Tibet空気シャワーアレイ / SK による 10TeV宇宙線強度の恒星時日周変動の観測

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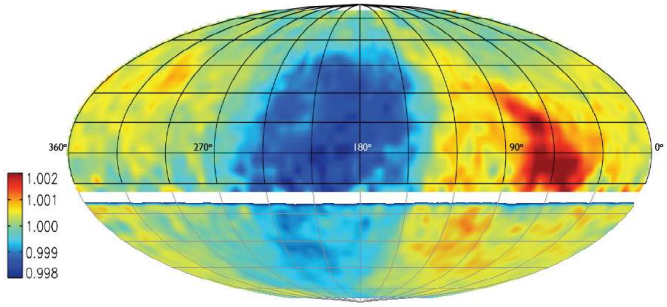
瀧田正人（ICRR）

旅費（松本⇔柏）：50千円（SK）/ 50千円（Tibet）

- CR anisotropy WS (10-13 Oct. 2017 in Mexico)
- Anisotropy models (brief review)
- ~100 TeV CR anisotropy



Tibet ASγ (7 TeV)
(Amenomori et al., Science, 314, 2006)

Ice Cube (20 TeV)
(Abbasi et al., arXiv:1005.2960v1, 2010)

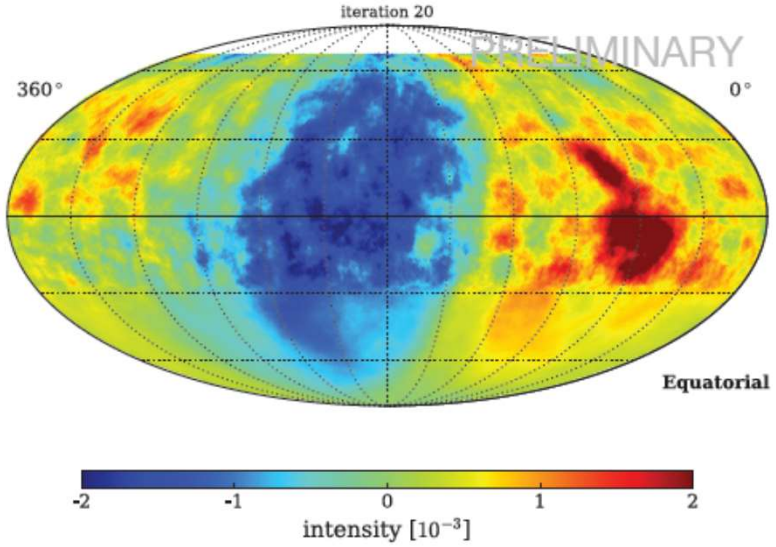
Cosmic Ray Anisotropy WS 報告

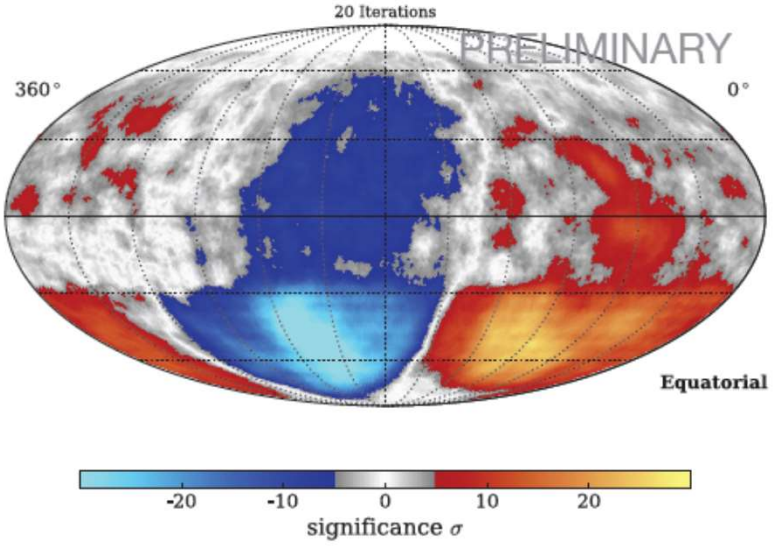
(Oct.10-13, 2017 @Guadalajara, Mexico)

- ~10 TeV anisotropy
  - ✓ HAWC-IceCube observation
  - ✓ Heliospheric modulation
  - ✓ Declination projection bias
  - ✓ ARGO-YBG (LAASO)
- <100 TeV anisotropy
  - ✓ Local structures?
  - ✓ Magnetic turbulence?
- Auger's dipole anisotropy
- AMS-CALET

HAWC (1yr) - IceCube (5yrs) @~10 TeV

Juan Carlos (arXiv:1601.07877)

