



Fermi
Gamma-ray Space Telescope


Identifying TeV sources candidates among Fermi -LAT unclassified blazars with Artificial Neural Network

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on behalf of Fermi LAT Collaboration

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IACTs are the most sensitive detectors of VHE rays but their observation time is limited by their small field of view (FoV), and by many science cases to study.

 The aim of this study is to search unclassified blazars that are likely detectable with Cherenkov telescopes within reasonable observation times using an artificial neural network algorithm, in order to save observing time and consequently to increase the number of detections.

TeV catalog
210 sources
48 HBL BL Lac
7 FSRQ

3FGL => 1745 AGN
573 BCU
1010 UCS

Saz Parkinson P.M. et al. (2016)

676 uncertain
blazar-like sources

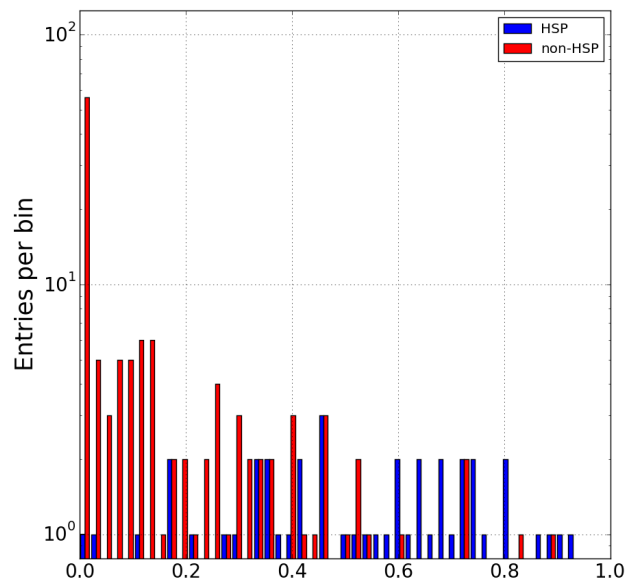
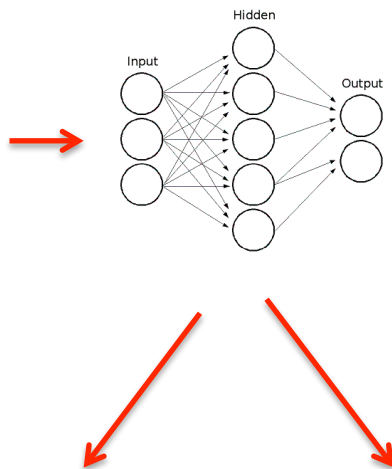
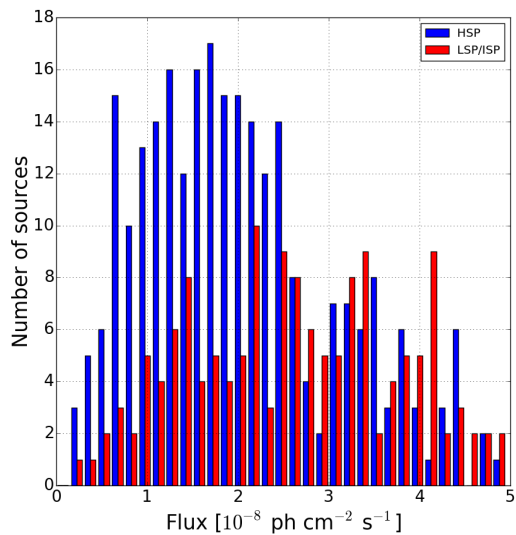
OUR SAMPLE

