

GeV-TeV AGN in the Fermi era

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for the Fermi-LAT collaboration

Gevernie Gevernev Gevernev Gevernev Gevernev Germa-ray Space Telescope





10GeV

300GeV





















2LAC vs ILAC



- Under integration time 24 months
- Better analysis methodology Binned
- Improved instrument response "Pass7"
- UNION Higher resolution Galactic model
- University of the second secon
- Over the sensitive test of source variability
- Three AGN association methods
- Optical follow-up studies of ILAC sources



Sermi Extragalactic TeV sky Space Telescope





Gamma-ray

(http://tevcat.uchicago.edu)



45 AGN

- 37 BL Lacs 29 HBL, 4 IBL and 4 LBL
- 3 FSRQ 3C279, 4C+21.35 and PKS1510-089
 - 3 FR-I radio galaxies M87,
 - NGC 1275, Cen A
- 2 unknown IC 310 and VER0521+211
- 2 SBG M82, NGC 253
- Fermi implicated in many of the recent TeV discoveries







			TeV Name	2F0	GL Name	1FGL Source	R.A. (J2000)	Dec. (J2000)	VHE Index	<i>Fermi</i> Index	z	Class
			SHBL J001355.9-185	406	-	-	00 13 56.0	-18 54 07	_*	-	0.095	HBL
2FGL Name	1FGL	R	RGB J0152+017	015	2.6+0148	-	01 52 33.5	+01 46 40	2.95	1.79	0.08	HBL
	Source	(J2	3C 66A	022	2.6+4302	Y	02 22 41.6	+43 02 35.5	3.64	1.85	< 0.58	IBL
1221.4+2814	Y	12 2	1ES 0229+200		-	-	02 32 53.2	+20 16 21	2.50	-	0.14	HBL
1224.9+2122	Y	12 2	IC 310	031	6.6+4119	-	03 16 43.0	+41 19 29	_*	2.1	0.0189	UNK
1230.8+1224	Y	12 3	NGC 1275	031	9.8+4130	Y	03 19 48.1	+41 30 42	_*	2.00	0.0176	FRI
1256.1-0547	Y	12 5	RBS 0413	031	9.6+1849	Y	03 19 51.8	+18 45 34	_*	1.55	0.19	HBL
-	-	13 1	1ES 0347-121			-	03 49 23.0	-11 58 38	3.10	-	0.188	HBL
1325.6-4300	Y	13 :	1ES 0414+009	041	6.8+0105	Y	04 16 52.41	+01 05 24.3	_*	1.98	0.287	HBL
1427.0+2347	Y	14 27	PKS 0447-439	044	9.4-4350	Y	04 49 24.7	-43 50 09	4.36	1.86	> 0.176	HBL
1428.6+4240	Y	14 2	1ES 0502+675	050	8.0+6737	Y	05 07 56.2	+67 37 24	_*	1.49	0.341	HBL
1442.7+1159	Y	14 4	VER J0521+211	052	1.7+2113	Y	05 21 55	+21 11 24	_*	1.93	_	UNK
1512.8-0906	Y	15 1	PKS 0548-322		-	-	05 50 42.9	-32 16 34	2.86	_	0.069	HBL
1517.7-2421	Y	15 1	RGB J0710+591	071	0.5+5908	Y	07 10 26.4	+59 09 00	2.69	1.53	0.125	HBL
1555.7+1111	Y	15 5	S5 0716+714	072	1 9+7120	Y	07 21 53 4	+71 20 36	3 45	2 01	0.31	I BI
1653.9+3945	Y	16 5	1ES 0806+524	080	9 8+5218	Y	08 09 59	+52 19 00	3.6	1.94	0.138	HBI
-	-	19 [,]	1BXS./101015.9-3110	909 100	9 7-3123		10 10 15 9	-31 19 09	_*	2.34	0 143	HBI
2000.0+6509	Y	19 5	1ES 1011+496	101	5 1+4925	Y	10 15 04 1	+49 26 01	4.0	1 72	0.110	HBI
2001.1+4352	Y	20 0	1ES 1101-232	110	13 1-2330	· ·	11 03 38	-23 20 31	2.04	1.8	0.186	HBI
2009.5-4850	Y	20 0	Markarian 421	110	A A+3812	· ·	11 0/ 27 3	±38 12 32	2.04	1.0	0.031	HBI
2158.8-3013	Y	21 5	Markarian 190	110	6.7,7000	I V	11 26 26 4	+70 00 07	2.20	1.74	0.031	
2202.8+4216	Y	22 0		101	7.0.2006	I V	10 17 50 1	+70 09 27	*	0.00	0.12	
2250.0+3825	Y	22 5	150 1010 : 004	121	7.0+3000	ř V	10 01 01 0	+30 07 01	-	2.02	0.13	
2347.0+5142	Y	23 4,	ΙΕΟ ΙΖΙΌ+3U4 υτ.υ Ι τοι τζι ιυ	122 2.33	1.3+3010	Т Т Т		+30 10 37	3.08	1./1	0.182	ΠΒΓ
2359.0-3037	Y	23 5	9 09 -30 37 22	3.06	1.89	0.165	HBL	-			(D.	Horan)
	2FGL Name 1221.4+2814 1224.9+2122 1230.8+1224 1256.1-0547 - 1325.6-4300 1427.0+2347 1428.6+4240 1442.7+1159 1512.8-0906 1517.7-2421 1555.7+1111 1653.9+3945 - 2000.0+6509 2001.1+4352 2009.5-4850 2158.8-3013 2202.8+4216 2250.0+3825 2347.0+5142 2359.0-3037	2FGL Name 1FGL Source 1221.4+2814 Y 1224.9+2122 Y 1230.8+1224 Y 1256.1-0547 Y 1256.1-0547 Y 1325.6-4300 Y 1427.0+2347 Y 1428.6+4240 Y 1442.7+1159 Y 1512.8-0906 Y 1515.7+1111 Y 1653.9+3945 Y - - 2000.0+6509 Y 2001.1+4352 Y 2009.5-4850 Y 2158.8-3013 Y 2250.0+3825 Y 2347.0+5142 Y 2359.0-3037 Y	2FGL Name1FGL SourceF (J21221.4+2814Y12.21224.9+2122Y12.21230.8+1224Y12.31256.1-0547Y12.513.11325.6-4300Y13.11325.6-4300Y13.11427.0+2347Y14.21442.7+1159Y14.41512.8-0906Y15.11517.7-2421Y15.11555.7+1111Y15.51653.9+3945Y16.519.2000.0+6509Y19.52001.1+4352Y20.02158.8-3013Y21.52202.8+4216Y22.02250.0+3825Y22.52347.0+5142Y23.5	$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	TeV Name 2FGL Name 2FGL Name 2FGL Name 2FGL Name SHBL J001355.9-185406 - 2FGL Name 1FGL Source 1/2 RGB J0152+017 0152.6+0148 3C 66A 0222.6+4302 1221.4+2814 Y 122 1ES 0229+200 - - 1224.9+2122 Y 122 1C 310 0316.6+4119 1230.8+1224 Y 123 NGC 1275 0319.8+4130 1256.1-0547 Y 125 0319.6+1849 - - 131 1ES 0347-121 - 1325.6-4300 Y 13: 1ES 0414+009 0416.8+0105 1427.0+2347 Y 142; 1ES 0502+675 0508.0+6737 1428.6+4240 Y 142; 1ES 0502+675 0508.0+6737 1428.6+4240 Y 142; 1ES 0502+675 0508.0+6737 1517.7-2421 Y 151 PKS 0548-322 - 1555.7+1111 Y 155 55 0716+714 0721.9+7120 1653.9+3945 Y <	$\begin{tabular}{ c c c c c c c c c c c c c c c c c c c$	TeV Name 2FGL Name 1FGL Source R.A. (J2000) 2FGL Name 1FGL Source rd (J2 001355.9-185406 - - 001356.0 2FGL Name 1FGL Source rd (J2 RBJ J0152+017 0152.6+0148 - 0152 33.5 1221.4+2814 Y 122 SC 66A 0222.6+4302 Y 0222.53.2 1230.8+1224 Y 1223 NGC 1275 0919.8+4130 Y 0316.64.30 1230.8+1224 Y 1225 RBS 0413 0319.6+1849 Y 0319.51.8 1256.1-0547 Y 125 RBS 0413 0319.6+1849 Y 0319.51.8 1250.2-4300 Y 133 1ES 0347-121 - - 03.49 23.0 1325.6-4300 Y 133 1ES 0414+009 0416.8+0105 Y 0416 52.41 1427.0+2347 Y 1427 PKS 0447-439 0449.4+350 Y 0507.56.2 1442.7+1159 Y 144 VER J0521+211 0521.7+2113 Y 0521.55	TeV Name 2FGL Name 1FGL Source R.A. (J2000) Dec. (J2000) 2FGL Name 1FGL Source NG - 001356.0 -185407 2FGL Name 1FGL Source NG 0152.6+017 0152.6+0148 - 0152.35.5 +0114640 3C 66A 0222.6+4302 Y 0223.53.2 +2016.21 1224.9+2122 Y 122 IC 310 0316.6+4119 - 0316.43.0 +4119.29 1230.8+1224 Y 123 NGC 1275 0319.8+1849 Y 0319.51.8 +1845.34 1256.1-0547 Y 125 RBS 0413 0319.6+1849 Y 034.9.23.0 -1158.38 1325.6-4300 Y 142 PKS 0447-439 0449.4-4350 Y 044.9.24.7 -4350.09 1422.0+2347 Y 142 PKS 0447-439 0449.4-4350 Y 044.9.24.7 -4350.09 1428.6+4240 Y 144 PKS 0524-675 0508.0+6737 Y 0507.56.2 +67.724 1517.7-2421 <t< td=""><td>$\begin{array}{ c c c c c c c c c c c c c c c c c c c$</td><td>$\begin{array}{ c c c c c c c c c c c c c c c c c c c$</td><td>TeV Name 2FGL Name FGL Source RAC (J200) Dec. VHE Fermi Index z 2FGL Name 1FGL Source 0.13 56.0 - - 0.03 56.0 - 0.03 56.0 - 0.095 1221.4+2814 Y 122 + 143 0.222 + - 0232 2.0 0.14 1224.9+2162 Y 125 0319.61.8419 Y 0319.61.841 +119.29 -<!--</td--></td></t<>	$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	TeV Name 2FGL Name FGL Source RAC (J200) Dec. VHE Fermi Index z 2FGL Name 1FGL Source 0.13 56.0 - - 0.03 56.0 - 0.03 56.0 - 0.095 1221.4+2814 Y 122 + 143 0.222 + - 0232 2.0 0.14 1224.9+2162 Y 125 0319.61.8419 Y 0319.61.841 +119.29 - </td

Gamma-ray pace Telescope

- TeV AGN population : 45
 - √ In 2FGL : 39 (20 HSP, 7 ISP, 5 LSP, 4 UNK, 3 RG)
 - \checkmark In 2LAC clean sample : 34^{*}
- Missing from 2FGL are,
 - SHBL J001355.9-185406 IES 0229+200
 - IES 0347-121 PKS 0548-322
 - IES I3I2-432 HESS JI943+2I3

all HBL with fluxes 0.4-2% of Crab Nebula flux

*Three sources have |b|<10deg and two are flagged as having possible problems in 2FGL.

reliminar



(D. Horan & D. Sanchez)



IES 0229+200 (z=0.14) is a TeV source detected by HESS and VERITAS, in observations separated by 3 years, but not seen by Fermi.

