Journal of Physics: Conference Series

PAPER • **OPEN ACCESS**

Unidentified EGRET sources and their possible Fermi counterparts

To cite this article: A R Lyapin *et al* 2017 *J. Phys.: Conf. Ser.* **798** 012005

Unidentified EGRET sources and their possible Fermi counterparts

A R Lyapin[1], I V Arkhangelskaja[2] and D S Larin[2]

[1] Moscow Institute of Physics and Technology (State University), Institutskiy pereulok 9, Dolgoprudny, Moscow Region, 141701, Russia
[2] National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Kashirskoe highway 31, Moscow, 115409, Russia

E-mail: l.alexander.2.71@gmail.com

Abstract. Unidentified EGRET sources from 3EG catalog have been analyzed. Preliminary data analysis has shown at least 23 of these sources coincide with those in 3FGL Fermi catalogue within 1, 2 and 3 sigma error intervals of the coordinates and fluxes. Their properties are discussed in the presented work. Even 3-sigma difference allows supposing sources similarity because of more than 3-sigma distinctions in values of fluxes between identified EGRET sources and their Fermi counterparts. For instance, the coincidence between 3EG J1255-0549 and 3FGL J1256.1-0547 was reported in Fermi catalogues 1FGL, 2FGL, 3FGL. However, these sources fluxes (in units of 10^{-8} photons $\times$ cm^{-2} $\times$ s^{-1}) in the energy band $E > 100$ MeV were 179.7 $\pm$ 6.7 (3EG), 44.711 $\pm$ 0.724 (3FGL), 53.611 $\pm$ 0.997 (2FGL) and 67.939 $\pm$ 1.861 (1FGL). Such effect was observed for sufficient portion of identified EGRET sources. It could cause by troubles of particles identification by Fermi/LAT trigger system. Very often charged particles recognized as gamma-quanta because of wrong backsplash analysis. Nevertheless, gammas counts as charged particles due analogous reason and rejected during ground data processing. For example, it appears as geomagnetic modulation presence on gamma-quanta count rate latitudinal profiles in energy band $E > 20$ MeV.

1. EGRET telescope and its data

EGRET (Energetic Gamma Ray Experiment Telescope) was the high-energy gamma-ray telescope on the Compton Gamma Ray Observatory (CGRO) and operated in energy range from 30 MeV to over 20 GeV [1]. It had a large field of view, about 80° in diameter, although the instrument point-spread function and the effective area degrade significantly beyond 30° off-axis. The effective area on-axis was more than 1000 cm^2 between 100 MeV and 3 GeV. The angular resolution was strongly energy dependent, with a 67% confinement angle of 5.5° at 100 MeV, falling to 0.5° at 5 GeV on axis. Bright gamma-ray sources can be localized with almost 10' accuracy. The energy resolution of EGRET was 20-25% over most of its range of sensitivity. Arrival times for photons were recorded with 50 μs accuracy. 1EG, 2EG and 3EG catalogs contain 31, 129 and 271 events, respectively. 1EG and 2EG data were being collected during CGRO Phase 1 (1991 April - 1992 November) [2] and Phase 2 (1992 November - 1993 September) [2]; 3EG events are based on data obtained by the Energetic Gamma-Ray Experiment Telescope (EGRET) on board the Compton Gamma-Ray Observatory (CGRO) during the period from 1991 April 22 to 1995 October 3 [1].

2. Gamma-telescope Fermi/LAT and its database

The baseline LAT is modular, consisting of a 4 × 4 array of identical towers. Each 40 × 40 cm^2 tower comprises a tracker, calorimeter and data acquisition module. The tracking detector consists of 18 x-y layers of silicon strip detectors. It is well-matched to the requirements of high detection efficiency (> 99 %), excellent position resolution (< 60 μm in this design), large signal : noise (> 20:1), negligible cross-talk, and ease of trigger and readout with no consumables. The calorimeter in each tower consists of eight layers of 12 CsI bars in a hodoscopic arrangement, read out by photodiodes, for a total thickness of 10 radiation lengths. The anticoincidence shield covers the array of towers, employs segmented tiles of scintillator, read out by wavelength-shifting fibers and miniature phototubes [3]. The LAT is self triggered; events that cause detector hits in three planes automatically trigger readouts of each tower and the anticoincidence system. Efficient rejection of the charged particle background, which is thousands of times more intense than the celestial γ-ray emission, is essential for Fermi to function. The expected raw trigger rate in orbit will average a few kHz, and the rate of celestial γ-rays will be a few Hz. The anticoincidence system is only the first line of defense in identifying cosmic rays that trigger the telescope. Some of the discriminators will be applied onboard to reduce the trigger rate to the ∼30Hz rate that can be stored and downlinked [4, 5]. 1FGL, 2FGL and 3FGL catalogs include 1451, 1873 and 3033 number of events, respectively. 1FGL data were being acquired from August 4, 2008 (this phase includes 11 months); 2FGL events collection began on same date (phase 2 lasted 24 months) [6]; 3FGL sources are based on four years of data from the Fermi Gamma-ray Space Telescope mission [7].