334 PULSAR
559 AGN
117 UNCERTAIN

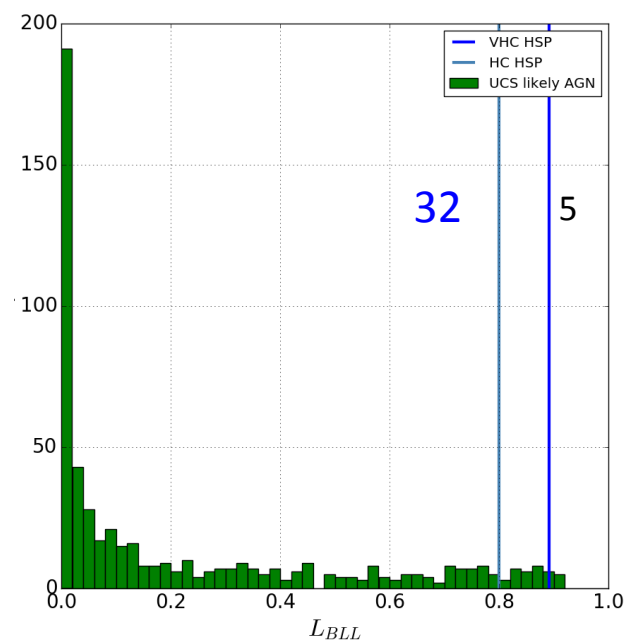
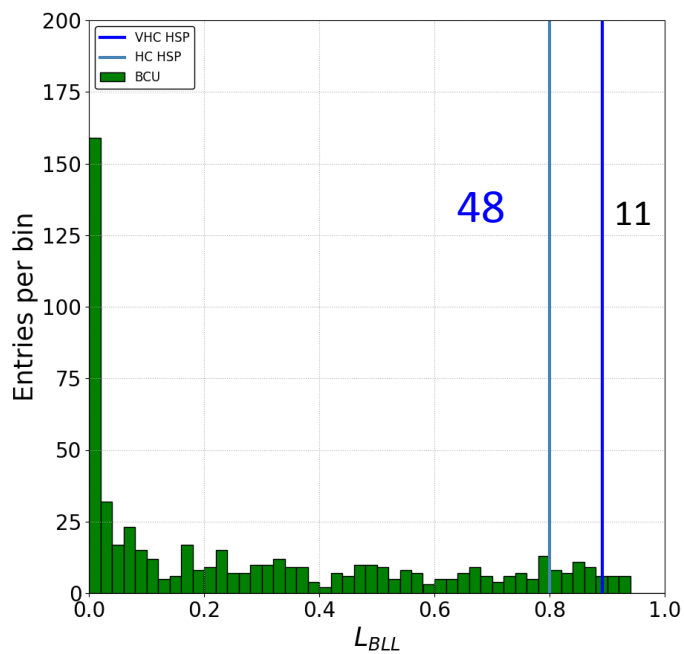
Salvetti D. et al (2017)

HBL/TeV candidates
from uncertain
blazar-like sources

271 BL Lac
185 FSRQ
103 UNCERTAIN



3FGL



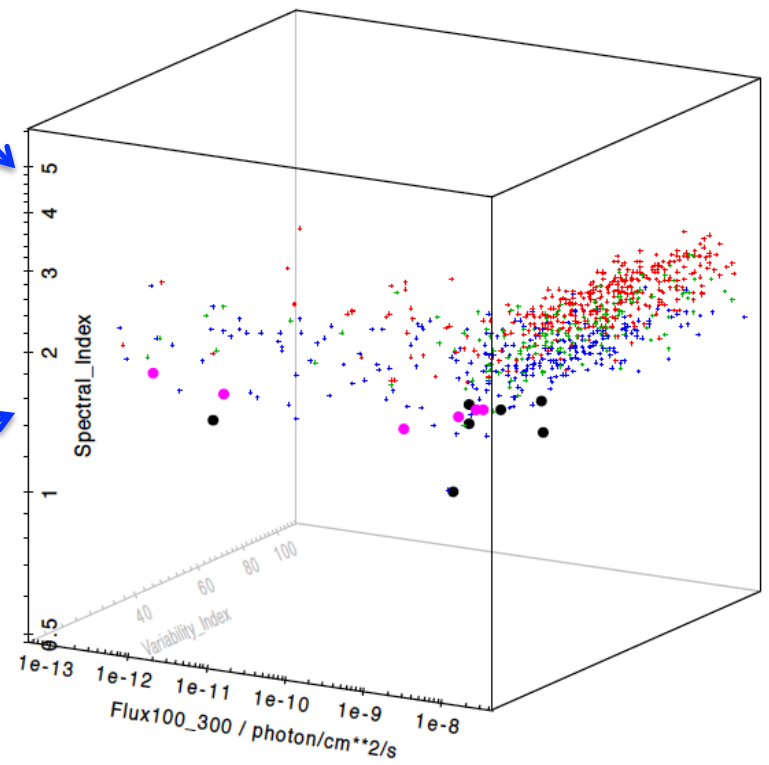
OUR SAMPLE

Table 1. Full list of BCU HBL candidates. Col.3) TS that represents the detection significance over the 100MeV-300 GeV band, Col.4) Spectral Index, Col.5) TS_{var} that represents the variability significance, Col.6) HBL Likelihood, Col. 8, 9, 10, 11) the observability at the IACT site. On the top of the list the BC scores ($L > 0.8$).

