

# Discovering the early Universe using the Cosmic Microwave Background

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**Rita Tojeiro**

Institute for Astronomy  
University of Edinburgh

# The plan for today:

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- What is the Cosmic Microwave Background (CMB)?
- Cosmology today.
- Some predictions and assumptions: *Gaussianity*.
- The current picture.
- Our work: the peak-peak correlation function.
- Summary and future work.

# What is the Cosmic Microwave Background?

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$$\Theta(\mathbf{n}) = \frac{\Delta T}{\langle T \rangle}$$

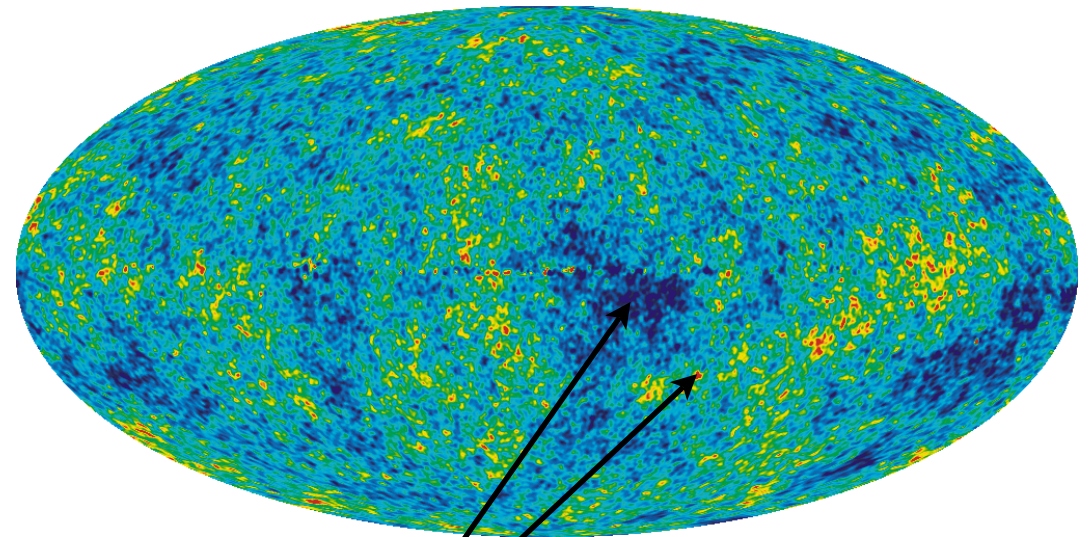
$$\Theta(\mathbf{n}) = \sum_{\ell=0}^{\infty} \sum_{m=-\ell}^{\ell} a_{\ell m} Y_{\ell m}(\mathbf{n})$$

$$a_{\ell m} = \int_{\theta=-\pi}^{\pi} \int_{\phi=0}^{2\pi} \Theta(\mathbf{n}) Y_{\ell m}^*(\mathbf{n}) d\Omega$$

$$\langle a_{\ell m} a_{\ell' m'}^* \rangle = \delta_{\ell\ell'} \delta_{mm'} C_{\ell}$$

