

SWEEPS: Synoptic Wide-field EVN- eMERLIN Pilot Survey

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 institute

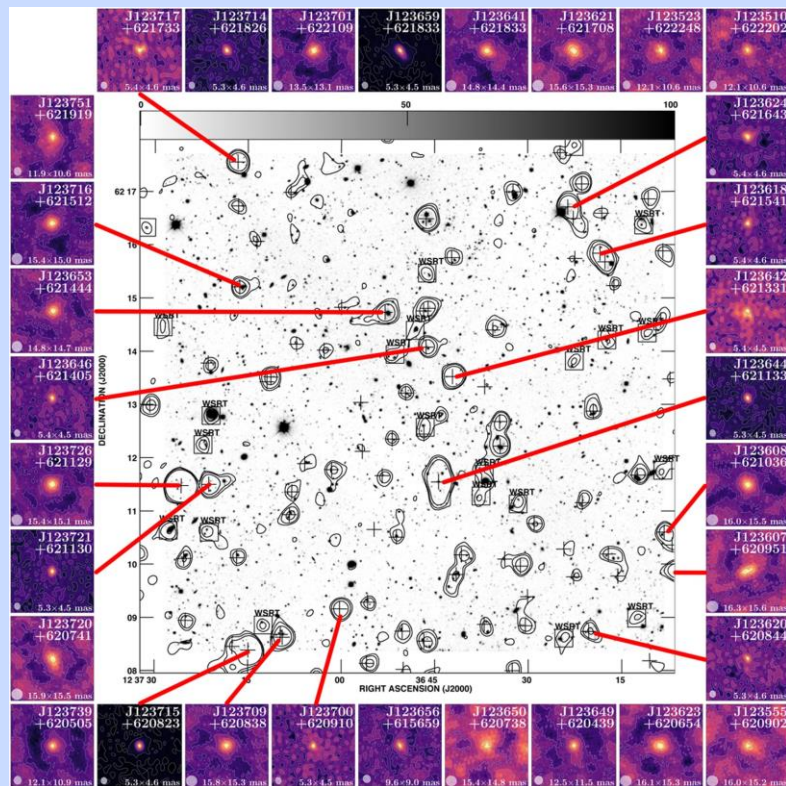


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VLBI Surveys

- Notoriously difficult
 - Limited by time, hardware and data sizes
- **Multiple Phase Centre correlation (MPC)** with software correlators solve hardware and data size constraints.
- MPC surveys:
 - Narrow and deep
 - E.g. GOODS-N (Radcliffe et al. 2018): 31 sources at $5\mu\text{Jy}/\text{beam}$ - 0.05 deg^2 in 24hrs
 - Broad and shallow
 - mJIVE-20 (Deller & Middelberg 2014): 5000 sources at $140\mu\text{Jy}/\text{beam}$ - 227 deg^2 in 364hrs

