Title: Searching for a Primordial Cold Spot in the CMB

Date: Dec 08, 2009 11:00 AM

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Abstract:

Searching for Primordial Cold Spot in CMB

arXiv:0903.3407 (BFHK); arXiv:0809.4904 (DEFROST)

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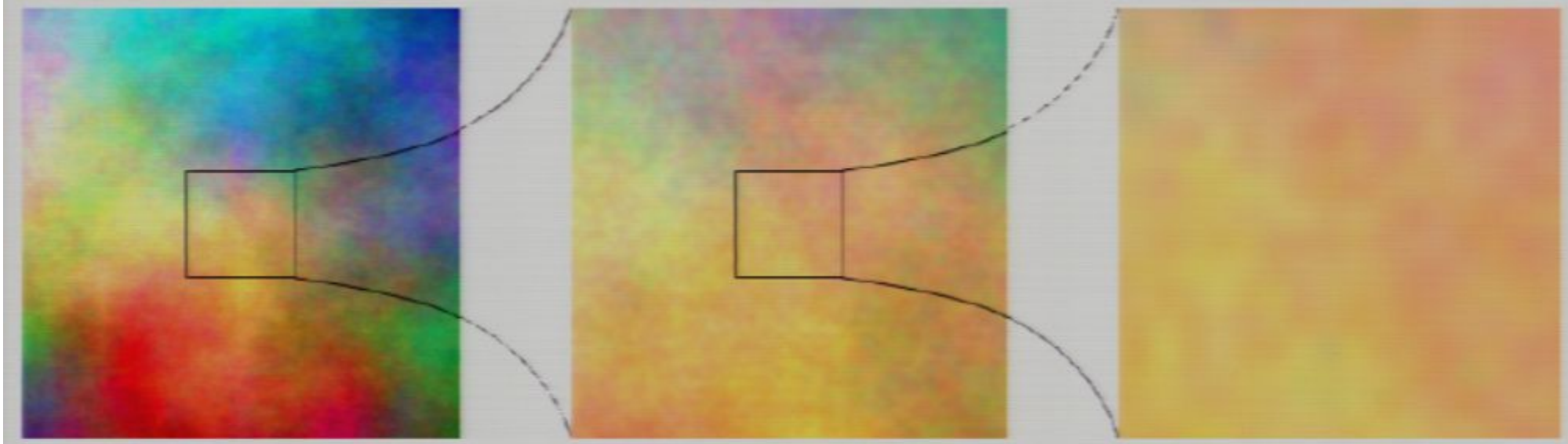
Department of Physics
Simon Fraser University

CITA/PI Meeting

Perimeter Institute
Waterloo, ON, Canada
8 December 2009

Inflation Solves Many Problems, But...



inflation wipes the slate clean and re-seeds the structure

... inflation has to end! But how?

Inflation is cold ? **Big Bang is hot**

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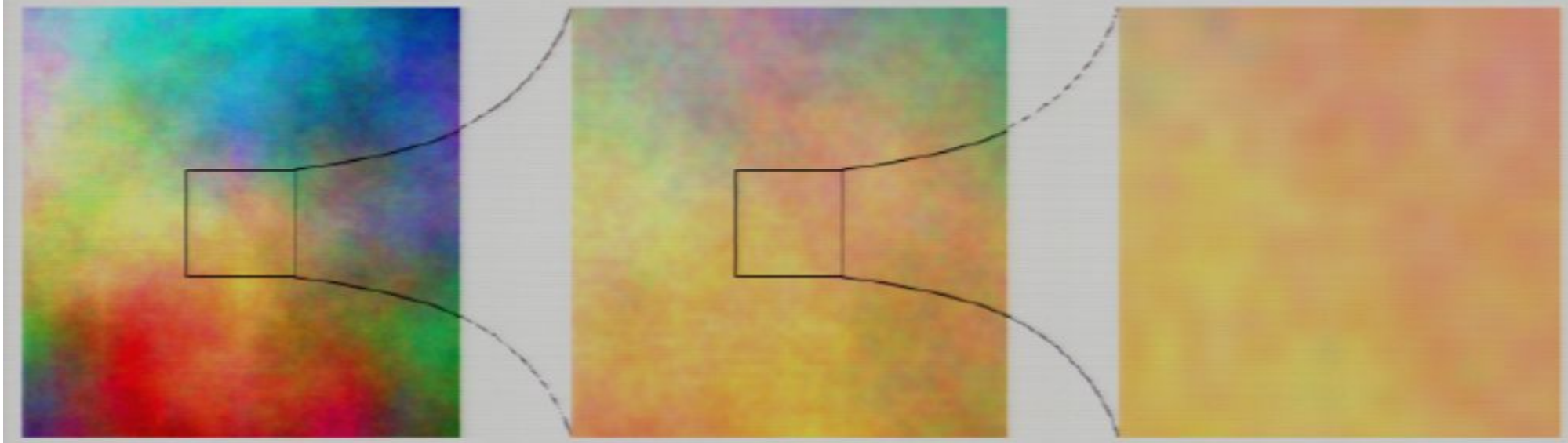

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Preheating Can Leave a Signature in CMB Sky!

the *way* inflation ends
can lead to a new signal:

usual non-Gaussianity:

$$\Phi(\vec{x}) = \Phi_G(\vec{x}) + f_{NL}\Phi_G^2(\vec{x})$$

new from preheating:

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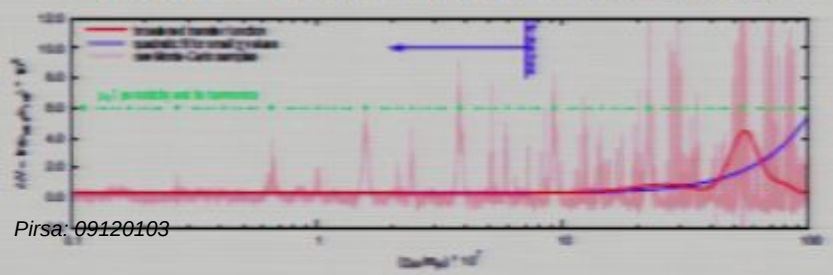
F_{NL} can be a *very*
non-trivial function:



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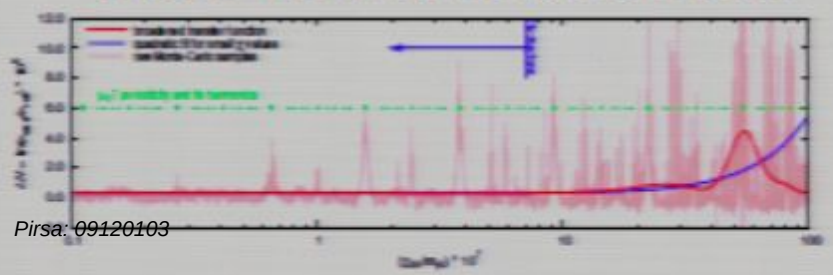
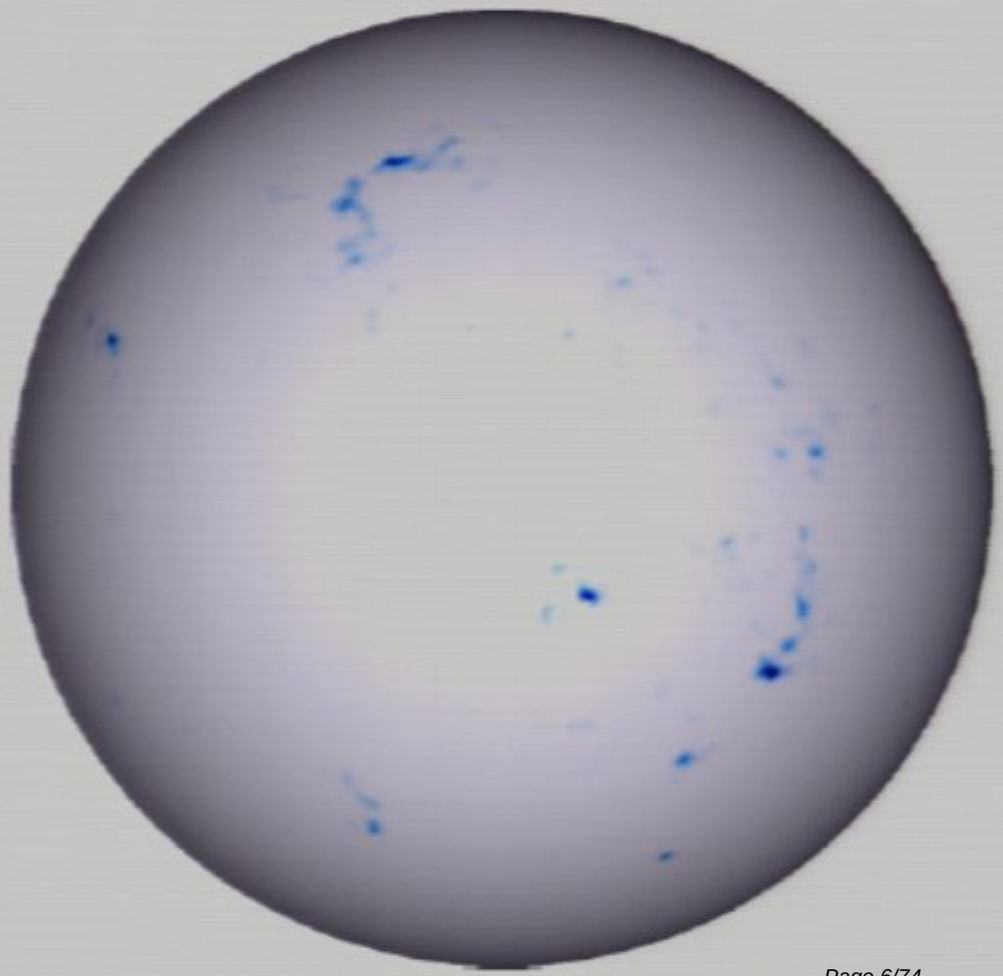
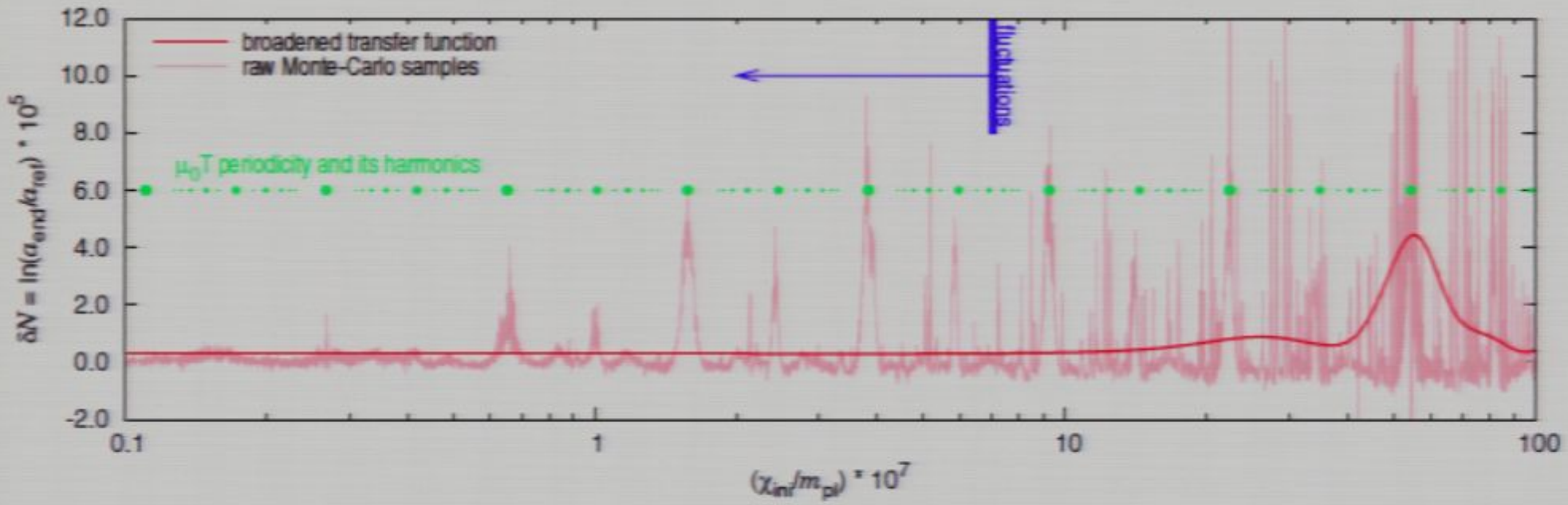


realization of *excursion set* can naturally give cold spots!



Non-Gaussian Contribution at CMB Scales



Very different from f_{NL} parametrization!

$$\Phi(\vec{x}) = \Phi_{\mathrm{G}}(\vec{x}) + F_{\mathrm{NL}}(\chi_{\mathrm{G}})$$

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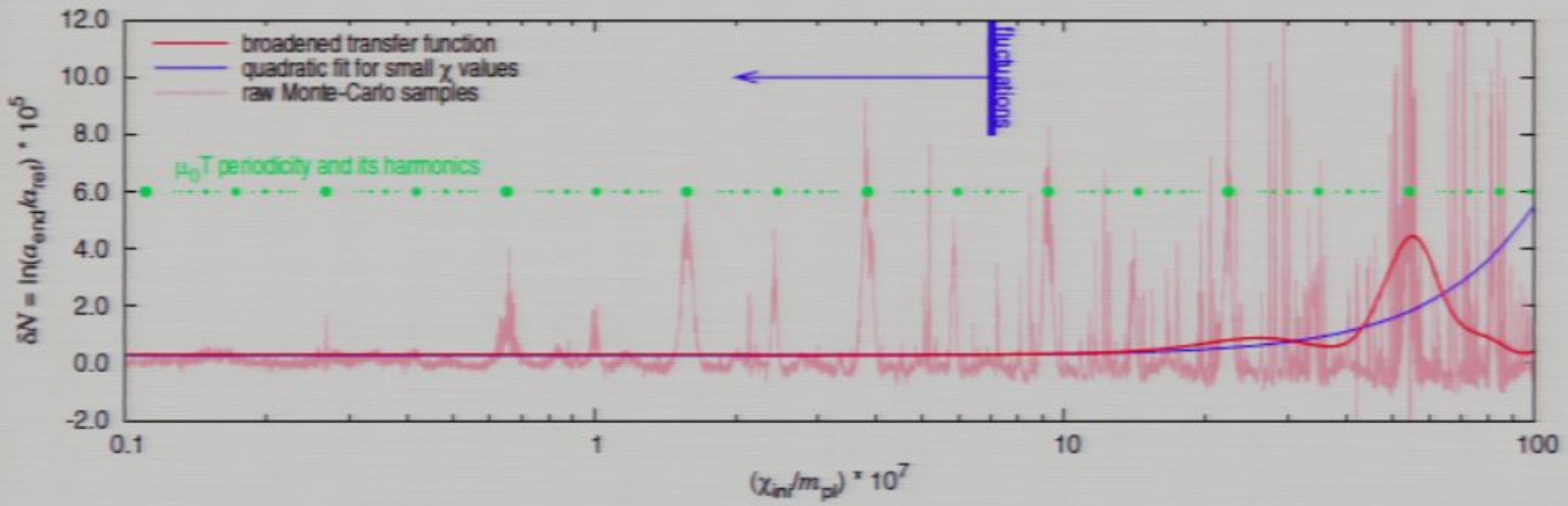

For small χ, *uncorrelated* quadratic!

$$\Phi(\vec{x}) = \Phi_{\mathrm{G}}(\vec{x}) + f_{\chi}\, \chi_{\mathrm{G}}^{2}(\vec{x})$$

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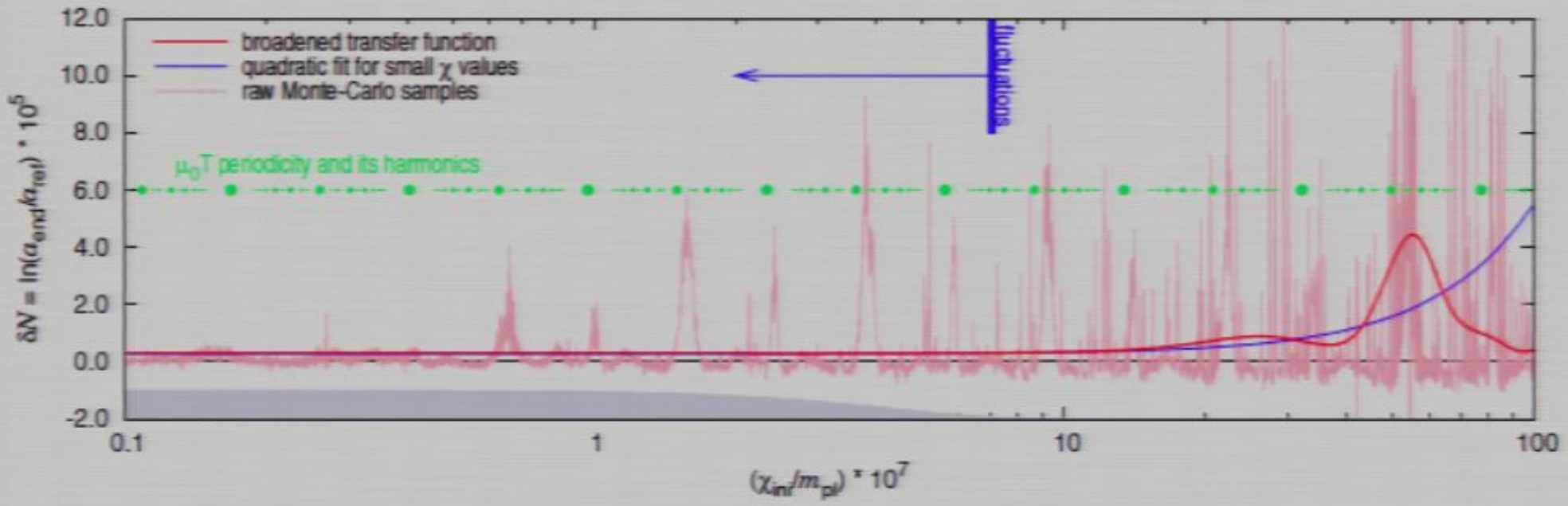

Sampling depends on super-horizon modes

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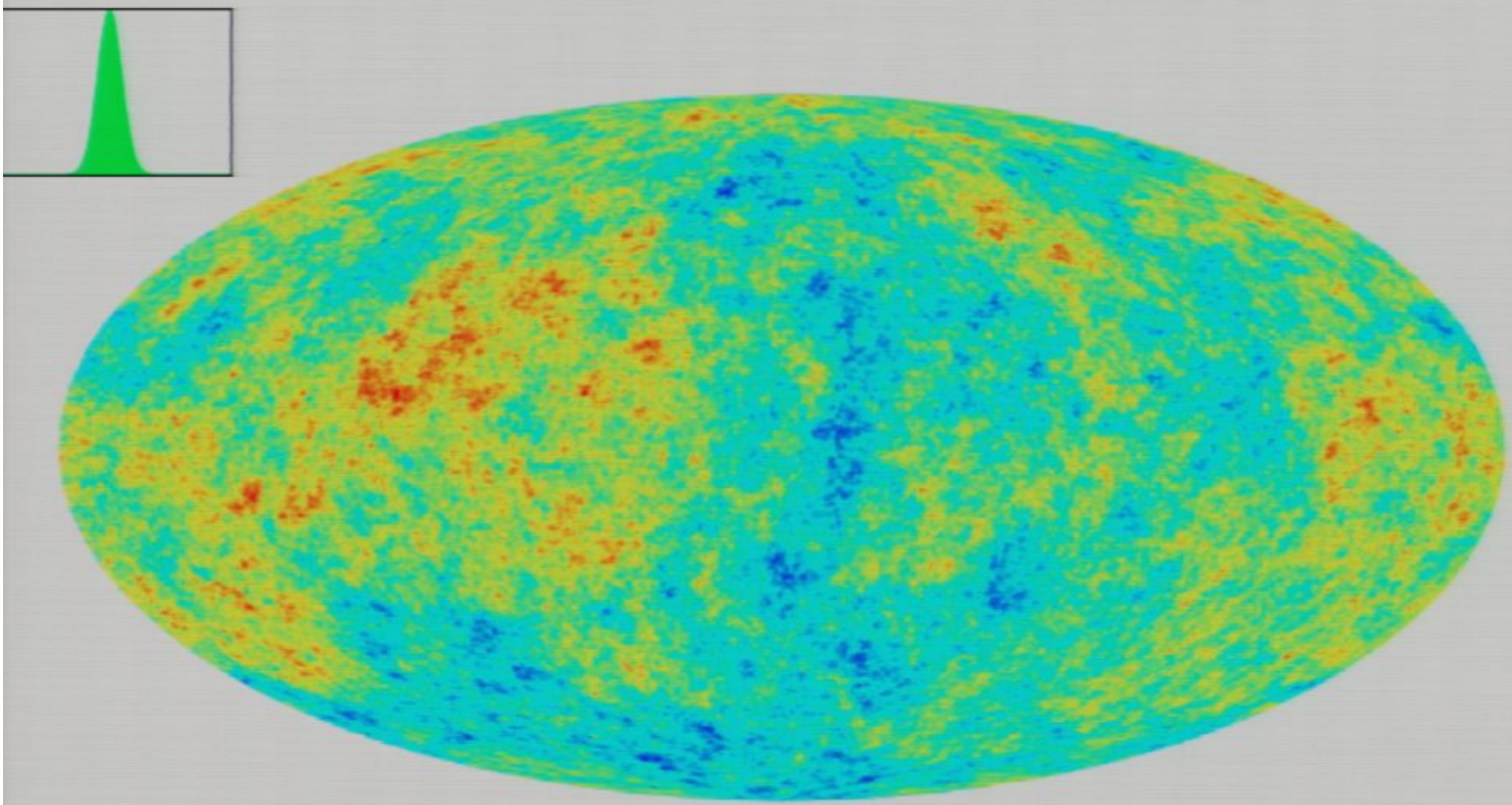

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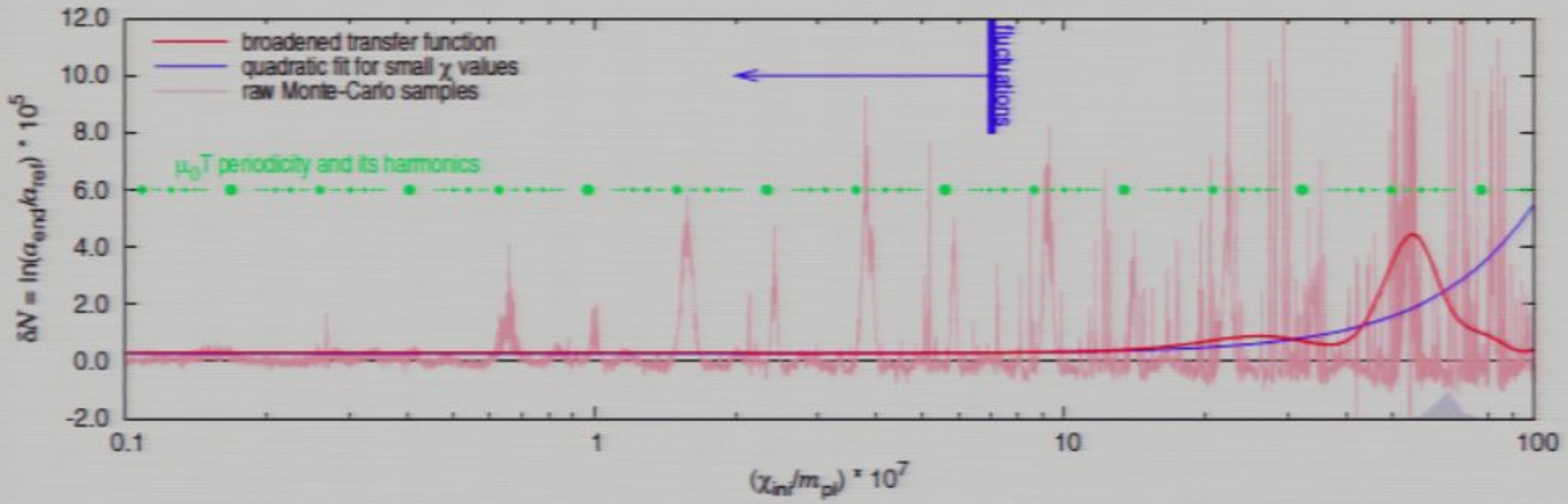

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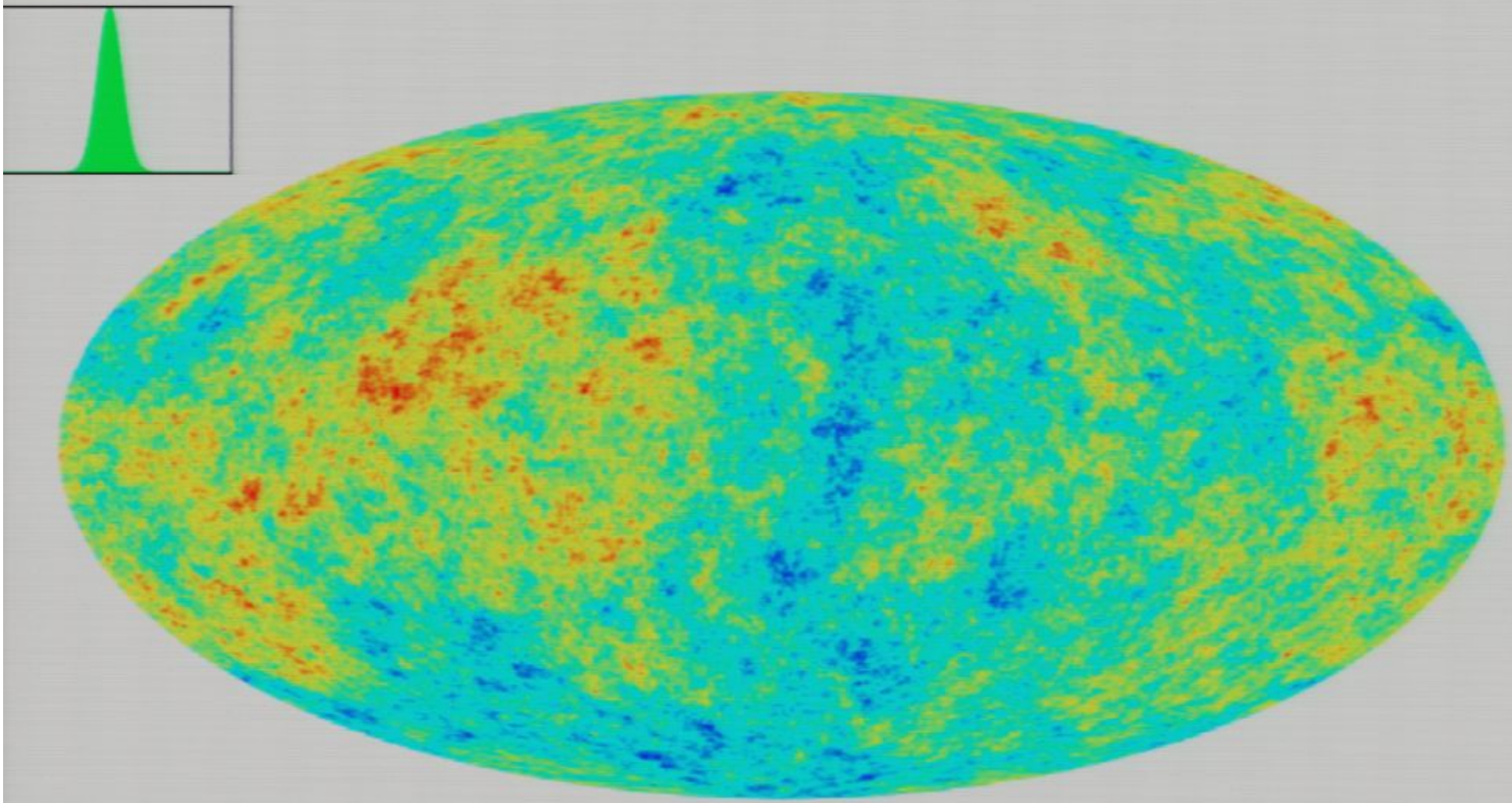

