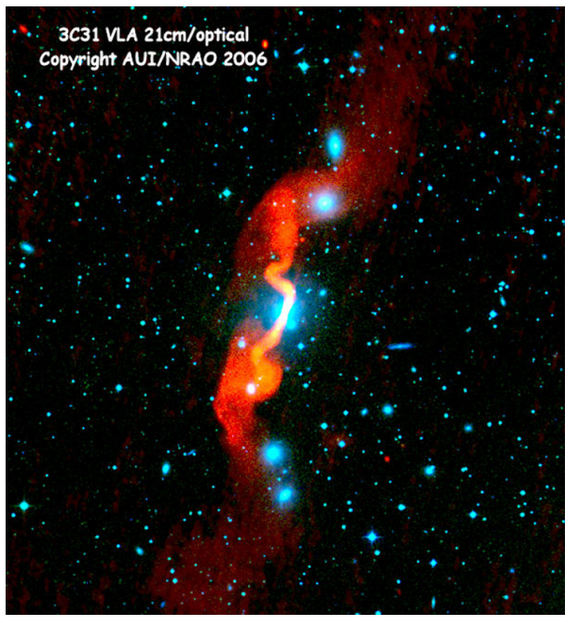
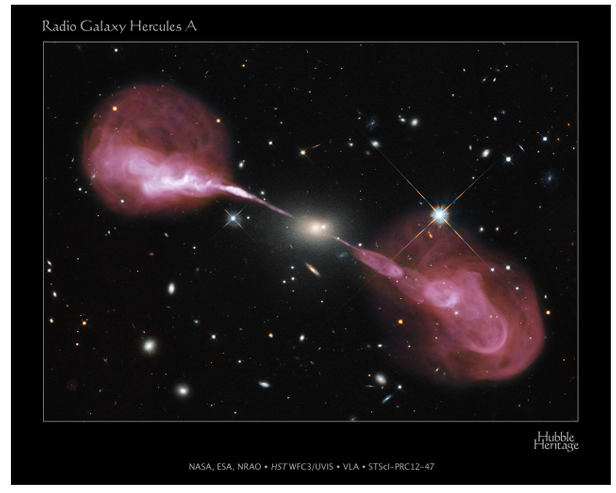
Extended radio emission from AGN in a semi-analytic model





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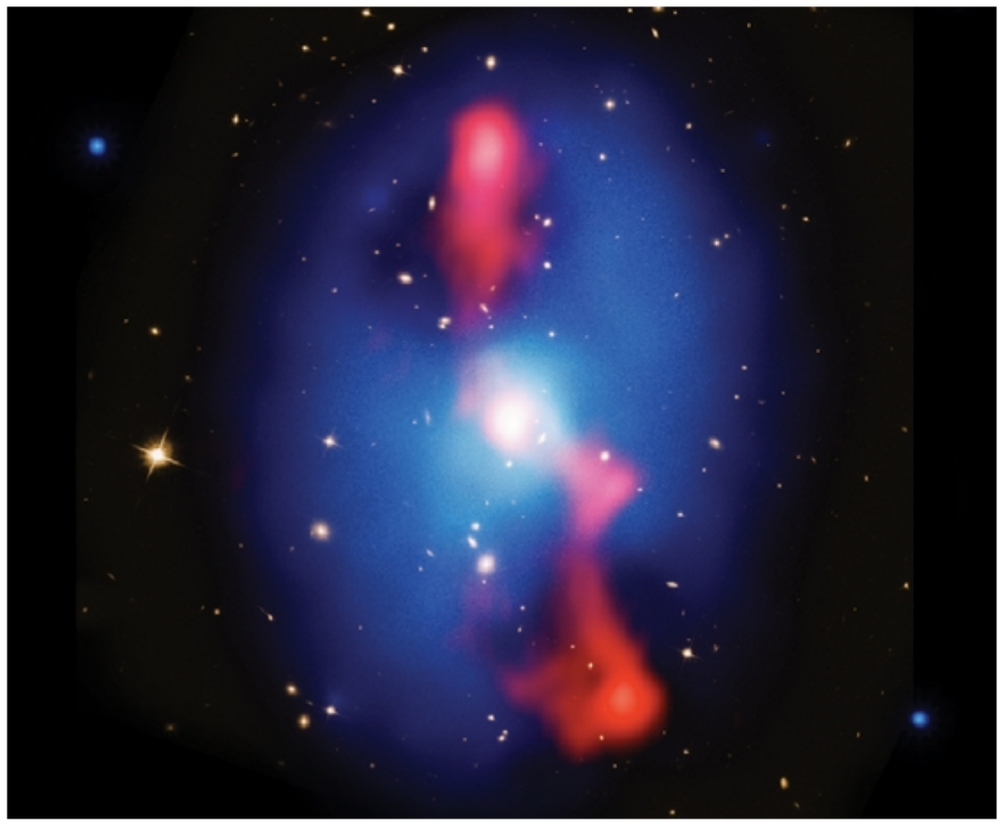
Motivation

