Outline of slides

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   - Cause of finding reference times outside of the good coincidence region
9. FADC minimum time difference between pulses
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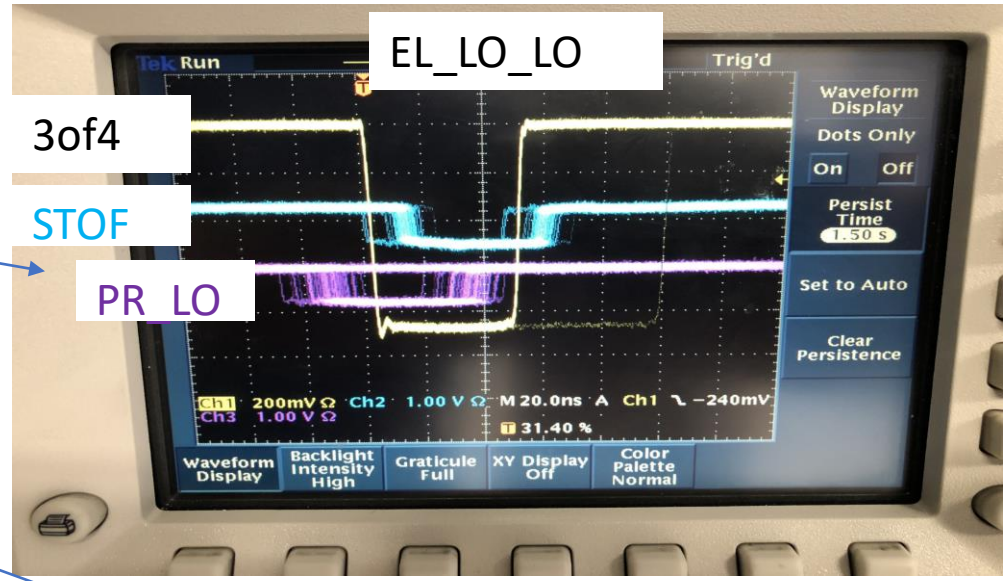
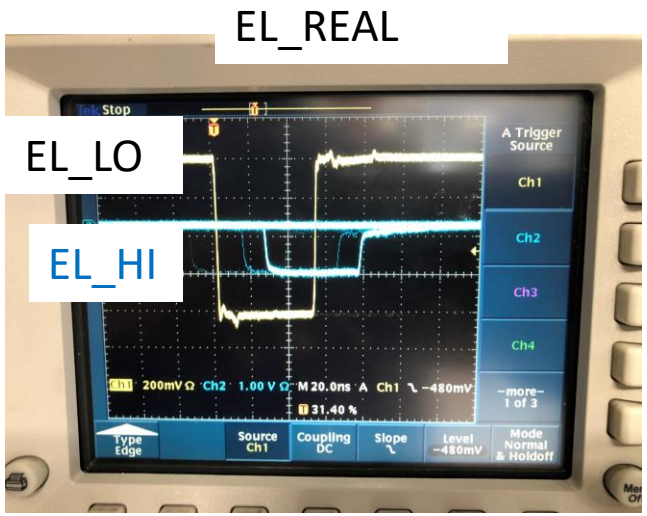
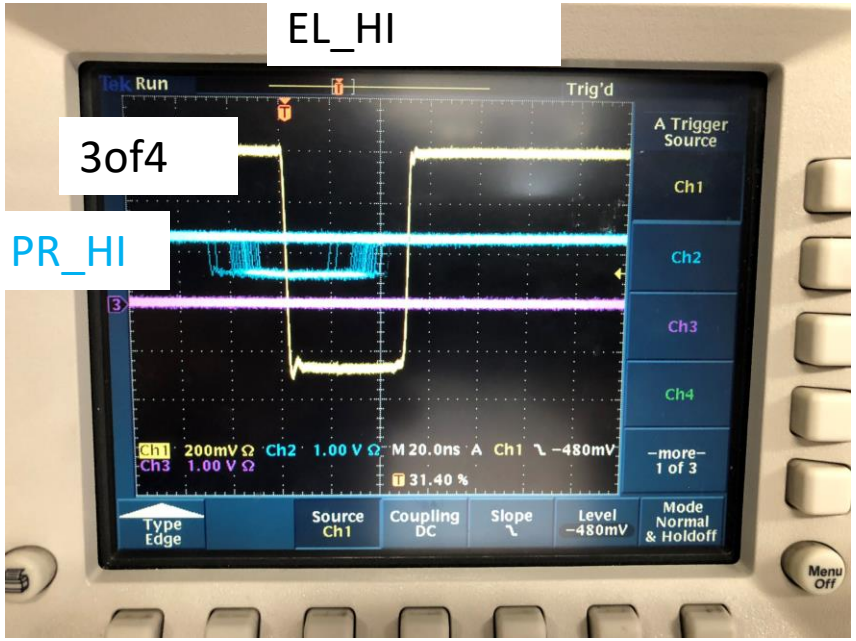
    - EL_REAL pulse associated with random HODO 3of4 is selected as good reference time instead of the pulse that form the trigger.
15. Summary

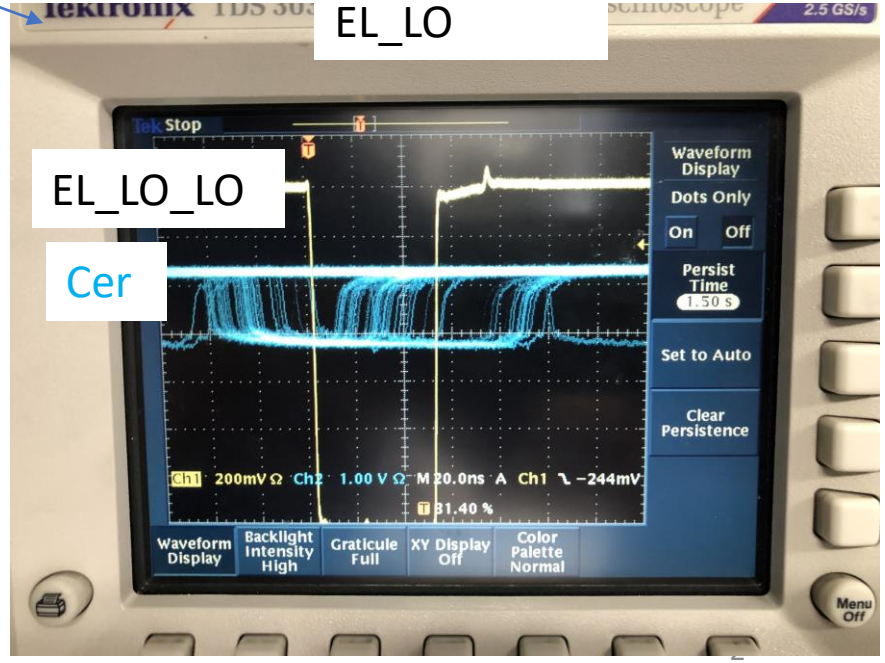
SHMS “electron” Trigger formation for fall 18

- The HODO 3of4 is used in all triggers except
  - EL_LO_LO can be STOF &&PR_LO or STOF && HODO3of 4
- EL_LO_LO is 2 of 3 of HODO 3of4, STOF or PR_LO
  - Normally HODO 3of4 sets the timing
  - If no HODO 3of4 or no PR_LO, then STOF sets time about 15ns later. Happens for random singles accidentals
- EL_LO is EL_LO_LO && CER (disc cut on sum of CER signals)
- EL_HI is HODO 3of4 && PR_HI
- EL_REAL is EL_LO || EL_HI (EL_HI delayed by 25ns)
- EL_CLEAN is EL_LO && EL_HI