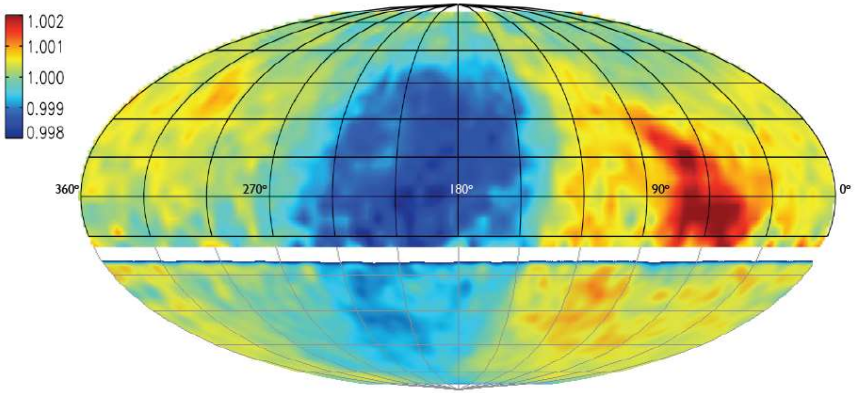


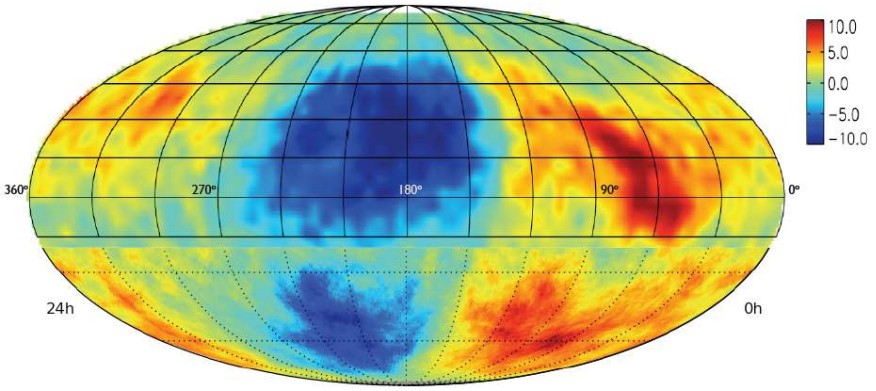


intensity

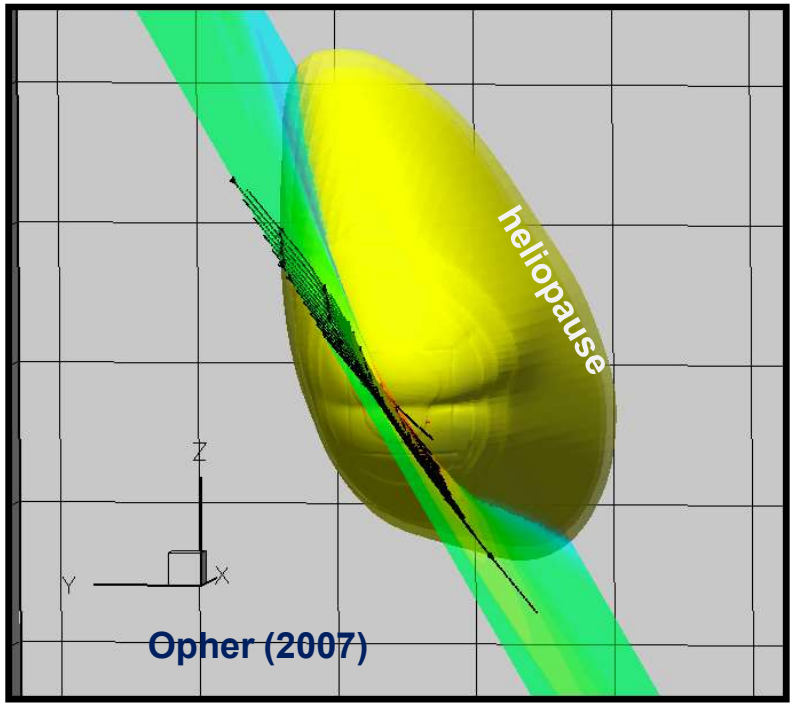
significance

Tibet (10yrs) @7 TeV - IceCube (1yr) @~20 TeV



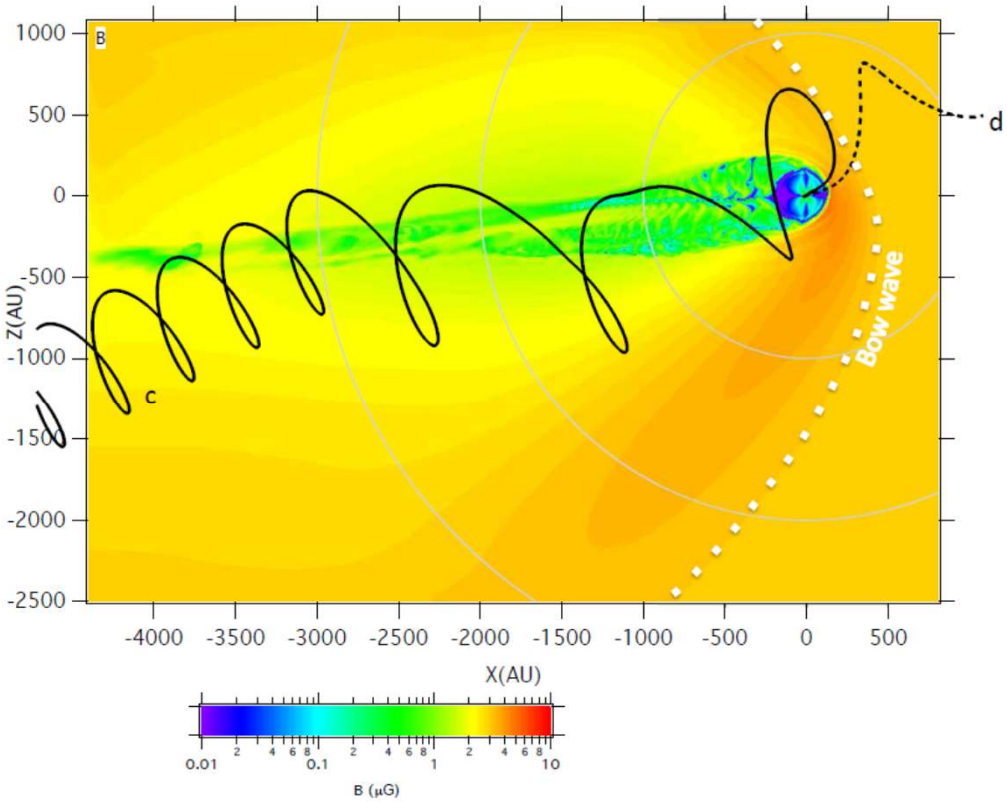


Heliospheric “distortion” model



Opher (2007)

