PLANCK'S VIEW OF THE UNIVERSE IN FRONT OF THE MICROWAVE BACKGROUND

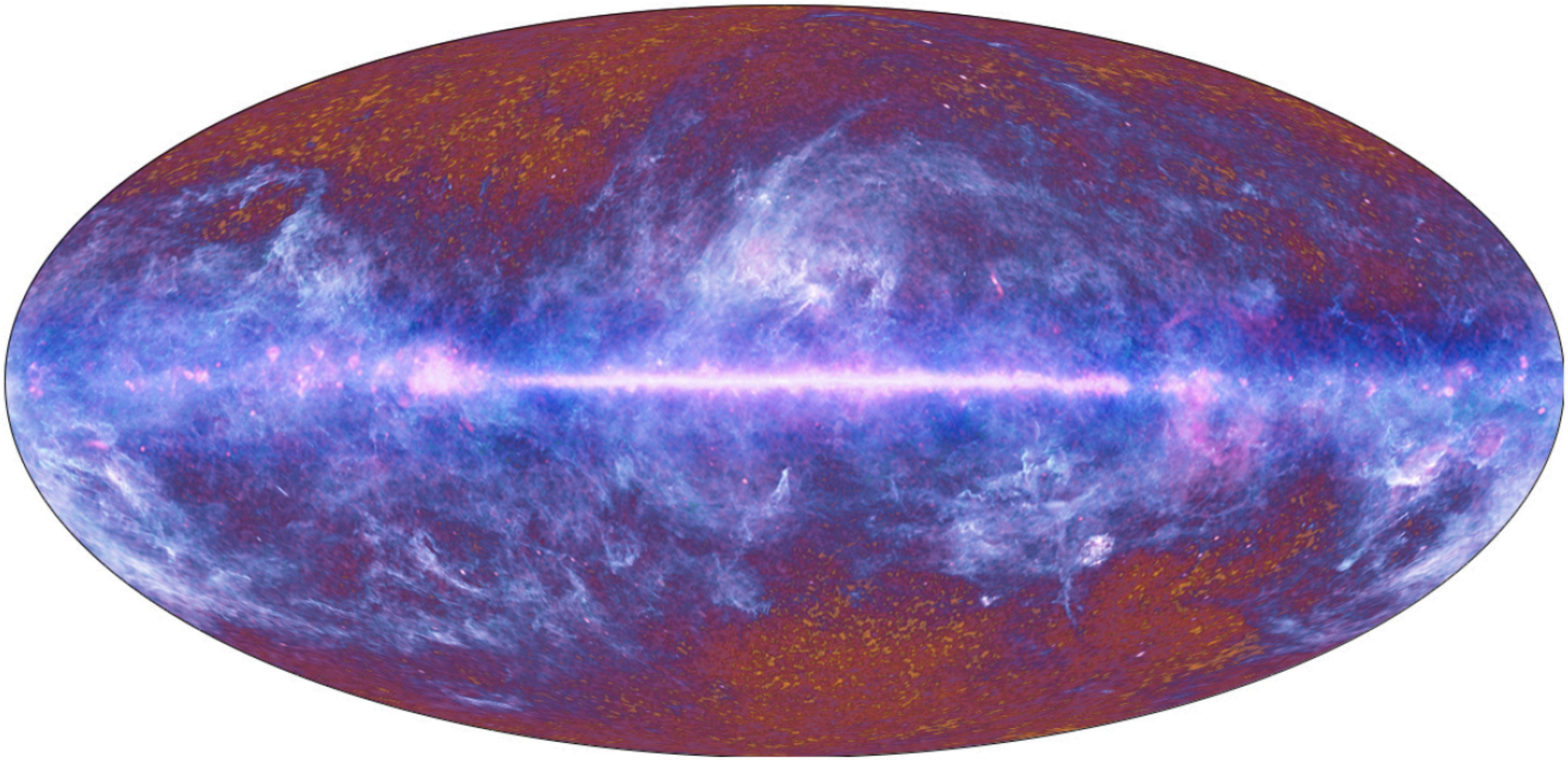
Gravitational lensing and Sunyaev-Zeldovich signals

The Planck Consortium (presented by Simon White)

Paris 21/03/2013

PLANCK'S FIRST IMAGE OF THE WHOLE SKY

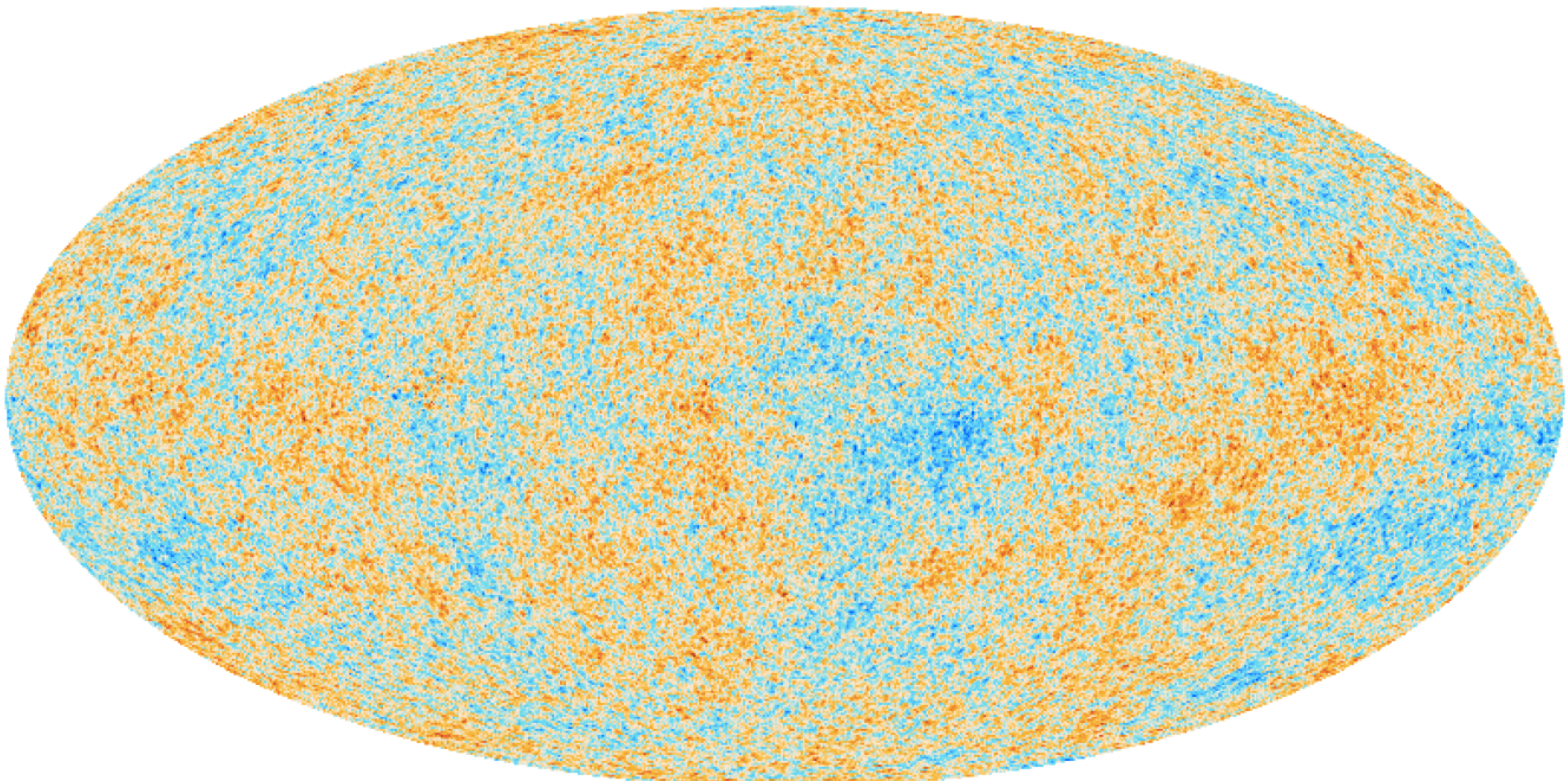
Planck's multi-frequency imaging allows different emission components to be separated and mapped



