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# Alien Crosstalk measurement limitations at low frequencies (1 MHz to ~ 10 MHz)

**Prepared for IEEE802.3an 10GBase-T task group**

Henriecus (“Henri” or “Riekus”) Koeman
Fluke Networks

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This presentation is to be made to the IEEE802.3an task group on 10GBase-T during the May 2005 meeting in Austin, Texas.

Comments and suggestions are always appreciated!

Henriecus (“Henri” or “Riekus”) Koeman
Fluke Networks (Monday/Tuesday/Wednesday)

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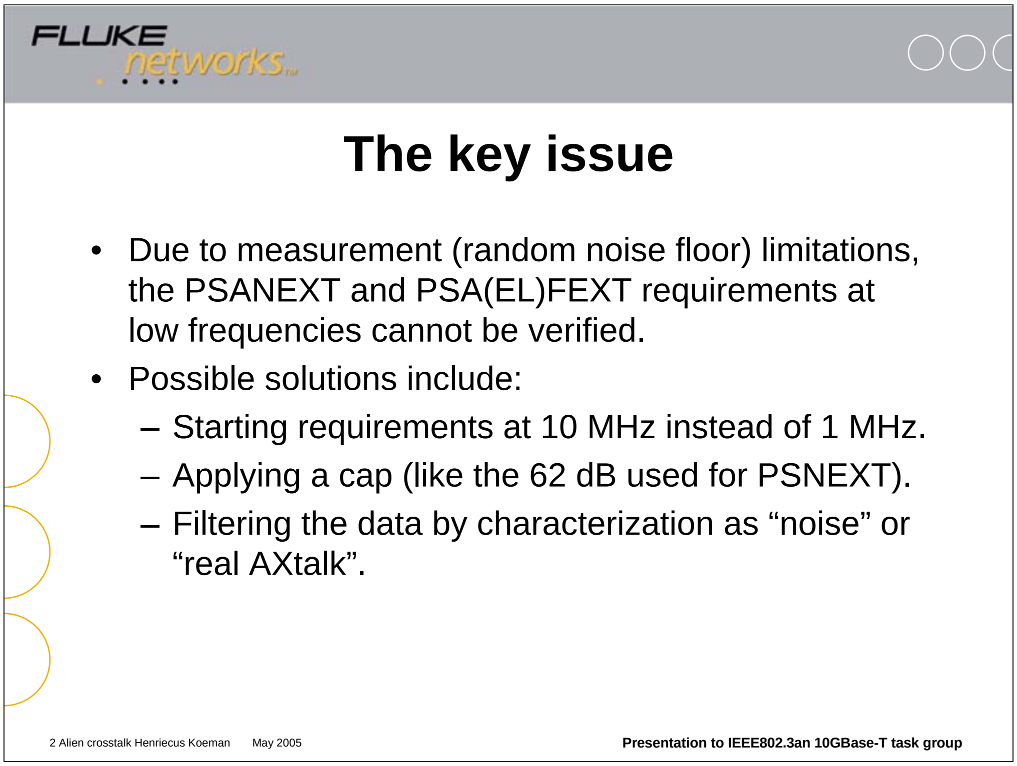
| P.O. Box 9090 | 6920 Seaway Boulevard |
| Everett, WA 98206 USA | Everett, WA 98203 USA |
| Tel: +1 425-446-5399 | Fax: +1 425-446-5043 |

E-mail: henriecus.koeman@flukenetworks.com

HK Engineering Services (Thursday/Friday)
1022 C Avenue
Edmonds, WA 98020
Tel: +1-425-775-2088
E-mail: henri_koeman@IEEE.org




The key issue is that as stated the PSANEXT and PSA(EL)FEXT requirements at low frequencies cannot be verified. It is felt strongly that any performance requirements must be reliably verifiable, otherwise they are meaningless.

Possible solutions include:

1) Starting the requirements at a higher frequency than 1MHz.
2) Applying a cap to the maximum values (like 70 dB) for PSANEXT and PSAFEXT.
3) Implementing a selection process of PP data by characterizing each as “noise” or a “real AXtalk” signal. This effectively results in a version of the 1) type of solution.

## A limitation as proposed is actually pretty harmless ….

- Cable and connector PSAXtalk will continue to response quite naturally at a 10 dB, 15 dB or 20 dB slope as applicable.
- Therefore a failure below 10 MHz will correspond to a failure above 10 MHz with very high level of confidence.
- Starting PSAXtalk requirements at 10 MHz will solve numerous measurement issues with installed cabling configurations, as well as cabling component testing.
- Less beneficial (given the complexity of multiple PP AXtalk measurements) are the use of caps (like currently found in cabling standards: 62 dB for PSNEXT).

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This proposal is practically not at all harmful to the 10GBASE-T application, given that natural responses are still subject to natural slopes of 10 dB, 15 or 20 dB as appropriate for cable, connectors or channels.

If there were a failure below 10 MHz, another failure will be found at frequencies above 10 MHz with very high level of confidence.

To resolve formal measurement issues, starting the PSAXtalk requirements at 10 MHz is most helpful. One also finds regularly caps on requirements in cabling standards (like 65 dB for PPNEXT and 62 dB for PSNEXT). Again, it translates in practice to a higher frequency where the tests become significant.

# Proposal

- The proposal is to increase the lower frequency limit of test for PS AXtalk from 1 MHz to 10 MHz. This will resolve random noise floor of measurement issues in most cases and not affect expected SNR performance in any significant manner.
- An alternative is to apply a 70 dB cap to both PSANEXT and PSAFEXT measurements (which in effect has the effect as in the original proposal).

