The II National Workshop of SKA science and technology
3-5 December 2018, Bologna

Cosmic magnetism with the SKA:
expectations on the study of intracluster magnetic fields

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Collaborators: M. Murgia, F. Govoni, V. Vacca, I. Prandoni, A. Bonafede, and L. Feretti,

What will be the contribution of the SKA on cosmic magnetism?

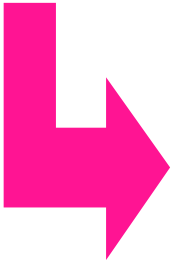
How we can manage the huge amount of SKA data to maximize its scientific impact?

What about future surveys?

...?

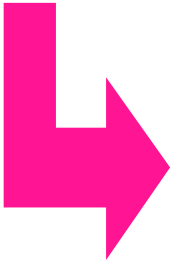
Full-Stokes simulation of the radio sky

Full-Stokes simulation of the radio sky



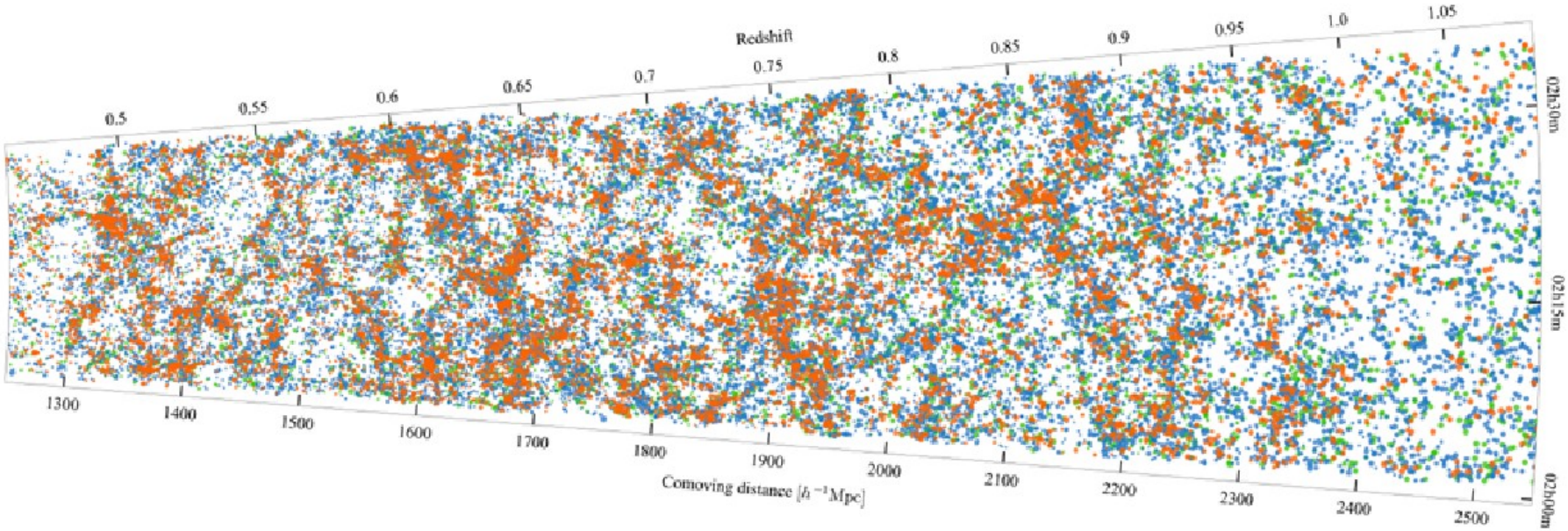
- Total Intensity (Stokes I)
- Polarized intensity (Stoke U, Q)

Full-Stokes simulation of the radio sky



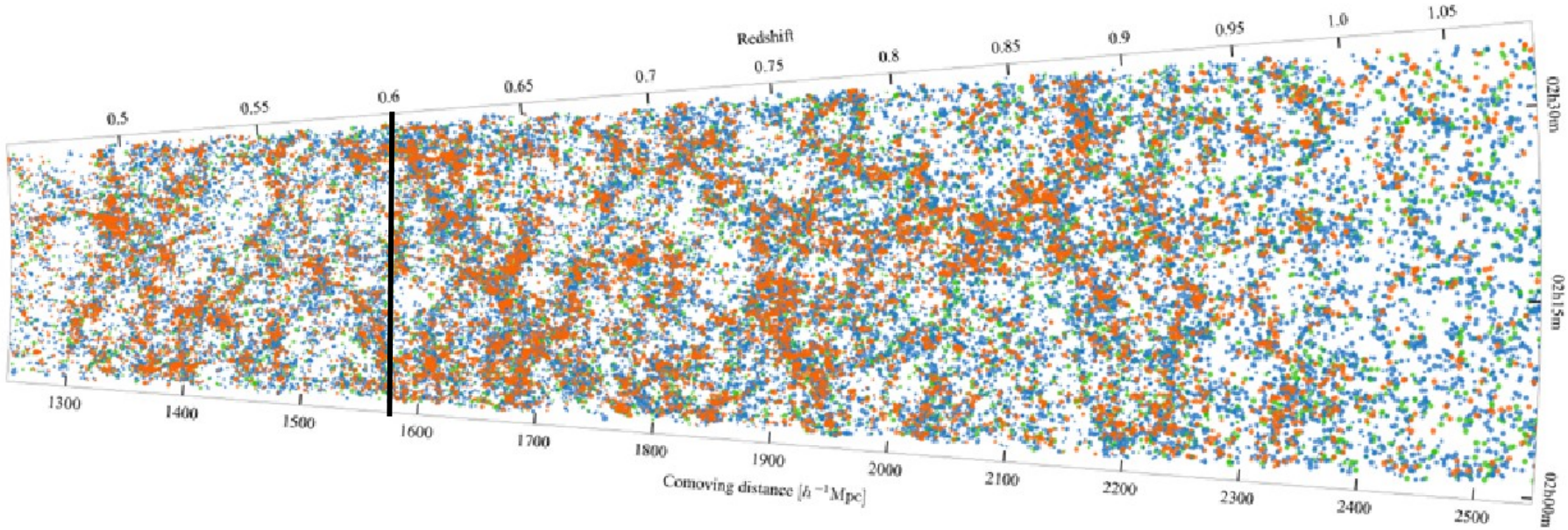
- Total Intensity (Stokes I) [Wilman+2008,2010]
- Polarized intensity (Stoke U, Q) [Bonaldi+2018]

A radio observation of a galaxy cluster



VIPERS
[Scodeggio+2016]

A radio observation of a galaxy cluster

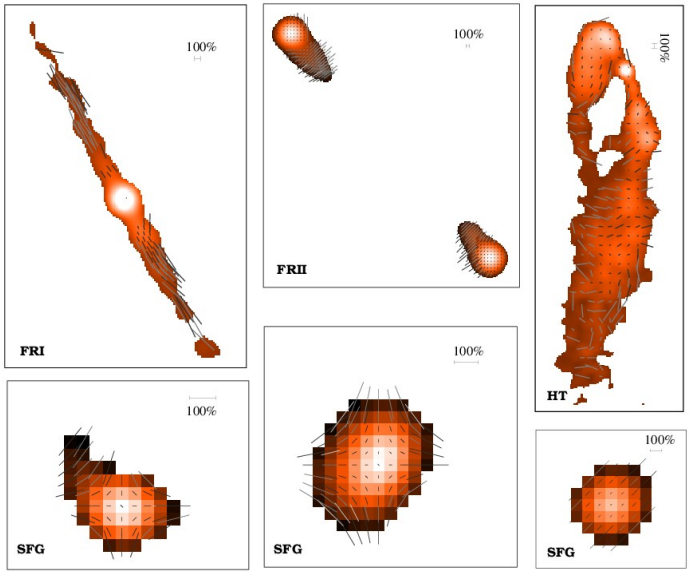


It must include:

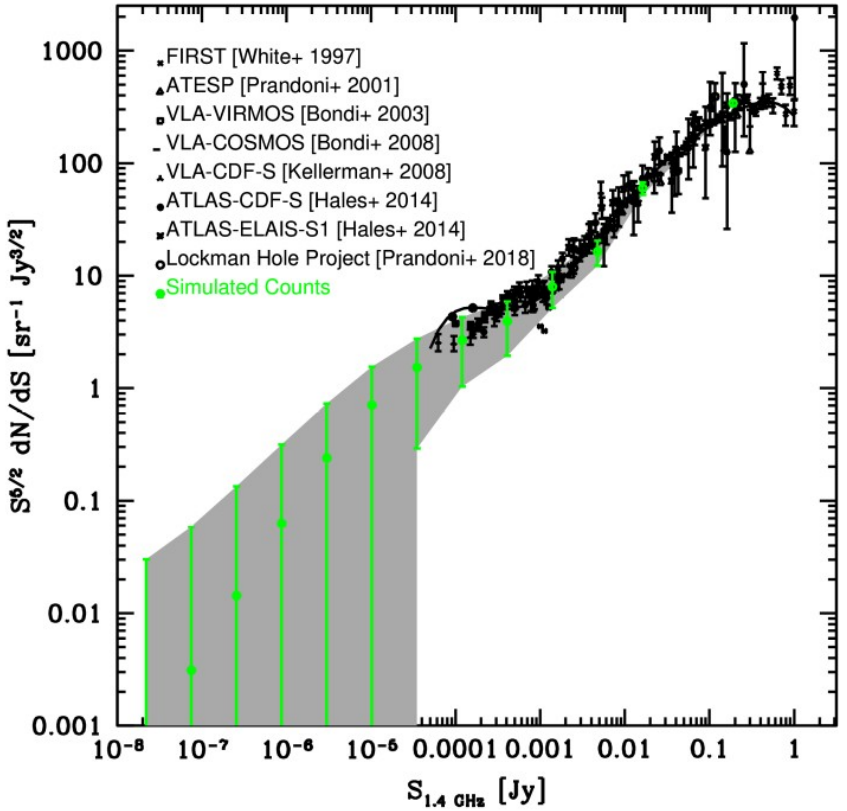
- Cluster-embedded radio sources (diffuse and discrete)
- Foreground/background discrete radio sources

