Isolating AGN Using Wide-field VLBI
& e-MERLIN Observations

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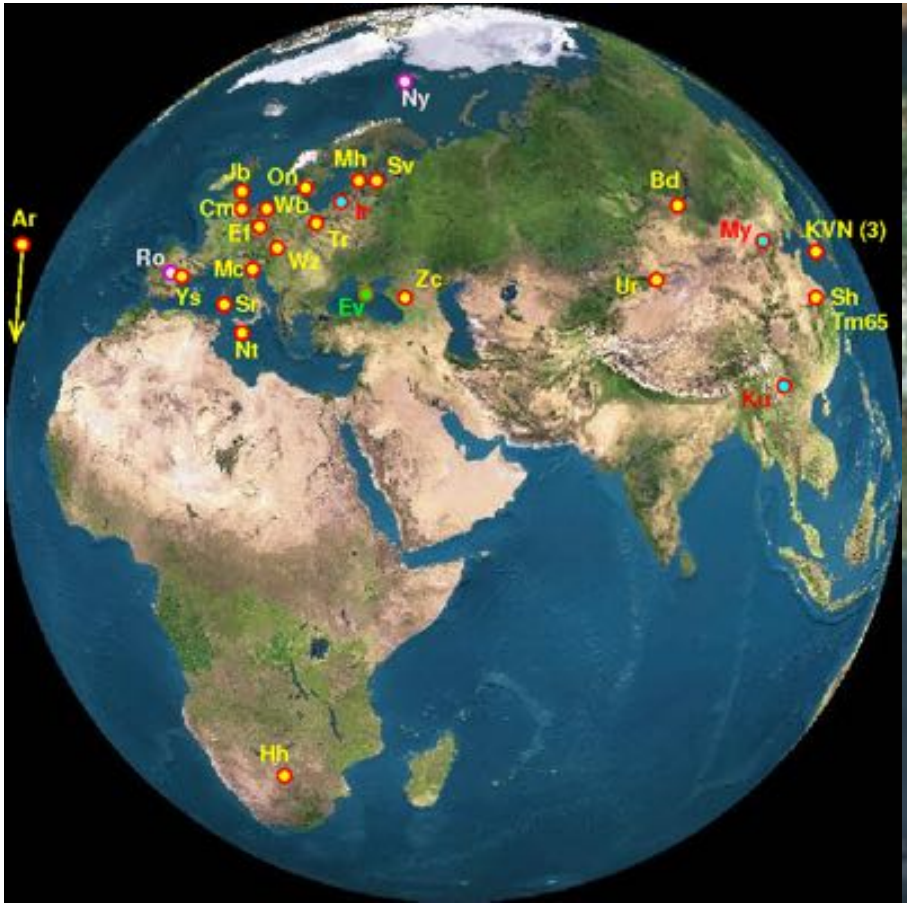
EVN & e-MERLIN


Ny
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eMERLIN

High resolution radio surveys, why are they **so** great?

1. Interferometers act as spatial frequency filters → Long baselines = only compact & bright ($T_b > 10^5 K$) objects.

2. Reduced effects from confusion

3. Radio observations @ cm wavelengths are (mostly) extinction free.

4. Probe sub-galactic (<kpc) scales in distant galaxies, separate SF & AGN activity.

High resolution radio surveys, why are they **not so** great?

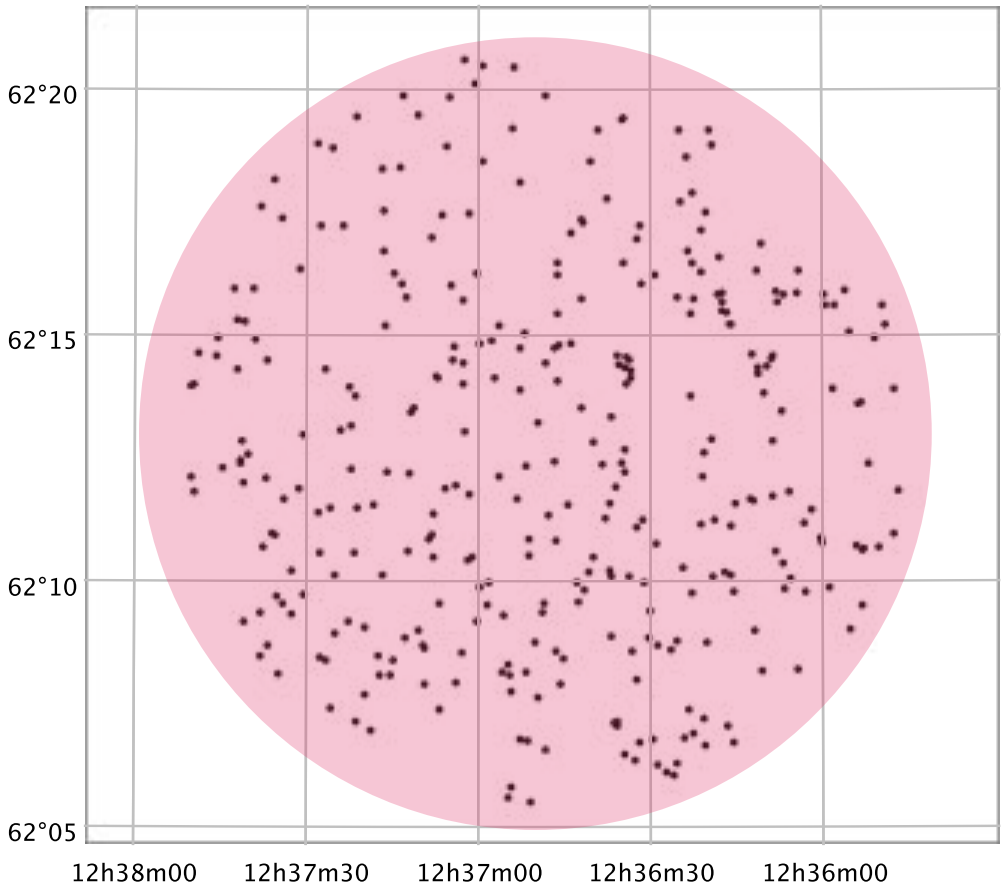
1. Interferometers act as spatial frequency filters → sparsely sampled Fourier plane, zero spacing

2. Relatively.. computationally intensive – e.g. 24hr EVN → ~ 5 TB of data to map entire primary beam.

3. Calibration can be difficult & users have to use ‘magic black boxes’ of CASA & AIPS.

4. The atmosphere (troposphere & ionosphere)

Putting the '*wide*' in Wide-field VLBI:
Traditional WF-VLBI



- Correlate on pointing centre (ultra high spectral & temporal resolutions)

