Todo list

OBSERVATIONS OF PWNE WITH THE FERMI GAMMA-RAY SPACE TELESCOPE

A DISSERTATION
SUBMITTED TO THE DEPARTMENT OF PHYSICS
AND THE COMMITTEE ON GRADUATE STUDIES
OF STANFORD UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

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April 2013

I certify that I have read this dissertation and that, in my opinion, it is fully adequate in scope and quality as a dissertation for the degree of Doctor of Philosophy.

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(Roger Romani)

Approved for the University Committee on Graduate Studies

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List of Acronyms

1FHL the first *Fermi* hard-source list. 122

2CG the second COS-B catalog. 8

2FGL the second *Fermi* catalog. 21, 36, 118, 123

2PC the second *Fermi* pulsar catalog. 22, 120, 121

3EG the Third EGRET Catalog. 9

ACD Anti-Coincidence Detector. 11

arcsec second of arc. 31

BPL broken-power law. 38

CGRO the Compton Gamma Ray Observatory. 8

CGS the Centimetre-Gram-Second System of Units. 38, 39

ECPL exponentially-cutoff power law. 38, 39

EGRET the Energetic Gamma Ray Experiment Telescope. 8–10

ESA the European Space Agency. 8

FWHM full width at half maximum. 6

GBM Gamma-ray Burst Monitor. 11

IACT Imaging air Cherenkov detector. 46, 115, 118, 122

IC inverse Compoton. 4, 18, 19, 30, 31, 34, 122

LAT the Large Area Telescope. iv, v, 11, 21, 22, 118, 119, 121–123, 125, 127

MIT the Massachusetts Institute of Technology. 6, 12

MSC massive star cluster. 121

MSP millisecond pulsar. 26

NASA the National Aeronautics and Space Administration. 7, 8

NRL the Naval Research Laboratory. 12

NS neutron star. 12, 24, 25, 28, 29

OSO-3 the Third Orbiting Solar Observatory. 6, 7, 20

PL power law. 38, 39

PSF point spread function. 122

PWN pulsar wind nebula. iv, v, 5, 13, 24, 28, 30–34, 118, 119, 121–125, 127

SA solid angle. 40, 41

SAS-2 the second Small Astronomy Satellite. 7, 8

SNR supernova remnant. 28, 30, 31, 39

UNID unidentified source. 121, 122

VHE very high energy. 118–125, 129

Chapter 9

Population Study of LATs-detected PWNe

This chapter is based the second part of the the paper "Constraints on the Galactic Population of TeV Pulsar Wind Nebulae using Fermi Large Area Telescope Observations" by Acero et al which is currently in prep.

In Chapter 6, we search for new spatially-extended *Fermi* sources and found that spatial extenion was an important characteristic for detecting new pulsar wind nebulae (PWNe). In the process, we discovered three new γ-ray emitting PWNs. In Chapter 7, we then searched in the off-peak phase interval of the Large Area Telescope (LAT)-detected pulsars for new pulsar wind nebula and discovered 3C 58. Finally, in Chapter 8 we searched in the regions surrounding PWNs candidates detected at TeV energies for GeV-emitting PWNs 4 new PWNe candidates (HESS J1119−614, HESS J1303−631, HESS J1420−607, and HESS J1841−055) and 1 new PWN (HESS J1356−645)

In this chapter, we take the population of γ-ray emitting PWNs and PWNs candidates

9.1 Summary of the PWNe detected by the LATs

9.2 The Evolution of γ-ray Emitting PWNe with the Properties of their Pulsars

Table 9.1.

