A13,E26: 高エネルギー宇宙線強度の恒星時異方性の観測

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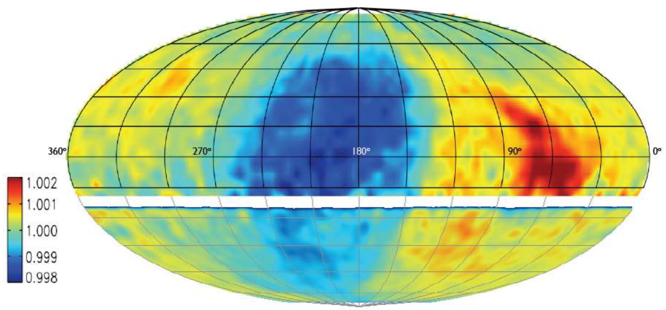
旅費（松本⇔柏）: 200千円

Heliospheric distortion model using MHD heliosphere by Washimi & Tanaka

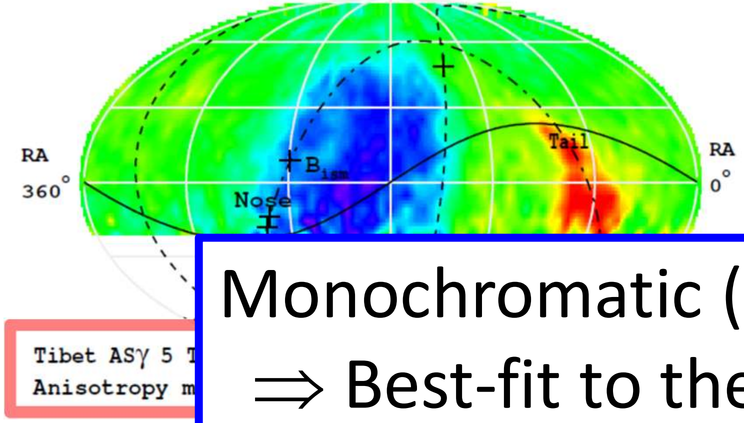


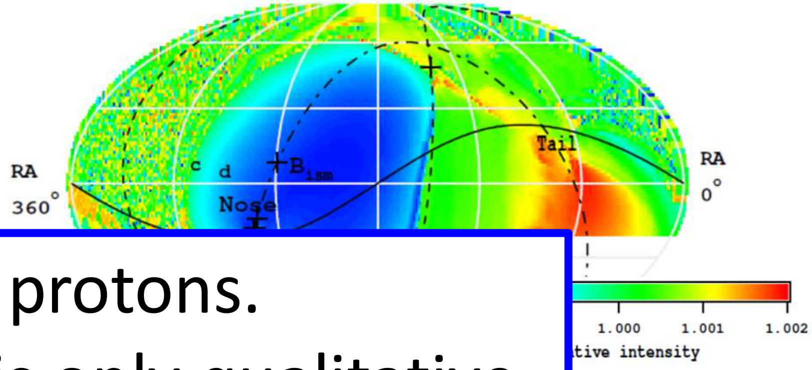
Tibet ASγ (7 TeV)
(Amenomori et al., Science, 314, 2006)

