Radio AGN in the Local Universe

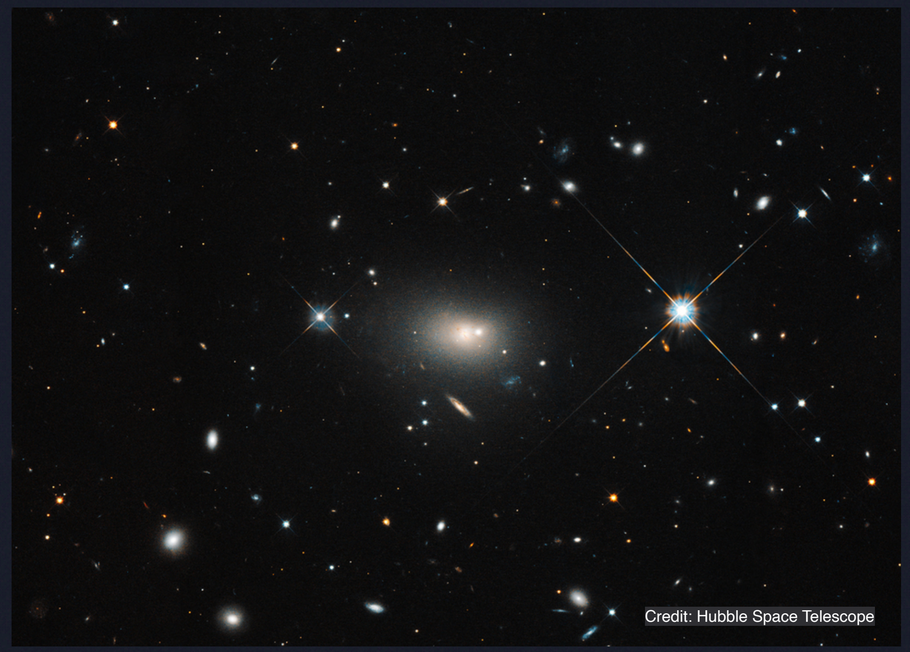
The role of galaxy properties and environmental factors on radio AGN prevalence

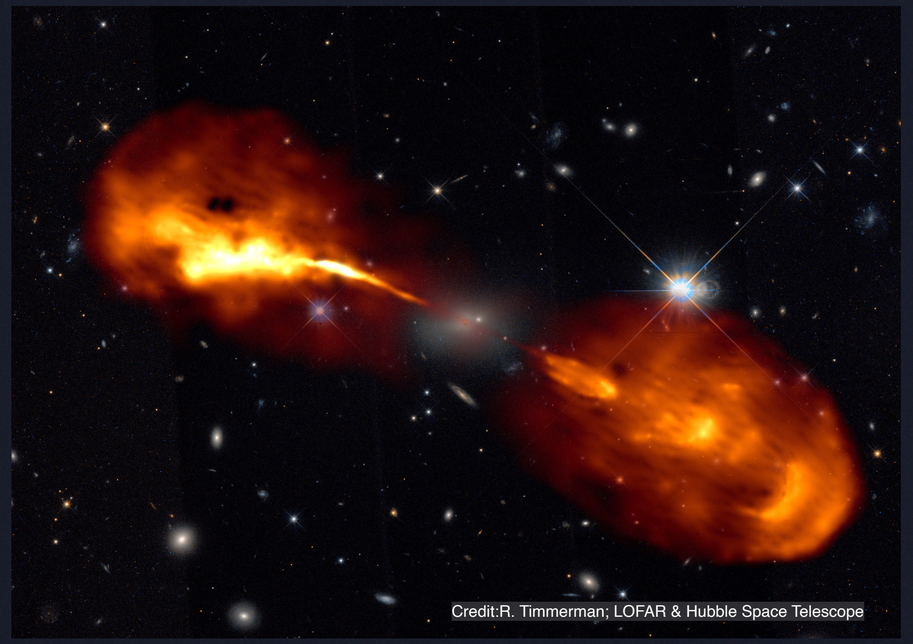
LOTSS DR2 DR7

Lara Alegre, LOFAR Family Meeting, Paris, 22nd September 2025

What drives radio AGN?

An elliptical galaxy listed in optical catalogues…





Hercules A, 3C 348, a powerful radio source!

Contents

Background

Best et al. 2005
Sabater et al. 2019

And others before…

Data

Hardcastle et al. 2024
Mendel et al. 2014
Sabater et al. 2013
Best and Heckman, 2012
Lintott et al. 2008

Methods

Sabater et al. 2019
Alegre et al. 2024
Drake et al. 2025

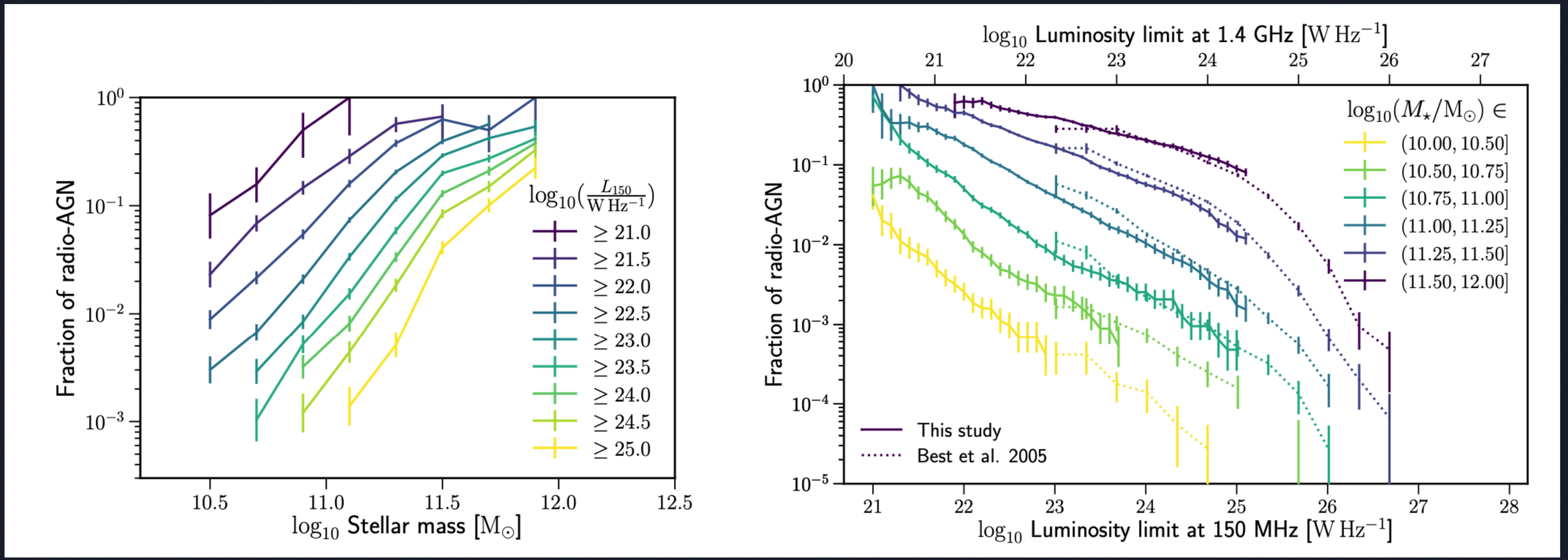
Results

Alegre et al. in prep

Background

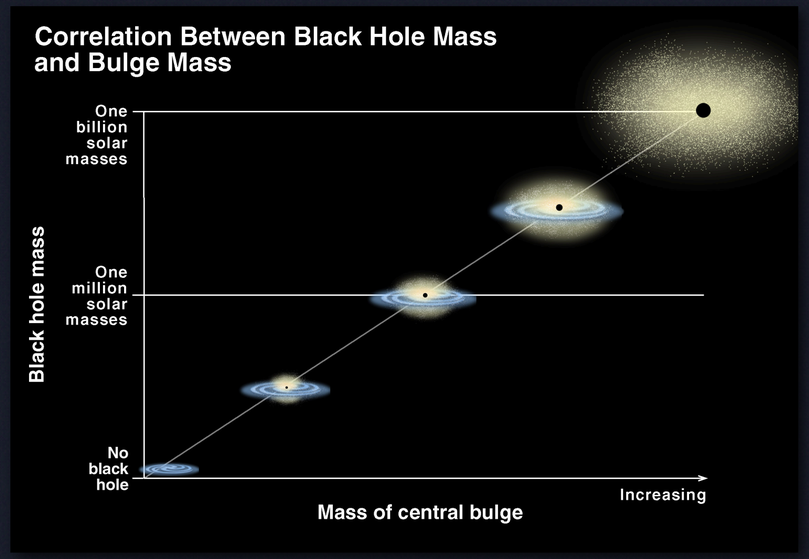
“The most massive galaxies are always switched on”

Sabater et al. 2019, The LoTSS view of radio AGN in the local Universe - LoTSS DR1



Radio AGN activity is strongly driven by stellar mass!

Data

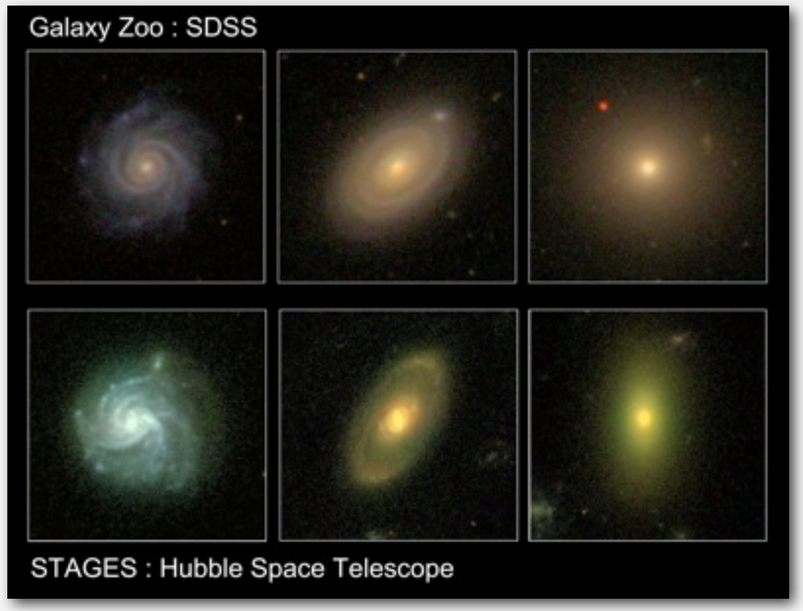


DR7

STELLAR MASS - BLACK HOLE MASS - BULGE MASS

- Star formation rates, Stellar Mass, Black Hole mass, Best and Heckman 2012
- Bulge/disc decomposition, Mendel et al. 2014

