

An EVN survey of hard spectrum gamma-ray sources

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and

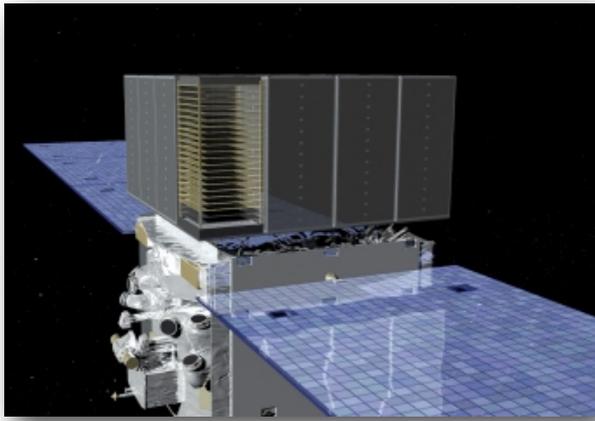
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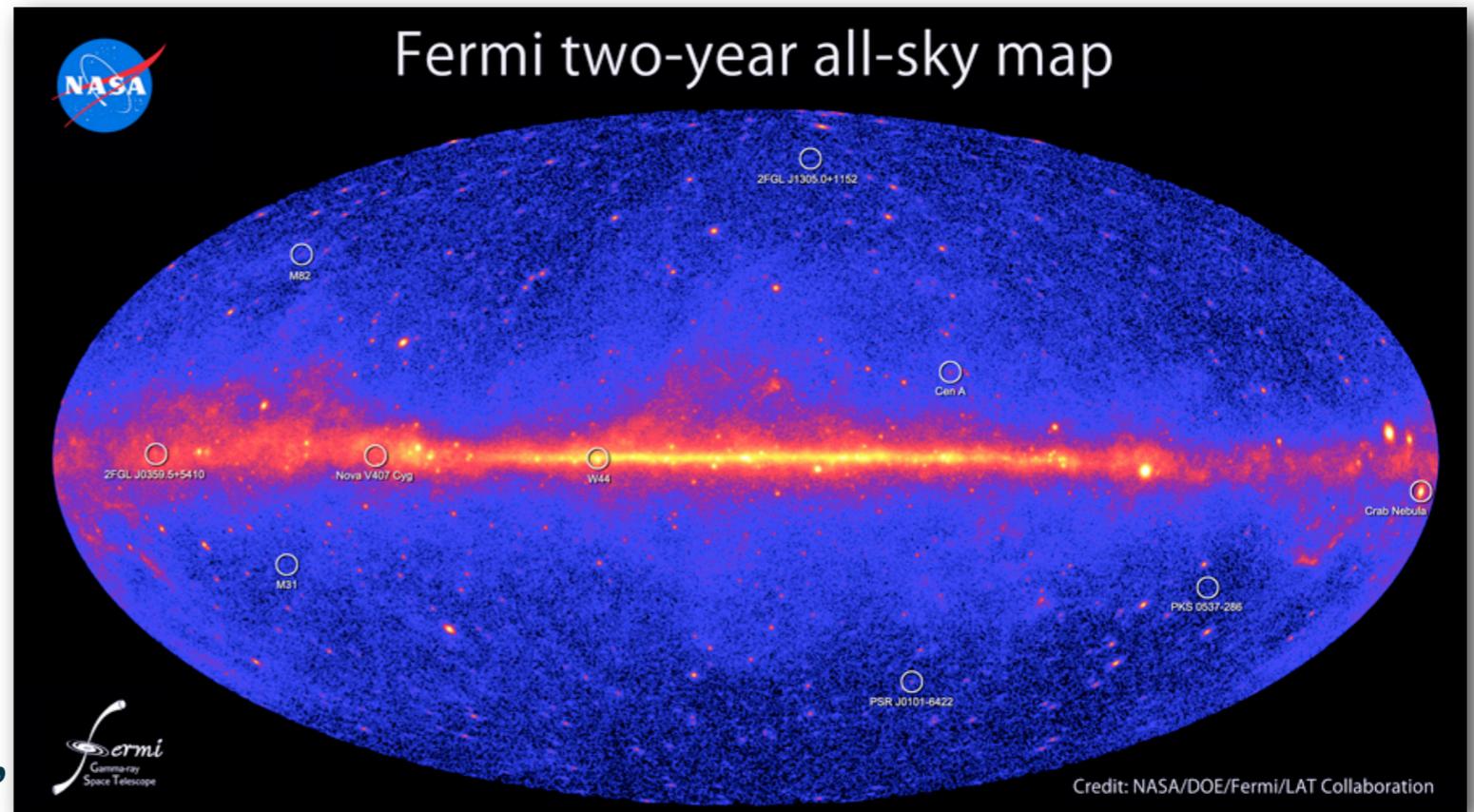
Abstract

