

SLICE: Combining strong lensing and X-ray data of AC 114

Further insights into the merger scenario[★]

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ABSTRACT

AC 114 is a historically significant galaxy cluster, being one of the first strong lensing clusters detected from the ground in the early 1990s, prior to the launch of the *Hubble* Space Telescope (HST). Despite this early prominence, no detailed lensing analyses were carried out for more than 15 years. We studied this cluster using *James Webb* Space Telescope (JWST) imaging obtained as part of the Strong Lensing and Cluster Evolution (SLICE) programme, complemented by archival HST and X-ray observations. JWST data reveal ten new multiply imaged systems and enabled the identification of conjugate substructures in several of the 16 systems, significantly increasing the number of strong lensing constraints. Using these data, we constructed a parametric mass model with LENSTOOL and extended it by explicitly incorporating the *Chandra* data in a combined strong lensing+X-ray fit, following the methodology recently introduced by us. Our best-fit model reproduces the multiple images with an RMS of 0.4'' while simultaneously matching the X-ray data. The dark matter distribution is unimodal and centred on the brightest cluster galaxy, with a large core radius of 83 ± 5 kpc, consistent with values reported in other strong lensing clusters. The strong lensing constraints require the inclusion of an external shear component whose position angle points unambiguously towards a nearby (~ 1 Mpc), well-defined mass concentration at the same redshift in the north-west, for which we propose the name AC 114b. The spatial coverage of the *XMM-Newton* data encompasses the whole structure, allowing us to probe the X-ray properties of the companion cluster and the thermodynamics of AC 114. This provided further evidence of a major merger, in line with previous signatures seen in *Chandra*, radio, and optical spectroscopic data. Our results shed new light on the merging scenario, revealing a major merger caught in a late post-collisional phase, where AC 114 is the dominant system and AC 114 b has likely been stripped of its hot gas. Our analysis highlights the power of combining strong lensing constraints with X-ray data to disentangle the dark matter and gas components and to investigate the dynamical processes driving cluster mergers. Our lens model and associated products are available for download at the [Strong Lensing Cluster Atlas Data Base](#), which is hosted at Laboratoire d'Astrophysique de Marseille.

Key words. galaxies: clusters: general – dark matter – large-scale structure of Universe

1. Introduction

The late 1980s marked the era of the first discoveries of giant gravitational arcs in galaxy clusters, made using ground-based

telescopes of the two-metre class (Lynds & Petrosian 1986; Soucail et al. 1987; Lavery & Henry 1988; Lynds & Petrosian 1989). These findings opened a new chapter in observational astronomy. Accompanied by theoretical insights, these early detections led to the conclusion that ‘the lensing hypothesis should be taken seriously’ (Grossman & Narayan 1988). In the early 1990s, pioneering studies transformed these initial

[★] Based on observations obtained with the *James Webb* Space Telescope and the *Hubble* Space Telescope.

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discoveries from scientific curiosities into powerful cosmological tools, especially with the advent of the *Hubble* Space Telescope (HST).

Galaxy cluster AC 114¹, at redshift 0.317, is one such example. Lensing features were first detected in ground-based images (Smail et al. 1991), then with WFPC1 on board the HST (Smail et al. 1995) and with WFPC2 shortly thereafter (Natarajan et al. 1998). Multiply imaged systems were reported, primarily by Natarajan et al. (1998), and spectroscopic redshifts were measured for some of them (Campusano et al. 2001; Lemoine-Busserolle et al. 2003), enabling early lensing analyses (e.g. Sereno et al. 2010). The strong magnification of this cluster has made it a valuable target for the study of distant galaxies (Richard et al. 2006).

AC 114 has been identified in major recent Sunyaev-Zeldovich (SZ) surveys. It is detected in the *Planck* PSZ2 catalogue (Planck Collaboration XXVII 2016), where it is referred to as PSZ2G008.31-64.74. This detection was confirmed at high significance in the SPTpol Extended Cluster Survey (Bleem et al. 2020), under the designation SPT-CLJ2258-3447, with a mass estimate $M_{500} = 7.23^{+0.82}_{-1.01} 10^{14} M_{\odot}$. AC 114 is also reported in the Atacama Cosmology Telescope catalogue (Aguena et al. 2026) with a mass estimate $M_{500} = 5.94^{+1.15}_{-0.97} 10^{14} M_{\odot}$. The discrepancy between experiments is not unexpected, and the impact of such differences on the SZ-mass scaling relations is discussed in Hilton et al. (2021).

AC 114 was first observed in X-rays with the *Chandra* telescope by De Filippis et al. (2004). While a sub-arcsecond offset between the X-ray peak and the brightest cluster galaxy (BCG) could suggest a relaxed cluster (Rossetti et al. 2016), the irregular morphology and a $\sim 10''$ offset between the X-ray centroid and the BCG instead indicate some merging activity. In particular, a soft X-ray tail is observed, connecting the cluster centre to the south-east.

This picture was confirmed by further X-ray observations with the *XMM-Newton* telescope, conducted as part of the CHEX-MATE survey (CHEX-MATE Collaboration 2021), which provided valuable constraints on the thermodynamical state and morphology of the system. Morphological classifications indicate a disturbed structure, and the cluster is ranked among the most disturbed systems in CHEX-MATE (Campitiello et al. 2022). This is significant since CHEX-MATE clusters are *Planck* SZ-selected and not biased towards merging clusters (Rossetti et al. 2017). In addition, the temperature profile shows a flat central shape and the absence of a strong cool core, both consistent with a merging state (Iqbal et al. 2023; Rossetti et al. 2024).

Based on radio-wavelength ASKAP observations, Duchesne et al. (2024) report the detection of a double radio relic system, along with additional residual emission at the cluster centre that has been proposed to be a candidate radio halo. More recently, MeerKAT observations (Balboni et al. 2026) clearly detect central diffuse radio emission that is well aligned with the thermal emission; this confirms its classification as a radio halo and is a characteristic signature of some merging activity. This dynamical activity is further evidenced by spectroscopic surveys (Proust et al. 2015; Saviane et al. 2023; Andrade et al. 2024; Pizzuti et al. 2025; Sereno et al. 2025), which report a velocity dispersion approaching 2000 km s^{-1} . The present work provides additional evidence of this dynamical state, based on both strong lensing (SL) and a re-analysis of

the *XMM-Newton* data, and offers insights into the merging scenario.

Recently, AC 114 was observed by the *James Webb* Space Telescope (JWST) as part of the Strong Lensing and Cluster Evolution (SLICE) survey (PID: 5594, PI: Mahler), with NIRCAM filters F150W2 and F322W2 and an effective exposure time of 1836 s in each filter. The NIRCAM data reduction is described in Cerny et al. (2026). We also used archival HST data from programme GO-11591, obtained from MAST and processed with DRIZZLEPAC/ASTRODRIZZLE to match the reduced JWST/NIRCAM imaging pixel scale and astrometry. The dataset includes ACS/F814W (4920 + 2380 s exposure) and WFC3/F160W and F110W observations (2412 s each).

The JWST data revealed new multiply imaged systems and offer additional insights into the previously known ones. In this paper, we present these newly identified systems and a parametric mass model we constructed using the LENSTOOL software (Jullo et al. 2007). We combined these data with *Chandra* X-ray observations to perform a strong lensing + X-ray (SL+X-ray) analysis of AC 114, with the goal of probing the mass distribution of this historically significant galaxy cluster.

We present the multiple images in Sect. 2. They serve as constraints for the SL mass model described in Sect. 3, where we detail the various steps involved in elaborating the model. We then turn to the available X-ray data for AC 114 in Sect. 4. We describe how the gas mass is explicitly incorporated into the mass model in order to construct our best-fit mass model of AC 114, which is presented in Sect. 5. In addition, we re-analysed the *XMM* data in order to derive further thermodynamic quantities relevant for probing the dynamical state of AC 114, which is discussed in Sect. 6.

All our results assume the Λ cold dark matter concordance cosmology, with $\Omega_M = 0.3$, $\Omega_{\Lambda} = 0.7$, and a Hubble constant $H_0 = 70 \text{ km s}^{-1} \text{ Mpc}^{-1}$. At the redshift of AC 114 ($z = 0.317$), this cosmology implies a scale of $4.63 \text{ kpc}''$. In all figures, north is up and east is to the left.

2. Multiple images

We begin by presenting the previously known multiple images, which we have renamed for consistency. As part of this process, we verified the reliability of these images using the JWST data. We then introduce the new systems identified in the JWST observations (Fig. 1). All multiple images are located within a circle of radius $30''$ (139 kpc), centred on the BCG. They are listed in Table A.1. We note that all the previously known multiple images are located in the north-west part of the cluster.

2.1. Previously identified systems

Six multiply imaged systems were reported prior to the JWST observations. They are marked with red circles in Fig. 1, and their coordinates and redshifts are listed in Table A.1.

System S was proposed by Smail et al. (1995), who reported two images, S1 and S2, both at a spectroscopic redshift of 1.86. Image S3 was later identified by Natarajan et al. (1998). The earlier redshift estimate was later confirmed by Campusano et al. (2001) and by Lemoine-Busserolle et al. (2003) at $z = 1.867$. This corresponds to system 1 in the present work.

System A was proposed by Smail et al. (1995), who reported six images, one of which at a spectroscopic redshift of 0.639. Natarajan et al. (1998) later identified five images belonging to the same system, with a predicted redshift of 1.67 ± 0.15 from their lens model, including a radial arc composed

¹ Also known as Abell S1077.

of two merging images. Based on a single emission line, Campusano et al. (2001) measured a spectroscopic redshift of 1.691 for images A1 and A2, which was later revised to 1.869 by Lemoine-Busserolle et al. (2003). This corresponds to system 2 in the present work, following the identification proposed by Natarajan et al. (1998).

System B was proposed by Natarajan et al. (1998), who reported five images with a predicted redshift of 1.17 ± 0.10 . Campusano et al. (2001) detected only a single emission line in their spectroscopic observations and were unable to distinguish between a redshift of 1.5 and 2.1. This corresponds to system 3 in the present work, whose redshift is optimised by the mass model.

System C was proposed by Natarajan et al. (1998), who reported three images of a ‘partial-ring shaped galaxy’, with a predicted redshift of 2.1 ± 0.30 . Campusano et al. (2001) measured a spectroscopic redshift of 2.854 for image C3. This corresponds to system 4 in the present work.

System D was proposed by Natarajan et al. (1998), who reported five images with a predicted redshift of 1.18 ± 0.10 . This corresponds to system 5 in the present work, whose redshift is optimised by the mass model.

System E was proposed by Campusano et al. (2001), who reported five images and measured a spectroscopic redshift of 3.347 for image E1. This corresponds to system 6 in the present work.

2.2. New systems

We identified ten new multiply imaged systems thanks to the JWST data (highlighted with cyan circles in Fig. 1). Most of these systems are located in the southern part of the cluster, where no multiple images had been reported prior to the JWST observations. The identification of the 10 new multiply imaged systems is based on visual inspection of the JWST images by several pairs of eyes (namely ML, BB, KS, GM, JR, DL, MJ, CC, and EJ). As is usually done, a multiply imaged system should satisfy the following criteria: similar colours and a geometrical appearance compatible with a lensing configuration. This identification process is a step-by-step process that uses the predictive power of the lens model. We started with a first lens model constructed from the previously identified systems in order to test a new system we detected by eye. Then this system is given as an extra constraint to the current lens model. Then the optimisation of a new model using this new system helps assess its reliability. More precisely, we verified that the RMS of the new model, which includes this new system, remains stable, i.e. it does not change by more than $\sim 0.2''$. And so on for the ten systems. No spectroscopic redshift measurements are currently available. The global uncertainty on the lens model takes into account this unknown redshifts, which are left free during the optimisation, adopting a broad prior, ranging from 1 to 10. Estimates on these redshifts are given in Table A.1.

