(Matsumoto, Nagano)

K. Munakata (Shinshu Univ.)

SH2.2-3 + SH3.1-3

SH2.2 : CME, ESP, FDs & structures (O*16/P*14)

SH2.3 : Particle acceleration (O*7/P*9)

SH3.1 : Outer heliosphere (O*5/P*3)

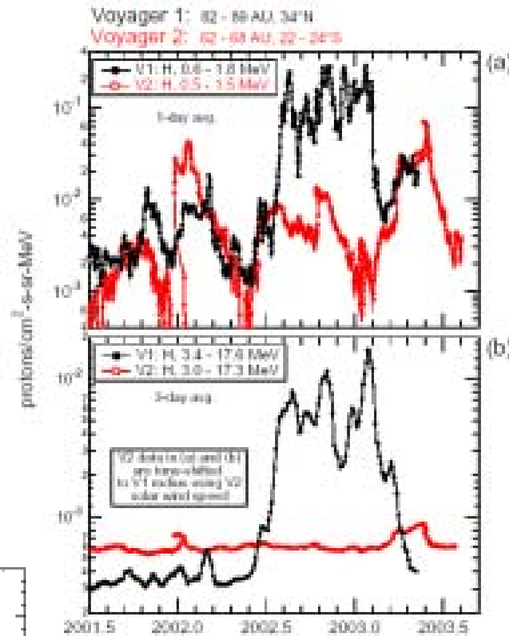
SH3.2 : Modulation in global structure (O*14/P*9)

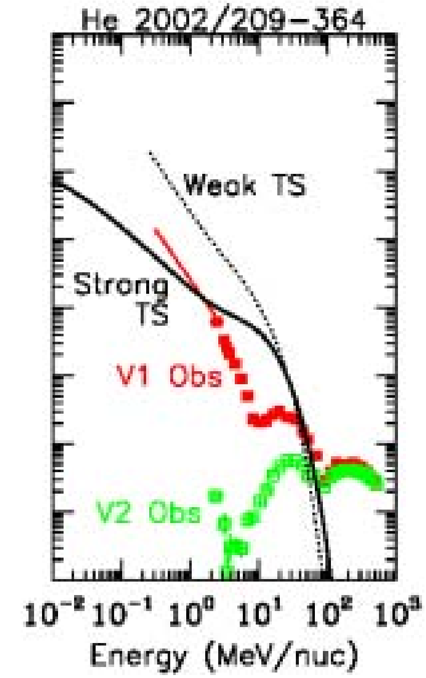
SH3.3 : Outer heliosphere + global modulation (O*14/P*16)

107 papers
56 Oral + 51 Poster

Measurements nearby TS

- Unusual enhancements seen during '02 to '03 by *V1* (85-88 AU) , but not by *V2* (67-70 AU).
- Series of "spikes" in *V1* & *V2* prior to the enhancement.
- Anti-sunward streaming in enhanced intensity.

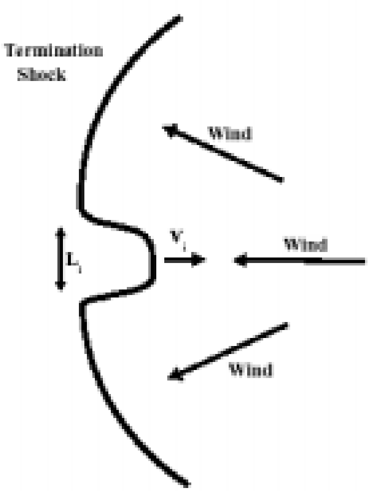




SH3.3-2 Hill et al.
SH3.3-13 Krimigis et al.

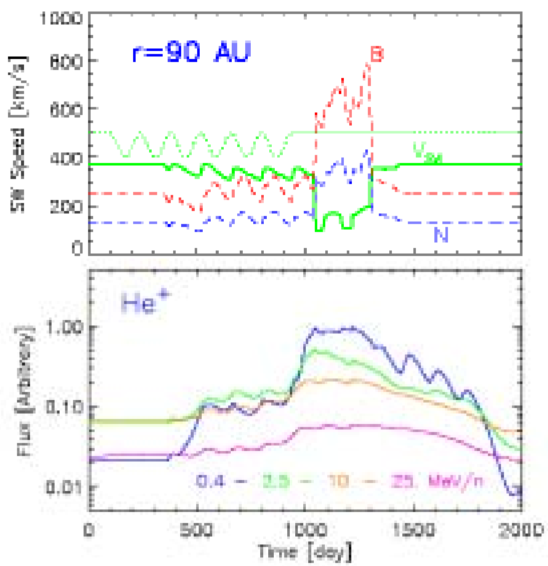
SH3.1-5 Cummings et al.
SH3.3-1 Stone et al.

- *V1* might be connected with acceleration region in TS, located downstream of SW.
- S/IP ions in GMIRs reaccelerated in TS.
- TS moved inward responding to SW disturbances.
- *V1* might have passed TS.



irregular incursion

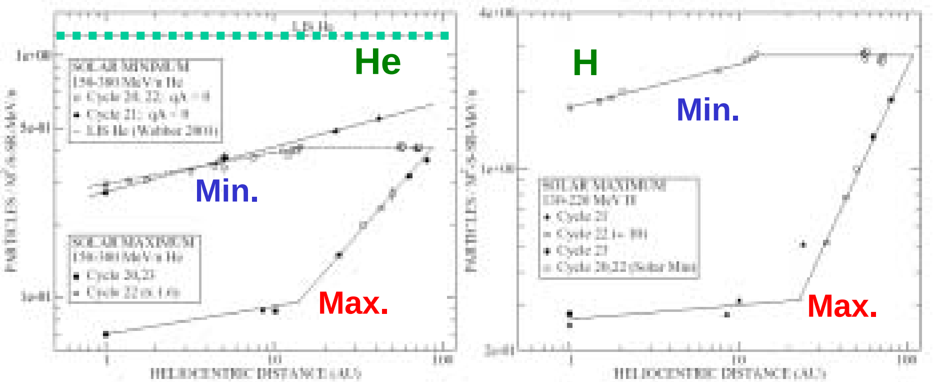
SH3.1-2
Jokipii & Giacalone



SH3.2-2-P-160
Kota & Jokipii

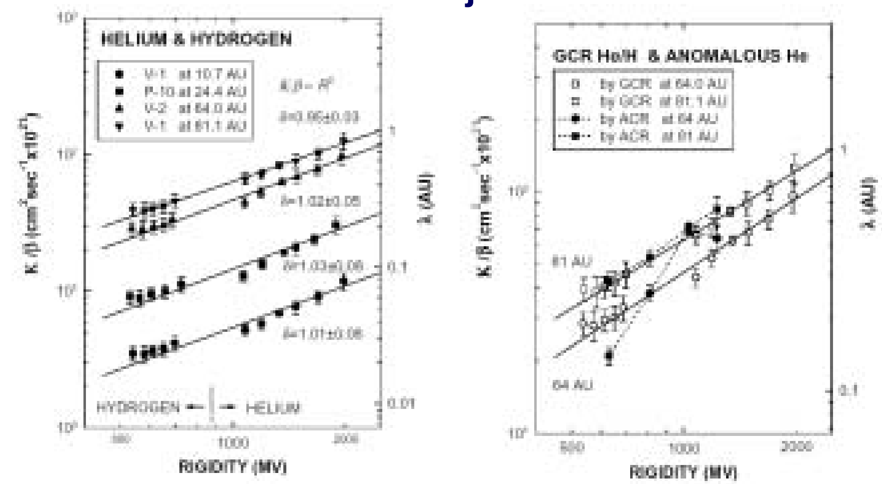
CR distribution in heliosphere (1/2)

SH3.3-2-P-178 McDonald et al.



