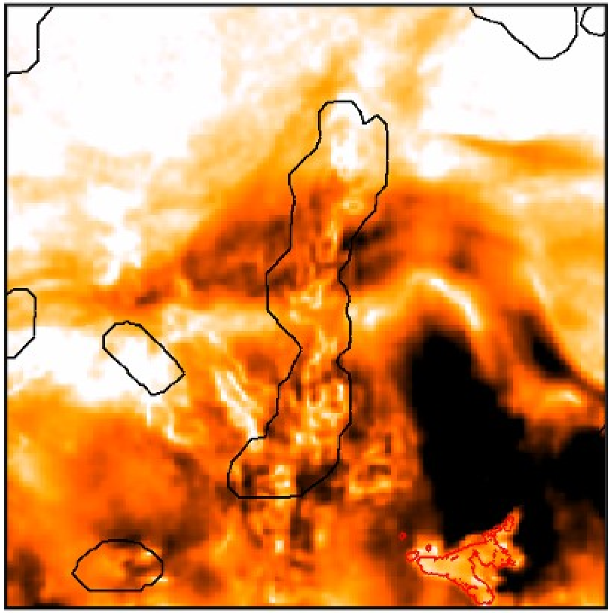
The Third National Workshop on the SKA Project - The Italian Route to the SKAO Revolution

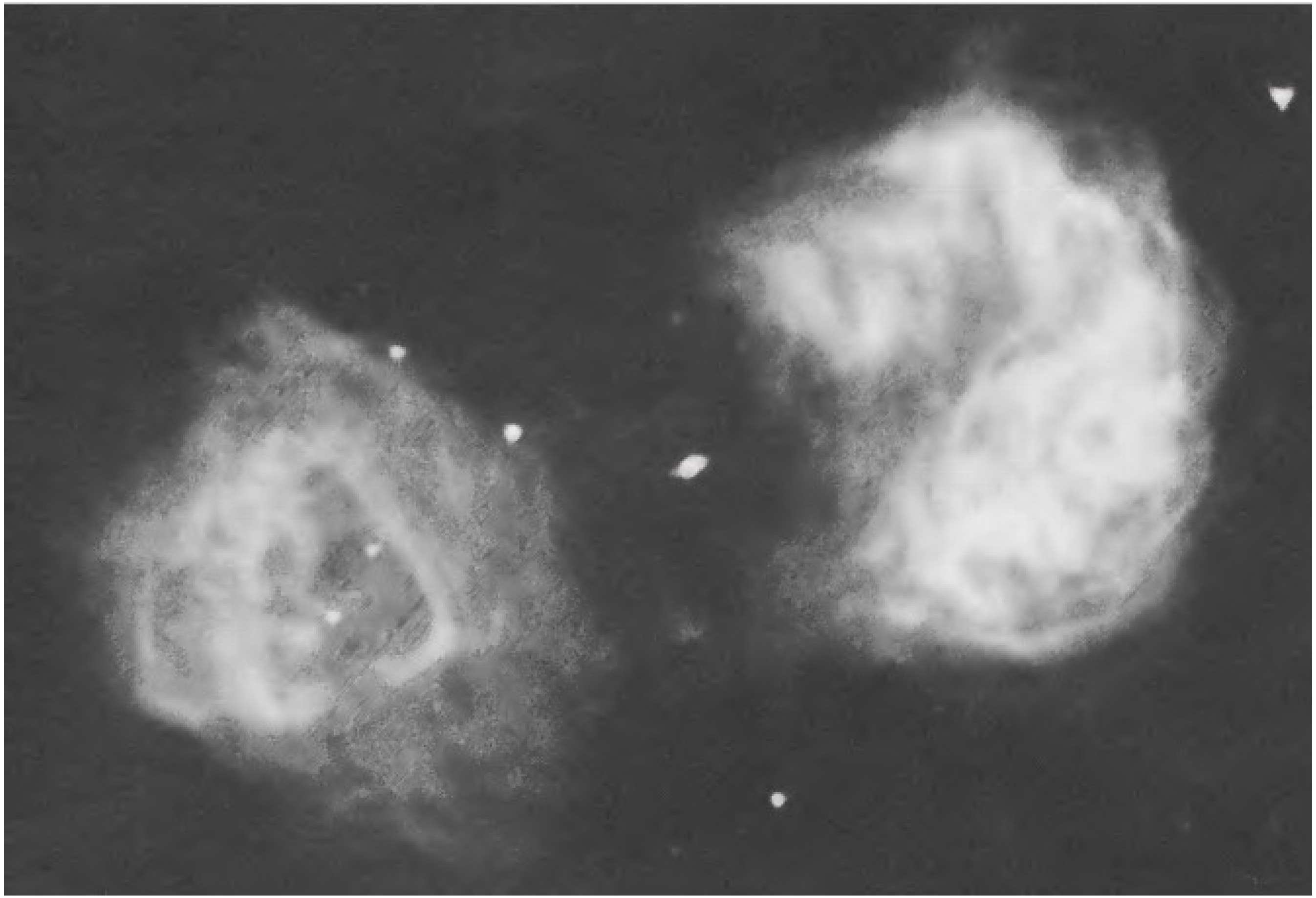


MeerKAT and ASKAP synergies: the discovery of a depolarizing HI tail in the western lobe of Fornax A

Francesca Loi @ INAF-OAC

Collaborators: Paolo Serra, Matteo Murgia, Federica Govoni, Craig Anderson, Emil Lenc, Dane Kleiner et al.

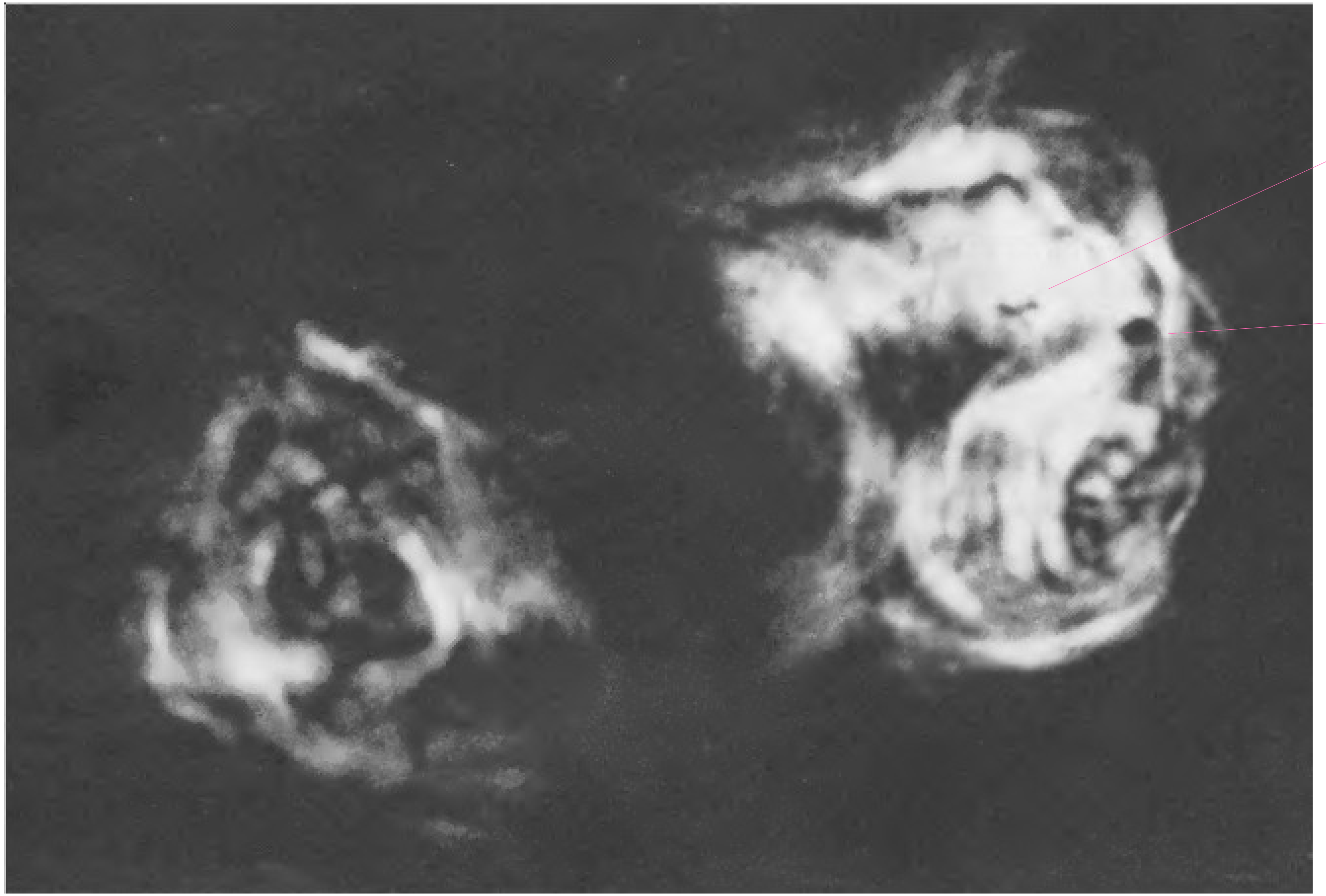
Fornax A – VLA I image by Fomalont et al. 1989



