CAUI-4 MTTFPA monitoring

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Introduction

The impact on MTTFPA performance of a DFE in the CAUI-4 C2C receiver was analysed in anslow_03_0913.

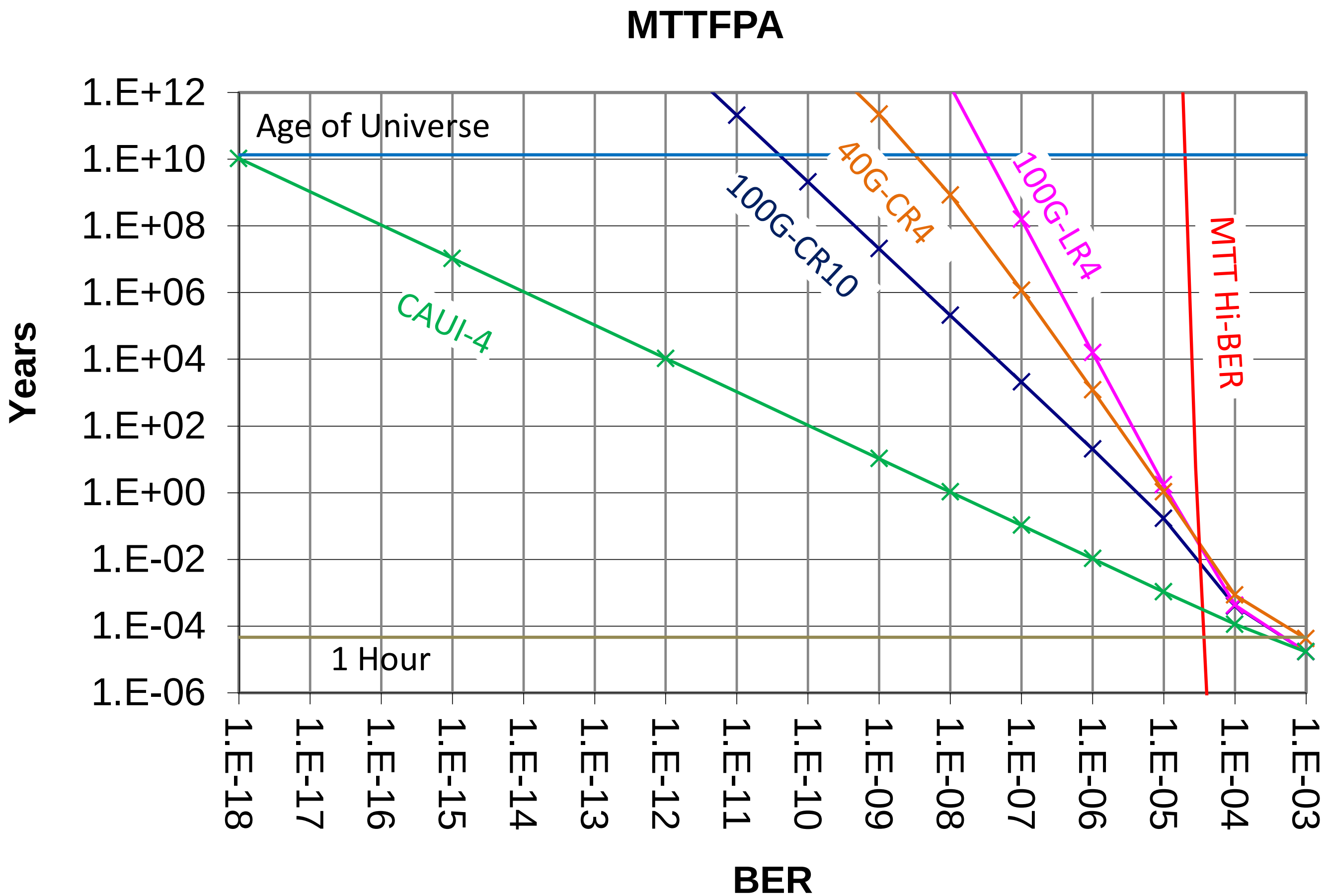
A possible BIP based error monitoring solution was proposed in ran_01_101413_CAUI and Multi-lane_BIP and this was discussed in the CAUI-4 Ad Hoc.

