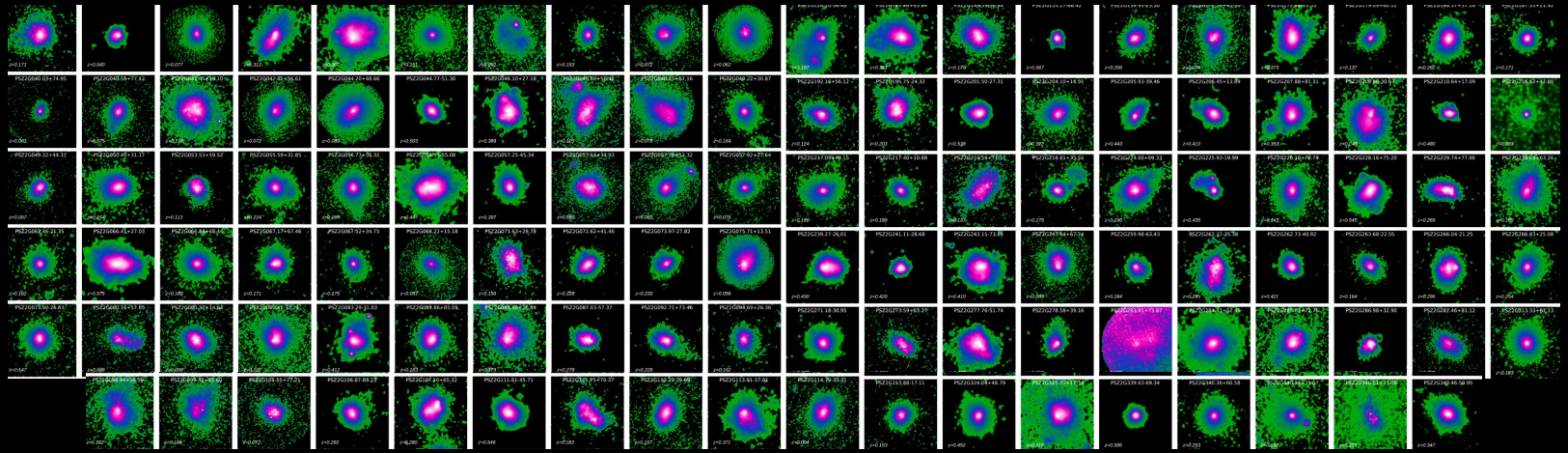
CHEX-MATE: The first census of ICM discontinuities in a representative sample of galaxy clusters



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Authors: Giulia Campitiello, Stefano Ettori, Lorenzo Lovisari, et al.

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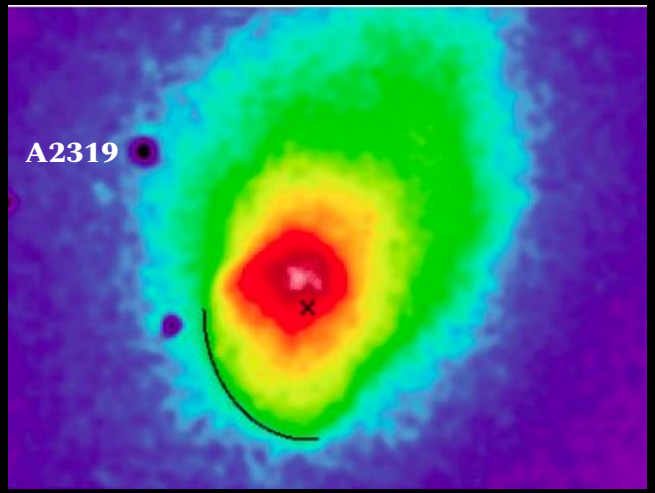
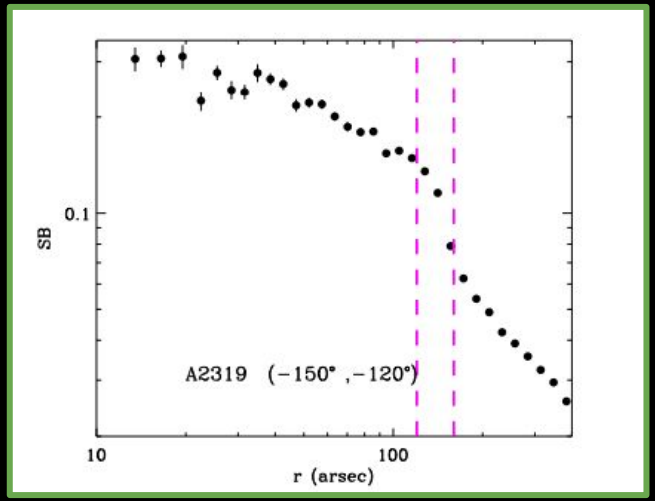
What do we mean by SB discontinuities?

