TRACING THE PROPERTIES OF GALAXY GROUPS WITH eROSITA

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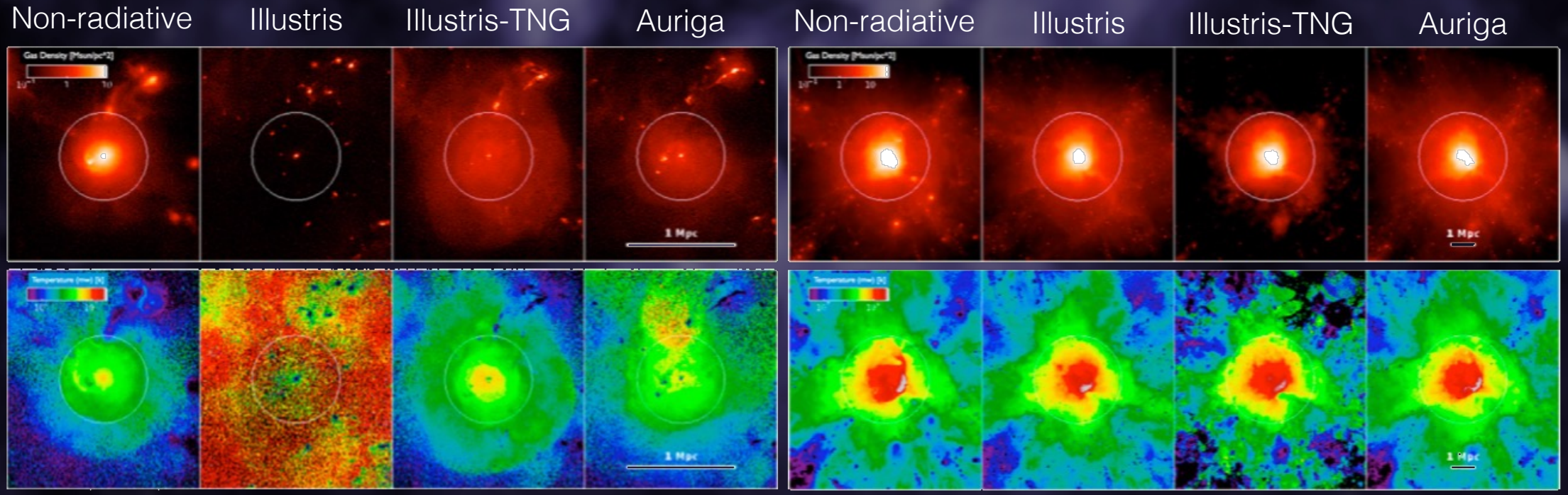
MOTIVATION

GALAXY GROUPS: THE ULTIMATE TESTING GROUND FOR NON-GRAVITATIONAL PROCESSES

Galaxy group: $M_h \sim 2 \times 10^{13}\, M_\odot$

Galaxy cluster: $M_h \sim 2 \times 10^{15}\, M_\odot$



Plot by A. Pillepich

Feedback can strongly affect the gas properties

Feedback has marginal effect on temperature and density

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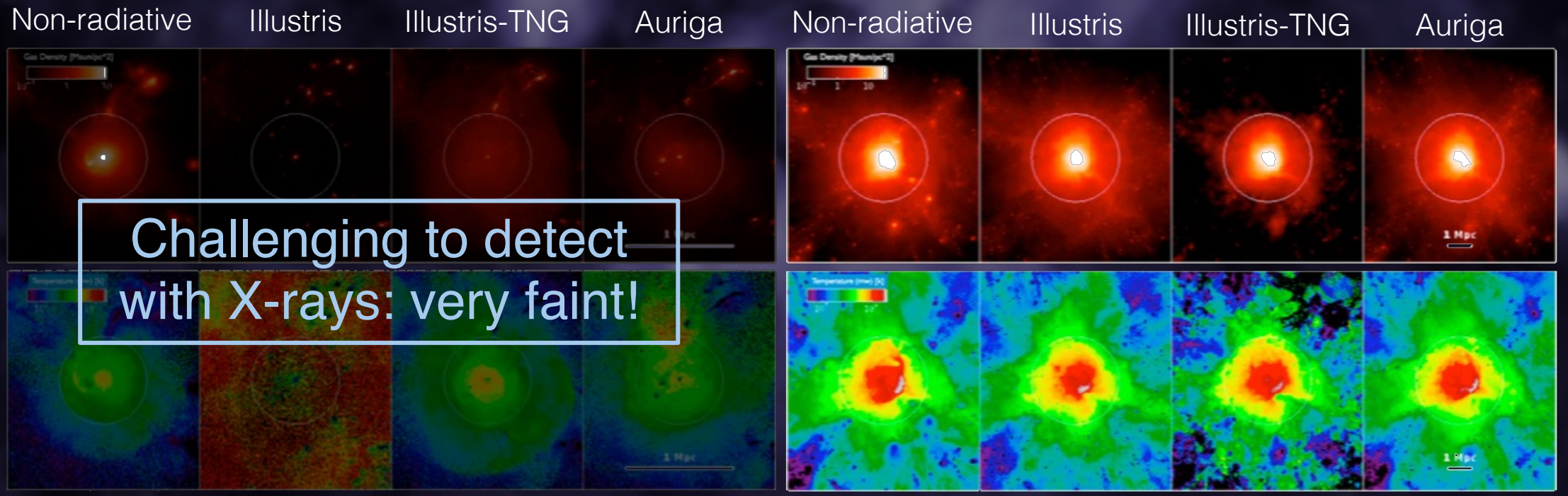


