The 3° Catalog of AGN detected by the Fermi-LAT

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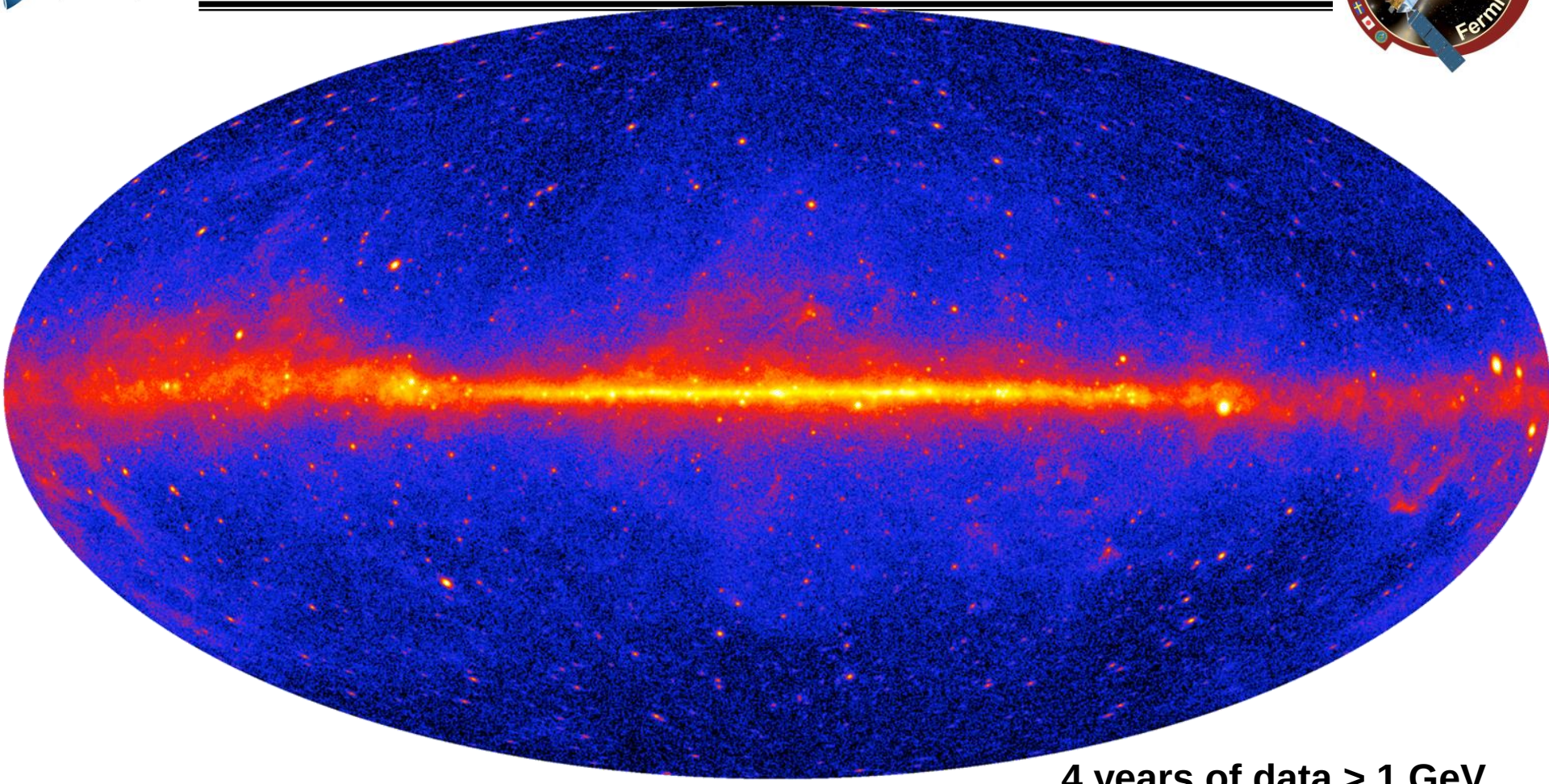
3FGL



4 years of data > 1 GeV

- 4 years, P7REP_SOURCE_V15, improved PSF
- Front/Back handled separately
- Energy range 100 MeV - 300 GeV

~3000 sources, 2200 at |b|>10°

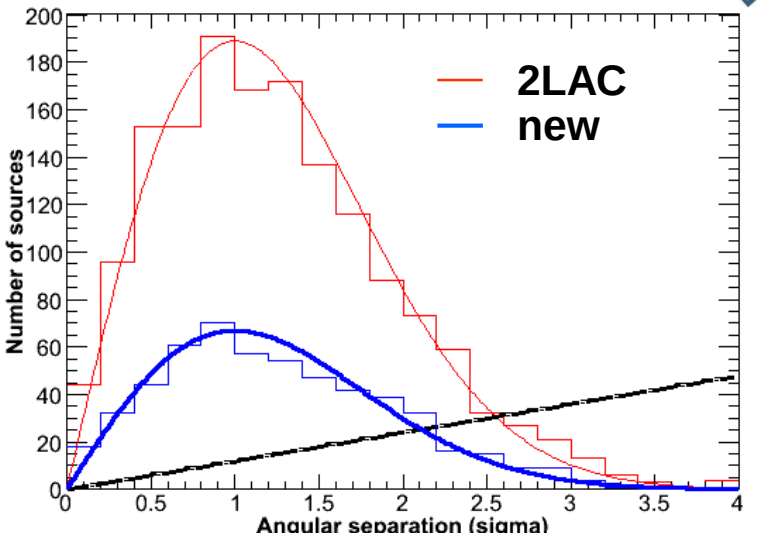
Associations

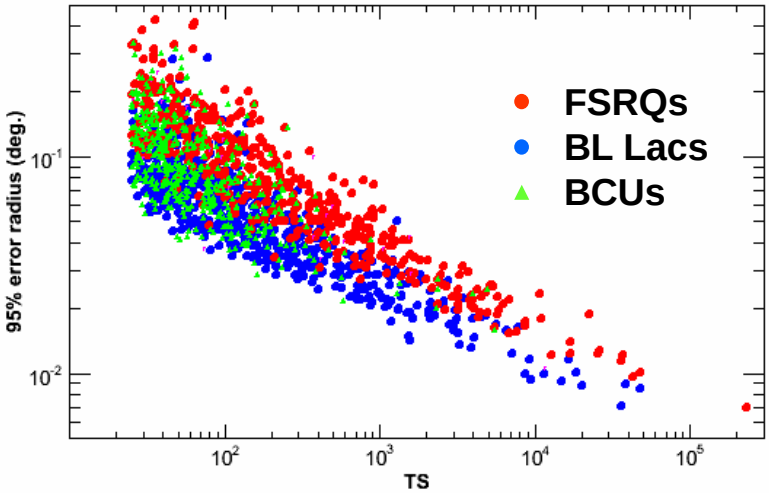
Two associations methods:

- **Bayesian method**
  - **new addition: WISE Counterpart catalogs**
- **Likelihood ratio (LR) method**
  - **new addition: AT20G catalog**

Association probability > 0.8 in one of the 2 methods:

  - **71% in common**
  - **379 only Bayesian**
  - **62 only LR**
- **False-positive rate < 2%**