**The slides that follow are intended to back up the observations that were made to support this proposal and will be presented only if so requested.**

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There are significant measurement challenges as a result of the extremely sensitive signals that need to be measured. On top of that, the results from these many measurements have to be added.

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## Outline of presentation details

- Review of special test conditions when measuring alien crosstalk parameters in both installed cabling and component testing.
  – Multiple measurements causes the random noise floor to accumulate. The low frequency limit becomes critical.
- Strategies to deal with the situation.
  – Increase the lower frequency (1 MHz currently) to a higher frequency (10 MHz?)
  – Applying a cap (70 dB to both PSANEXT and PSAFEXT)
  – Design strategies of classifying PP AXtalk test results as a real PP AXtalk contribution or as noise.

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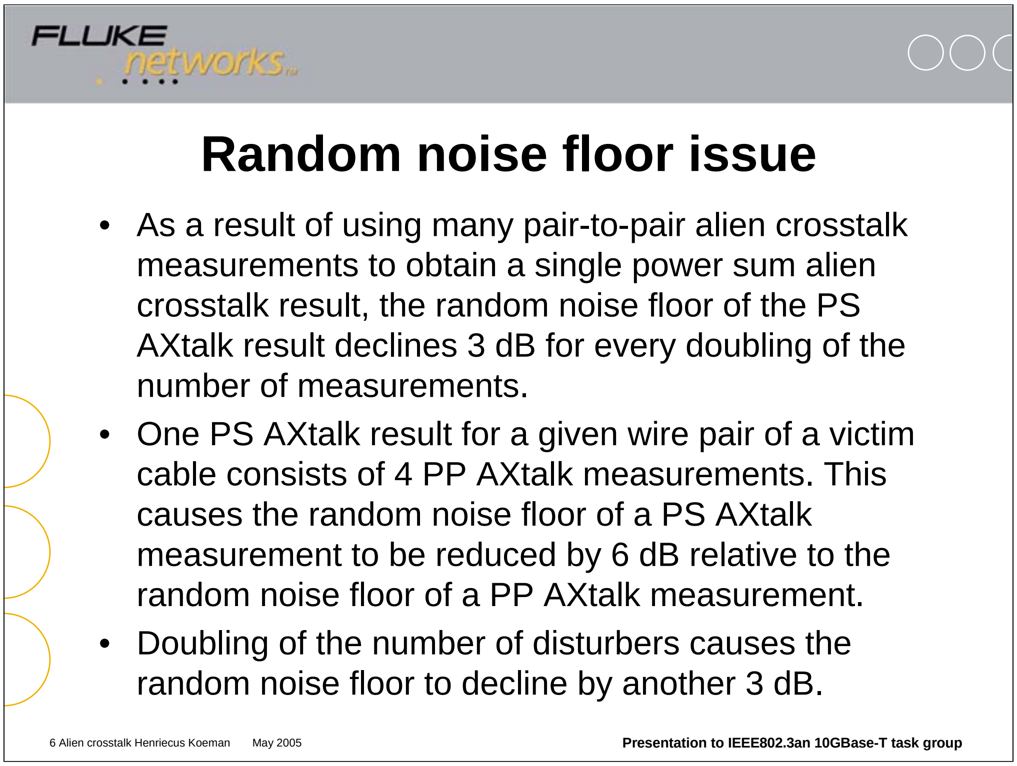
The detailed aspects of this presentation discuss the special test conditions when measuring alien crosstalk parameters in both installed cabling and component testing.

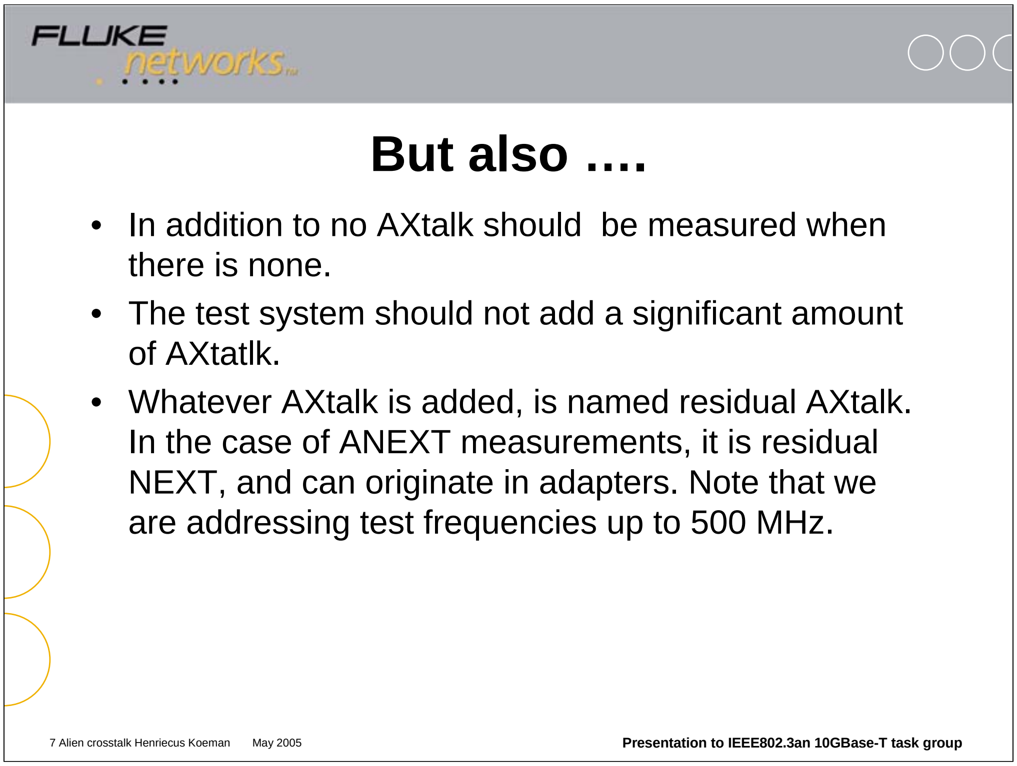
It also identifies some strategies to deal with the challenges.




