Highlights from monitoring candidate gamma-ray binary systems with Fermi/LAT

Thomas Glanzman (SLAC) and Richard Dubois (SLAC)
on behalf of the Fermi Large Area Telescope Collaboration

Summary: An automated processing system monitors known and candidate gamma-ray emitting binary systems.

Abstract

Ninety-four candidate gamma-ray emitting binary systems are automatically monitored on a weekly and monthly basis by a Routine Science Processing (RSP) task using LAT data from the Fermi Gamma-ray Space Telescope. This task executes a standard analysis which dynamically creates a source model with point sources (1FGL) and diffuse backgrounds, performs a spectral fit, creates counts maps, light curves and various plots in addition to a summary report. Analysis customization is allowed on a system-by-system basis, e.g., changes to the spectral model, and removal of nearby pulsar influence. This poster summarizes the current state of the analysis mechanism, planned enhancements, and presents selected highlights from this analysis.

Routine Science Processing (RSP):

- Automated weekly analysis on data collected from past seven days of Fermi/LAT [1] data
- Monthly submission of full-mission analysis
- Special 26.496 day interval (orbital period) analysis of LS I +61º 303
- Analysis driven by python scripts running in the Fermi Processing Pipeline [2]
- Monitoring and analysis program based on public data and public analysis tools [3,4,5]

RSP Science Goals:

- Monitor emission from well-known gamma-ray binary systems
- Search for gamma-ray emission from HMXB/LMXB and other systems (see table at right)
- Perform *standard analysis* on each source
- Data products include: fit results; plots; tabular data, photon and spacecraft FITS files, source model (xml) – all available for further analysis
- Generated summary reports stored in a web-based wiki (Confluence)

Standard Analysis details:

astroserver (SLAC FITS data retrieval system)
- radius = 10.0
- event class = diffuse
- dataset = P6_public_v2

gtselect
- emin = 100 MeV
- emax = 300 GeV
- zmax = 105 deg

Nearby pulsar on-phase removal

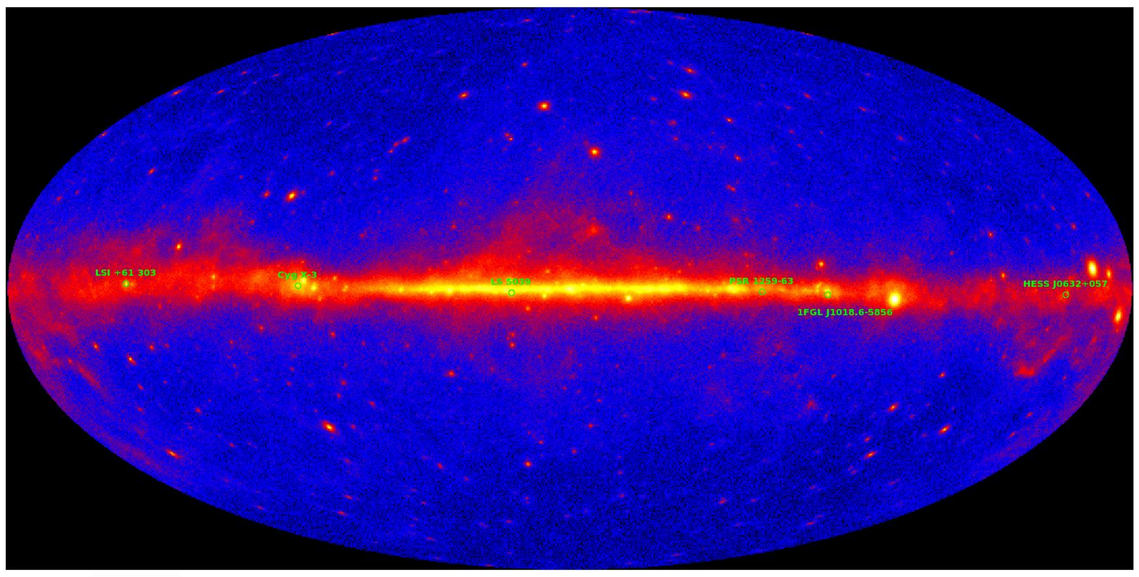
gtmktime
- filter = 'DATA_QUAL==1 && LAT_CONFIG==1 && ABS(ROCK_ANGLE)<52'
- roicut = yes