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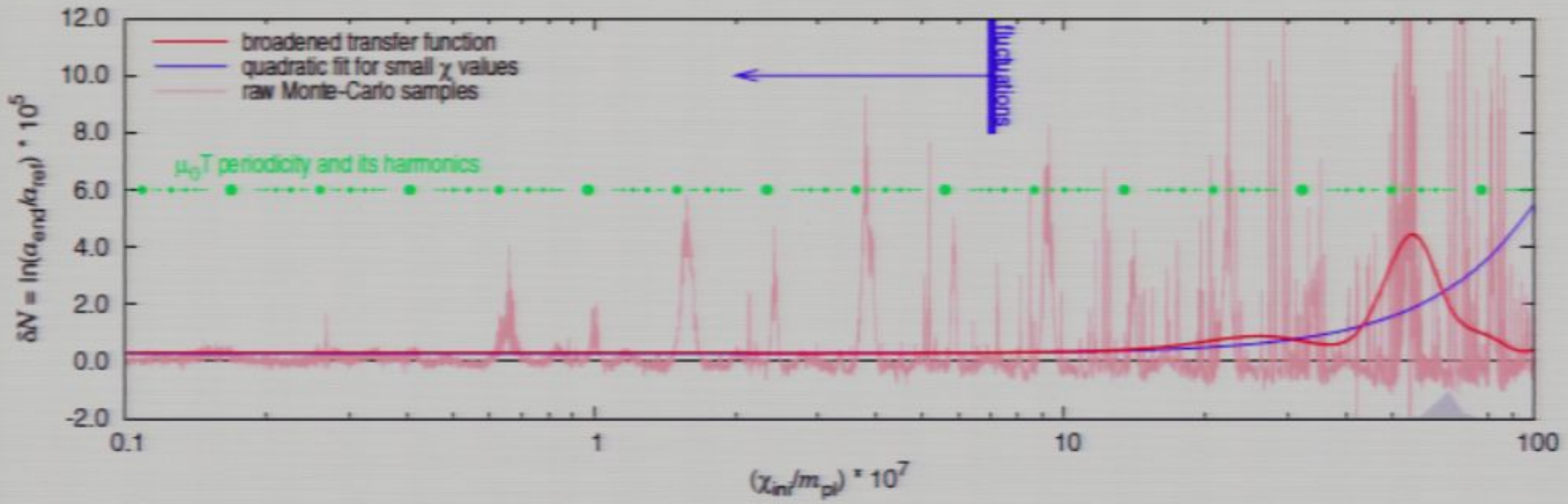

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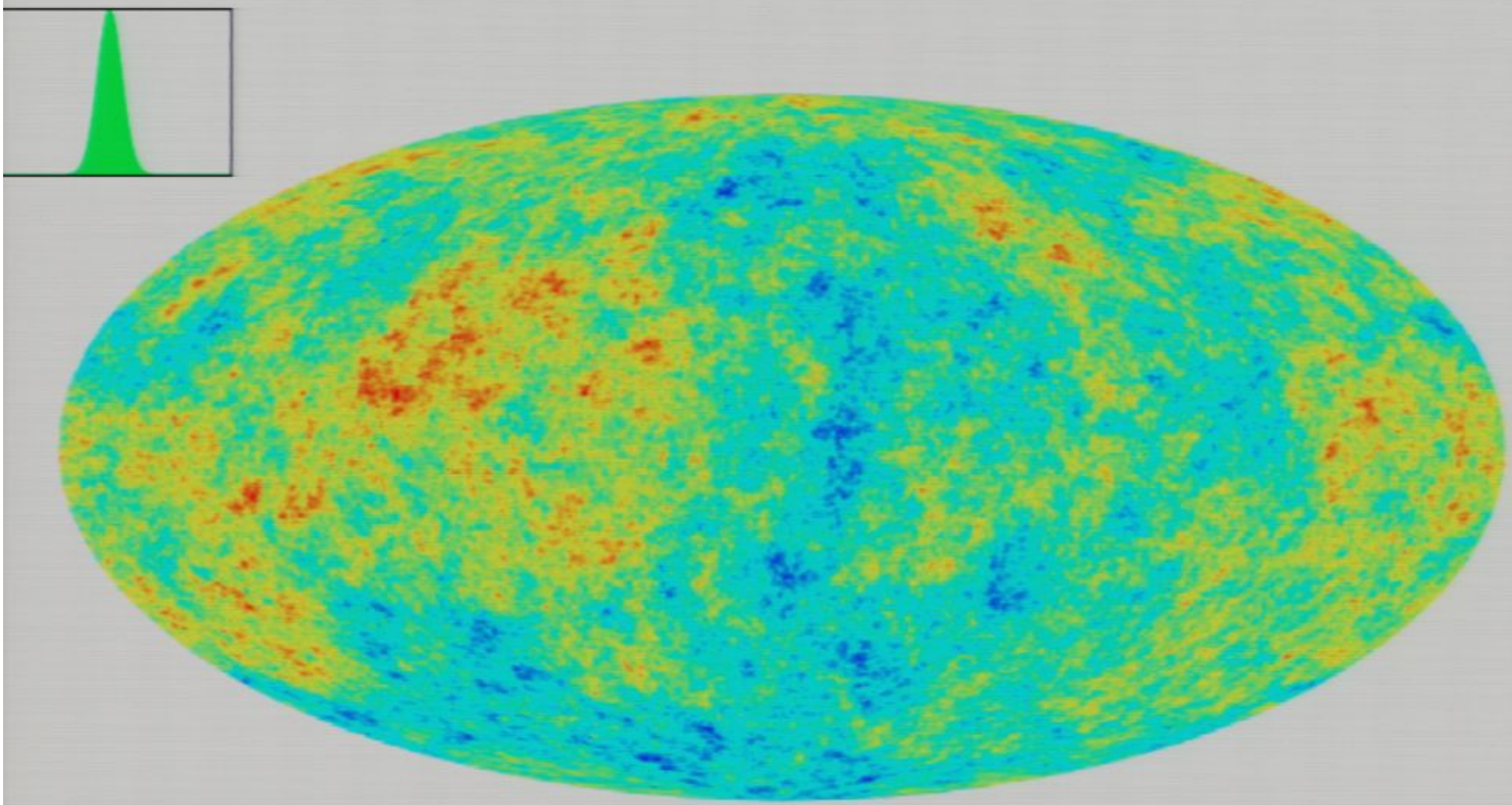

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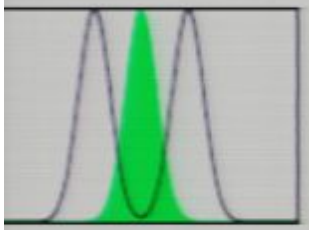

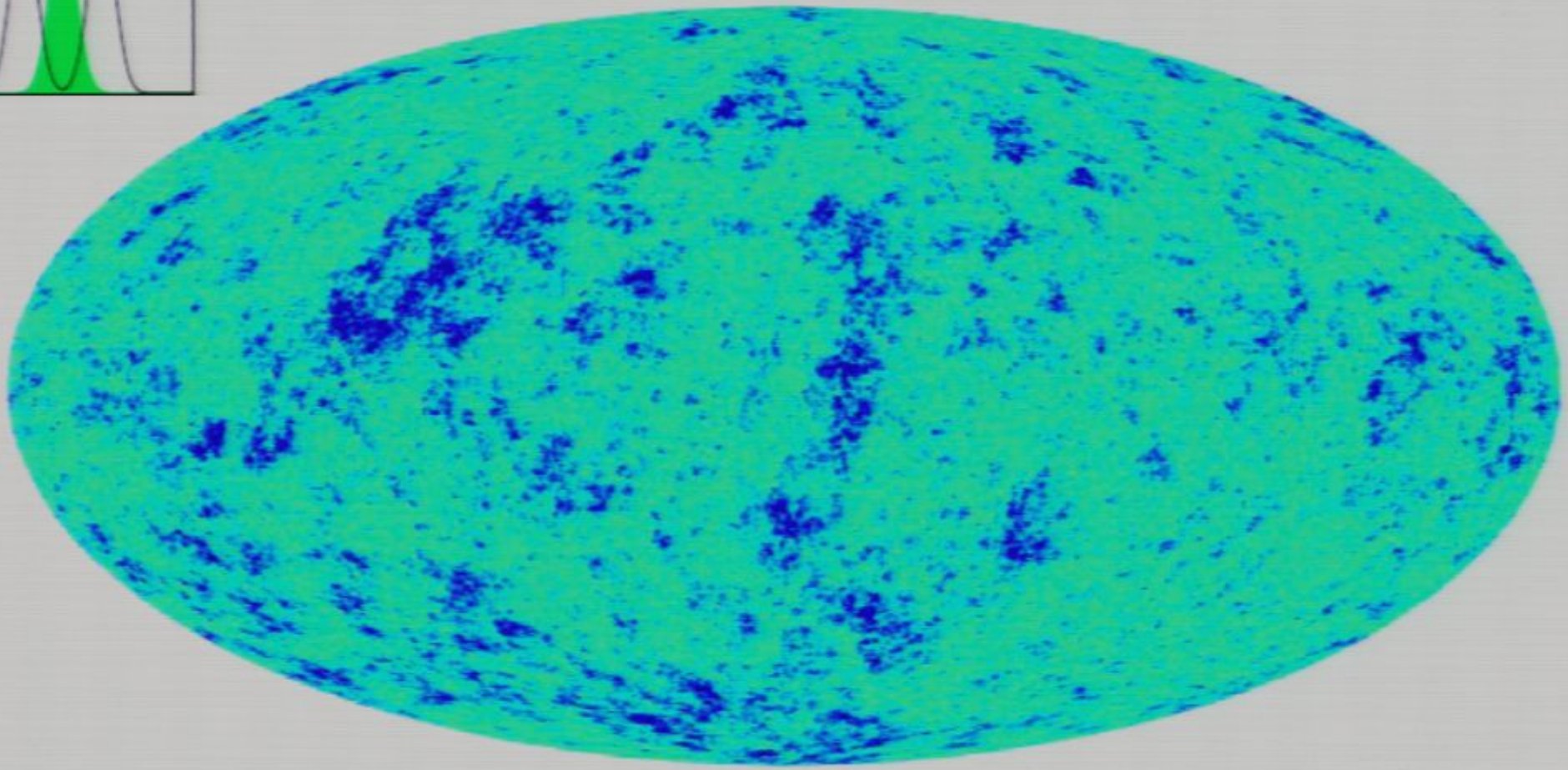

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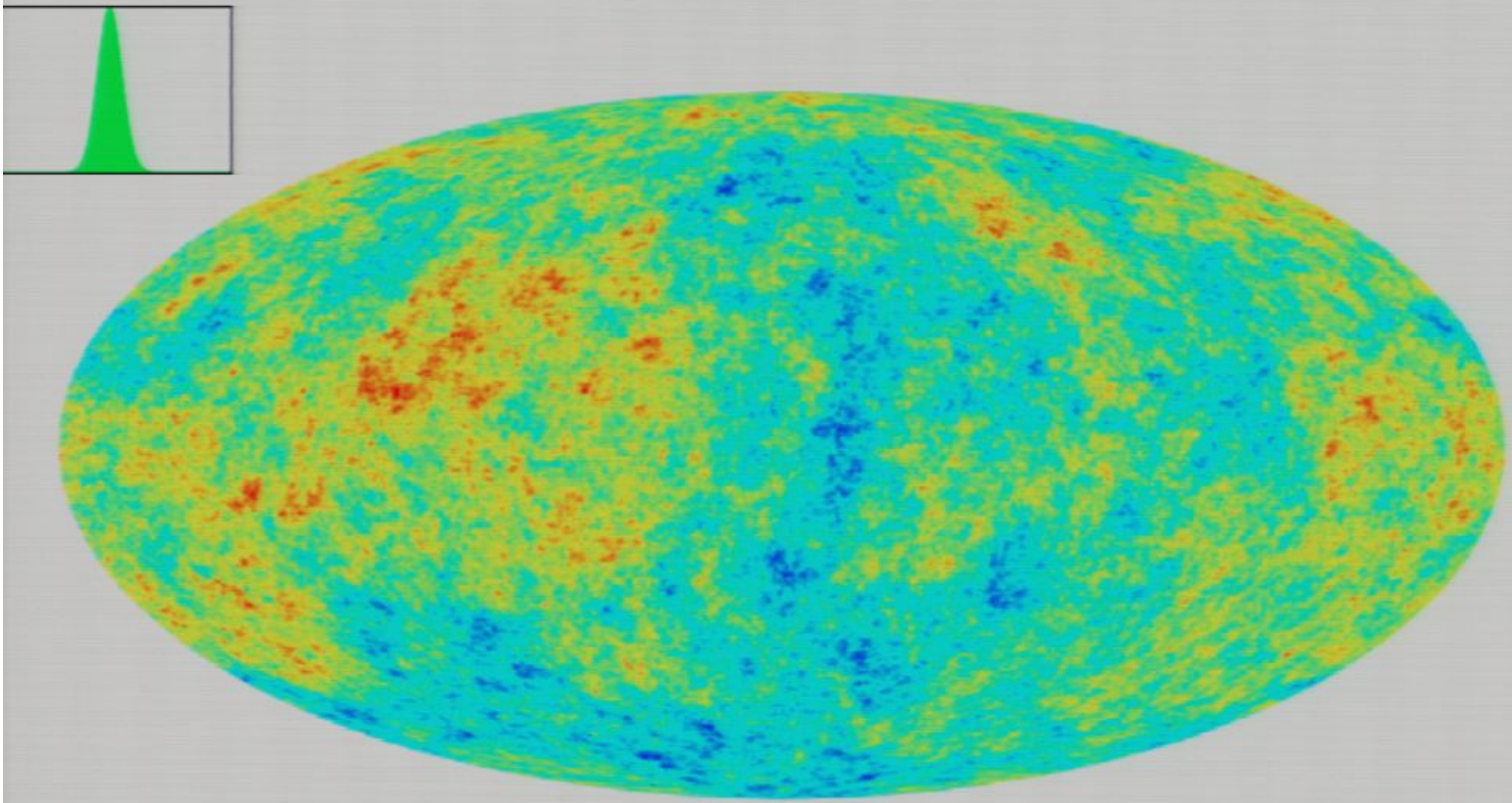

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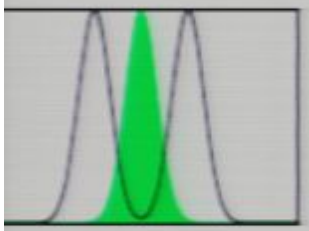

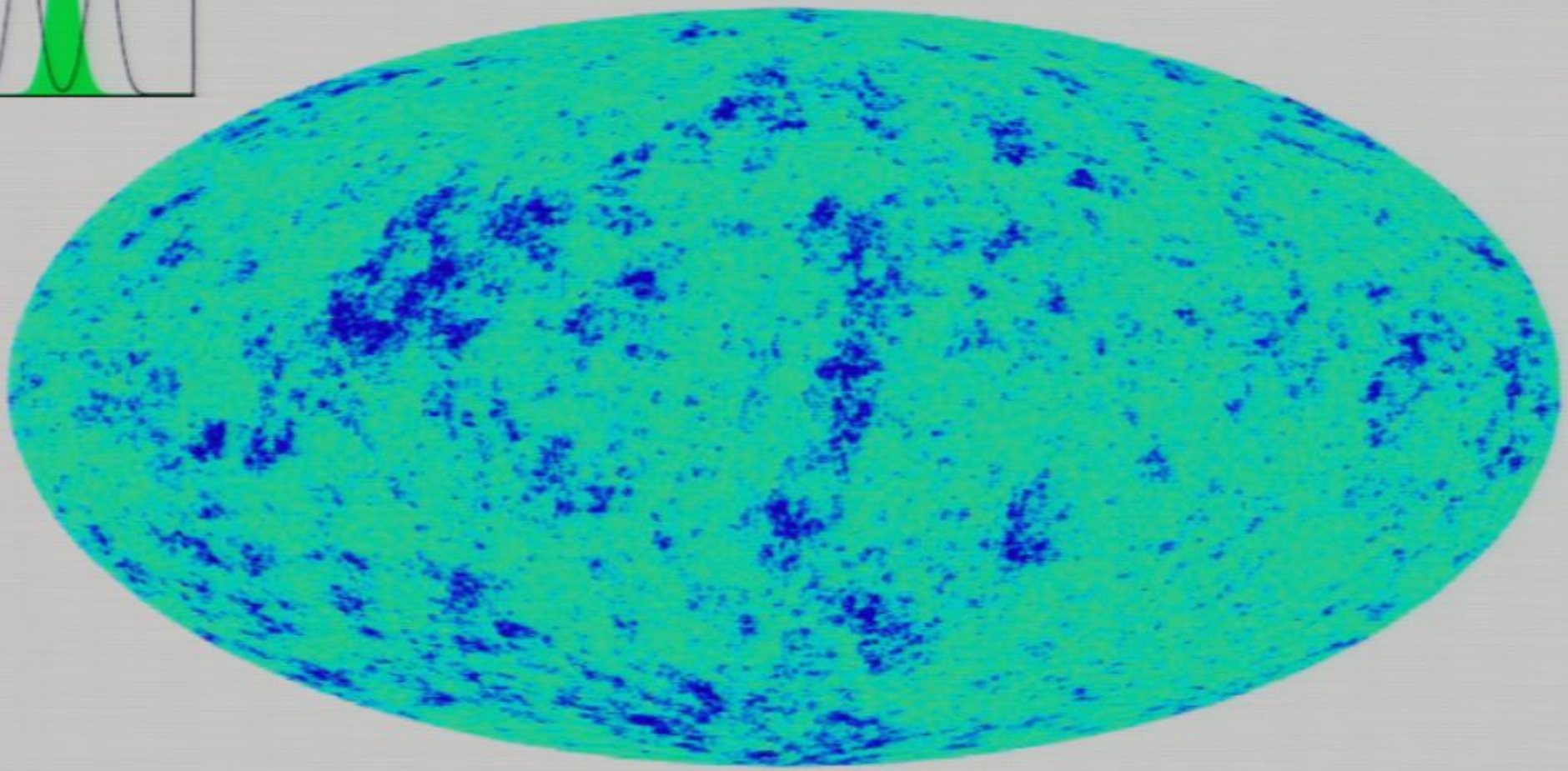

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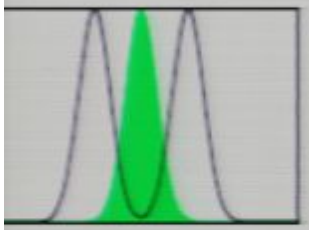

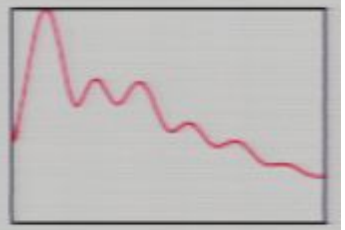

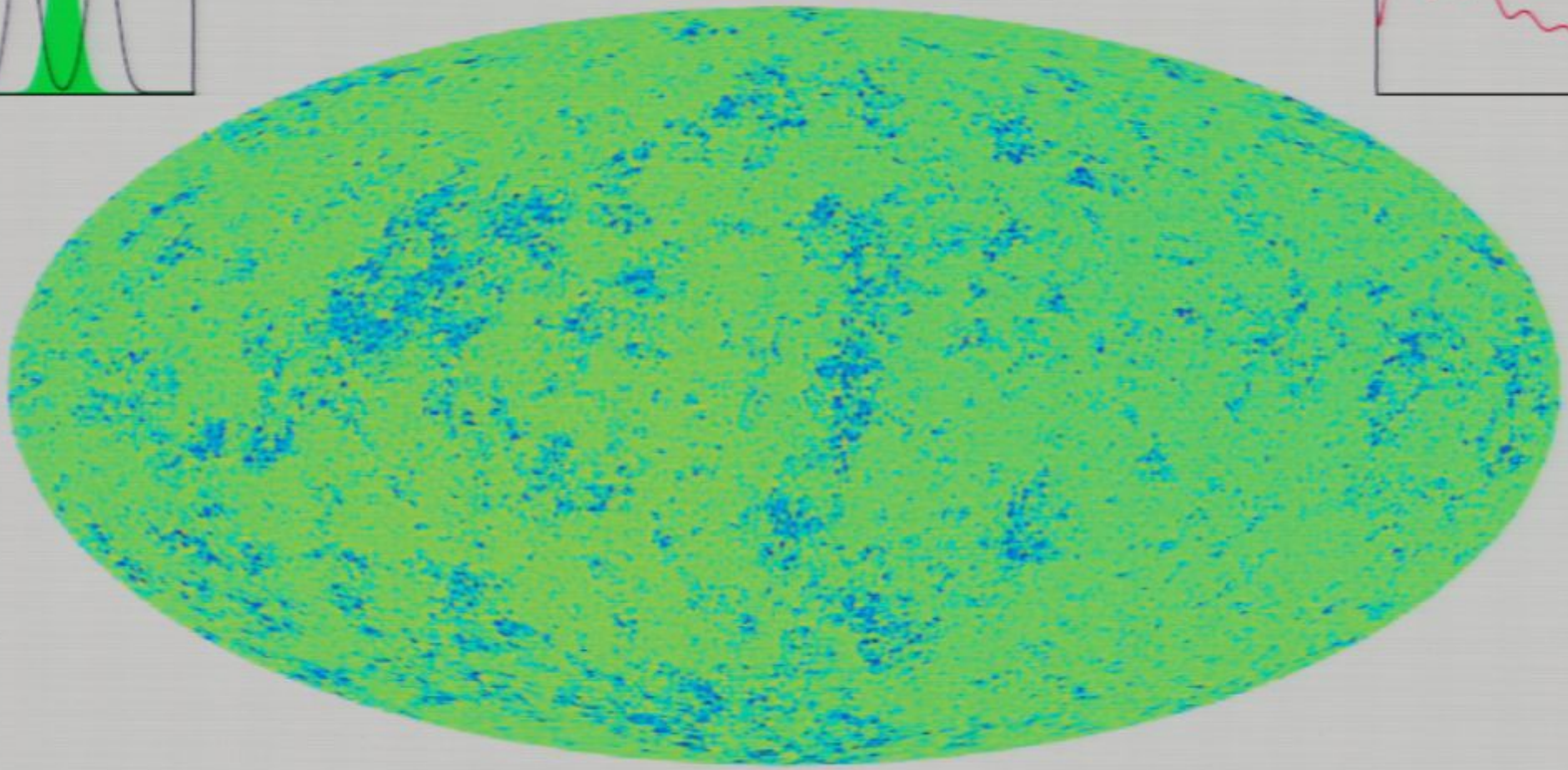

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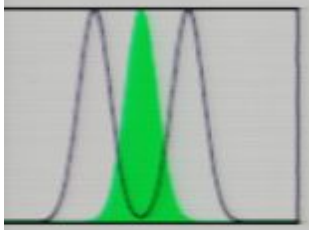

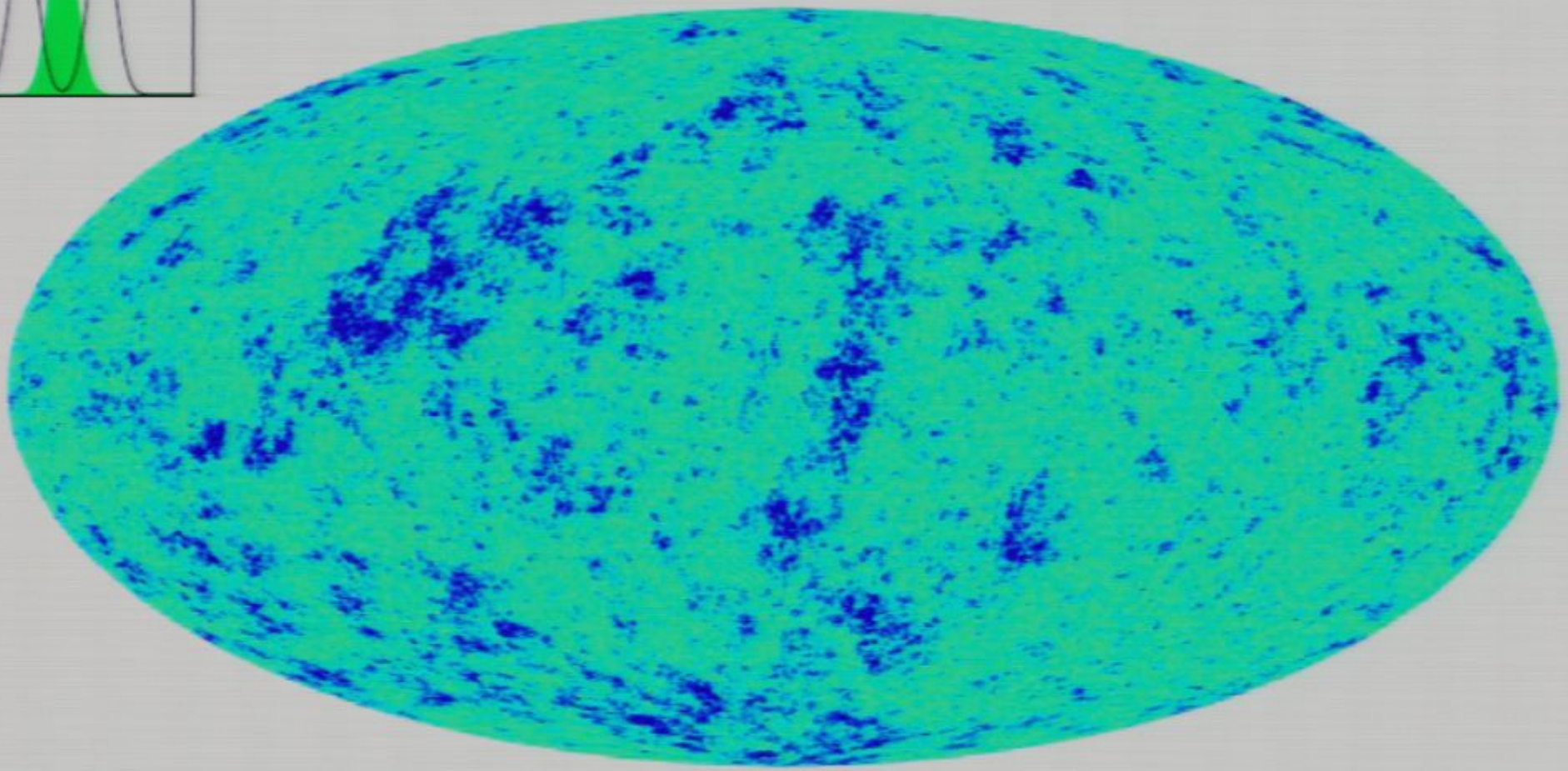

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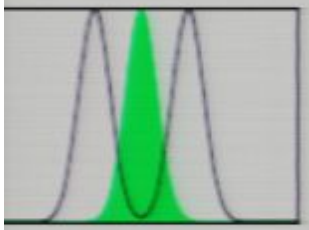