- About two million extragalactic radio sources have been observed throughout the Universe - some are AGN jets with extended structure with sizes larger than 1Mpc.

- Future surveys such as SKA will push this number into the tens of millions.

- Powerful relativistic jets from AGN play an important role in galaxy evolution - providing a mechanism for shutting off gas cooling and star formation to produce the “red and dead” ellipticals we observe today.

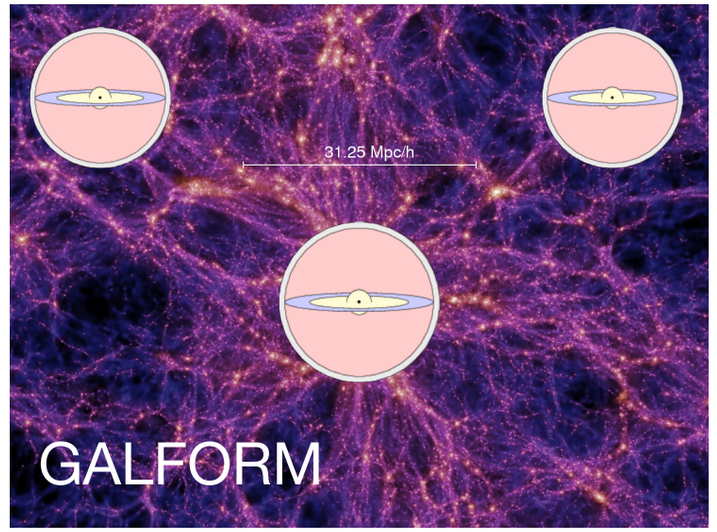
- We would like to understand how these radio lobes from AGN work, and therefore their role in galaxy formation.



The model

- We use the GALFORM semi-analytic model of galaxy formation coupled to the Turner & Shabala (2015) analytic model of radio lobe evolution.

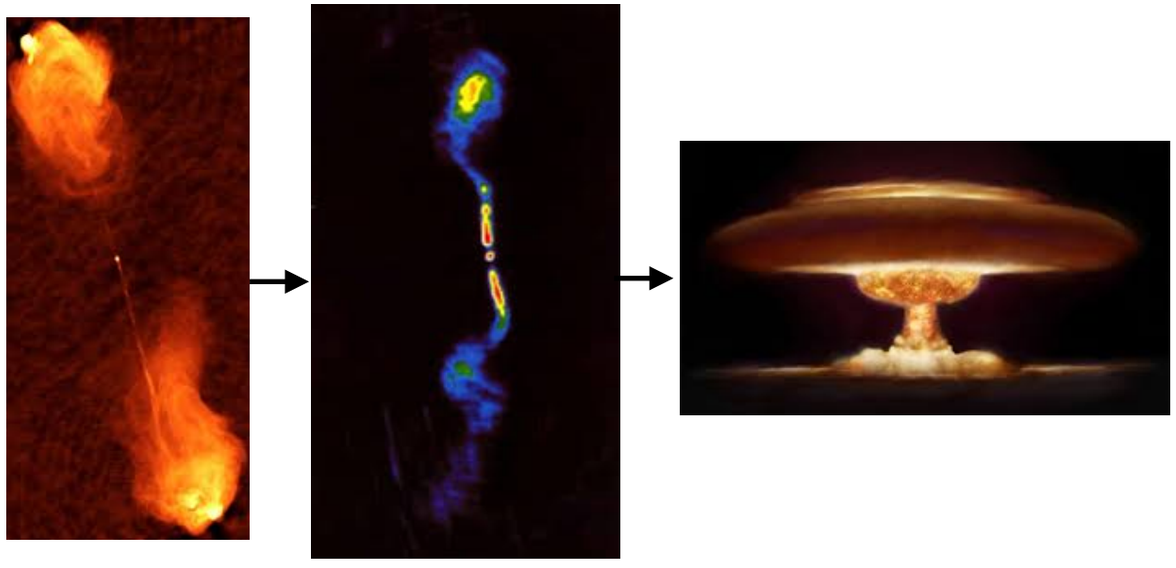
- Powerful FRIIs transition into FRIs before being destroyed by Rayleigh-Taylor instabilities.



