About the possibility for an unbiased estimation of primary energy spectra around the "knee" based on cherenkov light in EAS

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INRNE-BAS, 72 tsarigradsko chausse, 1784 Sofia, Bulgaria mechanisms. The region of the knee in their spectrum

Abstract: The characteristics of EAS with energies 10^4-10^{7} GeV are calculated with CORSIKA 5.62 code for observation level 536 g/cm^2 for proton and iron primaries .The shower selection was carried out taking into account the detector displacement described in the recent HECRE proposal for Chacaltaya. As proved before, the extensive air shower (EAS) selection with $\alpha_e(r_0)$=const gives the possibility to select with constant efficiency showers with given energies independly of the atomic number of the initiating primary particle. Similar result is obtained selecting showers with constant value of a new shower parameter $\eta(r)$, based on the Cerenkov light densities at distances 65 and 200m from the axis of the EAS with energies 10^4-10^7 GeV at observation level 536 g/cm^2. By this way it is possible to obtain information about the mass composition and energy spectrum of the primary cosmic radiation at energies 10^4-10^7 GeV selecting EAS with $\eta(r)$ =const and applying extended complex analysis of the electron and muon components at Chacaltaya observation level.

investigations carried out in the field of cosmic ray physics. The mass composition has a great interst in order to obtain some information about their origin and propagation mechanisms. The region of the 'knee' in their spectrum remain very interesting. Above 100 TeV this information only can be obtain by indirect measurements of EAS especaly from muon, Cerenkov and electromagnetic components. Independently of the obtained experimental and model results many problems need carefully studies on the basis on the new experimental and methodological level.

The calibration of the direct and indirect methods for primary cosmic radiation studies, the constant efficiency selection of EAS at given observation level and the influence of the development and registration noise to the searched physical information are of the interest in this field.

In this paper are studied this problems on the basis of HECRE array (Saavedra 2000).

proposal for Chacaltaya with CORSIKA 5.62 (Heck et al. 1993) code using VENUS (Werner 1993) and GHEISHA (Fesefeldt 1985) like hadronic models for observation level 536 g/cm^2 in the energy range 10^4-10^7 GeV in attempt to check and to propose some new possibilities for primary cosmic ray investigation.

1 Introduction

The mass composition and energy spectrum of the primary cosmic ray flux are one of the main topics of the

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2 Method

For the Chacaltaya observation level 536 g/cm^2 the EAS characteristics, precisely the electron,muon and hadron flux with energies grater then 0.5GeV and Cerenkov light flux are obtained with CORSIKA 5.62 code (Heck et al 1993) using the VENUS (Werner 1993) and GHEISHA (Fesefeldt 1985) models. Taking into account the results of the revious
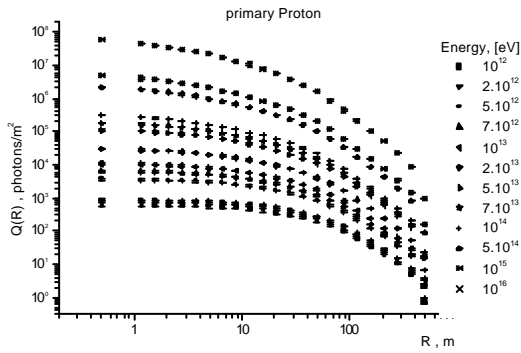
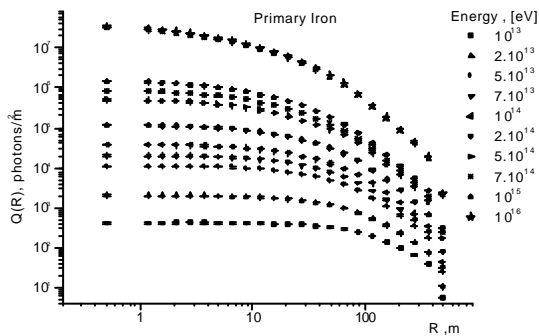Fig.1 Lateral distribution function of cerenkov light for primary protons

