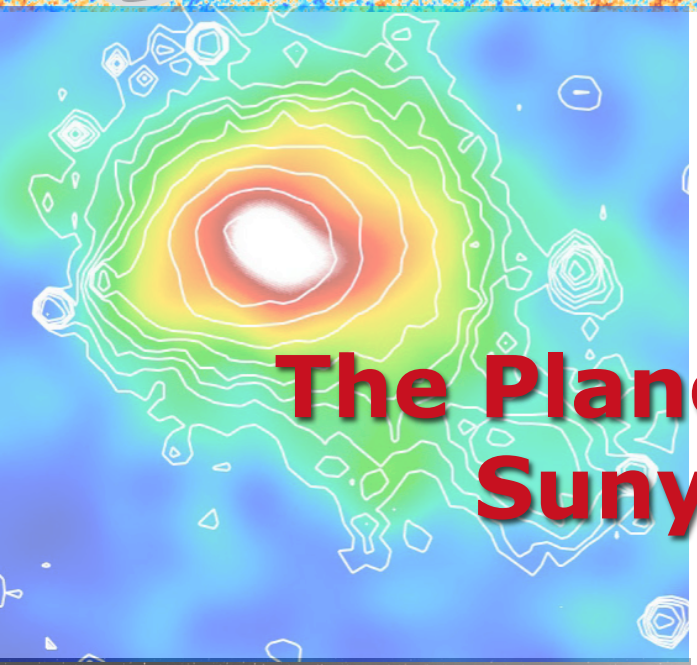
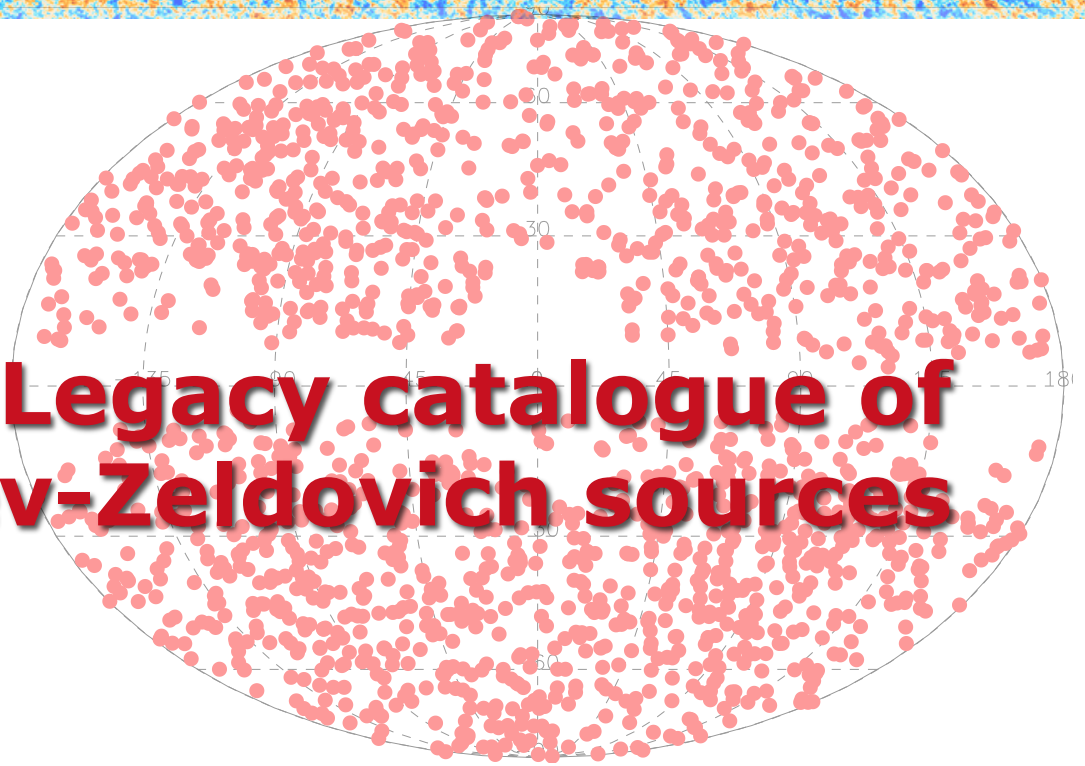
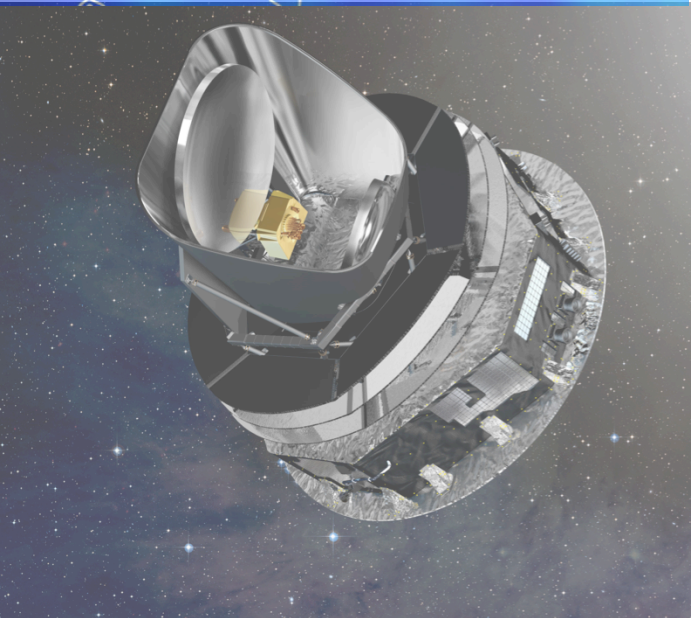




The Planck Legacy catalogue of Sunyaev-Zeldovich sources

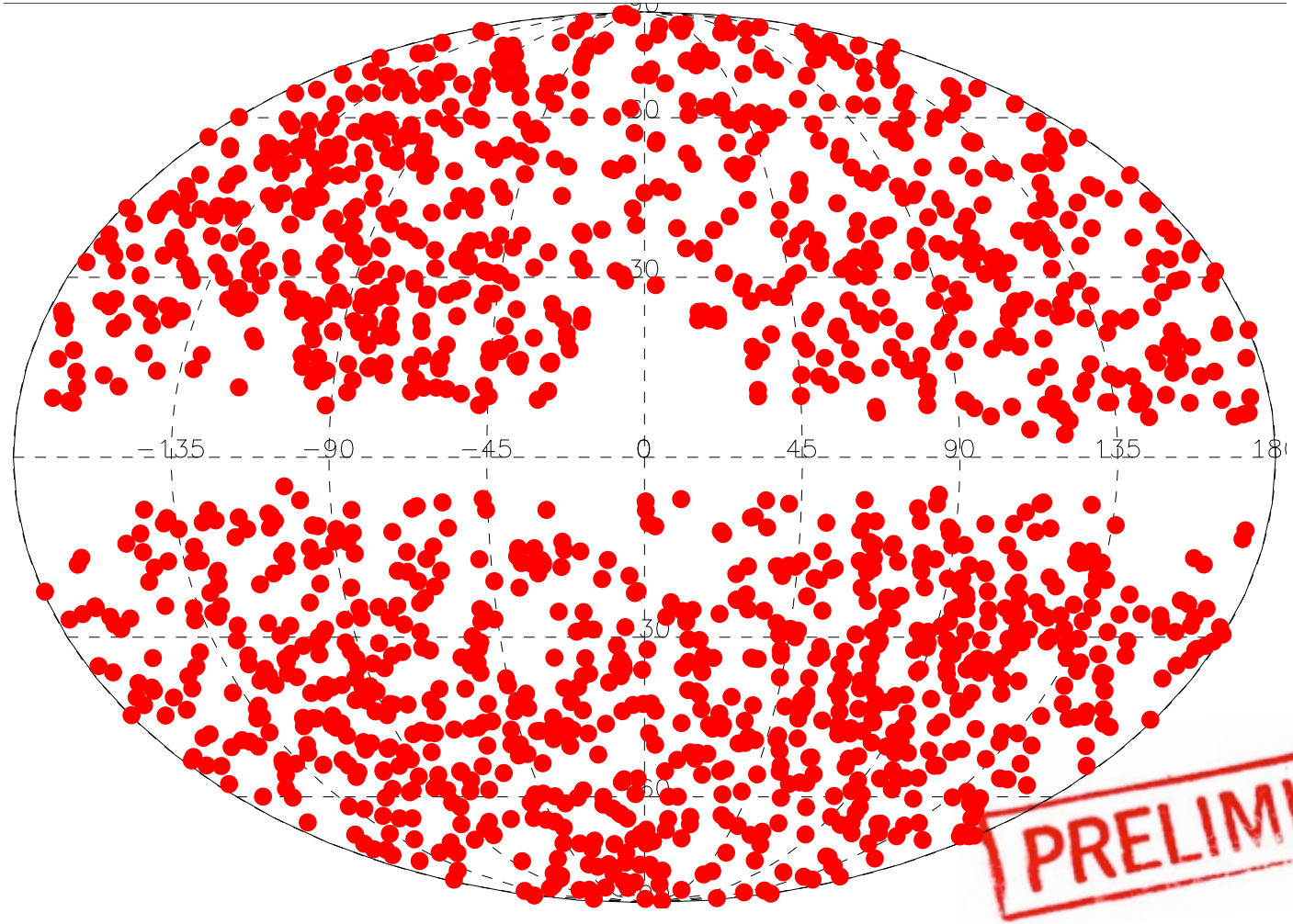


Mariachiara Rossetti

(Università degli Studi di Milano)

