Simultaneous Detection of Loss-Cone Anisotropy with Ooty(GRAPES-3) and Akeno Muon Telescopes

T.Nonaka[a], S.K.Gupta[b], Y.Hayashi[a], N.Hayashida[c], K.Honda[d], N.Ito[a], A.Jain[b], A.V.John[b], S.Karthikeyan[b], S.Kawakami[a] H.Kojima[e], K.Matsumoto[a], Y.Matsumoto[a], T.Matsuyama[a], D.K.Mohanty[b], P.K.Mohanty[b], S.D.Morris[b], K.Munakata[f] ,T.Okuda[a], A.Oshima[a] , B.S.Rao[b], K.C.Ravindran[b], K.Shivaprasad[b], B.V.Sreekantan[b], K.Takizawa[f], H.Tanaka[a] , S.C.Tonwar[b] , K.Viswanathan[b], T.Yoshikoshi[c]

(a) *Graduate School of Science, Osaka City University,Japan*
(b) *Tata Institute of Fundamental Research, Mumbai, India*
(c) *Institute of Cosmic Ray Research,University of Tokyo, Kashiwa,Japan*
(d) *Faculty of Engineering,Yamanashi University, Kofu, Japan*
(e) *Nagoya Women's University, Nagoya ,Japan*
(f) *Physics Department, Shinshu University,Matsumoto,Japan*

Correspondence to T.Nonaka (nonaka@alpha.sci.osaka-cu.ac.jp)

Abstract : To detect anisotropy which emerges in short time (e.g.Loss-Cone precursor decrease[1]) ,the coverage of field of view along longitudinal direction is important. To expand field of view of the GRAPES-3 muon telescope along longitude with keeping overlapping region through energy range of their response, new muon telescopes were developed at Akeno observatory (N35.8°,E138.5° and 900m altitude) using muon detectors operated as a part of akeno air shower experiment. Here,the first detection of Loss-Cone anisotropy using 2 muon telescopes with overlapped FOV are described.

AKENO and Ooty (GRAPES-3) Muon Telescopes:

(a) (N11.4°E76.7°2200m asl)

(b) (N35.8°E138.5°900m asl)

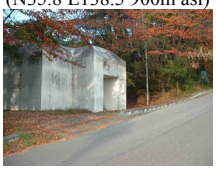

Fig1. (a) :GRAPES-3 Muon stations
(b) :AKENO Muon station

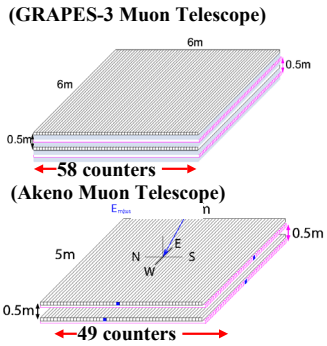

Fig2. Schematic view of GRAPES-3 and AKENO Telescopes. Each has same size of FOV.

	GRAPES-3	AKENO
PRC	10x10x600 cm^3	10x10x500 cm^3
Surface	35 m^2/module	25 m^2/module
Count rate	3200 cps/module	2100 cps/module
Threshold Energy	~1 GeV (kinetic)	~1 GeV(total)
module	16	3(*)

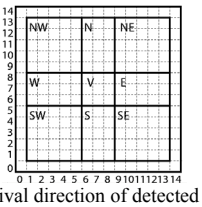

Fig3. Arrival direction of detected muon are categorized into 15x15 directions.

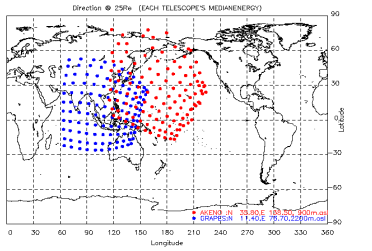

Fig4. Observing directions derived by asymptotic direction of median rigidity particle.

An Observation of Loss-Cone Anisotropy Event:

A "Loss-Cone" anisotropy event was observed at both of GRAPES-3 telescopes and Akeno telescopes. The anisotropy emerged at 30th Jul2004. It was a period of recovery phase of a large Forbush decrease which started at around UT3h 27th Jul 2004. Dividing FOV into 9 directions as defined in **Fig3**, Observed the variation is plotted in center and right panel of **Fig5**. In this analysis,all telescopes in Ooty(GRAPES-3) and one telescope ($25m^2$) in Akeno were used.