GOODS-N

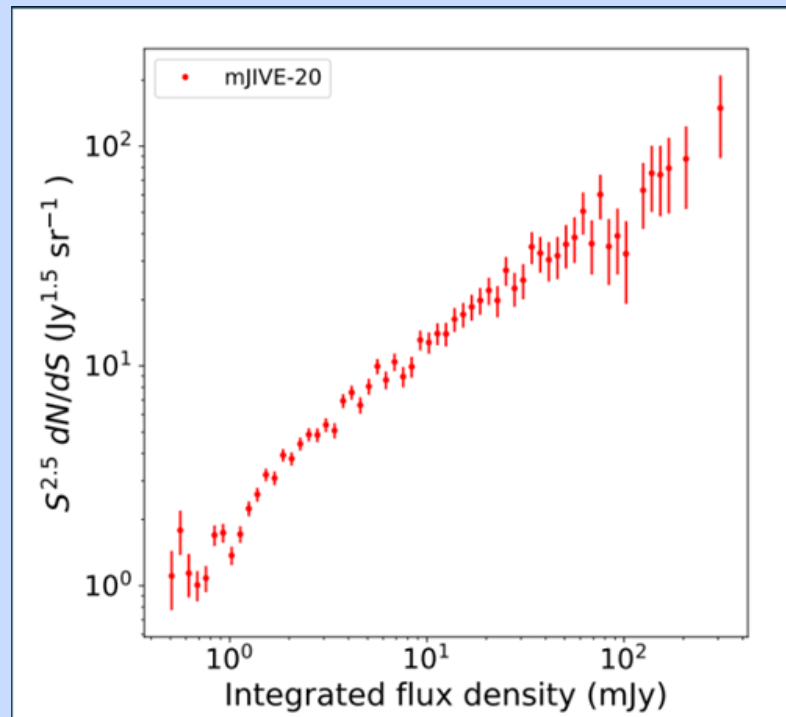


Credits: Radcliffe J. et al. (2018) & Chi S. et al. (2013)

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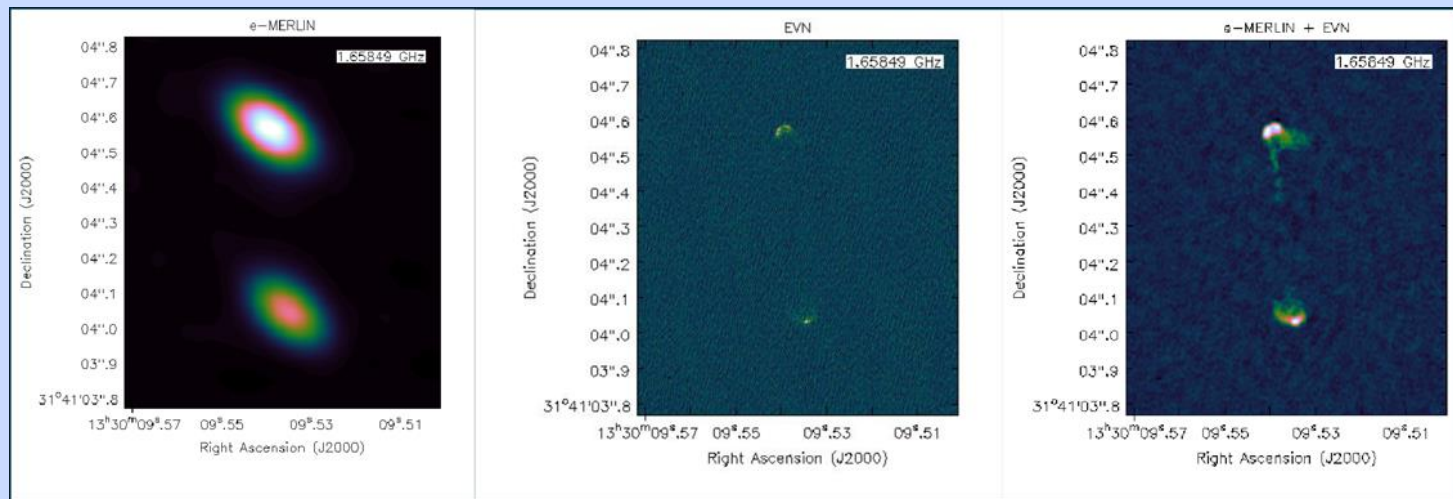
mJIVE-20



Credits: Rezaei et al. (In prep.)