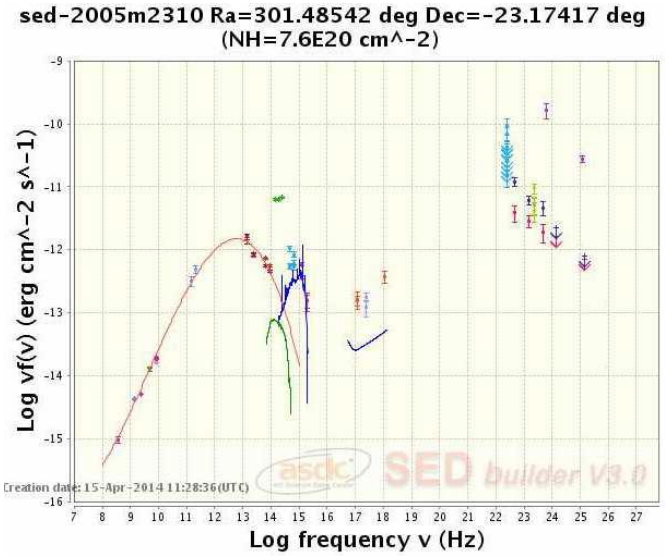
Classification

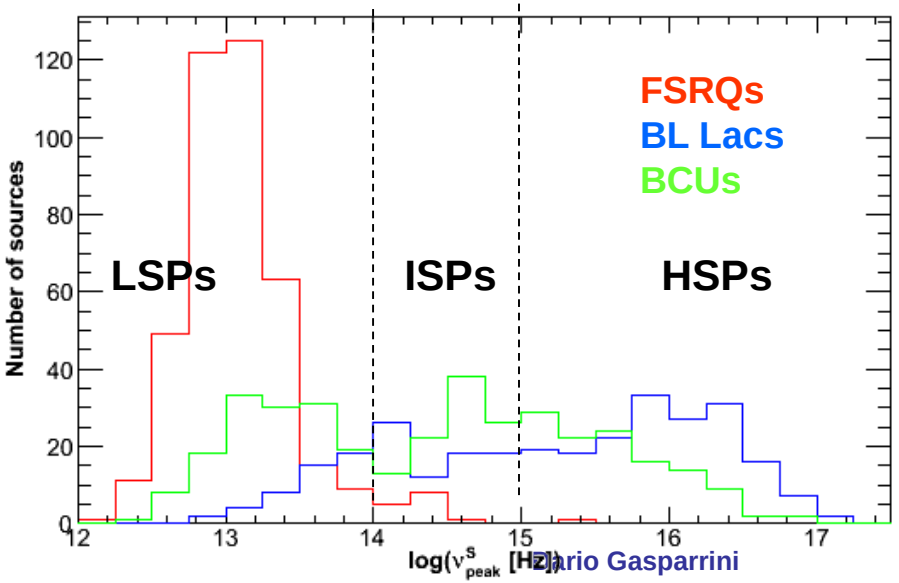
Two classification schemes:

• Optically-based (strength of broad lines): FSRQs, BL Lacs, BCUs (aka Blazar Candidate of Unknown type)

•SED-based: Low-, Intermediate-, High-Synchrotron-Peaked sources (LSPs, ISPs, HSPs resp.)

2LAC: automatic SED fit
3LAC: manually-controlled SED fit by 20 « sedders » over 3 continents





2LAC vs. 3LAC Census

2LAC

AGN type	Entire 2LAC	2LAC Clean Sample[a]	Low-lat sample
All	**1017**	**886**	**104**
FSRQ	**360**	**310**	**19**
...LSP	246	221	7
...ISP	4	3	2
...HSP	2	0	0
...no classification	108	86	10
BL Lac	**423**	**395**	**16**
...LSP	65	61	3
...ISP	82	81	3
...HSP	174	160	5
...no classification	102	93	5
Blazar of Unknown type	**204**	**157**	**67**
...LSP	24	19	10
...ISP	13	11	3
...HSP	65	53	13
...no classification	102	74	41
Other AGN	**30**	**24**	**2**

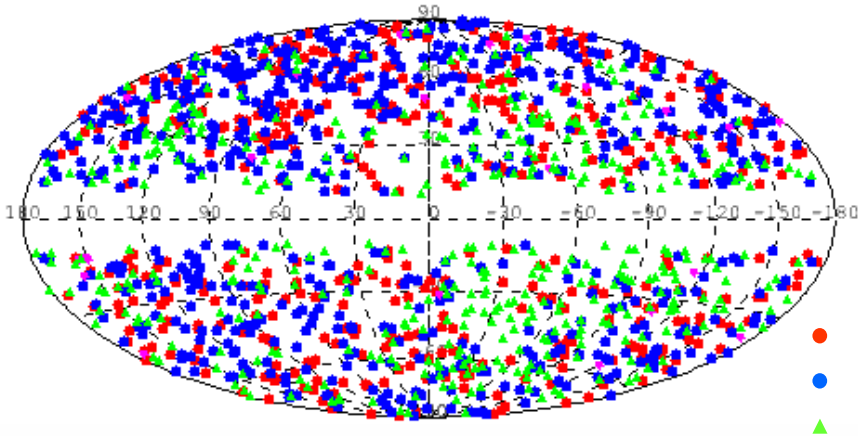
3LAC

AGN type	Entire 3LAC	3LAC Clean Sample[a]	Low-latitude sample
All	**1591**	**1444** +64%	**182**
FSRQ	**467**	**414** +34%	**24**
...LSP	412	366	24
...ISP	47	42	0
...HSP	3	2	0
...no SED classification	5	4	0
BL Lac	**632**	**604** +52%	**30**
...LSP	162	150	8
...ISP	178	173	6
...HSP	272	265	12
...no SED classification	20	16	4
Blazar of Unknown type	**460**	**402** +164%	**125**
...BCU I	57	49	11
...LSP BCU I	26	24	8
...ISP BCU I	11	9	1
...HSP BCU I	13	13	2
...BCU I w/o SED classification	7	3	0
...BCU II	346	308	85
...LSP BCU II	156	129	39
...ISP BCU II	78	70	13
...HSP BCU II	107	105	31
...BCU II w/o SED classification	5	4	2
...BCU III	57	45	29
...LSP BCU III	16	11	9
...ISP BCU III	0	0	0
...HSP BCU III	0	0	0
...BCU III w/o SED classification	41	34	20
Non-blazar AGN	**32**	**24**	**3**
...CSS	2	1	0
...NLSy1	5	5	0
...RG	14	13	2
...SSRQ	5	3	0
...Other AGN	6	2	1

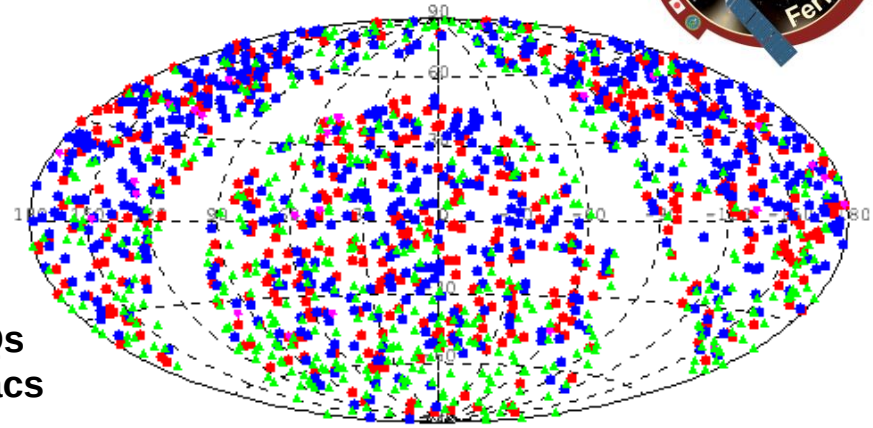
New varieties:

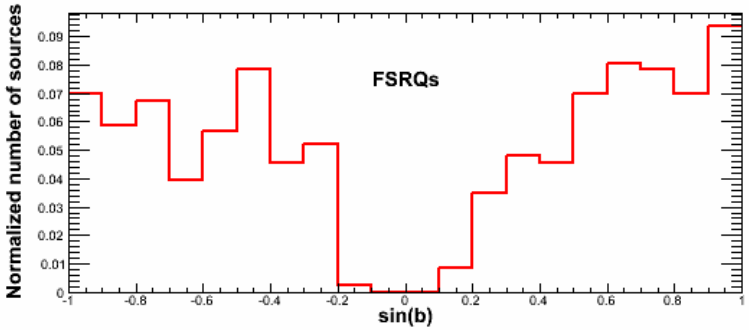
- **Six high-redshift (z>1) HSP-BL Lacs**
- **Two HSP FSRQs**

