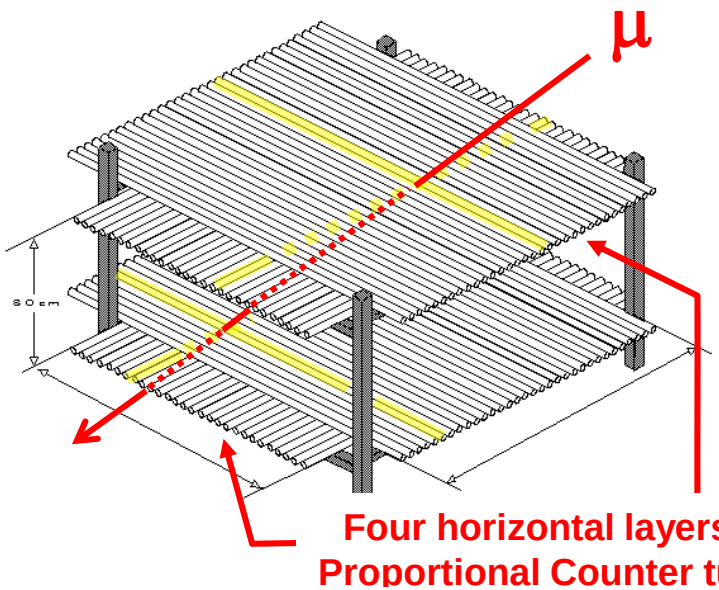
乗鞍岳におけるミューオンの精密測定

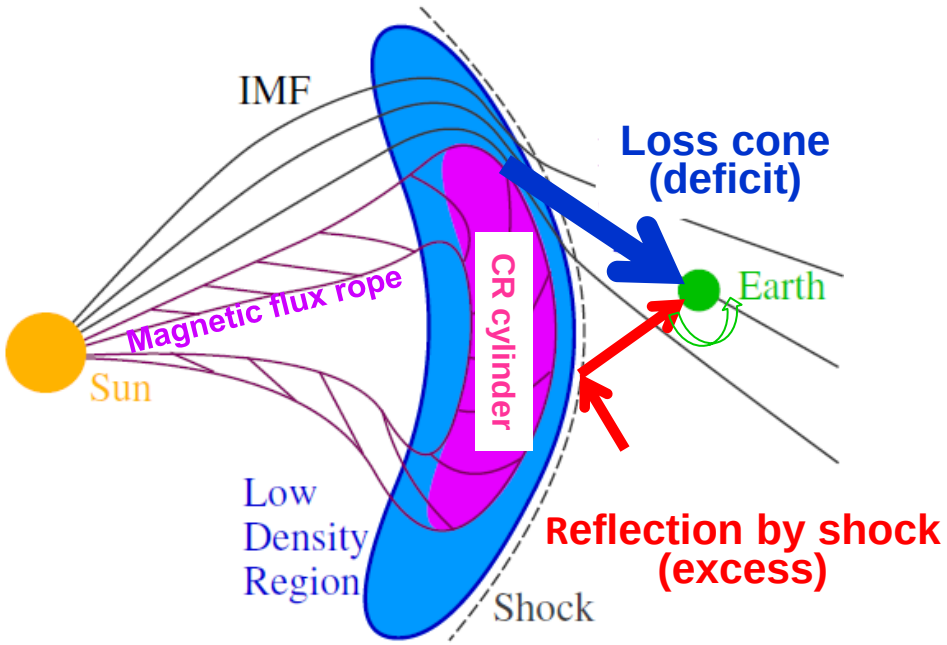
宗像、加藤、小財、中嶋、丹羽、中村（信州大理）、
青木（ICRR）、小島（愛工大）