“The EVN is helping us to discover, identify, and understand astrophysical sources in which particles are accelerated to extremely high energies.”

The Large Area Telescope (LAT) onboard *Fermi*



- 20 MeV - 300 GeV photon energies
- 2.4sr fov, survey mode operated, views entire sky every 3 hrs
- provides uniform sensitivity over whole sky in ~day time scale, providing great opportunities for
 - MWL studies of single (flaring) sources
 - all sky survey and population studies

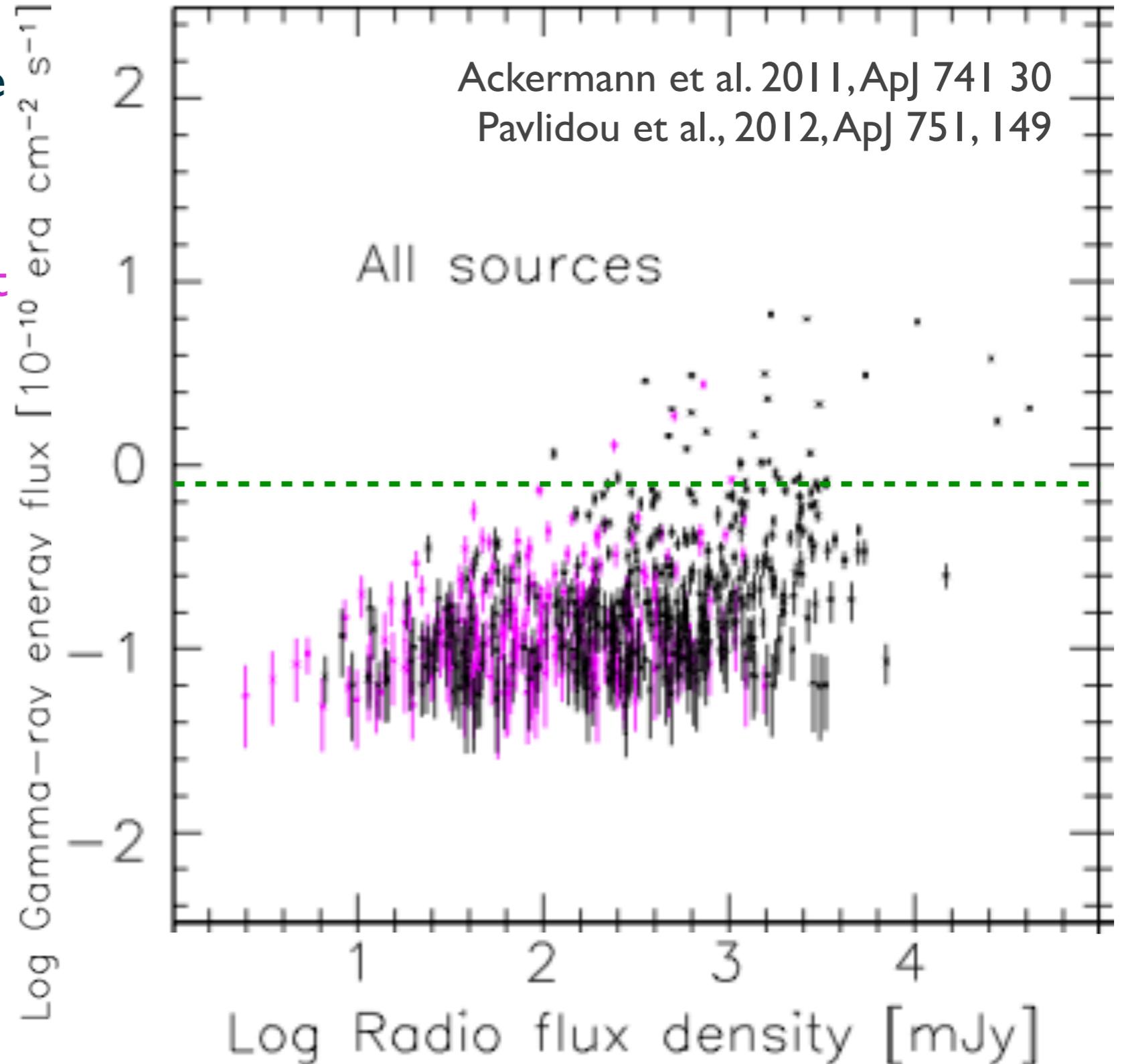


- latest catalog: 2FGL (2yr, 1873 src, Nolan et al. 2012)
 - AGN fraction ~58% (mix of FSRQs and BL Lacs, plus few radio galaxies)
 - unidentified fraction ~31%
- 3FGL in prep. based on 4yr
 - longer exposure, improved analysis

Fermi AGN radio-gamma connection

- All 599 sources in 1st “clean” LAT-AGN sample
- black: with redshift
- magenta: without redshift
- correlation coefficient: $r=0.47$
- **chance probability:**
 $p < 10^{-7}$

NB only two unassociated sources have gamma-ray flux larger than 8×10^{-10} erg cm⁻² s⁻¹ (green dashed line)



Very High Energy (VHE) gamma rays and lack of radio-VHE connection

- observations above ~ 100 GeV based on detection of Cherenkov atmospheric radiation (IACT)
- limited field of view, limited observing time, limited (integrated) sensitivity
- census: 47 AGNs over 151 detection (with 25 UNID and many galactic sources); mostly HSP-blazars
- bias: plenty of! no systematic survey, observations in flaring state, ...
- **physical elements: anti-correlation between SED peak and source power (blazar sequence), EBL attenuation, complex framework!**

The 1FHL

- 1FHL: first Fermi catalog of high energy sources ($E > 10$ GeV, Ackermann et al. 2013)
- three years of survey data, as uniform and unbiased as possible
- 514 sources, 76% of which are AGN, 13% unassociated
 - AGN fraction larger than in 2FGL, census leaning towards extreme spectral type blazars (HSP)
 - still significant fraction of unidentified sources
 - remarkable, given generally smaller positional ellipses

