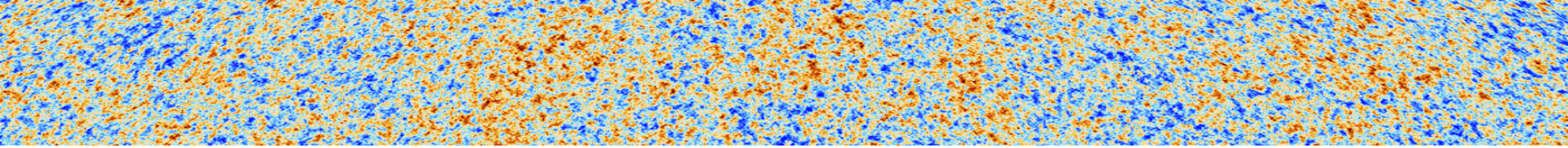


Title Sunyaev Zel'dovich Signal & Cross Correlations

Relatore Pasquale Mazzotta

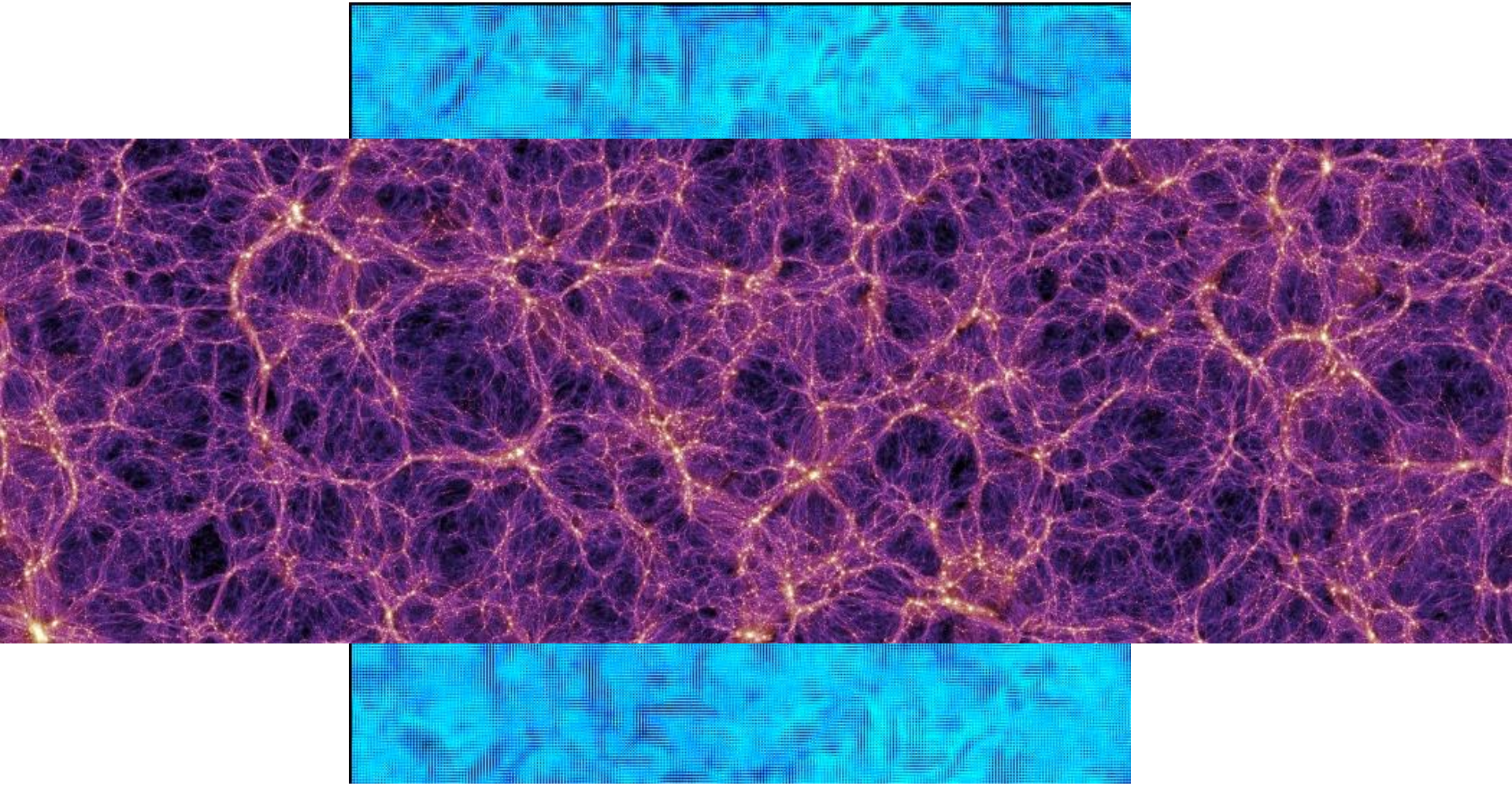
Universita' di Roma "Tor Vergata"

on behalf of the Italian CMB community

Overview

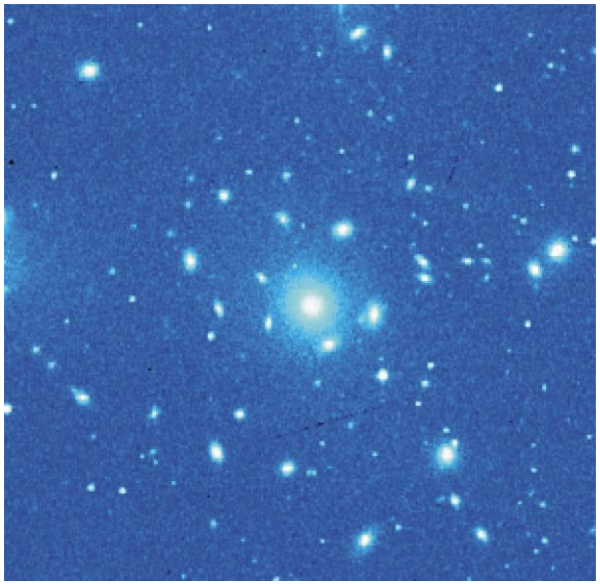
- Cosmic web and Clusters of Galaxies
- Observing clusters in the Microwaves: the SZ effect
- ground, balloon-borne and space SZ observations
- Review of some results obtained by Planck
- Cross correlation of SZ observations
- Conclusions: some important opportunities that the Italian CMB-SZ community cannot afford to miss include Olimpo, Core++ and Millimetron