This presentation looks at:

- What BER would be required to give an MTTFPA of the age of the universe with no restriction on the DFE – Slides 3 and 4
- How often the proposed hi_bip_mismatch mechanism would trigger vs. BER for random and burst errors – Slide 5
- Proposes and analyses an improved algorithm for hi_bip_mismatch using multiple 2-bit events – Slides 6 and 7
- Analyses the performance of the improved algorithm using the existing BIP counters read once a second – Slides 8 and 9

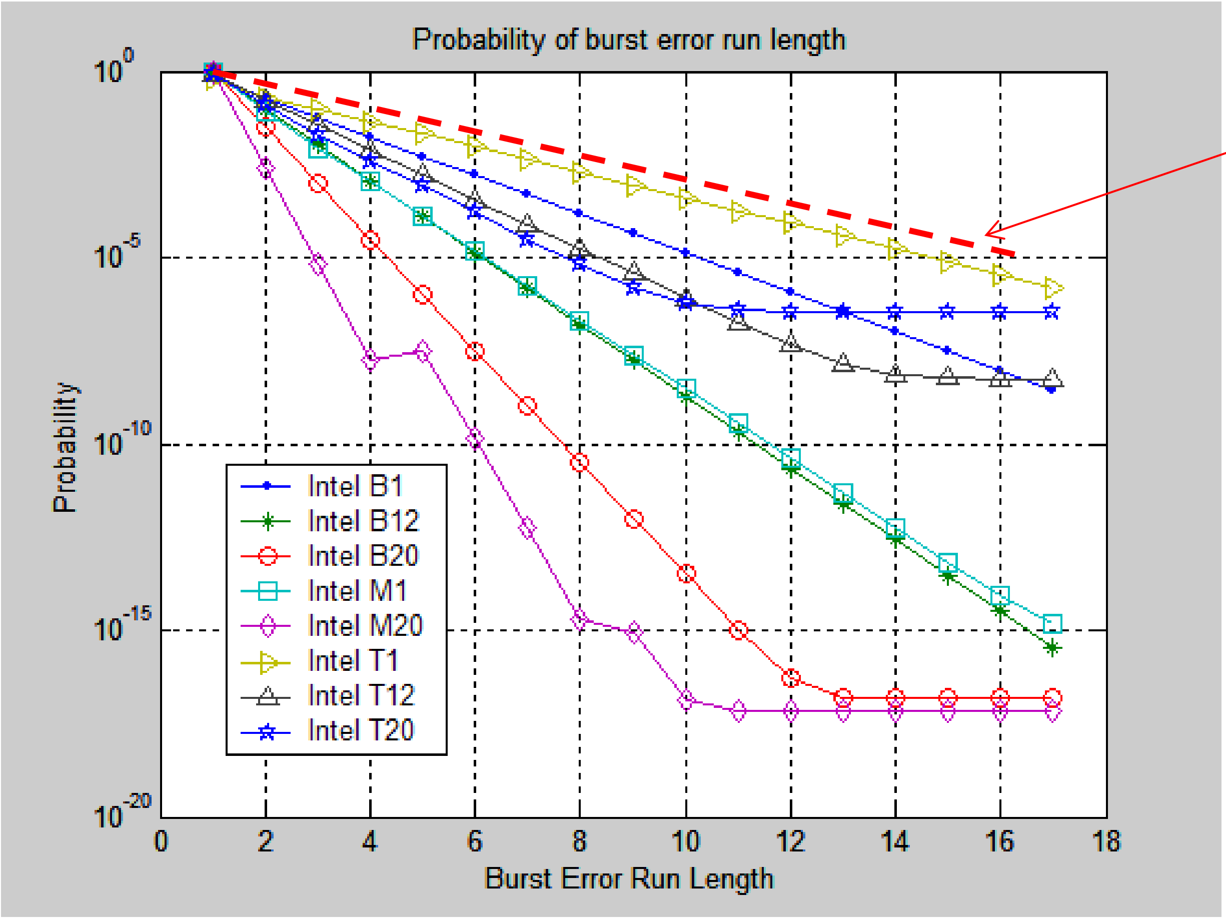
MTTFPA for a = 0.5

- If we set the probability that a burst continues to the worst case value of a = 0.5 as proposed in cideciyan_01_0512 (slide 3), then we need a BER of less than 1E-18 for MTTFPA > age of universe. This is 3.2 errors / year.



How conservative is a = 0.5?