3FGL name	Association	2WSP	TS	Sp.Index	TS_{var}	L_{HBL}	RAJ2000	DecJ2000	HESS	VERITAS	MAGIC
3FGL J0747.9+5447	IRXS J0747.9+5447	54.73	1.37	11.70	0.92	12.016036	34.30954405				
3FGL J1155.4-3417	NVSS J1155.20-341718	147.32	1.64	16.24	0.92	178.8740215	-34.33645279				
3FGL J1434.6+6640	IRXS J1434.62+664001	73.90	1.58	16.78	0.92	218.7229694	66.67084333				
3FGL J0921.0-2258	NVSS J0920.57-225721	62.51	1.73	10.50	0.91	140.2407961	-22.94845947				
3FGL J0648.1+1606	IRXS J0648.14+160708	44.30	1.83	13.91	0.9	102.0277929	16.39911409				
3FGL J1714.1-2029	IRXS J1714.05-2-02747	73.8	1.44	15.16	0.9	258.6700448	88.7072331				
3FGL J1910.8+2855	IRXS J1910.83-2+285622	102.25	1.62	15.16	0.9	258.5151502	-20.47598992				
3FGL J0153.4+7114	TXS 0149+710	80.86	1.81	19.72	0.89	287.7132869	28.94032688				
3FGL J0506.9-5435	IES 0505-546	455.43	1.49	29.82	0.89	76.75704891	-54.59583993				
3FGL J1944.1-4523	IRXS J1944.26-452326	100.09	1.63	11.11	0.89	292.1113217	-45.3896215				
3FGL J0742.4-8133c	SUMSS J0742.20-813310	32.29	2.08	11.80	0.92	115.4867982	-81.53259583				
3FGL J0040.3+4049	B3 0637+405	75.94	1.93	12.02	0.90	10.0870872	40.82305336				
3FGL J0043.7-1117	IRXS J0043.3-11612	60.40	1.91	12.51	0.88	10.3879737	-11.127612				
3FGL J1824.4+4310	IRXS J1824.87+430954	80.91	1.82	19.74	0.88	276.1228226	43.17807155				
3FGL J0528.3+1815	IRXS J0528.29+181657	35.69	1.67	14.66	0.87	82.1128303	18.2730451				
3FGL J0646.4-5452	PMN J0646-5451	190.34	1.46	17.37	0.87	101.6181351	-54.9183251				
3FGL J1959.8-4725	SUMSS J1959.45-472519	923.79	1.51	94.31	0.87	299.9397253	-47.42001942				
3FGL J2108.6-8619	IRXS J2108.9-5-861853	91.04	1.86	10.72	0.87	316.9864679	-86.31666306				
3FGL J0039.0-2218	PMN J0039-2220	89.34	1.66	11.61	0.86	9.70099607	-22.3130028				
3FGL J0305.2-1607	PKS 0302-16	147.60	1.60	22.94	0.84	46.20075388	-16.14813296				
3FGL J1040.8+1342	IRXS J1040.57+134226	69.15	1.70	11.06	0.86	160.2994773	13.7199601				
3FGL J2312.9-6923	SUMSS J2313.47-692332	35.32	1.72	16.13	0.86	348.4026935	-69.3920488				
3FGL J0515.5-0123	NVSS J0515.36-012427	45.66	1.79	11.76	0.85	78.87465087	-1.9402214				
3FGL J10620.6+2644	PKS 10620.6+2644	62.02	1.53	15.10	0.85	95.17349572	26.74060004				
3FGL		174.15	1.52	14.44	0.85	100.0137946	-12.00031415				
3FGL						113.3461751	51.86215575				
3FGL							68.082292				

Table 2. Full list of BCU HBL candidates. Col.2) TS that represents the detection significance over the 100MeV-300 GeV band, Col.3) Spectral Index, Col.4) TS_{var} that represents the variability significance, Col.5) HBL Likelihood, Col. 8, 9, 10) the observability at the IACT site. On the top of the list the BC scores ($L < 0.8$).

