Polarization of Cluster Radio Sources with LOFAR

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Emmen (NL) 23 – 27 April 2007

Outline of the Talk

Three-dimensional cluster magnetic field models

FARADAY program Murgia et al. (2004)

Abell 2255 Govoni et al. (2005, 2006)

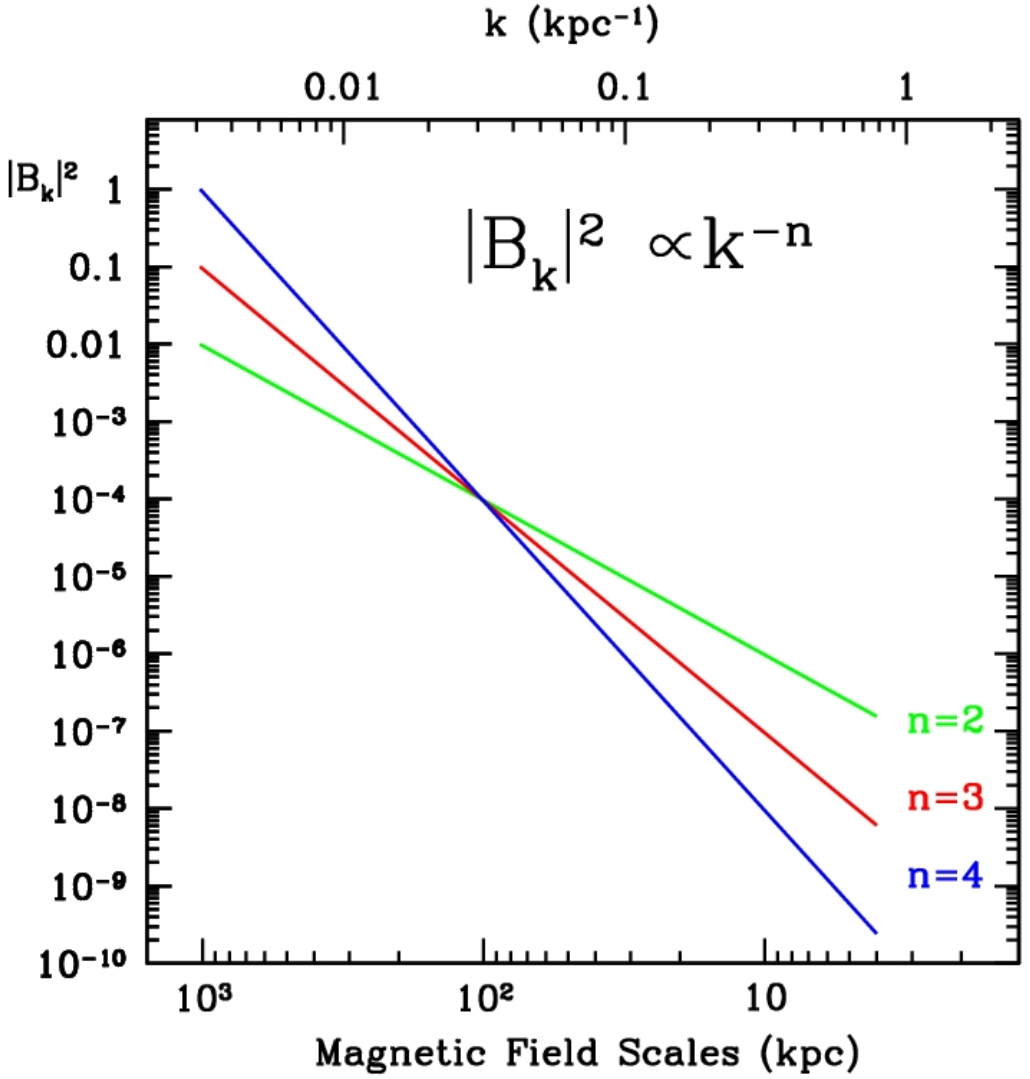
Radio Halo intensity and polarization

Rotation Measure

Radio Halos expectations with LOFAR

RM expectations of radio galaxies with LOFAR

3-Dimensional multi-scale cluster magnetic field models



Parameters of the magnetic field model:

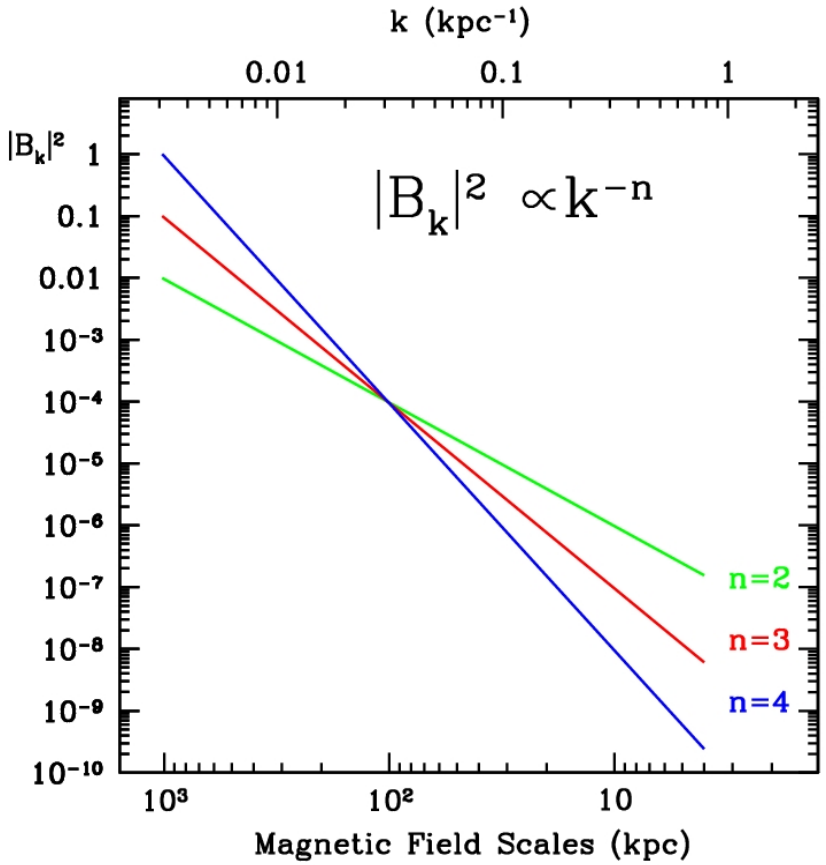
MAGNETIC FIELD SCALES

POWER SPECTRUM SPECTRAL INDEX

MAGNETIC FIELD STRENGTH

RADIO HALO EMISSION
ROTATION MEASURE OF RADIO GALAXIES

3-Dimensional multi-scale cluster magnetic field models



$B_0 = 1\mu G \qquad n = 3$

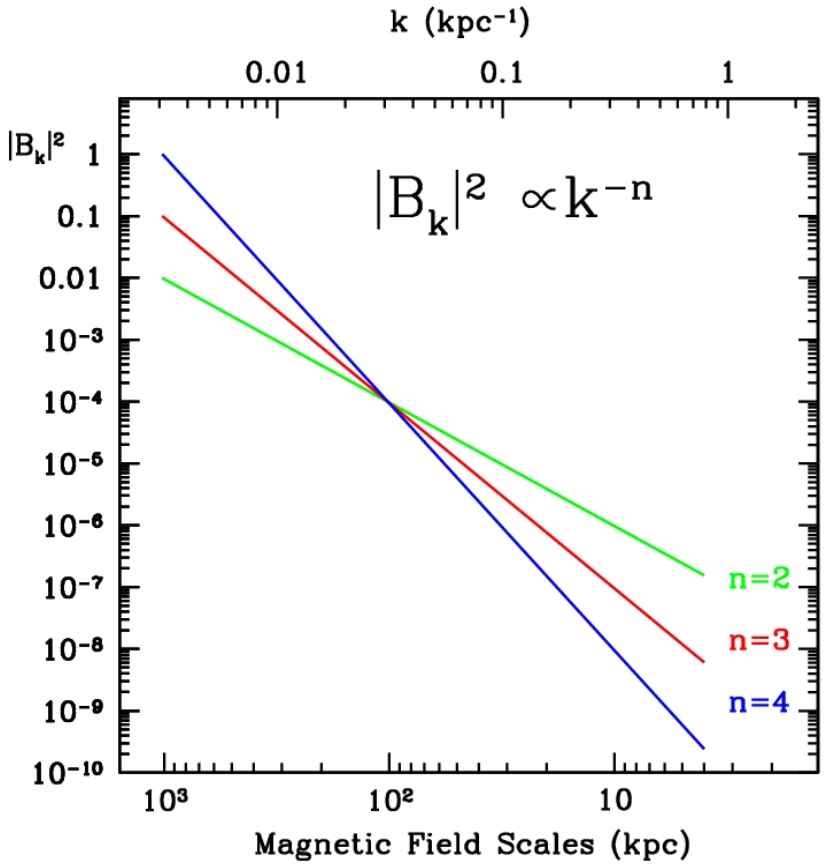
RADIO HALO EMISSION

$$N(\epsilon) = N_0 \epsilon^{-\delta}$$

$$I_\nu \propto \int N_0 B_\perp^{1+\alpha} \nu^{-\alpha} \, f(\epsilon_{min}, \epsilon_{max}, \alpha) dl$$

$$\delta = 2\alpha + 1$$

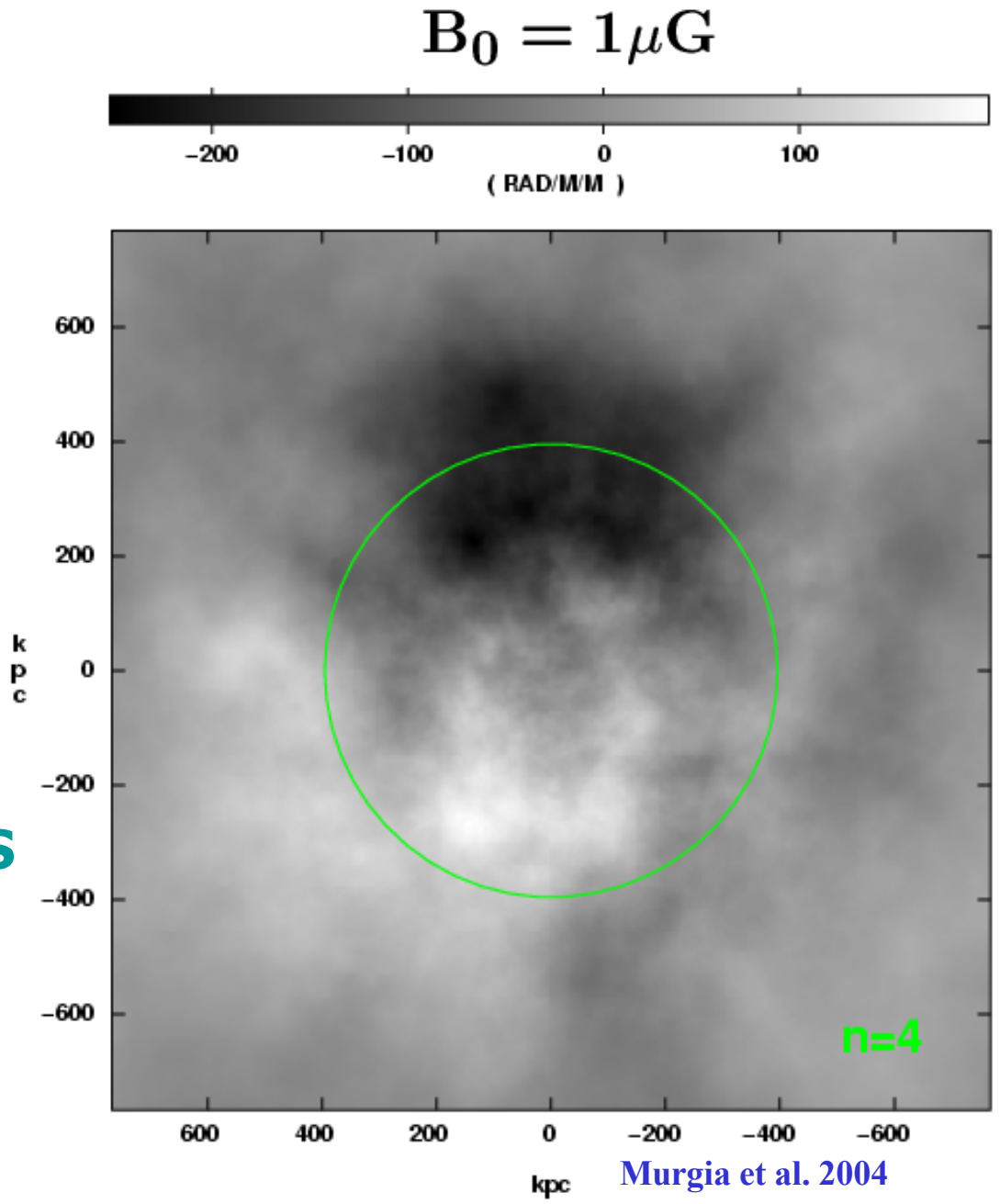
3-Dimensional multi-scale cluster magnetic field models



ROTATION MEASURE IMAGES

$$n_e(r) = n_0(1 + r^2/r_c^2)^{-3\beta/2}$$

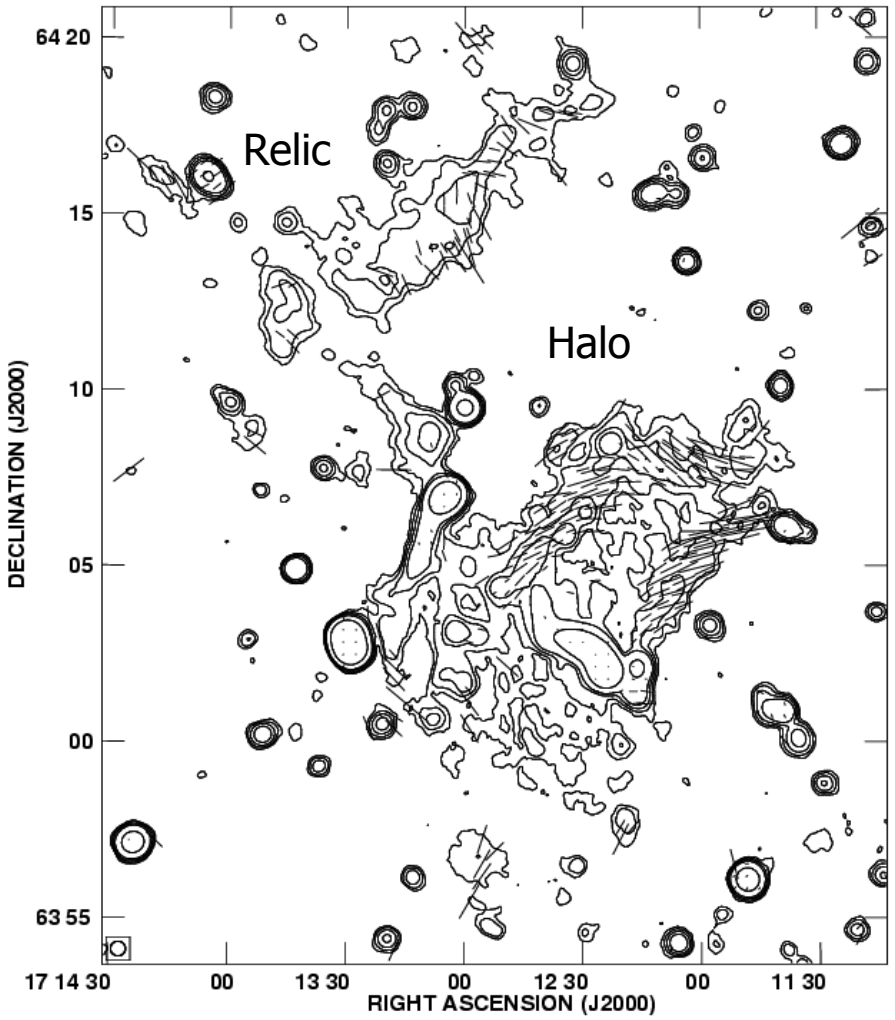
$$RM \propto \int n_e B_{||} dl$$



Murgia et al. 2004

ABELL 2255

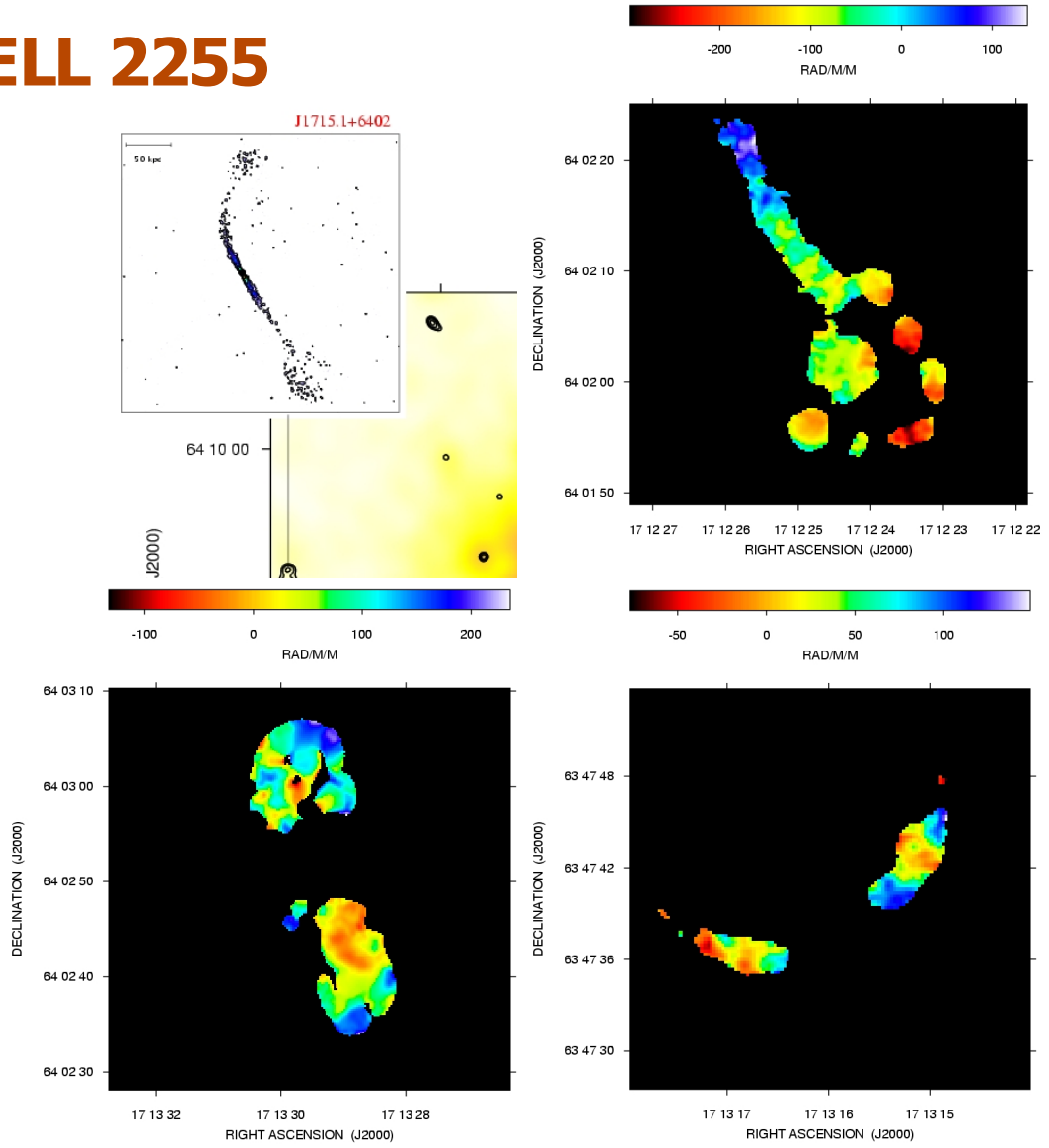
z=0.08



VLA 1.4 GHz, Beam 25"

