A low frequency view to the local radio AGN population: The most massive galaxies are always switched on.

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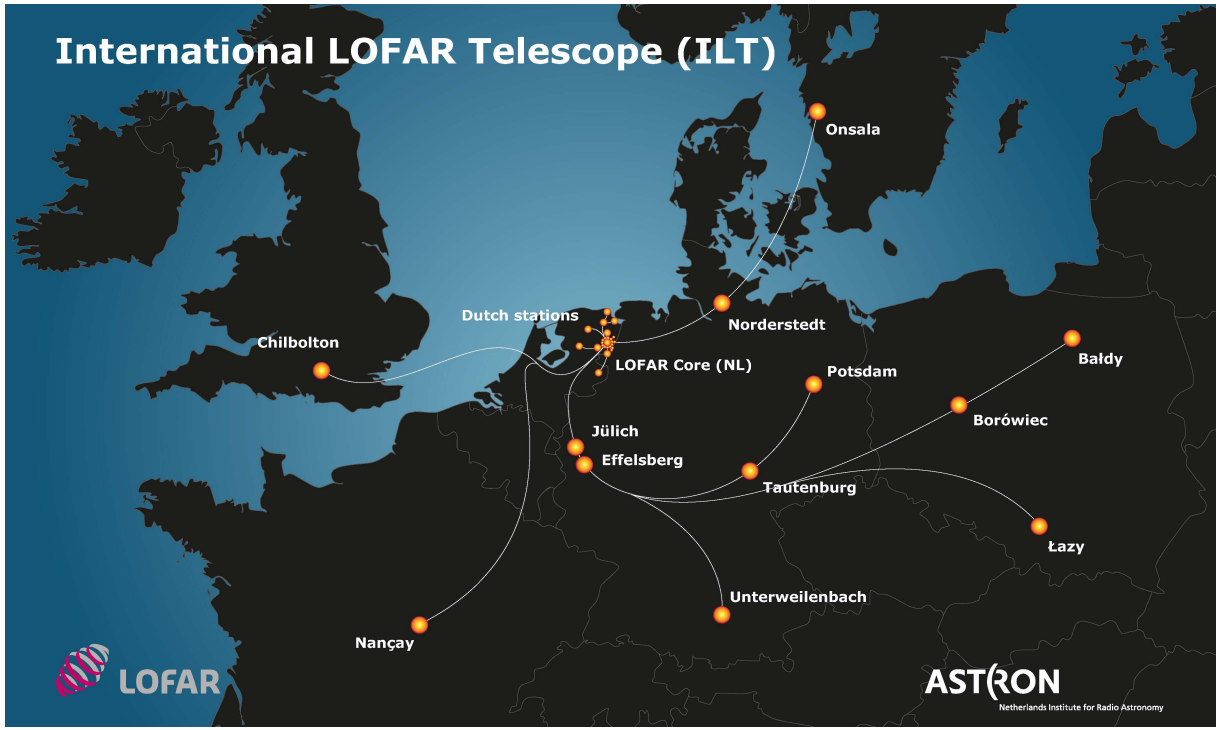
Aim

- Study of the local radio AGN population in the LoTSS DR1 radio survey using as a base the SDSS Main Galaxy Sample

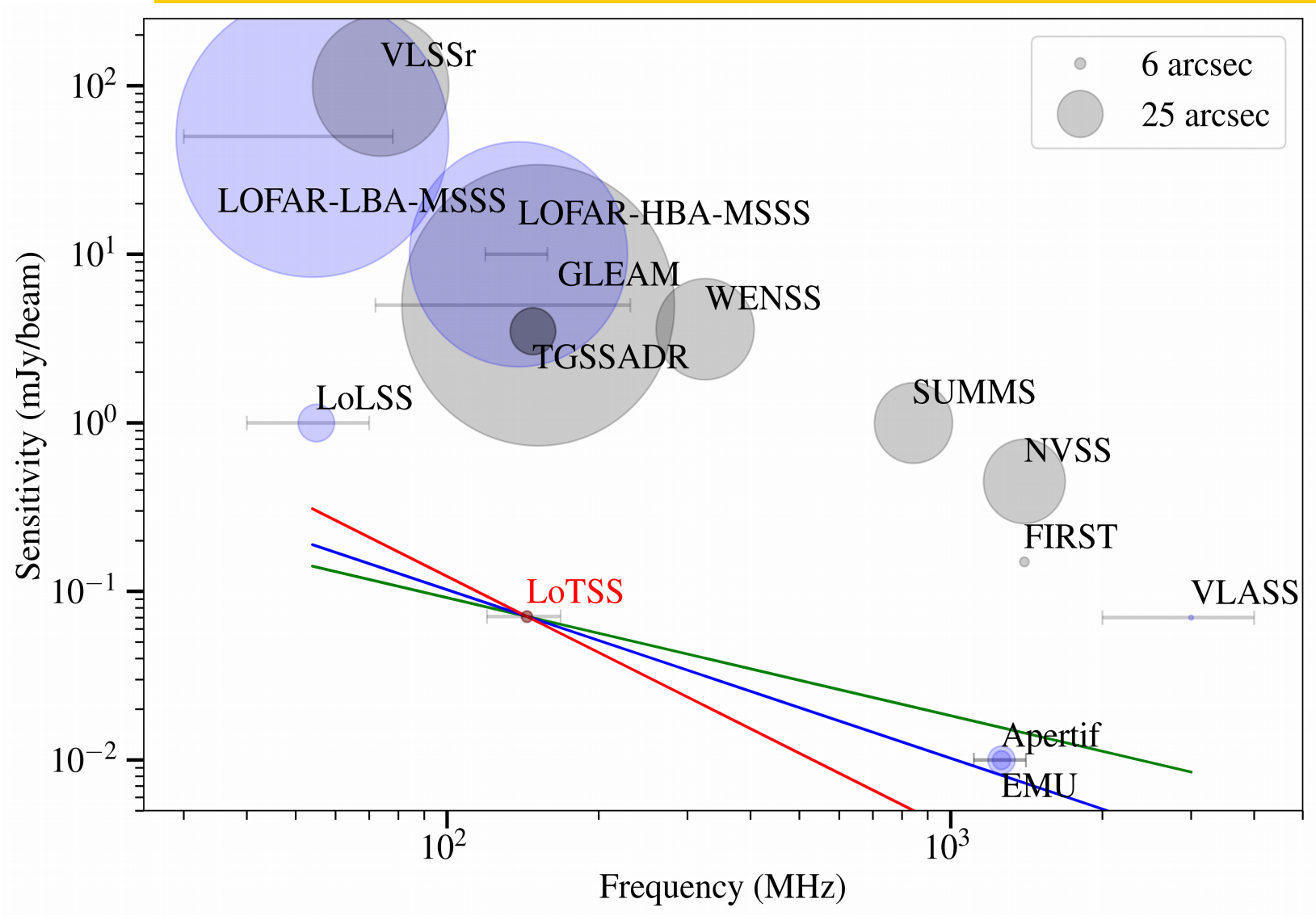


LoTTS DR1

- LOFAR Two-metre Sky Survey
  - 144 MHz (48 MHz bandwidth)
  - Northern hemisphere; 6 arsec. resolution
  - Data Release 1:
    - 424 sq. degrees (2% of the final coverage)
    - 325694 sources
    - 71 μJy/beam (median)
    - positional accuracy within 0.2 arcsec.