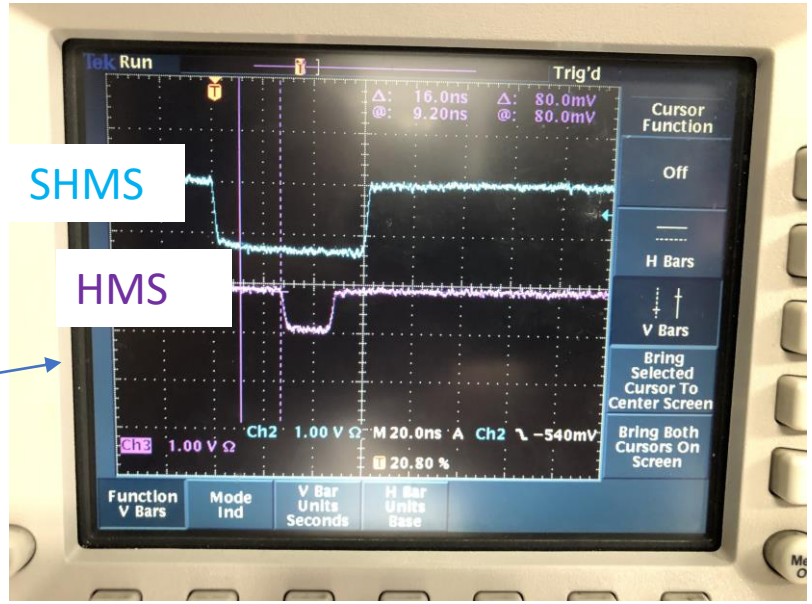




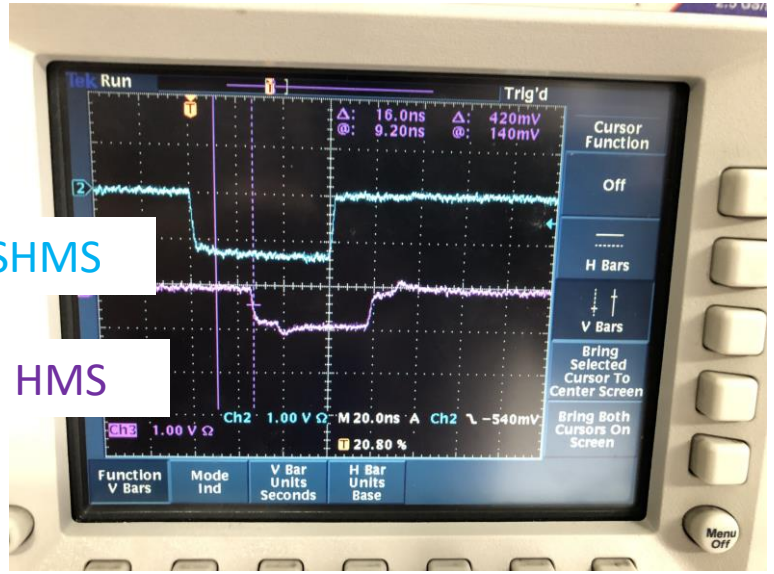
Coincidence Trigger

- Coincidence Trigger starting Fall 18
  - https://logbooks.jlab.org/entry/3599311
  - TRIG5 : SHMS 3of4 at 100ns and HMS EL_REAL 60ns
  - TRIG6 : SHMS 3of4 at 100ns and HMS EL_REAL 60ns
- Coincidence Trigger was changed on Oct 2,2018
  - https://logbooks.jlab.org/entry/3602842
  - TRIG5 : SHMS 3of4 at 60ns and HMS EL_REAL 20ns with HMS EL_REAL delayed by additional 24ns
  - TRIG6 : SHMS 3of4 at 60ns and HMS HODO 60ns with HMS Hodo delayed by additional 32ns
  - HMS trigger about 25ns after SHMS leading edge.

TRIG5



TRIG6



Why a Reference Time Signal?

- Why is TDC reference time signal needed?
  - The “stop” signal to the TDC comes from the Trigger Module.
  - Corrects for the “jitter” in the TDC “stop” signal.
    - The “stop” signal is used to set the “look back” window for selecting the TDC times in other channels is on a 40Mhz clock.
      - Start of the “look back” window has 25ns random jitter
    - Times in the channel are relative to the start of the “look back” window.
    - By taking differences between TDC channels can get bin resolution of 0.09976 ns.
  - Corrects the other shifts in TDC “stop” signal start of the “look back”.
      - If timing of triggers at the Trigger Module are different than the time of the start window changes.
      - For coincidence trigger, the arrival of the “stop” signal changes with timing of the random coincidence time.
- Why is ADC reference time signal needed?
  1. The start of the “look back” window is relative to trigger signal from Trigger Module.
  2. Corrects for shifts in start of the “look back” window.
      - If timing of triggers at the Trigger Module are different than the time of the start window changes.
      - For coincidence trigger, the arrival of the “stop” signal changes with timing of the random coincidence time
  3. Remember FADC time bin or channel is 0.0625ns.

TDC Reference Time Signal Formation

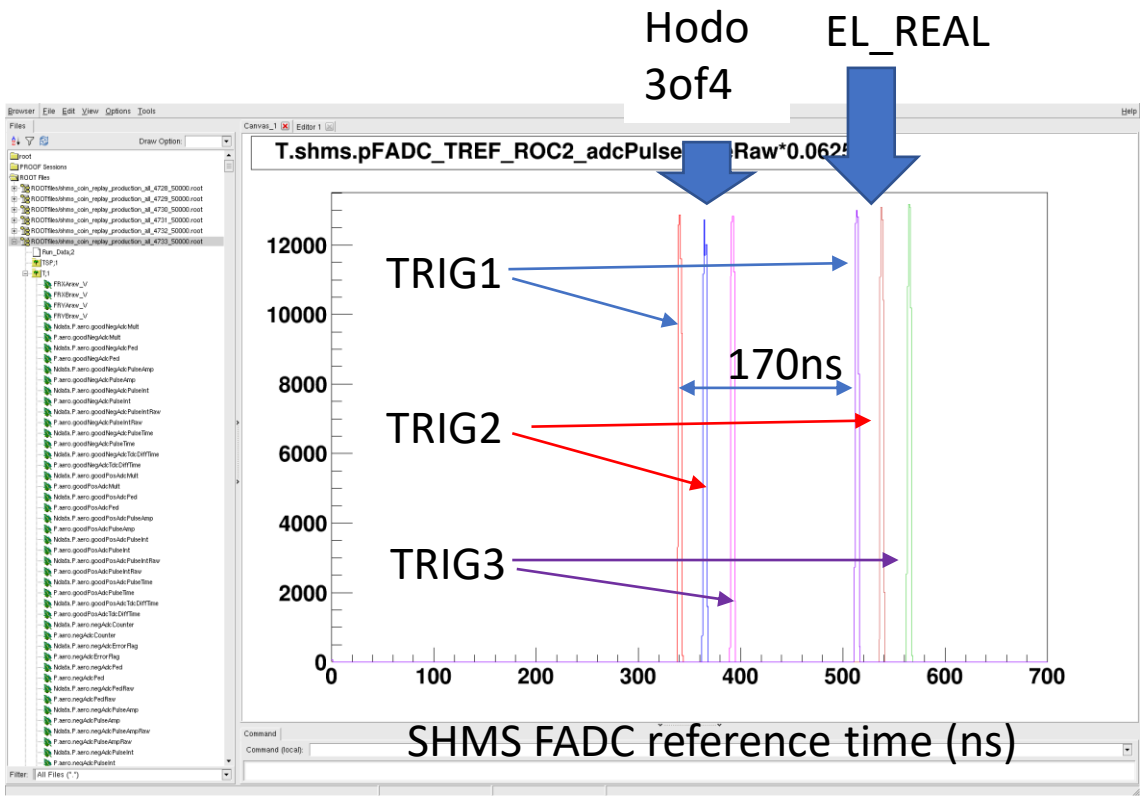
- Reference time needed for every event.
- Reference time signal
  - Combine logic signals from different triggers with each delayed to make one logic signal that is a “train” of the trigger signals.
  - Originally used HODO 3or4, STOF, EL_REAL and EL_CLEAN.
  - Spring 18 (3 signals combined)
    - HODO 3of4
    - EL_REAL delayed by 170ns
    - EL_CLEAN delayed by 340ns
    - Removed STOF since EL_REAL will be seen when it is triggered by STOF without HODO 3of4.
    - Each trigger can have up to 3 pulses in the “train”
  - Fall 18 (2 signals combined)
    - HODO 3of4
    - EL_REAL delayed by 170ns.
    - EL_CLEAN is NOT needed since there is an EL_REAL for every EL_CLEAN
    - Each trigger can have up to 2 pulses in the “train”

SHMS FADC reference time (ns) Fall 18

EDTM example for three triggers:

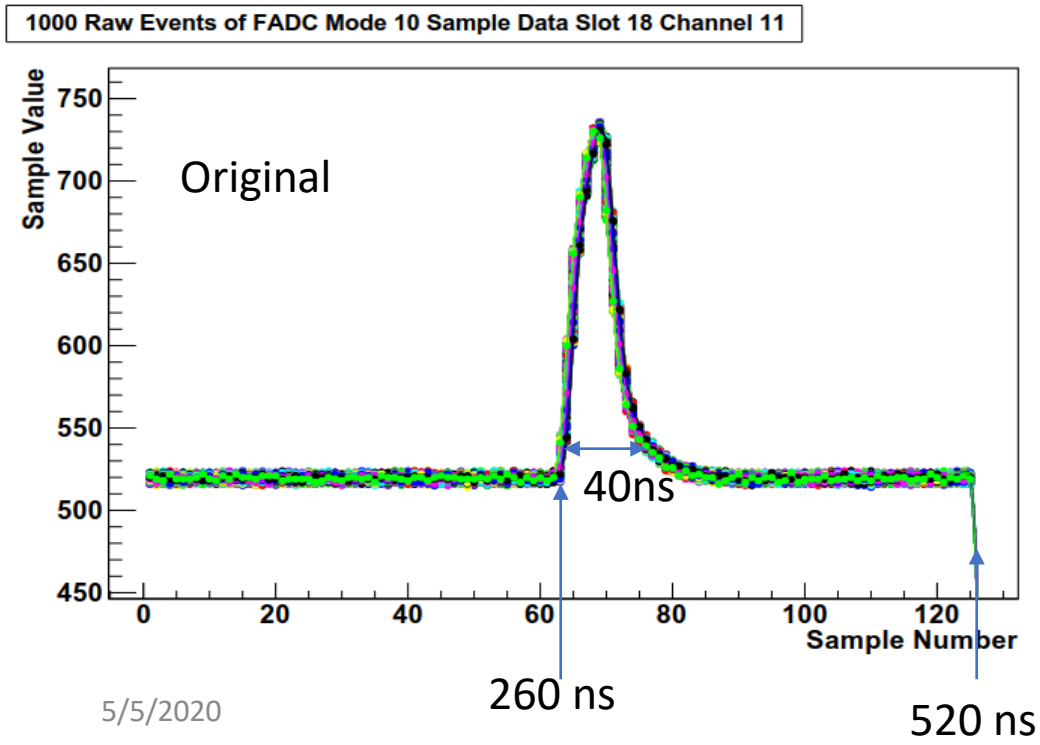
Hodo 3of4 (TRIG1) , EL_REAL (TRIG2) , EL_CLEAN (TRIG3)

