

Dying and restarted AGNs in the LOFAR sky

Marisa Brienza – Bologna, 23 Oct 2015

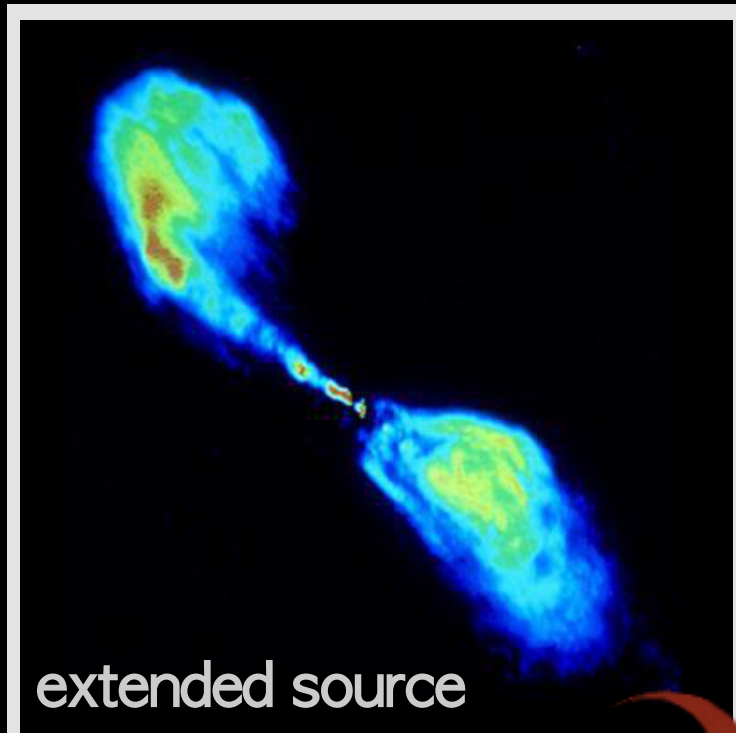
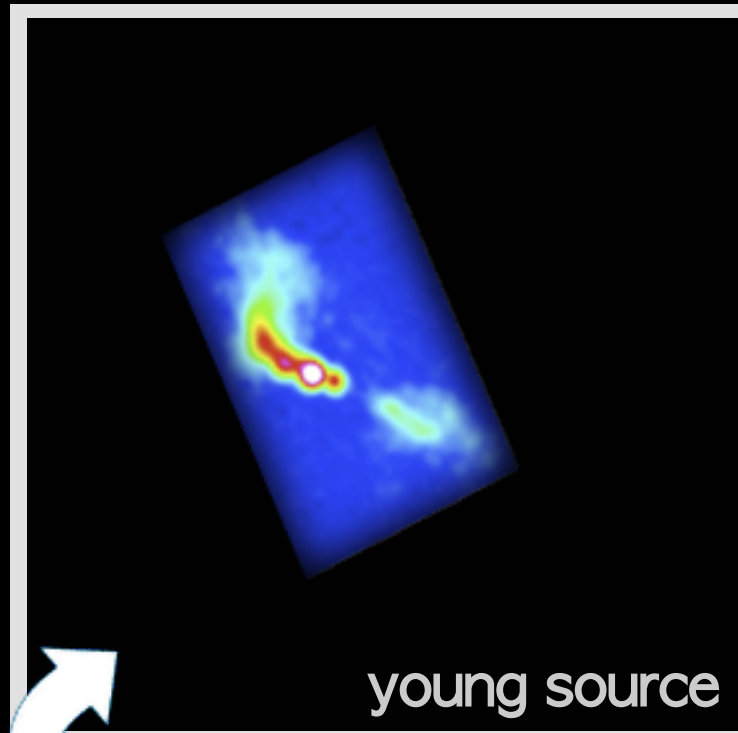
Morganti R., Godfrey L., et al.

ASTRON

university of
 groningen

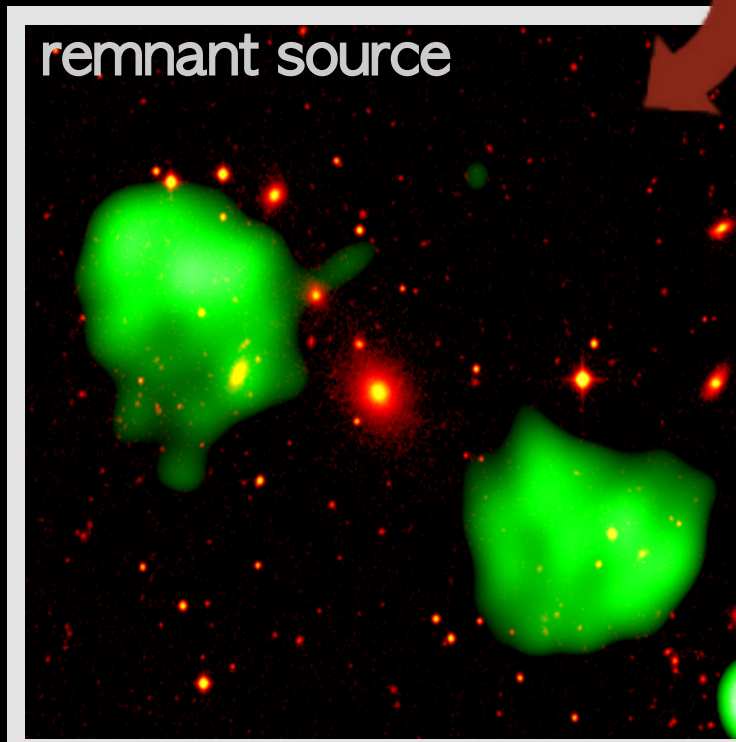
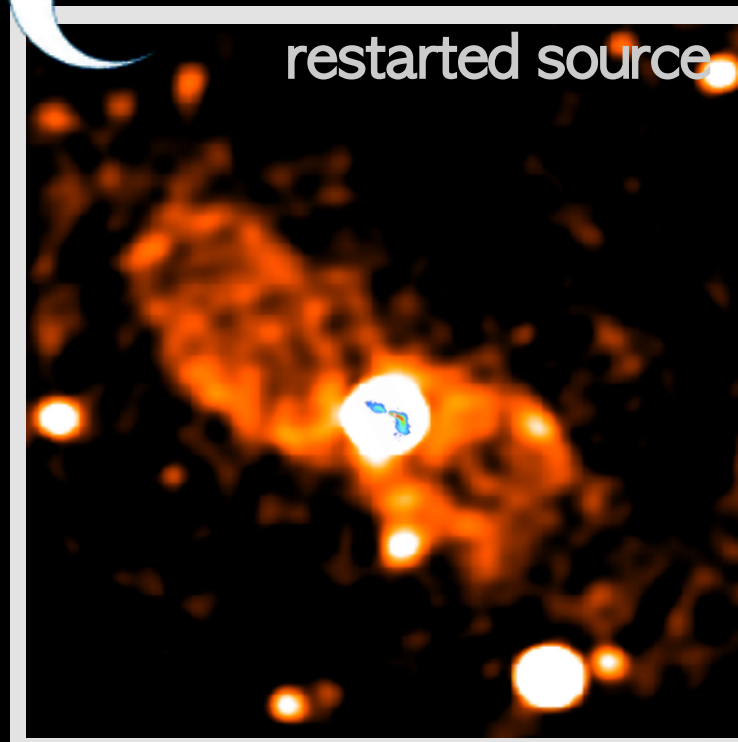
LOFAR

Giroletti+2005



S. Tingay (ICRAR)

Shulevski+2012

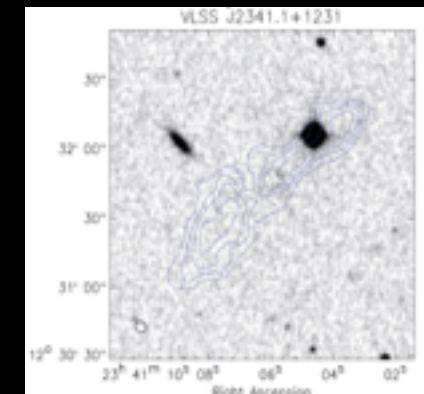
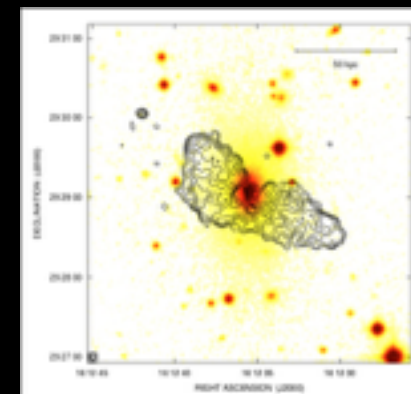
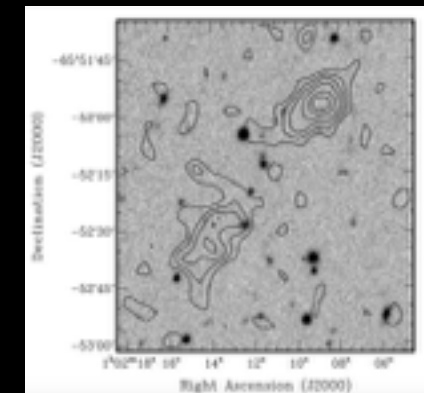
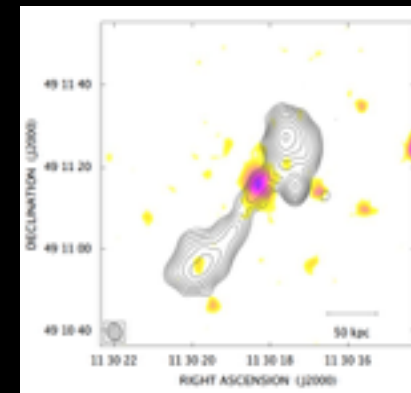


Murgia+2011

SELECTING REMNANT PLASMA

To understand the conditions of these phases of the radio galaxy evolution we need to build up **BIGGER SAMPLES** and **EXPAND THE PARAMETER SPACE**

