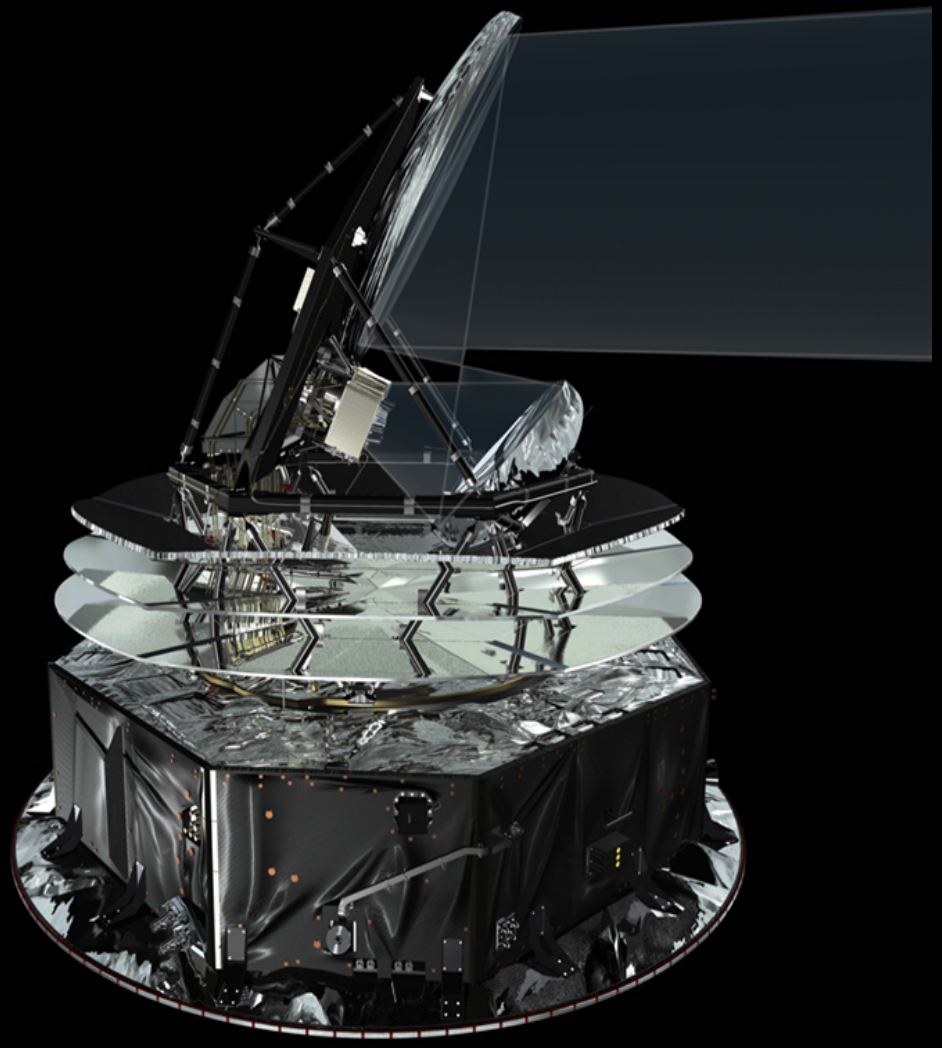
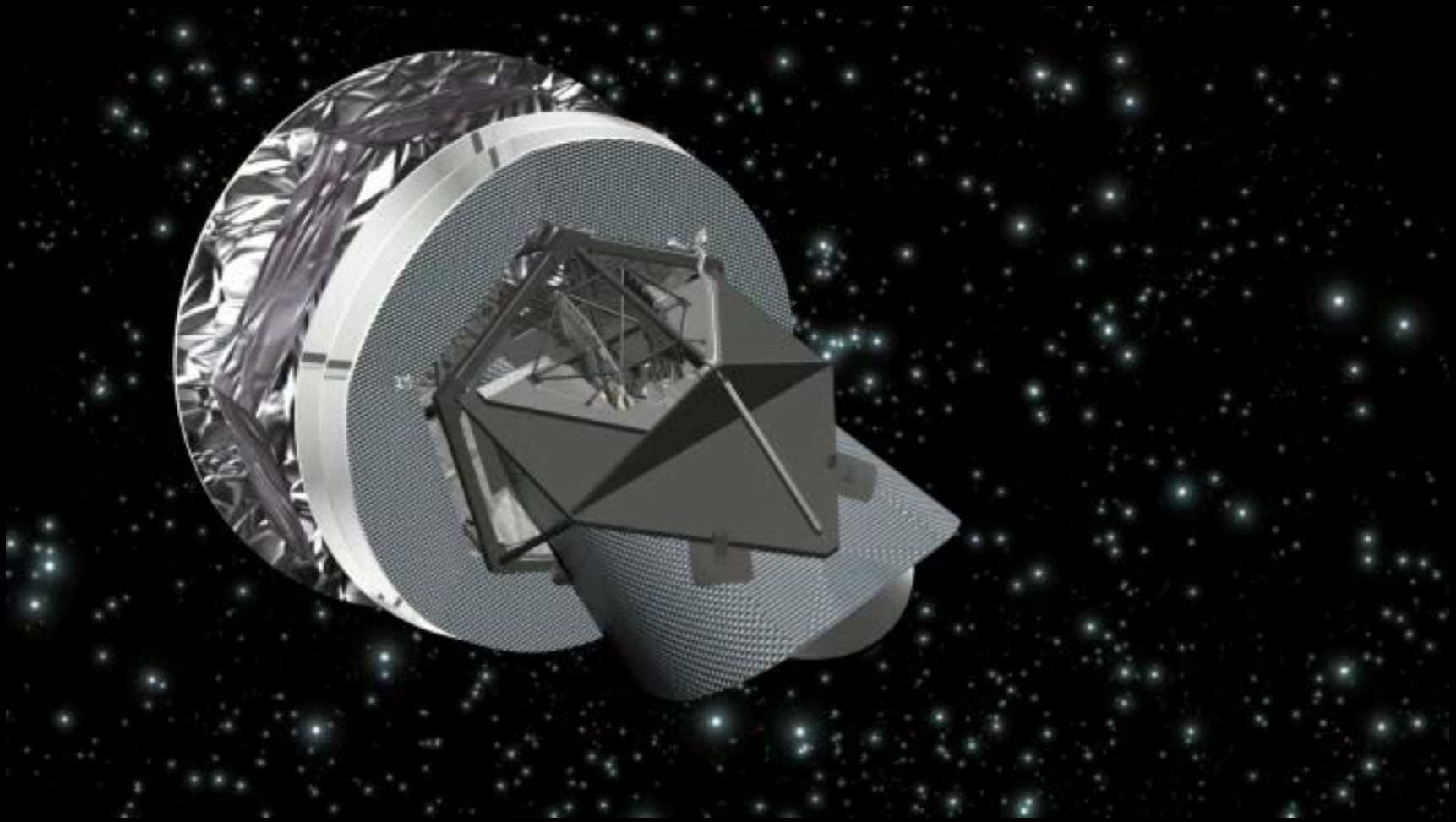
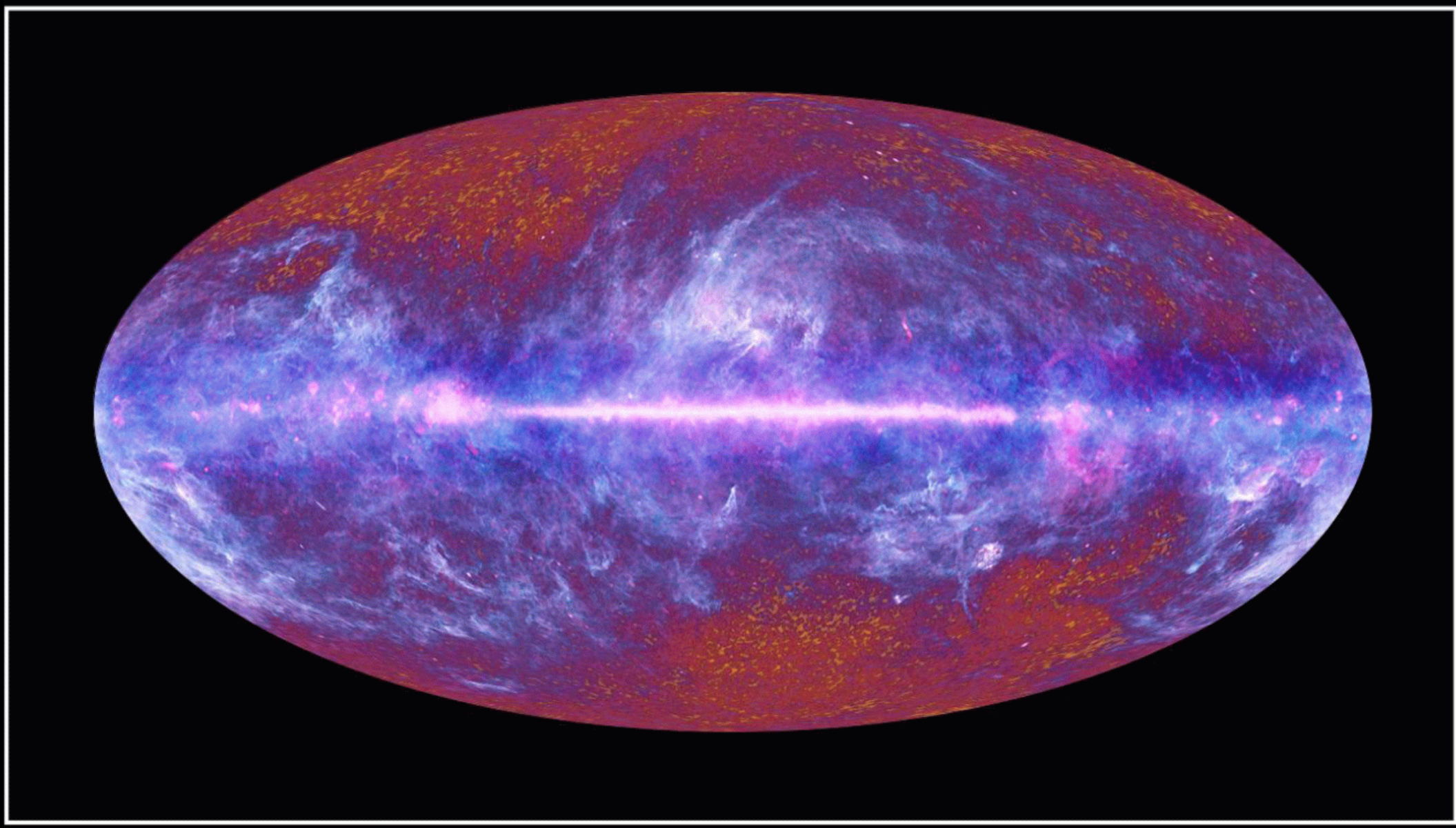
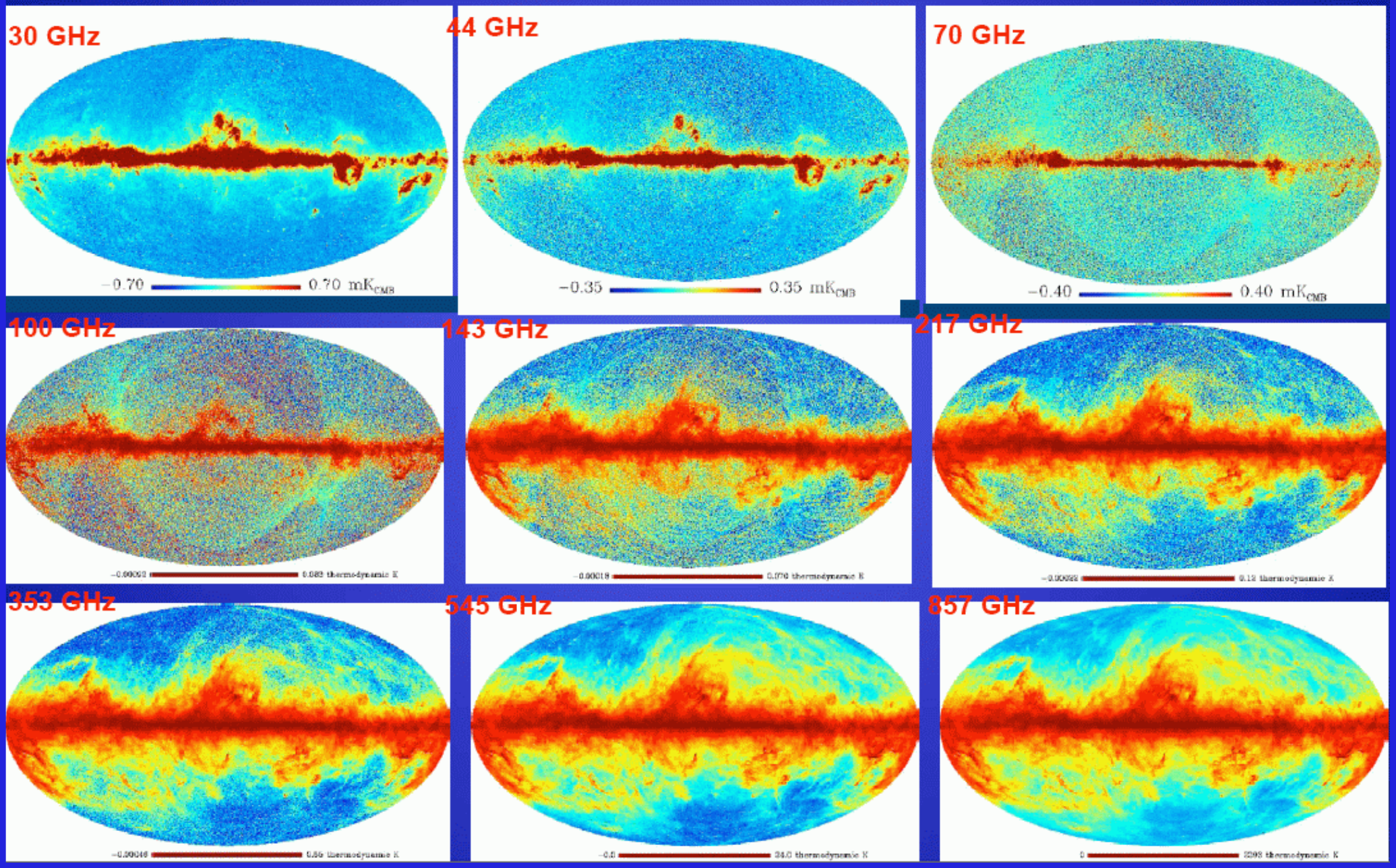
Planck: The First Results

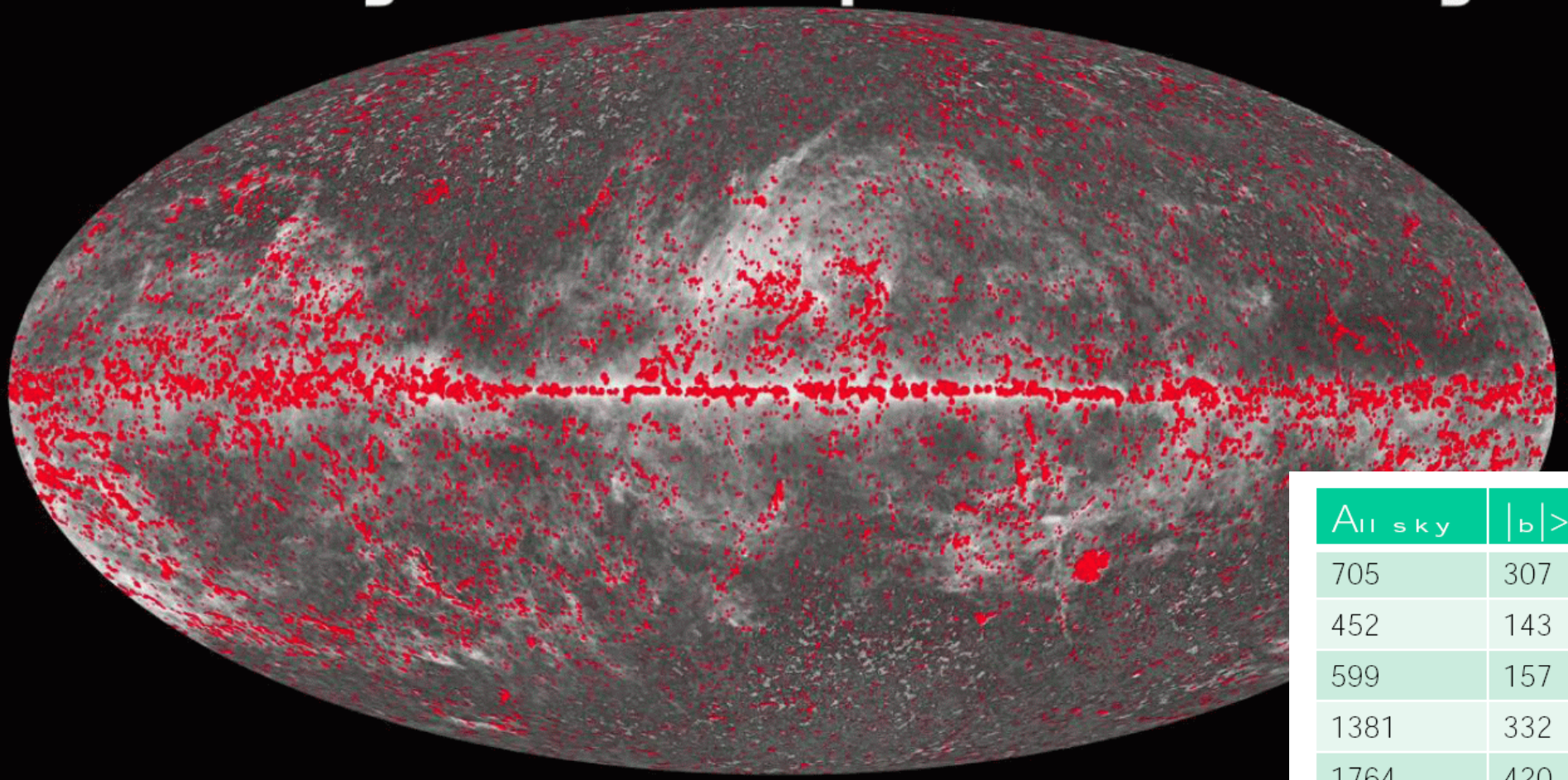






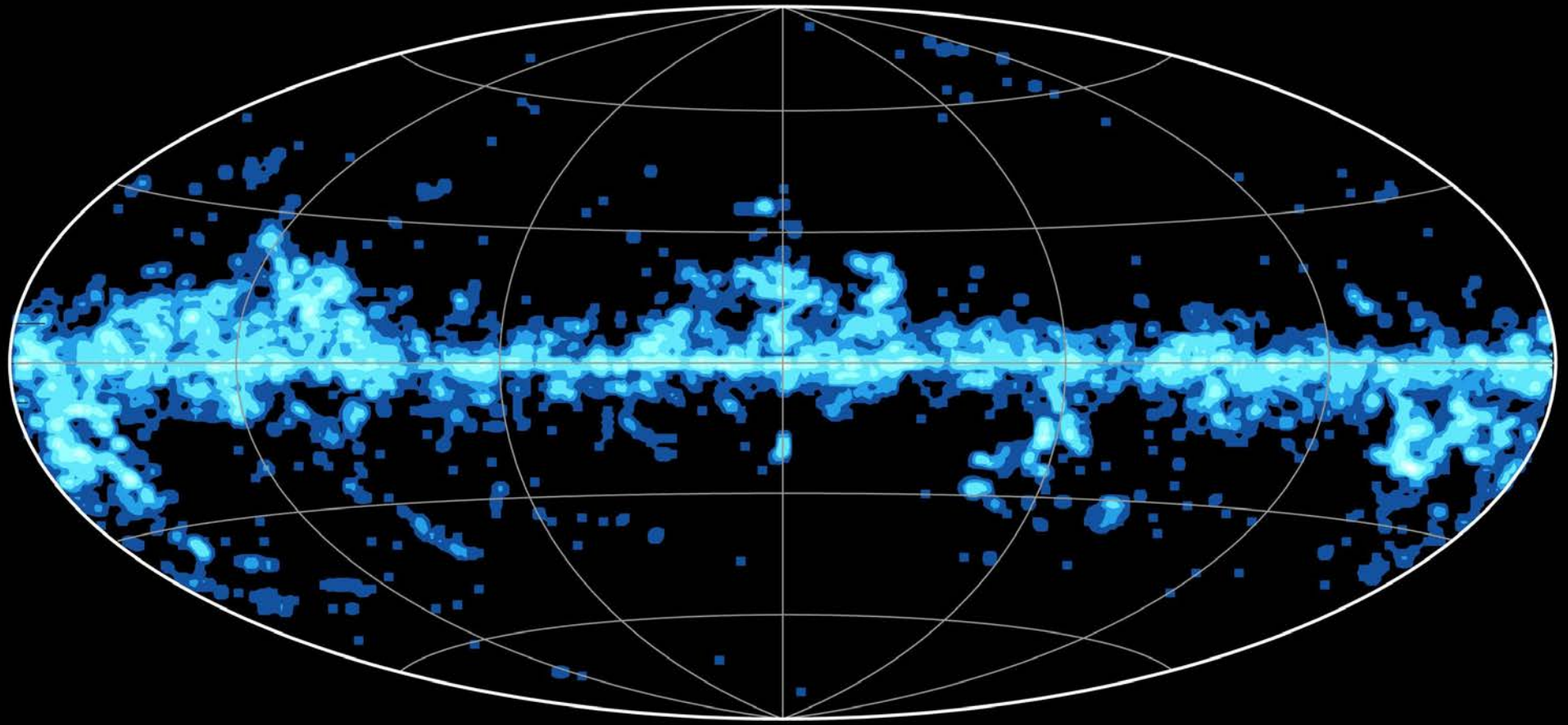

30 GHz
−0.70
0.70 mK$_{CMB}$
44 GHz
−0.35
0.35 mK$_{CMB}$
70 GHz
−0.40
0.40 mK$_{CMB}$
100 GHz
143 GHz
217 GHz
353 GHz
545 GHz
857 GHz