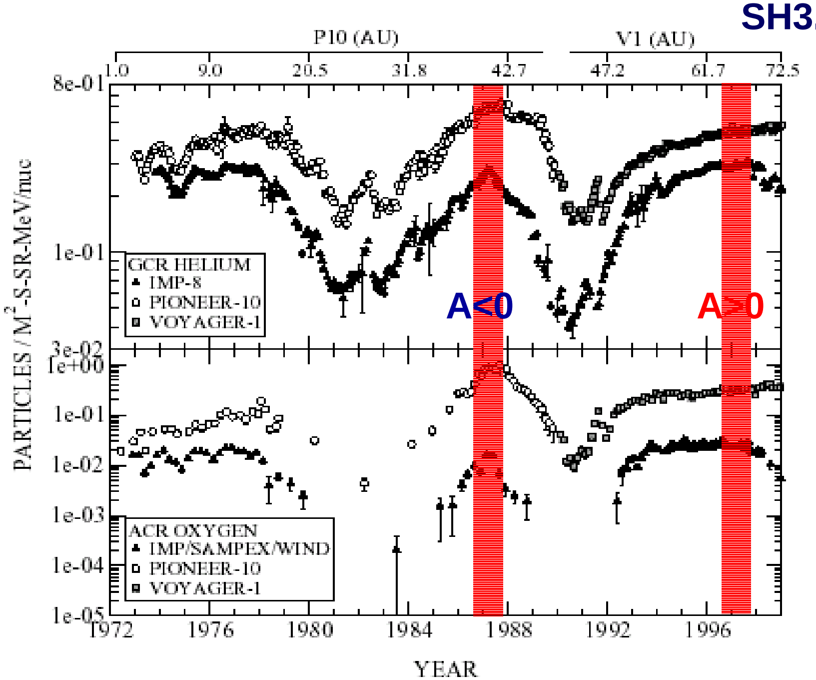
- **Most of modulation during A>0 sol.min occurs near TS or in the helipsheath.**
- **Modulation during sol.max occurs inside TS.**

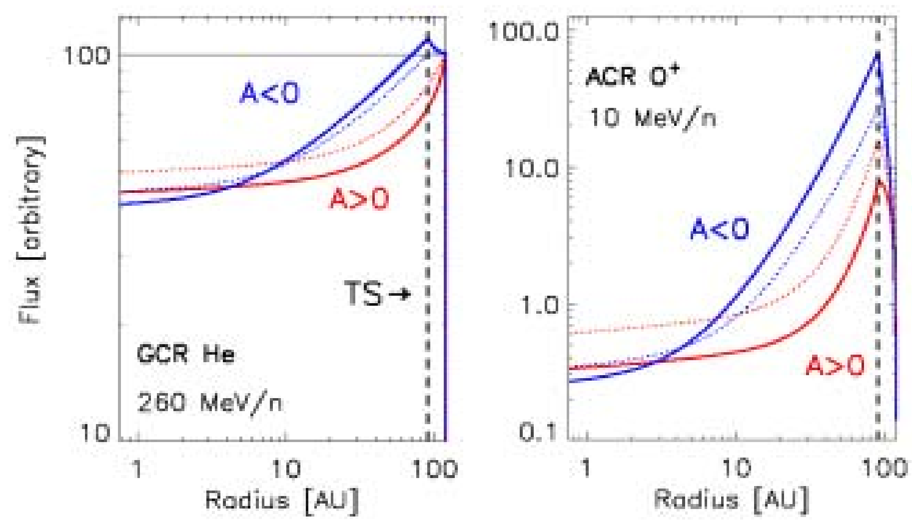
SH3.2-11 Fujii et al.



- **κ ~$R^{0.95}r^{1.21}$ for GCR & ACR during sol.max**

SH3.2-12 McDonald et al.



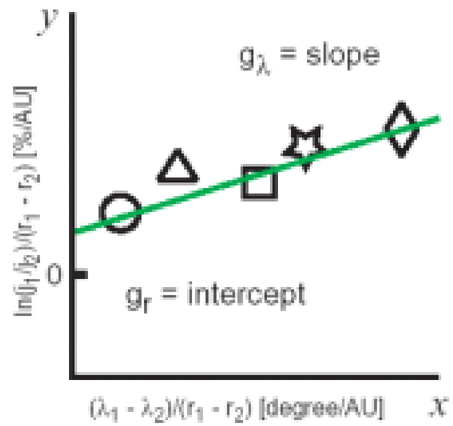


- **Reacceleration of GCR at TS during qA<0.**
- **Additional modulation in heliosheath.**

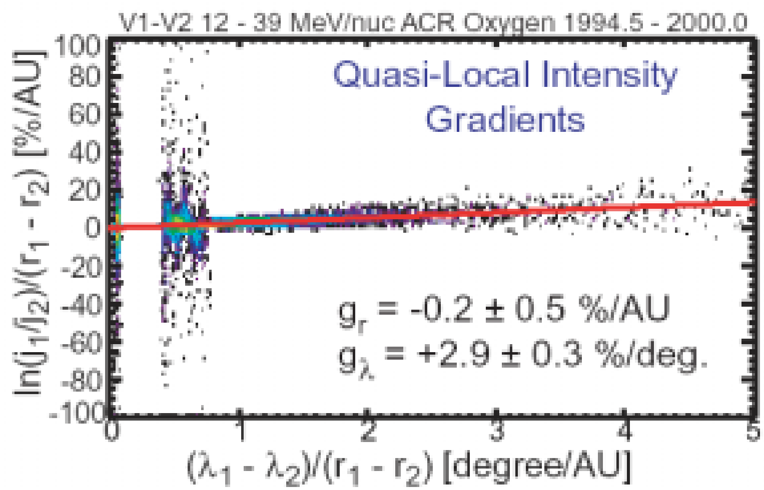
CR distribution in heliosphere (2/2)

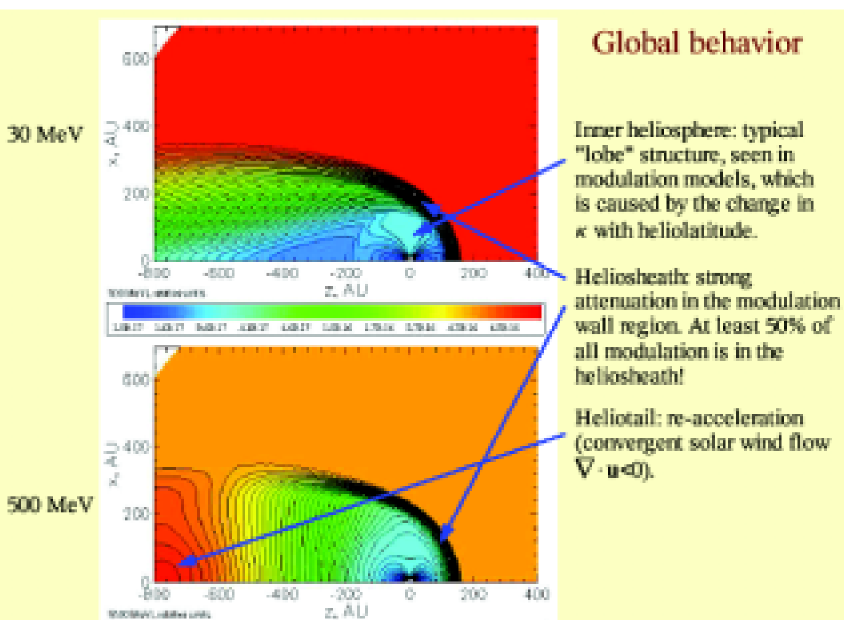
y: $\frac{ln(j_1/j_2)}{\Delta r}$ x: $\frac{\Delta\lambda}{\Delta r}$

$$\frac{ln(j_1/j_2)}{\Delta r} = g_r + \frac{\Delta\lambda}{\Delta r} g_\lambda$$



SH3.3-2-P-169 Hill et al.





Large-scale structure & CR modulation

SH3.2-14 Florinski & Zank

- **Self-consistent approach (MHD, n_H, turbulence + GCR/ACR).**
- **Hydrogen- & magnetic-walls in nose region.**
- **Acceleration in heliotail due to $\nabla \cdot u<0$.**

SH3.1-3 Florinski et al.