EVN + eMERLIN: VLBI with long & short baselines

- Lens candidate from mJIVE-20 (Spingola et al. 2019) perfect example of the need to **combine short and long baselines**
 - Developing robust imaging of multiple scales
- Example - Motivates future SKA-VLBI mode

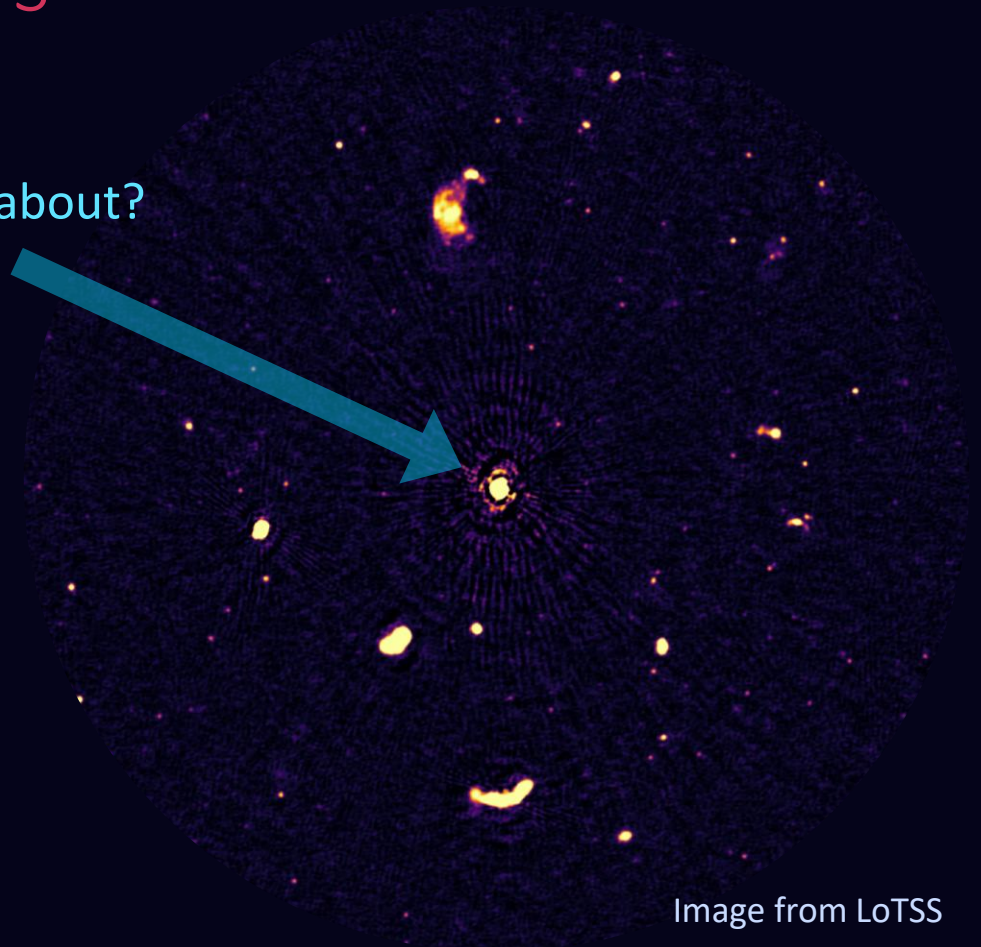


Credits: McKean J. P.

Introducing SWEEPS

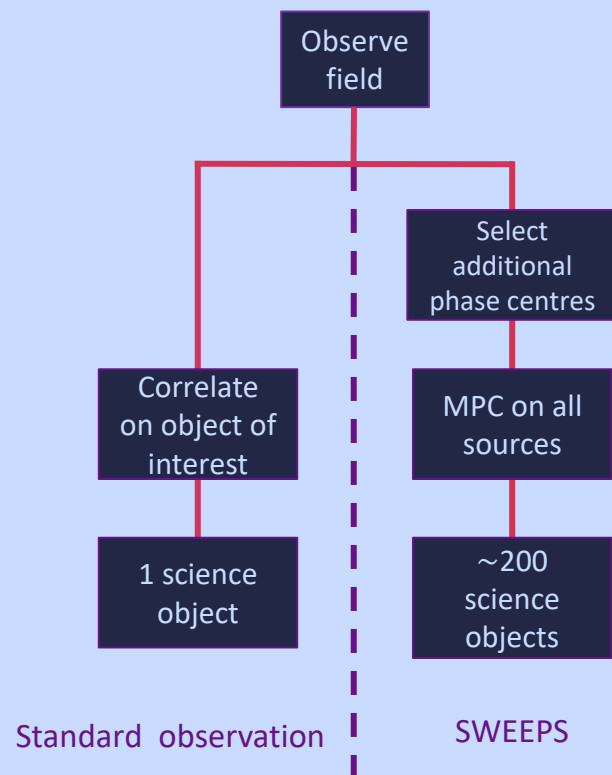
Is this the only object you're curious about?