M. Zhang (J. of Physics conf. ser. 767 012027 2016)



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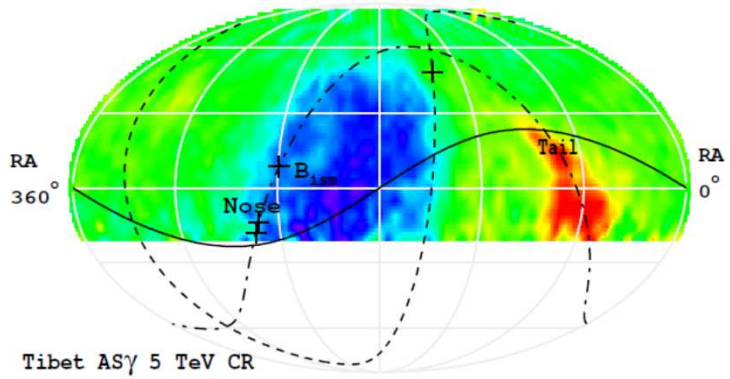
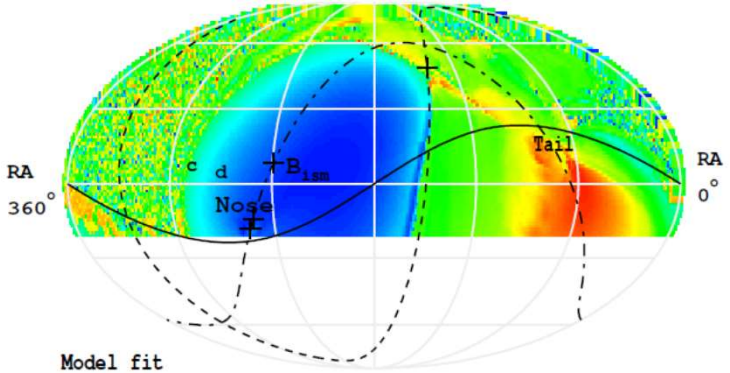
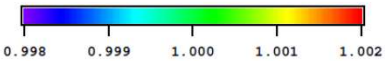
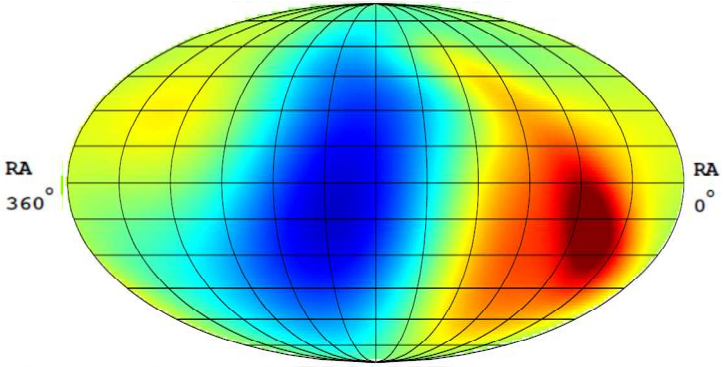