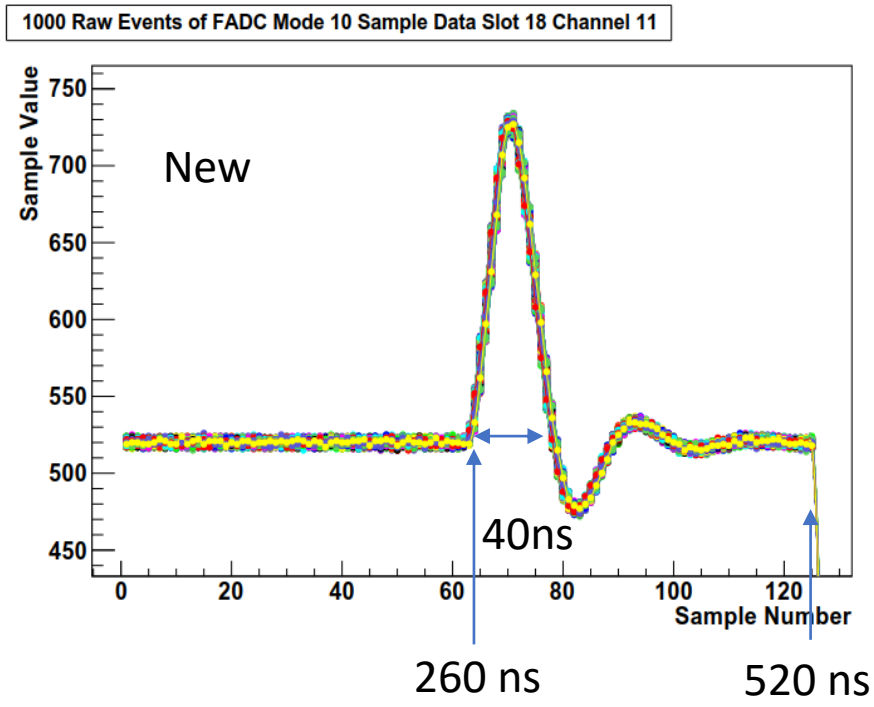
- Hodo 3of4 signal in the reference time pulse at 340ns for TRIG1. When TRIG2 or TRIG3 at the trigger module peak shifts by 25ns
- EL_REAL signal in the reference time pulse at 510ns for TRIG1. When TRIG2 or TRIG3 at the trigger module peak shifts by 25ns



FADC Reference Time Signal Formation

- The FADC reference time is formed by sending a copy of the TDC reference time signal to a pulse shaper (RC circuit) to produce an analog pulse for the FADC.
- A new pulse shaper was installed on August 13th, 2018. See https://logbooks.jlab.org/entry/3586571
- Below are histograms of the pulse shape seen in the FADC.
  - When FADC run in mode 10 then one gets 130 samples of the charge (integrated for 4ns bin or sample number)
  - Only showing the HODO 3of4 trigger. Pulse width about 40ns at baseline.
- The original FADC pulse shape looks better. Ringing seen with new pulse shaper.





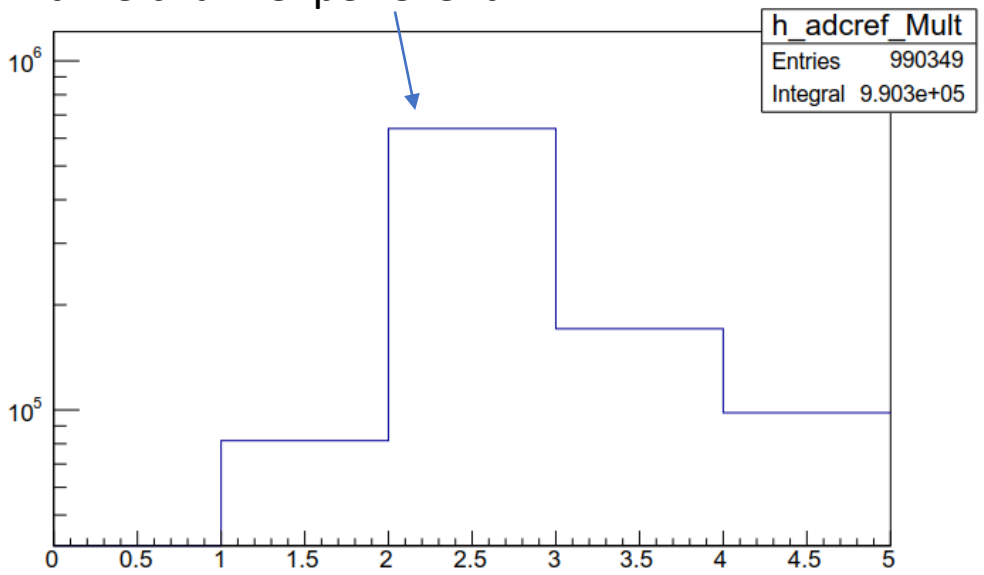
Run 5371 Overview

- Coincidence run 5371
  - Run on Oct 23,2018
  - LD2 target and Beam energy = 10.6
  - Trigger PS5=1 , other PS=-1,
  - Trig5 is HMS EL_REAL && SHMS HOD0 3of4
  - SHMS P = -5.27 Angle = 14.0
  - HMS P = -3.44 Angle = 16.3
  - SHMS pions with fire the HGCER Cerenkov to mostly cause SHMS EL_REAL trigger for every HODO 3of4 trigger.
  - Rates for the various triggers given in table.
  - SHMS EL_REAL almost equal to 3of4 rate so expect two pulses in SHMS reference time for almost every coincidence trigger.
  - HMS EL_REAL in coincidence trigger so expect two pulses in HMS reference time for almost every coincidence trigger.

Ave Current	HMS EL_REAL Rate (kHz)	SHMS 3of4 Hodo Rate (kHz)	SHMS EL_REAL Rate (kHz)
70.7 uA	21.3	610	536

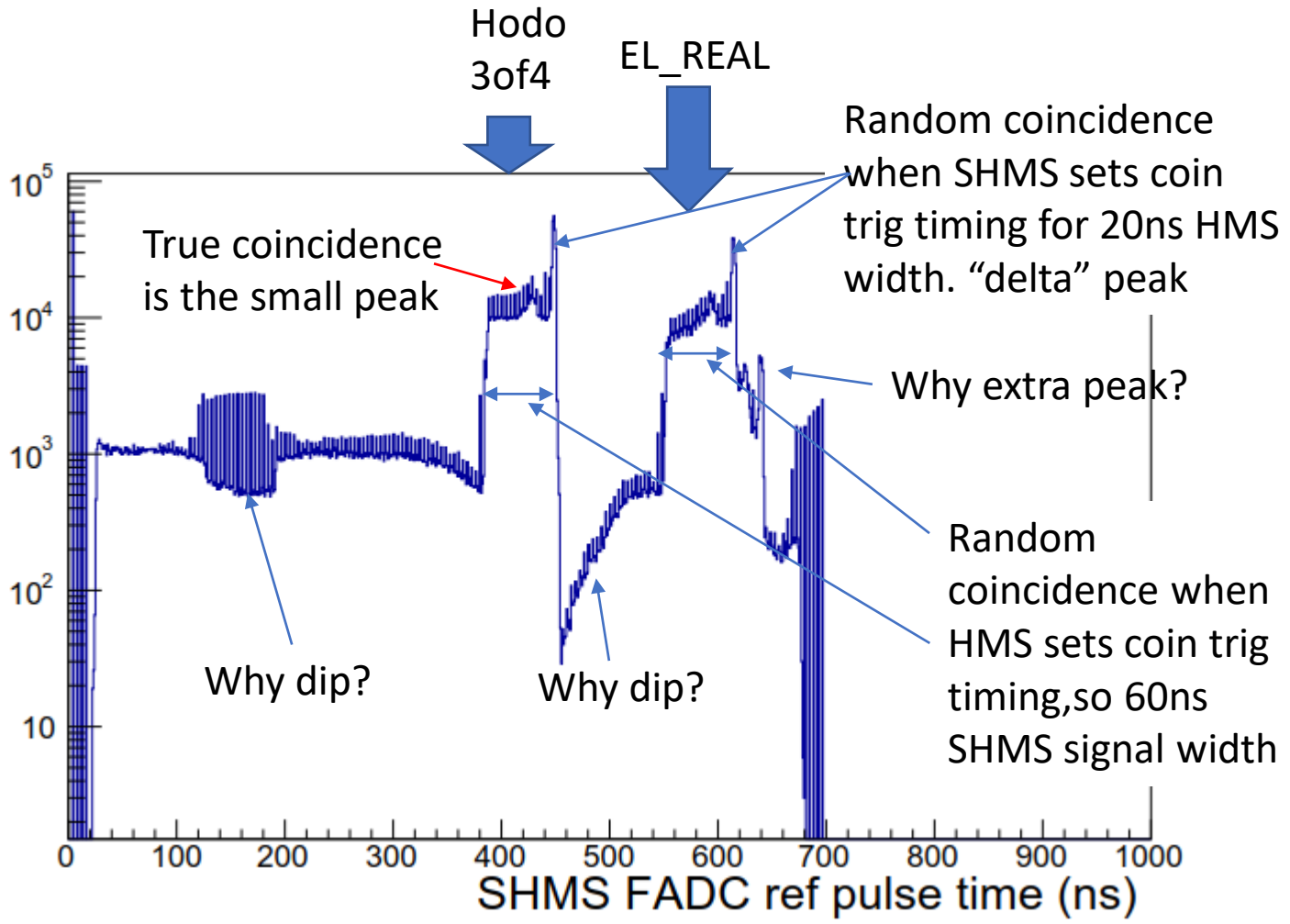
Run 5371 and SHMS FADC Reference Time

Expect mostly two pulses in reference time channel per event



- FADC window is 700ns.
- SHMS 3of4 is 610 KHz.
- Probability of extra hits (35%) within 700ns:
  - 1,2 or 3 extra is 28%,6%,1%
- The measured ratio of events with 3 or more to total is 28%.
- One note is that FADC channel can only take 4 pulses per event.

