Trigger Time-in

and

First Results from Tower A

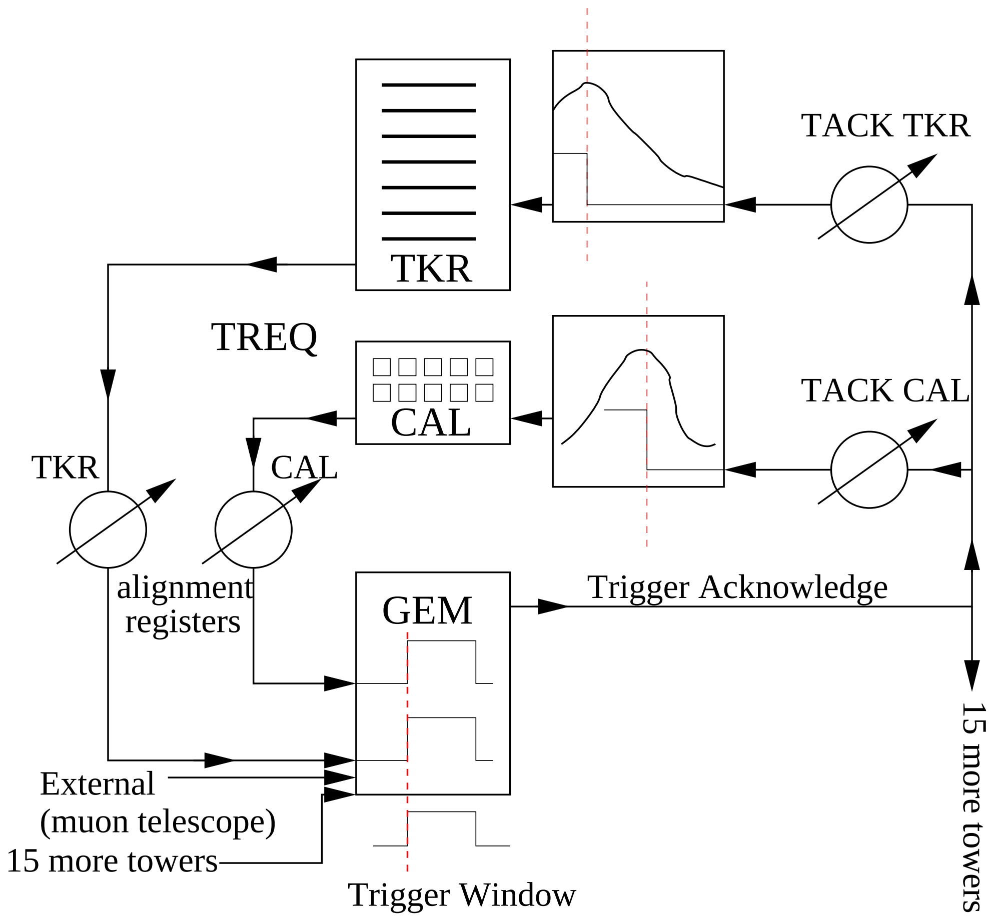
10 March 2005

Martin Kocian, SLAC

Introduction

Timing in works in 2 steps:

1. Line up trigger primitves (TREQ signals) at GEM input
2. Adjust acknowledge delay (TACK) for optimal data acquisition



TREQ Alignment

- A muon telescope provides an external trigger that is used as an independent reference to time in towers
- We are in transition towards a new GEM which allows for a much more efficient measurement of trigger request times.
- The new GEM records TREQ times for ACD, TKR, CAL, EXT, directly up to 31 clock ticks from the window open time.
- GASUs containing the new GEM are in the process of being commissioned.
- The methods for timing in TREQ are different with the old and new GEM