A standard observation only processes the data for the target, throwing away all the other objects in the field



The SWEEPS goals

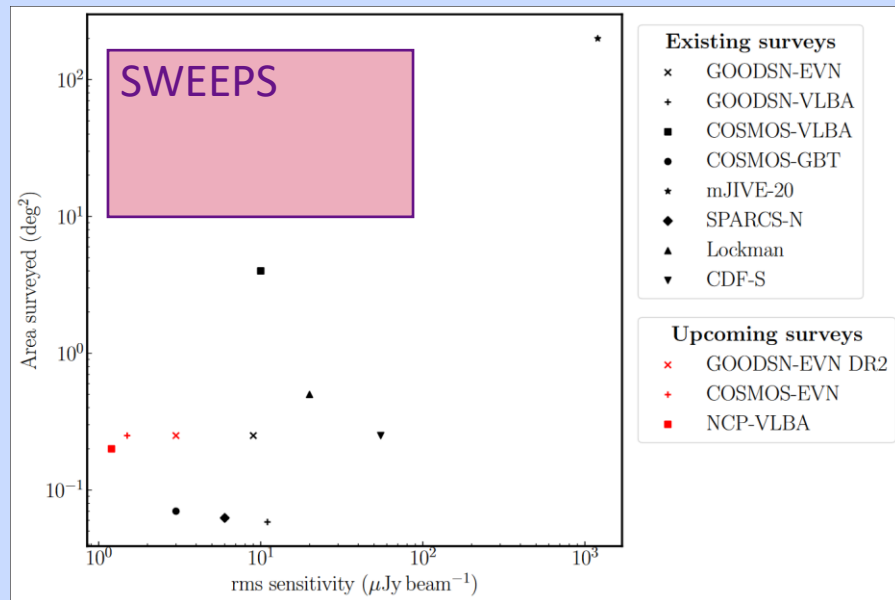
- **Idea**: perform MPC commensally on **all** EVN L-band observations (Target and Calibrator; 90 fields/year)
- Select the additional phase centres using **low resolution radio surveys** (LOFAR, MeerKAT)
 - Eventually, use the **short spacing baselines** of e-MERLIN
- ~10 000 VLBI targets/year at $>5\mu\text{Jy}/\text{beam}$ (varying depth): ~ **1000-2000 detections**
 - mJIVE-20: ~5000 sources in 364 hours
 - GOODS-N: ~31 sources in 24 hours
- Additional computing cost comes from **re-correlation** and **post processing** (see Jack Radcliffe's talk)



Towards all-sky surveys with VLBI

- SWEEPS would survey **3 orders of magnitude** more area
- Nearly fully-blind - **wide range** of science cases
 - Serendipitous discoveries (not normally targeted)
 - Triggering of radio sources
 - Radio galaxies evolution
 - BH co-evolutions
 - Star forming galaxies
 - Gravitational lenses
 - X-ray binaries
 - Supernova from nearby galaxies
- **Synergy** with LOFAR, MeerKAT and LSST (SKA & ngVLA in future)

