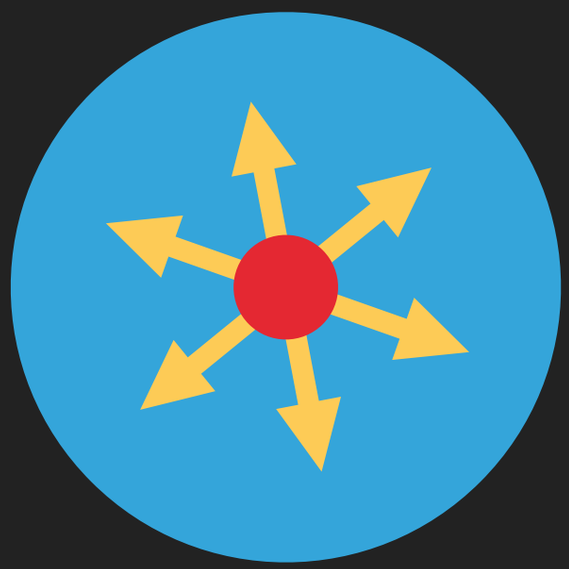
HANNAH STACEY, JOHN MCKEAN, NEAL JACKSON ET AL.

STRONG GRAVITATIONAL LENSES AT LOW RADIO FREQUENCIES

THE DIFFERENT MODES OF FEEDBACK

- Feedback from AGN and star formation
- To what extent do these affect their host galaxies?
- What feedback modes are at work in *radio-quiet* quasars?



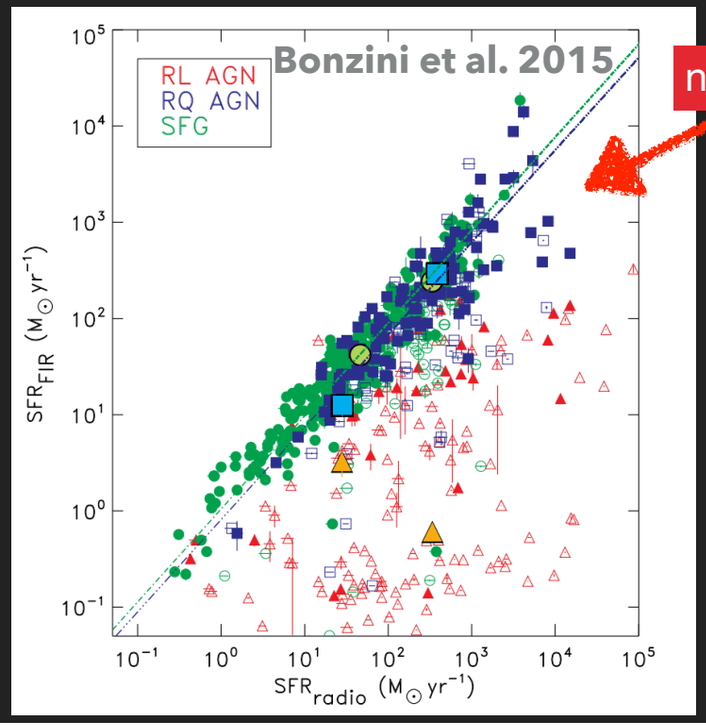
Radiative feedback

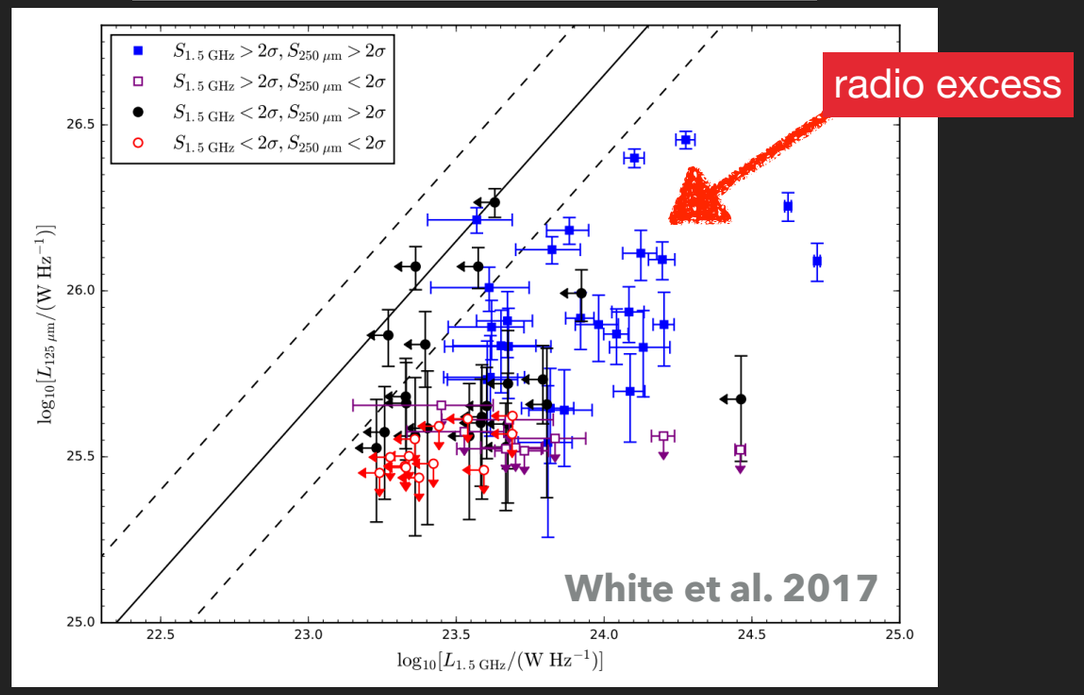
Mechanical feedback

Stellar feedback

WHAT POWERS THE RADIO EMISSION IN RADIO-QUIET AGN?

