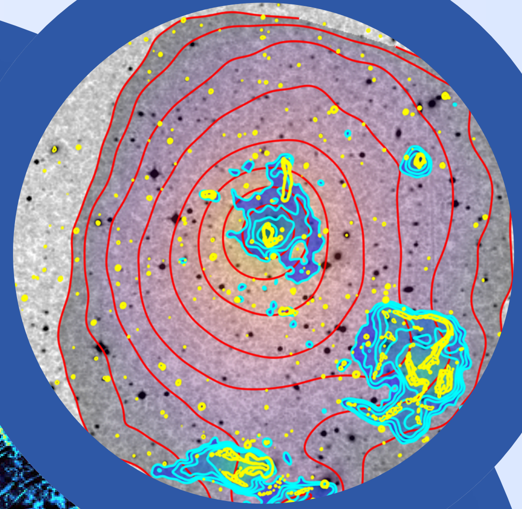
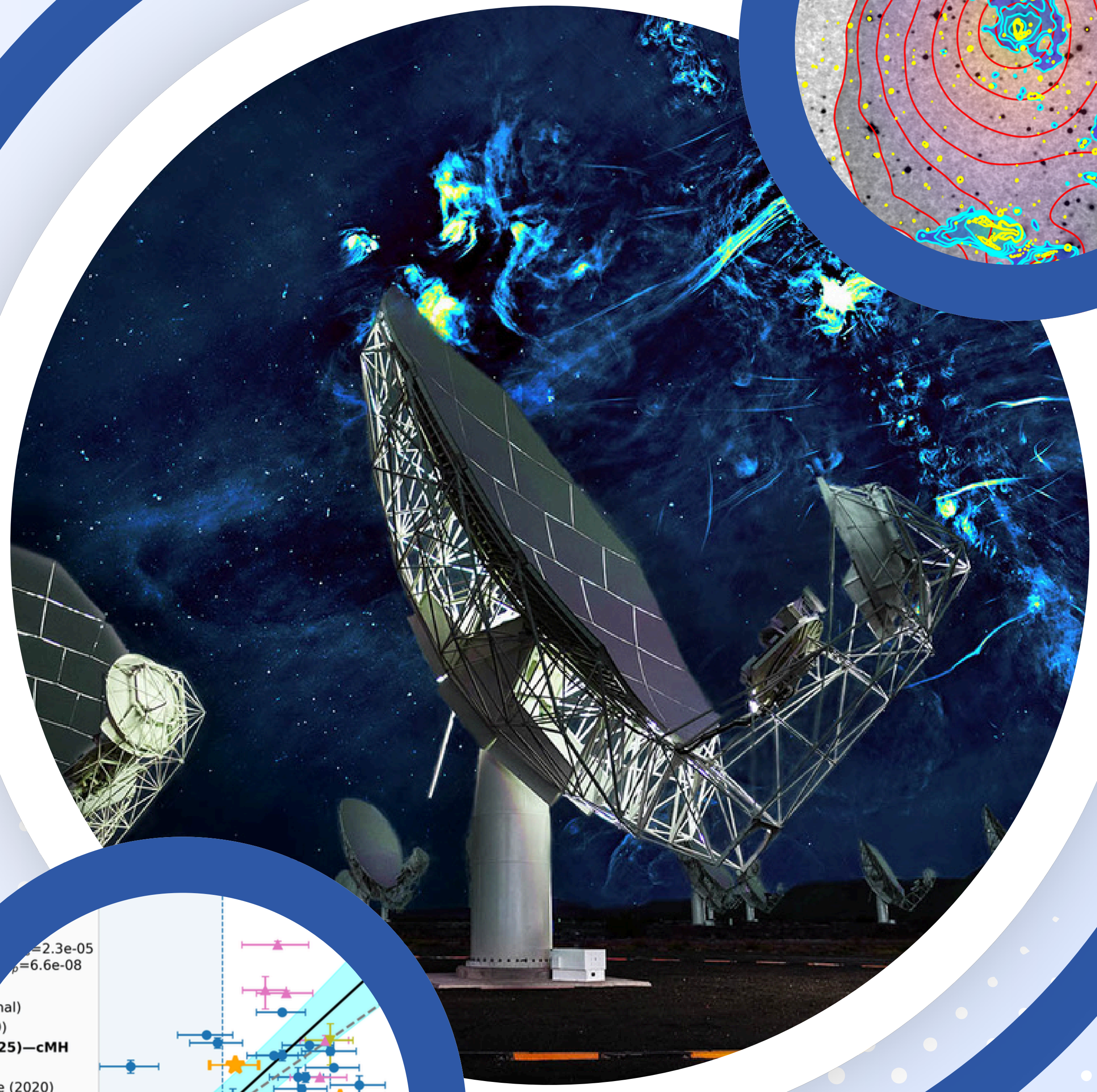
AFAS 2026 Conference

NEW AND KNOWN MINI-HALOS IN THE MEERKAT GALAXY CLUSTERS LEGACY SURVEY (MGCLS)



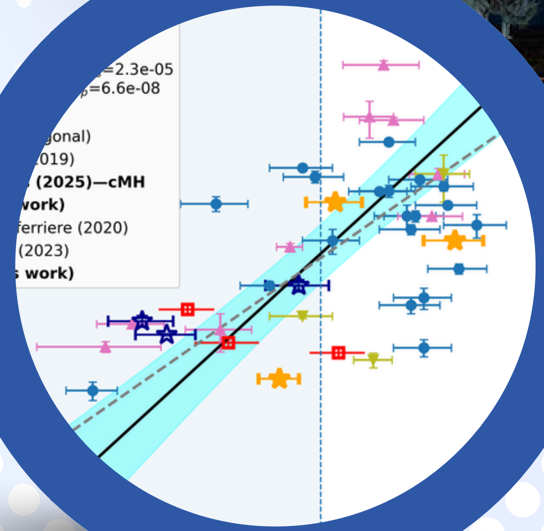


Prepared by:

Toivo Samuel Mabote[1,2]

Supervisors:

Prof. Oleg Smirnov[1,3,2],
Dr. Tiziana Venturi[2,1],
Dr. Konstantinos Kolokythas[1,3,2]



