



THE COSMIC DOWNSIZING OF FERMI- DETECTED FLAT SPECTRUM RADIO QUASARS

M. Ajello (SLAC/KIPAC)

*R. Romani, M. Shaw, C. Dermer, L. Costamante
on behalf of the Fermi-LAT collaboration*

Paper available as: [arXiv:1110.3787](https://arxiv.org/abs/1110.3787)

THE FSRQ SAMPLE: PROPERTIES

- * The sample:
 - * Extremely clean, ~5% incompleteness
 - * Based on the 11month catalog
 - * $TS > 50$, $|b| > 15\text{deg}$
 - * $z = [0.1 - 3.0]$
 - * Spans >2dex in flux
 - * Spans >4dex in luminosity
- * Very good dynamical range

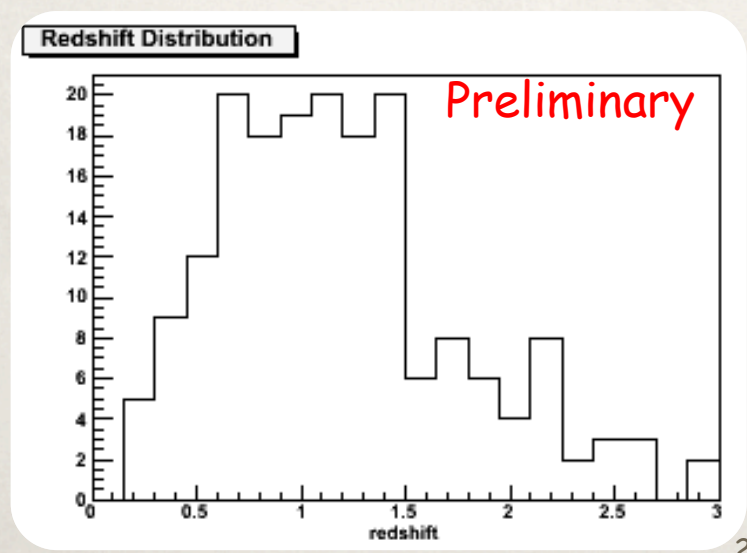
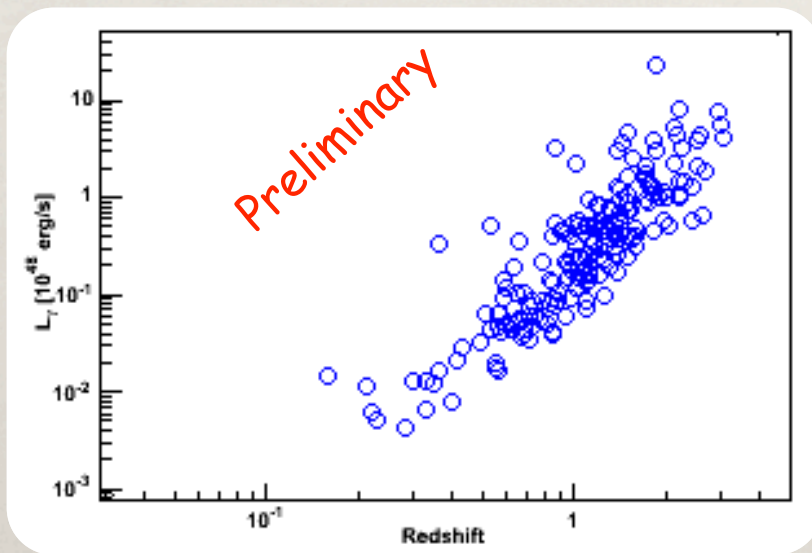
Table 1. Composition of the $|b| \geq 20$, $TS \geq 50$, $F_{100} \geq 10^{-8} \text{ ph cm}^{-2} \text{ s}^{-1}$ sample used in this analysis.

CLASS	# objects
Total	433
FSRQs	186
BL Lacs	157
Pulsars	28
Other ^a	16
Radio Associations ^b	17
Unassociated sources	29

Preliminary

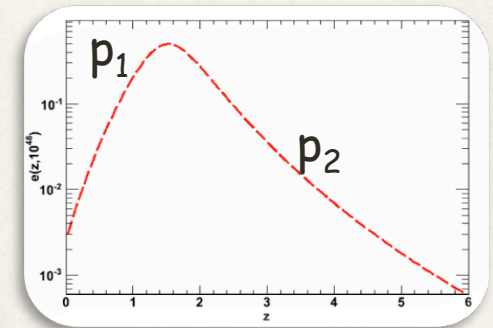
^aIncludes Starburst galaxies, LINERS Narrow line Seyfert 1 objects and Seyfert galaxy candidates.