EBL absorption and cascading on CMB produces GeV emission detectable by LAT unless IGMF scatters it away (or AGN engine is short lived).



(Dermer et al., 2011, ApJ, 733, 21)



Classical TeV HBL















 ν [Hz]

 ν [Hz]

(D. Paneque)





GeV-TeV FSRQ PKS 1222+21 (4C 21.35, z=0.432)





FSRQ have not generally been detected as TeV emitters in the pre-Fermi era (exception is 3C279 detected by MAGIC during big flare)

MAGIC observations prompted by increasing GeV flux detected and reported rapidly by *Fermi* flare advocate program.

MAGIC report 70-400GeV flux of ~ICrab.

Significant variability: doubling time of 10 minutes compatible with TeV observations

Fermi spectrum "compatible" with extension of MAGIC spectrum, but significant intrinsic hardening observed in spectrum between the two bands.

Multi-wavelength studies and modeling are ongoing.

(Aleksić, J. et al. 2011, ApJL, 730, L8)





Fermi resolves core and lobe emission from Cen A.

Extrapolation of LAT core spectrum under-predicts HESS emission from Cen A, though spectral indices compatible.

Marginal evidence for additional radiative component.

(Abdo, A. A. et al. 2010, Science 328, 725 & ApJ, 719, 1433)



