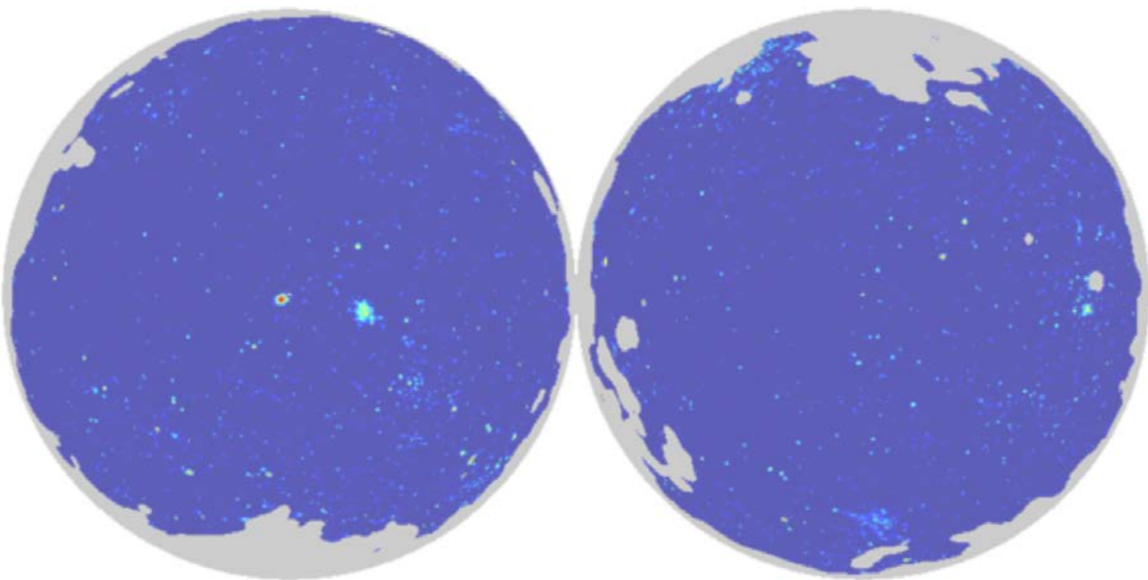
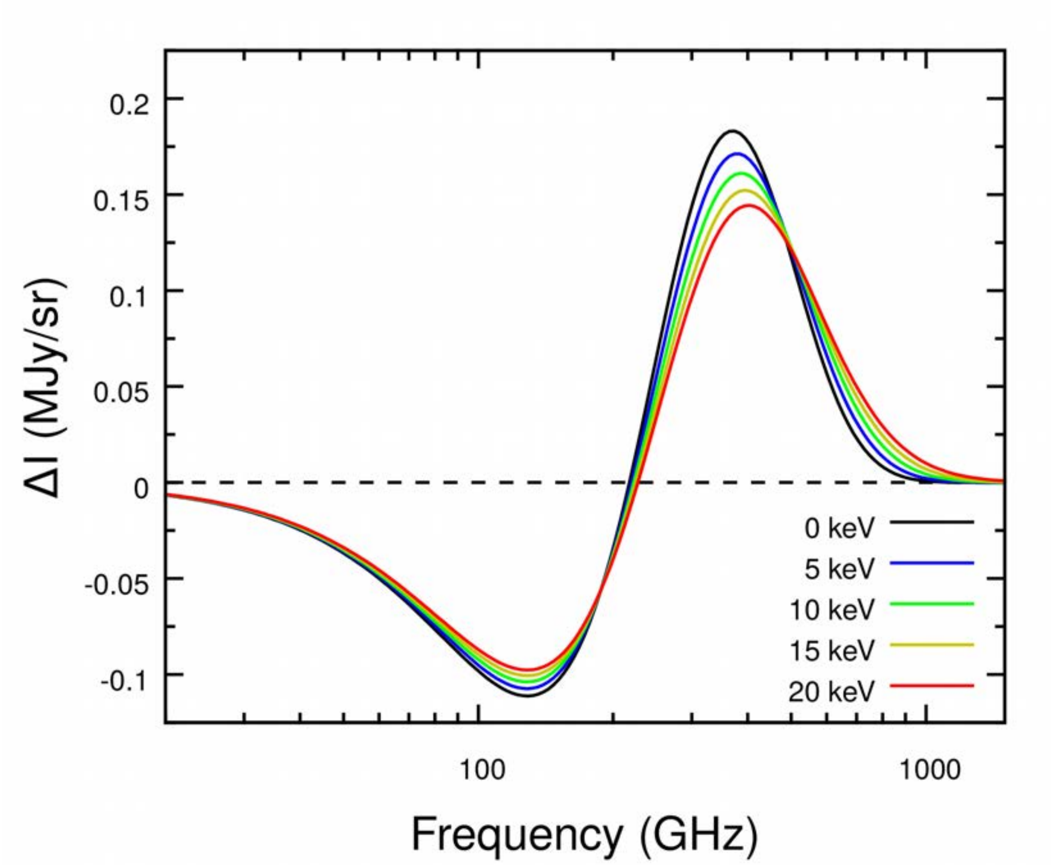
Observations of the relativistic SZ effect: from *Planck* to CCAT-prime



Jens Erler

Kaustuv Basu, Jens Chluba & Frank Bertoldi

ICM temperature measurements



The tSZ rel. corrections allow

- independent measurement of T_e
- direct measurement of n_e
- Measurements at high z

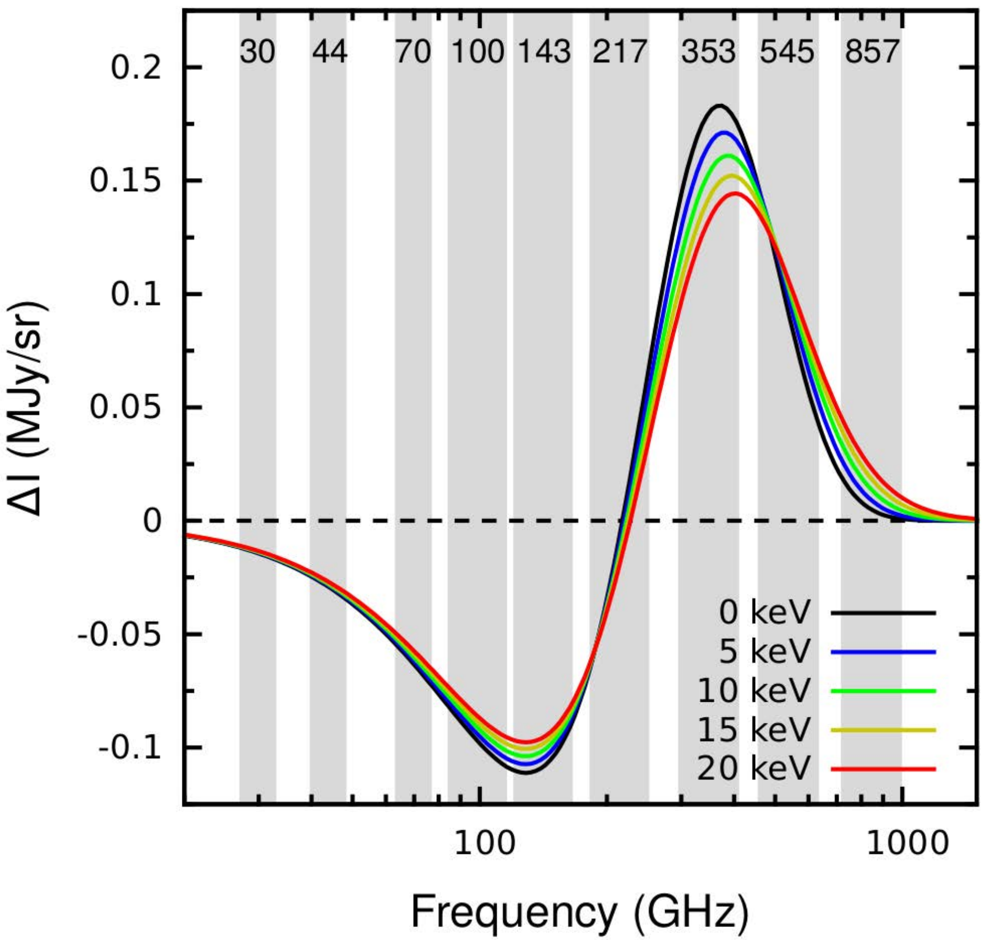
The temperature of the ICM is tightly related to the total (hydrostatic) mass of galaxy clusters

The *Planck* mission

- 3rd generation CMB experiment
- Observed CMB from 2009 to 2013 from L2 in 9 frequency bands
- 8 full all-sky surveys
- Resolution between 30' (30 GHz) and 5' (857 GHz)
- Full data release in Feb. 2015