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

Heliospheric distortion model

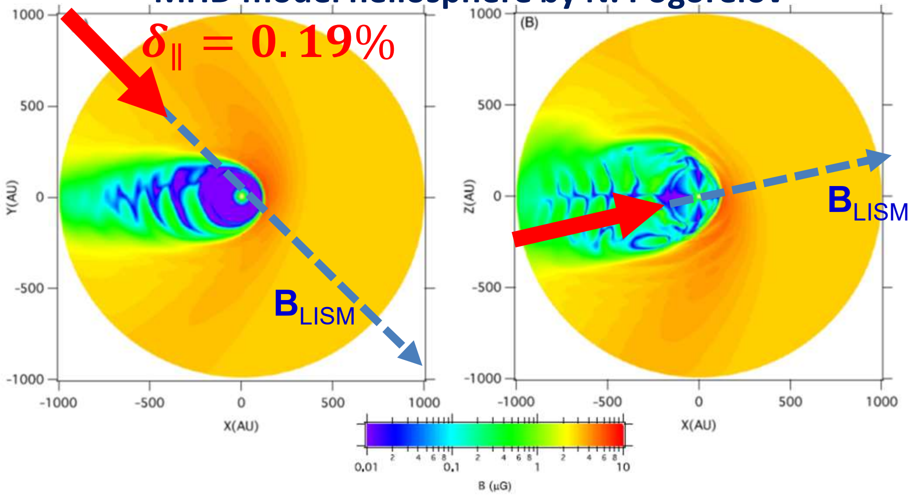
M. Zhang (J. of Physics conf. ser. 767 012027 2016)





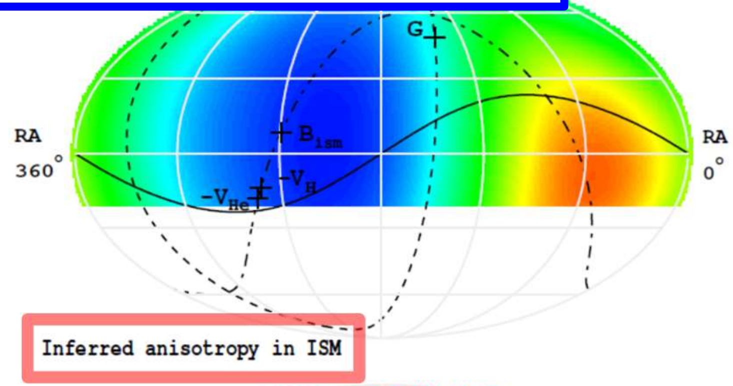
Monochromatic (5 TeV) protons.

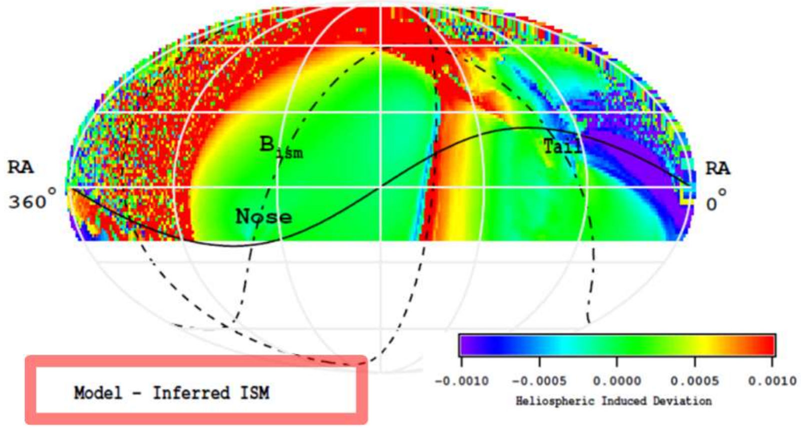
$\Rightarrow$ Best-fit to the data is only qualitative.



Observed features is reproduced by…

- ➢ $\delta_{\parallel}$ + heliospheric distortion
- ➢ CR "ring" along the B_{LISM} equator

