International Centre for Radio Astronomy Research

Constraining episodic jet activity in radio galaxies

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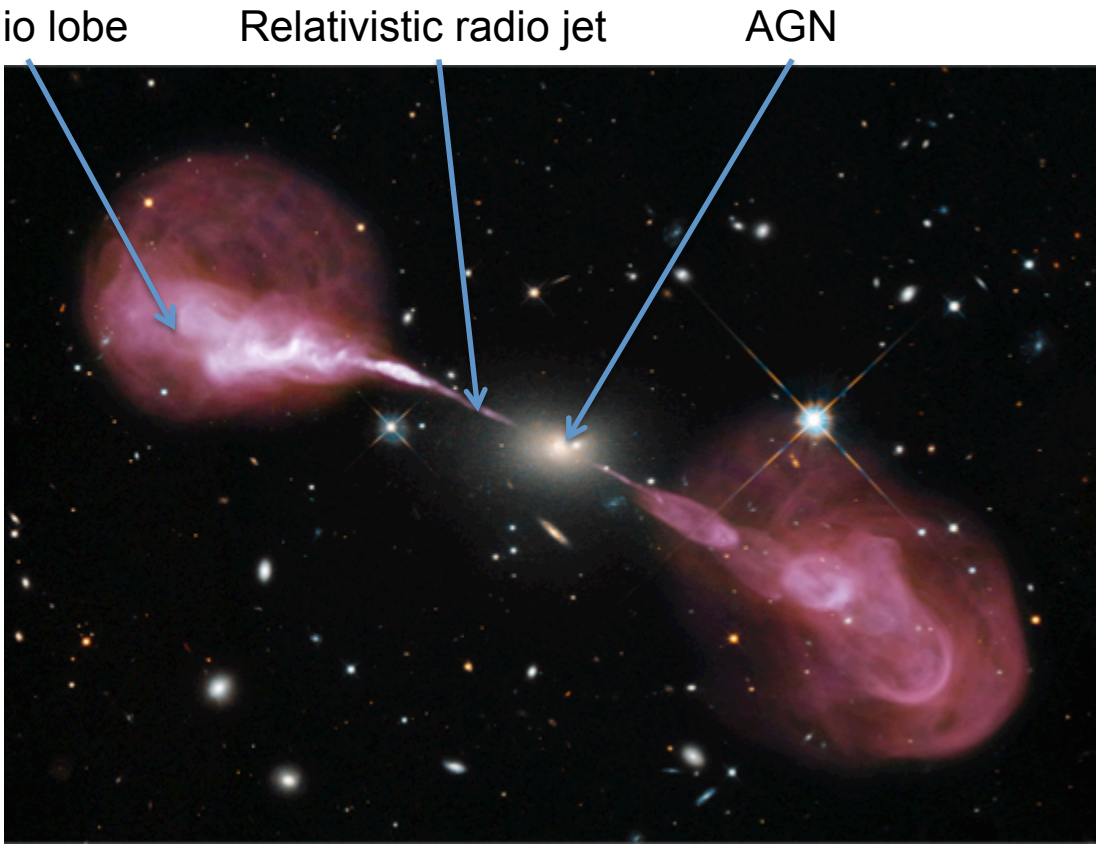
THE UNIVERSITY OF WESTERN AUSTRALIA