Here emission from our own Milky Way is emphasised, particularly infrared emission from interstellar dust warmed by star-light

PLANCK'S MAP OF THE MICROWAVE BACKGROUND

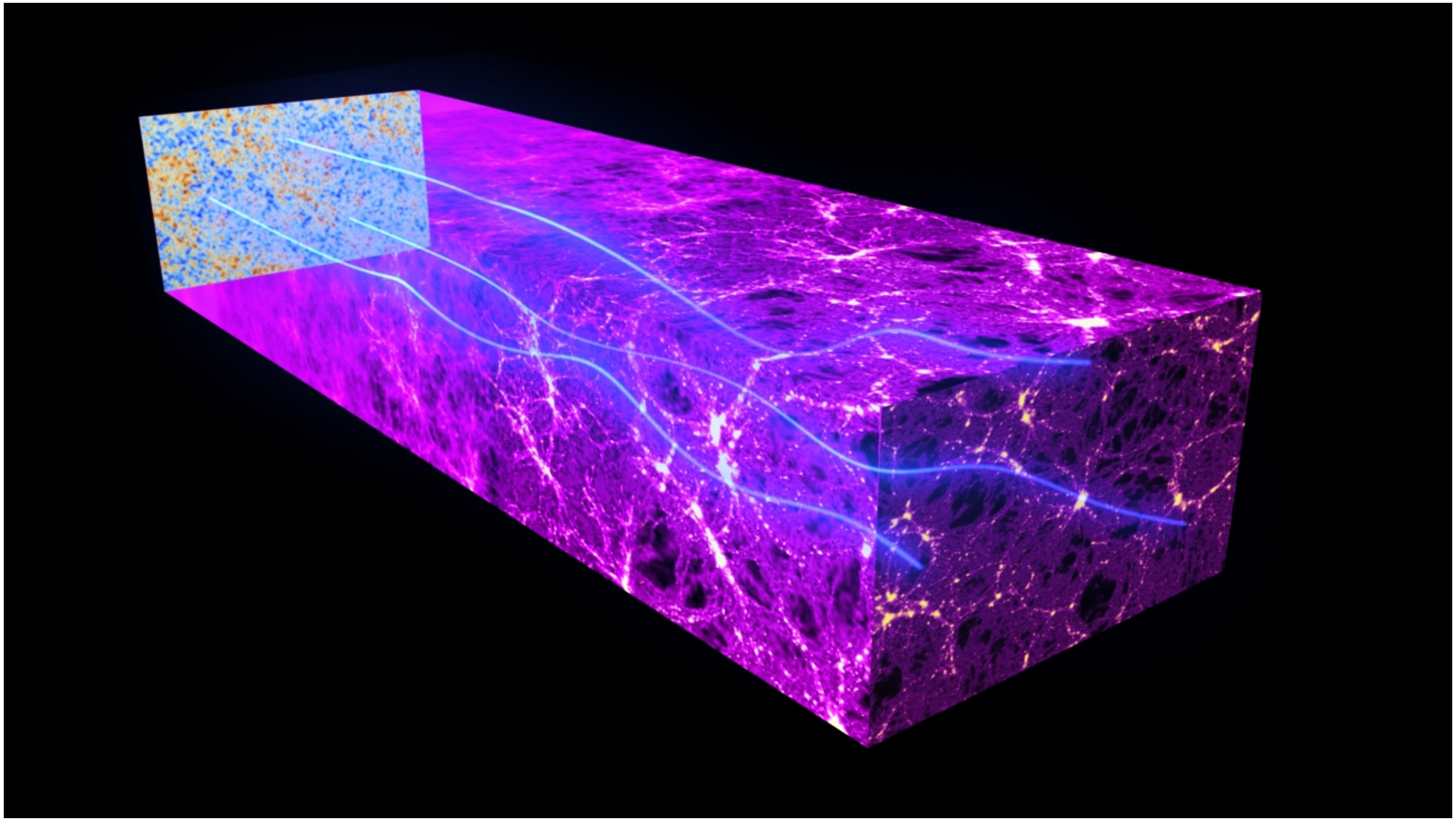
Planck's multi-frequency imaging allows different emission components to be separated and mapped



Here emission from our own Milky Way is removed, together with light from other galaxies, leaving an image of the young Universe (t~380,000 yrs)

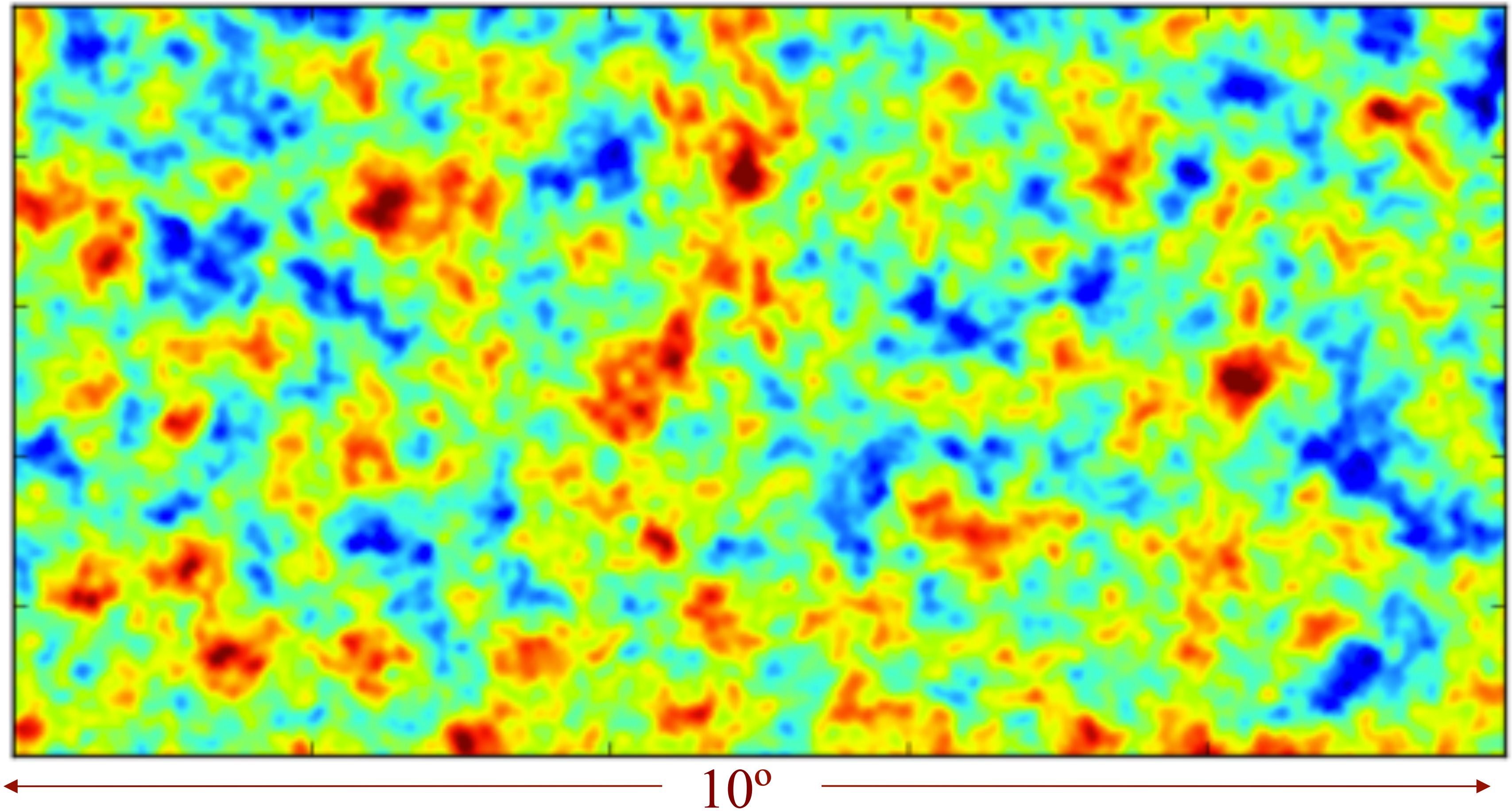
GRAVITATIONAL LENSING DISTORTS IMAGES

The gravitational effects of intervening matter bend the path of CMB light on its way from the early universe to the Planck telescope. This "gravitational lensing" distorts our image of the CMB