Challenging to detect with X-rays: very faint!

Feedback can strongly affect the gas properties

Feedback has marginal effect on temperature and density

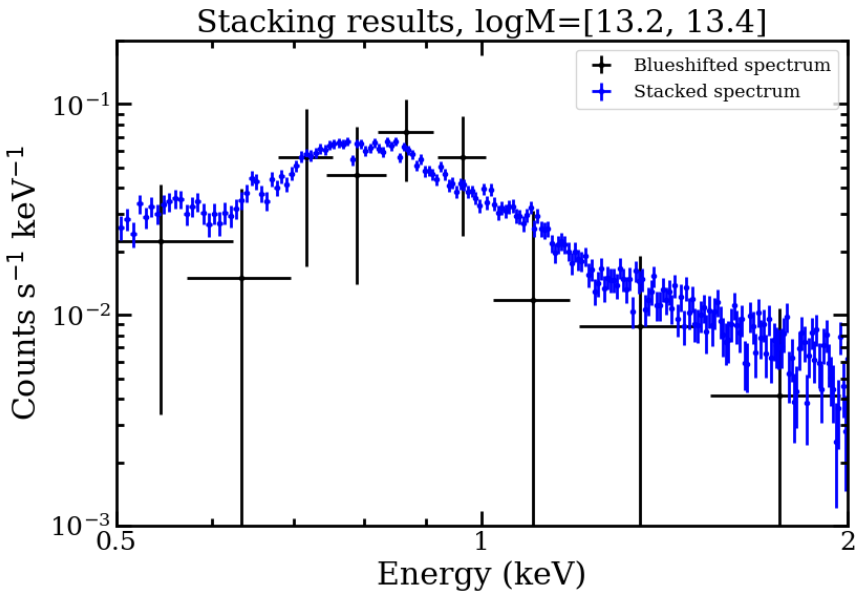
Plot by A. Pillepich

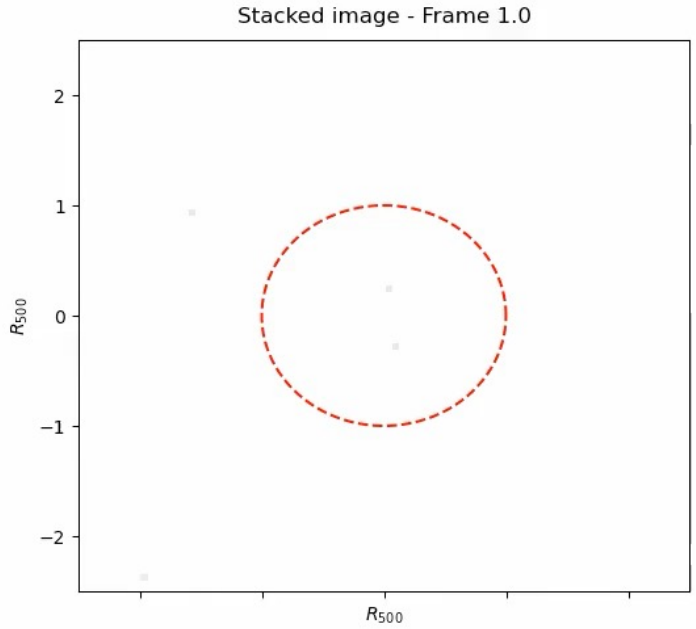

OUR METHODS

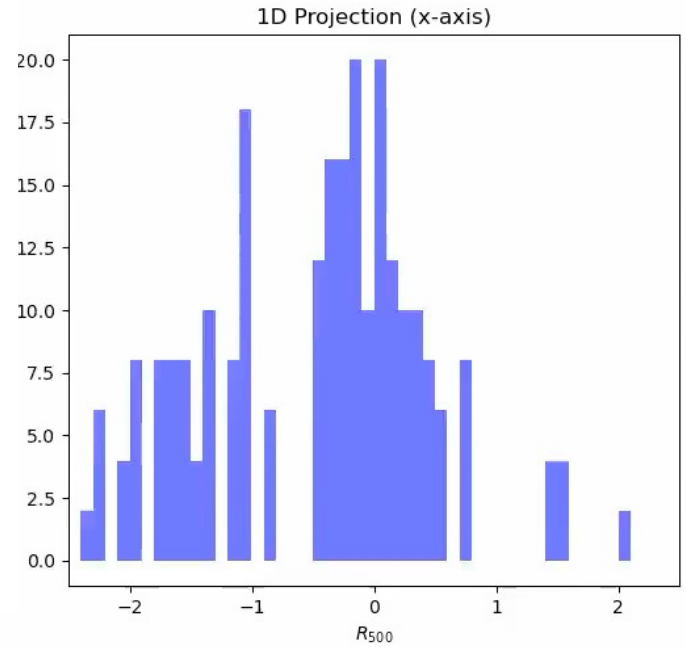
MAIN TECHNIQUE: STACKING

Using a sample of faint sources leads to a lack of photons, which prevents us from modeling the spectrum and estimating the temperature for most of the sources

but it could be avoided by stacking all the sources together in bins with the same properties







SAMPLE SELECTION BASED ON OPTICAL CLUSTER CATALOGS

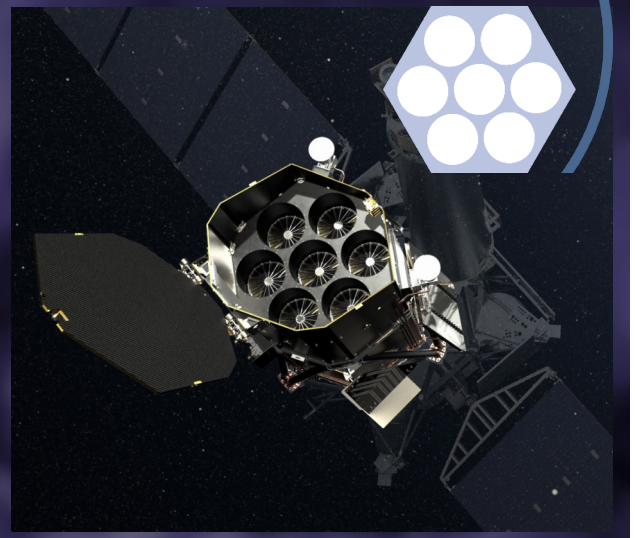
- Friend-of-friend algorithms for clusters and group selection
- Optical halo mass from proxies (total luminosity, total stellar mass)

+

ANALYSIS OF GAS PROPERTIES BASED ON STACKED X-RAY DATA

- Masking of the point sources
- Extraction of individual spectra
- Blueshifting to rest-frame
- Stacking all of them within the bin
- Spectral modeling
- Estimation of statistical errors

