A new extragalactic CMB foreground. Large scale anomalies, the Cold Spot (and other issues)

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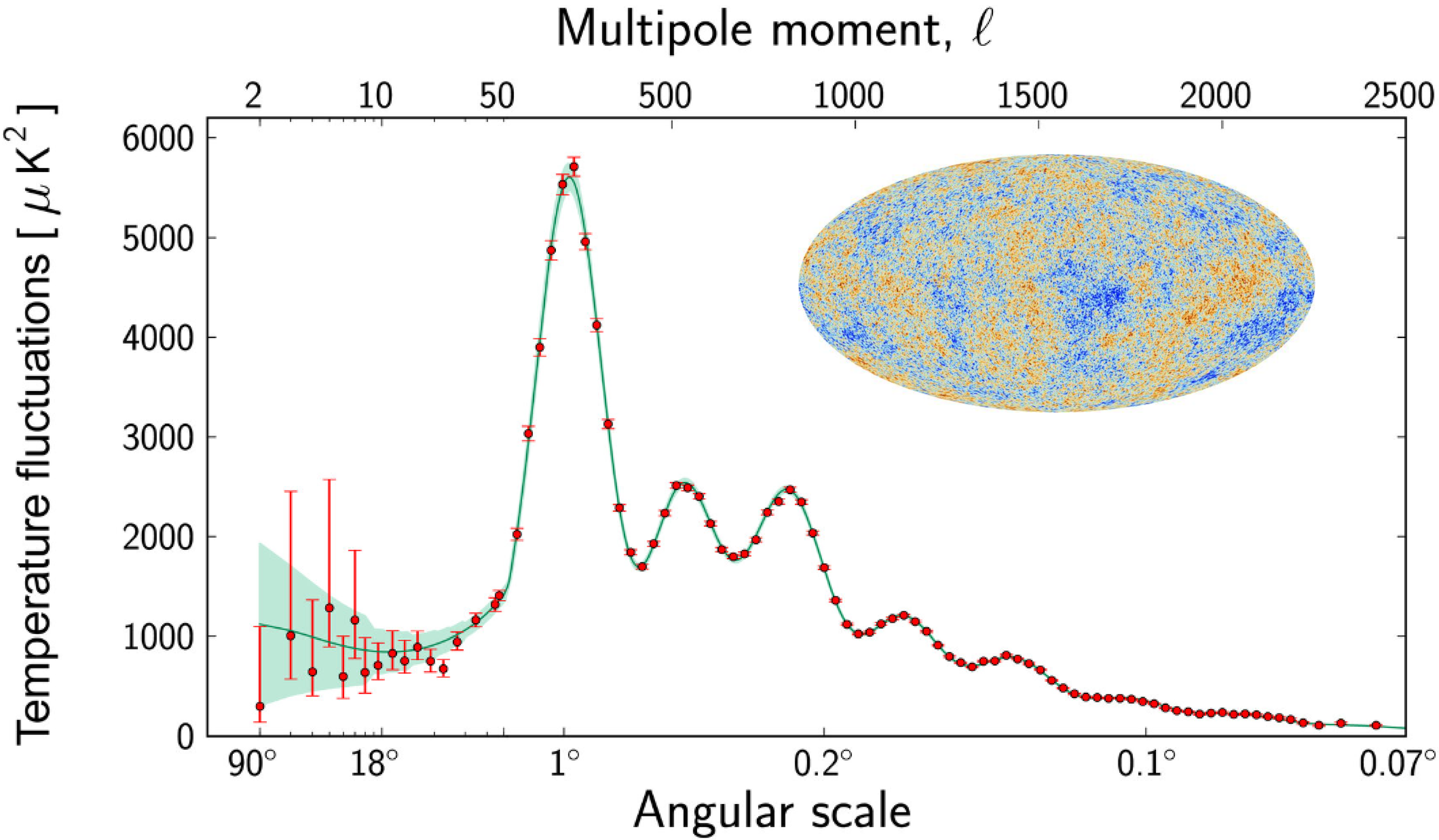
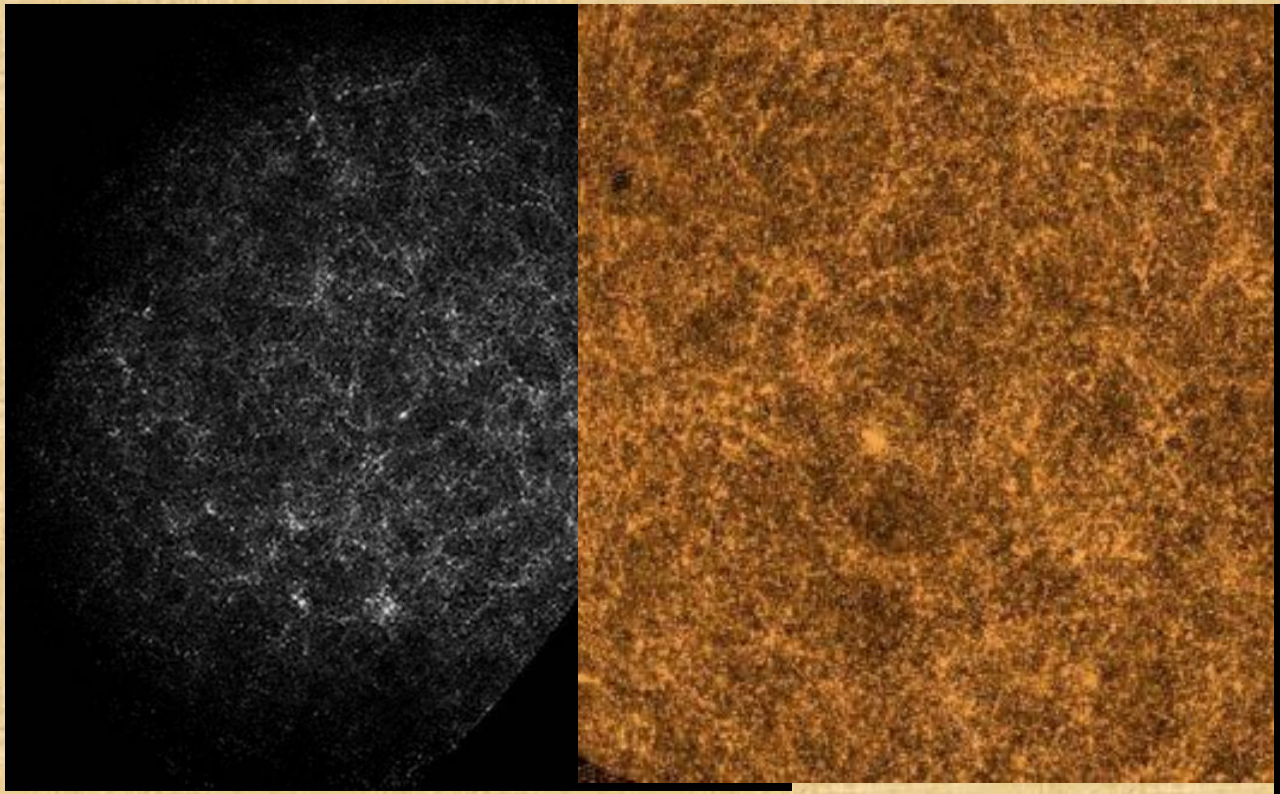
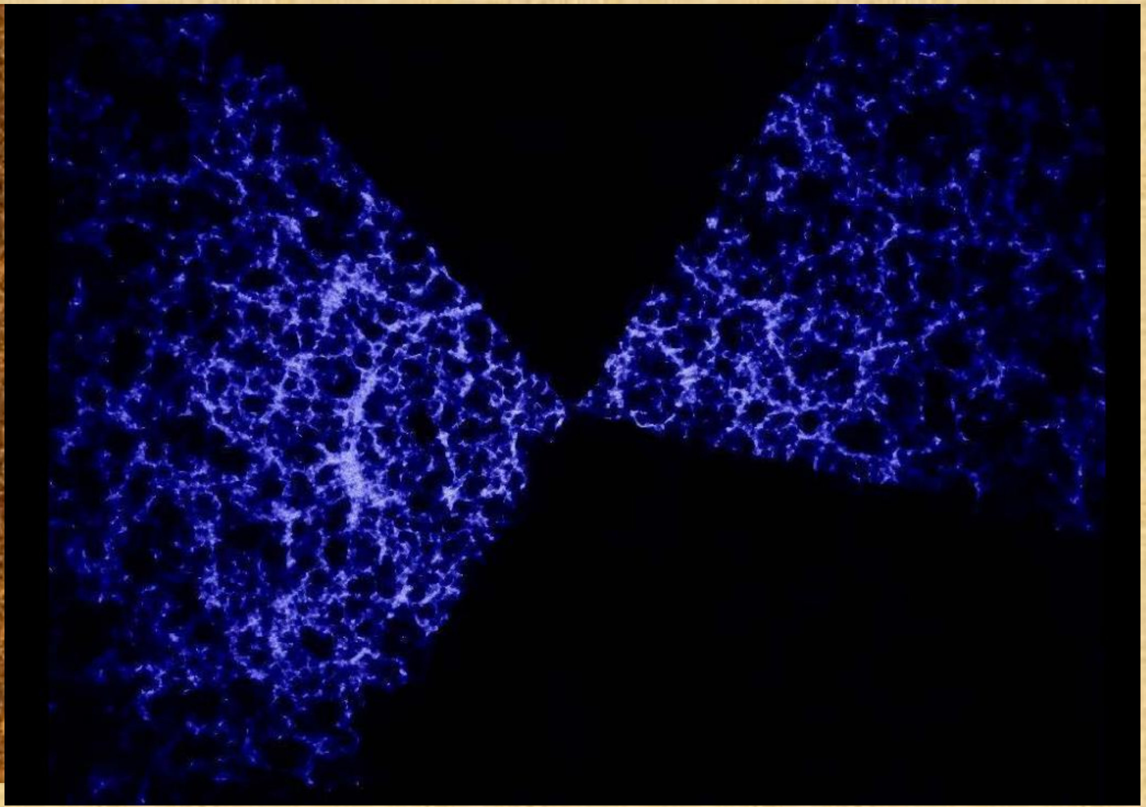


Multipole moment, ℓ
2
10
50
500
1000
1500
2000
2500
Temperature fluctuations [μK^2]
6000
5000
4000
3000
2000
1000
0
90°
18°
1°
0.2°
0.1°
0.07°
Angular scale

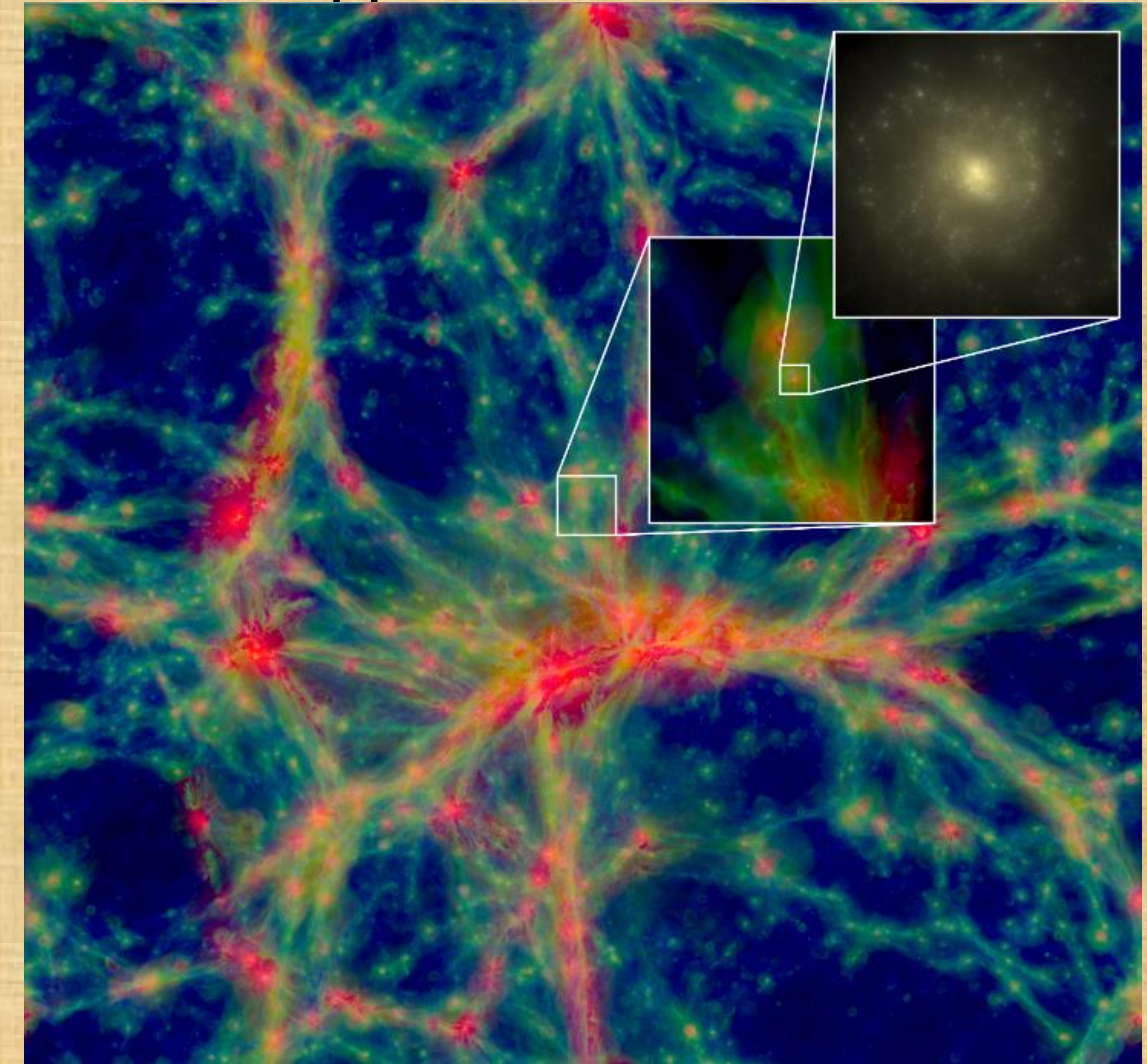
At lower redshifts, observed and simulated surveys have settled down the LCDM –type scenario.

- Simulations provide suitable agreement with observations

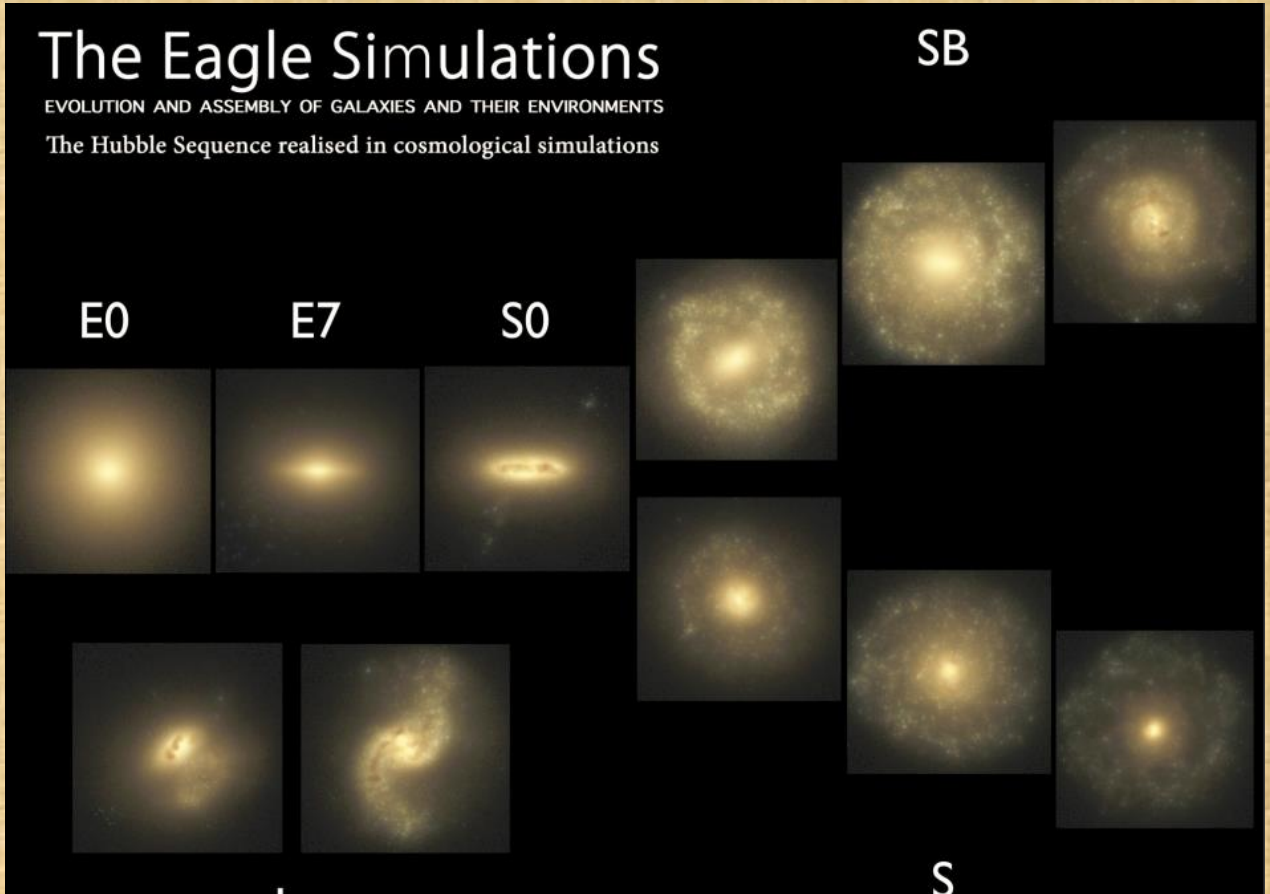




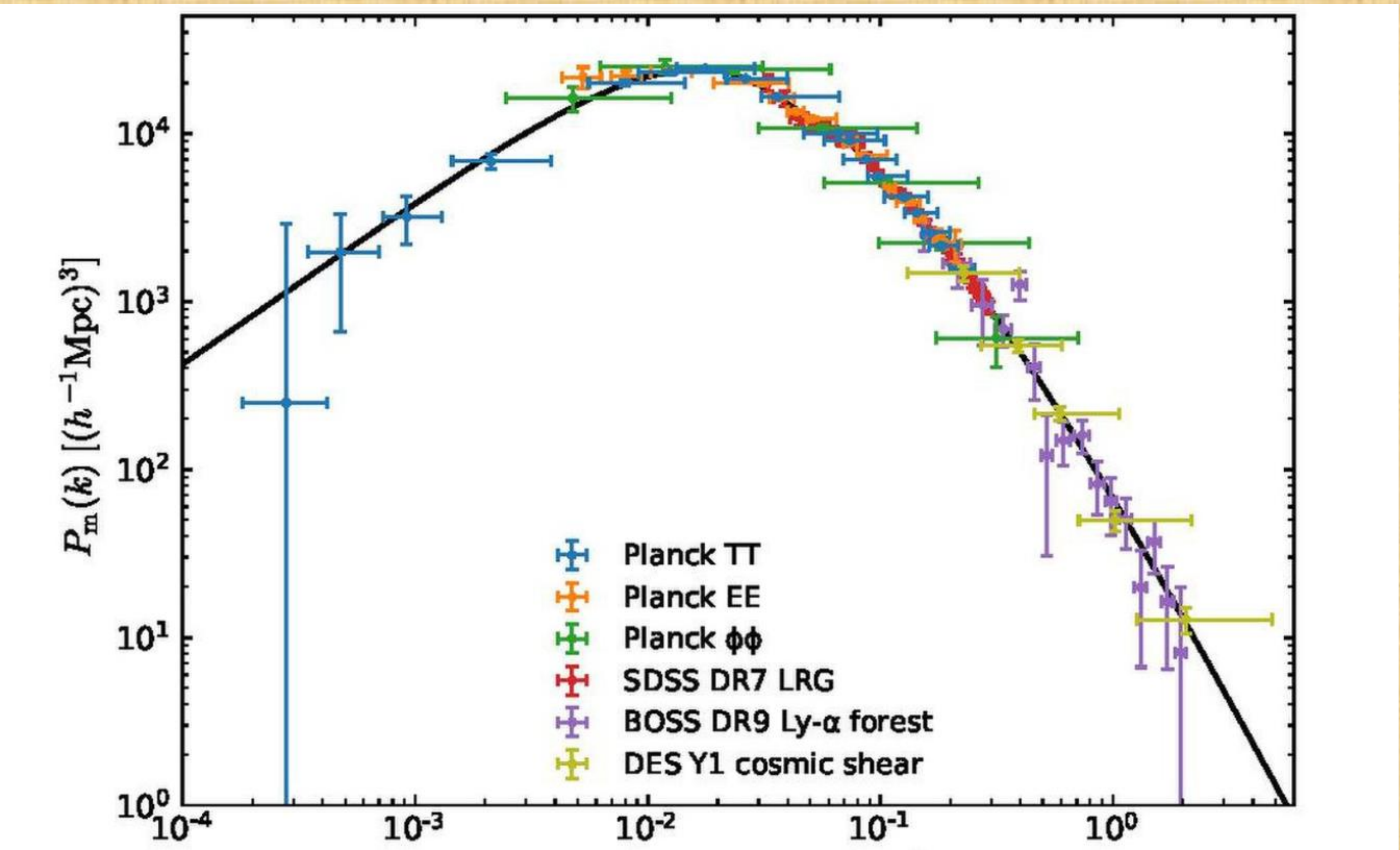
Research using Hydrosimulations give further insights on structure formation details