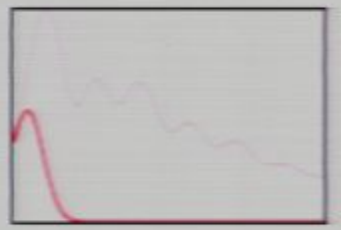

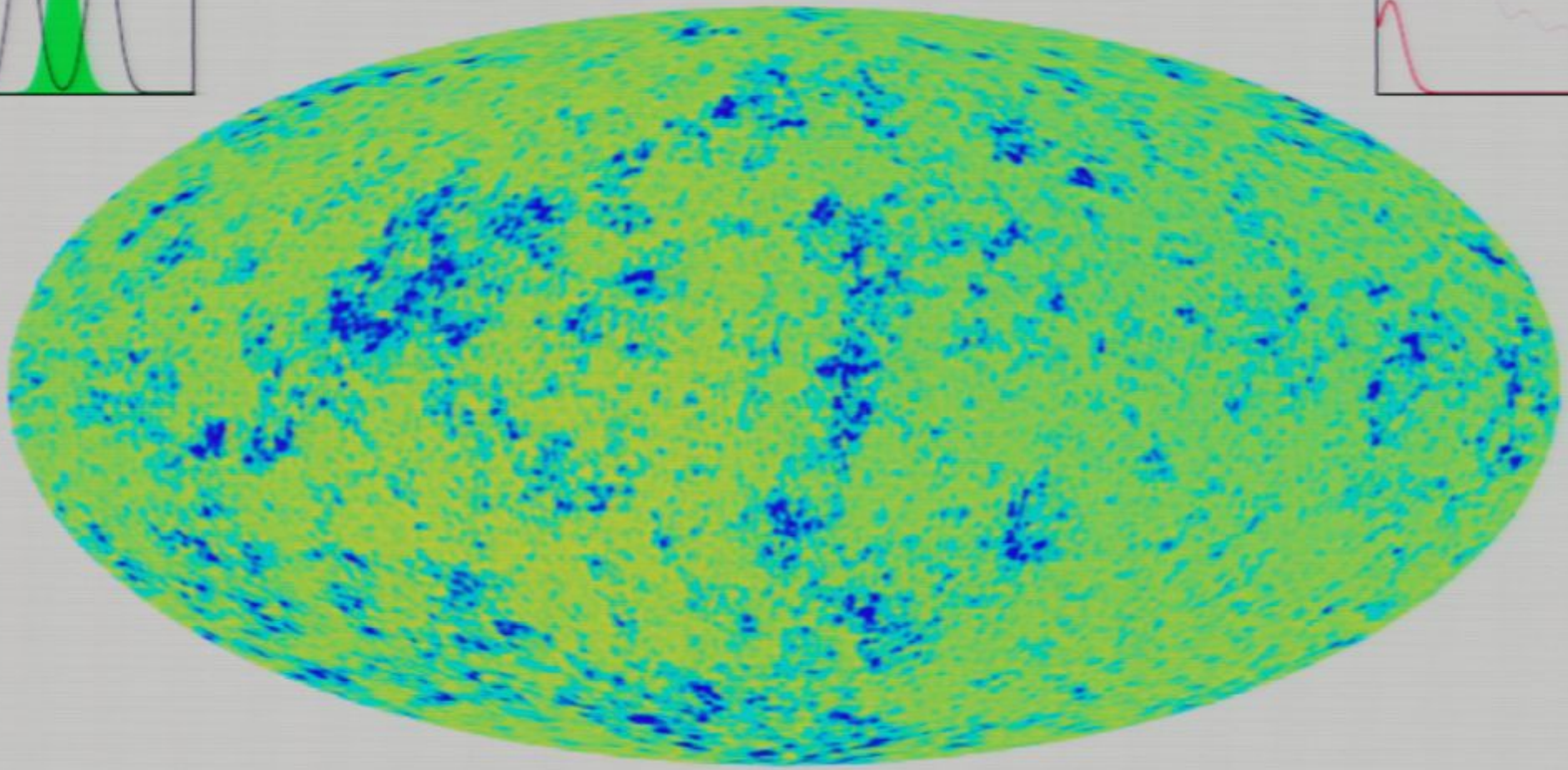

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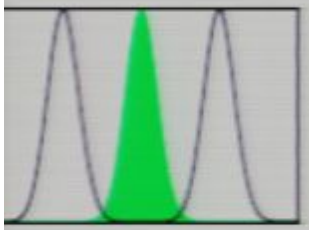

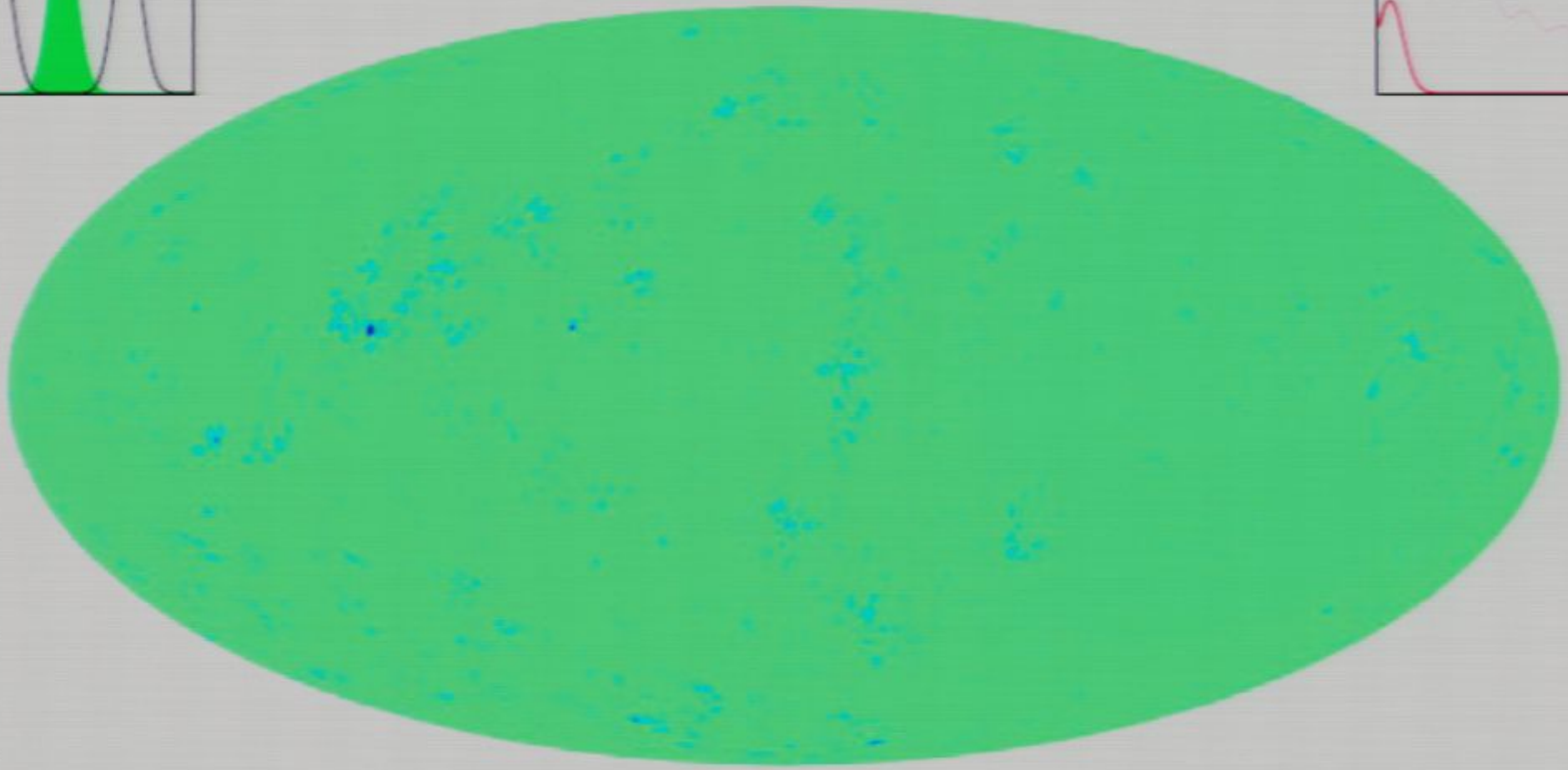

How do we search for this kind of non-Gaussianity in the CMB?

or,

my take on the infamous cold spot story...

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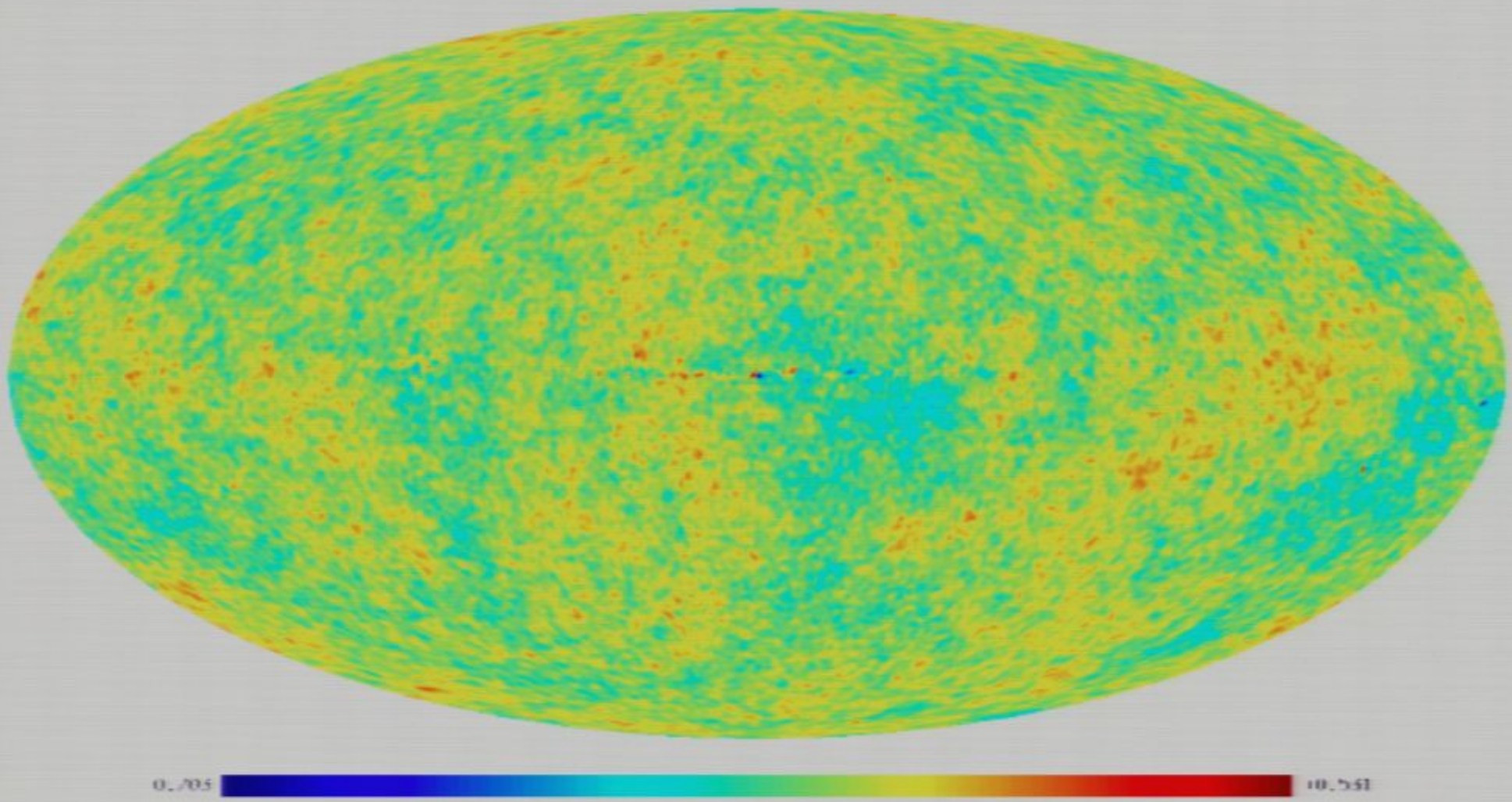
WMAP 5yr DR3 ILC Map + KQ85 Mask



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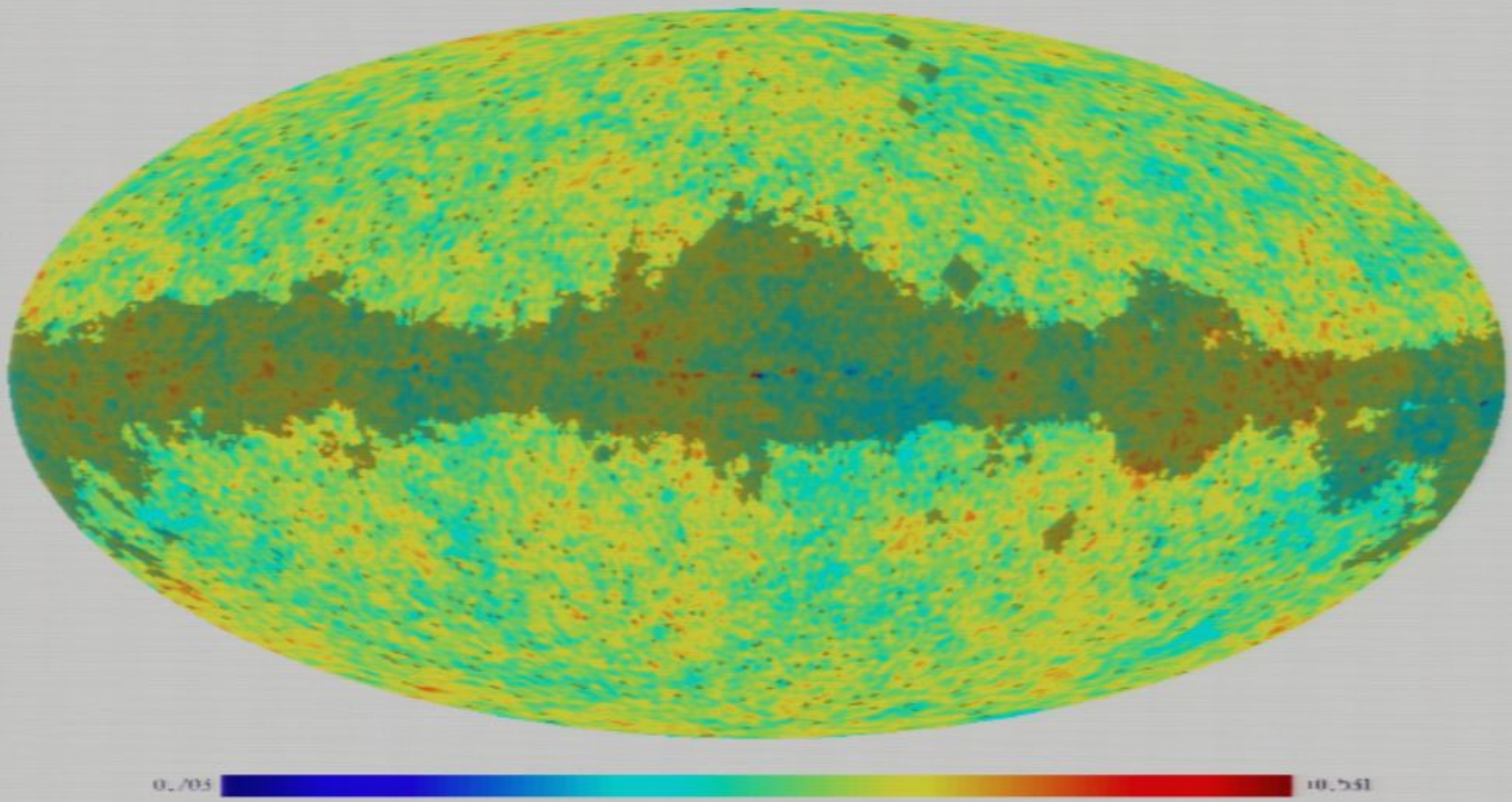


Threshold Detection and Filter Design

Threshold detector triggers predominantly on the signal *peak*

False alarm rate is set by trigger level x and noise statistics σ, ℓ

$$\langle \mathrm{FAR} \rangle = \frac{e^{-\frac{1}{2}\left(\frac{x}{\sigma}\right)^2}}{\pi \ell}, \qquad \sigma^2 = \langle n^2 \rangle, \qquad \ell^2 = \frac{\langle n^2 \rangle}{\langle \dot{n}^2 \rangle}$$

$$\text{Primary filter figure of merit} = \frac{\text{noise } \sigma \text{ attenuation}}{\text{signal peak attenuation}}$$

Use filter kernel shaping to optimize merit!

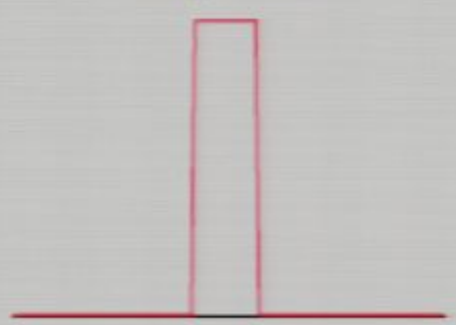
FIR Filter Kernels

FIR filter is a linear operator (discrete or continuous version):

$$f_j = \sum_{i=-n/2}^{n/2} F_i s_{j+i}, \qquad f(x) = \int_{-1}^{1} F(t) s(x+t)\, dt$$

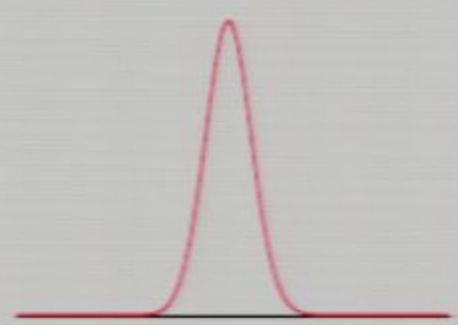
FIR filter is completely defined by its kernel... Common choices are:

top hat



"Mean Filter" (MF)

Gaussian



"Peak Correlator" (PC)

truncated $\sin(x)/x$

"Brick Wall" (SX)

Generalized Savitzky-Golay Filters

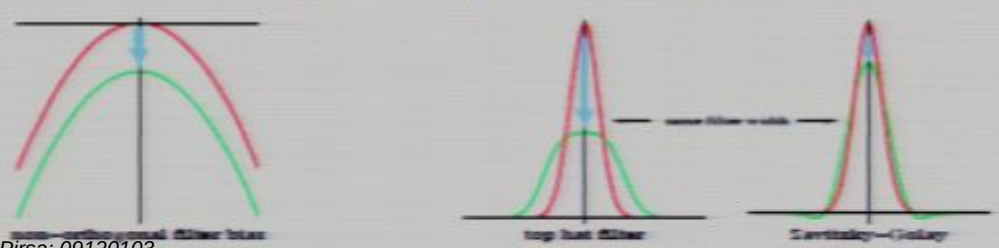
Generalized Savitzky-Golay filter kernel:

$$F_{n,k}(x) = \left(\sum_{i=0}^{n/2} a_i x^{2i} \right) (1 - x^2)^k$$

Orthogonal to polynomials up to order n:

$$\int_0^1 x F_{n,k}(x)\, dx = 1, \quad \int_0^1 x^{i+1} F_{n,k}(x)\, dx = 0$$

Non-orthogonality biases peaks low:



SSG02

SSG42

SSG84

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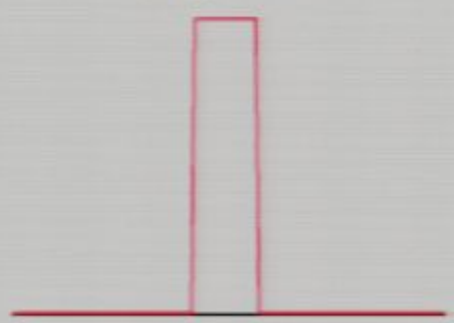

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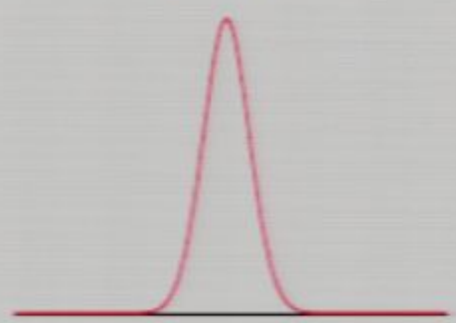

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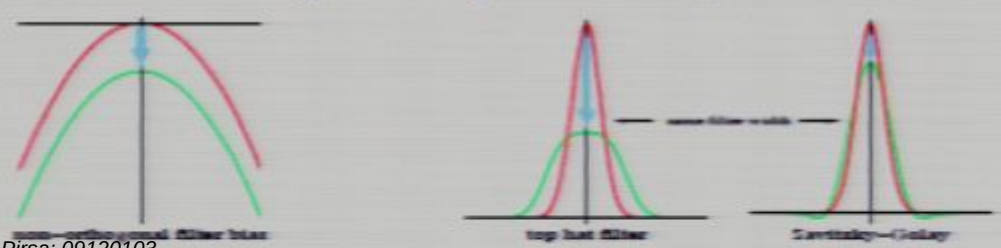
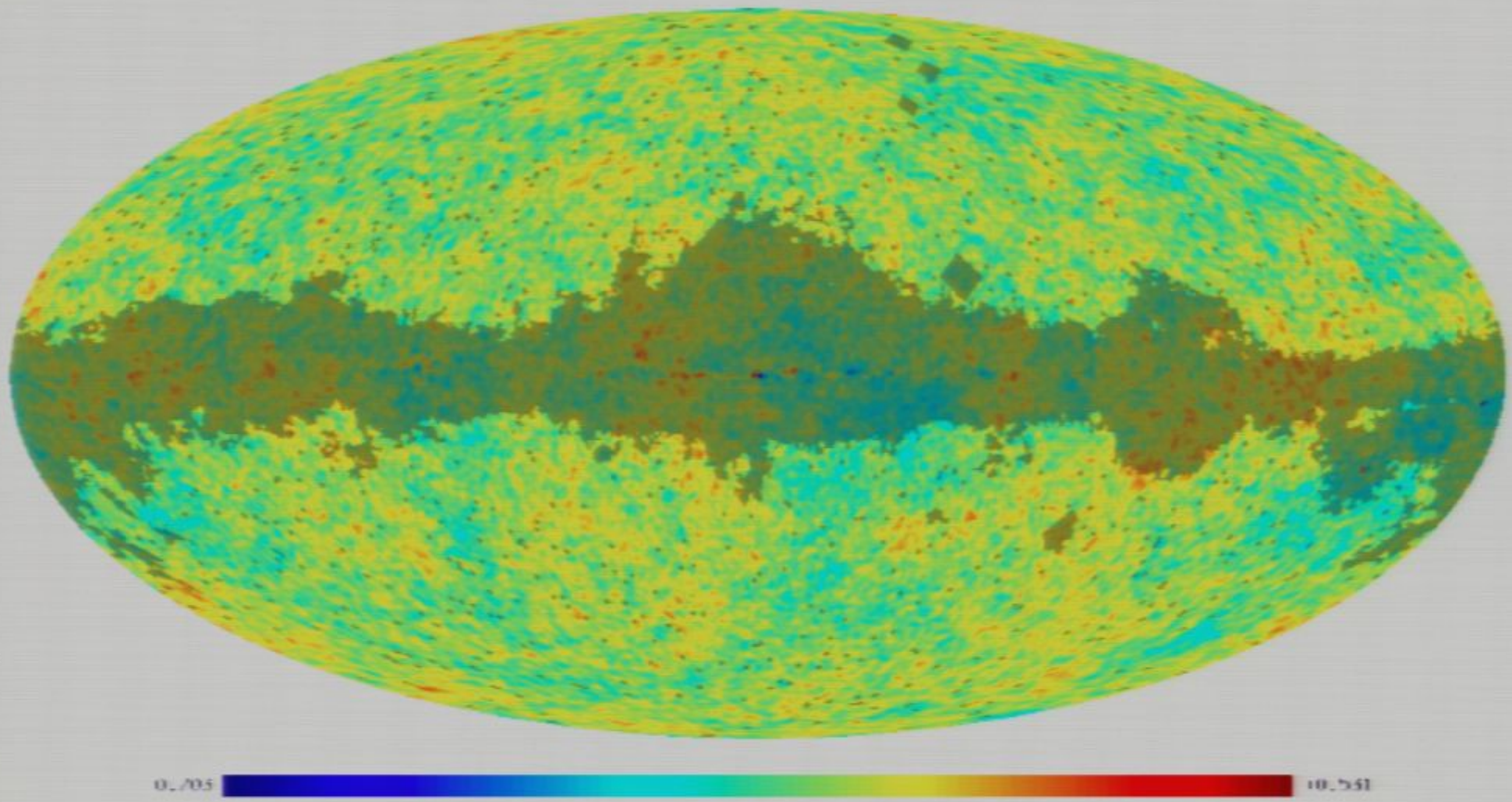


