Young radio-emitting AGNs at high redshifts

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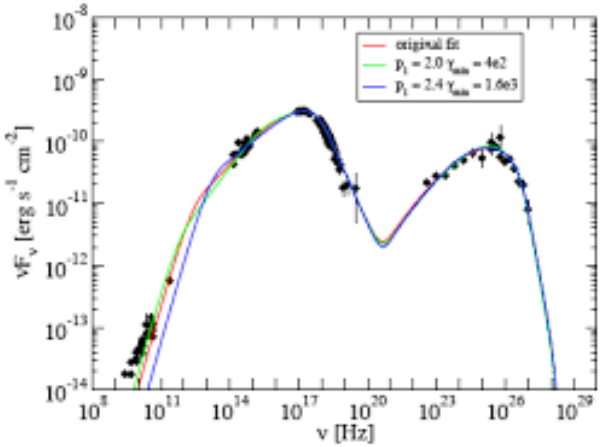
The population of high-z radio-emitting AGN

- Blazars: jet inclination angle $\leq 1/\Gamma$
- $\Rightarrow$ For every blazar there are $\sim 2\Gamma^2$ non-beamed radio AGN (Volonteri et al. 2011) $\Rightarrow$ can trace the population of all jetted AGN
- Number of radio AGN calculated from *Swift*/BAT luminosity function << number estimated from the known $z \gtrsim 4$ blazars

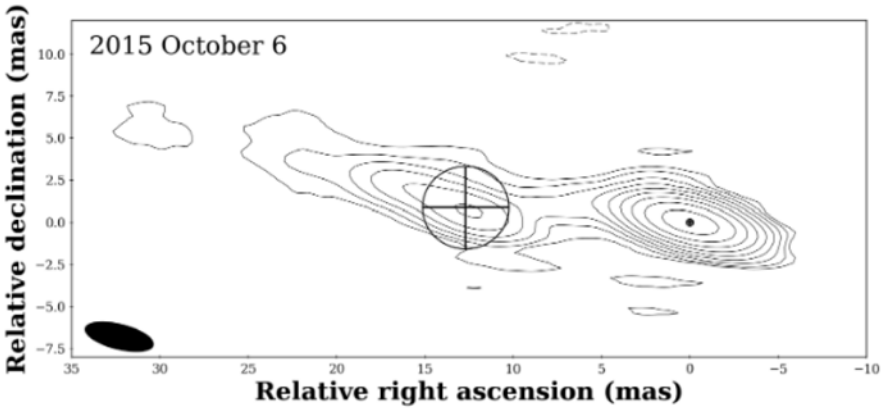
SED

Is it a blazar?

VLBI imaging



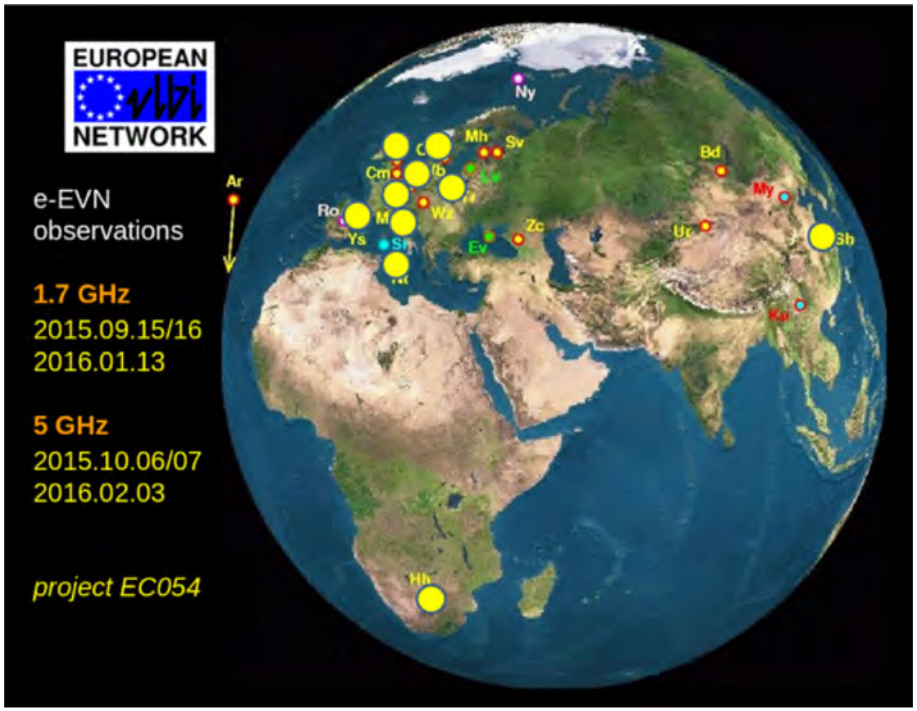
Abdo et al. 2011, ApJ, 736, 131



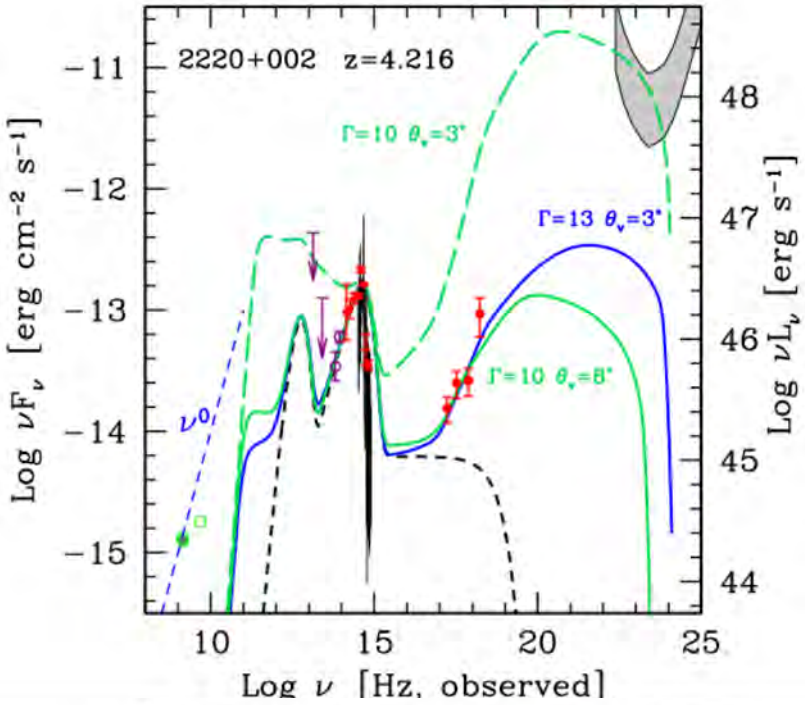
Perger et al. 2018, MNRAS, 477, 1065

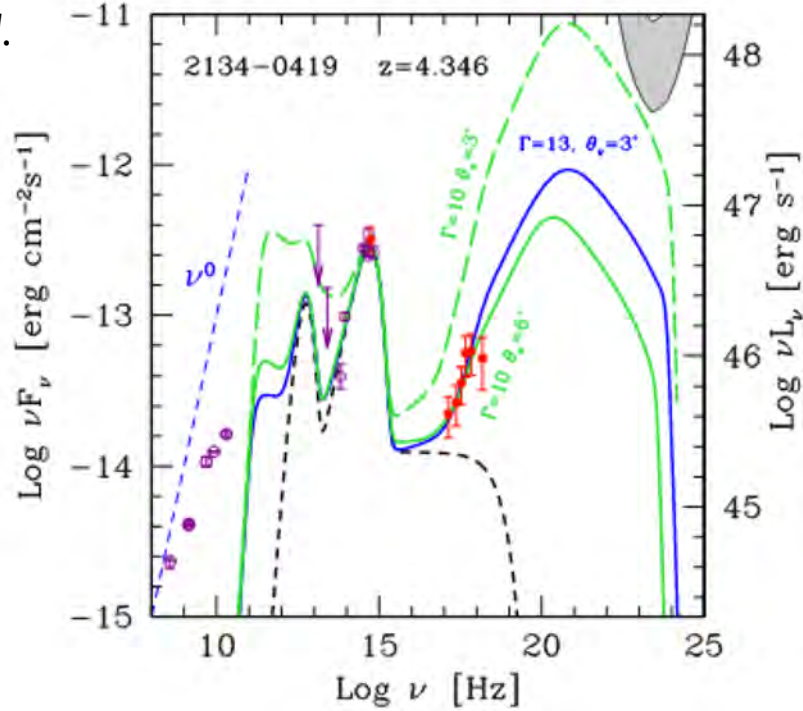
Radio interferometric observations

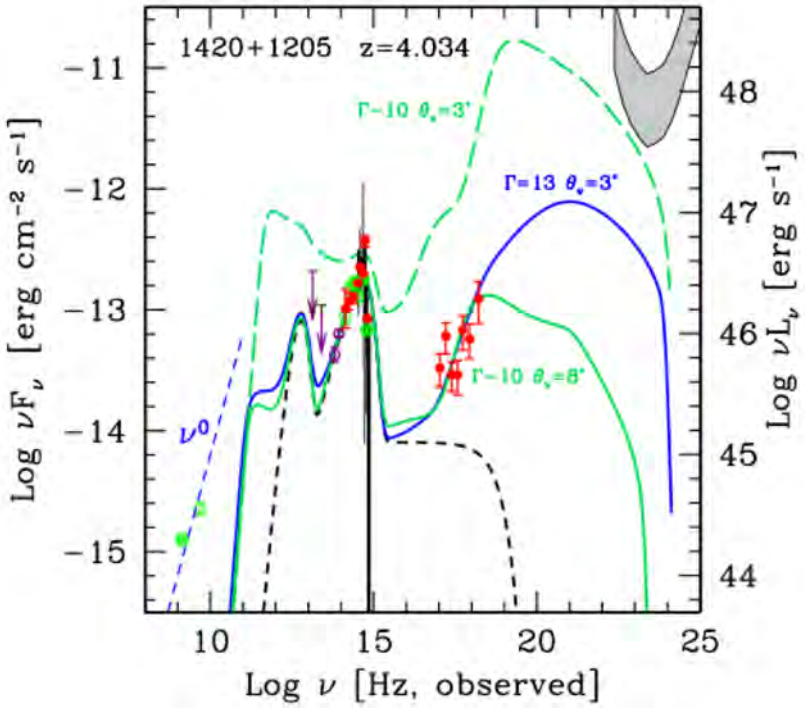
- European VLBI Network (EVN): mas-scale resolution
- E-MERLIN: 100 mas-scale resolution