Galaxy Clusters and the Cosmic web

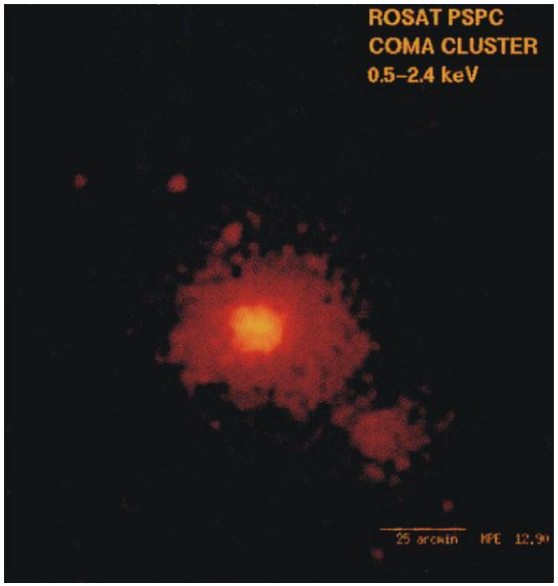


Cluster Components

1. Galaxies
2. Intergalactic Gas
3. Dark Matter



Optical image

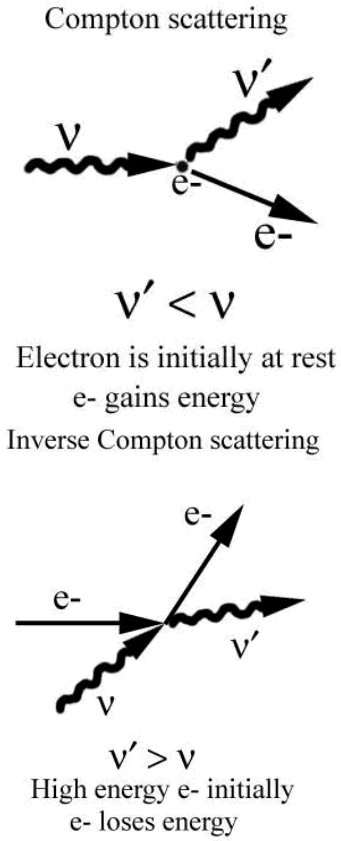


X-ray image

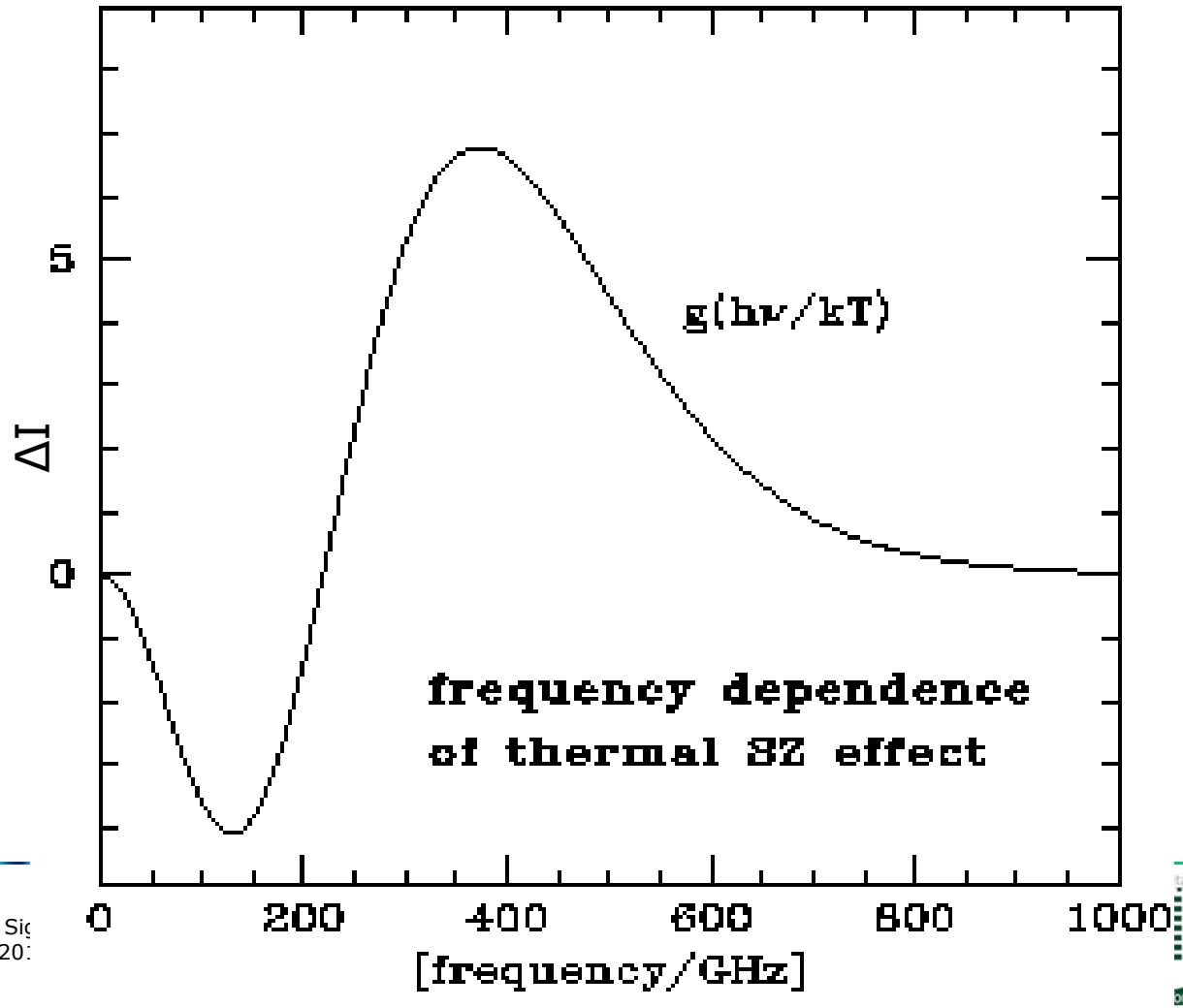
Gravitational Lensing

Sunyaev Zel'dovich effect

CMB+CLUSTERS

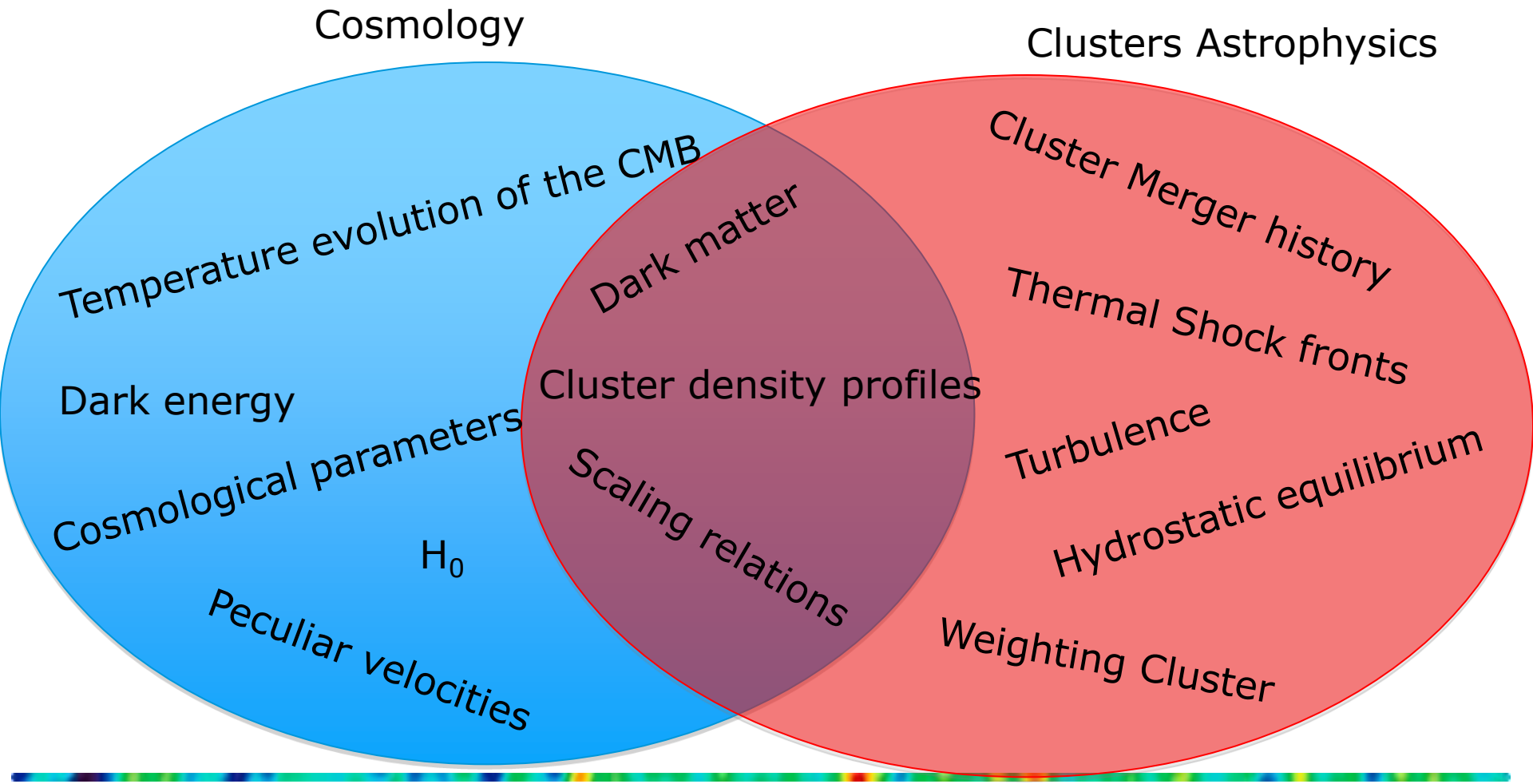


SZ effect (Sunyaev & Zel'dovich 1969)

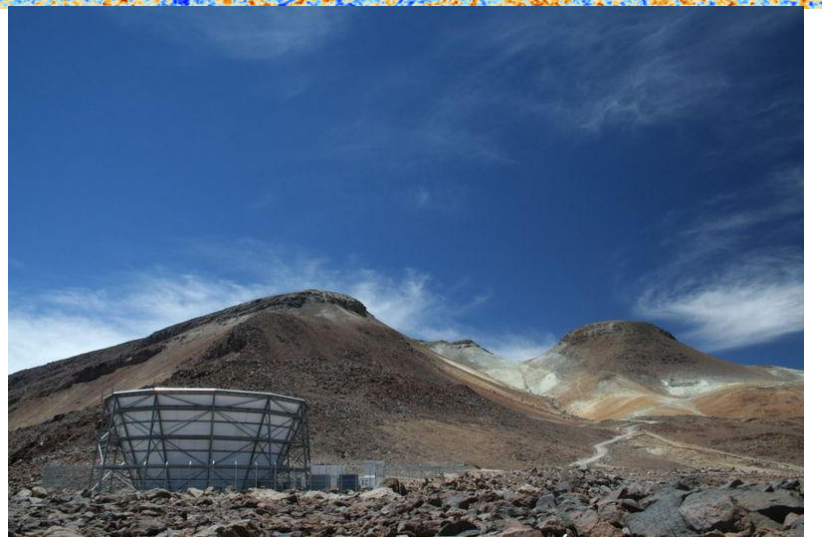


Investigations with SZ Observations

SZ observations as powerful tools (just some keywords)



