PERSPECTIVES IN THE LOW FREQUENCY STUDY OF DIFFUSE CLUSTER RADIO SOURCES

Tiziana Venturi [1]
Simona Giacintucci [1,2,3]
Gianfranco Brunetti [1]
Rossella Cassano [1,2]
Daniele Dallacasa [2,1]
Sandro Bardelli [3]
Giancarlo Setti [2,1]

[1] *Istituto di Radioastronomia – INAF, Bologna*
[2] *Dipartimento di Astronomia, Universita' di Bologna*
[3] *Osservatorio Astronomico – INAF, Bologna*

An observational perspective of R. Cassano's talk

What are "Diffuse Radio Sources"?

*They witness the presence of **B field** and **relativistic particles** are **found in massive galaxy clusters**, possibly in a late merger stage, with high X-ray luminosities (but w/o cooling core).*

***Halo**: **extended** (~ 1 Mpc) and **low surface brightness** region*
*roughly **circular** shape*
*located in the **central region** of massive and X-ray luminous clusters*
steep radio spectrum**, roughly **homogeneous
not associated to any particular AGN

***Relic**: **extended** (max size around 1 Mpc) and **low surface brightness** region,*
***elongated** shape*
*generally located in the cluster **peripheral region***
***steep radio spectrum** (difficult to measure, often 2-3 spectral points),*
*possibly with **gradients** along the minor axis*
not associated to any particular AGN
unknown relation with X-ray emitting hot gas

[see Giovannini's poster]

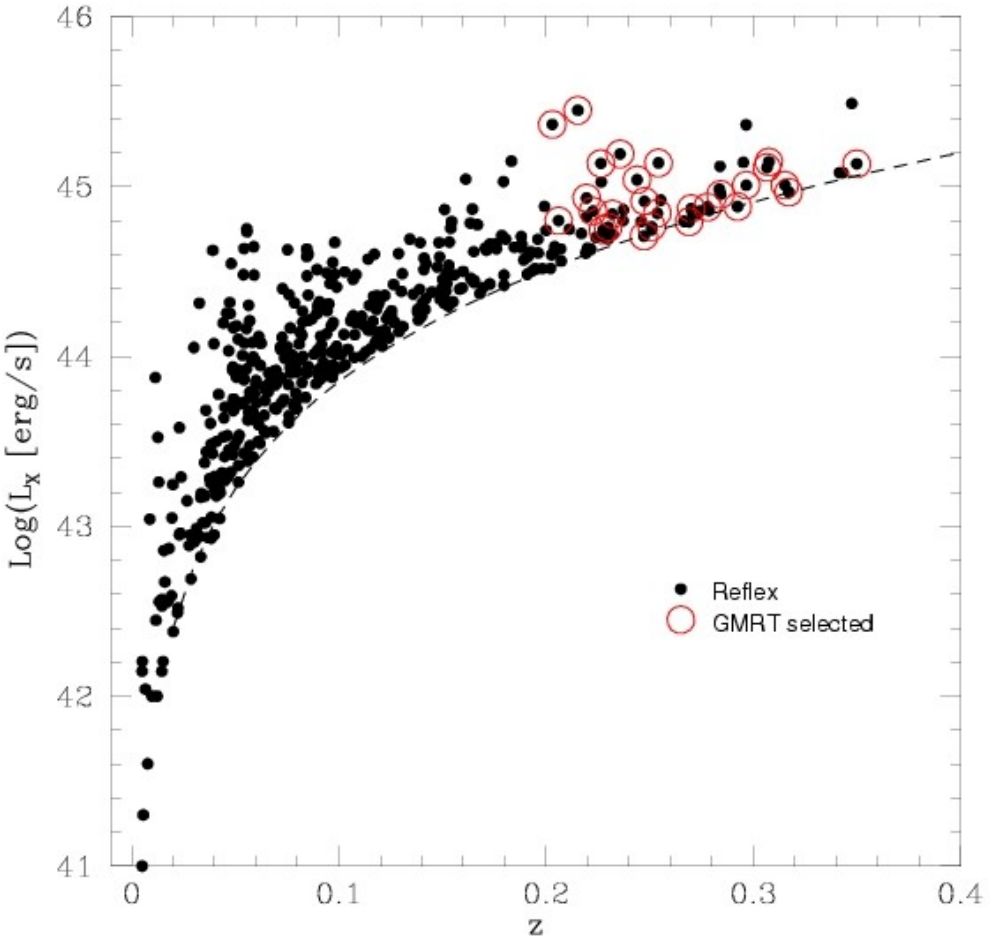
*The i**deal instrument** need to work at **low frequencies** and with a **high angular resolution**. The low surface brightness and large angular size (arcminutes) require **short spacings** and **high sensitivity***

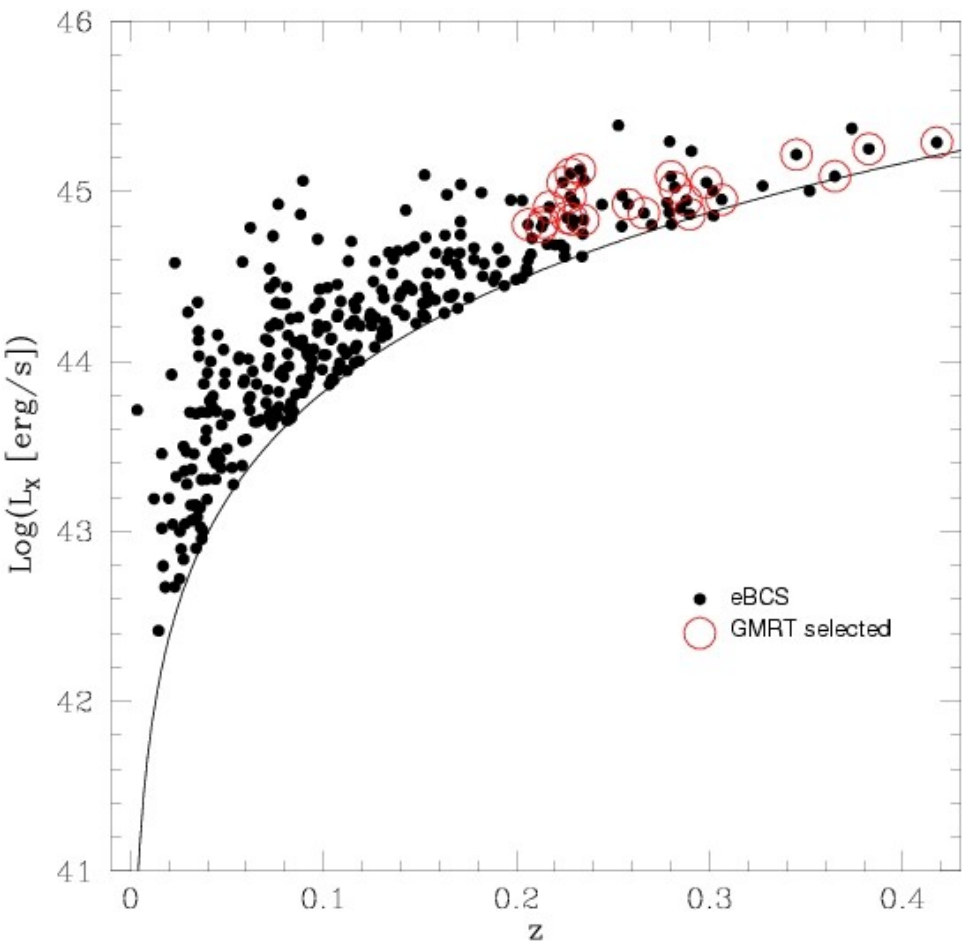
diffuse radio sources ⇔ X-ray luminous & massive clusters

The GMRT radio halo survey [1]

(massive galaxy clusters at z=0.2-0.4)

*Selected from the ROSAT-ESO Flux Limited X-Ray galaxy cluster sample [**REFLEX**, Böringer et al. 2004] (limit to $\delta < 2.5^o$) extended to northern declinations ($\delta < 60^o$) with the extended ROSAT Brightest Cluster Sample [**BCS**, Ebeling et al. 1998, 2000]*