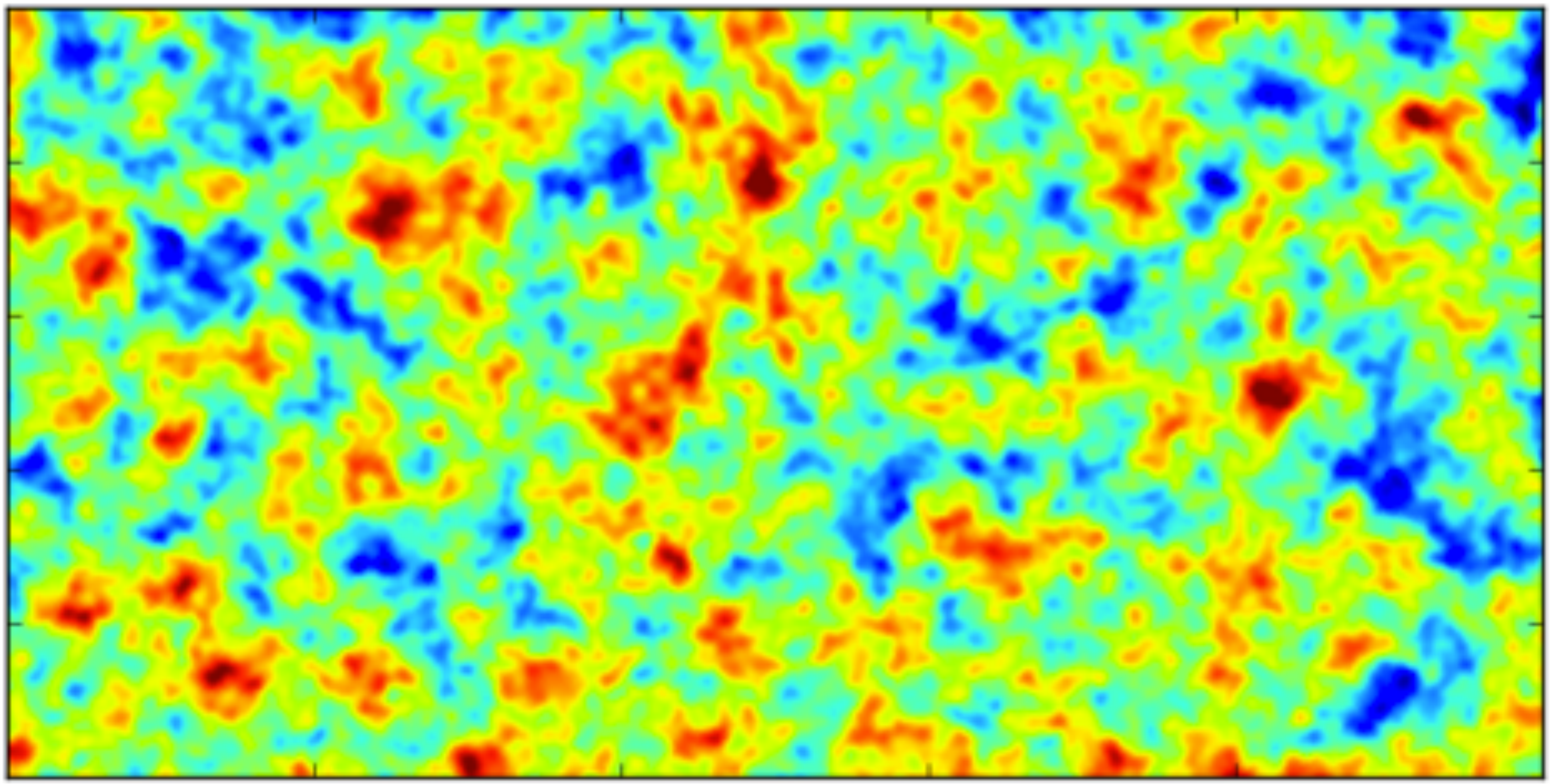
GRAVITATIONAL LENSING OF THE CMB

A simulated patch of CMB sky – **before lensing**



GRAVITATIONAL LENSING OF THE CMB

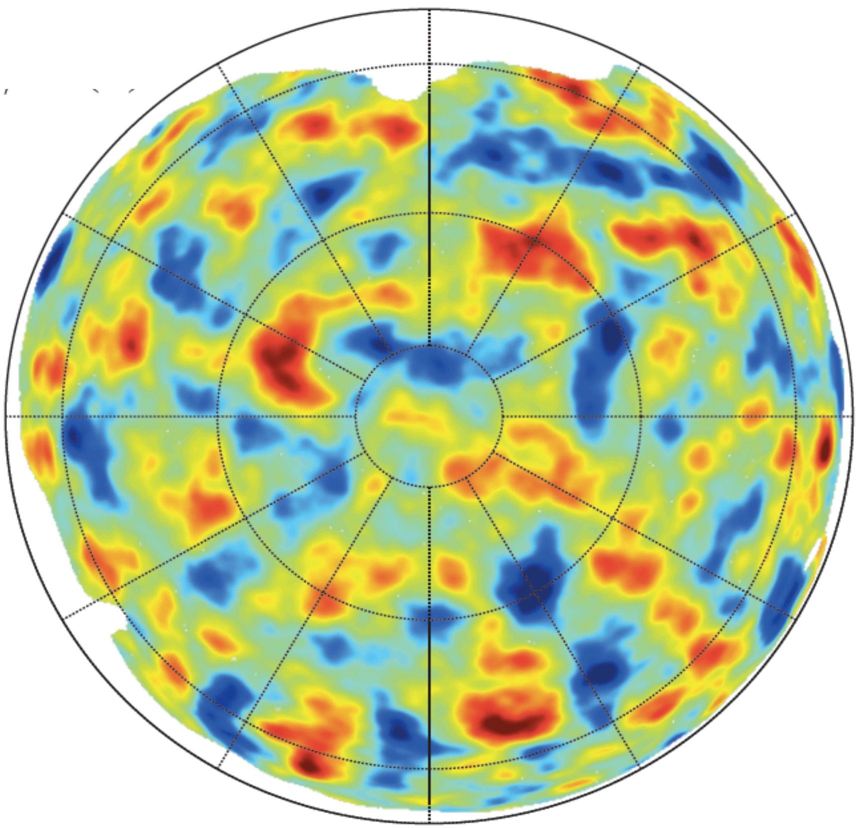
A simulated patch of CMB sky – **after lensing**



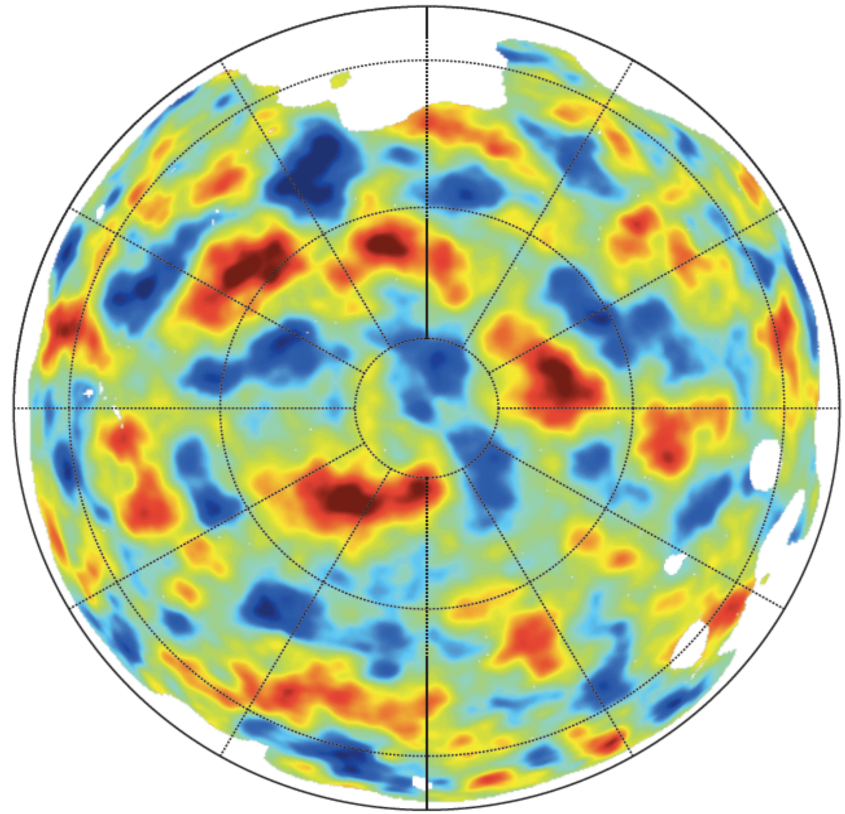
10°

PLANCK MAPS THE DARK MATTER DISTRIBUTION

Planck images of the mass distribution throughout (almost) the entire visible Universe. This is 85% Dark Matter, 15% ordinary matter....



