The faint source population at 15.7 GHz

The radio properties

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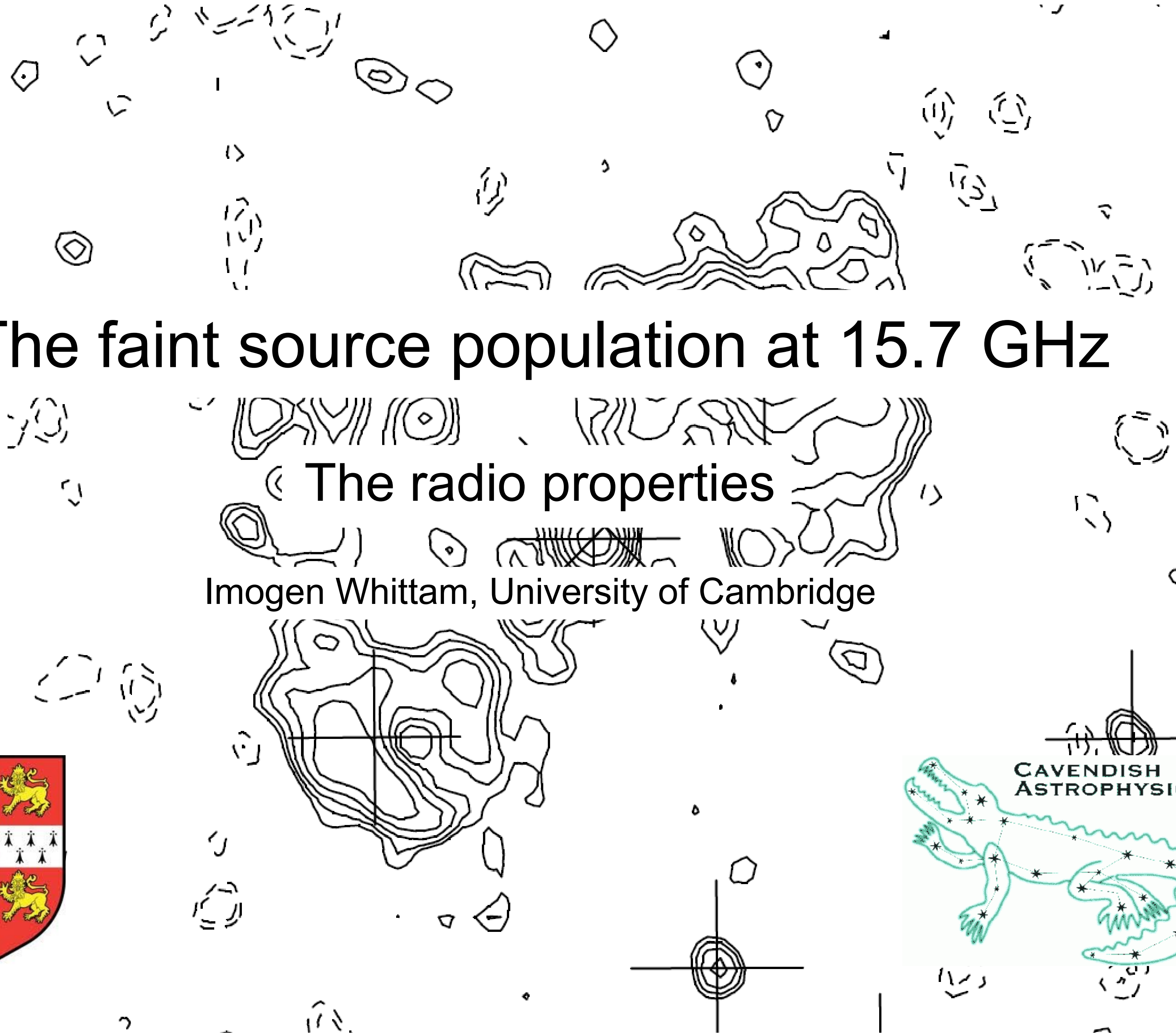
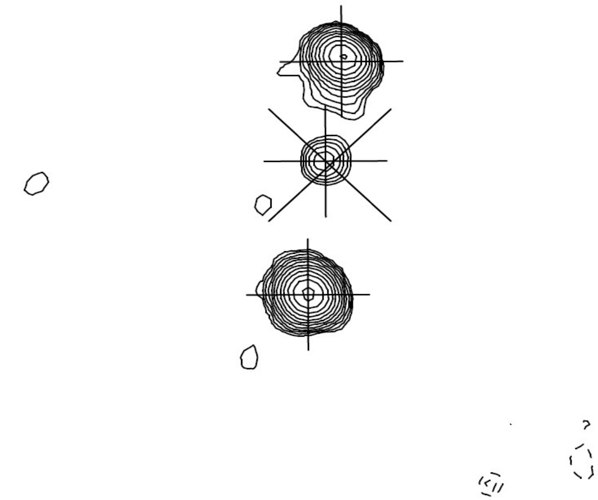


