GLAST The Gamma Ray Large Area Space Telescope

Report from the

GLAST Trigger

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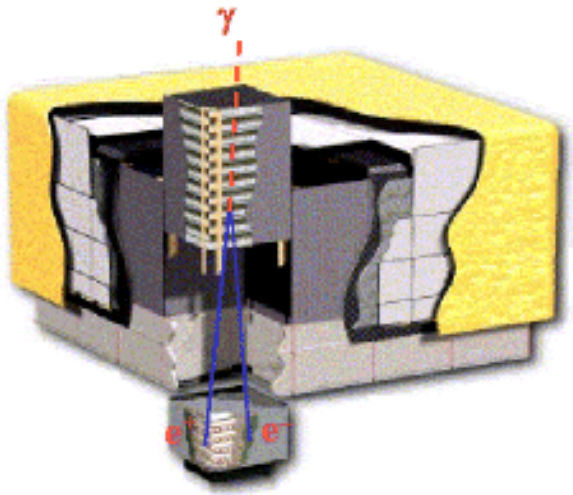


Outline

- Optimization of the window width
- CAL timing and jitter
- TKR timing and jitter
- One-shot and stretch-or
- Trigger display
- TEM diagnostic data

Trigger Window

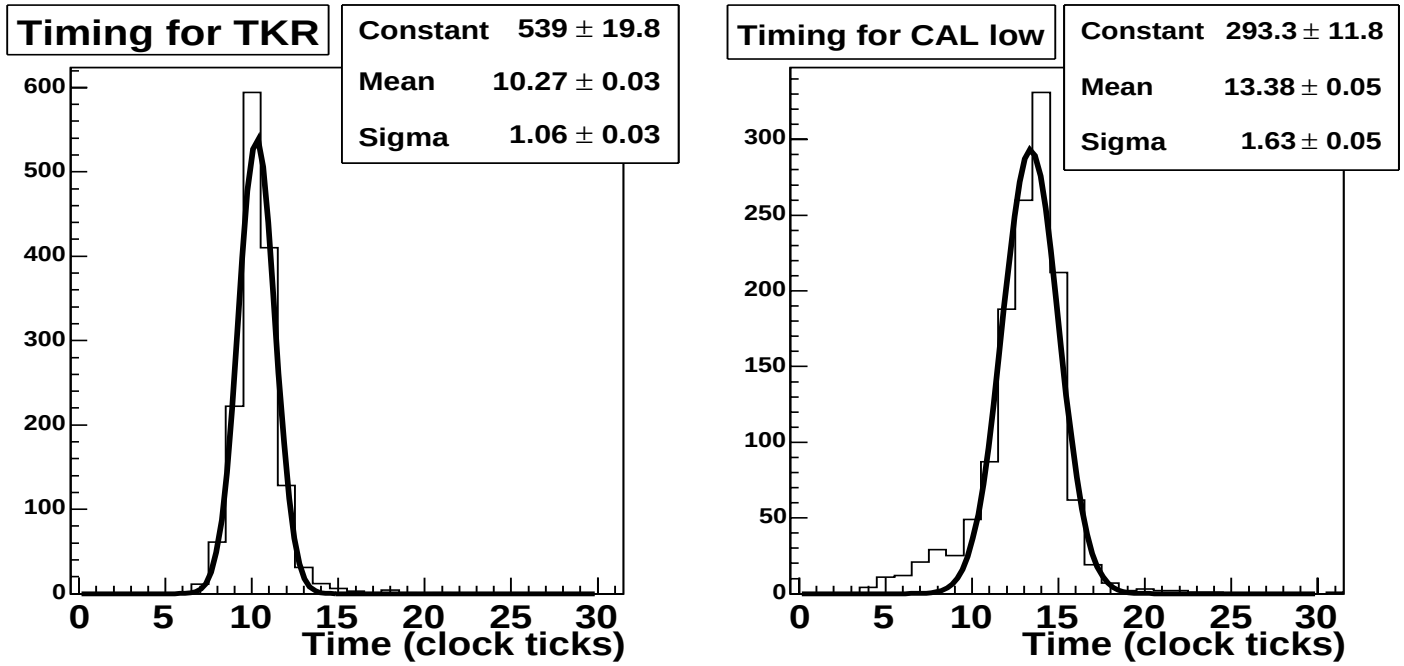
- Trigger requests arrive at different times.
- The goal is to latch all trigger lines that occur in an event to categorize the event.
- A trigger window is used to achieve this. The window opens for a fixed amount of time when the first line fires and includes all lines firing during the time window.
- A wider window means higher latching efficiency.
- A small window keeps dead times and trigger latency low and reduces random coincidences.

Trigger Window

- The window width has to be optimized.
- The determining factors are:
  - Quality of alignment of the various trigger lines
  - Jitter of the trigger lines
- The window width has been set to 12 clock ticks (700 ns).
- The following slides illustrate this choice.

Trigger Request Alignment

- For each new tower, a measurement of the arrival time of the trigger requests for TKR and CAL with respect to a muon telescope is performed.
- The muon telescope is used as an absolute reference. It provides a trigger signal that is much earlier than CAL or TKR.



Example: Tower 8

Trigger Request Alignment

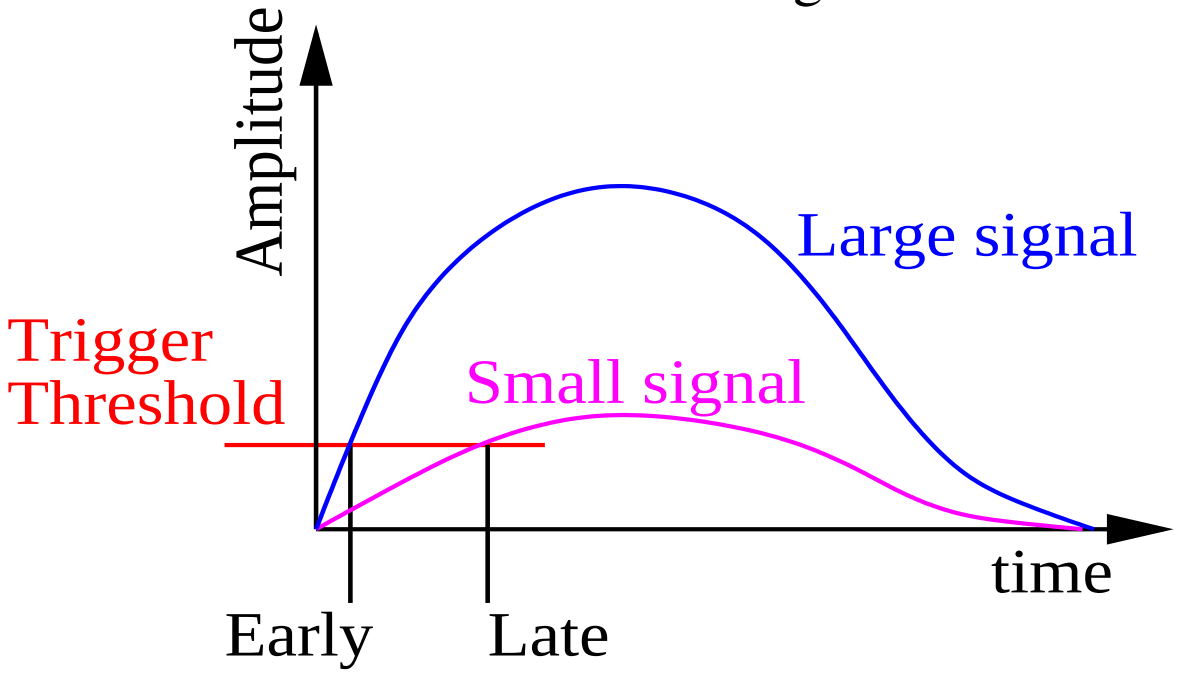
- Up to now 6 towers have been timed in.
- The results are very consistent so far:

Tower	0	1	4	5	8	9
TREQ CAL	0	0	0	0	0	0
TREQ TKR	3	3	3	3	3	4
TREQ EXT	13	13	13	13	13	14

EXT = Muon Telescope

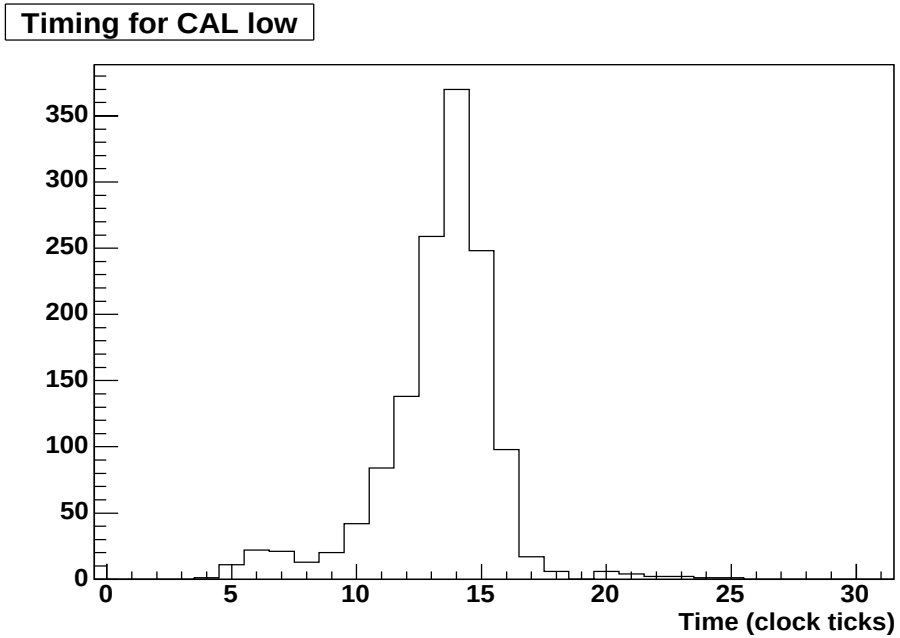
Trigger Jitter

- Trigger jitter is mainly caused by pulse height differences with respect to the trigger threshold.
- TKR: CNO produces large signals.
- CAL: Large variation in energy.
- These effects are not as visible on the ground.



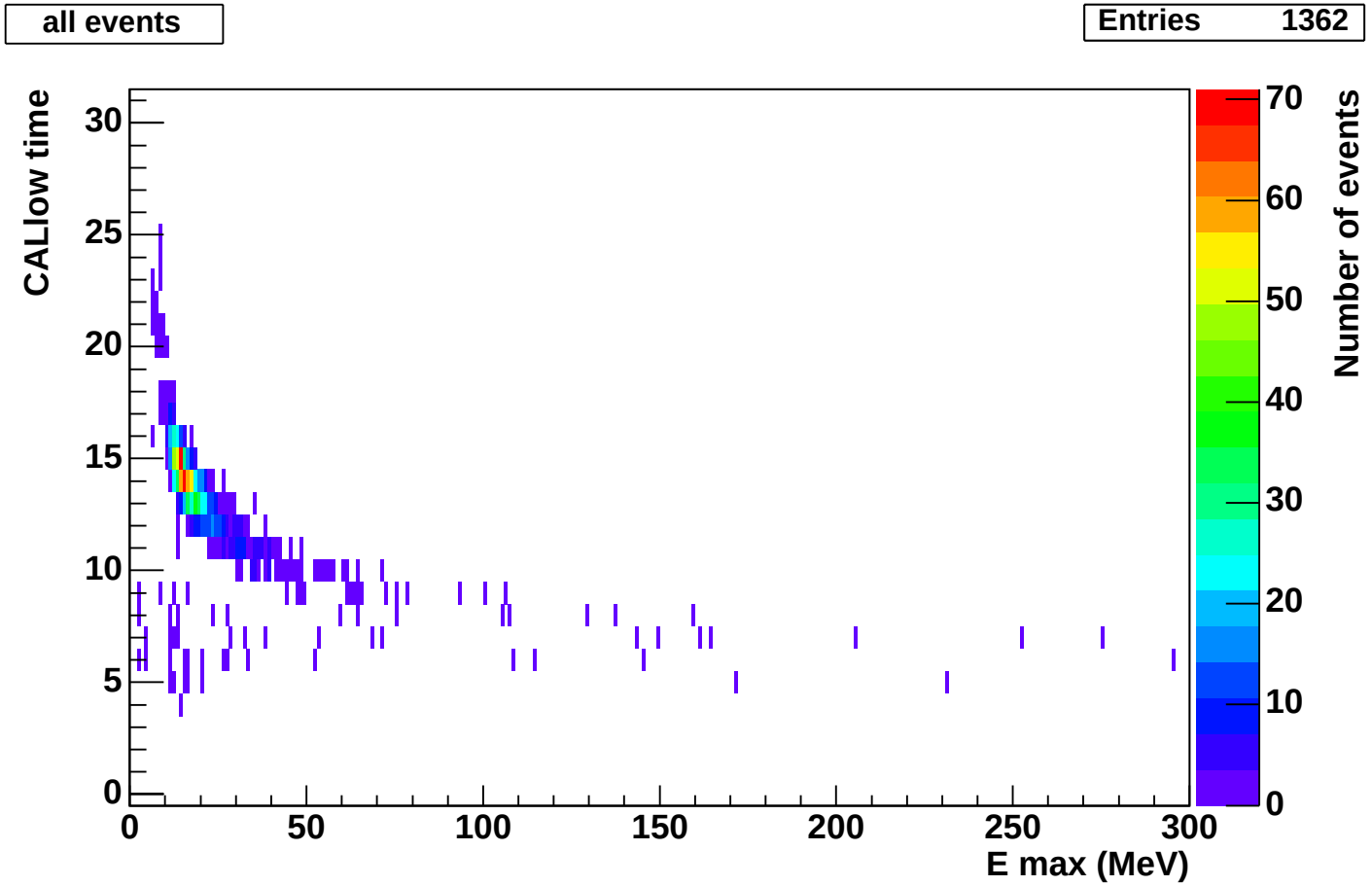
Calorimeter Jitter

- For timing in, the CAL thresholds are set very low.
- Measurement of TREQ arrival times:



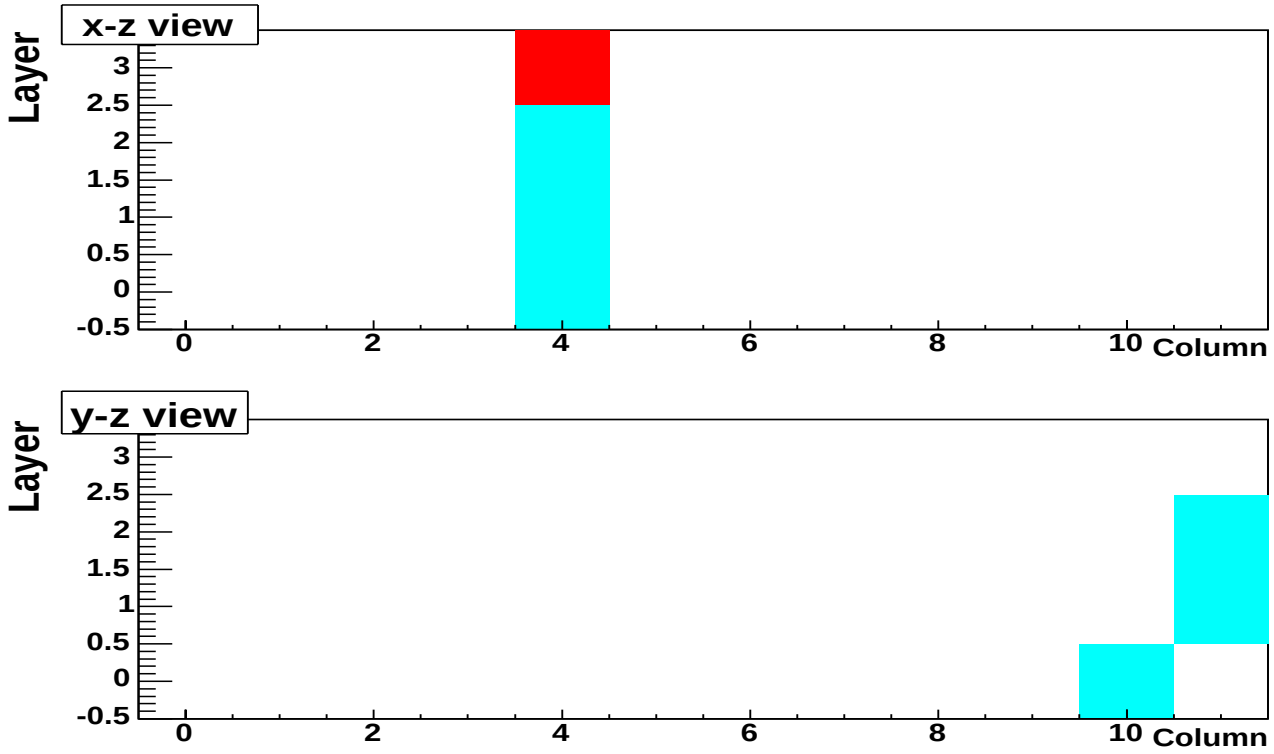
Calorimeter Jitter

- Highest crystal energy in event vs. arrival time:



Early CAL Triggers

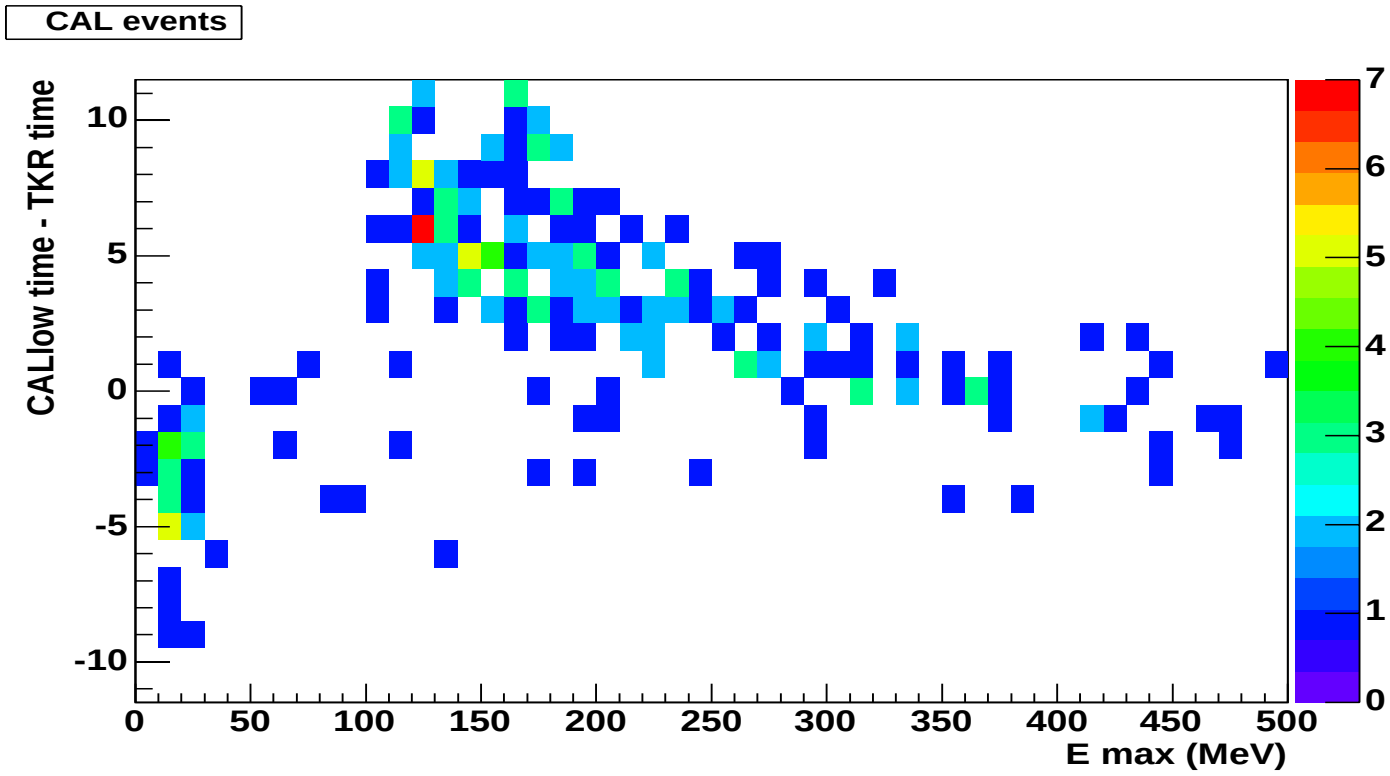
- Early events are caused by direct hits in the diodes.
- Example event display:



Blue: Regular hits Red: Hit only in one diode

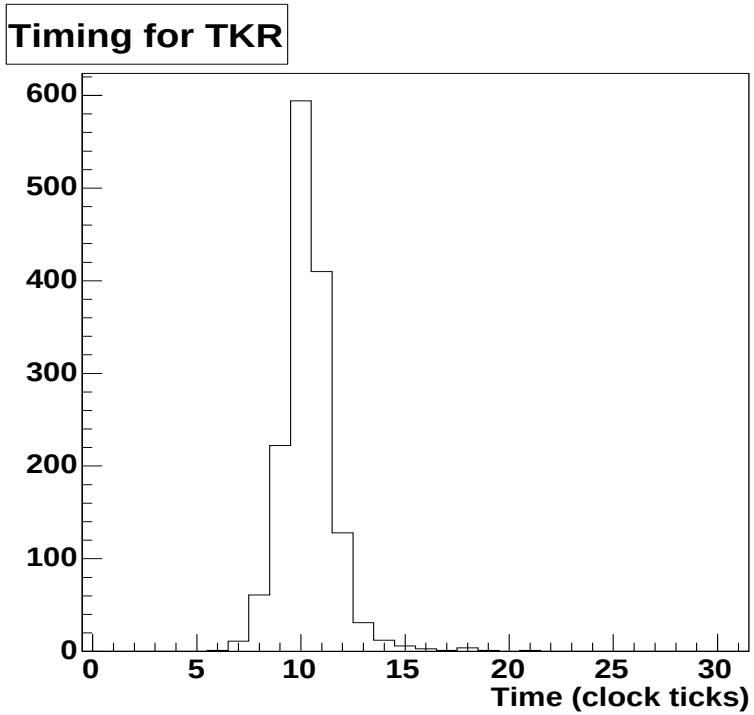
Early CAL Triggers

- The previous studies were done at low threshold
- Does the effect exist at realistic thresholds?