Source	$F_{1\,\mathrm{TeV}}^{30\,\mathrm{TeV}}$ (10^{-12}erg cm^{-2}s^{-1})	$F_{1\,\mathrm{KeV}}^{10\,\mathrm{KeV}}$ (10^{-12}erg cm^{-2}s^{-1})	PSR	$\dot{E}$ (erg s^{-1})	τ (kyr)	Distance (kpc)
VERJ0006+727	···	···	PSRJ0007+7303	4.5e+35	13.9	1.4 ± 0.3
Crab	80 ± 16	21000 ± 4200	PSR J0534+2200	4.6e+38	1.2	2.0 ± 0.5
MGROJ0631+105	···	···	PSRJ0631+1036	1.7e+35	43.6	1.00 ± 0.20
MGROJ0632+17	···	···	PSRJ0633+1746	3.2e+34	342	$0.2^{+0.2}_{-0.1}$
Vela-X	79 ± 21	54 ± 11	PSRJ0835-4510	6.9e+36	11.3	0.29 ± 0.02
HESSJ1018-589	0.9 ± 0.4	···	PSRJ1016-5857	2.6e+36	21	3
HESSJ1023-575	4.8 ± 1.7	···	PSRJ1023-5746	1.1e+37	4.6	2.8
HESSJ1026-582	5.9 ± 4.4	···	PSRJ1028-5819	8.4e+35	90	2.3 ± 0.3
HESSJ1119-614	2.3 ± 1.2	···	PSRJ1119-6127	2.3e+36	1.6	8.4 ± 0.4
HESSJ1303-631	27 ± 1	0.16 ± 0.03	PSRJ1301-6305	1.7e+36	11	$6.7^{+1.1}_{-1.2}$
HESSJ1356-645	6.7 ± 3.7	0.06 ± 0.01	PSRJ1357-6429	3.1e+36	7.3	$2.5^{+0.5}_{-0.4}$
HESSJ1418-609	3.4 ± 1.8	3.1 ± 0.1	PSRJ1418-6058	4.9e+36	1	1.6 ± 0.7
HESSJ1420-607	15 ± 3	1.3 ± 0.3	PSRJ1420-6048	1.0e+37	13	5.6 ± 0.9
HESSJ1458-608	3.9 ± 2.4	···	PSRJ1459-6053	9.1e+35	64.7	4
HESSJ1514-591	20 ± 4	29 ± 6	PSRJ1513-5906	1.7e+37	1.56	4.2 ± 0.6
HESSJ1554-550	1.6 ± 0.5	3.1 ± 1.0	···	···	18	7.8 ± 1.3
HESSJ1616-508	21 ± 5	4.2 ± 0.8	PSRJ1617-5055	1.6e+37	8.13	6.8 ± 0.7
HESSJ1632-478	15 ± 5	0.43 ± 0.08	···	3.0e+36	20	3
HESSJ1640-465	5.5 ± 1.2	0.46 ± 0.09	···	4.0e+36	···	···
HESSJ1646-458B	5.0 ± 2.0	···	PSRJ1648-4611	2.1e+35	110	5.0 ± 0.7
HESSJ1702-420	44 ± 8	0.01 ± 0.00	PSRJ1702-4128	3.4e+35	55	4.8 ± 0.6
HESSJ1708-443	23 ± 7	···	PSRJ1709-4429	3.4e+36	17.5	2.3 ± 0.3
HESSJ1718-385	4.3 ± 1.6	0.14 ± 0.03	PSRJ1718-3825	1.3e+36	89.5	3.6 ± 0.4
HESSJ1804-216	12 ± 2	0.07 ± 0.01	PSRJ1803-2137	2.2e+36	16	$3.8^{+0.4}_{-0.5}$
HESSJ1809-193	19 ± 6	0.23 ± 0.05	PSRJ1809-1917	1.8e+36	51.3	3.5 ± 0.4
HESSJ1813-178	5.0 ± 0.6	···	PSRJ1813-1749	6.8e+37	5.4	4.7
HESSJ1818-154	1.3 ± 0.9	···	PSRJ1818-1541	2.3e+33	9	$7.8^{+1.6}_{-1.4}$
HESSJ1825-137	61 ± 14	0.44 ± 0.09	PSRJ1826-1334	2.8e+36	21	3.9 ± 0.4
HESSJ1831-098	5.1 ± 0.6	···	PSRJ1831-0952	1.1e+36	128	4.0 ± 0.4
HESSJ1833-105	2.4 ± 1.2	40 ± 0	PSRJ1833-1034	3.4e+37	4.85	4.7 ± 0.4
HESSJ1837-069	23 ± 9	0.64 ± 0.24	PSRJ1836-0655	5.5e+36	2.23	6.6 ± 0.9
HESSJ1841-055	23 ± 3	···	PSRJ1838-0537	5.9e+36	4.97	1.3
HESSJ1846-029	9.0 ± 1.5	29 ± 1	PSRJ1846-0258	8.1e+36	0.73	5.1
HESSJ1848-018	4.3 ± 1.0	···	···	···	···	6
HESSJ1849-000	2.1 ± 0.4	0.90 ± 0.20	PSRJ1849-001	9.8e+36	42.9	7
HESSJ1857+026	18 ± 3	···	PSRJ1856+0245	4.6e+36	20.6	9.0 ± 1.2
MGROJ1908+06	12 ± 5	···	PSRJ1907+0602	2.8e+36	19.5	3.2 ± 0.3
HESSJ1912+101	7.3 ± 3.7	···	PSRJ1913+1011	2.9e+36	169	$4.8^{+0.5}_{-0.7}$

Table 9.1 (cont'd)

Source	$F_{1\,\mathrm{TeV}}^{30\,\mathrm{TeV}}$ ($10^{-12}\mathrm{erg\,cm^{-2}s^{-1}}$)	$F_{1\,\mathrm{KeV}}^{10\,\mathrm{KeV}}$ ($10^{-12}\mathrm{erg\,cm^{-2}s^{-1}}$)	PSR	$\dot{E}$ ($\mathrm{erg\,s^{-1}}$)	τ (kyr)	Distance (kpc)
VERJ1930+188	2.3 ± 1.3	5.2 ± 0.1	PSRJ1930+1852	1.2e+37	2.89	9^{+7}_{-2}
VERJ1959+208	···	···	PSRJ1959+2048	1.6e+35	···	2.5 ± 1.0
MGROJ2019+37	···	···	PSRJ2021+3651	3.4e+36	17.2	10^{+2}_{-4}
MGROJ2228+61	···	0.88 ± 0.02	PSRJ2229+6114	2.2e+37	10.5	0.80 ± 0.20

