Challenging the merger/sloshing cold front paradigm: A2142 revisited by XMM

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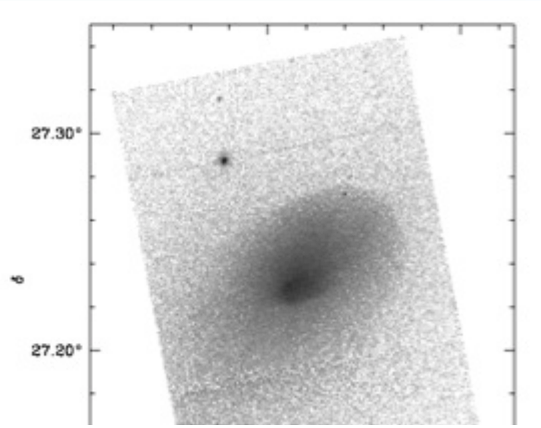
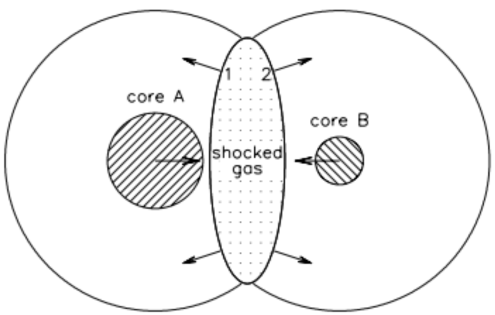
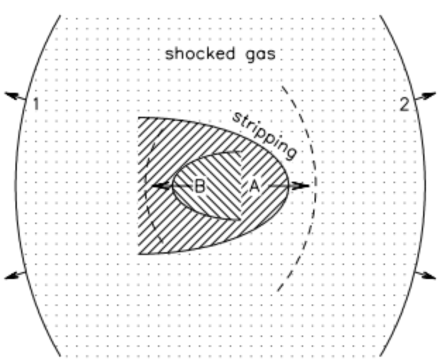
A tale of two cold fronts





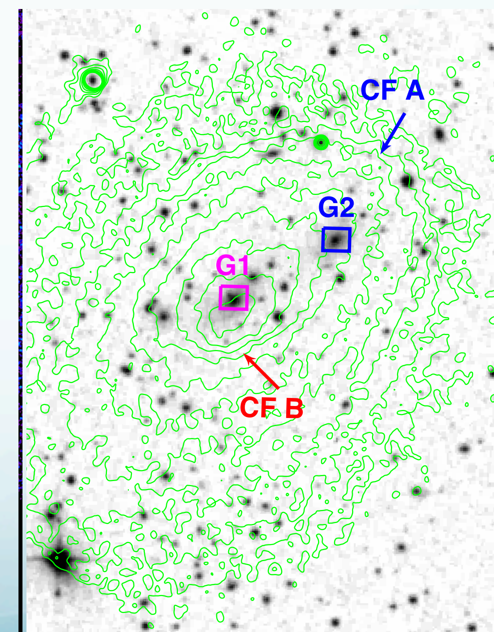


Cluster in which cold fronts have been discovered by Chandra (Markevitch et al. 2000): two sharp edges in the X-ray image, with a temperature jump

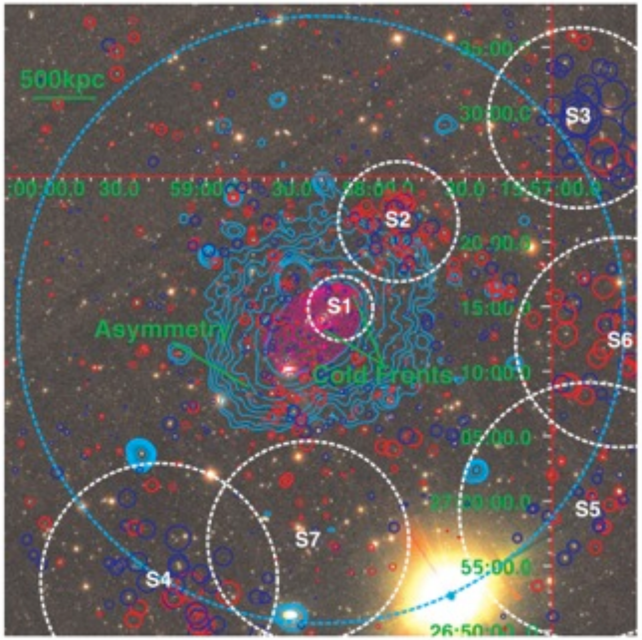
Interpreted in the discovery paper as the "remnant cores" of two merging subclusters

But problems with the galaxy distribution:

- G2 is isolated with a large velocity in the l.o.s
- G1 lags behind the gas



A tale of two cold fronts



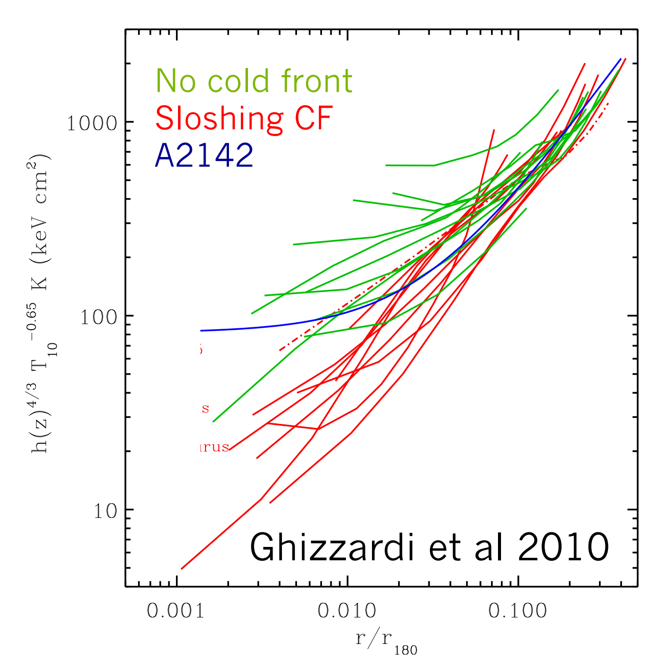
Resemblance of the X-ray image with the predictions of hydrodynamical simulations (Tittley & Henriksen 2005, Ascasibar & Markevitch 2006) changed the interpretation to sloshing (Markevitch & Vikhlinin 2007, Owers et al 2009)

Optical substructure analysis by Owers et al (2011) suggests two possible candidate perturbers

However:

A2142 is not a cool core cluster (K_0=68 keV cm^2) and morphology is elliptical and elongated SE-NW direction

