

Radio relics: Recent observations with WSRT and the Effelsberg telescope

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Outline

- **RELICS IN GALAXY CLUSTERS**
- **PECULIAR RELIC IN CIZA J2242.8 + 5301**
- **SPECTRAL INDEX OF CIZA J2242.8 + 5301**
- **RELIC IN CIZA J0649.3+1801**
- **CONCLUSIONS**

Relics in galaxy clusters

- Relics are diffuse and extended radio sources at clusters periphery, maybe found in galaxy clusters which host an halo
- Steep spectrum, $\alpha \leq -1$, maybe due to electrons aging
- Some relics are strongly polarized
- Counter-relics (symmetric, weaker)
- Relics come from shocks due to merging events in galaxy clusters

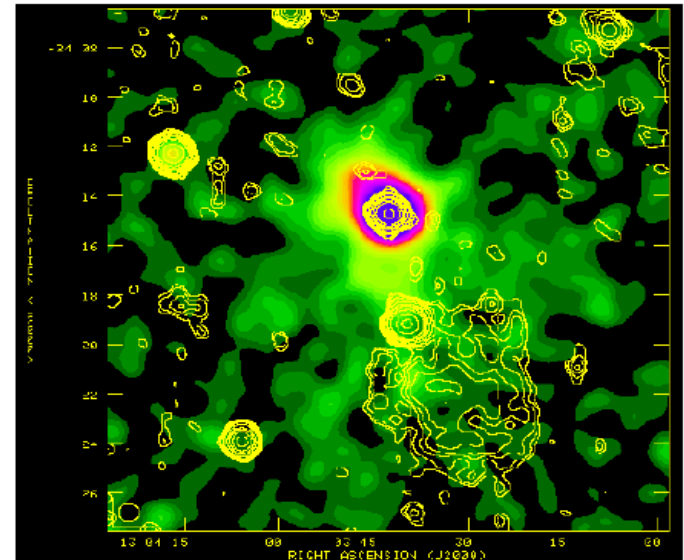


Fig. 2.— Radio image (contours) of the radio Relic in the cluster A1664 (Govoni et al. 2001a) from NVSS data, overlaid to the cluster ROSAT X-ray image (colour)

Giovannini & Feretti 2004

Relics in galaxy clusters

- Size $\sim 1\text{Mpc}$
- Most relics have redshift $z \sim 0.1$
- Morphology of relics
(Giovannini & Feretti 2004)
 - 1) elongated, found at cluster periphery (distance $\sim 1\text{-}2\text{Mpc}$)
 - 2) phoenix = small, very steep sources located at galaxy cluster center
 - 3) few “candidate” relics at large distance from cluster center ($>2\text{Mpc}$)

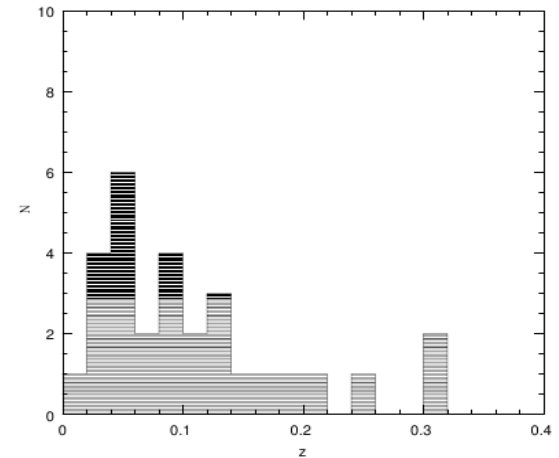


Fig. 7.— Distribution in redshift (z) of clusters with at least a Relic radio source