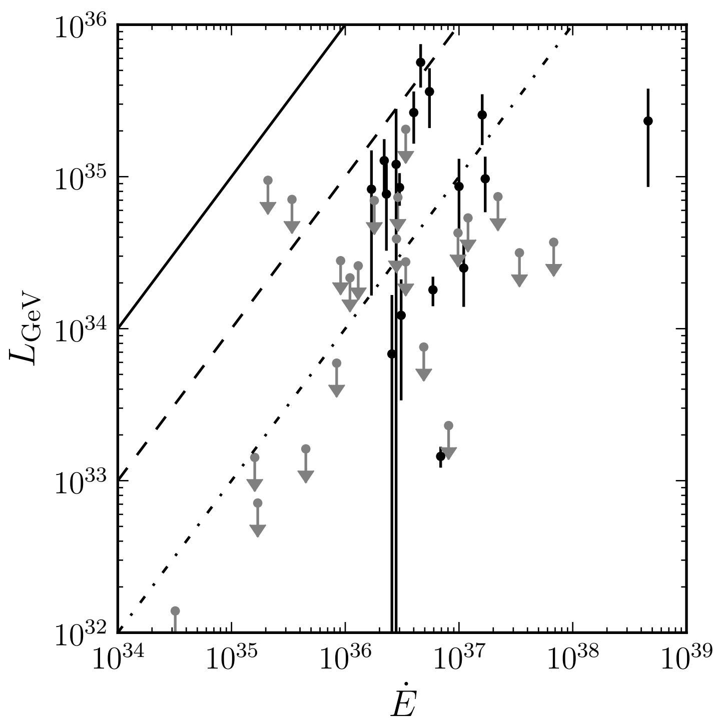
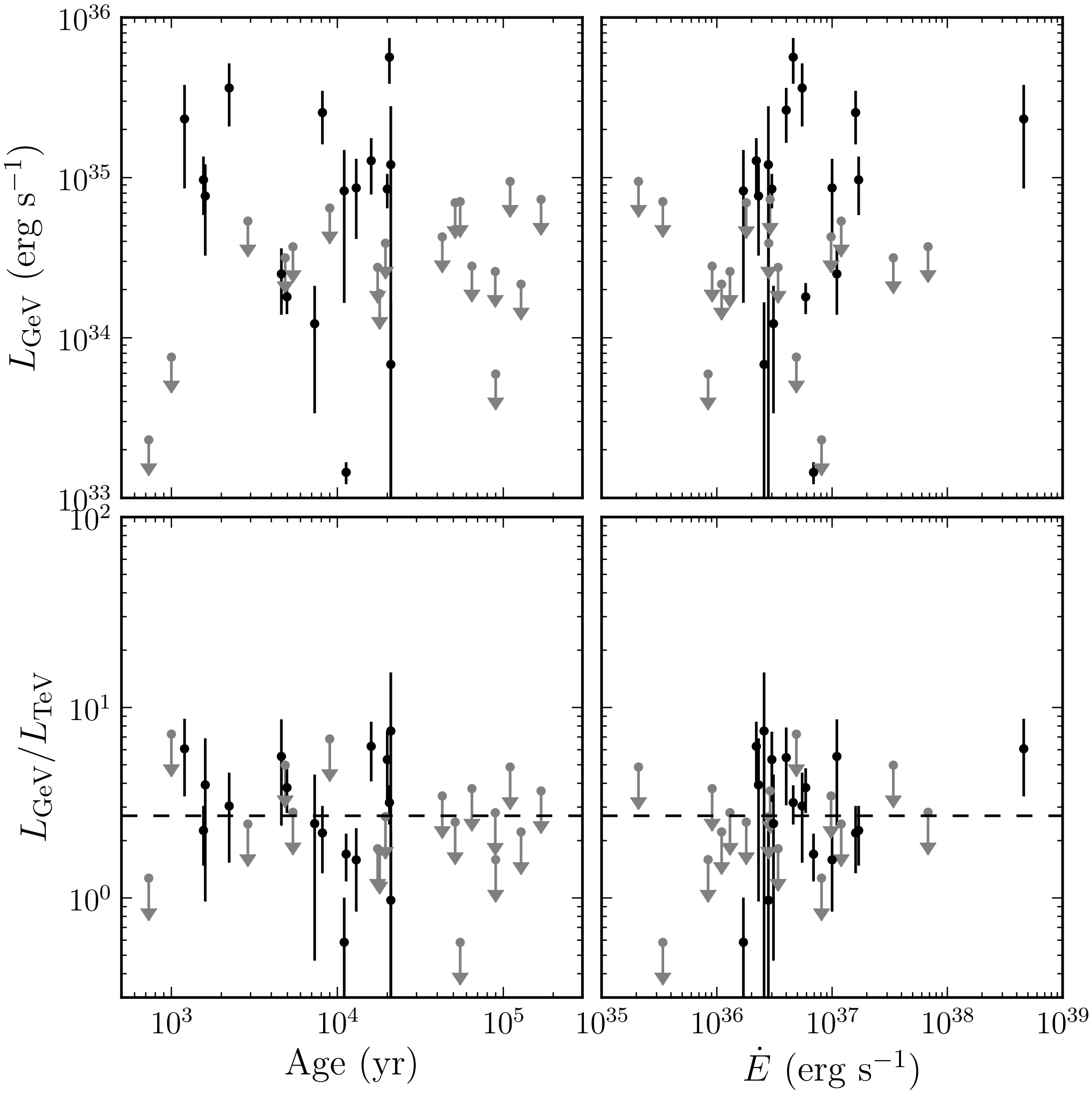