3FGL name	2WSP	TS	Sp.Index	TS_{var}	L_{HBL}	RAJ2000	DecJ2000	HESS	VERITAS	MAGIC
3FGL J1549.9-3044	64.26	1.9	10.10	0.919						
3FGL J2142.6-2029	36.07	1.68	8.19	0.914	325.637186	-20.4895455				
3FGL J2321.6-1619	34.14	1.73	45.13	0.91	350.9366202	-16.3171834				
3FGL J2145.5+1007	52.53	1.7	19.90	0.906	336.3814678	10.12898775				
3FGL J2300.0+4053	174.53	1.64	6.97	0.904	345.0583034	40.87501176				
3FGL J1153.3-1112	23.50	1.38	9.533	0.89	336.102	3.859				
3FGL J1525.8-0834	56.52	1.92	23.258	0.89	231.47	-8.579				
3FGL J1619.1+7538	107.12	1.86	14.91	0.88	244.961	75.673				
3FGL J0251.1-1829	104.26	1.58	10.203	0.88	42.797	-18.486				
3FGL J0020.9+0323	60.66	2.09	22.901	0.88	5.231	3.336				
3FGL J0813.5-0356	57.02	1.71	13.154	0.88	123.287	-3.929				
3FGL J1234.7-0437	51.54	2	29.762	0.87	188.697	-4.622				
3FGL J1922.2+2313	80.83	2.22	22.682	0.87	290.566	23.226				
3FGL J2043.6+0001	48.48	2.01	24.427	0.87	310.901	0.029				
3FGL J0312.7-2222	177.14	1.84	18.274	0.87	48.176	-22.371				
3FGL J1513.3-3719	54.74	1.91	18.061	0.87	228.329	-37.319				
3FGL J0524.5-0307	94.15	2.05	18.366	0.86	81.128	-69.528				
3FGL J1225.4-3448	22.27	1.74	7.006	0.86	186.356	-34.807				
3FGL J1222.7+7952	43.83	2.12	14.79	0.86	185.9965	79.921				
3FGL J2309.0+5428	77.06	1.75	17.677	0.85	347.252	54.476				
3FGL J2015.3-1431	17.42	1.81	14.63	0.85	303.8543	-14.5344				
3FGL J2053.9+2922	359.63	1.76	43.971	0.85	313.476	29.374				
3FGL J0242-0629	90.70	2	20.73	0.84	236.205	-6.0997				
3FGL J1545.0-6641	150.10	1.99	11.852	0.84	112.974	-30.177				
3FGL J0731.8-3010	37.07	1.99	14.122	0.84	148.217	7.199				
3FGL J0952.8+0711	50.96	1.91	14.781	0.83	81.9	66.7787				
3FGL J0527.3+6647	51.89	1.9	11.717	0.83	232.086	-29.768				
3FGL J1528.1-2904	26.28	1.8	16.583	0.82	12.285	12.413				
3FGL J0049.0+4234	36.95	1.8	15.543	0.82	164.439	-40.862				
3FGL J1087.6-4051	40.23	1.71	15.543	0.82	142.03	-52.868				
3FGL J0928.3-5255	98.75	2.09	26.678	0.80						



LBL
IBL
HBL

FERMI - LAT ANALYSIS

104 months Pass 8 / 16°x16°ROI / Fermi.py Ajello et al. (2017)