Radio source properties

- Type
- Redshift
- Coordinates
- Size
- Luminosity
- Morphology
- Spectro-polarimetric properties

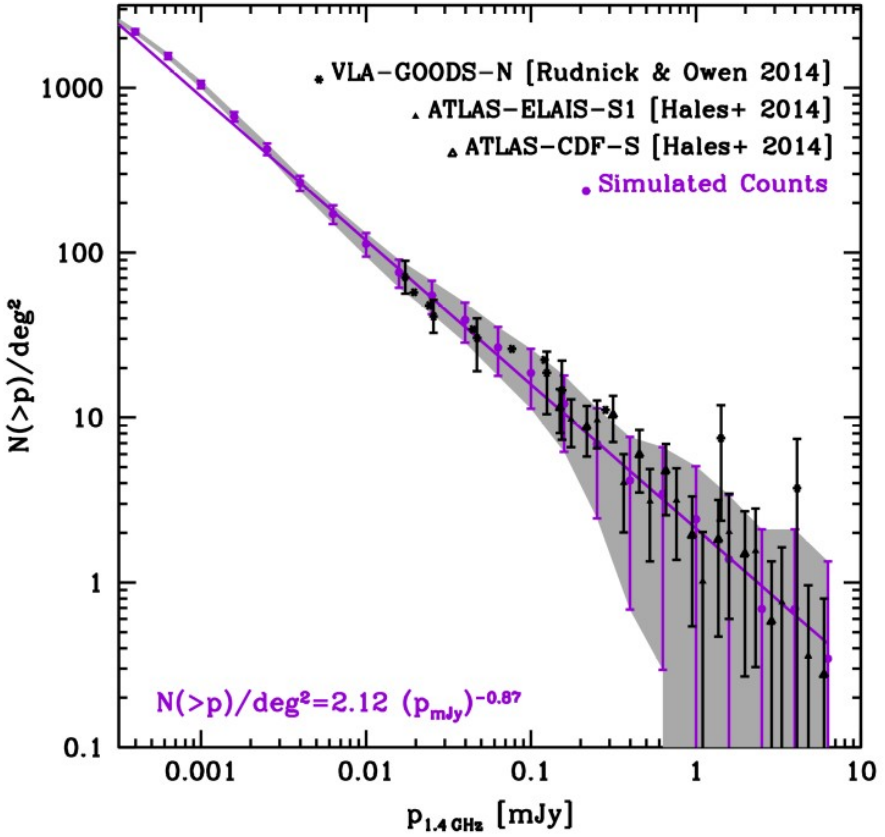


Total intensity differential source counts at 1.4 GHz



Loi+ submitted

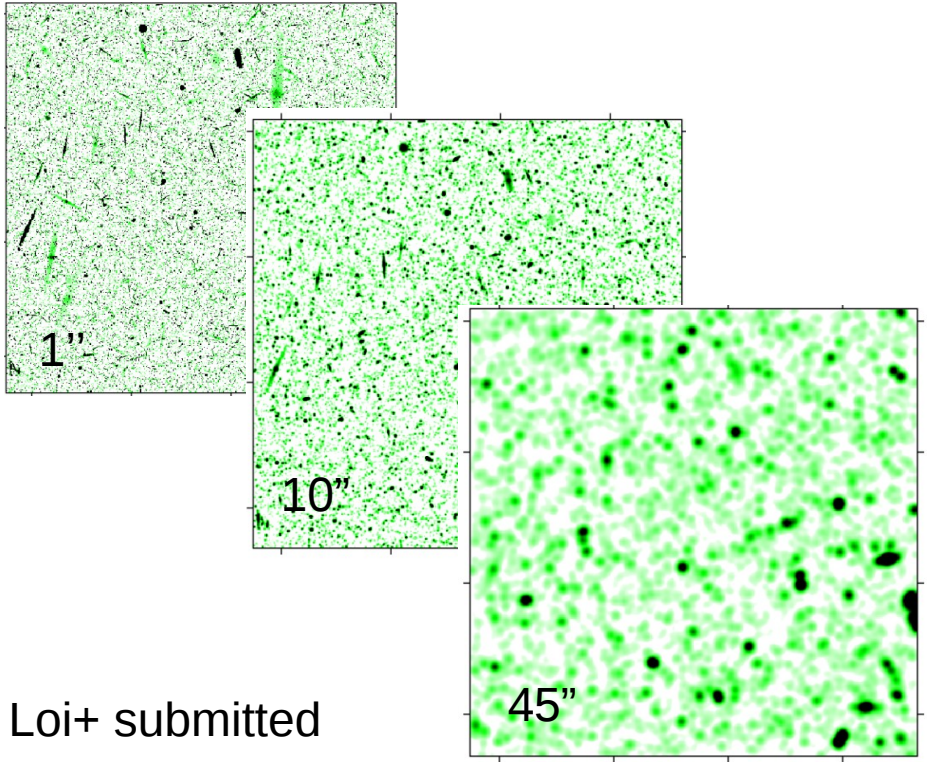
Number of polarized sources at 1.4 GHz



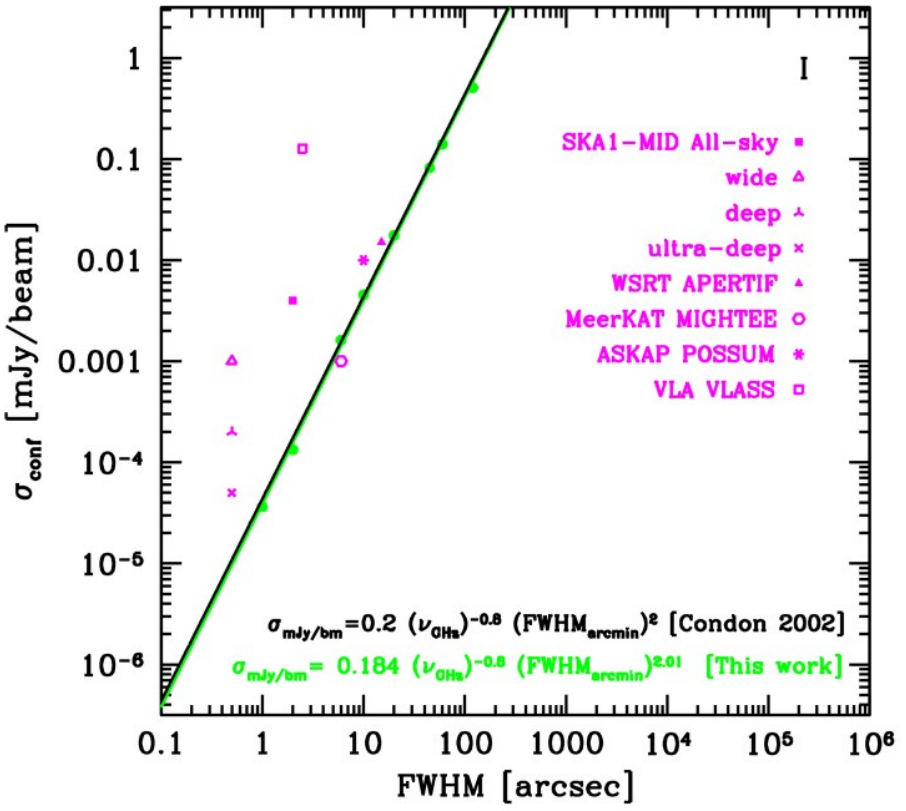
Survey	σ_p[μJy]	N/deg^2	FoV[deg^2]	N[$\times 10^3$]
VLASS	89	7	33885	576
Apertif	10	45	3500	158
POSSUM	7	61	30000	1830
MIGHTEE	0.7	453	20	9
SKA1-MID all-sky	2.8	136	31000	4216
wide	0.7	453	1000	453
deep	0.14	1837	30	55
ultra-deep	0.035	6136	1	6

