PAM4 test pattern characteristics

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Introduction

Several presentations in the Norfolk meeting provided measurement results using a PRBS15 test pattern.

This contribution analyses the baseline wander and clock content characteristics of PAM4 encoded PRBS15 compared to those of PAM4 encoded random data and shows PRBS15 to be significantly less stressful than random data.

An alternative pattern, SSPR as defined in 2.D.2 of OIF-CEI-03.1, is proposed as a short pattern with similar stress to random data.

Baseline wander

Previous NRZ contributions have used a “baseline wander” parameter

This was defined as:

Baseline Wander is the instantaneous offset (in %) in the signal generated by AC coupling at the bit rate / 10,000.

This analysis re-uses this definition unmodified, but it should be noted that for PAM4, the eye height is 1/3 that of NRZ so the effects of a given amount of baseline wander will be greater.

For NRZ contributions see:

P802.3ba anslow_01_0108
P802.3ba anslow_06_1108
P802.3bj anslow_01a_0112

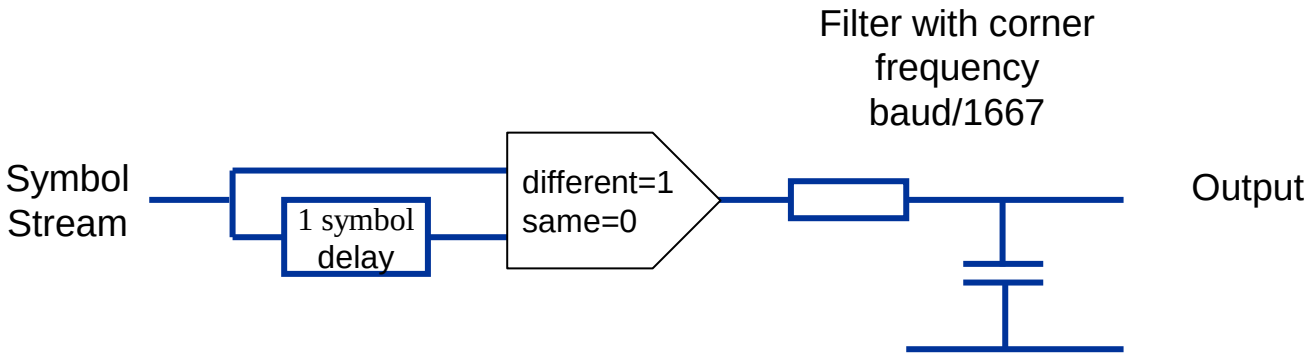
Clock content

Previous NRZ contributions have also used a “clock content” parameter

This was defined as:

Create a function which is a 1 for a transition and a 0 for no transition and then filter the resulting sequence with a corner frequency of baud/1667.

This analysis also re-uses this definition unmodified but defines a transition as the two adjacent PAM4 symbols being different from each other and taking no account of the magnitude of the difference.