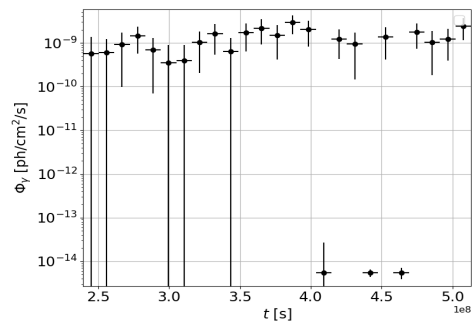
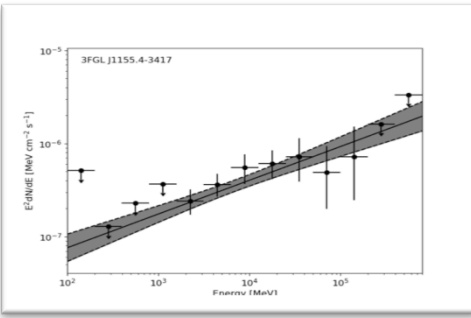
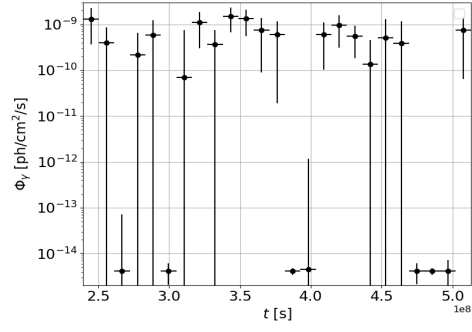
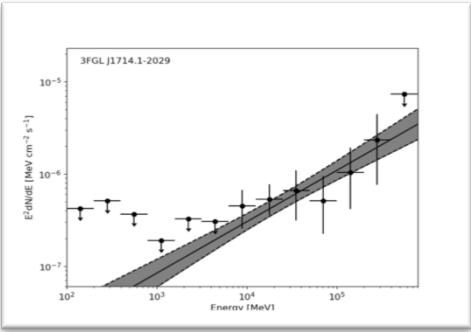
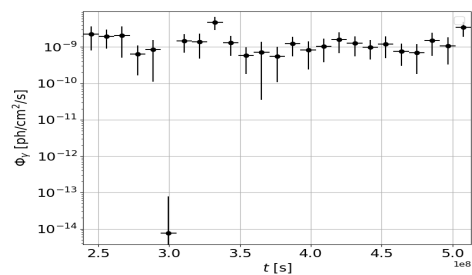
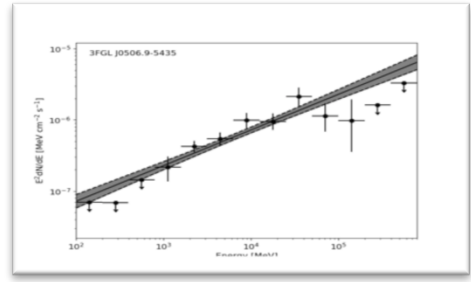


Table Browser for 1: 3fgl_j0039.0-2218_sed.fits

	e_min	e_ref	e_max	ref_dnde_e_min	ref_dnde_e_max
1	100	141,25375	199,52623	1,000000E-11	2,511886E-11
2	199,52623	281,83829	398,10717	2,511886E-12	6,309573E-12
3	398,10717	562,34133	794,32823	6,309573E-13	1,584893E-12
4	794,32823	1122,01845	1584,89319	1,584893E-13	3,981072E-13

Table Browser for 2: 3fgl_j0039.0-2218_sed.fits-2

energy	dnde	dnde_lo	dnde_hi	dnde_err	dnde_ferr	
1	100	6,15072E-12	4,23153E-12	8,94034E-12	2,78962E-12	0,382786
2	120,679	4,49374E-12	3,13695E-12	6,45044E-12	1,95678E-12	0,369386
3	145,635	3,28315E-12	2,31622E-12	4,65373E-12	1,37058E-12	0,355987
4	175,751	2,39868E-12	1,71376E-12	3,35734E-12	9,58659E-13	0,342601
5	212,095	1,75249E-12	1,26803E-12	2,42203E-12	6,69543E-13	0,329246
6	255,955	1,29037E-12	9,38234E-13	1,74728E-12	4,66907E-13	0,315942
7	308,884	9,38234E-13	6,74728E-13	1,29037E-12	3,35734E-13	0,302715
8	372,759	6,74728E-13	4,89374E-13	9,38234E-13	2,42203E-12	0,290246
9	449,843	4,89374E-13	3,57341E-13	6,74728E-13	1,74728E-12	0,278601
10	542,868	3,57341E-13	2,59868E-13	4,89374E-13	1,29037E-12	0,267715
11	655,129	2,59868E-13	1,89374E-13	3,57341E-13	9,38234E-13	0,257599
12	790,604	1,89374E-13	1,37058E-13	2,59868E-13	6,74728E-13	0,248146
13	954,095	1,37058E-13	1,00000E-13	1,89374E-13	4,89374E-13	0,239246
14	1151,4	1,00000E-13	7,29037E-14	1,37058E-13	3,57341E-13	0,230899
15	1389,5	7,29037E-14	5,29037E-14	1,00000E-13	2,59868E-13	0,223099
16	1676,83	5,29037E-14	3,89374E-14	7,29037E-14	1,89374E-13	0,215899
17	2023,59	3,89374E-14	2,89374E-14	5,29037E-14	1,37058E-13	0,209246

