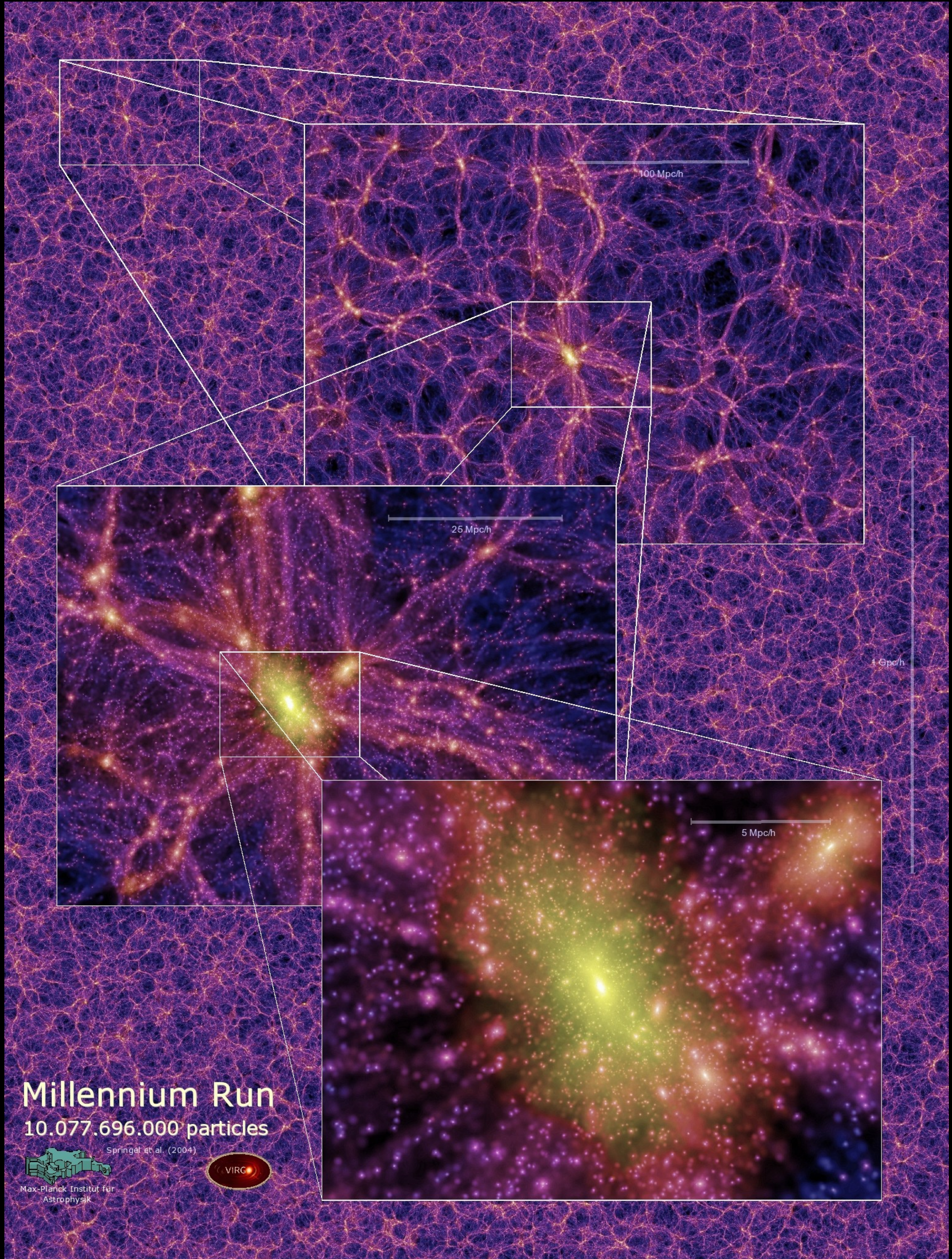
OBSERVATIONS OF A NEARBY FILAMENT OF GALAXY CLUSTER

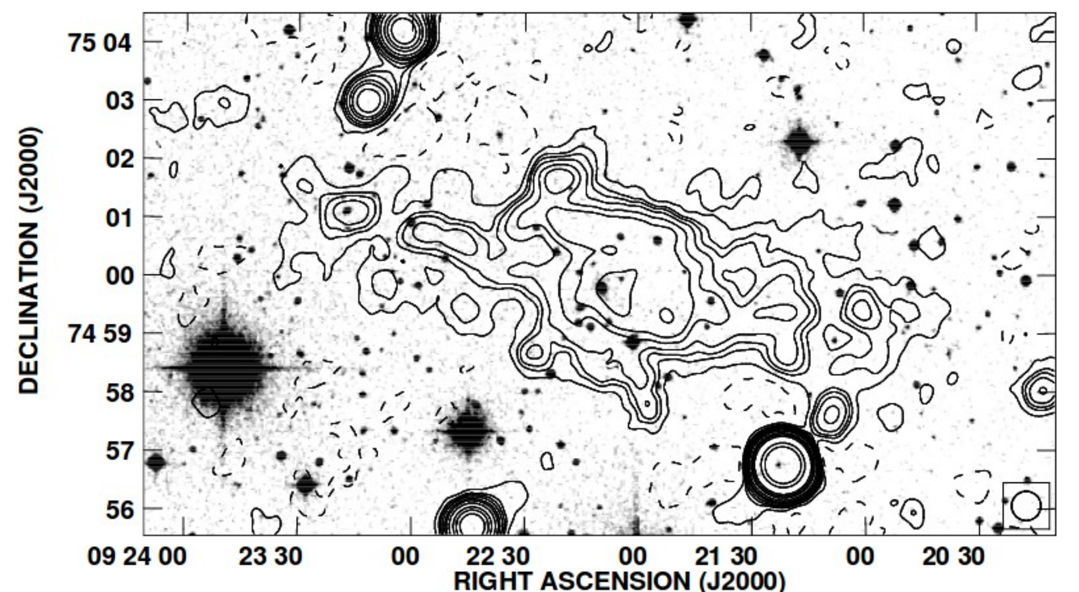
Valentina Vacca

In collaboration with: M. Murgia, F. Govoni, F. Loi, F. Vazza, A. Finoguenov, E. Carretti, L. Feretti, G. Giovannini, T. A. Enßlin, N. Oppermann, et al.

Introduction

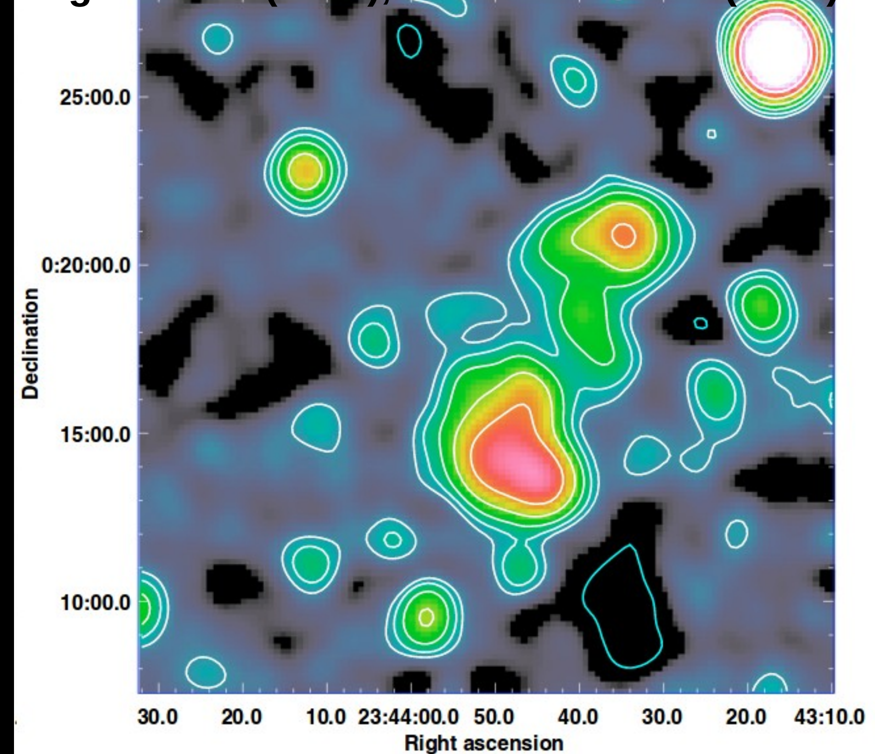


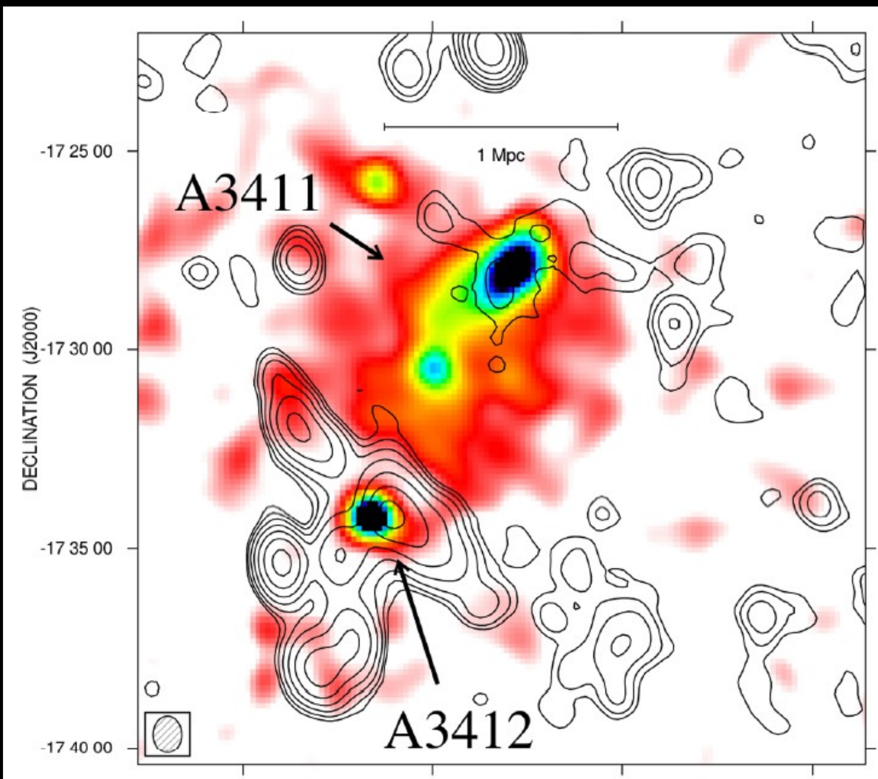
Introduction



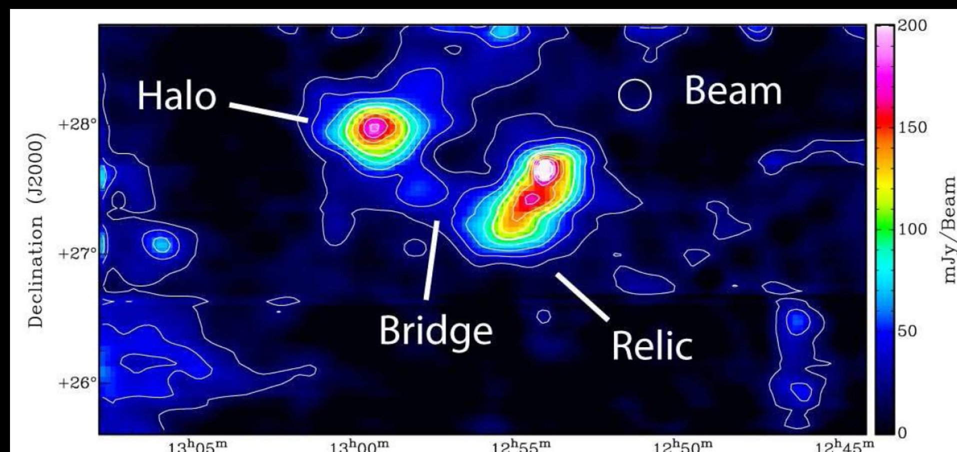
Dewdney et al. (1991), Giovannini & Feretti (2000)

