SLAC-PUB-12888

LAT Onboard Science: Gamma-Ray Burst Identification

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Abstract.
The main goal of the Large Area Telescope (LAT) onboard science program is to provide quick identification and localization of Gamma Ray Bursts (GRB) onboard the LAT for follow-up observations by other observatories. The GRB identification and localization algorithm will provide celestial coordinates with an error region that will be distributed via the Gamma ray burst Coordinate Network (GCN). We present results that show our sensitivity to bursts as characterized using Monte Carlo simulations of the GLAST observatory. We describe and characterize the method of onboard track determination and the GRB identification and localization algorithm. Onboard track determination is considerably different than in the on-ground case, resulting in a substantially altered point spread function. The algorithm contains tunable parameters which may be adjusted after launch when real bursts characteristics at very high energies have been identified.

Keywords: Gamma-ray Bursts, GLAST
PACS: 95.55.Ka; 95.85.Pw; 98.70.Rz

ALGORITHM OVERVIEW

These procceedings describe the software used to determine GRB positions onboard the LAT. Our localizations are meant to be position estimates useful for followup observations by observatories interested in studying GRBs in other wavebands. While the Glast Burst Monitor will also be producing its own onboard detections and localizations, it is the hope that the LAT's better point spread function will result in an improved localization if GRBs are bright enough in the high energy regime. The detection of GRB photons by the EGRET instument in the energy range $\sim$20 MeV - $>$10GeV makes a strong case for the LAT team's development of such an algorithm.

The quantities available to the onboard algorithm differ substantially from the on-ground information. The onboard software calculates 3D tracks used by our trigger and localization algorithms. However, the true gamma direction is measured much better by the ground reconstructed variables. We are currently investigating improvements to the onboard tracking.The onboard point spread function is about a factor of 2-5 worse than the one onground. Another limitation is the available energy measurement. Onboard we have access to a crude estimate of the true energy. However, we depend on this energy measurement for determining track quality. Higher energy tracks play a more important role in determining the final localization.

The onboard GRB detection algorithm described here capitalizes on both temporal and spatial characteristics of GRBs. It works by associating a probability for a cluster of tracks to be located in a small part of the sky during a short interval of time. Triggering on bursts depends on setable parameter choices. We use a phenomenological burst simulator and expected background events to help in determining our parameter choices. They are adjustable in flight, however.

Events (photons and background) with onboard 3D tracks are fed to the algorithm in time order. In this study, a list of the most recent 40 events is maintained. The algorithm searches this list for the cluster of events that has the smallest probability of occurring in time and space; this is presumed to be a candidate GRB. When the associated spatial and temporal probabilities pass a pre-selected threshold we 'trigger' on a GRB (see the figure). Events from this cluster and all clusters within the next 10 seconds that pass our cut get added to a list used to obtain a localization. The size of the list, the photon accumulation time window and the propability cut are tunable parameters.

Contributed to 1st GLAST Symposium, 02/05/2007--2/8/2007, Stanford, CA

Work supported in part by US Department of Energy contract DE-AC02-76SF00515

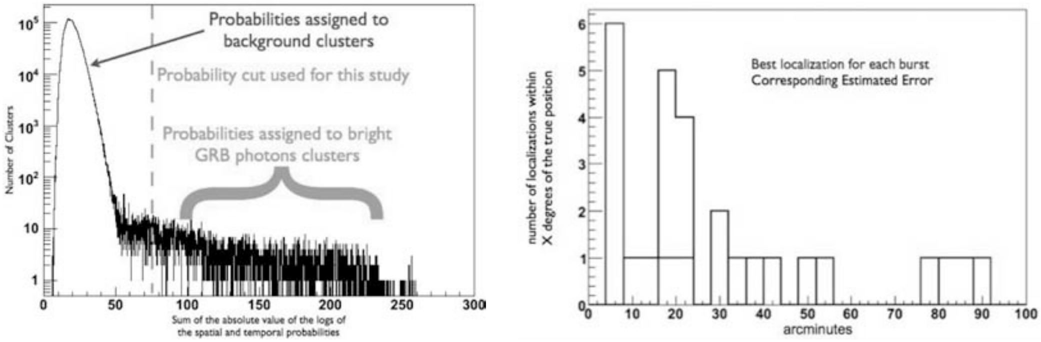
DISCUSSION

We measure the trigger efficiency using GRB photons interleaved with background events using the Monte Carlo LAT simulator GLEAM [1].Our full sample of bursts was generated over the full sky. For those that lie within 70 degrees zenith angle ∼70 bursts have 5 or more photons with onboard 3D tracks, and the brightest burst has ∼1000 tracks. The mean background rate of onboard 3D tracks over our field of view, esentially a quater the sky, is ∼210 Hz. To study the localization we set the estimated false trigger rate to once every 35 days. This high threshold effectively requires that a burst have more than 10 onboard 3D tracks, reducing the total number of available bursts to ∼50. Our trigger efficiency is ∼ 6% of all our bursts (generated over the the whole sky), ∼ 16% of the subset in our field of view (0 - 70 degrees off axis), or 18 GRBs. This corresponds to ∼ 34% of the burst with at least than 10 photons. Looseing our cuts so as to increase the estimated false trigger rate to once per week only increases the number of bursts found by one.

Once a burst has triggered we maintain a list of all events that pass our cuts during the next 10 seconds and perform a localization. With the cuts used in this analysis, the list of photons that we use for localizations is, on average, 97% GRB photons. Very few background events contaminate our localization results. The localization is an energy weighted average of the position of the events in this list. The right hand side figure shows the resolution obtained for our localizations, choosing the best localization for each burst. It also shows the corresponding estimated error. We aim to identify bursts to better than 1 degree of accuracy onboard.

We are currently working on two improvements. The first is to change the triggering portion of the algorithm to be based on a histogram/binning of the sky. This has the impact of reducing the computational load by removing the need to calculate many probabilities that depend on transcendental functions. Thus far it appears that both methods procduce similar results. The second is an improvement in the quality of the onboard 3D tracks. The improved point spread function should help in better determining GRB positions. These different tracks may affect the overall efficiency of the onboard filter software. We are testing that these improvement do not affect the quality of data sent to the ground for other science analyses.

Understanding the potential for a good localization is a function of the number of tracks, the energy of the incoming photons, the zenith angle of the GRB, and the rate of background. We will be more likely to trigger if there are a large number of photons that occur simultaneously. These will most likely be at lower energies. However, the lower quality point spread function works against a good localization, especially at low energies. At large zenith angles (where most of the bursts will be found) we also have a degredation of the psf. We are testing the algorithm by using samples of synthetic bursts placed in accordance with the BATSE sky distribution and also samples placed at fixed zenith angle and with fixed spectral parameters (though we only report on the first method of testing here). We can therefore characterize the performance on average and under specific conditions. If our simulations hold true, it appears that we will be able to produce localizations useful to the rapid follow-up astronomy community.



The left hand plot shows schematically how the sums of the negative logs of the probabilities for clusters appear for a mix of background and GRB photons. The large hump is due to clusters of background events, whereas the tail is due to clusters of events from bright GRBs. The right hand plot shows the localization accuracy.

REFERENCES

1. P. Boinee, et al., "Gleam: the GLAST Large Area Telescope Simulation Framework," in *Science with the New Generation of High Energy Gamma-ray Experiments*, 2003.