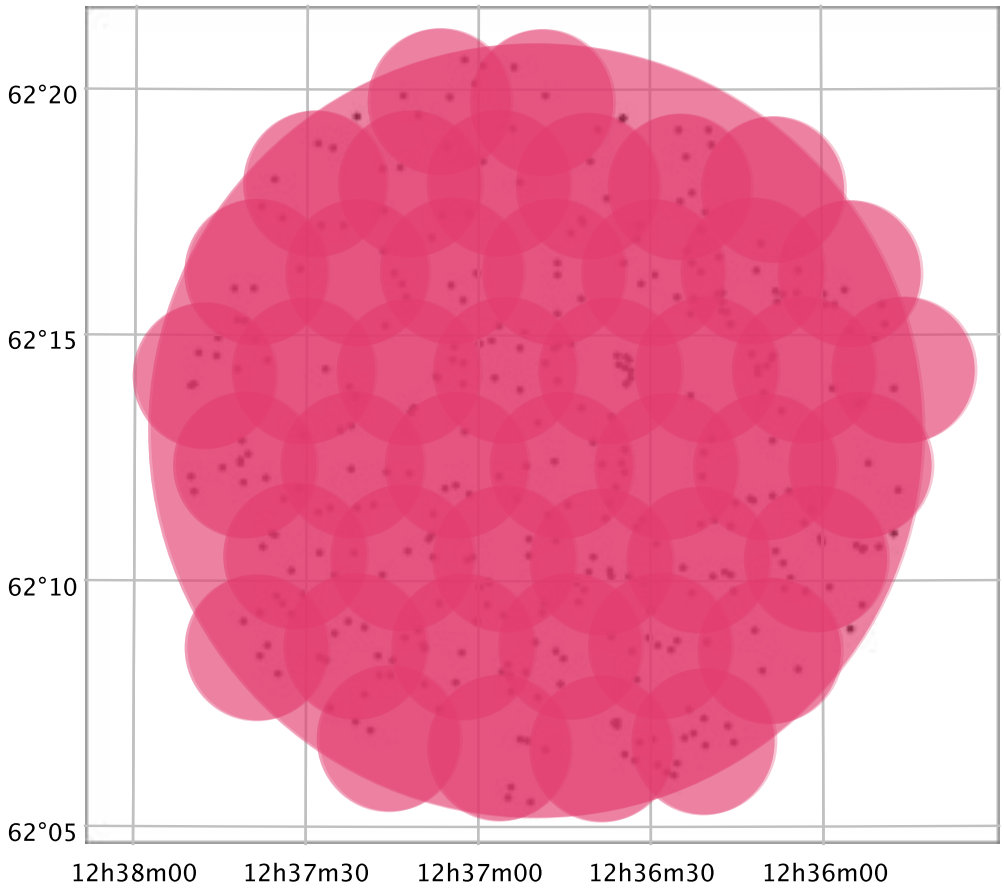
Problems:

- Large (>TB), single data set

- Have to phase shift whole data set to image sources with shifting errors occurring.

Multiple simultaneous phase centre observing

(Deller+2011, 2013, Keimpema+2015)



- Correlate on pointing centre, shift and re-correlate w/ coarser temporal & spatial averaging.
- Large (>TB) data but comprised of small (~GB) sets
- Same calibration applies to all

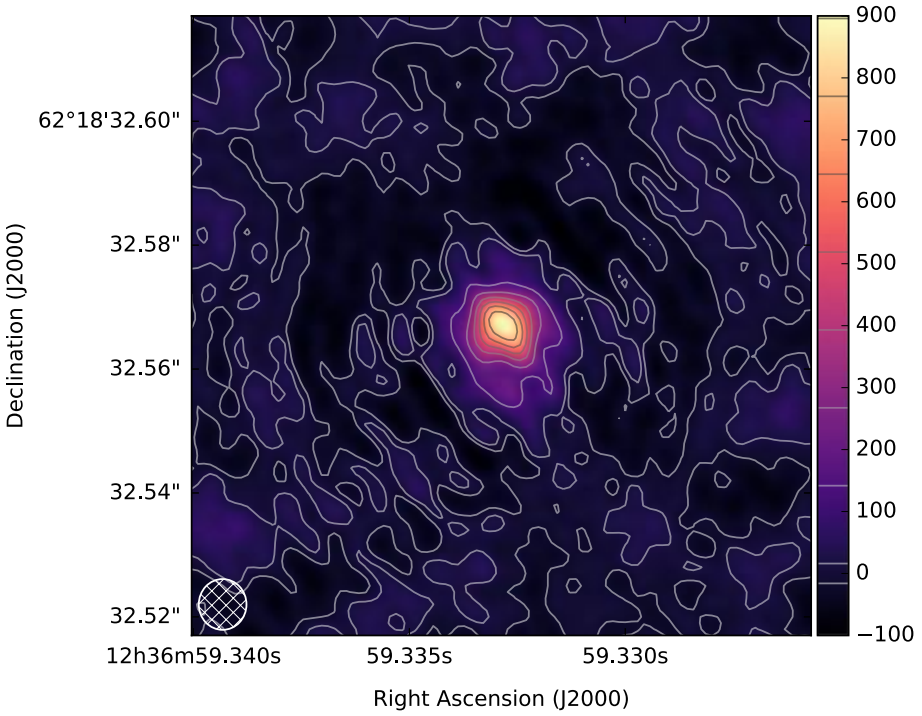
→ embarrassingly parallel

Multi-source Self-calibration (Garrett+2004, Middelberg+2012, Radcliffe+2016) arXiv:1601.04452

- Uses the combined response of targeted sources to permit self-calibration and reduce phase errors further.