Tibet ASγ 5 TeV CR
Anisotropy measurement

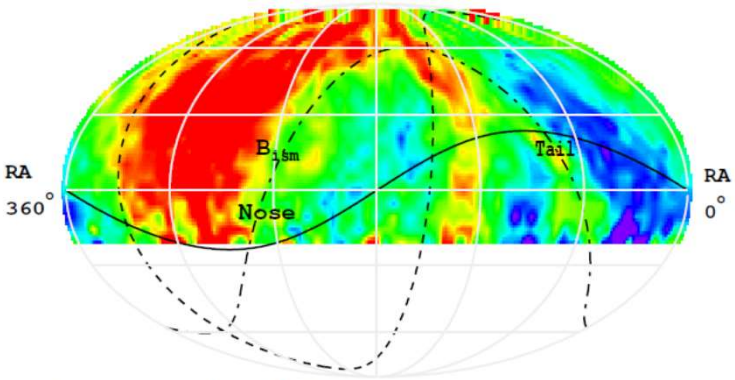


Model fit

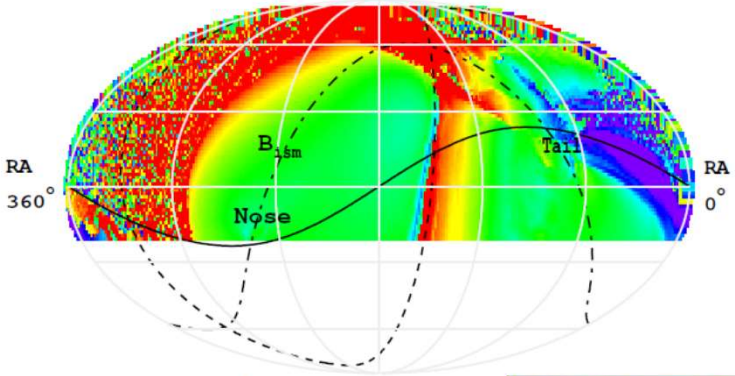




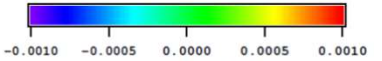
Inferred anisotropy in ISM



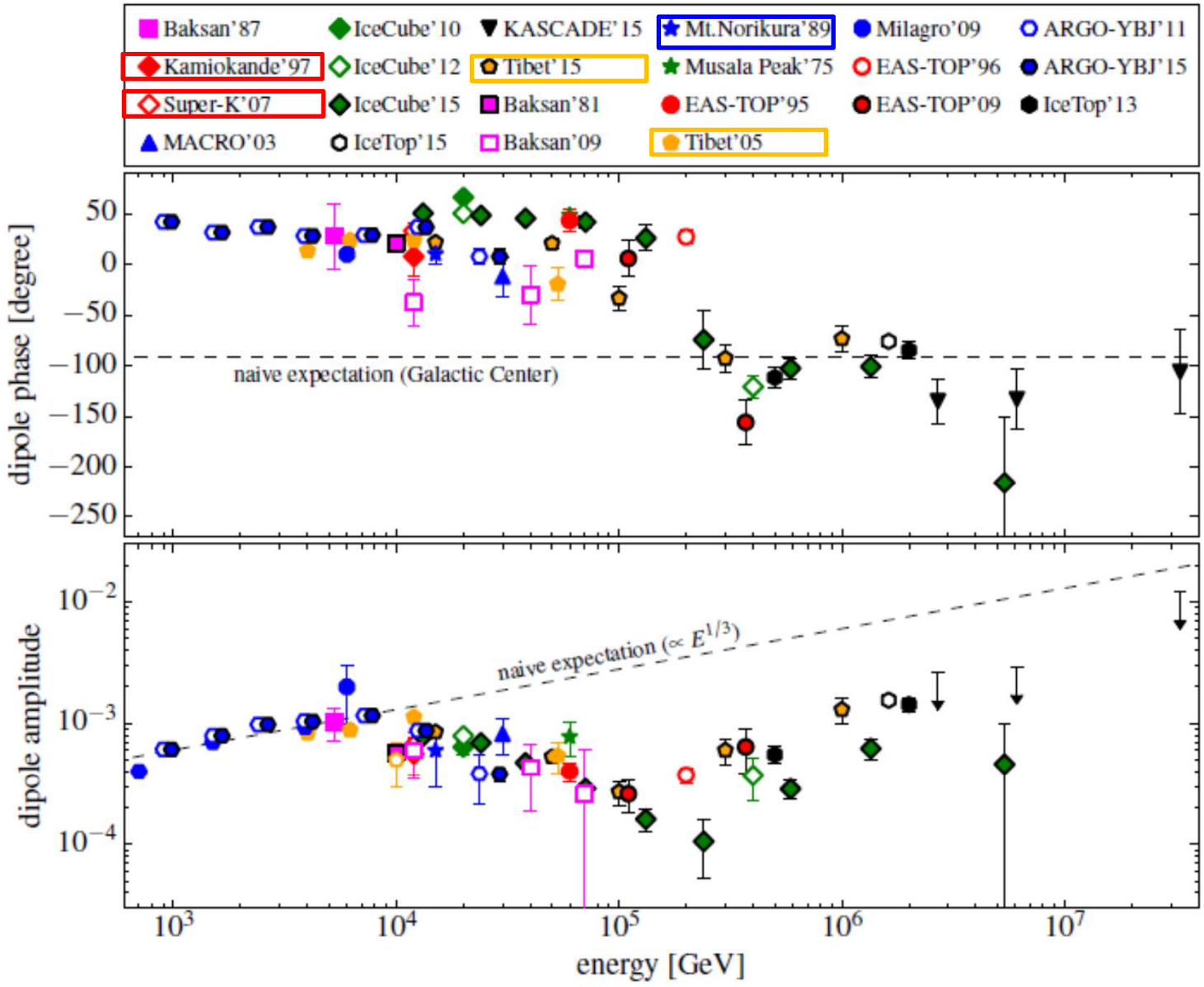
Measurement - inferred ISM



Model - Inferred ISM



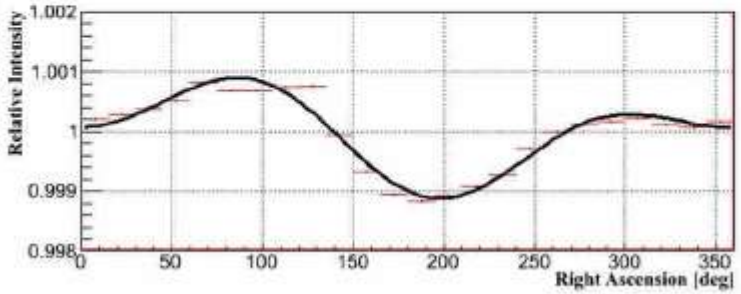
Observed Dipole Amplitude and Phase



[MA'16]

High energies (>100 TeV) with ARGO—YBJ

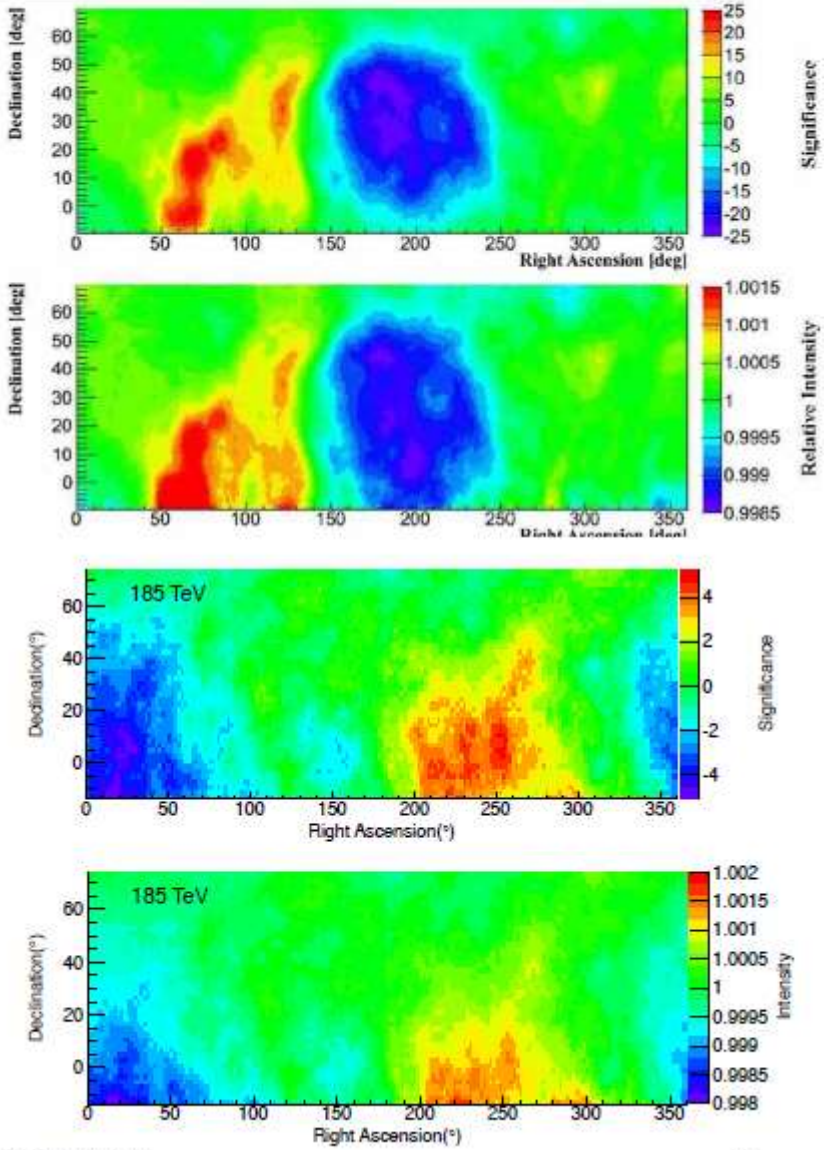
At 185 TeV dramatic change of anisotropy !



