CLUSTERS OF GALAXIES IN THE PLANCK SURVEY

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IRAP

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on behalf of the Planck Collaboration

THE PLANCK MISSION

THE PLANCK MISSION AND THE SUNYAEV-ZEL'DOVICH EFFECT IN THE PLANCK SURVEY

ETIENNE POINTECOUTEAU, XMM WORKSHOP, MADRID, MAY 2012

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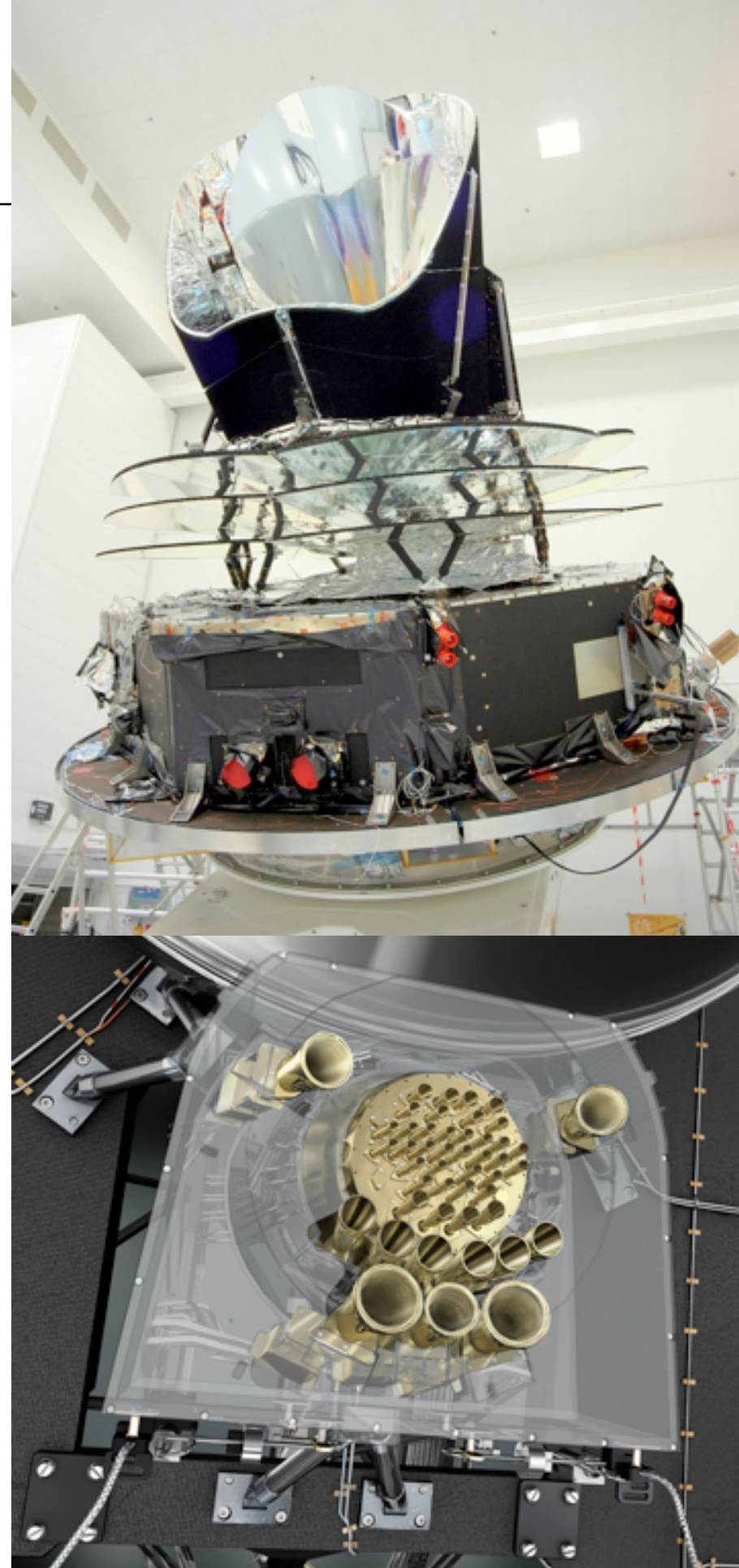
THE PLANCK MISSION

- Launch in May 2009
- 2 instruments: LFI + HFI
- 9 frequency bands 30-857GHz
- ~5-30 arcmin resolution

→ **Performed better than goals!**

- first survey (7 months)
  early Planck results (01/2011)
- nominal mission = 2 full sky surveys
  intermediate Planck results (ongoing)
  cosmology & legacy results (beginning of 2013)
- extended mission ~ 5 surveys
  further results, polarisation, etc (beyond 2014)

