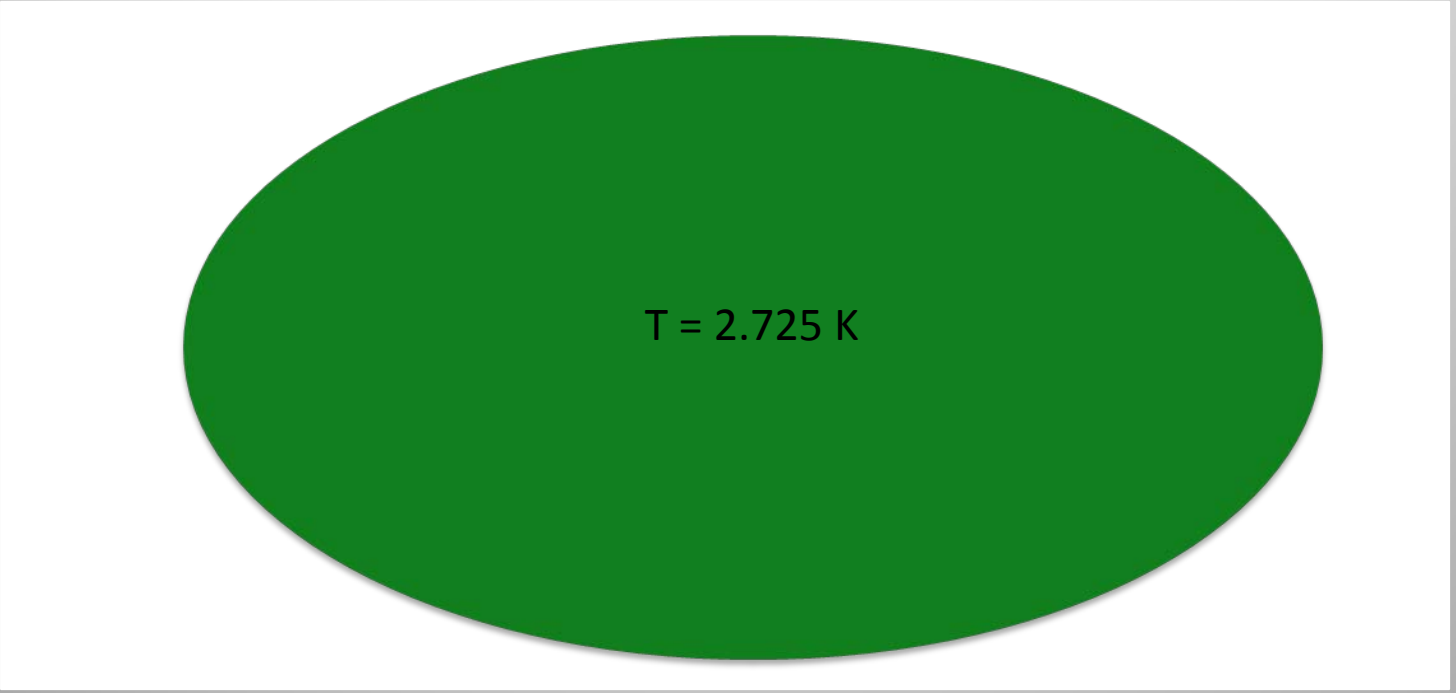
Testing Statistical Isotropy of the CMB: The Effect of Foreground on Low-l Multipoles