THE DATASET

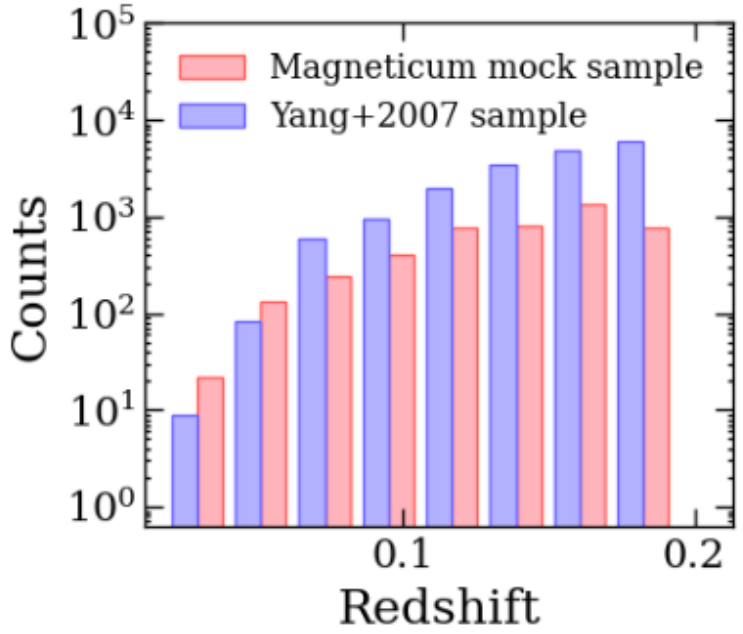


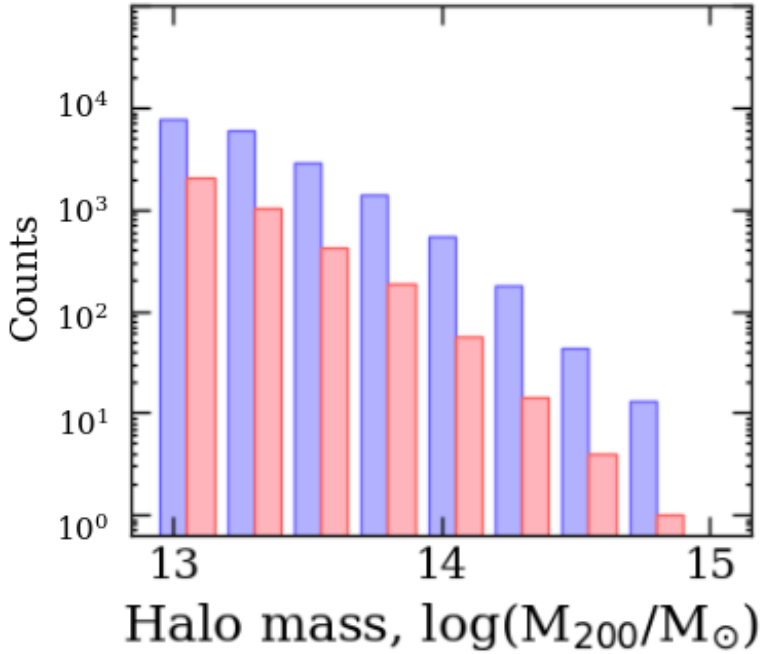
- Yang+2007 groups sample selected by SDSS; all targets in the SDSS field
- eRASS1 publicly available data

- Only local Universe up to z=0.2
- Removed all sources that contain other sources inside R_{500}
- Only sources without point-sources inside R_{500} in the eRASS1 catalog

- The “mimic” sample with the same selection criteria from Magneticum for additional clarification

Toptun et al. 2025





RESULTS

Toptun et al. 2025:

SPECTRAL STACKING to estimate the temperature

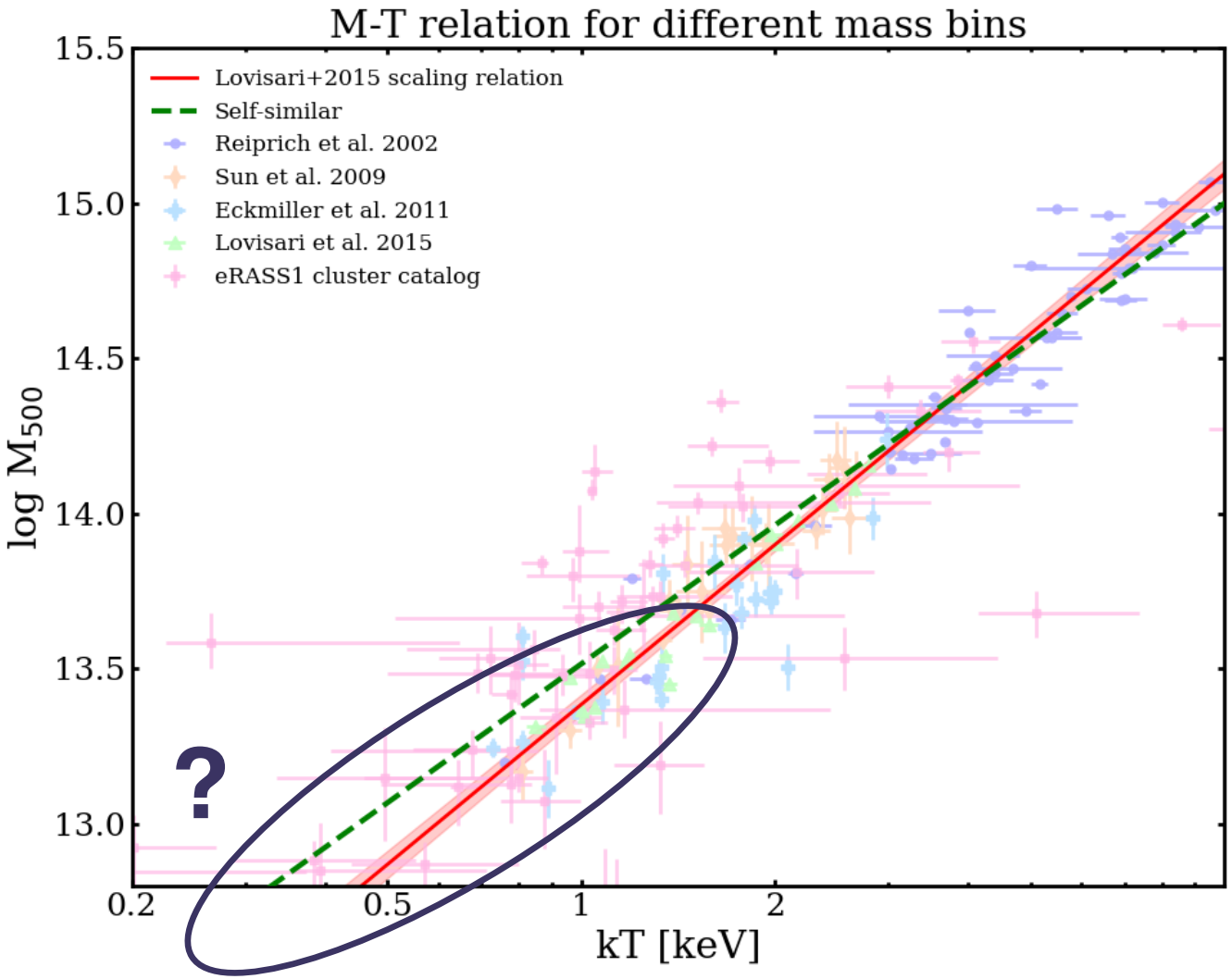
dividing the sample into halo mass bins (from optical proxies)