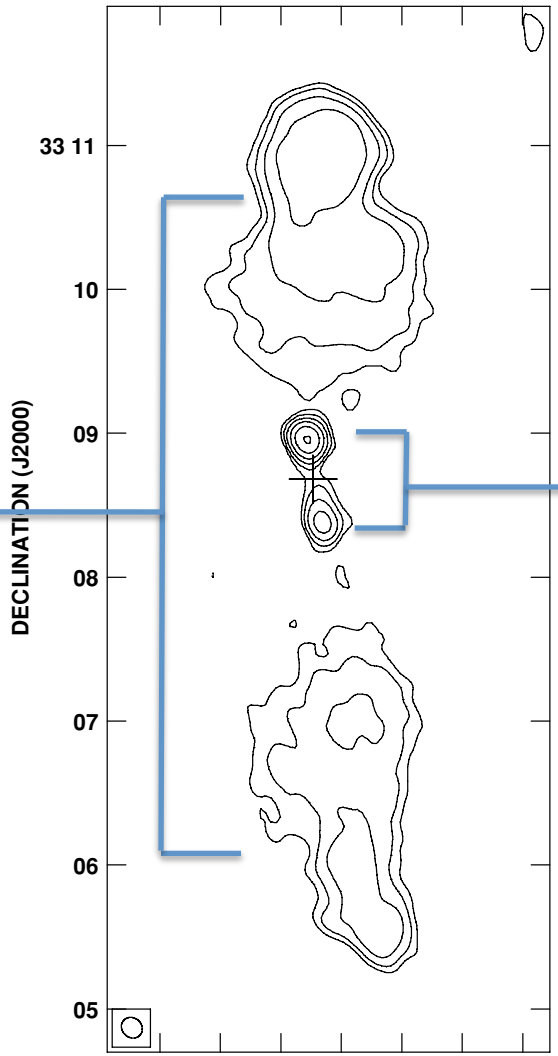
Introduction



3C348 - optical in white/yellow, radio in red

In most powerful radio galaxies, period of jet activity is short (< 10^8 years) compared with the lifetime of parent galaxy (10^{10} years).

Double-double radio galaxies



Older pair of radio lobes (~50 Myr)

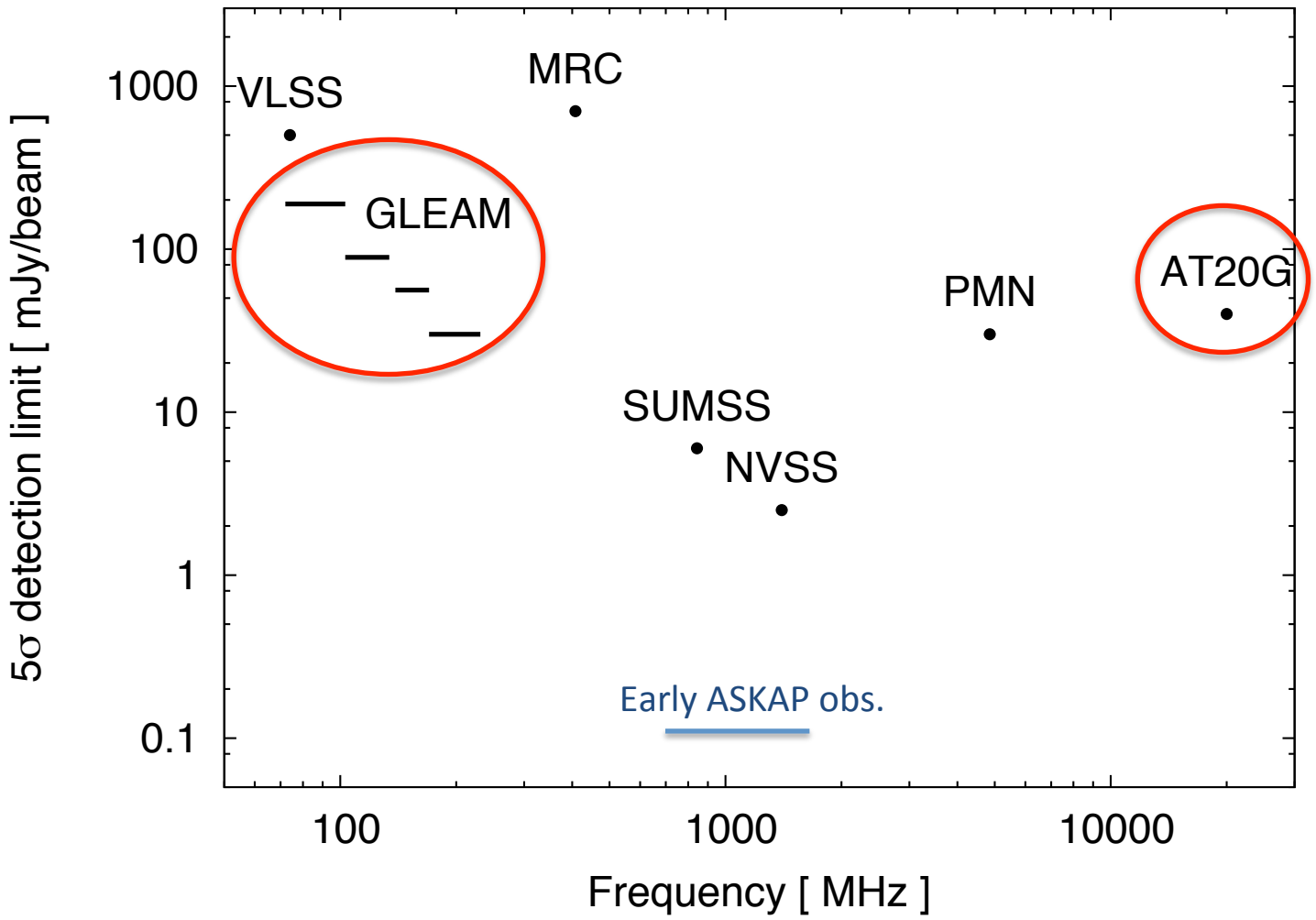
Younger pair of radio lobes (~2 Myr)