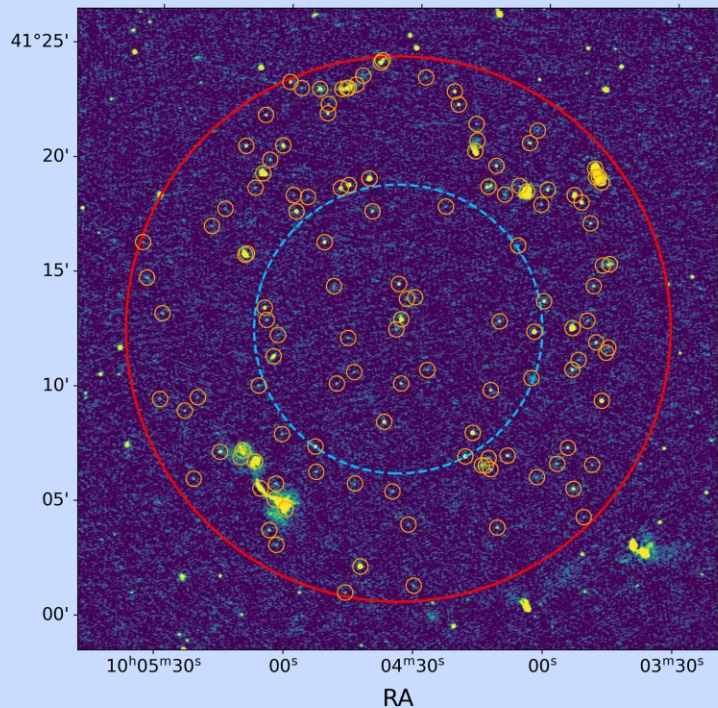
Wide-field VLBI surveys



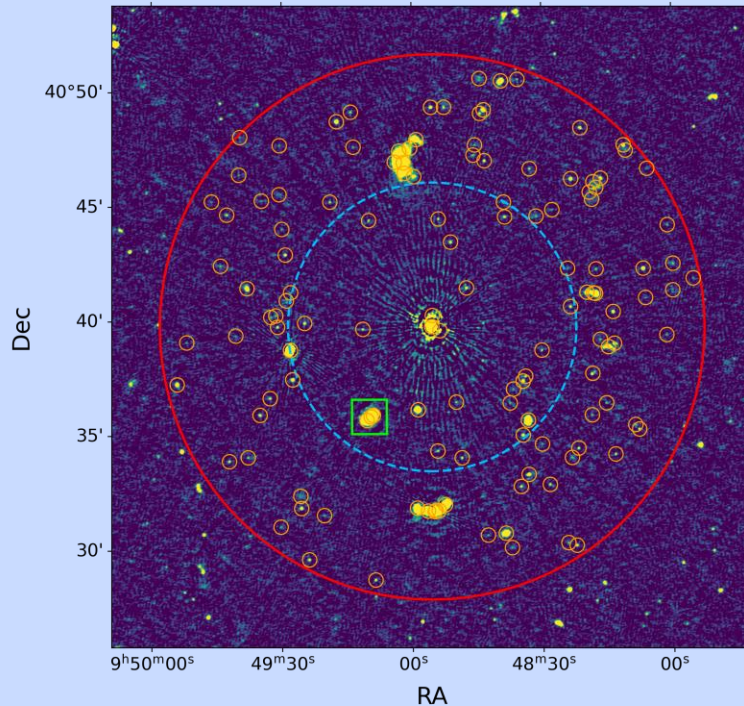
Credits: Adapted from Radcliffe J. (In prep.)