New Muon Telescope

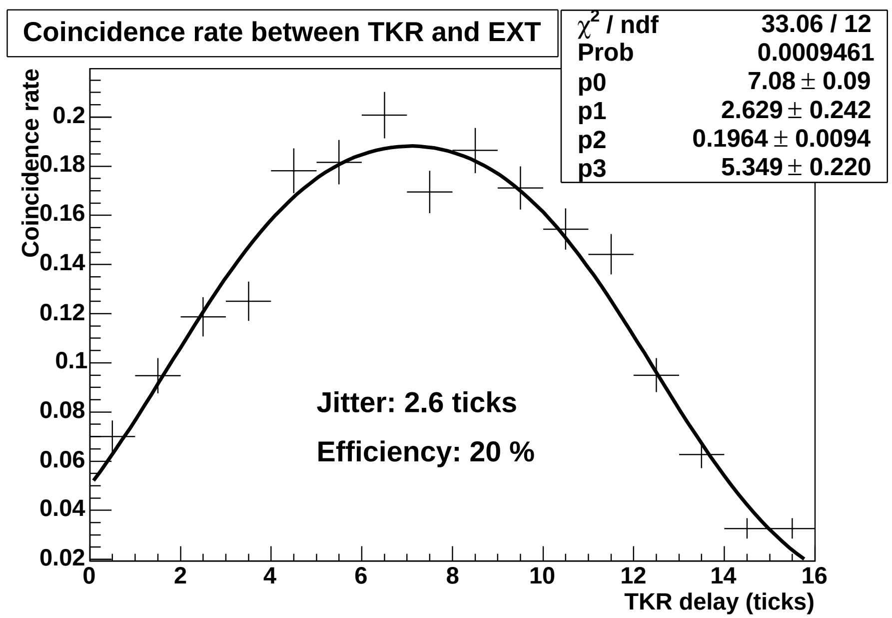
The muon telescope has been modified:

- Smaller panels
- 3 panels instead of 2
- Split panels

The main reason for the modification was to eliminate large cosmic showers. As a consequence the rate of usable events dropped by 1/3 (rate is down by a factor of 3, but efficiency is up by a factor of 2), and coverage of the tower is less uniform (less statistics near the edges).

Old GEM TREQ Alignment

- A scan over the full range of trigger primitive delays is performed (0 - 15 clock ticks for CAL and TKR)
- For each setting cosmic events are recorded and the number of coincidences of ext vs. subsystem trigger within the trigger window is determined and plotted against delay
- A fit is performed to determine optimal delay and also jitter
- The scan has to be performed seperately for CAL and TKR