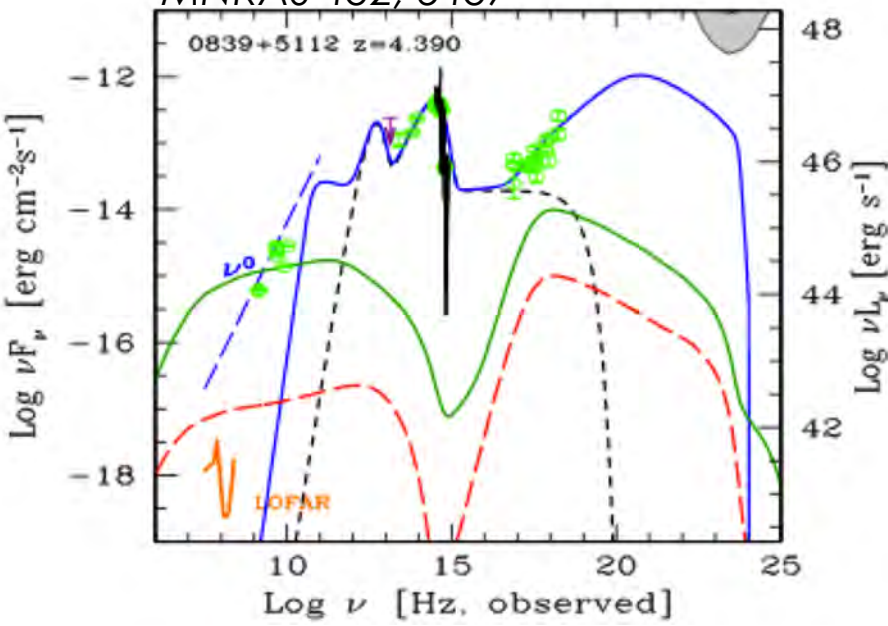
Sbarrato et al. 2015, MNRAS 466, 2483

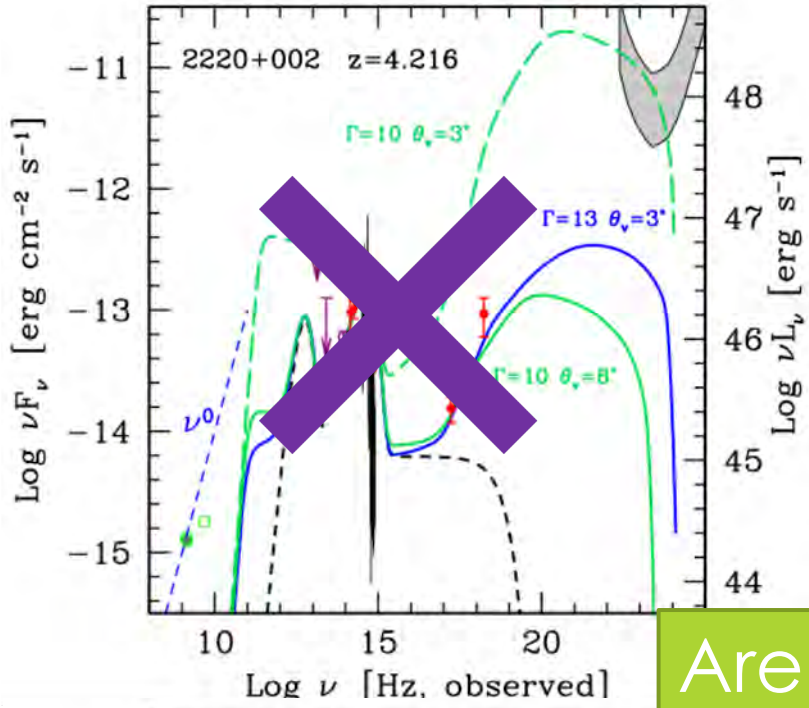




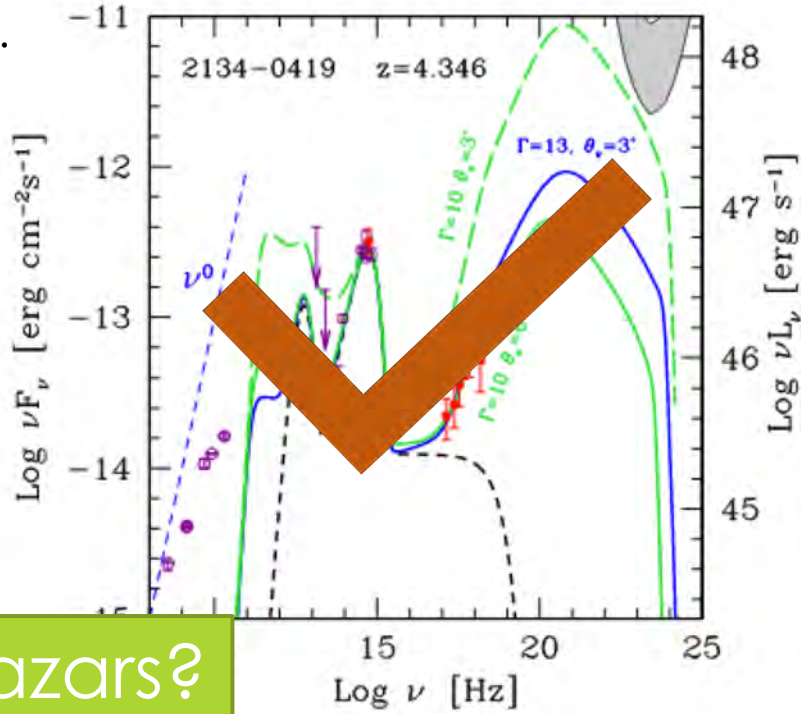


Ghisellini et al. 2015, MNRAS 452, 3457

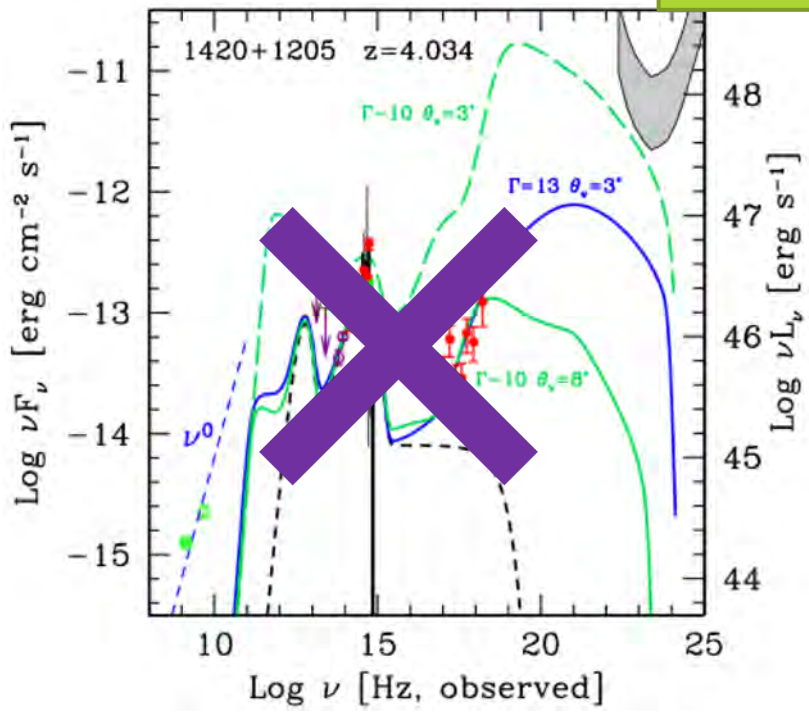




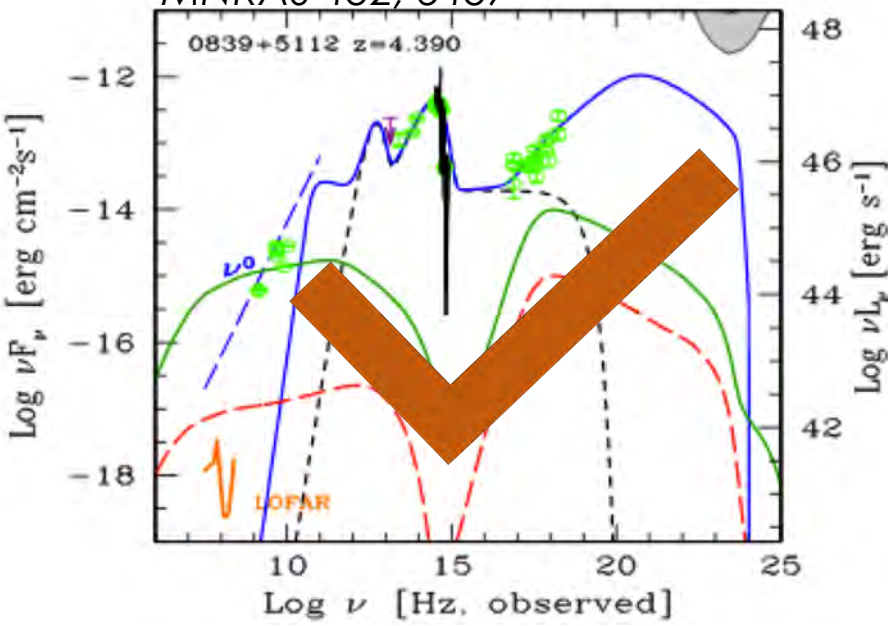
Sbarrato et al. 2015, MNRAS 466, 2483

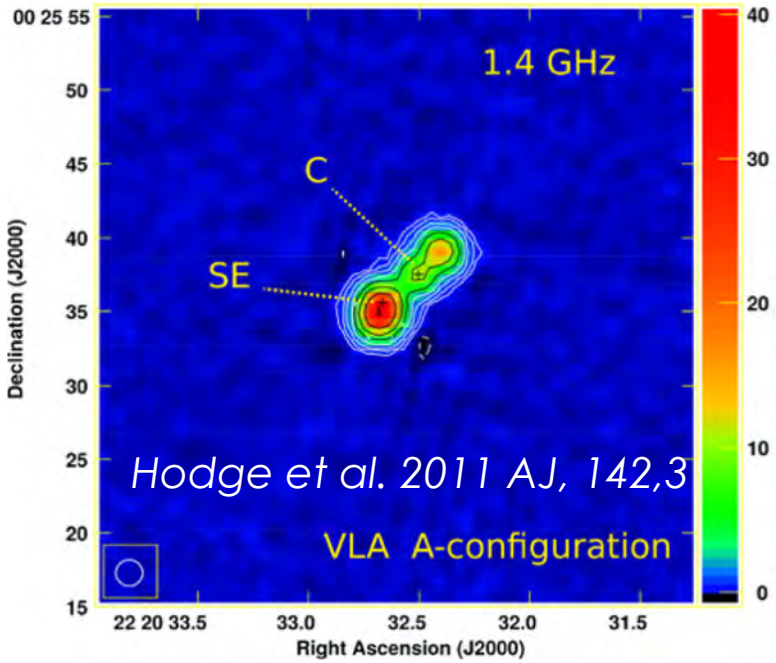


Are they blazars?