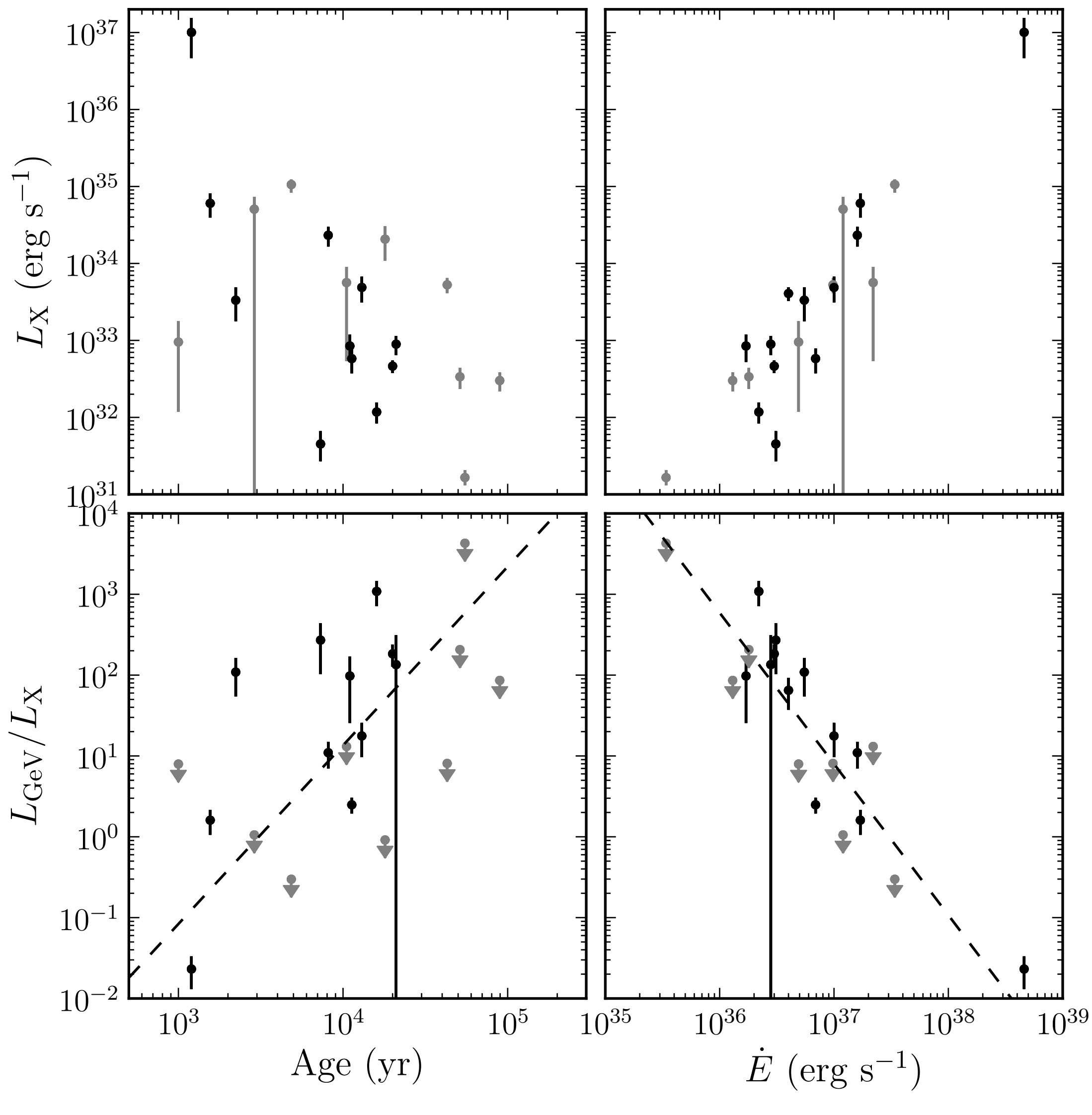