Bagchi et al. (2002), Giovannini et al. (2010)





Giovannini et al. (2013)

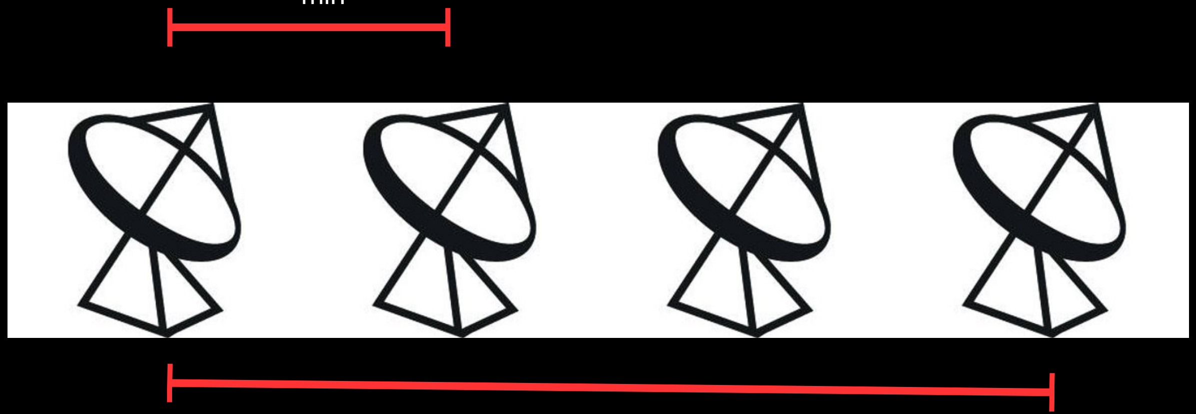


Rudnick et al. (2017)

Introduction

B_{min}

maximum angular scale (e.g., VLA 1.4 GHz, B_{min} = 35 m, $\theta_{max} \leq$ 10-15')



B_{max}

resolution (e.g., VLA 1.4 GHz, B_{max} = 1 km, $\theta_{min} \leq$ 1')

SKA, B_{min} = 20 m, 1.4 GHz, $\theta_{max} \leq$ 20-30'

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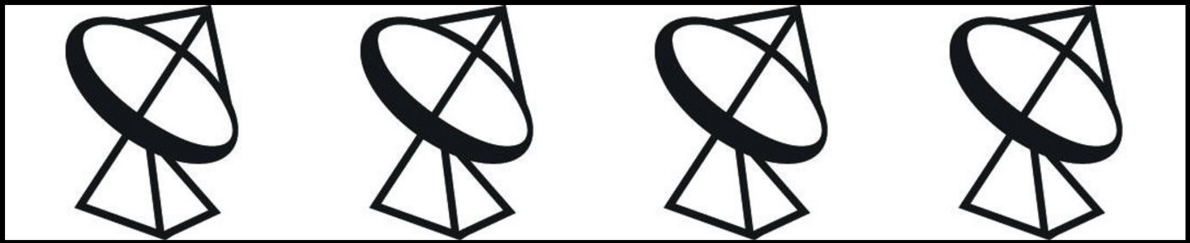

B_{max} resolution (e.g., VLA 1.4 GHz, B_{max} = 1 km, $\theta_{min} \leq$ 1')

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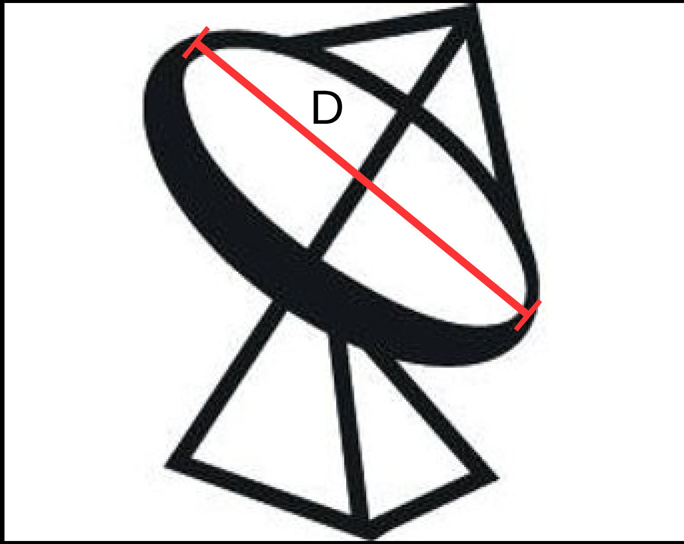