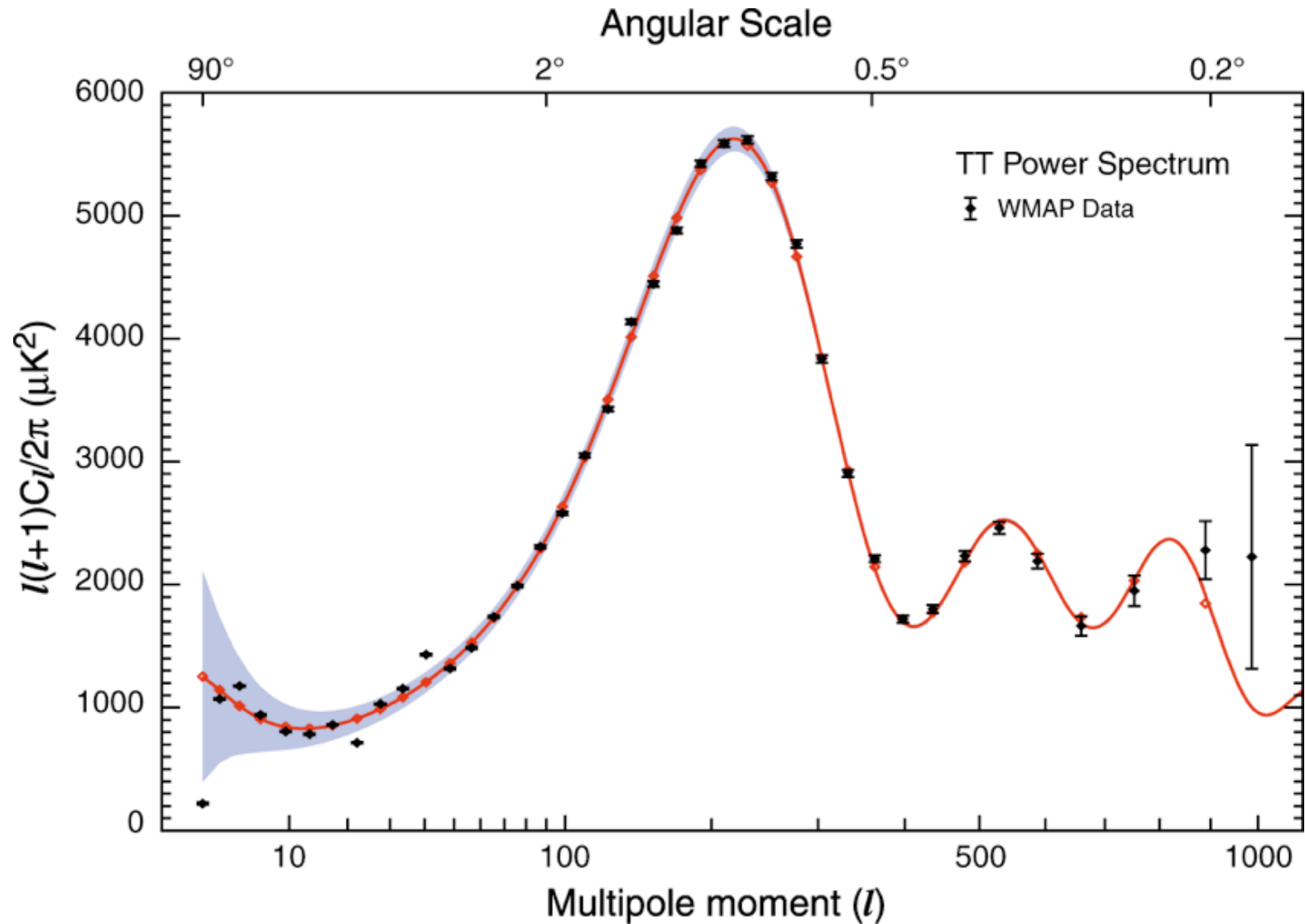
$$C_{\ell} = \frac{1}{2\ell + 1} \sum_{m=-\ell}^{\ell} \langle |a_{\ell m}|^2 \rangle$$