D~20Mpc from us

R~1.3 Mpc from the cluster center

Fornax A - VLA P image by Fomalont et al. 1989



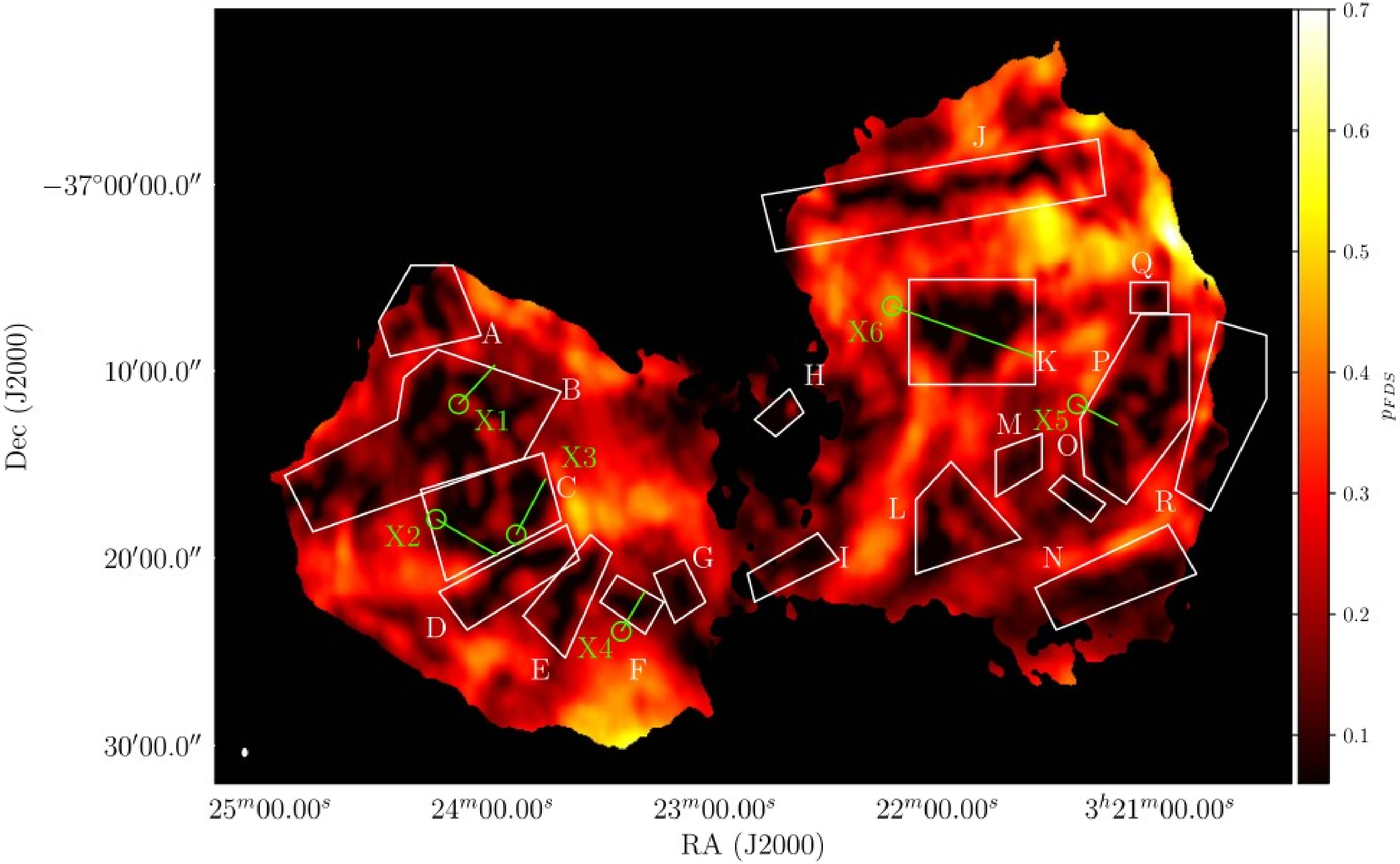
The "ant"

NGC 1310

Faraday effect:

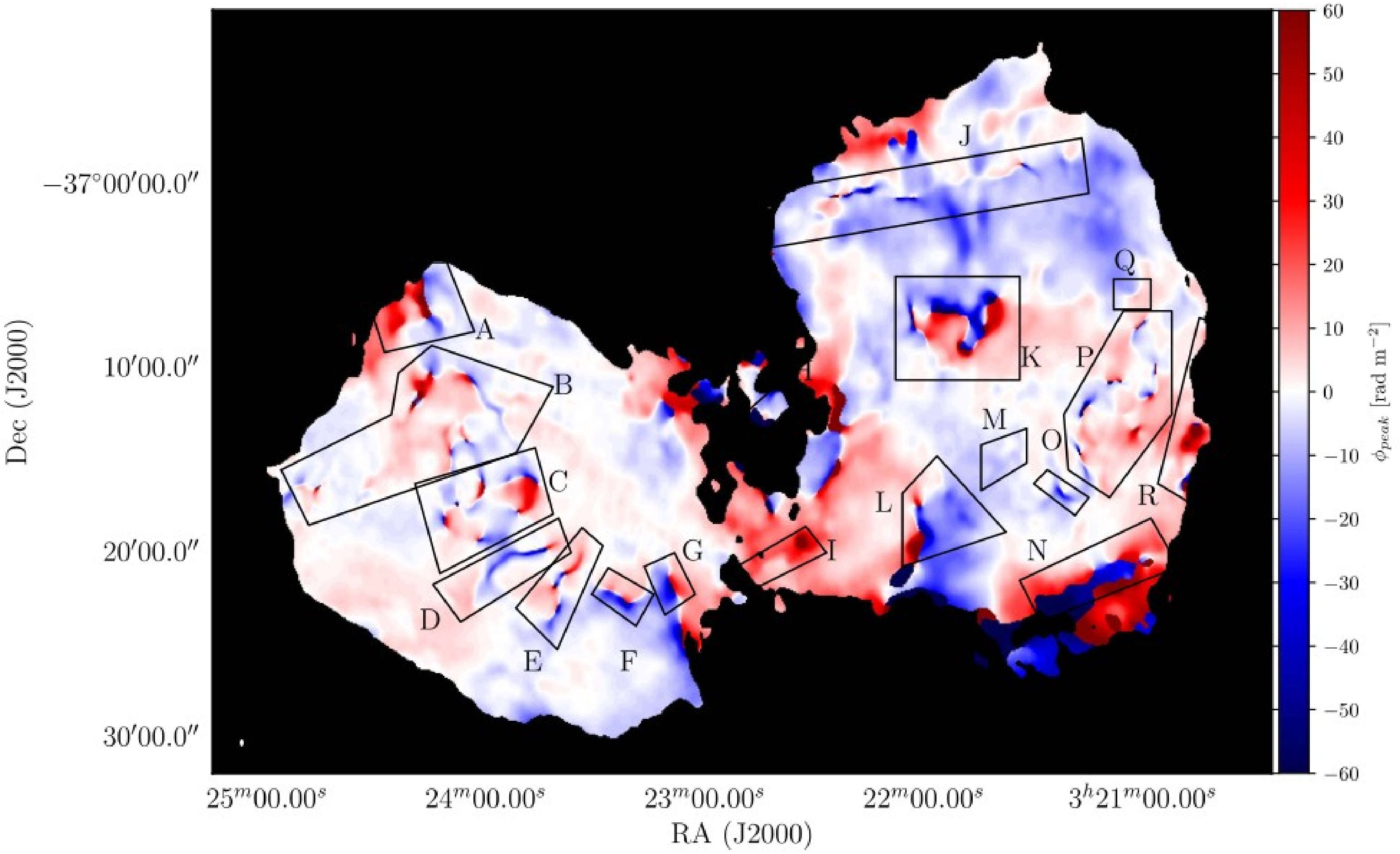
$\Delta\Psi = RM \cdot \lambda^2$

Fornax A – ATCA Pol image by Anderson et al. 2018



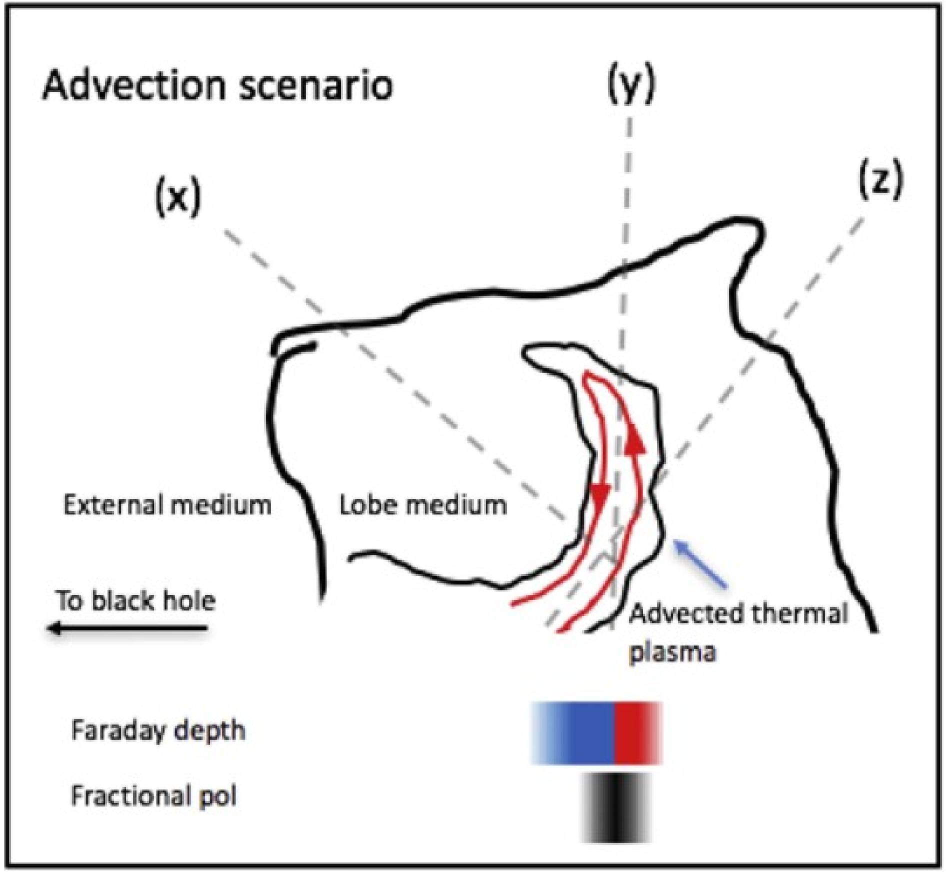
ATCA FDF peak
1.1-3.1GHz
20x30arcsec²

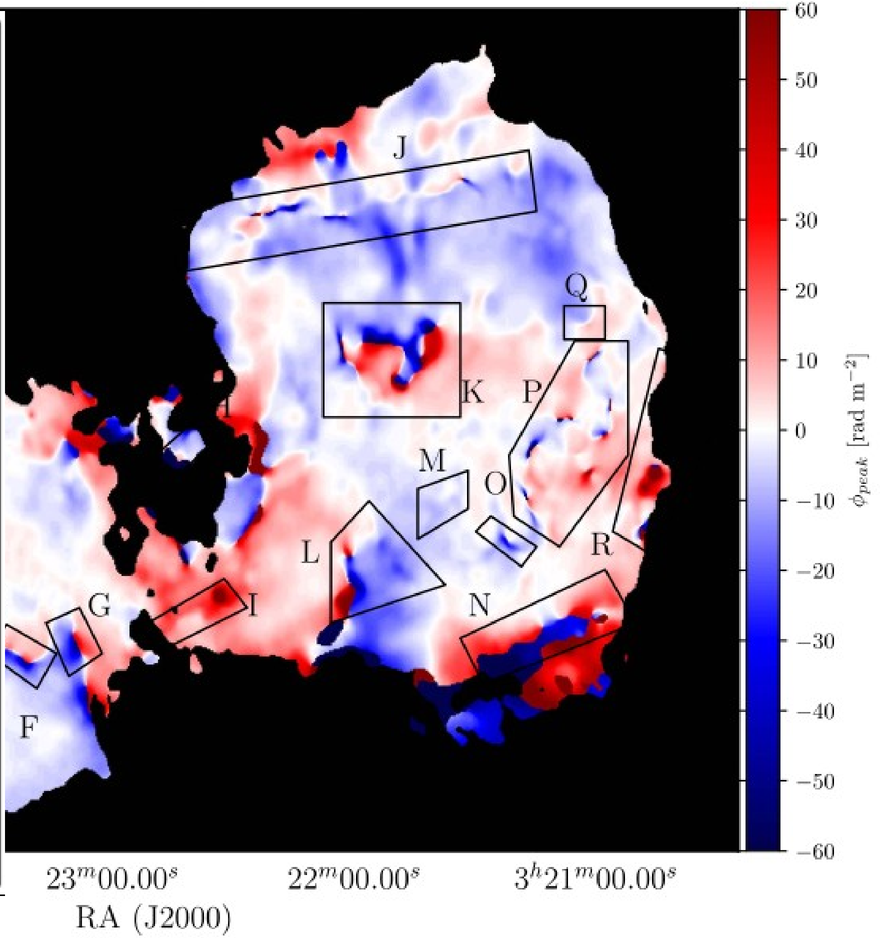
Fornax A – ATCA RM image by Anderson et al. 2018



