HADRON INTENSITY AND ENERGY SPECTRUM AT 4380 m ABOVE LEVEL

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The flux value of hadrons with $E_h^{(\gamma)} \geqslant 5$ TeV, where $E_h^{(\gamma)}$ is the energy transferred into electromagnetic component is presented. It is shown that the energy spectrum slope β of hadrons with $E_h \geqslant 20$ TeV is equal to 1.9.

The present work is based on the experimental data obtained by means of "Pamir" carbon X-ray chamber. [1] contains the detailed description of detectors's arrangement.

Two sets of experimental data are used.

The first of them represents the result of exposure of "Pamir 77-78" chamber ST = 60 m^2 x 11 months. The lead thickness t in hadron block is equal to 10 c.u. For each spot coordinates, zenith and azimuthal angles and darkness have been measured. Hadrons with zenith angle $\theta \leqslant 20°$ have been used only.

The second set of the experimental data is composed by selection of spots with darkness $D_{140} \geqslant 0.6$, measured by aperture of the radius $r = 140 \mu m$, that approximately corresponds to $E_h^{(\gamma)} \geqslant 25$ TeV. On the total area S = 471 m^2 hadrons with zenith angles $\theta \leqslant 20°$ have been selected in the chambers with lead thickness in hadron t = 8

In all used chambers carbon layer was 60 cm thick.

Connection between $E^{\pm}$ and $E_h^{(\gamma)}$ spectra is given in the [2] (here $E^{\pm}$ is an energy estimated by means of the dependence E(D) for e^+e^--pair, the so-called "e^+e^--pair curves", and $E_h^{(\gamma)}$ is an energy in fact transferred into electromagnetic component):

$$I(>E_h^{(r)}) = C\,10^{B\beta}(E^{\pm})^{\Delta}(E^{\pm})^{-\beta} \qquad (1)$$

According to [2] , in the case of r = 140μm, if $E^{\pm}$ will be esimated by "e^+e^--pair curves" for $t_o + \Delta t$, where t_o is the lead thickness in chamber and Δt is equal to 2 c.u., the parameters will take the following values: B = 0, $\Delta = 0$.

Hence, to obtain the correct estimate of $E_h^{(r)}$ one can use curves for lead thickness t = 12 c.u. in the first set of experimental data and t = 10 c.u. in the second one.

Both sets of data are presented in Table 1.

Table 1

No of set	Area (m^2)	$N(E_h^{(r)} \geq 7$ TeV)	$N(E_h^{(r)} \geq 30$ TeV)	$N(E_h^{(r)} \geq 100$ TeV)
1	60	422	24	-
2	471	-	197	29

The value of vertical intensity of hadron flux is calculated by well-known formula:

$$I_o(>E_h^{(r)}) = \frac{N}{ST\omega}\,\frac{1}{\rho(\theta_o)}\,\frac{m+2}{2\pi} \qquad (2)$$

where N is number of hadrons with $E_h^{(r)}$ greater than the threshold; S is chamber area; $T = 2.7 \cdot 10^7$ s exposure time; $\omega = 0.55$ is the probability of hadron interaction in C-chamber; $\rho(\theta_o) = 1 - \cos^{m'+2}\theta_o$ is the angular factor, which converts hadrons intensity for $\theta < \theta_o$ to the global one with $\theta_o = 90^\circ$ (m' is the exponent of angular distribution of hadrons, registered in hadron block); $(m + 2)/2\pi$ is converting factor from global intensity to the vertical one. Here m is the exponent of angular distribution for hadrons falling on the chamber. According to [1] , $m = H/\lambda + 2 = 8 \pm 1$. Here $H = 600\,g/cm^2$ is atmospheric depth, $\lambda = 90 \div 100\,g/cm^2$ is the attenuation length for protons.

The experimental value of m', obtained by formula

$$(m'+2)/(m'+3) = \langle\cos\theta\rangle \quad (3)$$

where $\langle\cos\theta\rangle = 0.92 \pm 0.01$ is the average cosinus of zenith angle is equal to $m = 9.5 \pm 1.5$, that is in a satisfactory agreement with results of Monte-Carlo simulations for $m = 8$.

