

Credit: SKAO



Wide-field VLBI surveys in the SKA-era

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VLBI in the SKA-era - 15/02/2022



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Outline

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1. Importance of wide-field VLBI surveys

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2. What will wide-field VLBI look like in the SKA-era?

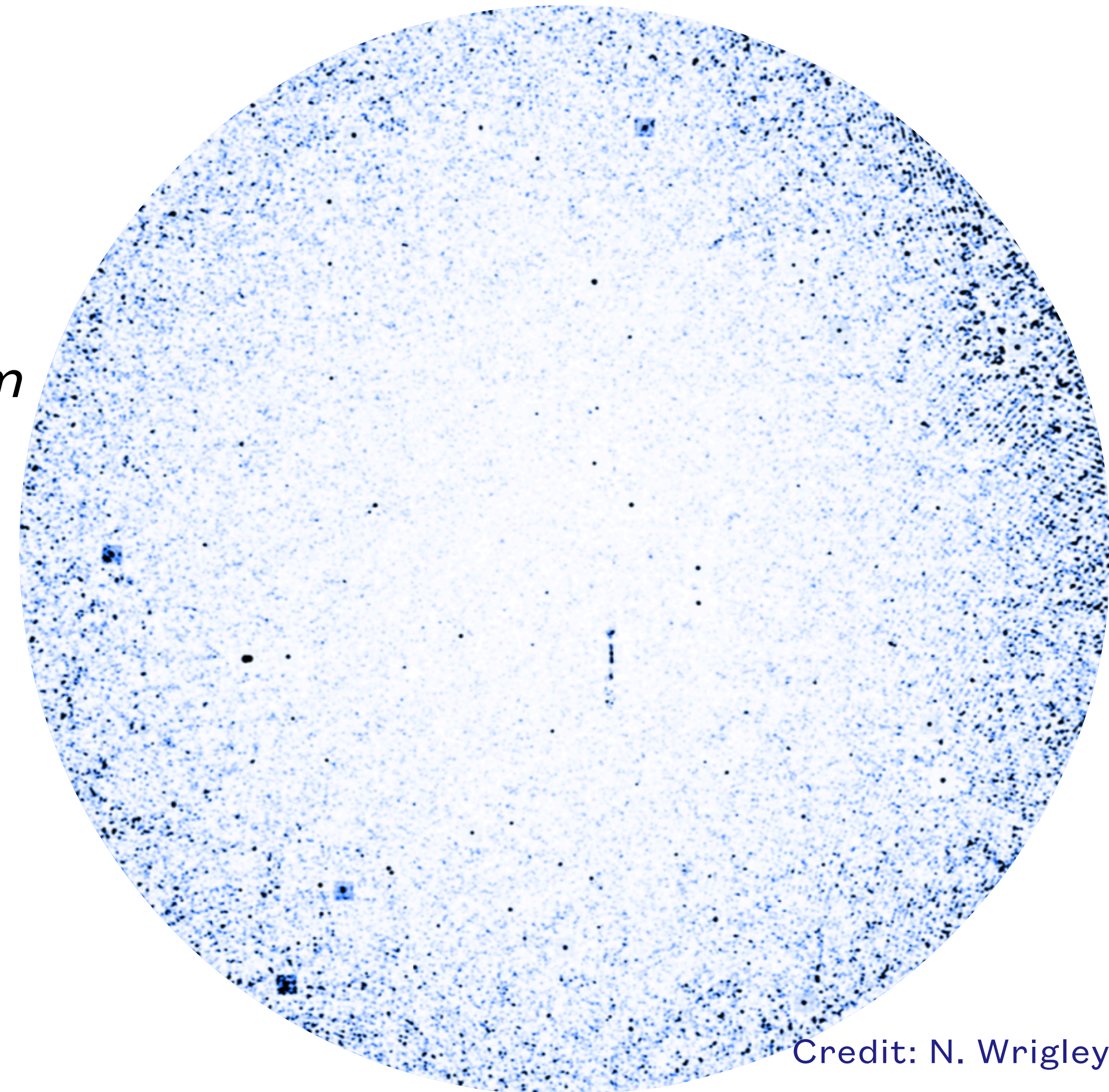
Outline

1. Importance of wide-field VLBI surveys
2. What will wide-field VLBI look like in the SKA-era?
3. The SKA-VLBI simulations working group

Defining wide-field VLBI

What do we mean by wide-field VLBI?

- Simply concerned with *imaging the entire primary beam of a VLBI array*
- Multiple science targets in one observation



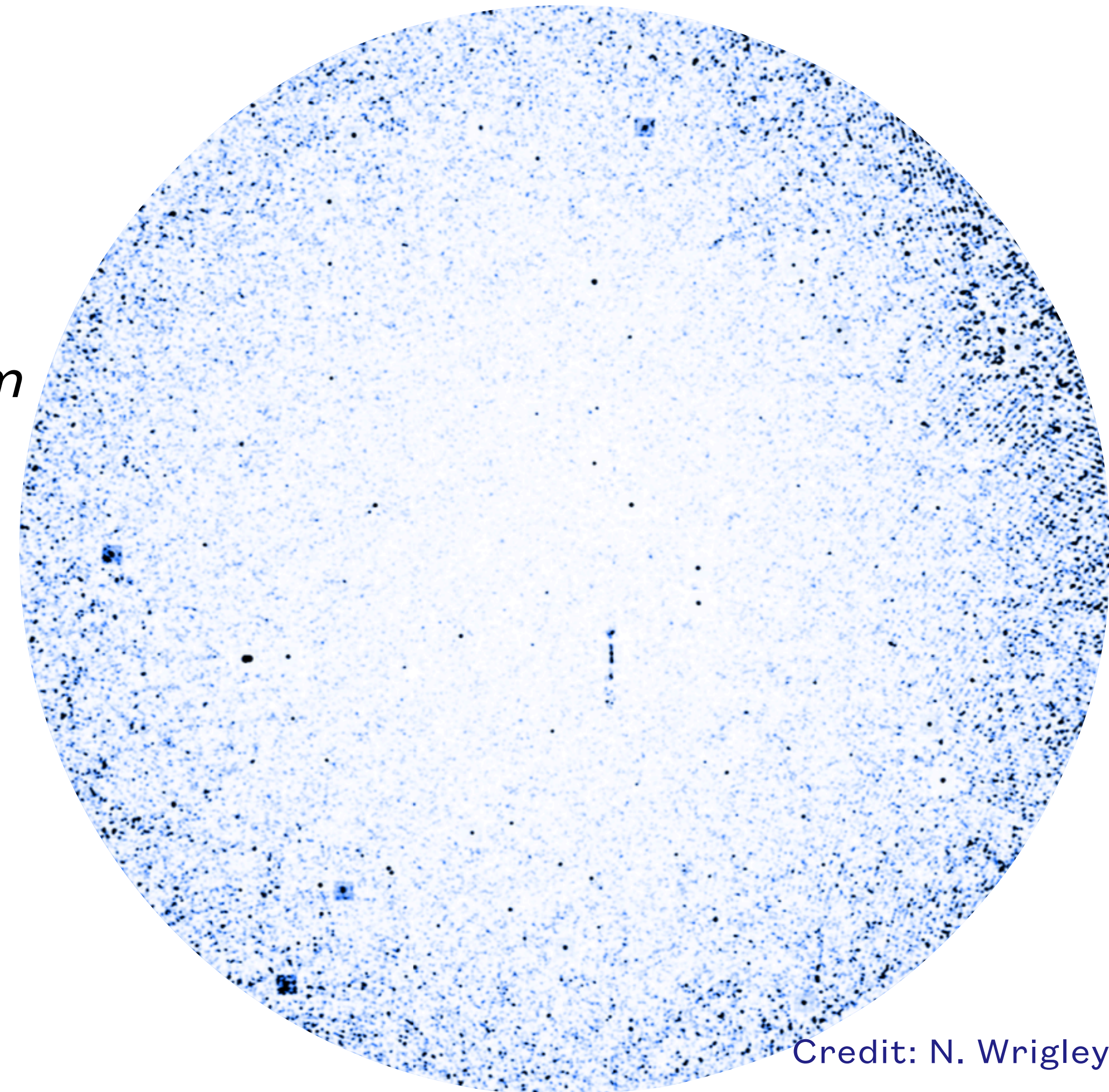
Primary beam corrected
JVLA+MERLIN image of the GOODS-N field