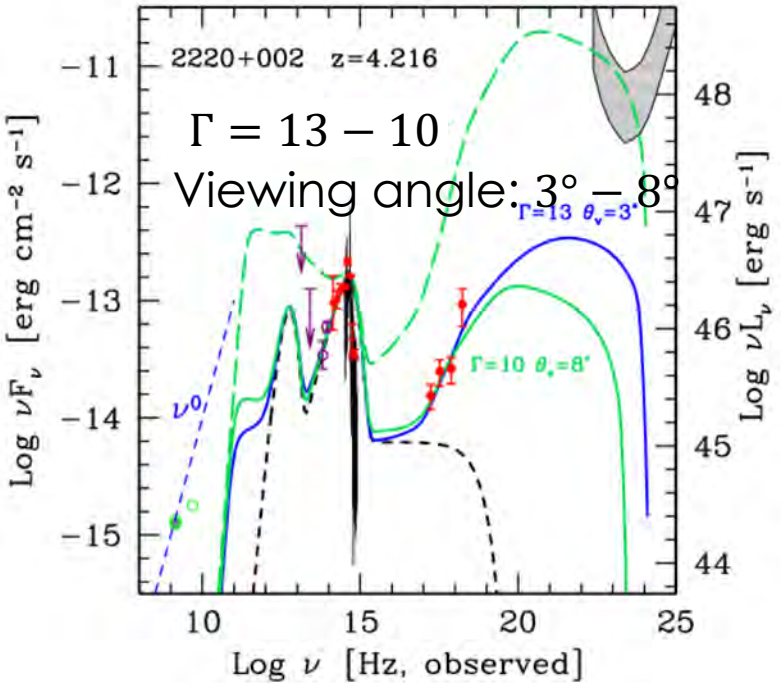


Ghisellini et al. 2015, MNRAS 452, 3457

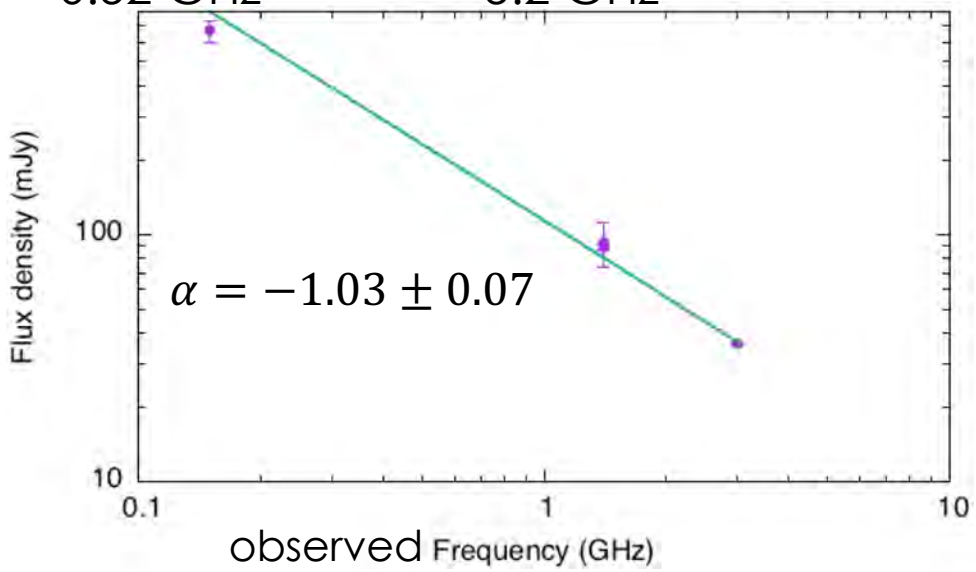




Sbarrato et al. 2015, MNRAS 466, 2483



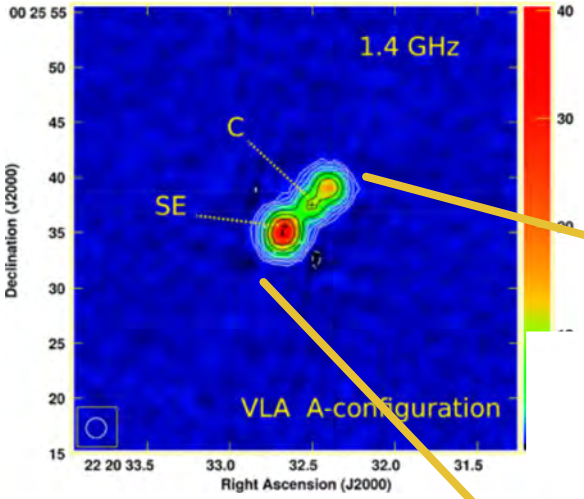
0.52 GHz 5.2 GHz

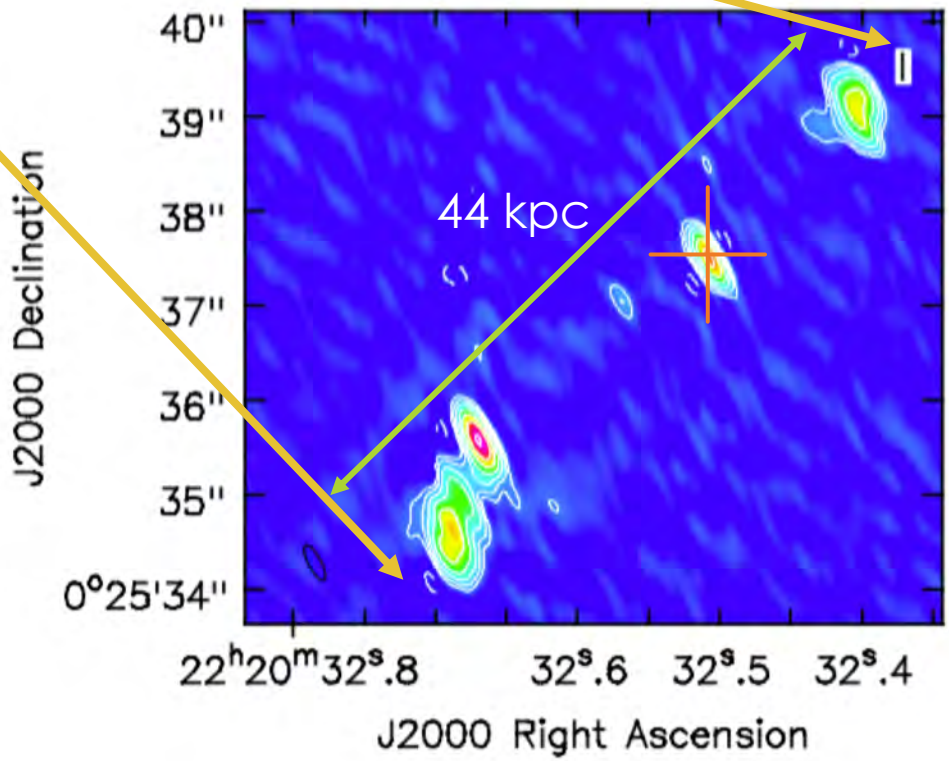


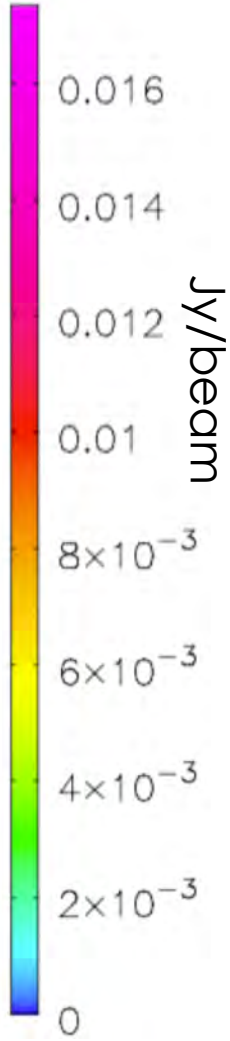