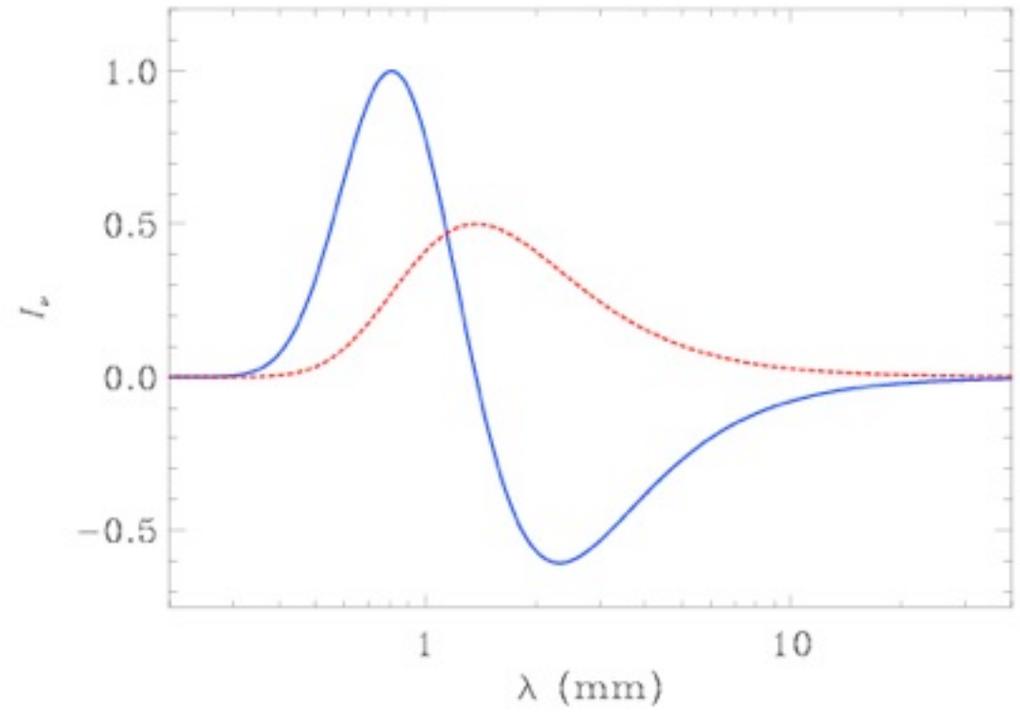


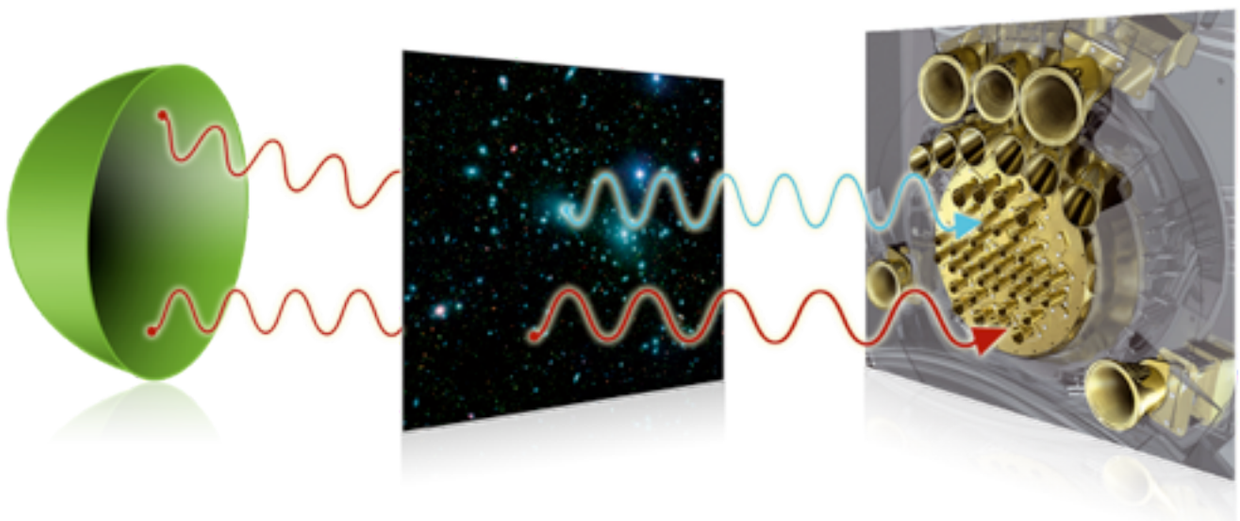
THE SUNYAEV-ZEL'DOVICH EFFECT

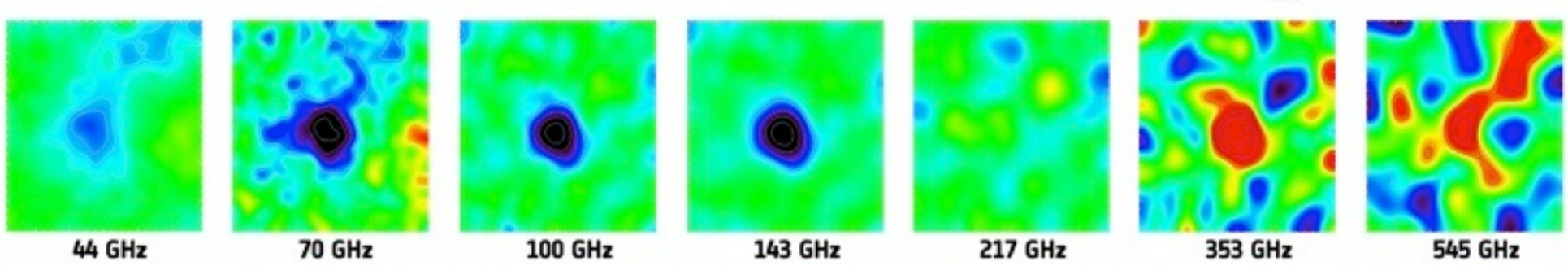
Inverse Compton scattering

$$y = \frac{\sigma_T}{m_e c^2} \int_l (P_{th} = k_B n_e T) dl$$

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



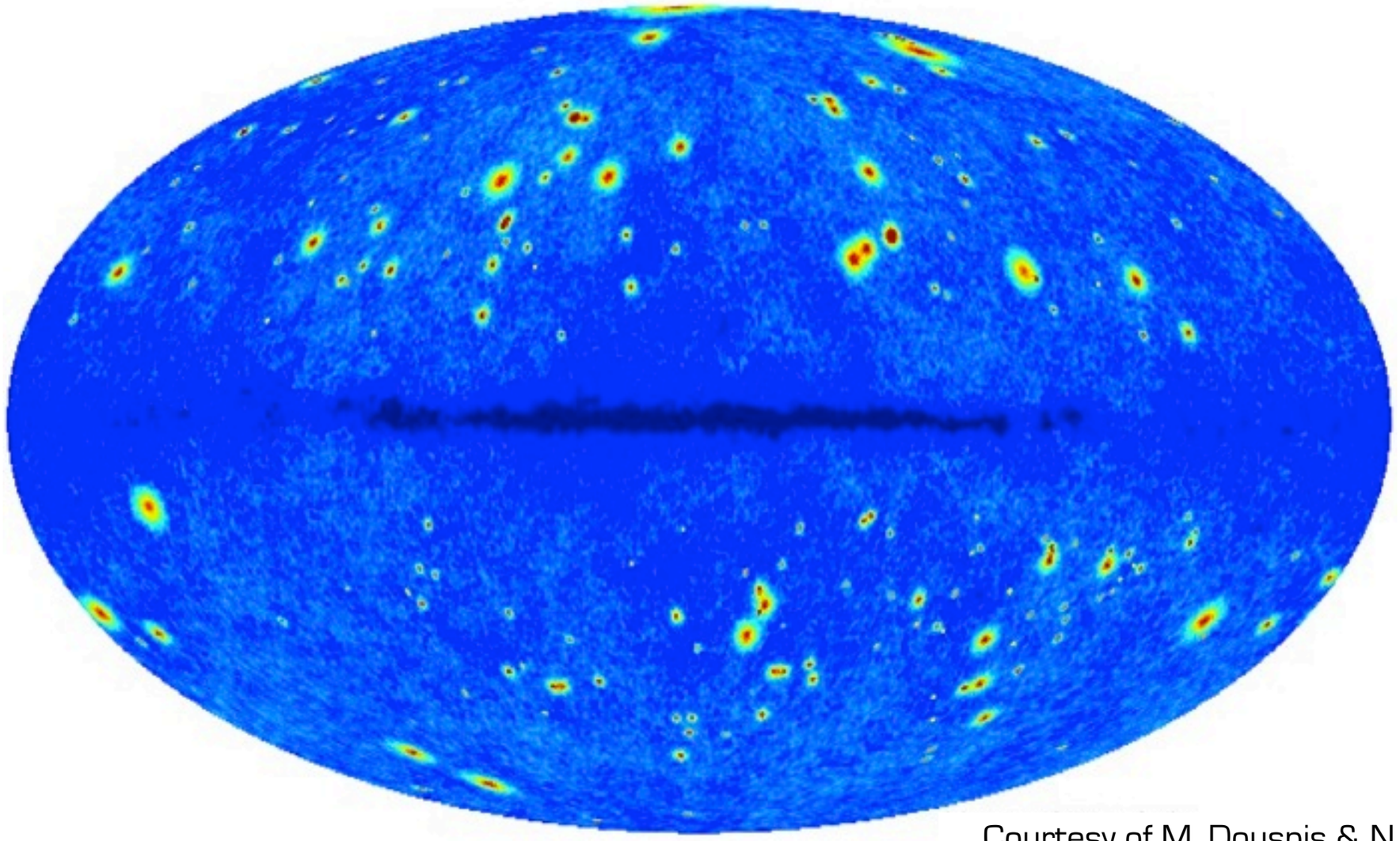




THE PLANCK EARLY SZ SKY

189 SZ sources with S/N > 6

- first SZ measure for ~80% of the known clusters
- 20 new clusters
- 8 unconfirmed ESZ candidates
- now 7 confirmed by third party (SPT, AMI)

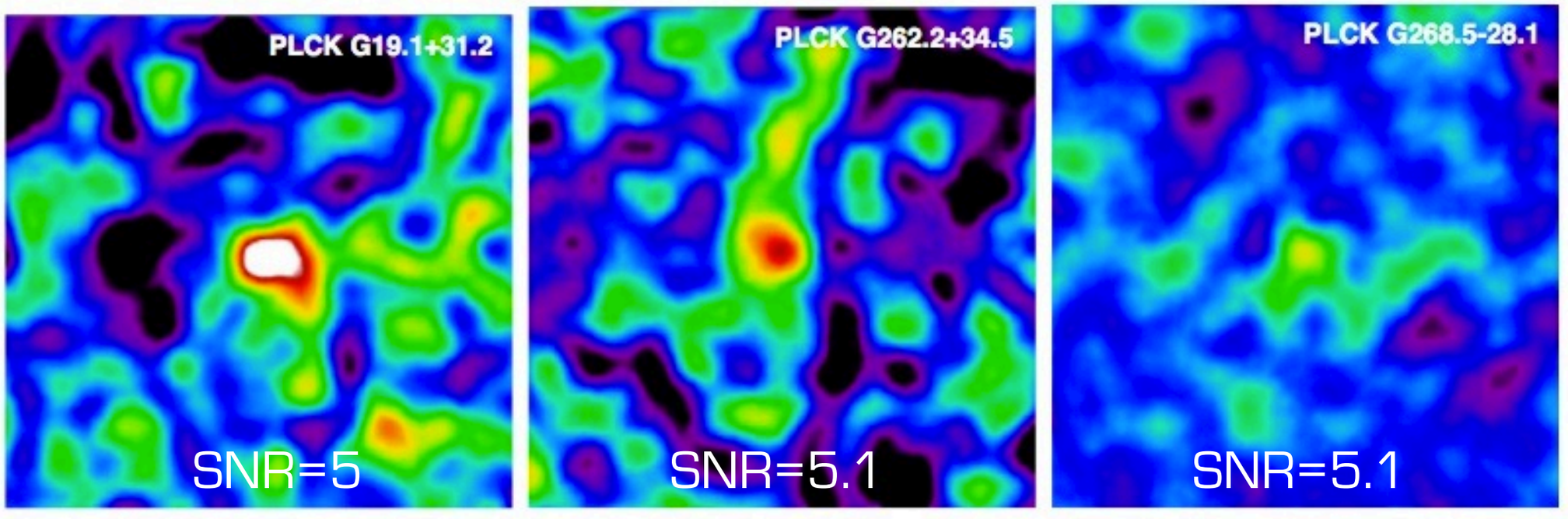


Courtesy of M. Douspis & N. Aghanim

DETECTION OF CLUSTERS IN PLANCK

Detection of SZ clusters in the Planck Survey

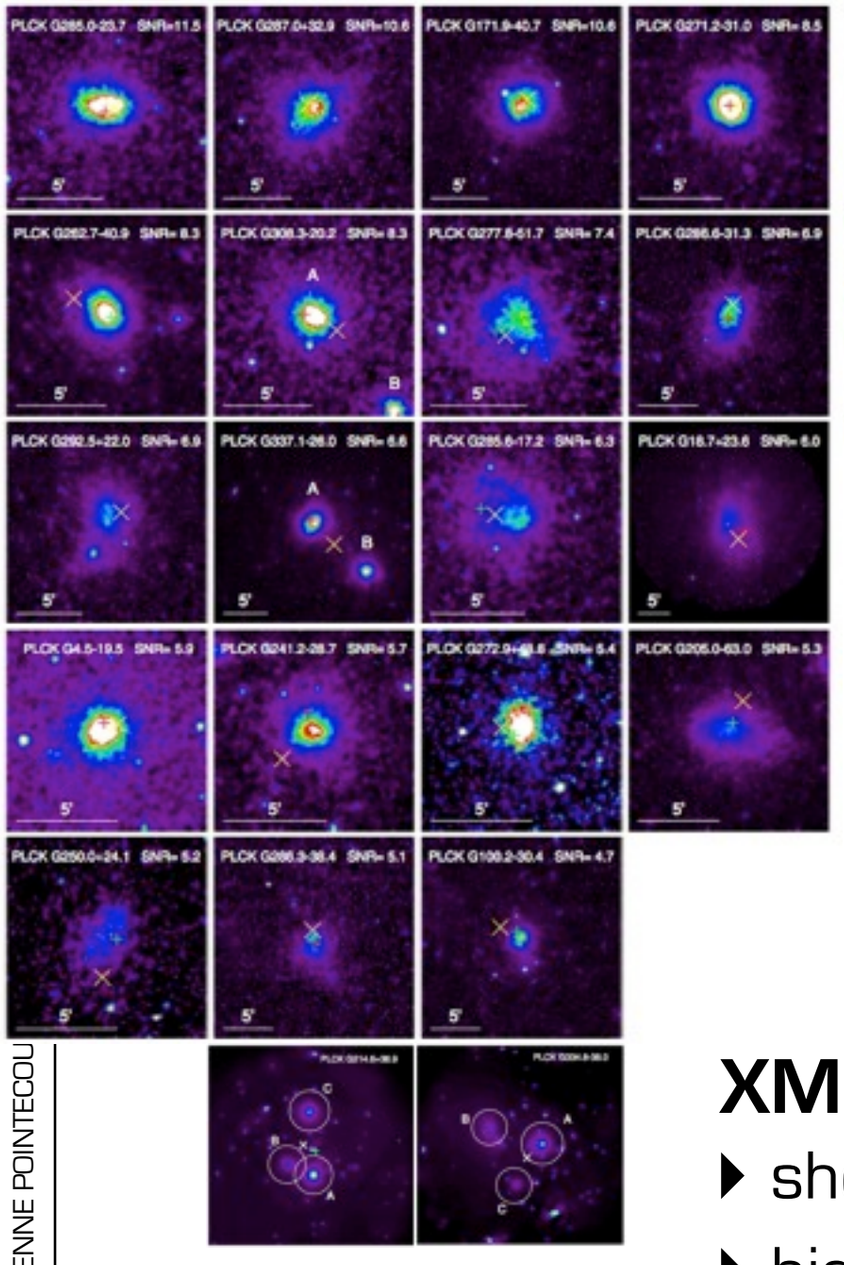
- multi-matched filter (Herantz+02, Melin+06), Powel-Snake (Carvalho+09+11)
- internal validation of SZ the detection, ancillary data and catalogues, logs of observatories,...