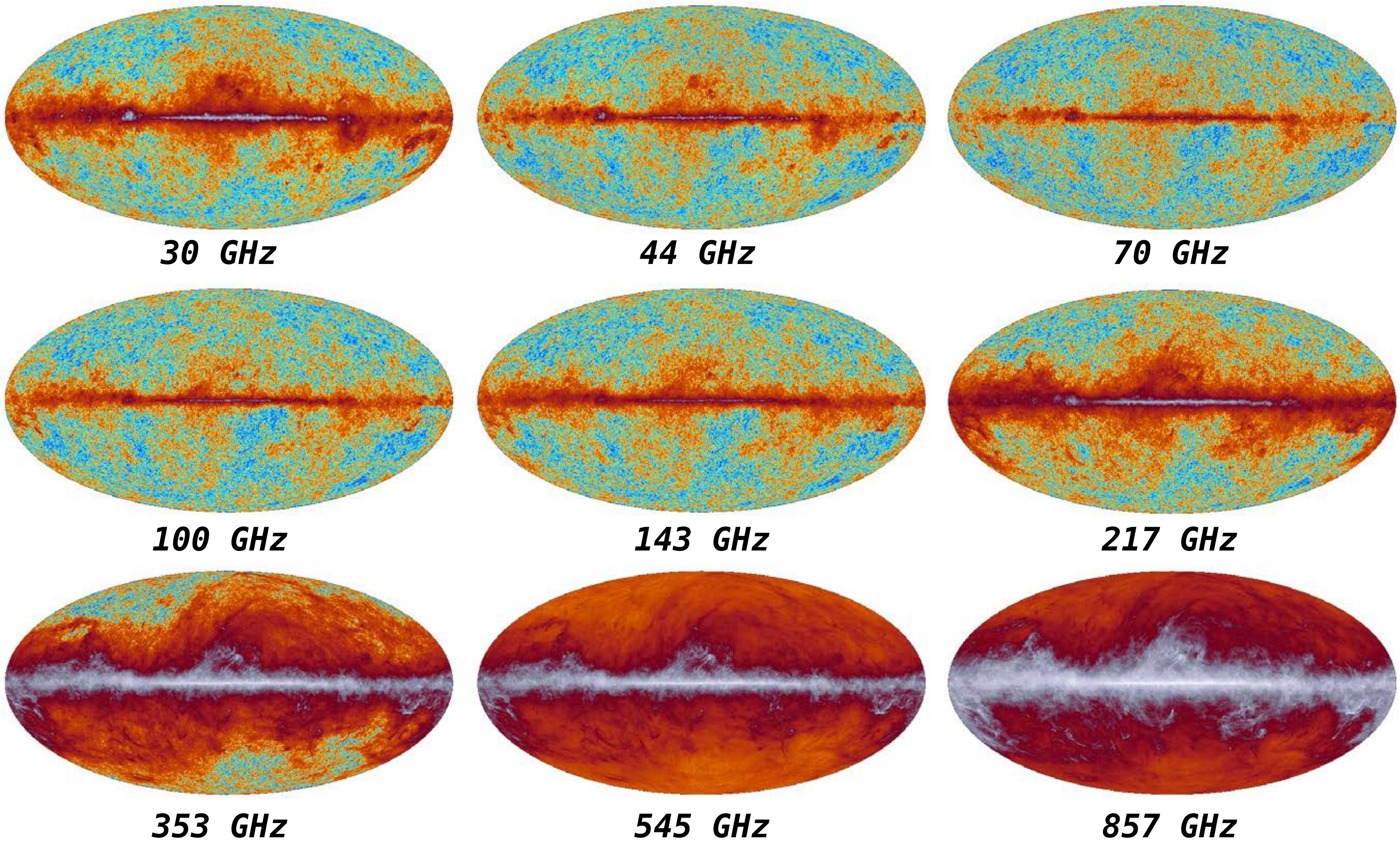
Credit: ESA Planck Collaboration

Why *Planck*?



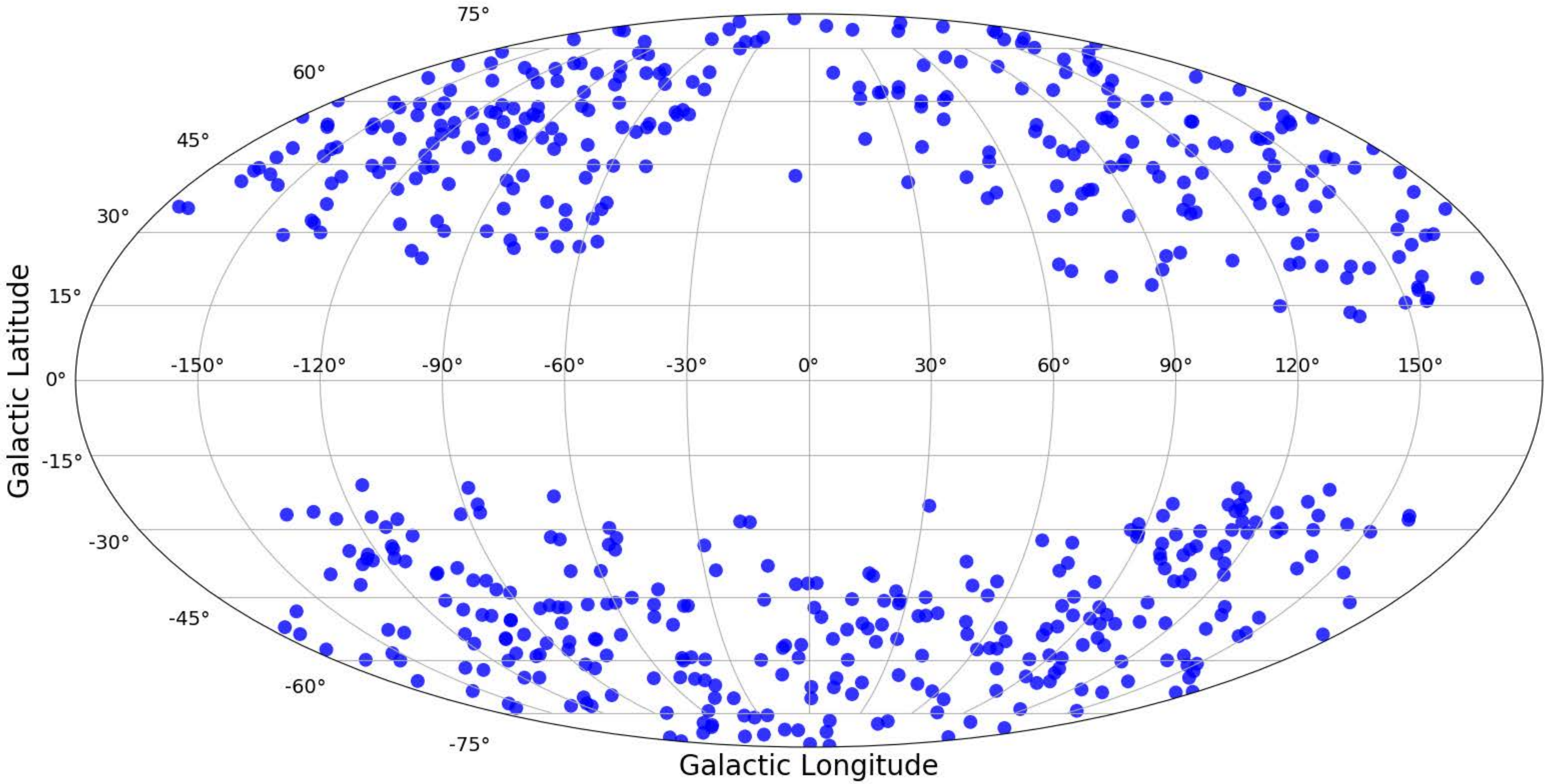
- Planck covers the entire SZE spectrum
- Planck has all-sky coverage
- Good sensitivity
- Drawback: low resolution