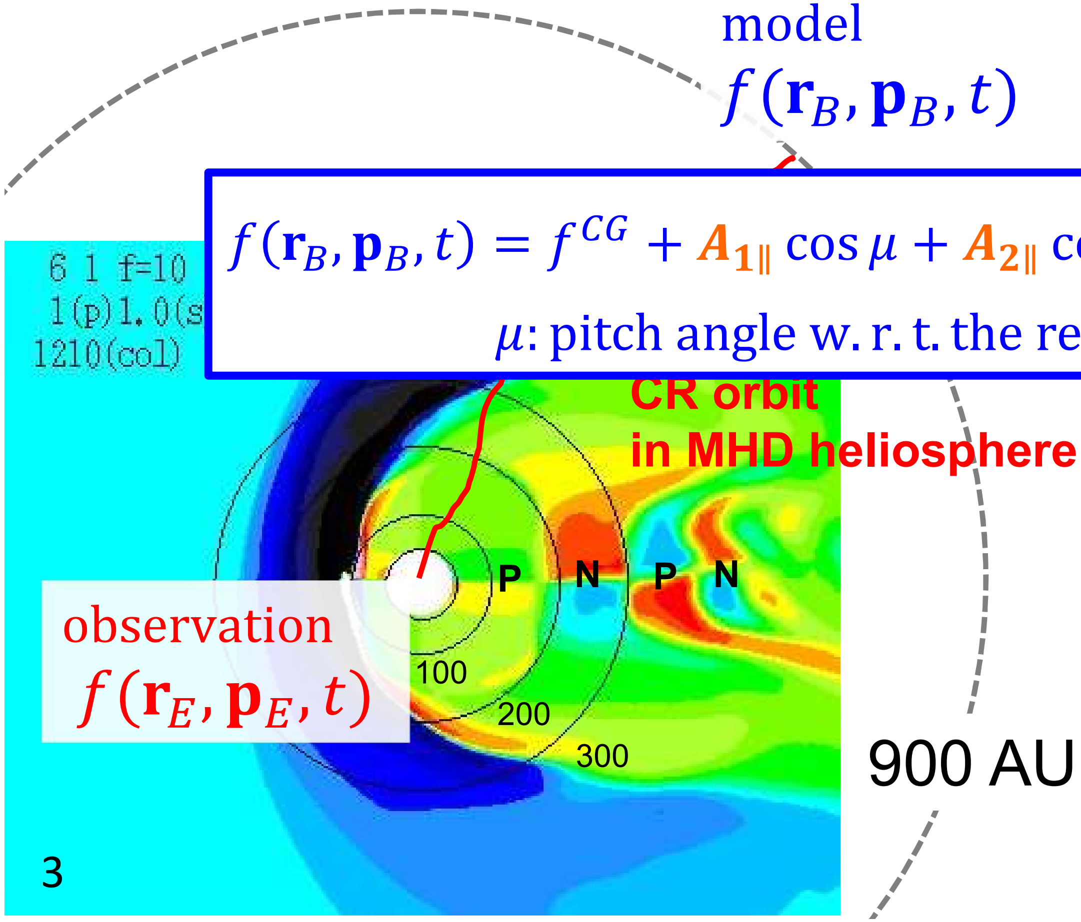




Phase-space density of CRs: $f(\mathbf{r}, \mathbf{p}, t)$

$$Df = \frac{\partial f}{\partial t} + \frac{d\mathbf{r}}{dt}\cdot\frac{\partial f}{\partial \mathbf{r}} + \frac{d\mathbf{p}}{dt}\cdot\frac{\partial f}{\partial \mathbf{p}} = \left(\frac{\partial f}{\partial t}\right)_c \approx 0$$

$$\frac{d\mathbf{p}}{dt} = Ze\left(\mathbf{E} + \frac{d\mathbf{r}}{dt}\times\mathbf{B}\right)$$