^b*Fermi* sources with a radio counterpart, but no optical type and redshift measurement.



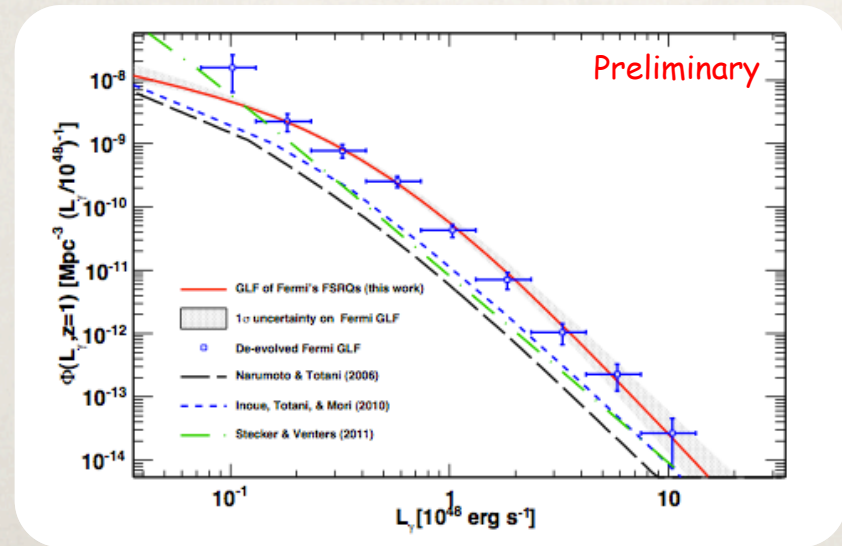
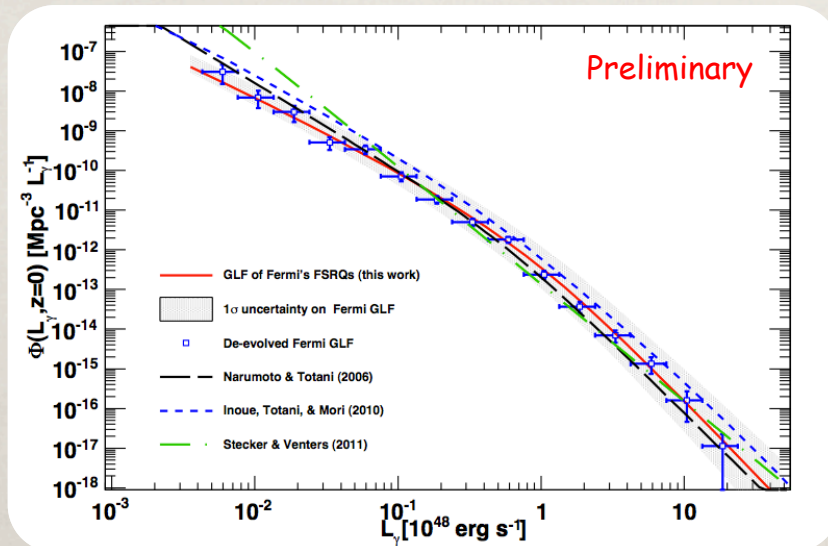
FERMI'S LUMINOSITY FUNCTION

- * Luminosity Dependent Density Evolution (LDDE) represents the *Fermi* data well
- * It implies:
 - * Strong evolution of FSRQ: factor 100 more FSRQs at $z=1.5$
 - * A cut-off in the evolution that changes with luminosity
- * The results are robust against in-completeness (e.g. lack of ID/redshifts) problems