GMRT, NVSS, FIRST, VLASS

J2220+0025
z=4.21

J2220+0025
z=4.21

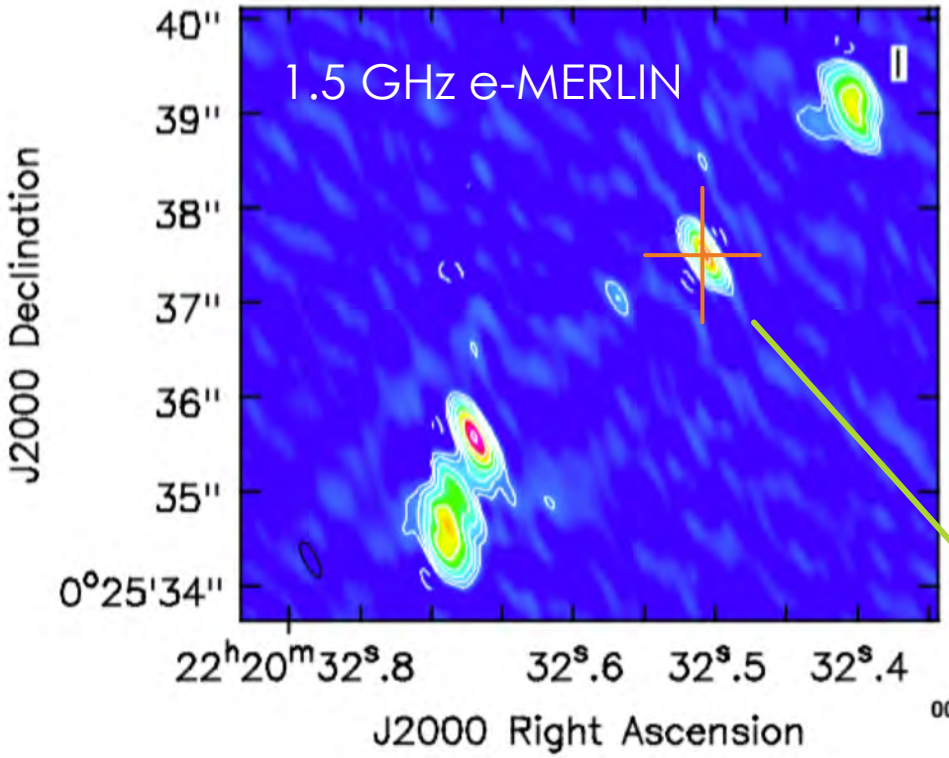




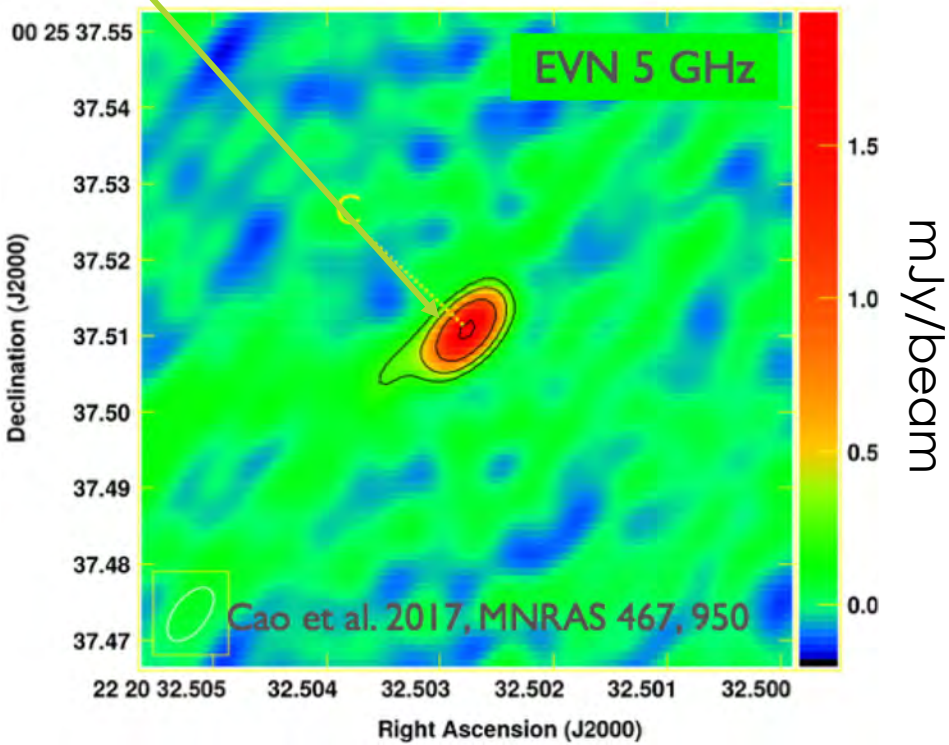


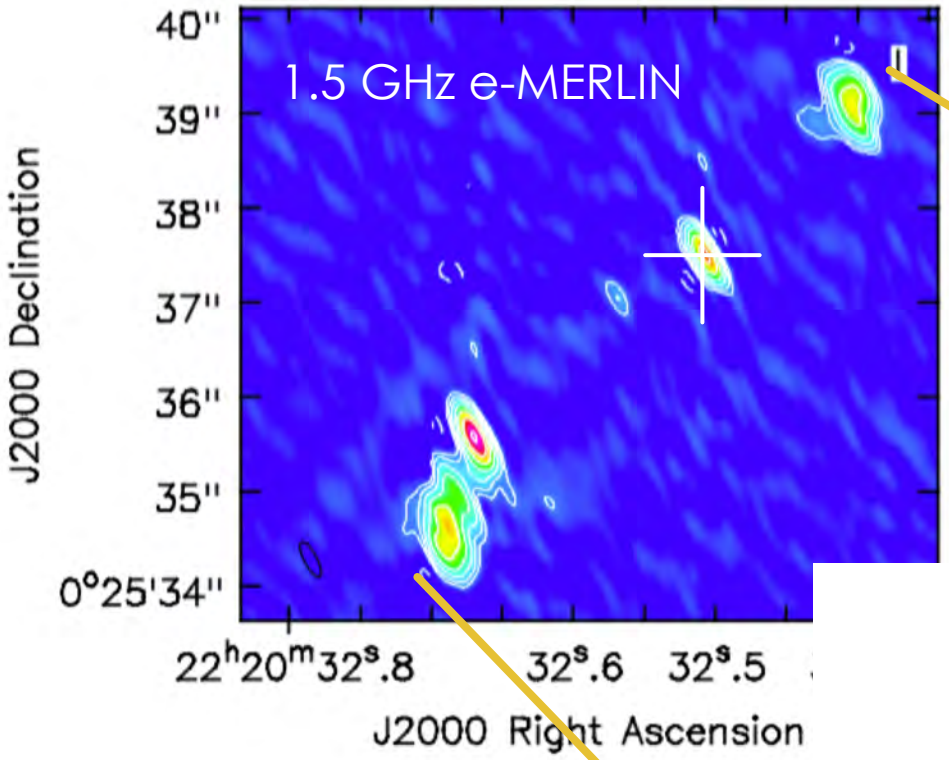
1.5 GHz e-MERLIN

J2220+0025
z=4.21



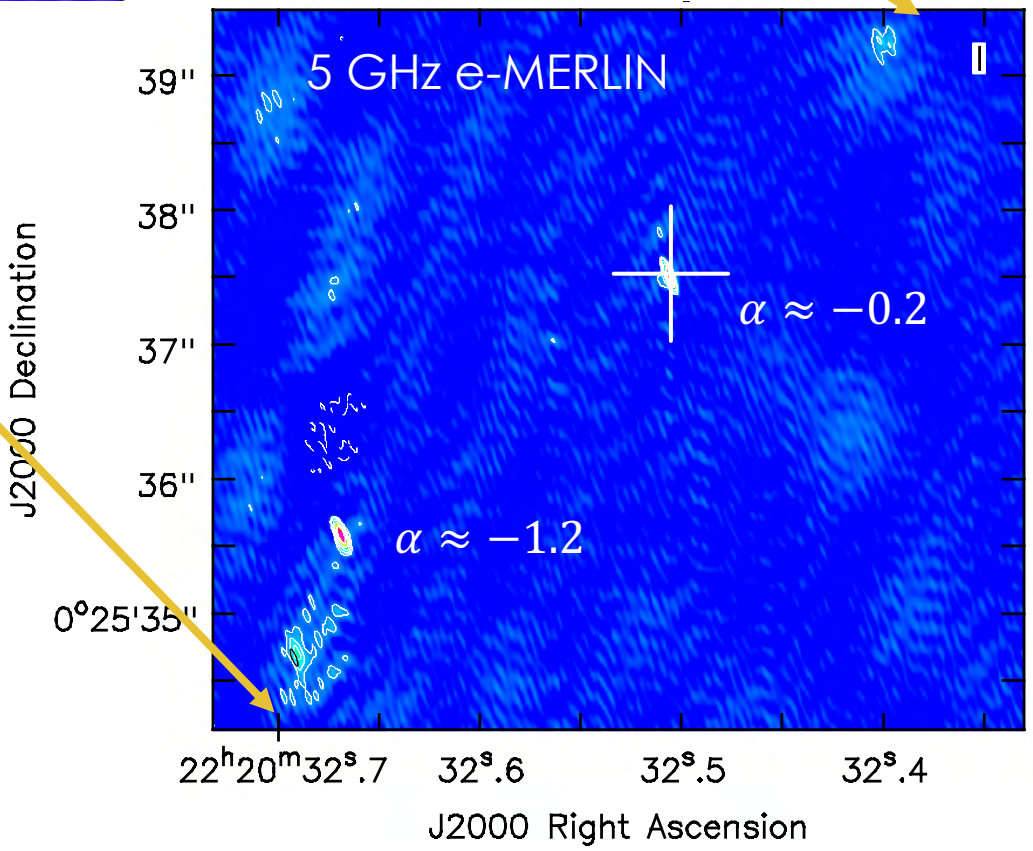
$T_{\rm B} = (0.07 \pm 0.03) \cdot 10^9 {\rm K}$