Flat entropy profile with respect to clusters hosting sloshing cold fronts



A tale of two cold fronts

Remnant cores

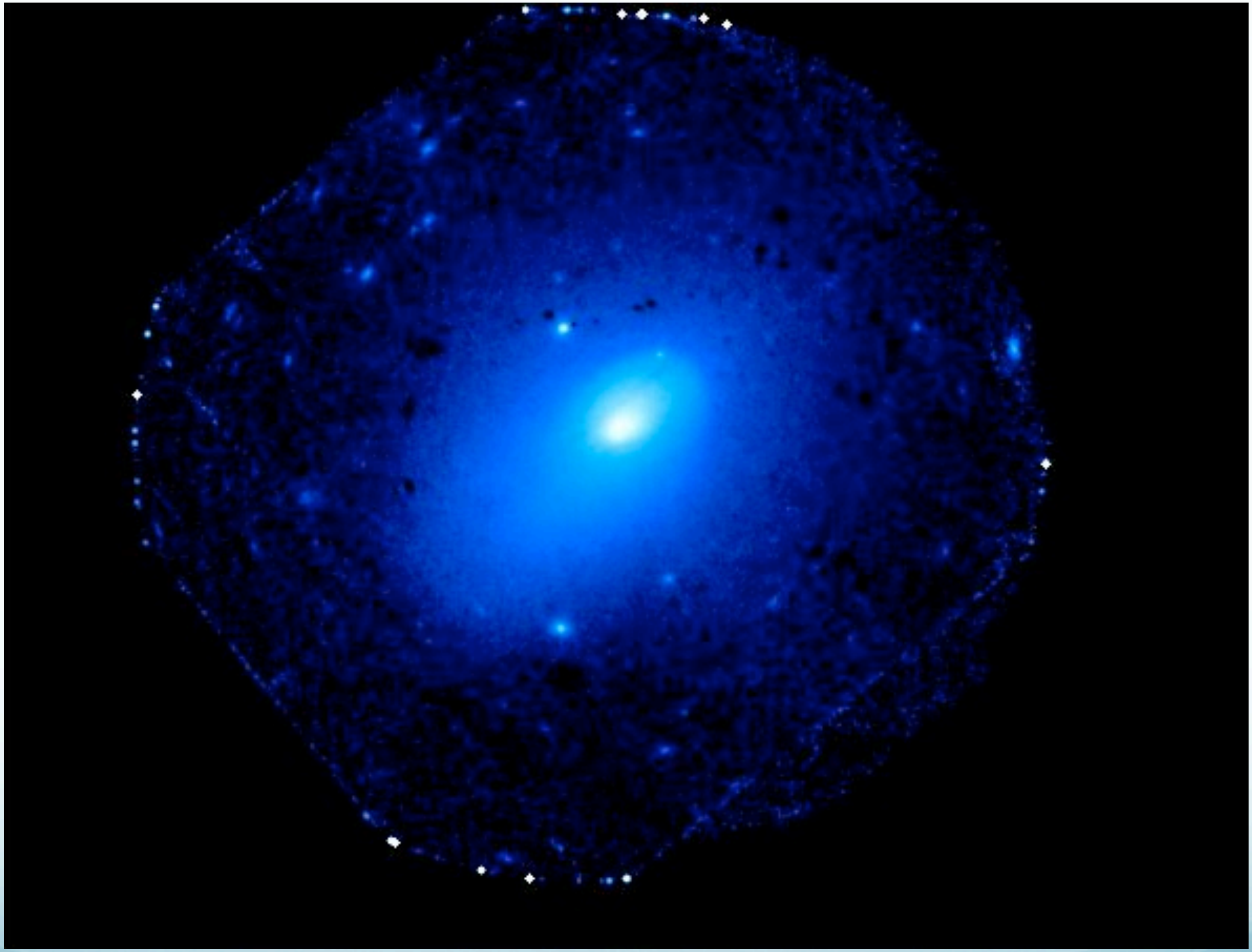
- ✓ Cometary shape of the edges
- ✓ Overall elongation in X-rays and in the optical in the SE-NW direction
- ✓ Not a relaxed, cool core cluster
- ✗ Problem with the optical distribution: where are the galaxies associated to the NW CF?

Sloshing

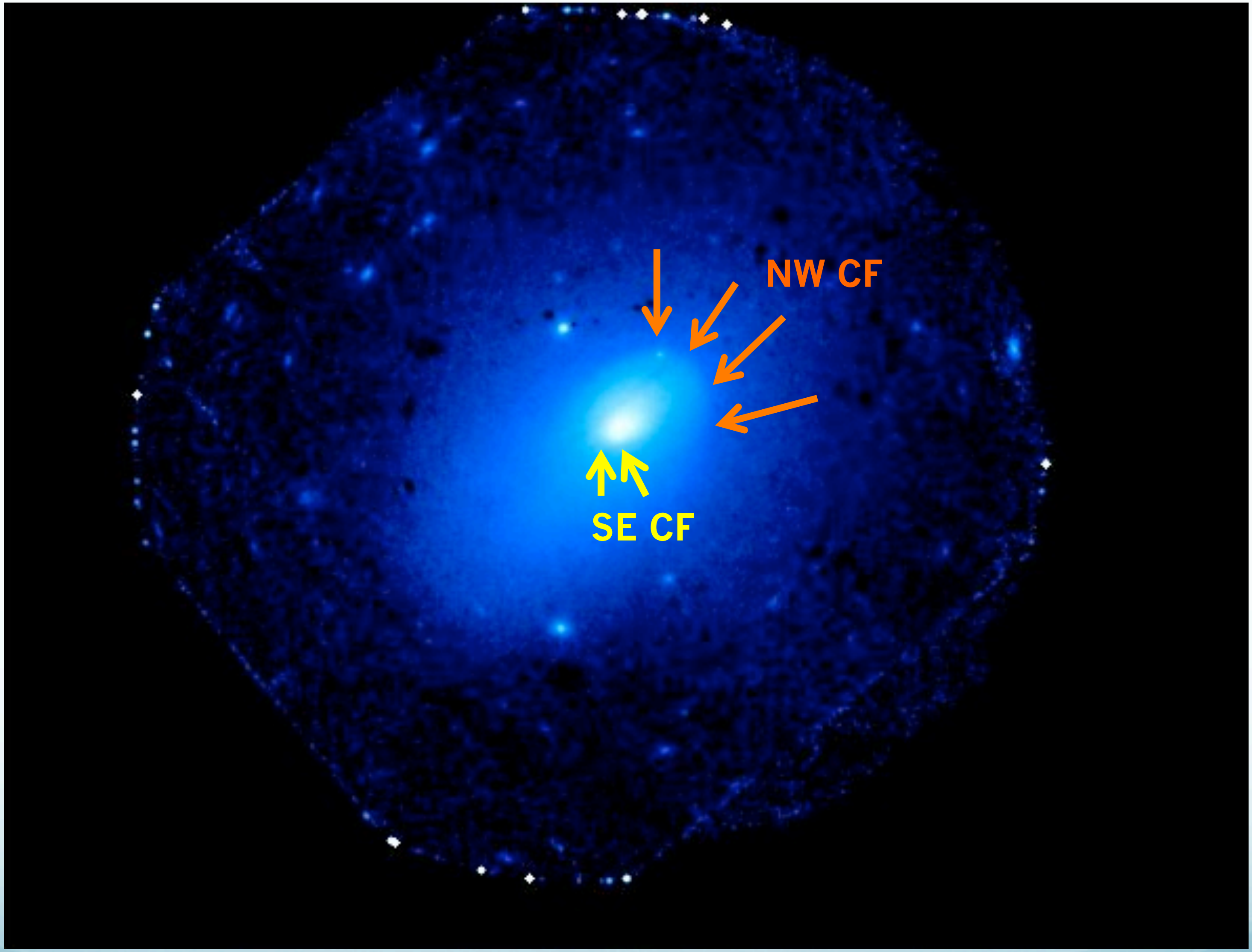
- ✓ Concentric edges as in simulations
- ✓ Optical subcluster identified as candidate perturber, with orbit consistent with the overall morphology
- ✗ Not a relaxed, cool core cluster, flat entropy profile