Jeremy D. Bradford
with
Dr. Dragan Huterer

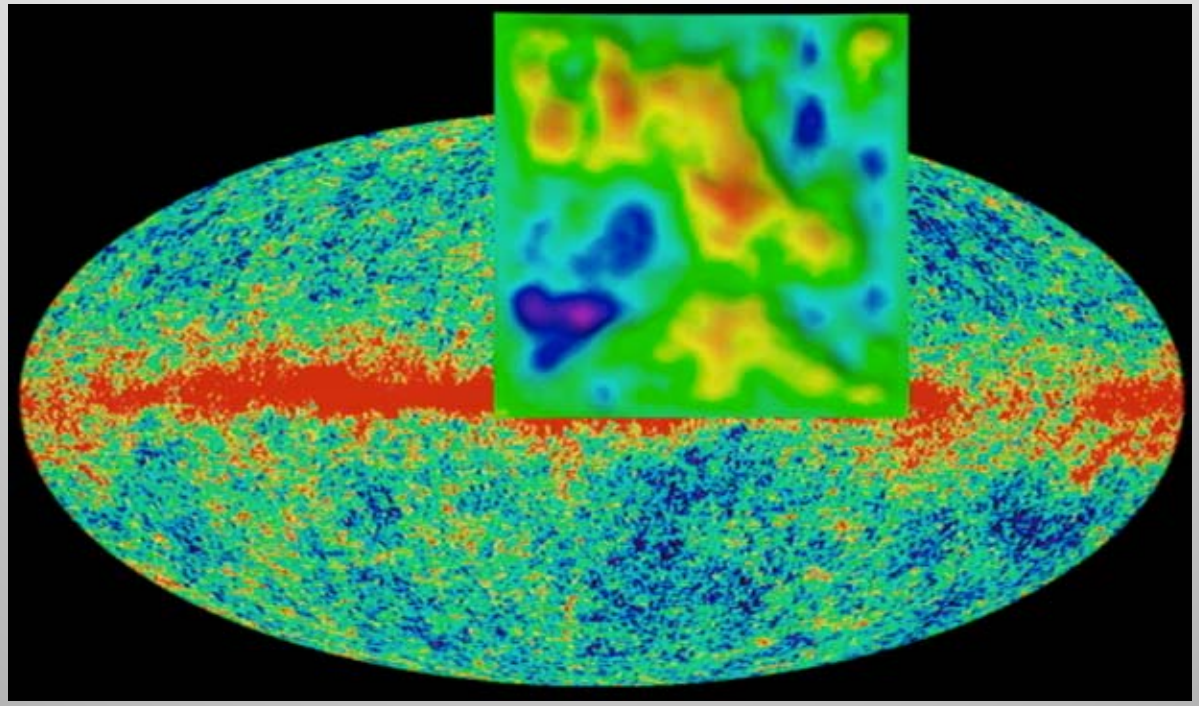
July 28, 2010

The Universe is Isotropic and Homogeneous



- The universe looks the same in all directions
- The universe is uniform, regardless of position

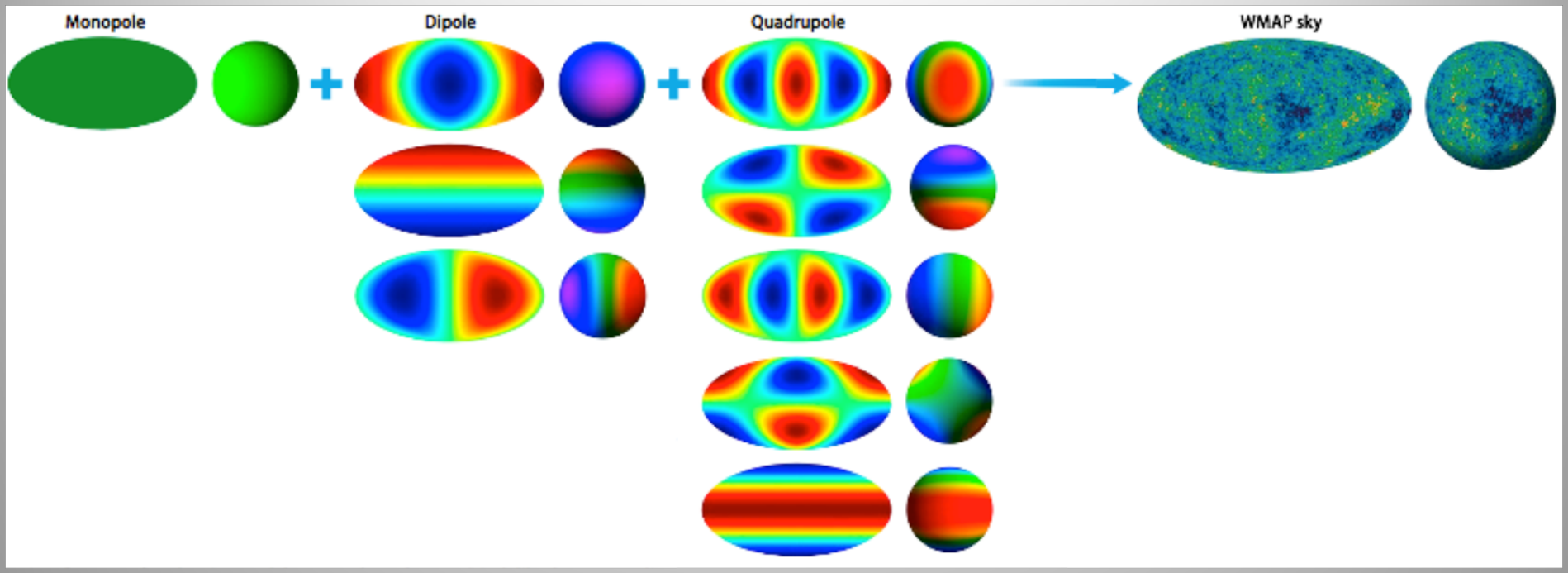
Temperature Differences



- The CMB is isotropic, but has hot and cold spots

- We are interested in the differences in temp **ΔT/T**, we call the differences anisotropies, and they are distributed like a bell-shaped curve