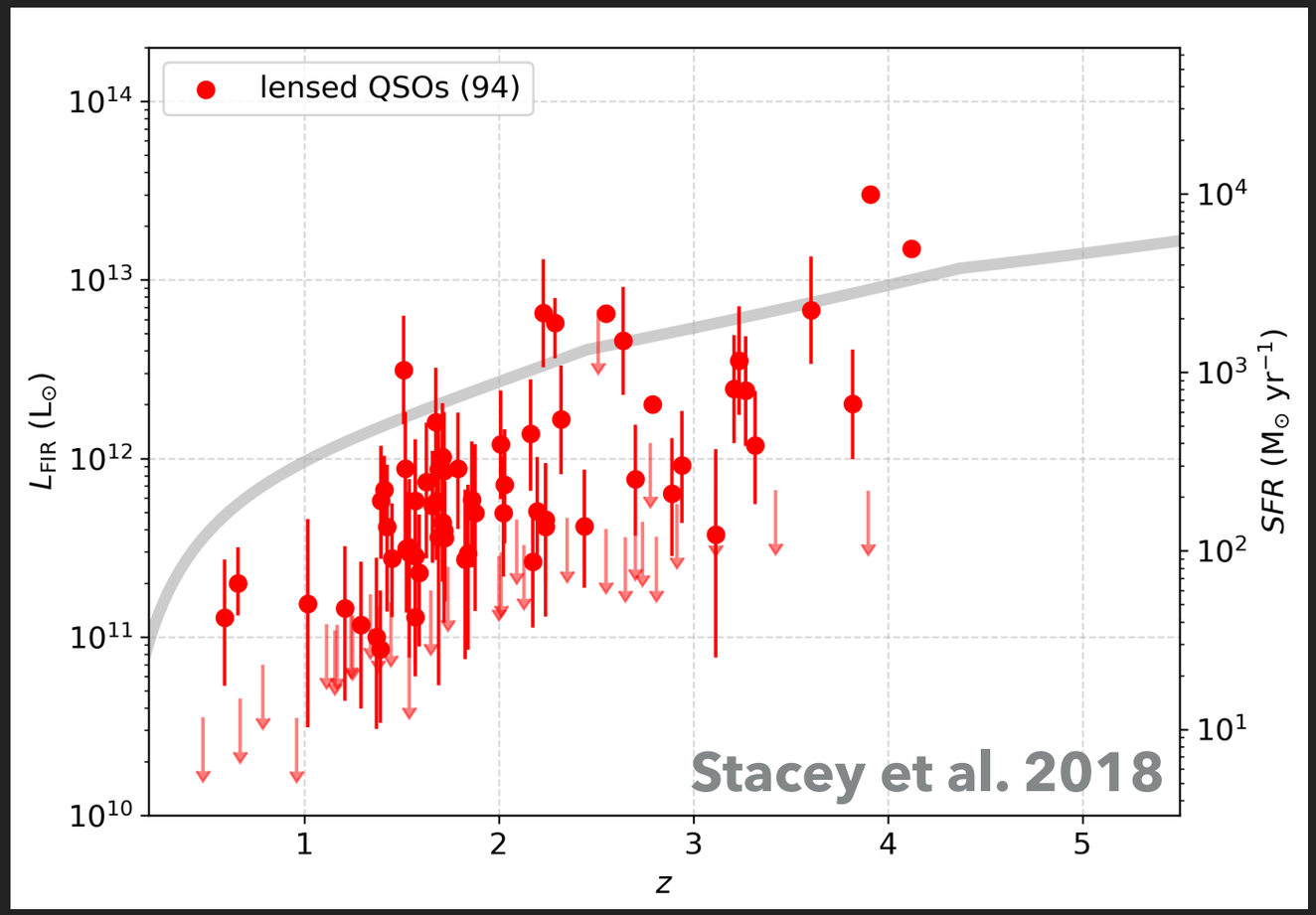
- Radio–infrared correlation to determine whether there is excess due to radio emission associated with BH accretion
- Excess could hint at radio-mode feedback
- Differing results – could depend on how study is designed?