3. Data analysis

Table 1 shows unidentified EGRET sources and their possible 3FGL Fermi counterparts. Coordinates of these sources and spectrum of their fluxes' relation are presented in figure 1.

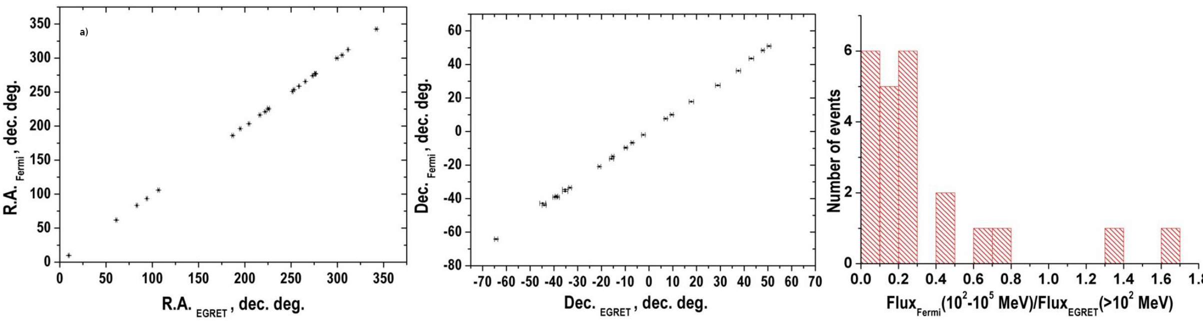

Figure 1. Coordinates of 3EG sources and their potential 3FGL counterparts together with their spectrum of fluxes' relation.

Figure 2 illustrates the same parameters for 3EG sources and their 3FGL ID and associated counterparts. Mutual fluxes' dependence of 3EG sources and their potential 3FGL counterparts is shown in figure 3(a). Finally, figure 3(b) represents correspondent mutual dependence for ID and associated 3FGL sources in the same energy range. As a part of present work, it was noticed that 2FGL sources have less 3EG associations than 3FGL ones. This also applies to those in 1FGL catalogue.

IOP Conf. Series: Journal of Physics: Conf. Series **798** (2017) 012005 doi:10.1088/1742-6596/798/1/012005

Table 1. 3EG sources and their possible Fermi counterparts.

Name 3EG[1]	R.A.[1]	Decl.[1]	θ_{95}[1]	F[1]	ΔF[1]	Name 3FGL[7]	R.A.[7]	Decl.[7]	θ_1[7]	F_{25}[7]	ΔF_{25}[7]
J0038−0949	9.74	−9.82	0.59	12	3.7	J0039.1−0939	9.782	−9.658	0.283	0.6577	0.3651
J0404+0700*	61.15	7	0.7	11.1	2.8	J0407.5+0740	61.887	7.672	0.095	2.5262	0.5011
J0533+4751*	83.32	47.85	0.6	14	2.8	J0533.2+4822	83.307	48.378	0.032	6.4675	0.4697
J0616−3310	94.15	−33.17	0.63	12.6	3.2	J0614.1−3329	93.537	−33.495	0.013	8.0242	0.3983
J0706−3837	106.72	−38.63	0.9	52	17.8	J0703.4−3914	105.861	−39.238	0.075	0.9901	0.4288
J1227+4302	186.76	43.04	0.99	21.7	7.1	J1224.6+4332	186.158	43.546	0.115	1.5388	0.2821
J1300−4406	195.06	−44.1	0.84	10.6	2.9	J1304.3−4353	196.096	−43.9	0.022	2.4188	0.6635
J1337+5029	204.38	50.48	0.72	9.2	2.6	J1333.7+5057	203.426	50.954	0.062	1.9746	0.3942
J1424+3734	216.22	37.58	0.88	16.3	4.9	J1424.9+3615	216.244	36.254	0.04	0.9693	0.388
J1447−3936	221.95	−39.61	0.87	11	2.7	J1444.0−3907	221.009	−39.13	0.018	1.9755	0.6945
J1500−3509	225.43	−35.25	1.15	10.9	2.8	J1457.4−3539	224.355	−35.657	0.021	14.8047	0.6087
J1500−3509	225.43	−35.25	1.15	10.9	2.8	J1505.0−3432	226.25	−34.547	0.091	1.2926	0.5204
J1646−0704*	251.62	−7.08	0.53	11.8	3.1	J1643.6−0642	250.921	−6.706	0.06	3.2776	0.7365
J1652−0223*	253.02	−2.4	0.73	16.6	3.7	J1653.6−0158	253.419	−1.98	0.036	4.6241	0.5762
J1714−3857	258.52	−38.96	0.51	43.6	6.5	J1714.5−3832	258.643	−38.549	0.029	18.5705	4.9001
J1741−2050	265.41	−20.84	0.63	24.1	3.9	J1741.9−2054	265.491	−20.914	0.022	18.0778	1.1014
J1813−6419	273.34	−64.33	0.68	14.2	4	J1816.0−6407	274.002	−64.133	0.123	1.6642	0.4471
J1824−1514	276.2	−15.24	0.52	35.2	6.5	J1826.2−1450	276.568	−14.847	0.019	59.4559	3.4415
J1825+2854*	276.29	28.91	0.97	34.3	10.9	J1829.2+2731	277.313	27.525	0.131	2.095	0.4768
J1958−4443	299.5	−44.72	1.23	33.6	10.4	J1959.1−4245	299.781	−42.76	0.062	3.7896	0.4319
J2020−1545	305.1	−15.75	0.9	11.8	3.4	J2017.6−1616	304.425	−16.269	0.075	0.7117	0.4214
J2046+0933*	311.58	9.57	0.6	20.8	6.2	J2049.7+1002	312.44	10.045	0.09	2.4271	0.5704
J2248+1745	342.24	17.77	0.94	12.9	3.5	J2250.3+1747	342.581	17.796	0.091	3.6048	0.9975