Galactic North

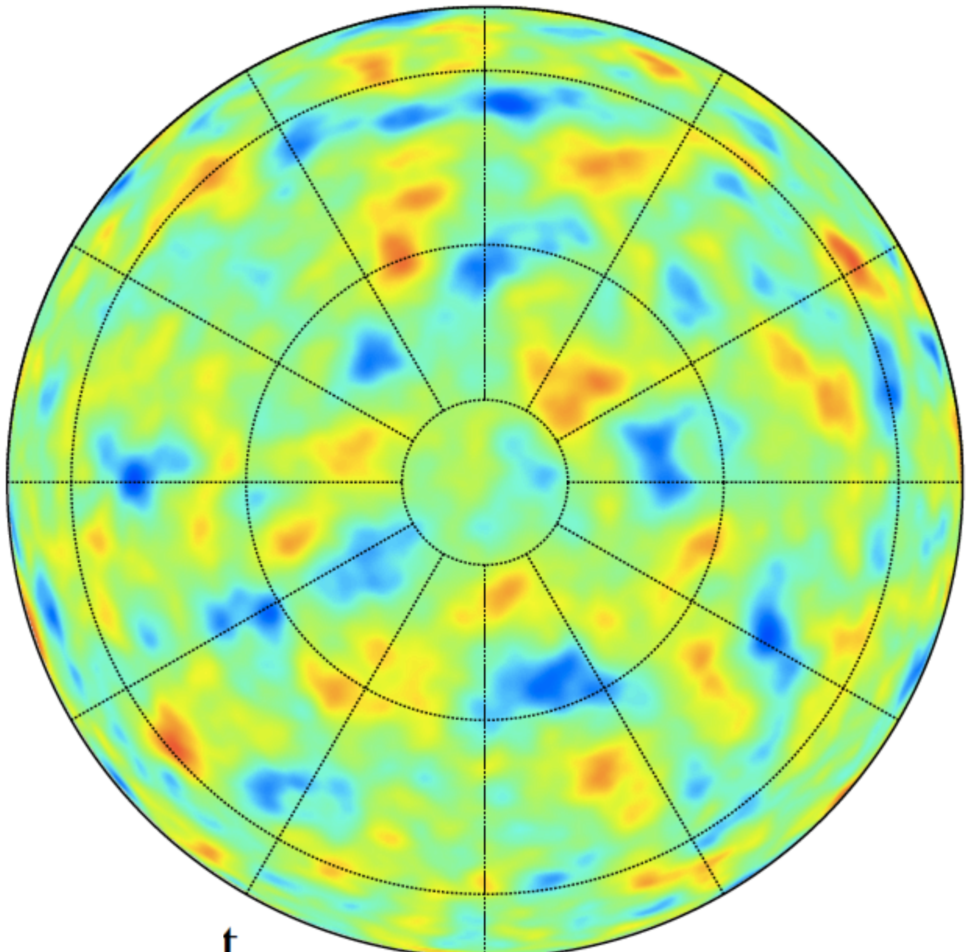


Galactic South

...but these maps are noisy!