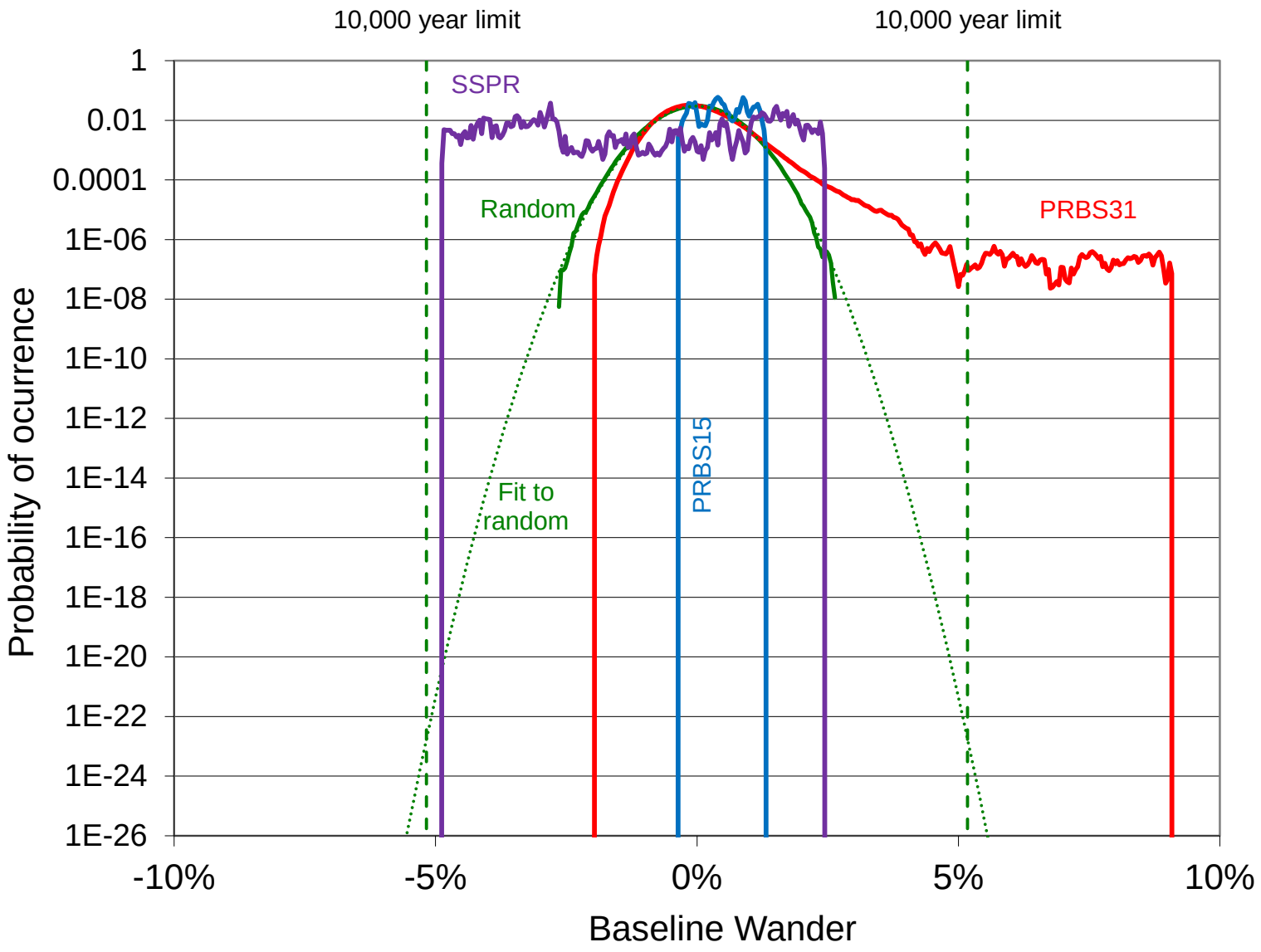
Assumptions

The assumptions used in the PAM4 analysis contained in this presentation were:

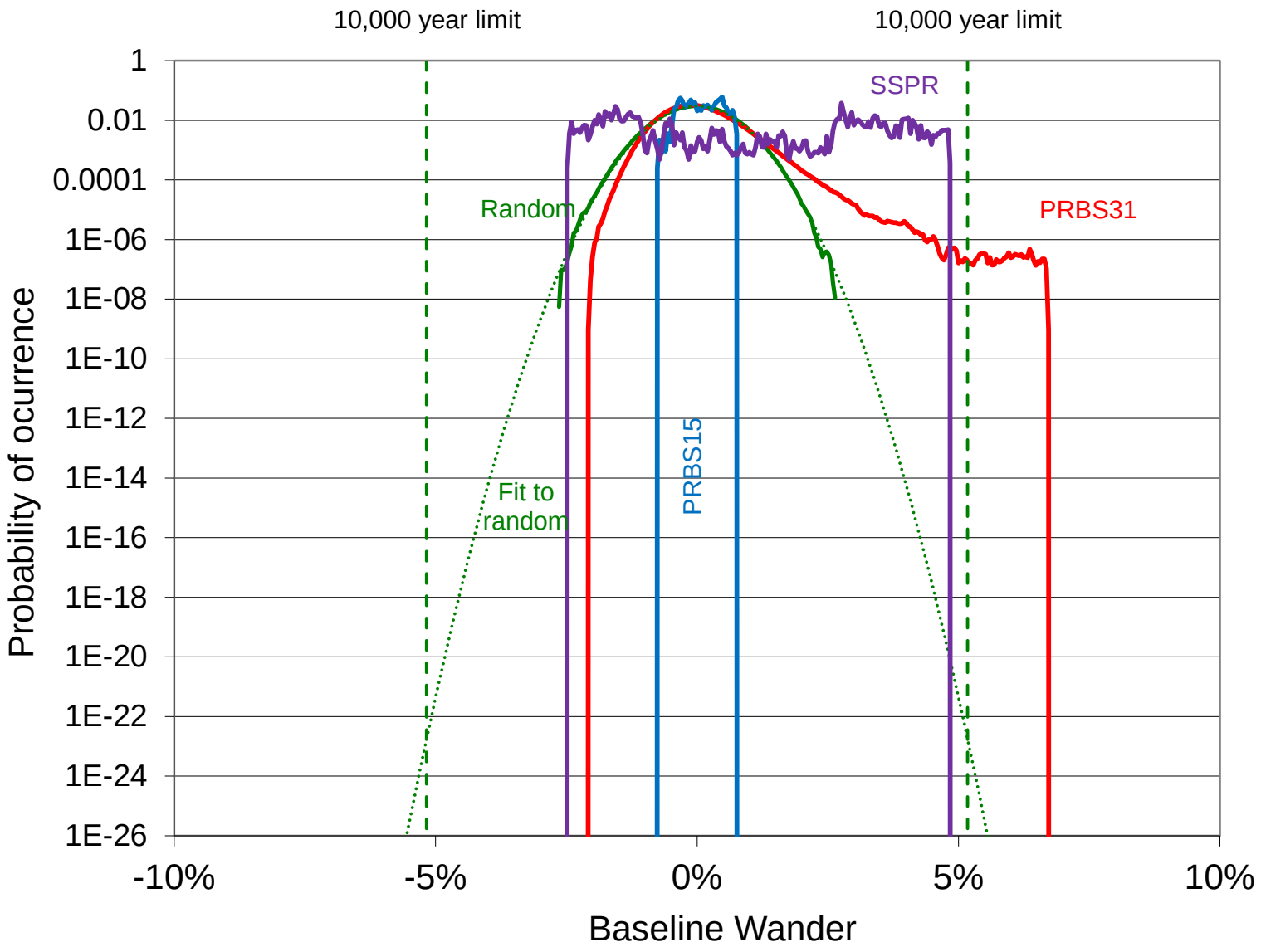
- The test pattern bits are divided into two bit symbols xy which is the bit x followed by the bit y
  - E.g. 011011001010 becomes 6 symbols: 01 10 11 00 10 10
- The patterns were also analysed one bit shifted
  - E.g. x011011001010y becomes 7 symbols: x0 11 01 10 01 01 0y
- The two bit symbols were mapped to PAM4 levels as either:
  - {11,10,01,00} map to {+1,+1/3,-1/3,-1}
  - {10,11,01,00} map to {+1,+1/3,-1/3,-1} as for 100GBASE-KP4

The results for baseline wander are presented first (slides 6 to 8) followed by clock content (slides 9 to 11).