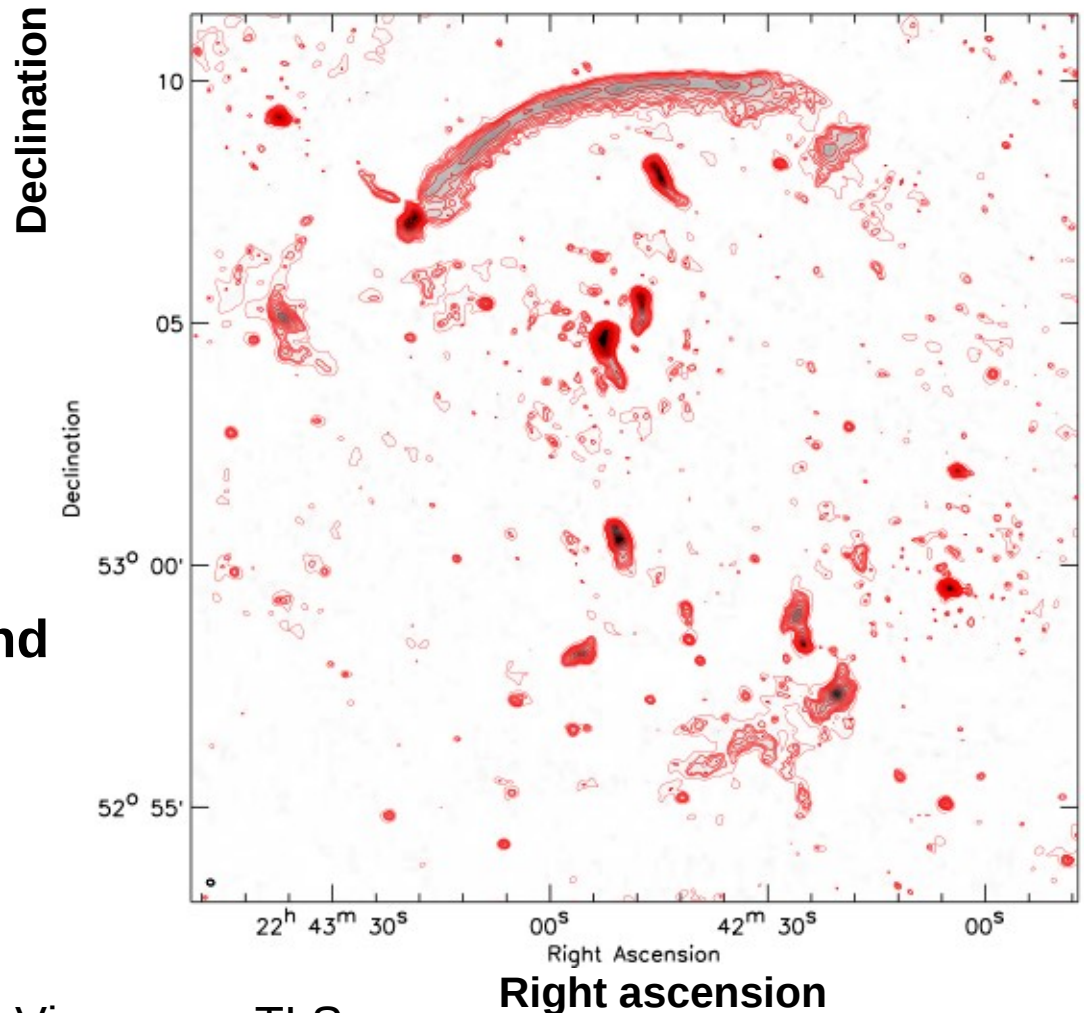
Giovannini & Feretti 2004

Peculiar relic in J2242.9+5301

- Relic in galaxy cluster
CIZA J2242.8+5301,
a.k.a. “the sausage”
- Bright relic from a binary
merging cluster
- Redshift $z=0.19$
- Peculiar elongated shape
- Size $\sim 2\text{Mpc}$
- Effelsberg obs at 3.6cm and
6.3cm, on October,
December (2010) and
January (2011)