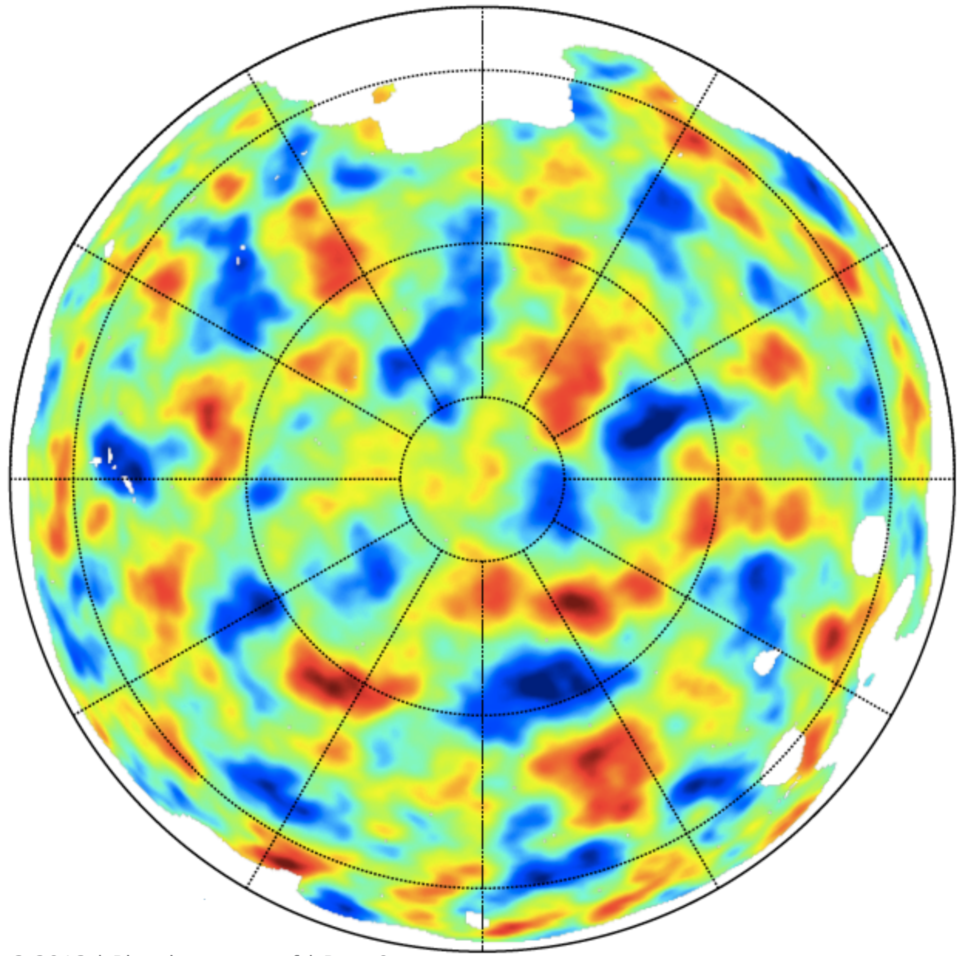
THE EFFECT OF NOISE ON THE MASS MAPS

Simulated Planck mass image without noise



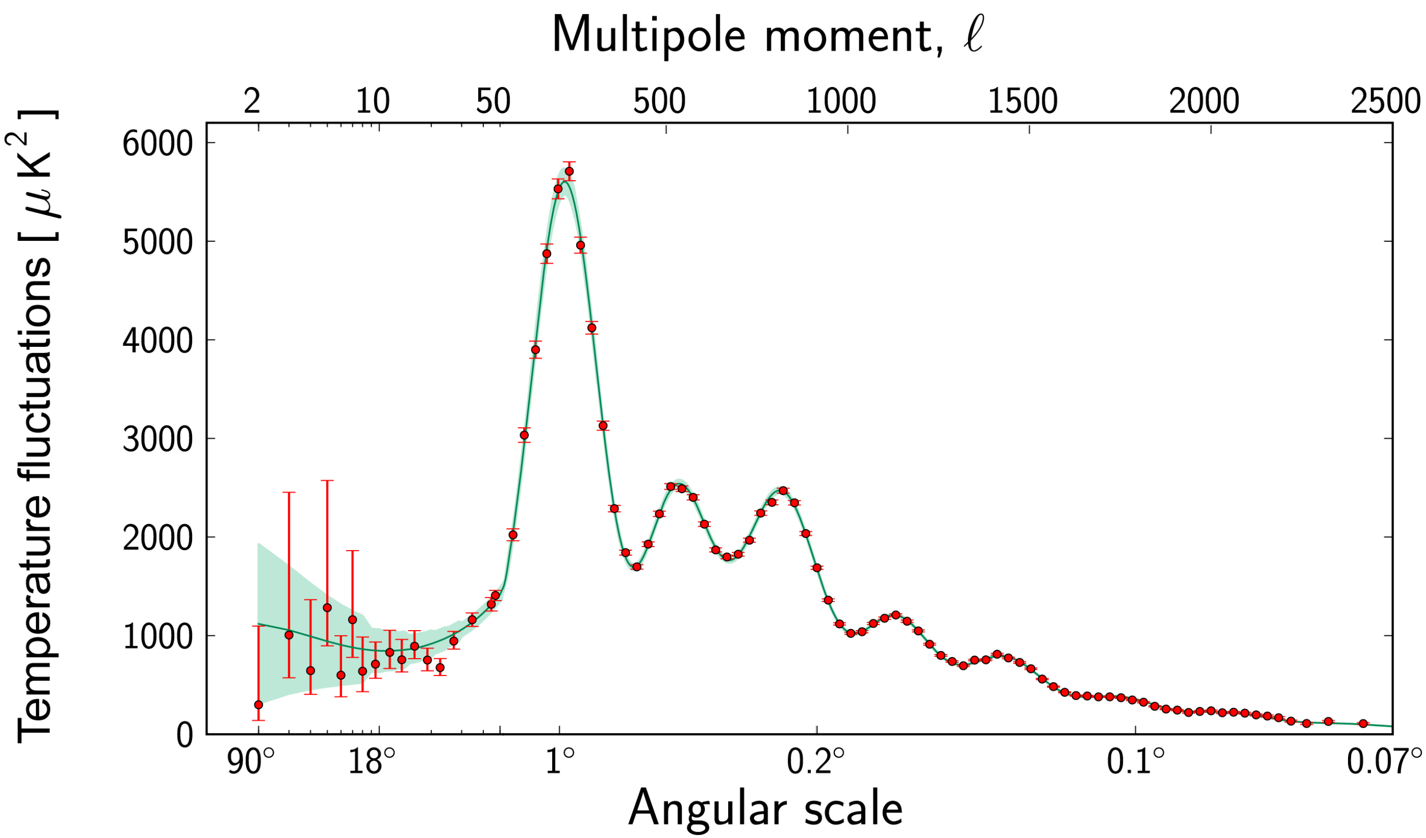
THE EFFECT OF NOISE ON THE MASS MAPS

Simulated Planck mass image with realistic noise



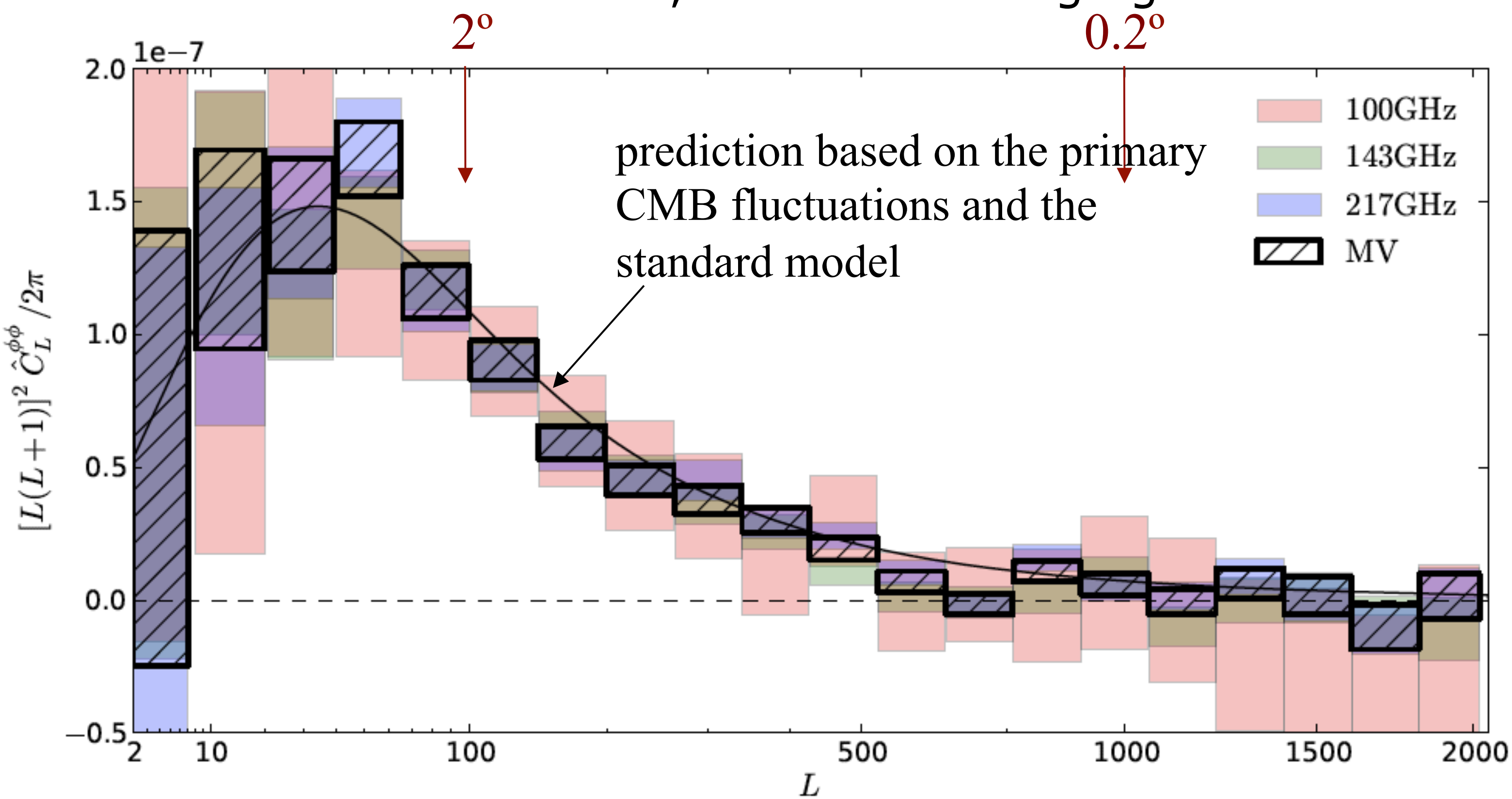
THE CLUMPINESS OF THE PLANCK CMB MAP

Fluctuations in the Planck CMB map as a function of angular scale. This is clumpiness in the early universe at an age of 380,000 years