物品費：490千円

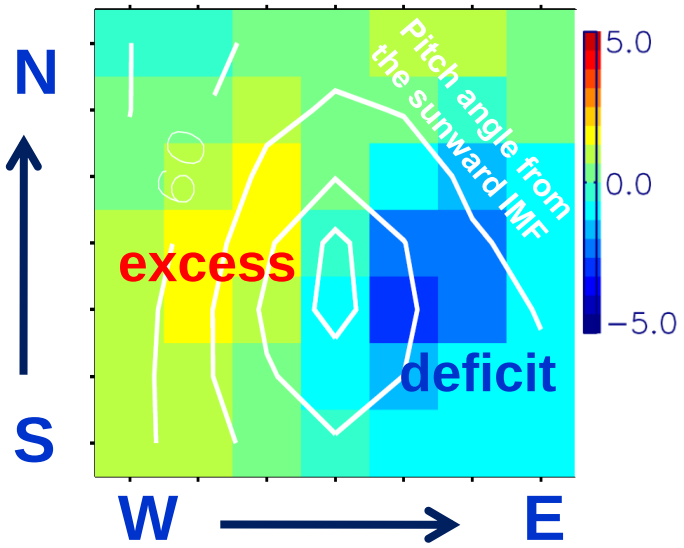
旅費 （松本～乗鞍、松本～柏）：100千円

乗鞍ミューオン計





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



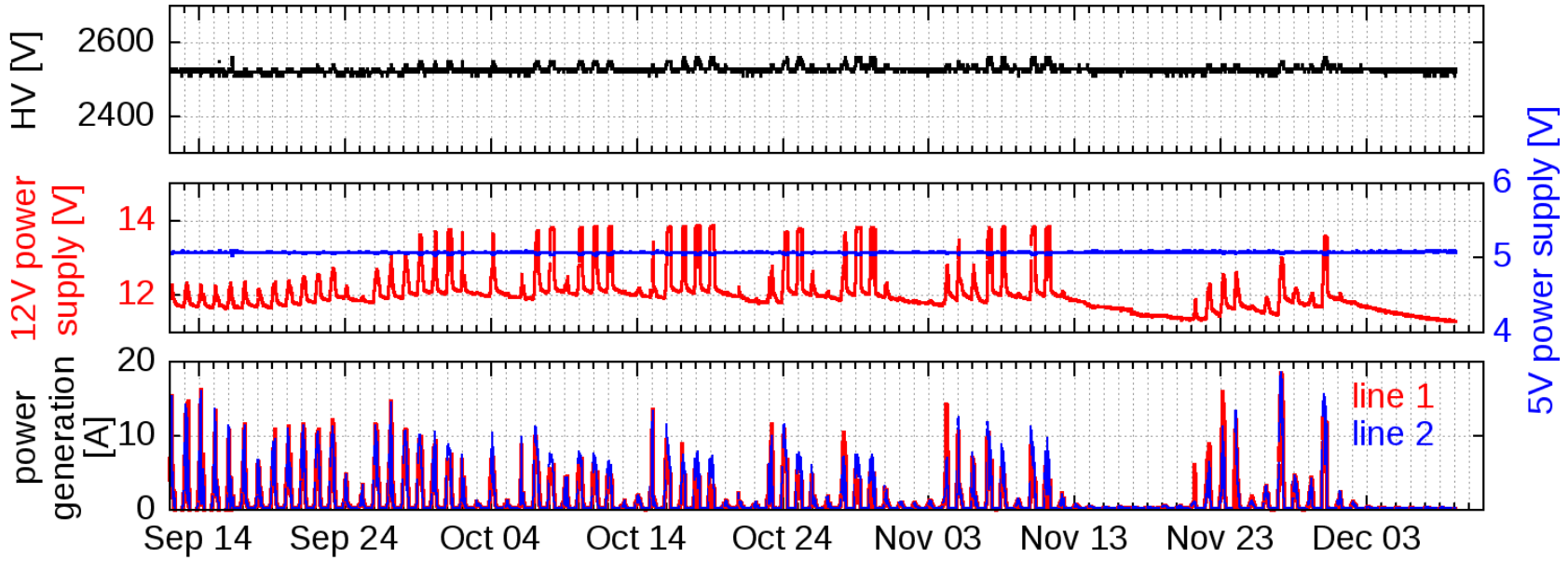
2014年度状況

2月25日

4月8日

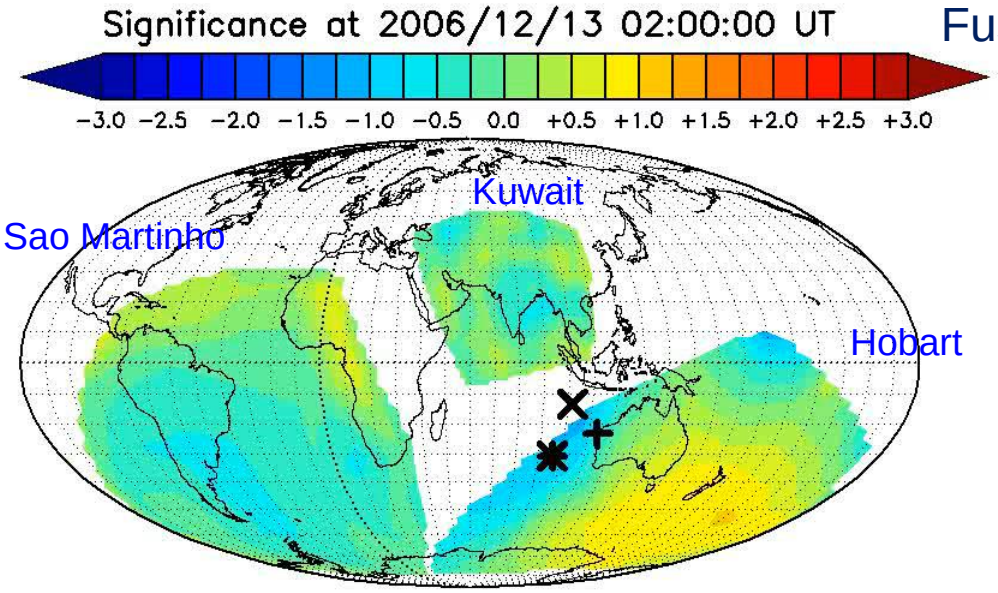
12月10日 (給電停止)