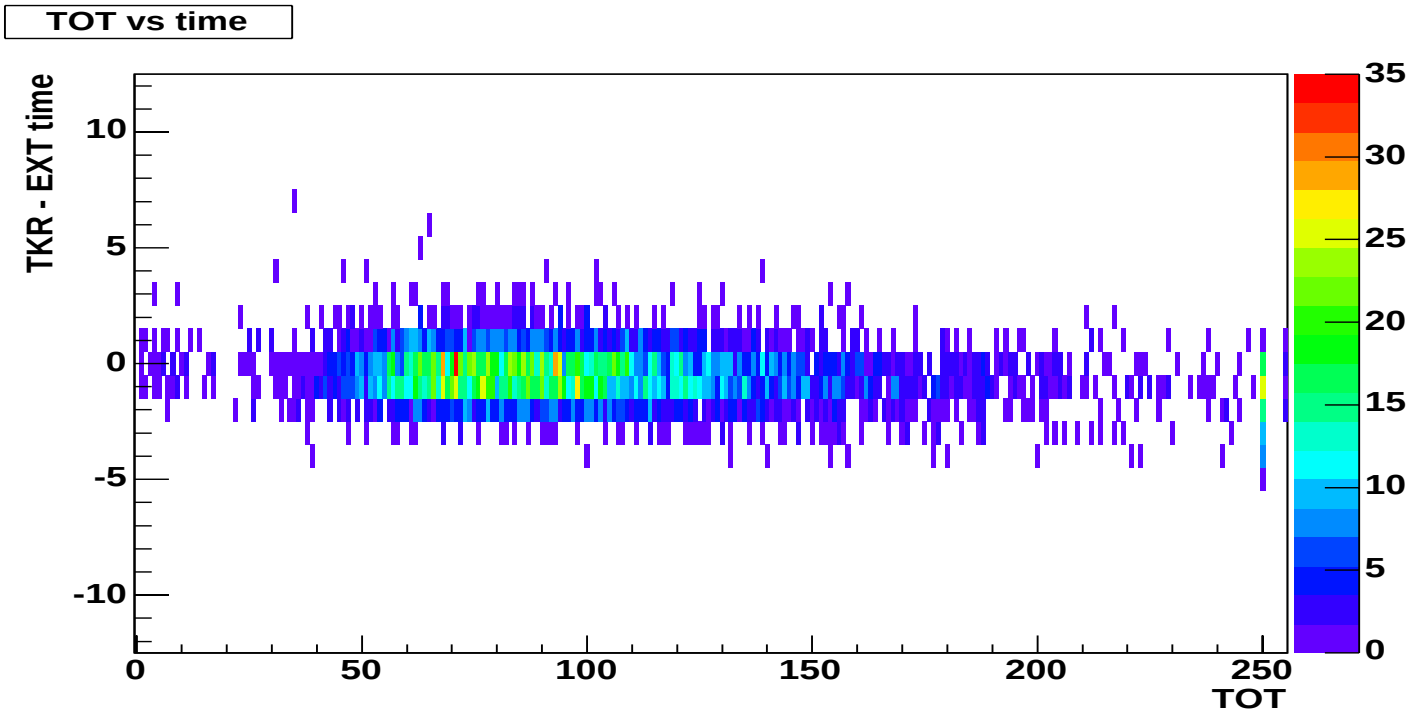
TKR Jitter

- The TKR threshold is set at ¼ MIP
- For cosmics, the timing distribution is very narrow.
- There is, however, a high tail.



TKR Jitter

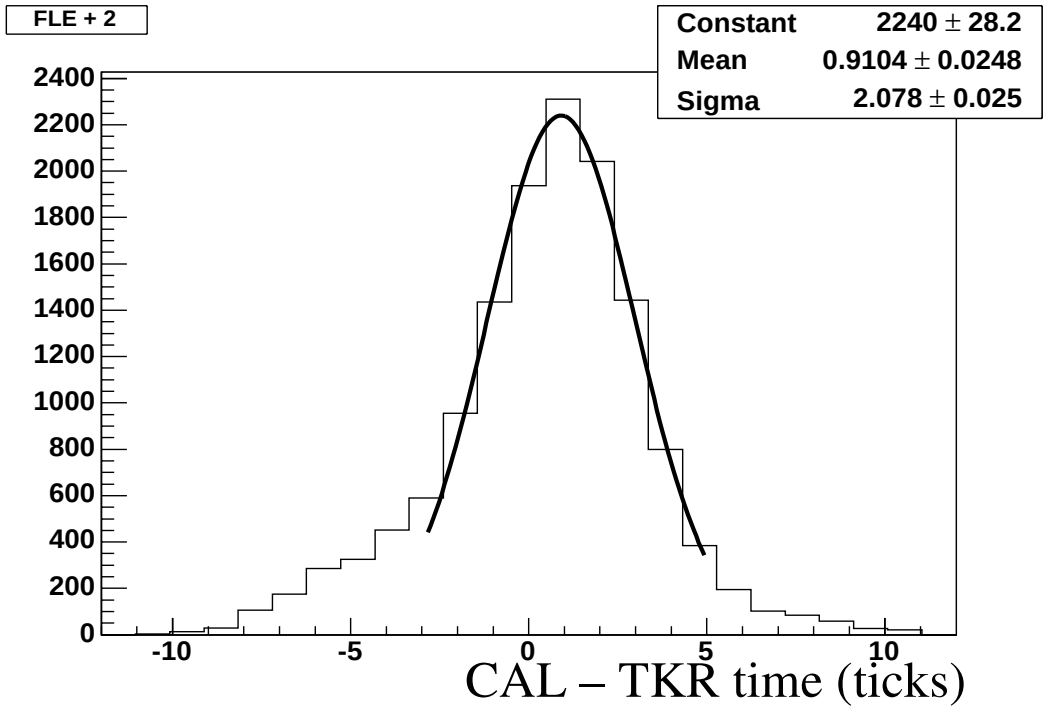
- Plot maximum TOT vs. conditions arrival time:



The distribution is quite flat, with some outliers. The correlation between trigger time and TOT is somewhat problematic since we are looking at 6-fold coincidences.

CAL versus TKR timing

- In normal operation TKR or CAL opens the window.
- Timing depends on both subsystems.
- Plot shows the TREQ arrival time for CAL – TKR.
- A window width of 12 is a reasonable choice.