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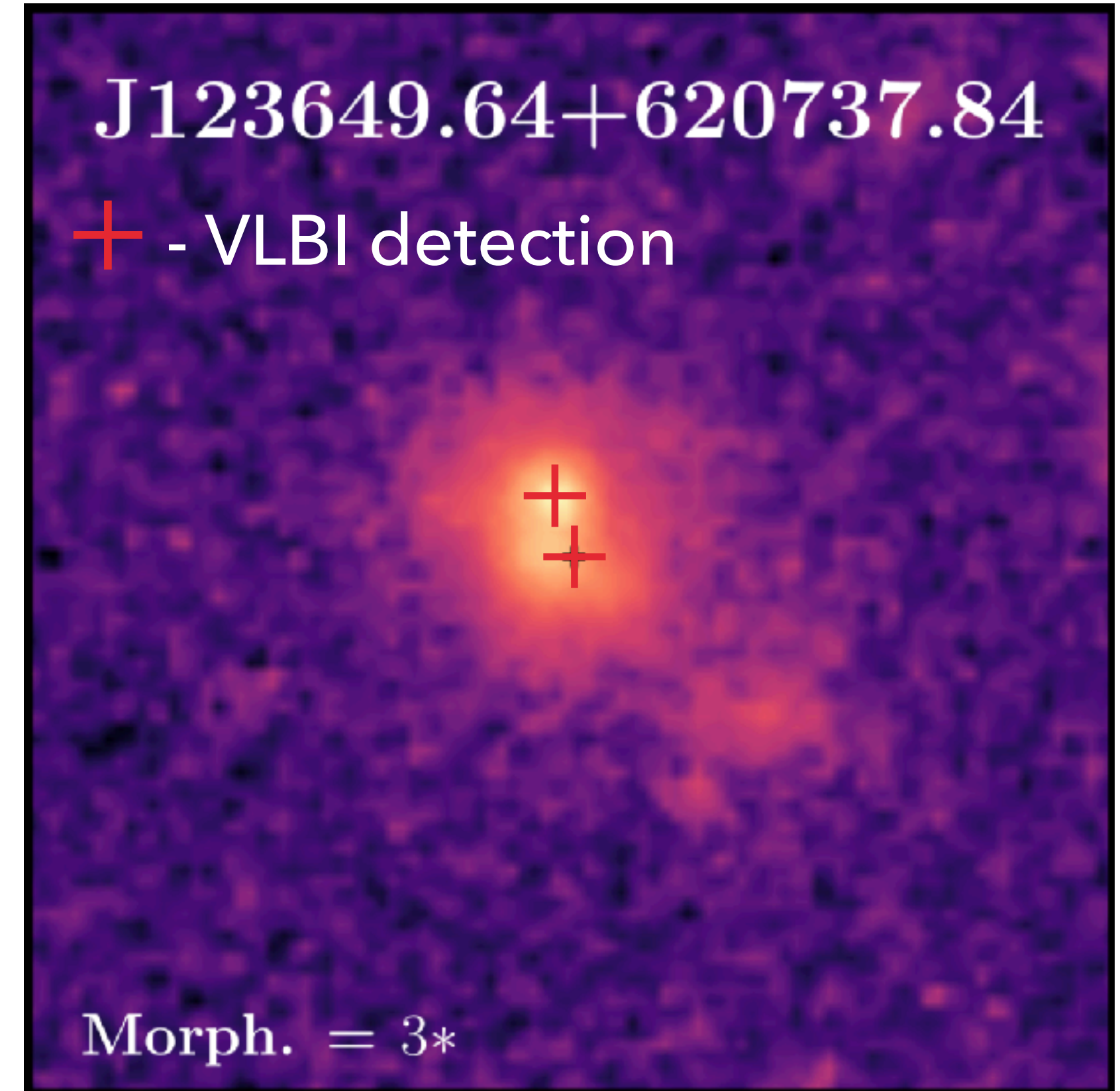
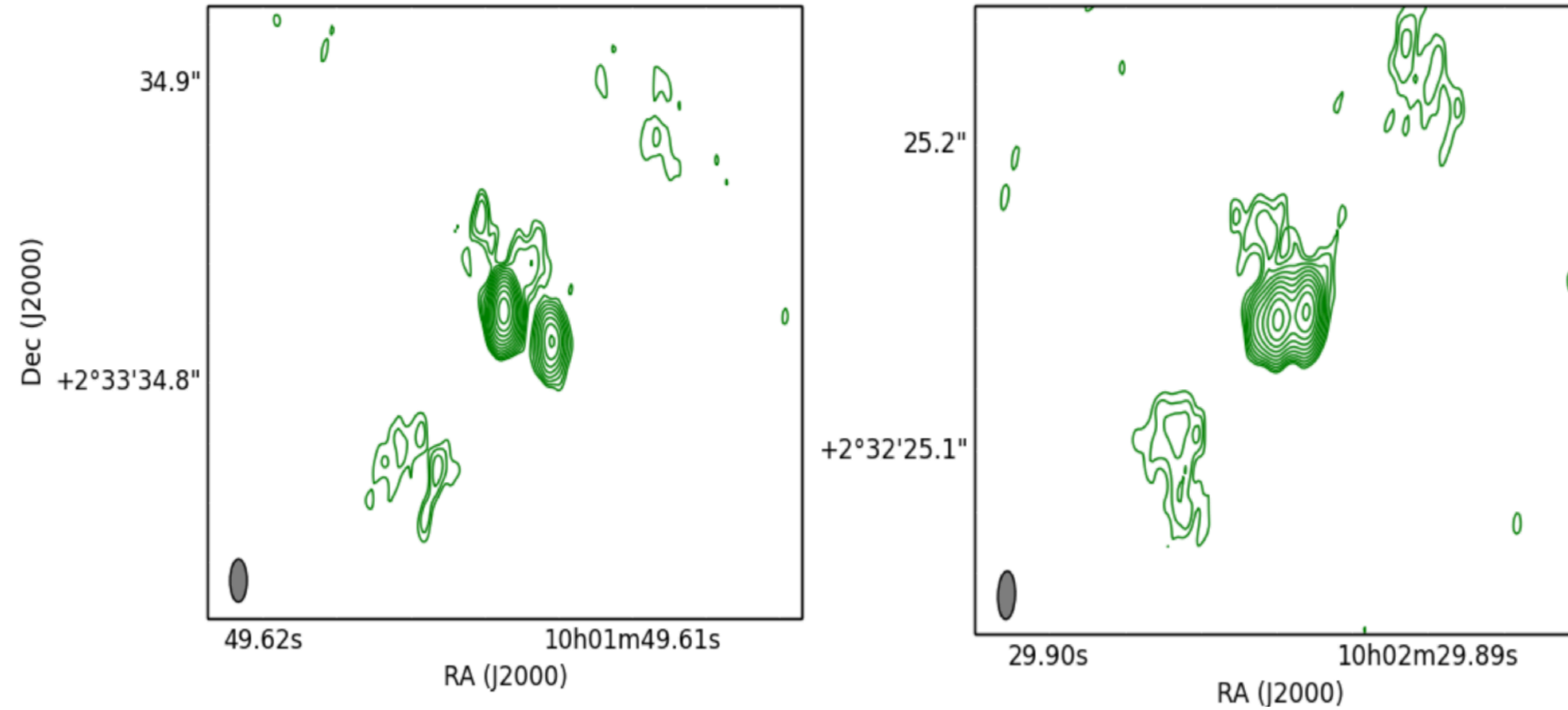
What are the advantages of imaging the entire primary beam?