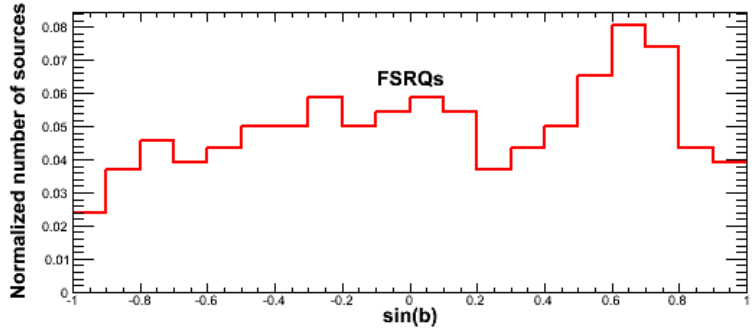
Sky loci

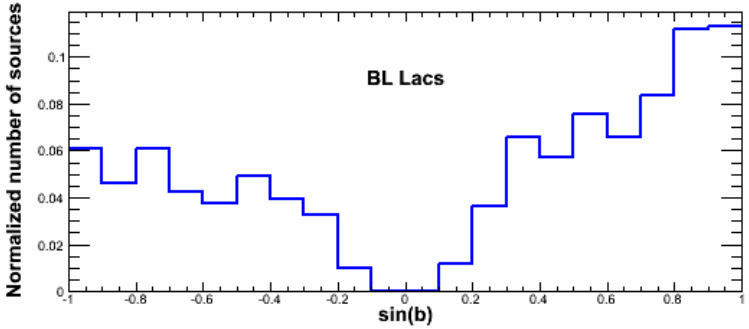


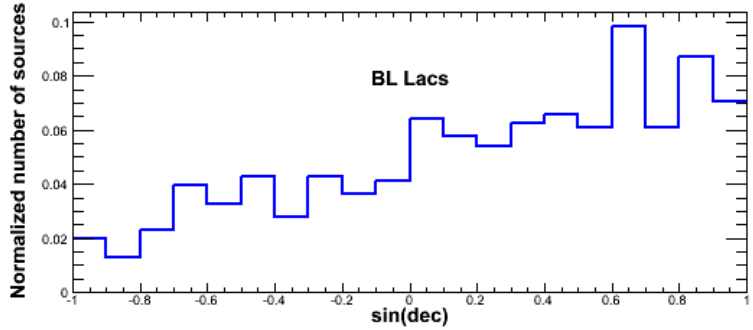
FSRQs
BL Lacs
BCU









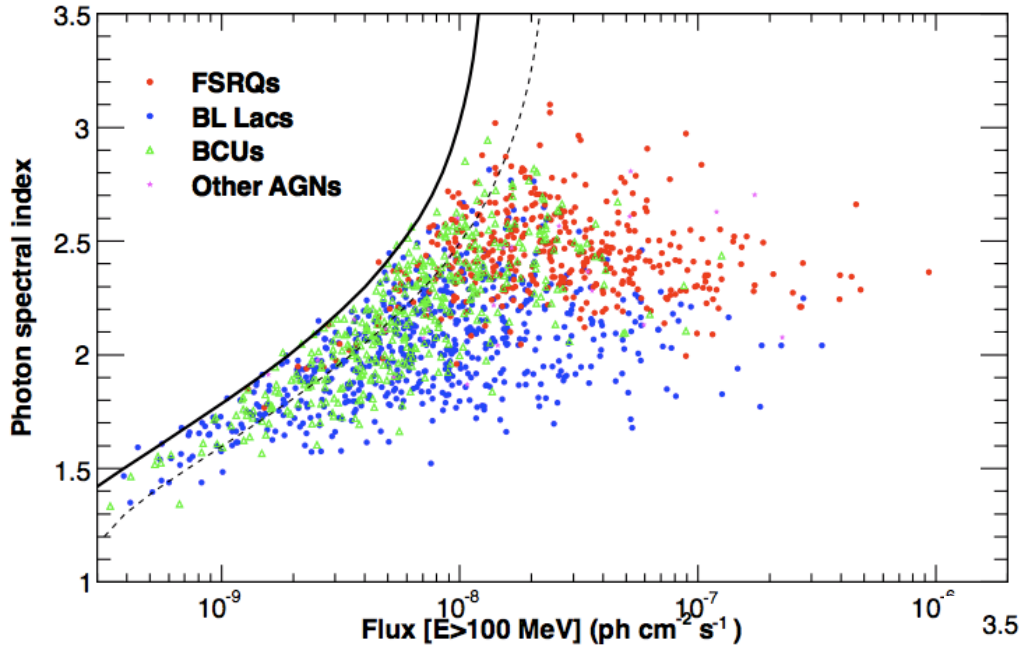


Misaligned AGNs

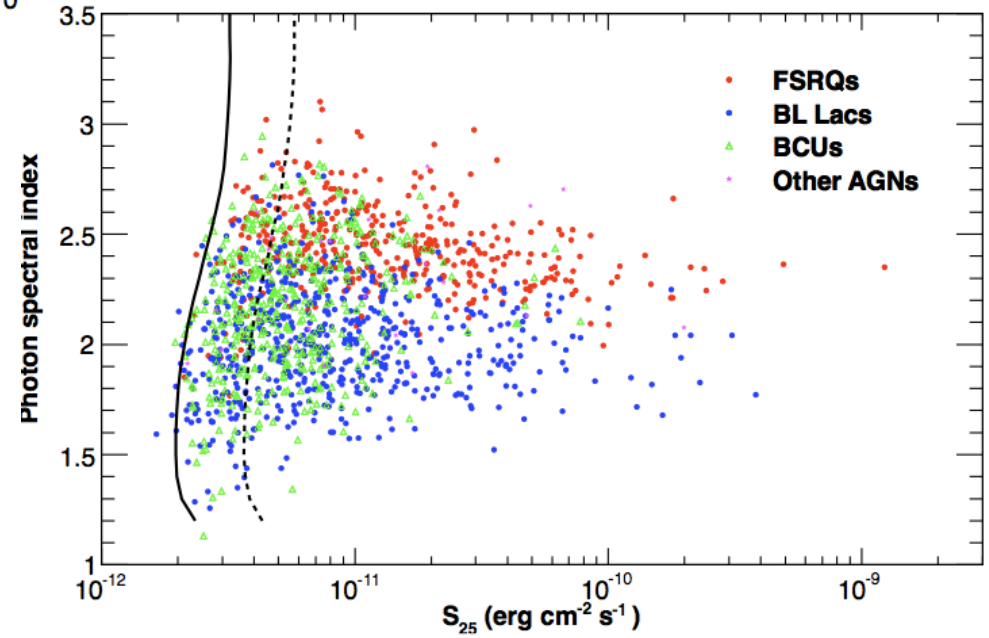
Name	3FGL	2FGL	1FGL	Type	Photon index	Notes
NGC 1218	J0308.6+0408*	···	J0308.3+0403*	FRI	2.07±0.11	
IC 310	J0316.6+4119*	J0316.6+4119	···	FRI/BLL	1.90±0.14	Neronov et al. (2010)
NGC 1275	J0319.8+4130*	J0319.8+4130*	J0319.7+4130*	FRI	2.07±0.01	Abdo et al. (2009c); Kataoka et al. (2010)
1H 0323+342	J0325.2+3410*	J0324.8+3408*	J0325.0+3403*	NLSy1	2.44±0.12	
4C +39.12	J0334.2+3915*	···	···	FRI/BLL?	2.11±0.17	Giovannini et al. (2001)
TXS 0348+013	J0351.1+0128*	···	···	SSRQ	2.43±0.18	
3C 111	J0418.5+3813	···	J0419.0+3811	FRII	2.79±0.08	Abdo et al. (2010e); Kataoka et al. (2011); Grandi et al. (2012)
Pictor A	J0519.2−4542*	···	···	FRII	2.49±0.18	Brown & Adams (2012); Kataoka et al. (2011)
PKS 0625−35	J0627.0−3529*	J0627.1−3528*	J0627.3−3530*	FRI/BLL	1.87±0.06	
4C +52.17	J0733.5+5153	···	···	AGN	1.74±0.16	Part of a duplicate association. Most probable counterpart is a BCU III.
NGC 2484	J0758.7+3747*	···	···	FRI	2.16±0.16	quasar SDSS J075825.87+374628.7 is 0.8' away
4C +39.23B	J0824.9+3916	···	···	CSS	2.44±0.10	
3C 207	J0840.8+1315*	J0840.7+1310	J0840.8+1310	SSRQ	2.47±0.09	
SBS 0846+513	J0849.9+5108*	···	···	NLSy1	2.28±0.04	
3C 221	J0934.1+3933	···	···	SSRQ	2.28±0.12	