MORPHOLOGY ▶ Spirals, Ellipticals, Lintott et al. 2008



ENVIRONMENT ▶ Density, PCA1, PCA 2, Sabater et al. 2013

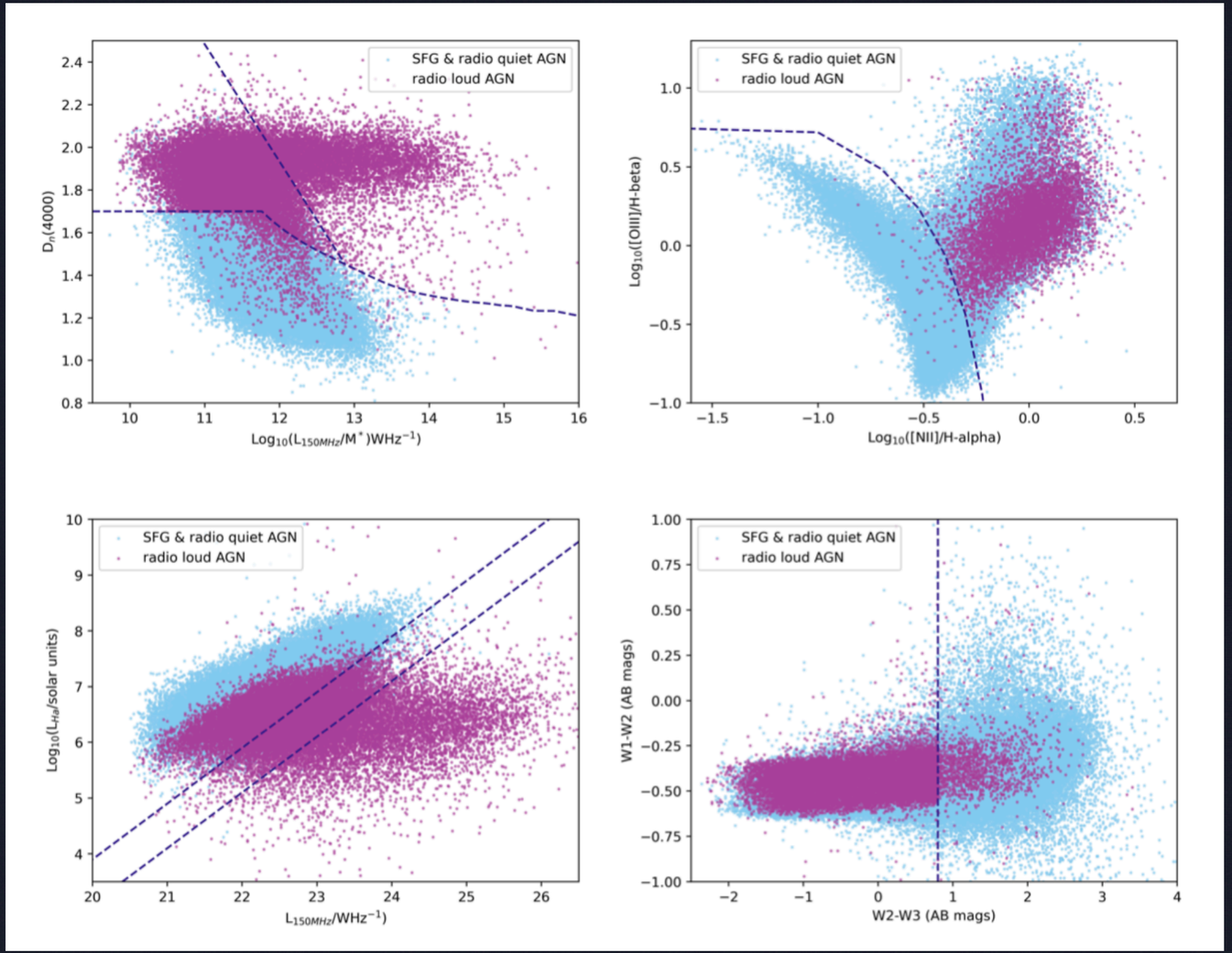
ESA/Hubble

Isolated Galaxies
Bluer colors
Spiral morphology
Star forming

Galaxies in groups/clusters
Redder colors
Elliptical morphology
Quenched

AGN vs SF

Sabater et al. 2019 method

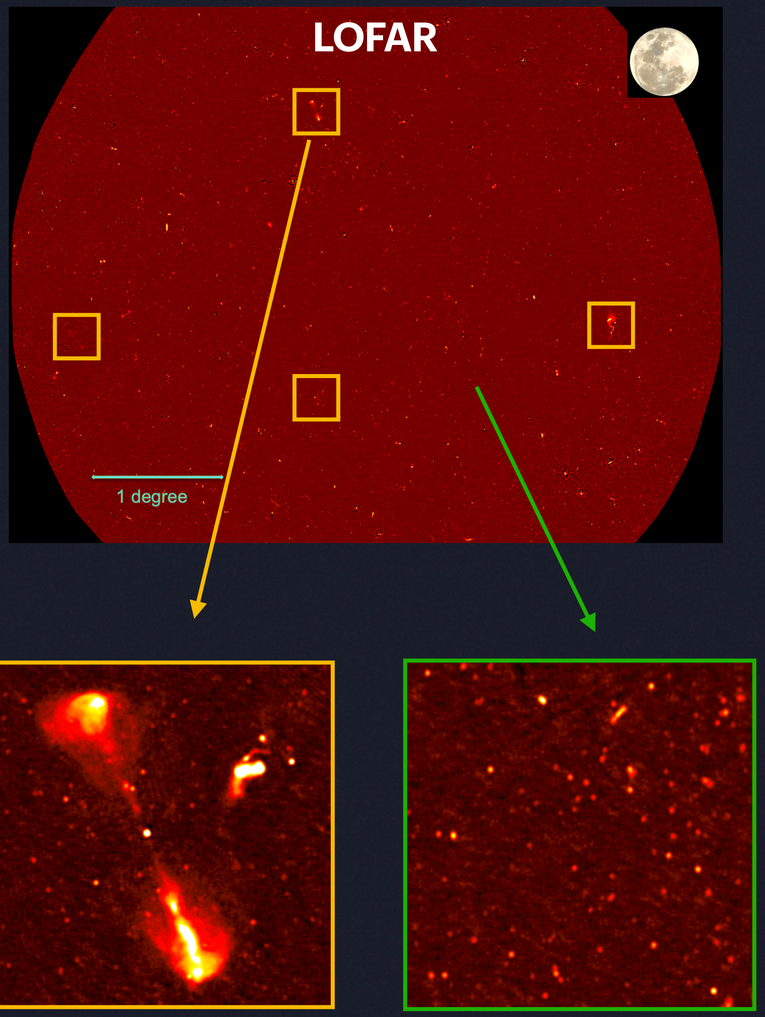


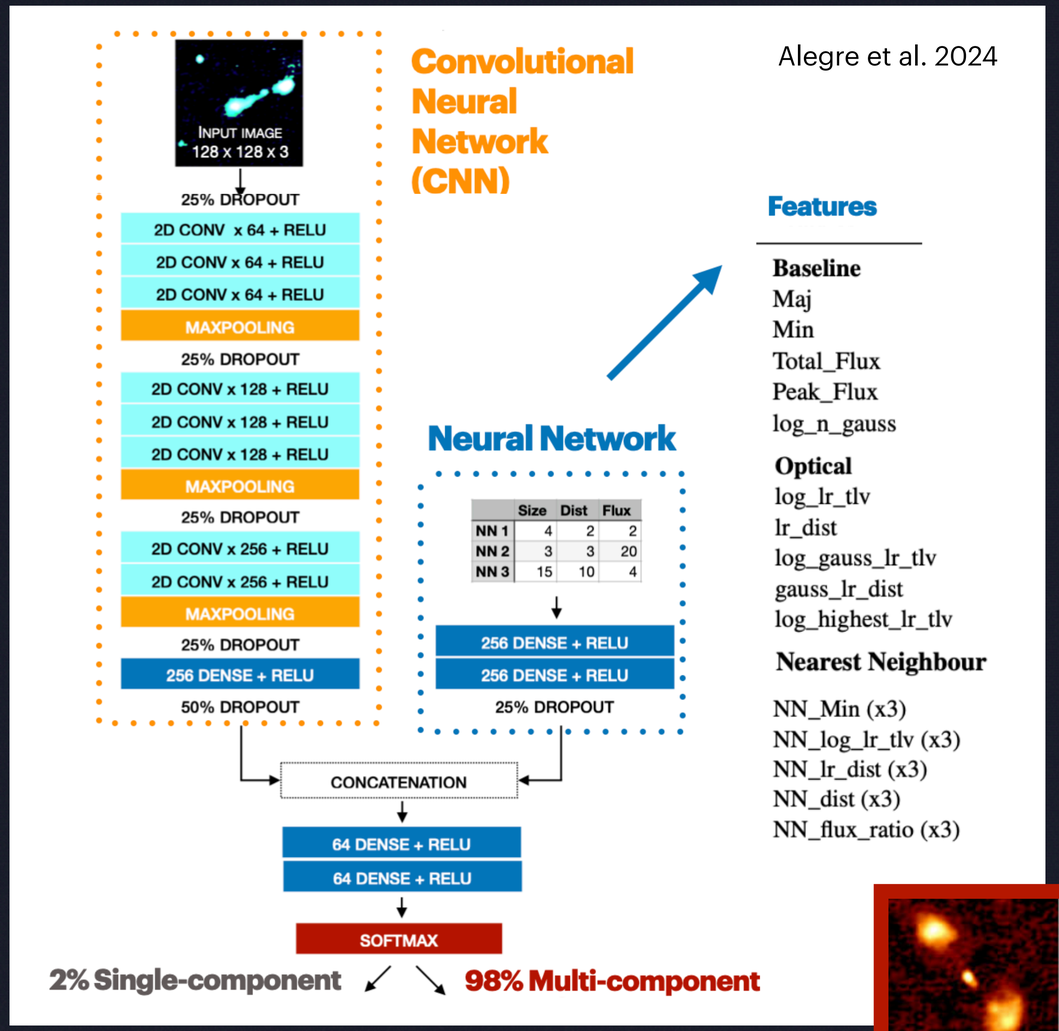
Final sample: 26,562 AGNS (vs 2,121 AGNs in Sabater et al. 2019)