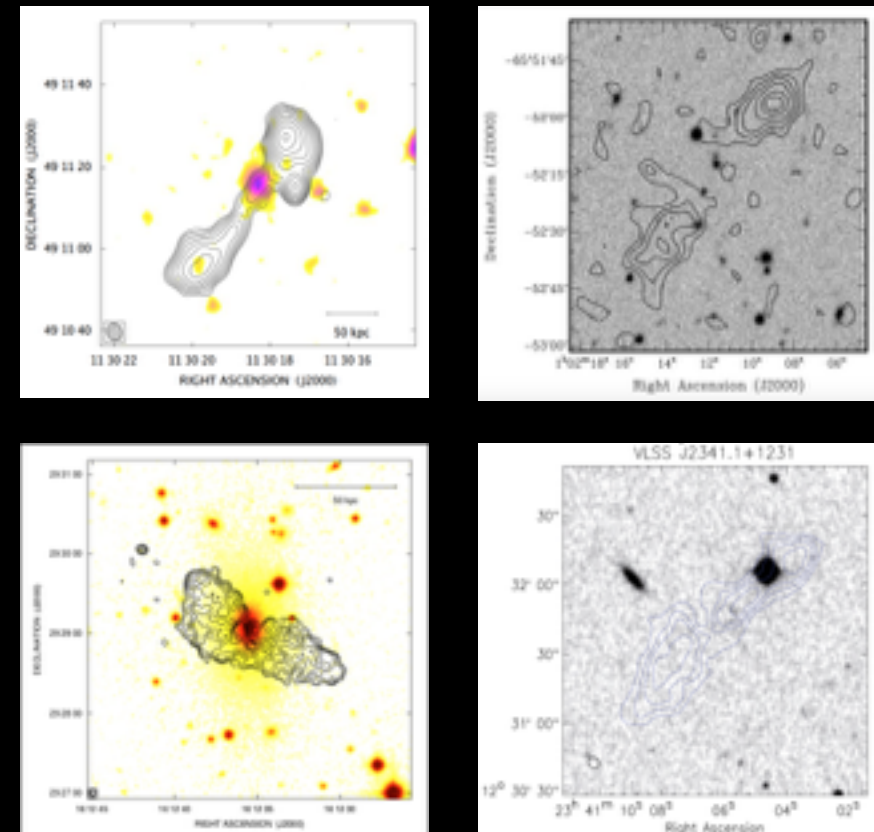
- ★ **STEEP SPECTRAL INDEX**
(e.g. Parma+2007, Dwarakanath+2009, Sirothia+2009, VanWeeren+2009)
- ★ **SPECTRAL CURVATURE**
(Murgia+2011)
- ★ **MORPHOLOGY**
(e.g. Saripalli+2009)



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CAVEATS!!!

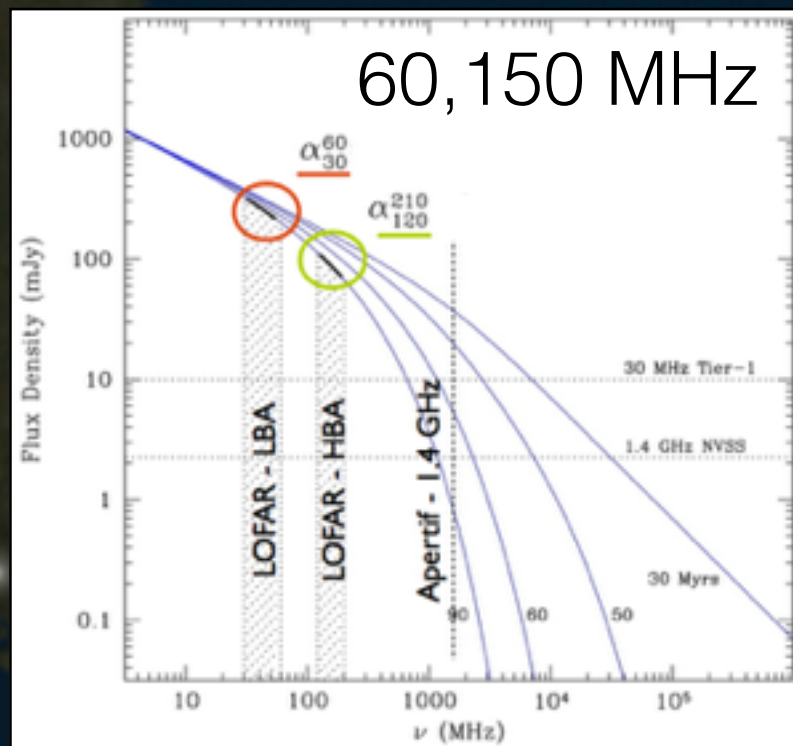
- not all AGN remnants have steep spectrum at low frequencies
(e.g. low magnetic field, different evolution, etc.)
- not all diffuse, low surface brightness emission is signature of AGN remnants
(e.g. low level activity, uncollimated jets etc.)

Dying and restarted AGN with LOFAR



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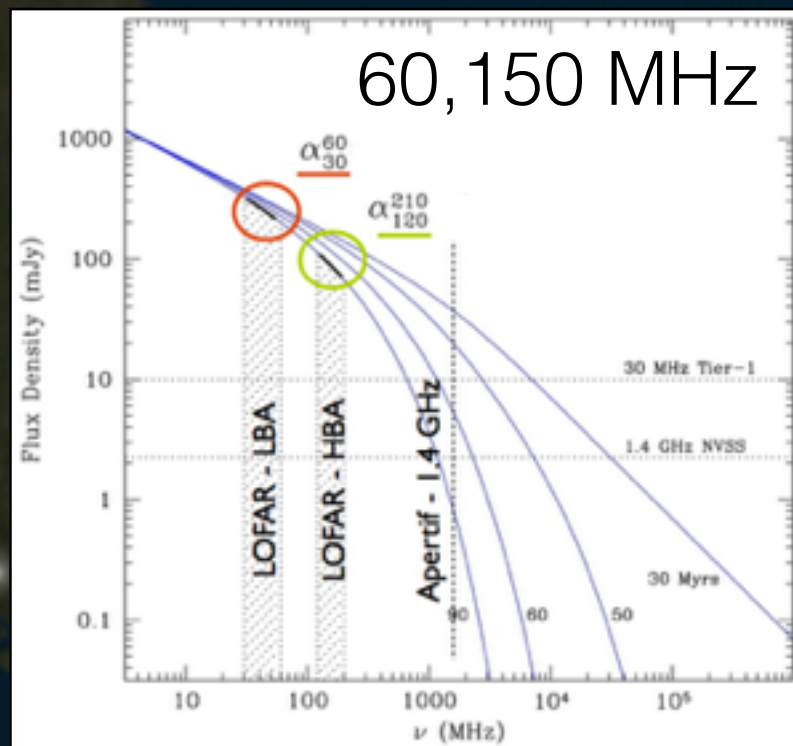
★ LOW FREQUENCY



Courtesy of M.Murgia

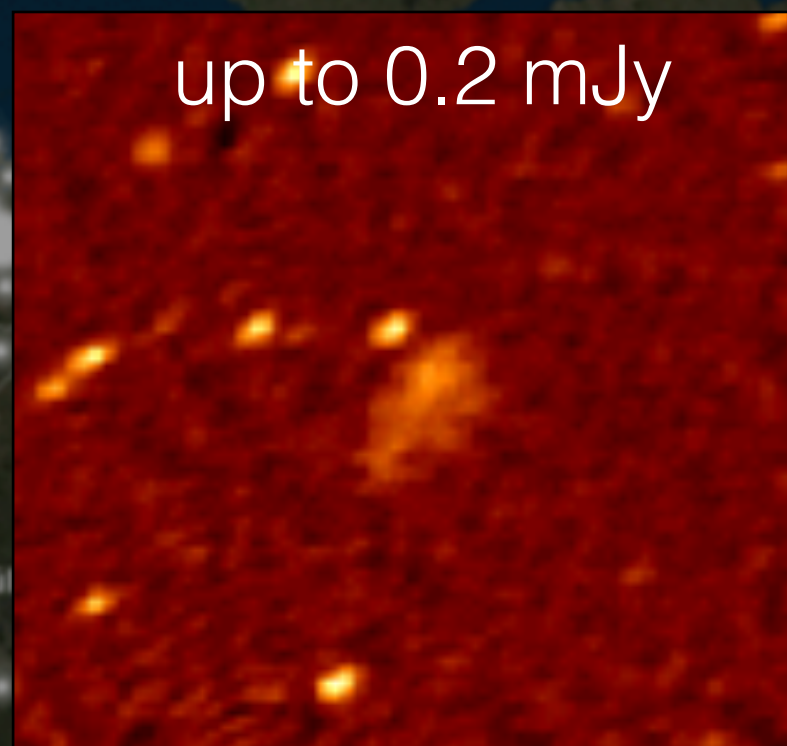
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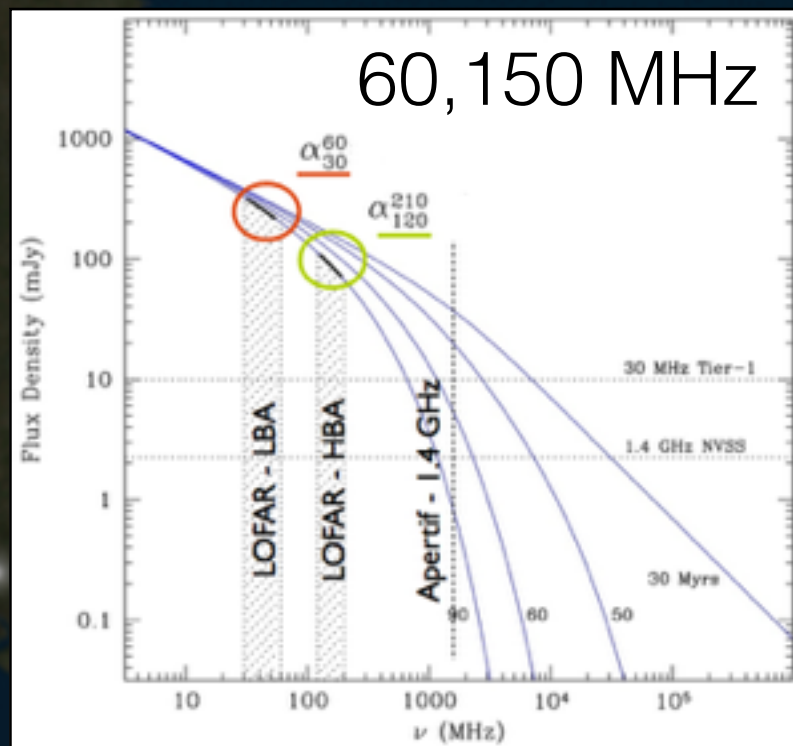
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★ HIGH SENSITIVITY



