Young Radio AGN in the ngVLA Era

An Example of Heavily Obscured Quasars

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Motivation

- Most massive galaxies are now thought to go through an Active Galactic Nucleus (AGN) phase one or more times.
- Characterizing the onset of AGN activity is essential to our understanding of the evolution of galaxies and growth of SMBHs .
- Young, compact radio AGNs represent an important phase in the life cycles of jetted AGN and provide direct insights into associated physical processes.

Key Science Questions

- The nature of AGN: Triggering, intermittency, duty cycles, variation in intrinsic and observed properties
- Role of AGN in the SMBH-host galaxy co-evolution across cosmic time
- The energetic and dynamic impact of radio jets on their surroundings

Need for the next-generation facilities

- In-depth studies using current instrumentation are limited to either nearby or distant and luminous populations.
- A complete census of radio AGN will only be possible by superb sensitivity, high spatial resolution, and broad continuum coverage offered by next-gen radio telescopes.

A Case Study: WISE/NVSS selected Quasars

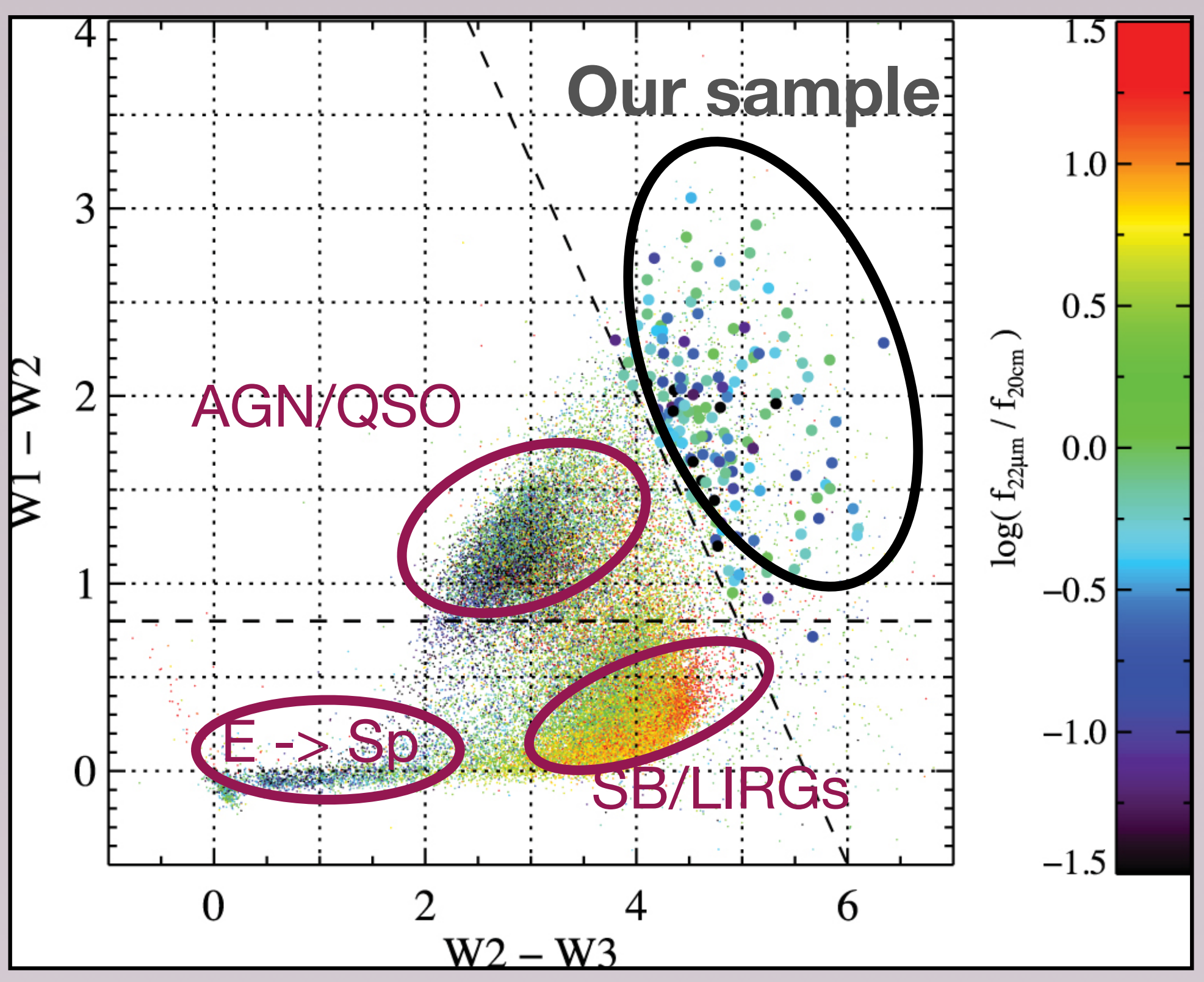

Fig 1. The WISE Color space: Heavily obscured and luminous sources tend to occupy redder MIR colors. Our sample is highlighted by a black circle (Lonsdale et al. 2015).

