High-resolution VLA Imaging of Heavily Obscured and Luminous Quasars with Young Radio Jets at z~2

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Motivation

- Identifying jet-ISM feedback during the peak epoch of cosmic assembly requires catching luminous quasars embedded in large gas and dust reservoirs with recently triggered radio jets.
- Such quasars are expected to be heavily obscured, but identifiable based on their red mid-IR colors and bright, compact radio emission.
- Here we present radio properties of a sample heavily obscured quasars selected by cross-matching WISE and NVSS.
- **Our sample is believed to be in a unique evolutionary stage just after the (re)ignition of the radio AGN, and the host is likely to be in the post-merger blowout phase.**

Sample Selection

WISE	NVSS	SDSS
Bright at 22 μm + very red MIR-optical colors	Bright and unresolved (<45") radio source	Optically faint or undetected

- 156 sources, z ~ 0.47-2.8, L_{IR} ~ $10^{12.5\text{-}14}$ $L_\odot$
- MIR analyses ➜ luminous, radiative-mode AGN and heavy obscuration possibly due to peak fueling phase

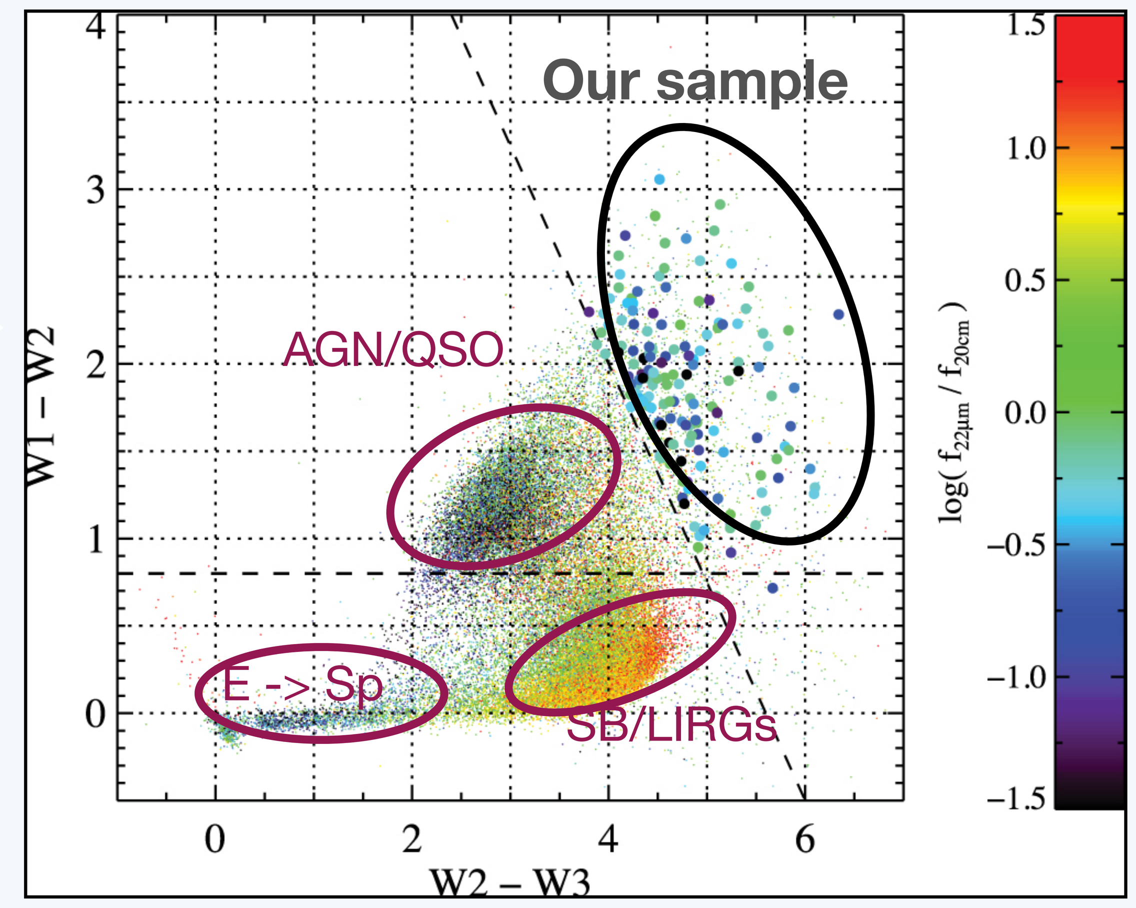


Fig 1. The WISE Color space: Heavily obscured and luminous sources tend to occupy redder MIR colors. Our sample is highlighted by a black circle (Lonsdale et al. 2015).

