

L1 CalTrack

Overview:

Level 1 CalTrack is a system designed to more closely determine the path of a particle through the detector. Currently, tracks within the calorimeter can be identified only to within a 90 degree quadrant in ϕ . By comparison, the L1 Central Track Trigger can locate tracks to within 4.5 degrees. Since these tracks are reconstructed with data from the Level 1 Calorimeter, Level 1 Central Track Trigger, and Level 1 Forward Pre-Shower, the calorimeters coarseness has limited the usefulness of the system. Being able to locate a track more tightly in the calorimeter adds a level of filtering against residual deposited energy. This residual energy is related to the luminosity seen by the detector. Since the three pieces of the CalTrack system will be affected differently by residual energy, being able to filter out energy that does not correspond to a particle's path will eliminate a portion of this noise.

The CalTrack system itself is highly similar to the one currently tracking muons in Level 1 Muon. The hardware and infrastructure are nearly the same because they have been adapted from L1Muons to track for EM and hadronic particles.

Data Transfer in CalTrack:

Output signals from the ADFs are passed to the TAB's sliding window algorithms chips. These data are the values of energy deposited into the EM and Hadronic portions of each of the 16 trigger towers each ADF is responsible for. The SWA chips locate EM and Hadronic objects using identification parameters and compare their energy levels to a list of energy thresholds. The information passed is not the value of the energy but a number 0-7 that indicates the highest of these energy threshold passed in that TT. These thresholds are arranged in increasing value and serve to make energy cuts easier as well as limit the length of data transmission.

The Global chip combines into a single mask the thresholds passed in four adjacent η regions within a ϕ slice. Four masks are created per event corresponding to four regions of ϕ . These four masks are the first four words in a seven word per event transmission to the Serial Link Daughter Boards. The final three words contain zeros. All three SLDBs per TAB receive and transmit the same data.

Each word passed to the SLDBs contains 18 bits. The 8 least significant of these are the mask of which EM thresholds were passed. The eighth bit is currently unused as there are only 7 thresholds. The next 8 bits are the equivalent Jet thresholds that were passed. The two most significant bits are the parity bit and enable bit. The parity bit is set high every seven words on the last word of an event. Setting this bit high instructs the SLDBs to calculate the parity of the words since the previous parity signal. The calculated parity is inserted into the seventh word. Although our system is set up for 7 words per event, this

flexibility is good to have. The enable bit is set high and stays high for all non-sync gap events. When the enable bit is low, the CalTrack system expects that the TAB is sending NULL data.

From this list of thresholds passed in various regions of eta-phi space, combined with information from CTT and FPS, L1 CalTrack makes a decision whether to pass the data onto level 2.

Testing:

The first step to test the CalTrack system was to confirm that the size and form of the sync gap pulse sent from the TAB to CalTrack was the same as the real sync gap. We also confirmed that the sync-gap pulse was arriving at the right frequency. The CalTrack system is able to count the frequency that a sync gap pulse is received and this can be compared to the real turn rate. The correct frequency as well as the one we saw is once per turn or the BOT rate of 47712 Hz. This set the standard for future testing since we knew that the link was established and working correctly.

The next step was to send non-zero data terms. For testing purposes, the CalTrack system is taking an OR of all 96 (16×6) data bits per event (As the parity word is not data it is currently ignored.) Counting the rate at which this OR term goes high yields a rate we can use to test the transmission of data. We then compare this rate for how often CalTrack receives our test data to the rate at which it receives our sync gap pulse (i.e. The BOT rate). Due to a memory limitations on the TAB, we could only send 32 events with data before having to repeat our events. Since a turn has 142 physics bunch crossings (159 total BC – 17 sync gap BC) we obtained a rate of $(142/32) \times \text{BOT}$. This rate corresponds to one 1 on the first word of an event. Since the bits within an event are being ORed the number of non-zero bits should not affect the rate, nor should the position of the non-zero terms affect the rate. This has been shown to be true using the above mentioned trigger rates by altering the patterns in the test memory of the TAB. The rate can be affected by sending various numbers of events to CalTrack and measuring the rate. Juxtaposition of events should not alter this rate. The following combination of transmissions of data to CalTrack have been successfully tested.

- Single bit on single word on single event
 - Word number, event number and position within word are not factors in output rate
- Multiple bits on single word on single event
 - Word number, event number and position within word are not factors in output rate
- Single bit on multiple words on single event
 - Word number, event number and position within word are not factors in output rate
- Multiple bits on multiple words on single event
 - Word number, event number and position within word are not

- factors in output rate
 - Single bit on single word on multiple event
 - Word number, event number and position within word are not
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 - Single bit on multiple words on multiple event
 - Word number, event number and position within word are not
- factors in output rate
 - Multiple bits on multiple words on multiple event
 - Word number, event number and position within word are not
- factors in output rate
 - Sequential and non-sequential patterns of varying number of constituents were tested when using multiple bits, multiple words or multiple events.

The only factor in determining the rate is the number of events per turn sent to CalTrack.

Currently, we are using the ADF test memory to send data from simulated trigger towers through the TAB to the Cal-Track system. The ADFs have test memory for 159 events. Using this setup the output rate no longer has the factor of (142/32). Our first test using the ADFs involved setting a single trigger tower to maximum energy deposited for only a single event: BC10. All other towers at all other times were set to zero. Knowing the value of energy we put into the which trigger tower we were able determine if each component was properly handling the data. We have analyzed the input data to TAB and confirmed it showed only a single tower with energy and that the energy was the maximum allowed. We analyzed the data coming out of the SWA chips and confirmed they showed only a single TT with energy and that the energy had passed all energy thresholds. We analyzed the data coming out of the global chip and saw that there was a TT that had passed all thresholds in the correct region of eta-phi space. Finally we saw that the rate at which CalTrack received this data was the rate we expected for a single bit on a single word on a single event: 47712 Hz. We are now in the process of using a rate that is the AND of this single bit with a known bunch crossing. This rate will be zero when our data arrives at CalTrack at a time different that we want. Our timing parameters can be adjusted in order to insure that the data arrives at the correct time. When our data arrives at the correct time the rate will go from 0 to the BOT rate.

Format of data from ADF to SWA chips:

http://www.nevis.columbia.edu/~evans/l1cal/hardware/cabling/adf_to_tab_cable_map.html

Format of data from SWA chips to Global chip:

http://www.nevis.columbia.edu/~evans/l1cal/hardware/tab/sw_to_global.html

Format of data from Global through SLDB to CalTrack:

http://www.nevis.columbia.edu/~evans/l1cal/hardware/tab/tab_to_caltrack.html

Specification on SLDB TX:

http://atlas.physics.arizona.edu/~johns/l1muo/l1caltrack/Transmitter_Specs_06-11-04.pdf

Further L1 CalTrack Trigger Documents:

<http://atlas.physics.arizona.edu/~johns/l1muo/l1caltrack/l1caltrack-top.htm>