PMN J0948+0022	J0948.8+0021*	J0948.8+0020*	J0949.0+0021*	NLSy1	2.32±0.05	
PMN J1118-0413	J1118.2-0411*	···	···	AGN	2.56±0.08	
B2 1126+37	J1129.0+3705	···	···	AGN	2.08±0.13	Part of a duplicate association. Most probable counterpart is a BLL.
3C 264	J1145.1+1935*	···	···	FRI	1.98±0.20	
PKS 1203+04	J1205.4+0412	···	···	SSRQ	2.64±0.16	Part of a duplicate association. The other counterpart is a FSRQ.
M 87	J1230.9+1224*	J1230.8+1224*	J1230.8+1223*	FRI	2.04±0.07	Abdo et al. (2009d)
3C 275.1	J1244.1+1615	···	···	SSRQ	2.43±0.17	
GB 1310+487	J1312.7+4828*	J1312.8+4828*	J1312.4+4827*	AGN	2.04±0.03	
Cen A Core	J1325.4−4301*	J1325.6−4300	J1325.6−4300	FRI	2.70±0.03	radio core
Cen A Lobes	J1324.0−4330e	J1324.0−4330e	J1322.0−4515	FRI	2.53±0.05	giant lobes detected (Abdo et al. 2010b)
3C 286	J1330.5+3023*	···	···	SSRQ/CSS	2.60±0.16	
Cen B	J1346.6−6027	J1346.6−6027	···	FRI	2.32±0.01	Katsuta et al. (2013)
Circinus	J1413.2−6518	···	···	Seyfert	2.43±0.10	Hayashida et al. (2013)
3C 303	J1442.6+5156*	···	···	FRII	1.92±0.18	
PKS 1502+036	J1505.1+0326*	J1505.1+0324*	J1505.0+0328*	NLSy1	2.61±0.05	
TXS 1613−251	J1617.3−2519	J1617.6−2526c	···	AGN	2.59±0.10	Part of a duplicate association. Most probable counterpart is a BCU II.
PKS 1617−235	J1621.1−2331*	J1620.5−2320c	···	AGN	2.50±0.23	
NGC 6251	J1630.6+8232*	J1629.4+8236	J1635.4+8228*	FRI	2.22±0.08	
3C 380	J1829.6+4844*	J1829.7+4846*	J1829.8+4845*	SSRQ/CSS	2.37±0.04	
PKS 2004−447	J2007.8−4429*	J2007.9−4430*	J2007.9−4430*	NLSy1	2.47±0.09	