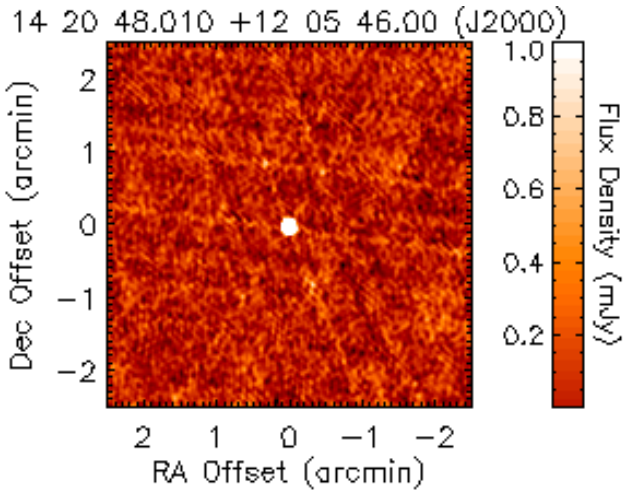




J2220+0025

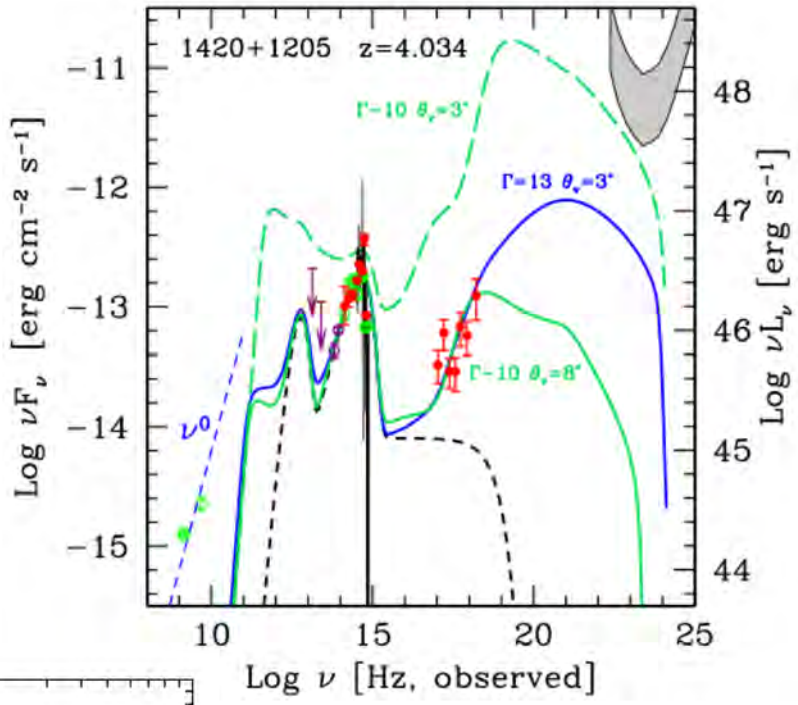
z=4.21



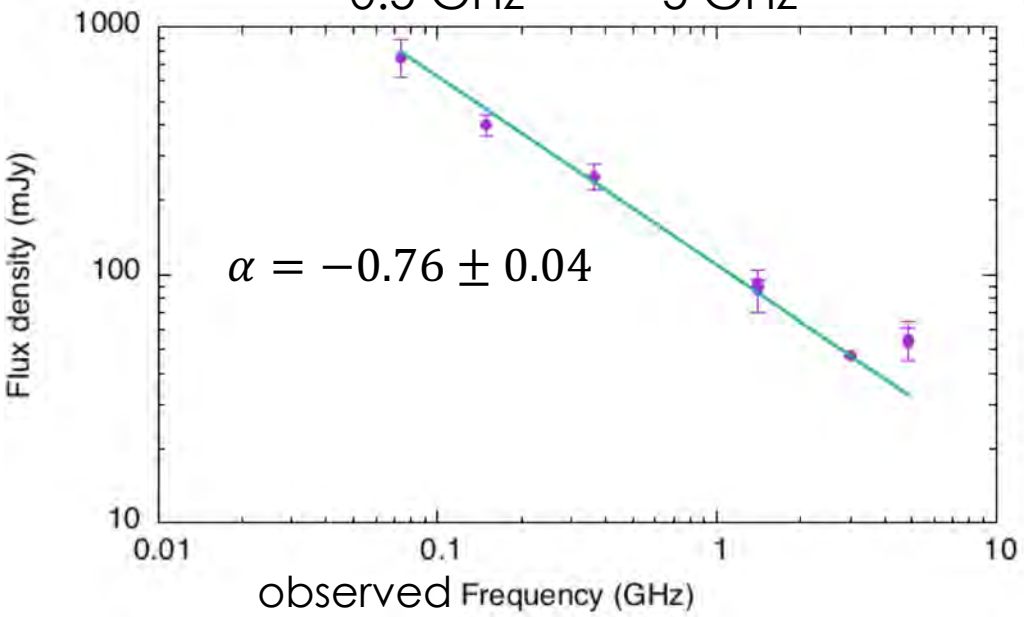


Peak: 81.7mJy/beam
Rms: 0.154 mJy
FIRST image

Sbarrato et al. 2015, MNRAS 466, 2483

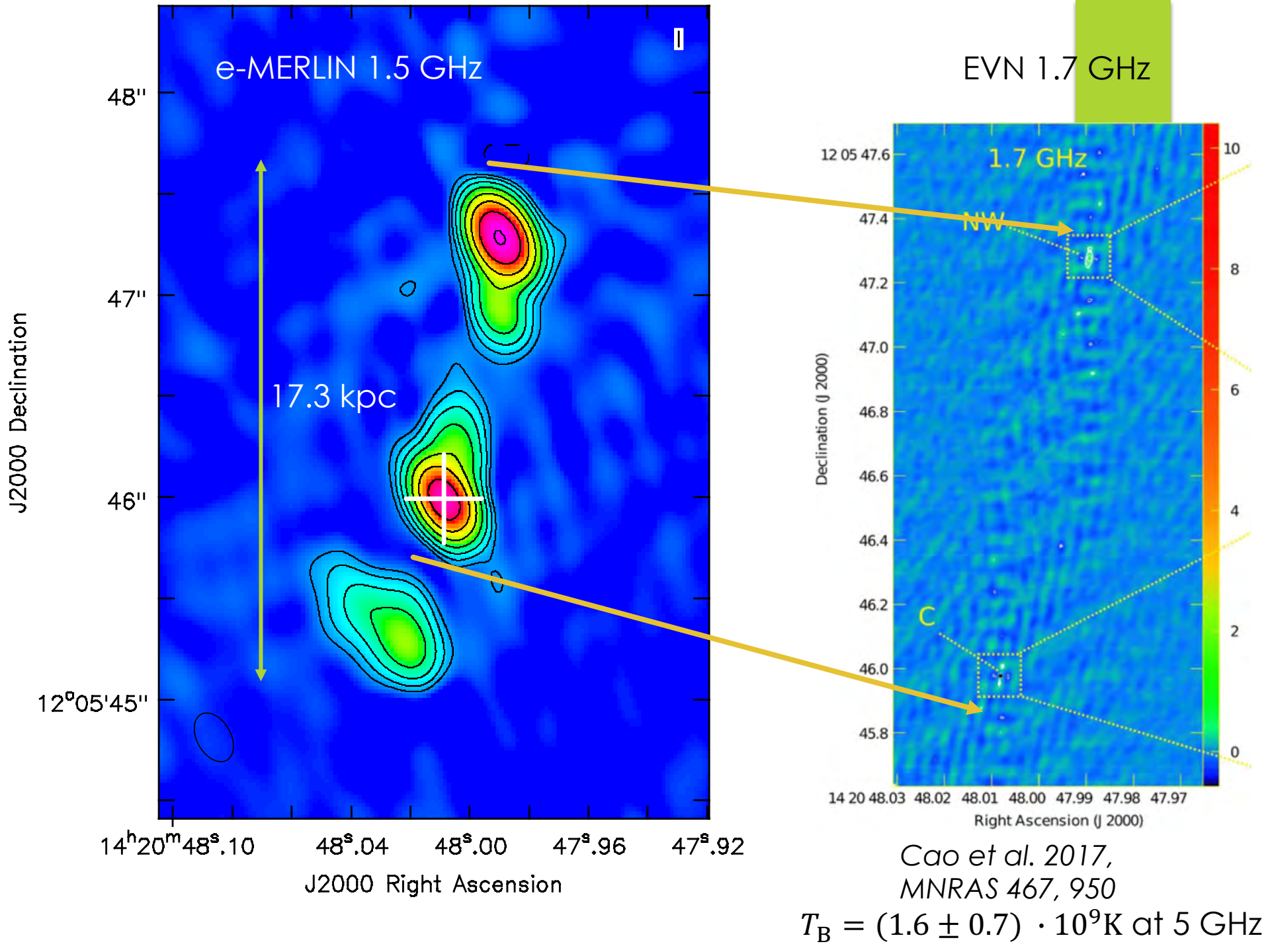


0.5 GHz 5 GHz



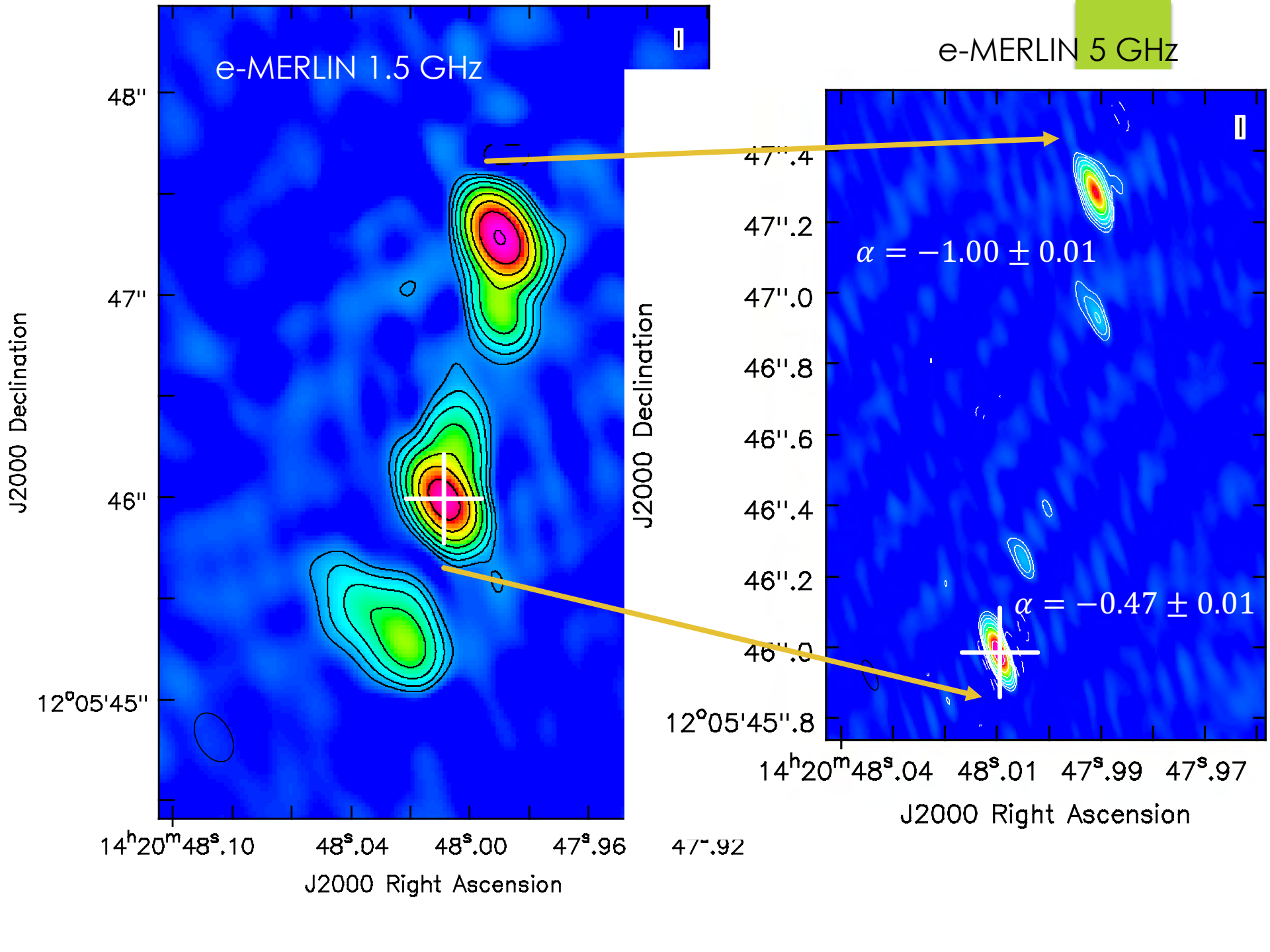
VLSS, GMRT, Texas, NVSS, FIRST, VLASS, GB6

J1420+1205
z=4.034

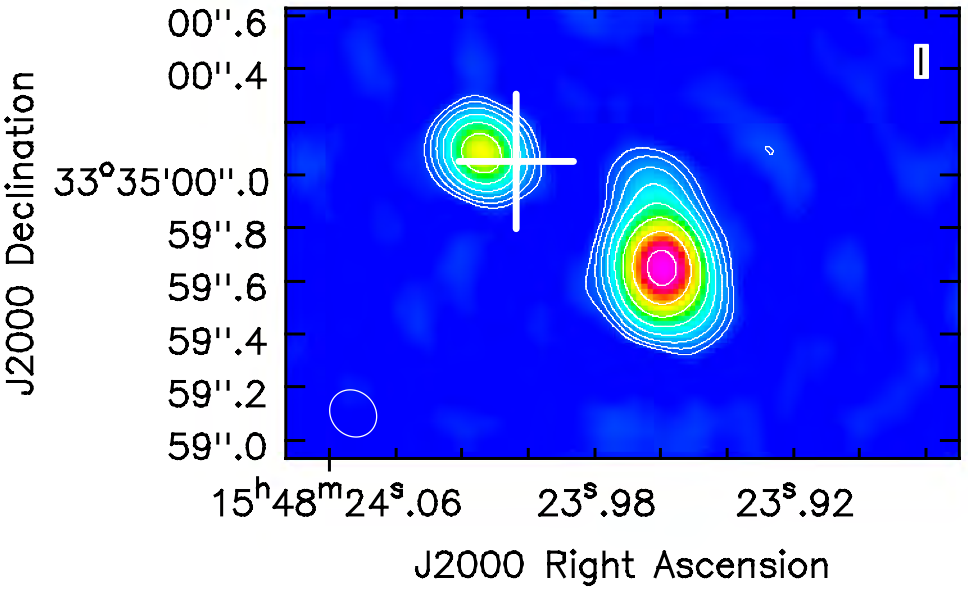