While usually shown as textbook example of cold fronts, A2142 challenges our current interpretation of the cold front feature.
New observations are needed!
(Puzzling objects are interesting targets)

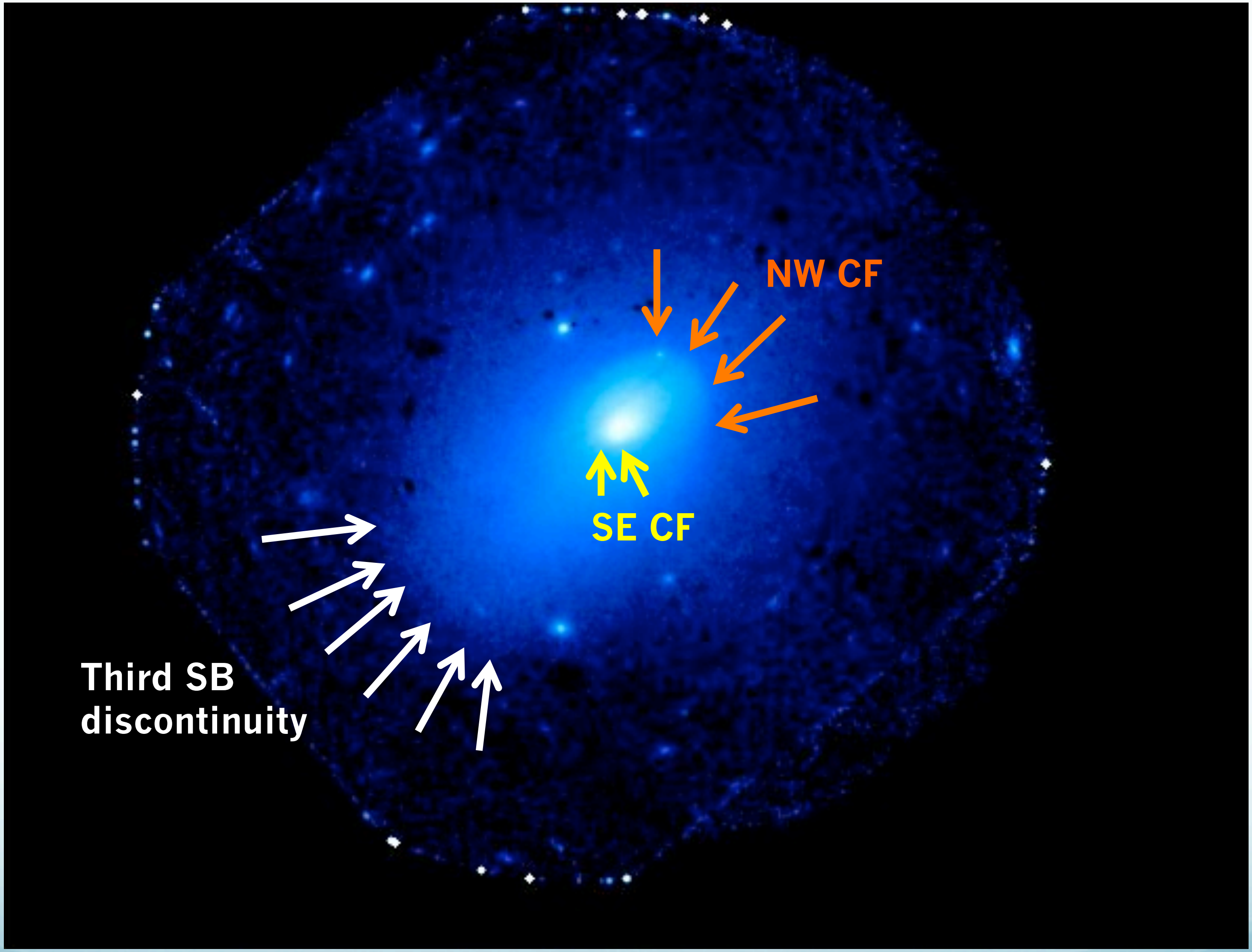
A2142 as seen by XMM-Newton



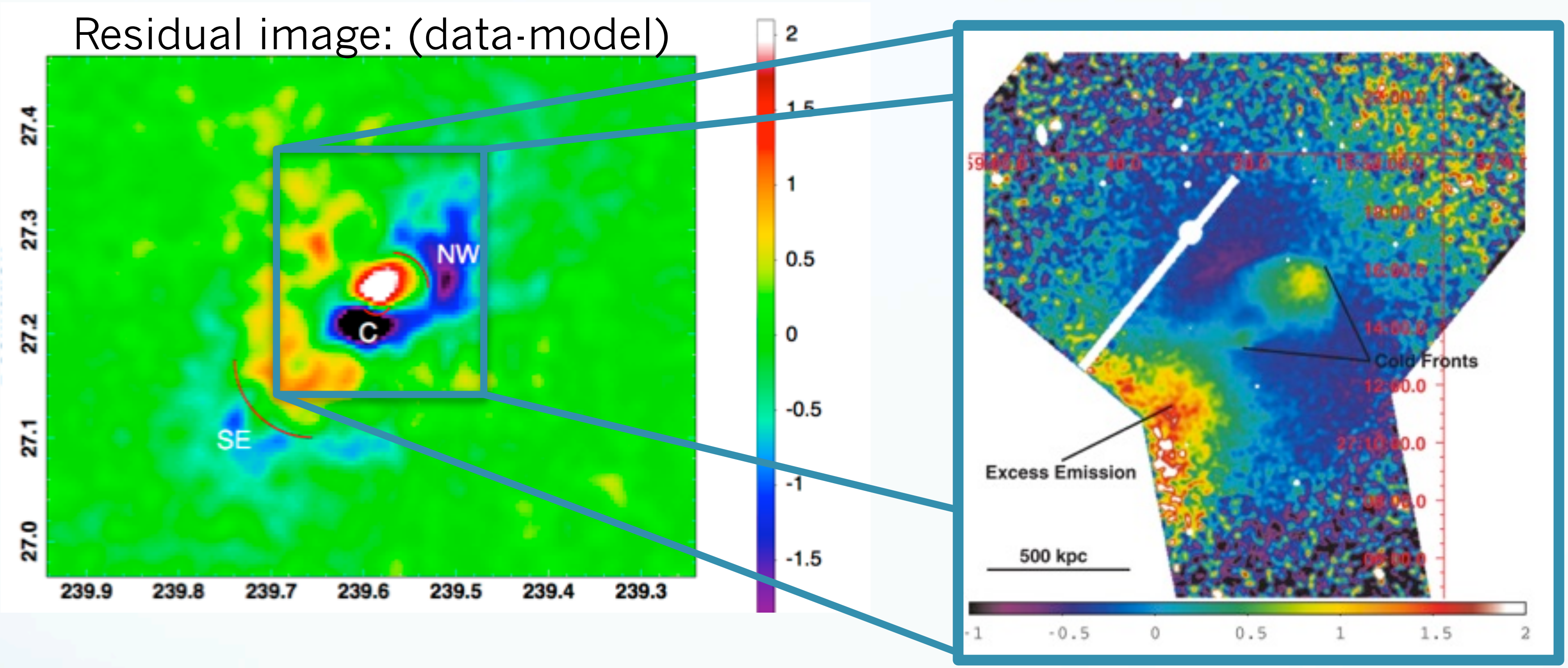
A2142 as seen by XMM-Newton