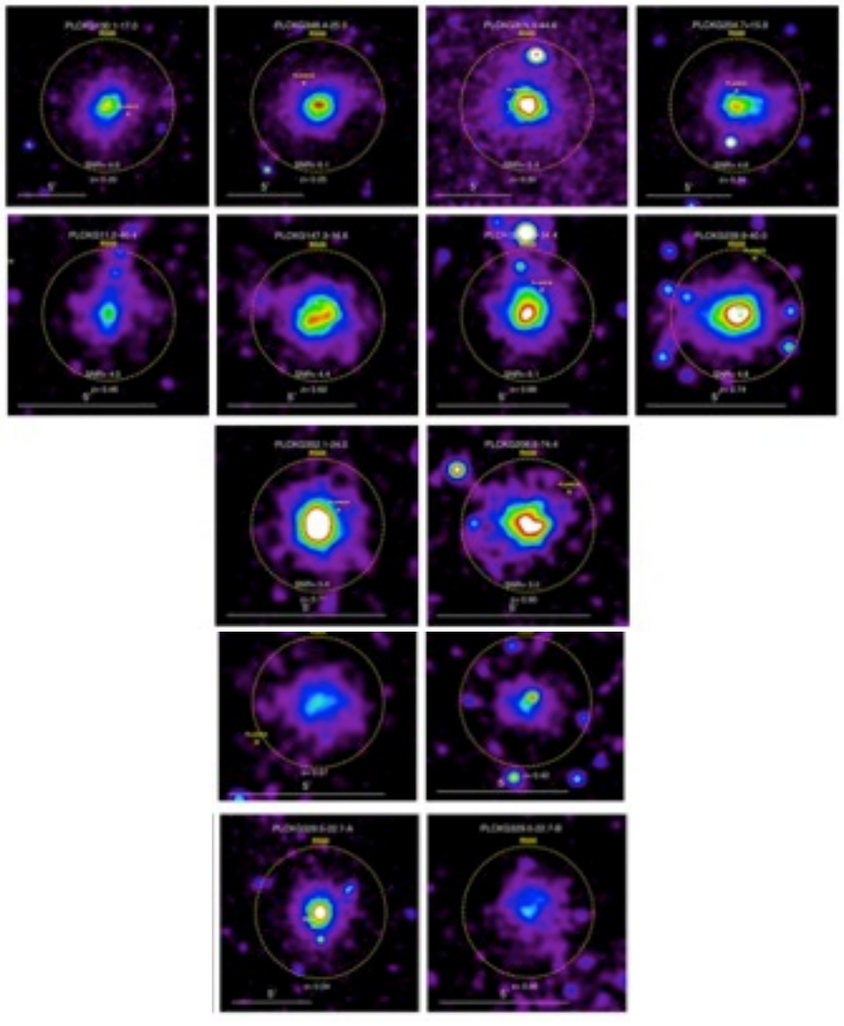


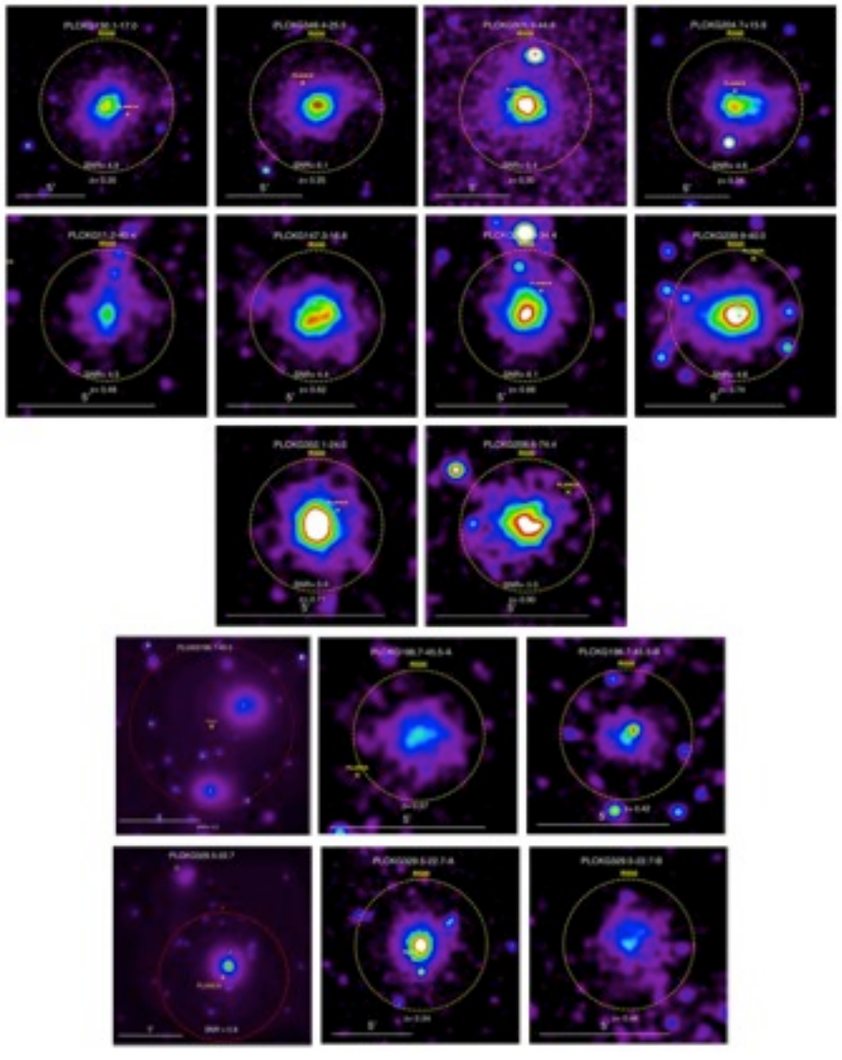
Follow-ups

- X-rays (XMM-Newton), SZ (AMI), optical (ENO/INT-WHT-TNG, ESO/MPG-NTT, RTT, NOT, NOAO,...)
- Confirmation, redshift estimation, global physical parameters

XMM VALIDATION PROGRAMME







XMM-Newton DDT program

- short snapshot exposures (10ksec)
- high success rate (>85%)
- 43 Planck SZ candidates confrmed
- 51 new clusters confirmed with XMM-Newton
- ~ 14% of multiple systems

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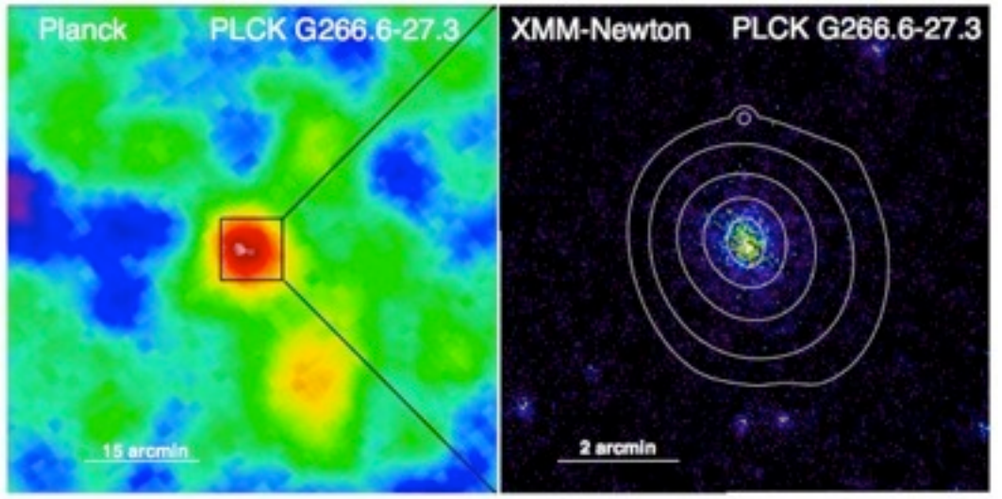
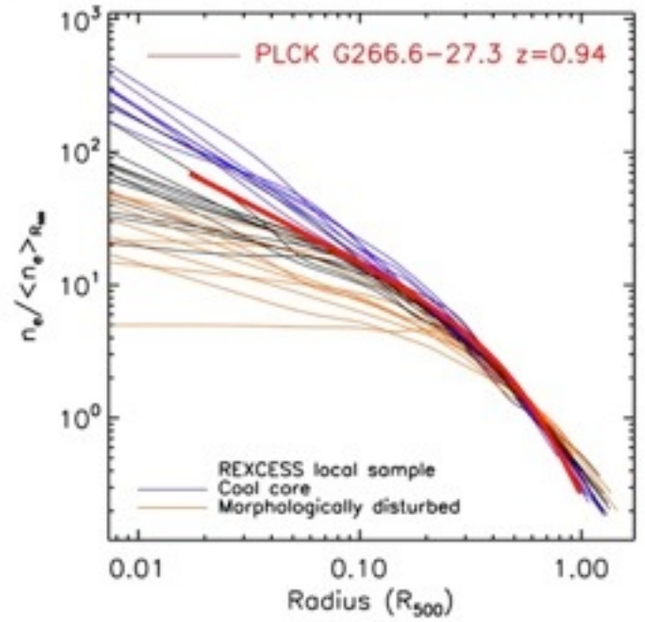
DISTANT CLUSTERS



PLCK G266.6-27.3

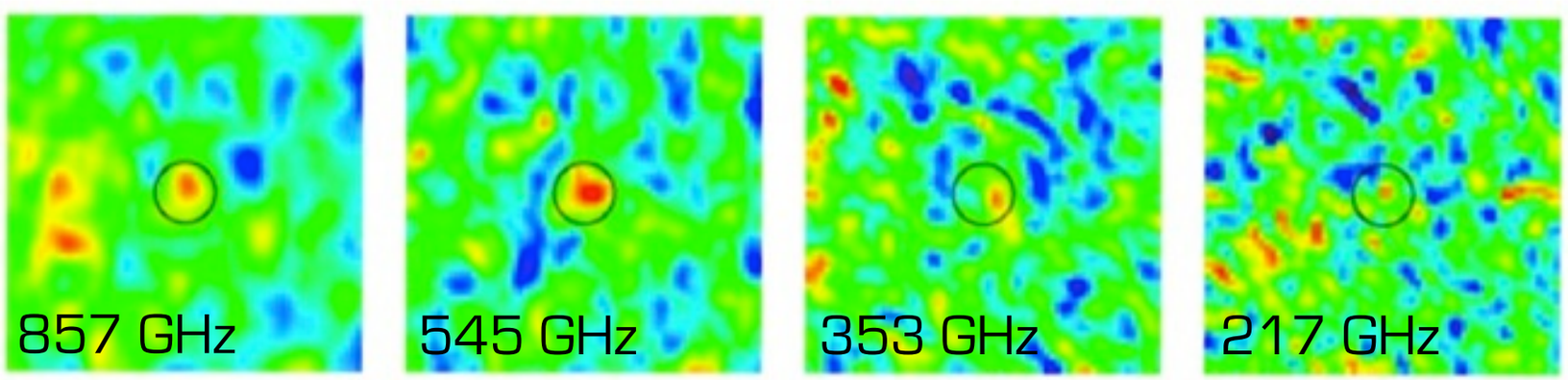
- SNR_{PLCK} = 5
- z_{FeK}=0.94
- L_X[0.5-2keV]=(1.4±0.5)×10^{45} erg/s
- M_{500}=(7.8±0.8)×10^{14} $M_\odot$
- highly relaxed
- independently detected by SPT (Williamson+11)

(Chandra C13 programme, PI: P. Mazzotta)



Distant (proto)clusters are seen in the Planck survey

- via their galaxies emission (submm)