Galactic Foregrounds

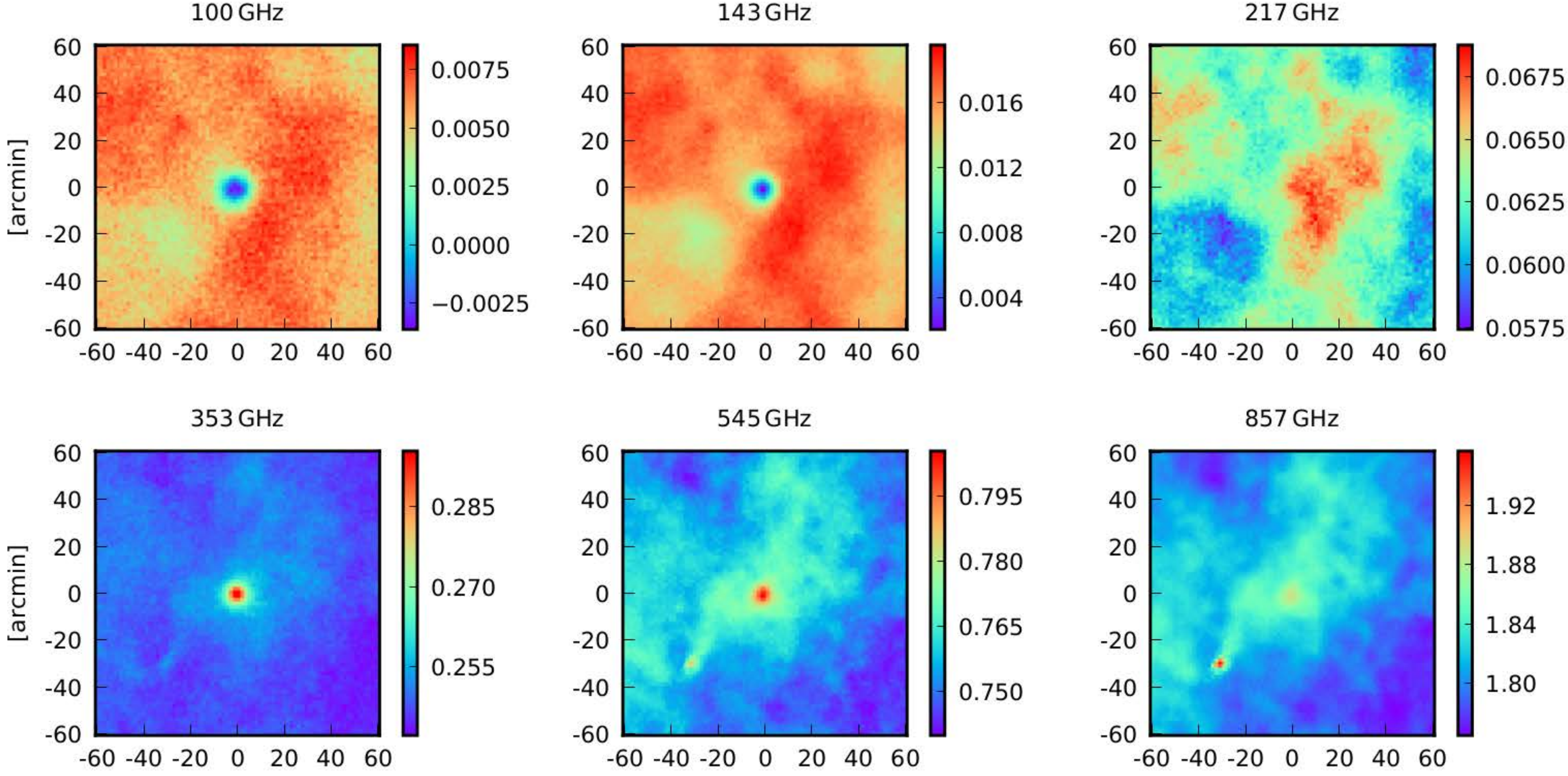


Credit: ESA Planck Collaboration

Sample Selection

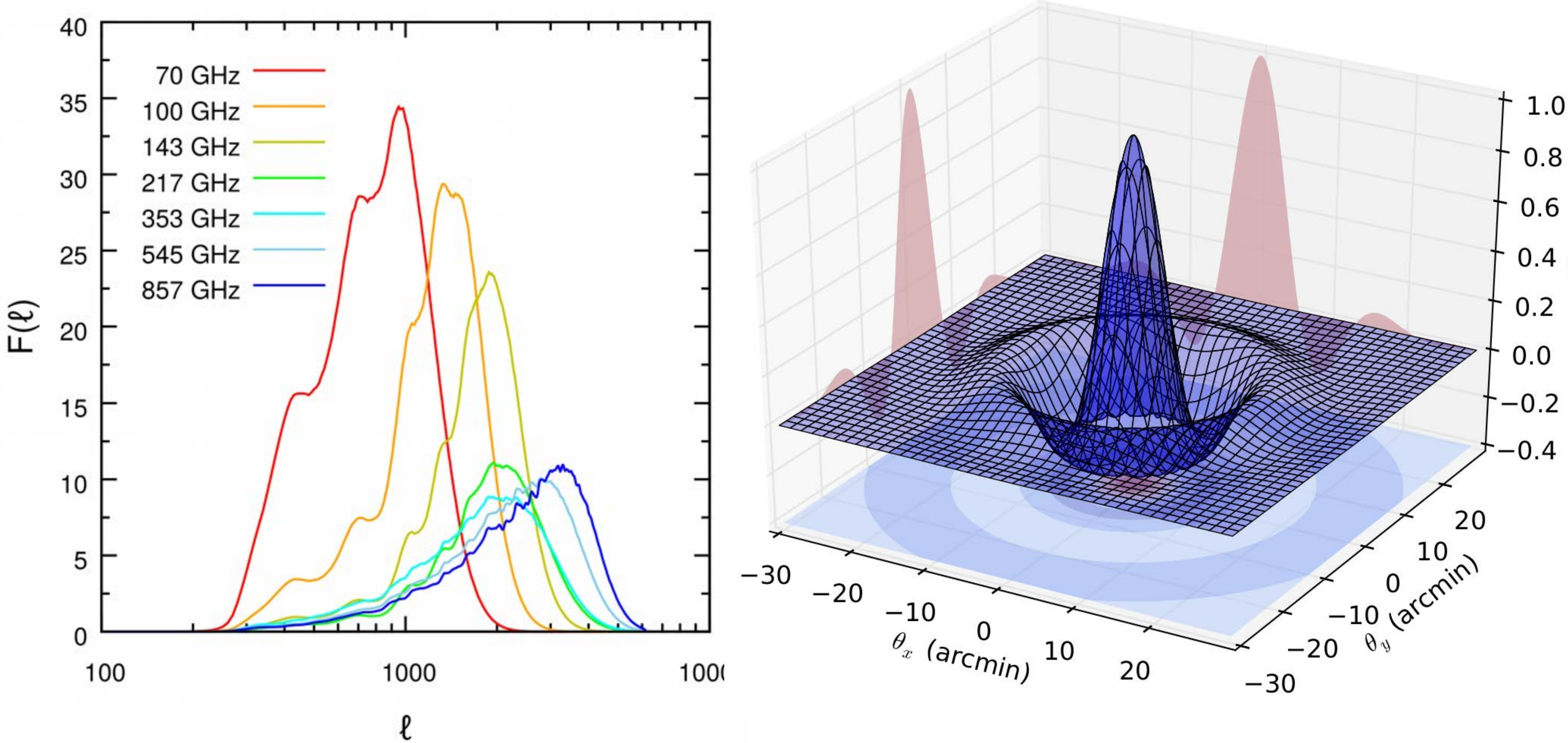


Stacked Cluster Sample