Introduction

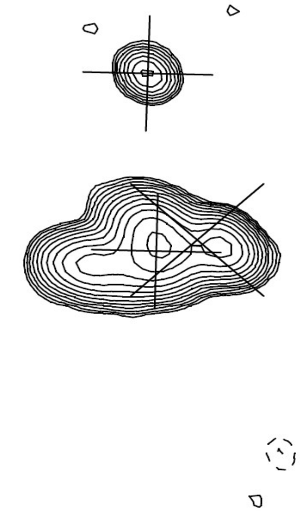
- Since 1950s, radio surveys have provided valuable insights into the makeup of the universe.
- However, the faint, high frequency sky has not been studied in any detail due to the increased time required to survey a field to an equivalent depth at higher frequencies.
- There have been several attempts to model the high frequency source population, mainly extrapolating from lower frequency (1.4 GHz) surveys.
- These models are increasingly poor fits to the observed source counts, significantly underestimating the number of sources.
- Shows that the properties of high frequency sources below approx 10 mJy are not well understood.
- A multi-frequency study of the faint, high frequency sky is required to better understand these sources and constrain the models.
- Here I describe just such a study.

Outline



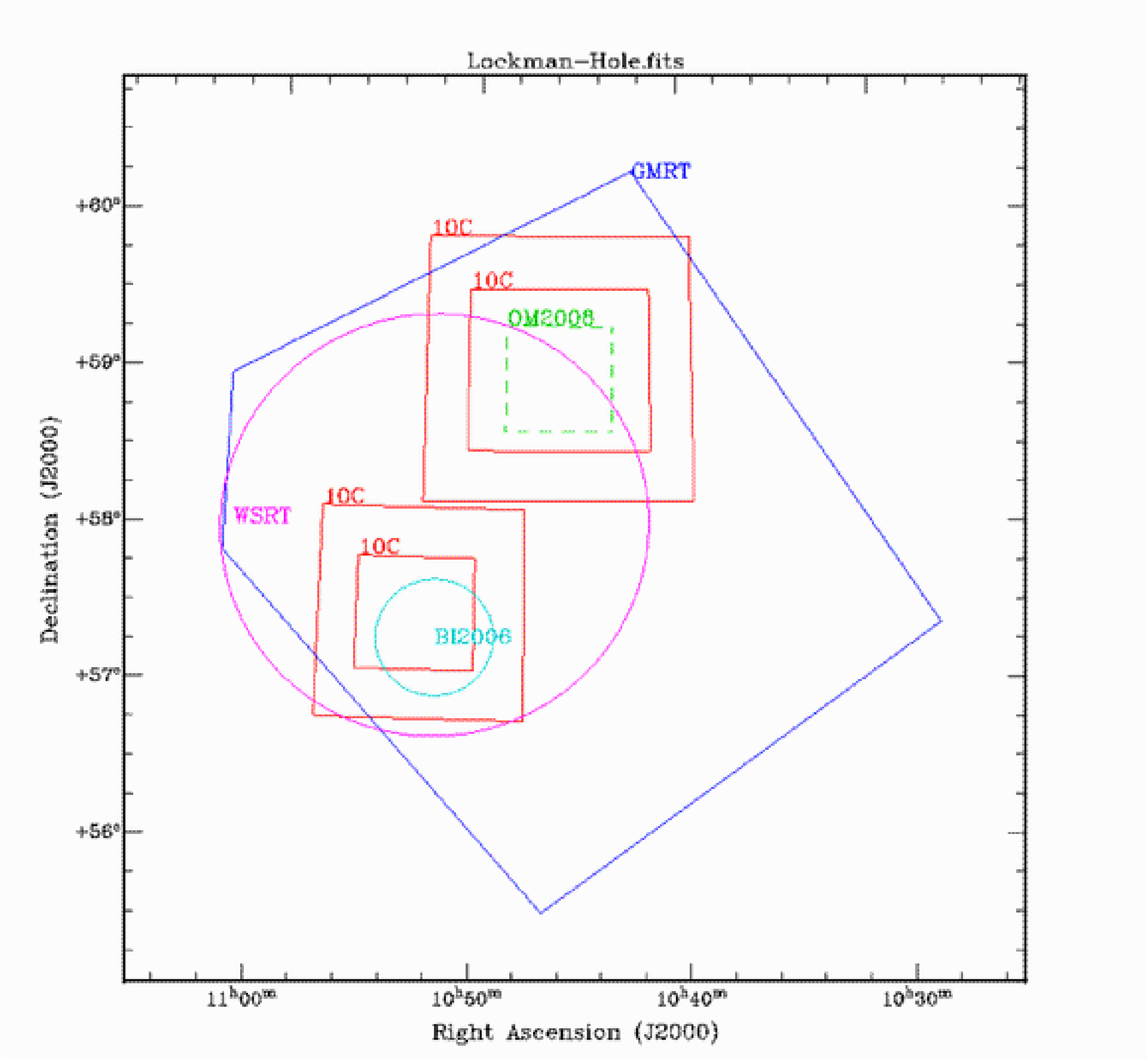
- Sample selection
- Radio spectral properties
- Comparison with sources selected at 1.4 GHz
- Comparison with SKADS Simulated Sky
- Conclusions

10C Survey



- Observed with the Arcminute Microkelvin Imager (AMI) in Cambridge.
- Ten fields observed at 15.7 GHz.
- 27 deg^2 complete to 1 mJy.
- A further 12 deg^2 complete to 0.5 mJy contained within these fields.
- Deepest high frequency radio survey to date – enables us to investigate the faint, high frequency population.
- Used in this work – two fields in the Lockman Hole – total of 296 sources.