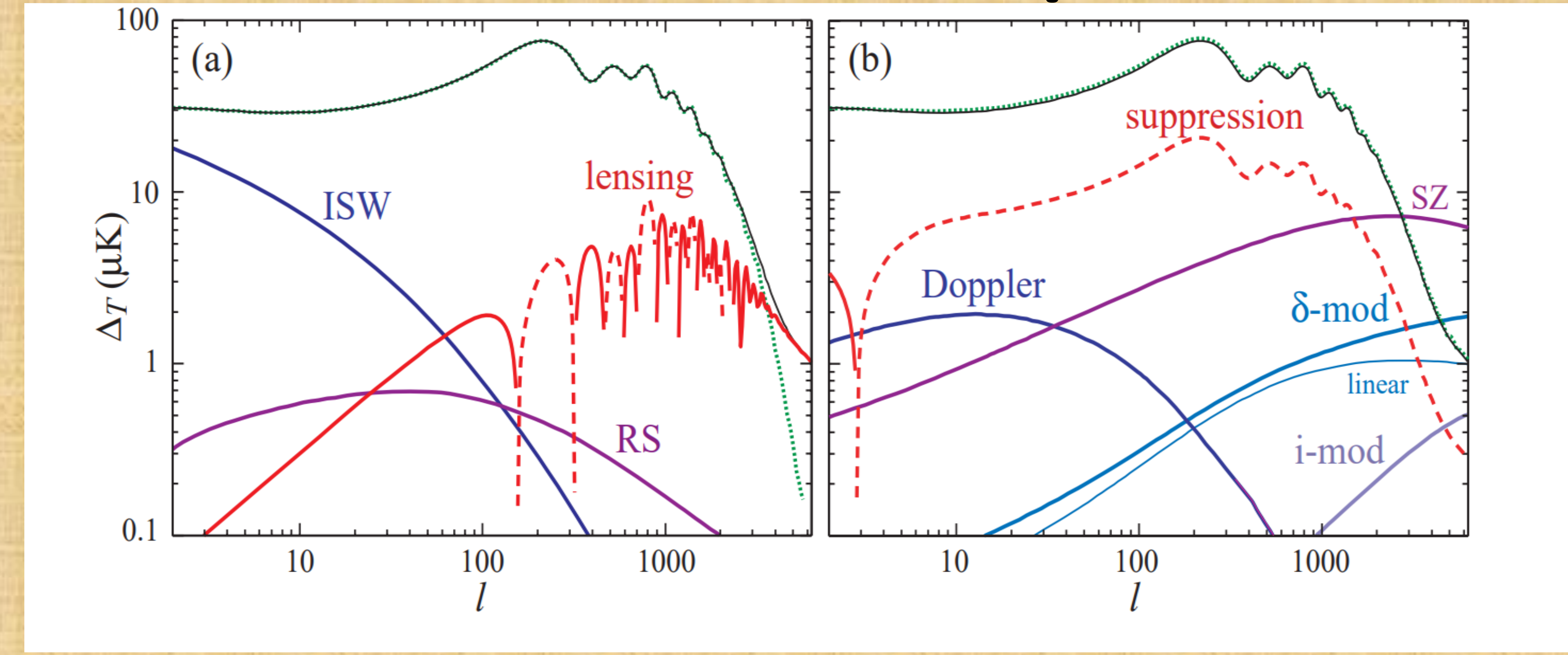
Reaching now a suitable range of volume with high resolution



Properly scaled, low (galaxies) and high (CMB) redshift observations coincide within the LCDM paradigm



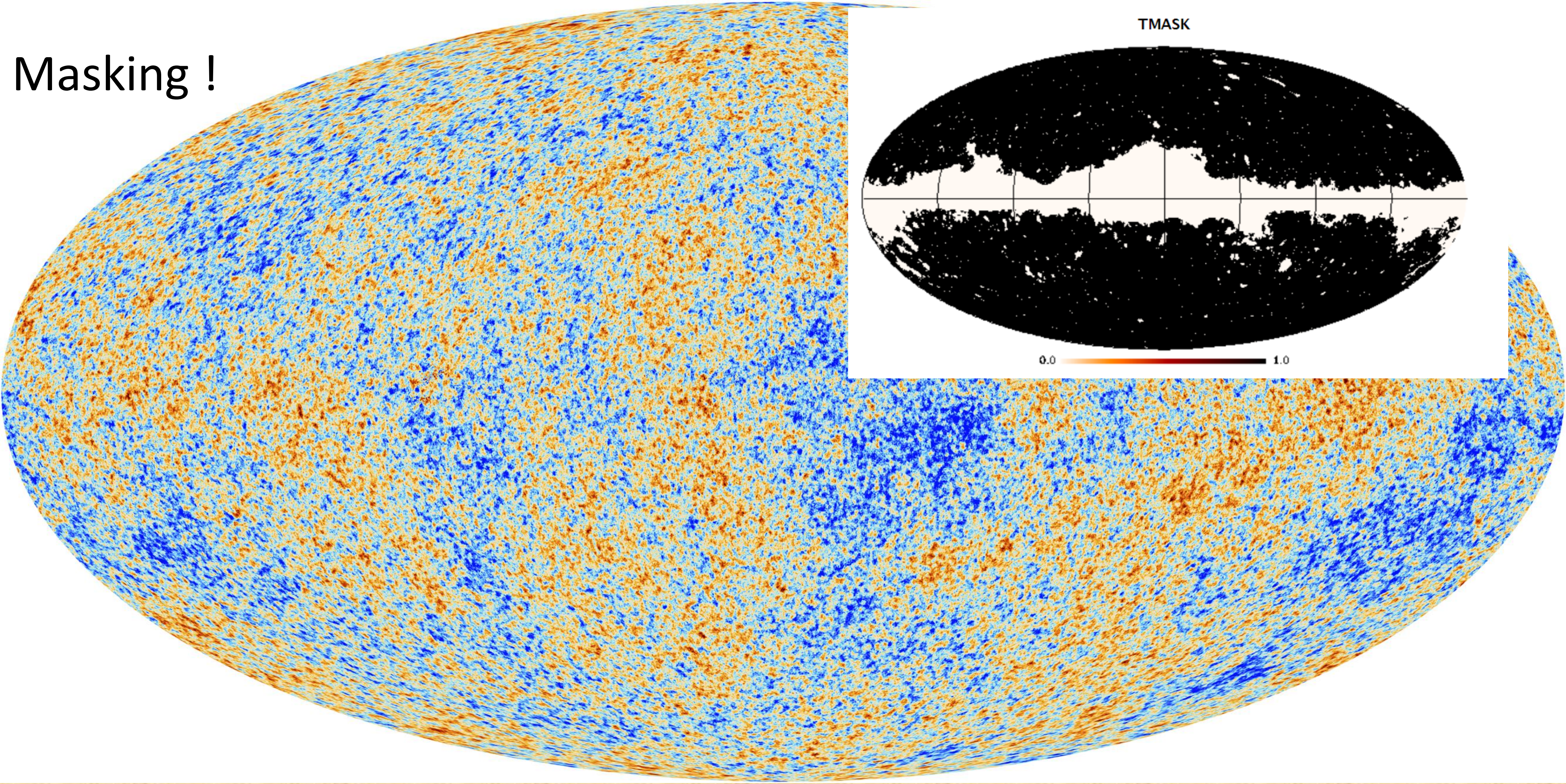
Primordial and secondary CMB anisotropies



Hu & Dodelson, 2002

Understanding all possible sources of contamination and biases is crucial for extracting useful cosmological information.

Masking !

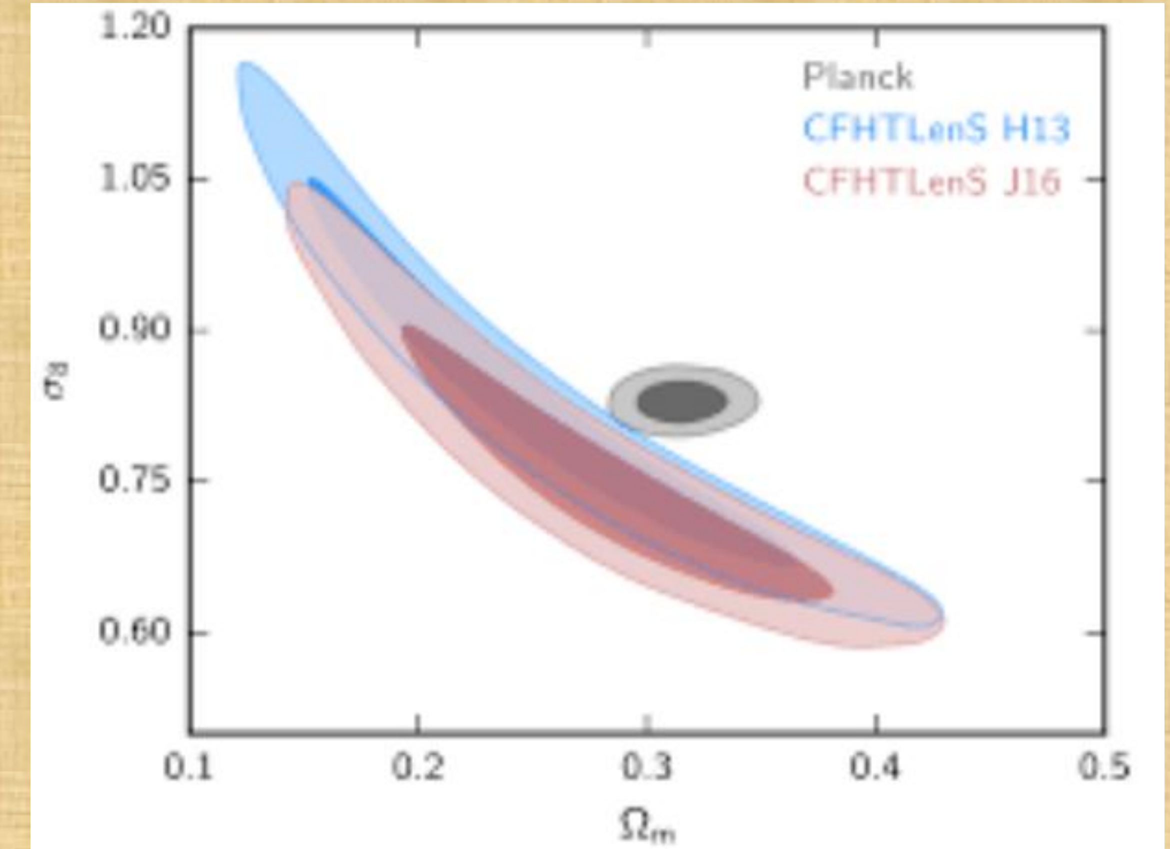


Tensions …

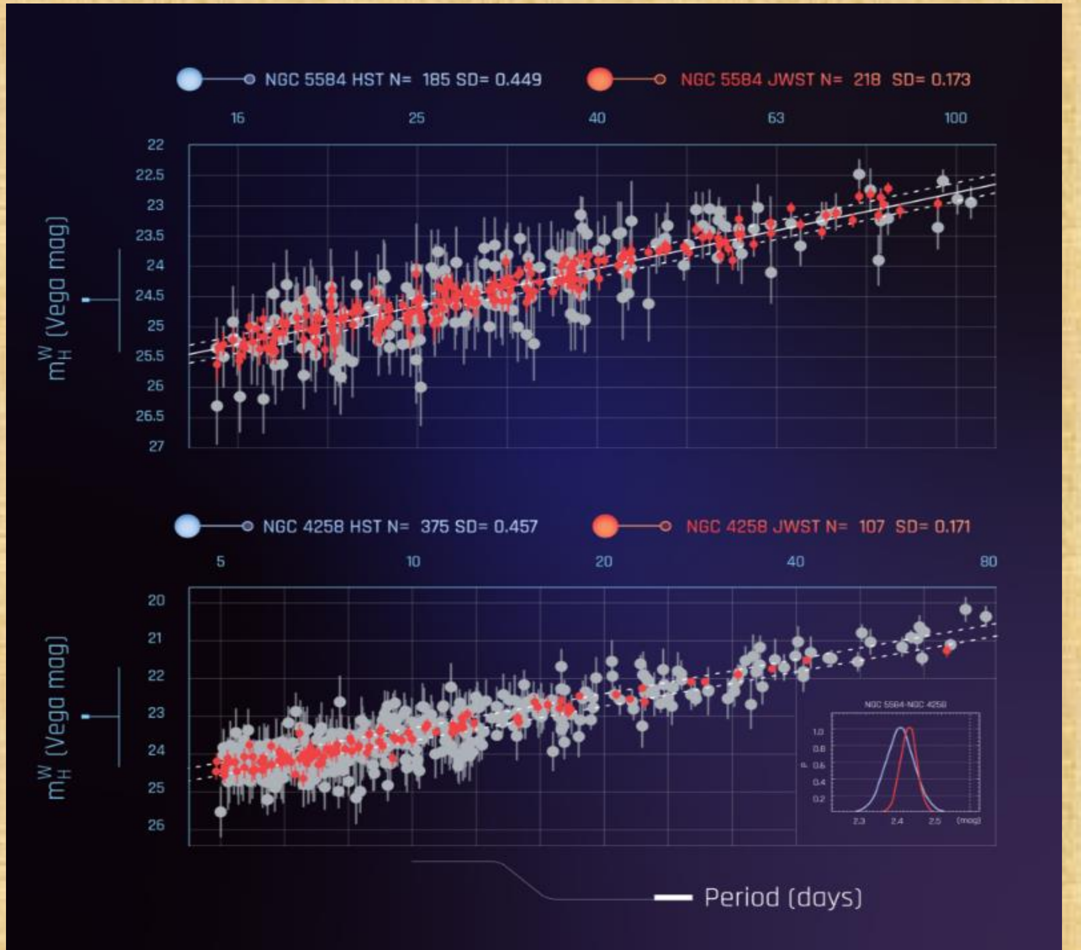
Cepheids/SN	Ho = 74 km/s/Mpc
CMB	Ho = 67 km/s/Mpc

Solutions: stellar astrophysics bias ?, new physics ? …

Also tension in σ - Ω_{matter}



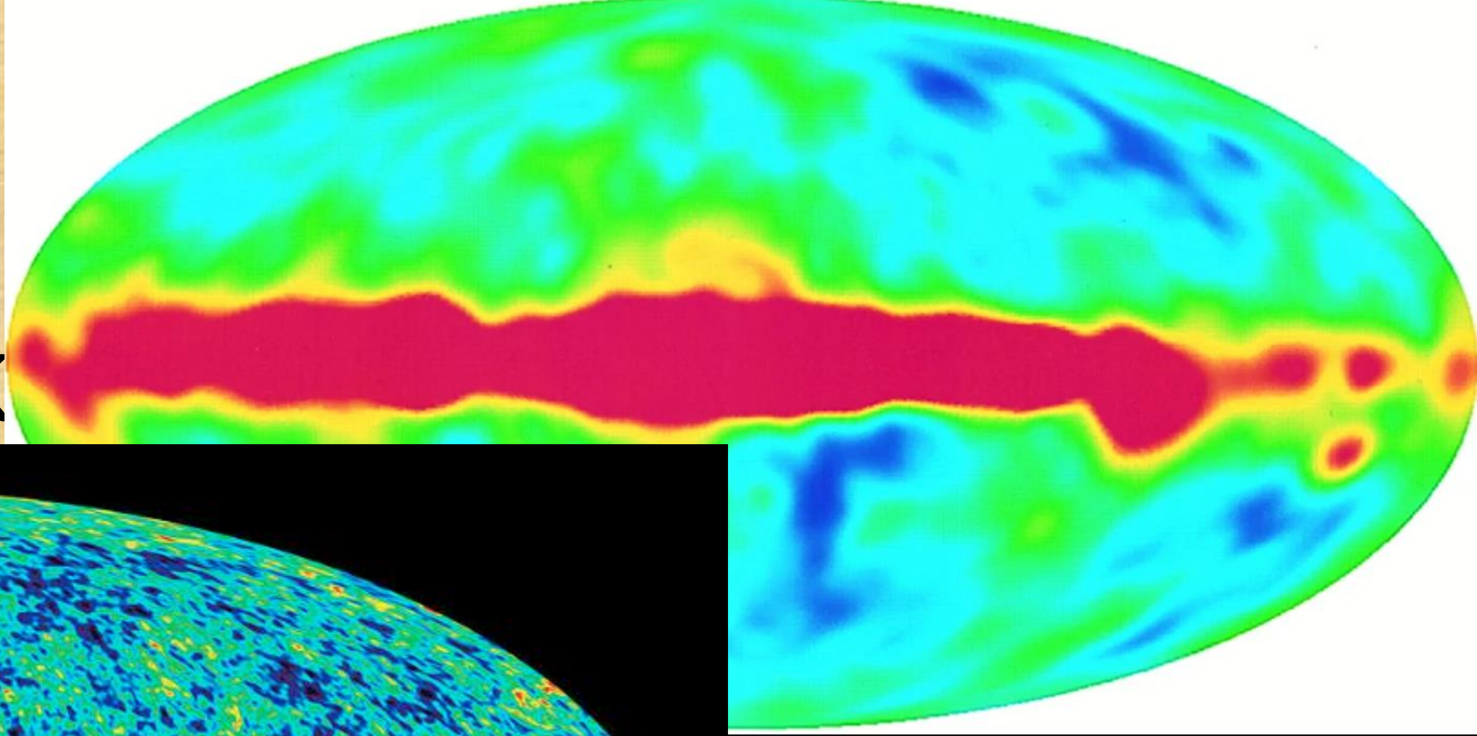
JWST cepheid data

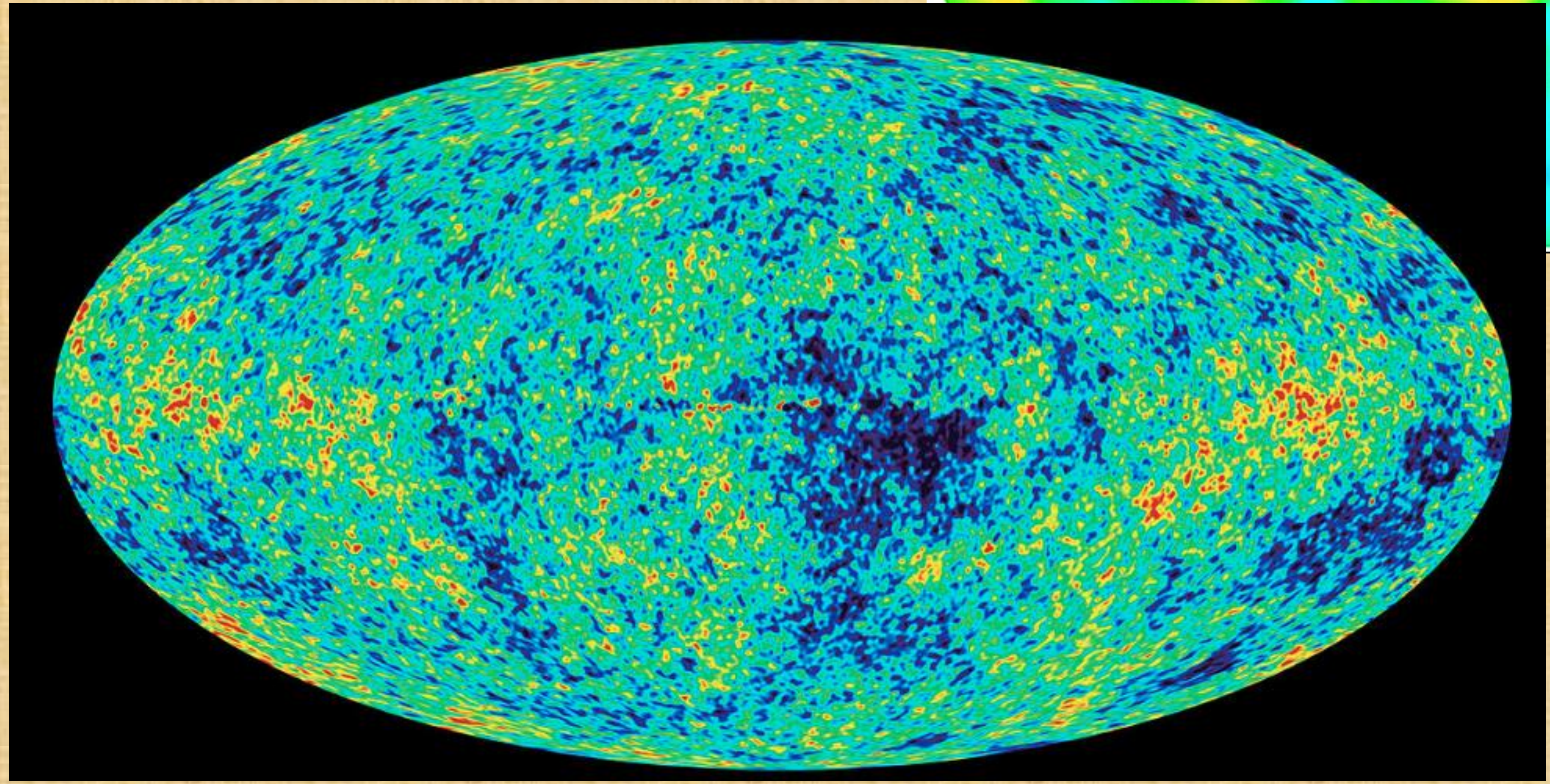


Primordial Gaussianity in CMB temperature fluctuations. Fundamental prediction of the canonical scenario