Govoni et al. 2005

See also Pizzo R. talk

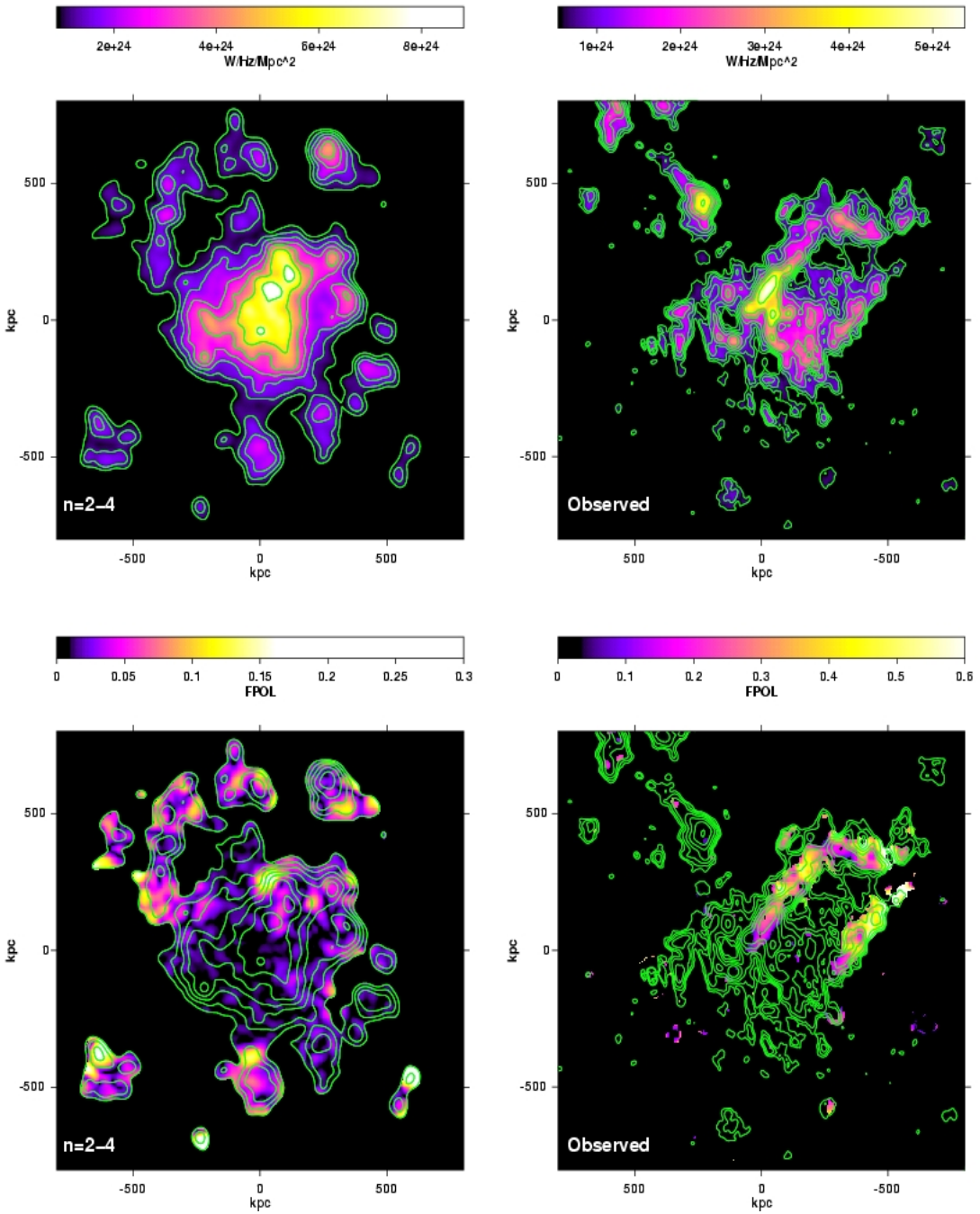


VLA 5 - 8 GHz, Beam 2" Govoni et al. 2006

$$\Psi_{OBS} = \Psi_{INT} + \Delta\Psi = \Psi_{INT} + \lambda^2 \times RM$$

$$RM \propto \int_0^L n_e B_{\parallel} dl$$

ABELL 2255



RADIO HALO EMISSION

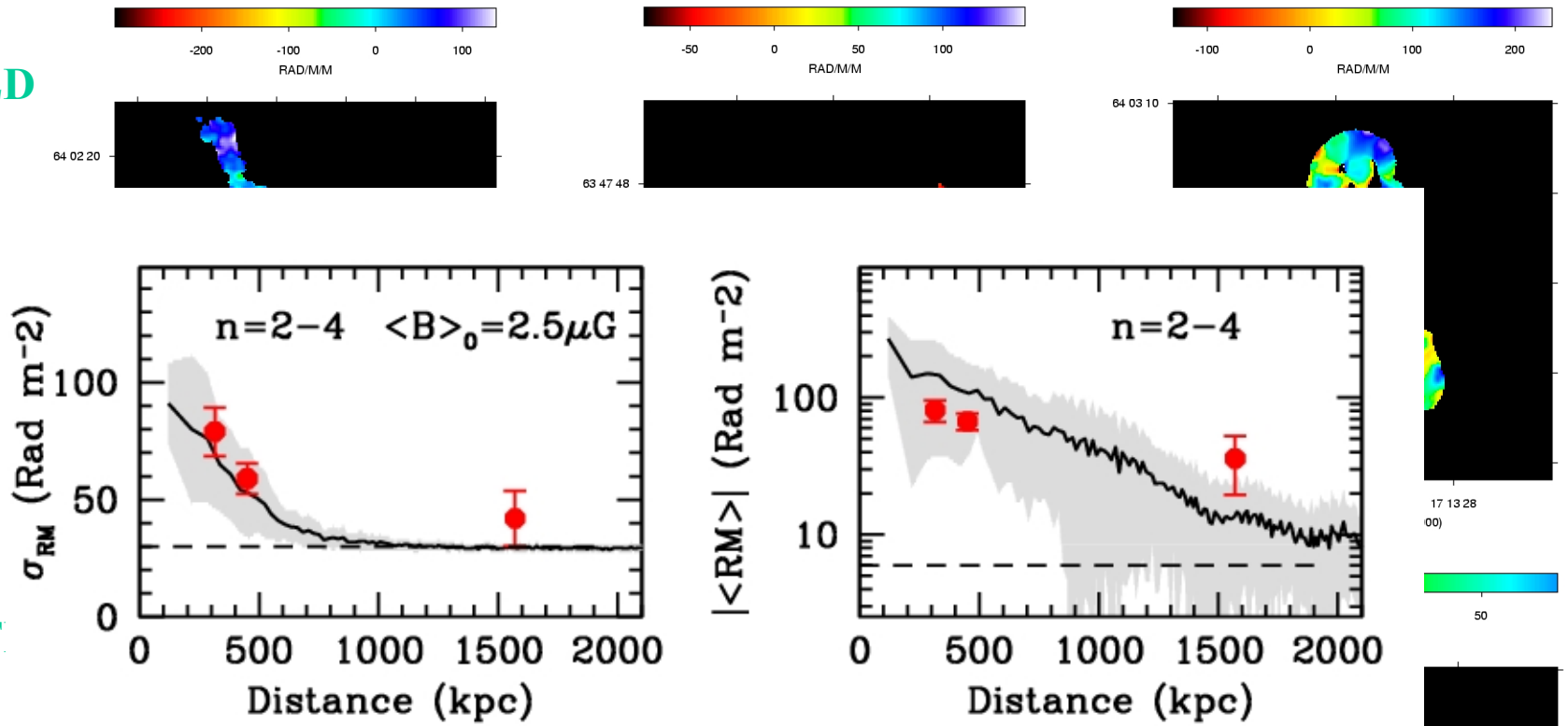
-Power spectrum spectral index:
n=2 at the cluster center
n=4 at the cluster periphery
-Magnetic field strength at the center
2.5μG