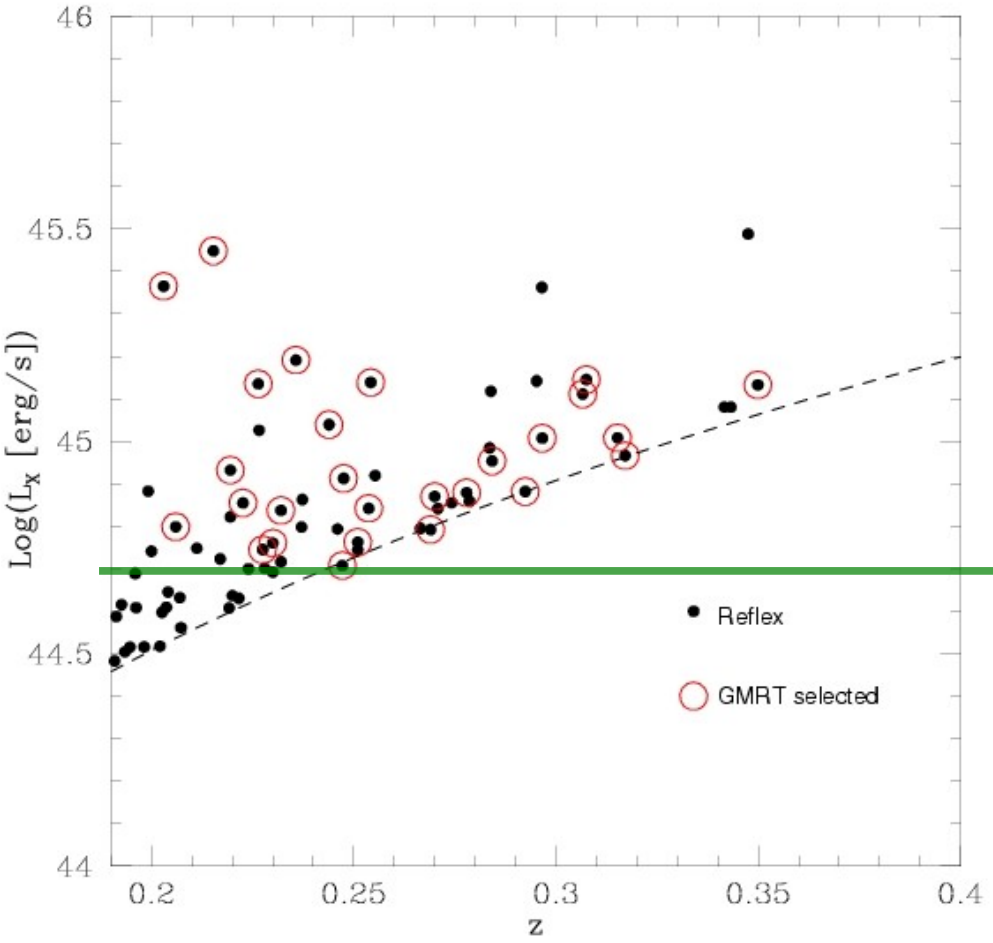


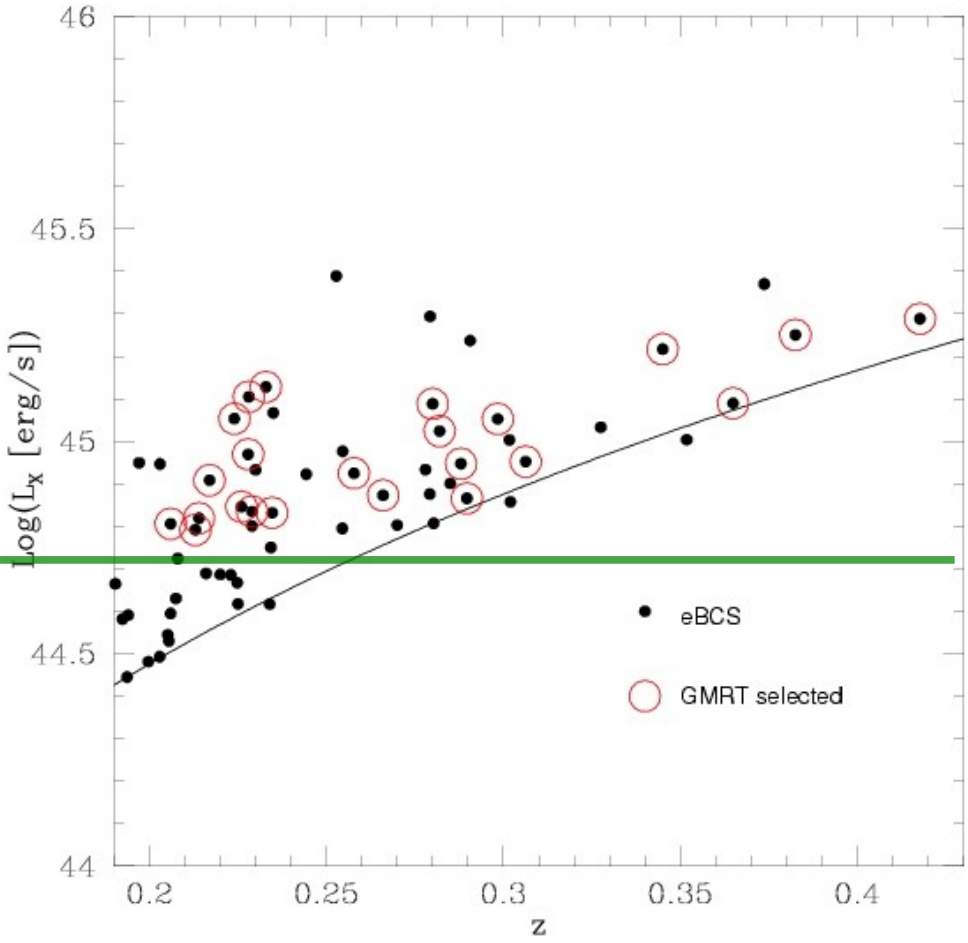


The GMRT radio halo survey [2]

Total of 50 clusters

1. $L_x(0.1-2.4\,keV) > 5\cdot10^{44} \quad erg\,s^{-1}$
2. $0.2 < z < 0.4$
3. $-30^o < \delta < +60^o$





The GMRT observations:

Detection: 610 MHz (~ 12 MHz effective bandwidth [x 2])

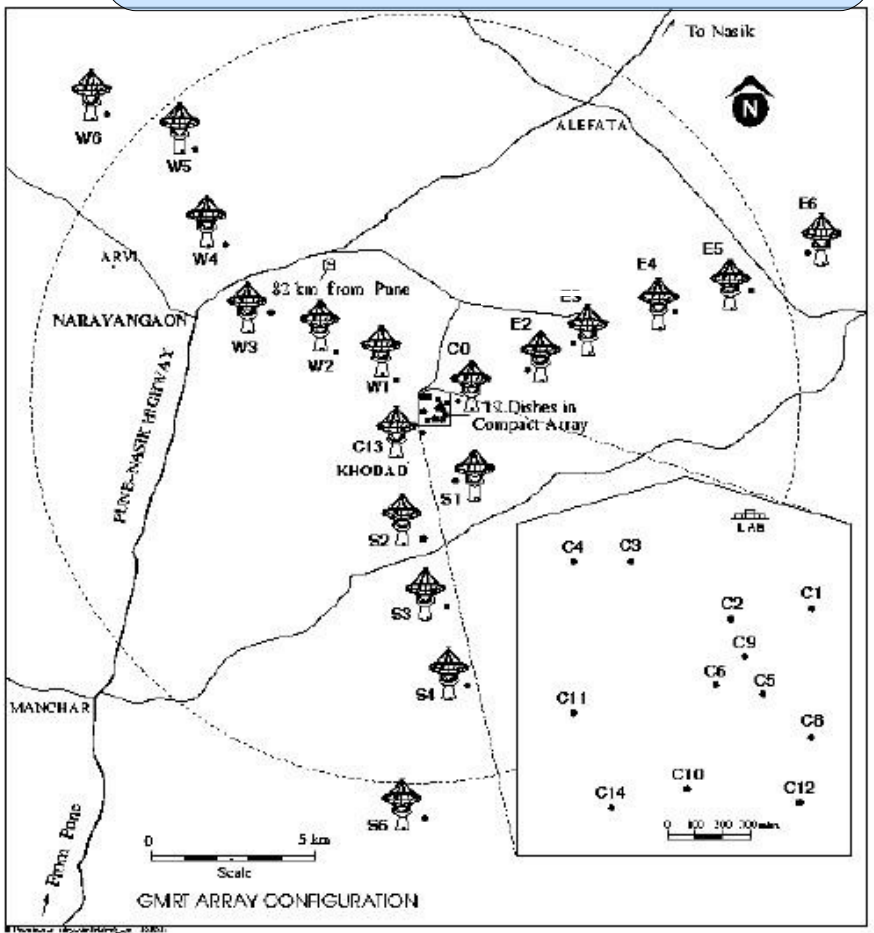
follow up of detections at 325 and 235 MHz (ongoing)