1.Centre for Radio Astronomy Techniques and Technologies, Rhodes University

2. INAF, Bolonia, Italy

3. South African Radio Astronomy Observatory

Rhodes University Where leaders learn | RATT https://ratt.center | Ministry of Foreign Affairs and International Cooperation | Farnesina Ministero degli Affari Esteri e della Cooperazione Internazionale | INAF Istituto Nazionale di Astrofisica | AMAS Associação Moçambicana de Astronomia

26th March, Botswana

Overview

- Mini-Halos
  - Research Goal
  - Reduction
  - Preliminary Results
- Future work

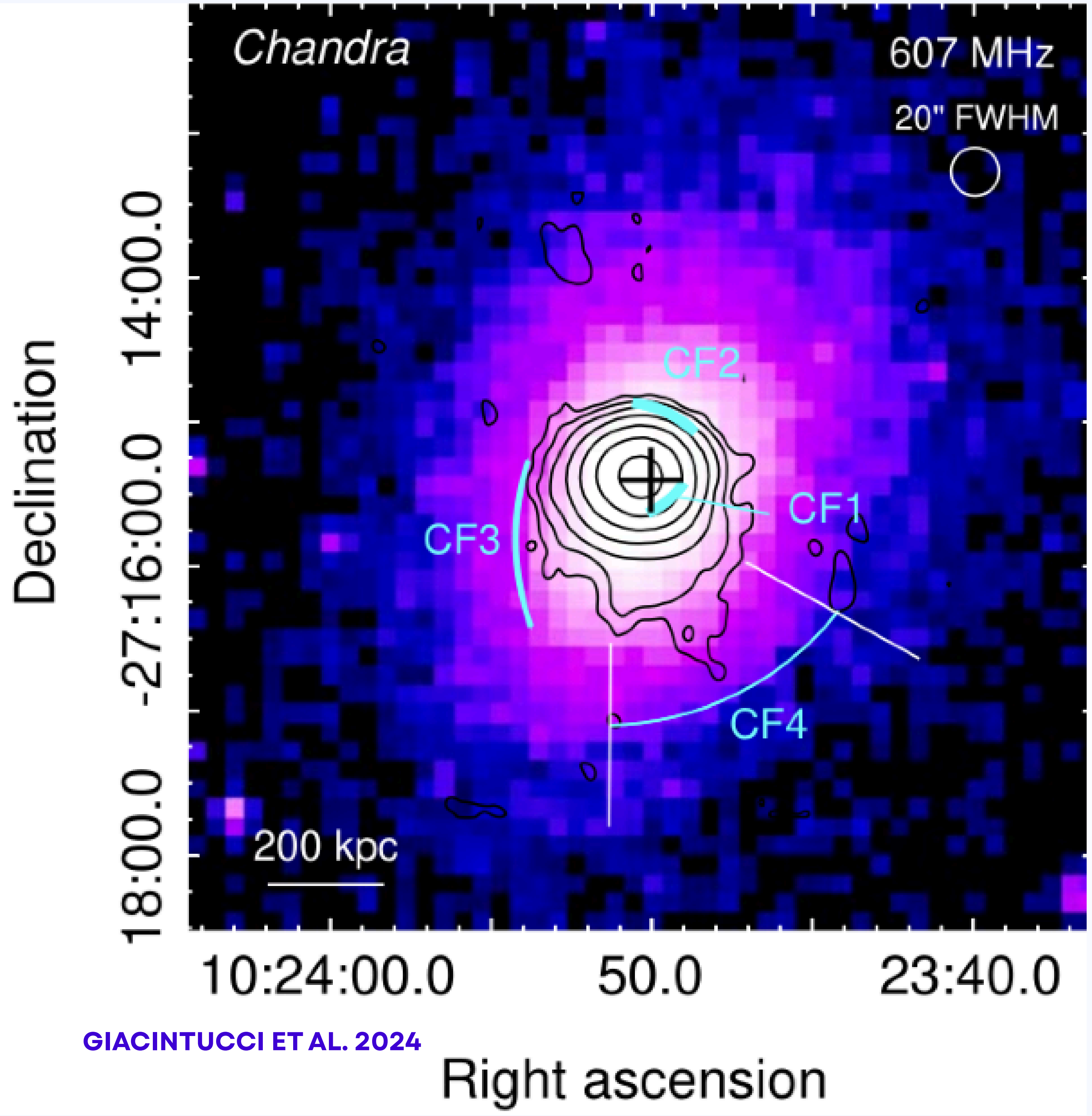
What is MH?

- **Mini-halos** (MH) are centrally located, steep-spectrum diffuse radio sources found in the cool cores of relaxed galaxy clusters

- **MHs** are rare, with only ~ 40 known including candidates.

- Cluster hosting MH always has radio active **BCG** whose emission is embedded in MH itself.

- The radio active BCG provides at least a **fraction of the seed electrons that produce** the diffuse emission



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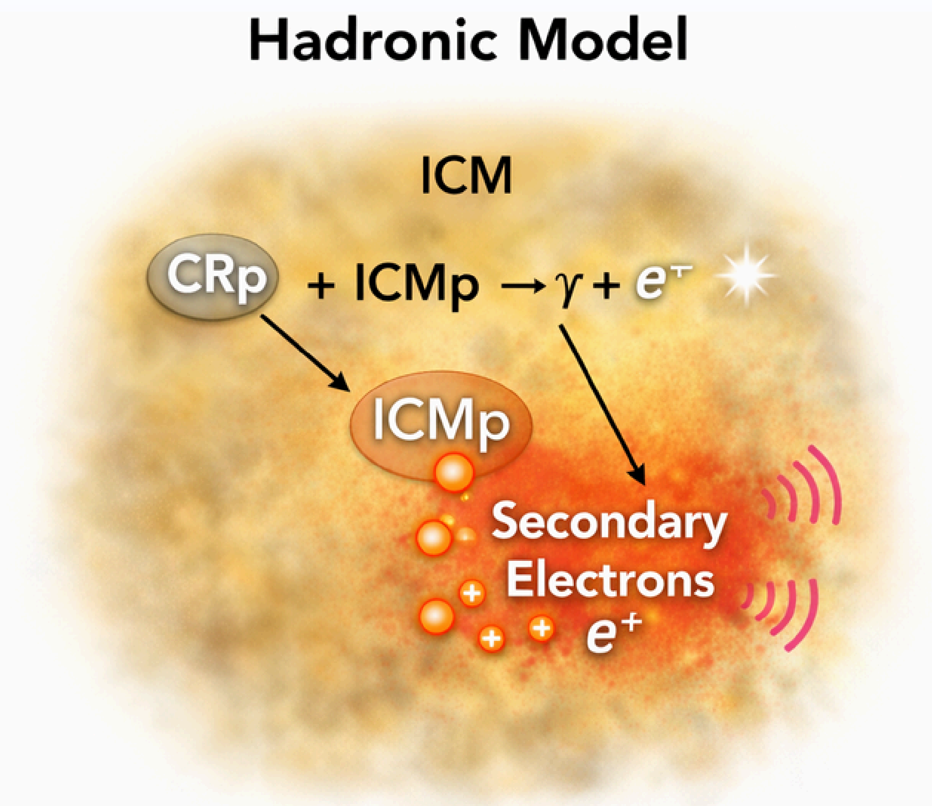
Origin of the MH?