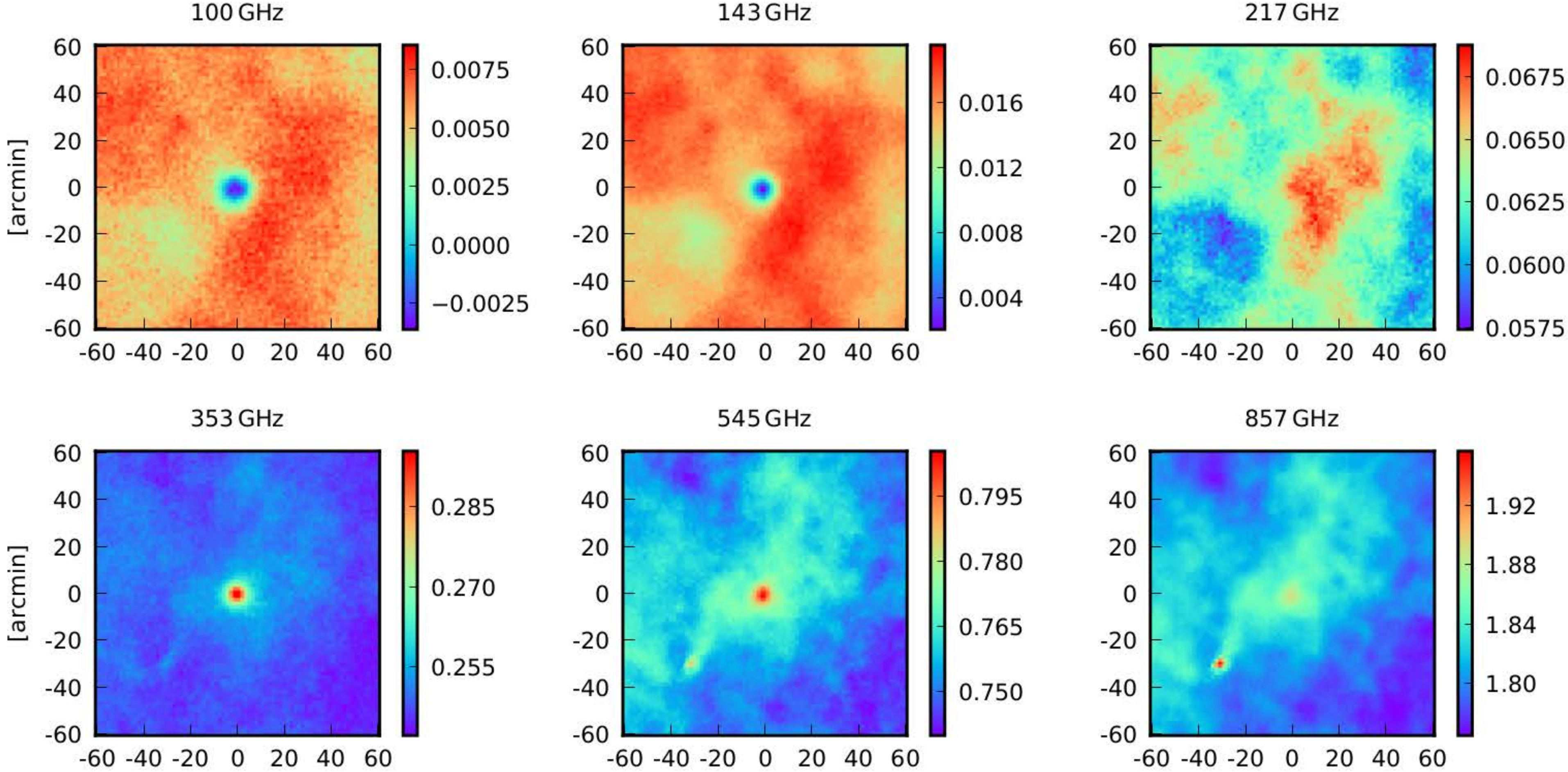


Matched Filtering

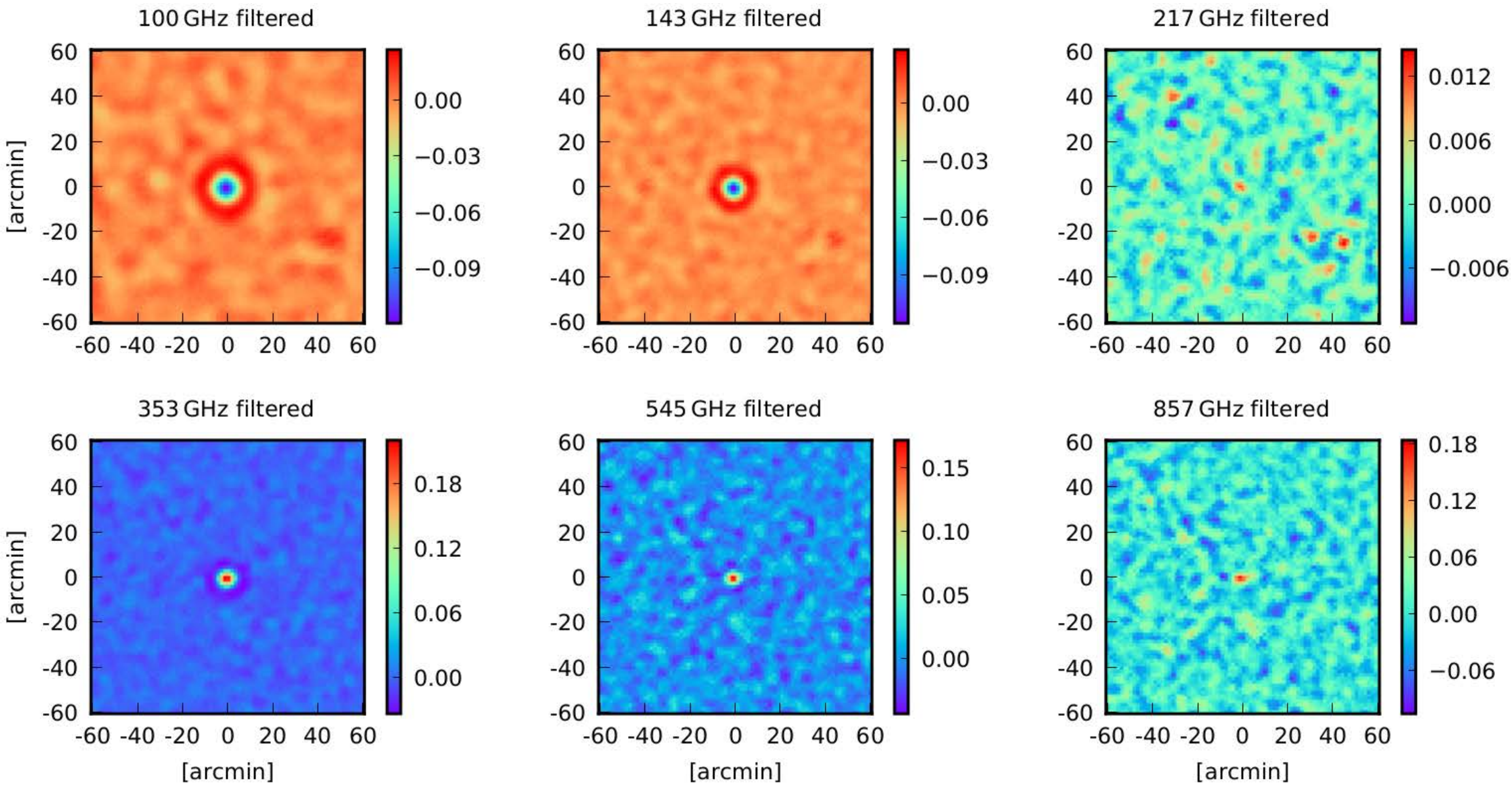
Uncorrelated foregrounds can be reduced by matched filtering