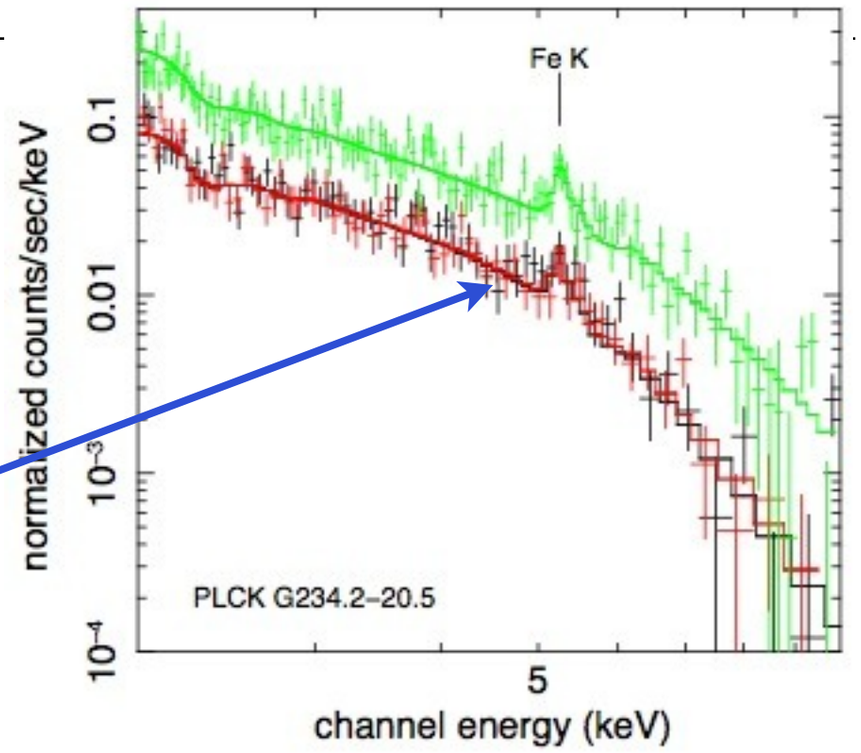


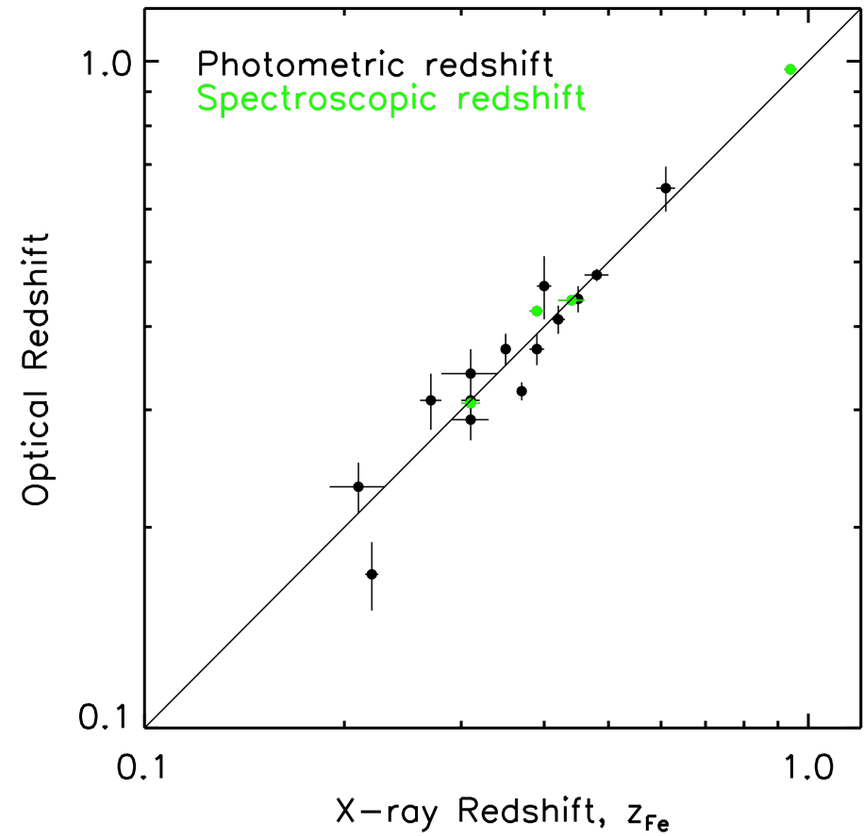
(see talk by
I. Flores-Cacho)

Redshift estimates

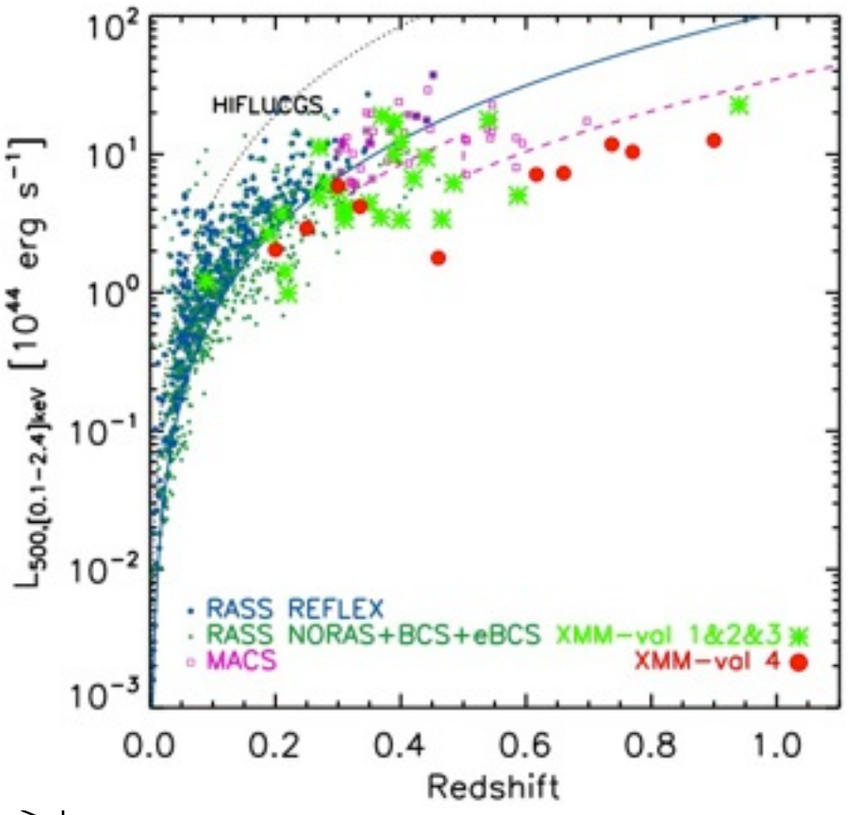
Name	z_{Fe}	z_{opt}	Ref.
PLCK G100.2−30.4	0.31 ± 0.03	0.34 ± 0.03	1 (p)
PLCK G171.9−40.7	0.27 ± 0.01	0.31 ± 0.03	1 (p)
PLCK G193.3−46.1	0.59 ± 0.02	0.65 ± 0.05	2 (p)
PLCK G205.0−63.0	0.31 ± 0.01	0.31 ± 0.02	3 (p)
PLCK G210.6+17.1	0.48 ± 0.02	0.478 ± 0.01	2 (p)
PLCK G214.6+37.0	0.45 ± 0.02	0.44 ± 0.02	3 (p)
PLCK G241.2−28.7	0.42 ± 0.01	0.41 ± 0.02	3 (p)
PLCK G262.2+34.5	0.21 ± 0.02	0.23 ± 0.02	3 (p)
PLCK G262.7−40.9	0.39 ± 0.01	0.422	4 (s)
PLCK G266.6−27.3	0.94 ± 0.02	0.972	5 (s)
PLCK G271.2−31.0	0.37 ± 0.005	0.32 ± 0.01	5 (p)
PLCK G272.9+48.8	0.40 ± 0.01	0.46 ± 0.05	3 (p)
PLCK G277.8−51.7	0.44 ± 0.02	0.438	5 (s)
PLCK G285.0−23.7	0.39 ± 0.005	0.37 ± 0.00	6 (p)
PLCK G285.6−17.2	0.35 ± 0.01	0.37 ± 0.02	3 (p)
PLCK G286.3−38.4	0.31 ± 0.01	0.307 ± 0.003	6 (s)
PLCK G286.6−31.3	0.22 ± 0.005	0.17 ± 0.02	3 (p)
PLCK G287.0+32.9	0.39 ± 0.01	0.37 ± 0.02	3 (p)
PLCK G292.5+22.0	0.31 ± 0.02	0.29 ± 0.02	3 (p)
PLCK G334.8−38.0	0.35 ± 0.03	0.37 ± 0.02	3 (p)

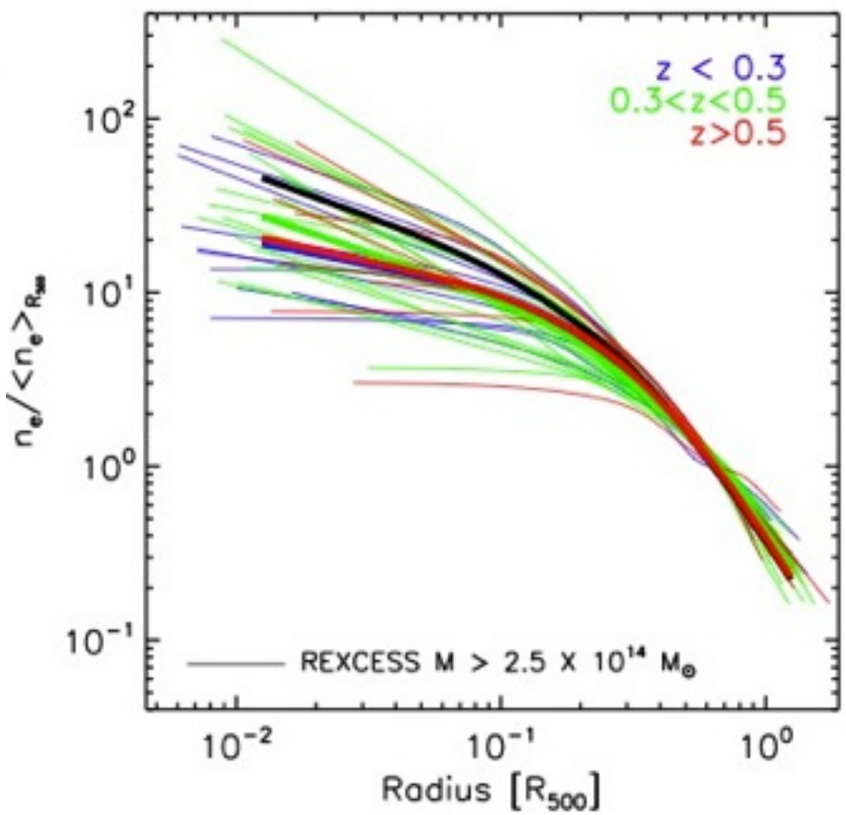
References: (1) Present work from ENO/IAC80 observations; (2) SDSS-DR7 data base http://www.sdss.org/dr7/; (3) Present work from ESO/MPG2.2m observations; (4) Hughes et al. (2011) ACT J0438−5419 (5) Williamson et al. (2011); SPT-CLJ0615-5746, SPT-CLJ0549-6204, SPT-CLJ0254-5856, respectively. (6) Planck Collaboration et al. (2011c)

