Optimal Use of TOFHIR
Dual threshold at High
Dark Count Rate- focus on
5e13->Run 44734

Run 44734 conditions:
Lyso bar rotated by 52 deg from normal incidence. Representative of real CMS BTL track angle of 38°.
5E13 irrad bar @~ -20° C. Bias -> ~1.5v OV-> DCR~40 GHZ
Note data recorded in DRS w 2 Gain range copies->Hi/Low=10.4.
I have been focusing on this data set for the moment but both lab measurements with Arjan and delay line clipped scope data likely useful.

Performance with DCR - dependence on $N_{pe}$

- $V_{ov} = 1.5$ V, DCR = 30 GHz, delay = 0b01111111
- Studied as a function of $N_{pe}$ [3000-10000]:
  - UV laser intensity varied

Recent BTL meetings focused on this shortfall from TDR expectation. Yesterday activity focused on photoelectron Yield where there is prospect of some Improvement over ~85 picosecond timing.

Projection from A. Benaglia
10/6/21 BTL mtg
Limitations of current timing FEE/algorithms:

- Rather than starting from performance where CMS HL-LHC integrated luminosity dominates…

- This project has slowly evolved from another place:
  - PET imaging “TOFPET”
  - Timing at higher rates. “TOFHIR”
  - Timing at still higher rates/DCR-> “TOFHIR2x/B”

- Still time to focus on highest DCR data without prejudice about FEE we are working with. May lead to practical mods of TOFHIR.
Now take tight cut on Amplitude and restrict x track to +/- 1.5 mm

Various attempts to exploit Multiple thresholds of TOFHIR did not yield improvement. Milan also tried similar exercise.
Effect of Delay line shaping on DarkCount Noise

How far apart in time do 2 thresholds have to be to eliminate correlation?

-> Sample noise waveform for 10k empty Triggers and vary dt relative to arbitrary sample.

Ie compare
Rms of V at thresh1
With rms of average of 2 points
Separated by dt.
How far apart in time do we need to be to get independent samples? One way to see it is look at fluctuations in amplitude directly.

These plots based on 12k noise waveforms.

<table>
<thead>
<tr>
<th>Delay</th>
<th>Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>50 mV</td>
</tr>
<tr>
<td>0.9 nsec</td>
<td>8.8 mV</td>
</tr>
<tr>
<td>0.5 nsec</td>
<td>5.15 mV</td>
</tr>
<tr>
<td>0.3 nsec</td>
<td>2.8 mV</td>
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</tbody>
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Changing the delay affects the Rms noise but need to move by ~1.5 nsec to get uncorrelated sample. Pretty much independent of delay. Similar to 300 Mhz hump in fig.8.
There is no noticeable improvement with 2 thresholds relative to 1. We can speculate that we are sampling too close together.

SiPM0 and time dif from 30 to 90 mV threshold – nsec

Time difference between thresholds in nanoseconds.

Can only get out to 90 mV threshold on Single Delay line shaped signal w 0.9 nanosec delay.
Note very different bin widths after calibration. Also correlates roughly from event to event.

Confirmed with Stefan Ritt that He expects this behavior. After calibration, Bin widths wobble around 0.2 nanosecond.
But features of Discrete FT remain same if adjust for uneven intervals

We use this plot to justify approximation of equally binned time series. Alternate would be “time variant discrete Fourier Transform”
Sample Delay line shaped - compare 2 different SiPM channels

Amplitude of DCR noise by DFT – with and without Delay Line Shaping

- SiPM0
  - Raw
  - 0.25 nsec shaped
  - 0.5 nsec shaped
  - 1.5 nsec shaped

- SiPM1
  - Raw
  - 0.25 nsec shaped
  - 0.5 nsec shaped
  - 1.5 nsec shaped

MHz vs. |DFT|