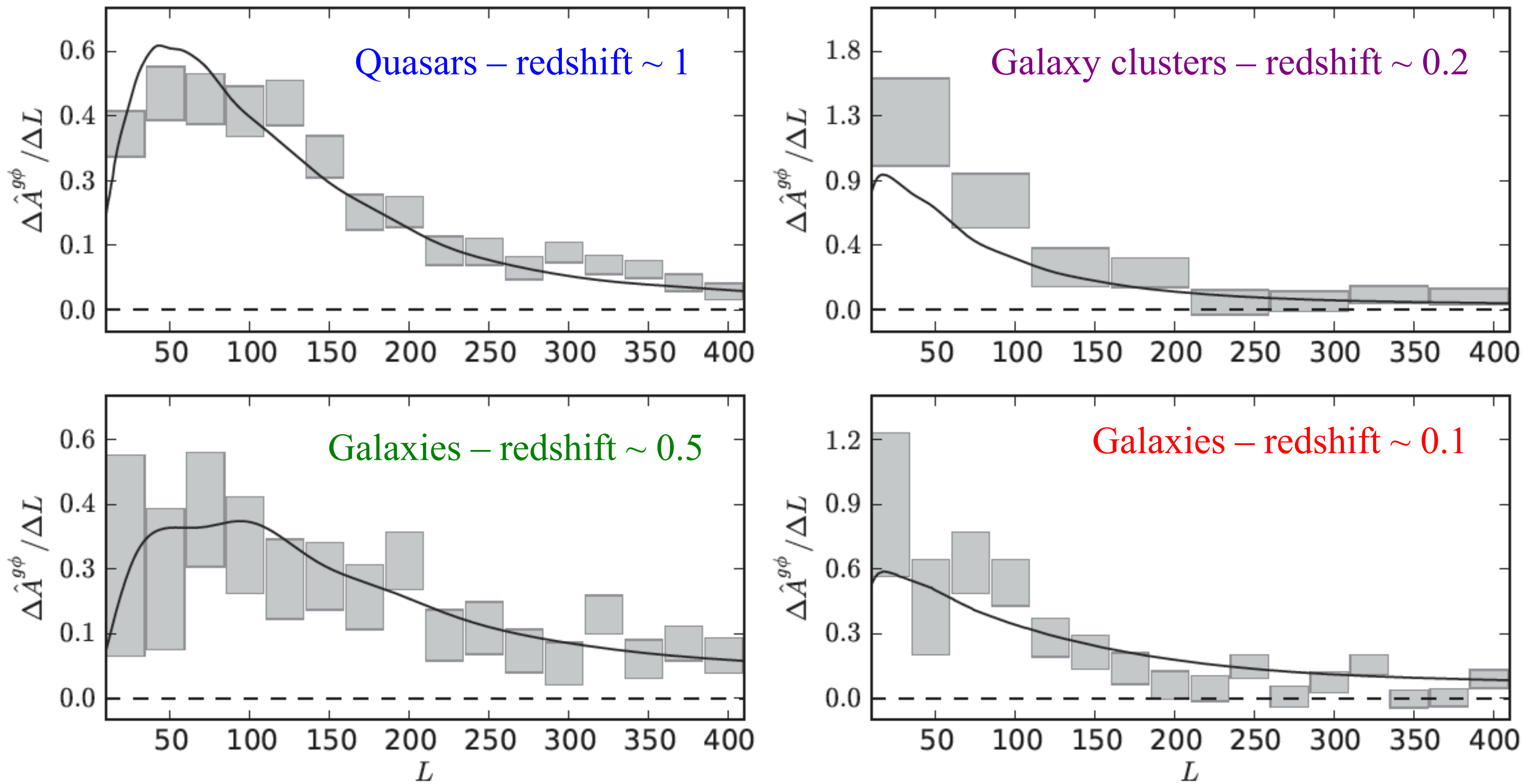
THE CLUMPINESS OF THE PLANCK MASS MAP

Fluctuations in the Planck mass map as a function of angular scale. This is clumpiness in the modern universe, measured though gravitational lensing.



GALAXIES MIRROR THE PLANCK MASS MAP

The mass distribution seen in the Planck map follows the distributions of galaxies, galaxy clusters and quasars found by other telescopes

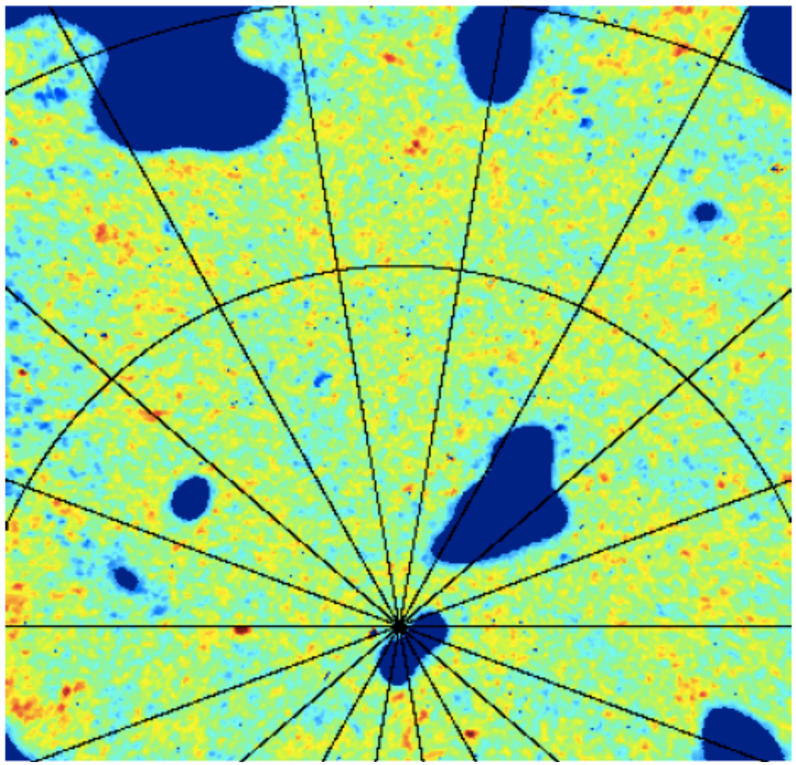


THE COSMIC INFRARED BACKGROUND

Planck image of part of the sky with little Milky Way dust emission. What there is has been removed using Galactic hydrogen maps made by other telescopes.

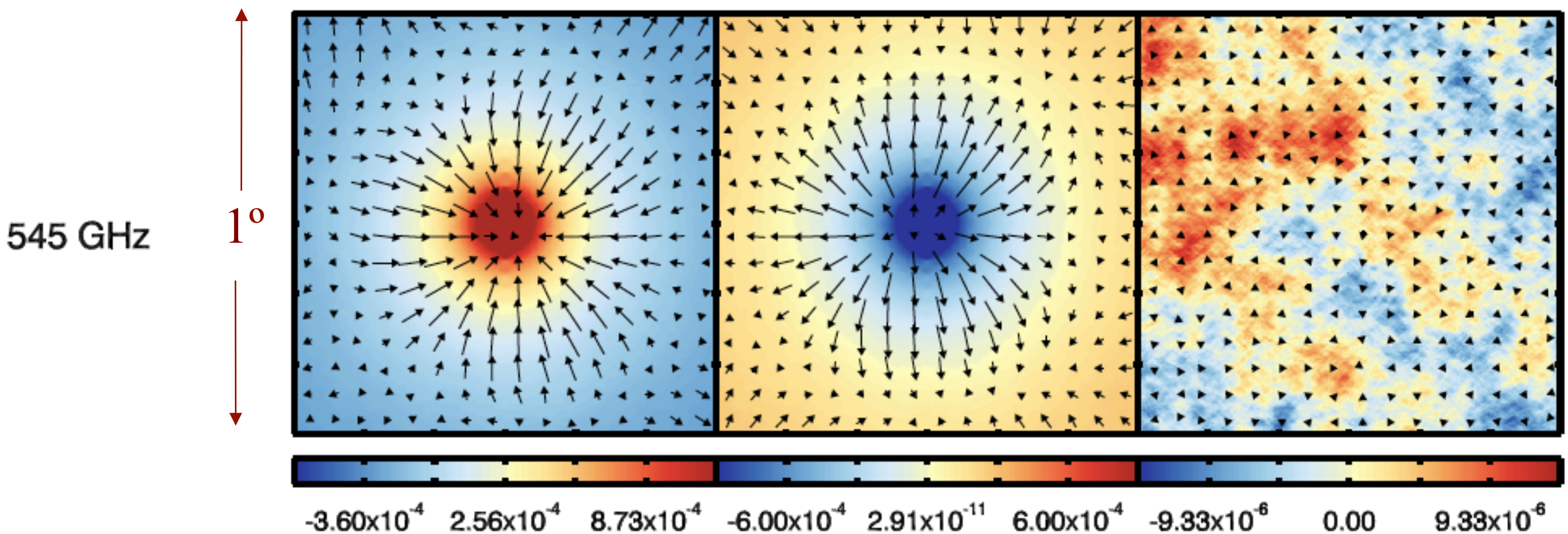
This map primarily shows the **Cosmic Infrared Background**, emission from warm dust in distant star-forming galaxies at redshifts between 1 and 3