[Ghizzardi et al. 2010]



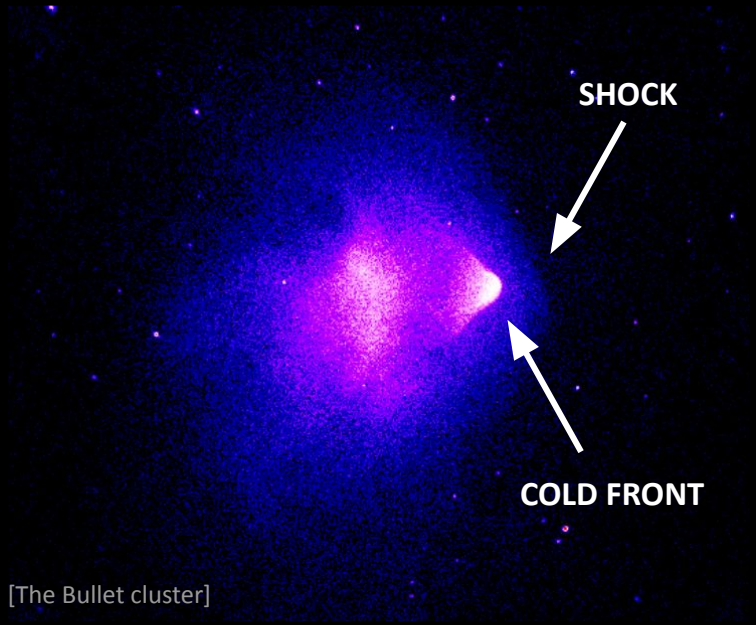


X-ray images and brightness profiles reveal **sharp changes** in ICM structure.

Classification: shocks or cold fronts?

Key morphological features in galaxy clusters help distinguish between dynamical interactions.

SHOCKS: pressure **waves** triggered by high-velocity mergers.



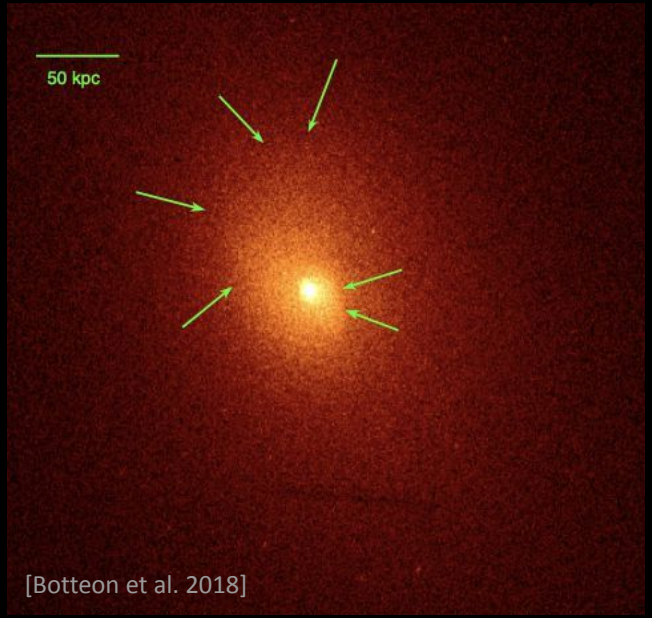
[The Bullet cluster]

COLD FRONTS: 1) **contact discontinuity** between distinct gas substructures

Classification: shocks or cold fronts?

Key morphological features in galaxy clusters help distinguish between dynamical interactions.

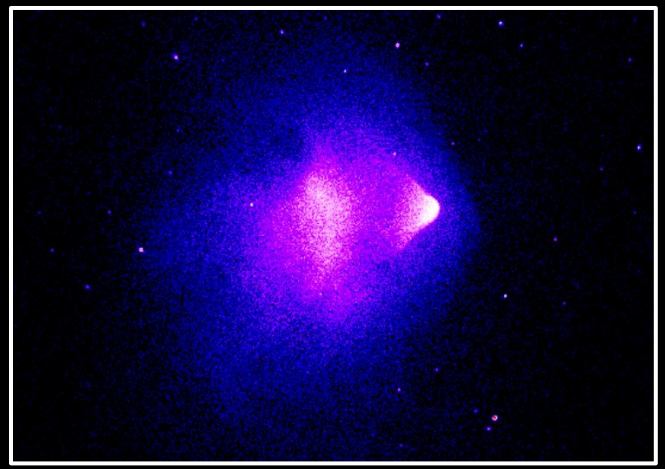
SHOCKS: pressure **waves** triggered by high-velocity mergers.