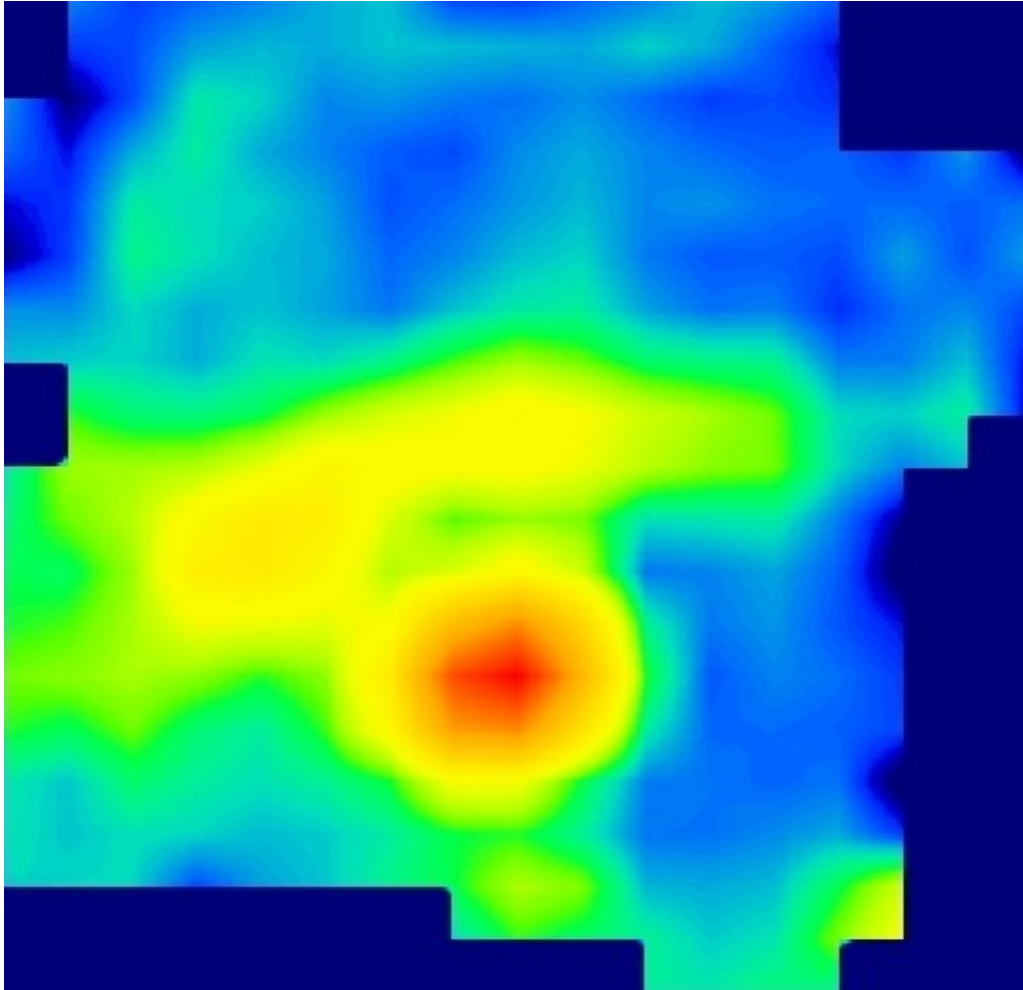
van Weeren et al. 2011

GMRT, $\nu=325\text{MHz}$



J2242.8+5301 @ 6cm - Effelsberg

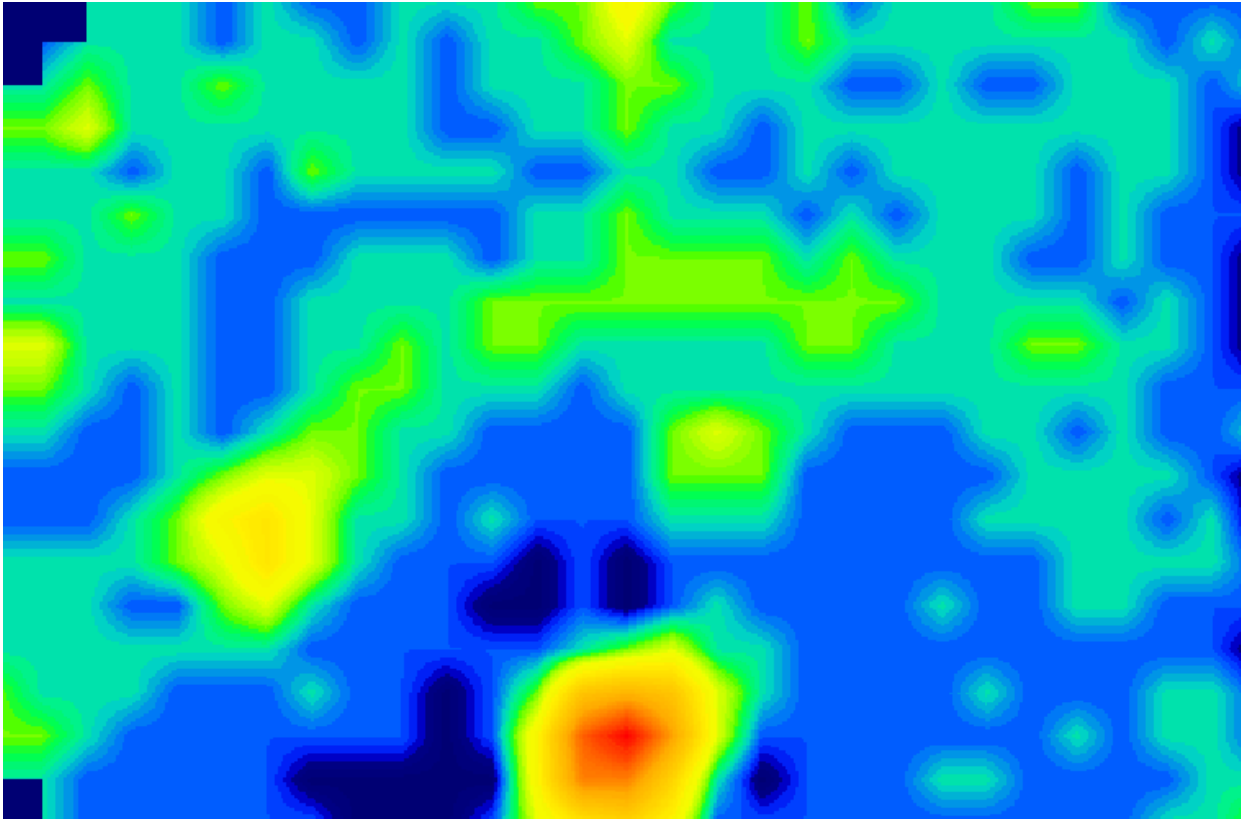
J2242.8+5301,
Effelsberg,
 $\nu=4.85\text{GHz}$,
 $\lambda=6.3\text{cm}$
(30 maps)
2.45arcmin