gtbin (binned analysis):
- nypix = 60
- nxpix = 60
- binxz = 0.2

gtltcube
- irfs = P6_V3_DIFFUSE

Source model
- PowerLaw or PL with exp cutoff point source
- backgrounds from 1FGL catalog modeled as PL: use all sources within 15-deg, those within 3-deg have free spectral parameters (normalization and index)

gtlike
- DRMNGB followed by MINUIT
- binned likelihood for full-mission
- unbinned likelihood for 7-day



1-year gamma-ray sky showing location of known gamma-ray emitting binary systems.

Monitoring characteristics:

- 7-day sampling appropriate for "few day" to long-term flux changes
- Fitted flux plots below illustrate:
  - Long-term flux change in LS I +61º 303
  - Relatively stable behavior from LS 5039
  - Multi-week outburst from PSR B1259-63
  - Multi-day to multi-week flares from Cyg X-3 and Crab
  - Not all flares observed (too short and/or weak)
- Continuing to understand sensitivity of 7-day sample approach

Future work:

- Extend standard analysis to include improved fitting/limits calculations, flare detection, periodicity analysis, and additional plots.
- Continue per source customizations to better handle challenging areas of the sky, e.g. GX 339-4, which produce false positive alerts
- Add daily RSP cycles for a few sources, e.g., Cygnus X-3 for increased flare sensitivity
- Consider making certain data products ***public***, e.g., plots and tabular data.

