A selection of different cosmic ray primaries using a new selection parameter based on Cerenkov light registration

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Abstract

In the field of cosmic ray investigations are few very important problems to resolve. One of them is the precise determination of the primary cosmic ray energy spectra in the very interesting region of the knee. One possible method is based on Cerenkov light from extensive air showers measurements. It is very important to propose methods and techniques, which gives the possibility to obtain huge statistics or not used previously. One of the most important problems in experimental studies is the selection with constant efficiency of extensive air showers. In this work using previously proposed selection parameter based only on Cerenkov light registration different detector configurations are investigated. To use this parameter is very important to determine with big precision the shower axis at given observation level. The influence of the shower axis determination accuracies is investigated.

1. Introduction

The precise determination of cosmic ray spectrum and mass composition in the range above of 10^{14} eV is very important in aim to obtain some information of their origin and acceleration mechanisms. It is clear that in this very interesting energy range of high and ultra high energies the only possible way of cosmic rays registration is indirect from extensive air showers produced in atmosphere. The reconstruction of the energy and the mass composition from ground observation alone is very difficult but possible from measuring one or few components of an extensive air shower. In this paper according HECRE [1] experiment proposal precisely the Cerenkov detectors similar to AEROBICC [2] a new selection parameter previously defined [3]is studied. The shower axis determination which is very important for use this parameter is studies as the registration response of the detectors.

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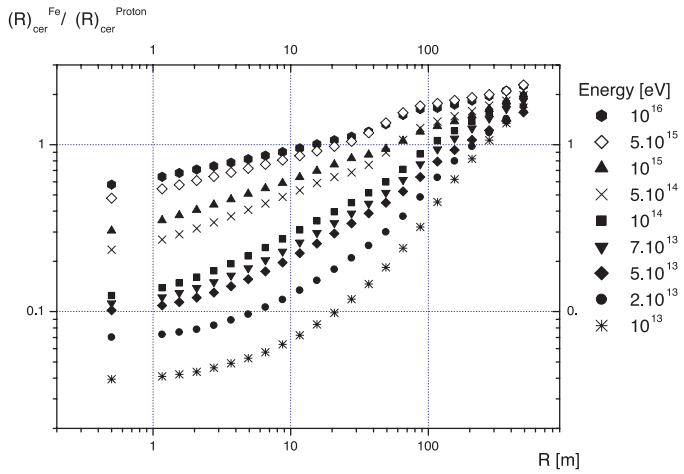

Fig. 1. The ratio between lateral distributions of Cerenkov light for iron and proton primaries.

2. Selection parameter

The calibration of the direct and indirect methods for primary cosmic radiation studies and the constant efficiency selection of EAS at given observation level are one of the most important problems in the field of experimental cosmic ray studies. At the same time the influence of the development of showers and registration noise to the searched physical information are of the interest in this field. Then lateral distributions of Cerenkov light EAS are obtained with help of CORSIKA [4] code using VENUS [5] and GHEISHA [6] like hadronic models for primary protons,iron,helium, carbon and primary gamma quanta. The ratio between primaries iron and proton functions as well as helium and proton (fig.1 and fig.2) is calculated at different distances from the shower axis. The selection parameter is defined as [3]

$$\eta(R) = lg[Q(R_1) - Q(R_2)] \setminus \lg[(Q(R_1)] \qquad (1)$$

where R_1=65 m from the shower axis and R_2=208m from the shower axis.

The parameter behavior in function of the energy is show in fig.3 for the different primaries. It easy to see that the parameter values is near to 1 in whole energy range for all primary nuclei. It is clear that the use of this parameter is linked with the shower axis determination.

First at all for two different detector displacements (fig.4) using a new method [7] for energy estimation and mass composition determination based only on Cerenkov light registration are investigated. Precisely the influence of axis determination is studied.