[deg] [deg] [10 ⁻¹⁰ ph cm ² s ⁻¹] [10 ⁻¹⁰ ph cm ² s ⁻¹] Crab Nebula units" 166.123 38.207 MRK421 0.031 Biazr 41.21.25 1.78±0.07 12.4 1.28 275.13 -13.852 MESS/1825-137 3.9 kpc PWN 71.143.3 2.34±0.07 9.7 1 225.76 -30.21 PFS 3155-304 0.117 Blazar 23.712.0 2.010.10.0 4.8 0.49 238.934 11.18 PG1553 0.5 Blazar 12.51.19 1.97±0.11 4.7 0.48 253.844 39.756 Mr601 0.034 Blazar 12.71.4 1.72±0.12 4.3 0.44 273.332 6.991 HES11837.069 ??? UNID 6.911.4 1.45±0.20 4.1 0.42 284.95 2.819 HES11837.065 ??? UNID 3.911.1 13.0±0.83 3.5 0.37 243.97 5.192 HES11817.05 0.341 Blazar 7.6±1.0 1.5±0.13 3.3	RA	DEC	Association		Туре	Flux (E>10 GeV)	Photon Index	Flux (E>50 GeV)	Flux (E>50 GeV)
166,123 38,207 MRK421 0.031 Bizar 41,24,2,5 1.78 ± 0.07 12.4 1.28 38,666 22021 CKAB 2kpc PWN 77.1113.3 234 ± 0.07 9.7 1 276.13 -13.852 HESSIB25-137 3.5 kpc PWN 272.15.7 1.50 ± 0.13 6.6 0.68 239.726 -30.21 PK5 2155.304 0.117 Bizar 223.71.20 2.01 ± 0.10 6.4 0.49 238.934 11.188 PG1553 0.5 Bizar 21.51 ± 9 1.97 ± 0.11 4.7 0.48 253.844 39.756 Mri501 0.034 Bizar 21.51 ± 9 1.97 ± 0.11 4.7 0.44 242.925 2.819 HESS 11857-026 ??? UNID 6.914 1.45 ± 0.20 4.1 0.42 242.925 2.419 HESS 11857-026 ??? UNID 3.911.1 1.30 ± 0.28 3.5 0.37 35.657 4.3.042 3.6564 0.444 Bizar 7.611.0	[deg]	[deg]				[10 ⁻¹⁰ ph cm ⁻² s ⁻¹]		[10 ⁻¹⁰ ph cm ⁻² s ⁻¹]	Crab Nebula units**
B8.626 22.021 CRA8 2 kpc PWN 71.1 ± 3.3 2.34 ± 0.07 9.7 1 276.13 -13.852 HISS1B27.137 3.9 kpc PWN 272.± 3.7 1.90 ± 0.13 6.6 0.68 239.726 -30.11 PK5 215530 0.17 Blazar 22.± 51.9 2.01 ± 0.10 4.8 0.49 238.94 11.188 PG1553 0.5 Blazar 21.5 ± 1.9 1.97 ± 0.11 4.7 0.48 273.932 -6.991 HKSS 11837.0569 ??? UNID 6.9 ± 1.4 1.45 ± 0.00 4.1 0.42 284.259 2.819 HKSS 11837.0569 ??? UNID 3.9 ± 1.1 1.30 ± 0.28 3.5 0.37 35.657 43.042 3.666a 0.444 Blazar 7.6 ± 1.0 1.59 ± 0.13 3.3 0.34 185.34 30.183 1 = ± 118 0.182 Blazar 5.2 ± 0.9 1.59 ± 0.13 3.3 0.34 185.34 30.133 1 = ± 118 0.182 Blazar	166.123	38.207	MRK421	0.031	Blazar	41.2 ± 2.5	1.78 ± 0.07	12.4	1.28
	83.626	22.021	CRAB	2 kpc	PWN	71.1 ± 3.3	2.34 ± 0.07	9.7	1
132,726 -30,21 PKS 2155-304 0,17 Bizar 23,72.0 2.01±0.10 4.8 0.49 238,384 11.188 PG1553 0.5 Bizar 215.19 1.97±0.11 4.7 0.48 253,484 39,756 Mrk501 0.034 Bizar 12.7±1.4 1.72±0.12 4.3 0.44 279,332 -6.991 MESS 11837-069 ??? UNID 6.9±1.4 1.45±0.02 4.1 0.42 284.295 2.819 MESS 11857-026 ??? UNID 3.9±1.1 1.30±0.28 3.5 0.37 35.657 43.042 3.666a 0.444 Bizar 7.6±1.0 1.59±0.13 3.3 0.34 185.34 30.183 1est218 0.182 Bizar 7.5±0.9 1.53±0.19 3.1 0.32 94.31 22.58 IC(43 1.5kpc SNR 2.66±2.1 2.6±0.14 2.4 0.25 126.755 23.802 PKS 1424:240 ??? Slizar 1.5±1.6 2.3±	276.13	-13.852	HESSJ1825-137	3.9 kpc	PWN	27.2 ± 3.7	1.90 ± -0.13	6.6	0.68
228.934 11.188 P61553 0.5 Bizar 21.5 ± 1.9 1.97 ± 0.11 4.7 0.48 253.484 39.756 Mrk501 0.034 Bizar 12.7 ± 1.4 1.72 ± 0.12 4.3 0.44 279.332 -6.991 HES5 J1837-069 ??? UNID 6.9 ± 1.4 1.45 ± 0.20 4.1 0.42 284.295 2.819 HES5 J1837-069 ??? UNID 3.9 ± 1.1 1.30 ± 0.28 3.5 0.37 33.657 43.042 3.666a 0.444 Bizar 7.6 ± 1.0 1.59 ± 0.13 3.3 0.36 7.023 67.621 1E5 050.2675 0.341 Bizar 5.2 ± 0.9 1.53 ± 0.19 3.1 0.32 243.97 -51.982 HESS J163+518 ??? Masive Star Cluster 3.7 ± 1.1 1.41 ± 0.27 2.6 0.27 94.31 22.58 1.643 1.5 kpc SN ± 1.1 1.43 ± 0.17 2.4 0.25 126.765 23.802 PKS 1042+240 ??? SH ± 1.6	329.726	-30.21	PKS 2155-304	0.117	Blazar	23.7 ± 2.0	2.01 ± 0.10	4.8	0.49