Loi+ submitted

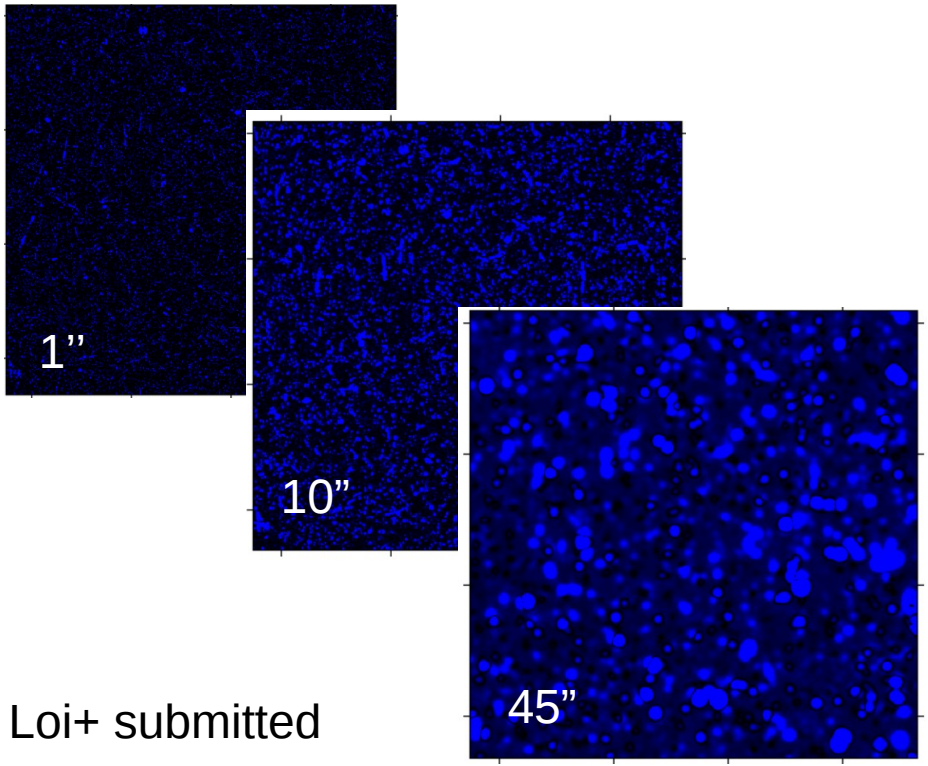
Future surveys vs confusion at 1.4 GHz



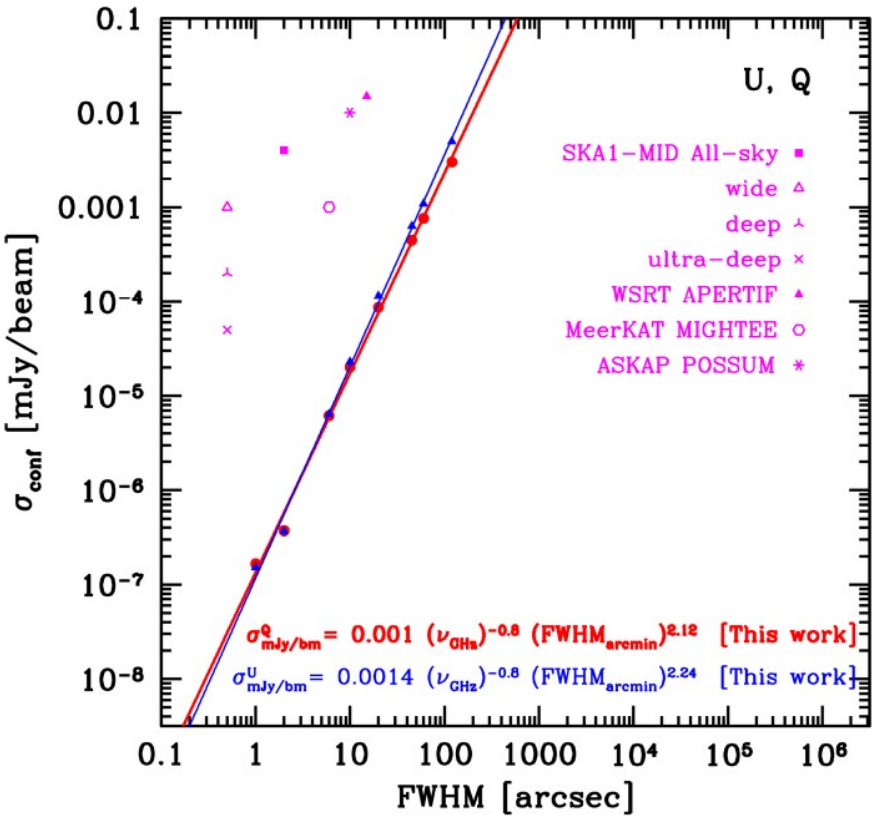
Loi+ submitted



Future surveys vs confusion at 1.4 GHz



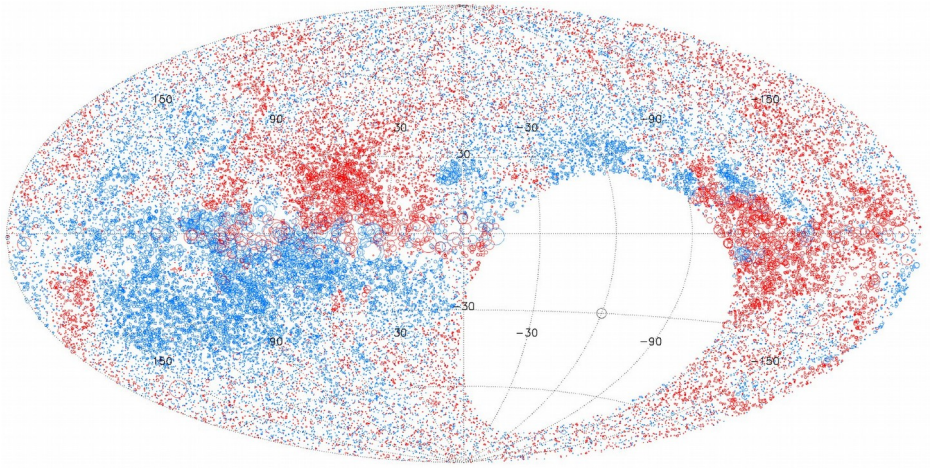
Loi+ submitted



Constraining intracluster magnetic fields

Rotation Measure

Up to now….

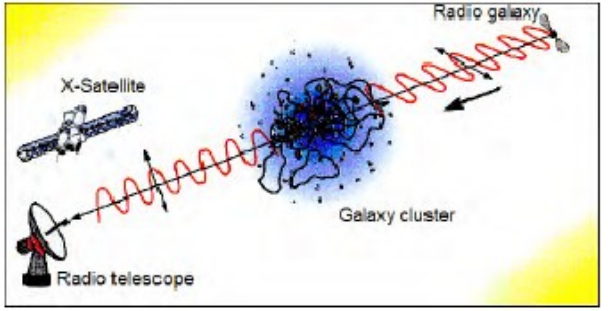


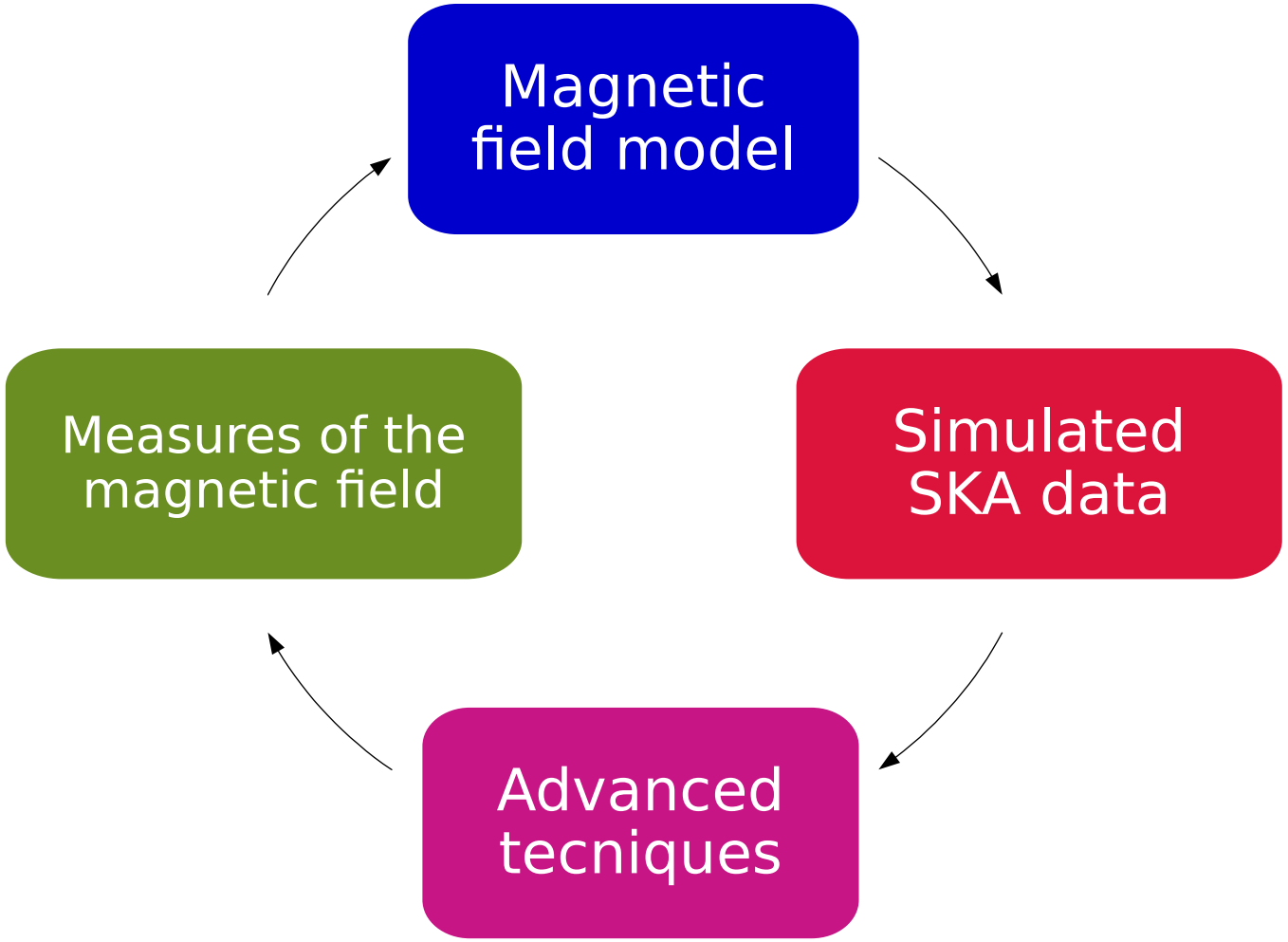
RM grid ~ 1 RM/deg² [Taylor+ 2009]