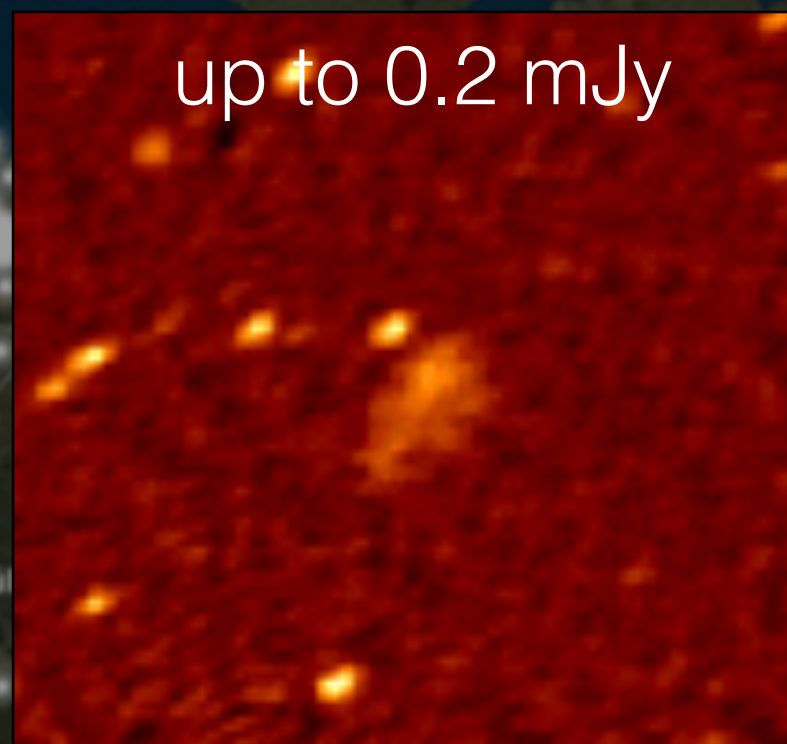
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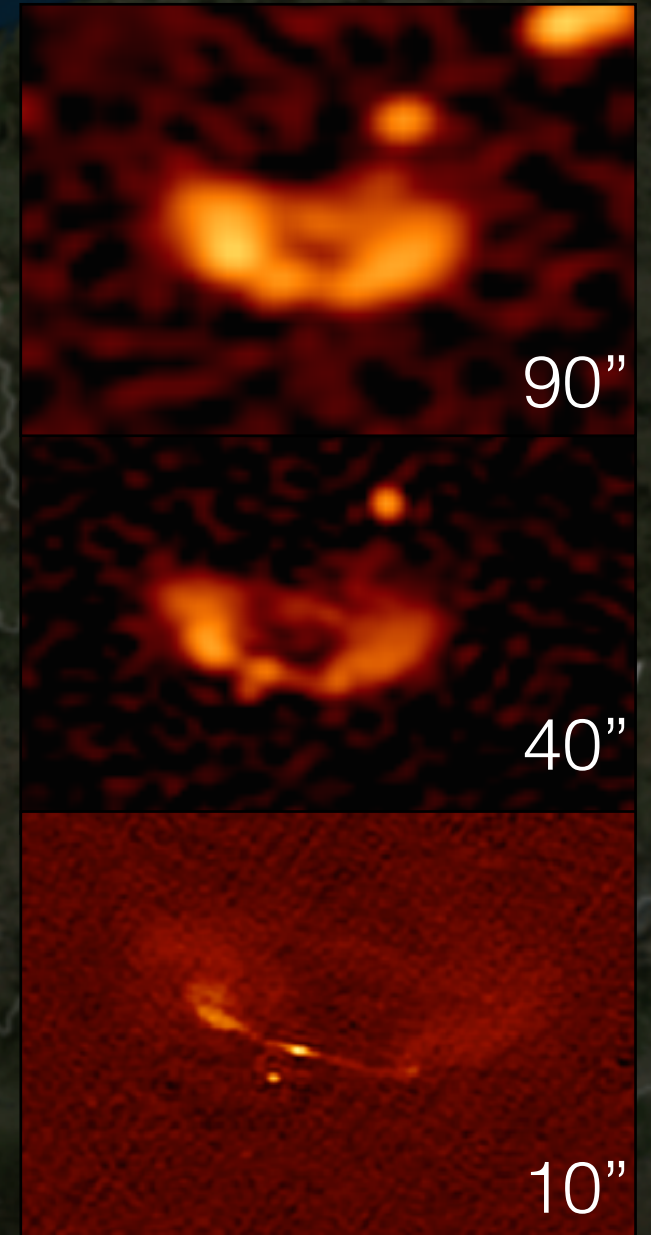


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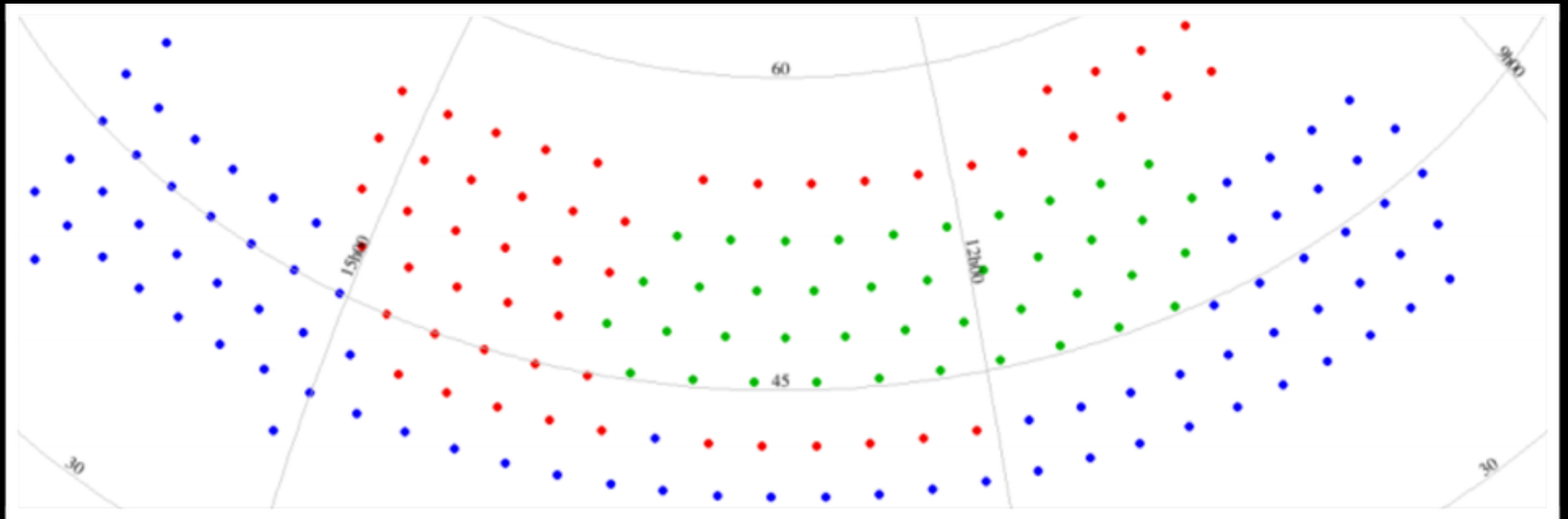
★ HIGH SENSITIVITY



★ RESOLUTION



LOFAR Tier-1 survey



- All-sky @ 150 MHz
- 48 MHz bandwidth
- ~0.3 mJy noise
- 5 arcsec resolution



A CASE STUDY:

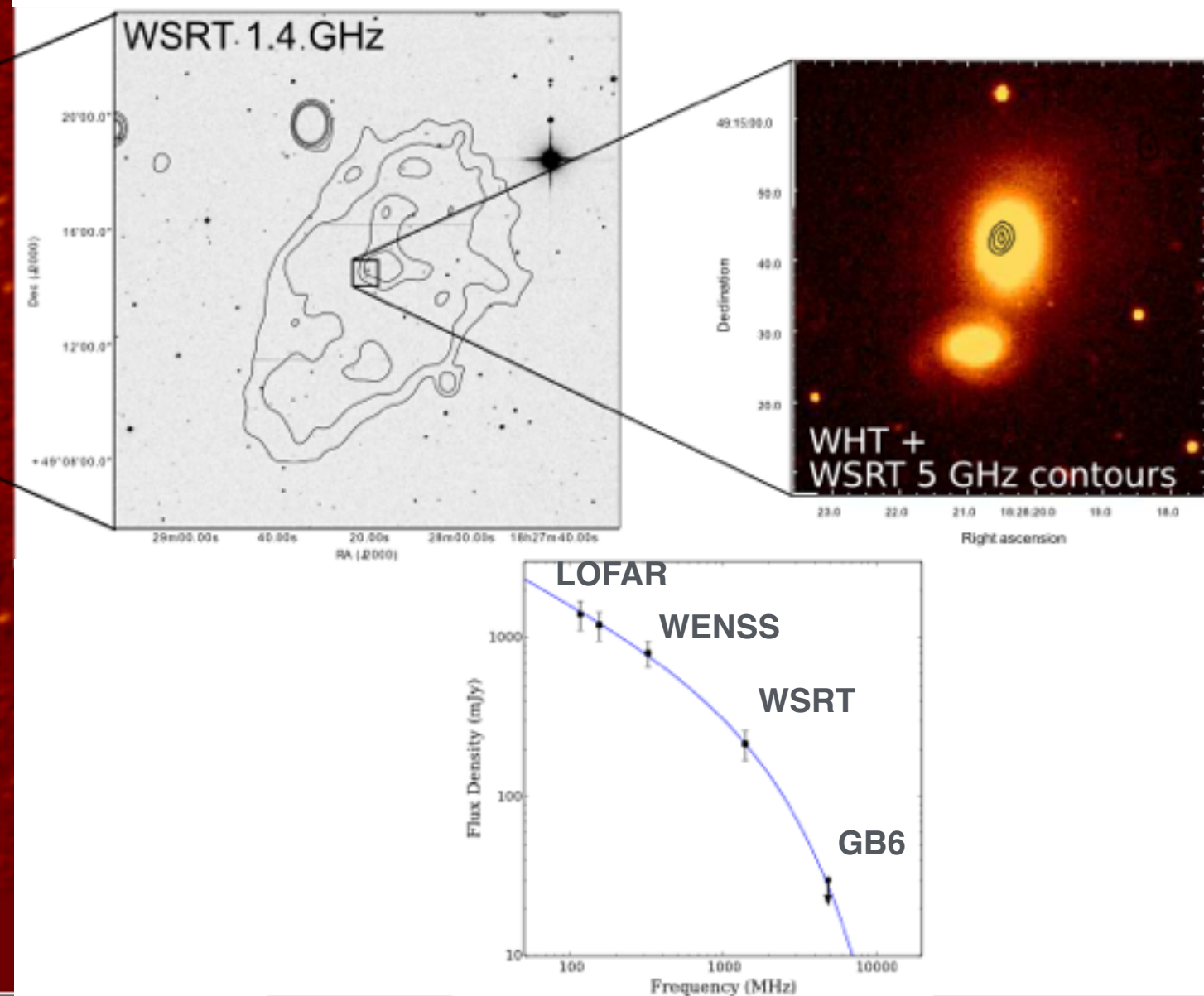
LOFAR discovery of a 700-kpc remnant radio galaxy at low redshift