ATCA peak FD
1.1-3.1GHz
20x30arcsec^2

Fornax A – ATCA RM image by Anderson et al. 2018

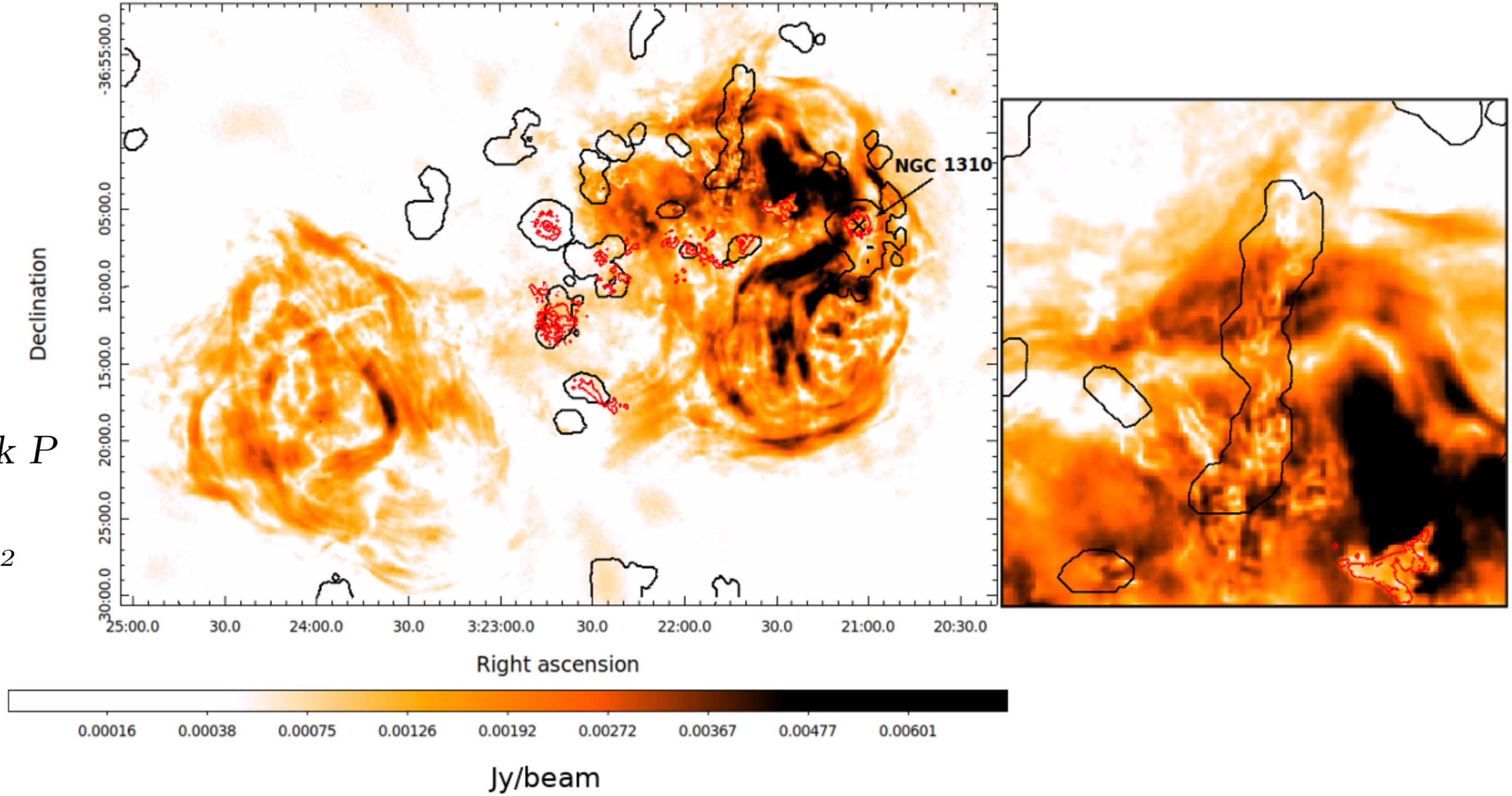




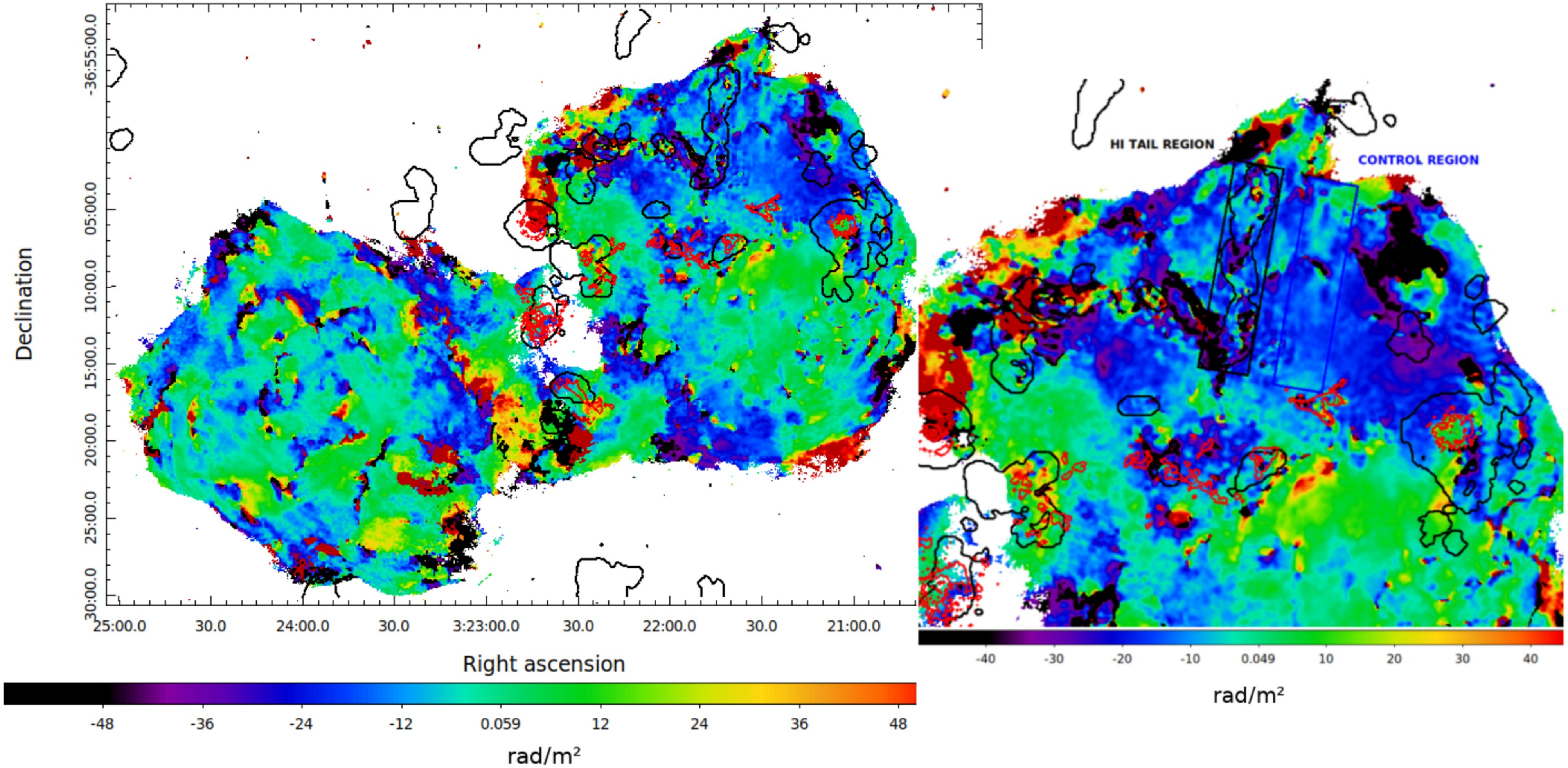
ATCA
1.1-3.1
20x30a

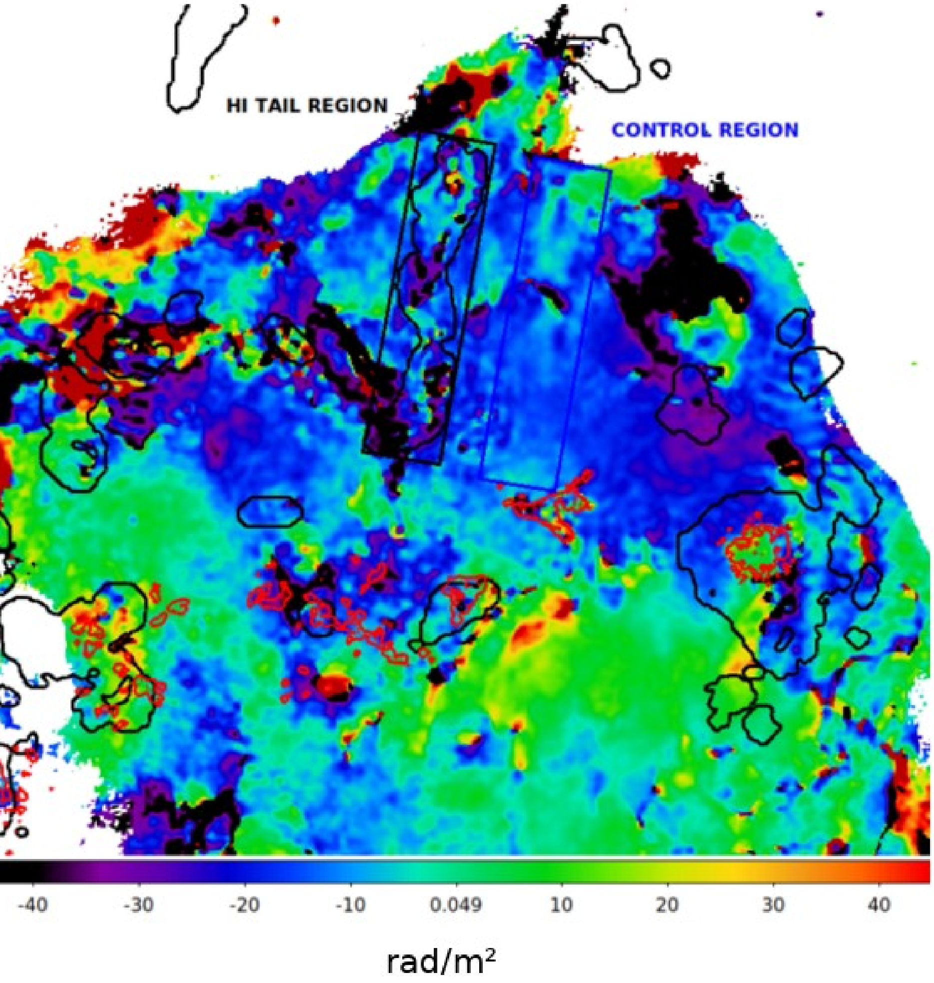
Fornax A – ASKAP P + HI & Hα by Kleiner et al. 2021