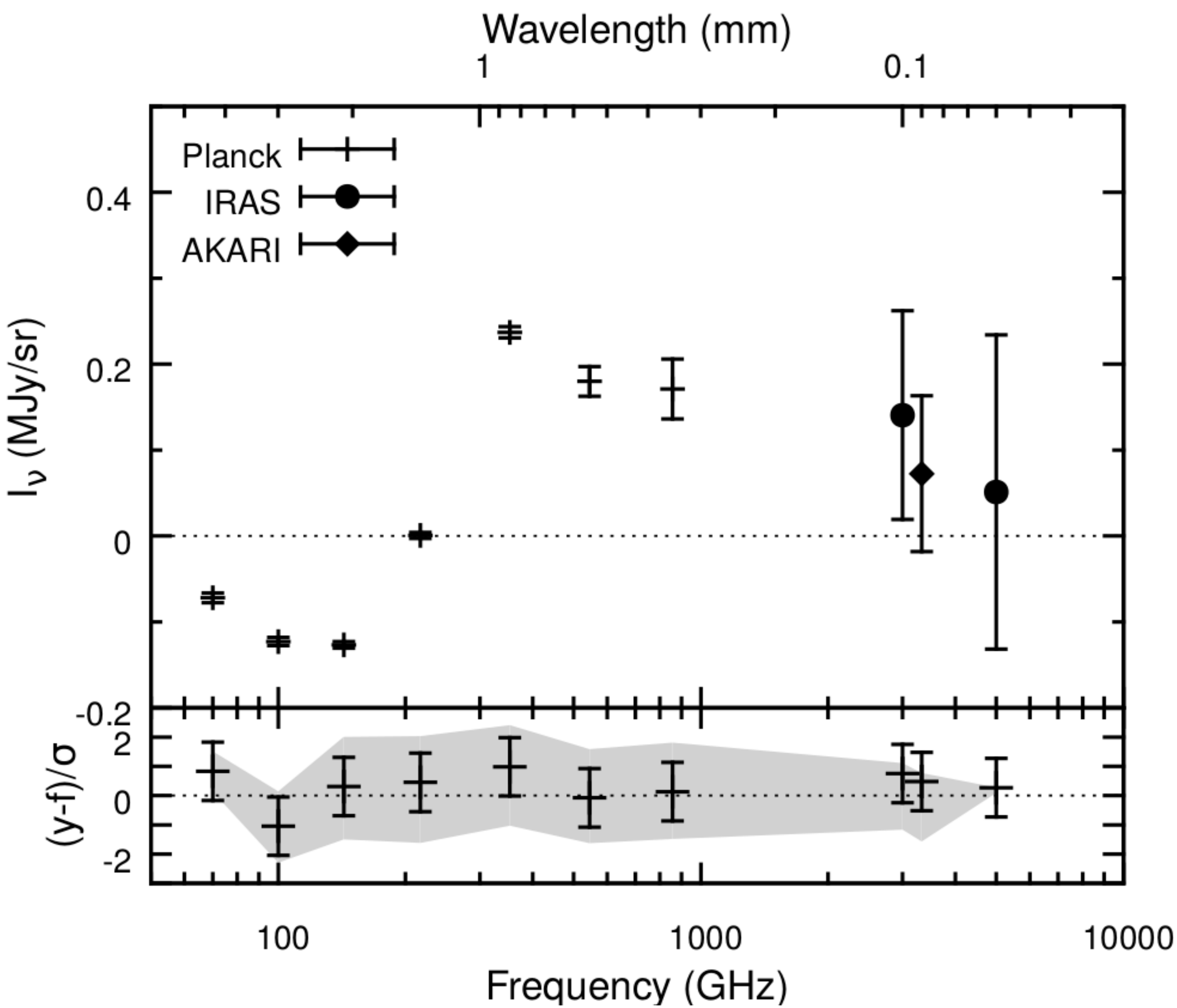
Stacked Cluster Sample



Stacked Cluster Sample



Extracted Spectrum



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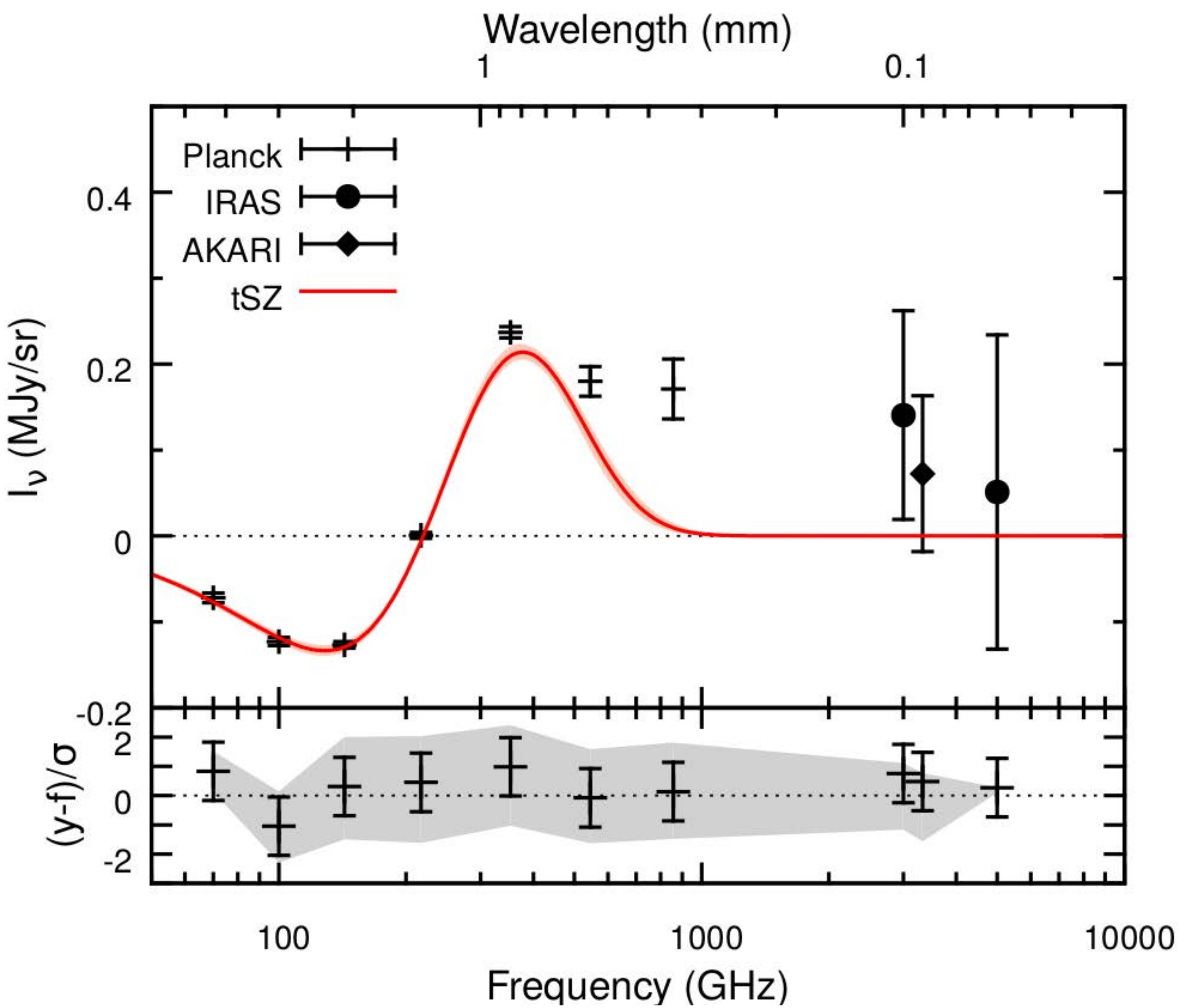