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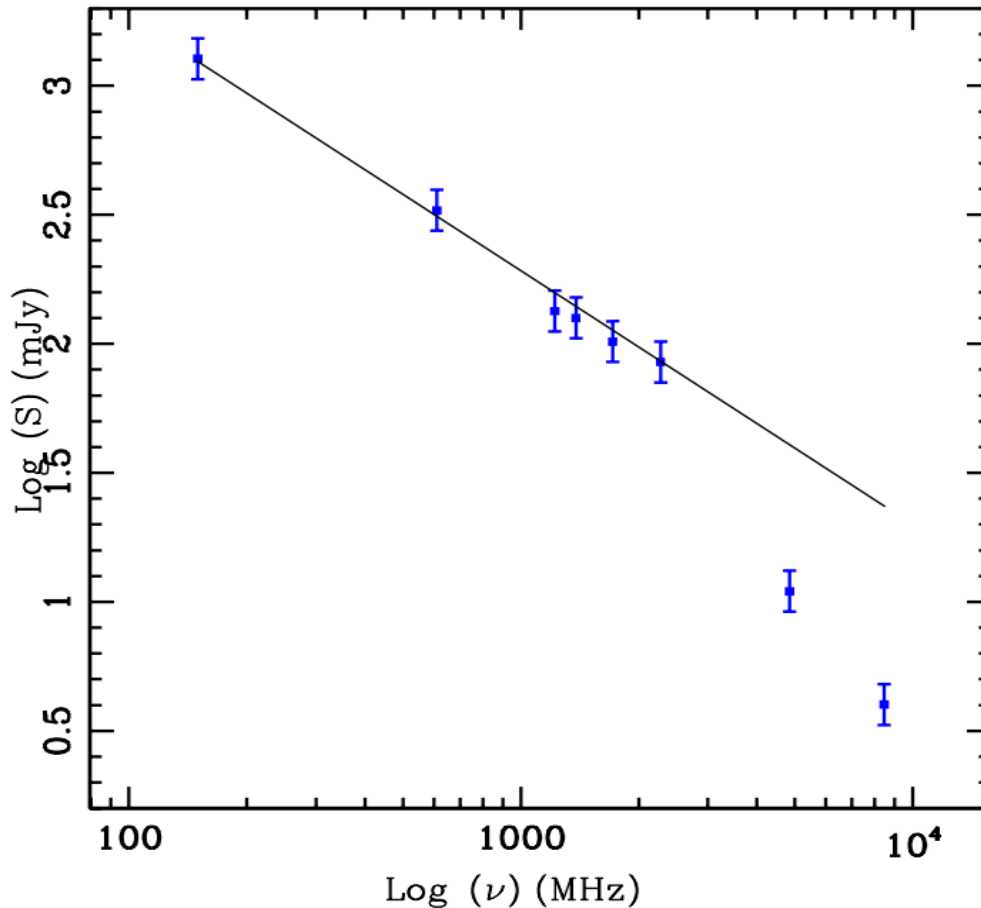
J2242.8+5301 @ 3cm - Effelsberg

J2242.8+5301,
Effelsberg,
 $\nu=8.35\text{GHz}$,
 $\lambda=3.6\text{cm}$
(6maps)
1.2arcmin