M_{halo}, M_{hot}

$M_{BH}, \dot{M}, a$

Jet powers



FRII

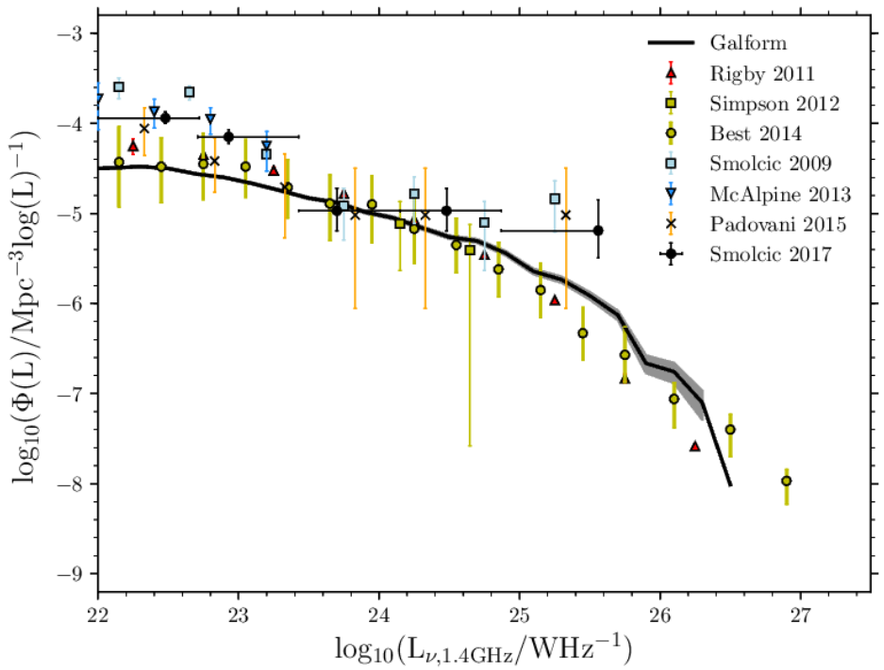
FRI

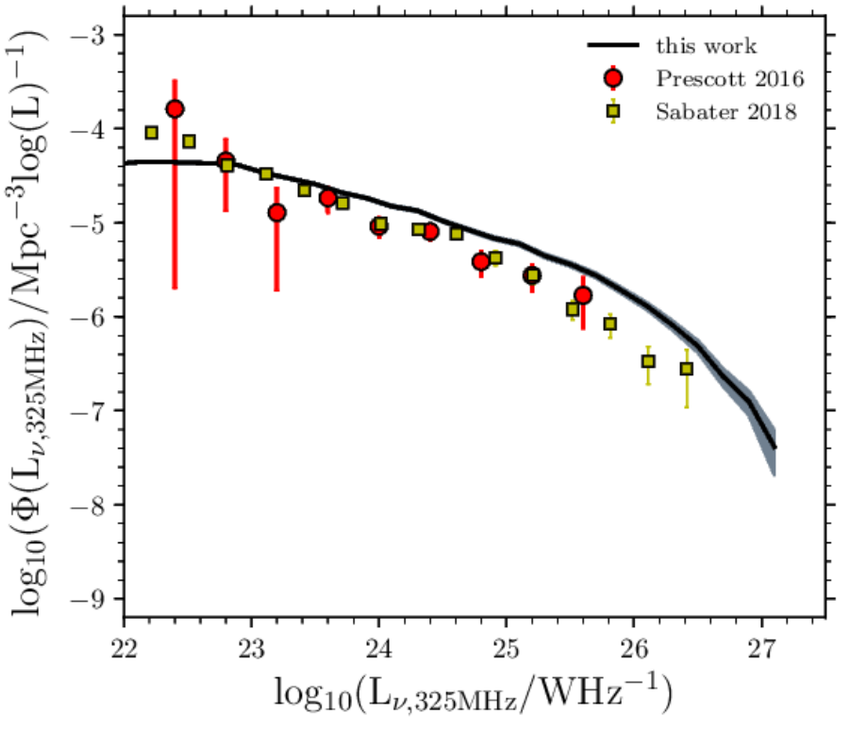
Rayleigh-Taylor

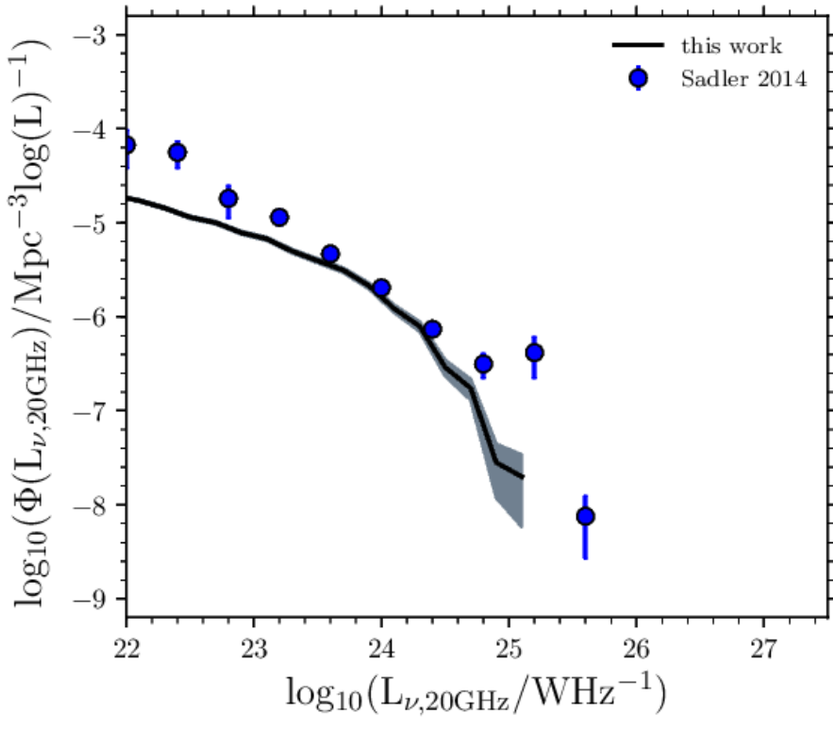
Radio Luminosities

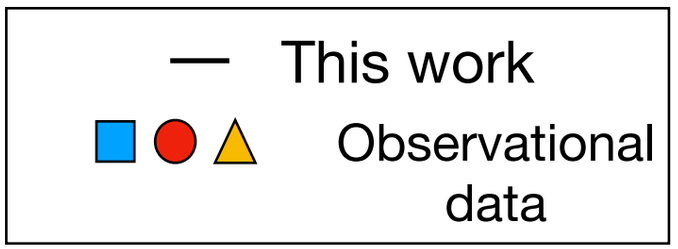
- We show the predictions of the model compared to observational estimates at 325MHz, 1.4GHz, and 20GHz.

- Higher frequencies probe compact emission from young electrons, while lower frequencies probe emission from older electron populations.