Some Ground SZ telescopes



Atacama Cosmology Telescope

South Pole Telescope

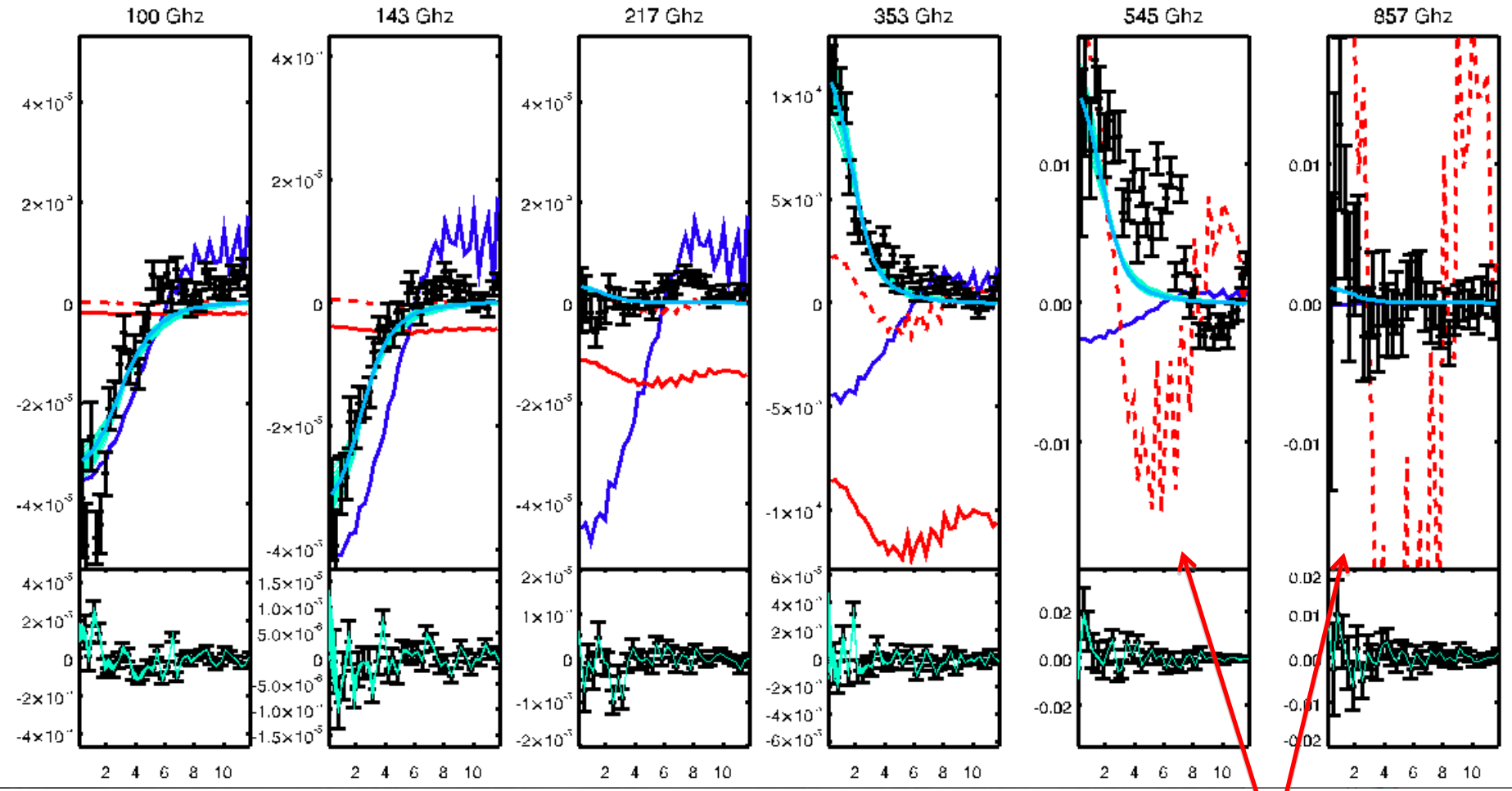
Sunyaev–Zel'dovich Array

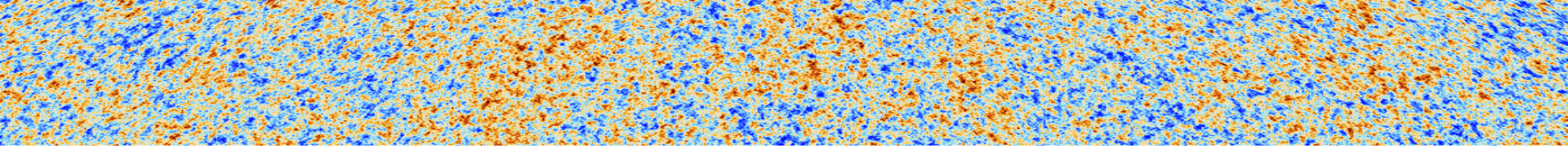
Nika and Nika2

AMI
AMiBA
APEX
SuZIE
MUSTANG

Accurate foreground separation requires High frequencies observations

z~1 cluster observed with Planck

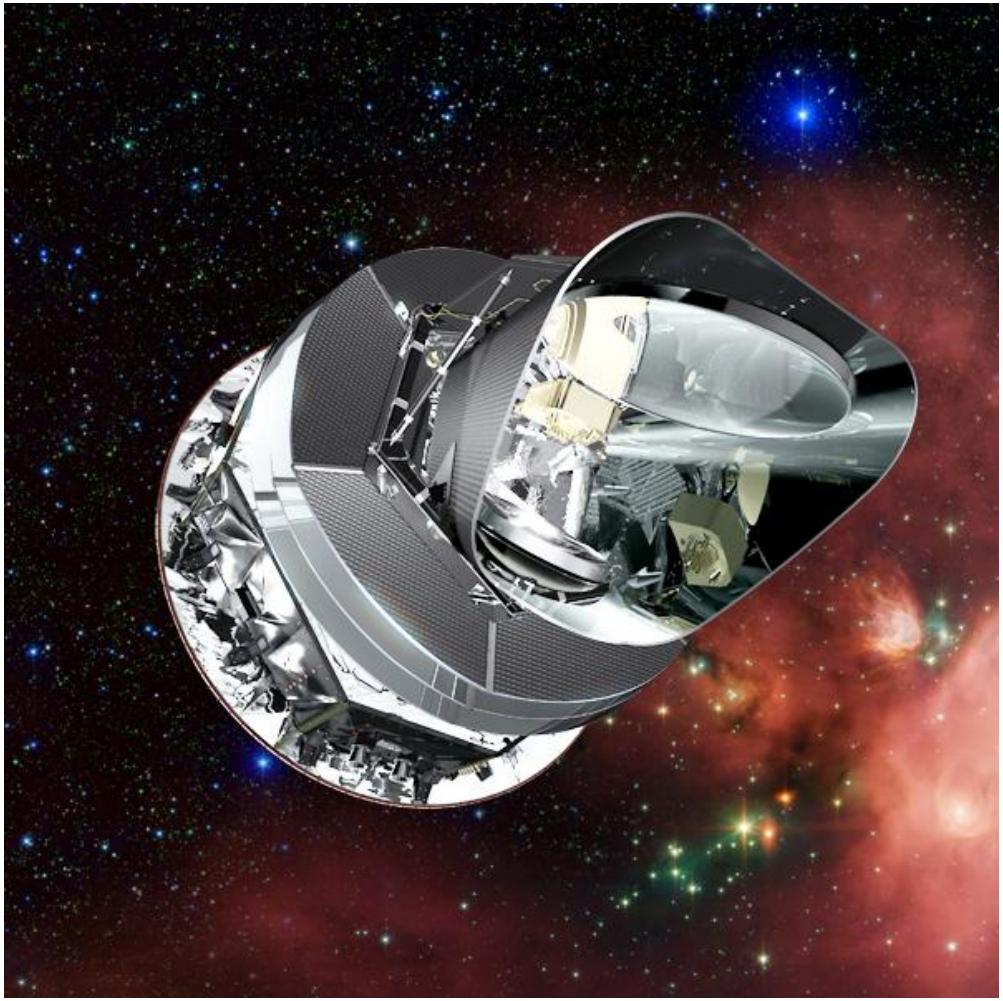




Accurate foreground separation requires High frequencies observations!