Spectral index of J2242.9+5301

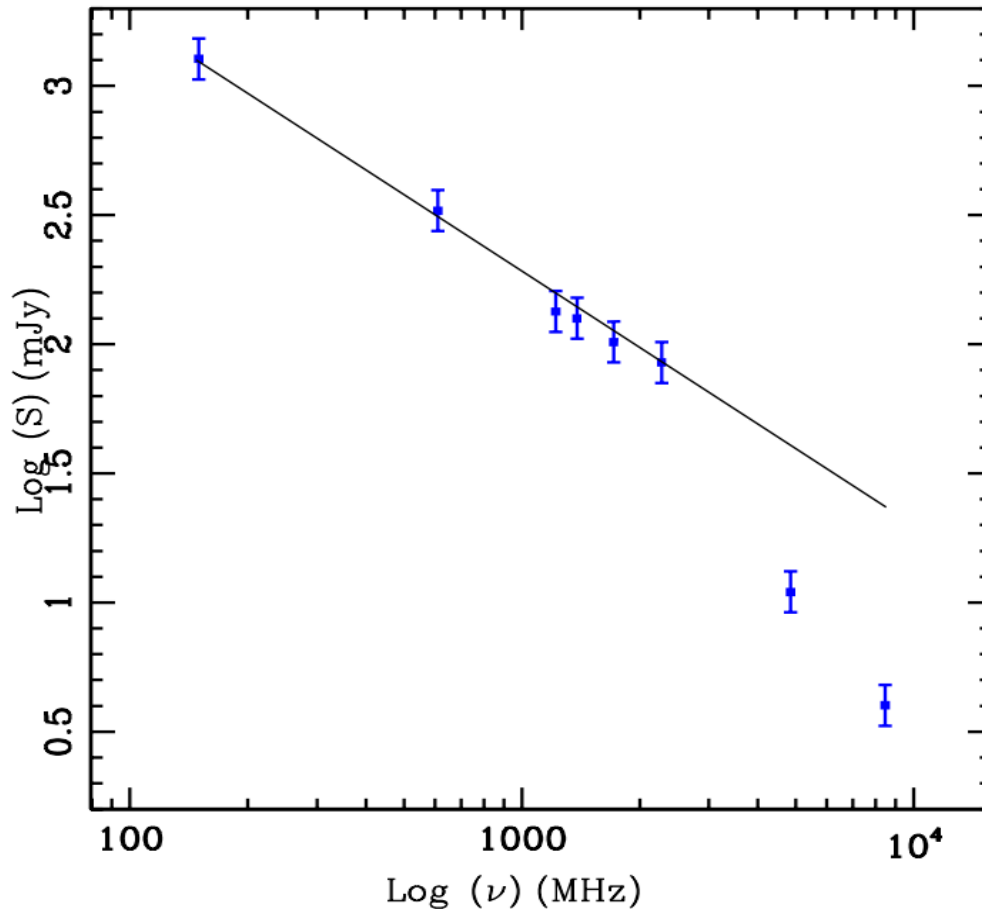
CIZA J2242.8+5301 - Spectral index



- **Preliminary results!**
- Effelsberg flux measurements show a steepening in the spectral index
- Steepening in the spectrum looks like aging of electrons