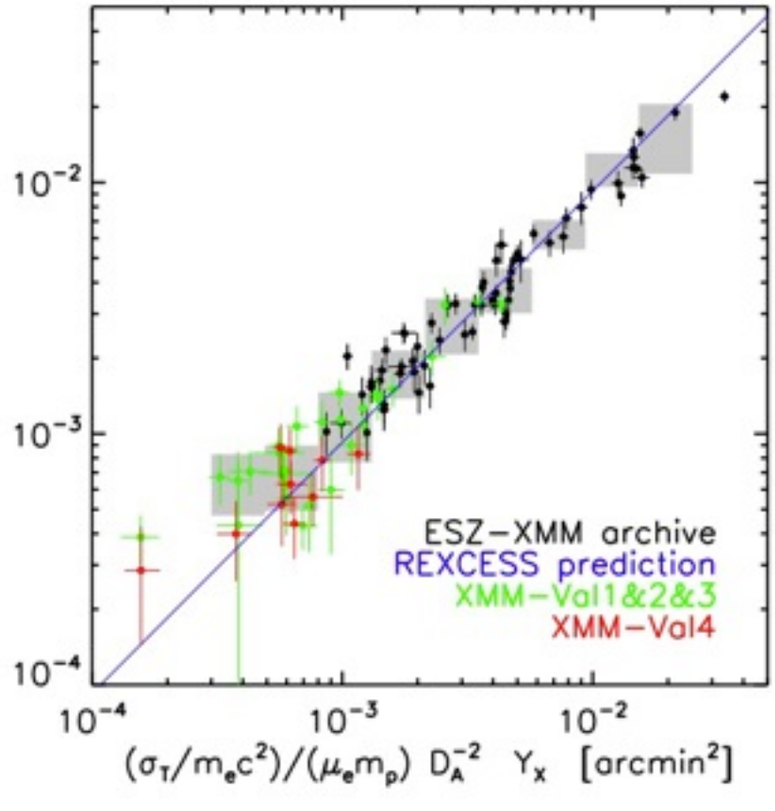




PHYSICAL CHARACTERISATION

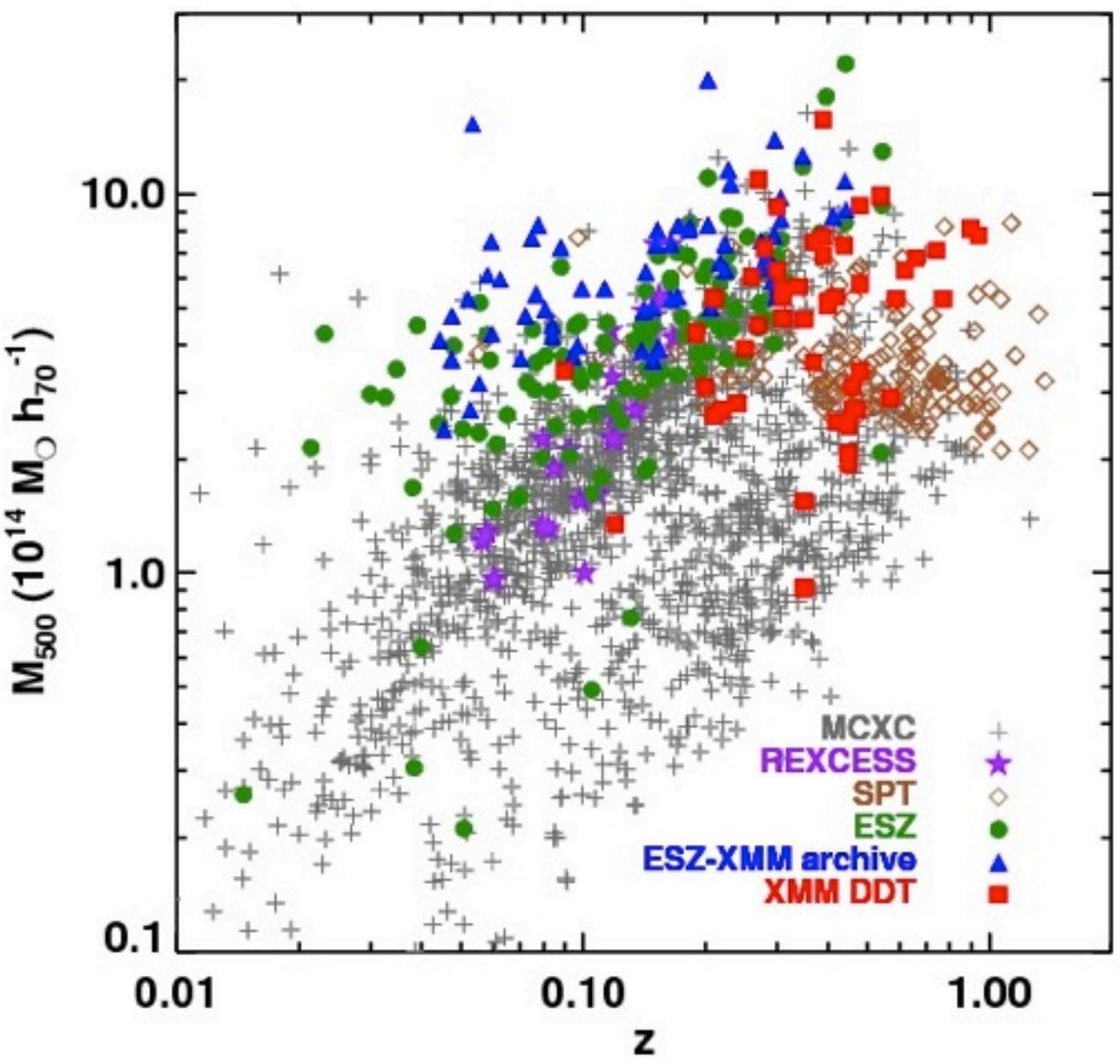






- large variety of dynamical state with new clusters more disturbed and under-luminous (see B. Maughan's talk on WL selected clusters)
- confirm at lower Y and/or higher z massive clusters
- good agreement between Y_X and Y_{SZ} ; constant Y_{SZ}/Y_X with z
- self similar behaviour across the redshift range

WHERE WE STAND



- 0.09 < z < 0.97
- $2.9\times10^{-4} < Y_{SZ} < 3\times10^{-3}$ arcmin^2
- $2.5\times10^{14} < Y_{SZ} < 1.6\times10^{15}$ $M_\odot$

→ a successful synergy between Planck and XMM

SCALING RELATIONS AND CLUSTER MASSES

SZ SCALING RELATIONS

The precise calibration of the relation between SZ effect signal and other physical quantities, especially mass (Y-M) is crucial

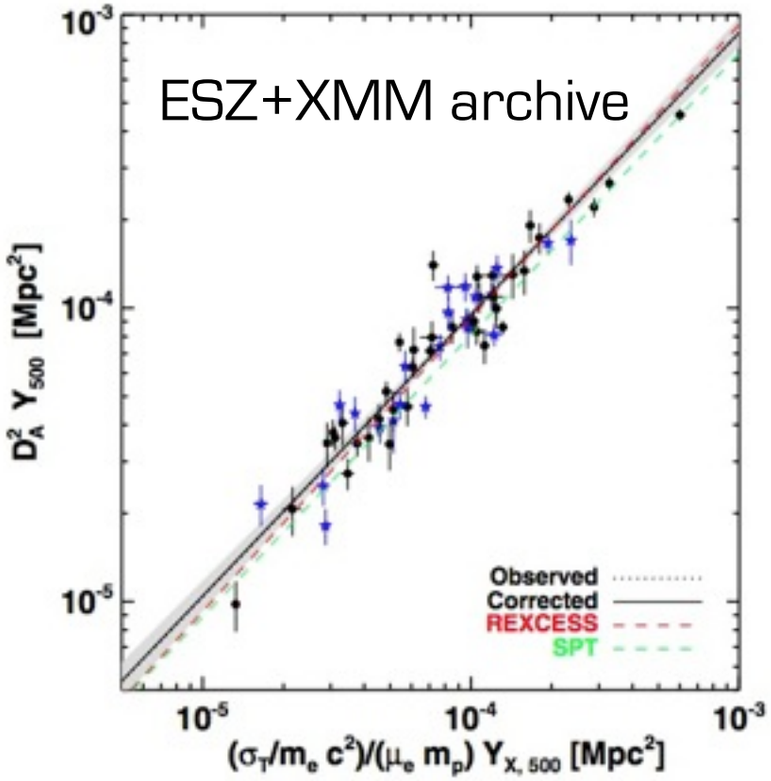
Cosmology

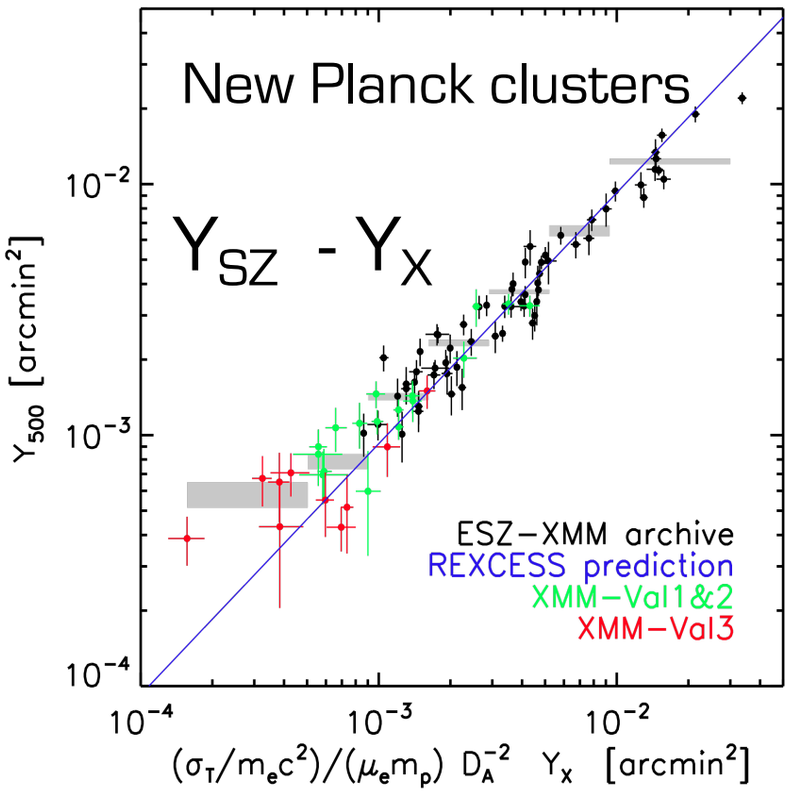
- Relationship between SZ signal and mass is (Y-M) needed for any precision cosmological test using a SZ cluster sample alone
- Needed to test virtually any model outside of ΛCDM with clusters

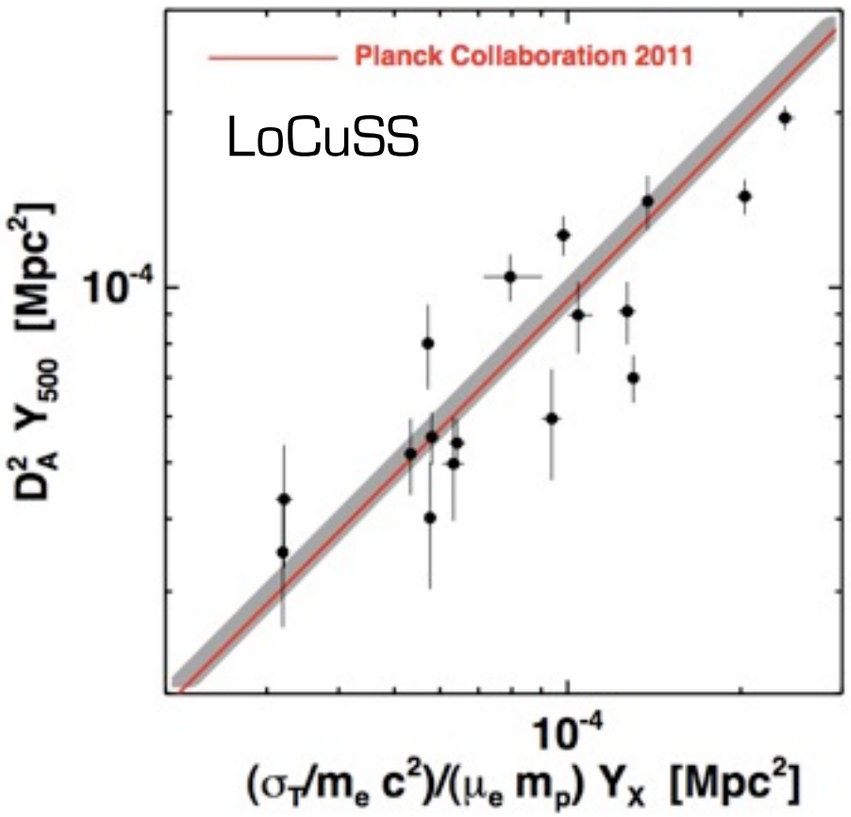
Astrophysics

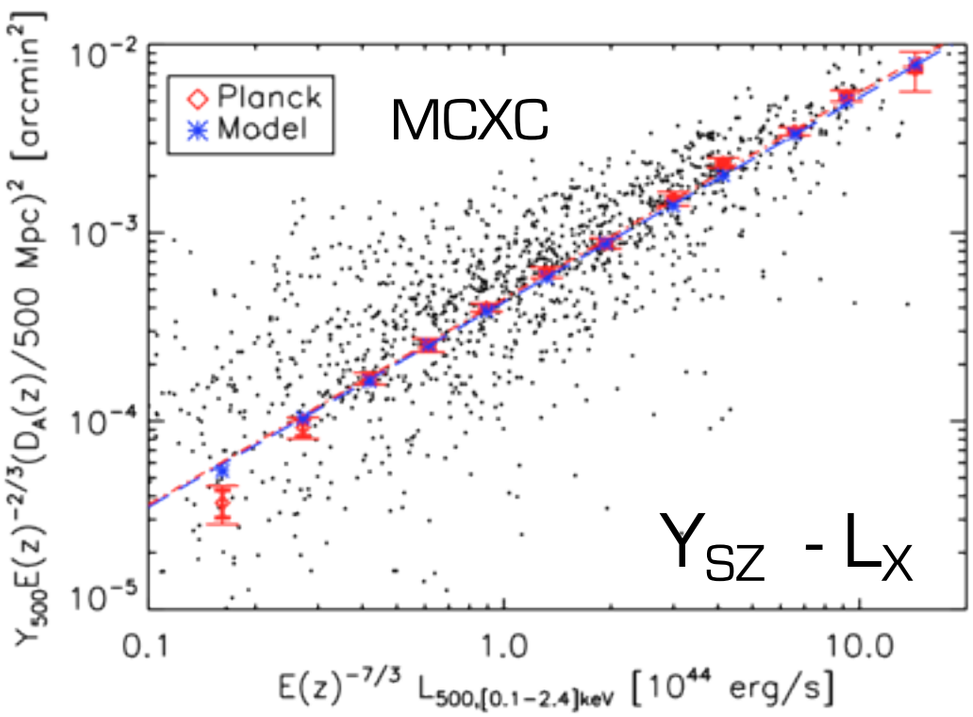
- Relationship between SZ signal and mass, luminosity, entropy, etc can be used as test of structure formation