- Selection Criteria: Extremely Red WISE Colors, Compact and Bright NVSS Emission, Optically Faint
- 151 sources, $z \sim 0.47\text{-}2.8$, $L_{IR} \sim 10^{12.5-14} L_\odot$
- MIR analyses ➜ luminous, radiative-mode AGN and heavy obscuration possibly due to peak fueling phase
- 10 GHz JVLA imaging and radio SED analyses ➜ Majority have compact radio morphologies and curved/peaked radio SEDs
- ***Our sample is believed to be in a unique evolutionary state with new-born radio jets***

A sample of young radio AGN

- Our ongoing and planned multi-wavelength approach:
- VLBA and eMERLIN ➜ energetics of the radio jets; ALMA ➜ ISM properties; LBT ➜ host morphologies; Chandra and NuSTAR ➜ constrain the accretion properties and directly quantify the obscuration

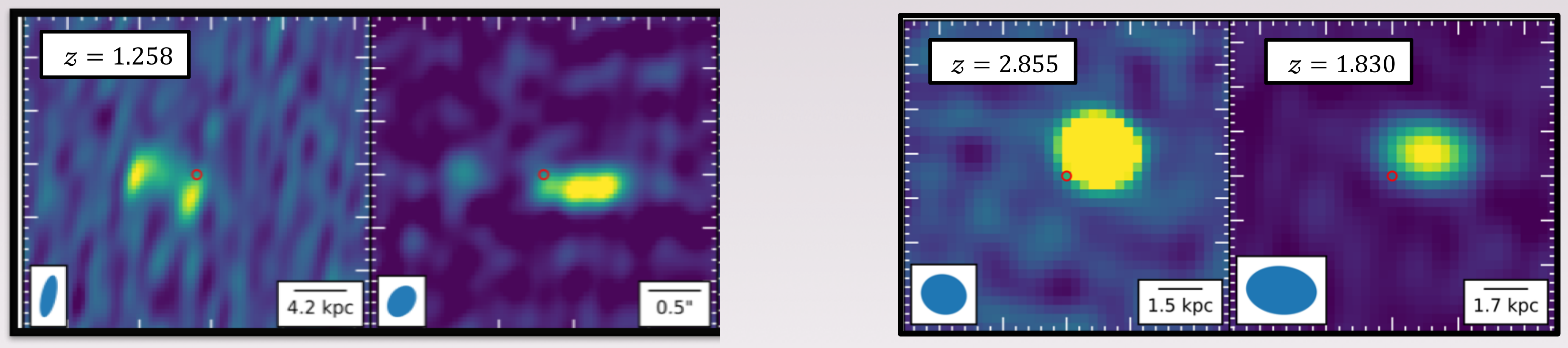

Fig 2. JVLA10 GHz observations of our sample. Majority are unresolved, thus having linear sizes <2 kpc (right panel). The remaining 28% of sources show interesting morphologies on scales < 50 kpc

ngVLA capabilities

- Number of Antennas: ~ 214 (main) + 30 (LBA)
- Frequency Range: 1-116 GHz
- Resolution: 0.5-44 (main) + 0.06-5 (LBA)

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- Improved Sensitivity
- Spectral and Spatial Resolution

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Deep, spatially, and spectrally-resolved surveys of compact radio jets in a wide range of systems