Time on source 2-3 hr allowing an image r.m.s. 50-80 μJy/beam

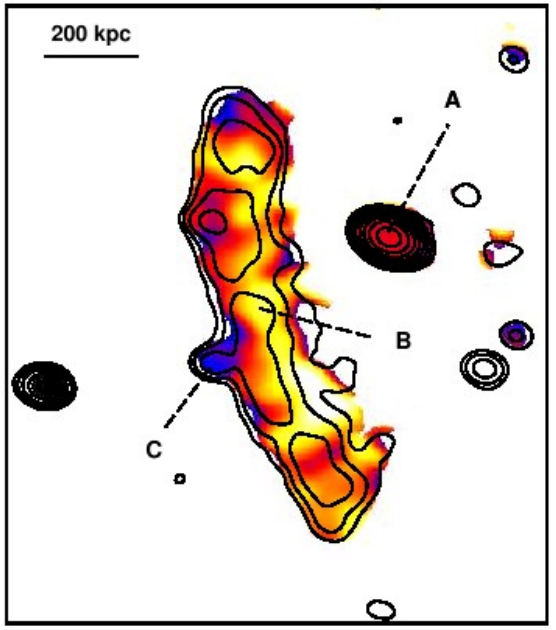
Typical (full) resolution 6 x 10 arcsec

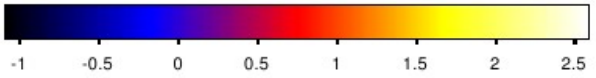
I: The REFLEX sub-sample

Venturi et al. 2007, A&A, 463, 937

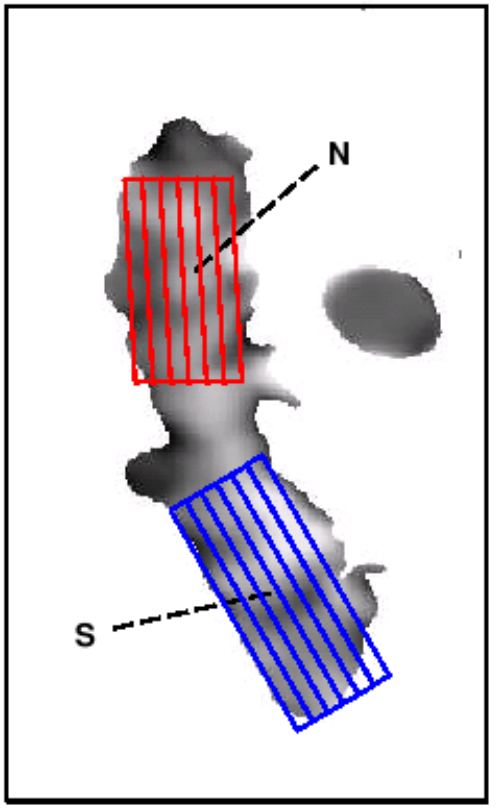


Results (examples)