Power Spectrum



1 part in 10,000

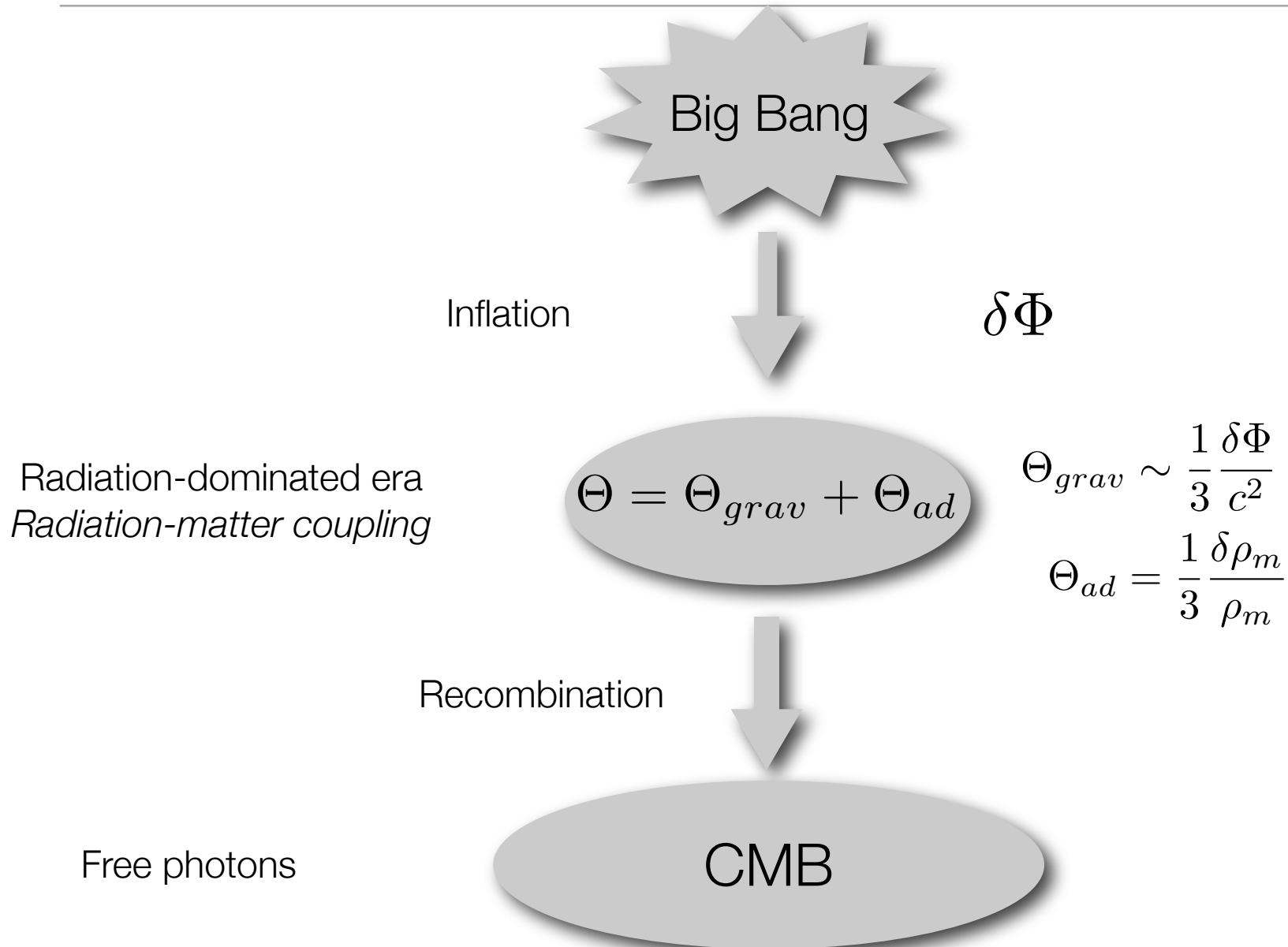
# The CMB as a source of cosmological information