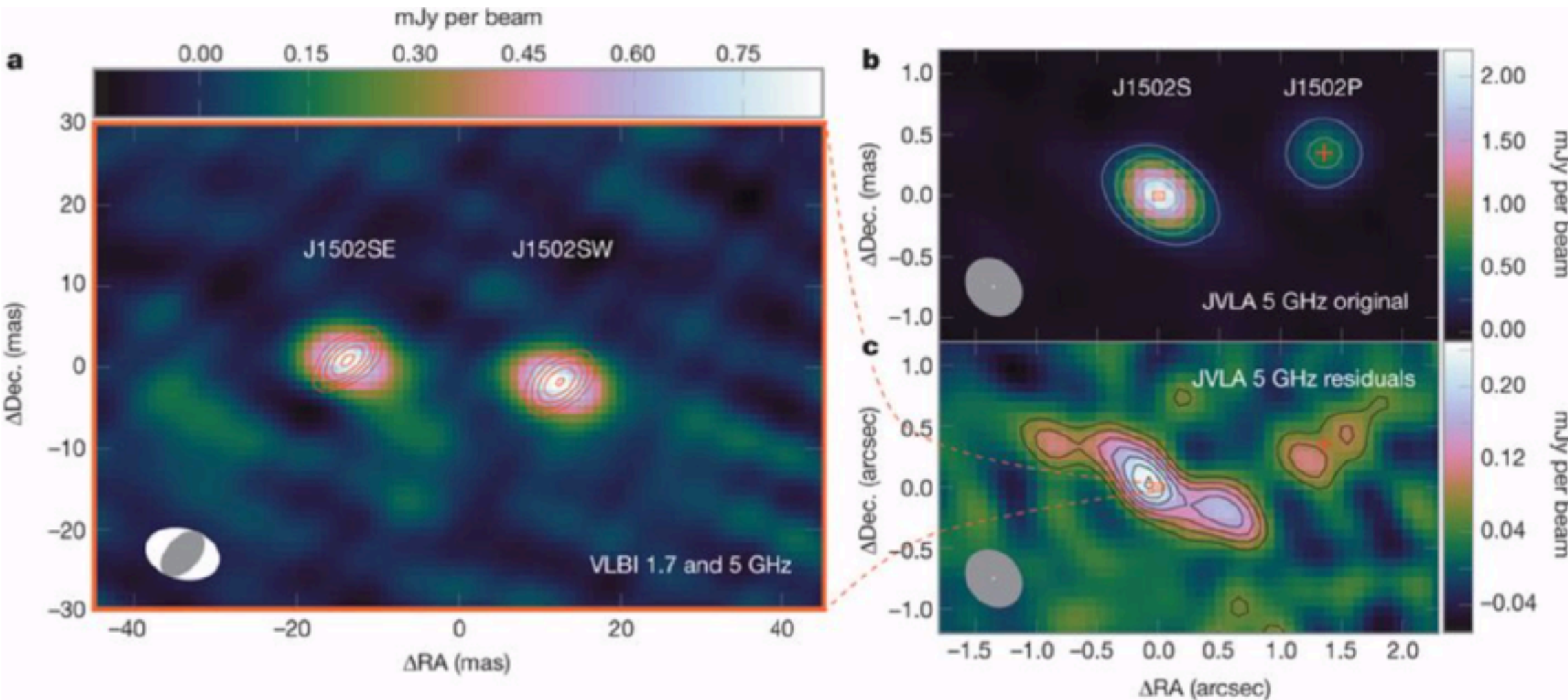
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Some science examples - supermassive black hole binaries

Herrera-Ruiz+17



Radcliffe+ in prep.

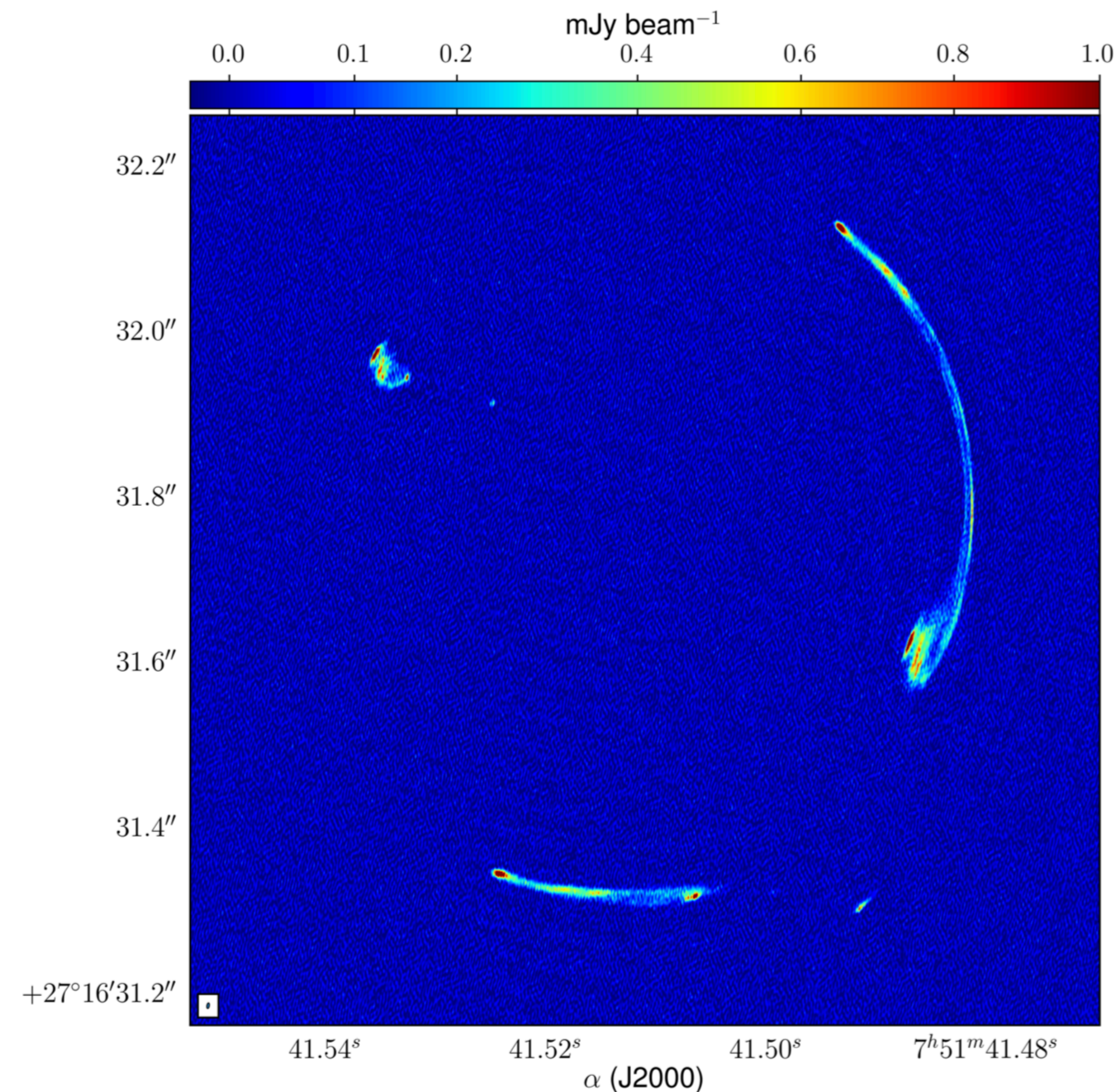
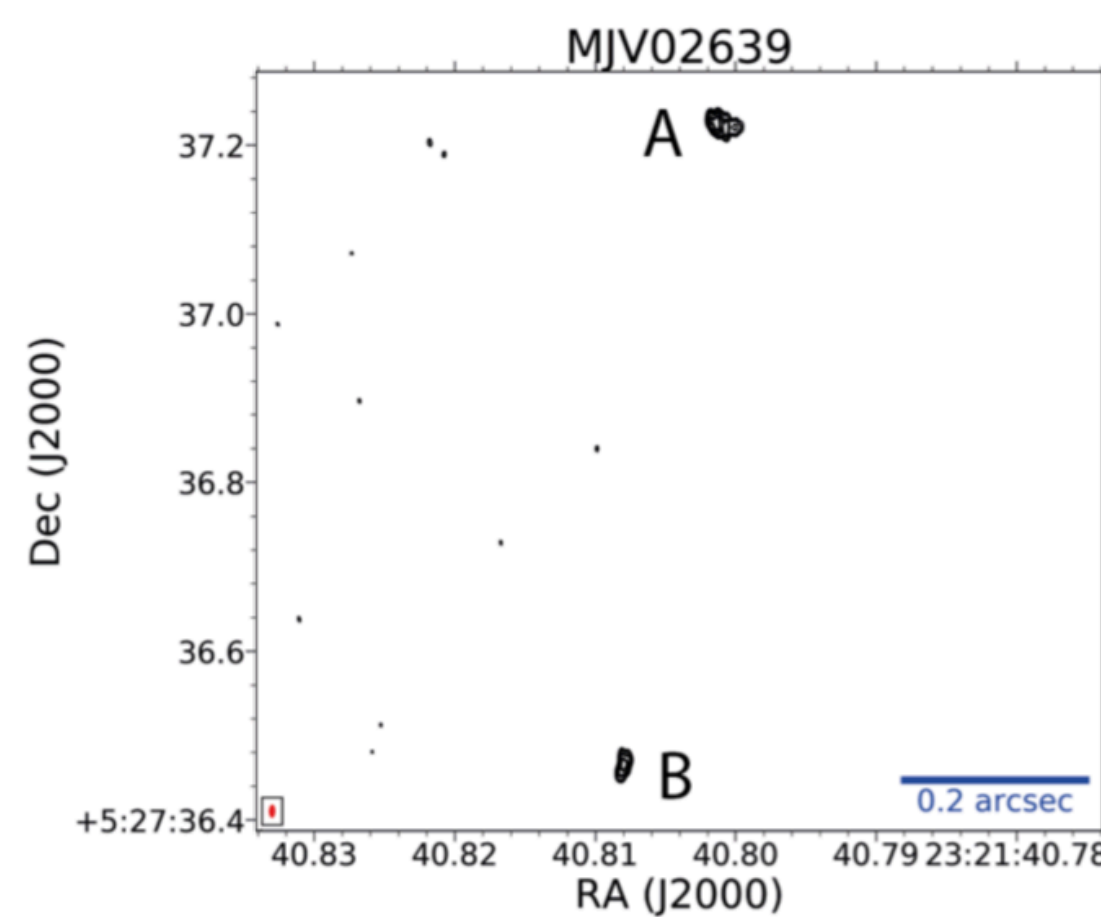
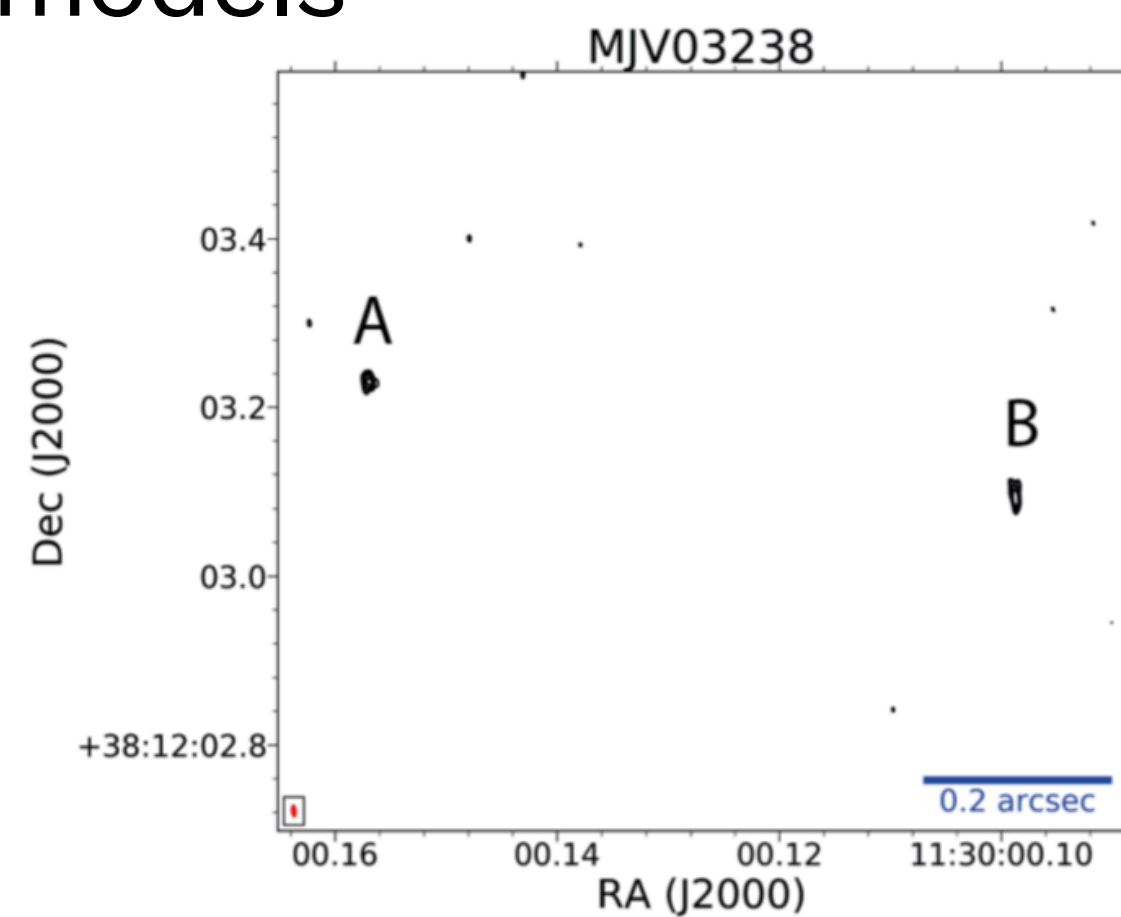