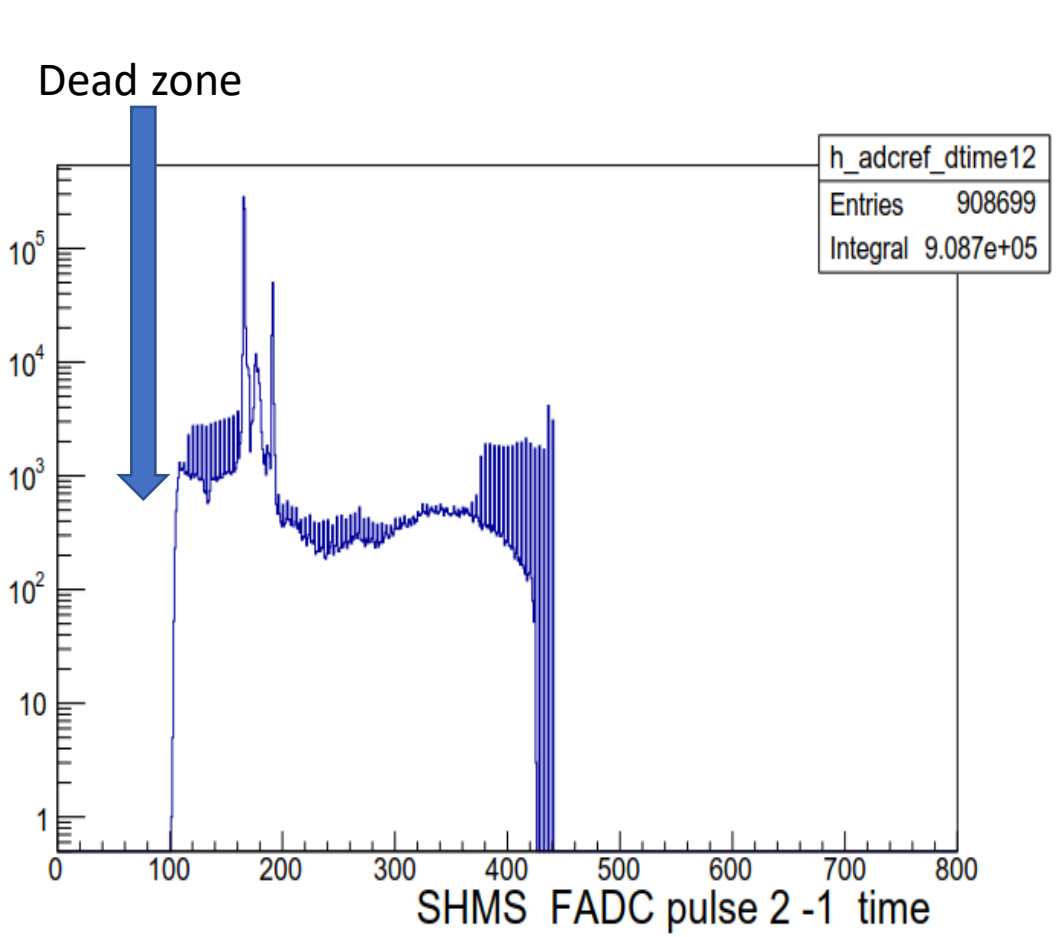
- Fill a Histogram with the FADC Raw reference time for each pulse in the event.
- Usually have two pulses (HODO 3of4 and EL_REAL) separated by 170ns for each event.

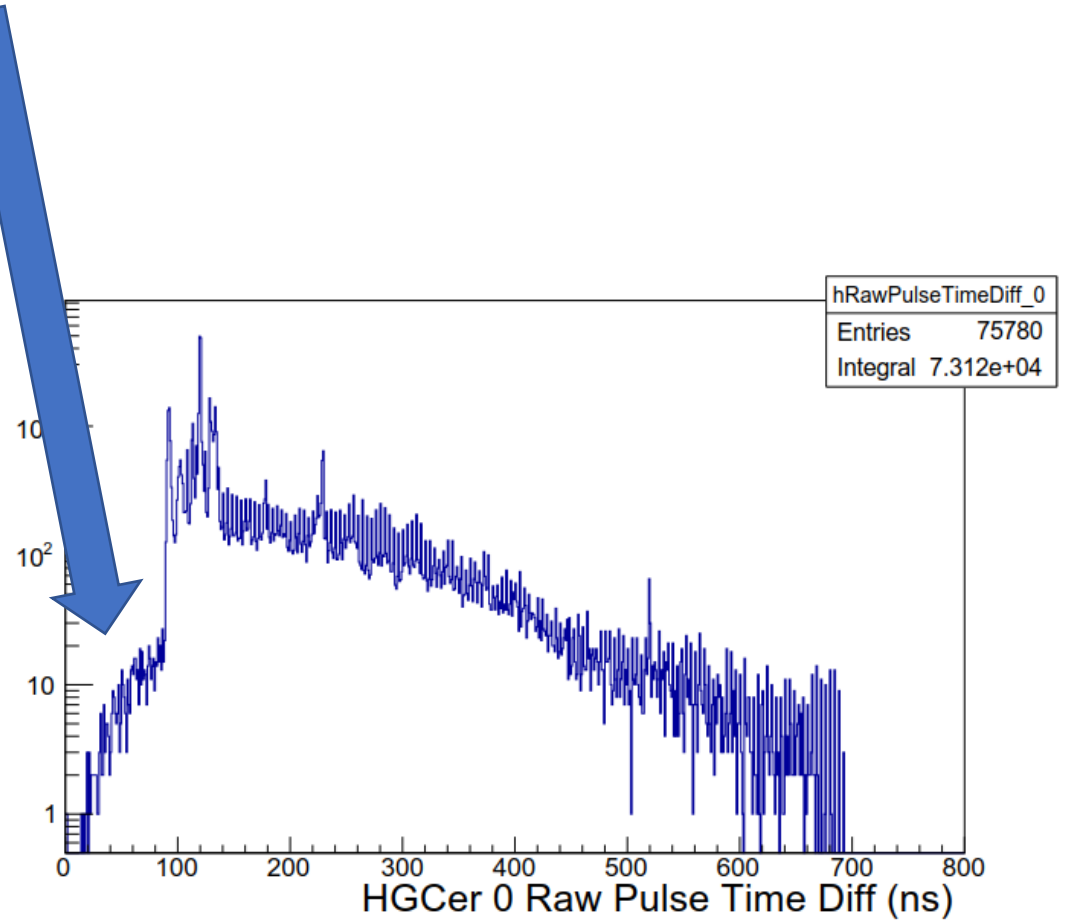


Difference in time between successive FADC Reference time pulses in an event

- No pulses are closer than 100ns. 100ns is the width of the pulse integration programmed for FADC
- This allows random HODO 3of4 trigger which do not cause a coincidence trigger (accidental or true) to block the pulse from the HODO 3of 4 which form the coincidence trigger.
- See the same with the HMS FADC reference time , HGCER Cherenkov FADC and other detectors