This can be achieved only from space and (partially) from balloon-borne experiments

SZ observation from space: Planck



Pros:

- Larger frequency coverage: better foreground subtraction
- All sky survey: first all sky map of the SZ signal

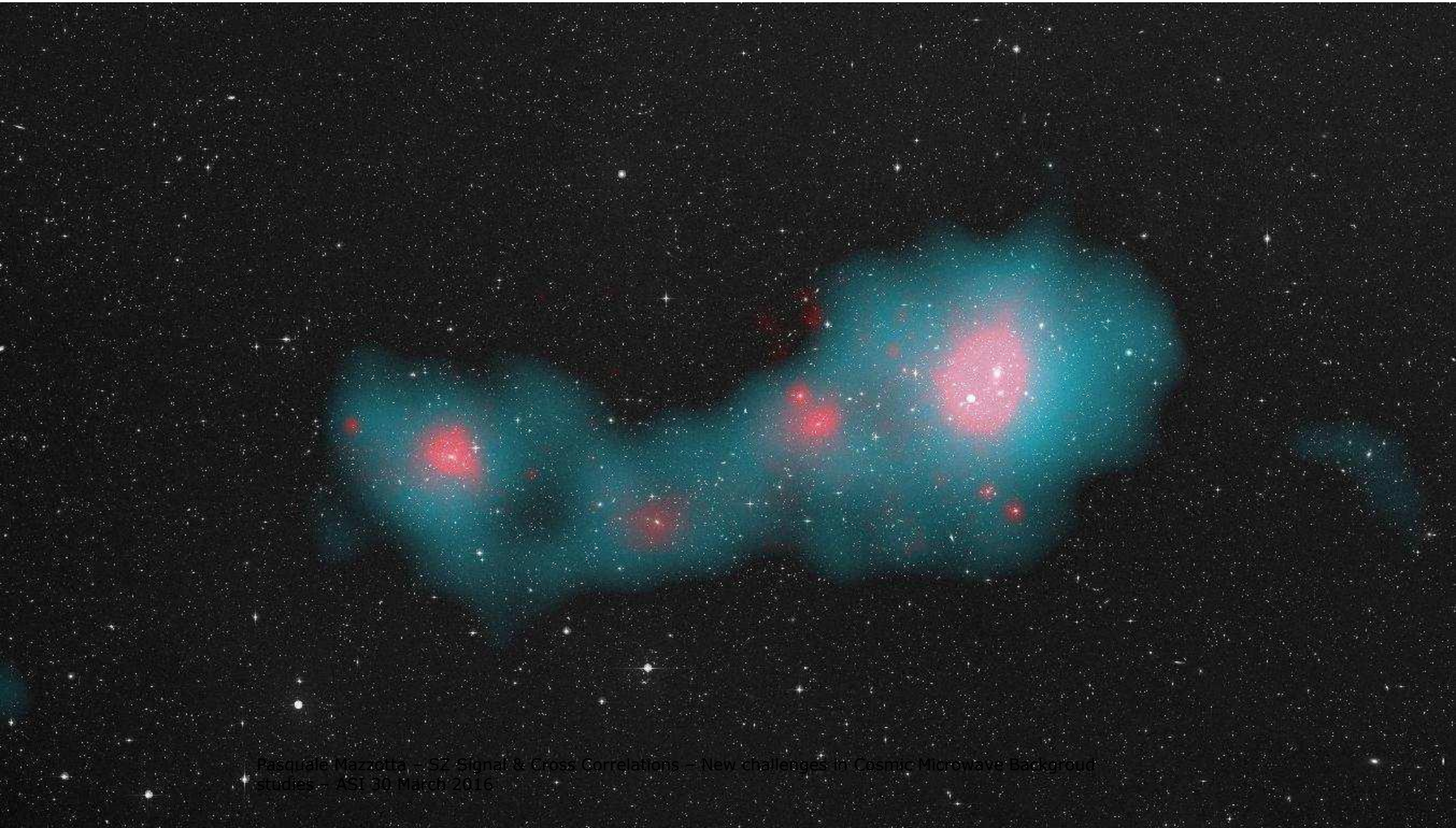
Cons:

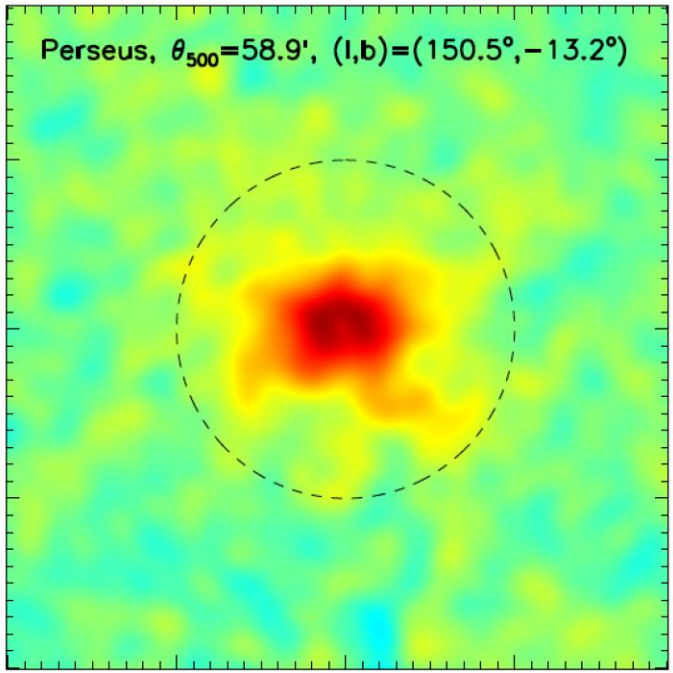
- Lower angular resolution and lower exposure time per clusters: impossibility to detect clusters at z>1