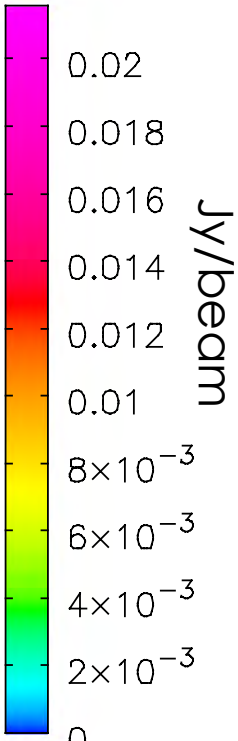
Cao et al. 2017, MNRAS 467, 950

$T_{\mathrm{B}} = (1.6 \pm 0.7) \cdot 10^{9}\mathrm{K}$ at 5 GHz


e-MERLIN 1.5 GHz
I
48''
47''
46''
12°05'45''
J2000 Declination
14h20m48s.10
48s.04
48s.00
47s.96
J2000 Right Ascension
e-MERLIN 5 GHz
I
47''.4
47''.2
47''.0
46''.8
46''.6
46''.4
46''.2
46''.0
12°05'45''.8
J2000 Declination
$\alpha = -1.00 \pm 0.01$
$\alpha = -0.47 \pm 0.01$
14h20m48s.04
48s.01
47s.99
47s.97
J2000 Right Ascension

