GLAST The Gamma Ray Large Area Space Telescope

LAT Timing

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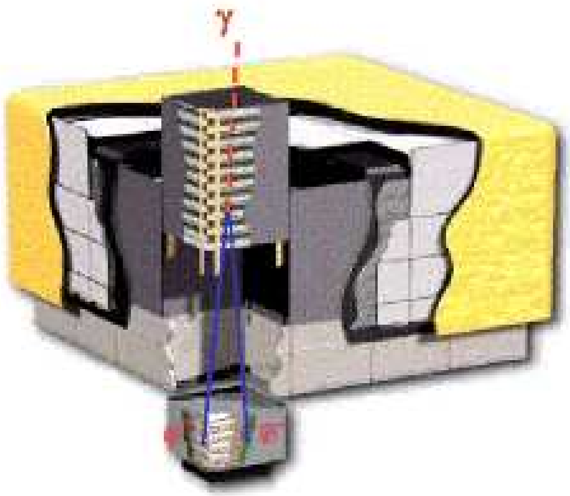


Outline

- Overview of timing parameters
- TREQ alignment
- TACK optimization
- ACD single channel timing
- CAL single channel timing
- AEM hitmap timing
- Consistency checks

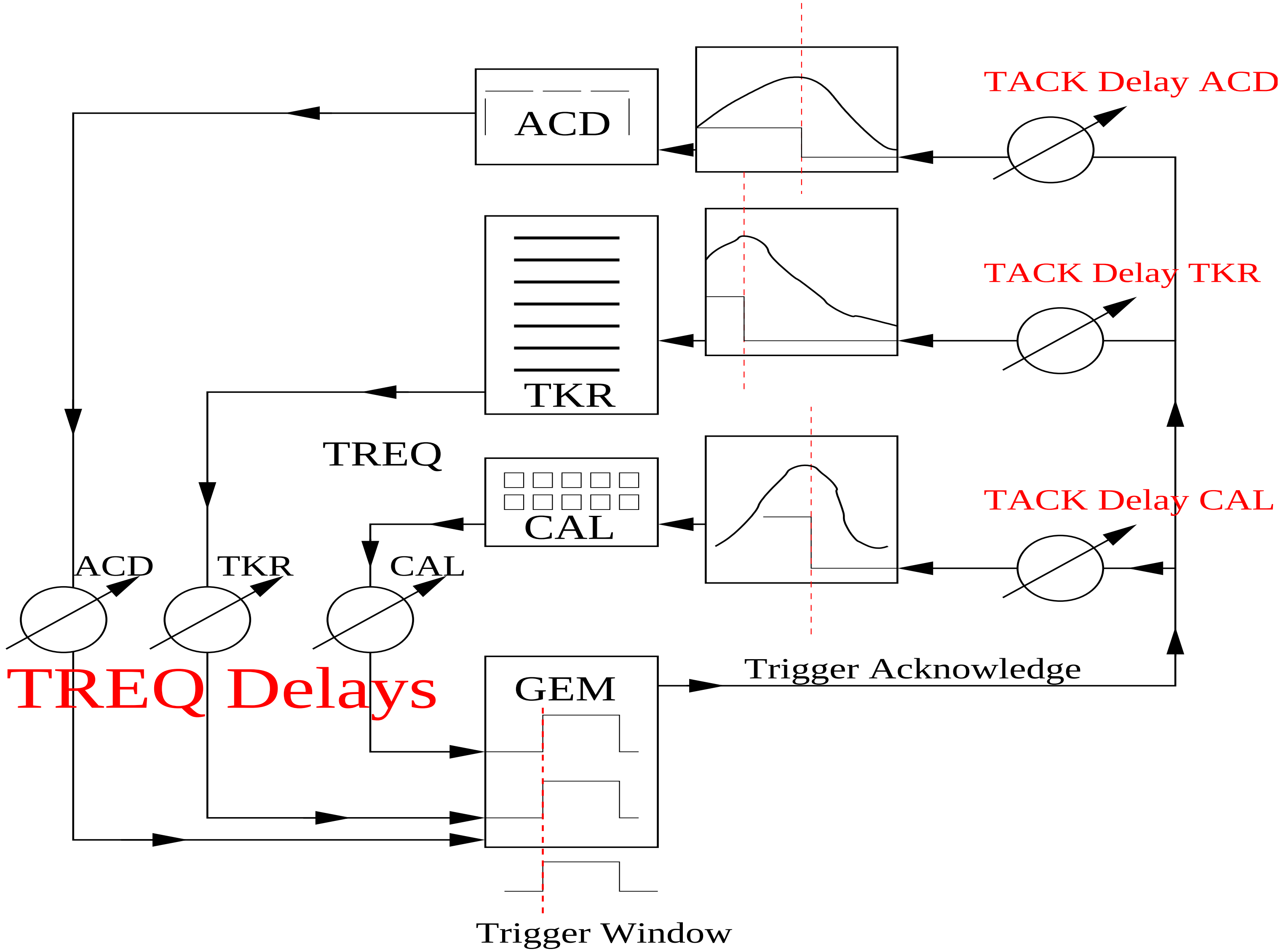
Timing Objectives

- First goal: Line up trigger requests.
- Trigger requests are generated by the subsystems and sent to the GEM.
- All trigger requests within a window of 12 clock ticks will be registered for the event.
- It is important to latch all requests because the trigger decision fully depends on the combination of trigger lines.
- The trigger requests have to be aligned in time by applying delays to the faster lines so all requests arrive simultaneously.
- Because of jitter from event to event the events are not completely simultaneous but spread out over the window.

Timing Objectives

- Second goal: Optimize the delay for latching data
- The shapers for the different subsystems have different time constants.
- The data has to be latched at a different delay for each subsystem for optimal signal to noise ratio.