SSG02

SSG42

SSG84

WMAP 5yr DR3 ILC Map + KQ85 Mask



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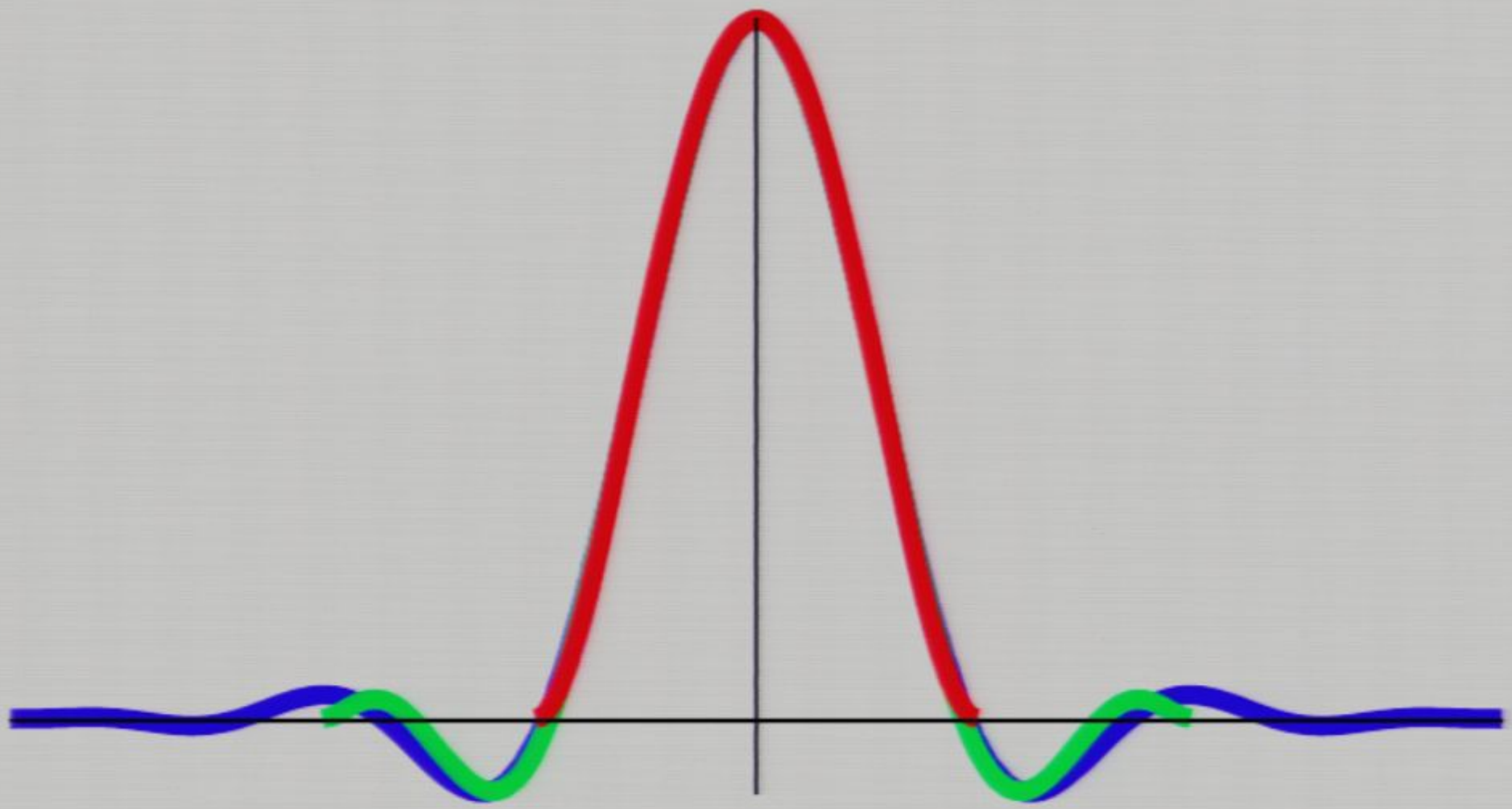

Gaussian Random Field Peak Statistics

$$\frac{n_{\mathrm{max}} + n_{\mathrm{min}}}{n_{\mathrm{pk}}}\left(\frac{x}{\sigma} > \nu\right) = \sqrt{\frac{3}{2\pi}}\gamma^2 \nu \exp\left(-\frac{\nu^2}{2}\right) + \frac{1}{2}\mathrm{erfc}\left[\frac{\nu}{\sqrt{2(1-2\gamma^2)}}\right]$$

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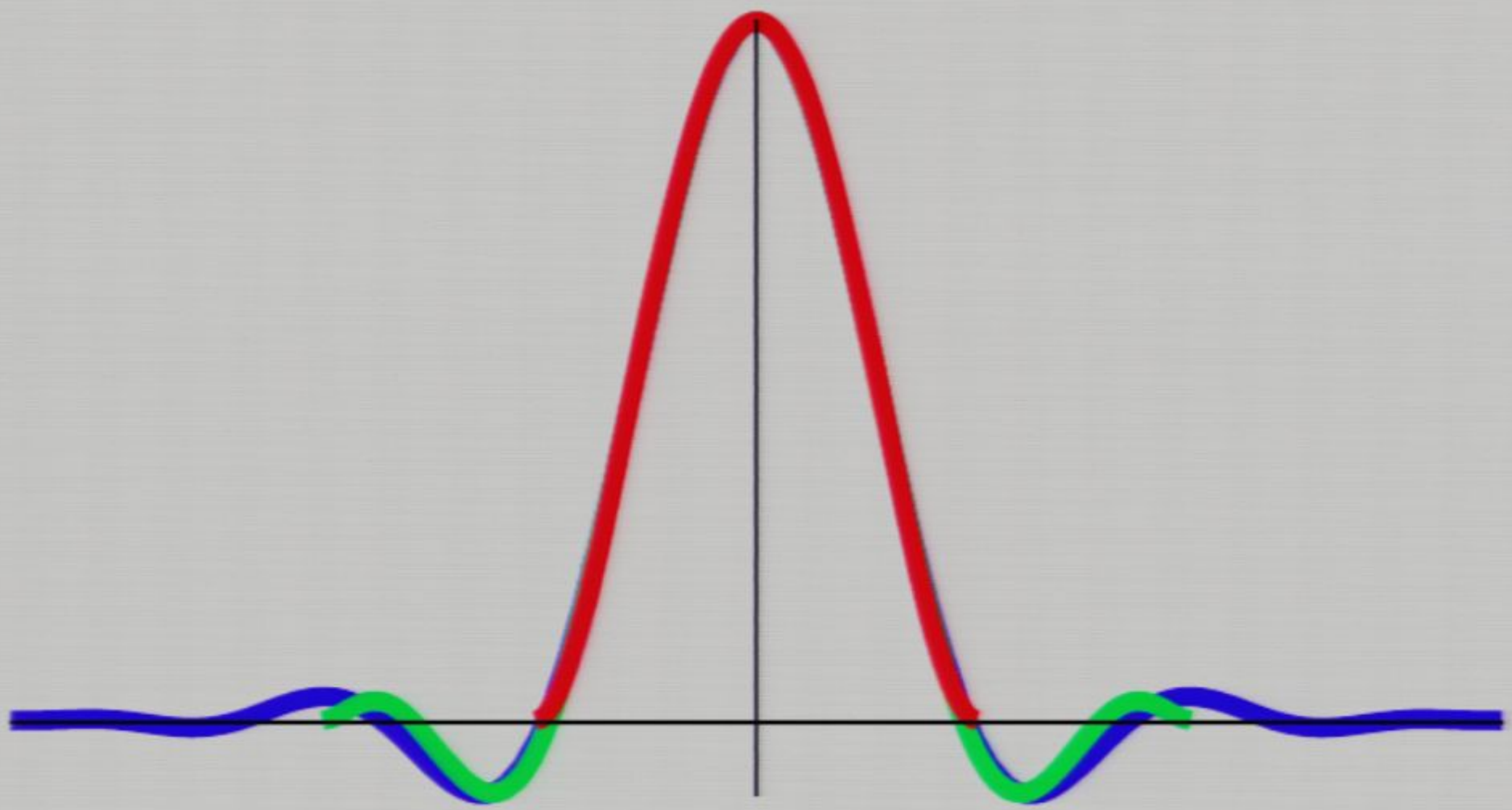

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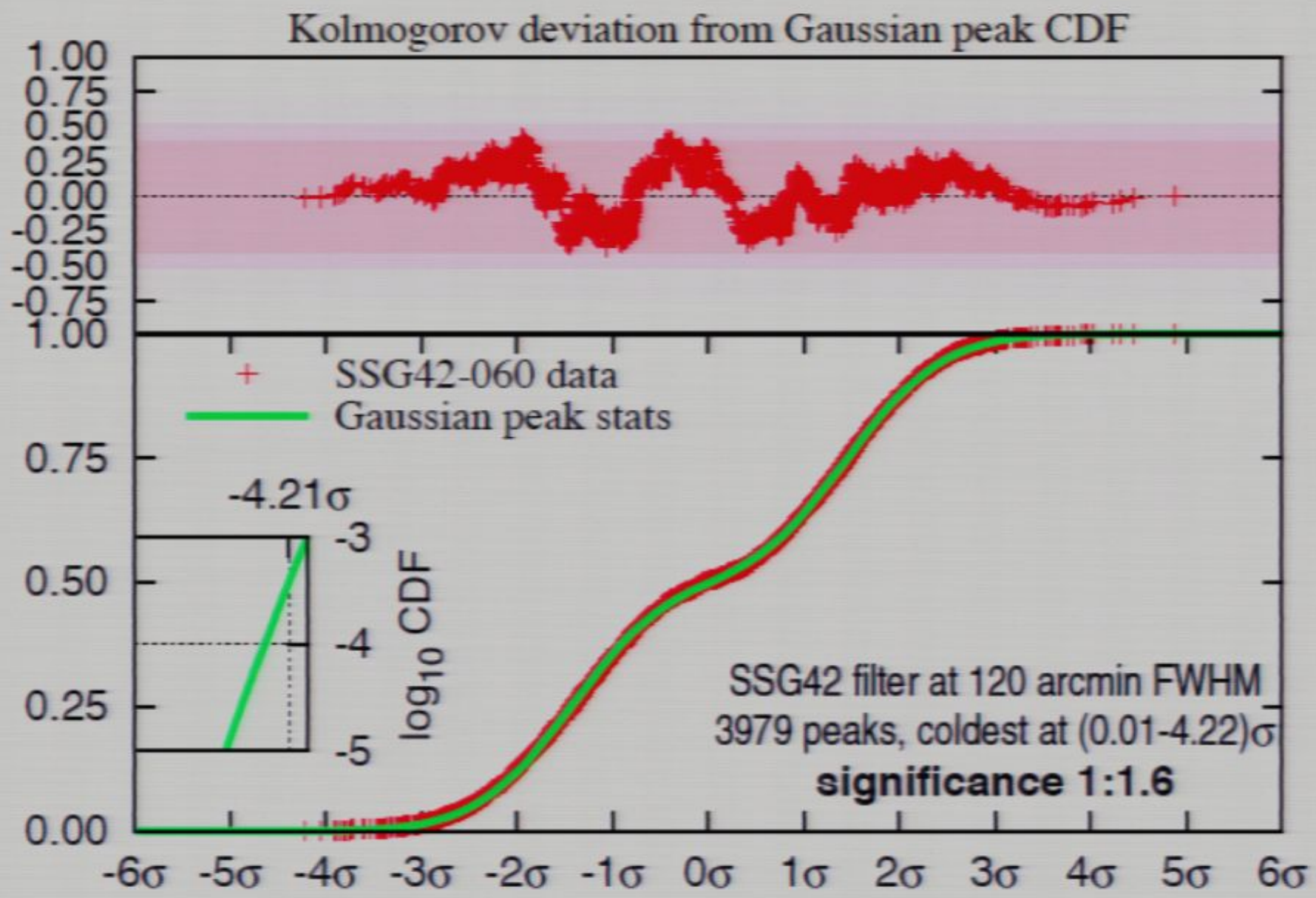
Testing CMB Peak Statistics [SSG42]



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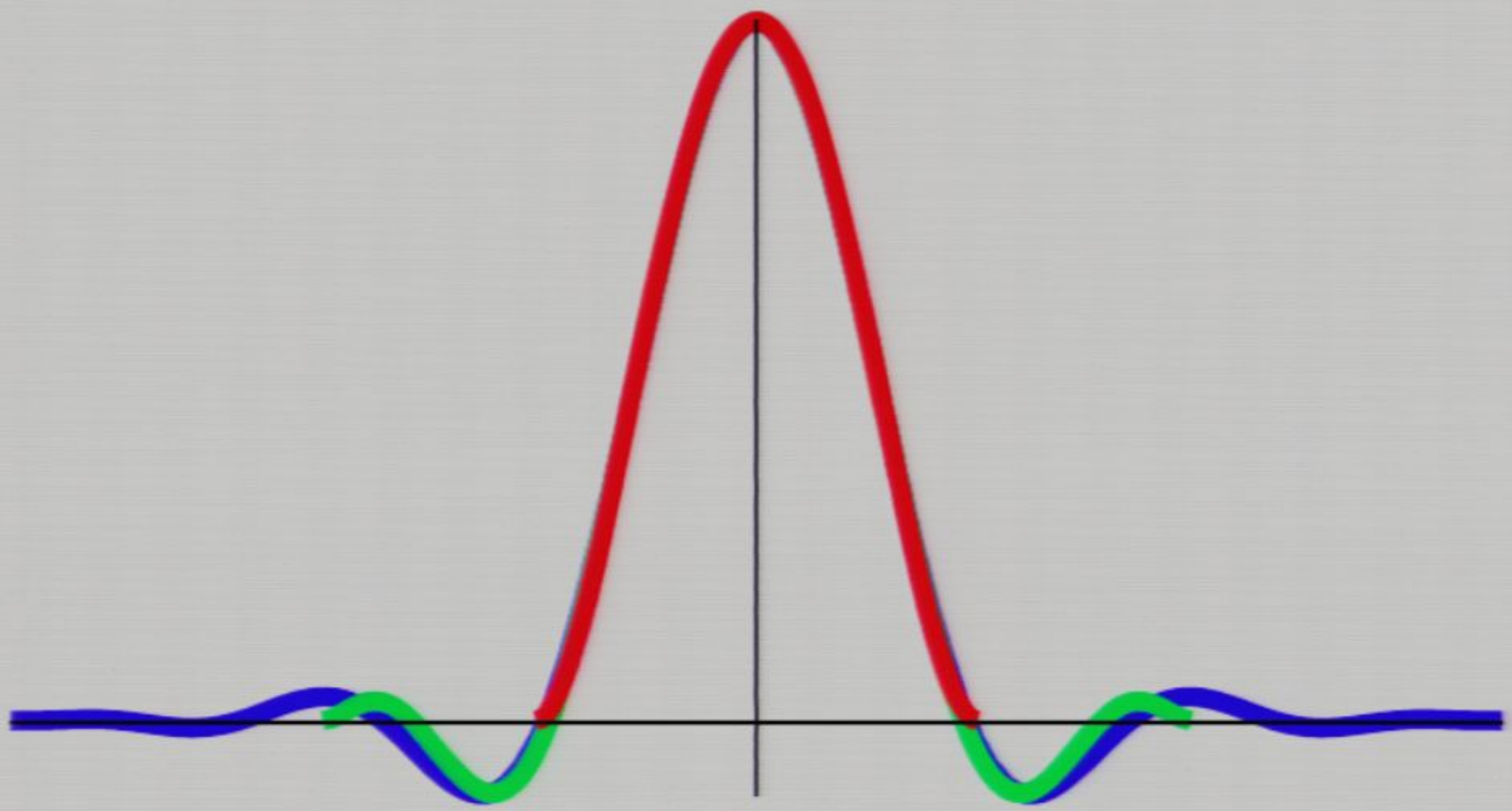

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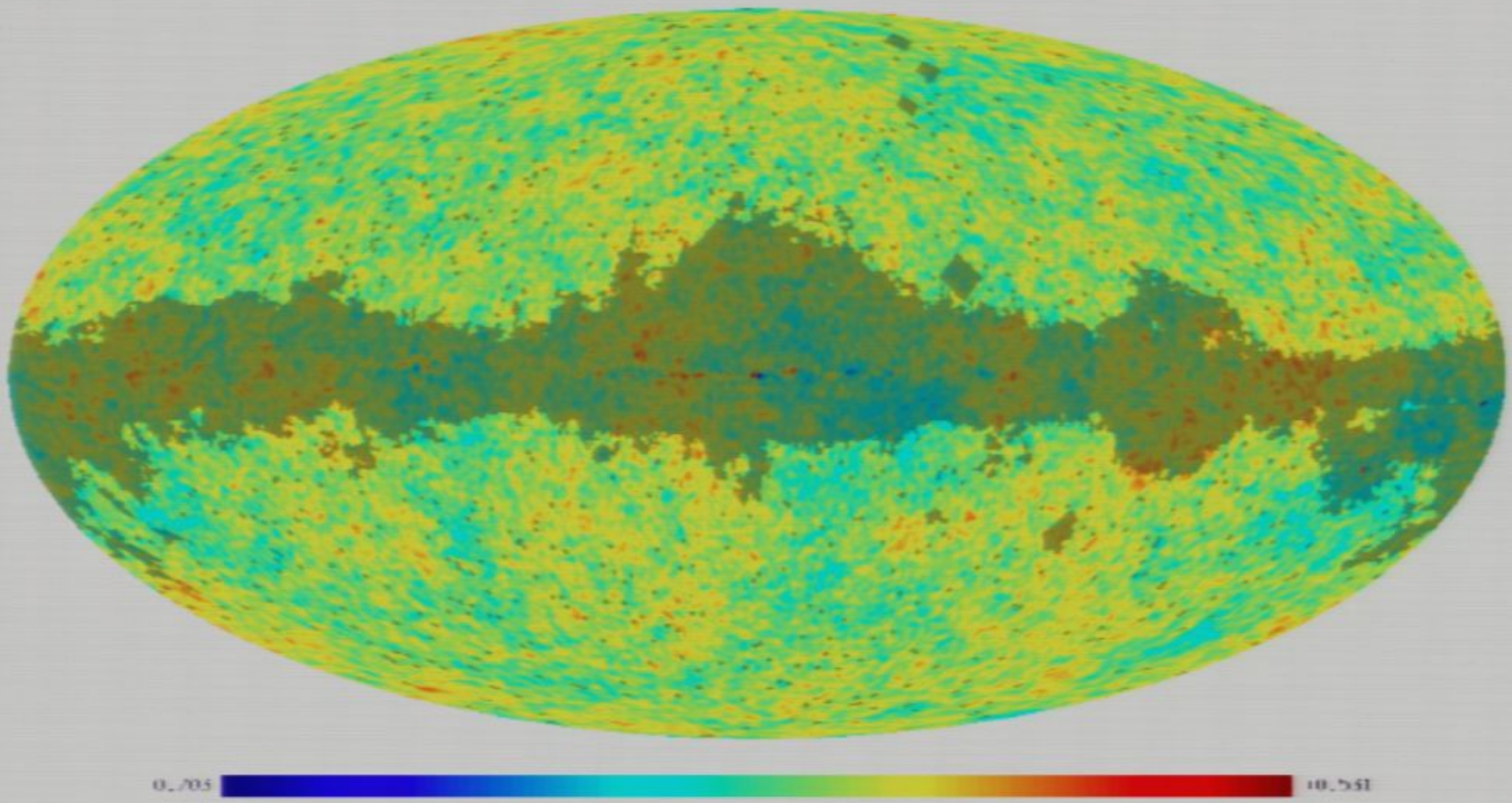

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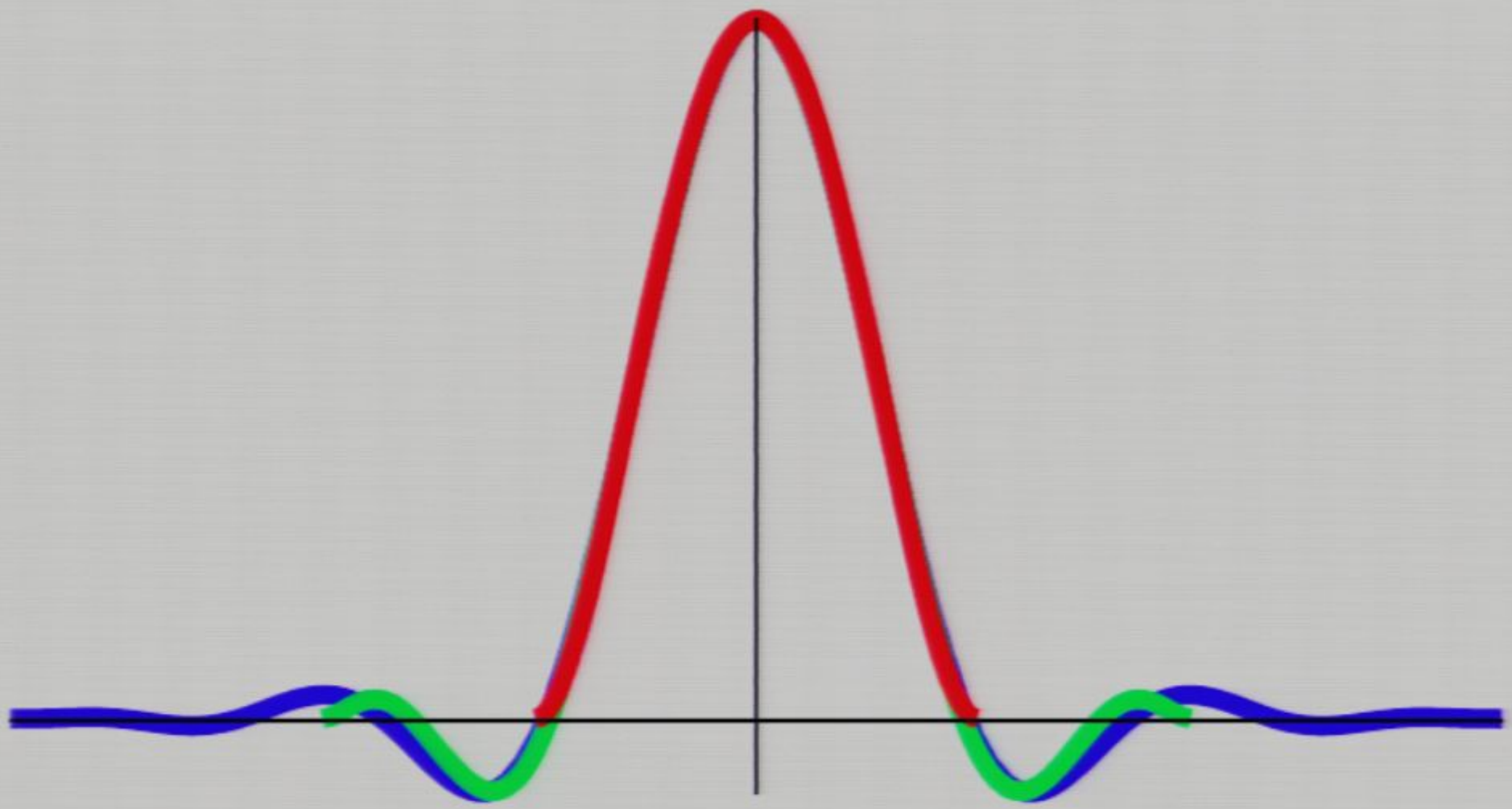
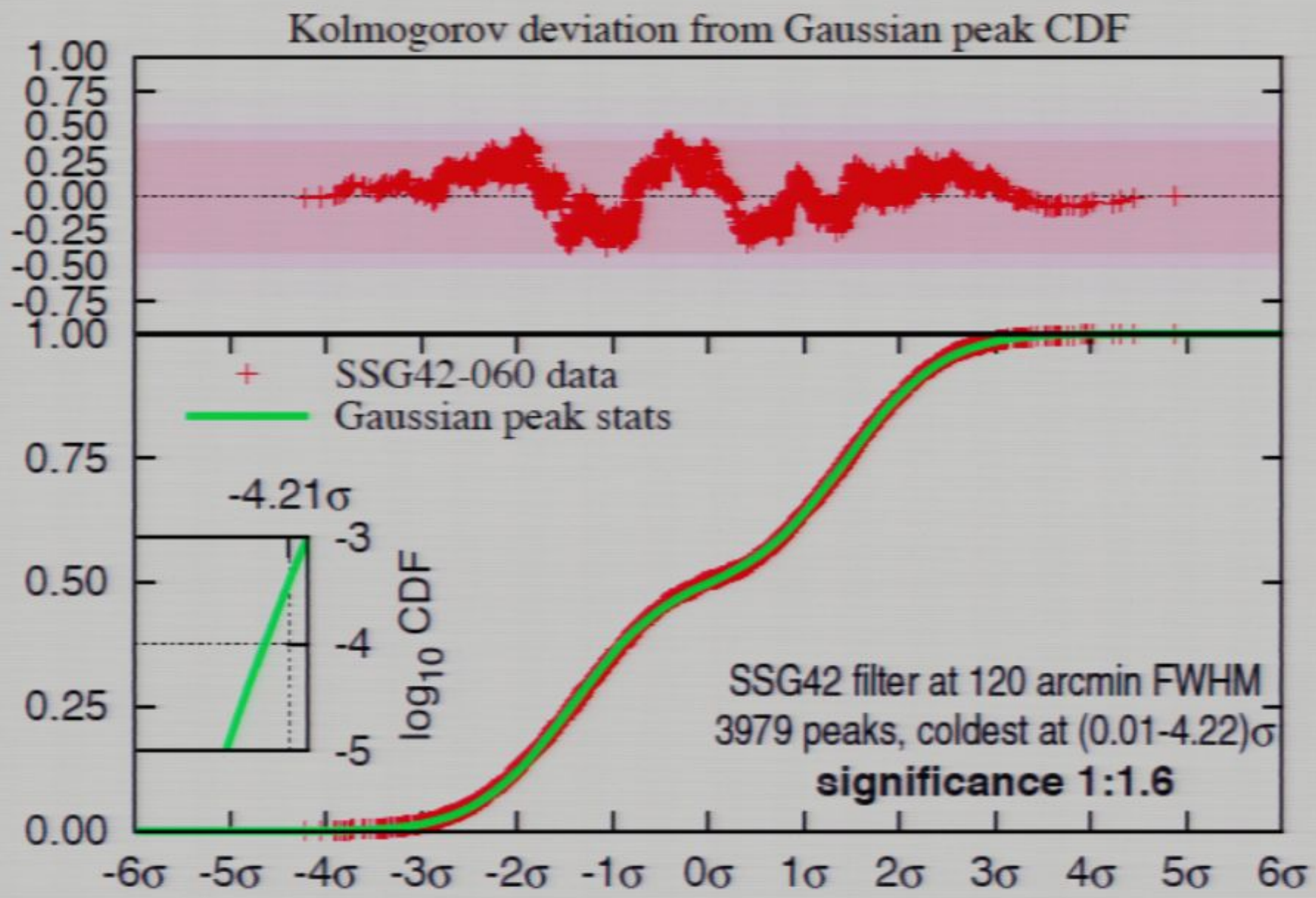