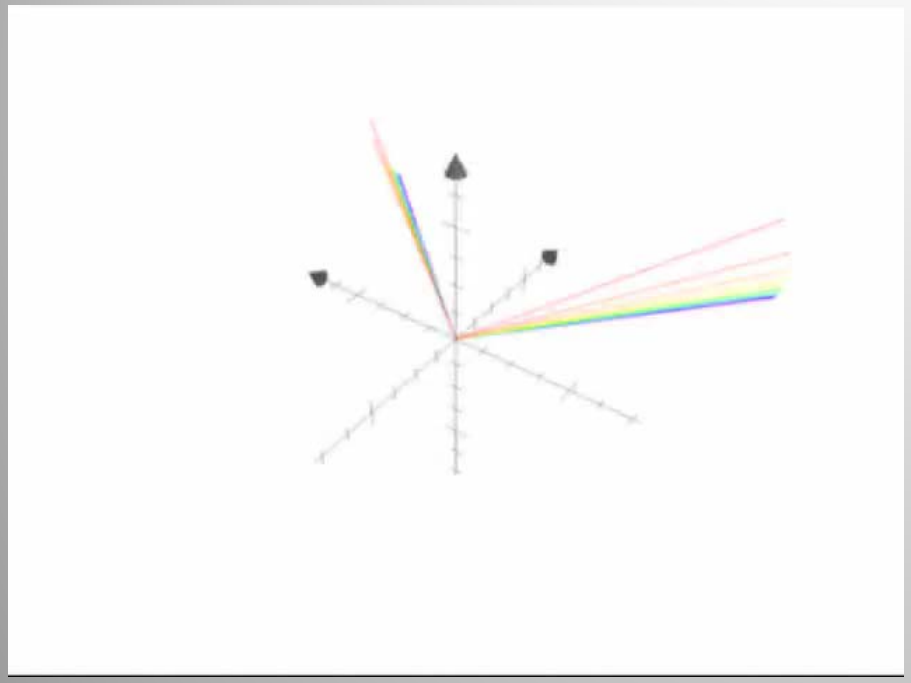
Decomposing the Universe

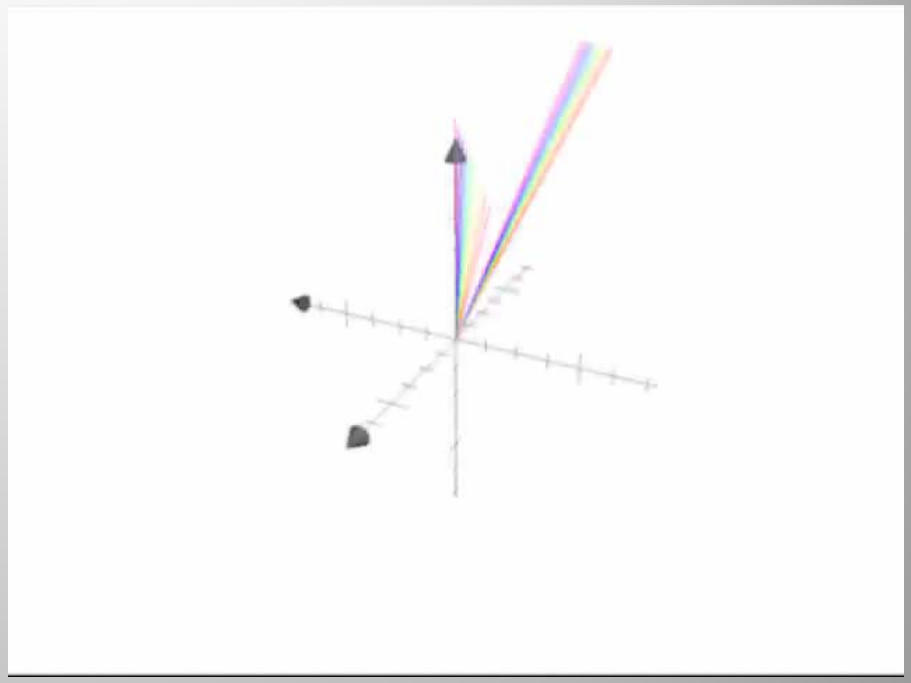


- The CMB can be decomposed into multipoles using the usual spherical harmonics

- We can also decompose the CMB sky into vectors

Project Goal

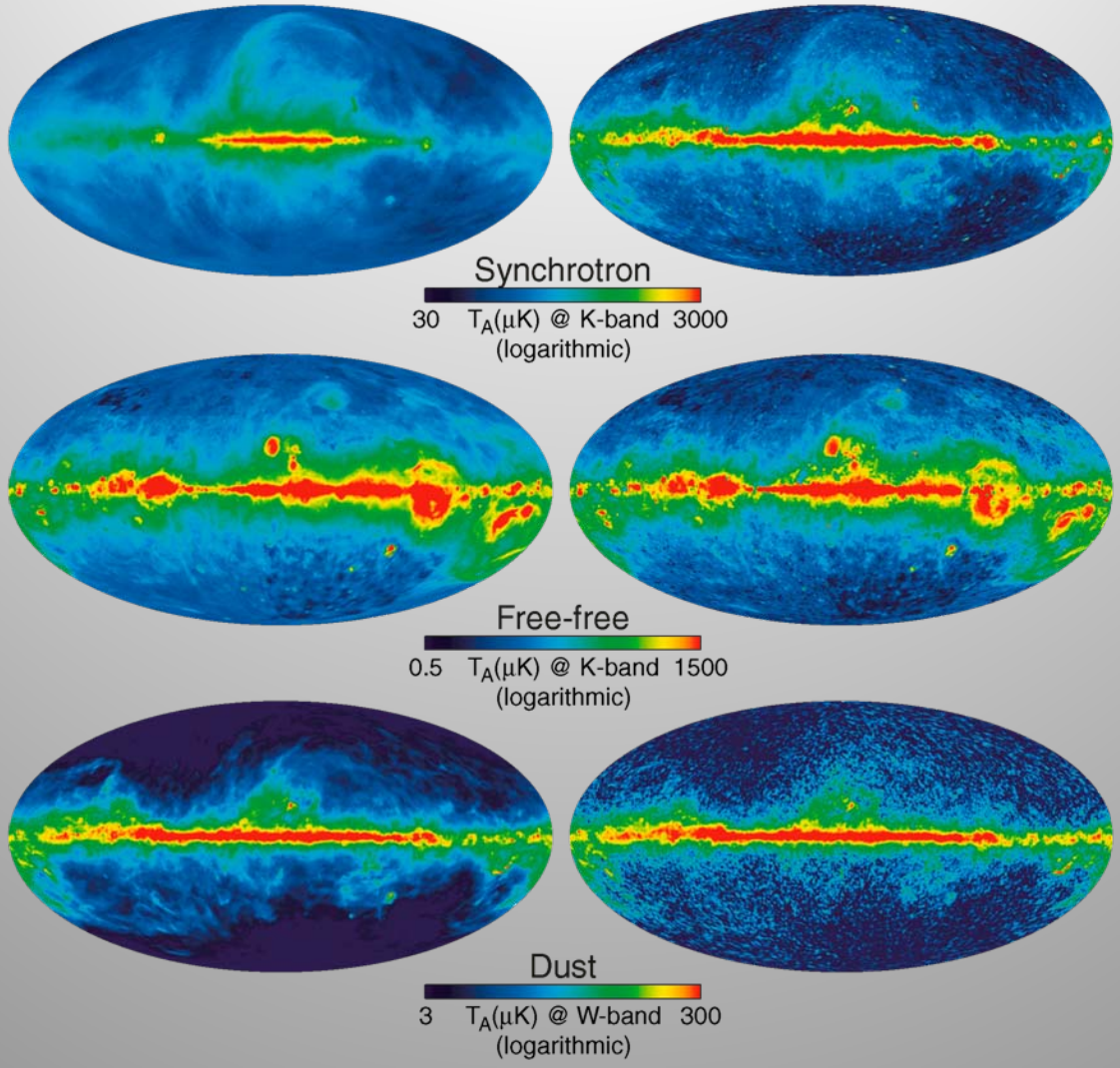




