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Search for several tens GeV muons from Mkn 501 during the Gamma-Ray bursts in September 1997

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Abstract

We have examined muon data collected with the Okayama muon telescope in search of a muon flux from the direction of Mkn 501 during the period Augusut 1997 untill October 1998. We found some evidence for an excess for several tens GeV muons from the direction of Mkn 501 during its Gamma-Ray bursts in September 1997.

1 Introduction:

Markarian 501 was discovered as a γ -ray source by the Whipple Collaboration in 1995 (Quinn et al., 1996) and has been verified by the HEGRA Collaboration (Bradbury et al., 1997). The Mkn 501 has shown very high emission in TeV γ -ray from March to October, 1997 and during this period the source was continuously monitored with the Stereoscopic Imaging Atmospheric Cherenkov Telescope System of HEGRA (Aharonian et al., 1999, Konopelko et al., 1999, and Kranich et al., 1999). BeppoSAX observations of Mkn 501 in April 1997 (Pian et al., 1998), have revealed an extraordinary X-ray emission in energy region, 0.1 ~ 200 keV from this BL Lac object, during a phase of high activity at TeV energies, as monitored with the Whipple, HEGRA and CAT Cerenkov telescopes. Ghisellini (1997) explained that emission from BL Lac object with the modified model based on the synchrotron self-Compton emission. However, the emission in energy region, 10 ~ 200 GeV is absent in models and observations.

We tried the muon measurements from the direction of Mkn 501 in momentum region, 5 ~ 100 GeV /c with the OKAYAMA cosmic-ray telescope (Yamashita, et al., 1996) from August 1997 to October 1998 continuously.

2 Measurements:

The OKAYAMA cosmic-ray telescope was operated from 16 August 1997 to 04 October 1998 tracing of Mkn 501 among 10 hours per day. The operated schedule is shown in Figure 1. The observed periods of the HEGRA and OKAYAMA telescope are shown. The hatched period of HEGRA was under presence of high emission in TeV γ -rays and our observations ovelapped with the HEGRA in the period A. The HEGRA is impossible to observe during moonshine and from October till next March.

3 Muon data:

The Figure 2 shows the muon flux at different zenith angle regions for total observing term. Each incoming muon direction is innner 1.2° from the Mkn 501 direction and muon-momentum region is 12.5 ~ 100 GeV /c. The muon flux at larger than zenith angle, 62° is high for the period A and B. However, the flux is constant at zenith angles, from 50° to 8°.

The distribution of incoming muon directions is shown in Figure 3. Here, 0° indicates the

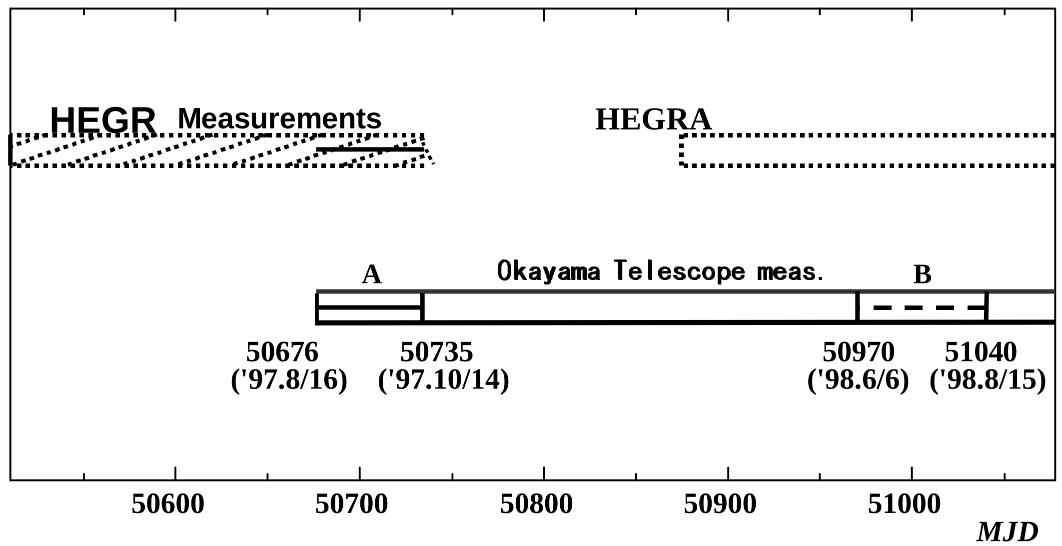

Figure 1: The observed period of the HEGRA and OKAYAMA telescope. The hatched period of HEGRA was under presence of high emission in TeV γ -rays.

