

The 300th-NIKA2 LPSZ Twin Samples: synthetic clusters to support real observations

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The Three Hundred Project

What?

The Three Hundred Project ¹ is a large sample of simulated galaxy clusters and their environment modelled using a range of simulation packages and physics modules. It provides mock maps of the clusters in X-ray, optical, gravitational lensing, radio, and Sunyaev-Zeldovich (SZ) observations:

- 324 regions of radius $15h^{-1}\text{Mpc}$ having a cluster identified at $z = 0$ with mass $M_{200} > 6.42 \times 10^{14} h^{-1} M_{\odot}$, at its centre
- Hydrodynamical simulations run for each region using standard SPH (GADGET-MUSIC) and modern SPH (GADGET-X, GIZMO-Simba)
- Semi-analytical model (SAM) counterparts produced using Galacticus, SAG, and SAGE

¹<https://the300-project.org>

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Weiguang Cui's talk
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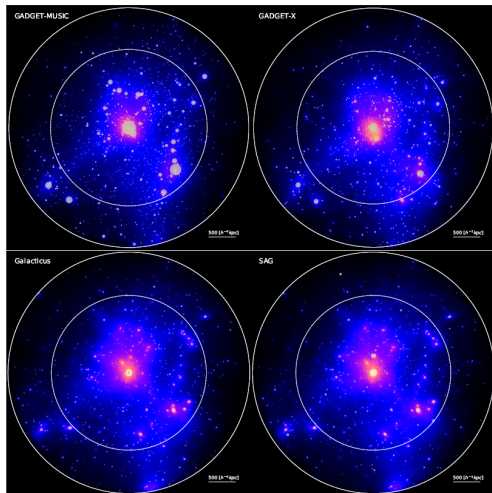
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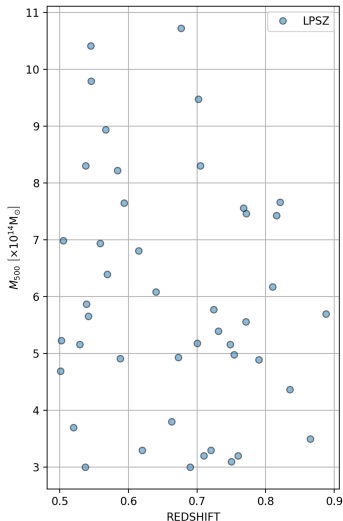


The distribution of galaxies within R_{200} (outer circle) and R_{500} (inner circle) of the most massive cluster within a simulation region. The coloured maps show the projected dark matter density, galaxy colours are calculated from the SDSS band magnitudes, and the sizes represent their stellar mass. Weiguang C. et al. 2018.

NIKA2 LPSZ sample

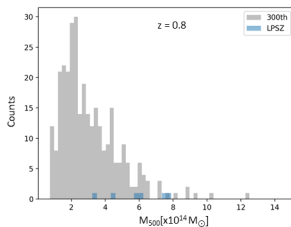
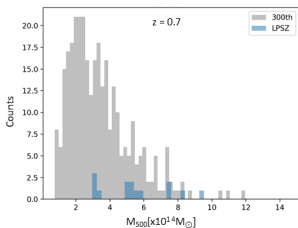
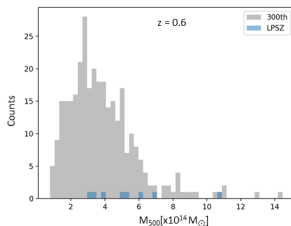
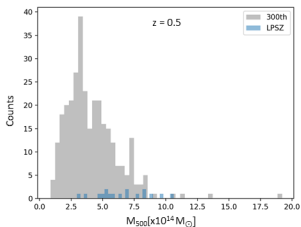
Laurence Perotto's talk

- 45 Galaxy clusters at intermediate and high redshift ($0.5 < z < 0.9$), covering about one order of magnitude in mass
- Follow-up of SZ-selected clusters from the Planck and Atacama Cosmology Telescope (ACT) catalogs
- Representative of the Planck and ACT clusters in terms of mass and redshift