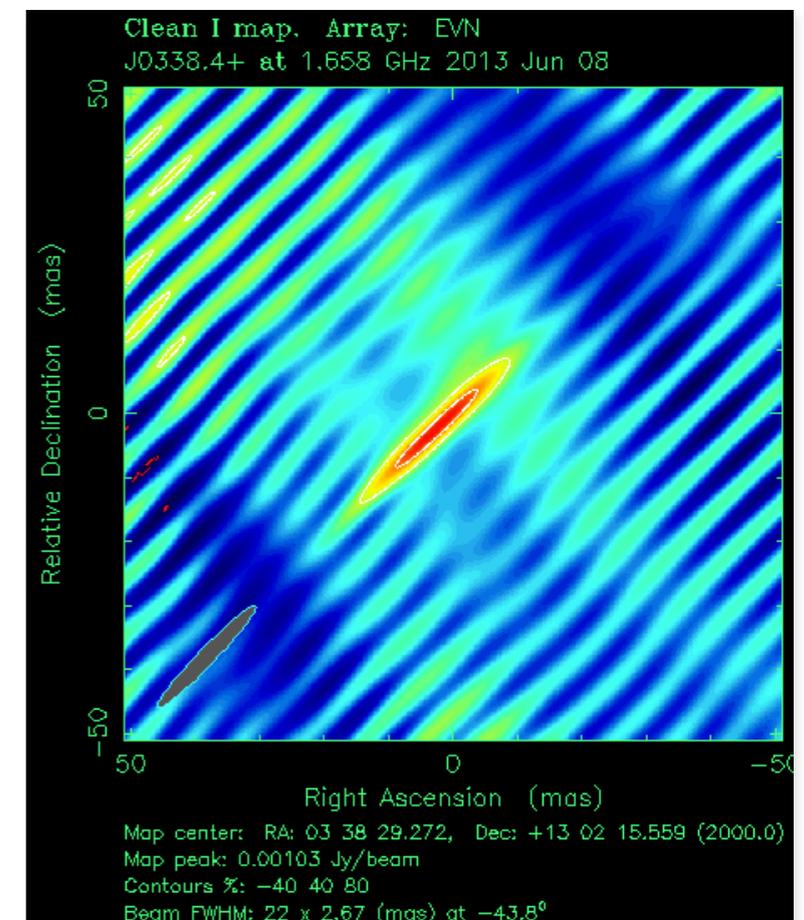
IFHL & VLBI

- Our goal: collect mas scale data for all northern IFHL sources
- through new observations for 77 unobserved ones, with EVN @1.6 GHz and VLBA @5 GHz
- to study parsec scale morphology, spectrum, luminosity of extreme blazars (Lico+11, Piner&Edwards05,...)
- to confirm classification for blazar candidates (Massaro+13)

(Rocco Lico's PhD thesis)