e-MERLIN 1.5 GHz



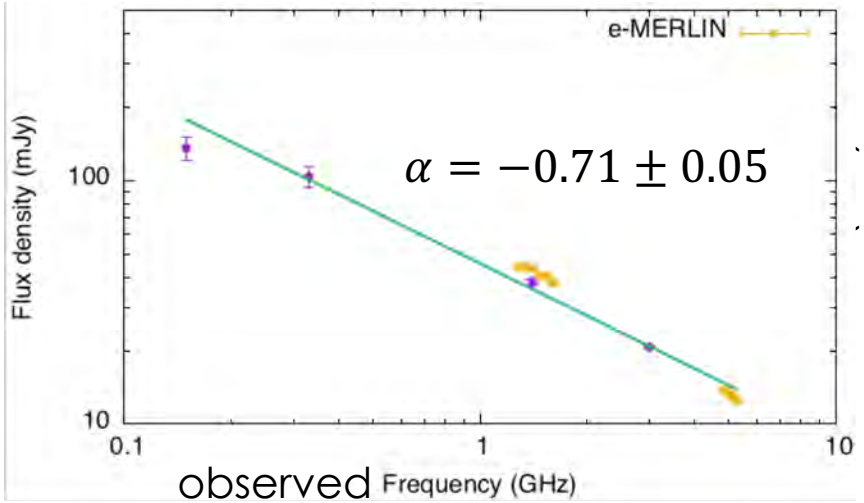


J1548+3335
z=4.68

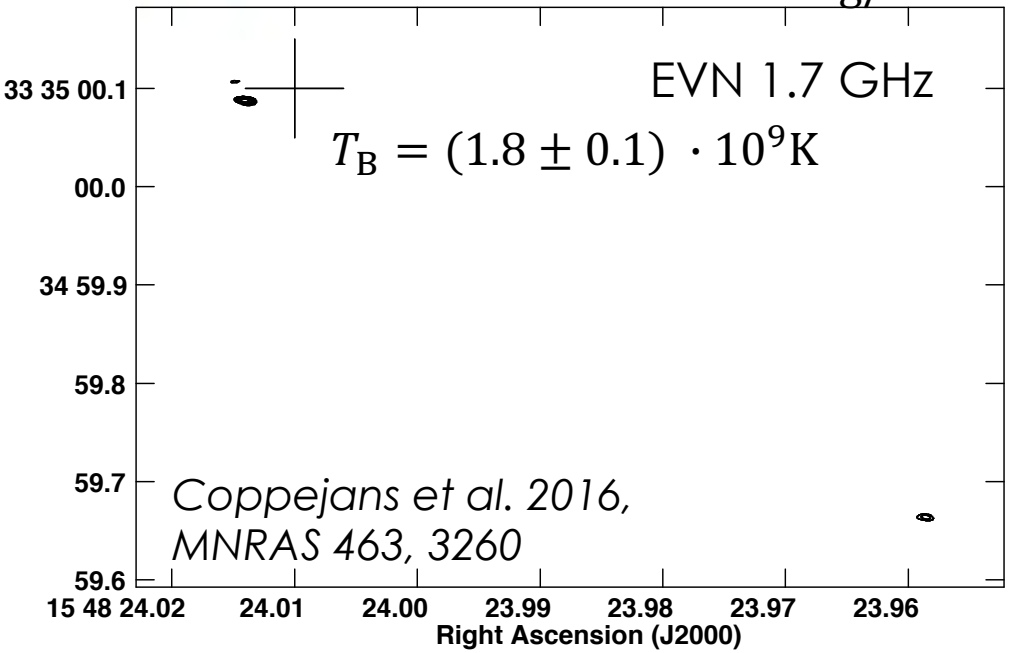
Brightest X-ray source in the Snios+ 2020 sample

