

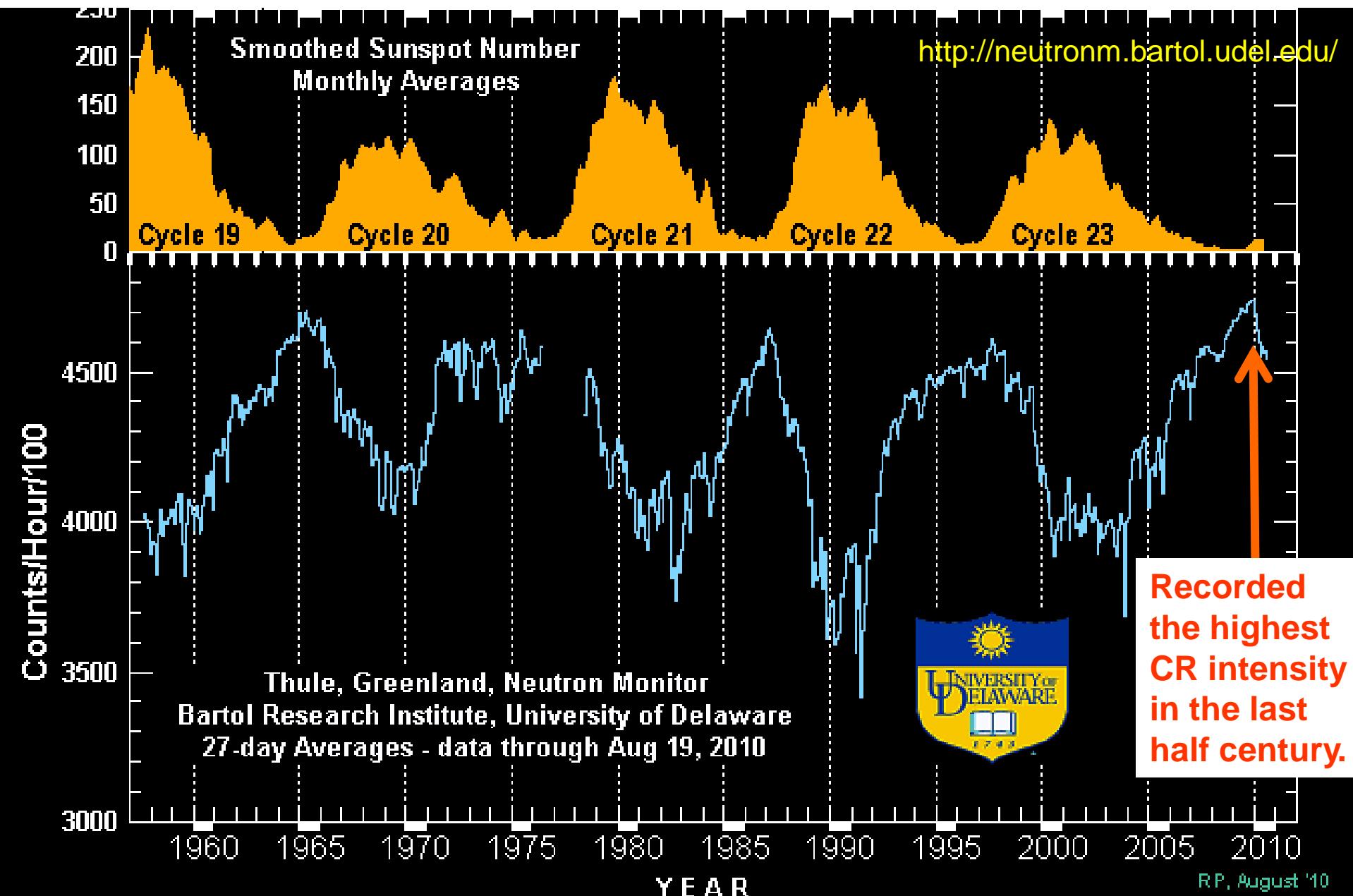
乗鞍岳における ミューオンの精密測定

宗像、加藤、安江、稲葉、小財、正川、山際(信州大理)
瀧田・青木(ICRR)、小島(名女大)

校費:400千円(太陽電池パネル8枚:破損パネル交換用)、
旅費:150千円(松本～乗鞍、柏)

- Global Muon Detector Network (GMDN)の一部として、高統計で方向分解能の高い観測を行う(宇宙天気研究)。

We may find the Solar Cycle 24 unique!?



昨年度までの経過：

2005年度：

- ・システム構築

2006年度：

- ・バッテリー増設(計10台)
- ・給電再開時のPC自動再起動
⇒ノートPCの故障で再起動
せず(冬期欠測)