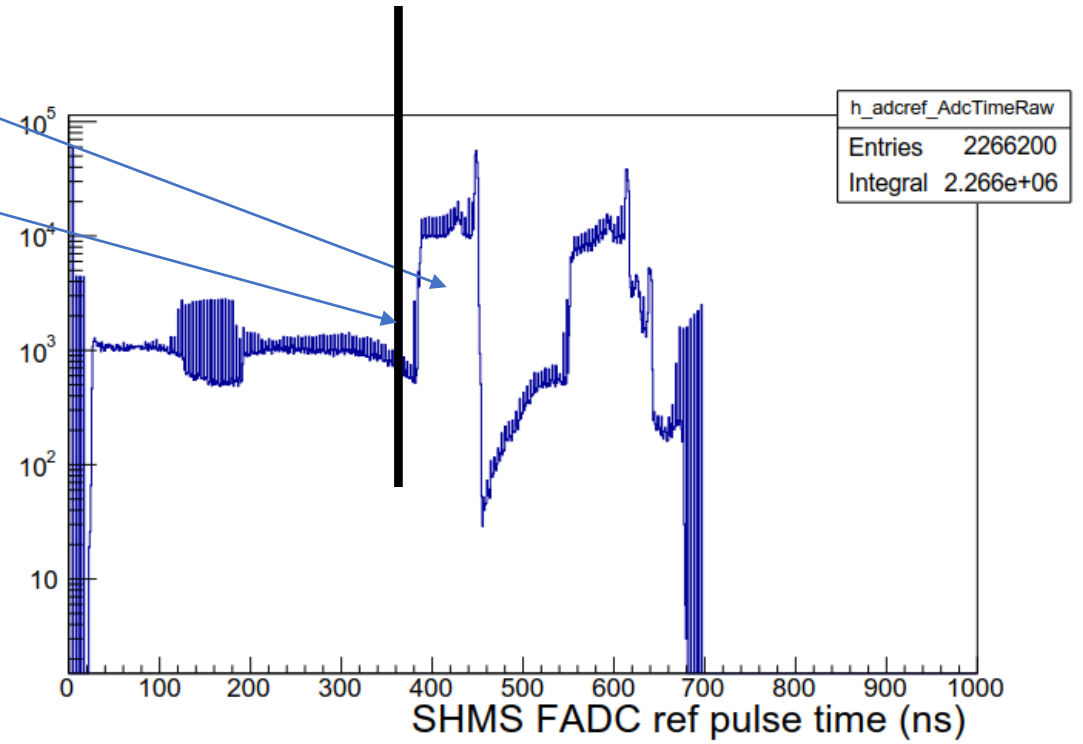
Dead zone





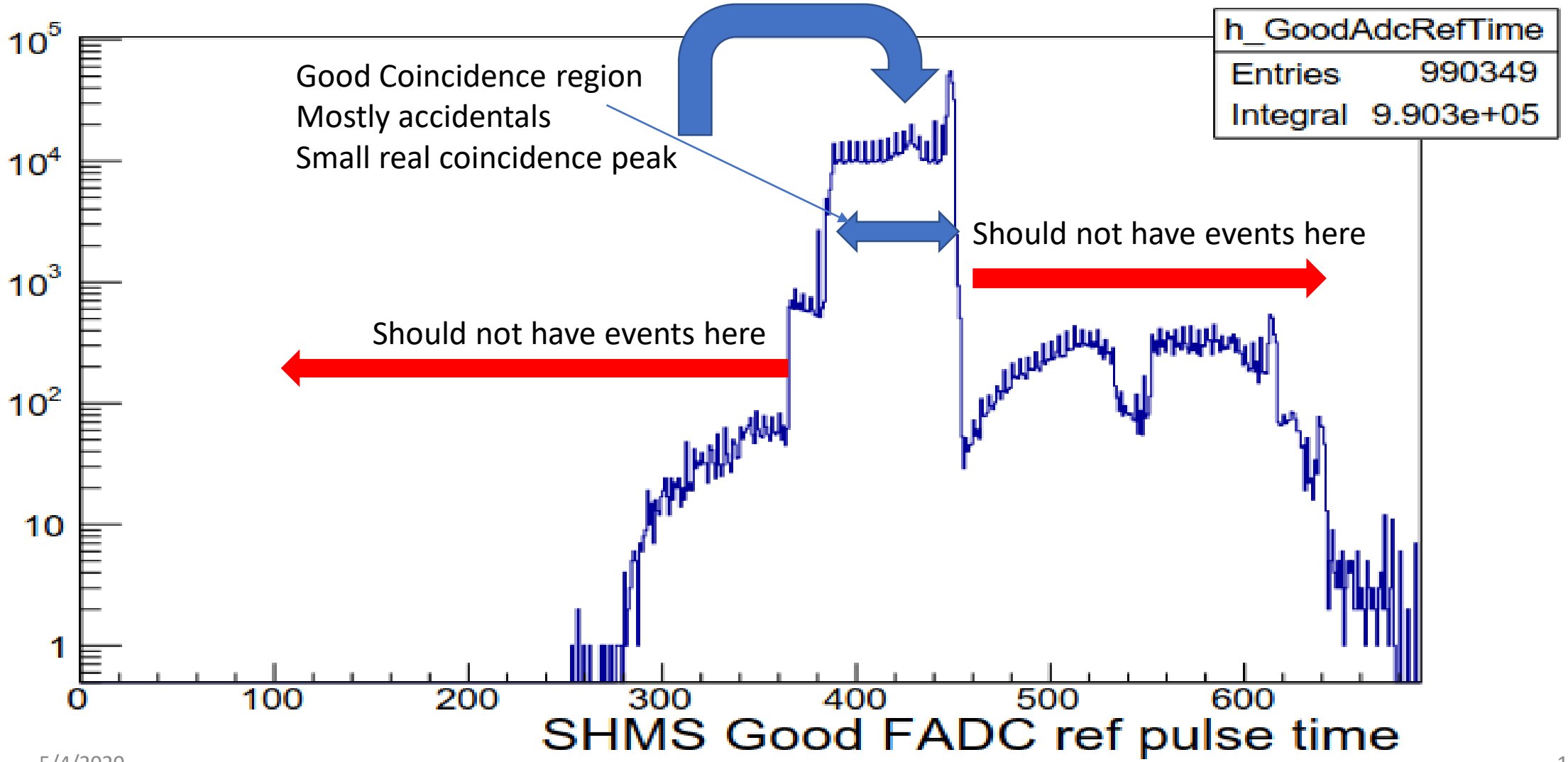
Selecting Good SHMS FADC Reference Time

- Need to select the “good” SHMS FADC Reference time pulse when more then one pulse.
  - Want to select pulse in the coincidence trigger region that includes coincidence trigger accidentals from 385 to 455ns
- Set a reference time cut.
  - Set at channel 5840 or 365ns.
  - Slightly below the coincidence region.
- First pulse above the cut is the good pulse
- If no hit is above the cut, pick last pulse.
- There always should be one “good” hit above the reference time cut, since reference time pulse is in the trigger.



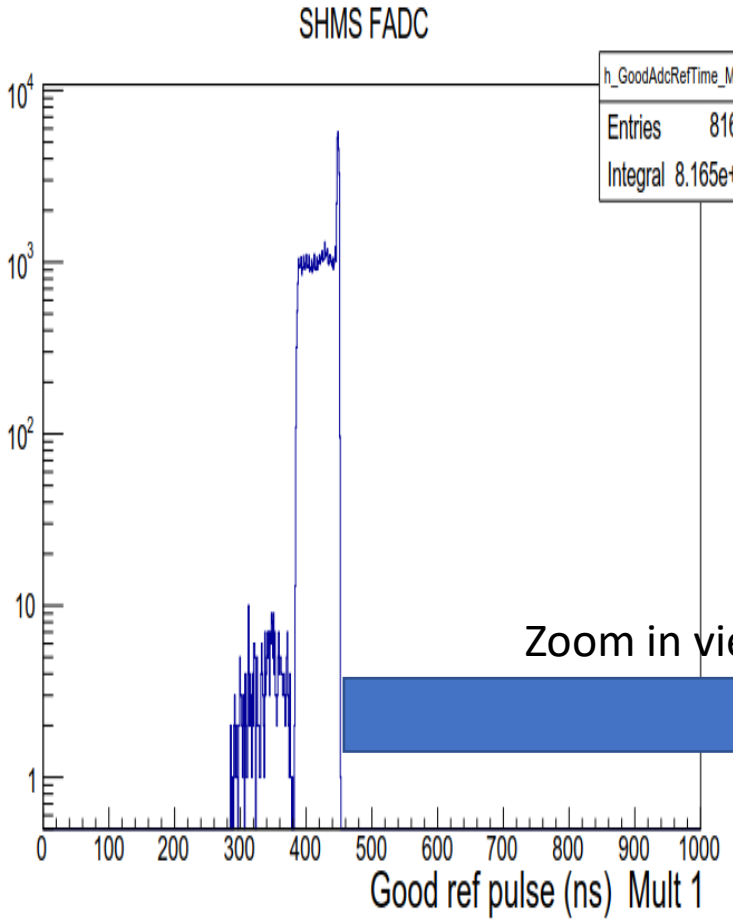
Good SHMS FADC Reference Time Histogram

Why are there Good FADC Reference Time pulses found above and below the good coincidence region?
Answer: The good pulse from the coincidence trigger is being blocked by random.

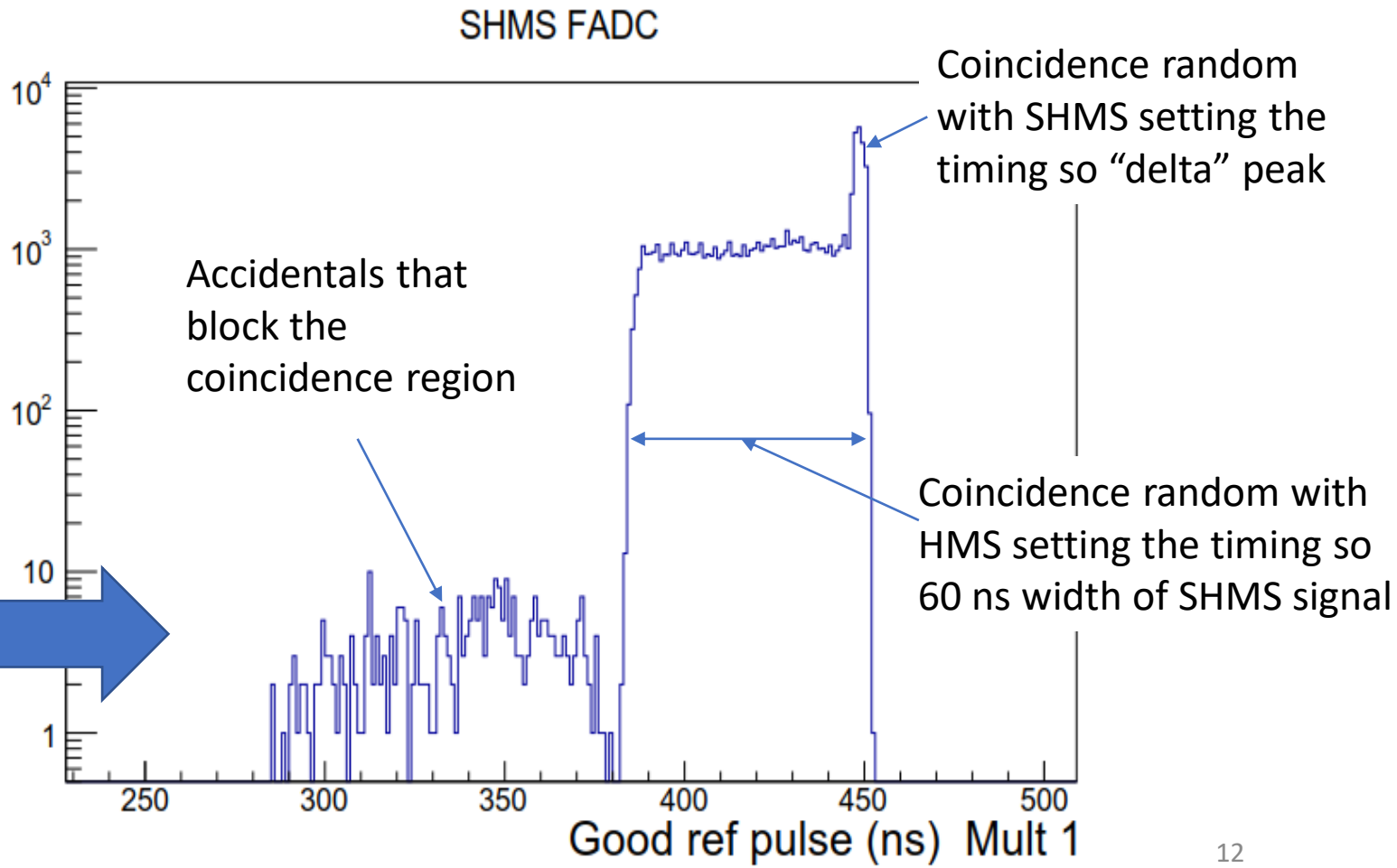


Good SHMS FADC Reference Time Histogram for Multiplicity = 1

- Select events with only one pulse in FADC reference and look at Good Reference Time
- Expect only good reference time in the coincidence region, but events with good reference times below 390ns.
- The coincidence region is mostly random coincidence between the SHMS and HMS.
- Randoms (that do not make random coincidence trigger) which arrive 100ns before the good region and block the pulse that formed the coincidence trigger.