A2142 as seen by XMM-Newton

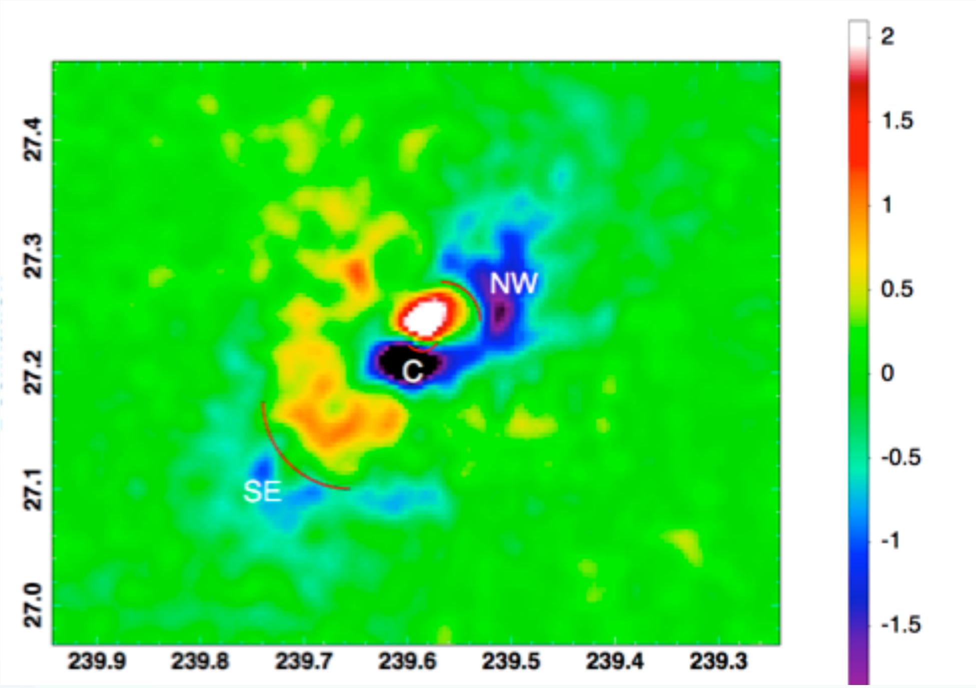


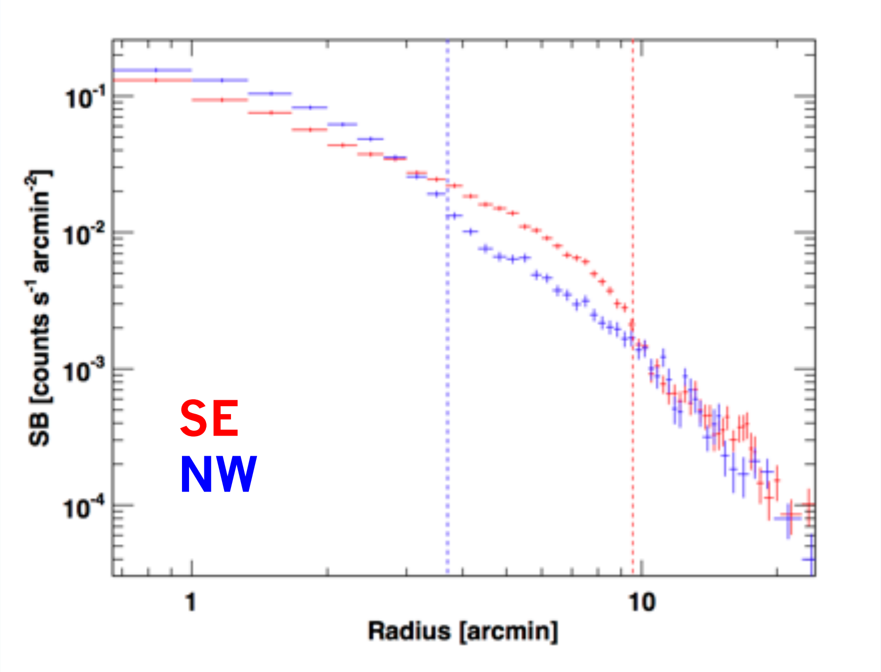
A2142 as seen by ROSAT PSPC



The SE feature was not totally unexpected: we had already noticed it in ROSAT PSPC residual maps and profiles.
SE excess partly seen in Chandra residual maps (Owers et al 2011)

