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Strong lensing with upcoming wide-field radio surveys

Samuel McCarty
(Univ. of Washington, CfA grad student in the fall)
Advised by Liam Connor (CfA)

VLA from public.nrao.edu

Why do strong lensing science in the radio?

Extremely high angular resolution with VLBI

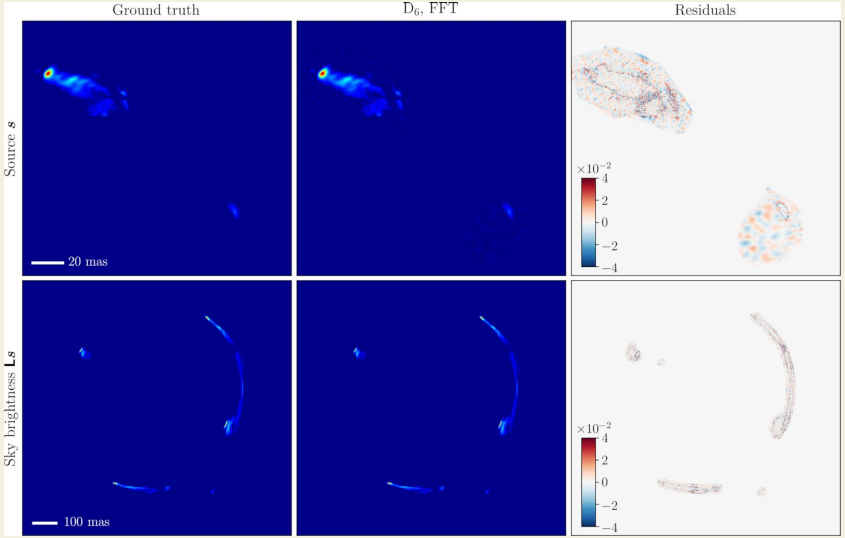
Radio sources observable to high redshift

Polarization (Stokes IQUV is preserved)

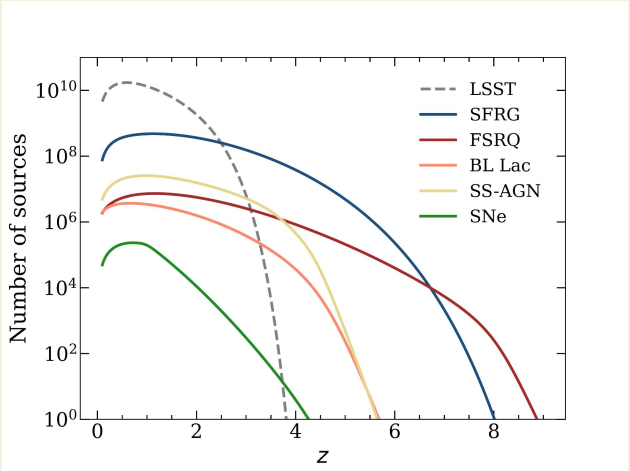
Clean - deflector galaxy is often radio quiet

No dust, no atmosphere (seeing)

Complementary information to other wavelengths!



0.25% error in recovered lens parameters with 3 mas resolution from VLBI!



$\langle z_{\rm source} \rangle \approx 2$

For DSA-2000

Spingola et al. 2018, Powell et al. 2020

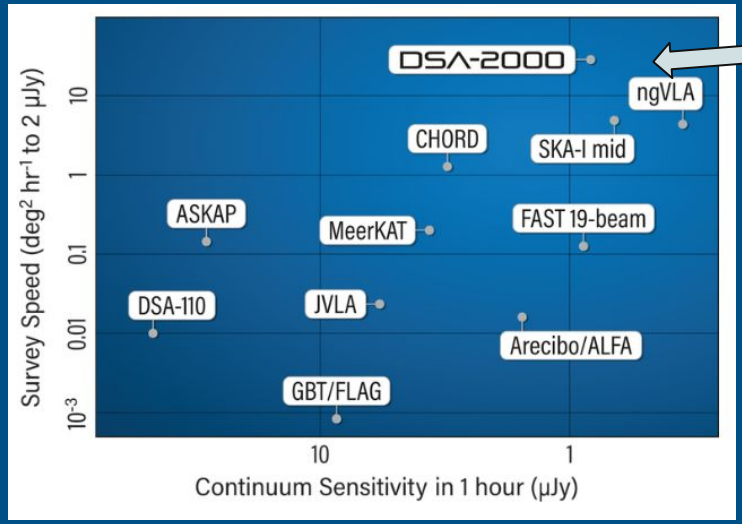
Strong lens studies in the radio have been limited in past decades by the less than ~100 known radio lenses.
How will this change with next generation radio telescopes?