One-Shot and Stretch-Or

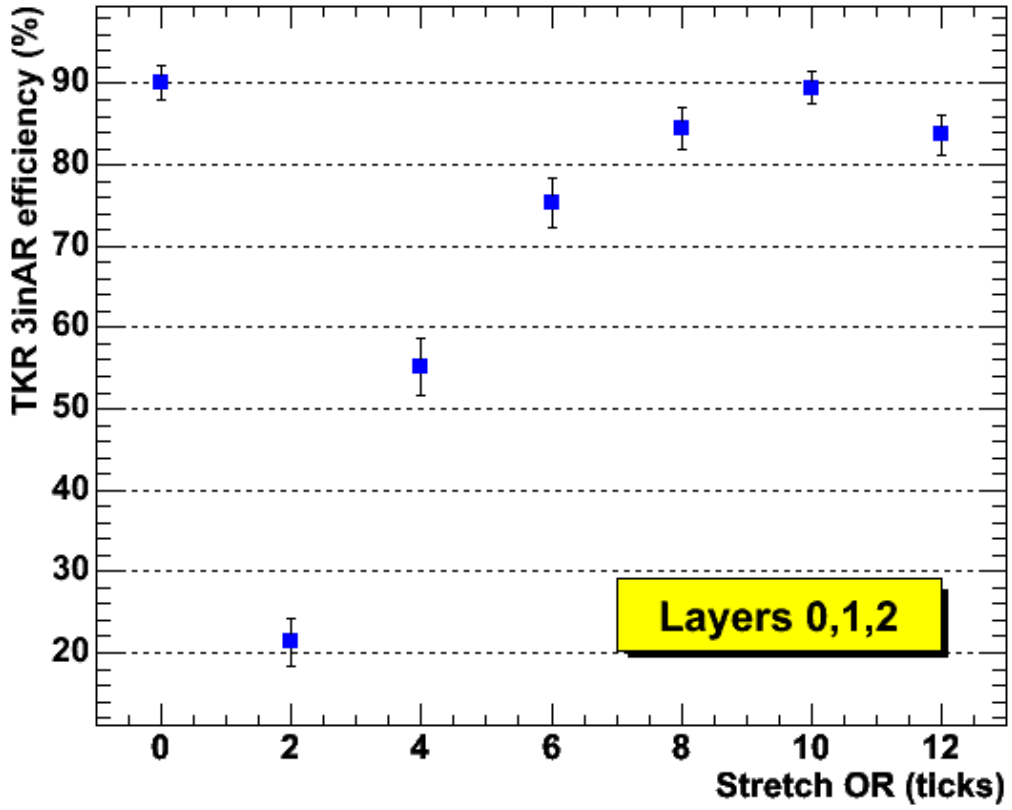
- The tracker triggers on a coincidence of the trigger signals of 6 adjacent layers
- The layer trigger signals that form the coincidence can either have their natural length (typically around 5 μs) or a fixed length between 100 ns and 1.6 μs.
- The advantages of short fixed-length signals include lower tower dead times and a reduction of retriggering rates at the tail end of an event. For a more detailed discussion see `http://www.slac.stanford.edu/exp/glast/trigger/meetings/050525/oneshots-v4.ppt`
- The stretch needs to be long enough to account for time jitter in the timing of the six layers. If the stretch is too short, trigger efficiency will suffer.

Stretch-Or

- A special test (STR 8) was conducted to determine the implications of turning the stretch-or on:
- The one-shot functionality was verified using charge injection. The test also revealed a problem with charge being spilled to neighboring layers at relatively low charges (ca. 5 – 7 MIP).
- No differences in the absolute timing were found when using the stretch-or.
- An efficiency scan was performed to establish a value for the stretch.
- The result of the study was a recommendation to turn on the one-shot/stretch-or with a stretch of 14.

Stretch-Or efficiency

- 14 was picked to add a safety margin.
- The efficiency shown is for exactly one combination of 6 layers.



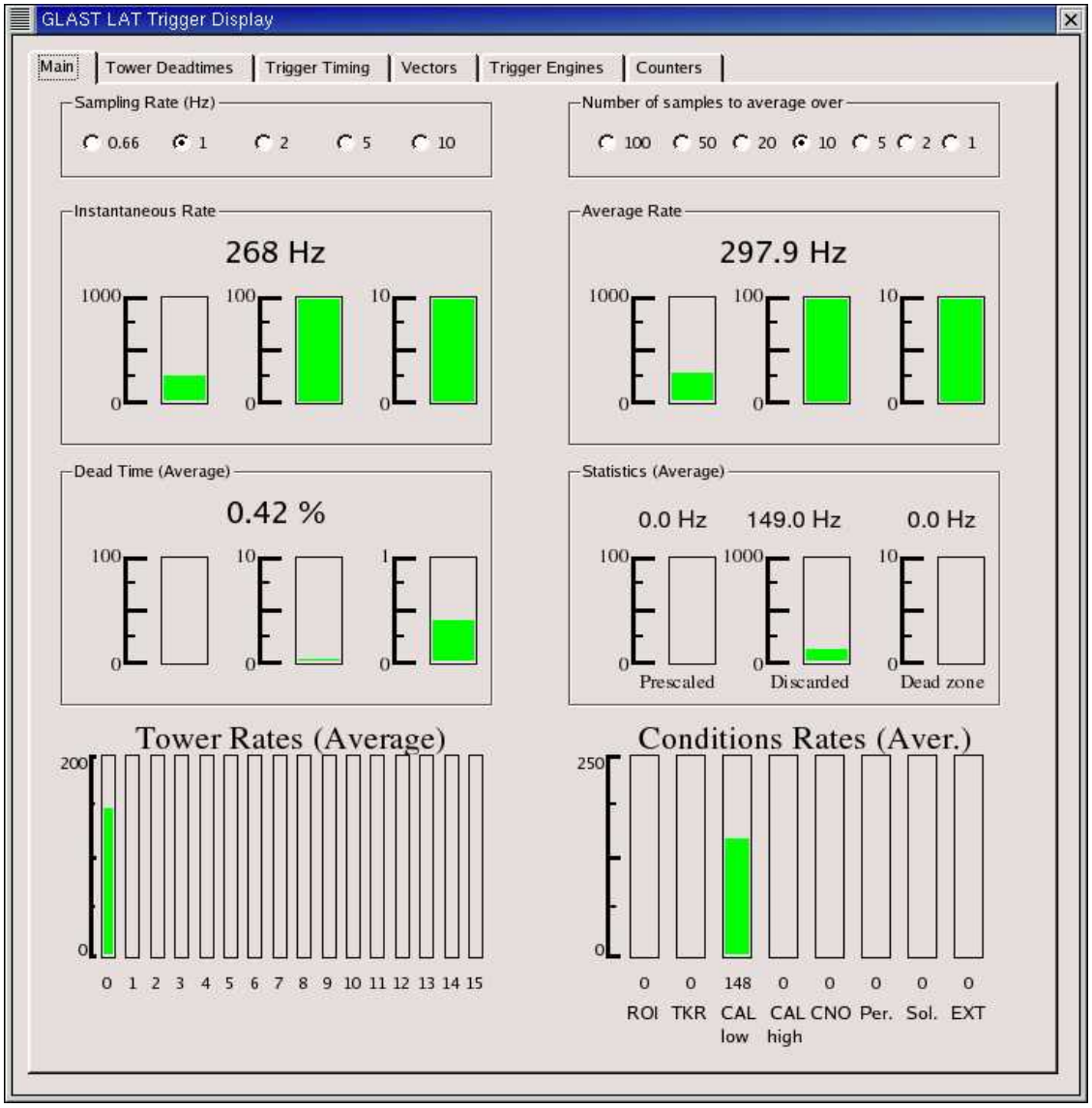
A stretch value of 0 means one-shot off.