High Resolution VLA Imaging

- A follow-up snapshot survey at X band (8-12 GHz), A and B arrays, 0.2" and 0.6" resolution, 15-50 μJy/beam noise levels
- Goal is to characterize morphologies and radio spectra of our sample

Morphologies

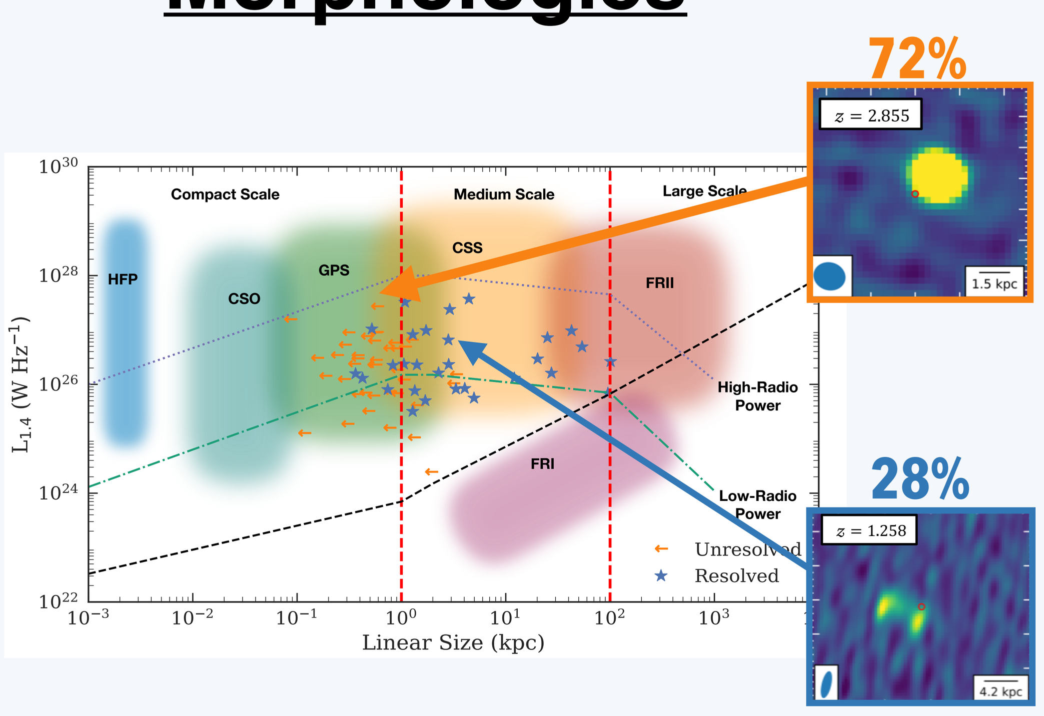


Fig 2. Left: Linear size vs 1.4 GHz Luminosity Diagram. **Right:** Example snapshot images. Majority are unresolved, linear sizes <2 kpc. Rest 28% of sources have morphologies < 50 kpc

