Identifying Fermi AGN using high-frequency radio surveys

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› The AT20G Survey
› Why it’s an ideal catalogue for cross-matching with Fermi
› Fermi-AT20G detections
› 20 GHz flux vs gamma-ray flux density
› Detection rate against Galactic latitude
› Confusing sources

Image credit: NASA/DOE/Fermi LAT Collaboration
The Australia Telescope 20 GHz (AT20G) survey

› Blind survey of entire southern sky at 20 GHz
› Using the Australia Telescope Compact Array
  - Located in Narrabri, northern N.S.W.
› Observations carried out from 2004-2008
› Catalogue of 5890 sources
  - Essentially all radio-loud AGN

The Australia Telescope Compact Array

Image credit: ATNF, CSIRO
The Australia Telescope 20 GHz (AT20G) survey

- Flux limited at 40 mJy,
- 93% completeness at 100 mJy
- Near-simultaneous observations at 5, 8 and 20 GHz
  - provides spectral information
- Most sensitive high-frequency, large area survey!

- Public data release (Murphy et al. 2010, MNRAS)
- AT20G Website:
  http://www.atnf.csiro.au/research/AT20G/

Why AT20G is ideal for Fermi cross-matching

› Clean sample – completely blind survey at 20 GHz
  - No spectral pre-selection based on lower radio frequencies
  - Cleaner sample for doing statistical analysis
  - Uniform sky coverage (excluding Galactic plane, b<1.5)

› Positional accuracy, better than 1 arcsec
  - Ideal for finding optical counterparts -> spectra, redshifts, intrinsic properties, spectral classification etc.

› AT20G sky very similar to Fermi sky
  - Large number of FSRQ/blazars, particularly at brighter fluxes

› 20 GHz emission is mainly from the cores of AGN

› Ideal for finding AGN identifications
  - Don’t see any of the Galactic Fermi sources in AT20G
  - Therefore all AT20G-Fermi detections are AGN
Optical properties of AT20G sources

- AT20G positions are accurate to 1 arcsec
  - Ideal for finding correct optical counterpart
- Large numbers of FSRQ/Blazars
  - Number of radio galaxies increases with decreasing 20 GHz flux
- 28% have redshifts
  - Median redshift for QSOs: $z=1.25$
  - Median redshift for gal: $z=0.25$

Mahony et al. 2010, in prep.

Greyscale: SuperCOSMOS
B-Band image
Blue contours: 20 GHz flux
Total of 233 AT20G-Fermi matches (43% of southern Fermi sources detected in AT20G)

95% completeness and 95% reliability

In agreement with the 1LAC catalogue
- No missing high-freq population

8 new identifications – all at low galactic latitudes where 1LAC in known to be incomplete

Detection rate increase with 20 GHz flux
- A few % at 100 mJy
- Close to 100% above 1 Jy

The AT20G detection rate for variable Fermi sources is 87%.
For non-variables only 32%.

Similar correlation noted by Ghirlanda et al., 2010.
Non-simultaneous observations (separated by 2-5 years)
- Is beaming making this correlation tighter?
We also have additional high resolution data available for most of the AT20G sources. Clearly shows two different AT20G populations:
- Compact, flat-spectrum sources
- Resolved, steep-spectrum sources

The Fermi detections are preferentially the compact, flat-spectrum sources
- With the exception of a few nearby galaxies (e.g. NGC 253, NGC 4945)

Chhetri et al., in prep
Detection rate as a function of Galactic latitude

- Expect AT20G detection rate to be constant with Galactic latitude
- Binned in equal area bins
- AT20G detection rate of Fermi sources is lower at low Galactic latitudes
- Only partially accounted for by the known Fermi Galactic sources
- Implies there is an unidentified Galactic population causing the AT20G detection rate to vary with $|b|$
Unidentified Galactic Fermi sources

- At least 50 unidentified high-latitude Galactic sources in the south
- Large spread in Galactic latitude
- Many of these probably pulsars
  - Young pulsars: all at |b|<3.
  - Milli-second pulsars: quasi-isotropically distributed
- So far ~40 young pulsars discovered to be gamma-ray emitters
- ~18 confirmed msp's


Abdo et al., 2010, ApJS 187, 460
Due to the large error ellipse on the Fermi positions, confusion is increasingly becoming an issue.

For example:
- PKS 1101-536
- AT20G cross-matching identifies an AGN counterpart
- Also appeared in the pulsar follow-up catalogue
- Confirmed milli-second pulsar
- **Which one is the gamma-ray source??**

This will only become more of an issue as Fermi goes deeper!
AT20G is a blind survey of the southern sky at 20 GHz
- An ideal catalogue for identifying Fermi AGN
  - Clean sample – no spectral pre-selection
  - Large sample of FSRQ and blazars, similar to Fermi population
- There are 233 Fermi sources with AT20G counterparts
  - The Fermi detection rate increases with 20 GHz flux
- Gamma-ray flux density is correlated with 20 GHz flux
- Detection rate of AT20G sources changes with Galactic latitude, suggesting that there are many Galactic Fermi sources that remain unidentified
  - At least 50 in the southern sky
  - Most probably pulsars
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