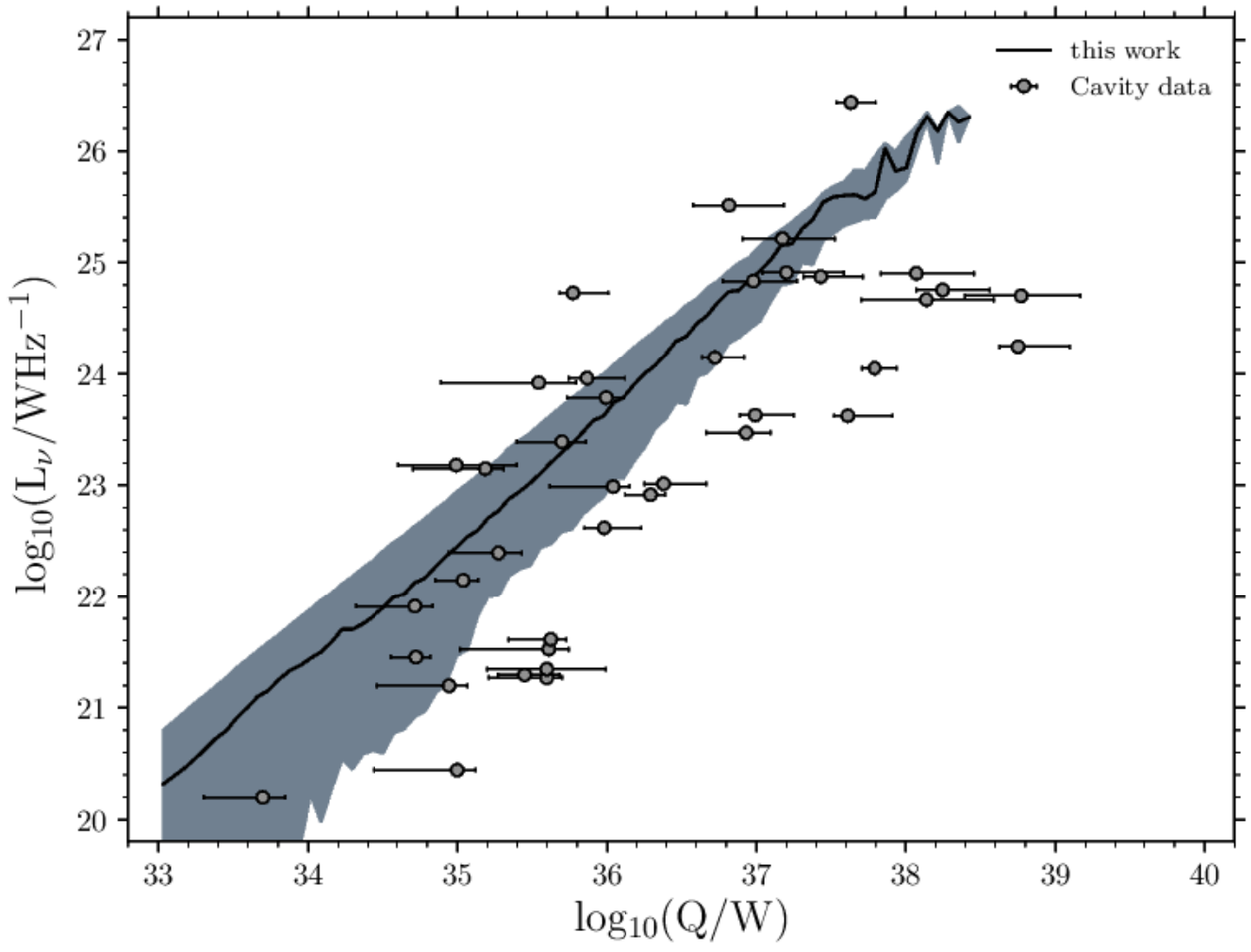






Radio luminosities and jet powers

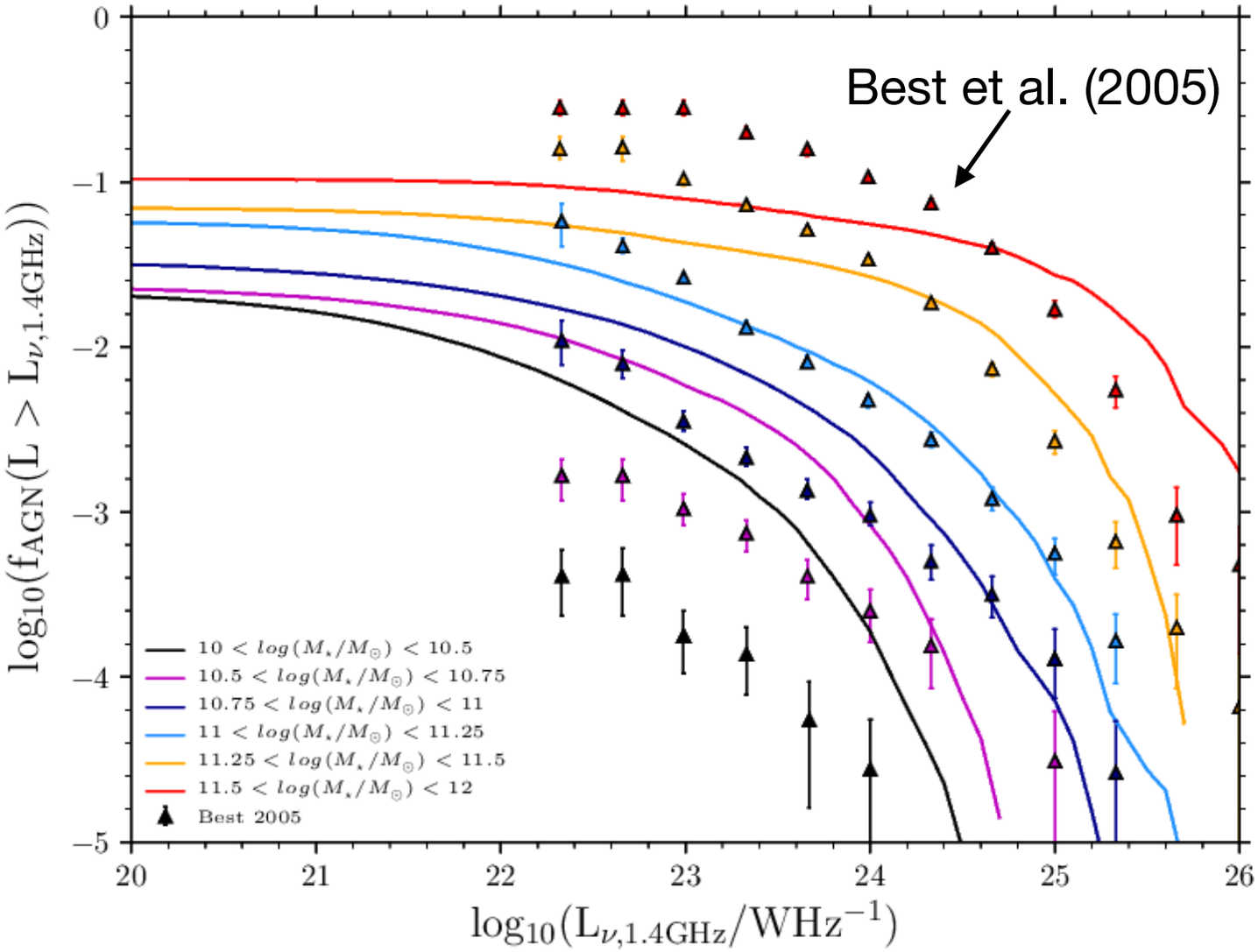
- The relation between radio luminosity and jet kinetic power.
- The shading represents the 10-90 percentiles.
- Model consistent with observations.



Radio luminosities and stellar masses (1)

- Fraction of galaxies with a radio source above that luminosity, split by stellar mass, compared to Best et al. (2005).

- Model closest to observations in middle stellar mass bins ($M_* \sim 10^{11}\ M_{Sun}$).