DSA-2000

The next generation radio survey

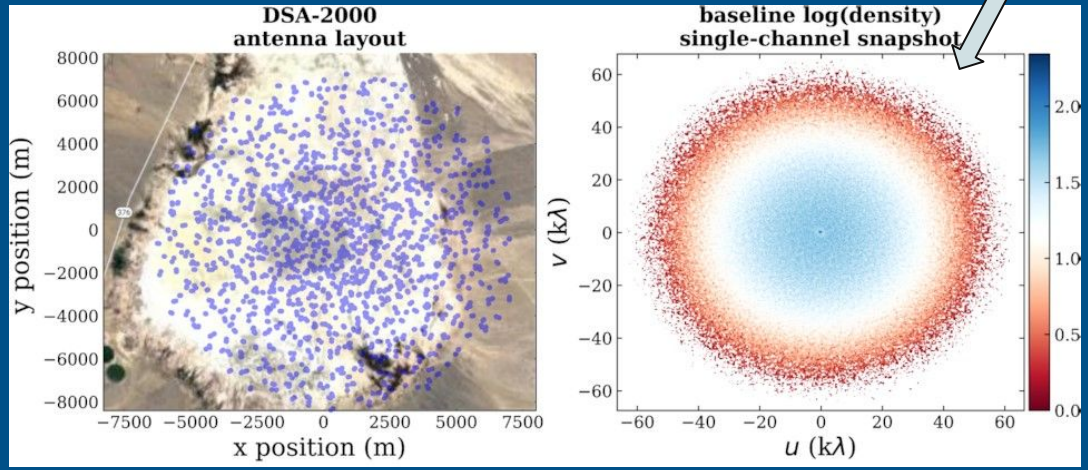
Unprecedented survey speed and sensitivity

2″ resolution at top of 0.7–2 GHz radio band



Order of magnitude better survey speed!

Filled aperture radio "camera"!

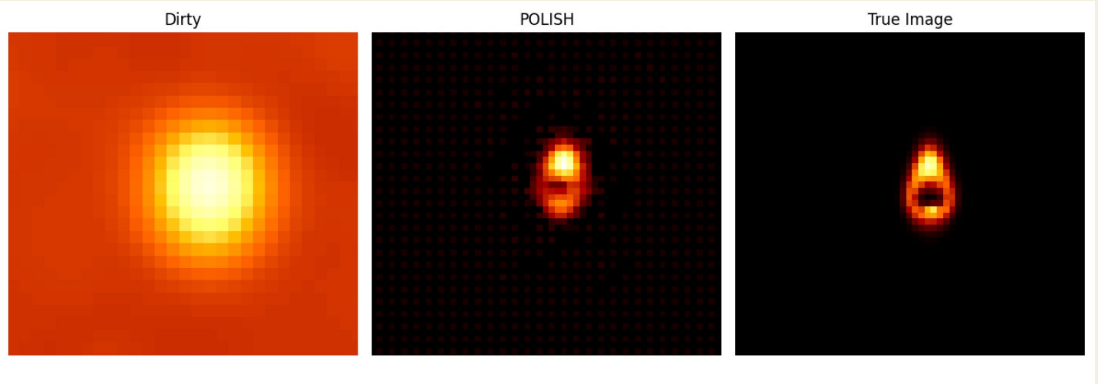


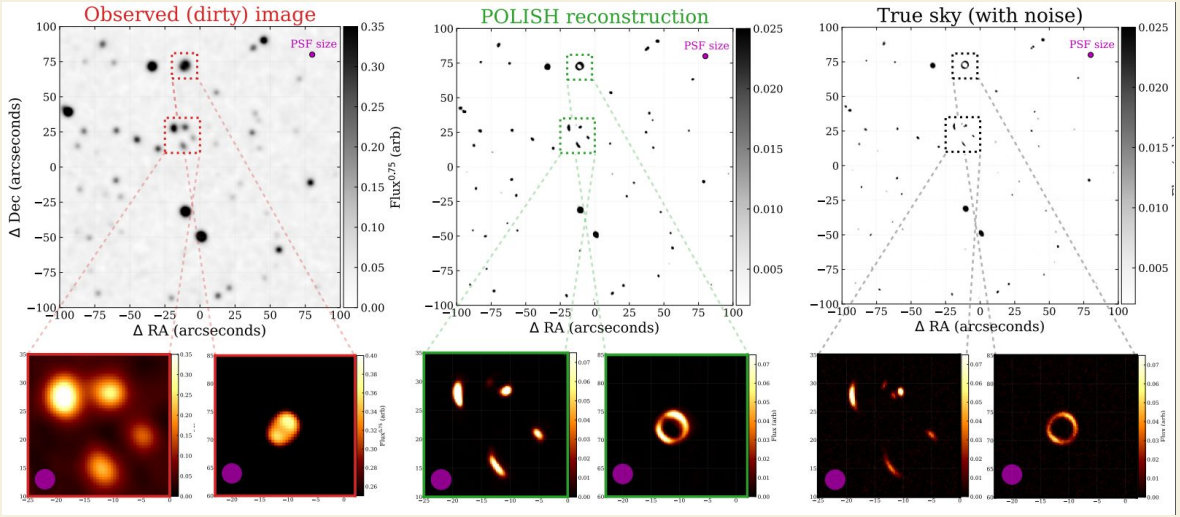
Hallinan et al. 2019, Connor et al. 2022, deepsynoptic.org