This contribution deals with the challenge of random noise of the measurement system. This is really a major issue due to the number of measurements involved in obtaining one PS AXtalk result.

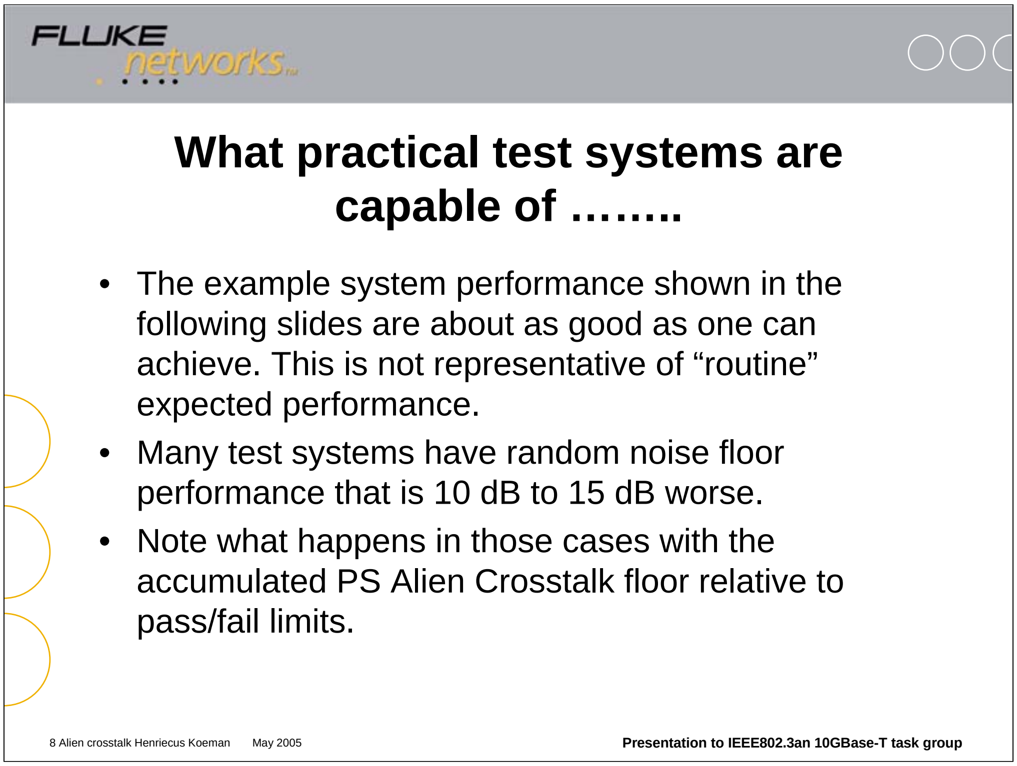
Starting with a PP AXtalk noise floor, the PS AXtalk noise floor is 6 dB worse (for every doubling of the number of measurements, the noise floor power increases by 3 dB).

Then we have to measure potentially many disturbers to a single victim. This further decreases the random noise floor of the PSAXtalk result.



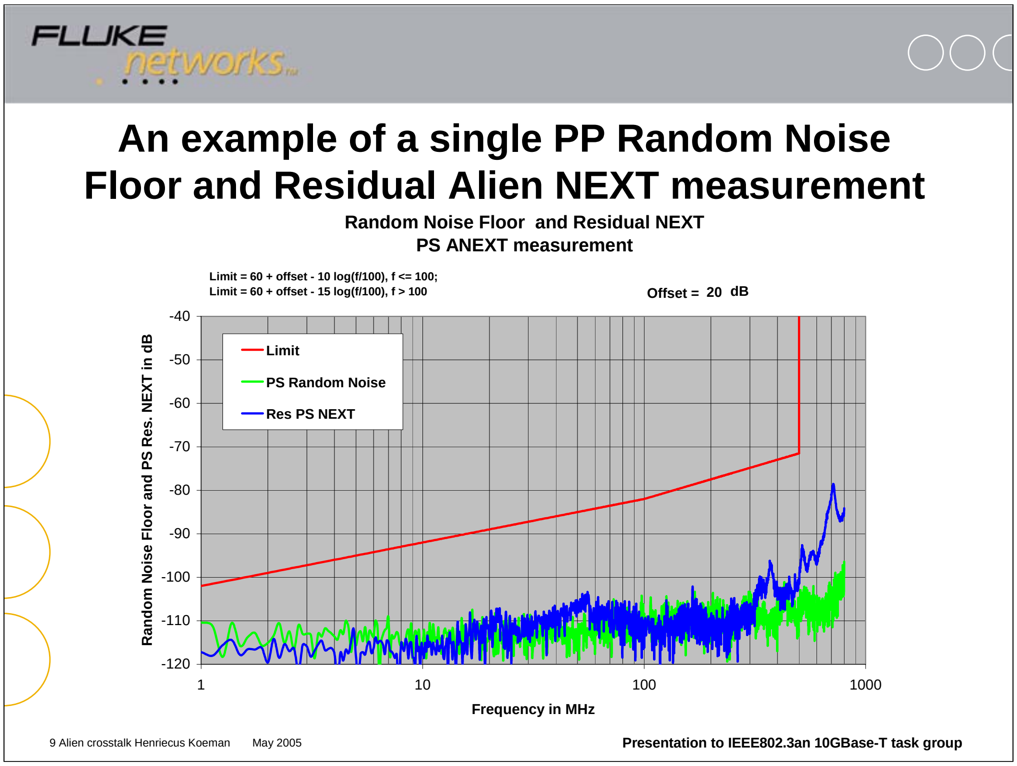

Of course, one should not measure any Alien Crosstalk, if there is nothing connected to the test system. The residual Alien NEXT is measured by further extending the averaging and measurement times to reduce the influence of random noise. Practically, there is a limit of what additional averaging really does, though. So some influence of random noise on the measured result remains visible.