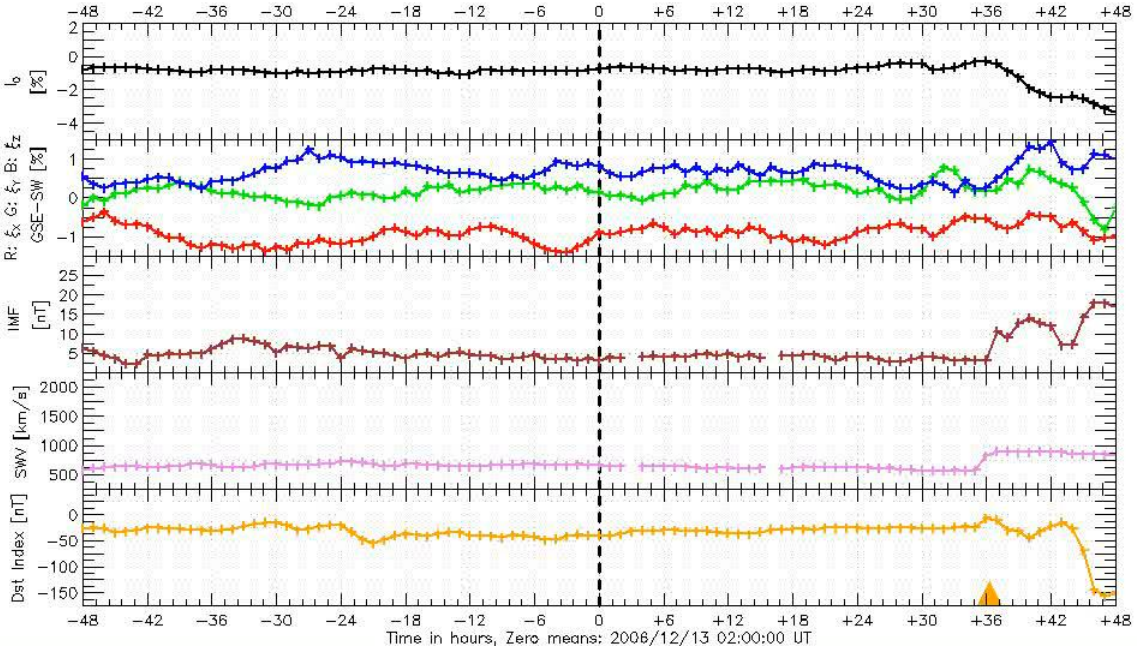
改修後、昨冬の積雪による架台の変形は見られない

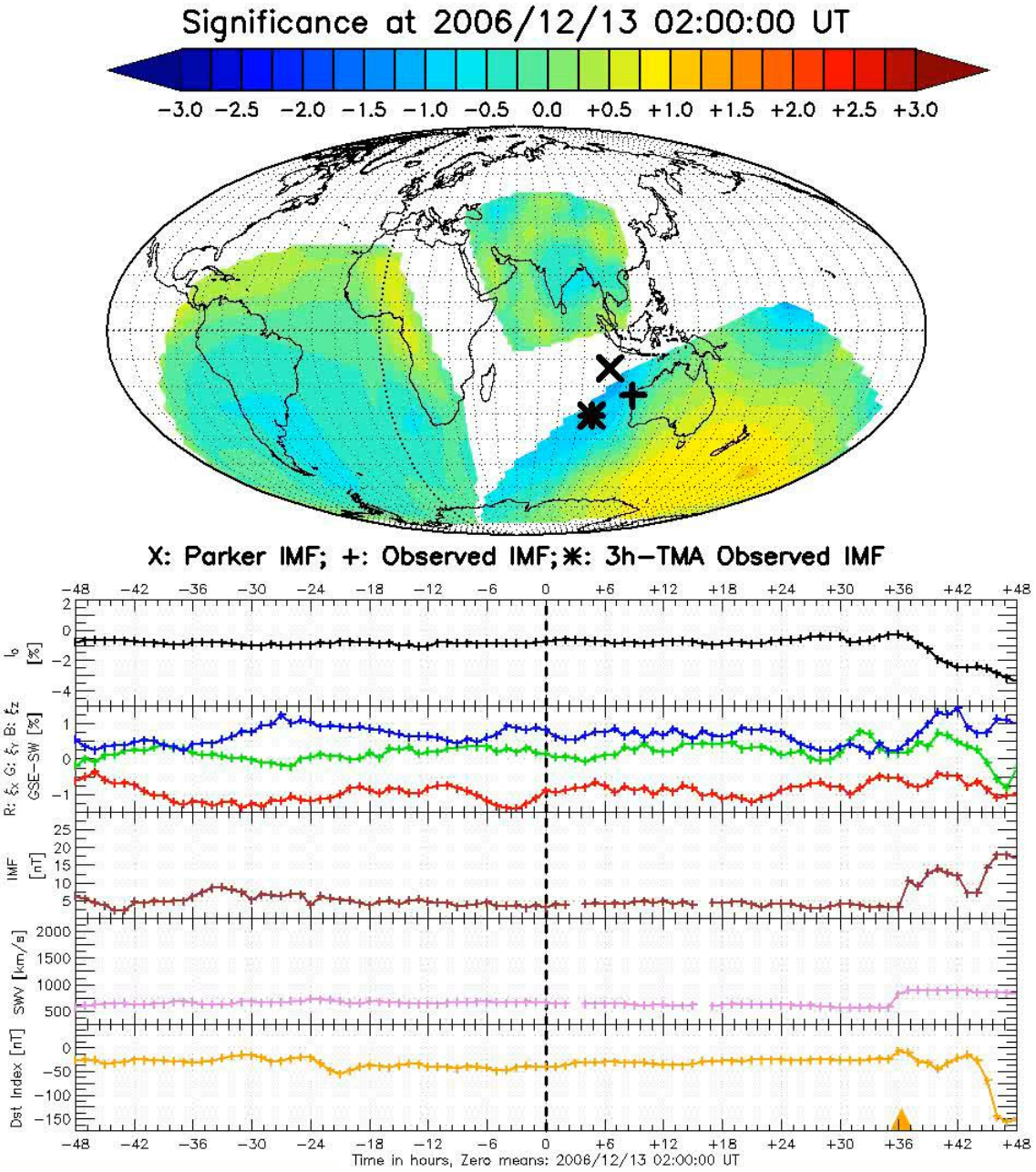


GMDNによる観測例（2006年12月の前兆現象）

Fushishita+ ApJ 2010






Significance at 2006/12/13 02:00:00 UT
−3.0 −2.5 −2.0 −1.5 −1.0 −0.5 0.0 +0.5 +1.0 +1.5 +2.0 +2.5 +3.0
X: Parker IMF; +: Observed IMF; ✳: 3h−TMA Observed IMF
−48 −42 −36 −30 −24 −18 −12 −6 0 +6 +12 +18 +24 +30 +36 +42 +48
l_b [%]
R: ξ_X G: ξ_Y B: ξ_Z GSE−SW [%]
IMF [nT]
SWV [km/s]
Dst Index [nT]
Time in hours, Zero means: 2006/12/13 02:00:00 UT

