

Removing foregrounds from CMB maps using non-Gaussianity measurement



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A FOREGROUND CLEANED CMB MAP FROM NON-GAUSSIANITY MEASUREMENT
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Accepted in ApJL, (arxiv:1105.6298)

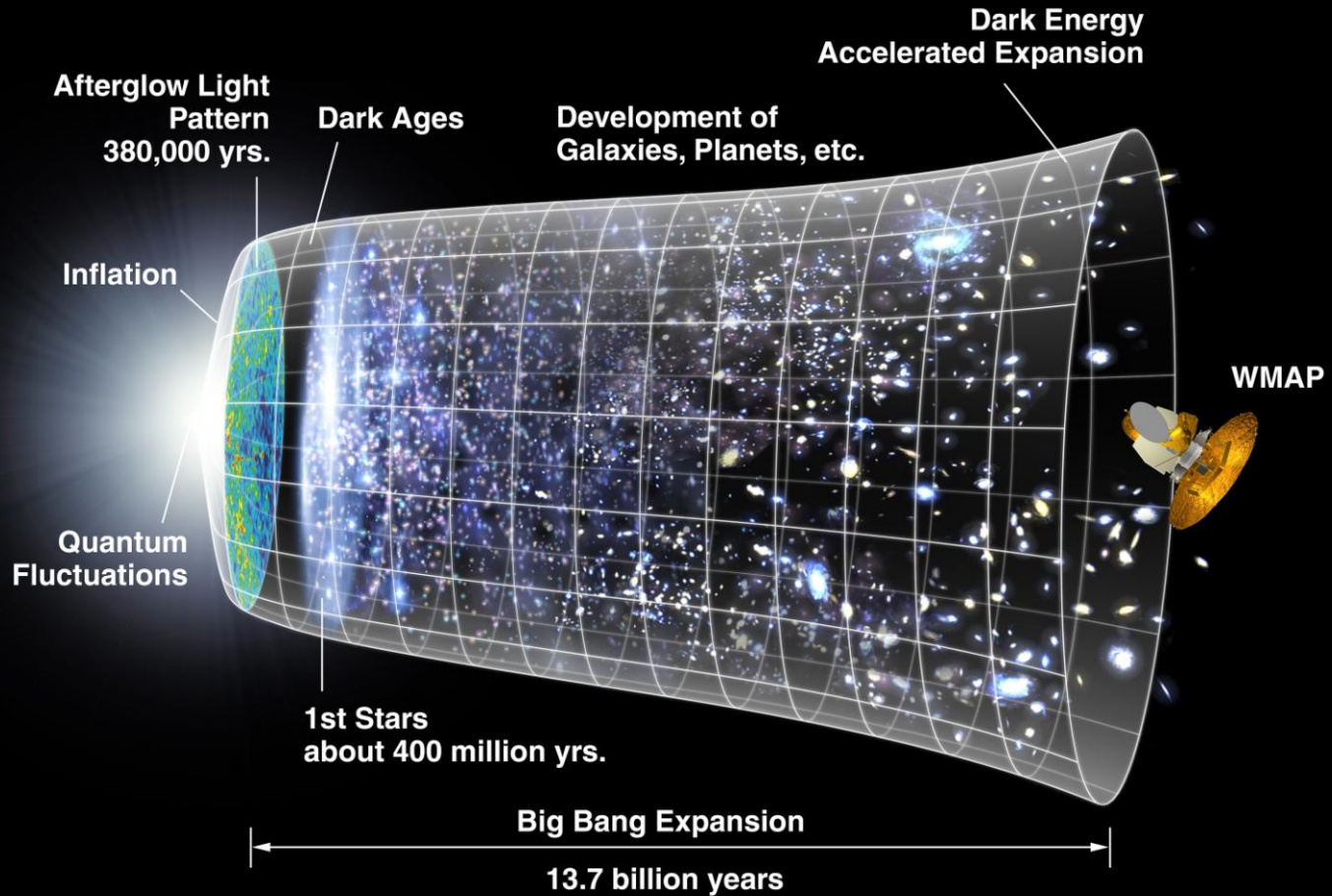
INDO-UK Scientific Seminar: Confronting particle cosmology with PLANCK and LHC
IUCAA, August 11, 2011

*In the beginning rose Hirannyagarbha, born
Only Lord of all created beings.*

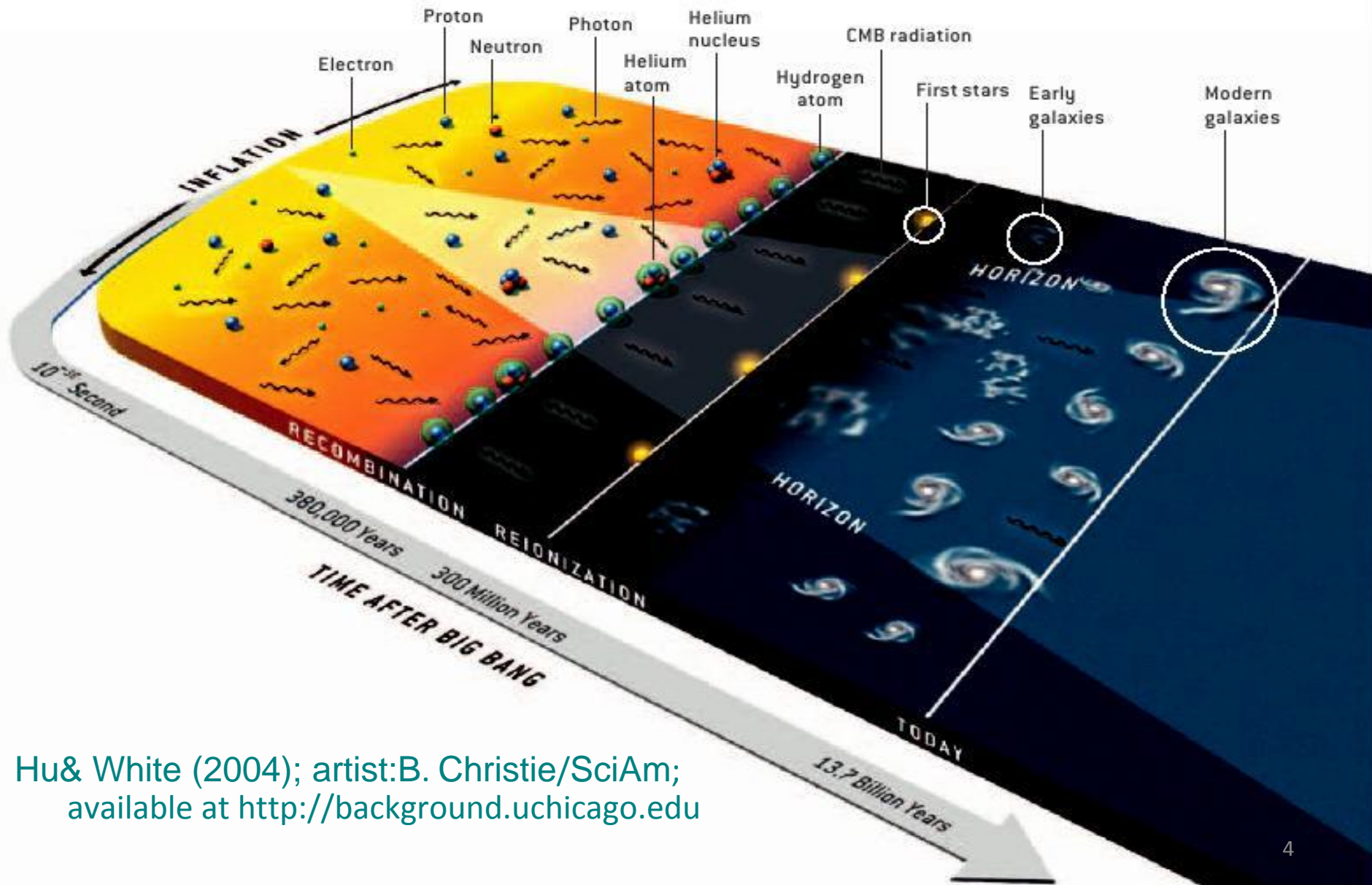
*He fixed and held up this earth and heaven
What God shall we adore with our oblation?*

--RIGVEDA (Translated by R.T.H. Griffith)

A brief History ..



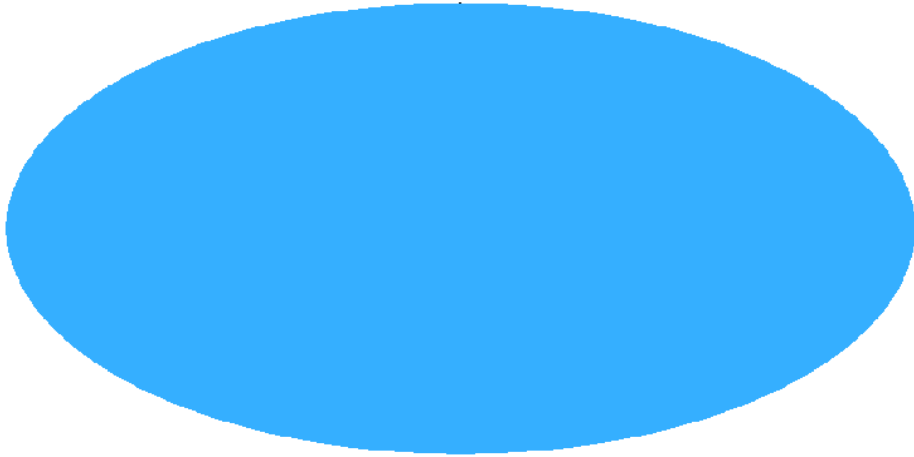
Cosmic Microwave Background Signal



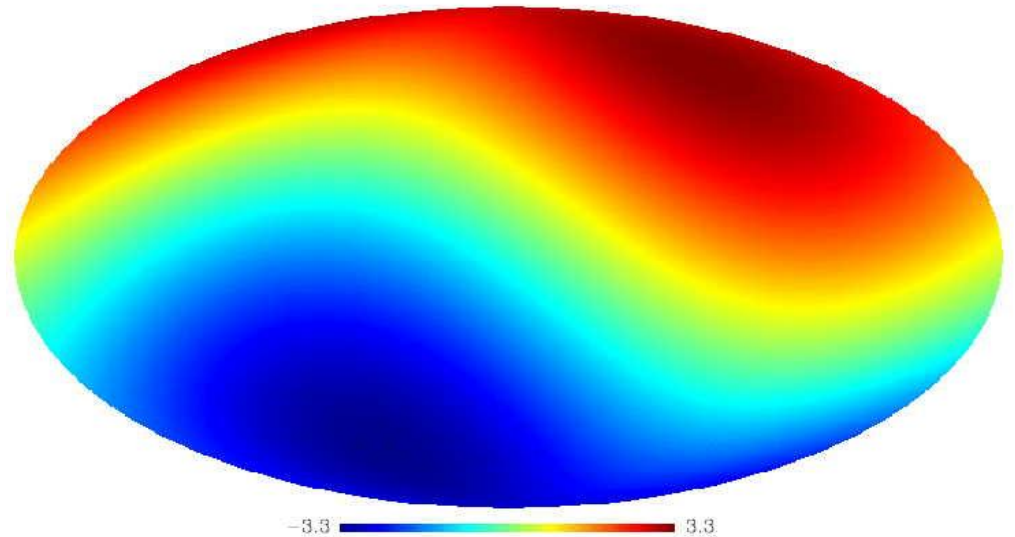
Hu & White (2004); artist: B. Christie/SciAm;
available at <http://background.uchicago.edu>

Cosmic Microwave Background Signal

CMB looks same in all directions ($T=2.728$ K)....