↓

result: stacked X-ray spectrum in each bin

↓

temperatures from the spectral modeling

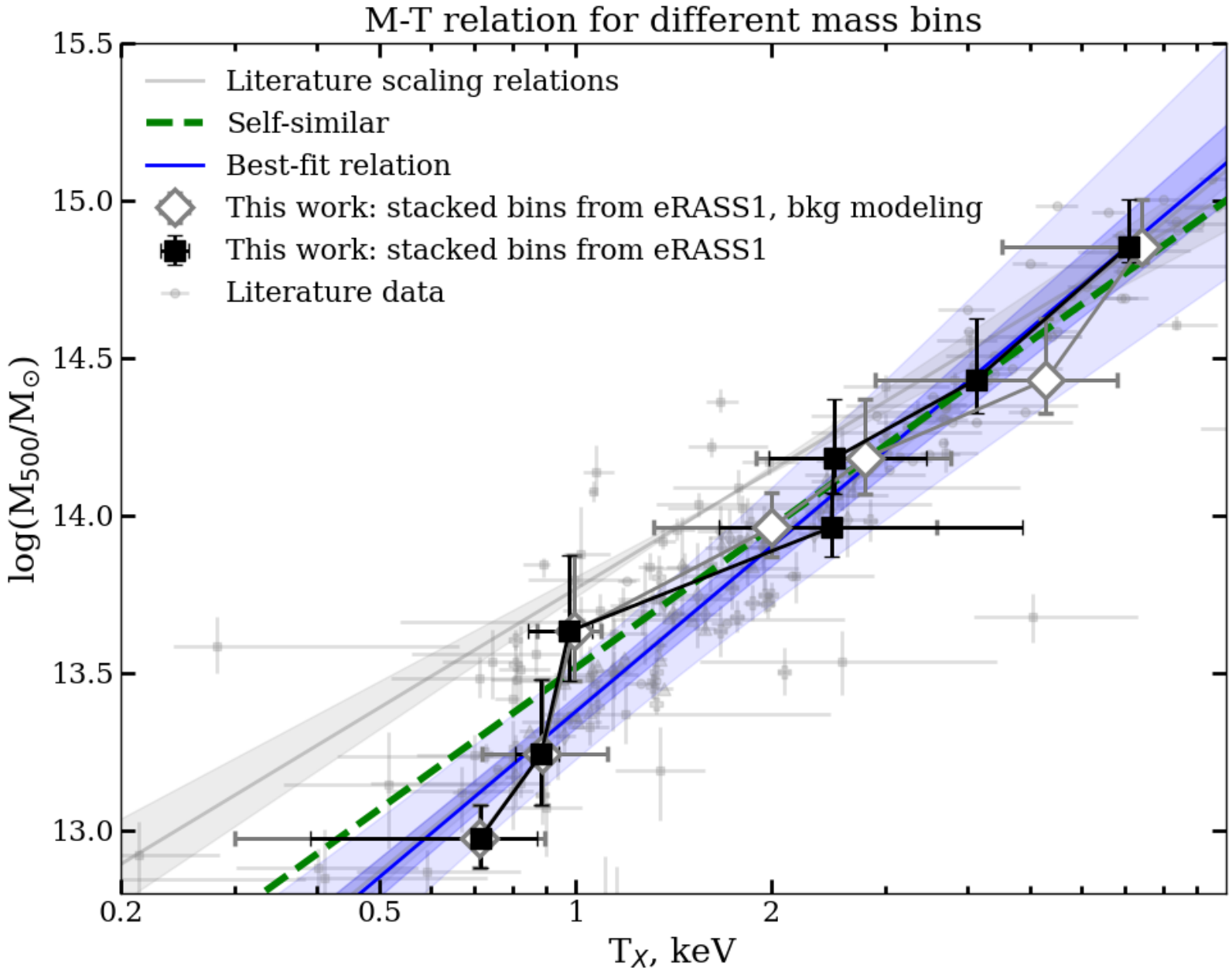


RELATION REVEALED

Stacking + wide-field data allows us to look up to $\log M_{500} \approx 13.0$

No significant impact of feedback on average temperature inside R_{500}

Pushing the gas away? (Popesso+26)



Toptun et al. 2025

Toptun et al. 2026

STELLAR-TO-HALO MASS RELATION

dividing the sample into stellar mass (GSWLC catalog) bins to estimate average temperature in each bin

↓

from the M-T relation (Toptun et al. 2025) we can estimate M_{halo} from the temperature