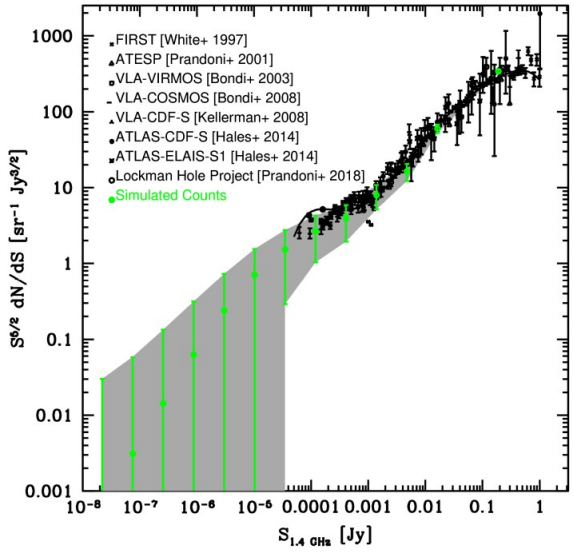
...with the SKA

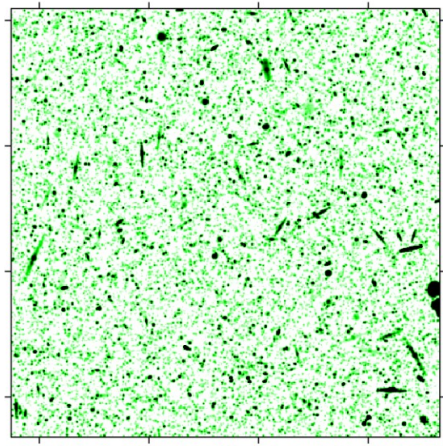
RM Grid ~ 300 RMs/deg²

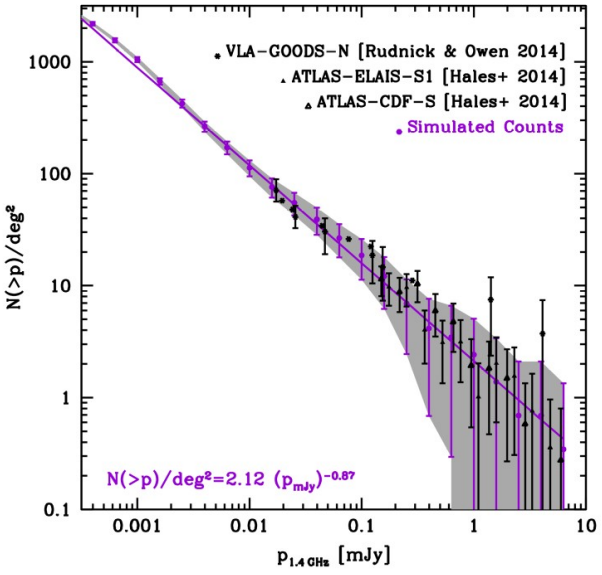
[Johnston-Hollitt+2015]



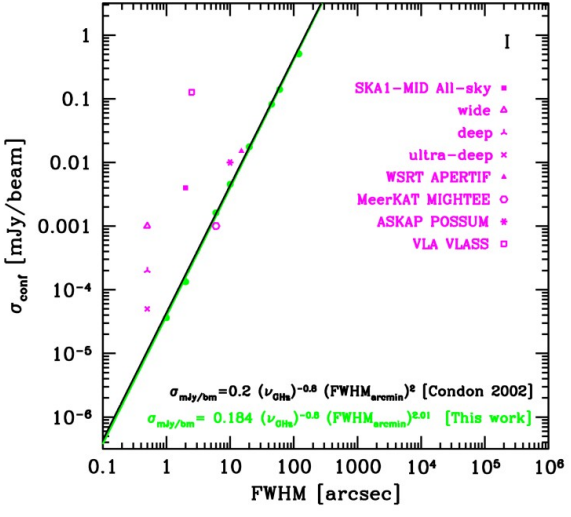

Magnetic field model
Simulated SKA data
Advanced tecniques
Measures of the magnetic field

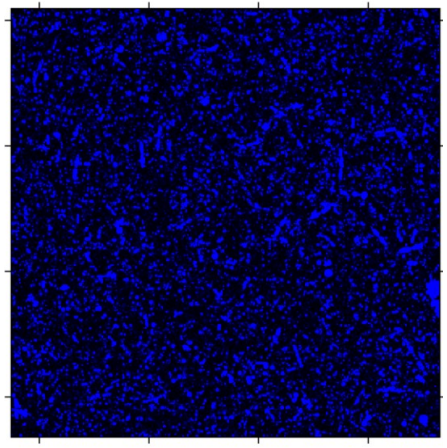

FIRST [White+ 1997]
ATESP [Prandoni+ 2001]
VLA-VIRMOS [Bondi+ 2003]
VLA-COSMOS [Bondi+ 2008]
VLA-CDF-S [Kellerman+ 2008]
ATLAS-CDF-S [Hales+ 2014]
ATLAS-ELAIS-S1 [Hales+ 2014]
Lockman Hole Project [Prandoni+ 2018]
Simulated Counts
S^5/2 dN/dS [sr^-1 Jy^3/2]
S1.4 GHz [Jy]

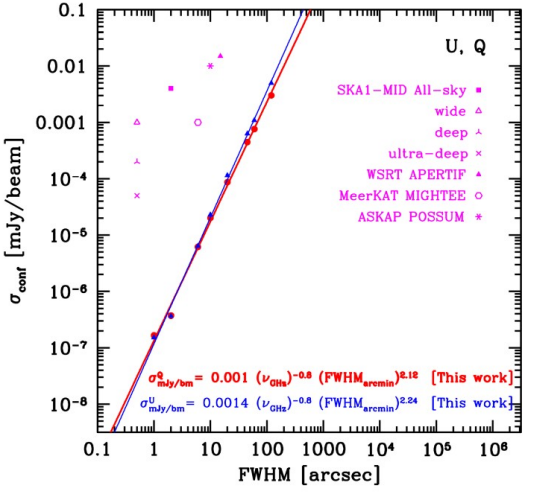



VLA-GOODS-N [Rudnick & Owen 2014]
ATLAS-ELAIS-S1 [Hales+ 2014]
ATLAS-CDF-S [Hales+ 2014]
Simulated Counts
N(>p)/deg²=2.12 (p_mJy)^-0.87
N(>p)/deg²
p1.4 GHz [mJy]

Thank you!


I
SKA1-MID All-sky
wide
deep
ultra-deep
WSRT APERTIF
MeerKAT MIGHTEE
ASKAP POSSUM
VLA VLASS
σmJy/bm=0.2 (νGHz)^-0.8 (FWHMarcmin)² [Condon 2002]
σmJy/bm= 0.184 (νGHz)^-0.8 (FWHMarcmin)^2.01 [This work]
σconf [mJy/beam]
FWHM [arcsec]