Govoni et al. 2006

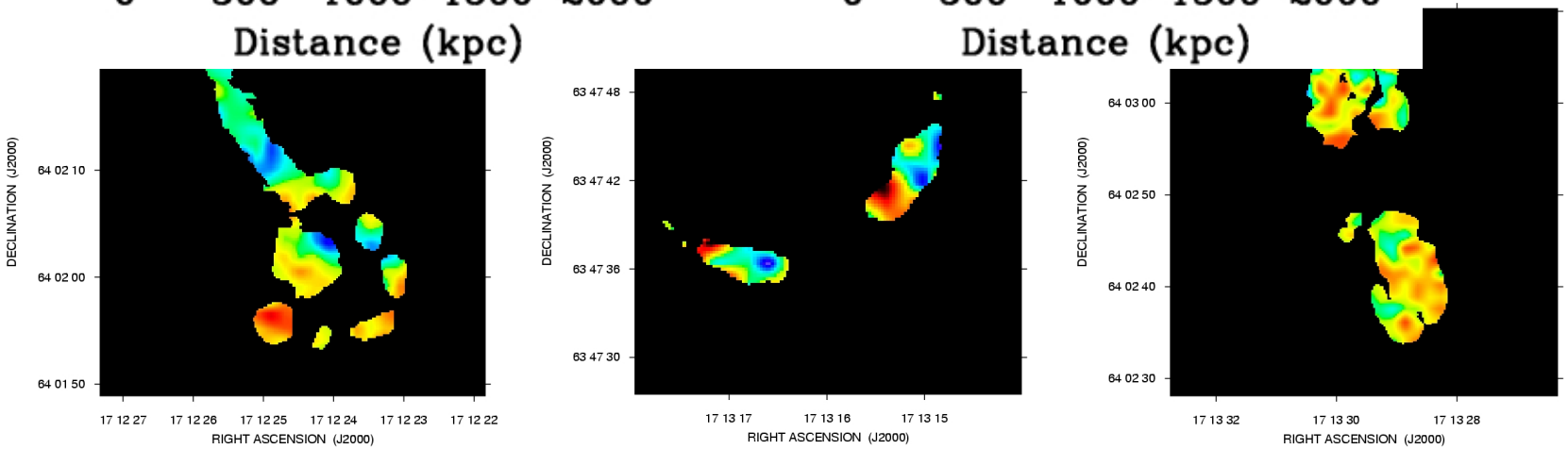
ABELL 2255

ROTATION MEASURE IMAGES

OBSERVED



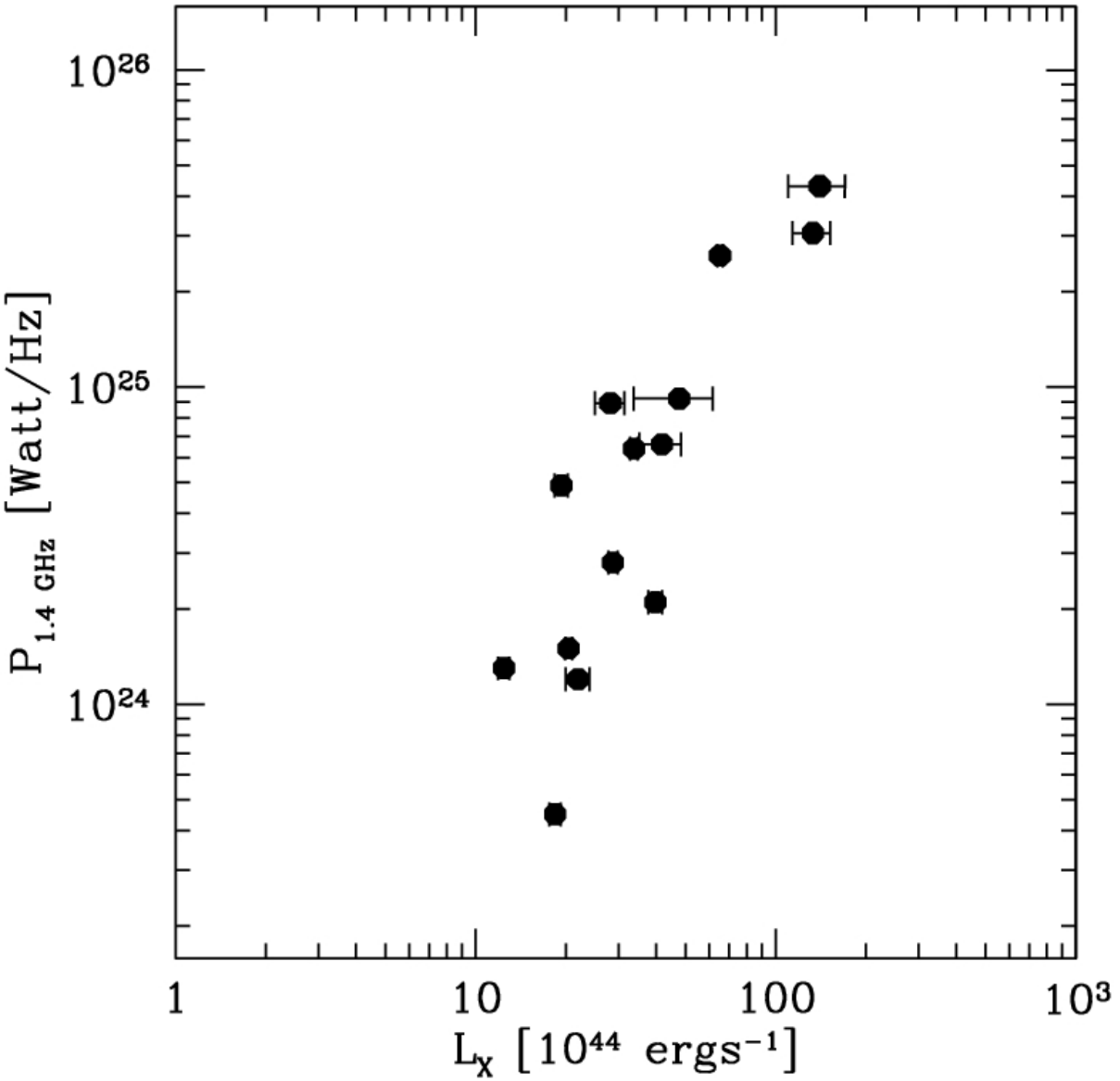
SIMULAT



Govoni et al. 2006

RADIO HALOS WITH LOFAR

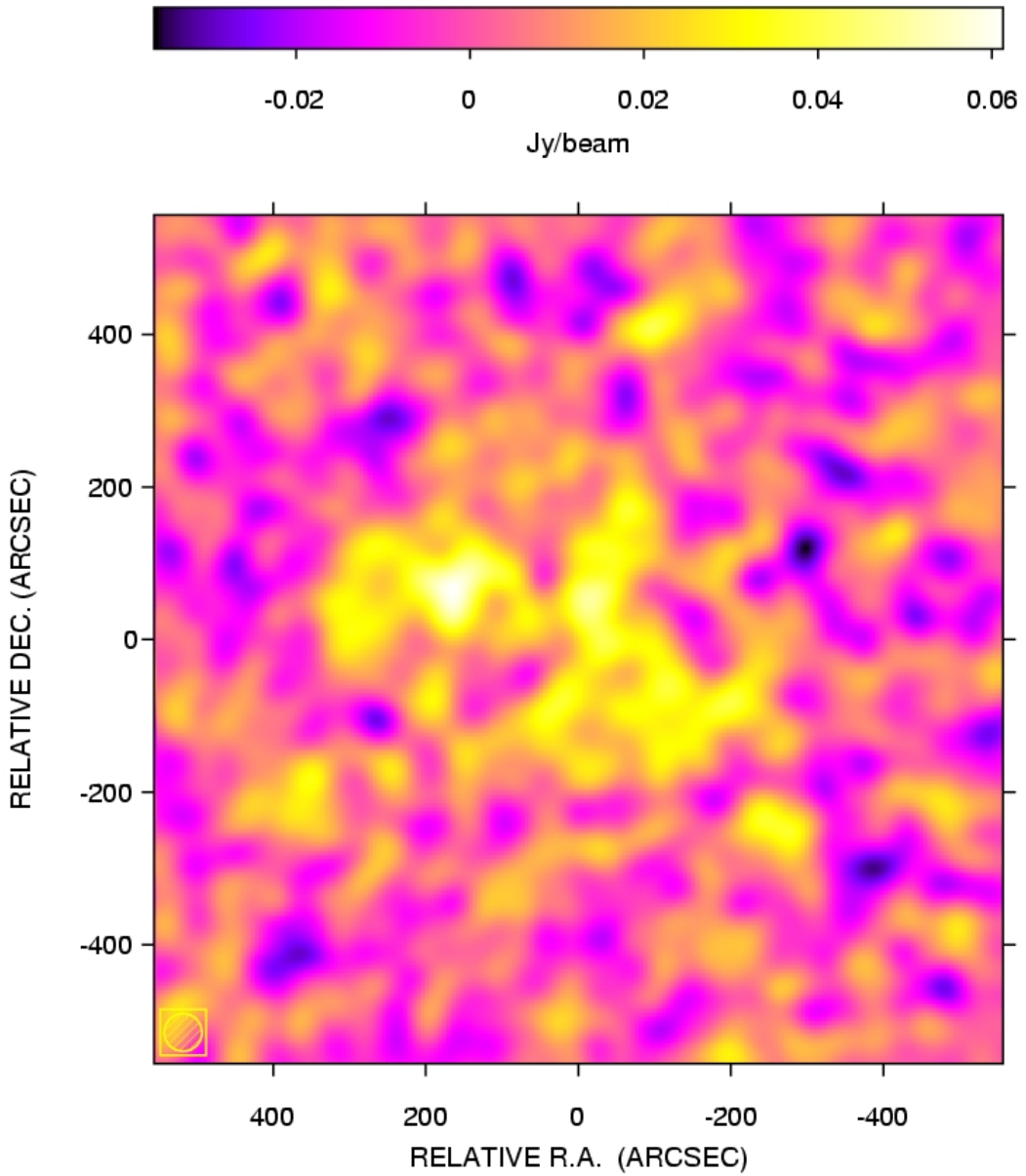
SIMULATIONS



Bright Halo

Faint Halo

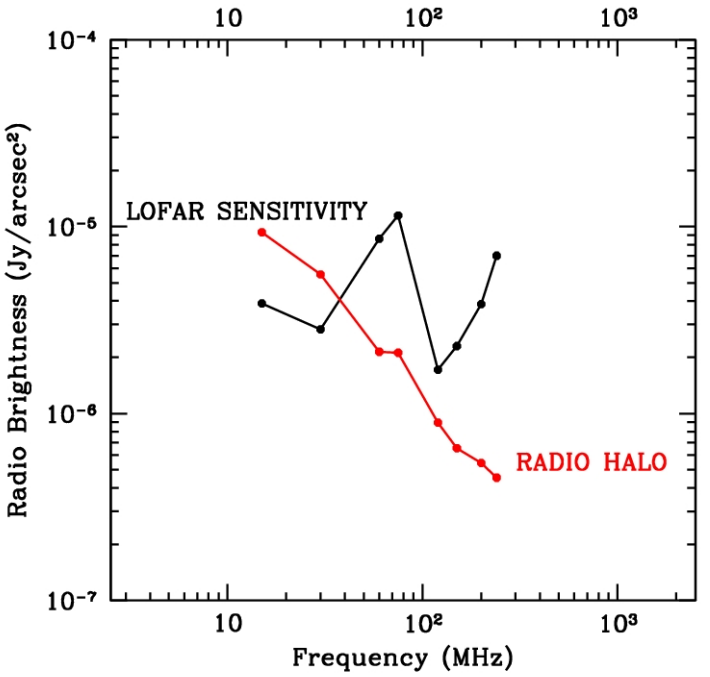
RADIO HALOS WITH LOFAR



Frequency=15 MHz

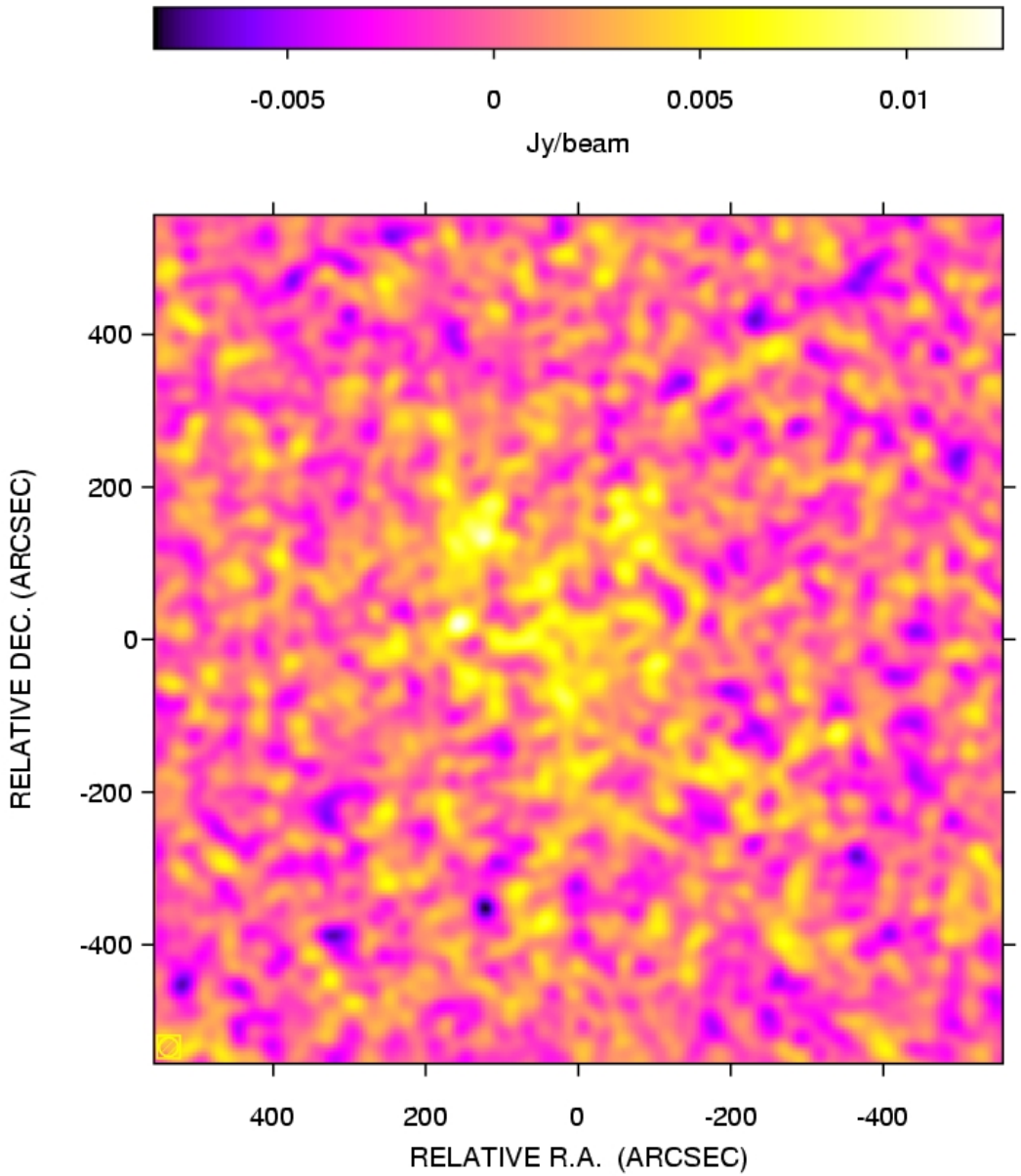
Beam=50″

Sensitivity=11 mJy/beam



$B_0 = 1\mu G$ $n = 3$

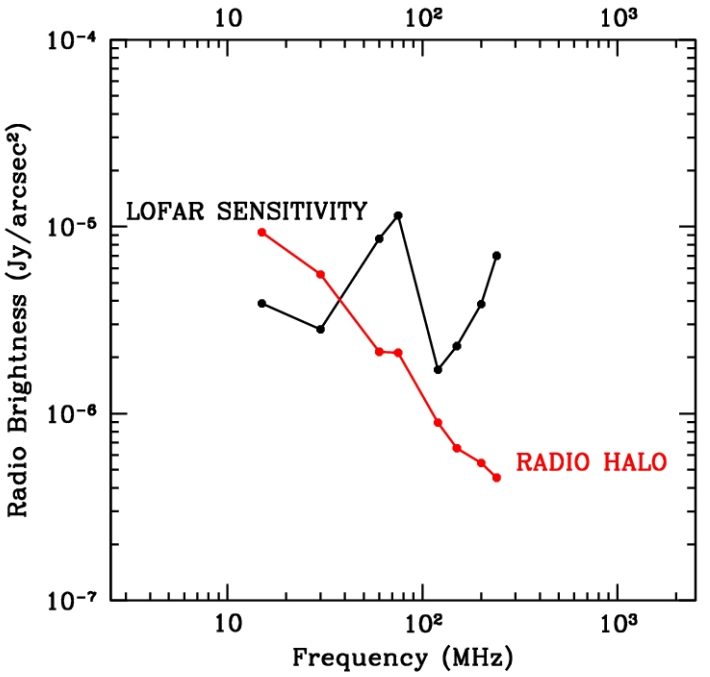
RADIO HALOS WITH LOFAR



Frequency=30 MHz

Beam=25″

Sensitivity=2 mJy/beam



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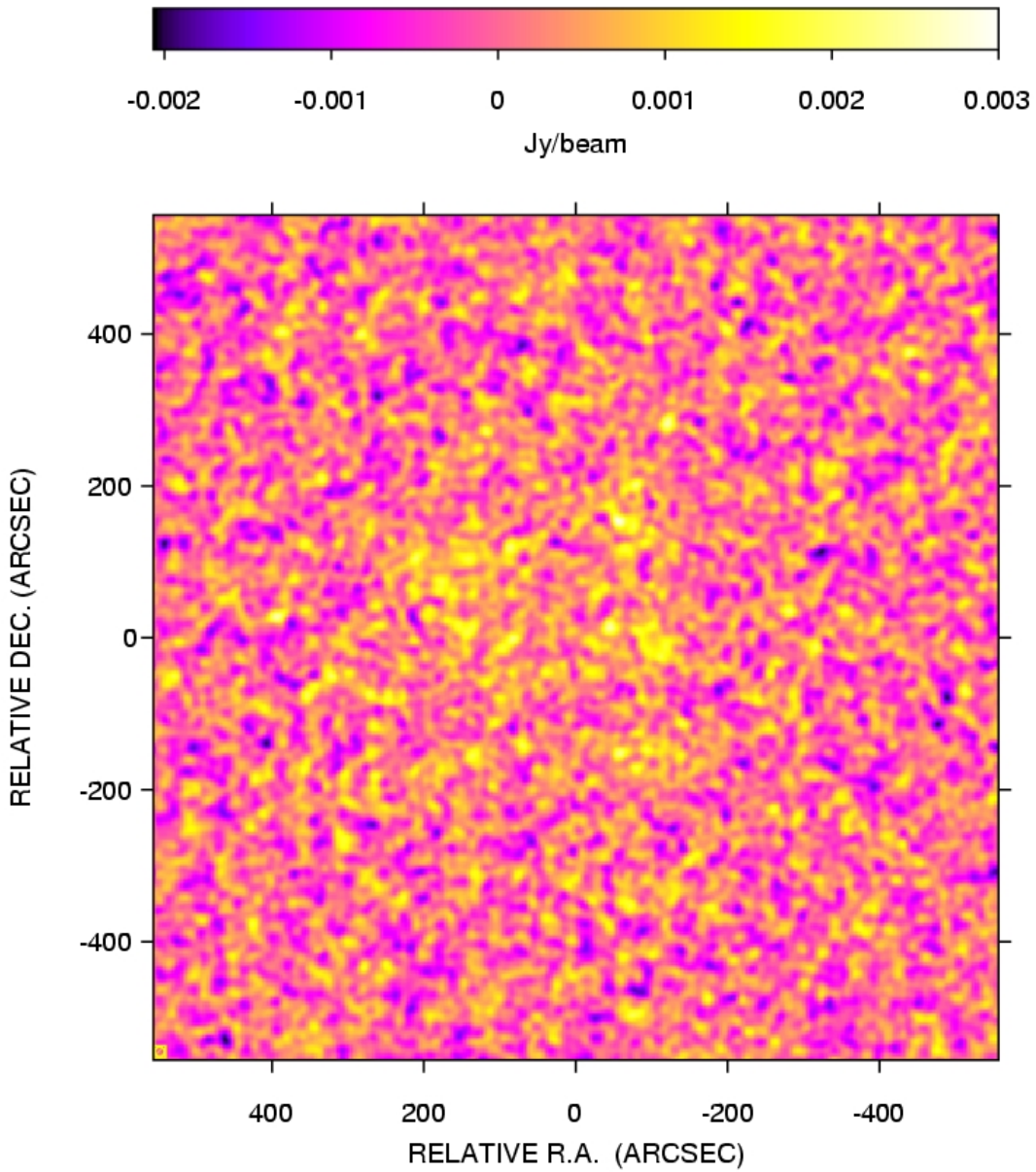
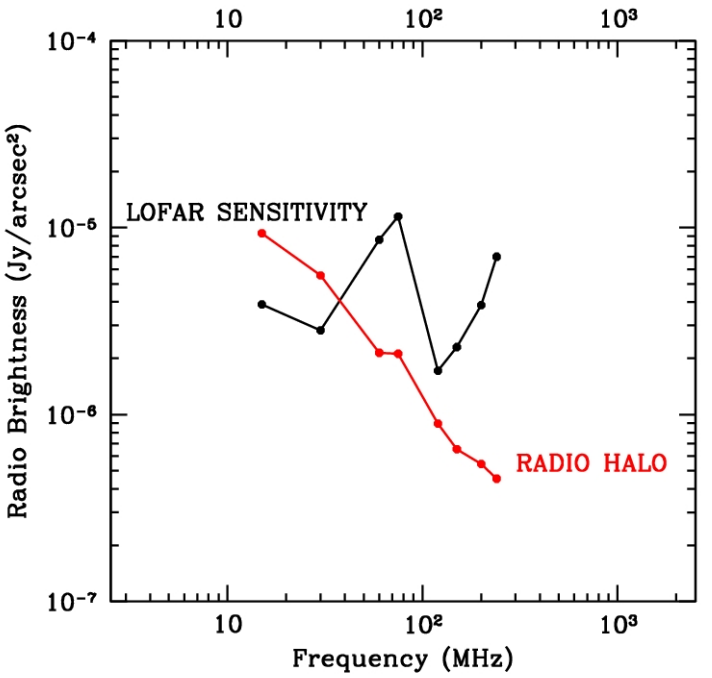


Frequency=60 MHz

Beam=13″

Sensitivity=1.65 mJy/beam



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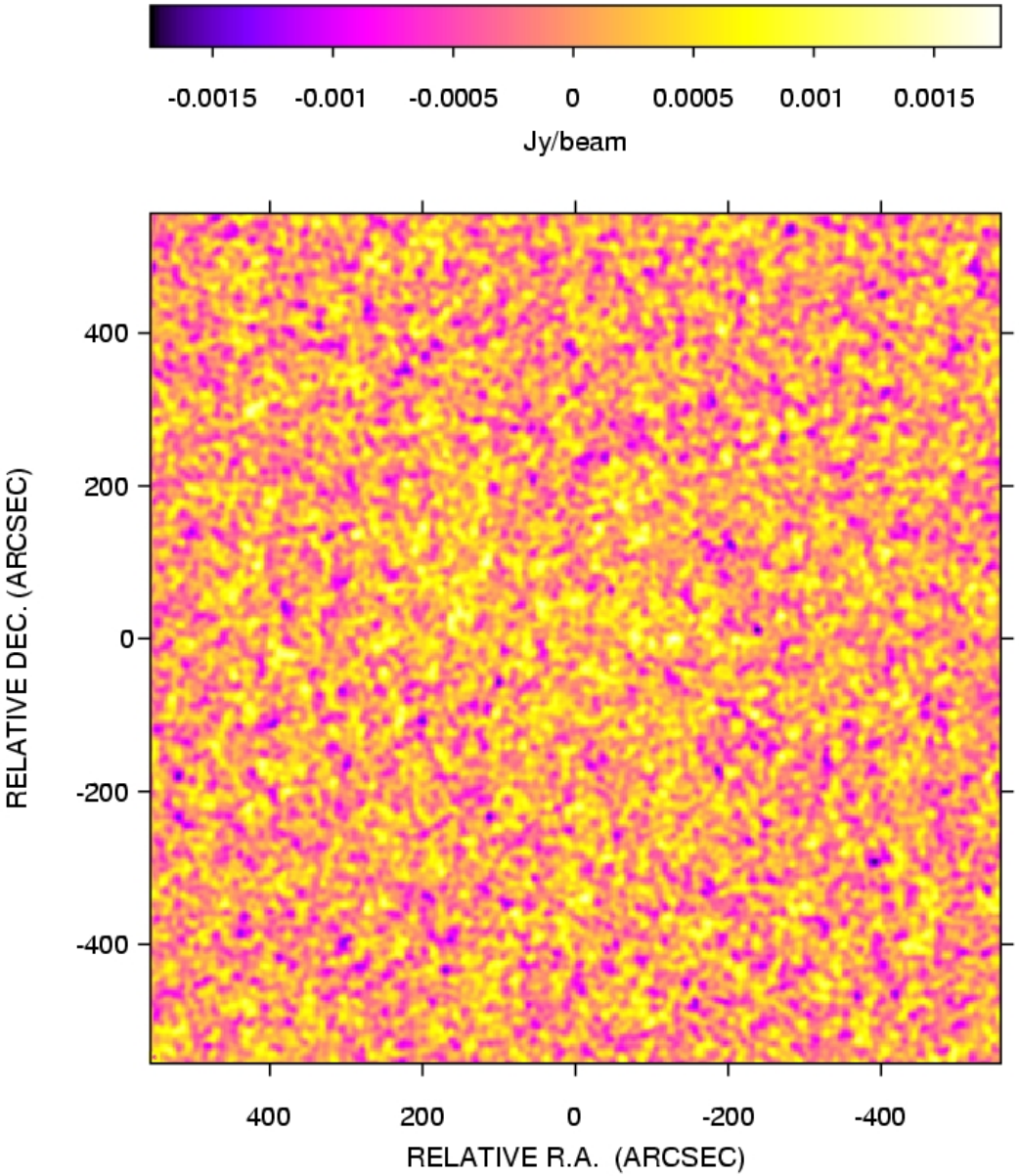
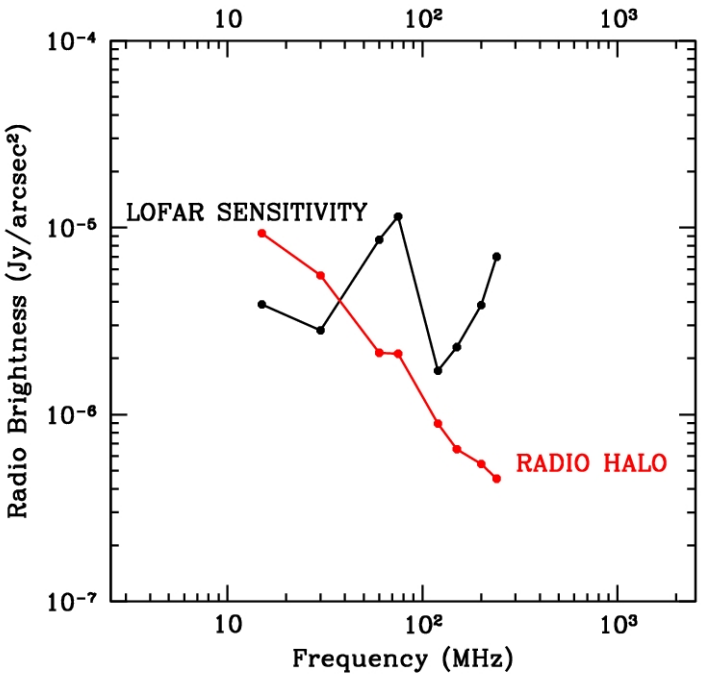
RADIO HALOS WITH LOFAR