Planck Early Release Compact Source Catalogue

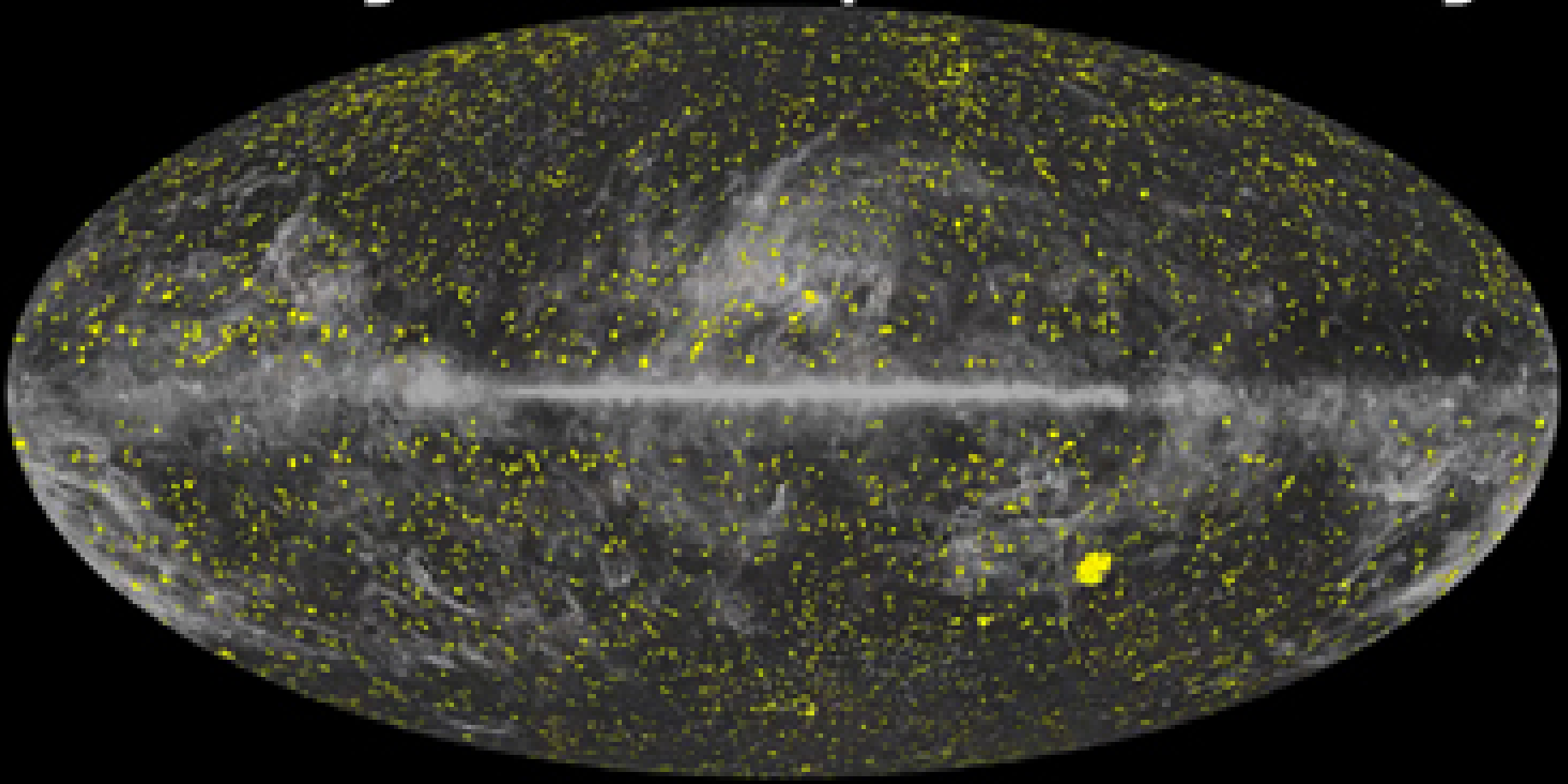


All compact sources

All sky	|b|>30
705	307
452	143
599	157
1381	332
1764	420
5470	691
6984	1123
7223	2535
8988	4513



Planck Early Release Compact Source Catalogue

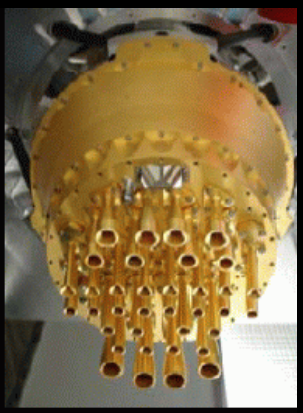


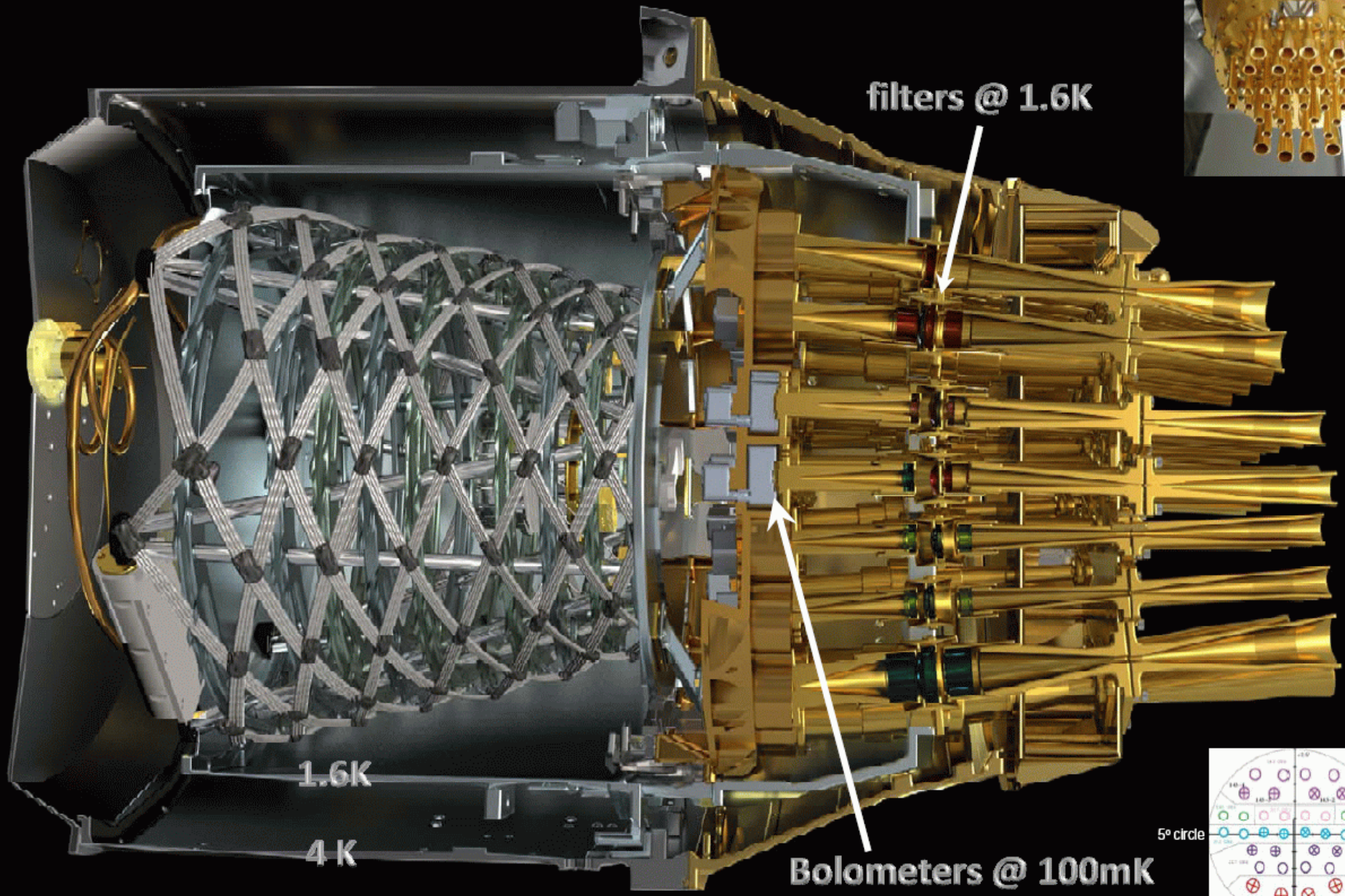
Extragalactic sources

Early Science Results from Planck:

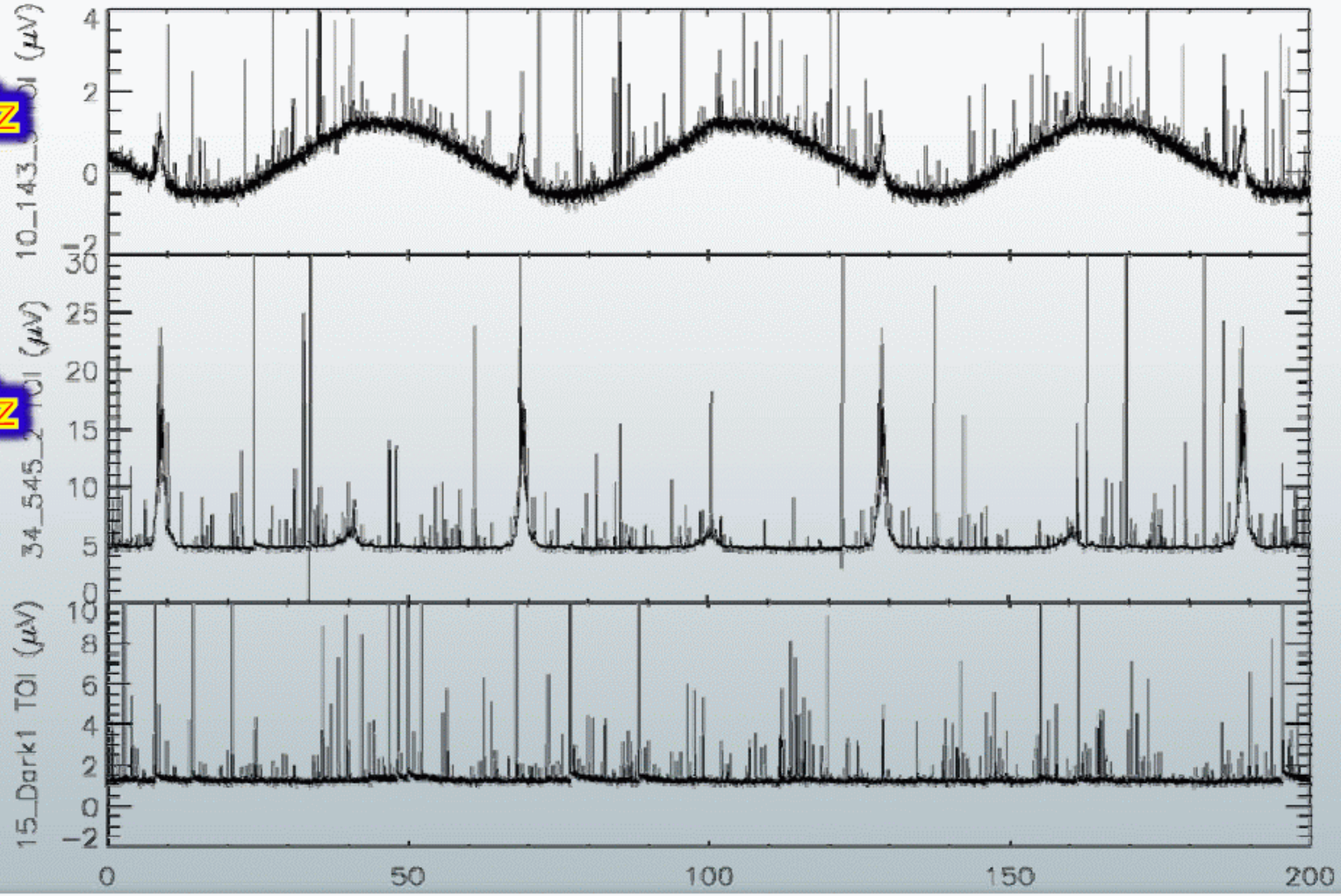
- Study of massive and distant clusters of galaxies via the Sunyaev-Zeldovich effect, and the relationship of the SZ flux with X-ray and optical properties
- Study of the Spectral Energy Distributions of radio sources, including data not only from Planck but other ground- and space-based observatories
- Study of dust emission in nearby infrared galaxies, based on the Planck and IRAS data
- Measurement of the angular power spectrum of the Cosmic Infrared Background
- Study of the radial distribution of molecular, neutral and ionised gas in the Milky Way
- Study of the physical properties of dust in both molecular clouds and the diffuse interstellar medium
- Study of the distribution and properties of the coldest clumps in the Milky Way, and in-depth studies of some specific objects
- Study of components of the interstellar medium whose properties the Planck data allows to pin down better: spinning grains, CO-less gas

HFI cut-away

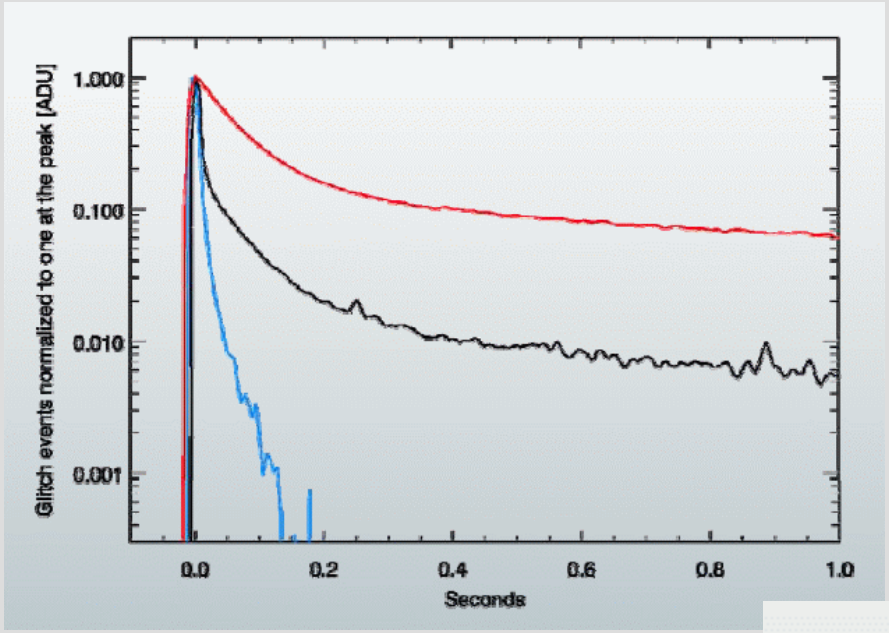


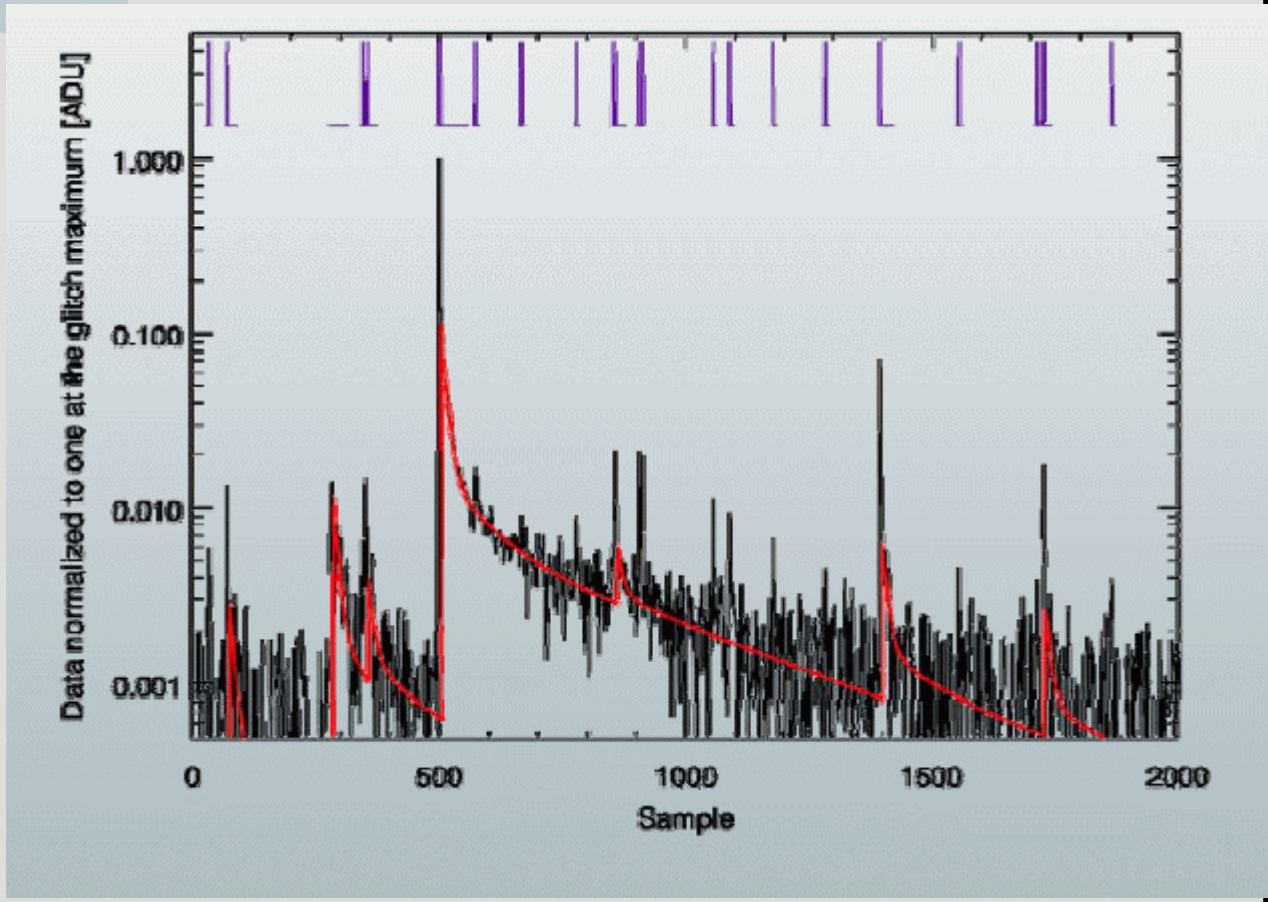


Raw Detector TOI (Time Ordered Information)



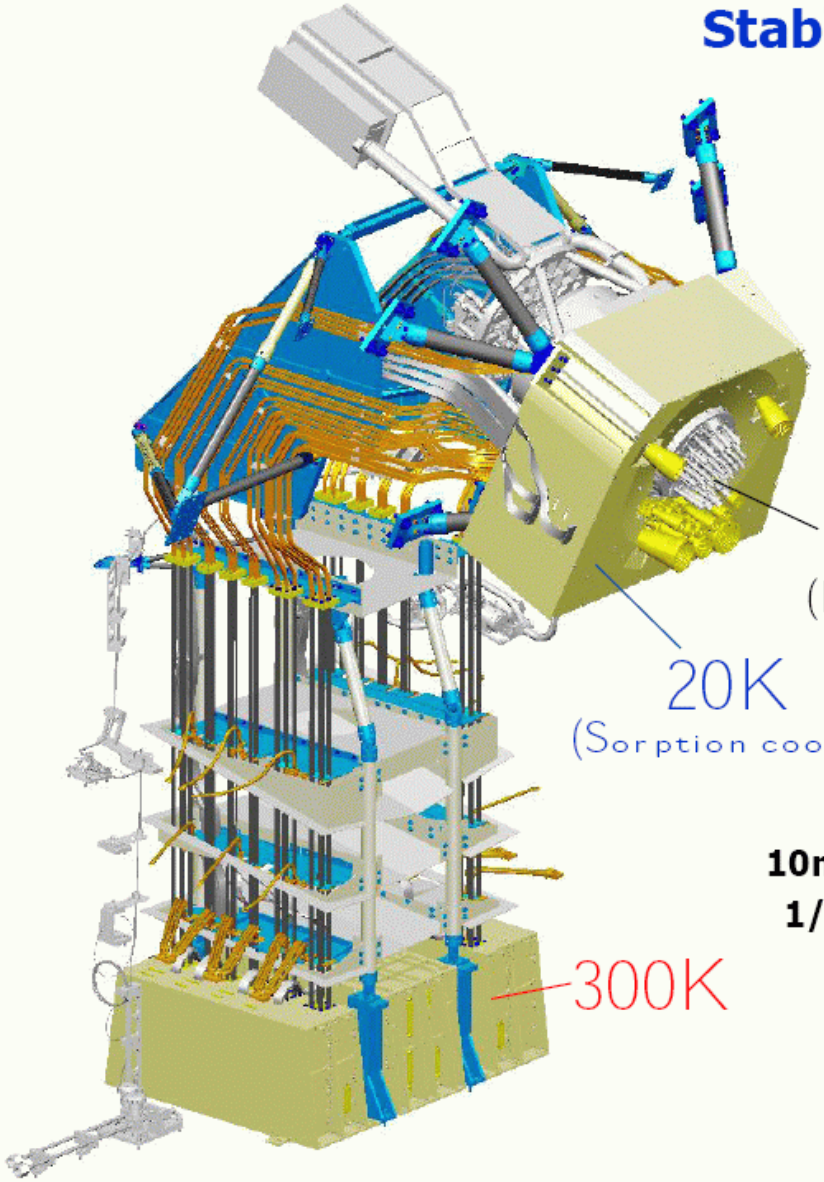
3 minutes of quasi 'raw" data (i.e. only demodulated).The Solar (cosmological) dipole is clearly visible at 145GHz with a 60 seconds period (the satellite rotates at 1 rpm), while the Galactic plane crossings (2 per rotation) are more visible at 545 GHz than at 143 GHz. The Dark bolometer sees no sky signal, but displays a similar population of glitches from cosmic rays.