*Denotes that the value was obtained by multiplying the 68% radius by 1.62. This was necessary in cases of unclosed or extremely irregular 95% contours [1].

IOP Conf. Series: Journal of Physics: Conf. Series **798** (2017) 012005 doi:10.1088/1742-6596/798/1/012005

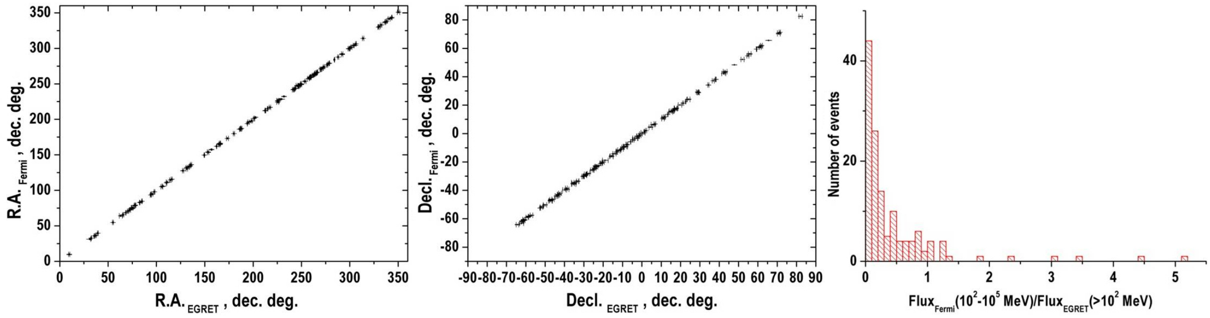

Figure 2. Coordinates of 3EG sources and their ID and associated 3FGL counterparts together with their spectrum of fluxes' relation.

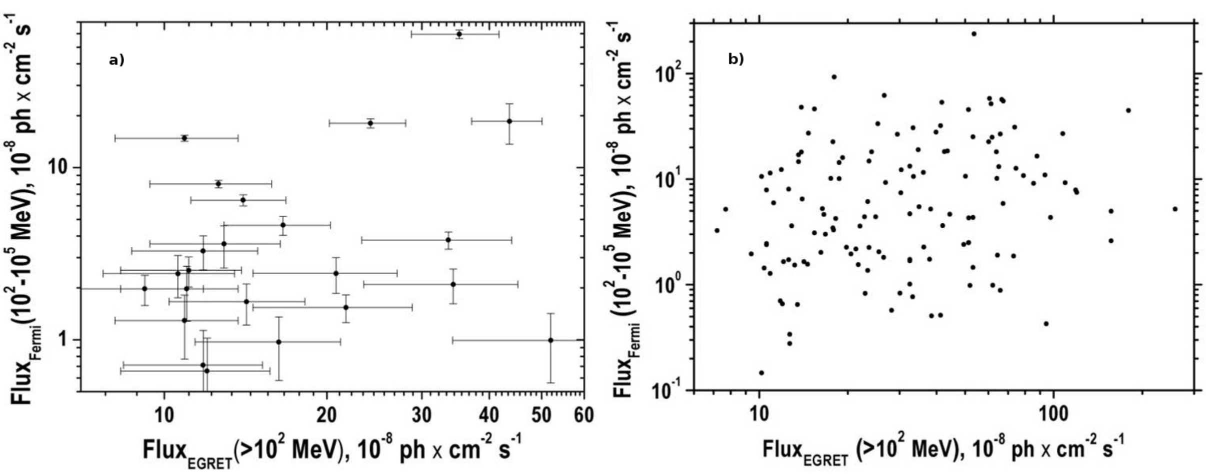

Figure 3. Mutual dependence of fluxes of 3EG sources and their (a) possible 3FGL counterparts and (b) ID and associated 3FGL sources.