SZ - X SCALING RELATIONS







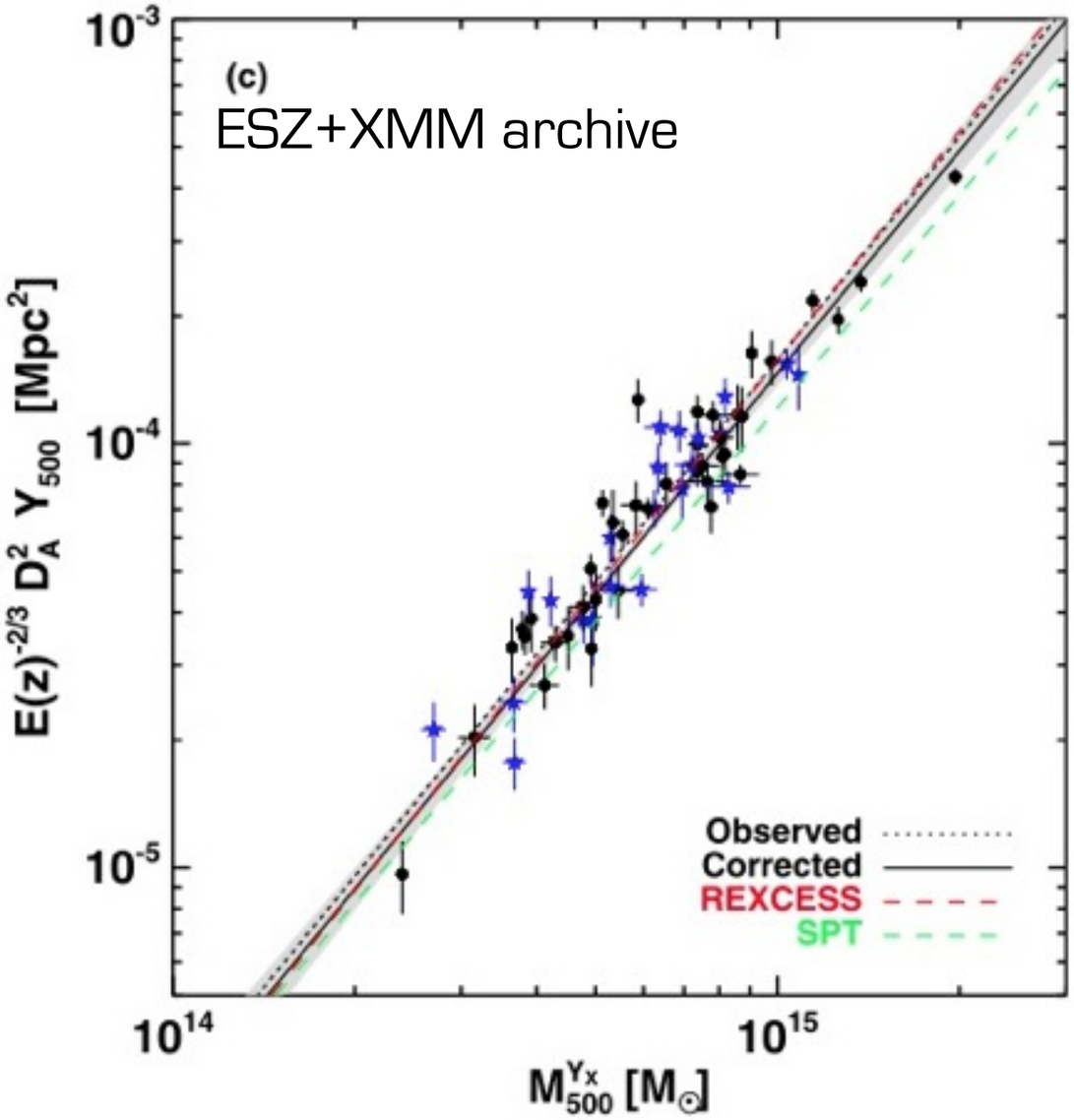


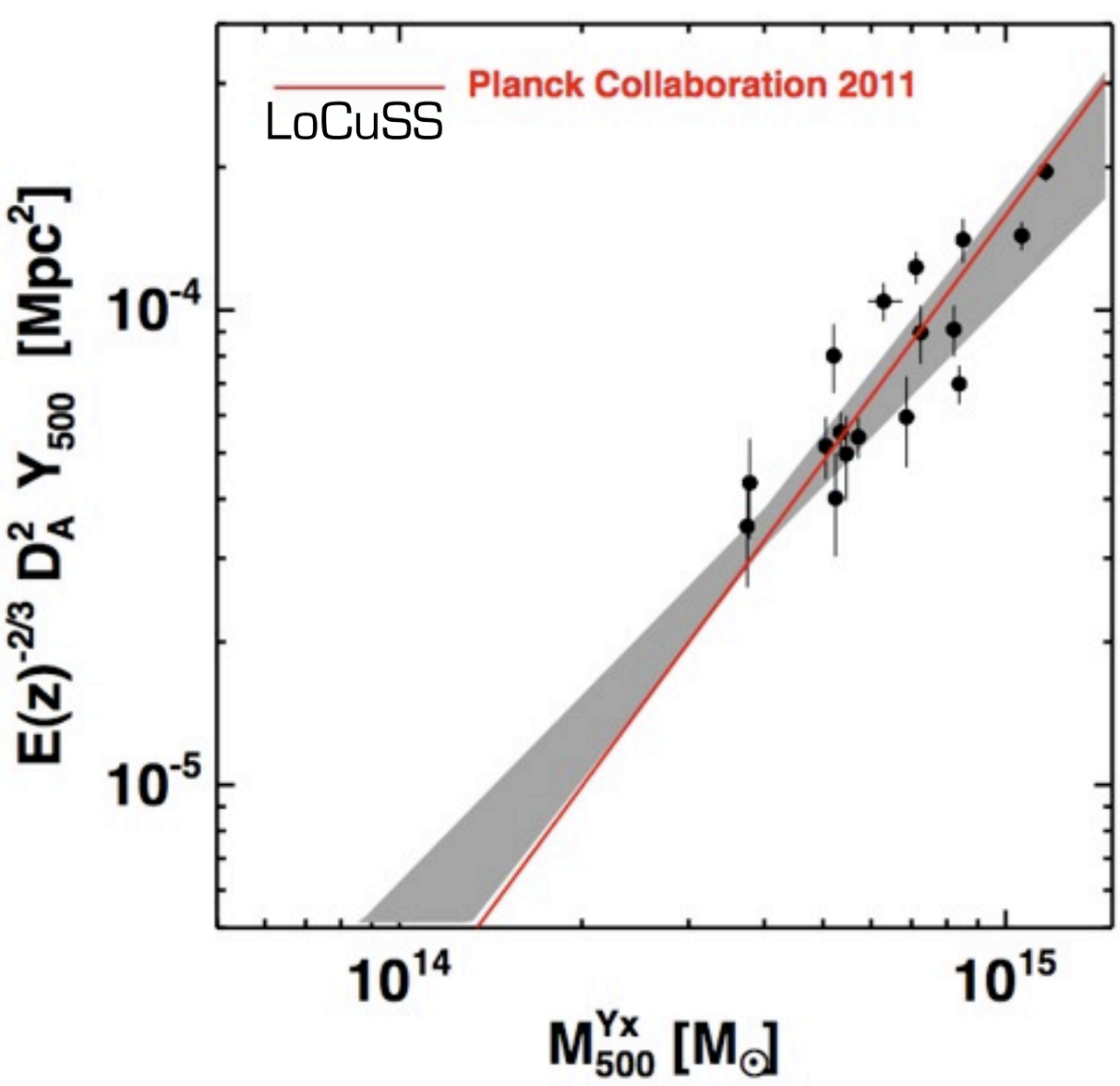
SZ and X-ray data are consistent

(at least within R_{500})