Data used



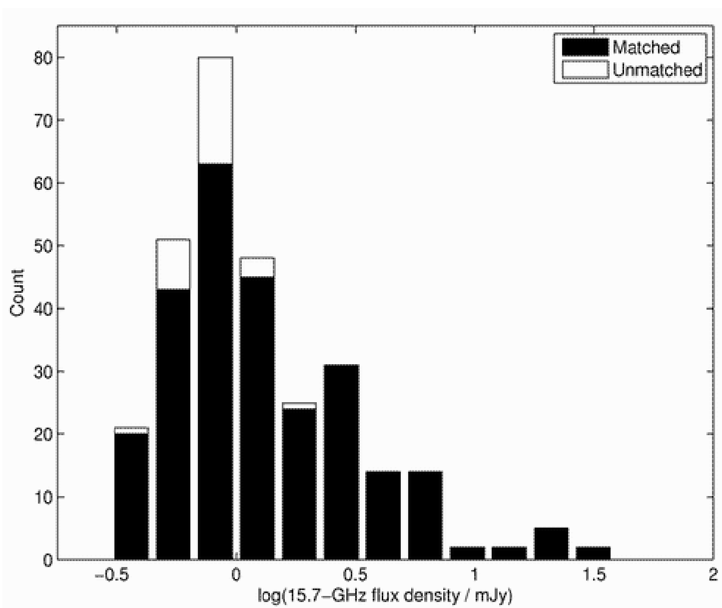
- 10C = 15.7 GHz
- GMRT = 610 MHz
- WSRT, OM2008, OM2006 = 1.4 GHz
- FIRST, NVSS and WENSS cover the whole area.

Survey details

Catalogue	Frequency /GHz	Beam size / arcsec	rms noise / mJy
10C - shallow	15.7	30	0.1
10C - deep	15.7	30	0.05
GMRT	0.610	6 x 5	0.06
WSRT	1.4	11 x 9	0.011
OM2008	1.4	1.6	0.0027
BI2006	1.4	1.3	0.0046
FIRST	1.4	5	0.15
NVSS	1.4	45	0.45
WENSS	0.325	54	3.6

Matching the catalogues

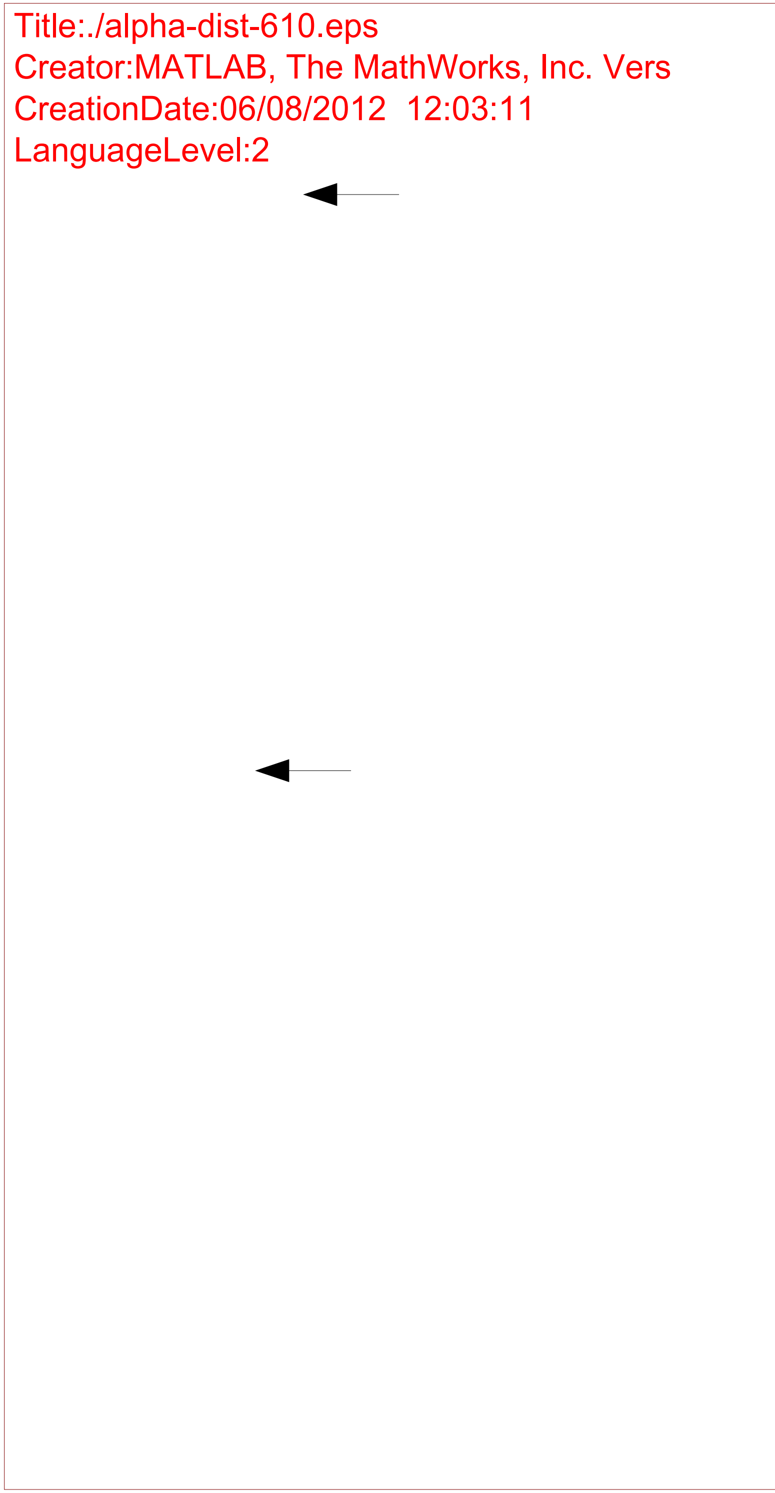
- 15 arcsec match radius.
- 266 out of 296 sources have at least one match.
- Unmatched sources – upper limit placed on the flux density at 610 MHz from the GMRT map and at 1.4 GHz from the WSRT/FIRST maps.