Fig.2 Lateral distribution function of cerenkov light for primary iron
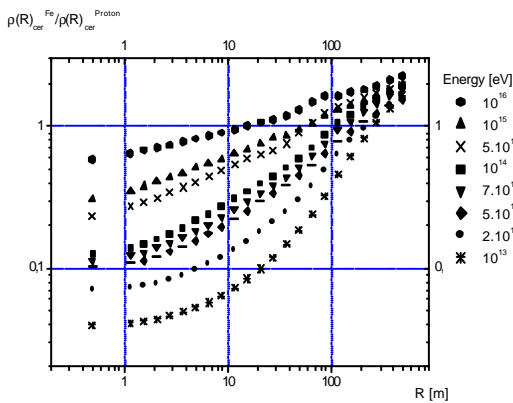

Fig.3 The ratio between lateral distributions of Cerenkov light for iron and proton primaries

The ratio for primaries iron and proton functions is calculated at different distances from the shower axis (fig.3). We are searching the distance when this ratio is almost constant near to 1 in the whole energy range. This gives the possibility of registration of EAS independent of their primary masses in large energetic range. By this conditions additionally the electron and muon flux in function of the energy of primary particle is obtained and

analysis of their fluctuations was made. The aim is to obtain information about the mass composition of the primary cosmic ray radiation.

3 Results and discussions

Taking into account the detector displacement in HECRE proposal we are studied the possibility to satisfy $\eta(r)=1$ for a whole interval using the simulated Cerenkov light flux. This is important and necessary because the selection of small EAS ($E_0 \approx 10^{13}$ eV) using the alpha parameter is not with big precision (Brankova et al. 2001) because the relative fluctuation of the parameter $\alpha_e(r_0)$ increases very fast. The new EAS selection parameter $\eta(r)$ is defined as

$$h(r) = \frac{\log[q(r_1) - q(r_2)]}{\log[\,q(r_1)\,]}$$

where $q(r)$ are the densities of Ccerenkov light flux at distancies $r_1=65m$ and $r_2=208m$.

On fig. 3 one can see that for the chosen distance 200m [8] the value of $\eta(r)$ remain const. in very large energy range 10^4-10^7 GeV independent of the atomic number of the incident primary particle. One can see that this ratio is near to 1 in a large energy range for proton and iron primaries (fig.4).
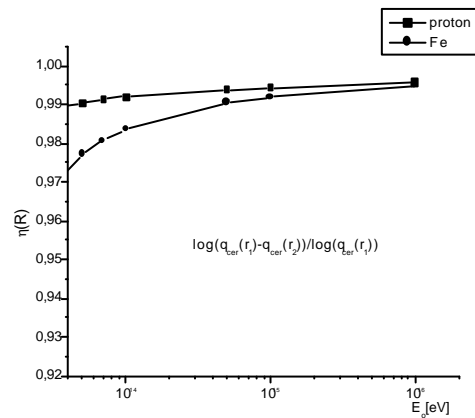

Fig.4 The $\eta(r)$ for proton and iron primaries

The knowledge of Cerenkov light photons generation mechanism in the atmosphere the comparison with the correspondent electron flux and the relatively small fluctuations of Cerenkov light flux densities permits to made shower selection with $\eta(r)$=const. of the Cerenkov component independent of the mass number of the initiating particle. So measuring Cerenkov light density at 200 and 65 m we could measure directly the primary energy spectrum without any suppositions about primary mass composition. Moreover selecting EAS with

$\eta(r)$=const one can select E_0=const events independent of the mass composition of the primary cosmic ray flux .

Making the comparison between the behaviour of the electron and muon fluxes as functions of the primary particle energy and analysing the fluctuation distributions one can obtain information about the mass composition of the primary cosmic ray flux (fig. 5 a,b and 6a,b). On the other hand one can see that the in very interesting energy range 10^4-10^7 GeV the calibration of direct and indirect methods for primary mass composition estimation is possible.
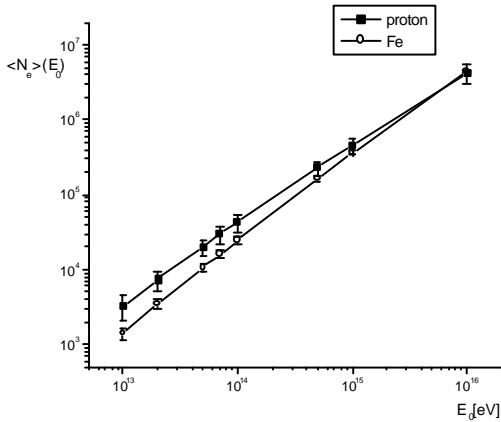