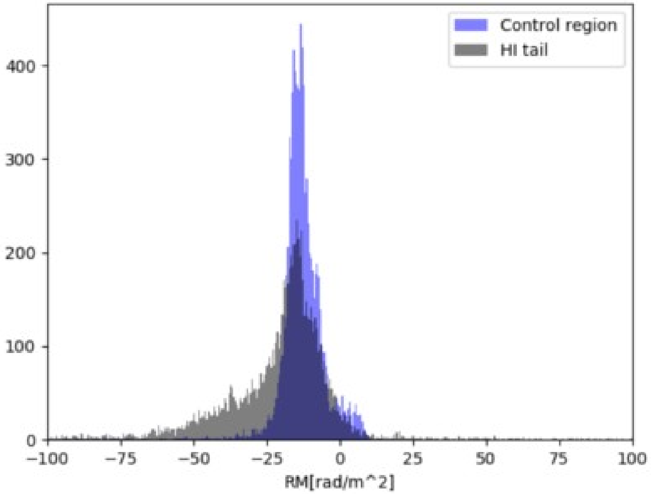
ASKAP peak P
1.1-1.3 GHz
12x12 arcsec²



Fornax A – ASKAP RM + HI & Hα by Kleiner et al. 2021







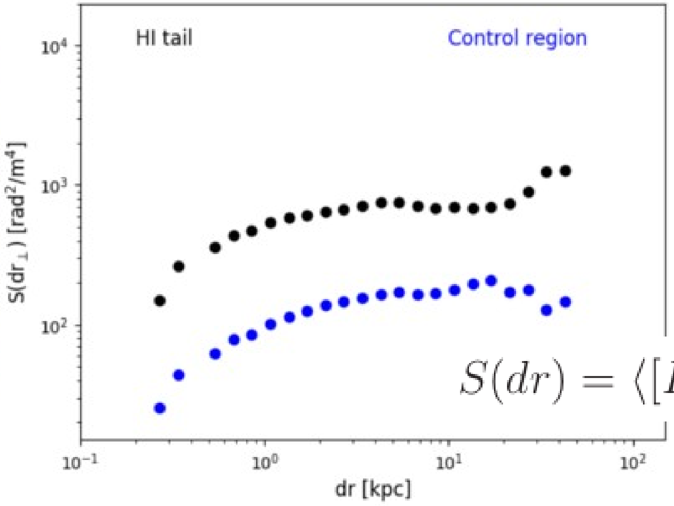
RM Histogram

<RM>=-17 rad/m ^{2}

σ_{RM}=20 rad/m ^{2}

<RM>=-13 rad/m ^{2}

σ_{RM}=9 rad/m ^{2}

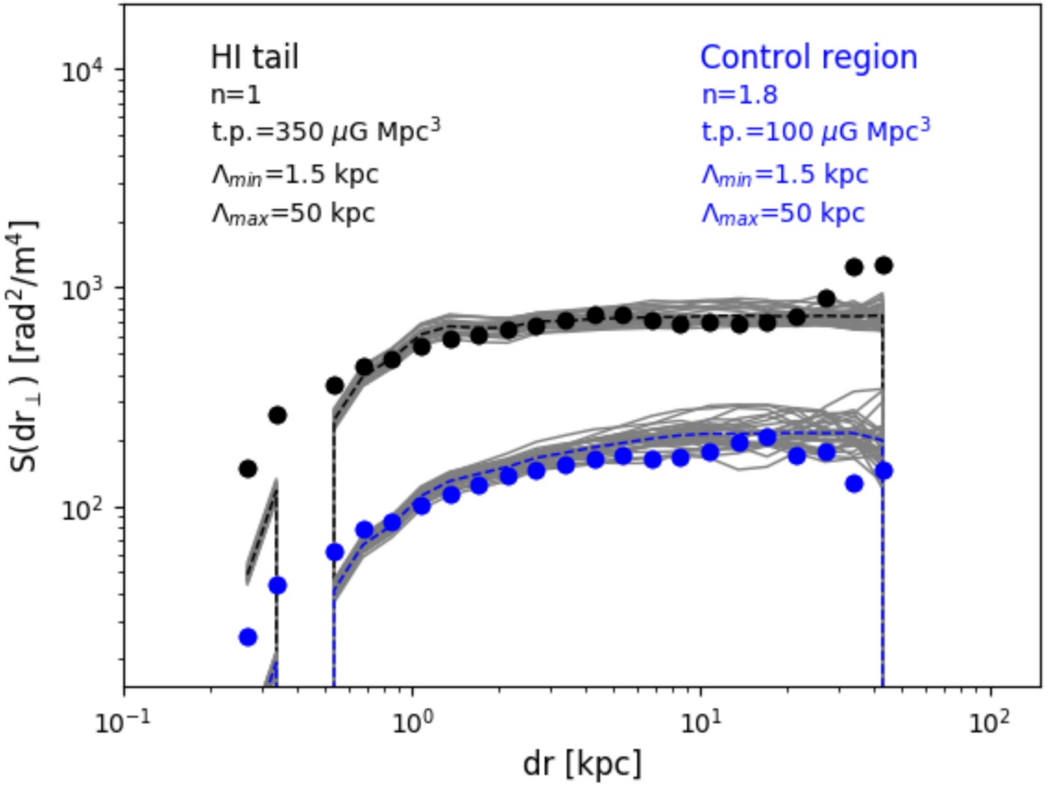


RM Structure functions

$$S(dr) = \langle [RM(r) - RM(r + dr)]^2 \rangle$$

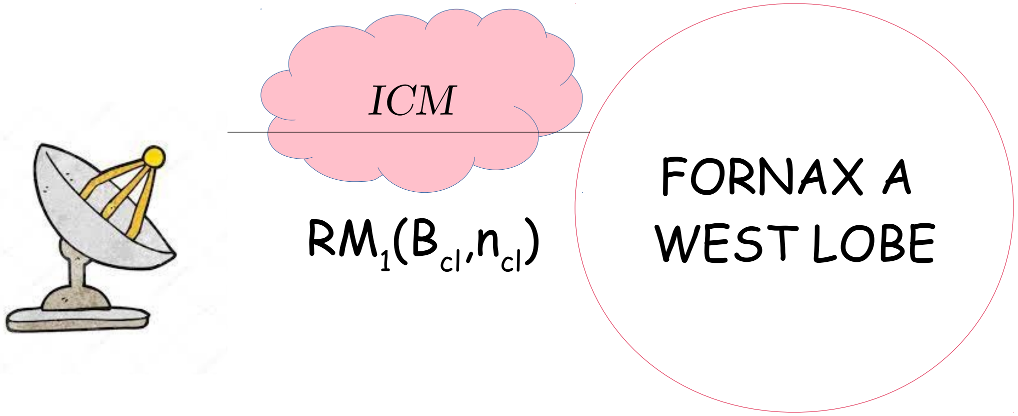
2D simulations – Magnetic field power spectrum

FARADAY tool by Murgia et al. 2004



The two regions host magnetic fields with a different geometry and strength