Glitch events normalized to one at the peak [ADU]
1.000
0.100
0.010
0.001
0.0
0.2
0.4
0.6
0.8
1.0
Seconds


Data normalized to one at the glitch maximum [ADU]
1.000
0.100
0.010
0.001
0
500
1000
1500
2000
Sample

Planck-LFI: the Instrument

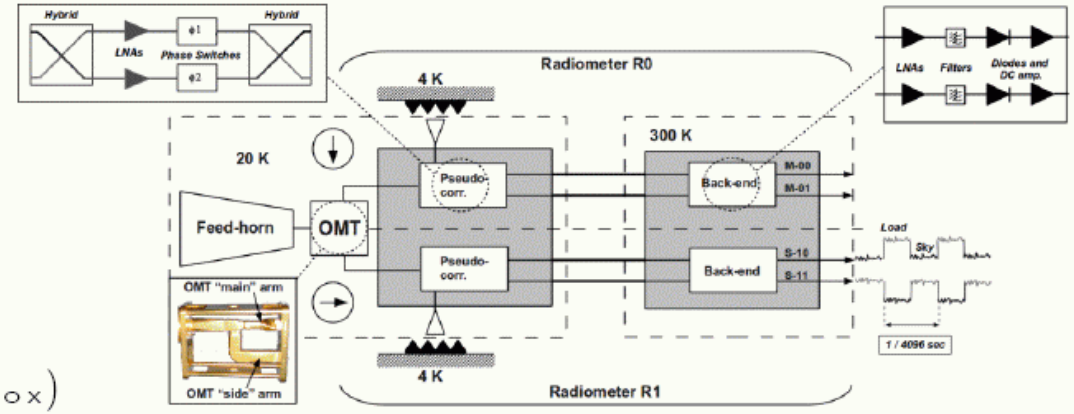
Sensitivity, stability & low systematics



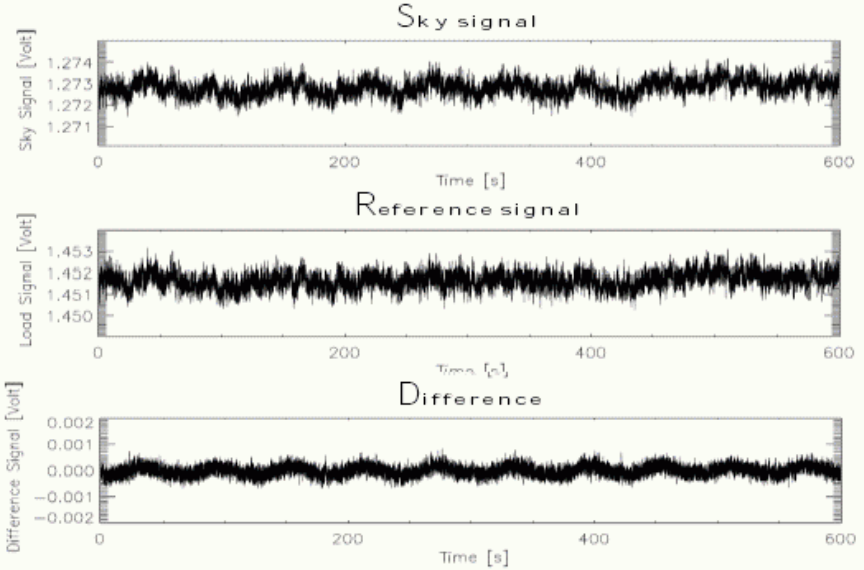
(MB et al 2010, Mandolesi et al 2010)

Stability (f_K < 50 mHz) & Low systematics (~1μK)

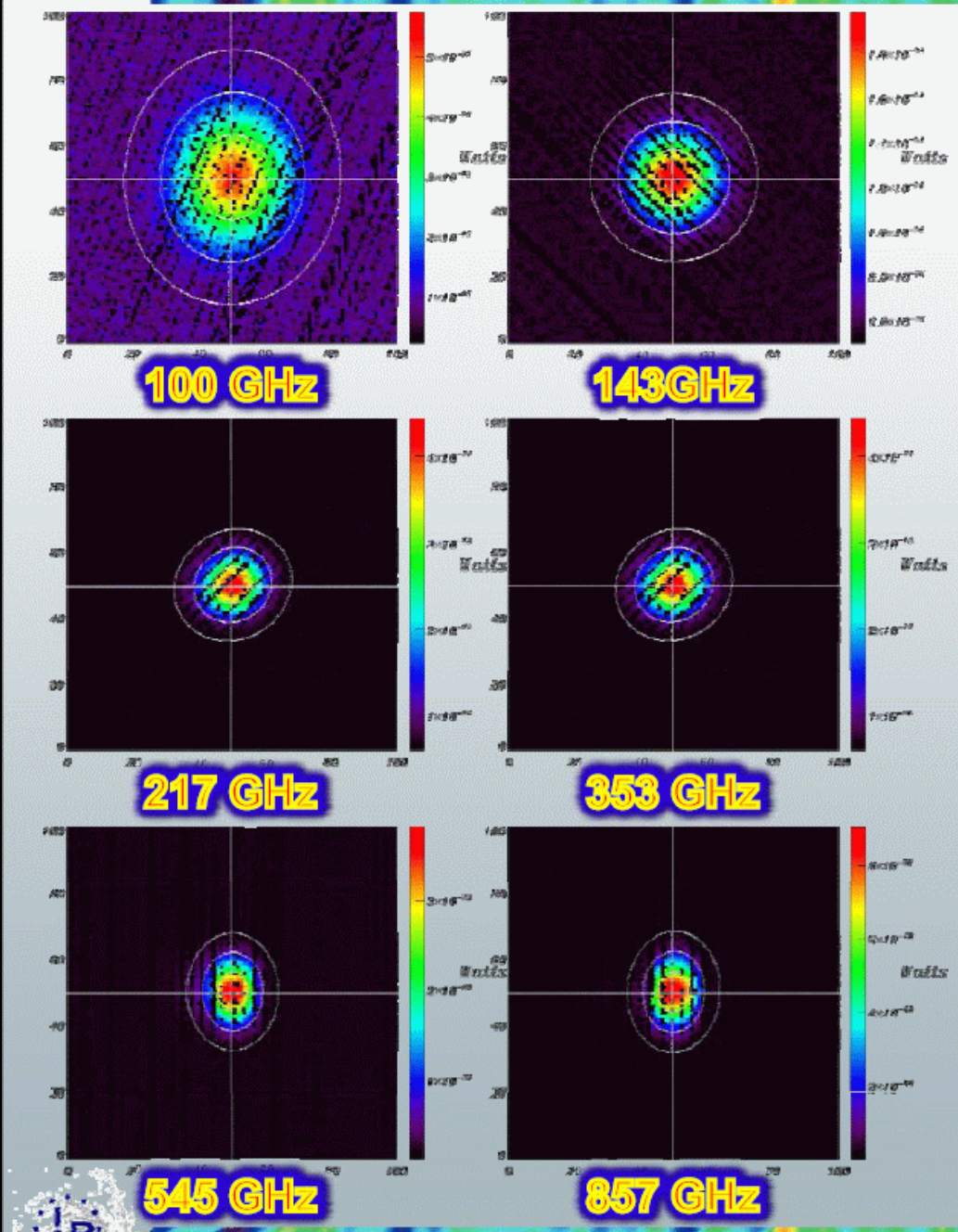
- Pseudo-correlation radiometer design
- Refs cooled to 4K

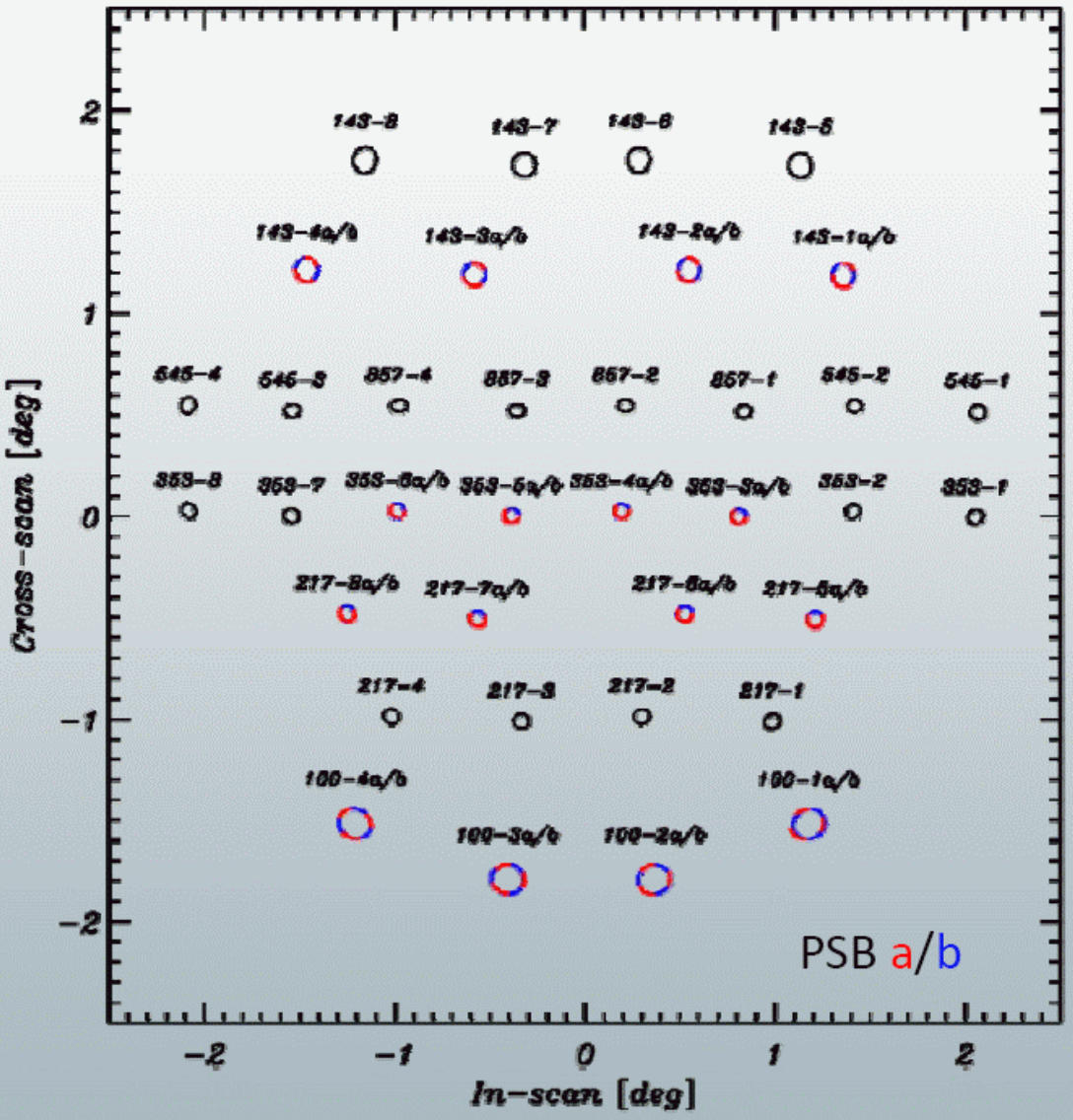


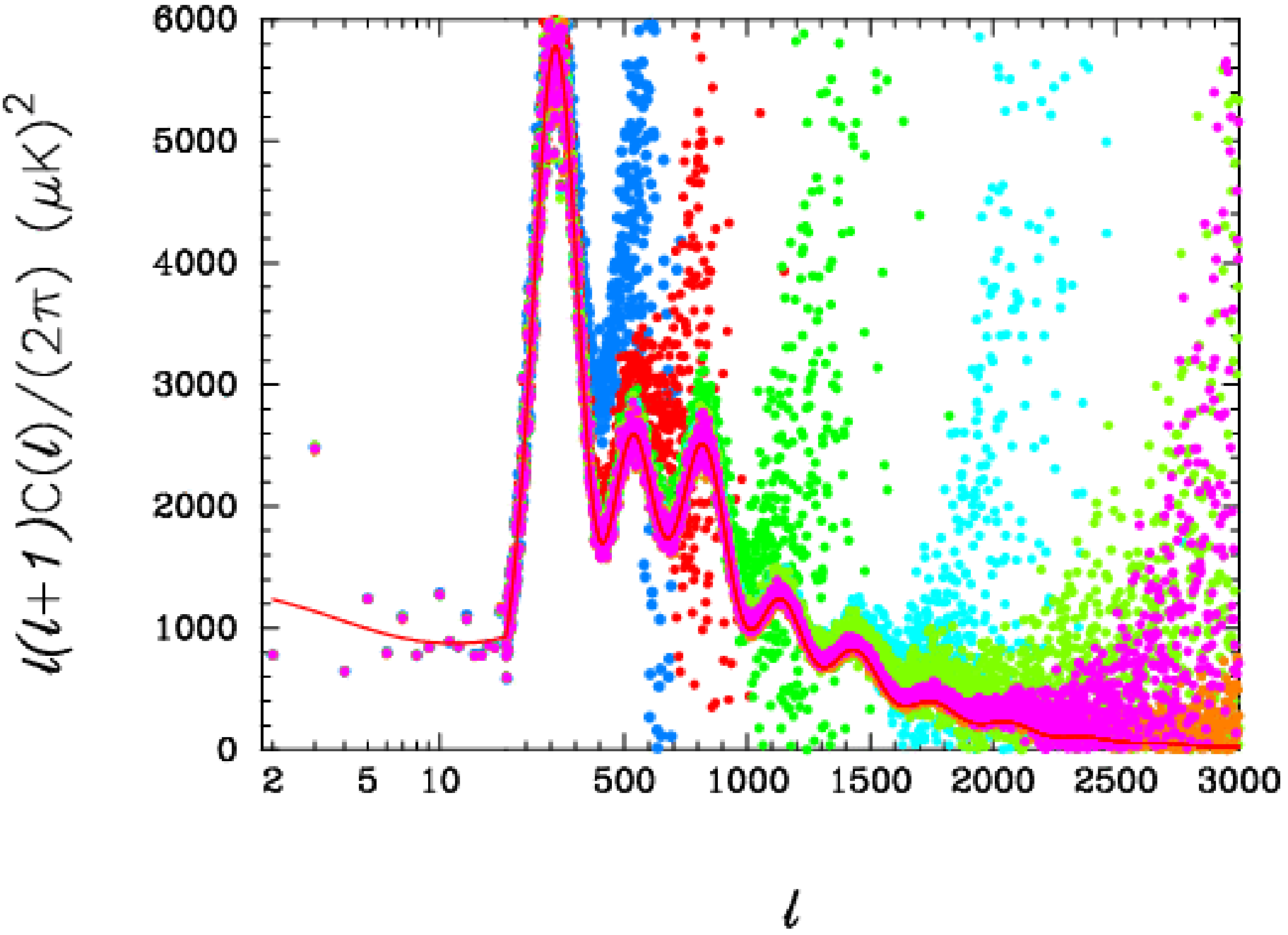
10min of flight data
1/44 LFI detectors
(LFI27S-11)