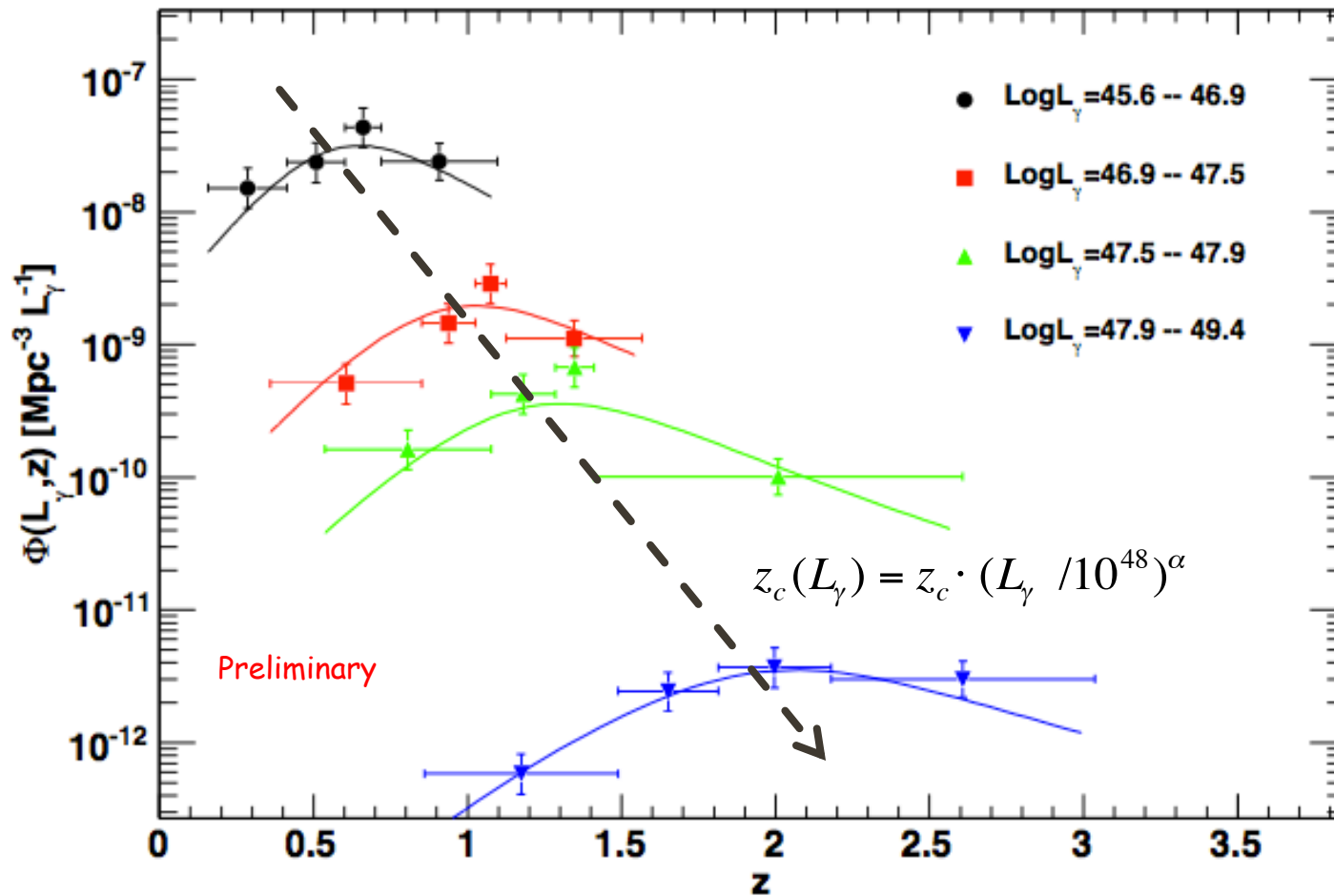


Local GLF (Z=0)