2.3. Conjugating sub-spots in the images

Thanks to the high-resolution capabilities of JWST, we were able to identify and conjugate emission knots in several of the lensed galaxies—specifically those corresponding to systems 1, 2, 3, 4, 6, 7, and 11. This feature was already noted in the JWST-SLICE data (Cerny et al. 2026). As a result, we increased the total number of images used as constraints from 52 to 124. This corresponds to an increase in the number of constraints from 72 to 166. It is worth noting that while conjugating sub-spots in multi-

ple images provides additional constraints, they are not as strong as those obtained from newly identified multiply imaged systems. We quantify the added value of these sub-spot constraints in Appendix A.1 by comparing the constraints on mass model parameters with and without their inclusion. Appendix A.1 also lists and illustrates the sub-spots that we were able to conjugate. Our final multiple image catalogue, used in all subsequent analyses, includes these sub-spots.

3. Strong lensing modelling

We describe here our parametric SL mass modelling of AC 114, based on the multiple-image systems presented in the previous section. All mass components are described using the dual pseudo-isothermal elliptical mass distribution (dPIE) profile. We refer the reader to Limousin et al. (2005) and Elíasdóttir et al. (2007) for a description of this mass profile. Here we only give a brief overview. The geometrical parameters are the position, ellipticity and position angle. Then it is parametrised by a fiducial velocity dispersion, σ , a core radius, r_{core} , and a scale radius, r_s , usually fixed to 1500 kpc for cluster-scale dark matter (DM) halos since SL cannot constrain it. Between $r = 0$ and $r = r_{\text{core}}$, the mass density is constant. Then between $r = r_{\text{core}}$ and $r = r_s$, the mass density is isothermal (r^{-2}), then it falls as r^{-4} beyond r_s .

The photometric catalog for identifying cluster members was generated using Source Extractor (Bertin & Arnouts 1996) in dual-image mode in F814W and F160W, with F814W used as the detection image. The magnitudes and magnitude errors were measured as MAG_AUTO with DETECT_THRESH = 10 and DETECT_MINAREA = 5. Cluster members were selected from a F814W–F160W versus F160W colour-magnitude diagram using the red sequence technique (Gladders & Yee 2000).

We include all cluster members within $50''$ of the centre of AC 114, down to $m = 25$ (HST F160W). This radius is sufficient to encompass the SL region, which lies within $30''$ of the cluster centre. Cluster members located outside this area are not included, as they have a negligible impact on the positions of the multiple images while unnecessarily increasing the computational time. This results in a sample of 107 cluster members. Each galaxy was visually inspected to confirm its likely cluster membership. In addition, to assess the reliability of the red-sequence selection, we considered publicly available spectroscopically confirmed cluster members and verified whether they are recovered by the red-sequence method. We searched the NASA/IPAC Extragalactic Database (NED²) for redshifts of objects located within a circular region of radius 2 arcmin centred on the BCG. From this sample, we selected cluster members as galaxies with velocities within $\pm 2000 \text{ km s}^{-1}$ of the BCG redshift. Finally, we restricted the sample to galaxies located within $50''$ of the BCG. A visual inspection revealed that two objects did not have counterparts in the HST or JWST images at the reported coordinates and were therefore not considered. This resulted in a final sample of 21 spectroscopically confirmed cluster members, all of which are successfully selected by our red-sequence method. We used the LENSTOOL software, and all optimisations were performed in the image plane.

3.1. First model

We began by describing the mass distribution in AC 114 as the superposition of one large-scale DM halo and galaxy-scale perturbers associated with cluster members, which are

² <https://ned.ipac.caltech.edu>

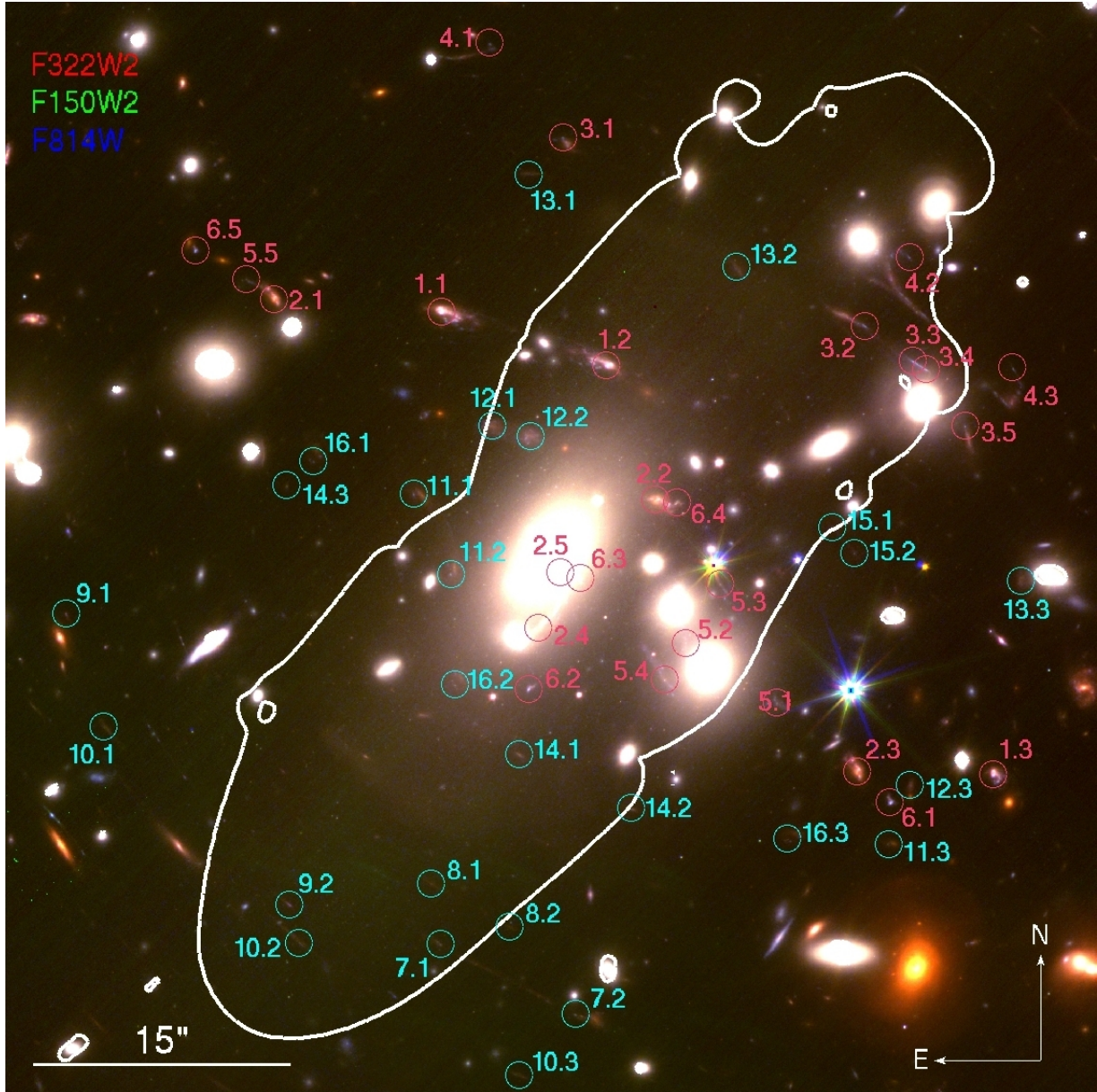


Fig. 1. Colour image of the core of AC 114 produced with SAOImage ds9, using JWST/NIRCam F322W, F150W, and HST/ACS F814W in the red, green, and blue channels, respectively. We show in red the multiple images known before JWST, and in cyan the one discovered thanks to the JWST data. We draw in white the critical curve for $z = 1.87$, the redshift of systems 1 and 2.

included via a scaling relation that links their mass to their luminosity (see e.g. Limousin et al. 2007). We imposed the position of the cluster-scale DM halo to coincide with the light distribution, within a dozen kiloparsecs, $3''$ in practice, consistent with the typical offset allowed in a self-interacting dark matter (SIDM) scenario (see the discussion in Limousin et al. 2022).

Regarding the luminosities of the cluster members, we used magnitudes in the HST F160W band, which allowed us to adopt the results from Bergamini et al. (2019) to constrain the scaling relations and limit degeneracies between the smooth large-scale component and the galaxy-scale components (see the discussion in Limousin et al. 2016). Bergamini et al. (2019) propose a Gaussian prior on the velocity dispersion of a galaxy with magnitude $m = 17.05$ (F160W) of $248 \pm 28 \text{ km s}^{-1}$ for MACS 0416. We imposed a Gaussian prior of $248 \pm 50 \text{ km s}^{-1}$, broadening the

uncertainty to account for differences between the populations of cluster galaxies.

We find that this initial model reproduces the multiple images with an RMS precision of $0.66''$, which is noteworthy given the simplicity of the parametrisation. The optimised position of the DM clump coincides with the centre of the stellar component and is not stuck to any bound of the adopted prior. If we enlarge this prior beyond what might be allowed by SIDM, i.e. setting it to $\pm 15''$ from the centre of the stellar component, the optimised position remains coincident with the centre of the stellar component, and all model parameters are consistent with the model in which the prior on the position of the DM is set to $\pm 3''$ from the centre of the stellar component. The same holds if we set this prior to $\pm 25''$. This demonstrates that the coincidence between the DM halo and the BCG is not driven by the adopted prior.

3.2. Optimising the BCG individually

We then removed the BCG from the galaxy catalogue and optimised it individually. Indeed, the BCG is not representative of the cluster galaxy population. Moreover, several multiple images lie close to the BCG, including the radial arc (images 2.4 and 2.5) as well as image 6.3. The overall RMS decreases to $0.49''$, with a notable improvement in the RMS of the images located near the BCG.

We find that the optimised position of the BCG coincides with the centre of the stellar component. The ellipticity, position angle, and scale radius of the BCG are found to be unconstrained, while its core radius converges to 0. We therefore adopted a circular halo in the following, with a vanishing core radius and a fixed scale radius of 40 kpc, a value that does not influence the results.

The ellipticity of the cluster-scale DM component is high, with a value of 0.80 ± 0.01 , which is larger than typically expected for a unimodal cluster (Despali et al. 2016). Its position angle is 54 ± 1 deg, in agreement with the position angle of the light distribution of the BCG. We note that such an alignment between the two position angles could suggest a relaxed rather than disturbed state. This will be further discussed in Sect. 6.4. The core radius of the DM component is 83 ± 5 kpc. The high ellipticity of the large-scale DM component motivated us to examine the surroundings of AC 114, as such a pronounced ellipticity can indicate the presence of unaccounted mass in the outskirts (Keeton et al. 1997).