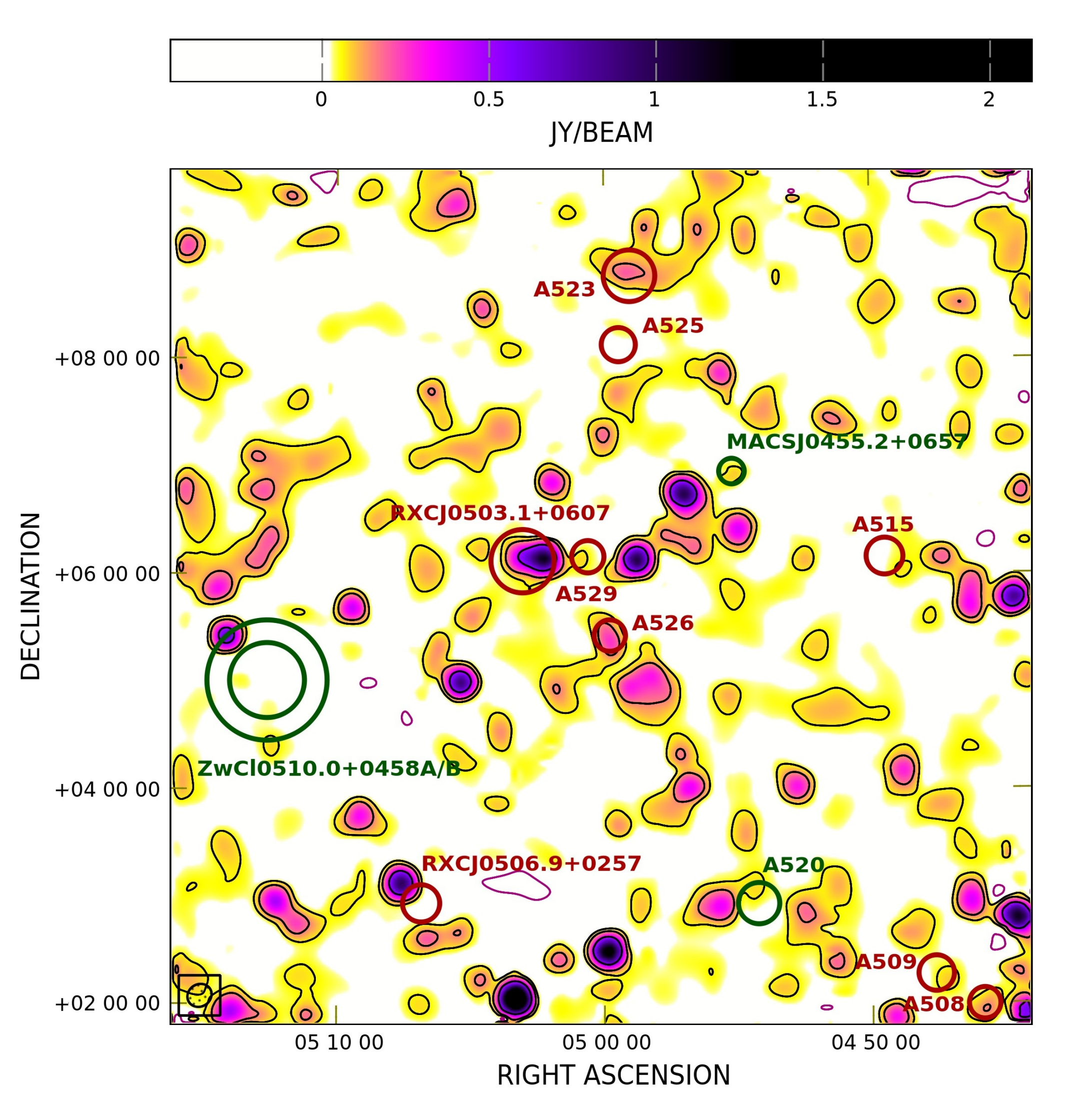
D resolution

Maximum angulard scale = size of the scanned region

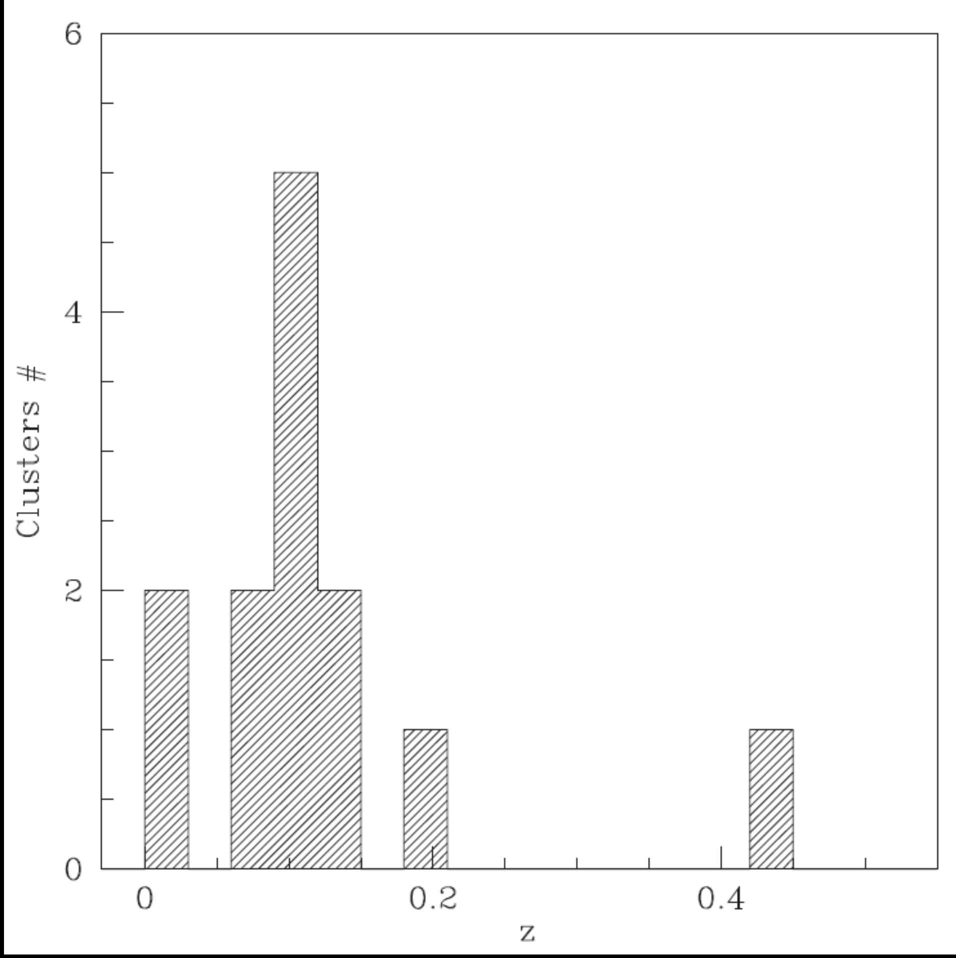
SCUBE (Murgia et al. 2016)

Filaments of the large-scale structure

Vacca et al. (2018)



13 clusters with redshift



SRT

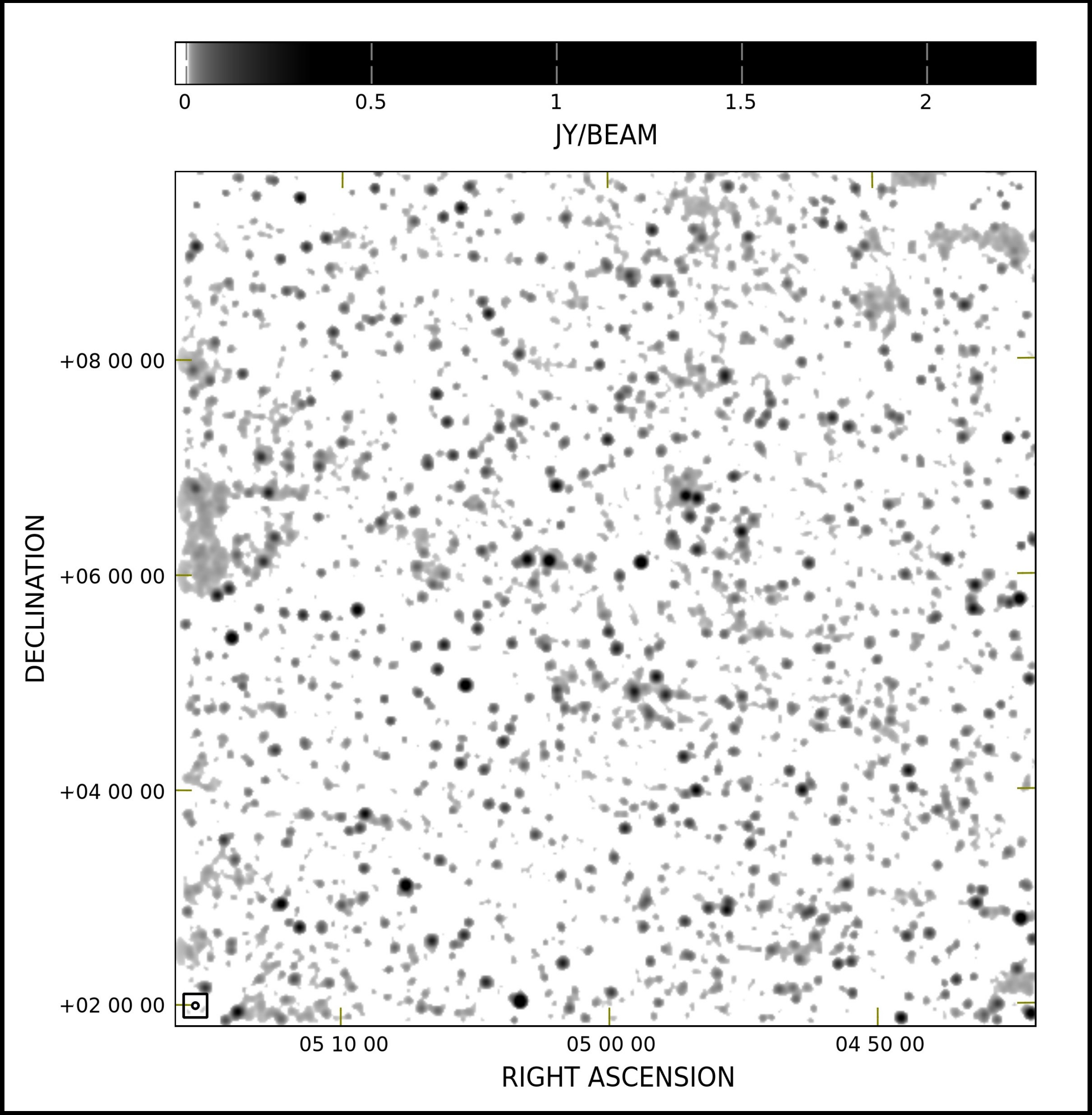
ν = 1.55 GHz

σ = 20 mJy/beam

FWHM = 13.9' x 12.4'

Filaments of the large-scale structure

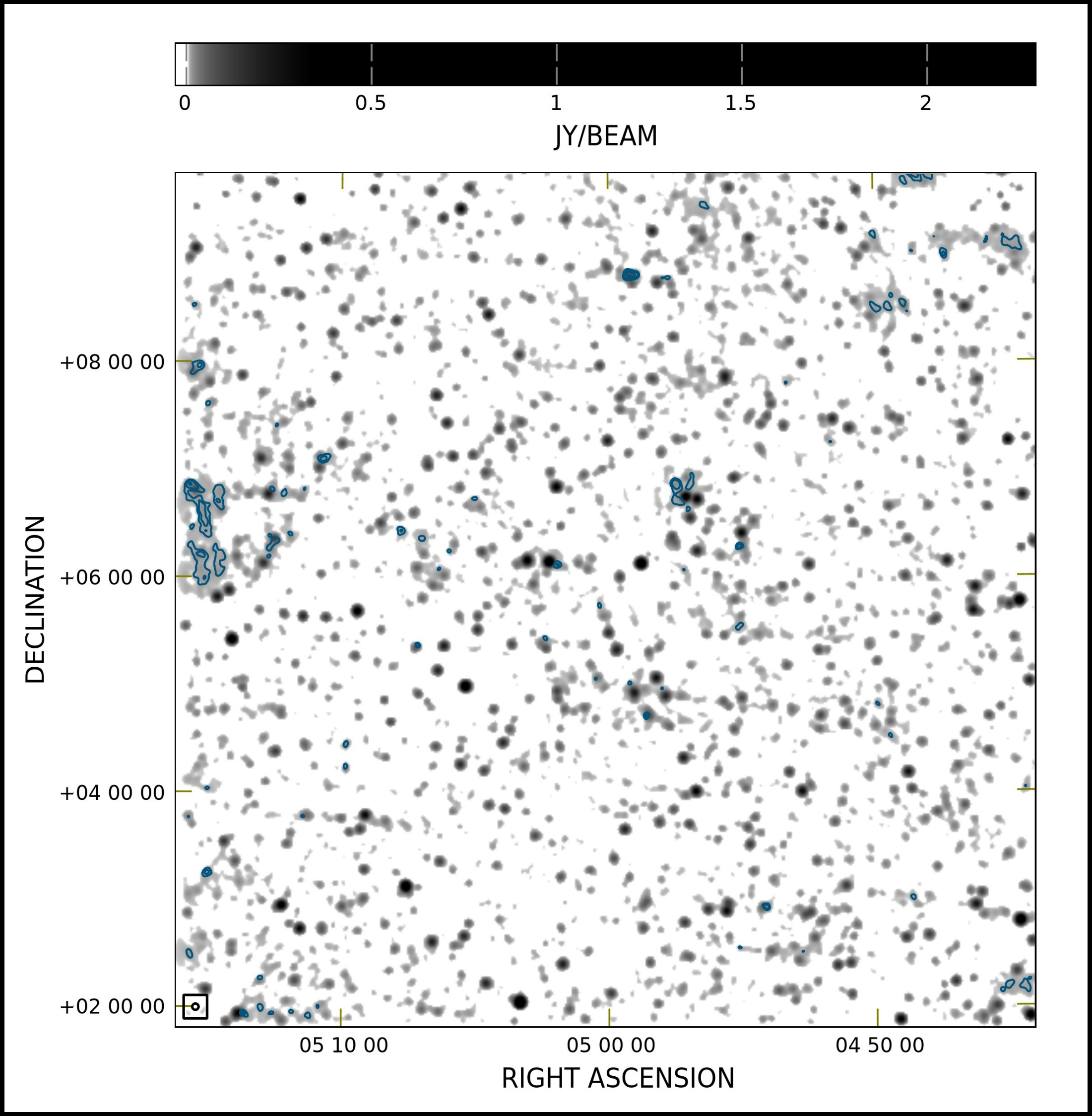
Vacca et al. (2018)



Gray colors: SRT + NVSS
ν = 1.4 GHz
σ = 0.45 mJy/beam
FWHM = 45'' x 45''

Filaments of the large-scale structure

Vacca et al. (2018)

