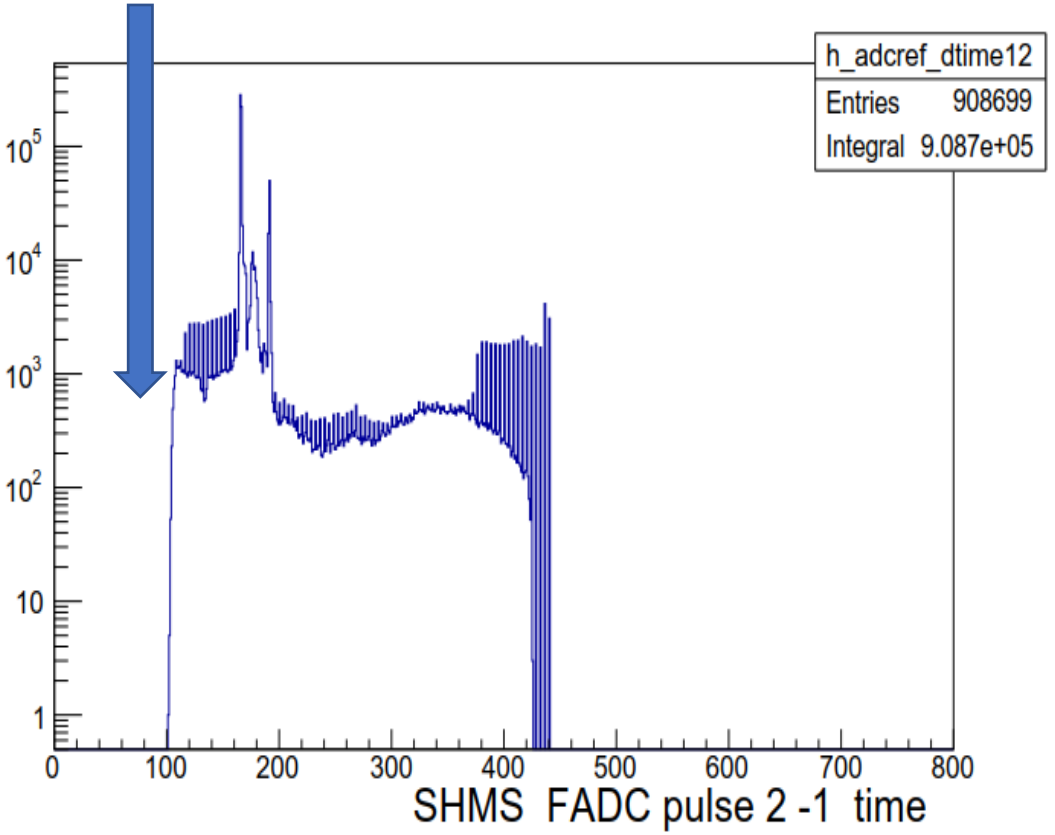
HCANA/Software Update

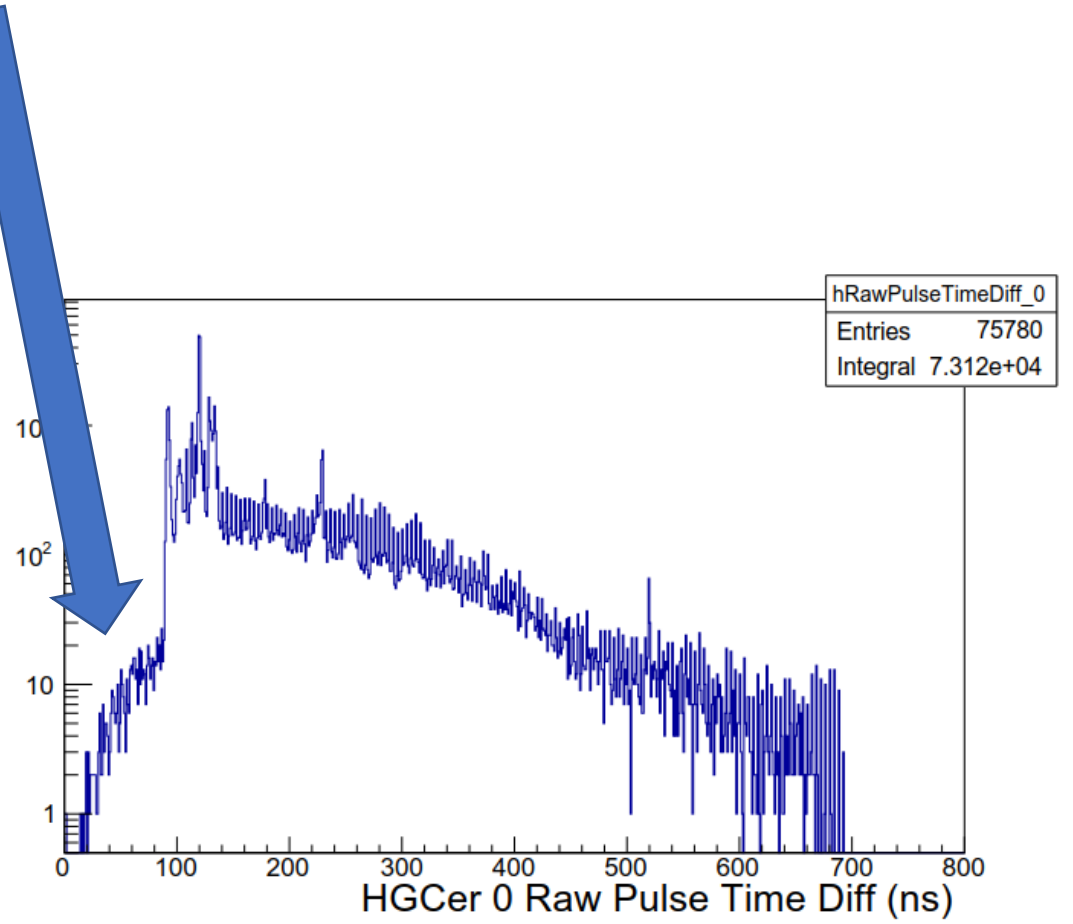
- Substantial changes to HCANA in April 2020 Branch
  - New tree variables of the reference time used in each detector.
    - Impossible to determine TRUE ADC/TDC reference time for every event. Rate dependent.
    - Difficulty exacerbated by multiple hits in reference time (for HODO3/4 , EL_REAL, EL_CLEAN triggers)
    - Best to put cuts on these variables to skip events with bad reference time and then correct data for fraction of events that were skipped.
  - Modified the way detectors handled the hits with FADC PulseAmpRaw ==0 .
    - Previously discarded these hits which meant a rate dependent loss of events
  - Modified THcHodoscope
    - ProcessHits changed so that it finds match between TDC and ADC hits in PMT regardless of the cut on the ADC time-TDC time.
    - Updated algorithm to find Start Time and focal plane time
      - Need to have hit in 3 planes to determine Start Time (previously 1 plane was enough).
      - Should set p(h)tof_tolerance to 3-5ns range.
      - Important to cut events that do not have good start time (hod.goodstarttime==0) which are accidental singles triggers. Coincidence time is not calculated for these events.
- Pushed changes to main “develop” branch on Jan 27, 2021.