Figure 9.1 ...



10^{36}
10^{35}
10^{34}
10^{33}
L_{GeV} (erg s^{-1})
10^{2}
10^{1}
10^{0}
$L_{\mathrm{GeV}}/L_{\mathrm{TeV}}$
10^{3}
10^{4}
10^{5}
Age (yr)
10^{35}
10^{36}
10^{37}
10^{38}
10^{39}
$\dot{E}$ (erg s^{-1})

Figure 9.2 ...



10^{37}
10^{36}
10^{35}
10^{34}
10^{33}
10^{32}
10^{31}
L_X (erg s^{-1})
10^{4}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
L_{GeV}/L_X
10^{3}
10^{4}
10^{5}
Age (yr)
10^{35}
10^{36}
10^{37}
10^{38}
10^{39}
$\dot{E}$ (erg s^{-1})

Figure 9.3 ...

Bibliography

Abdo, A., Ackermann, M., Ajello, M., et al. 2010, Astrophys.J., 722, 1303

Abdo, A. A., Allen, B., Berley, D., et al. 2007, ApJ, 664, L91

Abdo, A. A., Ackermann, M., Ajello, M., et al. 2009a, ApJ, 706, L1

—. 2009b, ApJS, 183, 46

Abdo, A. A., Allen, B. T., Aune, T., et al. 2009c, ApJ, 700, L127

Abdo, A. A., Ackermann, M., Ajello, M., et al. 2009d, Astroparticle Physics, 32, 193

—. 2010a, ApJ, 714, 927

Abdo, A. A., Ackermann, M., Ajello, M., et al. 2010b, A&A, 523, A46

Abdo, A. A., Ackermann, M., Ajello, M., et al. 2010c, Science, 328, 725

—. 2010d, ApJS, 188, 405

—. 2010e, ApJ, 708, 1254

—. 2010f, ApJ, 718, 348

Abdo, A. A., Ackermann, M., Ajello, M., et al. 2010, The Astrophysical Journal, 713, 146

Abdo, A. A., Ackermann, M., Ajello, M., et al. 2010a, Science, 327, 1103

—. 2010b, ApJ, 712, 459

Abdo, A. A., Ackermann, M., Ajello, M., et al. 2010c, A&A, 512, A7

Abdo, A. A., Ackermann, M., Ajello, M., et al. 2010d, Physical Review Letters, 104, 101101

—. 2010e, ApJS, 187, 460

—. 2011, ApJ, 734, 28

Acciari, V. A., Aliu, E., Arlen, T., et al. 2009, ApJ, 698, L133

—. 2010, ApJ, 719, L69

—. 2011, ApJ, 738, 3

Acero, F., Ackermann, M., Ajello, M., & et al. in prep., ApJ

Acero, F., Djannati-Ataï, A., Förster, A., et al. 2012, ArXiv e-prints

Ackermann, M., Ajello, M., Allafort, A., et al. in prep, ApJ

—. 2011, ApJ, 743, 171

Ackermann, M., Ajello, M., Albert, A., et al. 2012, ApJS, 203, 4

Aharonian, F., Akhperjanian, A. G., Aye, K.-M., et al. 2005a, A&A, 435, L17

—. 2005b, A&A, 439, 1013

Aharonian, F., Akhperjanian, A. G., Bazer-Bachi, A. R., et al. 2006a, A&A, 460, 743

—. 2006b, A&A, 456, 245

—. 2006c, A&A, 460, 365

—. 2006d, A&A, 448, L43

—. 2006e, ApJ, 636, 777

—. 2007a, A&A, 472, 489

—. 2007b, ApJ, 661, 236

—. 2007c, A&A, 464, 235

—. 2008a, A&A, 481, 401

Aharonian, F., Akhperjanian, A. G., Barres de Almeida, U., et al. 2008b, A&A, 484, 435

—. 2008c, A&A, 477, 353

Aharonian, F., Akhperjanian, A. G., Anton, G., et al. 2009, A&A, 499, 723

Aharonian, F. A., & Bogovalov, S. V. 2003, New A, 8, 85

Aharonian, F. A., Coppi, P. S., & Voelk, H. J. 1994, ApJ, 423, L5

Aharonian, F. A., Akhperjanian, A. G., Bazer-Bachi, A. R., et al. 2007d, A&A, 469, L1

Ajello, M., Allafort, A., Baldini, L., et al. 2012, ApJ, 744, 80

Akaike, H. 1974, IEEE Transactions on Automatic Control, 19, 716

Albert, J., Aliu, E., Anderhub, H., et al. 2006, Science, 312, 1771

Aliu, E. 2011, in International Cosmic Ray Conference, Vol. 7, International Cosmic Ray Conference, 227

Arnold, J. R., Metzger, A. E., Anderson, E. C., & van Dilla, M. A. 1962, J. Geophys. Res., 67, 4878

Arons, J. 1996, Space Sci. Rev., 75, 235

Ashworth, William B., J. 1981, Proceedings of the American Philosophical Society, 125, pp. 52

Atwood, W. B., Abdo, A. A., Ackermann, M., et al. 2009, ApJ, 697, 1071

Balbo, M., Saouter, P., Walter, R., et al. 2010, A&A, 520, A111

Baltz, E. A., Berenji, B., Bertone, G., et al. 2008, J. Cosmology Astropart. Phys., 7, 13

Bamba, A., Ueno, M., Koyama, K., & Yamauchi, S. 2003, The Astrophysical Journal, 589, 253

Bartoli, B., Bernardini, P., Bi, X. J., et al. 2012, ApJ, 745, L22

Baum, W. A., Johnson, F. S., Oberly, J. J., et al. 1946, Phys. Rev., 70, 781

Bertsch, D. L., Brazier, K. T. S., Fichtel, C. E., et al. 1992, Nature, 357, 306

Bignami, G. F., Boella, G., Burger, J. J., et al. 1975, Space Science Instrumentation, 1, 245