Gaussian Random Field Peak Statistics

$$\frac{n_{\mathrm{max}} + n_{\mathrm{min}}}{n_{\mathrm{pk}}}\left(\frac{x}{\sigma} > \nu\right) = \sqrt{\frac{3}{2\pi}}\gamma^2 \nu \exp\left(-\frac{\nu^2}{2}\right) + \frac{1}{2}\mathrm{erfc}\left[\frac{\nu}{\sqrt{2(1-2\gamma^2)}}\right]$$

Testing CMB Peak Statistics [SSG42]



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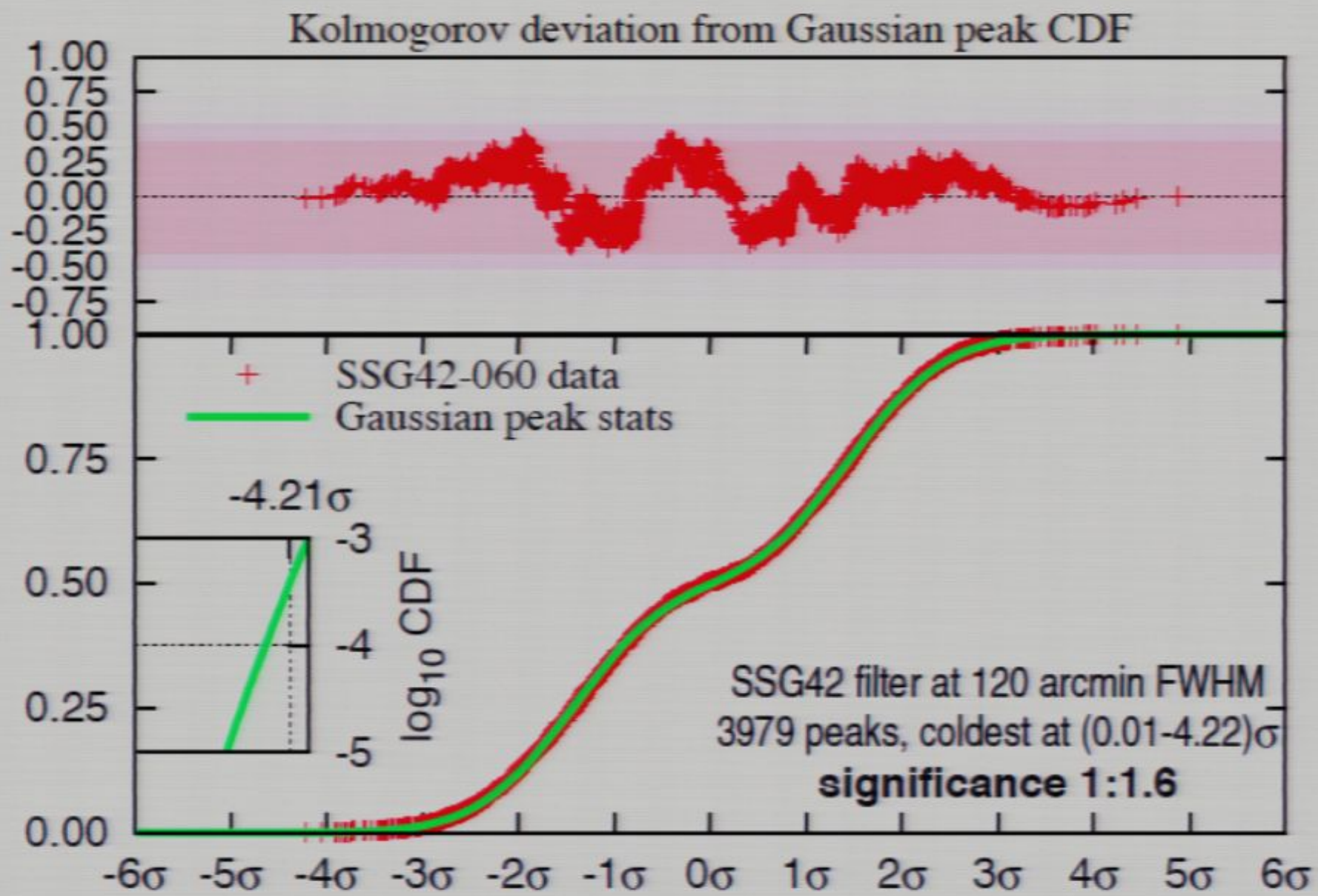

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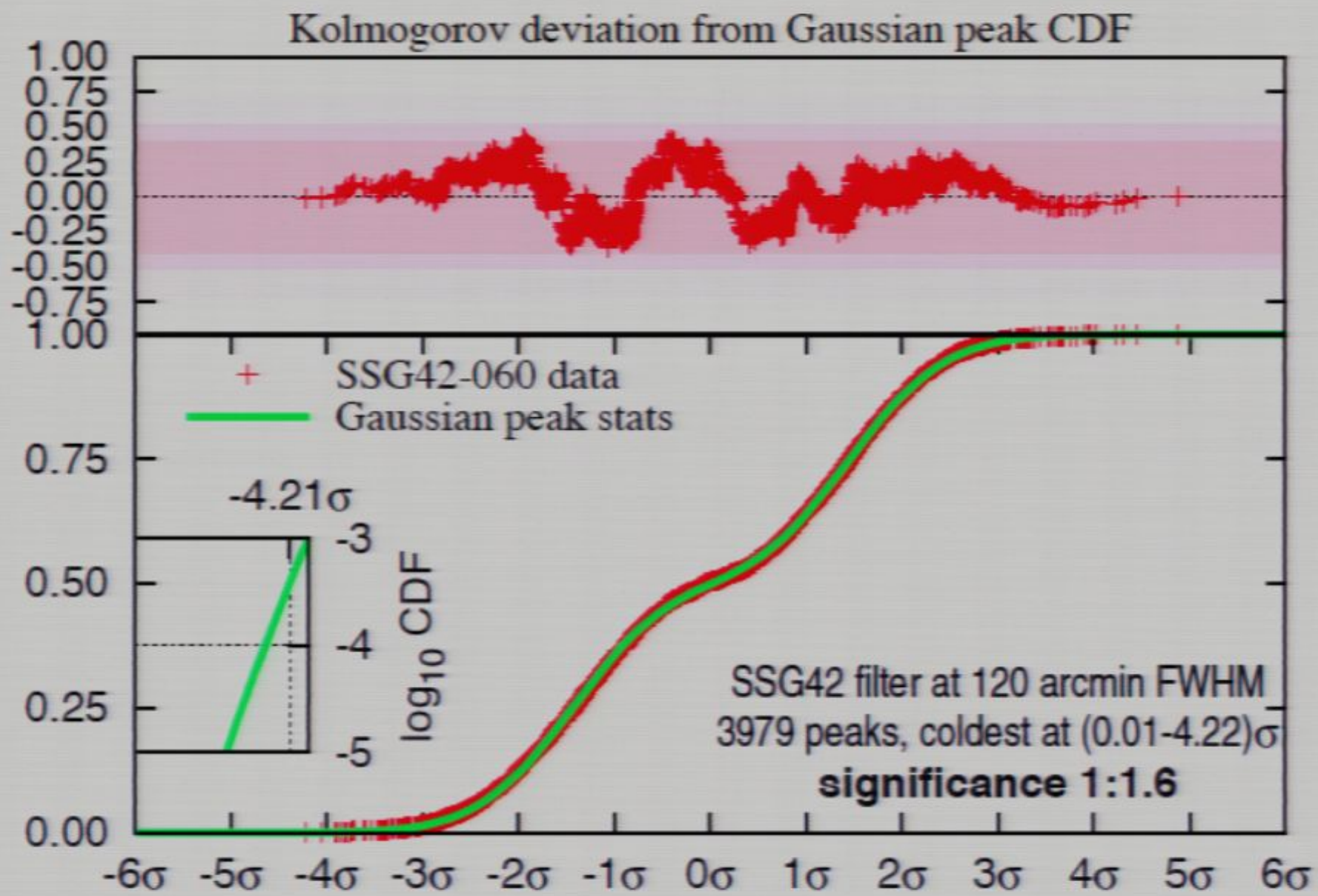

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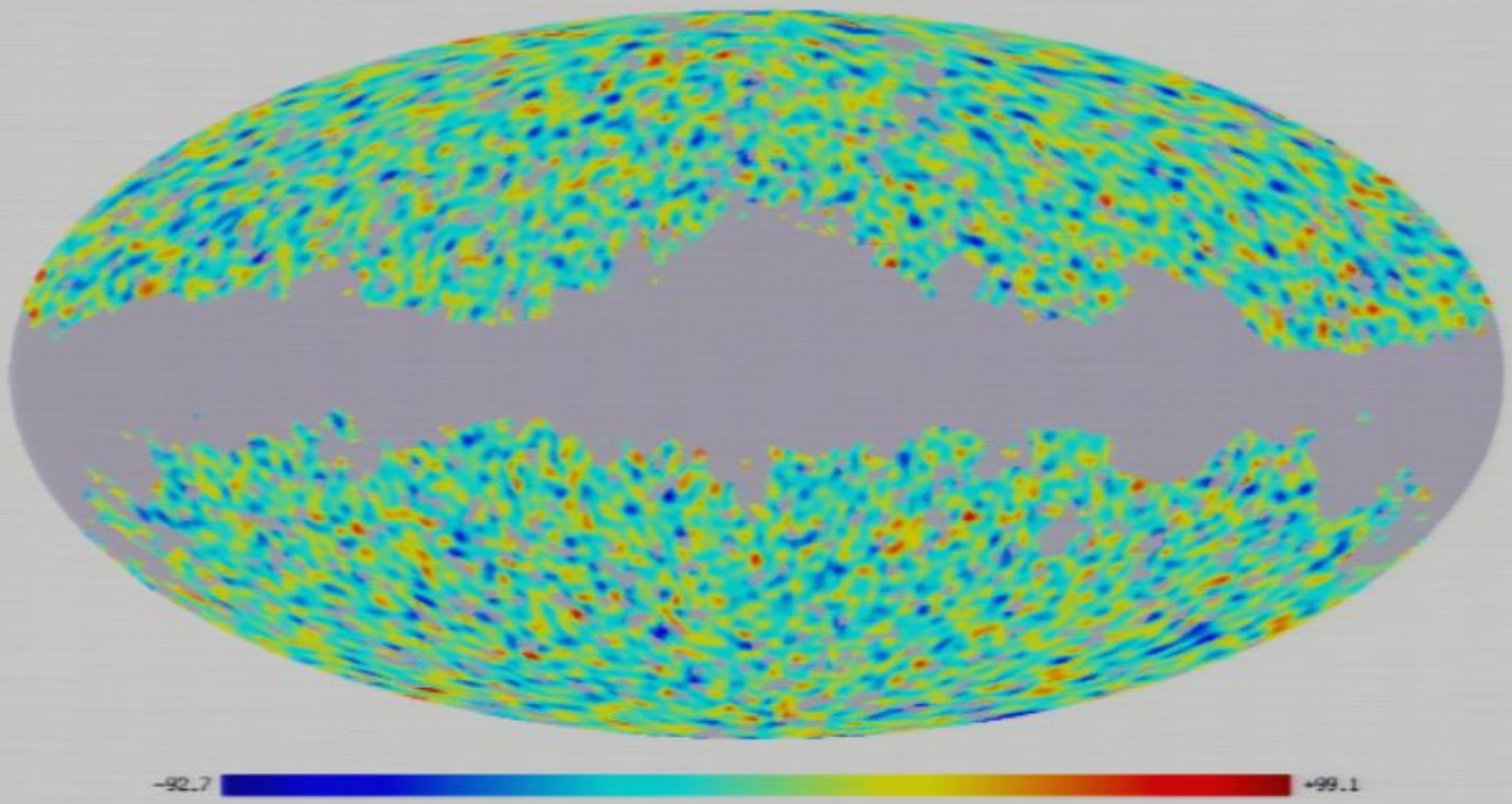

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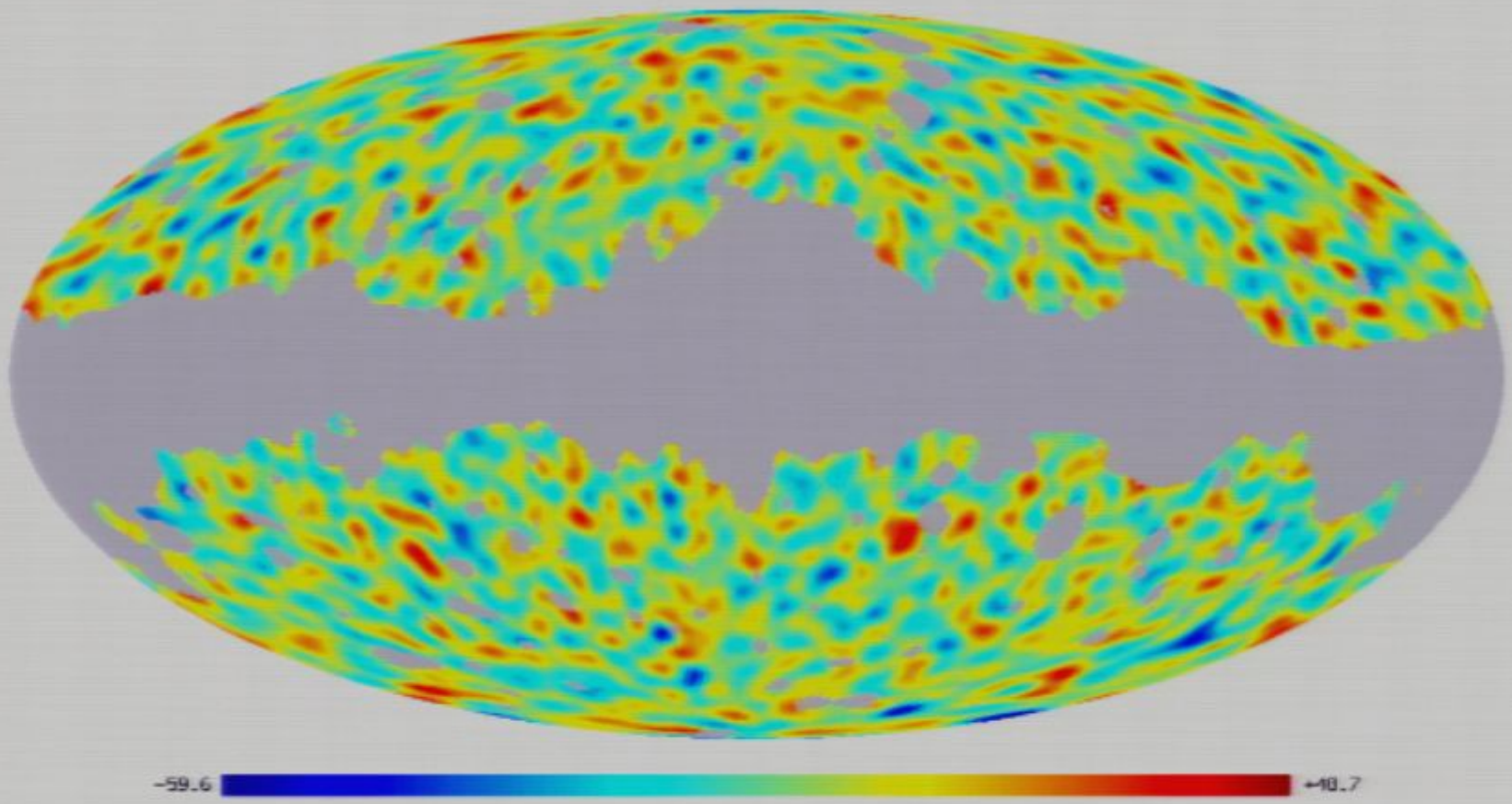

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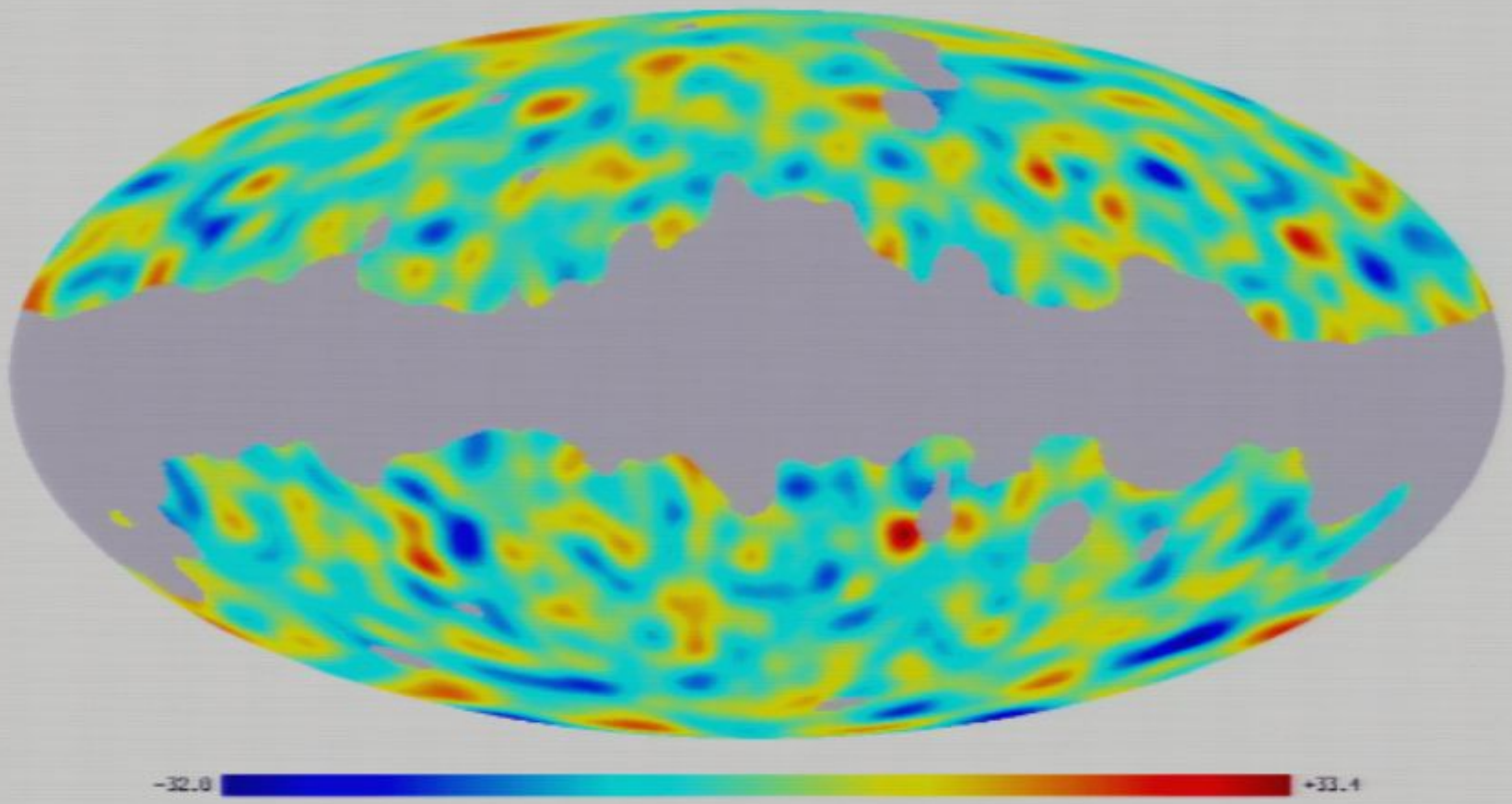

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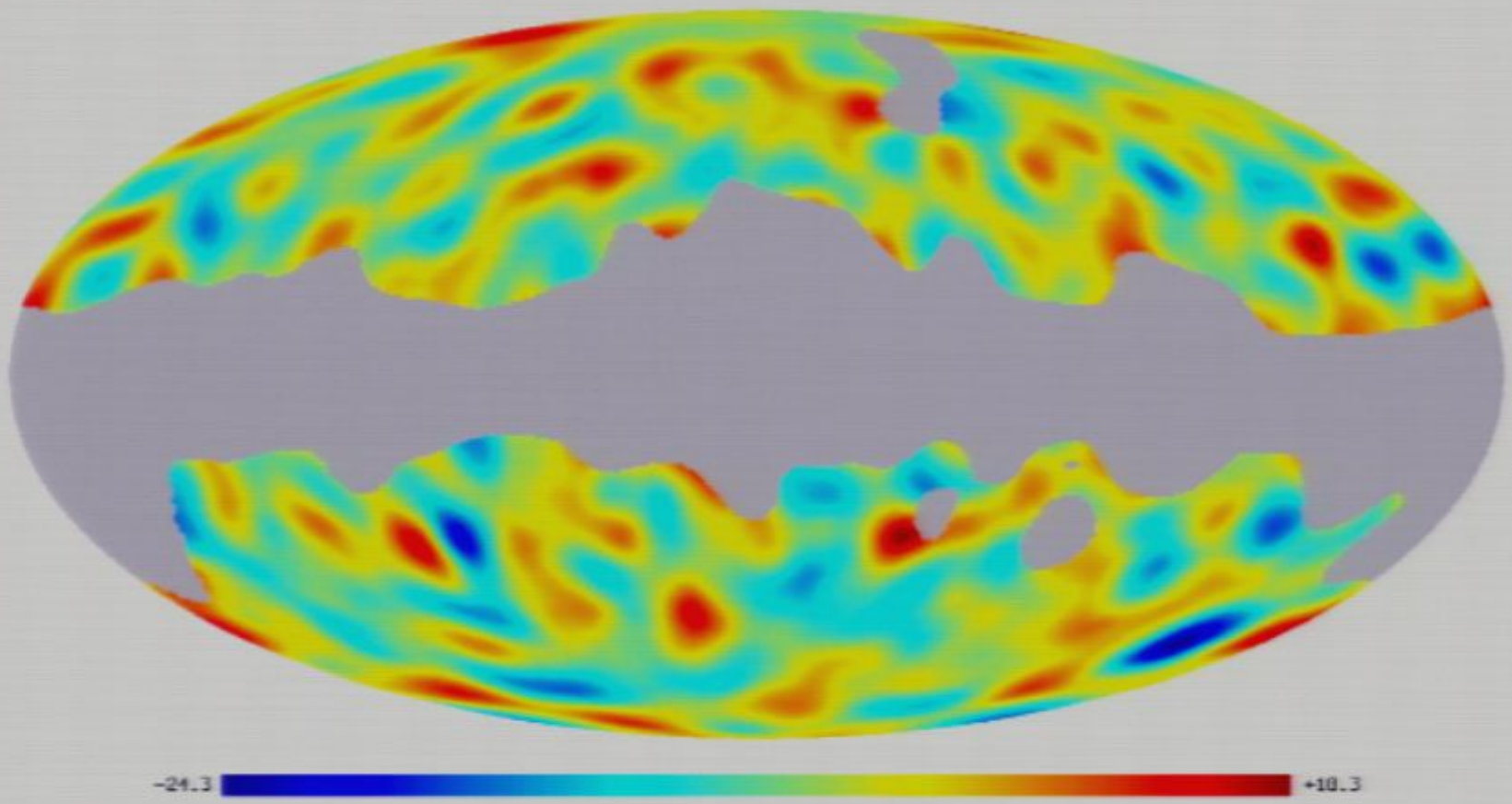

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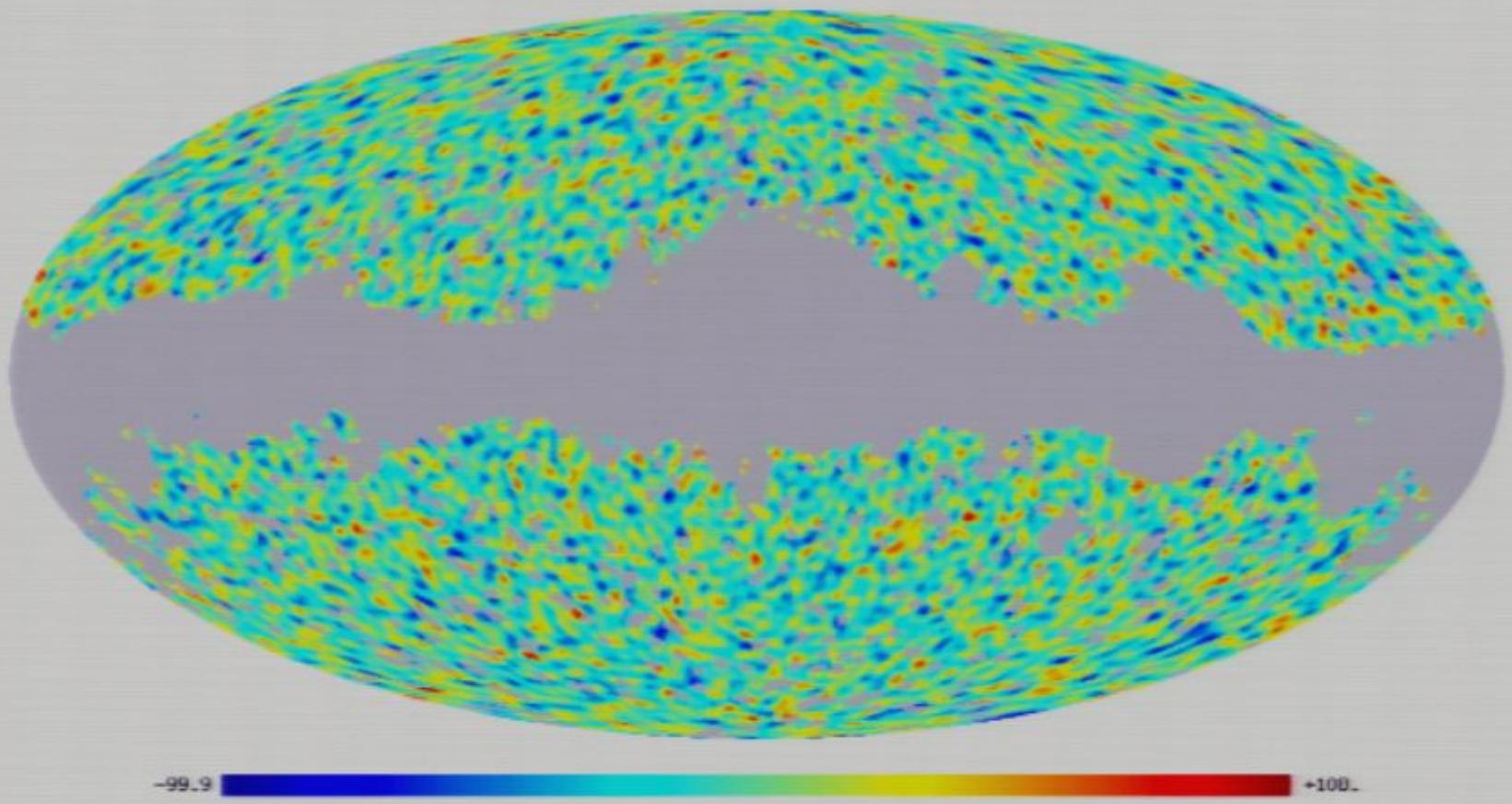