545 GHz



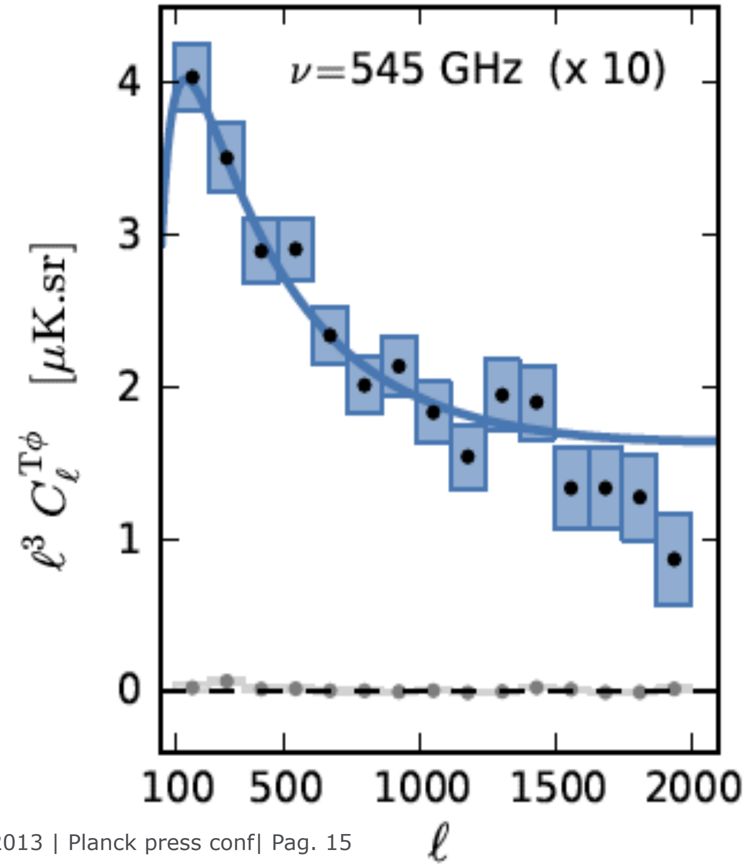
CIB PEAKS CORRESPOND TO MASS PEAKS

Stacking the Planck mass maps at the positions of peaks and troughs of Cosmic Infrared Background leads to a strong detection of the mass associated with these distant star forming galaxies. This is mostly Dark Matter,



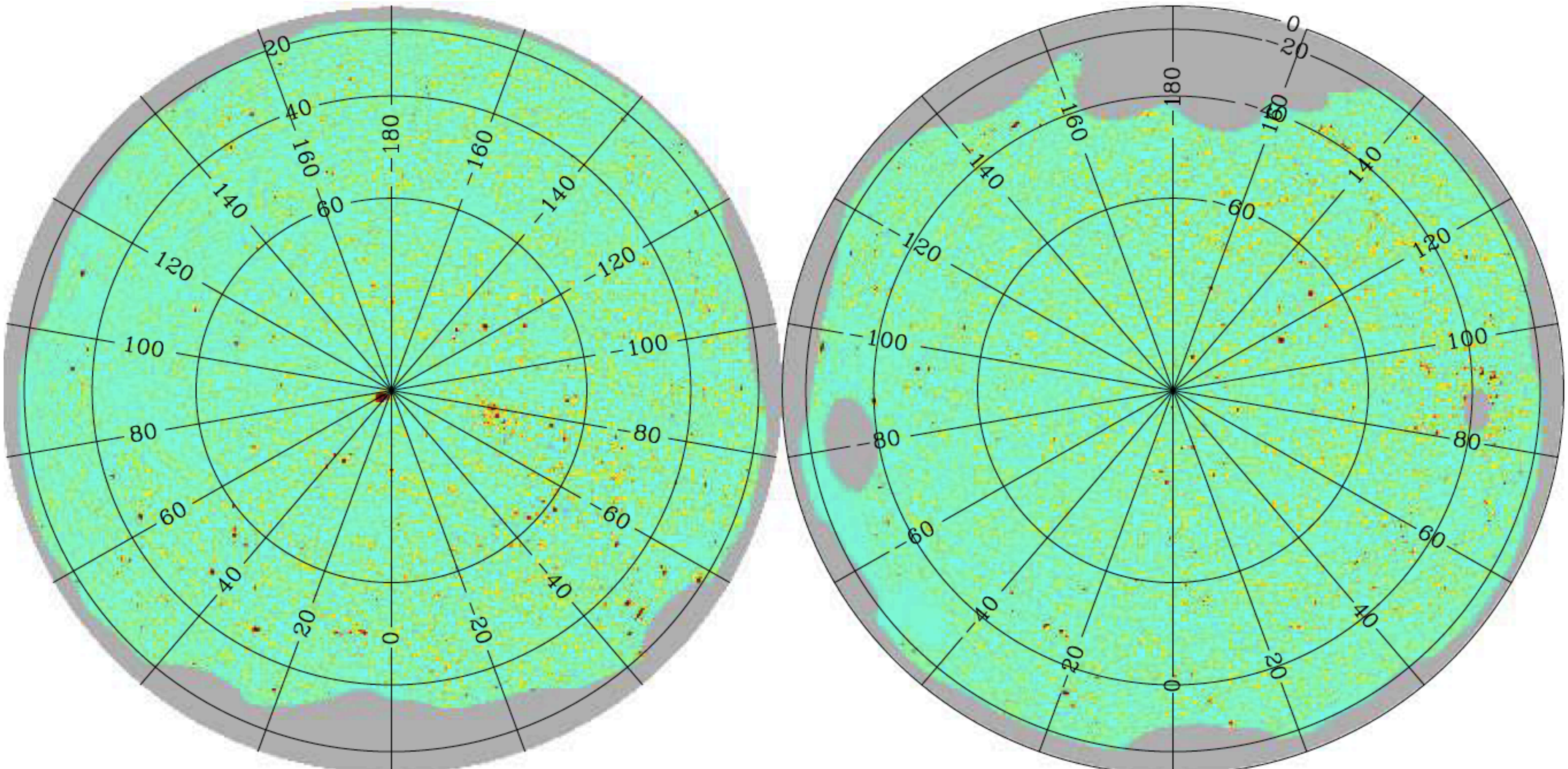
THE MASS AND CIB MAPS CORRESPOND CLOSELY

The Planck mass map correlates very strongly with the CIB maps. This is a direct detection of the total mass associated with galaxies at the time they were making most of their stars. During this epoch, the Universe went from 20% to 50% of its present age.



PLANCK MAP OF THE BARYON DISTRIBUTION

Planck can also image the gas (baryon) distribution in the low-redshift Universe using scattering of CMB photons off the electrons. This SZ (Sunyaev-Zeldovich) effect causes a change in the shape of the CMB spectrum