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

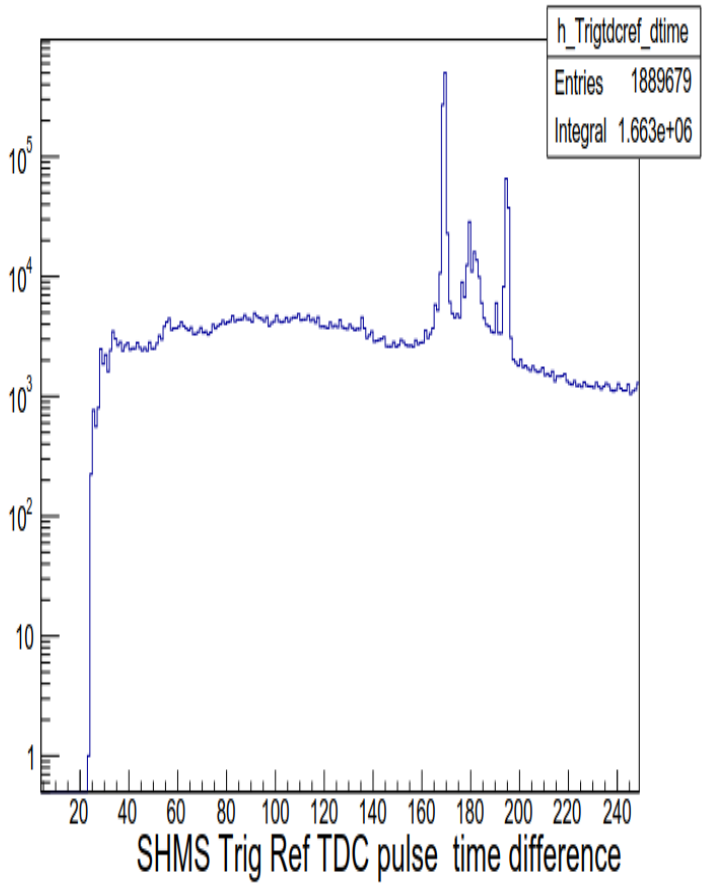
Dead zone

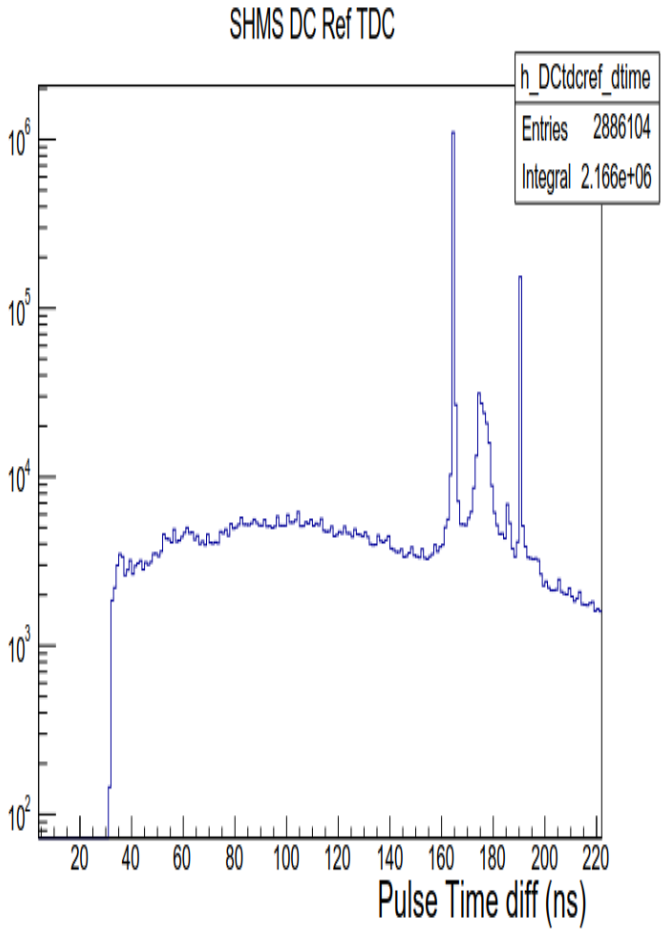


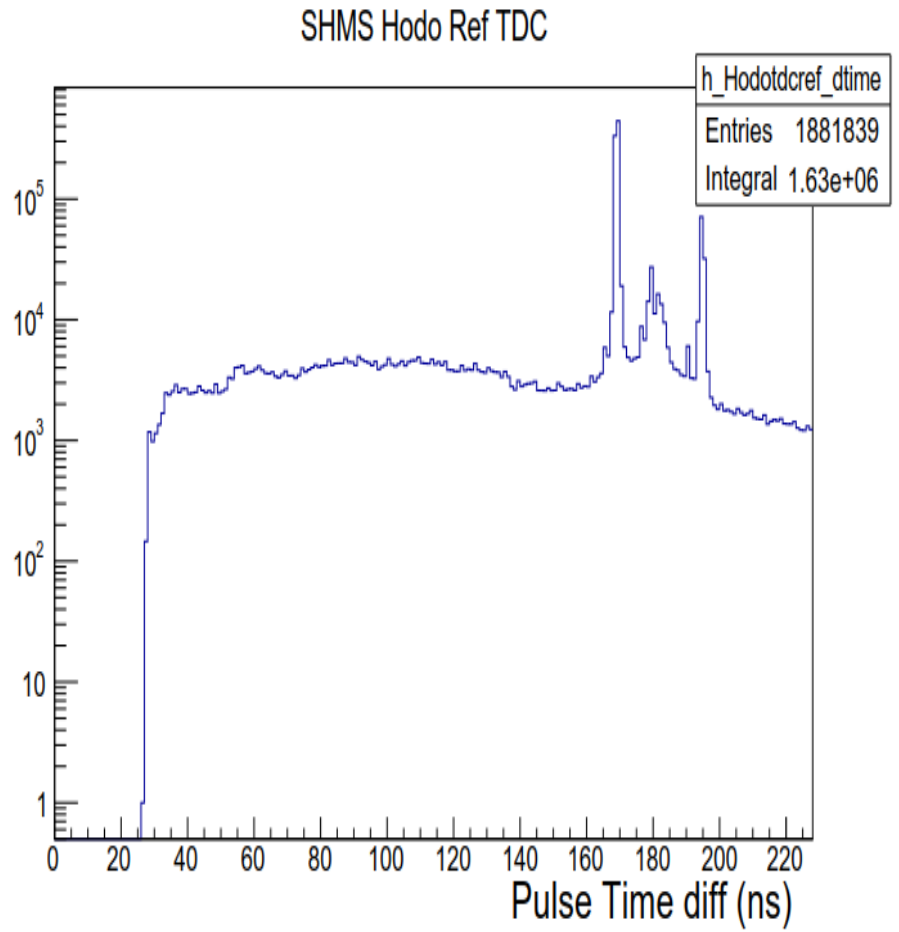


Difference in time between successive SHMS TDC Reference time pulses in an event

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

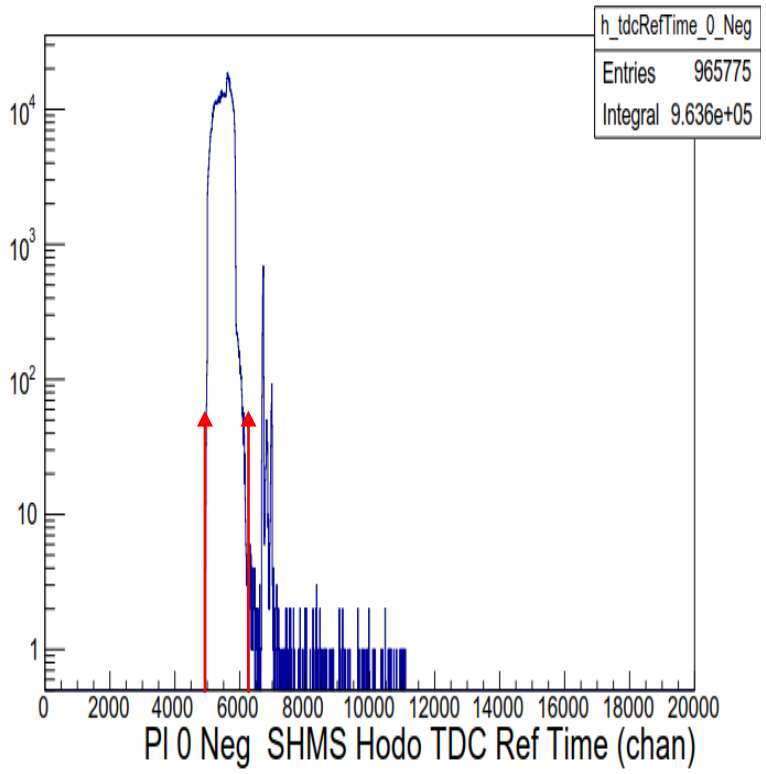


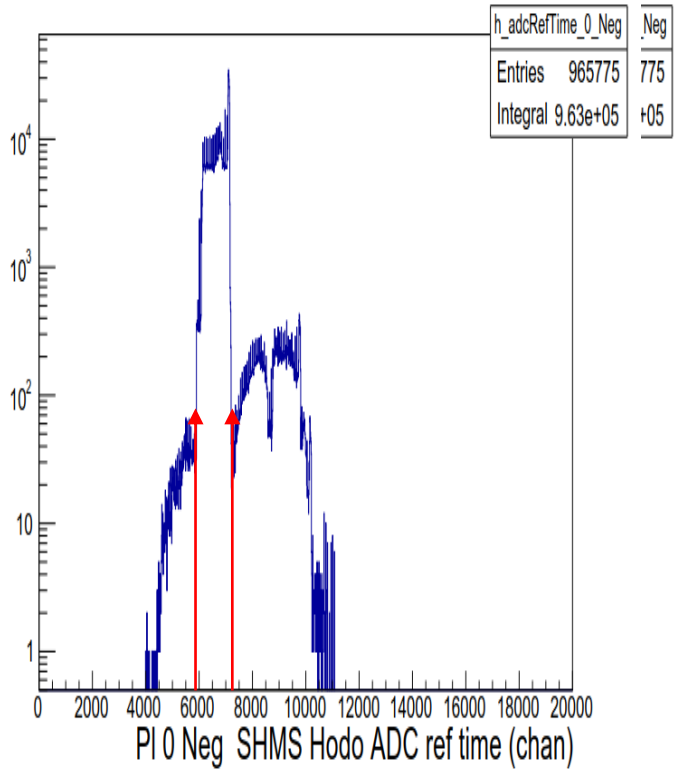