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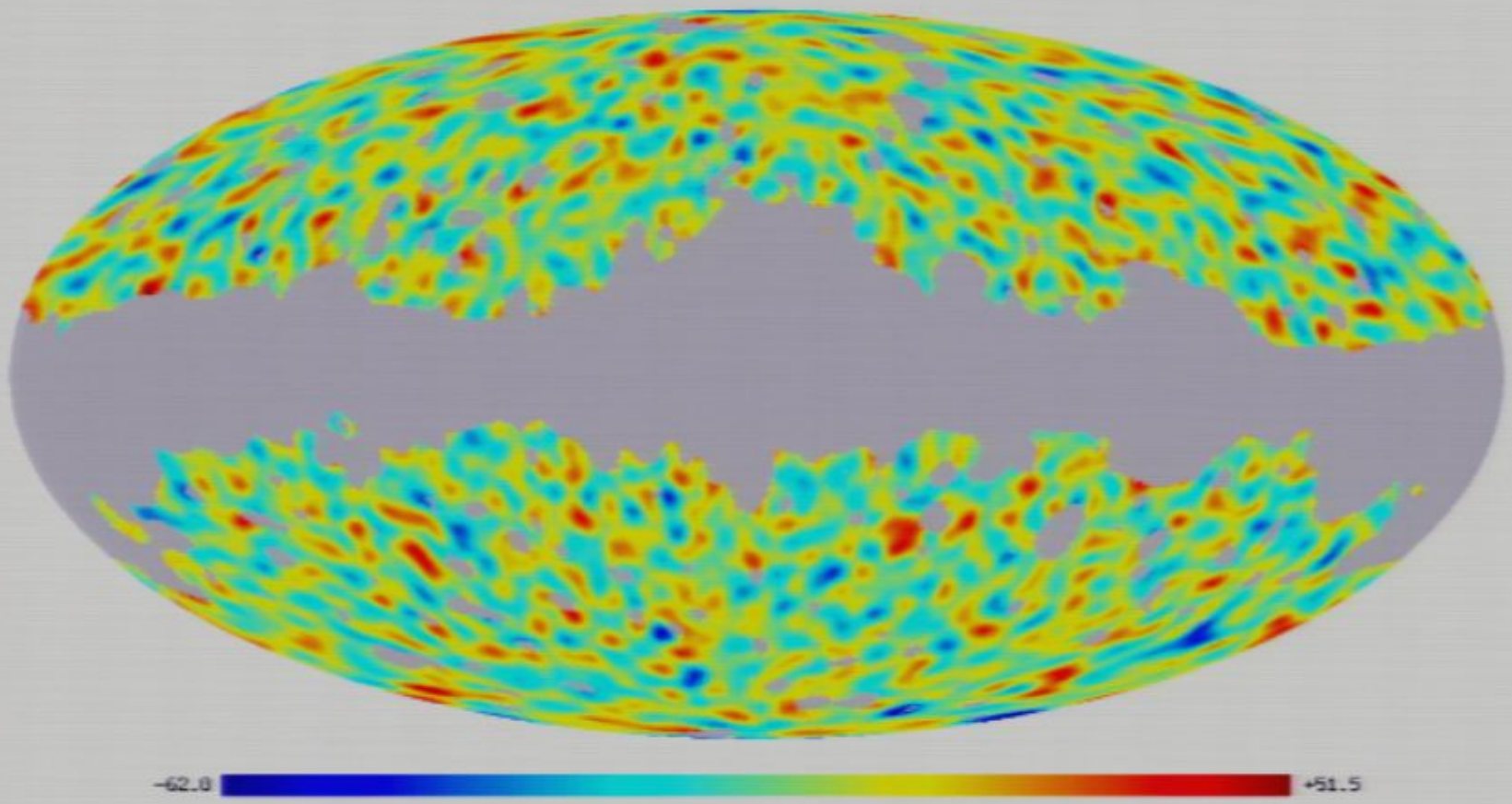

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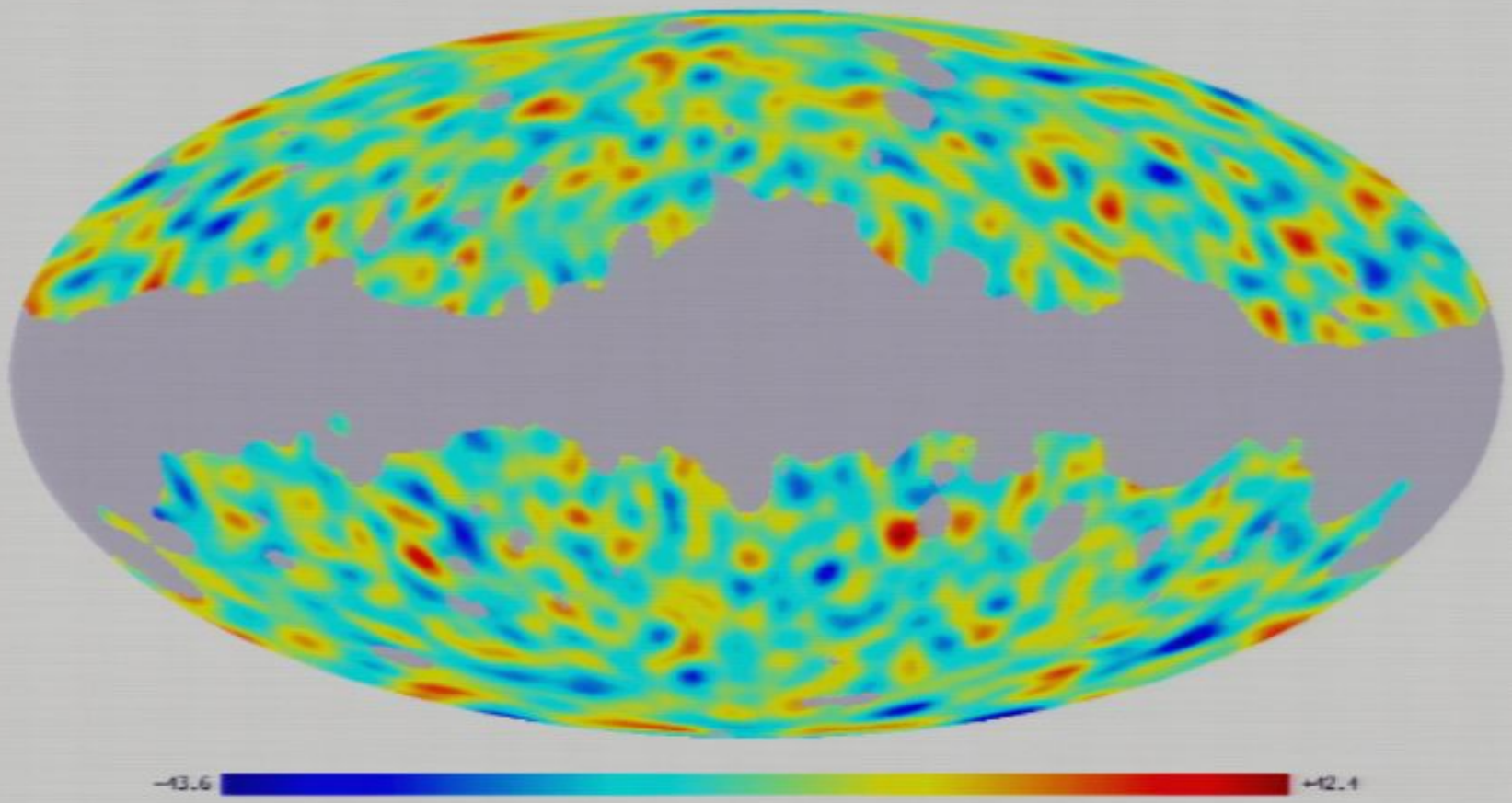

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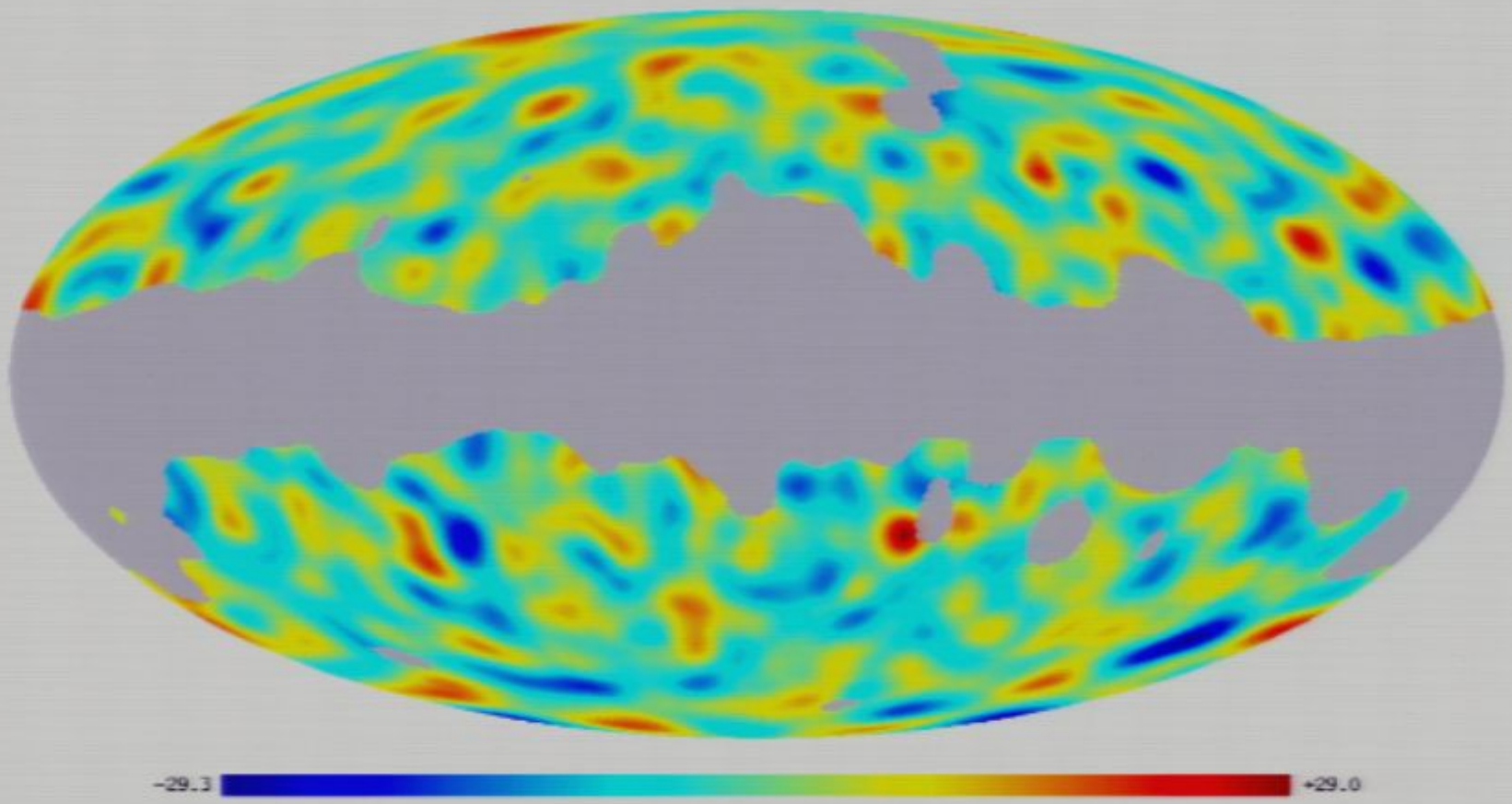

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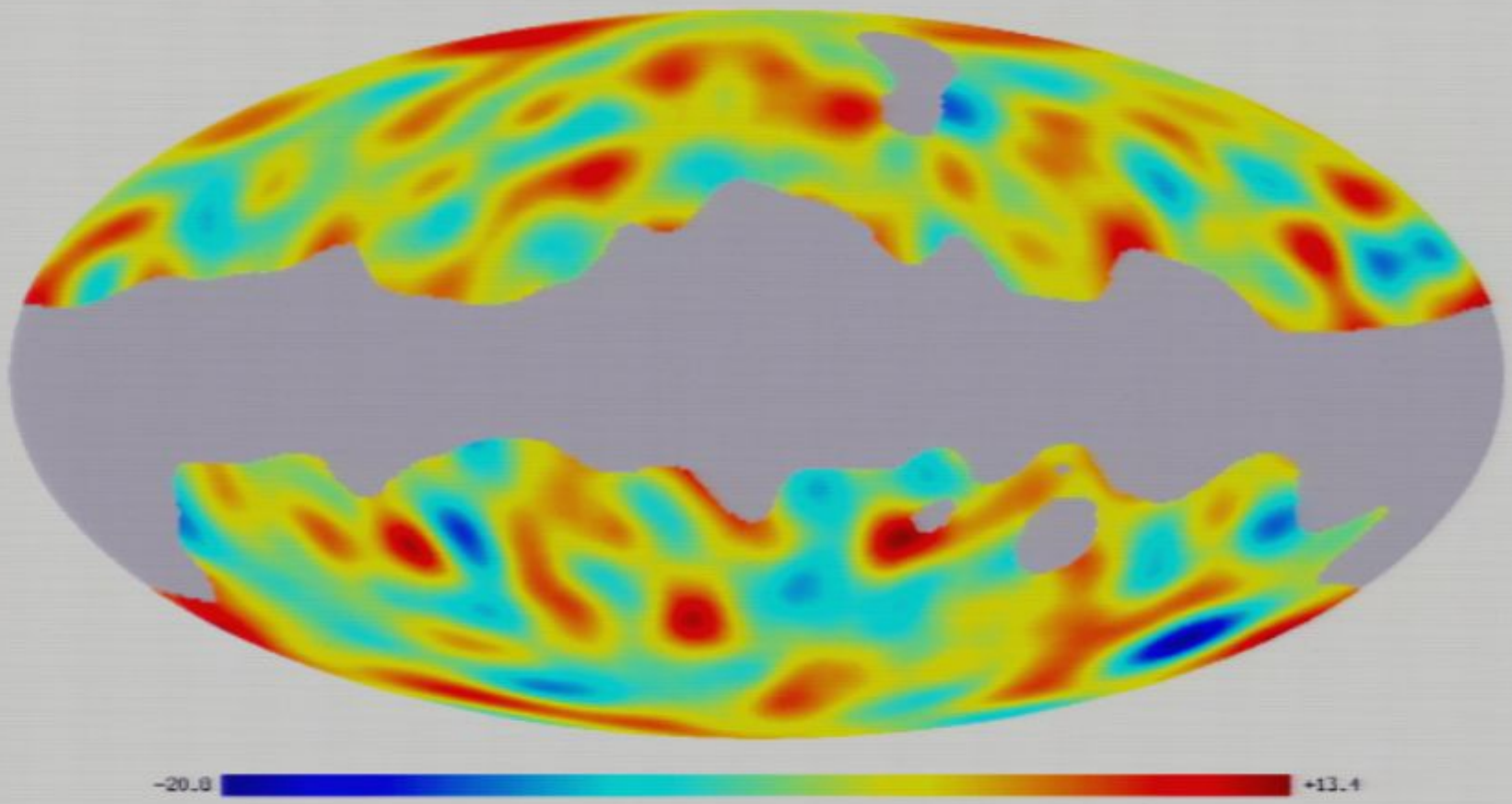

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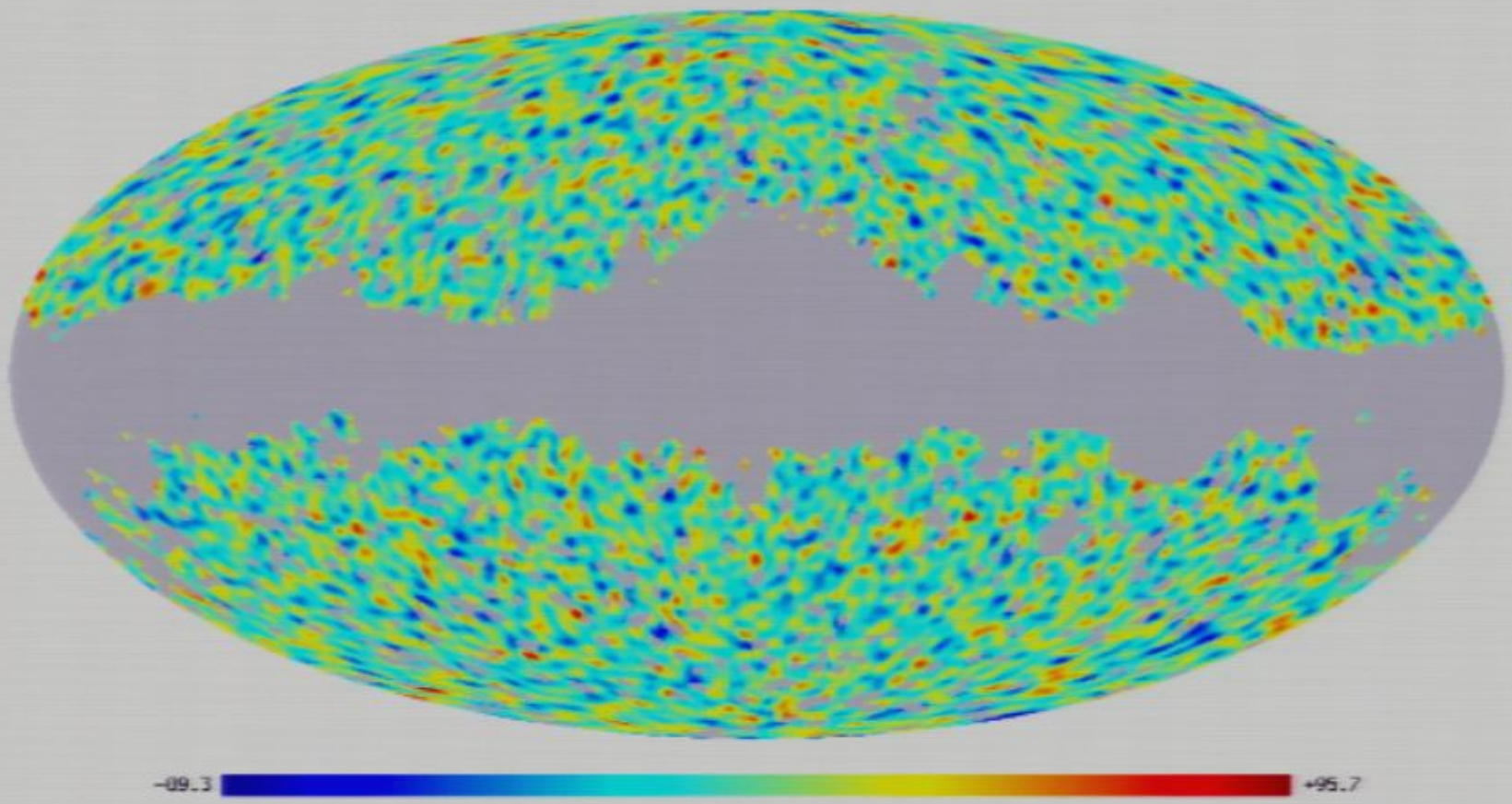

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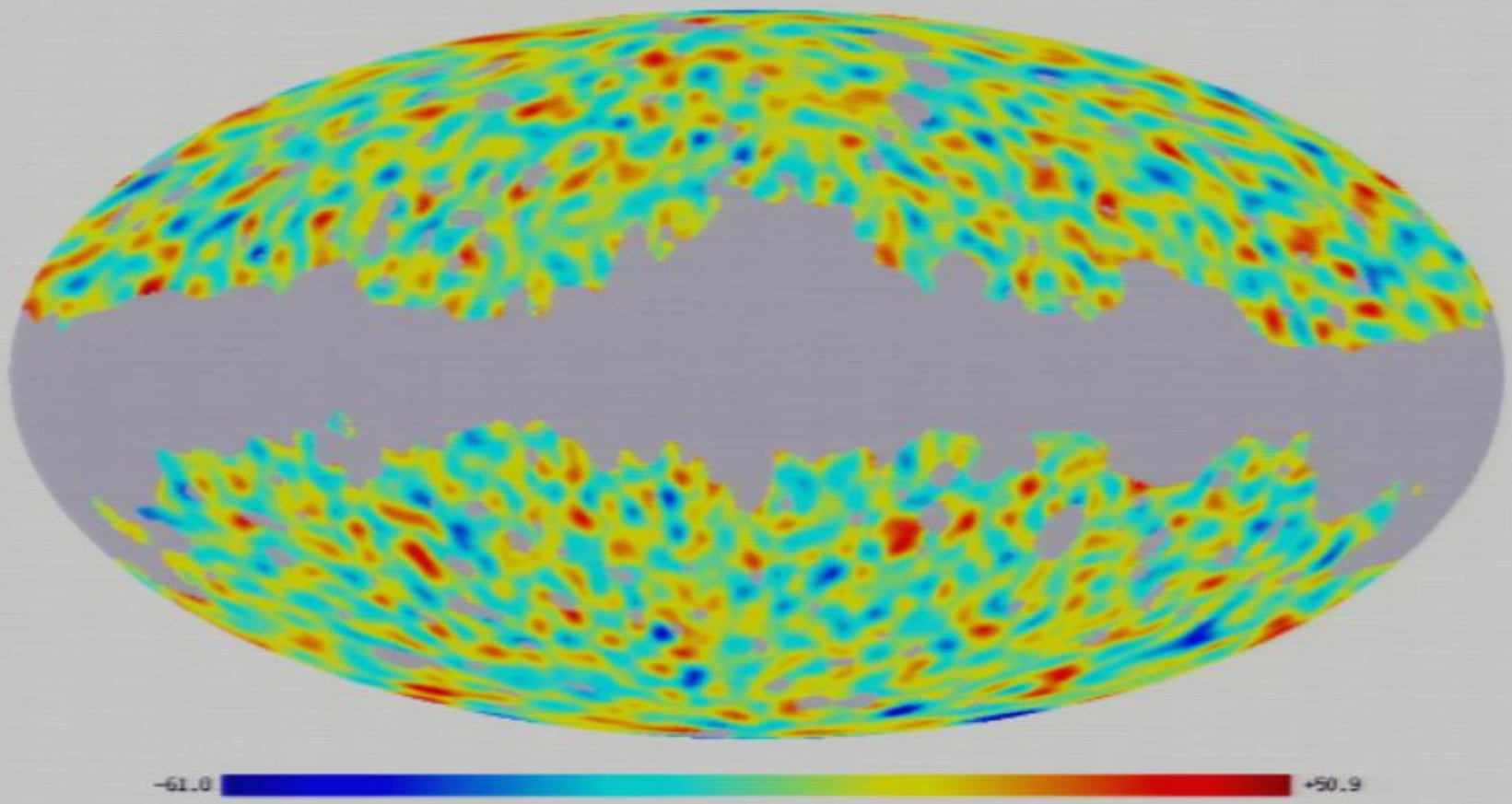

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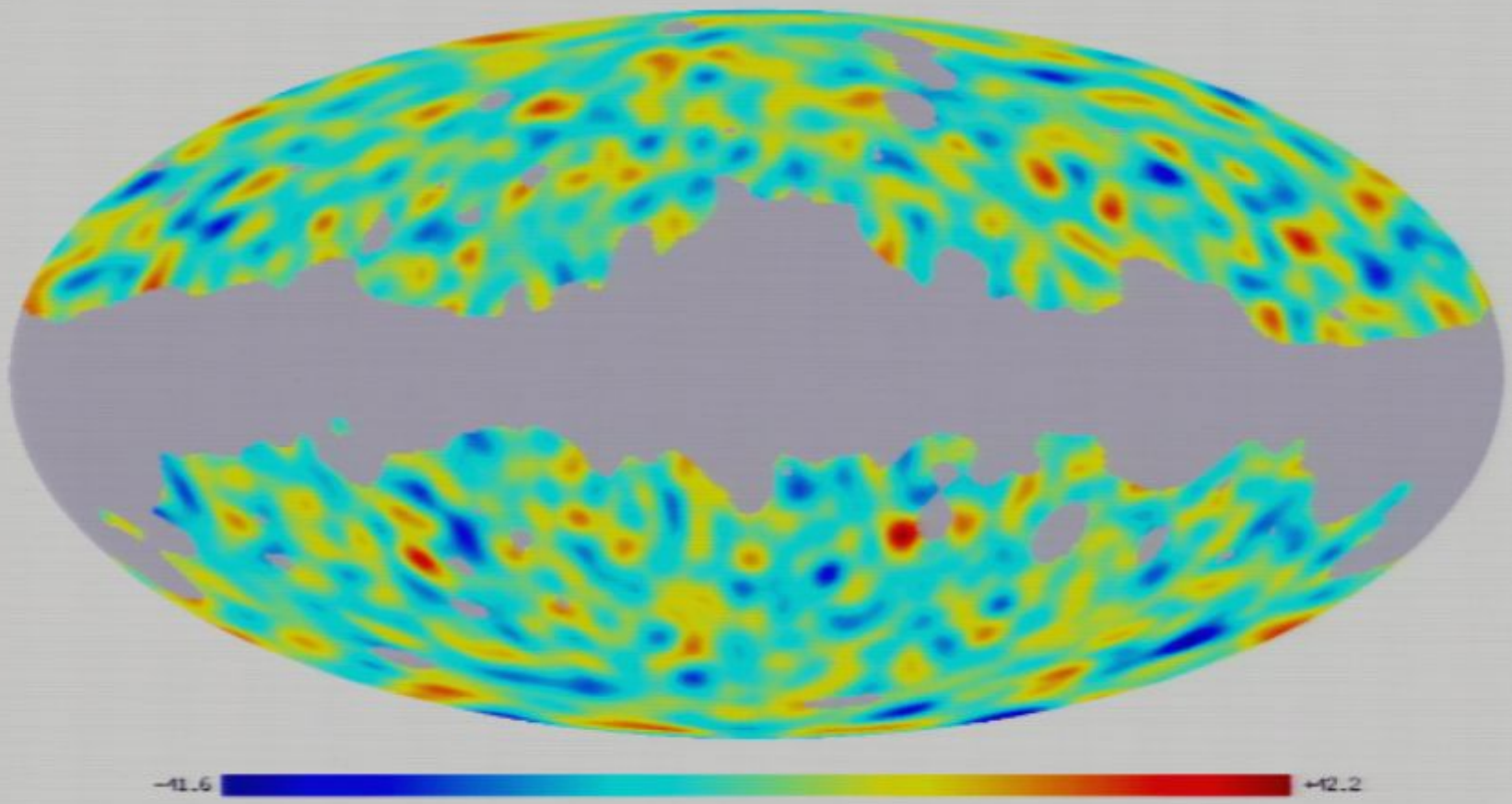