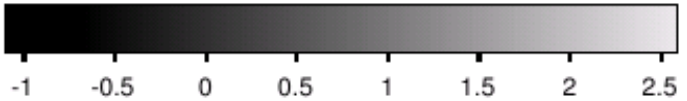




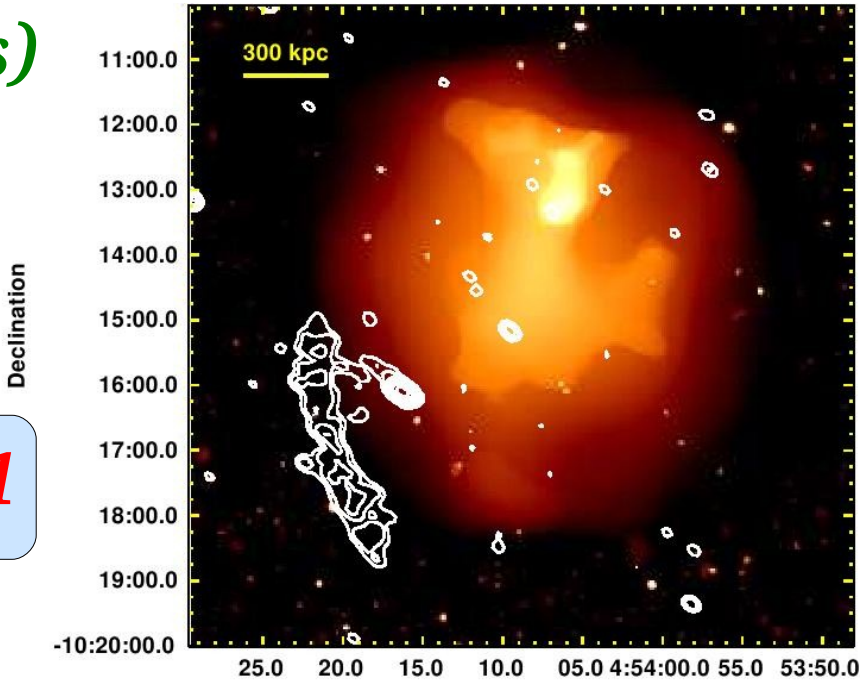
The relic in A521

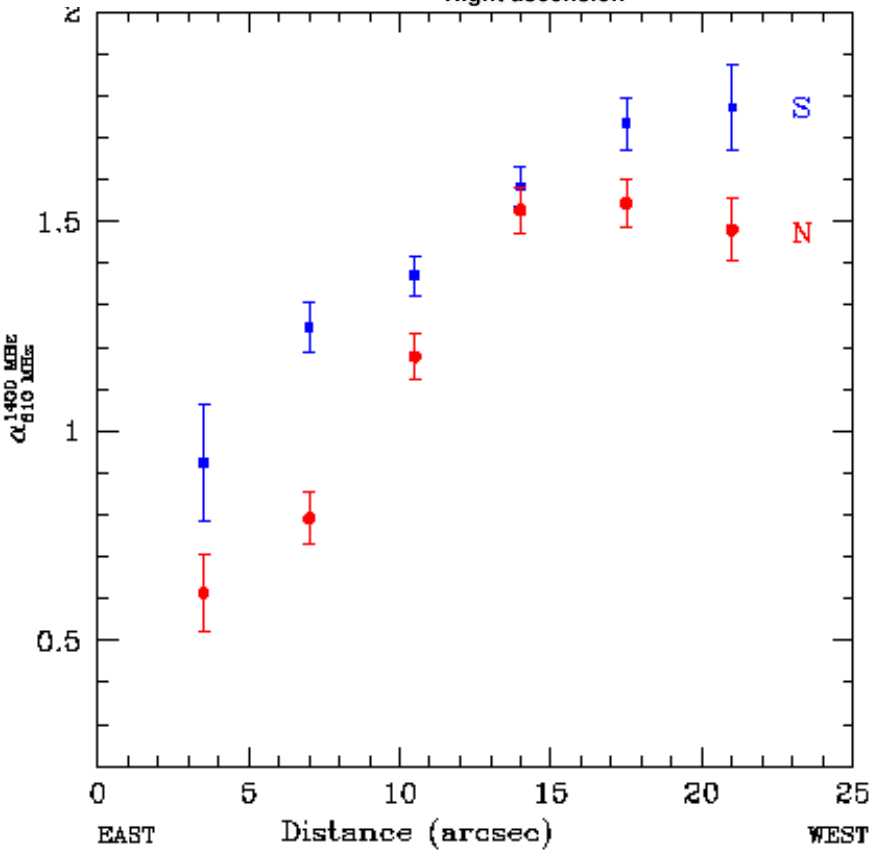


610 MHz GMRT
.vs.
1.4 MHz VLA

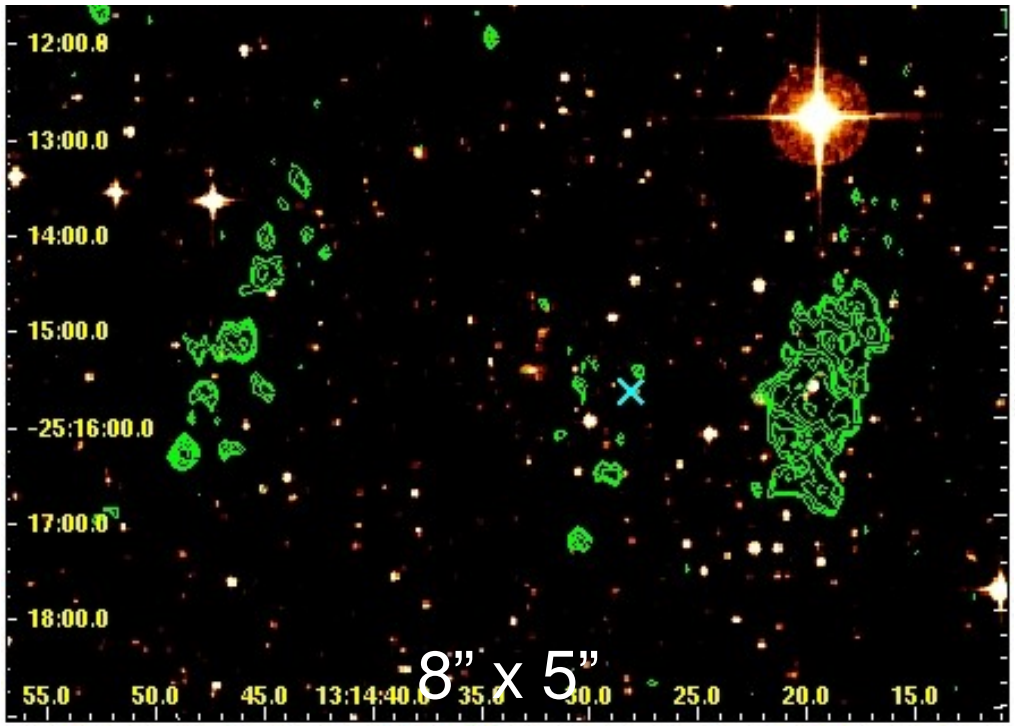


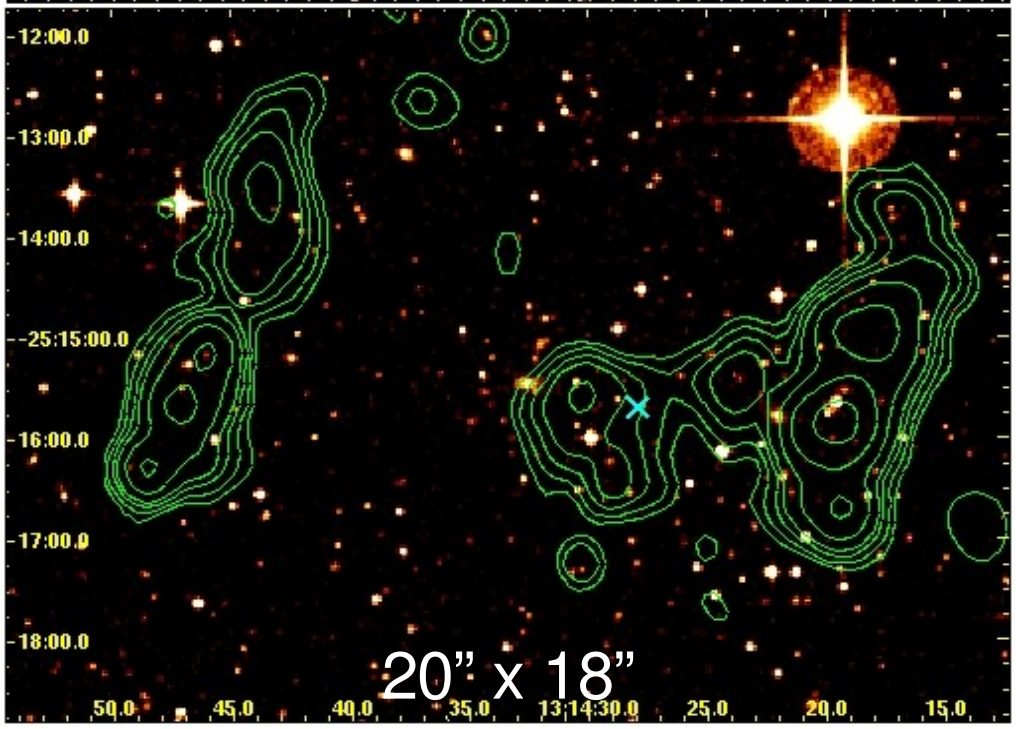
VLA at 1.4 GHz:
see Ferrari et al. 2006

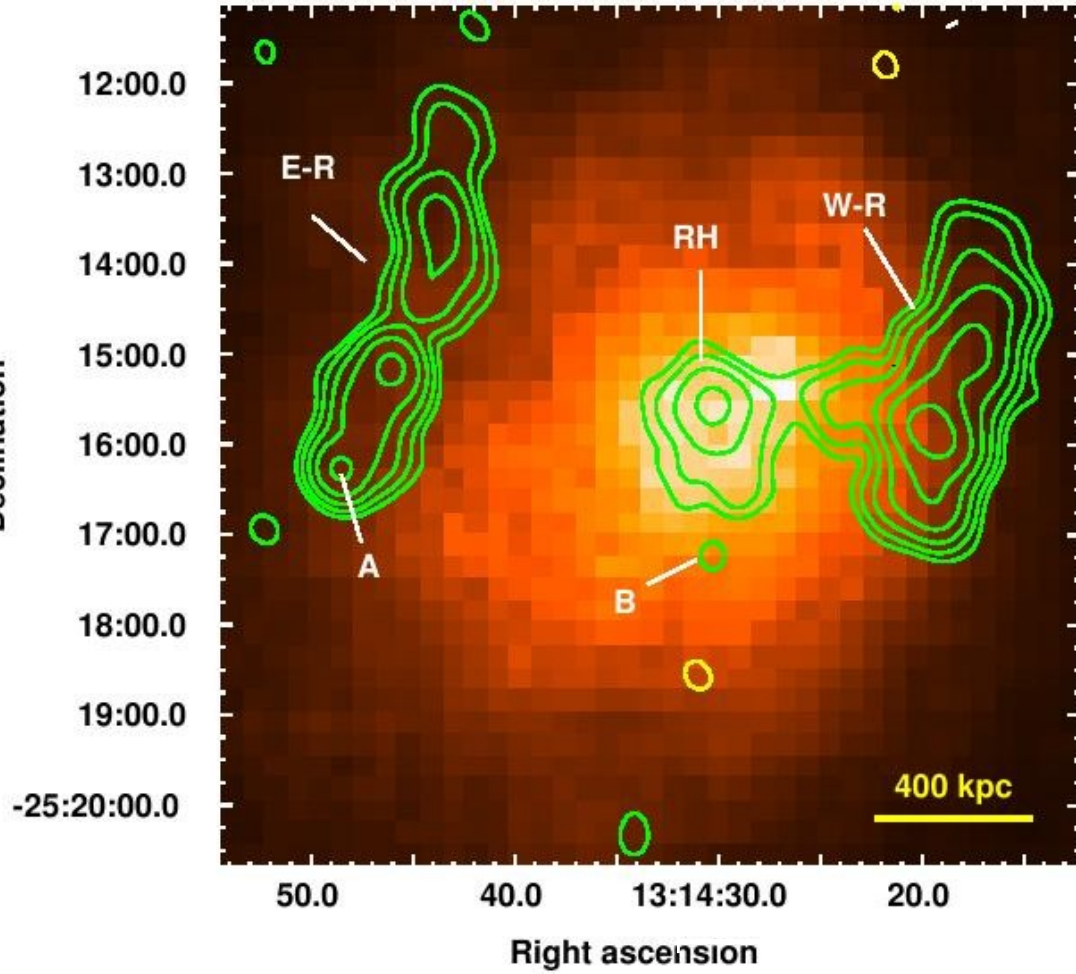




Results (examples) [2]