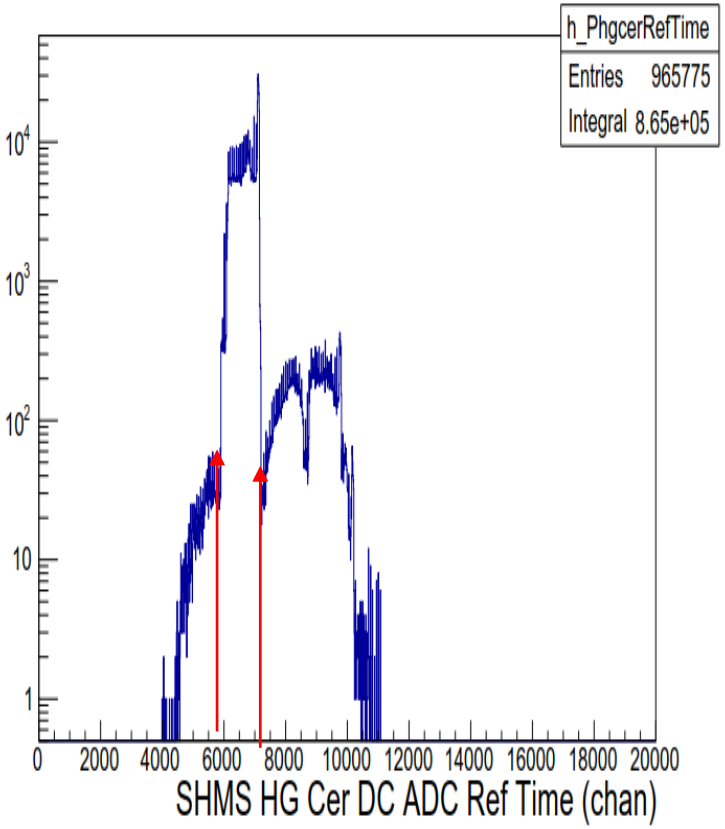


New tree variables of the Reference time used by the detector

- For HGCER and Aerogel P.hgcer.RefTime, P.aero.RefTime
- For each HODO plane, P.hod.1x.AdcRefTime or P.hod.1x.TdcRefTime
- For each DC plane , P.hod.u1.RefTime
- The ADC reference time spectra should be the same for all detectors.
- Can put cut on the hodoscope to skip events with bad reference time.