Spectral index of J2242.9+5301

CIZA J2242.8+5301 - Spectral index

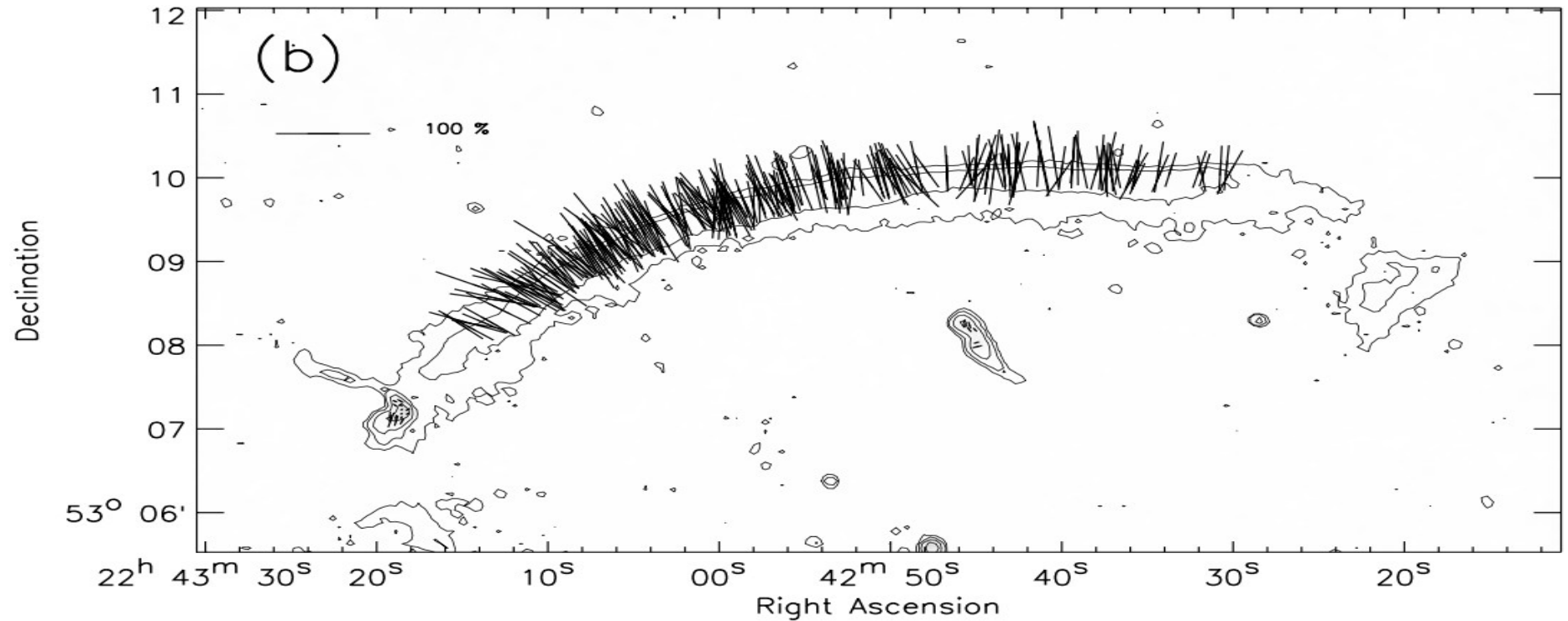


- **Preliminary results!**
- α (overall) ~ -1.4
- $\alpha_{2.3}^{0.15} \sim -1.1$
- $\alpha_{8.4}^{2.3} \sim -2.3$

Speculation: Why is the spectrum curved?

- Initial electron spectrum could be curved
- Less efficient electron injection
- Downstream gradient in the magnetic field
- ?