Frequency=75 MHz

Beam=10″

Sensitivity=1.30 mJy/beam



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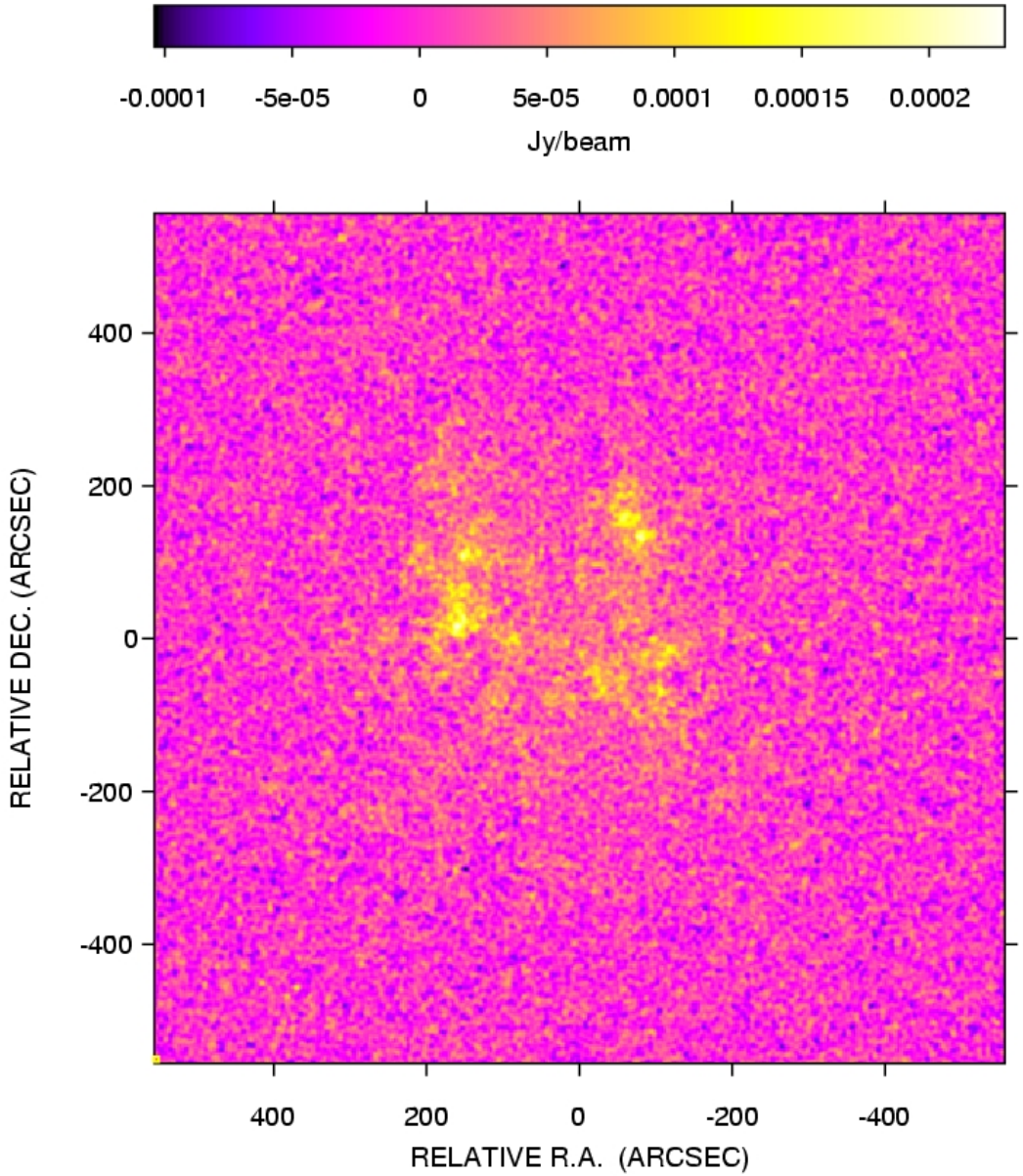
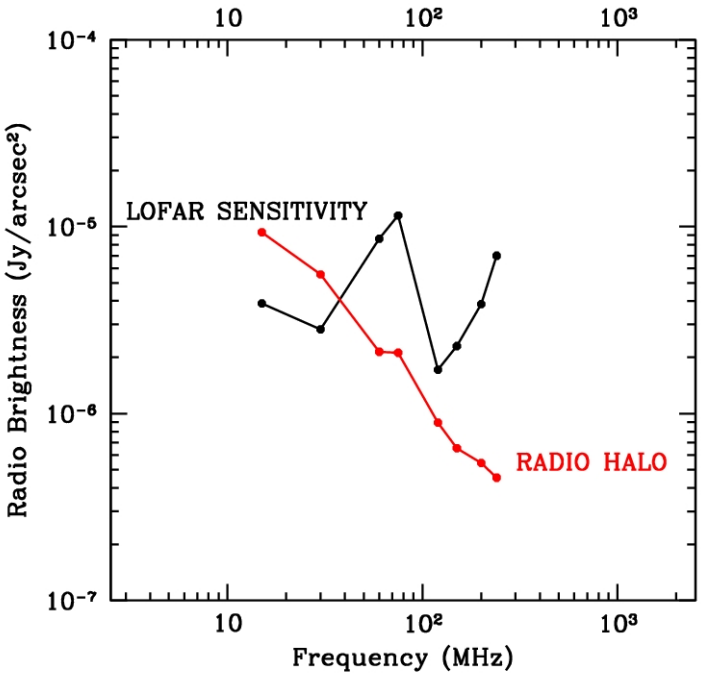
RADIO HALOS WITH LOFAR



Frequency=120 MHz

Beam=6″

Sensitivity=0.070 mJy/beam



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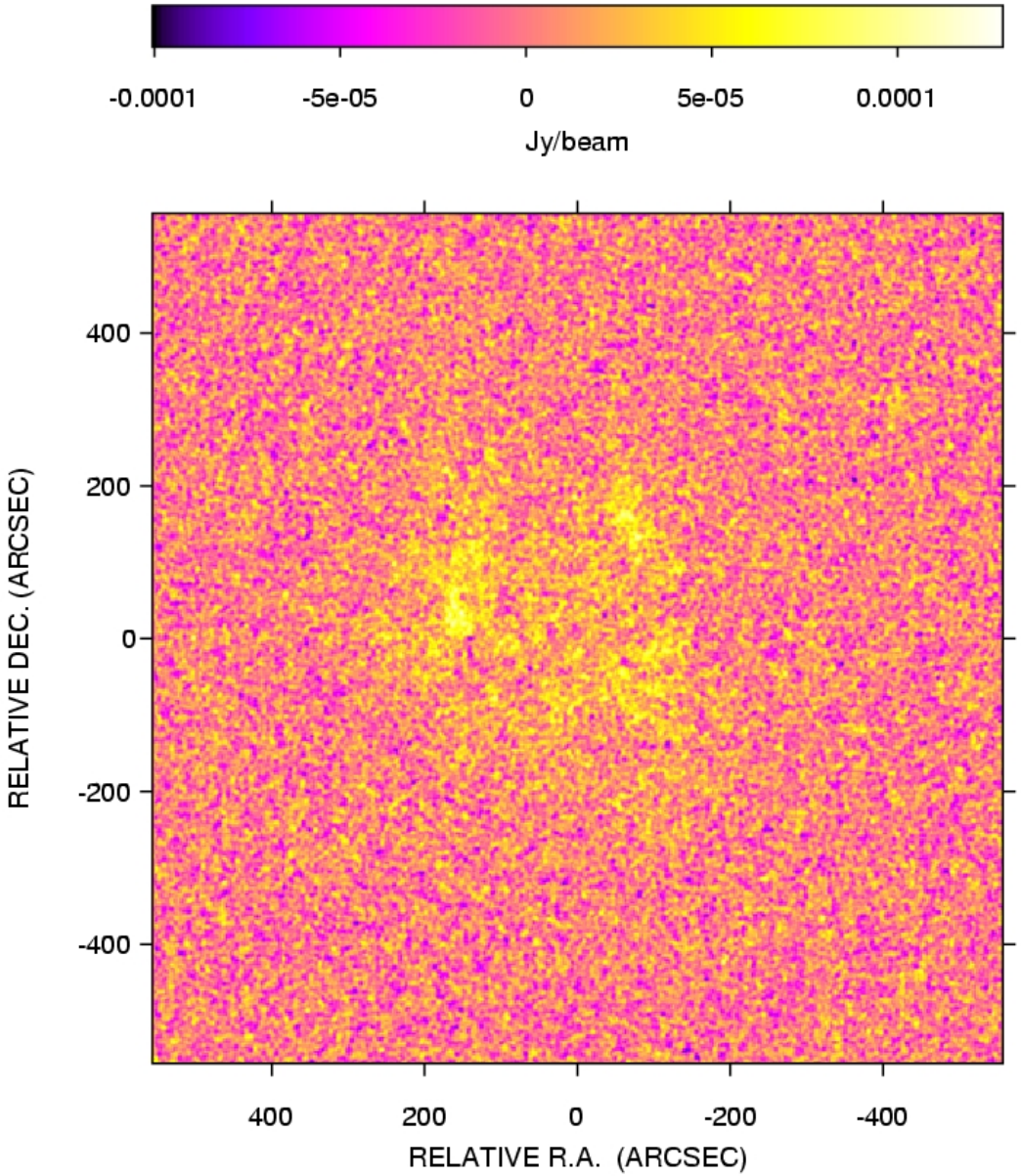
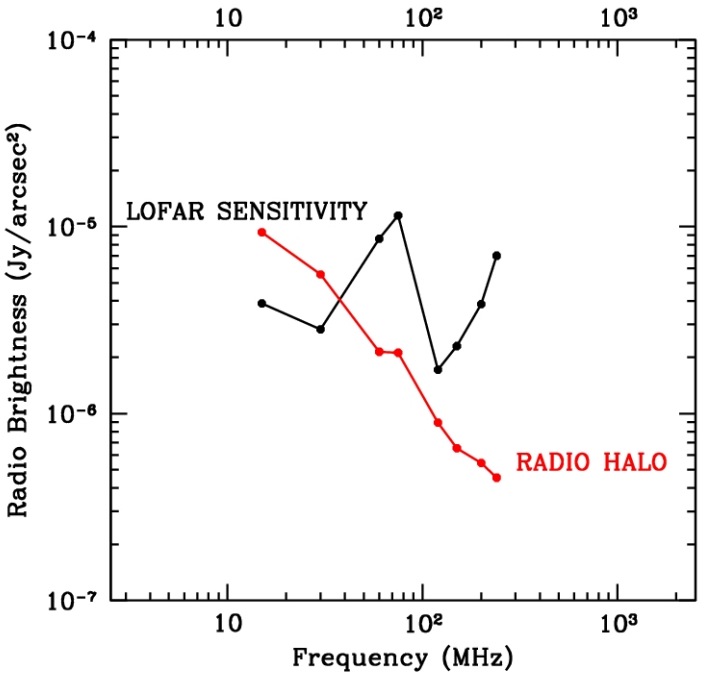


Frequency=150 MHz

Beam=5″

Sensitivity=0.065 mJy/beam



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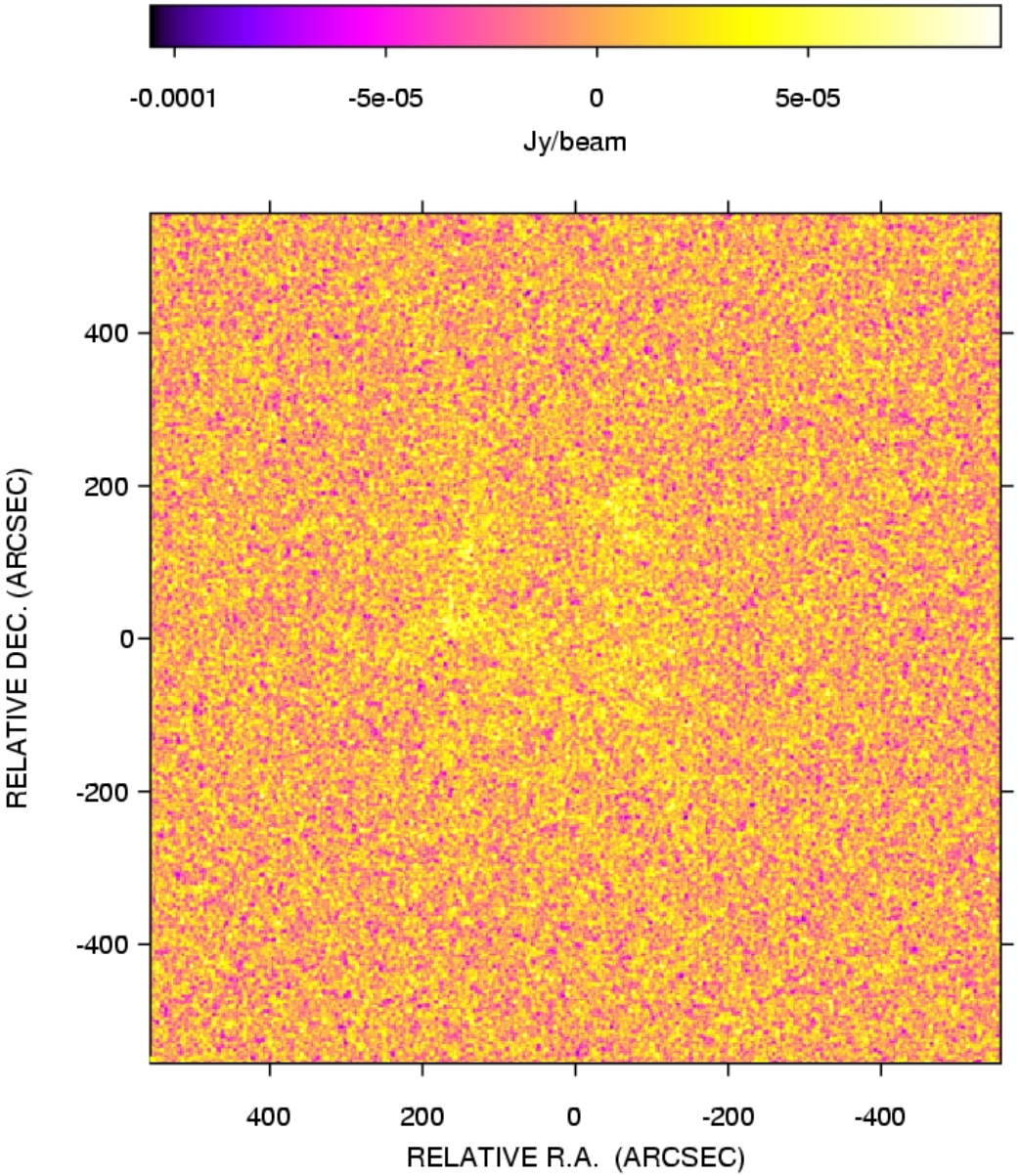
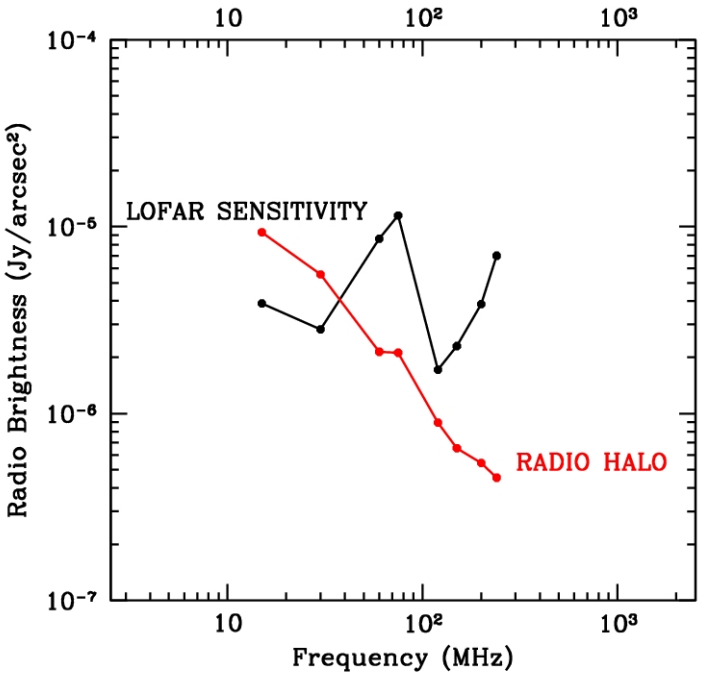


