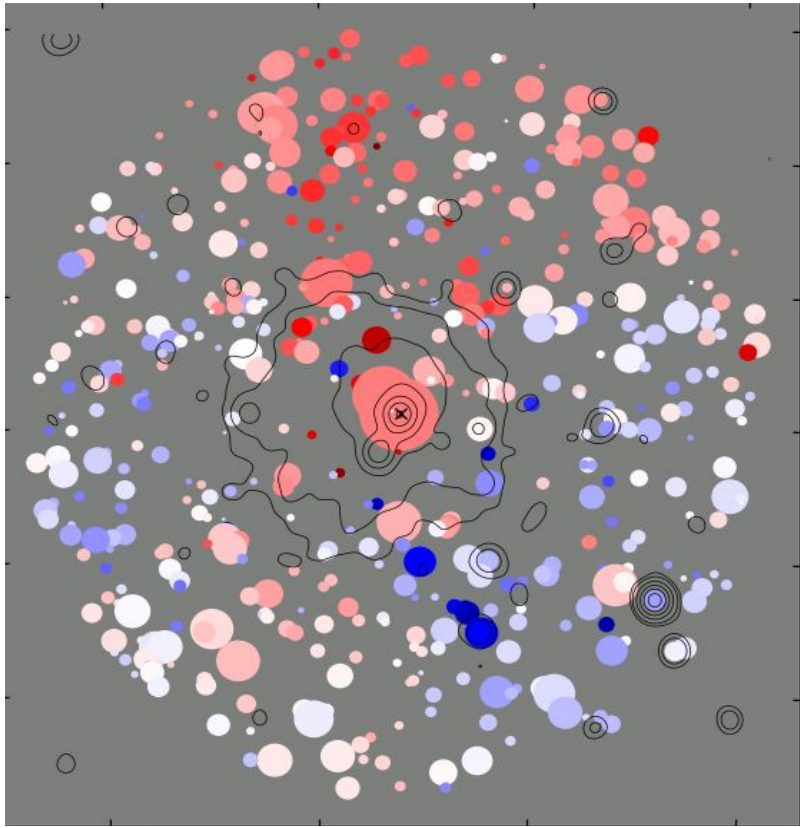
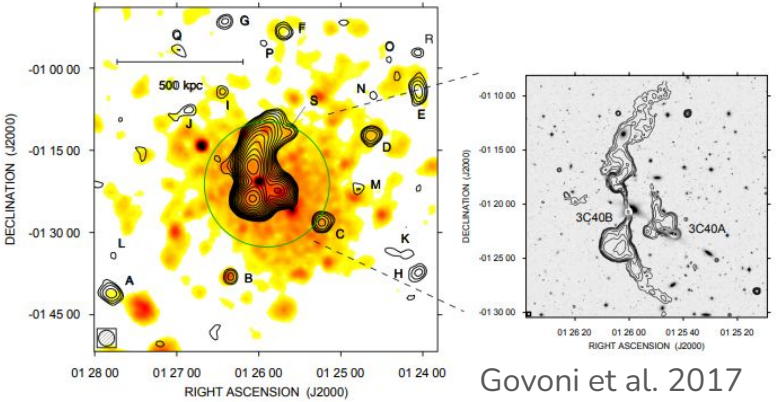


Studying physics in galaxy clusters with dense rotation measure grids

Francesca Loi @ INAF-OAC

The Faraday effect

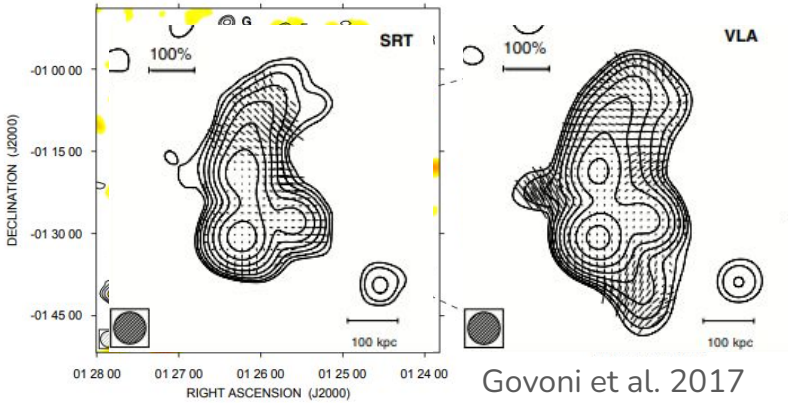
A194 – SRT 6.6 GHz – VLA 1.4 GHz



Govoni et al. 2017

The Faraday effect

A194 – SRT 6.6 GHz – VLA 1.4 GHz



Govoni et al. 2017

The Faraday effect

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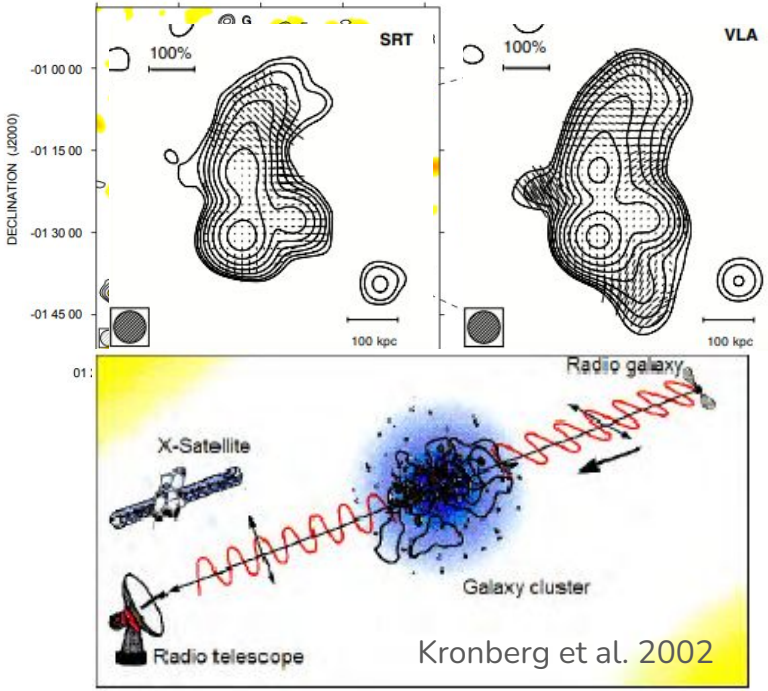
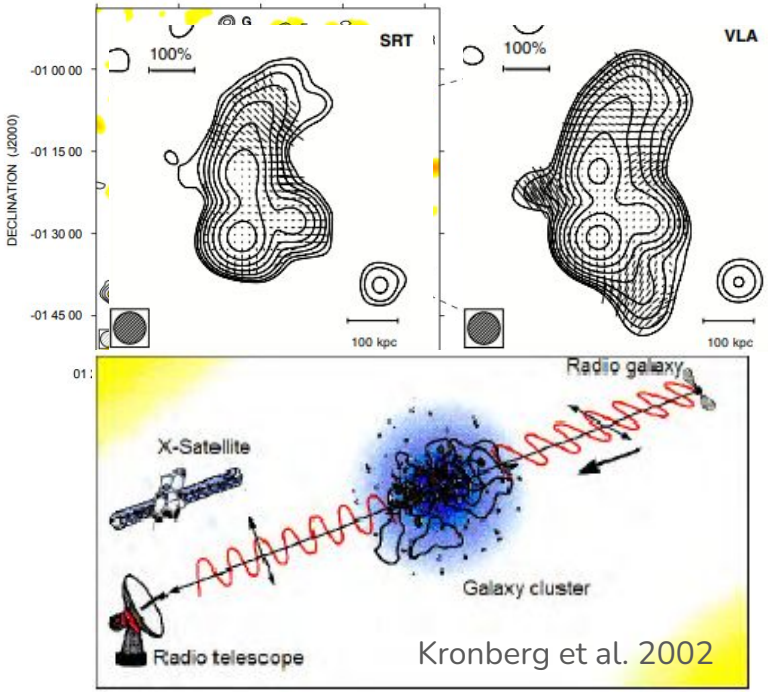