RM due to the ICM of the Fornax cluster?



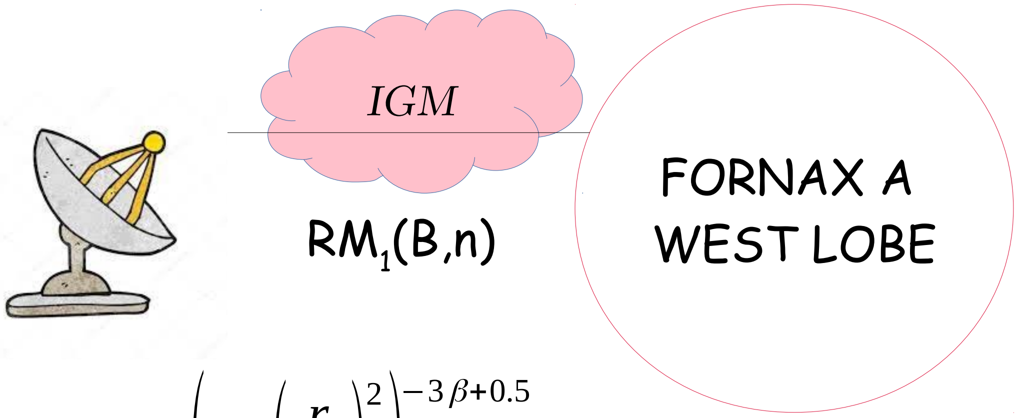
Thermal plasma $n = n_0 \left(1 + \left(\frac{r}{r_c}\right)^2\right)^{-3\beta+0.5}$

Magnetic field $B = B_0 \left(\frac{n}{n_0}\right)^{\eta}$

$$\sigma_{RM}(r) = K B_0 \Lambda_c^{0.5} n_0 r_c^{\frac{1}{2}} \frac{1}{\left(1 + \frac{r^2}{r_c^2}\right)^{\frac{6\beta(1+\eta)-1}{4}}} \sqrt{\frac{\Gamma[3\beta(1+\eta) - \frac{1}{2}]}{\Gamma[3\beta(1+\eta)]}} \longrightarrow 10^{-26} \text{ rad/m}^2$$

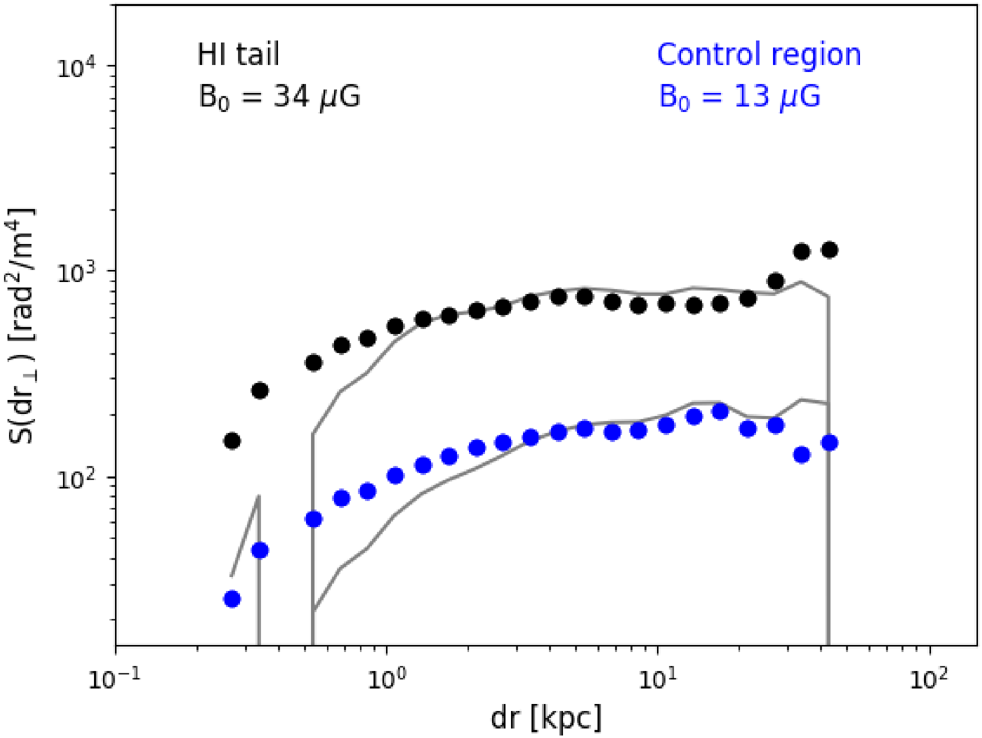
References: Dolag et al. 2001, Lawler&Dennison 1982, Felten 1996 (model), Paolillo et al. 2002 (thermal plasma)