on behalf of the Planck Collaboration

The Planck SZ Legacy Catalogue



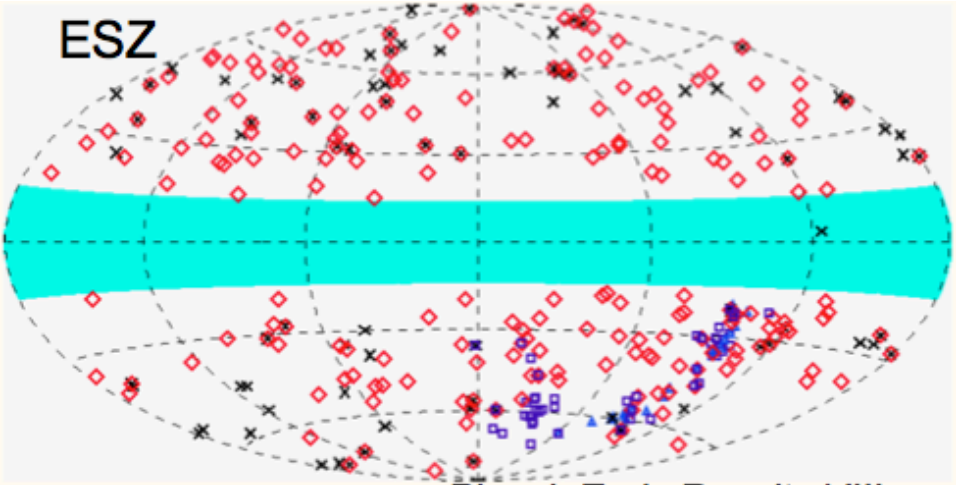
1651 SZ sources with S/N>4.5

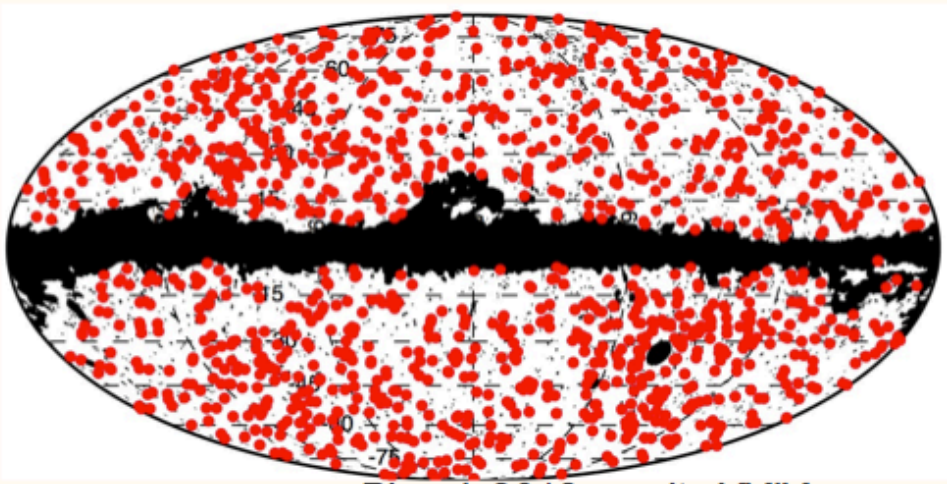
Obtained from full-mission data (29 months).

The Planck SZ legacy catalogue

Largest SZ-selected sample and deepest all sky survey of galaxy clusters

Third SZ catalogue based on Planck data:

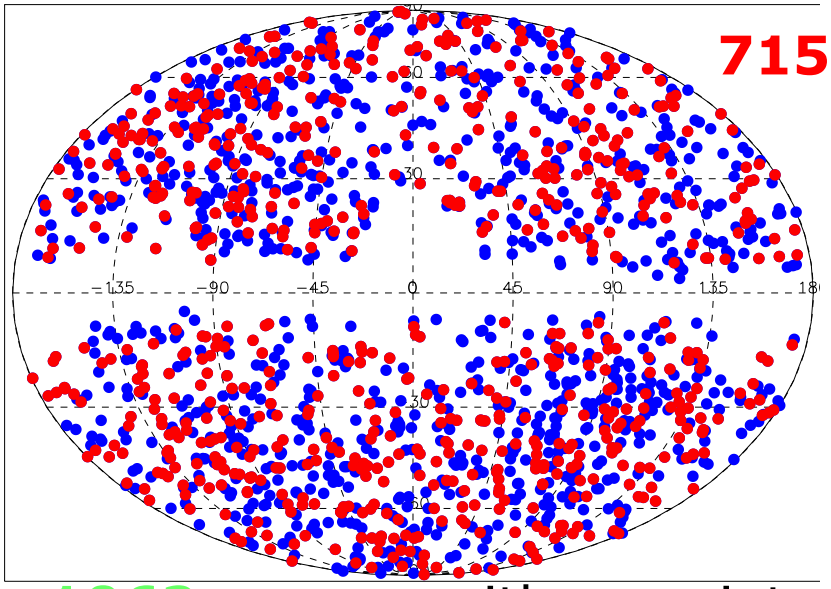




ESZ *Planck Early Results VIII (2011)*
189 sources S/N>6
20 new detections (19 confirmed)

PSZ1 *Planck 2013 Results XXIX*
1227 sources S/N>4.5
687 known clusters
178 New confirmed clusters
(extensive and successful follow-up)

The Planck SZ Legacy Catalogue



715 new detections with respect to **PSZ1**

(Planck 2013 Results XXIX)

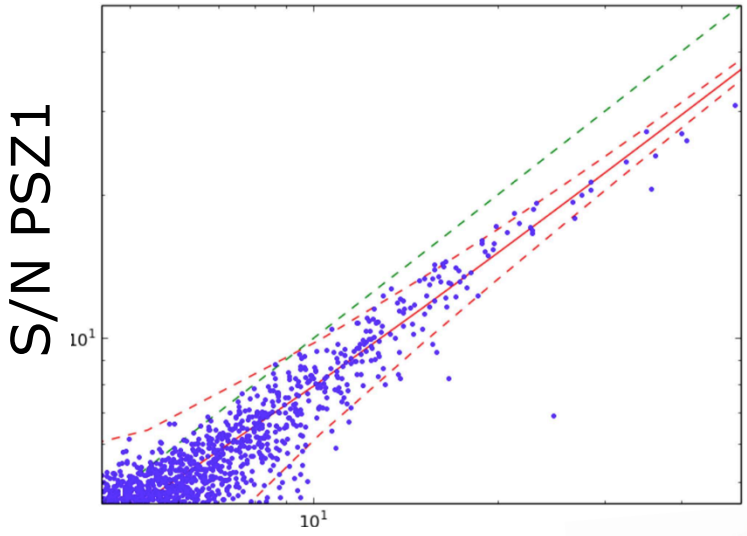
PSZ1	PSZ2	Common	New
1227	1651	936	715

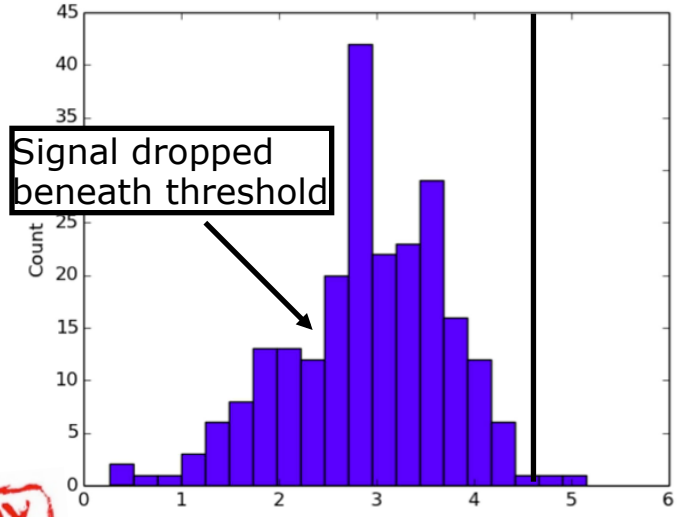
1062 sources with associated counterpart and redshift, through ancillary external information

	PSZ1	PSZ2	Common	New
Confirmed	861	1110	767	343
Redshift	813	1062	724	338
Candidates	366	544	112	429
Low-reliabiility	142	152	42	110

Consistency with PSZ1

1. We re-detect **936** of 1227 PSZ1 detections
2. S/N typically increases by 32%, due to extra data
3. However, simulations of half-full mission transition suggest a few hundred detections should fluctuate downwards in S/N, beneath survey threshold
4. 232 detections do this. All were S/N<6 in PSZ1





How do we build the catalogue?