12 FRI
3 FRII
8 SSRQ or CSS

Spectral photon index vs photon/energy flux

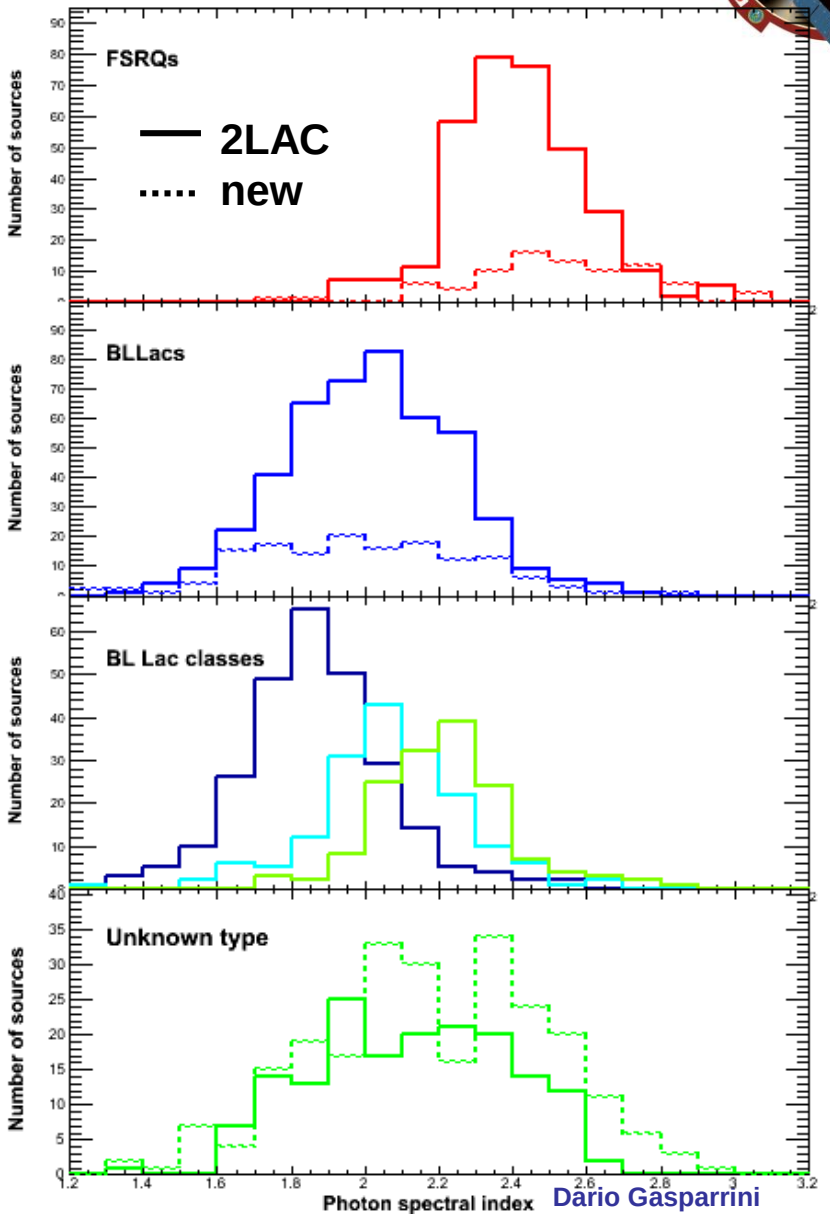


Strong bias in photon flux but not in energy flux

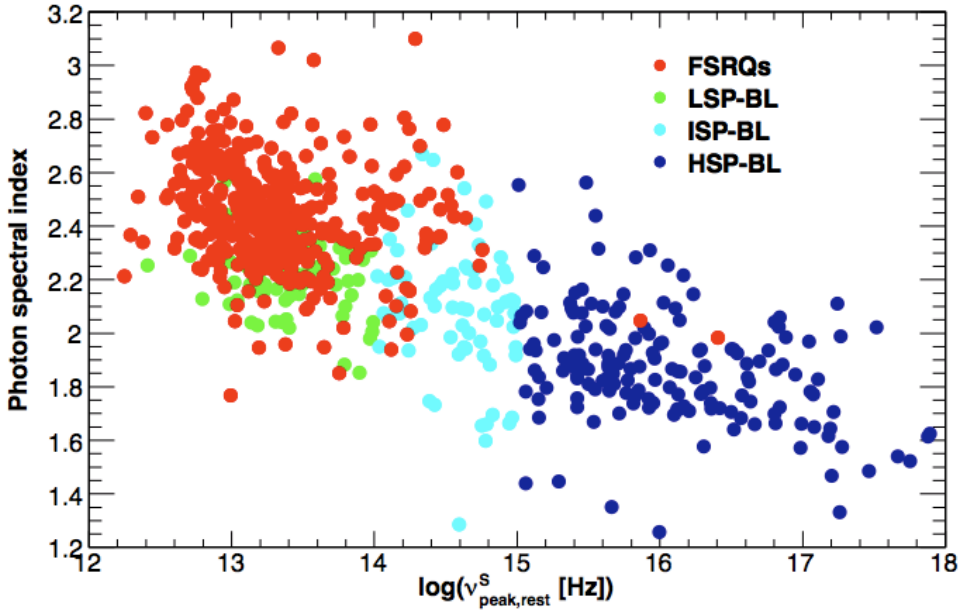


Spectral photon index

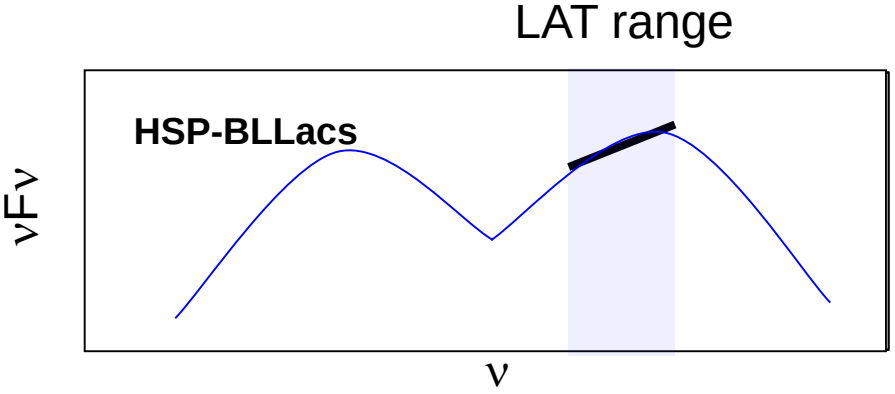
- Little overlap between FSRQs and BL Lacs
- New FSRQs slightly softer than 2LAC ones: (<Γ>=2.53 vs. 2.41)
- Not so for BL Lacs
- BCUs index distribution straddling the two classes' and extending beyond 2.5

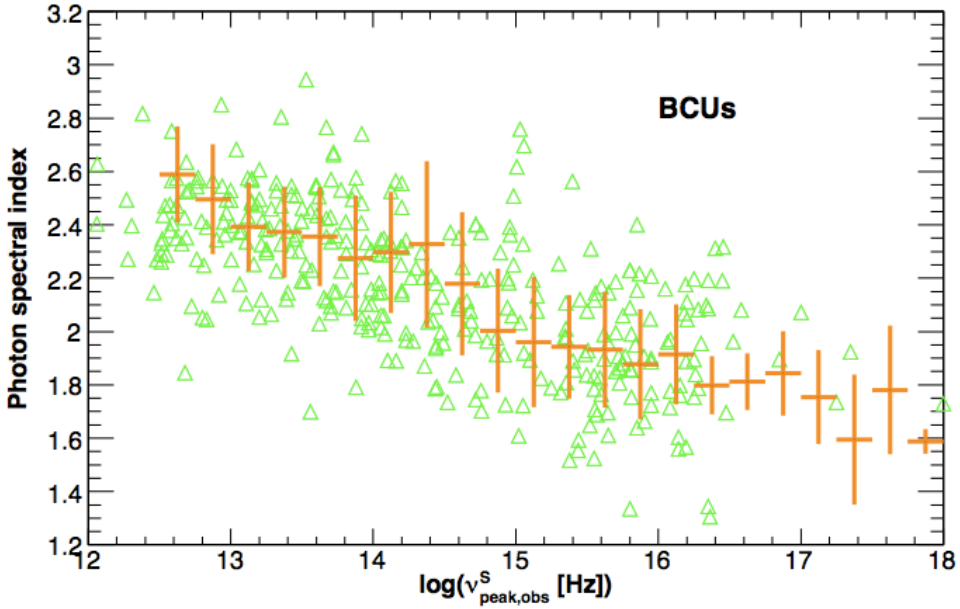


Spectral photon index vs ν_{peak}



- Correlation between spectral hardness and ν_{peak} confirmed
- Same implies to BCUs