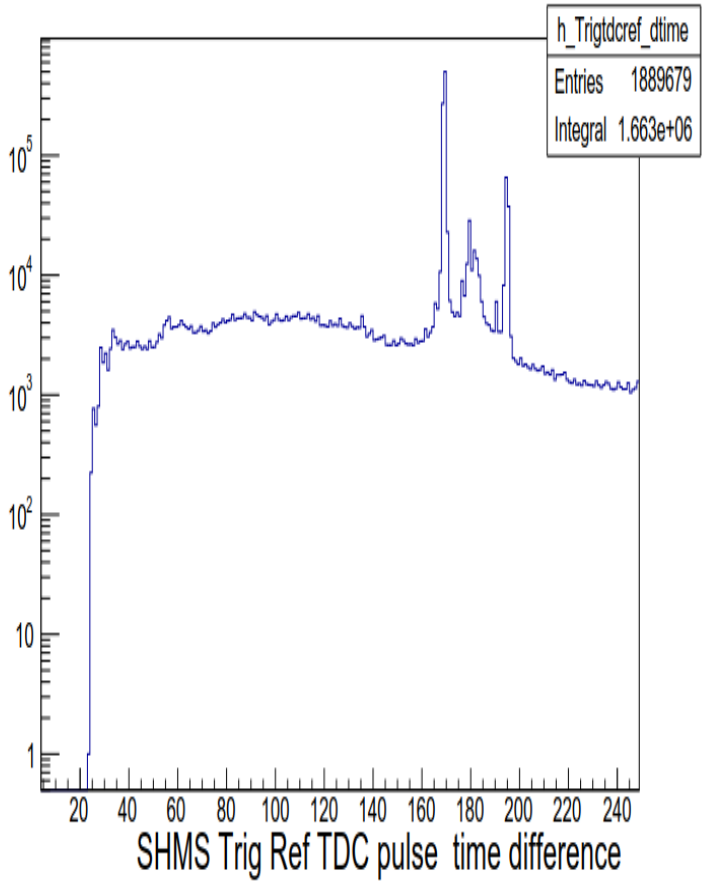


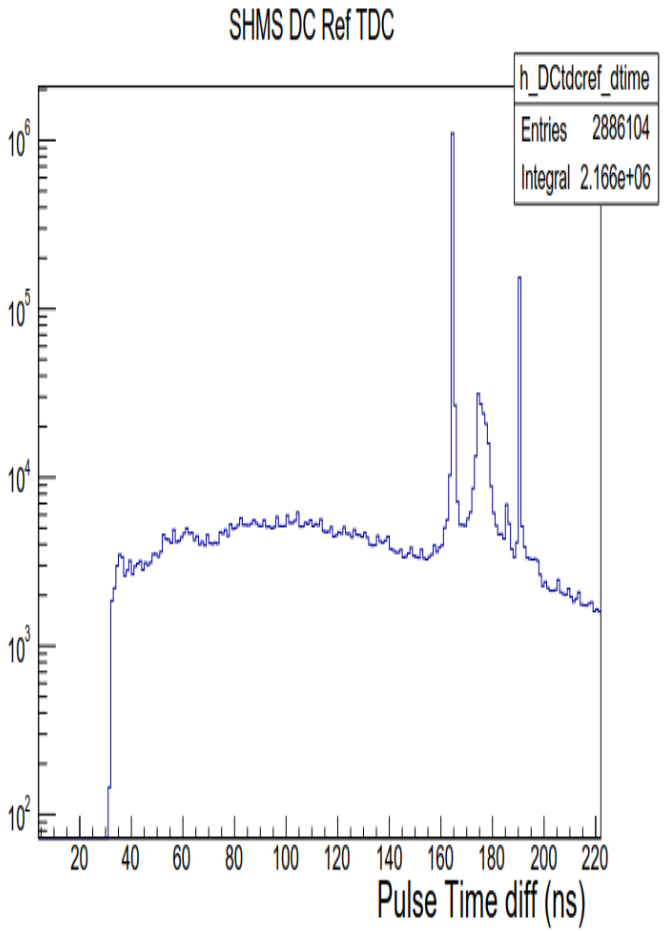
Zoom in view

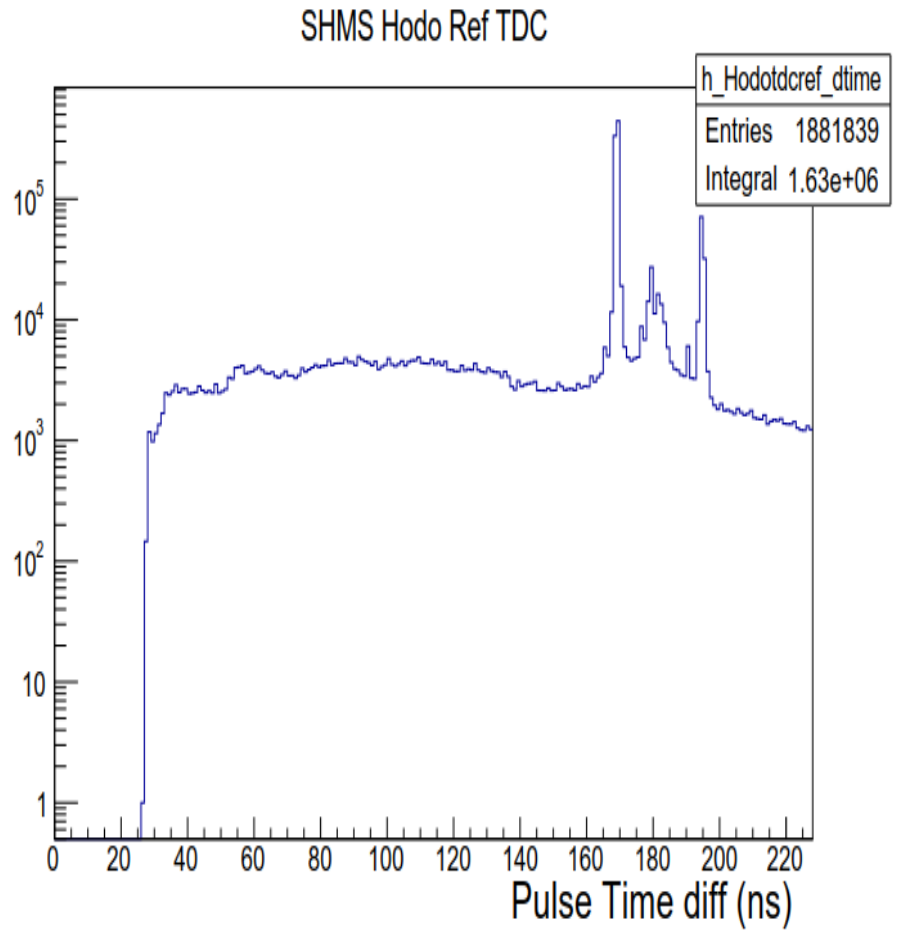


Difference in time between successive SHMS TDC Reference time pulses in an event

- Trigger Module, DC and Hodo TDC reference minimums are 25ns, 30ns and 30ns







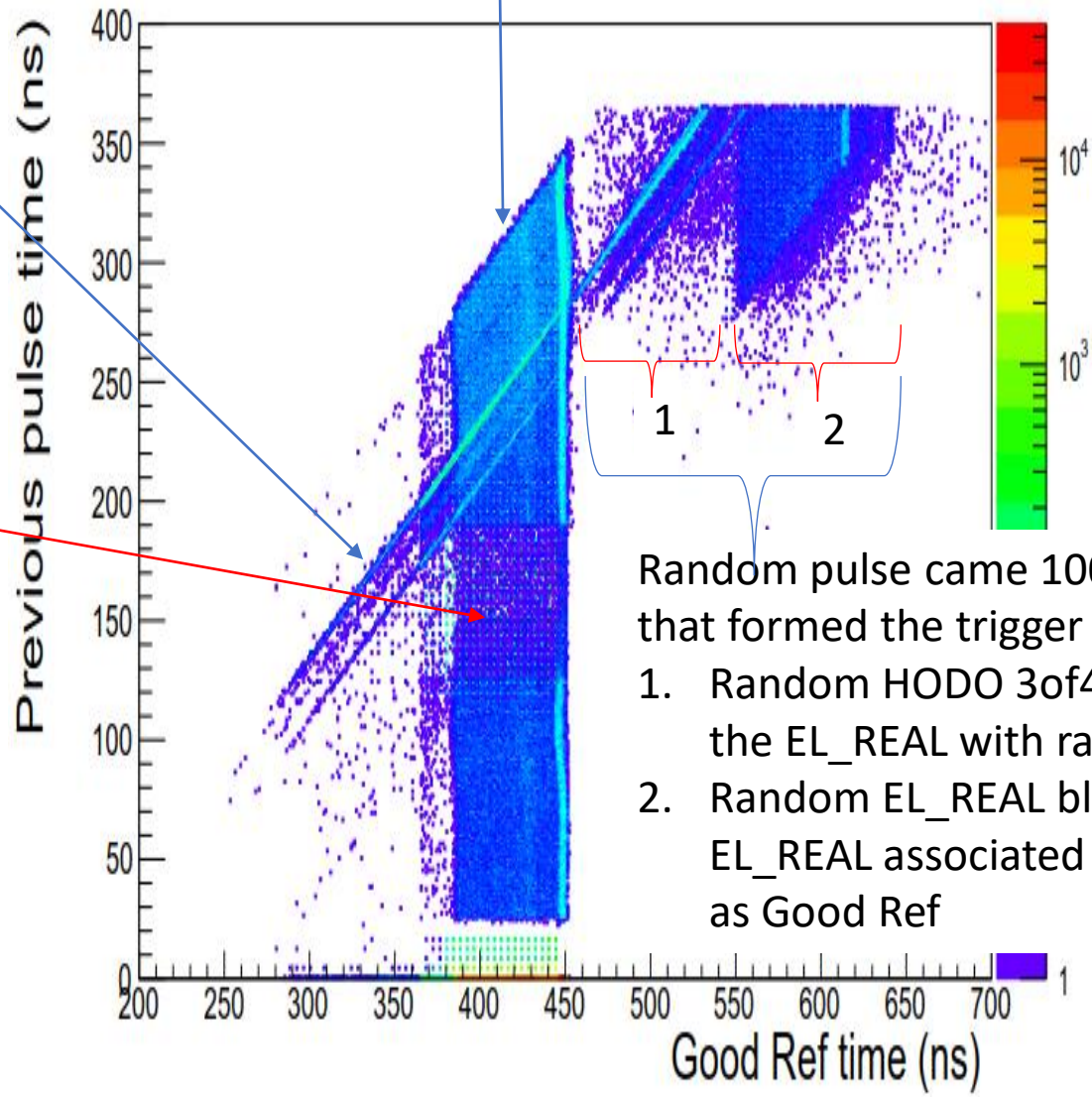
Good SHMS FADC Reference Time Histogram for Multiplicity >=2