# Cosmology today:

## Big Bang and Inflation

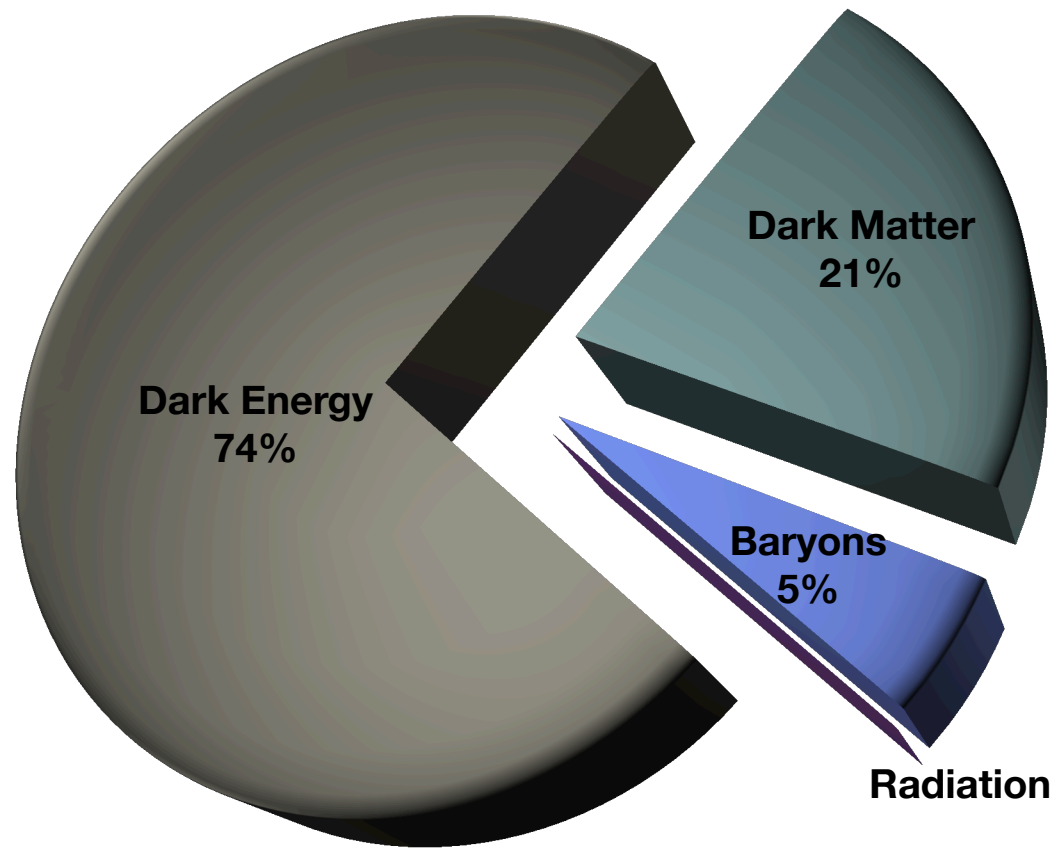
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# Cosmology today:

## The content of the Universe

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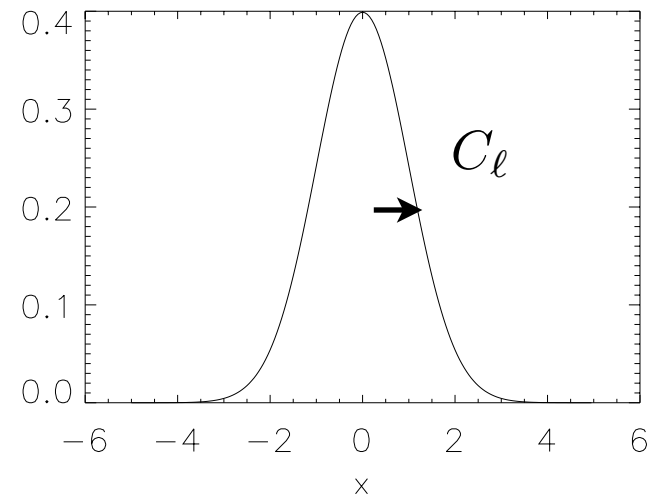
# Gaussianity

$$\langle a_{\ell m} a_{\ell' m'}^* \rangle = \delta_{\ell\ell'} \delta_{mm'} C_\ell$$

$$C_\ell = \frac{1}{2\ell + 1} \sum_{m=-\ell}^{\ell} \langle |a_{\ell m}|^2 \rangle$$