1. Hadronic Model

Inelastic collisions

CRp

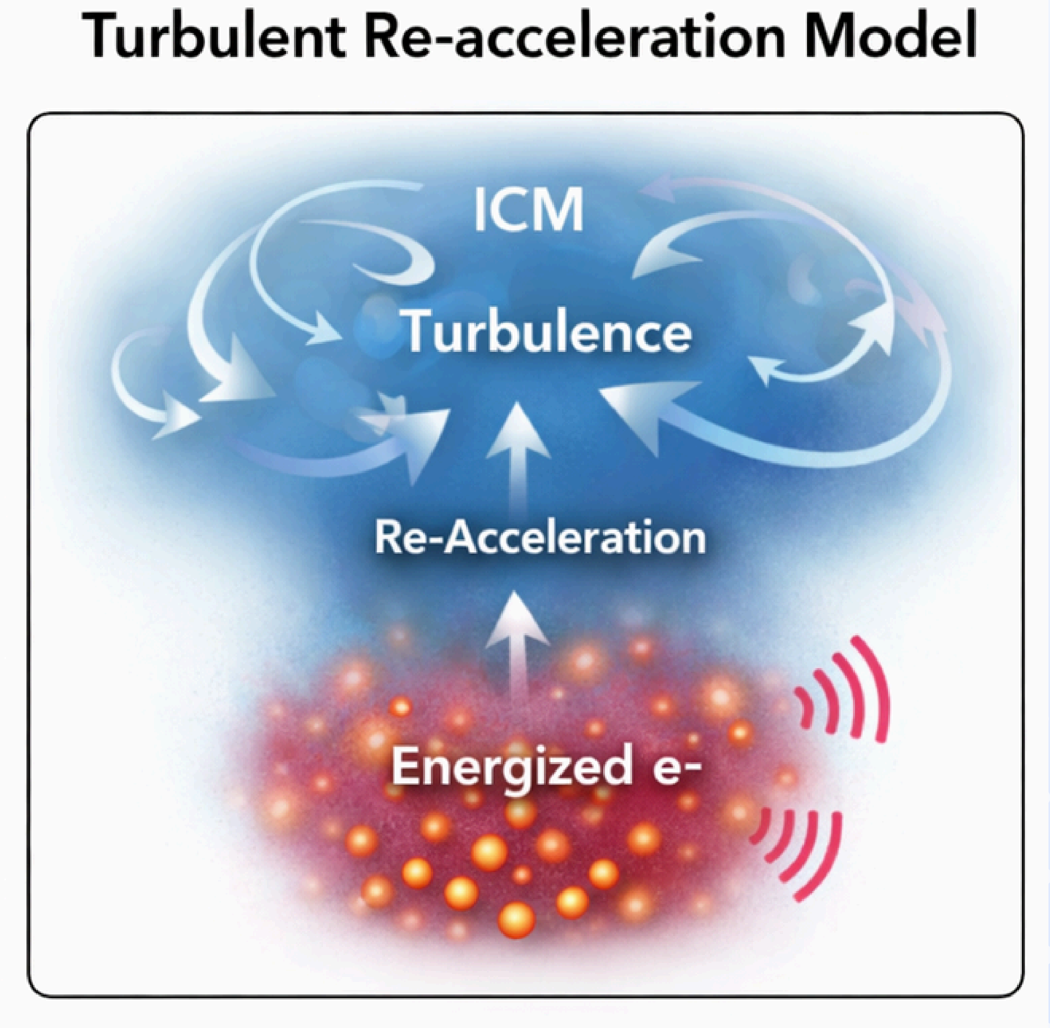
ICMp

2. Turbulent Re-acceleration Model

Seed electrons

re-accelerated

gas sloshing



Research Goal

1. **Derive the observational properties** of the 3 new MHs and 7 new candidates (cMH) from MGCLS. (Knowles et al., 2022; Kolokythas et al., 2025)