- ・アンプ基板上の高圧絶縁対策

2007年度：

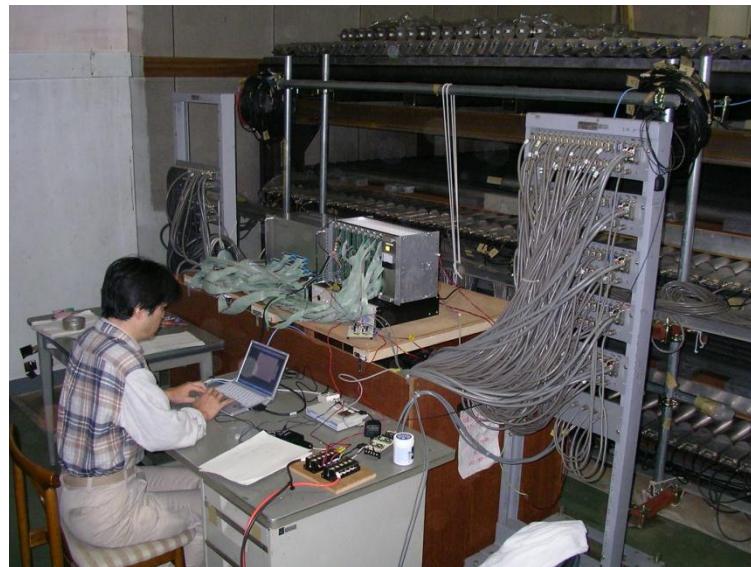
- ・給電再開時のPC自動再起動
⇒リレースイッチ動作不良で
再起動せず(冬期欠測)
- ・FPGA回路書換装置導入

2008年度：

- ・IP-switch導入⇒給電再開時
のPC再起動に成功

2009年度：

- ・バッテリー増設(計14台)
- ・連続観測開始(通年稼働率 82.9 %を達成)



