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THE PRIMARY COSMIC RAY MASS COMPOSITION AT ENERGIES ABOVE 10^{14} eV

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1. INTRODUCTION. It has been demonstrated by us (Gawin et al 1984) that the experimental data on EAS at the energy interval 10^{15} - 10^{17} eV seems to be described best if it is assumed that the Galactic cosmic rays are described by some sort of a two component picture. The first component is of a mixed composition similar to that at lower energies and the second is dominated by protons. Overall spectrum starts to be enriched in protons already at energies about 10^{15} eV but the effective mass of the primaries remains constant up to energies around 10^{16} eV. That results from the fact that composition gradually changes from multi-component to mixture of protons and heavies.

That picture receives also some sort of support from recent observations of relatively high number of energetic protons in JACEE and Concorde experiments (Burnett et al 1984 and Capdevielle 1984).

2. THE MASS COMPOSITION FOLLOWING FROM TWO COMPONENT PICTURE OF THE GALACTIC COSMIC RAYS.

The integral ebergy spectra of the primary particles of different masses are described by following expression:

$$\boxed{j_A(>E)=(C_A/1.7)\,E^{-1.7}\exp(-(E/D_A)^2)(1+E/3.33\,10^4)^{0.3}},$$

insentity in $m^{-2}\,s^{-1}\,sr^{-1}$ and energy in GeV/ nucleus.

A	C_A	D_A
p	$1.72\ 10^4$	$3.33\ 10^5$
α	$9.2\ 10^3$	$6.67\ 10^5$
CNO	$6.2\ 10^3$	$2.17\ 10^6$
H+VH	$9.2\ 10^3$	$4.33\ 10^6$
Fe	$6.2\ 10^3$	$8.66\ 10^6$

The integral spectrum of the additional proton component

$$\boxed{\begin{aligned} j_p(>E)&=2.78(E^{-1}-2.5\ 10^{-7})\ ,\text{for } E\leq 2\ 10^6\ \text{GeV}\\ &=2.78\ 10^6\ E^{-2}\ ,\text{for } E>2\ 10^6\ \text{GeV}\ .\end{aligned}}$$

3. THE FLUXES OF HADRONS AT SEA LEVEL. We have already demonstrated (Kempa and Wdowczyk 1983) that the fluxes of hadrons at mountain altitudes can be well described using the discussed here mass composition and the picture of high energy interactions described elsewhere in this proceedings (HE- 1.2-4). In figure 1 we have compared the fluxes of hadrons observed at sea level with predictions based on the above stated assumptions. We can see that the agreement is moderately good.

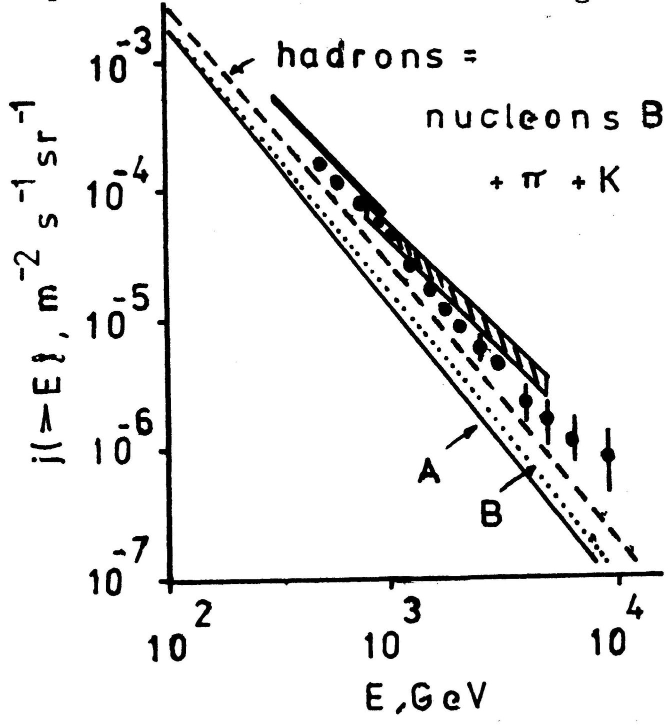

Fig.1. Hadron energy spectra at sea level. The dotted line is the prediction for the two component spectrum B-flux of nucleons for the two component model and A- the flux of nucleons for the heavy enriched spectrum (Tan et al 1982).(♦-Siohan 1976, — Arvela et al 1981, ▨ Ashton et al and Baruch et al 1977)