Plot by Su Dong

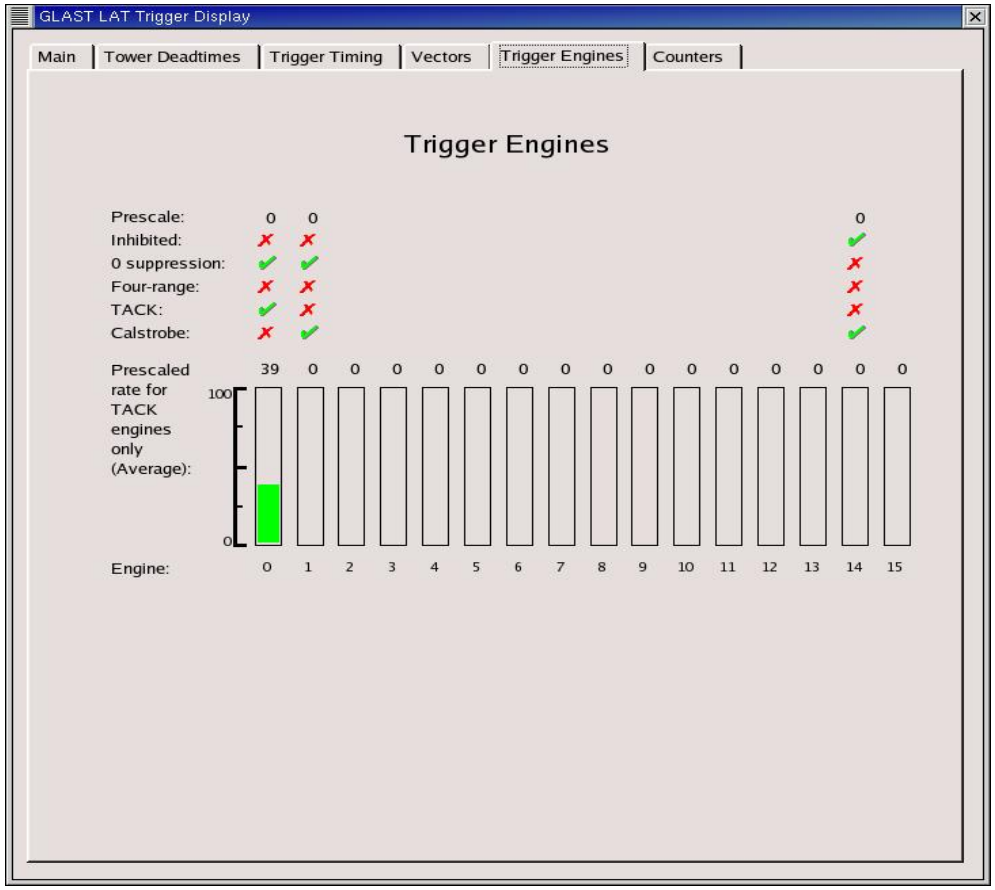
Trigger Display

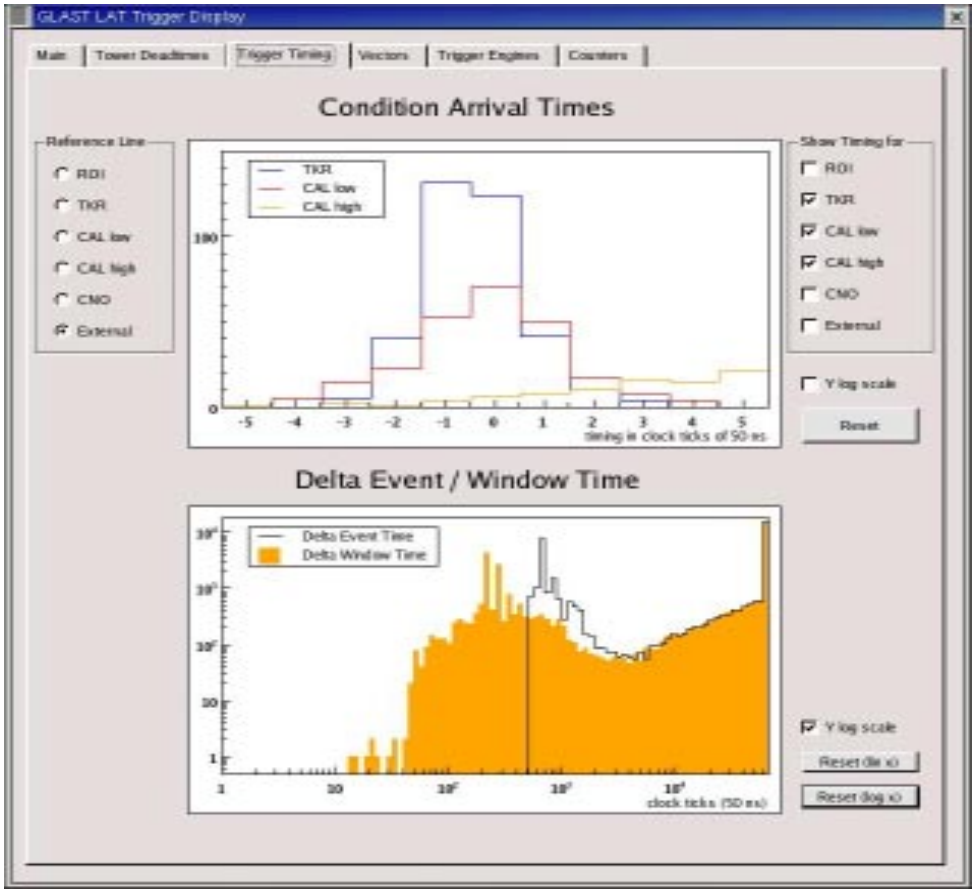
- A trigger display was added to LATTE.
- Rates are displayed in various ways:
  - By tower
  - By subsystem
  - By trigger engine
- Dead time monitoring
- Delta times and Conditions arrival time histograms
- Display uses register and event information