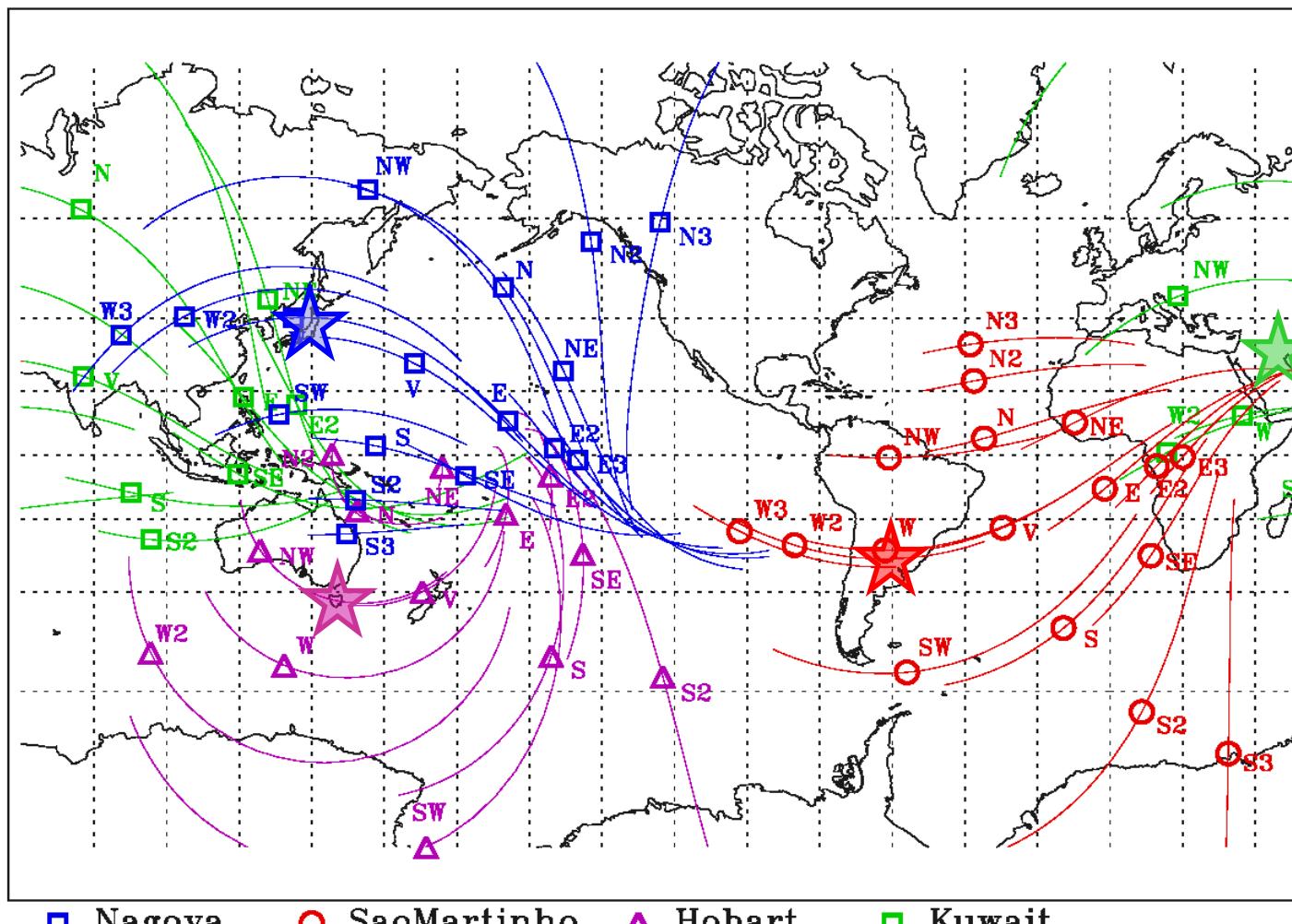
2010年度：

- 前冬季の雪圧により太陽電池パネル損傷(夏季の給電は正常)。
⇒ 太陽電池パネル交換とパネルフレーム修理を来夏に予定



- 観測所networkの故障によりデータのモニターが出来ず。
⇒ 給電さえ行われていれば、観測は継続しているはず…

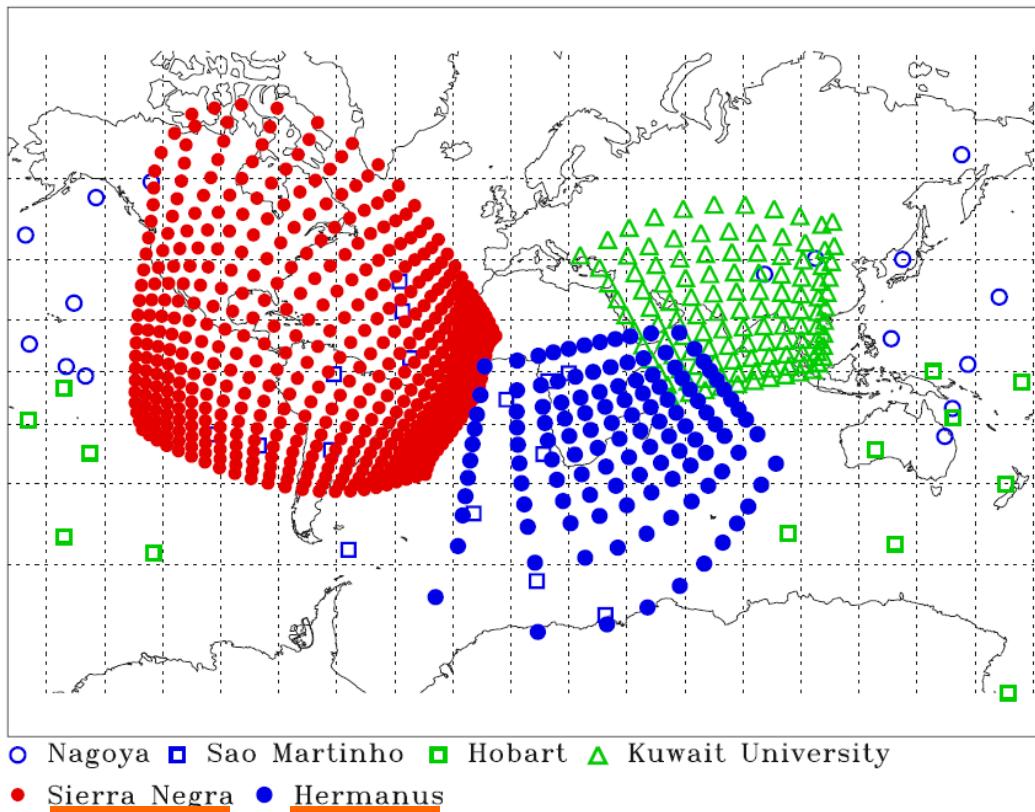
Global Muon Detector Network (GMDN) for GCR streaming



- **★** indicates the location of the detector.
- **○□△** display the asymptotic viewing directions of median energy cosmic rays corrected for the geomagnetic bending.
- Thin lines indicate the spread of viewing direction for the central 80 % of the energy response to primary CRs.

Possible future expansions of GMDN

- We plan to expand detection areas of two small detectors.
 - ✓ Hobart: $9 \text{ m}^2 \Rightarrow 16 \text{ m}^2$, □ Kuwait : $9 \text{ m}^2 \Rightarrow 25 \text{ m}^2$
- We also plan to install new detectors in Mexico and South Africa.



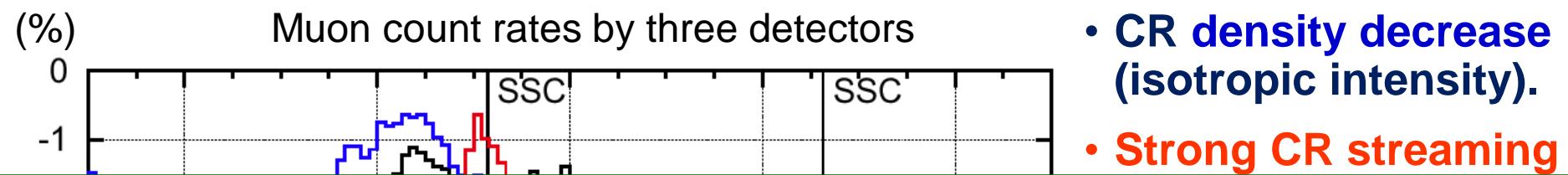
Sierra Negra (Mexico)

- 4600 m a.s.l..
- 14k SciBars viewed by 220 multi-anode PMTs.
- Primarily for the solar neutron detection, but can be used for muon measurement.

Hermanus (South Africa)

- 200 PRC tubes in four horizontal layers will form a 25 m^2 muon detector.

Why we need global network?