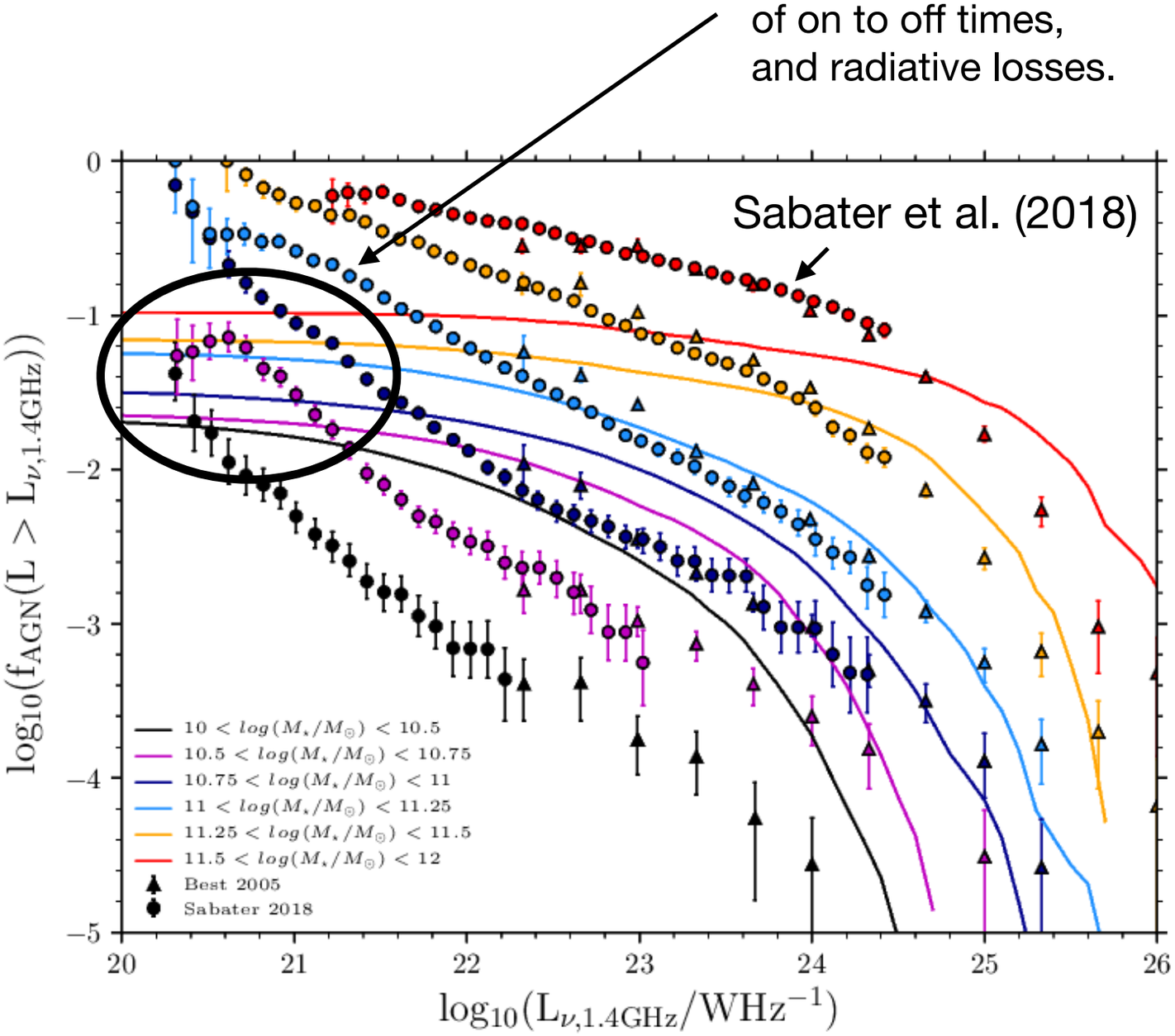


Radio luminosities and stellar masses (2)

- Same plot, but this time including LOFAR data - Sabater et al. (2018).

- Sabater et al. (2018) - 100% of massive galaxies have radio AGN activity with $L > 10^{21}$ WHz^{-1}, whereas in my model that fraction is about 10%.

- At these luminosities, the radio fraction is determined by the choice of t_{off}/t_{on}, and radiative losses of the synchrotron emitting electrons.



Summary

- We present predictions using an analytic model of radio lobe evolution coupled to the GALFORM semi-analytic model of galaxy formation.

- Model matches well to observational estimates of radio luminosity function, and radio luminosity versus jet power relation.

- Recent observations suggest all massive galaxies have radio AGN activity with $L > 10^{21}$ WHz^{-1}, in tension with my model.

- Will need to investigate the duty cycle of AGN in model and radiative losses to understand this luminosity regime.

Radio luminosity function evolution