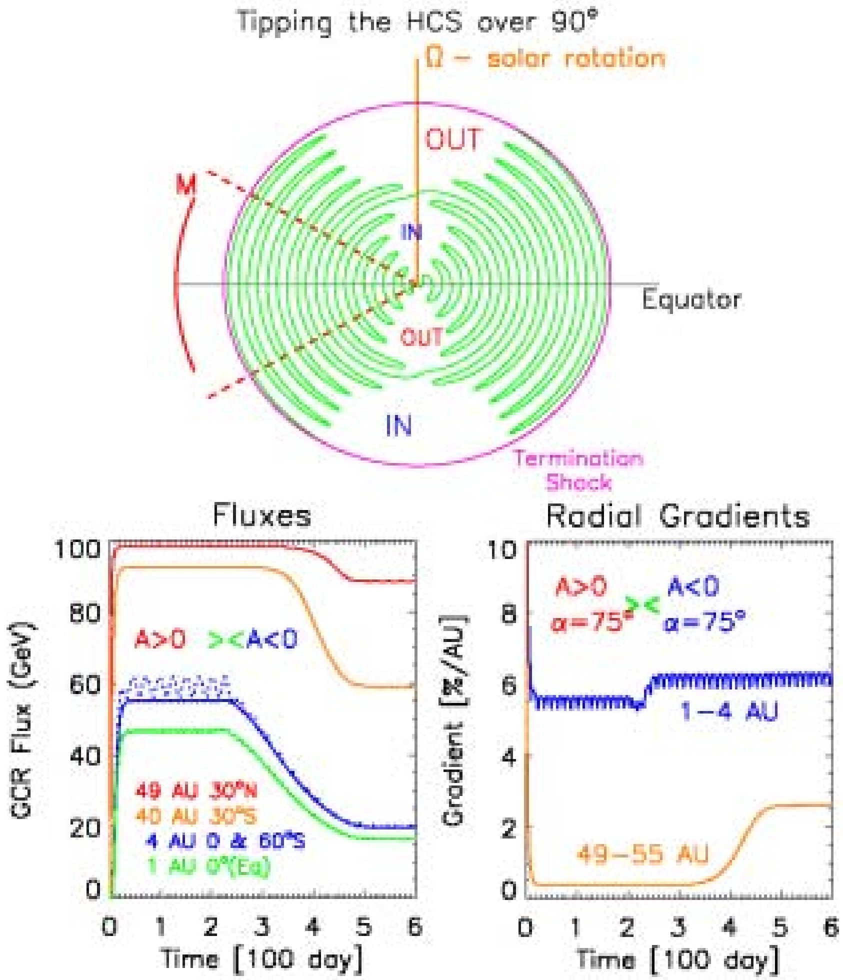
- **ACR has small impact of on heliosphere.**

SH3.1-2-P-153 Berezhko et al.

- **Impact on heliosphere is sensitive on ACR injection efficiency.**

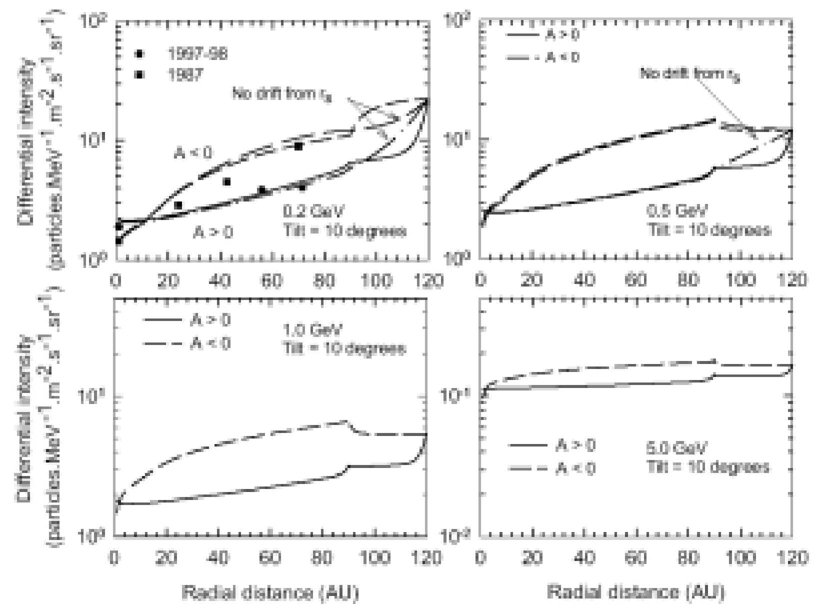
Modulation models (1/2)

SH3.2-1 Kota & Jokipii



- t-dependent & 3-D model with Bθ (Fisk field)
- 26-day variation appears in high latitude
- Abrupt change in HCS tilt over 90 °

SH3.2-9 Potgieter & Langner



- Heliosheath is a modulation barrier for GCR
- Modulation depends on energy, magnetic polarity and solar activity

SH3.2-10 Coballero-Lopez et al.

- Heliosheath doesn't cause GCR modulation in solar minimum condition

SH3.2-13 Ball & Zhang

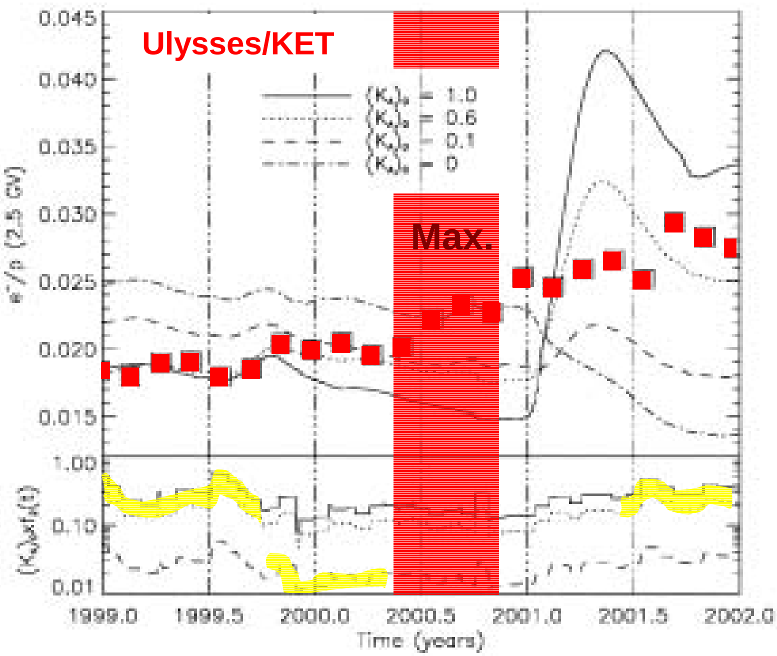
- GCRs still modulated outside TS, due to adiabatic deccel. in downstream of TS

SH3.1-1 Potgieter & Langner

- ACR modulation increases in sol.max due to the decreasing SW comp. ratio

Modulation models (1/2)

SH3.2-5 Ferreira et al.



- t-dependent model with $\kappa_A \sim (B_0/B(t))^{\alpha(t)/\alpha_0}$ is successful.
- But drift must be reduced during solar maximum.

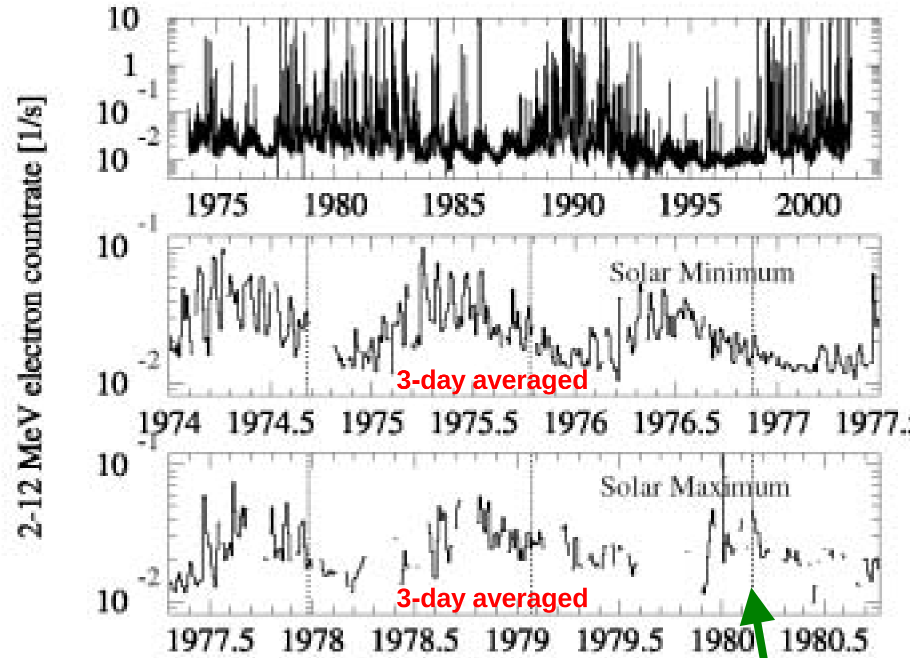
SH3.2-8 Henize et al.

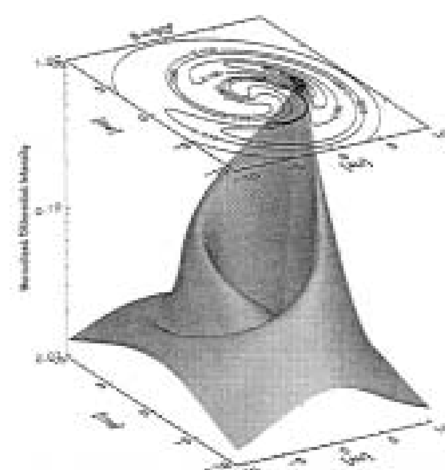
- Ulysses electron profile requires time dependences of Jovian source & $\kappa_\perp/\kappa_{//}$ around solar maximum.