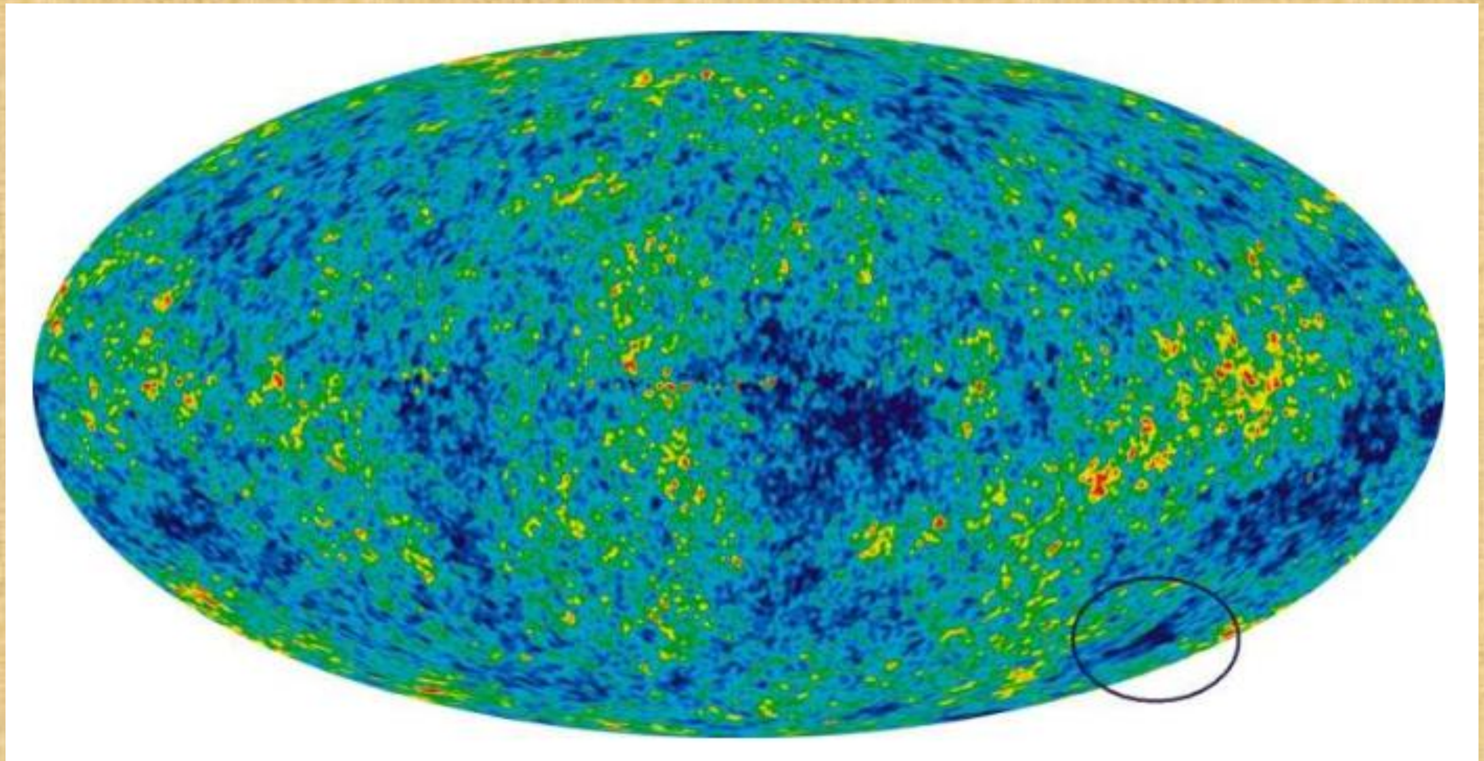
The Cold Spot is a rare event under Gaussian conditions

The Cold Spot anomaly in COBE and WMAP/Planck





The CS was not original detected as a strange feature by COBE, ... part of its anomaly …



Too cold (50 - 150 muK)

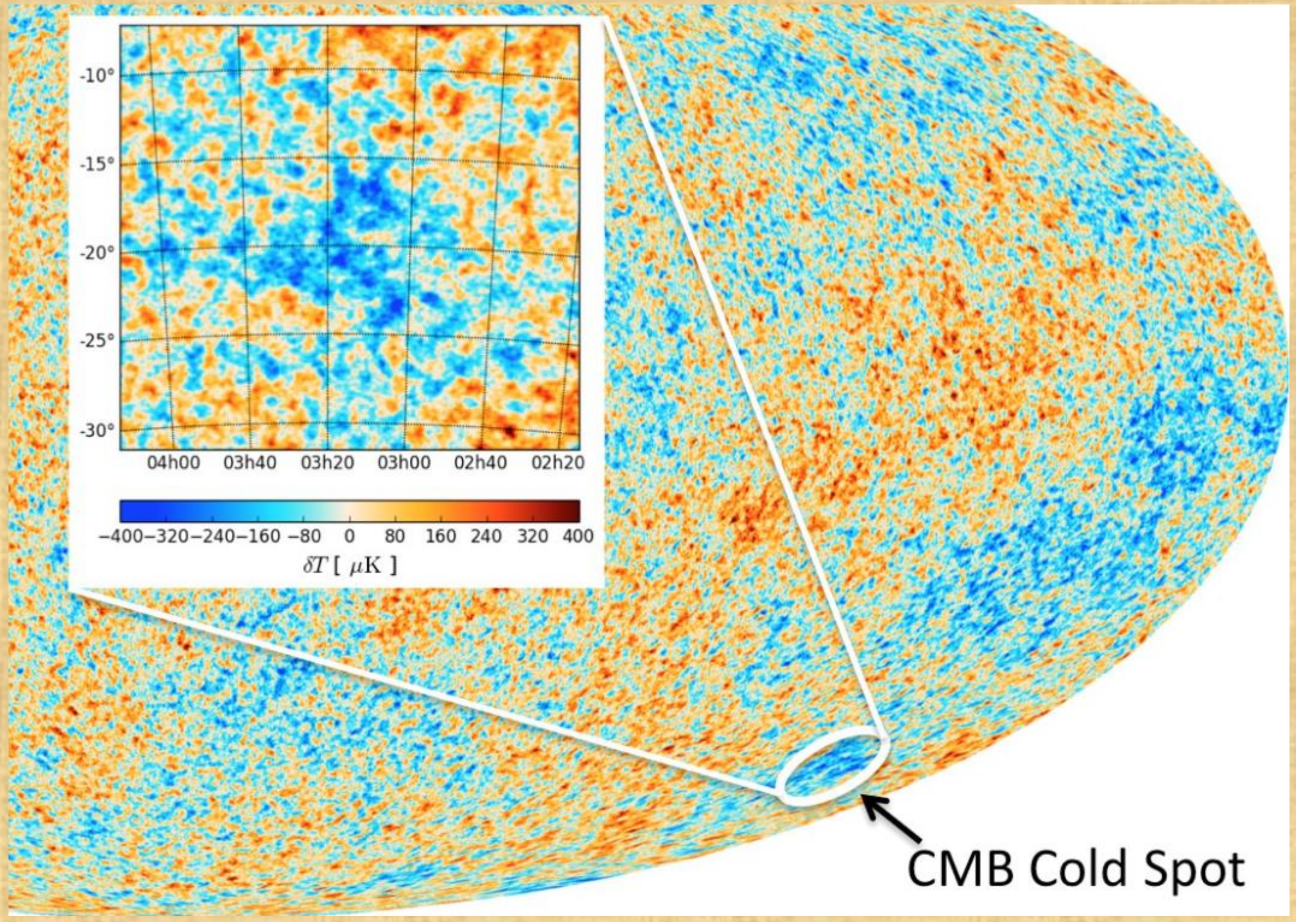
Too large (5 deg radius)

Surrounded by a hot ring

ESA Planck collaboration

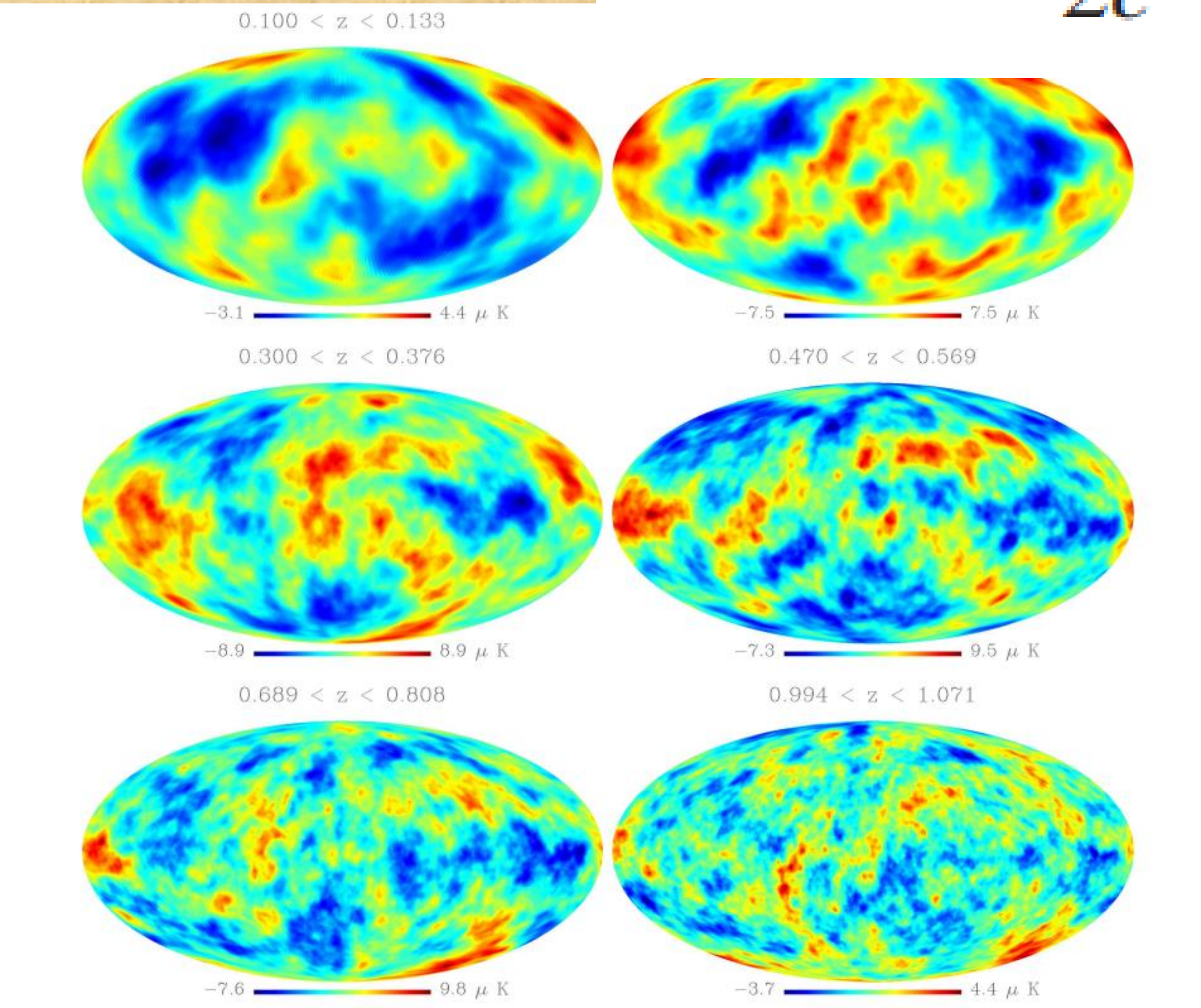
Only a 1% occurrence of a CS feature in CMB sinthetic maps of the LCDM model.

Ade et al. Planck Collaboration (2016)



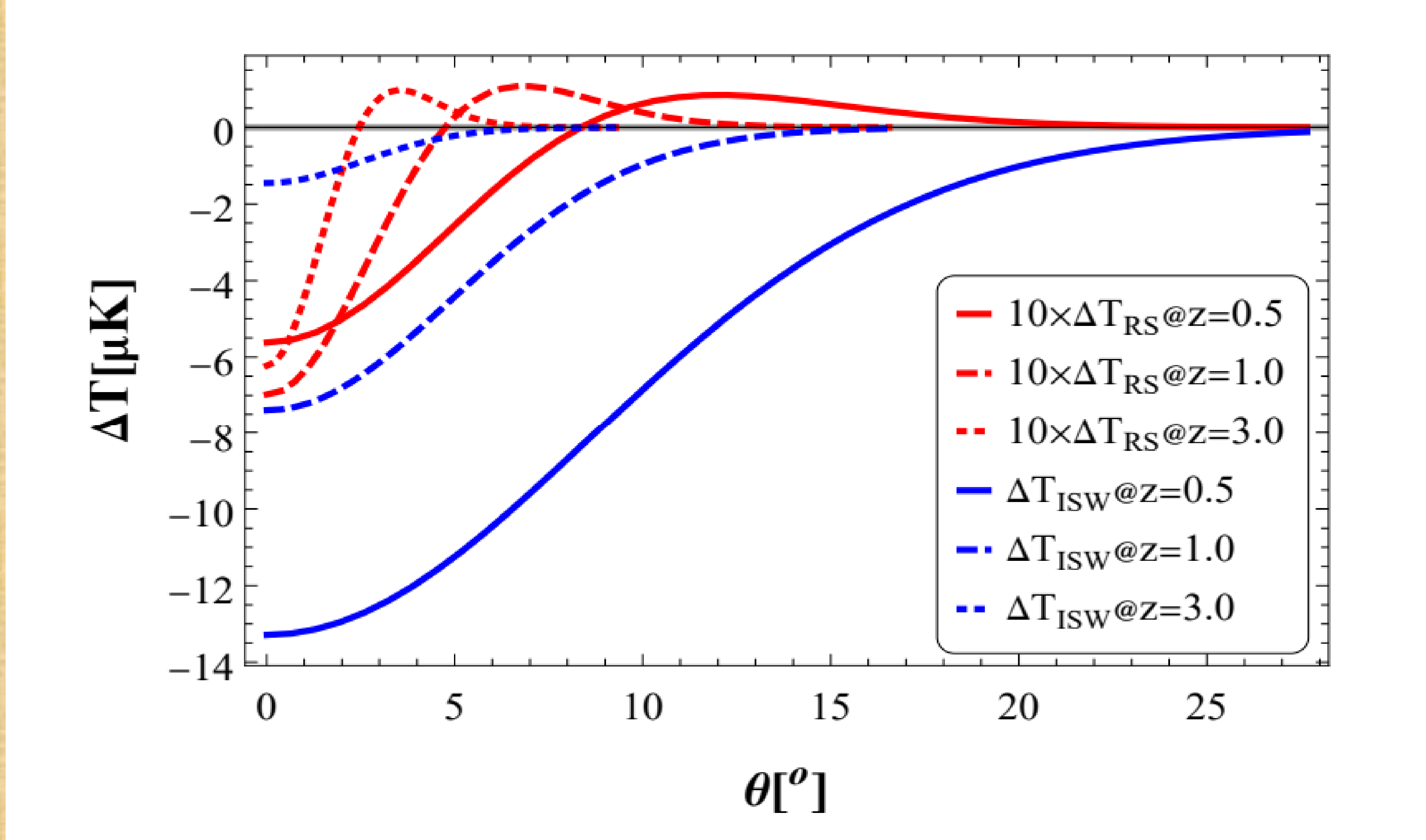
ISW supervoid solution ?

$$\kappa(\theta) = \frac{3H_0^2\Omega_m}{2c^2}\int_0^{r_{\max}} \delta(r,\theta)\frac{(r_{\max}-r)r}{r_{\max}}\,\mathrm{d}r.$$

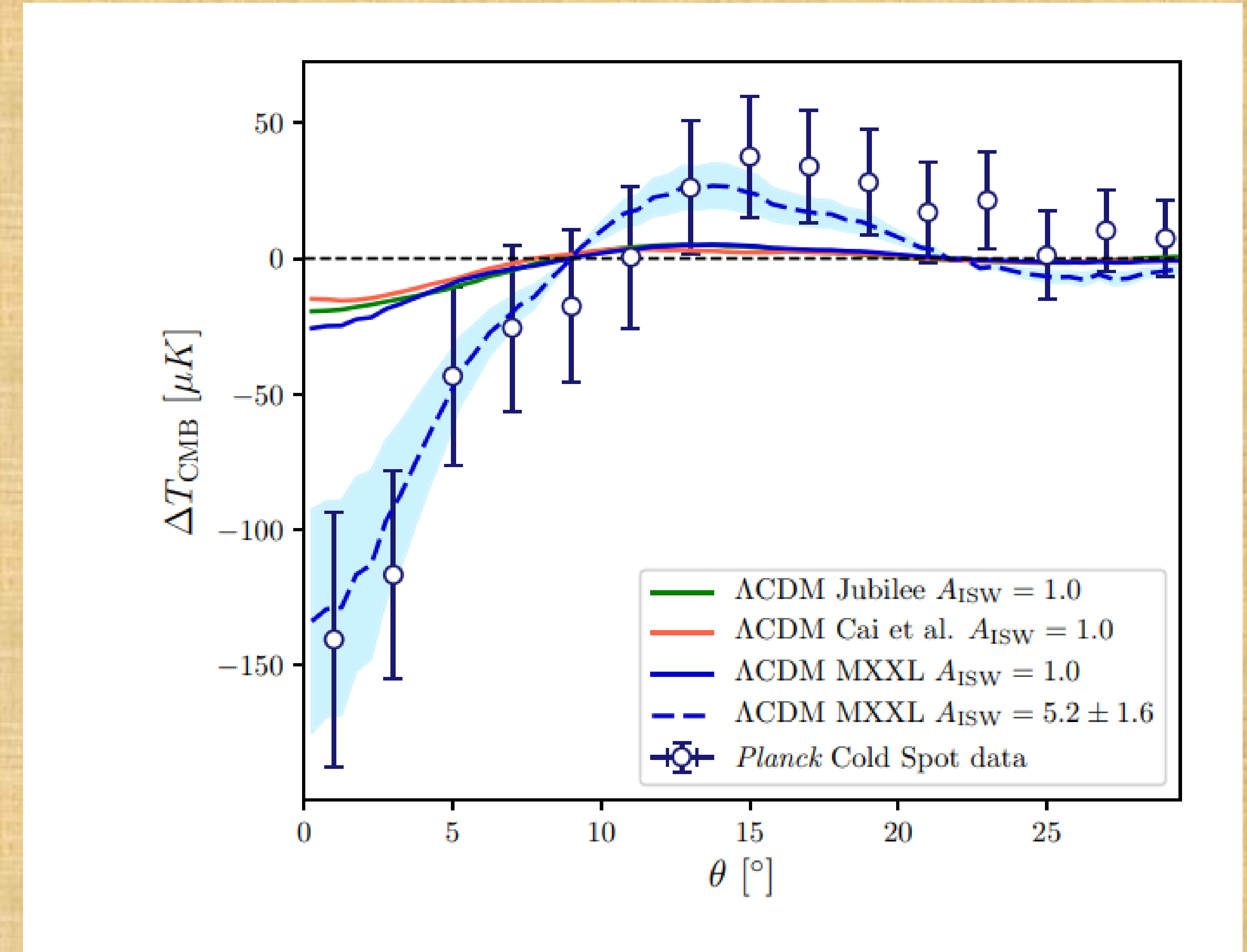


Watson et al. 2014
Jubilee ISW Project

- **A 150 μK amplitude cannot be accounted by normal voids produced in a LCDM model**