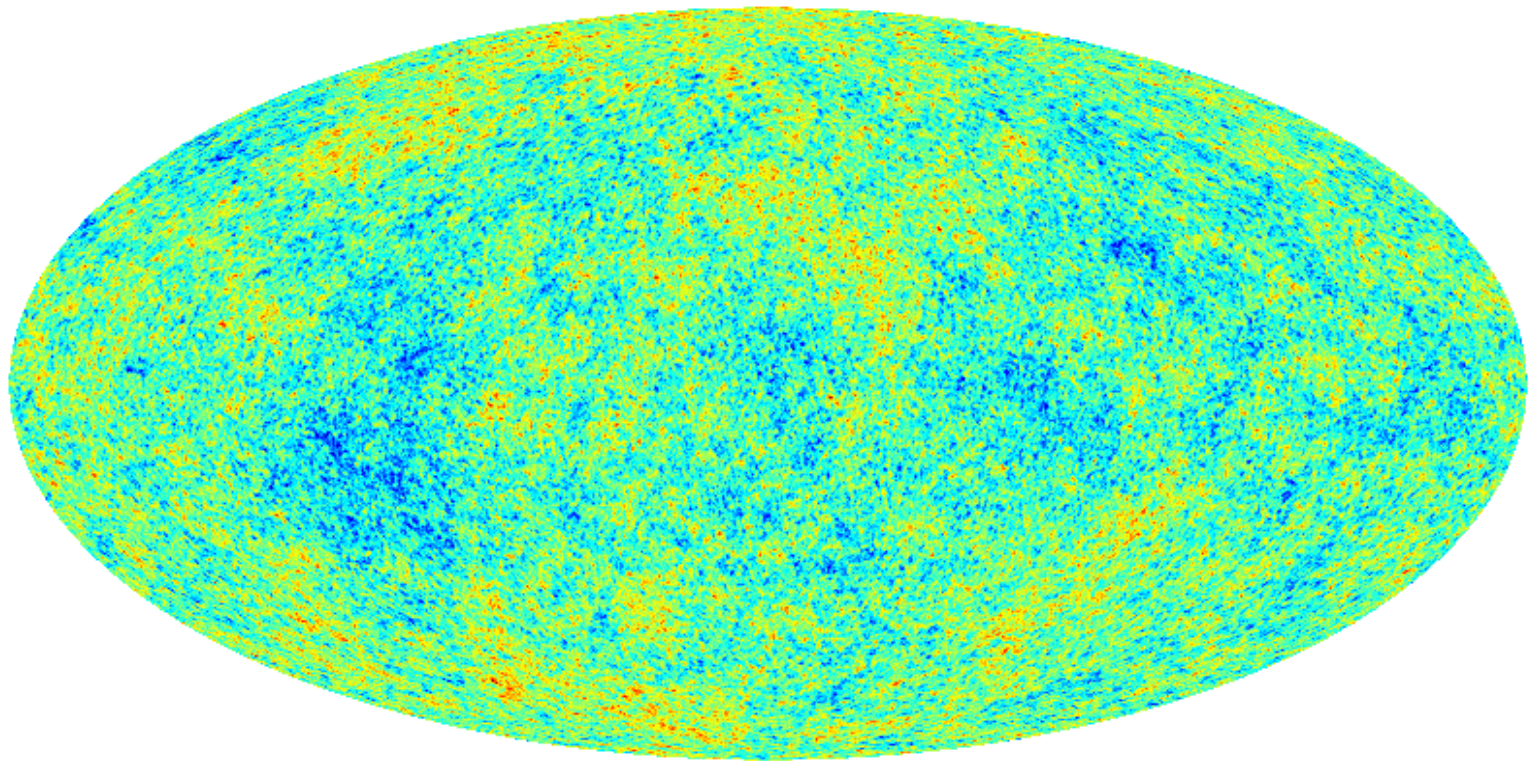
.... until we zoom in quite a bit



dipole anisotropy ($\Delta T/T \sim 1$ part in 1000) 5

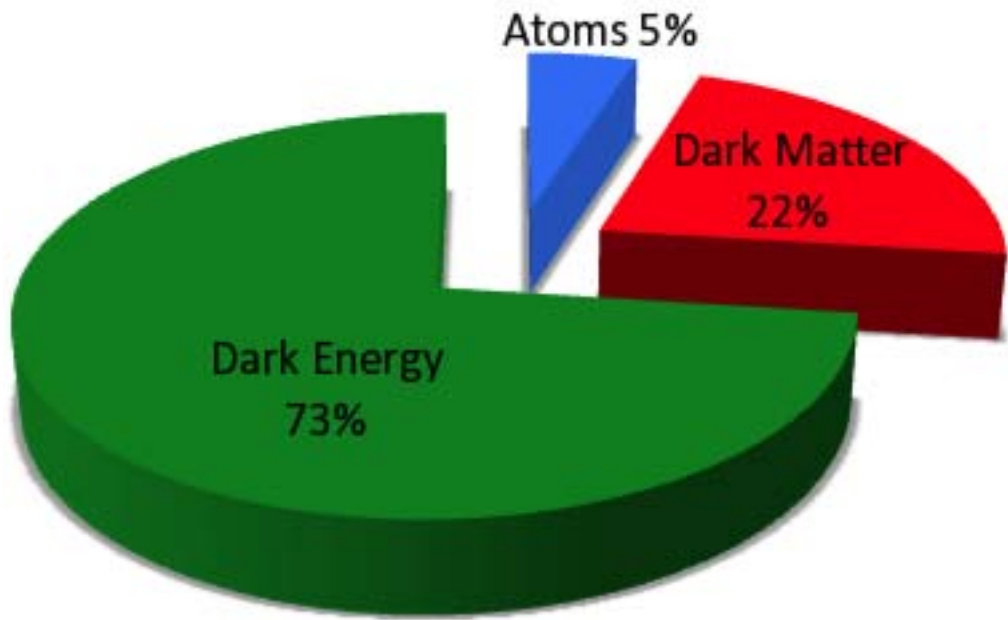
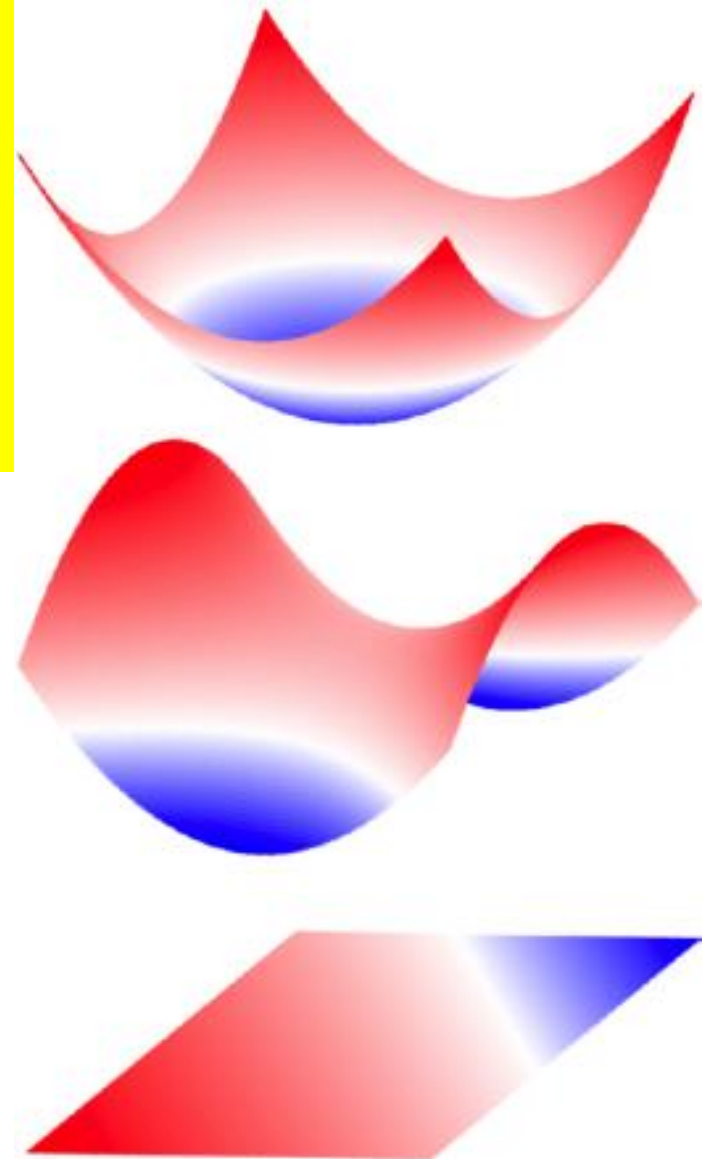
Cosmic Microwave Background Signal

