Refining TDECQ (continued)

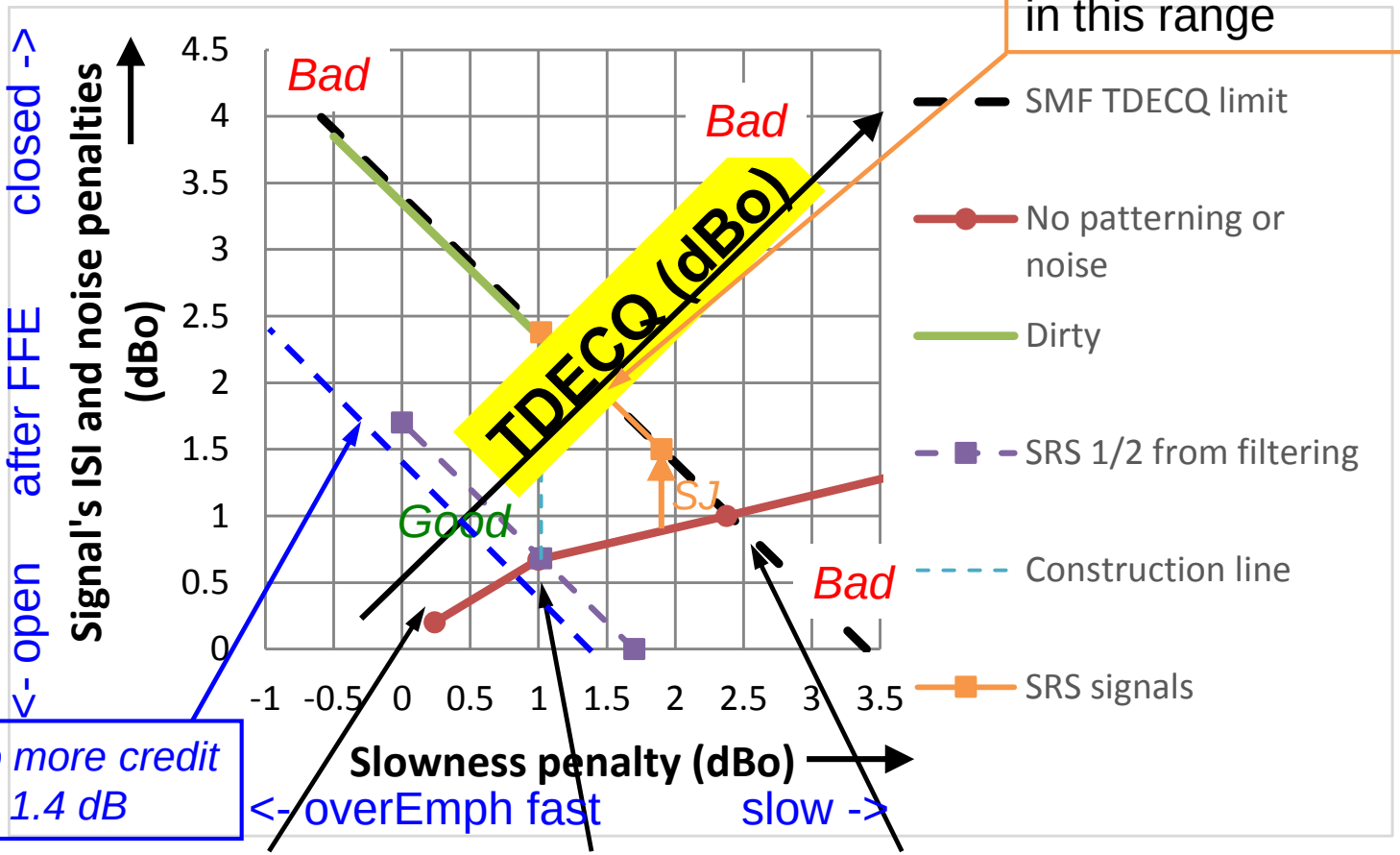
Piers Dawe

Mellanox

Not all maximum-TDECQ signals are equal

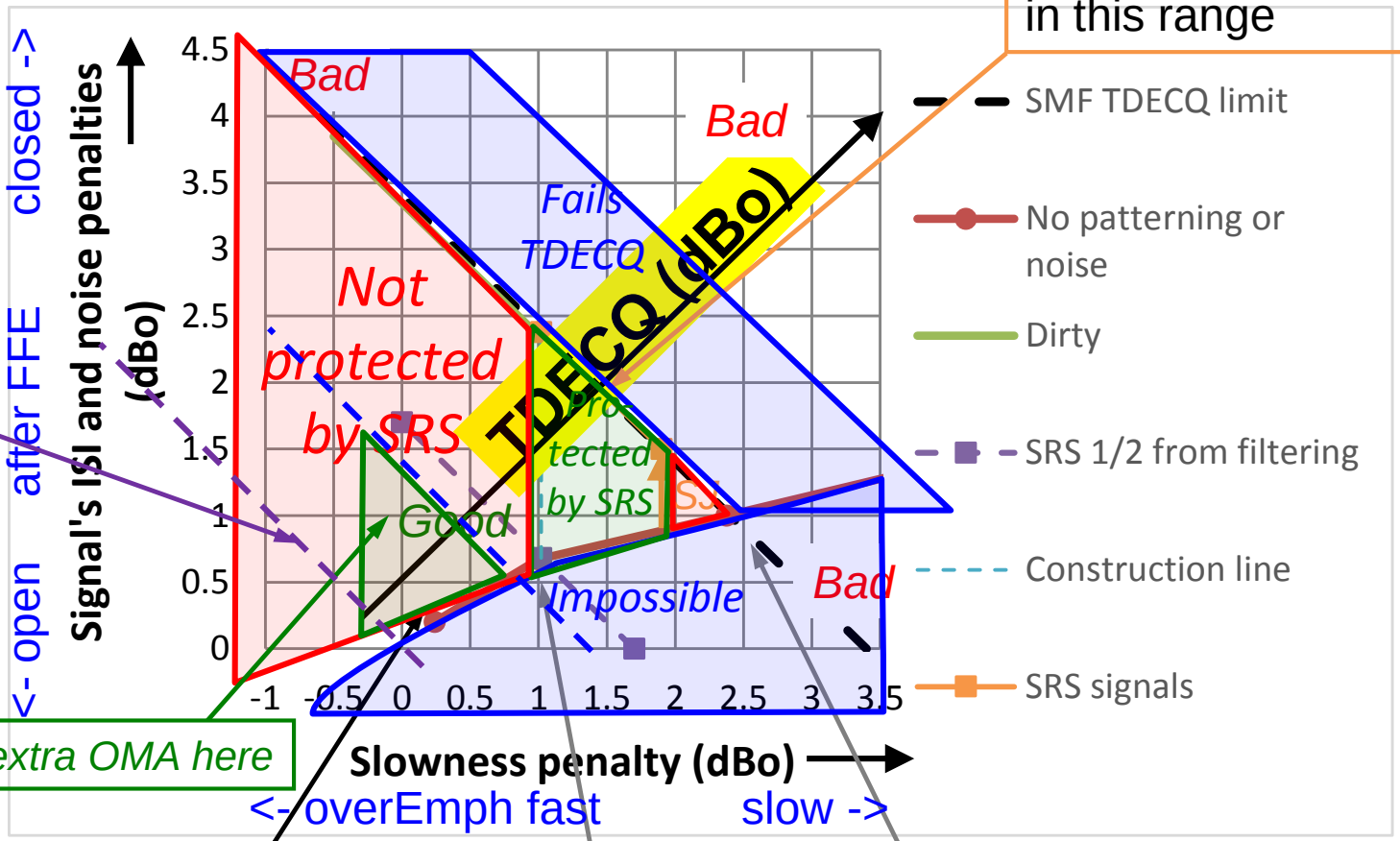
- Continuing to investigate the variety of bad signals (both in-service signals and stressed receive signals) and considering where the limits of compliance should be
- Follows dawe_3cd_01a_0318.pdf , dawe_032118_3cd_adhoc.pdf , dawe_040418_3cd_adhoc , dawe_1_0418 and dawe_041118_3cd_adhoc-v2
- *New this week – more on peak/OMA ratio, risetime, sum of other taps, TDECQrms. New slides 9, 10, 11*