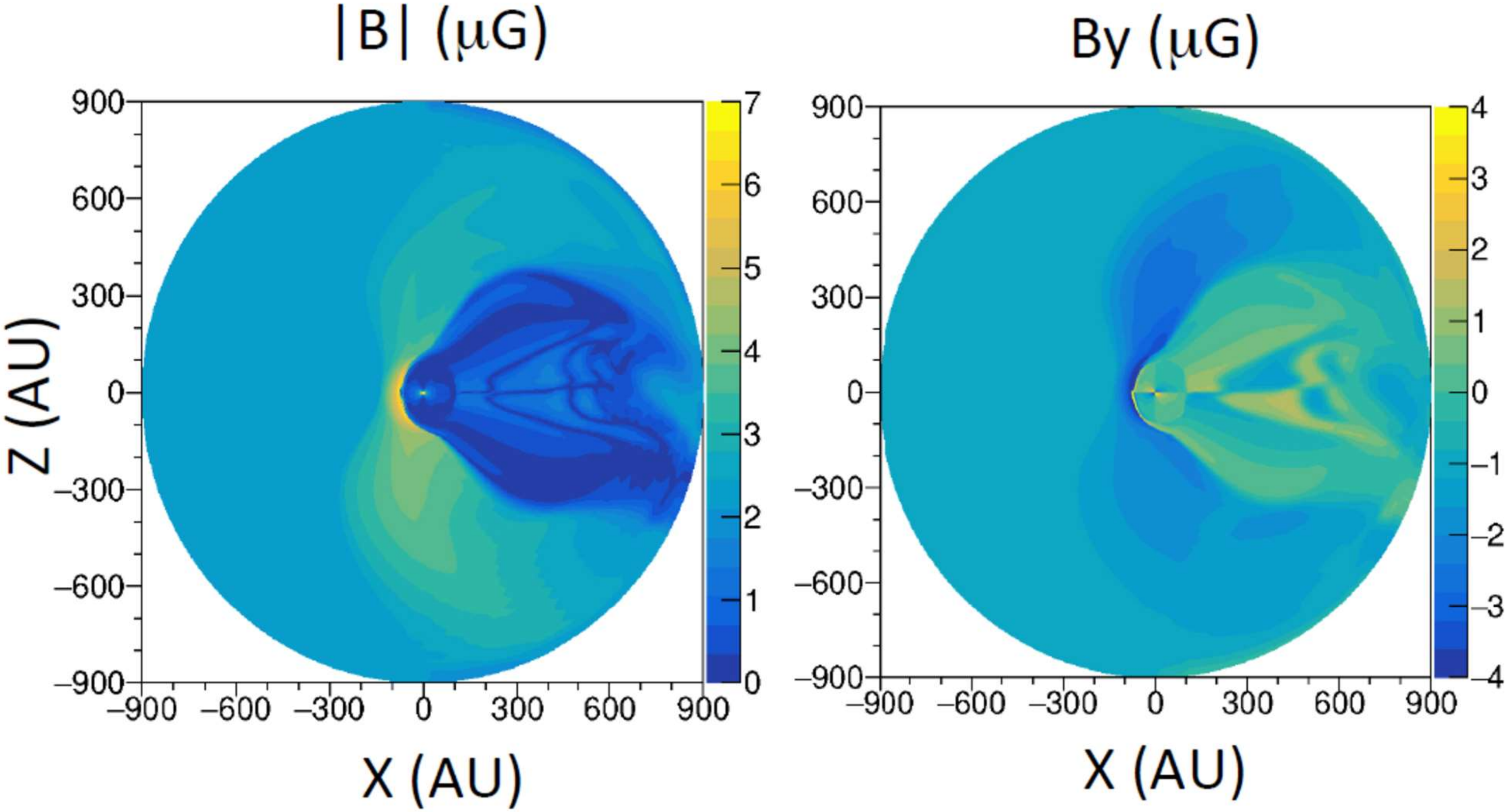
$$f(\mathbf{r}_B, \mathbf{p}_B, t) = f^{CG} + A_{1\parallel}\cos\mu + A_{2\parallel}\cos^2\mu + A_{1\perp}\sin\mu\cos\alpha_\perp$$

μ: pitch angle w. r. t. the reference axis

$$f(\mathbf{r}_E, \mathbf{p}_E, t) \approx f(\mathbf{r}_B, \mathbf{p}_B, t)$$

- Obtain model $f(\mathbf{r}_B, \mathbf{p}_B, t)$ best-fit to the observed $f(\mathbf{r}_E, \mathbf{p}_E, t)$.
- We use MHD heliosphere ...aka for ...on.
- Assume uni- and bi-directional anisotropy for $f(\mathbf{r}_B, \mathbf{p}_B, t)$.
- Take accounts of composition, E-spectrum and AS-array performance for quantitative best-fitting.