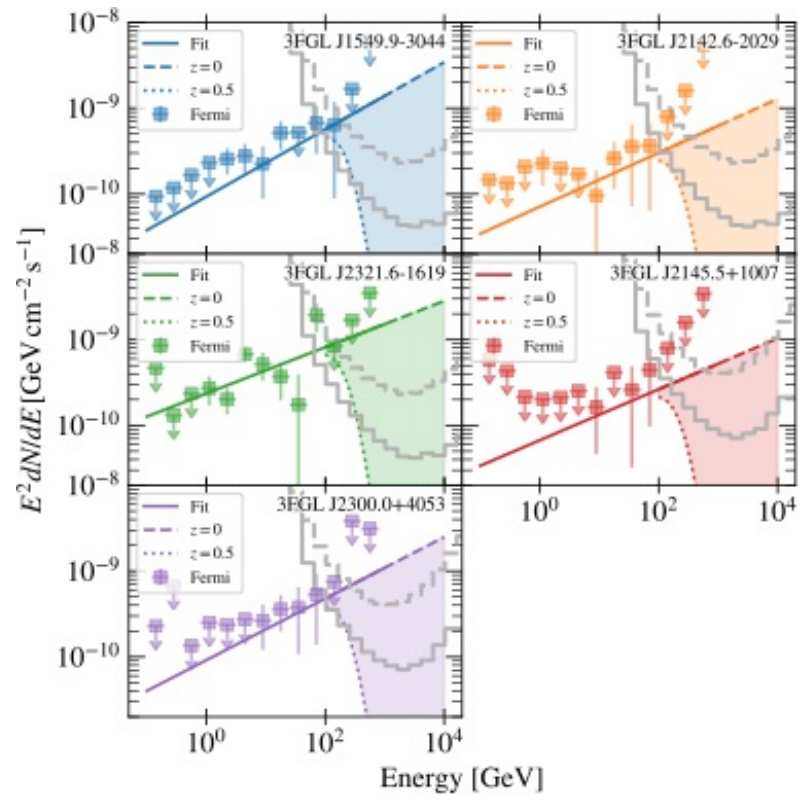
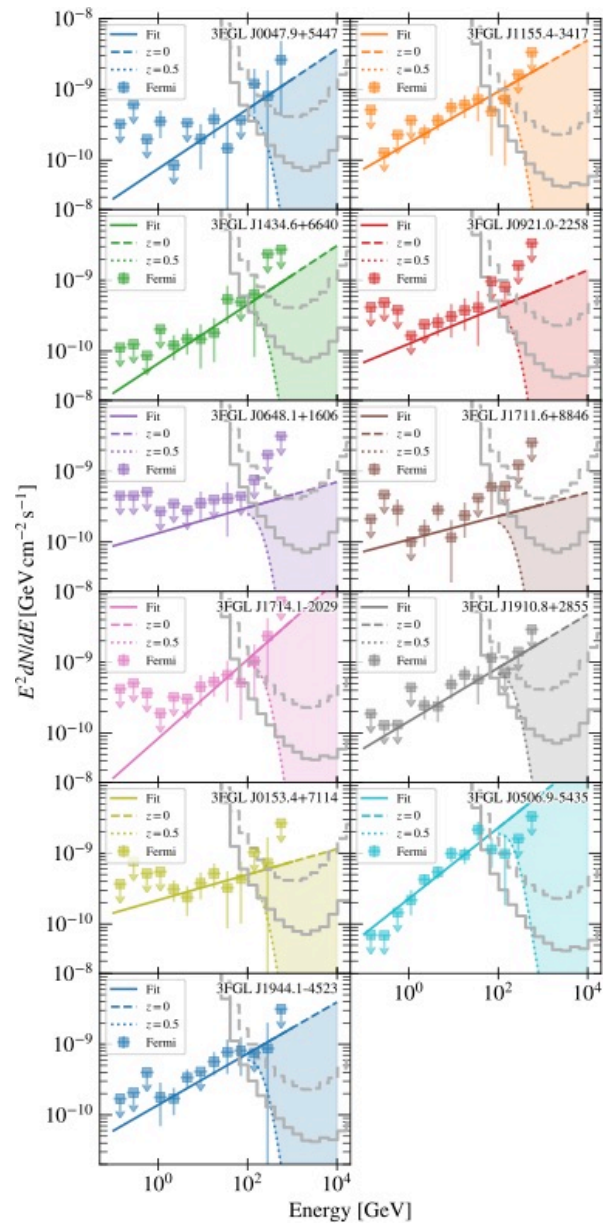
Table Browser for 3: 3fgl_j0039.0-2218_sed.fits-3