Frequency=200 MHz

Beam=3.8″

Sensitivity=0.063 mJy/beam



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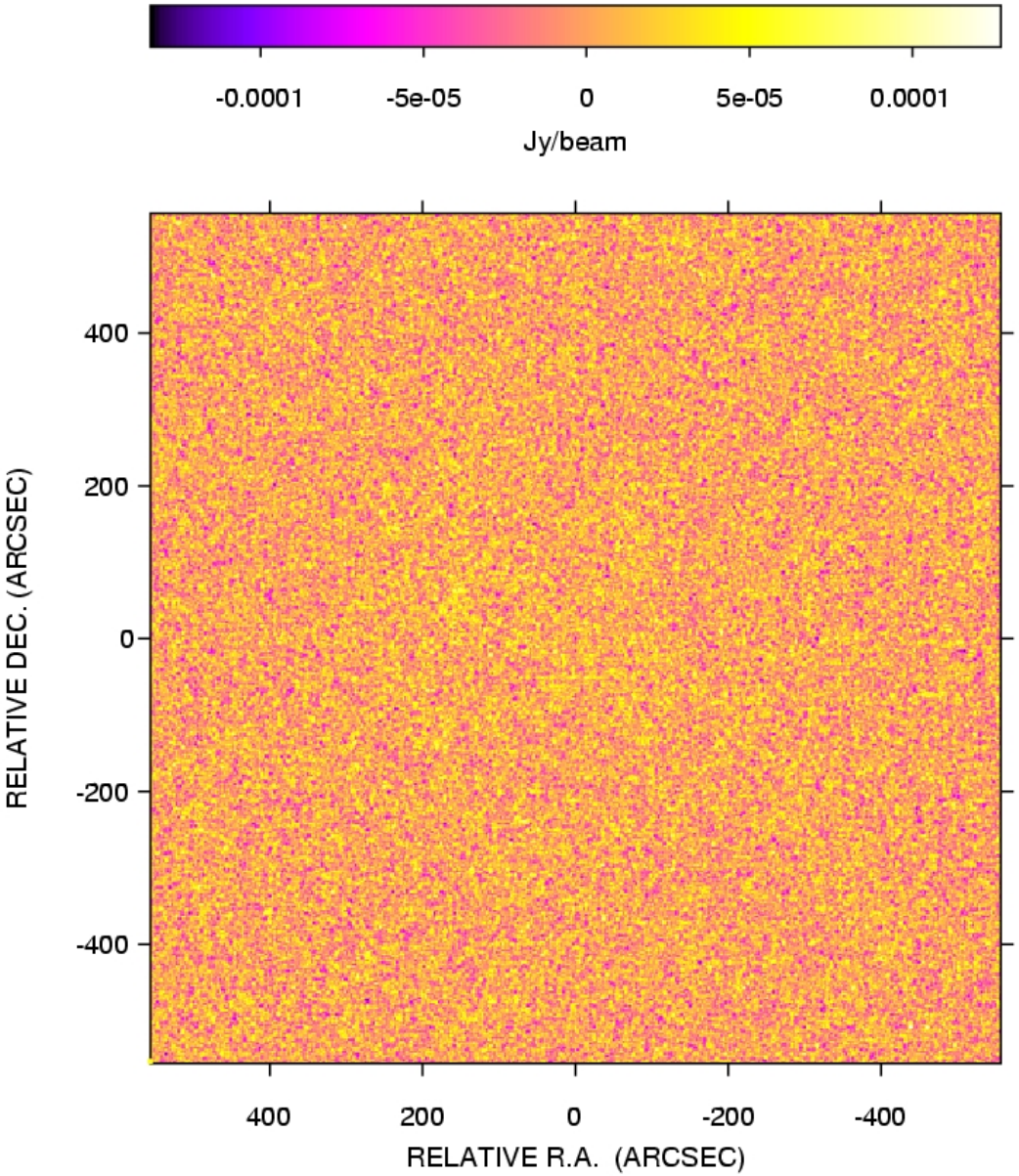
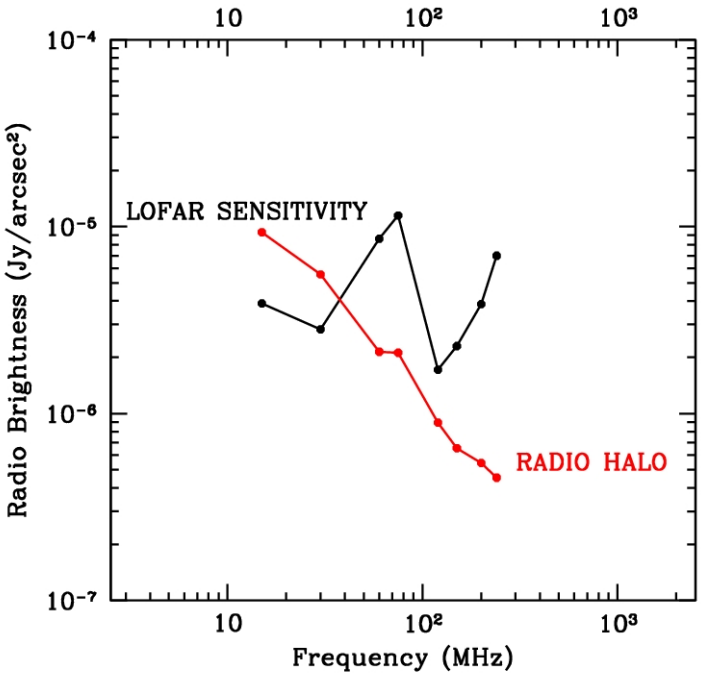


Frequency=240 MHz

Beam=3.1″

Sensitivity=0.076 mJy/beam



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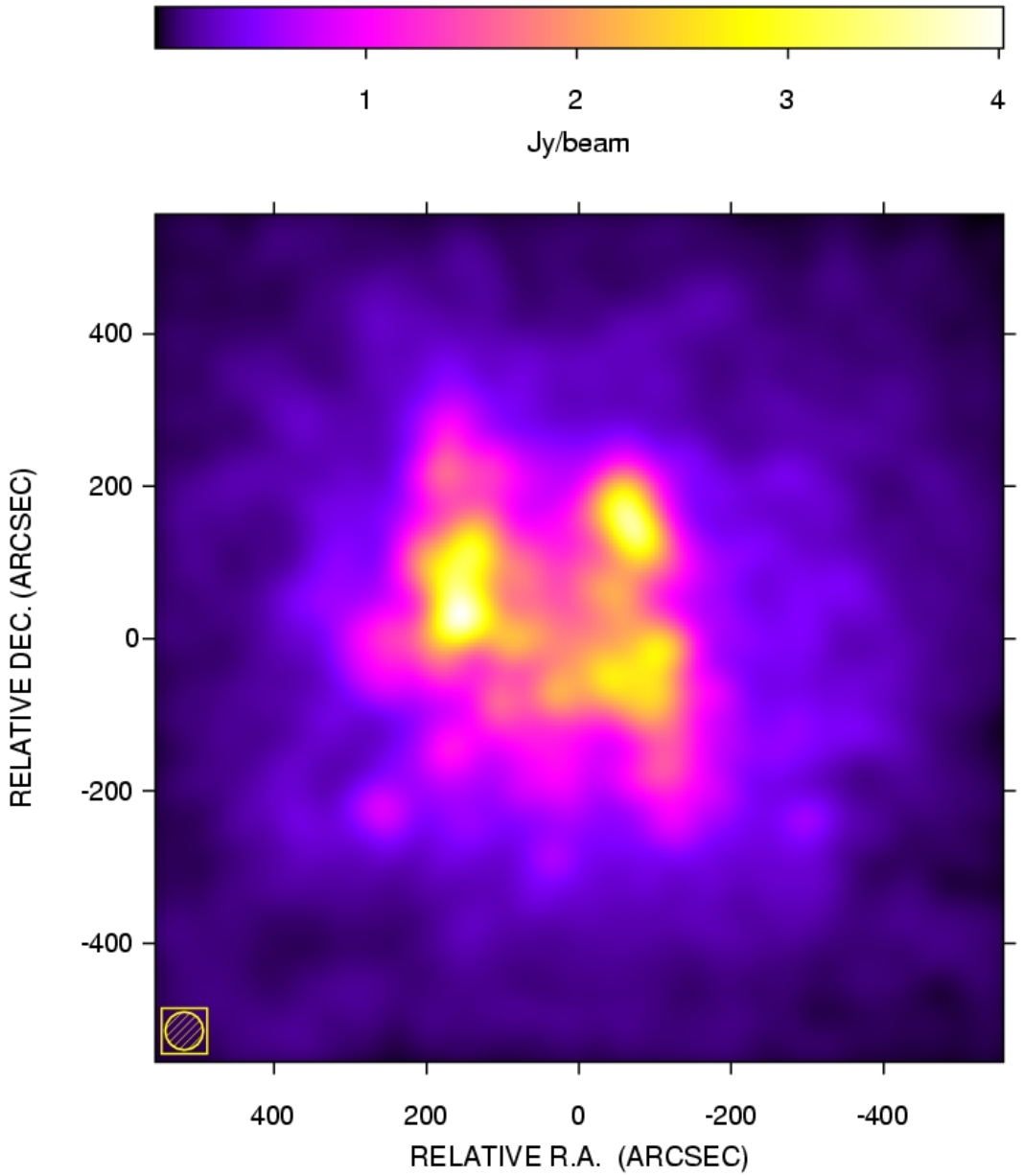

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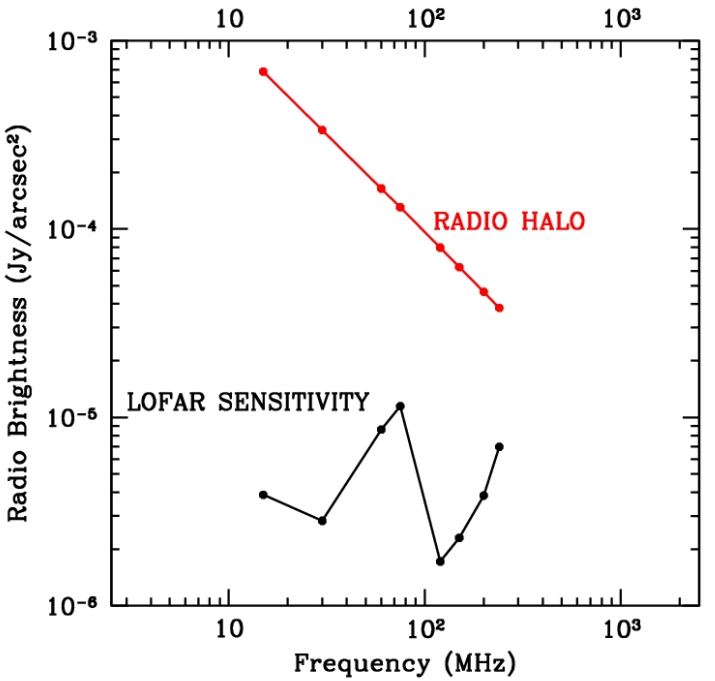
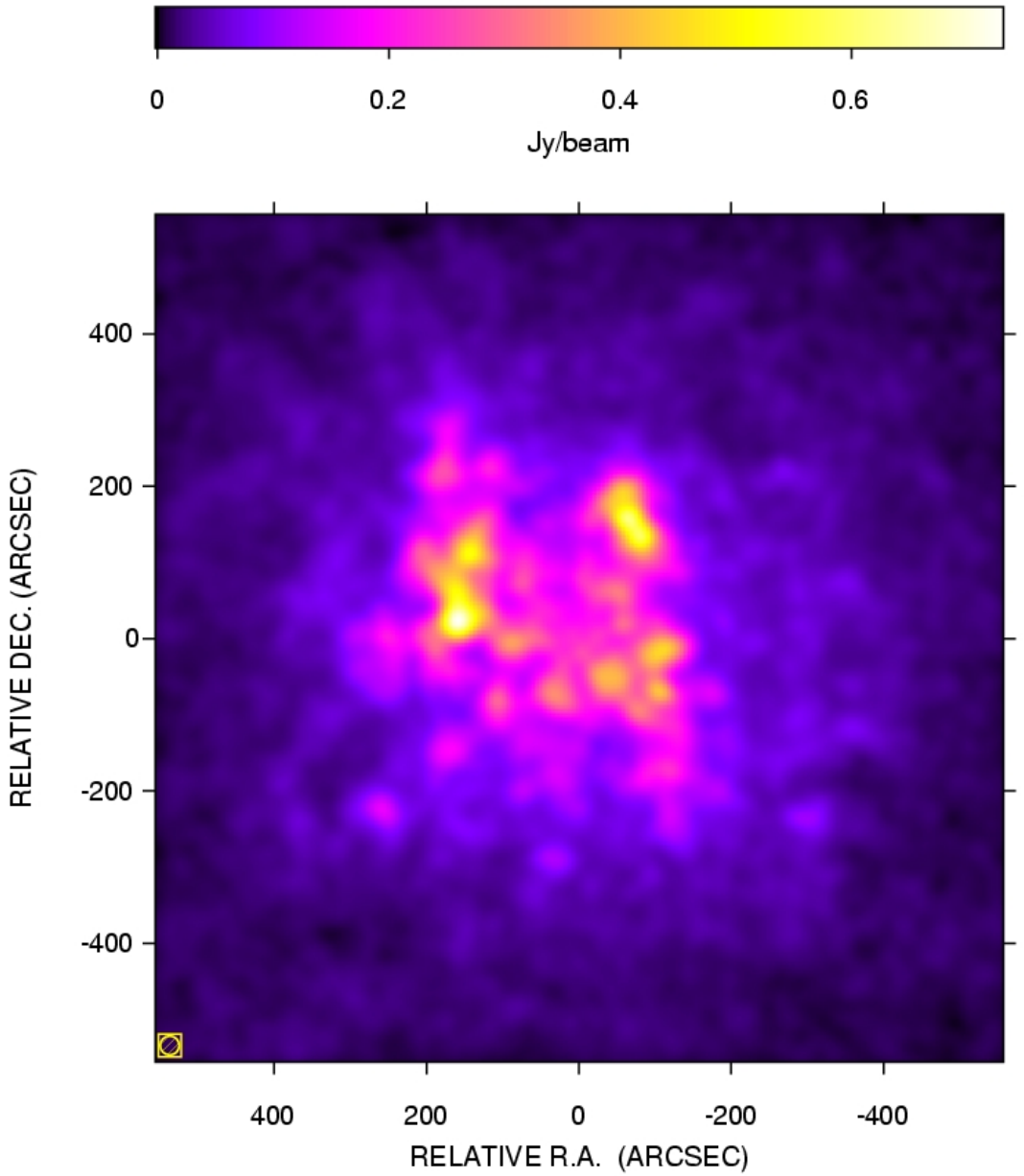


$B_0 = 3\mu G$ $\quad$ $n = 3$

RADIO HALOS WITH LOFAR



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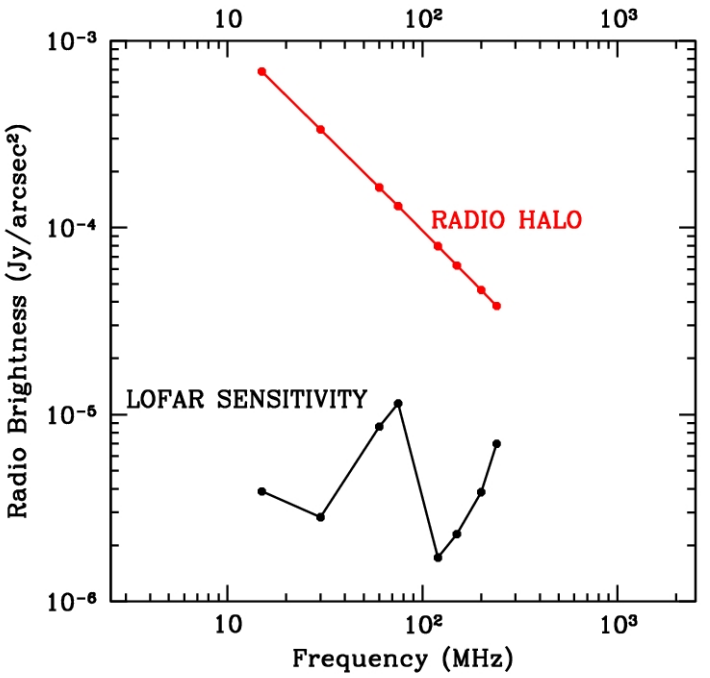