Schematic of trigger timing

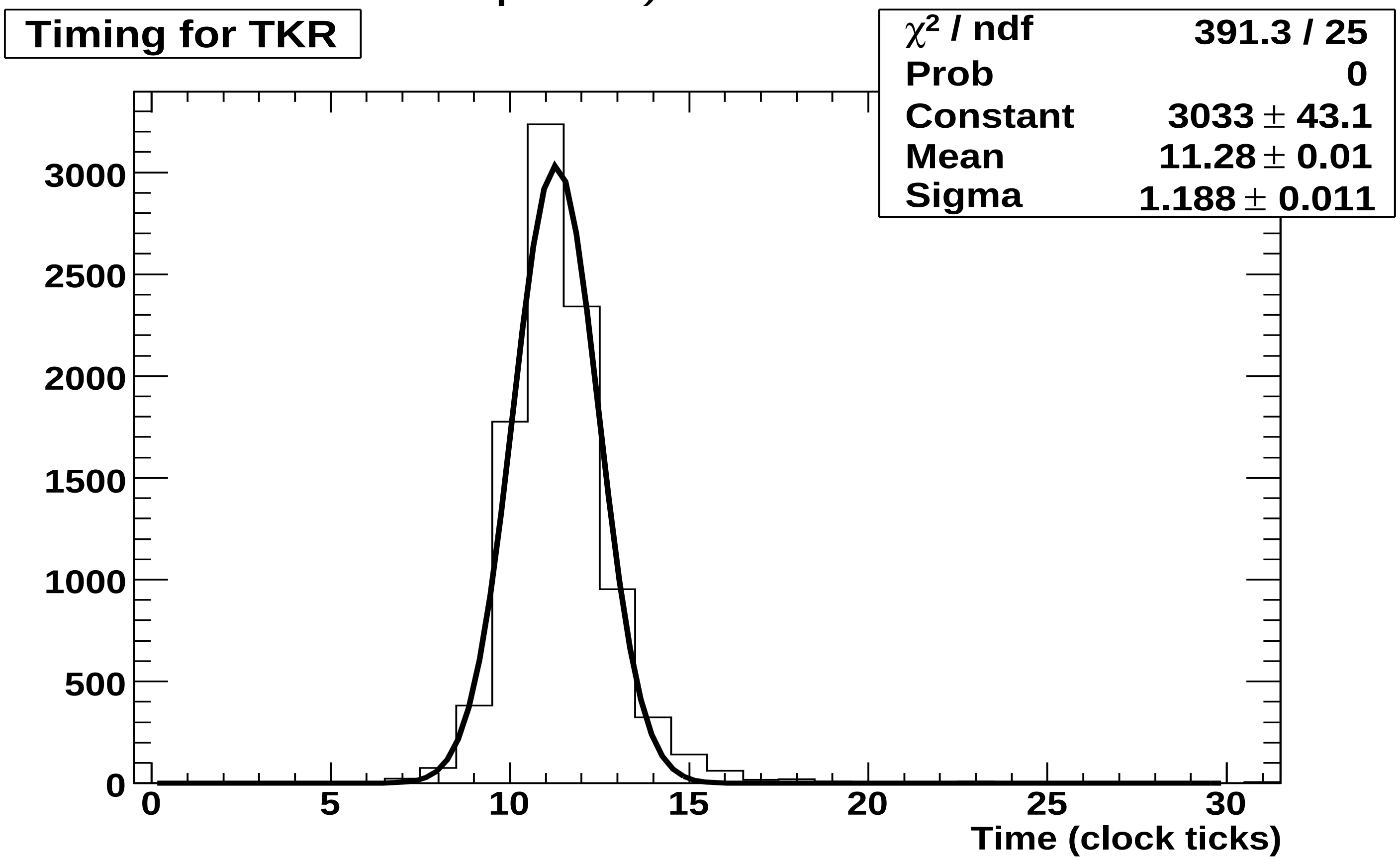


Trigger Request Alignment

- Method:
  - Trigger on cosmics with the ACD (single tile configuration)
  - Measure arrival time for CAL and TKR requests
  - Only use unambiguous events (only 1 CAL, 1 TKR fired)
  - Histogram and fit arrival times
  - Compute best delay

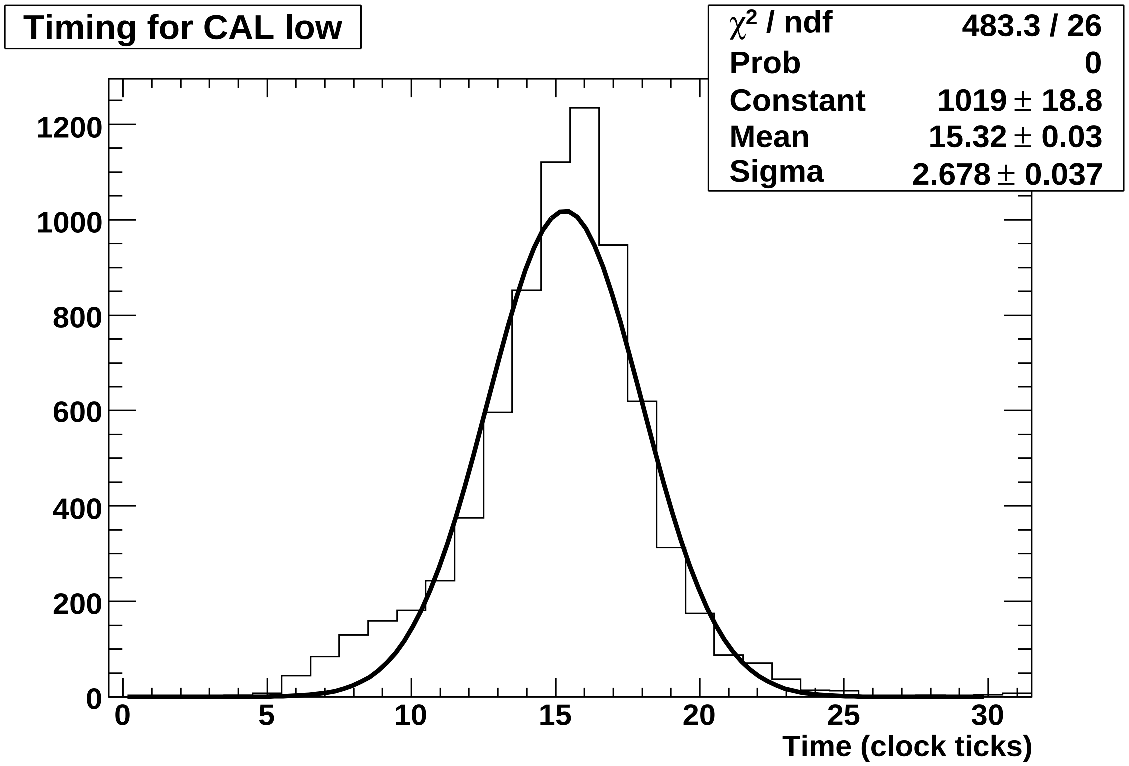
Tracker TREQ

- The jitter of TKR vs. ACD is about 1.2 ticks.
- Overall, the timing distribution from tower to tower is narrow (ca. ½ clock ticks of spread).



CAL TREQ

- The calorimeter jitter is about 2.5 clock ticks (sigma).
- The early peak which is due to direct diode hits is enhanced because unlike the muon telescope the ACD does not select vertical tracks only.