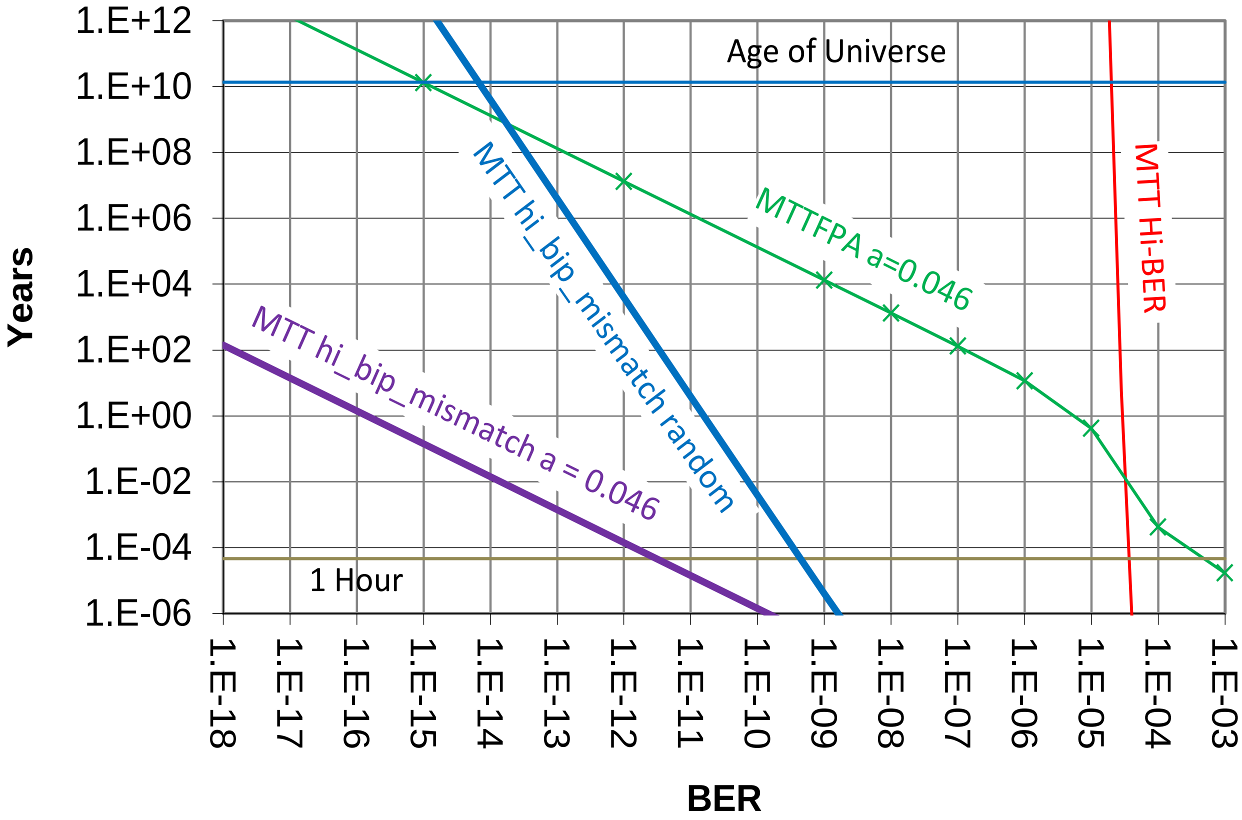
- Taking the worst case curves found in liu_01_1105 (page 13) and superimposing the curve for a = 0.5 shows that this is not very conservative if the DFE implementation is not restricted.



The curve for a = 0.5 crosses P = 10^{-5} at 16.6

Mean time to hi_bip_mismatch

- The mean time to high_bip_mismatch is plotted below for the case of random errors (blue) and for a = 0.046 which gives an MTTFPA of the age of the universe (purple). For a = 0.046 and a BER of 1E-15 the MTT high_bip_mismatch is 50 days, for 1E-16 it is 1 year.



Discussion

The previous curves are based on asserting hi_bip_mismatch for a single event with 3 mis-matched BIPs as per the definition in Multi-lane_BIP.