name	value	error	covar
1	Prefactor	8,79510E-15	1,55755E-15 (2.4)
2	Index	-1,66989	-0,105076 (-5.0)
3	Scale	5052,59	(NaN)
4			(NaN)
5			(0.0,
6			(0.0,
7			(0.0,
8			(0.0,
9			(0.0,
10			(0.0,

HBL = 1.87 +/- 0.20
IBL = 2.07 +/- 0.20
LBL = 2.21 +/- 0.18

Tsvar, TS>25

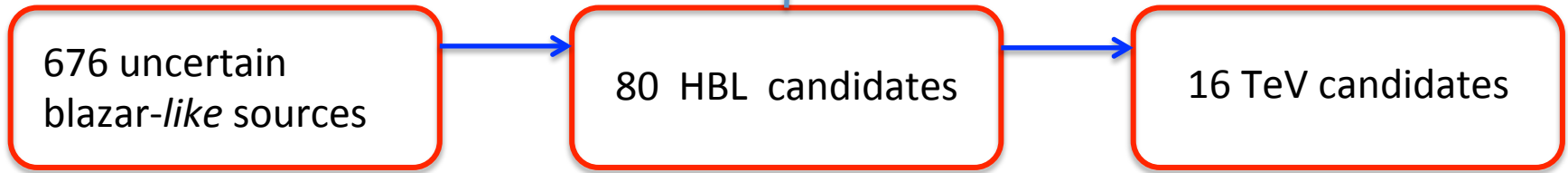
TeV candidates



Fermi-LAT SEDs
 z = 0 / z = 0.5
 1TeV – 10 TeV
 EBL model Dominguez et al.(2011)
 IACTs = 5 HOURS CTA

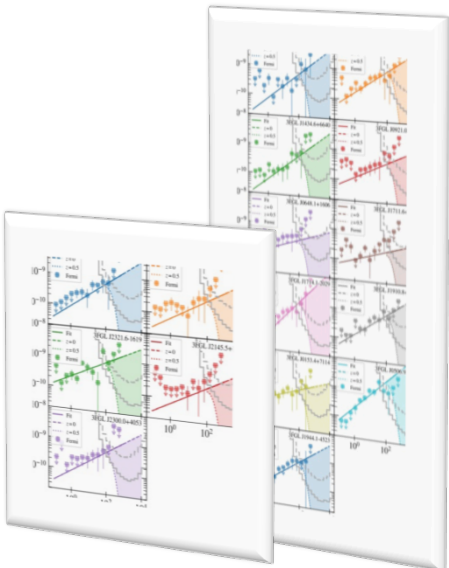
RESULTS

Candidates are consistent with 2WHSP and HSP catalog (in preparation P.Giommi)



