Atmospheric Muon Measurements at Sea Level I: The Detector

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Abstract

The OKAYAMA telescope is a solid iron magnet spectrometer reorganized in 2001. This telescope is able to measure the atmospheric muon flux at sea level for any azimuth and zenith angles. The momentum resolution are improved and a solid angle acceptance are increased as compared with our previous experiments. We report the specifications for the new telescope.

1. Introduction

Precise atmospheric muon observation gives significant informations for cosmic-ray physics, the neutrino flux, the primary flux and so on. Many muon fluxes have been reported, however most of them were obtained from the experiments at near-vertical or near horizontal regions.

The OKAYAMA cosmic-ray telescope is a solid iron magnet spectrometer located at sea level. It is able to turn around any directions and measure the zenith or azimuthal dependence of the muon flux. The telescope was reorganized mainly to improve its angular resolution and increase the acceptance in 2001. In this paper, we report the specifications for the new telescope.

2. The OKAYAMA telescope

The main characteristics are summarized in Table 1. The telescope consists of trigger counters (scintillation counters)(SC1 and SC2), position chambers(multi-wire proportional chambers used as drift chambers)(PC1,PC2, PC3 and PC4), an iron core magnet(M), a theodolite(T) and azimuthal boards(A).

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Table 1. The main characteristics of the OKAYAMA cosmic-ray telescope

Geographical environment	
Location	34°40' N latitude, 133°56' E longitude
Height	28 m above sea level
Geomagnetic field	48°15' N inclination, 6°52'W declination
	horizontal component 3.14×10^{-5} T
Properties of the telescope	
Opening angle	16.3°
Trigger counters	Scintillation counters (40 × 50 cm^2) SC1,SC2
Position chambers	Drift chambers
	(40×40 cm^2, unit cell: 20×20×400 mm^3)
	PC1X (3 layers) PC1Y (2 layers)
	PC2X (3 layers) PC2Y (2 layers)
	PC3X (3 layers) PC3Y (2 layers)
	PC4X (3 layers) PC4Y (2 layers)
Zenith angle (movable)	0°- 80°
Azimuthal angle (movable)	0°-360°
Solid iron magnet data	
Useful magnetic Volume	32 cm× 32 cm × 32 cm
Current, coil	350A,15 turns
Magnet induction	18.0±0.4 kG
Maximum detectable momentum	160 GeV/c
Geometrical acceptance solid angle	
(The distance between the top of PC1 and the bottom of PC4)	24.4cm^2sr
(The distance between SC1 and SC2)	132.2cm^2sr

3. Improvement of the angular resolution and the acceptance

The telescope was improved its angular resolution and increased the acceptance to observe the atmospheric muons precisely. We show the improvement of the angular resolution and the increment of the solid angle acceptance as compared with the previous reported telescope which was before reorganized [2,3]. In Fig. 2, the telescope after reorganizing shows "New type" and the one before reorganizing shows "Old type". We calculate the solid iron magnet in the New type structure and the Old one. White circle plots and white square ones shows the calculated acceptances in New type and Old type respectively. The lines are fitted each calculation plots. The solid angle acceptance of New type shows 24.4 cm^2 sr in Fig. 2(left) in high momentum region. It is about 1.5 times larger than the one of Old type. In Fig. 2(right), ψ shows the deflective angle in the magnet and N shows number of observed muon events. The muon momentum is larger, the plots shows constant value. This beginning constant means the limit of the