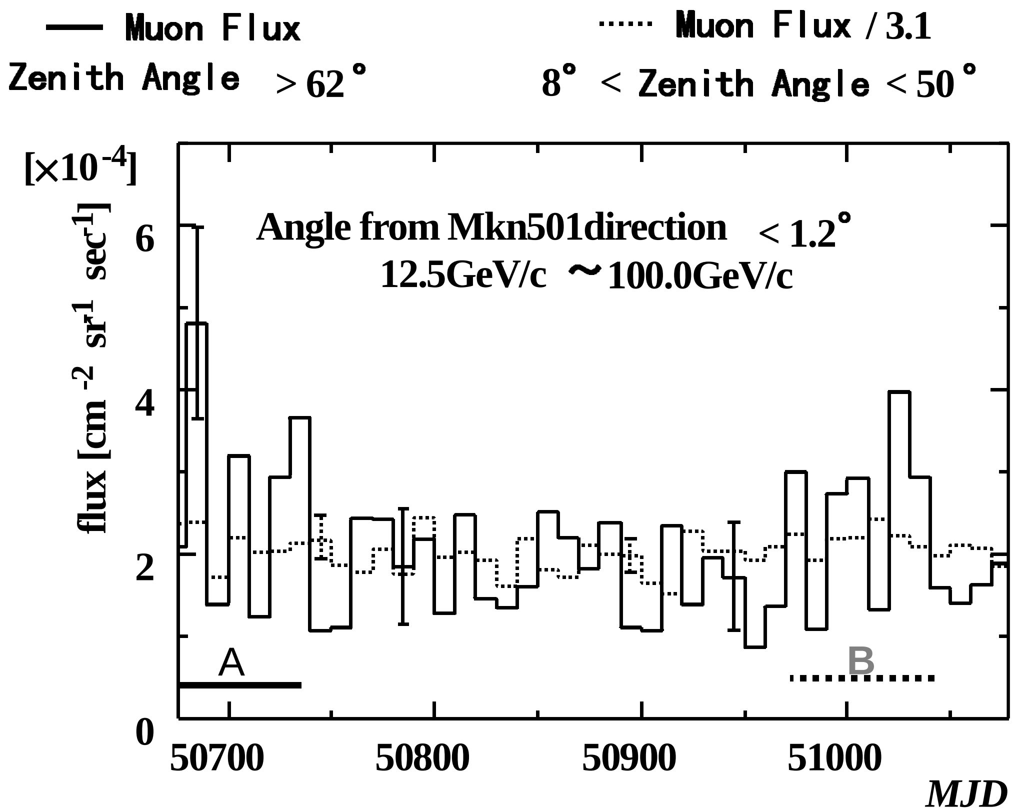

Figure 2: The muon flux at different zenith angle regions for total observing term. Each incoming muon direction is innner 1.2° from the Mkn 501 direction and muon-momentum region is 12.5 ~ 100 GeV /c.