New GASU

The GEM has been improved. New features include

- Arrival times for trigger conditions
- Triggering on edge instead of level. This avoids retriggering which we saw with the previous model.
- Delta window open time in addition to delta event times.
- A "missed" register that counts triggers that occured within 2 counts of a trigger window

These features make the understanding of the trigger much more efficient.

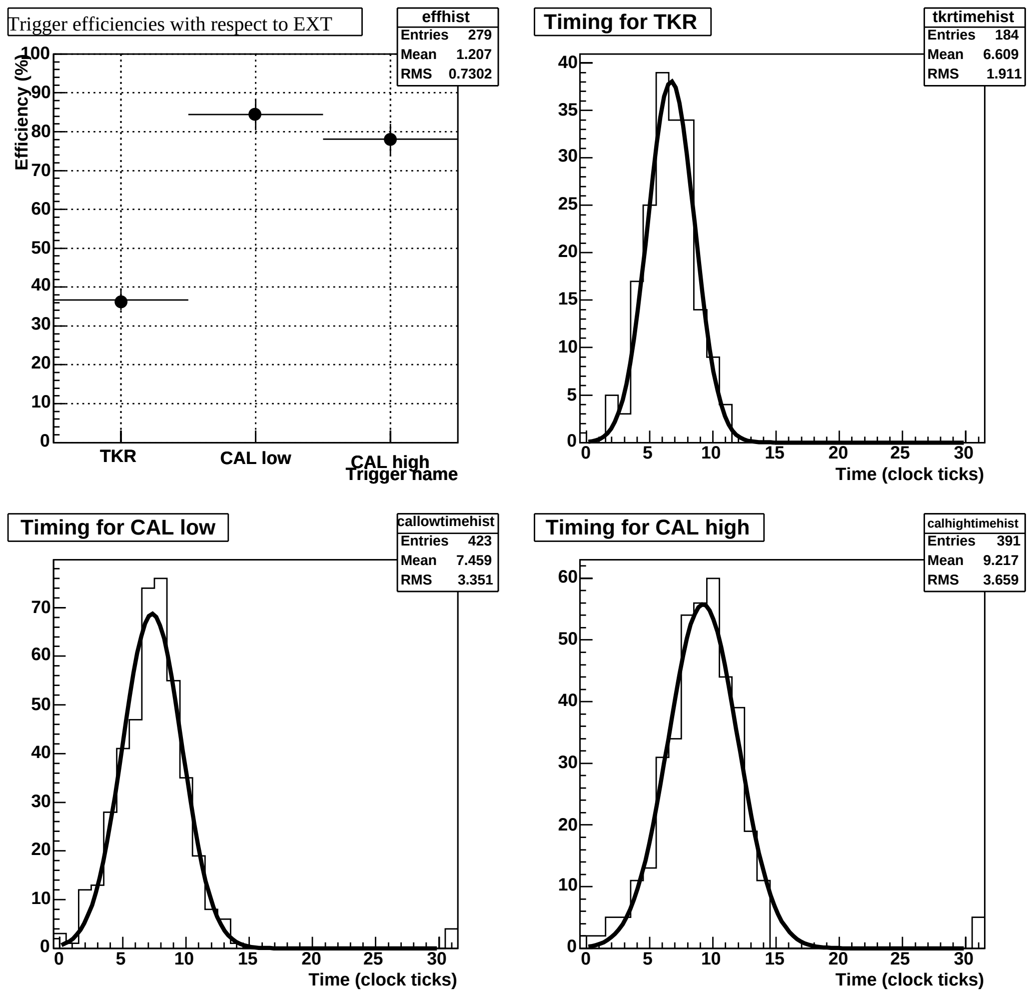
One remaining issue is the complicated way in which triggers are routed through an 8-bit lookup-table which then dispatches them to 16 trigger engines. This makes it tedious to trace back prescales for physically meaningful trigger definitions. Trigger configuration for physics will need much more careful thought to effectively extract unbiased samples for calibration and efficiency determinations.