- Most of the unmatched sources are faint

Spectral Index

- Radio spectra are often represented as a simple power law: $S \propto \nu^{-\alpha}$
- Gives important information about the emission mechanism of a source.
- Sources with $\alpha < 0.5$ are classified as having a flat spectrum, while sources with $\alpha > 0.5$ are steep spectrum.
- alpha(15.7-0.61) and alpha(15.7-1.4) are calculated for all sources. Upper limits calculated for sources undetected at 610 MHz and/or 1.4 GHz.

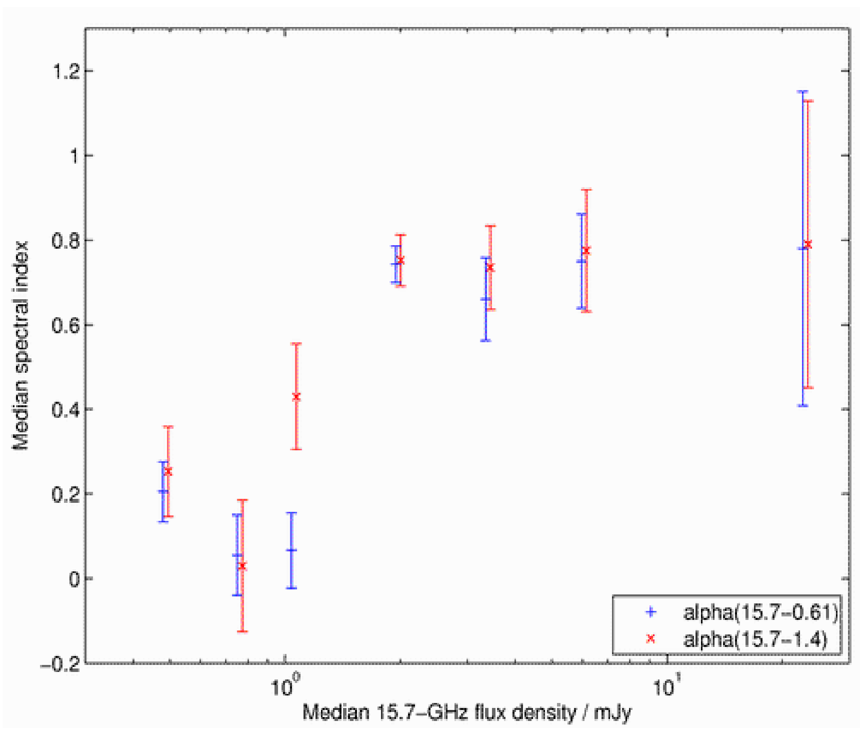


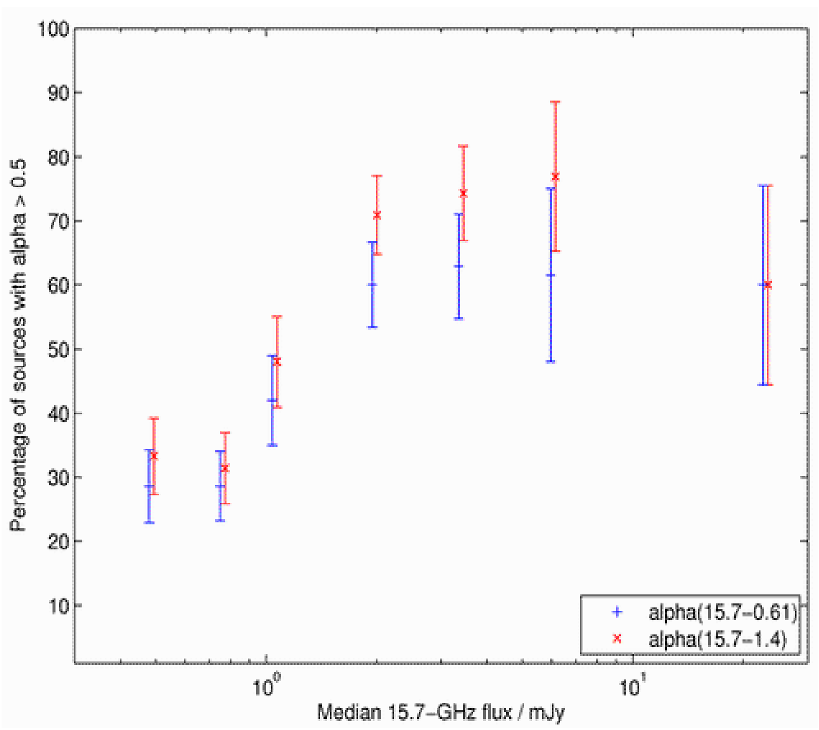
Low flux density
0.3 < S < 0.8 mJy
Median α = 0.08