Blandford, R. D., & Romani, R. W. 1988, MNRAS, 234, 57P

Blumenthal, G. R., & Gould, R. J. 1970, Rev. Mod. Phys., 42, 237

Bogovalov, S. V., & Aharonian, F. A. 2000, MNRAS, 313, 504

Bradt, H., Rappaport, S., & Mayer, W. 1969, Nature, 222, 728

Browning, R., Ramsden, D., & Wright, P. J. 1971, Nature Physical Science, 232, 99

Burnham, K. P., & Anderson, D. R. 2002, Model selection and multimodel inference: a practical information-theoretic approach, 2nd edn. (Springer)

Burnight, T. 1949, Phys. Rev, 76, 19

Caballero, I., & Wilms, J. 2012, Mem. Soc. Astron. Italiana, 83, 230

Carroll, B. W., & Ostlie, D. A. 2006, An Introduction to Modern Astrophysics, 2nd edn. (Benjamin Cummings)

Cash, W. 1979, ApJ, 228, 939

Castelletti, G., Dubner, G., Golap, K., & Goss, W. M. 2006, A&A, 459, 535

Chandrasekhar, S. 1931, ApJ, 74, 81

Chaves, R. C. G., Renaud, M., Lemoine-Goumard, M., & Goret, P. 2008, in American Institute of Physics Conference Series, Vol. 1085, American Institute of Physics Conference Series, ed. F. A. Aharonian, W. Hofmann, & F. Rieger, 372–375

Chen, A. W., Piano, G., Tavani, M., et al. 2011, A&A, 525, A33

Cocke, W. J., Disney, M. J., & Taylor, D. J. 1969, Nature, 221, 525

Critchfield, C. L., Ney, E. P., & Oleksa, S. 1952, Physical Review, 85, 461

Dame, T. M. 2011, ArXiv e-prints

de Geus, E. J., Bronfman, L., & Thaddeus, P. 1990, A&A, 231, 137

de los Reyes, R., Zajczyk, A., Chaves, R. C. G., & for the H. E. S. S. collaboration. 2012, ArXiv e-prints

de Naurois, M., & H.E.S.S. Collaboration. 2013, Advances in Space Research, 51, 258

Demorest, P. B., Pennucci, T., Ransom, S. M., Roberts, M. S. E., & Hessels, J. W. T. 2010, Nature, 467, 1081

Djannati-Ataĭ, A., de Jager, O. C., Terrier, R., & et al. 2008, in International Cosmic Ray Conference, Vol. 2, International Cosmic Ray Conference, 823–826

Eadie, W. T., Drijard, D., & James, F. E. 1971, Statistical methods in experimental physics (North-Holland Pub. Co.)

Espinoza, C. M., Lyne, A. G., Kramer, M., Manchester, R. N., & Kaspi, V. M. 2011, ApJ, 741, L13

Esposito, J. A., Bertsch, D. L., Chen, A. W., et al. 1999, ApJS, 123, 203

Falanga, M., Kuiper, L., Poutanen, J., et al. 2005, A&A, 444, 15

Feenberg, E., & Primakoff, H. 1948, Phys. Rev., 73, 449

Fichtel, C. E., Hartman, R. C., Kniffen, D. A., et al. 1975, ApJ, 198, 163

Fisher, R. A. 1925, Statistical Methods for Research Workers (Edinburgh: Oliver and Boyd)

Fritz, G., Henry, R. C., Meekins, J. F., Chubb, T. A., & Friedman, H. 1969, Science, 164, 709

Funk, S., Hinton, J. A., Pühlhofer, G., et al. 2007, ApJ, 662, 517

Gaensler, B. M., Schulz, N. S., Kaspi, V. M., Pivovaroff, M. J., & Becker, W. E. 2003, ApJ, 588, 441

Gaensler, B. M., & Slane, P. O. 2006, ARA&A, 44, 17

Gaisser, T. K., Protheroe, R. J., & Stanev, T. 1998, ApJ, 492, 219

Gelfand, J. D., Slane, P. O., & Zhang, W. 2009, ApJ, 703, 2051

Giordano, F., & Fermi LAT Collaboration. 2011, in High-Energy Emission from Pulsars and their Systems, ed. D. F. Torres & N. Rea, 69

Gold, T. 1968, Nature, 218, 731

Goldreich, P., & Julian, W. H. 1969, ApJ, 157, 869

Górski, K. M., Hivon, E., Banday, A. J., et al. 2005, ApJ, 622, 759

Gotthelf, E. V., & Halpern, J. P. 2008, ApJ, 681, 515

Grenier, I. A., Casandjian, J.-M., & Terrier, R. 2005, Science, 307, 1292

Grondin, M.-H., Funk, S., Lemoine-Goumard, M., et al. 2011, ApJ, 738, 42

Gunn, J. E., & Ostriker, J. P. 1969, Nature, 221, 454

H. E. S. S. Collaboration, Abramowski, A., Acero, F., et al. 2012, A&A, 541, A5

Hall, T. A., Bond, I. H., Bradbury, S. M., et al. 2003, ApJ, 583, 853

Hartman, R. C., Bertsch, D. L., Bloom, S. D., et al. 1999, ApJS, 123, 79

Haug, E. 1975, Zeitschrift Naturforschung Teil A, 30, 1099

Hayakawa, S. 1952, Progress of Theoretical Physics, 8, 571

Herschel, W. 1800, Philosophical Transactions of the Royal Society of London, 90, pp. 284