At 500 MHz, any exposed wire acts like an antenna; it does not take much to pick up signals from such antenna.




We show in the following slides example of a level of random noise performance that is as good as one may desire. This level of performance is most often NOT achieved, and not uncommonly is 10 dB to 15 dB worse.

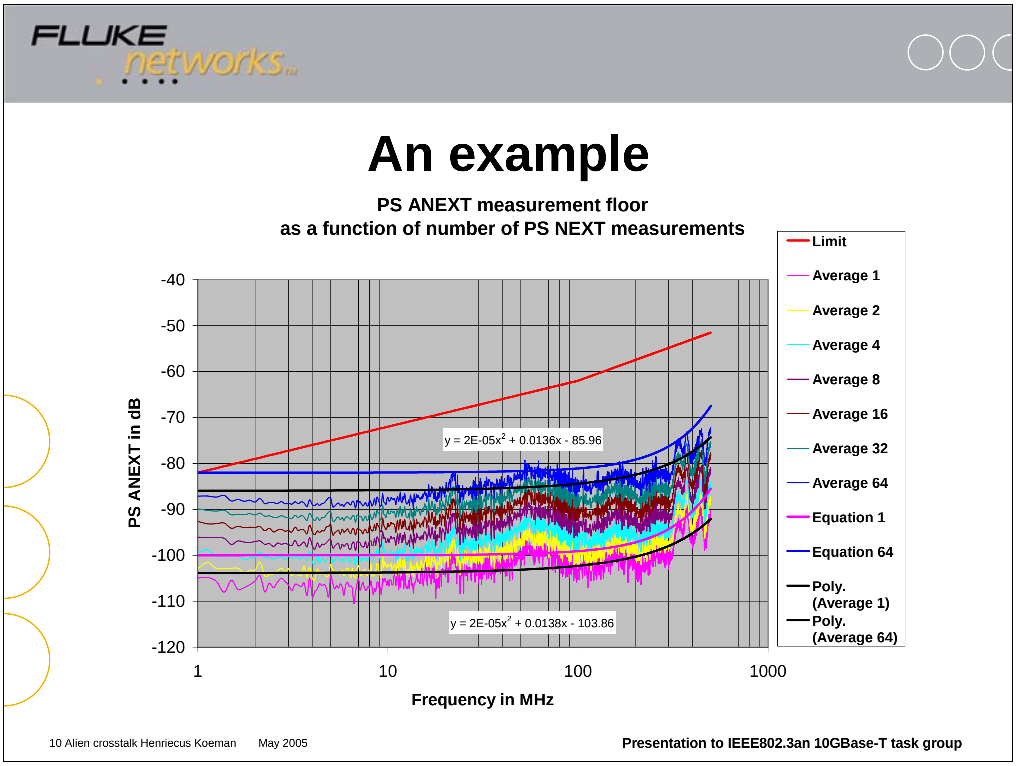
You may worry about such measurement conditions.



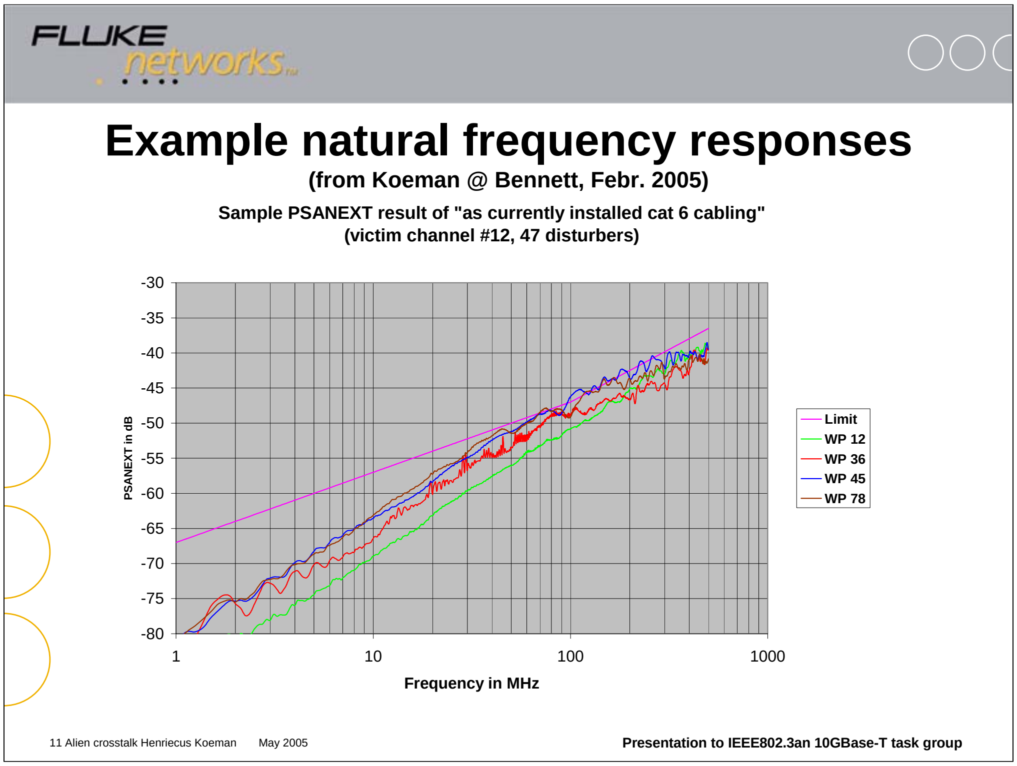

This slide shows an example of a random noise floor and residual AXtalk for a PP ANEXT measurement. The random noise floor is almost -110 dB over the 1 MHz to 100 MHz range and then declines to approx. -100 dB at 500 MHz. Given that there is a trade-off between measurement time (IFBW) and noise floor, this is about as good as what one can practically obtain.