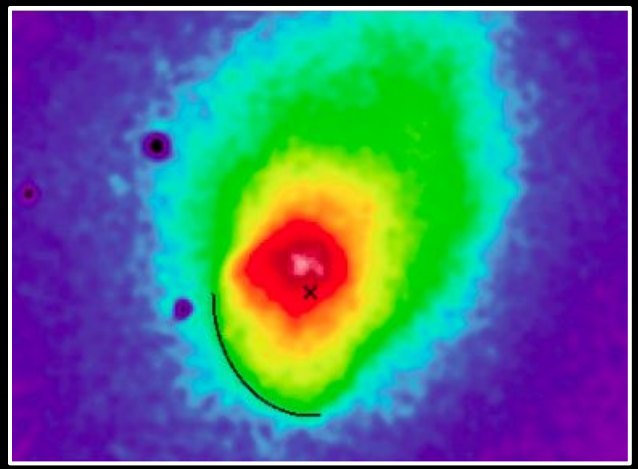
COLD FRONTS: 2) **sloshing** triggered by off-axis/minor merger events.

The challenge: detect edges in CHEX-MATE

A XMM-Newton analysis of a large sample of galaxy clusters (**116 objects**).
How to identify these features in the **most objective** way possible?



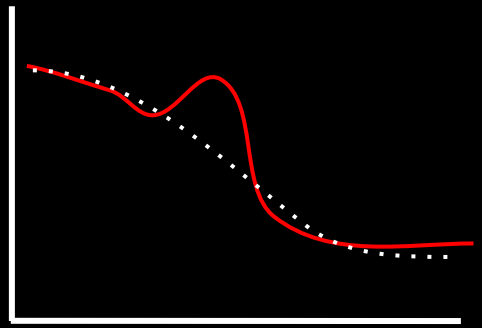
Chandra: resolution~0.5 arcsec.

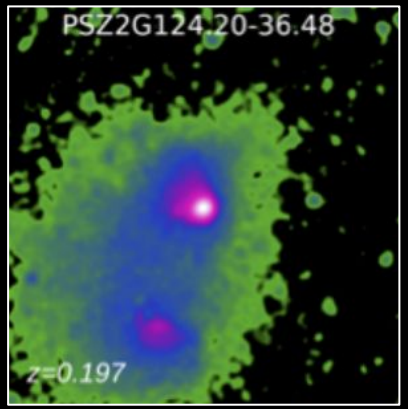


XMM: resolution~13 arcsec

The method

Using the best-fit **β-model** of the SB profile, we generate a **model image** to identify **SB excesses/deficits** and **gradient steepness variations**, revealing the following features:

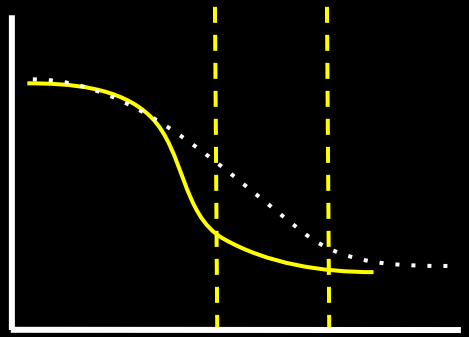


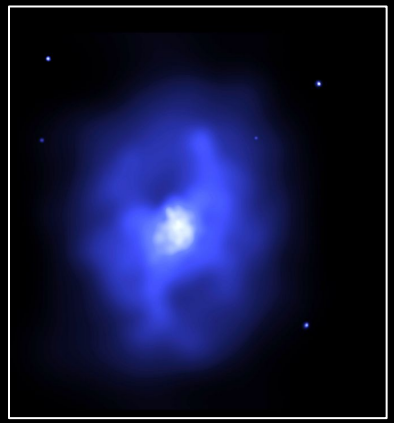


CASE A: SB excess with **gradient steepening**-> **SUBSTRUCTURES**

The method

Using the best-fit **β-model** of the SB profile, we generate a **model image** to identify **SB excesses/deficits** and **gradient steepness variations**, revealing the following features:

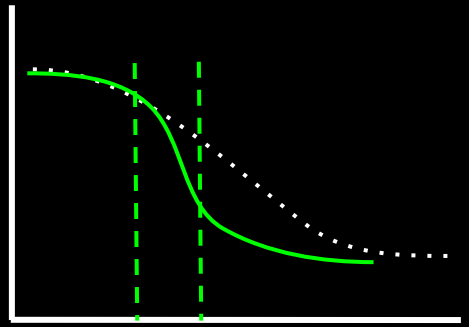


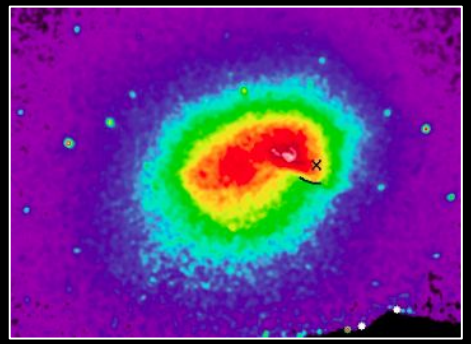


CASE B: SB deficit with **gradient flattening**-> **CAVITIES**

The method

Using the best-fit **β-model** of the SB profile, we generate a **model image** to identify **SB excesses/deficits** and **gradient steepness variations**, revealing the following features:

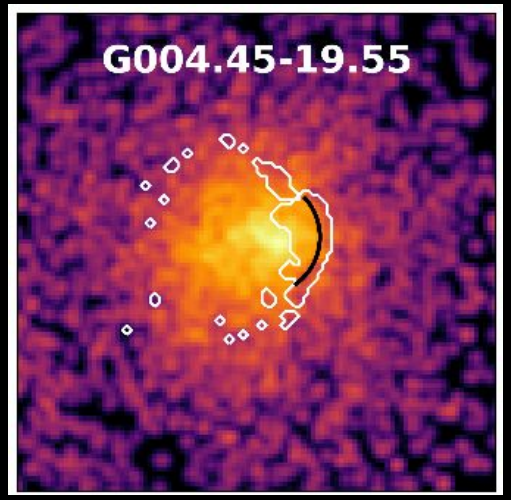




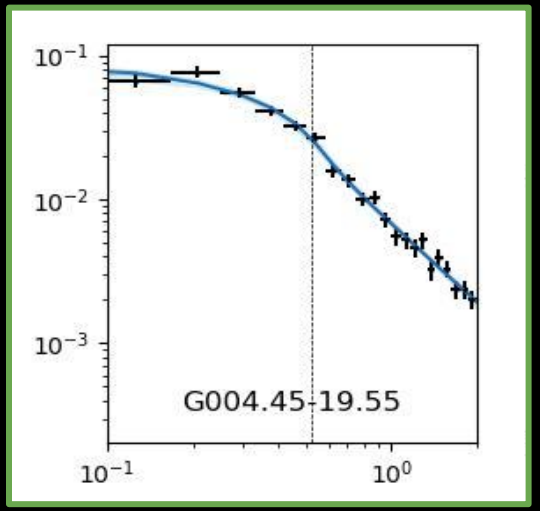
CASE C: SB deficit with **gradient steepening**-> **EDGES**

Application on CHEX-MATE

Example of a **cold front** detection in one object from the sample.

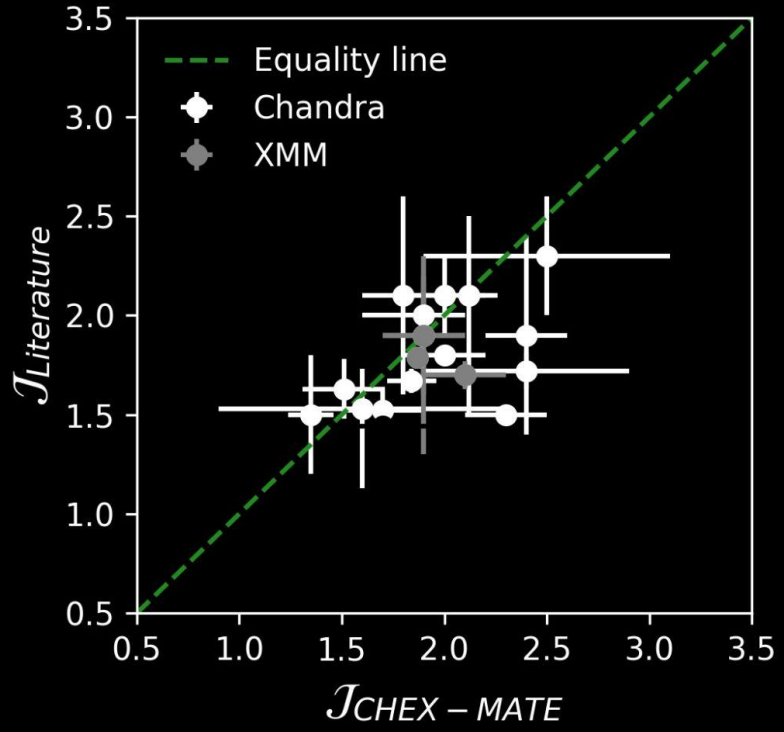


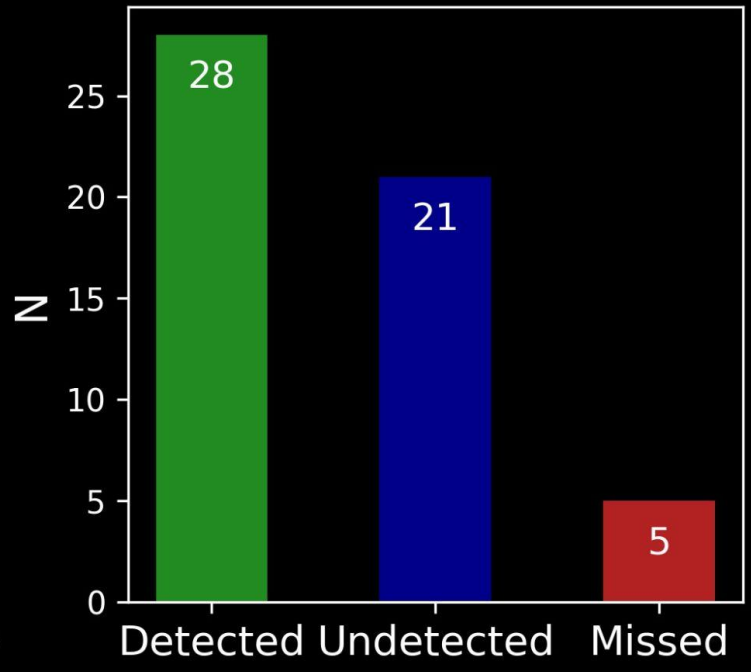
Candidate region shown in white, detected **edge** in black..