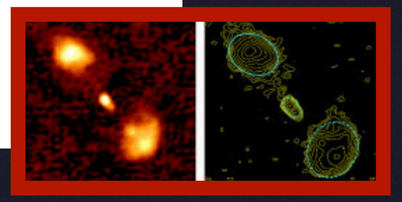
Machine Learning

LOFAR TWO-METRE SKY SURVEY LoTSS DR2

FLUX < 4MJY

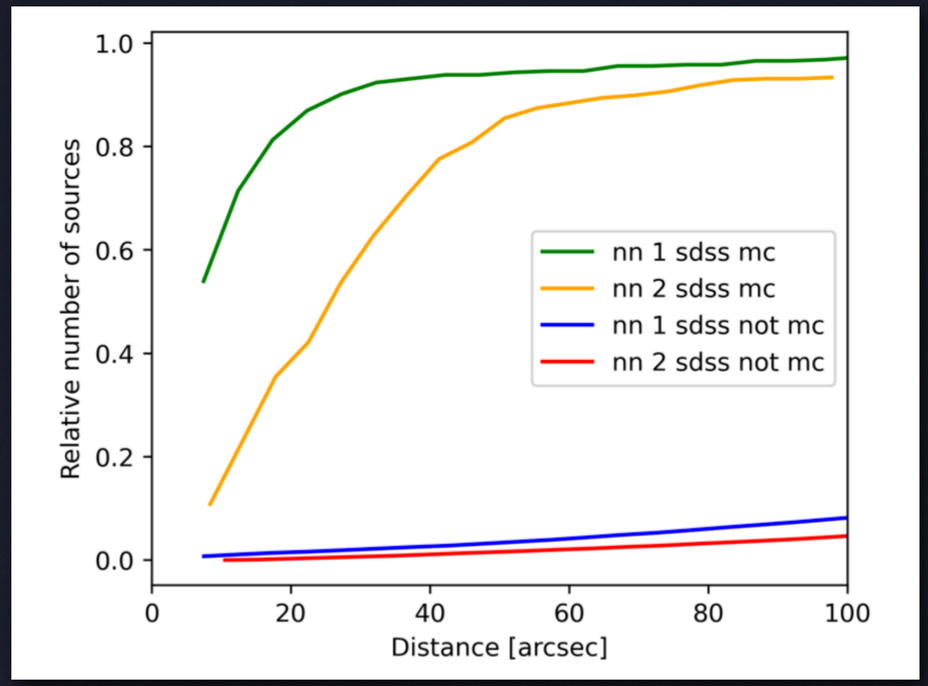




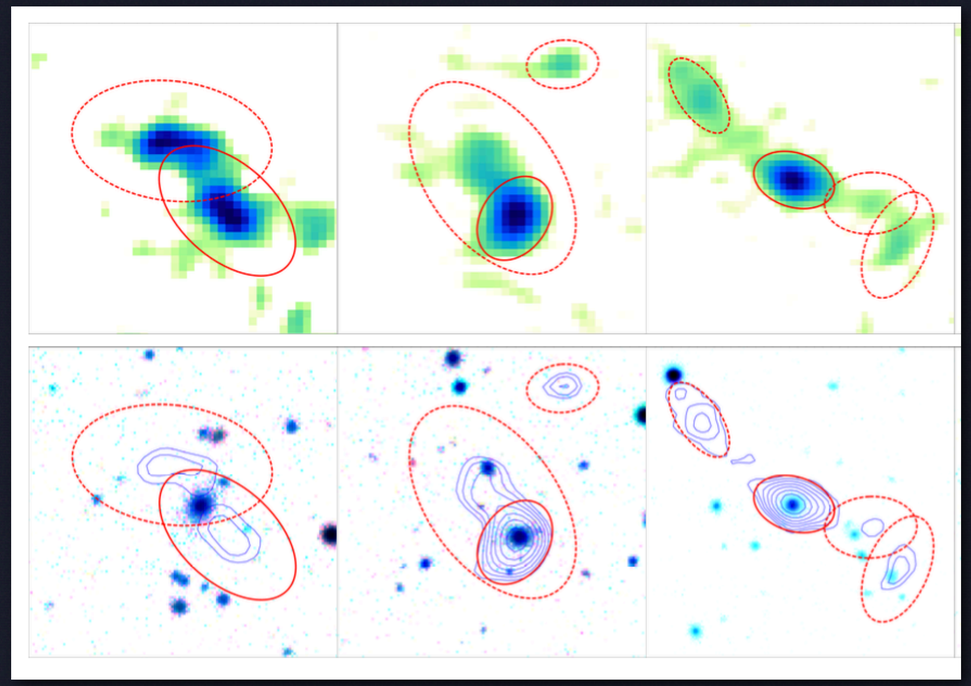


Machine Learning

SDSS & NEAREST NEIGHBOURS (NN)