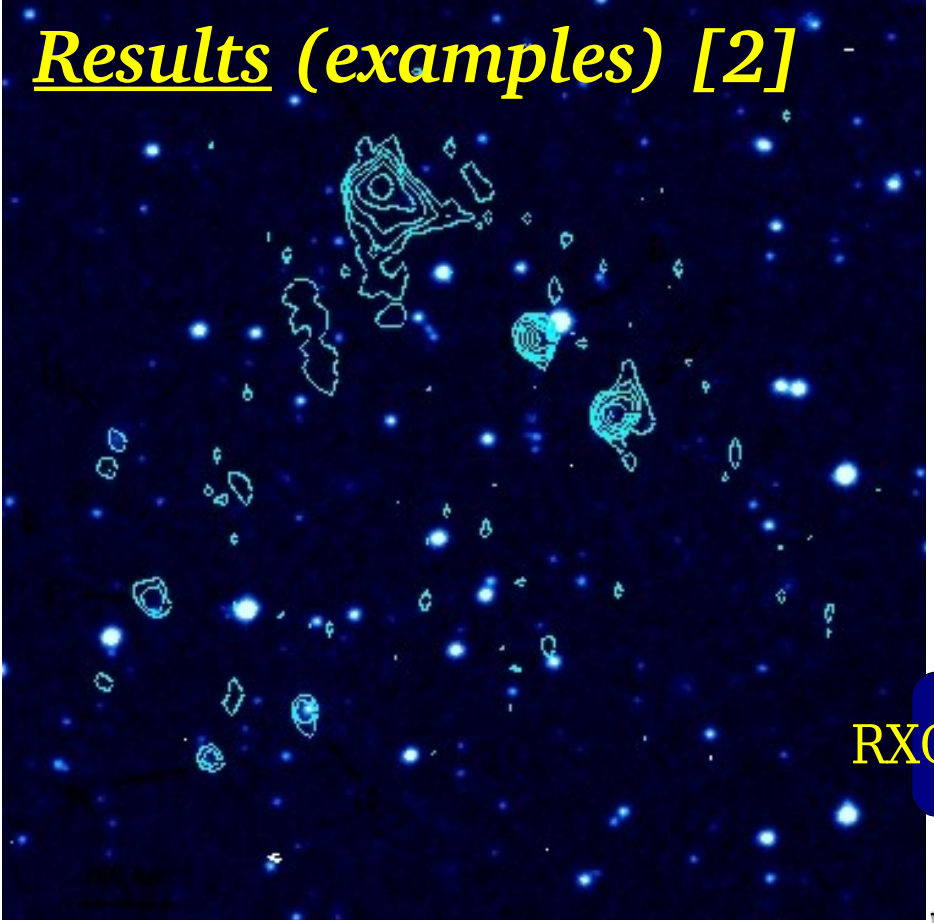




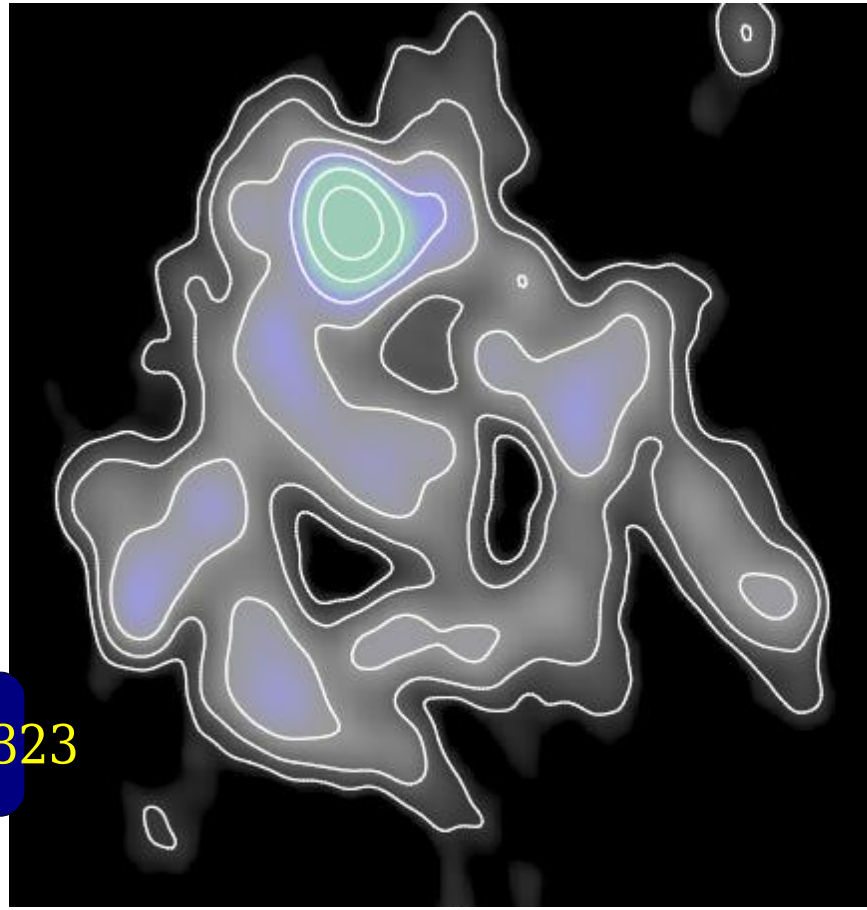
RXC J 1314.4 – 2515

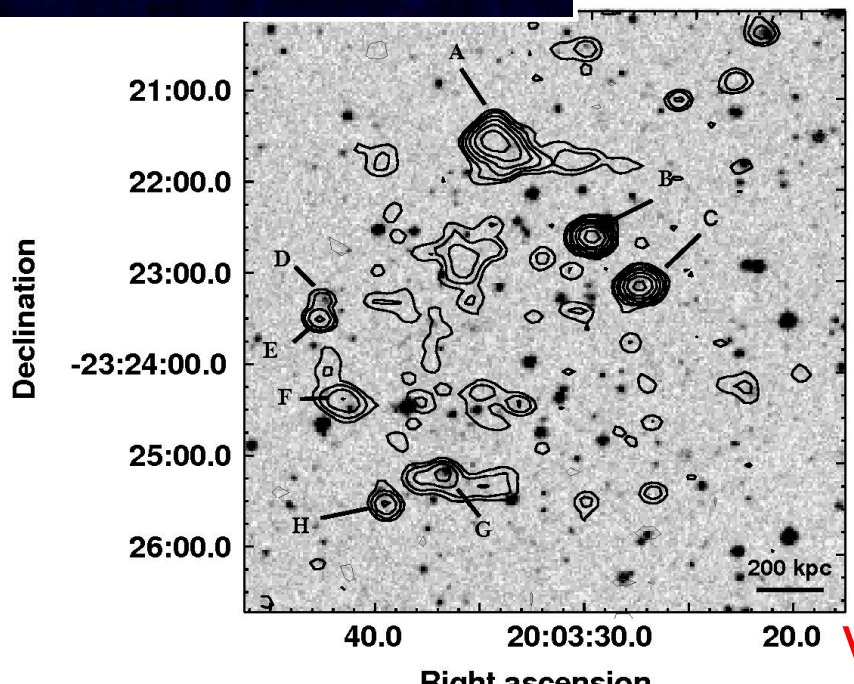
see also 1.4 GHz VLA: Feretti et al. 2005

Results (examples) [2]