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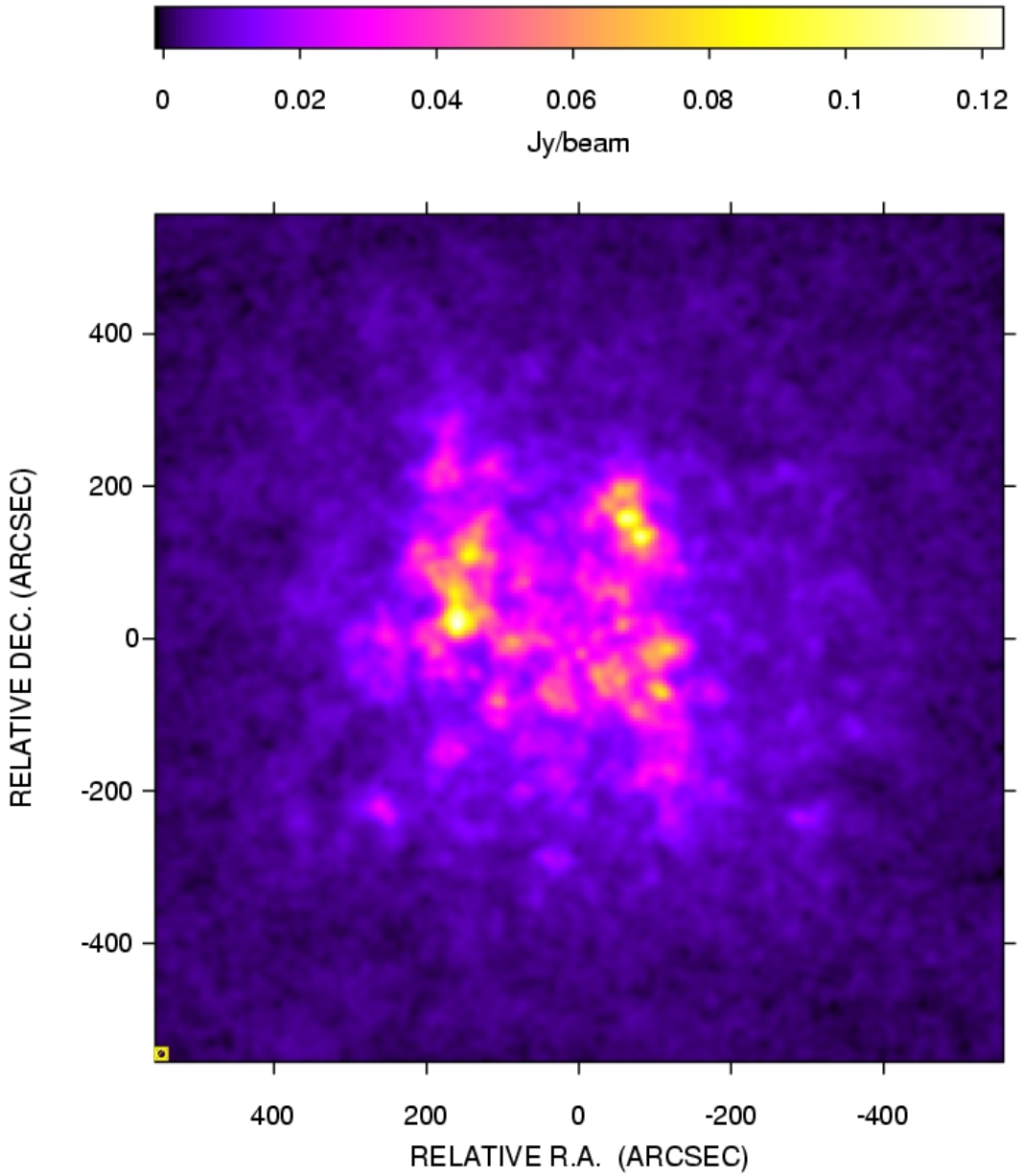

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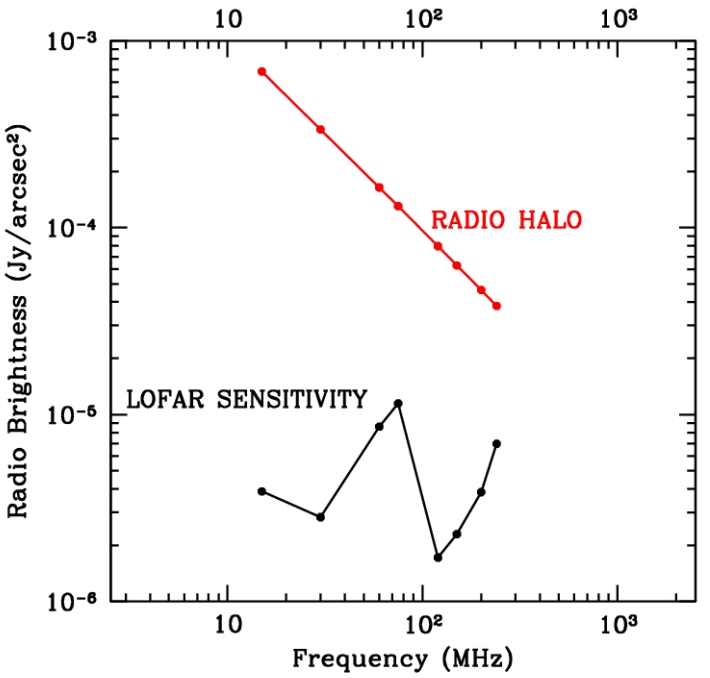

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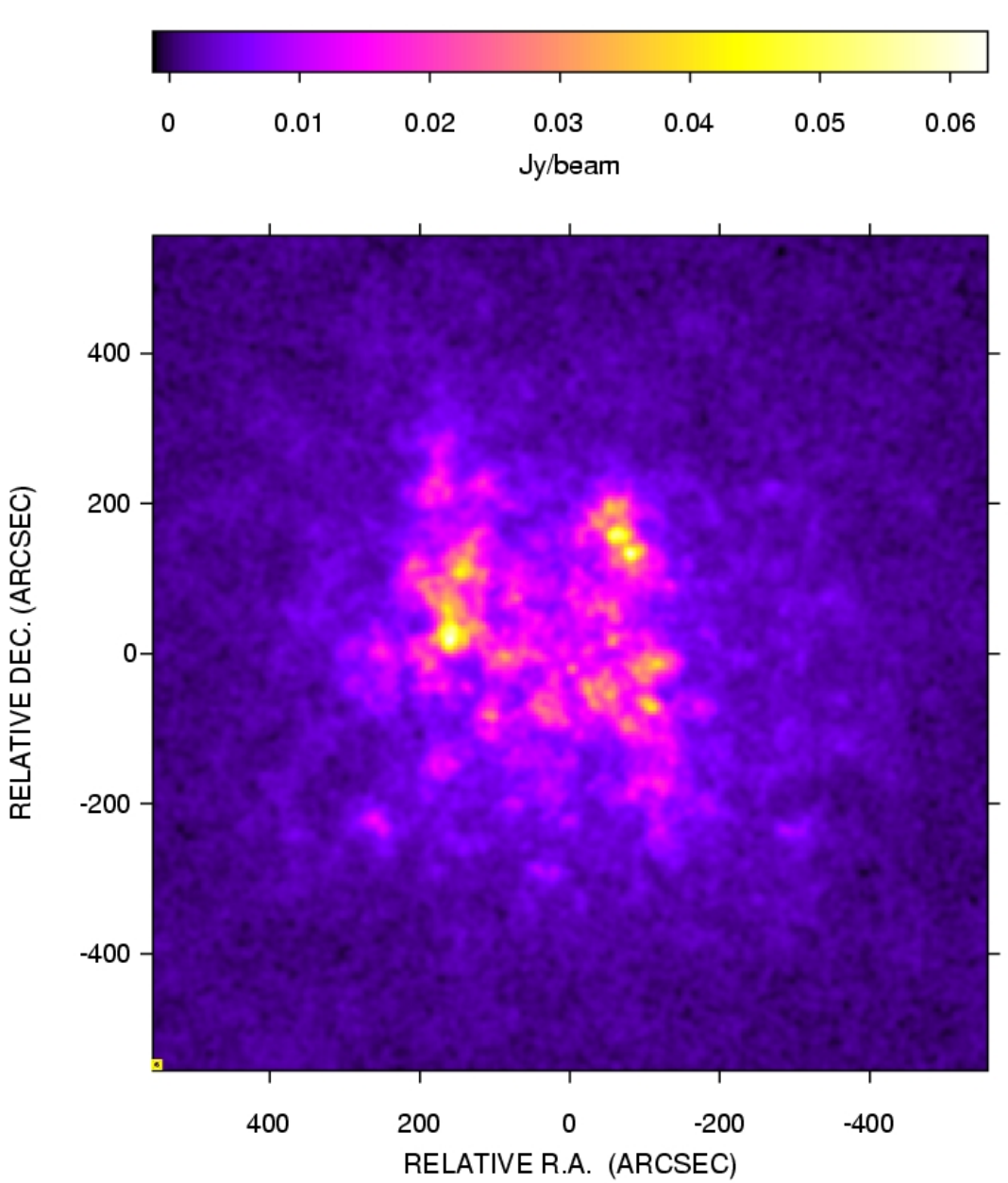

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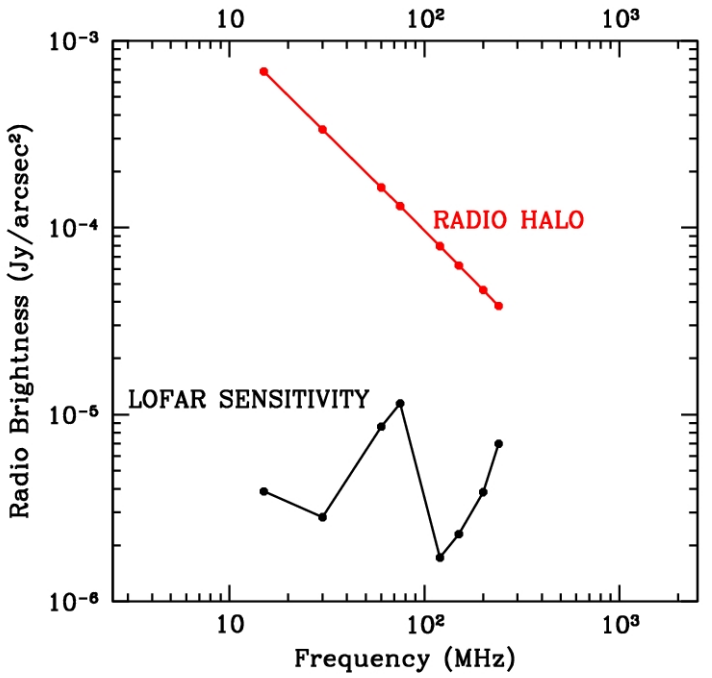

$B_0 = 3\mu G$ $n = 3$

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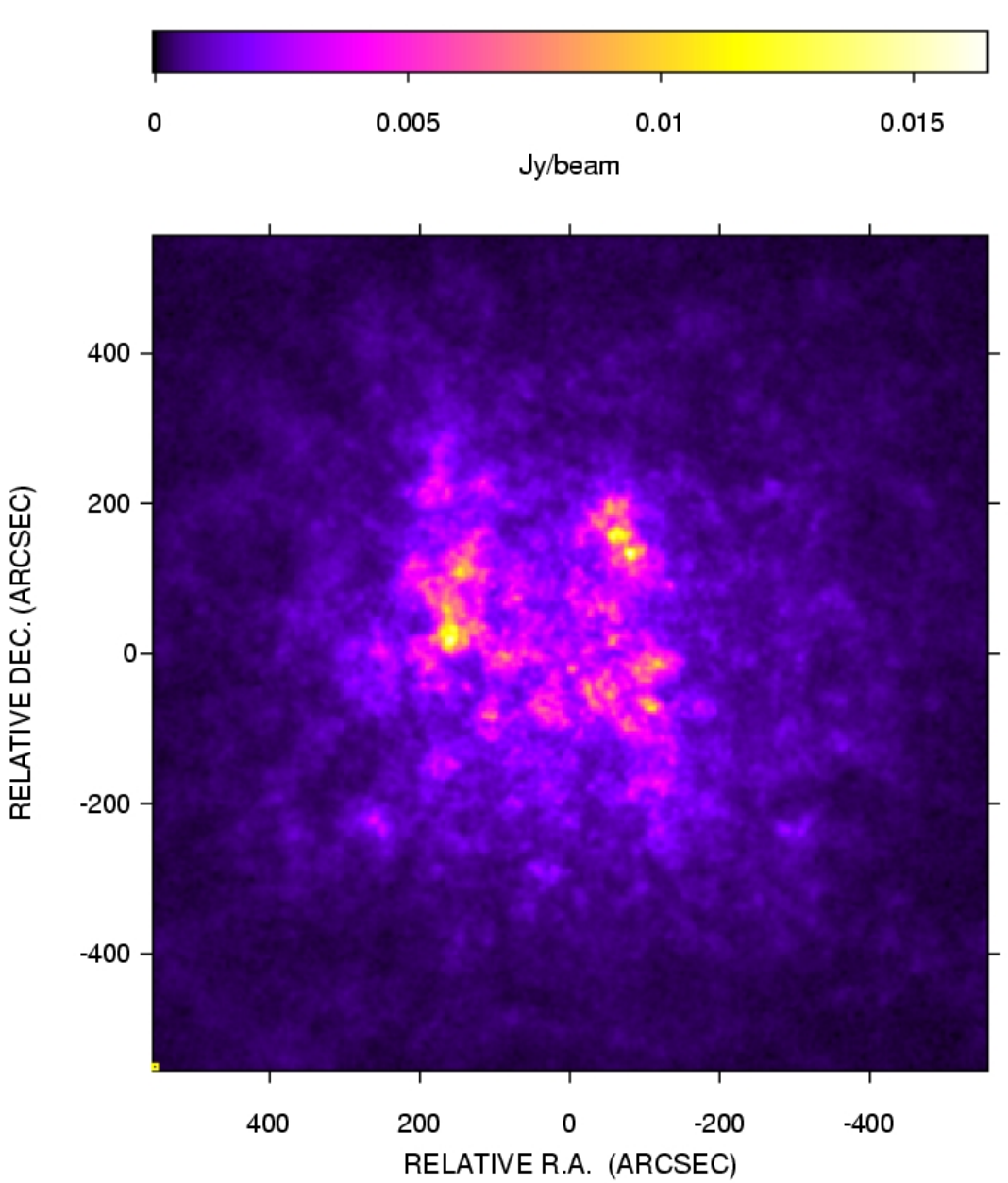

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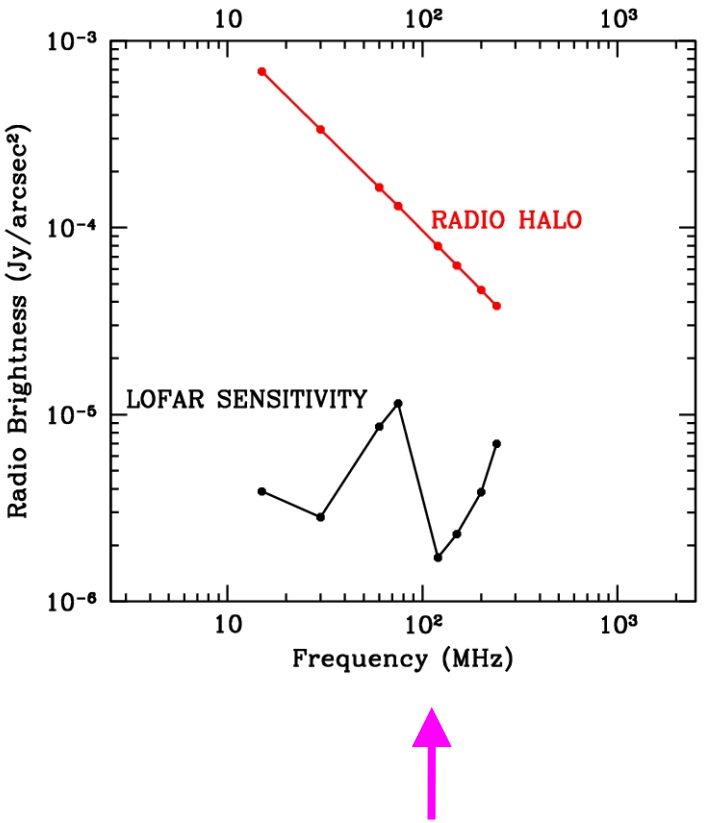

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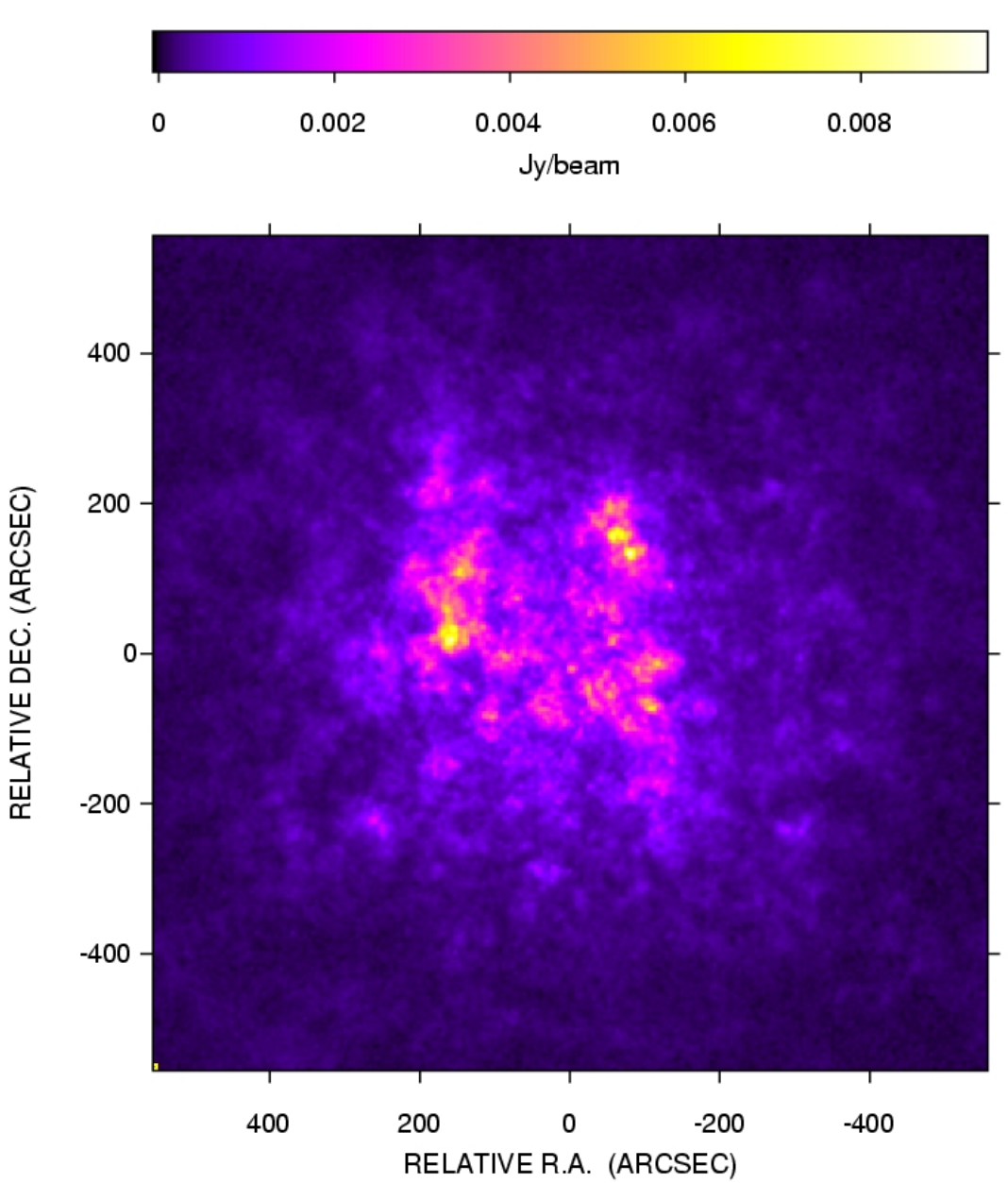