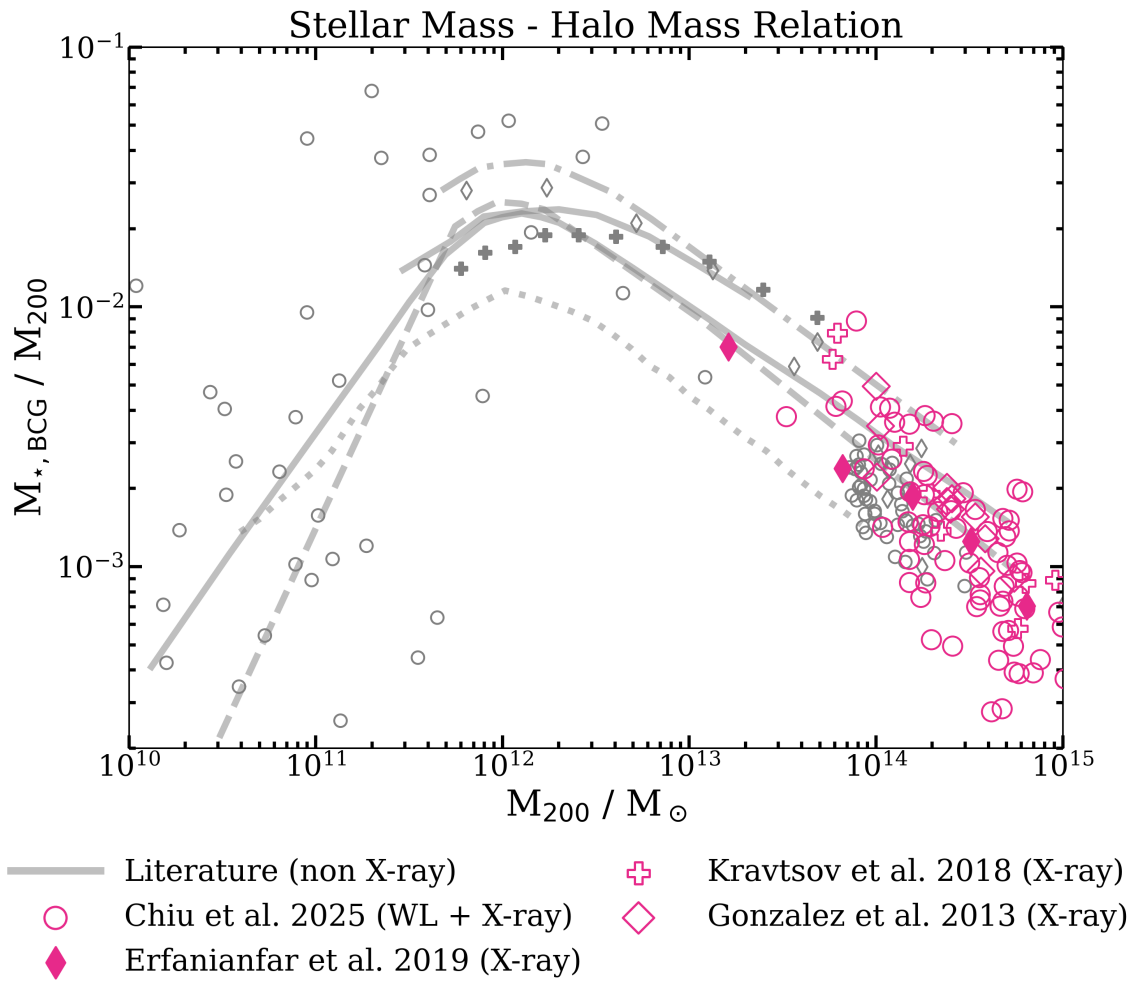
↓

stellar-to-halo mass relation based on independent halo mass estimates

stellar feedback becomes less and less effective in