$$L(2-10\mathrm{keV}) = 23.2\times10^{45}\mathrm{erg/s}$$

0.57 GHz 5.7 GHz

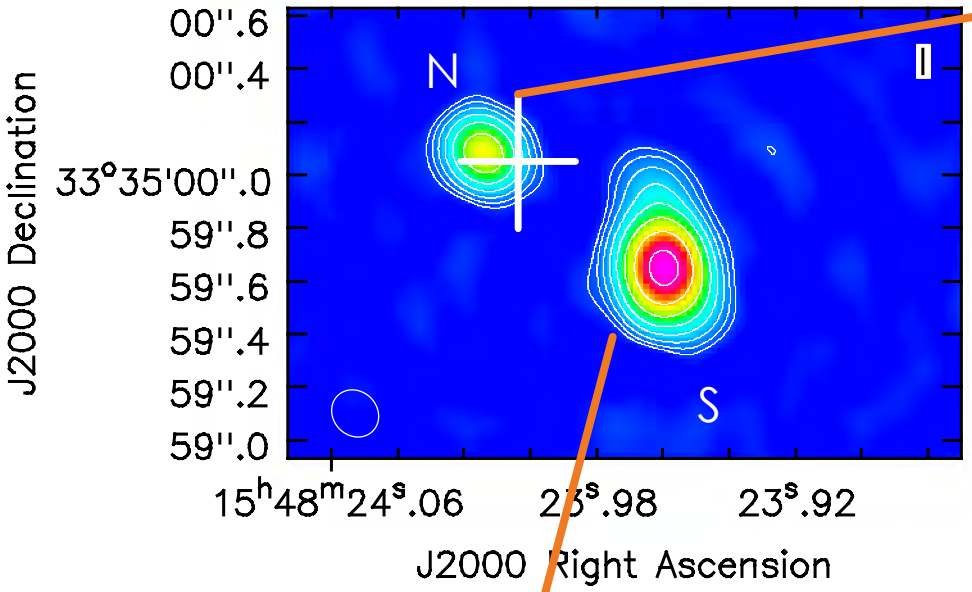


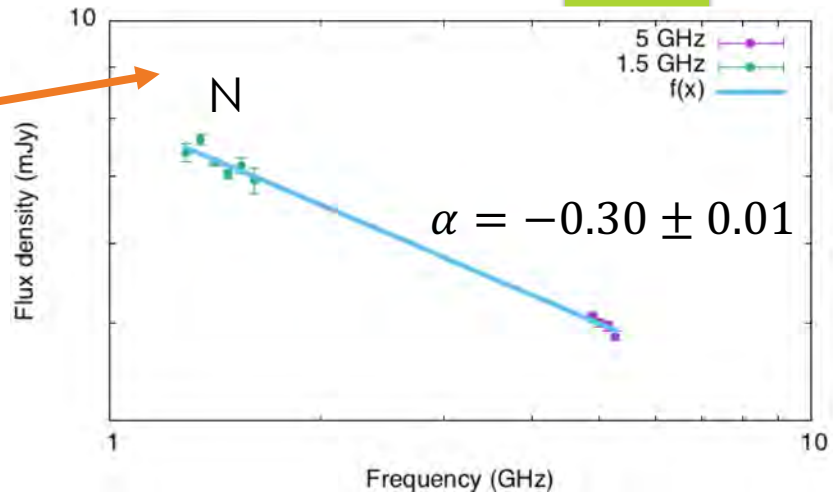
WENSS, GMRT, NVSS, FIRST, VLASS

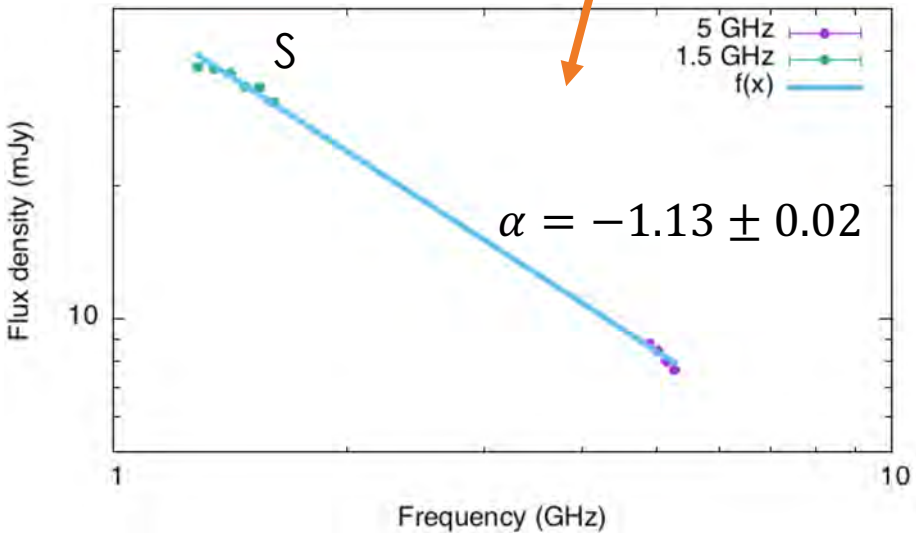


Coppejans et al. 2016, MNRAS 463, 3260

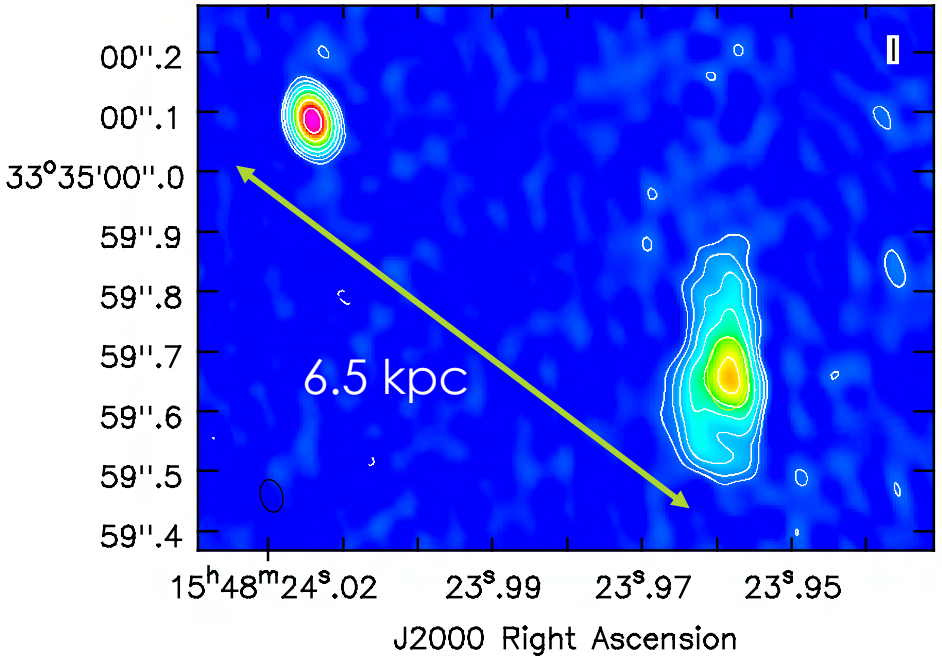
e-MERLIN 1.5 GHz



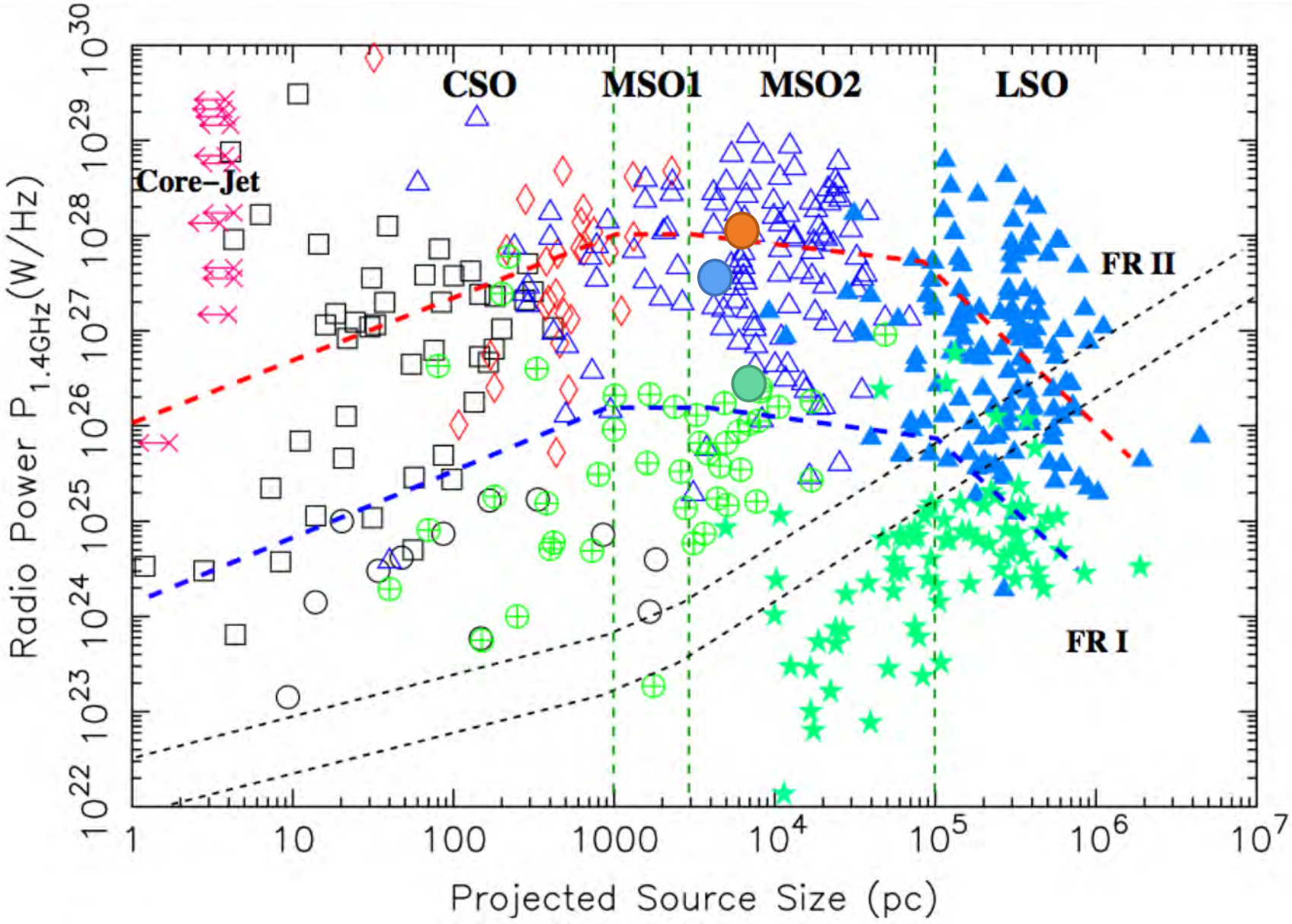




e-MERLIN 5 GHz



J1548+3335 J1420+1205 J2220+0025

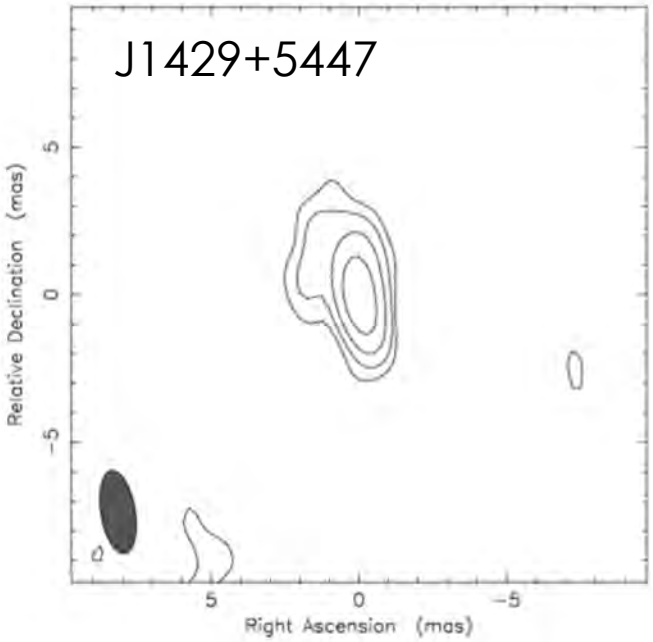


An & Baan, 2012, ApJ, 760, 77

+ another X-ray bright non-blazar

"SGR/eROSITA uncovers the most X-ray luminous quasar at z>6"
Medvedev et al. 2020, MNRAS, 497, 1842

$L(2-10\mathrm{keV}) = 2.6^{+1.7}_{-1.0}\times10^{46}$erg/s



Frey et al., 2011, A&A, 531, L5

EVN 5 GHz map
$T_{\mathrm{B}} = (7.7 \pm 0.7)\cdot 10^{8}\mathrm{K}$

$\nu L \sim 10^{43}$ erg/s

Summary

- VLBI can confirm or falsify the blazar nature
- E-MERLIN can map the hot spots, lobes and jets – the 100 mas-scale structure, can reveal CSO/MSO-like features
- But where does the X-ray emission come from
  - Hot spot?
  - Inner region produces beamed X-ray, outer region produces radio structure?

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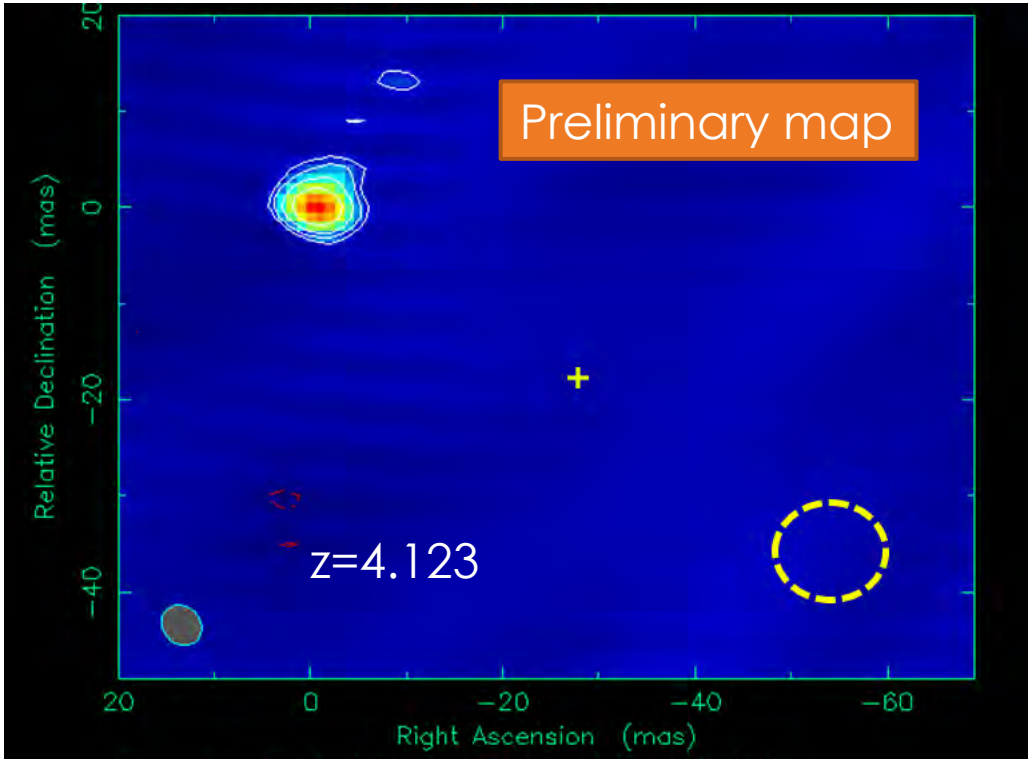
Stay tuned …



1.7 GHz and 5 GHz EVN observations of 13 z>4 radio AGN
FIRST flux densities: 4 mJy - 71 mJy

Krezinger et al. 2021 in prep.