TREQ Parameters

- CAL FLE: noise based
- CAL FHE: noise based
- CAL readout: range 0
- CAL high energy muon gain: On
- Zero suppression: On
- Diagnostic Data: On
- TKR thresholds: Nominal
- CAL TREQ delay: 6
- TKR TREQ delay: 6
- Window width: 15
- Trigger source: Muon telescope (External)
- Duration: less than 1 hour

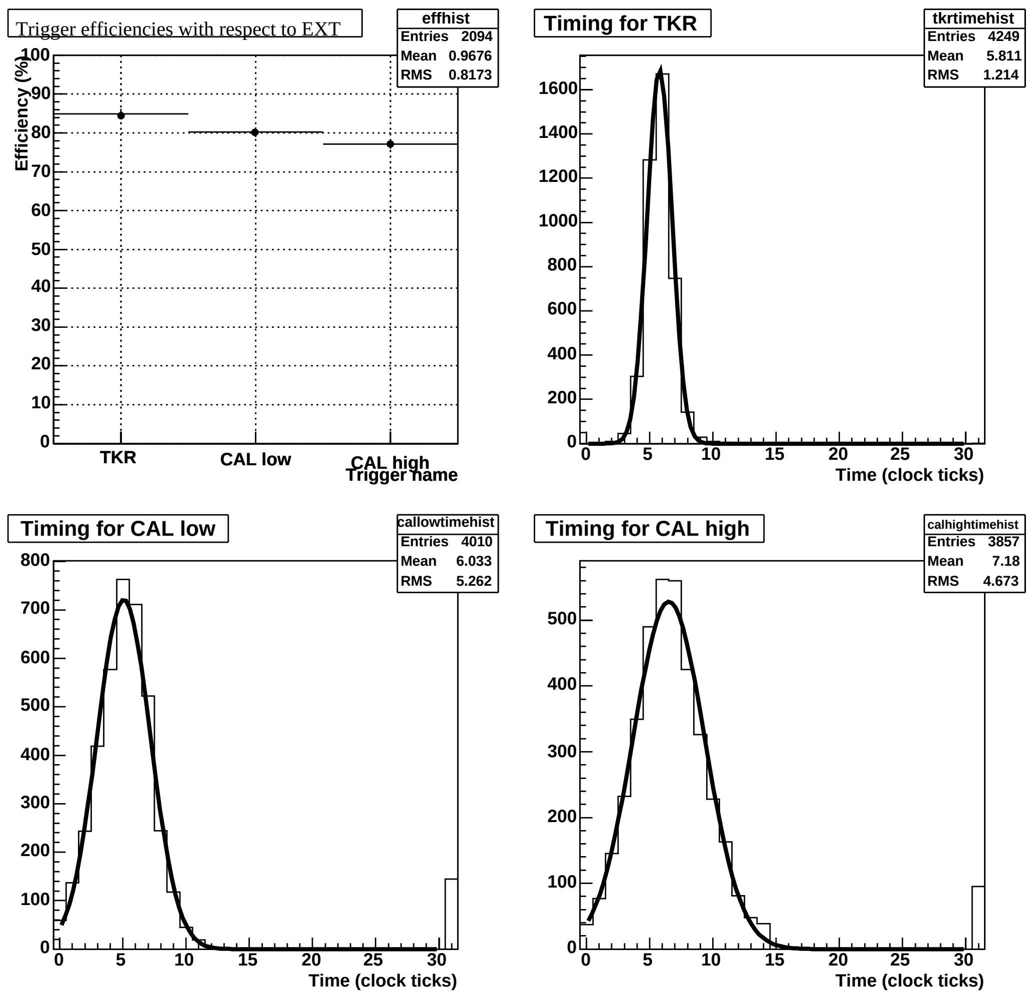
New GEM TREQ Alignment

- Set alignments so the earliest one is at 0
- Plot below is EM2



New GEM TREQ Alignment

- First data from the first tower:
- This is the output from the online script.



New GEM TREQ Alignment

- Tracker triggers 4 ticks earlier than mini Tracker
- Tracker triggers 5 ticks earlier than CAL
- TKR jitter: 0.99 ticks
- CAL jitter: 2.12 (low) and 2.85 (high)

On the mini tower the CAL timing and jitter were comparable. The mini tracker, on the other hand, had a significantly wider jitter of 2 clock ticks.

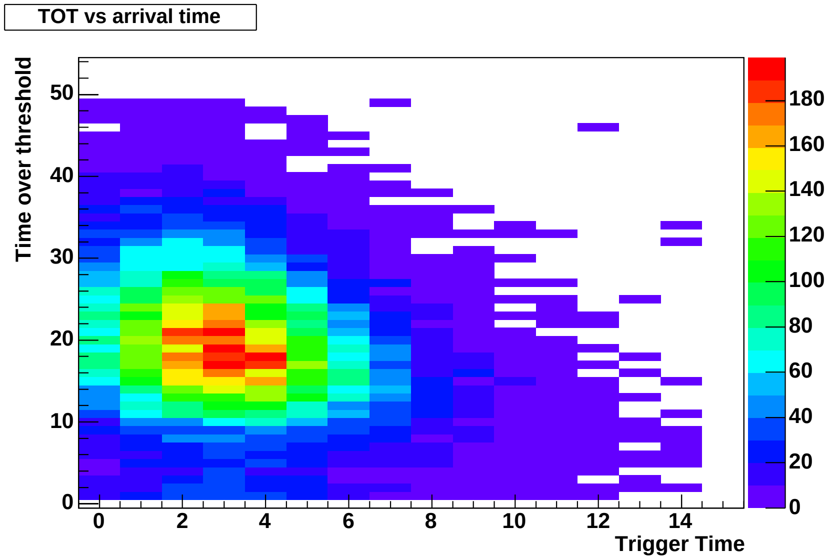
Trigger thresholds

- The trigger time depends on the trigger threshold
- Timing is done at a threshold just above noise
- In real life signal height varies significantly which causes a jitter in the trigger time
- The trigger window needs to be wide enough to keep efficiency high
- On the other hand, a wide trigger window means late latching of the data which decreases hit efficiency

