

Evidence of magnetic fields in cosmological galaxy filaments

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Recent observational results on diffuse magnetic fields:

Tavecchio et al. 2010:

TeV photons from blazars, interacting with the optical-IR cosmic background, are efficiently converted into electron-positron pairs which lose their energy through inverse Compton scatterings with the photons of the microwave cosmic background, producing emission in the GeV band.

They apply this treatment to the blazar 1ES 0229+200, comparing the predicted reprocessed emission with the **upper limits measured by the Fermi/LAT**, they constrain the value of the intergalactic magnetic field to be **larger than $B \sim 5 \times 10^{-15}$ Gauss**

Aleksic et al. 2010:

searched for an extended emission around the bright blazars Mrk 421 and Mrk 501 using the MAGIC telescope. They obtain **upper limits on the extended emission around both sources** putting constraints on the existence of extragalactic magnetic fields: **strength around a few times 10^{-15} G.**

Blasi et al. 1999:

studied the effect of inhomogeneities in the matter distribution of the universe, well described by the Ly alpha forest on the Faraday rotation of light from distant QSOs, and derived a limit on the cosmological magnetic field: $|B_{IGM}| < 10^{-8}-10^{-9} G$.

Lee et al. 2009:

Observational evidence for the existence of cosmic magnetic fields in intergalactic space, coherent over Mpc scales. They used Faraday rotation measures of radio sources from the NVSS and the photometric redshift galaxy catalog from the SDSS.

It is shown that the rotation measures for sightlines passing through high density regions are significantly enhanced.

They interpret this result as intergalactic magnetic fields coherent over 1 Mpc/h with mean field strength

$B \sim 0.03 \times 10^{-6} G$

The origin and properties of large scale cosmological magnetic fields are still poorly known.

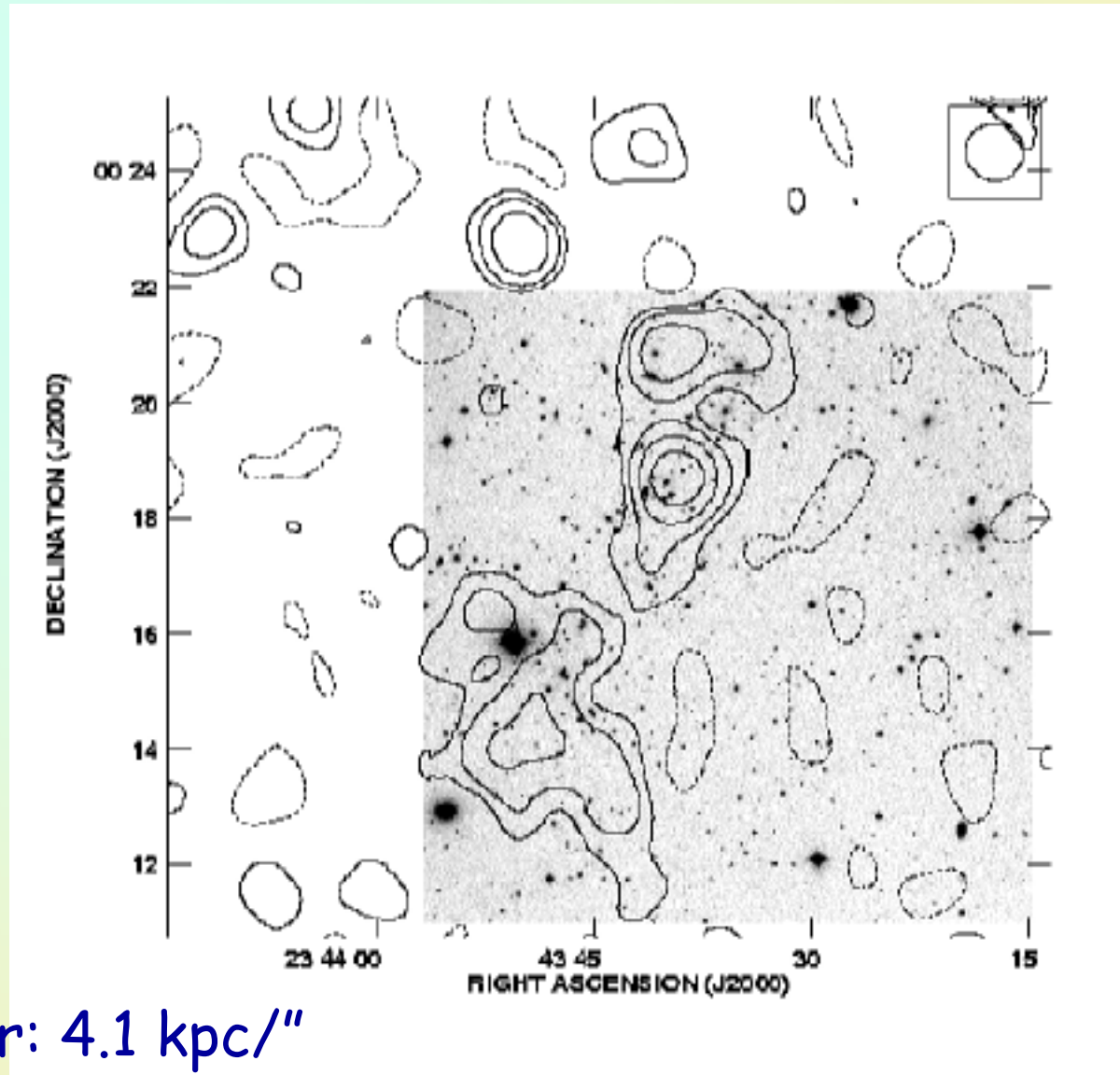
Cluster observations in the radio and X-Ray band have shown the existence of Mpc scale magnetic fields (see next many talks....).

I would like to present observational evidences of magnetic fields on larger scale (a few Mpc) and lower density: galaxy filaments connecting rich clusters.

One of the best candidate is the radio emission found in the filament of galaxies ZwCl 2341.1+0000

$z = 0.27$ conversion factor: 4.1 kpc/''

