rx.
  - Can't agree on highly correlated ordering of all channels based on Rx
- Straw Pole
  - Spec Tx and channel ac parameters
  - Insure capacity to receive data as a confidence exercise
  - Do not spec Rx – Let competition drive good Rx
- Impact
  - Tx designer have clear design path
  - Channel designer have clear design path
  - Rx designer do not have a clear design path but have most freedom to compete.