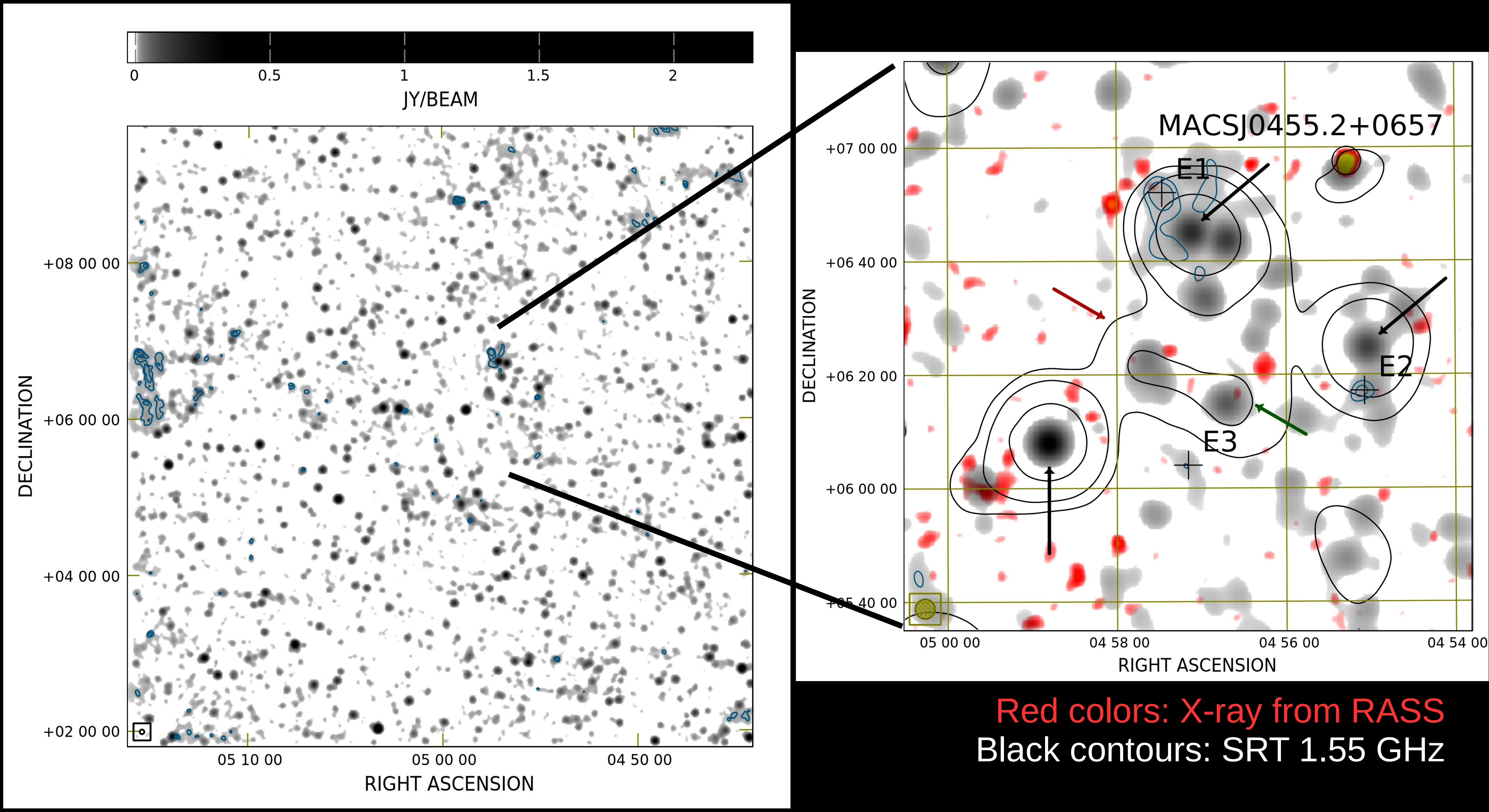


Gray colors: SRT + NVSS 1.4 GHz

Blue contours: SRT+NVSS 1.4 GHz
(after point source subtraction)

Filaments of the large-scale structure

Vacca et al. (2018)



Red colors: X-ray from RASS

Black contours: SRT 1.55 GHz

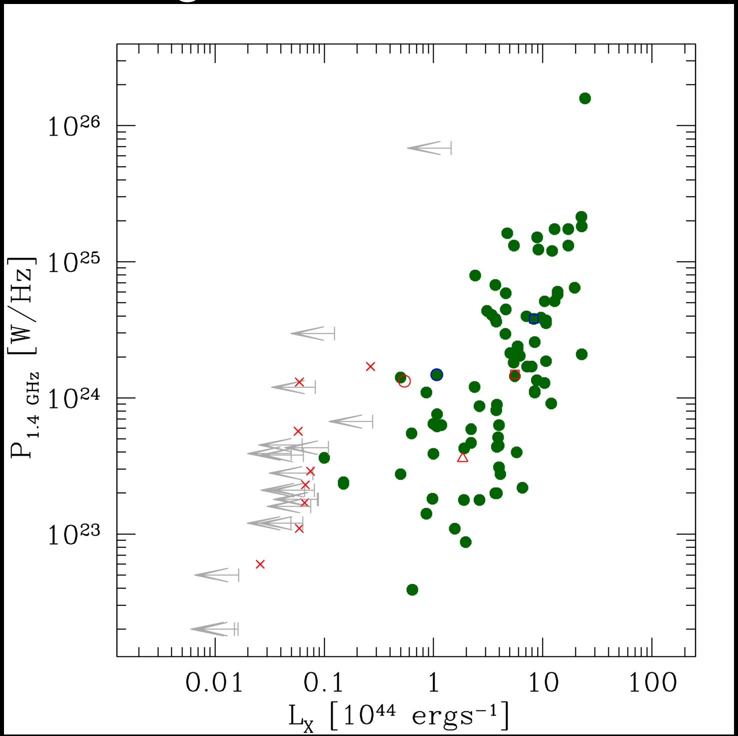
Gray colors: SRT + NVSS 1.4 GHz

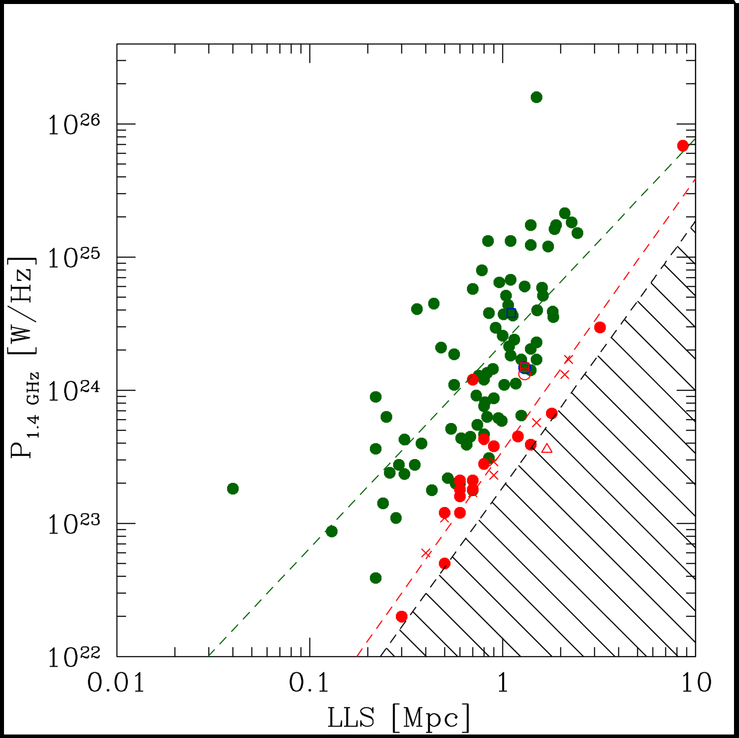
Blue contours: SRT+NVSS 1.4 GHz (after point source subtraction)

35 patches of which 28 new sources

Filaments of the large-scale structure

Vacca et al. (2018)