Observing anisotropy vector with GMDN

$I_{i,j}^{obs}(t)$: **pressure corrected count rate in the j th directional channel of the i th detector**

$$I_{i,j}^{cal}(t) = I^0(t) + \xi_x^{\mathrm{GEO}}(t)\left(c_{1\,i,j}^{1}\cos\omega t_i - s_{1\,i,j}^{1}\sin\omega t_i\right) + \xi_y^{\mathrm{GEO}}(t)\left(s_{1\,i,j}^{1}\cos\omega t_i + s_{1\,i,j}^{1}\sin\omega t_i\right) + \xi_z^{\mathrm{GEO}}(t)\,c_{1\,i,j}^{0}$$

$c_{1\,i,j}^{1}$ $s_{1\,i,j}^{1}$

coupling coefficients

$$\begin{cases} c_{n\,i,j}^{m} = \dfrac{1}{\bar{I}_{i,j}}\displaystyle\int_{p_{c;\,i,j}}^{\infty}\int_{\Omega_{i,j}}\int_{S_{i,j}} Y\, G(p)\cdot P_n^m(\cos\theta_{or})\cdot\cos m(\phi_{or}-\phi_{st})\,dS d\Omega dp \\ s_{n\,i,j}^{m} = \dfrac{1}{\bar{I}_{i,j}}\displaystyle\int_{p_{c;\,i,j}}^{\infty}\int_{\Omega_{i,j}}\int_{Si_{,j}} Y\cdot G(p)\cdot P_n^m(\cos\theta_{or})\cdot\sin m(\phi_{or}-\phi_{st})\,dS d\Omega dp \end{cases}$$

$Y(p;\ x_i, \theta_j, E_{th}^{\mu})$: response function

We derive $I^0(t), \xi_x^{\mathrm{GEO}}(t), \xi_y^{\mathrm{GEO}}(t), \xi_z^{\mathrm{GEO}}(t)\ldots$