Z=1



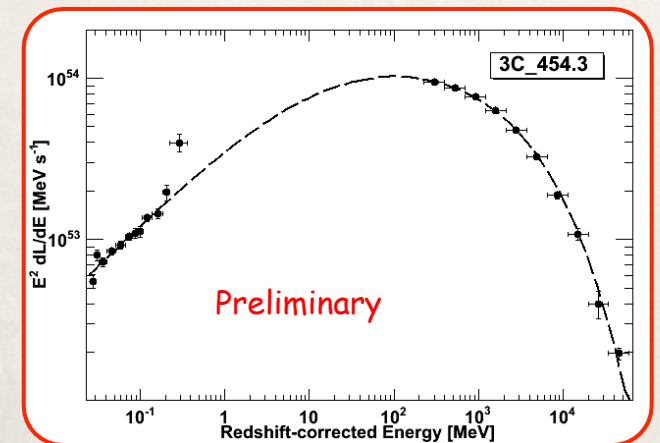
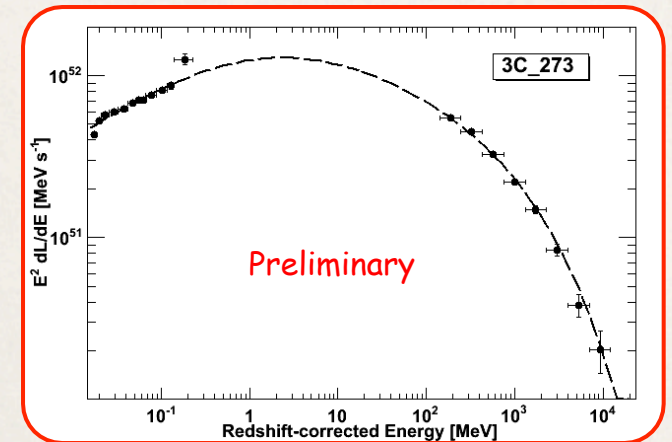
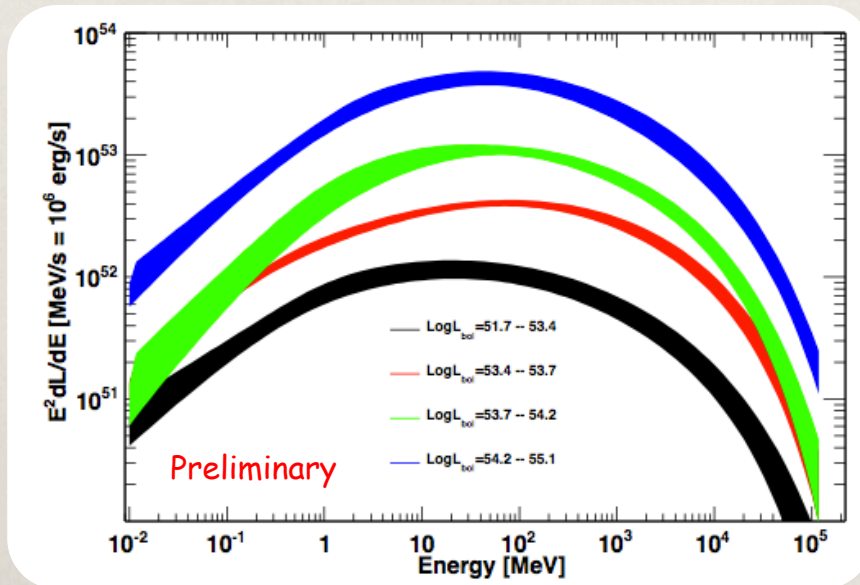
REDSHIFT PEAK EVOLUTION



THE SEDS OF FSRQs

* Recipe:

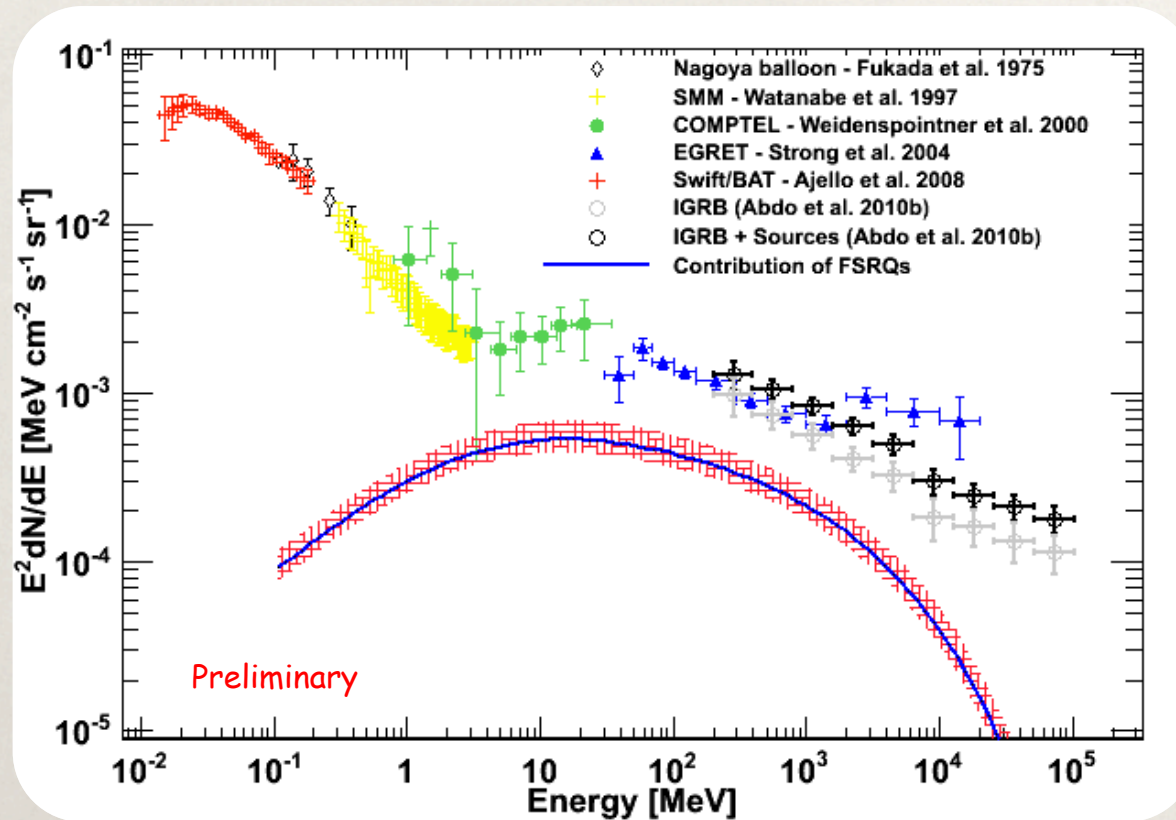
- * Take all the FSRQs in the complete sample
- * Extract *Swift*/BAT and *Fermi*-LAT data
- * Correct for source redshift
- * Fit them together