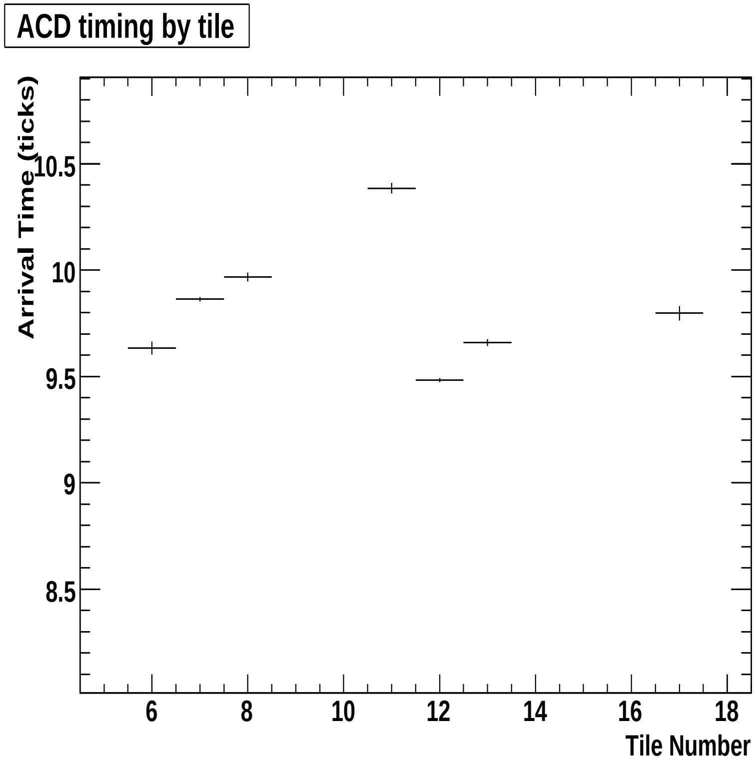
Plot shows tower 0.

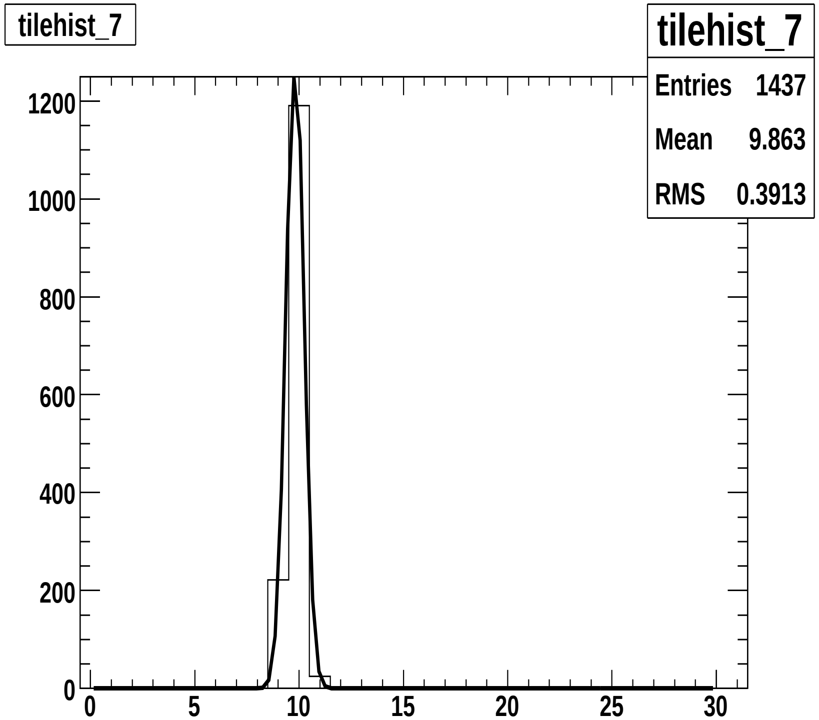
ACD TREQ

- To see the jitter in the ACD the muon telescope was used.
- The telescope does not cover the whole ACD so only a few tiles were measured this way.
- For the actual delay setting TKR/CAL give the delays.

TREQ with Muon Telescope

- ACD is almost 1 clock tick faster than the muon telescope, ACD was delayed by 10 ticks for measurement
- Jitter is very small, but there is some channel variation