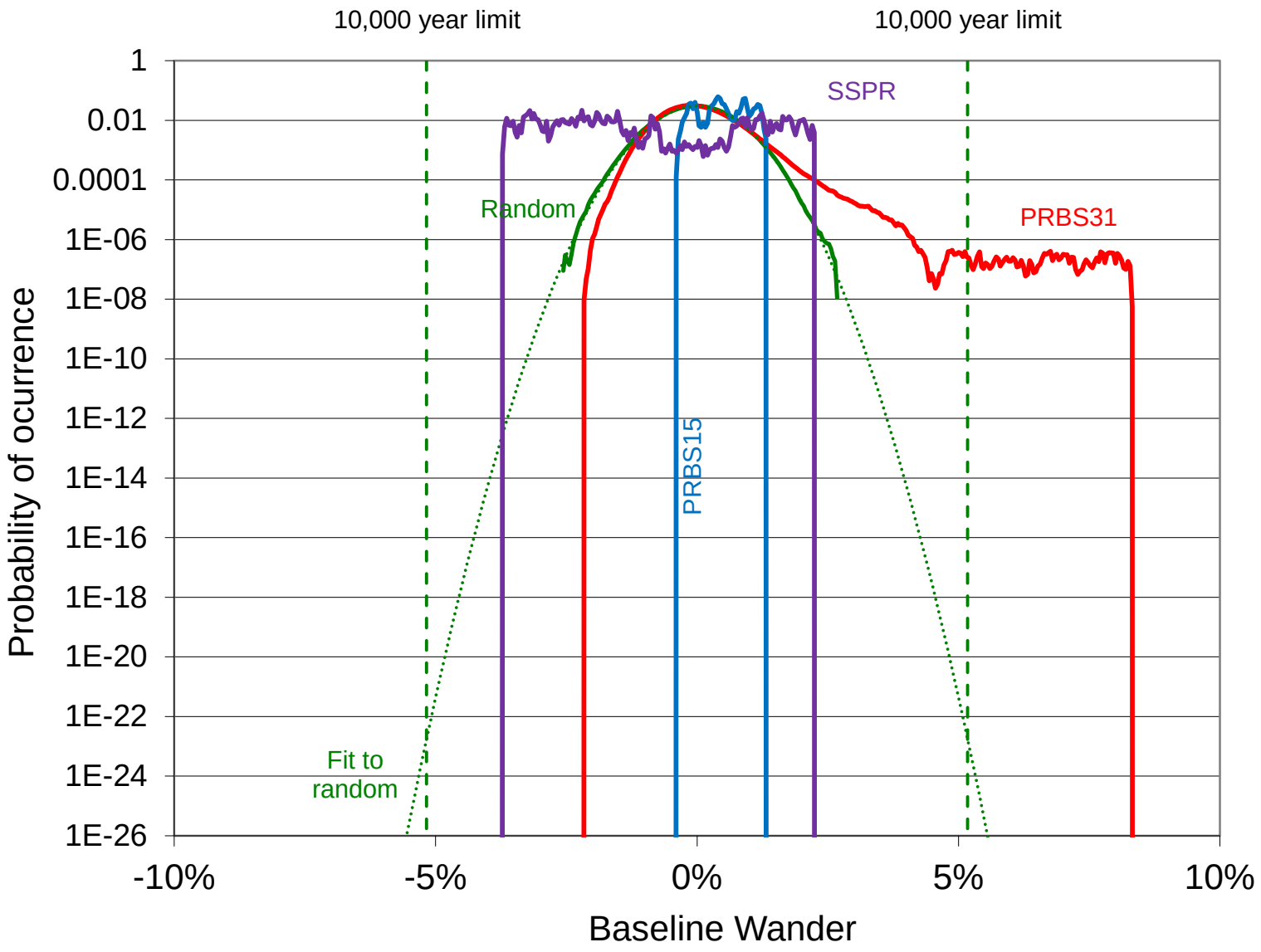
{11,10,01,00} map to {+1,+1/3,-1/3,-1} no shift