Special issue of Astronomy & Astrophysics in February

LoTSS DR1 compared



SDSS DR7 Main Galaxy Sample

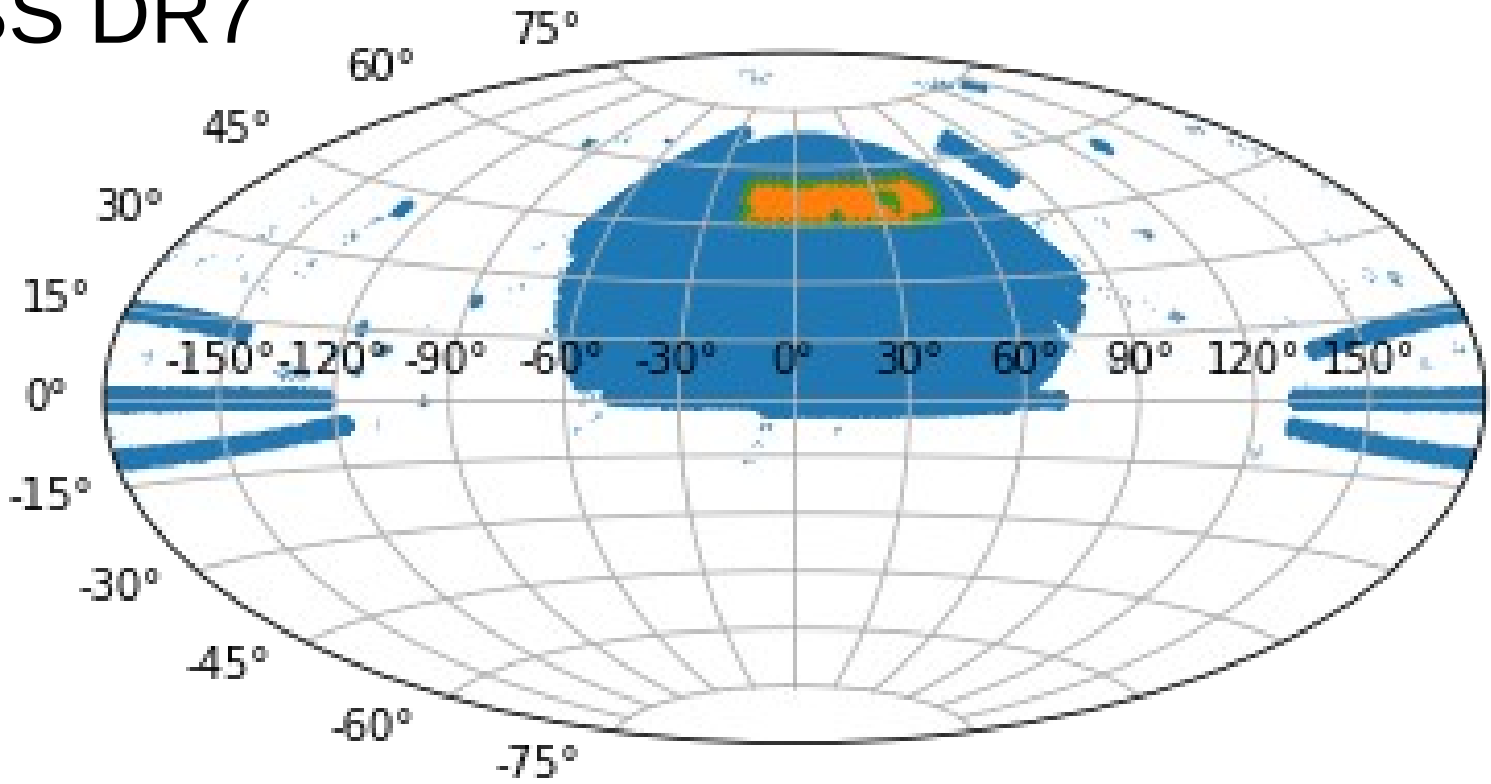
- Broadly complete for galaxies with r-band magnitudes between 17.77 and 14.5
- Use the additional data from the MPA-JHU catalogue → stellar mass, optical lines and AGN classification, SFR, etc.

Numbers

- Galaxies of the SDSS DR7 Main Galaxy Sample with r-band magnitudes between 17.77 and 14.5 in the LoTSS DR1 area (n=34709)
- Redshift between 0.01 and 0.3 (413 + 47 dropped)
- Discard galaxies with possible errors in the redshift (z warning flag set; 34 dropped)
- Discard duplicates (711 dropped)
- **Total: 33504 galaxies**