Redshifts

- Slightly higher z for new FSRQs relative to 2LAC ones
<z>=1.33 vs. 1.17

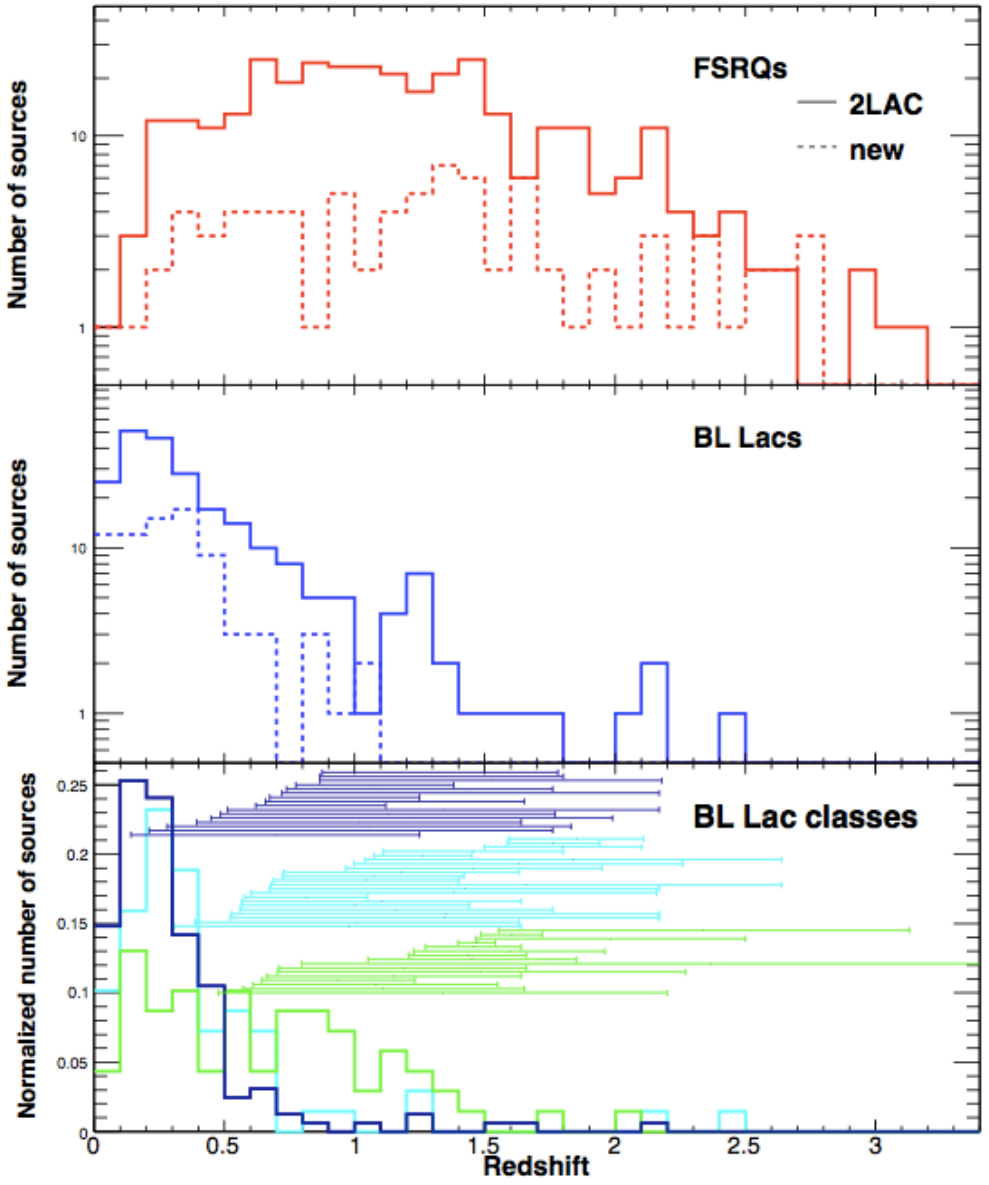
- Maximum redshift still z=3.1

- 295/604 BL Lacs have no measured redshifts (55%, 61%, 40%) for (LSPs, ISPs and HSPs)

- Narrower z distribution for BL Lacs than 2LAC

- 134 constraints from Shaw et al. (2013)

- Redshift limits for BLLacs not compatible with measured redshifts: measured redshifts are biased low.



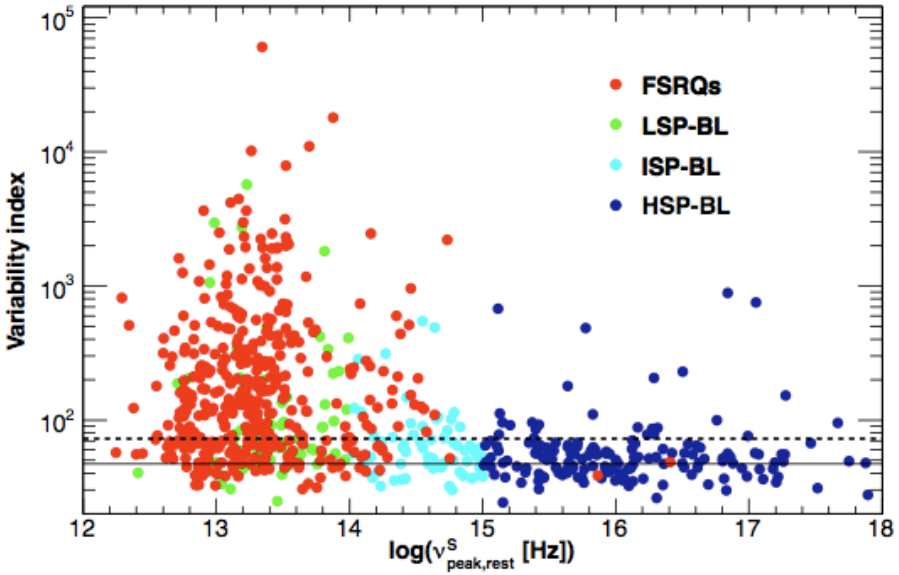
Variability

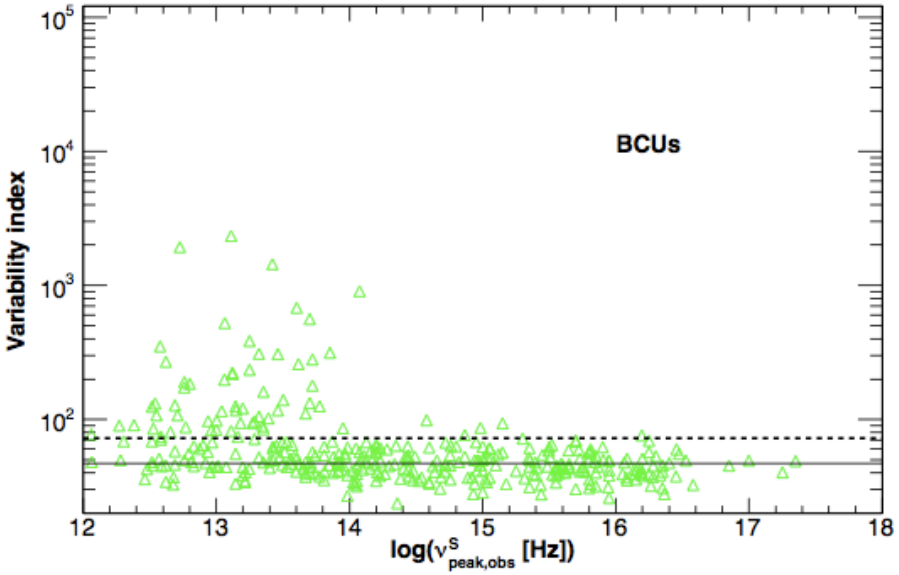
Variability index distributed as

a χ^2 with 47 d.o.f. for non-variable sources.

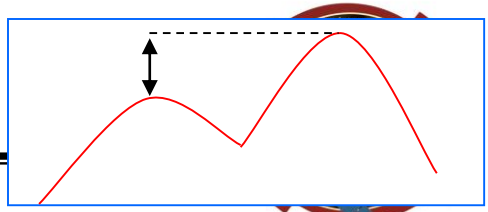
Fractions of sources showing significant variability
FSRQS: 69%
BL Lacs 23 %
(39%, 23%, 15%) for (LSP, ISP,HSP)

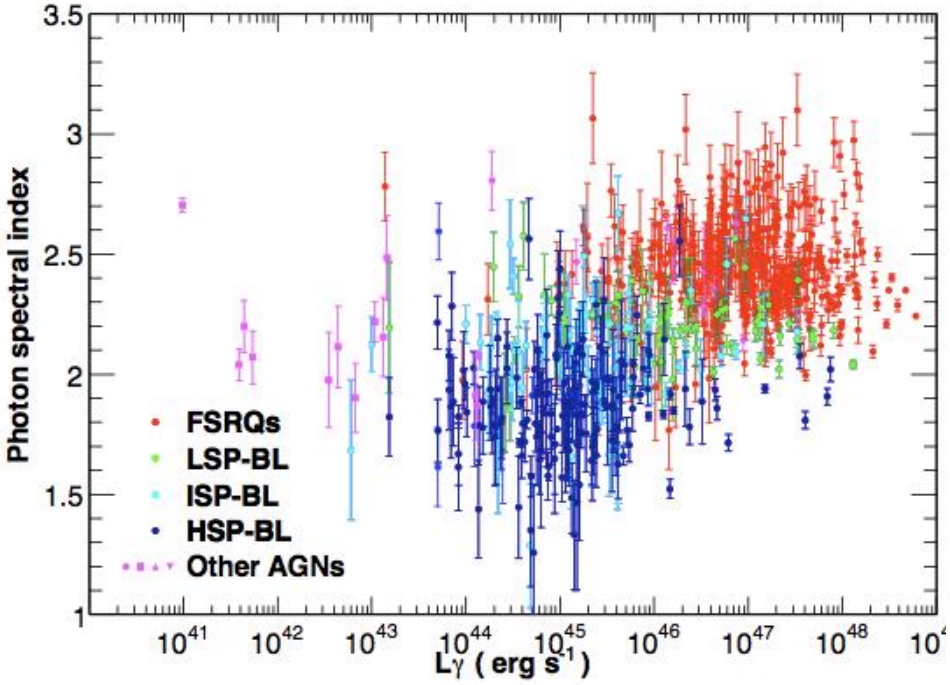
Monthly light curves to be extended beyond 48 months, continuously updated and posted on the ASDC site