Brienza+2015, arXiv:1508.07239

LOFAR 150 MHz

BLOB1

20 mJy/arcmin²



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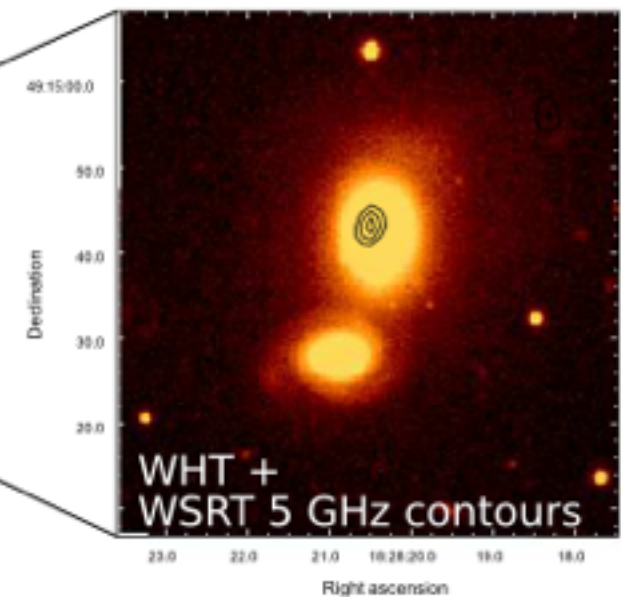
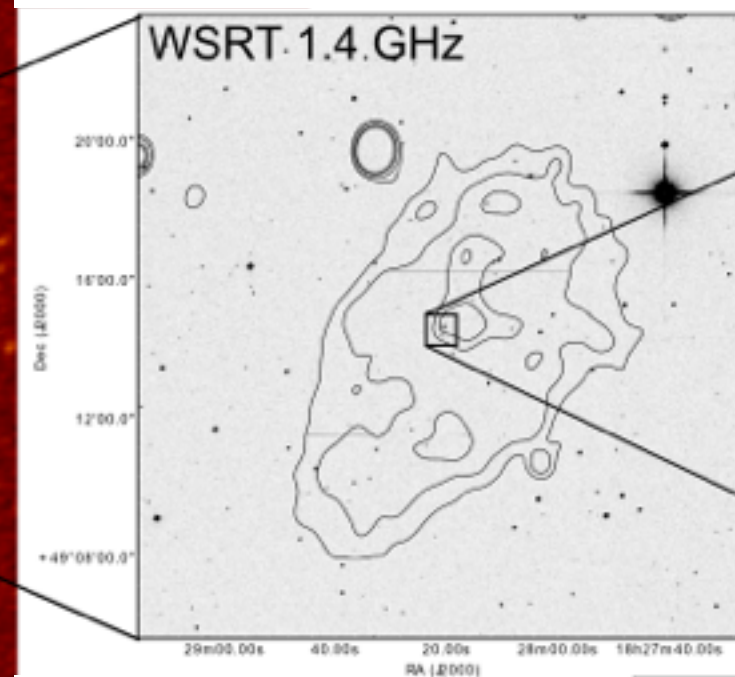
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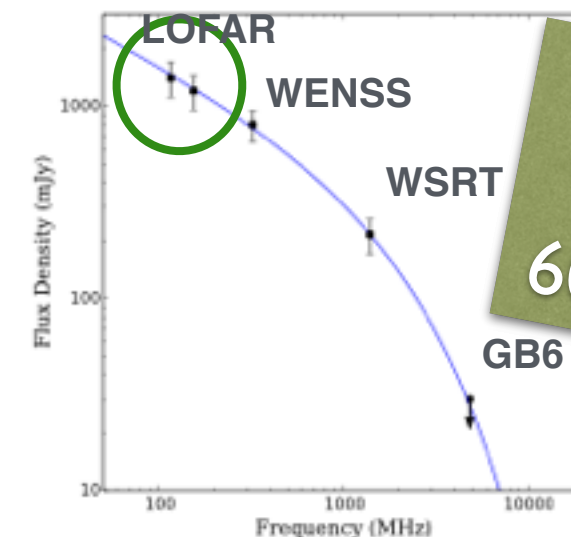
LOFAR 150 MHz

BLOB1

interacting early type
galaxies outside clusters!



non-steep
spectral index
at low frequency
&
 $\text{SPC} > 0.5$



15 Myr ON
+
60 Myr OFF

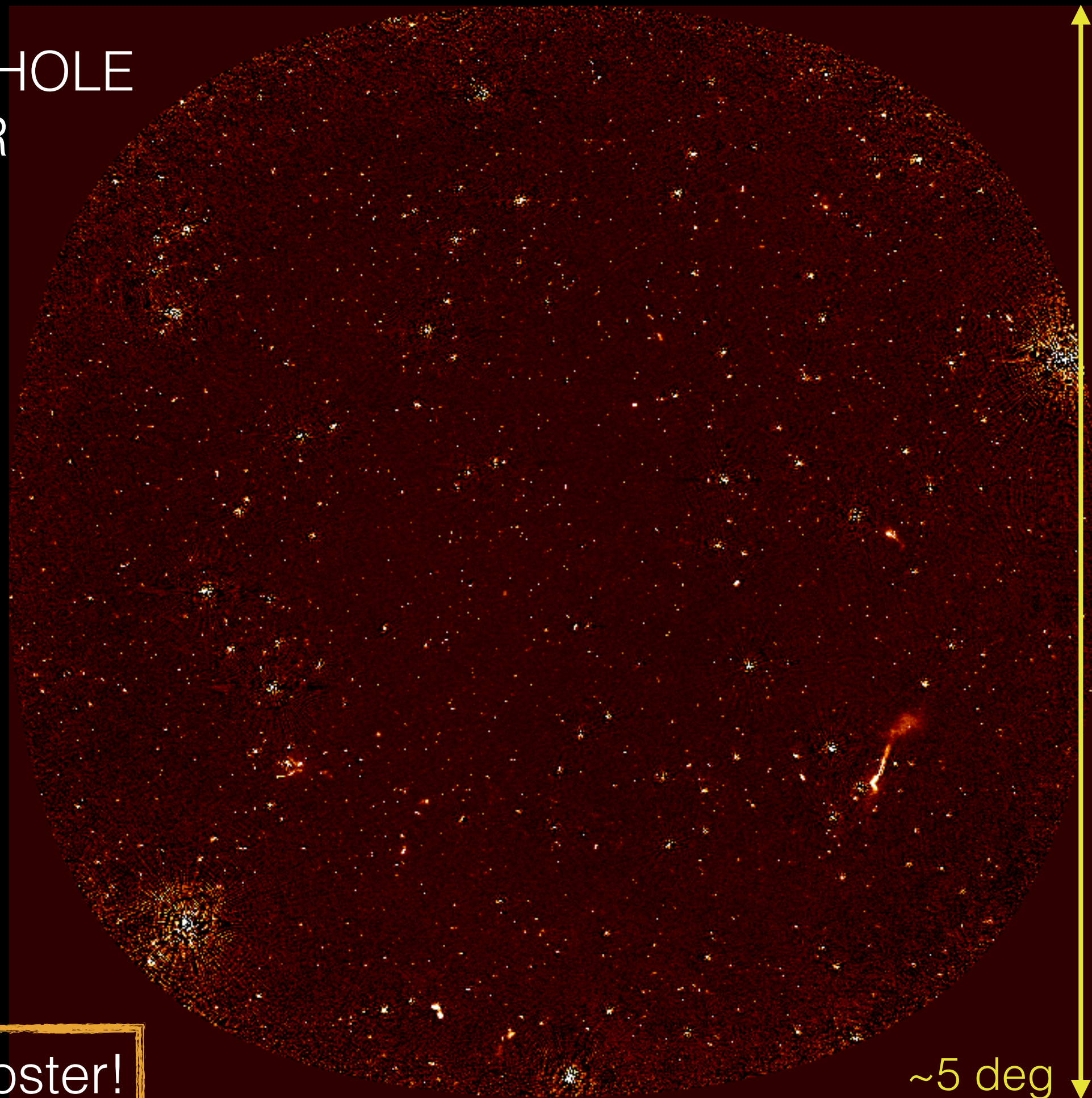
SEARCH IN THE LOFAR SURVEY FIELDS:

USING COMPLEMENTARY APPROACHES

- morphology
- spectral index
- spectral curvature

The LOCKMAN HOLE with LOFAR

- HBA observation
(110-180 MHz)
- 70 MHz bandwidth
(300 subbands)
- 10 hrs int. time
- 14''x18'' resolution
- rms~0.75 mJy
- about 6000 sources