Superresolution with the DSA-2000 for lens finding

Superresolution down to 1″ for DSA-2000 enables discovery of more galaxy scale lenses

Not *necessary* for lens finding, but *possible* with modern computer vision and deterministic PSF in the radio





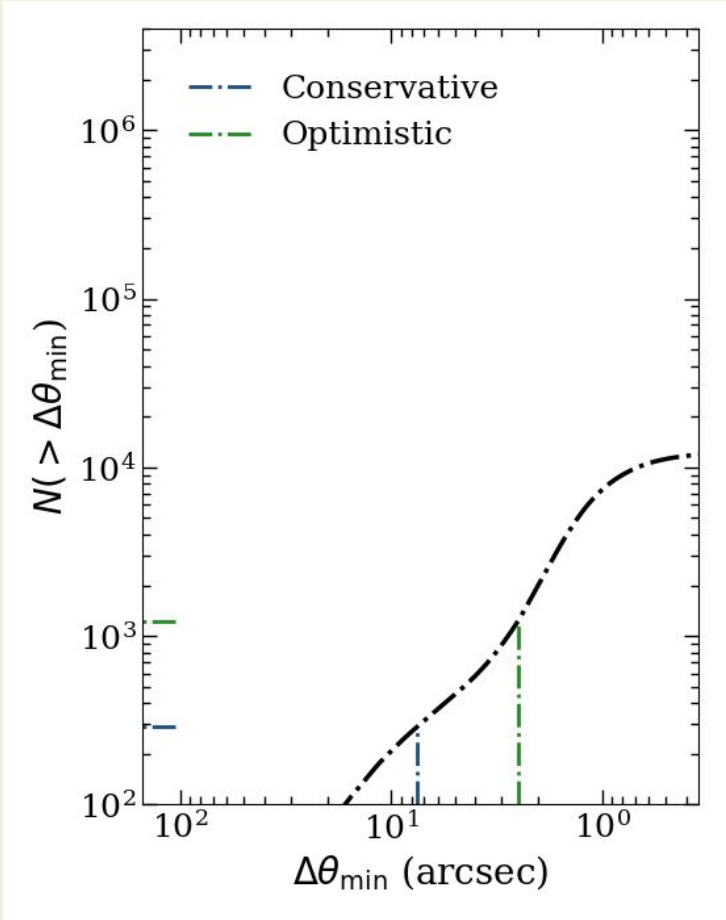
Connor et al. 2022

Our work

Forecasting expected lensing yields in DSA-2000, SKA-mid, and VLA all sky surveys, using up to date expected performances

Modeling galaxy, galaxy group, and galaxy cluster lenses

Δθ > **3** x PSF FWHM (conservative) or Δθ > PSF FWHM (optimistic)



VLASS

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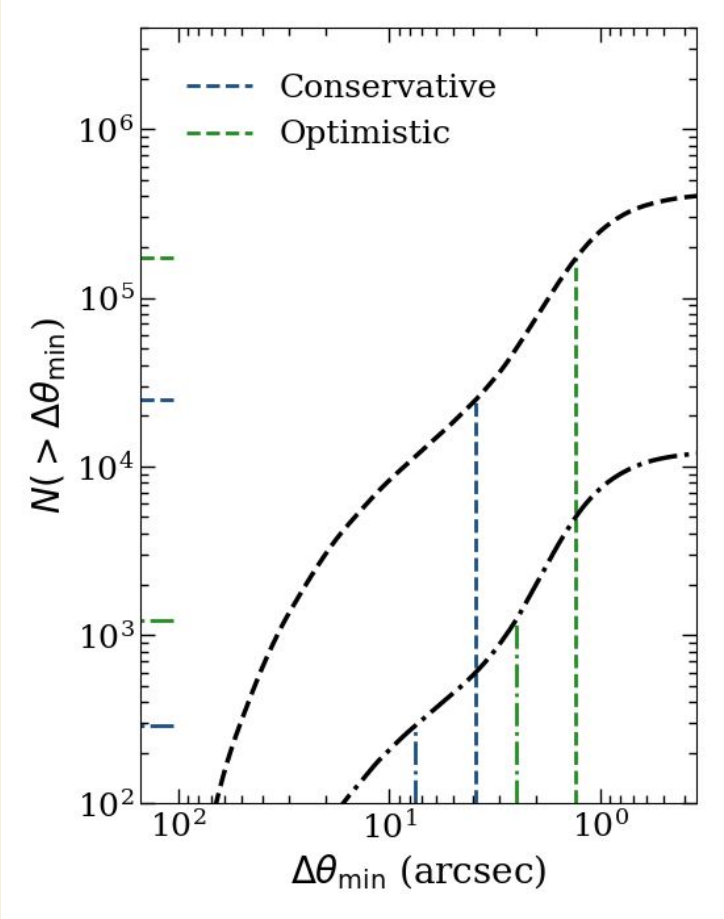