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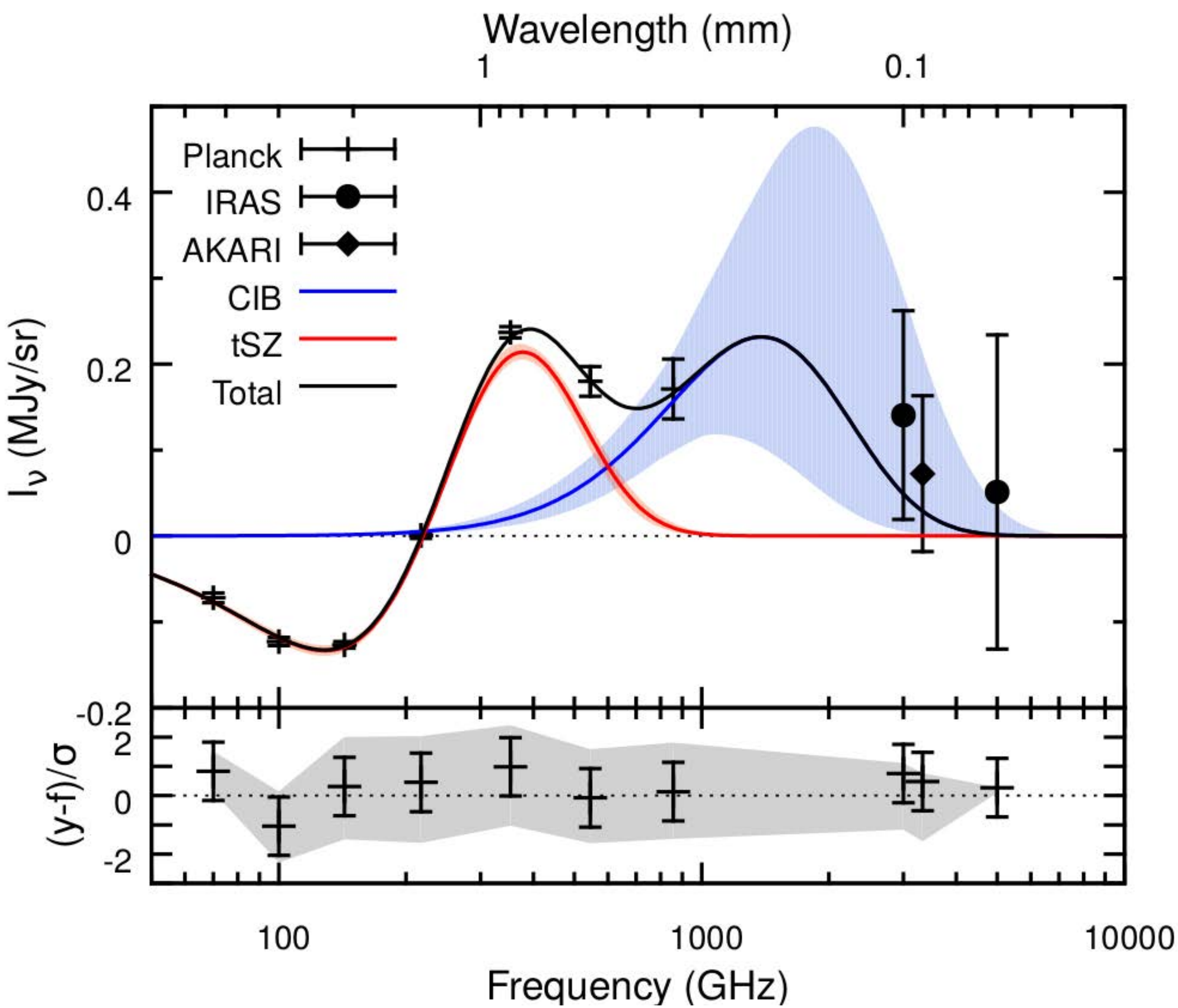
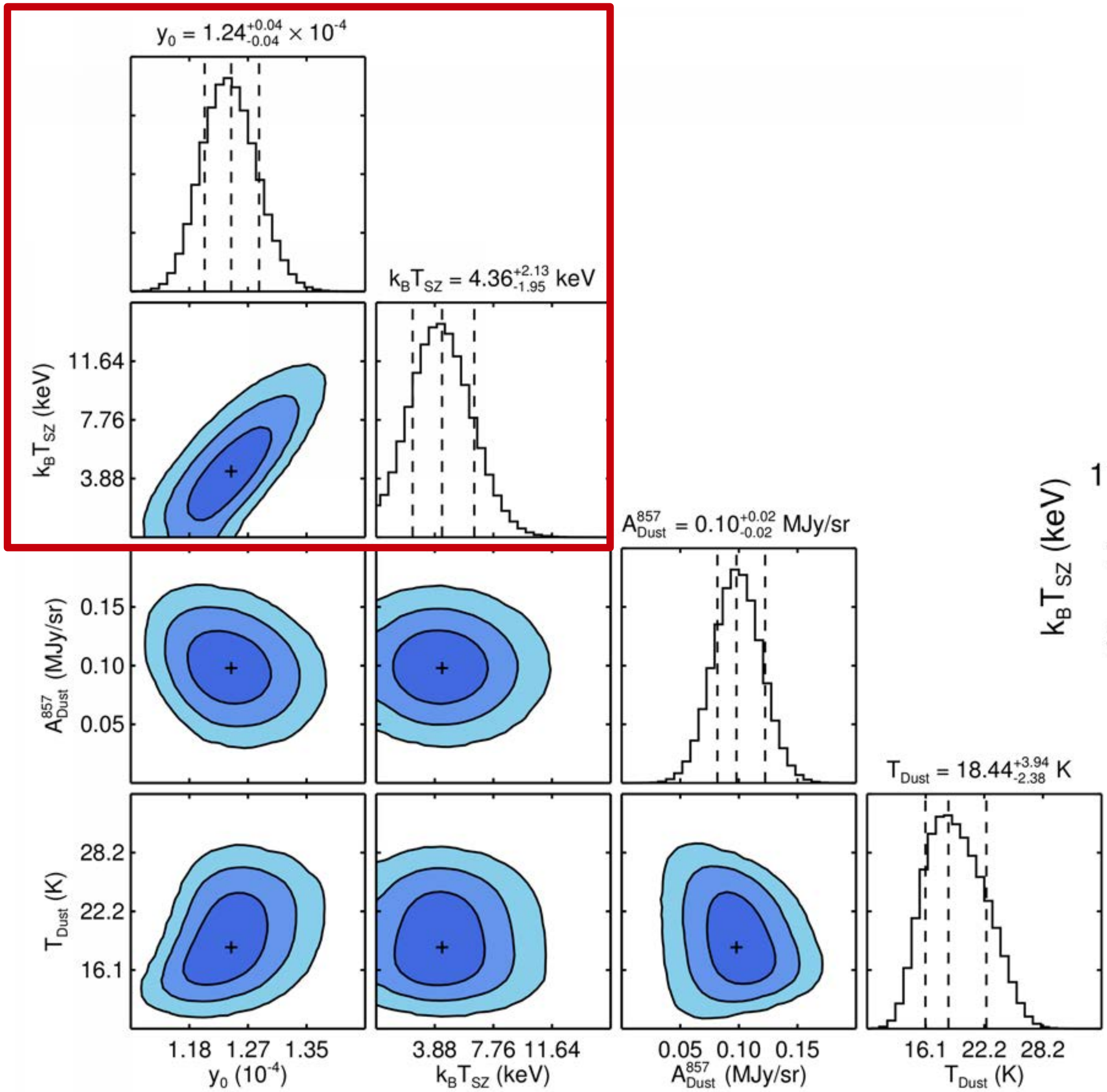
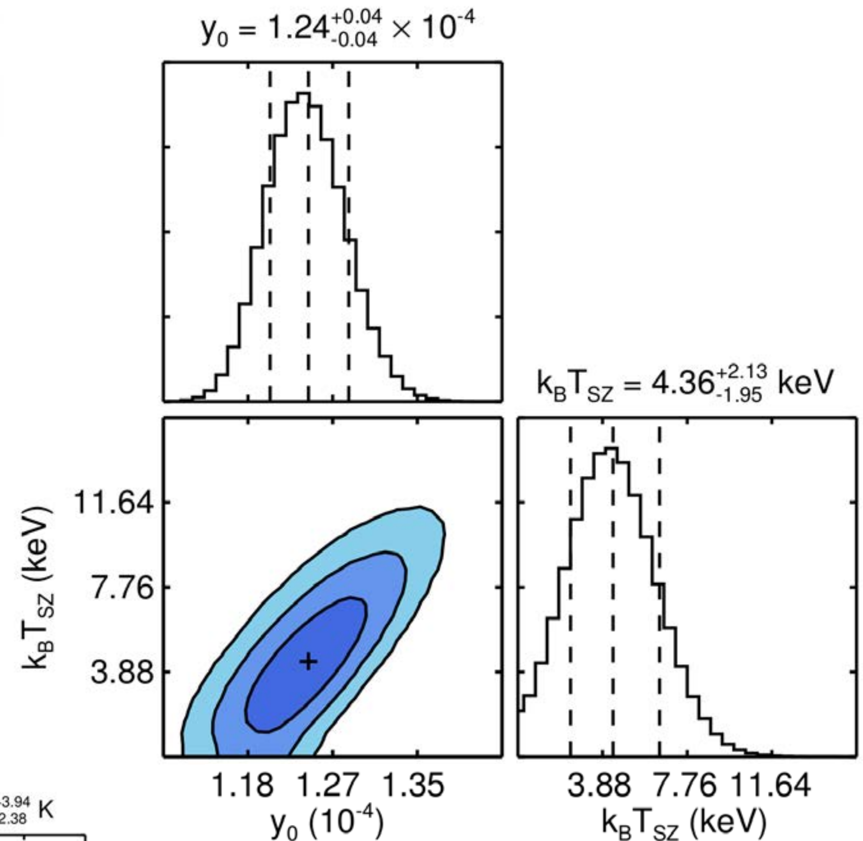