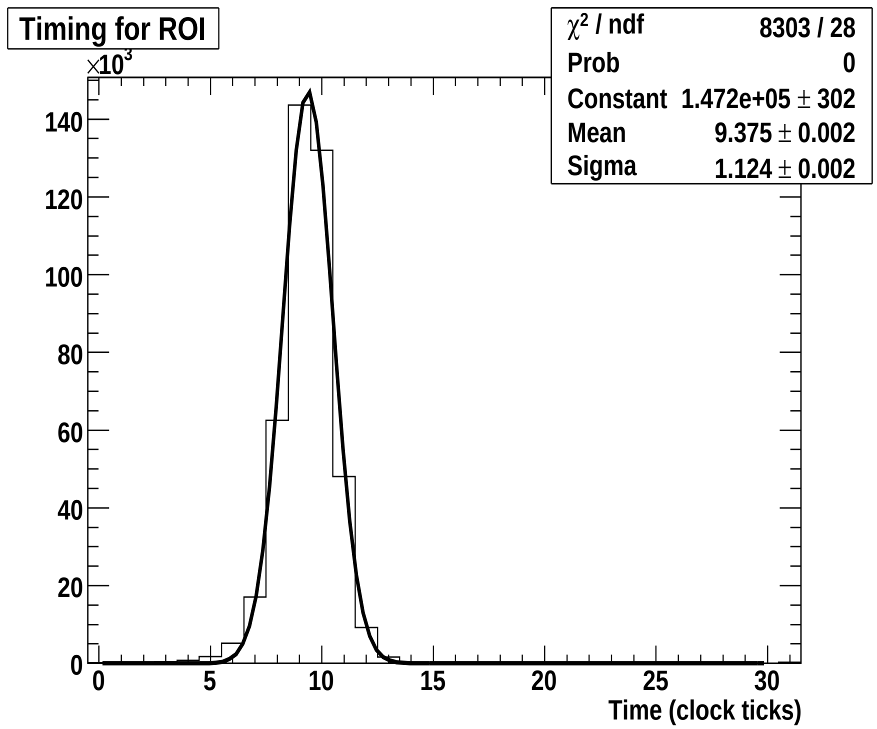




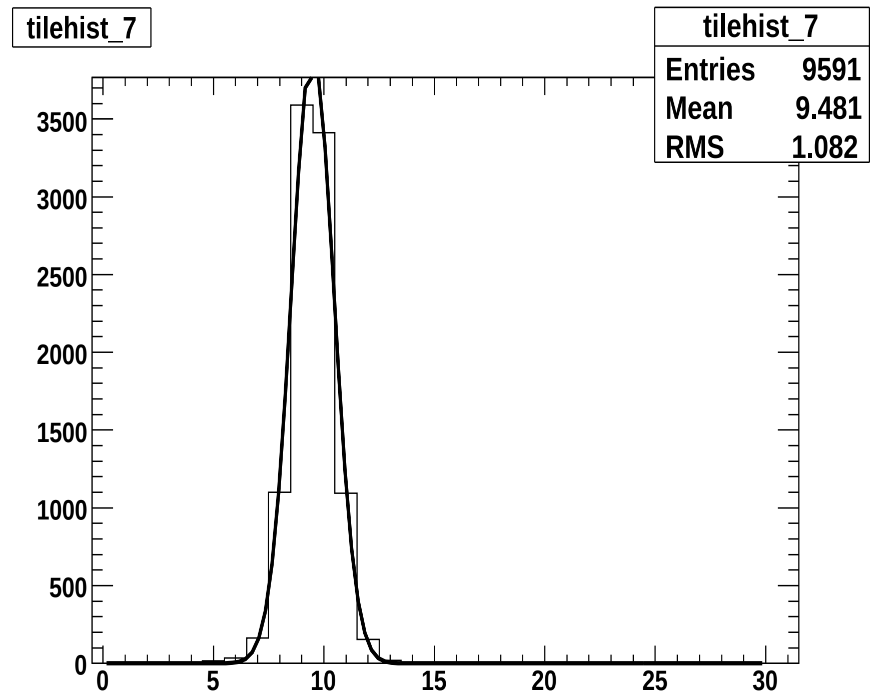
ACD TREQ using the Tracker

- All tiles and ribbons have enough entries to analyze their timing.
- The tracker has a slightly higher jitter and is not as uniform.
- The ACD was delayed by 15 ticks to fire long after TKR.

Timing for all channels

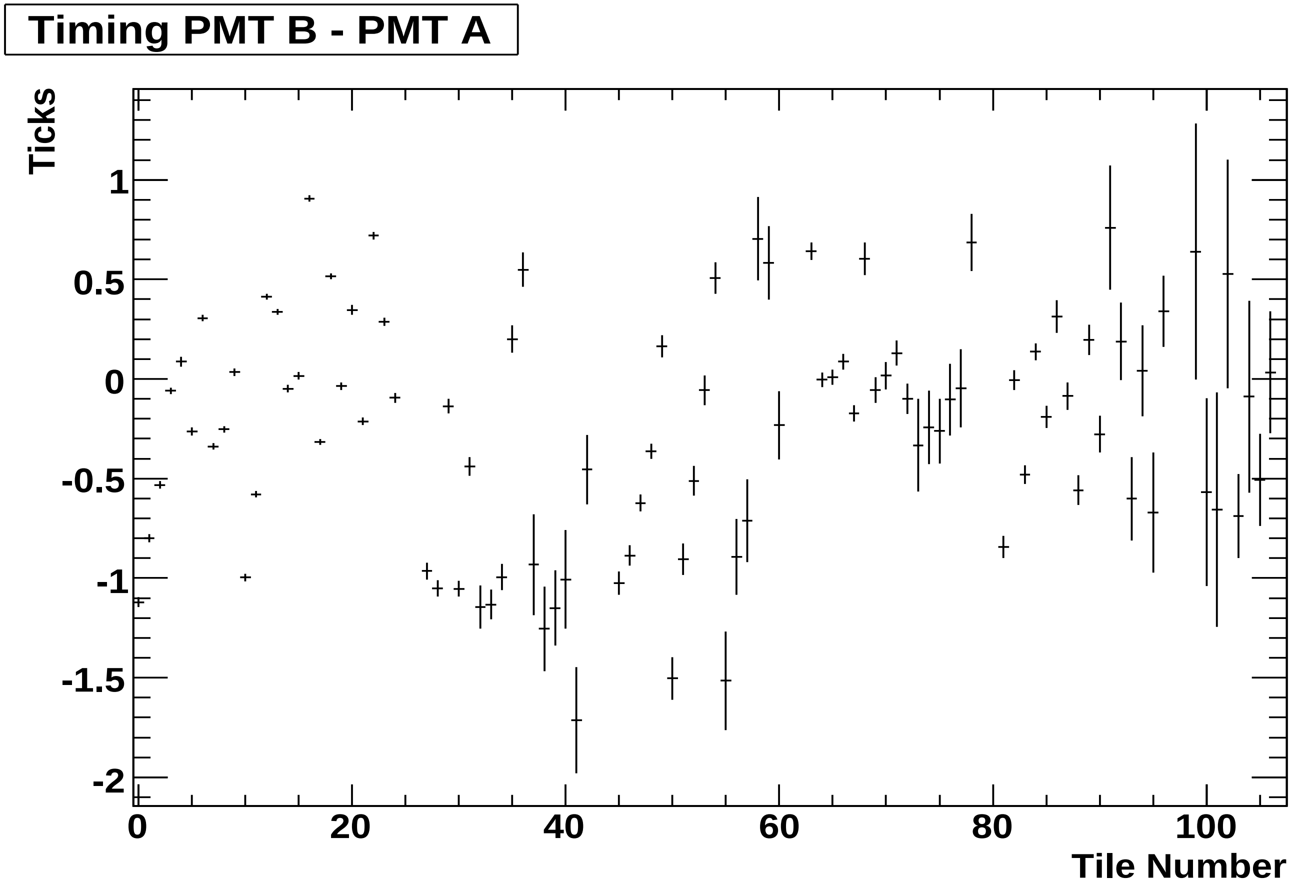


Timing for 1 channel (tile 7)



TREQ PMT A/B

- Each tile is read out through two independent electronics chains
- Plot the difference in timing between the 2 channels of each tile



