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III-2-15. Bolivian Air Shower Joint Experiment

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A joint air shower experiment is being set up and is near the full operation at an altitude of 5,200 m in Bolivia. The principal objectives and brief account of the equipment will be given.

(I) Objectives

A joint air shower experiment is being set up and is near the full operation at an altitude of 5,200 m (530 mb) in Bolivia (Mt. Chacaltaya Cosmic Ray Laboratory, geographic latitude 16°19′S, longitude 68°10′W). The principal objectives are:

(1) To search for showers generated by primary cosmic gamma rays the energy of which is more than a few times 10^{13} ev,

(2) To search for evidence of high Z primaries,

(3) To study the characters of ultra high energy nuclear interaction.

The first of principal objectives is a sort of high energy gamma ray astronomy suggested by many authors. Showers produced by gamma rays could be distinguished from the much more numerous showers produced by the charged component of cosmic rays because they should not contain any appreciable number of μ-mesons and nuclear particles. The number of μ-mesons or nuclear particles involved in gamma-ray shower might be an order of one hundredth of that in charged primary showers. Of course, amount of μ-mesons and nuclear particles in individual shower fluctuates for wide range due to the statistical reason, height of the first interaction and fluctuation of nuclear interaction. In order to confirm the extremely small amount of μ-mesons or nuclear particles which is an evidence of gamma-ray showers, we must be very careful of the contamination of ordinary showers which have especially small amount of μ-mesons or nuclear particles as the results of fluctuation. Therefore, we are forced to construct a detector for μ-mesons and nuclear particles with great area (60 m^2) to observe a large number of these particles and reduce the Poisson fluctuation. Also, the altitude of Mt. Chacaltaya is very convenient to observe gamma ray showers, because 5,200 m is near the shower maximum and the fluctuation of amount of μ-mesons due to height of first interaction of primary particle is much reduced.

The expected ratio of the number of gamma ray showers to ordinary showers is so small as to be order of 10^{-3} to 10^{-5}, depending upon the assumption of density of interstellar matter, the arrival direction in celestial sphere and cross section of π^0-production by proton-proton collision. The number of shower particles for gamma-ray shower at shower maximum is larger than that for charged primary shower with same energy and the attenuation of shower particles in gamma ray shower is rapider than that in charged-primary shower. Therefore, at a high altitude, we are able to have better ratio of gamma ray shower to charged primary shower at a given size. We want to emphasize that we are able to look at the center of Galaxy, Magellanic cloud and local possible cosmic ray source such as Centaurus which cannot be seen from north hemisphere.

The second of main objectives is to observe evidence of heavy primaries, following a method suggested by Tokyo group[1] which is to confirm the much more content

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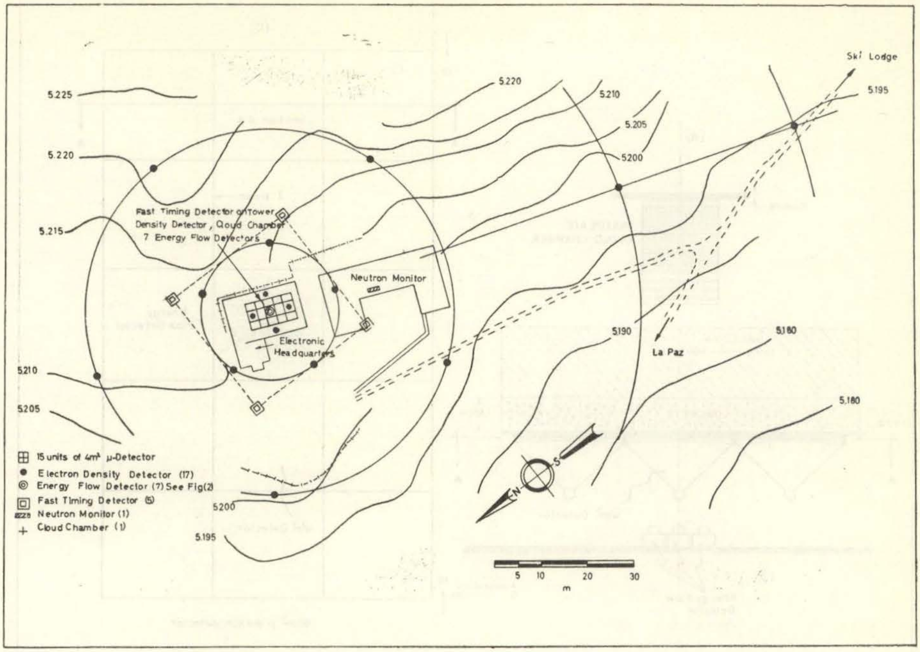

Fig. 1.

of μ-mesons in shower produced by heavy primary than that by proton primary. The fluctuation of number of μ-mesons which comes from the variation of height of first interaction for a given size will be much reduced at an altitude of 5,200 m., approaching the shower maximum.

The third of main objectives is to get the detailed information on the core of shower especially focussing our attention on the high energy nuclear particles, because high energy nuclear particles are playing important role for the development of air shower and are concentrated in the core.