3D simulations - RM due to the IGM of the Fornax A group?



$$n = n_0 \left(1 + \left(\frac{r}{r_c} \right)^2 \right)^{-3\beta + 0.5}$$

$$B = B_0 \left(\frac{n}{n_0} \right)^{\eta}$$

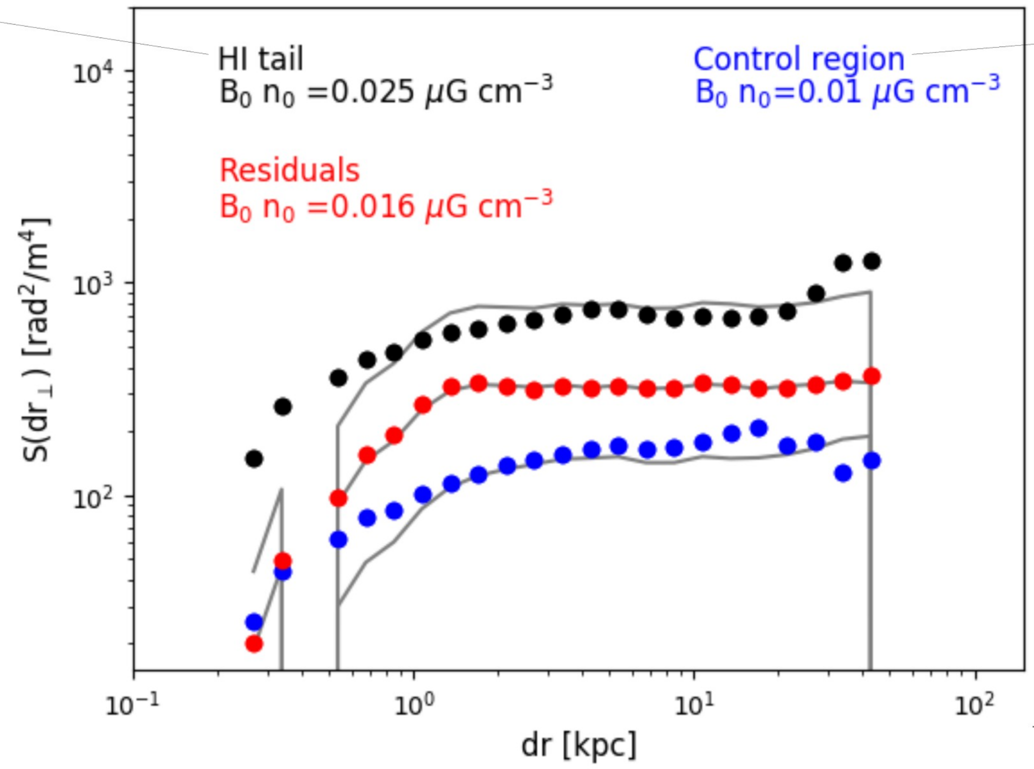


References: Babyk et al. 2018 (thermal plasma)

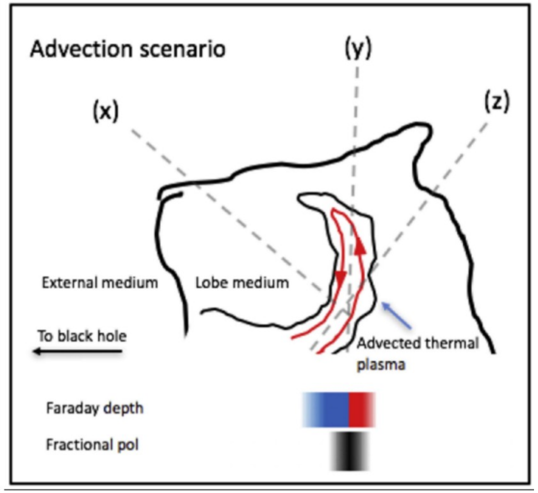
3D simulation - Faraday screen on the lobe surface

$RM_1 = RM_{tail}(B_{tail}, n_{tail})$

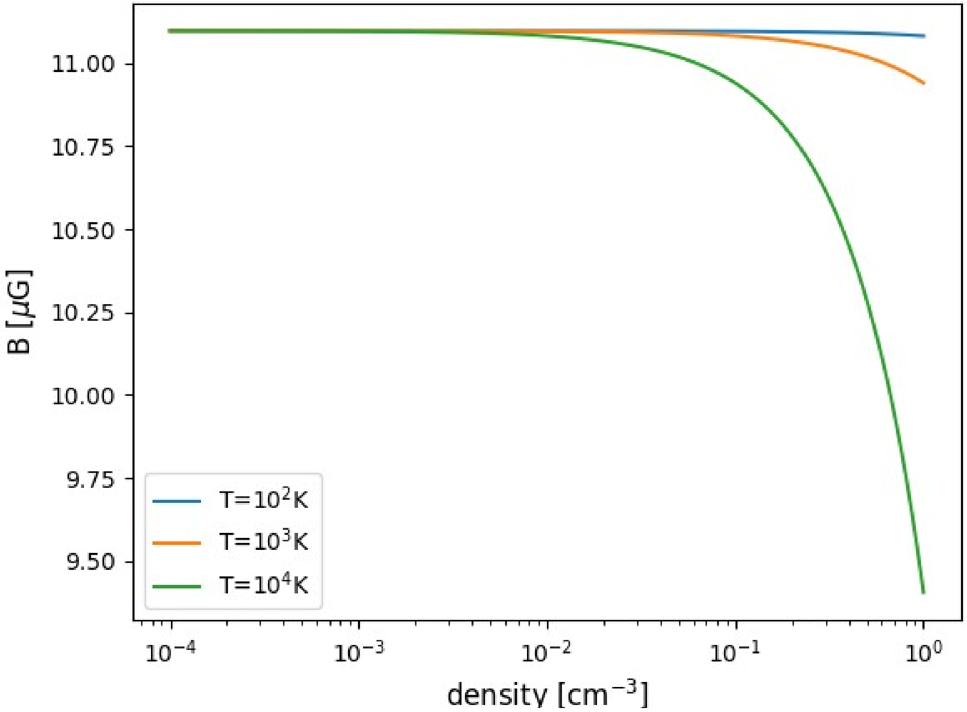
The HI tail is on the lobe surface



$RM = RM_{lobe}(B_{lobe}, n_{lobe})$



The HI tail is inside the lobe - Equilibrium condition



$$P_{nth} = P_{gas} + P_B$$

B ~ 9-11 μG

References: Maccagni et al. 2020 (non-thermal jet pressure)