TREQ Summary

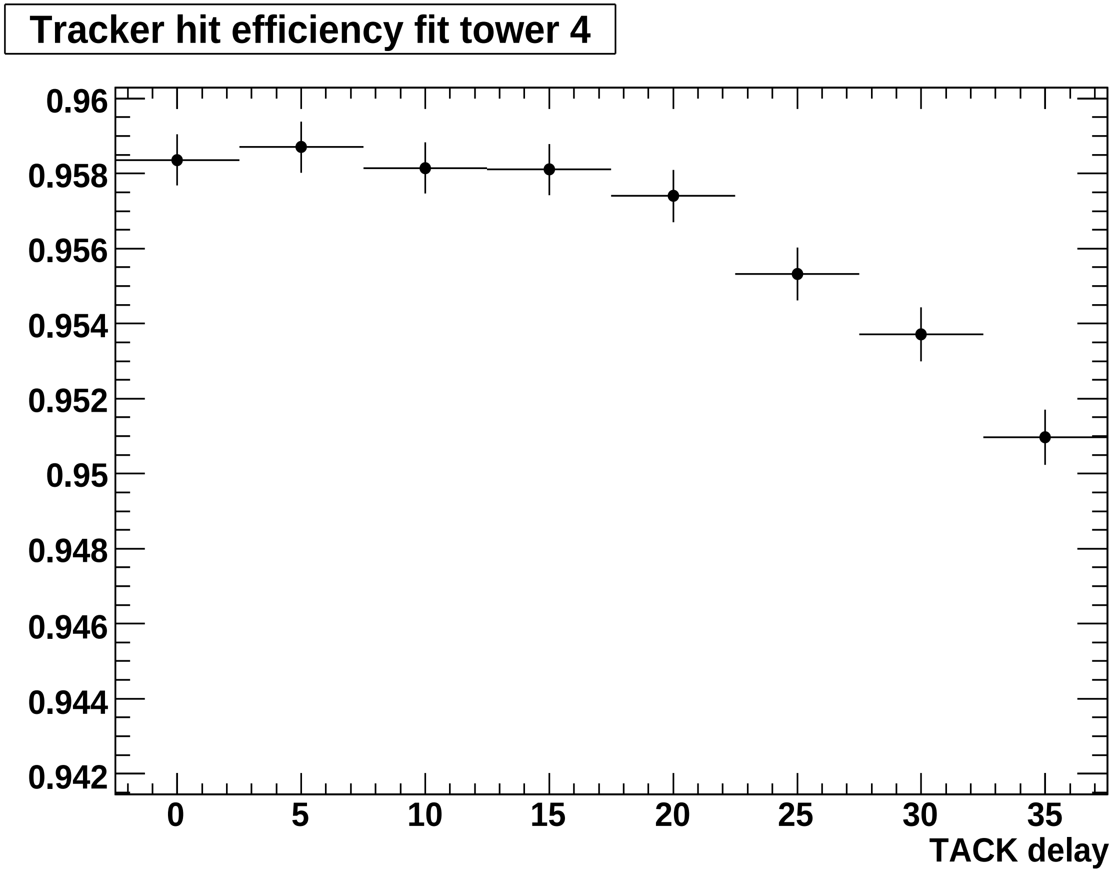
- Both TKR and CAL show a spread of about ½ tick in timing between towers.
- The CAL distributions have an enhanced early peak. The fit does not take this into account so the actual CAL timing is slightly later than the fit result (ca. 0.2 ticks).
- Because of rounding to full clock ticks some there is a spread of 1 tick in between CAL towers and TKR towers.
- The best delays for ACD/TKR/CAL would be between 15/4/0 and 16/5/0.
- For the SVAC runs 16/5/0 was used.

TACK scan

- 8 cosmic runs were taken with different TACK delays for each point.
- For TKR, the fraction of latched layers in a track is recorded for each point.
- For CAL and ACD, the ADC spectra are recorded for each channel. Fits are performed, and waveforms are assembled from the 8 runs. The peak of the waveform is the optimal TACK delay.