軌道計算に使った磁場データ



- 約 8 solar cycles (88 years) の積分

Washimi et al., ApJ, 809, 16 (2015)

- 50 AU < r < 900 AU: provided by Washimi (電場成分 $\boldsymbol{E} = -\boldsymbol{V} \times \boldsymbol{B}$ 込み)
- r < 50 AU: Parker magnetic field ($\boldsymbol{E} = 0$)

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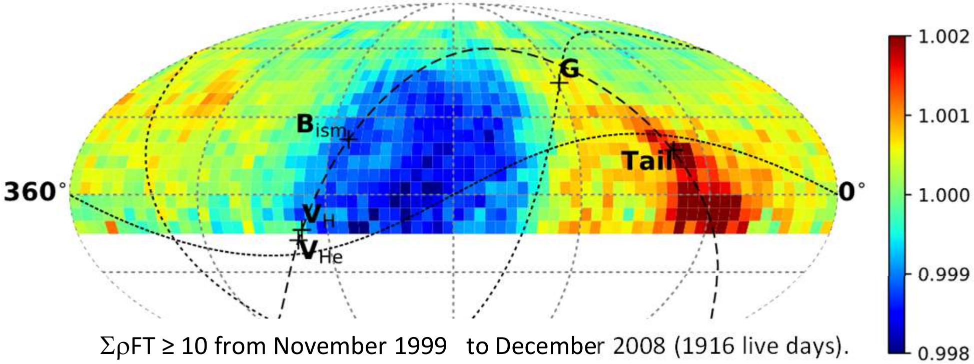
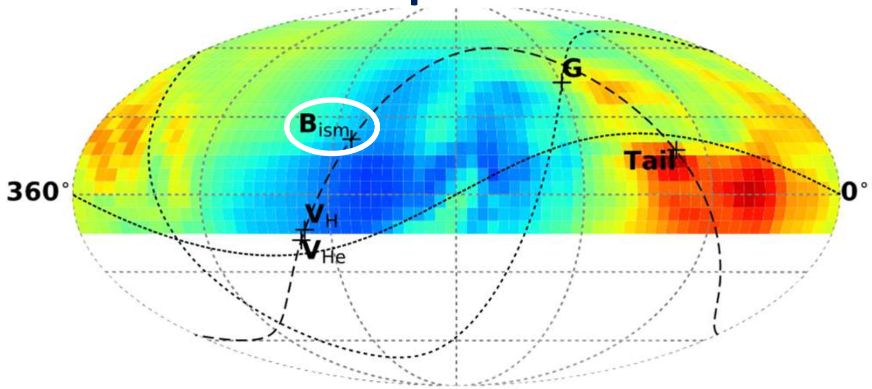
Setting the ref. axis parallel to B_{ISM}

Observed



ΣρFT ≥ 10 from November 1999 to December 2008 (1916 live days).
modal energy is 7.0 TeV.