Deane+14

Gravitational lenses

Spingola et al. 2018, 2019

- Rare ($\sim 0.3\%$ of VLBI sources)
- Independently measure the sub-structure mass-function within galaxies.
- Unique probing of the low-mass end of the dark matter halo mass-function
- High resolution of VLBI can constrain lens models

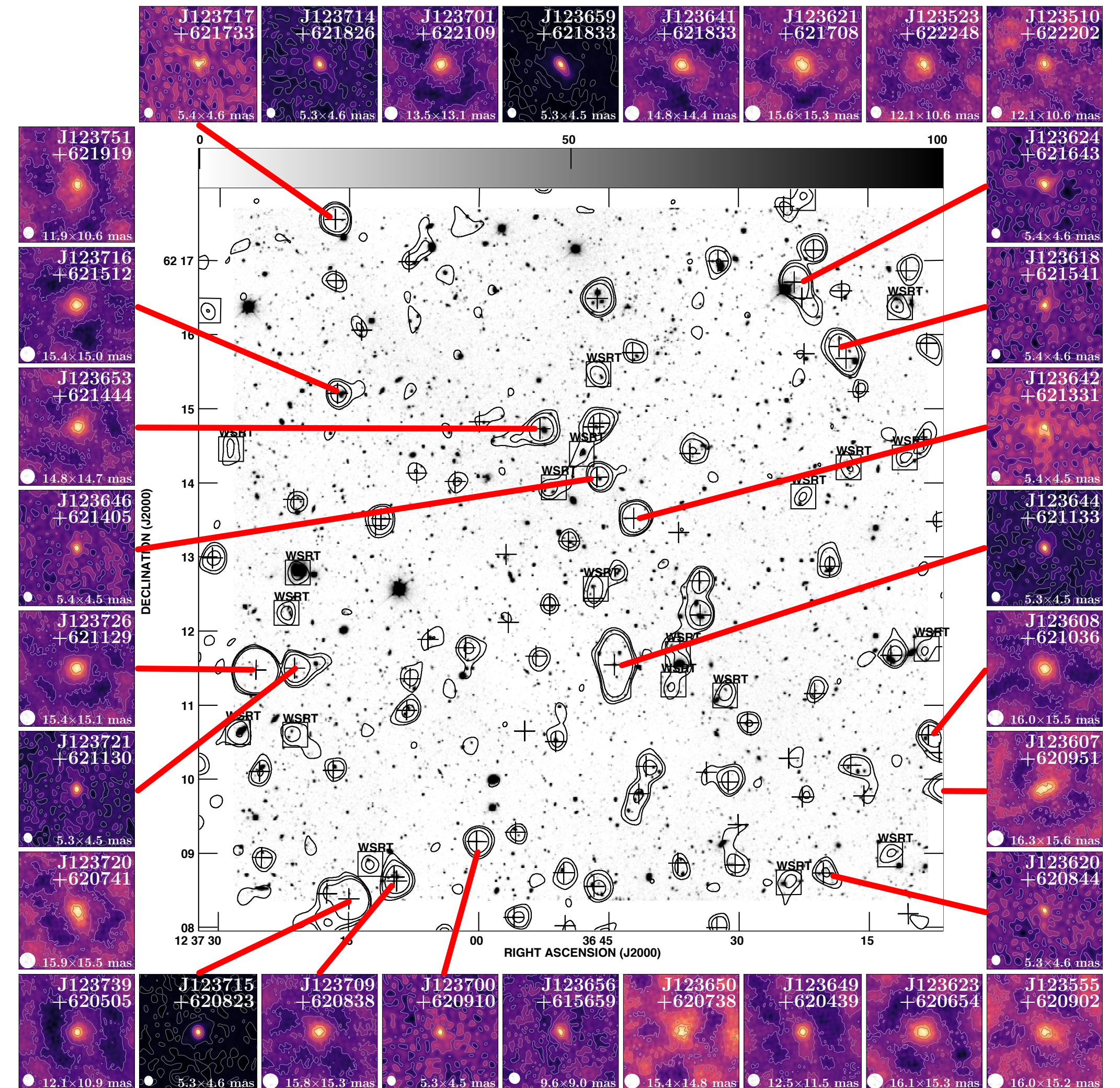


AGN surveys

- VLBI detection sure indicator of AGN (high brightness temperatures $> 10^5$ K)
- Use VLBI to understand nature of radio-mode AGN.
- Other AGN identification methods are incomplete or contaminated (e.g. Radcliffe+21a).
- *Many more wide-field VLBI use-cases too (e.g. ISM of nearest galaxies; Morgan+13, supernovae; Radcliffe+19, YSOs; Forbrich+21 etc.)!*

e.g. Middelberg et al. 2011, 2013; Herrera-Ruiz et al. 2017, 2018; Radcliffe et al. 2018, 2021a,b