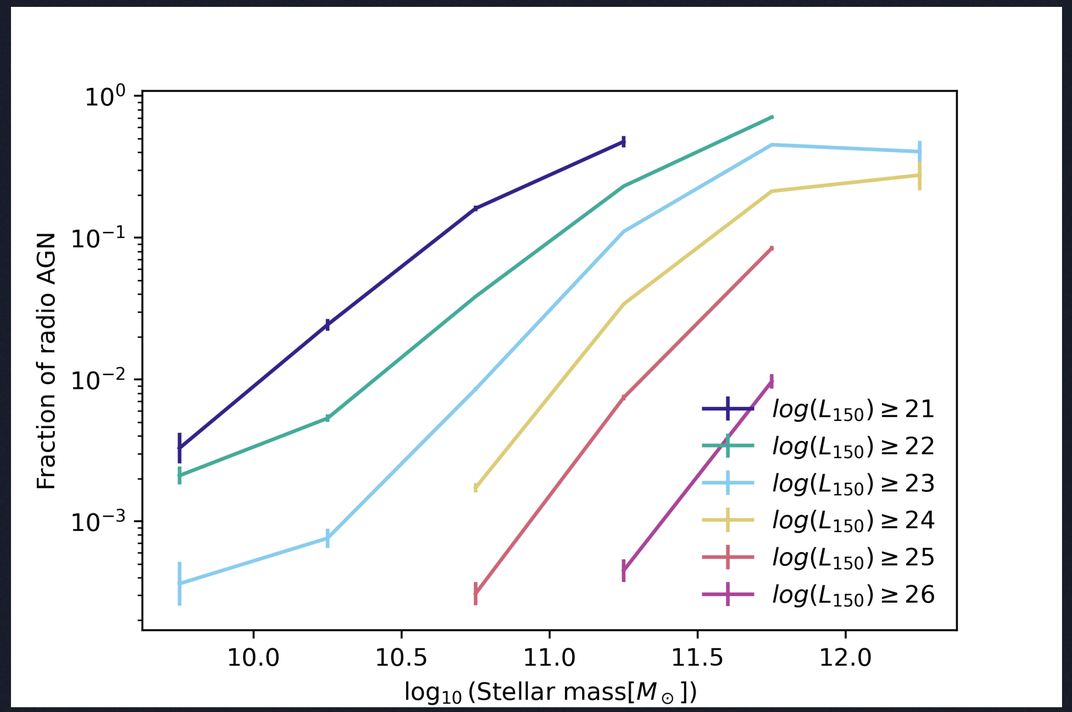


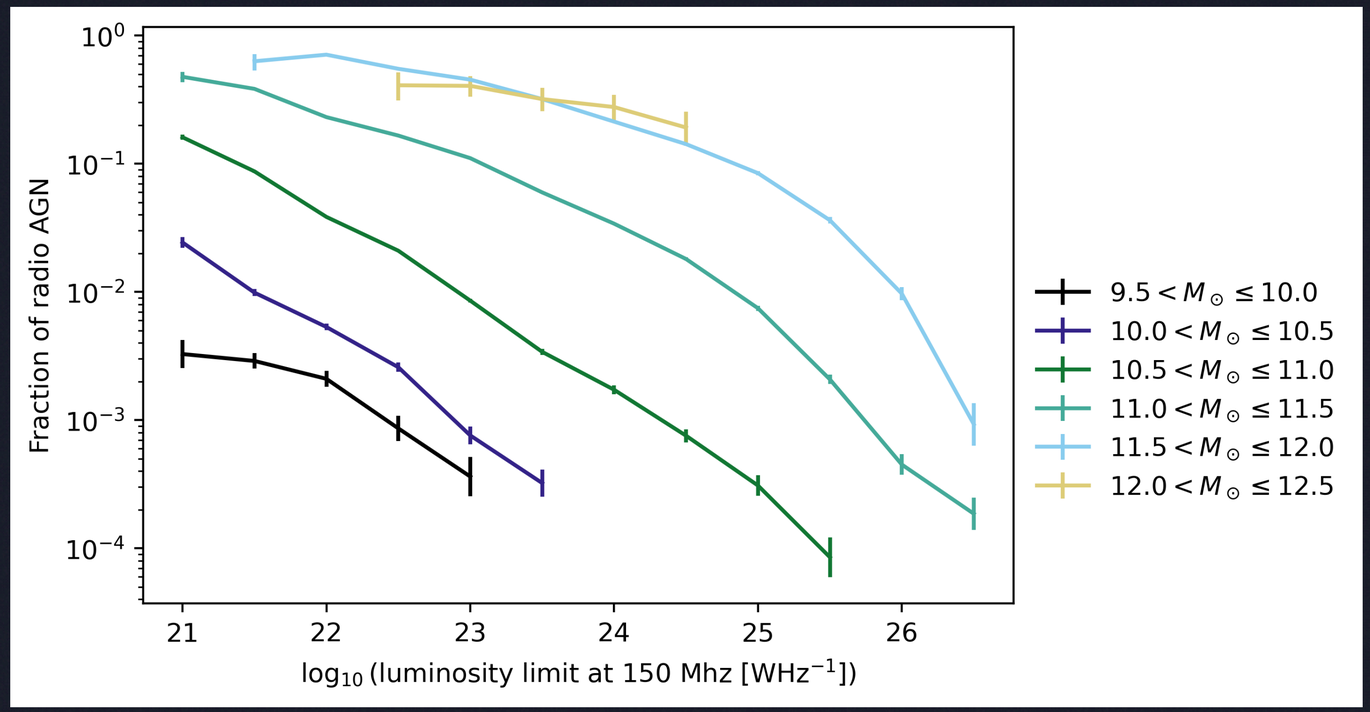
MULTI-COMPONENT (MC) SOURCES



Results

Radio AGN in the local Universe LoTSS DR2 - Stellar Mass



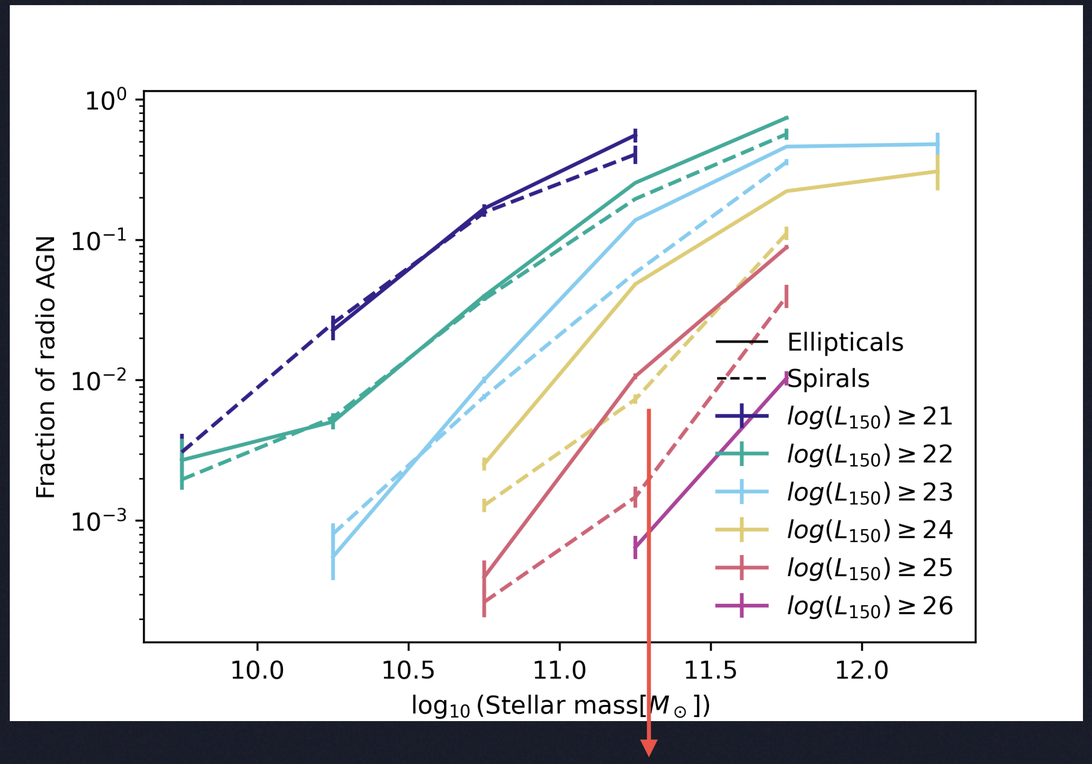


Stellar masses from Heckman and Best, 2012

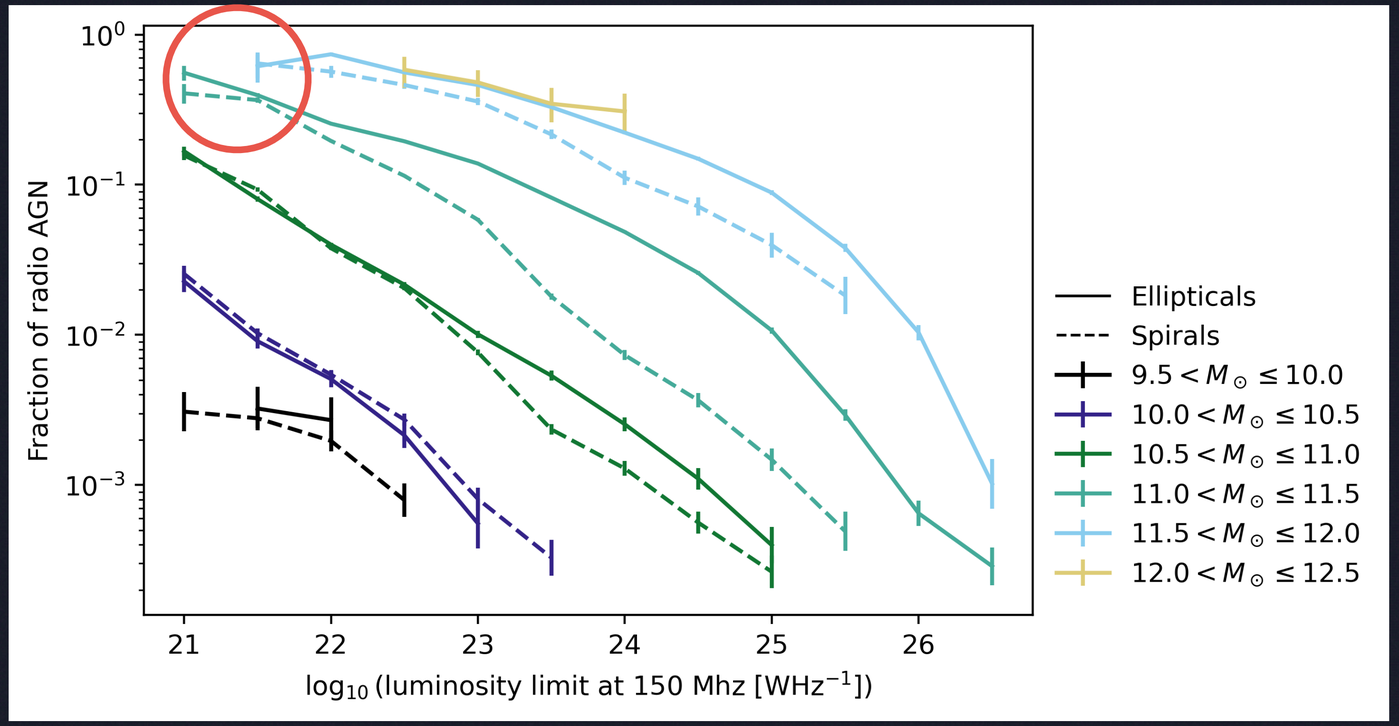
SIMILAR RESULTS BLACK HOLE MASS - BULGE MASS

Radio AGN in the local Universe LoTSS DR2 - Spirals vs Ellipticals

Both high mass spirals and ellipticals host radio AGNs

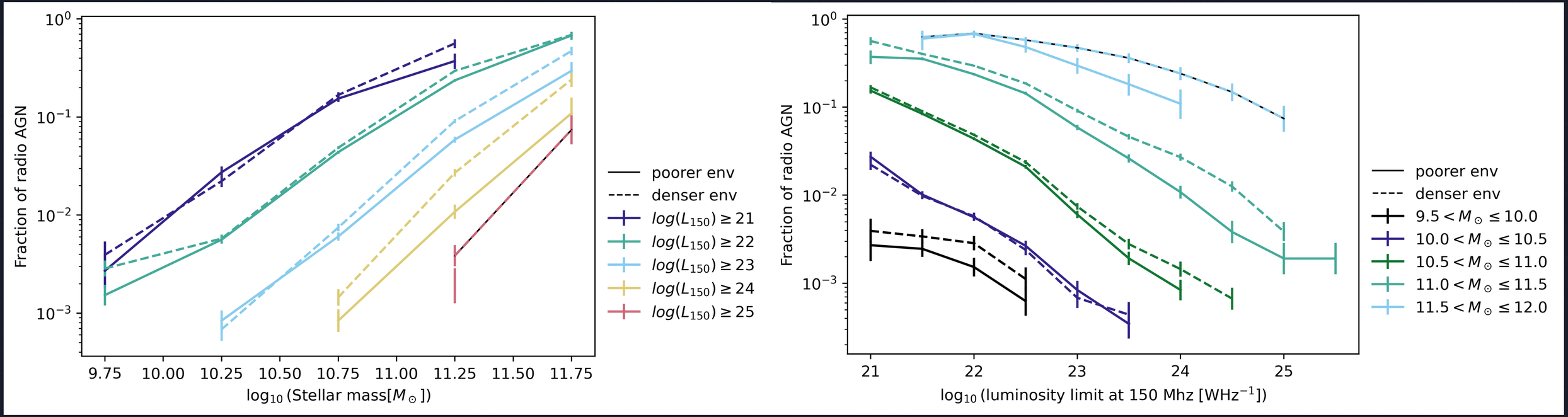


Major differences at higher passes and luminosities



Galaxy morphology from the Galaxy zoo, Lintott et al., 2008

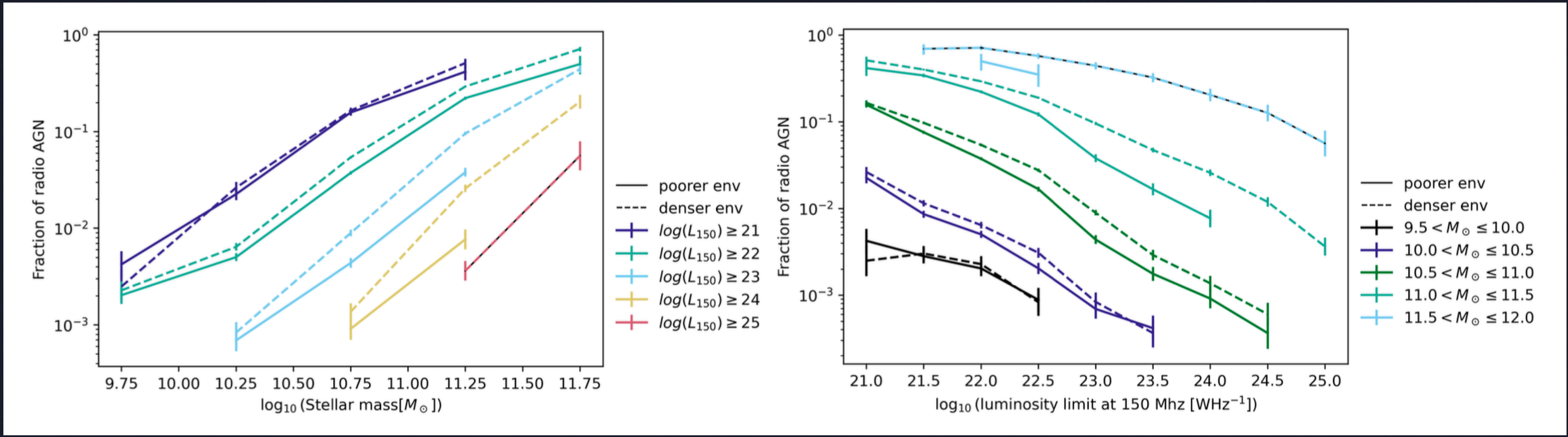
Radio AGN in the local Universe LoTSS DR2 - local density



Density: Measures the number of nearby galaxies; traces the overall local environment of a galaxy

Local density parameter from Sabater et al. 2013, distance to the 10th nearest neighbour (e.g Dressler, 1980)

Radio AGN in the local Universe LoTSS DR2 - PCA1

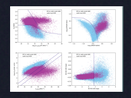


PCA1: correlates with large-scale environment; reflects clustering and group/cluster richness

Parameter from Sabater et al. 2013; weighted combination of density, tidal forces, and cluster richness

AGN vs SF (Drake et al. 2025)