As a limit the PSANEXT limit for 100 m Cat 6 cabling is shown (62 dB @ 100 MHz) + 20 dB. This margin is expected to decline by 6 dB to get to a PSANEXT measurement for a single disturber to victim result, and further by the number of disturbers to be included in the overall result.

The residual ANEXT result (which actually includes some of the effects of random noise, which are reduced by even longer measurement times for this test), shows that one has to be very careful with the shielding of the test interface connections.

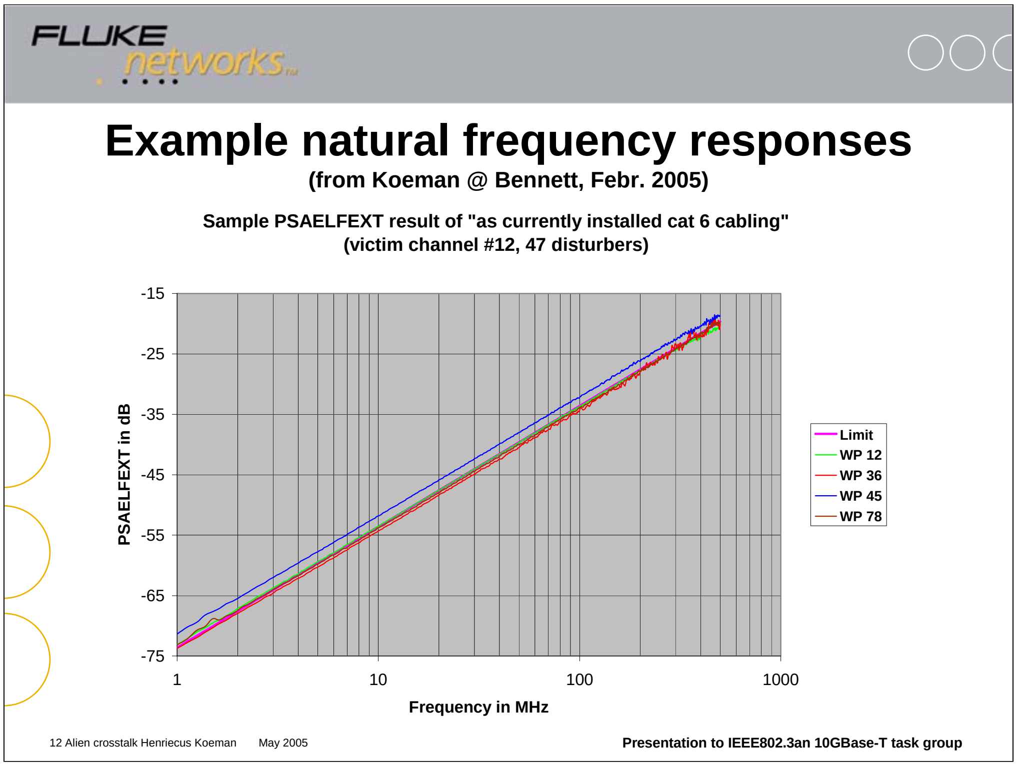



This slide shows the degradation of a random noise floor as a function of the number of measurements that is included in a PSAXtalk result. With the number of cables that may be in a cable bundle (48) in one example, one can observe that the limits at low frequencies can easily reach into the expected random noise floor.