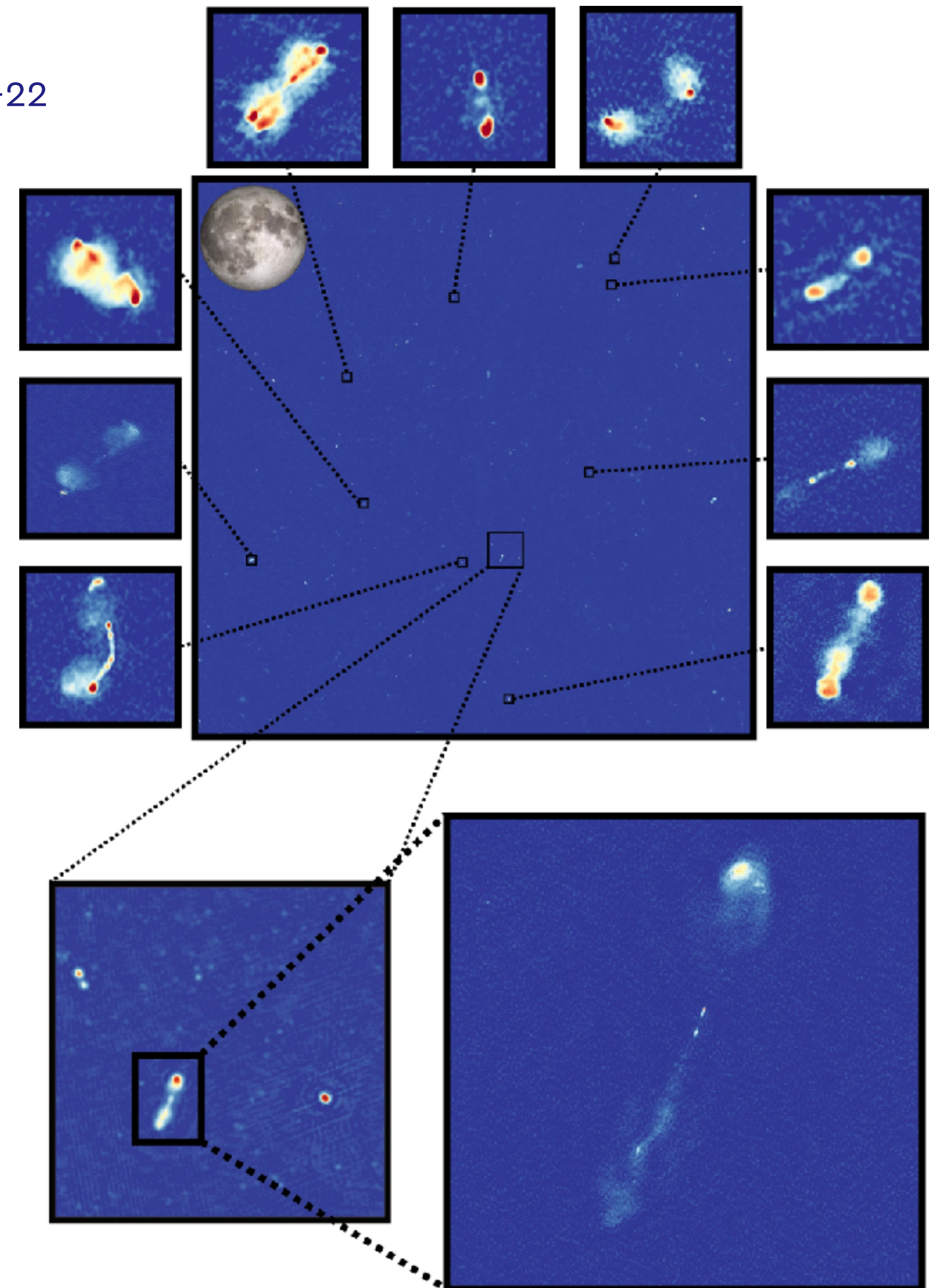
VLBI-detected AGN in GOODS-N (Radcliffe+18)



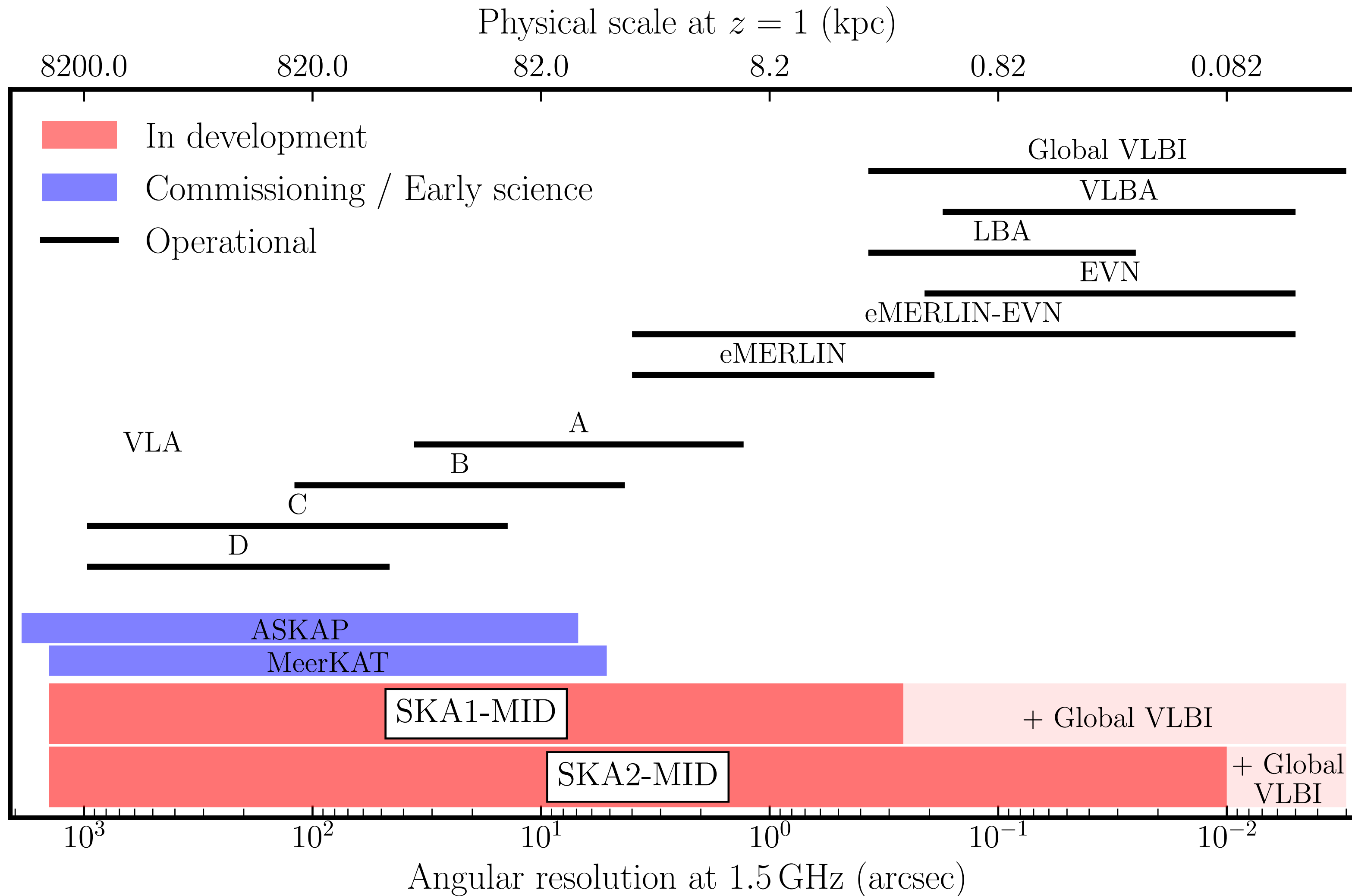
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Sweijen+22