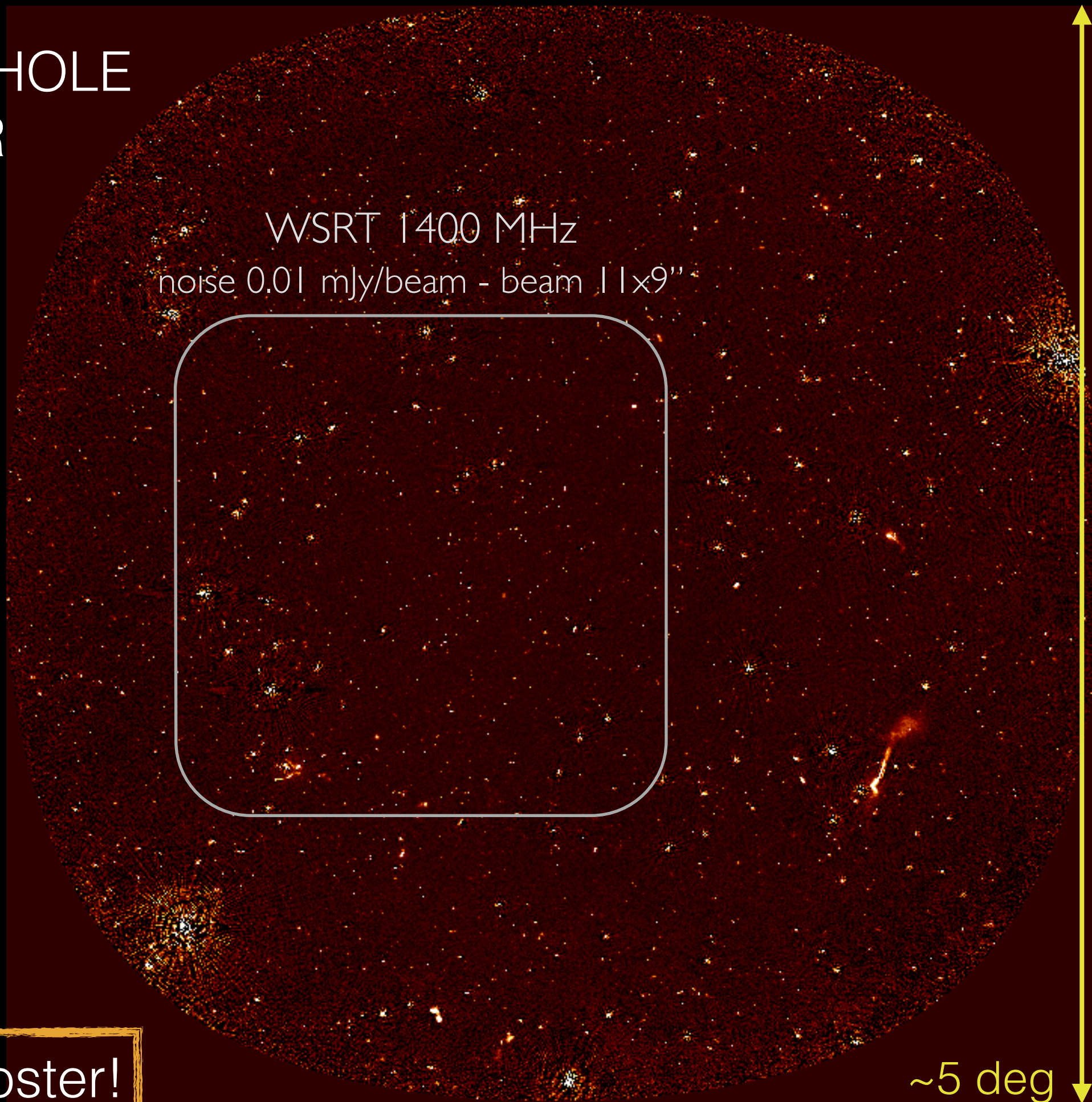
see Mahony's poster!

~5 deg

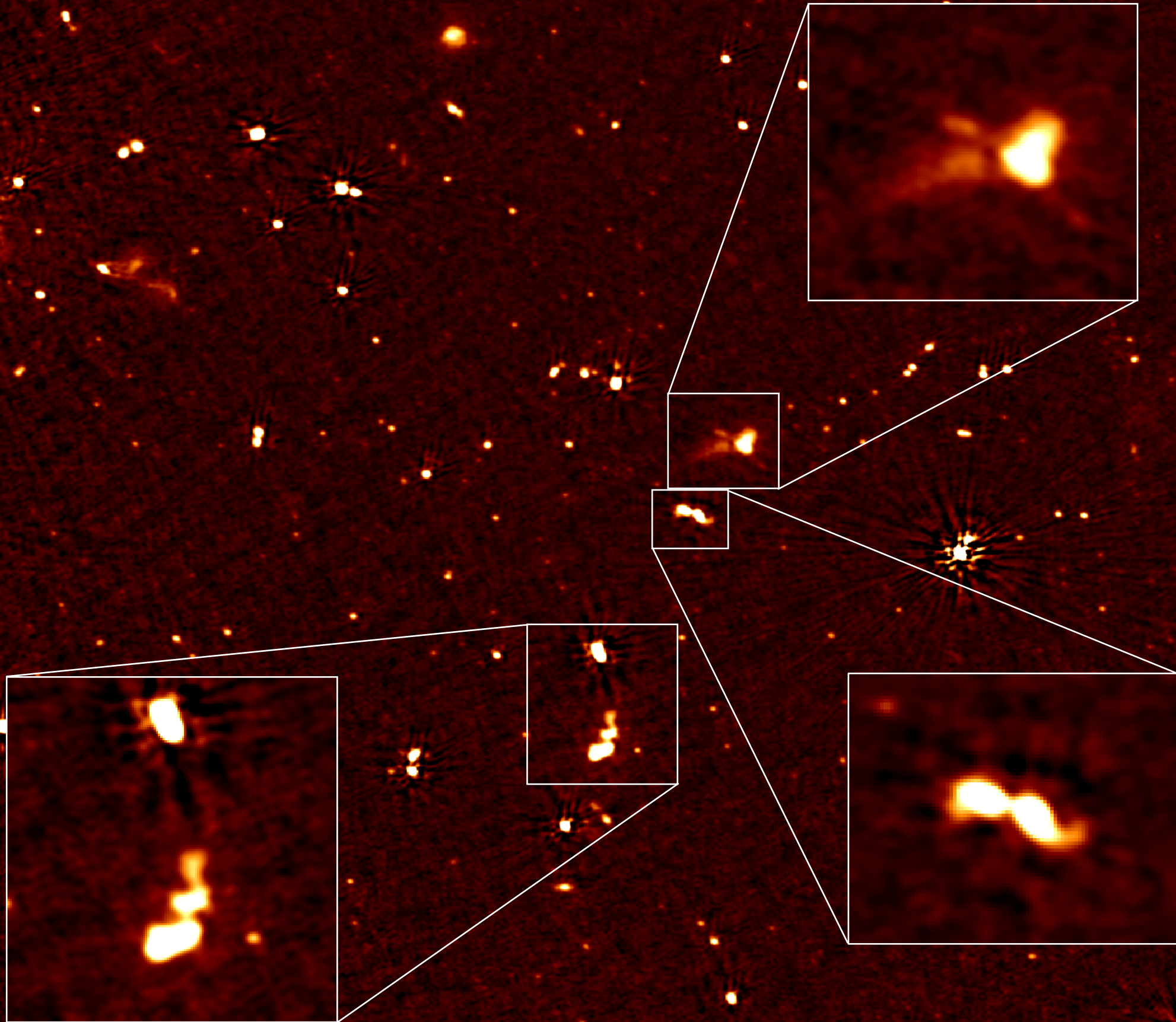
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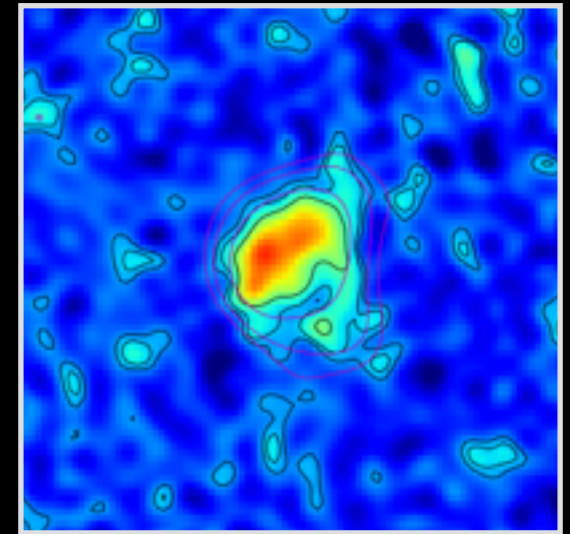
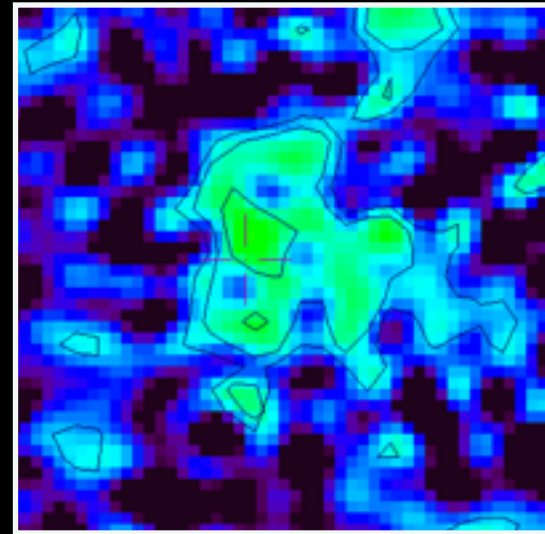
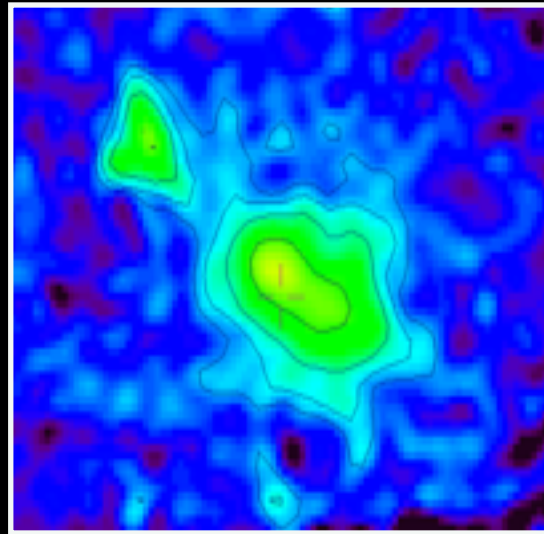
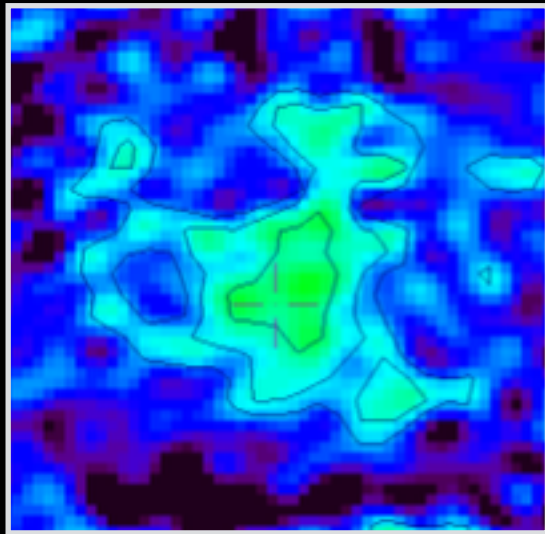
A1132