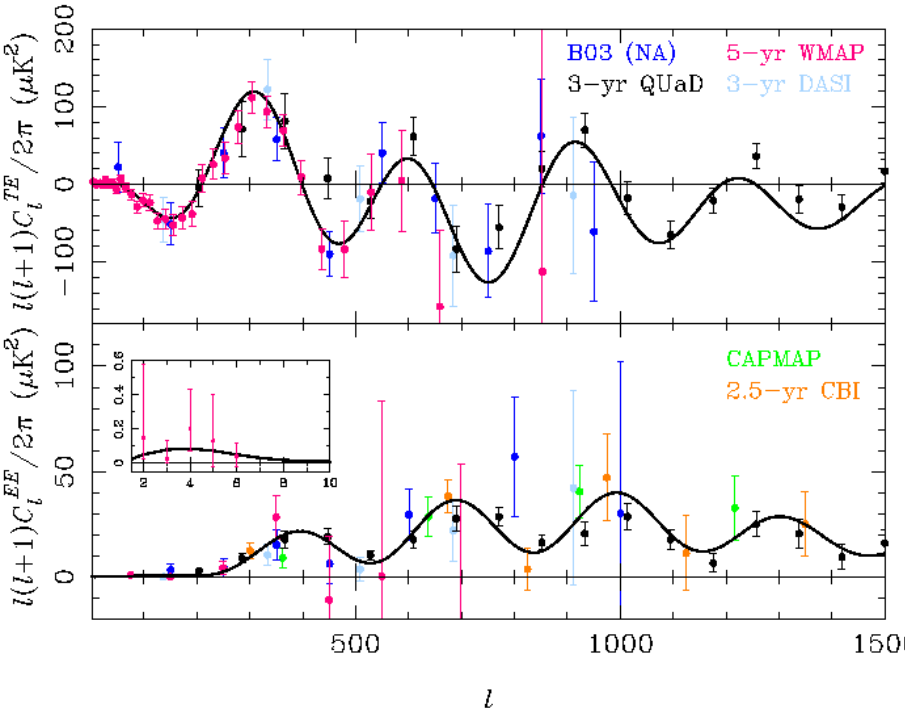
Scanning Mars



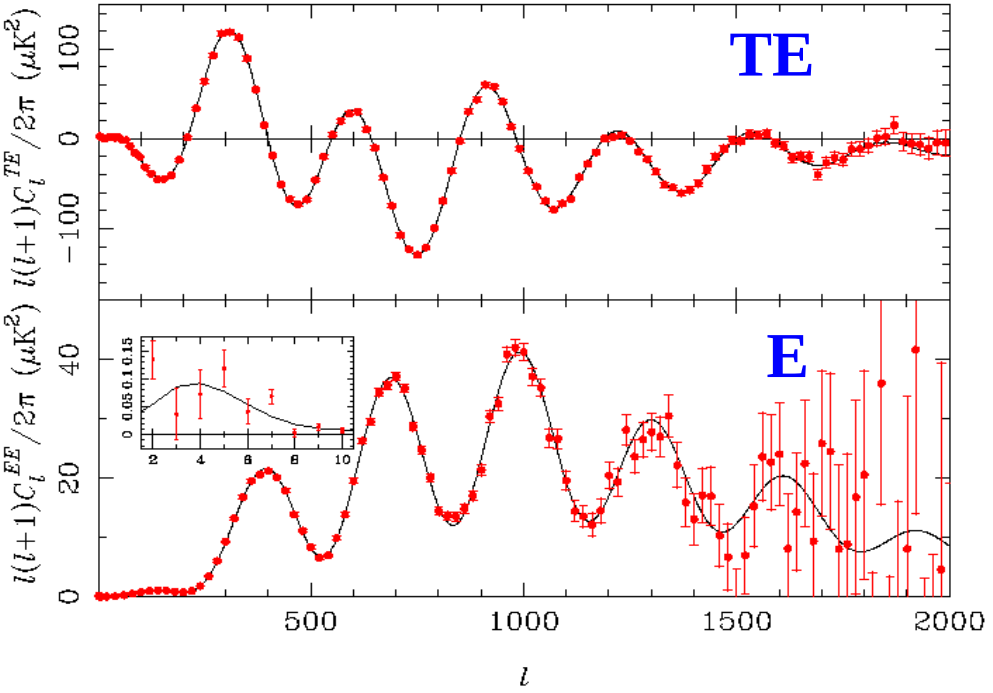


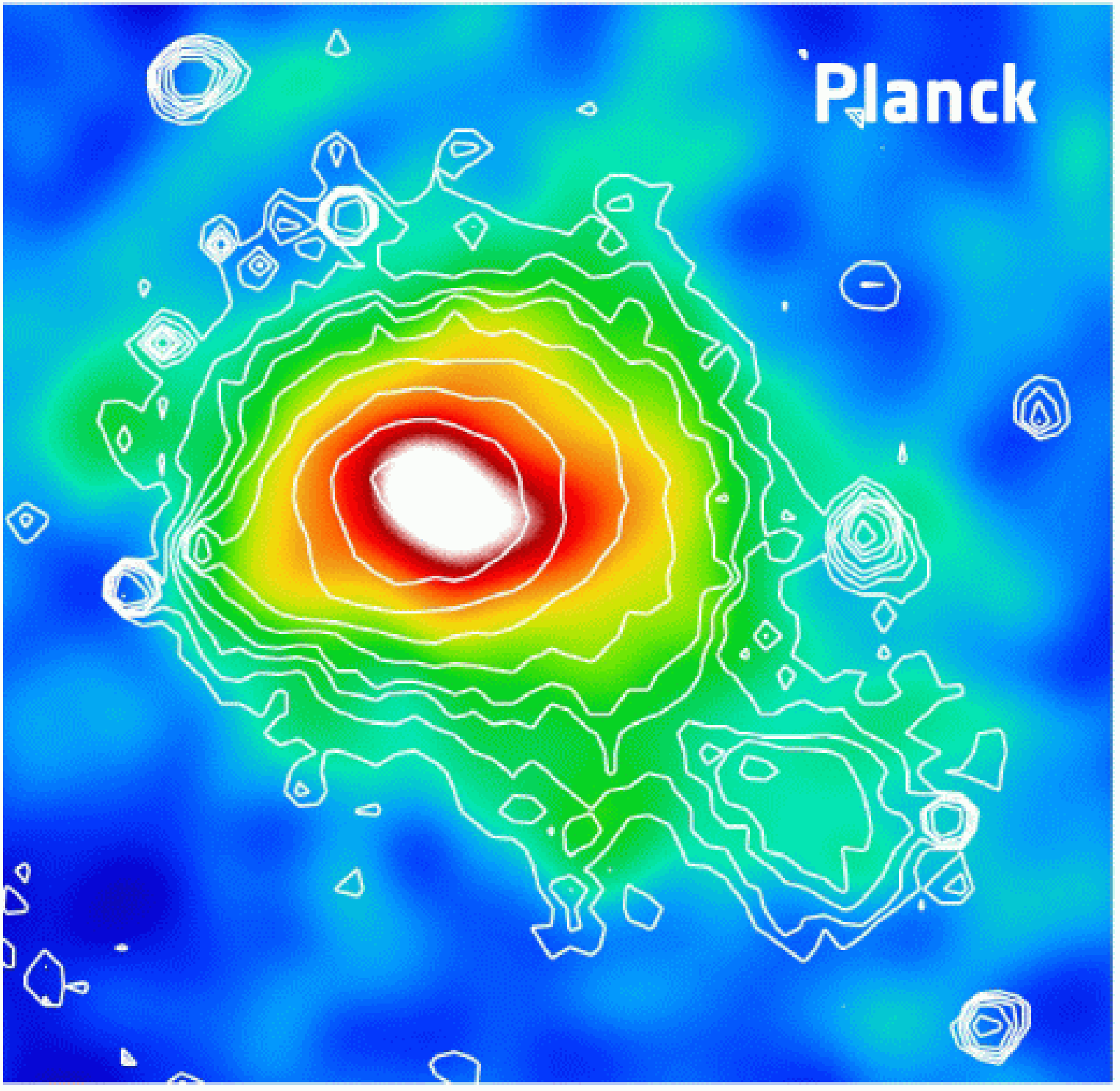

$l(l+1)C(l)/(2\pi)\ (\mu K)^2$
6000
5000
4000
3000
2000
1000
0
2
5
10
500
1000
1500
2000
2500
3000
l

CURRENT OBSERVATIONS



PLANCK FORECAST

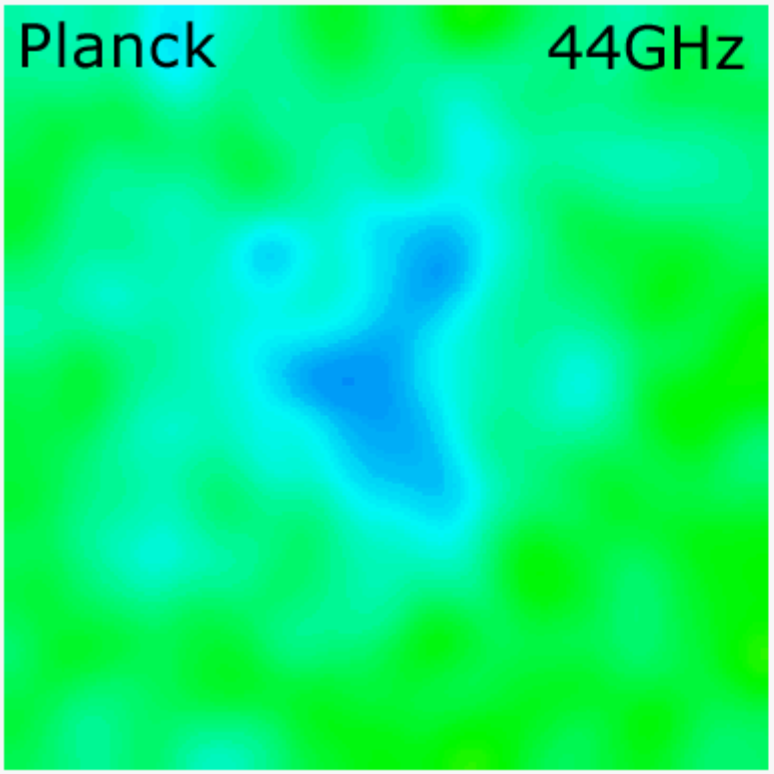


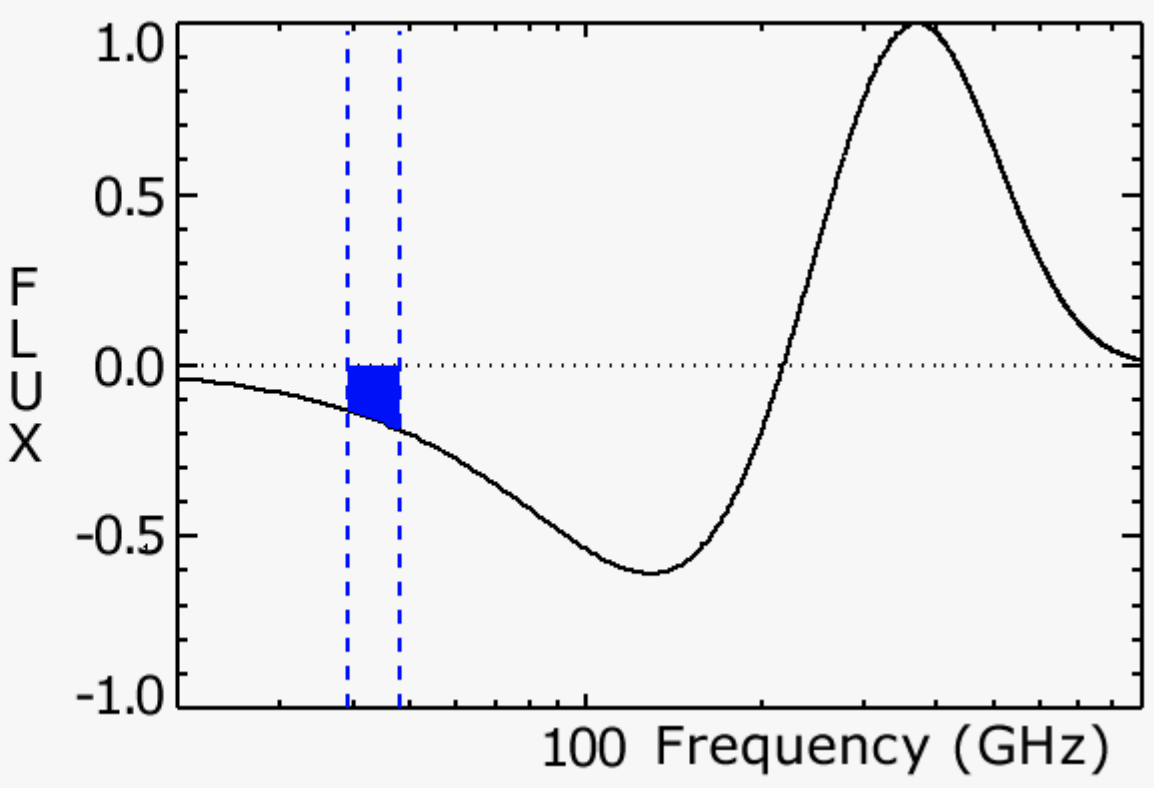

Planck

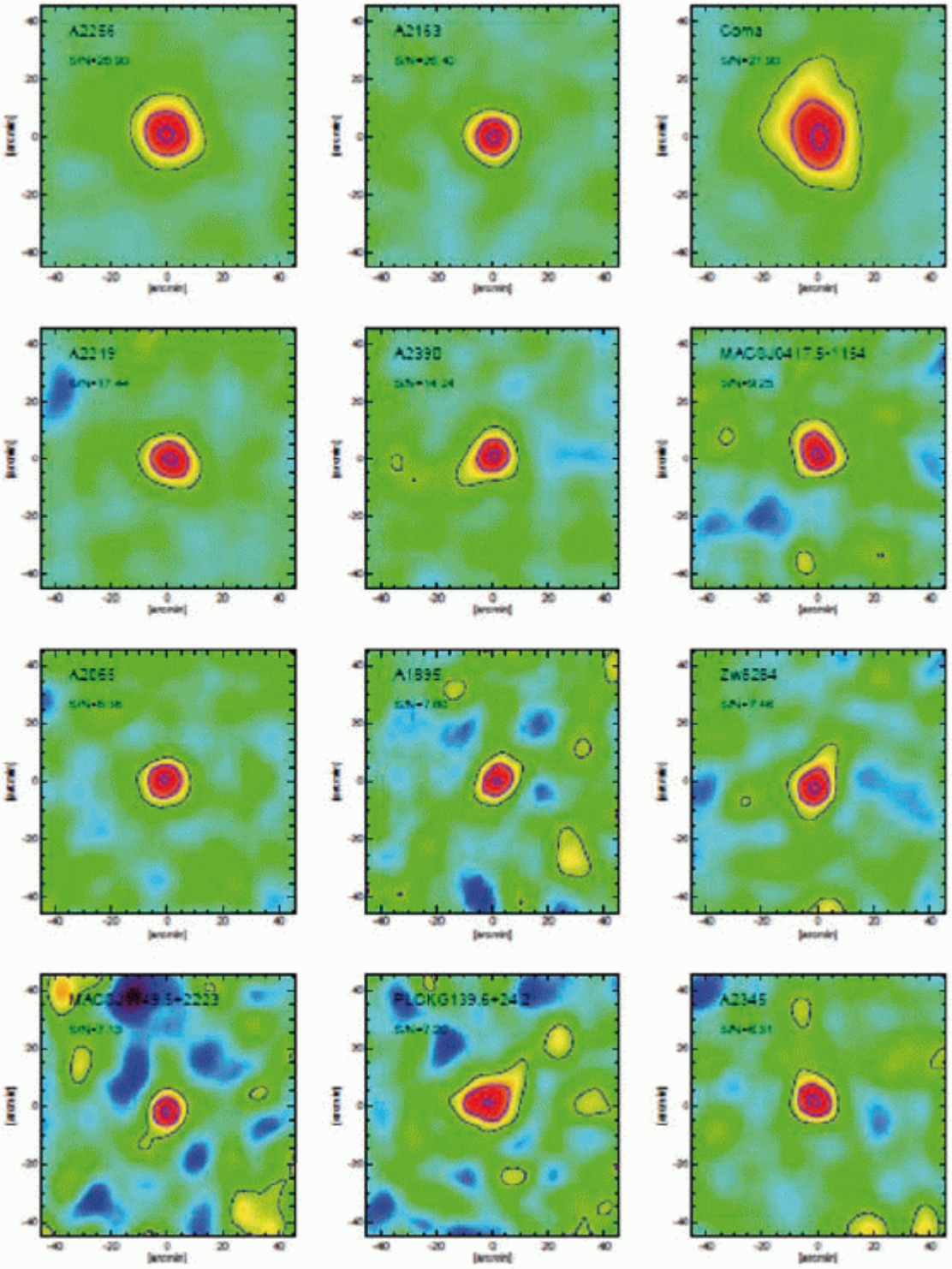
Thermal Sunyaev-Zeldovich Effect

$$\frac{\Delta T}{T}(\theta) = f(x)\frac{\sigma_T}{m_e c^2}\int n_e(r)T_e(r)dl_{\rm los}$$

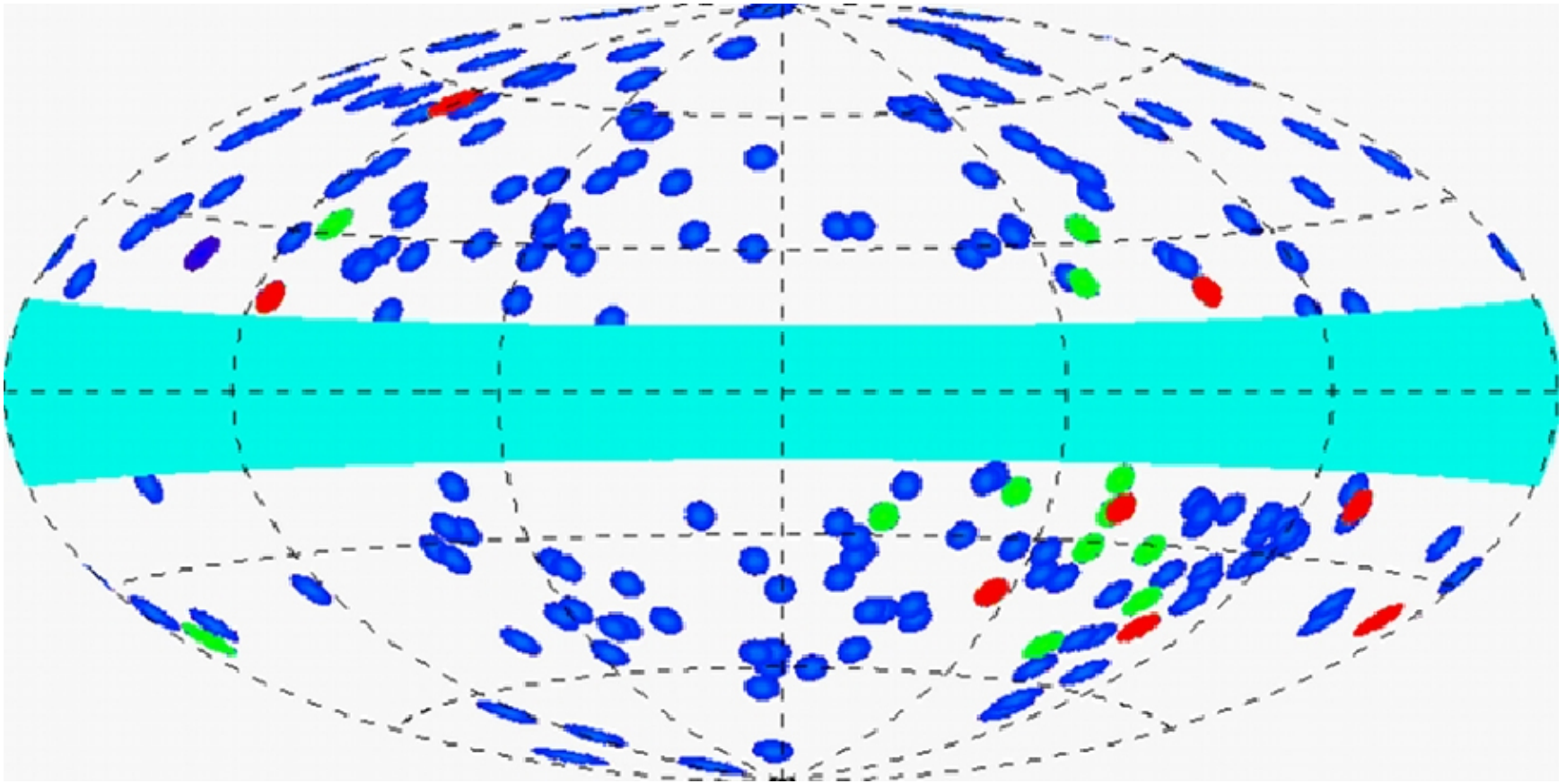
$$f(x) = x\frac{(e^x+1)}{(e^x-1)} - 4, \quad x = \left(\frac{h\nu}{kT_\gamma}\right)$$