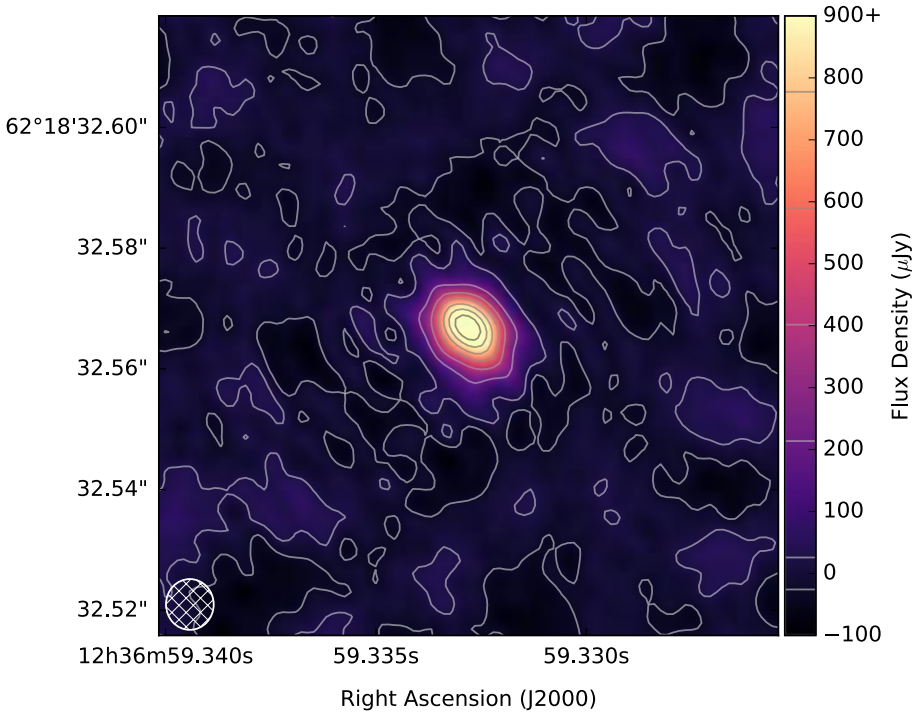
Phase referencing

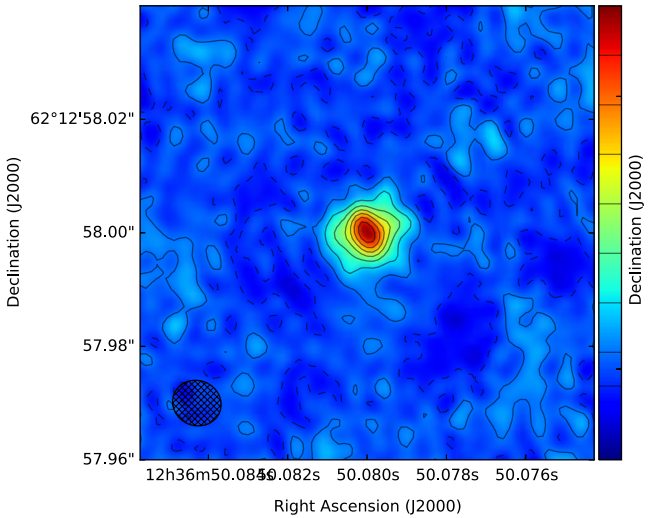
S/N ~ 43, I_i ~ 1348



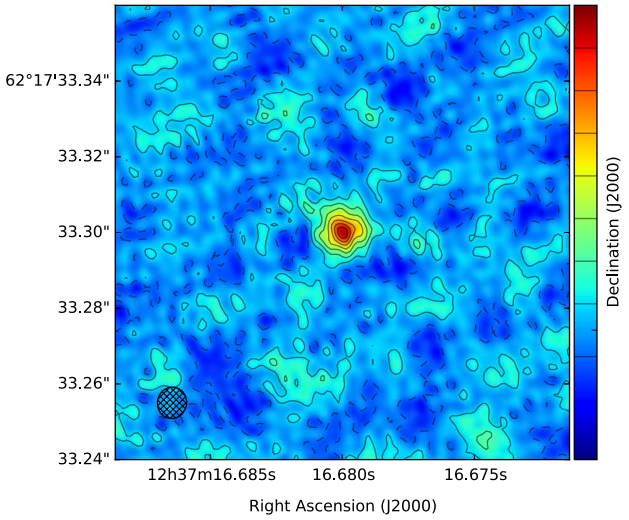
Multi-source self calibration

S/N ~ 116, I_i ~ 1733





/ CLEAN Model



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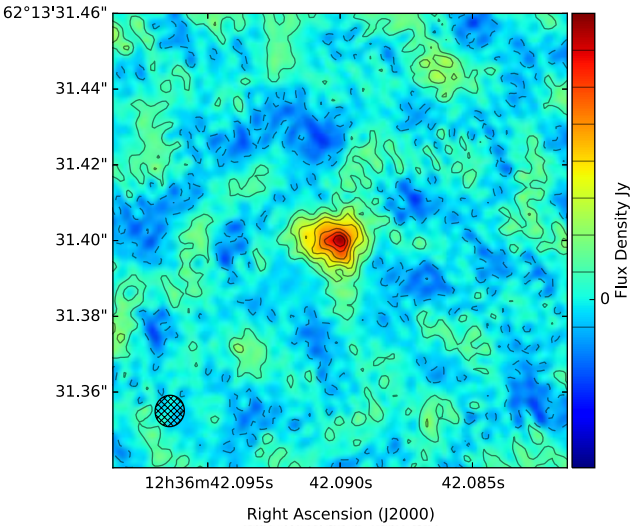
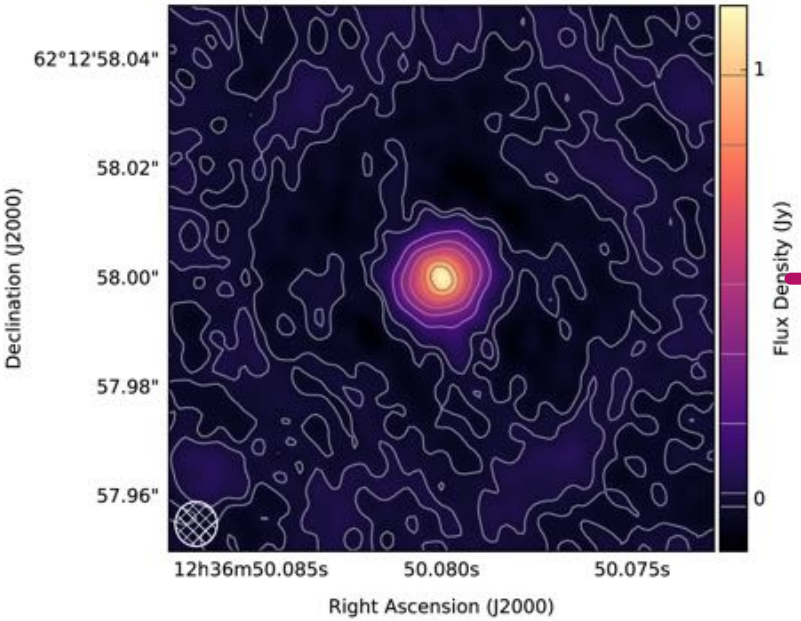
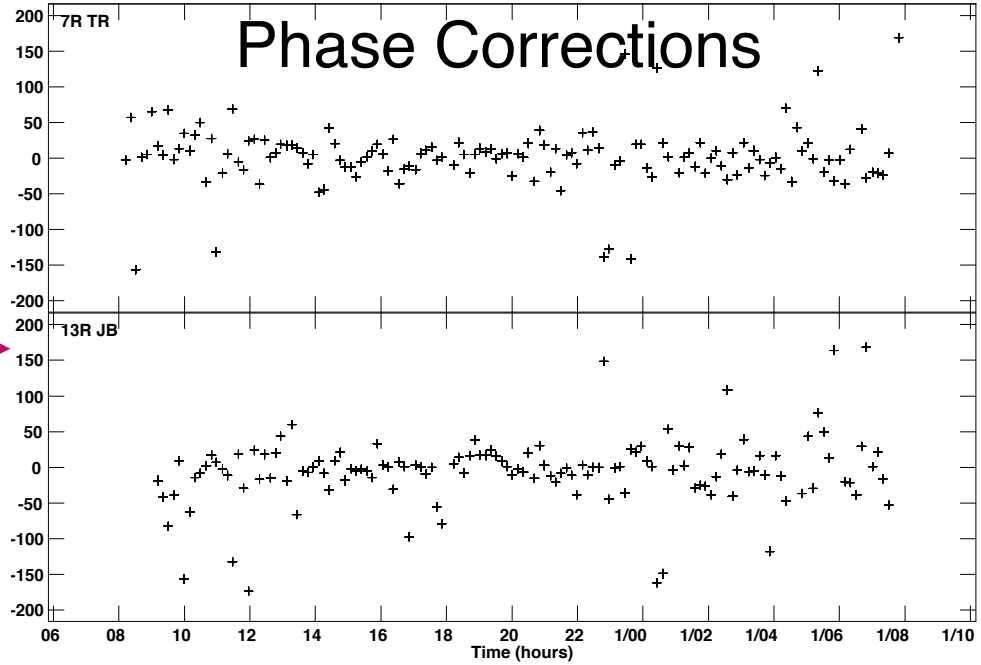