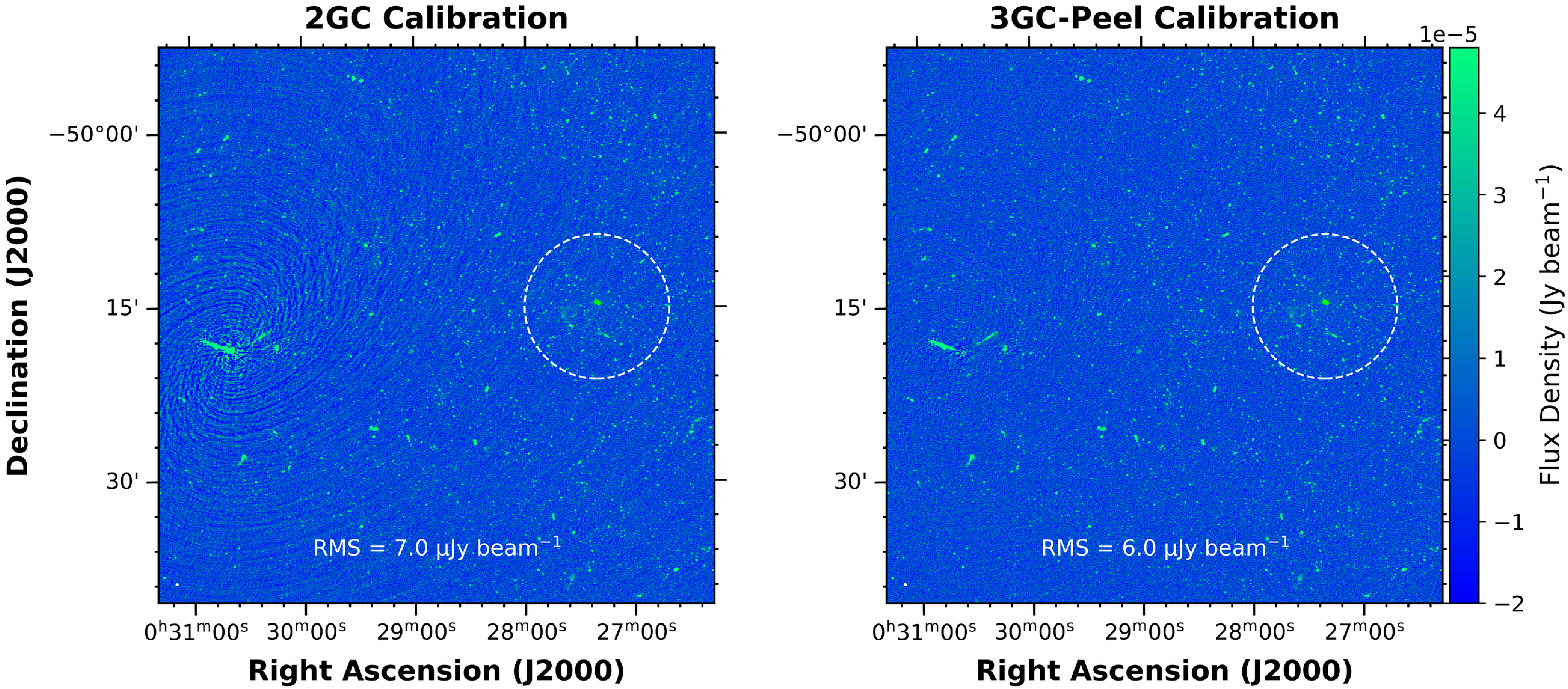
2. **Confirm the nature** of the cMH

3. **Revise the statistics** of mini-halos with the inclusion of the new detections to study the systems in the context of the theoretical models for their formation