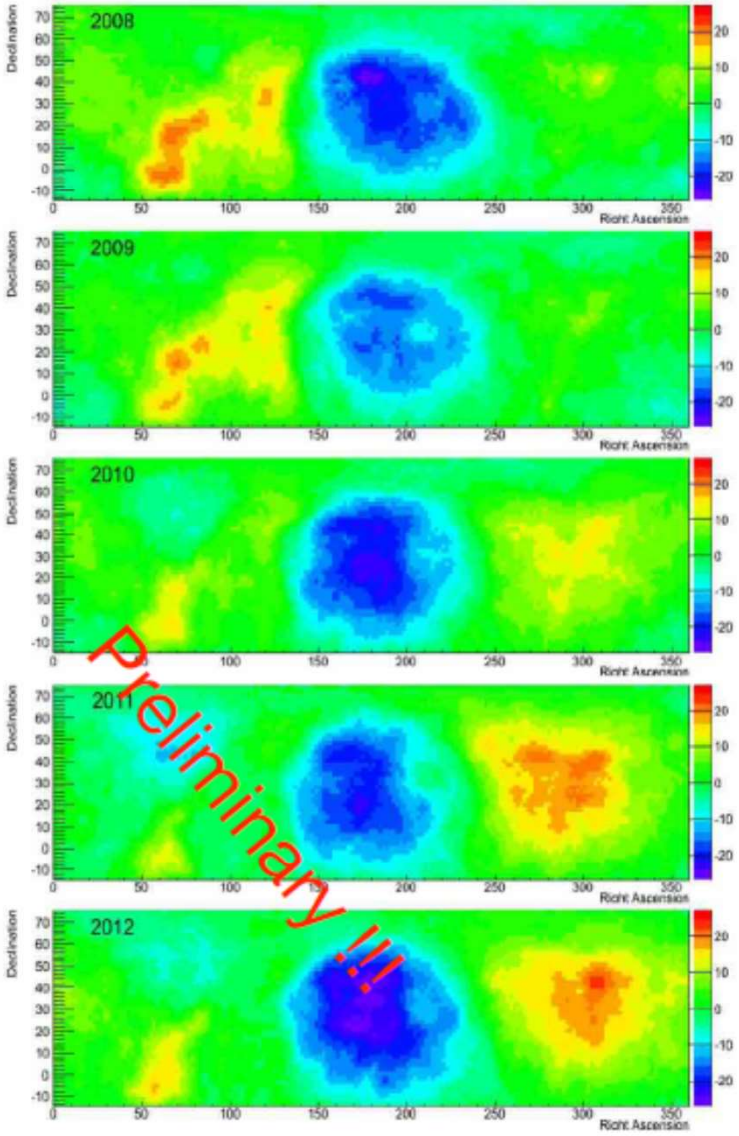
excess region: $\alpha \approx 240°$

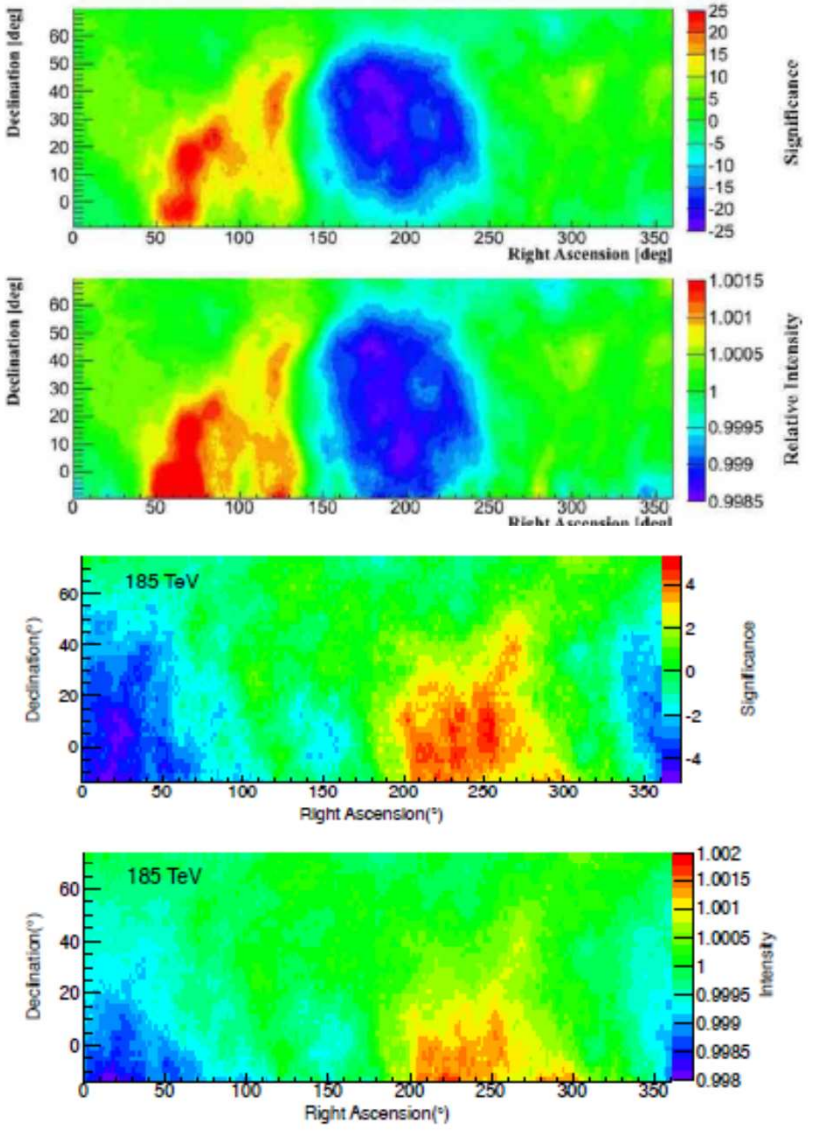
deficit region: $\alpha \approx 70°$

consistent with IceCube/IceTop and Tibet ASγ results



Years (TeV) vs Energy (TeV and 200 TeV)