Filament of galaxies ZwCl 2341.1+0000

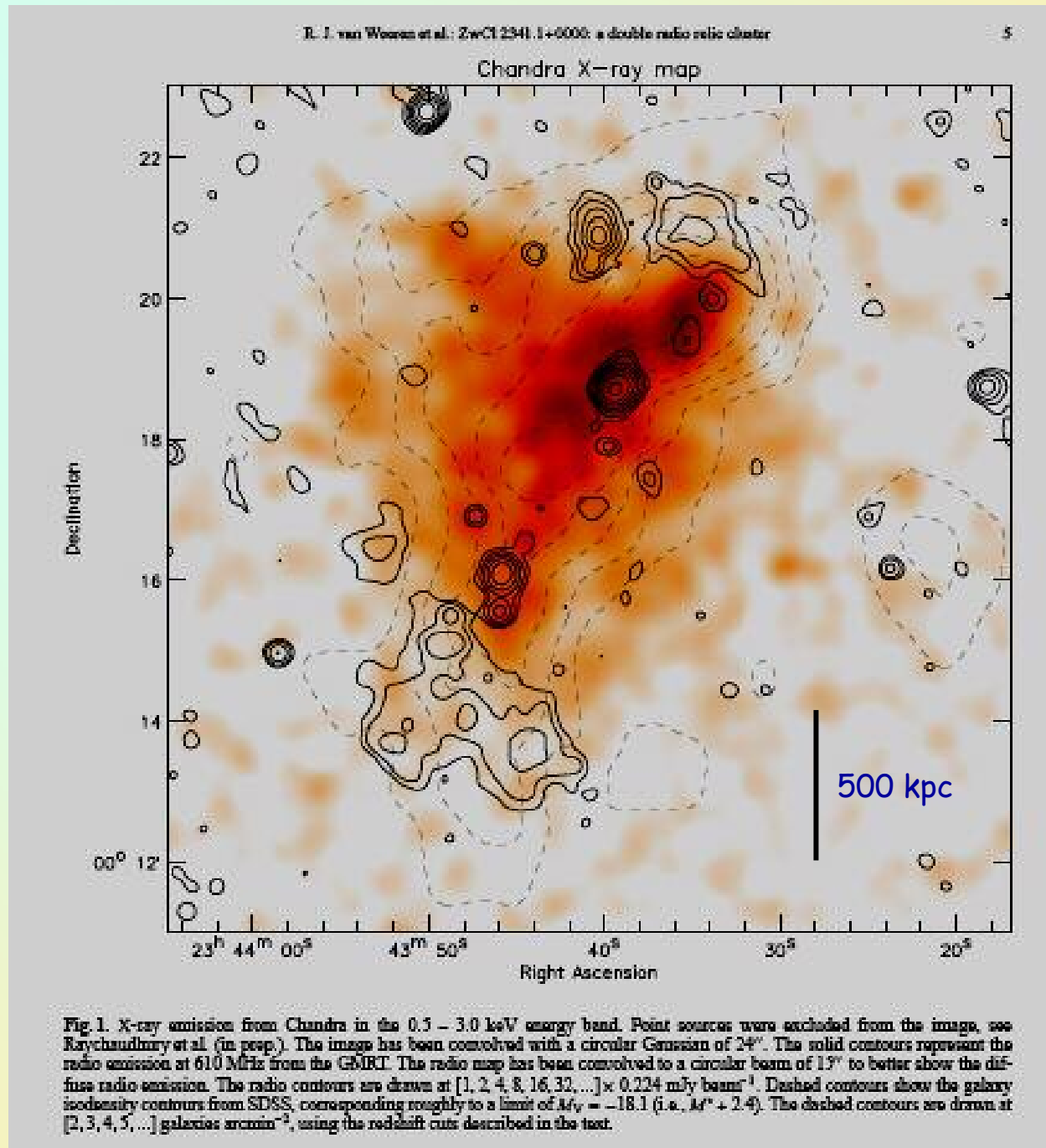


$z \sim 0.27$

conversion factor: 4.1 kpc/''

Size ~ 3.5 Mpc

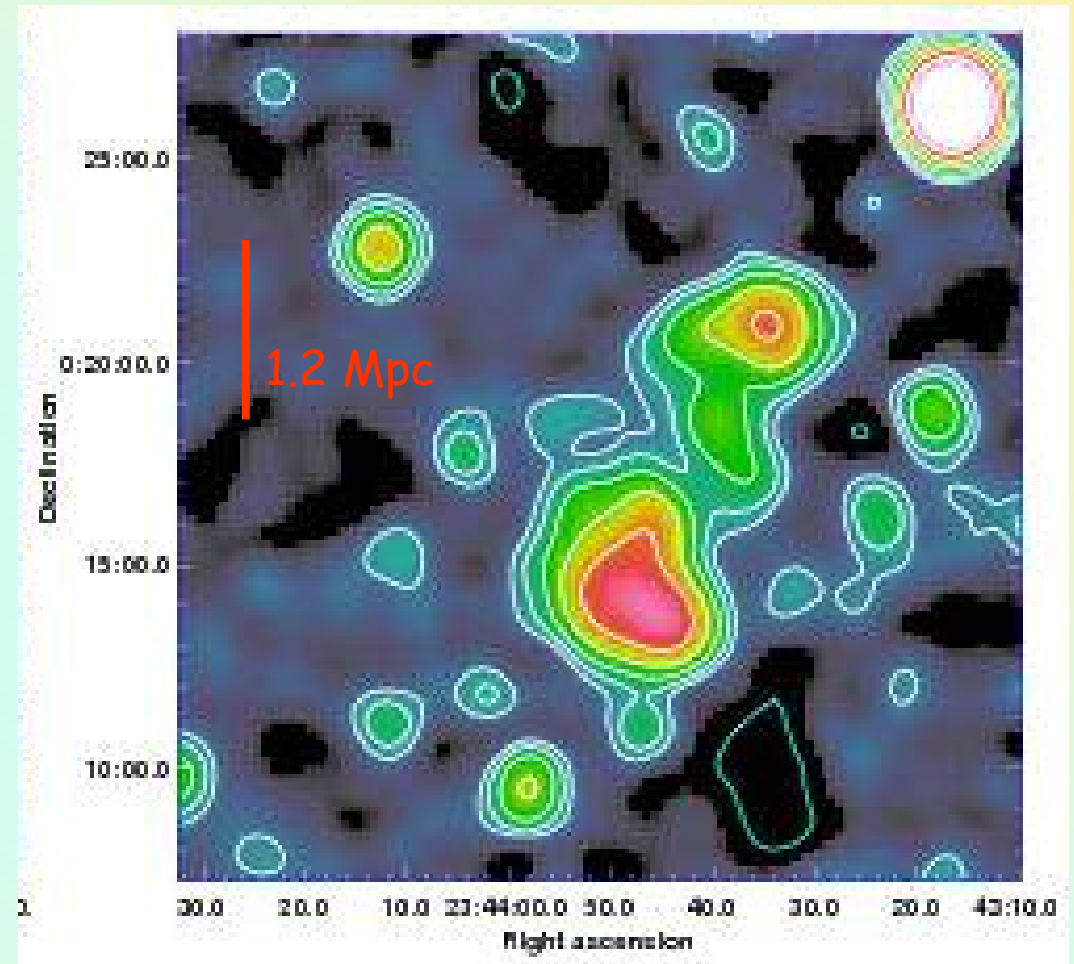
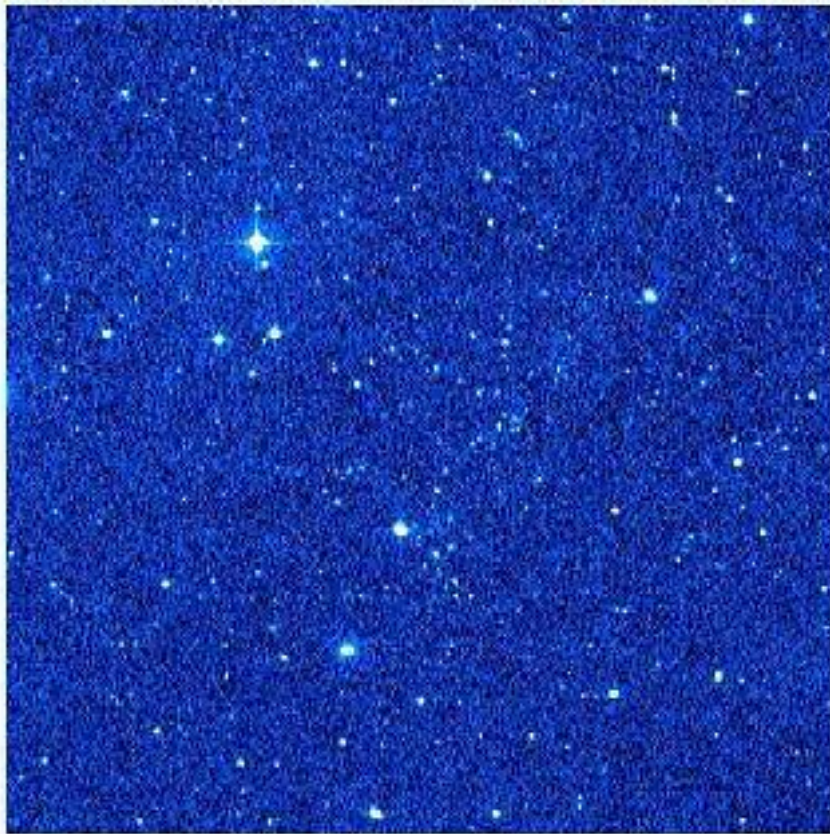
(Bagchi et al. 2002)