suppressing star formation →

peak of star formation efficiency

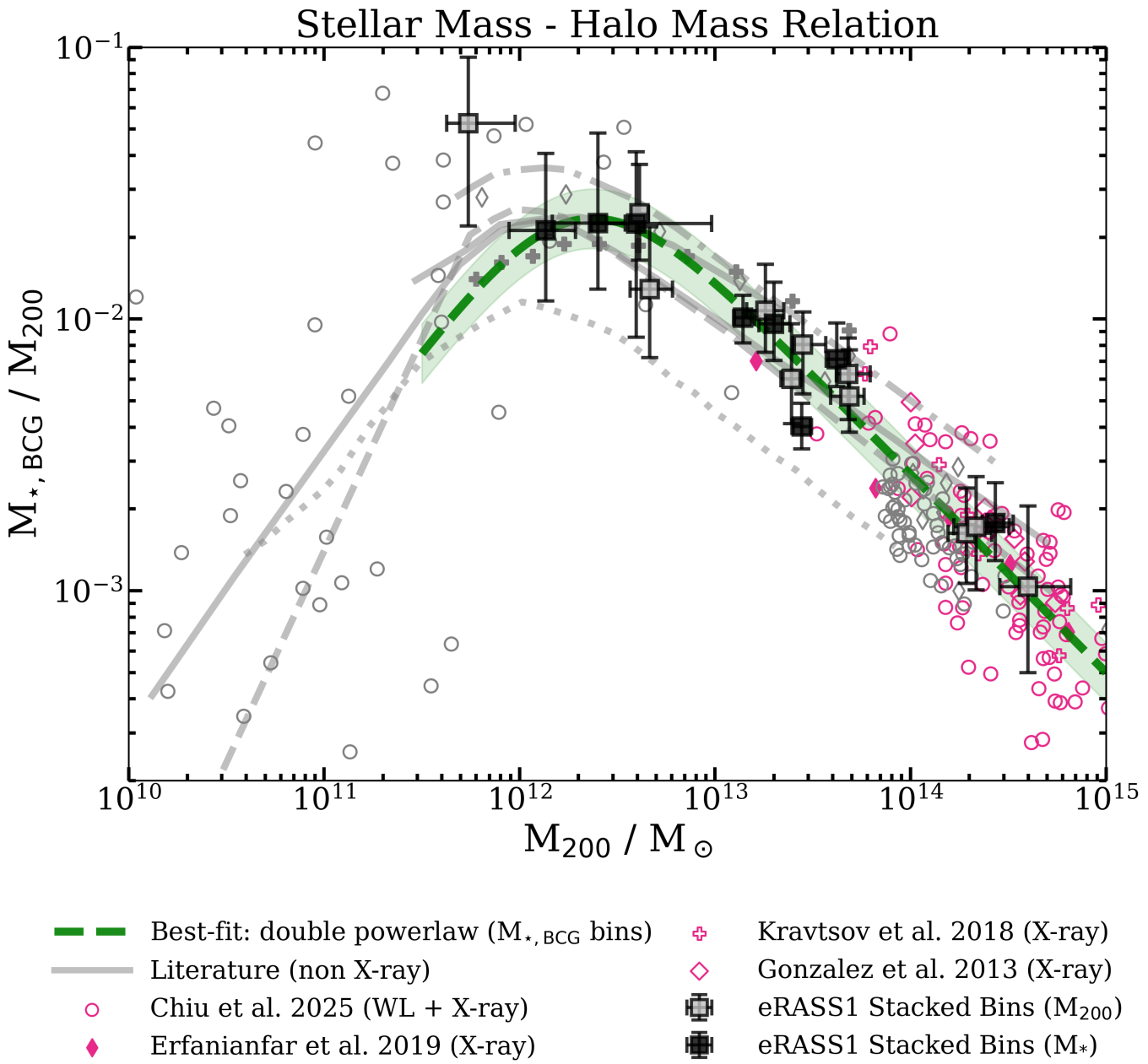
AGN feedback and long cooling time prevent active star formation →