/ CLEAN Model

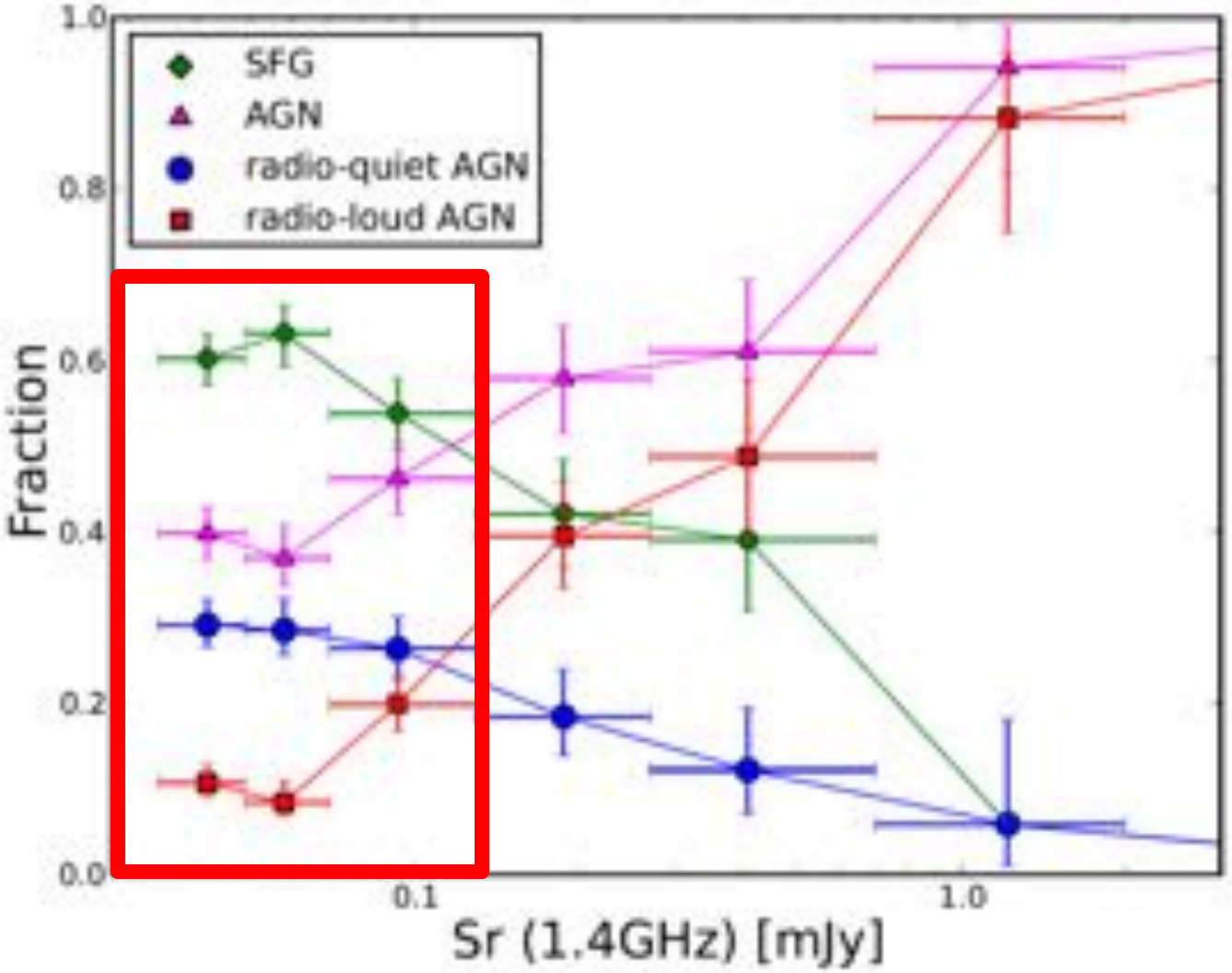
UV Stacking



Phase Corrections

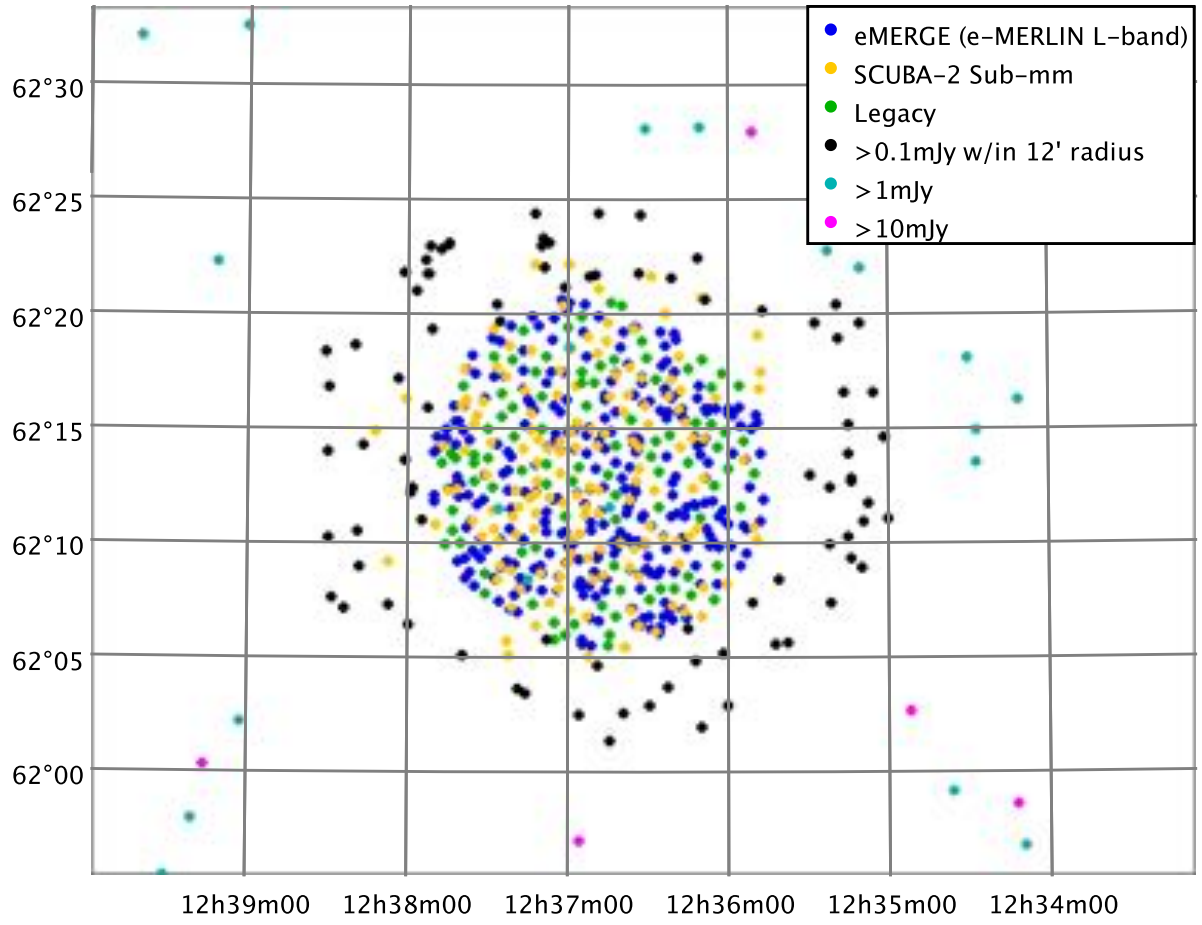


Aim:



Padovani+ 2014, Bonzini+2013 E-CDFS

Wide-field EVN observations of GOODS-N



- 699 targeted sources
- EVN 1.6 GHz, 128MHz BW
- Two areas:
  - Central 15’
  - Outer annulus (20’ diameter)
- Science targets
  - Sub-mm
  - eMERGE
  - Transients

Previous VLBI surveys of GOODS-N

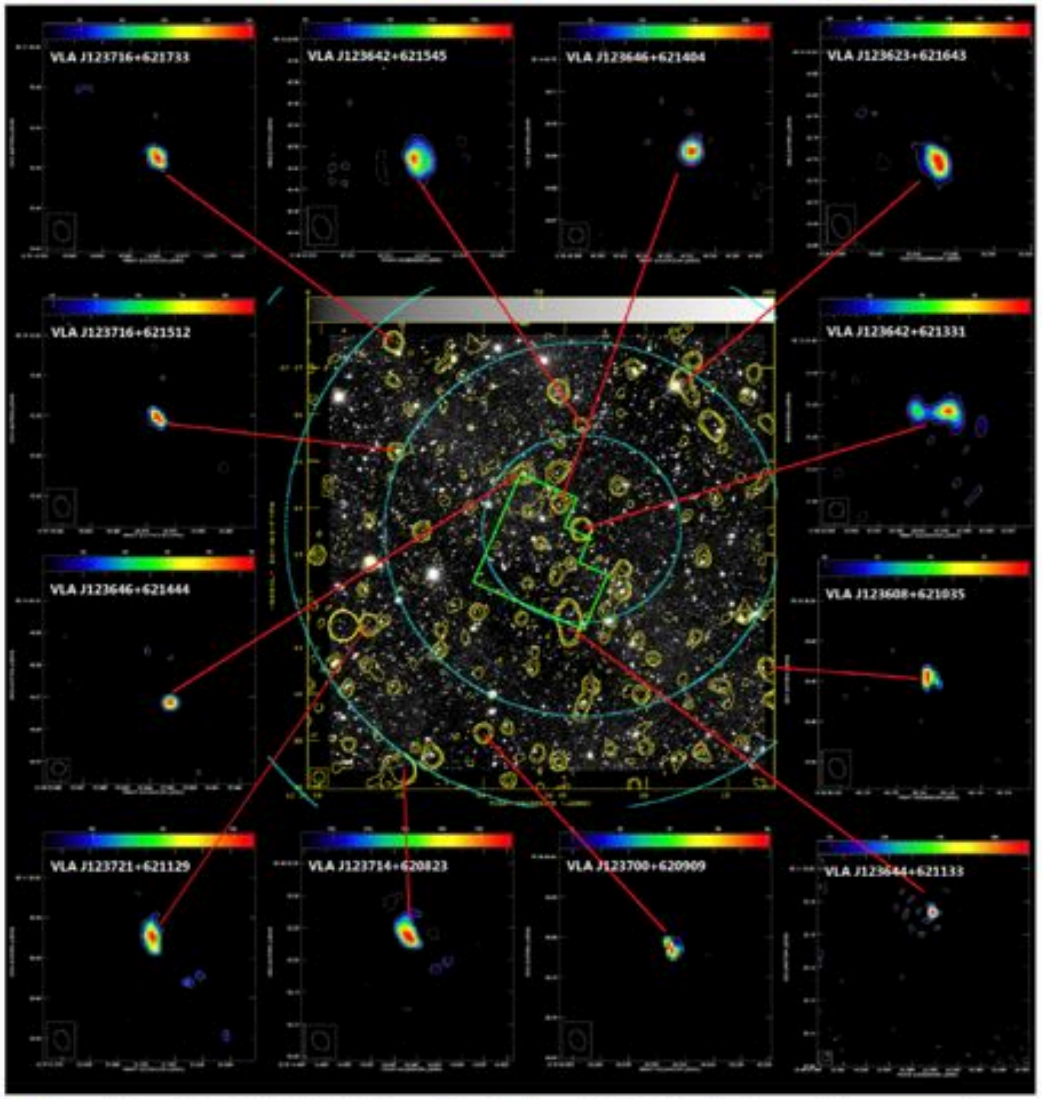


Fig. 1. Composite image of the radio (WSRT 1.4 GHz) – optical overlay image of the HDF-N and HFF, surrounded by postage stamp images of the twelve compact VLBI-detected radio sources. The cyan circles represent annuli of decreasing resolution and sensitivity, and are drawn at 2, 4, 6, and 8 arcmin radius w.r.t. the phase center which coincides with radio AGN VLA J123642+621331 (see text Sect. 3).

- Garrett+2001:
  - 2(.5) detections
  - First wide-field, ultra-deep VLBI observation
- Chi+2013:
  - 12 detections, with r.m.s. 7.3μJy/bm r.m.s

