SIMULATION OF EAS PROPERTIES ON THE BASIS OF HIGH ENERGY INTERACTION MODEL DEDUCED FROM THE ACCELERATOR DATA

G.Kubiak, J.Szabelski and J.Wdowczyk
Institute of Nuclear Studies
90-950 LODZ 1, box 447
POLAND

A.W.Wolfendale
University of Durham, Durham DH1 3LE
ENGLAND

1. Introduction. Calculations of extensive air showers in atmosphere have been performed using formulae describing p-p and p-air nucleus interactions presented elsewhere in this proceedings /HE 1.2-4/. The formulae fitted to the accelerator data have been extrapolated taking the same trend up to 10^{16} eV. Above that energy it was assumed that the degree of scaling violation /α -parameter/ is saturating or even decreasing. The latter assumption follows from earlier work of some of us /Wdowczyk and Wolfendale, 1984/ where we found that without this restriction shower maxima at the highest energies are located too high in the atmosphere. Results of calculations have been compared with experimental data. The comparison was made separately for the curves obtained from the so called equal intensity cuts and for the Cerenkov data.

2. Method of calculations. In the first stage using Monte Carlo method there were calculated EAS longitudinal development curves for three different requirements. These requirements are: fixed primary energy, fixed size of shower at every observation level and fixed size at the sea level. Examples of the curves for proton primaries with energies around 10^{16} eV are given in figure 1. In the next stage the curves calculated for fixed sizes at every observation level and for different primary masses are combined according to the assumed mass composition. The mass composition have been taken according to the two component model of the galactic cosmic rays /Wdowczyk, 1984, also see OG 5.4-6 this proceedings/.

3. Results. In figure 2. the longitudinal development curves are compared with experimental data. In figure 3. the position of the shower maxima obtained from the equal intensity cuts are compared with predictions /here the predictions are taken for fixed shower sizes at the observation levels/. Finally in figure 4. the data on shower maxima positions obtained from the Cerenkov observations are compared with the predictions /in that case the predictions are taken for the fixed size at sea level as the observations are performed usually at sea level/. Separately are shown curves obtained under the assumption that the scaling violation parameter $\alpha = 0.25$ above 10^{16} eV and

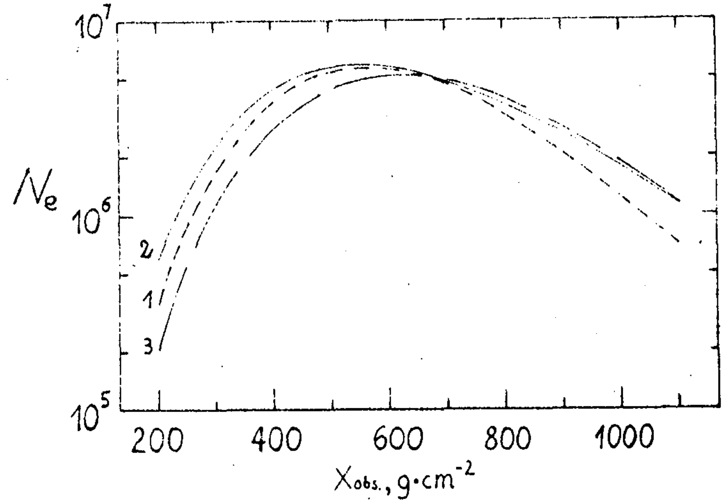

Fig.1. EAS longitudinal developement curves. 1-fixed primary energy, 2-fixed size of the shower at every observation level, 3-fixed size at sea level.

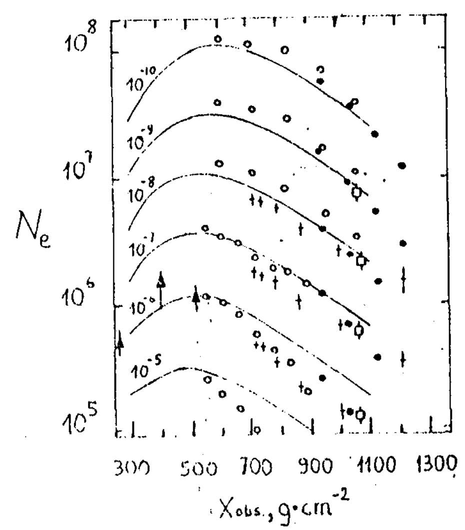

Fig.2. The longitudinal developement of EAS in the atmosphere obtained for proton-air nucleus interactions compared with the experimental data, see J.Gawin et al., /1984/.