Power Spectrum

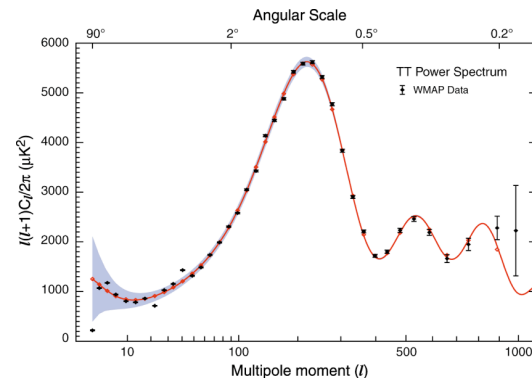
Probability distribution



A prediction:

Inflation  $\Rightarrow \delta\Phi \Rightarrow \Theta$

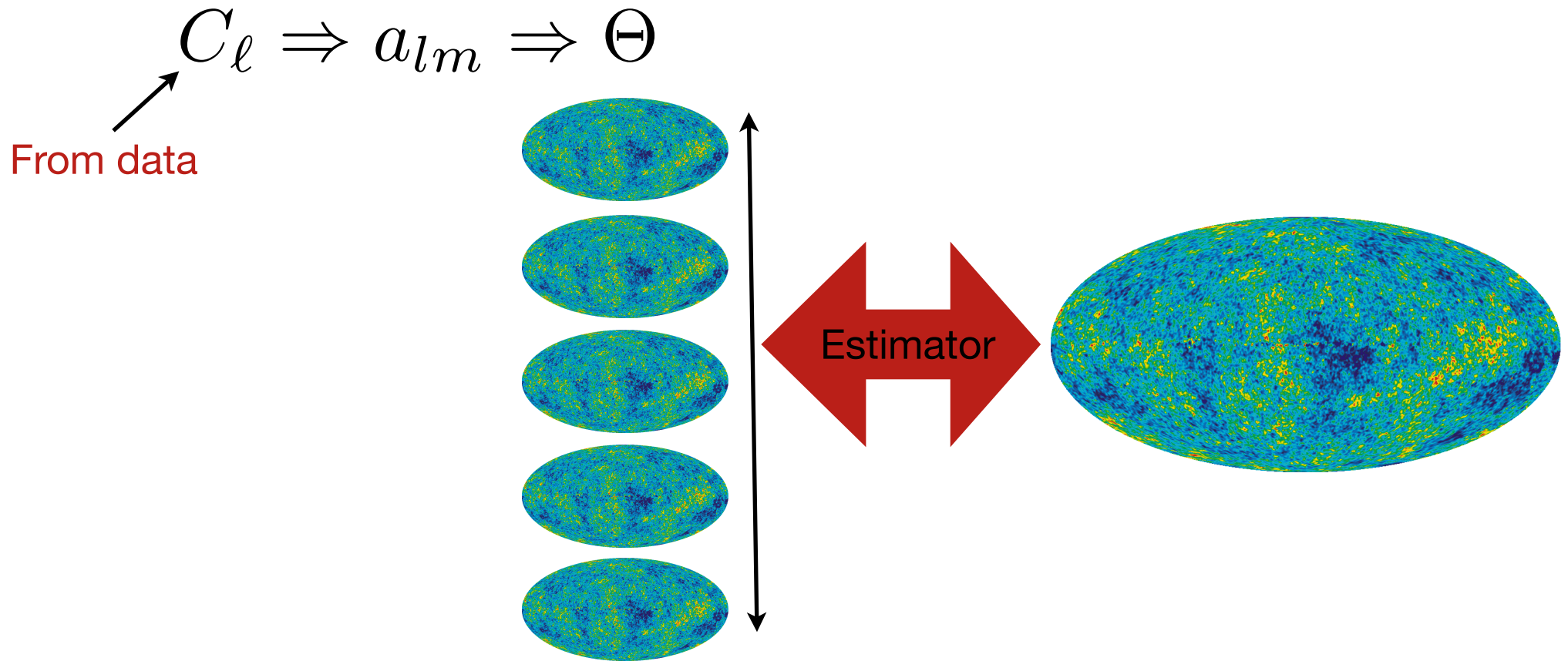
An assumption:



# Searching for a signal

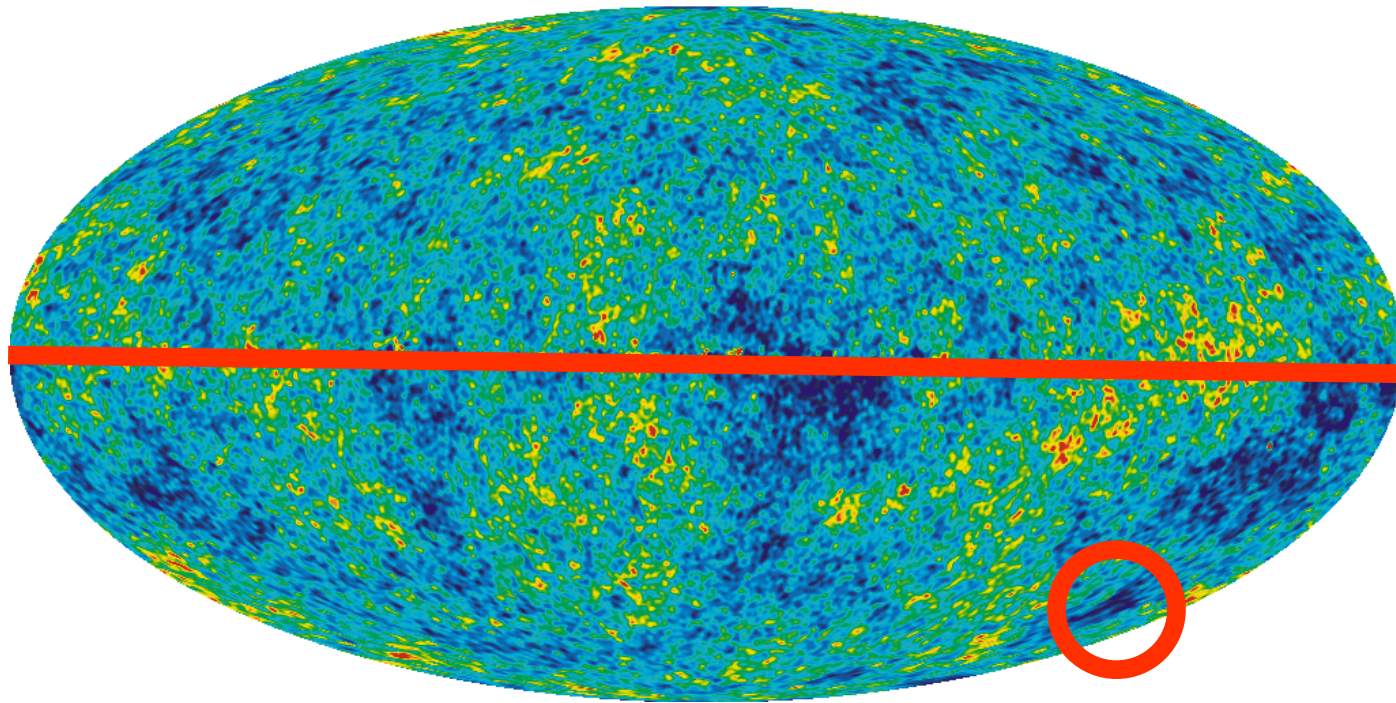
## Testing the Gaussian Hypothesis