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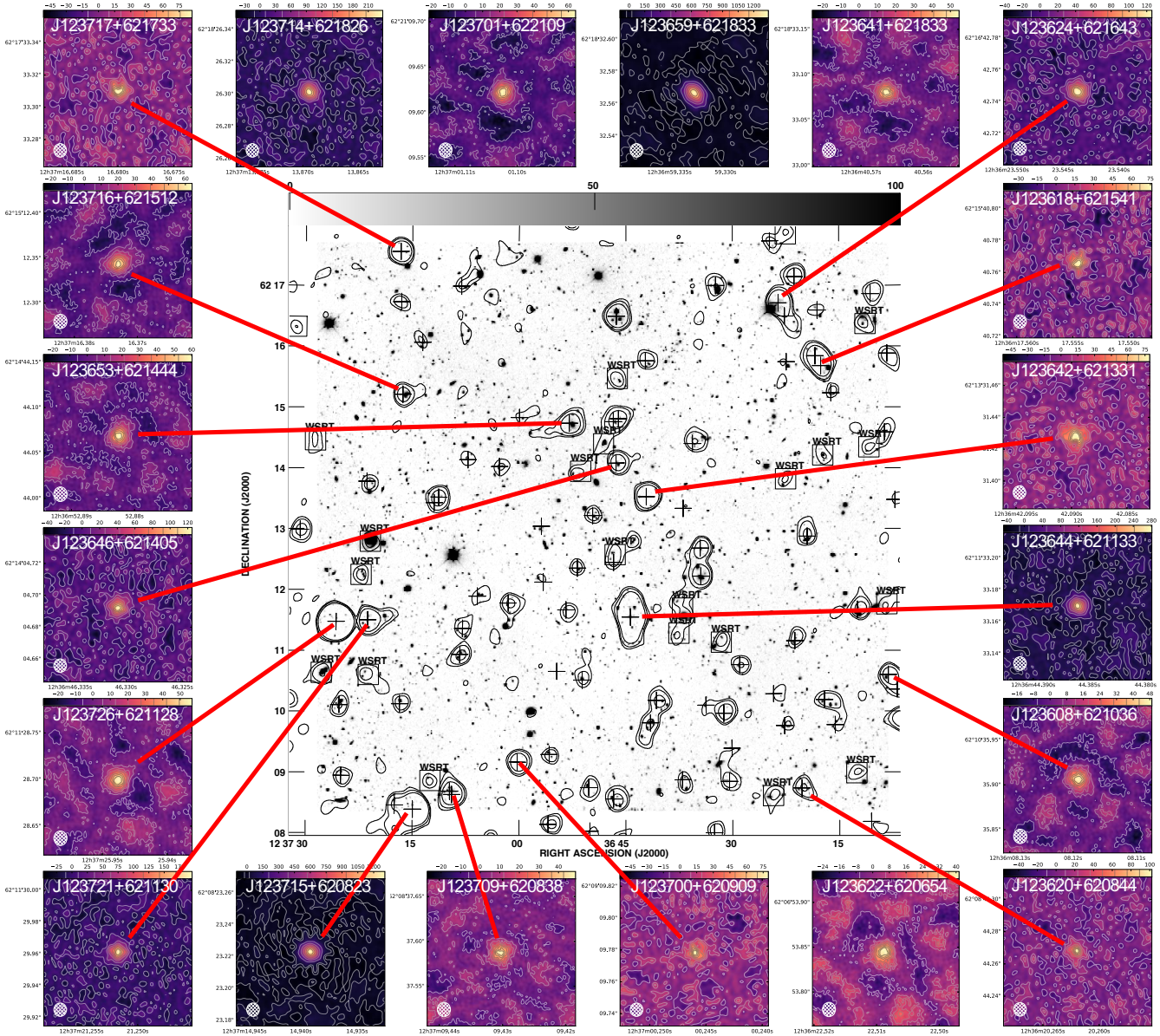
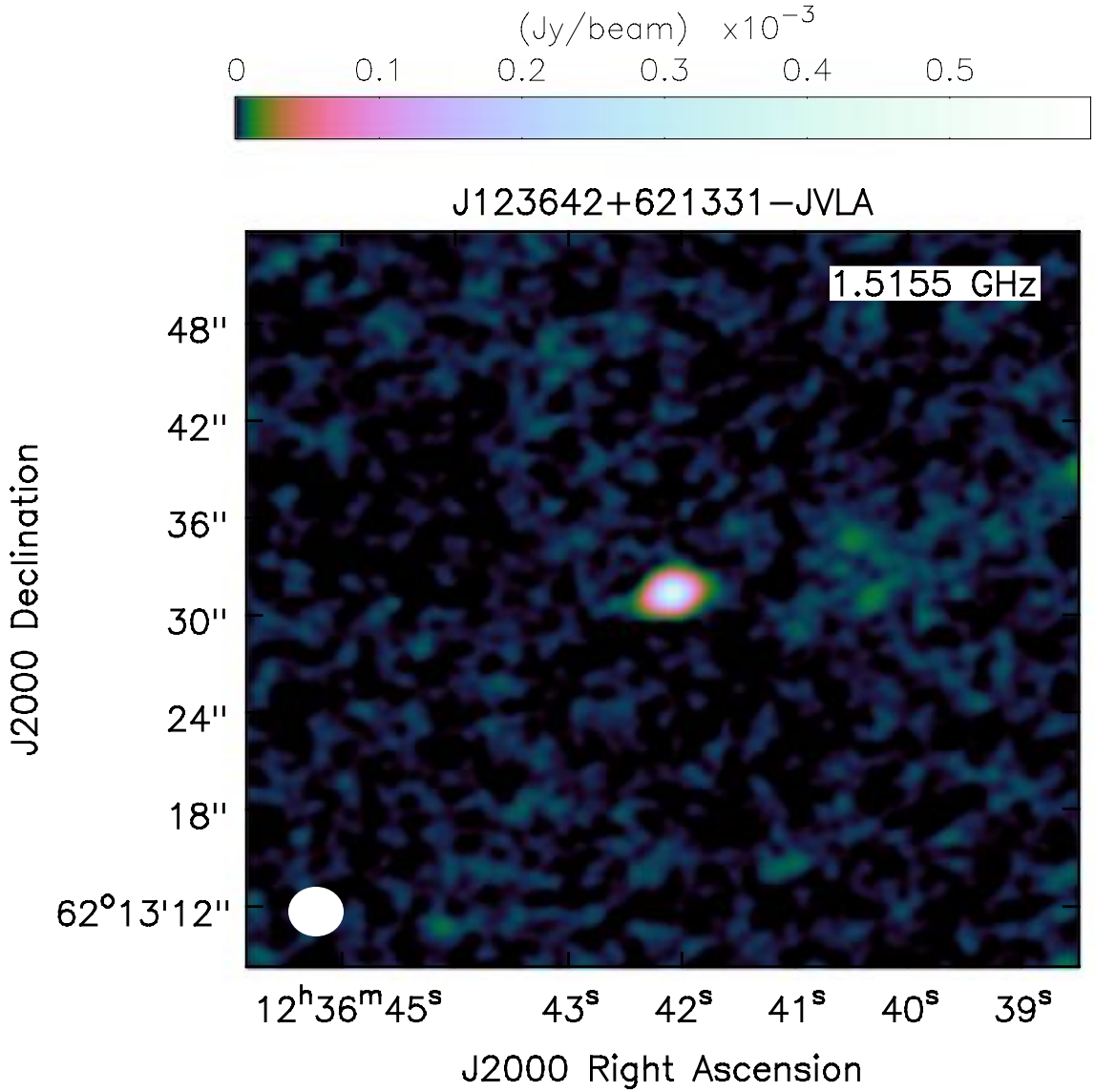
And the present:



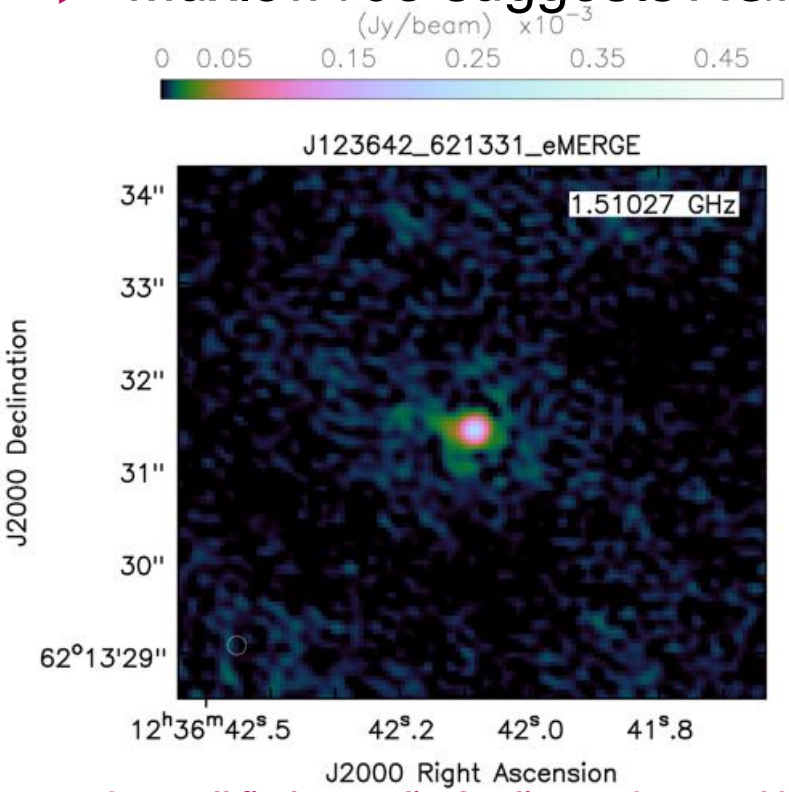
- 20 detections
- 5.5uJy/bm (expect 1-2uJy in the end)
- Mixture of AGN cores, sub-mm galaxies and SF + AGN hybrids