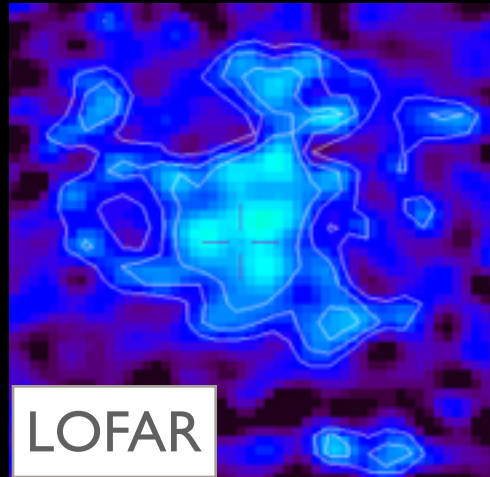
MORPHOLOGY

- ★ EXTENDED
- ★ IRREGULAR MORPHOLOGIES
- ★ LOW SURFACE BRIGHTNESS (OUTSIDE CATALOGUE < 5 SIGMA)
- ★ WITHOUT COMPACT COMPONENTS

11 CANDIDATES



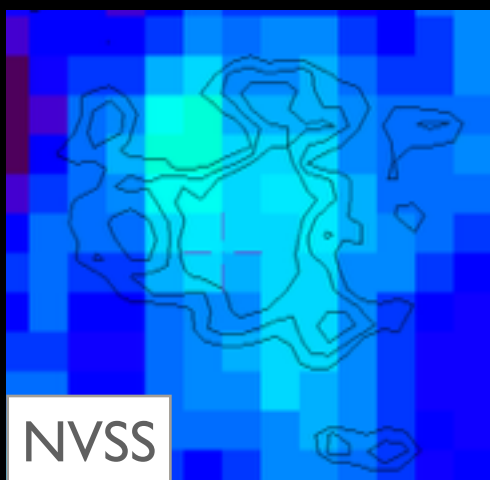
MORPHOLOGY



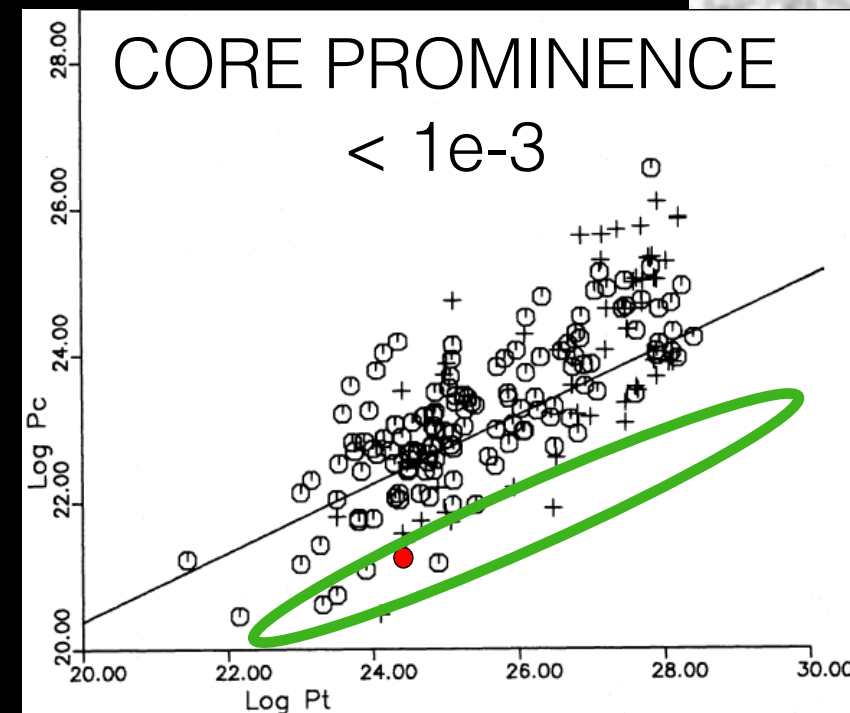
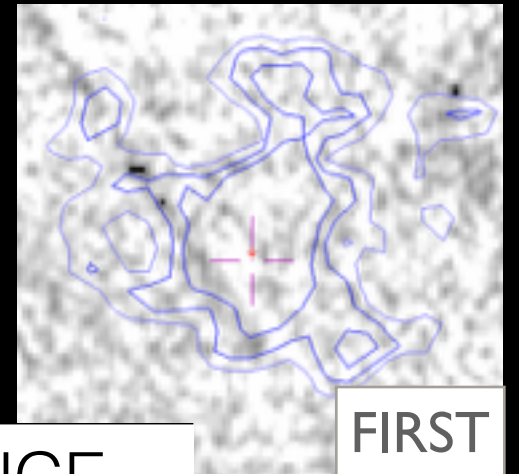
-MATCH
OTHER SURVEYS



SPECTRAL INDEX
(not always steep!)