Wind in typhoon

$$\mathbf{F} \propto \boldsymbol{\Omega} \times \nabla P$$

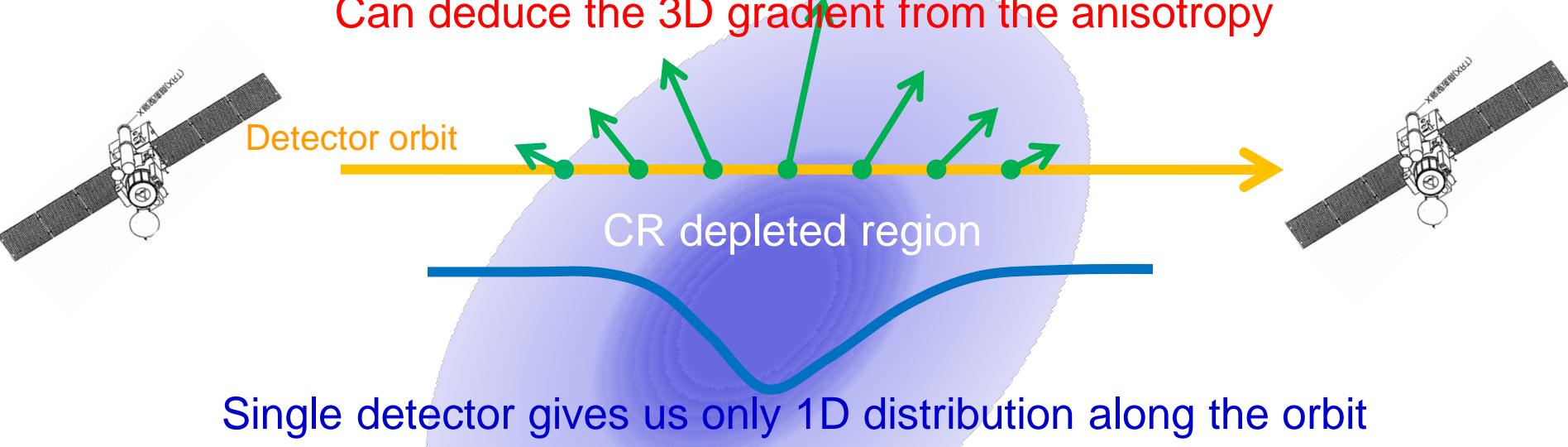
$$\therefore \mathbf{F} \Rightarrow \nabla P, \text{ given } \boldsymbol{\Omega}$$

CR streaming

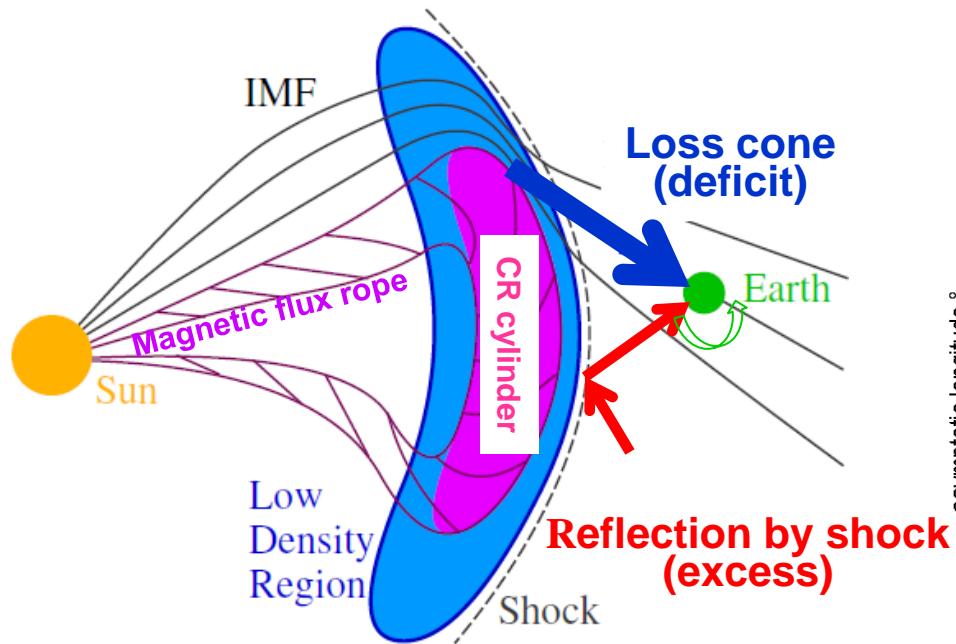
$$\mathbf{S} \propto \mathbf{B} \times \nabla n$$