U, Q
SKA1-MID All-sky
wide
deep
ultra-deep
WSRT APERTIF
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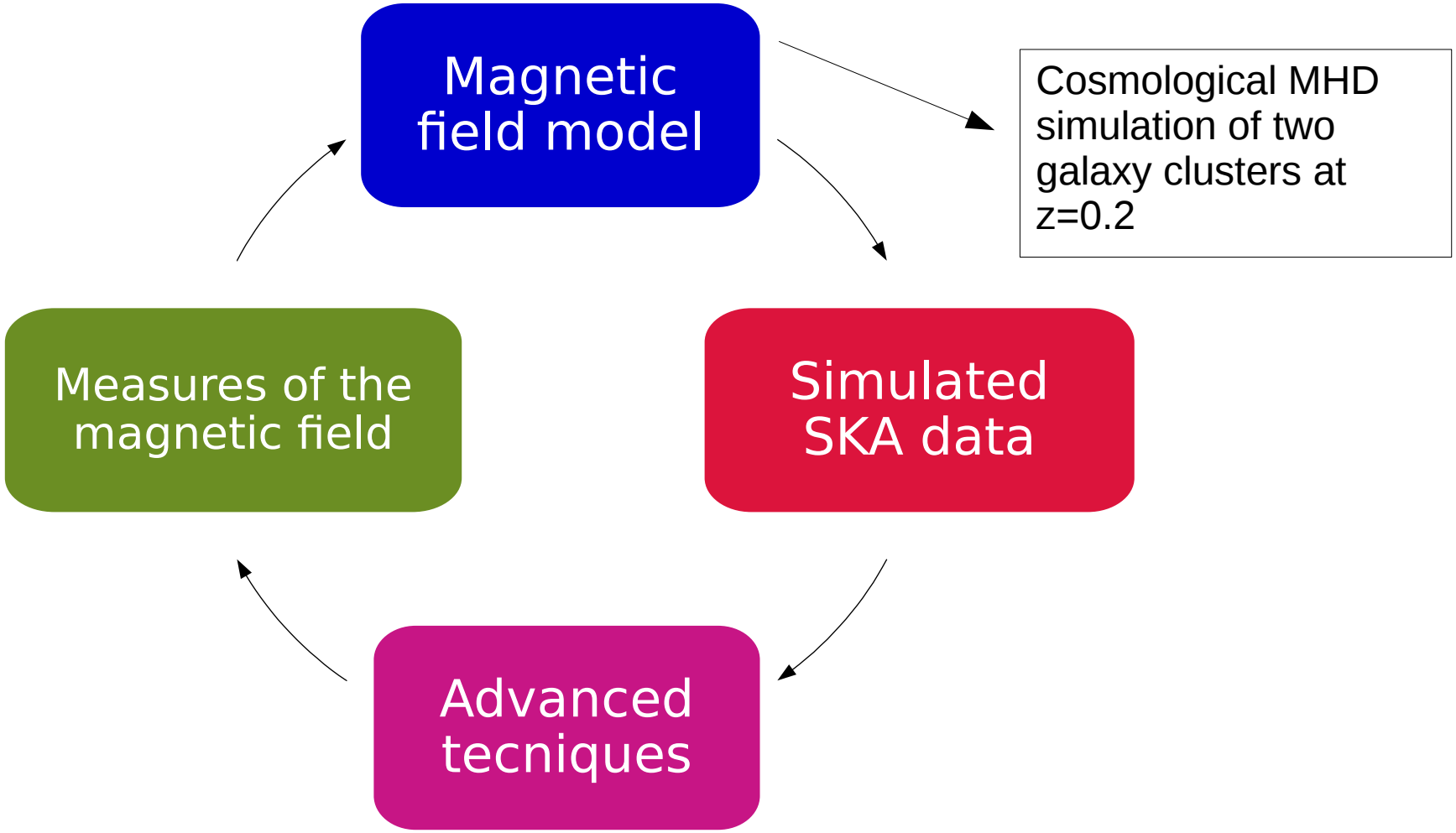
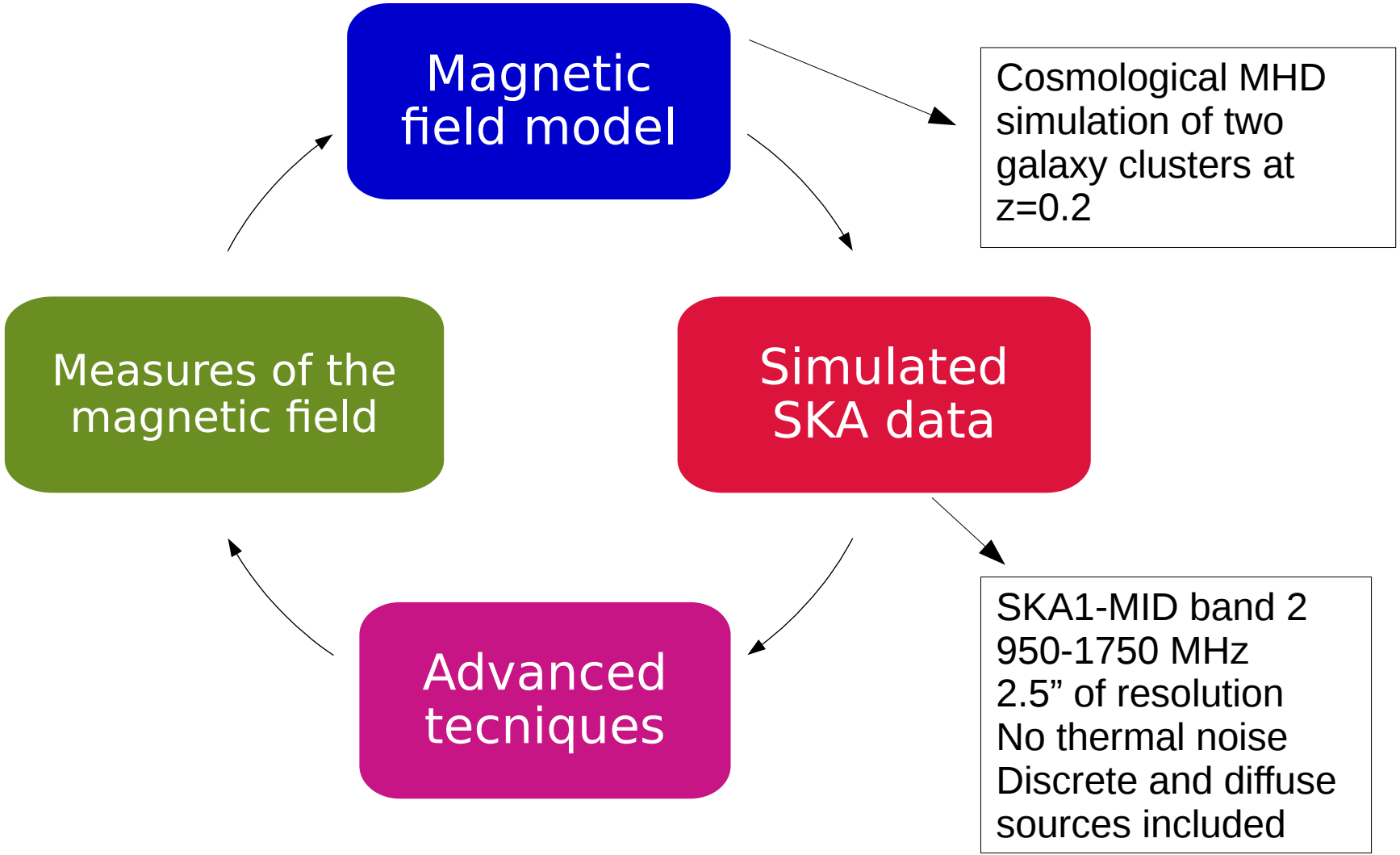
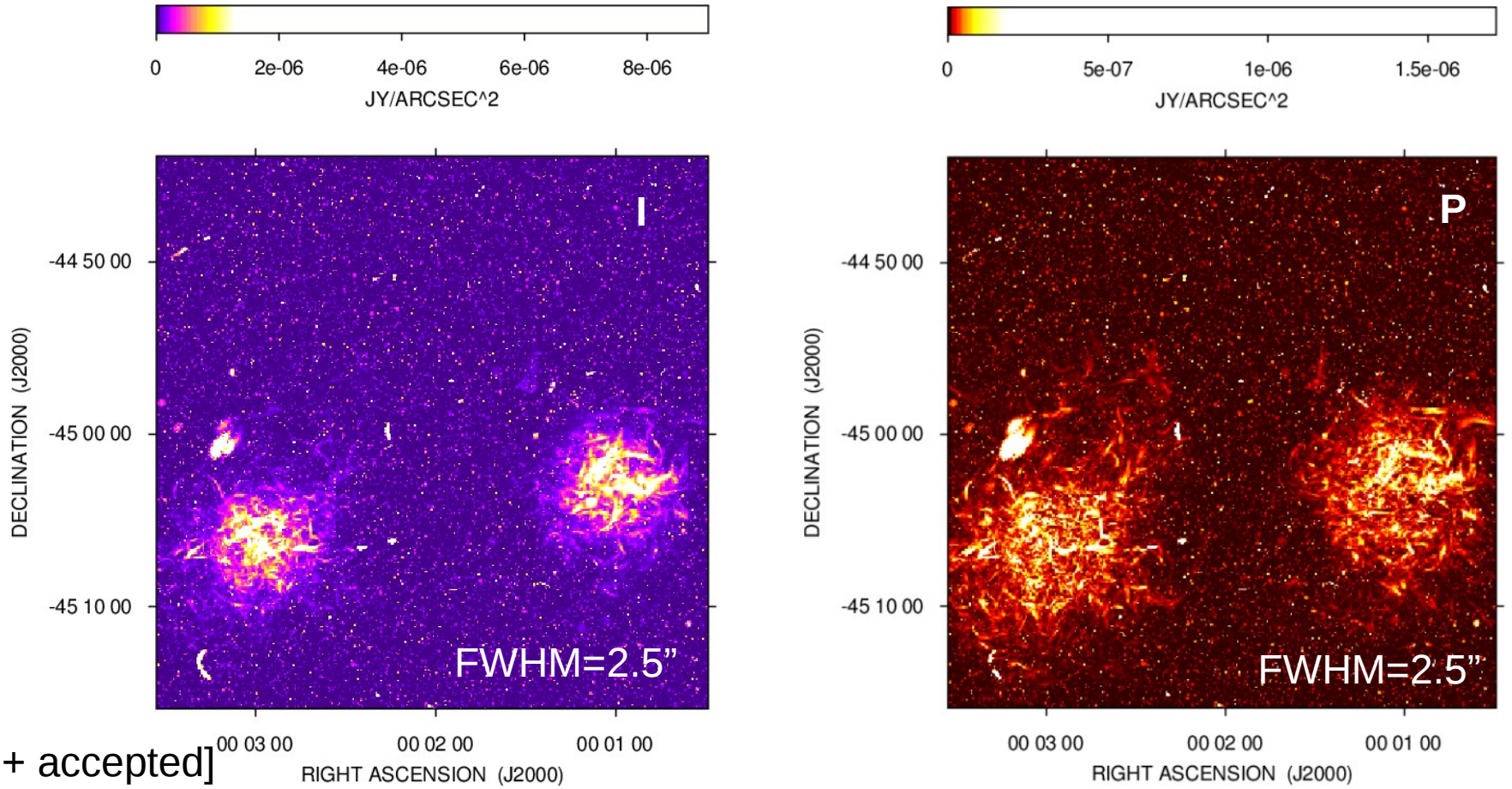
ASKAP POSSUM
σQmJy/bm= 0.001 (νGHz)^-0.8 (FWHMarcmin)^2.12 [This work]
σUmJy/bm= 0.0014 (νGHz)^-0.8 (FWHMarcmin)^2.24 [This work]
σconf [mJy/beam]
FWHM [arcsec]