Owusu et al.2023



Besides the depth of the CS, a "hot ring" is difficult to reproduce with a supervoid ISW

Kovacs et al 2021

SW generated by a super void (DES Supervoid) should have a large lensing convergence. **However, this is not observed**

Owusu et al. 2023, +

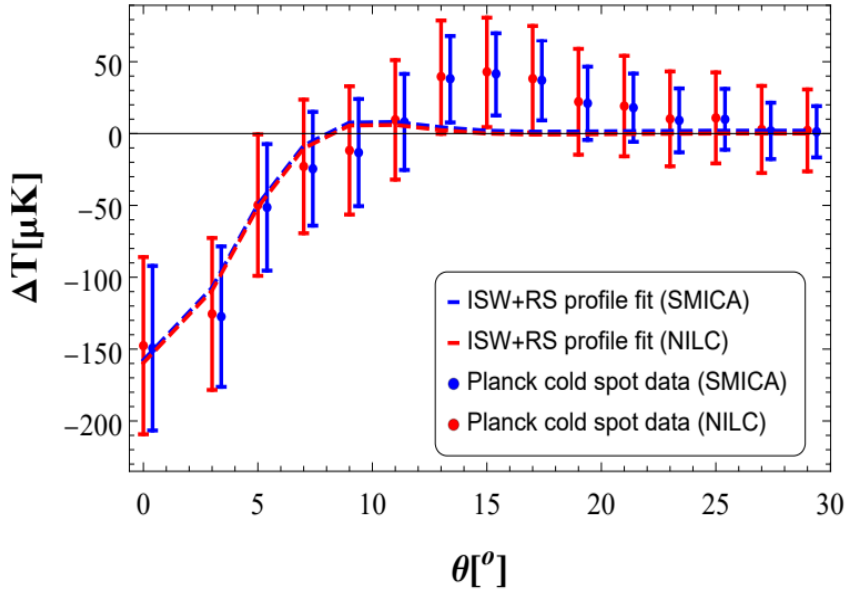


Figure 4: Planck 2018 SMICA and NILC CS temperature data, with best fit theoretical profiles. The data points and error bars are slightly displaced horizontally for clarity.

Best fit:

$\delta 0 = -0.34$

Distance = 6910 Mpc/h

Void radius = 806 Mpc/h !

Tests with known voids imply a 12 S/N detection

Discovery of new extragalactic foregrounds associated to spiral galaxies.

Collaborators:

Heliana Luparello, IATE

Frode Hansen, Insitute of Astrophysics, Oslo

Facundo Toscano, IATE

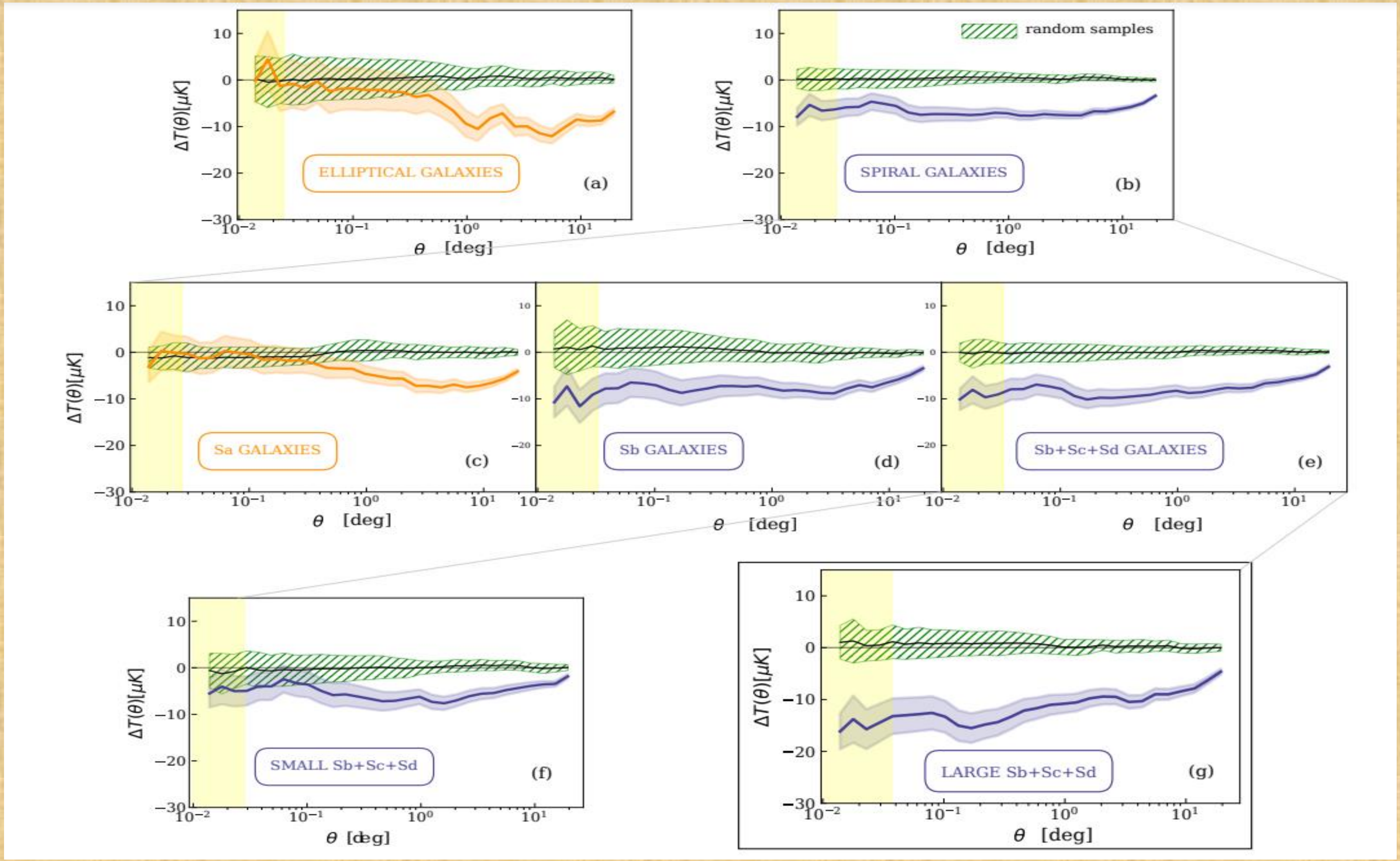
Ezequiel Boero, IATE – FaMAF

Marcelo Lares, IATE

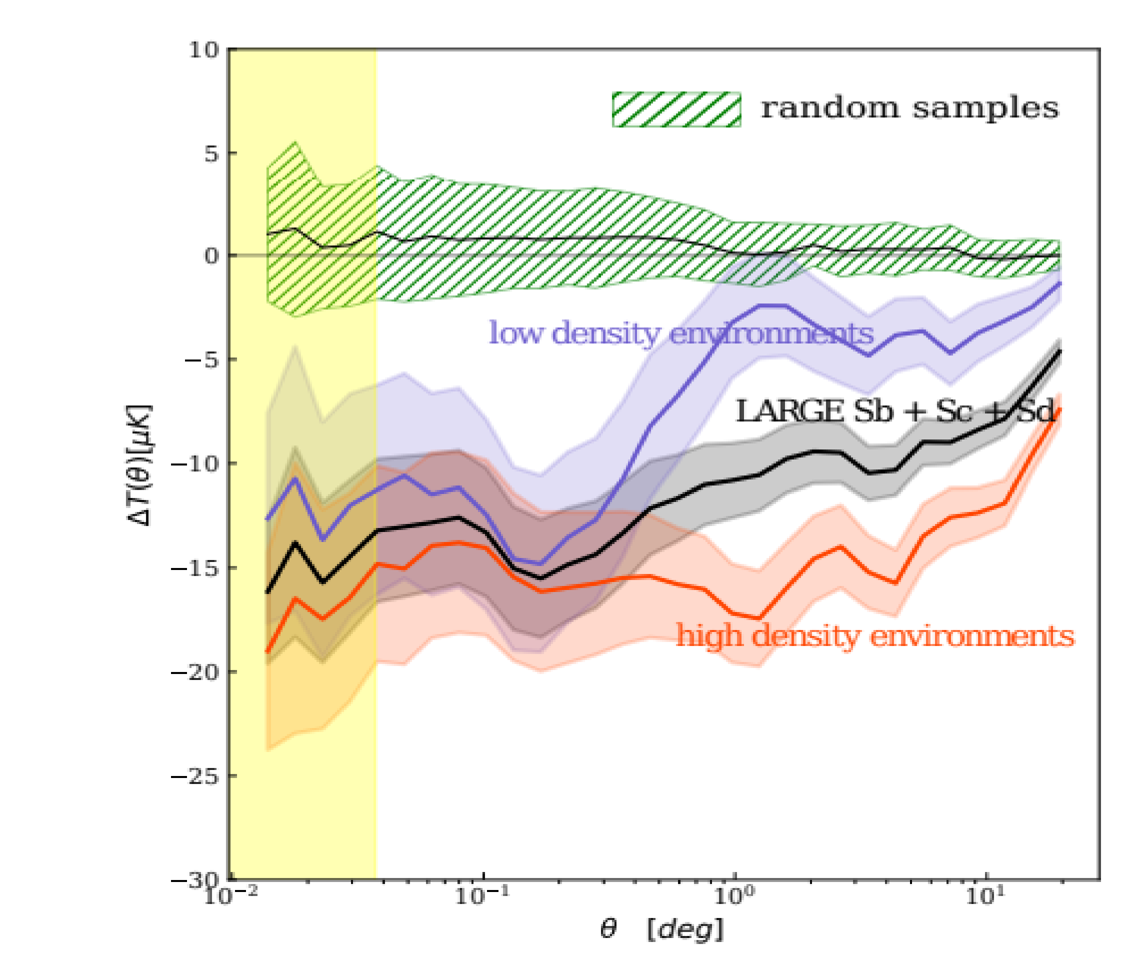
Ariel Sanchez, MPE

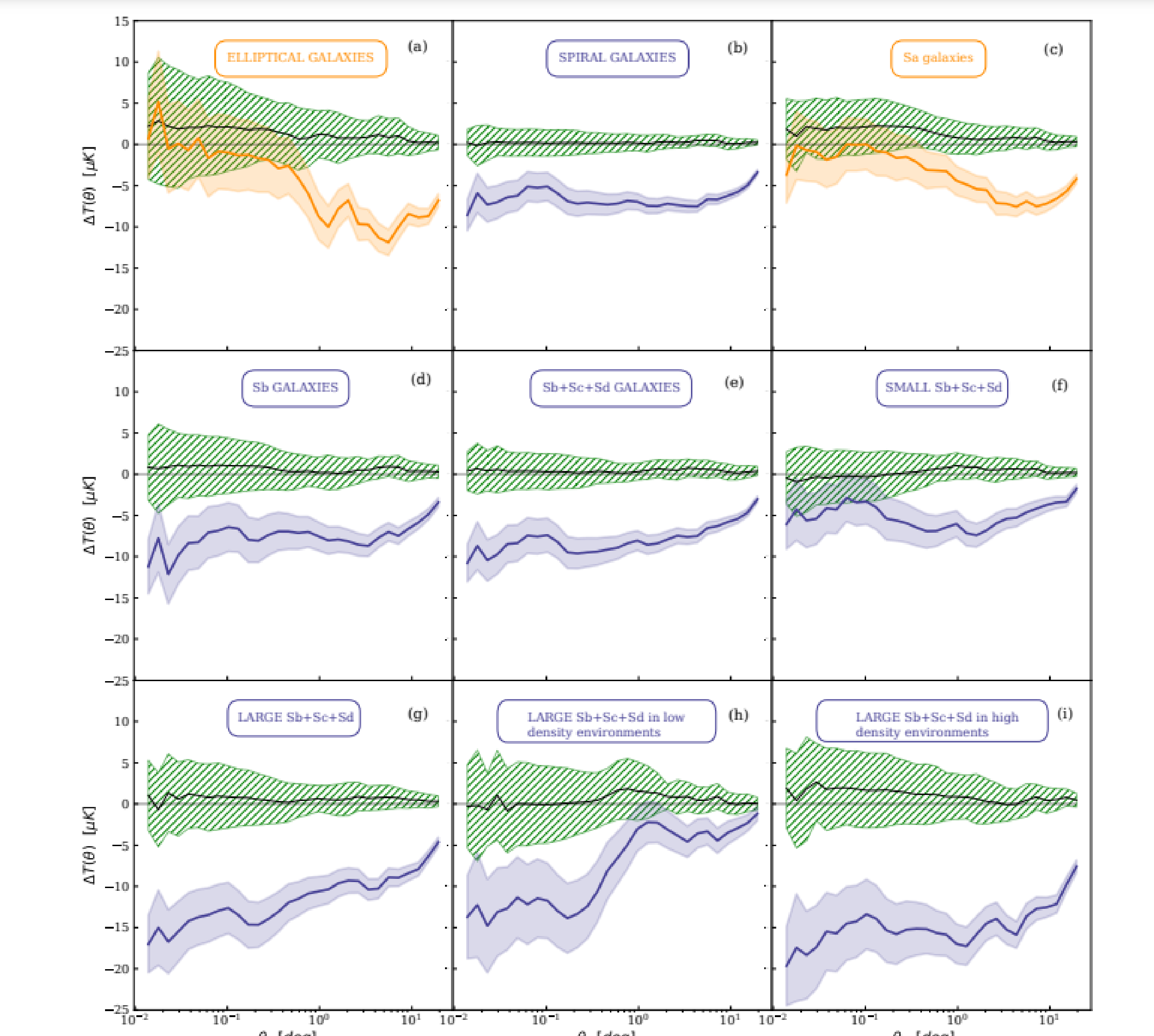
A potential local solution to the CMB Cold Spot and other anomalies ?

Serendipitous discovery of a new extragalactic foreground associated to late-type galaxies. Luparello et al. 2023

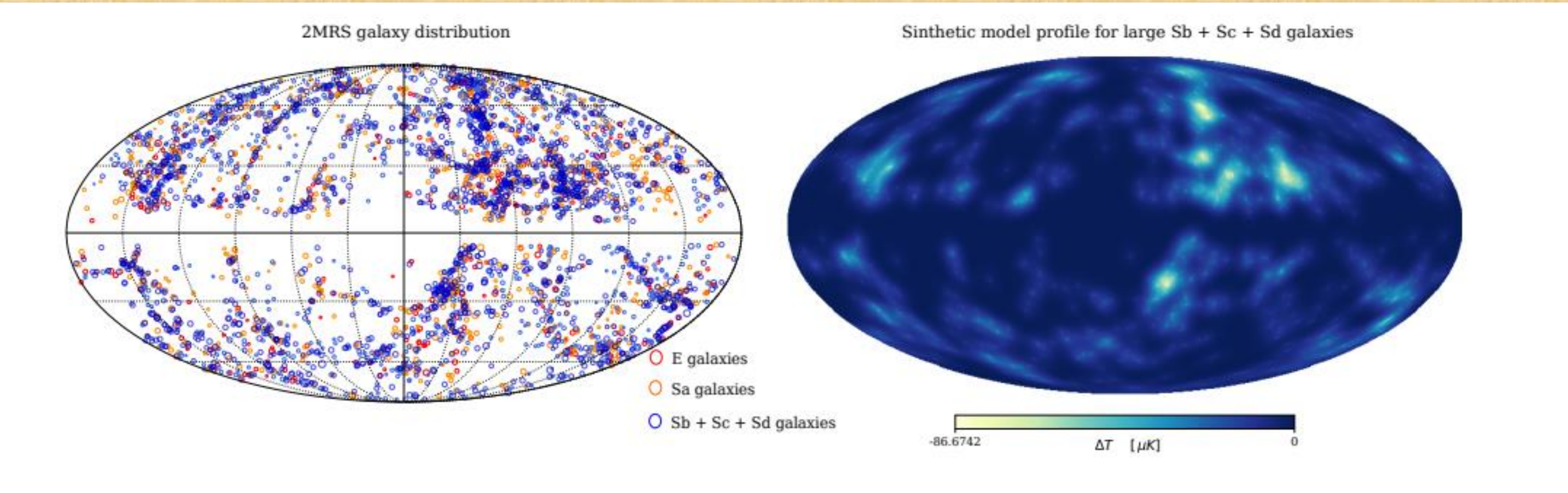


Extragalactic foreground traced by late-type galaxies. An unknown (molecular? + ?) interaction with CMB photons ?