Middle flux density
0.8 < S < 1.5 mJy
Median α = 0.36

High flux density
S > 1.5 mJy
Median α = 0.75

Variation in spectral index with flux density



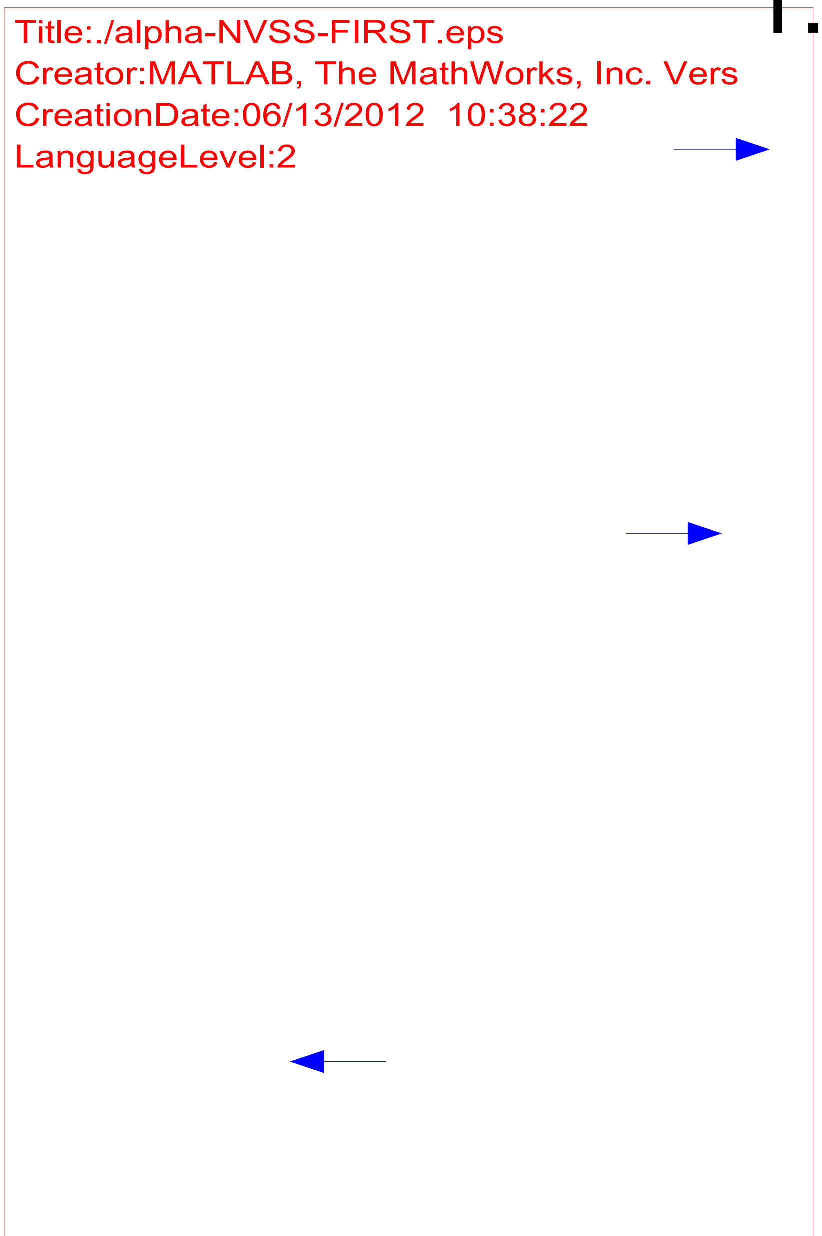


Clear decrease in spectral index at lower flux densities. Upper limits included using survival analysis.

Comparison with 1.4 GHz sources

- Population at 1.4 GHz has been much more widely studied.
- Models of the source population at higher frequencies are often extrapolated from 1.4 GHz – interesting to compare 10C spectral properties to a sample selected at 1.4 GHz.
- Two sample selected – one from FIRST and one from NVSS.
- Matched to 10C catalogue.
- Upper limits found from 15.7 GHz maps for unmatched sources.