3.3. Exploring the environment of AC 114

We examined the Legacy Survey³ DR10 data around the position of AC 114 (Fig. 2), identifying an overdensity of bright elliptical galaxies to the north-west. The brightest galaxy at (RA, Dec) = (344.6579, -34.7557) has a spectroscopic redshift of 0.317 (Proust et al. 2015). We hereafter refer to this galaxy as BCG₂. It is located $210''$ (972 kpc) from the centre of AC 114, aligned with the position angle of the DM halo describing AC 114. A redshift of 0.317 is also measured for several bright elliptical galaxies located in this area (see Fig. 1 in Andrade et al. 2024).

Therefore, a companion cluster (AC 114 b hereafter) is located in the north-west of AC 114 and must be taken into account in the modelling. In fact, some elliptical galaxies are found between AC 114 and AC 114 b, suggesting the presence of a filamentary structure connecting the two components. We then realised that Krick & Bernstein (2007), who studied the intra-cluster light (ICL) in the field of AC 114, had already mentioned AC 114 b, but only one redshift was available at that time, preventing the authors from concluding on whether AC 114 b was physically associated with AC 114. They reported a centralised ICL component associated with AC 114, as well as a diffuse component associated with AC 114 b.

We included AC 114 b as an external shear component in the modelling. This slightly improved the fit, with the RMS dropping to $0.43''$. Furthermore, the ellipticity of the main DM clump decreases to ~ 0.74 , which lies at the higher end of values expected from numerical simulations (Despali et al. 2016). The strength of the external shear is ~ 0.13 . The angle of this external shear⁴, constrained to be equal to $\sim 139^\circ$, points unambiguously

and consistently towards AC 114 b as the source of this shear. We also included AC 114 b as a singular isothermal sphere centred on BCG₂. The resulting RMS is $0.49''$, comparable to the RMS obtained when using an external shear, and the velocity dispersion of AC 114 b is equal to $750 \pm 150 \text{ km s}^{-1}$. The ellipticity of the main DM clump decreases to ~ 0.74 . In all models investigated hereafter (i.e. the SL+X-ray models), AC 114 b is modelled as an external shear component, not as an SIS profile. The SIS description is only used in Fig. 2 in order to present mass contours associated with AC 114 b and to illustrate the bimodality of the mass distribution in the AC 114–AC 114 b system.

To summarise, our SL-only analysis provides strong evidence of the presence of a massive companion cluster to AC 114 in the north-west, which we propose naming AC 114 b. Note that we did not attempt to further improve the RMS by optimising individual cluster members located close to certain multiple images (namely images 2.4, 3.3, 3.4, 4.1, and 4.2).

Finally, we examined how the model responds to brighter magnitude cuts in the cluster member catalogue. When applying magnitude cuts at 24, 23, and 22, the RMS remains at $0.43''$. For a cut at magnitude 21, the RMS increases slightly to $0.44''$. The model parameters remain consistent regardless of the magnitude cut applied. This suggests that the model is primarily sensitive to the brightest cluster members.

4. X-ray datasets

4.1. Presentation

Chandra observations of AC 114 (De Filippis et al. 2004) total 74.3 ks of exposure time. The observations are available in the *Chandra* Data Collection (CDC) 453⁵. The data have been reduced and analysed following the procedure detailed in Beauchesne et al. (2024) with CIAO⁶ 4.17 (Fruscione et al. 2006) and CALDB 4.12.0. To measure the cluster temperature, we limited our analysis to the $[0.5, 7.5]$ keV energy range and used a hydrogen column density (n_{H}) of $1.079 \times 10^{20} \text{ atoms/cm}^2$. We obtained n_{H} with the n_{HI} measurement from HI4PI Collaboration (2016), for which we accounted for molecular hydrogen following Willingale et al. (2013).

AC 114 was observed by *XMM-Newton* on June 11, 2018, for a total of 45 ks (observation ID 0827010901). We processed the observation using the XMMSAS v22.0 package and the X-COP analysis pipeline (Ghirardini et al. 2019). After running the standard event screening procedures, we extracted light curves of the observation from the three cameras of the European Photon Imaging Camera (EPIC) and filtered out the time periods affected by flaring background. The clean observing time after flare filtering is 29 ks (PN), 35 ks (MOS1), and 37 ks (MOS2). From the clean event lists, we used the MOSSPECTRA and PMSPECTRA executables to extract count images, exposure maps, and non X-ray background maps of the full field of view in the $[0.7\text{--}1.2]$ keV band, which maximises the signal-to-background ratio. We then combined the data from the three cameras to generate a single EPIC image.

To extract X-ray emission contours, we used ASMooth (Ebeling et al. 2006) to smooth the EPIC image and generate an adaptively smoothed, exposure corrected, and background subtracted map. We then extracted isophotes from the resulting map. For more details on the data processing technique, we refer the reader to Rossetti et al. (2024).

³ <https://www.legacysurvey.org>

⁴ This corresponds to the angle of the shear generated by the external mass component and experienced by the SL constraints. Like other angles, it is defined with respect to the X axis (east-west direction), measured positively counter-clockwise.

⁵ doi: [10.25574/cdc.453](https://doi.org/10.25574/cdc.453)

⁶ <https://cxc.cfa.harvard.edu/ciao/>

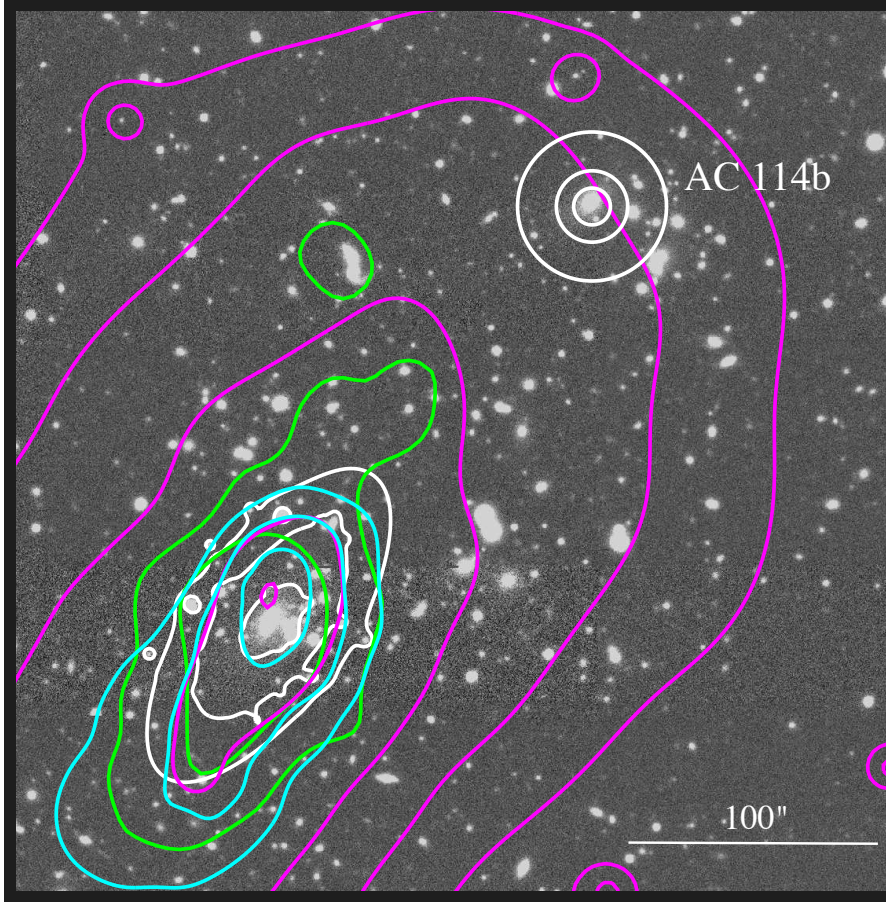


Fig. 2. *i* band image of the AC114-AC114b complex from Legacy Survey DR10 data. In white, we show contours of the total mass as inferred from the SL analysis, where AC114b is modeled as a singular isothermal sphere. Contours of the X-ray count maps from CHANDRA and XMM-NEWTON are shown in cyan and magenta, respectively, while radio contours from MEERKAT are shown in green. AC114b is dominated by BCG₂, located at the centre of the northeast mass contours in this figure. It lies at a projected distance of 210'' (972 kpc) from the BCG. 100'' corresponds to 463 kpc.

4.2. Chandra data: Combining SL with X-ray data

Figure 3 shows the map of the X-ray counts, with the CSMOOTH⁷ (Ebeling et al. 1996) contours overlaid in cyan. The morphology is irregular, typical of a cluster undergoing dynamical activity, with a soft X-ray tail extending towards the south-east.

Here we used the *Chandra* data, as it offers the highest spatial resolution among X-ray observatories while fully covering the SL region. Our goal is to explicitly include the X-ray gas mass in a combined strong lensing+X-ray (SL+X-ray) fit, following the methodology recently proposed by Beauchesne et al. (2024) and implemented in LENSTOOL. We refer the reader to that work for a detailed description of the modeling procedure. To model the intra-cluster medium (ICM) mass, we relied on its X-ray emission, using a combination of surface brightness and spectral data. The surface brightness was derived from photon count maps, while the spectral information provided the conversion factor needed to relate surface brightness to gas mass.

4.2.1. Fitting the X-ray data only

We began by fitting the X-ray data only with LENSTOOL. In this analysis, we considered the map of X-ray photon counts along with the relevant associated inputs. Our goal is to describe the distribution of the X-ray gas mass using a superposition of dPIE profiles, which will later be incorporated into the combined SL+X-ray fit.

We first investigated how many dPIE clumps are required to adequately reproduce the X-ray only data. As discussed in

Beauchesne et al. (2024), we considered a model of the X-ray gas to be reliable if the likelihood of the observed data lies within the 5σ credible interval (CI) of the expected likelihood for that model.

Following De Filippis et al. (2004), we began by modelling the X-ray data as a superposition of two components: one located in the BCG region, and the other in the southern part of the field. However, this model is not considered reliable, as the resulting likelihood does not lie within the 5σ CI. We then introduced a third dPIE clump, allowing its position to vary freely within $\pm 70''$ of the cluster centre. This addition improves the fit, with the resulting likelihood falling within the 3σ CI. Including a fourth dPIE clump still provides an acceptable description, as the likelihood remains within the 5σ CI, although it lies outside the 3σ CI. We therefore adopted the simplest model composed of three dPIE components to describe the mass associated with the X-ray-emitting gas. In Fig. 3 (left panel), we show the positions of these clumps and the resulting mass map, along with the CSMOOTHED contours of the X-ray photon counts.

Note that the dPIE clumps used to describe the X-ray gas mass should not be interpreted as ‘regular’ mass clumps. Their parameters are not representative of physical mass clumps like the ones used to model the DM components, nor of clumps that typically arise in numerical simulations. This approach is similar to the method presented in Jullo & Kneib (2009), where a grid of dPIE components is used to describe mass distributions in a kind of ‘free-form’ modelling (see also Limousin et al. 2010).