TDECQ map



Signals below the blue line have to provide more power than OMA-TDECQ limit

TDECQ map

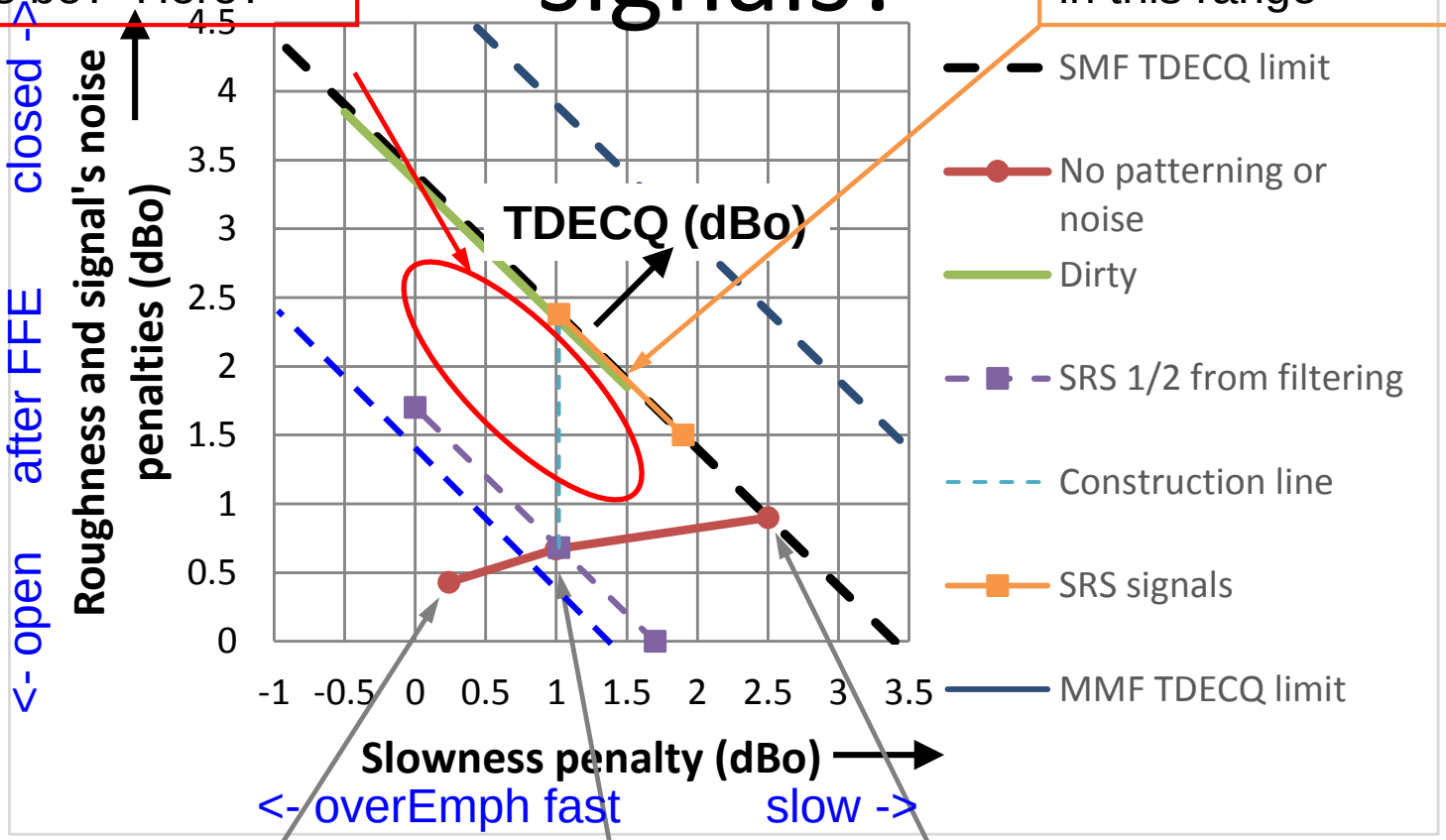


Transmitted signals are allowed that receivers don't have to receive (red regions)

Mismatch between SRS and real signals?

Where will real poor signals be? Here?

SRS signal must be in this range



Ideal waveform

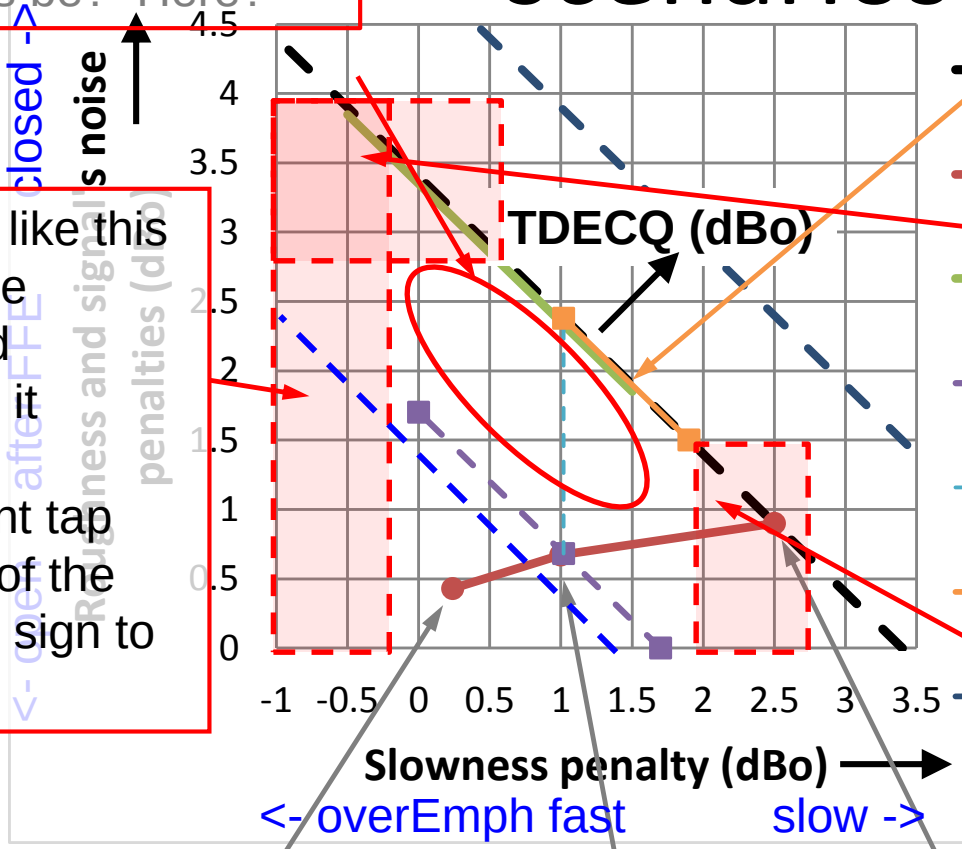
Half the SECQ from filtering

Slowest, as dawe_3cd_01a_0318 slides 2 to 5

Don't support unrealistic bad scenarios

Where will real poor signals be? Here?