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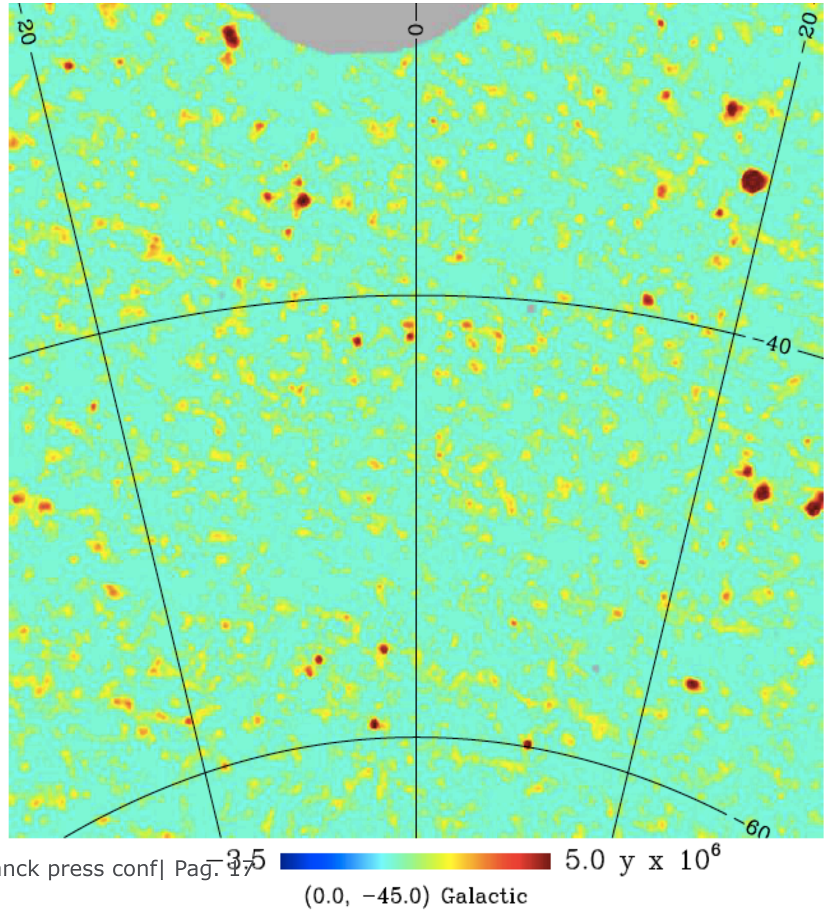
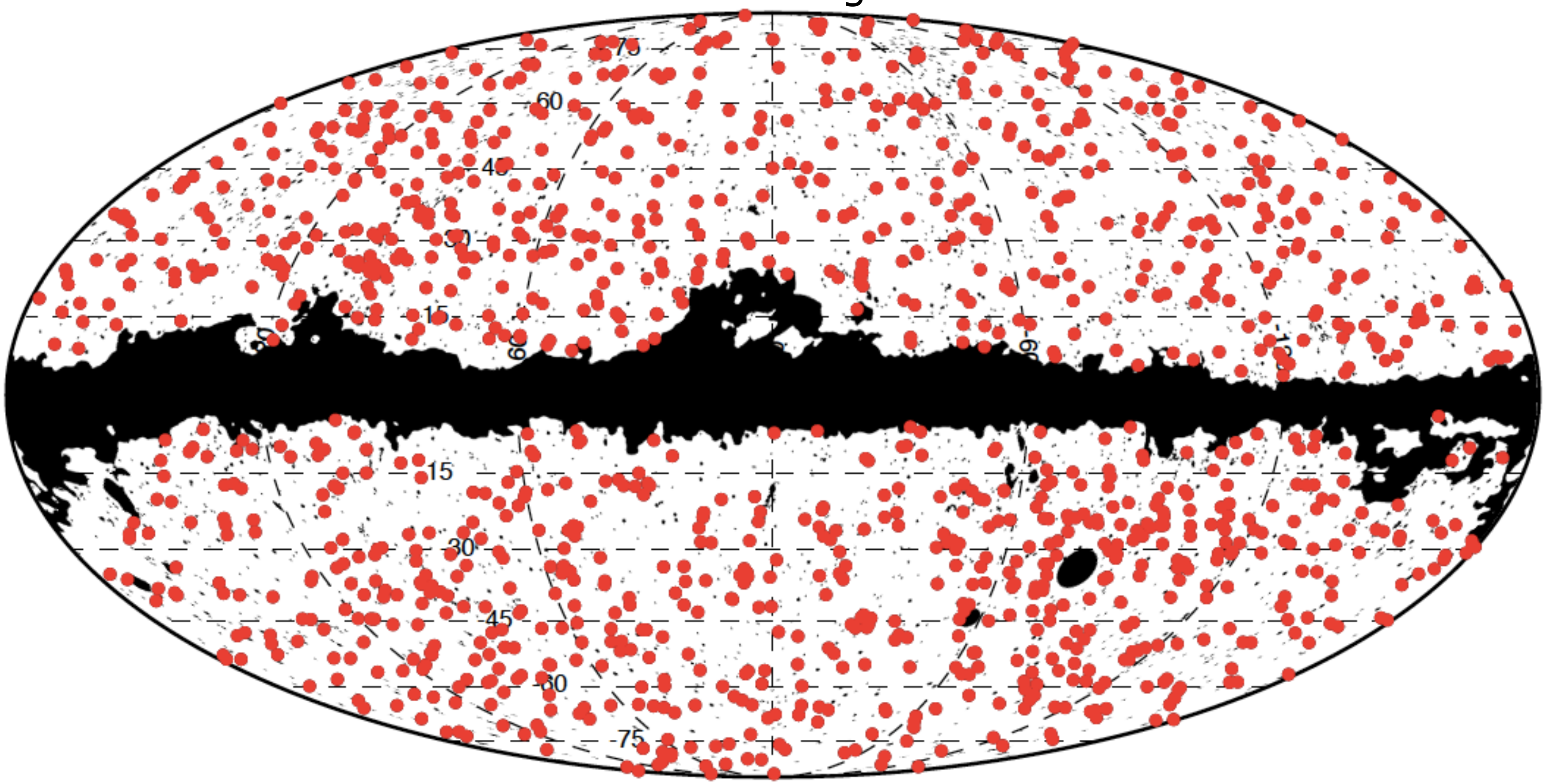


PLANCK'S CATALOGUE OF BIG GALAXY CLUSTERS

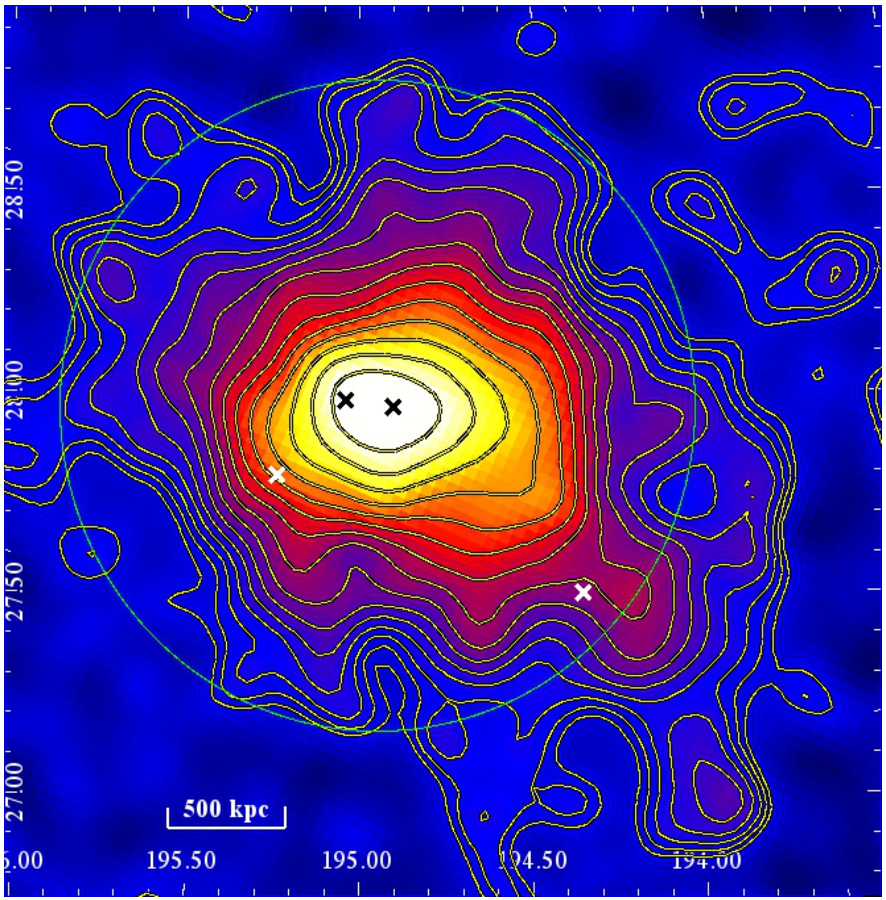
The SZ effect allows Planck to find massive galaxy clusters over the whole sky. The most massive object in the observable universe is probably among them.

1227 cluster candidates including 861 confirmed clusters



PLANCK IMAGE OF THE COMA GALAXY CLUSTER

The nearest very massive cluster of galaxies. Planck detects the cluster atmosphere much farther from the centre than was previously possible



Planck not only allows us to explore the early universe by mapping the clouds at t~380,000 years which hide it from us, but also maps the ordinary and Dark Matter distributions throughout the visible universe in front of those clouds.

This brings us closer to understanding how today's universe emerged from the Big Bang

THANK YOU

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