.... and more



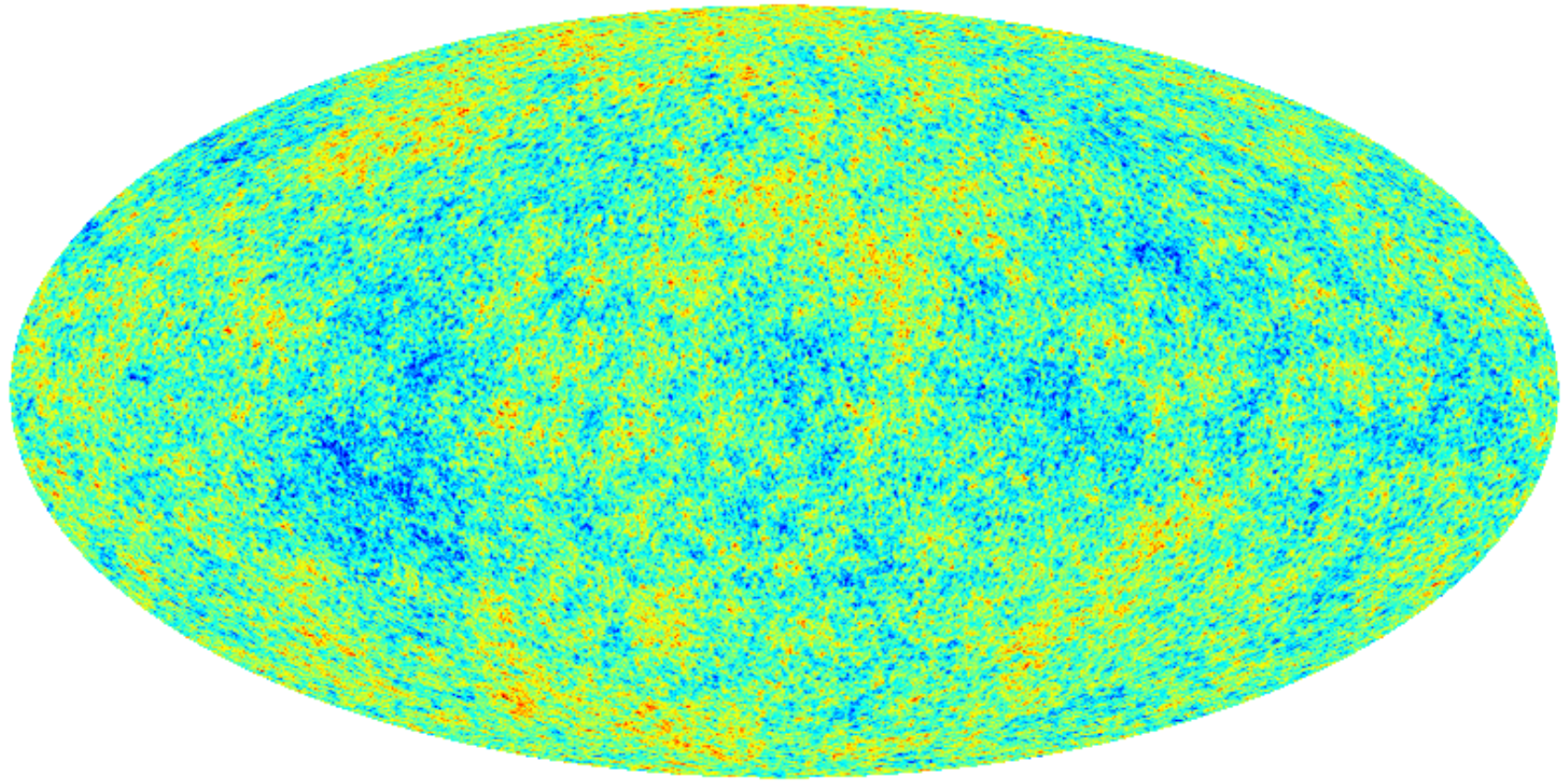
-4.727E+02  +5.142E+02

Standard Model of Cosmology says that –
(Fourier transformation of) CMB contains
information about *most of* past evolution of
Universe,
as well as,
its content, shape and size



However, CMB gets contaminated by our own Galaxy



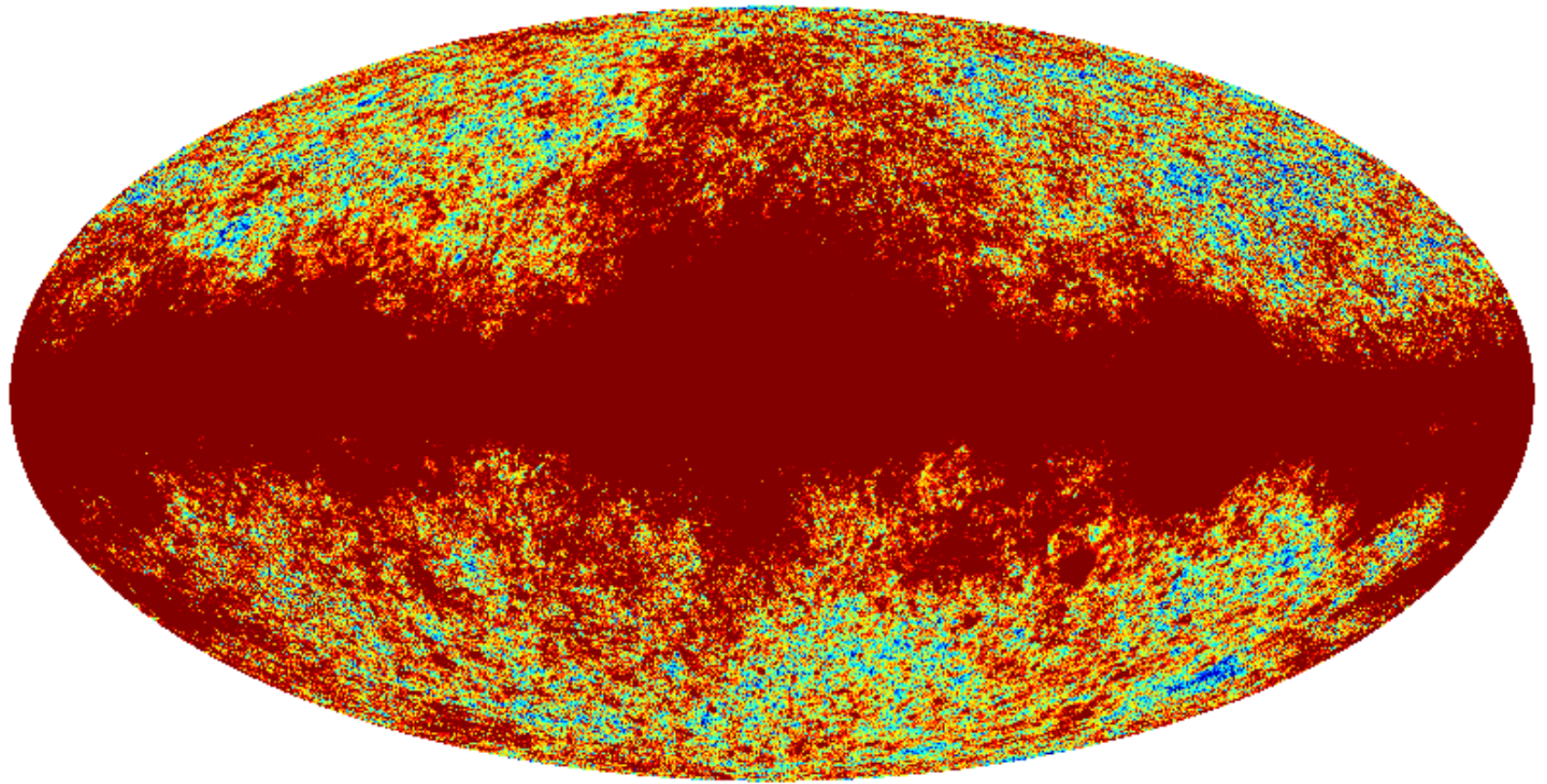


-4.727E+02



+5.142E+02

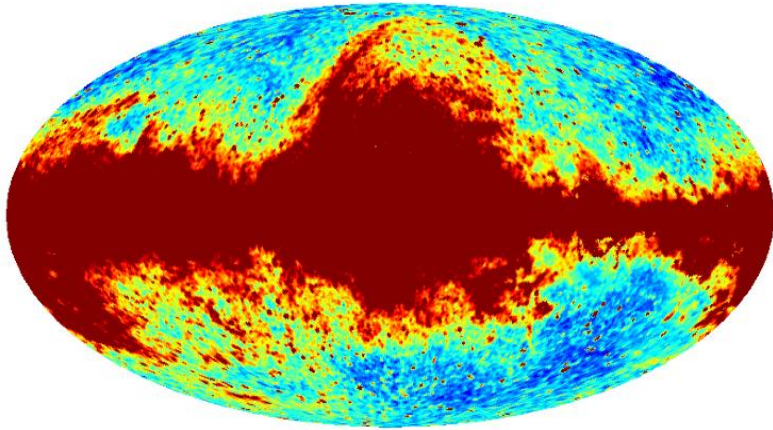
Pure Signal



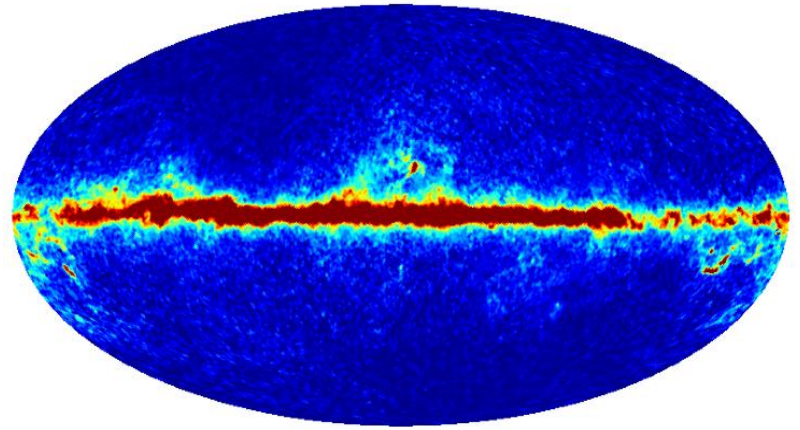
Contaminated Signal

Foreground Emission

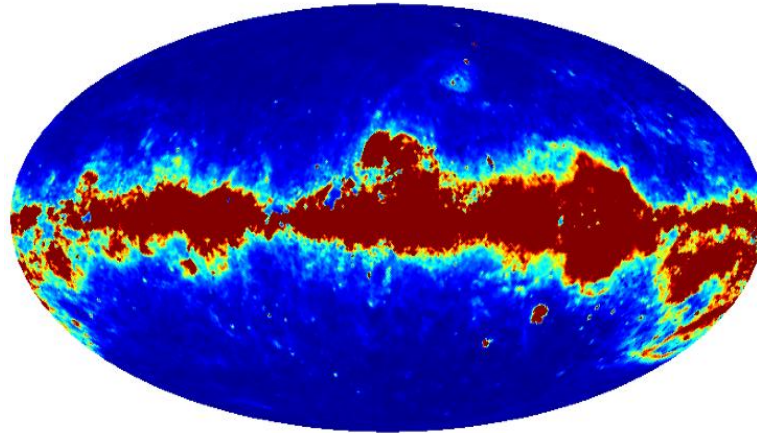
Synchrotron emission



Thermal Dust emission



Free Free emission



The problem is-

how to remove contamination from observed CMB signal --

Solution :