GMRT
610 MHz

Revised equipartition magnetic field: 0.59 and $0.55 \times 10^{-6} \text{ G}$

1.4 GHz VLA $\sim 1.2'$ resolution



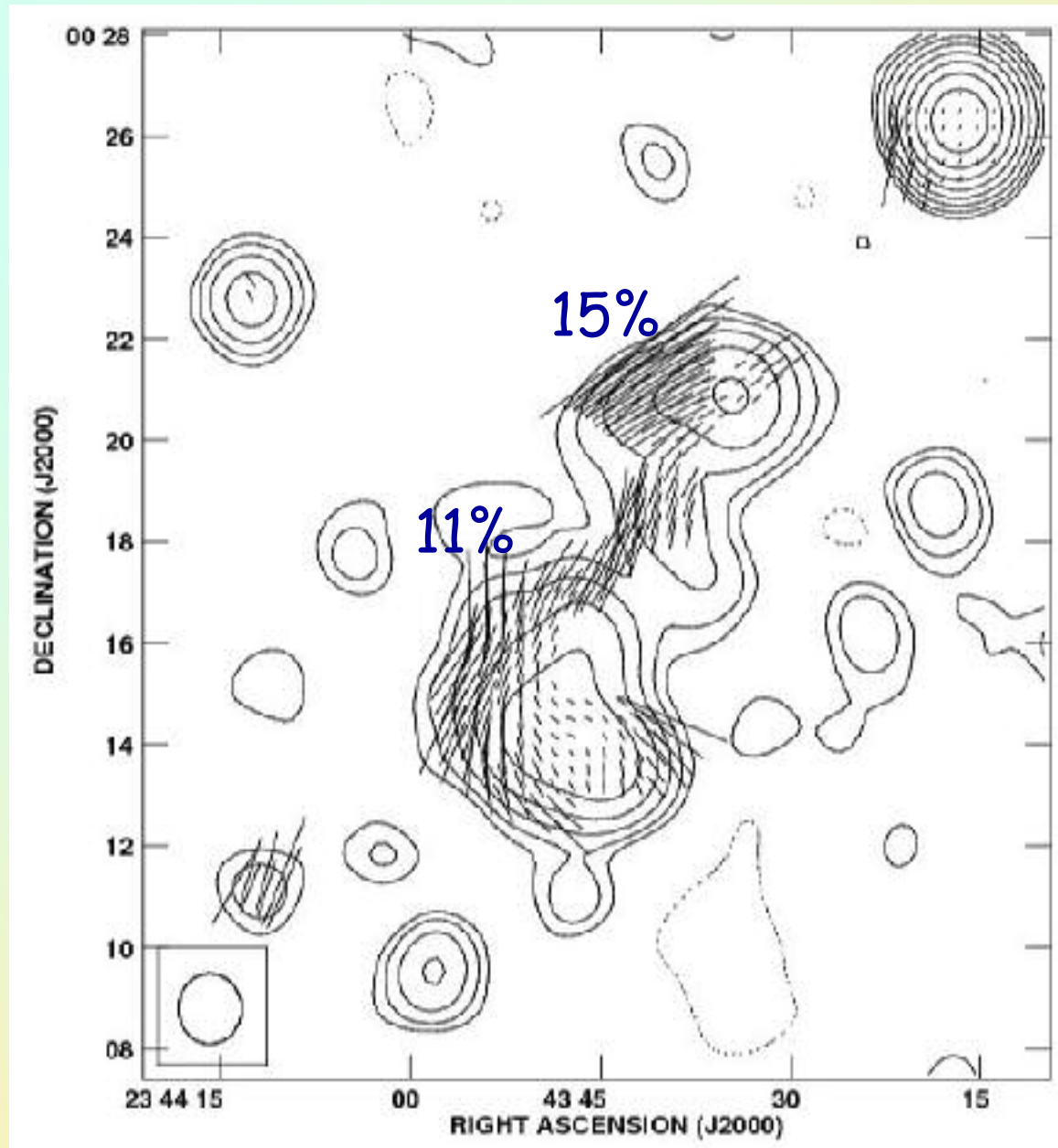
Equipartition magnetic field: $0.28 \times 10^{-6} \text{ G}$