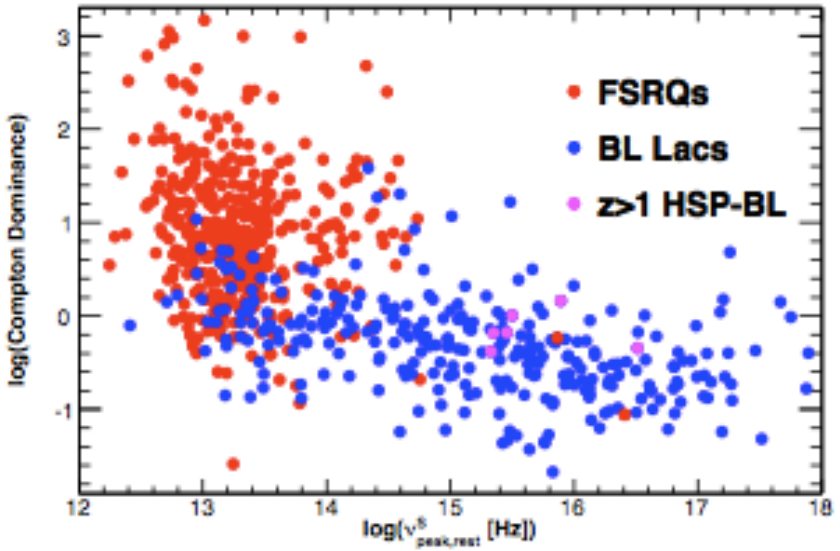


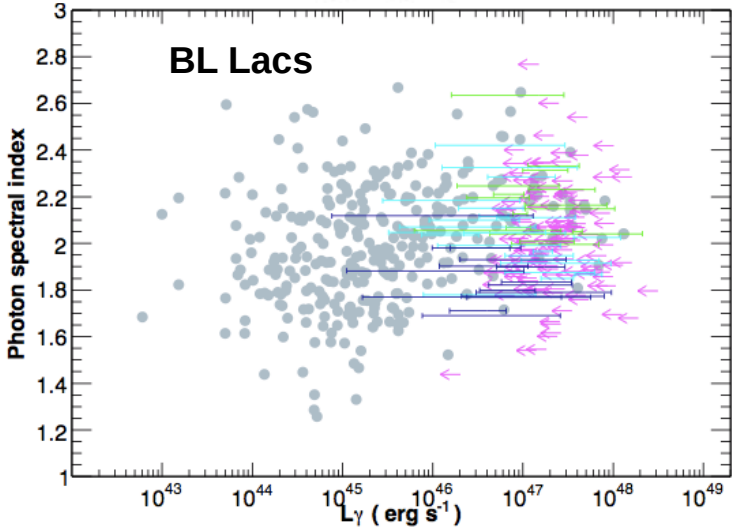


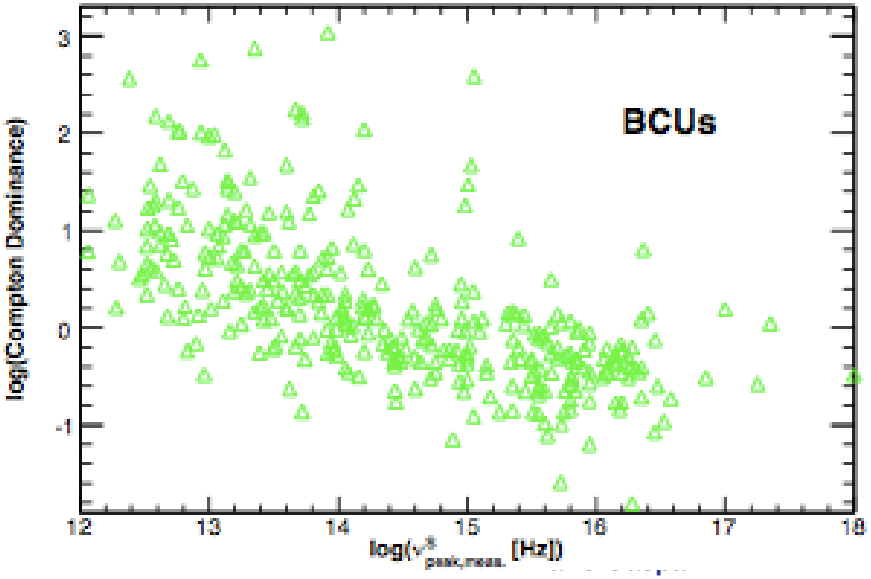
Lγ / Compton dominance



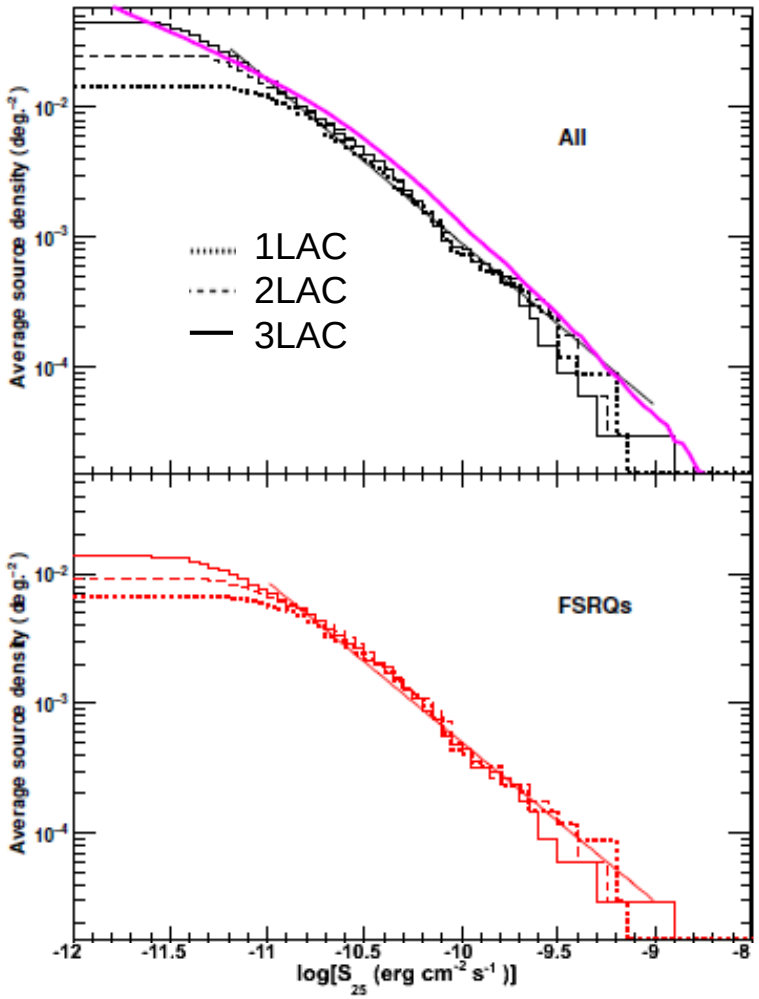


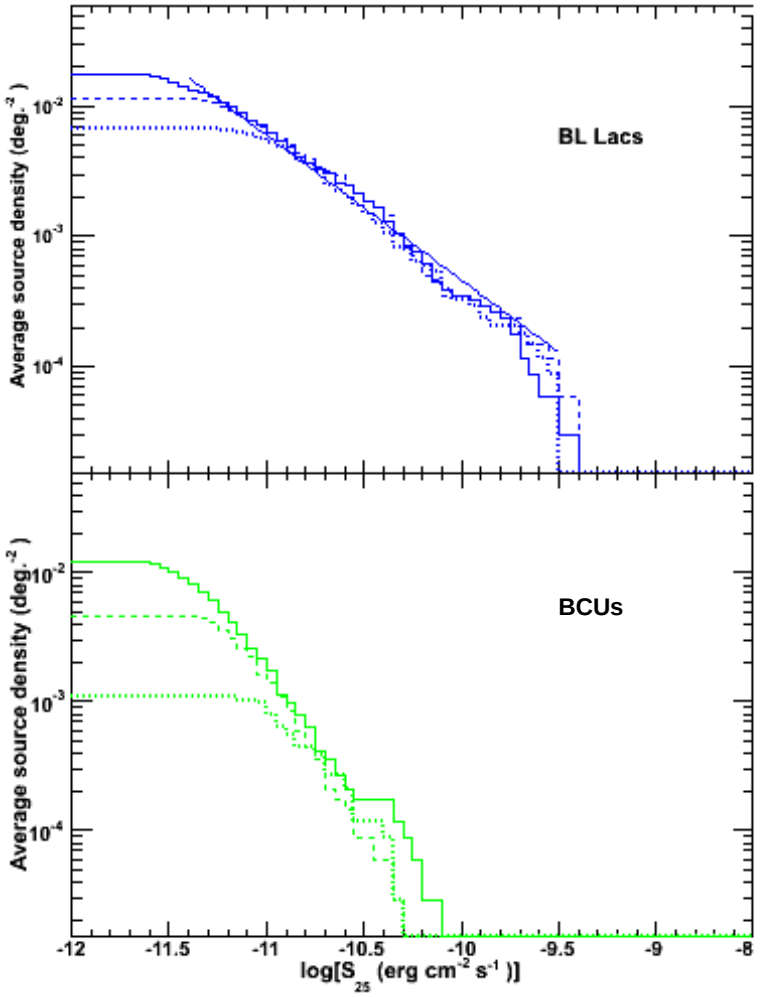






log N-log S





Contribution to diffuse gamma-ray background compatible with previous estimates

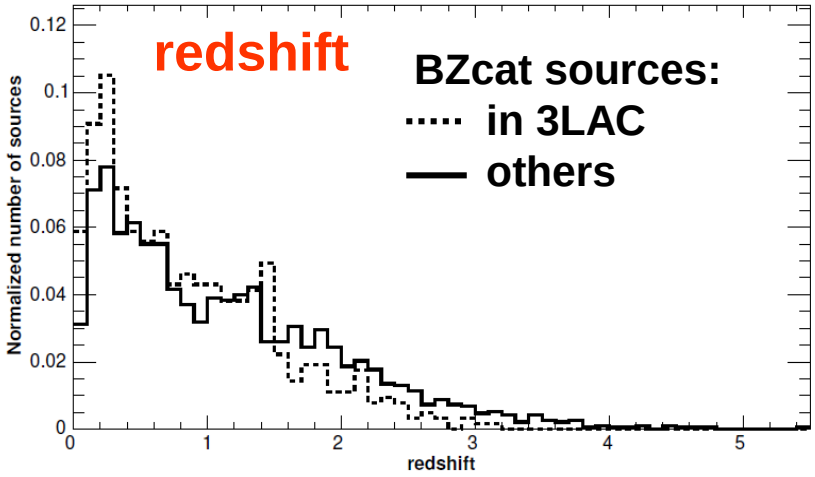
Connections with neighboring bands

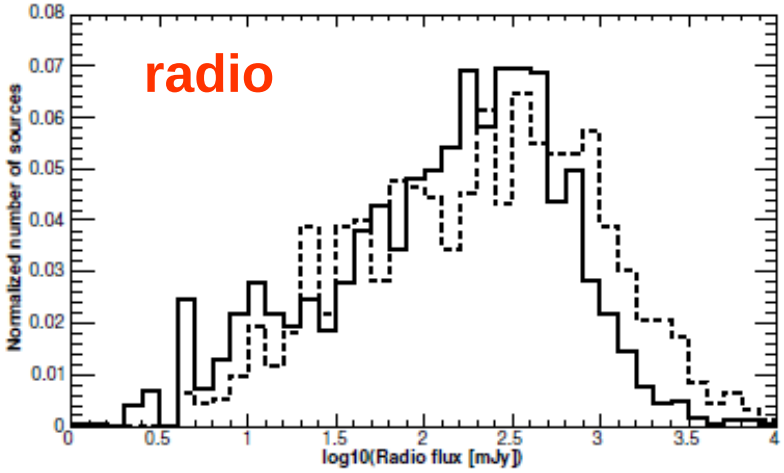
- 85 3LAC sources in the Swift BAT 70-month survey
- Only 9 BAT FSRQs and 7 BL Lacs missing in 3LAC
- 96 3LAC AGNs in the V38 INTEGRAL Cat.

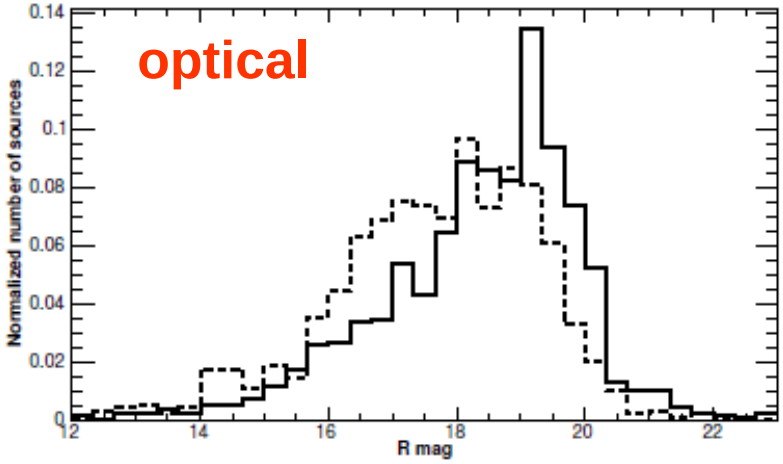
- 55 out of 56 TeV AGNs in 3LAC
  - HESS J1943+213 was missing but Peter et al. reported a detection
  - 39 are HSP-BLL $< \Gamma >$=1.78 vs. 1.88 (3LAC HSP)