$$\therefore \mathbf{S} \Rightarrow \nabla n, \text{ given } \mathbf{B}$$

Can deduce the 3D gradient from the anisotropy

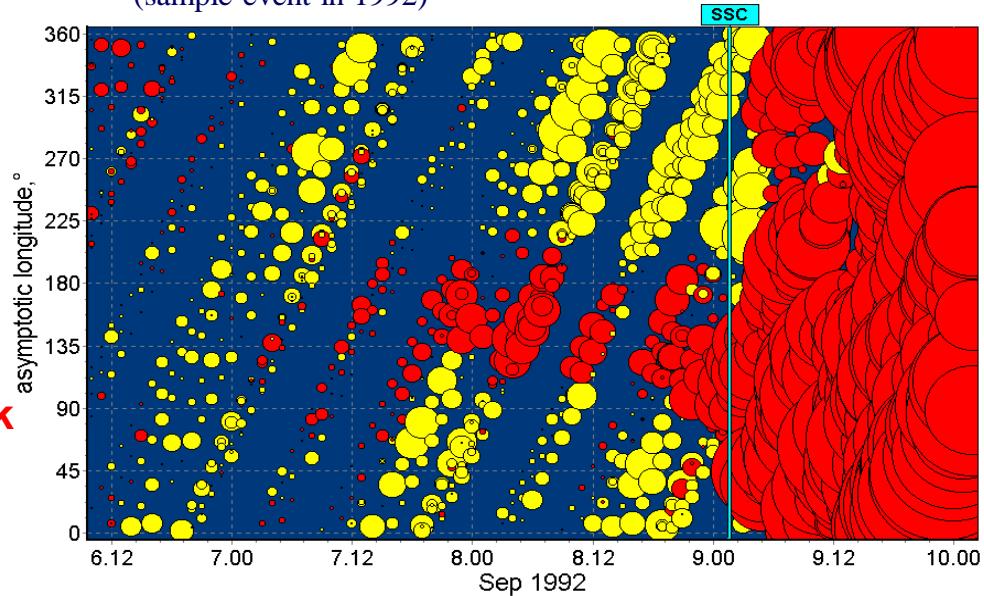


Muon precursors seen by GMDN

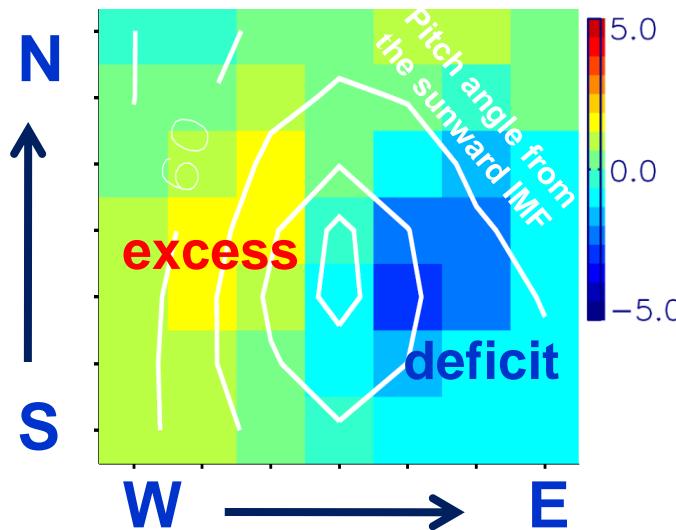


Best representation by NM network

(sample event in 1992)

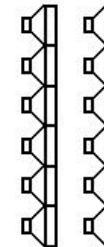


2D map of 1 hour data (2006 12/14 08:30UT)

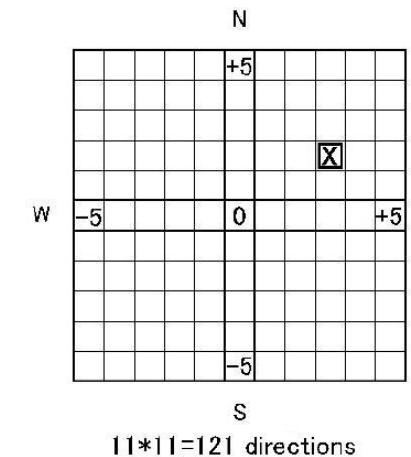
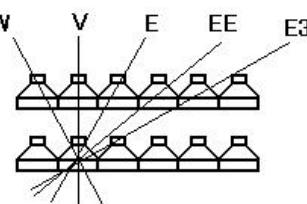


top view

31	32	33	34	35	36
25	26	27	28	29	30
19	20	21	22	23	24
13	14	15	16	17	18
7	8	9	10	11	12
1	2	3	4	5	6



side view



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

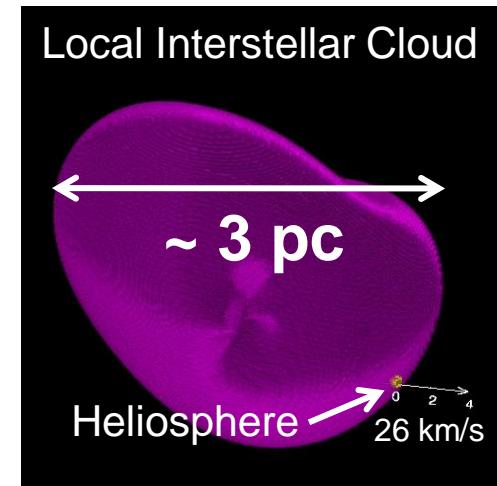
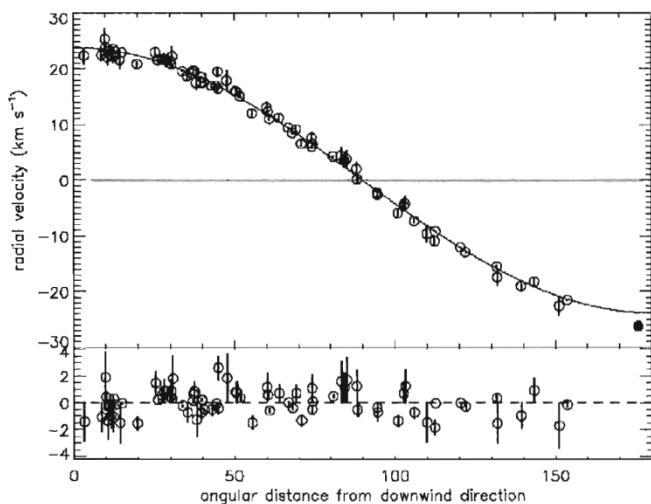
宗像、加藤、安江、小財、正川、山際(信州大理)、瀧田(ICRR)

旅費(松本 ⇄ 柏): 100千円(SK) / 100千円(Tibet)