3D simulation - Faraday screen on the lobe surface

$RM_1 = RM_{tail}(B_{tail}, n_{tail})$

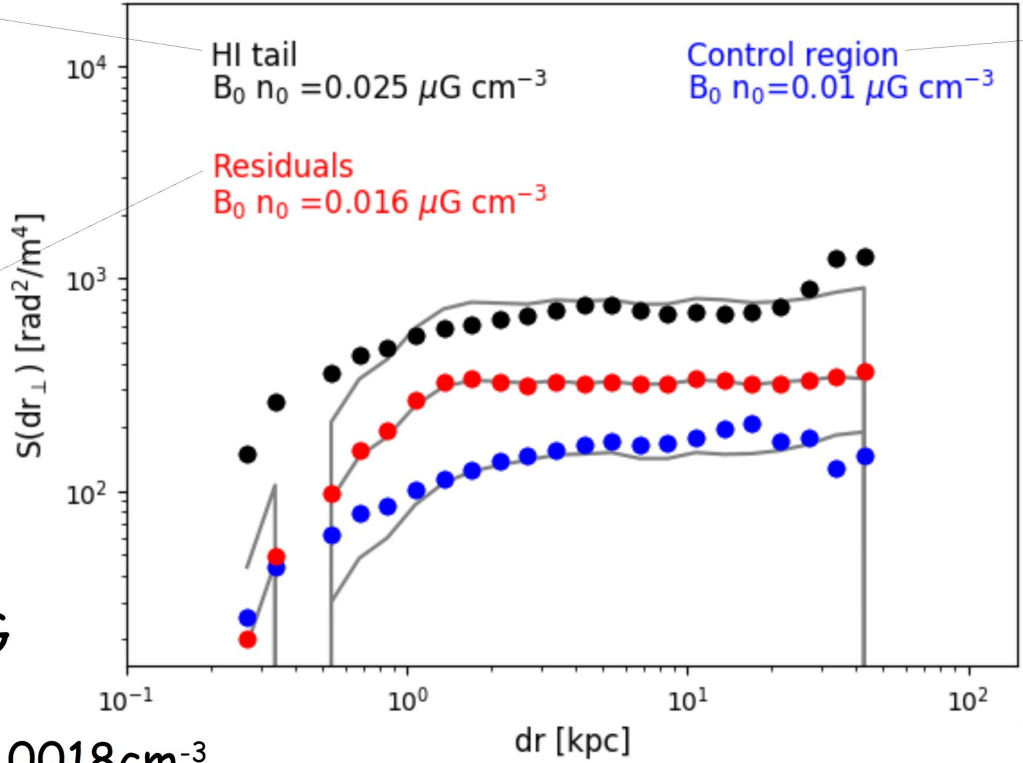
The HI tail is on the lobe surface

$RM_2 = RM_{tail} + RM_{lobe}$

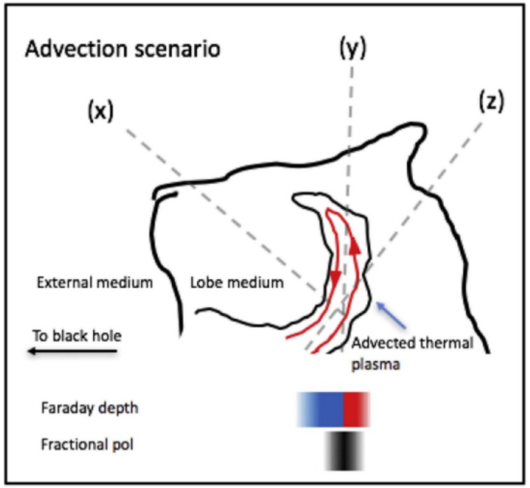
The HI tail is within the lobe

$B \sim 9\text{-}11\ \mu G$

$n = 0.0015\text{-}0.0018 cm^{-3}$



$RM = RM_{lobe}(B_{lobe}, n_{lobe})$



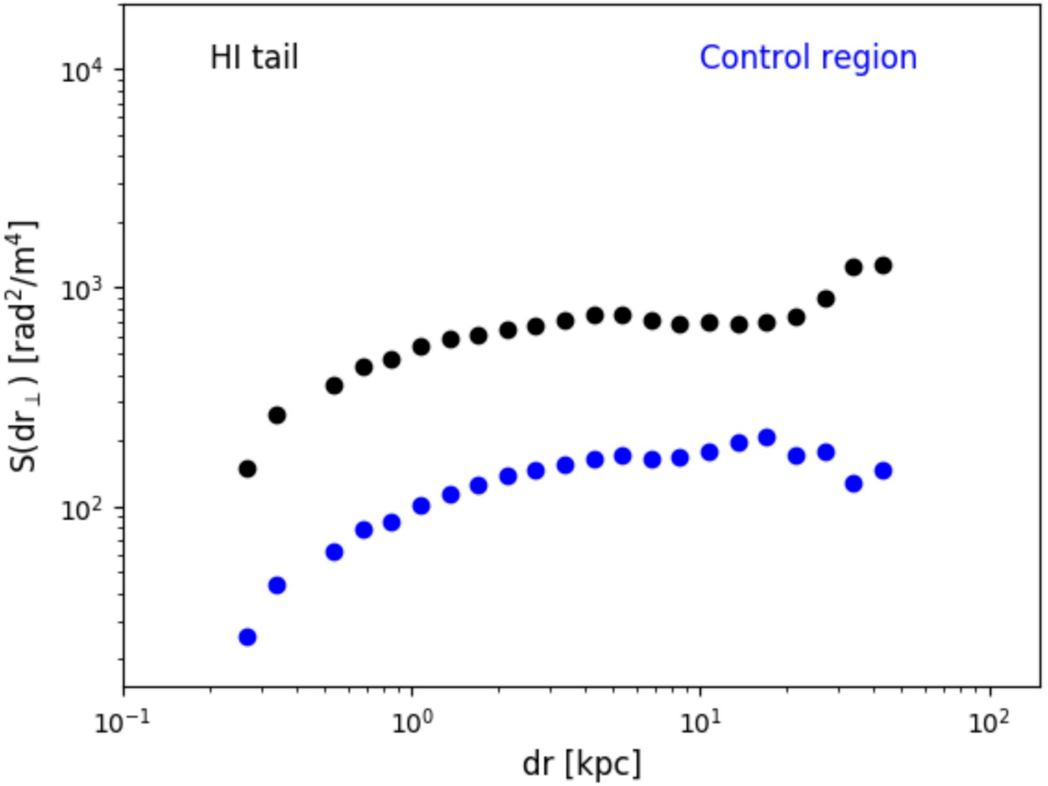
Conclusion

- The RM of the Fornax A lobes is not due to the ICM of the Fornax cluster
- It is unlikely that this is due to the IGM of the Fornax A group
- The HI tail could be driving its own magnetic field across the Fornax A lobe.

Backup slides

2D simulations – Magnetic field power spectrum

1) *Assume a shape for the magnetic field power spectrum: power-law (minimum, maximum scale, slope)* $|B_k|^2 \propto k^{-n}$
2) *Generate a RM image from the magnetic field power spectrum*
3) *Evaluate the S(dr) in the tail and control region and compare with data*
4) *Repeat*



2D simulations – Magnetic field power spectrum

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