Results

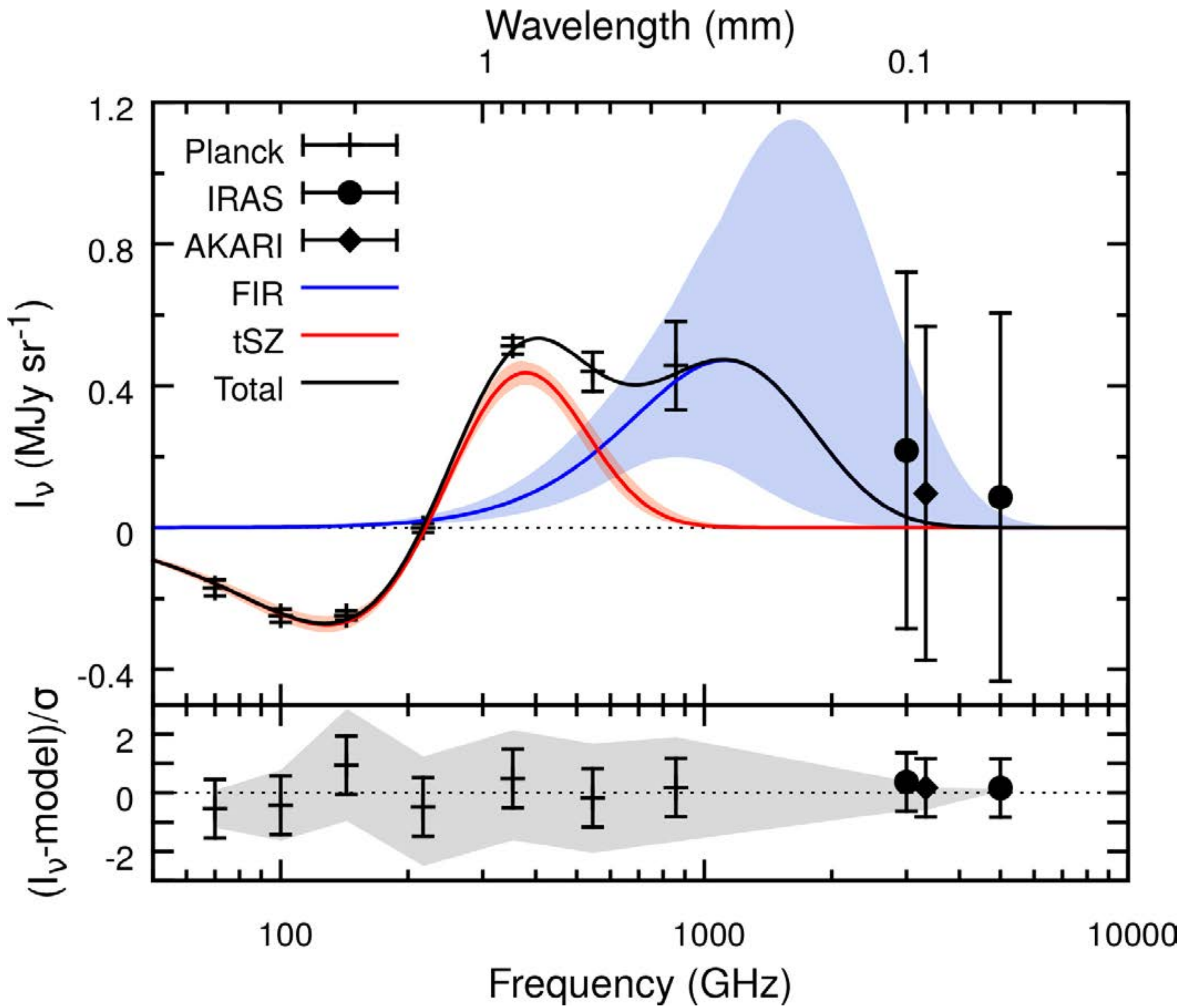




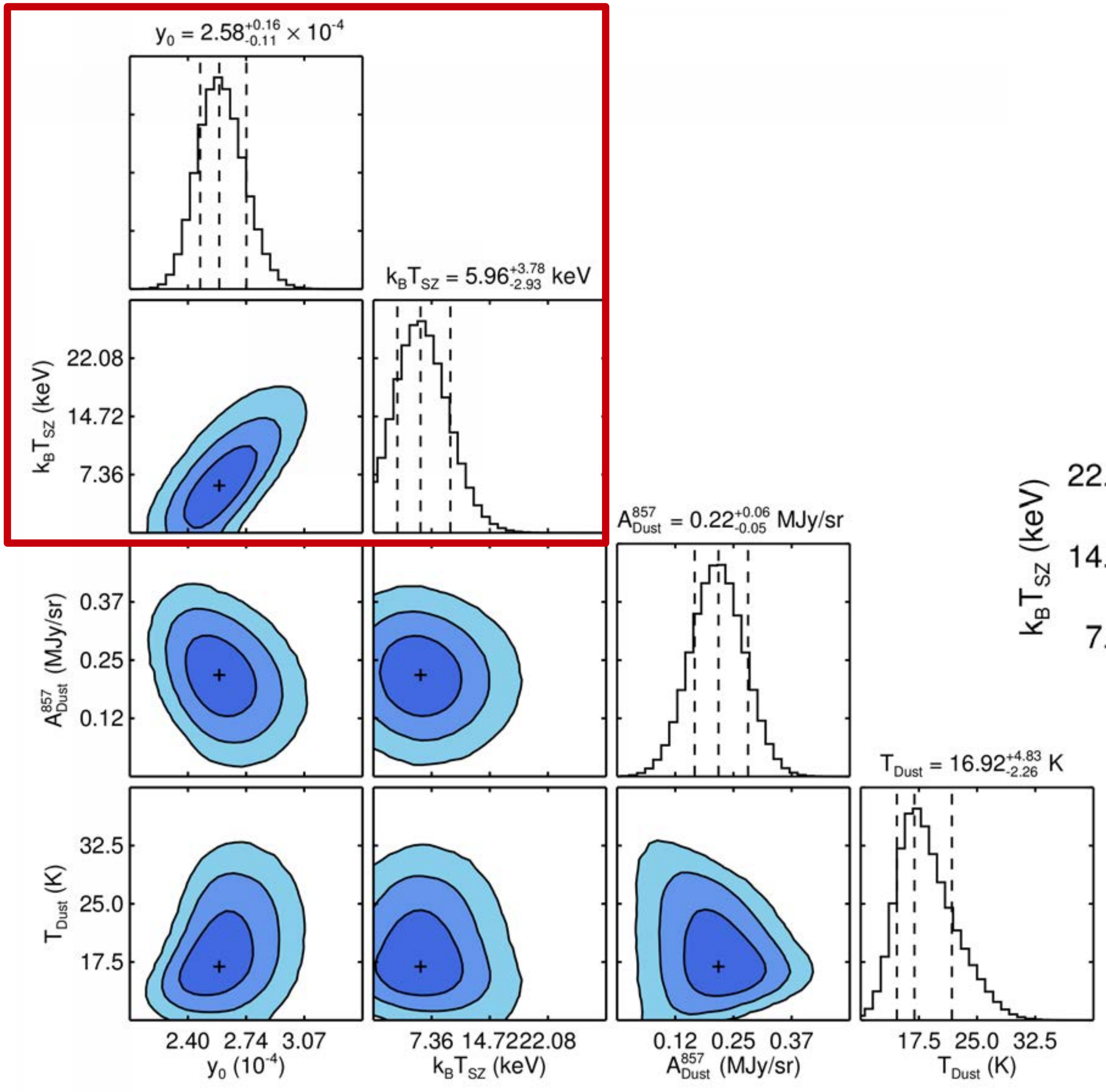
$T_{SZ} = 4.4 \pm 2$ keV

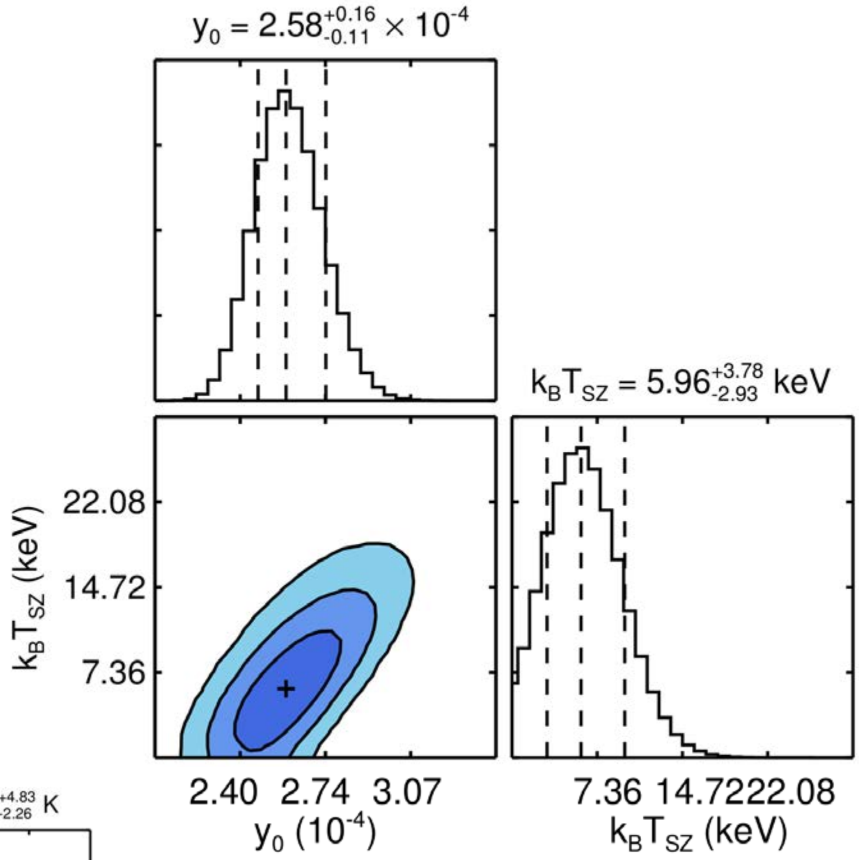
$\langle T_X \rangle = 6.9$ keV

Extracted Spectrum: 100 most massive



Results: 100 most massive

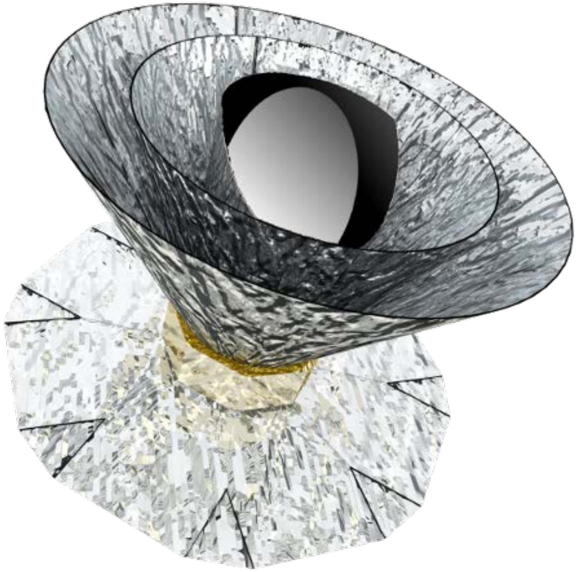




$T_{SZ} = 6.0 \pm 3.4$ keV

$\langle T_X \rangle = 8.5$ keV

What is next?



PRISM

- 32 channels
- 3.5m aperture

COrE

- 19 channels
- 1.5m aperture

PIXIE

- 400 channels
- ~degree resolution

Outlook: CCAT-prime

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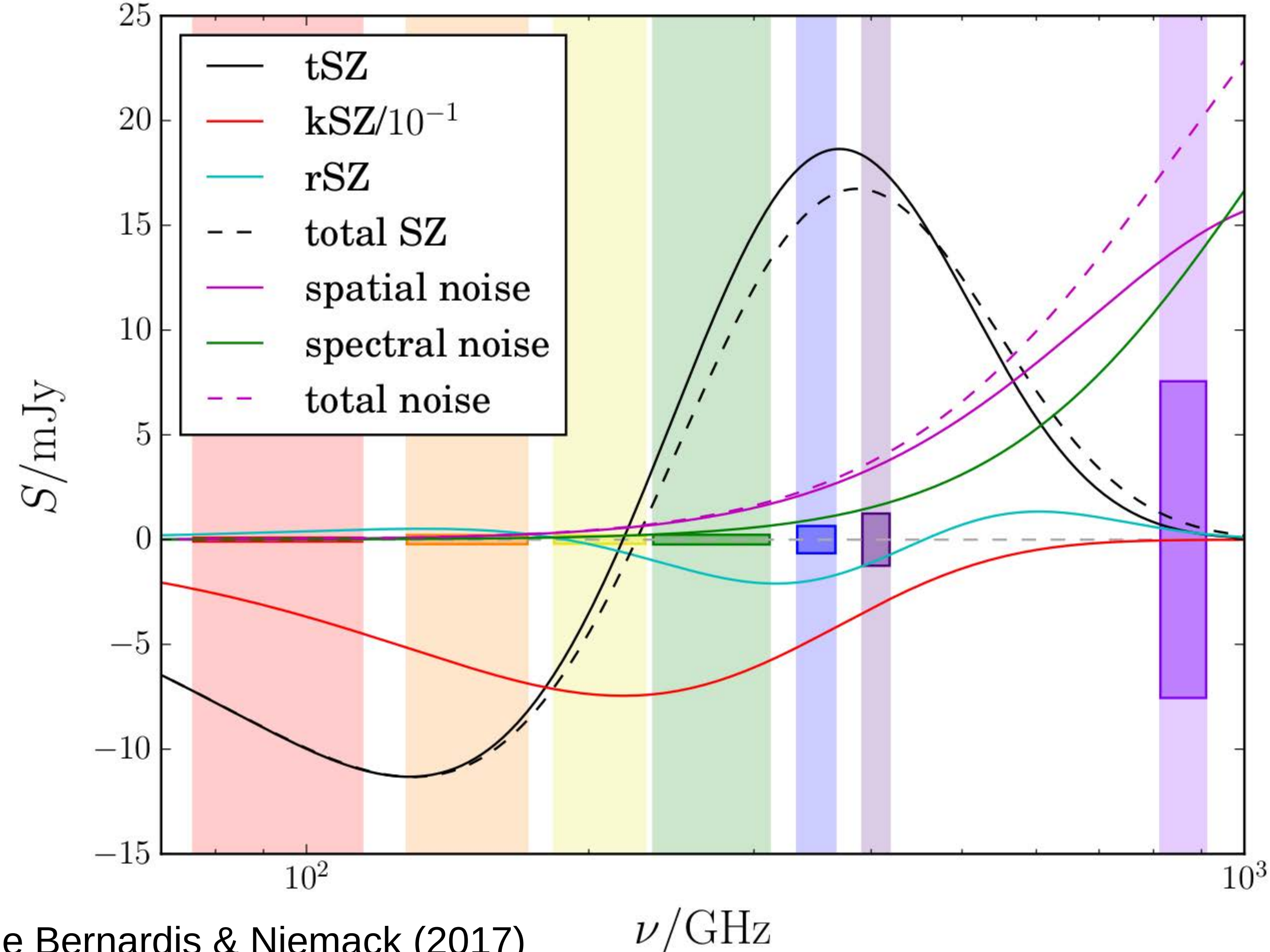