334 MHz GMRT image of J1453+3308 (Konar et al. 2006)
z = 0.249
linear size ~ 1.3 Mpc

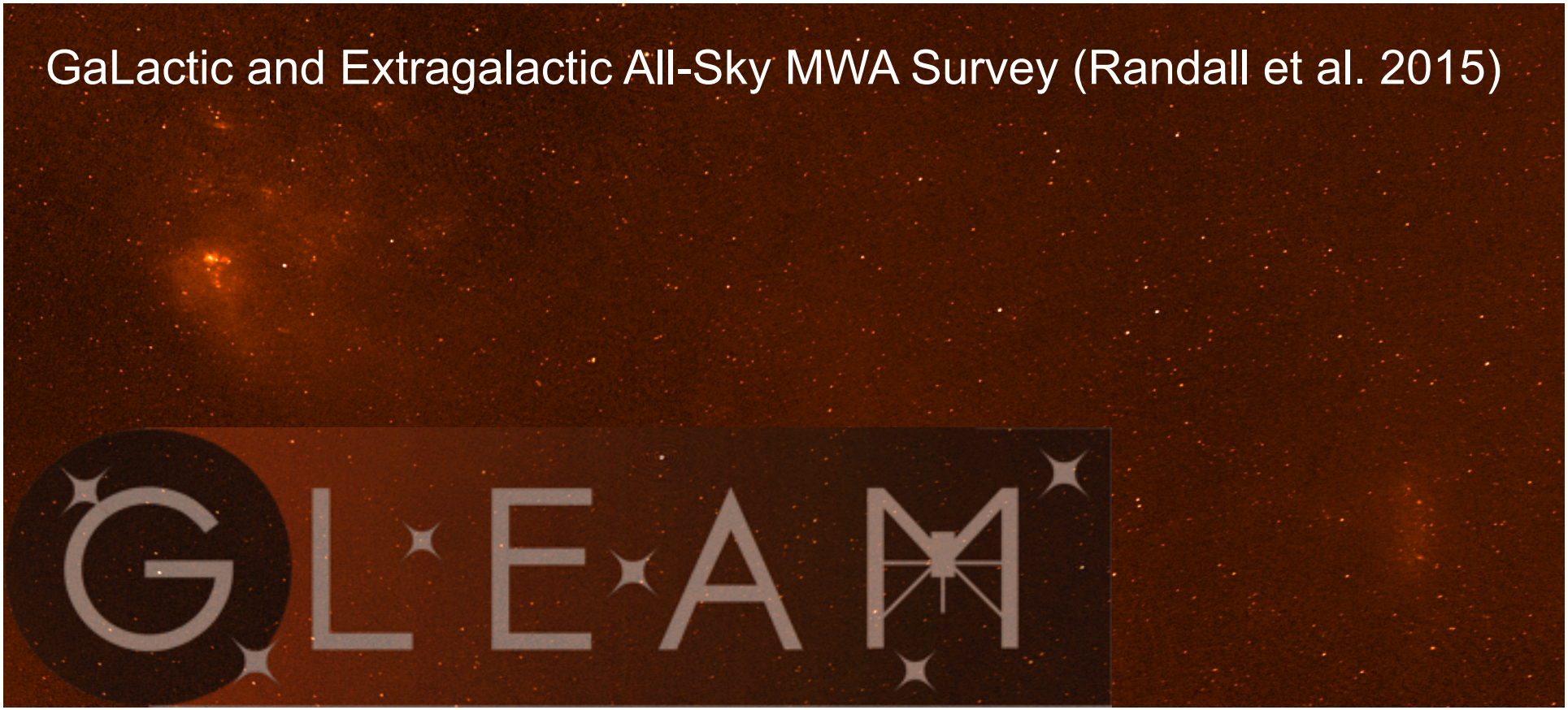
Advancing our knowledge of episodic jet activity