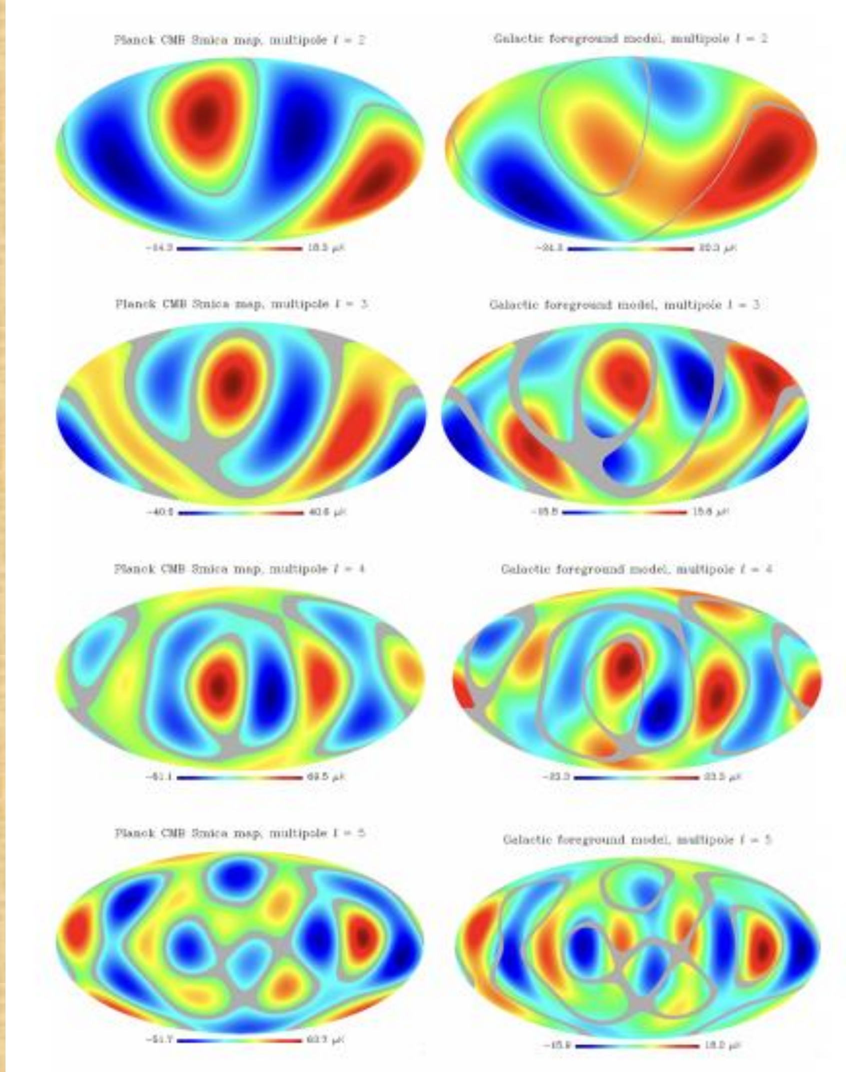




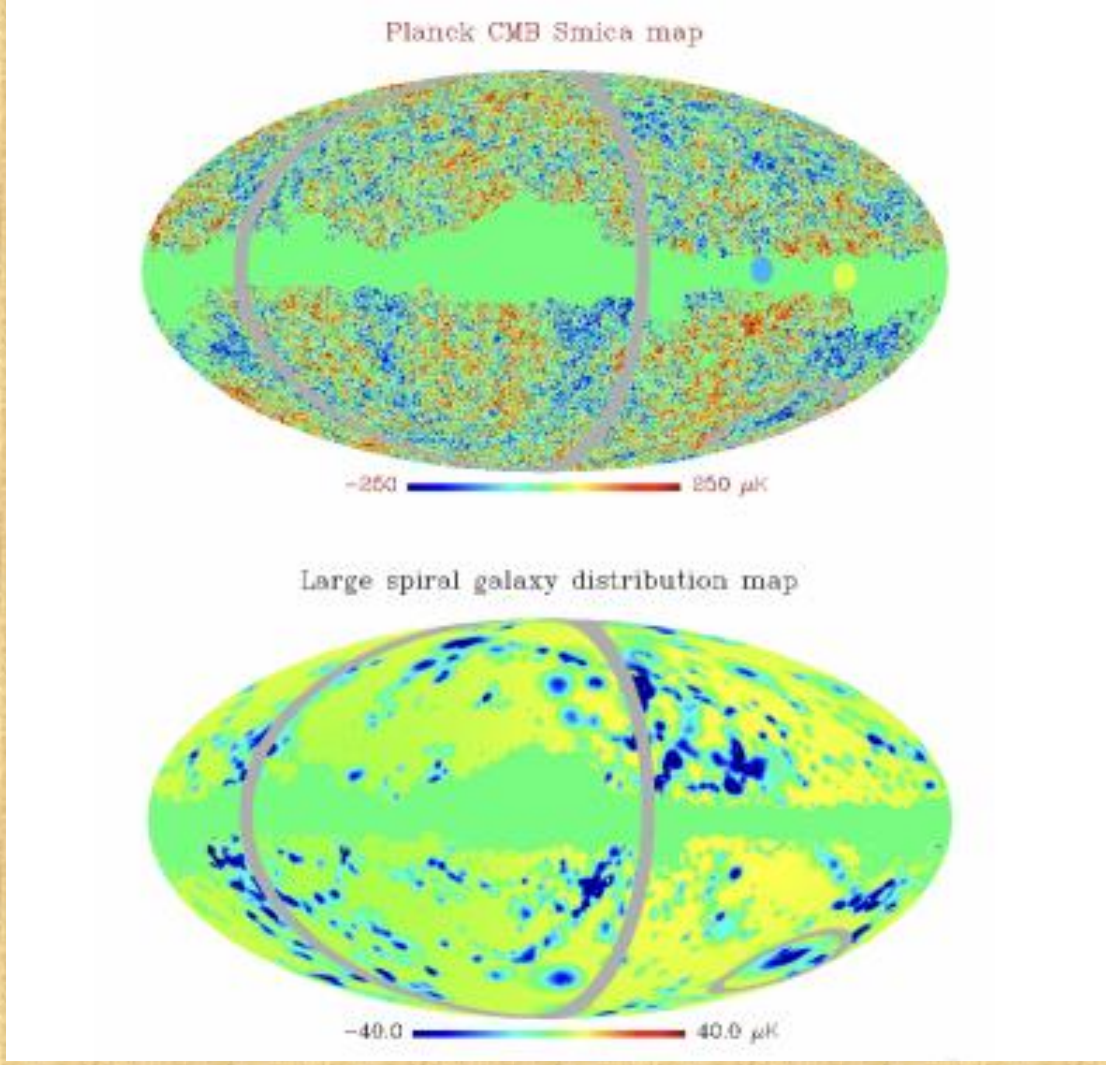
Predicted (local extragalactic) foreground CMB map.



CMB large angular anomalies has coincidence with the model foreground

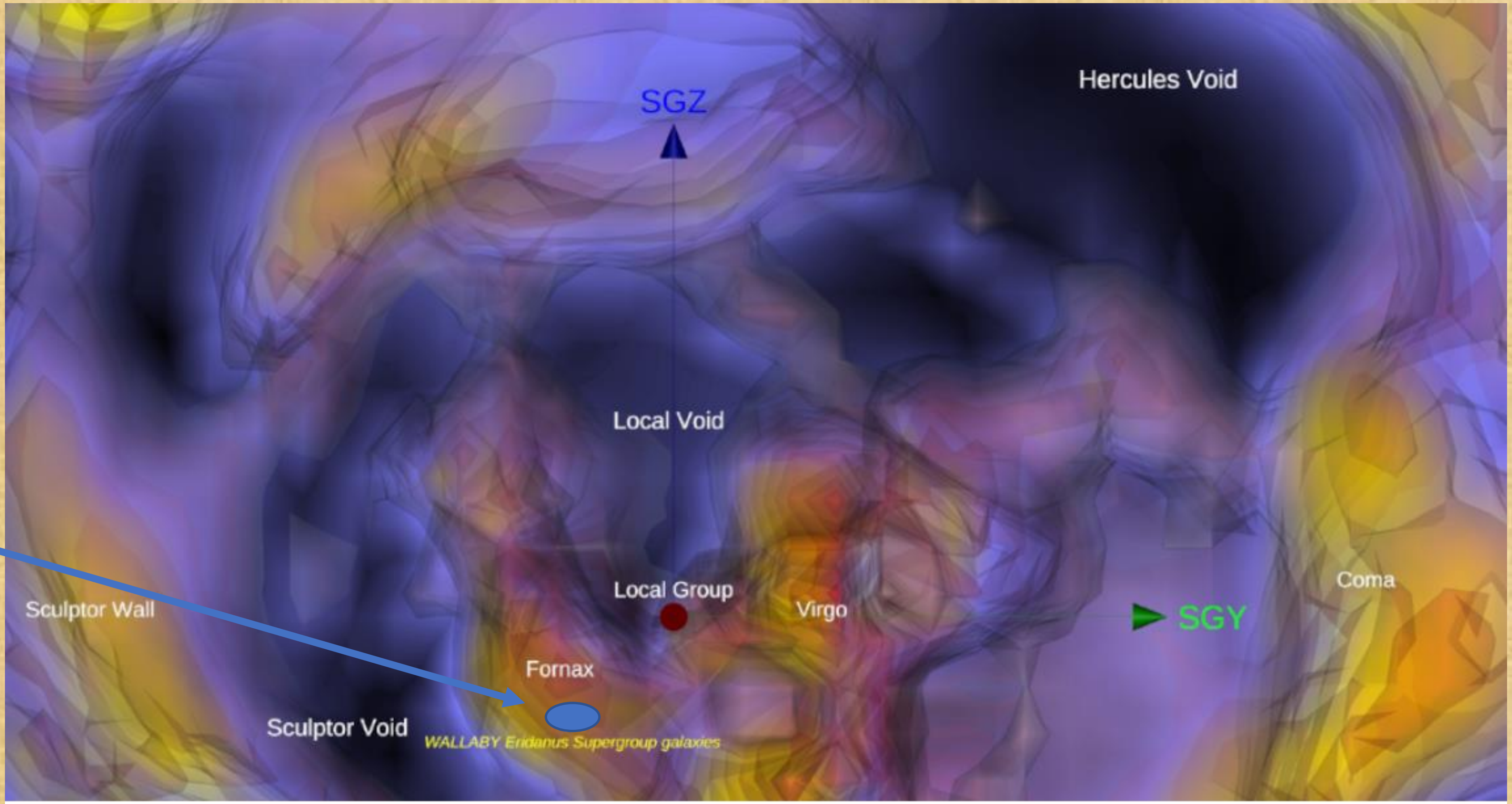


Hansen et al. 2023



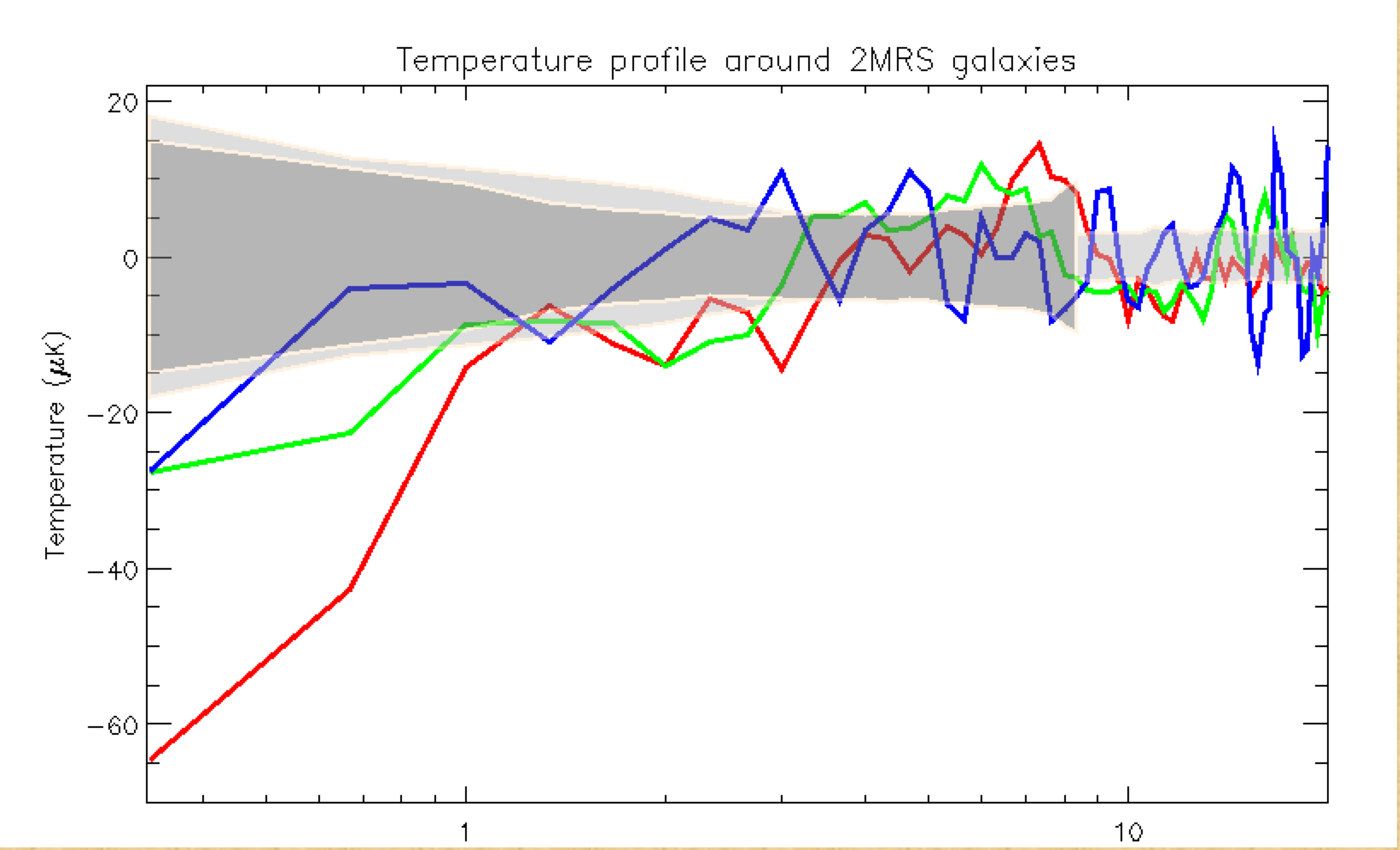
A nearby alternative explanation for the Cold Spot: Eridanus galaxy association: Eridanus, NGC 1332,1407, +

<u>The CS area</u>
densely populated by members of this group cloud.

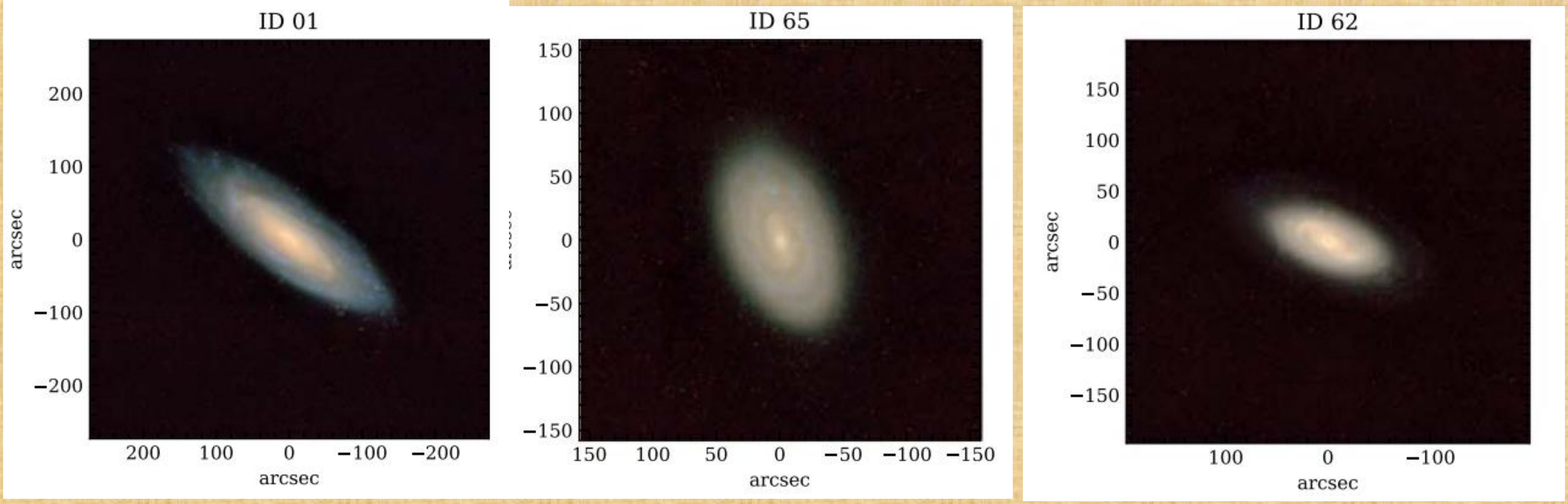


The positions of the Eridanus supergroup galaxies. The contours in the image represent underdense (blue) to overdense (yellow) regions. Credit: B.-Q. For et al. 2021.

SMICA T profiles around galaxies in the CS region with local monopole removed



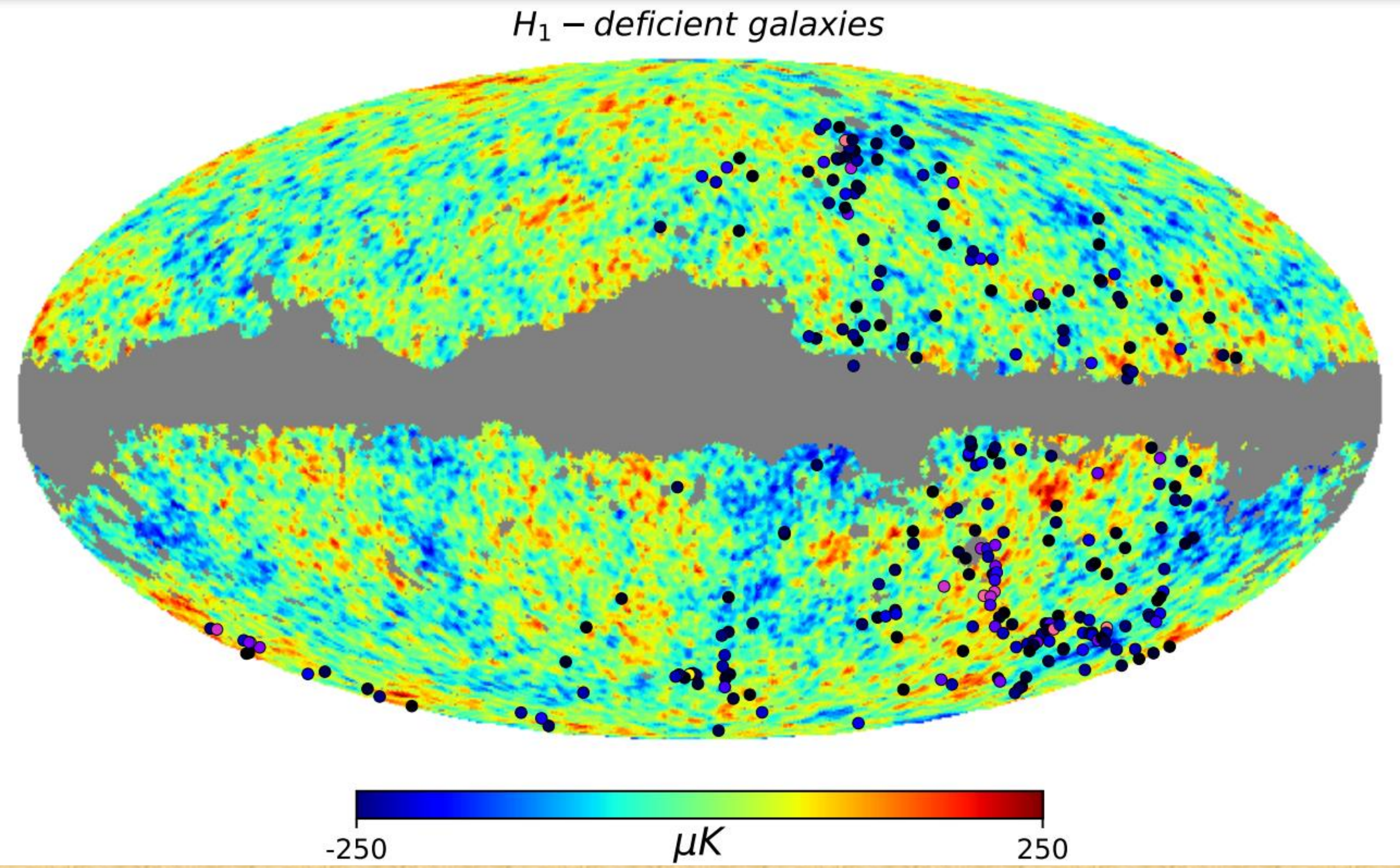
Bright Spirals in the Eridanus cloud coincide with the most cold regions