Mittal, de Bernardis & Niemack (2017)

Outlook: CCAT-prime

ν GHz	FWHM arcmin	ΔT mK_{RJ}-arcmin	ΔT mK_{CMB}-arcmin	ΔI kJy/sr-arcmin
***Planck* (all-sky-average full mission data)**				
100	9.68	61.4	77.3	18.9
143	7.30	19.8	33.4	12.4
217	5.02	15.5	46.5	22.5
353	4.94	11.7	156	44.9
545	4.83	5.10	806	46.8
857	4.64	1.90	1.92×10^4	43.5
CCAT-p (4000 h, 1000 deg^2 survey)				
95	2.2	3.9	4.9	1.1
150	1.4	3.7	6.4	2.6
226	0.9	1.5	4.9	2.4
273	0.8	1.2	6.2	2.7
350	0.6	2.1	25	7.9
405	0.5	3.1	72	16
862	0.2	4.7	6.9×10^4	109

G. Stacey

Outlook: CCAT-prime

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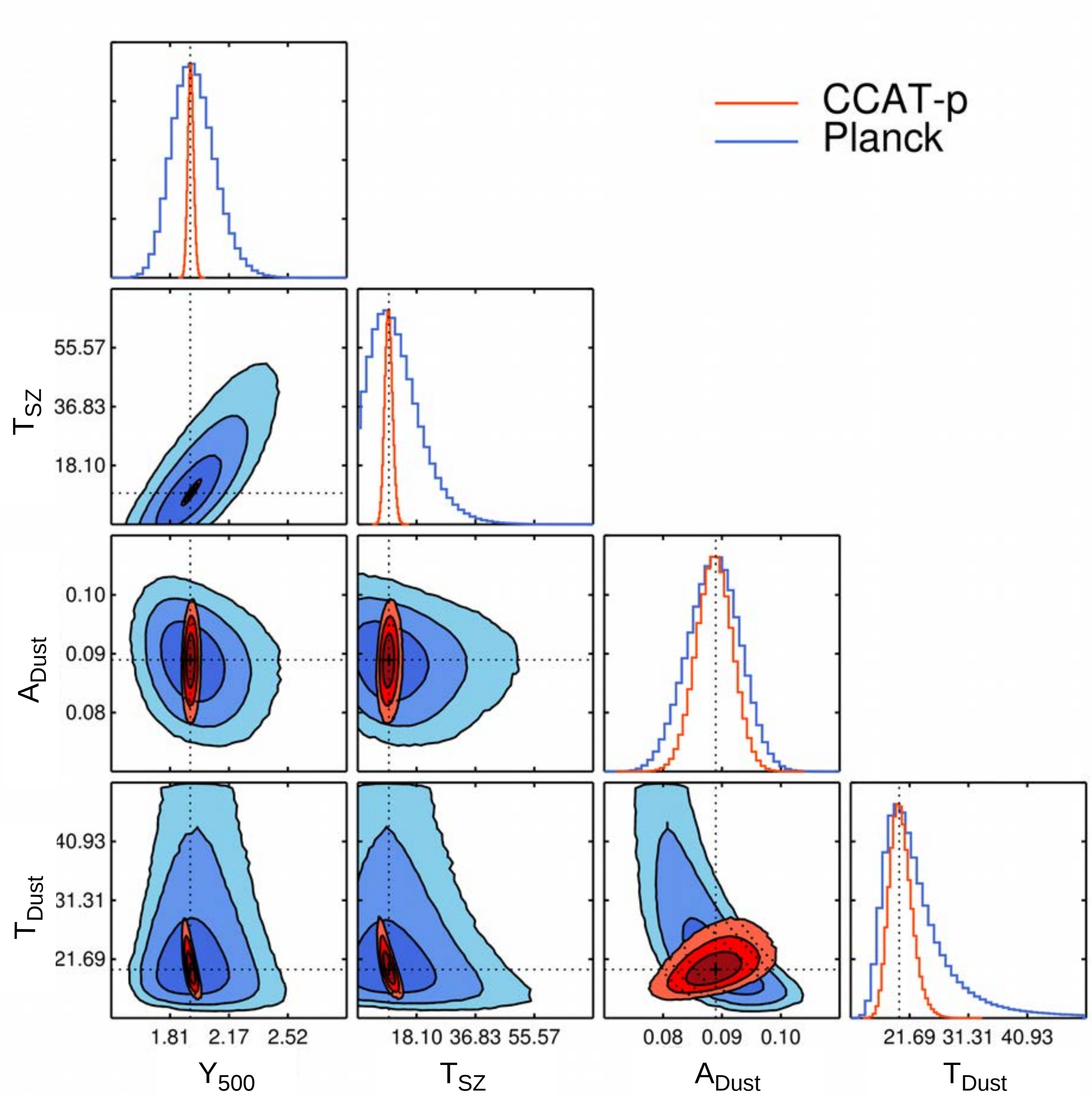
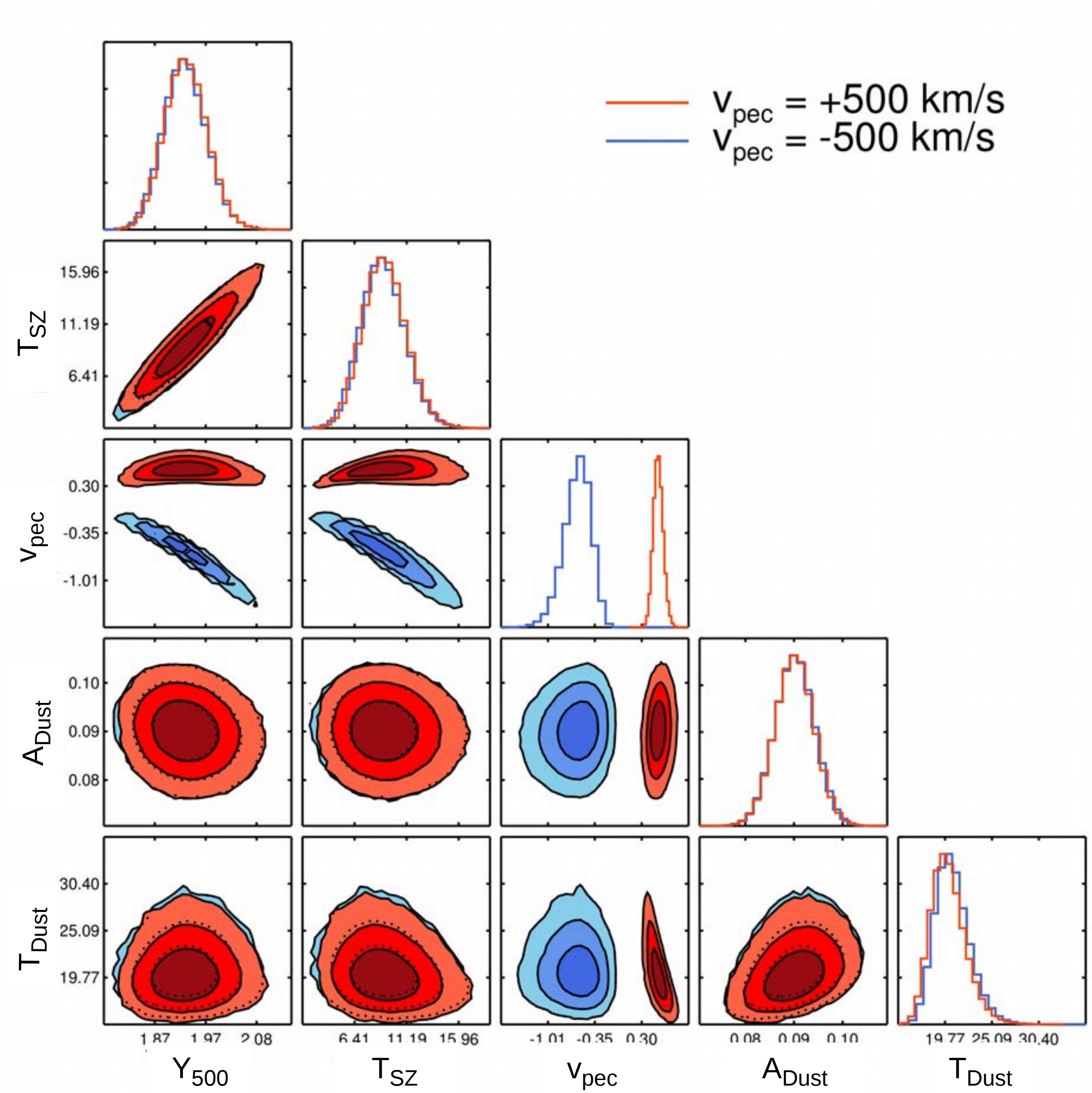
CCAT-prime simulations



CCAT-prime simulations



Summary

- The SZ effect is a powerful tool to study clusters
- Rel. corrections to the SZ allow to measure ICM temperature
- Galactic foregrounds and cluster FIR-emission are major challenges
- CCAT-prime will measure the rSZ and kSZ with high precision