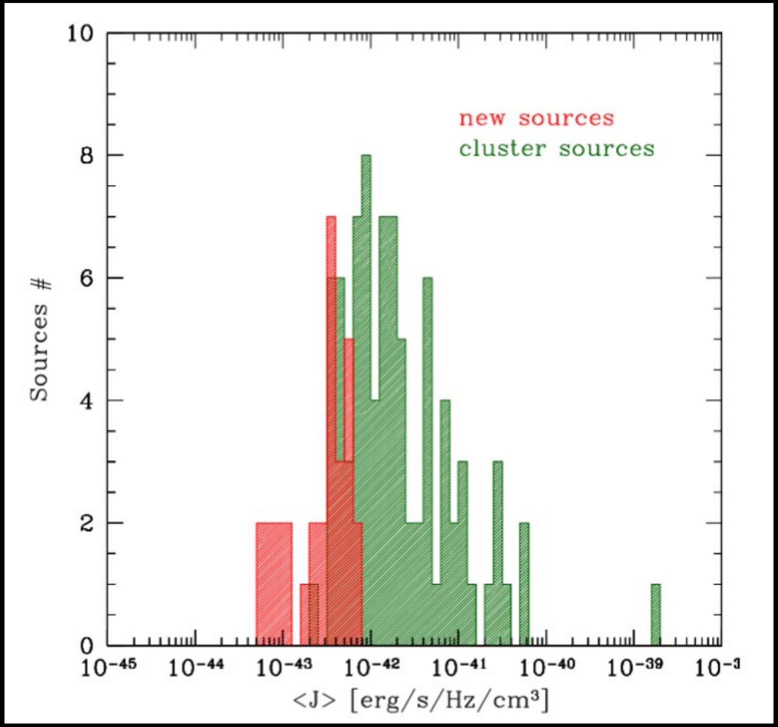




cluster sources

vs

new sources

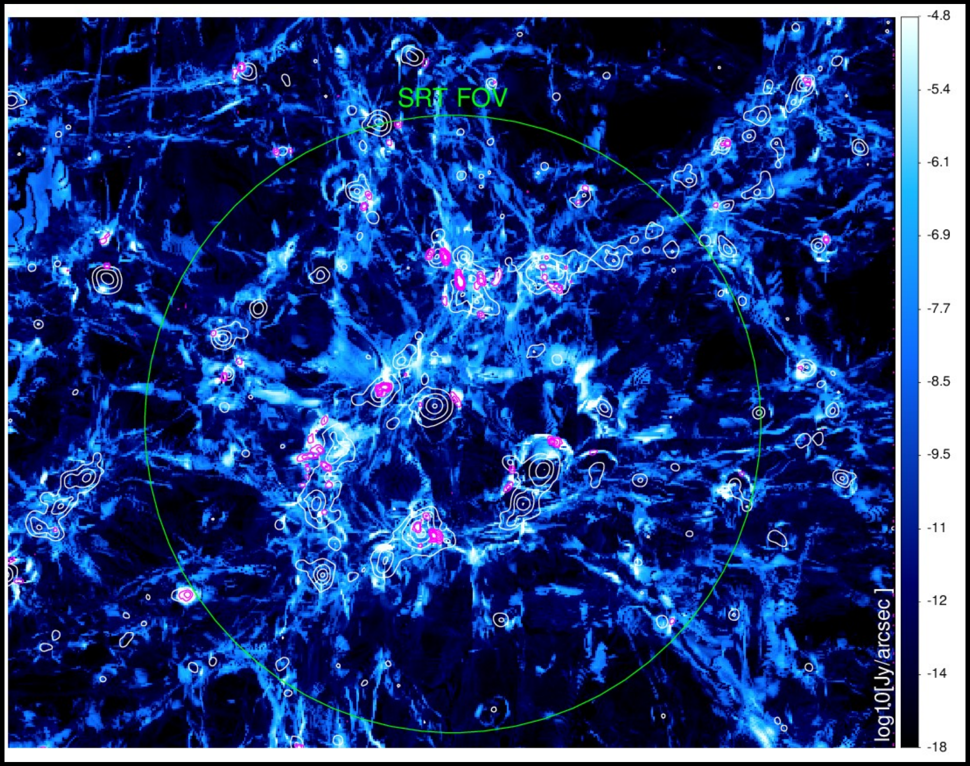


$J_{1.4} \approx 3 \times 10^{-41}$ erg/s/Hz/cm^3

vs

$J_{1.4} \approx 3 \times 10^{-43}$ erg/s/Hz/cm^3

Filaments of the large-scale structure **Vacca et al. (2018)**

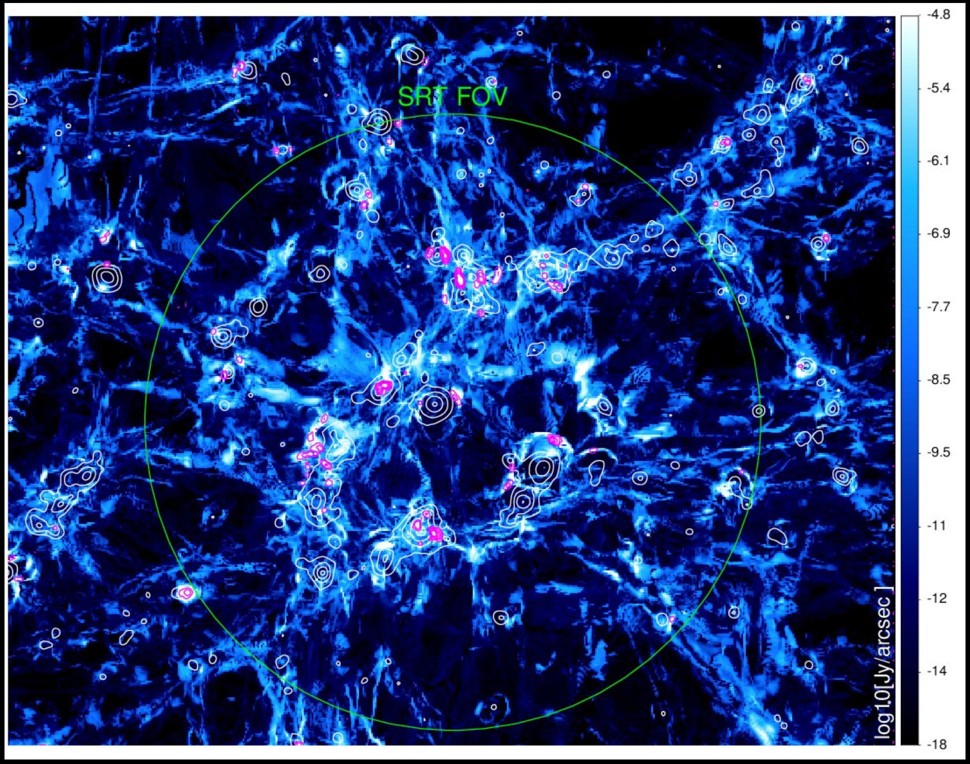


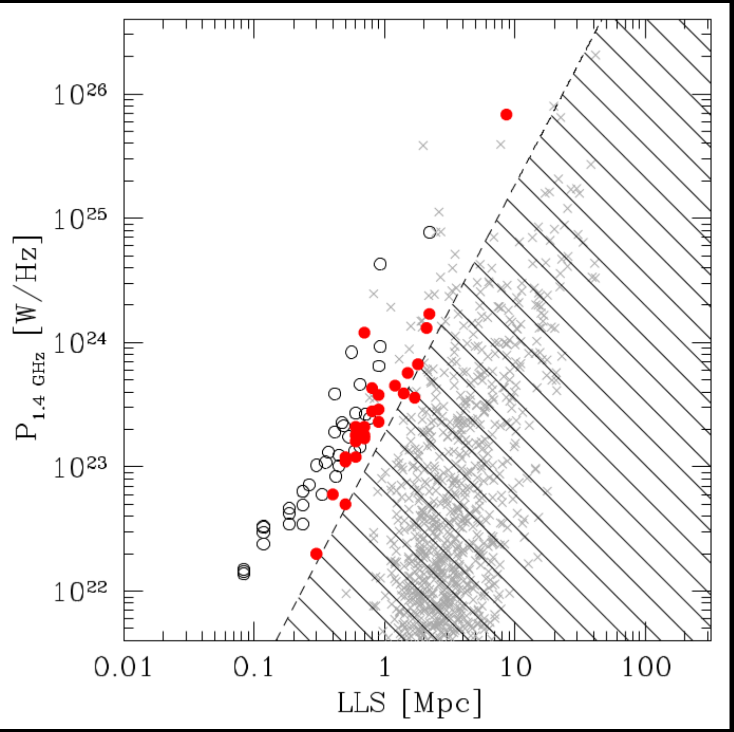
Contours: detectable radio emission in the SRT observing configuration

Colors: projected full radio emission

Filaments of the large-scale structure

Vacca et al. (2018)





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Filaments of the large-scale structure

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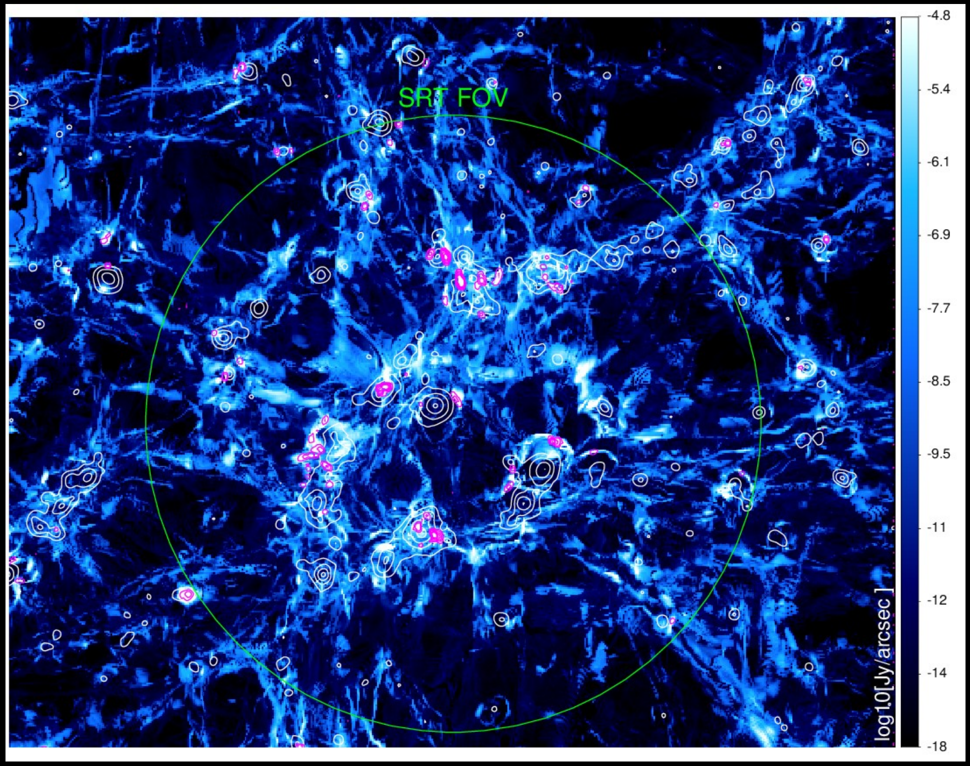
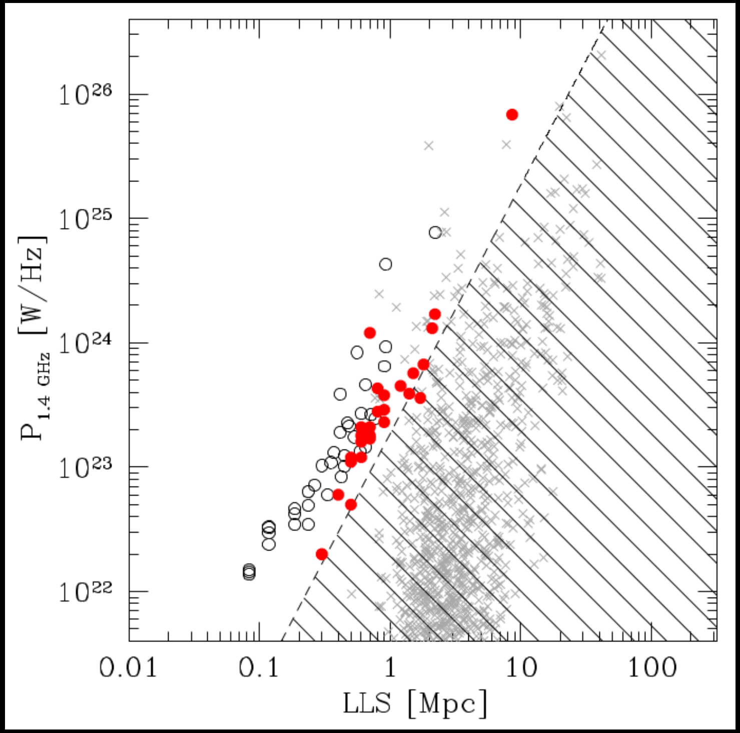
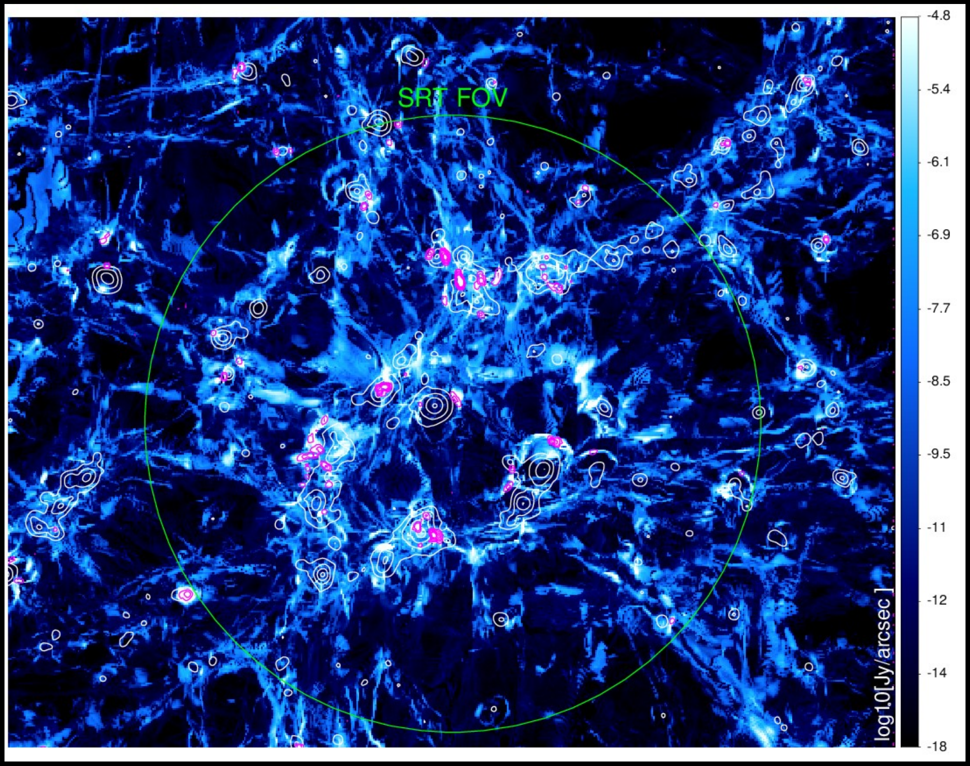