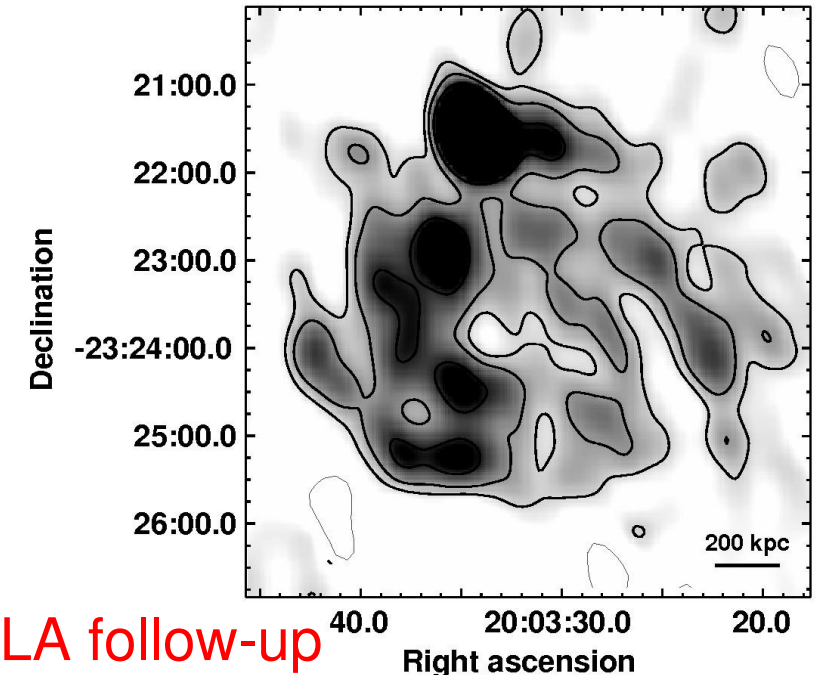


RXCJ 2003.5 – 2323



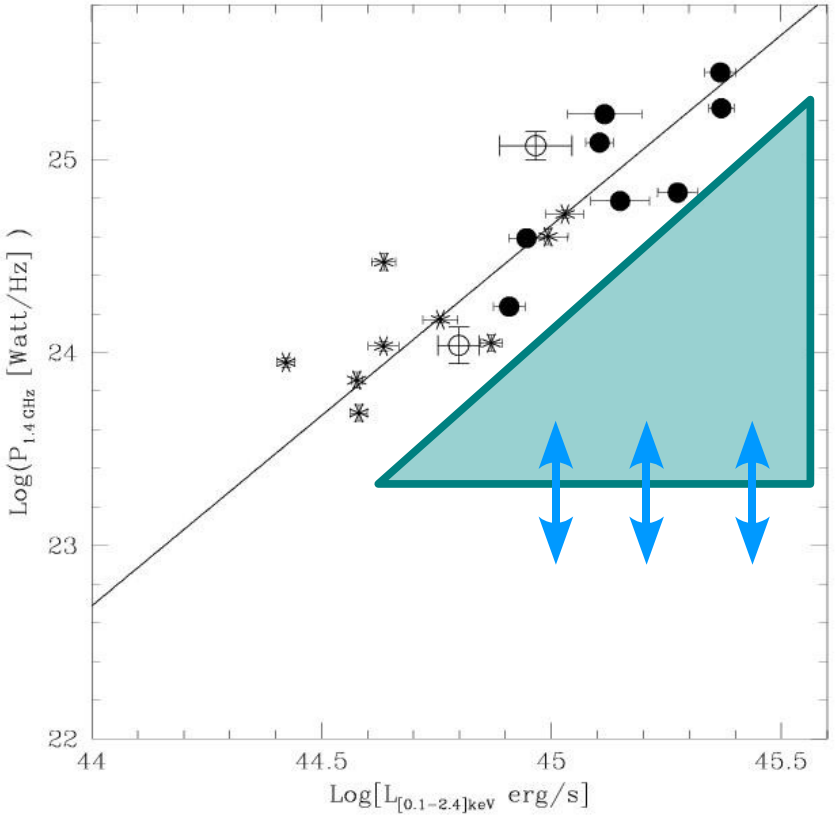


VLA follow-up



Radio Halos: $L_X - L_R$ *Relationship*

It is well known from the literature (e.g. Giovannini et al. 1999) that most radio halos have been found in massive and X-Ray luminous clusters



Detections are at both high radio and X-ray luminosities.

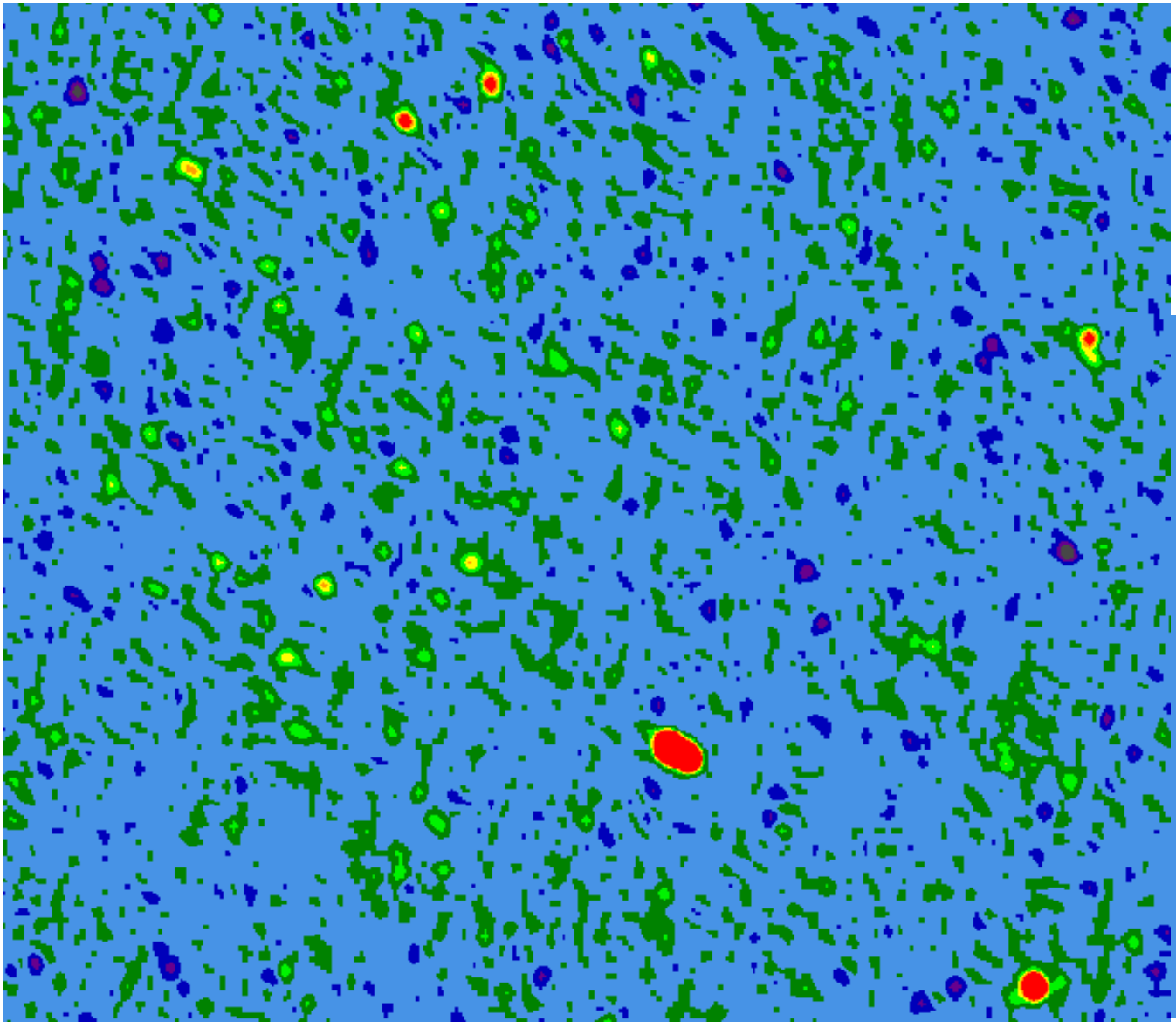
⇒ *Is there a "zone of avoidance" ?*

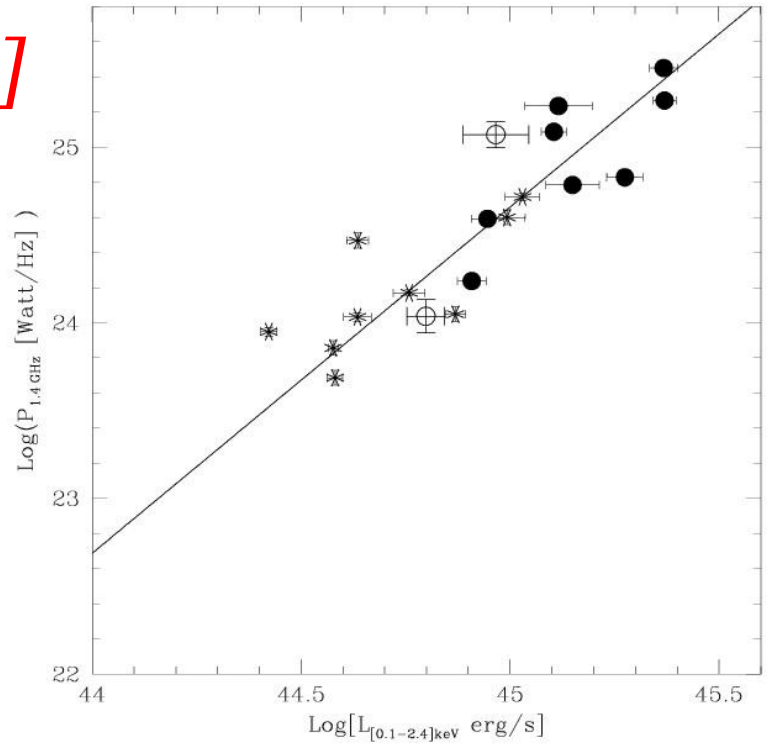
⇒ *Is it a "technical" problem ?*

are Diffuse Radio Sources elusive? [1]

where undetected clusters are located in the $L_X - L_R$ relationship?