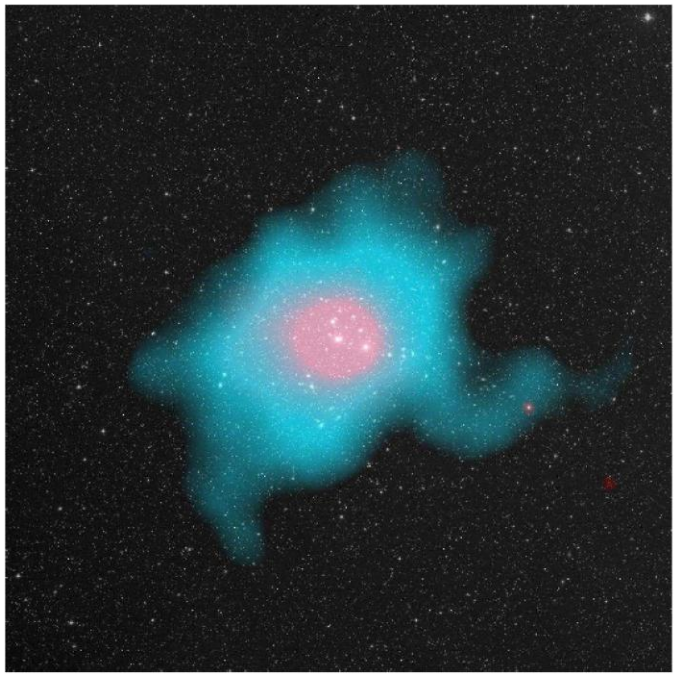
Some nice pictures

Shapley supercluster: SZ observation of hot gas in filaments

Planck 2013. XXIX, A&A

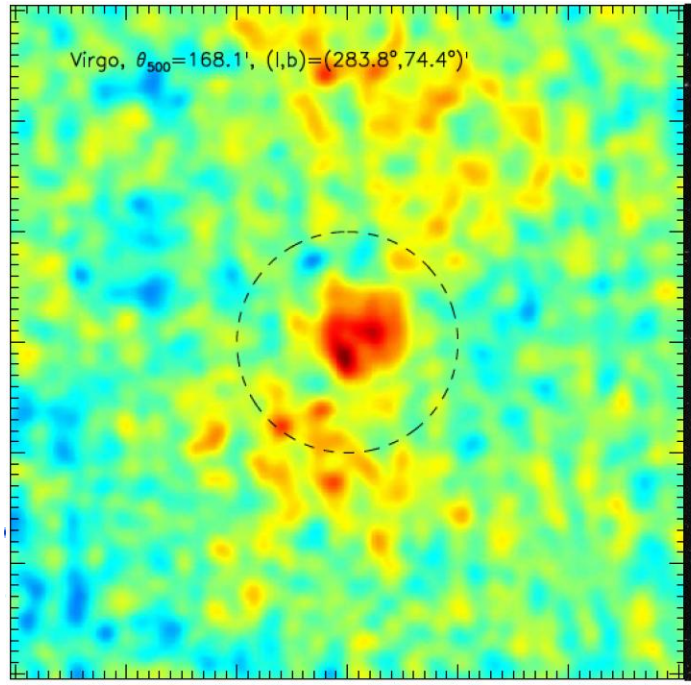


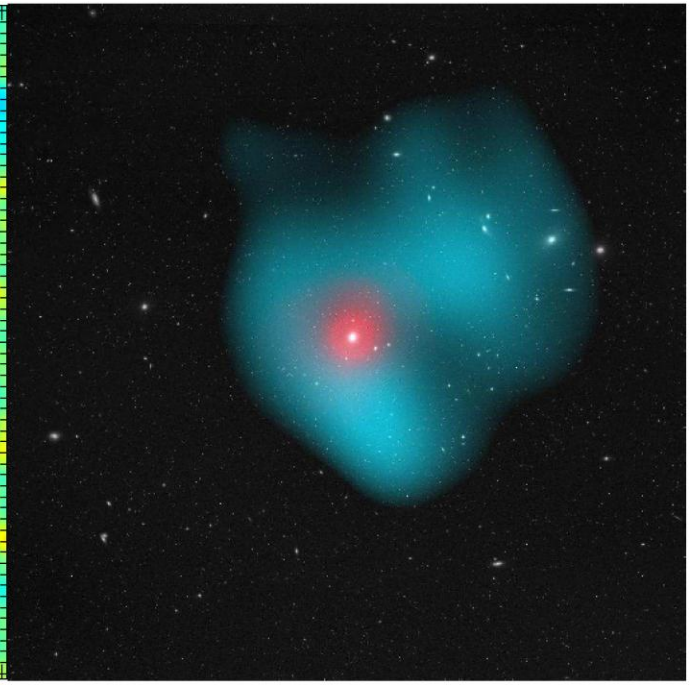




Planck 2013. XXIX, A&A

2x2 deg



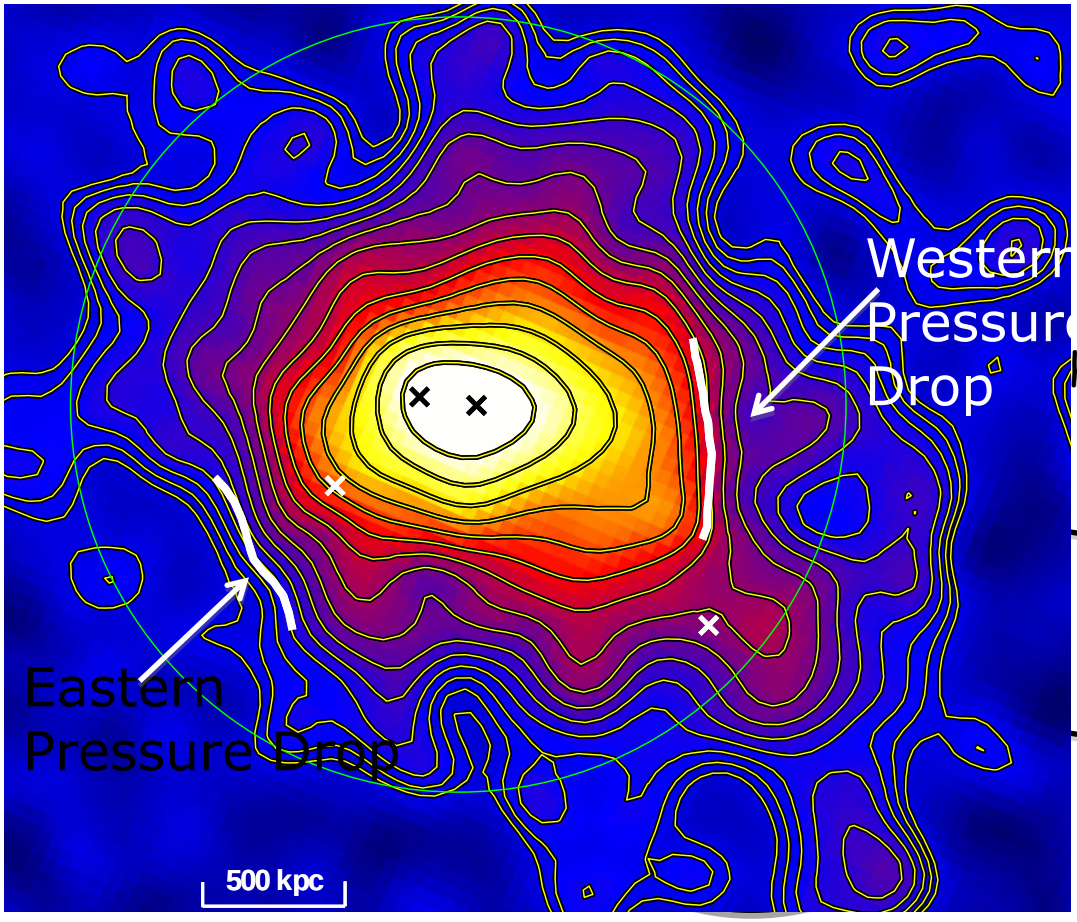


3.84x3.84 deg

:groud

Università di Roma
Tor Vergata

Planck y Map of Coma



MILCA 10 arcmin
Levels> 2*σ
σ= 2.13x10^{-6}
Levels log equispaced by $2^{1/4}$
Green circle = R_{500}