The pipeline follows the same structure as for PSZ1 catalogue (Planck 2013 Results XXIX) with some refinements

Main steps:

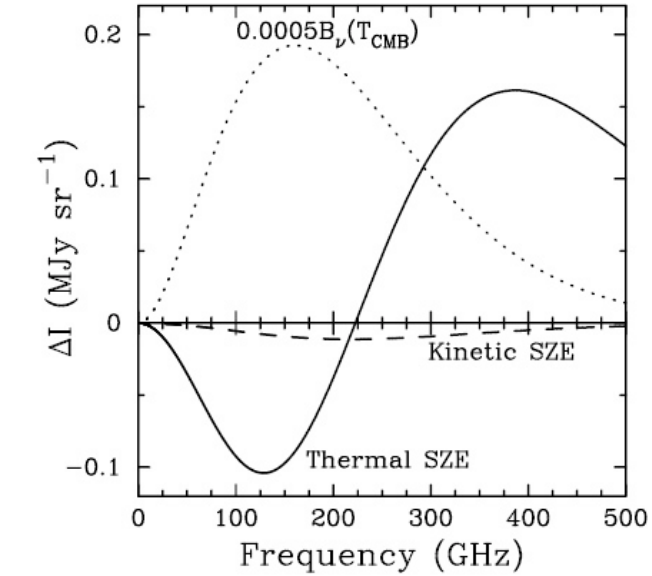
1. Pre-process Planck maps (100-857 GHz) and fill bright point sources
2. Run 3 detections codes (MMF1, MMF3, PwS) and merge to form a union catalogue.
3. Flag IR spurious based on point source (PCCS2) and galactic cold-clumps (C3PO) information
4. Cross-match with ancillary information to associate redshifts

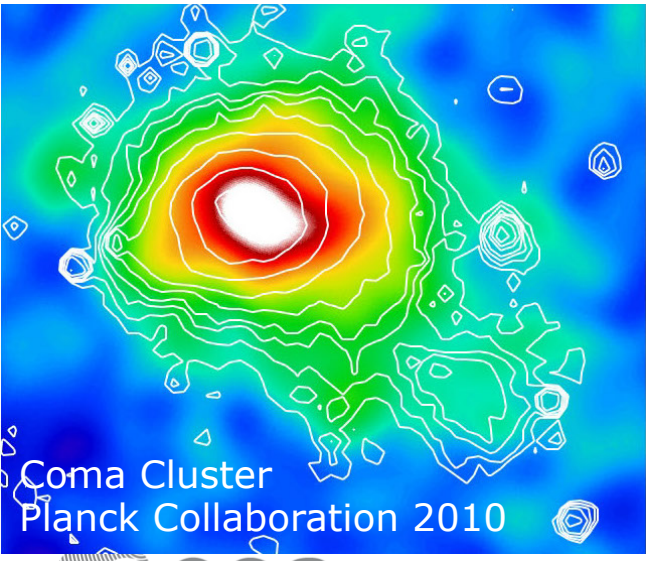
Catalogue products overview

1. **Union catalogue**, merging all reliable detections from the three detection codes on 83.6% of the sky, with relevant observables and derived quantities. Two subsamples:
    - Intersection catalogue: 829 high reliability sources detected by all codes (<2% spurious contamination outside of the galactic plane)
    - Cosmology catalogue (Talk by A. Bonaldi): 492 intersection detections with S/N>6 and 65% galactic and point source mask
2. **Single-code catalogues** with posterior probability contours for each detection and Mass(z)
3. **Survey completeness**

PRELIMINARY

The thermal Sunyaev-Zeldovich effect





- Inverse-Compton scattering of CMB photons by thermal electrons in the hot intracluster medium
- Distorsion in the CMB spectrum, well observed by Planck multi-frequency instruments.
- Relevant quantities:

$$y = \frac{\sigma_T}{m_e c^2} \int P(l)\, dl$$

$$Y = \int_{\Omega} y\, d\Omega$$

- The scaled gas pressure has an approximately universal shape (Arnaud et al 10)

$$P(x) = \frac{P_0}{(c_{500}x)^{\gamma}[1+(c_{500}x)^{\alpha}]^{(\beta-\alpha)/\gamma}}$$

$$x = \frac{r}{R_{500}}$$

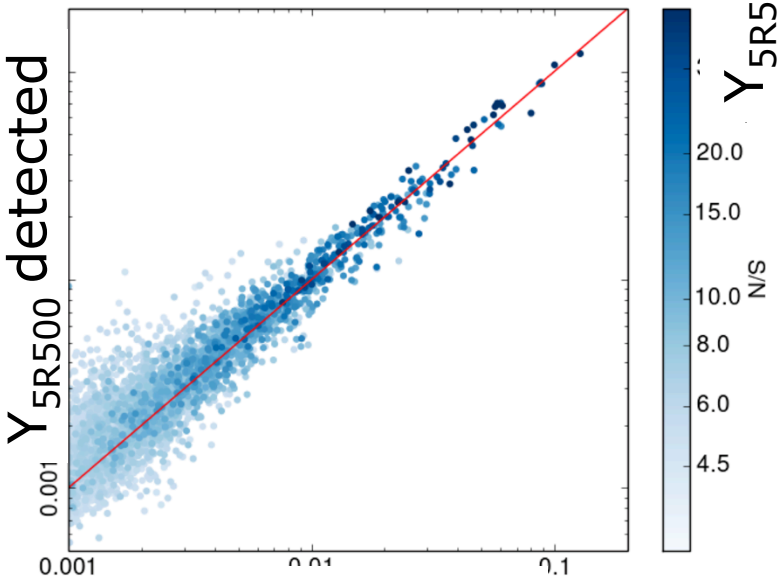
Typical cluster scale

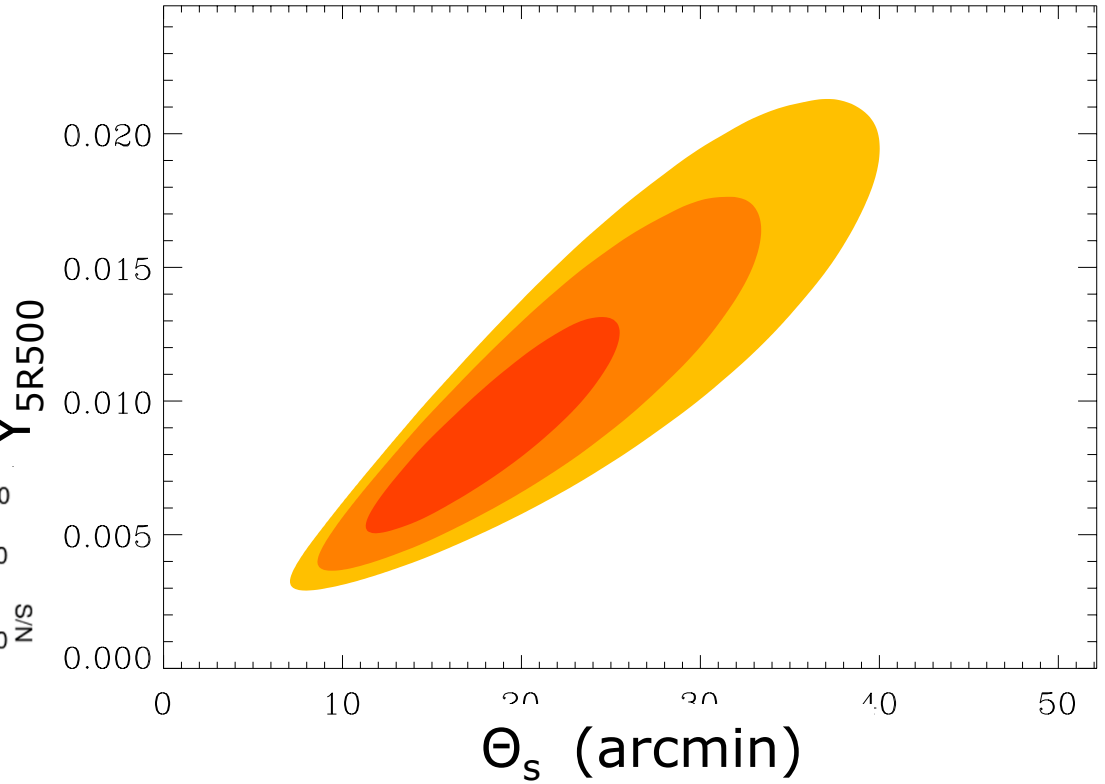
What do we measure?