H.E.S.S. Collaboration, Abramowski, A., Acero, F., et al. 2011a, A&A, 531, A81

—. 2011b, A&A, 528, A143

H.E.S.S. Collaboration, Acero, F., Aharonian, F., et al. 2011c, A&A, 525, A45

H.E.S.S. Collaboration, Abramowski, A., Acero, F., et al. 2011d, A&A, 533, A103

—. 2011e, A&A, 525, A46

Hewish, A., Bell, S. J., Pilkington, J. D. H., Scott, P. F., & Collins, R. A. 1968, Nature, 217, 709

Hewitt, J., Grondin, M.-H., Lemoine-Goumard, M., et al. 2012

Hofverberg, P. 2011, in International Cosmic Ray Conference, Vol. 7, International Cosmic Ray Conference, 247

Hoppe, S. 2008, in International Cosmic Ray Conference, Vol. 2, International Cosmic Ray Conference, 579–582

Houck, J. C., & Allen, G. E. 2006, ApJS, 167, 26

Hulsizer, R. I., & Rossi, B. 1948, Phys. Rev., 73, 1402

Hutchinson, G. 1952, Philosophical Magazine Series 7, 43, 847

Hwang, U., Petre, R., & Flanagan, K. A. 2008, ApJ, 676, 378

James, F., & Roos, M. 1975, Computer Physics Communications, 10, 343

Jansky, K. 1933, Proceedings of the Institute of Radio Engineers, 21, 1387

Kargaltsev, O., Pavlov, G. G., & Wong, J. A. 2008, ArXiv e-prints

Kaspi, V. M., & Helfand, D. J. 2002, in Astronomical Society of the Pacific Conference Series, Vol. 271, Neutron Stars in Supernova Remnants, ed. P. O. Slane & B. M. Gaensler, 3

Katagiri, H., Tibaldo, L., Ballet, J., et al. 2011, ApJ, 741, 44

Katsuta, J., Uchiyama, Y., Tanaka, T., et al. 2012

Kennel, C. F., & Coroniti, F. V. 1984, ApJ, 283, 710

Kerr, M. 2010, PhD thesis, University of Washington

King, I. 1962, AJ, 67, 471

Klein, O., & Nishina, T. 1929, Zeitschrift fur Physik, 52, 853

Kniffen, D. A., & Fichtel, C. E. 1970, ApJ, 161, L157

Krause, J., Carmona, E., Reichardt, I., & for the MAGIC Collaboration. 2011, ArXiv e-prints

Kraushaar, W., Clark, G. W., Garmire, G., et al. 1965, ApJ, 141, 845

Kraushaar, W. L., Clark, G. W., Garmire, G. P., et al. 1972, ApJ, 177, 341

Landi, R., de Rosa, A., Dean, A. J., et al. 2007a, MNRAS, 380, 926

Landi, R., Masetti, N., Bassani, L., et al. 2007b, The Astronomer's Telegram, 1047, 1

Large, M. I., Vaughan, A. E., & Mills, B. Y. 1968, Nature, 220, 340

Li, T.-P., & Ma, Y.-Q. 1983, ApJ, 272, 317

Longair, M. S. 2011, High Energy Astrophysics, 3rd edn. (The Edinburgh Building, Cambridge CB2 8RU, UK: Cambridge University Press)

Markwardt, C. B., & Ogelman, H. 1995, Nature, 375, 40

Matsumoto, H., Ueno, M., Bamba, A., et al. 2007, PASJ, 59, 199

Matsumoto, H., Uchiyama, H., Sawada, M., et al. 2008, PASJ, 60, 163

Mattox, J. R., Bertsch, D. L., Fichtel, C. E., et al. 1992, ApJ, 401, L23

Mattox, J. R., Bertsch, D. L., Chiang, J., et al. 1996, ApJ, 461, 396

Mayer-Hasselwander, H. A., Kanbach, G., Bennett, K., et al. 1982, A&A, 105, 164

McArthur, S. 2011, ArXiv e-prints

McK Mahille, J., Schild, R., Wendorf, F., & Brenmer, R. 2007, African Skies, 11, 2

Mizukami, T., Kubo, H., Yoshida, T., et al. 2011, ApJ, 740, 78

Morrison, P. 1958, Il Nuovo Cimento, 7, 858

Murphy, T., Mauch, T., Green, A., et al. 2007, MNRAS, 382, 382

Neronov, A., Semikoz, D. V., Tinyakov, P. G., & Tkachev, I. I. 2011, A&A, 526, A90