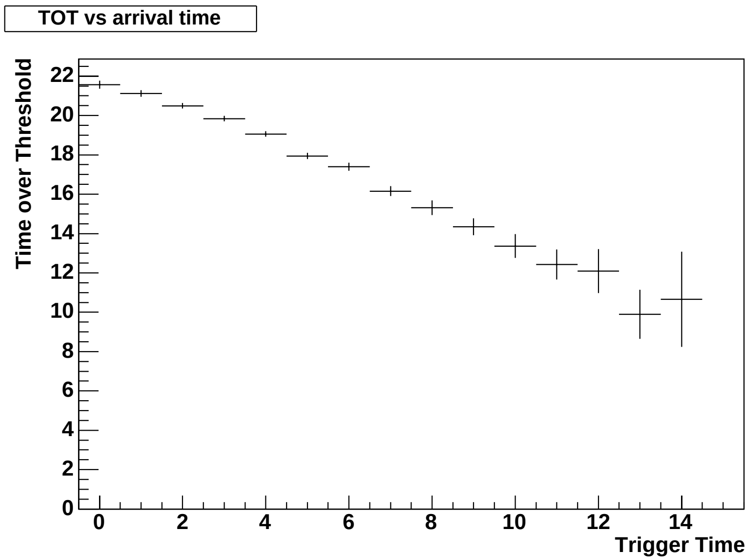
$\Longrightarrow$ An optimal point has to be found

- We take runs with 2 (later maybe 3) different window widths for efficiency studies
- To study the jitter, we will take runs on the mini tower triggered with the muon telescope and correlate trigger times with signal height for CAL and TKR. We have to be careful with the results, knowing that there are considerable differences between EM and flight hardware.

- Preliminary test on mini tower: Trigger on CAL (cosmics)

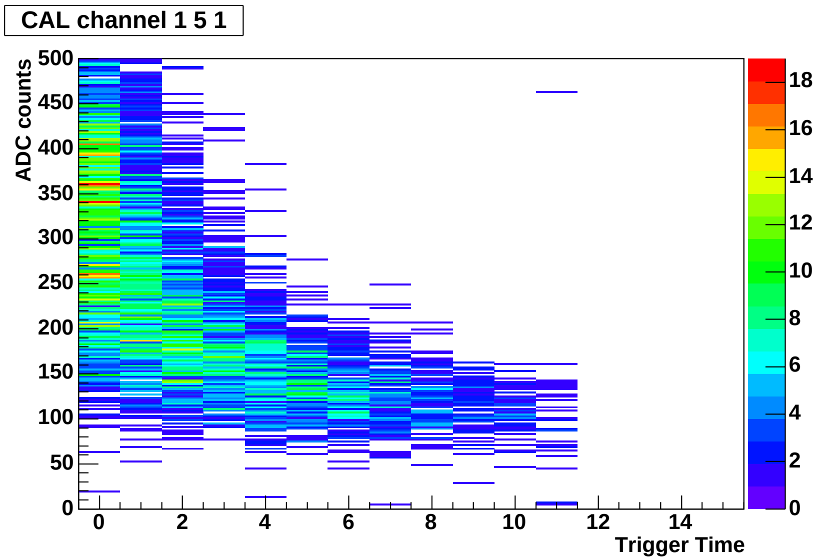


TOT vs. trigger time

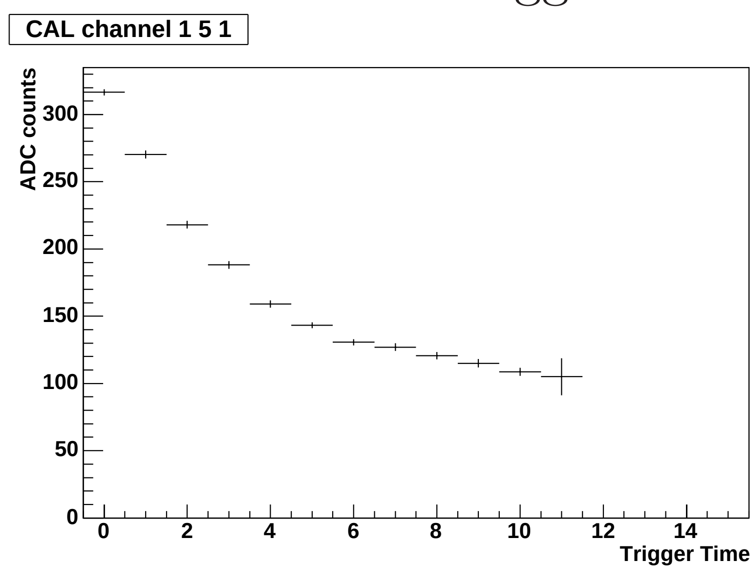


CAL jitter

- Preliminary test on mini tower: Trigger on TKR (cosmics)



ADC counts vs. trigger time



Digression: Diagnostic Data

- Both CAL and TKR provide diagnostic data with trigger information
- Information is by layer end, channels are ORed
- Latching of the diagnostic information is tricky
- CAL: trigger bits are high for 3 - 18 clock ticks (configurable through a "stretch" register) and can be delayed by up to 15 clock ticks through a "shape" register.
- TKR: trigger bits are high for 2 - 31 clock ticks or alternatively for the actual duration of the trigger signal. They can also be delayed by up to 15 clock ticks.
- Assuming a trigger window width of 0, the maximum delay is 11 on GASU based systems. Above this value the latching would occur before the trigger information becomes available.