The integrated Comptonization parameter Y_{SZ} is degenerate with the cluster size. We provide the posterior 2D contours

$$Y_{TOT} \approx Y_{5R500} = \int_{\Omega_{5\theta_{500}}} y d\Omega$$

$$\theta_s = \frac{\theta_{500}}{c_{500}}$$





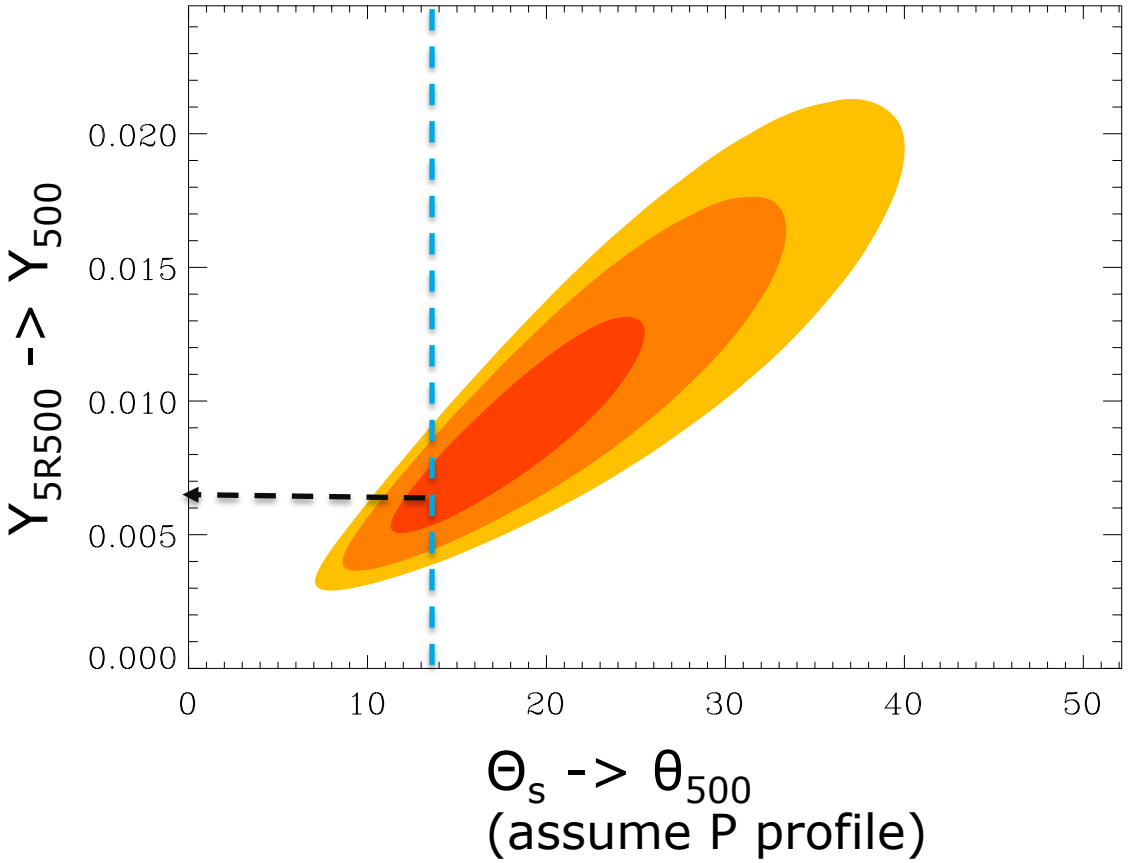
Unbiased measurement of Y_{5R500} tested with simulations

What do we measure?

The integrated Comptonization parameter Y_{SZ} is degenerate with the cluster size. We provide the posterior 2D contours

Need to break the degeneracy to measure unbiased quantities on the R_{500} scale:

- Fixed radius prior (simulations)



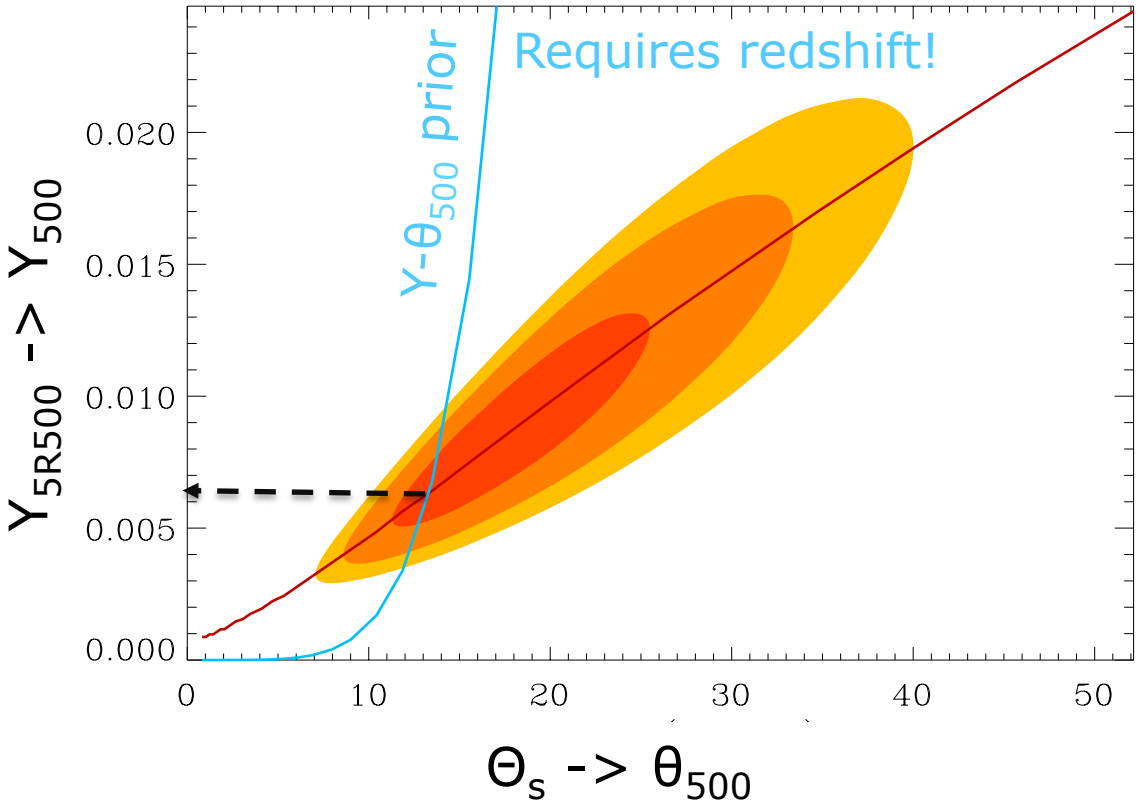
What do we measure?

The integrated Comptonization parameter Y_{SZ} is degenerate with the cluster size. We provide the posterior 2D contours

Need to break the degeneracy to measure unbiased quantities on the R_{500} scale:

- Fixed radius prior (simulations)
- Scaling relation prior:

Combine Y_{500}-M_{500} (calibrated in X-rays) and M_{500}-R_{500}-θ_{500} Used to estimate Y_{500} and M_{500} *(Arnaud et al in prep, Planck 2013 Results XXIX)*



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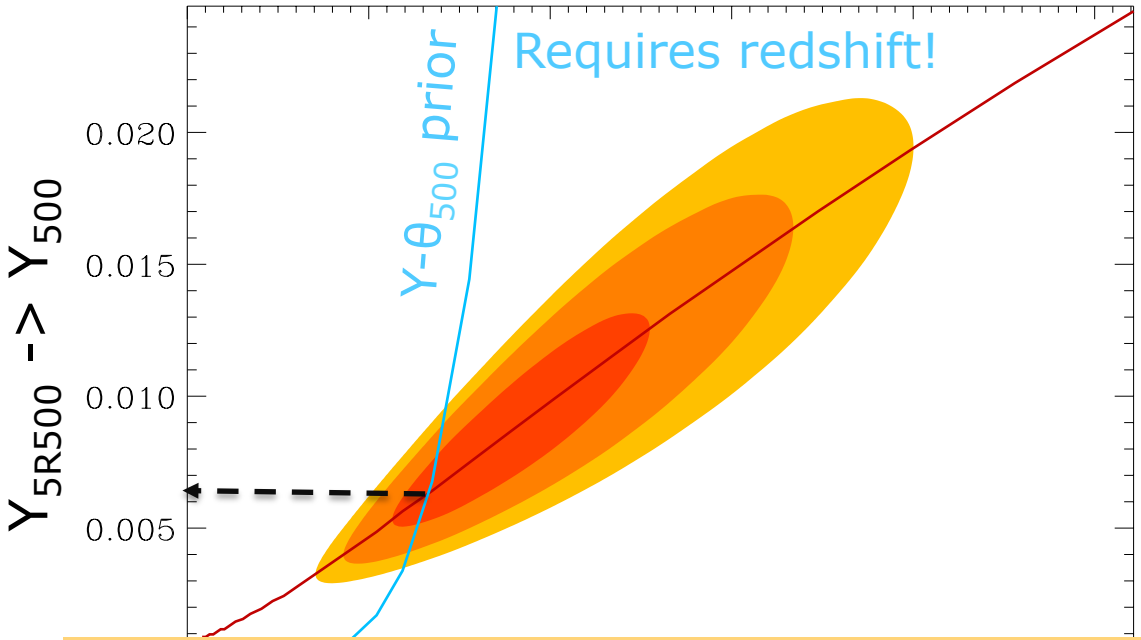


We provide masses and errors for all detections with redshift in PSZ2.
Warning: only statistical errors!

Characterizing the survey

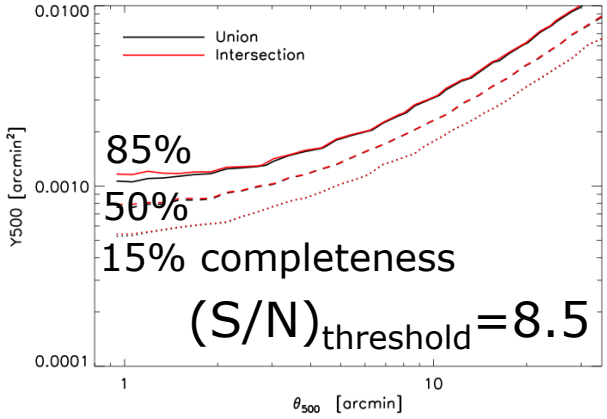
Two key properties to characterize a survey.