253.484 39.756 Mrk01 0.034 Blaar 12.7±1.4 1.7±0.12 4.3 0.44 279.332 6.991 HESS J1837-069 ??? UNID 6.9±1.4 1.45±0.20 4.1 0.42 284.295 2.819 HESS J1837-066 ??? UNID 3.9±1.1 1.30±0.28 3.5 0.37 35.657 43.042 3c66a 0.444 Blazar 21.9±1.8 2.15±0.11 3.5 0.36 77.023 67.621 1155052-675 0.341 Blazar 7.6±1.0 1.5±0.01 3.3 0.34 185.34 30.183 1esi218 0.182 Blazar 5.2±0.9 1.5±0.01 3.1 0.32 243.97 -5±1.92 HESS 1161-518 ??? Masive Star Cluster 3.7±1.1 1.4±0.27 2.6 0.27 94.31 2.25.8 IC443 1.5 kpc SNR 2.6±6±2.1 2.6±±0.14 2.4 0.25 80.436 21.11 VER I0521+211 ??? Blazar 10.6±1.2	238.934	11.188	PG1553	0.5	Blazar	21.5 ± 1.9	1.97 ± 0.11	4.7	0.48
279.332 -6.991 HESS I1837-069 ??? UNID 6.9±1.4 1.45±0.20 4.1 0.42 284.295 2.819 HESS I1857-026 ??? UNID 3.9±1.1 1.30±0.28 3.5 0.37 35.657 43.042 3.66a 0.444 Blazar 21.9±1.8 2.15±0.11 3.5 0.36 77.023 67.621 150502+675 0.341 Blazar 7.6±1.0 1.59±0.13 3.3 0.34 243.97 -51.982 HESS I1614-518 ??? Masive Star Cluster 3.7±1.1 1.41±0.27 2.6 0.27 94.31 22.58 1(643 1.5 kpc SNR 26.6±2.1 2.6±1.0 2.4 0.25 216.765 23.802 PKS 14/4-40 ??? Blazar 15.4±1.6 2.34±0.17 2.4 0.20 240.946 49.049 J1603-4904 ??? P??? Natar 10.4±1.3 2.1±0.17 1.8 0.18 240.946 49.049 J1603-4904 ??? ???<	253.484	39.756	Mrk501	0.034	Blazar	12.7 ± 1.4	1.72 ± 0.12	4.3	0.44
284.295 2.819 HESS I1857+026 ??? UNID 3.9 ±1.1 1.30 ± 0.28 3.5 0.37 35.657 43.042 3.666a 0.444 Blazar 21.9 ± 1.8 2.1.5 ± 0.11 3.5 0.36 77.023 67.621 1.15 0.02+675 0.341 Blazar 7.6 ± 1.0 1.5 ± 0.13 3.3 0.34 185.34 30.183 1est 218 0.182 Blazar 5.2 ± 0.9 1.5 ± 0.13 3.1 0.32 243.97 -5.1982 HESS 11614-518 ??? Masive Star Cluster 3.7 ± 1.1 1.41 ± 0.27 2.6 0.27 94.31 22.58 1(243 1.5 kpc SNR 26.6 ± 2.1 2.61 ± 0.14 2.4 0.25 80.436 21.21 VEN 10521+211 ??? AGN (unknown type) 8.7 ± 1.2 1.94 ± 0.17 2.4 0.25 216.765 23.802 PK5 1424240 ??? Blazar 10.4 ± 1.3 2.11 ± 0.16 2.0 0.21 72.379 43.841 PK5047-439 0	279.332	-6.991	HESS J1837-069	???	UNID	6.9 ± 1.4	1.45 ± 0.20	4.1	0.42
35.657 43.042 3c66a 0.444 Blazar 21.91.8 2.15 ± 0.11 3.5 0.36 77.023 67.621 115 0502+675 0.341 Blazar 7.6±1.0 1.55 ± 0.13 3.3 0.34 185.34 30.183 1et218 0.182 Blazar 5.2±0.9 1.55 ± 0.13 3.1 0.32 243.97 -5.1982 HESS 11614-518 ?? Masive Star Cluster 3.7±1.1 1.4±0.27 2.6 0.27 94.31 22.58 1C443 1.5 kpc SNR 26.6±2.1 2.61±-0.14 2.4 0.25 216.755 23.802 PKS 1024+240 ??? Blazar 15.4±1.6 2.3±0.15 2.0 0.21 72.379 -43.841 PKS 0447.439 0.2 Blazar 10.4±1.3 2.1±0.16 2.0 0.20 240.946 49.049 11603.4904 ??? ??? 10.3±1.3 2.1±0.17 1.8 0.19 300.308 43.881 MAGC(J201+435 ??? ???	284.295	2.819	HESS J1857+026	???	UNID	3.9 ± 1.1	1.30 ± 0.28	3.5	0.37
77.02367.6211ES 0502+6750.341Blazar7.6±1.01.59±0.133.30.34185.3430.1831est2180.182Blazar5.2±0.91.53±0.193.10.32243.97-51.982HESS 1614-518???Masive Star Cluster3.7±1.11.41±0.272.60.2794.3122.581C4431.5 kpcSNR26.6±2.12.61±-0.142.40.2580.43612.11VER 10521+211???ASN (unknown type)8.7±1.21.94±0.172.40.25216.76523.802PKS 124+240???Blazar15.4±1.62.34±0.152.00.2172.379-43.841PKS 0447-4390.2Blazar10.4±1.32.11±0.162.00.20240.946-49.049J.1603-4904???P??10.3±1.32.12±0.171.80.19300.30843.881MAGIC 12001+435???Blazar10.0±1.22.17±0.171.80.18161.247-59.699Eta Carinae???IBV5.3±1.11.8±0.231.50.15248.633-47.661??????P??5.9±1.51.91±0.261.40.14256.453-28.983TeV Galactic Centre8.5 kpcUNID18.0±2.12.09±0.201.40.14256.453-28.983TeV Galactic Centre8.5 kpcSNR14.4±1.72.50±0.181.30.13266.453-48.826PKS 2005-4890.071Blazar6.4±1.0<	35.657	43.042	3c66a	0.444	Blazar	21.9 ± 1.8	2.15 ± 0.11	3.5	0.36