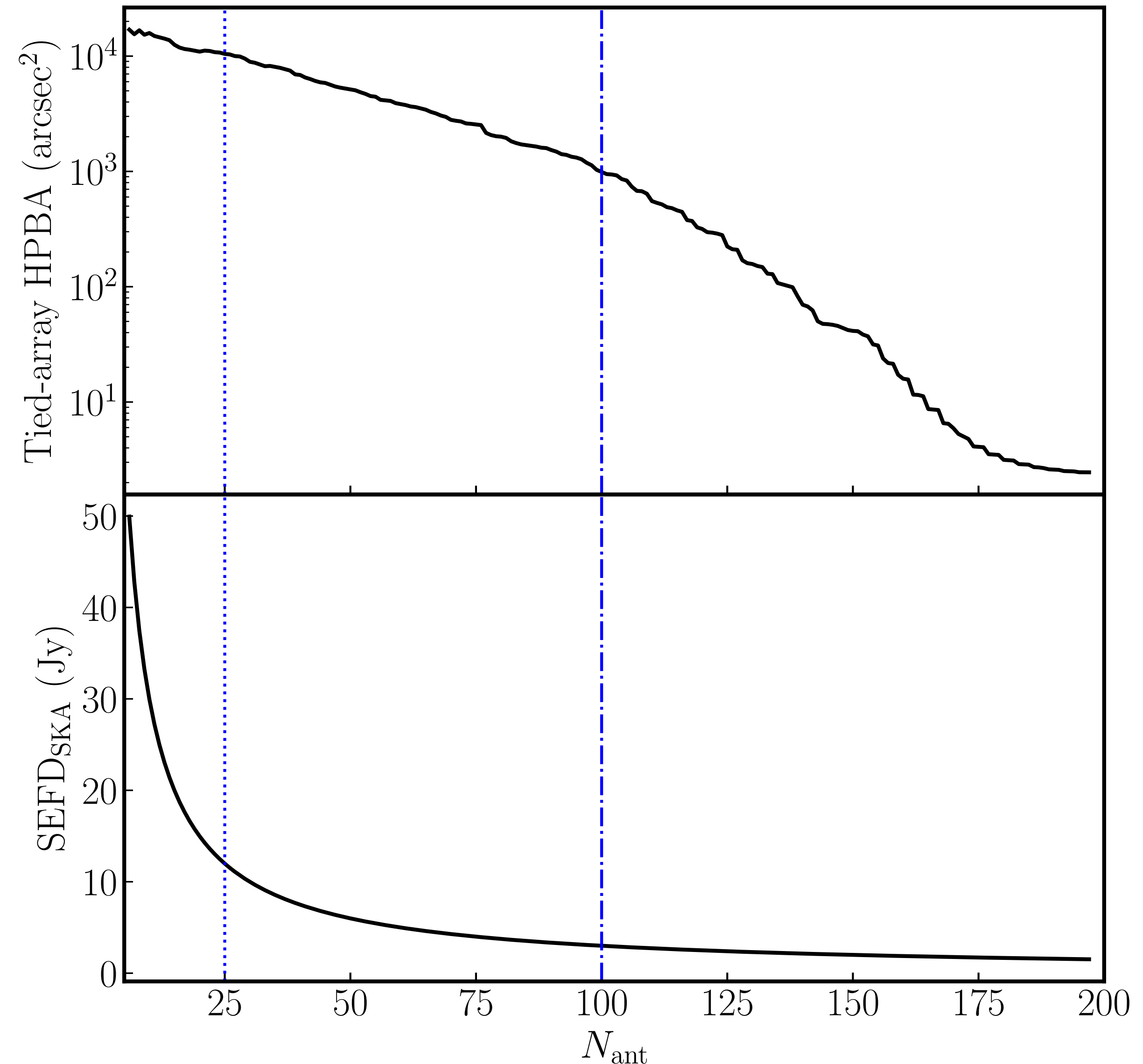
What will WF-VLBI look like in the SKA-era



- An initial thought on the capabilities of SKA-VLBI:
- Sub- μ Jy sensitivities due to very sensitive elements.
- Huge frequency coverage \rightarrow great uv coverage
- Huge imaging 'dynamic range' \rightarrow great image quality

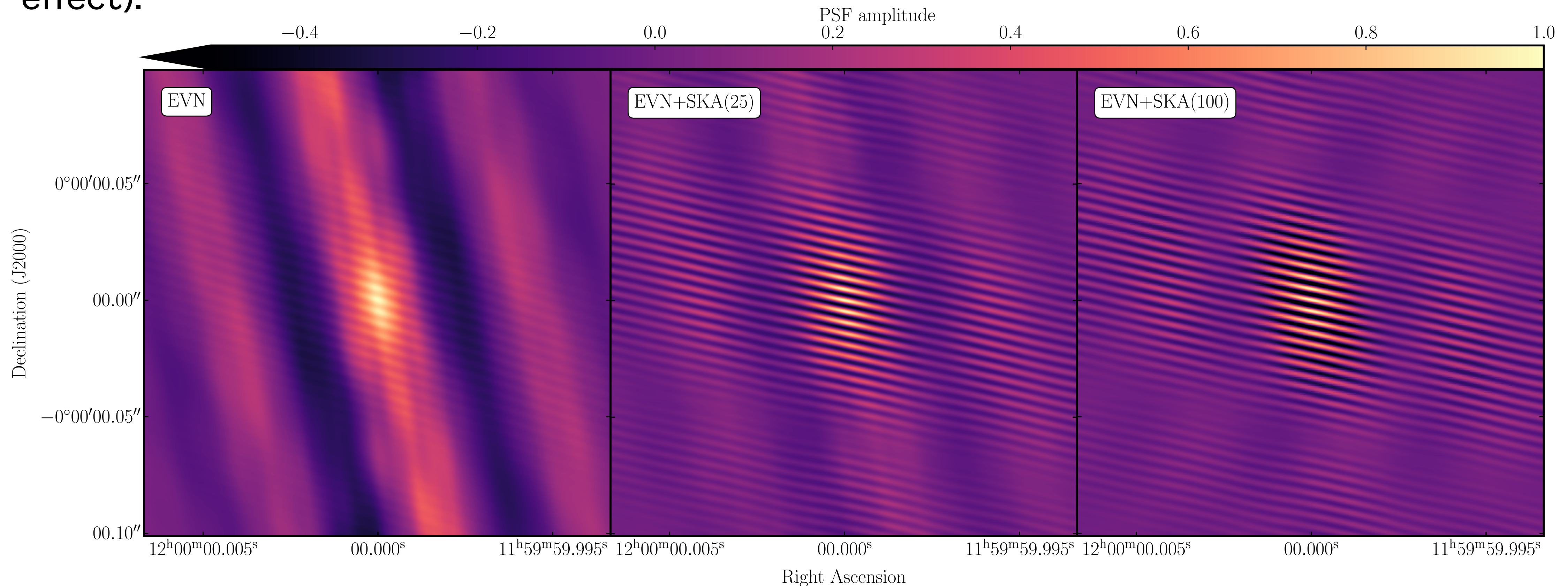
In reality

- We simply **do not know**... but we desperately need to find out.
- As a result, we need simulations and **fast**.
- For the next few slides, have replicated an EVN + SKA-MID observation (1.6 GHz, 1024 Mbps, 12hr @ RA=12h, Dec.=0d)
- SKA has single tied-beam with either central 25 antennae - SKA(25) - or 100 antennae - SKA(100).
- Primary beam size is taken as the tied-array PSF.