$$\sum_{i,j}\left|I_{i,j}^{obs}(t) - I_{i,j}^{cal}(t)\right|^2/\sigma_{i,j}^2$$

Ecliptic flow by Nagoya & GMDN

$$\xi_x(t) \;\&\; \xi_y(t)$$

Munakata+, ApJ, **791**, 2014

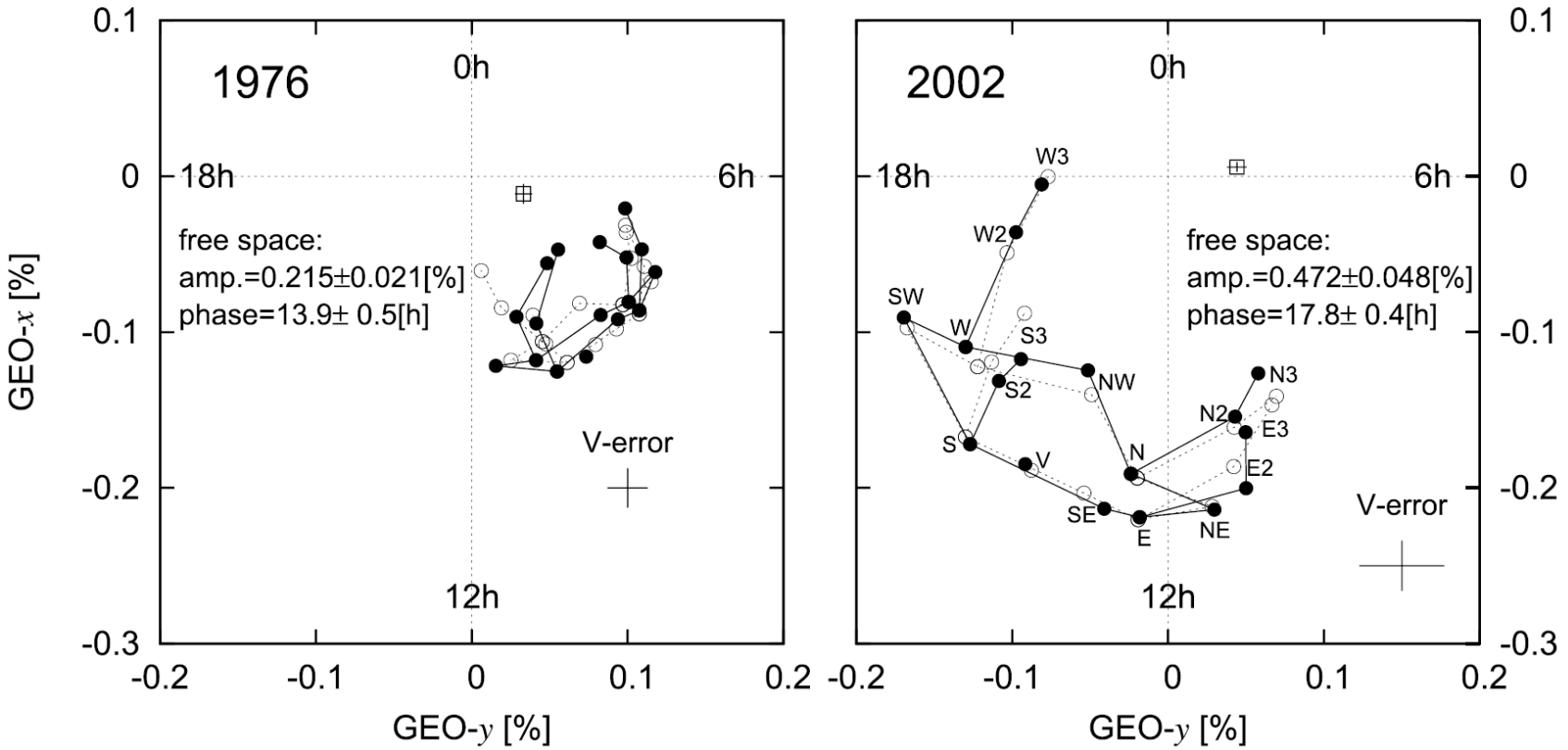
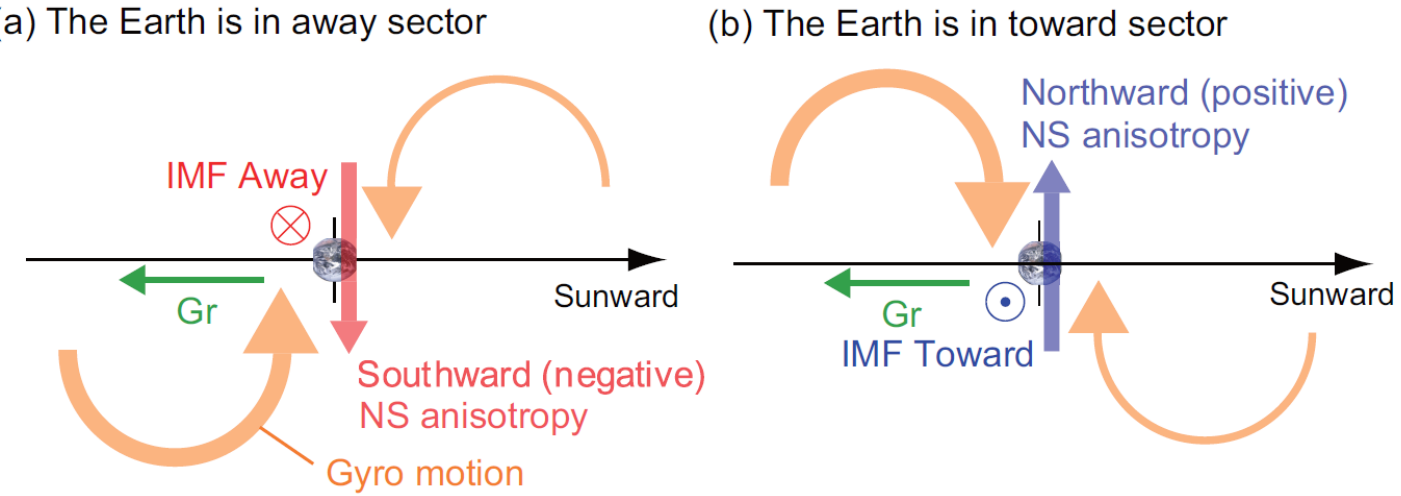