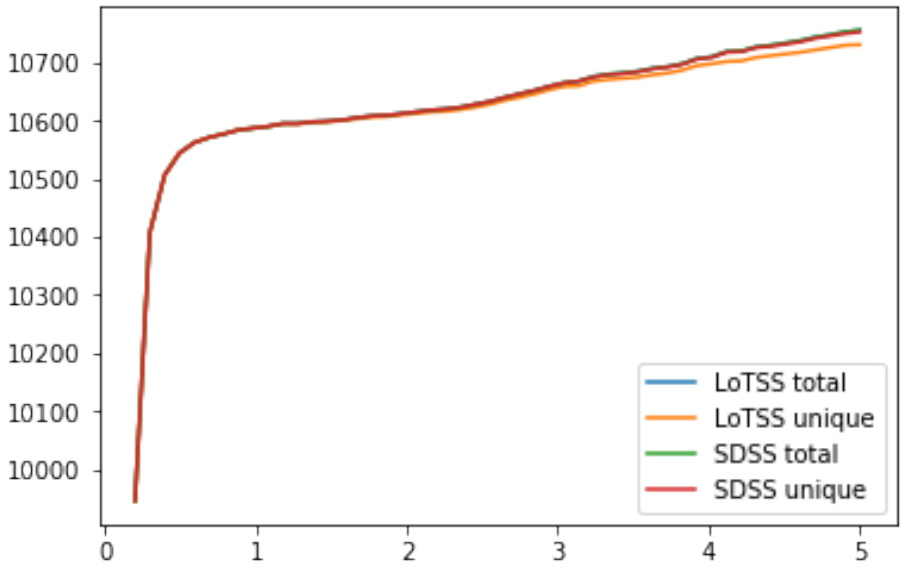
Cross-match

- Coverage of the SDSS DR7



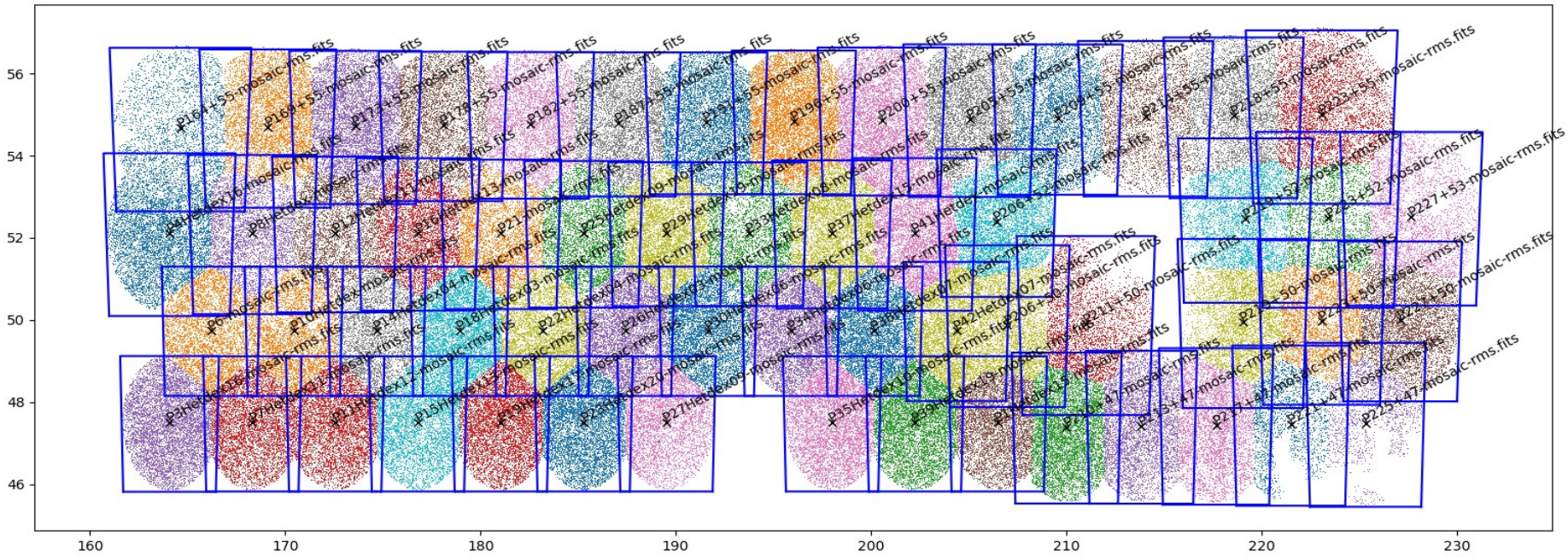
Cross-match

- > ~1" to get all the genuine counterparts
- < 2.4" to avoid the random matches regime
- Final choice of 2" → **10615** SDSS galaxies with LoTSS DR1 counterparts (32%)



Noise for non-detections

- LoTSS DR1 images
- Determine the exact correspondence between positions and images



Luminosity limits

- If no source is cross-matched extract the rms noise on the position to get an estimate of the luminosity limit
- Estimate of the area in which the source would be visible

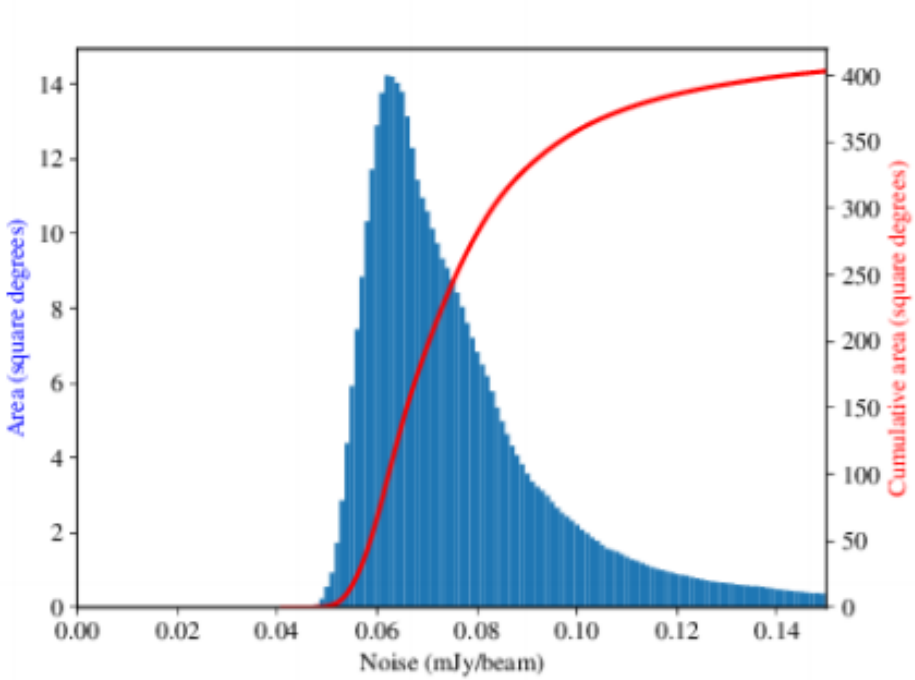
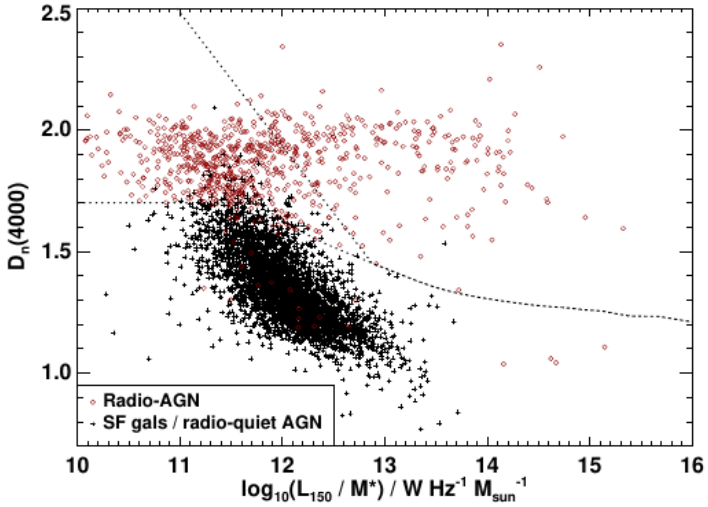