SRS signal must be in this range



A region like this should be excluded because it requires significant tap weights of the opposite sign to normal

A region like this should be excluded because the eye after FFE is very closed, and small amounts of e.g. nonlinearity would cause big additional penalties (cliff edge)
Like VEC issue in C2M

A region like this should be excluded because it requires strong tap weights not useful in practice, and is not screened for in SRS

Ideal waveform

Half the SECQ from filtering

Slowest, as dawe_3cd_01a_0318 slides 2 to 5

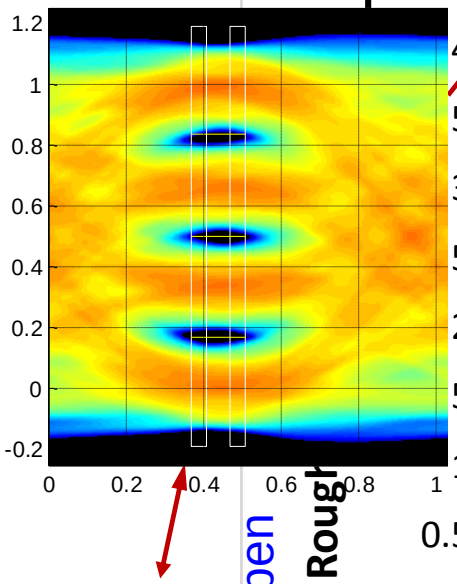
"Exclusion" could be by giving signals in the red boxes worse TDECQ scores, or by "hard" pass-fail rules

The upper two signals are shown with all but 1 dBo of Rx noise

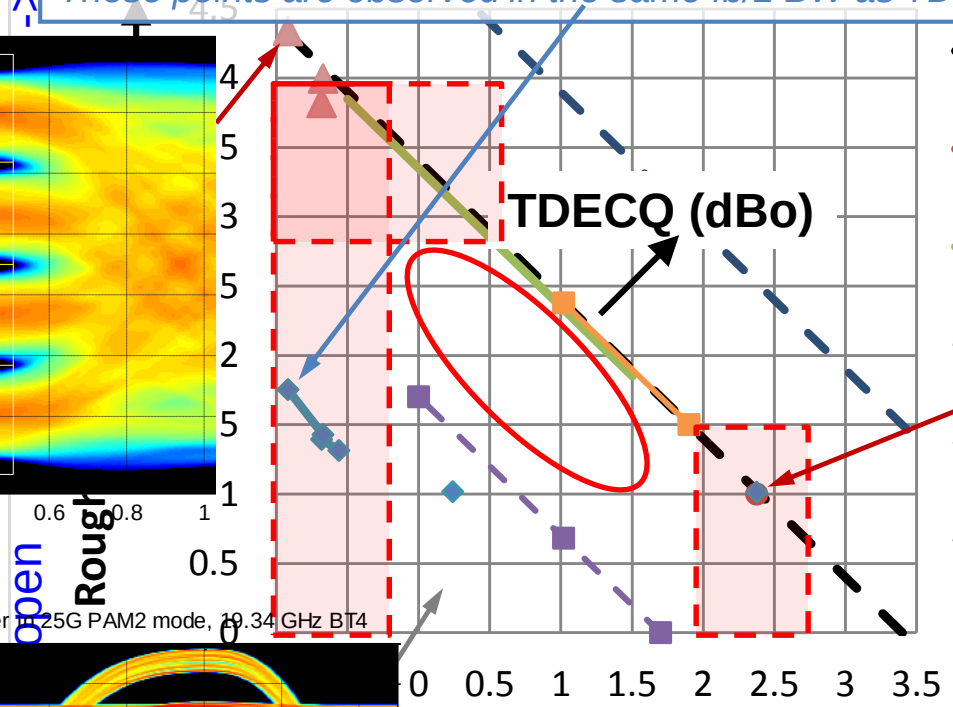
Extremes of worst-case signals

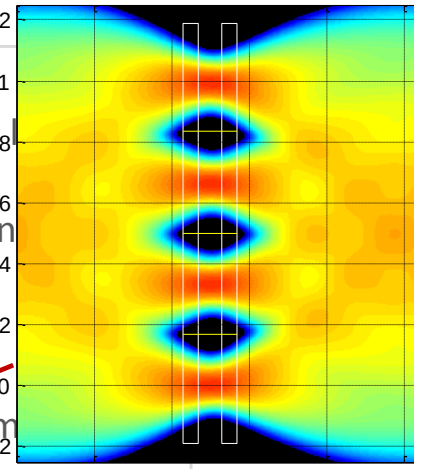
Peak/OMA increases when signal is over-emphasised

