







Preliminary results from the fourth catalog of AGN detected by the Fermi-LAT

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B. Lott, S Ciprini and 4LAC team on behalf of the Fermi-LAT collaboration



- What is the 4LAC?
  - The 4° LAT AGN Catalog (4LAC) is the companion of the 4FGL catalog focused on AGNs (~75% of the all highgalactic-latitude sources )
- Why so important?
  - We provide:
    - AGN associations
    - Redshifts
    - Estimation of the synchrotron peak frequency
    - More focused discussion on the AGN class population (blazar sequence, BL Lac-FSRQ dichotomy, blazar evolution)
    - Reference for works on individual sources



#### **Yesterday**



LBAS-high latitude (Abdo et al 09) (3 months of data, TS>100, P6\_V1) 50% FSRQs 36% BL Lacs 9% AGU 5% Other AGNs



1LAC-clean sample (Abdo et al 10) (11months of data, TS>25, P6 V3) 42% FSRQs 45% BL Lacs 9% AGU 4% Other AGNs



2LAC-clean sample (Ackermann et al. 10) (24 months of data, TS>25, P7\_V6) 36% FSRQs 45% BL Lacs 17% AGU 2% Other AGNs



(48 months of data, TS>25,



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## **Tomorrow (4LAC)**

- 8 years of data
- New IRFs: Pass 8
- Energy Range: 100 MeV 1 TeV
- New version of the Diffuse Model
- Number of sources two times the previous catalog



- FL8Y list (~ 5500 sources) was made public on January 3<sup>rd</sup>
  - It will be entirely superseded by 4FGL with the new interstellar emission model
    - Source positions will be recalculated, also associations could change
- In this "pre 4LAC" we started to perform the same association procedures that we will perform once the 4FGL list will be out.
  - Two associations methods (used in 2FHL, 3FHL) :
    - Bayesian method
      - Variety of counterpart catalogs including non AGN
    - Likelihood ratio (LR) method
      - Surveys: NVSS, SUMSS, RASS, 2RASS, AT20G
  - Association probability >0.8 in one of the 2 methods



# Associations

# 3LAC

Sample	All Methods		Bayesian Method			LR Method		
	Total	N <sub>false</sub>	Total	N <sub>false</sub>	N <sub>s</sub>	Total	N <sub>false</sub>	N <sub>s</sub>
All	1591	29.7	1529	34.5	379	1212	120.5	62
Clean	1444	23.4	1391	17.5	337	1107	107.3	53

71% in common, False-positive rate < 2%

$$N_{false} = \sum_{i} (1 - P_i)$$

# 4LAC up to now

Sample	All Methods		Bayesian Method			LR Method		
	Total	N <sub>false</sub>	Total	N <sub>false</sub>	N <sub>S</sub>	Total	N <sub>false</sub>	N <sub>S</sub>
All	2752	48.8	2614	34.1	580	2614	143.0	138
Clean	2675	40.2	2613	34.1	945	2613	99.7	62

68% in common, False-positive rate < 2%



- Two classification schemes:
  - Optically-based (strength of broad lines):
    - FSRQs,
    - BL Lacs,
    - **BCUs** (aka Blazar Candidate of Unknown type) •
      - (NH=7.6E20 cm^-2) -10 s^-1) -11 -15 Creation date: 15-Apr-2014 11:28:36(UT -16 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 10 Log frequency v (Hz)

sed-2005m2310 Ra=301.48542 deg Dec=-23.17417 deg



- Low-Synchrotron-Peaked ,
- Intermediate-Synchrotron-Peaked
  High-Synchrotron-Peaked
  manually-controlled SED fit

4LAC : manually-controlled SED fit with polynomial fit parameters

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## **Some preliminary numbers**

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AGN type	Entire 4LAC	$4 {\rm LAC} \ {\rm Clean} \ {\rm Sample}^{\rm a}$	Low-latitude sample	Clean Sample (3LAC)
All	2752	2675	373	+ 85% (1444)
FSRQ	716	705	39	+ 70% (414)
LSP	632	630	23	. ,
ISP	17	17	6	
HSP	16	16	4	
no SED classification	51	42	6	
PL Los	1180	1194	02	$\pm 0.60/(60.4)$
I SD	1189	279	92	+ 90% (004)
ISD	2010	205	14	
ISP USD	970	323	14	
no SED classification	210	209	11	
no SED classification	221	211	20	
Blazar of Unknown type	792	732	227	+ <mark>82</mark> % (402)
LSP	296	295	104	
ISP	64	64	25	We have to verify their
HSP	97	97	33	blazarness
no SED classification	335	276	65	
Non-blazar AGN	55	54	15	+ 125% (24)
CSS	1	1	0	
NLSy1	8	8	0	
RG	35	34	2	
SSRQ	1	1	0	
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- As in the previous catalogs we can spot a difference in the southern hemisphere:
  - Less Optical Coverage

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### **Photon index**



Dermi

- Little overlap between FSRQs and BL Lacs
- In the new sources:
  - we have softer FSRQs
  - Slight effect also on
    BL Lacs but need to
    be quantified
  - BCUs covers all the parameter space.



 Peaks are obtained using a polynomial fit of archival data

- Little tail in the distribution of FSRQs
  - More HSP FSRQs?





#### Synchrotron peak vs Photon Index





## Redshift



- Redshift mining still on going
  - We have more
    literature to add (E.g.:
    Paiano et al.)
  - New observations are coming especially BCUs
- We are moving the limits of higher redshift seen in gamma



#### **Luminosity vs Photon Index**





- Fractions of sources showing significant variability
  - More for FSRQs than BL Lacs
  - BCUs shows less variability





- The 4LAC will represent a significant improvement over the 3LAC also in term of analysis method and data quality.
- Some new features already can be seen in this "pre 4LAC"
  - In term of population, this "pre-4LAC" shows an further increase in BL Lacs (44% of the clean sample) w.r.t. FSRQs (26%)
  - Fermi-LAT starts to detect faraway objects
    - In 3LAC the furthest detected object has z=3.1, here we already found few new gamma ray emitters that break this limit.
  - Not only Blazars: In 3LAC some Misaligned AGNs (FRI, FRII, SSRQ, CSS, etc) pop up.
    - Here we have 125% increase (54 vs 24)
- The work is in progress...we can still have other surprises



# **THANK YOU!**

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