SWEEPS Pilot fields – EM160

J1004+4112



J0948+4039

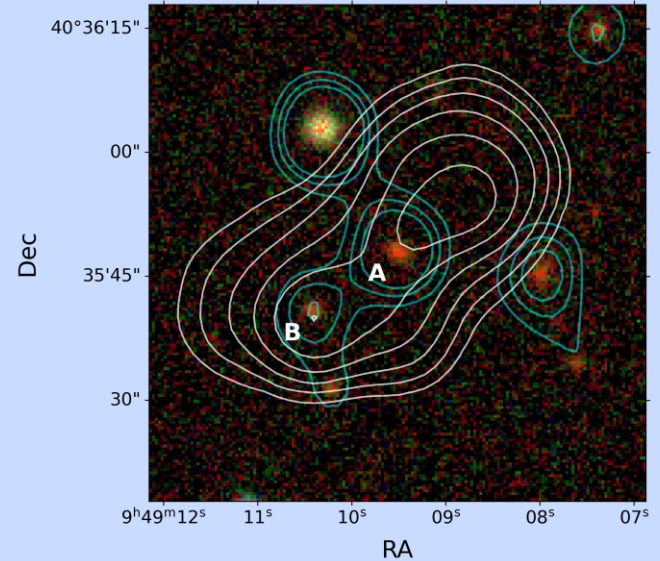
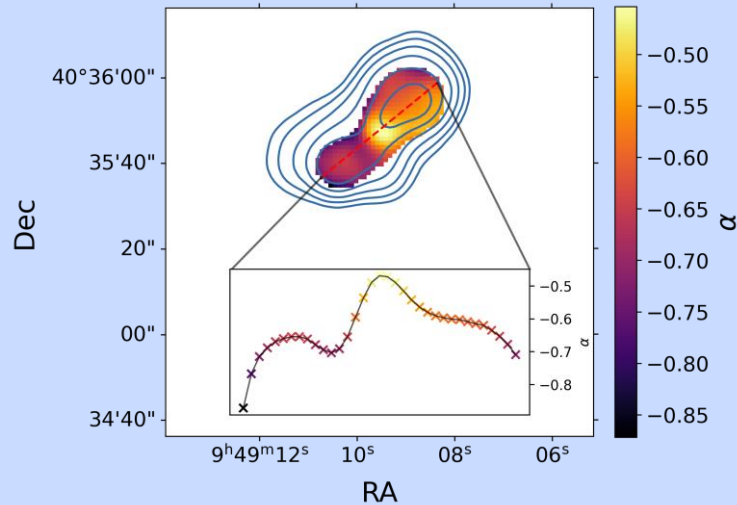
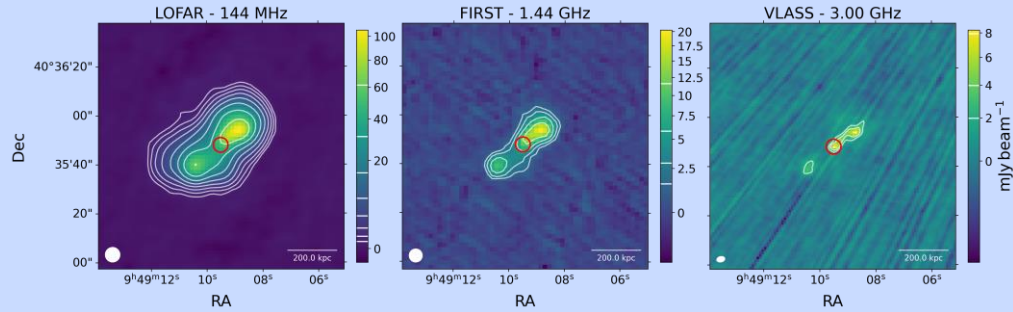


- Solid red circle: HPBW of 32m dish
- Dashed blue circle: HPBW of 100m dish
- Orange circles: 10% smearing radius

Data from LoTSS

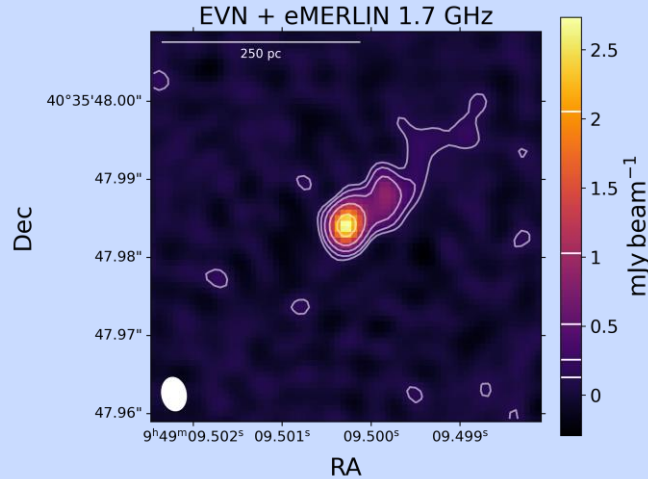
257 phase centres in 2 fields from a separate PI project not intended for this use