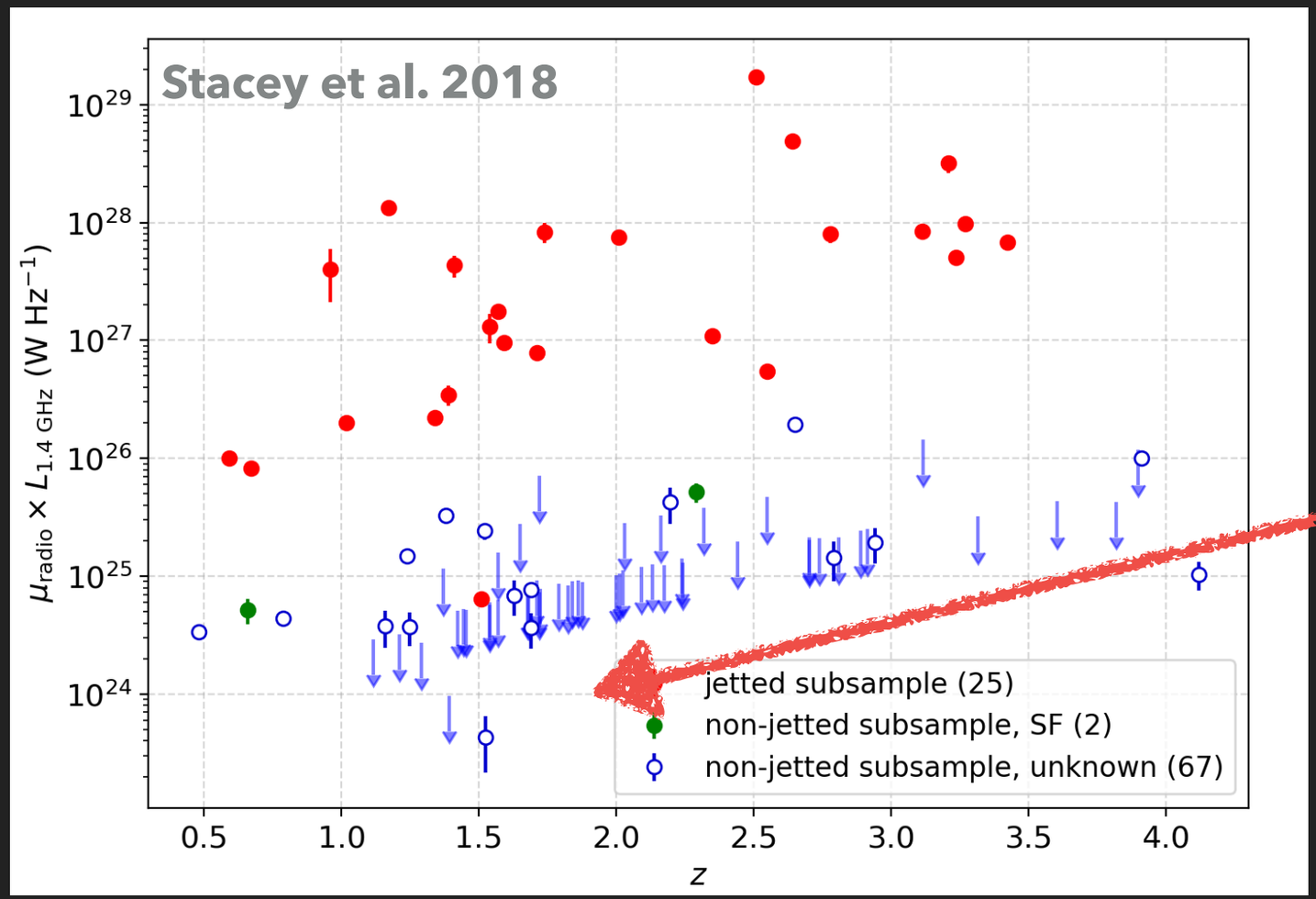


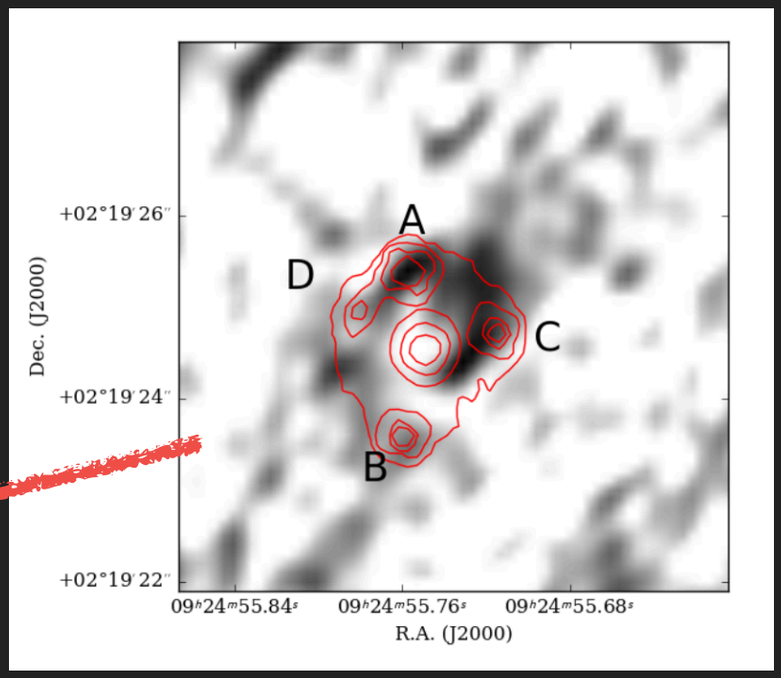
STAR FORMATION IN GRAVITATIONALLY LENSED QUASAR HOSTS

- Probing intrinsically fainter luminosities
- At least 66% quasar hosts have high levels of dust emission seen with Herschel
- Extreme SFR >1000 $M_\odot$ yr^{-1} observed in some cases – in tension with models of galaxy evolution?
- Targets for detailed follow-up