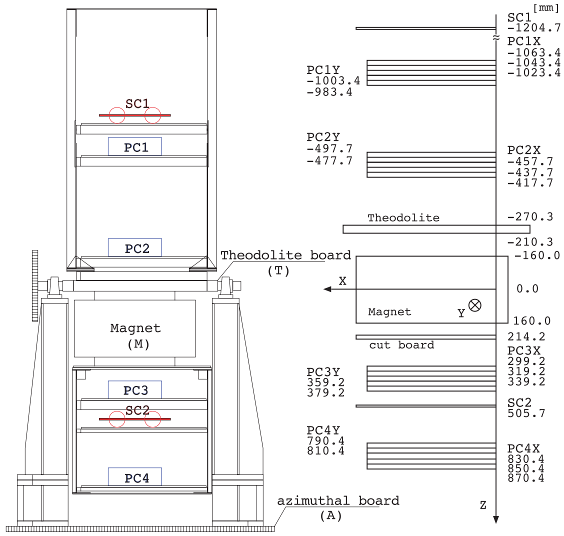

Fig. 1. A sketch of the OKAYAMA telescope. SC1 and SC2: scintillation counters, PC1,PC2,PC3 and PC4: position chambers, M: iron core magnet, A:azimuthal board, T:theodolite board.

angular resolution. The Old type angular resolutions shows about 40 GeV/c, New type one shows more than 100 GeV/c. More than 100 GeV/c, the precise resolution is not decided from this figure, since fluctuations of plots is becoming large. The angular resolution of New type improved 2.5 times more accurately than the Old type. This results shows that the limit of the angular resolutions are decided by observed muon data. It is useful to check the calculated angular resolution value.

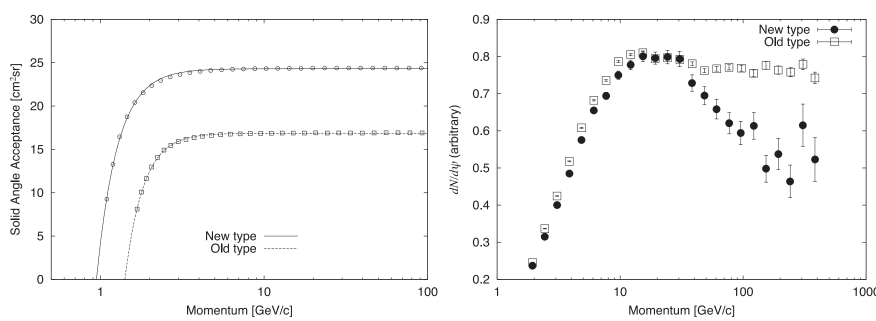

Fig. 2. Left: The solid angle acceptance. White circle: New type telescope. White square: Old type telescope. Solid line: Fitted white circle. Dash line: Fitted white square. Right: The limit of the angular resolutions. (Beginning 'flat' presents it.) Black circle: New type telescope. White square: Old type telescope.

4. Summary

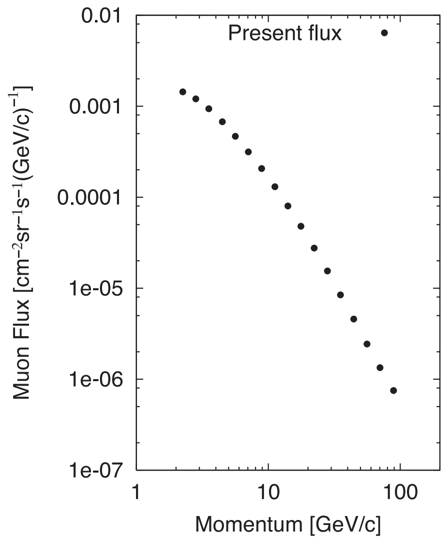

Fig. 3. The atmospheric muon fluxes in vertical. This is preliminary result.

We show the specifications for the new telescope, especially the improvement of the solid angle acceptance and the angular resolution as compared with the old type telescope. The angular resolution is improved more than 100 GeV/c, and the solid angle acceptance is 24.4 cm^2 sr. We show the atmospheric muon fluxes in vertical and in momentum range from 2 to 100 GeV/c as shown in Fig. 3. This is applied the maximum likelihood techniques [1]. However this is the preliminary result, further more checks in this results are needed.

References

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