- Few systematic searches for AGN with recurrent activity
  - 4 double-double radio galaxies discovered during a search for large, extended radio sources in WENSS at 325 MHz (Schoenmakers et al. 2000)
  - GMRT observations to examine structure of 400 sources in galaxy cluster field; no evidence of episodic activity from source structure alone (Sirothia et al. 2009)
- Understanding history of jet activity hampered by lack of radio data covering wide range of frequencies

Large-area radio surveys covering the southern sky



GaLactic and Extragalactic All-Sky MWA Survey (Randall et al. 2015)

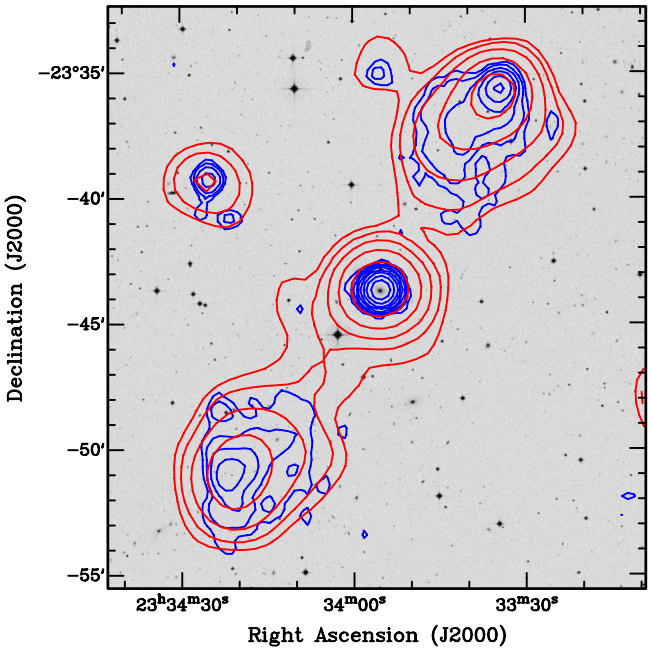


- Covers entire sky south of Dec 30° at 72-231 MHz
- Rms ~5-10mJy but limited by confusion
- Resolution ~2 arcmin
- 1st year GLEAM extragalactic catalogue of ≈ 300,000 components expected to be released in mid 2016 (Hurley-Walker et al., in prep.)
- Sensitive to sources with steep synchrotron spectra, favours old emission originating from extended lobes

Australia Telescope 20 GHz Survey (AT20G)

- Covers entire southern sky at 20 GHz
- Follow-up at 5, 8 and 20 GHz
- Resolution ~10 arcsec
- 5890 sources with $S_{20\ GHz} > 40$ mJy (Murphy et al. 2010)
  - Dominated by compact, flat-spectrum sources
  - Mainly probes current and very recent AGN activity

Recently restarted radio galaxy in GLEAM



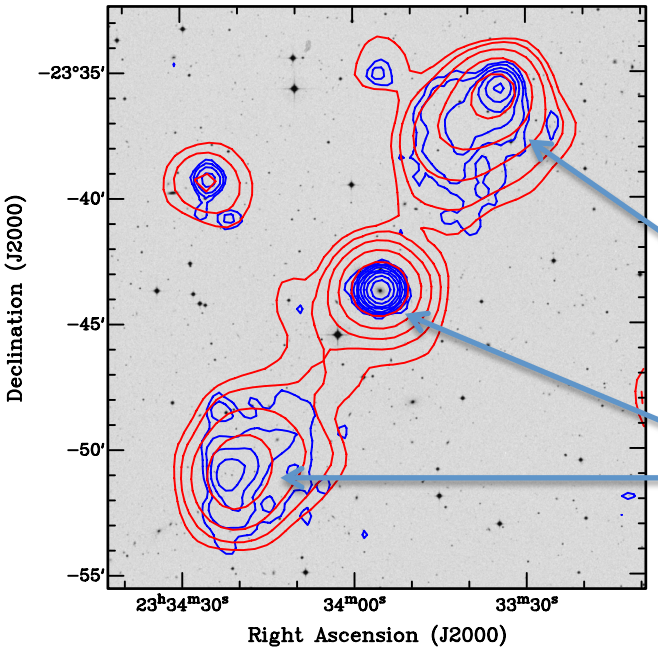
Giant radio galaxy B2331-241

GLEAM (200 MHz)