RADIO PROPERTIES OF GRAVITATIONALLY LENSED QUASARS

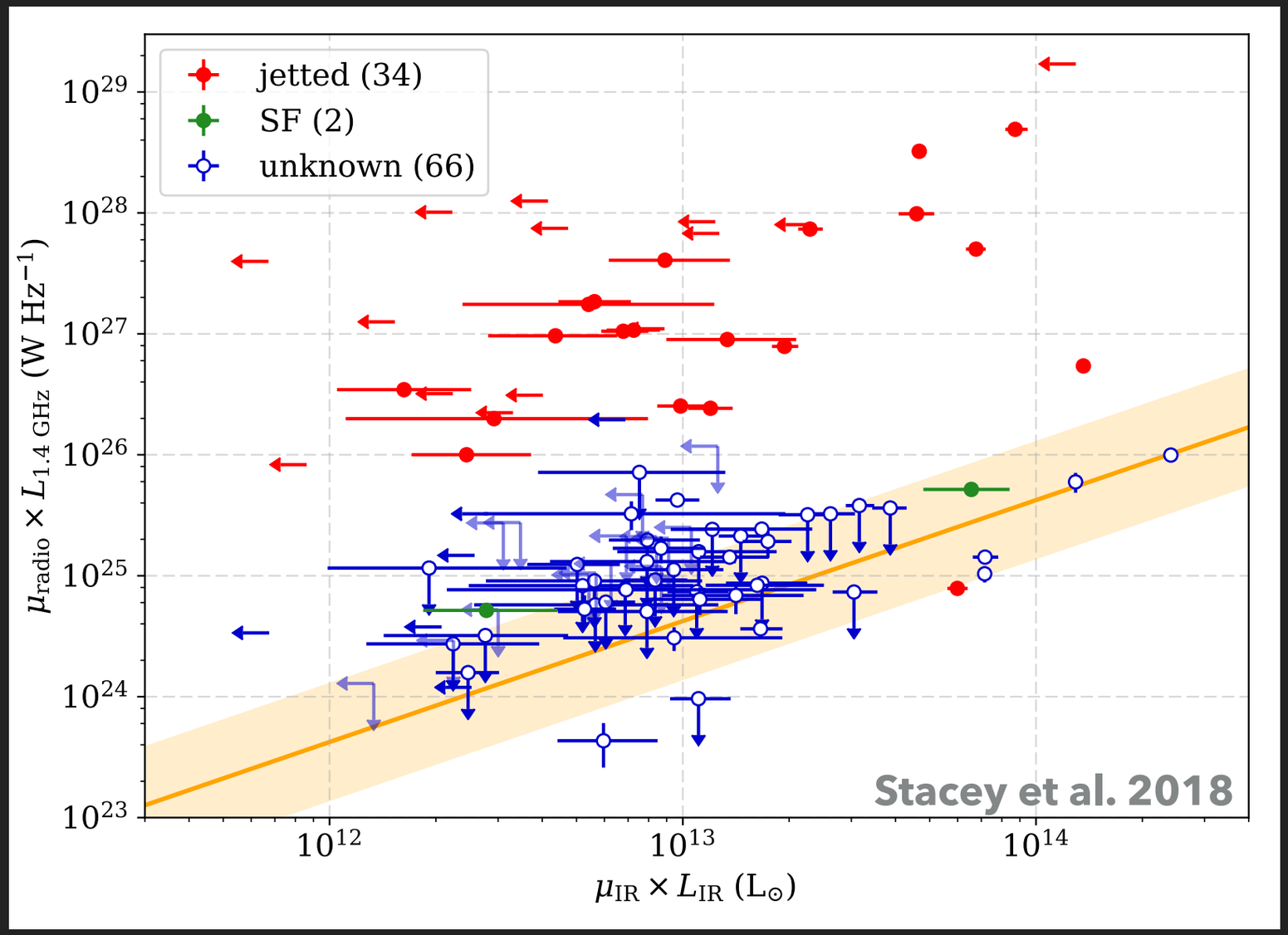




Jackson et al. 2015

- Understanding radio properties currently limited by lack of radio detections (mostly limits from FIRST or NVSS)

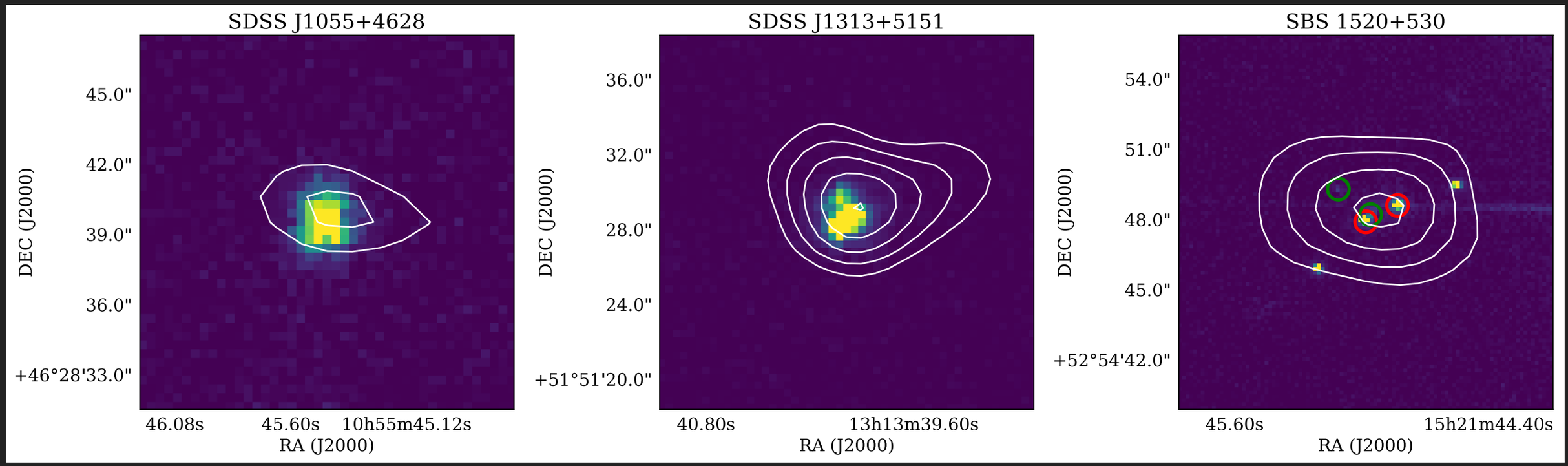
RADIO–INFRARED CORRELATION FOR LENSED QUASARS



- Radio-quiet quasars scattered close to correlation but still dominated by upper-limits