Kronberg et al. 2002

Govoni et al. 2017

The Faraday effect

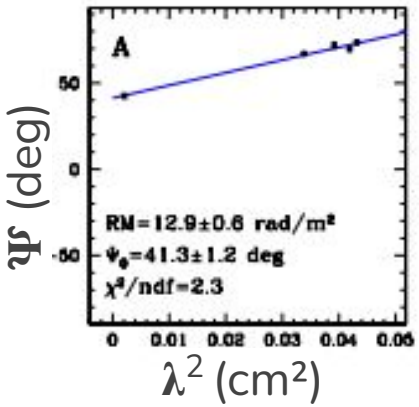
A194 – SRT 6.6 GHz – VLA 1.4 GHz



Kronberg et al. 2002

$$\Delta\Psi = RM \cdot \lambda^2$$

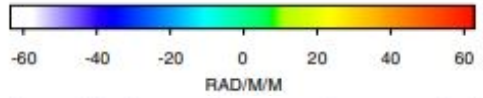
$$RM = \int B_{||} \cdot n_e \cdot dl$$

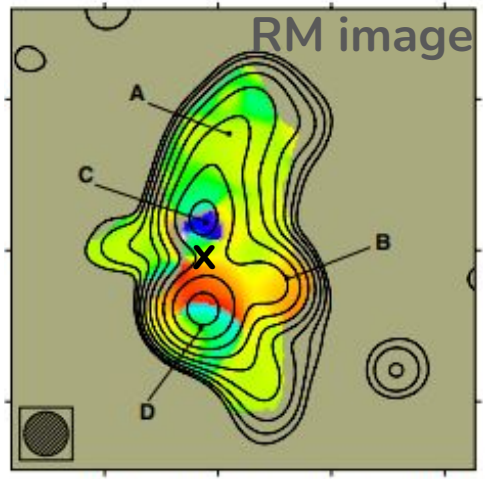


Govoni et al. 2017

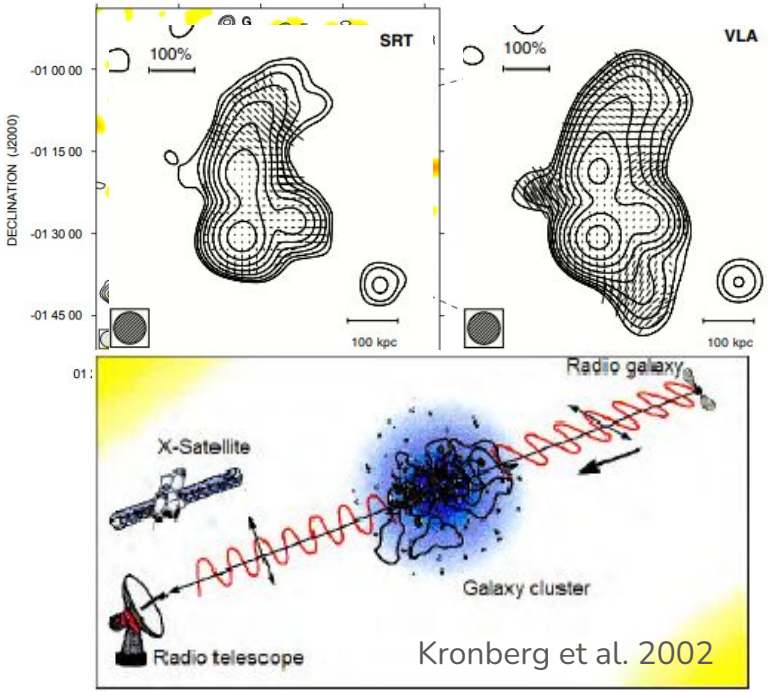
The Faraday effect

Govoni et al. 2017





A194 – SRT 6.6 GHz – VLA 1.4 GHz



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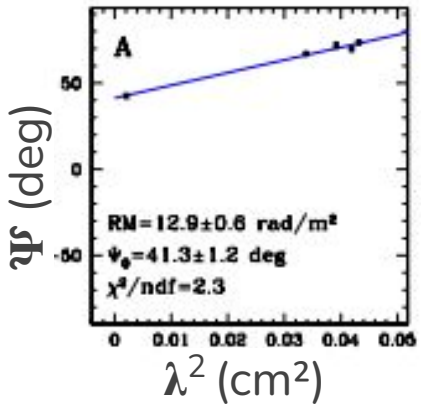
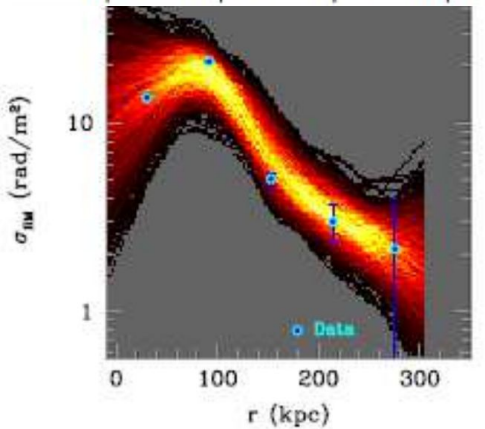




The RM grid

SKA Cosmic Magnetism Science Working Group:

950-1760 MHz

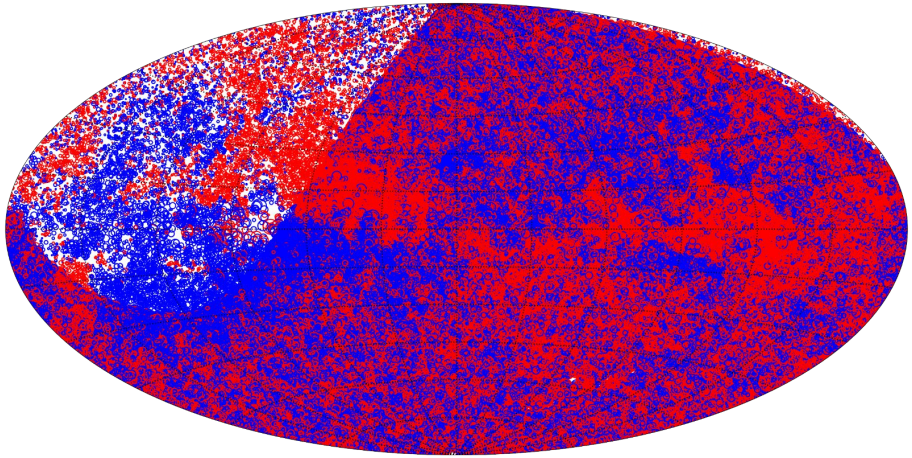
4 μJy/beam of sensitivity

2 arcsec of resolution

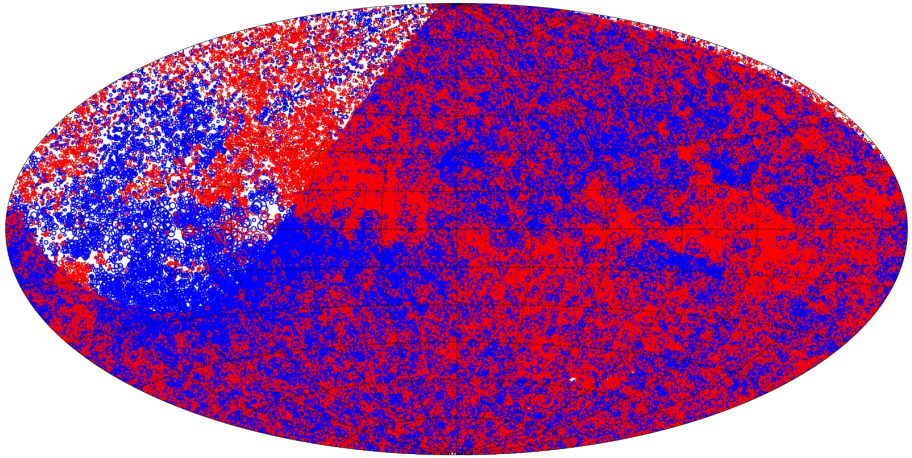
60–90 pol.sources/deg²

30’000 pointings, 15 min/pointing

Heald+2020 (see also the update in Loi et al. in the SKA white book)



The RM grid



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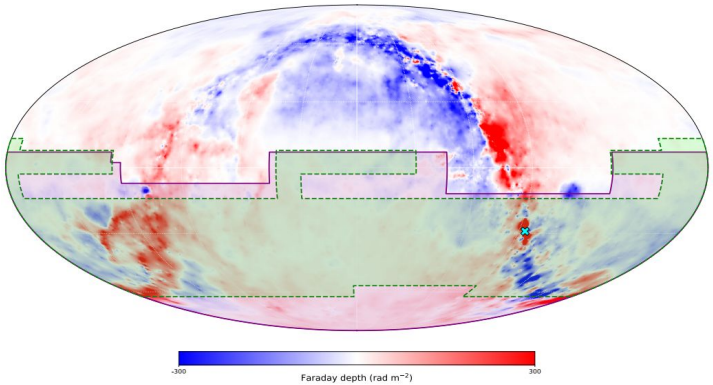


Polarisation Sky Survey of the Universe’s Magnetism (POSSUM)

All-sky survey of the Southern Sky

800–1088 MHz

18 μJy/beam sensitivity

20'' of resolution

30–50 pol.sources/deg²

10 hrs/pointing

Gaensler+2025

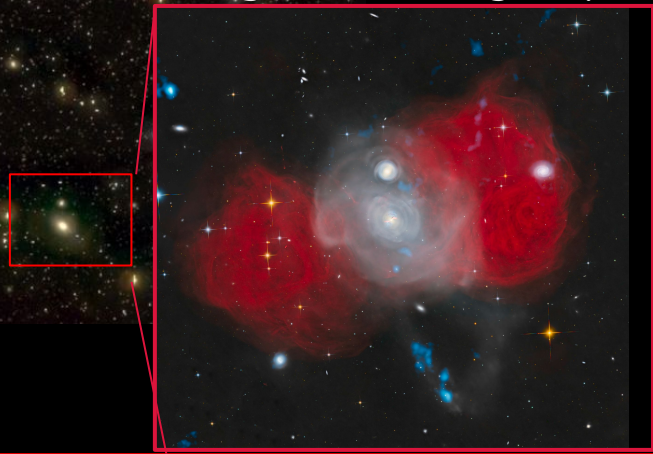
The MeerKAT Fornax Survey

One of the 5 key science projects
(P.I. P. Serra)

Low Mass Cluster: ~5×10^{13} M_{sun}

Nearby: ~20 Mpc

Infalling Fornax A group



Fornax Deep Survey (VST)

The MeerKAT Fornax Survey

91 pointings (2x5hrs)

zoom band data to study galaxy evolution with HI

(see Serra+2023, Loni+2023, Kleiner+2023,...)

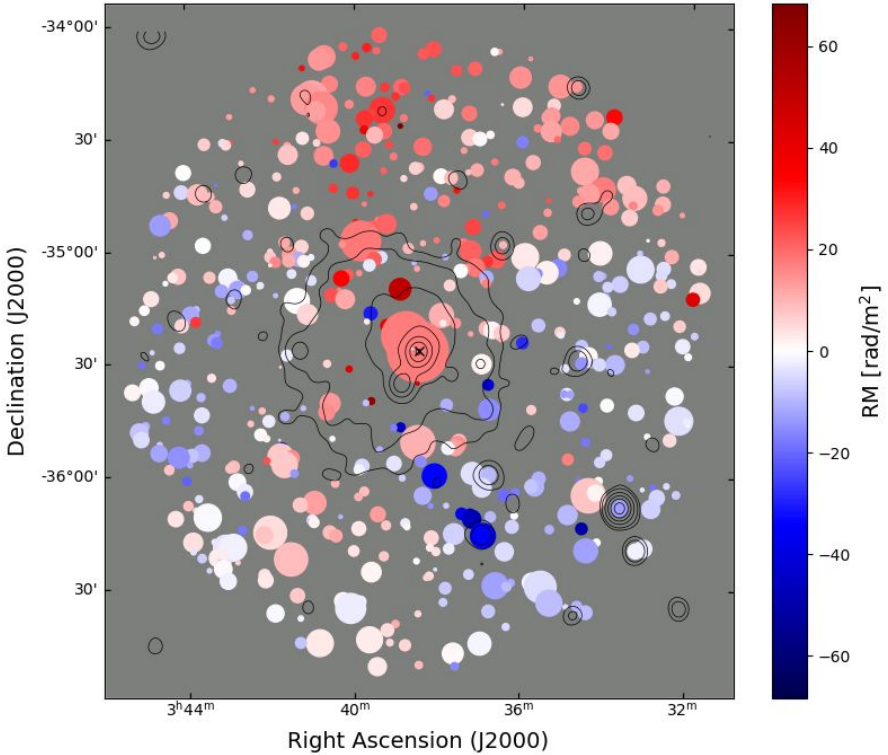
broadband full-Stokes data between 0.9 – 1.4 GHz

(Loi+2025, Loi+ to be sub.., ...)

~1PB of data processed with

CARACAL

The MFS RM grid: an anticipation of the SKA-mid



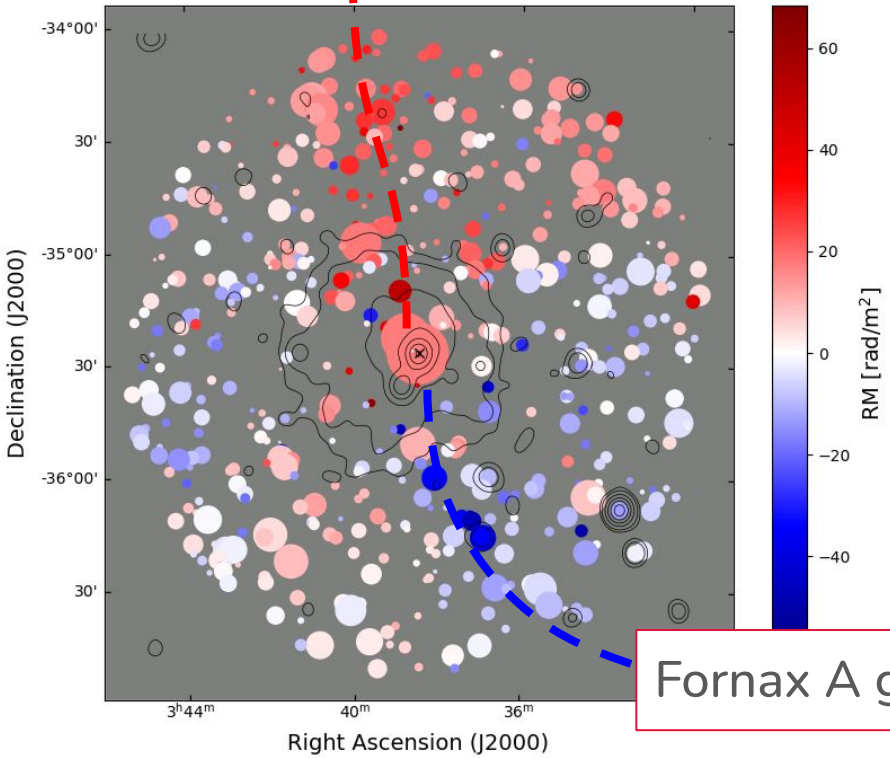
r<1.42deg (~500 kpc) (r_c=173 kpc)