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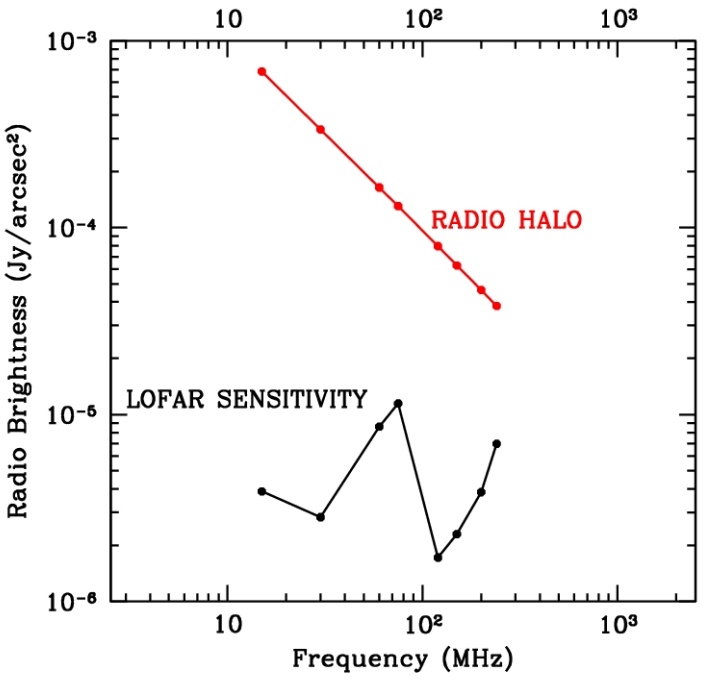
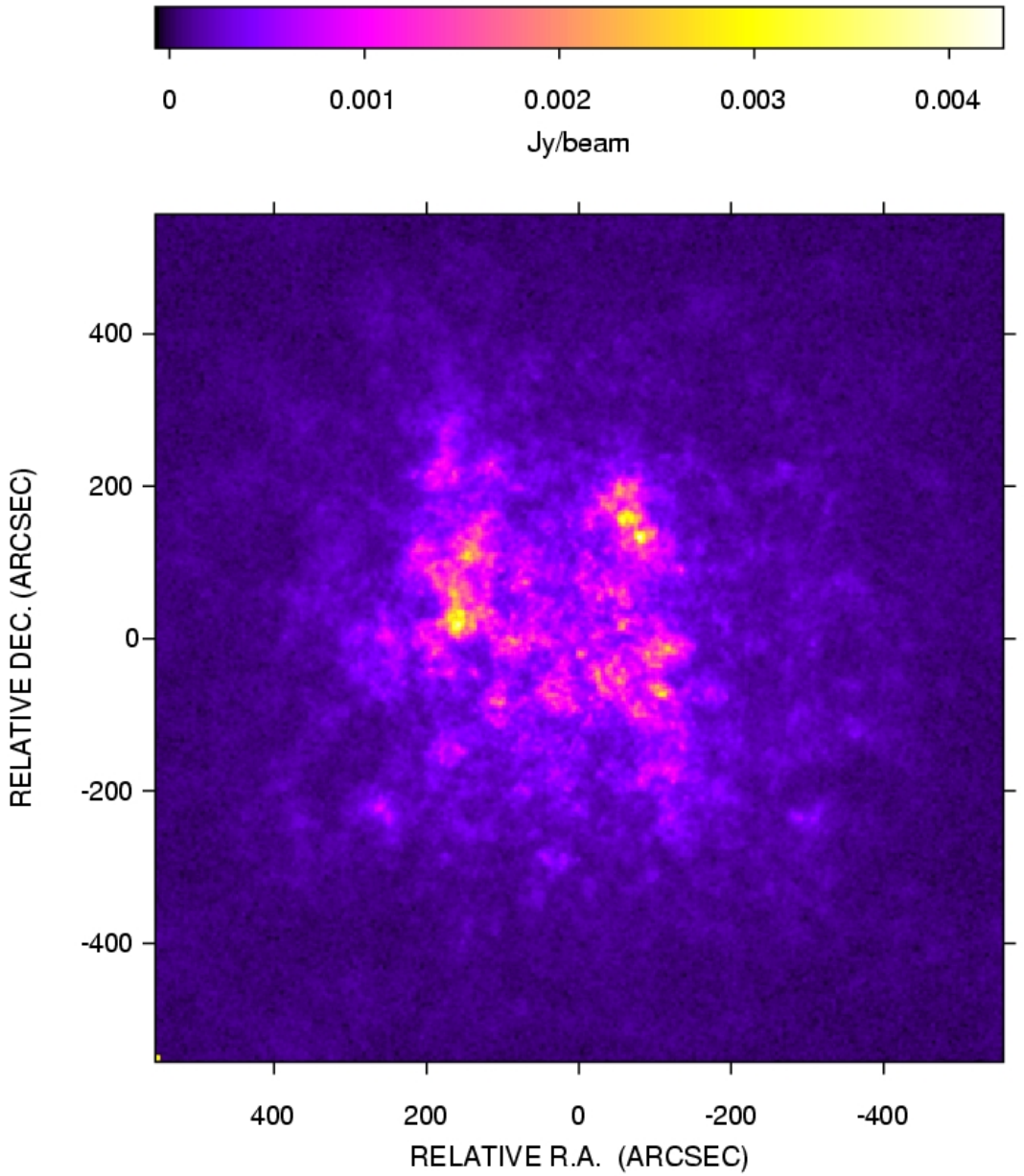


$B_0 = 3\mu G$ $n = 3$

RADIO HALOS WITH LOFAR



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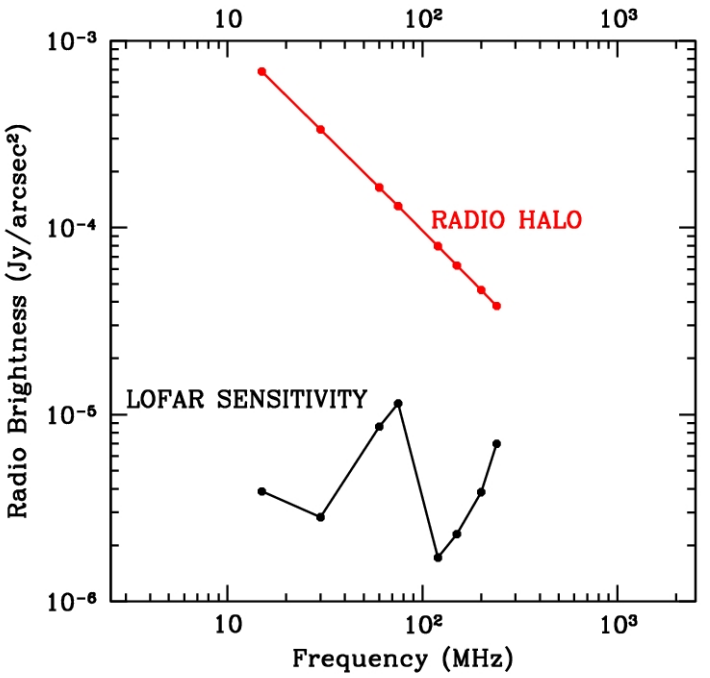

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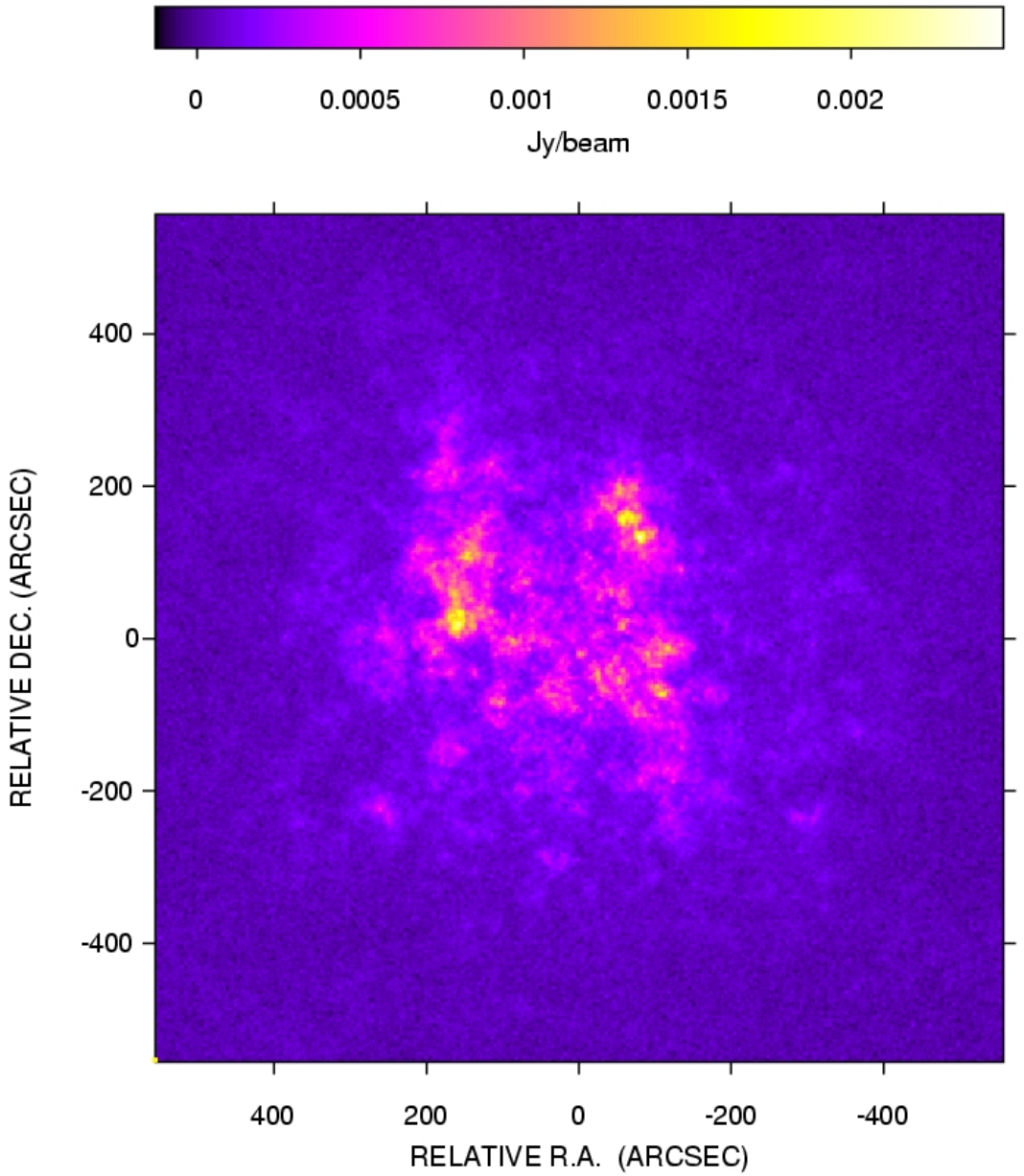
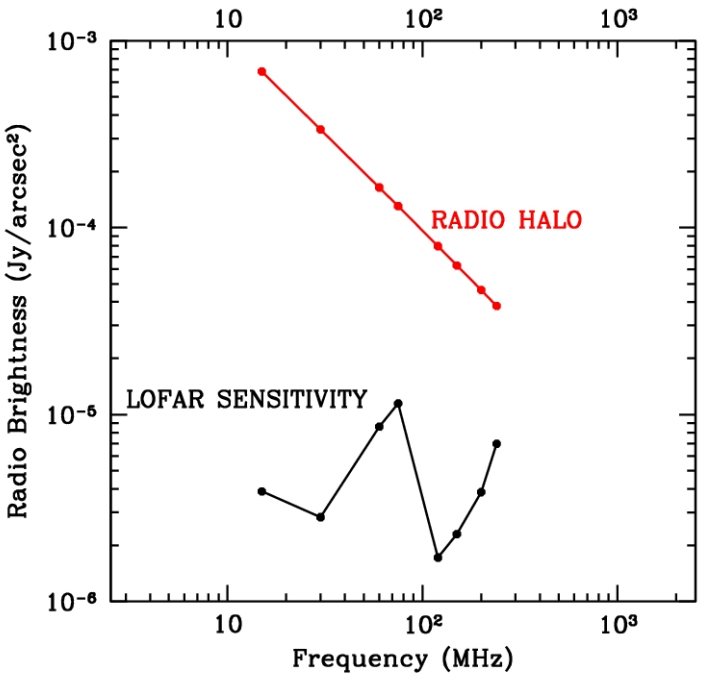


