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Compact multicomponent array for EAS study (MULTICOM)

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Abstract. We plan to make a new type of array at Baksan just above the running 175 m^2 Muon Detector of Carpet-2 array. This will be a multi-component and multi-purpose array detecting electron, gammas, muons, neutrons and Cherenkov light of the EAS above 10^{13} eV. The array will be specially designed for achieving the best angular resolution ~0.5^o.

1 Introduction

Angular resolution is the main parameter for an array for γ-ray astronomy. Nevertheless, none of them was designed to achieve the best angular resolution. As it was shown (Chernyaev et al., 1995), such an array should have high energy deposit threshold in each timing detector to avoid events with only a few particles passed through it. On the other hand, to achieve as low primary energy threshold as 10 TeV, one should make the energy deposit threshold in each detector as lower as possible. A compromise can be achieved in a case of thick shower detectors (> 1 radiation length) not transparent for gamma-quanta, as the total number of the latter in EAS is much higher than that of electrons. Moreover, the gammas have flatter EAS disc curvature and so are preferable for timing. This is essentially a development of Linley's idea to cover thin detectors with lead for better timing.

Another advantage of our array is using of specially designed thermal neutron detectors 1 m^2 each to be placed on ceiling and viewing the array area for albedo neutrons during a period of several ms after EAS passage. This is a new phenomenon in cosmic ray physics (Stenkin et al., 2001a; Stenkin et al., 2001b; Stenkin and Valdes-Galicia, 2001) and we hope it will help us to select primary γ - ray EAS as well as to study primaries chemical composition. In conjunction with running nearby Carpet-2 array, we shall be able to cover a wide range of primary energy to study the knee region.

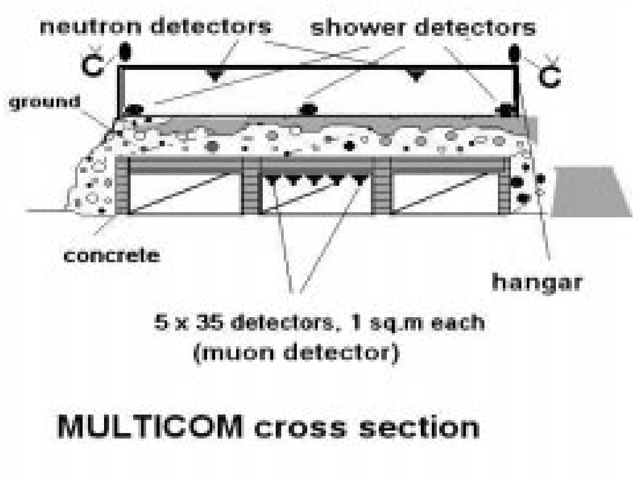

Fig. 1. Multicom array cross section.

Measurement of muon and Cherenkov light components will allow us to perform the multi-parameter data analysis for better result.

2 The array set-up

The Multicom array will be not a simple flat array. Fig. 1 shows its cross section. One can see here 4 detectors level: underground (500 g/cm^2) muon detector; ground level thick shower detectors; 2 m above ground (ceiling) thermal

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neutron detectors and Cherenkov detectors on the roof. Fig. 2 shows a plan view of the array without muon detector. The figures show the minimal configuration needed to start the experiment. Later it can be expanded.

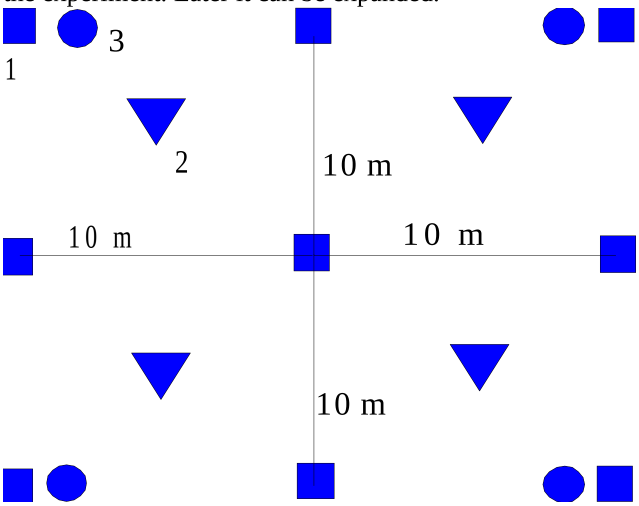

Fig. 2. Multicom plan view.

1- thick shower scintillator detector (53 g/cm^2, 0.43 m^2)
2- thermal neutron detector (ZnS +B^{10}, 1 m^2)
3 - Cherenkov air detector (no focusing)

The shower detector cross section and its dimensions are shown in Fig. 3. It will have an area of 0.42 m^2 and thickness of 53 g/cm^2 of liquid scintillator viewed by 2 PM tubes: fast 3” (Hamamatsu R6091) for timing and slow 6” PMT (FEU-49) for energy deposit measurements.

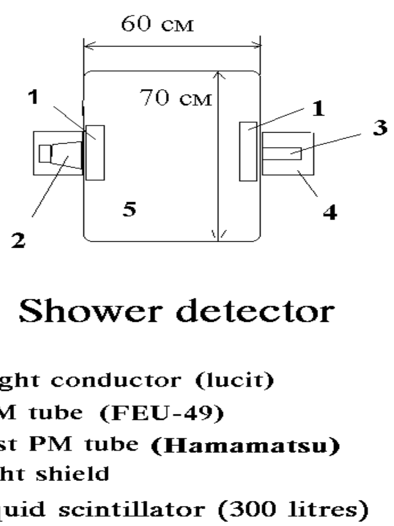

Fig. 3. The shower detector cross section.