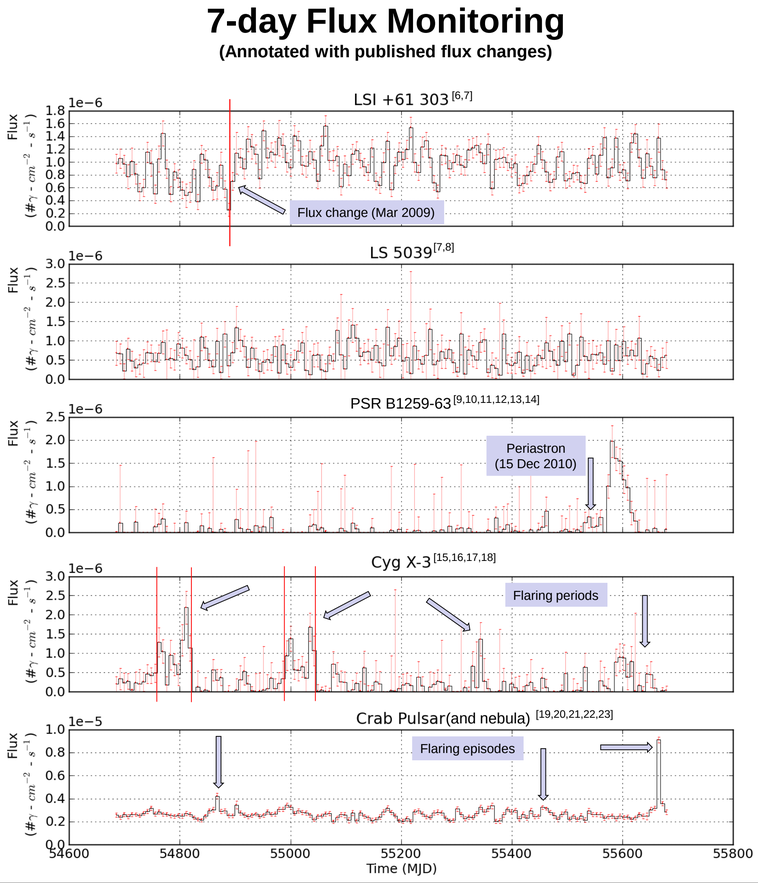
SOURCE	RA	DEC
SMC_X-1	19.27144	-73.4433
GS_1124-683	171.6108	-68.6756
LMC_X-4	83.20746	-66.3705
PSR_B1259-63	195.6986	-63.8357
GX_304-1	195.3217	-61.6019
Cen_X-3	170.3158	-60.623
IGR_J11215-5952	170.445	-59.8616
1FGL_J1045.2-5942	161.305	-59.7057
1FGL_J1018.6-5856	154.6444	-58.9507
Cir_X-1	230.1703	-57.1667
XTE_J1550-564	237.7446	-56.4767
4U_1636-536	250.2313	-53.7514
4U_1608-52	243.1792	-52.4231
1FGL_J1617.5-5105c	244.391	-51.0856
XTE_J1650-500	252.5042	-49.9625
GX_339-4	255.7063	-48.7897
4U_1543-47	236.7858	-47.6694
4U_1630-47	248.5017	-47.3942
XTE_J1701-462	255.2436	-46.1857
GX_340+0	251.4488	-45.6111
IGR_J16479-4514	251.996	-45.2166
Vela_Pulsar	128.836	-45.176
IGR_J08408-4503	130.199	-45.0584
4U_1735-444	264.7429	-44.45
4U_1705-440	257.227	-44.102
4U_1702-429	256.5638	-43.0358
Vela_X-1	135.5286	-40.5547
GRO_J1655-40	253.5006	-39.8458
GX_349+2	256.4354	-36.4231
GX_354-0	262.9892	-33.8347
SLX_1746-331	267.4521	-33.2051
XTE_J1817-330	274.4314	-33.0188
1FGL_J1835.3-3255	278.833	-32.9289
H1743-322	266.2583	-32.2267
XTE_J1720-318	259.9958	-31.7503
4U_1820-303	275.9186	-30.3611
XTE_J1739-302	264.798	-30.3438
1E_1740.7-2942	265.9785	-29.7452
1FGL_J1745.6-2900c	266.419	-29.0139
XTE_J1748-288	267.0211	-28.4738
IGR_J17497-2821	267.4088	-28.3547
GX_3+1	266.9833	-26.5636
IGR_J17544-2619	268.607	-26.3328
GRS_1758-258	270.3013	-25.7433
V4641_Sgr	274.8399	-25.407
H1705-250	257.0608	-25.0914
GX_5-1	270.2842	-25.0792
1FGL_J1824.5-2449	276.137	-24.8292
XTE_J1818-245	274.605	-24.5419
PSR_J1614-2230	243.652	-22.509
GX_9+1	270.3846	-20.5289
1FGL_J1748.7-2020	267.19	-20.3485
GX_13+1	273.6315	-17.1574
SAX_J1818.6-1703	274.673	-17.0593
GX_9+9	262.9342	-16.9617
Sco_X-1	244.9795	-15.6401
MAXI_J1659-152	254.79	-15.27
LS_5039	276.5627	-14.8484
GX_17+2	274.0058	-14.0364
AX_J1841.0-0536	280.252	-5.5963
IGR_J18483-0311	282.075	-3.1617
SWIFT_J1753.5-0127	268.3679	-1.4525
AE_Aqr	310.0382	-0.87085
1A_0620-00	95.685	-0.34583
Aql_X-1	287.8167	0.585
FIRST_J102347.6+003841	155.9487	0.644806
SS_433	287.9565	4.98267
Ser_X-1	279.9896	5.03583
SAX_J0635.2+0533	98.8225	5.55583
HESS_J0632+057	98.24292	5.80556
4U_0614+091	94.28042	9.13694
XTE_J1908+094	287.2212	9.38469
GRS_1915+105	288.7983	10.94556
1FGL_J1916.0+1110c	289.0246	11.1725
Geminga	98.476	17.77
Crab_Pulsar	83.633	22.014
XTE_J1859+226	284.6733	22.65817
GS_2000+251	300.7066	25.23647
1A_0535+26	84.72738	26.31578
GRO_J0422+32	65.42821	32.90742
1FGL_J2004.7+3343	301.185	33.7168
GS_2023+338	306.0158	33.86756
Cyg_X-1	299.5903	35.2016
Her_X-1	254.4576	35.34239
XTE_J2012+381	303.1575	38.18364
Cyg_X-2	326.1717	38.32167
Cyg_X-3	308.1074	40.95779
3EG-J2033+4118	308.41	41.32
AGL_J2241+4454	340.3918	44.81171
XTE_J1118+480	169.5454	48.03694
AM_Her	274.0555	49.86783
1E_2259+586	345.2846	58.87901
LSI_+61_303	40.131	61.229
4U_0115+63	19.63292	63.74

