EGRET GAMMA RAY POINT SOURCES ABOVE 1 GEV

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ABSTRACT

Data from EGRET observations during Phase 1 to 4 (April 1991 to October 1995) were used to determine point sources with photon energies above 1 GeV. Fifty-seven sources were found, thirty previously identified with objects at other wavelengths: 24 AGNs, 5 Pulsars and the Large Magellanic Cloud. Twenty-seven sources remain unidentified, including twenty objects previously reported in EGRET catalogs (E > 100 MeV). Six new unidentified sources significant only above 1 GeV were reported first here. A summary of the-EGRET sources above 1 GeV is given, representing a valuable information in respect to the multiwavelength behaviour of identified and still unidentified γ–ray sources, especially for ground based, low energy threshold atmospheric Cherenkov telescopes.

INTRODUCTION

EGRET, the Energetic Gamma Ray Experiment Telescope aboard the NASA Compton Gamma Ray Observatory, has detected more than 300 γ–ray point sources (E > 100 MeV) during four observation cycles between April 1991 and October 1995 (3EG-catalog, Hartman et al. 1997). A survey at higher energies could account for γ–ray emitting objects with hard spectra, and therefore find sources not visible at lower energies. The narrower instrument point spread function (psf) and therefore better angular resolution at energies above 1 GeV allows to detect γ–ray point sources more easily against the Galactic diffuse emission, resulting in smaller positional errors of known sources or detection of new hard-spectrum emitters.

ANALYSIS TECHNIQUE

In the analysis described here we have used 169 EGRET pointings from Phase 1 to 4, each one lasting typically from a few days to three weeks. In order to prevent the analysis from large off-axis detections (i.e. low exposure at the edge of the FOV), all maps are restricted to contain only data within 30º of the instrument viewing axis. Co-added maps were made of the number of detected photons and the instrument exposure in a 0.5º binning, in Galactic coordinates as well as Celestial coordinates. These maps are searched for point sources by using the maximum-likelihood technique, described in Mattox et al. 1996. All candidate sources were determined exclusively from photons with energies above 1 GeV, independently in Galactic and Celestial coordinates. In order to compensate the slightly larger in-flight psf (Esposito et al. 1997) compared to the psf from pre-flight calibration (Thompson et al. 1993) a psf at a slightly lower energy instead of the 1 GeV instrument psf is used.