Figure 2. Yearly mean harmonic dials of the diurnal anisotropy observed by the Nagoya multi-directional muon detector in 1976 (left) around the $A > 0$ solar activity minimum and in 2002 (right) in the $A < 0$ epoch. Solid circles display the harmonic vector $(a_{1,j}^{1,\mathrm{obs}}, b_{1,j}^{1,\mathrm{obs}})$ observed by the jth directional channel with $a_{1,j}^{1,\mathrm{obs}}$ and $b_{1,j}^{1,\mathrm{obs}}$ plotted on the vertical (GEO-x) and horizontal (GEO-y) axes, respectively, while open circles display the best-fit vectors. The phases of the diurnal anisotropy with $x > 0$ and $y = 0$; $x = 0$ and $y > 0$; $x < 0$ and $y = 0$; and $x = 0$ and $y < 0$ are 00:00, 06:00, 12:00, and 18:00 hr in the local solar time, respectively. To demonstrate the relative configuration of the observed (best-fit) harmonic vectors in 17 directional channels, the head of each vector is connected with each other by solid (dotted) thin lines (see directional channels indicated in the right panel). An open square with an error cross in each panel displays the common vector representing the atmospheric temperature effect. The amplitude and phase of the best-fit harmonic vector in free space are indicated in each panel. For reference, the cross in the bottom right corner in each panel represents errors of $a_{1,j}^{1,\mathrm{obs}}$ and $b_{1,j}^{1,\mathrm{obs}}$ in the vertical (V) channel, deduced from the dispersion of monthly values.

NS flow & GG component

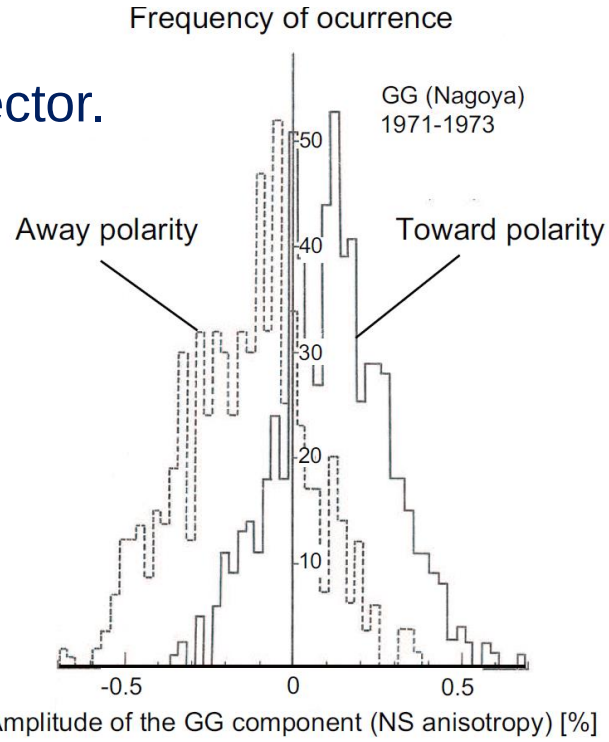
$\xi_z(t)$



NS flow (ξ_z) directs…
toward the South (North) in Away (Toward) IMF sector.

GG ≡ (N49 °– S49 °) + (N49 °– E49°)