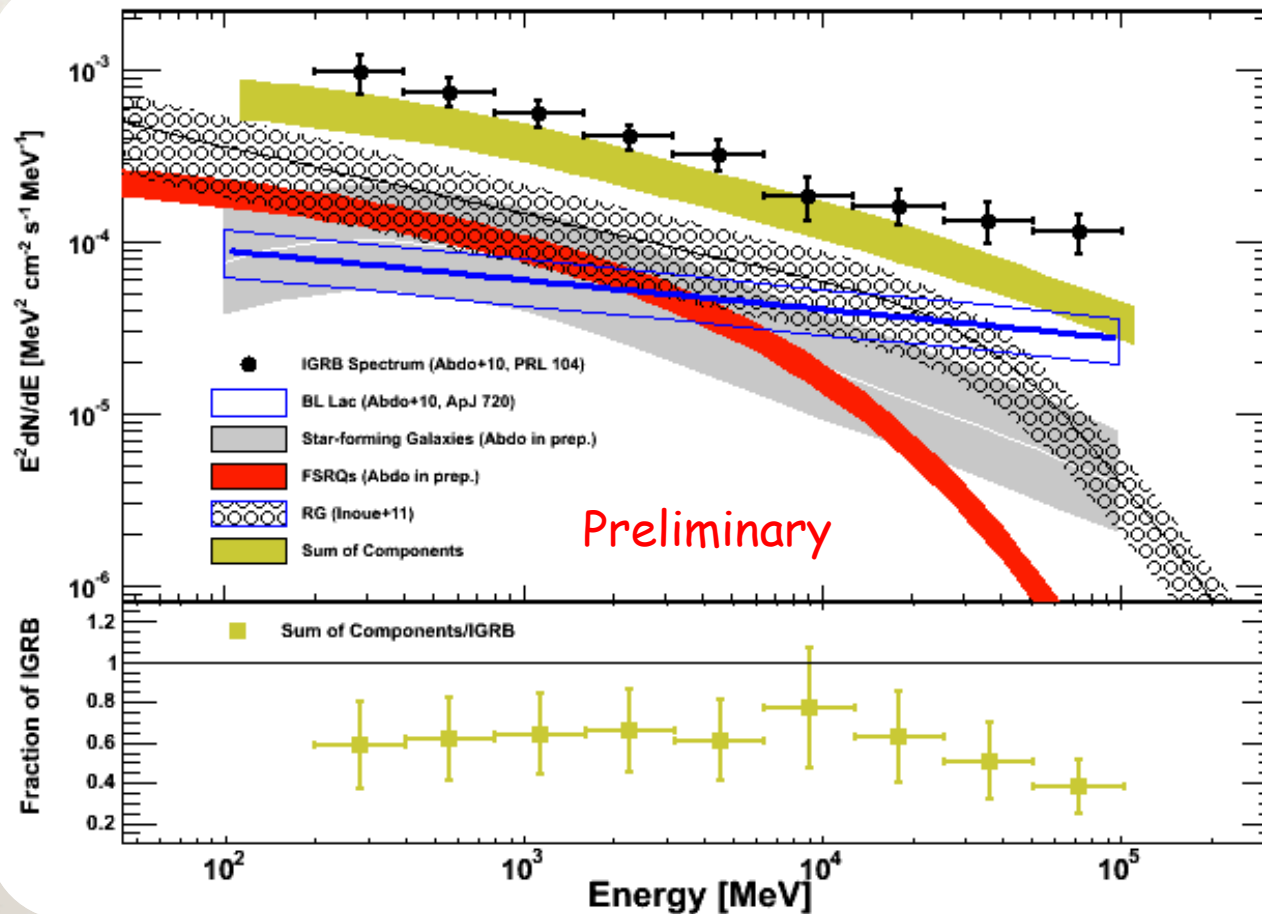
Caveats: *Swift* data extracted over 2005-2011, *Fermi* data in 2008-2011
Swift and *Fermi* might sample two different components (e.g. SSC/EC)