Table 1 EGRET Sources above 1 GeV

GeV source name	l (º)	b (º)	RA (º)	Dec (º)	error (arcmin) 68 %	95%	flux (10^{-8} cm^{-2} s^{-1})	sigma	EGRET catalog name	ID name
GRO J0009+7312	119.90	10.58	2.49	73.20	10	14	7.48±1.6	8.3	2EG J0008+7307	SNR CTA1, PSR ?
GRO J0211-5053	275.86	-61.84	32.78	-50.90	5	7	10.01±1.4	15.3	2EG J0210-5051	0208-512
GRO J0222+4255	140.21	-16.87	35.69	42.92	8	13	2.65±0.8	6.4	2EG J0220+4228	0220+4245 (3C66A)
GRO J0237+1643	156.36	-39.18	39.34	16.72	10	15	3.91±1.0	6.7	2EG J0238+1657	0235+164
GRO J0241+6102	135.83	0.95	40.30	61.05	8	11	6.10±1.3	7.6	2EG J0241+6119	
GRO J0433+2906	170.48	-12.63	68.35	29.11	7	10	3.45±0.7	7.8	2EG J0432+2910	PKS 2320-035
GRO J0443-0038	197.62	-28.50	70.82	-0.64	17	25	1.15±0.5	3.7	2EGS J0442-0033	0440-003
GRO J0530+1343	191.15	-10.98	82.65	13.73	7	10	2.53±0.5	7.8	2EG J0531+1324	0528+134
GRO J0534+2154	184.55	-5.85	83.57	21.99	5	6	21.28±1.3	33.5	2EG J0534+2158	PSR B0531+21 (CRAB)
GRO J0539-4401	250.04	-30.91	84.95	-44.02	10	16	2.07±0.7	5.8	2EG J0536-4348	0537-441
GRO J0545-7043	281.28	-30.94	86.30	-70.72	14	23	1.04±0.5	4.3	2EG J0532-6914	LMC
GRO J0615+4157	171.51	11.61	93.85	41.95	10	19	1.61±0.6	4.3		
GRO J0617+2241	188.97	3.13	94.36	22.69	6	8	5.87±0.8	11.7	2EG J0618+2234	SNR IC 443 ?
GRO J0632+0646	204.78	-1.03	98.20	6.78	9	12	2.19±0.6	5.5	2EG J0635+0521	SNR Monoceros ?
GRO J0634+1755	195.12	4.32	98.52	17.81	4	4	72.00±2.5	64.8	2EG J0633+1745	GEMINGA
GRO J0721+7124	143.91	27.99	110.36	71.40	11	18	1.73±0.5	5.7	2EG J0720+7126	0716+714
GRO J0834-4511	263.53	-2.82	128.78	-45.18	3	3	145.40±4.1	75.2	2EG J0835-4513	PSR B0833-45 (VELA)
GRO J0957+5513	158.83	47.96	149.34	55.23	13	20	1.04±0.3	4.8	2EG J0957+5515	0954+556 (4C55.17)
GRO J1025-5814	284.75	-0.60	156.50	-58.24	12	18	7.13±1.5	6.7	2EG J1021-5835	
GRO J1048-5843	287.53	0.42	162.09	-58.72	9	11	6.10±1.3	6.8	2EG J1049-5847	
GRO J1058-5227	286.06	6.68	164.62	-52.45	10	13	3.45±0.9	7.1	2EG J1059-5237	PSR B1055-52
GRO J1104+3808	179.98	65.08	166.15	38.13	8	13	3.11±0.7	9.7	2EG J1104+3812	1101+384 (Mrk 421)
GRO J1201+2903	200.05	78.93	180.50	29.05	13	20	1.50±0.5	5.1	2EG J1158+2906	1156+295 (4C29.45)
GRO J1222+2840	197.43	83.52	185.73	28.68	7	11	1.84±0.6	6.6	---	1219+285
GRO J1224+2117	255.13	81.55	186.15	21.29	8	15	0.81±0.3	4.4	2EG J1224+2155	1222+216 (4C21.35)
GRO J1231-1359	295.55	48.59	187.83	-13.99	10	17	1.61±0.5	5.5	2EG J1233-1407	
GRO J1248-8304	302.85	-20.21	192.19	-83.08	8	13	1.38±0.6	4.1	2EG J1248-8308	
GRO J1256-0549	305.08	57.02	194.03	-5.83	5	7	7.48±0.8	18.9	2EG J1256-0546	1253-055 (3C379)
GRO J1409-0745	334.30	50.28	212.47	-7.75	11	19	2.19±0.6	6.5	2EG J1409-0742	1406-076
GRO J1419-6040	313.49	0.38	214.82	-60.67	11	17	6.44±1.5	5.3	2EGS J1418-6049	
GRO J1613+3423	55.42	46.38	243.44	34.40	12	20	2.30±0.9	5.2	2EG J1614+3431	1611+343

Table 1 Continued

GeV source name	l (º)	b (º)	RA (º)	Dec (º)	error (arcmin) 68 %	95%	flux (10^{-8} cm^{-2} s^{-1})	sigma	EGRET catalog name	ID name
GRO J1624-2958	348.54	13.43	246.22	-29.98	9	12	3.45±0.7	7.4	---	1622-253
GRO J1625-2505	352.44	16.55	246.47	-25.09	9	13	2.76±0.7	5.4		
GRO J1635+3809	61.12	42.22	248.97	38.15	6	9	4.26±1.2	8.1	2EG J1635+3813	1633+382 (4C38.41)
GRO J1709-4440	343.04	-2.71	257.41	-44.55	6	8	20.70±2.2	17.0	2EG J1710-4432	PSR B1706-44
GRO J1732-1344	11.41	10.53	263.18	-13.75	12	15	1.96±0.6	4.9	2EG J1735-1312	1730-130
GRO J1740-2829	359.75	1.23	265.06	-28.50	15	19	4.60±1.0	5.7		
GRO J1746-2851	0.15	-0.10	266.59	-28.87	8	10	13.57±1.6	10.8	2EG J1746-2852	GC ?
GRO J1746-3017	358.95	-0.89	266.65	-30.29	19	26	3.91±1.0	4.1	2EG J1747-3039	
GRO J1809-2329	7.43	-1.98	272.47	-23.50	8	11	5.18±0.9	7.2	2EG J1801-2312	
GRO J1814-1232	17.52	2.39	273.53	-12.55	19	25	3.22±0.9	4.5	2EG J1813-1229	
GRO J1822-1219	18.70	0.68	275.65	-12.32	8	10	4.14±1.0	5.0	2EG J1825-1307	
GRO J1833-2139	11.58	-5.90	278.31	-21.67	12	19	1.50±0.5	3.8	2EG J1834-2138	PKS 1830-210
GRO J1835+5921	88.78	25.07	278.89	59.35	5	8	10.93±1.6	13.8	2EG J1835+5919	
GRO J1837-0615	25.76	0.28	279.32	-6.25	7	9	5.41±1.3	5.0		
GRO J1856+0111	34.59	-0.61	284.16	1.20	10	15	7.48±1.8	5.2	2EG J1857+0118	SNR W44 ?
GRO J1908+0556	40.19	-1.11	287.17	5.95	11	14	6.33±1.6	5.1		
GRO J2009-4840	350.56	-32.61	302.39	-48.67	17	27	2.19±0.9	4.1	---	2005-489
GRO J2017+3630	74.53	0.52	304.37	36.51	13	19	4.26±1.0	5.1	2EG J2019+3719	
GRO J2020+3659	75.26	0.31	305.09	37.00	10	14	7.82±1.3	8.1	2EG J2019+3719	
GRO J2020+4021	78.01	2.25	305.05	40.36	7	8	10.47±1.4	10.8	2EG J2020+4026	SNR γ -Cygni, PSR ?
GRO J2024+4055	78.97	1.86	306.18	40.93	10	13	6.56±1.4	6.4		
GRO J2024-0758	36.40	-24.31	306.15	-7.97	20	27	2.53±0.9	4.4	2EG J2023-0836	2022-077
GRO J2034+4203	80.97	1.04	308.63	42.07	14	21	5.75±1.3	5.8	2EG J2033+4112	
GRO J2056+5706	95.01	7.60	314.10	57.11	12	18	2.53±0.8	4.5		
GRO J2058-4655	352.99	-40.73	314.56	-46.93	14	23	1.61±0.8	4.1	2EG J2058-4657	2052-474
GRO J2253+1622	86.15	-37.94	343.37	16.37	6	10	3.80±0.9	9.0	2EG J2253+1615	2251+158 (3C454.3)