Radio Spectra

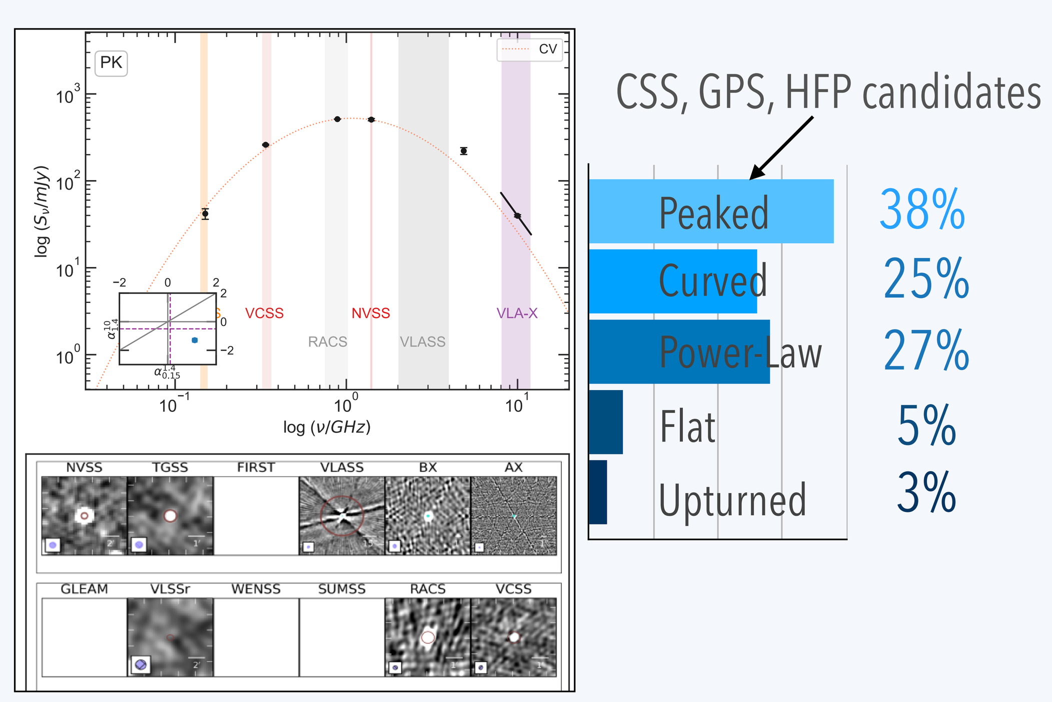


Fig 3. Left: An example of radio spectral fitting and heuristics for data quality checks **Right:** Spectral shape distribution. Majority show curved or peaked spectra due to absorption suggesting compact and young jets.

Application of Adiabatic Lobe Expansion Model

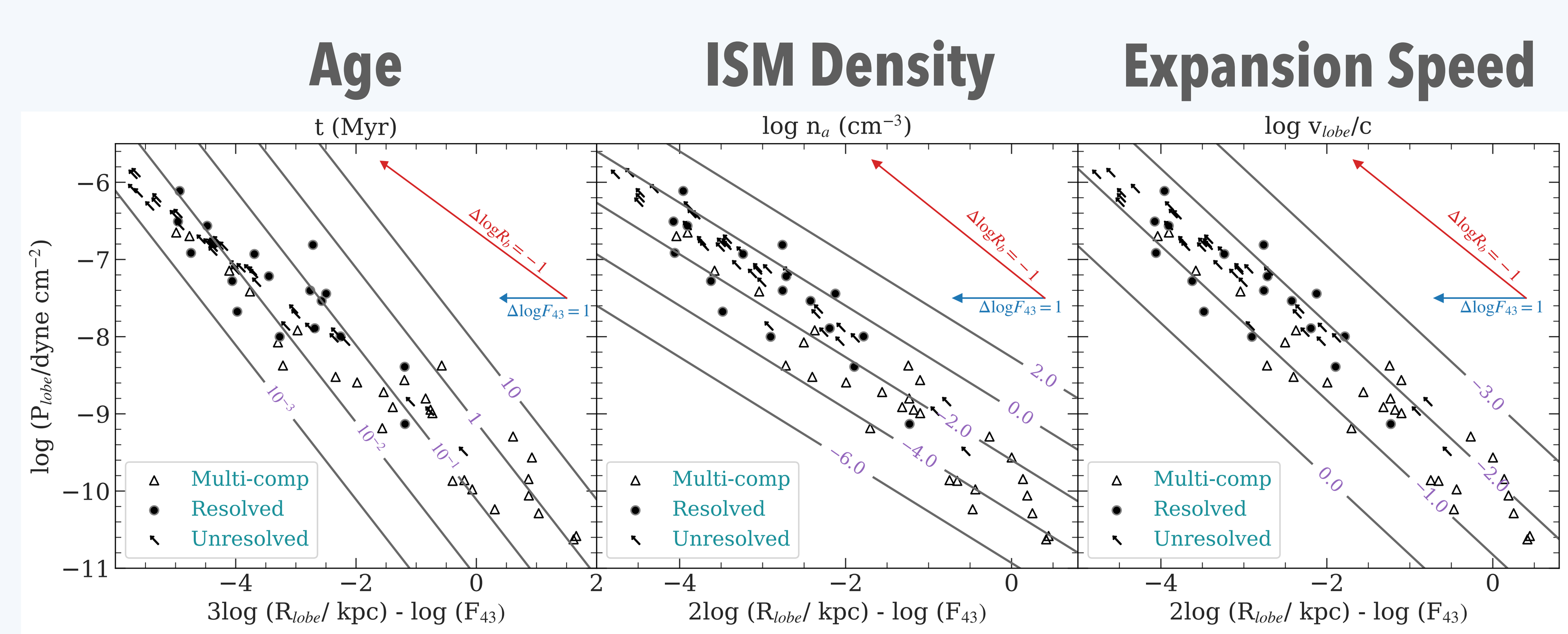
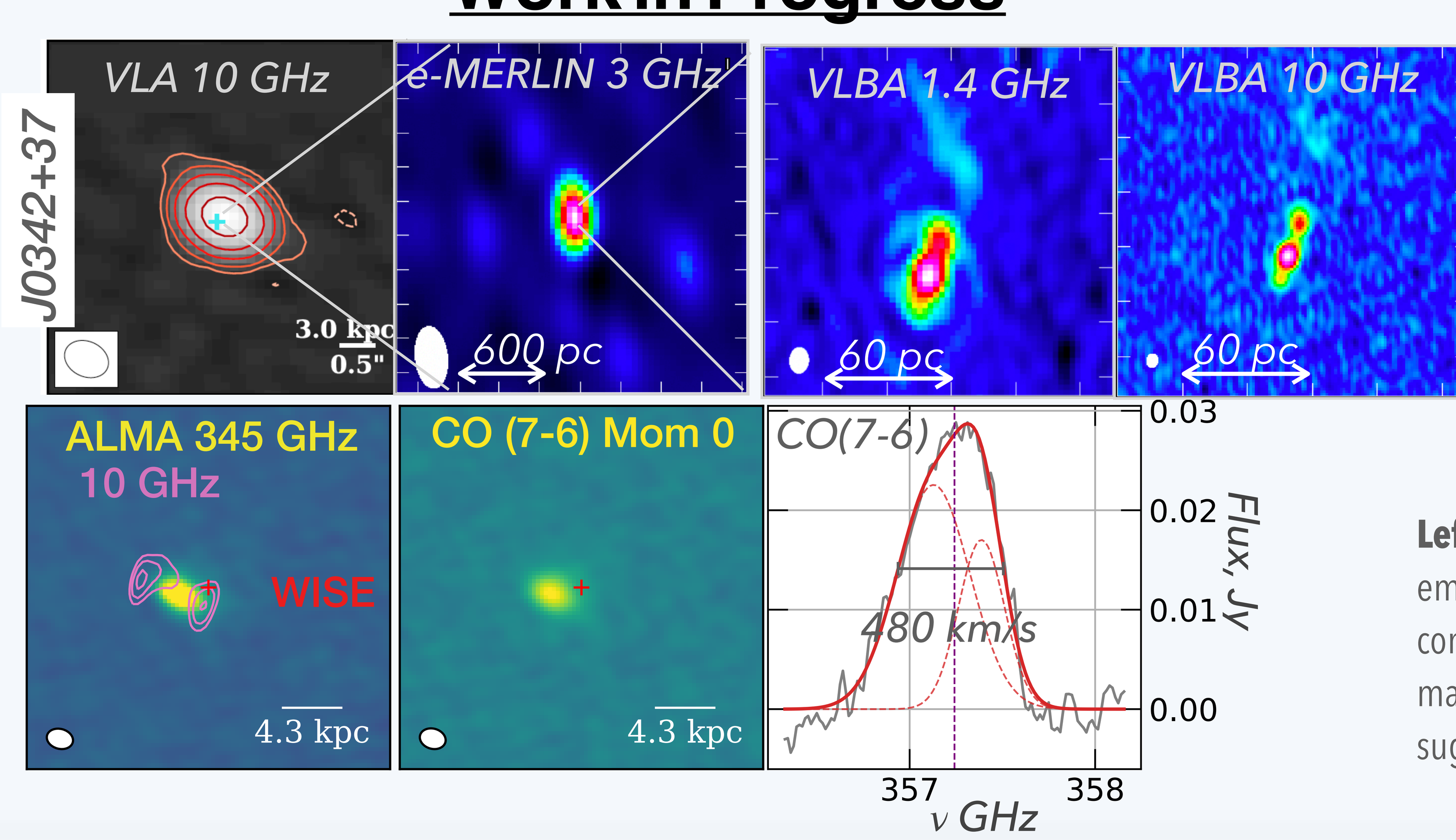