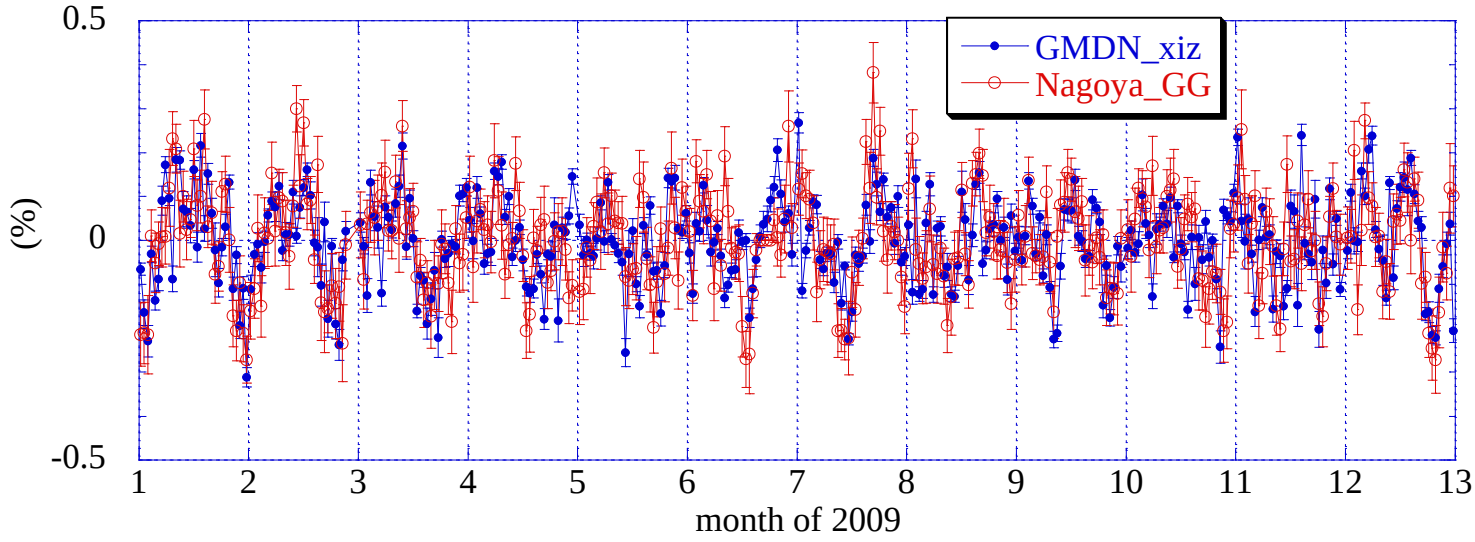
GG(T)>0, GG(A)<0

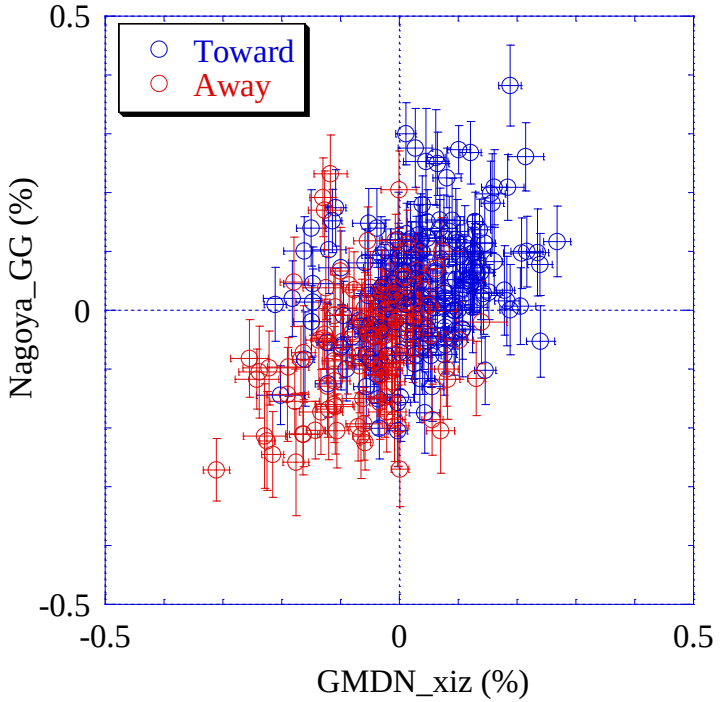


Laurenza, Storini & Fujii, JGR, 108, 2003:

GG-inferred daily mean IMF polarity matches with the direct measurement in overall 72 % of the analyzed period. The success rate can be 95 % in selected conditions, occurring for 30% of the time.

NS flow by GG & GMDN





$$GG(t) = (c^1_{1,GG}\cos\omega t - s^1_{1,GG}\sin\omega t)\xi_x(t) + (s^1_{1,GG}\cos\omega t + c^1_{1,GG}\sin\omega t)\xi_y(t) + c^0_{1,GG}\xi_z(t) \quad : \omega = 2\pi/24$$

0.8 0.1 0.1 0.8 1.1

$$\langle GG\rangle_{24h} \neq c^0_{1,GG}\langle\xi_z(t)\rangle_{24h}$$

when $\xi_x(t)$ and $\xi_y(t)$ are not constant and…

$$\langle(c^1_{1,GG}\cos\omega t - s^1_{1,GG}\sin\omega t)\xi_x(t)\rangle_{24h} + \langle(s^1_{1,GG}\cos\omega t + c^1_{1,GG}\sin\omega t)\xi_y(t)\rangle_{24h} \neq 0$$

ま と め

- 乗鞍ミューオン計は、太陽光発電パネルへの着雪により、12月10日から観測を休止中。
- 昨年夏に改修された太陽光発電パネル架台は、昨冬の大雪でも雪圧による変形は全く見られなかった。
- GMDNで観測された南北異方性 (ξ_z)の日平均値は、名古屋GG成分と良く一致している。
- 時折見られる両者の間の違いは、GG成分に対する$\xi_x(t)$ と $\xi_y(t)$からの寄与によることが判った。

本共同研究へのご支援に感謝します。