These points are observed in the same fb/2 BW as TDECQ

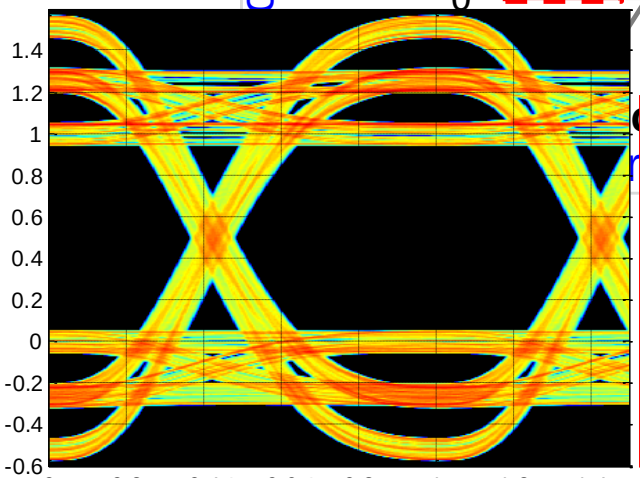


Same transmitter in 25G PAM2 mode, 19.34 GHz BT4



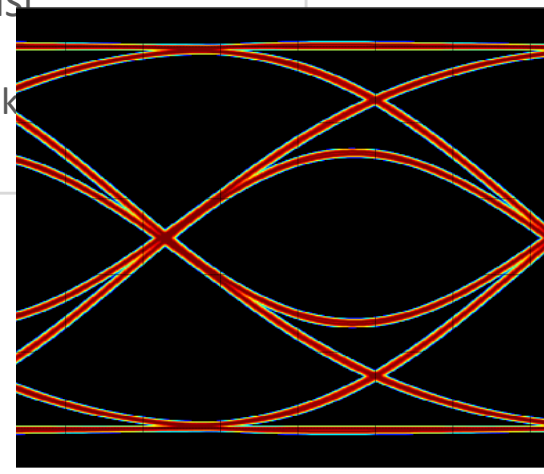


Same transmitter in 25G PAM2 mode, 19.34 GHz BT4



UI at 25.78125 GBd

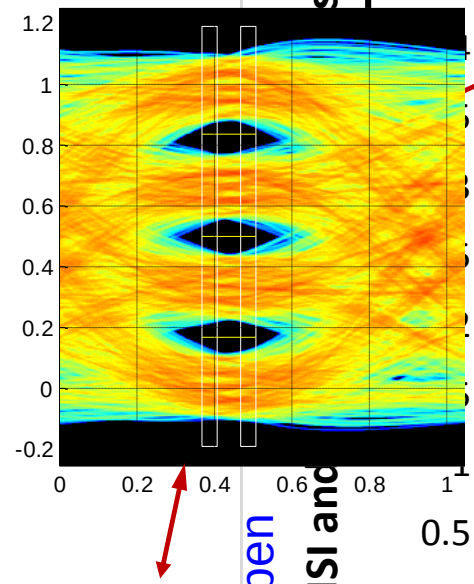
The signal on the left is bad because nothing can be done to improve it – neither sensitivity nor EQ. Worse is allowed by the draft

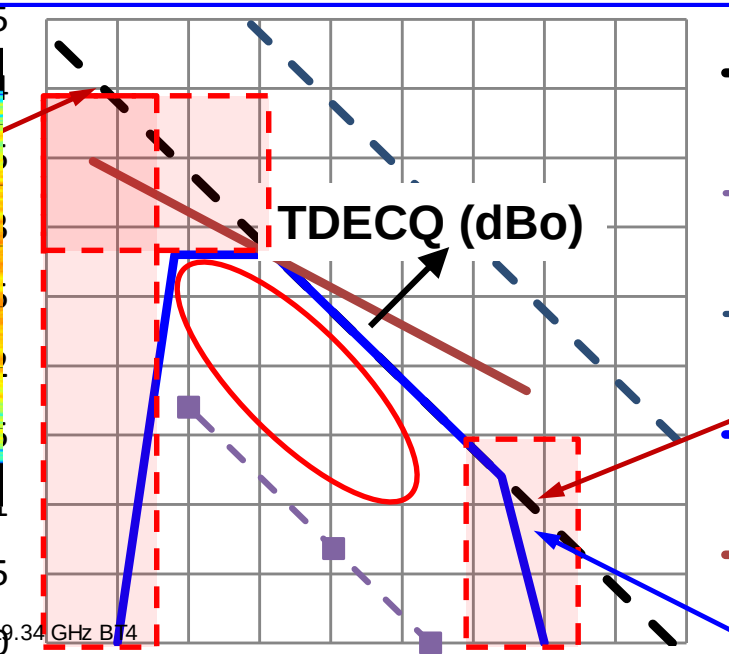


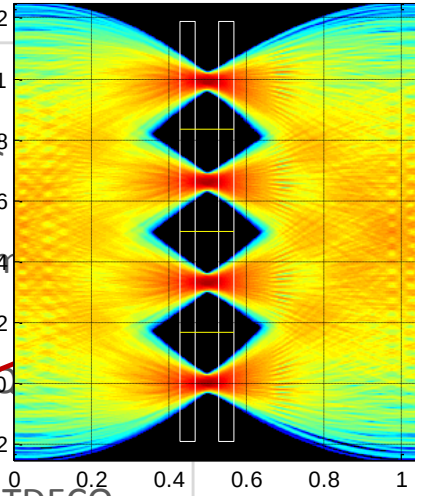
UI at 25.78125 GBd

Example improved specs

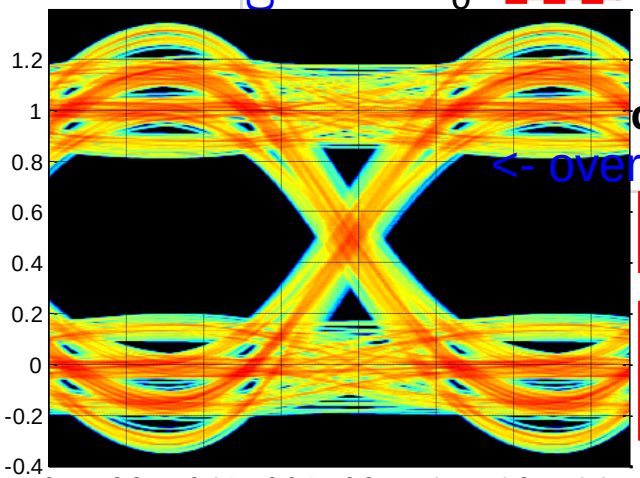
These signals are shown with very little noise