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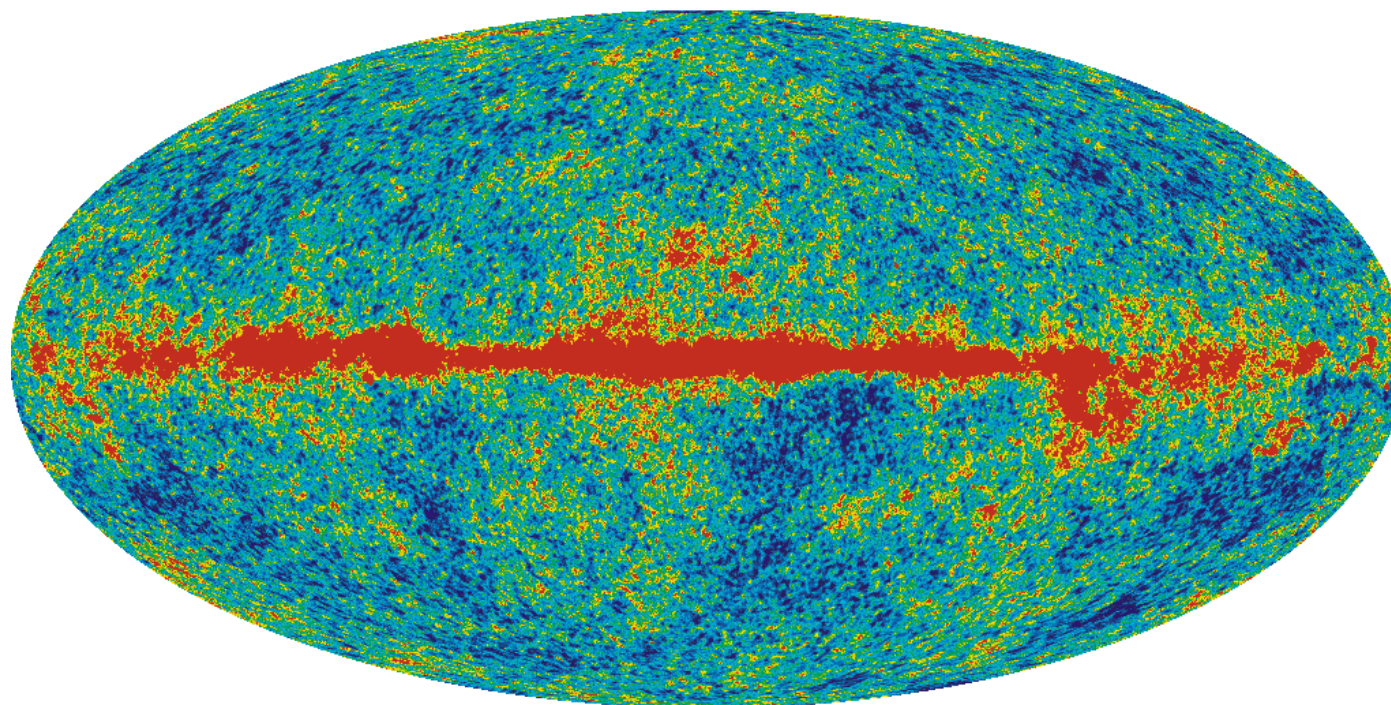
# The current picture