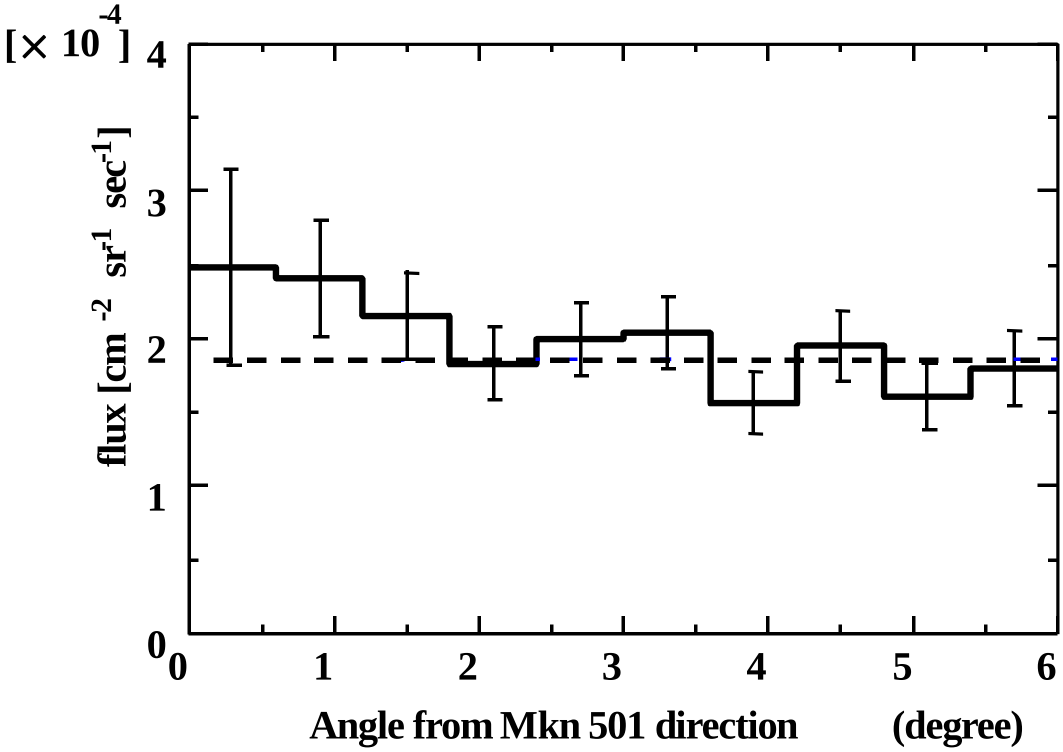

Figure 3: The distribution of incoming muon directions. Here, 0° indicates the direction from Mkn 501.

direction from Mkn 501. The muon flux for the period A is high at less than 1.2°. However, the one for the B is constant at all angle, it means that flux for the B is statistical fluctuation.

4 Results:

As shown in Figure 4, the muon intensities of momentum region, 20 ~ 100 GeV /c and at less than 1.2° for the same period, A with the HEGRA TeV γ -ray burst (Kranich et al., 1999) have the excess comparing with the intensities of total observed term and at larger than 1.2°. The intensities for the period B are almost same with total data. The HEGRA reported no outburst during the period B.

If we assume that γ -ray produces muon pair at atmospheric air, we are possible to estimate primary γ -ray flux for energy region, 40 ~ 200 GeV, that is nearly 10^{-3} cm^{-2}sec^{-1}. The values are one order high as compared with the extrapolating CAT results above 220 GeV in March and April 1997.

We must examine the muon production mechanism and introduce other mechanism.

5 Acknowledgments:

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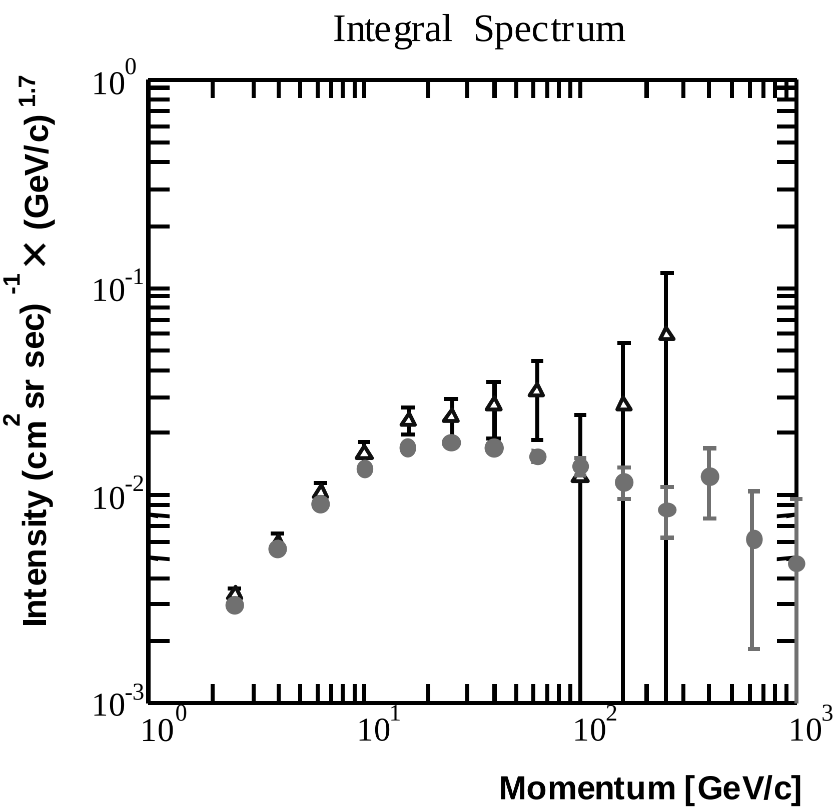

Figure 4: The muon integral intensity.
△:Opening angles of the telescope, 0° ~ 1.2°, for the period A, 50676 ~ 50735 MJD.
●:Opening angles of the telescope, 1.2° ~ 6.0°, for the total period 50676 ~ 51778 MJD.

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