Spectral properties of sources selected at 1.4 GHz



- Spectral index distributions significantly different.
- Additional population of flat spectrum sources poorly represented by selecting at 1.4 GHz.
- This is why extrapolating from lower frequencies to predict the higher frequency population is challenging – relies on accurate modeling of how spectral behaviour of a source varies with frequency.

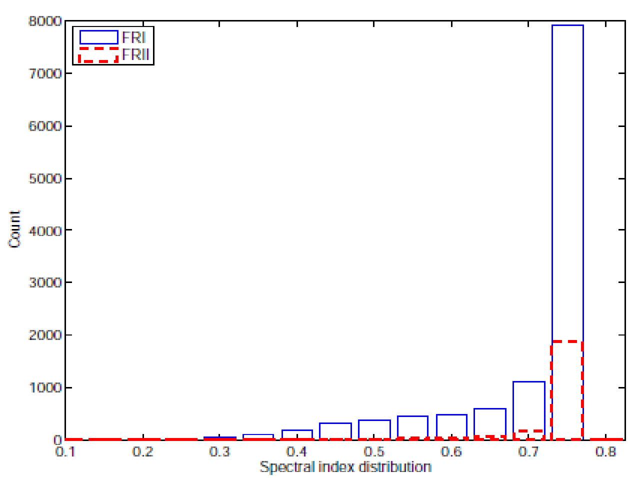
SKADS Simulated Sky (S^3)

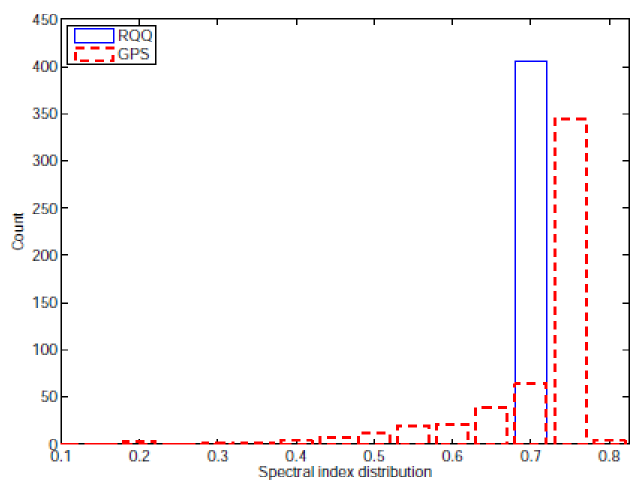
- Wilman et al. (2008, 2010) produced a semi-empirical simulation of the radio continuum sky which contains over 320 million sources.
- Covers 20 x 20 deg^2 out to redshift z = 20.
- Flux density limit 10 nJy at 151, 610 MHz, 1.4, 4.86 and 18 GHz.
- Sources are split into six types: FRI, FRII, RQQ, GPS sources, quiescent starforming and starbursting galaxies.
- Selected a sub-sample of sources with flux density at 18 GHz > 0.5 mJy – comparable to the 10C sample studied here.

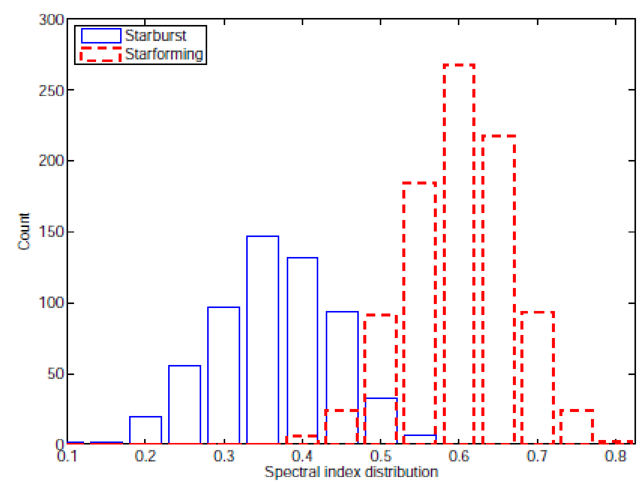
S^3 sample

Source type	Percentage
FRI	71
FRII	13
Radio quiet AGN	3
GPS	3
Starburst	4
Quiescent starforming	3