SKA-mid AA*

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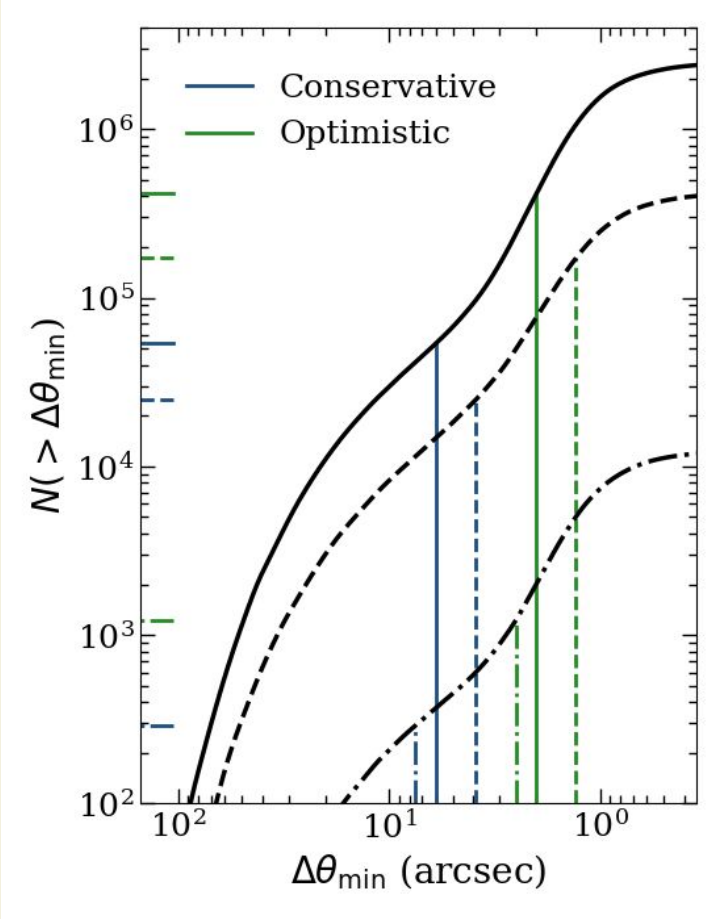


DSA-2000

SKA-mid AA*

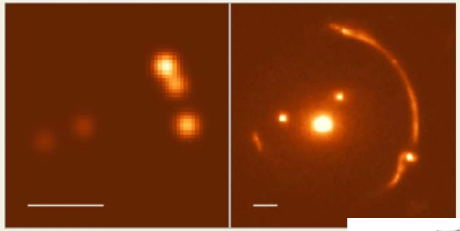
VLASS

Applications

DSA-2000 is a **discovery engine**

Dark Matter (Sub)structure

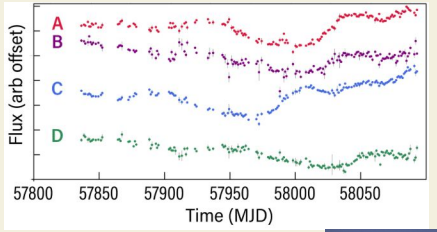
Increase sample size by OOMs



High res ngVLA follow-up

Time-delay Cosmography

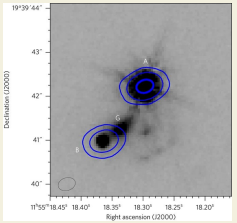
100s of lensed time-variable sources

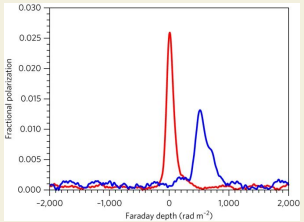


High cadence multiwavelength follow-up

High-redshift Universe

Thousands of lenses at z_{source}>5

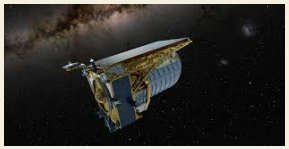


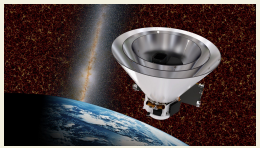


Magnetic fields at cosmological distances and more

Significant Survey Overlap

30,000 deg² footprint





Vegetti et al. 2023, Mao et al. 2017, deepsynoptic.org