Results from Pilot – First detection

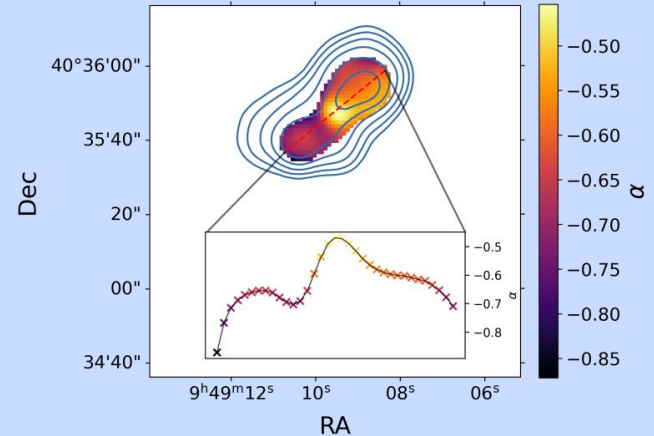
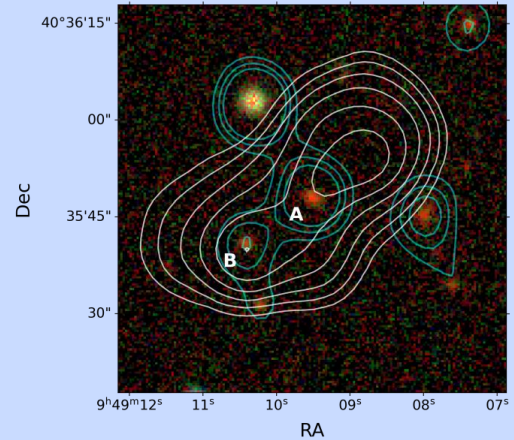