Nolan, P. L., Arzoumanian, Z., Bertsch, D. L., et al. 1993, ApJ, 409, 697

Nolan, P. L., Fierro, J. M., Lin, Y. C., et al. 1996, A&AS, 120, C61

Nolan, P. L., Abdo, A. A., Ackermann, M., et al. 2012, ApJS, 199, 31

Pacini, F. 1967, Nature, 216, 567

—. 1968, Nature, 219, 145

Pacini, F., & Salvati, M. 1973, ApJ, 186, 249

Paron, S., Dubner, G., Reynoso, E., & Rubio, M. 2008, A&A, 480, 439

Petre, R., Becker, C. M., & Winkler, P. F. 1996, The Astrophysical Journal Letters, 465, L43

Pollock, A. M. T. 1985, A&A, 150, 339

Protassov, R., van Dyk, D. A., Connors, A., Kashyap, V. L., & Siemiginowska, A. 2002, ApJ, 571, 545

Rea, N., & Esposito, P. 2011, in High-Energy Emission from Pulsars and their Systems, ed. D. F. Torres & N. Rea, 247

Rees, M. J., & Gunn, J. E. 1974, MNRAS, 167, 1

Renaud, M., Goret, P., & Chaves, R. C. G. 2008, in American Institute of Physics Conference Series, Vol. 1085, American Institute of Physics Conference Series, ed. F. A. Aharonian, W. Hofmann, & F. Rieger, 281–284

Reynoso, E. M., Dubner, G. M., Goss, W. M., & Arnal, E. M. 1995, AJ, 110, 318

Reynoso, E. M., Green, A. J., Johnston, S., et al. 2003, MNRAS, 345, 671

Richards, D. W., & Comella, J. M. 1969, Nature, 222, 551

Rodriguez, J., Tomsick, J. A., Foschini, L., et al. 2003, A&A, 407, L41

Rousseau, R., Grondin, M.-H., Van Etten, A., et al. 2012, A&A, 544, A3

Rowell, G., Horns, D., Fukui, Y., & Moriguchi, Y. 2008, in American Institute of Physics Conference Series, Vol. 1085, American Institute of Physics Conference Series, ed. F. A. Aharonian, W. Hofmann, & F. Rieger, 241–244

Rybicki, G. B., & Lightman, A. P. 1979, Radiative processes in astrophysics (New York: John Wiley & Sons Ltd)

Schwarz, G. 1978, The Annals of Statistics, 6, pp. 461

Sheidaei, F. 2011, in International Cosmic Ray Conference, Vol. 7, International Cosmic Ray Conference, 243

Slane, P., Castro, D., Funk, S., et al. 2010, The Astrophysical Journal, 720, 266

Sreekumar, P., Bertsch, D. L., Hartman, R. C., Nolan, P. L., & Thompson, D. J. 1999, Astroparticle Physics, 11, 221

Sreekumar, P., Bertsch, D. L., Dingus, B. L., et al. 1992, ApJ, 400, L67

Sreekumar, P., Bertsch, D. L., Dingus, B. L., et al. 1998, The Astrophysical Journal, 494, 523

Staelin, D. H., & Reifenstein, III, E. C. 1968, Science, 162, 1481

Strong, A. W., & Moskalenko, I. V. 1998, ApJ, 509, 212

Sugizaki, M., Mitsuda, K., Kaneda, H., et al. 2001, ApJS, 134, 77

Swanenburg, B. N., Hermsen, W., Bennett, K., et al. 1978, Nature, 275, 298

Swanenburg, B. N., Bennett, K., Bignami, G. F., et al. 1981, ApJ, 243, L69

Tanaka, T., Allafort, A., Ballet, J., et al. 2011, ApJ, 740, L51

Taylor, A. R., Gibson, S. J., Peracaula, M., et al. 2003, AJ, 125, 3145

Terrier, R., Mattana, F., Djannati-Atai, A., et al. 2008, in American Institute of Physics Conference Series, Vol. 1085, American Institute of Physics Conference Series, ed. F. A. Aharonian, W. Hofmann, & F. Rieger, 312–315

Thompson, D. J. 2008, Reports on Progress in Physics, 71, 116901

Thompson, D. J., Fichtel, C. E., Hartman, R. C., Kniffen, D. A., & Lamb, R. C. 1977a, ApJ, 213, 252

Thompson, D. J., Fichtel, C. E., Kniffen, D. A., & Ogelman, H. B. 1977b, ApJ, 214, L17

Thompson, D. J., Bertsch, D. L., Fichtel, C. E., et al. 1993, ApJS, 86, 629

Tomsick, J. A., Lingenfelter, R., Walter, R., et al. 2003, IAU Circ., 8076, 1

Torii, K., Kinugasa, K., Toneri, T., et al. 1998, ApJ, 494, L207

van der Swaluw, E., & Wu, Y. 2001, ApJ, 555, L49

Vladimirov, A. E., Digel, S. W., Jóhannesson, G., et al. 2011, Computer Physics Communications, 182, 1156

Weekes, T. C., Cawley, M. F., Fegan, D. J., et al. 1989, ApJ, 342, 379

Weinstein, A., & for the VERITAS Collaboration. 2009, ArXiv e-prints

Young, E. T., Lada, C. J., & Wilking, B. A. 1986, ApJ, 304, L45