Digression: Diagnostic Data

- In real life, the window width is non-zero. To latch all triggers that occured while the trigger window was open, the following criteria have to be satisfied:
- shape $\leq$ 11
- CAL: shape $\geq$ 9 - stretch + window width
- TKR: shape $\geq$ 11 - stretch + window width
- If the two relations are satisfied by a range of values for the shape register, diagnostic information can be latched beyond the boundaries of the trigger window
- If the size of the trigger window is larger than 17, the diagnostic information will not be latched for all triggers that occur inside the trigger window.

TACK delay scan

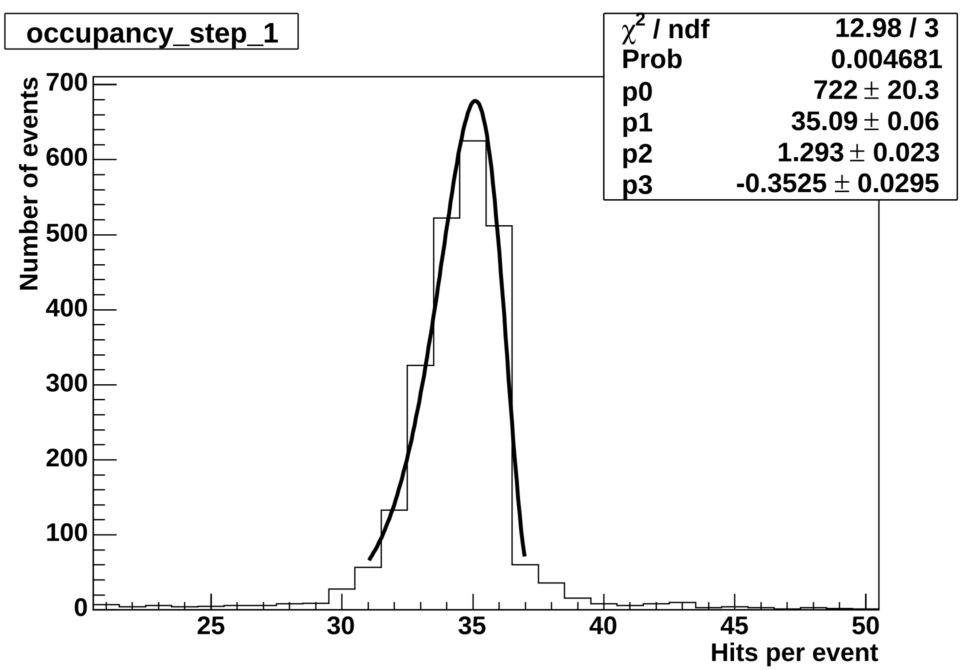
- Goal is to find optimal delays for latching CAL and TKR data.
- A scan is performed, varying the TACK delay.
- For each point cosmic data is collected with a TKR trigger.
- A fit is performed in the end to find optimal delays.
- Duration: About 4 hours

Parameters:

- CAL FLE: noise based
- CAL readout: range 0
- CAL high energy muon gain: Off
- Zero suppression: On
- Diagnostic Data: On
- TKR thresholds: Nominal
- Window Width: 5
- CAL/TKR alignment: Nominal