A2142 as seen by ROSAT PSPC

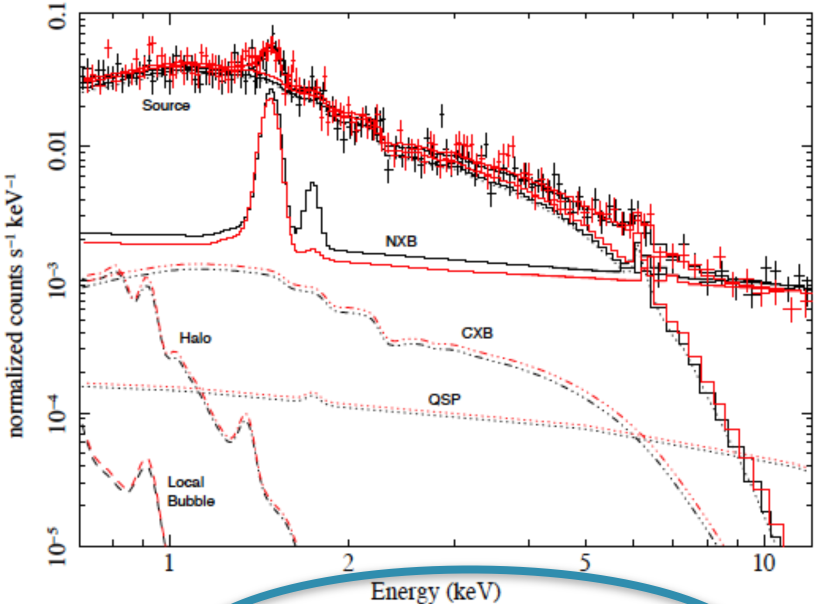




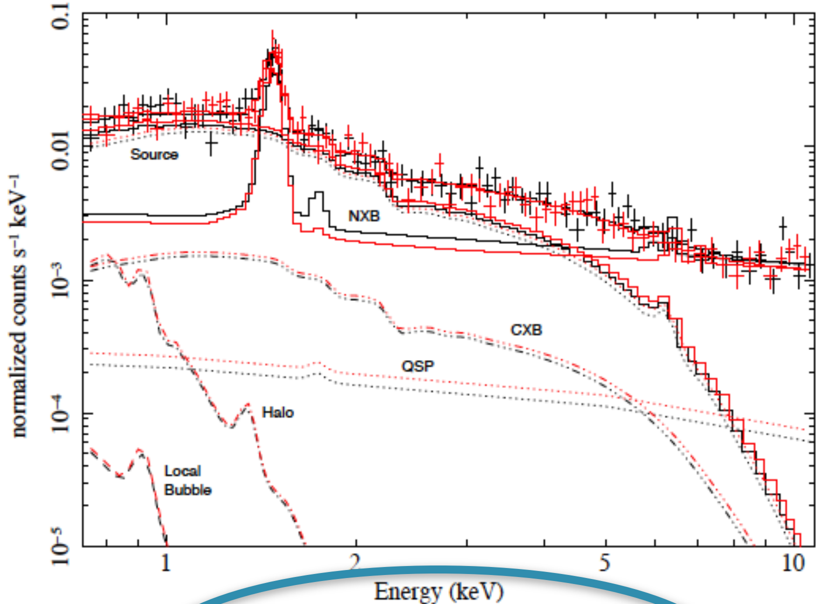
The discontinuity is seen also in the SB profile in the SE.
Fit with a broken power-law density model gives n_{IN}/n_{OUT}= 1.92±0.1, R_{cut}=986±10 kpc

Nature of the SE discontinuity

DENSER PART OF THE DISCONTINUITY



RAREFIED PART OF THE DISCONTINUITY



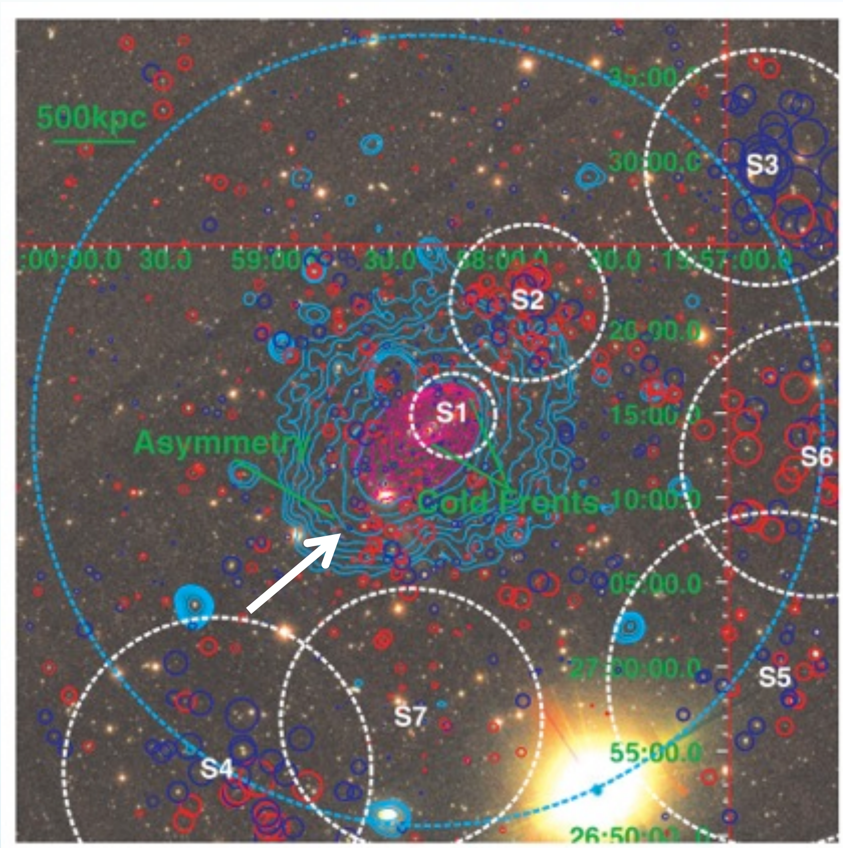
$$kT_{IN} = 6.3^{+0.45}_{-0.37}$$

$$kT_{OUT} = 9.0^{+2.4}_{-1.5}$$

The temperature difference is only marginally significant (1.8σ).Still consistent with the shock front?
Using Rainkine-Hugoniot condition with our measured density jump, we can predict kT_{OUT}= 3.9 keV, rejected at $> 5\ \sigma$