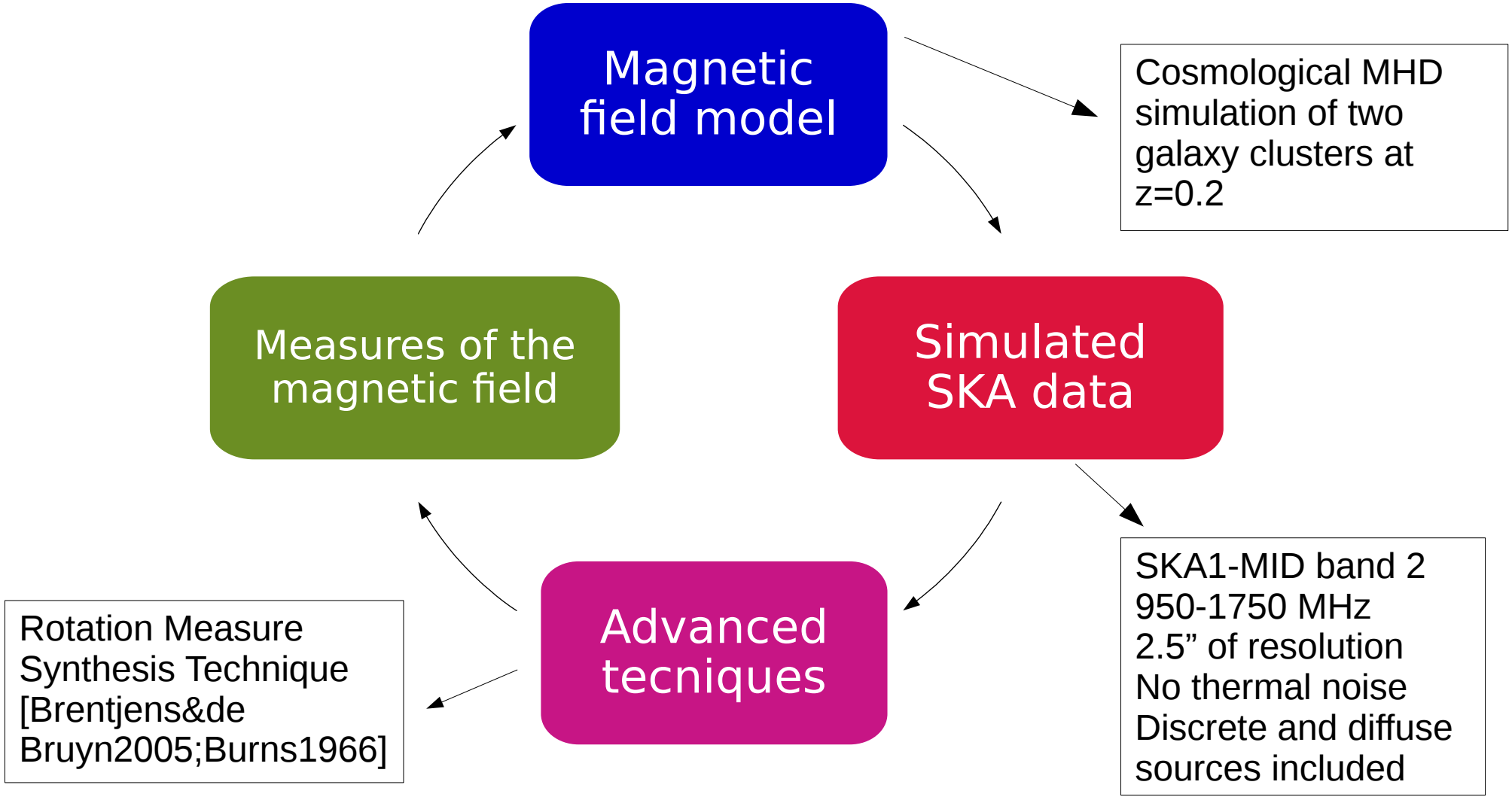

Magnetic field model
Cosmological MHD simulation of two galaxy clusters at z=0.2
Simulated SKA data
Advanced tecniques
Measures of the magnetic field


Magnetic field model
Cosmological MHD simulation of two galaxy clusters at z=0.2
Simulated SKA data
SKA1-MID band 2
950-1750 MHz
2.5” of resolution
No thermal noise
Discrete and diffuse sources included
Advanced tecniques
Measures of the magnetic field

Simulated SKA1-MID band 2 images



[Loi+ accepted]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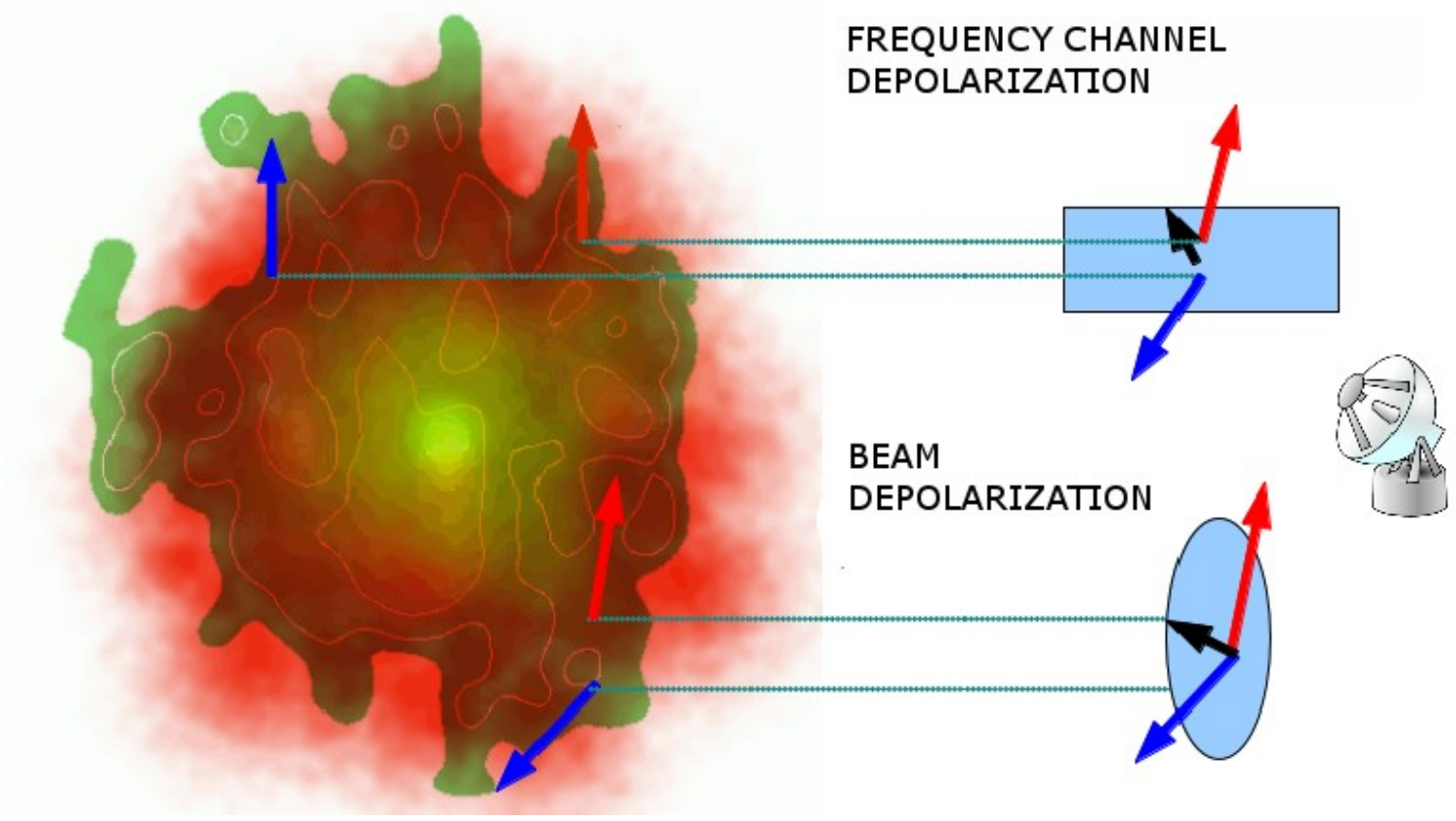
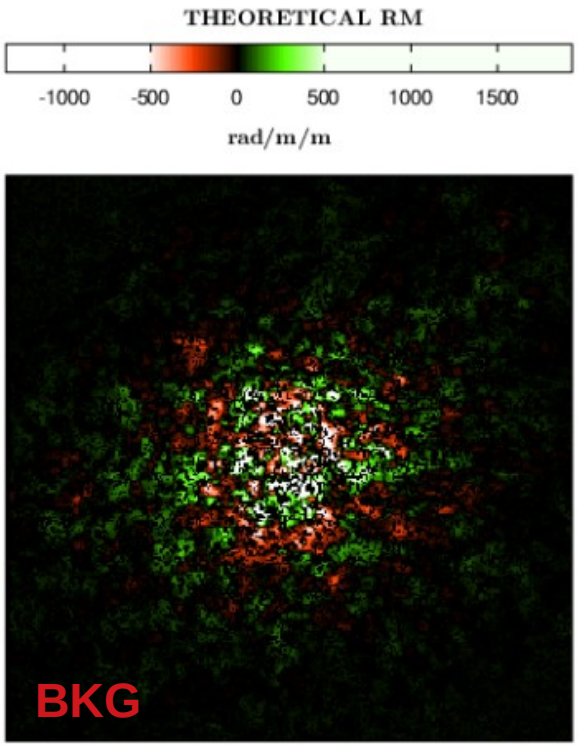
SKA1-MID band 2
950-1750 MHz
2.5” of resolution
No thermal noise
Discrete and diffuse sources included
Advanced tecniques
Rotation Measure Synthesis Technique [Brentjens&de Bruyn2005;Burns1966]
Measures of the magnetic field