SH3.2-2 Parhi et al.

- Ab-initio modulation model with 2D CR transport.

SH2.3-1-P-230 Kissmann et al.



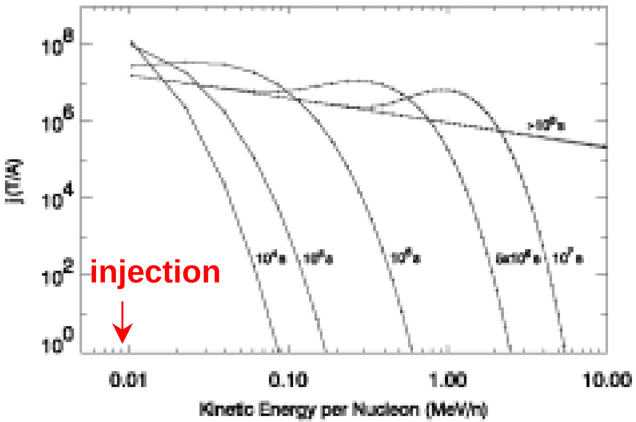


- 13 months variation shows changes in phase & amplitude.
- provides a good opportunity to test modulation model.

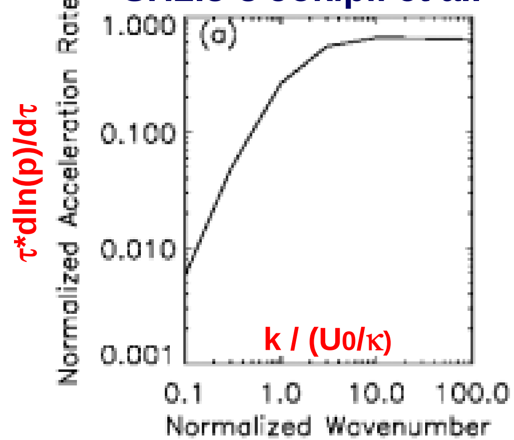
Ferreira et al. (*JGR*, 2001)

Particle acceleration (1/2)

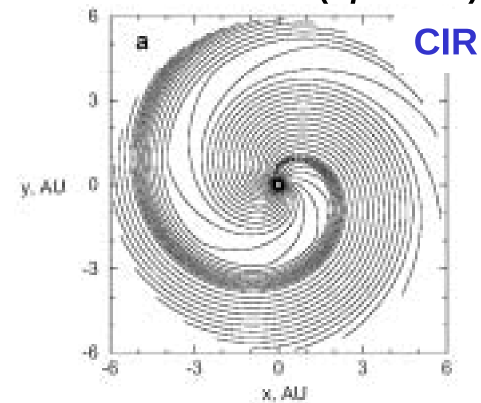
SH2.3-2 Ruffolo



SH2.3-3 Jokipii et al.



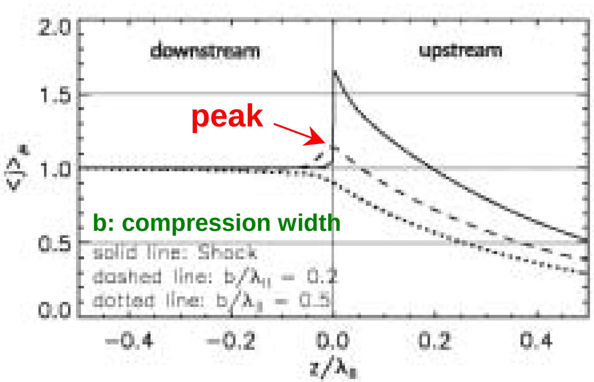
Giacalone et al. (*ApJ* 2002)

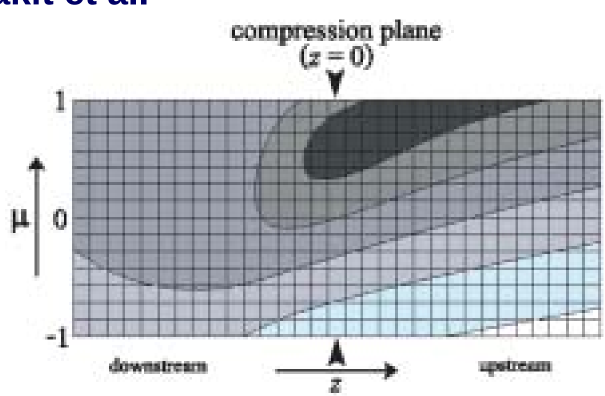


- Finite-time shock acceleration.
- Temporal evolution of spectrum.

- 1D DC equation with gradual dU/dx.
- Diffusive compression acceleration occurs, if $\kappa/U \geq Lc$.
- Important mechanism in region without shock.

SH2.3-1 Malakit et al.

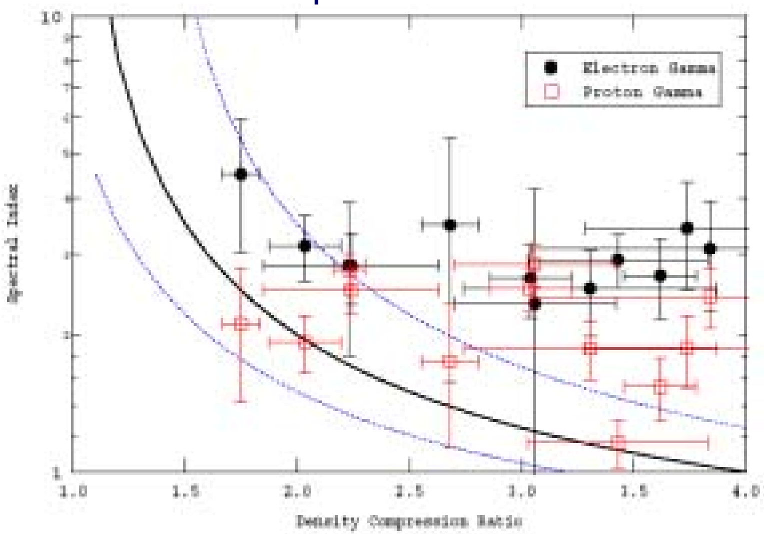




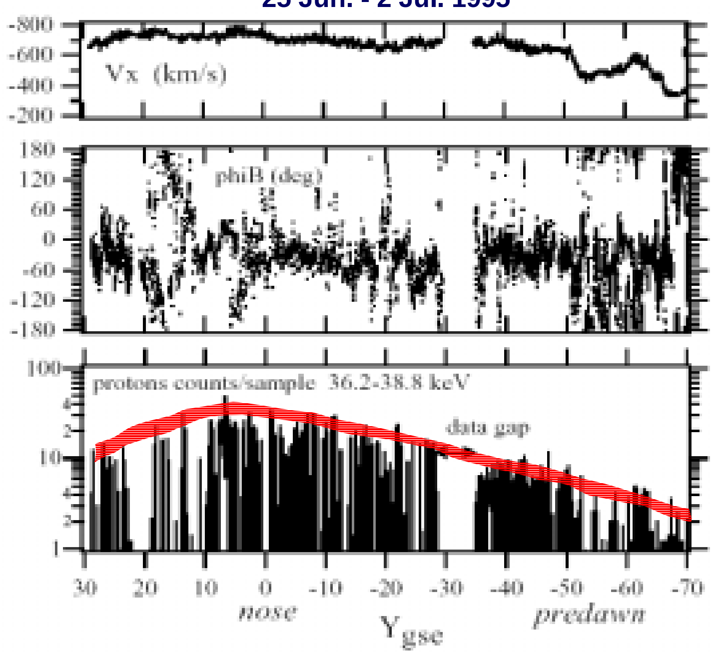
- 1 D Boltzmann eq. with PA diffusion.
- Density peak occurs due to mirroring.
- Spectrum becomes softer at higher energy & in wider compression

Particle acceleration (2/2)

Sept. 1997- Dec. 2001



25 Jun. - 2 Jul. 1995



SH2.3-4 Ho et al.

- ACE obs. of ESP (≥40keV) accelerated in IP shock is consistent with weak (single-interaction) shock drift acceleration.
- Expected activity in waves is not observed.

SH2.3-1-P-225 Nakata et al.

- GEOTAIL observed e (<40keV) accelerated by whistler waves associated with the Bastille-day IP shock.
- Whistler waves are generated by interaction of shock accelerated protons with low-frequency alfvén waves.