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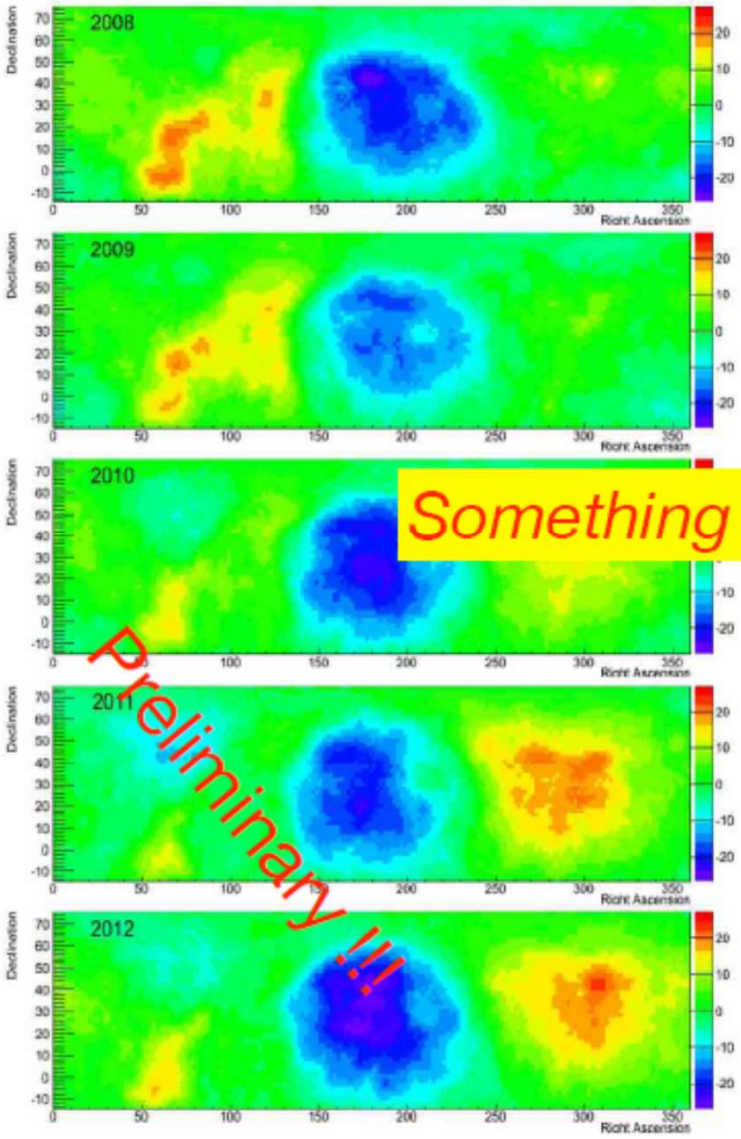
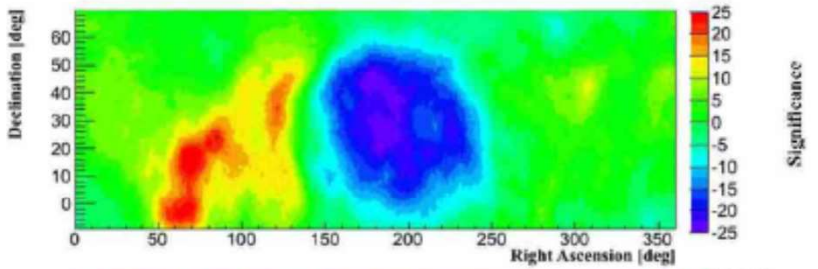
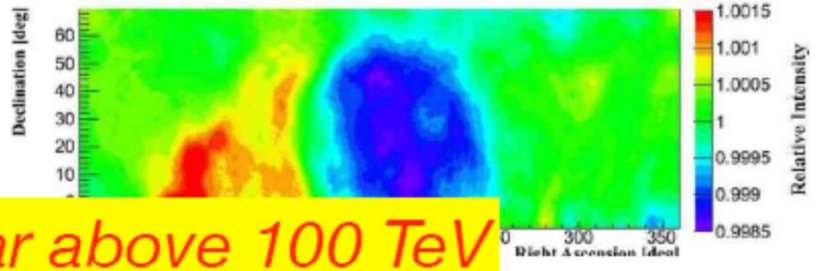
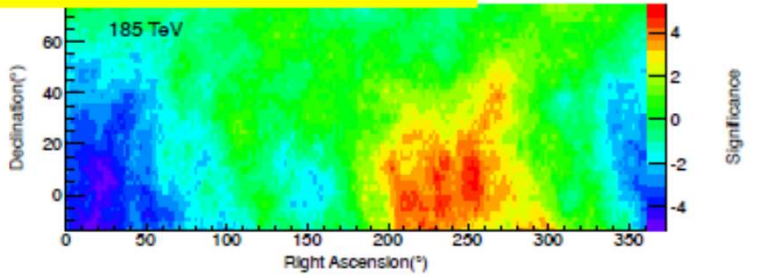


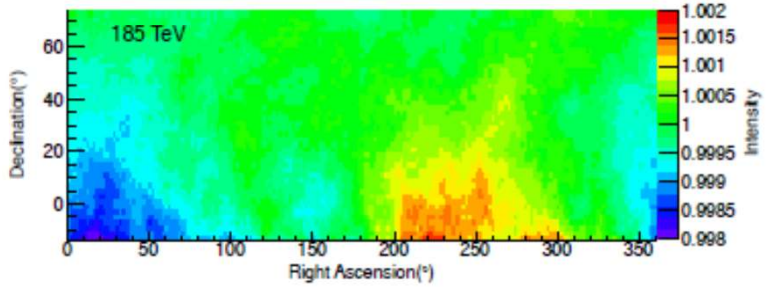
Preliminary !!!