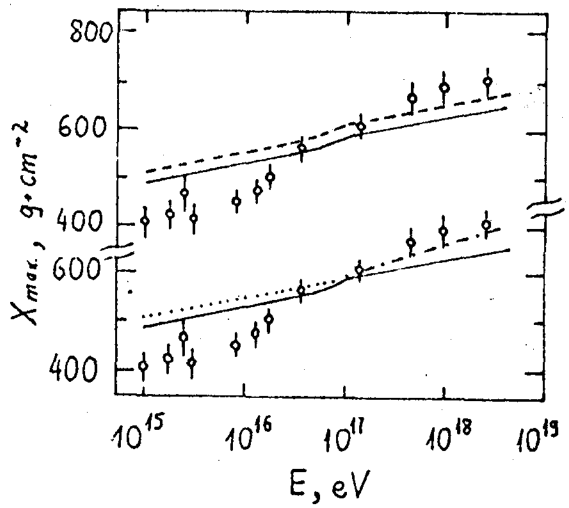

Fig.3. The positions of shower maxima. Calculations were performed with fixed shower sizes at every observation level. Experimental points are from equal intensity cuts. Predictions are from the following models: proton-proton interactions /— — —/, proton-air nucleus interactions with full mass composition /———/ and with primary protons only /· · · ·/, scaling sets for energies higher then 1E16 eV /— · —/.

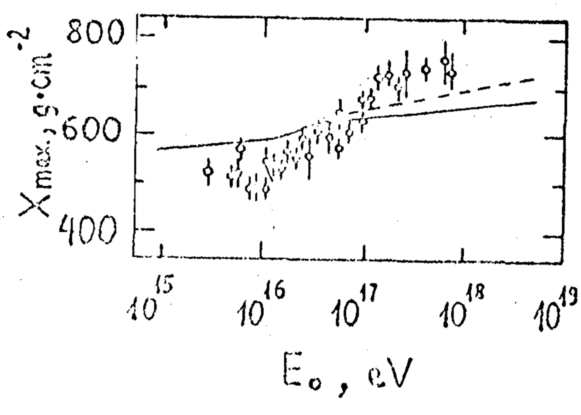

Fig.4. Predictions for the locations of shower maxima obtained with fixed size at sea level. Full line is for proton-air nucleus interactions with scale-breaking model, the dashed one is from the model with scaling for energies above 1E16 eV. The experimental points are from Cerenkov measurements.

assuming that effectively scaling sets at that energy.

In figures there are given results of calculations obtained with the farmula for proton - air nucleus interactions. In figure 3. for comparison there is also shown the development curve obtained using formula for protõn-proton interactions /we may say for a proton atmosphere/.

4. Conclusions. If we use the model based on direct extra polation of the accelerator data the predicted variation of the shower maximum position is different than that obtained from the observations. The predicted positions of shower maxima are located too low at energies 10^{15}-3×10^{16} eV and too high for energies above. The situation can not be significantly improved by the variation of the primary particle mass as the used composition is already proton dominated at energies above 10^{16} eV and reasonably heavy below that energy.

Practically sufficient improvement is obtained if it is assumed that some sort of scaling is introduced above 10^{16} eV. By term of scaling we mean hare that the multiplicity of the secondary particles at those energies saturates.

It seems extremely difficult to restore the agreement with the data at energies 10^{15} - 10^{16} eV. Introduction of heavy particles here is not only insufficient but also contradictory with other observations /for instance multiple muons/. It seems that the observations require an assumption about existence of some new feature at energies around few times 10^{15} - 10^{16} eV. That reqirement is strengthened by the fact that the same tendency is observed both in the data obtained from the equal intensity cuts and those from the Cerenkov observations.

Important point which follows from the comparisons made in figures 3. and 4. is that the positions of shower maxima should be calculated differently for the case of the equal intensity cuts and for the case of the Cerenkov observations.

References

1. Gawin, J. et al., /1984/, Acta Universitatis Lodziensis, Folia Phisica 7, 59.
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3. Wdowczyk, J., Wolfendale, A. W., /1984/, J. Phys., A: Nucl. Phys., 10, 257.