4.2.2. Combined strong lensing and X-ray fit

We next turned to a combined SL+X-ray fit. Technically, we merged the parameter file used in the SL-only analysis with the

⁷ <https://cxc.cfa.harvard.edu/ciao/ahelp/csmooth.html>

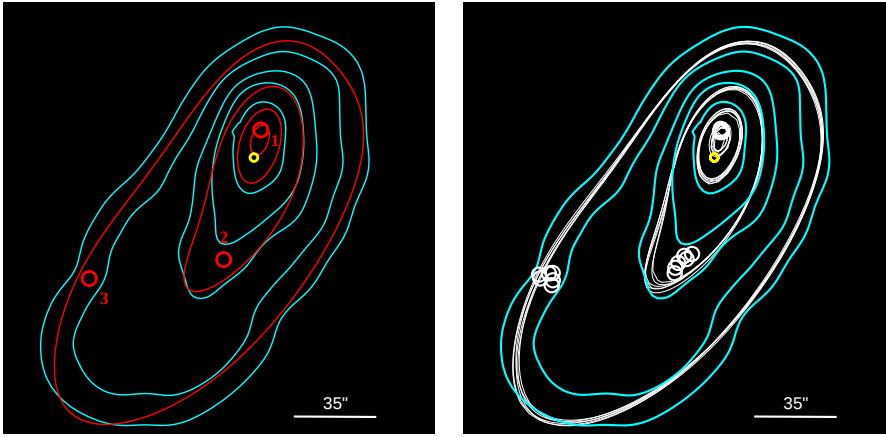


Fig. 3. csmooth CHANDRA X-ray contours are shown in cyan. The position of the BCG is marked by a yellow circle. Left: Mass contours derived from fitting the X-ray data only are shown in red. The gas distribution is modeled as a superposition of three dPIE profiles, whose positions are indicated by red circles. Right: Mass contours, shown in white, correspond to different models of the gas distribution used in the combined SL+X-ray fits. The positions of the dPIE components for each realisation are indicated by white circles.

one used in the X-ray only analysis. This resulted in a model where the following mass components are optimised: the DM clump, the BCG, the external shear component, the galaxy-scale component, and the three dPIE profiles describing the X-ray gas. In practice, we performed six identical SL+X-ray fits to assess the stability of the results. In particular, we aim to determine whether the addition of the three dPIE mass components introduces further degeneracies. These six combined models are found to be stable, in the sense that the RMS values, the description of the gas component, and the remaining model parameters are all consistent across the different runs. We note that six is an arbitrary number; we considered that if six realisations of the same SL+X-ray model are in agreement, there is no need to add more. We find that these models reproduce the multiple images as accurately as the SL-only model, with RMS values ranging between $0.42''$ and $0.44''$. In Fig. 3 (right panel), we show the mass contours corresponding to the different prescriptions for the X-ray gas mass: they are in very good agreement with one another, as well as with the mass contours obtained from the X-ray only fit. The positions of the dPIE components for each realisation are also found to be stable.

4.3. XMM-Newton data: Thermodynamic quantities

Figure 2 shows the contours of the XMM-Newton X-ray counts map overlaid in magenta on the Legacy Survey image. Comparison with the Chandra contours reveals a very good agreement between the datasets, in terms of the irregular morphology and the offset between the X-ray emission peak and its centroid. The XMM-Newton data are much more extended, reaching up to 2 Mpc from the cluster centre, therefore encompassing AC 114 b. We can immediately note the absence of X-ray emission from AC 114 b, suggesting that any X-ray-emitting gas that might have been associated with AC 114 b has been stripped.

The sensitivity of XMM-Newton allows us to derive important thermodynamical quantities. Rossetti et al. (2024) present the temperature profile. We here revisit the XMM data in order to derive the entropy profile, which is presented in the following.

5. Results

We present the description of AC 114 resulting from our combined SL+X-ray fit, as detailed in the previous sections. We then present the results of the gas properties inferred from the XMM-Newton data.

5.1. Best SL+X-ray fit model

This model succeeds in reproducing both the multiple images' positions, with an RMS of $0.43''$, and the X-ray data. It was obtained using a RATE parameter of 0.005 and an NB value of 2000. The (RATE, NB) test is presented in Appendix B. For a detailed discussion of these parameters and the associated testing procedure, we refer the reader to Limousin et al. (2025a).

All parameters of the model – including the DM clump, the BCG, the galaxy-scale perturbers, the external shear, and the three dPIE profiles describing the X-ray gas mass component – are listed in Table 1. The PDFs of the main cluster parameters (parameters of the DM clump, velocity dispersion of the BCG, strength of the external shear) are shown in black in Fig. 4. Note that, for clarity, we do not display all model parameters in Fig. 4 nor in the other corner plots presented in this paper. We omit the parameters of the galaxy-scale perturbers, and we do not show the posterior distributions of the position of the DM clump, as they always fall within the adopted prior of $\pm 3''$ from the centre of the BCG. All Markov chain Monte Carlo (MCMC) chains are made publicly available, allowing anyone to investigate their behaviour if necessary.

Results of the best fit model are compared with those derived using SL constraints only (obtained in Sect. 3.3 and shown in violet in Fig. 4). The parameter PDFs are generally narrower when X-ray data are included, indicating improved constraints on the model parameters. Parameters of the DM clump are consistent in the two runs, except for the velocity dispersion, which is found to be lower when X-ray data are included, as expected, since part of the mass is then attributed to the X-ray gas. The strength of the external shear is also found to be slightly smaller when including the X-ray constraints. This is consistent with the shape of the gas mass component (Fig. 2), which is elongated along the south-east to north-west direction, i.e. colinear with the line connecting AC 114 and AC 114 b. We also show in Fig. 4 the results obtained by fitting the SL constraints while including the description of the X-ray component derived in Sect. 4.2.1 from the X-ray only fit. This approach is similar to the one proposed by Bonamigo et al. (2018). The results are very close to those obtained from the full SL+X-ray analysis, except for the strength of the external shear, which lies between the values derived from the SL-only and SL+X-ray models. Moreover, the parameter uncertainty is smaller in the full SL+X-ray analysis, highlighting the advantages of a fully combined analysis compared to a two step approach.

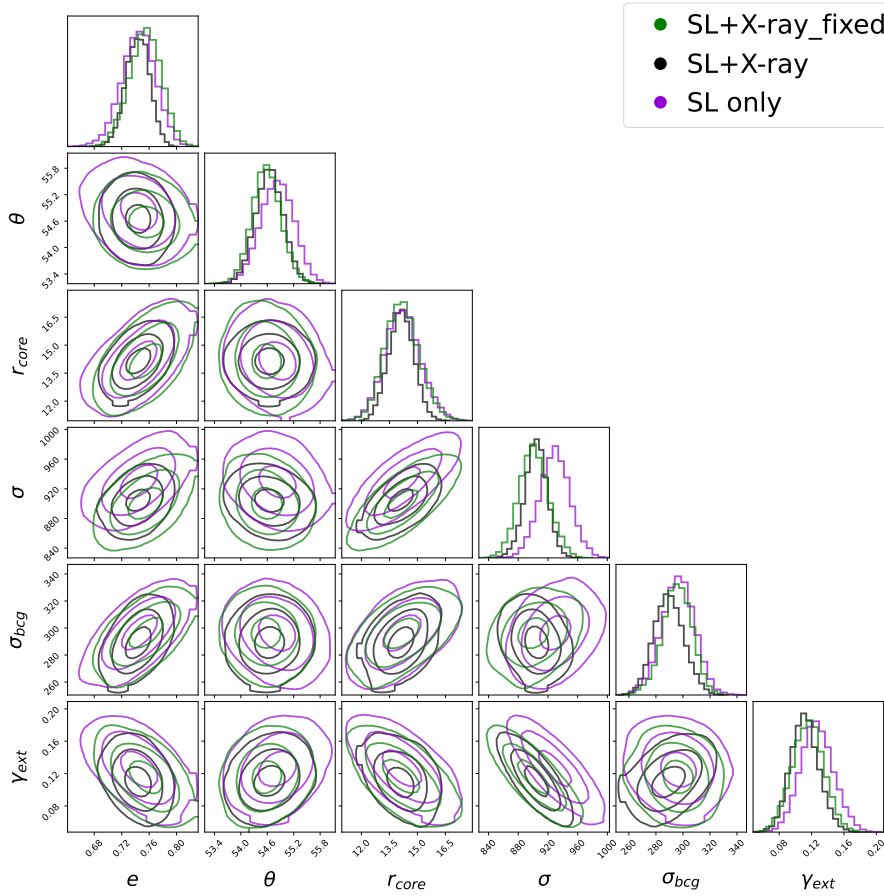


Fig. 4. Corner plots showing the posterior distributions of the main cluster parameters for the SL+X-ray fit (black) and for the SL only fit (violet): ellipticity e , position angle θ , core radius r_{core} and velocity dispersion σ of the DM mass distribution; velocity dispersion of the BCG σ_{bcg} and strength of the external shear γ_{ext} . We also show in green the results obtained by fitting the SL constraints while including the description of the X-ray component derived in Section 4.2.1 from the X-ray only fit. The RMS is equal to $0.43''$ in all cases.

Table 1. dPIE parameters.

Model	ΔRA ($''$)	ΔDec ($''$)	e	θ	σ (km s^{-1})	r_{core} ($''$)	r_s ($''$)
DM	0.32 ± 0.21 (0.37)	-1.13 ± 0.27 (-1.0)	0.74 ± 0.02 (0.72)	54.6 ± 0.3 (54.9)	904 ± 15 (895)	14.1 ± 0.7 (14.0)	[325]
BCG	0.59 ± 0.13 (0.37)	-0.13 ± 0.17 (-0.06)	—	—	289 ± 11 (284)	[0]	[10.0]
Gas #1	3.15 ± 0.38 (2.69)	13.24 ± 0.67 (12.69)	0.51 ± 0.03 (0.50)	68.3 ± 1.8 (68.7)	168 ± 5 (172)	18.1 ± 0.8 (18.7)	[270]
Gas #2	-12.5 ± 1.9 (-9.1)	-41.7 ± 2.3 (-39.0)	0.81 ± 0.02 (0.82)	45.8 ± 1.2 (46.3)	272 ± 12 (270)	62.4 ± 3.8 (64.0)	[270]
Gas #3	-68.5 ± 1.5 (-68.7)	-49.9 ± 3.6 (-52.3)	0.20 ± 0.09 (0.25)	126.5 ± 11.3 (127.8)	328 ± 10 (325)	110.7 ± 5.7 (325.5)	[270]

Notes. dPIE parameters inferred for the mass model of AC 114, constrained using both SL and X-ray constraints, with an RMS equal to $0.43''$. Error bars on all parameters quoted in this paper correspond to $\pm 1\sigma$ confidence levels inferred from the MCMC optimisation. Coordinates are given in arcseconds relative to $\alpha = 344.701518$, $\delta = -34.802364$; e and θ are the ellipticity and position angle of the mass distribution. Each parameter is given as the median with the best fit value in parenthesis except the ones fixed a priori that are shown in brackets. For an L^* galaxy, we have $\sigma = 187 \pm 5 \text{ km s}^{-1}$ and $r_s = 11 \pm 1.2''$. The external shear component is equal to 0.11 ± 0.01 , with an angle of 138.1 ± 0.8 .

5.2. Mass profiles of the different components

We show in Fig. 5 the mass profiles of the different components describing AC 114. The shapes of the DM and gas mass distributions are similarly elongated along the south-east north-west direction, with their position angles differing by $\sim 18^\circ$.

Regarding the positions of the different components and their offsets, we find that the peak of the mass associated with the BCG coincides with the centre of its light distribution. This position is also coincident with the peak of the mass associated with

the main DM halo, as well as with the peak of the total mass inferred from SL. However, we find an offset of $\sim 9''$ between this position and the centroid of the X-ray-emitting gas, as reported by De Filippis et al. (2004).