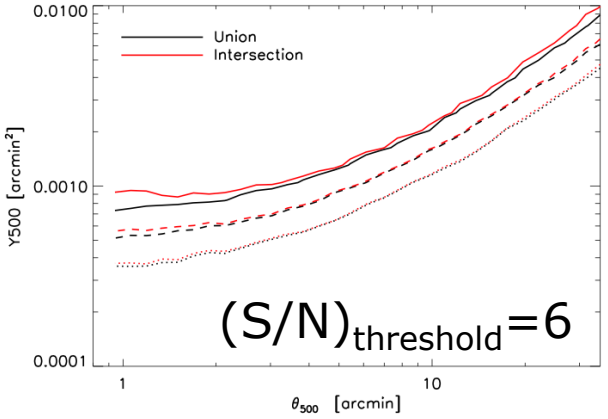
1. **Completeness**: probability that a cluster with a given observable is detected in the survey
   - Estimated through Monte-Carlo simulations and semi-analytic treatment
   - Will be released as a **product** for various masks and detection thresholds

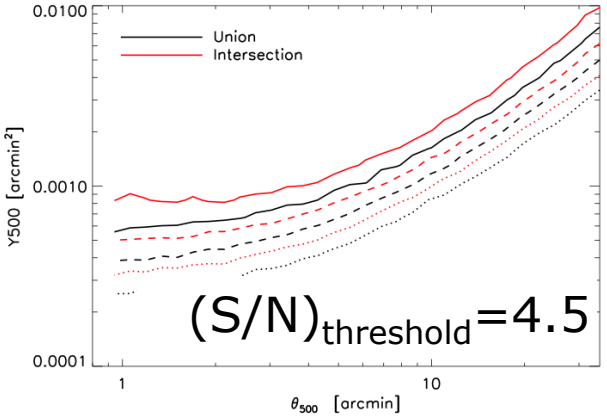
2. **Reliability** (or purity): probability that a detection with given characteristics is a real cluster
   - **83-87%** union catalogue
   - **95%** intersection
   - **Higher** for cluster cosmology mask (65% of the sky)

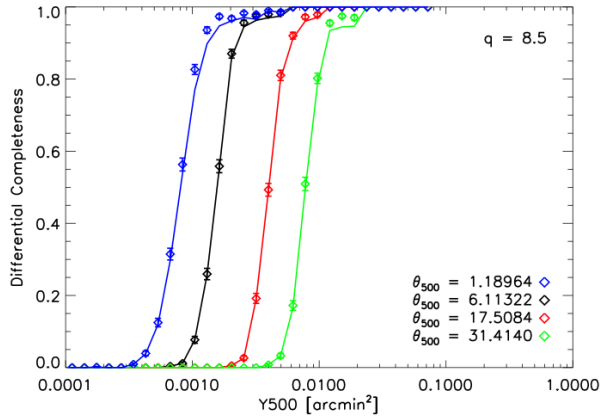
Completeness

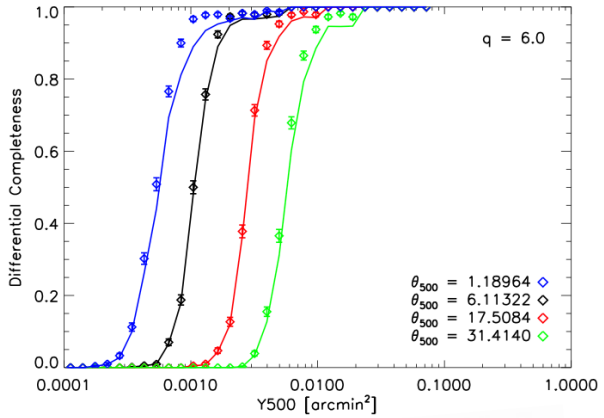
Decreasing S/N threshold

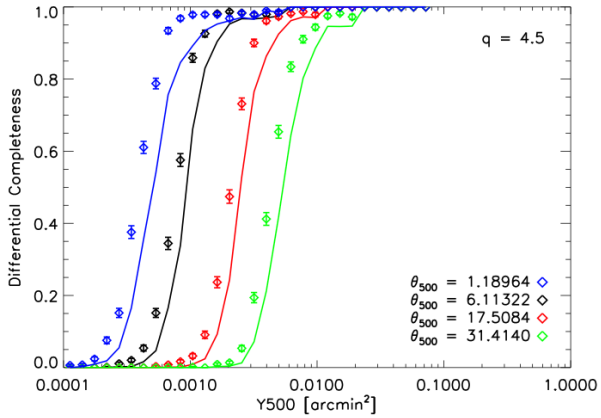












PRELIMINARY

Reliability

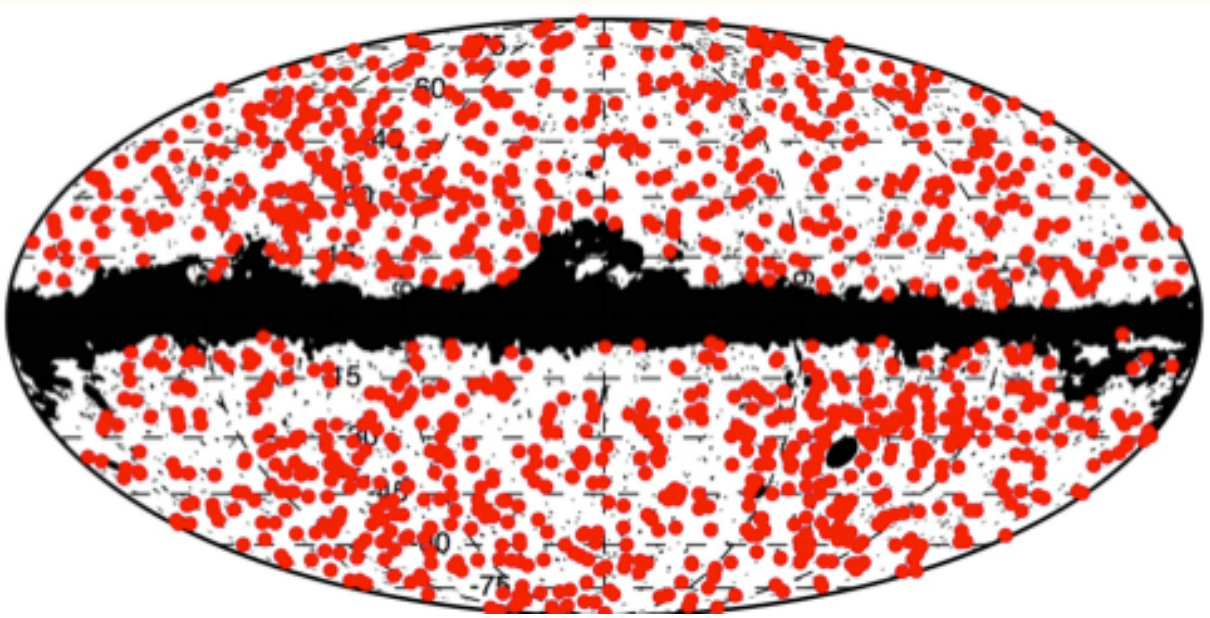
We use two methods:

1. **Simulation**: Injection of cluster signal into simulated maps, run detection pipeline and identify spurious detections
2. **Machine-learning**: Detection-by-detection quality assessment using neural networks trained on PSZ1 nominal mission data (Aghanim et al. 2014)

Counterpart associations and redshifts

Use of ancillary external data-sets at different wavelengths to associate counterparts (and redshifts) to PSZ2 detections.

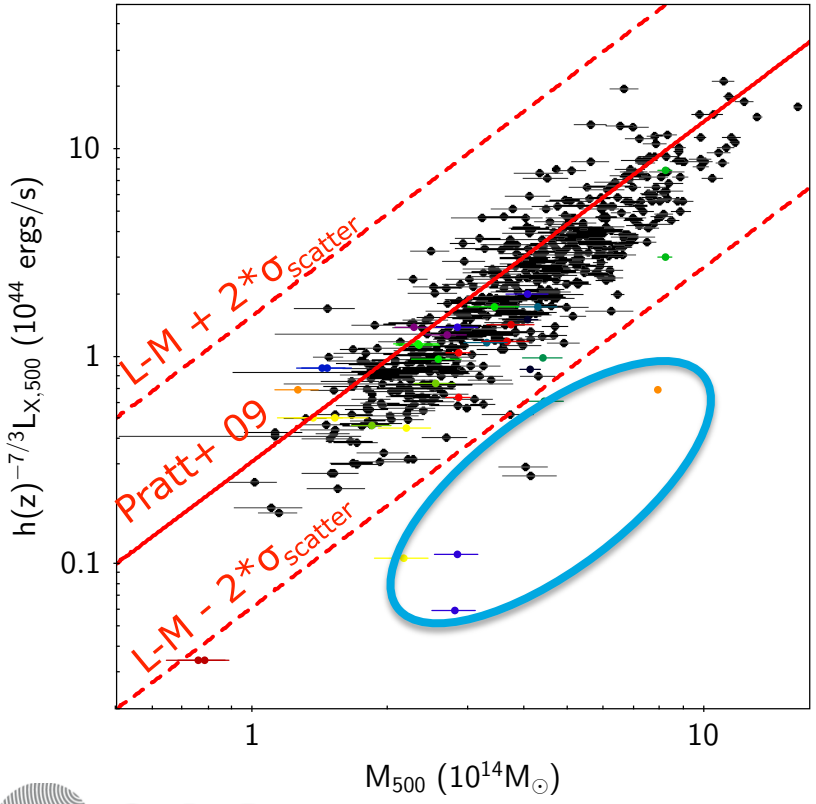
The starting point is the **PSZ1**, validated through external catalogues and multi-λ dedicated follow-up (Planck 2013 Results XXIX, Planck Intermediate Results I, PIP IV, PIP XXVI), eventually updated on a case by case basis