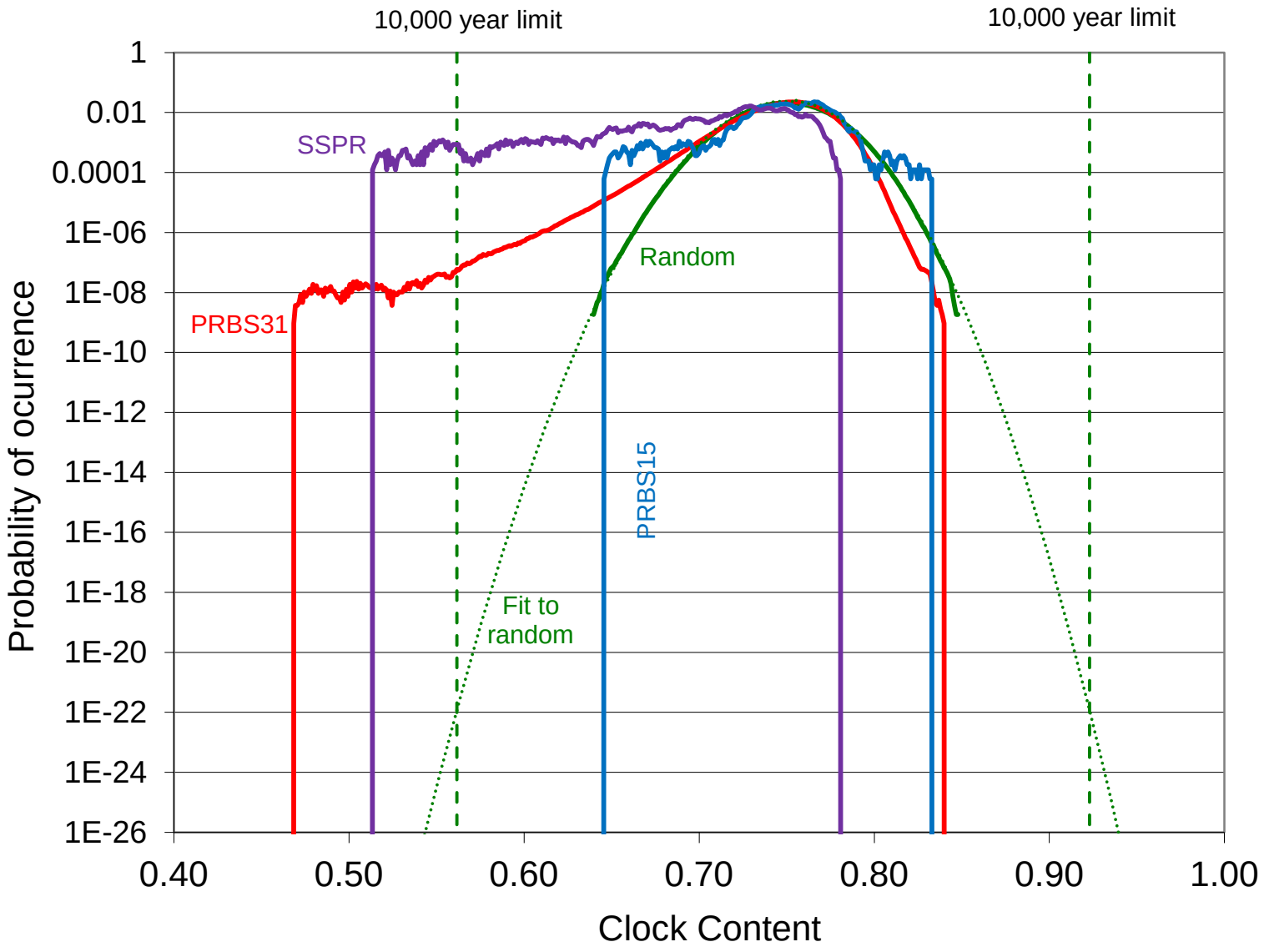
{11,10,01,00} map to {+1,+1/3,-1/3,-1} 1 bit shift