13 arcsec of resolution (~1 kpc)
σ ~ 2.6 μJy/beam (1.4–19 μJy/beam)

508 polarized sources detected in ~6.35 deg²
→ 80 p.sources/deg²

Loi et al. 2025

The Eridanus group d: an anticipation of the SKA-mid



Fornax A group

r<1.42deg (~500 kpc) (r_c=173 kpc)

13 arcsec of resolution (~1 kpc)
σ ~ 2.6 μJy/beam (1.4–19 μJy/beam)

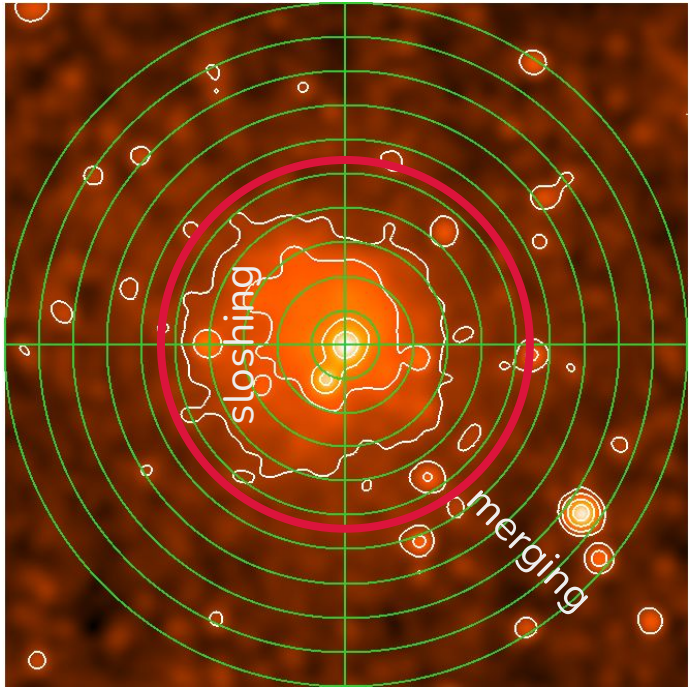
508 polarized sources detected in ~6.35 deg²
→ 80 p.sources/deg²

A dense RM grid reveals unexpected features

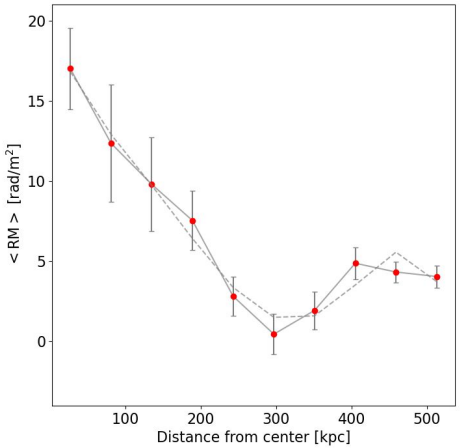
Localized RM enhancement as a consequence of accretion phenomena within the cluster virial radius

Loi et al. 2025

RM directional profiles

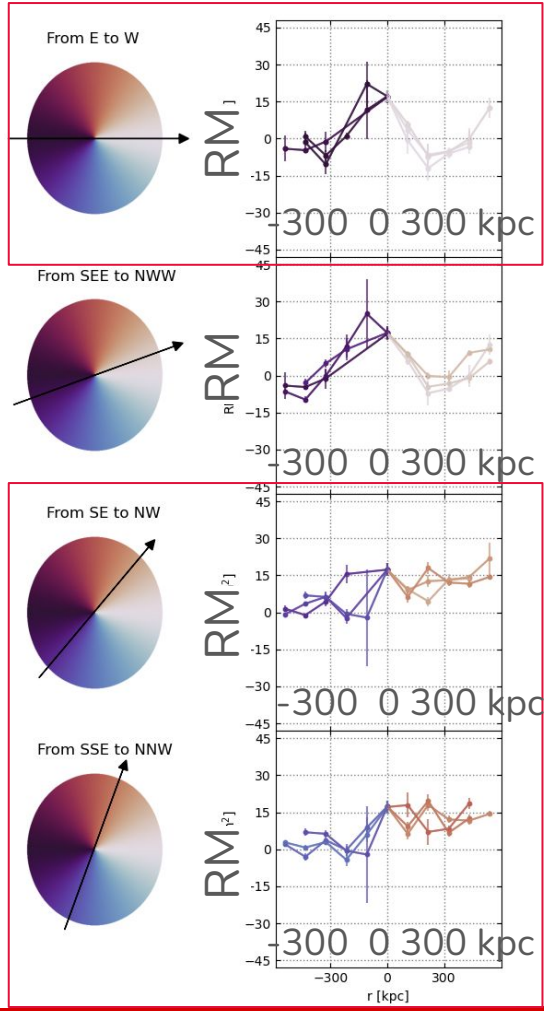


Loi et al. 2025

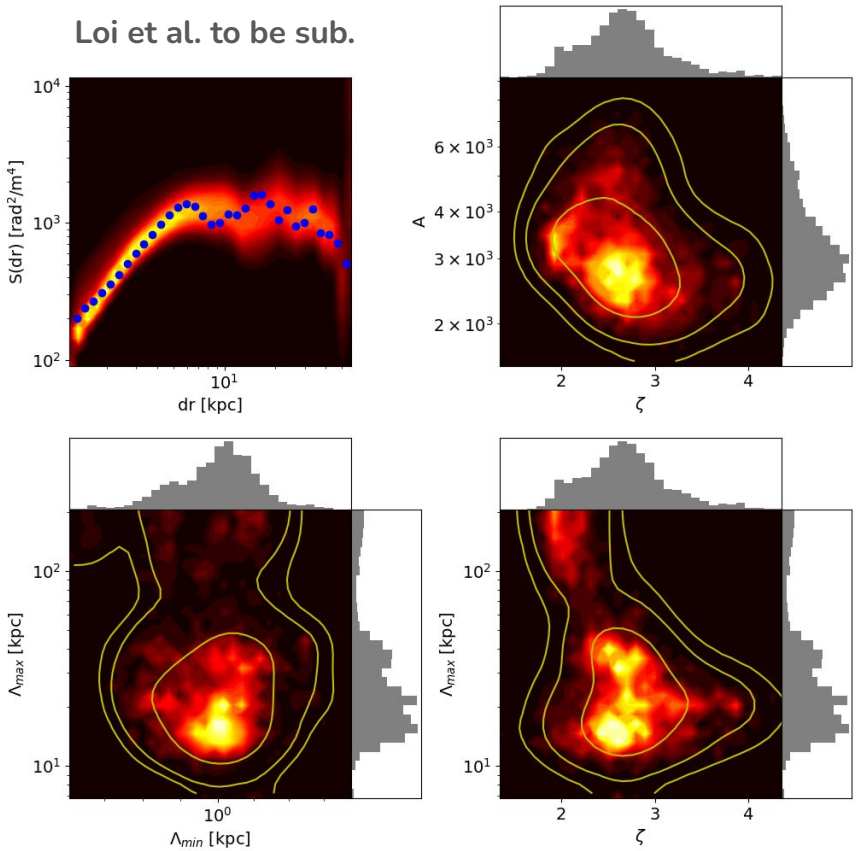


RM depends on:

- n_e thermal plasma density
- B strength
- **Λ_c magnetic field auto-correlation length**



B measurements



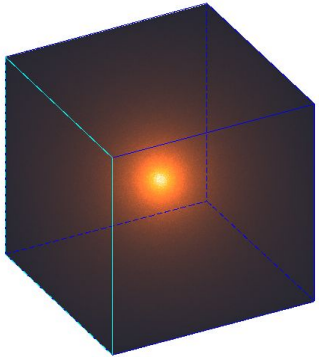
Simulations of the RM images with the FARADAY tool (Murgia et al. 2004):

bayesian inference to maximize the posterior probability of the observed **RM Structure function**

$$|B_k|^2 = A \cdot k^{-\zeta}$$

$n = 2.7 \pm 0.4$
$\Lambda_{min} = 1.01 \pm 0.02$ kpc
$\Lambda_{max} = 15 \pm 9$ kpc
$\Lambda_c = 3.4 \pm 1$ kpc

B measurements



thermal plasma model

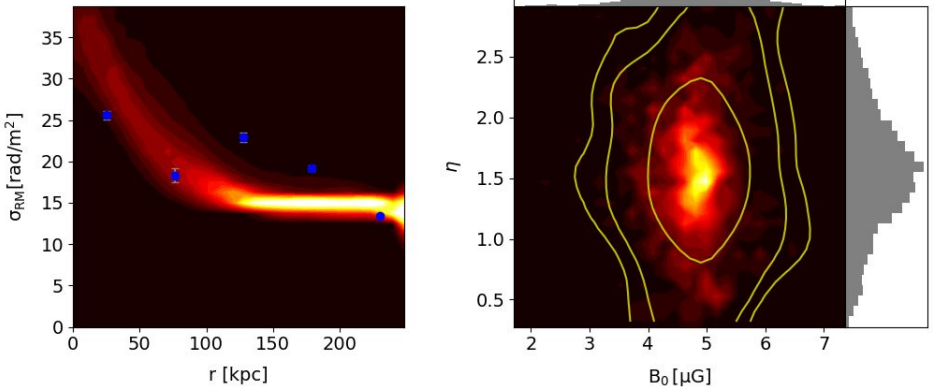
sim. RM

Simulations of the RM images with the FARADAY tool (Murgia et al. 2004):

bayesian inference to maximize the posterior probability of the observed **RM radial profile**

$$B(r) = B_0 \, (n(r)/n_0)^{\eta}$$

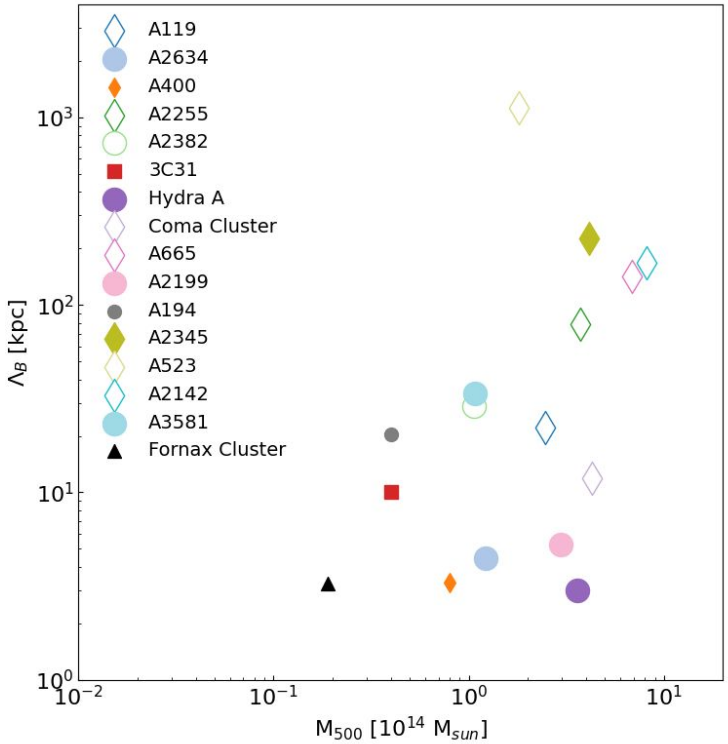
Loi et al. to be sub.



$B_0 \simeq 5$ μG

$\eta \simeq 1.6$

Comparison with the literature



How to read it:

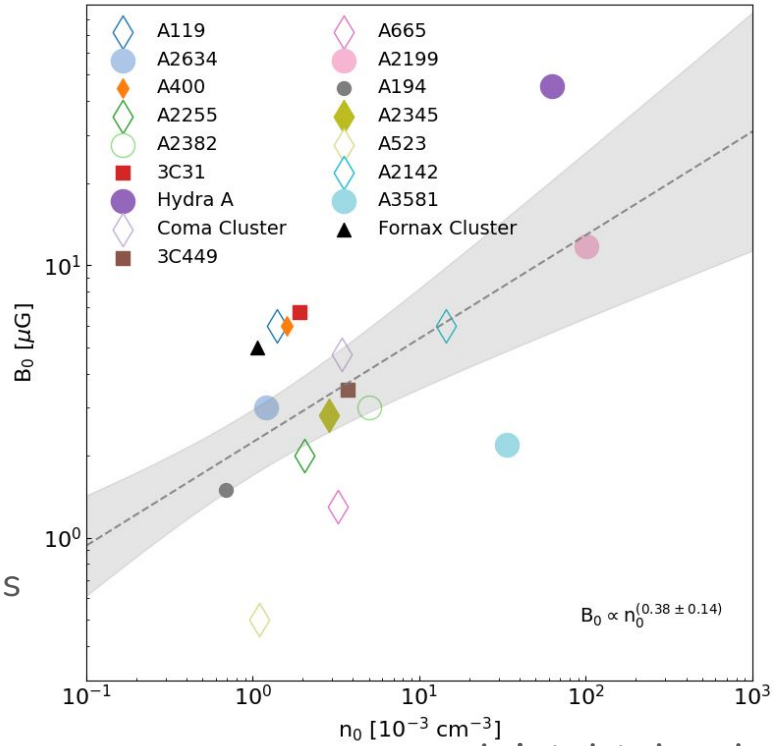
big = massive
small = low mass

circle = relaxed
diamond = merger

square = group

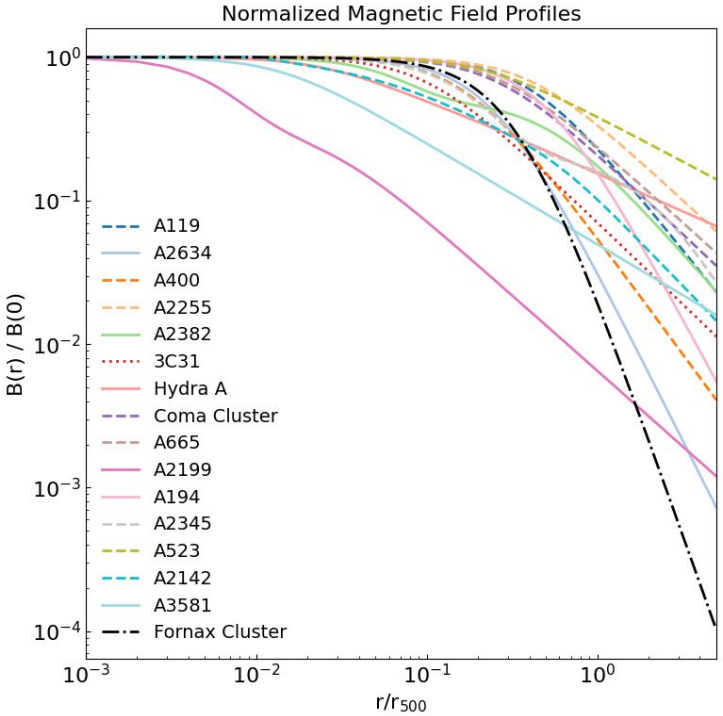
triangle = ?

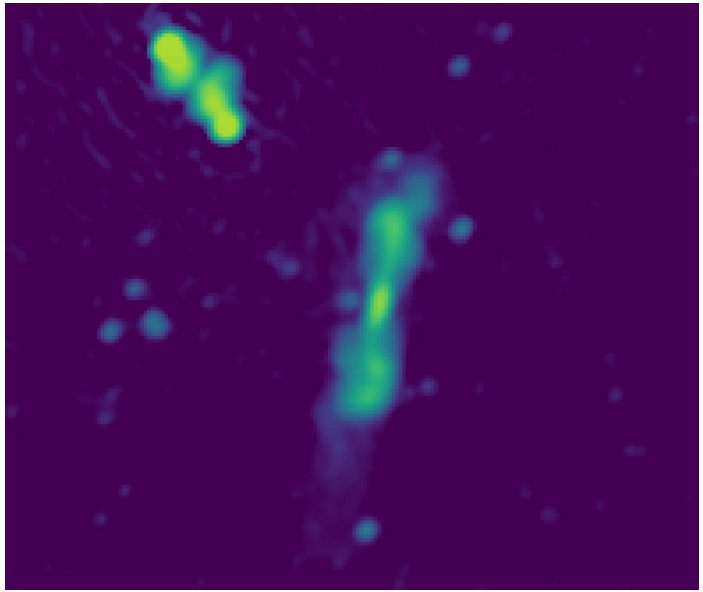
filled = extended RGs at the center
empty = no RGs at the center



Loi et al. to be sub.

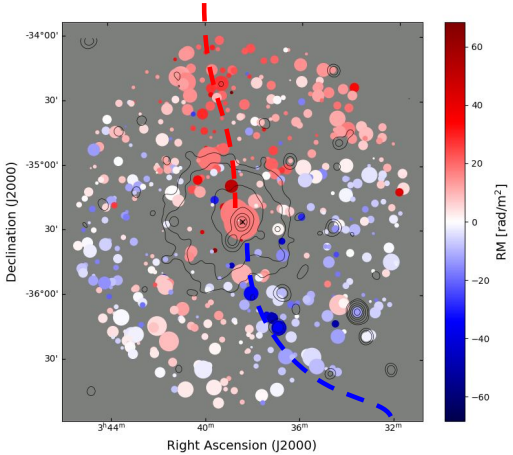
Comparison with the literature

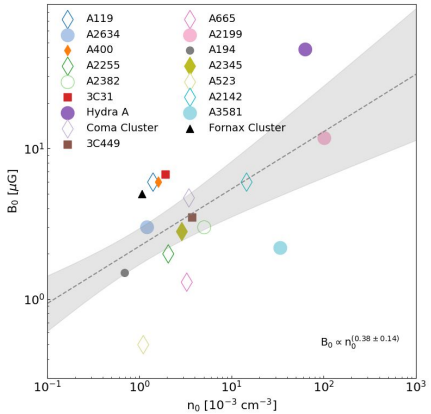




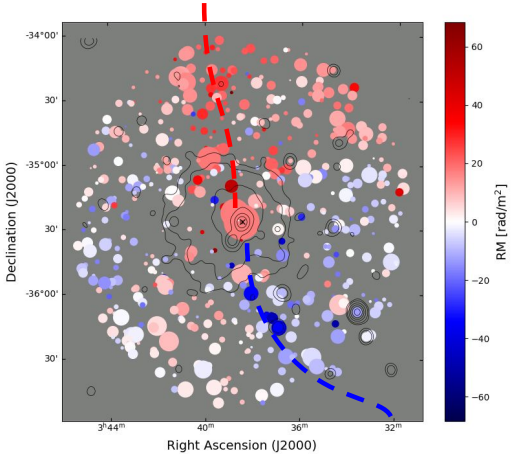
Loi et al. to be sub.

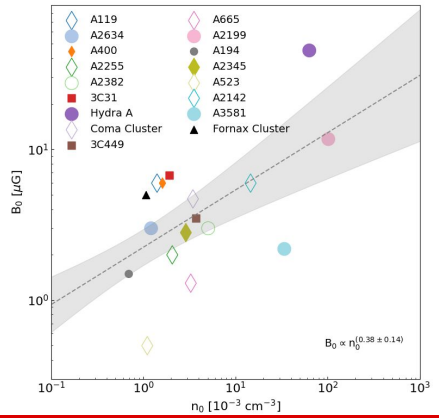
Conclusion


-34°00'
30'
-35°00'
30'
-36°00'
30'
Declination (J2000)
3h44m
40m
36m
32m
Right Ascension (J2000)
60
40
20
0
−20
−40
−60
RM [rad/m²]


A119
A2634
A400
A2255
A2382
3C31
Hydra A
Coma Cluster
3C449
A665
A2199
A194
A2345
A523
A2142
A3581
Fornax Cluster
B0 [μG]
n0 [10−3 cm−3]
B0 ∝ n0(0.38 ± 0.14)

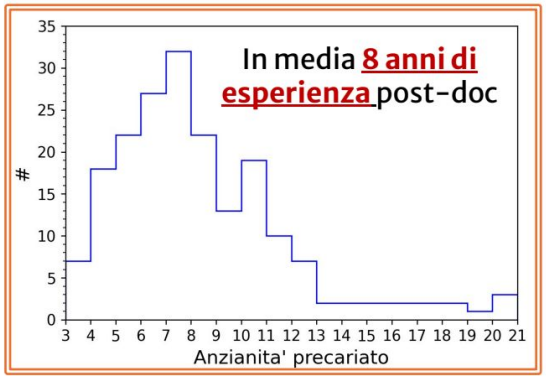
Conclusion



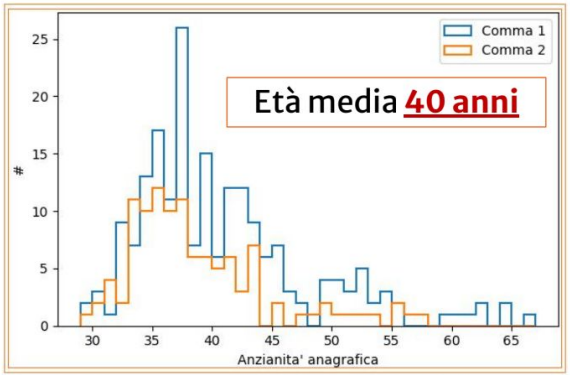


La situazione del personale precario in INAF è INSOSTENIBILE!