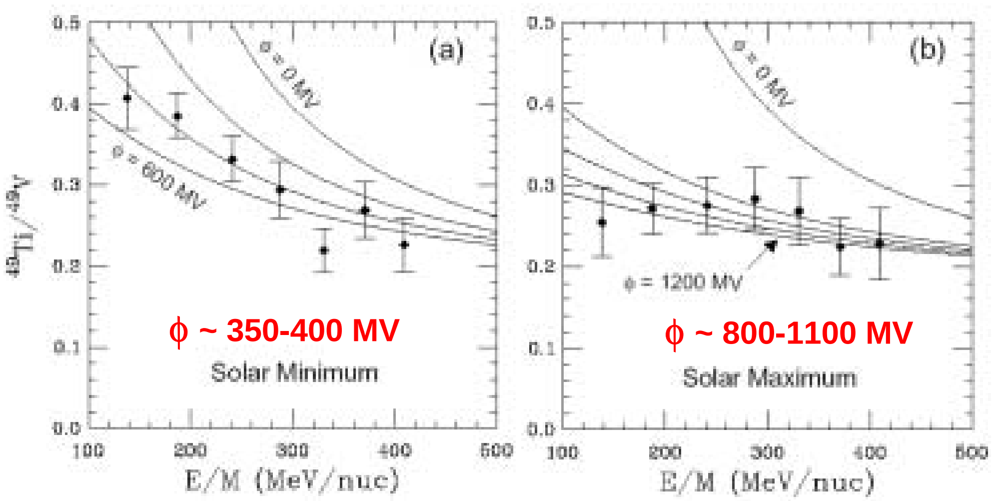
SH2.3-1-P-226 Den et al.

- Spectrum of p (ACE 47keV-4.7MeV) accelerated in IP shock (255doy 1999) evolved softer in time.
- Simulation of this event suggests insufficiently accelerated p existing around 1 AU.

SH2.3-1-P-227 Terasawa et al.

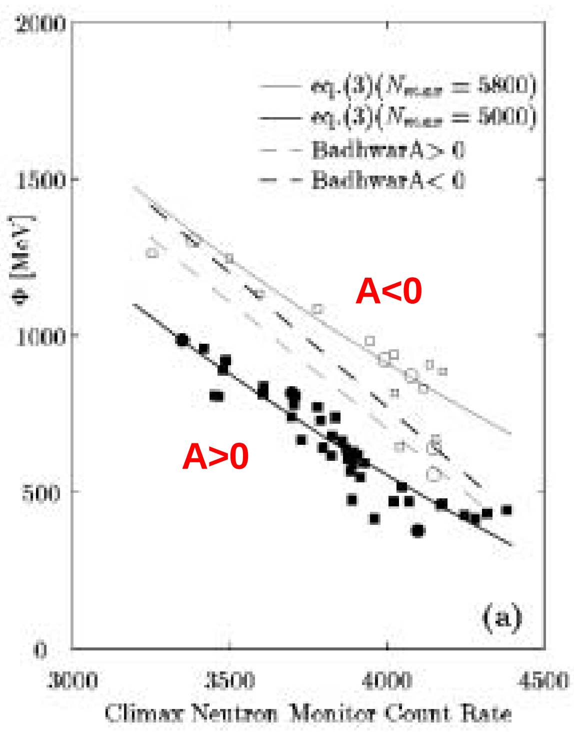
- p (≤40keV) by GEOTAIL is accelerated in nose upstream region of bow-shock.
- Anisotropy tells ExB drift to predawn region.

Modulation potential (1/2)



SH3.2-6 Scott et al.

- **Direct measurement of adiabatic energy loss in SW, by using energy dependent e-capture-decay isotopes.**
- **No assumption of interstellar spectrum is needed.**
- **Derived ϕ is consistent with spectral fits.**



SH3.2-2-P-156 Komori

- **Charge-dependent modulation seen between F-F parameter ϕ for e (0.1-1GV) & NM count rate.**
- **Simple analytical expression for ϕ is also derived.**

SH3.2-2-P-161 Caballero-Lopez et al.

- **F-F approximation doesn't work in outer heliosphere, particularly for ACRs.**
- **Should use numerical solution for DC equation, which works much better even in 1D model.**
- **Get the code at…**

http://www.puk.ac.za/physics/Physics%20Web/Research/modl1Dsimple.f

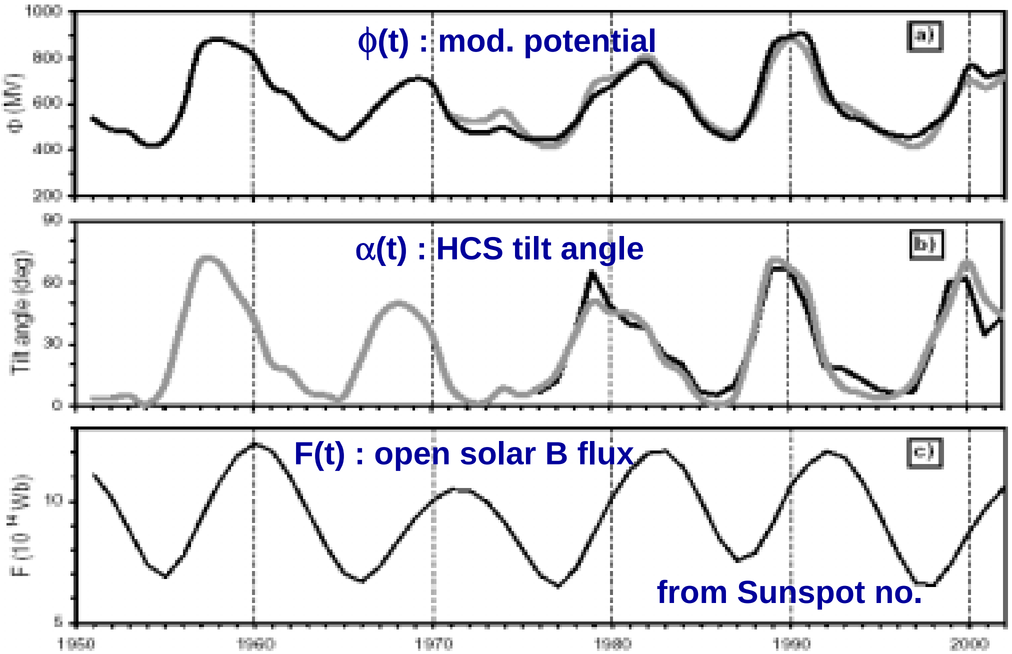
Modulation potential (2/2)

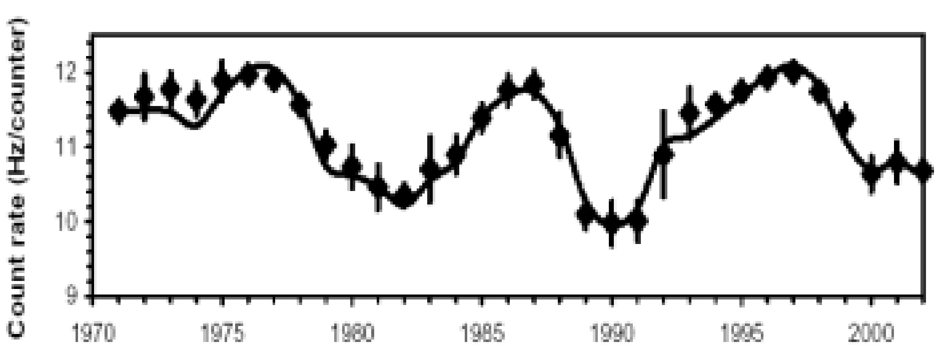
SH3.2-4 Usoskin et al.

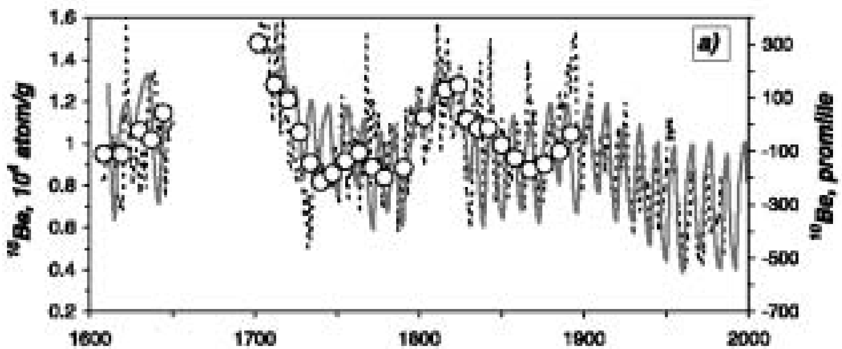
$$\Phi(t) = \boxed{\Phi_0} + \boxed{\Phi_1} \cdot \frac{F(t-\boxed{\tau})}{F_0} \cdot \left(1 + \frac{\alpha(t-\tau)}{\boxed{\alpha_0}}\right) \cdot (1 + \boxed{\beta} p(t-\tau)) \quad (1)$$

Only 5 free parameters for a NM count rates over 30 years!!