4. FLUXES OF HIGH ENERGY MUONS. Under the same assumptions about high energy interactions and primary particle mass composition we have calculated the fluxes of high energy muons in the atmosphere. The fluxes were calculated taking formulae for p-nucleus interaction,making detailed allowance for the muon energy losses in the atmosphere and the losses due to the muon decays. Probabilities of the decay were calculated taking into account varying energy of muons with depth. Curvature of the atmosphere was taken into account in the calculations for the inclined direction. The results of calculations are compared with experimental data in figures 2-4. In figure 2 the comparison is made for muons recorded at ground level,in figure 3 underground at shallower depth and in figure 4 at large depths. It should be pointed out that the good agreement seen in figures is obtained without any normalisation.The predicted intensities are plotted as they are obtained from the assumed primary spectra mass compositions and assumptions about the picture of high energy interactions. In figure 2 are also plotted predictions obtained for the heavy enriched spectrum (Tan et al 1982).

In calculations of the depth intensity curve the fluctuations in muon range were taken into account.

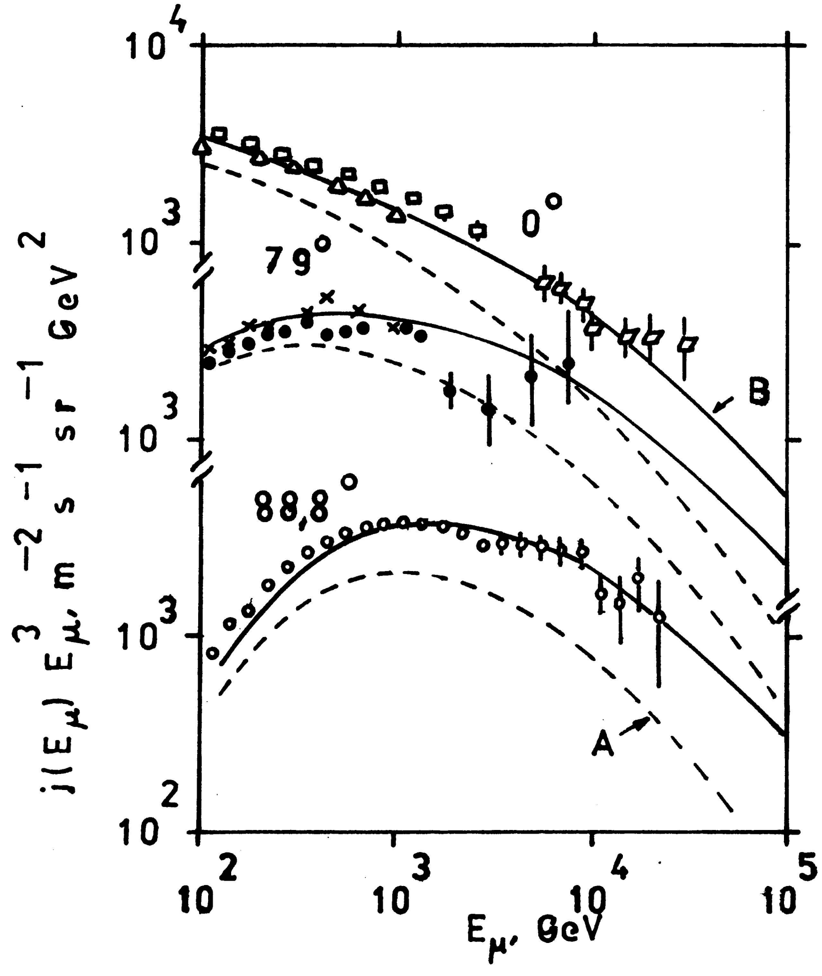

Fig.2. The muon energy spectra at various angles.The continous lines are the predictions based on the two component model,the dotted lines are the predictions for the heavy enriched spectrum (Tan et al 1982) (⧫ Allkofer et al 1981, △ ---- 1971, × Jokish et al 1979, ▱Khrenov 1977, ◊Matsuno et al 1984, □ Thompson et al 1977)