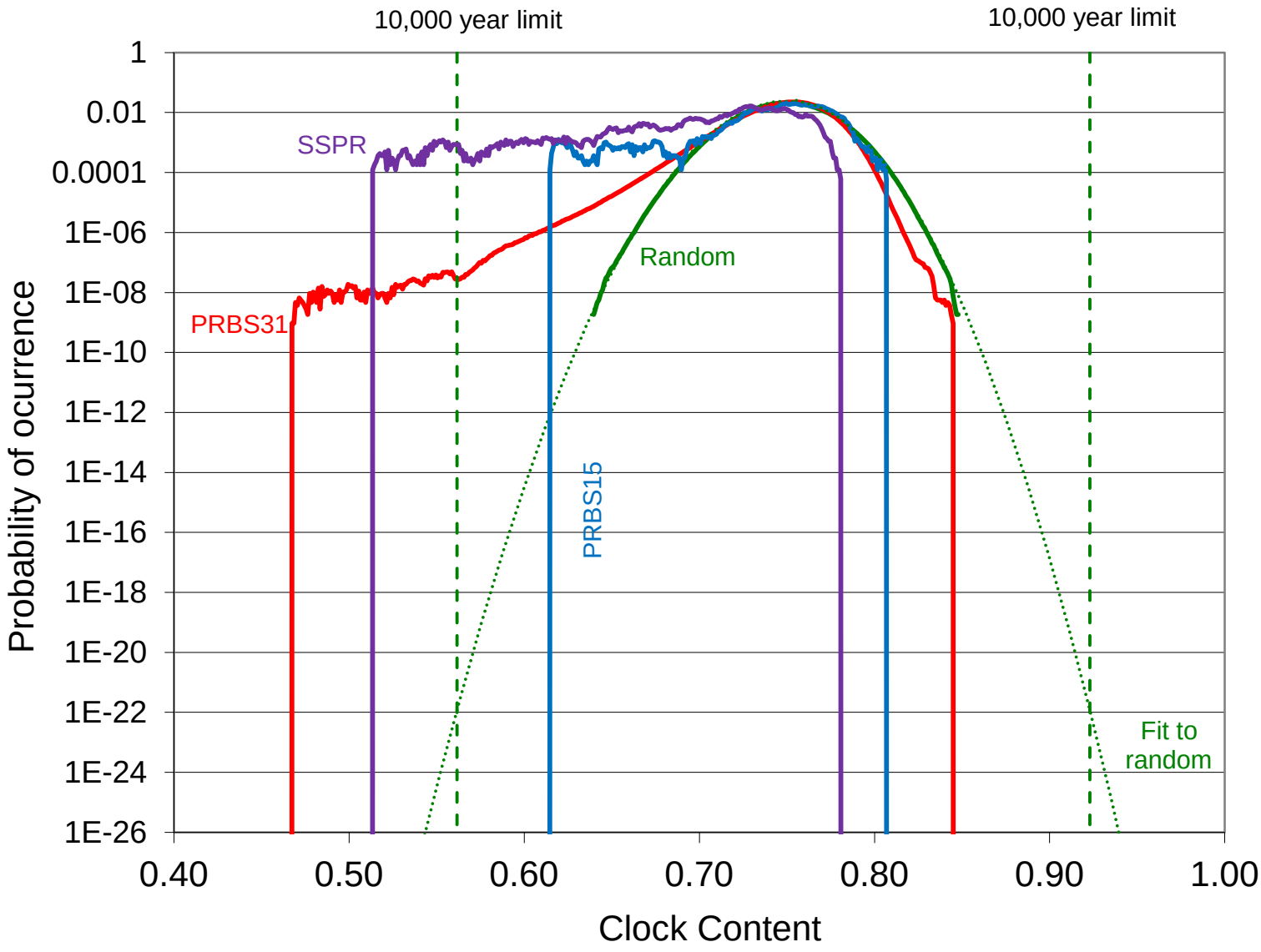
{10,11,01,00} map to {+1,+1/3,-1/3,-1} no shift