SZ mass proxy: YSZ - M

- SZ fluxes and HE X-ray masses agree

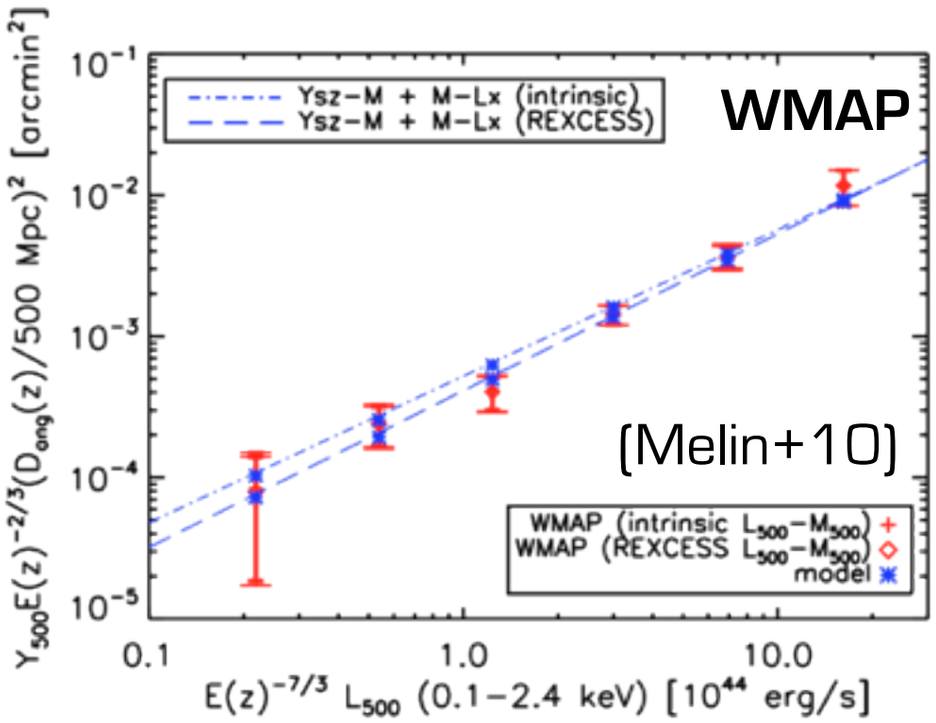


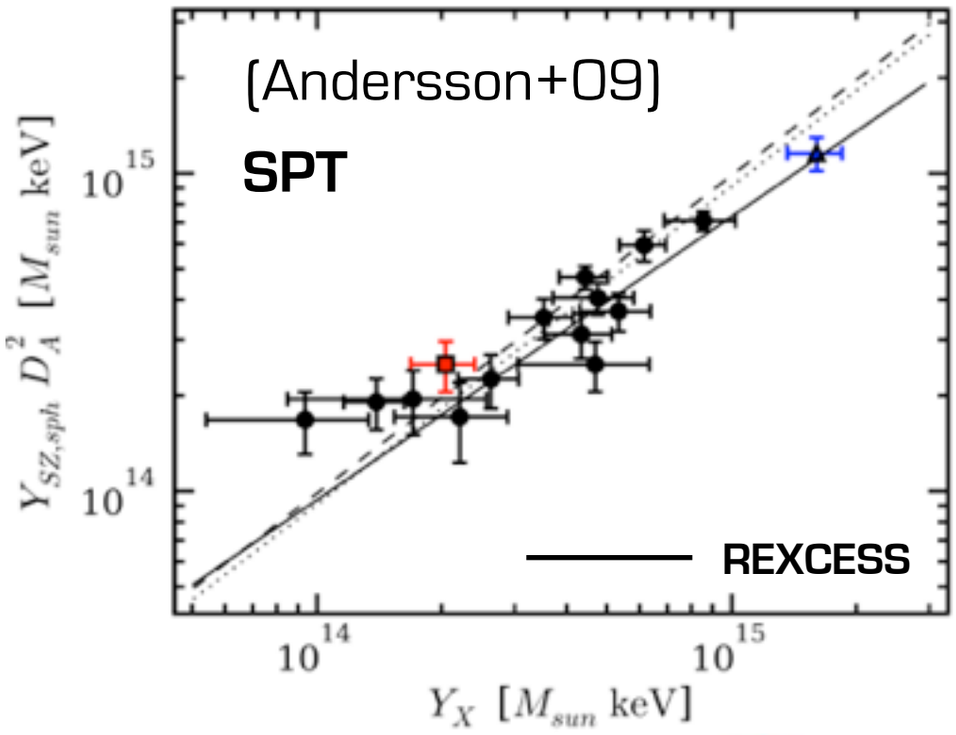


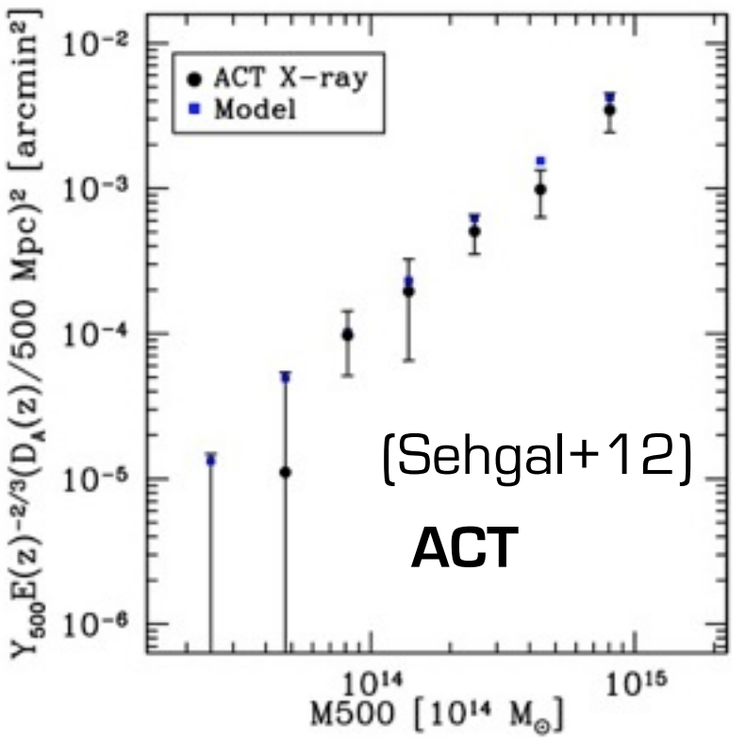
(see G.W. Pratt's talk)

