Transient Detection by the ACD (DRAFT for Review and comment)
Note by J. F. Ormes
June 22, 2000

This is a summary of the discussions that have taken place at GSFC on using the rate counters in the ACD electronics for detecting GRB, solar flares and other high intensity gamma-ray transients. In addition to the rate counters themselves (already planned), there would need to be some additional simple logic, presumably also in the ACD, to implement this functionality. It is a note for review by the GLAST LAT development team, by the ACD development team, and for presentation at the ACD electronics review on June 23.

<u>The basic idea</u>

Soft photons convert in the ACD scintillator tiles are detectable given the signal to noise characteristics of the PMT readout. The tiles are nominally 1 cm thick and straight through MIPs (minimum ionizing particles) deposit 2 MeV. We will have two separate discriminator settings to select events that "hit" these tiles, one nominally set at 0.1 MIP and the other at nominally 0.3 MIP. Because photons with energy ~ 1 MeV usually don't leave all their energy in 1 cm of plastic, the > 0.1 MIP rate will be responding to the integral flux of photons >200 keV, i.e. by forming the rate of >0.1 but NOT > 0.3 we can count them. Note that since the detectors by design are 0.9997 efficient to charged particles above the 0.3 MIP threshold, this trigger mode includes, by definition, only 0.0003 of the charged particle background.

Jay Norris has studied this set of >200 keV photons, including the spectra of GRB photons, the scintillator areas and conversion efficiencies, the presence of photon background, etc. and has estimated the ACD sensitivity by scaling the BATSE NaI response for real GRBs. He has determined that the ACD tiles would trigger on the brightest 60% of the BATSE triggers. (In the real world this will be somewhat less – e.g. if non-Poisson fluctuations in the background is included, there is additional noise, etc.) This is essentially the same efficiency as he expects for the GBM monitor. The orientation of the ACD tile planes provides a natural means for triangulating positions in much the same manner as BATSE but we haven't studied how to implement finding this directional information yet. If we decide to pursue this mode Jay tells me he will redo his analysis more carefully.

So ~ 200 bursts per year could be detected by the ACD and an alert given to the GLAST LAT on a time scale consistent with their flux doubling time.

> Note: The idea of using the >0.1 but NOT > 0.3 events should be credited to Alex Moiseev. It came once we realized we'd need a threshold at 0.1 MIP to carefully measure where the 0.3 MIP threshold actually was set. If we had thought of it before we might have included it in our proposal and it would have obviated the

need for a separate GRB trigger. However, the GBM is still needed to give the spectrum.

South Atlantic Anomaly (SAA)

I have checked that the ACD rate counters would be able to detect the rate increase due to entry into the South Atlantic Anomaly (SAA) in time to turn the detectors off. The time scales for doubling of fluxes are sufficiently long that this is possible. This is not to say the ACD could be used as a sensor for the SAA. (Once these detectors turn themselves off because the flux gets too high, they cannot sense when the flux goes down again to a point where it would be safe to turn back on again.) The detector of SAA entry was based on looking for the rate of increase in the counting rate increase.

Detecting solar flares

Solar flares however, have rate of increase in the counting rate increase about the same as and sometimes faster than those due to entry into the SAA, so they could be detected, too. If there is a separate counter that does the SAA detection (ref. notes by E. Grove), then provided we aren't being fooled by the SAA a rate increase trigger could be provided by the ACD to the instrument.

So solar flares could be detected by the ACD and an alert given to the GLAST LAT on a time scale consistent with their rise time. (We might want more stringent criteria to eliminate false triggers, e.g. two successive 5 (TBR) sigma increases.)

Why do this?

This trigger (and/or a similar one from the GBM) can be used to place the electronics and/or the ACD into a high rate mode. High data rates will lead to "ACD freeze-up" where good events are lost due to false ACD vetos. This may be especially relevant for the brightest 10-20% of the bursts. We have specified that there should be no more than 1% loss of photons due to false vetos. Our time constants have been determined based on 1% loss due to chance crossings of cosmic rays assuming, conservatively, a hit in 1 m^2 area of tile and 1 Hz/cm^2 rates in a single tile and 30 Hz gamma-ray rates.

We don't actually know how high the fluxes might be during a GRB (EGRET was dead time limited) and we do know that there were flares that saturated or almost saturated the EGRET ACD. During GRB and solar flares we might want to have a mode that ignores ACD info and grabs all the triggers it can get for some limited duration. The spacecraft could reserve some part of the data storage for such events assuming the LAT can deal with them – pump them through, background and all, essentially without any on-board software selection. Then the ACD could be applied (or not) during ground processing.