1.200 TI Vs 650 precari: più di 1 precario ogni 2 persone di ruolo



Plot di un campione rappresentativo dei precari INAF al 31/12/2024



Dei 650: "comma 1 e 2" → 181+114=295

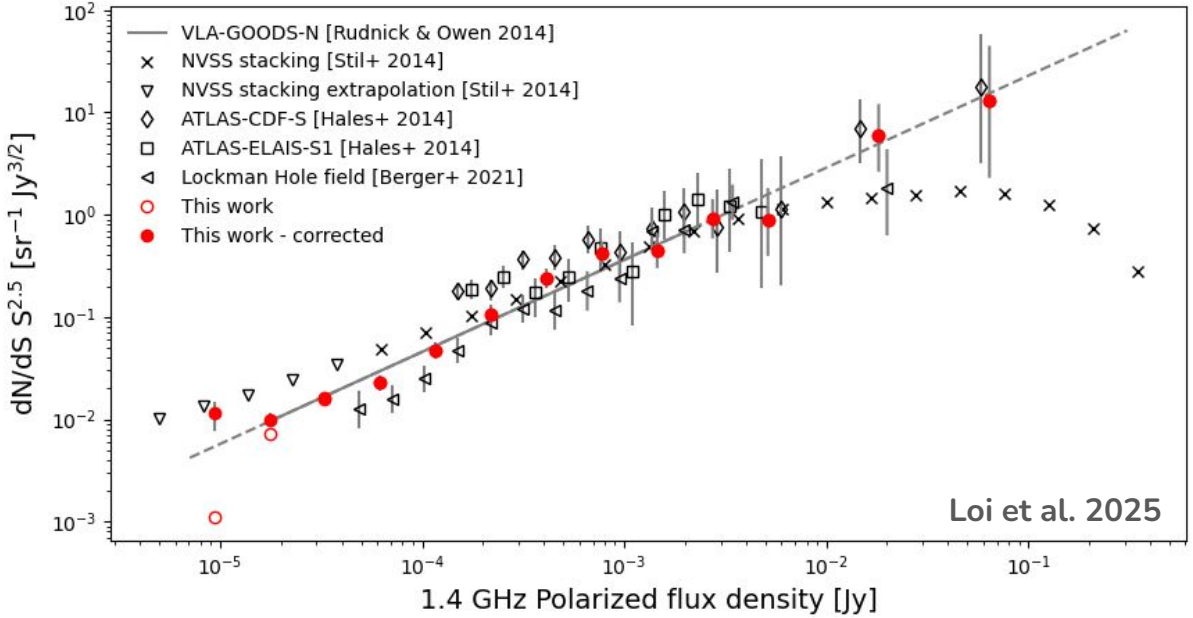
Entro l'anno, l'attuale situazione determinerà l'esodo di > 100 lavoratori altamente qualificati e il MUR se ne lava le mani

È URGENTE che INAF PROCEDA ORA con le STABILIZZAZIONI TRAMITE MADIA: unica soluzione per questa emergenza

Molti colleghi (972) hanno già firmato per sostenerci, fallo anche tu. Scrivi a
retestabilizzandi1.inaf@gmail.com

Backup slides

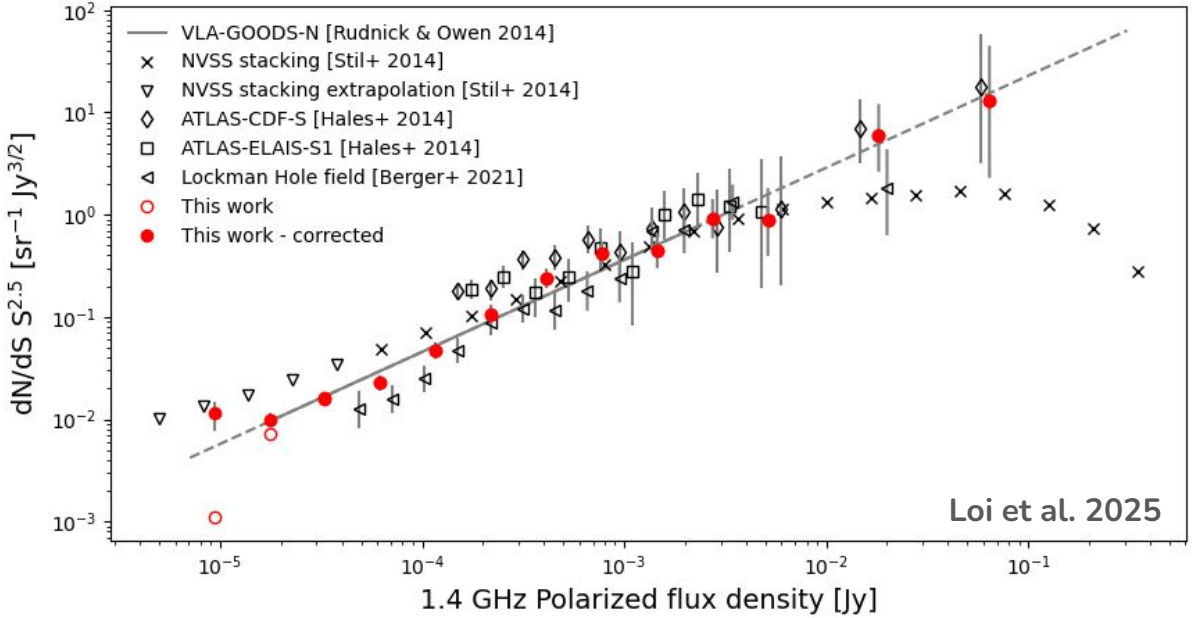
Euclidean normalized differential P source counts



508 polarized sources detected (13 arcsec, σ_{QU} ~ 1.4÷19 μJy/beam)

↝ **80 pol.sources/deg²**

Euclidean normalized differential P source counts



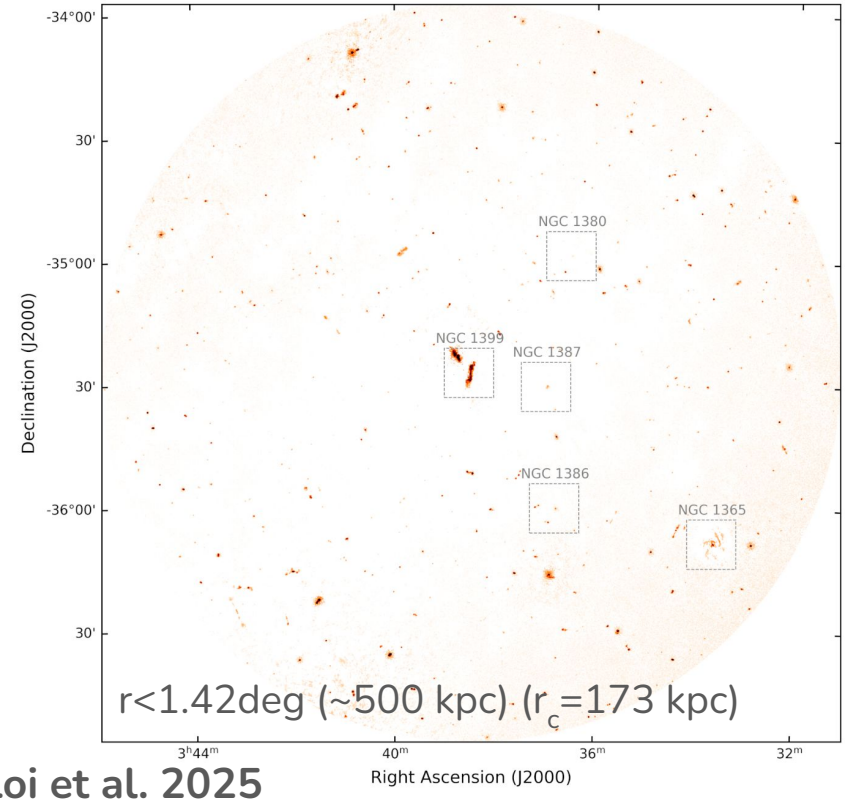
508 polarized sources detected (13 arcsec, σ_{QU} ~ 1.4÷19 μJy/beam)