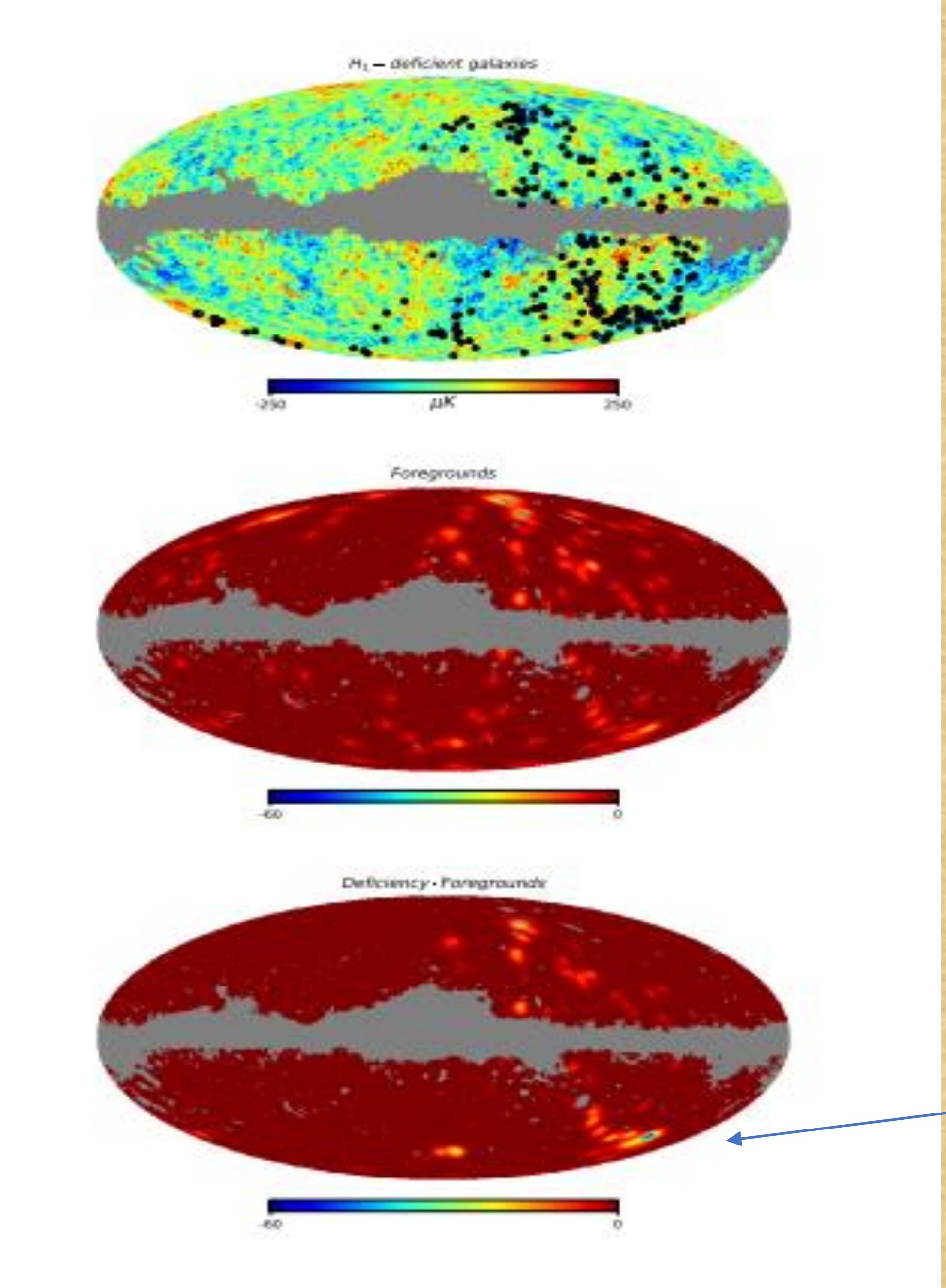
The CS region is populated by late-type Spirals. Images from the WALLABY Prepilot Survey, Wang et al. 2022

Interestingly cloud/group environment are ideal at removing material from the interior of galaxies through interactions

Distribution of HI deficient galaxies (low quartile)

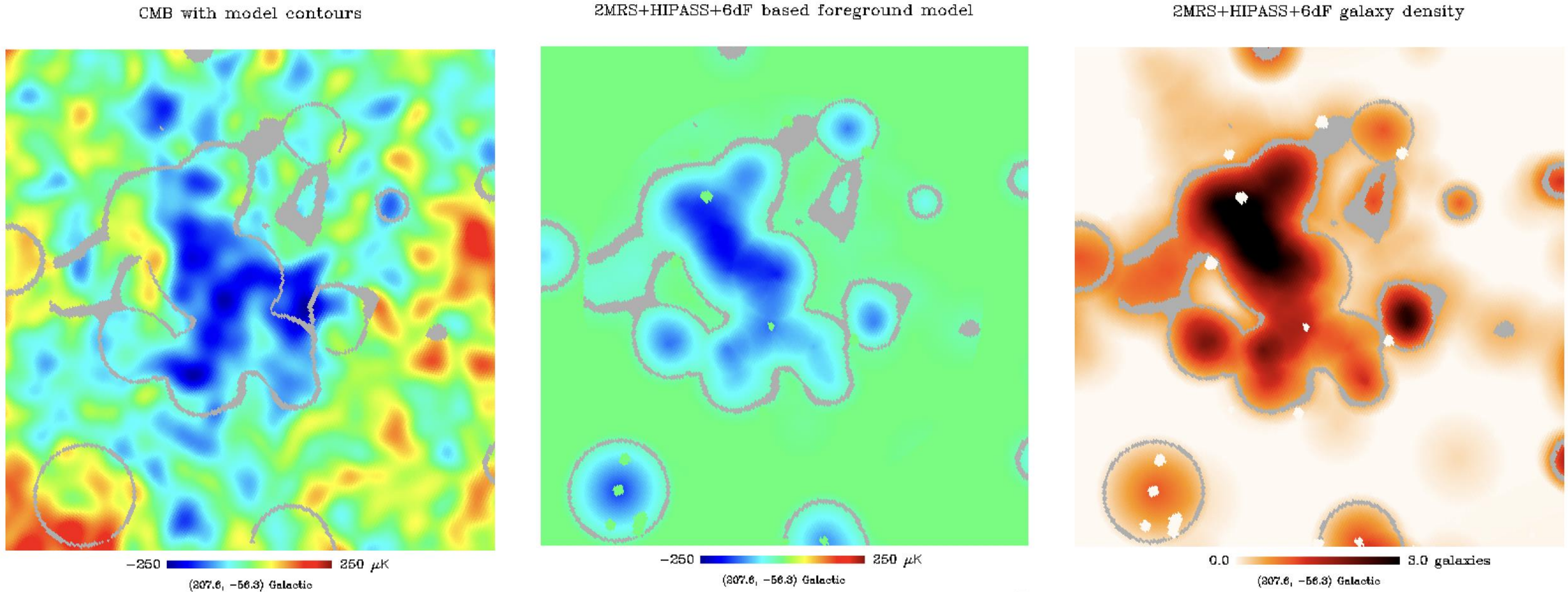


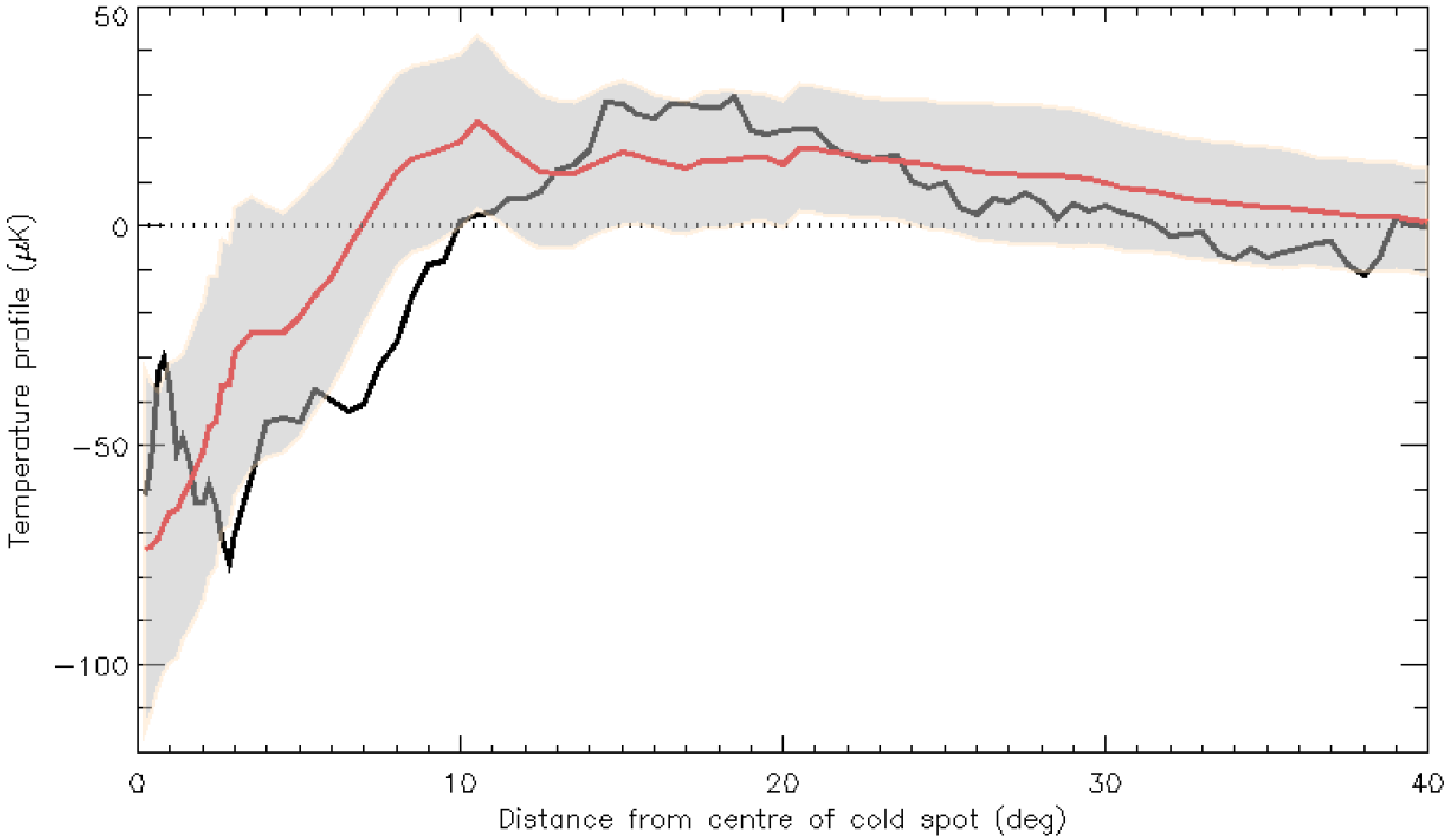
HI-deficient galaxies populate the CS region



Combining the L2023 foreground and HI deficiency maps highlight the Cold Spot area

Cold Spot (left) and Galaxy Foreground model prediction





Sinthetic CMB simulations produce a suitable profile with 50% hot ring chance

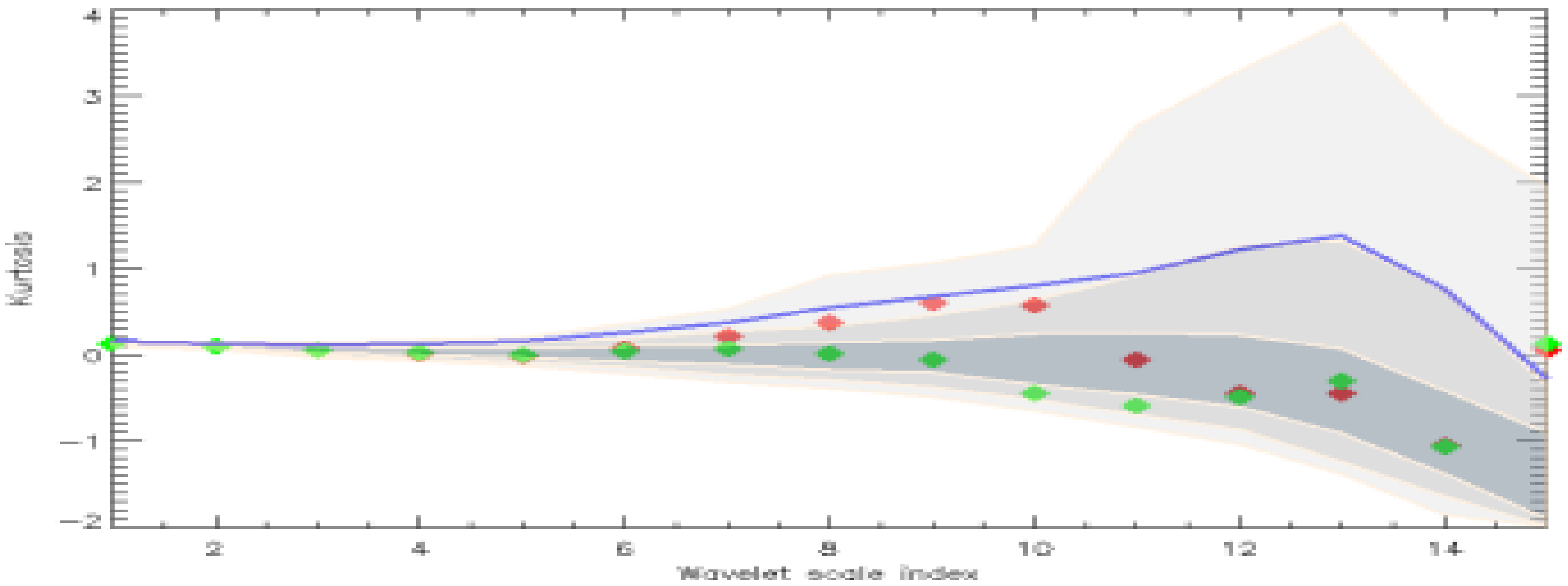
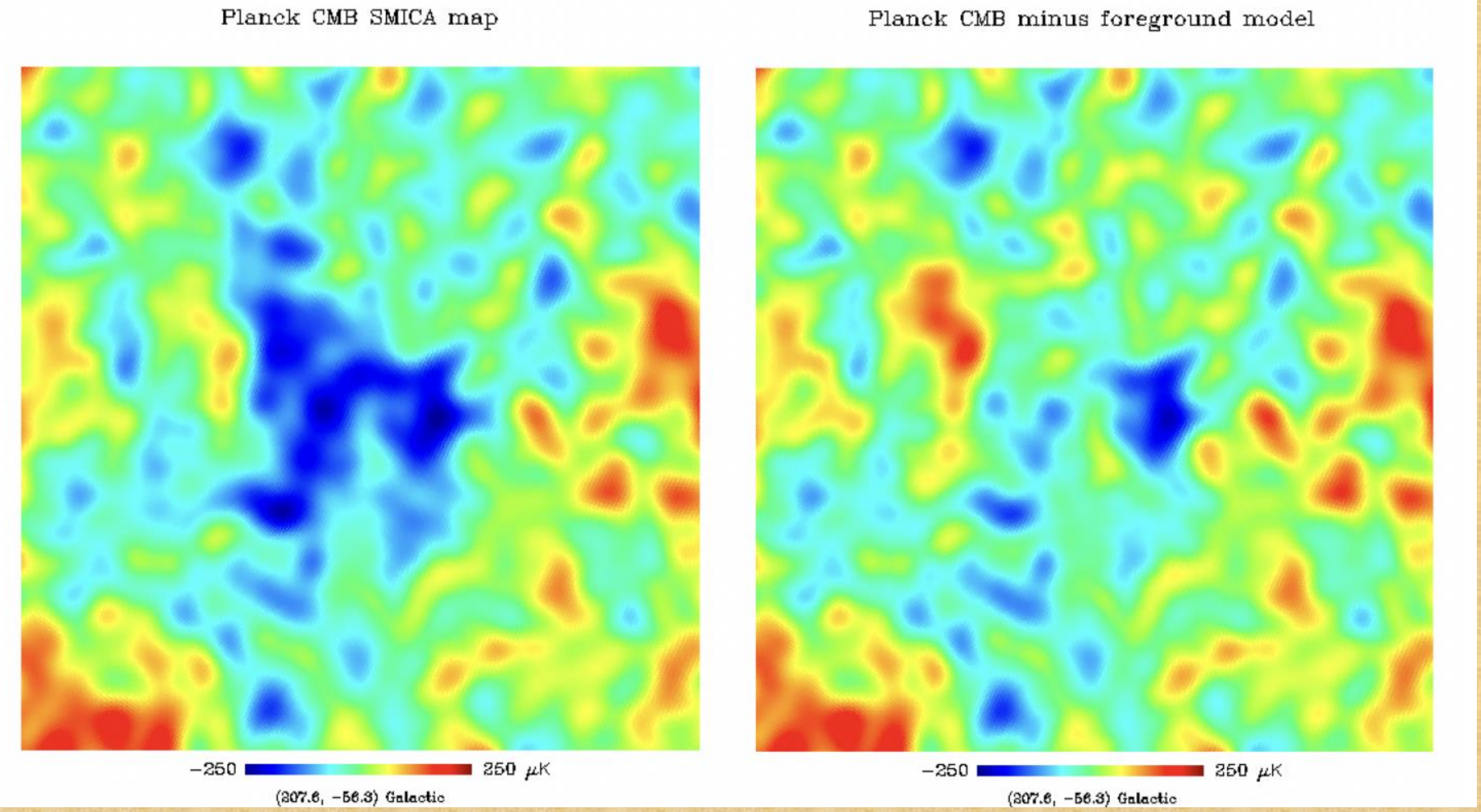


Fig. 4. Kurtosis of SMHW wavelet coefficients. The grey bands show the 1, 2 and 3σ spread of kurtosis in 1000 Gaussian simulations. The red dots show the kurtosis of wavelet coefficients of the Planck SMICA map before correction for the galaxy based model. The green dots show the kurtosis after the correction. The blue line shows the upper limit of the 2σ band for Gaussian simulations where the galaxy model was added to each simulation.

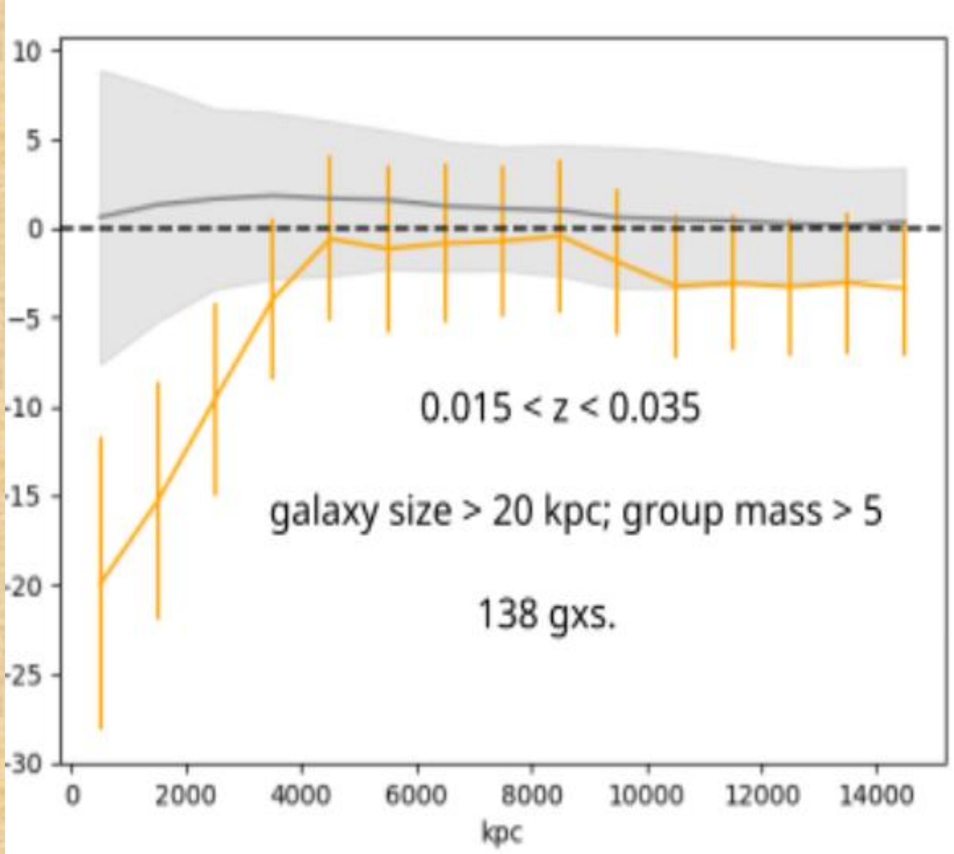
Anomalous kurtosis is largely removed with the foreground correction