NVSS (1.4 GHz)

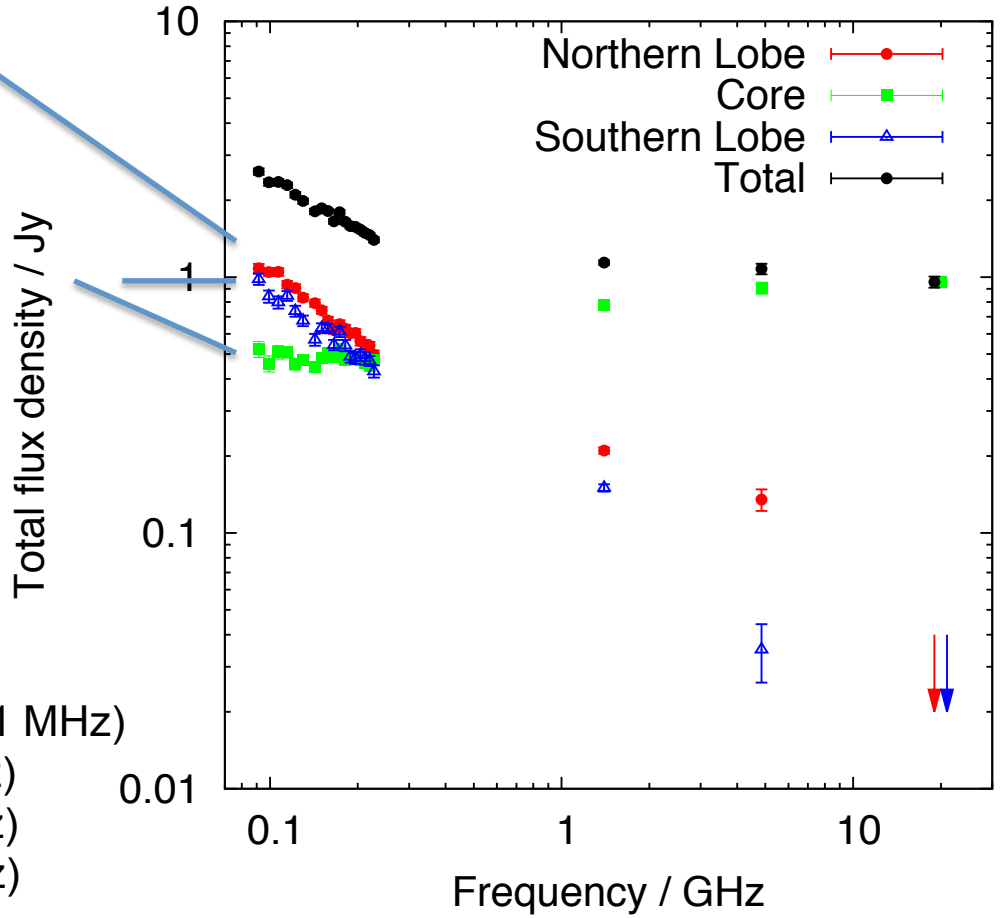
- Unambiguous case of recurrent AGN activity in local universe
- Resolved into 3 components in GLEAM
- Linear size = 1.07 Mpc, z = 0.0477
- Only core detected by Australia Telescope 20 GHz survey

Recently restarted radio galaxy in GLEAM



Giant radio galaxy B2331-241

Even though they may be unresolved at higher redshift, candidate restarted radio galaxies can be identified from their broad-band radio spectra



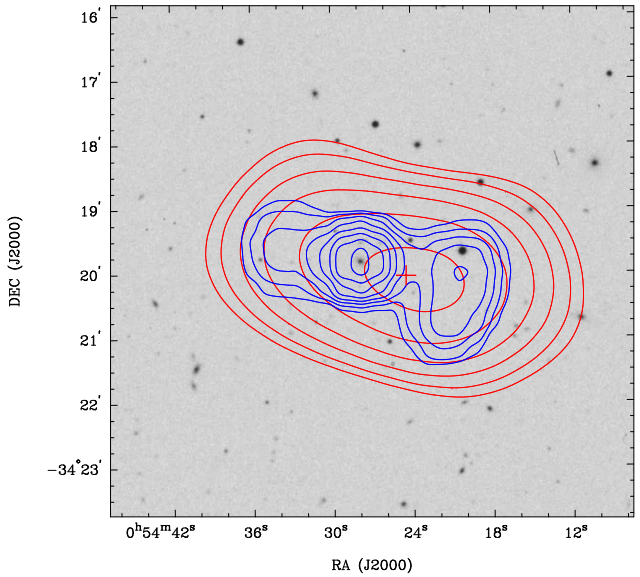
GLEAM (70-231 MHz)
NVSS (1.4 GHz)
PMN (4.85 GHz)
AT20G (20 GHz)