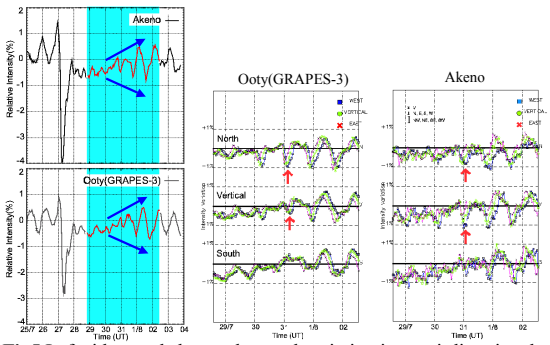

Fig5 Left side panel shows observed variation in omni-directional muon intensity. Center and right side panel shows variation observed at each 9 directions.

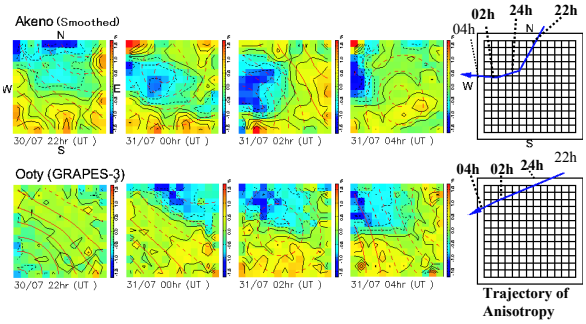

Fig6. Relative intensity map of cosmic ray observed at Akeno and GRAPES-3 from 30th Jul to 31th Jul. The color range corresponds to relative intensity of -1.7% to +1.7%. Statistical accuracy of each cell in FOV are 0.1% at the center of FOV and 0.3% at the corner in GRAPES-3 data. In Akeno data, each cell's relative intensity was smoothed by taking weighted average among surrounding cells since statistical accuracy was not enough. Opening angle between IMF direction and viewing direction are shown in red colored contour line. The one division of the contour corresponds 15° at each panel.

Discussion

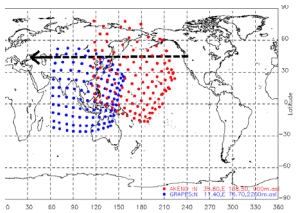

Fig7. Estimated trajectory of Loss-Cone center on Geographical coordinate.

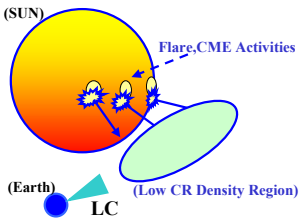

Fig8. Possible configuration of Inter Planetary environment to explain observed anisotropy.

The FD on 27th Jul 2004 looks to be a result of M1/sf flare occurred in UT 15:14 25thJul,2004 and associating CME. After the flare the active region at N08° W35° continued activities while it's rotating towards west side of the Sun. Thus the anisotropy around IMF direction can be a result of Loss-Cone effect between the Earth and region of low cosmic ray density located in the western direction in the interplanetary space.

It is interesting that omni-directional muon flux displayed in left panel of **Fig5** showing large daily variation after emerging the Loss-Cone anisotropy. The observed amplitude of diurnal variation seems to be becoming larger while the anisotropy persists. This implies that some of high amplitude diurnal variation [3] reported from omni directional observations are corresponding to this kind of phenomena found in this observation.

Summary

- **This is the first success to observe local anisotropy event as 2-D map with 2 muon telescopes with over lapping FOV.**
- **Observed Loss-Cone anisotropy looks to be a result of CME activities at west side on the sun.**
- **Some of large amplitude diurnal variation event have been observed and investigated by many authors are possible to be explained with the phenomena found in this observation.**

References :

[1] K.Nagashima,K.Fujimoto et.al Planet,Space,Sci (1992) 40 1109

[2] T.Nonaka et.al Proc,28th ICRC (2003) ,v6,3569

[3] S.Kumar et.al ,Proc,28th ICRC (2003) ,v7,3981