Automated Science Processing for GLAST LAT Data

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Abstract. Automated Science Processing (ASP) will be performed by the GLAST Large Area Telescope (LAT) Instrument Science Operations Center (ISOC) on data from the satellite as soon as the Level 1 data are available in the ground processing pipeline. ASP will consist of time-critical science analyses that will facilitate follow-up and multi-wavelength observations of transient sources. These analyses include refinement of gamma-ray burst (GRB) positions, timing, flux and spectral properties, off-line searches for untriggered GRBs and gamma-ray afterglows, longer time scale monitoring of a standard set of sources (AGNs, X-ray binaries), and searches for previously unknown flaring sources in the LAT band. We describe the design of ASP and its scientific products; and we show results of a prototype implementation, driven by the standard LAT data processing pipeline, as applied to simulated LAT and GBM data.

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INTRODUCTION

ASP comprises automated processing of Level 1 (L1) LAT data for time-critical science analyses. Level 1 data are the event and spacecraft data that have passed through standard event reconstruction, classification, and filtering. These data are packaged as FITS files for delivery by the GLAST Science Support Center to the astronomical community, and can be analyzed using the LAT suite of ScienceTools.

"Time-critical science" entails the monitoring of transient behavior from astrophysical sources. If such behavior is observed at an appropriate level of significance, it triggers a call for follow-up observations at other wavelengths, or by the LAT itself. Note that owing to the latencies in transmission through the ground network and the time required for L1 processing, events in the L1 data will typically be several hours old before the onset of ASP.

The ASP tasks fall into two broad categories: GRB detection and follow-up, and flaring source monitoring and detection. Table 1 lists the specific tasks in these categories, the data products that will be publicly available, delivery methods, and the proposed latencies associated with each task. Note that the latencies are referred to the time of the availability of the L1 data needed for the specific analysis. The content of the deliverables and their latencies are defined in the LAT Data Release Plan (DRP).

TABLE 1. ASP Tasks and Data Products

Task	Products	Delivery Method	Proposed Latency
GRB Position Refinement using LAT data	Position & error, date, time-of-day, and fluences or upper limits	GCN Notice; Web site	15 min
Blind search for GRBs in L1 data	Position & error, date, time-of-day, and fluences or upper limits	GCN Notice; Web site	15 min
GRB afterglow detection and analysis	Flux estimates on various time scales, hardness or spectral index estimates; position and error	GCN Circular; Web site	1 hour
Monitoring of DRP "Sources-of-Interest"	Fluxes and errors (or ULs) on day and week intervals in 5 bands spanning 100 MeV to 30 GeV	Web site	Weekly updates
Flare detection of new DRP sources	Coordinates, ID, flare onset and duration, fluxes in 5 standard bands	IAU Circular or email notice; Web site	12 hours

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TABLE 2. Data Release Plan Sources-of-Interest

Source	3EG Flux (10^{-8}cm^{-2}s^{-1})	Source	3EG Flux (10^{-8}cm^{-2}s^{-1})
0208−512	85.5 ± 4.5	1730−130	36.1 ± 3.4
PKS 0528+134	93.5 ± 3.6	3C 454.3	53.7 ± 4.0
0827+243	24.9 ± 3.9	W Comae*	11.5 ± 1.8
Mrk 421	13.9 ± 1.8	PKS 2155−304*	30.4 ± 7.7
3C 273	15.4 ± 1.8	Mrk 501*	···
3C 279	74.2 ± 2.8	1ES 1959+650*	···
1406−076	27.4 ± 2.8	1ES 2344+514*	···
PKS B 1622−297	47.4 ± 3.7	H 1426+428*	···
1633+382	58.4 ± 5.2	LSI +61 303	69.3 ± 6.1

GRB ANALYSIS AND FLARING SOURCE MONITORING

ASP analyses of GRBs can be triggered in two ways: (1) by the arrival of L1 data with each TDRSS downlink (every ~ 3 hours); (2) by notification of a burst detection by the GBM, on-board by the LAT, or via a GCN Notice that would be issued for detections by other instruments. In the latter cases, the GRB position estimate and trigger time are used by the ASP GRB position refinement task in querying the L1 database for the appropriate event and spacecraft data that will be needed for the subsequent position, light curve, and spectral analyses. In the blind search case, the position and timing estimates obtained from the blind search analysis are sent to these sub-tasks.

Figure 1 shows a scatter plot of photons from a simulated GRB event that was analyzed with ASP. These data were part of the recent GLAST Data Challenge II (DC2) exercise.

The LAT DRP specifies "sources-of-interest" that will be monitored on daily and weekly time scales. In the current plan, these sources consist of the 18 objects listed in Table 2. The content of this list is under review, and the revised list will be posted at `http://glast.gsfc.nasa.gov/ssc/data/policy/LAT_Monitored_Sources.html`. Presently, eleven of these objects are blazars that have been detected by EGRET at a significance greater than 5σ. The remaining 6 blazars (indicated with an asterisk) have marginal ($<5\sigma$) or non-detections by EGRET but are known emitters at TeV energies. The final source is LSI +61 303, a high mass X-ray binary with a strongly suspected EGRET association.

In addition to these sources, ASP will search for any other source that flares in the LAT band on 1 day or 1 week time scales. Sources which flare with fluxes greater than 2×10^{-6} cm^{-2}s^{-1} ($E > 100$ MeV) will have IAU circular or email notifications sent out indicating the onset of the flare and will have their daily and weekly fluxes reported on a weekly basis until the flux of the source returns below 2×10^{-7} cm^{-2}s^{-1}.

Figure 1 shows flux estimates obtained using ASP analyses for a simulated flare from 3C 279 during DC2.

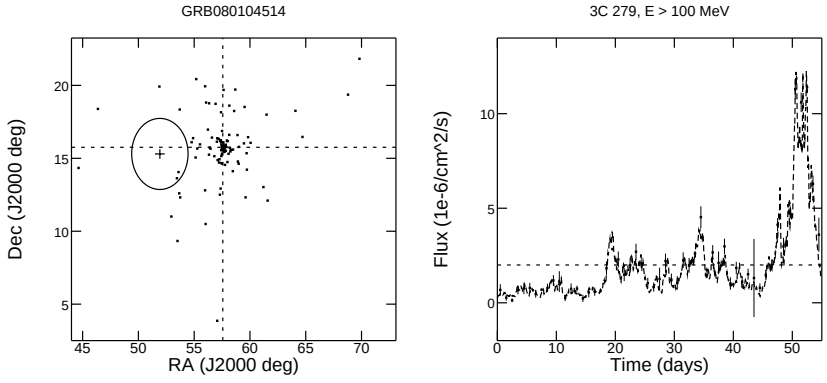

FIGURE 1. Left: Scatter plot of detected events from a simulated GRB from DC2. The plus sign and contour indicate the GBM position estimate and error circle. The dotted horizontal and vertical lines show the ASP position estimate based on L1 data; the 90% C.L. error circle radius is 0.08°. Right: Example of ASP flux monitoring results for 3C 279 in the DC2 data. The dashed light curve is the input model and the data points are the measurements. The dotted horizontal line shows the 2×10^{-6} cm^{-2}s^{-1} ($E > 100$ MeV) flux trigger for including new transients.