Use the fact -

Contaminations are highly non-Gaussian but

CMB follows Gaussian distribution

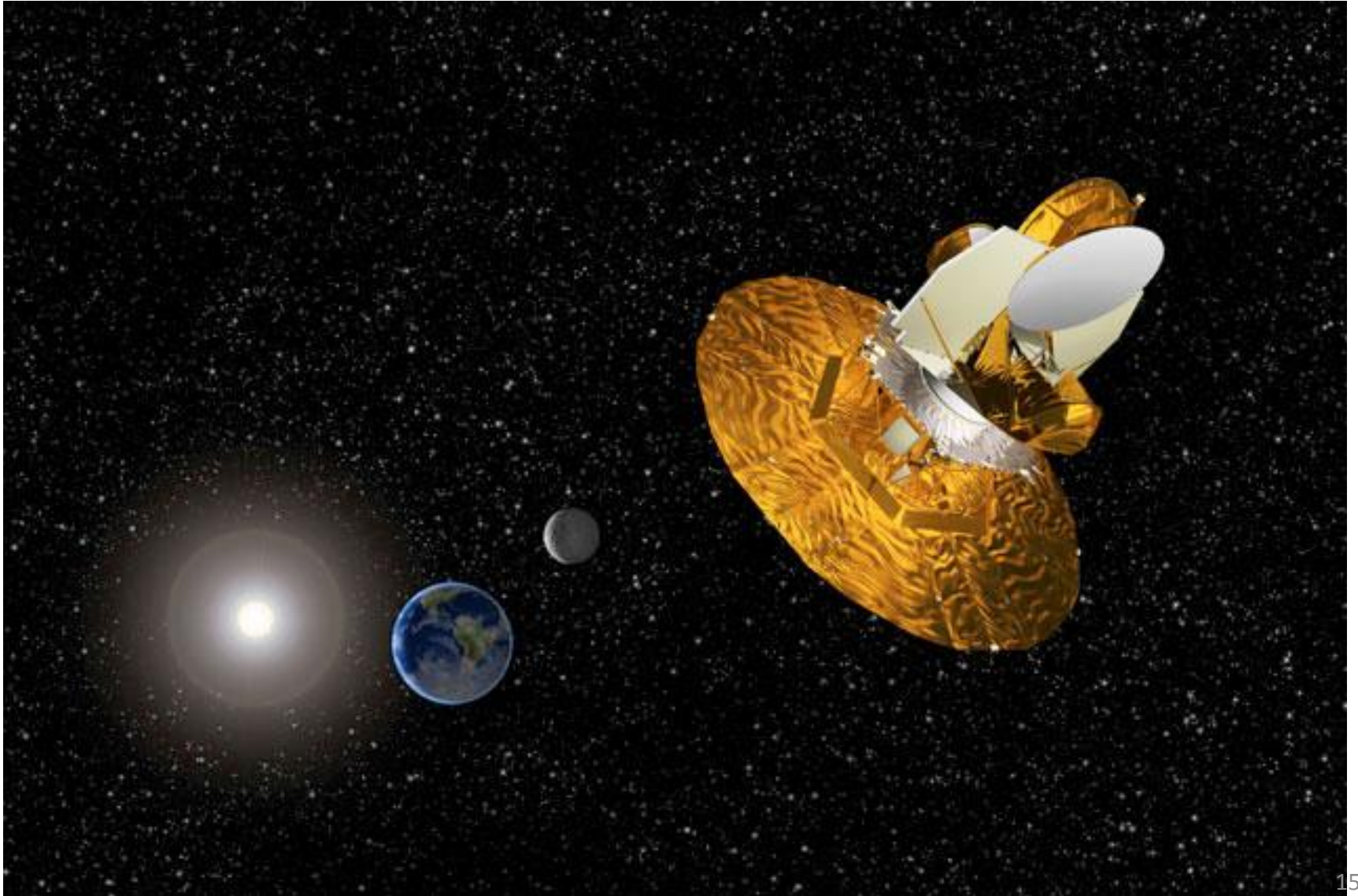
- A measure of non-Gaussianity → Kurtosis

$$K = \frac{1}{n} \sum_{i=1}^n \frac{(x_i - x_0)^4}{\sigma^4} - 3$$

- K is 0 for Gaussian distribution and hence for CMB
but positive when contaminations are present

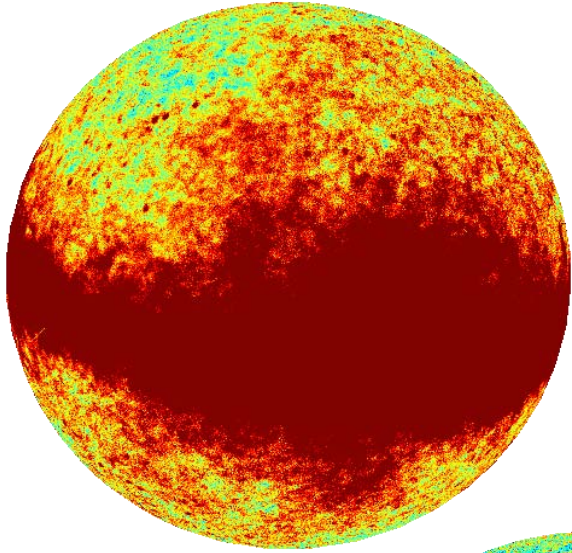
WMAP Satellite

Proposed in 1995 and launched into space in 2001 by NASA

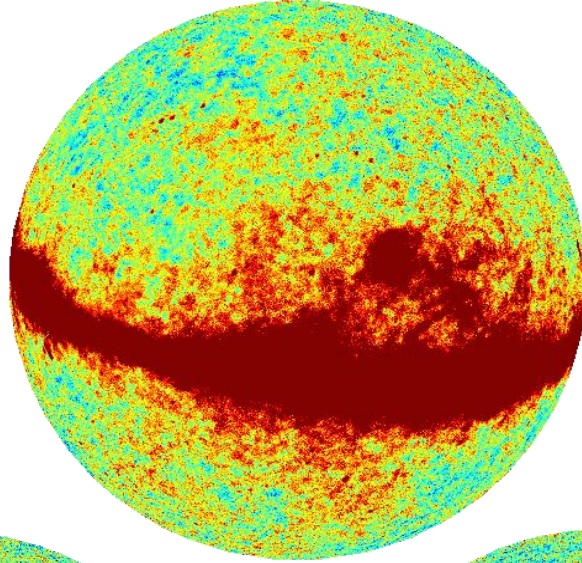


WMAP DATA

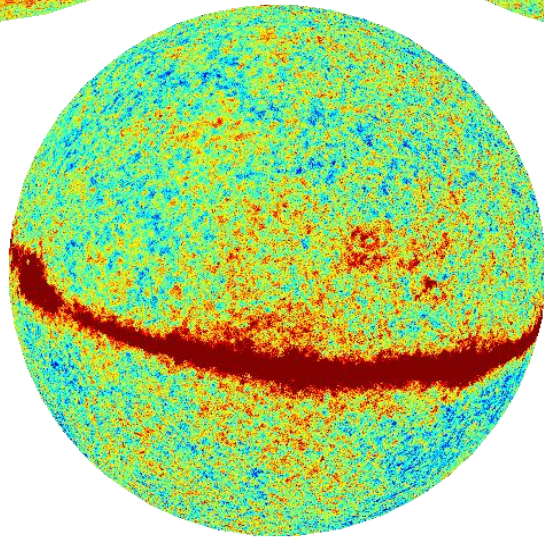
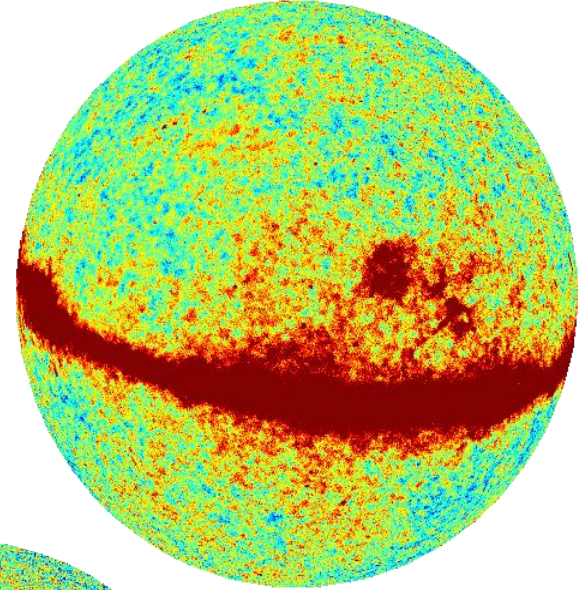
23Ghz