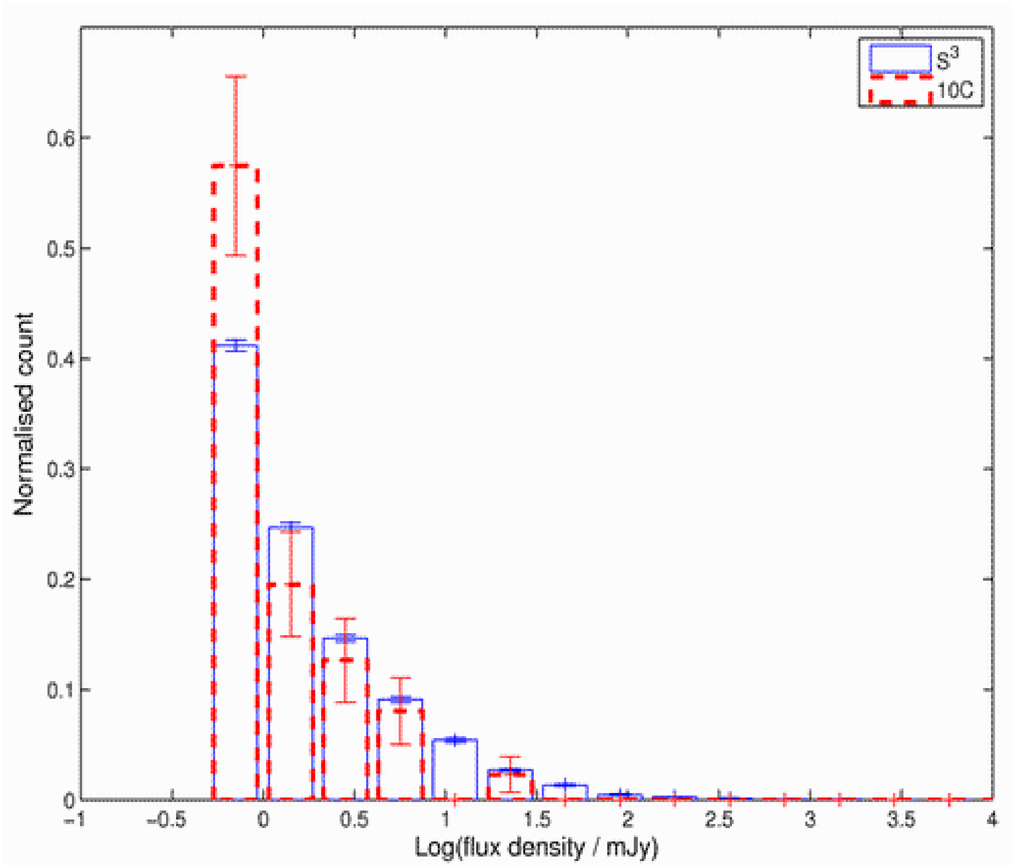
- Sample dominated by FRI sources.
- FRI, FRII and GPS sources modeled assuming extended emission has α = 0.75.
- Orientation dependent relativistic beaming model used to find contribution of flat spectrum core.





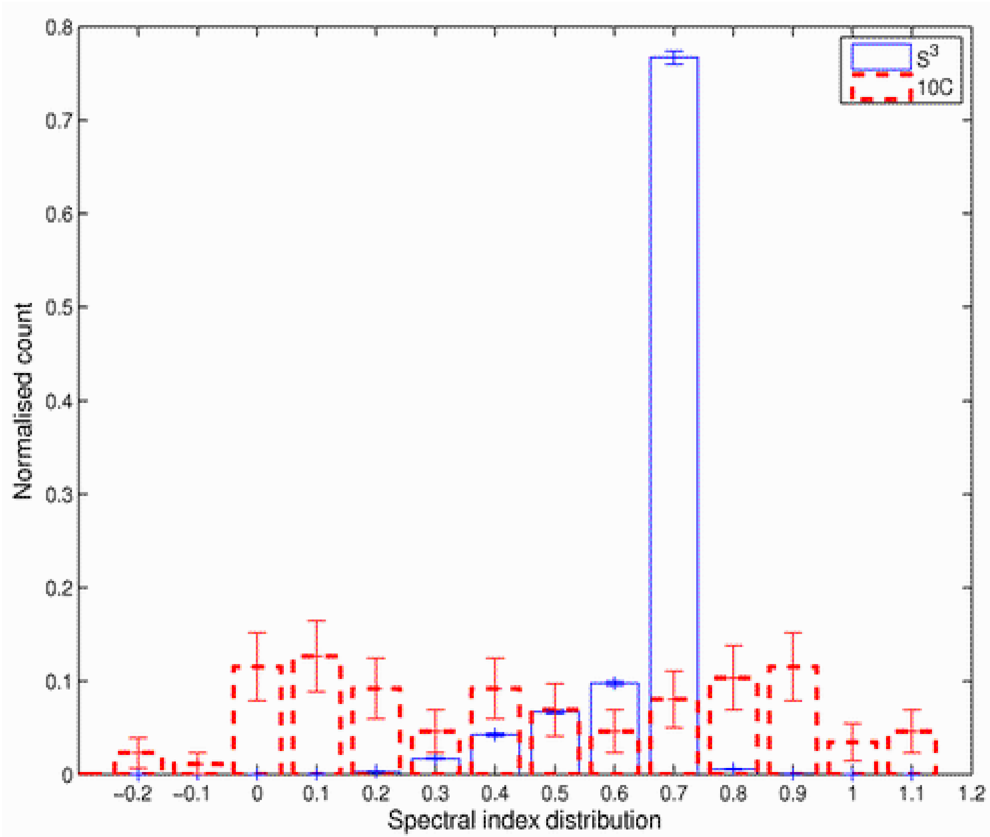


Comparing S^3 and 10C – flux density



- Over all flux density distributions similar, but 10C contains a larger proportion of sources with flux densities < 1 mJy.