OUR SAMPLE

Source ID	RA	DEC	...
1J0042.6-0731+00	0042.6	-0731	...
1J0043.1-0731+00	0043.1	-0731	...
1J0043.6-0731+00	0043.6	-0731	...
1J0044.1-0731+00	0044.1	-0731	...
1J0044.6-0731+00	0044.6	-0731	...
1J0045.1-0731+00	0045.1	-0731	...
1J0045.6-0731+00	0045.6	-0731	...
1J0046.1-0731+00	0046.1	-0731	...
1J0046.6-0731+00	0046.6	-0731	...
1J0047.1-0731+00	0047.1	-0731	...
1J0047.6-0731+00	0047.6	-0731	...
1J0048.1-0731+00	0048.1	-0731	...
1J0048.6-0731+00	0048.6	-0731	...
1J0049.1-0731+00	0049.1	-0731	...
1J0049.6-0731+00	0049.6	-0731	...
1J0050.1-0731+00	0050.1	-0731	...
1J0050.6-0731+00	0050.6	-0731	...
1J0051.1-0731+00	0051.1	-0731	...
1J0051.6-0731+00	0051.6	-0731	...
1J0052.1-0731+00	0052.1	-0731	...
1J0052.6-0731+00	0052.6	-0731	...
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1J0053.6-0731+00	0053.6	-0731	...
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1J0054.6-0731+00	0054.6	-0731	...
1J0055.1-0731+00	0055.1	-0731	...
1J0055.6-0731+00	0055.6	-0731	...
1J0056.1-0731+00	0056.1	-0731	...
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1J0058.1-0731+00	0058.1	-0731	...
1J0058.6-0731+00	0058.6	-0731	...
1J0059.1-0731+00	0059.1	-0731	...
1J0059.6-0731+00	0059.6	-0731	...
1J0060.1-0731+00	0060.1	-0731	...
1J0060.6-0731+00	0060.6	-0731	...
1J0061.1-0731+00	0061.1	-0731	...
1J0061.6-0731+00	0061.6	-0731	...
1J0062.1-0731+00	0062.1	-0731	...
1J0062.6-0731+00	0062.6	-0731	...
1J0063.1-0731+00	0063.1	-0731	...
1J0063.6-0731+00	0063.6	-0731	...
1J0064.1-0731+00	0064.1	-0731	...
1J0064.6-0731+00	0064.6	-0731	...
1J0065.1-0731+00	0065.1	-0731	...
1J0065.6-0731+00	0065.6	-0731	...
1J0066.1-0731+00	0066.1	-0731	...
1J0066.6-0731+00	0066.6	-0731	...
1J0067.1-0731+00	0067.1	-0731	...
1J0067.6-0731+00	0067.6	-0731	...
1J0068.1-0731+00	0068.1	-0731	...
1J0068.6-0731+00	0068.6	-0731	...
1J0069.1-0731+00	0069.1	-0731	...
1J0069.6-0731+00	0069.6	-0731	...
1J0070.1-0731+00	0070.1	-0731	...
1J0070.6-0731+00	0070.6	-0731	...
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1J0072.1-0731+00	0072.1	-0731	...
1J0072.6-0731+00	0072.6	-0731	...
1J0073.1-0731+00	0073.1	-0731	...
1J0073.6-0731+00	0073.6	-0731	...
1J0074.1-0731+00	0074.1	-0731	...
1J0074.6-0731+00	0074.6	-0731	...
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1J0077.1-0731+00	0077.1	-0731	...
1J0077.6-0731+00	0077.6	-0731	...
1J0078.1-0731+00	0078.1	-0731	...
1J0078.6-0731+00	0078.6	-0731	...
1J0079.1-0731+00	0079.1	-0731	...
1J0079.6-0731+00	0079.6	-0731	...
1J0080.1-0731+00	0080.1	-0731	...
1J0080.6-0731+00	0080.6	-0731	...
1J0081.1-0731+00	0081.1	-0731	...
1J0081.6-0731+00	0081.6	-0731	...
1J0082.1-0731+00	0082.1	-0731	...
1J0082.6-0731+00	0082.6	-0731	...
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1J0090.6-0731+00	0090.6	-0731	...
1J0091.1-0731+00	0091.1	-0731	...
1J0091.6-0731+00	0091.6	-0731	...
1J0092.1-0731+00	0092.1	-0731	...
1J0092.6-0731+00	0092.6	-0731	...
1J0093.1-0731+00	0093.1	-0731	...
1J0093.6-0731+00	0093.6	-0731	...
1J0094.1-0731+00	0094.1	-0731	...
1J0094.6-0731+00	0094.6	-0731	...
1J0095.1-0731+00	0095.1	-0731	...
1J0095.6-0731+00	0095.6	-0731	...
1J0096.1-0731+00	0096.1	-0731	...
1J0096.6-0731+00	0096.6	-0731	...
1J0097.1-0731+00	0097.1	-0731	...
1J0097.6-0731+00	0097.6	-0731	...
1J0098.1-0731+00	0098.1	-0731	...
1J0098.6-0731+00	0098.6	-0731	...
1J0099.1-0731+00	0099.1	-0731	...
1J0099.6-0731+00	0099.6	-0731	...
1J0100.1-0731+00	0100.1	-0731	...
1J0100.6-0731+00	0100.6	-0731	...



Thank you.

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