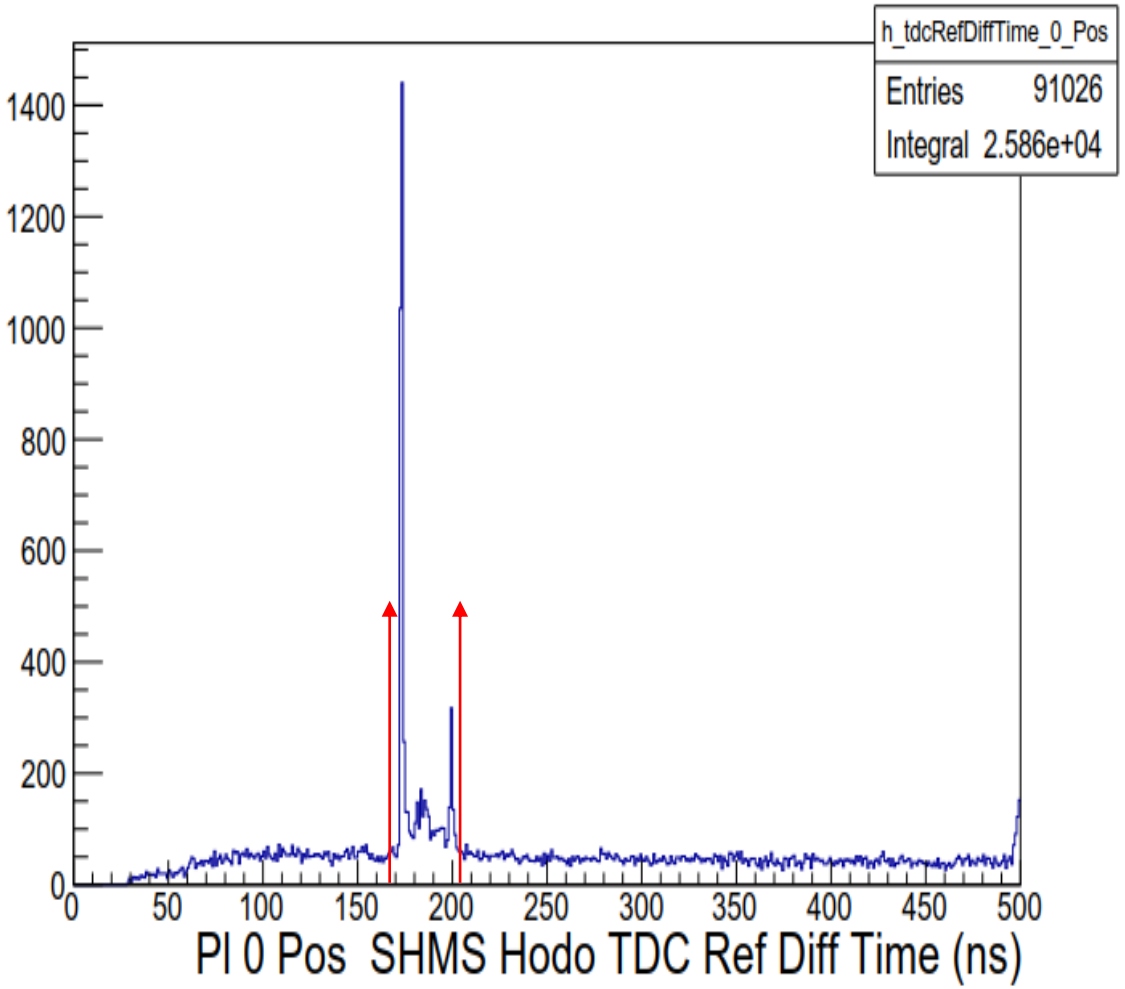


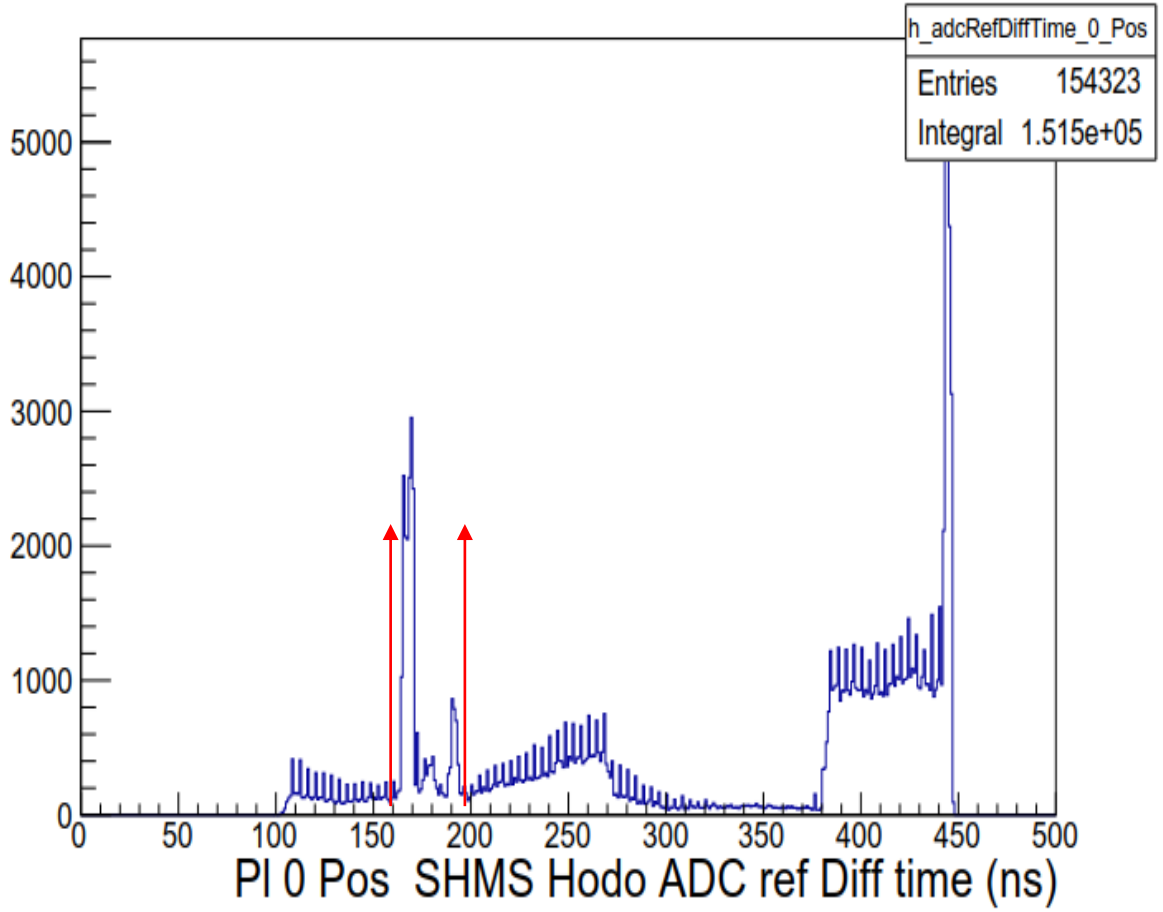




New tree variables of time difference between good Reference Time pulse and previous for hodoscope

- The good reference time in the coincidence region should only have a random pulse previous to it.
- If time difference is between 170 to 200ns then the previous pulse was actually the El_REAL associated with the random HODO 3of4.
- Can reject events in the 170 to 200ns region.





HCANA changes for other detectors

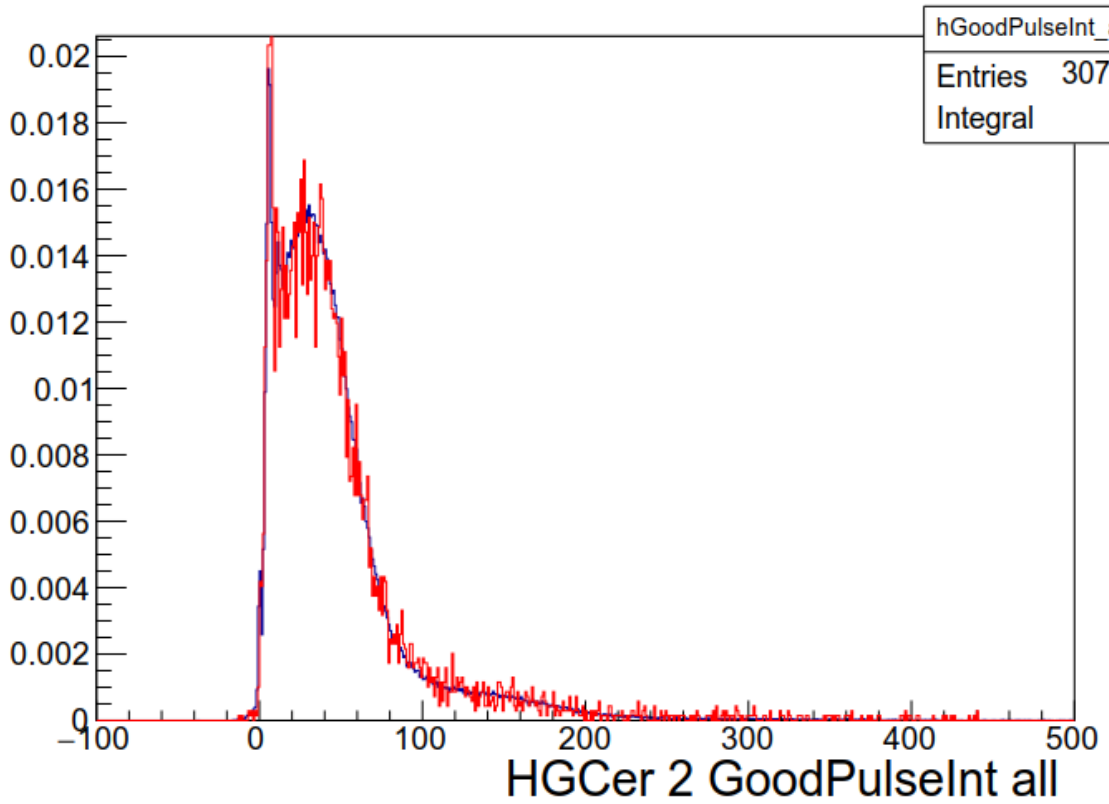
- Modified the way FADC PulseAmpRaw ==0 events are handled
  - Need to set up Default pedestals for all detectors
  - SHMS HG Cerenkov comparison
- New tree variables of the Reference time used by the detector
  - Can put cut on the reference time to skip events with bad reference time outside the good real + accidental coincidence region
- New tree variables of time difference between good Reference Time pulse and previous pulse (if it exists)
  - Can put cut of time difference to exclude events in which
- Add calculation of the difference between the average difference between raw ADC times and TDC times for paddles with “good” hits at both ends.
  - Corrects for picking different reference time in FADC and TDC due to deadtime (mainly in the caused by FADC 100ns deadtime)
  - Tree variable P(H).hod.adctdcoffset
  - Created hodoscope method GetOffSetTime that can be used by other detectors
  - Set the ADCTDCDiffTime for detectors to HodStartTime – AdcPulseTime + Hod.adctdcoffset