This new population is potentially the tip of the iceberg of diffuse emission associated with the filaments of the cosmic web

Filaments of the large-scale structure

Vacca et al. (2018)



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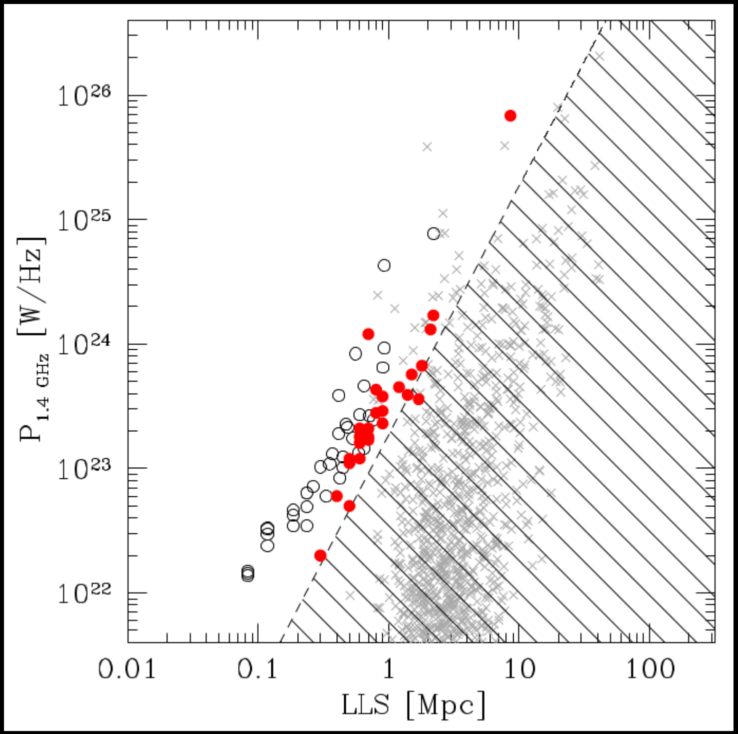
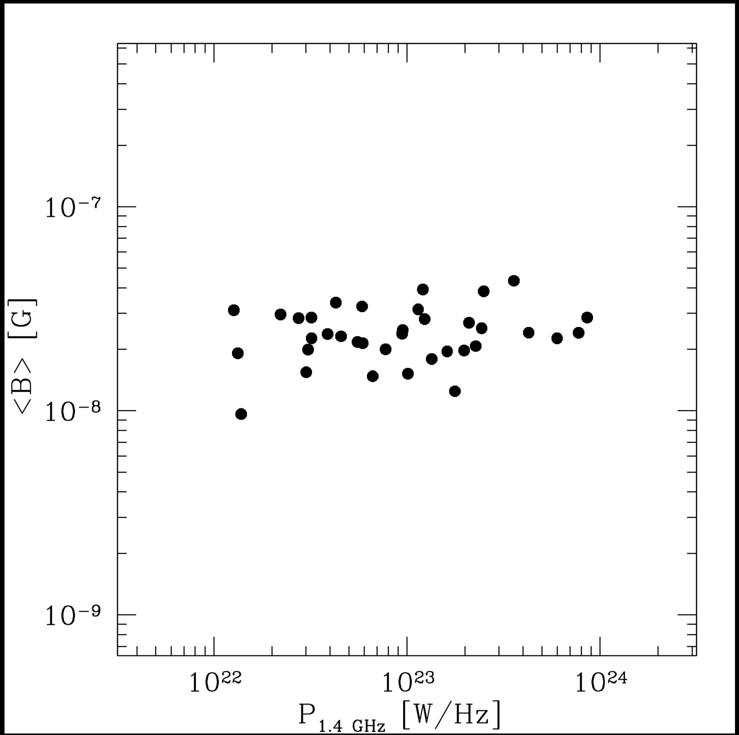
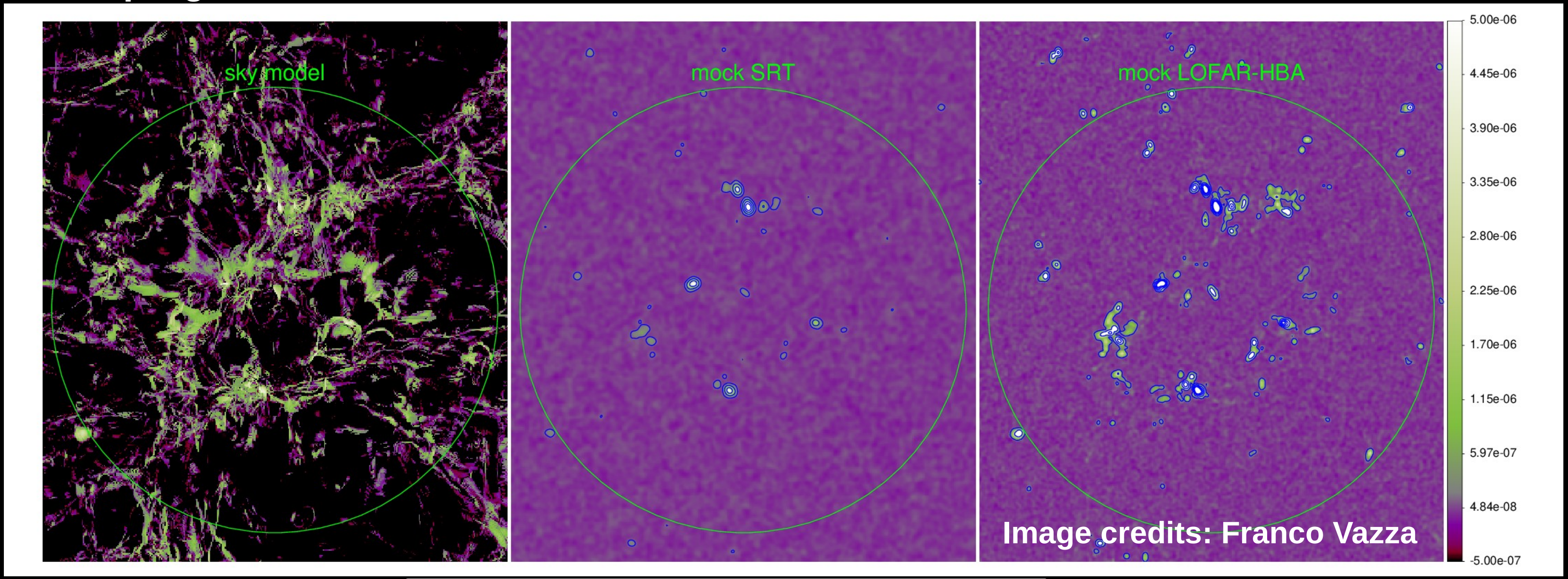




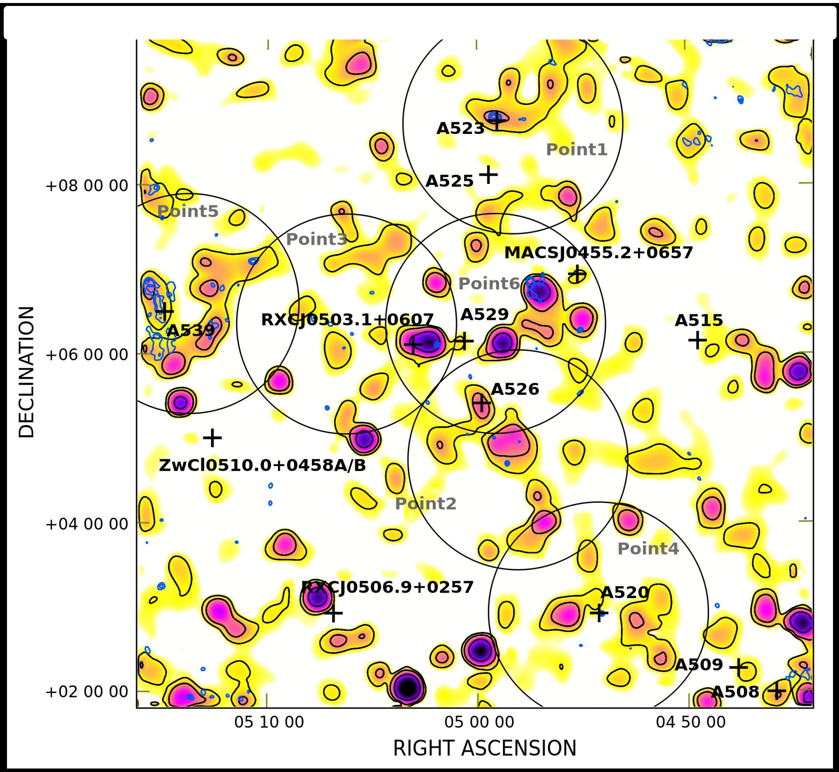
B ≈ 20-50 nG

Work in progress



LOFAR
ν = 120-168 MHz
σ = 0.15 mJy/beam
FWHM = 7”