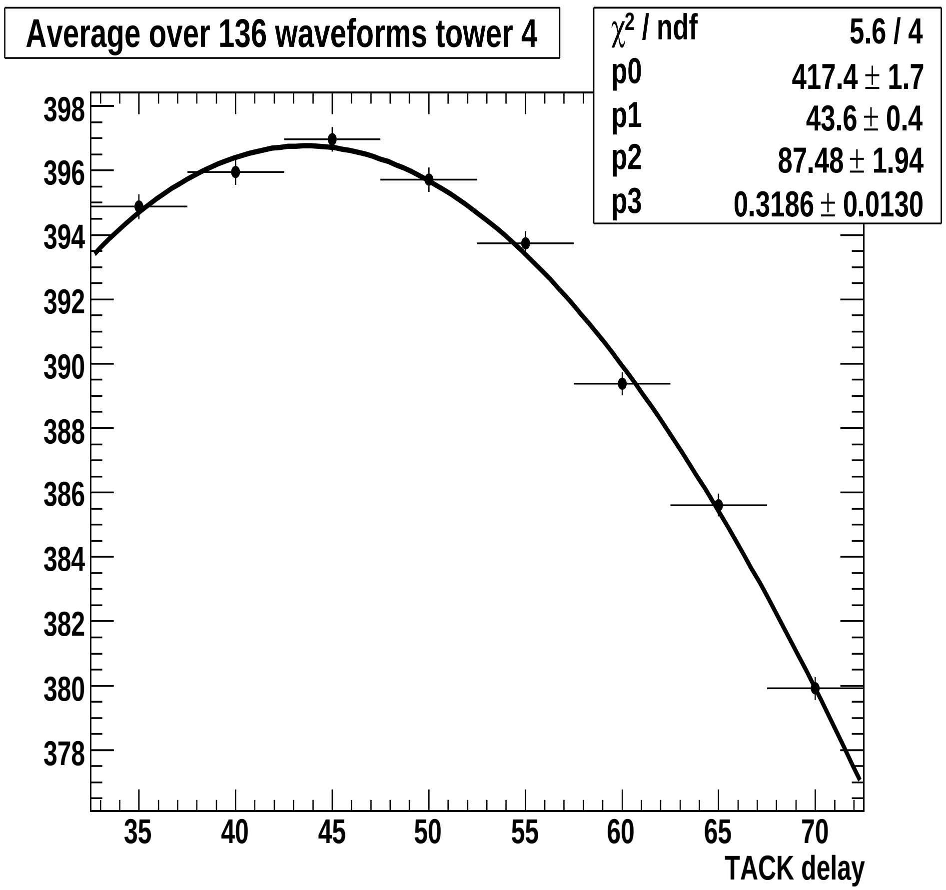
Tracker TACK

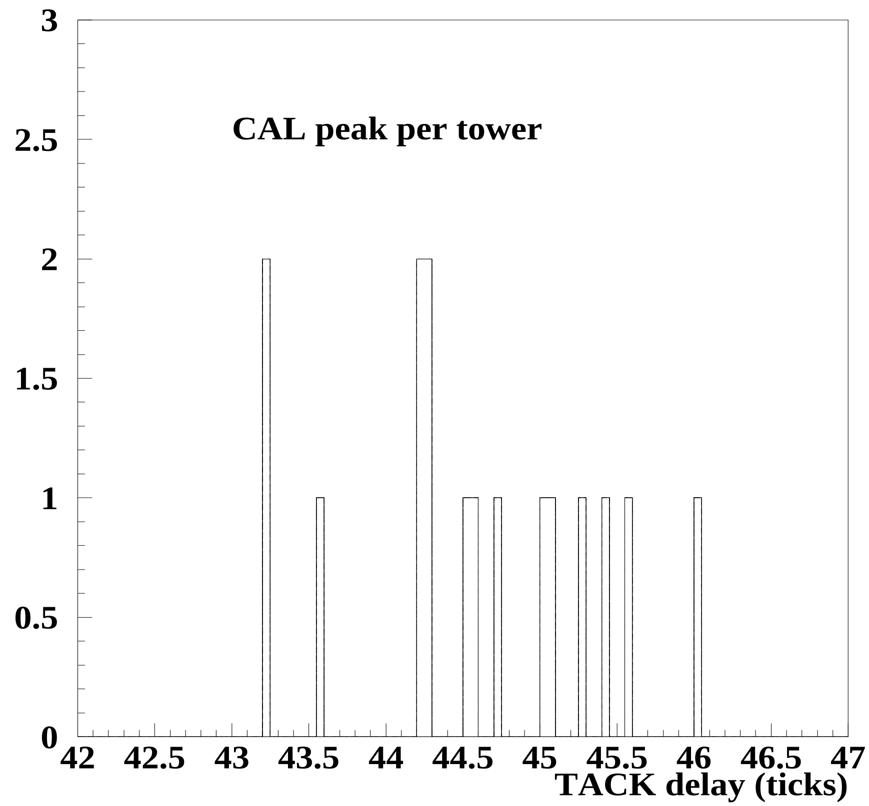
- The optimal point for all towers is a delay of 0.
- Latching efficiency starts dropping off at a delay of around 20.



Calorimeter TACK

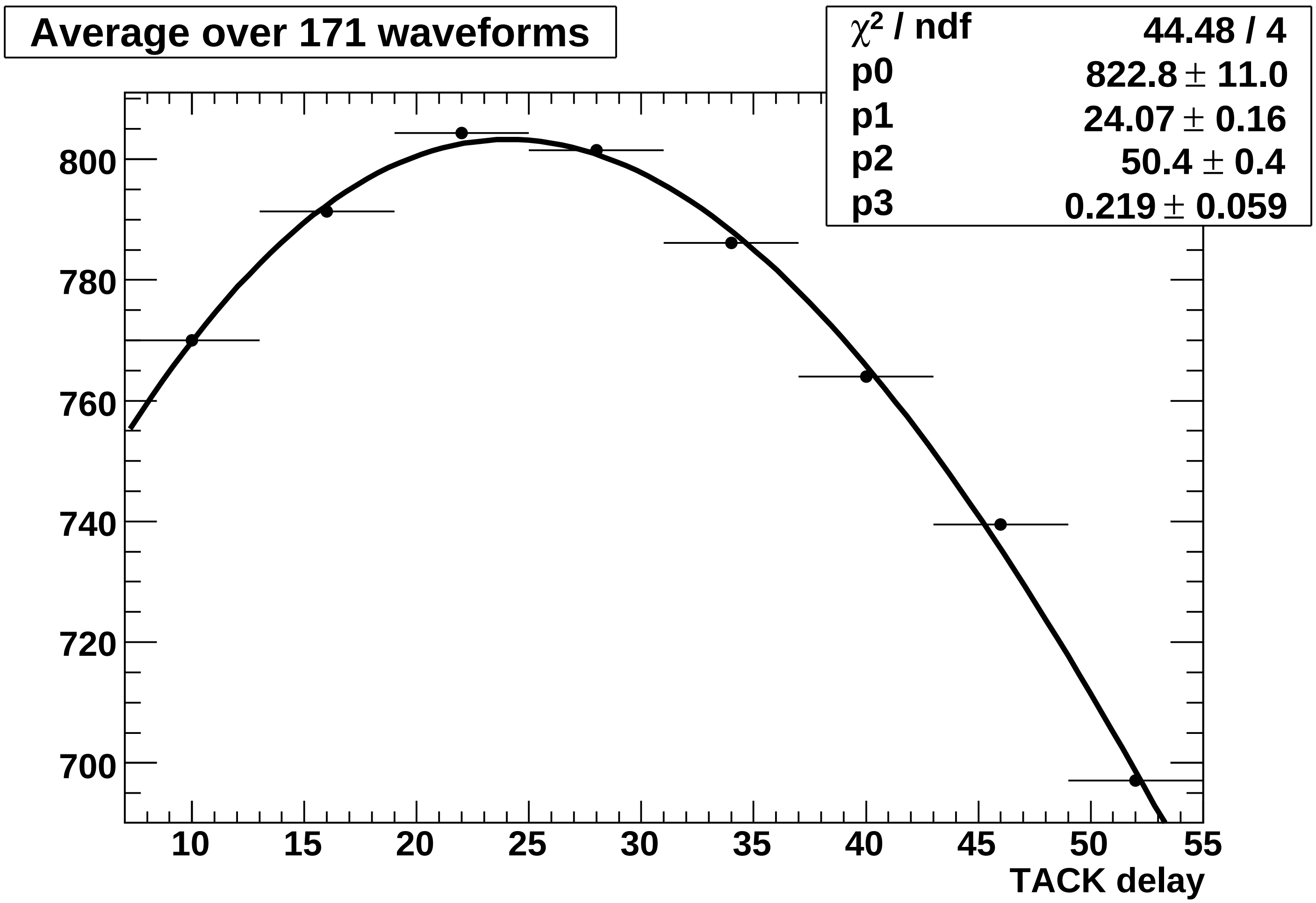
- There is a bit of variation in peak times as the waveforms are rather flat.





ACD TACK

- ACD peaks at a TACK delay of 24.