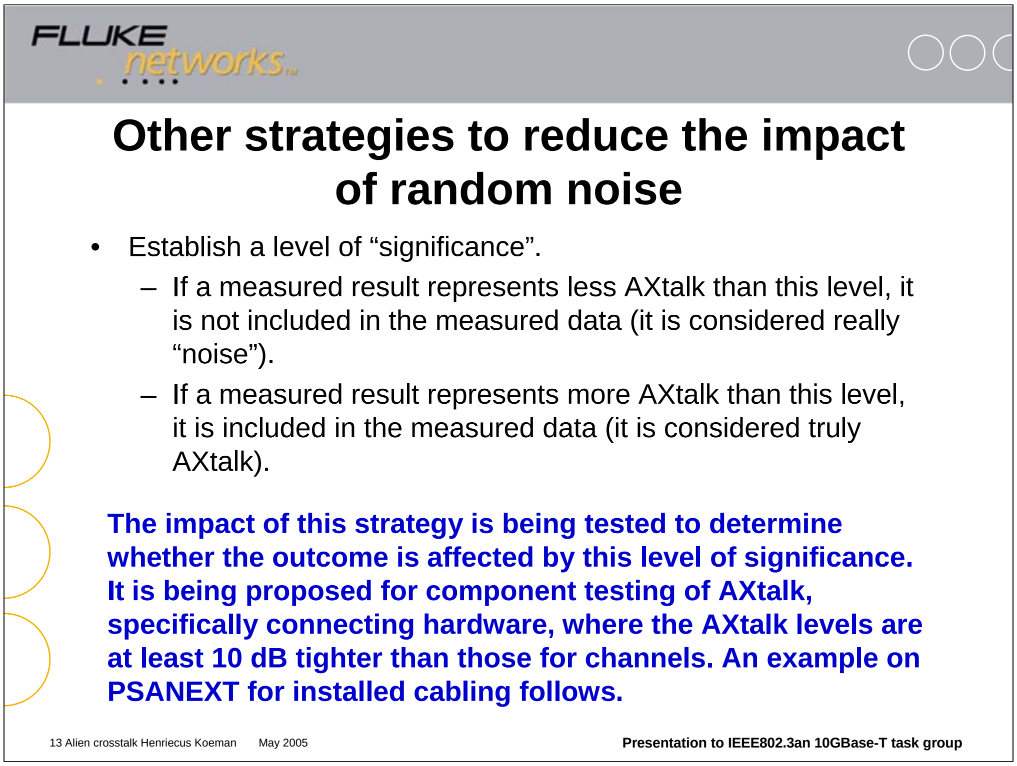



We claim that we really should not worry too much about passing limits at low frequencies. Both alien NEXT and alien (EL)FEXT exhibit behavior that is well predictable, we can therefore assuming with high confidence that a failure at high frequencies will cause the same at low frequencies and vice versa.

In the example shown, the link was relatively short and therefore the performance relative to the limit line came out better than at higher frequencies; again this can be predicted from the length dependency of alien NEXT.



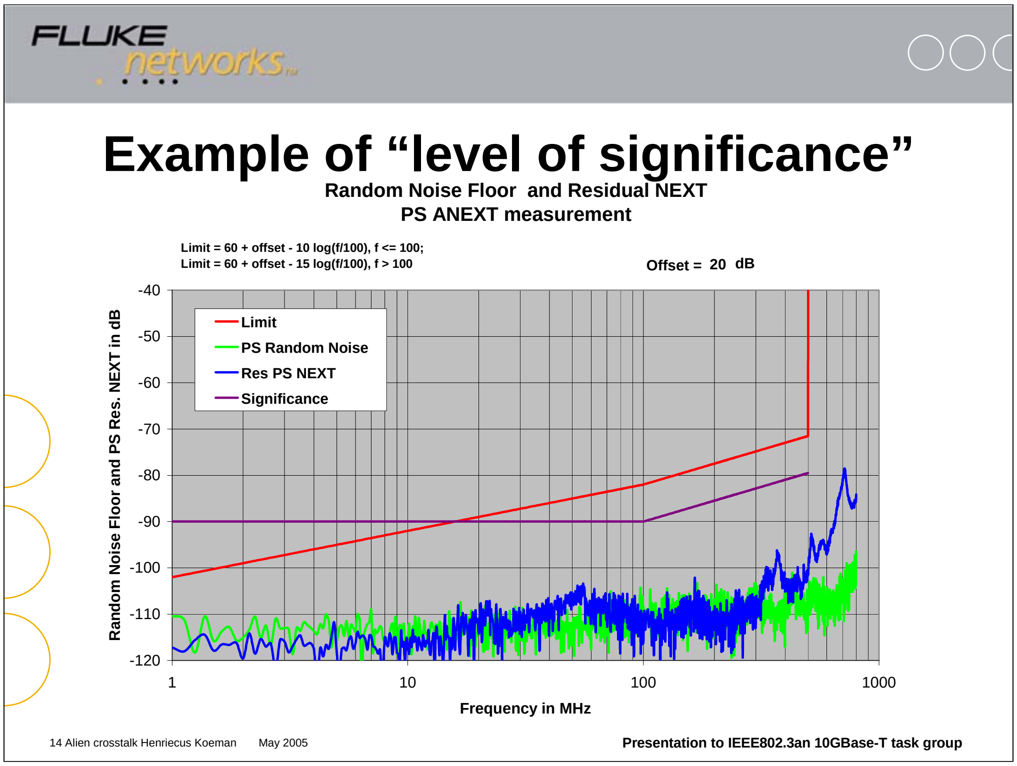

Alien ELFEXT is extremely well behaved and closely approaches a 20 dB/decade slope. Therefore very likely a fail condition at low frequencies will cause a fail condition at high frequencies as well.




Within the cabling standards committees there are discussions on establishing "significance" limits for alien crosstalk tests, and especially for cabling components where the requirements are extremely tight and require the measurement of extremely sensitive signals.