Correlation between fluxes of 2FGL and 3FGL sources can be seen in figure 4. These sources refer to the same 3EG ones.

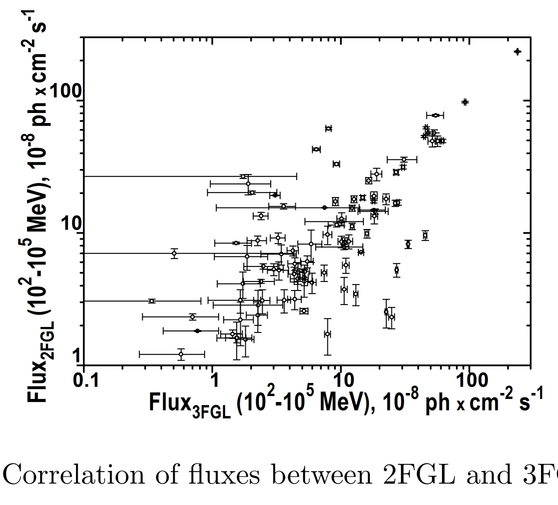

Figure 4. Correlation of fluxes between 2FGL and 3FGL sources.

We also should report on discrepancy in minima of fluxes between the same 2FGL and 3FG sources. That is, they both appear to have the most minimal values of fluxes, each one in its own catalogue. But as it can be seen in table 2, there exists above-mentioned discrepancy. Table 2 also presents some additional information. All fluxes and their errors are in units of 10^{-8} photons $\times$ cm^{-2} $\times$ s^{-1} for the energy range $E > 100$ MeV.

Table 2. Data on extremal values of fluxes in 3FGL, 2FGL and 3EG catalogues.

Magnitudes	2FGL	3FGL	3EG
flux min (f.min.)	1.213	0.33792	7.2
f.min. err	0.12	0.47558	1.7
f.min. name	J1513.5-2546	J1630.2-1052	J0500-0159
number in sample	53	61	15
f.min.(swapped)	3.058	0.57032	—
f.min. err (swapped)	0.1	0.2994	—
number in sample (swapped)	61	53	—
f.min. name (swapped)	J1631.0-1050	J1513.4-2549	—
flux max (f.max.)	234.003	237.12	258.9
f.max. err	2.073	1.7729	15.3
f.max. name	J2253.9+1609	J2254.0+1608	J1625-2955
number in sample	95	95	59

4. Conclusions

Unidentified EGRET sources from 3EG catalog have been analyzed. Preliminary data analysis has shown at least 23 of these sources coincide with those in 3FGL Fermi catalogue within 1, 2 and 3 sigma error intervals of the coordinates and fluxes. Their properties are discussed in the presented work. Even 3-sigma difference allows supposing sources similarity because of more than 3-sigma distinctions in values of fluxes between identified EGRET sources and their Fermi counterparts. The difference in amount of 3EG associations between 2FGL and 3FGL sources could cause by troubles of particles identification by Fermi/LAT trigger system.

Acknowledgments

Authors thank for the support from National Research Nuclear University MEPhI in the framework of the Russian Academic Excellence Project (contract No.02.a03.21.0005, 27.08.2013).

References

[1] Hartman R C *et al.* 1999 *The Astrophysical Journal Supplement Series* **123** 79-202
[2] Thompson D J *et al.* 1995 *The Astrophysical Journal Supplement Series* **101** 259-86
[3] *http://fermi.gsfc.nasa.gov/science/instruments/lat.html*
[4] Swensen E *et al.* 2001 *GLAST Tracker Mechanical Design PDR Design Review Document* HTN-102070-0002
[5] Ackermann M *et al.* 2012 *The Astrophysical Journal Supplement Series* **123** 4 (*arXiv:1206.1896*)
[6] Nolan P L *et al.* 2012 *The Astrophysical Journal Supplement Series* **199** 31 (*arXiv:1108.1435*)
[7] Acero F *et al.* 2015 *The Astrophysical Journal Supplement Series* **218** 23 (*arXiv:1501.02003*)