HFI from 100 GHz to 857 Ghz

Y map extended in the East-West direction

extended Y emission

Planck IR. X, A&A

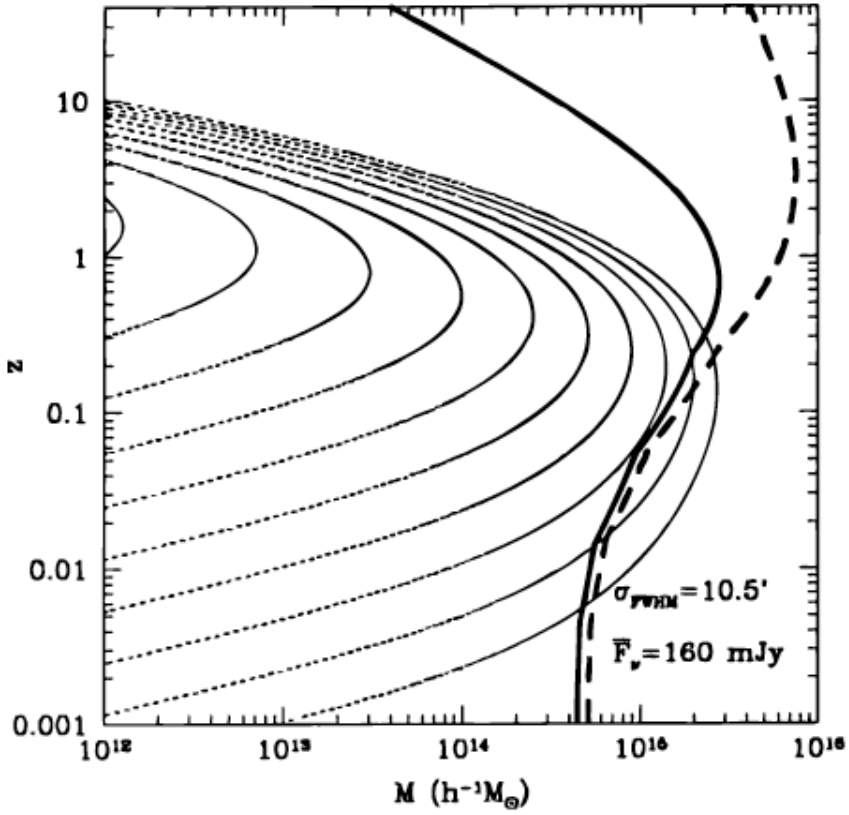
The Planck SZ catalogue

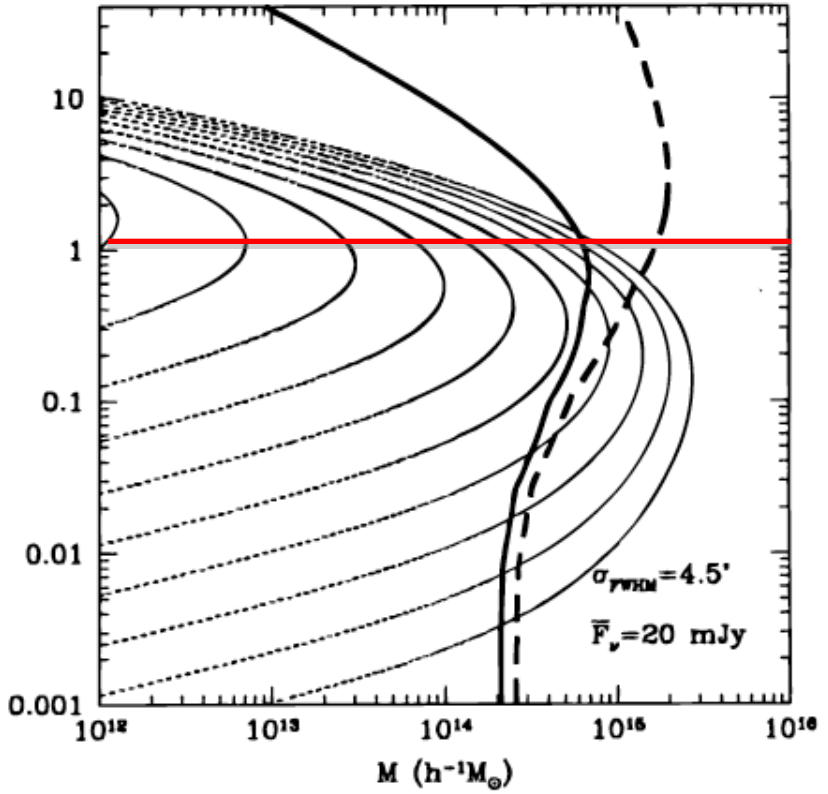
1653 SZ detections
0<Z<1

TABLE 5

NUMBER COUNTS AT 2 σ LEVEL DETECTION FOR THE C/S 400 GHz CHANNEL

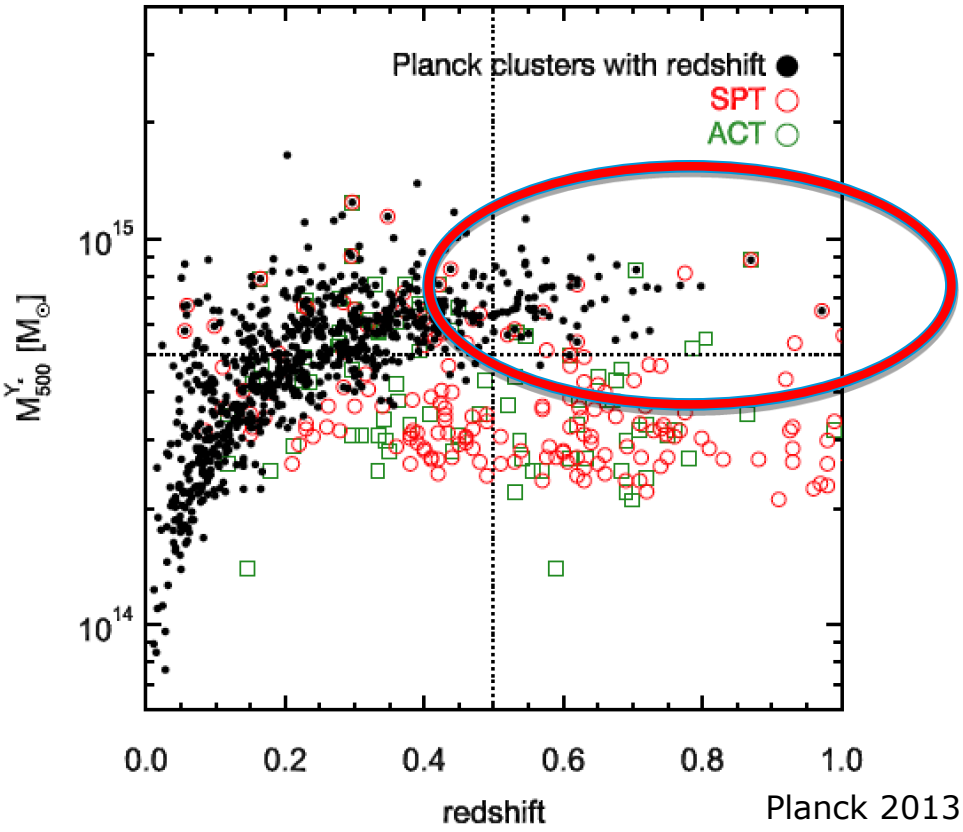
MODELS	$N(>2\bar{F}_\nu^{noise})$ AT 400 GHz: With ICM Evolution	Without ICM Evolution
CDM; $\Omega = 1.0$; $h = 0.5$:		
$n = 1$.....	1063	3459
$n = 0.8$	1220	3792

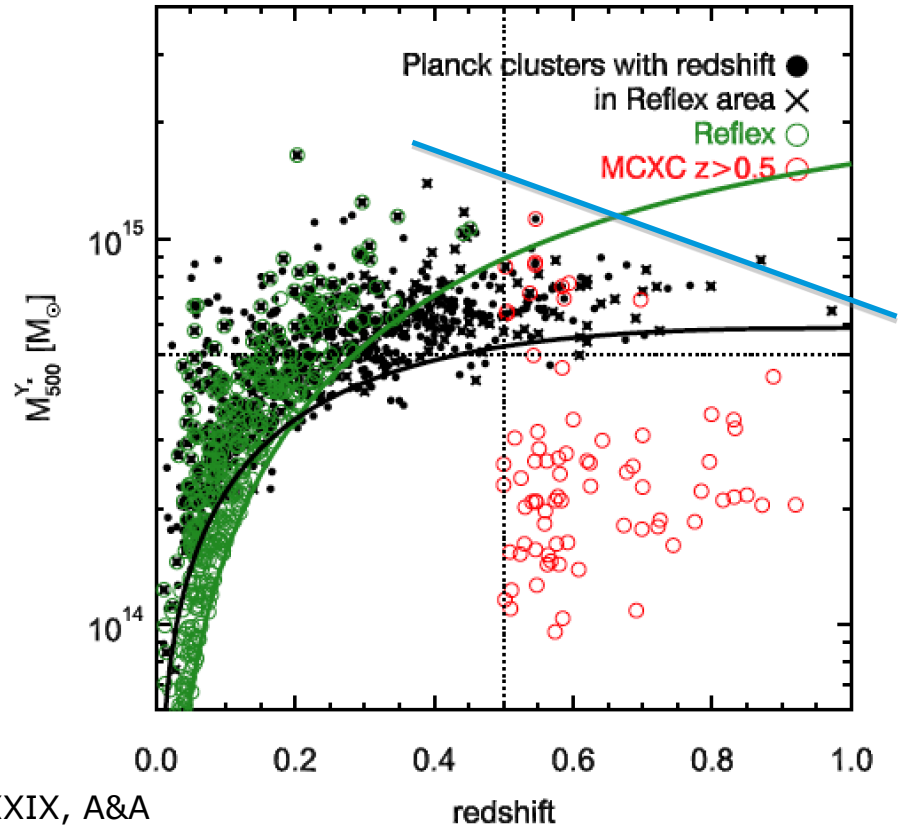




redshift distribution

Space all-sky SZ survey allows to access region of the mass-redshift plot
That are inaccessible to current ground experiments