185.3430.1831est2180.182Blaar5.2±0.91.53±0.193.10.32243.97-51.982HESS J1614-518???Masive Star Cluster3.7±1.11.41±0.272.60.2794.3122.58IC4431.5kpcSNR26.6±2.12.61±0.142.40.2580.43621.21VER J0521+211???AGN (unknown type)8.7±1.21.94±0.172.40.25216.76523.802PKS 1424+240???Blazar10.4±1.62.34±0.152.00.2172.379-43.841PKS 0447-4390.2Blazar10.4±1.32.11±0.162.00.20240.946-49.049J1603-4904??????10.3±1.32.11±0.162.00.20300.30843.881MAGIC J2001+435???Blazar10.0±1.22.17±0.171.80.19300.30843.881MAGIC J2001+435???Blazar10.0±1.22.17±0.171.80.15248.633-47.661?????????5.9±1.51.91±0.261.40.15248.633-47.661?????????5.9±1.51.91±0.261.40.15248.633-47.661?????????5.9±1.51.91±0.261.40.1445.871-24.114PKS 0301-2430.25Blazar6.4±1.02.09±0.201.40.14256.643-28.983TeV Galactic Centre8.5kpcUNID18.0±2.12.59±0.181.3<	77.023	67.621	1ES 0502+675	0.341	Blazar	7.6 ± 1.0	1.59 ± 0.13	3.3	0.34
243.97-51.982HESS J1614-518???Masive Star Cluster3.7 ± 1.11.41 ± 0.272.60.2794.3122.58IC4431.5 kpcSNR26.6 ± 2.12.6 ± 0.142.40.2580.43621.21VFE ND521+211???AGN (unknown type)8.7 ± 1.21.94 ± 0.172.40.25216.76523.802PKS 1424+240???Blazar15.4 ± 1.62.34 ± 0.152.00.2177.379-43.841PKS 0447-4390.2Blazar10.4 ± 1.32.11 ± 0.162.00.20240.946-49.049J1603-4904??????10.3 ± 1.32.11 ± 0.162.00.20300.30843.881MAGIC I2001+435???Blazar10.0 ± 1.22.17 ± 0.171.80.18161.247-59.699Eta Carinae???I.BV5.3 ± 1.11.83 ± 0.231.50.15248.633-47.661?????????5.9 ± 1.51.91 ± 0.261.40.14266.463-28.983TeV Galactic Centre8.5 kpcUNID18.0 ± 2.12.59 ± 0.201.40.1445.871-24.114PKS 0301-2430.26Blazar6.4 ± 1.02.00 ± 0.201.30.14290.81814.145W51C5 kpcSNR14.4 ± 1.72.50 ± 0.181.30.13278.659-7.111SNR 6024.700.6SNR5.5 ± 1.31.91 ± 0.281.30.1328.507-59.256M5H-15-525.2 kpcPWN<	185.34	30.183	1es1218	0.182	Blazar	5.2 ± 0.9	1.53 ± 0.19	3.1	0.32
94.3122.58IC4431.5 kpcSNR26.6 ± 2.12.61 ± 0.142.40.2580.43621.21VER J0521+211???AGN (unknown type)8.7 ± 1.21.94 ± 0.172.40.25216.75523.802PKS 1424+240???Blazar15.4 ± 1.62.34 ± 0.152.00.2172.379-43.841PKS 0447-4390.2Blazar10.4 ± 1.32.11 ± 0.162.00.20240.946-49.04911603-4904???P??10.3 ± 1.32.12 ± 0.171.80.19300.30843.881MAGIC J2001+435???Blazar10.0 ± 1.22.17 ± 0.171.80.18301.1247-59.699Eta Carinae???LBV5.3 ± 1.11.8 ± 0.231.50.15248.633-47.661??????P??5.9 ± 1.51.91 ± 0.261.40.15266.463-28.983TeV Galctic Centre8.5 kpcUNID18.0 ± 2.12.59 ± 0.011.40.14256.463-28.983TeV Galctic Centre8.5 kpcUNID18.0 ± 2.12.59 ± 0.181.30.13250.81814.145W51C5 kpcSNR14.4 ± 1.72.50 ± 0.181.30.13278.659-7.111SNR G02.7+00.6SNR5.5 ± 1.31.91 ± 0.281.30.13278.659-7.111SNR G02.7+00.6SNR5.5 ± 1.31.91 ± 0.281.30.1328.67-5.826PKS 2005-4890.071Blazar4.9 ± 0.9<	243.97	-51.982	HESS J1614-518	???	Masive Star Cluster	3.7 ± 1.1	1.41 ± 0.27	2.6	0.27