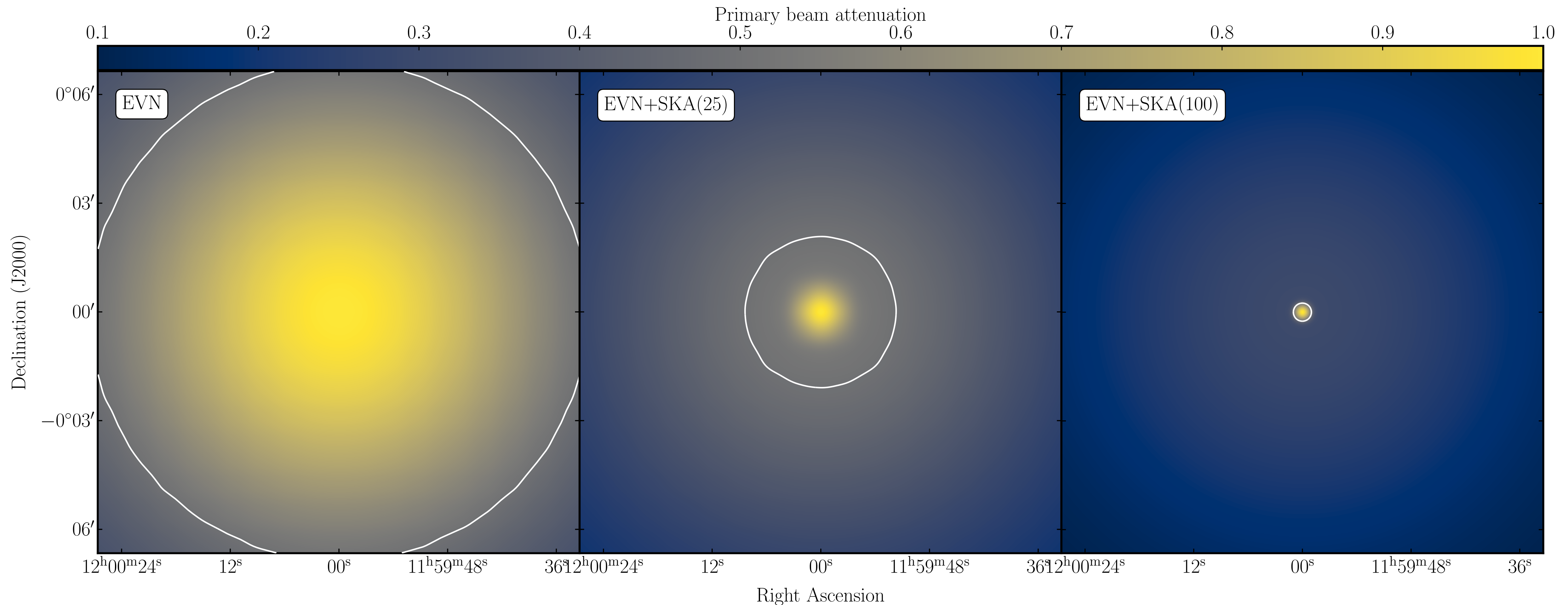


SKA-VLBI point spread function

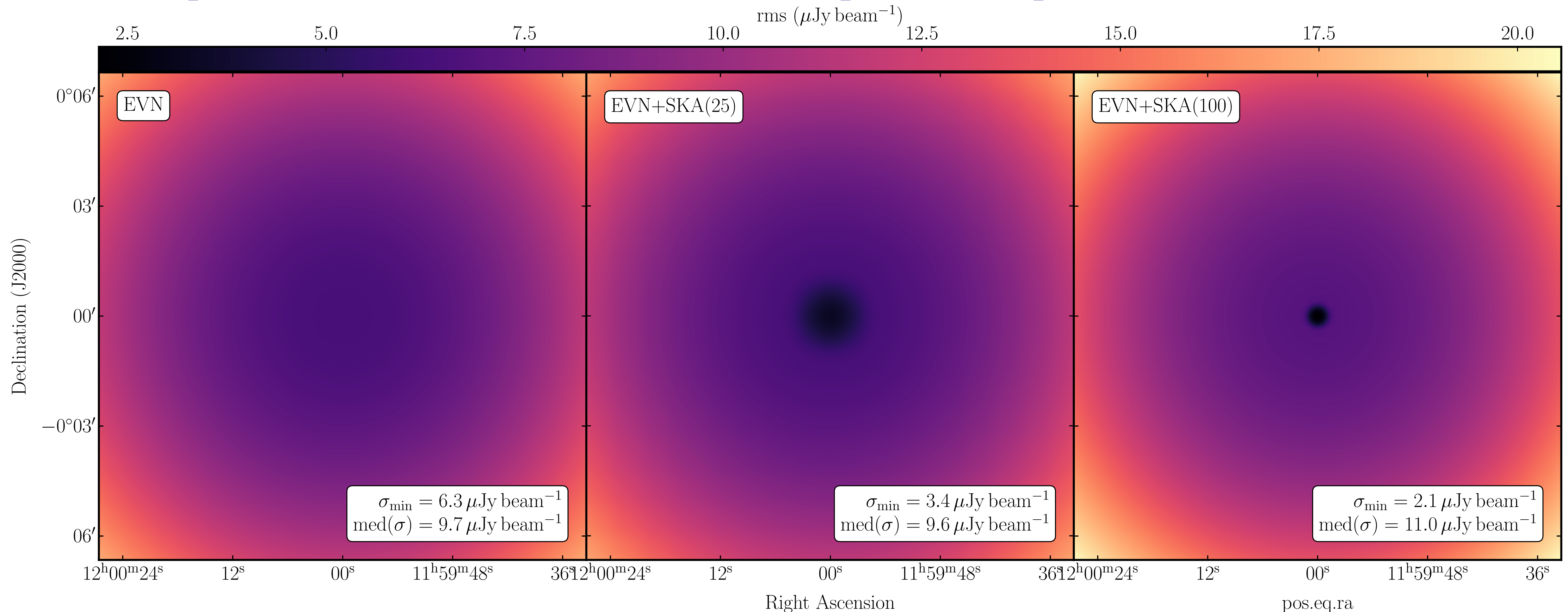
- Very non-Gaussian PSF
- Max. sensitivity images dominated by certain spatial scales i.e. long-sensitive SKA-baselines
- Flux densities will be systematically offset due to non-Gaussian PSF (Jorsater-van Moorsel effect).



Surveys with SKA-VLBI? - the primary beam issue



Surveys with SKA-VLBI? - the primary beam issue



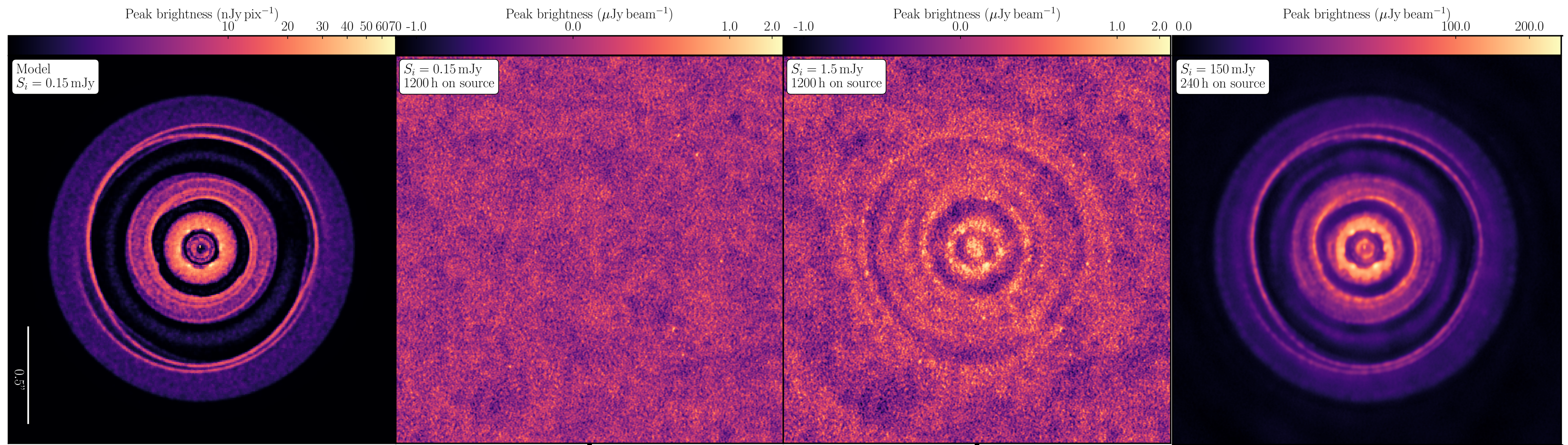
Strategies are needed for optimal sub-arraying, source correlation locations, and time-on source.