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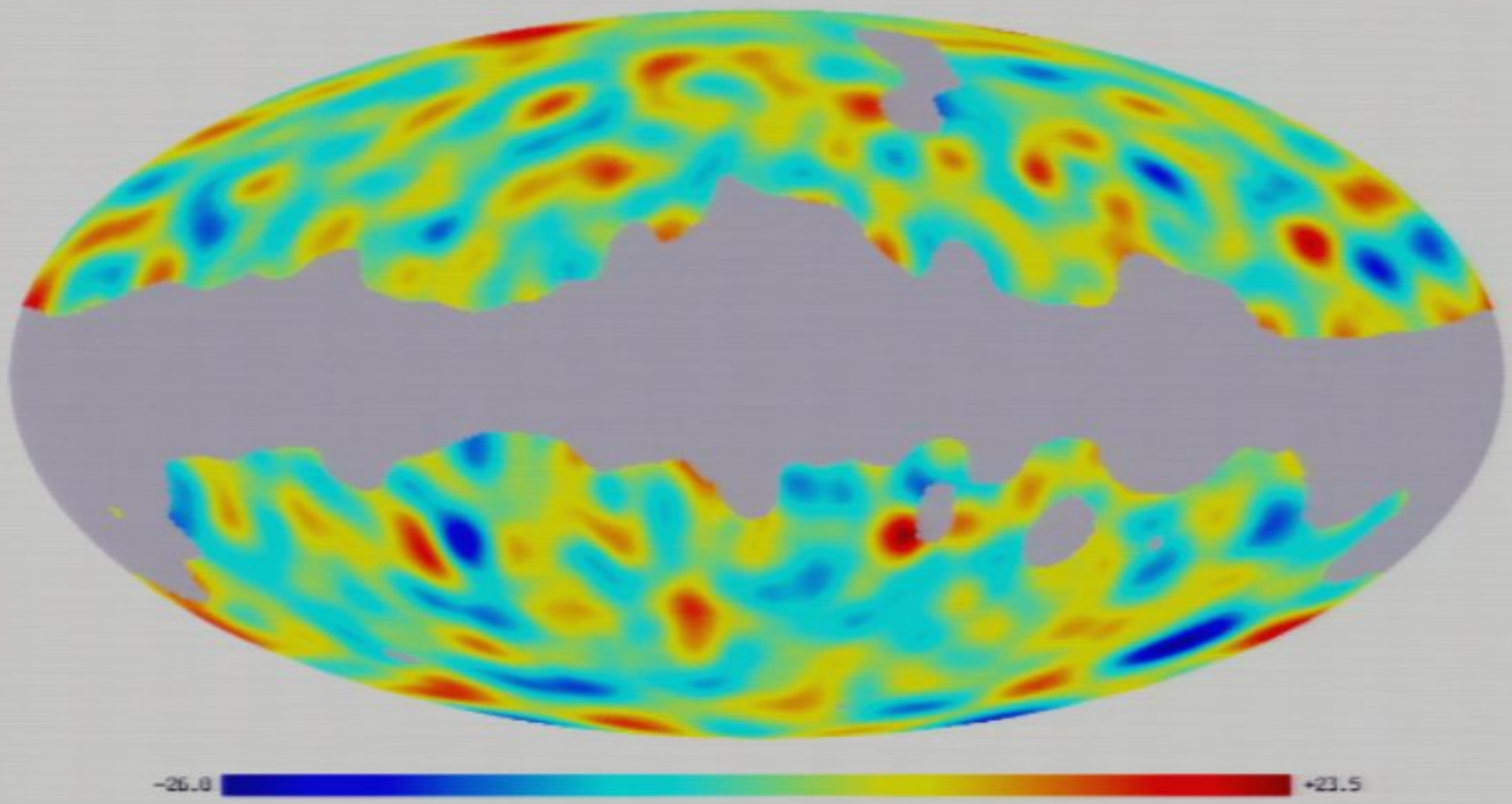

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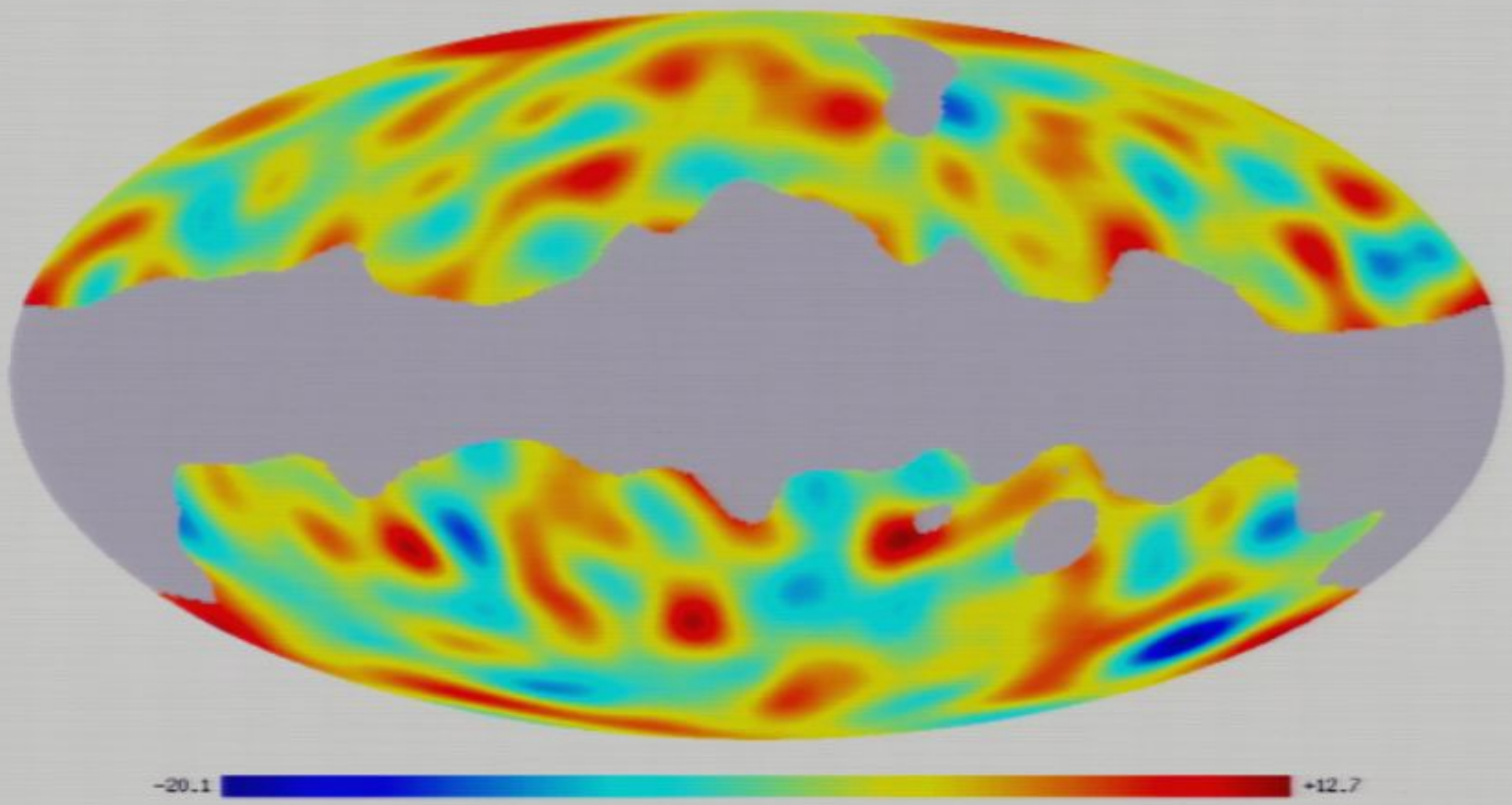

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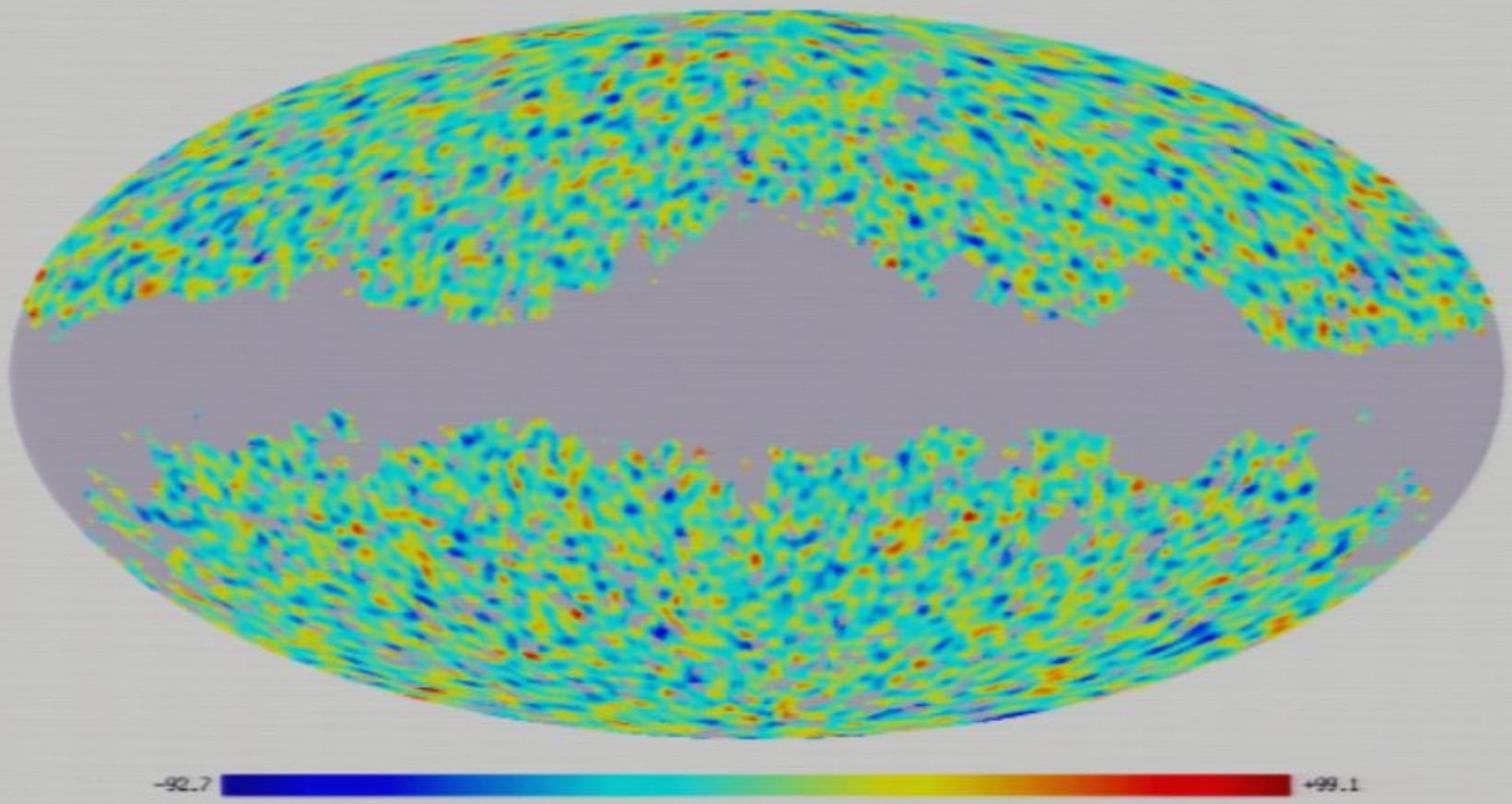

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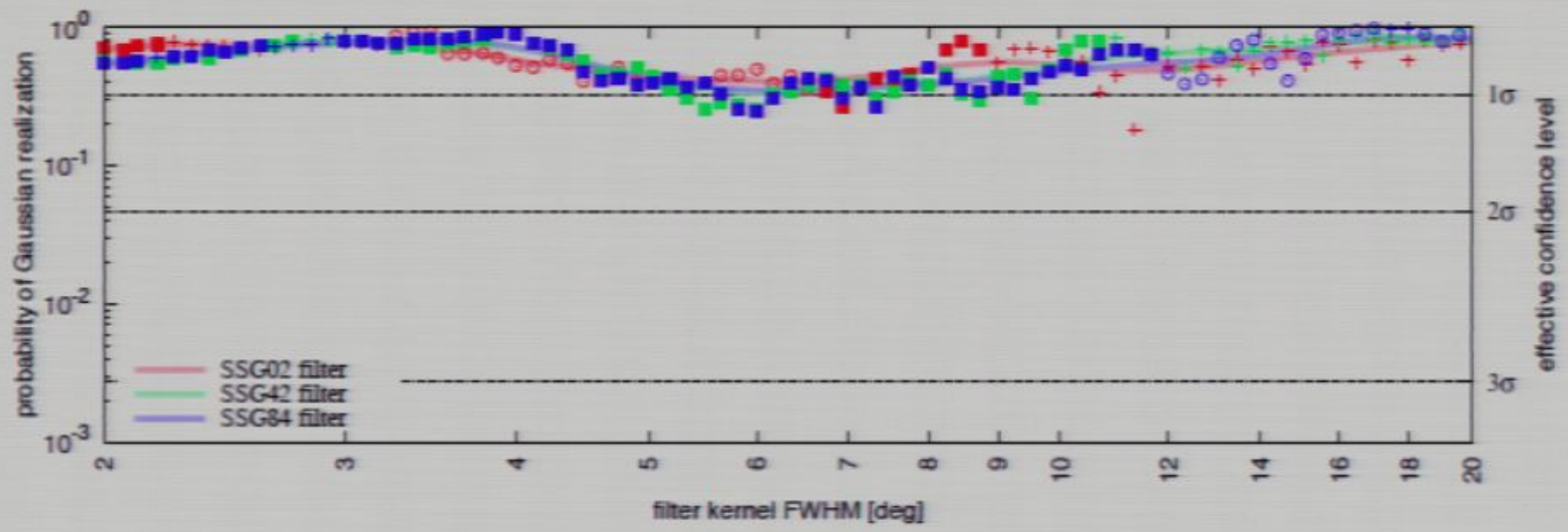

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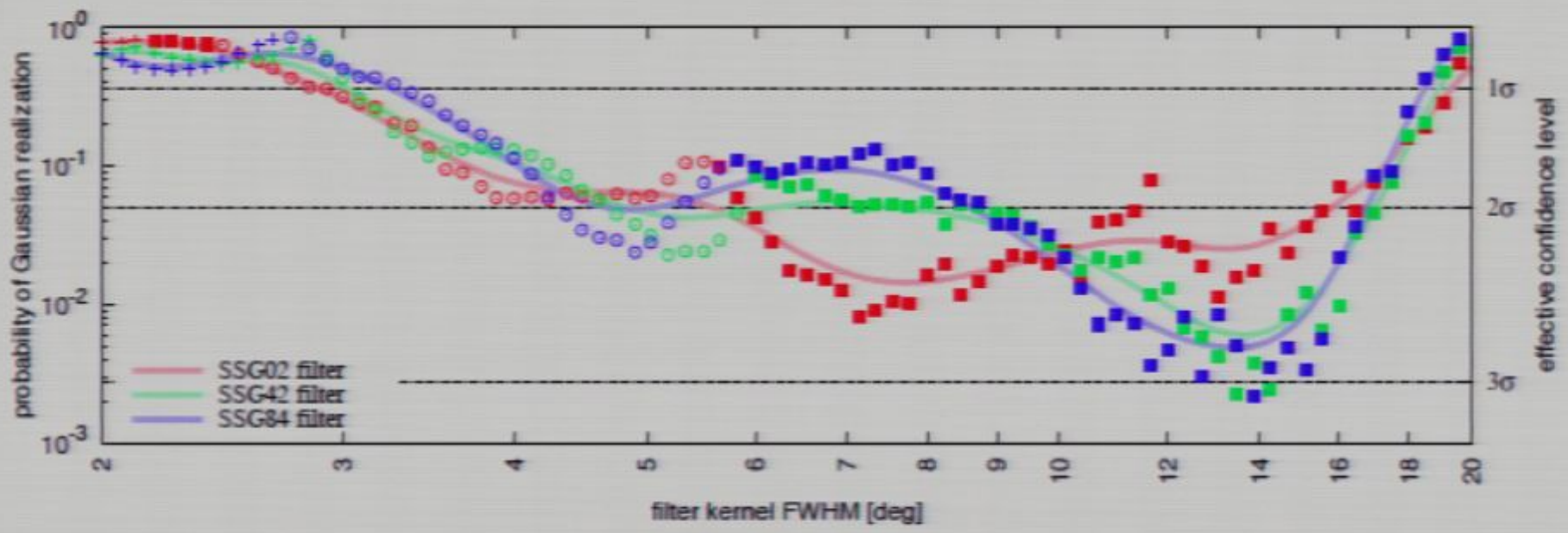

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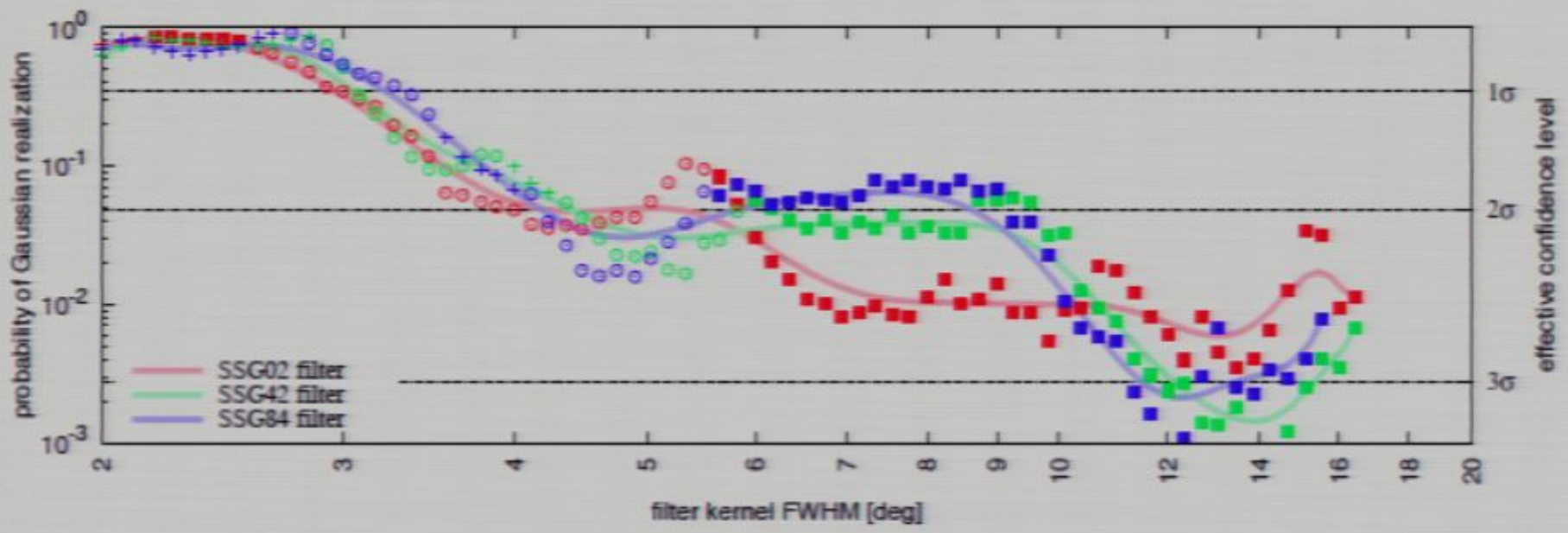

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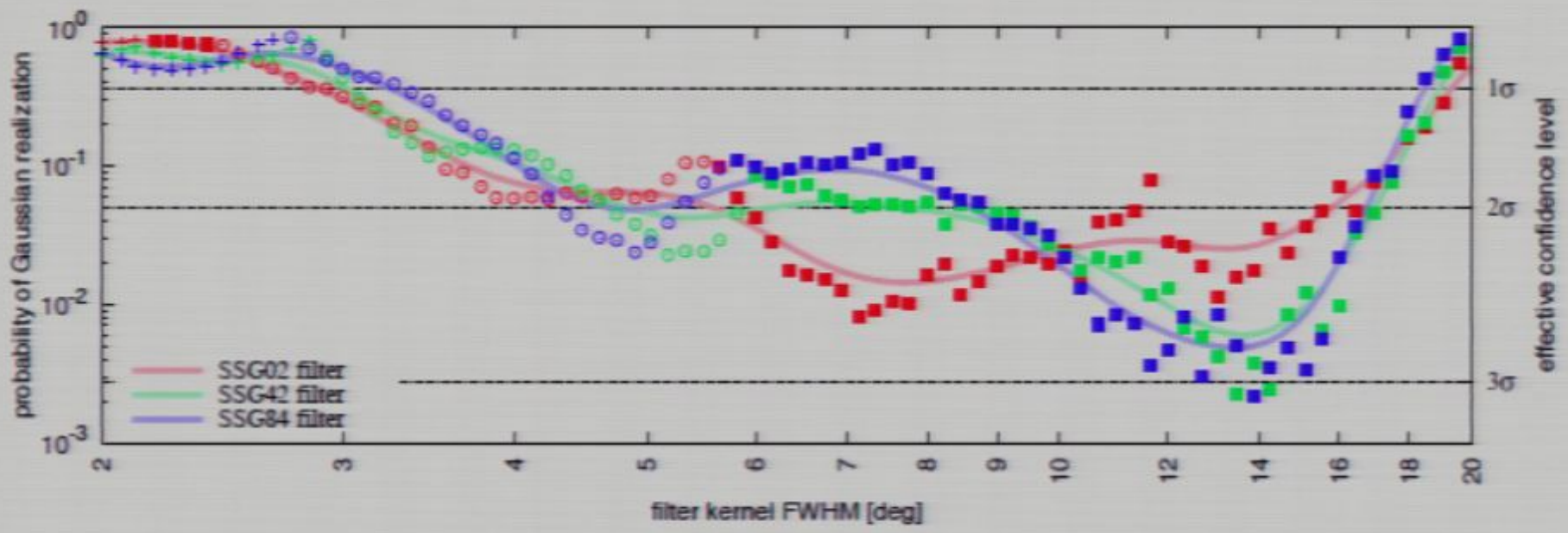

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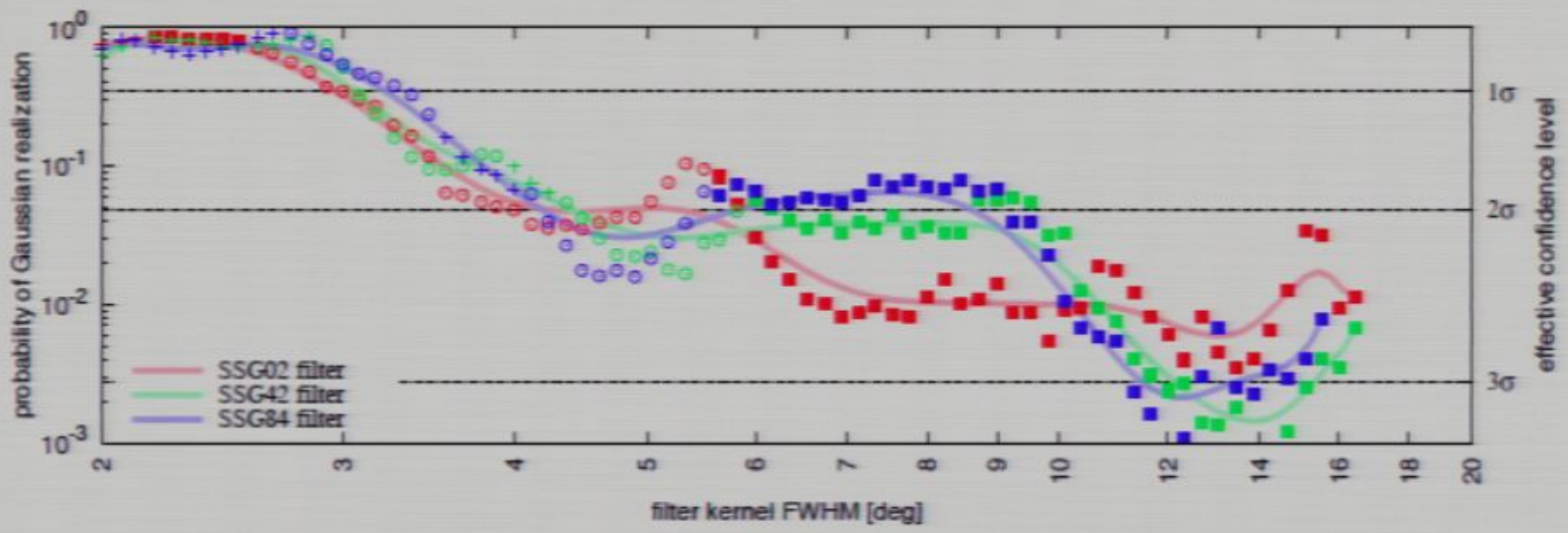