80.43621.21VER J0521+211???AGN (unknown type)8.7 ± 1.21.94 ± 0.172.40.25216.76523.802PKS 1424+240???Blazar15.4 ± 1.62.34 ± 0.152.00.2172.379-43.841PKS 0447-4390.2Blazar10.4 ± 1.32.11 ± 0.162.00.20240.946-49.049J1603-4904??????10.3 ± 1.32.12 ± 0.171.80.19300.30843.881MAGIC J2001+435???Blazar10.0 ± 1.22.17 ± 0.171.80.18161.247-59.699Eta Carinae???LBV5.3 ± 1.11.88 ± 0.231.50.15248.633-47.661?????????5.9 ± 1.51.91 ± 0.261.40.14266.463-28.93TeV Galactic Centre8.5 kpcUNID18.0 ± 2.12.59 ± 0.201.40.1445.871-24.114PKS 0301-2430.26Blazar6.4 ± 1.02.00 ± 0.201.30.14290.81814.145W51C5 kpcSNR14.4 ± 1.72.50 ± 0.181.30.13302.265-48.826PKS 2005-4890.071Blazar4.9 ± 0.91.87 ± 0.221.30.13302.365-48.826PKS 2005-4890.071Blazar4.9 ± 0.91.87 ± 0.231.20.12302.365-48.826PKS 2005-4890.071Blazar4.9 ± 0.91.87 ± 0.231.20.13302.365-48.826PKS 2005-4890.	94.31	22.58	IC443	1.5 kpc	SNR	26.6 ± 2.1	2.61 ± -0.14	2.4	0.25
216.76523.802PKS 1424+240???Blazar15.4 ± 1.62.34 ± 0.152.00.2172.379-43.841PKS 0447-4390.2Blazar10.4 ± 1.32.11 ± 0.162.00.20240.946-49.049J1603-4904??????10.3 ± 1.32.12 ± 0.171.80.19300.30843.881MAGIC J2001+435???Blazar10.0 ± 1.22.17 ± 0.171.80.18161.247-59.699Eta Carinae???LBVS.3 ± 1.11.83 ± 0.231.50.15248.633-47.661?????????Y??5.9 ± 1.51.91 ± 0.261.40.14266.463-28.983TeV Galactic Centre8.5 kpcUNID18.0 ± 2.112.59 ± 0.201.40.1445.871-24.114PKS 0301-2430.26Blazar6.4 ± 1.02.00 ± 0.201.30.14290.81814.145W51C5 kpcSNR14.4 ± 1.72.50 ± 0.181.30.13278.659-7.111SNR 6024.7+00.6SNR5.5 ± 1.31.91 ± 0.281.30.13302.365-48.826PKS 2005-4890.071Blazar4.9 ± 0.91.87 ± 0.221.30.13228.507-59.256M5H-15-525.2 kpcPWN5.5 ± 1.01.96 ± 0.231.20.12	80.436	21.21	VER J0521+211	???	AGN (unknown type)	8.7 ± 1.2	1.94 ± 0.17	2.4	0.25
72.379.43.841PKS 0447-4390.2Blazar10.4±1.32.11±0.162.00.20240.946.49.049.11603-4904?????????10.3±1.32.12±0.171.80.19300.30843.881MAGIC J2001+435???Blazar10.0±1.22.17±0.171.80.15161.247.59.699Eta Carinae???IBV5.3±1.11.83±0.231.50.15248.633.47.661?????????5.9±1.51.91±0.261.40.15266.463.28.983TeV Galactic Centre8.5 kpcUNID18.0±2.12.59±0.201.40.1445.871.24.114PKS 0301-2430.26Blazar6.4±1.02.00±0.201.30.14290.81814.145W51C5 kpcSNR14.4±1.72.50±0.181.30.13278.659.7.111SNR 6024.7±0.6SNR5.5±1.31.91±0.281.30.13302.365.48.826PKS 2005-4890.071Blazar4.9±0.91.87±0.221.30.13228.507.59.256M5H-15-525.2 kpcPWN5.5±1.01.96±0.231.20.12	216.765	23.802	PKS 1424+240	???	Blazar	15.4 ± 1.6	2.34 ± 0.15	2.0	0.21
240.946-49.049J1603-4904??????10.3 ± 1.32.12 ± 0.171.80.19300.30843.881MAGIC J2001+435???Blazar10.0 ± 1.22.17 ± 0.171.80.18161.247-59.699Eta Carinae???LBV5.3 ± 1.11.83 ± 0.231.50.15248.633-47.661?????????5.9 ± 1.51.91 ± 0.261.40.15266.463-28.983TeV Galactic Centre8.5 kpcUNID18.0 ± 2.12.59 ± 0.201.40.1445.871-24.114PKS 0301-2430.26Blazar6.4 ± 1.02.00 ± 0.201.30.14290.81814.145W51C5 kpcSNR14.4 ± 1.72.50 ± 0.181.30.13278.659-7.111SNR 6024.7+00.6SNR5.5 ± 1.31.91 ± 0.281.30.13302.365-48.826PKS 2005-4890.071Blazar4.9 ± 0.91.87 ± 0.221.30.13228.507-59.256MSH-15-525.2 kpcPWN5.5 ± 1.01.96 ± -0.231.20.12	72.379	-43.841	PKS 0447-439	0.2	Blazar	10.4 ± 1.3	2.11 ± 0.16	2.0	0.20
300.30843.881MAGIC J2001+435???Blazar10.0 ± 1.22.17 ± 0.171.80.18161.247-59.699Eta Carinae???LBV5.3 ± 1.11.83 ± 0.231.50.15248.633-47.661?????????5.9 ± 1.51.91 ± 0.261.40.15266.463-28.983TeV Galactic Centre8.5 kpcUNID18.0 ± 2.12.59 ± 0.201.40.1445.871-24.114PKS 0301-2430.26Blazar6.4 ± 1.02.00 ± 0.201.30.14290.81814.145W51C5 kpcSNR14.4 ± 1.72.50 ± -0.181.30.13278.659-7.111SNR 6024.7+00.6SNR5.5 ± 1.31.91 ± 0.281.30.13302.365-48.826PKS 2005-4890.071Blazar4.9 ± 0.91.87 ± 0.221.30.13228.507-59.256MSH-15-525.2 kpcPWN5.5 ± 1.01.96 ± -0.231.20.12	240.946	-49.049	J1603-4904	???	???	10.3 ± 1.3	2.12 ± 0.17	1.8	0.19
