ACD calibration (DRAFT for Review and comment)
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This is a summary of the presentation on ACD calibration made at Stanford on Jan 4, 2000. The Data Acquisition System Requirements Document dated April 24, 2000 has modes that would accommodate what is described herein. It is a DRAFT for review by the ACD development team and for presentation at the ACD electronics review on June 23. There is a section for ground testing and calibration and for in-flight calibration. Attached is a copy of an email Steve Ritz wrote on calibration modes.

On the ground

The photo-electron number will be measured for each fabricated ACD tile using naturally occurring sea level muons before integrating it into the mechanical structure. The muon flux is ~ 100 m^{-2} sr^{-1} s^{-1} . A single tile test requires 10^5 events and takes about 1 day. For this test a flight tile will be put into a test setup with independent scintillators forming the trigger.

The efficiency will be rechecked after the whole ACD unit is fabricated as part of the pre-ship testing. It requires that the whole ACD unit be capable of being turned on its side – to optimally expose the side tiles. It will probably require that the electronics be dedicated to the ACD during this time so that every cosmic ray becomes a "trigger" and all rejection of triggers based on ACD information is suppressed. For side tiles the trigger will be one tile on one side in coincidence with any tile on the opposite side. For the top tiles, coincidences between a tile and a MIP in the calorimeter or a single straight track in the tracker would be ideal. This test takes about 2 days (or nights).

This test can be repeated at any time during test and integration as part of the functional testing procedures. The only concern is that cosmic ray muons come from "above" (distributed approximately as $\cos^2$(zenith angle)) and so a full set of calibration runs requires reorientation of the ACD.

> High Z calibration: The response of plastic scintillator to highly charged heavy nuclei is well understood. We should probably take one sample to an accelerator and measure the non-linear response of our particular material.

Light leaks (or other unusual signal noise) will be detectable in the rate counters. Singles rates above the various thresholds should be part of the diagnostic readout and if they exceed (TBD) levels should produce warnings and alarms as appropriate or initiate predetermined action automatically.

In flight calibration is described on the next page.

In flight

We will use the isotropic background for calibration. We require some mode that allows us to collect a pulse height distribution of hits on ACD tiles (either on-board or on the ground). For side tiles, coincidences between tiles on opposite sides are the easiest to interpret. For the top tiles, coincidences between a tile and a MIP in the calorimeter or a single straight track in the tracker would be ideal. We select events for this analysis above the 0.1 MIP threshold and we compare distributions with and without the 0.3 MIP threshold signal. We should have the ability to trigger on one tile (or at random) and look at another to get the noise distribution.

During normal operations we want some way to continuously monitor performance of the tiles. It could be by having periodic dedicated calibration periods as described in the next paragraph. Or we could cycle through the tiles one by one using some kind of switching network and/or a roving AtoD converter and PHA. Nominally, a pulse height distribution could be accumulated for one tile for an orbit – 90 minutes (including a few minutes of random triggers) would provide $>10^4$ events per histogram and allow us to check the MIP peak location, threshold and noise – and hence the stability of the ACD efficiency. We get a pulse height distribution from each tile every 9 days. This should suffice to monitor their performance and check for degradation. To check for systematic effects with energy of the charged particles, we might want to select particles from a given portion of an orbit only. Runs with such "constraints" might require longer integration times.

During startup/check-out or if we suspect problems we should have a mode equivalent to the ground testing described above. As above, it will probably require that the electronics be dedicated to the ACD during this time so that every cosmic ray becomes a "trigger" and all rejection of triggers based on ACD information is suppressed.

The CNO modes will be self-calibrating. The charge peaks for CNO are readily identifiable once the pulse heights are corrected for path length in the scintillator.

Light leaks (or other unusual signal noise) will be detectable in the rate counters. Singles rates above the various thresholds should be part of the diagnostic readout and if they exceed (TBD) levels should initiate predetermined action automatically. For example, entry into the radiation belts or an unexpected solar energetic particle storm should lead to automatic turn-down or shut-down of high voltage. Such action should lead to action that makes the ACD subsystem safe and notifies the Instrument Operations Center for corrective action.

A philosophical point

We will develop Ground Support Equipment (GSE) that allows us to test ACD counters at various levels of integration with their electronics. In this way we can assure no additional electronics destroys the resolution or adds unacceptable noise. We want to preserve the ability to test at the various stages throughout the integration and test of the whole LAT. Once these GSE are examining digital signal outputs from the ACDs and we can form pulse height distributions from digital data directly, this will become the primary mode of operation during the following development, integration and testing steps. At all stages of higher level integration of the ACD, once the ACD data disappears into data acquisition electronics, we will want to be able to get that data back to compare with what went in. We will need a "spigot" of both "in and out" data. If we do this, we will be able to tell a test manager whether or not our subsystem is working at any time. If we don't do this, it will be more difficult to see if something has changed and in which subsystem that change might have taken place.

<u>ACD PHA readout modes</u>

Steve Ritz suggested some possible PHA readout modes for the ACD. They are described below.

MODE 1 (Zero suppressed): ADC information from all tiles above an internally set threshold shall be read out with each event. The mean value of the number of such tiles per event shall be less than 10(TBR). The ADC information includes a 9-bit channel number label. [Note that the average event at L1 has a mean of a little more than 2 tiles hit per event, according to our simulations. Of course, the zero suppression threshold is lower than the ACD-LO discriminator threshold, so the number 10 was chosen to be comfortable.]

MODE 2 (Cyclic sampling): ADC information from 2 (TBR) tiles, independent of pulse height, shall be read out with each event. The ADC information includes a 9-bit channel number label. The set of tiles cycles through the entire list of active PMT channels in a pre-specified order.

MODE 3 (Zero suppressed plus Cyclic sampling): ADC information from all tiles above an internally set threshold shall be read out with each event. The mean value of the number of such tiles per event shall be less than 10(TBR). In addition, ADC information from 2 (TBR) tiles, independent of pulse height, shall be read out with each event. The set of tiles cycles through the entire list of active PMT channels in a pre-specified order. The ADC information includes a 9-bit channel number label, and the sets of tiles In the two classes may(TBR) overlap.

MODE 4 (Calibration): In a calibration event, ADC information from all active PMT channels is read out, independent of pulse height. ACD calibration events shall occur during regular data taking every 60 (TBR) seconds. In addition, special calibration runs, in which 1000 (TBR) ACD calibration events are taken in a row, shall be scheduled as needed.

Note that there is some overlap of functionality in these modes, and we can discuss if this is acceptable. We tried to make them very simple and straightforward. The nominal mode would presumably be MODE 1 or MODE 3, with periodic calibration runs. Note that in MODE 1 we can learn how to set the ACD discriminator (LO, HI) thresholds since the zero suppression threshold will be lower than the LO discriminator threshold, BUT we will not get pedestal information. The cyclic sampling and calibration modes give us pedestals. The numbers of tiles given allows us to get reasonable statistics (10^2 - 10^3) on each tile over a period of time that is commensurate with any orbital variations. I personally prefer MODE 3. There is the small issue of the potential list member overlap. We could resolve this by a fancier algorithm that ensures there is no overlap, but I suggest instead we simply keep the analyses of the zero-suppressed and cyclic-sampled tiles separate and not worry about a small fraction of events with twice-read tiles. This might even come in handy for diagnostics.