Same transmitter in 25G PAM2 mode, 19.34 GHz BT4

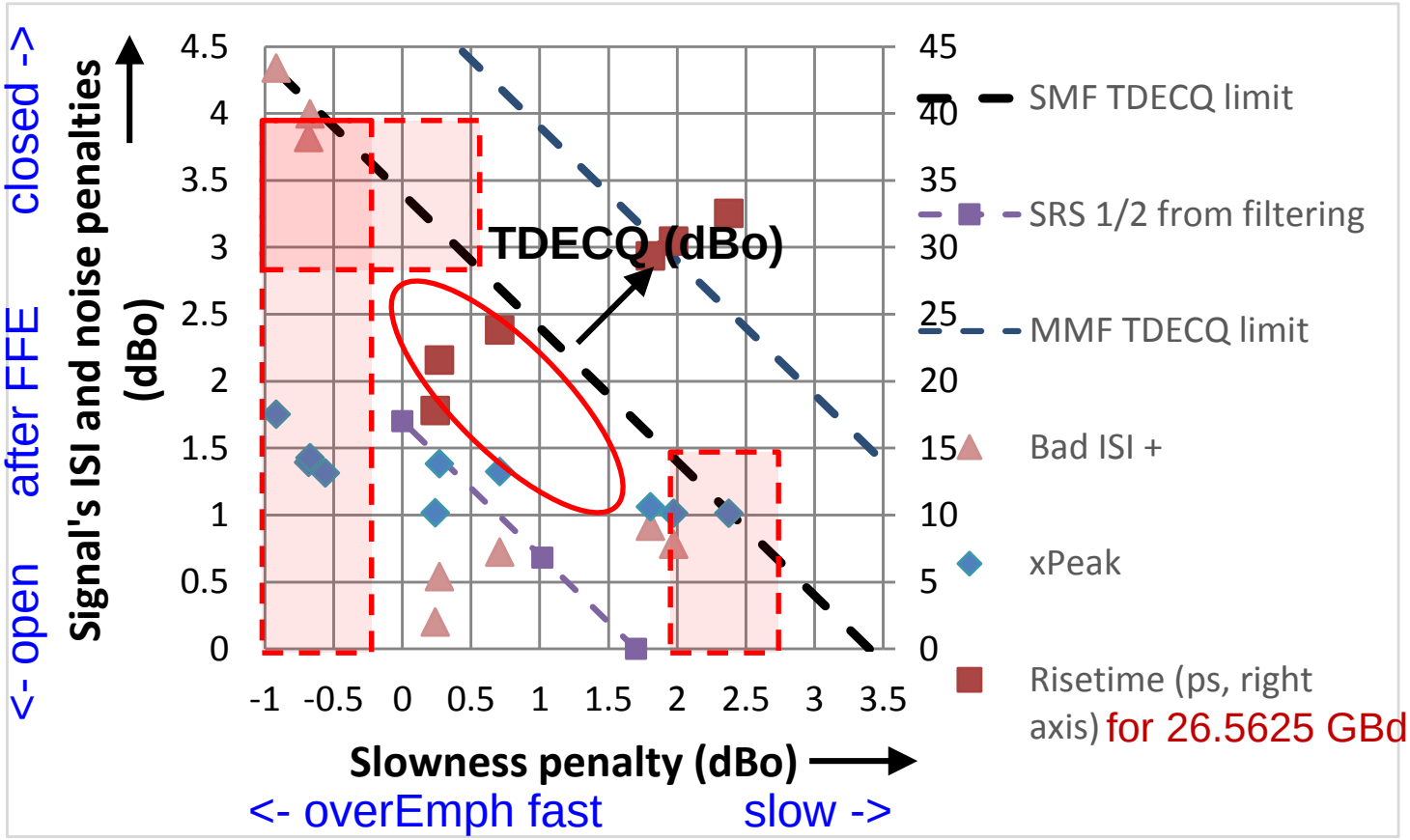


Very slow corner would make more sense for 100G lanes than 50G lanes

Need to come to a consensus on what's reasonable

Upper left: Example of a signal that no reasonable 400GBASE-F/D/LRn should have to receive