- **Obtain free parameters using actual $\phi(t)$ & F(t).**
- **Inversely solve above equation for $\alpha(t)$ using the reproduced $\phi(t)$.**
- **Then tracing NM count rate back to 400-y ago becomes possible!**



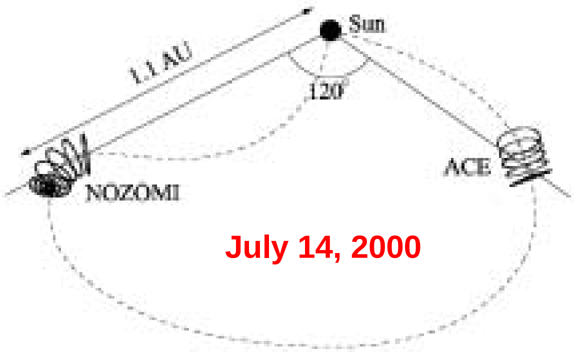




Usoskin et al., *JGR* 2002

CMEs & CR modulation (1/2)

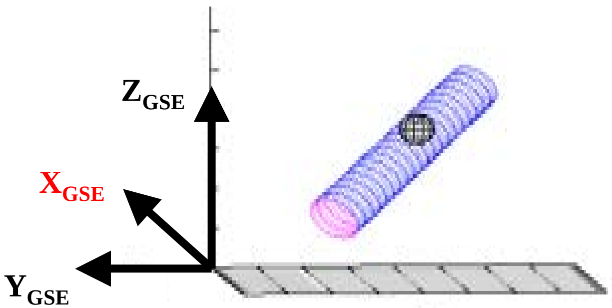
SH2.2-3 Ihara et al.



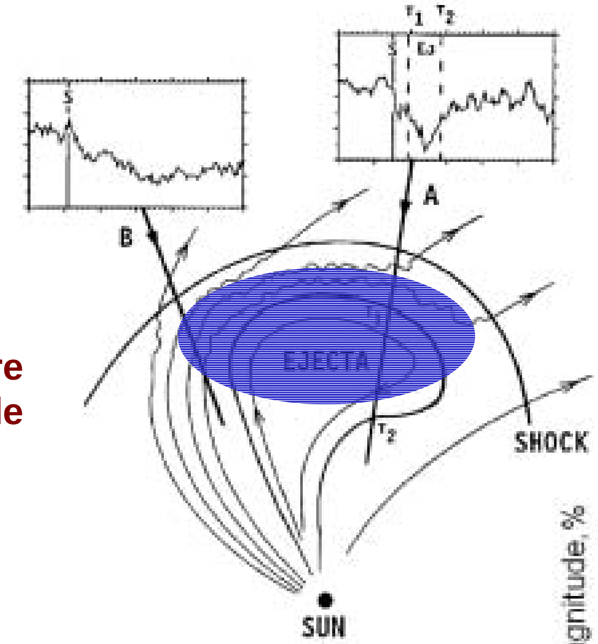
- Local IMF data by ACE/NOZOMI are consistent with a single large-scale flux rope.

SH2.2-4 Munakata et al.

August 27, 2001



- High-energy CR observation allows “remote-sensing” over large gyro-radius.
- Deduction of CME geometry is possible.

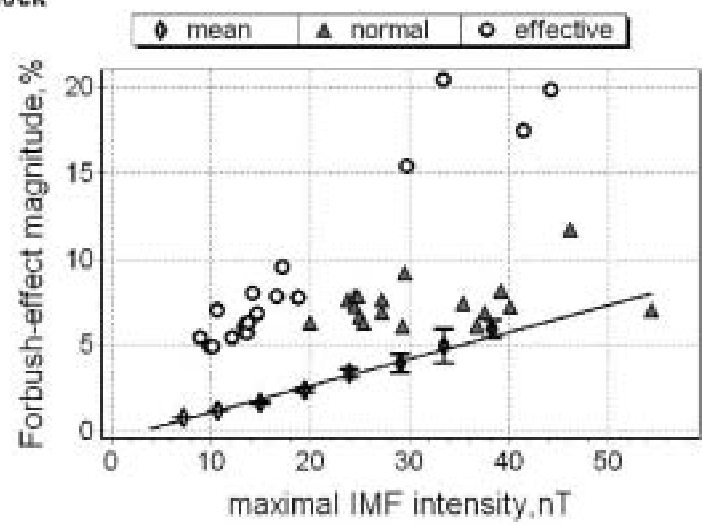


Cane
(*Space Sci. Rev.*, 2000)

SH2.2-1 Gopalswamy et al.

- High-intensity SEP events preceded by other CME.
- Preceding CMEs are faster & wider.
- Primary CME propagate through medium disturbed by preceding CME.

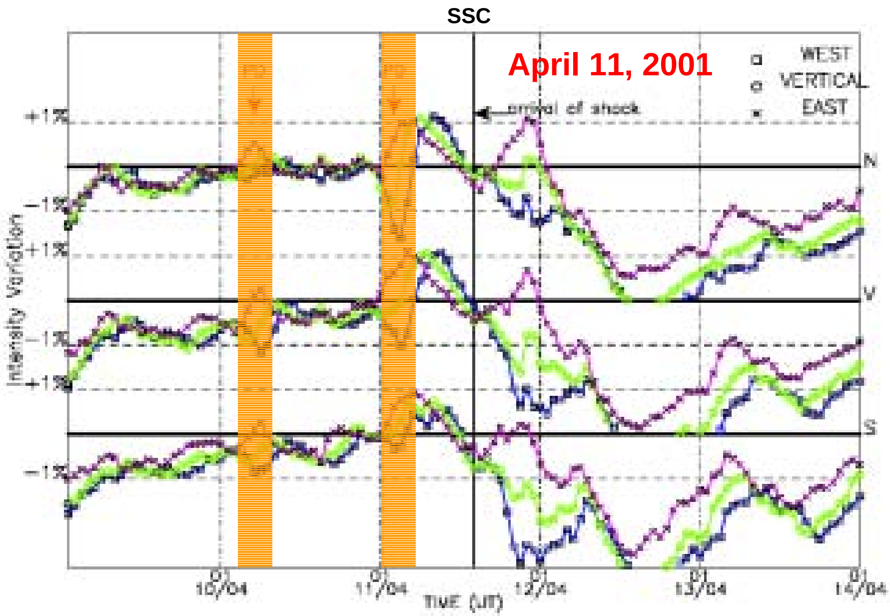
SH2.2-9 Belov et al.

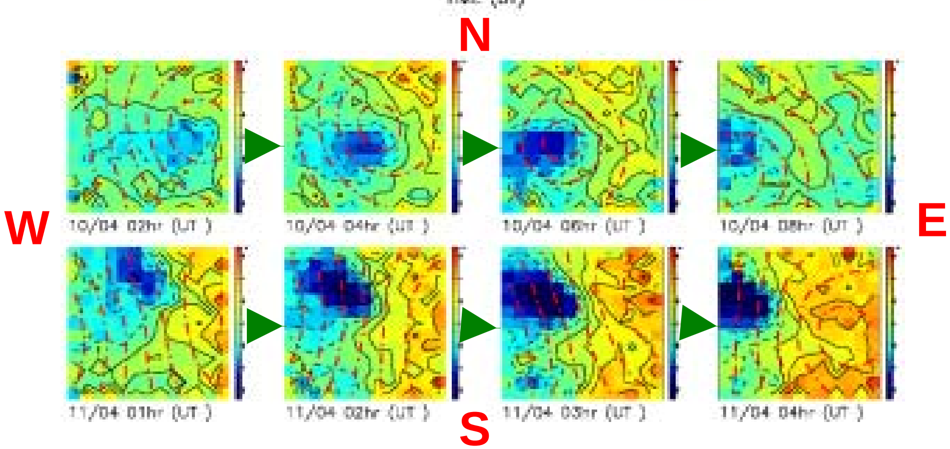


- High-efficiency events causing big FDs with minor IMF disturbance.
- CRs are affected by much larger structure than measured in situ.

CMEs & CR modulation (2/2)

Muon hodoscopes





SH2.2-6 Nonaka et al.

- 560m² array of PC recording 1.8×10⁸ muons/h with ~10° angular resolution (GRAPES3).
- Clearly detected the loss-cone precursor twice, ~24h preceding to a CME-event on April 11, 2001.
- Significant deviation of loss-cone center from sunward IMF is observed half a day preceding the SSC.

SH2.2-5 Fujimoto et al.