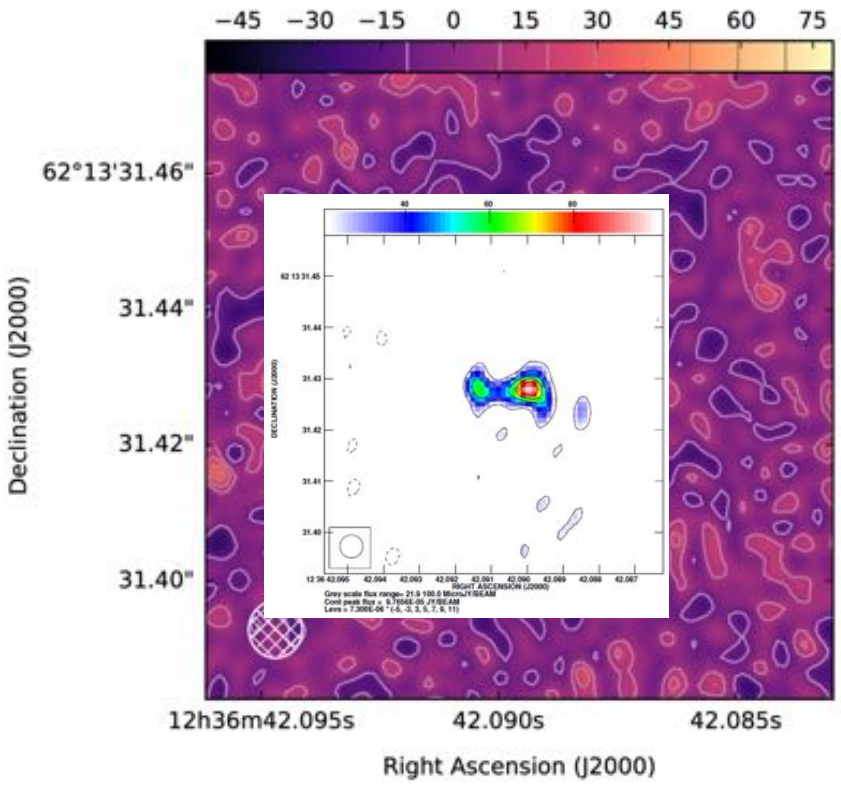
SF+AGN - J123642+621331



SF+AGN? - J123642+621331

- AGN Confirmed w/ detection by Garrett+01 & Chi+13
- Phot-z suggests z~2 (OIII), originally 4.424 (Lyα) emission (Cowie priv. comm.)
- ISO detection + HST NIR
- Muxlow+05 suggests AGN & SB