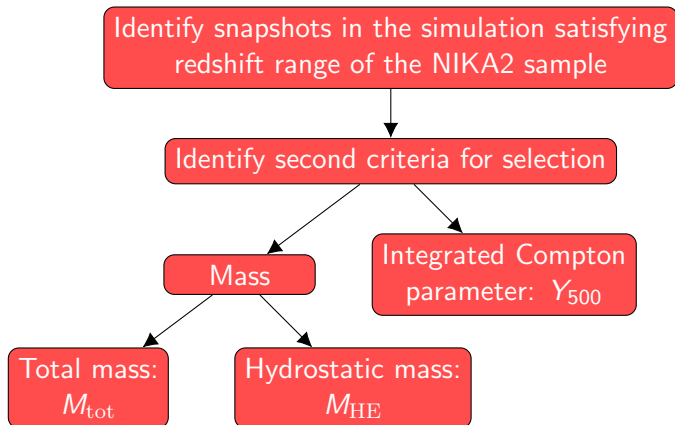


Selection of Twin Sample (TS)

Identify snapshots in the simulation satisfying redshift range of the NIKA2 sample



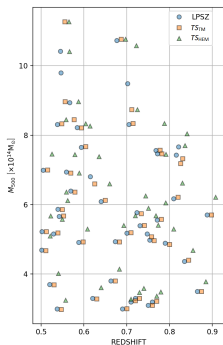
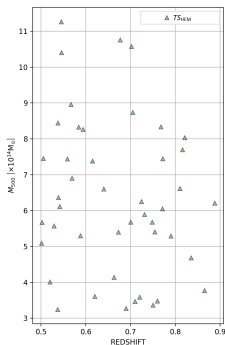
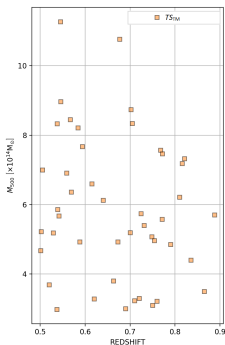
Selection of Twin Sample (TS)



Selection of Twin Sample (TS)

Selection of first two samples TS_{TM} and TS_{HEM} , with closest total mass and hydrostatic mass, respectively, to NIKA2 sample gives:

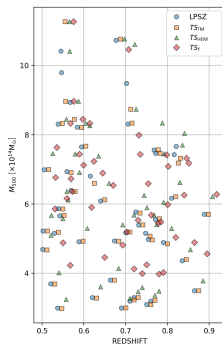
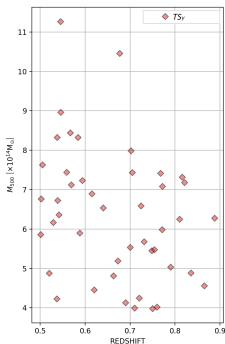
- $\left\langle \frac{M_{LPSZ}}{M_{TS_{TM}}} \right\rangle = 1.01 \pm 0.02$
- $\left\langle \frac{M_{LPSZ}}{M_{TS_{HEM}}} \right\rangle = 0.93 \pm 0.02$



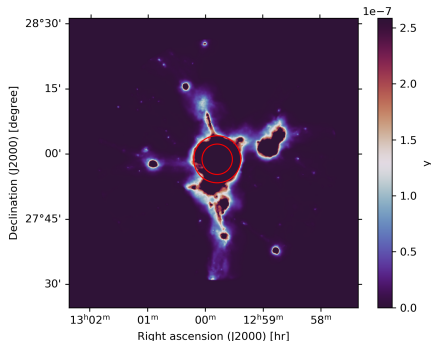
Selection of Twin Sample (TS)

Selection of third sample TS_Y , with closest integrated Compton parameter to NIKA2 sample gives:

- $\left\langle \frac{M_{LPSZ}}{M_{TS_Y}} \right\rangle = 0.9 \pm 0.1$
- $\left\langle \frac{Y_{500LPSZ}}{Y_{500TS_Y}} \right\rangle = 1.01 \pm 0.03$



SZ data (y maps)

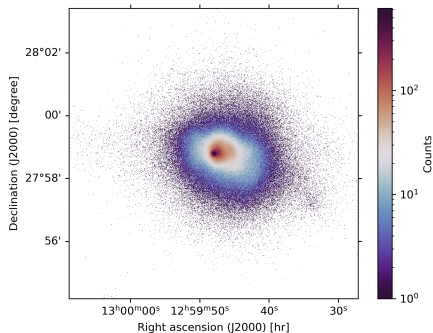


Credit: Weiguang Cui.

Compton parameter (y) map for a cluster with $\log[M_{200}/h^{-1}M_{\odot}] = 14.690$, $R_{200} = 1676.2 h^{-1}\text{kpc}$, at $z = 0.70$. Map size: $\sim 1.1^{\circ} \times 1.1^{\circ}$. Pixel size: $\sim 5''$. The two concentric circles represent R_{500} and R_{200} .

- The y maps will be utilised to calculate Y_{500} by directly using the projected data and via deprojected profiles
- Calculations will be done along different lines of sight in a given mass and redshift range to assess the dynamical state of clusters and its impact
- Scaling laws to be calculated: $Y_{500} - M_{\text{tot}}$ and $Y_{500} - M_{\text{HE}}$

X-ray data

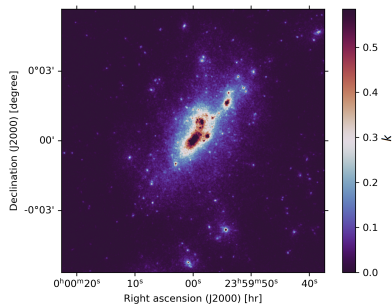


Credit: Weiguang Cui.

Mock X-Ray photon count image for the Athena WFI, of a cluster with $\log[M_{200}/h^{-1}M_{\odot}] = 14.824$, $R_{200} = 1693.4 h^{-1}\text{kpc}$, at $z = 0.82$. Map size: $\sim 9.2' \times 9.2'$. Pixel size: $\sim 0.7''$.

- Scaling laws to be calculated: $L_X - M_{\text{tot}}$ and $L_X - M_{\text{HE}}$
- Will cross-correlate scaling laws to minimise the scatter on inferred mass

Other wavelengths

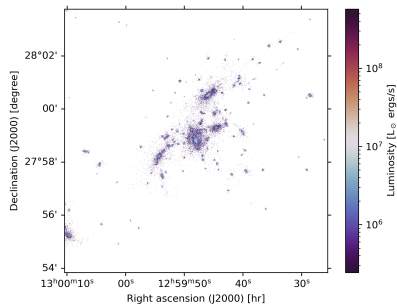


Credit: Massimo Meneghetti.

Lensing convergence (κ) map for a cluster with $\log[M_{200}/h^{-1}M_{\odot}] = 14.760$, $R_{200} = 1723.2 h^{-1}\text{kpc}$, at $z = 0.70$.

Map size: $\sim 11.3' \times 11.3'$.

Pixel size: $\sim 0.3''$.



Credit: Weiguang Cui.

Mock SDSS r band image for a cluster with $\log[M_{200}/h^{-1}M_{\odot}] = 14.577$, $R_{200} = 1490.9 h^{-1}\text{kpc}$, at $z = 0.56$.

Map size: $\sim 9.9' \times 9.9'$.

Pixel size: $\sim 0.4''$.

Other wavelengths

Other observables and products of the simulation to be used for the following tasks:

- Inferring observational estimates of the hydrostatic mass bias
- Forecasting gas fraction measurements
- To infer the impact of systematics on H_0 measurements

Thank You!