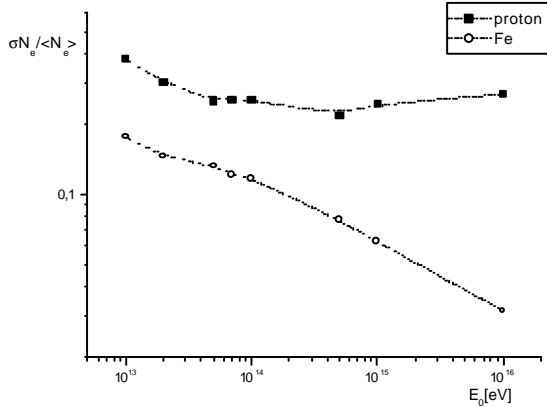Fig.5a N_e for primary proton and iron

Fig.5b Relative fluctuations of N_e for primary proton and iron

As it was pointed out previously (Procureur and stamenov 1998) the muon flux fluctuations analysis of small EAS require an extremely large detector area. However the present analysis shows that using the experimental information from Cerenkov light and electron flux such analysis on the electron flux fluctuations it is possible to obtain information about the mass composition of the primary cosmic ray radiation.
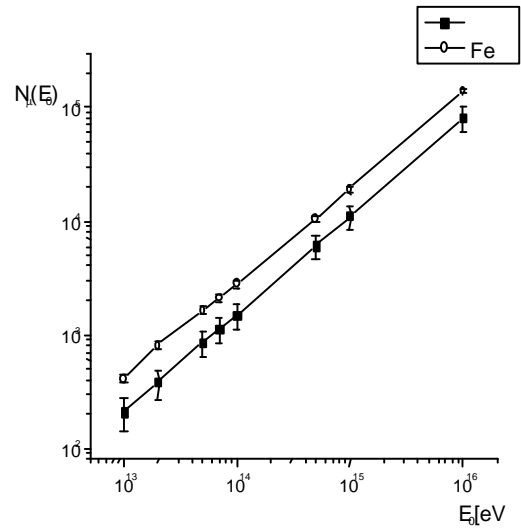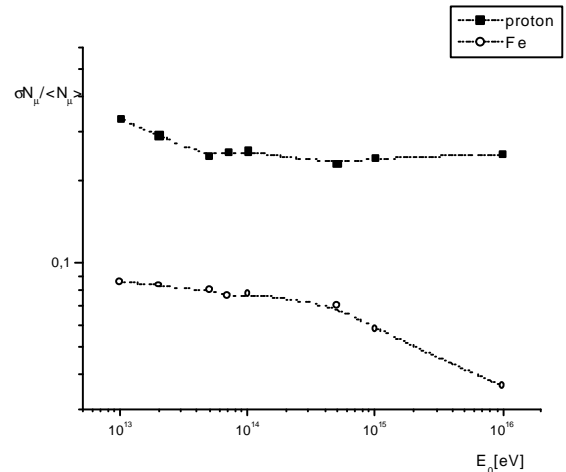

Fig.6a N_μ for primary proton and iron

Fig.6a Relative fluctuations of N_μ for primary proton and iron

4 Conclusions

Analysing the characteristics of the cerenkov light of EAS simulated with Corsika 5.62 code for observation level of Chacaltaya and taking into account the HECRE proposal it was shown that the EAS selection with constant value of the new shower parameter $\eta(r)$ based only on the densities of Cerenkov light fluxes at 65 and 208m gives the possibility to obtain information about energy spectrum of the primary cosmic ray radiation. Moreover,the additional analysis of the EAS electron flux fluctuations permits to investigate the mass composition of primary cosmic ray with constant efficiency in the very interesting energy range 10^4-10^7 GeV.

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