LENSED QUASARS IN LOTSS DR1

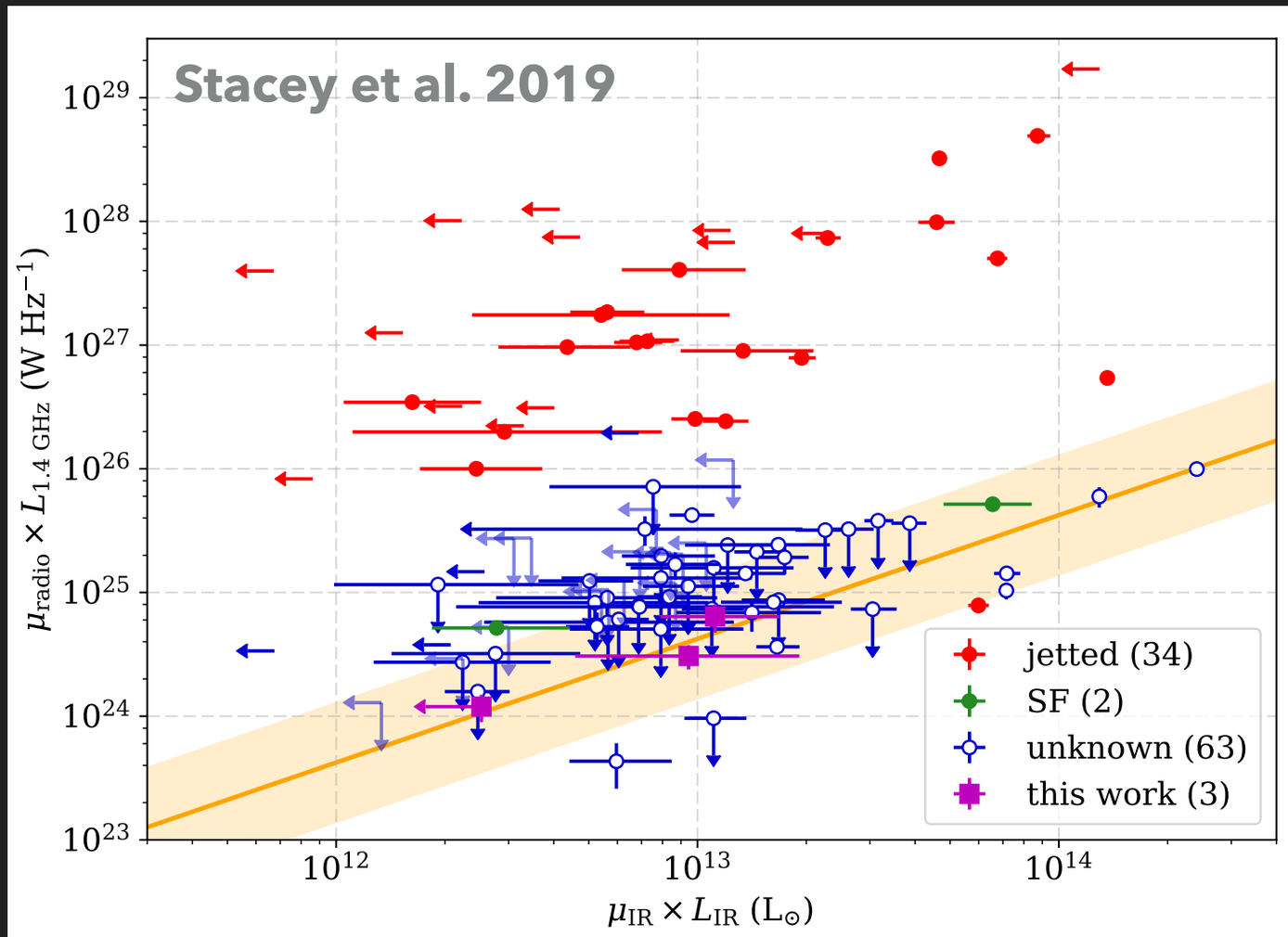
- Three lensed quasars in the parent sample happen to be in HETDEX field covered by LoTSS DR1 and all are detected