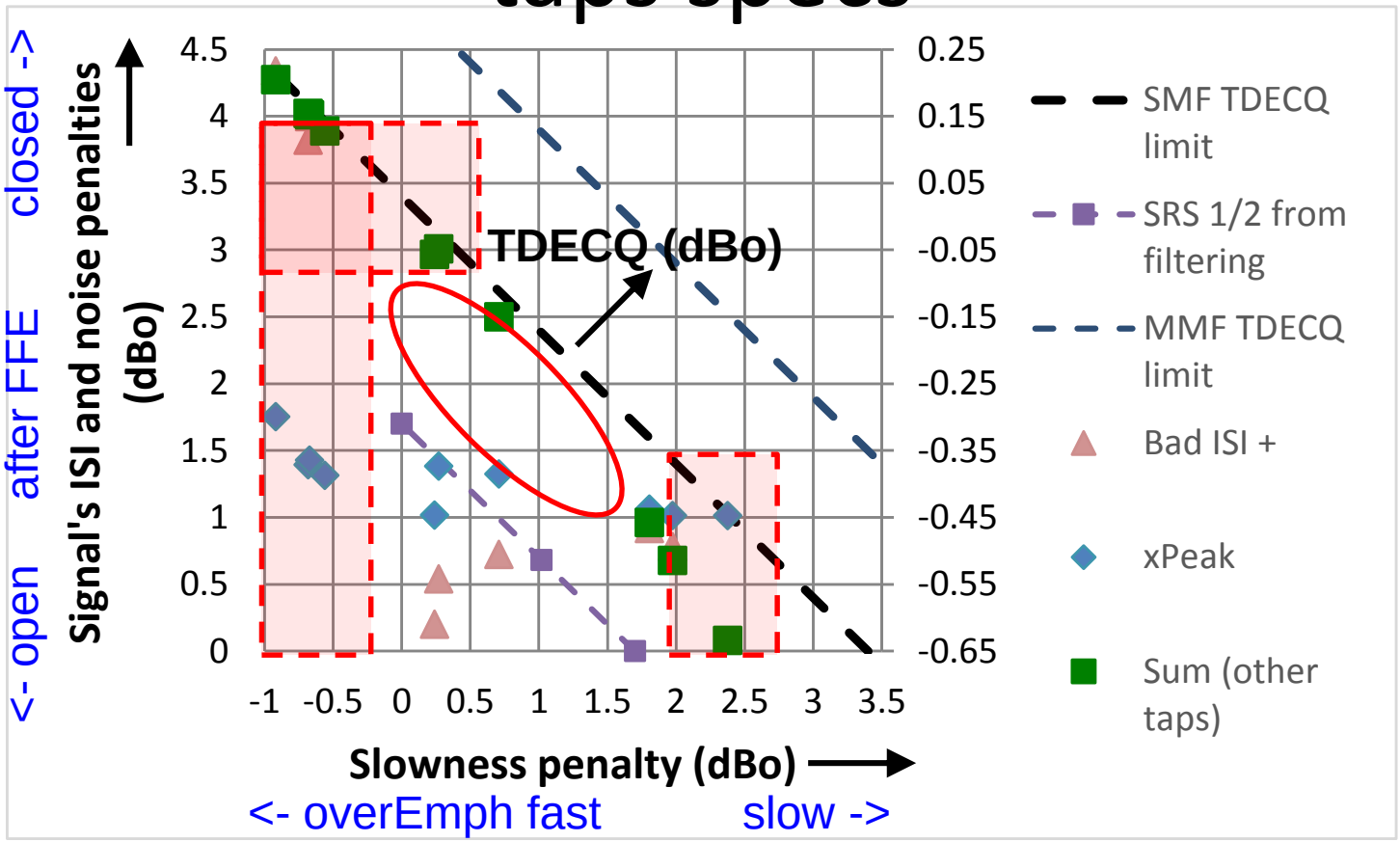
Possible peak/OMA and risetime specs



A peak/OMA spec would exclude signals that have too much "dynamic range", but does not seem to control over-emphasis unless very bad

A risetime spec around 30 ps seems to screen signals that are slower than allowed for PAM2
Scatter unknown, measurement may be inaccurate