Total size: 2.2 Mpc

Log P(1.4): 23.66 W/Hz

Giovannini et al. 2010

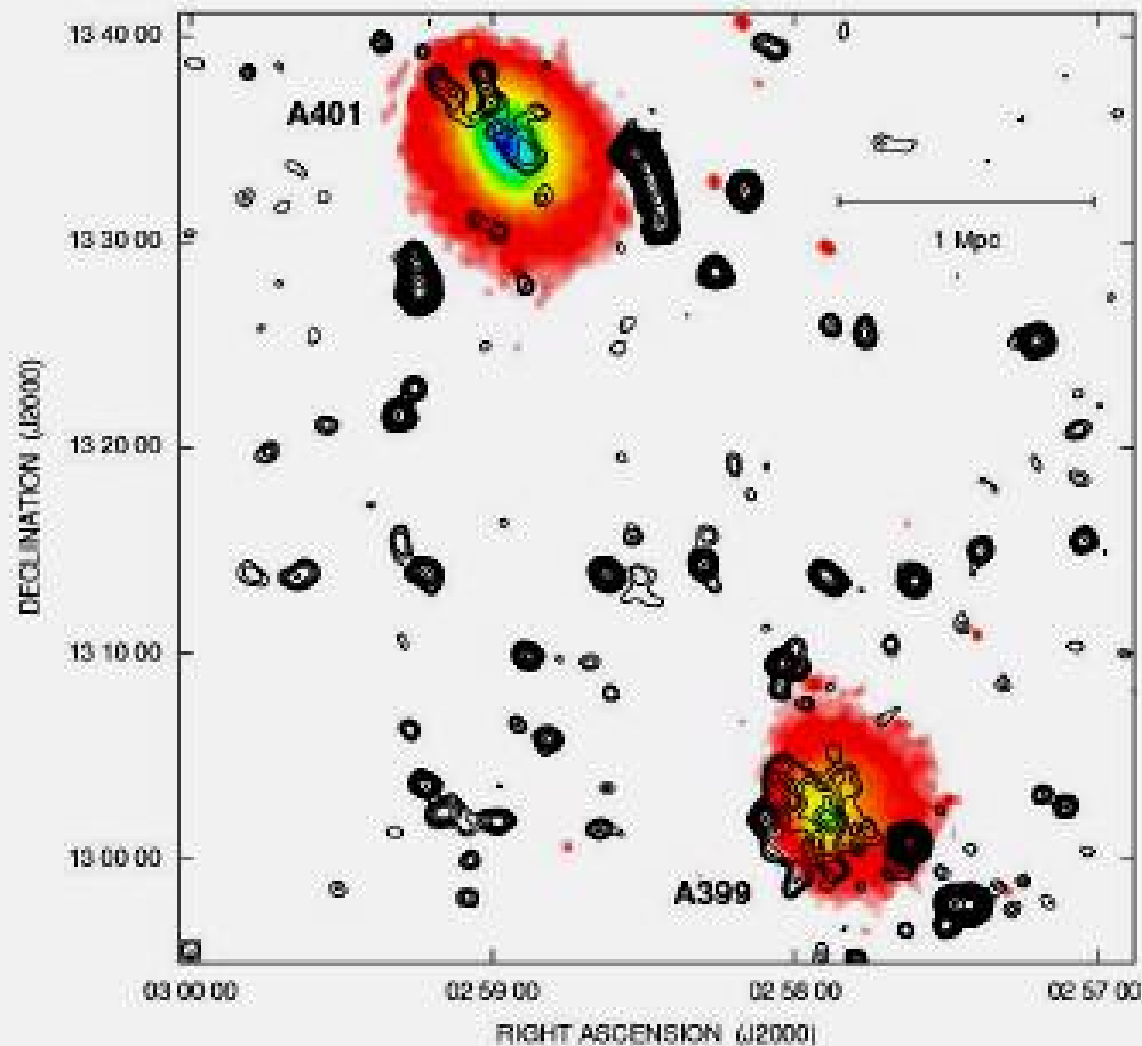
1.4 GHz VLA ~1.2' resolution



Giovannini et al. 2010

Possible interpretations

- 1- Large-scale shocks originated by multiple mergers
 - consistent with the detection of polarization and low depolarization
- 2- two peripheral relics and a central radio halo
 - consistent with size - power relation
 - difficult to reconcile with polarization
- 3- two halo clusters (like A399-A401 system) with a radio bridge in-between
 - may be difficult to reconcile with optical and with polarization



$z = 0.07$

Fig. 4. Total intensity radio contours of the complex A401-A399, obtained by combining the two VLA observations at 1.4 GHz in D configuration of the two clusters, as described in the text. The radio image is shown by the iso-contours and has an FWHM of $45'' \times 45''$. The first contour level is drawn at $120 \mu\text{Jy/beam}$ and the rest are spaced by a factor of $\sqrt{2}$. The sensitivity (1σ) is $40 \mu\text{Jy/beam}$. Total intensity radio contours are overlaid on the XMM X-ray image in the 0.2–12 keV band. The X-ray image has been convolved with a Gaussian kernel of $\sigma = 12''$.

Diffuse emission 0917+75

Relic galaxy?

Relic radio source?

Radio emission from a galaxy filament?

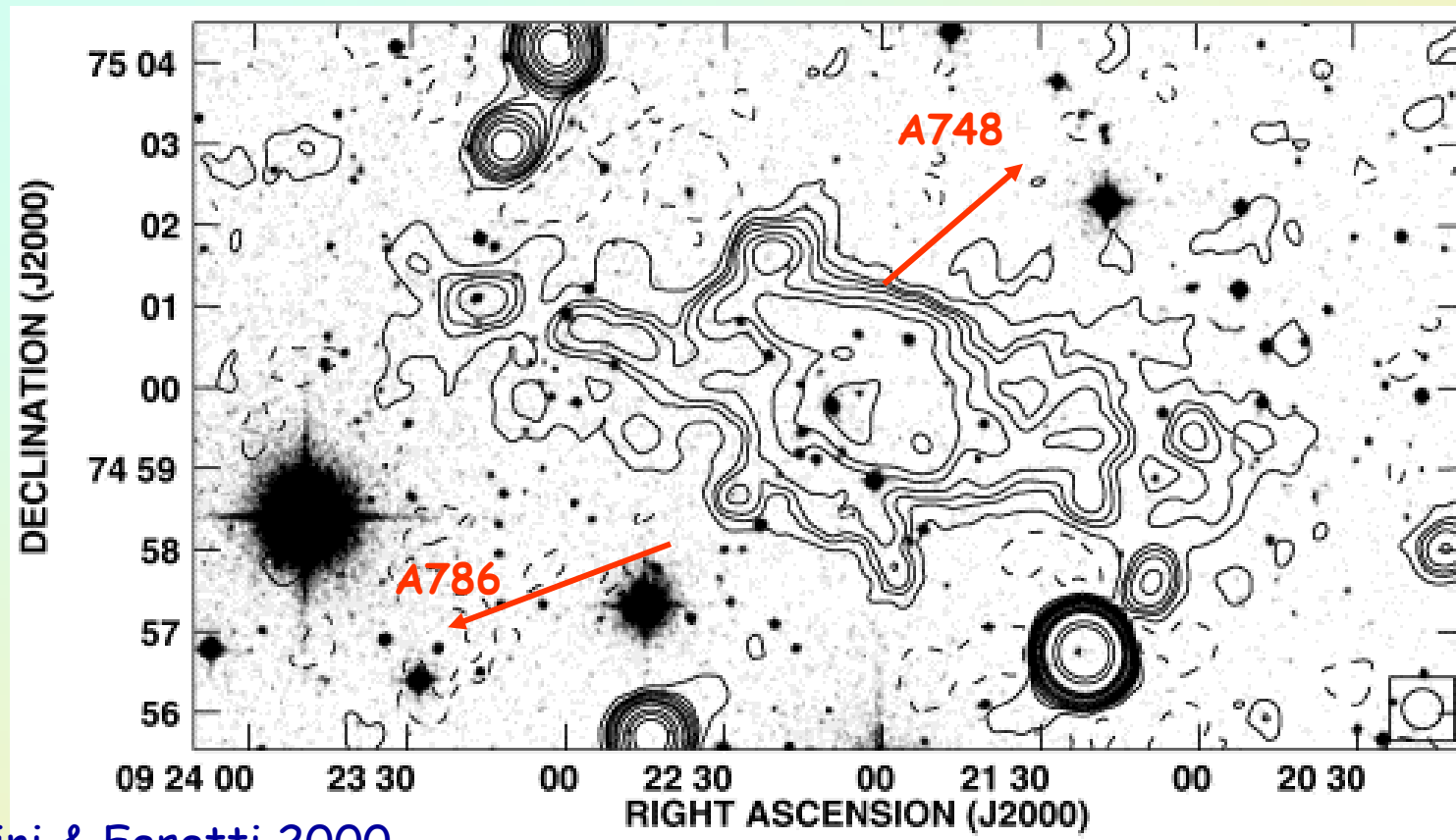
Studied in detail by:

Dewdney et al. 1991 (radio halo)

Harris et al. 1993 (Relic: shape + polarization)