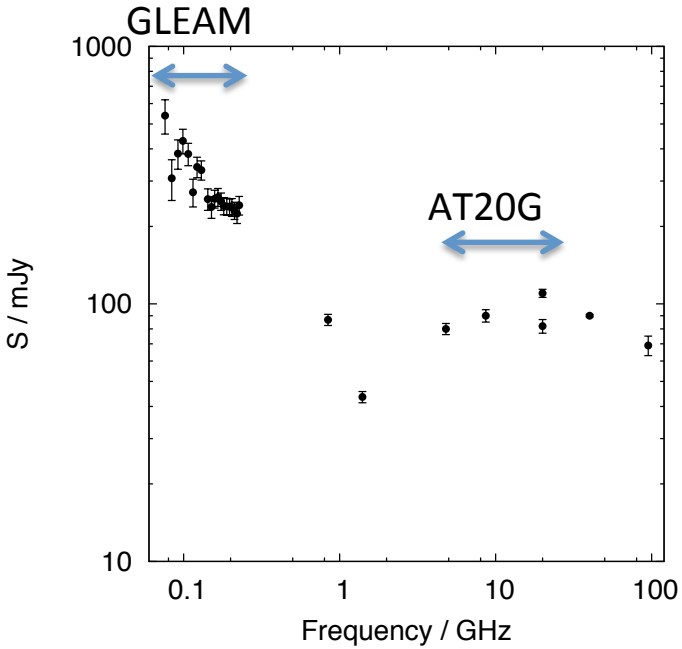
High-frequency peaking GPS galaxies with diffuse extended emission

- Hancock et al. (2010) followed up 21 sources with inverted spectra between 8 & 20 GHz in AT20G
- Of these, 12 found to be genuine GPS galaxies, of which 3 showed evidence of being restarted