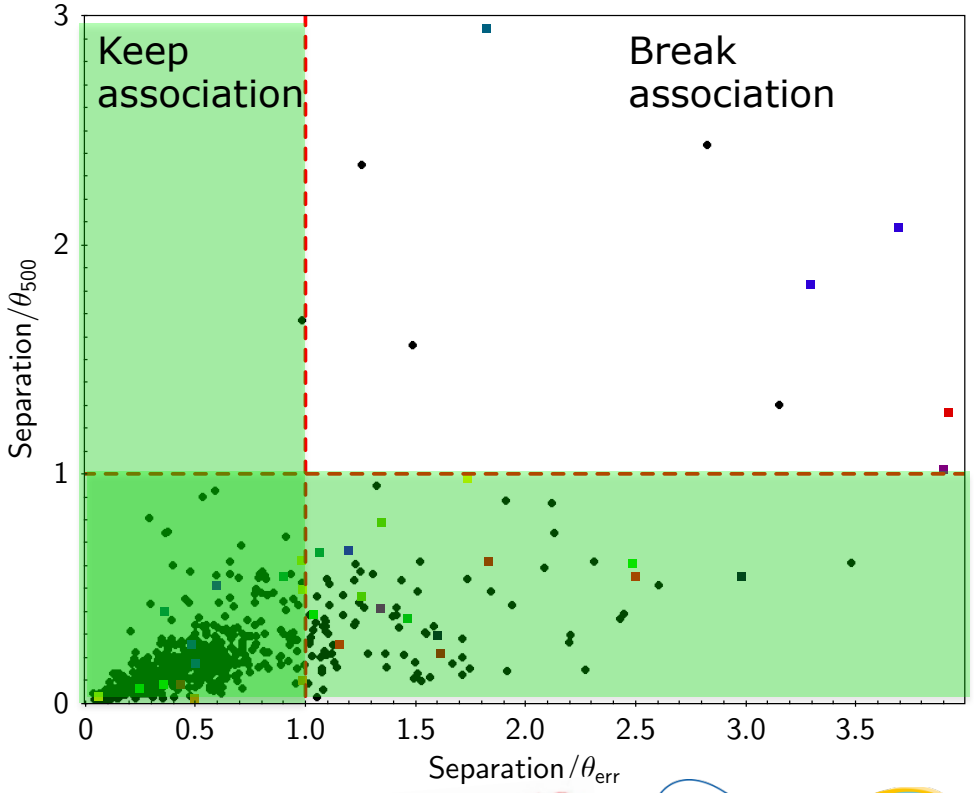


Counterpart associations and redshifts

Associations with **X-ray clusters** (MCXC, Piffaretti et al 2011): **550 matches, 122** not in PSZ1 **(preliminary)**

1. Positional matching between Planck and X-ray positions (10 arcmin)
2. Check of counterpart selection with L-M scaling (Pratt et al 2009) relation and two positional constraints



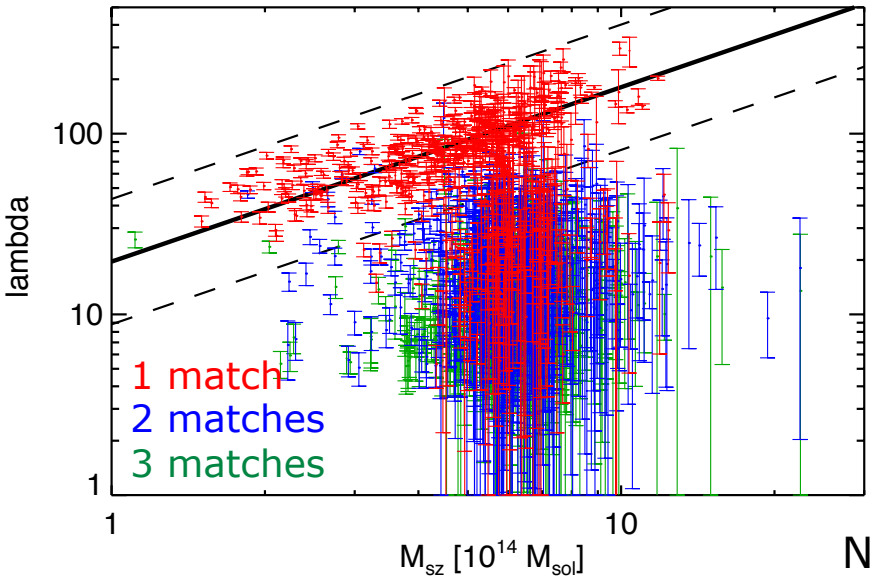


PRELIMINARY

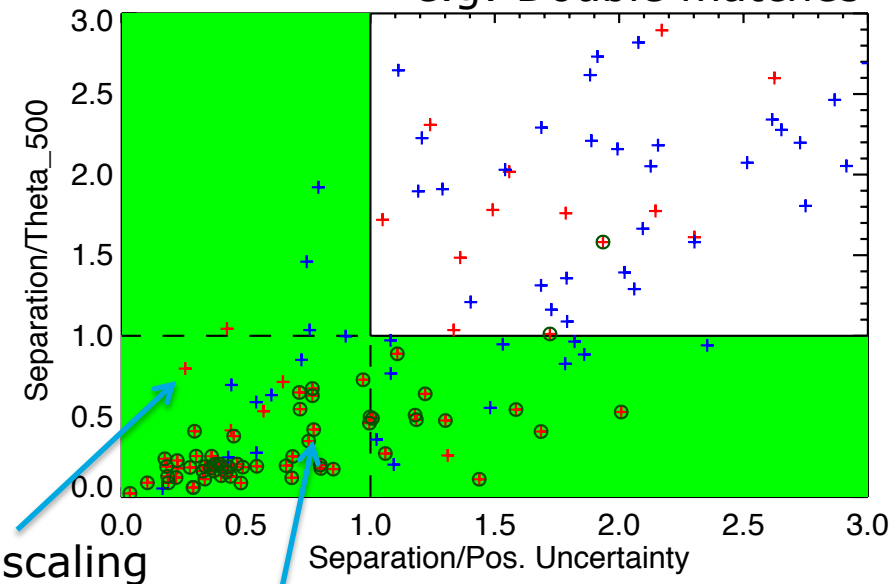
Counterpart associations and redshifts

Associations with **optical clusters** (redMAPPer, Rykoff et al 2014): **375 matches (preliminary)**

1. Positional matching within 10 arcmin: up to 3 matches
2. Check with scaling relation (Rozo et al 2014) and two angular cuts



e.g: Double matches



No: scaling violated

Yes: all 3 satisfied

Only 8 cases with >1 possible counterpart; take richest object, but could be projection.

PRELIMINARY

Counterpart associations and redshifts

- Cross-match with SZ selected ACT (Hasselfield et al 2013) and SPT (Bleem et al 2014) catalogues: 28 and 94 good matches with redshift
- Evaluation on a case by case basis for detections with counterparts in different catalogues

1062 detections with associated counterpart and redshift

38 confirmed clusters without redshift

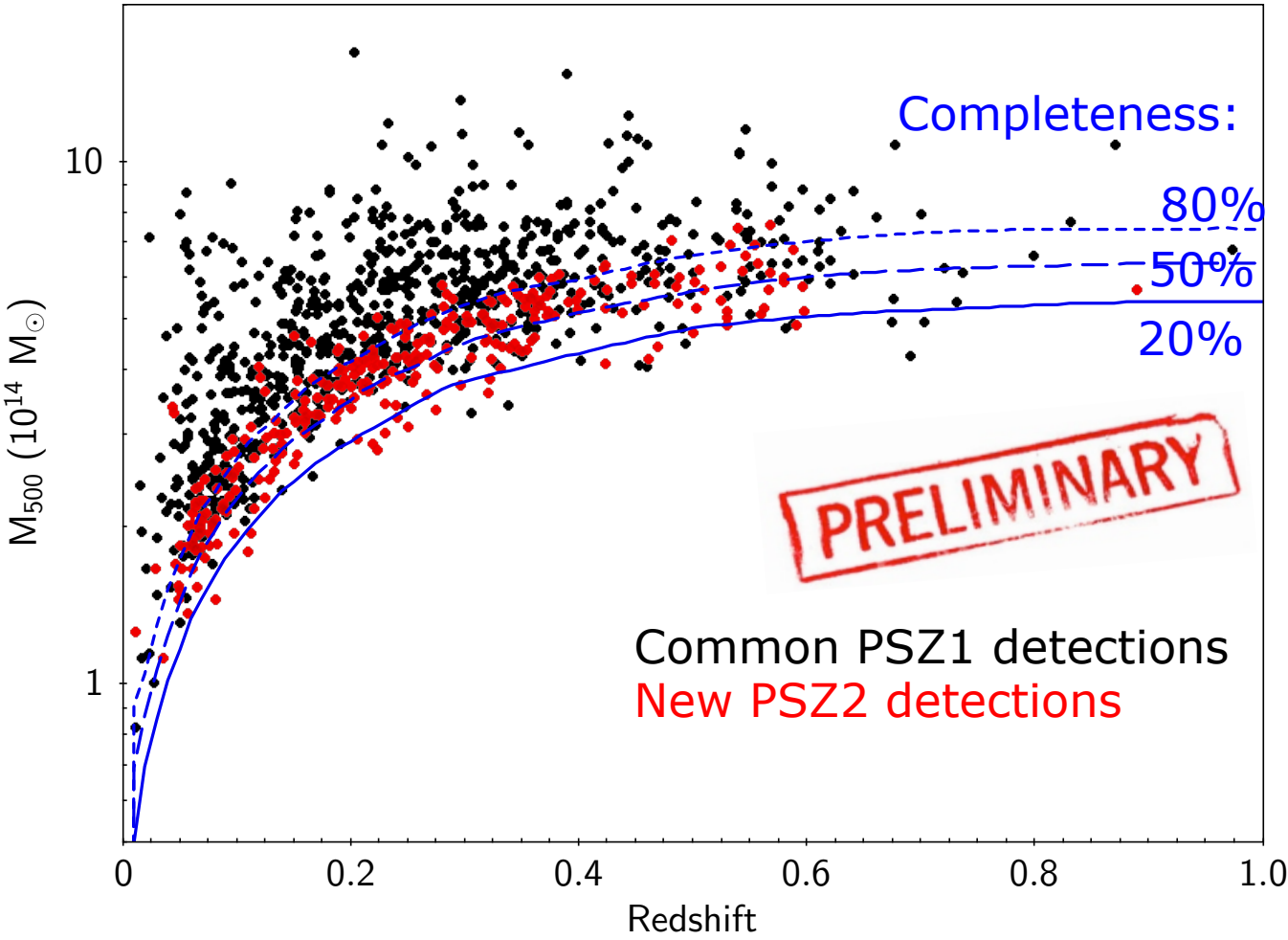
(AMI follow-up)