Plot time of pulse that is previous to the Good Reference Time pulse versus the Good Reference Time

Diagonal cut because minimum of Previous pulse – Good Ref = 100ns

Three stripes because Good Ref pulse is EL_REAL associated with the previous HODO 3of4 pulse

1. The EL_REAL blocks the trigger pulse. The trigger pulse is just a HODO 3of4 with no associated EL_REAL. This causes the “gap” between 385 to 460 in the Good Ref time.
2. A random HODO 3of4 blocks without an associated EL_REAL blocks a trigger without an El_REAL.



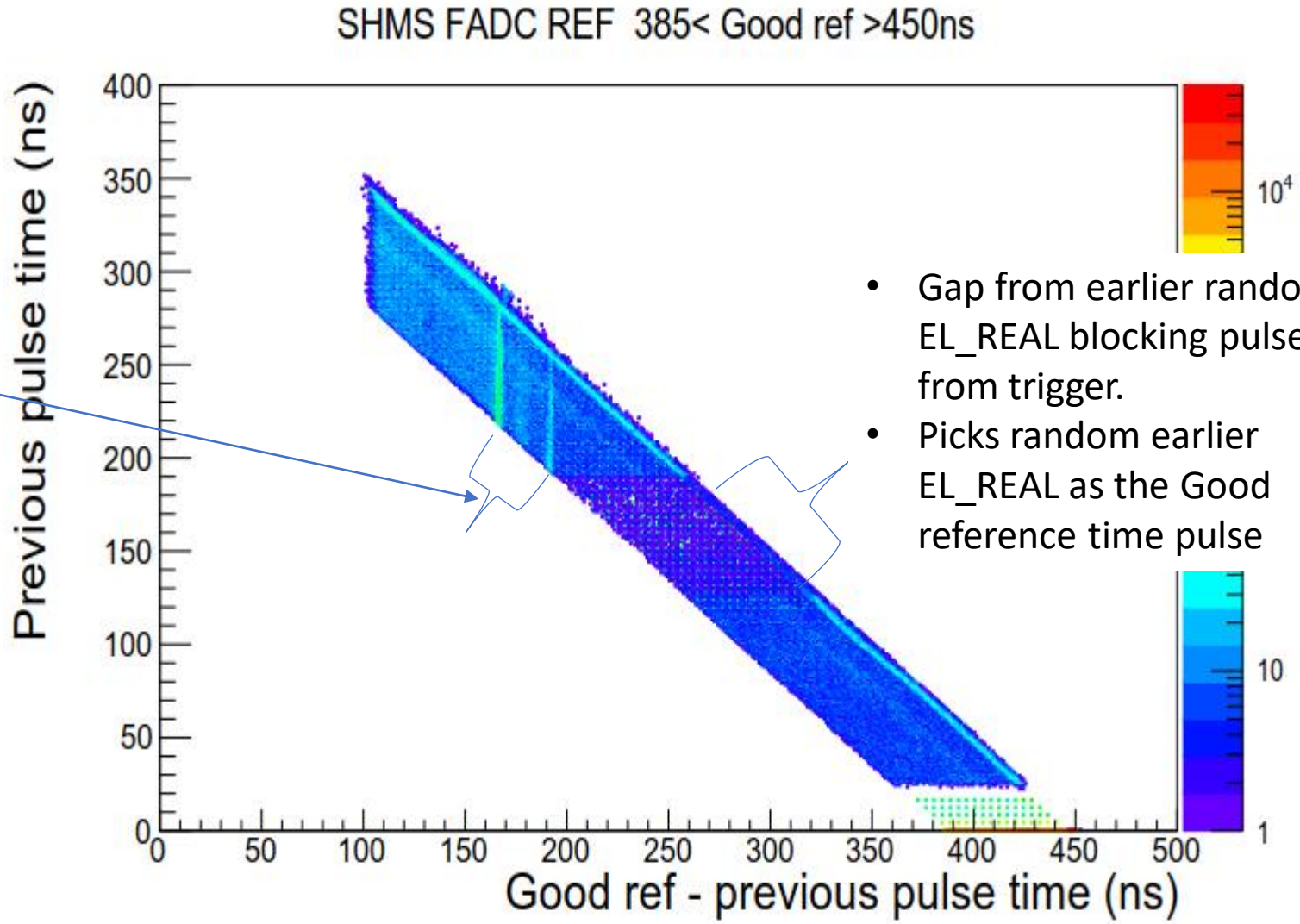
Random pulse came 100ns before the “good” pulse that formed the trigger and blocked the trigger pulse

1. Random HODO 3of4 blocks the trigger pulse and the EL_REAL with random selected as Good Ref
2. Random EL_REAL blocks the trigger pulse and the EL_REAL associated with the trigger pulse selected as Good Ref

Additional problem for events with FADC Reference Multiplicity >=2

- Select events with Good Reference time between 385 and 450 ns
- Plot the time of the previous pulse versus the difference between Good reference time and previous pulse time

- All pulses in this Good Reference Time region should be HODO 3of4 pulses associated with the coincidence trigger.
- Find pulses in the region which are random EL_REAL. See the three bands between 170 and 200ns in the time difference.
- These random EL_REALs are chosen instead of the pulse associated with the trigger.
- This will cause mismatch between FADC and TDC reference times that are selected.



- Gap from earlier random EL_REAL blocking pulse from trigger.
- Picks random earlier EL_REAL as the Good reference time pulse

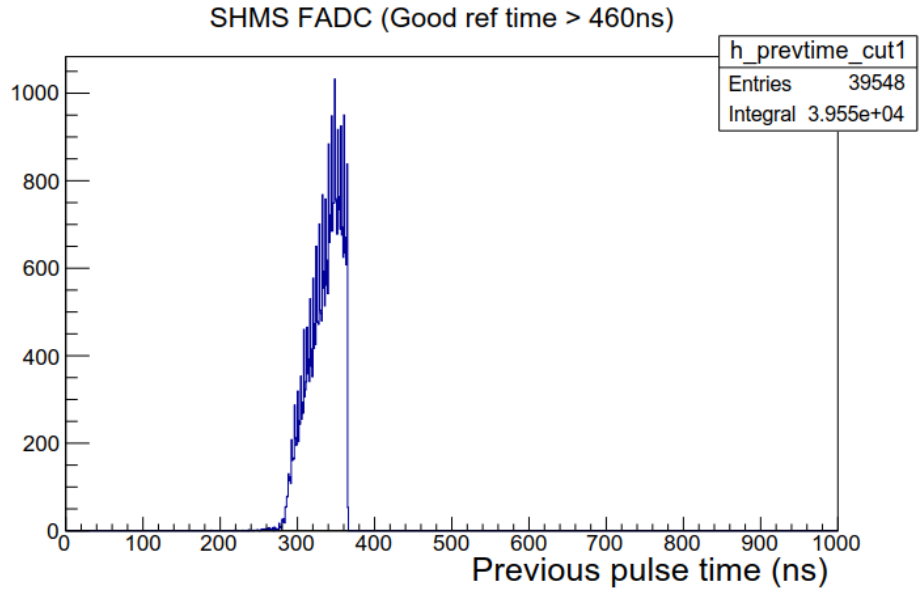
Summary

- 100ns minimum time between pulses in FADC causes problems
  - Random blocks the reference time pulse from the coincidence trigger from being recorded
  - Creates mismatch between the ADC and TDC reference time since the ADC reference time pick the random while TDC picks the coincidence pulse.
  - For detectors, causes blocking of good signal.
    - Mainly a problem for the Cerenkov detectors since each PMT covers a larger fraction of phase space. Need to look at rates on Cerenkov.
    - Maybe the aerogel needs to be looked at.
    - For hodoscope, it is less of a problem. HCANA will be changed to so that PMT hit is accepted regardless of the difference of the ADC and TDC time. Most particle are minimum ionizing, so the ADC amp that is used in the code is basically the same for random and trigger particle.
  - Can put a cut to skip events which have FADC reference time outside the good coincidence region and correct for the skipped fraction. But does not correct for the blocking of the detector signal.
- The EL_REAL as 2nd pulse in the reference time causes problems.
  - Can have random EL_REAL taken as the good reference instead of the pulse associated with the trigger in the good coincidence reference time region, since the random HODO 3of4 occurs 170-200ns earlier.
- To-do
  - Look at runs with pions below Cherenkov threshold. No EL_REAL. Need to worry about blocking aerogel.
  - Look at spring 18 runs which could have 3 pulses in reference time “train” and different SHMS/HMS coincidence signal widths.