↝ 80 pol.sources/deg²

Considering the completeness correction there could be **1007 polarized sources**

↝ **160 pol.sources/deg²**

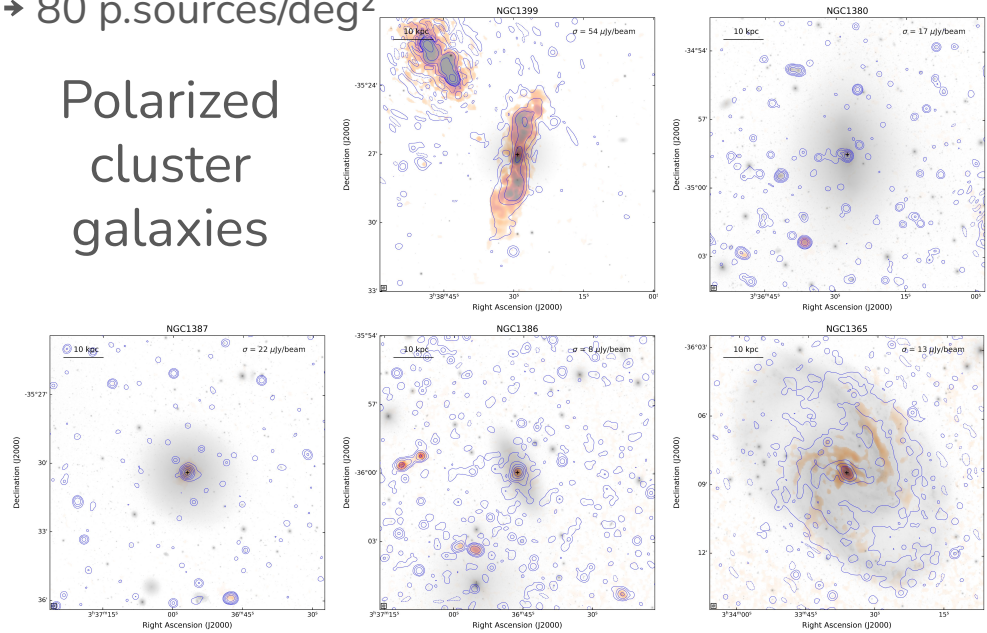
Polarized intensity mosaic (after RM synthesis)



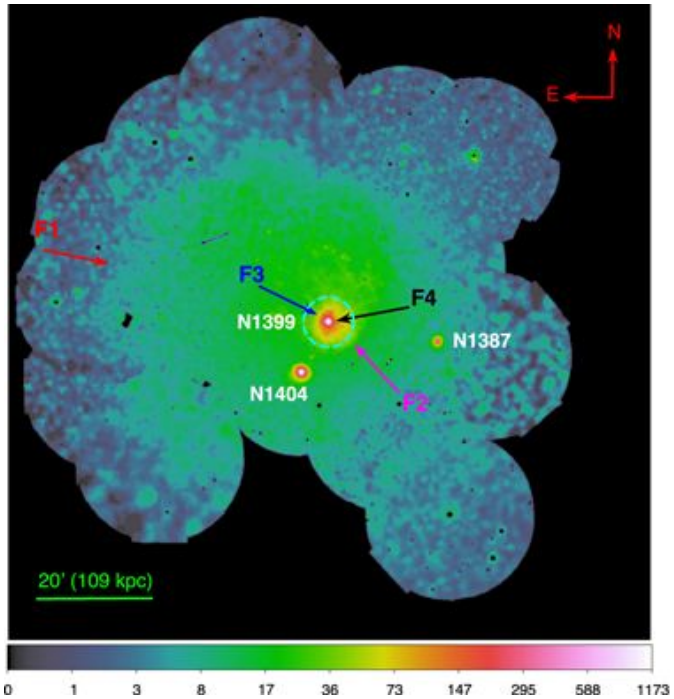
Loi et al. 2025

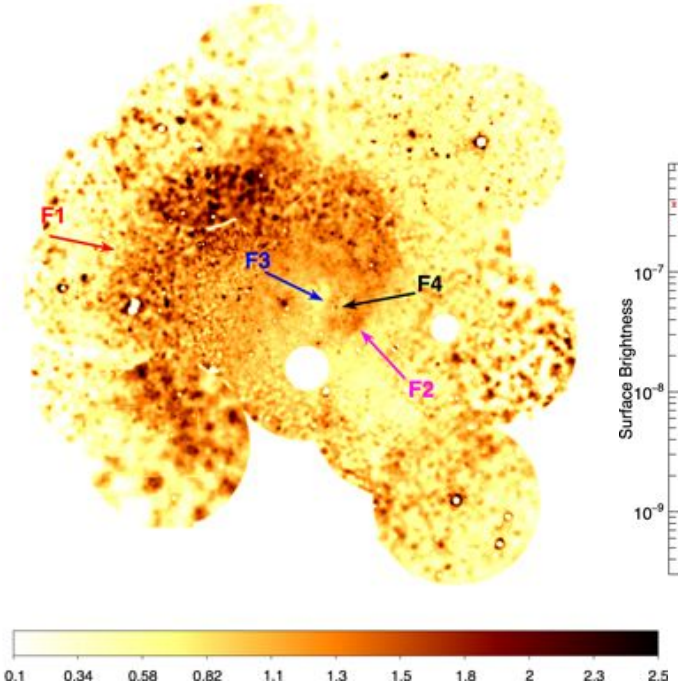
13 arcsec of resolution (~1 kpc)
σ ~ 2.6 μJy/beam (1.4–19 μJy/beam)
508 polarized sources detected in ~6.35 deg²
➔ 80 p.sources/deg²

Polarized cluster galaxies

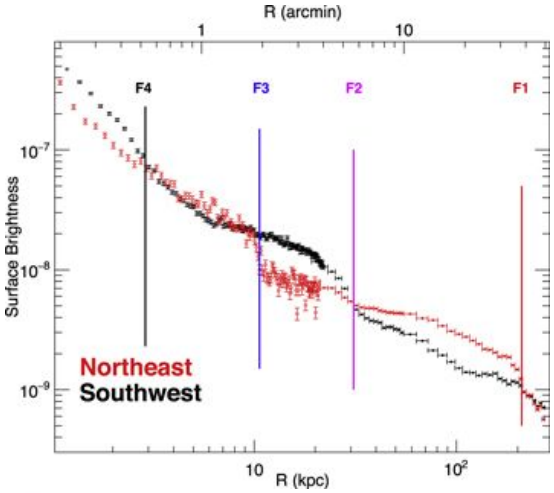


“Gas sloshing Regulates and Records the Evolution of the Fornax Cluster”





XMM-Newton mosaic image and residual image



Su et al. 2017