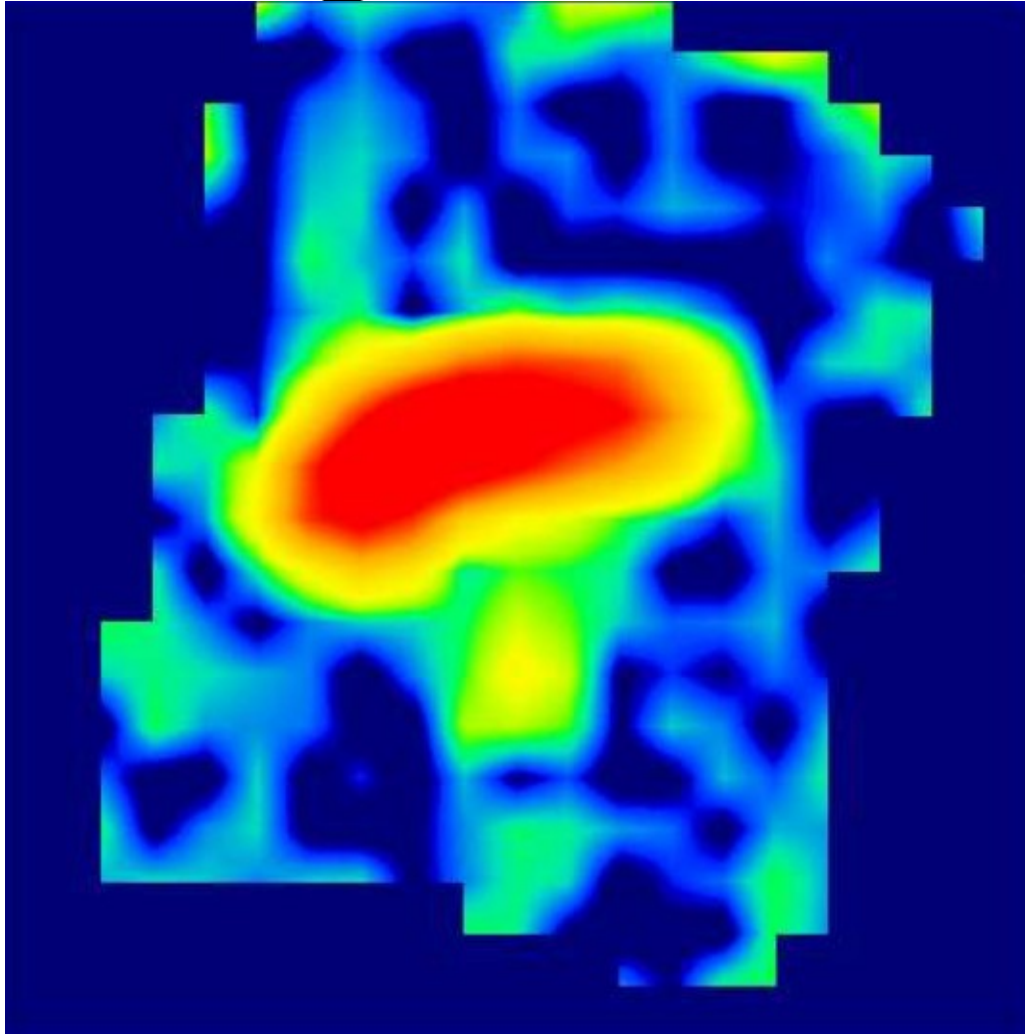
J2242.8+5301 – polarized intensity VLA



J2242.8+5301,
polarization vectors → VLA, $\nu=4.9\text{GHz}$,
contours → WSRT, $\nu=1.4\text{GHz}$

van Weeren et al. 2010
(Science)

J2242.8+5301 – polarized intensity @ 6cm - Effelsberg



J2242.8+5301,
Effelsberg,
 $\nu=4.85\text{GHz}$,
 $\lambda=6.3\text{cm}$
2.45arcmin

POLARIZED
INTENSITY



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Relic in CIZA J0649.3+1801

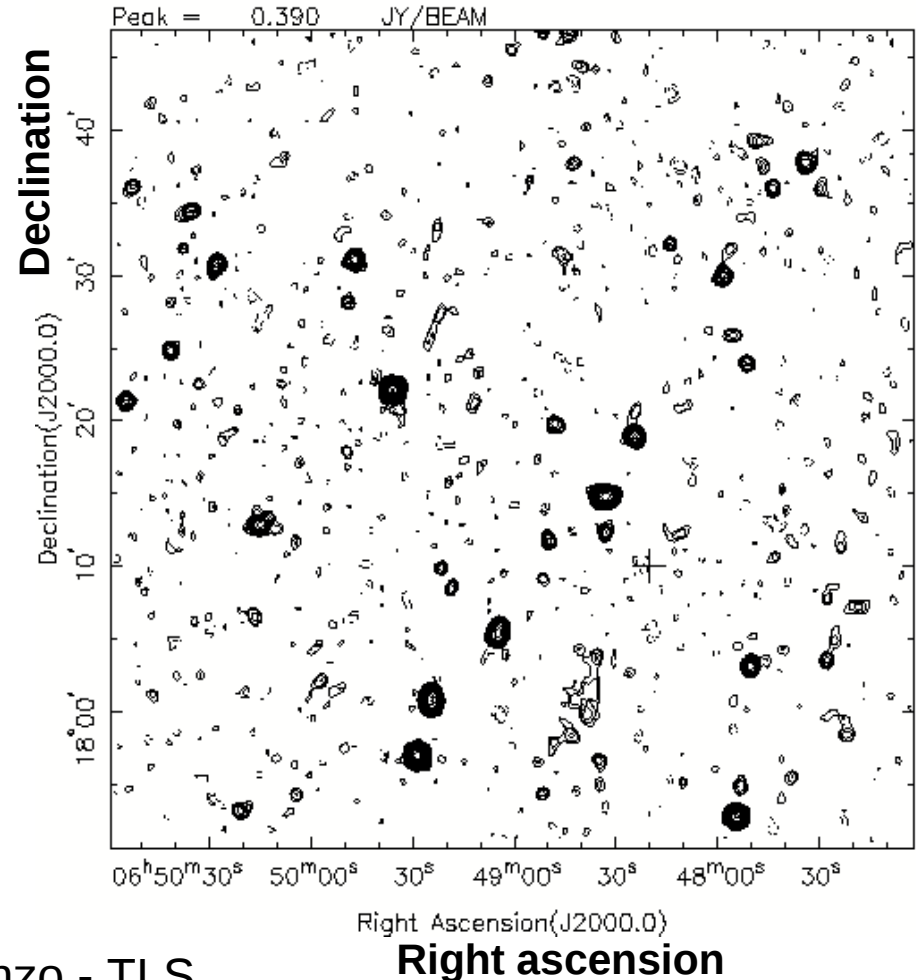
NVSS, $\nu=1.4\text{GHz}$

NVSS: No_Name (lvs=+/-1,1.4,2,2.8,4...mJy/b)