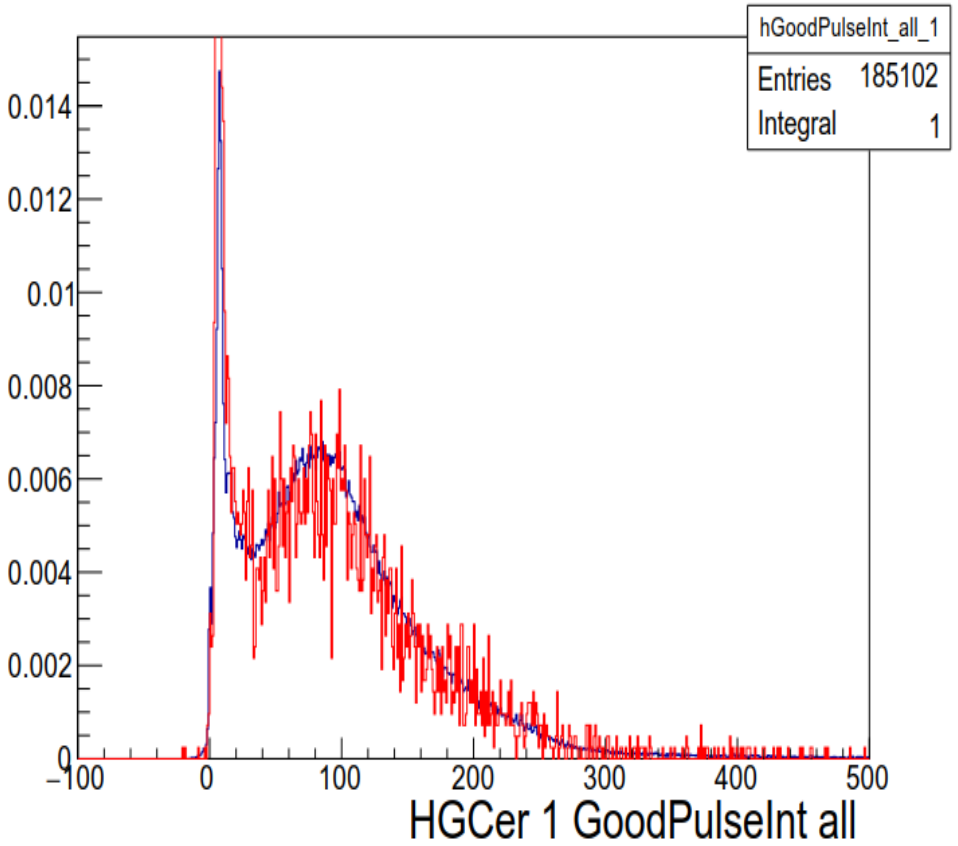
Modified the way FADC PulseAmpRaw ==0 events are handled

- The FADC uses the first four samples of the FADC time window to determine the pedestal.
- In a pulse is detected in the first four samples
  - FADC sets the raw pulse amp for all pulses in the window to zero
  - The pedestal is not the true pedestal for later pulses in the window.
- Old Code : Throw out the detector hits when found PulseAmpRaw ==0
- New Code: When PulseAmpRaw ==0
  - Uses an average pedestal value, PedDefault, that is a parameter for each detector PMT.
  - Calculates the PulseInt = PulseIntRaw – PedDefault
  - Set PulseAmp=0. Can be used as tag to look for these events.
  - Hodoscope detector is special. It does not use PedDefault. The PulseAmp is used for time walk correction. So when PulseAmpRaw==0, set PulseAmp=200.

SHMS HG Cerenkov comparison

- Normalized histogram of SHMS HGCer Pulse Integral for PMT1 and PMT2.
  - Black histogram is all events.
  - Red histogram is events will PulseAmp=0 and Multiplicity > 1.
    - Interested in events with FADC channel has pulse in the pedestal region and pulse in the good ADC time – Starttime region.





Need to set up Default pedestals for all detectors

- Created new subdirectory set_peddefault in hallc_replay/CALIBRATION .
  - The 2d histograms of goodADCPed versus the paddle number are contained in HMS_PedDefault.def and SHMS_PedDefault.def
    - Move files to DEF-files/SHMS/PRODUCTION/SHMS_PedDefault.def and DEF-files/HMS/PRODUCTION/HMS_PedDefault.def
    - Include the files in your tree/histogram def file set in replay script.
      - #include "DEF-files/SHMS/PRODUCTION/SHMS_PedDefault.def"
      - #include "DEF-files/HMS/PRODUCTION/HMS_PedDefault.def"
  - Replay the data
  - Start root in set_peddefault
    a) .L run_ped_default.C
    b) run_shms_ped_default("entirepath/DirName/filename.root")
    c) run_hms_ped_default("entirepath/DirName/filename.root")
  - The SHMS does HGCER, NGCER, AERO, Preshower and Shower
  - The HMS does CER and CAL.
  - By hand copy each set of Pedestal defaults into the detector "cuts" file
    - For example: phgcer_PedDefault= 2086, 2153, 2320, 1987

Updates to HCANA for Hodoscope

1. Added additional THcHodoHit::SetCorrectedTimes method for hits with just one PMT
2. ScintillatorPlane::ProcessHits
   - Save the TDC and ADC good reference time used for each plane.
     - Tree variable: P(H).hod.*pl*.PosTdcRefTime , NegTdcRefTime, PosAdcRefTime , NegAdcRefTime
   - Save the TDC and ADC difference between good reference time and time of previous pusle used for each plane.
     - Tree variable: P(H).hod.*pl*.PosTdcRefDiffTime , NegTdcRefDiffTime, PosAdcRefDiffTime , NegAdcRefDiffTime
   - Changed matching of ADC hit to TDC hit.
   - If ADC Raw AMP = 0 , test that hit instead of skipping it.
3. Updated algorithm to find Start Time and focal plane time
4. Add calculation of the difference between the average difference between raw ADC times and TDC times for paddles with “good” hits at both ends.
   - Tree variable P(H).hod.adctdcoffset
   - Created hodoscope method GetOffSetTime that can be used by other detectors