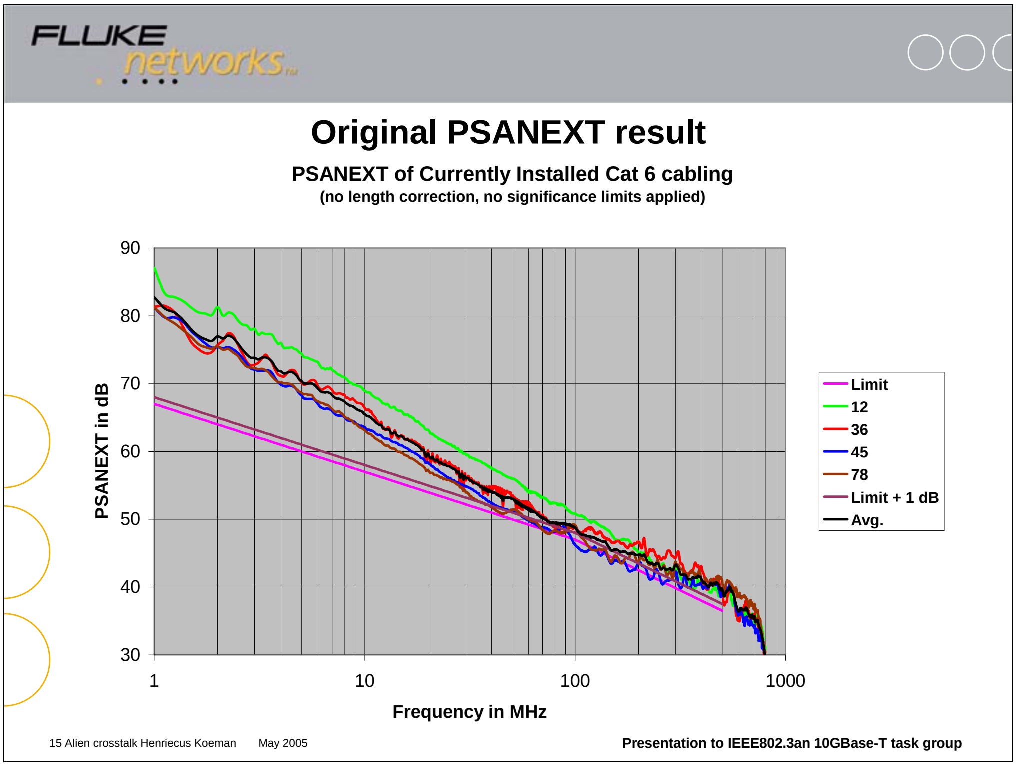
If a datapoint in the frequency response exceeds the threshold (meaning to say that the signal amplitude is higher than the limit), it is included in the overall determination of PSAXtalk. If that datapoint does not exceed that threshold it is NOT included.

The author has just evaluated what the impact of such operation could be on the results. More evaluation is needed.

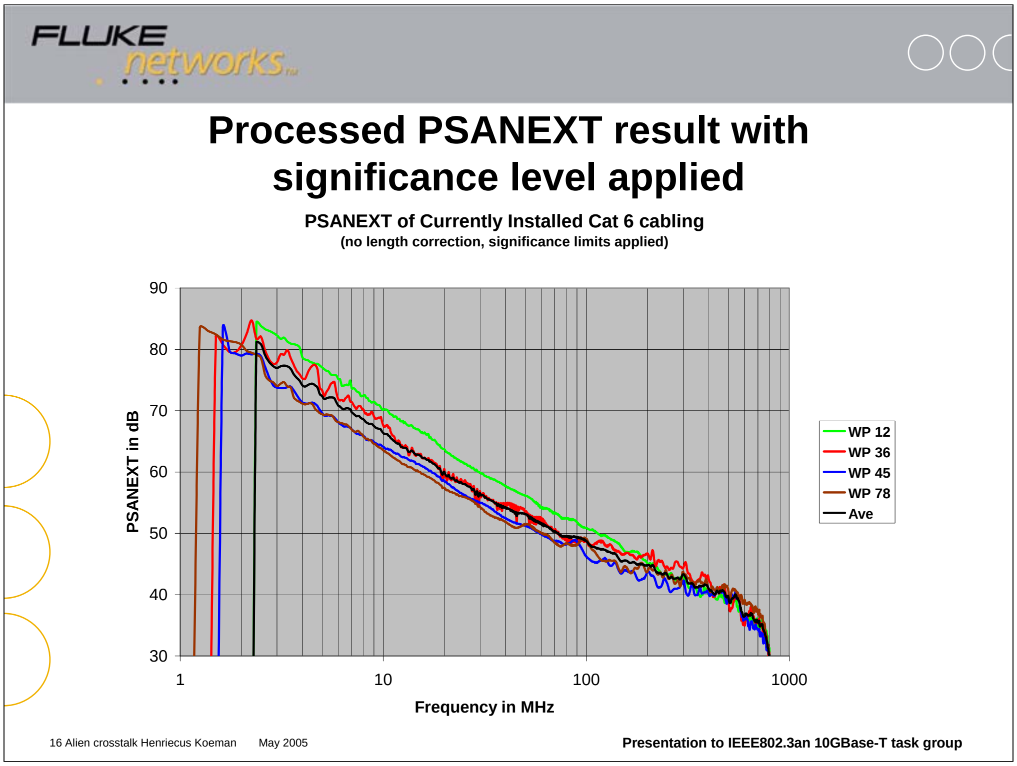



An example level of "significance" is shown in this slide.

This level is being considered for the testing of alien NEXT in connecting hardware.




This data represents the PSANEXT of a victim channel in a 48 bundle at Lawrence Berkeley National Laboratories that was reported to the IEEE-802.3an Task Group in March 2005. No post-processing was implemented.




This is the data that remains after post-processing using the “significance” level approach.

The green trace is wire pair 12.