4. Perform a radio/X-ray analysis of confirmed MH.

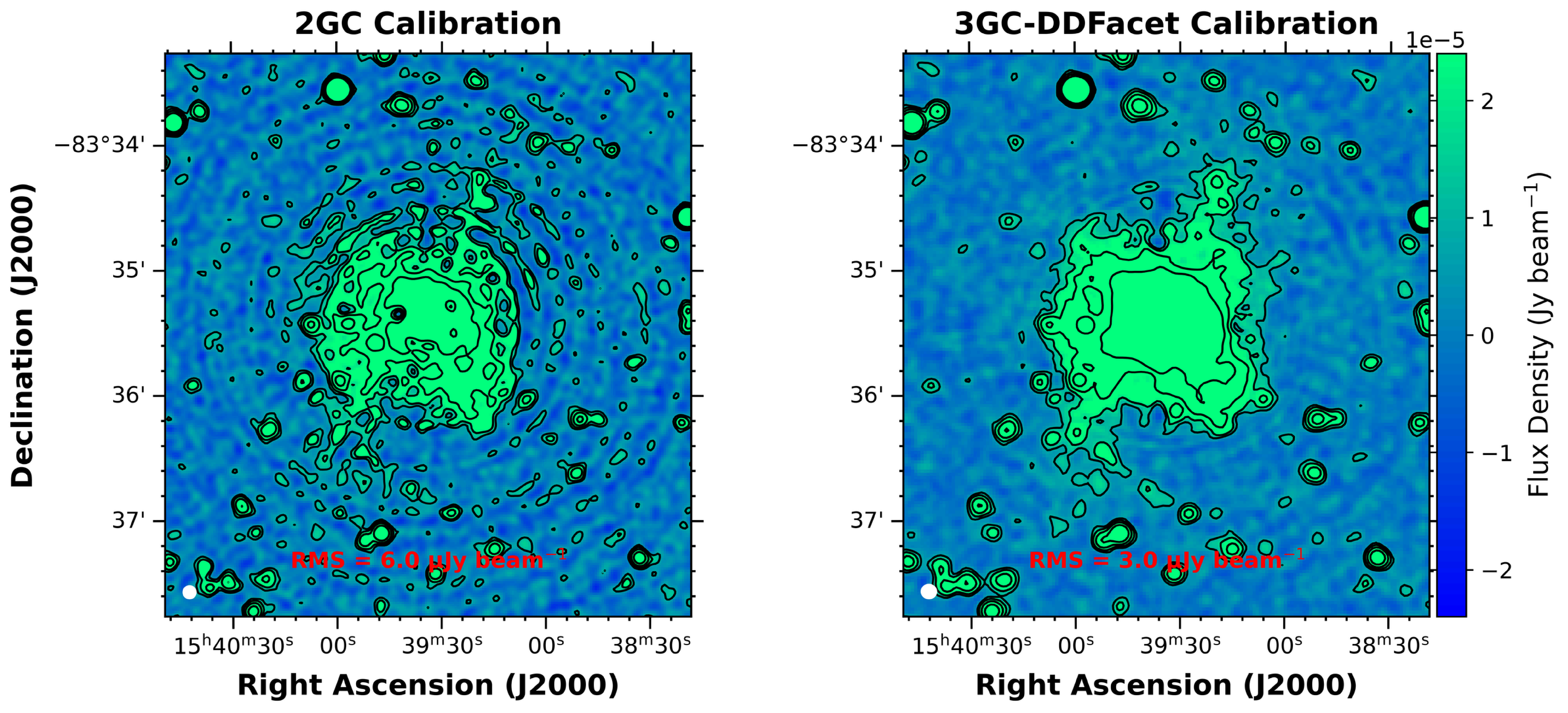
Data Reduction

J0027.3−5015



Data Reduction

J1539.5−8335



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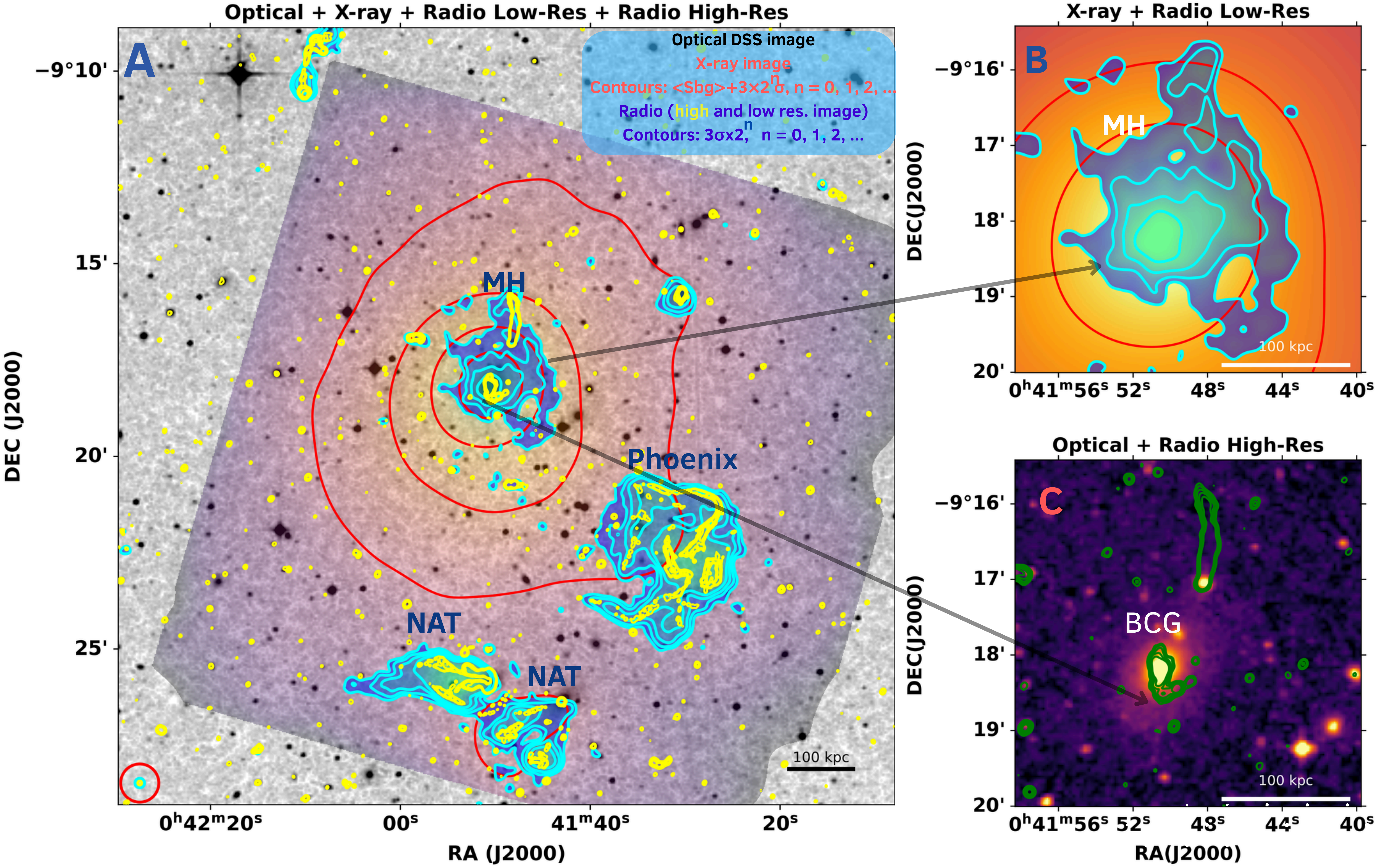


Radio Properties

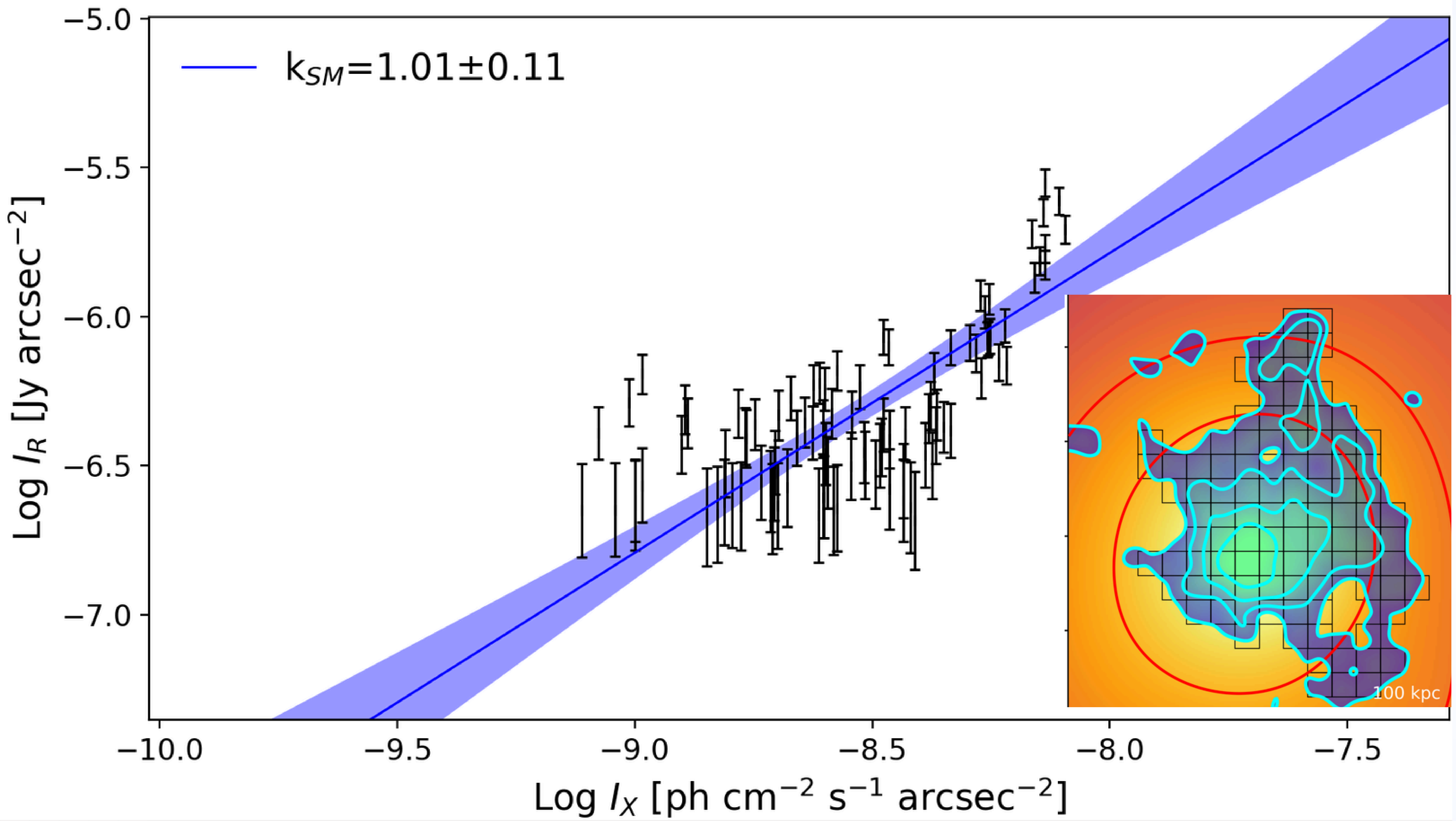
MH:

- Beam: $15'' \times 15''$
- RMS: $18\,\mu\mathrm{Jy\,beam}^{-1}$
- LLS: $155 \times 276\,\mathrm{kpc}^2$
- $S_{1.4\,\mathrm{GHz}} = 13.2\,\mathrm{mJy}$
- $P_{1.4\,\mathrm{GHz}} = 0.8 \times 10^{23}\,\mathrm{W\,Hz}^{-1}$

BCG:

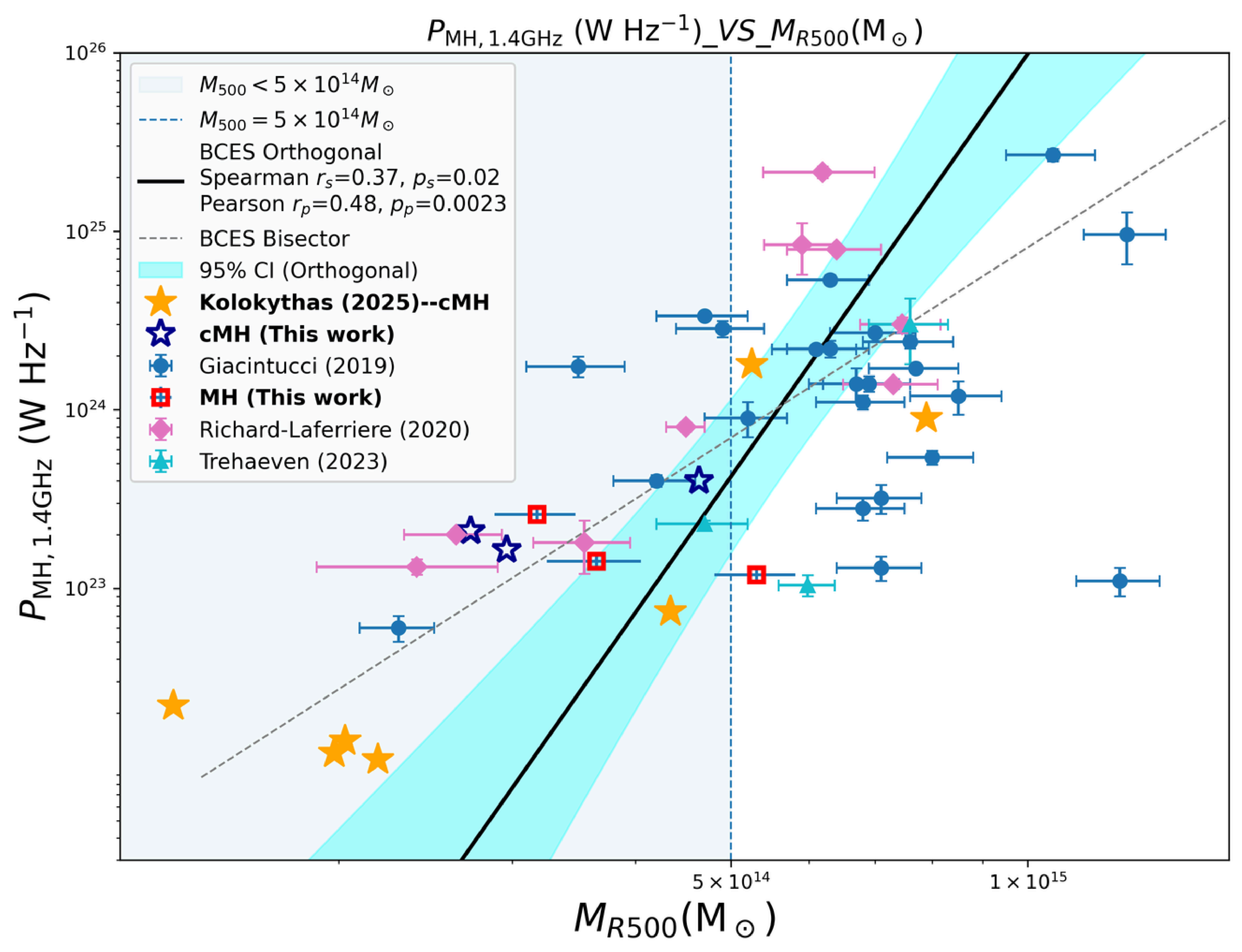
- Beam: $5'' \times 5''$
- RMS: $15\,\mu\mathrm{Jy\,beam}^{-1}$
- $S_{1.4\,\mathrm{GHz}} = 58.9\,\mathrm{mJy}$
- $P_{1.4\,\mathrm{GHz}} = 3.7 \times 10^{23}\,\mathrm{W\,Hz}^{-1}$

A85 Point-to-Point Correlation



- The radio emission scales linearly with the thermal gas (k ≈ 1)
- Strongly favors turbulent re-acceleration models.
- Turbulence (e.g., from sloshing in cool cores) re-accelerates relativistic electrons
- Turbulence is stronger where gas density (X-ray) is higher