Trigger Display Main Page

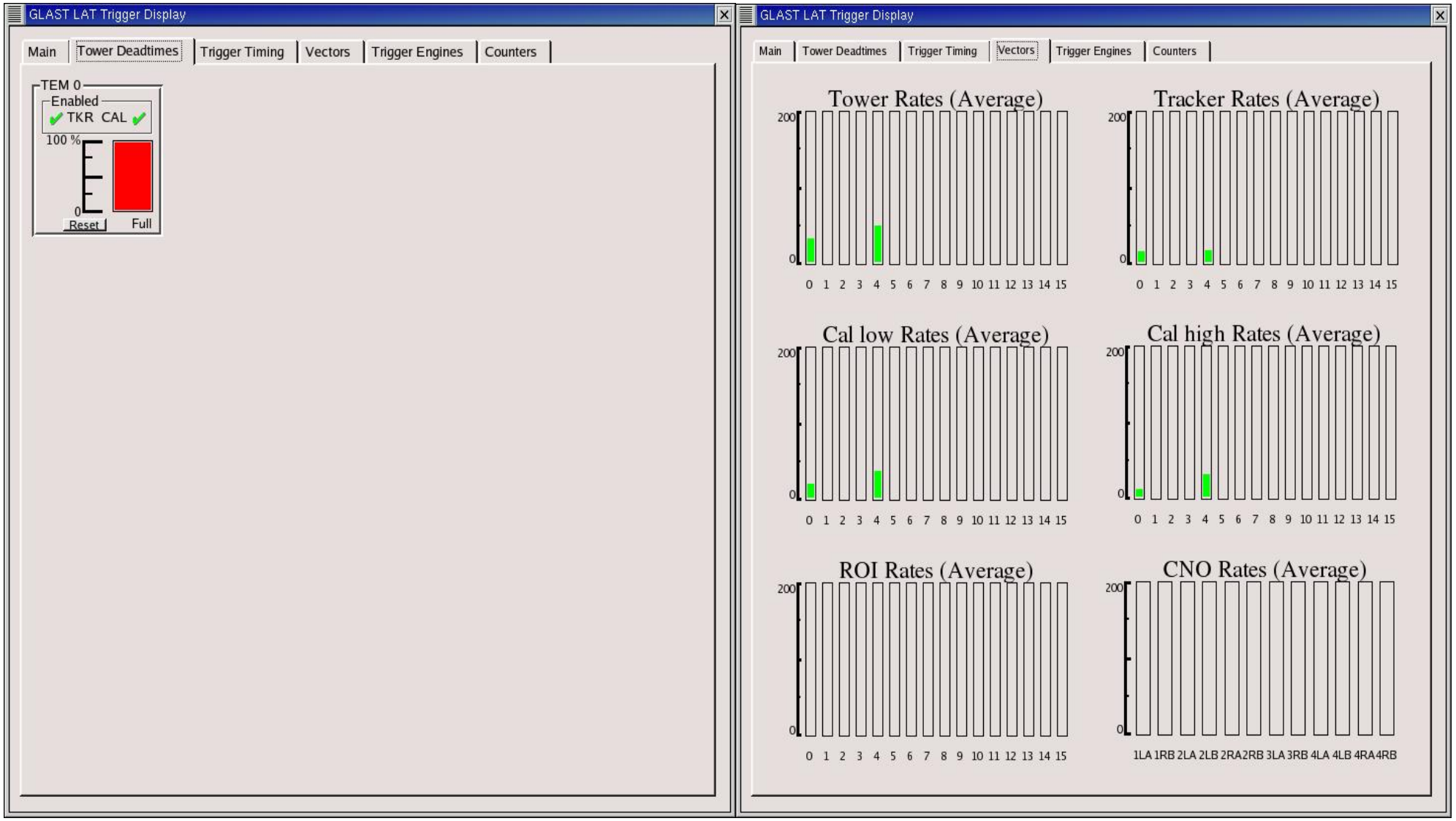


Trigger Display Pages





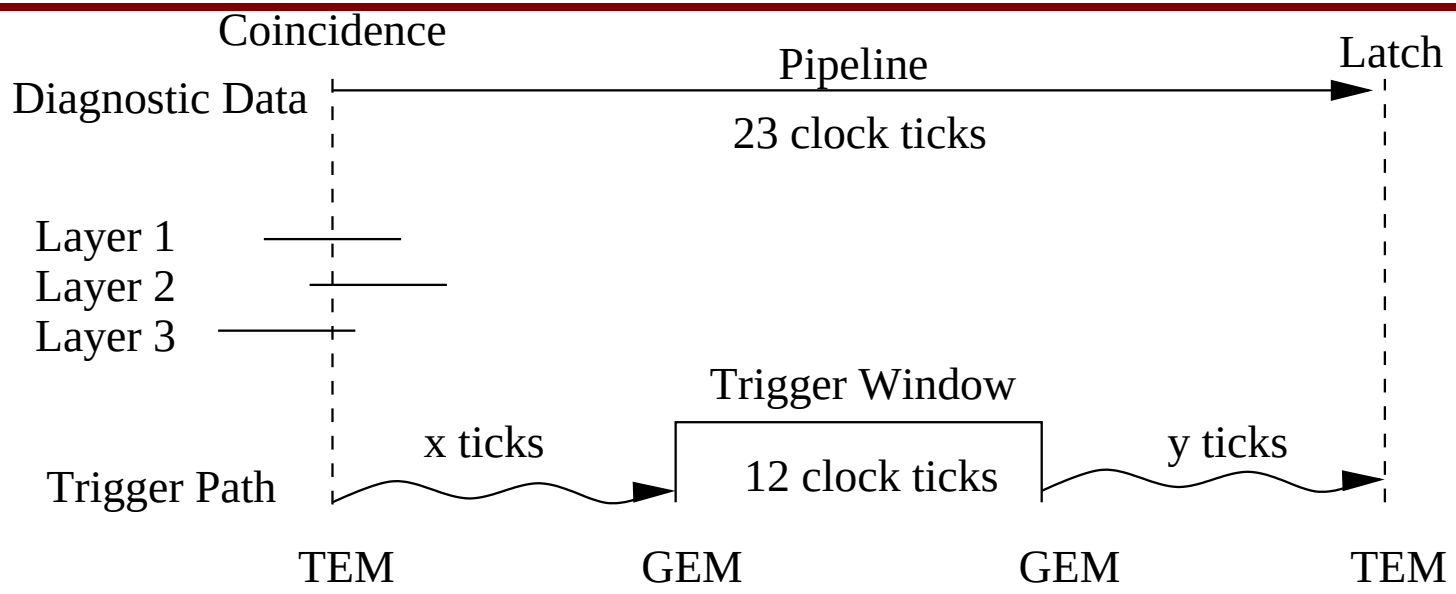
Trigger Display Pages



TKR diagnostic data

- If diagnostic data is switched on, the TEM will provide the trigger information for each layer end.
- The information is latched much later than at the time of interest which was when the trigger occurred.
- A pipeline of shift registers exists that allows to sample the trigger bits at an earlier time.
- The user has to set the length of the pipeline.

