

A STUDY ON MUONS ASSOCIATED WITH  
EXTENSIVE AIR SHOWERS

Thesis presented

by

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## P R E F A C E

An experiment, to study high energy muons (Energy  $\geq$  150 Gev) associated with Extensive Air Showers (EAS) of cosmic rays, has been conducted by the author, at Kolar Gold Fields (K.G.F.), India, in collaboration with the Tata Institute of Fundamental Research (TIFR), Bombay. The thesis incorporates the results from this experiment.

The basic aim of such a study is to derive information about the characteristics of nuclear interactions in which such high energy muon component of EAS is produced. The muon component of EAS arises mainly through the decay of the parent particles e.g. pions and kaons. High energy pions and Kaons, in turn, are produced in the first few high energy ( $\geq 10^{13}$  eV) interactions in the upper regions of the atmosphere. These muons, after being produced, maintain their direction and spectrum very closely and hence carry information, about the various features of the high energy interactions as well as about the nature of the particles participating in the interactions. Thus a study, such as the present one, is helpful in obtaining information about the nuclear interactions and the composition of the primary cosmic rays at high energies.

The experimental set-up consists of

- i) an air shower array at the surface, consisting of 20 plastic scintillators arranged along the

peripheries of concentric circles of increasing radii; and

- ii) a penetrating particle detector located at a depth of 194 m underground.

The author, working at Physical Research Laboratory, Ahmedabad, under the guidance of Dr. Bibha Chowdhuri and Prof. V.A. Sarabhai was responsible for the fabrication, setting-up and maintenance of the penetrating particle detector and the associated electronic circuits used in the present experiment. The EAS array and associated circuitry, used in the present experiment, form part of the experimental set-up of the TIFR EAS group at K.G.F. The data reduction and the analysis of the EAS data to fit shower parameters was done by the author, on CDC 3600/160A computer installation at TIFR, in collaboration with and using a computer programme of the TIFR EAS group. Further analysis, to obtain the results presented in the thesis, was done by author himself using CDC 3600/160A computer system at TIFR and IBM 1620 computer at Physical Research Laboratory, Ahmedabad. The author is responsible for the results and the conclusions presented in the thesis. The material presented in the thesis is divided into seven chapters.

The first chapter contains a brief review of the present knowledge about the various components of EAS. Some of the aspects of EAS studies, the importance of the muon component of EAS and the scope of the present work are outlined together with a brief description of the theories and models of high energy interactions, involved in the development of EAS.

The second chapter deals with the experimental set-up used in the present experiment. Triggering, recording and selection procedures are described.

The third chapter describes the data reduction procedure and gives details of the analysis done to obtain the various parameters of the recorded showers. Results of an error analysis are presented.

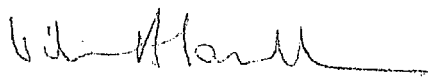
The fourth chapter gives the results obtained from the experiment. The main results relate to the size spectra of the EAS recorded with and without the associated muons, the number of muons of energy  $\geq 150$  Gev in showers of different sizes and the energy spectrum of the muons in EAS.


The results of Monte-Carlo calculations, carried out for some of the models on muon component of EAS are presented in the fifth chapter. A comparison of the predictions of the models with the results from present experiment is given. The implications of the results are discussed.

In sixth chapter results from the data obtained with neon flash tube hodoscope are presented. A discussion of these results along with their comparison with the results obtained in other similar experiments is given. The results are also compared with the predictions of the known theories.

The seventh chapter contains a summary of the results and the conclusions from the present experiment.

The thesis presents new results on the muons of energy  $\geq 150$  Gev in EAS, having sizes in the range  $10^5 \leq N \leq 5.10^6$  particles, which may be helpful in better understanding of the high energy interactions and the composition of primary cosmic rays in relevant energy range ( $10^{14}$  eV -  $5.10^{15}$  eV)

  
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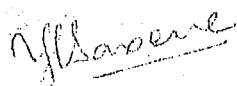
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