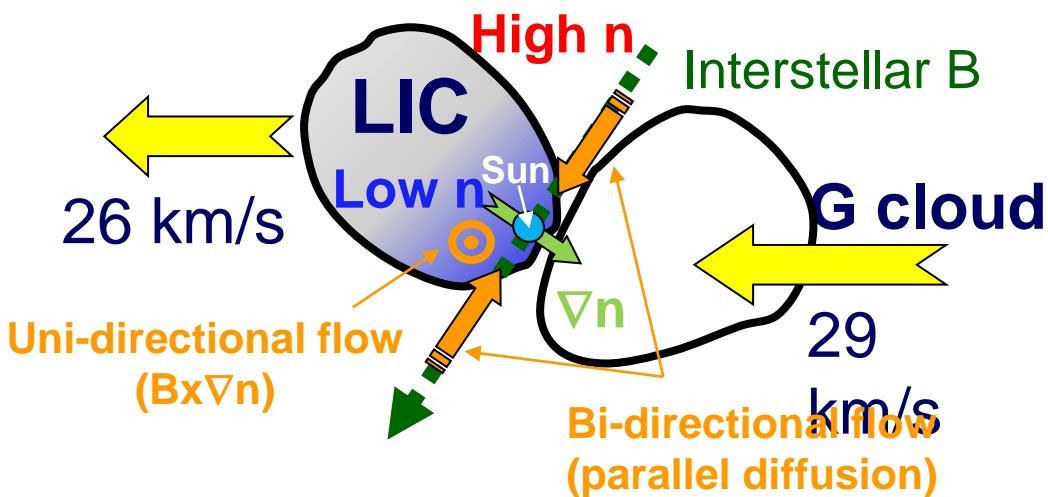
- Modeling the large-scale anisotropy with Global Anisotropy (**GA**) and Midscale Anisotropy (**AE**).
⇒ Amenomori et al., proc. AIP conf., in press (2010).
- Solar cycle dependence of the diurnal anisotropy observed with the Matsushiro UG- μ detector.
⇒ Munakata et al., ApJ, 712, 1100 (2010).
- Two-hemisphere observations with the Tibet (**AS**), SK (**UG μ**) & Ice Cube (**UG μ**).
⇒ private communications with Ice Cube (2010).