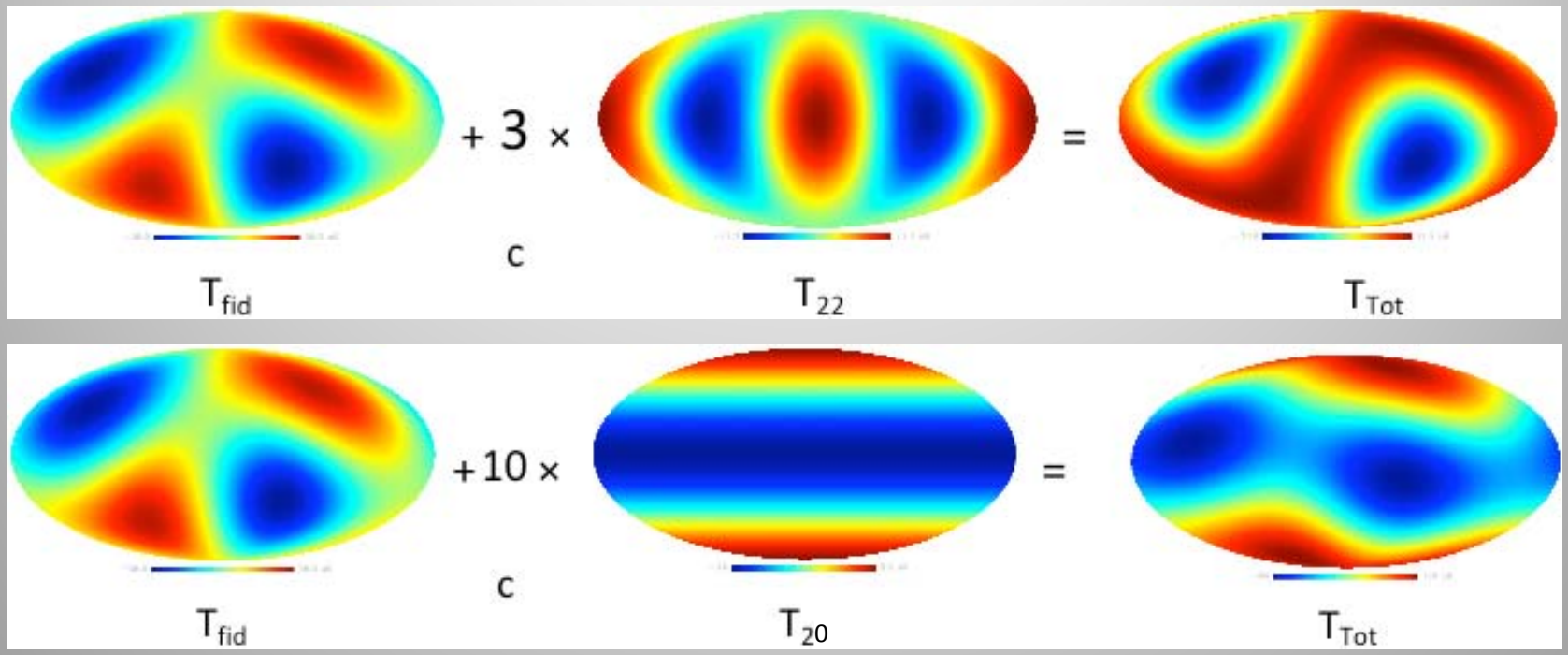
- My goal was to see how sensitive we need to be to detect violations of statistical isotropy, using multipole vectors

- Accomplished this with Monte-Carlo simulations and multipole vectors to test for statistical isotropy