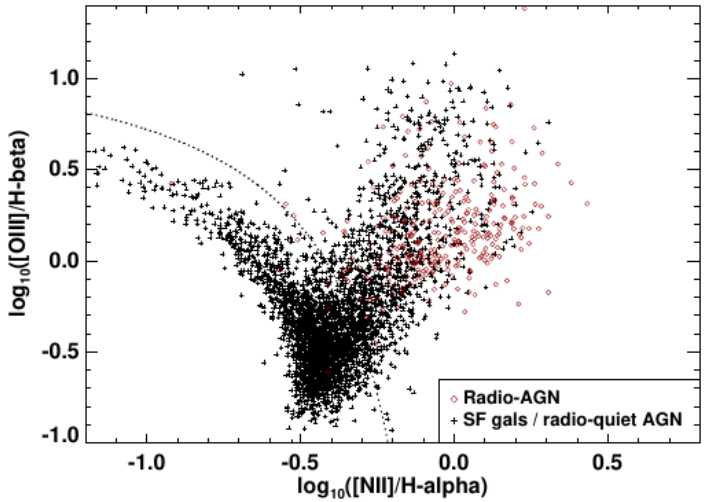
Fig. 12 Shimwell et al. 2019

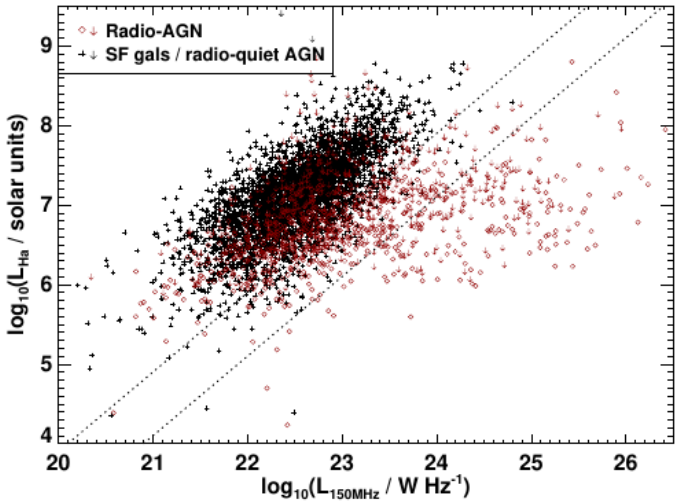
Radio AGN classification

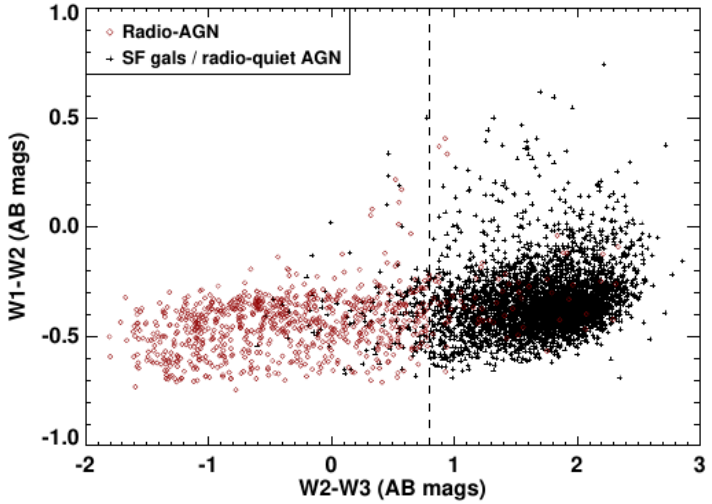
- Combines 4 diagnostic diagrams to obtain a classification:
  - D_{4000} vs. L_{150MHz}/M^*
  - $L_{H\alpha}$ vs. L_{150MHz}
  - BPT [NII]
  - WISE colour (W2-W3)