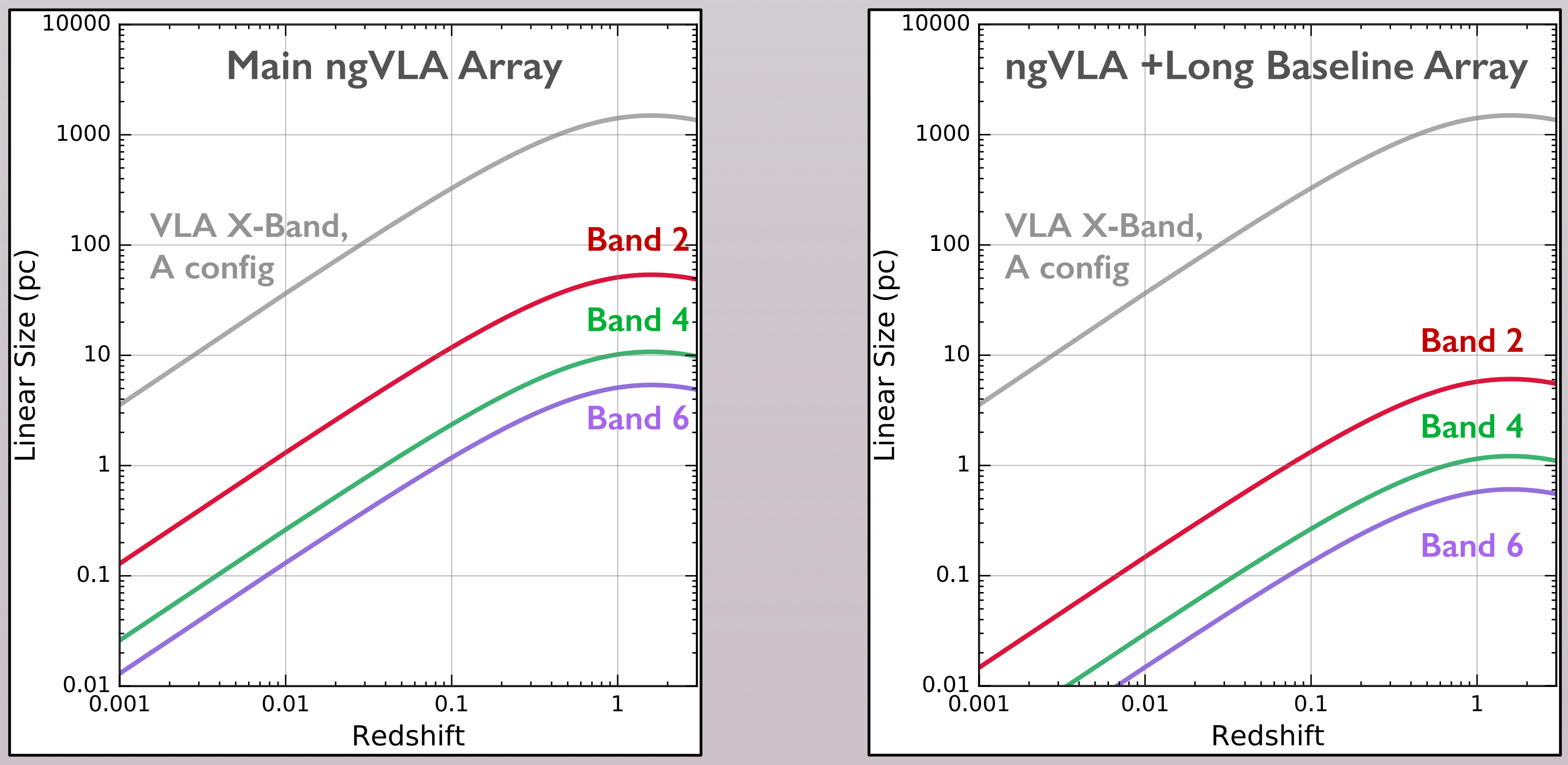

Fig 3. Linear size probed by ngVLA frequency bands as a function of redshift. The ngVLA main array with the addition of continental baselines will be able to resolve parsec-scale radio emission at z ~ 2.