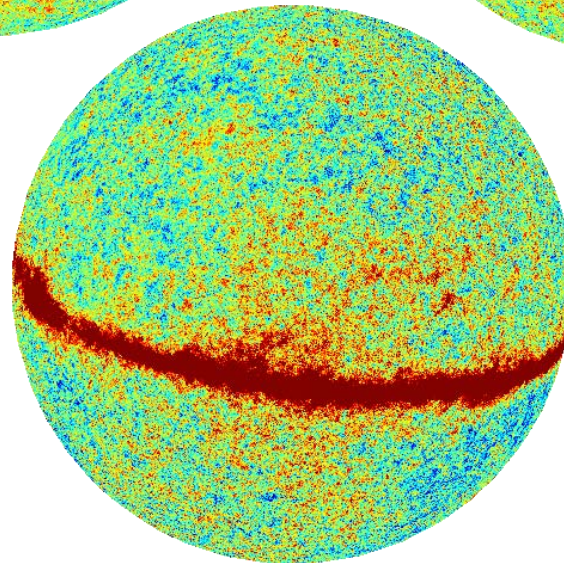
33Ghz



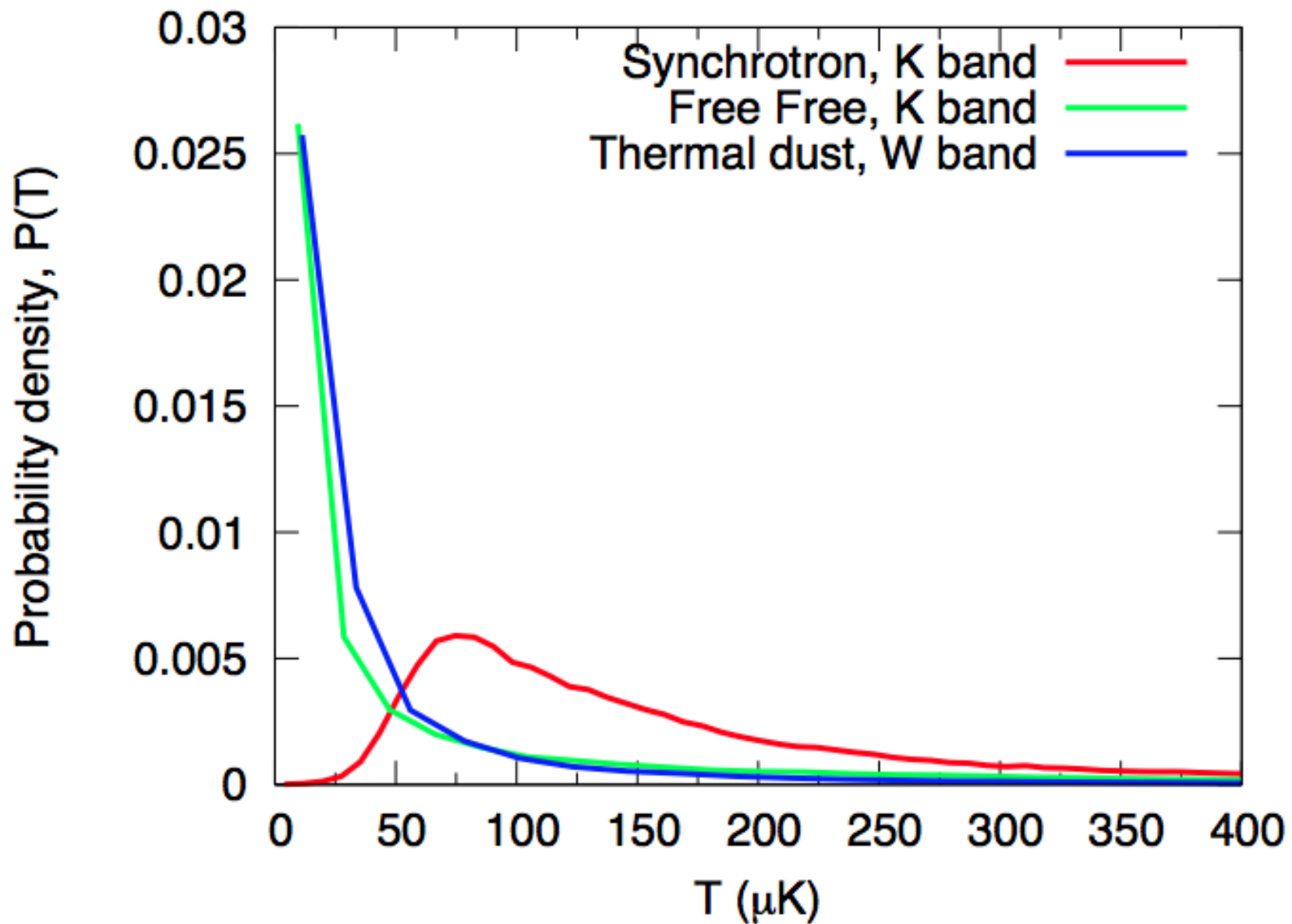
41Ghz



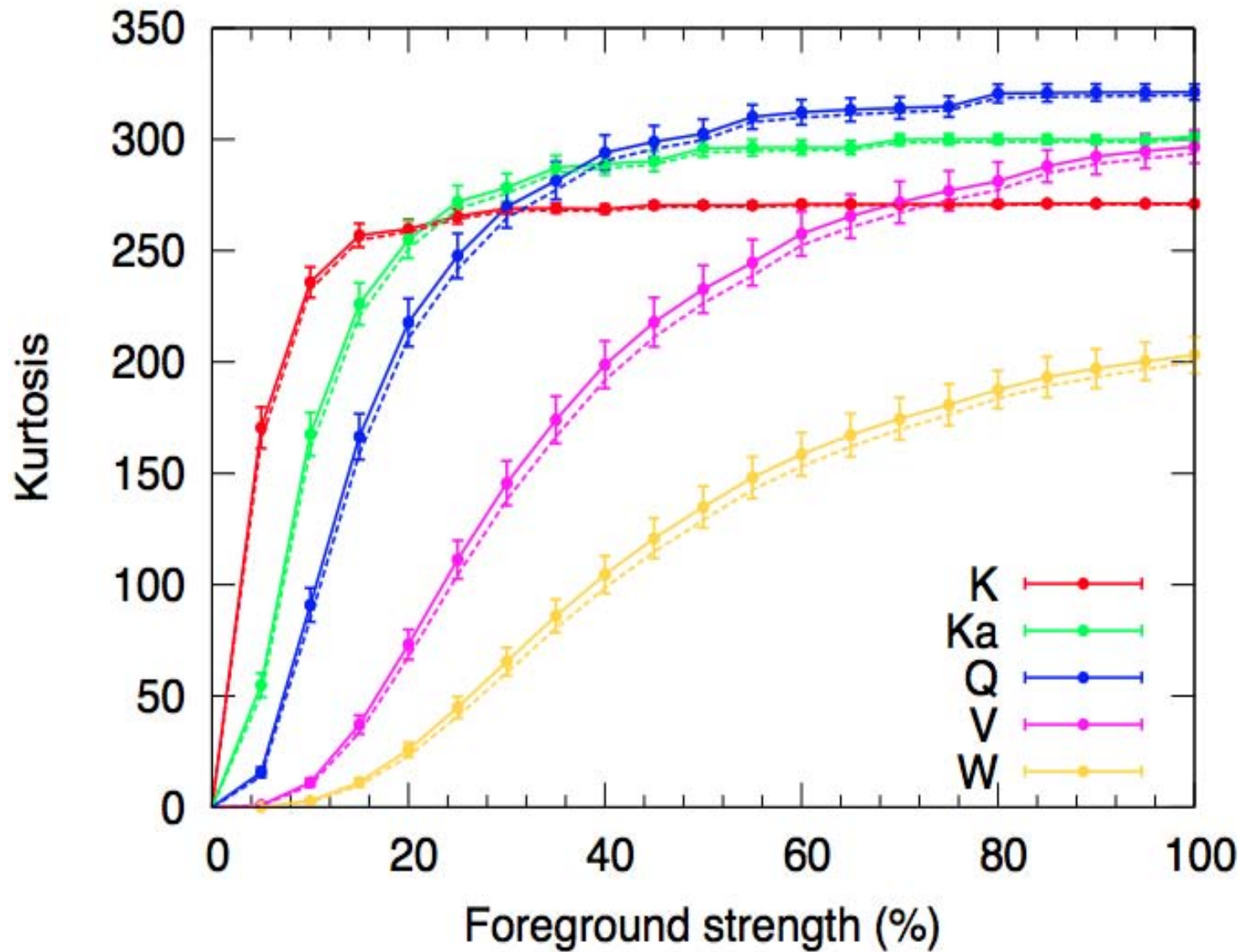
94 GHz



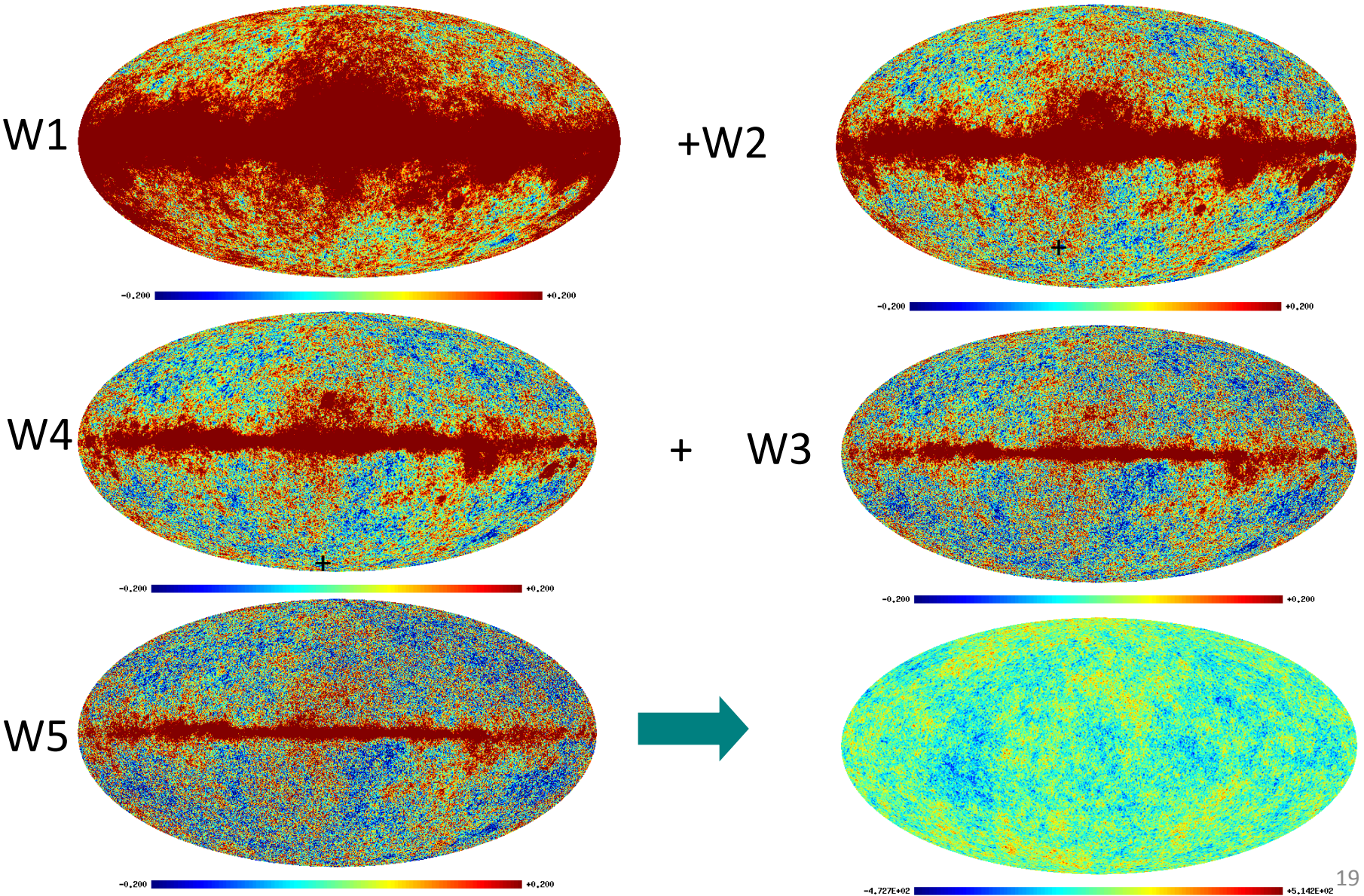
61GHz



More contamination, more Kurtosis

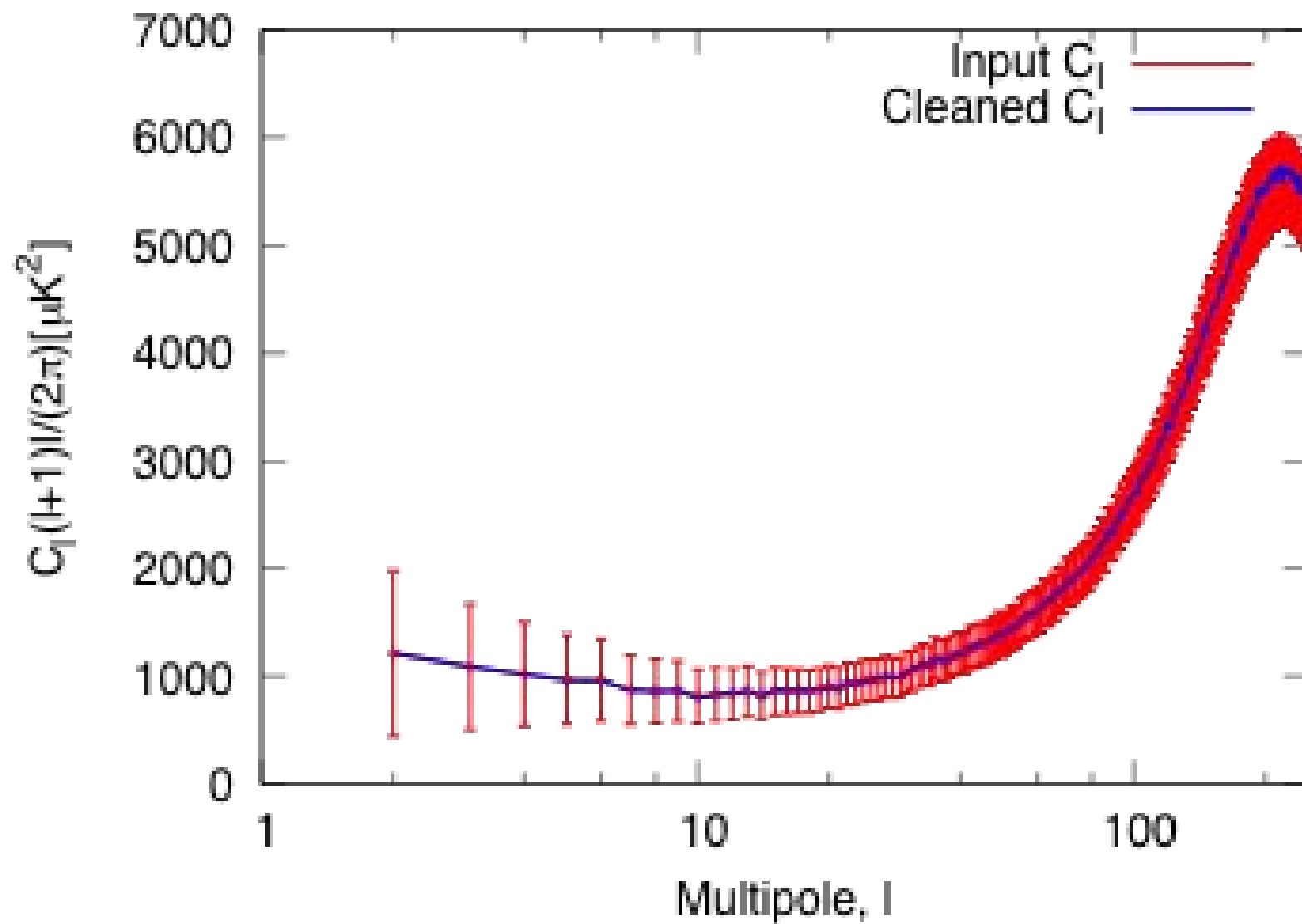