Comparing S^3 and 10C – spectral index



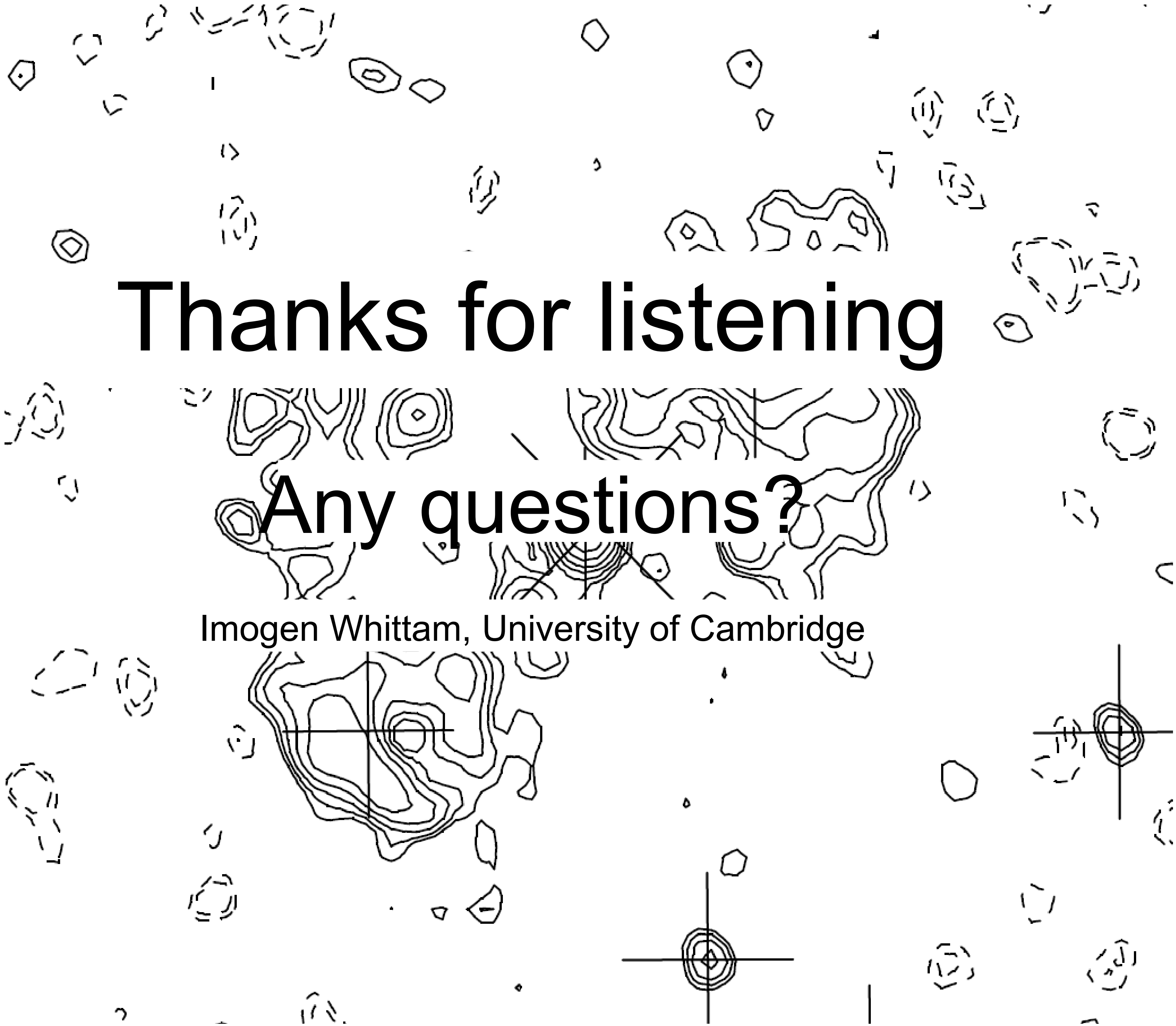
- Simulation clearly fails to represent spectral index distribution of 10C sources.
- Failure at α > 0.7 is due to input assumption that all sources have α = 0.75.
- More significantly, conspicuous absence of sources with α < 0.3.
- One possibility – population dominated by starbursts instead of FRIs.
- Or, FRI emission hasn't been modelled correctly.
- Highlights the difficulties with predicting the behaviour of the high frequency population be extrapolating from lower frequencies.

Conclusions

- Investigated the radio properties of 296 sources selected at 15.7 GHz
- Clear change in spectral index with flux density – median alpha changes from 0.75 for sources with flux densities > 1.5 mJy to 0.08 for sources fainter than 0.8 mJy.

  – population of faint, flat spectrum sources are emerging.
- 10C sample compared to a sample selected at 1.4 GHz – spectral index distributions significantly different.
- The 10C sample was compared to S^3 – the spectral index distributions of the two sample differ significantly.

  – This could be due to cores of FRI sources being more dominant than the model suggests.
- **Our unique, faint 15.7 GHz samples are clearly of great value when investigating the faint, high frequency source population.**
- This work is being extended by finding optical and infrared counterparts for 10C sources – can then find photometric redshifts and further information about the source types.



Thanks for listening

Any questions?

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