Foregrounds: Deviations from Gaussianity

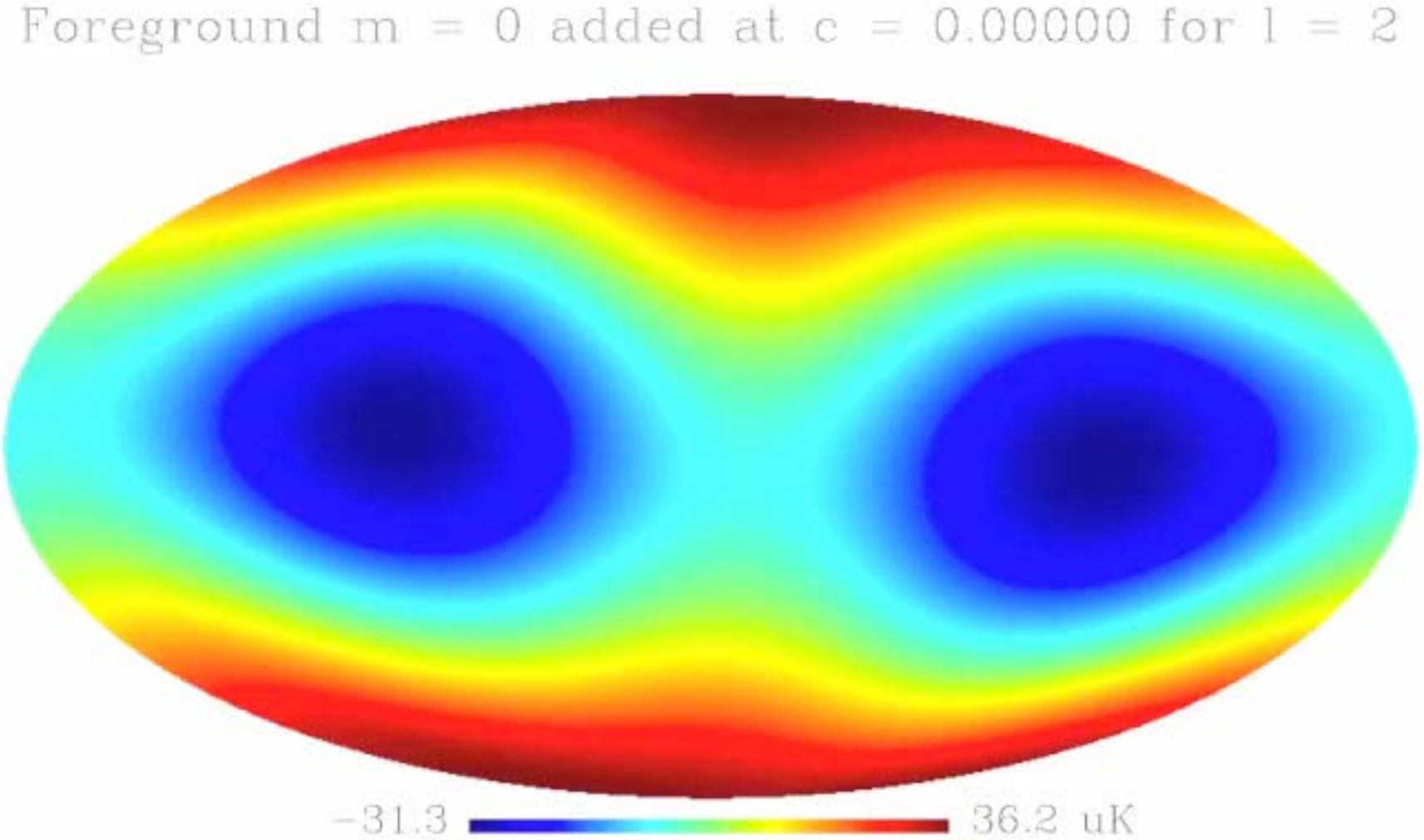


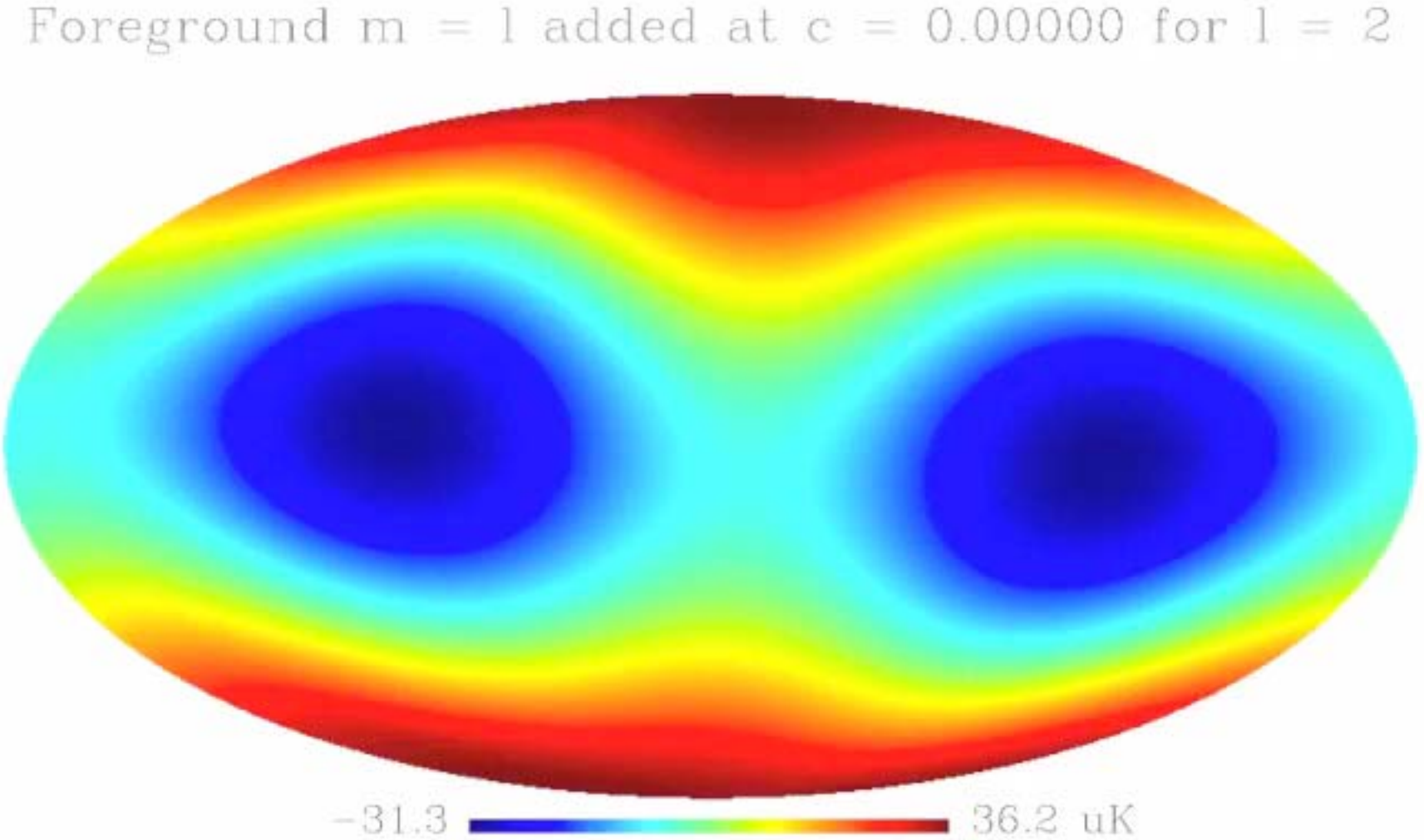
Adding Foregrounds to the Quadrupole



- We used two control foregrounds to test with, we knew what to expect

- Tested for what the picture looked like after foreground was added at various c's