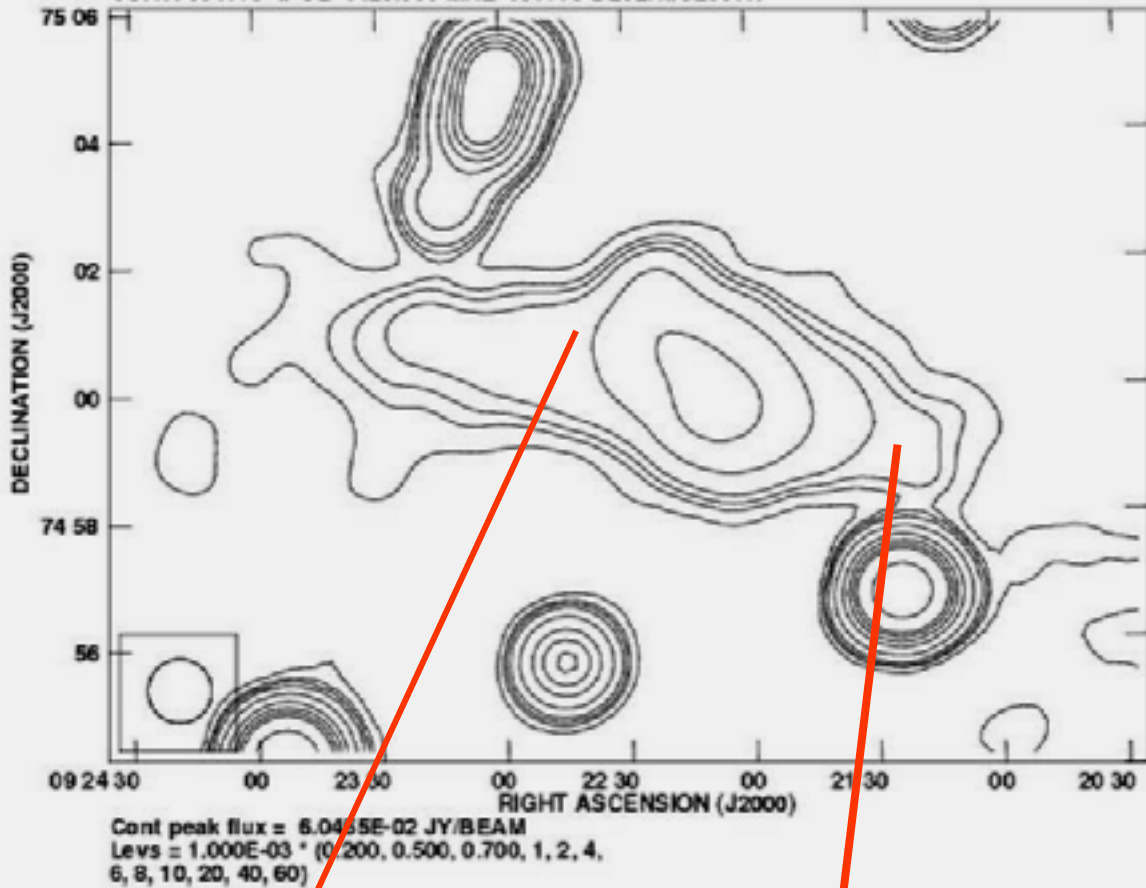
Giovannini & Feretti 2000, peculiar, very far (>4Mpc)
from the nearest rich cluster

VLA 1.4 GHz



Giovannini & Feretti 2000

Filament of galaxies same PA of the radio emission. z_{phot} is 0.138 (Girardi pc)
This filament could connect A786 and A748 nearby clusters at the same distance



VLA 1.4 GHz D array

Size: 1.7 Mpc

$H_{eq} = 0.5-0.7 \cdot 10^{-6} G$

$\log P_{1.4} = 24.61 W/Hz$

(Giovannini et al. in preparation)

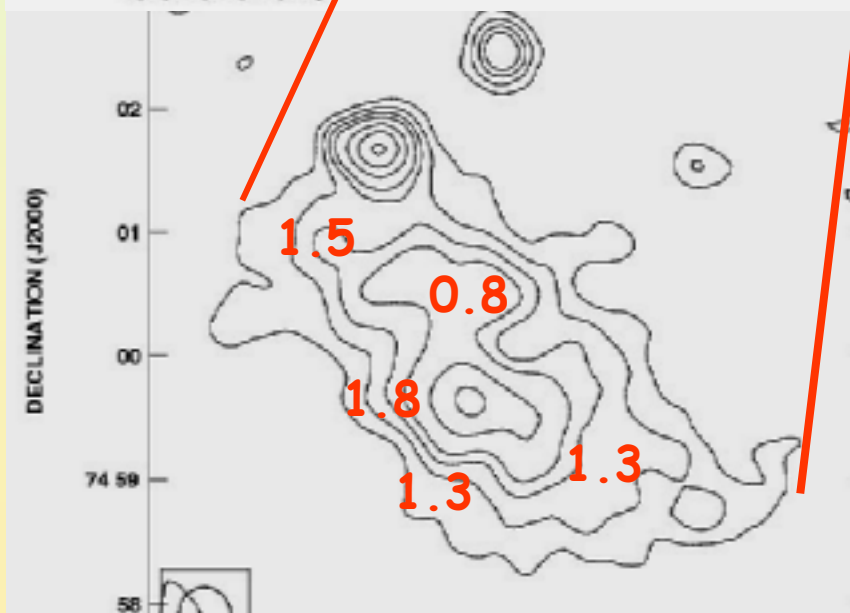
Not detected by XMM →

$H > 0.81 \cdot 10^{-6} G$

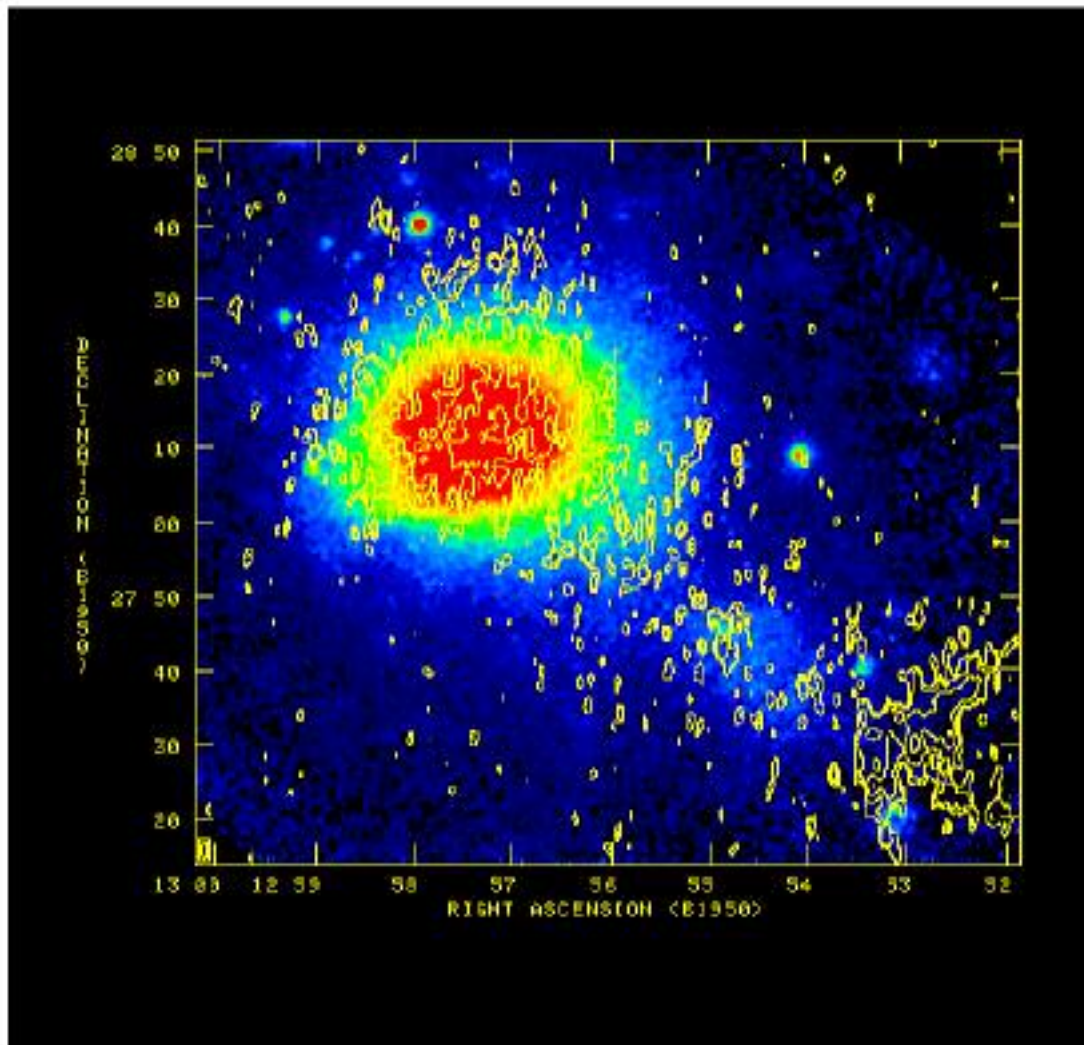
(Chen et al. 2008)