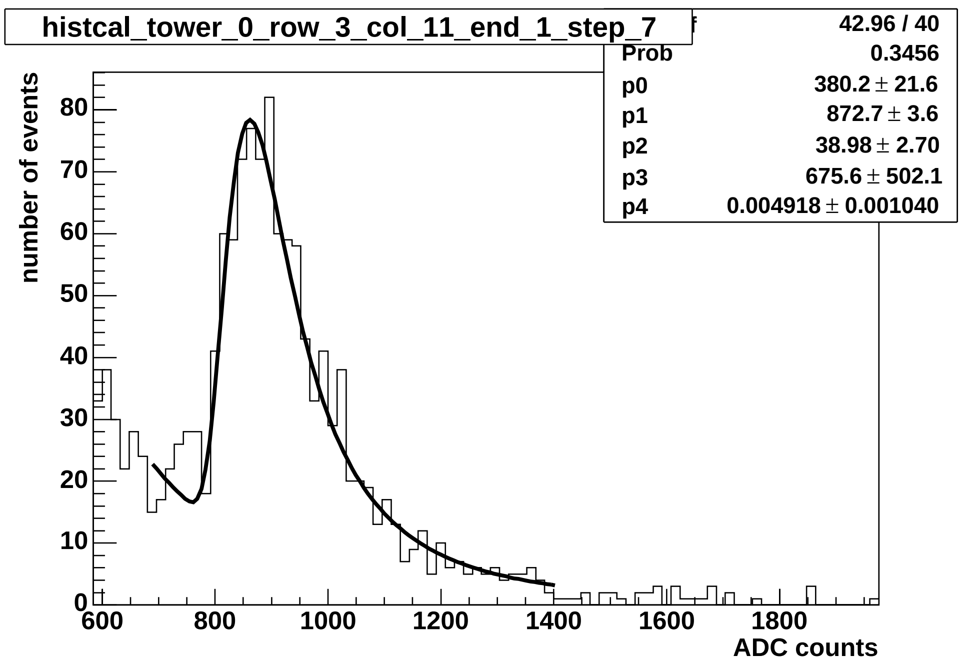
TACK delay scan (Tracker)

- No pulse height information is available.
- Use hit efficiency instead for optimization
- Fit number of hits per event for each TACK setting to determine optimal TACK setting.



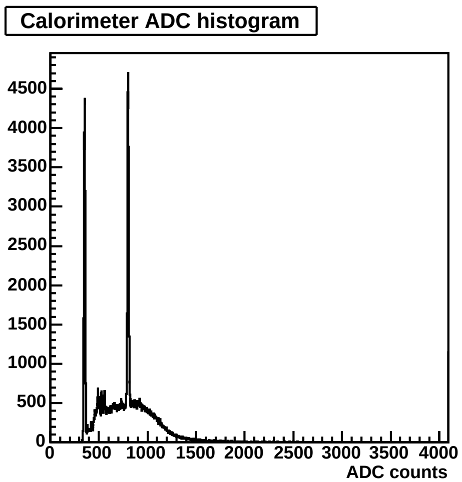
TACK delay scan (Calorimeter)

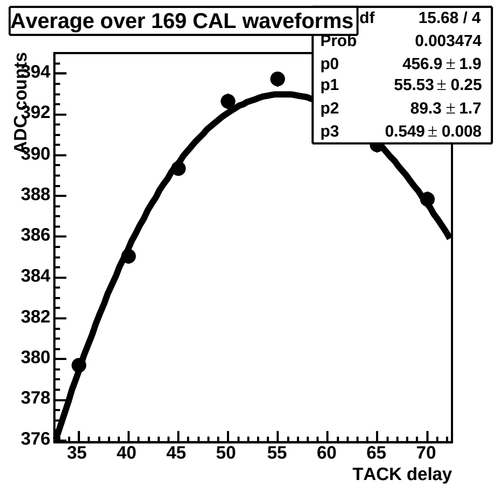
- Fit single channel pulse height spectra at each point
- Average over all channels with good fits
- Fit sum waveform