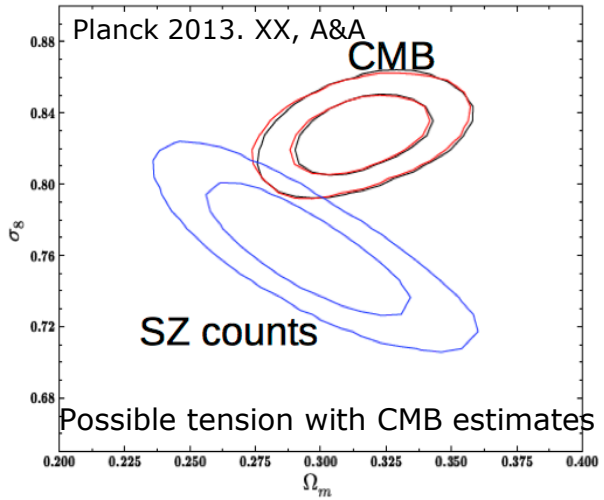




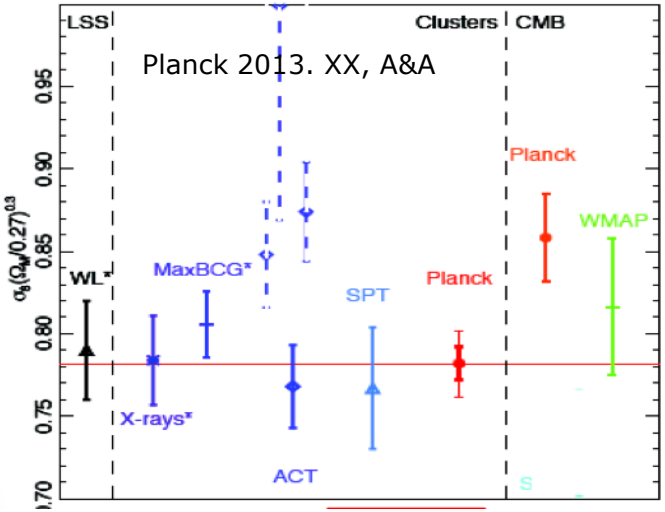
Planck 2013. XXIX, A&A

Joint analysis of Planck SZ data with other data sets

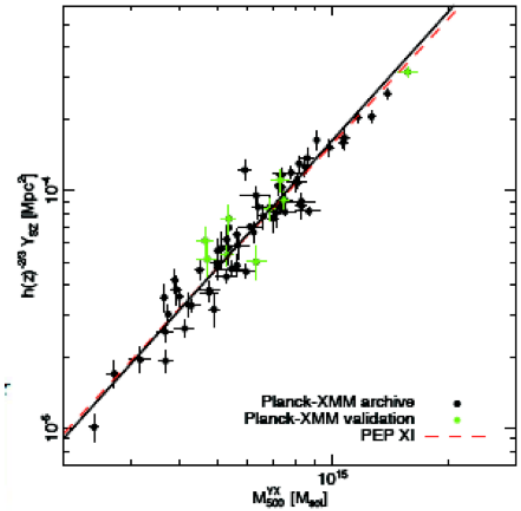
Estimates of Ω_m-σ_8



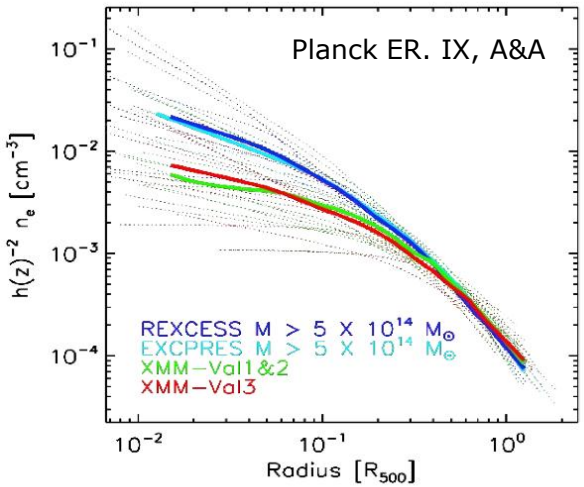
"Accuracy" of the σ_8



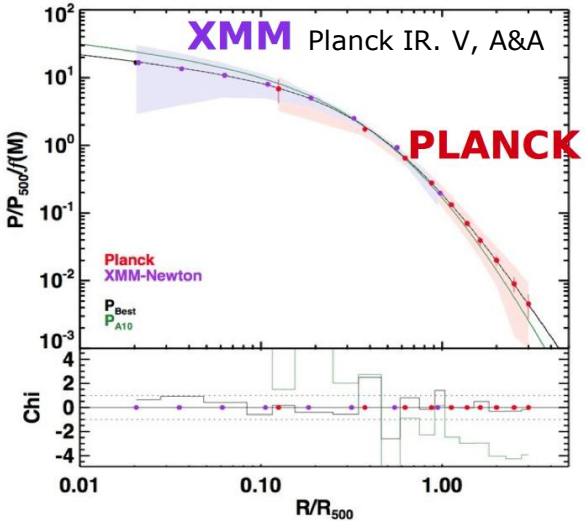
Y_{sz}-Y_x Relation



X-ray profiles of a SZ selected population



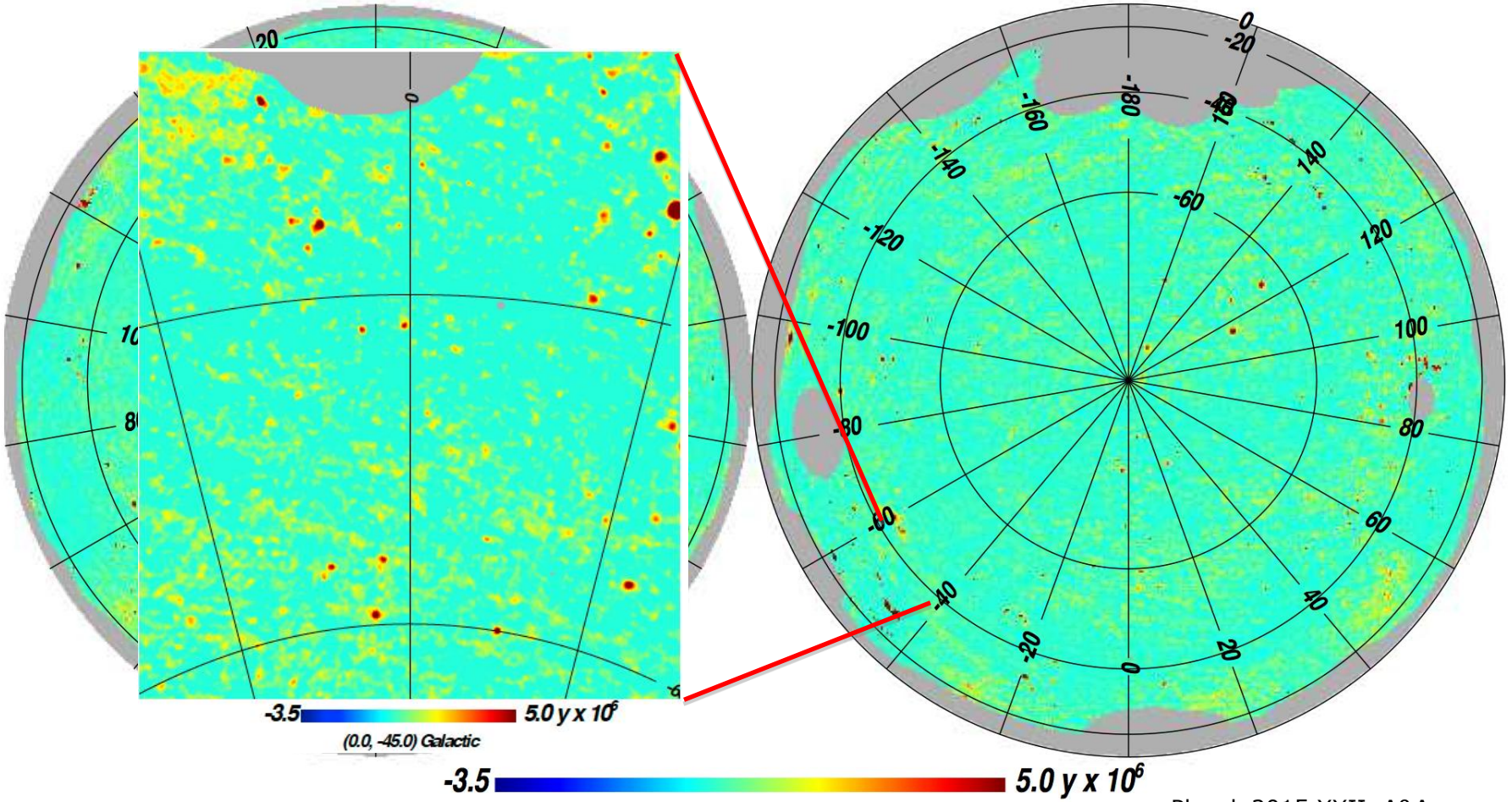
ICM pressure profile in cluster outskirts



Planck Map of the Thermal SZ

First All-sky map of the diffuse SZ signal

This can be achieved only from space (balloon) as we need high frequencies to properly model and remove foreground and background components