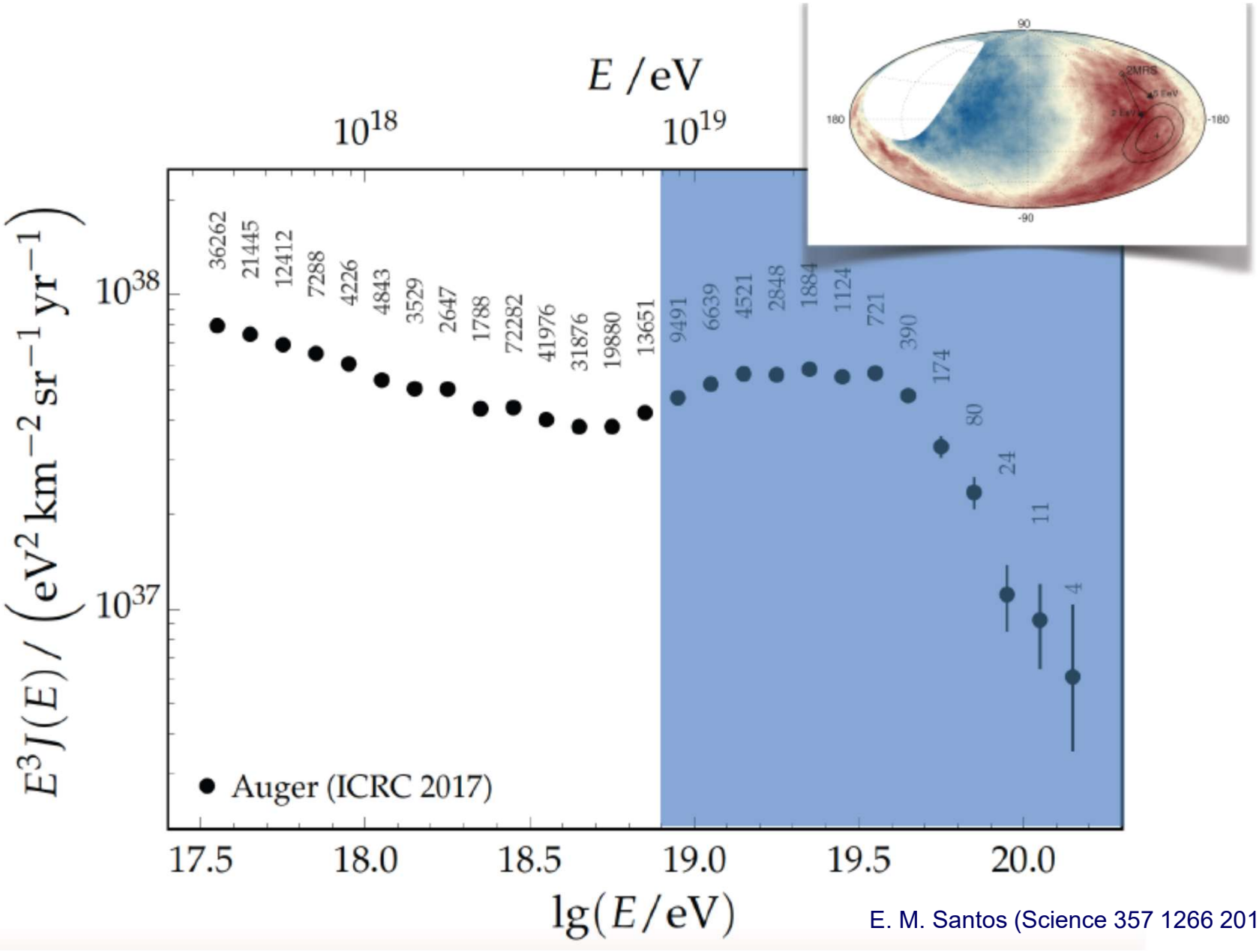


Something similar above 100 TeV





Dipole anisotropy by Auger



E. M. Santos (Science 357 1266 2017)

Dipole detection

Analysis of first harmonic modulation in RA and azimuth

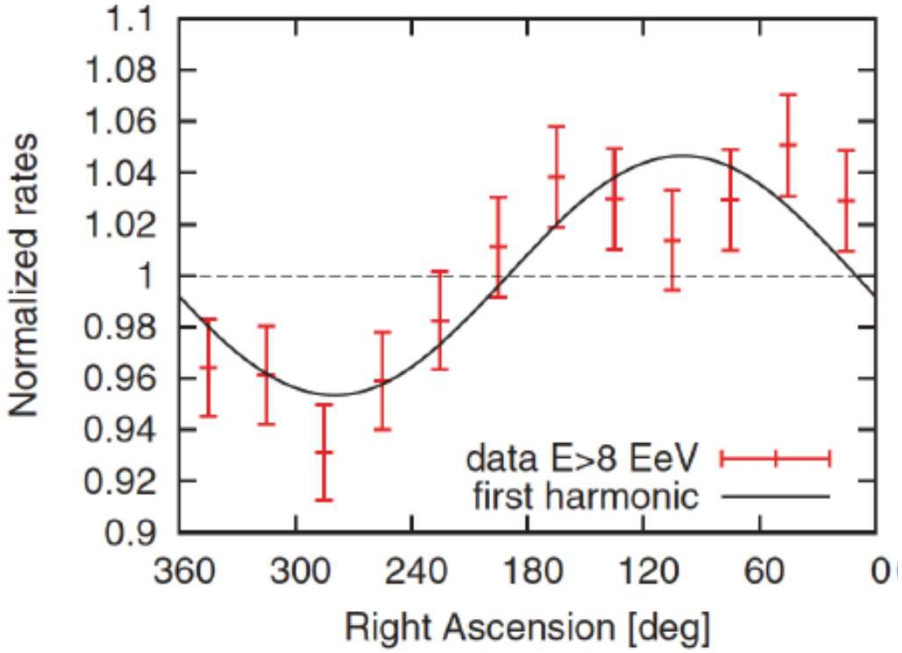
$$a_\alpha = \frac{2}{\mathcal{N}} \sum_{i=1}^{N} w_i \cos \alpha_i$$