Note that Fig. 5 is restricted to the core of AC 114 and does not encompass the full field of view of interest when considering the major merger scenario involving AC 114 b. Nevertheless, the mass map of Fig. 5 is highly elliptical, with a position angle pointing towards AC 114 b, which can be interpreted as a remnant of the major merger. To illustrate the bimodality

of the whole structure, we considered the SL model in which AC114b is described as an SIS mass component (Sect. 3.3) and present the resulting 2D projected total mass contours in Fig. 2. The bimodality can be appreciated, with one mass concentration associated with AC 114 and another associated with AC 114 b.

We integrated the mass maps in circular apertures starting from the centre of the BCG in order to derive the corresponding 1D mass profiles, which are shown in the right-hand panel of Fig. 5. The (1σ) error bars are derived from the MCMC realisations.

5.3. The central entropy

The central entropy characterises the thermodynamical state of the cluster core and determines whether the system hosts a cool core (Cavagnolo et al. 2009). We estimated the central entropy, K_0 , by fitting the deprojected entropy profile (Sect. 4.3) with a power law including a central floor (Cavagnolo et al. 2009). We measure $K_0 = 131 \pm 26 \text{ keV cm}^2$, indicating that the gas in the central regions has high entropy and classifying the system as a non-cool-core cluster (Hudson et al. 2010).

5.4. A cored DM distribution

We have seen that the mass distribution of AC 114, as described by a dPIE profile, features a core radius of $18 \pm 1''$, which corresponds to $83 \pm 5 \text{ kpc}$. Following the approach presented in previous works (Limousin et al. 2016, 2022; Cerny et al. 2025), we repeated the analysis, imposing a non-cored DM profile, i.e. forcing the core radius of the dPIE profile to be smaller than 10 kpc. We obtain an RMS of $2.0''$, and the X-ray likelihood lies outside the 5σ credible interval. In order to compensate the need for a cored DM profile, the ellipticity of the DM halo increases to 0.83 ± 0.005 , and the strength of the external shear is stuck to the upper bound of the prior (0.2), which is an unrealistically high value. When this parameter is constrained to be smaller than 0.15, which is already at the upper end of what might be expected, the RMS increases to $2.16''$.

We therefore conclude that a cored DM distribution is favoured in AC 114. Such core-like DM profiles in SL galaxy clusters have been reported for more than two decades in many systems (see e.g. Sand et al. 2004; Newman et al. 2011, 2013; Bergamini et al. 2019; Limousin et al. 2022; Lagattuta et al. 2023; Beauchesne et al. 2024; Cerny et al. 2025). Some of these clusters display radial arcs, as AC 114 does, which are known to form in shallow potentials (Bartelmann 1996; Molikawa & Hattori 2001). Large core radii are naturally explained in SIDM (see Limousin et al. 2022, for a discussion). In the case of AC 114, the core radius is comparable to that found in AS 1063 using the same dPIE mass profile ($\sim 90 \text{ kpc}$; see Bergamini et al. 2019; Granata et al. 2022; Limousin et al. 2022). Recent study by Diego (2026) interpreted the value of this core within SIDM, finding a self interaction cross-section equal to $0.3 \text{ cm}^2 \text{ g}^{-1}$. If we interpret our result for AC 114 within SIDM, we therefore obtain the same constraint on the self interaction cross-section. However, Limousin et al. (2008) report a cusp-like DM profile in Abell 1703 determined using SL techniques, suggesting a possible diversity in the inner DM profiles of SL clusters.

6. A major merger in a post-collisional phase

We argue that we are witnessing a major merger between AC 114 and AC 114 b in a post-collisional phase. Evidence for this sce-

nario is already present in the literature, and we provide further compelling evidence in support of this interpretation. We use the term ‘major merger’ to refer to a cluster–cluster interaction with a mass ratio of order 1:1–1:3, as commonly adopted in merger-rate and cluster dynamical studies (see e.g. Fakhouri et al. 2010).

6.1. Radio evidence of a major merger in a post-collisional phase

Duchesne et al. (2024) report the detection of three radio sources. Two of these are radio relics, located in the south-east and north-west regions. The third source is classified as a candidate radio halo.

Balboni et al. (2026) clearly detect central diffuse radio emission. This allows a robust classification of the emission as a radio halo. They also confirm the south-east relic, which exhibits a clear spectral steepening towards the cluster centre. In contrast, they argue that the north-west relic is more likely associated with a complex of radio-galaxy tails rather than a genuine relic. We are therefore left with the firm detection of a radio halo and a radio relic. The radio halo is shown in Fig. 2; the radio relic is located farther to the south-east and is not shown.

The correlation between a disturbed dynamical state and the presence of a radio halo has been firmly established since the early study of Buote (2001). See also Cassano et al. (2010). The widely accepted current scenario for radio-halo formation invokes the reacceleration of particles by turbulence induced during a merger (see the reviews by Brunetti & Jones 2014 and van Weeren et al. 2019).

The radio halo is relatively bright even at 1.3 GHz. This indicates that a highly energetic merger has occurred, releasing a substantial amount of energy to power the diffuse radio emission. The radio and X-ray emissions are well aligned (see Fig. 2). This suggests that the mechanism responsible for the radio-halo emission has also significantly modified the thermal ICM distribution.

Similarly, the location of the radio relic is well aligned with the south-east-north-west elongation of the system. This suggests that the merger event occurred along this axis. Indeed, radio relics are thought to trace shock waves associated with cluster mergers. This is supported by simulations of cluster mergers (e.g. Ricker & Sarazin 2001).

Regarding the stage of the merger, the presence of both a radio halo and a relic suggests that the system is in a post-merger phase. Radio halos require roughly 1 Gyr to form (e.g. Donnert et al. 2018). This is because the turbulent reacceleration mechanism that produces the diffuse emission is inefficient.

For the radio relic, the shocks that generate relics originate after the passage of the DM cluster cores (see van Weeren et al. 2019, and references therein). However, the relic emission becomes visible only once these shocks reach the cluster outskirts (Vazza et al. 2012). The typical shock crossing time is of the order of $\sim 1 \text{ Gyr}$.

Numerical simulations show that the production of cosmic-ray electrons peaks about 1 Gyr after core passage. These electrons eventually produce the radio synchrotron emission. The peak of the relic emission itself occurs slightly earlier, at roughly 0.7 Gyr (van Weeren et al. 2019; Nuza 2025). We conclude that radio observations provide evidence for a major merger in a post-collisional phase.

6.2. X-ray evidence of a major merger

X-ray morphological indicators have long been recognised as powerful probes of the dynamical state of galaxy clusters (see

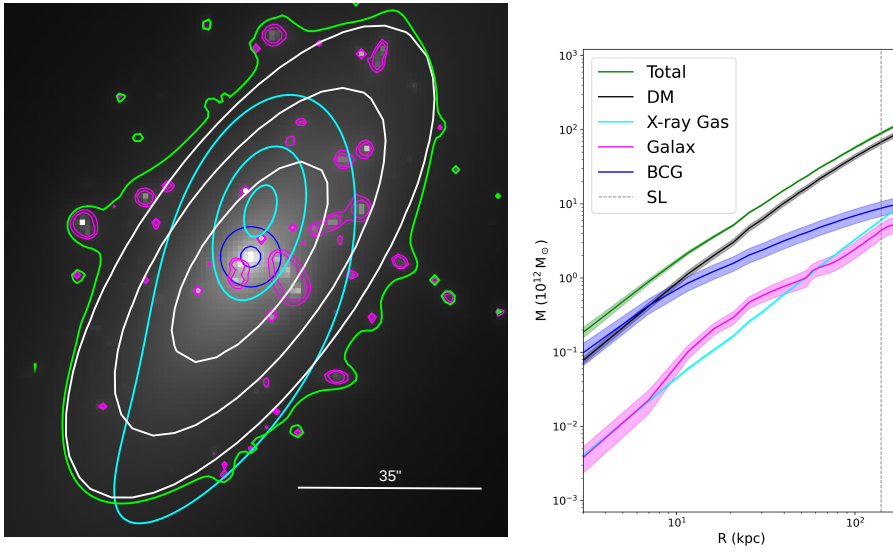


Fig. 5. Left: 2D projected total mass map. White contours correspond to the DM component, cyan to the X-ray gas, blue to the BCG, and magenta to the galaxy scale perturbors. The green contour corresponds to the total mass. For clarity, we show only one. Its similarity with the white contour highlights that the DM component dominates the overall shape of the total mass map. Right: Corresponding 1D mass profiles for the total mass (green), the X-ray gas mass (cyan), the dark matter component (black), the BCG (blue), and the galaxy-scale perturbors (magenta). The vertical dashed line corresponds to the extent of the SL region.

Buote 2001 for an early review). Dynamically relaxed systems exhibit regular X-ray isophotes and a centrally peaked surface-brightness profile, which are absent in dynamically disturbed clusters. In particular, post-core-passage mergers produce irregular X-ray morphologies and disrupt the central cool core. In the case of AC 114, X-ray data from both *Chandra* and *XMM-Newton* reveal an irregular morphology, a $\sim 10''$ offset between the X-ray centroid and the BCG, and a soft X-ray tail (Fig. 2).

The joint use of multiple morphological parameters provides a powerful discrimination of the dynamical state of galaxy clusters, justifying the adoption of aggregated metrics such as the M parameter proposed by Campitiello et al. (2022). According to X-ray morphological indicators, AC 114 is dynamically active and ranks among the most disturbed clusters in the CHEX-MATE sample, with a disturbance rank of 100 out of 118.

Thermodynamical indicators for AC 114 further support the presence of a major merger. The temperature profile is flat (Rossetti et al. 2024) and does not display any cool core. Such a lack of a central cool core is generally characterised by elevated central entropy, consistent with our re-analysis of the *XMM-Newton* data (Sect. 5.3).

Morphological and thermodynamic indicators do not always provide consistent classifications of the dynamical state of galaxy clusters. For instance, in the Bullet Cluster (G266.04–21.25) the M parameter is low ($M = 0.02$, Campitiello et al. 2022), whereas spectroscopically derived thermodynamic quantities rank among the most extreme in a CHEX-MATE subsample (Lovisari et al. 2024), clearly signaling a major merger. When the two classes of indicators agree, as in the case discussed here, this concordance constitutes additional, robust evidence that the system is a merger (see Hudson et al. 2010). We conclude that X-ray observations provide evidence for a major merger in AC 114.

6.3. Dynamical considerations

In addition to the velocity dispersion approaching 2000 km s^{-1} , Pizzuti et al. (2025) computed the Anderson–Darling statistic, A^2 , which quantifies deviations from Gaussianity in the line-of-sight velocity distribution, and find values larger than the median of the CHEX-MATE population (0.57 versus 0.44). As mentioned by Pizzuti et al. (2025), a more detailed dynamical analy-

sis focussed on AC 114 will be presented by these authors. While awaiting this analysis, we can already draw some conclusions based on the publicly available spectroscopic data.