Correlation Between $P_{1.4}$ GHz and Cluster Mass



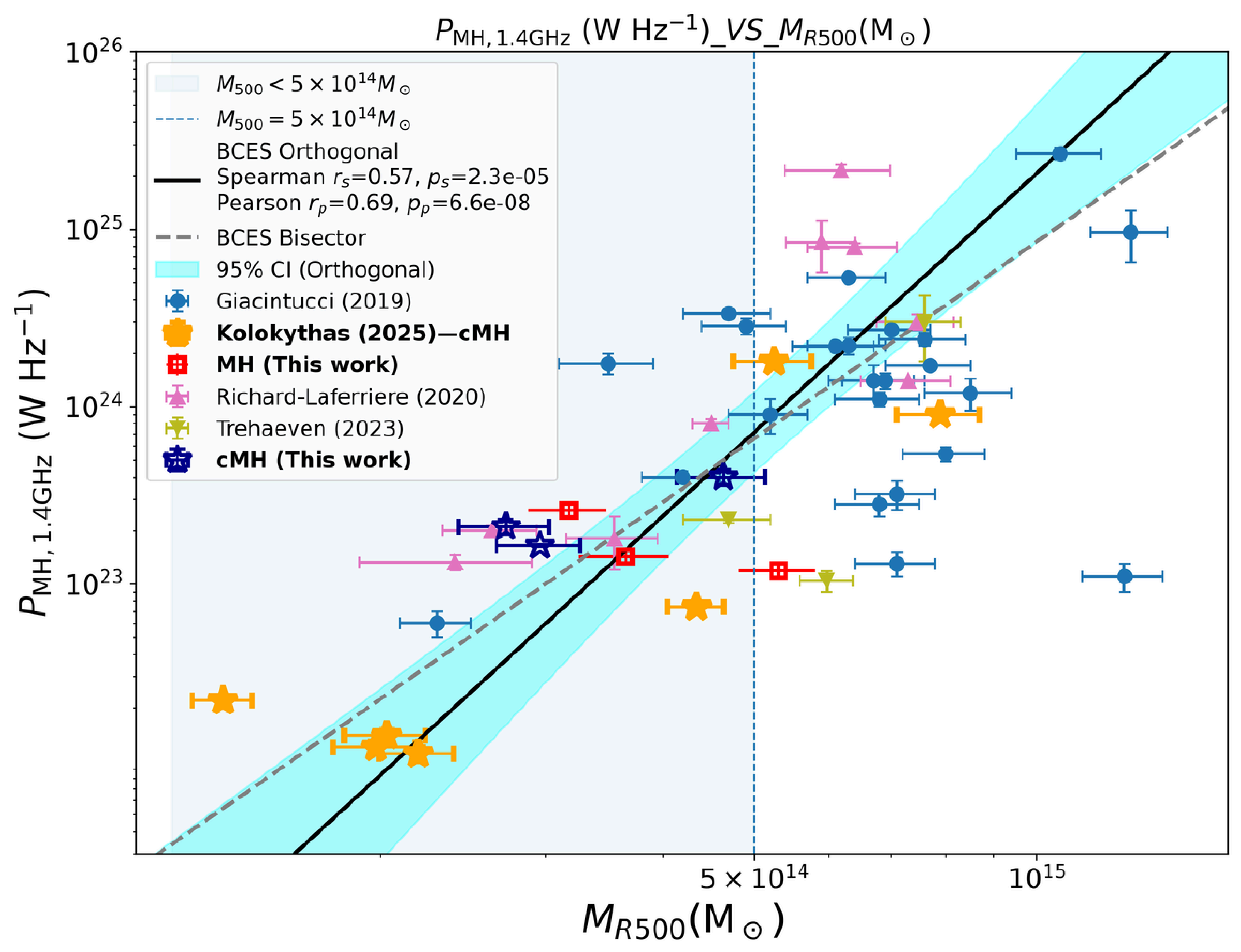
Moderate Correlation

(Laferriere et al., 2020)

- Pearson coefficient: $r_p = 0.44$
- p-value: $p_p = 0.011$

- Including MGCLS MH (Kolokythas et al., 2025)
- Pearson coefficient: $r_p = 0.48$
- p-value: $p_p = 0.002$

Correlation Between $P_{1.4}$ GHz and Cluster Mass



With MGCLS MHs & cMH:

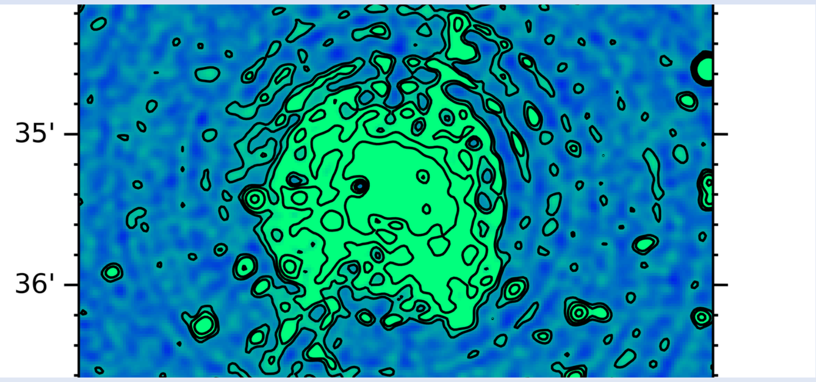
Strong Correlation Observed

Pearson correlation coefficient: r_p =0.69

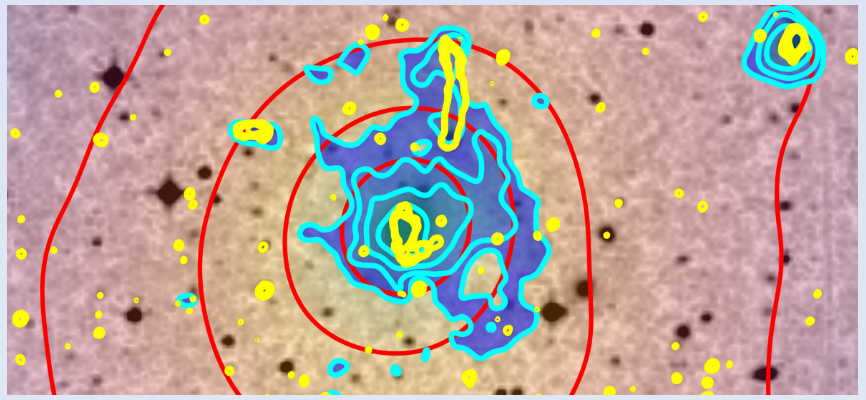
Probability (p-value): p_p =0.006 %

A second order correlation is seen as the BCG correlate with the cluster mass and it provides at least a fraction of the seed electrons that might produce the diffuse emission