- Flat to Steep spectrum source
- Spectroscopic $z = 0.52$

Results from Pilot – First detection

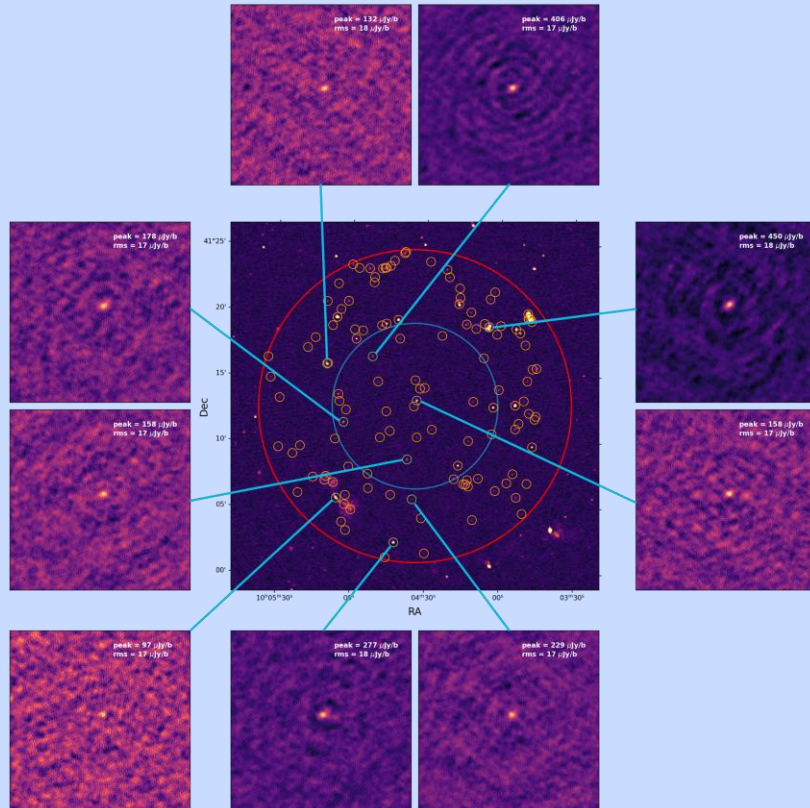


- Proof of concept demonstrated
- $T_b = 2.8 \times 10^8$ K \rightarrow AGN
- IR and optical galaxy at southern lobe – potentially two different sources
 - Steep spectral index suggests lobe
 - No VLBI detection (upper limit 150 μ Jy)

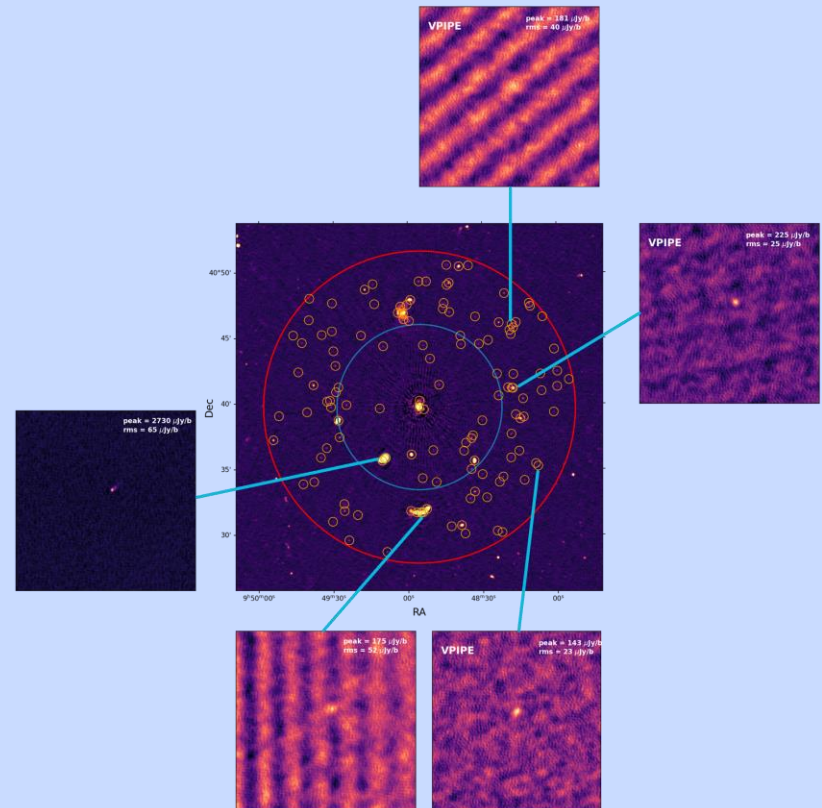


Result from Pilot – 14 detections

Target field - 9 detections



Calibrator field - 5 detections



Sweeping up!

Results from Pilot:

- We have demonstrated that **commensal multiple phase correlation can be done**
- **Scientific potential** with combining SWEEPS with LOFAR, VLASS, FIRST, SDSS (LSST) demonstrated for first detection
- Verified **expected number of detections** (~10 per field)
- Presence of bright sources affects our ability to make detections

Next steps:

- Robust eMERLIN **short-spacing calibration** to be developed
- Bright **source subtraction during** correlation needed
- Additional pipeline development
- Writing a white paper on the science case of a public survey – if interested get in touch

SWEEPS has the potential to be a fantastic resource for the community as a **public survey** and an **important path finder** for future SKA-VLBI and ngVLA surveys