An offset between the velocity of the BCG and the mean velocity of the cluster members is commonly used as a diagnostic of a major cluster disturbance. The BCG has a redshift of $z = 0.31665$ (Driver et al. 2022), whereas the mean cluster redshift is $z = 0.31533$ (Sereno et al. 2025). Therefore, the BCG exhibits a line-of-sight velocity offset of $\sim 300 \text{ km s}^{-1}$ relative to the cluster mean, suggesting that the system is fully dynamically relaxed. However, this alone is insufficient to confirm the presence of a major merger. Such an offset can be produced by several effects without invoking a major merger (wobbling of the BCG around the centre of the potential; substructure in the redshift distribution; projection effects; uncertainty in the cluster mean redshift).

Another relevant question for our study is whether we are able to disentangle AC 114 and AC 114 b in velocity space and eventually estimate a dynamical mass for each component. BCG₂ has a redshift of $z = 0.31708$ (Proust et al. 2015). This translates into a velocity difference equal to 98 km s^{-1} with respect to the BCG. This is comparable to the typical uncertainty on the redshift measurement (80 km s^{-1} , Pizzuti et al. 2025). Although this prevents us from resolving AC 114 and AC 114 b in velocity space, the small offset suggests that the merger axis is likely oriented predominantly in the plane of the sky, along the line connecting the BCG and BCG₂, i.e. along the principal axis of the cluster. This is further supported by the morphology of the X-ray and radio emission contours.

6.4. BCG–DM alignment

We revisited the alignment between the position angles of the BCG and the DM halo, and examined its consistency with the merger scenario proposed here. At first glance, such an alignment might be interpreted as indicative of a relaxed, rather than a disturbed, dynamical state. However, this is not the case, as the observed alignment is fully consistent with the major merger scenario we advocate. Moreover, this alignment can be interpreted as further evidence that the system is being observed in a post-collisional phase of a major merger.

Cosmological hydrodynamical numerical simulations by [Ragone-Figueroa et al. \(2020\)](#) show that major mergers can disrupt the alignment. Nevertheless, after some time (of the order of a gigayear) without further major perturbations, the alignment is restored. Moreover, mergers occurring along the principal axis of the cluster, as is likely the case here, tend to affect the alignment less than off-axis mergers.

On the observational side, [Wittman et al. \(2019\)](#) studied the orientations of BCGs and their host clusters in a sample of 22 clusters undergoing major mergers. Interestingly, they selected clusters with properties similar to those of AC 114-AC 114 b: binary mergers observed after first pericentric passage, as inferred from their radio properties, i.e. typically ~ 1 Gyr after the collision. Moreover, these systems exhibit unimodal line-of-sight velocity distributions, suggesting the mergers occurred predominantly in the plane of the sky. Finally, the projected separations are typically of the order of ~ 1 Mpc. They report an alignment consistent with that observed in the general cluster population, further supporting the interpretation that the alignment we find here is fully consistent with the major merger scenario we propose. Altogether, these simulation and observational results strengthen the case that AC 114 is being observed in the post-collisional phase of a major merger.

6.5. A picture of the merger

We propose a qualitative picture of the merger in AC 114. Our SL analysis reveals a significant mass concentration to the north-west, where an overdensity of bright galaxies is located. This companion cluster, AC 114 b, is therefore the most likely candidate involved in the major merger, perfectly aligned with the elongation of the X-ray and radio contours.

We are not able to derive a precise mass for AC 114 b at this stage and we note that our mass estimates are indirect only. Nevertheless, we argue that AC 114 b is likely to have a cluster-scale mass. When included in the SL modelling as an external shear, it yields a shear strength of ~ 0.13 , a typical value at a projected distance of $\sim 200''$ from the centre of a galaxy cluster⁸. Alternatively, modelling AC 114 b as a singular isothermal sphere centred on BCG₂ results in a velocity dispersion of $750 \pm 150 \text{ km s}^{-1}$, which is characteristic of a galaxy cluster. Considering the lower bound of 600 km s^{-1} , and using the scaling relations from, for example, [Munari et al. \(2013\)](#), this velocity dispersion can be associated with a halo with an expected global temperature of $\sim 2.5 \text{ keV}$, typical of a group-like structure hosting an X-ray-emitting gas component. Finally, [Krick & Bernstein \(2007\)](#) report the presence of diffuse ICL associated with AC 114 b, indicating past galaxy interactions and a DM halo massive enough to trap stars released during these interactions.

Therefore, AC 114 b is likely massive enough that, prior to the collision, it hosted an X-ray-emitting gas component. The absence of an X-ray peak at the position of AC 114 b in the *XMM-Newton* data suggests that its gas has already been stripped, consistent with a post-merging phase. The X-ray tail to the south-east could then be interpreted as the result of interactions between the gas components of both clusters: while the DM and galaxies of AC 114 b are found to the north-west, its gas lags behind to the south-east, interacting with the gas of AC 114. Such X-ray-emitting stripped gas mass clumps have been reported in other merging clusters, for example

MACS 0717 ([Jauzac et al. 2018](#)) and Abell 2744 ([Merten et al. 2011; Jauzac et al. 2016](#)).

Within this scenario, AC 114 is likely the more massive system, as indicated by the X-ray centroid being located close to its position. The relative amount of ICL associated with AC 114 and AC 114 b further supports this mass segregation, as does our SL analysis.

7. Conclusions

We have presented a new SL and X-ray study of AC 114 based on JWST, HST, *Chandra*, and *XMM-Newton* data. The unprecedented quality of the JWST imaging allowed us to more than double the number of SL constraints and to identify conjugated sub-spots in several of the 16 systems. This increased the number of constraints and allowed us quantify the improvements brought by the inclusion of sub-spots within certain multiple images.

Using these SL constraints, we constructed a parametric mass model that explicitly incorporates the *Chandra* data into a combined SL+X-ray fit, using the recently developed methodology described in [Beauchesne et al. \(2024\)](#). This is only the second application of this functionality, the first being the study of AS 1063 by [Beauchesne et al. \(2024, 2025a,b\)](#). This allowed us to disentangle the DM and the X-ray-emitting components. The DM component in AC 114 is found to be unimodal, spatially coincident with the BCG, and characterised by a large core radius, $83 \pm 5 \text{ kpc}$, consistent with values reported in other SL clusters.

Adding the XMM data provides important clues, further indicating that AC 114 is undergoing a major merger with a north-western companion, AC 114 b, now largely devoid of its hot gas. This scenario naturally explains the strong external shear, the X-ray and radio evidence of violent dynamics (X-ray tail and thermodynamic properties, radio relic, central radio halo), and the very high velocity dispersion. This work demonstrates the value of fully combined SL+X-ray modelling in the JWST era, particularly for systems with complex assembly histories.

A next step would be to observe AC 114 b with JWST in order to directly probe its mass distribution using possible SL signatures and/or weak lensing. This would also allow us to test for any possible offset between its DM and stellar components. If DM is collisionless as proposed in the cold DM scenario, the association between mass and light (stars) should be perfect, i.e. the offset between the peaks of each component should be consistent with 0 ([Roche et al. 2024](#)). In contrast, if DM is self-interacting, which is more likely to occur during a cluster merger, the DM could experience a drag force while the stars would not, leading to a possibly measurable offset ([Valdarnini 2024; Sirks et al. 2024](#)).

In addition, the recently launched XRISM satellite ([XRISM Collaboration 2024](#)), with the Resolve microcalorimeter ([Ishisaki et al. 2022](#)), can measure gas velocities in the ICM, offering a promising avenue to better understand the geometry of the merger (see e.g. [Heinrich et al. 2026](#)). AC 114 is also scheduled to be observed by *Euclid*, which will enable wide-field weak-lensing studies that could result in a direct mass estimate of AC 114 b. Combined with deeper spectroscopy of cluster members, these observations will provide complementary constraints on the large-scale structure and the kinematic state of the merger, yielding a more complete picture of mass assembly in AC 114.

⁸ This is the order of magnitude of the shear measured at similar distances from the centre of Abell 1689, (see [Limousin et al. 2007](#)).

Data availability

Our mass model and associated products are made publicly available for download at the [Strong Lensing Cluster Atlas Data Base](https://data.lam.fr/sl-cluster-atlas/home), which is hosted at Laboratoire d'Astrophysique de Marseille (<https://data.lam.fr/sl-cluster-atlas/home>).