Summary Table

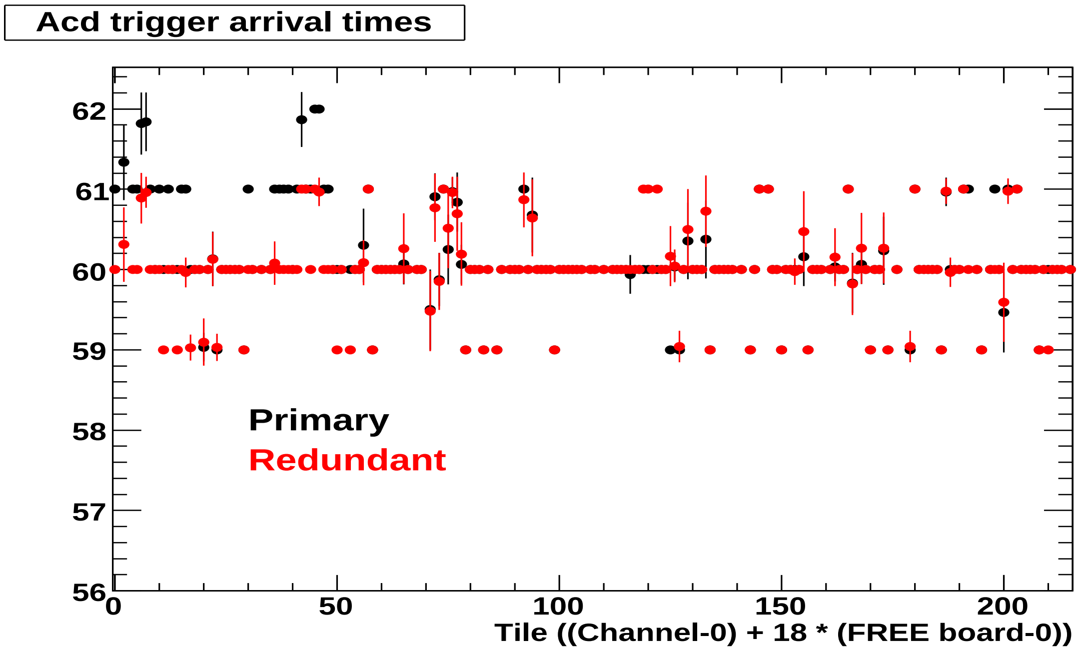
Tower	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
TREQ delay CAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TREQ delay TKR	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
TACK delay CAL	45	43	46	46	44	43	44	45	45	44	45	44	45	44	45	46
TACK delay TKR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TREQ delay ACD: 16

TACK delay ACD: 24

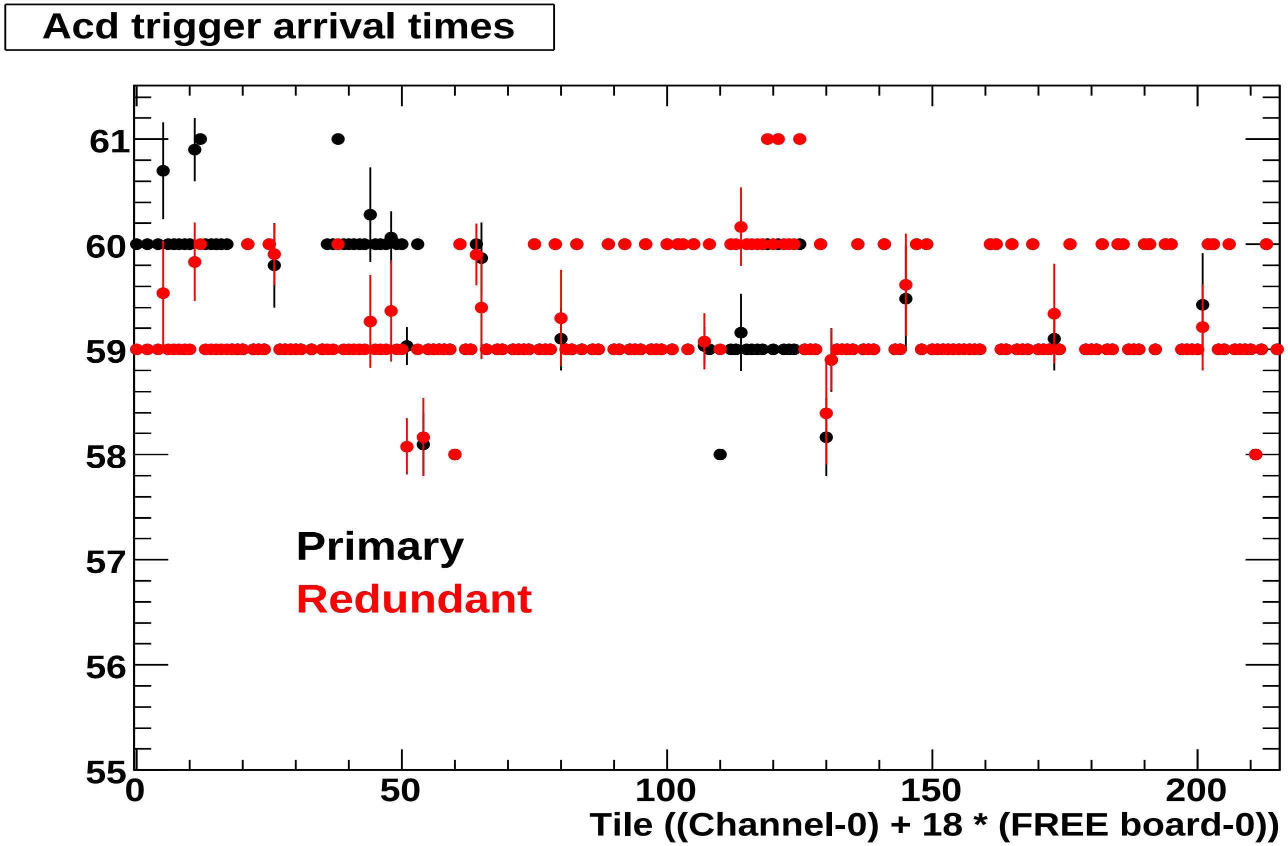
Veto Channel Uniformity

- Method: Inject charge into each channel separately. Measure time until a trigger arrives.
- Test was performed on both the primary and the redundant side
- In addition, the GEM veto map is cross-checked against the GARC/GAFE channel number as a verification.