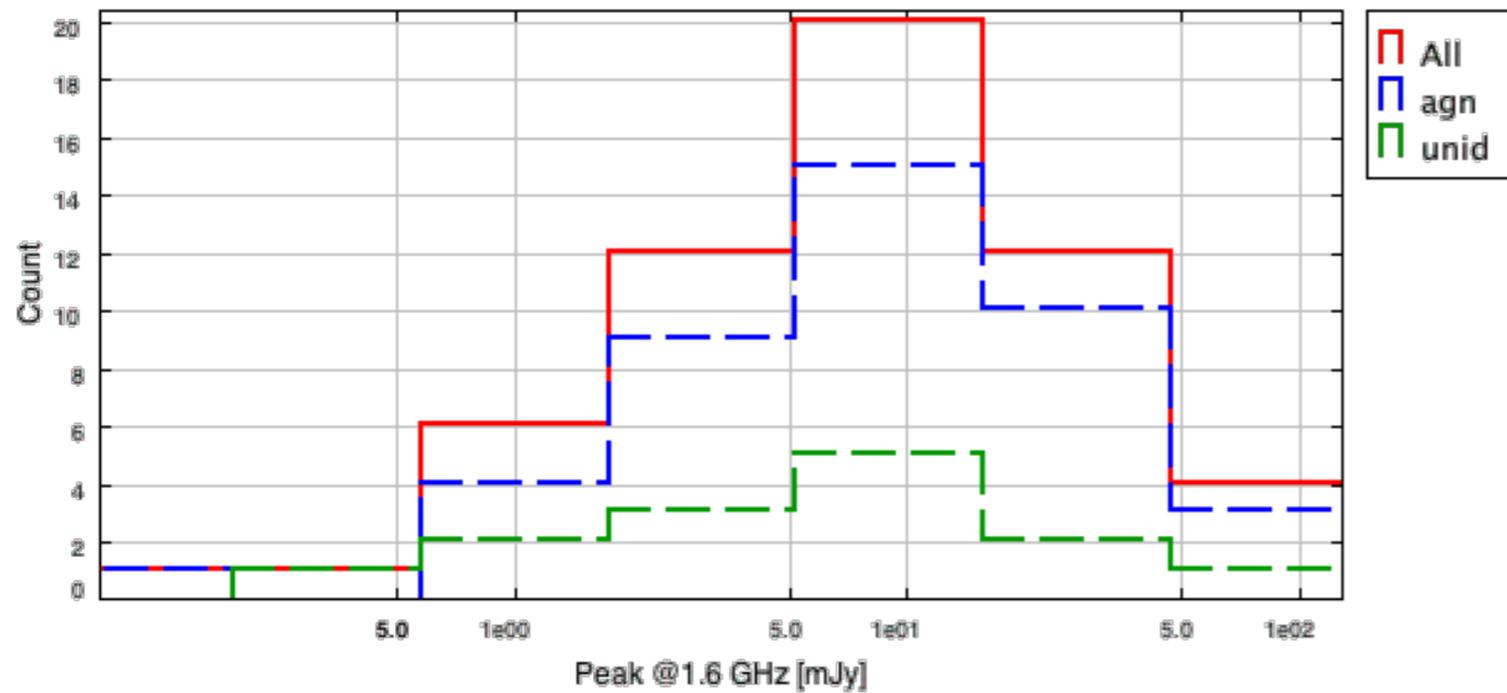
EVN observations

- two 18-hr 1.6 GHz e-VLBI runs
 - April 2013 with Sh (sources with $\text{Dec} > 30^\circ$)
 - June 2013 with Ar ($\text{Dec} < 30^\circ$)
- phase reference, no known position
- found offsets as large as 6'' from NVSS centroid
- detection rate
 - 83% overall
 - 100% for blazar candidates
 - 70% for unassociated sources