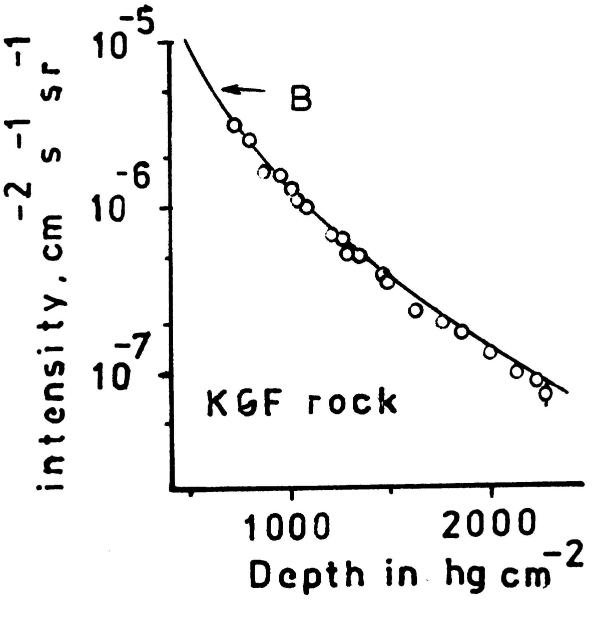

Fig.3. Depth intensity curve (after Krishnaswamy 1981) for shallow depths compared with that calculated from the muon spectrum obtained by us (B).

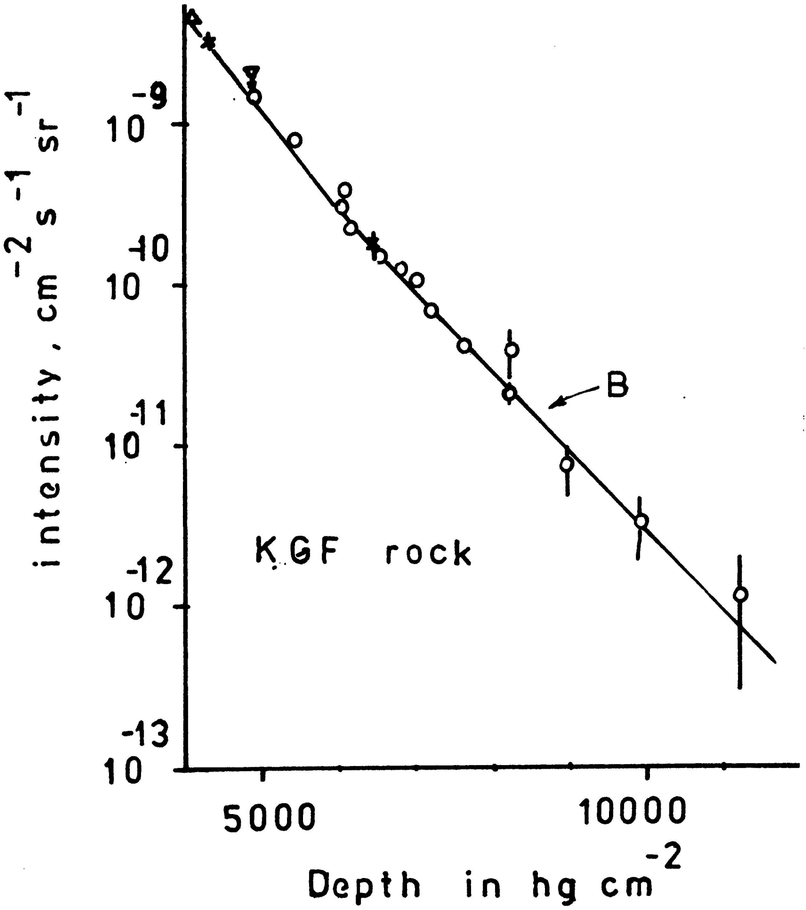

Fig.4. The same as in figure 3 but for the greater depths.

5. CONCLUSIONS. We have demonstrated that the fluxes of high energy secondary particles observed in atmosphere can be well predicted on the basis of the two component picture of the Galactic cosmic ray and the picture of high energy hadron - nucleus interaction deduced from the accelerator data.

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