It's not a shock! It is a cold front

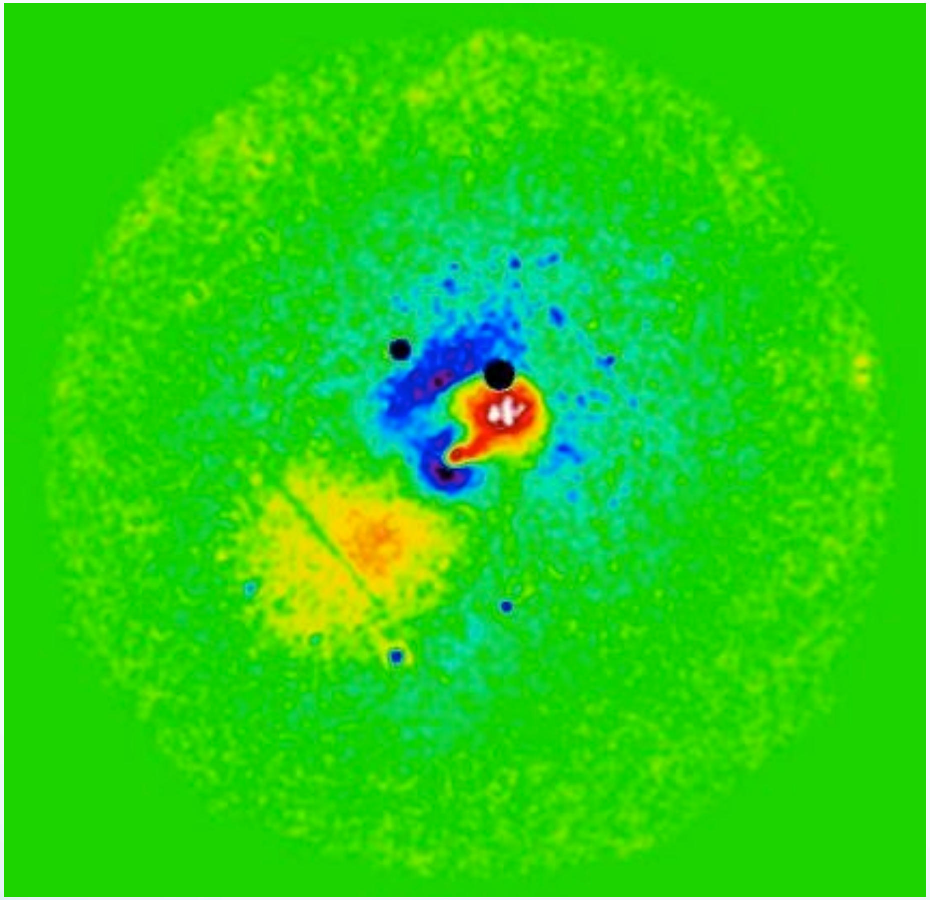
Properties of the SE cold front

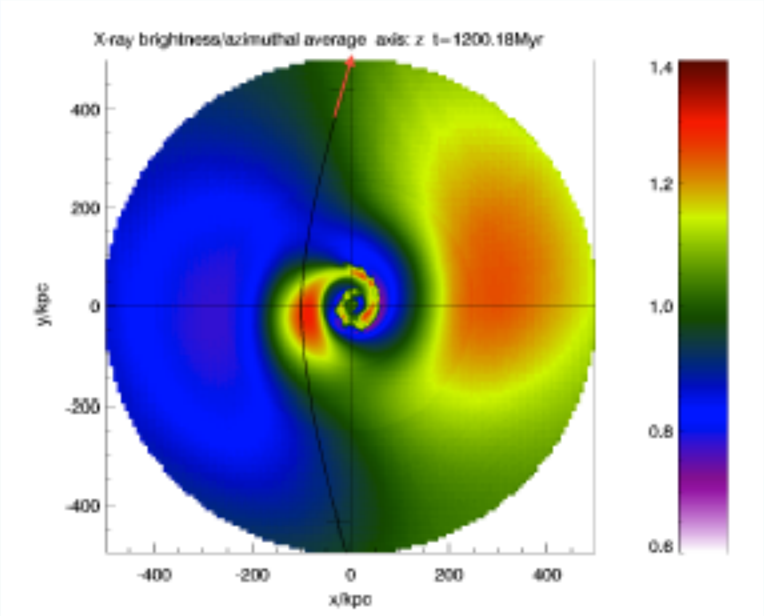


No obvious dark matter halo is associated with the SE CF: no substructure in the galaxy distribution (Owers et al. 2011) or in the weak lensing map (Okabe & Umetsu 2008) ahead or behind the front.

At 1 Mpc from the center, this is the **most peripheral cold front unassociated with a galaxy concentration** ever detected in a galaxy cluster

XMM-Newton residual map

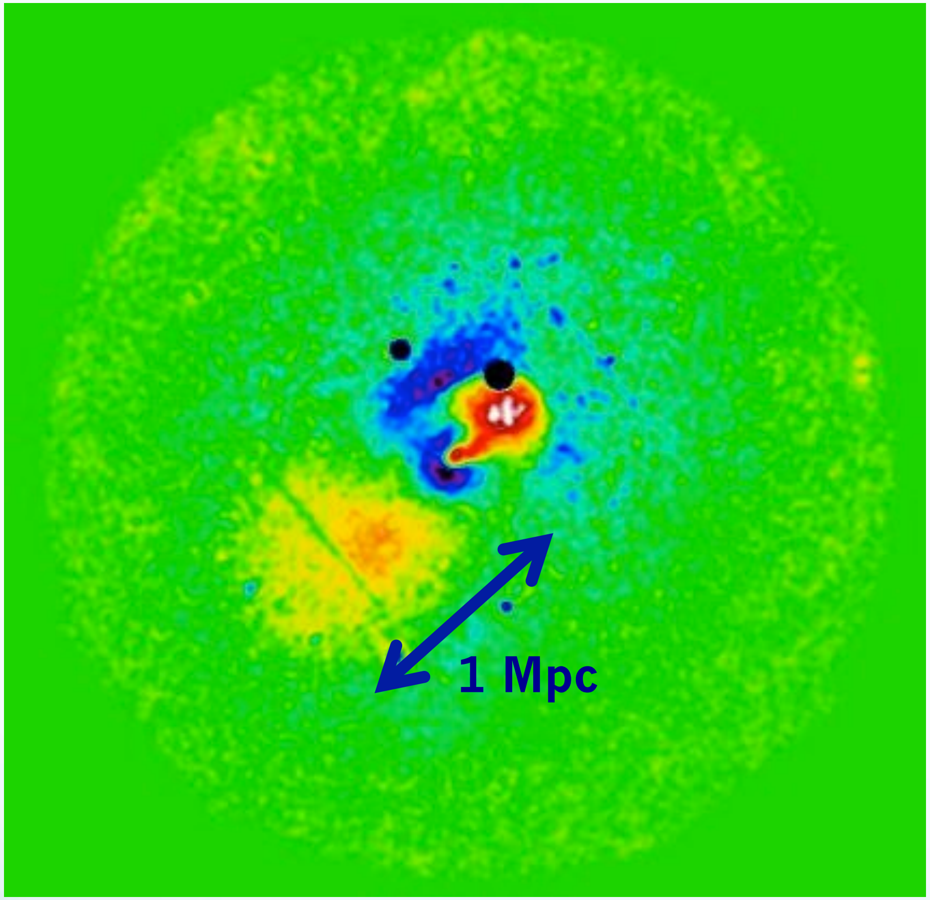


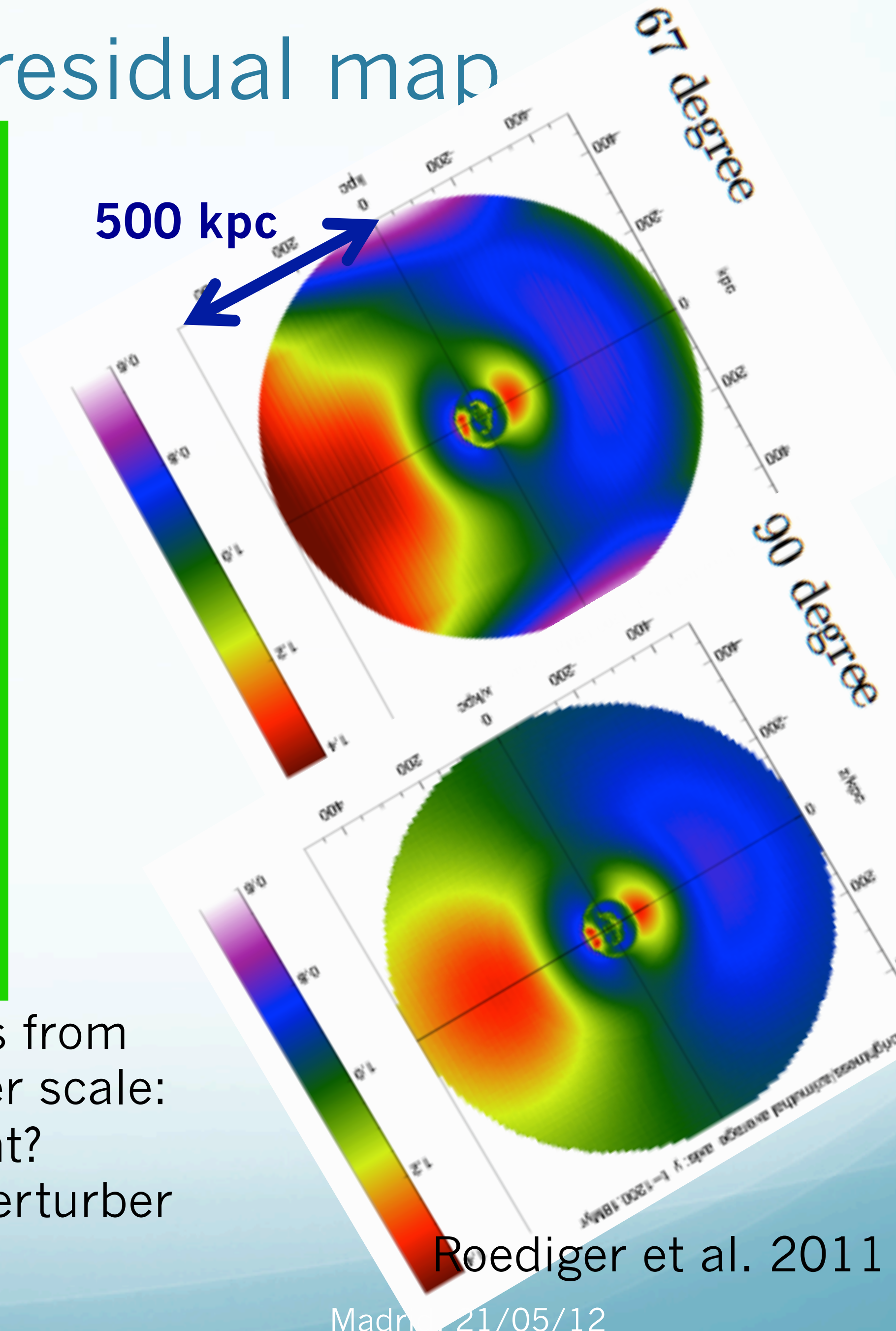


Roediger et al. (2011)