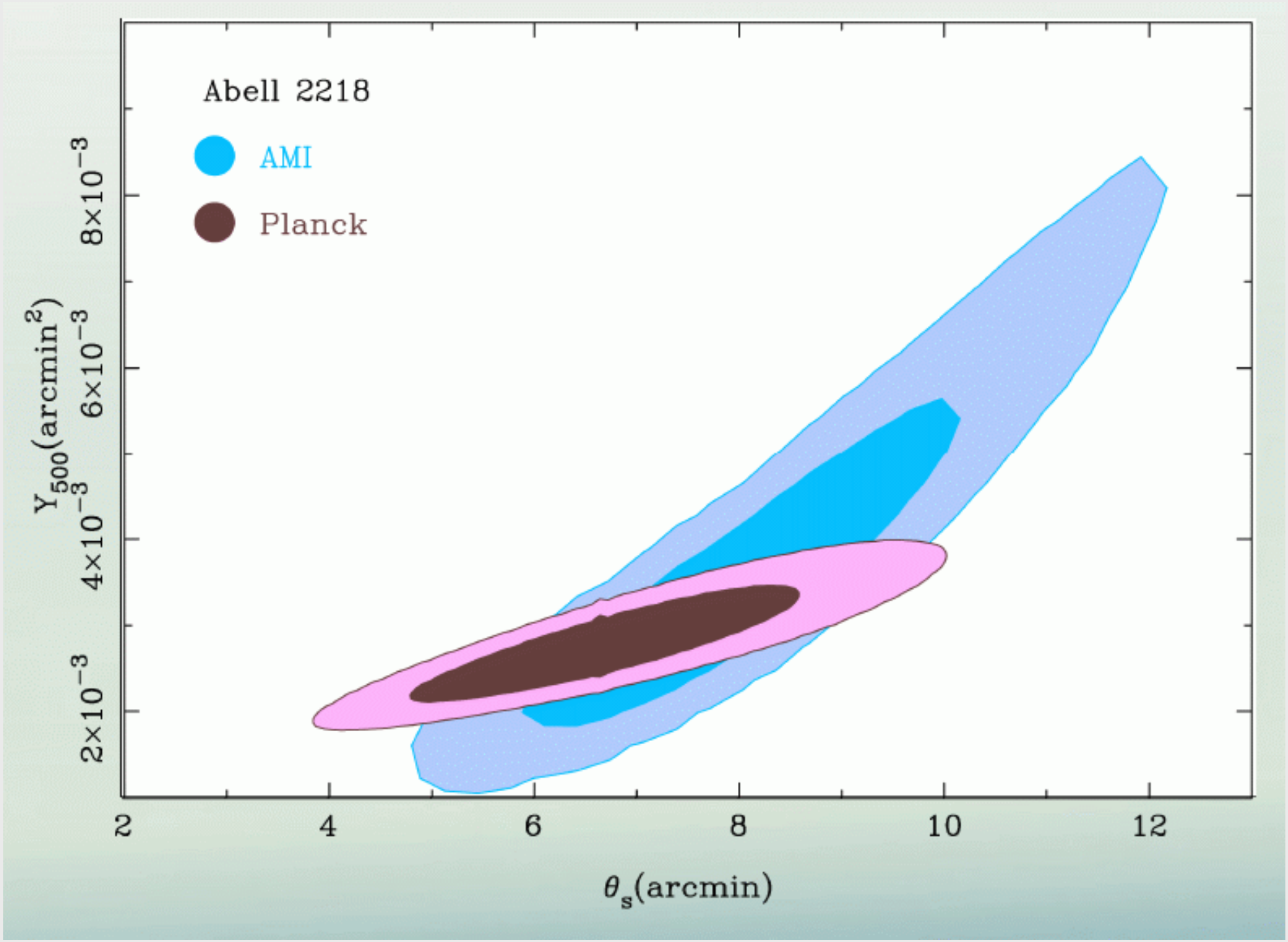
Gallery of some Planck ESZ clusters

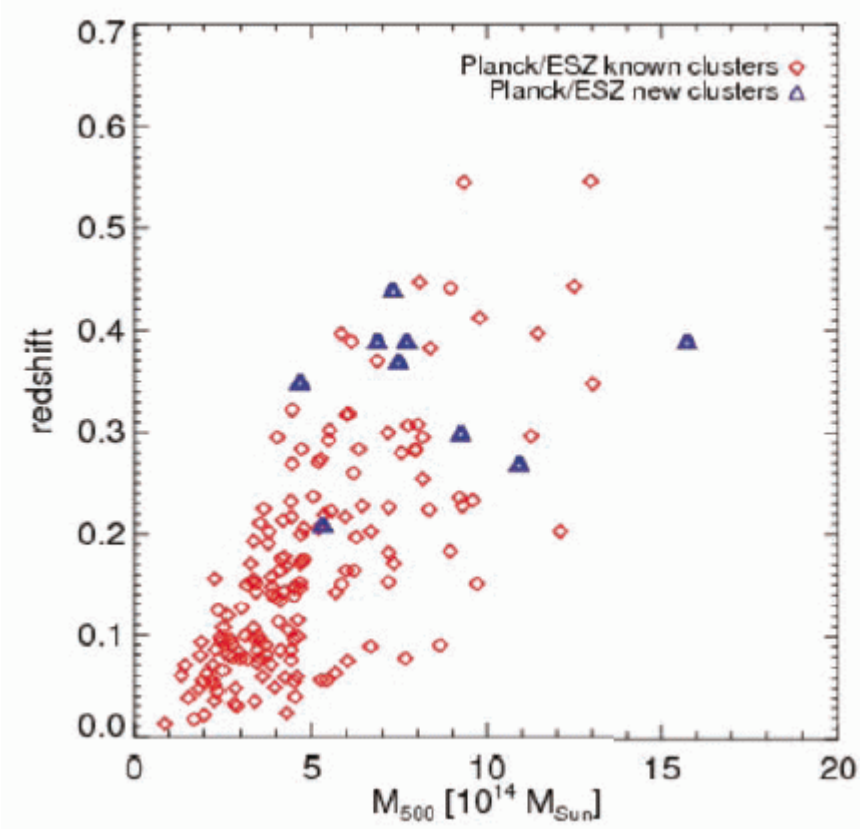


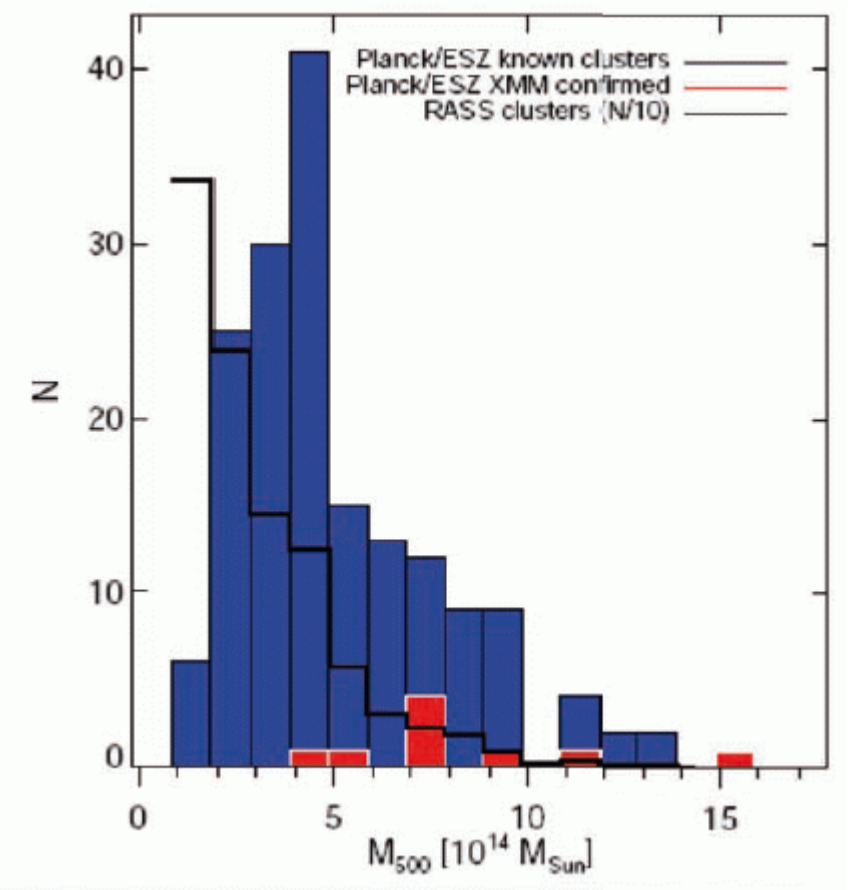
Known X-ray clusters

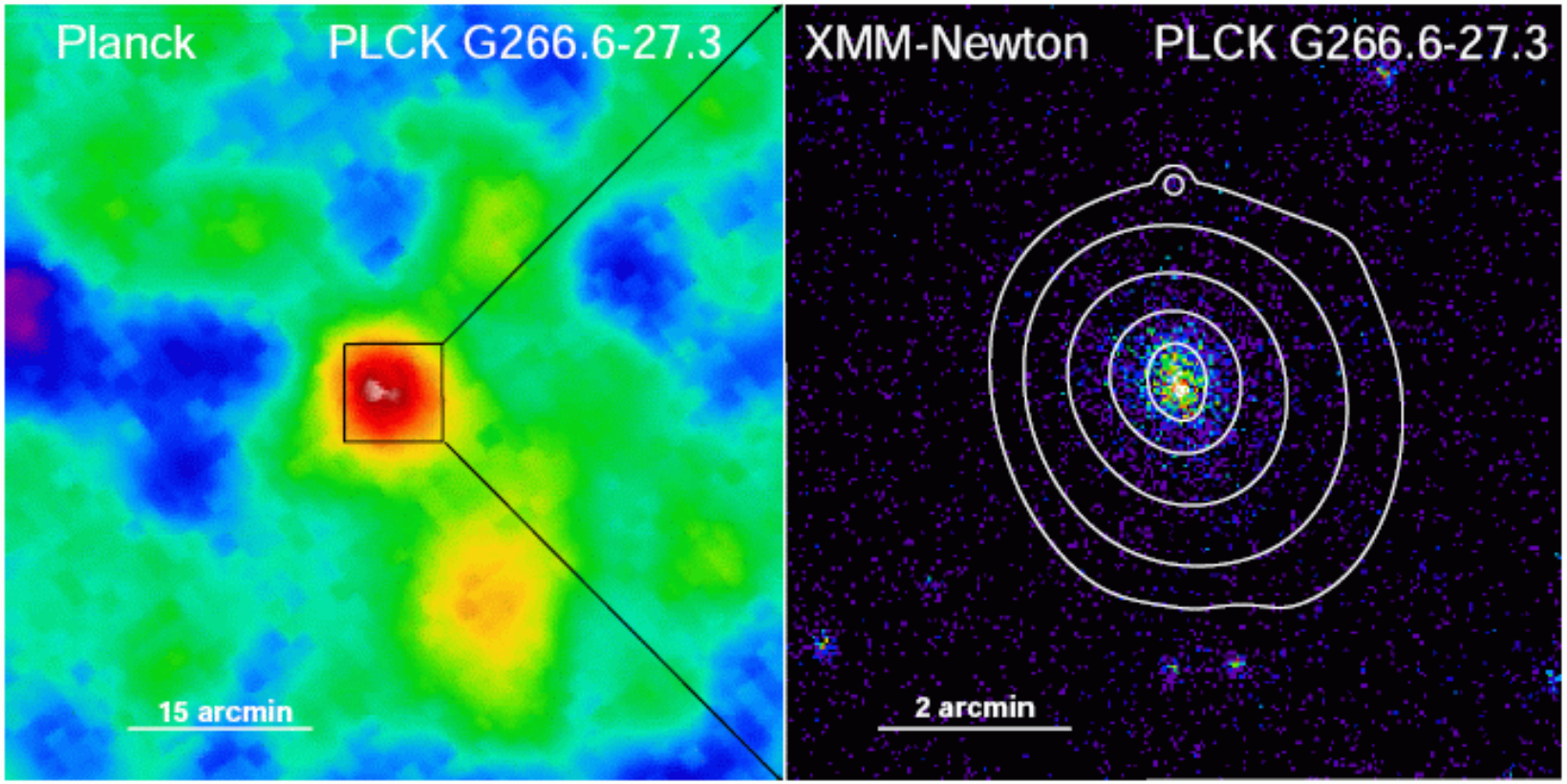
Confirmed by XMM

Unconfirmed


Abell 2218
AMI
Planck
$Y_{500}(\mathrm{arcmin}^2)$
2×10^{-3}
4×10^{-3}
6×10^{-3}
8×10^{-3}
2
4
6
8
10
12
$\theta_s(\mathrm{arcmin})$


Planck/ESZ known clusters
Planck/ESZ new clusters
redshift
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
5
10
15
20
M500 [10^14 MSun]

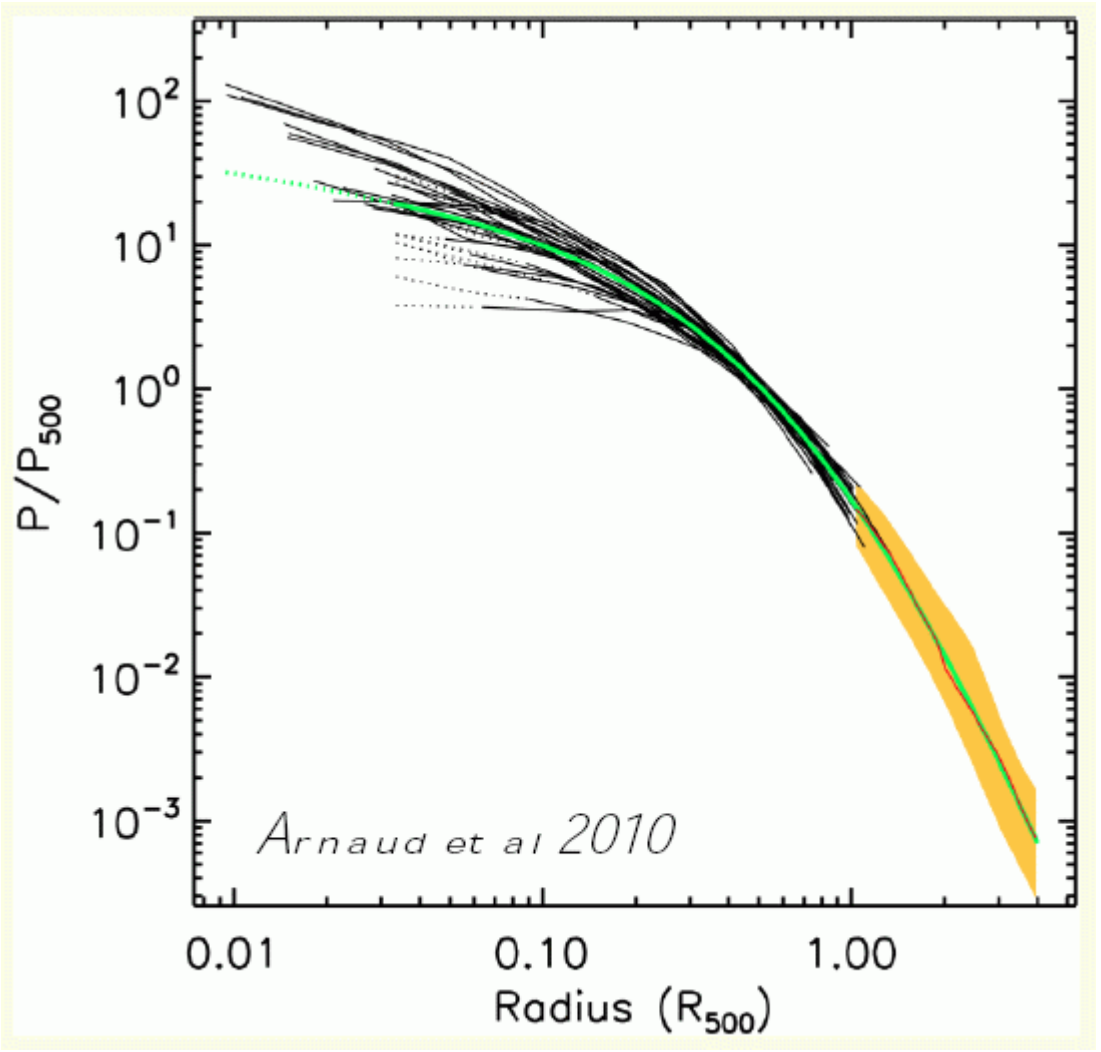

Planck/ESZ known clusters
Planck/ESZ XMM confirmed
RASS clusters (N/10)
N
0
10
20
30
40
0
5
10
15
M500 [10^14 MSun]



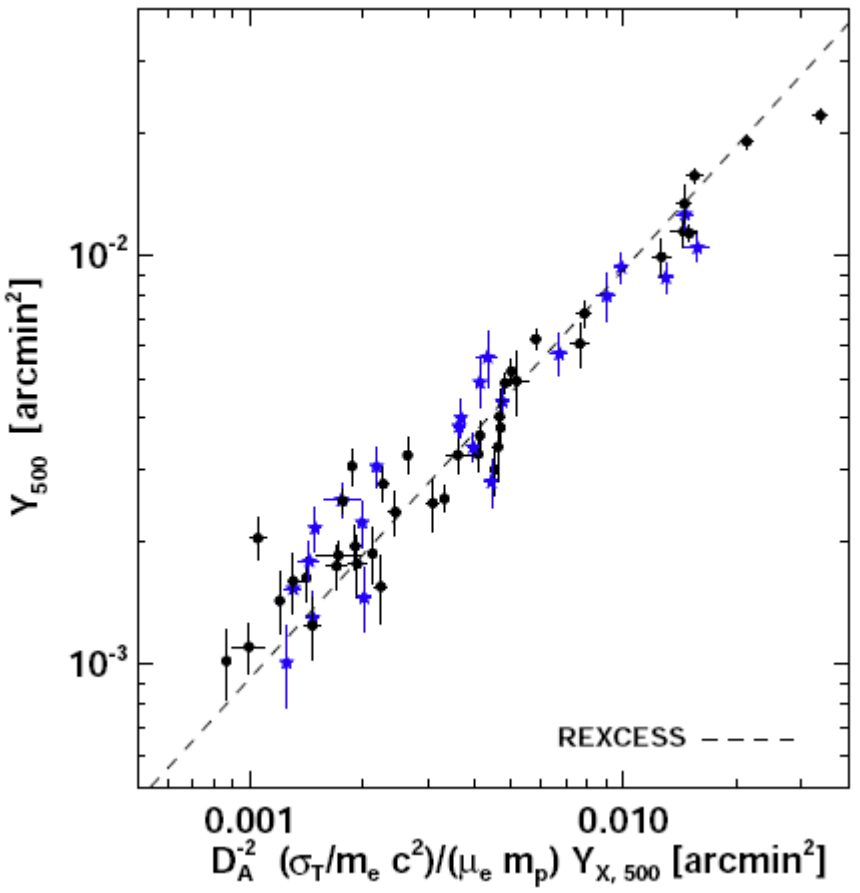
$$z = 0.94 \pm 0.02$$

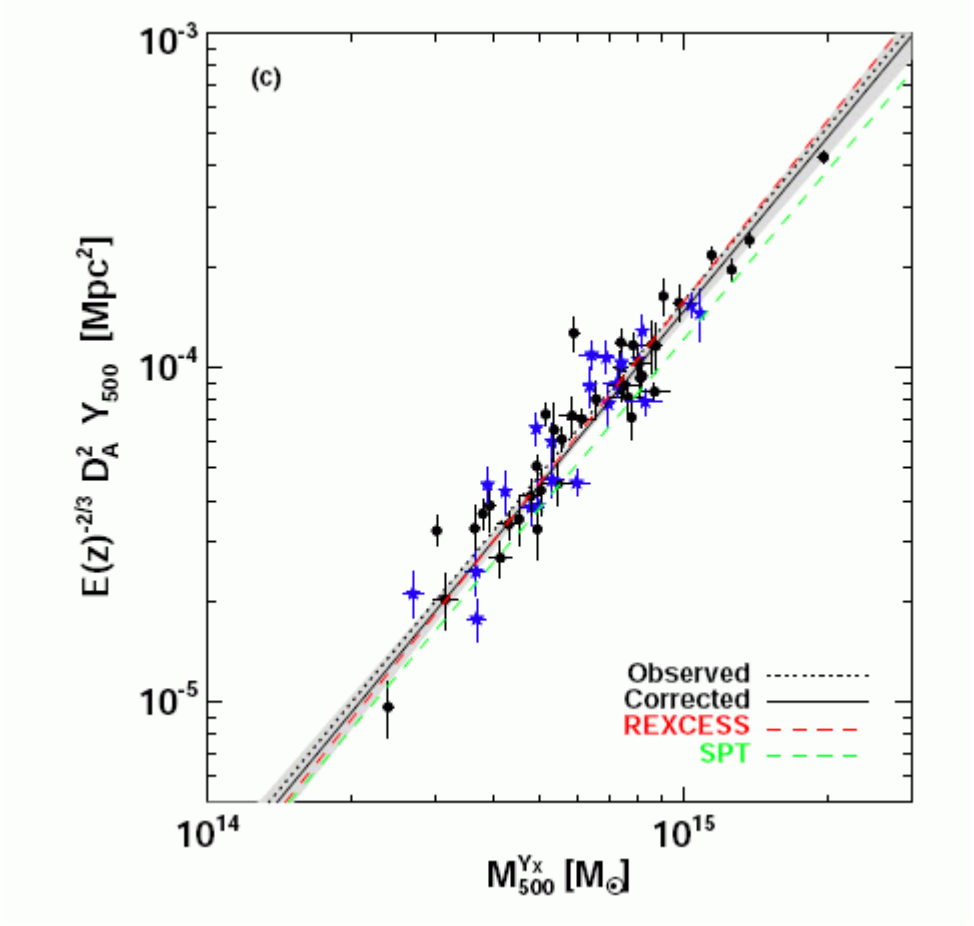
$$M_{500} = 7.8 \pm 0.8 \times 10^{14} M_{\odot}$$