Frequency=240 MHz

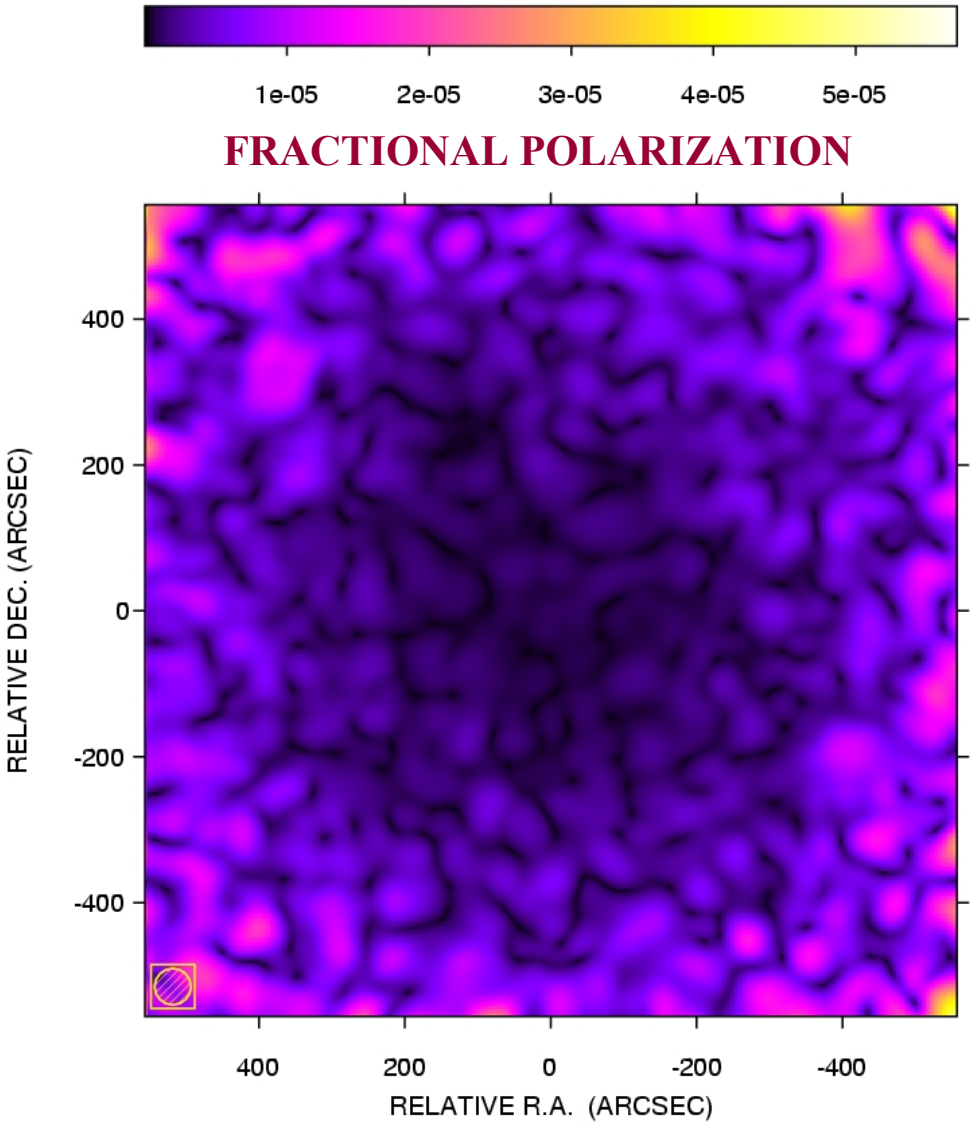
Beam=3.1″

Sensitivity=0.076 mJy/beam



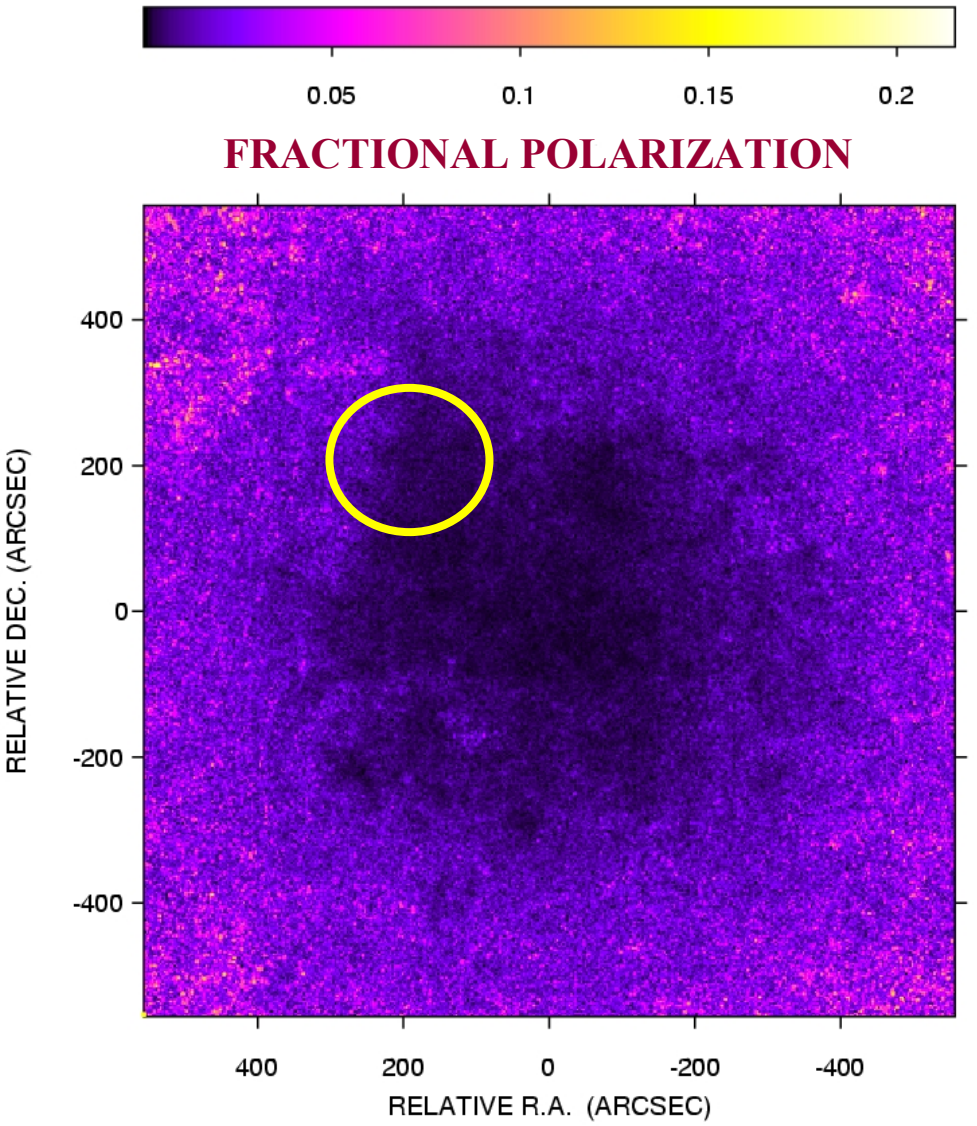
$B_0 = 3\mu G$ $n = 3$

POLARIZATION OF RADIO HALOS



Frequency=15 MHz

Beam=50″



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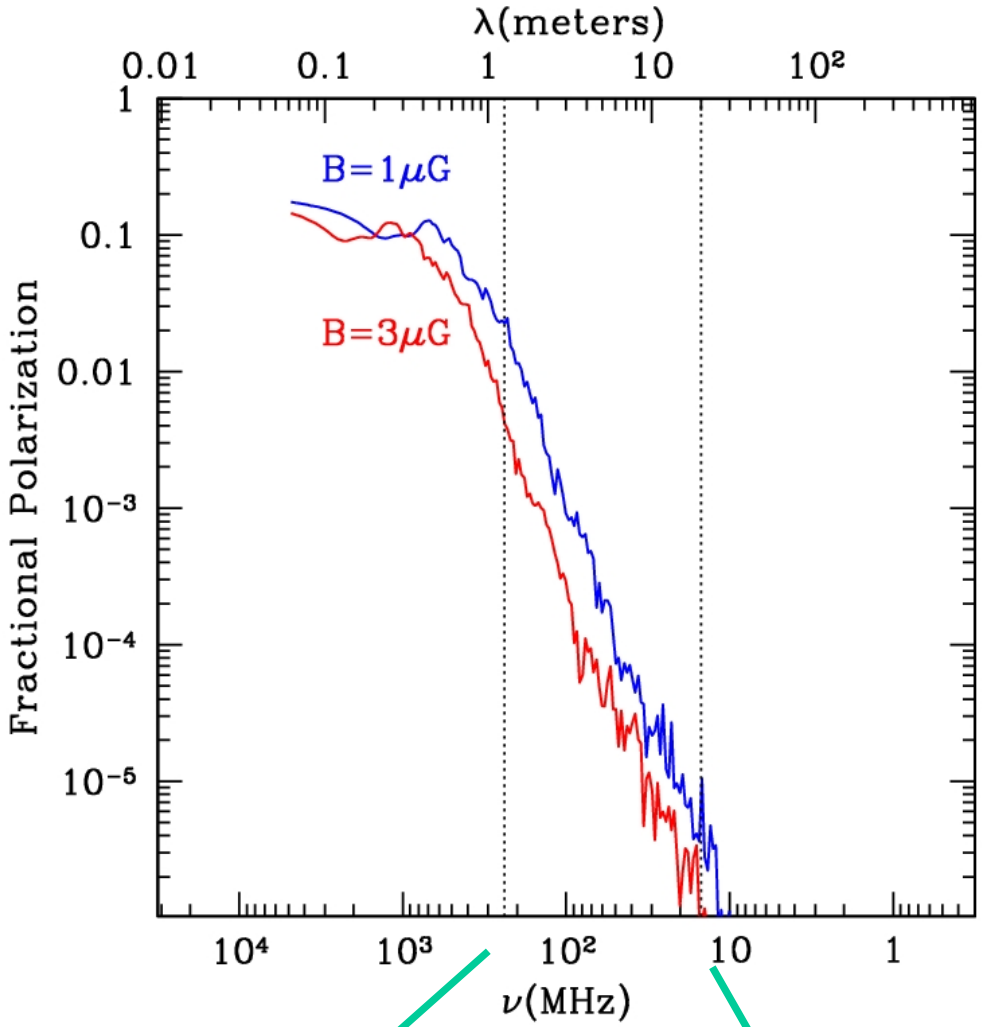
Beam=3.1″

POLARIZATION OF RADIO HALOS



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Beam=3.1″

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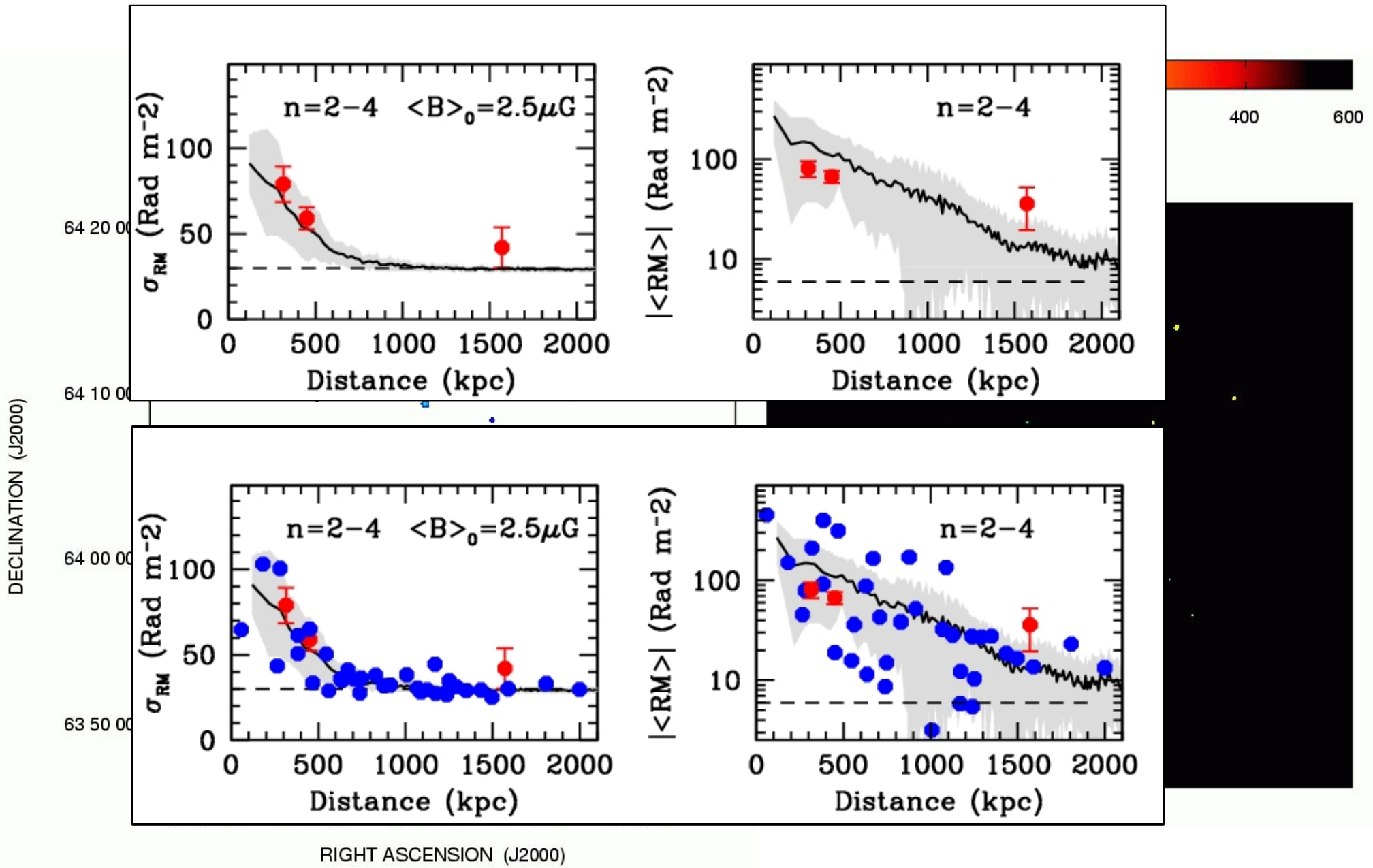
Beam=50″

ROTATION MEASURE OF RADIO GALAXIES



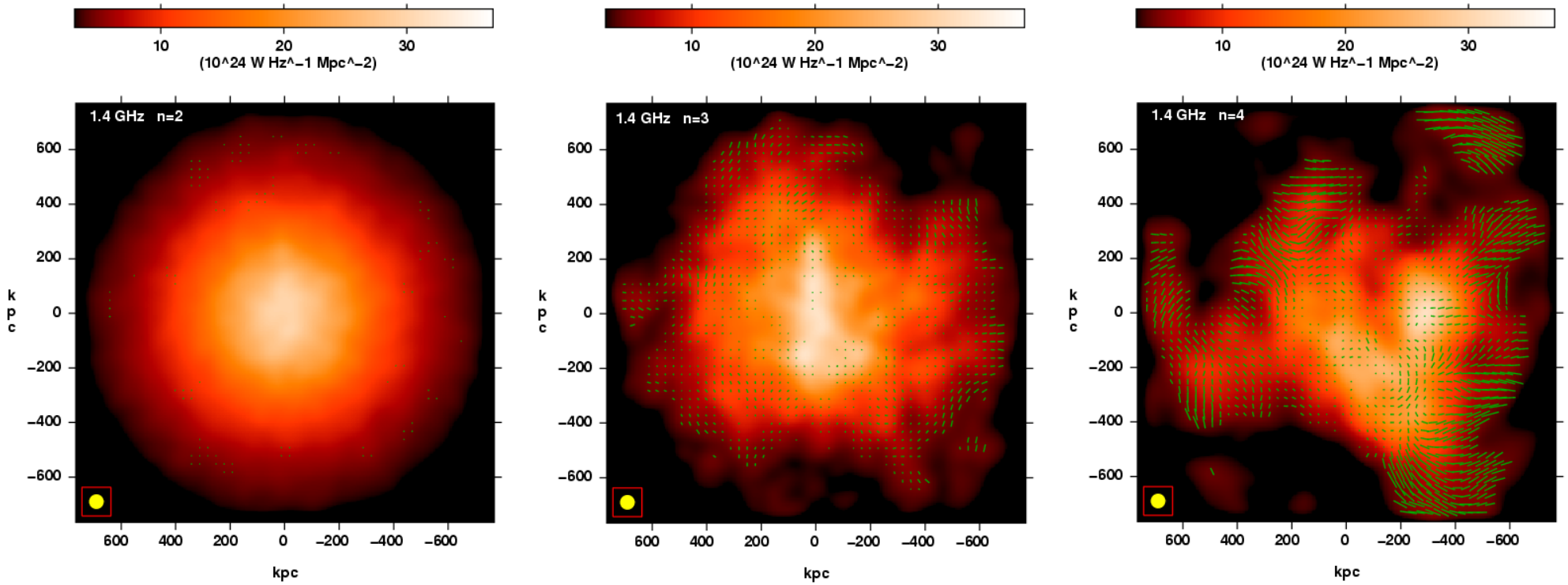
Conclusions

Radio Halos expectations with LOFAR:

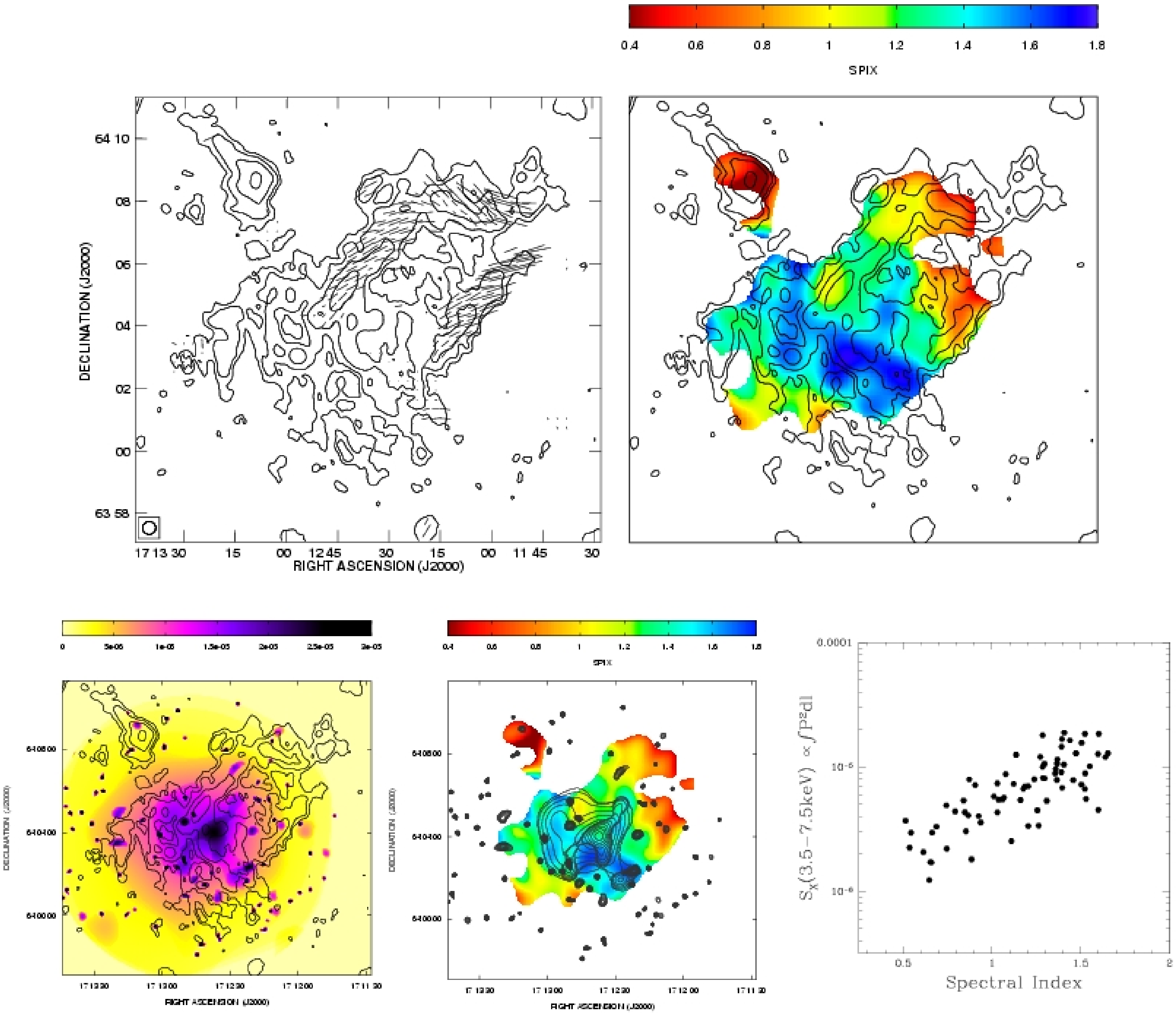
- **LOFAR will be an extraordinary instrument to study the morphology of bright radio halos at very low frequencies;**
- **Thanks to its arcsecond-resolution there could be a chance to detect polarized emission at levels of few % at least at 240 MHz.**

RM expectations of radio galaxies with LOFAR:

- **LOFAR will produce detailed RM images for hundred of radio sources into (or in background to) a cluster of galaxies. This will permit to determine the power spectrum of the magnetic field fluctuations for a large number of clusters of galaxies.**



Murgia et al. 2004



0.4 0.6 0.8 1 1.2 1.4 1.6 1.8
SPIX
DECLINATION (J2000)
64 10
08
06
04
02
00
63 58
17 13 30 15 00 12 45 30 15 00 11 45 30
RIGHT ASCENSION (J2000)
0.0001
S_X(3.5−7.5keV) ∝ ∫P²dl
0.5 1 1.5 2
Spectral Index