Mapping Radio Morphology

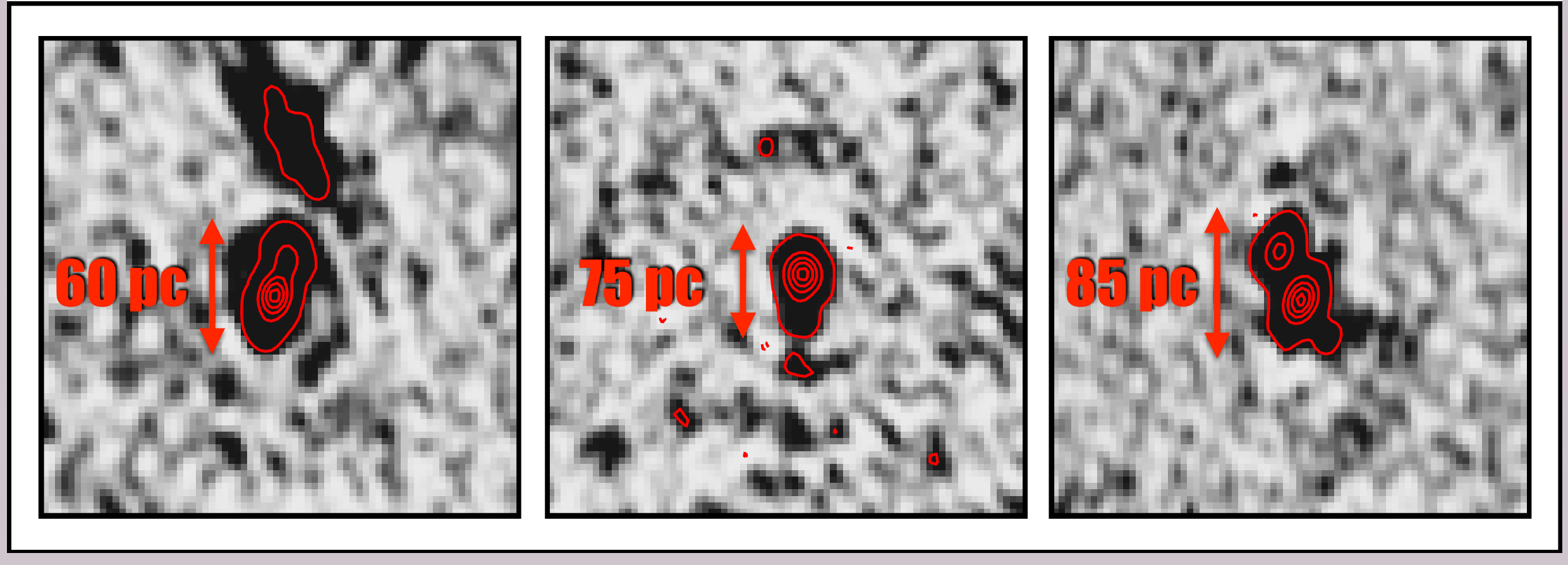

Fig 4. Example Very Long Baseline Array continuum images (Nyland et al. 2018; Patil et al.2018) of young, compact radio AGN with extents of tens of pc. These sources are drawn from the WISE-NVSS sample (Lonsdale et al. 2015)

- The high spatial resolution of the ngVLA will enable resolved mapping of young radio AGN on sub-kiloparsec scales (10pc-1kpc) over redshifts z~1-6.
- Such surveys will provide the structural, spectral, and polarimetric information on the radio jets necessary to quantify their energetic impact on their hosts and improve our understanding of their role in galaxy evolution.

Multi-wavelength Synergy and AGN Science

A complete understanding of young radio AGN in luminous quasars at z > 1 will require the combination of ngVLA + ngLOBO observations with current and future next-generation instruments in the mm/submm, optical, and X-ray

Radio	Submm	Infrared	Optical	X-ray
SKA ngVLA, ngLOBO	ALMA	WFIRST JWST	TMT GMT	Lynx
Interpreting evolutionary stage of radio sources, spectral studies HI absorption, low-J CO emission	SFRs, dust & ISM conditions high-J CO lines	Delineating AGN & SF, AGN outflows, and excitation mechanisms	Resolving host morphologies, kinematics of warm ionized gas	AGN Accretion properties

References

Patil et. al, 2018, ASP, 517, 595; Lonsdale, C. J., et al., 2015 ApJ, 813, 45. Nyland, K., et al., 2018, ApJ, 859, 23, Patil et. al. in prep, Taylor, G., et al., 2017, Arxiv e-prints. 1809:0090; O'Dea, C. P. 1998, PASP, 110, 493

Next Generation Very Large Array
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