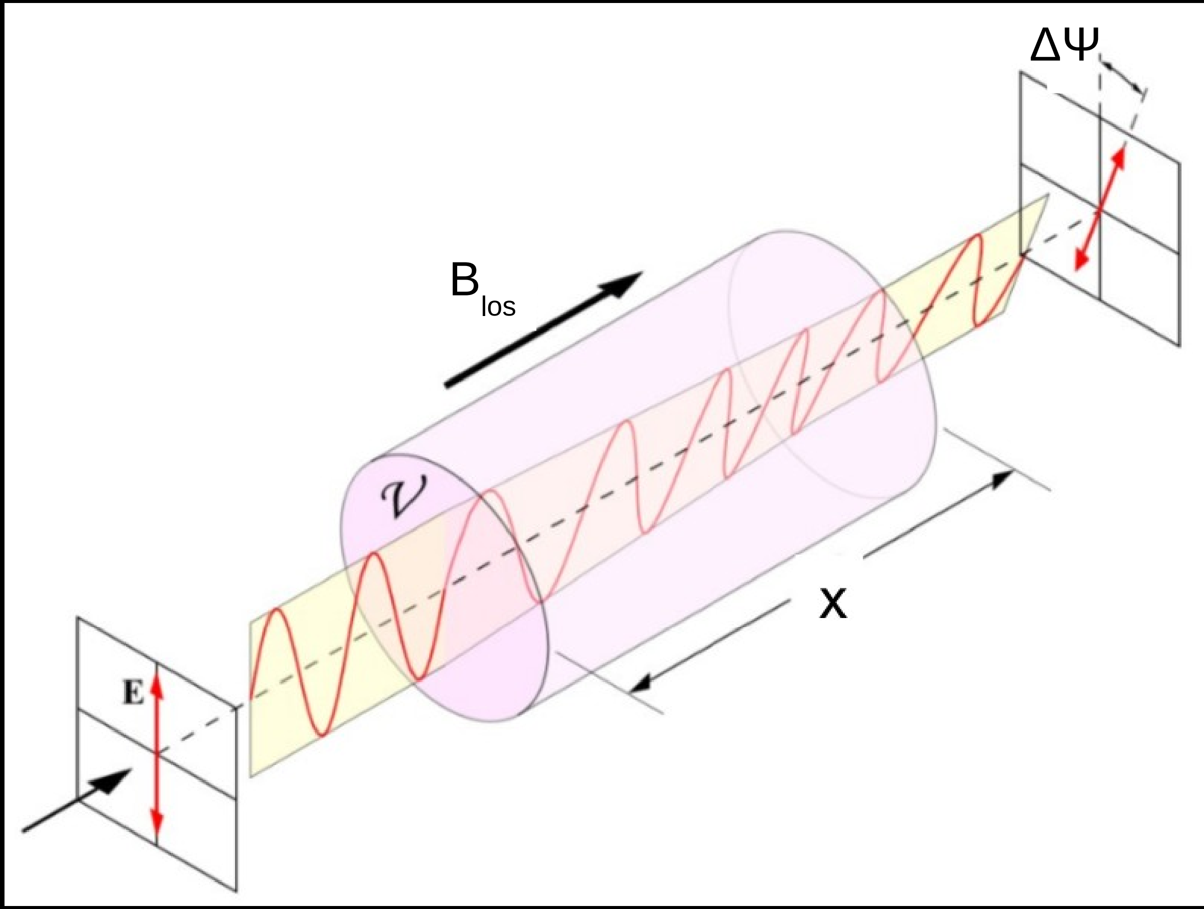
Cycle 10, 35 h



Colors and contours:
SRT 1.55 GHz

Blue contours:
SRT+NVSS 1.4 GHz
(after point source subtraction)

Faraday effect



$$\phi \propto \int B_{los} n_e \, dl$$

Future perspectives

$$\phi \propto \int B_{los} \, n_e \, dl$$

$$\phi_i = \phi_{g,i} + \phi_{e,i} + n_i$$ Oppermann et al. (2015)

$$\langle \phi^2_{e,i} \rangle = \sigma^2_{int,i} + \sigma^2_{env,i}$$ Vacca et al. (2016)

Other contributions (magnesium absorbers, ionosphere, etc.) can be easily included.

Future perspectives

$$\phi \propto \int B_{los}\, n_e\, dl$$

$$\phi_i = \phi_{\mathrm{g},i} + \phi_{\mathrm{e},i} + n_i$$

$$\langle \phi^2_{\mathrm{e},i} \rangle = \sigma^2_{\mathrm{int},i} + \sigma^2_{\mathrm{env},i}$$

INTRINSIC

$$\left(\frac{L_i}{L_0}\right)^{\chi_{\mathrm{lum}}} \frac{\sigma^2_{\mathrm{int},0}}{(1+z_i)^4}$$

LLS

$$\frac{D(z_i, \chi_{\mathrm{red}})}{D_0} \sigma^2_{\mathrm{env},0}$$

Vacca et al. (2016)

Future perspectives

$$\phi \propto \int B_{los}\, n_e\, dl$$

$$\phi_i = \phi_{\mathrm{g},i} + \phi_{\mathrm{e},i} + n_i$$

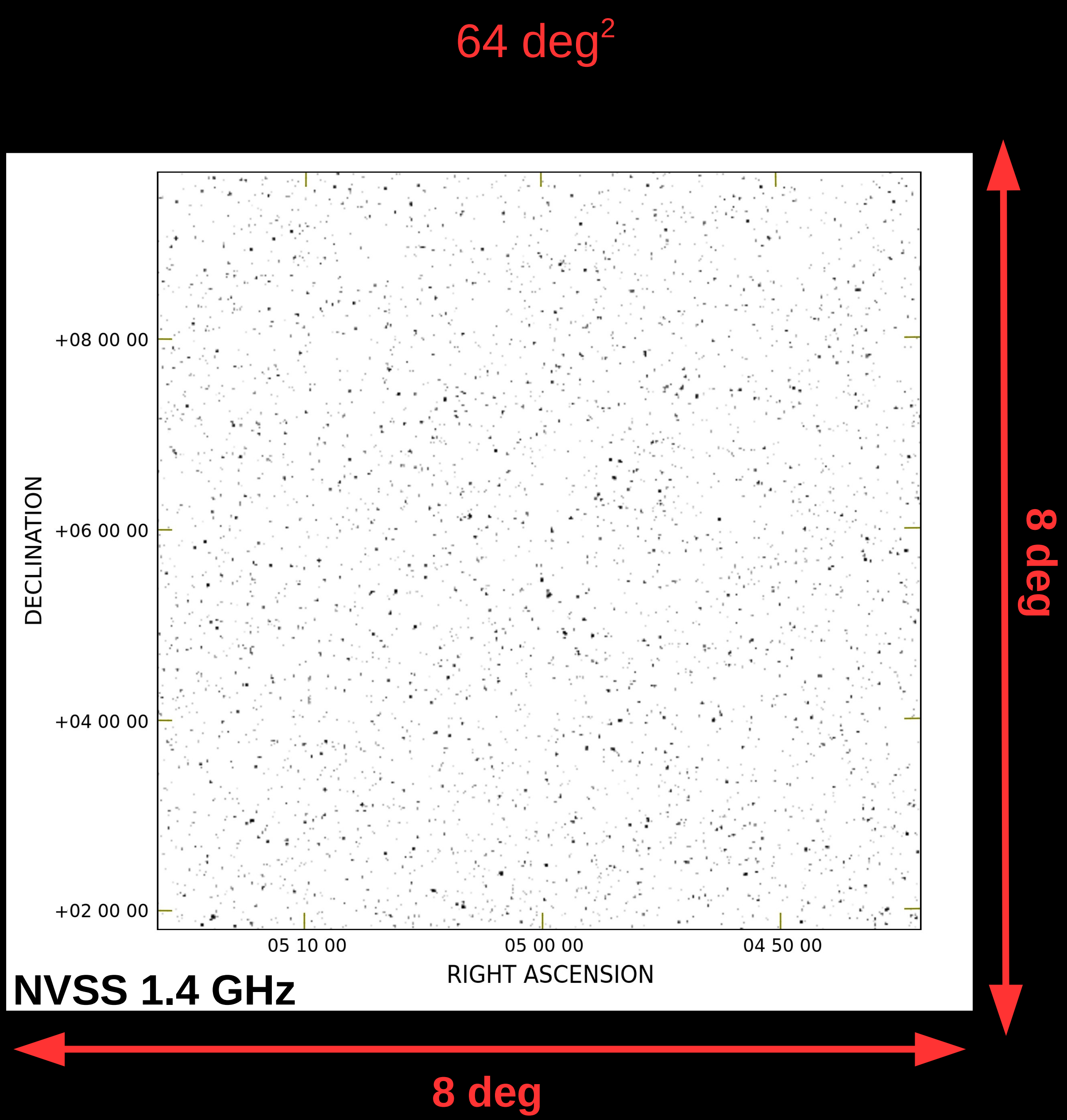
$$\langle \phi_{\mathrm{e},i}^2 \rangle = \sigma_{\mathrm{int},i}^2 + \sigma_{\mathrm{env},i}^2$$

$$\left(\frac{L_i}{L_0}\right)^{\chi_{\mathrm{lum}}} \frac{\sigma_{\mathrm{int},0}^2}{(1+z_i)^4}$$

$$\frac{D(z_i, \chi_{\mathrm{red}})}{D_0} \sigma_{\mathrm{env},0}^2$$

Vacca et al. (2016)