Possible peak/OMA and sum-of-other-taps specs

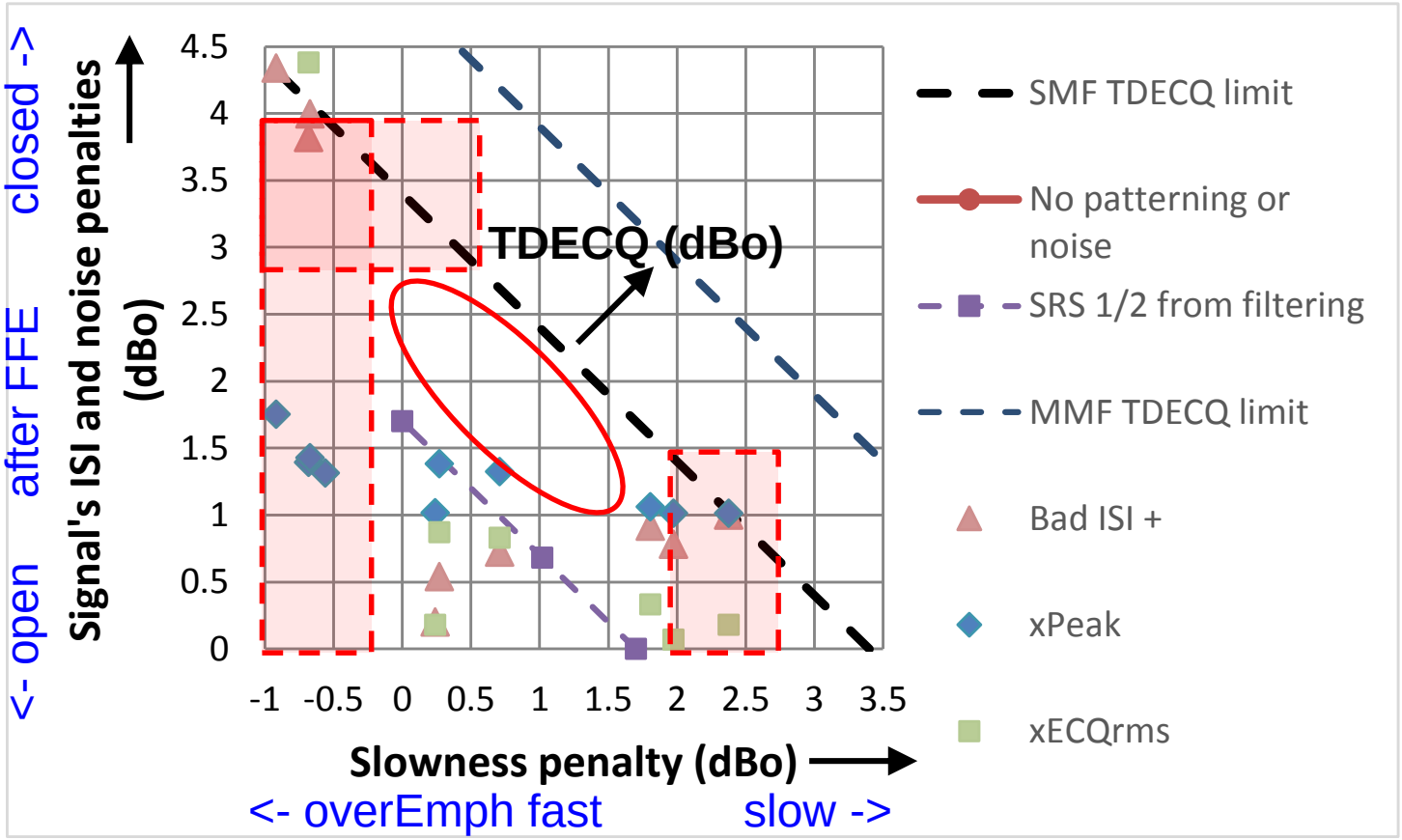


A peak/OMA spec would exclude signals that have too much "dynamic range", but does not seem to control over-emphasis unless very bad

So far, the correlation between slowness penalty in dB and sum of the non-cursor taps looks promising

This might be just luck

TDECQrms



TDECQrms is below TDECQ on the right, above on the left – goes with a TDECQ limit having a shallower slope on this plot, as on slide 8

Most serious gaps

- The most serious gaps are on the left
- To address over-emphasis, either

1. Constrain cursor or constrain sum of other 4 taps, or
2. Constrain Ceq in TDECQ, or
3. Reject signals with Ceq < limit, or
4. Reject signals with (peak-mean)/OMA > limit

- 1 and 2 are more lenient to otherwise good signals
- All are "free": by-product of TDECQ measurement, or part of it
- Option 4 can be done without the full TDECQ analysis
- See next two slides for example remedies

Bound the left side (too much emphasis)

- *Cl* **138** *SC* **138.8.5.1** *P* **274** *L* **1**
- A much wider range of signals are allowed to be transmitted than are covered by SRS (required to be received).
- At present it is allowed to make a transmitter with a noisy or distorted signal, use heavy emphasis to get it to pass the TDECQ test, yet a compliant receiver that passes SRS would not need to receive it. The range needs to be bounded on the left hand side of the maps in this presentation so that the receiver design can be bounded in terms of having to "invert" heavily over-emphasised signals, and the gap between possible signals and SRS closed or narrowed.
- The remedy doesn't directly outlaw over-emphasised signals, but gives them worse TDECQ scores.
- D3.1 comment 71
- *SuggestedRemedy*
- This remedy lets the transmitter designer use reasonable amounts of emphasis, balancing his own transmitter bandwidth and the reference receiver front-end bandwidth.
- After saying where the largest magnitude tap coefficient is, add **"The tap coefficients are constrained so that the sum of the other four tap coefficients is less than zero."**
- **Similarly in clauses 139, 140.**

Bound the top (irreparably bad)

- *Cl* **139** *SC* **139.6.1** *P* **292** *L* **45**
- A much wider range of signals are allowed to be transmitted than are covered by SRS (required to be received).
- At present it is allowed to make a transmitter with a noisy or distorted signal and use emphasis to get a "noise enhancement credit" to pass the TDECQ test, yet the eye closure is more than the TDECQ limit and a compliant receiver that passes SRS would not need to receive it. The range needs to be bounded on the top side of the maps in this presentation so that the receiver design can be bounded in terms of resolution and patterning, and the gap between possible signals and SRS closed or narrowed.
- The first remedy has the disadvantage that errors in OMA measurement degrade its accuracy.
- D3.1 comment 71
- *SuggestedRemedy*
- Either:
- 1. **Limit TDECQ -10*log10(Ceq) to <=2.8 dB**.
- **or**:
- 2. Define **TDECQrms** = 10*log10(A_RMS/(s*3*Qt*R)) where A_RMS is the standard
- deviation of the measured signal after the 13.28125 GHz filter response (before the FFE), Qt and R are as already in Eq 121-12. s is the standard deviation of a fast clean signal with OMA=2 and without emphasis, observed through the filter response (0.6254 for 13.28125 GHz).
- **Limit 3 dB**.
- Either remedy to apply to **all SMF PMDs** that use TDECQ.