SB profile across the edge: model includes PSF smoothing.

Comparison with the literature



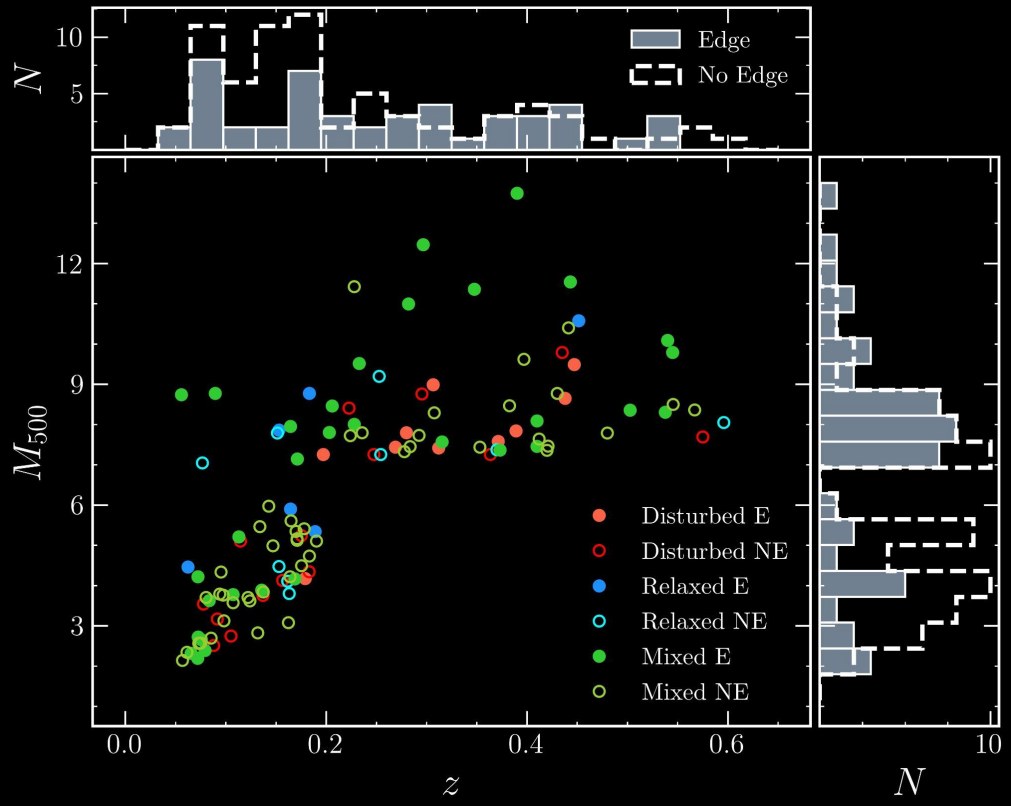


The CHEX-MATE catalog of ICM discontinuities

We found **69 edges**, of which **41** are **newly detected**;

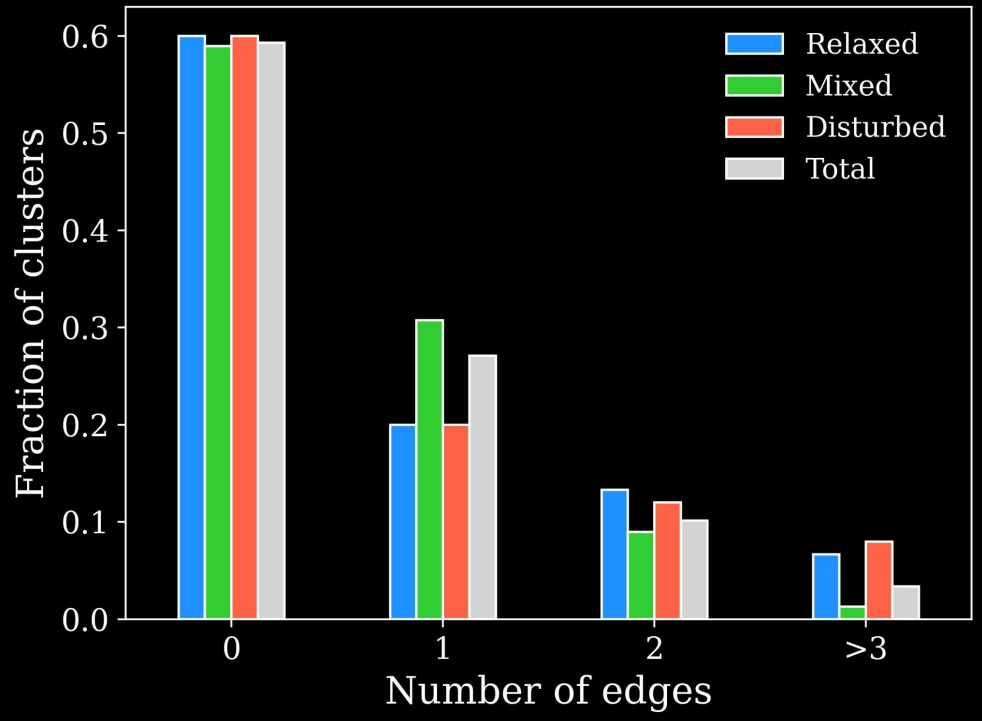
48 clusters out of 116 (**~ 40%**) show at least **one edge**.