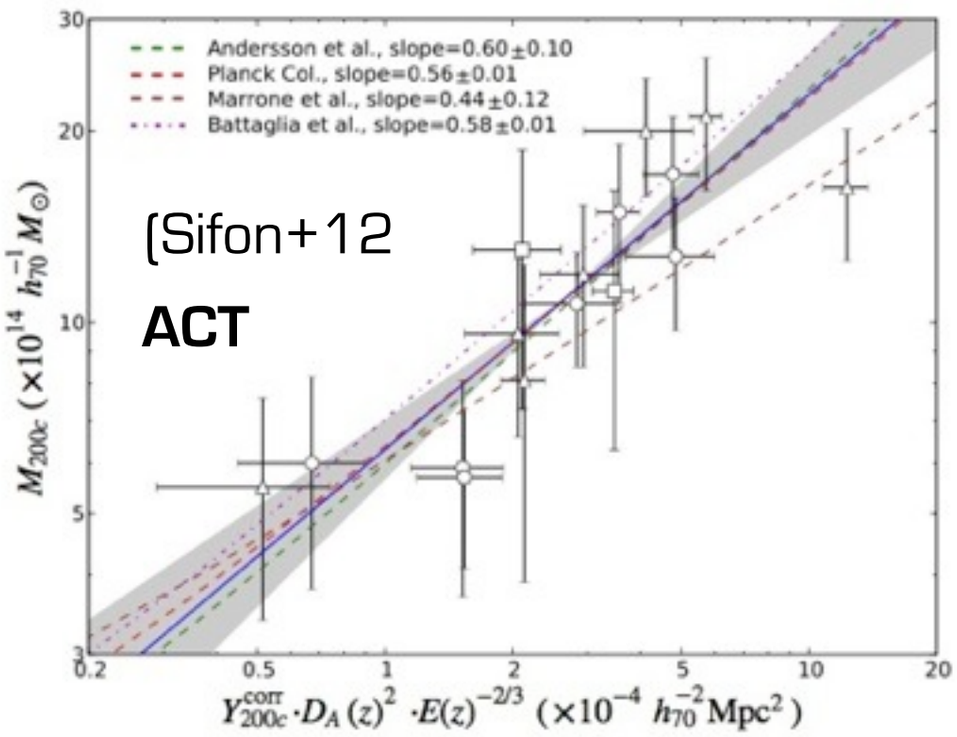
SZ - X SCALING RELATIONS

- Homogenous results from pre/post-Planck studies

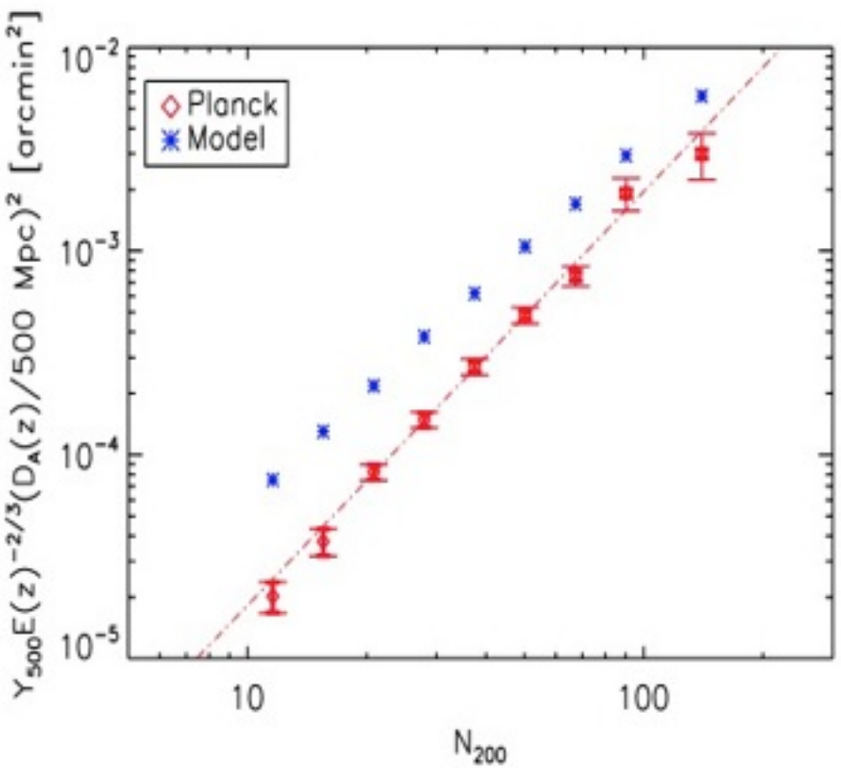




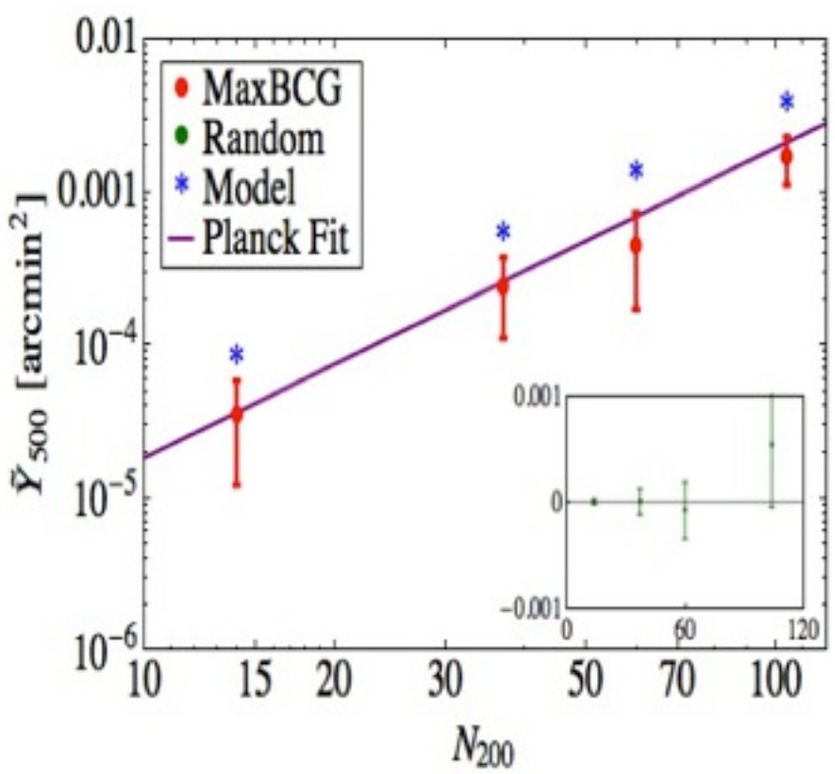




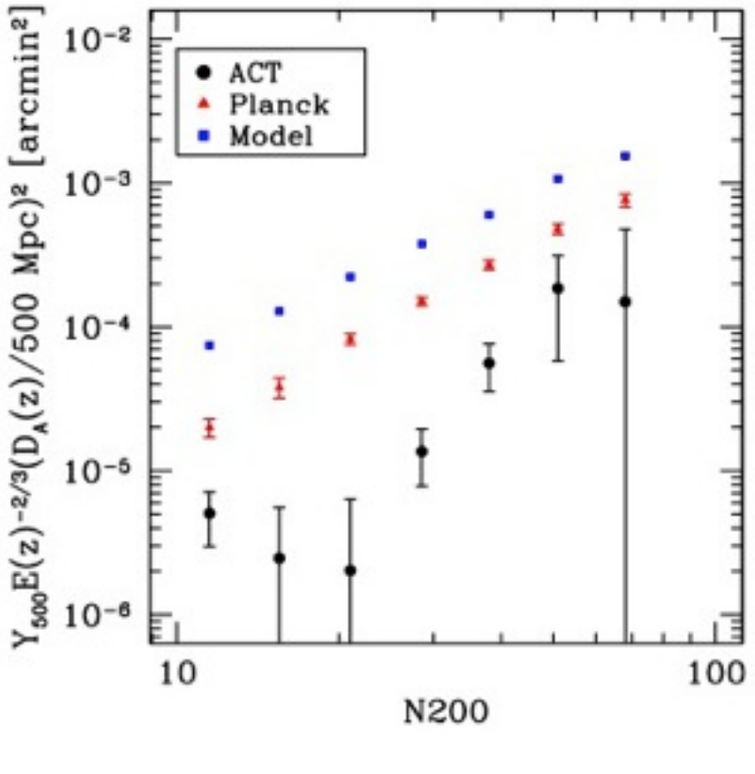
SZ - OPTICAL SCALING RELATIONS



PC+11



Draper+11



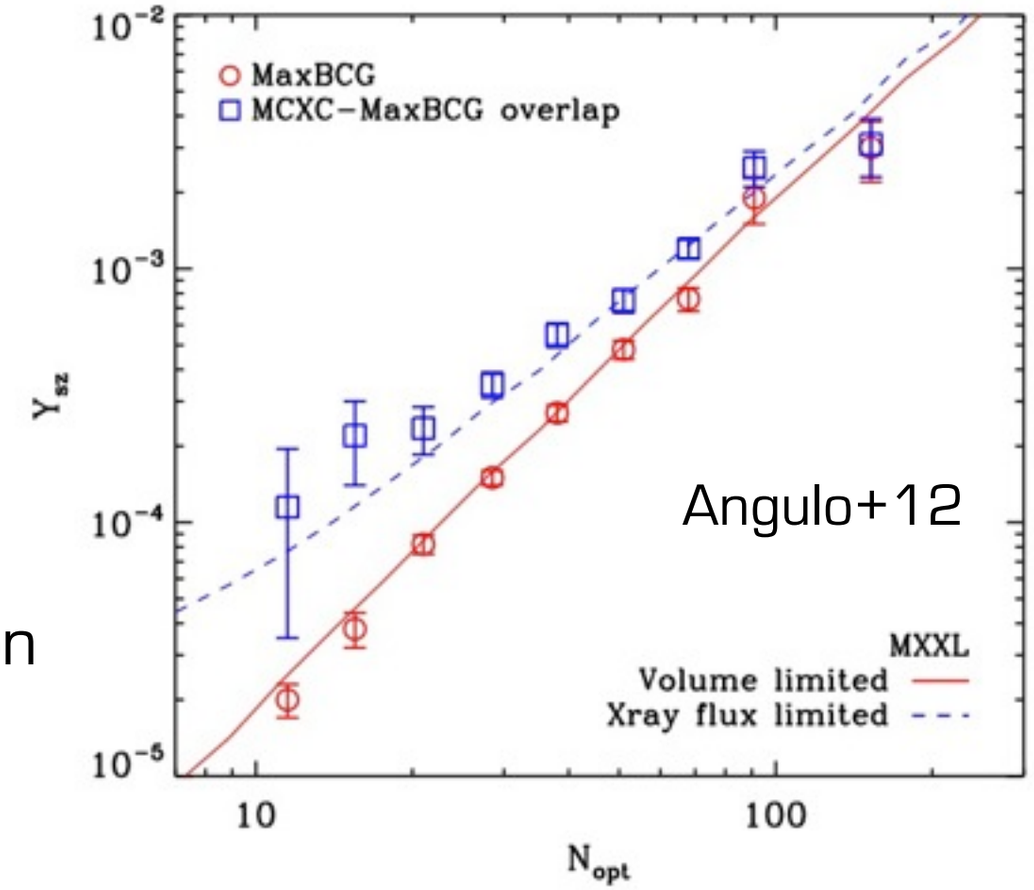
Sehgal+12

- Selection effect (X-ray vs optically selected samples)?
- SZ not an adequate proxy for halos?
- systematic biases?
- use N_{opt} - M_{wl} instead of N_{opt} - L_X

AN OPEN QUESTION

Survey biases

- volume effect, Malmquist bias
- complex dynamical structures
- orientation, projection, miscentering
- foreground and background contamination



Angulo+12

Observable biases

- residual uncertainties on absolute calibration (X, SZ, optical,...)
- systematics on mass estimation (HE, lensing masses, richness)
- covariance between observables
- lack of constraints on the evolution
- complex physics

→ **affect slope, normalisation and intrinsic scatter**

MEANWHILE ON THE X-RAY SIDE...

V09, M10, P11 comparison

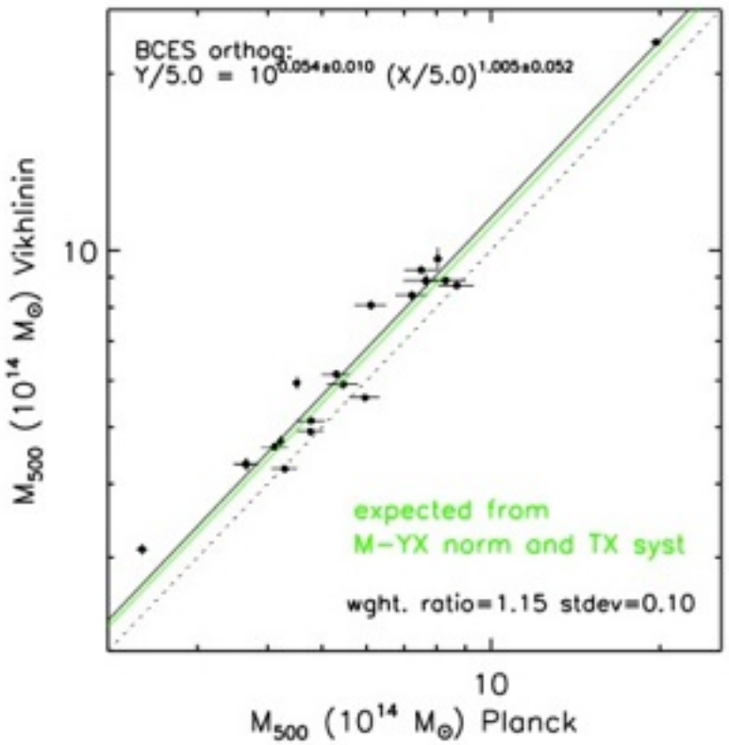
V09 = vikhlinin+09
M10 = Mantz+10
P11 = Planck Collaboration +11

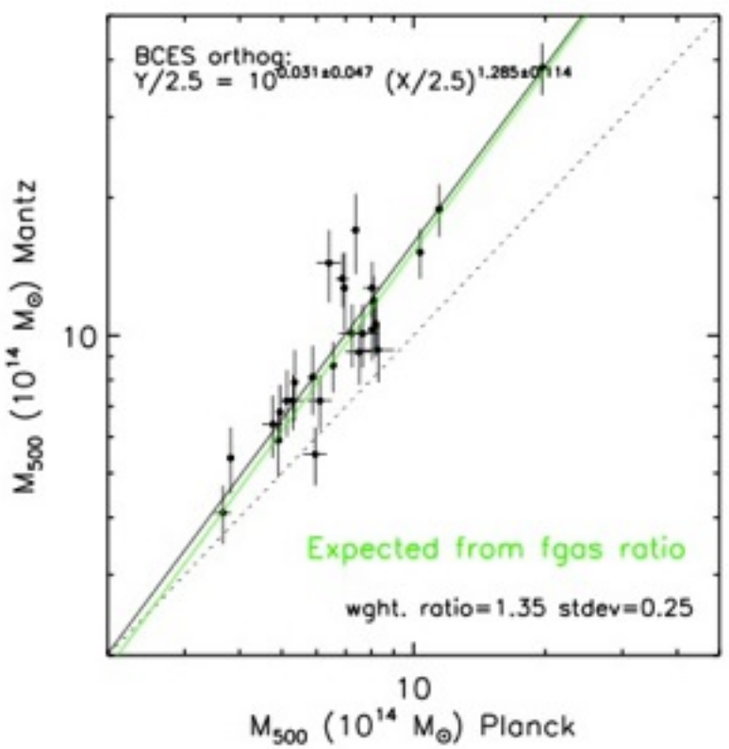
- X-calib. @ low E agree: no issue for ne(r), $M_{gas}(r)$
- X-calib. @ high E: <10% ; effect on kT
- < 4% on mass proxy ; however can go up to ~15% for individual clusters
- aperture
- $f_{gas}(M)$
- sample selection can create artificial evolution effect

→ **once homogenised these various X-ray data are consistent**

{see also Madhavi's talk}

Courtesy of M. Arnaud & G.W. Pratt





CLUSTER PHYSICS WITH PLANCK: THE CASE STUDY OF COMA

ETIENNE POINTECOUTEAU, XMM WORKSHOP, MADRID, MAY 2012

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Planck Collaboration 2012, in preparation

CONCLUSION

SOME CONCLUSIONS

ALL SKY SZ DETECTION UP TO HIGH Z (0.2<z<1.0)

- ESZ: 189 clusters, largest sample of SZ
- 51 new clusters confirmed with XMM-Newton from Planck SZ candidates
- multi-wavelengths follow-up program: X-rays, SZ and optical
- Unveiling a population of dynamically perturbed clusters, X-ray underluminous, possibly underrepresented in X-ray surveys
- Detection of new distant very massive clusters

STRENGTHEN OUR OVERALL VIEW OF ICM PROPERTIES AND MASS CONTENT OF CLUSTERS

- Close long standing issue of the « missing hot baryons » from excellent agreement between observed Y_{SZ} and X-ray-based predictions
- High precision calibration of the $Y_{SZ} - Y_X$ and $Y_{SZ} - L_X$ and $Y_{SZ} - M$
- Correlation between the thermal and non thermal emission

→ **MORE COMING OUT THIS YEAR**

→ **NOMINAL MISSION PUBLIC DATA RELEASE BEGINNING OF 2013**

PLANCK RESULTS ON CLUSTERS

1. Planck Early Results VIII: The all-sky Early Sunyaev-Zeldovich cluster sample (2011, A&A 536, A8)

2. Planck early results IX: XMM-Newton follow-up for validation of Planck cluster candidates (2011, A&A 536, A9)

3. Planck early results X: statistical analysis of SZ scaling relations for X-ray galaxy clusters (2011, A&A 536, A10)

4. Planck Early Results XI: Calibration of the local galaxy cluster Sunyaev-Zeldovich scaling relations (2011, A&A 536, A911)

5. Planck Early Results XII: Cluster SZ-Optical Scaling Relations (2011, A&A 536, A12)

6. Planck Early Results XXVI: Detection with Planck and confirmation by XMM-Newton of PLCK G266.6−27.3, an exceptionally X-ray luminous and massive galaxy cluster at z~1 (2011, A&A 536, A911)

7. Planck Intermediate Results. I. Further validation of new Planck clusters with XMM-Newton (arXiv:1112.5595P)

8. Planck Intermediate Results II: Comparison of Sunyaev-Zeldovich measurements from Planck and from the Arcminute Microkelvin Imager for 11 galaxy clusters [arXiv1204.1318P]

9. Planck intermediate results. III. The relation between galaxy cluster mass and Sunyaev-Zeldovich signal [arXiv1204.2743P]

10. Planck Intermediate Results. IV. The XMM-Newton validation programme for new Planck clusters [arXiv1205.3376P]