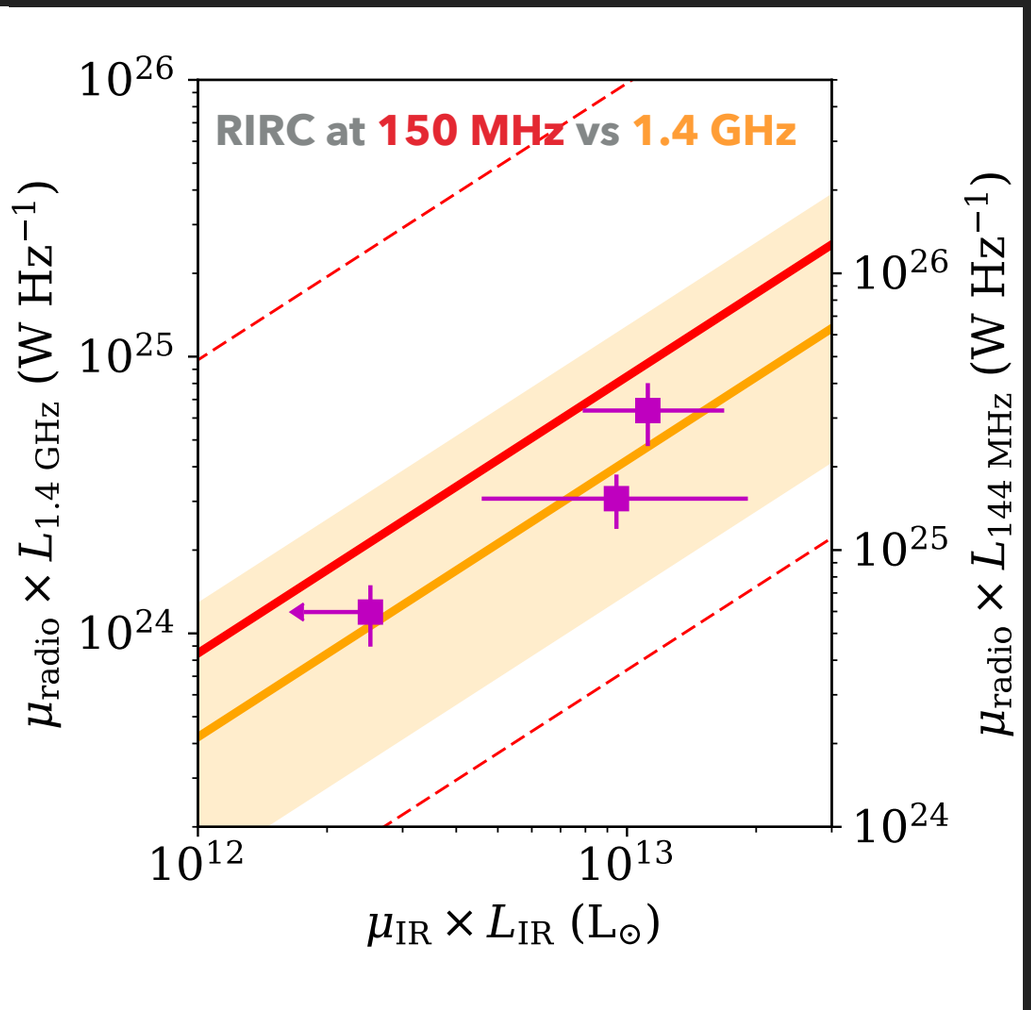


Stacey et al. 2019

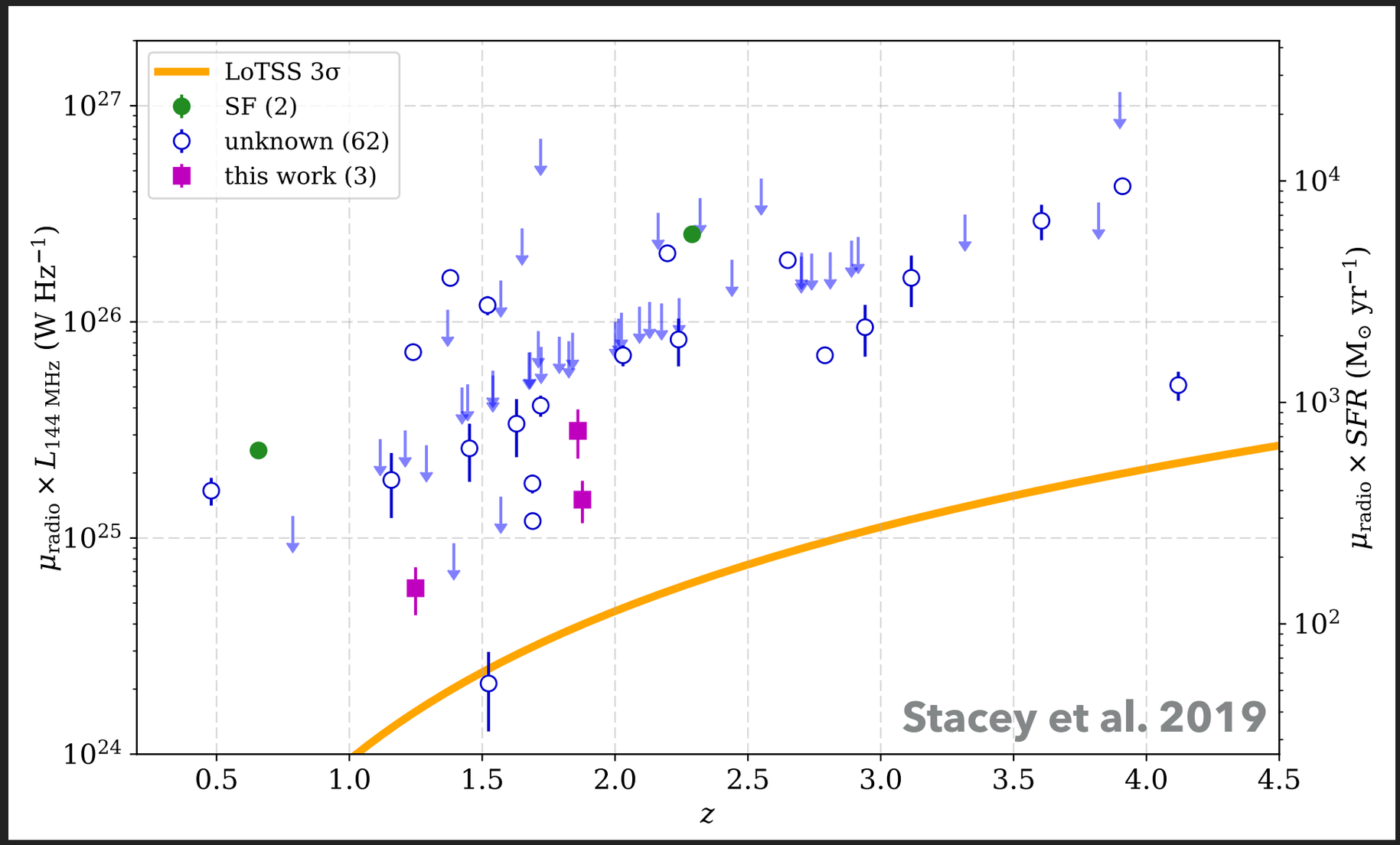
LENSED QUASARS IN LOTSS DR1

- Three LoTSS detected sources are on the radio–infrared correlation, i.e. consistent with being SF-dominated