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References

- Elíasdóttir, Á., Limousin, M., Richard, J., et al. 2007, arXiv e-prints [arXiv:[0710.5636](https://arxiv.org/abs/0710.5636)]
- Aguena, M., Aiola, S., Allam, S., et al. 2026, *Open J. Astrophys.*, **9**, 55863
- Andrade, A., Saviane, I., Monaco, L., Yegorova, I., & Proust, D. 2024, *A&A*, **686**, A81
- Balboni, M., Gastaldello, F., Bonafede, A., et al. 2026, *A&A*, **707**, A143
- Bartelmann, M. 1996, *A&A*, **313**, 697
- Beauchesne, B., Clément, B., Hibon, P., et al. 2024, *MNRAS*, **527**, 3246
- Beauchesne, B., Clément, B., Limousin, M., et al. 2025a, arXiv e-prints [arXiv:[2509.07762](https://arxiv.org/abs/2509.07762)]
- Beauchesne, B., Clément, B., Limousin, M., et al. 2025b, arXiv e-prints [arXiv:[2509.07777](https://arxiv.org/abs/2509.07777)]
- Bergamini, P., Rosati, P., Mercurio, A., et al. 2019, *A&A*, **631**, A130
- Bertin, E., & Arnouts, S. 1996, *A&A*, **117**, 393
- Bleem, L. E., Bocquet, S., Stalder, B., et al. 2020, *ApJS*, **247**, 25
- Bonamigo, M., Grillo, C., Ettori, S., et al. 2018, *ApJ*, **864**, 98
- Brunetti, G., & Jones, T. W. 2014, *Int. J. Mod. Phys. D*, **23**, 1430007
- Buote, D. A. 2001, *ApJ*, **553**, L15
- Campitiello, M. G., Ettori, S., Lovisari, L., et al. 2022, *A&A*, **665**, A117
- Campusano, L. E., Pelló, R., Kneib, J. P., et al. 2001, *A&A*, **378**, 394
- Cassano, R., Ettori, S., Giacintucci, S., et al. 2010, *ApJ*, **721**, L82
- Cavagnolo, K. W., Donahue, M., Voit, G. M., & Sun, M. 2009, *ApJS*, **182**, 12
- Cerny, C., Jauzac, M., Lagattuta, D., et al. 2025, *MNRAS*, **541**, 2341
- Cerny, C., Mahler, G., Sharon, K., et al. 2026, *ApJ*, **1001**, 60
- CHEX-MATE Collaboration (Arnaud, M., et al.) 2021, *A&A*, **650**, A104
- De Filippis, E., Bautz, M. W., Sereno, M., & Garmire, G. P. 2004, *ApJ*, **611**, 164
- Despali, G., Giocoli, C., Bonamigo, M., Limousin, M., & Tormen, G. 2016, *MNRAS*, **466**, 181
- Diego, J. M. 2026, arXiv e-prints [arXiv:[2602.15940](https://arxiv.org/abs/2602.15940)]
- Donnert, J., Vazza, F., Brüggen, M., & ZuHone, J. 2018, *Space Sci. Rev.*, **214**, 122
- Driver, S. P., Bellstedt, S., Robotham, A. S. G., et al. 2022, *MNRAS*, **513**, 439
- Duchesne, S. W., Botteon, A., Koribalski, B. S., et al. 2024, *PASA*, **41**, e026
- Ebeling, H., Voges, W., Bohringer, H., et al. 1996, *MNRAS*, **281**, 799
- Ebeling, H., White, D. A., & Rangarajan, F. V. N. 2006, *MNRAS*, **368**, 65
- Fakhouri, O., Ma, C.-P., & Boylan-Kolchin, M. 2010, *MNRAS*, **406**, 2267
- Fruscione, A., McDowell, J. C., Allen, G. E., et al. 2006, *SPIE Conf. Ser.*, **6270**, 62701V
- Ghirardini, V., Eckert, D., Ettori, S., et al. 2019, *A&A*, **621**, A41
- Gladders, M. D., & Yee, H. K. C. 2000, *AJ*, **120**, 2148
- Granata, G., Mercurio, A., Grillo, C., et al. 2022, *A&A*, **659**, A24
- Grossman, S. A., & Narayan, R. 1988, *ApJ*, **324**, L37
- Heinrich, A., Zhang, C., Zhuravleva, I., et al. 2026, *AAS Meet. Abstr.*, **247**(445), 05
- HI4PI Collaboration (Ben Bekhti, N., et al.) 2016, *A&A*, **594**, A116
- Hilton, M., Sifón, C., Naess, S., et al. 2021, *ApJS*, **253**, 3
- Hudson, D. S., Mittal, R., Reiprich, T. H., et al. 2010, *A&A*, **513**, A37
- Iqbal, A., Pratt, G. W., Bobin, J., et al. 2023, *A&A*, **679**, A51
- Ishisaki, Y., Kelley, R. L., Awaki, H., et al. 2022, in *Space Telescopes and Instrumentation 2022: Ultraviolet to Gamma Ray*, eds. J. W. A. den Herder, S. Nikzad, K. Nakazawa (International Society for Optics and Photonics (SPIE)), 12181, 121811S
- Jauzac, M., Eckert, D., Schwinn, J., et al. 2016, *MNRAS*, **463**, 3876
- Jauzac, M., Eckert, D., Schaller, M., et al. 2018, *MNRAS*, **481**, 2901
- Jullo, E., & Kneib, J. 2009, *MNRAS*, **395**, 1319
- Jullo, E., Kneib, J.-P., Limousin, M., et al. 2007, *New J. Phys.*, **9**, 447
- Keeton, C. R., Kochanek, C. S., & Seljak, U. 1997, *ApJ*, **482**, 604
- Krick, J. E., & Bernstein, R. A. 2007, *AJ*, **134**, 466
- Lagattuta, D. J., Richard, J., Ebeling, H., et al. 2023, *MNRAS*, **522**, 1091
- Lavery, R. J., & Henry, J. P. 1988, *ApJ*, **329**, L21
- Lemoine-Busserolle, M., Contini, T., Pelló, R., et al. 2003, *A&A*, **397**, 839
- Limousin, M., Kneib, J.-P., & Natarajan, P. 2005, *MNRAS*, **356**, 309
- Limousin, M., Richard, J., Jullo, E., et al. 2007, *ApJ*, **668**, 643
- Limousin, M., Richard, J., Kneib, J.-P., et al. 2008, *A&A*, **489**, 23
- Limousin, M., Jullo, E., Richard, J., et al. 2010, *A&A*, **524**, A95
- Limousin, M., Richard, J., Jullo, E., et al. 2016, *A&A*, **588**, A99
- Limousin, M., Beauchesne, B., & Jullo, E. 2022, *A&A*, **664**, A90
- Limousin, M., Beauchesne, B., Niemiec, A., et al. 2025a, *A&A*, **693**, A33
- Limousin, M., Perera, D., Rihtaršič, G., Williams, L. L. R., & Liesenborgs, J. 2025b, *A&A*, **703**, A10
- Lovisari, L., Ettori, S., Rasia, E., et al. 2024, *A&A*, **682**, A45
- Lynds, R., & Petrosian, V. 1986, in *Bulletin of the American Astronomical Society*, 1014
- Lynds, R., & Petrosian, V. 1989, *ApJ*, **336**, 1
- Merten, J., Coe, D., Dupke, R., et al. 2011, *MNRAS*, **417**, 333
- Molikawa, K., & Hattori, M. 2001, *ApJ*, **559**, 544
- Munari, E., Biviano, A., Borgani, S., Murante, G., & Fabjan, D. 2013, *MNRAS*, **430**, 2638
- Natarajan, P., Kneib, J.-P., Smail, I., & Ellis, R. S. 1998, *ApJ*, **499**, 600
- Newman, A. B., Treu, T., Ellis, R. S., & Sand, D. J. 2011, *ApJ*, **728**, L39
- Newman, A. B., Treu, T., Ellis, R. S., & Sand, D. J. 2013, *ApJ*, **765**, 25
- Nuza, S. E. 2025, *Boletín de la Asociación Argentina de Astronomía La Plata Argentina*, **66**, 254
- Pizzuti, L., Barrena, R., Sereno, M., et al. 2025, *A&A*, **699**, A88
- Planck Collaboration XXVII. 2016, *A&A*, **594**, A27
- Proust, D., Yegorova, I., Saviane, I., et al. 2015, *MNRAS*, **452**, 3304
- Ragone-Figueroa, C., Granato, G. L., Borgani, S., et al. 2020, *MNRAS*, **495**, 2436
- Richard, J., Pelló, R., Schaerer, D., Le Borgne, J. F., & Kneib, J. P. 2006, *A&A*, **456**, 861
- Ricker, P. M., & Sarazin, C. L. 2001, *ApJ*, **561**, 621
- Roche, C., McDonald, M., Borrow, J., et al. 2024, *Open J. Astrophys.*, **7**, 65
- Rossetti, M., Gastaldello, F., Ferioli, G., et al. 2016, *MNRAS*, **457**, 4515
- Rossetti, M., Gastaldello, F., Eckert, D., et al. 2017, *MNRAS*, **468**, 1917
- Rossetti, M., Eckert, D., Gastaldello, F., et al. 2024, *A&A*, **686**, A68
- Sand, D. J., Treu, T., Smith, G. P., & Ellis, R. S. 2004, *ApJ*, **604**, 88
- Saviane, I., Yegorova, I., & Proust, D. 2023, *MNRAS*, **526**, 2458
- Sereno, M., Lubini, M., & Jetzer, P. 2010, *A&A*, **518**, A55
- Sereno, M., Maurogordato, S., Cappi, A., et al. 2025, *A&A*, **693**, A2
- Sirks, E. L., Harvey, D., Massey, R., et al. 2024, *MNRAS*, **530**, 3160
- Smail, I., Ellis, R. S., Fitchett, M. J., et al. 1991, *MNRAS*, **252**, 19
- Smail, I., Couch, W. J., Ellis, R. S., & Sharples, R. M. 1995, *ApJ*, **440**, 501
- Soucali, G., Mellier, Y., Fort, B., Hammer, F., & Mathez, G. 1987, *A&A*, **184**, L7
- Valdarnini, R. 2024, *A&A*, **684**, A102
- van Weeren, R. J., de Gasperin, F., Akamatsu, H., et al. 2019, *Space Sci. Rev.*, **215**, 16
- Vazza, F., Brüggen, M., Gheller, C., & Brunetti, G. 2012, *MNRAS*, **421**, 3375
- Willingale, R., Starling, R. L. C., Beardmore, A. P., Tanvir, N. R., & O'Brien, P. T. 2013, *MNRAS*, **431**, 394
- Wittman, D., Foote, D., & Golovich, N. 2019, *ApJ*, **874**, 84
- XRISM Collaboration (Audard, M., et al.) 2024, *PASJ*, **76**, 1186

Appendix A: Multiple images

Table A.1 lists the multiple images.

A.1. Sub-spots in multiply imaged systems

A.1.1. Presentation

We were able to conjugate sub-spots in the following multiply imaged systems: system 1 (12 sub-systems), system 2 (4 sub-systems), system 3 (2 sub-systems), system 4 (6 sub-systems), system 6 (2 sub-systems), system 7 (4 sub-systems), and system 11 (2 sub-systems). We associated the most secure sub-spots on each given image in order not to introduce misidentification. Sometimes we were not able to conjugate sub-spots for all images of a given system. For example, we have not been able to reliably define image 2.3.5, and hence this image is not mentioned in Table A.2. When defining the sub-spots, we changed the name of the former image ($i.j$) to ($i.1.j$). For example, image 2.1 becomes 2.1.1 and image 2.2 becomes 2.1.2.

All images are listed in Tables A.2 and A.3. We show the proposed identifications in Figs. A.2 and A.3. Colour images were produced with SAOImage ds9, using JWST/NIRCam F322W, F150W, and HST/ACS F814W in the red, green, and blue channels, respectively.

A.1.2. What do sub-spots contribute?

We aim to quantify the improvement in constraints brought by the inclusion of sub-spots within certain multiple images (Sect. 2.3). In Fig. A.1, we present the posterior distributions of the main clump parameters derived from the SL+X-ray fits performed using either 52 or 124 images. The PDFs are generally narrower when using 124 images. In particular, the PDFs for the velocity dispersion of the DM clump and the strength of the external shear are more sharply peaked and do not exhibit a plateau, as observed in the case of 52 images.

Appendix B: The (RATE, NB) test

We performed the (RATE, NB) test, which has been found to be useful for assessing whether the parameters describing the mass distribution have actually converged. Two key parameters matter when it comes to the convergence of the LENSTOOL MCMC sampler (Jullo et al. 2007): the RATE parameter, associated with the burn-in phase, and the number of iterations (NB), associated with the sampling phase. The lower the rate, the more slowly the sampler will move to the high-likelihood areas, and the less prone it will be to miss a mode of the posterior. The larger NB, the larger the number of iterations of the MCMC chains, the best the parameter space can be sampled. We refer the reader to Limousin et al. (2025a) for more details. In brief, we decreased the value of RATE and increased NB to evaluate their influence on the RMS and on the parameters of the mass clumps describing AC114 in the context of the combined SL+X-ray analysis. Convergence is considered to be attained when the values of these parameters no longer influence the resulting RMS or the parameters of the mass clumps. The results are presented in Table B.1 and Fig. B.1. We find that a RATE value of 0.01 is sufficiently small: the PDFs corresponding to the different runs with RATE = 0.01 are in good agreement with one another. In contrast, the PDFs obtained with RATE = 0.05 are broader, suggesting that this value is not small enough. Moreover, when lowering the RATE to 0.005, the resulting PDFs remain consistent

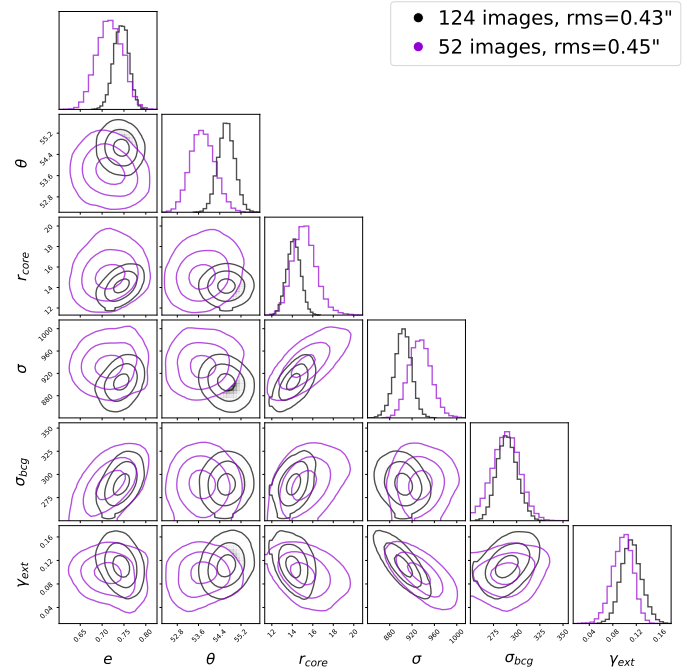


Fig. A.1. Posterior distributions of the main clump parameters from the SL+X-ray fits performed using either 52 or 124 images.

with those obtained using RATE = 0.01. Regarding NB, we find no significant differences between runs with values of 2000 or 4000, suggesting that when the RATE is sufficiently small, NB becomes less critical, as also found in Limousin et al. (2025b) for MACS J0416.