The fraction of edges is significantly higher at **high masses** and at **high redshift**.



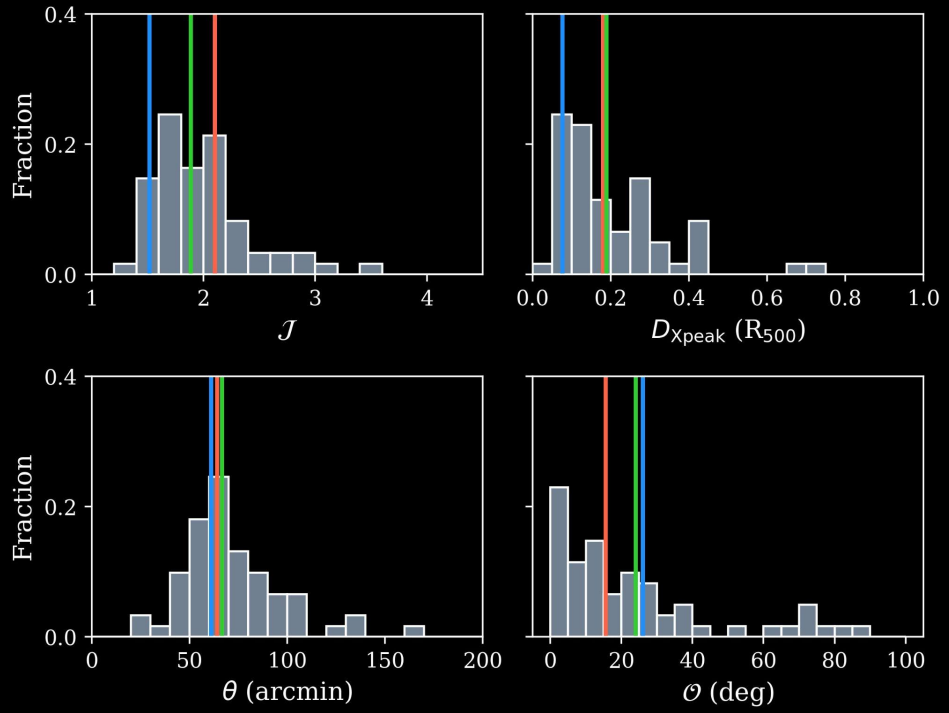
The CHEX-MATE catalog of ICM discontinuities

No peculiar trend is observed between **relaxed**, **mixed** and **disturbed** systems.



Properties of the edges

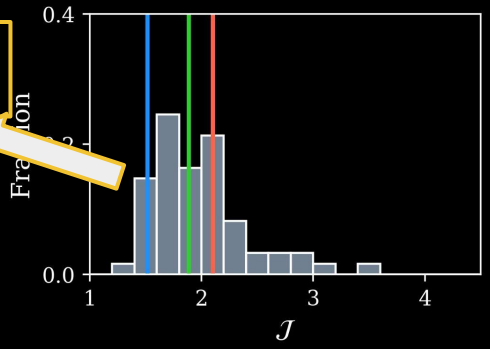
Edges in **disturbed** systems are **stronger**, **more distant** and **more aligned** than edges in **relaxed** systems.



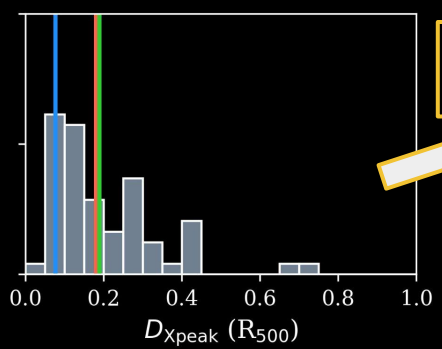
Properties of the edges

Edges in **disturbed** systems are **stronger**, **more distant** and **more aligned** than edges in **relaxed** systems.