Following Owers et al. 2011, we rotate simulated SB residual maps to match the proposed sloshing geometry with the subcluster orbit along the line of sight.

XMM-Newton residual map

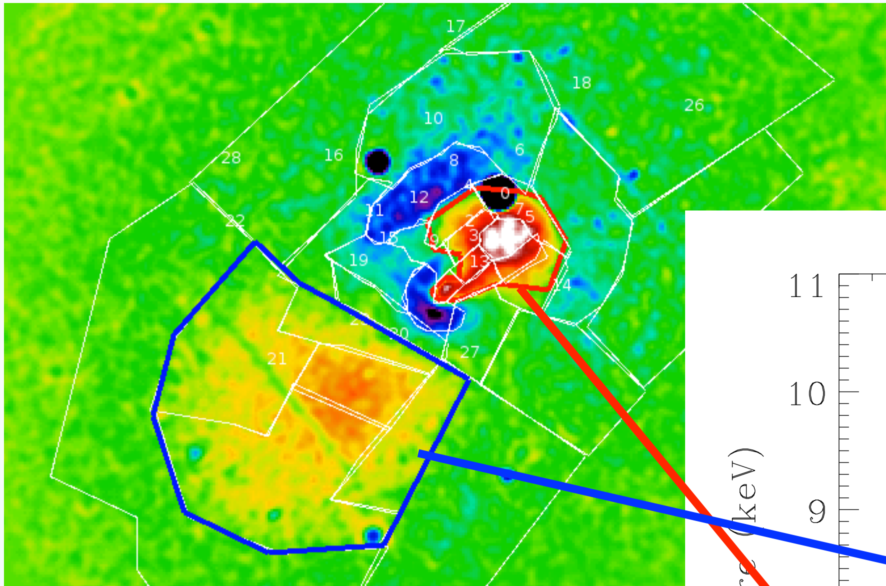




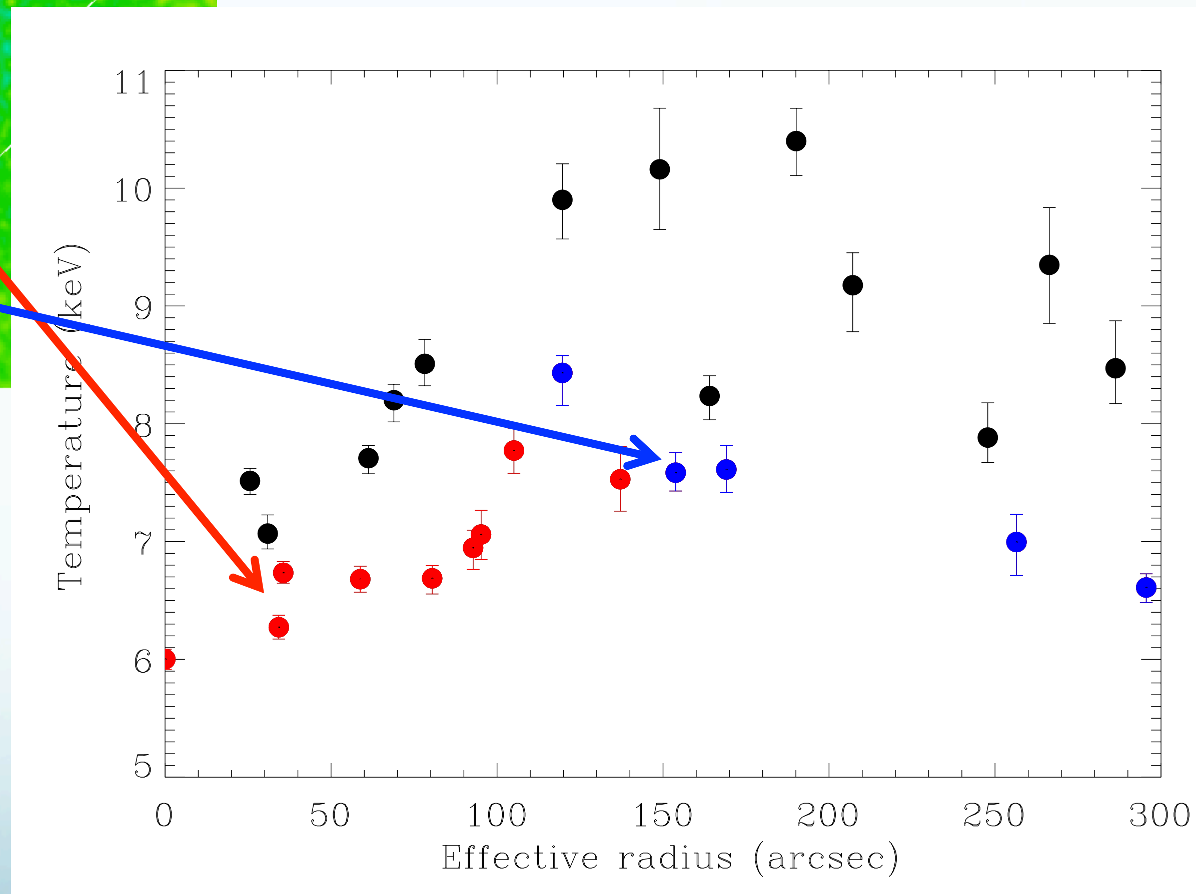
Morphological similarity with predictions from sloshing simulations but at a much larger scale: "extreme" sloshing along the line of sight? Consistent with orbit of the candidate perturber (Owers et al 2011)