  - 28 found to be variable

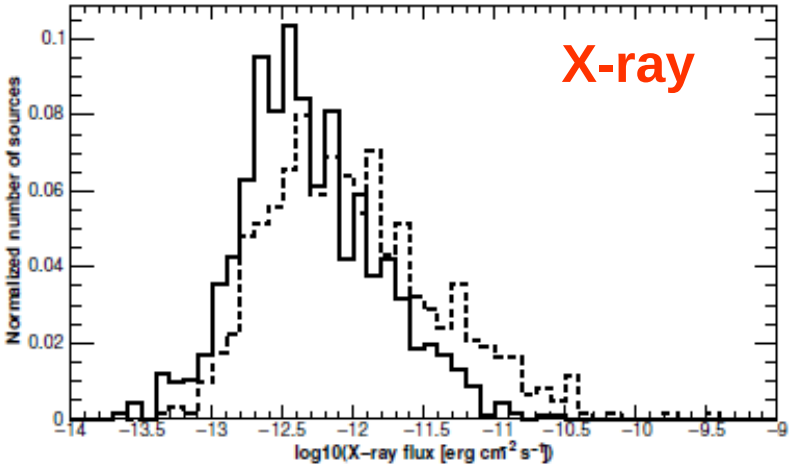
Connection with BZCat

LAT-detected fraction: 24% (409/1707) for FSRQs, 44% (543/1221) for BL Lacs and 27% (59/221) for BCUs









Conclusions

The 3LAC represents a significant improvement over the 2LAC also in term of analysis method and data quality.

An increase of 71% in the number of blazars mainly due to the increased exposure and the use of improved counterpart catalogs

Significant increase of non blazar AGN population (3 new FRI, 2 new FRII, 4 new SSRQ)

Main properties reported in 1LAC and 2LAC are confirmed.

The 4LAC will use >5 years of data and will make use of improved IRFs (Pass8). It will constitute another notable step forward. See Poster 84

Thank you!