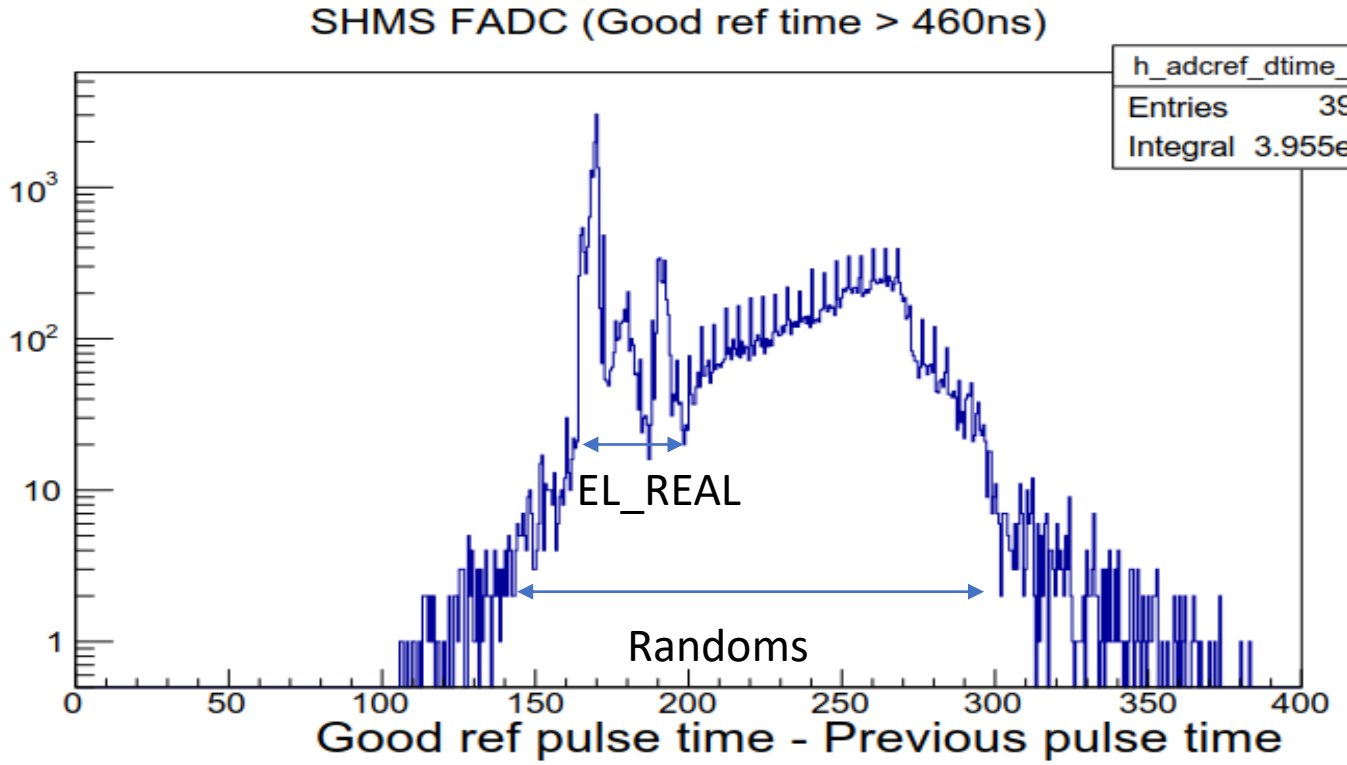
Exam events with “bad” Good FADC reference time for Multiplicity >=2

- Select events with “bad” Good Reference Time > 460ns

Time of the previous pulse recorded by the FADC before the “bad” Good Reference pulse



Random previous pulse arrived in region 265-365ns which blocks the FADC for 100ns
This keeps the pulse that should be in the coincidence region from being read by FADC.



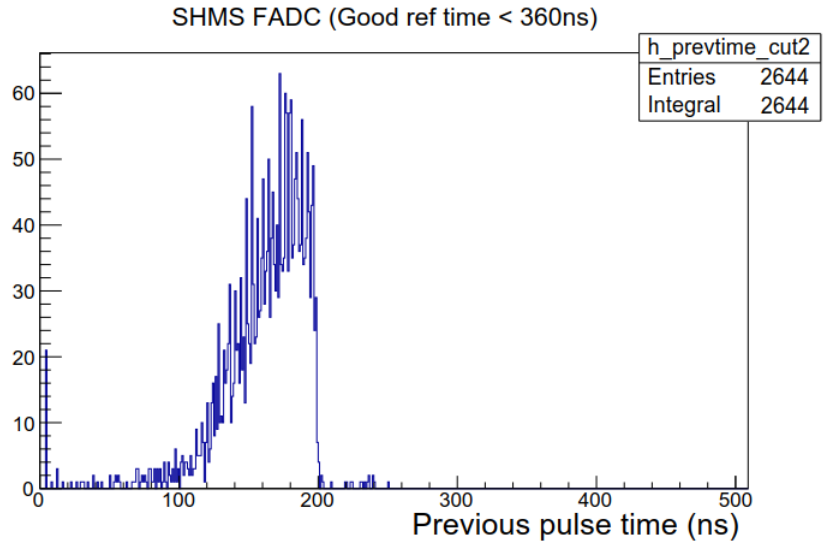
The “bad” Good reference pulse is

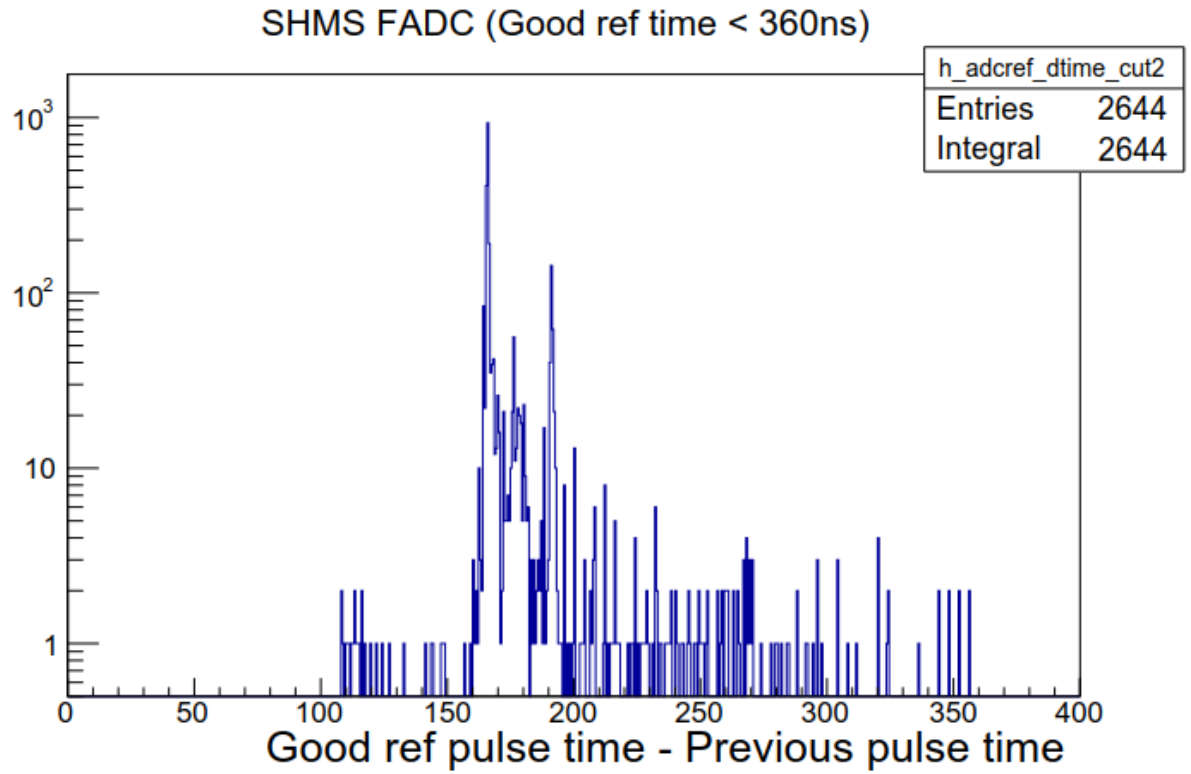
- EL_REAL (170-200ns later) associated with the previous random HODO 3of4 and the coincidence trigger was just HODO 3of4 so the time difference is a peak in 170-200ns range.
- EL_REAL associated with the missing pulse (that should be the Good Ref time) and the previous pulse had was only HODO 3of4,so the time difference is random

Exam events with “bad” Good FADC reference time for Multiplicity >=2

- Select events with 265 < “bad” Good Reference Time < 360 ns

Time of the previous pulse recorded by the FADC before the “bad” Good Reference pulse





1. Random previous HODO 3of4 pulse arrived in region 100-200ns is associated with EL_REAL which arrives 170-200ns later in region 265 to 360ns.
   - See peaks in the Good Ref – Previous Pulse Time in 170-200ns.
2. In region before 100ns, random HODO 3of4 and then another random HODO 3of4 in region from 265 to 360ns.
   - See random spread in the Good Ref – Previous Pulse Time histogram