Roediger et al. 2011

Temperature and metal distribution

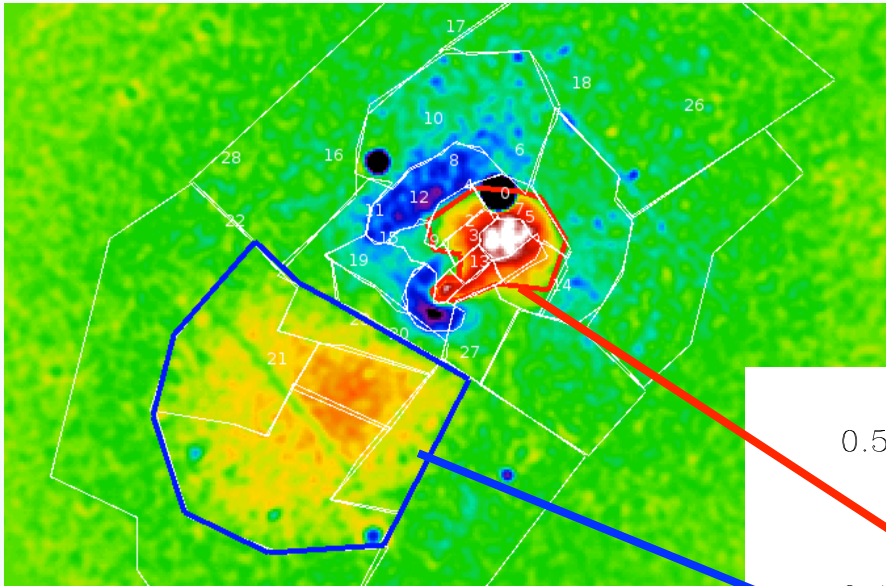


Selection of regions for spectral analysis with the residual image (see talk by S.Ghizzardi)



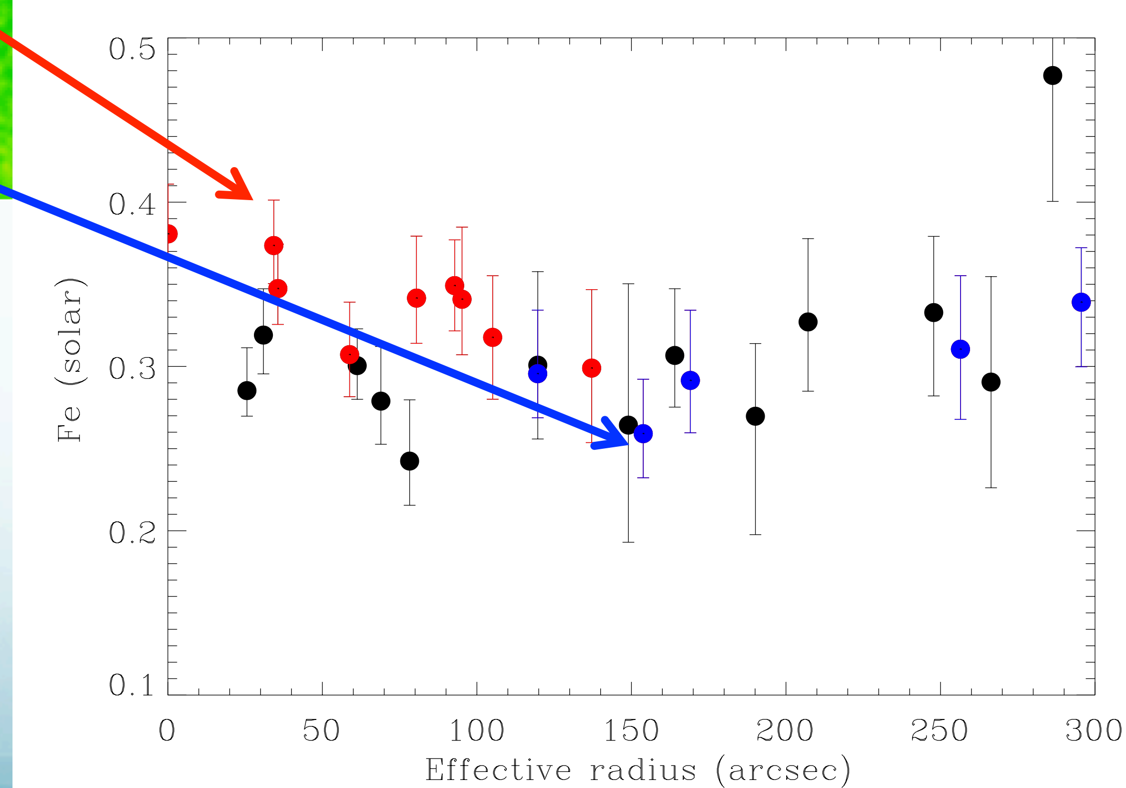
Regions on the SB excess (both to the NW and to the SE) are **COOLER** with respect to regions at the same distance from the center

Temperature and metal distribution



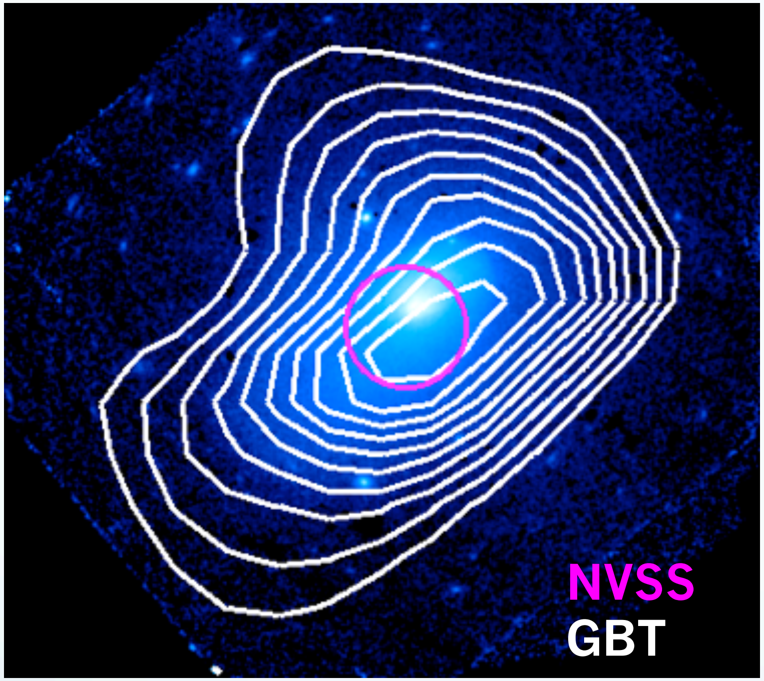
Regions on the SB excess to the NW show the largest metal abundance in the cluster (e.g. Roediger et al. 2011, see also S.Ghizzardi's talk)

Regions on the SB excess to the SE do not feature a significant metal abundance excess.



A new giant radio halo

Giovannini & Feretti (2000) detected extended radio emission, interpreted as a MINI RADIO-HALO due to its small size.



Low brightness radio emission extending beyond the mini-halo (2 Mpc diameter) found with GBT @1.4 GHz (Farnsworth, Rudnick & Brown, in prep.)

Giant radio halos are usually associated with major mergers, sloshing cold fronts to minor mergers.

A tale of ~~two~~ three cold fronts

Remnant core vs sloshing?

The position and size of the new feature and the presence of a giant radio halo are more expected in the "remnant core" scenario. But still problems with the galaxy distribution.

The similarity of the residual image, the temperature and metal abundance map with prediction of simulations, support the sloshing hypothesis. But scales are much larger.

The puzzle is not solved yet.

But the new pieces of information (XMM and radio) are pointing to either new phenomena either extreme versions of known mechanisms.
(Eckert et al. in prep, Rossetti et al. in prep., Farnsworth et al. in prep.)

Still need new multiwavelength observations AND new ''extreme'' simulations


THANKS!