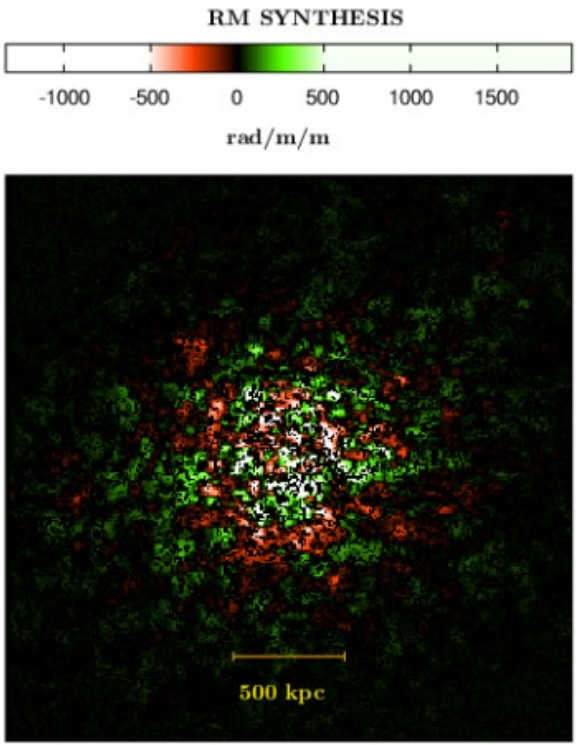
HALO DEPOLARIZATION

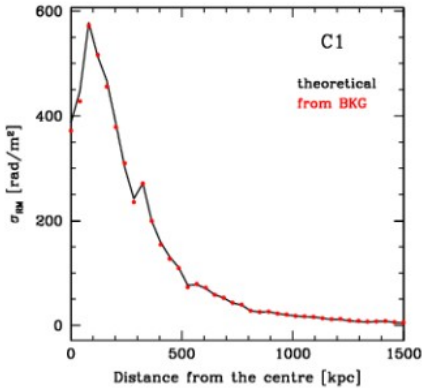
$$\Delta\Psi = RM(l) \times \lambda^2$$

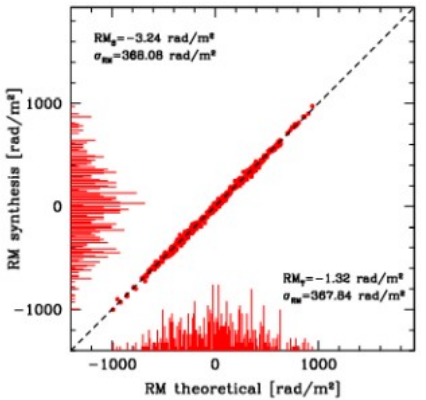


RM Synthesis on simulated data



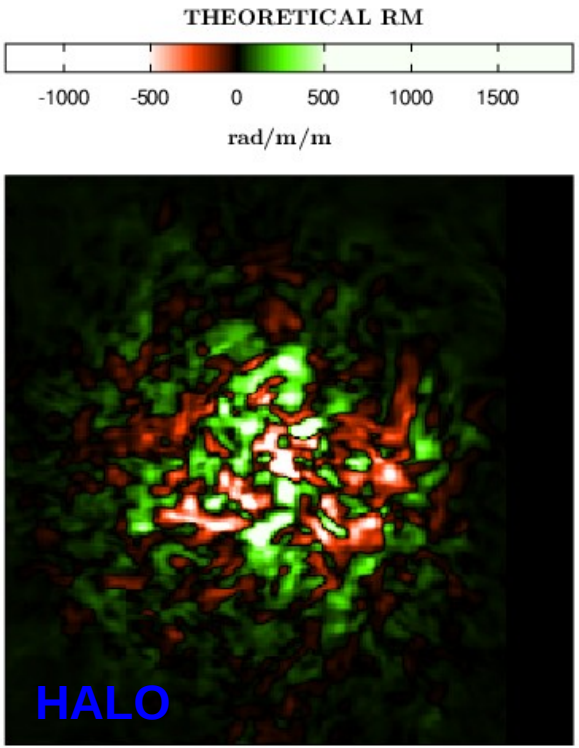


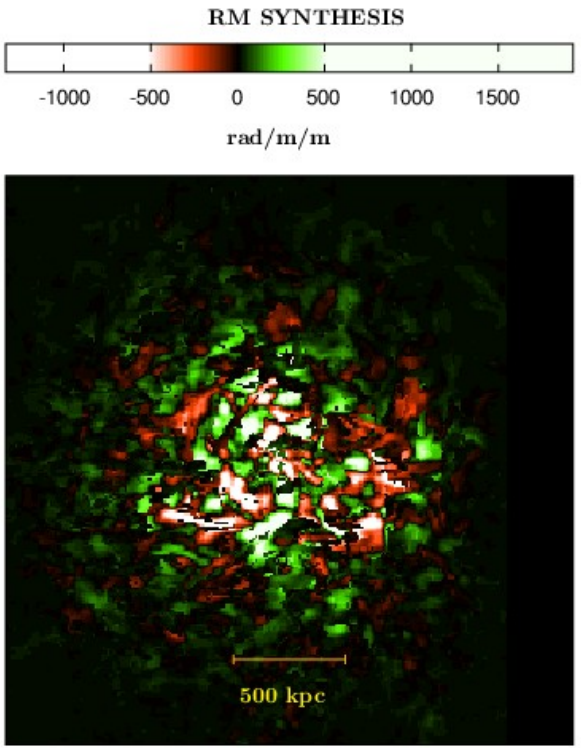


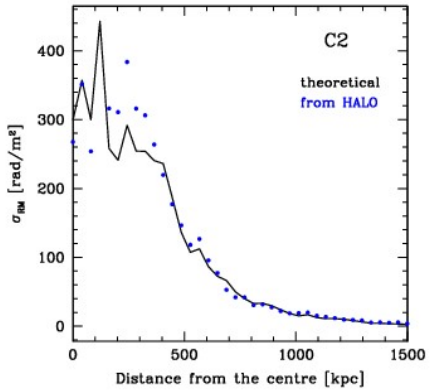


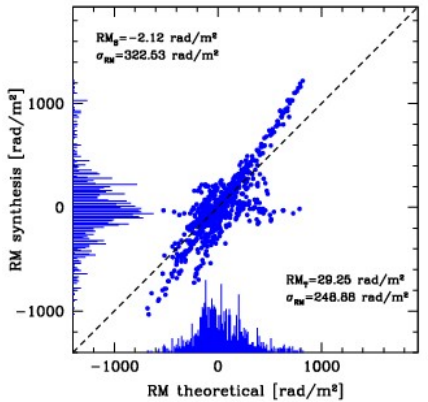
[Loi+in prep.]