Planck 2015 XXII, A&A

X-Correlations

Hosts galaxies

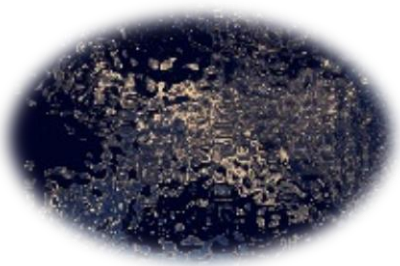
MATTER DISTRIBUTION

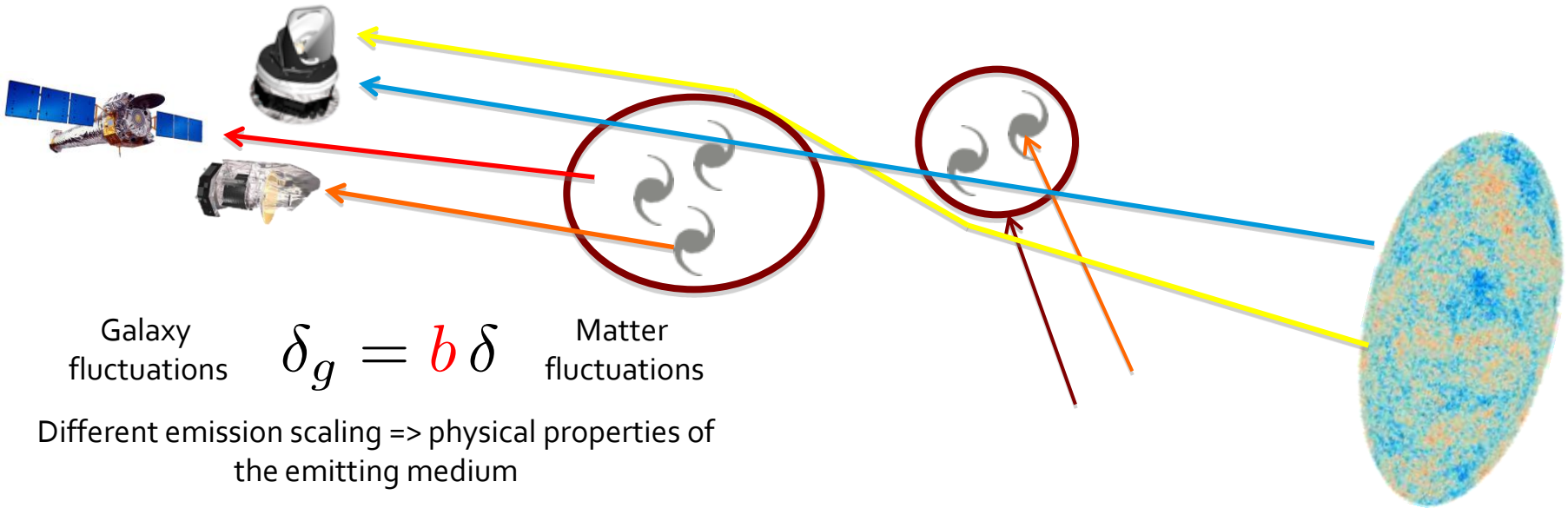
Lens CMB photons

Light is a (biased) tracer of matter

Lensing is insensitive to matter's nature

Thermal SZ and X-ray emission from Clusters of galaxies



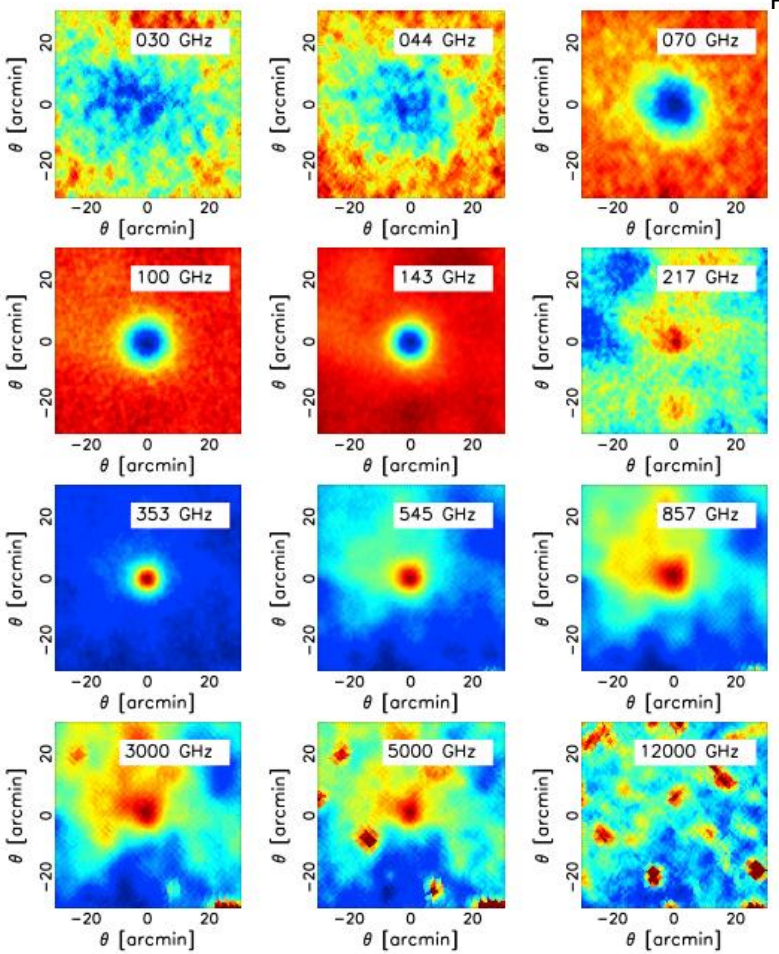


Galaxy fluctuations $\delta_g = b\,\delta$ Matter fluctuations

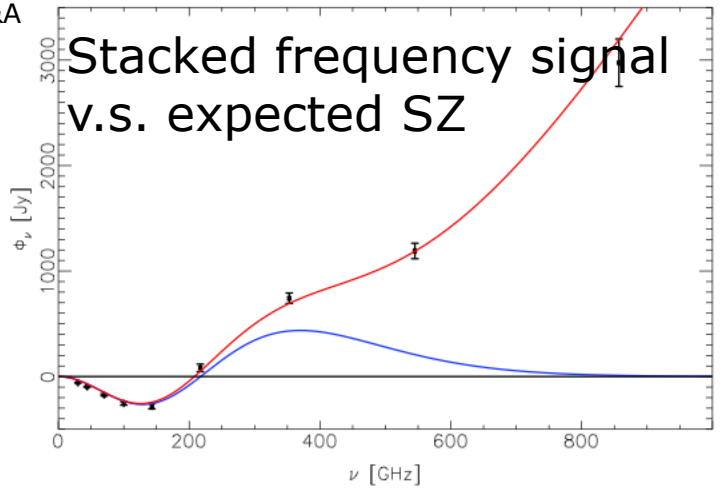
Different emission scaling => physical properties of the emitting medium

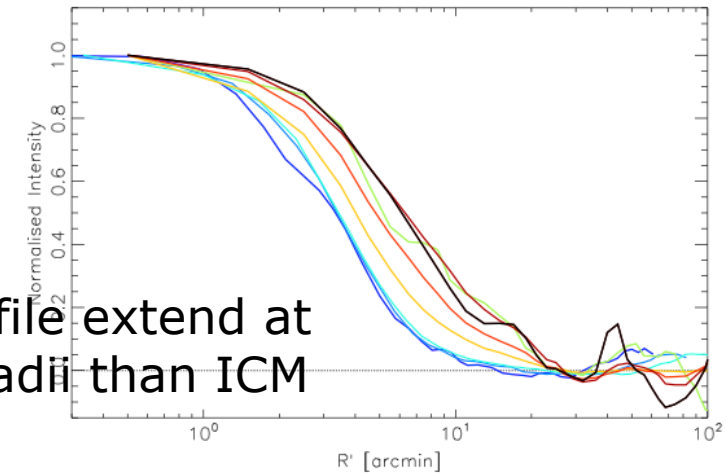
X-Correlations: The thermal Sunyaev-Zeldovich effect– cosmic v.s. infrared background

Planck 2015. XXIII, A&A



Stacked intensity maps of clusters



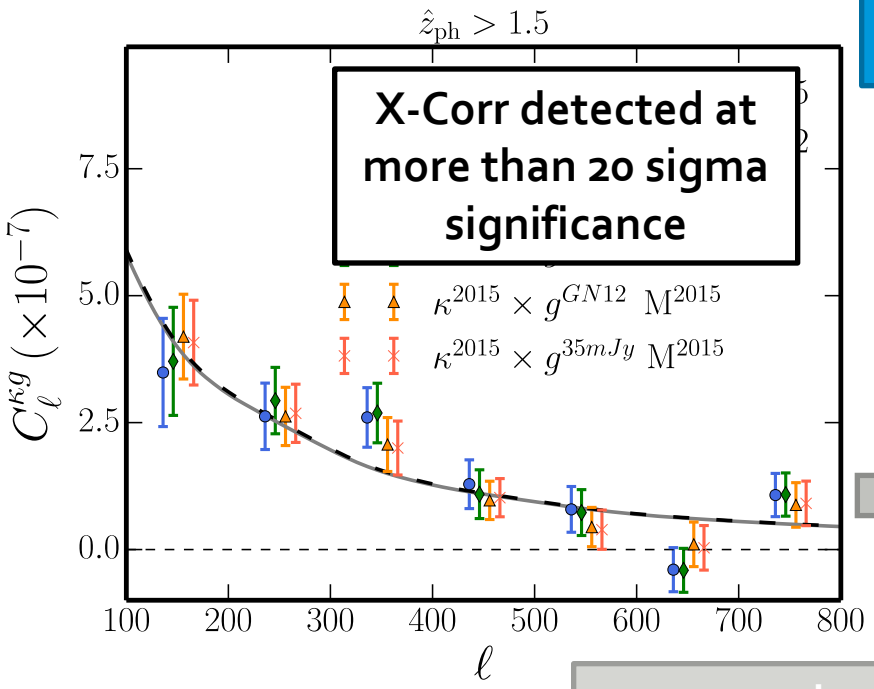


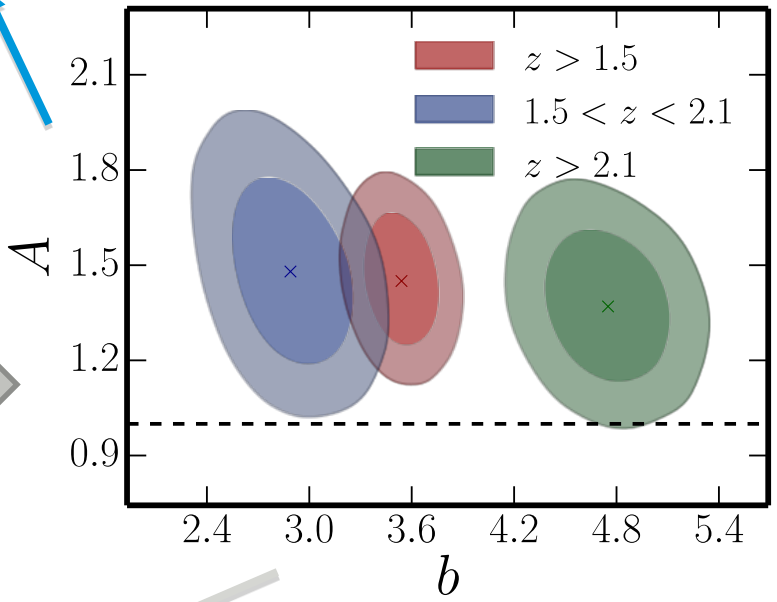
CIB profile extend at larger radii than ICM

Figure 10. *Top*: observed radial profile of the stacked signal toward galaxy clusters at the native angular resolution at 70 GHz (in dark blue), 100 GHz (blue), 143 GHz (light blue), 217 GHz (green), 353 GHz (orange), 545 GHz (red), 857 GHz (dark red), and 100 μm (black). *Bottom*: same as top panel, but as a function of the rescaled radius $R' = R(\mathcal{B}_\nu/\mathcal{B}_{857})$.

X-Correlations: High-z Galaxies vs. CMB lensing

constraints on cosmological parameters (e.g., dark energy)





constraints on astrophysics of structure formation (e.g., clustering)

Conclusion 1/2

- SZ Observations have opened a new and promising window of investigation related to the clusters of galaxies, large scale structure and cosmology.
- Here we reviewed just some of the main scientific results for which the Italian community has provided active and significant contributions.
- More specifically, in recent years the Italian community has acquired and developed many advanced skills and competences in the field from a Theoretical, Observational, Data Analysis, and Instrumental point of view.
- This research field has just started to bloom. Much more has still to be done and to be discovered.

Conclusion 2/2

- To significantly improve in almost the studies here briefly reviewed, beside increasing the sensitivity of future experiments, we necessarily need to find better ways to model and subtract the foreground components.
- This requires, on one hand to observe at hi-frequencies, and on the other hand to better sample the spectral range (see Masi and Piacentini talks).
- This requires both balloon-born and space observatories.

- Ideal instruments would be:
- Olimpo (see Masi Talk)
- Core+ (see De Bernardis Talk)
- Millimetron (see Piacentini Talk)

THE END

Cluster of Galaxies as seen by Planck