- 25m² PC array observed the same precursor.
- Loss-cone is 15° wide

SH2.2-1-P-214 Petrukhin et al.

- 9m² GMC array with ~7° angular resolution.
- "Tomography" of fluctuation in CME

SH2.2-7 Szabelski et al.

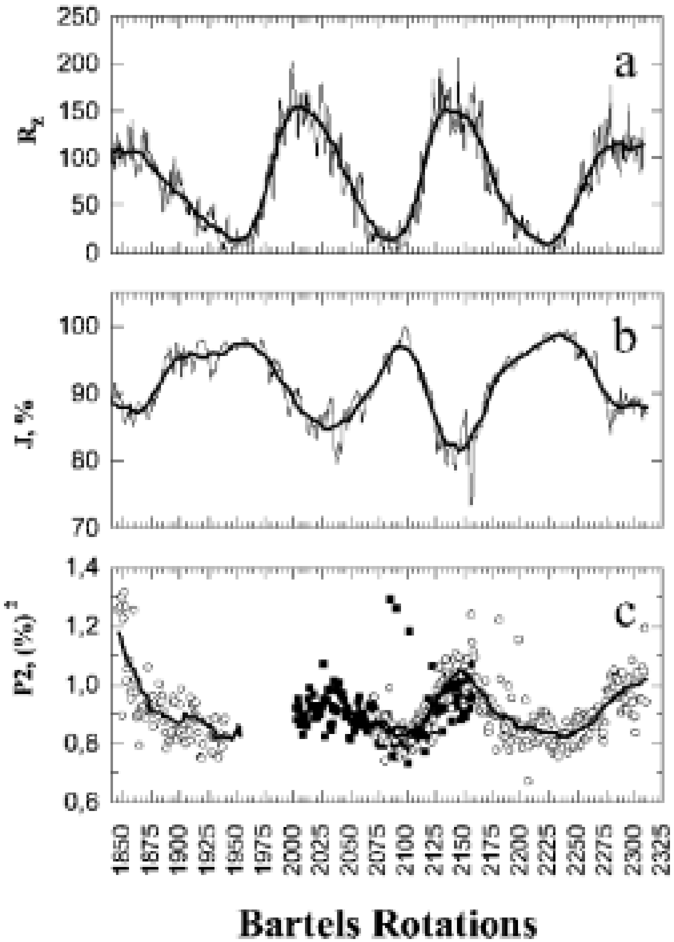
- 0.65m² GM array in operation in Poland.

SH1.5-1-P-197 Yasue et al.

- New recording system developed for muon telescope using FPGA & VHDL.

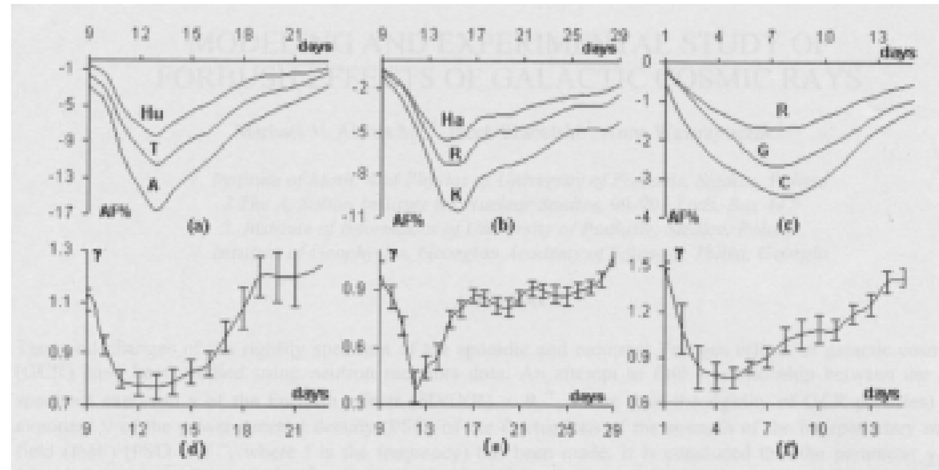
CR interaction with δB

SH3.3-5 Usoskin et al.



- Total power of CR scintillation (0.17-1.7×10^{-3} Hz) changing in phase with sol. acitivity.
- Possibly related to the IMF fluctuation spectrum

SH2.2-10 Alania et al.



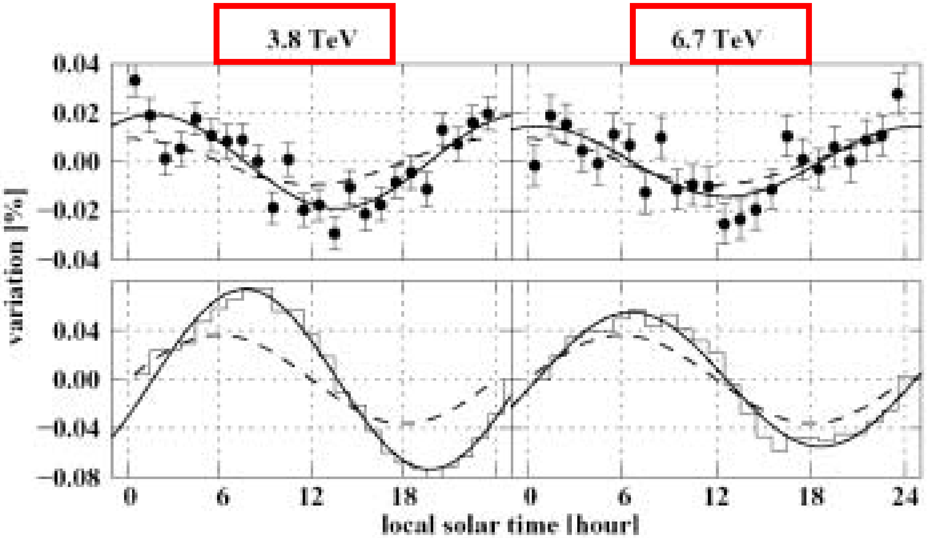
- Rigidity spectral index of FD is derived.
- The average index suggests the rigidity dependence of κ.
- It is also suggested that the large scale IMF fluctuations created by SW disturbance is the source of modulation.

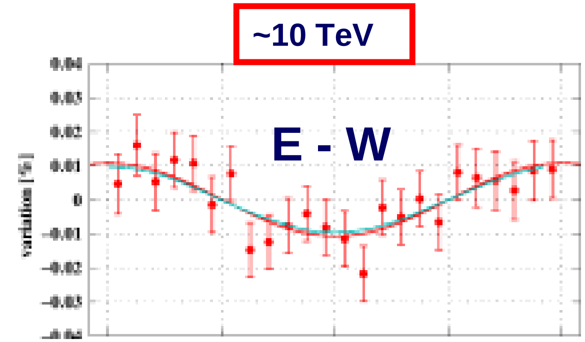
SH3.2-P-164 Alania et al.

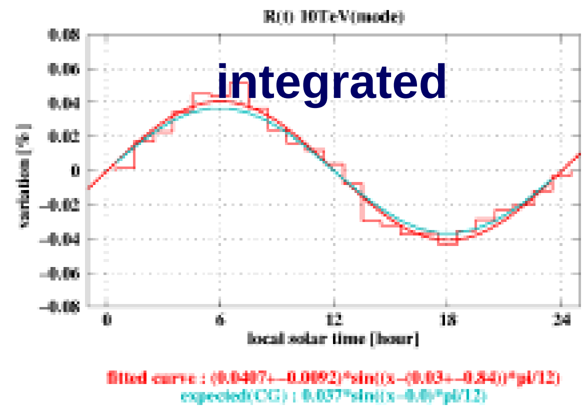
- Rigidity spectral index of 11-y variation.
- Relation between 11-y variation & the large scale IMF fluctuations is suggested.

High-energy CR anisotropy

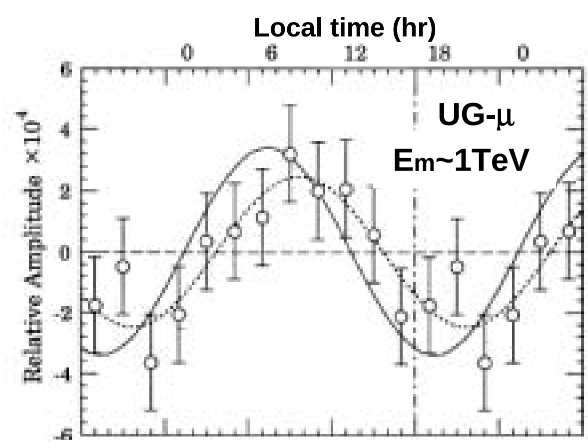
SH3.3-6 Udo et al. SH3.3-2-P-168 Munakata et al.