Table A.1. Multiple images used in this work.

Former ID	New ID	RA	Dec	z_{spec}	z_{model}
S1	1.1	344.70368	-34.798406	1.86	
S2	1.2	344.70045	-34.799264	1.867	
S3	1.3	344.69284	-34.805879		
A1	2.1	344.70698	-34.798195		
A2	2.2	344.69948	-34.801443	1.869	
A3	2.3	344.69552	-34.805826		
A4	2.4	344.70178	-34.803511		
A5	2.5	344.70135	-34.802603		
B1	3.1	344.70130	-34.795580		1.35 ± 0.03
B2	3.2	344.69536	-34.798629		
B3	3.3	344.69442	-34.799193		
B4	3.4	344.69416	-34.799334		
B5	3.5	344.69339	-34.800246		
C1	4.1	344.70275	-34.794065		
C2	4.2	344.69448	-34.797526		
C3	4.3	344.69246	-34.799303	2.854	
D1	5.1	344.69710	-34.804713		1.38 ± 0.04
D2	5.2	344.69888	-34.803751		
D3	5.3	344.69820	-34.802791		
D4	5.4	344.69930	-34.804344		
D5	5.5	344.70753	-34.797873		
E1	6.1	344.69487	-34.806320	3.347	
E2	6.2	344.70197	-34.804498		
E3	6.3	344.70096	-34.802696		
E4	6.4	344.69906	-34.801483		
E5	6.5	344.70853	-34.797417		
	7.1	344.70371	-34.808614		5.0 ± 1.0
	7.2	344.70106	-34.809743		
	8.1	344.70389	-34.807641		1.28 ± 0.06
	8.2	344.70234	-34.808337		
	9.1	344.71108	-34.803280		10*
	9.2	344.70669	-34.807969		
	10.1	344.71033	-34.805106		2.39 ± 0.14
	10.2	344.70649	-34.808592		
	10.3	344.70216	-34.810730		
	11.1	344.70424	-34.801347		1.27 ± 0.04
	11.2	344.70351	-34.802640		
	11.3	344.69490	-34.806995		
	12.1	344.70269	-34.800236		1.18 ± 0.03
	12.2	344.70193	-34.800411		
	12.3	344.69447	-34.806042		
	13.1	344.70197	-34.796186		1.87 ± 0.05
	13.2	344.69788	-34.797672		
	13.3	344.69230	-34.802744		
	14.1	344.70217	-34.805556		0.97 ± 0.02
	14.2	344.69995	-34.806415		
	14.3	344.70675	-34.801208		
	15.1	344.69601	-34.801881		6.76 ± 2.0
	15.2	344.69558	-34.802297		
	16.1	344.70622	-34.800816		1.24 ± 0.04
	16.2	344.70343	-34.804425		
	16.3	344.69688	-34.806907		

Notes. Multiple images used in this work. For systems already identified prior to the JWST observations, we list the IDs from previous works and the new IDs proposed in this study. We report the spectroscopic redshift when available, as well as the estimated redshift constrained by the best fit mass model (with 1σ error bars) presented in Sect. 5. The estimated redshift for system 9 is stuck to 10, the upper bound of the prior.

Table A.2. Sub-systems in systems 1, 2, and 3.

ID	RA	Dec	z_{spec}	z_{model}
1.1.1	344.70368	-34.798406	1.867	
1.1.2	344.70045	-34.799264		
1.1.3	344.69284	-34.805879		
1.2.1	344.70372	-34.798335	1.867	
1.2.2	344.70035	-34.799241		
1.2.3	344.69283	-34.805800		
1.3.1	344.70362	-34.798497	1.867	
1.3.2	344.70058	-34.799278		
1.3.3	344.69282	-34.805969		
1.4.1	344.70360	-34.798550	1.867	
1.4.2	344.70065	-34.799297		
1.4.3	344.69282	-34.806008		
1.5.1	344.70347	-34.798536	1.867	
1.5.2	344.70070	-34.799233		
1.6.1	344.70339	-34.798547	1.867	
1.6.2	344.70077	-34.799197		
1.6.3	344.69274	-34.805975		
1.7.1	344.70340	-34.798467	1.867	
1.7.2	344.70068	-34.799164		
1.8.1	344.70335	-34.798492	1.867	
1.8.2	344.70074	-34.799150		
1.8.3	344.69271	-34.805922		
1.9.1	344.70312	-34.798469	1.867	
1.9.2	344.70087	-34.799033		
1.10.1	344.70303	-34.798569	1.867	
1.10.2	344.70108	-34.799047		
1.11.1	344.70330	-34.798661	1.867	
1.11.2	344.70096	-34.799231		
1.12.1	344.70370	-34.798636	1.867	
1.12.2	344.70067	-34.799414		
2.1.1	344.70698	-34.798195	1.869	
2.1.2	344.69948	-34.801443		
2.1.3	344.69552	-34.805826		
2.1.4	344.70178	-34.803511		
2.1.5	344.70135	-34.802603		
2.2.1	344.70696	-34.79815	1.869	
2.2.2	344.69941	-34.801408		
2.2.3	344.69548	-34.805772		
2.2.4	344.70169	-34.803403		
2.2.5	344.70136	-34.802692		
2.3.1	344.70694	-34.798244	1.869	
2.3.2	344.69955	-34.801419		
2.3.3	344.69548	-34.805892		
2.3.4	344.70186	-34.803544		
2.4.1	344.70711	-34.798019	1.869	
2.4.2	344.69923	-34.801506		
2.4.3	344.69561	-34.805625		
2.4.4	344.7014	-34.803138		
2.4.5	344.70138	-34.803089		
3.1.1	344.70130	-34.795580		1.35 ± 0.03
3.1.2	344.69536	-34.798629		
3.1.3	344.69442	-34.799193		
3.1.4	344.69416	-34.799334		
3.1.5	344.69339	-34.800246		
3.2.1	344.70125	-34.795662		1.29 ± 0.03
3.2.2	344.69572	-34.798487		
3.2.5	344.69334	-34.800412		

Notes. We report the estimated redshift constrained by the mass model (with 1σ error bars) for each sub-system of system 3, in order to check that they are, as expected, in agreement.

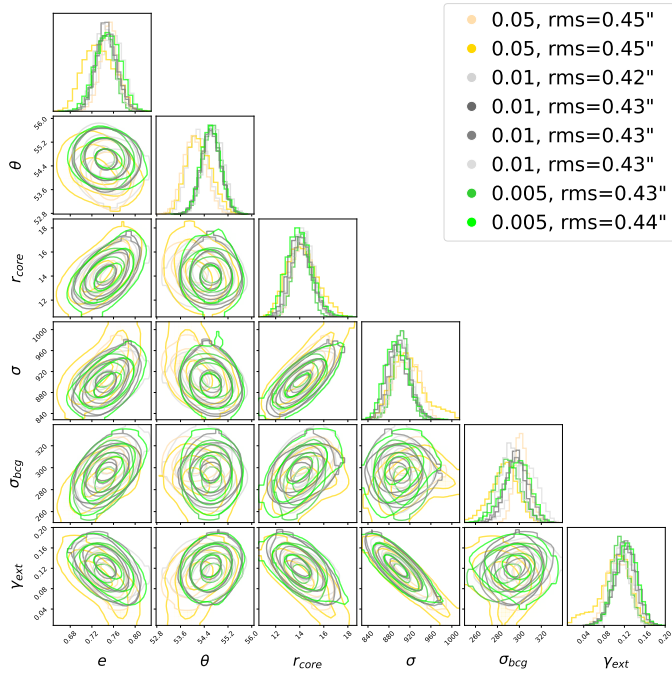
Table A.3. Sub-systems in systems 4, 6, 7, and 11.

ID	RA	Dec	z_{spec}	z_{model}
4.1.1	344.70275	-34.794068	2.854	
4.1.2	344.69448	-34.797526		
4.1.3	344.69245	-34.799311		
4.2.2	344.69473	-34.797422	2.854	
4.2.3	344.69230	-34.799617		
4.3.1	344.70292	-34.794202	2.854	
4.3.2	344.69484	-34.797489		
4.3.3	344.69234	-34.799700		
4.4.1	344.70331	-34.794289	2.854	
4.4.2	344.69485	-34.797883		
4.4.3	344.69248	-34.799878		
4.5.1	344.70356	-34.794292	2.854	
4.5.2	344.69454	-34.798189		
4.5.3	344.69264	-34.799837		
4.6.1	344.70370	-34.794272	2.854	
4.6.2	344.69422	-34.798438		
4.6.3	344.69281	-34.799703		
6.1.1	344.69487	-34.806325	3.347	
6.1.2	344.70198	-34.804493		
6.1.3	344.70097	-34.802690		
6.1.4	344.69909	-34.801494		
6.1.5	344.70854	-34.797411		
6.2.1	344.69491	-34.80623	3.347	
6.2.2	344.70188	-34.804442		
6.2.3	344.70094	-34.80277		
6.2.4	344.69898	-34.801495		
6.2.5	344.70857	-34.797338		
7.1.1	344.70371	-34.808614		5.0 ± 1.0
7.1.2	344.70106	-34.809743		
7.2.1	344.70377	-34.808564		6.1 ± 0.8
7.2.2	344.70094	-34.809769		
7.3.1	344.70328	-34.808819		6.5 ± 0.8
7.3.2	344.70161	-34.809522		
7.4.1	344.70302	-34.808933		5.7 ± 0.8
7.4.2	344.70179	-34.809442		
11.1.1	344.70424	-34.801347		1.27 ± 0.04
11.1.2	344.70351	-34.802640		
11.1.3	344.69490	-34.806995		
11.2.1	344.70408	-34.801364		1.28 ± 0.04
11.2.2	344.70344	-34.802514		
11.2.3	344.69480	-34.806983		

Notes. Systems for which we do propose sub-systems: systems 4, 6, 7 and 11. We report the estimated redshift constrained by the mass model (with 1σ error bars) for each sub-system when no spectroscopic redshift is available, in order to check that they are, as expected, in agreement.

Table B.1. RMS values obtained for various combinations of **RATE** and **N_B**.

RATE	N _B	RMS (")
0.05	2000	0.45
0.05	4000	0.45
0.01	2000	0.42
0.01	2000	0.43
0.01	3000	0.43
0.01	4000	0.44
0.005	2000	0.43
0.005	2000	0.44

**Fig. B.1.** Results of the (**RATE**, **N_B**) test. We show the posterior distributions of the main cluster parameters from the SL+X-ray fits performed for the different (**RATE**, **N_B**) values listed in Table B.1 and indicated in the upper right inset.