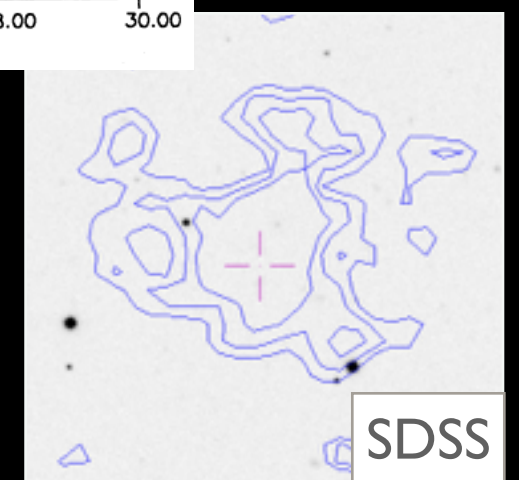


-COMPACT
COMPONENTS

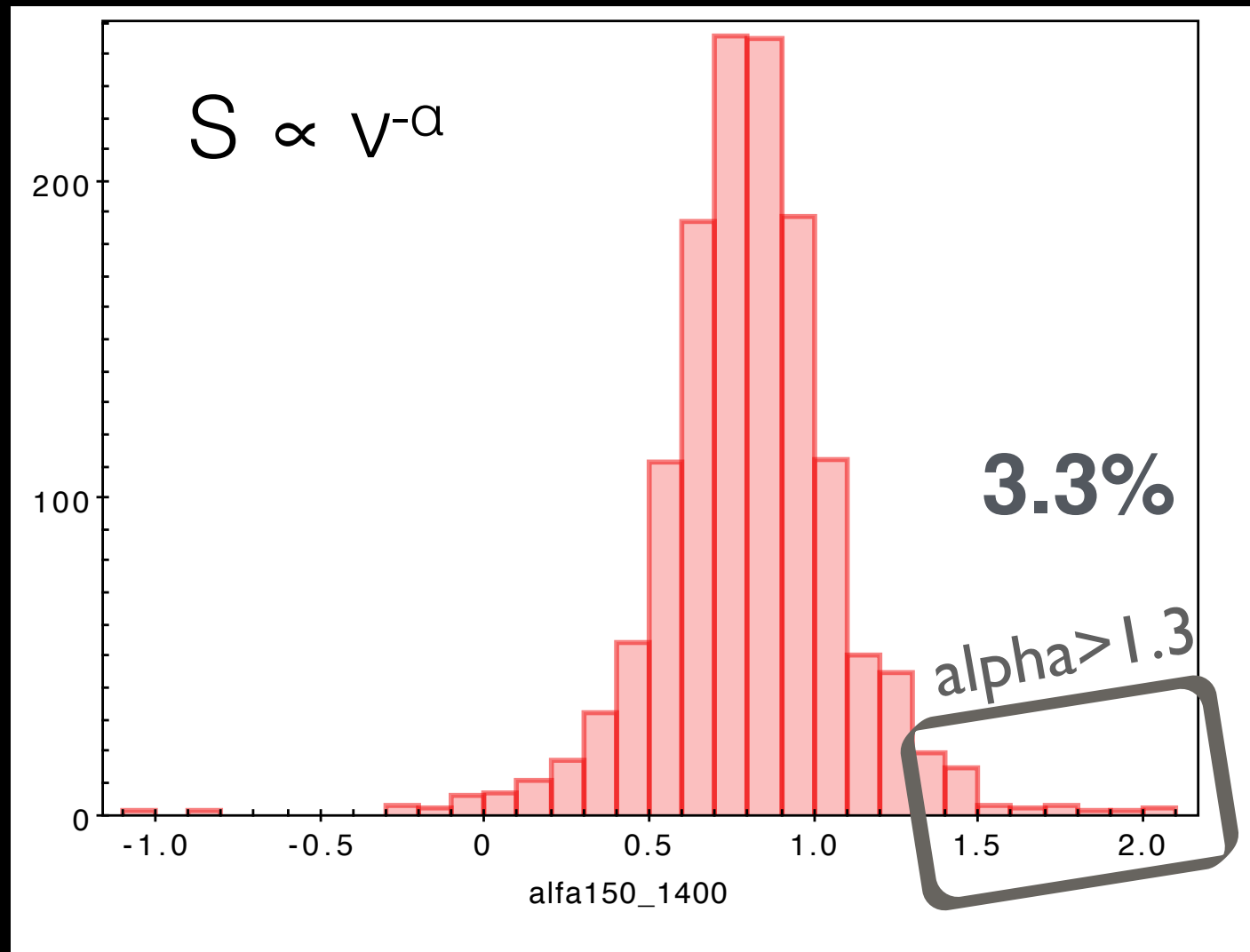


-HOST GALAXY

-ENVIRONMENT



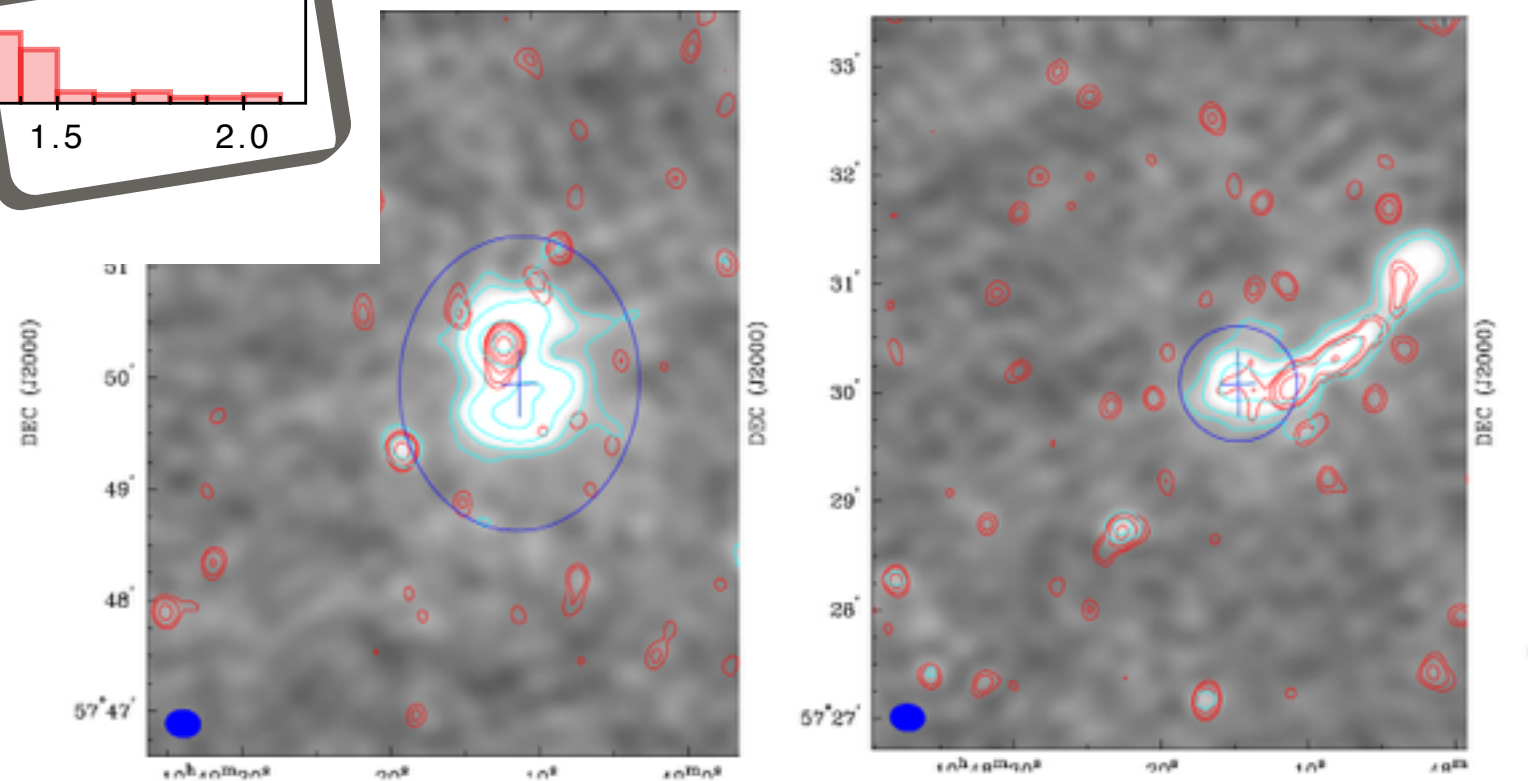
SPECTRAL INDEX - DEEP FIELD



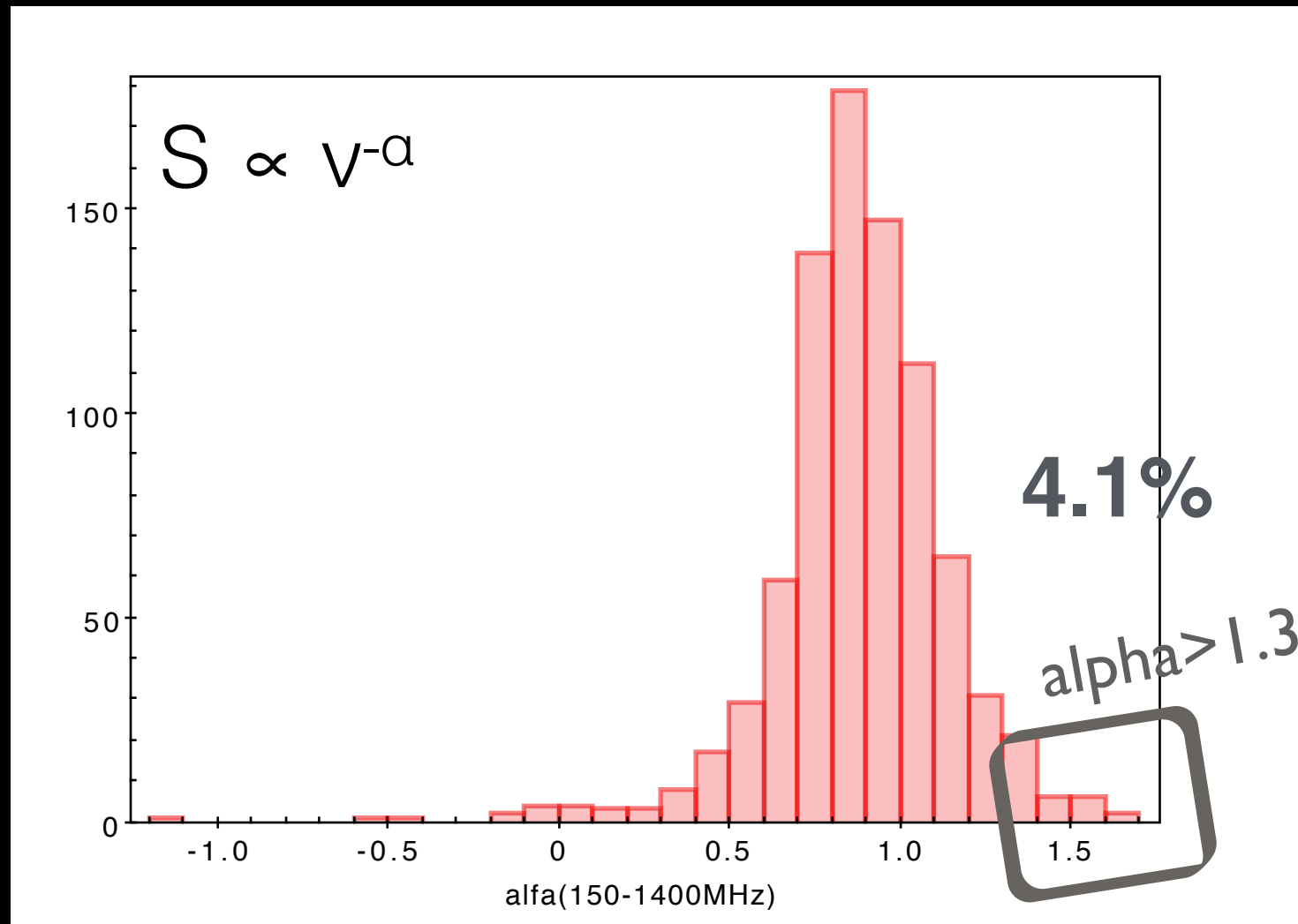
46/1379 sources have $\alpha > 1.3$
40/46 have WSRT counterpart
8/46 extended

WSRT 1400 MHz
noise **0.01** mJy/beam - beam $11 \times 9''$

LOFAR 150 MHz
noise 0.75 mJy/beam - beam $18 \times 14''$



SPECTRAL INDEX - WHOLE FIELD



35/840 sources have $\alpha > 1.3$
~60 have no NVSS counterpart
(still under investigation)
9/35 extended

NVSS 1400 MHz

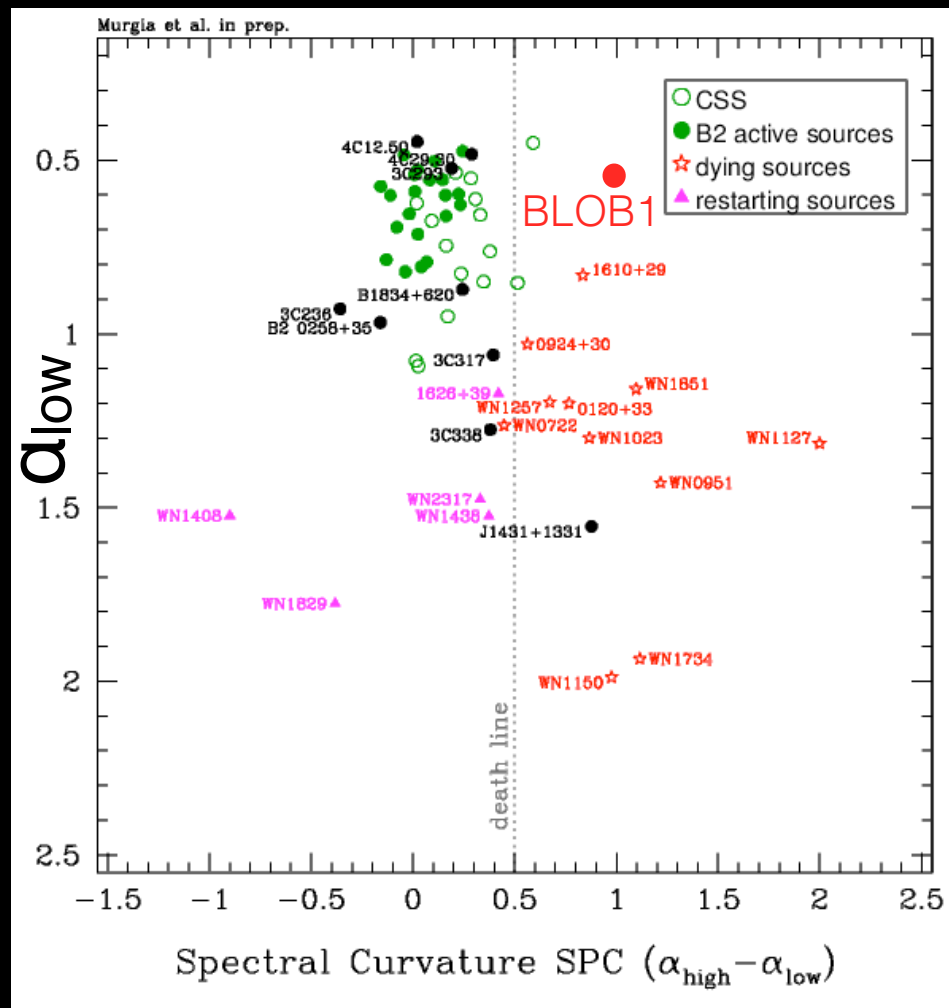
noise **0.45** mJy/beam - beam 45x45''