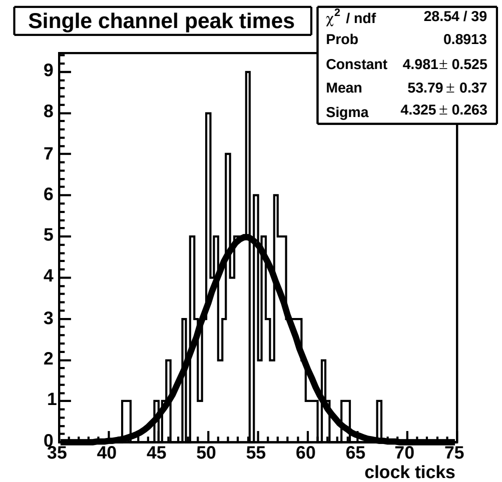


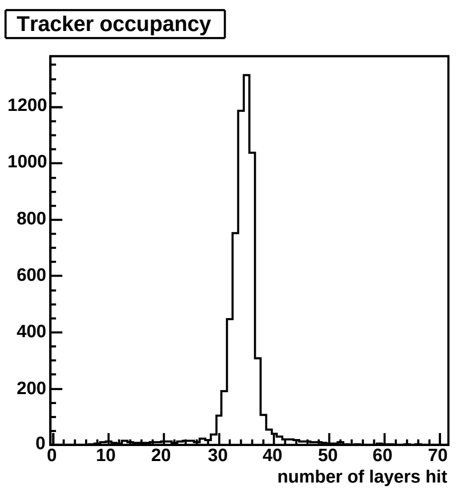
TACK Scan Output

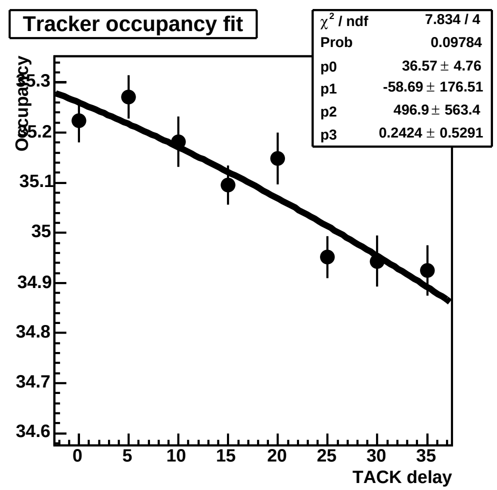
- Final fits are performed online and xml output is written
- Online plots from the first tower, data were taken today:





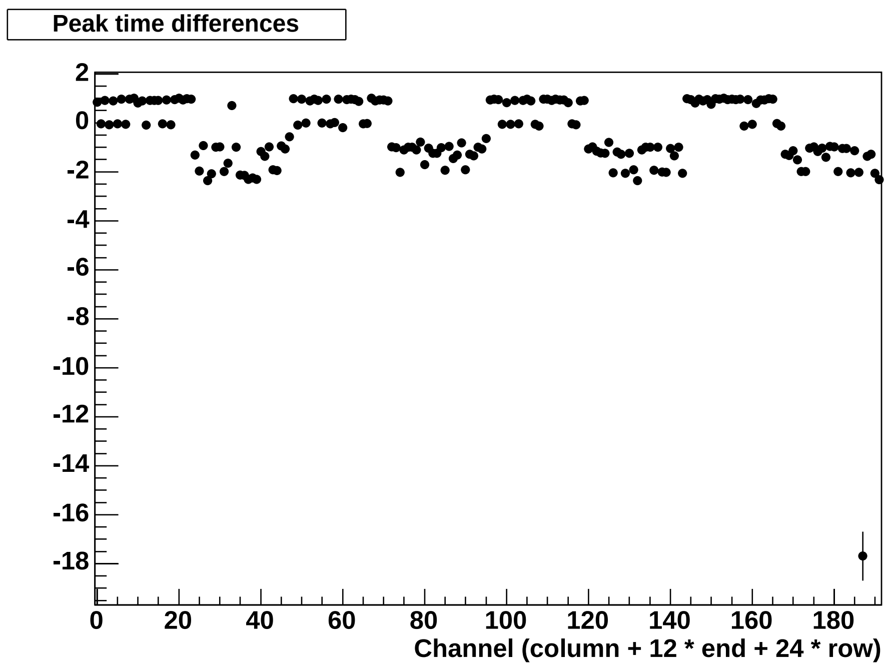






Additional Test

- CAL high is difficult to test with cosmics
- Perform charge injection with large charge instead
- Trigger on cal high and compare trigger time with timing for solicited triggers channel by channel
- Plot shows EM2 CAL



Summary

Summary:

- TREQ and TACK tests were performed on first tower
- A first look at the data looks very promising
- TKR triggers earlier and has less jitter than EM tracker
- New GASU is a big help for timing in trigger lines

Outlook:

- Do a thorough checkout of GASU
- Look closer at trigger jitter
- Continue cross-talk studies started on the mini CAL