PRELIMINARY

Sample properties

Mass-redshift distribution of Planck detections with z

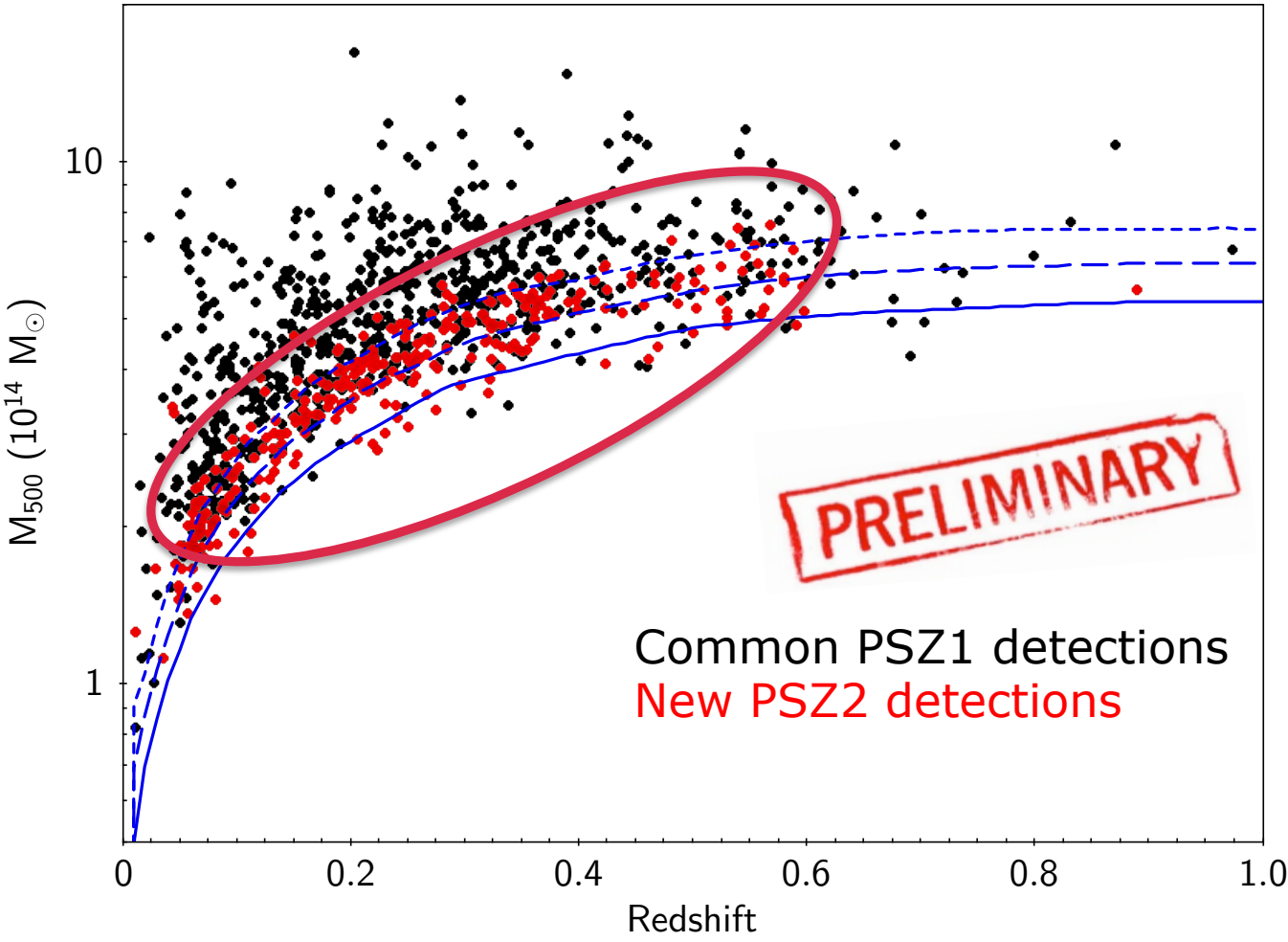
Warning:
Not fully representative of the Planck SZ selection, convolved with non uniform redshift knowledge



Sample properties

Mass-redshift distribution of Planck detections with z

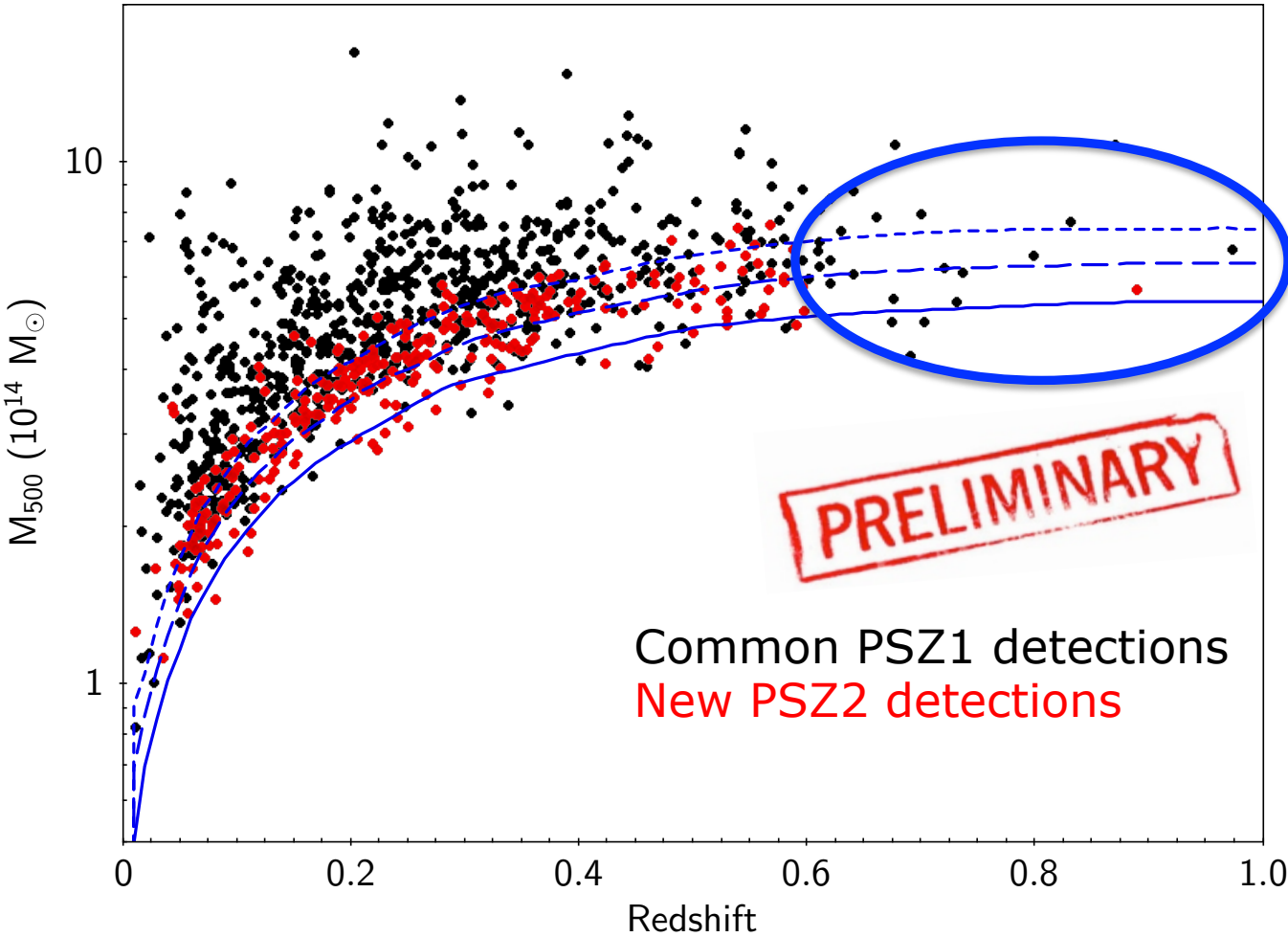
New PSZ2 detections are pushing the catalogue towards lower masses.