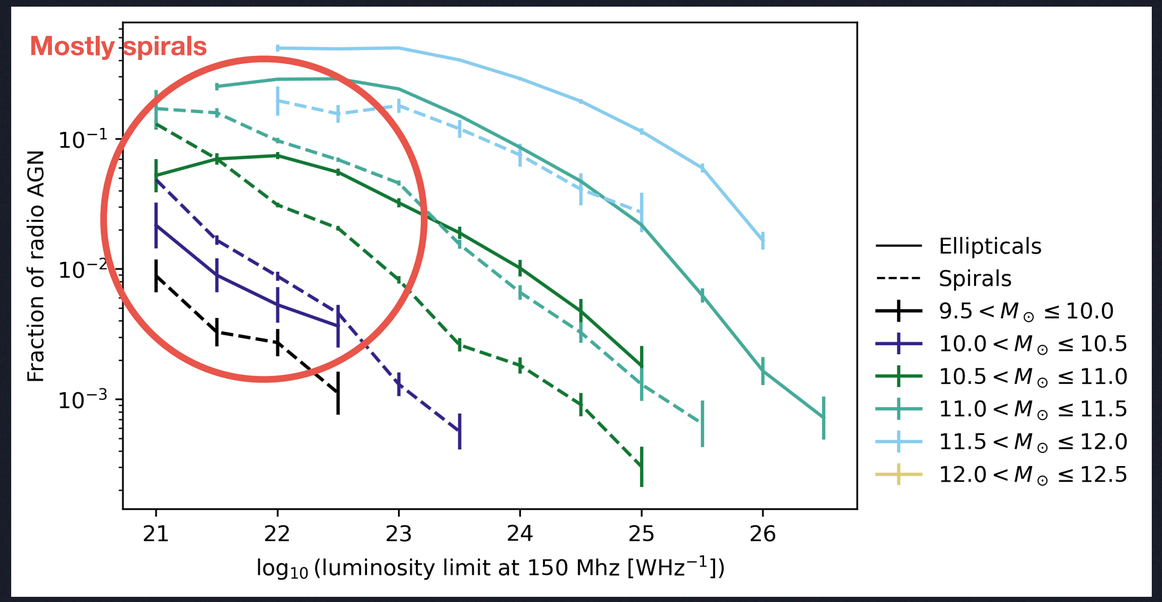
26,562



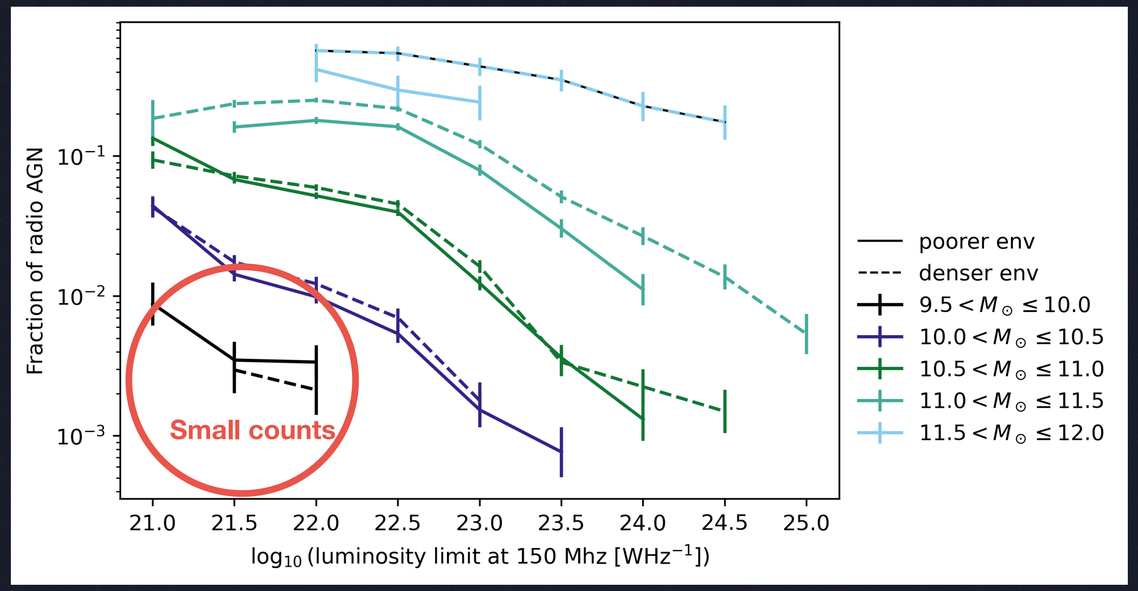
6,292

"RADIO_EXCESS">0.95

MORPHOLOGY

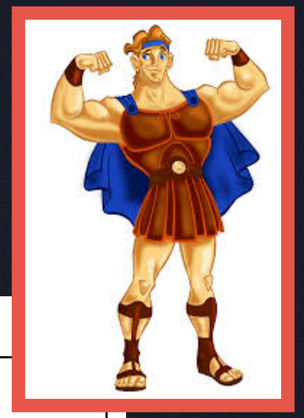


ENVIRONMENT - DENSITY

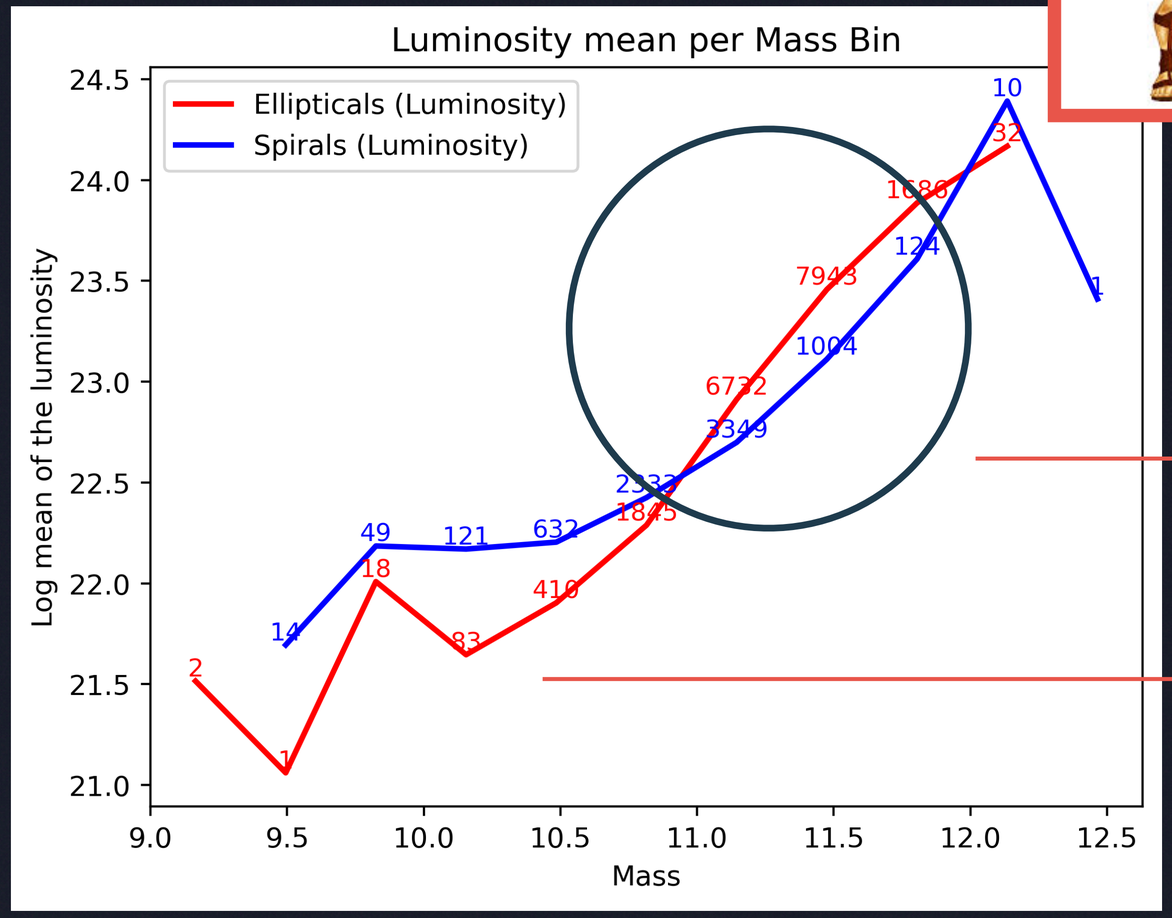


At low luminosities (<10^{23} W Hz^{-1}) and low stellar masses (<10^{11} M⊙), the population is dominated by spirals (>90%)

Summary



Large elliptical, central galaxy cluster



> 92% radio AGN, (~25% spirals, ~67% ellipticals out of the whole sample)