161.247-59.699Eta Carinae???LBV5.3 ± 1.11.83 ± 0.231.50.15248.633-47.661?????????5.9 ± 1.51.91 ± 0.261.40.15266.463-28.983TeV Galactic Centre8.5 kpcUNID18.0 ± 2.12.59 ± 0.201.40.1445.871-24.114PKS 0301-2430.26Blazar6.4 ± 1.02.00 ± 0.201.30.14290.81814.145W51C5 kpcSNR14.4 ± 1.72.50 ± -0.181.30.13278.659-7.111SNR 6024.7+00.6SNR5.5 ± 1.31.91 ± 0.281.30.13302.365-48.826PKS 2005-4890.071Blazar4.9 ± 0.91.87 ± 0.221.30.13228.507-59.256MSH-15-525.2 kpcPWN5.5 ± 1.01.96 ± -0.231.20.12	300.308	43.881	MAGIC J2001+435	???	Blazar	10.0 ± 1.2	2.17 ± 0.17	1.8	0.18
248.633-47.661??????5.9 ± 1.51.91 ± 0.261.40.15266.463-28.983TeV Galactic Centre8.5 kpcUNID18.0 ± 2.12.59 ± 0.201.40.1445.871-24.114PKS 0301-2430.26Blazar6.4 ± 1.02.00 ± 0.201.30.14290.81814.145W51C5 kpcSNR14.4 ± 1.72.50 ± -0.181.30.13278.659-7.111SNR 6024.7+00.6SNR5.5 ± 1.31.91 ± 0.281.30.13302.365-48.826PKS 2005-4890.071Blazar4.9 ± 0.91.87 ± 0.221.30.13228.507-59.256MSH-15-525.2 kpcPWN5.5 ± 1.01.96 ± -0.231.20.12	161.247	-59.699	Eta Carinae	???	LBV	5.3 ± 1.1	1.83 ± 0.23	1.5	0.15
266.463 -28.983 TeV Galactic Centre 8.5 kpc UNID 18.0 ± 2.1 2.59 ± 0.20 1.4 0.14 45.871 -24.114 PKS 0301-243 0.26 Blazar 6.4 ± 1.0 2.00 ± 0.20 1.3 0.14 290.818 14.145 W51C 5 kpc SNR 14.4 ± 1.7 2.50 ± -0.18 1.3 0.13 278.659 -7.111 SNR 6024.7+00.6 SNR 5.5 ± 1.3 1.91 ± 0.28 1.3 0.13 302.365 -48.826 PKS 2005-489 0.071 Blazar 4.9 ± 0.9 1.87 ± 0.22 1.3 0.13 228.507 -59.256 MSH-15-52 5.2 kpc PWN 5.5 ± 1.0 1.96 ± -0.23 1.2 0.12	248.633	-47.661	???	???	???	5.9 ± 1.5	1.91 ± 0.26	1.4	0.15
45.871 -24.114 PKS 0301-243 0.26 Blazar 6.4 ± 1.0 2.00 ± 0.20 1.3 0.14 290.818 14.145 W51C 5 kpc SNR 14.4 ± 1.7 2.50 ± -0.18 1.3 0.13 278.659 -7.111 SNR 6024.7+00.6 SNR 5.5 ± 1.3 1.91 ± 0.28 1.3 0.13 302.365 -48.826 PKS 2005-489 0.071 Blazar 4.9 ± 0.9 1.87 ± 0.22 1.3 0.13 228.507 -59.256 MSH-15-52 5.2 kpc PWN 5.5 ± 1.0 1.96 ± -0.23 1.2 0.12	266.463	-28.983	TeV Galactic Centre	8.5 kpc	UNID	18.0 ± 2.1	2.59 ± 0.20	1.4	0.14
290.818 14.145 W51C 5 kpc SNR 14.4 ± 1.7 2.50 ± -0.18 1.3 0.13 278.659 -7.111 SNR G024.7+00.6 SNR 5.5 ± 1.3 1.91 ± 0.28 1.3 0.13 302.365 -48.826 PKS 2005-489 0.071 Blazar 4.9 ± 0.9 1.87 ± 0.22 1.3 0.13 228.507 -59.256 MSH-15-52 5.2 kpc PWN 5.5 ± 1.0 1.96 ± -0.23 1.2 0.12	45.871	-24.114	PKS 0301-243	0.26	Blazar	6.4 ± 1.0	2.00 ± 0.20	1.3	0.14
278.659 -7.11 SNR G024.7+00.6 SNR 5.5 ± 1.3 1.91 ± 0.28 1.3 0.13 302.365 -48.826 PKS 2005-489 0.071 Blazar 4.9 ± 0.9 1.87 ± 0.22 1.3 0.13 228.507 -59.256 MSH-15-52 5.2 kpc PWN 5.5 ± 1.0 1.96 ± -0.23 1.2 0.12	290.818	14.145	W51C	5 kpc	SNR	14.4 ± 1.7	2.50 ± -0.18	1.3	0.13
302.365 -48.826 PKS 2005-489 0.071 Blazar 4.9 ± 0.9 1.87 ± 0.22 1.3 0.13 228.507 -59.256 MSH-15-52 5.2 kpc PWN 5.5 ± 1.0 1.96 ± -0.23 1.2 0.12	278.659	-7.111	SNR G024.7+00.6		SNR	5.5 ± 1.3	1.91 ± 0.28	1.3	0.13
228.507 -59.256 MSH-15-52 5.2 kpc PWN 5.5 ± 1.0 1.96 ± -0.23 1.2 0.12	302.365	-48.826	PKS 2005-489	0.071	Blazar	4.9 ± 0.9	1.87 ± 0.22	1.3	0.13
	228.507	-59.256	MSH-15-52	5.2 kpc	PWN	5.5 ± 1.0	1.96 ± -0.23	1.2	0.12