Sample properties

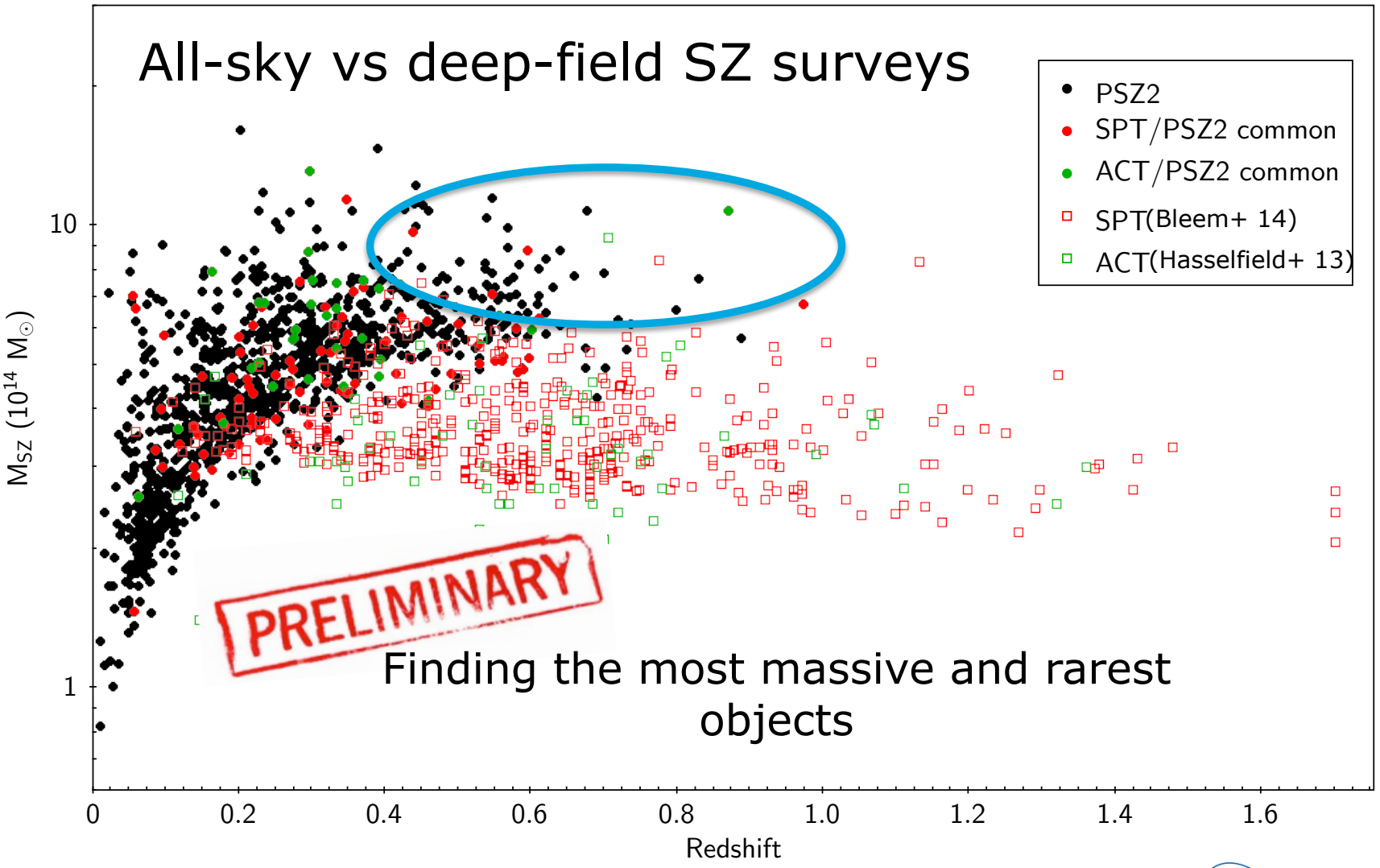
Mass-redshift distribution of Planck detections with z

Most high-z objects are PSZ1 detections: 19/26 confirmed through intensive follow-up campaigns of Planck detections *(Planck 2013 Results XXIX, Planck Intermediate Paper XXV).*

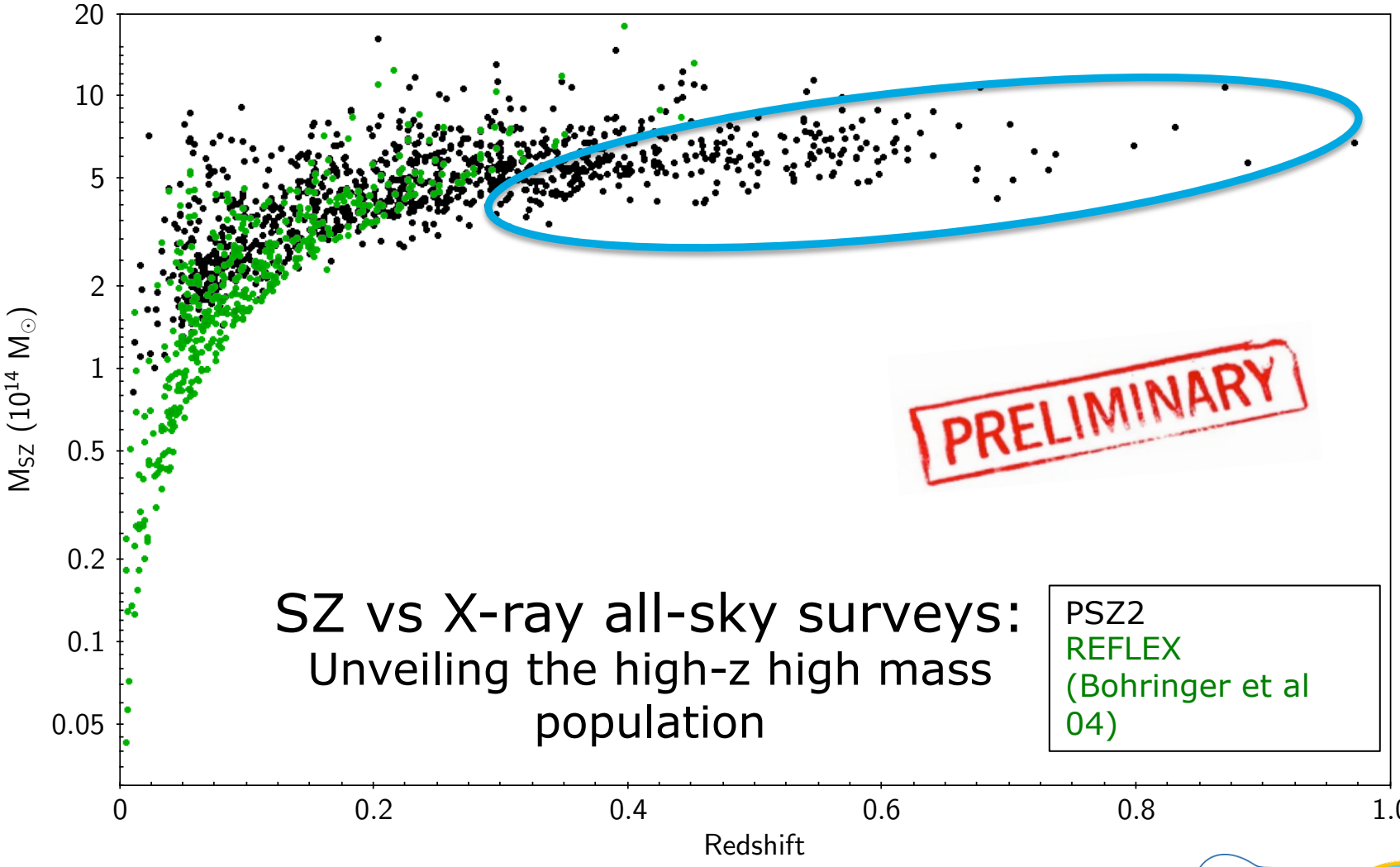


We expect the PSZ2 to contain about 160 clusters at z>0.6

Sample properties



Sample properties



Summary

- Planck Legacy catalogue of SZ sources from full-mission data
- It is the largest SZ-selected sample of galaxy clusters and the deepest all sky survey (in terms of mass)
- Based on parameter estimates well validated with simulations
- Multi-wavelength and robust counterpart search through ancillary datasets, leading to >1000 redshifts
- Detailed analysis of the survey selection function in terms of completeness (provided as a product) and reliability
- Lower mass limit than PSZ1 and X-ray all-sky surveys

The scientific results that we present today are a product of the Planck Collaboration, including individuals from more than 100 scientific institutes in Europe, the USA and Canada.

Planck is a project of the European Space Agency, with instruments provided by two scientific Consortia funded by ESA member states (in particular the lead countries: France and Italy) with contributions from NASA (USA), and telescope reflectors provided in a collaboration between ESA and a scientific Consortium led and funded by Denmark.