Toptun et al. 2026

STELLAR-TO-HALO MASS RELATION: RESULTS

- Widest known coverage of SHMR with halo masses estimated independently from optical data
- Consistent with previous studies based on weak lensing, individual X-ray studies, cluster dynamics, predictions of semi-empirical models and abundance matching
- We can trace the efficiency peak around 10^{12} M_{sun}

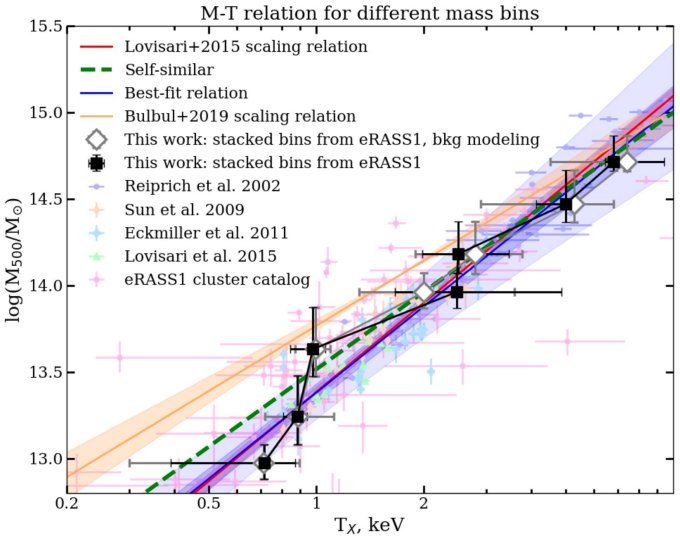


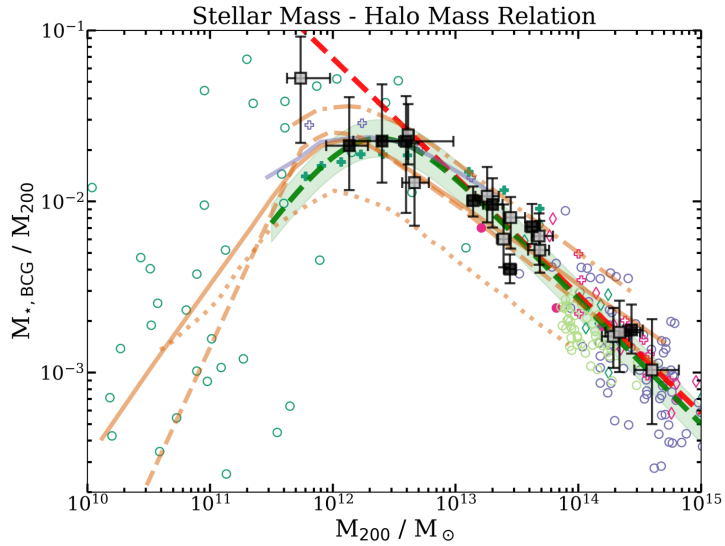
Toptun et al. (in prep.)

PRELIMINARY!

RESULTS & TAKE-HOME MESSAGES

- Stacking + optical selection is a reliable technique that lets us dig much deeper than we could with individual observations alone
- BCG correlates well with the halo mass (Toptun+2026)
- Average temperature inside R_{500} is consistent with self-similar predictions (Toptun+2025)…
- …but we see hints at differences in the internal structure of groups (stay tuned!)





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Questions and ideas are welcome!