The thermal neutron detector design is shown in Fig. 4. It looks like a traditional shower detector, but instead of commonly used plastic scintillator it will use special very thin layer (hundreds of microns) of inorganic scintillator ZnS (Ag) with addition of boron 10 isotope compound. This detector is insensitive to charged particles as well as to gamma ray, but it has rather high efficiency (~40%) for thermal neutron detection due to reaction B^{10}(n,α)Li^7 + 2.79 MeV. ZnS is very effective detector for heavy particles such as α - particle and even Li nuclei. We shall measure the number of delayed pulses in these detectors during, say 3 or 5 ms after the EAS disc passage (see Stenkin et al., 2001a; Stenkin et al., 2001b and Stenkin and Valdes-Galicia, 2001).

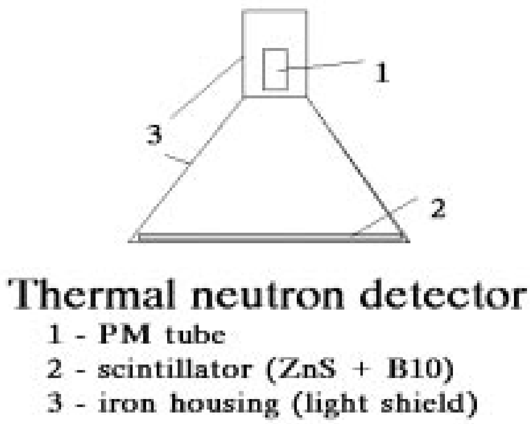

Fig. 4. Thermal neutron detector.

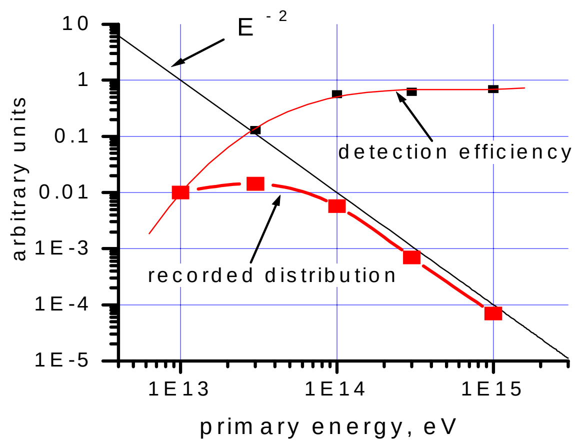

Fig. 5. Results of M-C calculation: expected EAS size spectrum

The Multicom array will have the following main features:

Primary threshold energy - ~10^{13} eV
Angular resolution ~ 0.5°
Sensitivity to all EAS components: e; gammas; muons; neutrons (hadrons); Cherenkov light
Altitude 1700 m a. s. l.
Location Baksan Valley

3 Calculations

This have been proved by the results of Monte – Carlo simulations (shown in Fig. 5 and Fig. 6) using CORSIKA codes and the program applying its data for real array:
Calculations were made in 2 steps:
1) CORSIKA EAS simulations for primary gamma rays for a number of primary energies.
2) Application of "artificial" showers to the array with different core position and checking for triggering conditions.
Thus, primary energy threshold has been obtained. Angular resolutions have been obtained using another program described elsewhere (Chernyaev et al., 1991).

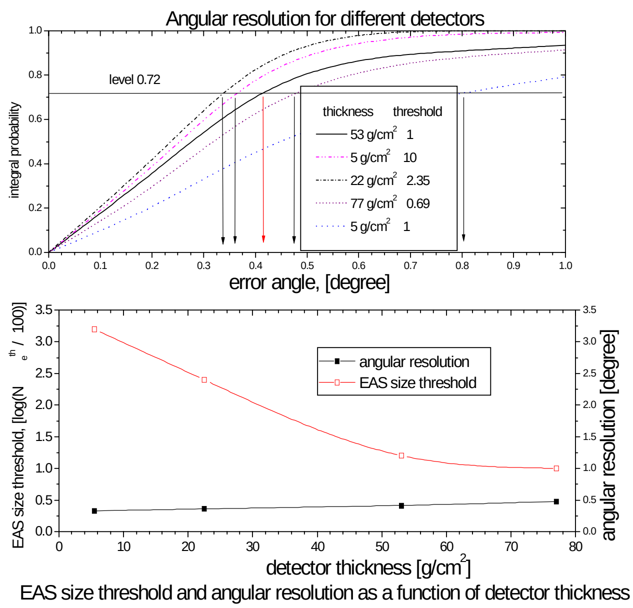

Fig. 6. Results of M-C simulation: angular resolution and threshold

Results are shown for one sell of 10x10 m^2 with at least 3-fold coincidence with energy deposit >106 MeV in each detector.
To estimate the array counting rate and expected number of events from local sources we can refer to (Amenomori et al., 1999) where an excess from Crab Nebula has been measured. Taking into account the differences in effective area (~20 times), in threshold energy (10 TeV instead of 3 TeV) and in altitude, we can expect an excess of about 15 events per year from Crab direction.

4 Conclusion

We proposed a new type of array for EAS study. Using its advantages (first of all its record angular resolution) we plan to perform an experiment to search for local sources of cosmic ray with energy above 10 TeV as evidences for its existence appeared now (Amenomori et al., 1999). Also we plan to study primary cosmic ray chemical composition making multi – parameter data analysis and also, to study the origin of neutron bursts. And finally, good timing will permit us to study EAS time structure with a good accuracy, to check for existence of "double-front" EAS (Alekseenko et al., 1999) and probably to explore Linsley's idea (Linsley, 1985) to detect EHE EAS with a mini – array.

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