Radio AGN dominated by spirals at low mass and luminosity

Denser environments -> higher radio AGN activity

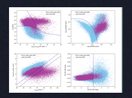
University of Hertfordshire UH

Thank you

The role of galaxy properties and environmental factors on radio AGN prevalence

Radio AGN in the local Universe LoTSS DR2 - Stellar Mass

PNB

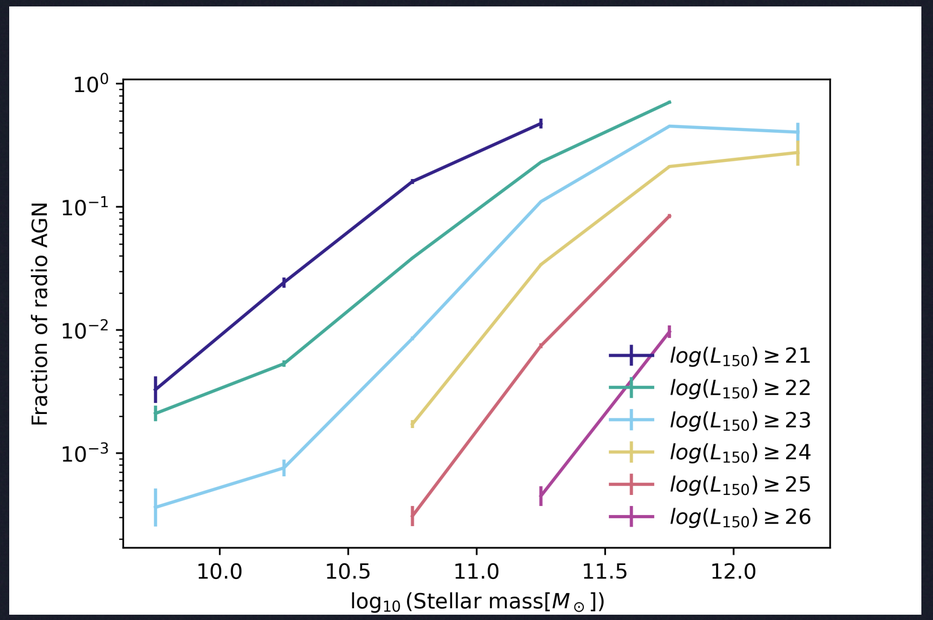


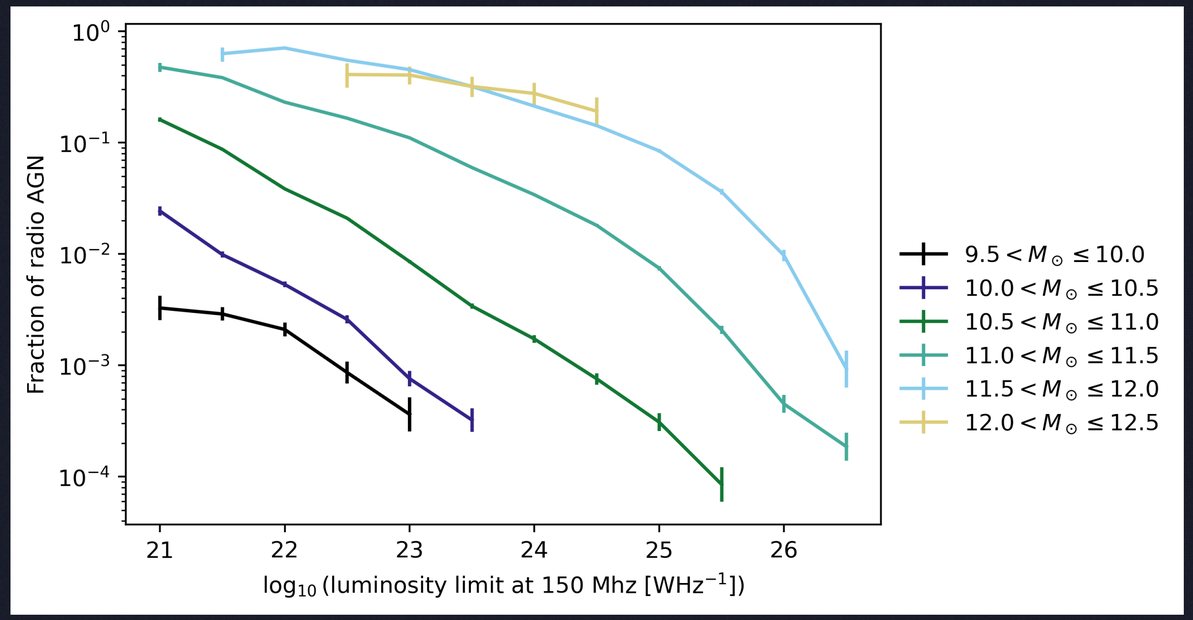
26,562

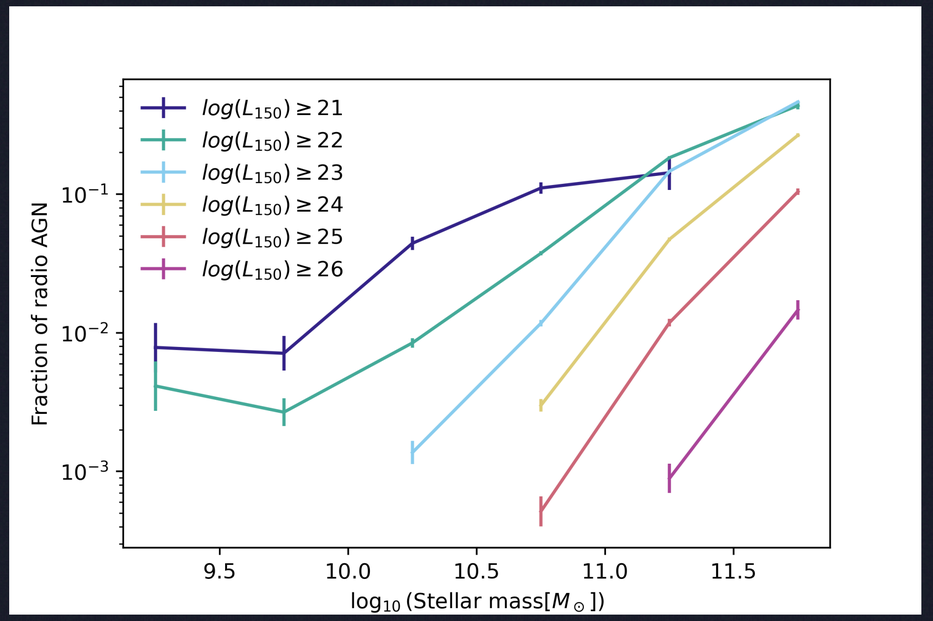
AD

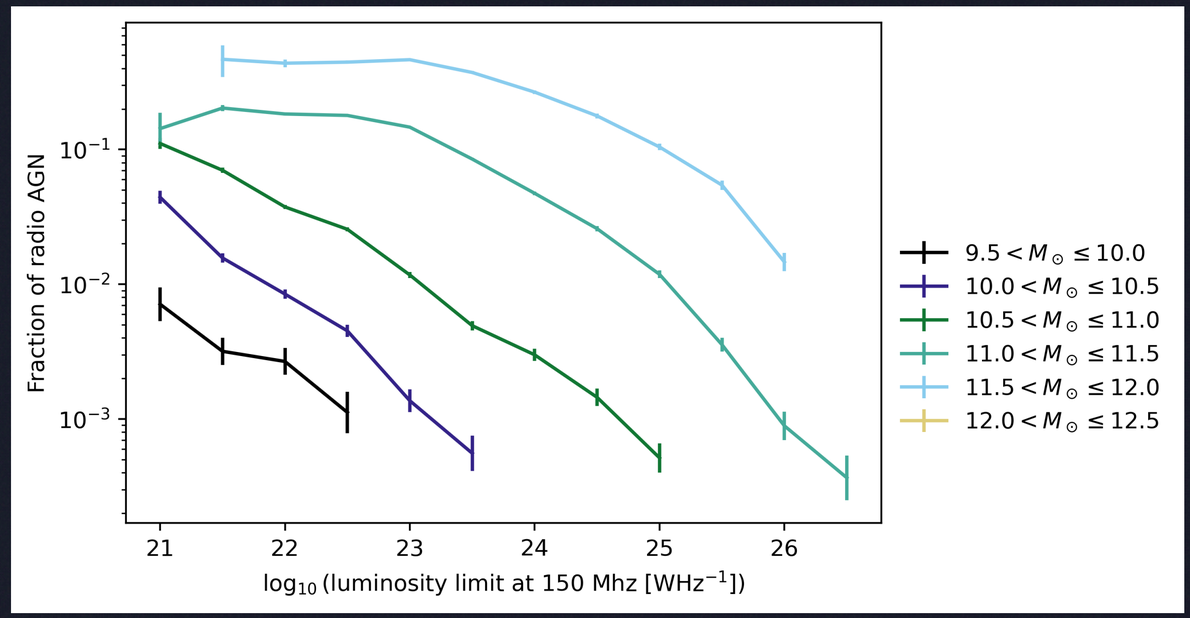
"RADIO_EXCESS" >0.95

6,292



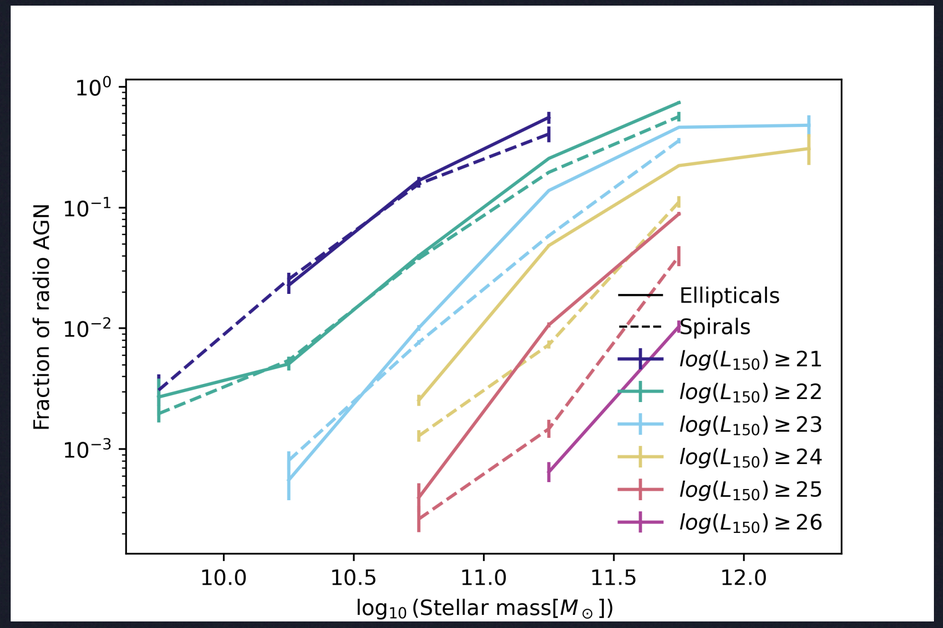


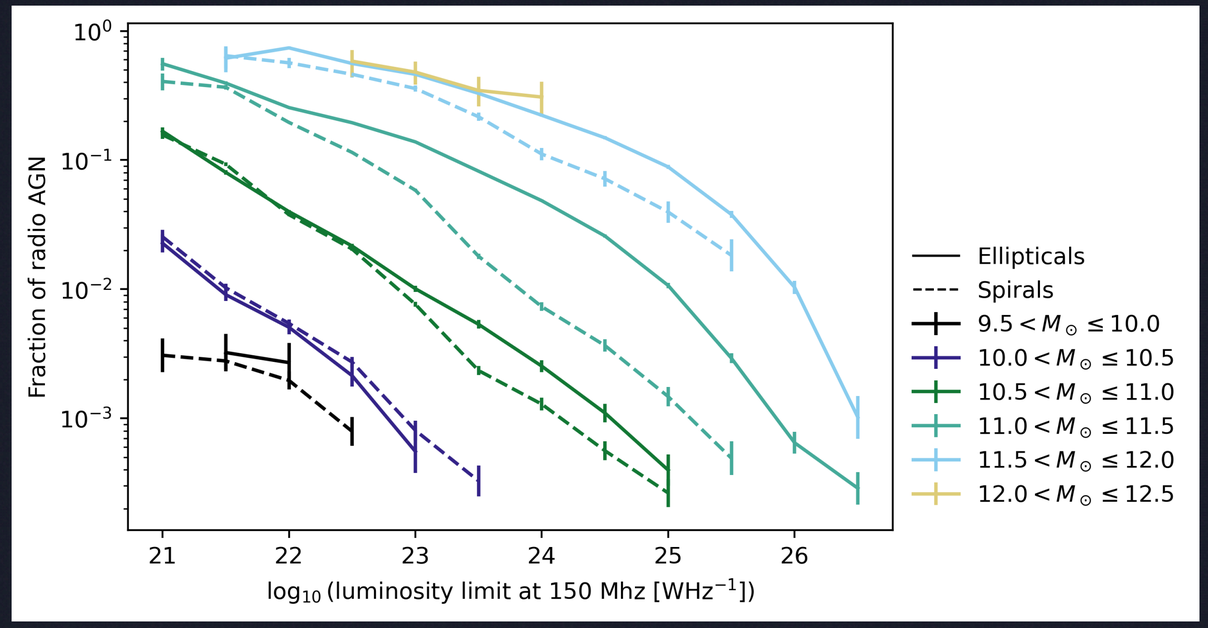