Sermi Future perspectives Instruments





Gamma-ray Space Telescope

> HESS - new 28m telescope at center of HESS array VERITAS - high QE PMTs and new trigger system MAGIC - second telescope operating now

Fermi's 5-year prime mission extends into 2013. Extended mission possible and would have large impact on future GeV-TeV studies, such as MW campaigns and GeV triggering.





The TeV community is working towards the next-generation HAWC and CTA observatories, which will have vastly improved sensitivity and energy range.

Probe AGN variability on shorter timescales.

Extend GeV-TeV studies of EBL/EMF using more distant sources.

Additional slides



Ap Lib light curve













Fig. 3.— Spectrum of the Cen A core from differential fluxes derived for successive energy ranges from model B (black circles). The black bowtie indicates the best fit 0.1 - 30 GeV LAT flux and Γ with statistical errors only, while the green bowtie indicates this with systematic errors as well. The LAT spectrum is extrapolated into the HESS energy range (dashed lines). The HESS data from Aharonian et al. (2009) are shown (red squares) and the HESS data shifted to lower flux by their statistical and systematic normalization error (blue squares). The latter are also shifted in energy by 10% for clarity.



Fig. 5.— The SED of the Cen A core with model fits. Colored symbols are observations between August and May 2009, the epoch of the LAT observations. These include observations of, from low to high frequency: the TANAMI VLBI (red squares), *Swift*-XRT (red crosses), *Suzaku* (brown circles), *Swift*-BAT (red circles), and *Fermi*-LAT (red diamonds). Black symbols are archival data, (Marconi et al. 2000) including HESS observations (Aharonian et al. 2009). Curves are model fits to nuclear region of Cen A. The green curve is a synchrotron/SSC fit to the entire data set. The dashed green curve shows this model without $\gamma\gamma$ attenuation. The violet curve is a similar fit but is designed to under fit the X-ray data, and the brown curve is designed to fit the HESS data while not over-producing the other data in the SED. The blue curve is the decelerating jet model fit (Georganopoulos & Kazanas 2003). See Table 2 for the parameters of these model curves.