Fig 4. Contours of source age, ISM density, and lobe velocity. Under adiabatic assumption and using empirical jet power-radio luminosity relation, we estimate that most compact sources are indeed young ($10^3 - 10^4$ yrs) and expand into a relatively dense ISM at speeds 0.01c – 0.1c

Results so far

- Followup imaging revealed that our sample of obscured quasars has **compact radio morphologies** (<0.2", <1.7 kc at z~2)
- 40% - 55% of our sample are curved or peaked (similar to CSS/GPS/HFP sources) and are mostly unresolved. They are likely to be **compact and young.**
- Application of a radio lobe expansion model suggests relatively **younger ages** and the red MIR-optical colors suggests a dense ISM.
- Current work includes: VLBA and eMERLIN ➜ energetics of the radio jets; ALMA ➜ ISM properties; LBT ➜ host morphologies; NuSTAR ➜ constrain the accretion properties and directly quantify the obscuration

Work in Progress



Radio

Multifrequency , multi-scale imaging with VLA, e-MERLIN, VLBA. We plan to fully establish the "evolutionary stage" of each source – its age and energetics, and its development and relation to the surrounding medium.

ALMA

Left. A resolved 870 micron continuum emission compared with radio emission contours (pink). **Middle:** CO (7-6) Moment 0 map. **Right**: A broad integrated CO line profile suggesting jet-driven outflows or turbulent ISM.

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References:

Patil et al. 2020, ApJ, 896, 18; Lonsdale, C. J., et al., 2015 ApJ, 813, 45. Nyland, K., et al., 2018, ApJ, 859, 23, Patil et. al, 2018, ASP, 517, 595; Patil et al. in prep

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