Global Anisotropy model

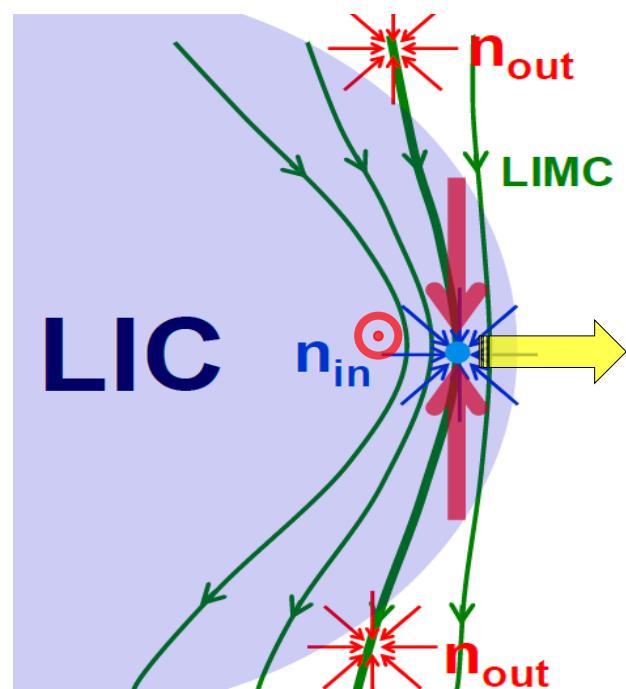
Slavin, AIP proc., 1156, 2009



Redfield & Linsky, ApJ, 534, 2000

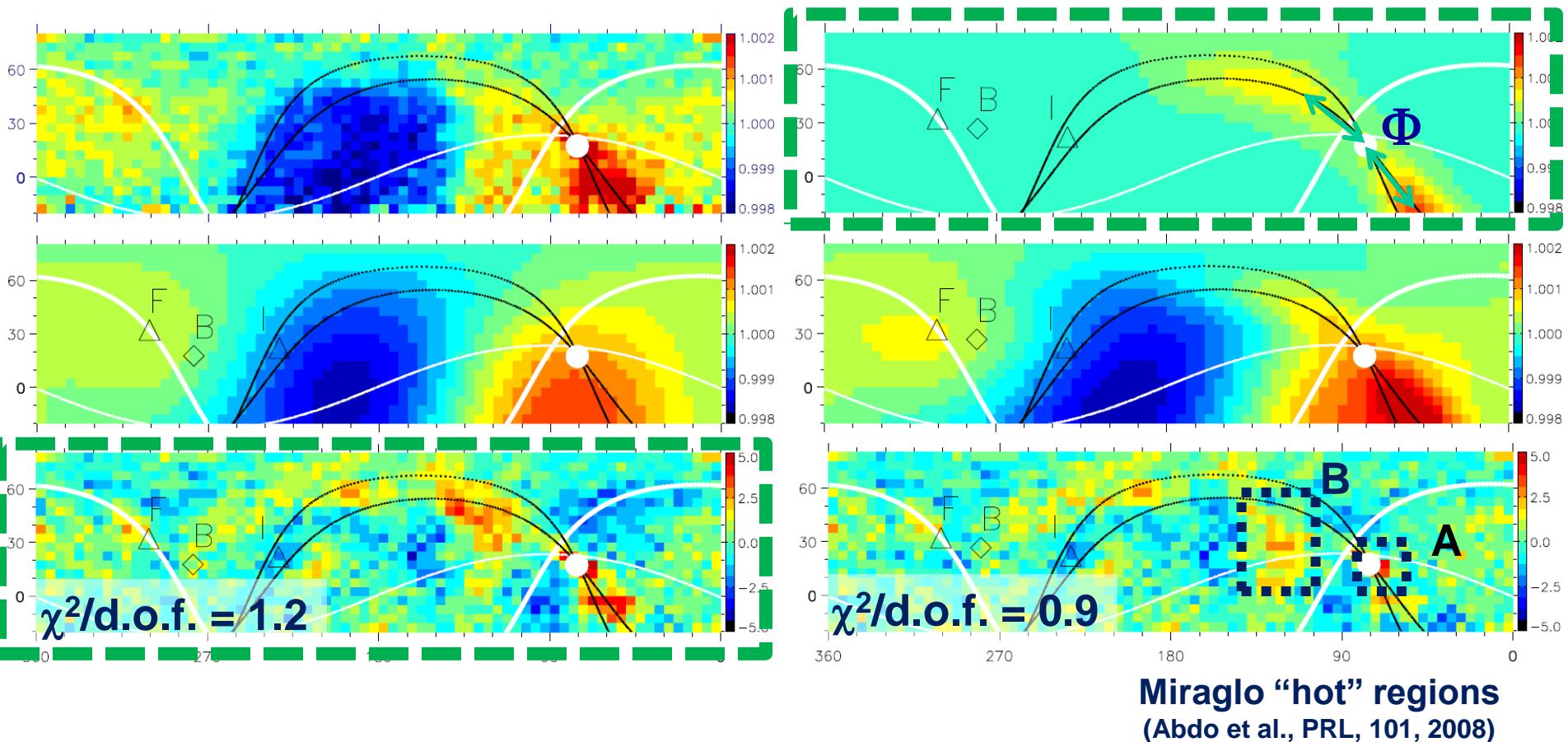


This model also allows us to infer
the polarity of B from ∇n



Midscale Anisotropy model (preliminary)

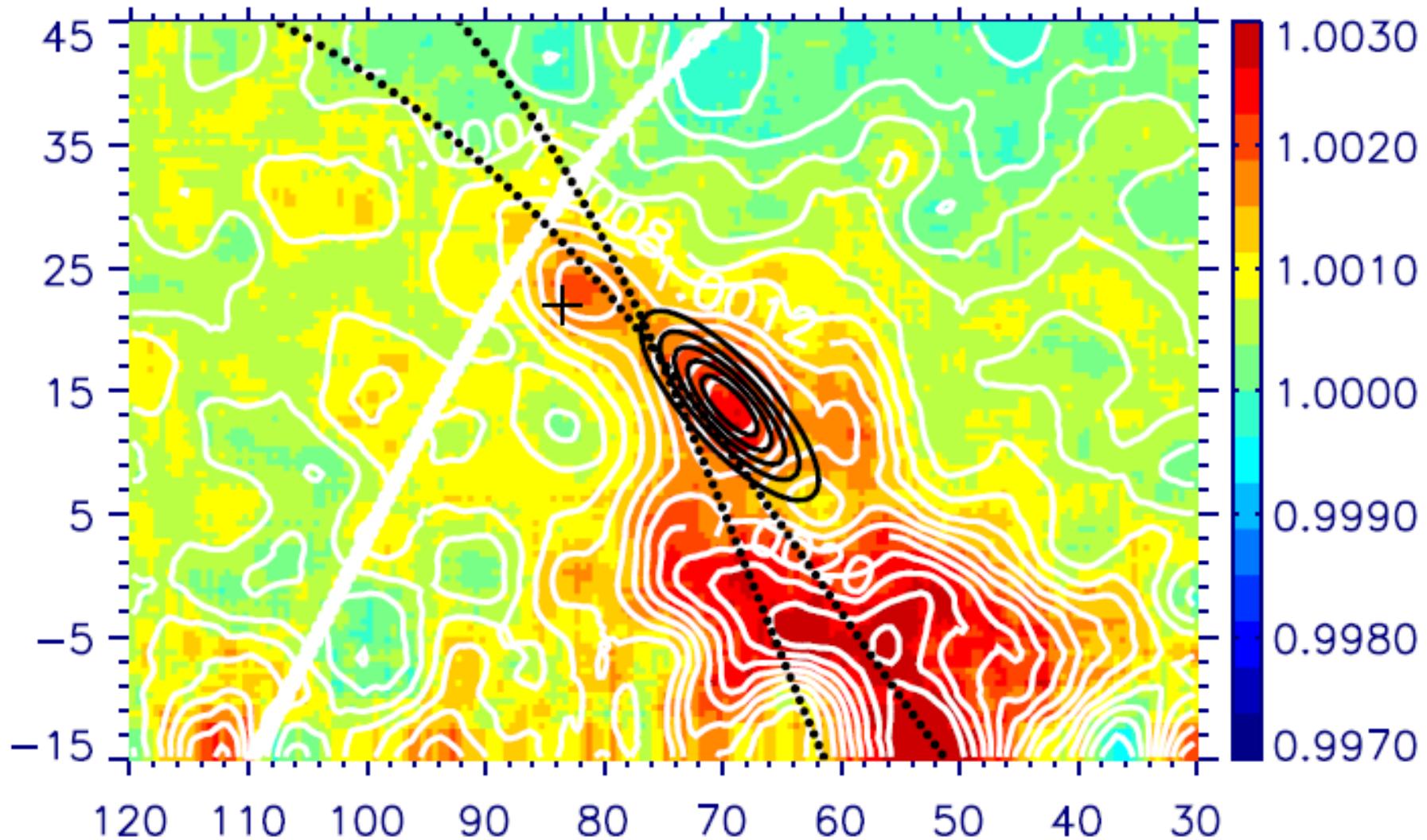
$$\left[b_1 \exp\left\{-\frac{(\phi_{n,m} - \Phi)^2}{2\sigma_\phi^2}\right\} + b_2 \exp\left\{-\frac{(\phi_{n,m} + \Phi)^2}{2\sigma_\phi^2}\right\} \right] \exp\left(-\frac{\theta_{n,m}^2}{2\sigma_\theta^2}\right)$$