Foreground m = 0 added at c = 0.00000 for l = 2
-31.3
36.2 uK


Foreground m = 1 added at c = 0.00000 for l = 2
-31.3
36.2 uK

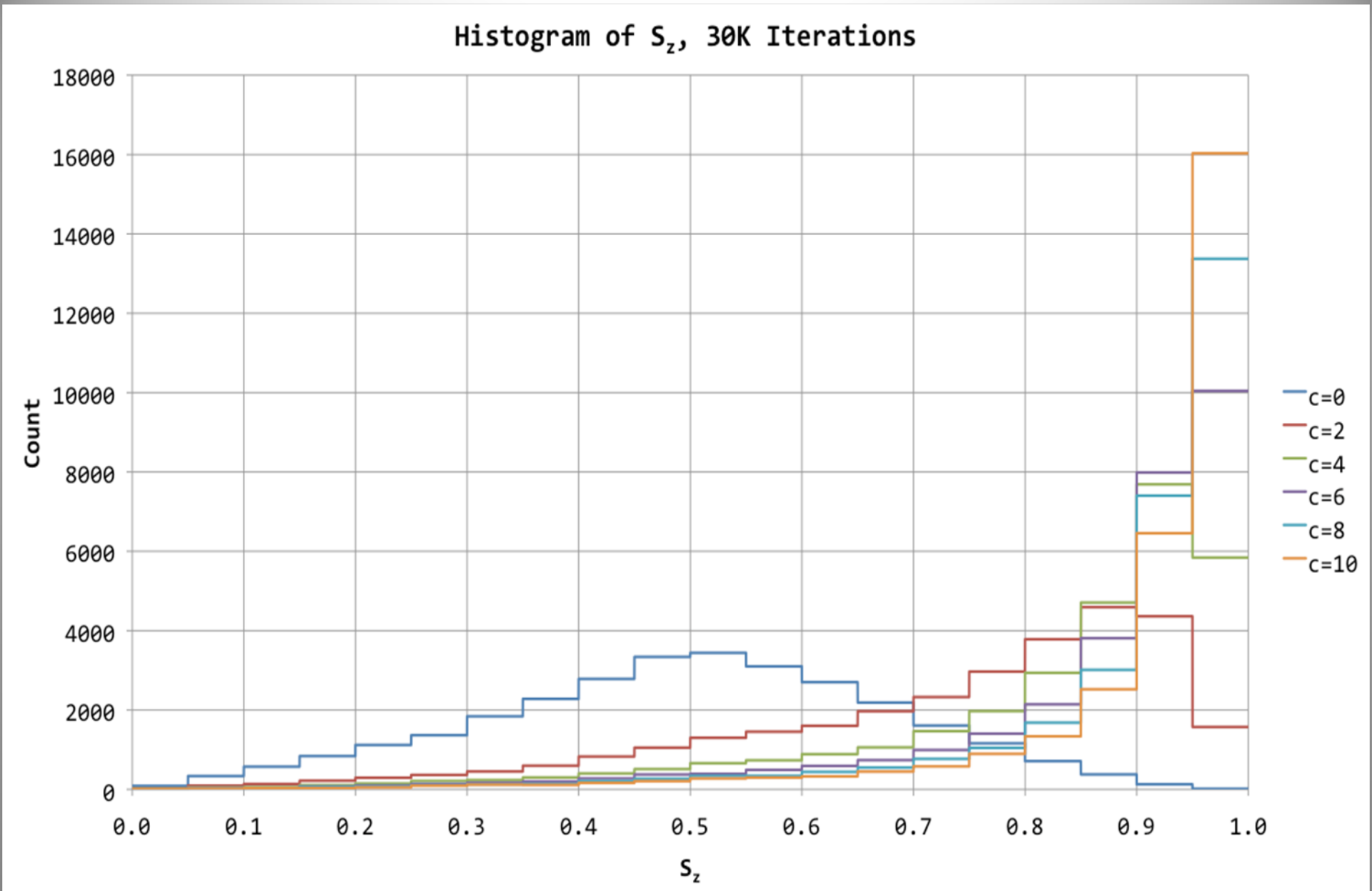
Measuring Changes in the Vectors

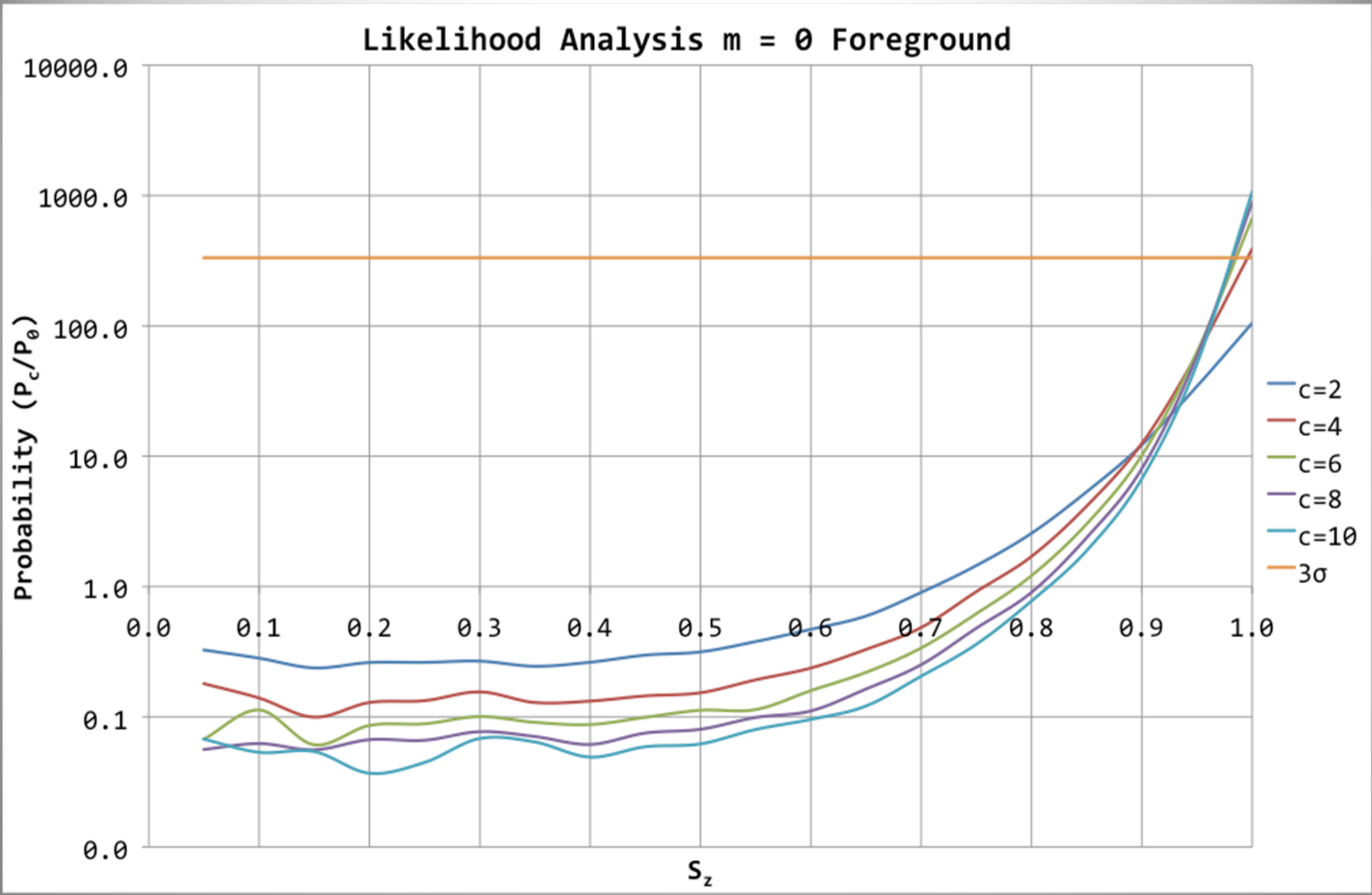
$$S_z = \frac{(\hat{v}^{2,1} + \hat{v}^{2,2}) \cdot \hat{z}}{2}$$

$$S_n = \frac{\hat{v}^{2,1} \times \hat{v}^{2,2}}{|\hat{v}^{2,1} \times \hat{v}^{2,2}|} \cdot \hat{z}$$

- We came up with statistics that we knew would measure the changes in the vectors

- The changes in the vectors were always proportional to the amount of foreground, and demonstrated deviations from statistical isotropy


Histogram of S_z, 30K Iterations
Count
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
S_z
c=0
c=2
c=4
c=6
c=8
c=10


Likelihood Analysis m = 0 Foreground
10000.0
1000.0
100.0
10.0
1.0
0.1
0.0
Probability (Pc/Pθ)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Sz
c=2
c=4
c=6
c=8
c=10
3σ

The End

Thank You

Sources

Bibliography within report.

All borrowed graphics are courtesy of NASA: http://map.gsfc.nasa.gov and Dr. Dragan Huterer.

Graphics generated with NASA's HEALPix software, Mac's Grapher program, Maple, MS Excel.