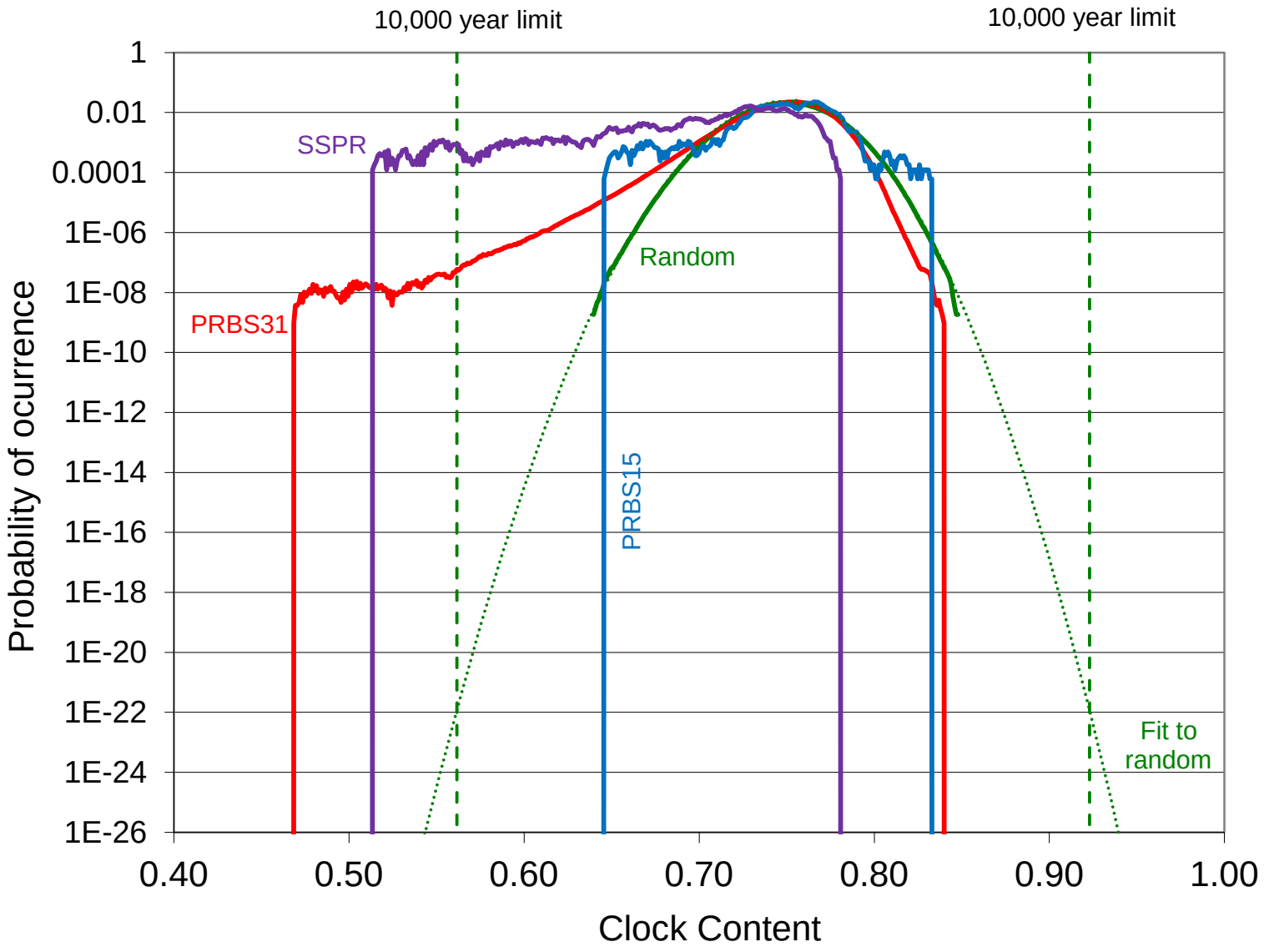
{11,10,01,00} map to {+1,+1/3,-1/3,-1} no shift



{11,10,01,00} map to {+1,+1/3,-1/3,-1} 1 bit shift



{10,11,01,00} map to {+1,+1/3,-1/3,-1} no shift



Conclusions

The baseline wander and clock content for 10,000 years of random data should be equalled or exceeded by test patterns.

It is likely that PAM4 encoded scrambled idle will be worse than random data.

For both baseline wander and clock content, PRBS15 encoded as PAM4 provides dramatically less stress than random data encoded as PAM4.

PRBS31 encoded as PAM4 provides more stress than random data encoded as PAM4 (the comparison with PAM4 encoded scrambled idle TBD).

SSPR encoded as PAM4 is a much better match to random data than PRBS15.

Thanks!