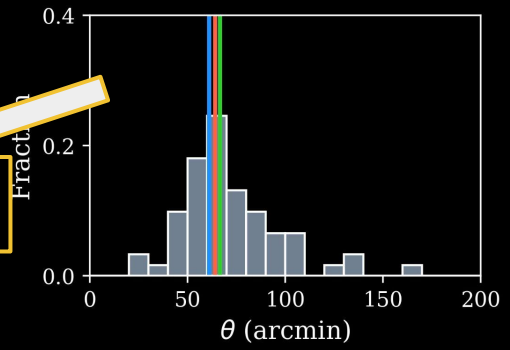
Entity of the jump



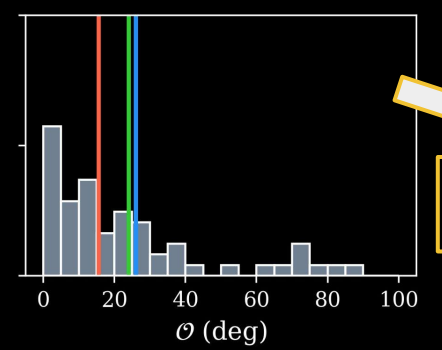
Distance from X-peak



Angular extension

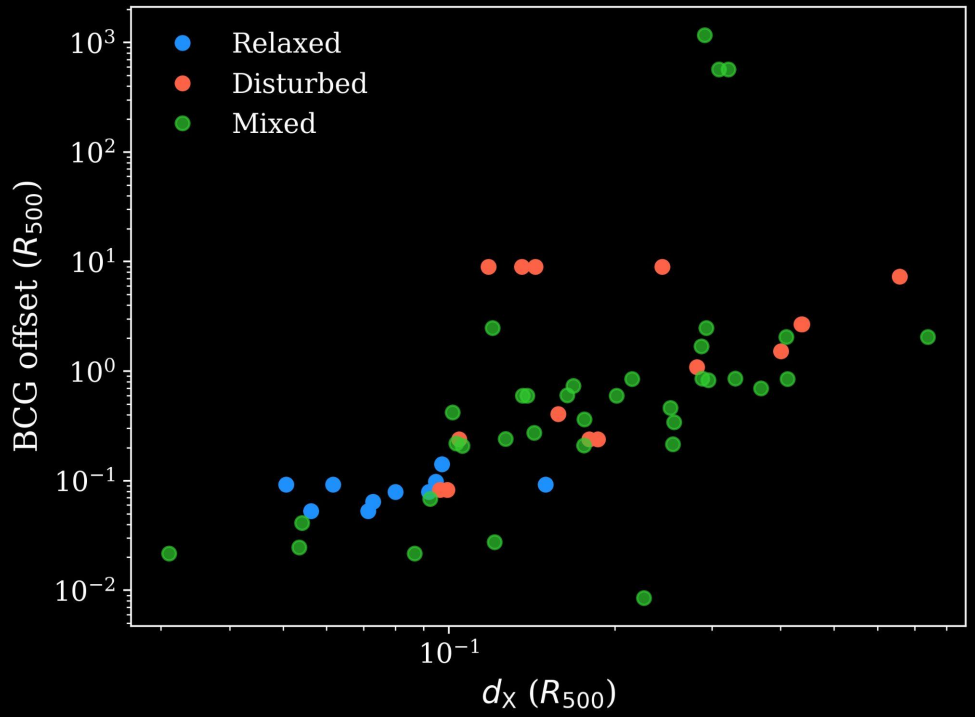


Alignment with X-ray morphology



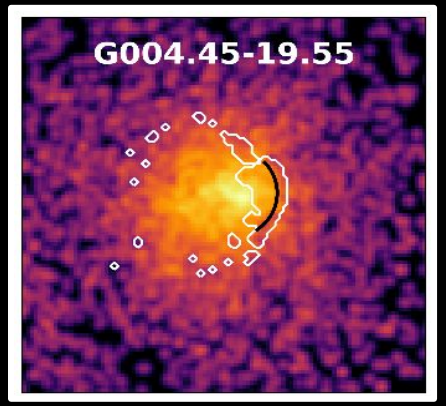
Properties of the edges

Strong correlation between **BCG offset** and **distance** from the X-ray peak.