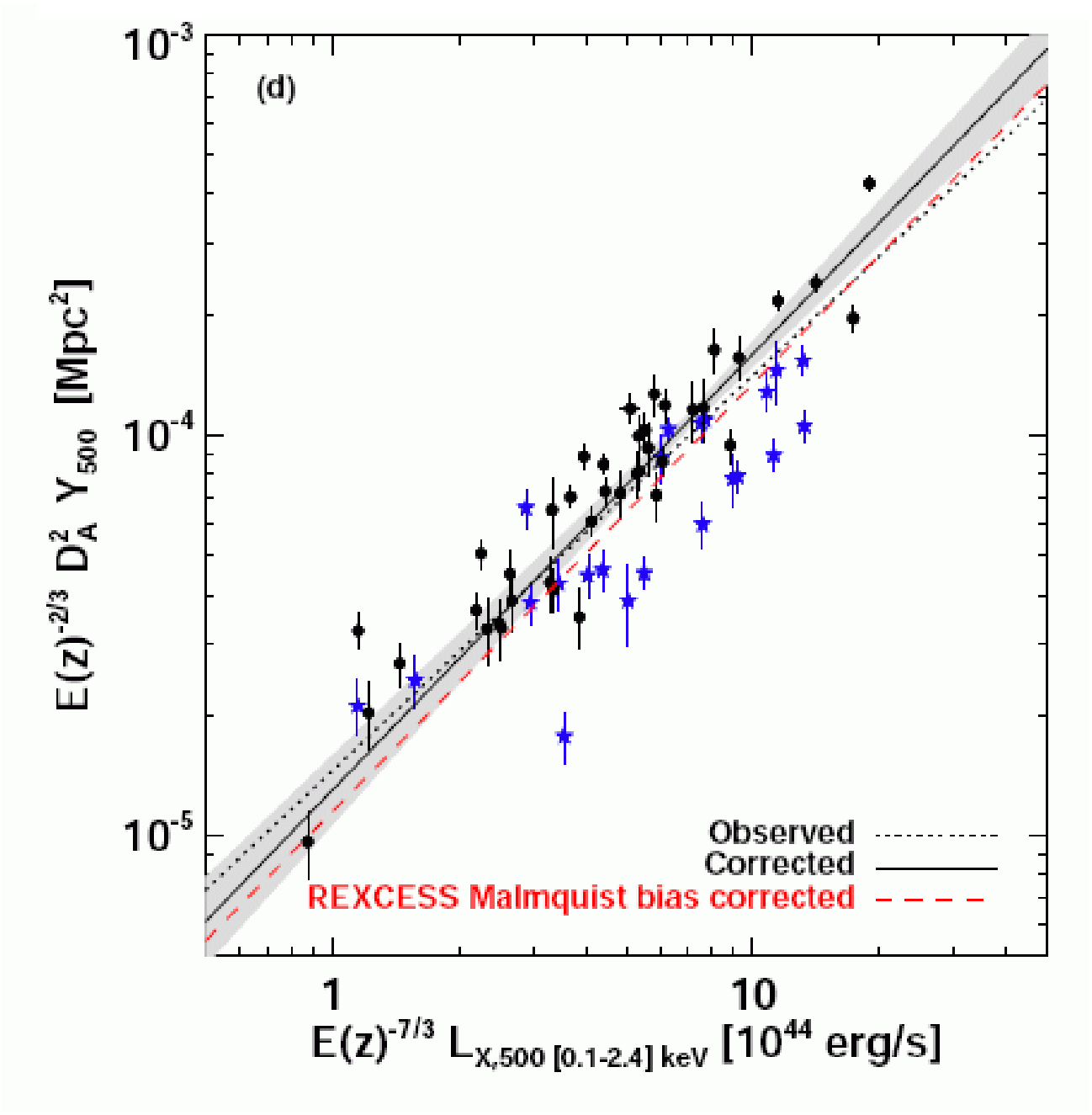
$$L_X = 1.4 \times 10^{45} \mathrm{erg/s}$$


10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
P/P500
Arnaud et al 2010
0.01
0.10
1.00
Radius (R500)

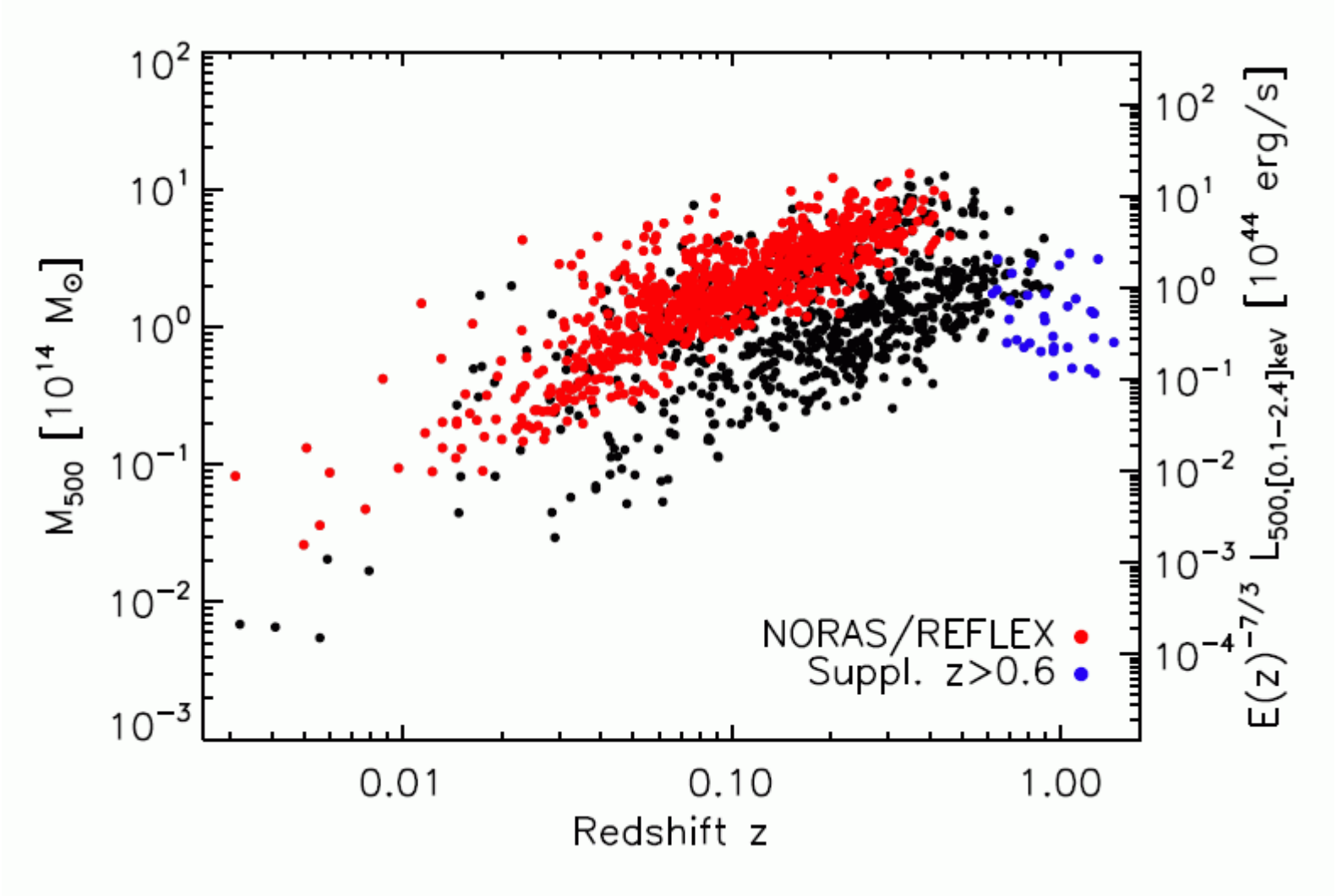
Planck view of 'well observed' X-ray Clusters:

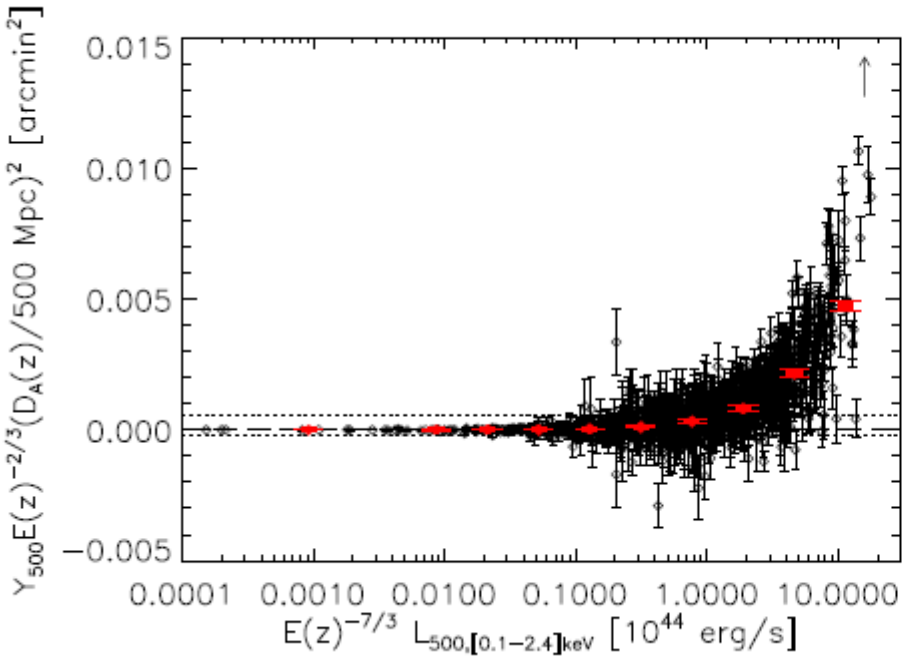


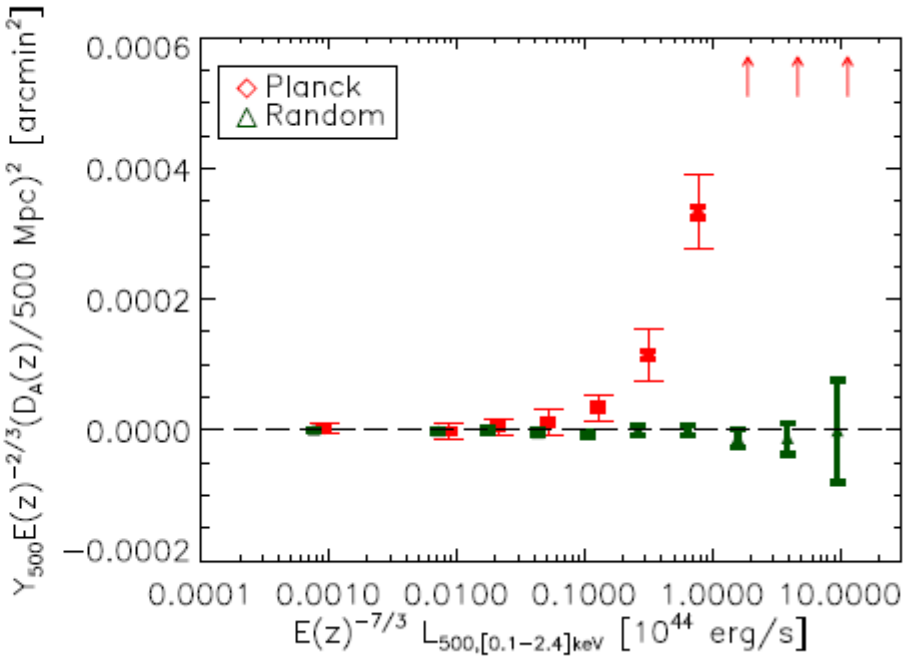


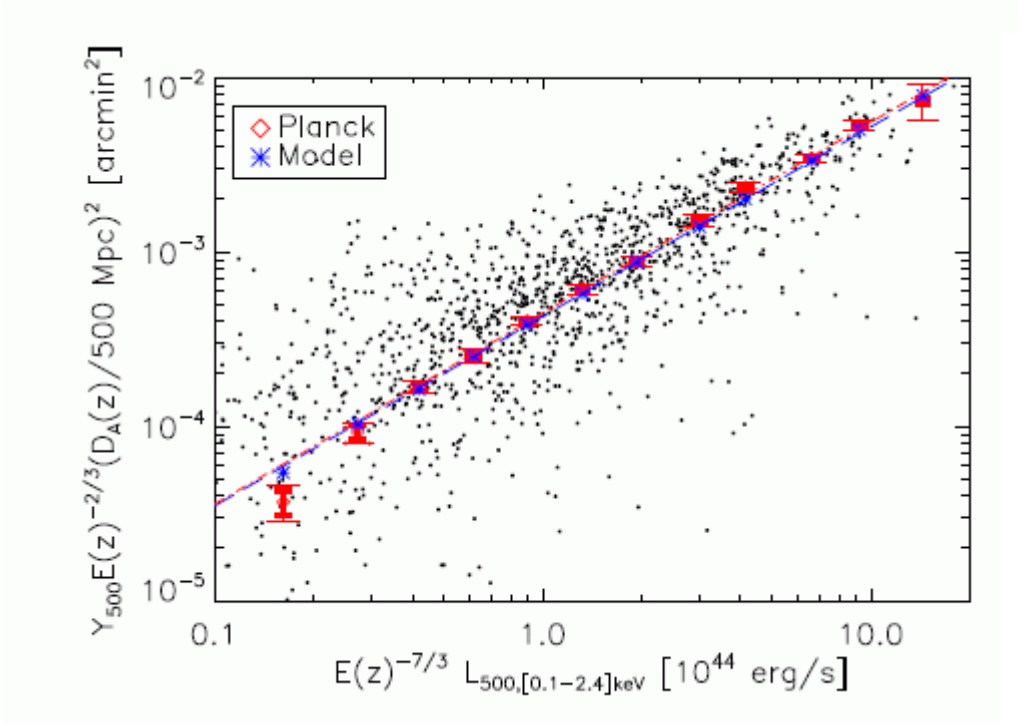

(d)
10^{-3}
10^{-4}
10^{-5}
$E(z)^{-2/3}\ D_A^2\ Y_{500}$ [Mpc^2]
1
10
$E(z)^{-7/3}\ L_{X,500\ [0.1\text{-}2.4]\ keV}$ [10^{44} erg/s]
Observed
Corrected
REXCESS Malmquist bias corrected

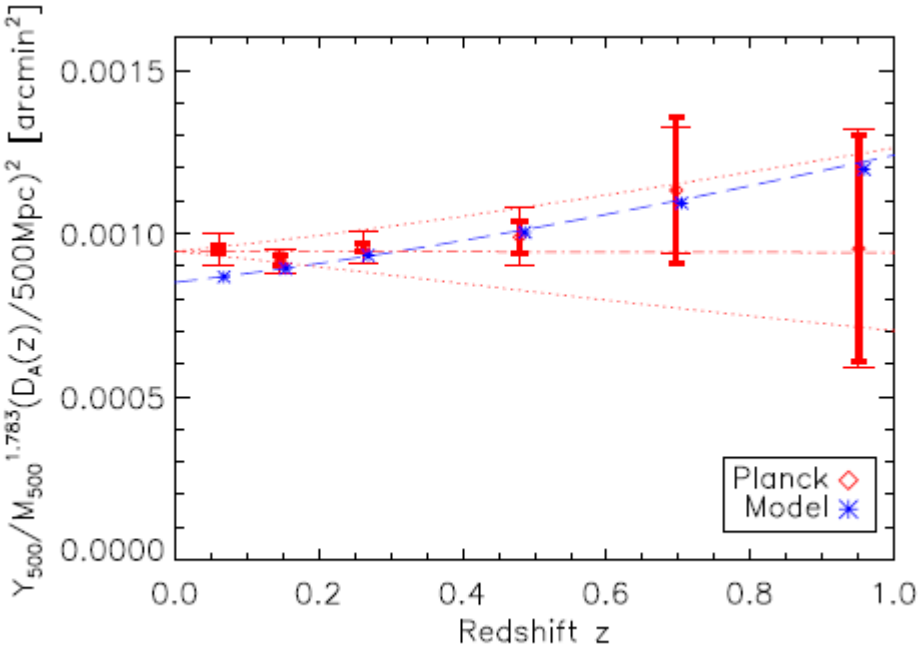
Planck 'statistical' view X-ray Clusters:



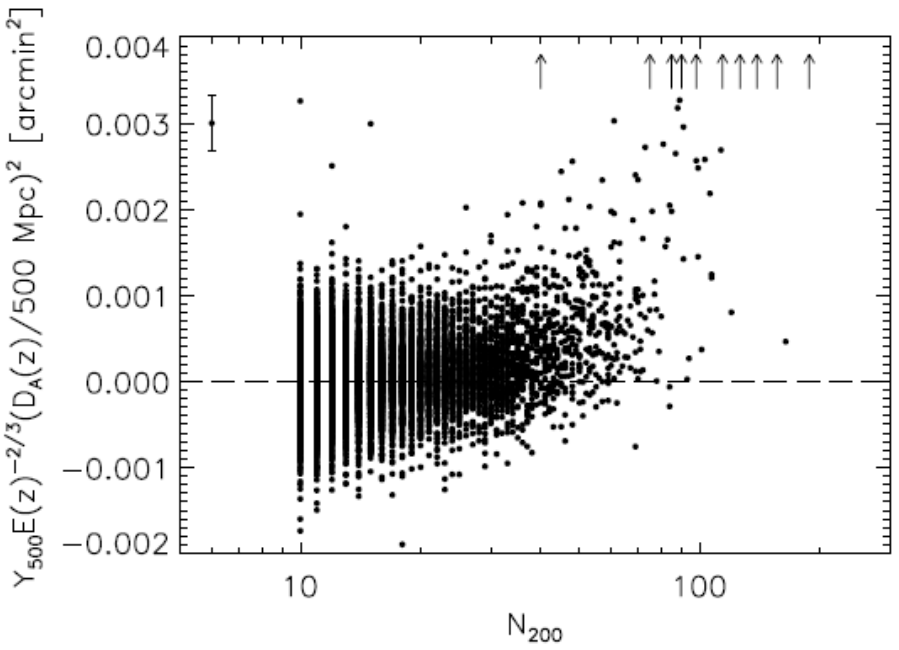

0.015
0.010
0.005
0.000
−0.005
0.0001
0.0010
0.0100
0.1000
1.0000
10.0000
$Y_{500}E(z)^{-2/3}(D_A(z)/500\ \mathrm{Mpc})^2$ [arcmin^2]
$E(z)^{-7/3}\ L_{500,[0.1-2.4]\mathrm{keV}}$ [10^{44} erg/s]

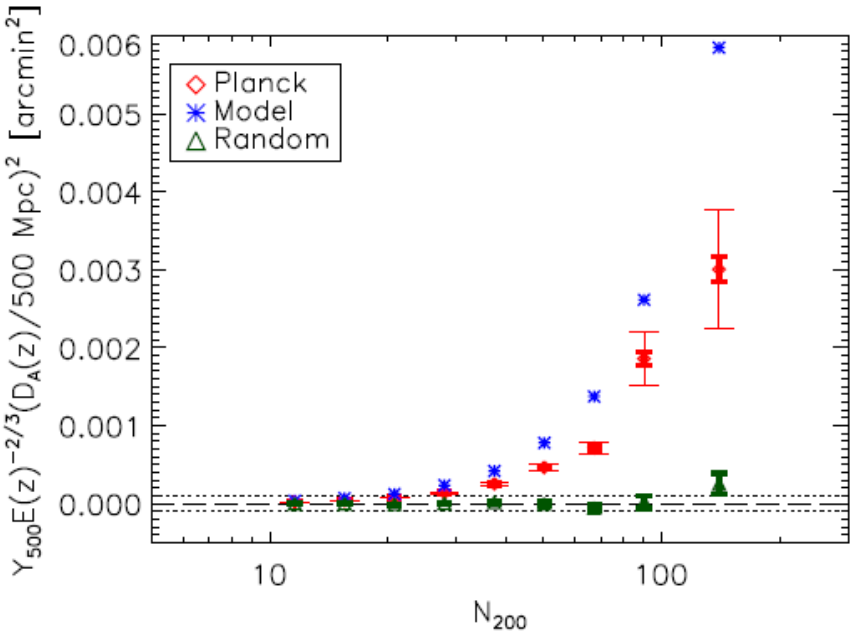

Planck
Random
0.0006
0.0004
0.0002
0.0000
−0.0002
0.0001
0.0010
0.0100
0.1000
1.0000
10.0000
$Y_{500}E(z)^{-2/3}(D_A(z)/500\ \mathrm{Mpc})^2$ [arcmin^2]
$E(z)^{-7/3}\ L_{500,[0.1-2.4]\mathrm{keV}}$ [10^{44} erg/s]