ScintillatorPlane::ProcessHits Changed method of matching of ADC to TDC hits

ScintillatorPlane::ProcessHits

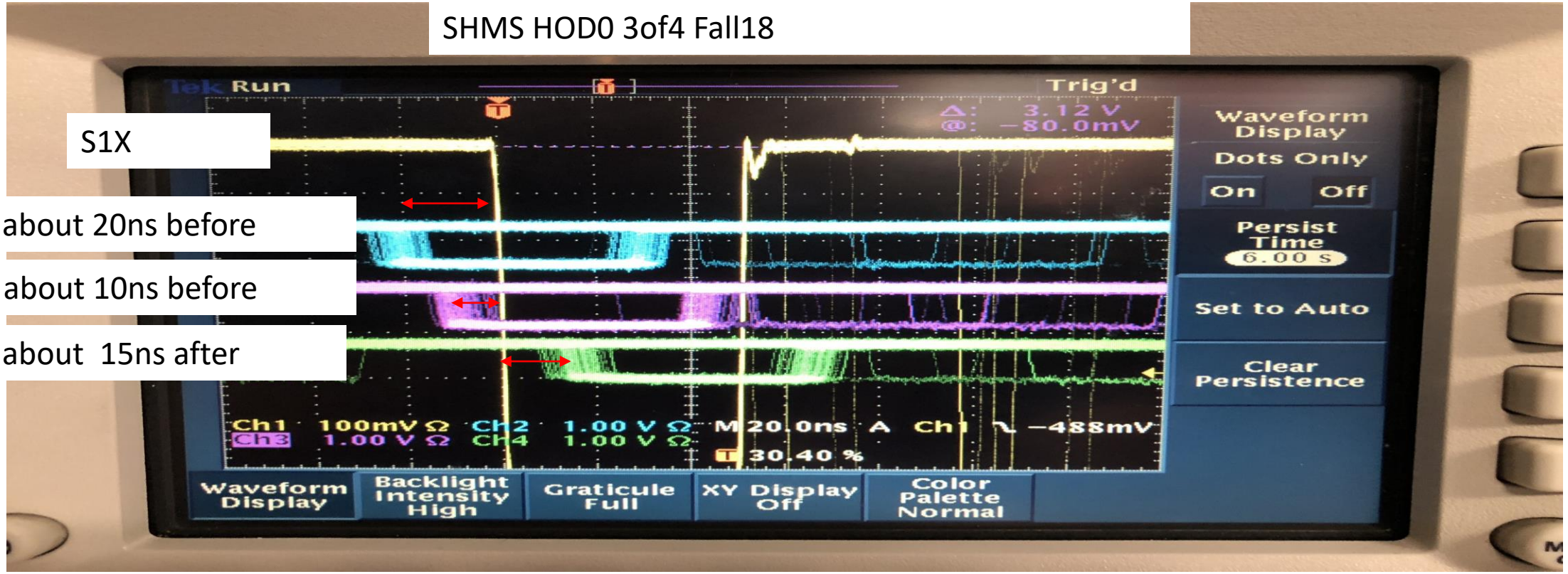
- Selects first TDC PMT hit within the TDC_min and TDC_max windows.
- Old code
  - If Raw ADC Amp = 0 , then do not use hit.
  - First ADC hit within ADCTDC_min < TDC_time – ADC_time < ADCTDC_max
  - If no ADC hit is found then PMT hit is not “good”. Need both ADC and TDC info for “good” PMT hit.
- New Code
  - If Raw ADC amp = 0, then use hit and test ADC hit setting ADC Amp =200.
    - Adc Amp=200 sets the timewalk correction to zero.
  - First ADC hit within ADCTDC_min < TDC_time – ADC_time < ADCTDC_max with largest ADC value
  - If none found then selects one with smallest TDC_time – ADC_time .
  - So if there is an ADC hit for paddle PMT, then it will set “good” PMT hit if there is TDC PMT hit.

New code ensures that if there is a TDC hit within the selection window and any ADC hit for the paddle PMT , then it will find a “good” hit.

Reminder about the Start Time and focal plane time

- Start Time determined only using Hodoscope.
  - Accounts for the fluctuations in trigger time due different paddles hit, where it hits in paddle, cable lengths etc.
  - Only uses paddles with both ends hit.
- Focal Plane Time is the same as Start Time but uses track information to determine TOF correction.
  - Includes paddles with only end hit.
  - Used in the coincidence time calculation.

SHMS HOD0 3of4 Fall18



S1X

S1Y about 20ns before

S2X about 10ns before

S2Y about 15ns after

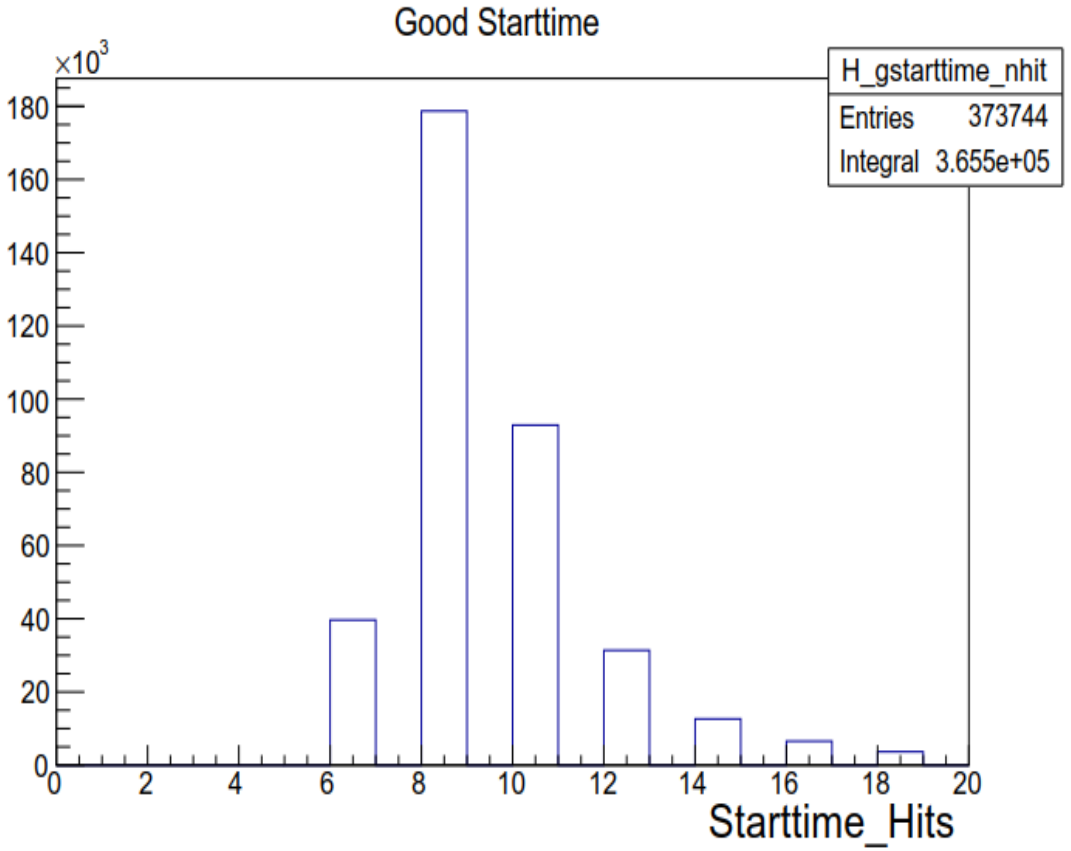
Updated algorithm to find Start Time and focal plane time