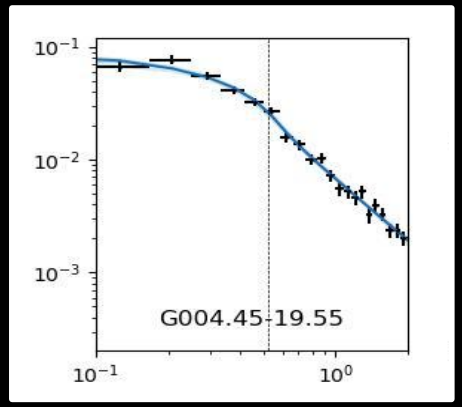


Spectral classification of the edges

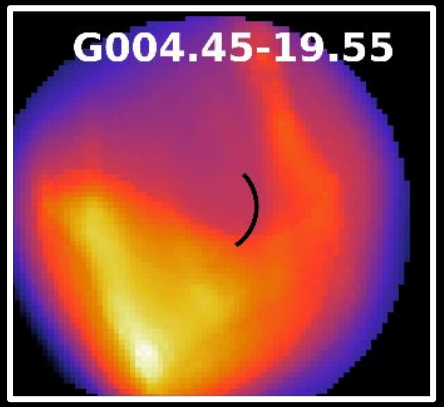
We used wavelet temperature maps for a **preliminary classification** of edges into shocks and cold fronts.
We found **14 candidate shocks** and **42 candidate cold fronts**.



SB map



SB profile



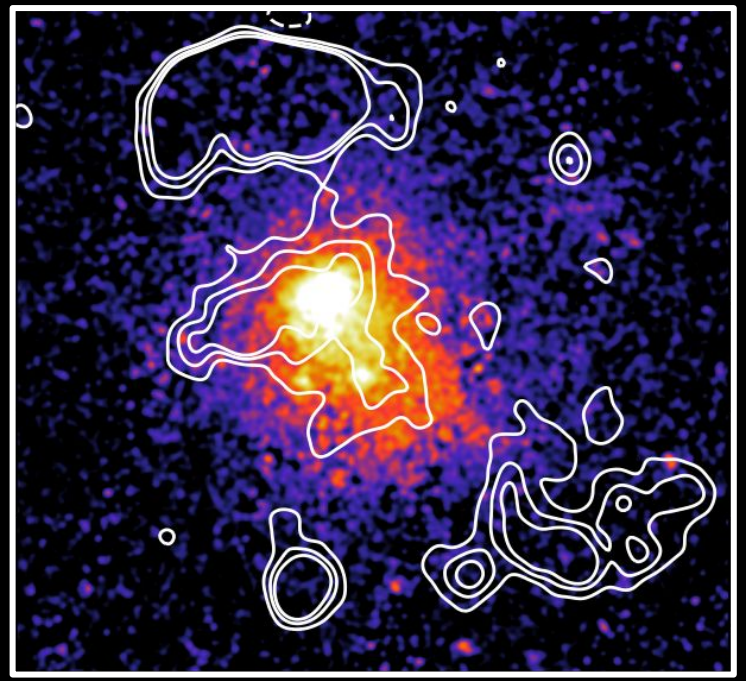
T map

Comparison with the radio information

All clusters **with at least one edge** host either a **radio halo, a radio relic, or a mini-halo**.

The reverse is not true: **only half** of the clusters with **diffuse radio emission** show at least **one edge**.

The majority of the mixed systems with radio emission, do not show any edge -> **Projection effects** at work.



[X-ray and radio view of G113.91 from **Campitiello et al. 2023**]

Conclusions

CHEX-MATE: The first census of ICM discontinuities in a representative sample of galaxy clusters

M. G. Campitiello[1,⋆], S. Ettori[2,3], L. Lovisari[4,5], F. Gastaldello[4], H. Bourdin[6,7], P. Mazzotta[6,7], M. Rossetti[4], A. Botteon[8], R. Cassano[8], F. De Luca[6,7], D. Eckert[9], B. Forman[4], M. Gaspari[10], S. Ghizzardi[4], M. Gitti[11,8], S. T. Kay[12], B. J. Maughan[13], E. Pointecouteau[14], G. W. Pratt[15], E. Rasia[16,17], J. Sayers[18], and M. Sereno[2,3]

- **Definition of a method** for the detection of edges up to **z~0.55**;
- **Identification** and **characterisation** of the edges in CHEX-MATE;
- **Preliminary classification** in shocks and cold fronts;
- Investigation of the **limits** of XMM analysis;
- Comparison with the **radio emission**

Conclusions

CHEX-MATE: The first census of ICM discontinuities in a representative sample of galaxy clusters

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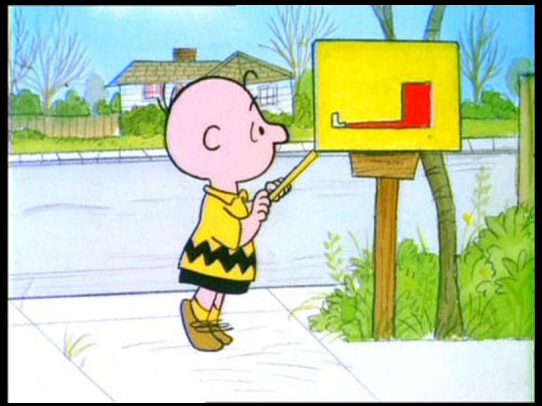

SUBMITTED...waiting for review!