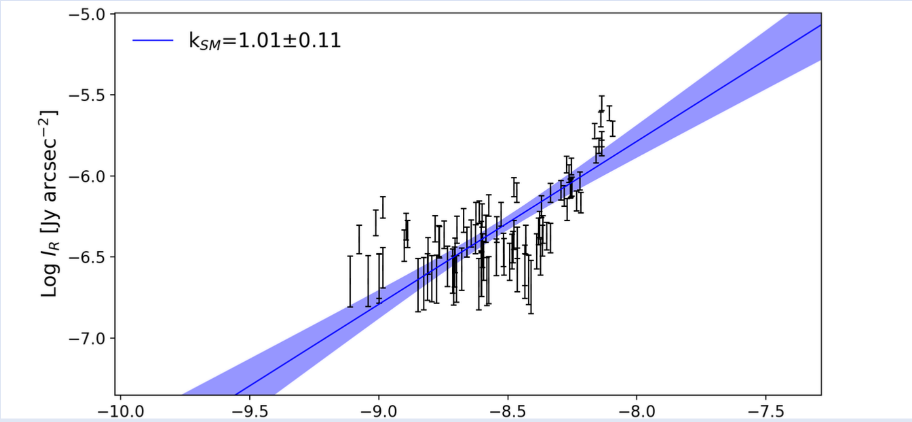
Future Work



Continue using DDfacet and performing point source subtraction for clusters affected by artefacts on source.



Perform a spectral index analysis of the MH/cMH using uGMRT and MeerKAT data



Continue point-to-point correlation analysis (radio vs. X-ray) for all the sample

Takeaways Notes

Radio &/ X-ray Analise

1. The MH spatially confined within the region of thermal X-ray emission, indicating a close connection with the intracluster medium (ICM)

2. We found a near-linear correlation (k = 1.01) between radio and X-ray surface brightness in A85, indicating a strong coupling between thermal and non-thermal components. This result supports a turbulent re-acceleration scenario.

Correlation Between $P_{1.4}$ GHz and Cluster Mass

3. Inclusion of MHs and cMHs of our sample in the radio power and mass correlation provides insight into a stronger correlation that were not seen before.

4. A second order correlation is seen as the BCG correlate with the cluster mass and it provides at least a fraction of the seed electrons that might produce the diffuse emission.

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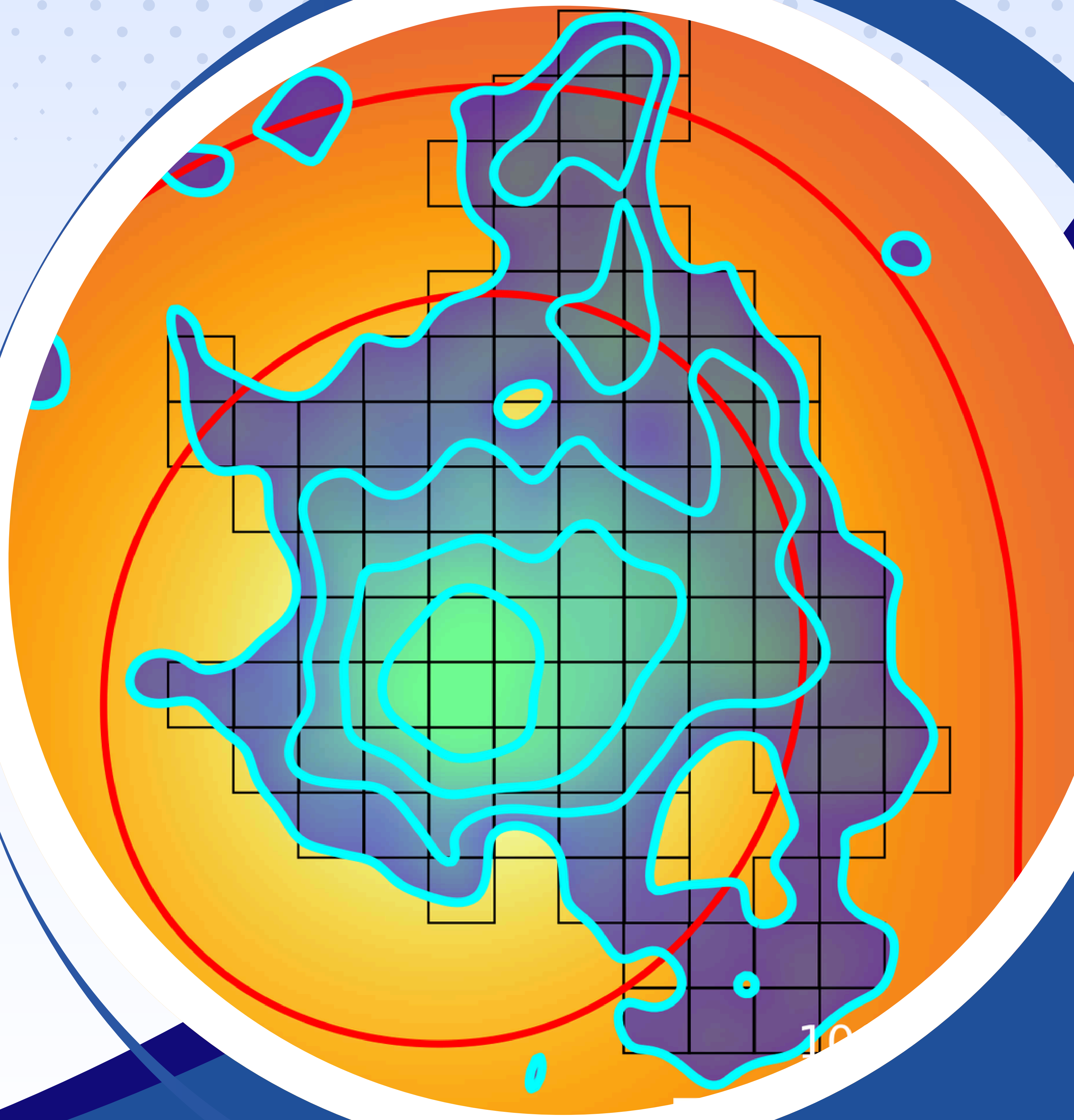
THANK YOU FOR YOUR ATTENTION



toivosamuel@gmail.com