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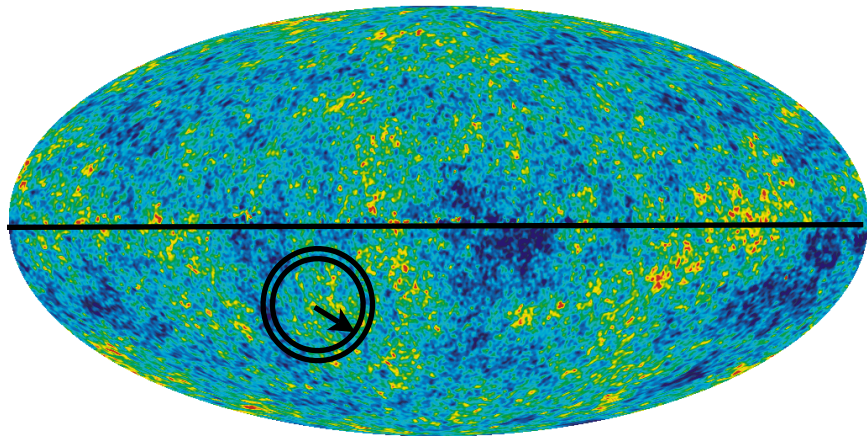
# The current picture

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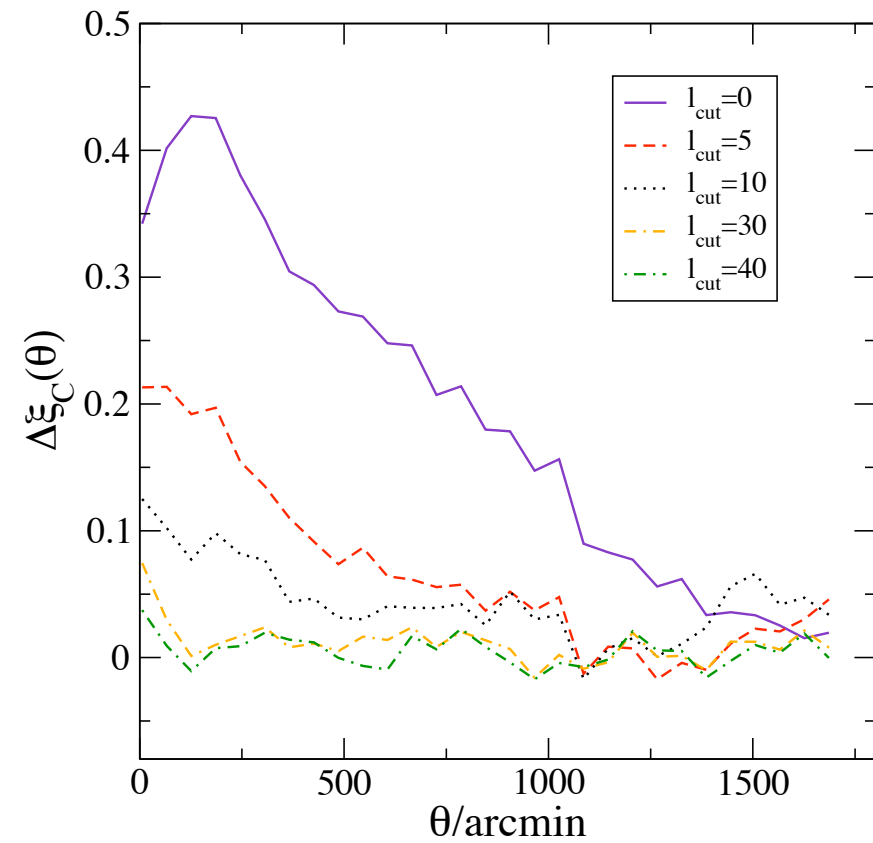


# Our work: the peak-peak correlation function

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We found:



# Summary and future work

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- The Cosmic Microwave Background provides us an **excellent window into the early Universe**.
- Inflation theories make **predictions** about the degree of deviation from Gaussianity in the temperature fluctuations.
- Current picture of the Universe heavily based on the **assumption** the CMB shows no significant deviation from Gaussianity.
- We analysed the WMAP CMB data in search for such a deviation - we found **no conclusive evidence of a cosmological signal**.
- Other results show more conclusive results, but we probably need a better data-set to get definite answers.
- Future WMAP data releases and the Planck satellite might provide this.