J005427-341949
z = 0.11
Linear size ~ 355 kpc

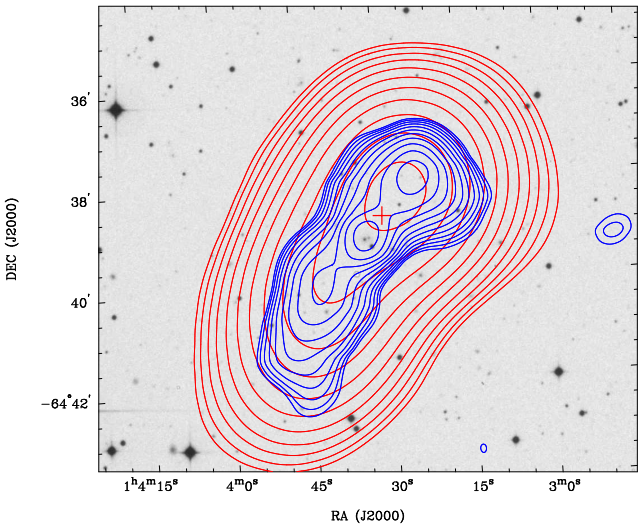
GLEAM
NVSS

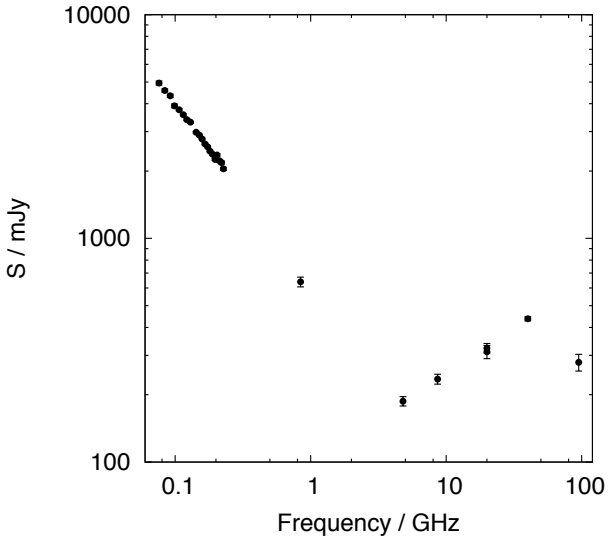




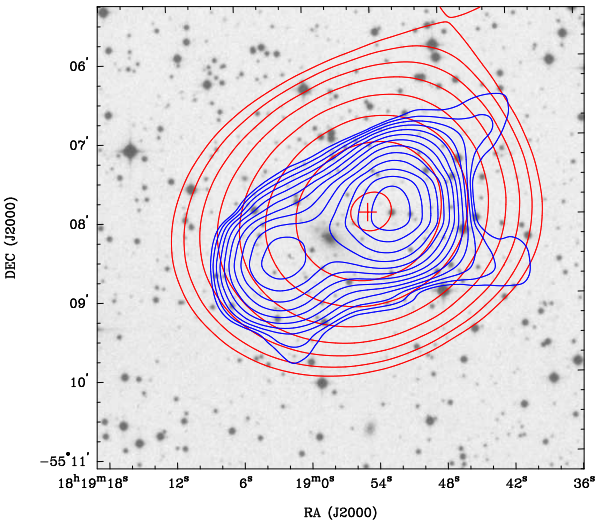
More examples

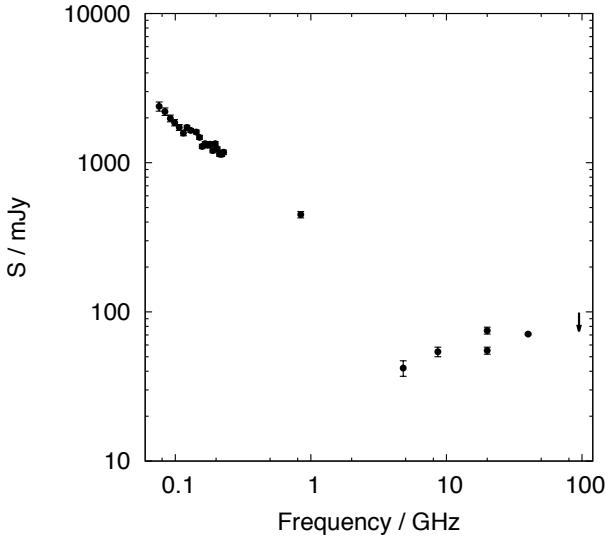
J010333-643907
z = 0.163
Linear size ~ 460 kpc





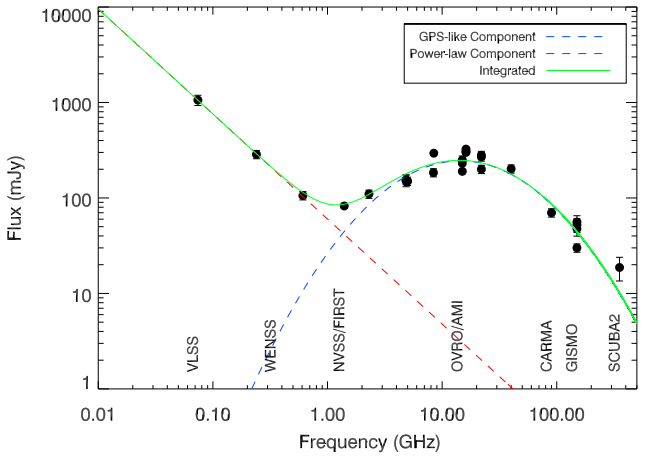
J181857-550815
z = 0.073
linear size ~ 110 kpc



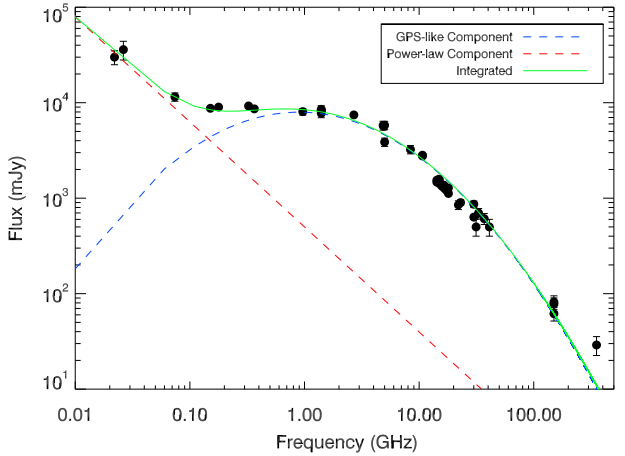


Complexity of multi-frequency radio spectra of brightest cluster galaxies (BCGs)