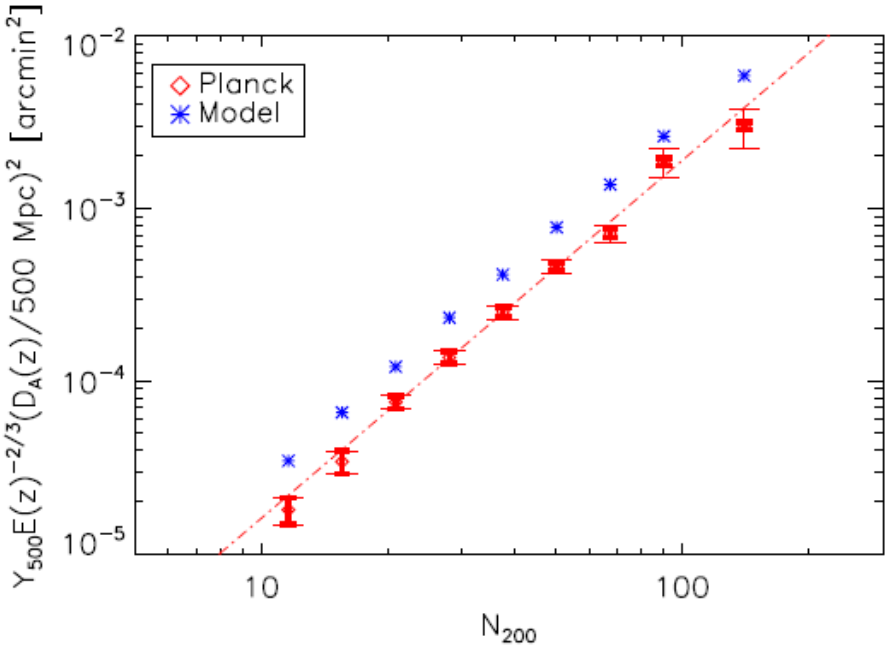

Planck
Model
$Y_{500}E(z)^{-2/3}(D_A(z)/500\ Mpc)^2$ [arcmin^2]
$E(z)^{-7/3}\ L_{500,[0.1-2.4]keV}$ [10^{44} erg/s]
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0.1
1.0
10.0

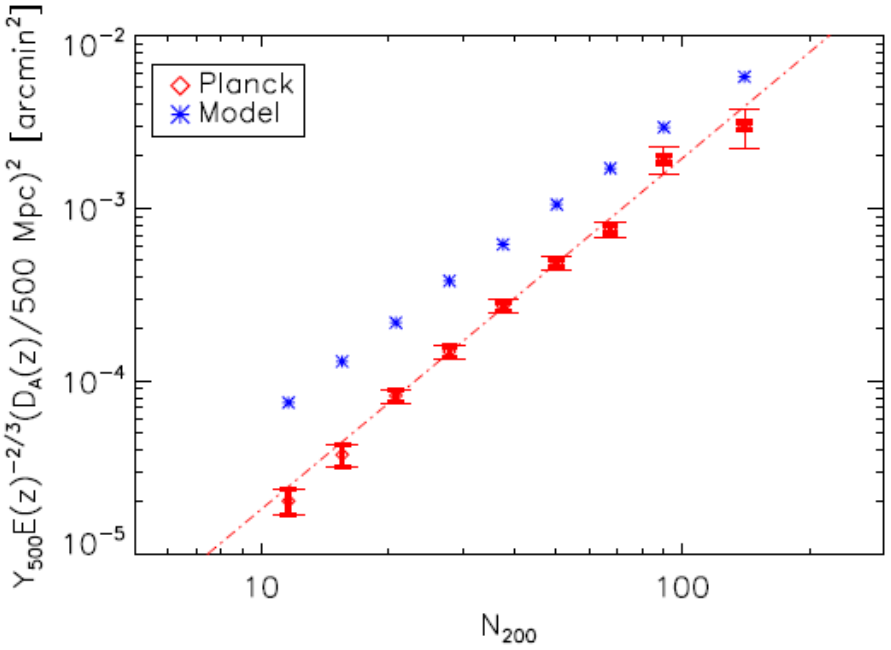

Planck
Model
$Y_{500}/M_{500}^{1.783}(D_A(z)/500Mpc)^2$ [arcmin^2]
Redshift z
0.0015
0.0010
0.0005
0.0000
0.0
0.2
0.4
0.6
0.8
1.0

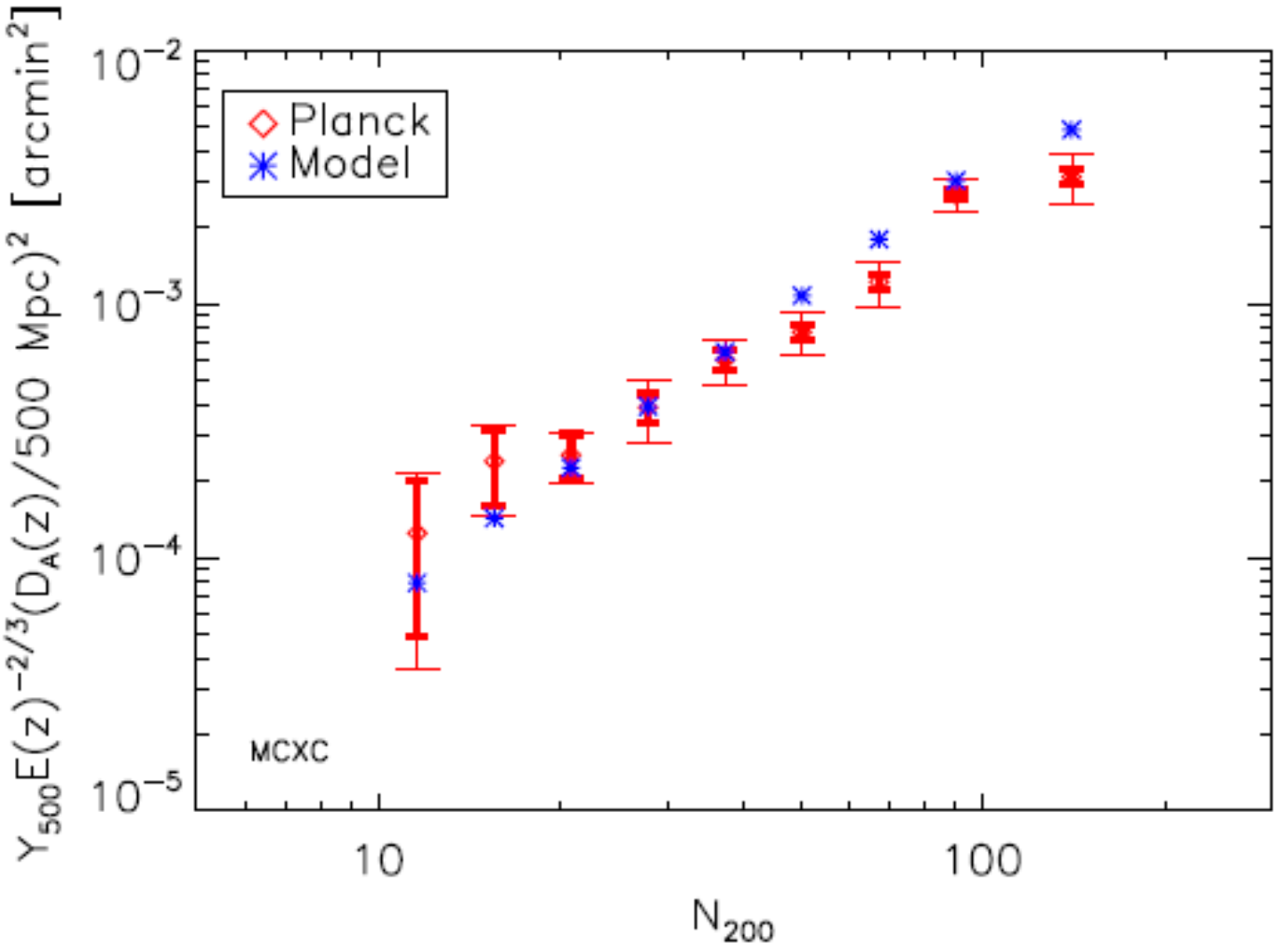
Planck 'statistical' view optical clusters:



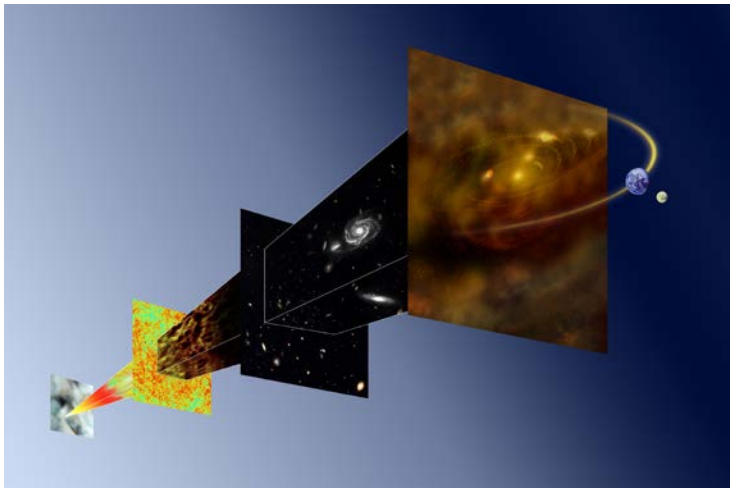



Planck
Model
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10
100
N_{200}
$Y_{500}E(z)^{-2/3}(D_A(z)/500\ \mathrm{Mpc})^2$ [arcmin^2]


Planck
Model
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10
100
N_{200}
$Y_{500}E(z)^{-2/3}(D_A(z)/500\ \mathrm{Mpc})^2$ [arcmin^2]


Planck
Model
MCXC
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10
100
N_{200}
$Y_{500}E(z)^{-2/3}(D_A(z)/500\ \mathrm{Mpc})^2\ [\mathrm{arcmin}^2]$

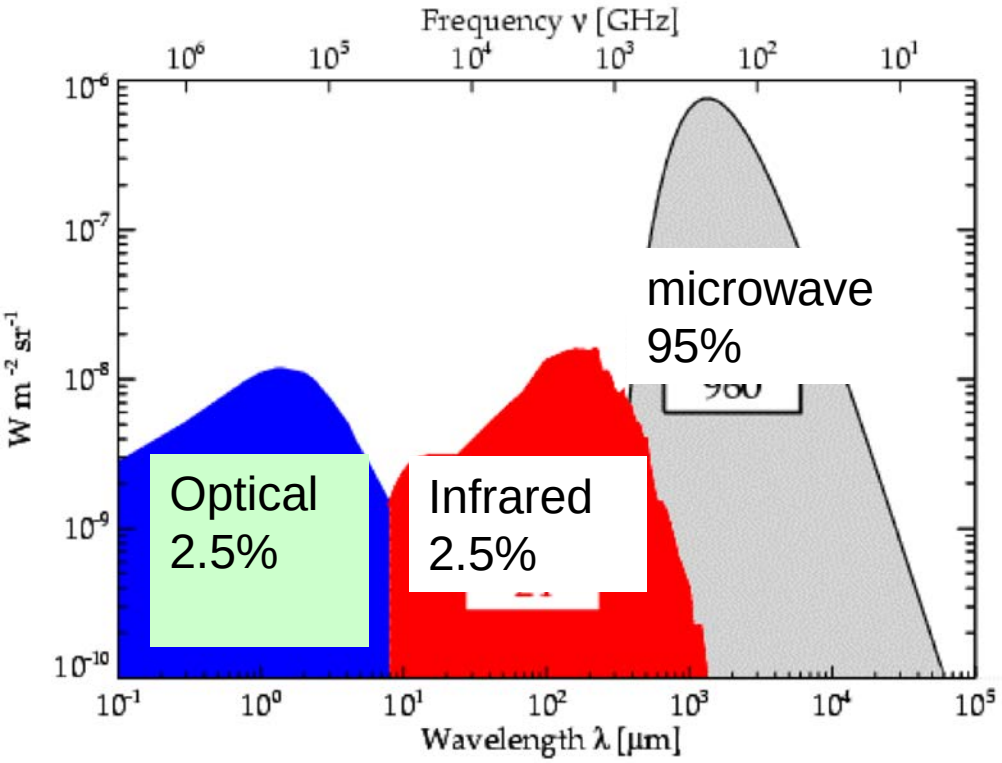
THE COSMIC RADIATION BACKGROUND

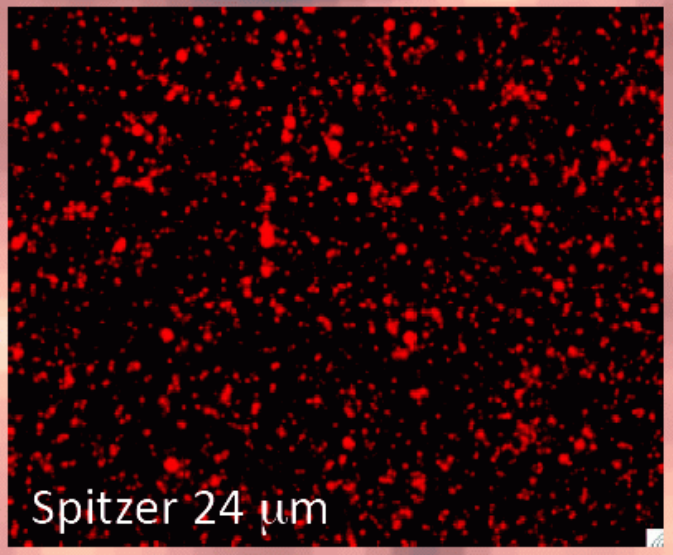


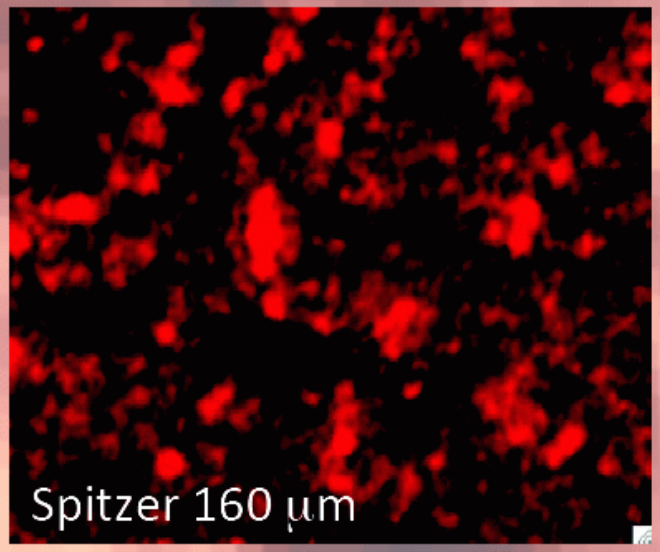
95% of the radiation is the CMB

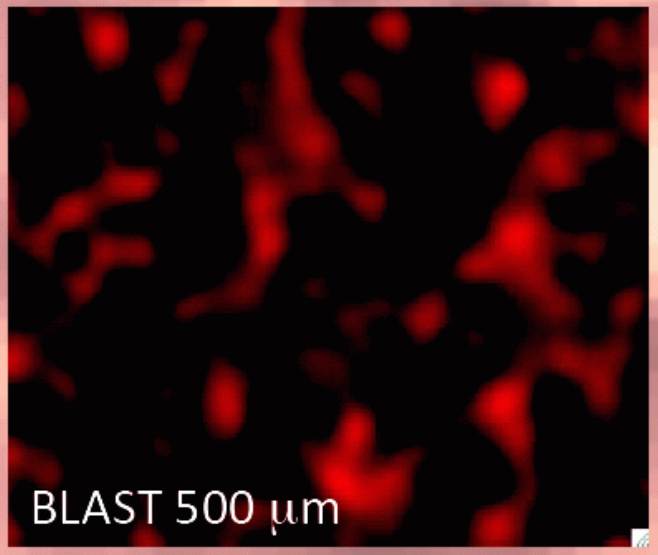
5% is the radiation from stars in all galaxies

- **half is in visible light directly from stars**
- **the other half has been absorbed by dust and re-radiated in the infrared**