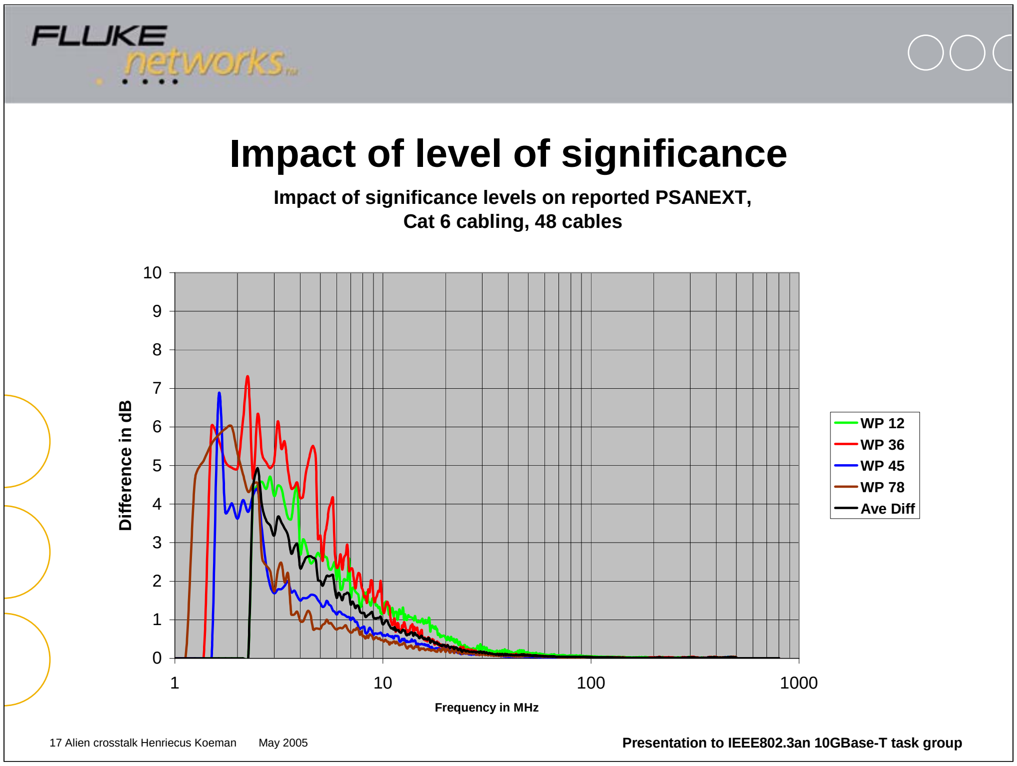
The red trace is wire pair 36.

The blue trace is wire pair 45,

The brown trace is wire pair 78.

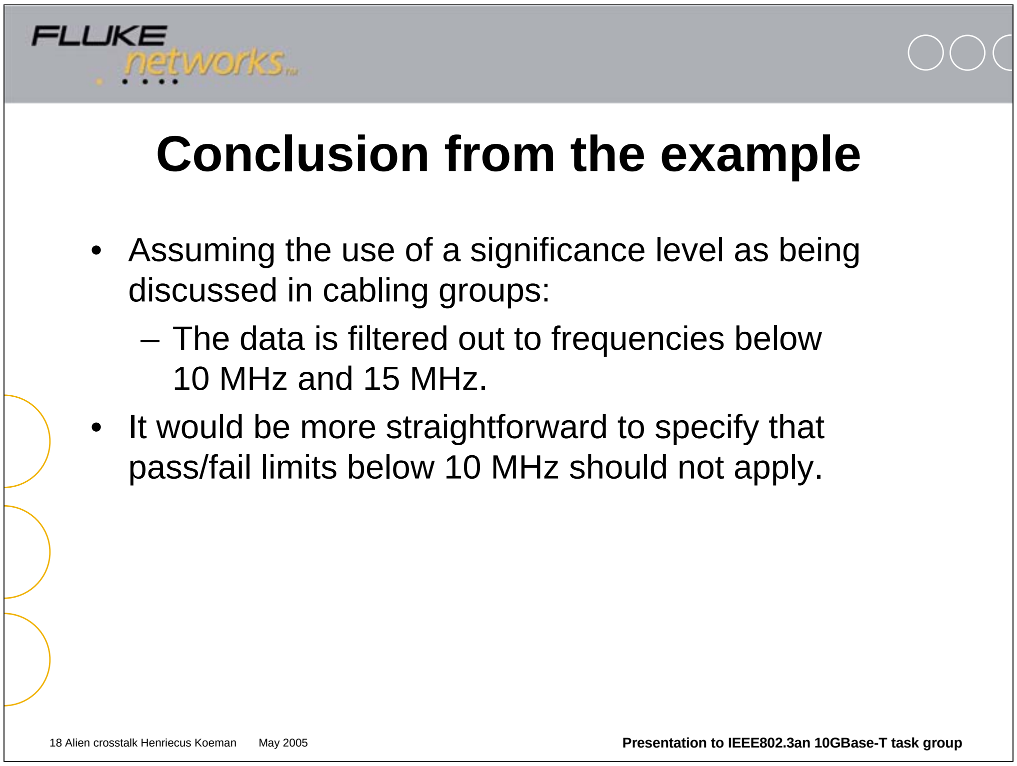
The black trace is the “average” of all 4 wire pair trace.

Note that defacto all data below between 1 MHz and several MHz (between 2 MHz and 3 MHz) gets wiped out and in fact no testing at all occurs in that frequency band.




The difference of the two results at data points that do exist show the distortion that occurs from this.

Note that there is some error (reporting of optimistic results) occurs up to approx. 30 MHz as a result.




The alternative to filtering out data is to start applying pass/fail limits at 10 MHz and not implement any filtering at all. This would prevent introducing distortion of measured results.

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## Conclusions

- To formally specify 10 MHz as a starting point for pass/fail testing of Alien Crosstalk would help the formal procedures for testing both installed cabling and cabling components tremendously, particular in regards to random noise floor properties of test equipment.
- Practically, the natural frequency responses of Alien Crosstalk assure to a high level of confidence that if there were a failure at low frequencies, a failure would exist at frequencies above 10 MHz as well. One may assume that the expected performance extends down to 1 MHz.

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The IEEE 802.3an Task Group, which is the responsible party for specifying performance for the physical layer, is key to consideration of this matter. By changing the starting frequency of testing, a significant issue with cabling standards committees would be resolved, without a practical degradation of practical performance.

Faced with serious random noise floor challenges, if such action is not taken, standards committees will need to implement some kind of filtering of data, which in affect accomplishes the same thing, but also introduces errors in reported data.