LOFAR 150 MHz

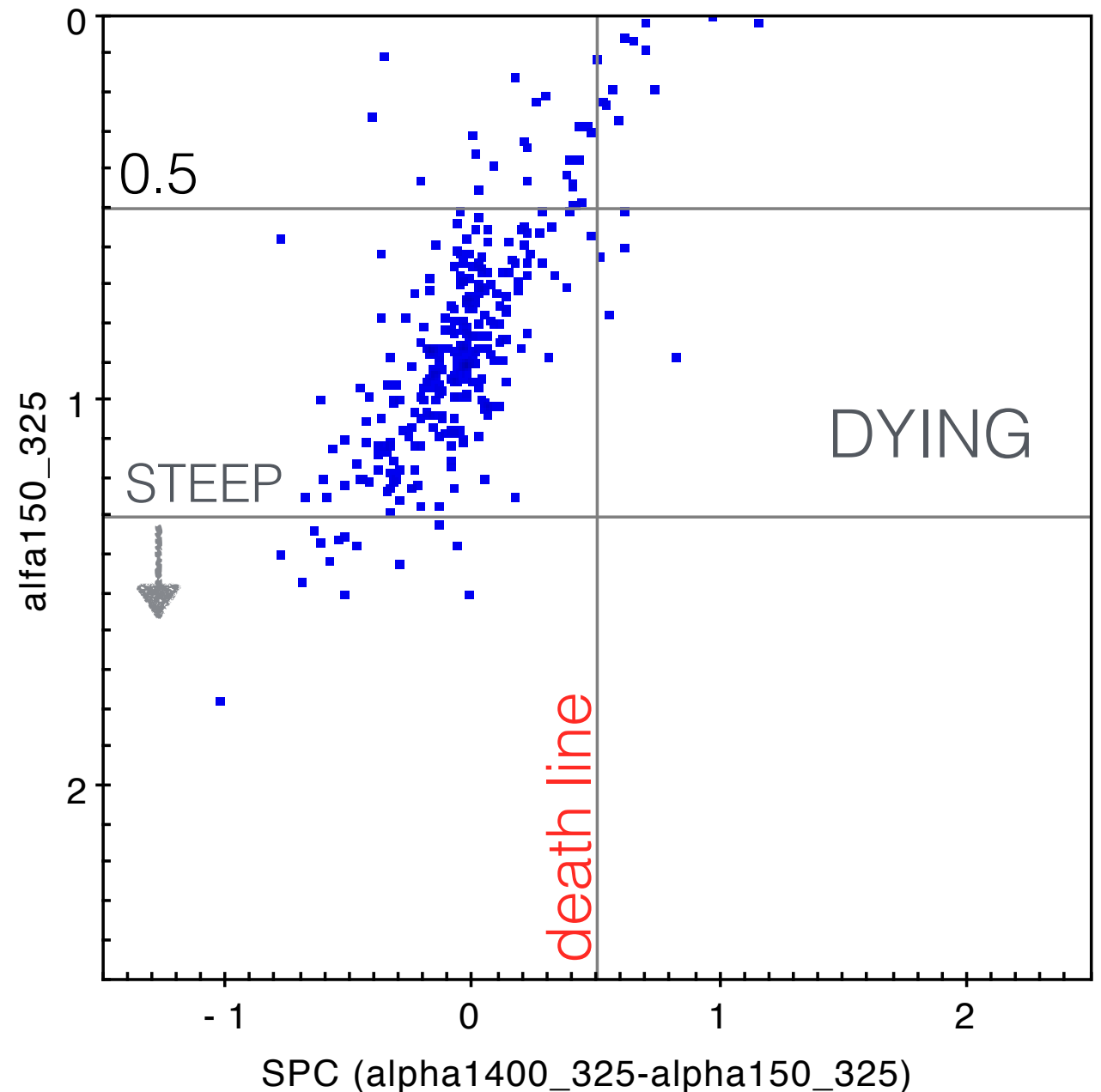
noise 1.2 mJy/beam - beam 38x40''

SPECTRAL CURVATURE

$SPC = \alpha(\text{high}) - \alpha(\text{low}) > 0.5$ according to Continuous Injection models



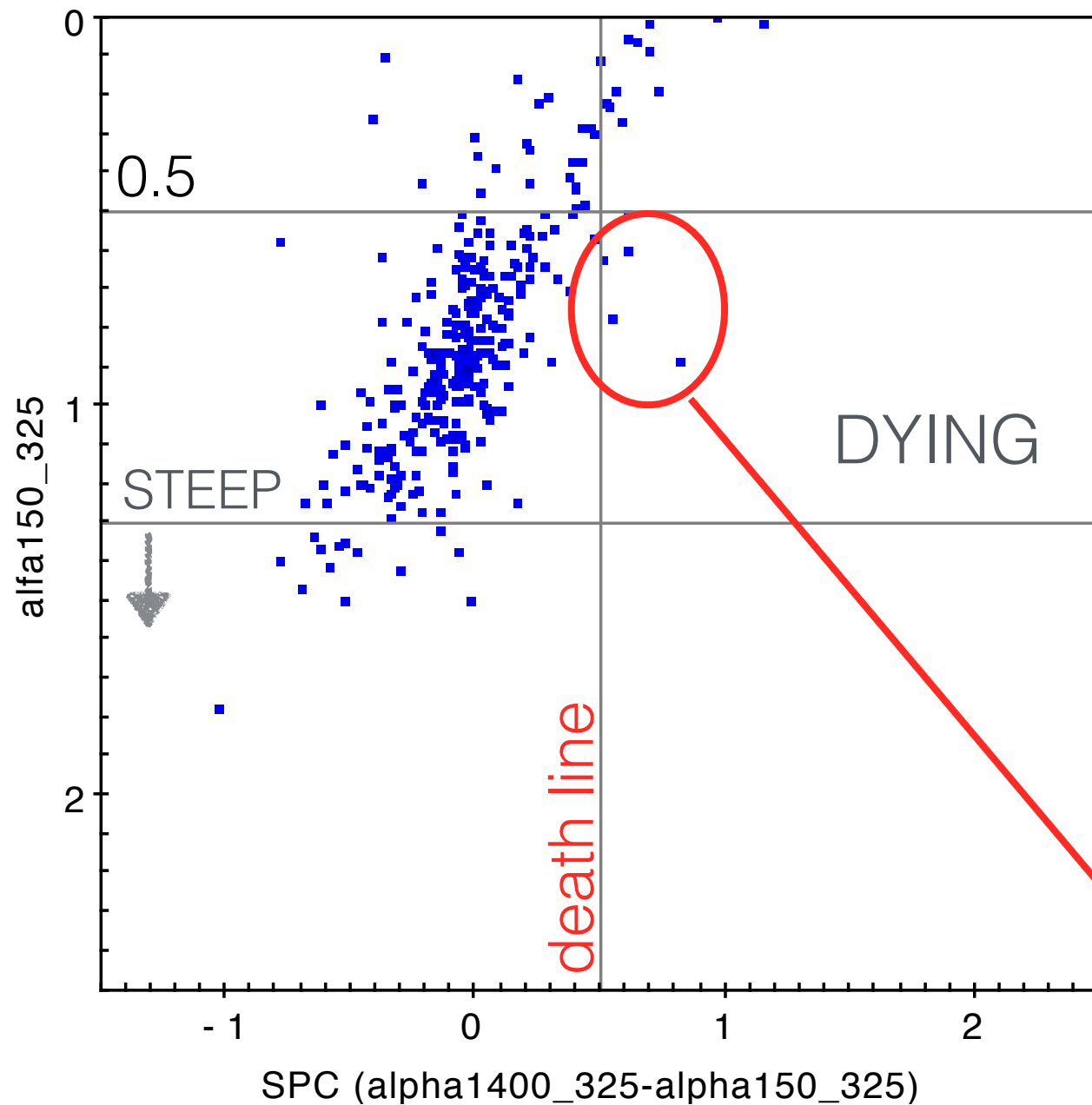
Murgia+ in prep



LOFAR-WENSS-NVSS
flux cut @ 325MHz > 50 mJy

SPECTRAL CURVATURE

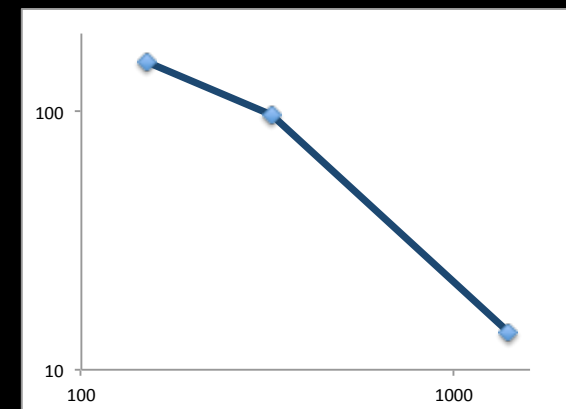
$SPC = \alpha(\text{high}) - \alpha(\text{low}) > 0.5$ according to Continuous Injection models



LOFAR-WENSS-NVSS

Search limited in frequency range and sensitivity

LOFAR 920 sources
WENSS 633 sources
NVSS 625 sources



2 unresolved
1 lobe of double galaxy
1 double galaxy

SUMMARY & FUTURE PLANS

SAMPLE OF CANDIDATES

morphology

11 sources

steep spectral index

3-4%

SPC

~1-2%

Need to further investigate and follow up

- Selection can be refined in the future with LOFAR LBA and high frequency data
- Expand the selection method to the whole LOFAR Tier-1 survey

CHALLENGES:

- identification
- optical counterpart
- disentangle from cluster radio sources