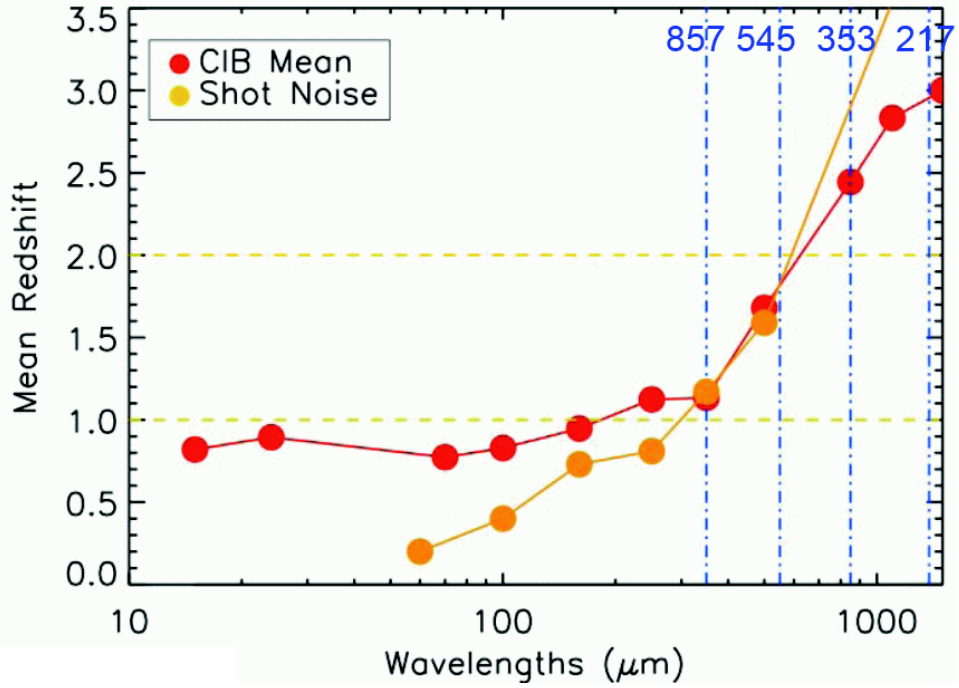


Resolved CIB: 80%

Resolved CIB: 15%

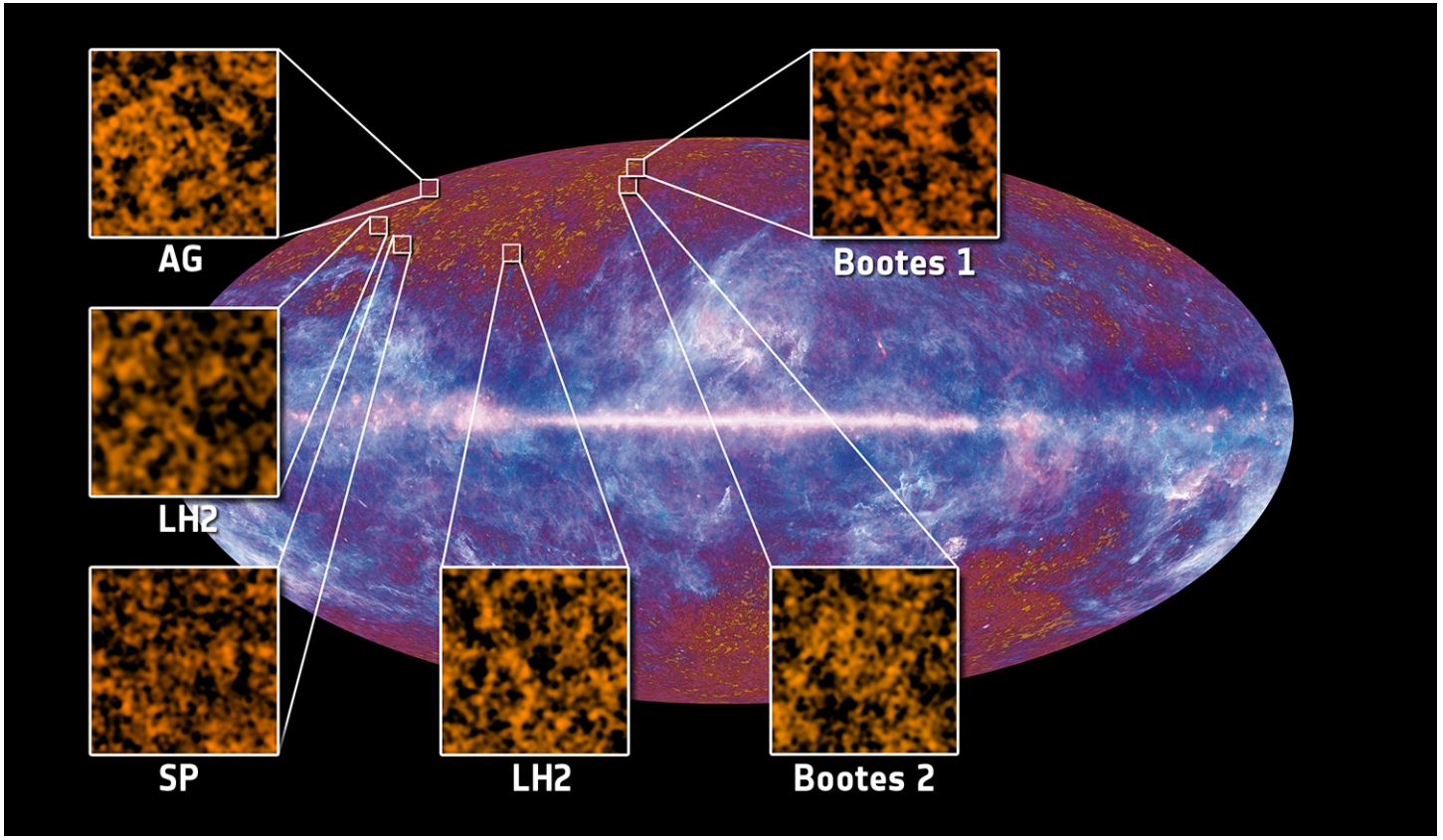
Resolved CIB: <1%

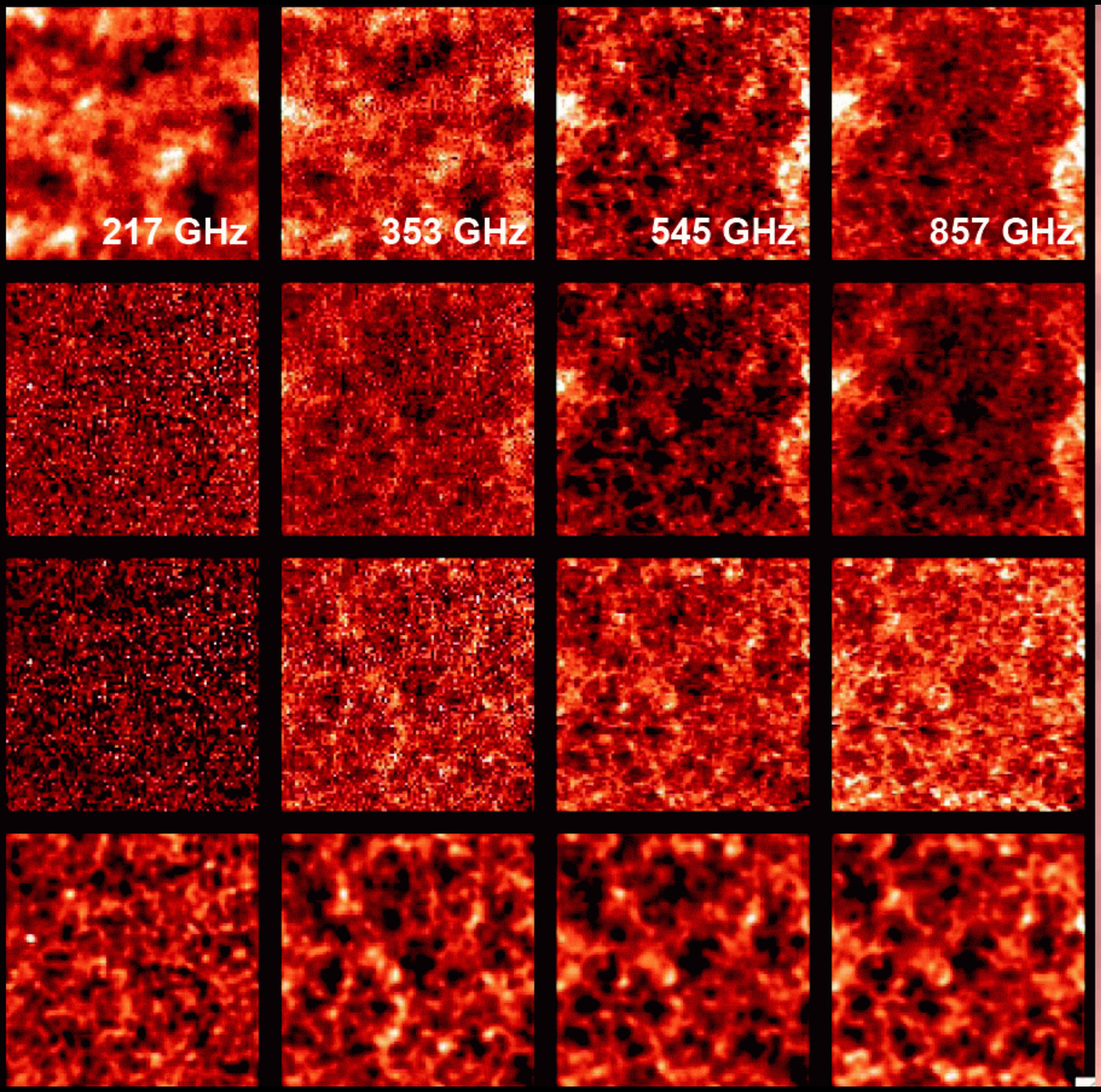
Longer wavelengths probe to higher redshifts



Planck CIB analysis:

6 high Galactic latitude fields
Low dust emission
Low HI column density
total area 140 sq deg



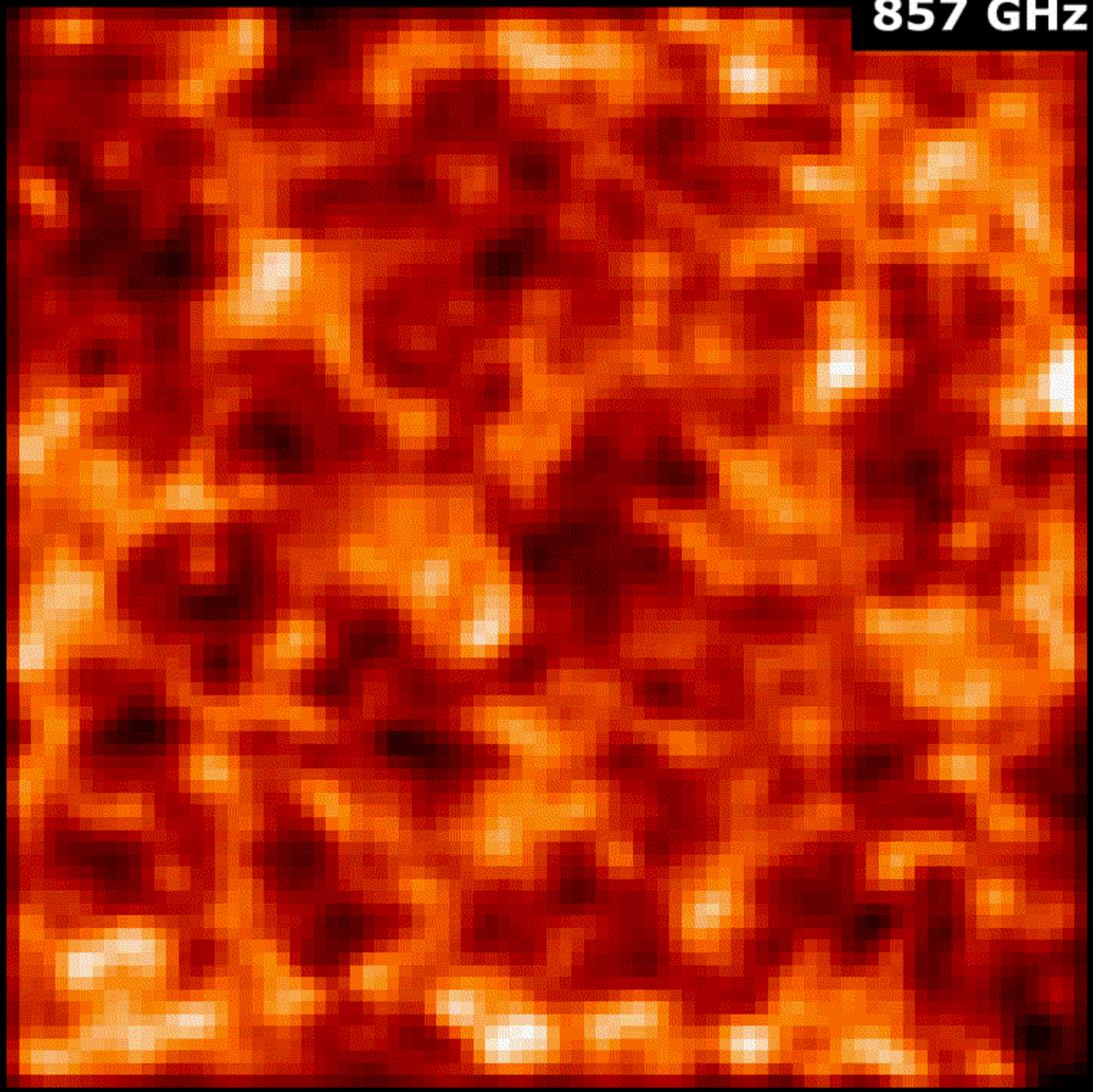


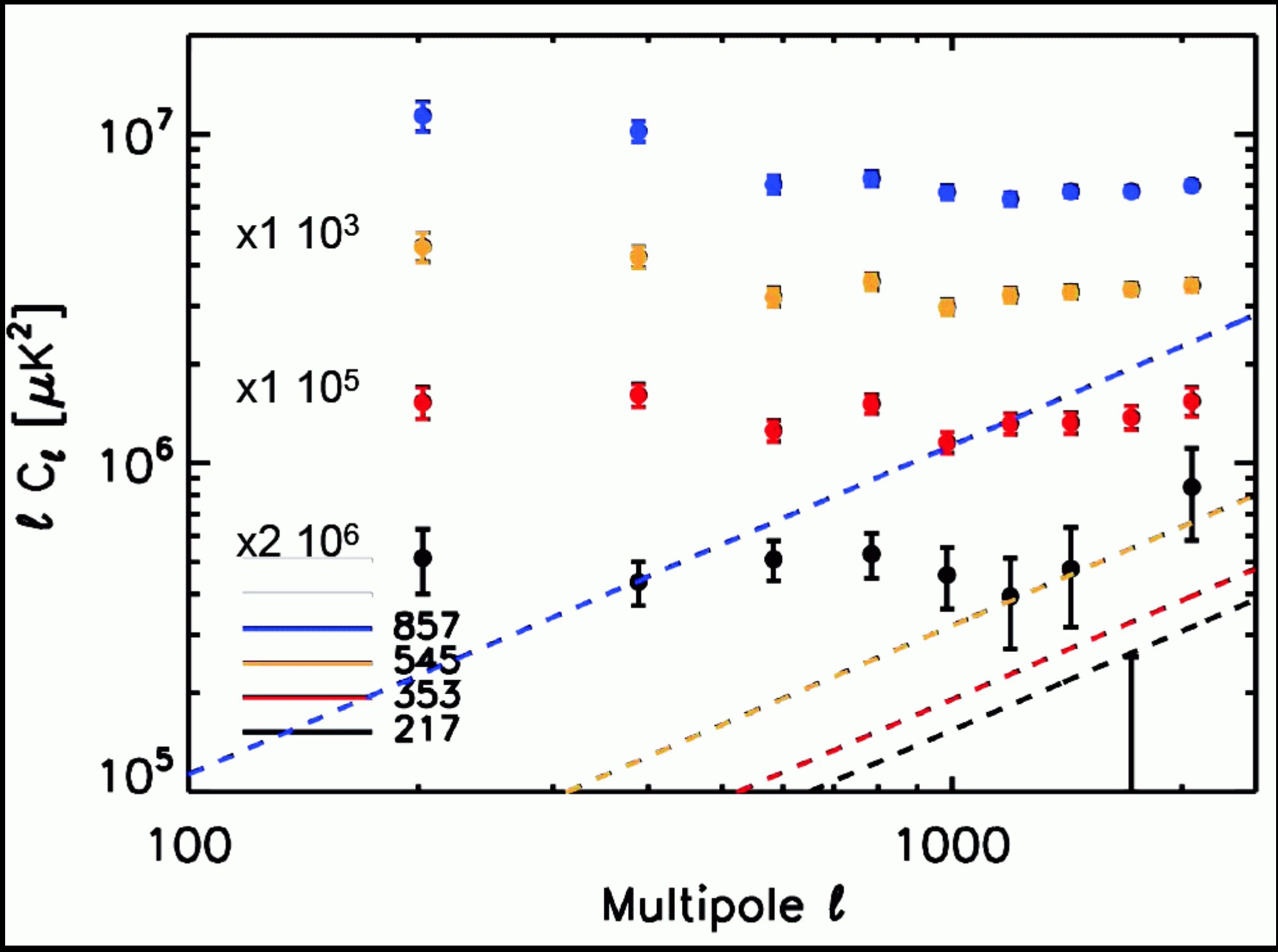
HFI « raw » maps
26.4 Sq. Deg.

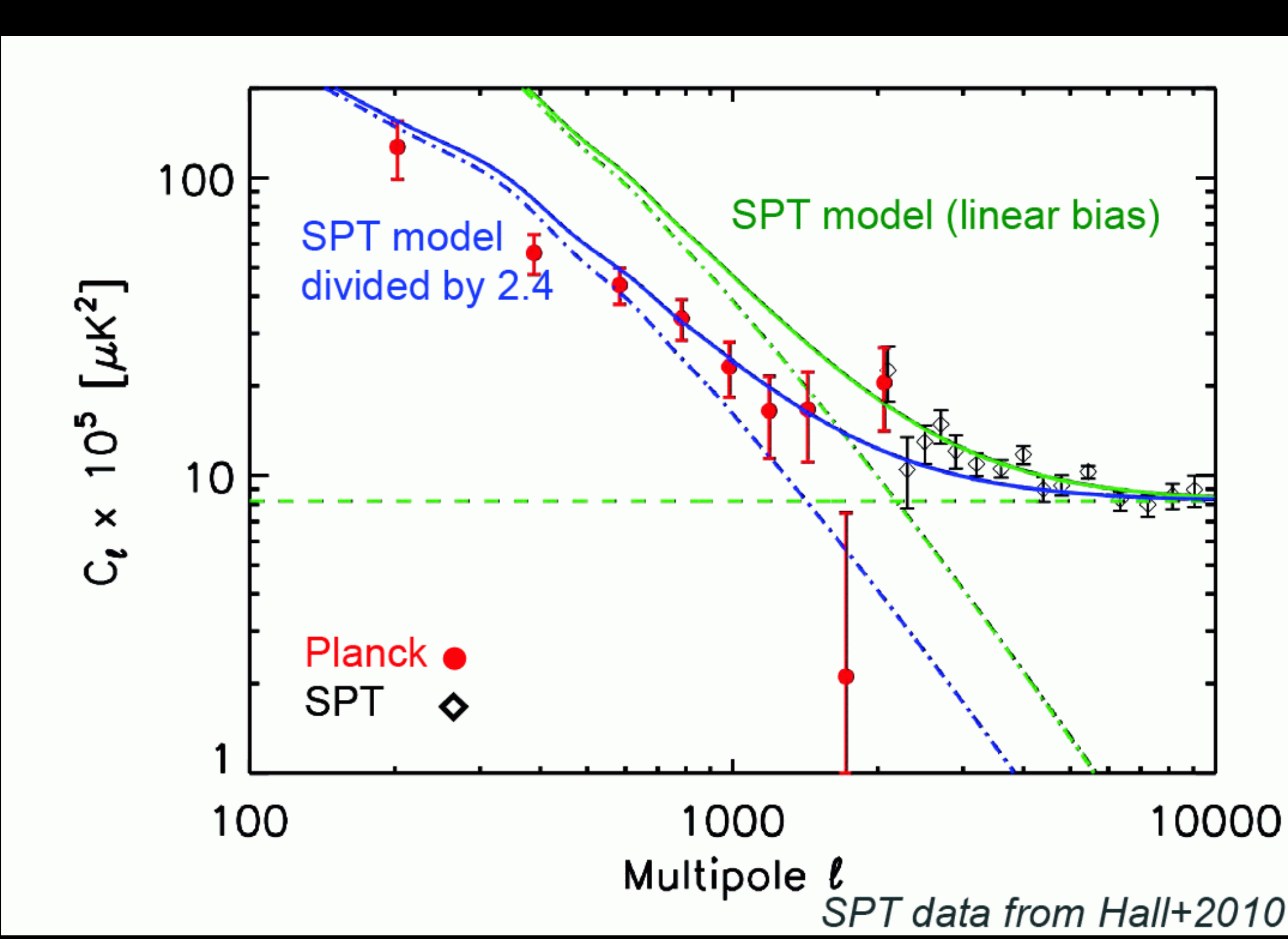
Raw maps
– CMB
– ERCSC point sources

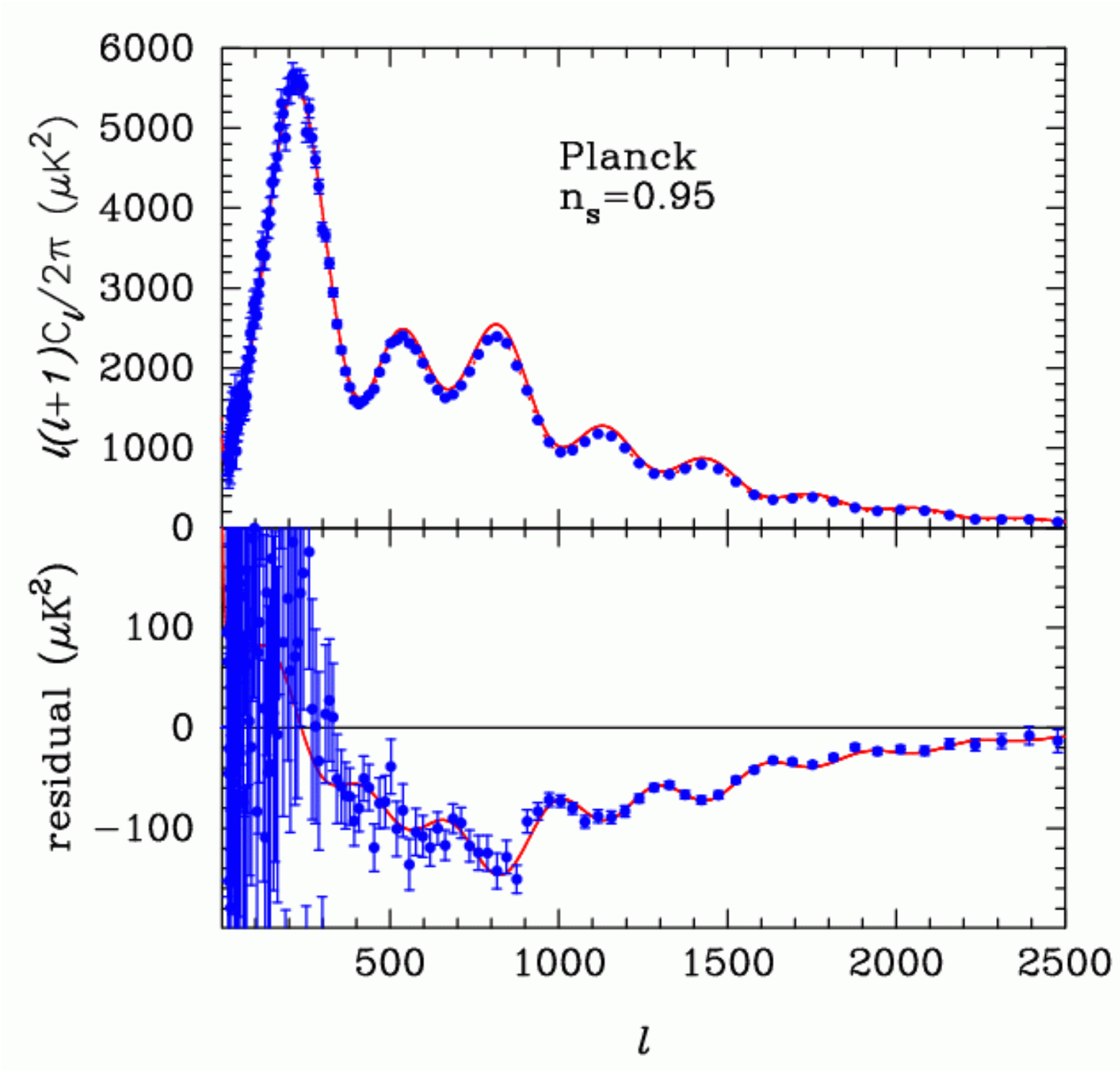
CIB maps
= Raw maps
– CMB
– ERCSC point sources
– Galactic dust

CIB maps @ 10 arcmin


857 GHz


10^7
10^6
10^5
$\ell\, C_\ell\ [\mu K^2]$
x1 10^3
x1 10^5
x2 10^6
857
545
353
217
100
1000
Multipole ℓ


100
10
1
$C_\ell \times 10^5$ [μK^2]
SPT model
divided by 2.4
SPT model (linear bias)
Planck
SPT
100
1000
10000
Multipole ℓ
SPT data from Hall+2010


Planck
n_s=0.95
$l(l+1)C_l/2\pi$ (μK^2)
residual (μK^2)
6000
5000
4000
3000
2000
1000
0
100
0
−100
500
1000
1500
2000
2500
l

The scientific results that will be presented this week are a product of the Planck Collaboration, including individuals from more than 50 scientific institutes in Europe, the USA and Canada

Planck is a project of the European Space Agency -- ESA -- 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.