VLA 5 GHz

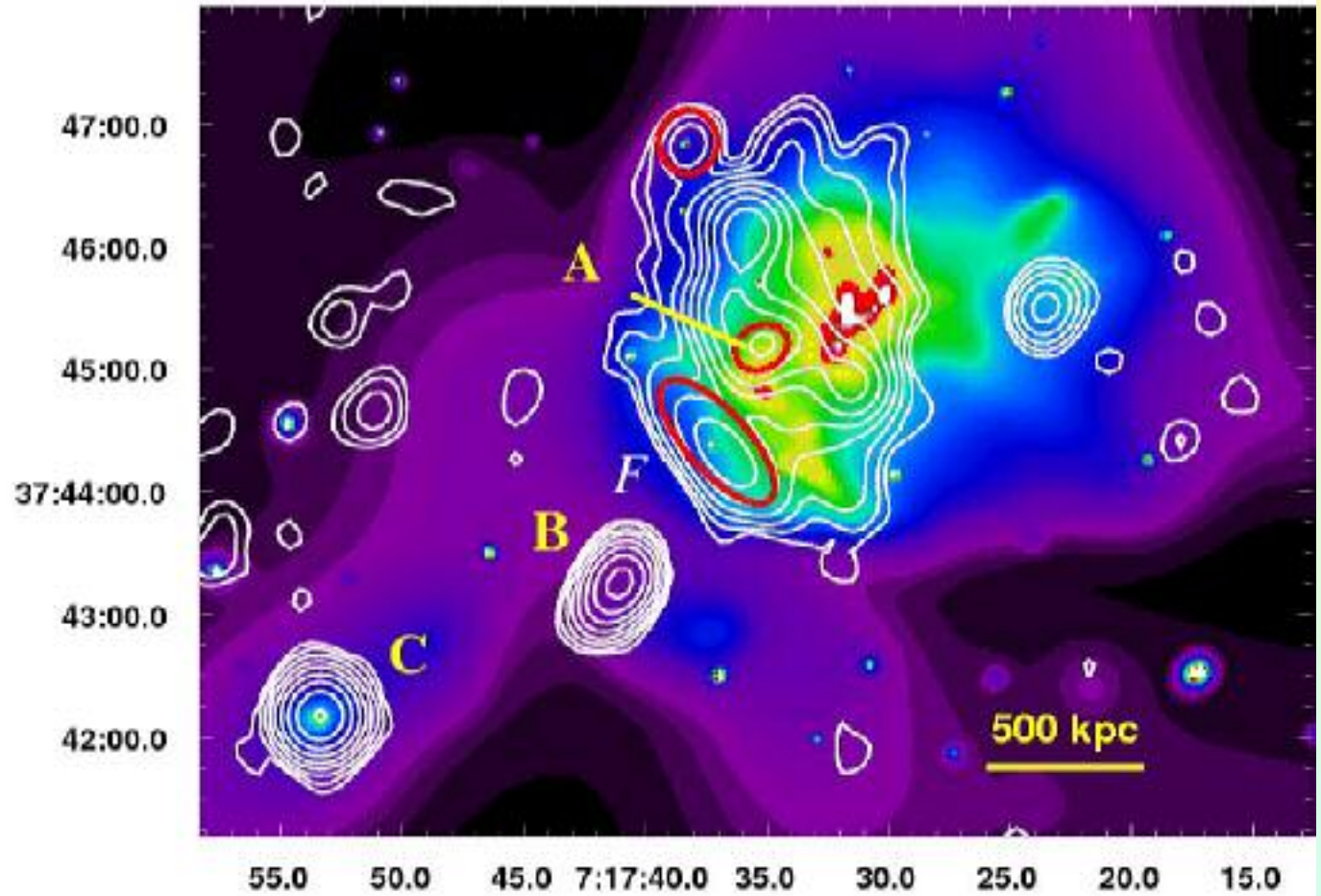
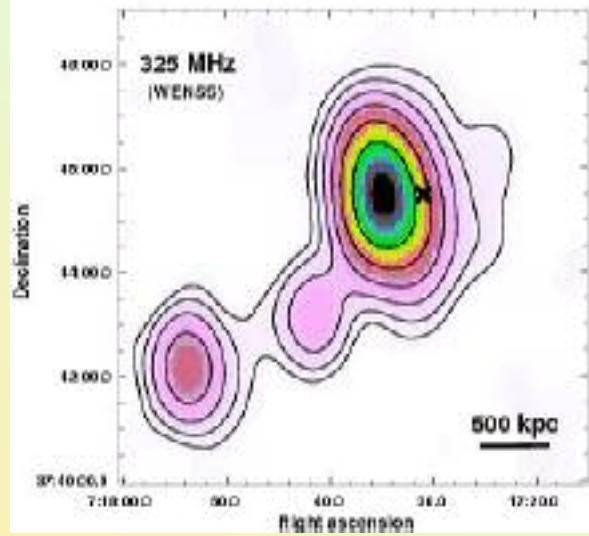
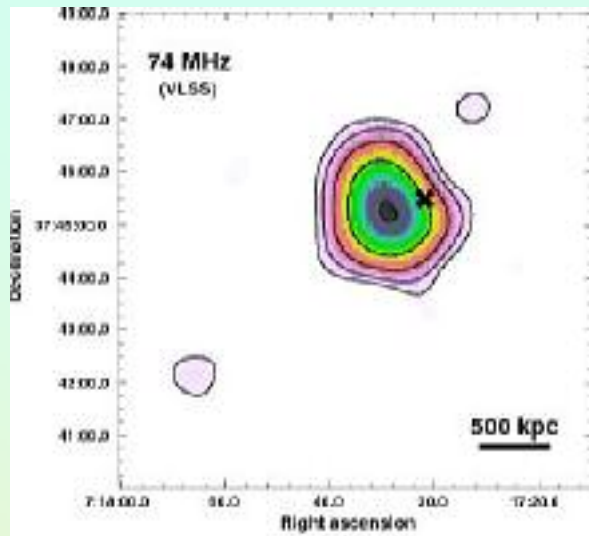
Spectral index 1.4 - 5 GHz



Other diffuse emission detected in the regions connecting rich clusters of galaxies: Coma and more.....