Radio AGN classification





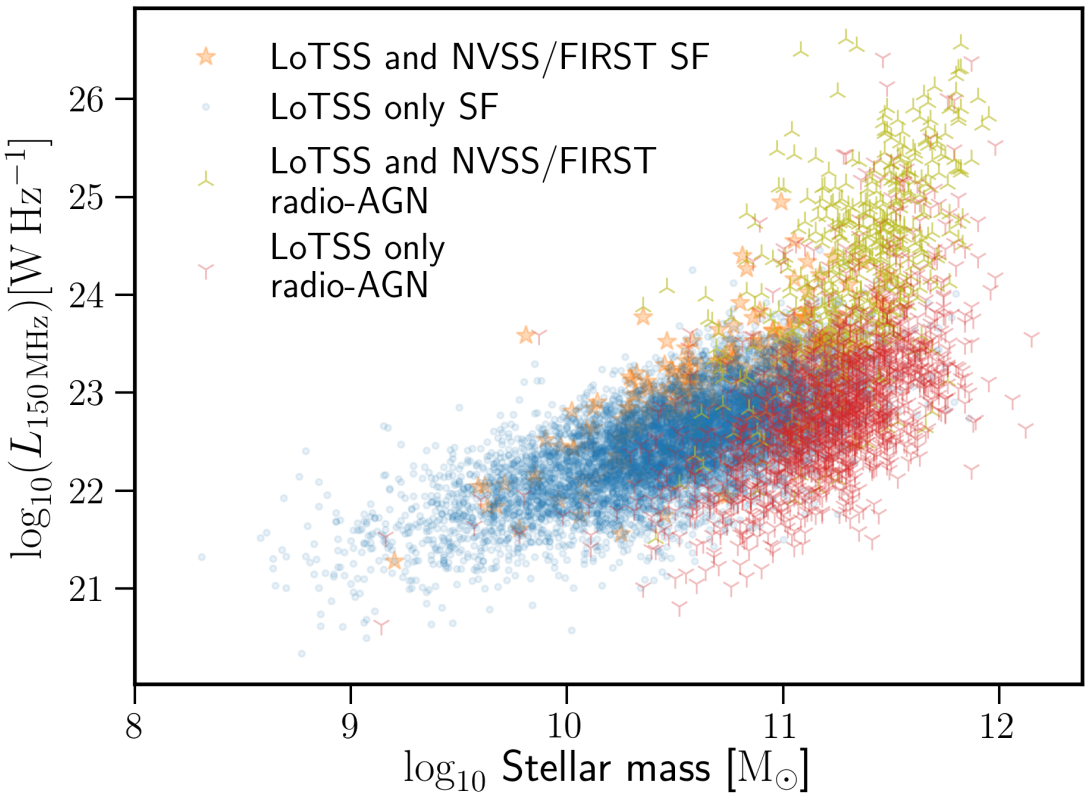




Radio AGN classification

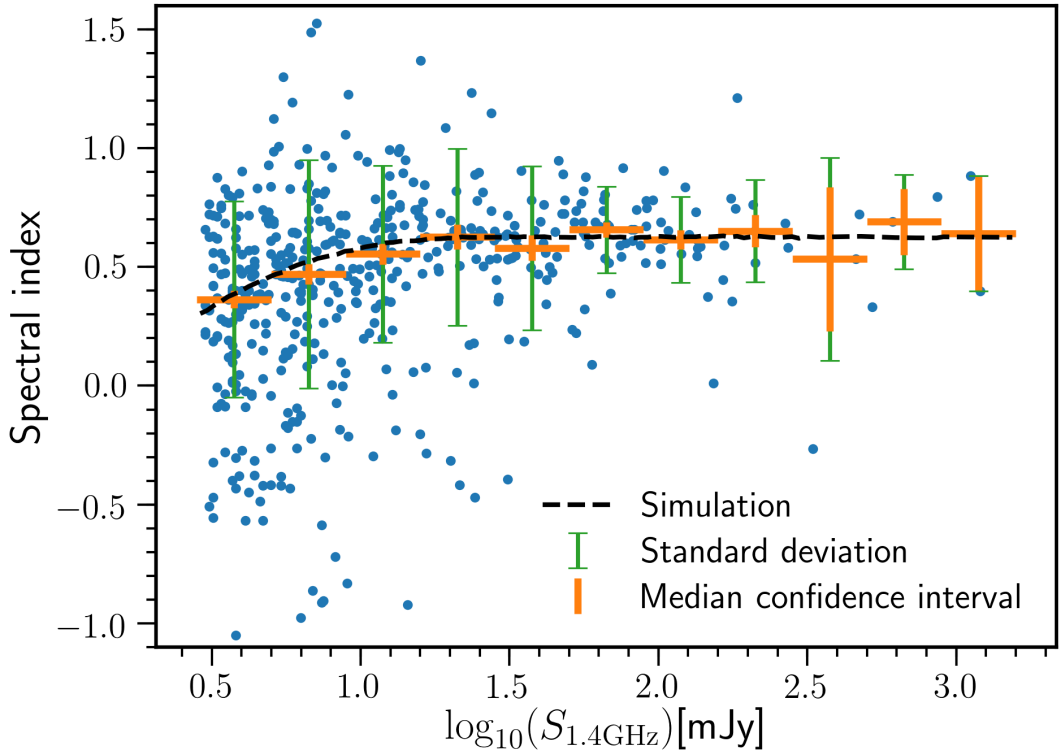
- **2121** galaxies classified as radio AGN

Distribution of stellar masses and luminosities



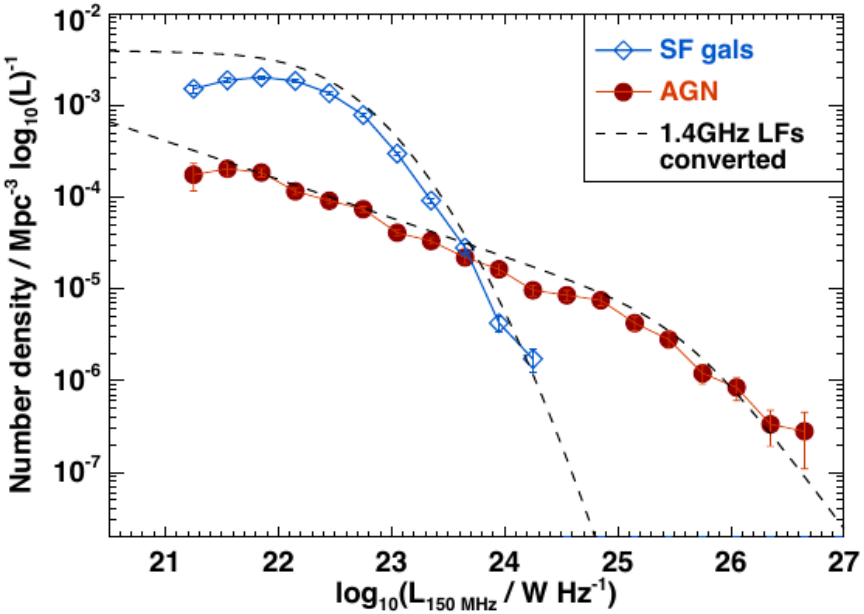
Spectral index

- For $S_{1.4\ GHz}$ > 20 mJy → 0.63
- Flatter or inverted spectrum population at low luminosities? Simulation of incompleteness:
  - Results compatible with incompleteness