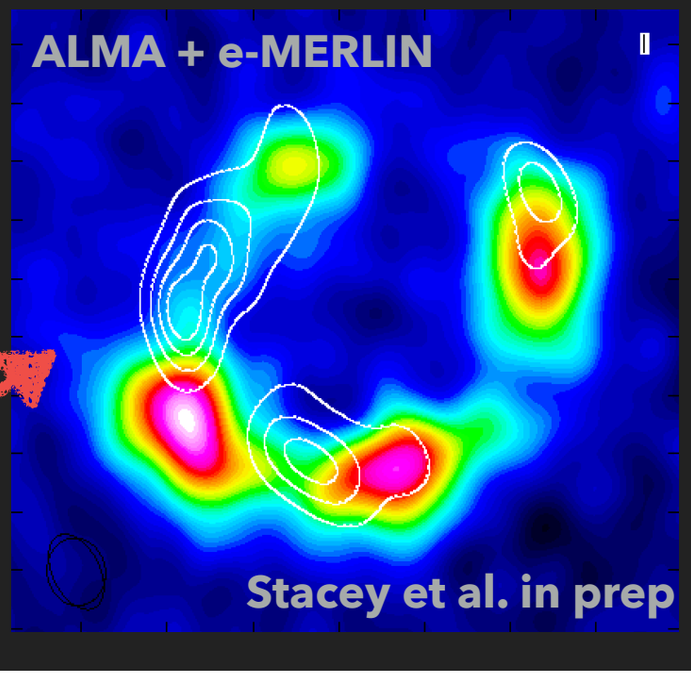
LENSED QUASARS IN LOTSS: FUTURE PROSPECTS

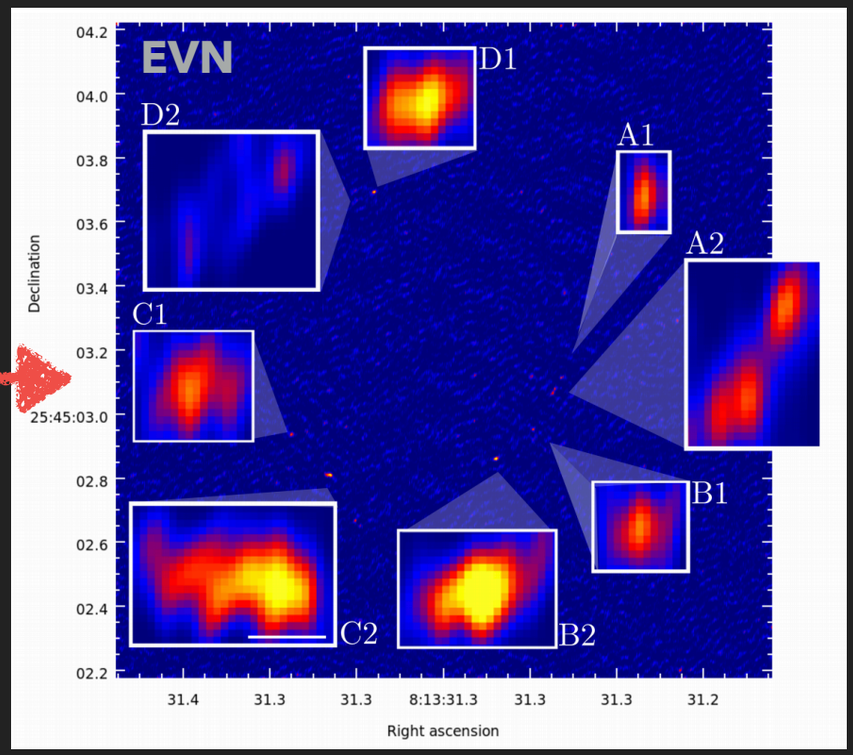


- Negative spectral index + LoTSS sensitivity = many more of the parent sample could be detected in future LoTSS data releases

LOFAR-VLBI: FUTURE PROSPECTS

- Constraining AGN contribution to radio emission not trivial even with VLBI
- Cloverleaf has radio jet and 10x radio excess, but not detected with EVN
- Quasars with no apparent radio excess can be jet-dominated
- LOFAR-VLBI resolution could help determine if high T_B ?