RM Synthesis on simulated data



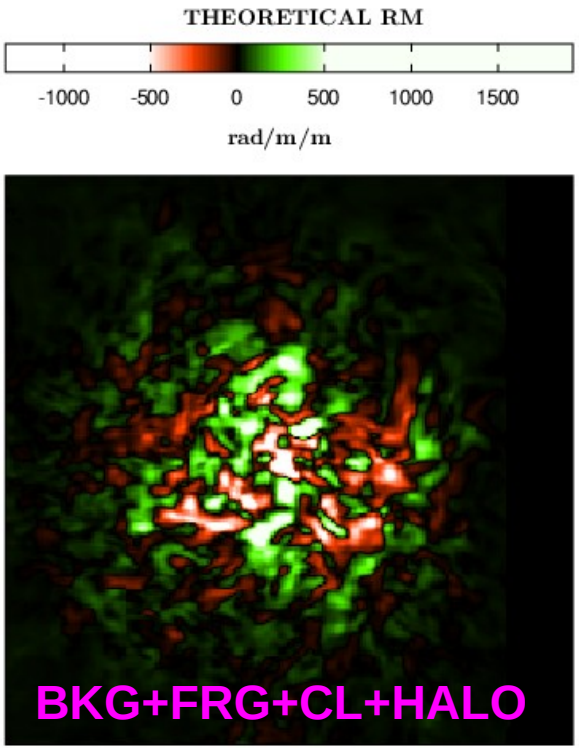


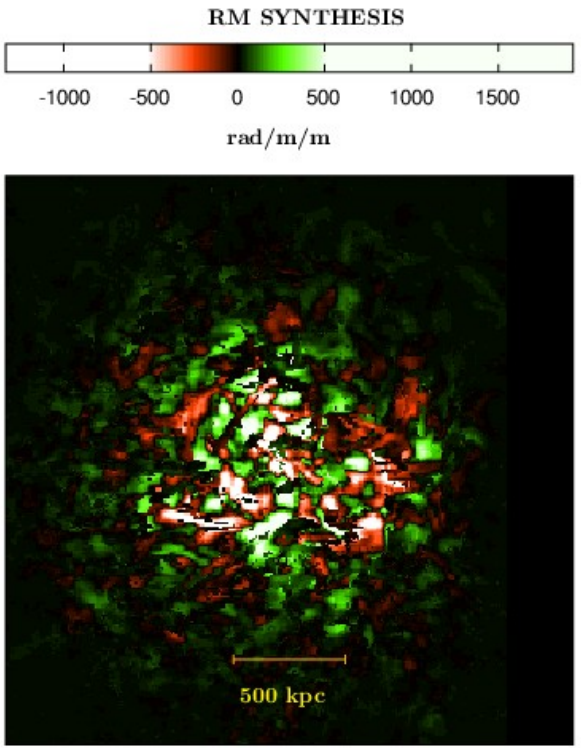


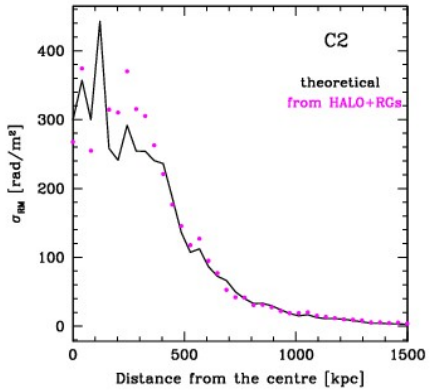


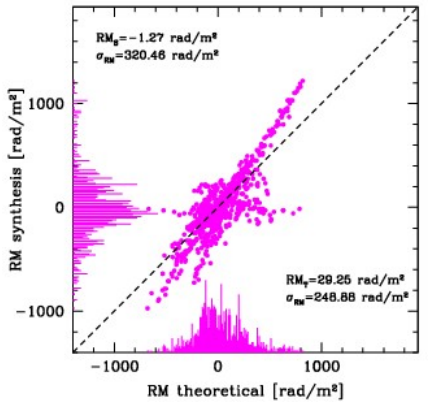
[Loi+ in prep.]

RM Synthesis on simulated data





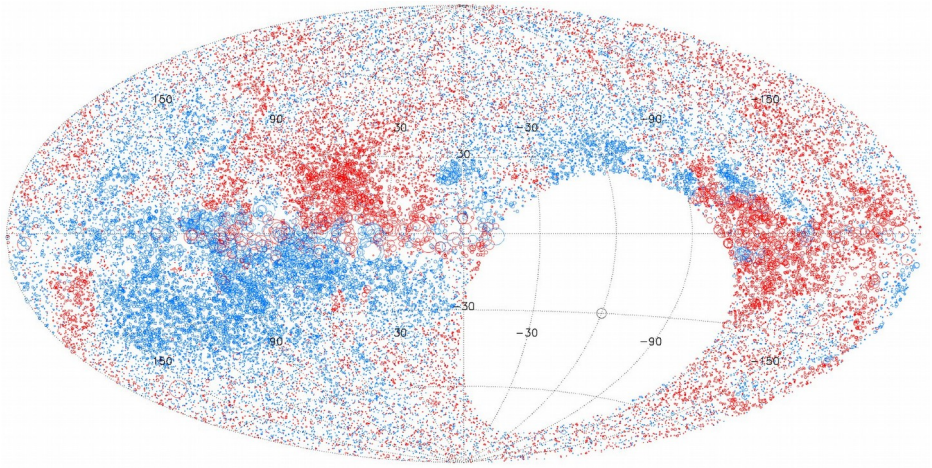




[Loi+ in prep.]

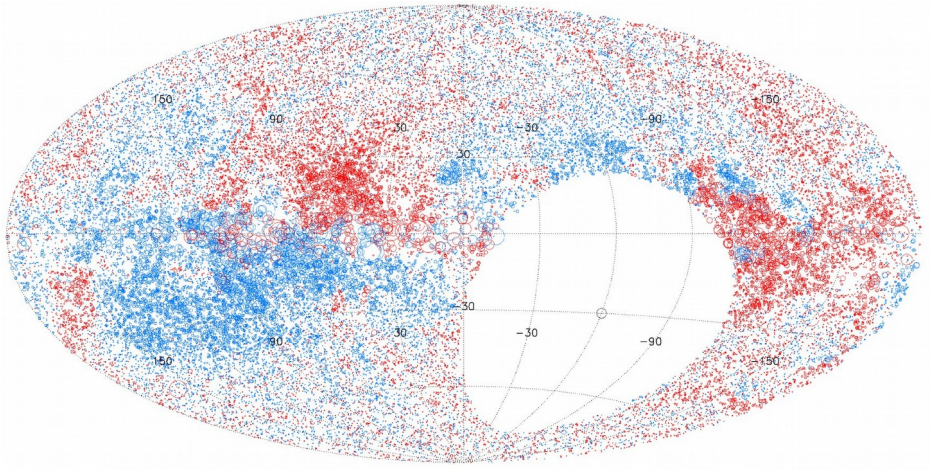
Conclusion

Cosmic magnetism with the SKA



RM grid ~ 1 RM/deg² [Taylor+ 2009]

Cosmic magnetism with the SKA

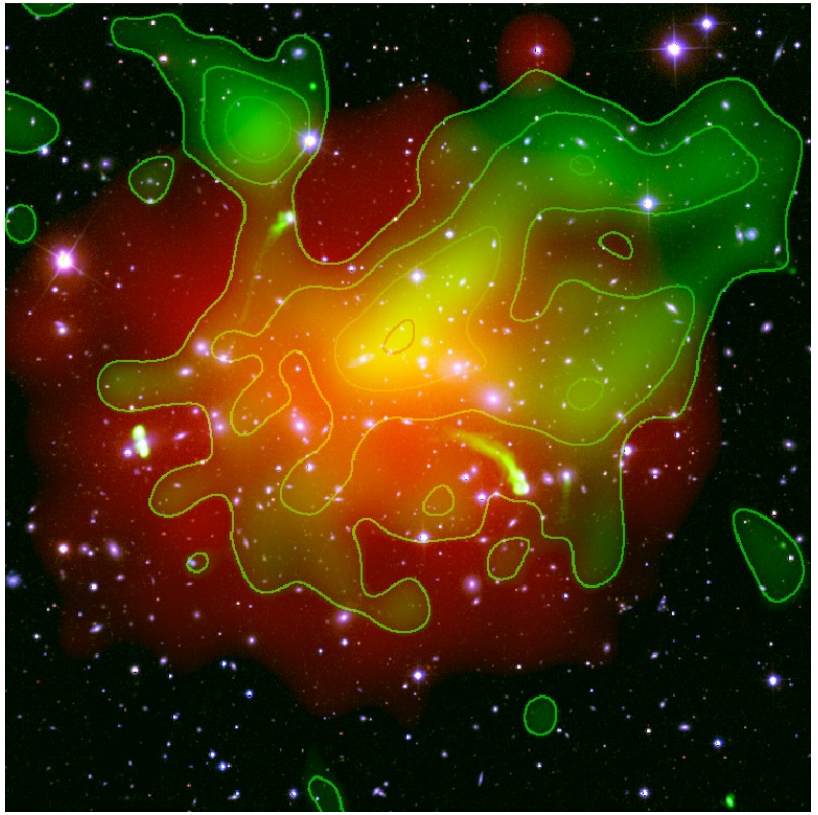


RM grid ~ 1 RM/deg² [Taylor+ 2009]

RM Grid ~ 300 RMs/deg²

Observations of diffuse radio sources

Galaxy clusters

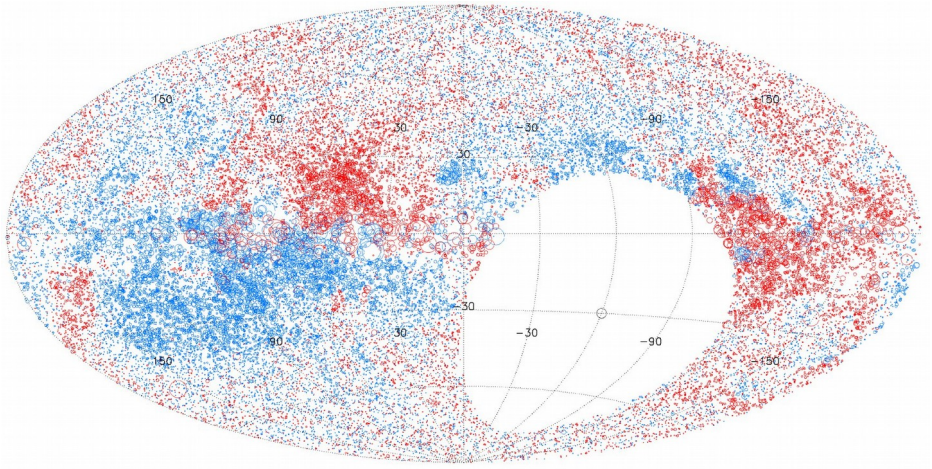


A2255 [Govoni et al. 2005, 2006]
Optical, X-ray, Radio

Radio halo:

- No optical or radio discrete counterparts
- Diffuse synchrotron source
- Low surface brightness
- 1 Mpc in size
- Polarized down to few percent

Cosmic magnetism with the SKA



RM grid ~ 1 RM/deg² [Taylor+ 2009]

RM Grid ~ 300 RMs/deg²

[Johnston-Hollitt+2015]

Observations of diffuse radio sources

New (polarized) radio halos!