Miraglo "hot" regions
(Abdo et al., PRL, 101, 2008)

Miraglo hot region A

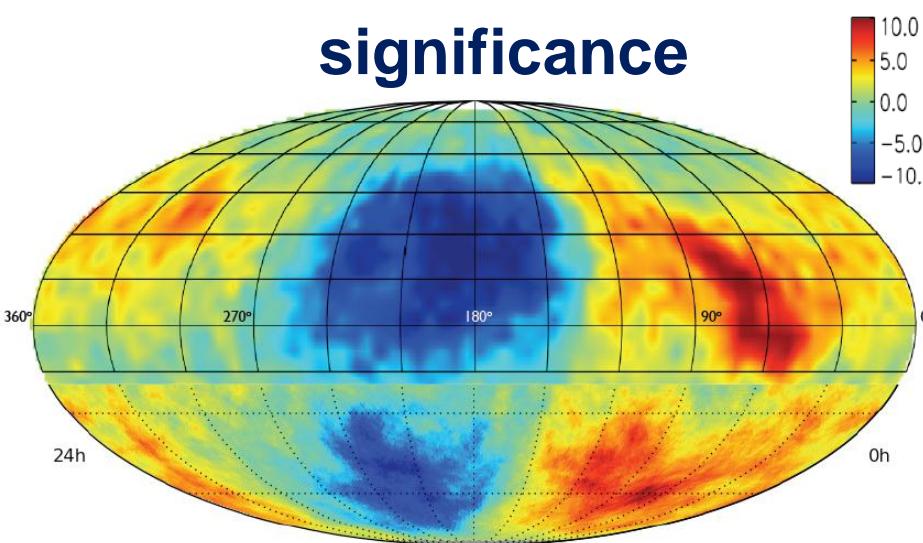
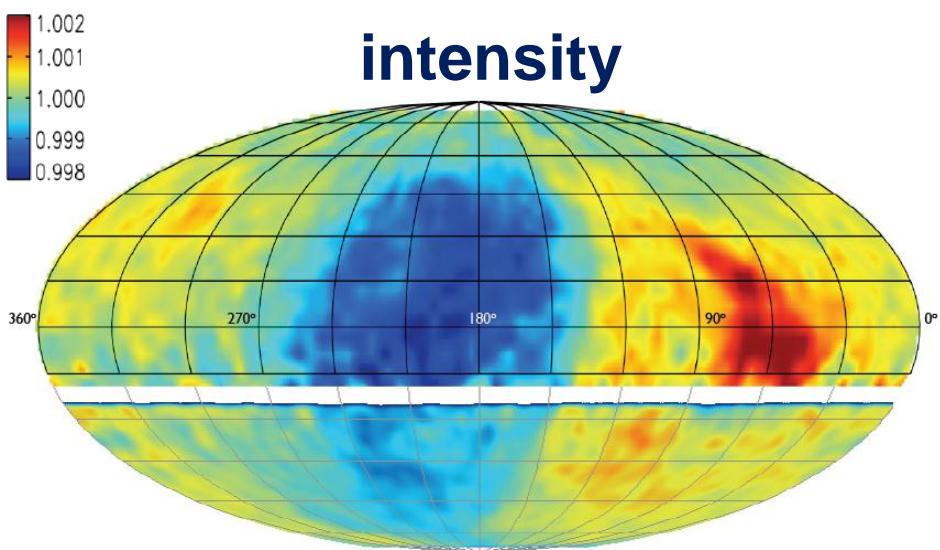
(Abdo et al., PRL, 101, 2008)



Two-hemisphere observations by Tibet & Ice Cube

Tibet AS γ
(Amenomori et al., Science, 314, 2006)

- AS measurement ($p+\gamma$)
- $E_{\text{mode}} = 7 \text{ TeV}$ (calibrated by using Moon shadow)
- 4.5×10^{10} events in 1999.11-2008.12
(270 Hz)



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

- muon measurement (p)
- $E_{\text{mode}} = 20 \text{ TeV}$
- 4.3×10^9 events in 2007.6-2008.3
(220 Hz)