Radio AGN in the local Universe LoTSS DR2 - Stellar Mass Spirals vs Ellipticals

PNB





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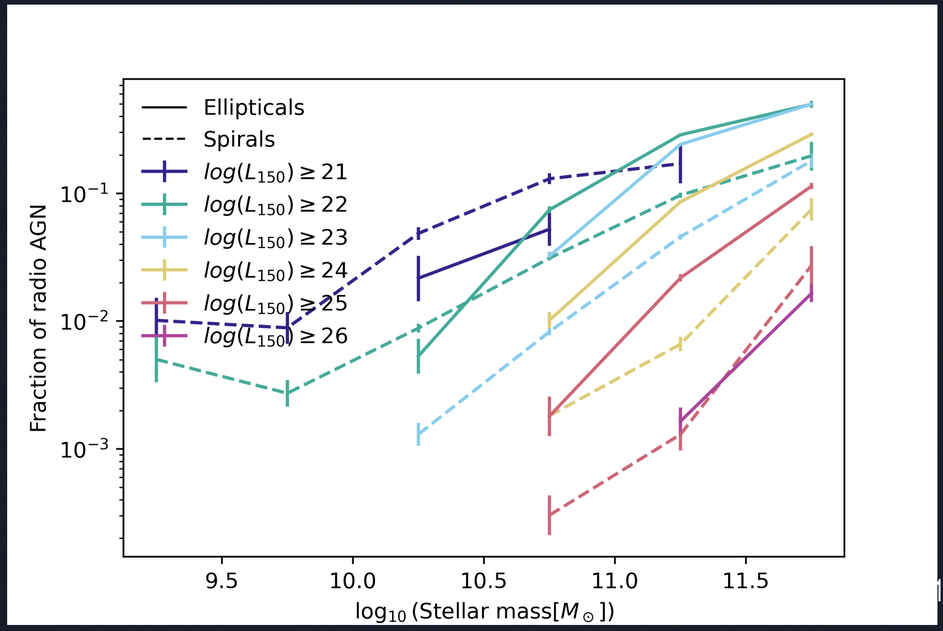
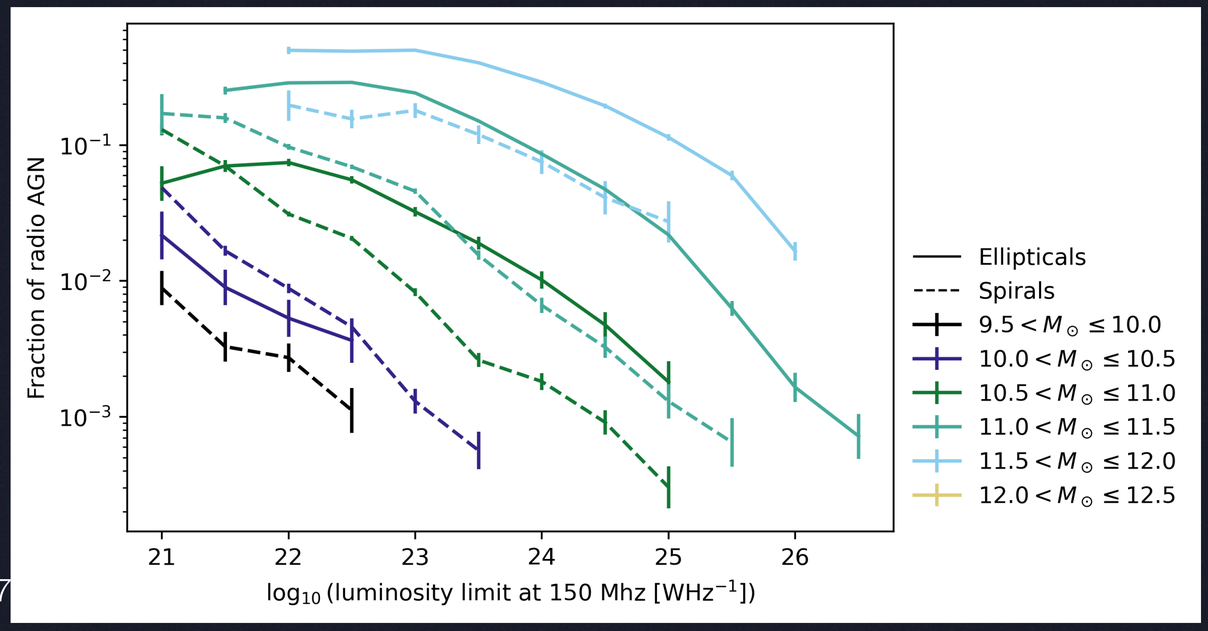
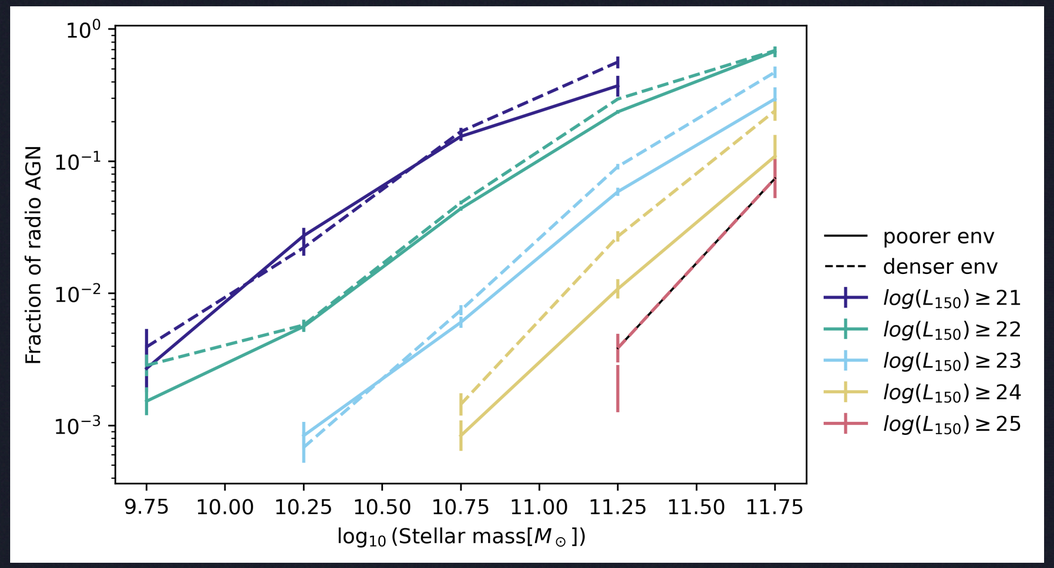
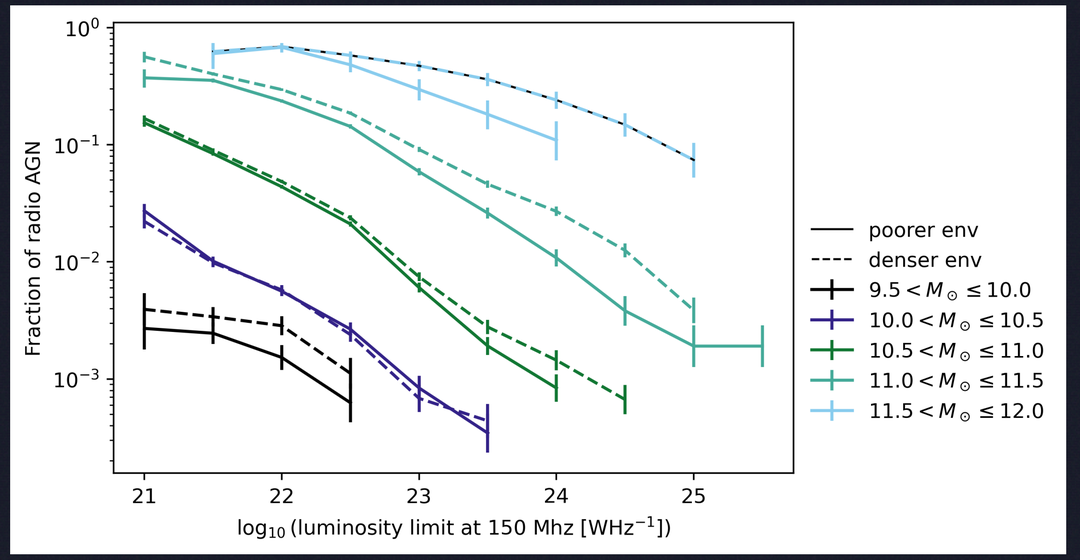




Radio AGN in the local Universe LoTSS DR2 - density

PNB





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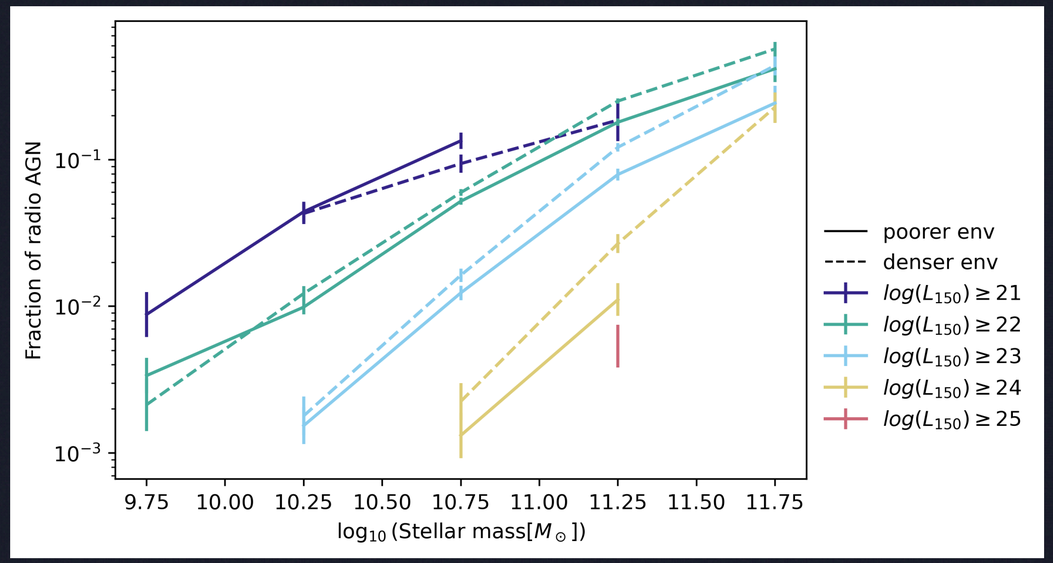
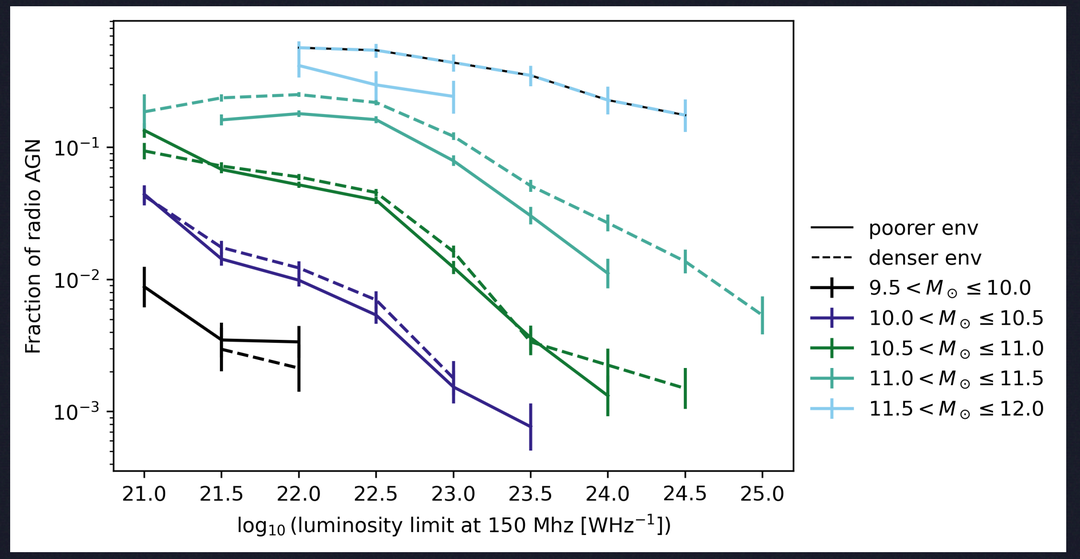
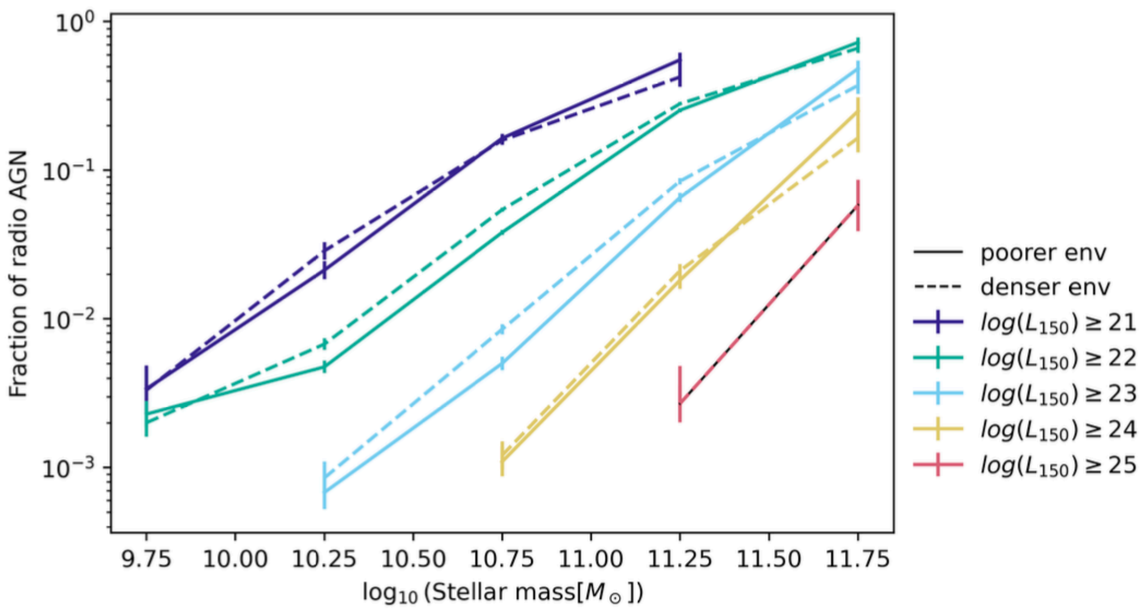
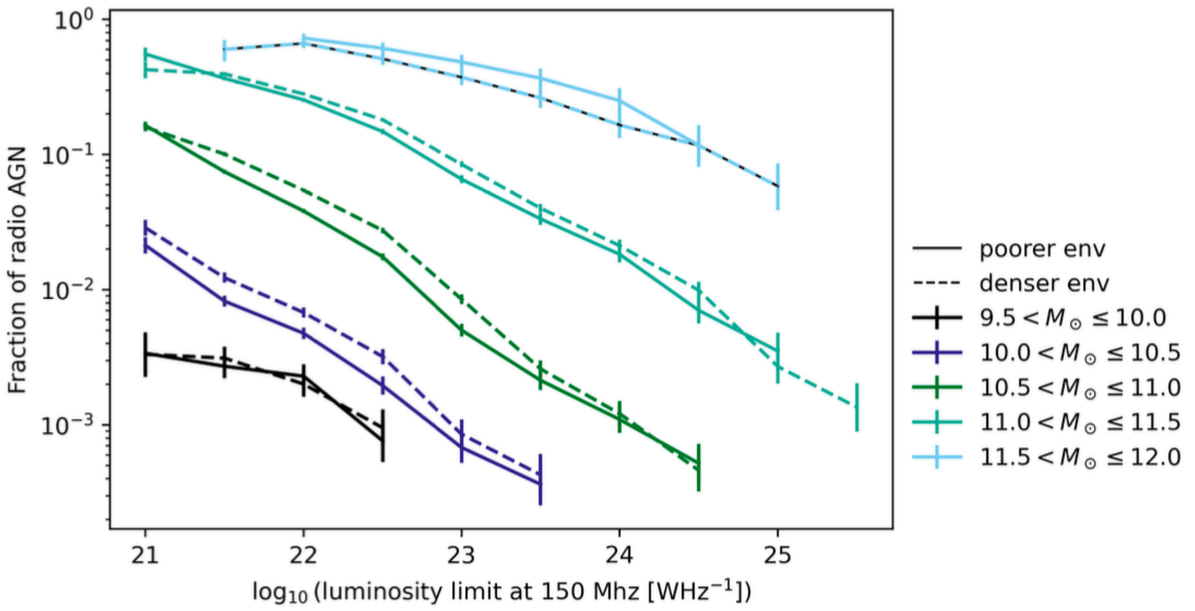