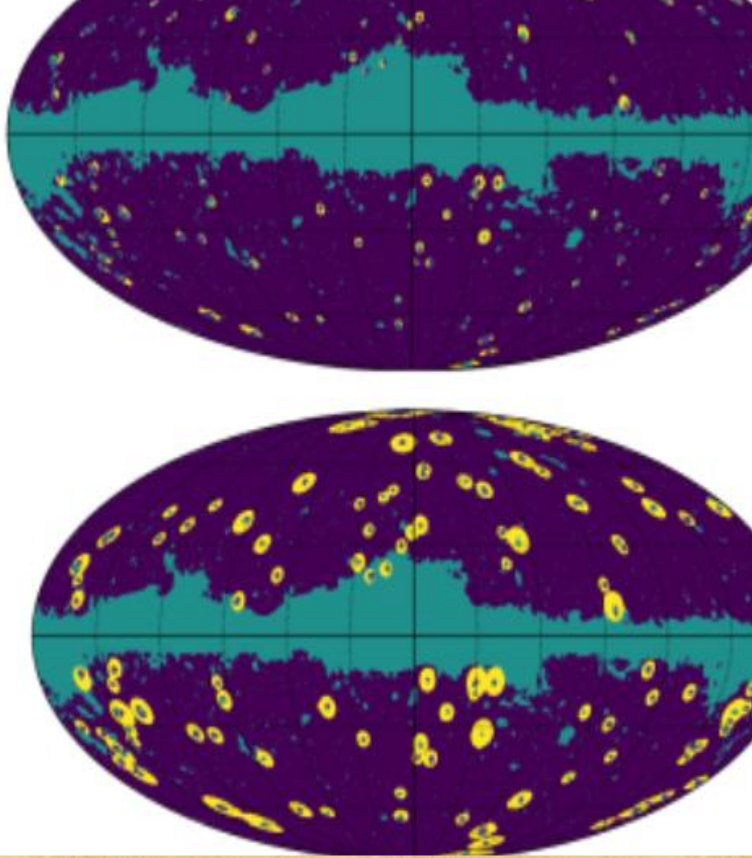


Original and foreground-model removed CS area

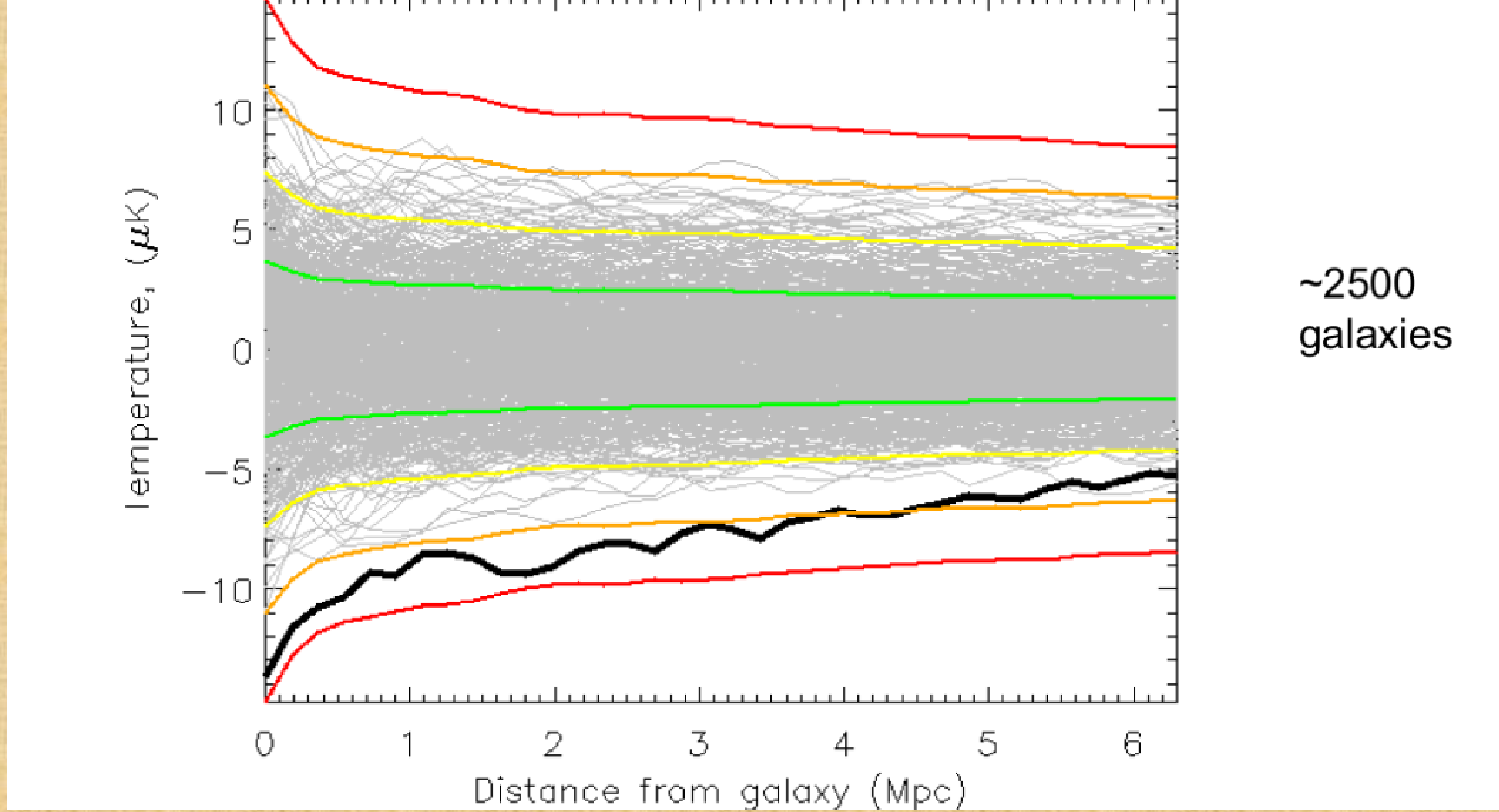
Extending the original 2023 results.
(ongoing work)
* Other galaxy samples
* scaling to projected Mpc

Distant 2MRS large late-type Spirals 0.015 <z< 0.035

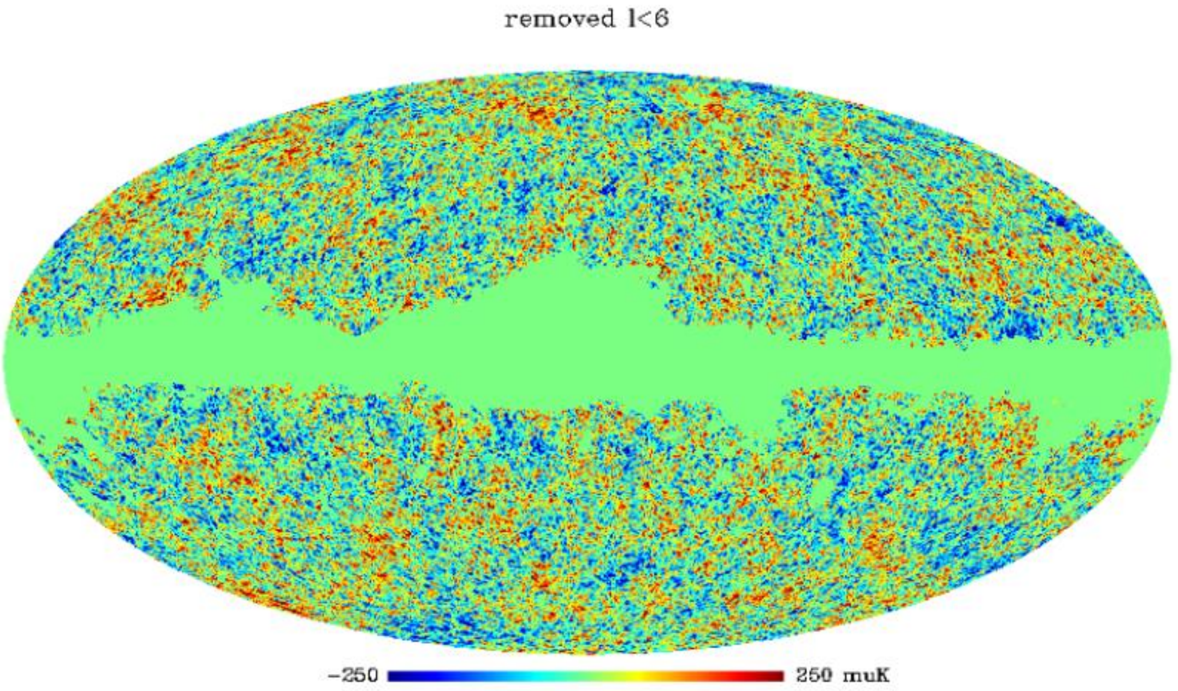


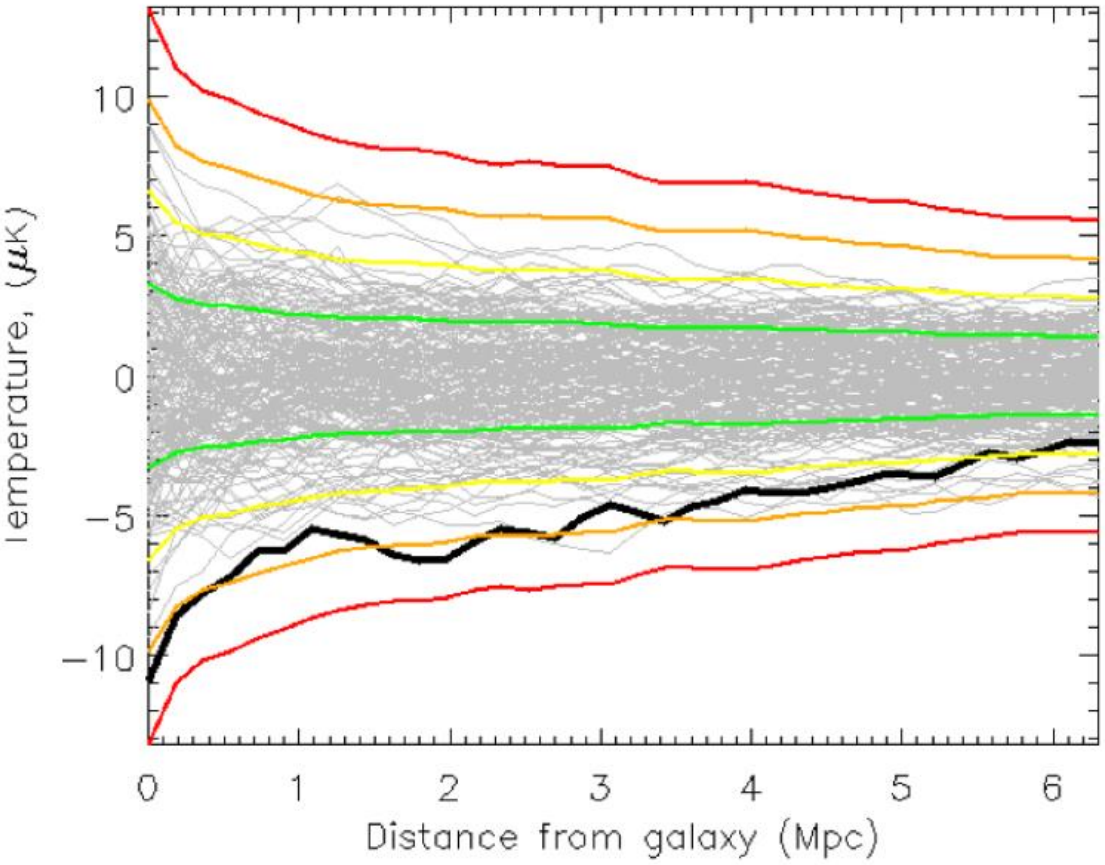


Intermediate-distance samples give independent confirmation of the foreground effect



ΔT profiles (projected Mpc) around large Spirals.
Comparison to LCDM simulations is at 3-4σ level.

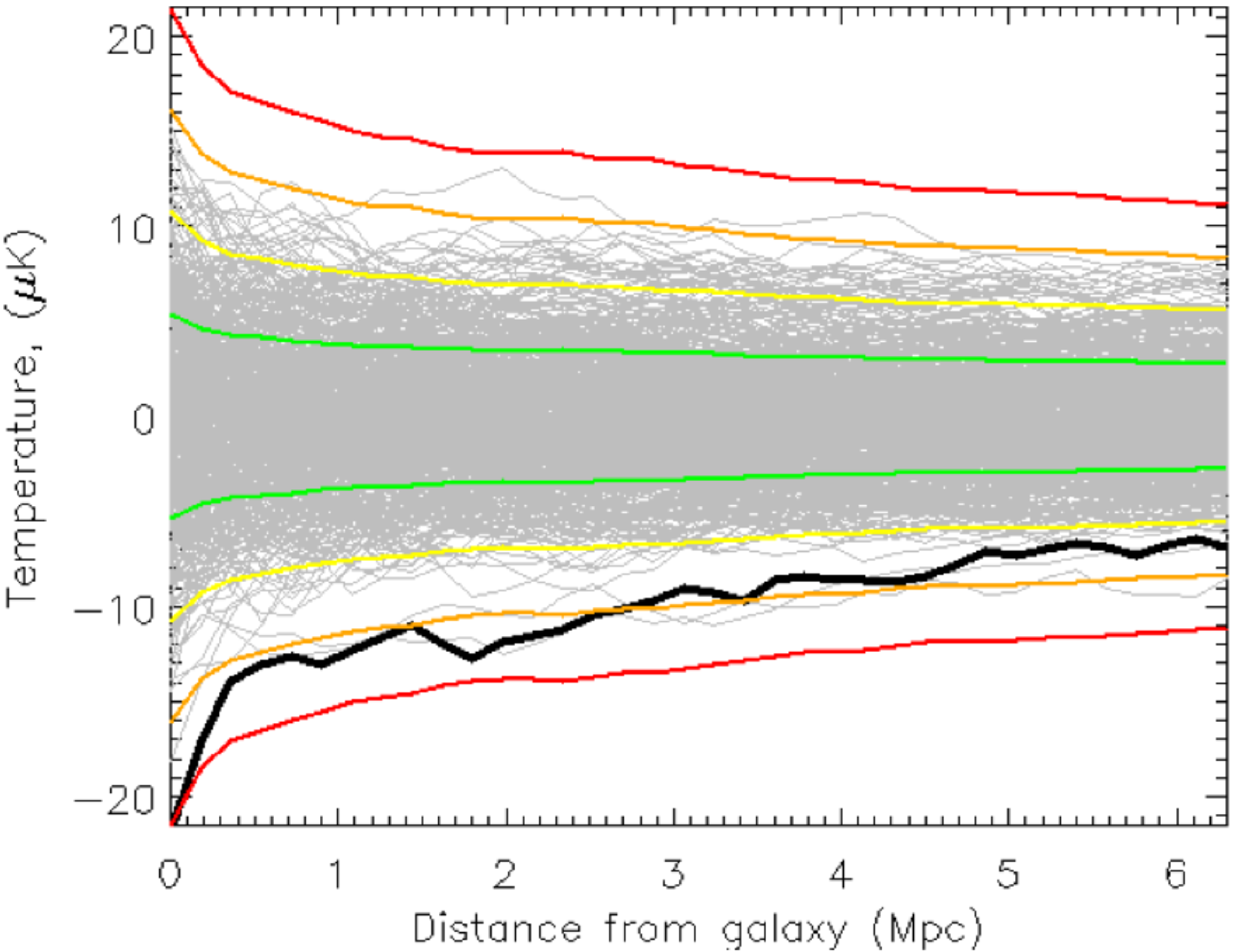




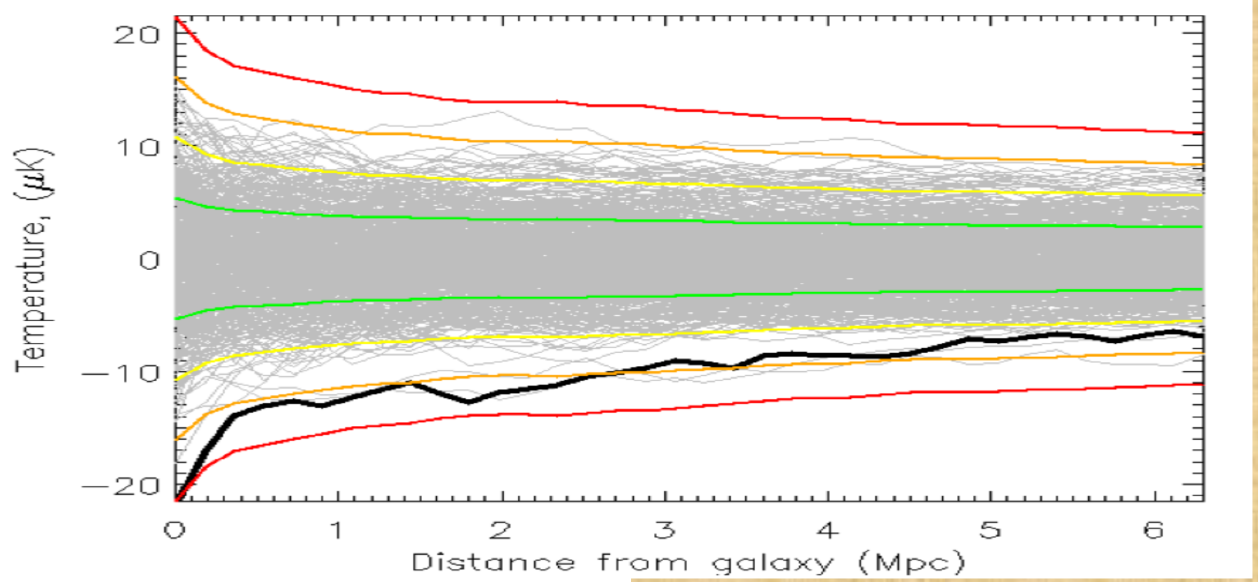
Testing the remotion of first 6 multipoles
leaves the results unchanged.
(The effect is not due to large-scale map features)

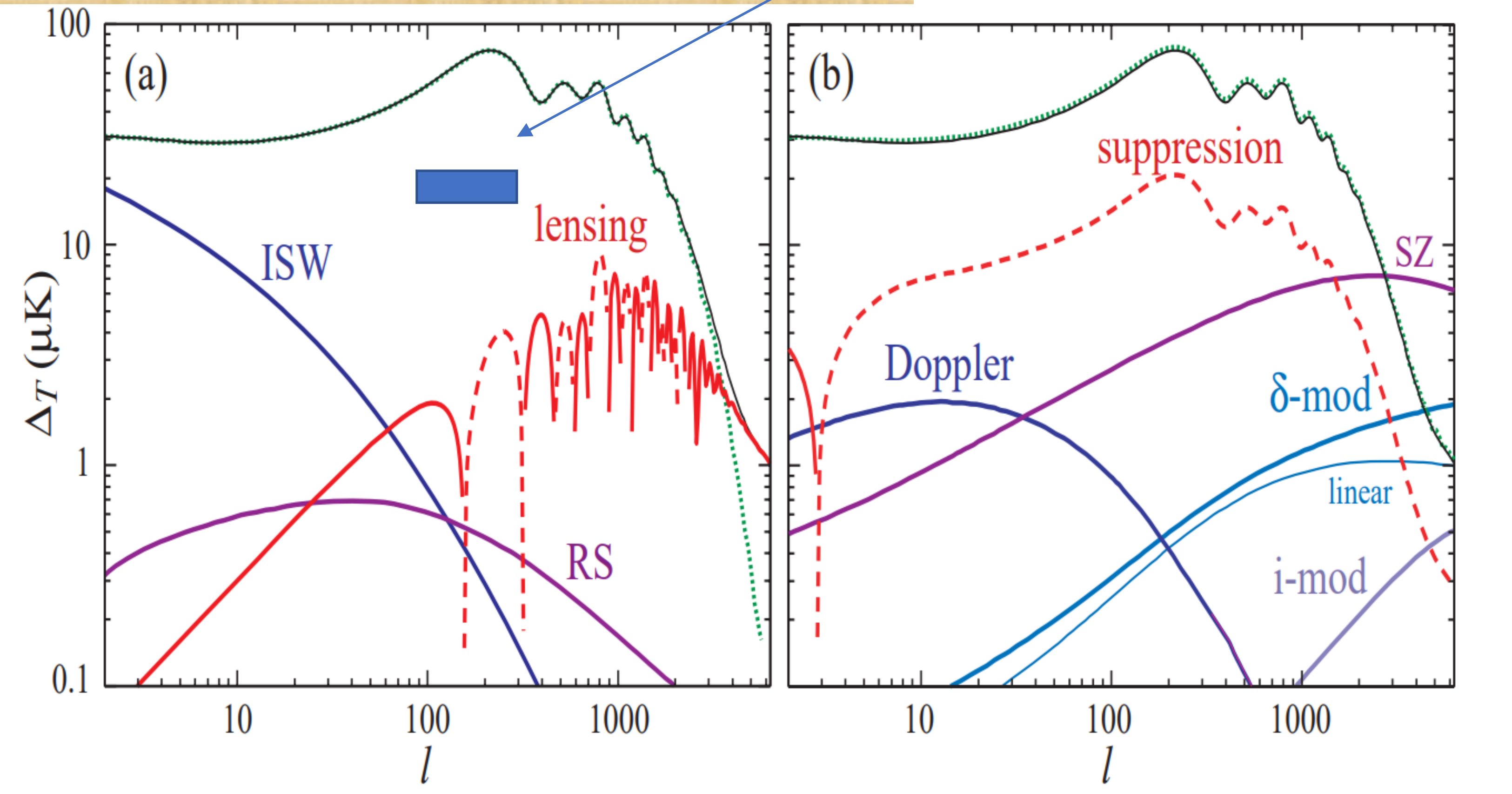
Large Spirals with neighbours have a stronger signal.