- Hogan et al. (2015) examined broadband SEDs of BCGs in sample of 726 X-ray selected galaxy clusters
- Cool-core clusters much more likely to contain distinguishable radio core
- Among 35 most core-dominated BCGs, 26 well fit by power-law + GPS-like component
- Suggests BCGs show near-continuous AGN activity

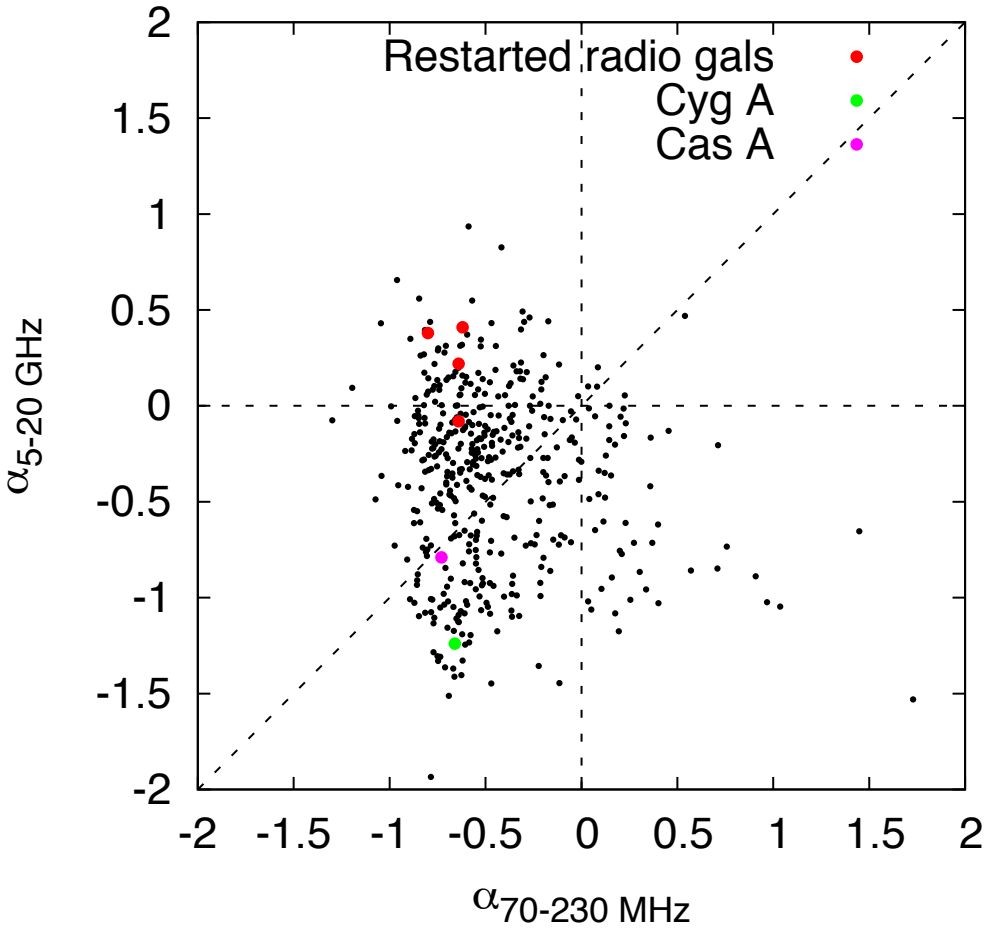


(a) *R0439+05*



(c) *4C+55.16*

Radio colour-colour plot for 20 GHz source population



- Take deepest region of GLEAM (2500 deg^2 complete to 50 mJy at 200 MHz)
- 560 AT20G sources with 5 & 8 GHz follow-ups lie in this region
- Of these, 504 (90%) have a counterpart in GLEAM

ASKAP/MWA synergy

- Early ASKAP data invaluable in providing 0.7-1.8 GHz spectral indices
  - Will cover GAMA fields & SDSS Stripe 82 - good optical redshift data
- Combine ASKAP & MWA data to identify both GPS sources with single period of activity & restarted sources
- High frequency follow-up observations + stacking experiments to probe low-frequency relic emission