Thus, vertical intesity values obtained from experimental sets turned out to be in a good agreement with each other

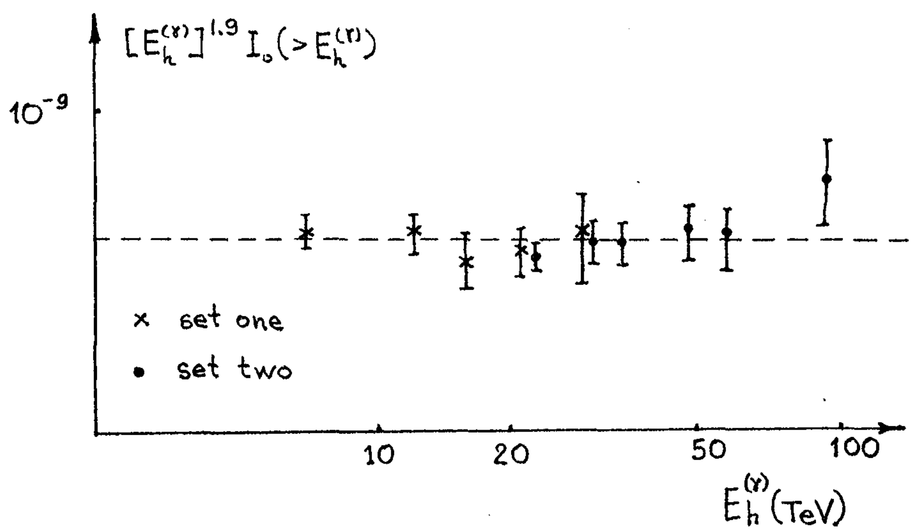
$$I_0(E_h^{(\gamma)} \geq 5\ \mathrm{TeV}) = (2.7 \pm 0.1)\cdot 10^{-10}\ \mathrm{cm^{-2}s^{-1}sr^{-1}} \quad (4)$$

$$I_0(E_h^{(\gamma)} \geq 30\ \mathrm{TeV}) = (0.7 \pm 0.1)\cdot 10^{-11}\ \mathrm{cm^{-2}s^{-1}sr^{-1}} \quad (5)$$

The slopes of energy spectra are in a good agreement also. In Fig.1 the concluding $E_h^{(\gamma)}$ spectrum with the slope 1.9 ± 0.1 is presented (here after the statistical errors are only given).

For chambers under investigation the value of effective coefficient $K_{eff} = E^{\pm}/E_h$ (here E_h is the energy of incident hadron) is given in [3]. At $E^{\pm} = 5$ TeV K_{eff} it is equal to 0.25. As energy $E^{\pm} = 5$ TeV turns into $E = 20$ TeV, and since the value $E^{\pm} = 5$ TeV corresponds to $E = 7$ TeV:

$$I_0(E_h^{(\gamma)} > 7\ \mathrm{TeV}) = I_0(E_h > 20\ \mathrm{TeV})$$



Thus, we can obtain energy spectrum of hadrons in the interval 20 ÷ 300 TeV:

$$I_0(>E_h) = (1.4 \pm 0.1)\cdot 10^{-10} \left(\frac{E_h}{20\ \mathrm{TeV}}\right)^{-(1.9\pm 0.1)} \ cm^{-2}s^{-1}sr^{-1} \quad (6)$$

In Table 2 the comparison with data from different installations is given. Each value of hadron flux intensity is calculated for Pamir altitude (H_0 = 600 g/cm^2) and energy $E_h^{(\gamma)} \geq$ 5 TeV.

Table 2.

Experiment	$I_0(E_h^{(\gamma)} \geq 5\ TeV)$ $(cm^{-2}s^{-1}sr^{-1})$	The slope
Fudji [4]	$(3.2 \pm 0.2)\cdot 10^{-10}$	2.0 ± 0.1
Canbala [5]	$(2.9 \pm 0.1)\cdot 10^{-10}$	1.85 ± 0.1
"Pamir" Pb chamber [1]	$(1.9 \pm 0.4)\cdot 10^{-10}$	1.96 ± 0.1
This work	$(2.7 \pm 0.1)\cdot 10^{-10}$	1.9 ± 0.1

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