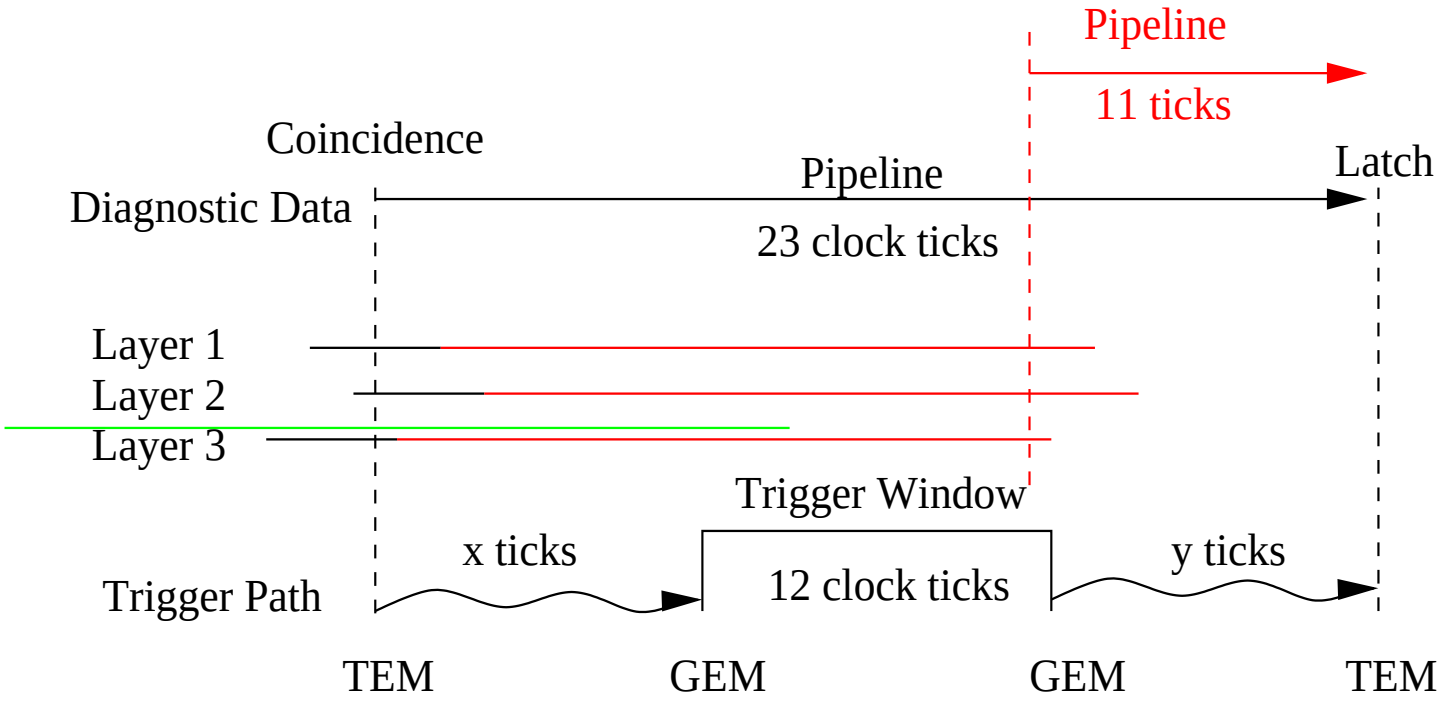
TKR Diagnostic Data



Unfortunately...

- The maximum length of the pipeline is 15 (not 23).
- The effective window width is variable because another trigger line might have opened the window already.
- Similarly, only the first TKR coincidence is latched properly.

TKR Diagnostic Data

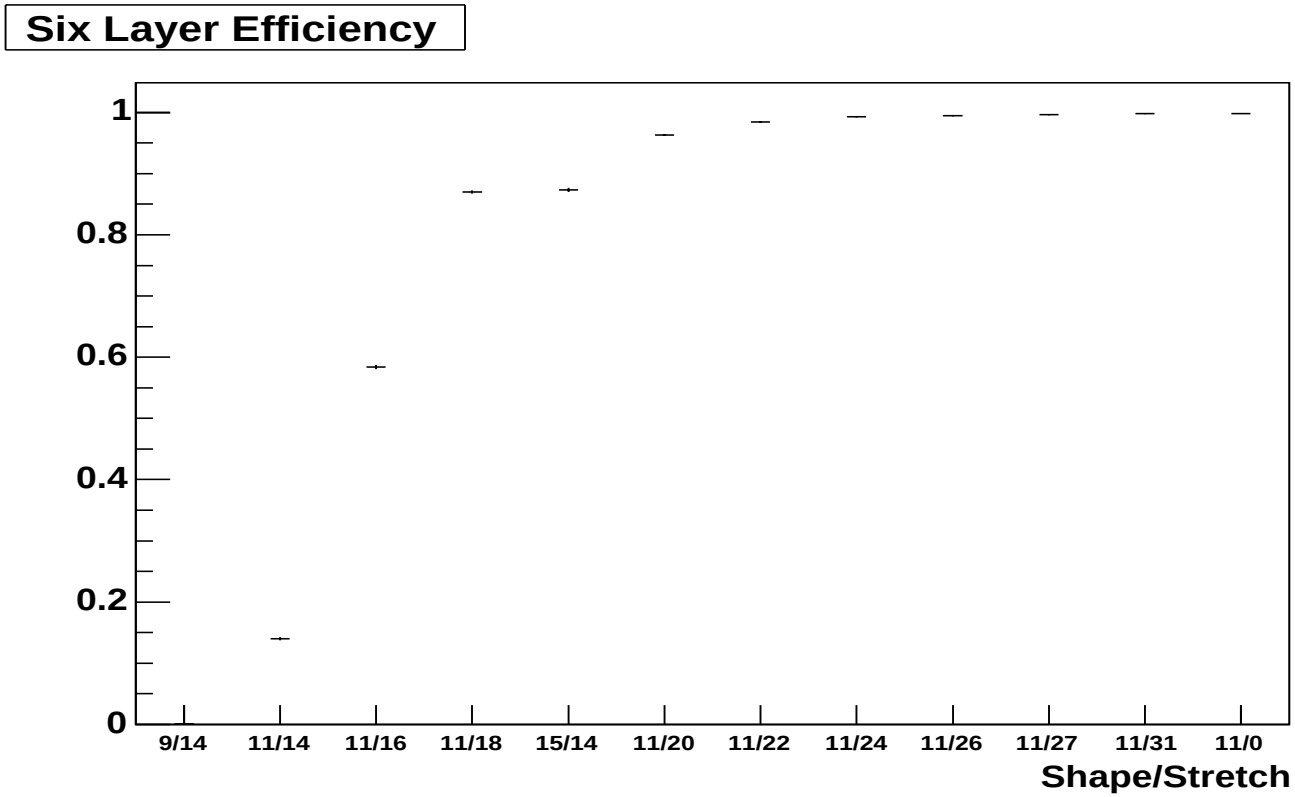


Kludge:

- Stretch the trigger primitives and use a shorter pipeline.
- With a high stretch and a pipeline length of 11 or less, the diagnostic data will be latched for any effective window width between 0 and 12.

TKR Diagnostic Data

- A special test (STR 14) was performed to measure what stretch would be needed for good efficiency.
- "Shape" is the parameter that sets the length of the pipeline.



TKR Diagnostic Data

- Due to the jitter between layers, a stretch value of 24 or higher would be needed for 99 % efficiency.

Caveats:

- Model is only deterministic for the latest layer. Other layers can fire significantly earlier, so no 100 % efficiency can be achieved.
- Since the signals are stretched far beyond window width, triggers (like noise) that occurred outside the trigger window will be latched as well. The user cannot tell the difference.

TKR Diagnostic Data

Conclusions:

- The stretch was left at 14 for the moment because some people were strongly inclined to keep it as short as possible. A serious study of the pros and cons of a longer stretch may be needed.
- The pipeline length was set to 15 which gives a latching efficiency of about 85 % for events where TKR opens the window.
- Because of all these difficulties, users should be extremely careful when using the TKR diagnostic data for analysis.
- CAL is unaffected.

Summary

- Six towers have been timed in.
- Timing and Jitter studies on tracker and calorimeter were performed.
- A window width of 12 was established.
- The one-shot/stretch-or for the TKR was turned on with a stretch parameter of 14.
- A trigger display was added to LATTE for monitoring purposes.
- The use of TEM diagnostic data was investigated.

Outlook

- Do several calorimeter studies:
  - Further investigate the early trigger issue.
  - Perform a special test to study retriggering which was found to be a problem at low thresholds by Sasha Chekhtman.
- Do a more detailed study of trigger efficiencies using the data that was collected on 6 towers.
- Think about trigger implementation in MC.
- ACD integration
- Close Trigger jitter NCR by through a more adequate spec.
- Work on a trigger configuration for flight conditions.