Short spacings and low surface brightness are the key problem





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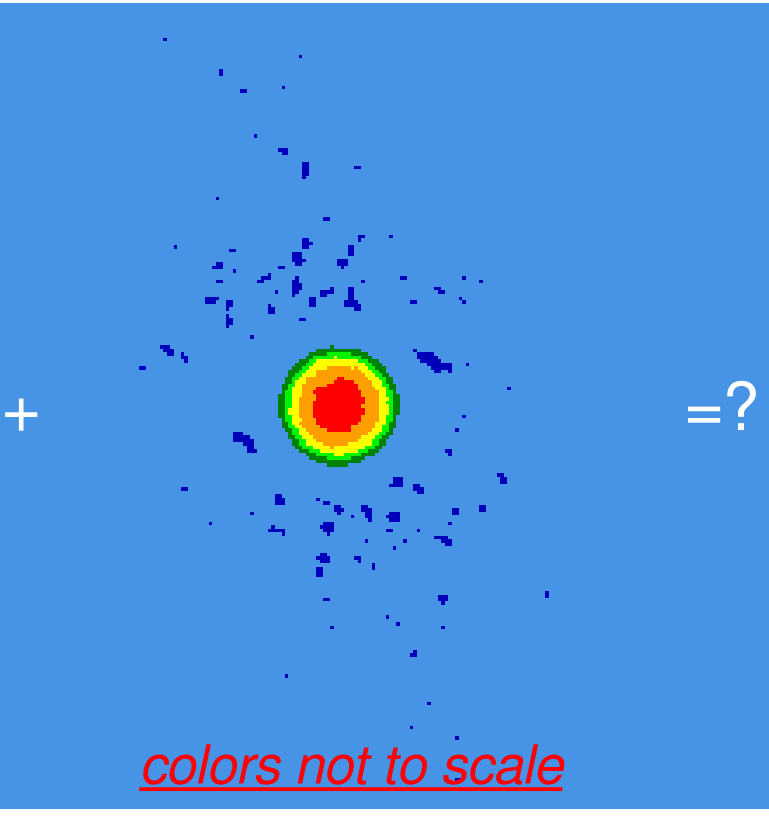
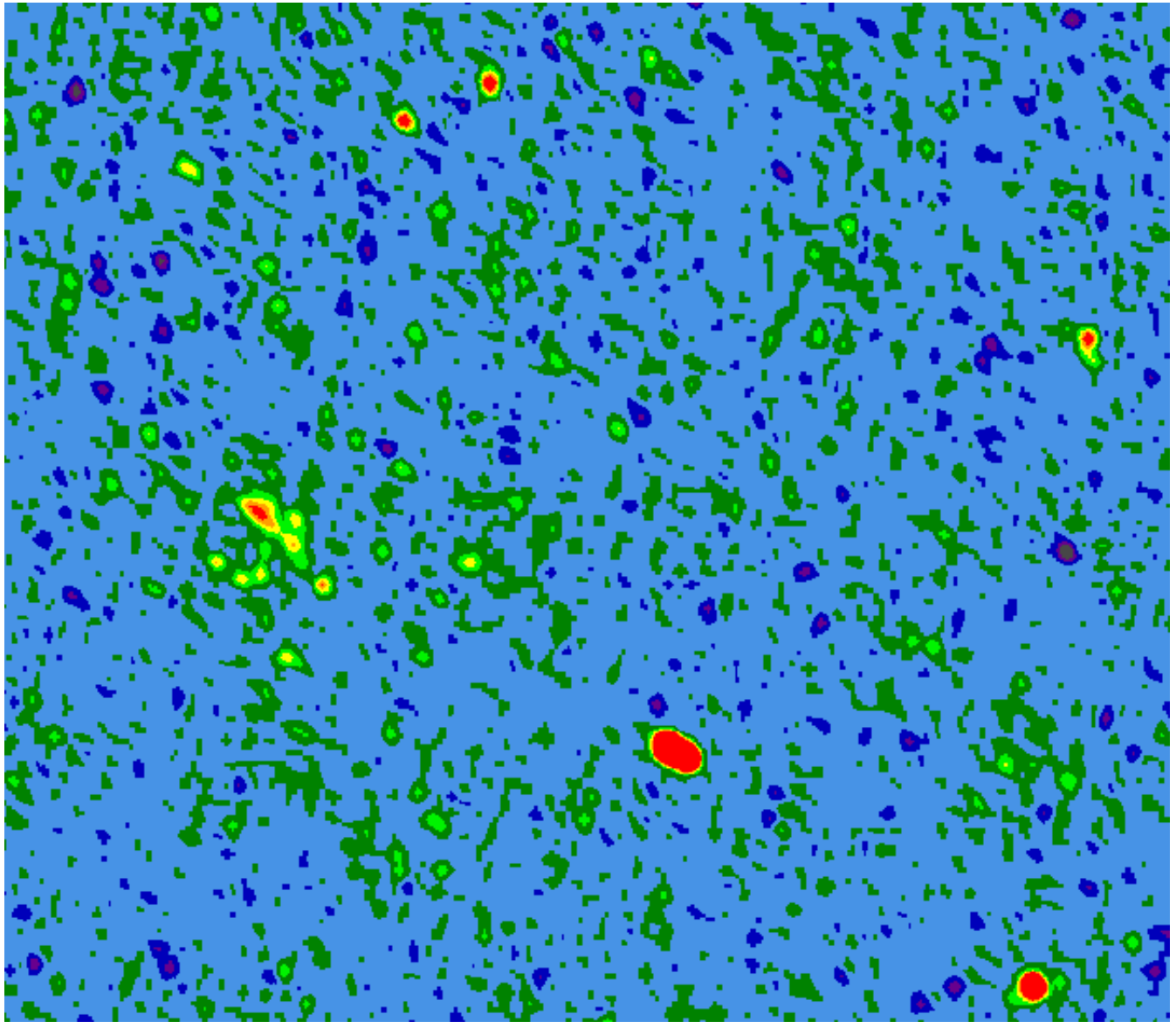


=?

colors not to scale

are Diffuse Radio Sources elusive? [2]

*Short spacings and low surface-brightness **are** part of the problem*



Method:

Various halo models [size, flux density] have been injected into data of clusters without GMRT detection

Outcome:

~ 5 mJy fake halo with ~150 arcsec size can be detected in a typical GMRT observation (2-3 hr on source)