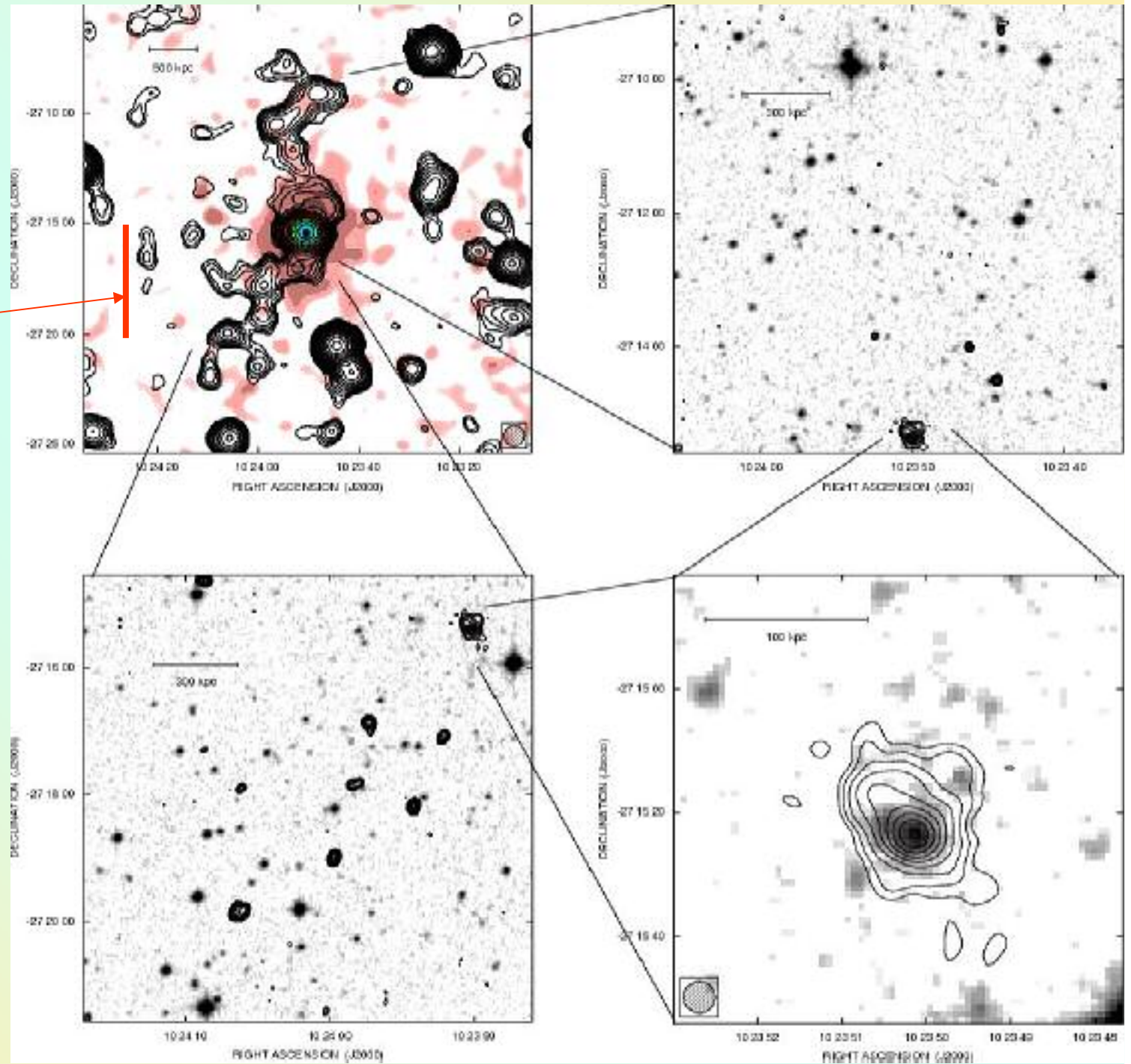
MACS J0717.5+3745 $z=0.55$



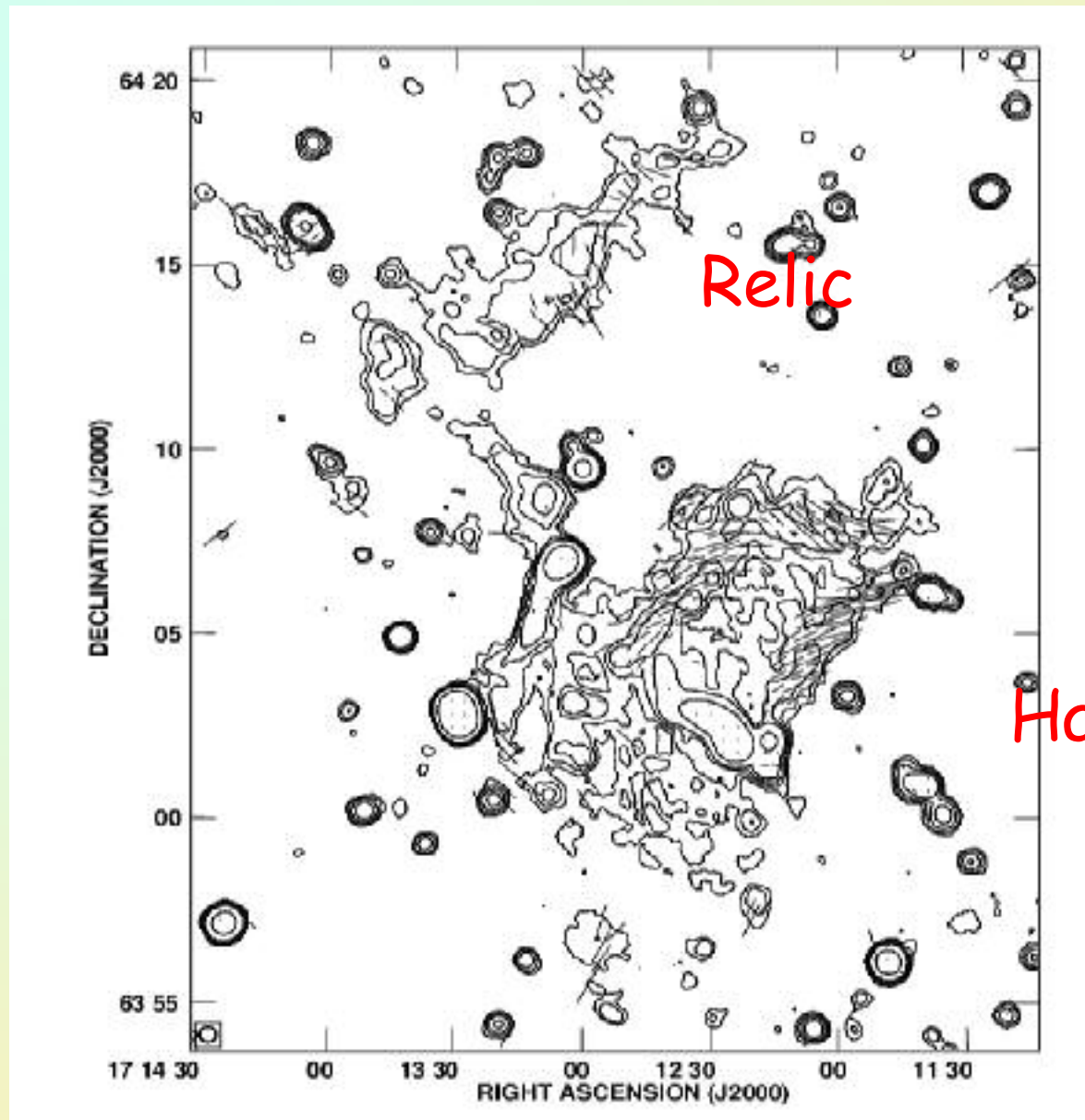
A3444
 $z = 0.0253$

Giovannini et al. 2009

1.2 Mpc



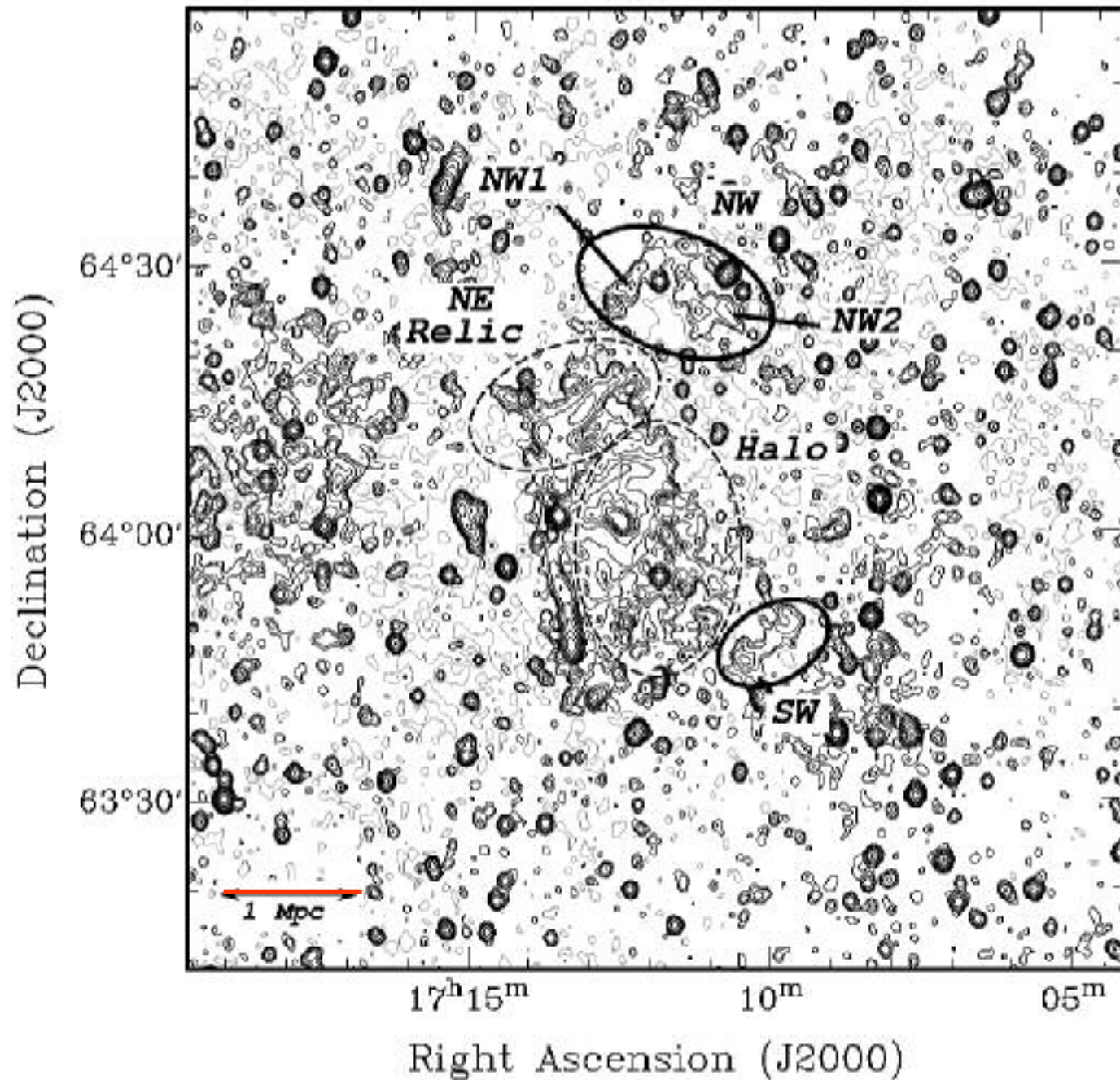
A2255



Govoni et al. 2006

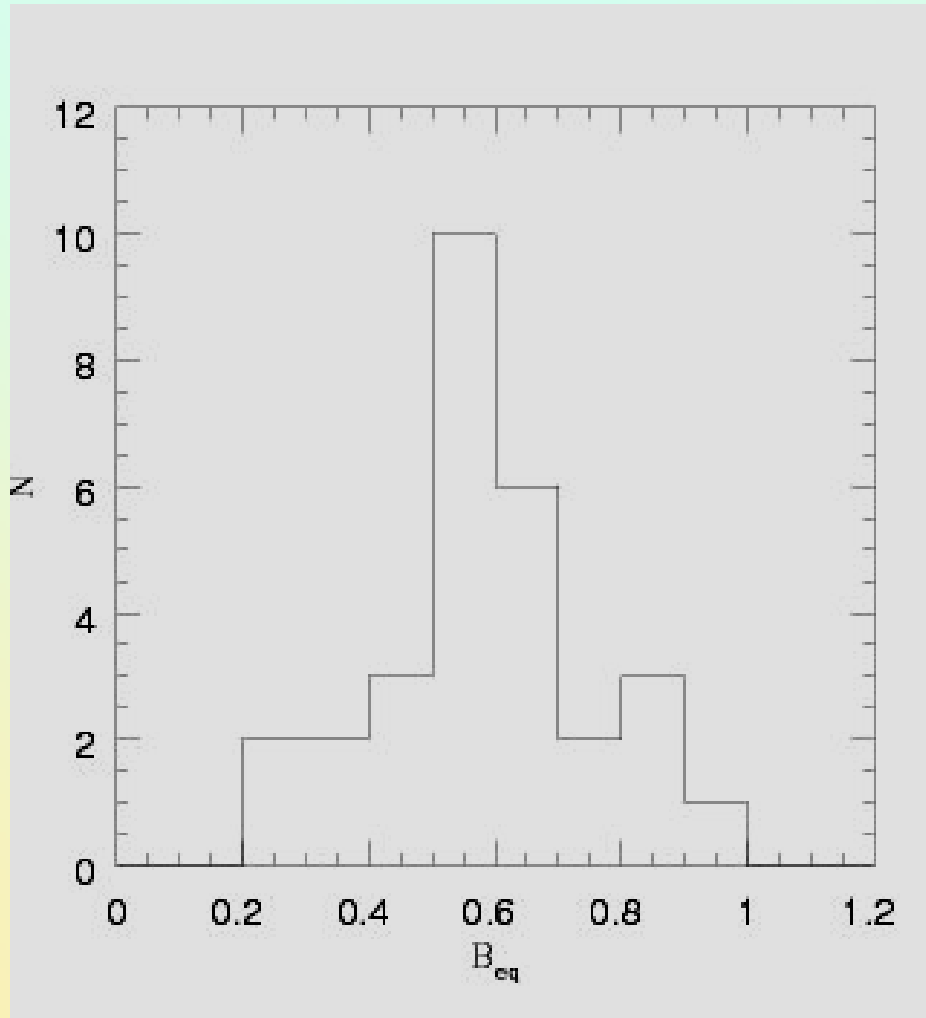
A2255

WSRT 85 cm



Pizzo et al. 2009

Magnetic field values from Halos Under Equipartition Conditions



classical estimate
(frequency range)

Summary

-Magnetic fields are present in all clusters up to $z = 0.55$, Mpc scale

-Magnetic fields have been detected also outside the center of rich clusters in regions where filaments of galaxies connecting rich clusters, are present (few Mpc scale). In most but not all of them X-Ray emission have been detected.

In progress, more soon

Thanks