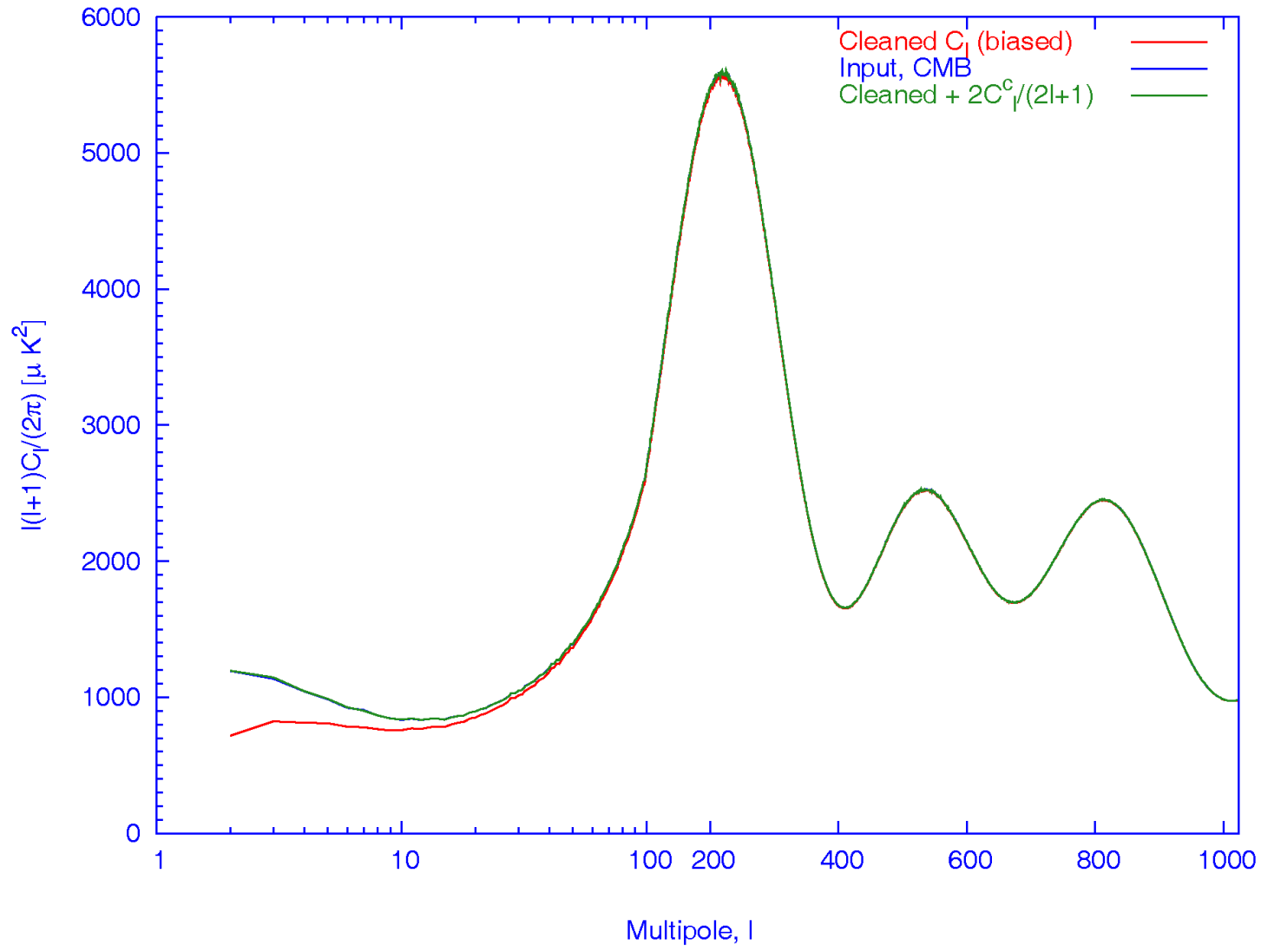
Linearly combine 5 WMAP maps with certain weights w_1, w_2, w_3, w_4, w_5



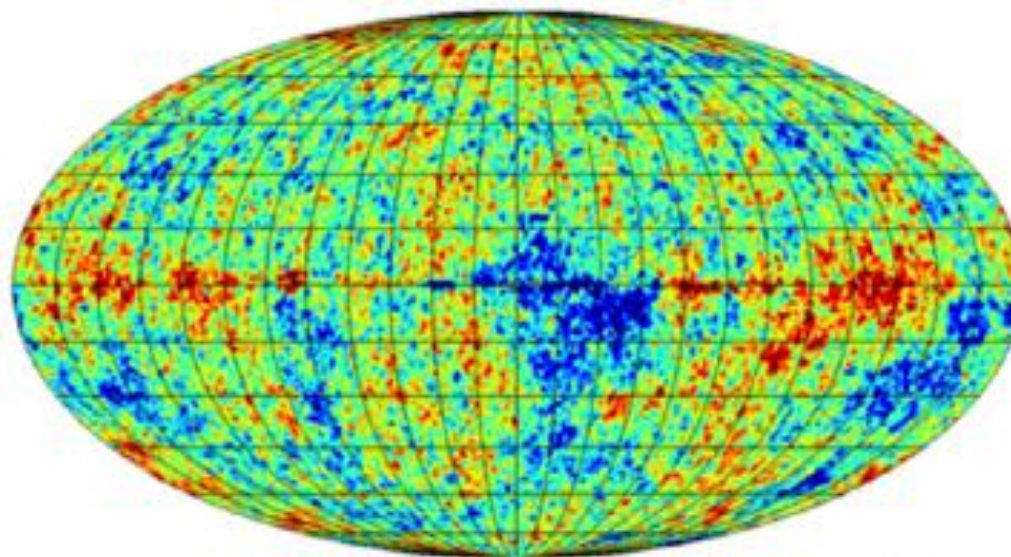
- Obtain weights by minimizing Kurtosis of the weighted map
- $W = (0.035368, -0.377965, -0.216677, 1.632449, -0.073175)$
- $K_{\min} = 1.17$

