SEARCH FOR GAMMA RAYS OF ENERGY $> 10^{15}$eV FROM CYGNUS X-3

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Finite flux of excess radiation of energy $> 10^{15}$eV has been reported by two groups[1,2] from the direction of Cygnus X-3, with the characteristic periodicity of 4.8 hrs. Samorski and Stamm[3] find that the muon content of the showers generated by this excess radiation is about 77% of that in normal cosmic ray showers, whereas the expectation for gamma ray showers is less than 10%. It is thus difficult to understand the nature of the radiation arriving from the direction of Cygnus X-3. Samorski and Stamm measured the muon densities close to the core ($\sim$ 10 m), where contamination due to other components is severe. Even though this does not explain the high ratio of muon densities, measurements should be carried out away from the core to establish the nature of the radiation.

In order to establish the signal from Cygnus X-3 and its muon content with better statistical significance, we have been operating an extensive air shower array, specifically designed for this purpose, at Kolar Gold Fields (longitude: $78^{o}.3$ E; latitude: + $12^{o}.95$; atmospheric depth: 920 g/cm^2) since September, 1984. The details of the array and the accuracy of arrival direction measurements will be discussed here.

Fig.1 shows the arrangement of detectors in the array. The array consists of 61 plastic scintillators, each of area 1 m^2, arranged in a hexagonal pattern, with a spacing of 20 m between neighbouring detectors. The total area covered by the array is 1.66×10^4 m^2. Each scintillator is instrumented for pulse height as well as fast timing measurement. Pulse height information, obtained from 5" diameter Philips XP-2050 photomultipliers is recorded on a linear scale using two amplifiers for each detector, with gains unity and 100, covering a dynamic range of 10^4. The relative arrival time at each detector is measured with respect to an arbitrary time decided by a fast coincidence circuit, using signals from a separate 2" diameter RCA 8575 photomultiplier, by means of LeCroy Time-to-Digital converters with a sensitivity of 0.3 ns. The threshold in particle density for timing measurement, is kept at 0.3 to minimise rise time effects.

The air shower trigger is provided by a coincidence of any three neighbouring detectors, forming a triangle, in which the particle density exceeded 1.5. An on-line LSI-II microprocessor recorded the events on a magnetic tape and also continuously monitored all the detectors.

The uncertainty in the arrival time measurement at single particle threshold was obtained from the distribution of the deviations in arrival times between the detector and a fast scintillator telescope kept directly below it. The error thus obtained is 3.5 ns.

The error in the arrival direction of the showers is obtained in the following way. First, events with more than 2 n detectors with timing information were selected, where n is the minimum number of timing detectors accepted for final analysis. These detectors were divided into two groups, each with a minimum of n detectors. Events were analysed using each group of detectors separately, thus obtaining two independent estimates of the zenith and azimuth angles, θ and φ, for each event. From the distribution of the relative deviations of the two estimates, the error in θ and φ were found to be 1.2^o and 1.8^o respectively, for n = 8. The shower size is about 10^5.

The array also contains seven muon detectors, with minimum penetration energy of 1 GeV, each of area 30 m^2. One of them is located at the centre and the others at the six vertices of a hexagon of side 60 m, as shown in Fig.1. A schematic of the detector is shown in Fig.2. It consists of two layers of 48 proportional counters each, under 600 g/cm^2 of concrete, separated by 4 radiation lengths of brick. Each proportional counter is 6 m long and 10 cm x 10 cm in cross section, and is instrumented for pulse height measurement. The two layer configuration enables us to separate muons from 'punch-through's due to other components. Total area of the muon detectors is 210 m^2.

The collecting power of the array is about 10 times that of the Kiel array[1] for showers of primary energy 2×10^{15} eV and we expect to detect a signal from Cygnus X-3 at the same level of significance as that reported by the Kiel group in a few months of operation. The array is in operation since September, 1984 and about 2.5 million events have been collected so far from within 45^o of the direction of Cygnus X-3.Analysis is under progress and results obtained till the time of the conference will be presented.

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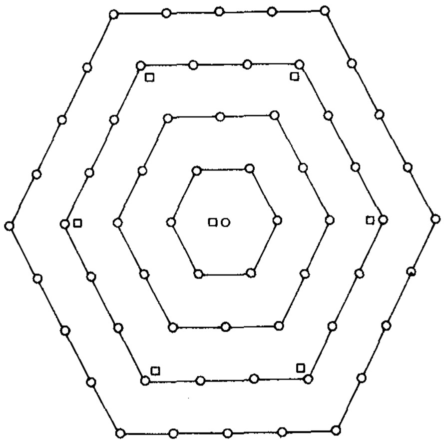
References

1. M. Samorski and W. Stamm, Astrophys. J. Lett., 268, L17 (1983).

2. J. Lloyd-Evans et al, Nature, 305, 784 (1983).

3. M. Samorski and W. Stamm, Conf. Papers, 18th ICRC, Bangalore, 11,244 (1983).

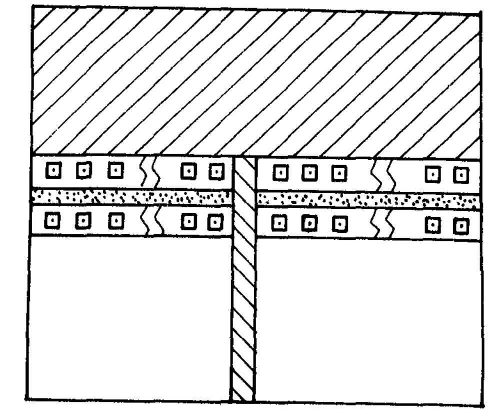


o 1 m^2 Plastic scintillator

□ 30 m^2 1 GeV Muon detector

FIG. 1

K.G.F. AIR SHOWER ARRAY



600 gms/cm^2 granite + concrete mixture

6 m x 0·1 m x 0·1 m Proportional counters

45 gms/cm^2 brick or sand absorber

Fig. 2

1 GeV Muon Detector