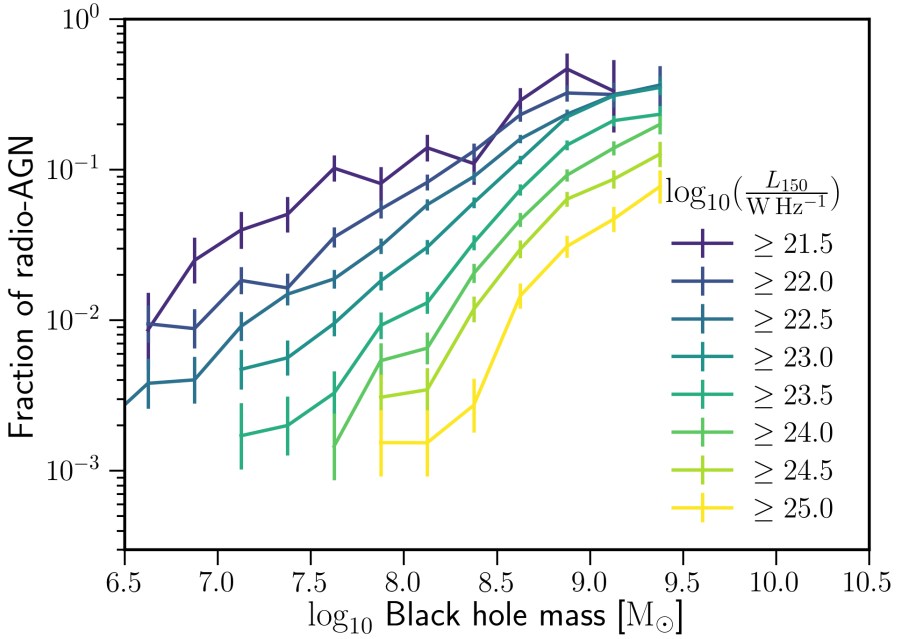


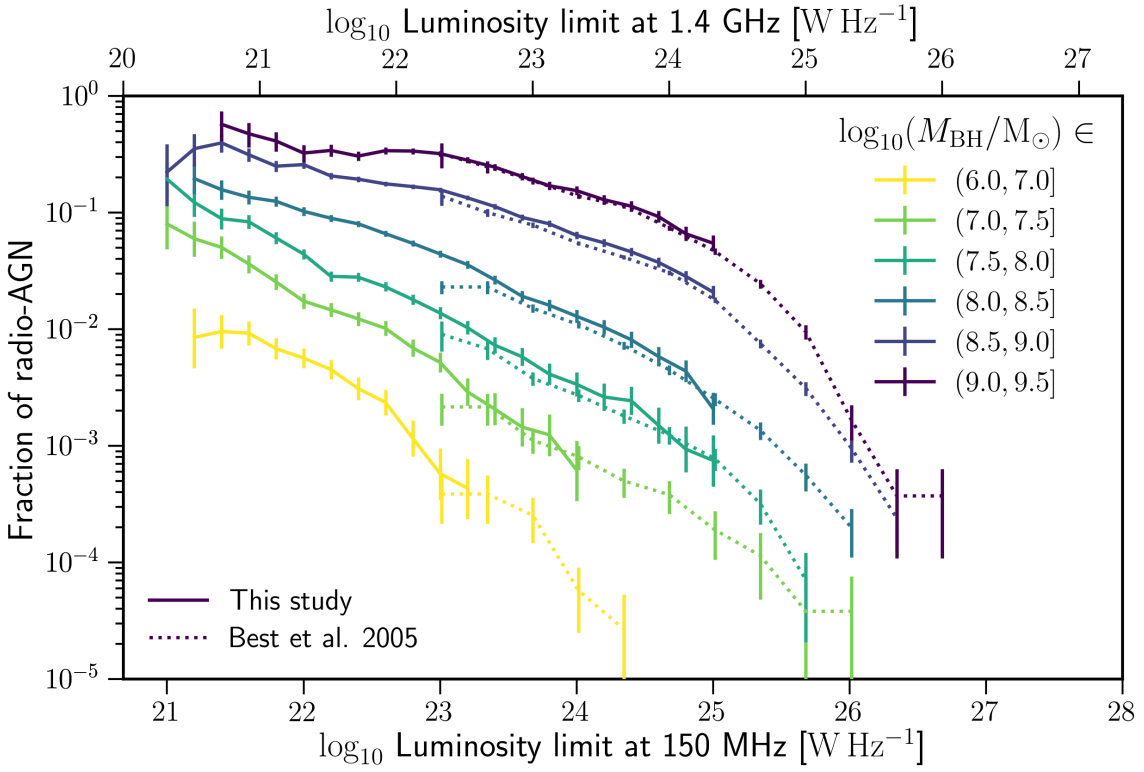
Luminosity functions

- “Canonical” spectral index of 0.7 but 0.63 gives a better fit
- Good fit to Heckman and Best 2014 radio AGN luminosity function (but deeper)
- Suggests that the separation method is robust