~1300 galaxies



Very large amplitude in comparison to known CMB effects !





Summing up …

Surroundings of late-type Spirals have sistematically lower CMB temperatures.

This temperature decrement obeys an approximately linear radial profile with central $\Delta T \sim -20\ \mu K$ extending up to **3-4 Mpc**.

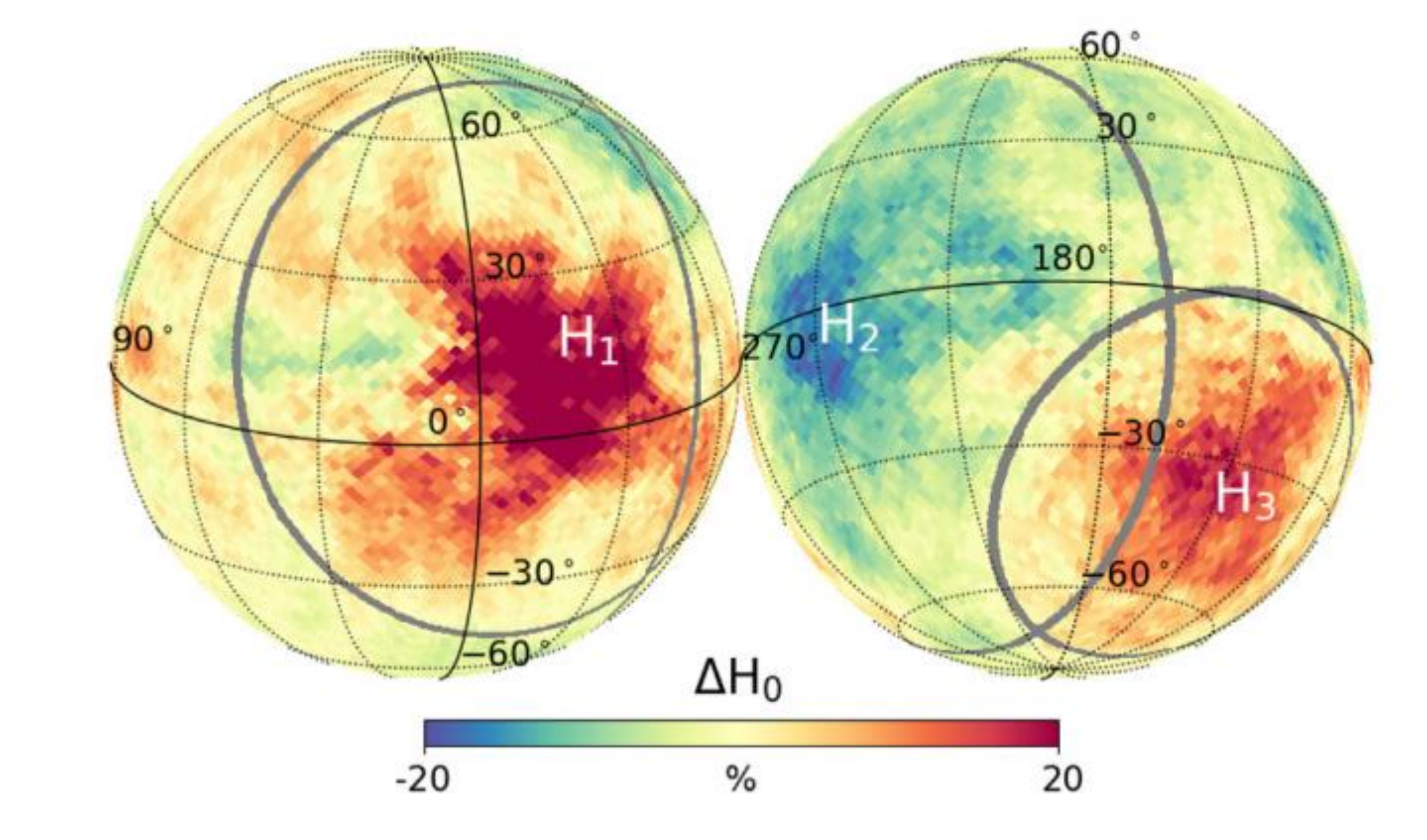
The CMB Cold Spot anomaly may be largely explained by a local extragalactic foreground associated to the Spiral environment in the Eridanus cloud.

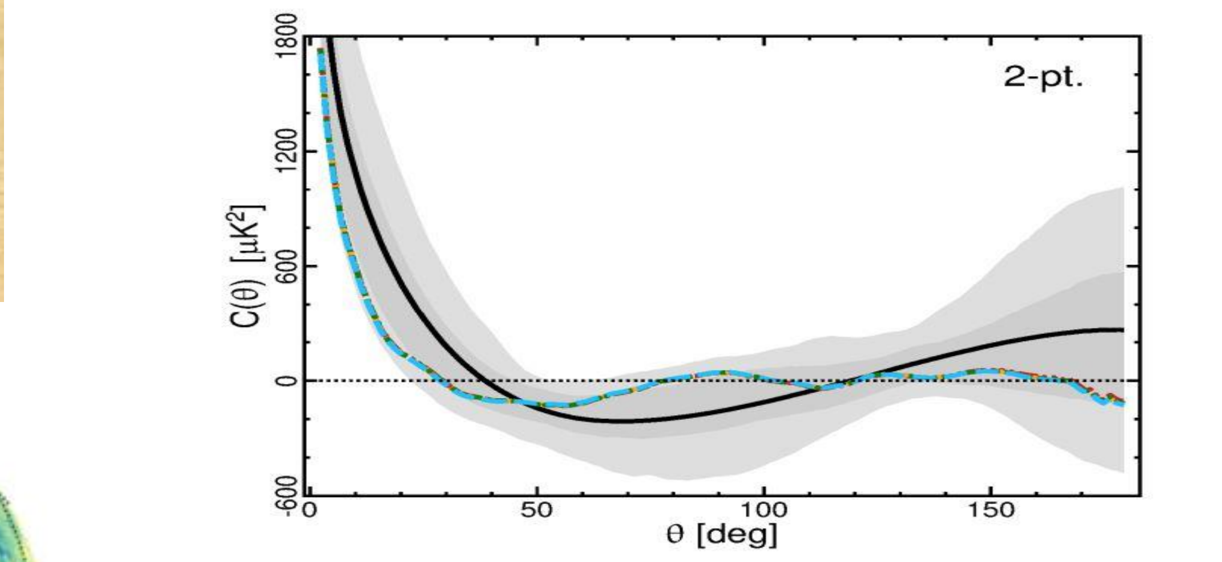
Other observed anomalies in the CMB may also be explained, at least partially, by these foregrounds.

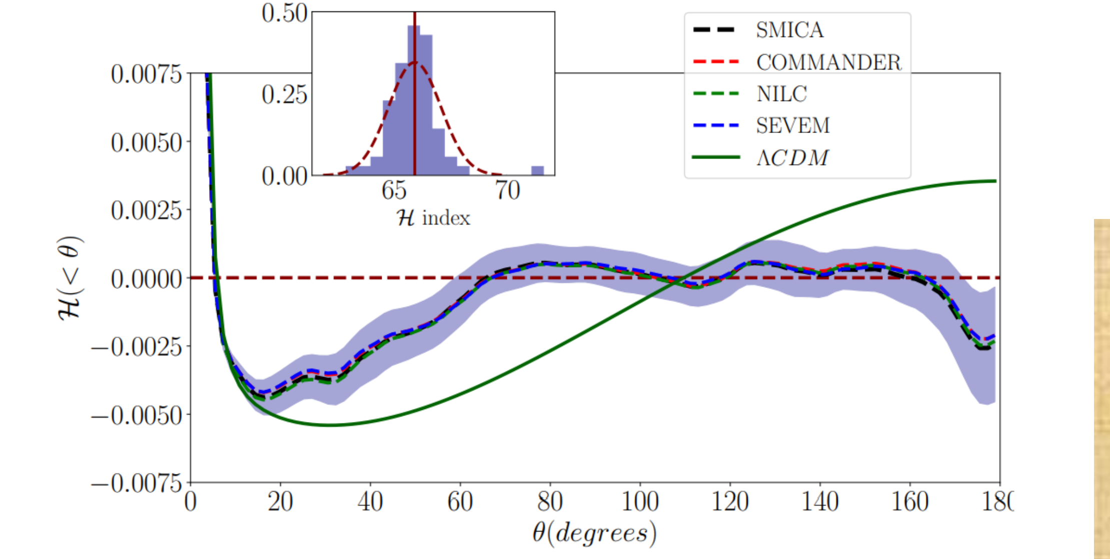
Several cosmological parameters may need to be revised.

CMB correlations/homogeneity scale at large separations

Casual horizons ?



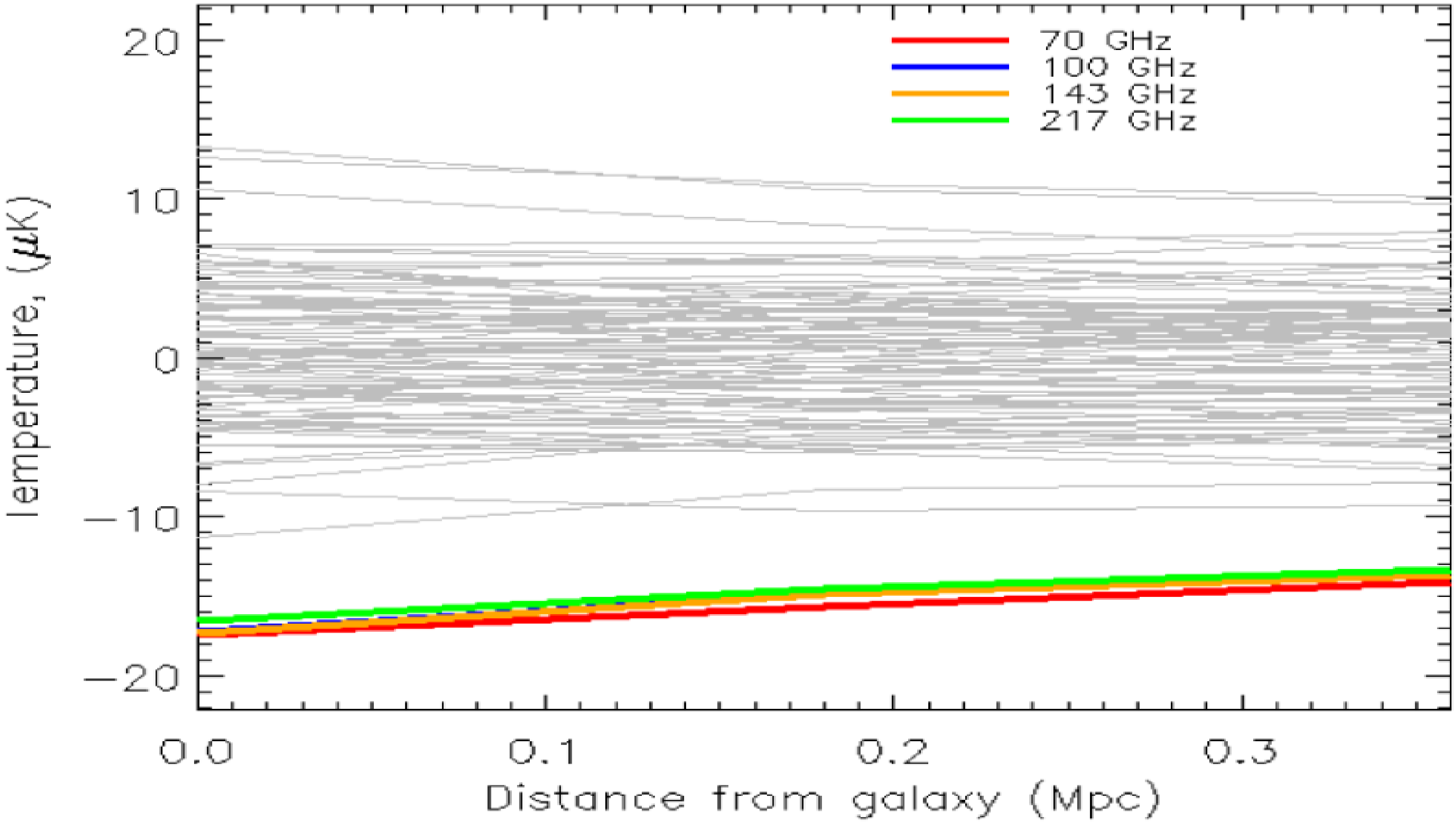




Fosalba & Gaztañaga 2021

Camacho & Gaztañaga 2021

Frequency dependence, SEVEM frequency cleaned maps



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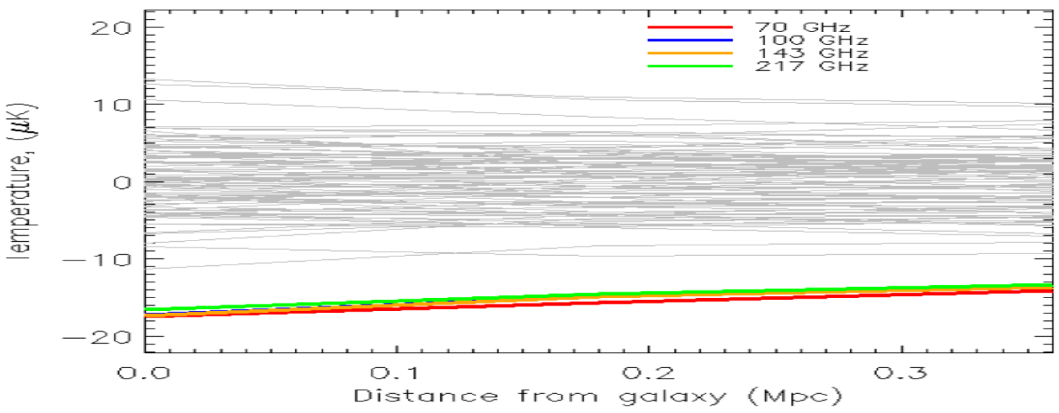
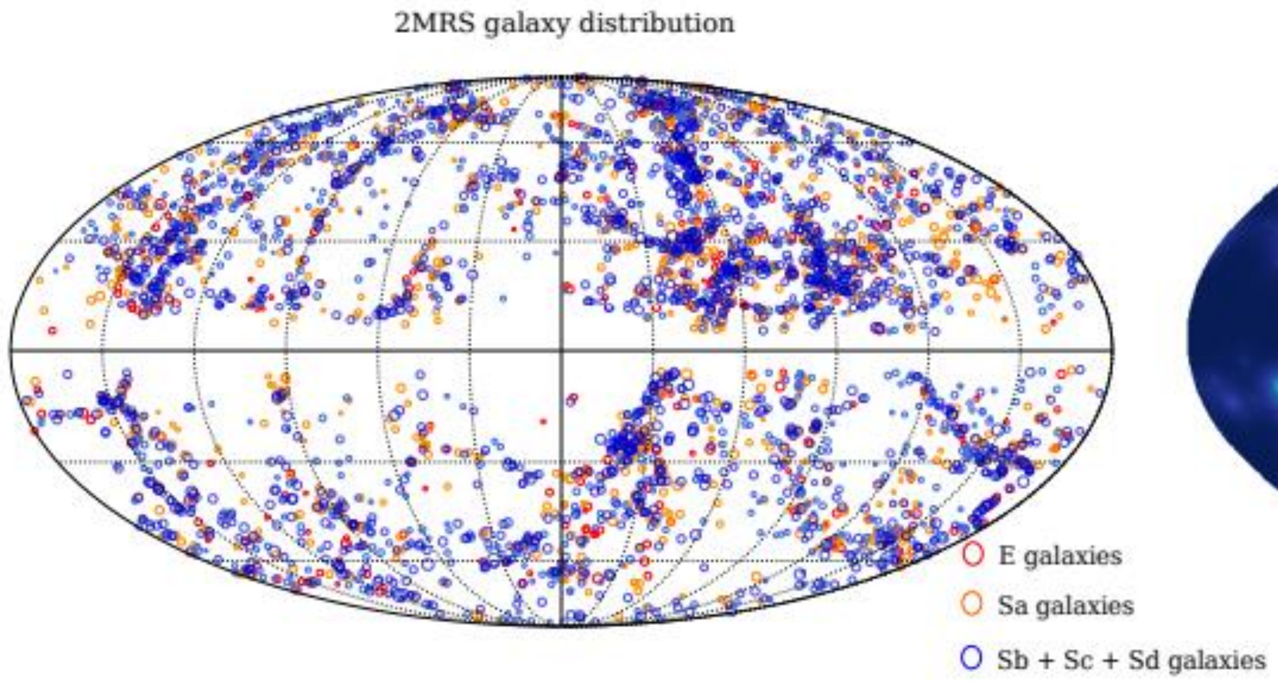
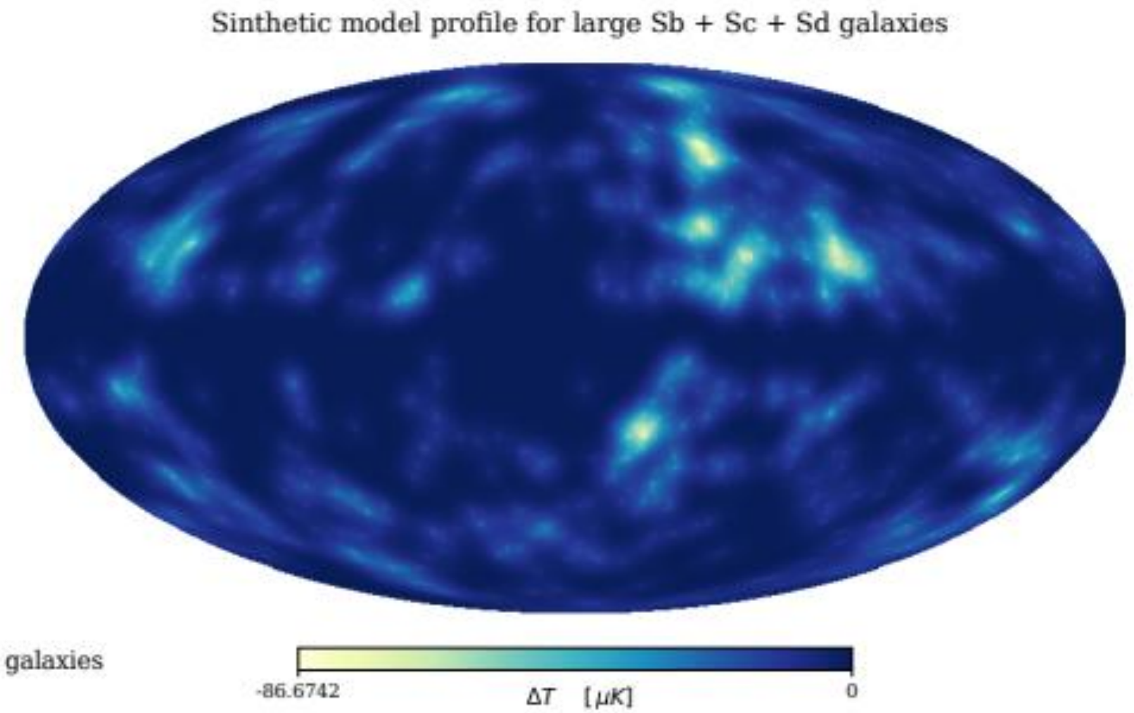


Either a molecular (not affecting the shape of the pristine CMB spectrum)

or other, yet unknown interaction





Thank you very much !