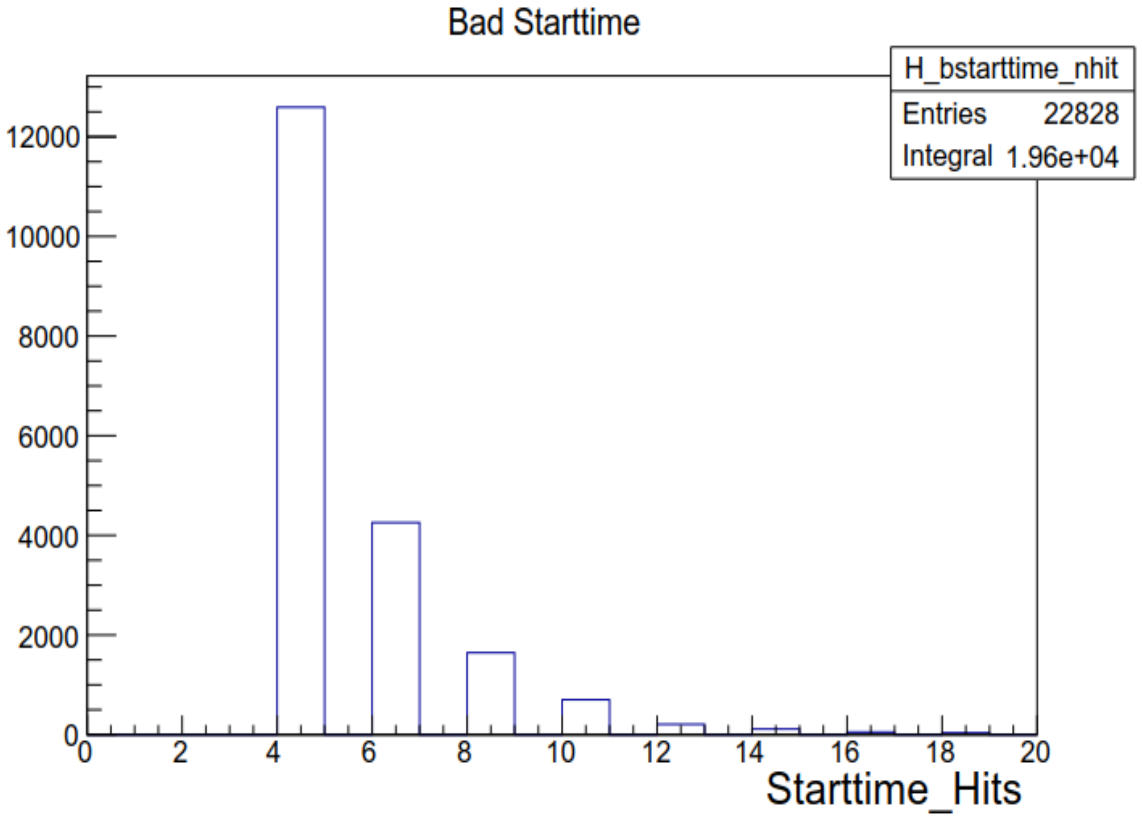
- Loops through hits (Note if no hits found after Decode then Start Time = -1000)
  - When hit HasCorrectedTime = kTRUE then fill histogram with hit times PosTofTime and NegTofTime over 0-200ns
- Need to determine the peak time =TPEAK with maximum number of hits.
  - Old code would just determine the peak time from the 0.5ns time bin with the maximum number of hits.
  - New method DetermineTimePeak which scans the histogram and gets running sum in 5ns bin.
    - If the bin has > 3 hits, then peak found. Can find multiple peaks in histogram.
    - If more than one peak chooses one closest to the fStartTimecenter which is a parameter that can be set.
- Again loop through hits in each plane
  - If HasCorrectedTime = kTRUE and PosTofTime and NegTofTime are within TPEAK +/- tof_tolerance
    - Adds the times to the TimeSum and NTimeSum++
  - If plane has good hit, NumPlanes++
- Set the Start Time = fStartTimecenter (fStartTimecenter is parameter p(h)
  - Old code: If NTimeSum>0 then Start Time = TimeSum/NTimeSum
  - New Code : If NumPlanes >= 3 then Start Time = TimeSum/NTimeSum

- With new code will have more failures where Start Time = fStartTimecenter
- But is better at ignoring the accidental singles triggers at high rates.
- For focal plane time if NumPlanes < 3
  - If GoodStartTime then fptime=fStartTime otherwise -2000;
  - In THcCoinTime do not calculate CoinTime if fptime=-2000;

Compare Starttime_Hits for "good" to "bad" Starttime

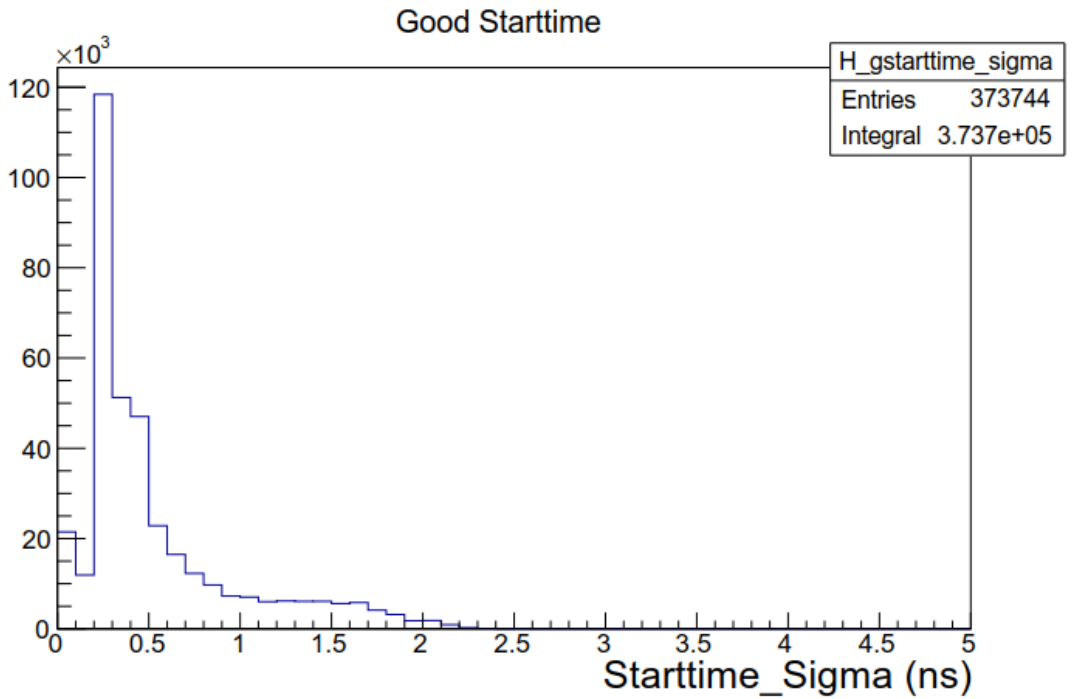
- If HCANA does not find a StartTime, then it sets P.hod.goodstarttime==0 and P.hod.starttime=p_start_time_center
- Look at coincidence run 5371, Hodo 3of4 rate about 600kHz.
- When HCANA finds a "good" starttime then Starttime_hits peaks at 8
- When HCANA does not "good" starttime, then Starttime_hits peaks at 4
  - Typically particle passes through two planes (so they are close in time giving a peak of 4 hits)
  - HODO 3of4 trigger formed because of random coincidence with 3rd plane which is out of time by more than 5ns.