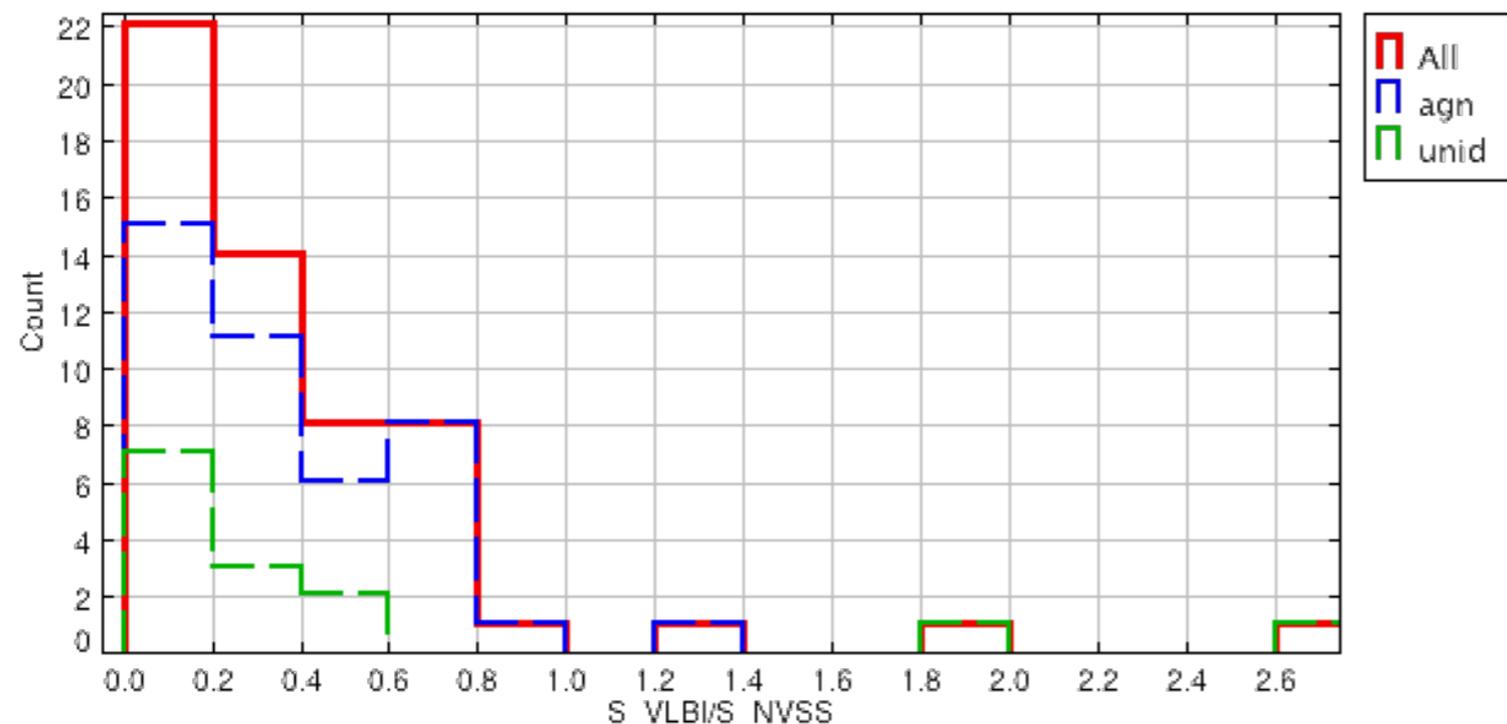
Radio flux densities

VLBI 1.6 GHz peak brightness distribution



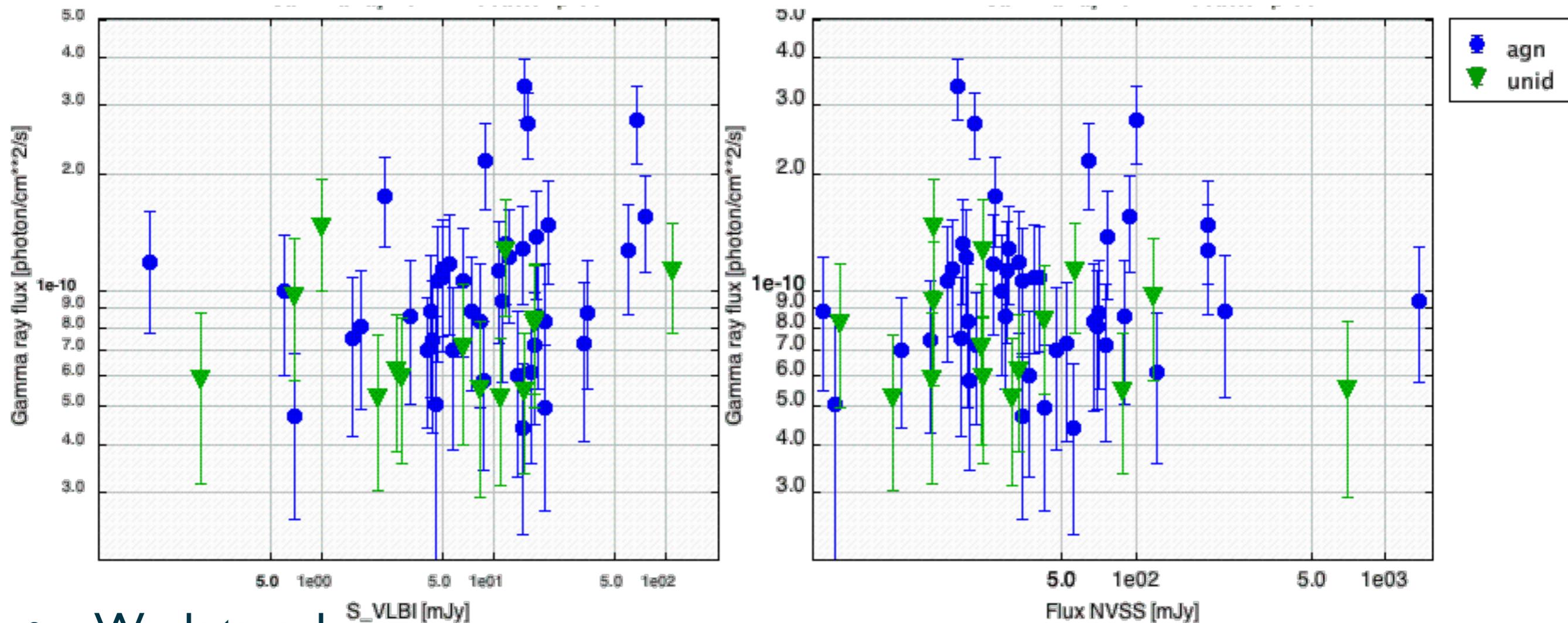
- Sources are generally weak (VLBI brightness distribution peaks ~10mJy)

- a fair amount of resolved flux is present ($S_{\text{vlbi}}/S_{\text{nvss}} \sim 0.1$)



- IFHL AGNs and UNID behave ~similarly

I FHL vs radio flux scatter plots



- Weak trend
- somewhat better for AGNs and for VLBI data
 - simultaneity, **physical scale**

Correlation coefficients

	vlbi	nvss
1fhl	0.21	0.050 (0.088 for AGNs)
2fgl	0.34	0.26

Correlation between radio and high energy data seems to vanish as we consider gamma-rays of higher energy

Discussion

- EVN observations show that these sources have a radio jet
- *Fermi* data show that these sources have a gamma-ray relativistic jet
- radio and high energy emission do not correlate strongly
- Doppler factor “crisis” continues
- constraints on jet structure (stratification/ deceleration), blazar sequence, ...

Take home notes

- EVN successful in revealing compact radio components in $E > 10\text{GeV}$ *Fermi* sources
- Lack of correlation between radio and gamma ray emission in blazars is not an artefact of IACT biases
- ...stay tuned for Rocco's thesis

References

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