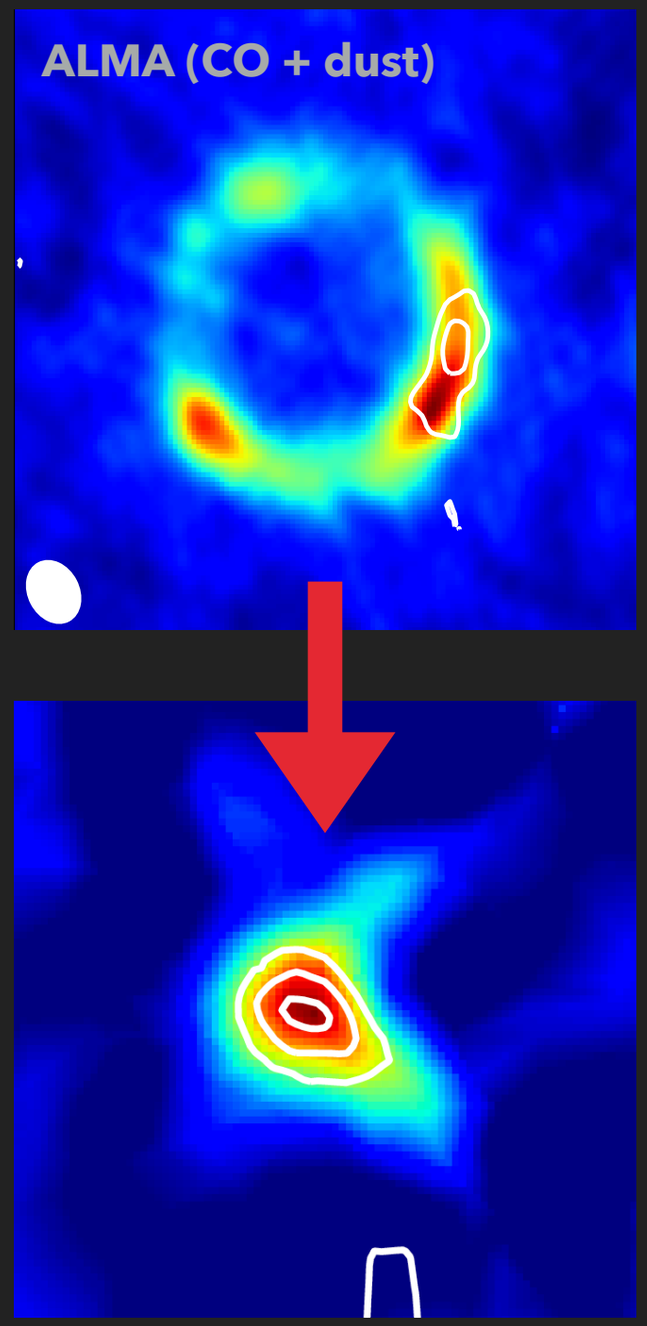




Hartley et al. 2019

LOFAR–VLBI: FUTURE PROSPECTS

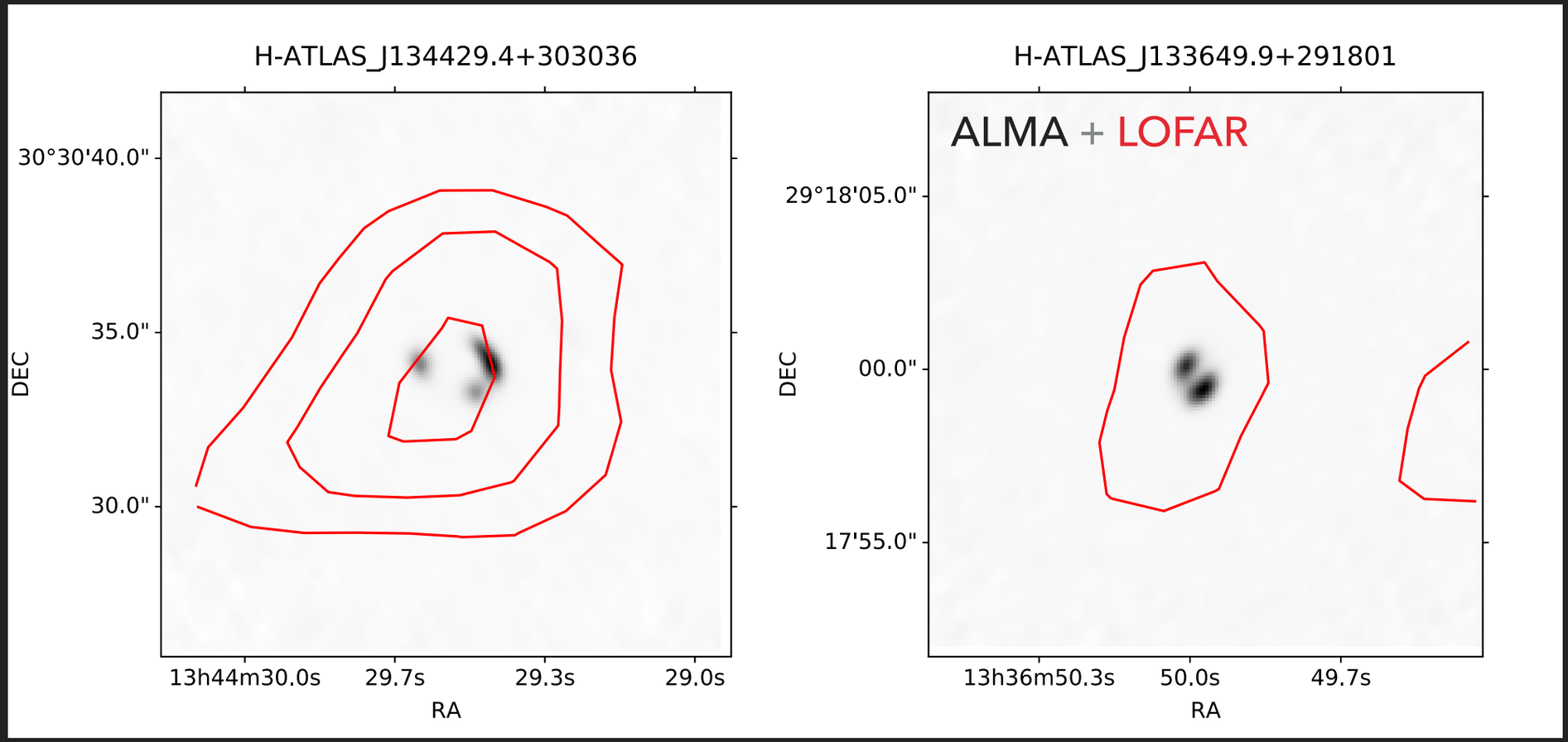
- Resolving interactions, inflows, feedback effects on ~100 pc scales at high redshift with ALMA
- In combination with LOFAR to spatially resolve radio emission from star formation
- Exploring radio–infrared correlation on small-scales, cosmic rays from stellar feedback?



Stacey et al. in prep

LOFAR–VLBI: FUTURE PROSPECTS

- Lensed dusty star-forming galaxies from H-ATLAS
- 6/9 H-ATLAS lenses detected in *old* LOFAR H-ATLAS data
- Targets for long baselines in combination with ALMA



SUMMARY

- 3 lensed quasars in LoTSS DR1 were detected and have radio emission consistent with star formation
- Many more lensed quasars in the parent sample will be detected in future LoTSS releases
- Future long-baseline campaigns can help disentangle AGN/SF, resolve radio–infrared in DSFGs, investigate AGN and stellar feedback in combination with multi-wavelength data