CNO Channel Uniformity

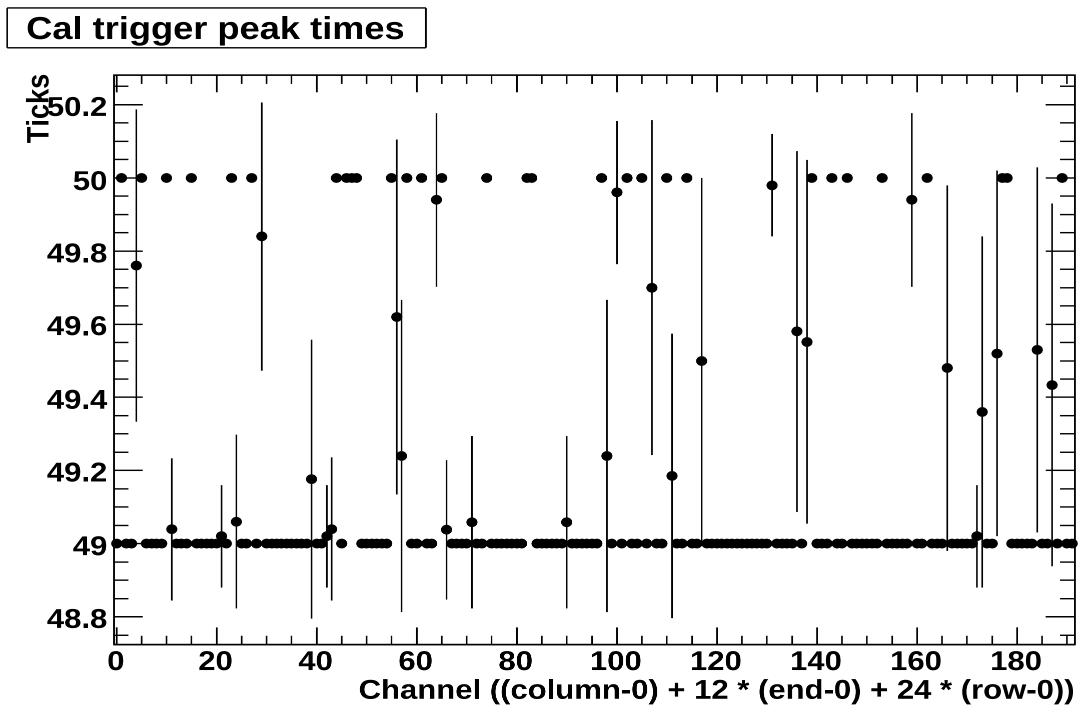
- The same test was applied to CNO.



CAL Channel Uniformity

- Method: Inject charge into each channel separately. Measure time until a trigger arrives.
- Test was performed on all 16 towers.
- Uniformity was found to be very good for both FLE and FHE on all towers.

Example plot shows FLE tower 2.

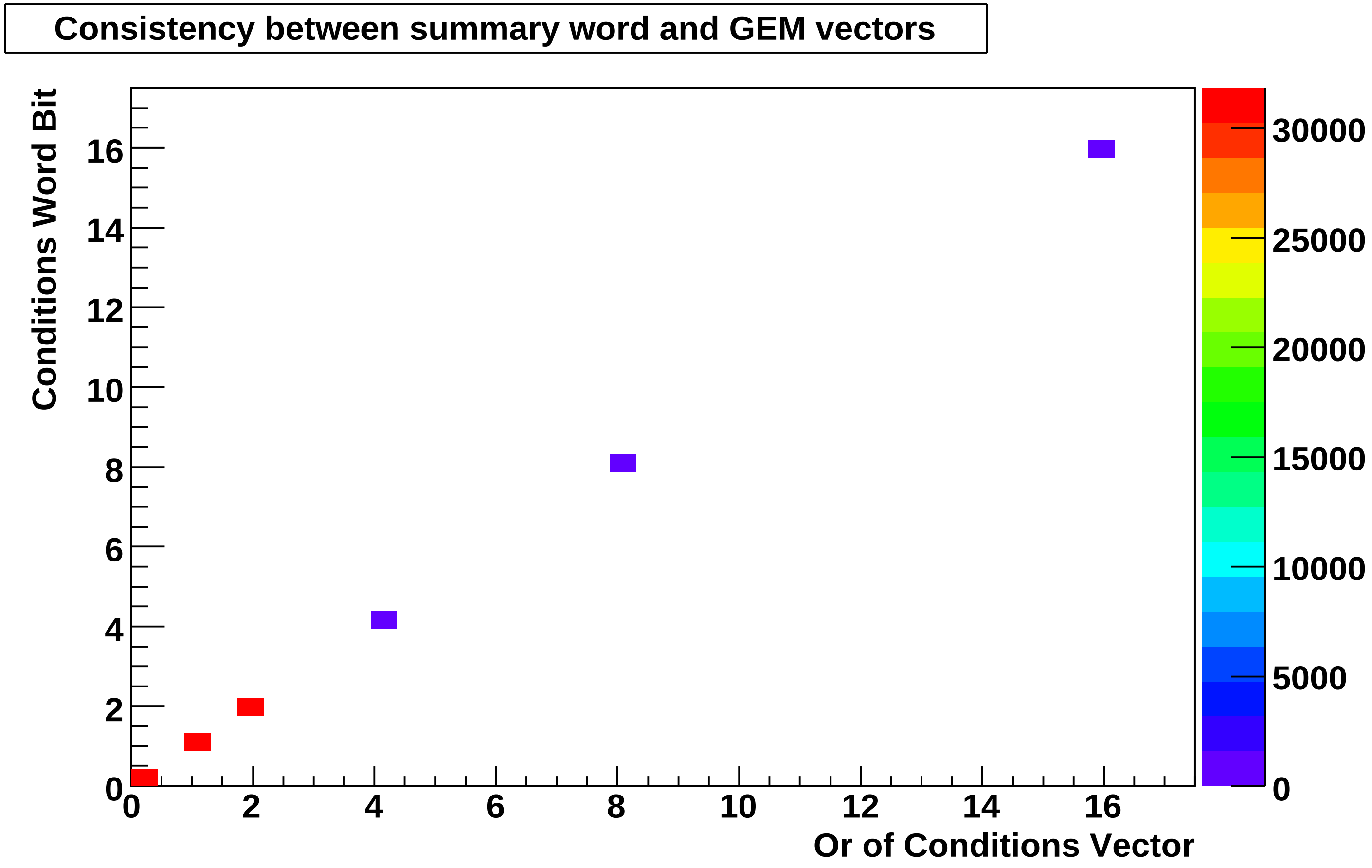


AEM Hitmap Timing

- In addition to the GEM vetomap there is a hitmap in the AEM that contains the tiles where the veto signal was over threshold. Unlike the GEM hitmap it distinguishes between PMT A and B.
- The hitmap latching needs to be timed.
- The goal is good consistency with the GEM hitmap.
- The timing measurement was performed and used for SVAC runs. After looking at these runs an optimization on the timing was performed.

GEM Consistency Checks

- To verify the perfect functioning of the GEM consistency checks are performed.



Summary

- The LAT has been timed in.
- TREQ and TACK delays have been determined.
- The channel uniformity for CAL and ACD is excellent.
- The AEM hitmap has been timed in.
- Consistency checks are being made.