(II) Arrangement

The main elements are a 60 m² scintillation detector shielded by galena (PbS ore), seventeen 1 m² density detectors, a fast timing array, seven total absorption Cerenkov detectors, a 60″ multiplate cloud chamber and a neutron detector. The arrangement of whole equipment is shown in Fig. 1.

a) Density detector—Seventeen density detectors made by plastic scintillators are used to determine the location of the shower axis and the size of shower by density sampling. Five of these are set in the central part of the array, five detectors are set on a circle the radius of which is 15 m. The other five detectors are on a circle the radius of which is 40 m. Another two detectors are set at distance of 80 m and 120 m from the center of array, respectively.

b) Fast timing array—Five scintillation detectors each with an effective area of 1 m² are used. Four are located on a horizontal plane at the corners of a square of side 30 m, and the fifth detector is set about 10 m above the horizontal plane at the center. Arrival direction of air shower is measured by this array. The accuracy of the estimated arrival direction is about 5°.

c) 60 m² detector—This element consists of fifteen units of 4 m² detector put tightly together, as shown in Fig. 2 (a) (side view) and (b) (top view). Every 4 m² detector is made by plastic scintillator and single 16″ photo-tube[2]. The uniformity of sensitivity over whole area is within 5% and the pulse height distribution is narrow enough to distinguish zero particle from single particle which strikes the detector. As the shield material, there is 150 g/cm² to 400 g/cm² of galena, 60 cm of concrete and 2 cm of lead. So, this 60 cm² detector acts as μ-meson detector when the axis strikes

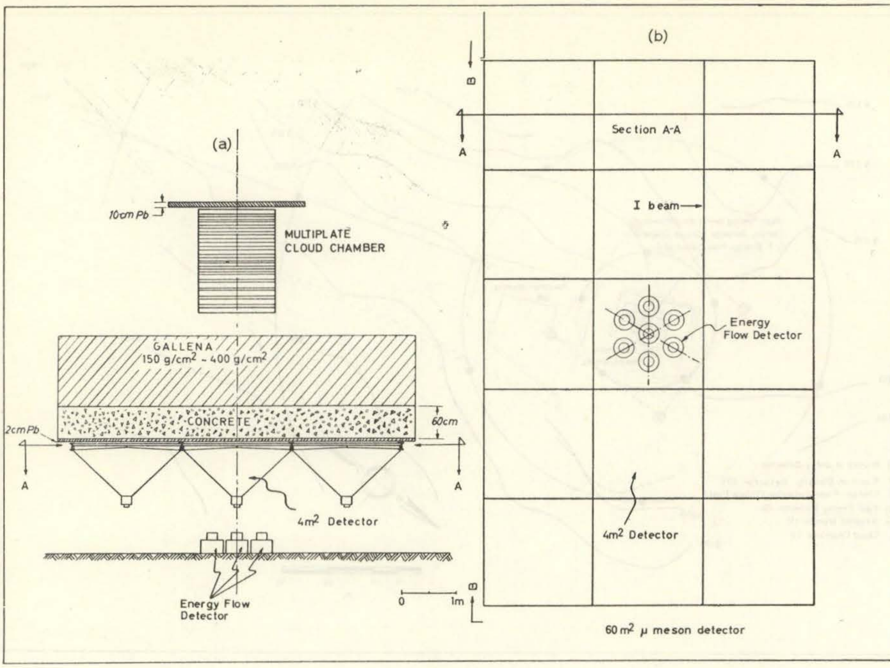

Fig. 2.

the outskirt of the array as well as nuclear particle detector when the axis strikes the central part of the array. In later case, 60 cm concrete is a producer of nuclear interaction and 2 cm of lead is producer of cascade showers for π^0-mesons which come from the nuclear interaction.

d) Total absorption Cerenkov detectors —Seven of these made by lead glass are set beneath one of 4 m² detector, as shown Fig. 2 (a) and (b), to look into the detailed spatial distribution of high energy nuclear particles in the core and estimate their energy. The effective area of each detector is about 0.2 m² and the depth is about 12 radiation lengths.

e) A 60″ multiplate cloud chamber—The cloud chamber contains seventeen 1/2″ steel plates and is shielded by 12 cm of lead from the electromagnetic component of air shower.

f) A neutron detector—Duplicated units of standard Simpson type monitor each of which contains six BF_3 counters. Neutrons which associate with air shower are recorded.

These elements mentioned above had been prepared at the Massachusetts Institute of Technology, the University of Tokyo, the University of Michigan and Universidad Mayor de San Andres. Dr. H. Bradt of M. I. T. has very much contributed to the set up of equipment and the final adjustment. Mr. R. Schulczewski, Mr. Y. Saravia, Mr. A. Garcia and Mr. H. Echeverria of the Laboratorio de Fisica Cosmica, Universidad Mayor de San Andres are also very much contributing to this project. Our sincere thanks are due to them.

References

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Discussion

Clark, G.: The most convincing evidence for the detection of γ-ray primaries, either in satellite or air shower experiments, will probably remain the observation of an anisotropic distribution of the arrival directions of special "γ-ray events."