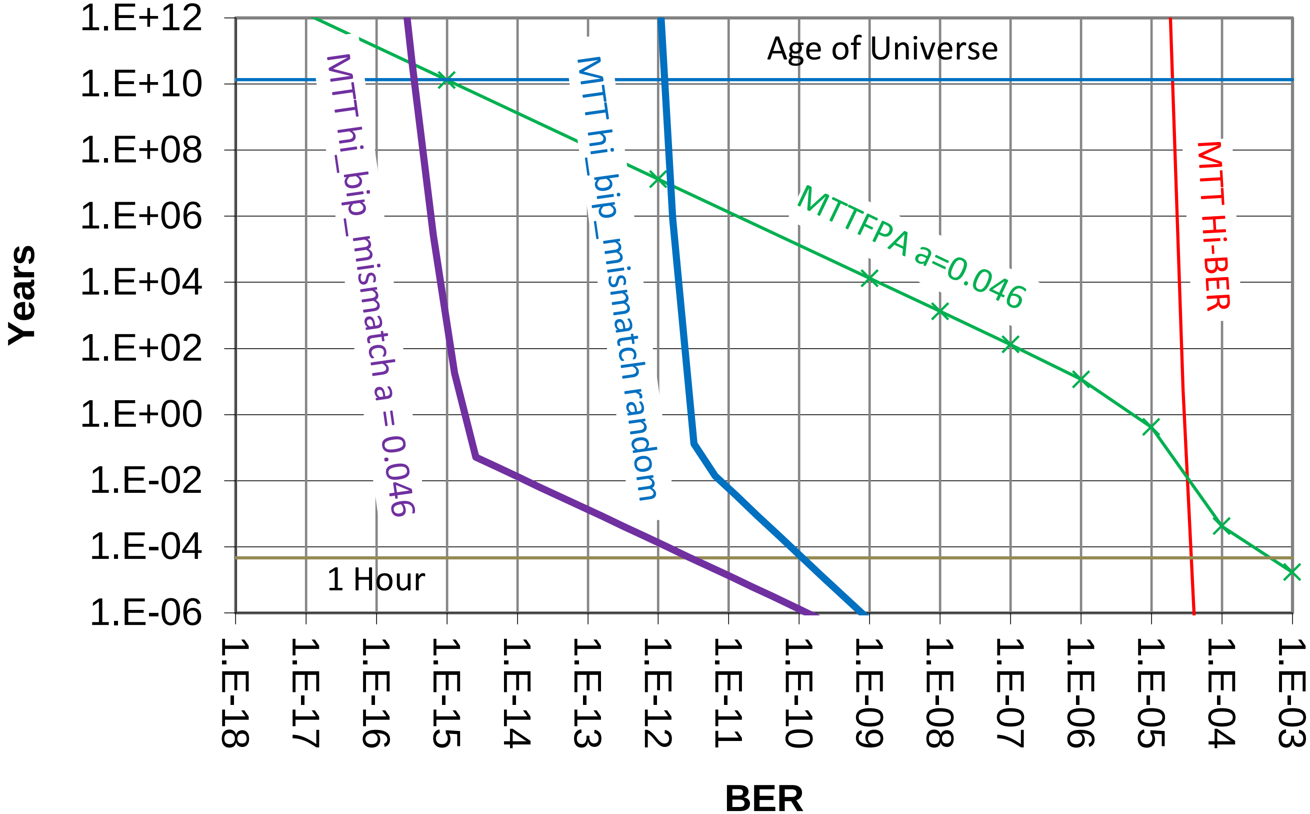
Better performance would be expected by using multiple events. As the arrival rate of 3-bit bursts for the limiting case is about one per 50 days, it seems that multiple 2-bit bursts would need to be used.

The next slide shows the performance based on asserting hi_bip_mismatch for greater than 20 events with 2 or more mis-matched BIPs within a 20-day window.

It is assumed that hi_bip_mismatch is asserted as soon as 20 events have occurred (rather than waiting for a complete 20 day window to expire).

20 2-bit events in 20 days

- The same curves as for slide 5 but with hi_bip_mismatch asserted for greater than 20 events with 2 or more mis-matched BIPs within a 20-day window. This has improved the MTT high_bip_mismatch for a BER of 1E-16 and a = 0.046 as well as for BER of 1E-12 random to greater than the age of the universe.