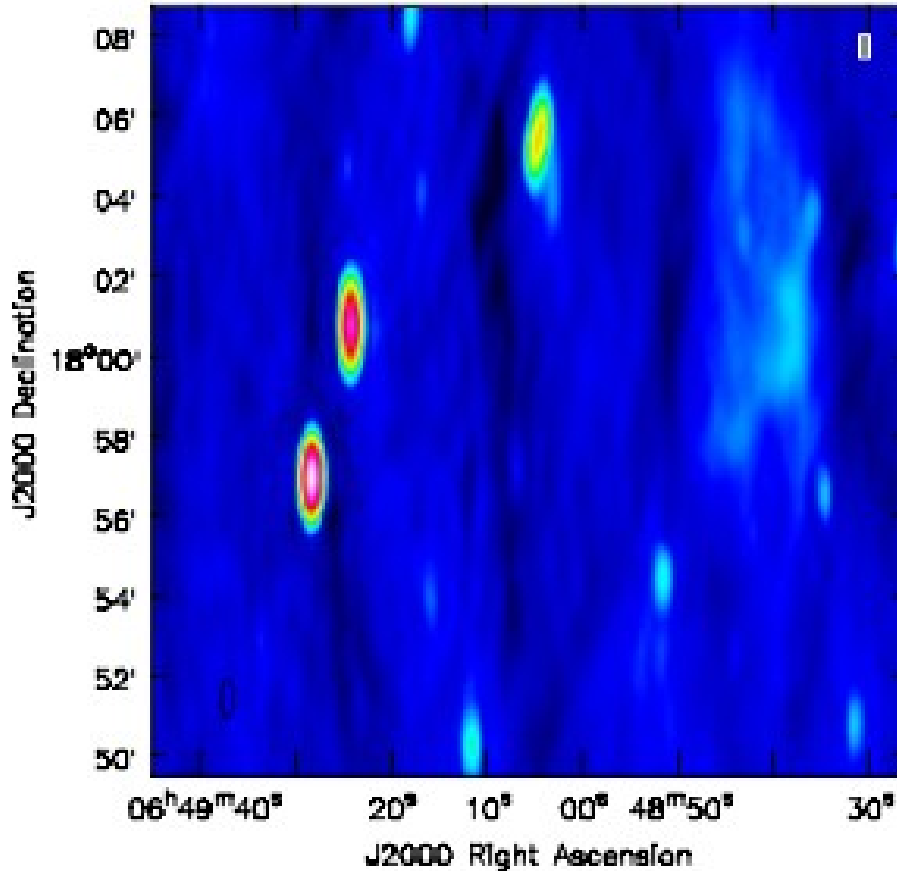
- Little studied galaxy cluster at redshift $z=0.064$
- Galaxy cluster discovered by Ebeling et al. 2002
- Size $\sim 800\text{kpc}$
- Candidate relic located at periphery of cluster ($\sim 0.8\text{Mpc}$ from center)
- Moderate X-ray luminosity associated with cluster
($L_{X, 0.1-2.4\text{keV}} = 2.38 \cdot 10^{44} \text{ erg s}^{-1}$)

van Weeren et al. 2011
(preprint)

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J0649.3+1801 @ 18cm Westerbork



- Data reduction → casapy
- Relic located on the west of cluster center
- WSRT $\nu=1.7\text{GHz}$, $\lambda=18\text{cm}$
- Flux → $S(1.7\text{GHz})=14\text{mJy}$, $S(1.4\text{GHz})=31\text{mJy(NVSS)}$
- 7 subbands
- December 2010

WSRT, $\nu=1.7\text{GHz}$,
 $\lambda=18\text{cm}$

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Summary

- **Relics are diffuse extended radio structures related to cluster mergers**
- **“sausage” relic (J2242.8+5301), observed at $\lambda=3,6$ and $\lambda=6\text{cm}$ (Effelsberg)**
- **Tentative detection of spectral steepening of J2242.8+5301**
- **Diffuse emission in J0649.3+1801, observed at $\lambda=18\text{cm}$**
- **Further work on polarization is needed**

Thank you!