The SKA-VLBI simulations working group

- This is just a one science/use case. **We need to understand the true capabilities of SKA-VLBI.**
- Motivates the formation of the **SKA-VLBI simulations working group.**
- Group aims to:
 - Understand true capabilities of SKA-VLBI (both MID & LOW) for to advise all SWG cases (each of which will have different requirements).
 - Produce end-to-end data-products to help prepare data-processing workflows and contribute to SKA data challenges.
 - Generate user-friendly software (not just for SKA-VLBI) which could be used for various activities such as feasibility studies for array expansions (e.g. SKA-LOW VLBI, AVN), proposals, user support, data pipelines etc. (see next slides).
 - Bring together experts around the world to unify simulation efforts. *'Don't reinvent the wheel'*

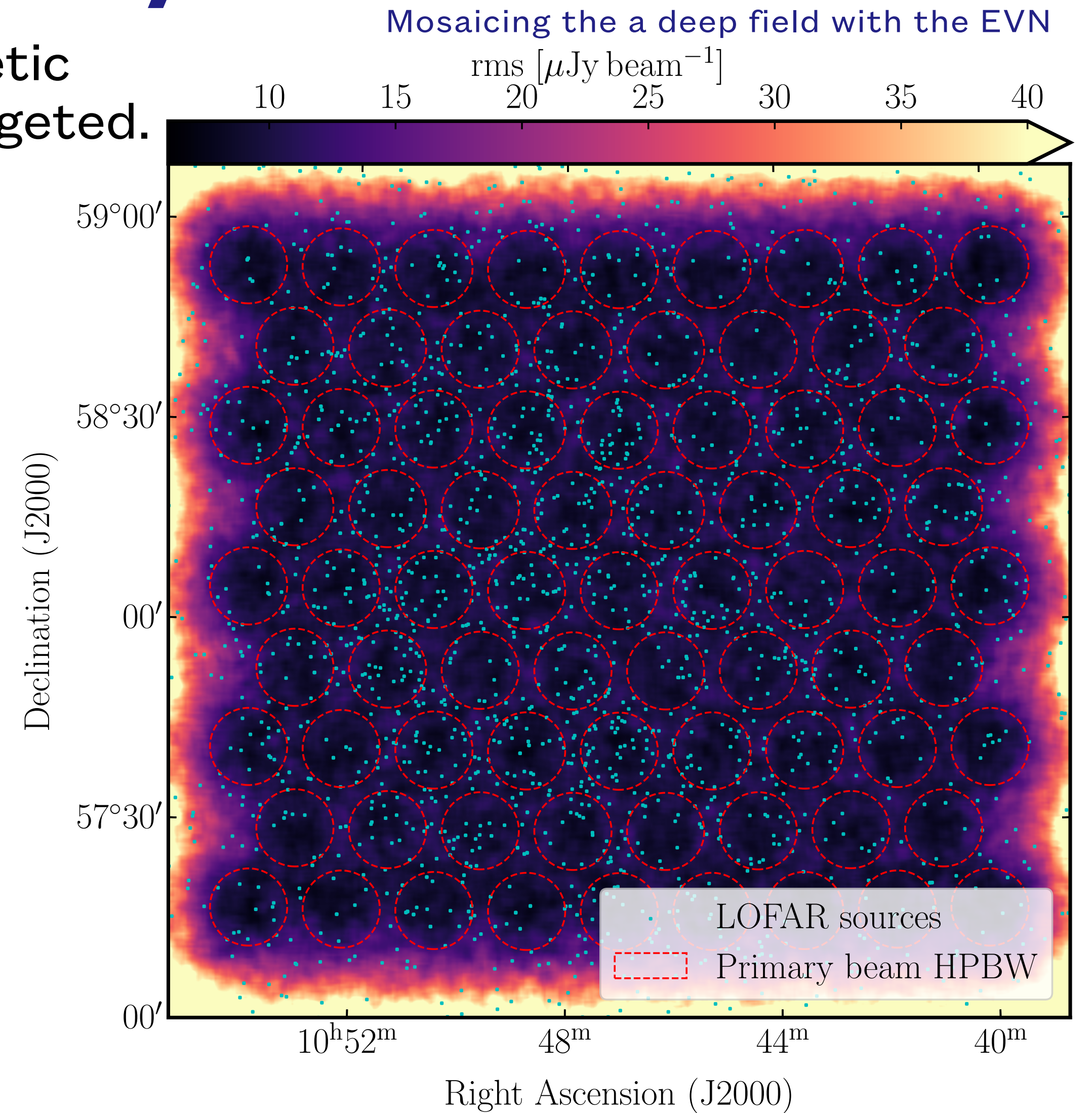
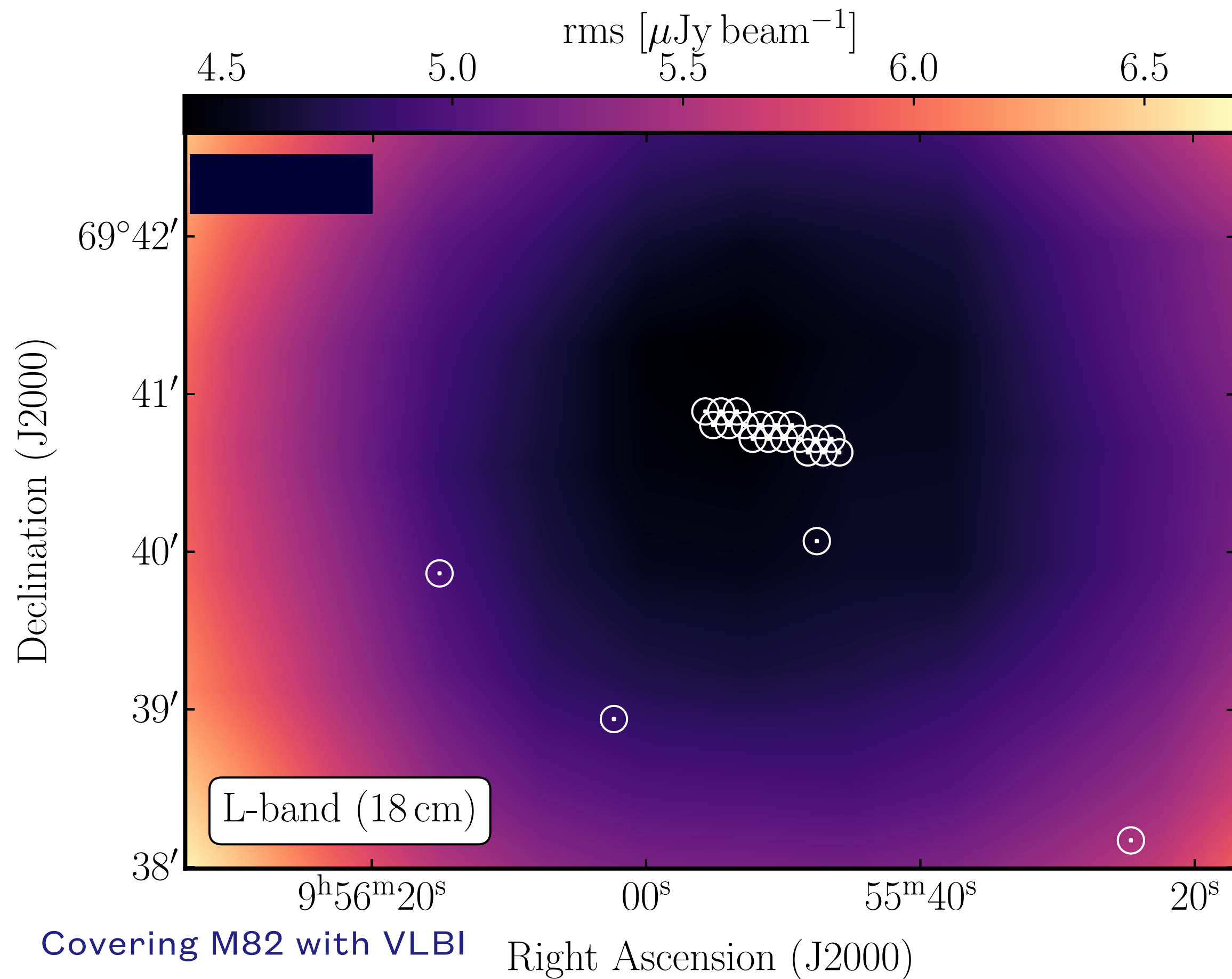
How the simulations can work for you

- Example of new instrument capabilities → proposed extension to e-MERLIN at X-band with a 6 GHz bandwidth receiver
- Below: simulations of a proto-planetary disk detection shows feasibility for new science cases



How the simulations can work for you

- For wide-field surveys, users could produce synthetic observations to ensure all feasible sources are targeted.



The SKA-VLBI simulations working group

- To achieve this we need your expertise (both science + technical)!
- If you are interested in joining / contributing please email me on:
 - jack.radcliffe@up.ac.za / jack.f.radcliffe@gmail.com or message on whova
- If you don't have time to write these down, keep an eye out for an email via the VLBI exploders this week and on the Whova conference page.

Questions?