Radio AGN in the local Universe LoTSS DR2 - PCA2





PCA2: Distinguishes between local density and tidal interactions.

Parameter from Sabater et al. 2013; relates to local-scale interactions (pairs/mergers)

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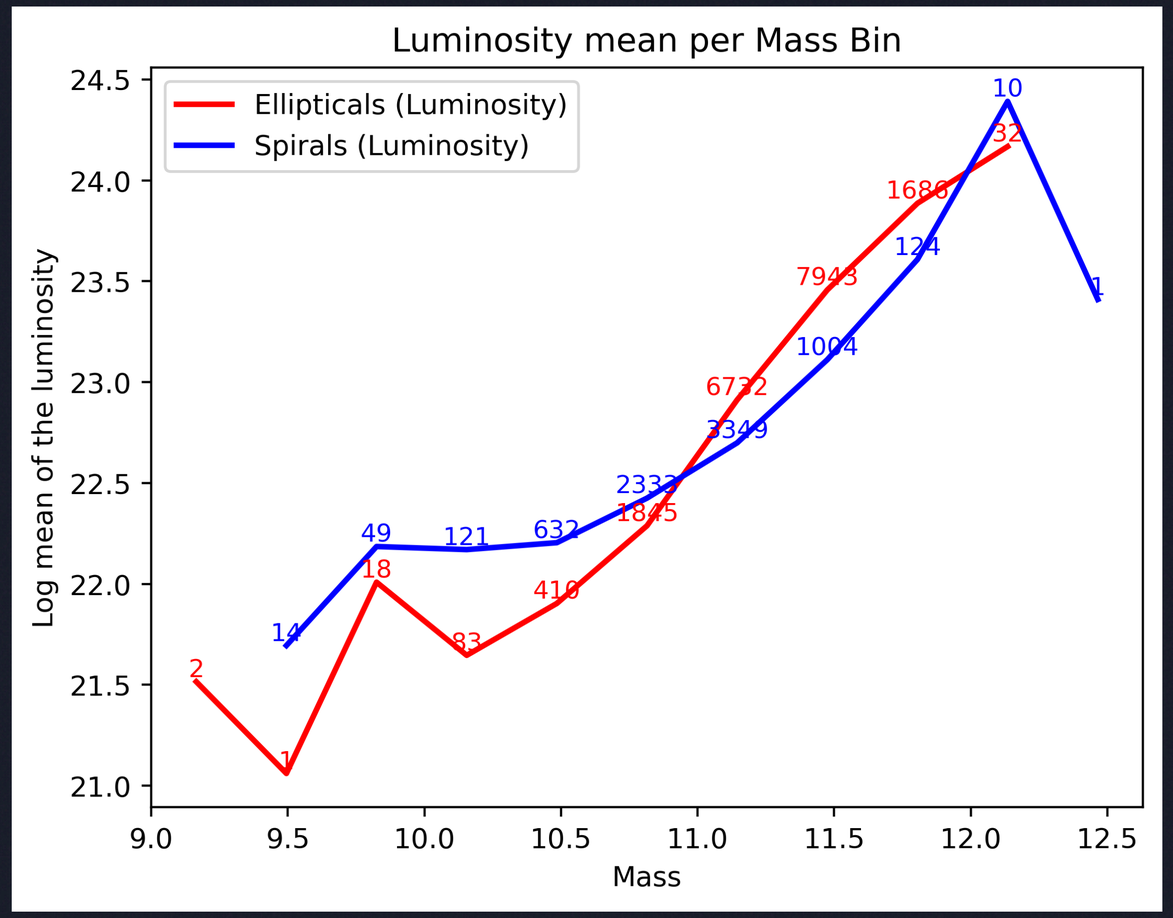
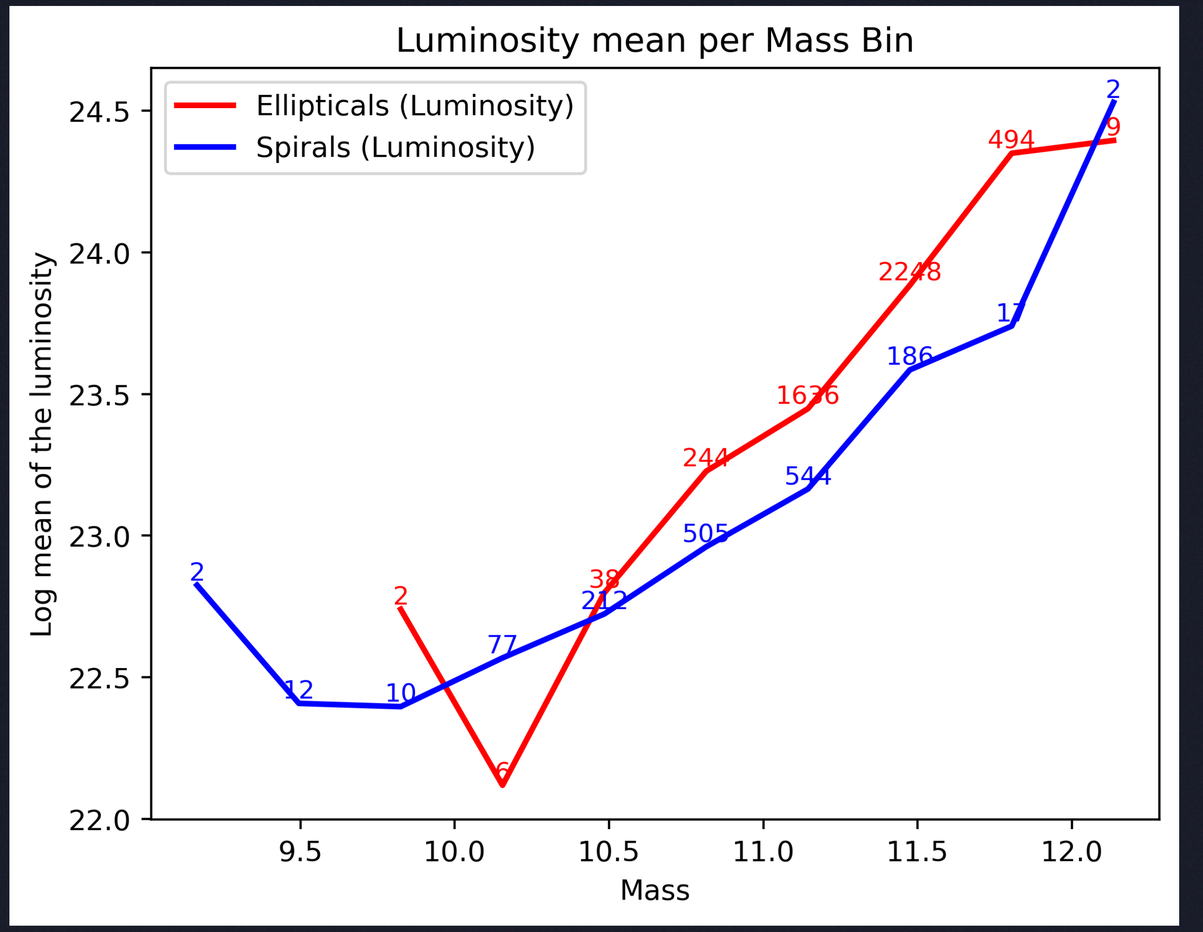
PNB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