Reproduced

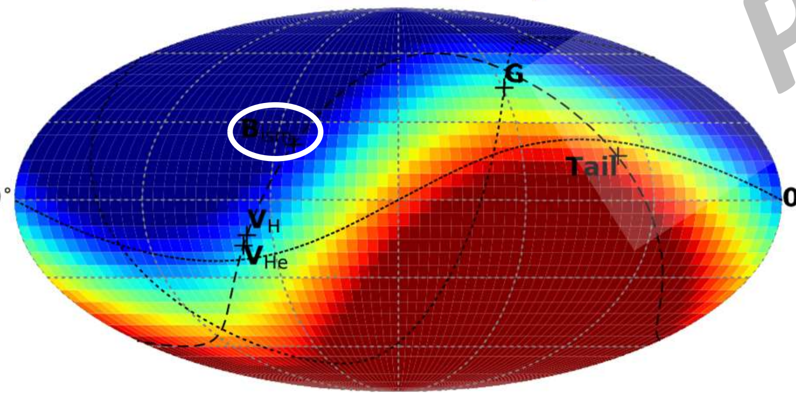


χ^2/ndf = 2434 / 1292 = **1.88**

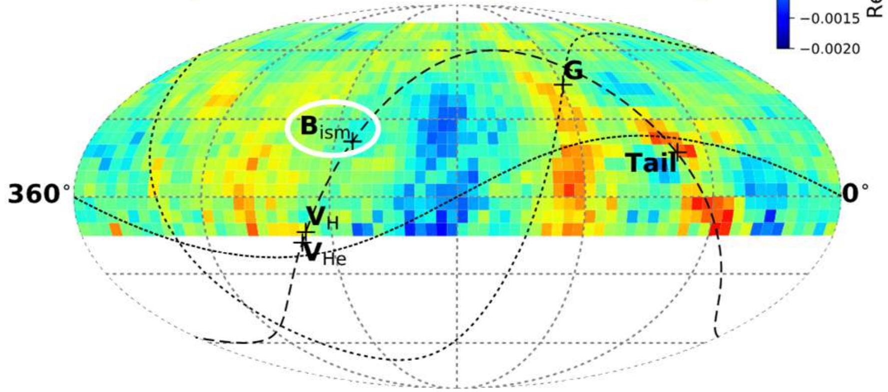
Parameter	$A_{1\parallel}$ (%)	$A_{2\parallel}$ (%)
bestfit value	0.234 ± 0.003	0.026 ± 0.004

$A_{1\perp}$ (%)	α_1 (°)	δ_1 (°)
0.330 ± 0.009	119.0 ± 0.3	44.3

$f(\mathbf{r}_B, \mathbf{p}_B, t)$

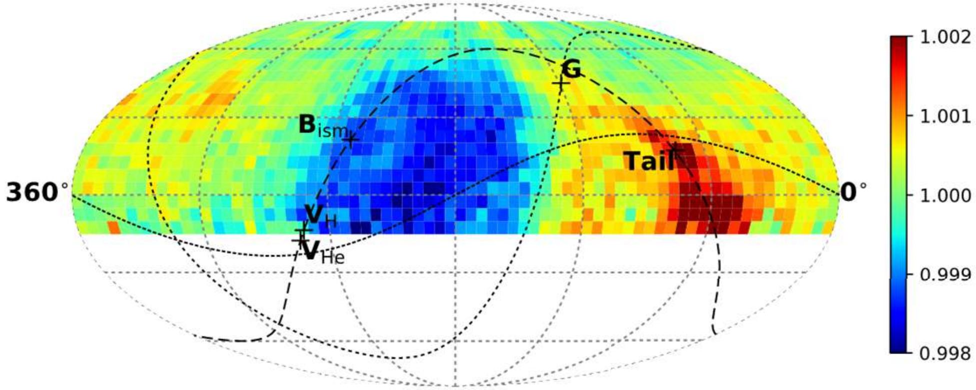


Residual (Observed-Reproduced)