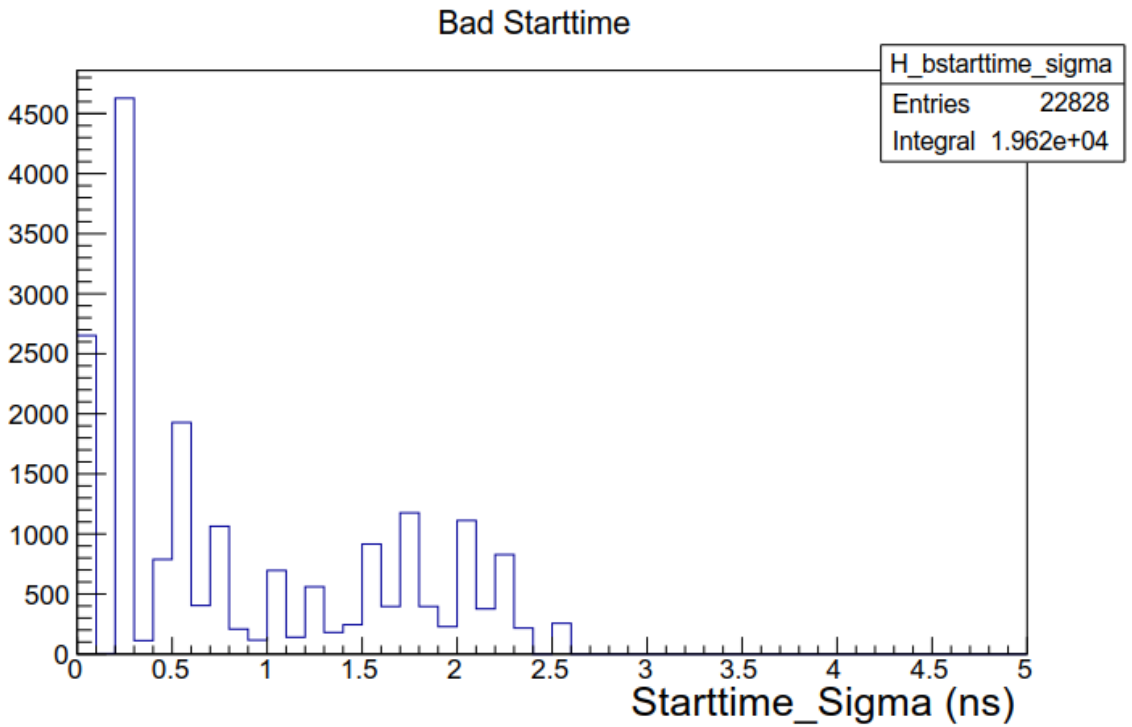




Compare Starttime_Sigma for "good" to "bad" Starttime

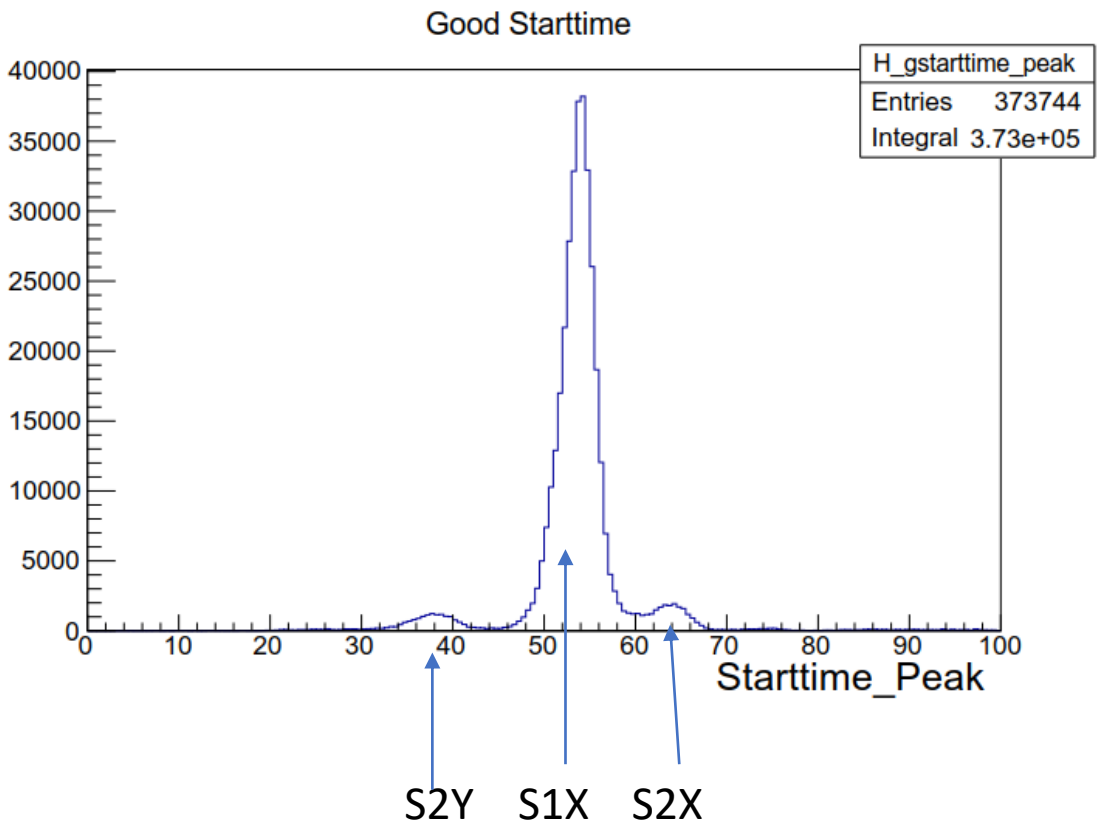
- If HCANA does not find a StartTime, then it sets P.hod.goodstarttime==0 and P.hod.starttime=p_start_time_center
- Look at coincidence run 5371, Hodo 3of4 rate about 600kHz.
- When HCANA finds a "good" starttime then Starttime_sigma has large peak at 0.2ns
- When HCANA does not "good" starttime, then Starttime_sigma has a relatively smaller peak at 0.2ns
  - Wider spread in sigma

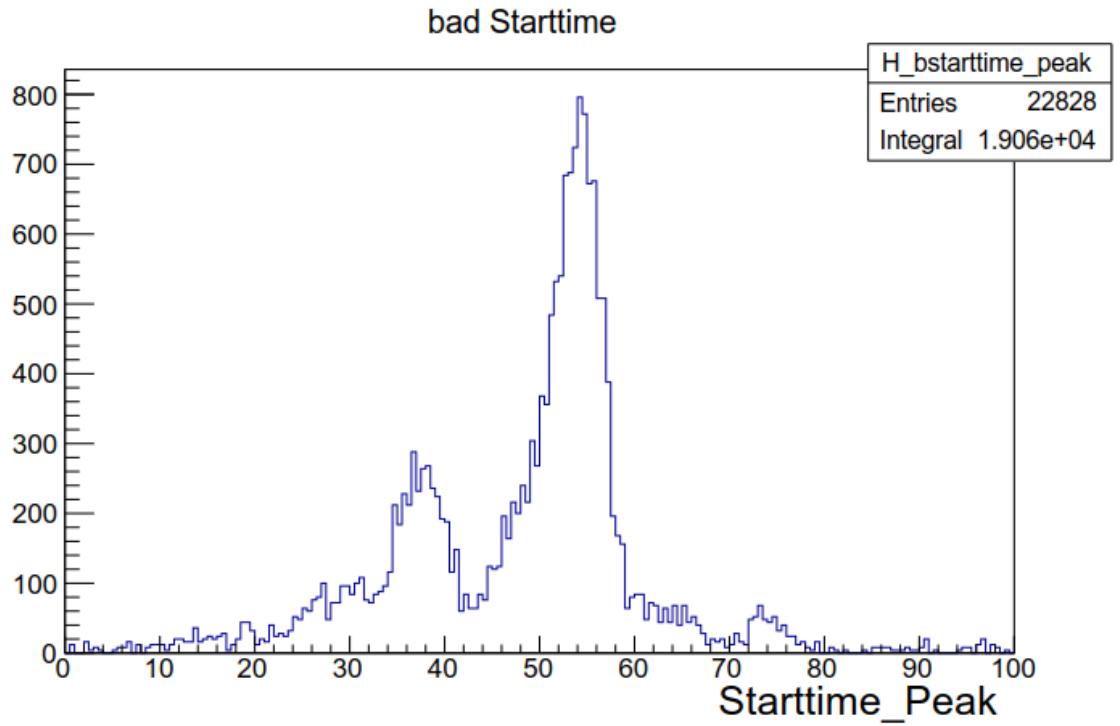




Compare Starttime Peak for “good” to “bad” Starttime

- If HCANA does not find a StartTime, then it sets P.hod.goodstarttime==0 and P.hod.starttime=p_start_time_center
- Look at coincidence run 5371, Hodo 3of4 rate about 600kHz.
- Hodo 3of4 trigger has usually S1X set the timing with peak at around 54ns
  - When S2Y sets the timing, then peak is at about 38ns
  - When S2X sets the timing, then peak is at about 64ns
- The “bad” starttime shows more random HODO 3of4





Conclusion

- Trigger change:
  - STOF has been eliminated from EL_REAL trigger, so only the HODO ¾ in the trigger. Now only HODO ¾ in the reference signal.
  - Eliminates problem of random EL_REAL pulse in reference time blocking the TRUE HODO ¾ pulse in reference time.
- FADC250 firmware change:
  - When pulse found during first 4 time bins, now it calculates the PulseAmp for second pulse in time window.
- Need to look at rate dependence and effect of cut on reference time.
  - New tree variables so that cuts can be placed on the reference time and reference time difference between consecutive pulses.
  - Eliminate bad reference times.
- Cannot eliminate the 100ns FADC deadtime.
  - Large area detectors like the Cherenkov, need to account for this deadtime.