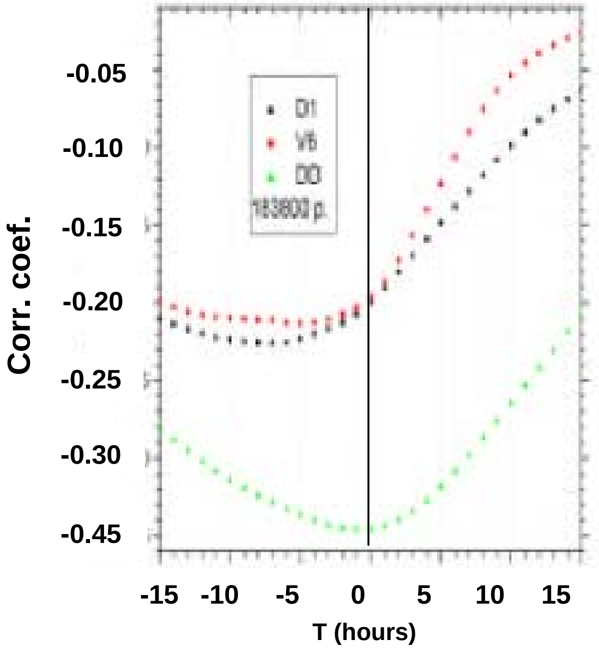
- Tibet II & III air shower arrays successfully observed the Compton-Getting anisotropy in solar time due to earth's revolution around the sun at ~10TeV.
- Observation of this anisotropy with an extremely small amplitude (~0.03%) offers a good opportunity for a crucial test of observation and data-analysis systems.
- Observed anisotropy starts deviating from the expectation at lower-energy down to multi-TeV region.
- Sidereal anisotropy (~0.1%) at ~10TeV is significant & consistent with the Mt. Norikura AS experiment.



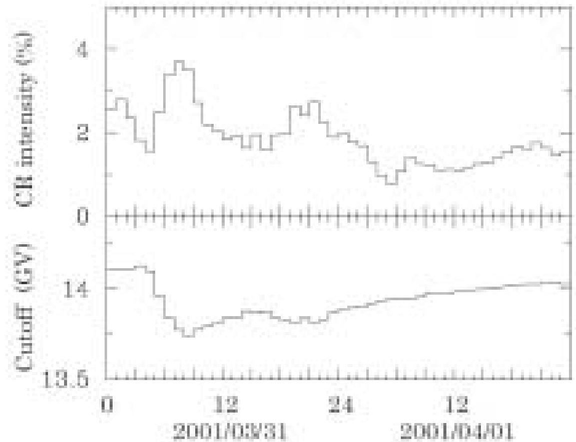
Cutler & Groom, *ApJ* 1991

Geomagnetic effects

SH2.2-11 Kudela & Storini



SH2.2-16 Miyasaka et al.



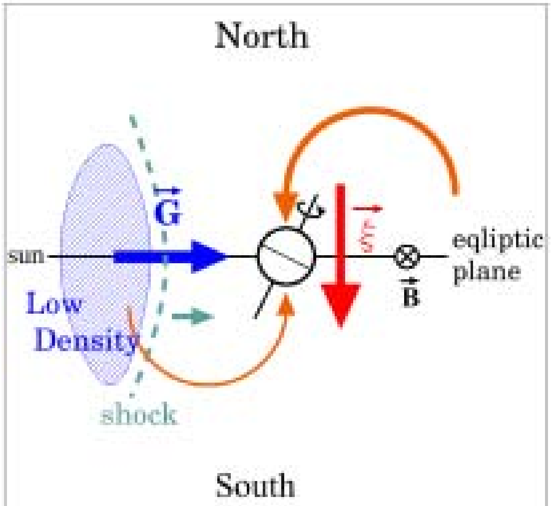
- **Tibet NM (Rc~14.1GV) observed abrupt intensity increases.**
- **These increases are consistent with sudden decreases in Rc.**

- **4 NMs data are correlated with 83 Dst events.**
- **Average $I_{NM}(t)$ over t-1h ~ t-25h show best correlation with Dst(t).**
- **However no correlation found with IMF Bz polarity.**

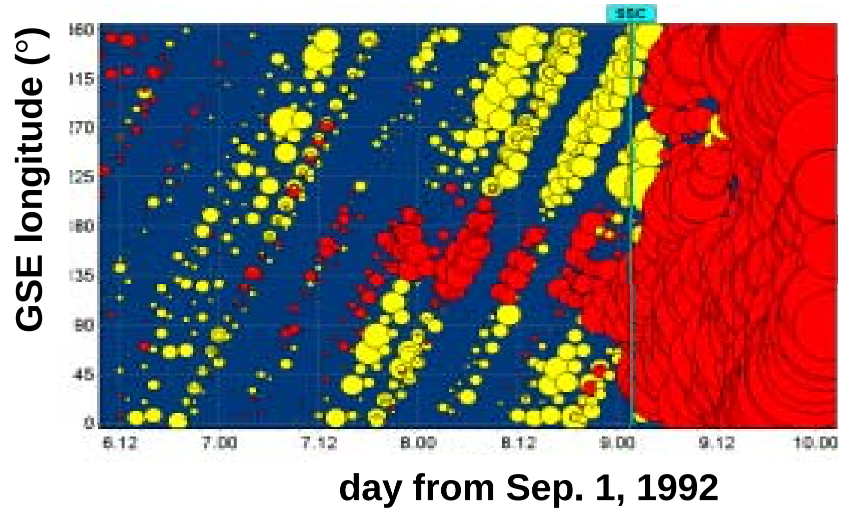
SH3.6-7 Humble & Duldig

- **Distortion of geomagnetic field by SW disturbance causes the viewing direction of NM to vary according to local-time & season.**
- **Computing for each hour is needed for low Rc stations.**

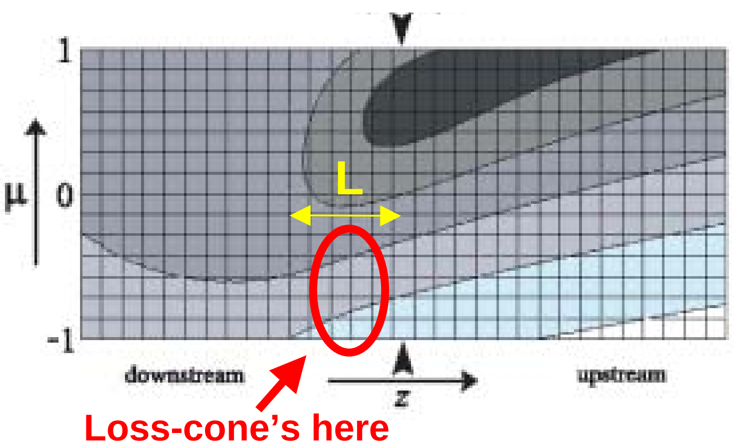
Spaceweather "prediction" & nowcast using CR



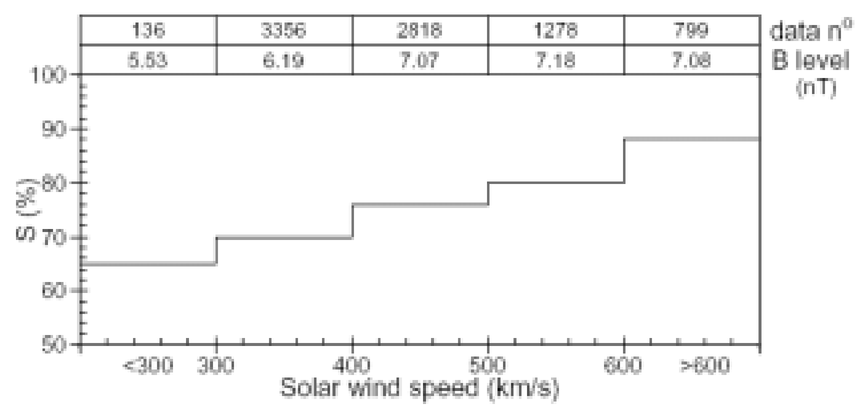
SH2.2-2 Dorman et al.



SH2.3-1 Malakit et al.



SH3.3-2-P-165 Storini et al.



- $L \sim 0.1\lambda \sim R^{\alpha}$ (Roffolo, 1999) & $R_L \sim R$.
- High-E GCR measurements give us an unique opportunity for the remote sensing of the CME over long distance.

- Success rate (S) evaluated for nowcasting IMF sector polarity by Nagoya-GG.
- S depends on the different SW regimes.

Thank you
for your attention!