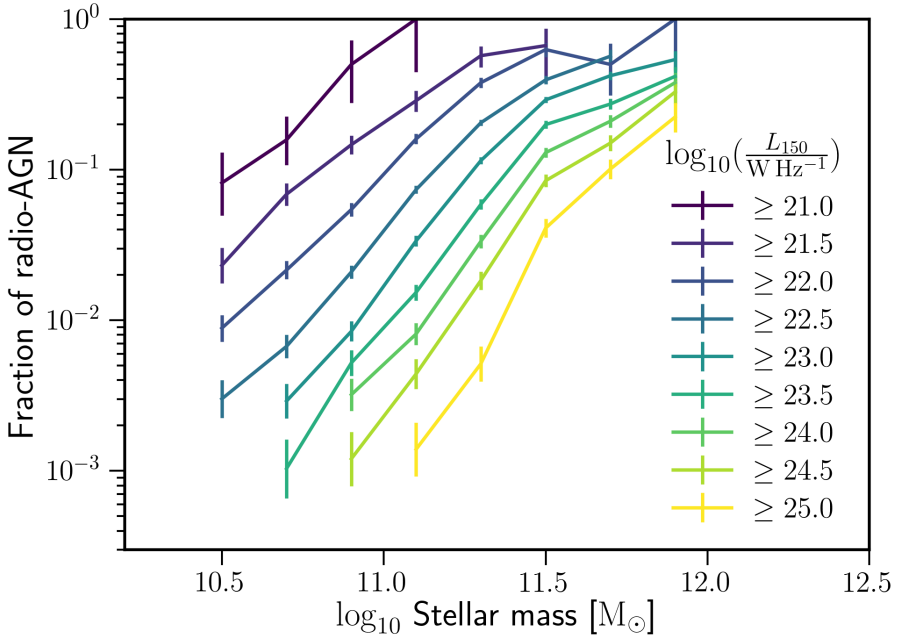


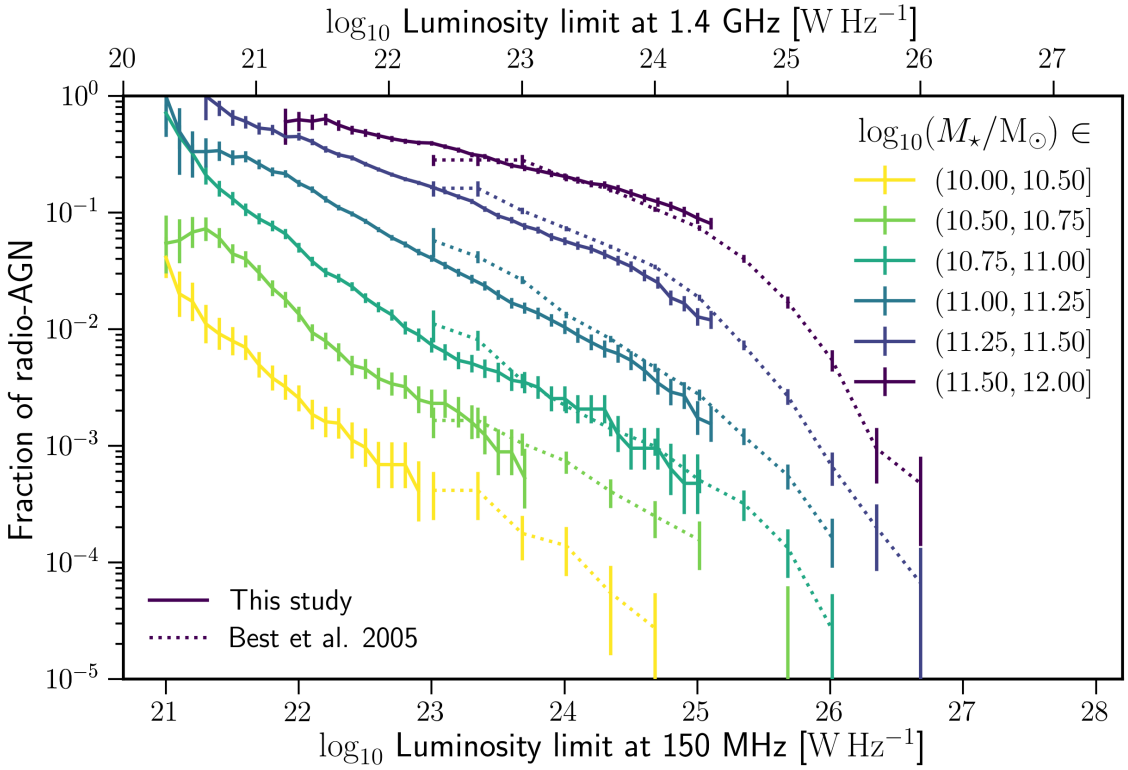
Fraction of radio AGN black hole mass



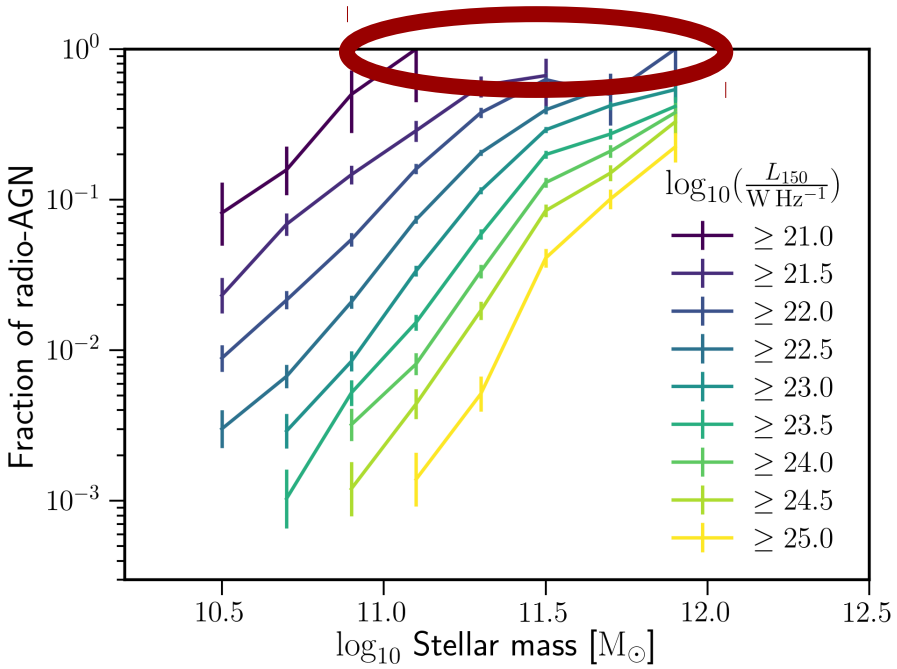


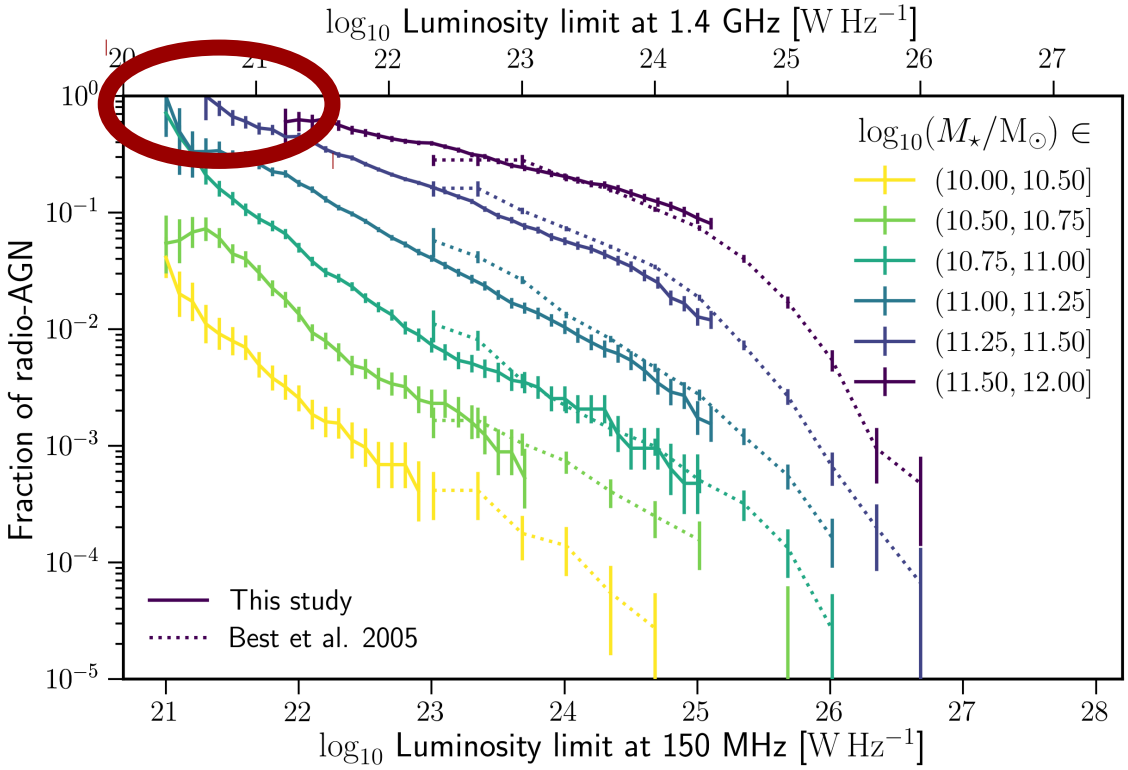
Fraction of radio AGN stellar mass



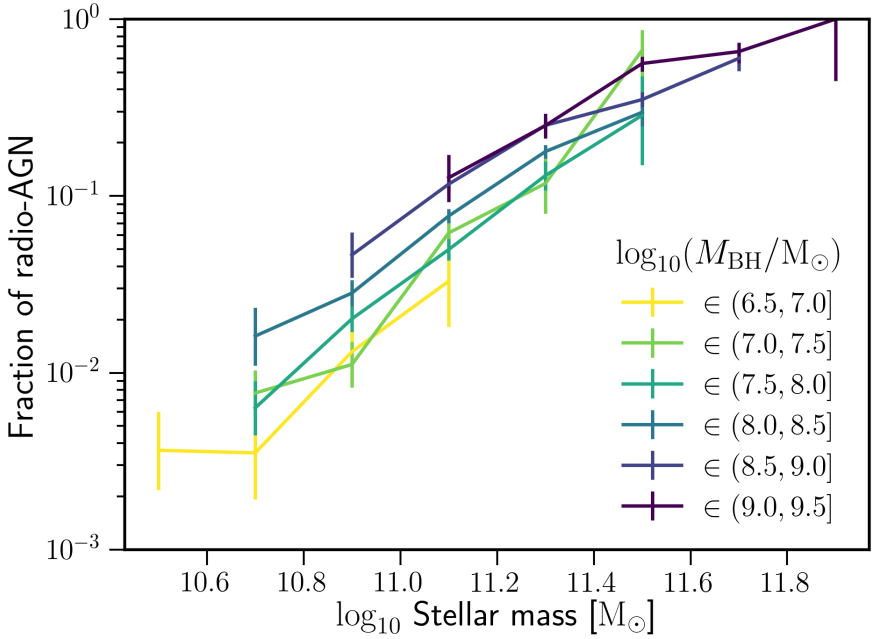


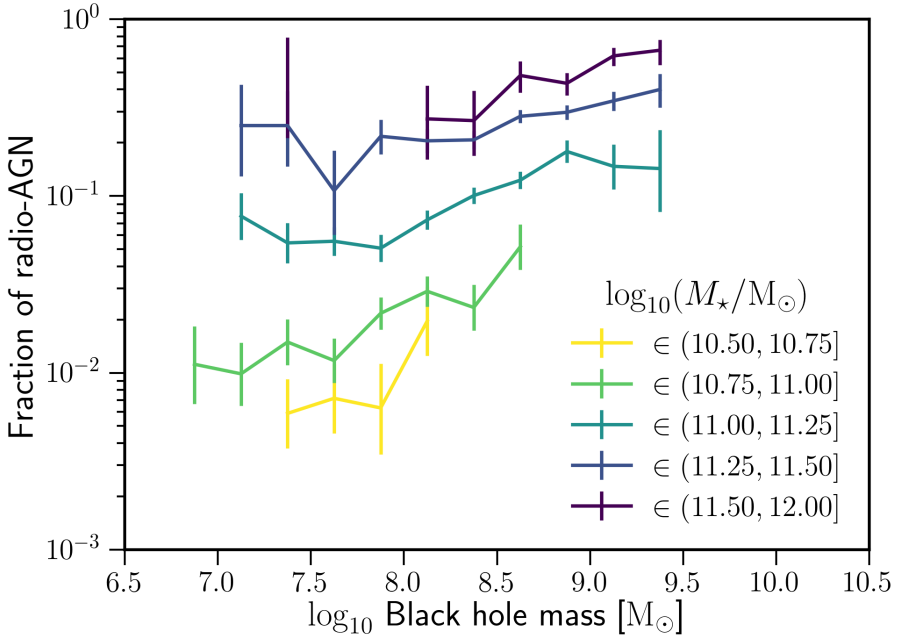
Fraction of radio AGN stellar mass





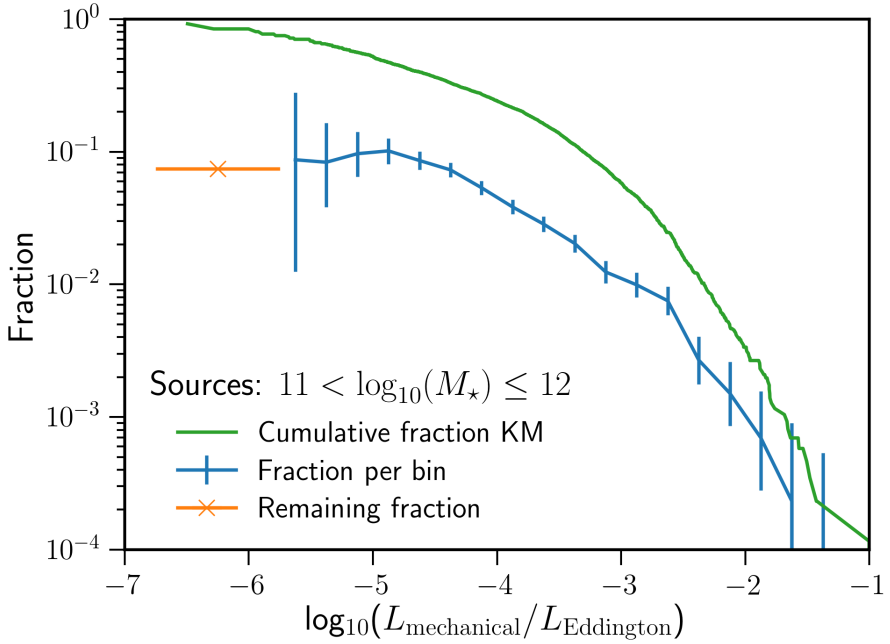
Stellar mass or black hole mass as main driver of radio AGN?





Eddington-scaled accretion rates

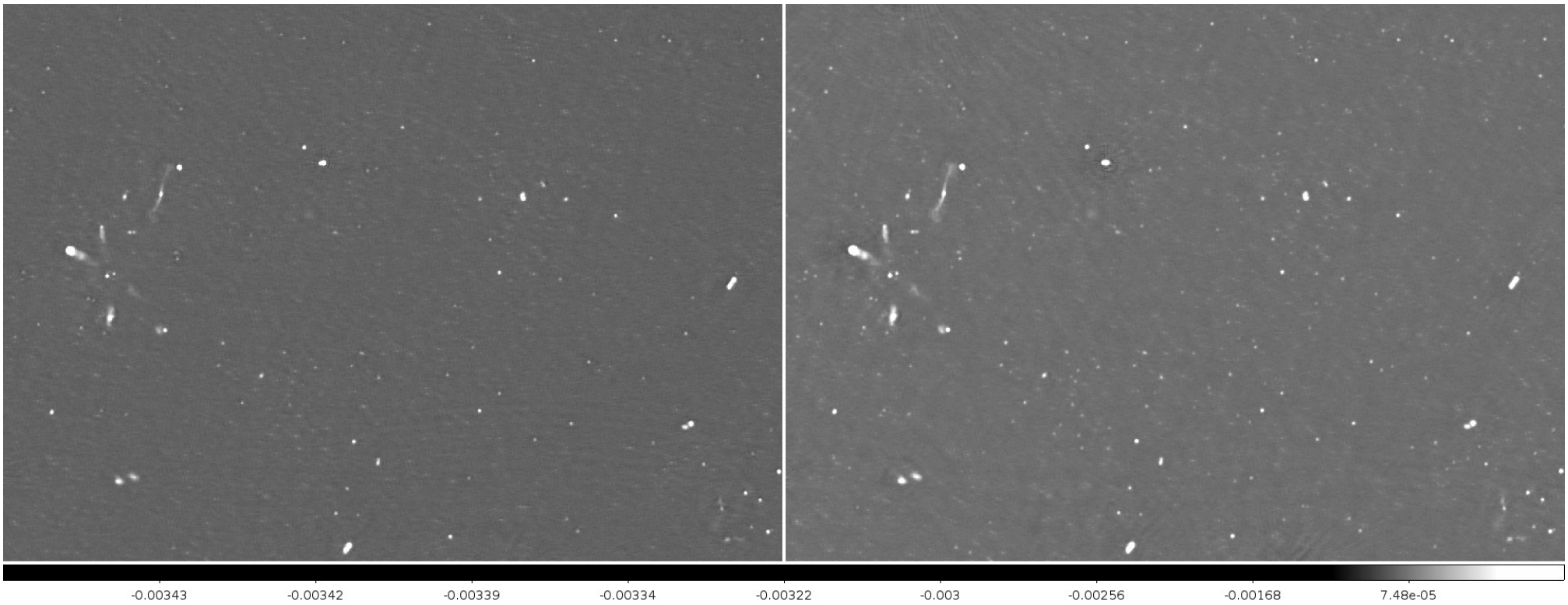
- Kaplan-Meier estimator
- Probe the full range of accretion rates* for the most massive galaxies
- 50% of the energy released during the <2% of time spent at the higher accretion rates



Future: deep field ELAIS-N1

4 datasets

10 datasets



~35 sq. degrees
multiwavelength data

24 to 30 μJy/beam
~50000 sources

see talk of Rohit Kondapally tomorrow

Summary

- LoTSS DR1 region: 33504 SDSS galaxies → 10615 radio detected → 2121 radio AGN
- Median spectral index of 0.63 ($S_{1.4\ GHz}$ > 20 mJy)
- Fraction of galaxies hosting a radio AGN depends strongly on mass
- The stellar mass is a stronger driver factor than the black hole mass → related to gas properties that trigger the radio activity
- 100% of the massive galaxies ($M^* > 10^{11}\ M_{Sun}$) host radio AGN when $L_{150MHz} > 10^{21}$ W Hz^{-1} → Always switched on at least at some level.
- Probe full range of Eddington scaled accretion rates for massive galaxies. More than half of the energy is released in the <2% of the time spent at the higher accretion rates.