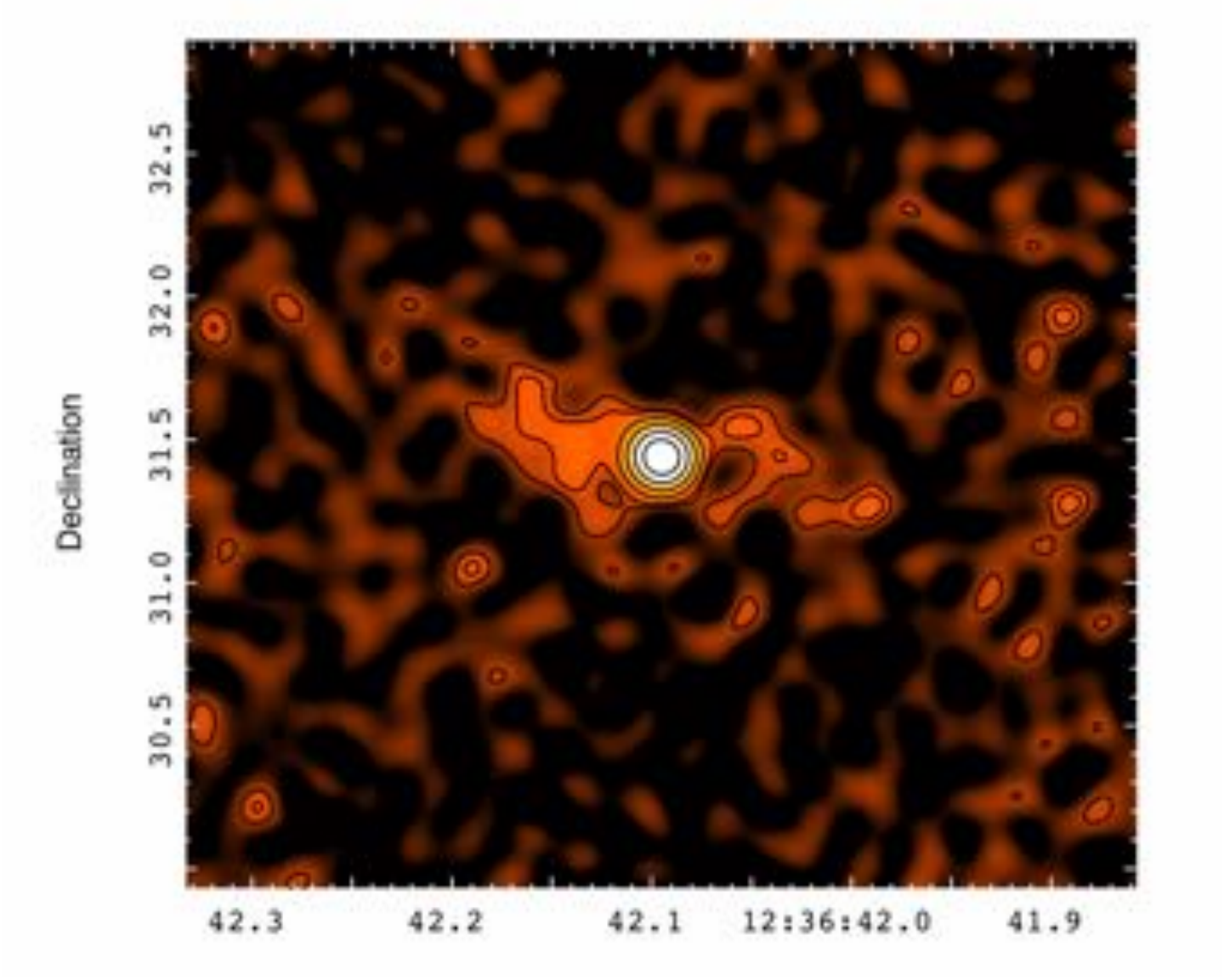




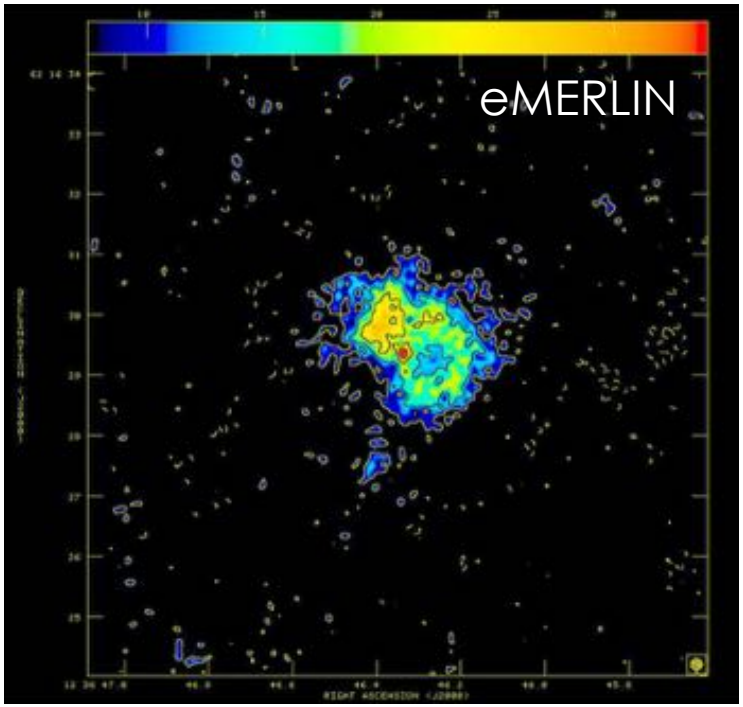
VLBI

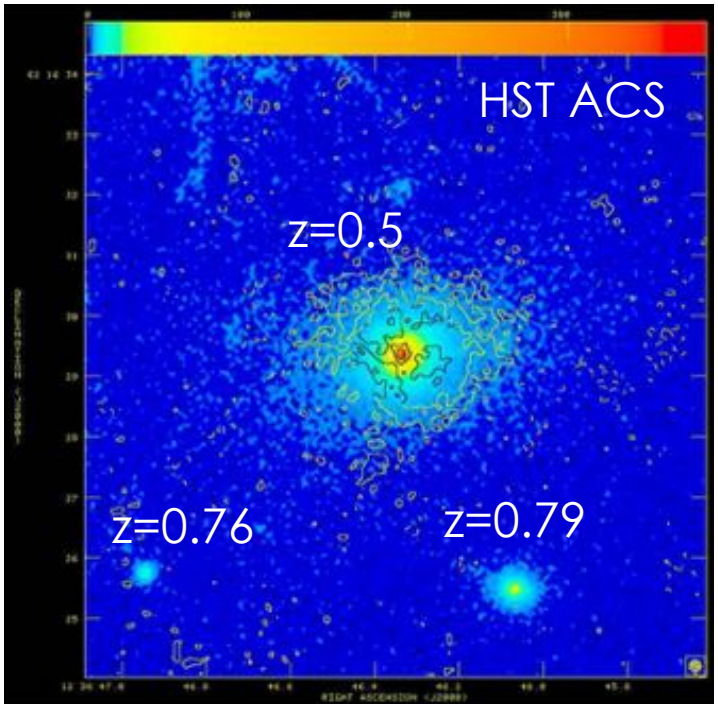
8.0 x 7.7mas bm

SF+AGN? - J123642+621331



SF + Radio-quiet AGN?





- Extended steep-spectrum (α>1.62) starburst with embedded AGN?
- Star-formation rate ~200 M⊙/yr
- BL emission → Optical AGN activity
- No C-Band/VLBI non-detection – NOT AGN

Take home messages:

- Recent advances in correlation methods & calibration techniques makes WF-VLBI possible anywhere on the sky.

- Sub arc-second resolution radio surveys can distinguish between SF and AGN & can investigate the ‘radio-quiet’ AGN population

- Need SKA-VLBI to provide the sensitivity ‘punch’ to investigate the ‘radio-quiet’ AGN population

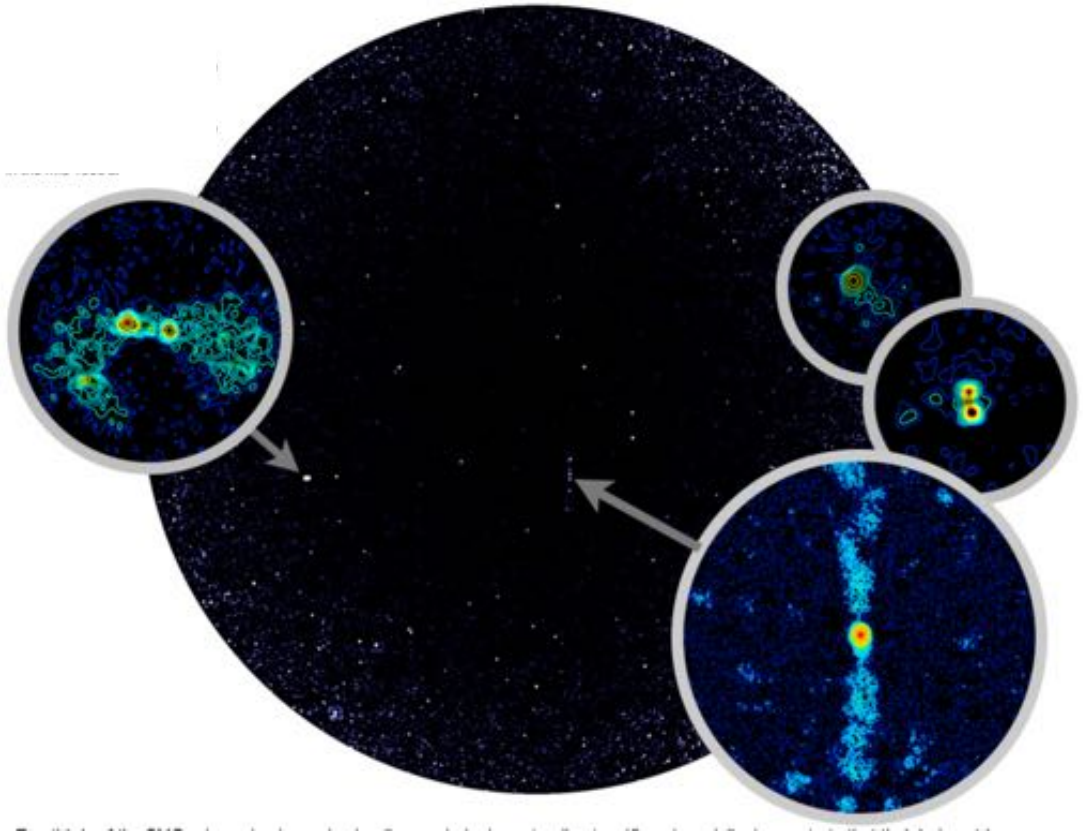
eMERGE - e-**MER**lin **G**alaxy **E**volution **S**urvey

Tier 1

- 1.4GHz & 5GHz eMERLIN legacy survey – 1σ <1uJy!

- Complemented with L-Band JVLA-A & EVN + C-Band JVLA-A/B/C + EVN

- See T. Muxlow's talk @ SKA2016



More info @ http://bit.ly/2ftdwMU