Using existing counters

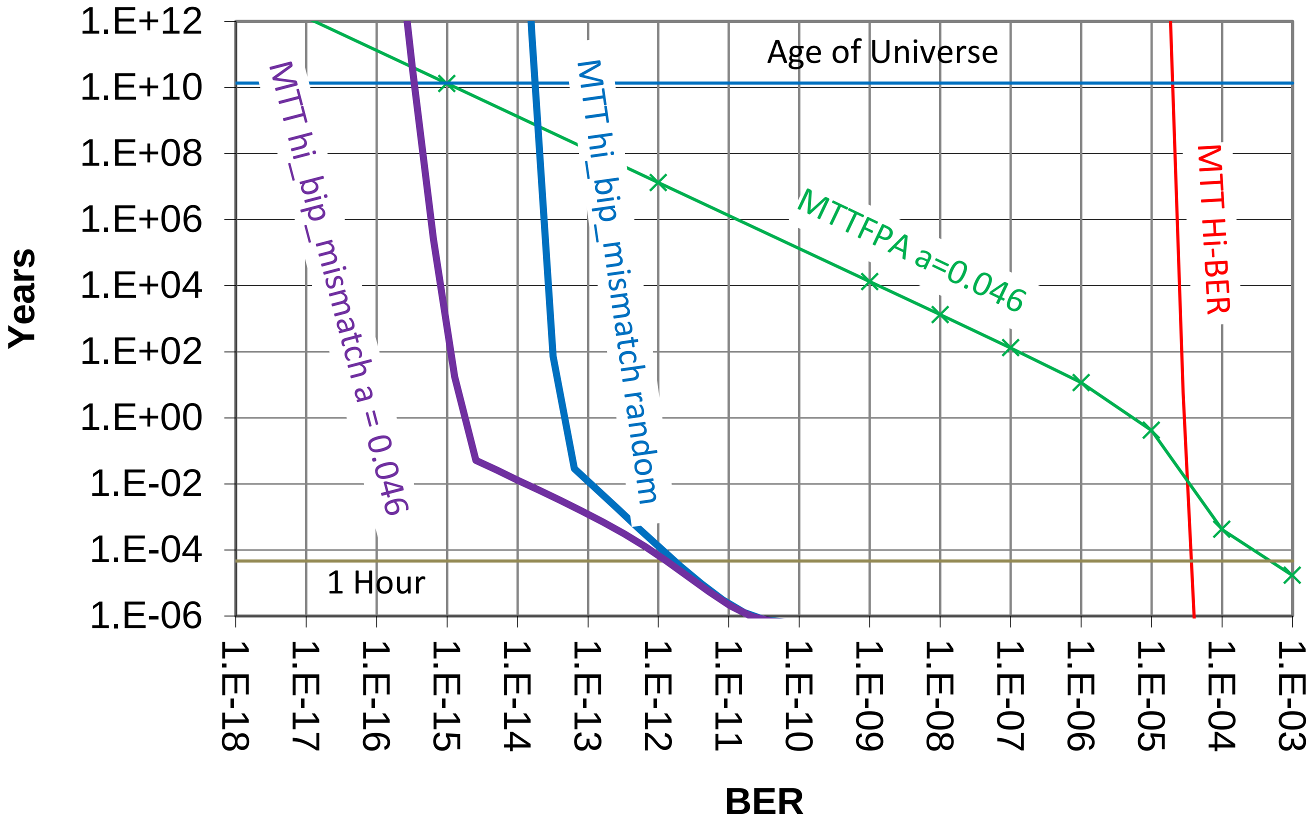
The algorithm defined in in Multi-lane_BIP would require a hardware change in the PCS to implement. To avoid this ran_01_101413_CAUI raised the possibility of reading the existing BIP mismatch counters once a second and counting how often two or more lane counters have registered a mismatch.

The next slide shows the performance of this based on asserting hi_bip_mismatch for greater than 20 events with 2 or more lanes with errors in 1 second within a 20-day window.

It is assumed that hi_bip_mismatch is asserted as soon as 20 events have occurred (rather than waiting for a complete 20 day window to expire).

20 2-bit events in 20 days

- The same curves as for slide 7 but using the existing counters read once a second with hi_bip_mismatch asserted for greater than 20 events with 2 or more lanes with errors within a 20-day window. This has reduced the MTT high_bip_mismatch for BER of 1E-12 random to an hour.



Performance summary

Accounting for burst errors by just improving the BER requires changing the BER requirement to < 1E-18 (< 3.2 errors / year). This does not seem practical.