Setting free ref. axis

Observed



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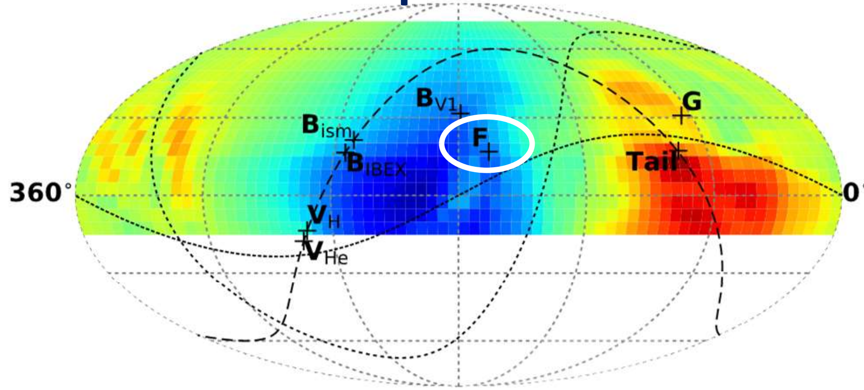
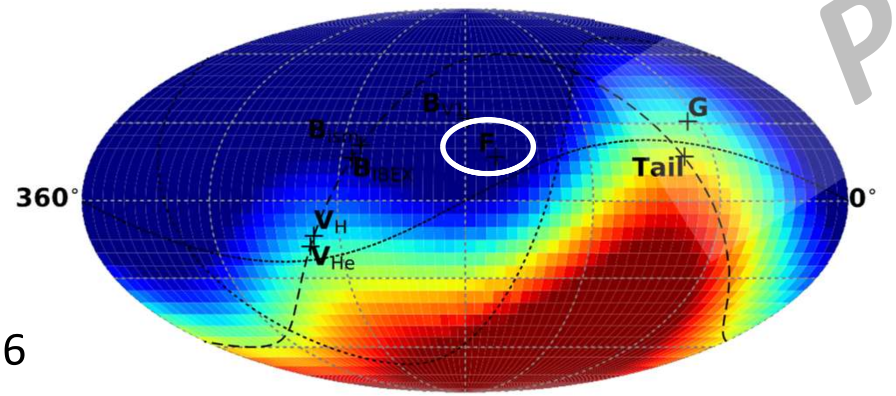


χ^2/ndf = 1625 / 1290 = **1.26**

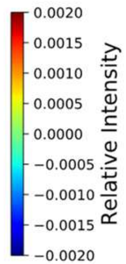
$A_{1\parallel}$ (%)	$A_{2\parallel}$ (%)	$A_{1\perp}$ (%)
0.007 ± 0.006	0.260 ± 0.010	0.302 ± 0.009

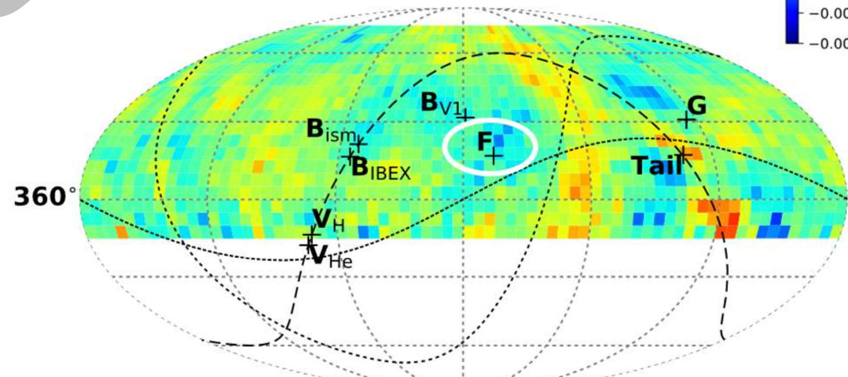
α_2 (°)	δ_2 (°)	α_1 (°)	δ_1 (°)
165.4 ± 0.7	16.7 ± 1.2	65.1 ± 1.1	30.9

$f(\mathbf{r}_B, \mathbf{p}_B, t)$



Residual (Observed-Reproduced)





“To do” list.

- Suppress the residual anisotropy (model/data improvement).
- Examine the observed E-dependent of anisotropy (below/above 100 TeV?).
- Sub-TeV anisotropy:
  - Solar cycle variation?
  - Solar modulation of amplitude?

    ⇒ e.g. the observation with Matsushiro