Monitored source list

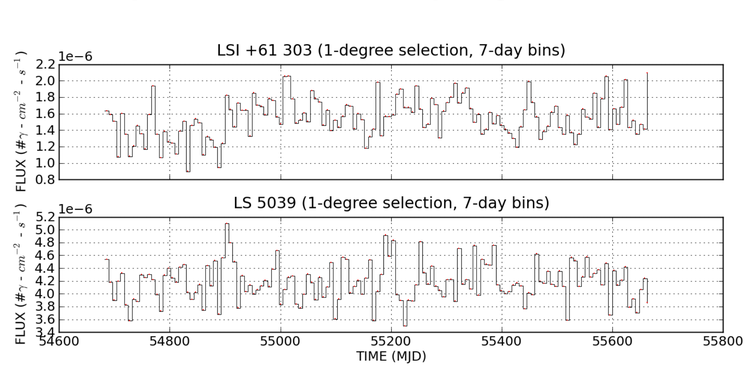
RED = known gamma-ray emitting binary system
GREEN = bright 'control' source

7-day Flux Monitoring

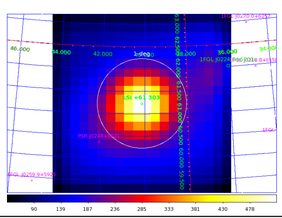
(Annotated with published flux changes)

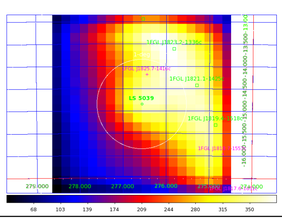


Aperture Photometry Light Curves

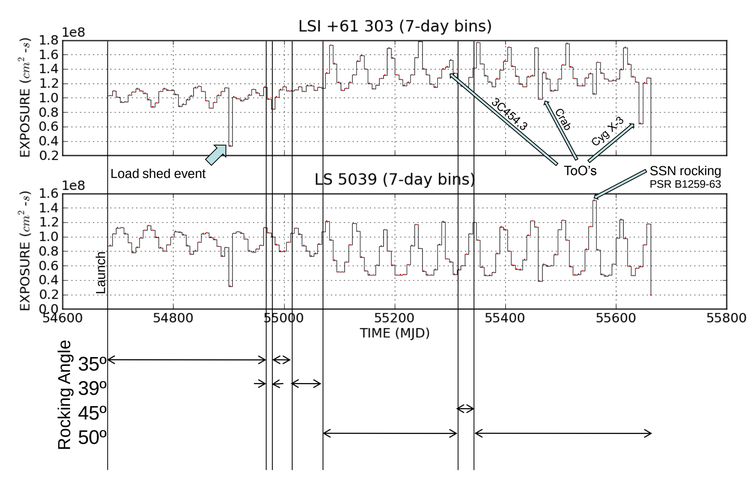


- Exposure corrected aperture photometry light curves with same 7-day binning as fitted flux curves
- Flux differences (compared with fitted flux plots) can become significant: aperture photometry alone does not account for backgrounds. Counts maps for LSI +61º 303 (left) and LS 5039 (right) show very different background characteristics:





Monitoring Exposure Variations



- Prominent features of these plots include the spacecraft 55-day precession period and exposure variations due to the different observatory modes: Survey (with various rocking angles); Targets of Opportunity; modified rocking angle; Autonomous Repoint Requests
- Rocking angle change from 35 to 50 degrees was a benefit to LSI +61º 303 (dec=61) but not for LS 5039 (dec=-15)

All plots generated using recorded RSP results from full-mission analysis on 14 Apr 2011, and from 143 weekly intervals from 4 Aug 2008 through 1 May 2011.

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dragon@slac.stanford.edu