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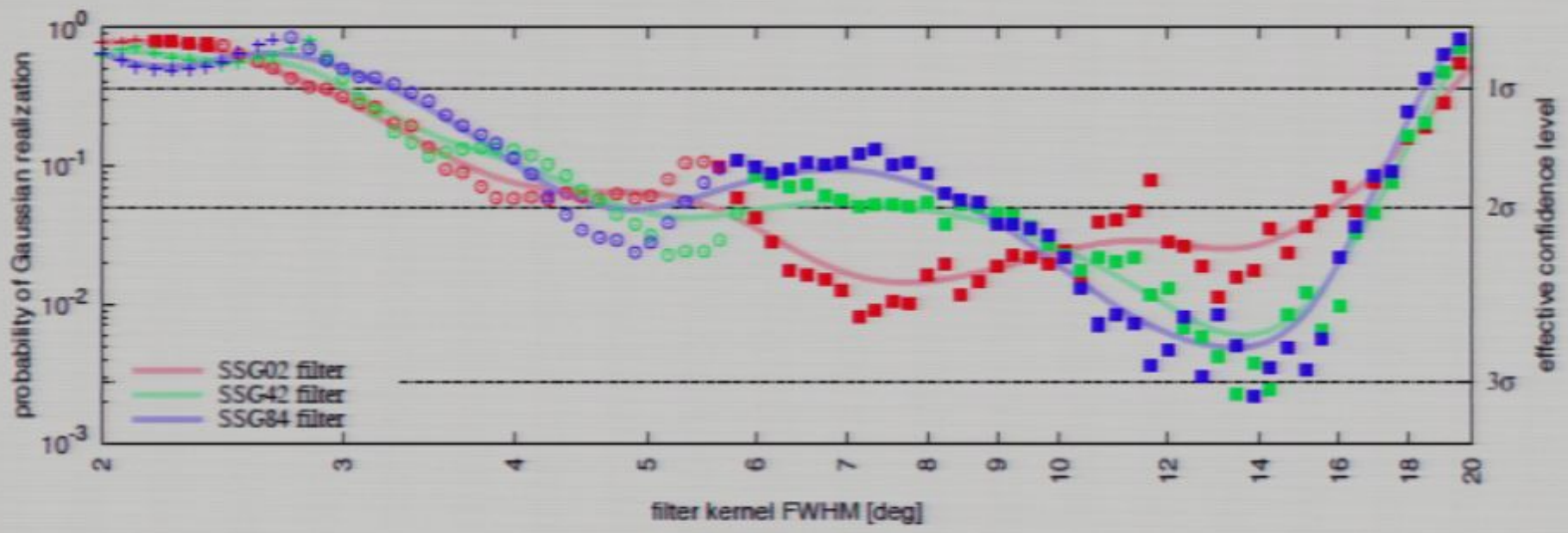

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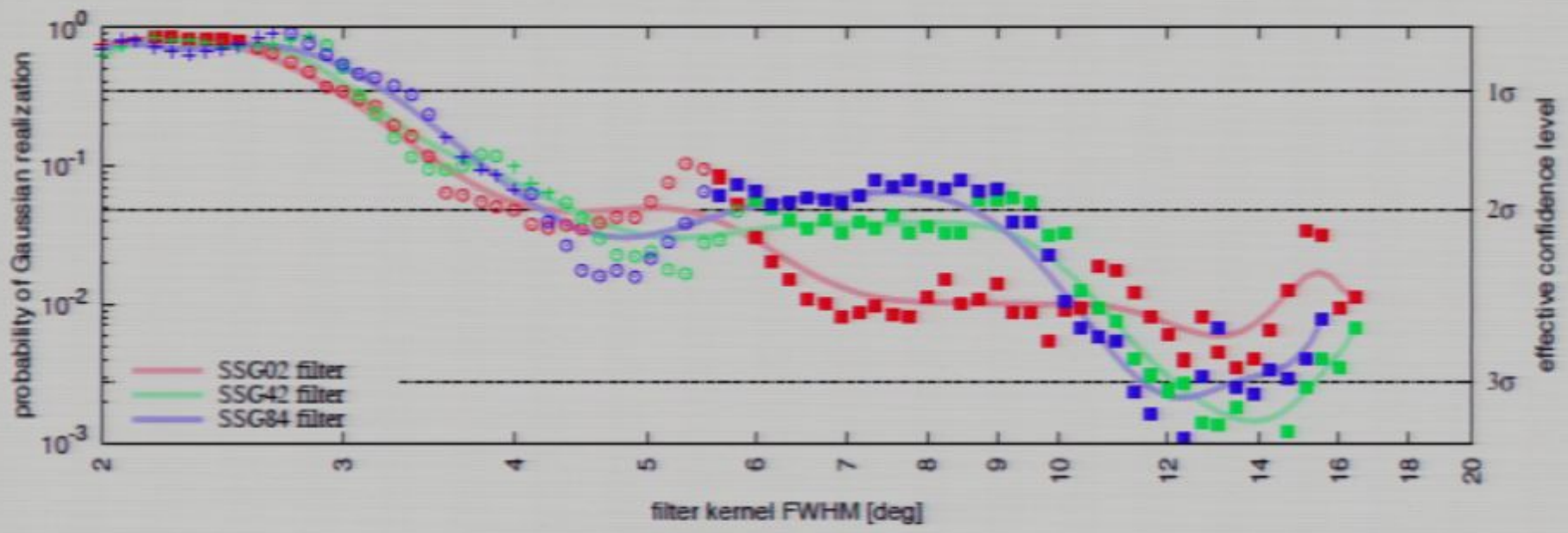

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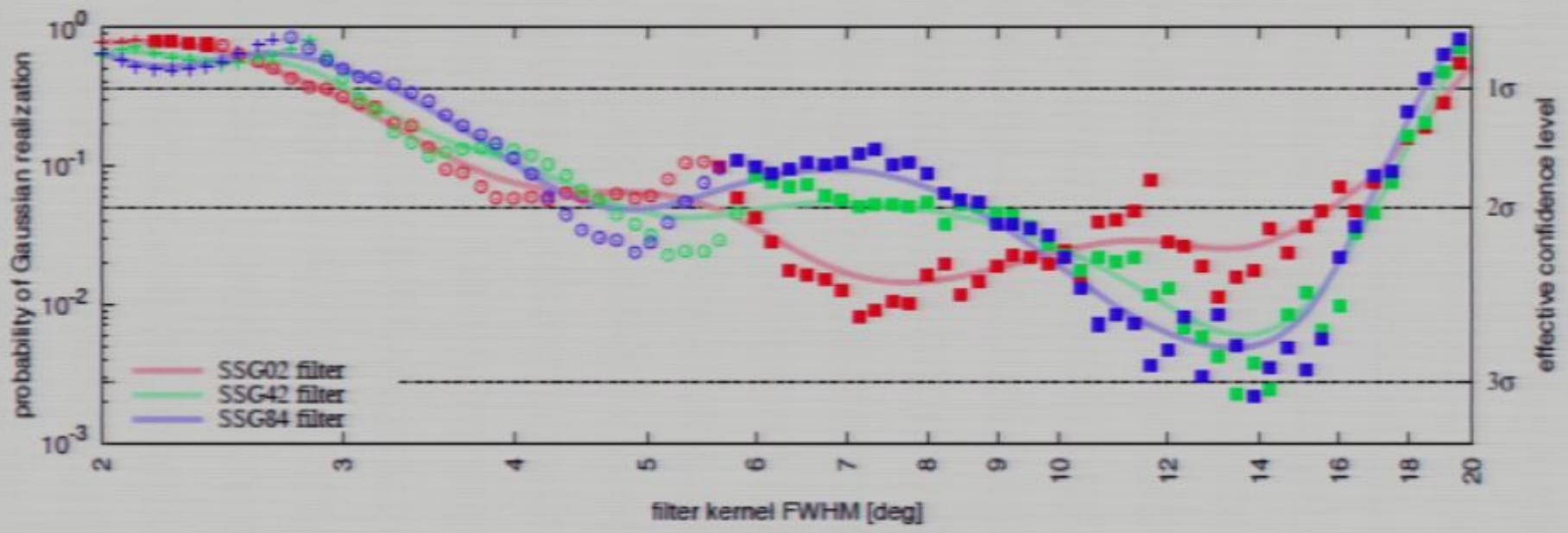

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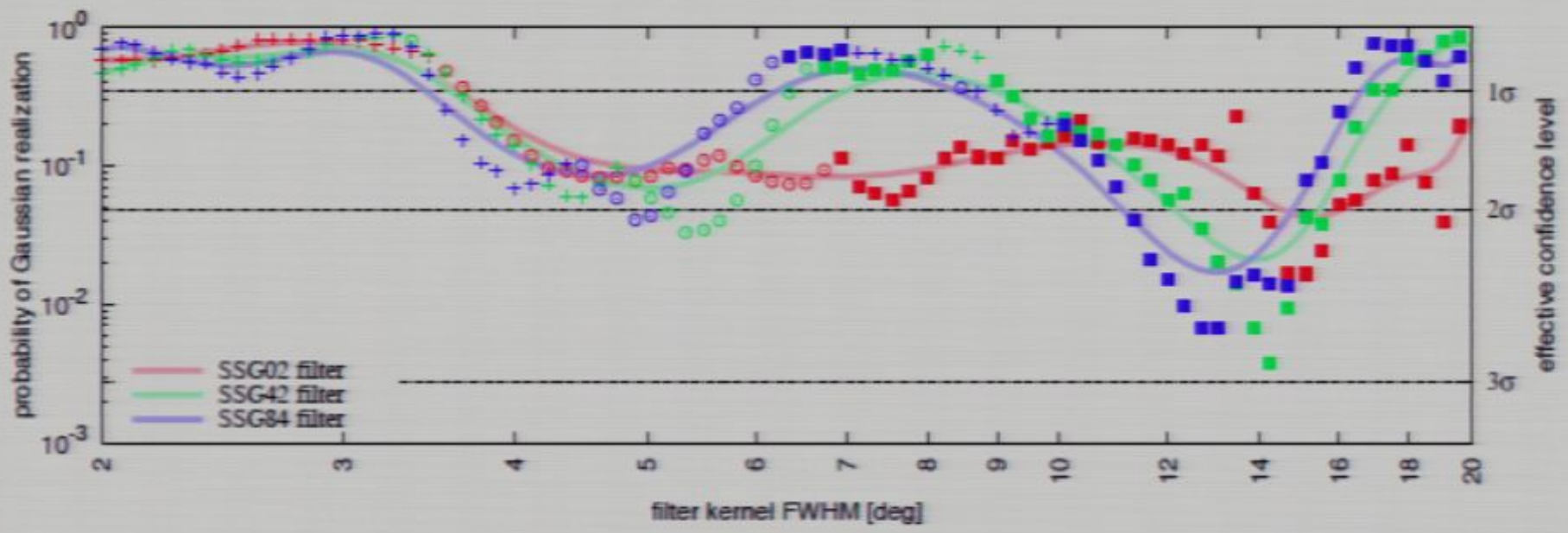

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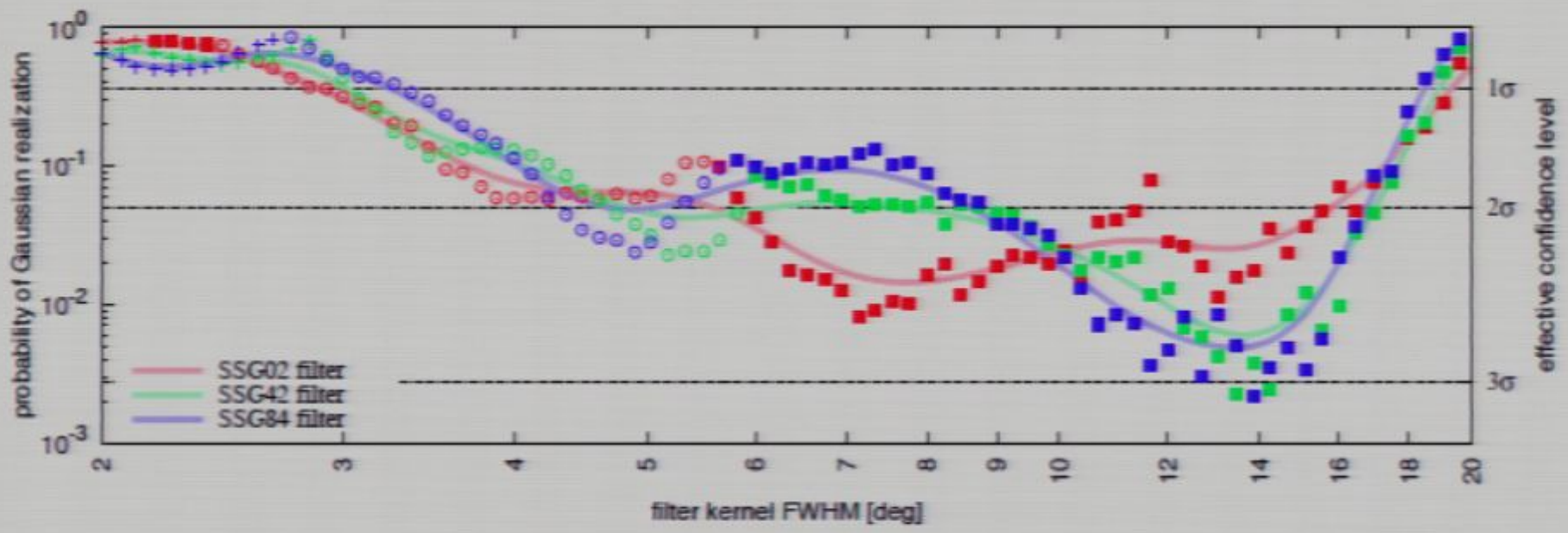

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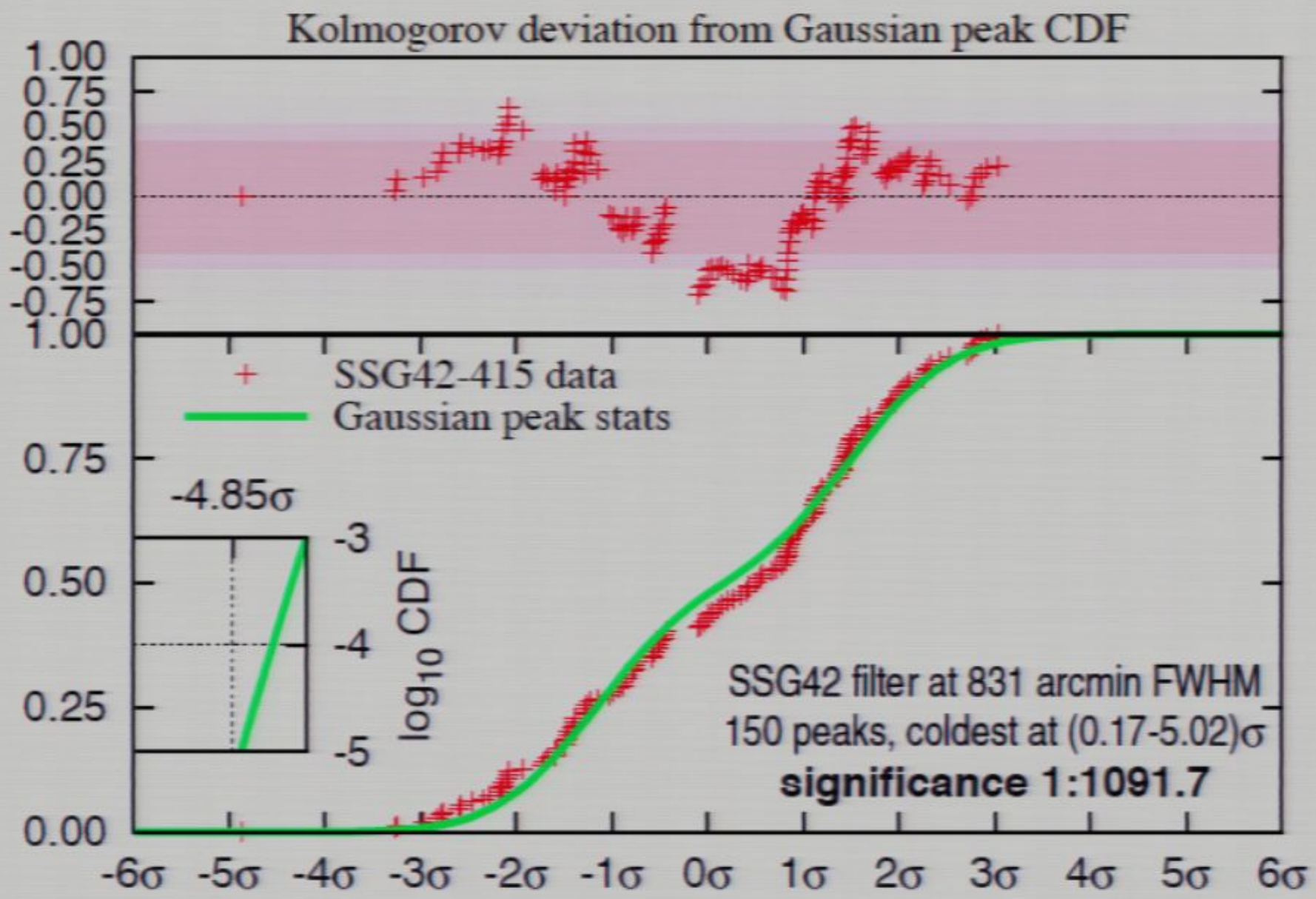

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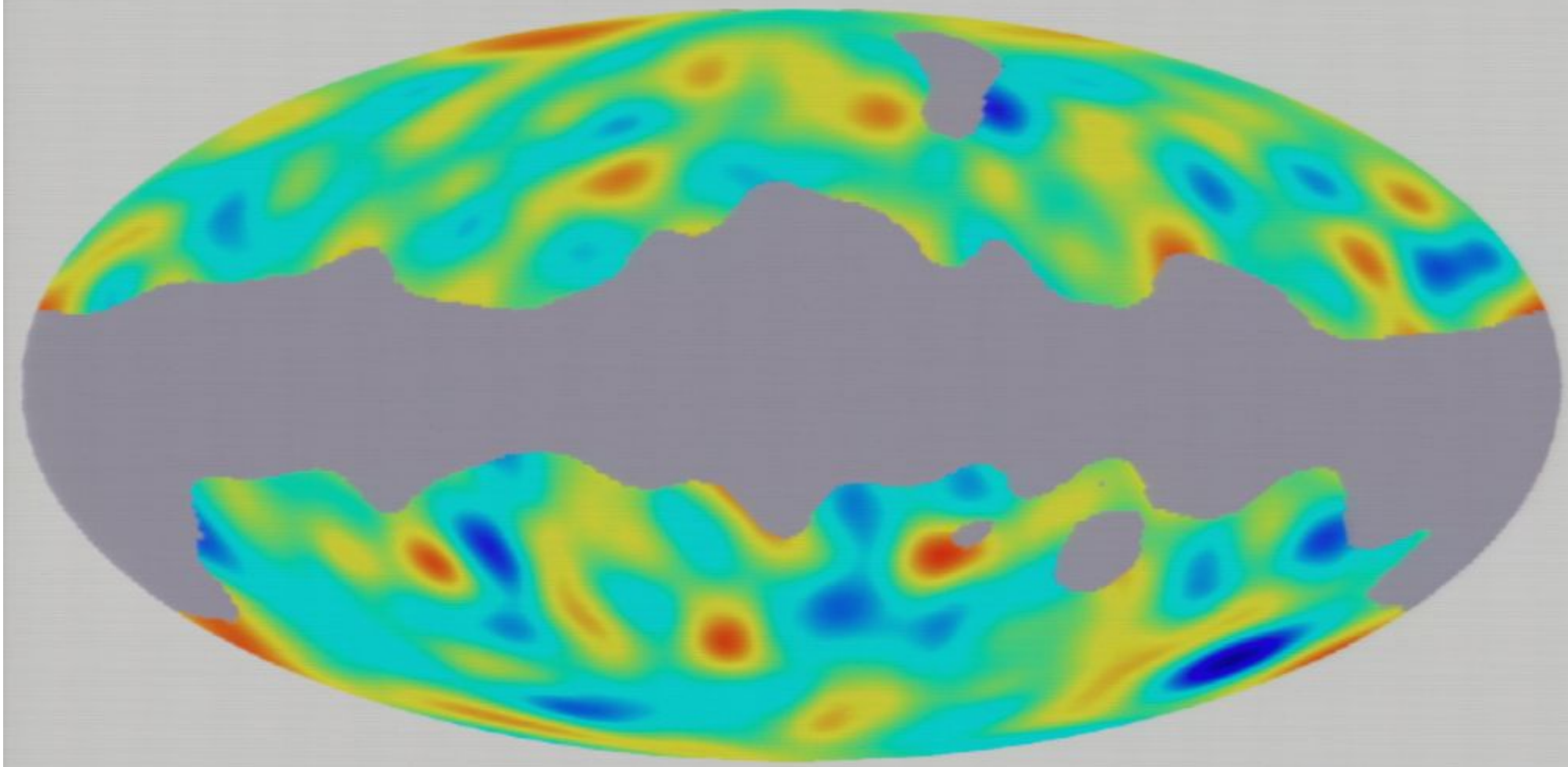

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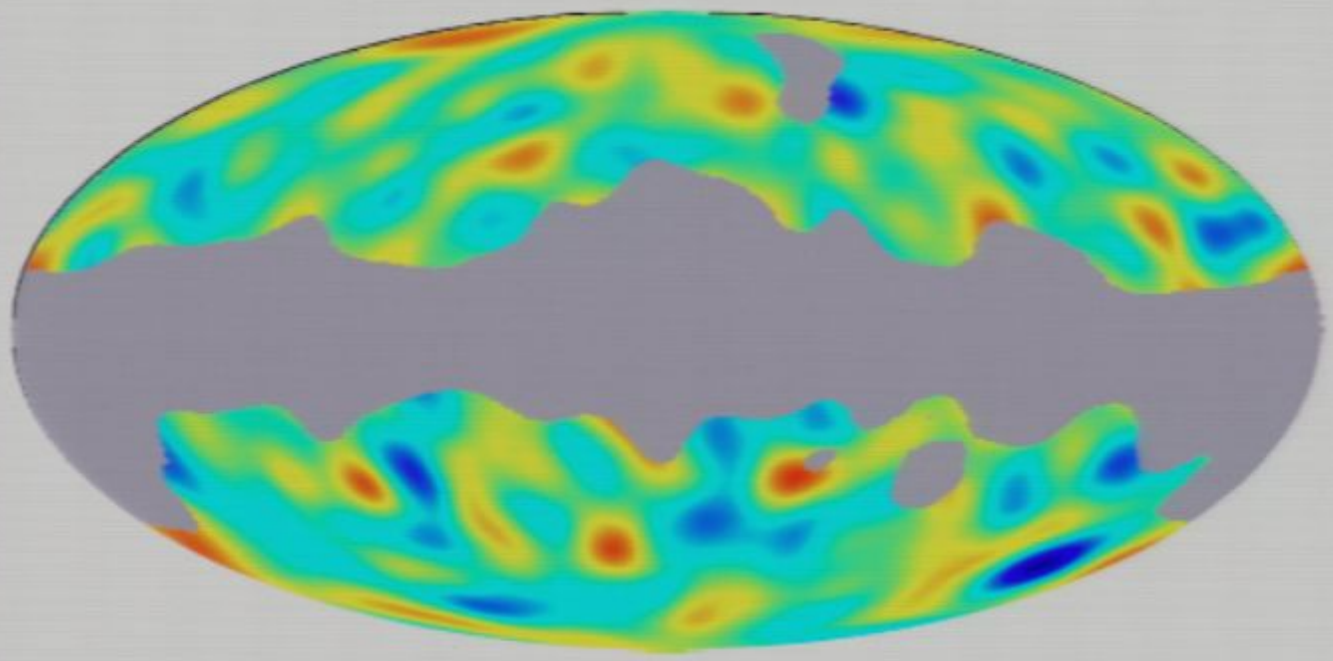

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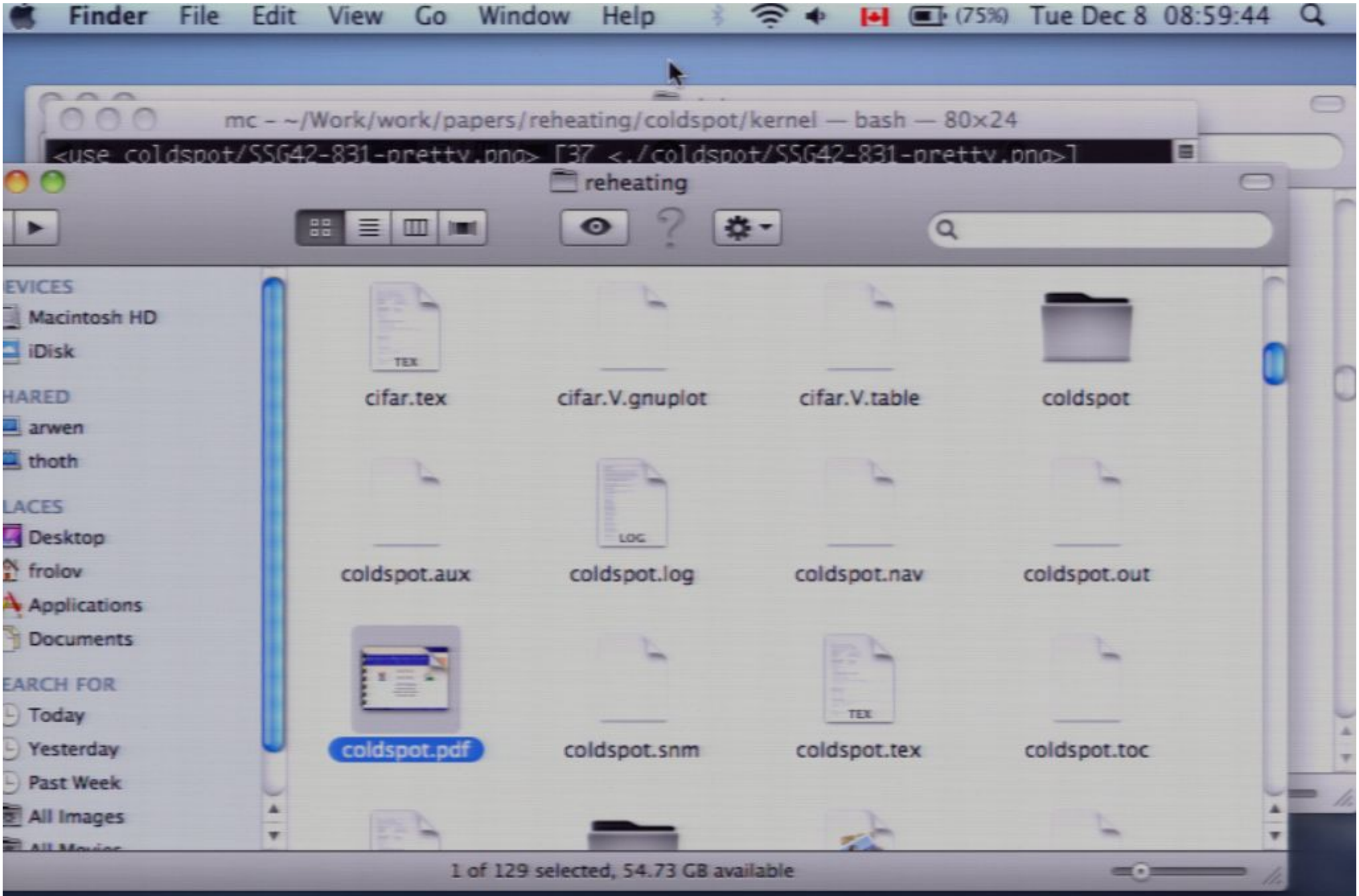
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