➤ Results

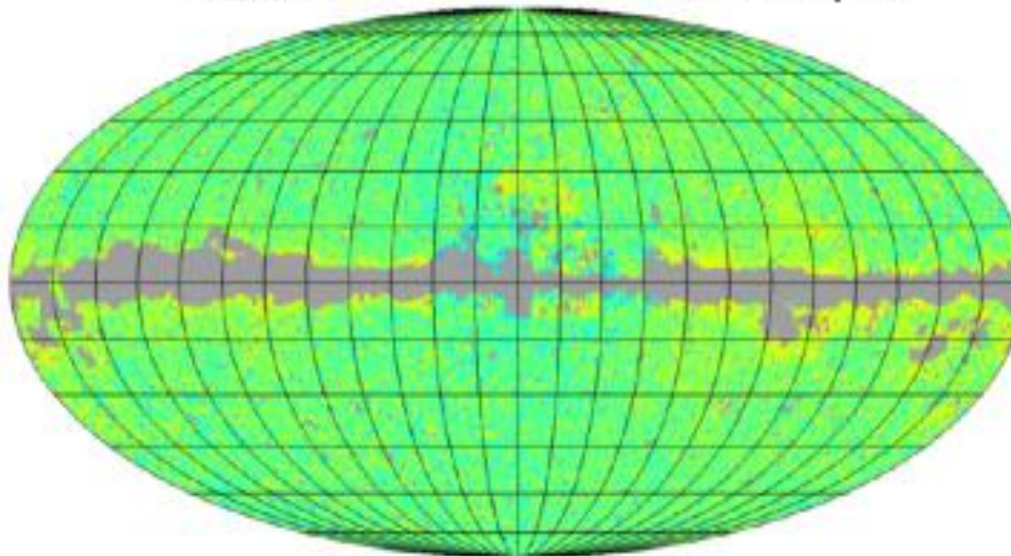




➤ Results

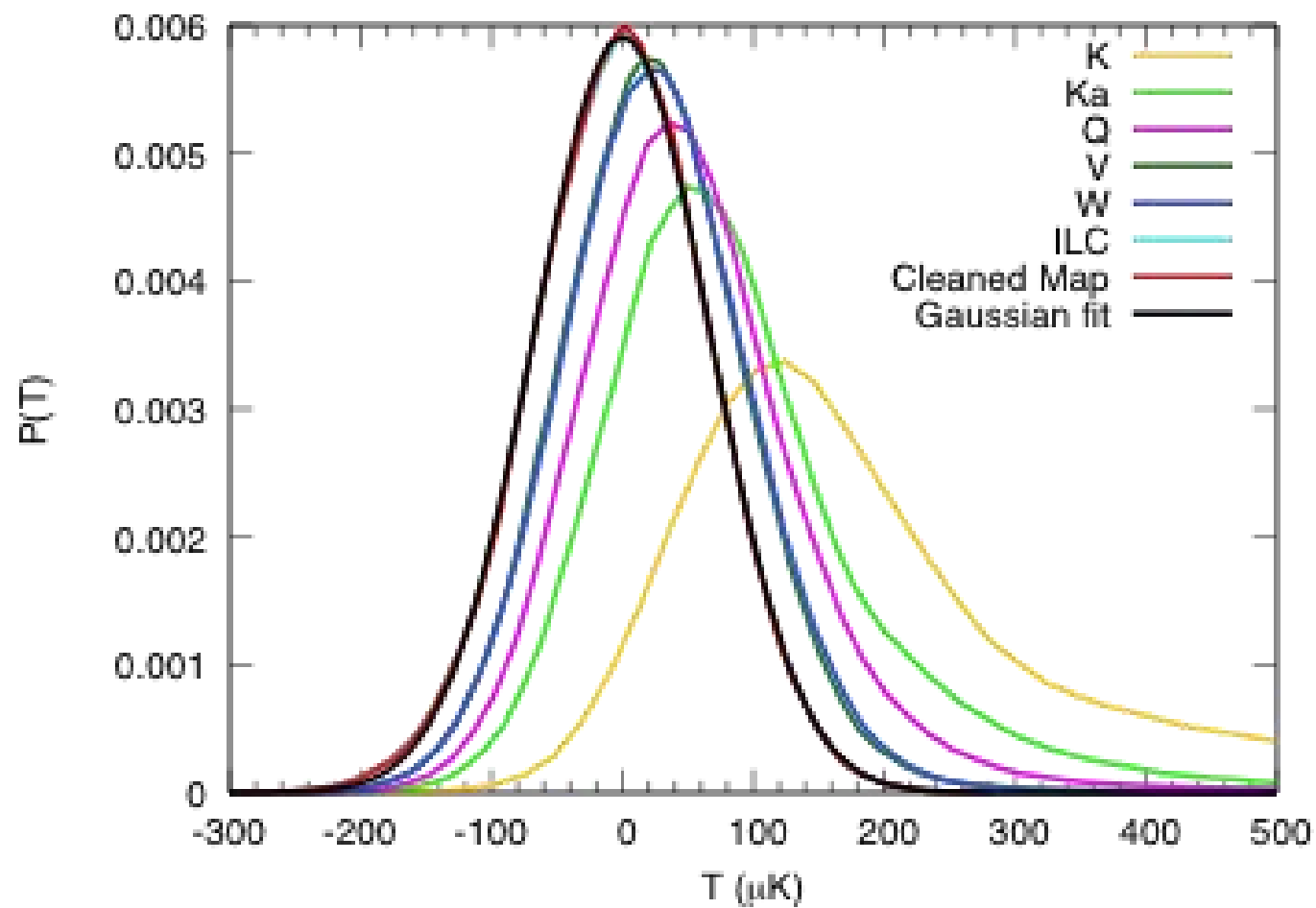


-200  200 μK

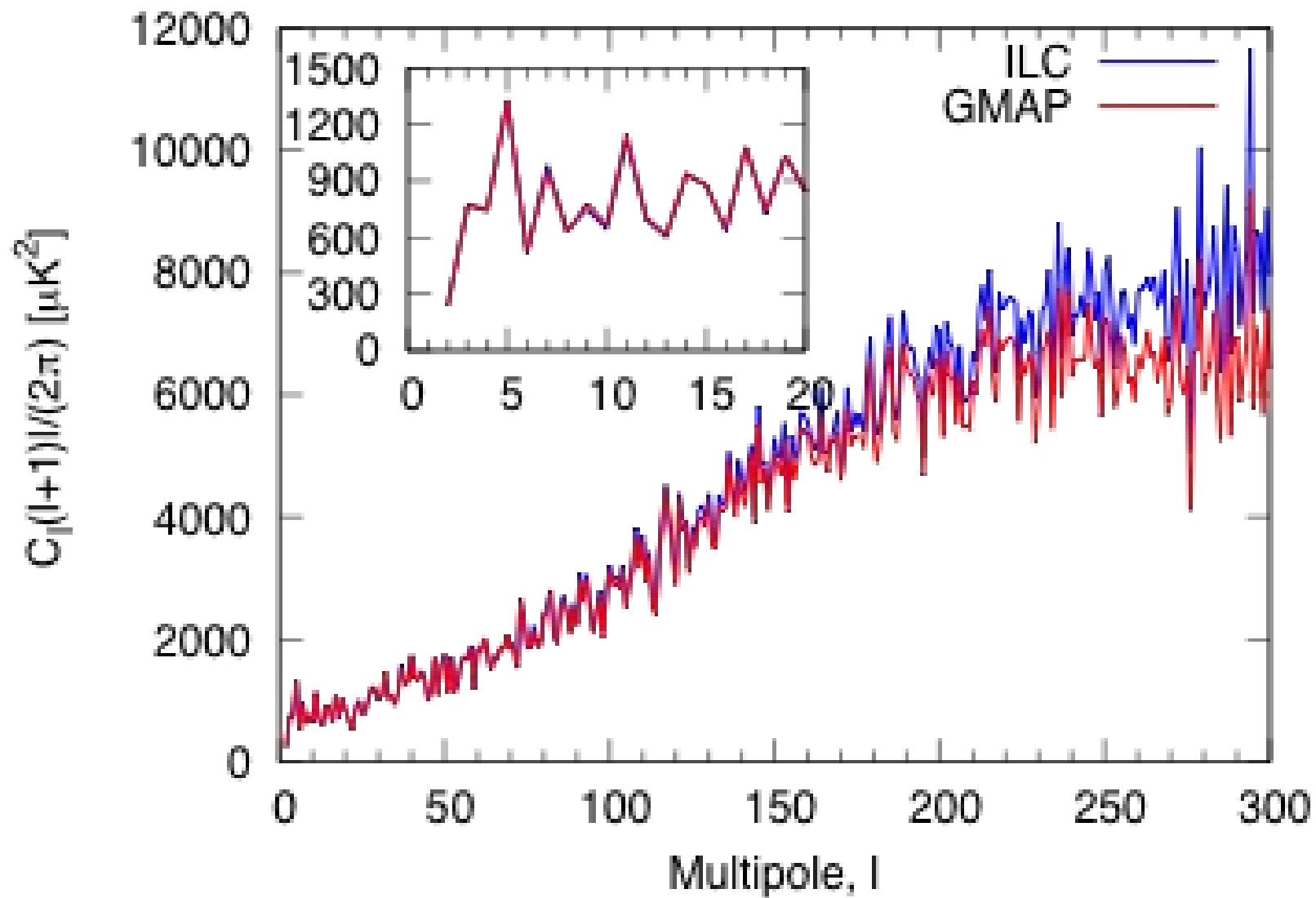


-50  50 μK

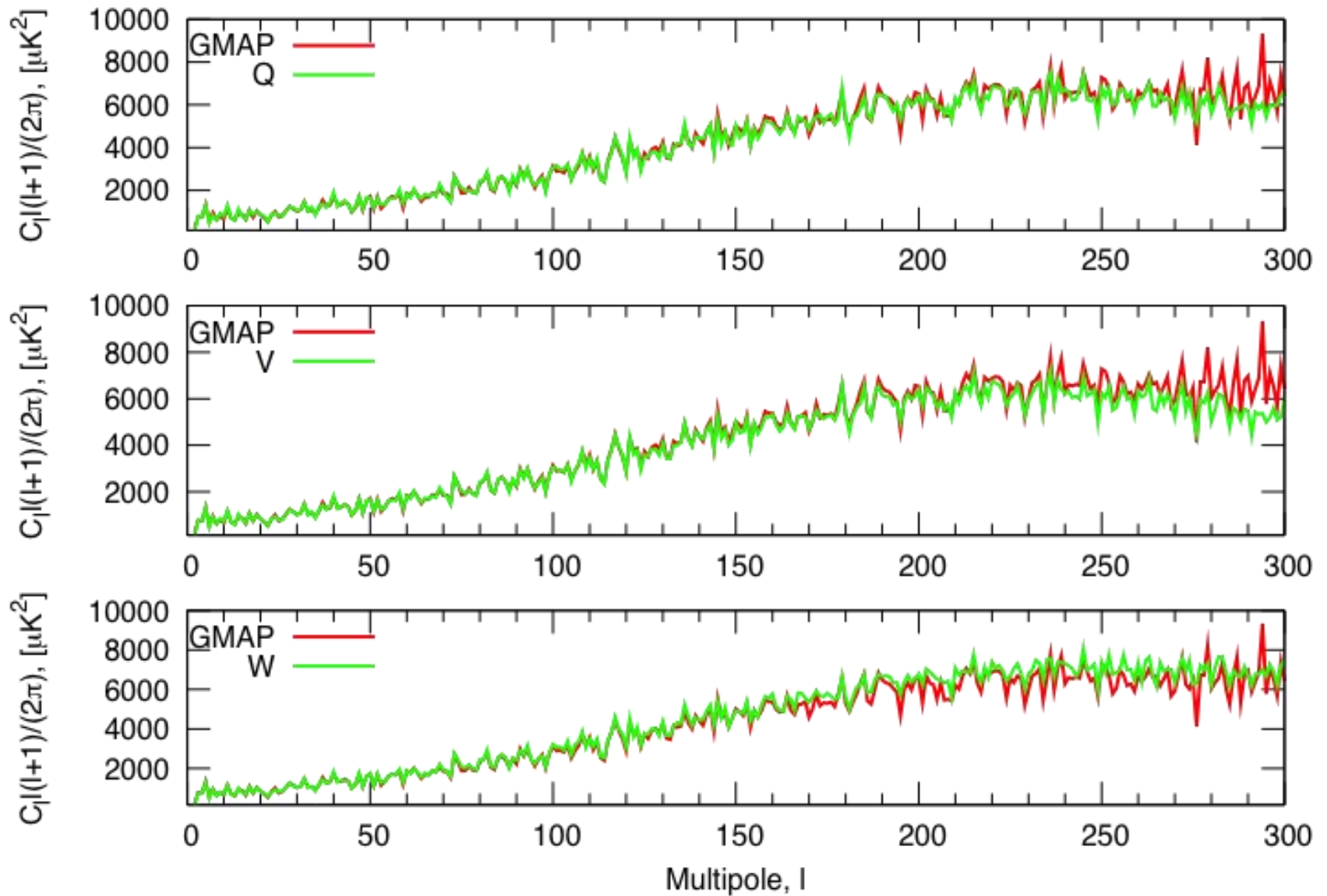
➤ Results



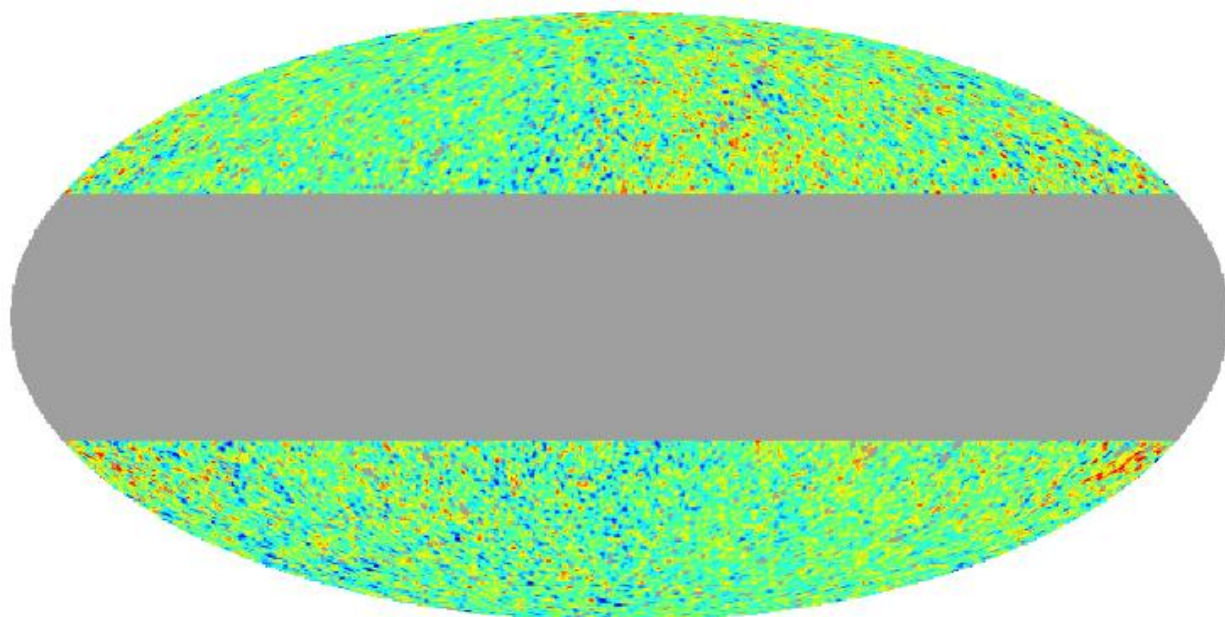
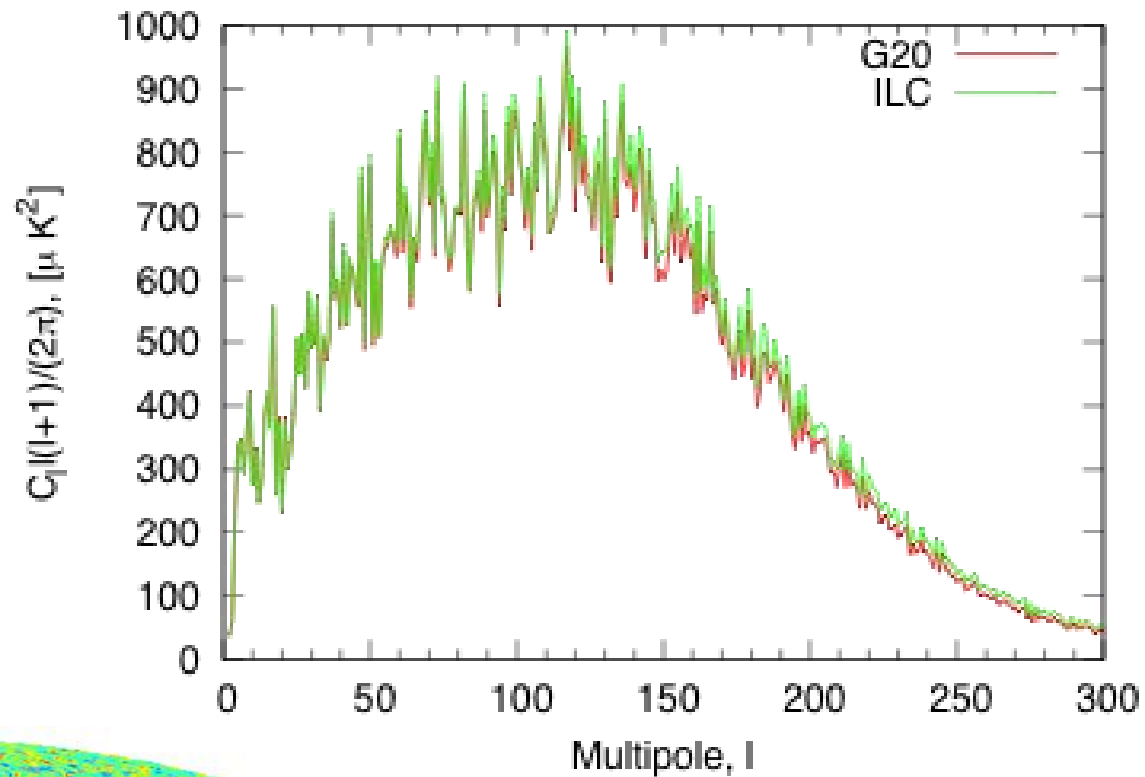
➤ Results



➤ Results



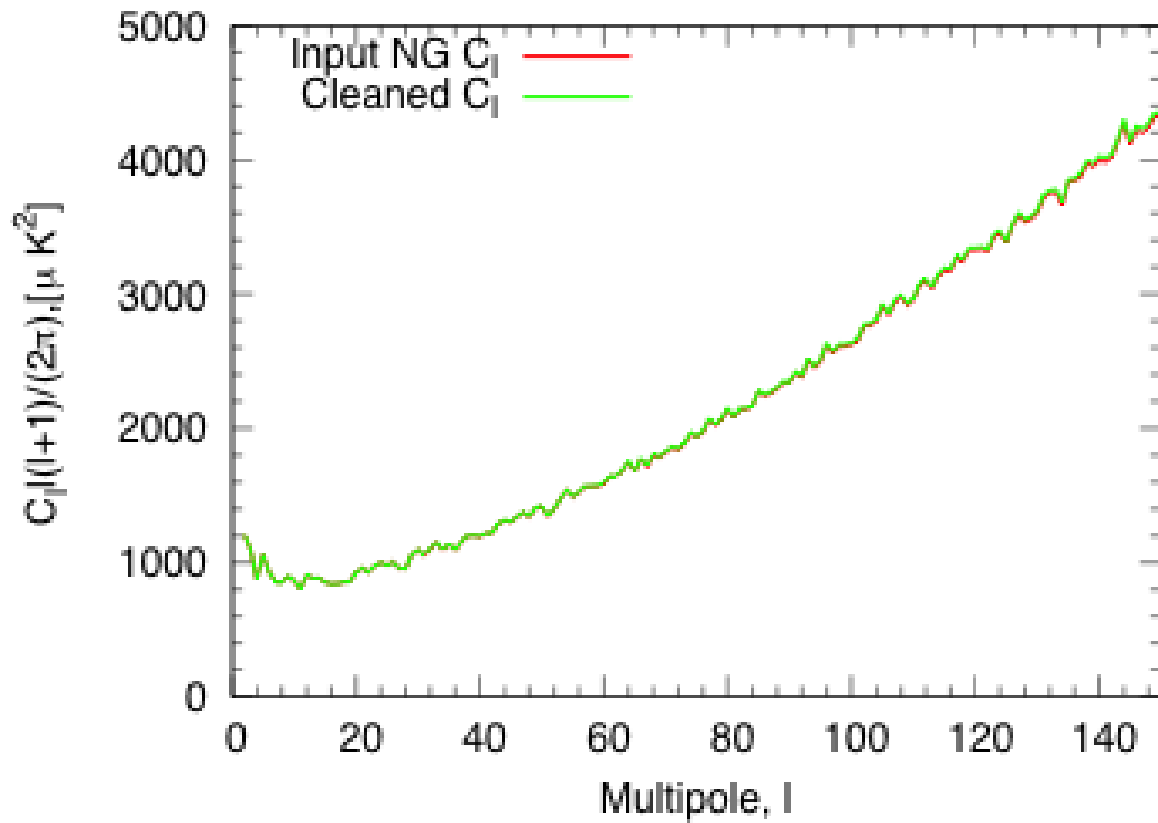
➤ Results



-22  22 μK

➤ Results

CMB remains preserved even if it was non-Gaussian!



➤ Discussions

✧ Direct relationship with the physics of the early universe!!

✧ It preserves CMB even if it has non-Gaussian properties

-- Breakdown of degeneracy between various models of very rapid expansion of space when universe was 10^{-33} sec old.

-- Information about structure formation in universe

-- More information from Planck, T, Q, U data

✧ Independent on explicit foreground modeling

✧ Does not have any negative bias unlike usual variance based methods.

Thank you !