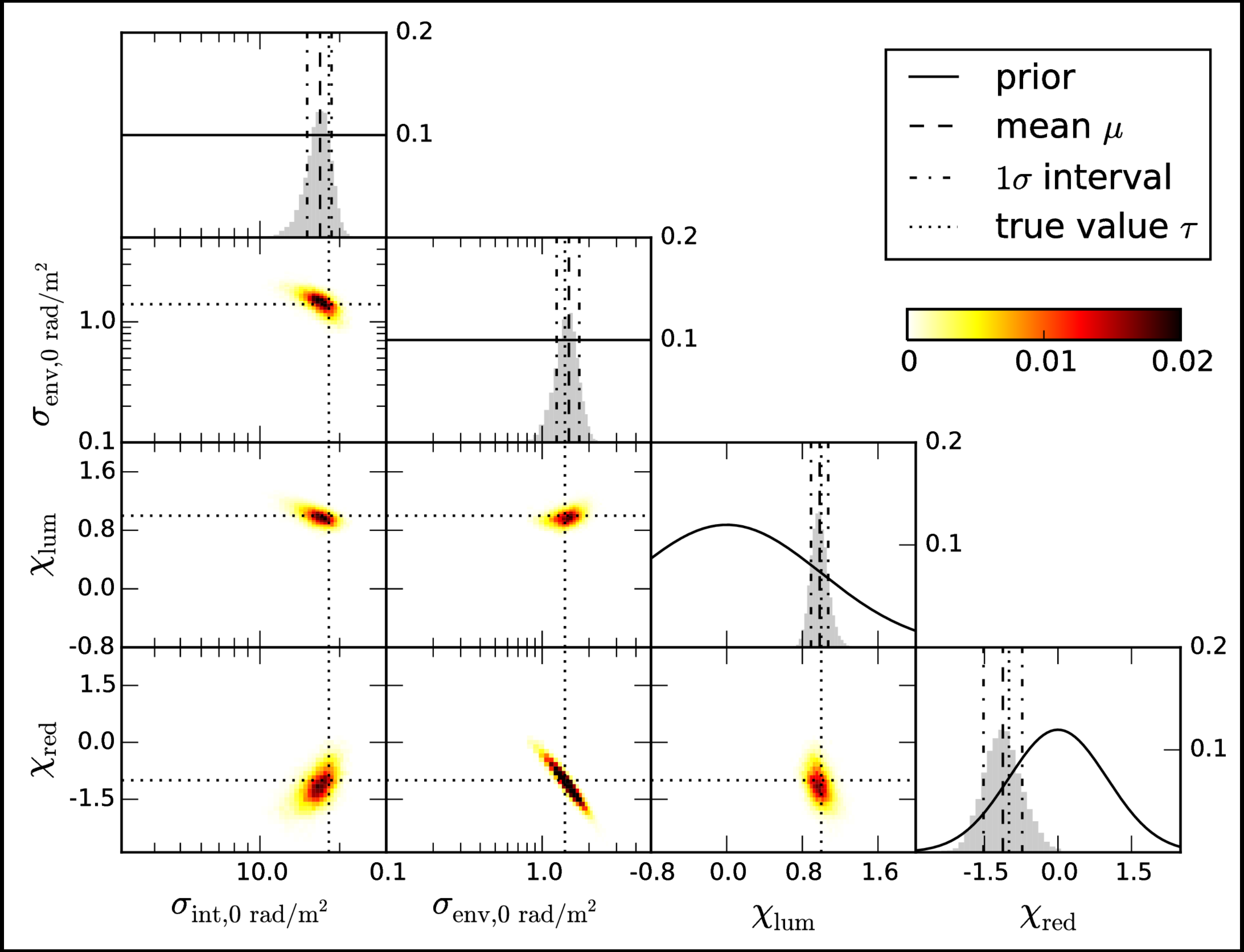
Future perspectives



POLARIZED SOURCES

INSTRUMENT	DENSITY (deg^{-2})	N_{TOT}
VLA (NVSS)	1	60-70
LOFAR (8h)	0.2	10
ASKAP (POSSUM)	30-70	$2\text{-}5\times10^3$
SKA1 (pol. survey)	200-300	$1\text{-}2\times10^4$

Future perspectives



ASKAP (POSSUM)

1130–1430 MHz

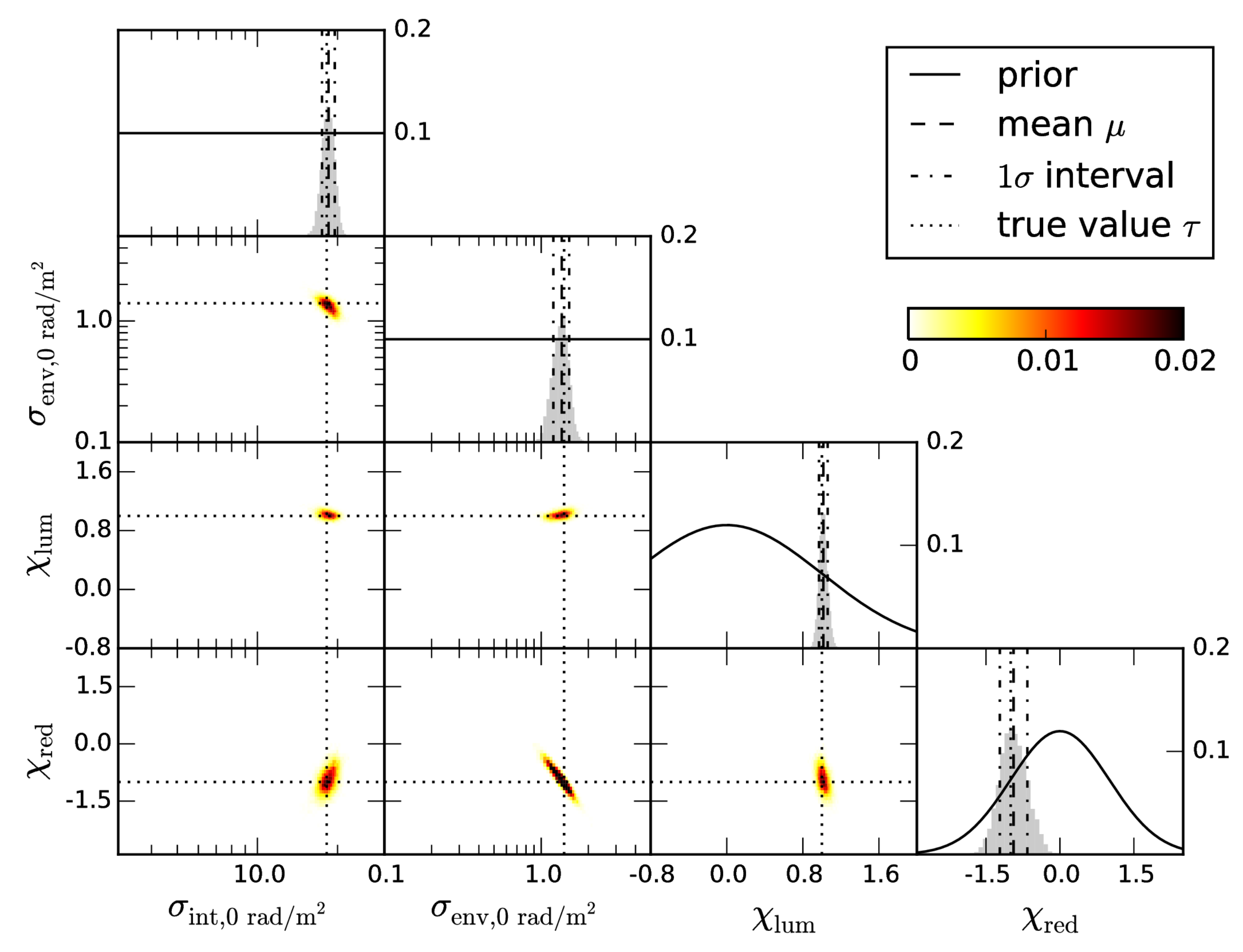
a few thousand sources

≈ 7 rad/m^2

B ≈ 0.5 – 1 μG

Vacca et al. (2016)

Future perspectives



SKA1

0.95–1.76 GHz

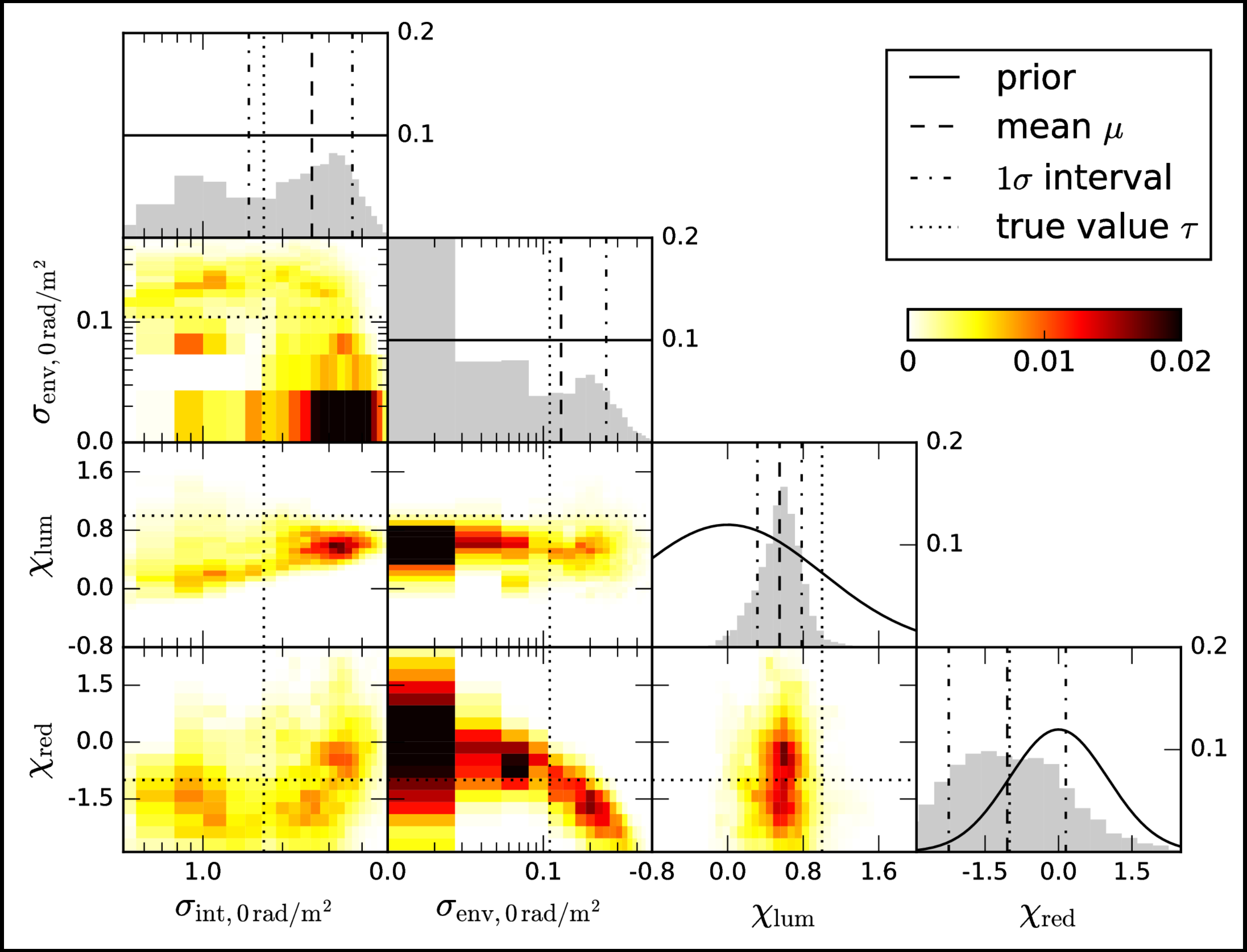
a few thousand sources

≈ 7 rad/m^2

B ≈ 0.5 – 1 μG

Vacca et al. (2016)

Future perspectives



a few thousand sources

≈ 7 rad/m^2

B ≈ 2 nG

only SKA1 can make it!

Vacca et al. (2016)

Summary and Conclusions

Magnetic fields in the large scale structure of the Universe can be studied both through diffuse synchrotron emission and the Faraday rotation effect on background radio sources:

- we begin to detect diffuse synchrotron sources potentially associated with the cosmic web thanks to the high sensitivity to surface brightness and large angular scales of single-dish observations;

- rotation measure grids with SKA, its precursors and pathfinders will play a crucial role.

THANK YOU (>*

Sergio Poppi

Image credits: Sergio Poppi