The performance of the three hi_bip_mismatch algorithms studied is:

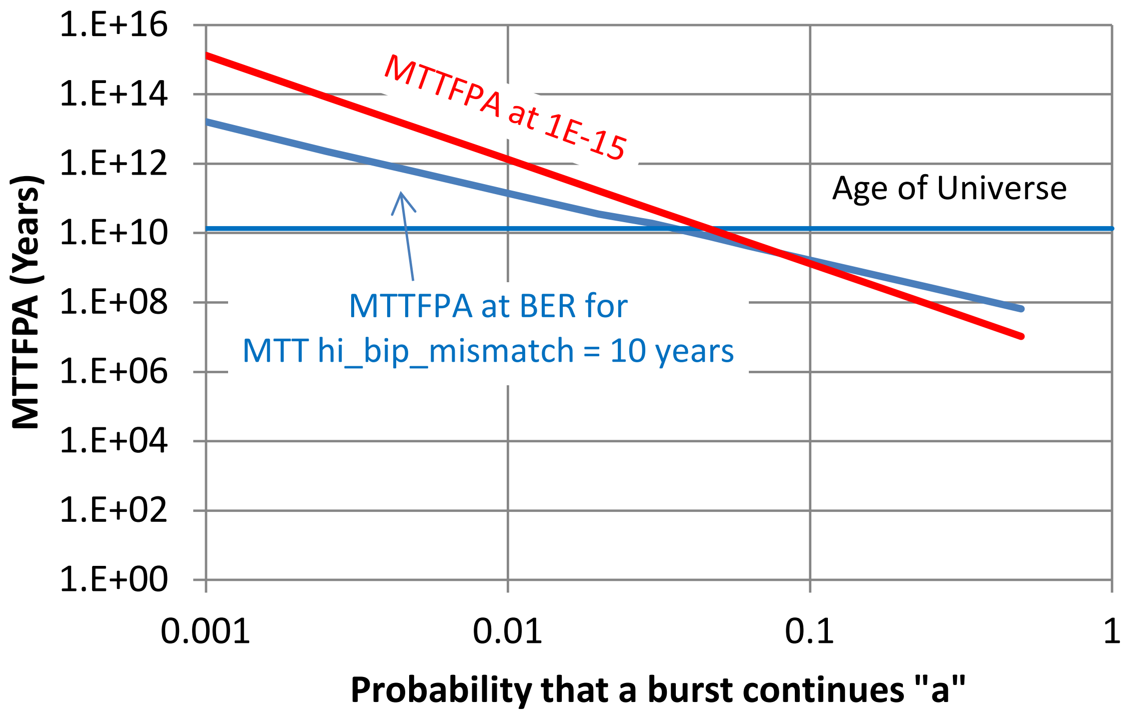
	3E-16 a=0.046	1E-15 a=0.046	1E-12 Random	1E-11 Random
3 mismatched BIPs	6 months	50 days	10,000 yr	4 years
20 x (2 mismatched BIPs) in 20 days	> AOU	300 years	>AOU	2 days
20 x (2 lanes with Err in 1 sec) in 20 days	> AOU	300 years	1 hour	1 min

The only one of these that might be acceptable is 20 x (2 mismatched BIPs) in 20 days.

Whether this algorithm is successful in protecting against false packet acceptance is also dependent on whether the relationship between the probability of 2-bit bursts and 4-bit bursts is as modelled or not.

20 2-bit events in 20 days

- For the 20 x (2 mismatched BIPs) in 20 days the blue curve below plots the MTTFPA at whatever BER gives a MTT hi_bip_mismatch of 10 years. This isn't much of an improvement over the red curve which is the MTTFPA at a BER of 1E-15.



Conclusion

None of the algorithms analysed in this presentation meet the goals of:

- Triggering reasonably frequently whenever the MTTFPA is below the age of the universe and the CAUI-4 BER is < 1E-15
- Not triggering for a 100GBASE-LR4 link operating at a BER of 1E-12

To meet the requirement of triggering reasonably frequently whenever the MTTFPA is below the age of the universe with a = 0.5 the threshold would have to be set at something in the region of 4 x (2 mismatched BIPs) in 365 days which isn't very practical and would trigger about once a month for LR4 at 1E-12.

Still to do:

Investigate the possibility of using an algorithm based on the ratio between 1-bit events and 2-bit events.

Thanks!