Account for non-uniformities of the exposure in RA and a slight tilt of the array

$$b_\alpha = \frac{2}{\mathcal{N}} \sum_{i=1}^{N} w_i \sin \alpha_i$$

Amplitude and phase of modulation

$$r_\alpha = \sqrt{a_\alpha^2 + b_\alpha^2} \qquad \tan \varphi_\alpha = \frac{b_\alpha}{a_\alpha}$$

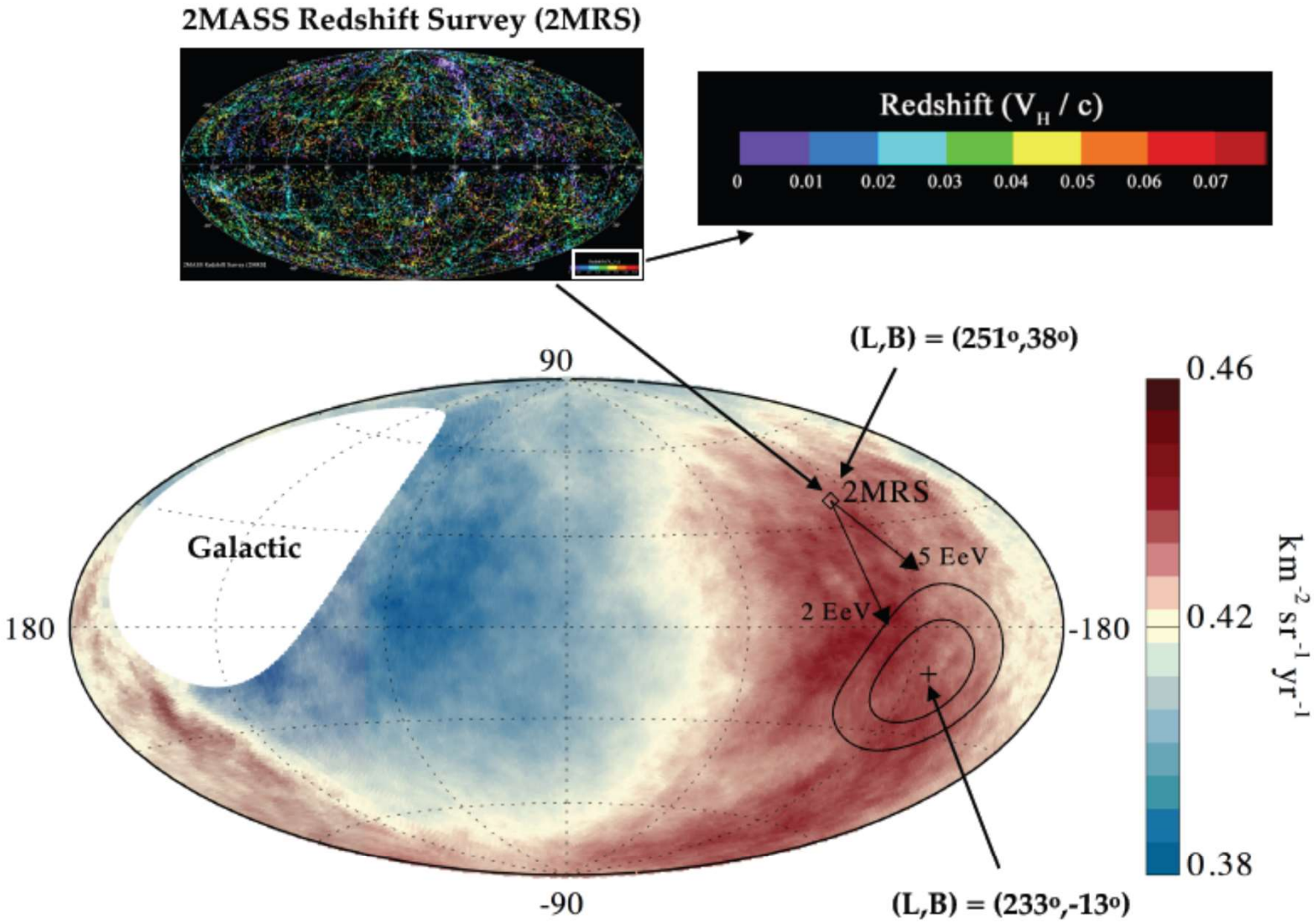


Energy (EeV)	Number of events	Fourier coefficient a_α	Fourier coefficient b_α	Amplitude r_α	Phase φ_α (°)	Probability $P(\geq r_\alpha)$
4 to 8	81,701	0.001 ± 0.005	0.005 ± 0.005	$0.005\ ^{+0.006}_{-0.002}$	80 ± 60	0.60
≥8	32,187	−0.008 ± 0.008	0.046 ± 0.008	$0.047\ ^{+0.008}_{-0.007}$	100 ± 10	2.6×10^{-8}

pre-trial probability:

$$P(\geq r_\alpha) = \exp\left(-\frac{N r_\alpha^2}{4}\right)$$

- 5.6 σ pre-trial signal
- 5.2 σ post-trial (penalized for scan in 2 energy bin)



Typically, 5-20% dipole amplitudes can be obtained from local inhomogeneities and diffusion through magnetic fields depending on CR composition