CONTRIBUTION OF FSRQs TO EGB

- * Total (e.g. resolved + unresolved) emission from FSRQs
- * No EBL/cascade considered, but unimportant for soft spectra



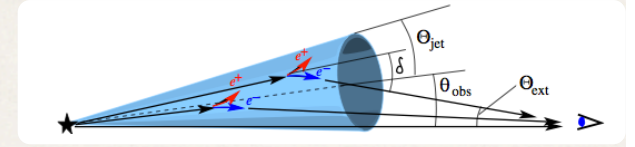
THE STATUS OF THE γ -RAY BACKGROUND



FSRQ
Star-forming Gal.
BL Lac
Radio Galaxies

See other studies by: Stecker&Salomon+96, Pavlidou&Fields+02, Narumoto&Totani06, Dermer07, Bhattacharya+09, Inoue&Totani09, Fields+10, Makiya+10, Inoue+11, Abazajian+10, Ghirlanda+11, Stecker&Venters11, Malyshev&Hogg11

BEAMING AND THE LF

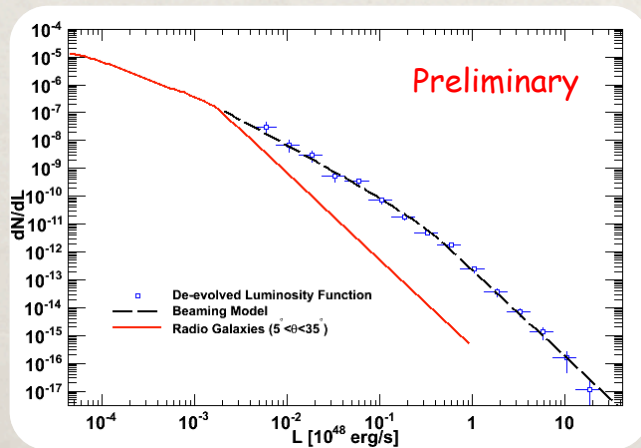


Beaming is known to alter the shape of the luminosity function
(Urry&Shafer84)

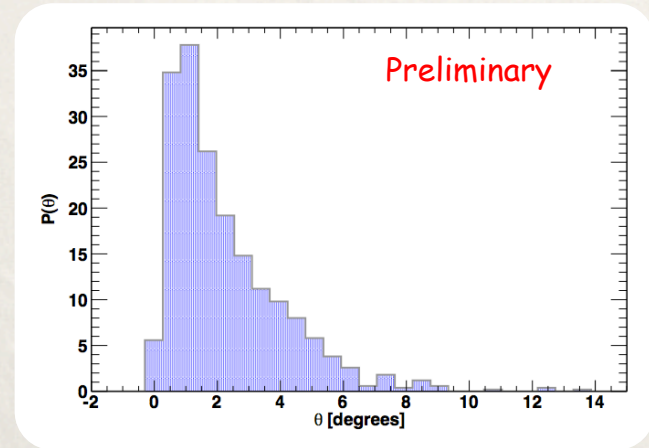
Apparent luminosity

$$L = \delta^p \mathcal{L}$$

Real luminosity



In agreement
with MOJAVE
(VLBA) results:
Lister+09,
Savolainen+10



1. The average bulk Lorentz factor of Fermi FSQR is $\Gamma = 15$
2. FSRQs are only 0.2% of their parent population
3. Most of the jets are seen within 5-6 degrees
4. The average angle is 2.9 degrees

SUMMARY

- * Wealth of results on FSRQs from γ -ray data alone (1 year):
 - * The luminosity function shows evidence for 'cosmic downsizing': i.e. more luminous objects were more abundant early in the Universe
 - * The average SED shows no strong dependence on either luminosity and redshift
 - * FSRQs make $\sim 20\%$ of the total (including sources) IGRB intensity
 - * FSRQs represent 0.1-0.2% of the parent population and are beamed within 5 degrees