DETECTED SOURCES

Only sources with a statistical significance greater than 4σ are considered as detected sources. Fifty-seven sources are listed above, thirty previously identified with objects at other wavelengths (24 AGNs, 5 Pulsars and the Large Magellanic Cloud). Twenty-seven sources remain unidentified, including twenty objects previously reported in EGRET catalogs (E > 100 MeV) (Thompson et al. 1995, 1996). Seven new unidentified sources were discovered at E > 1 GeV. Note, that five of the unidentified sources are positional coincident with SNRs (Sturner & Dermer 1995), two of them already potential PSR candidates (Brazier et al. 1996, 1997).

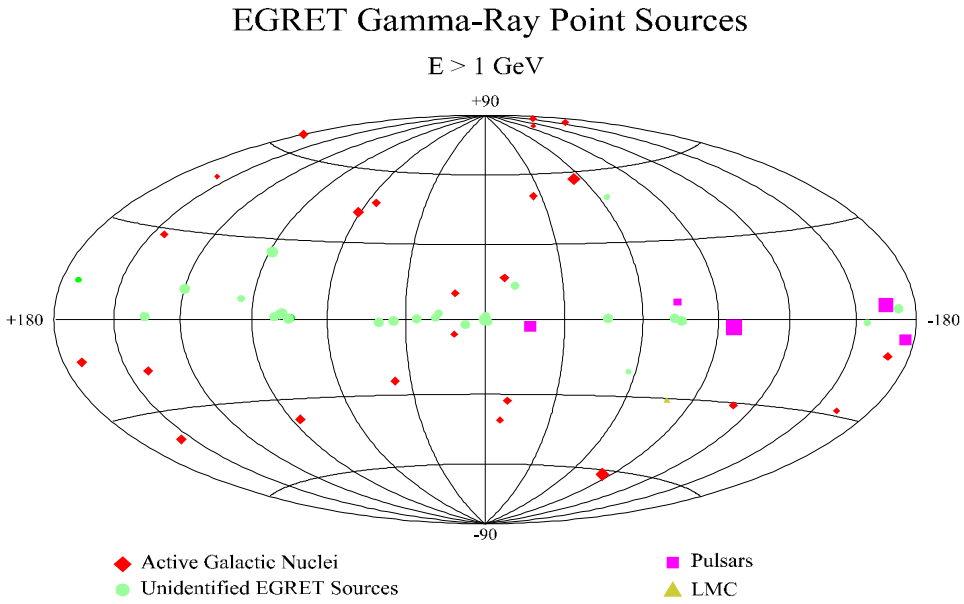

Fig. 1. Locations of the EGRET sources above 1 GeV, in Galactic coordinates. The size of the symbol represents the highest intensity seen by EGRET for E > 1 GeV. The symbol size scale is relative to the brightest source.

CONCLUSIONS

The EGRET source list above 1 GeV indicates, what kind of objects low energy threshold atmospheric Cherenkov telescopes may be able to see in the future. The analysis technique here represents the approach to detect sources solely from photons at energies > 1 GeV. Only for source identification the multiwavelength behaviour of sources is used.

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