⇒ "zone of avoidance" option

Consequences on the physics:

let's wait for G. Brunetti's talk

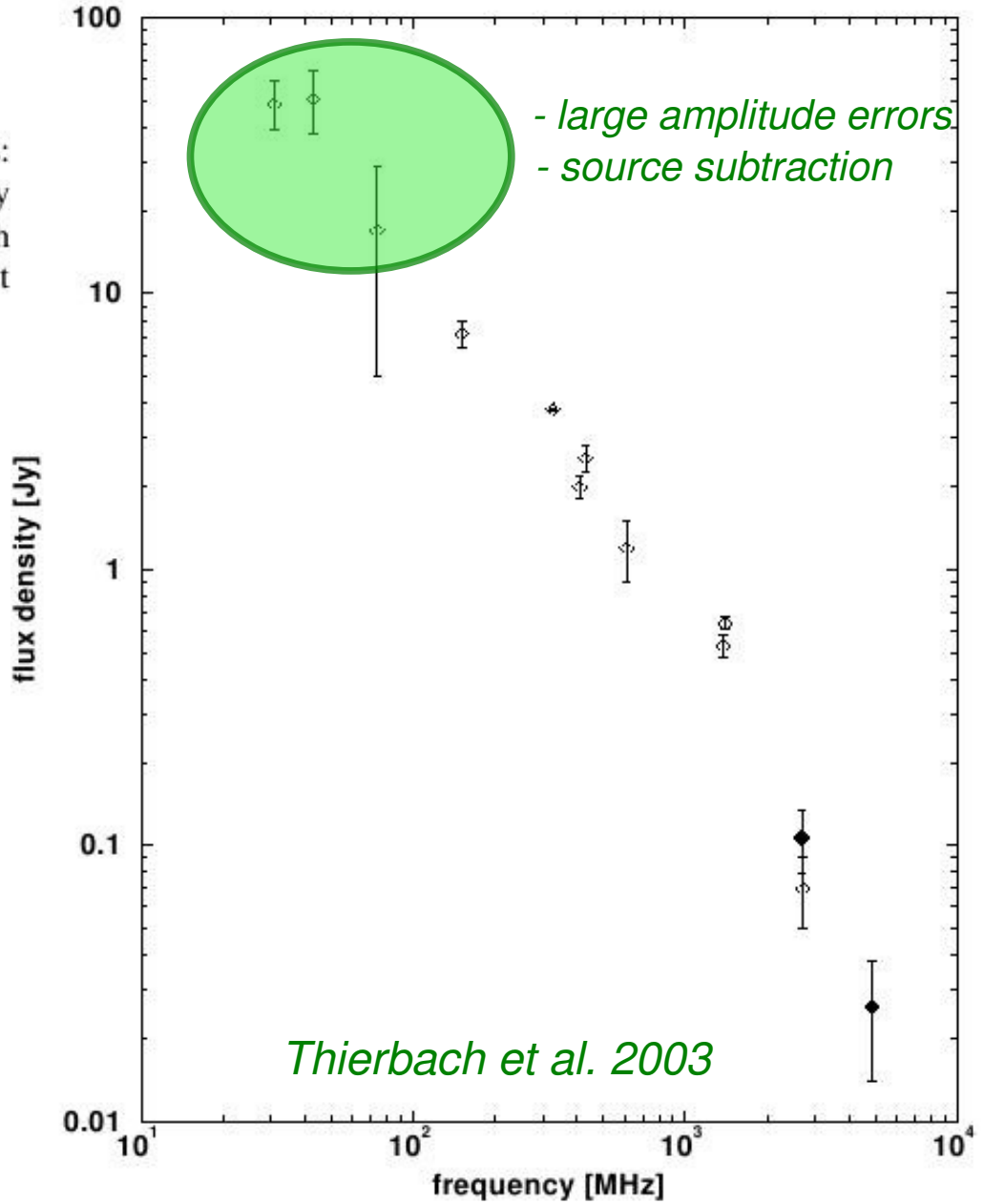
LOFAR: a key to understand the physics of "Diffuse radio sources"?

1. Accurate low-frequency spectra

2. Acceleration mechanisms

Table 6. Integrated flux densities from Coma C. References: (1) Henning (1989); (2) Hanisch & Erickson (1980); (3) Cordey (1985); (4) Venturi et al. (1990); (5) Kim et al. (1990); (6) Hanisch (1980); (7) Giovannini et al. (1993); (8) Deiss et al. (1997); (9) present paper; (10) Schlickeiser et al. (1987).

frequency [MHz]	flux density [Jy]			references
30.9	49	±	10	1
43	51	±	13	2
73.8	17	±	12	2
151	7.2	±	0.8	3
326	3.81	±	0.03	4
408	2.0	±	0.2	5
430	2.55	±	0.28	6
608.5	1.2	±	0.3	7
1380	0.53	±	0.05	5
1400	0.64	±	0.035	8
2675	0.11	±	0.03	9
2700	0.07	±	0.02	10
4850	0.03	±	0.01	9



LOFAR: a key to understand the physics of "Diffuse radio sources"?

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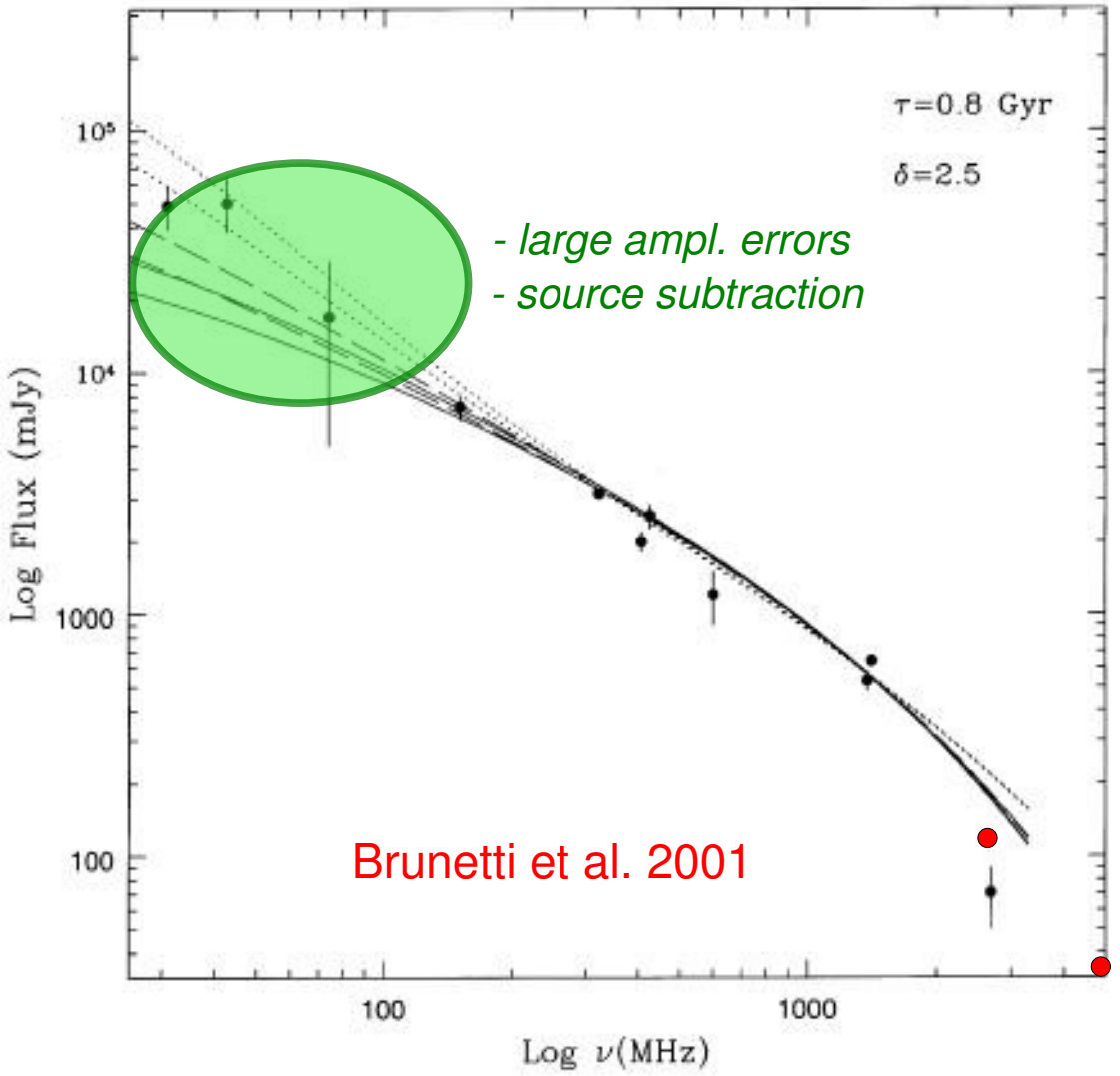

Does LOFAR meet the requirements of the ideal radio interferometer to study diffuse radio sources?

High sensitivity (and stability)
High resolution (baselines >100 Km)
Excellent sampling of the short spacings
Frequency coverage effective for studying the physics of the particles

Outcome:
LOFAR will play a key role in the study of diffuse (cluster) radio sources

*relevant **by-products** of the same observation will be:*

→ *the study of radio galaxies in cluster (e.g. the luminosity function)*
→ *the investigation of ghost radio plasma filling hot-gas cavities*
→ *the determination of cluster magnetic field from RM on background radio sources*
→ *etc.*

see Huub Röttgering's talk