Using the obtained analytical approximations (see the paper presented in this conference) for different primaries 10000 events are simulated (mixed mass

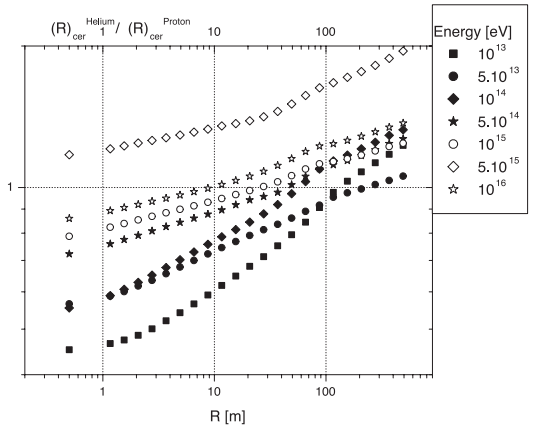

Fig. 2. The ratio between lateral distributions of Cerenkov light for helium and proton primaries.

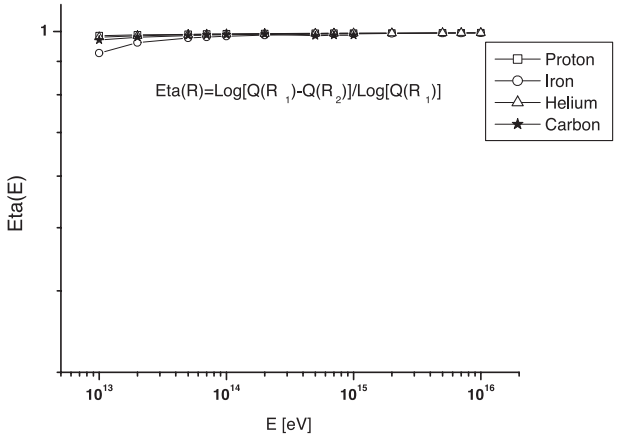

Fig. 3. The selection parameter for different primaries.

composition) for HECRE and SPIRAL configurations in energy range 10Tev-10PeV. In the case of HECRE (uniform displacement of detectors) the axis determination accuracy is in the range of 30m (maximal error). Taking into account the behavior of the parameter and lateral distribution function of Cerenkov light for different primaries the obtained variation of η is the range of less then 0.05.So the variation of the selection parameter is in the range of no more of 5 percent. This confirm our expectations (the logarithmic transformation in the parameter). An additional studies of the detector response and registration on the parameter is also studied. In the case of 30 percent registration error and taking into account the statistical fluctuations the parameter variance is less then 0.07. In conclusion it seems that the use of a new selection parameter based only of Cerenkov light registration is possible in conditions discussed above.

In the case of SPIRAL the accuracies in axis determination is biggest and

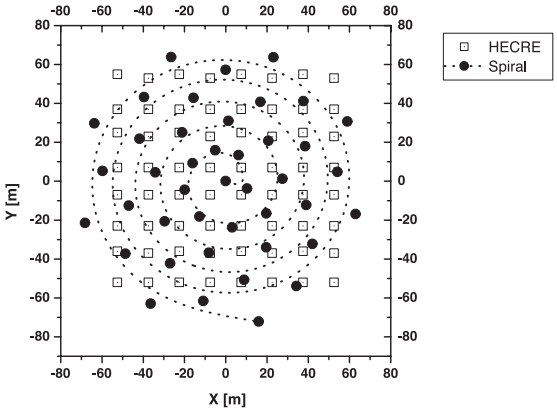

Fig. 4. The detector displacement of HECRE and SPIRAL.

so on the use of the η is most reasonable. An analogical results is obtained in the case of an additional 30 percent registration error of the detectors. Moreover an similar selection parameter which is without logarithmic transformation (analogical expression without logarithm) is studied and the obtained results are comparable. The difference is that in this case the accuracies in axis determination must be less then 20m.

3. Conclusions

The us e on a new selection parameter previously defined is possible in a large energy range between 10 Tev and 10 PeV for primary proton, iron, helium and carbon nuclei as primary gamma quanta. The axis determination accuracy is of a huge importance. The parameter use is reasonable if the axis is determined with error less then 30m.

4. References

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