HADRON INTENSITY AND ENERGY SPECTRUM AT 4380 m ABOVE LEVEL

Cananov S.D., Chadranyan E.Kh., Khizanishvili L.A., Ladaria N.K., Roinishvili N.N.

Institute of Physisc, Academy of Sciences of the Georgian SSR, Tbilisi, USSR

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 $r = 140\mu m$, 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

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

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

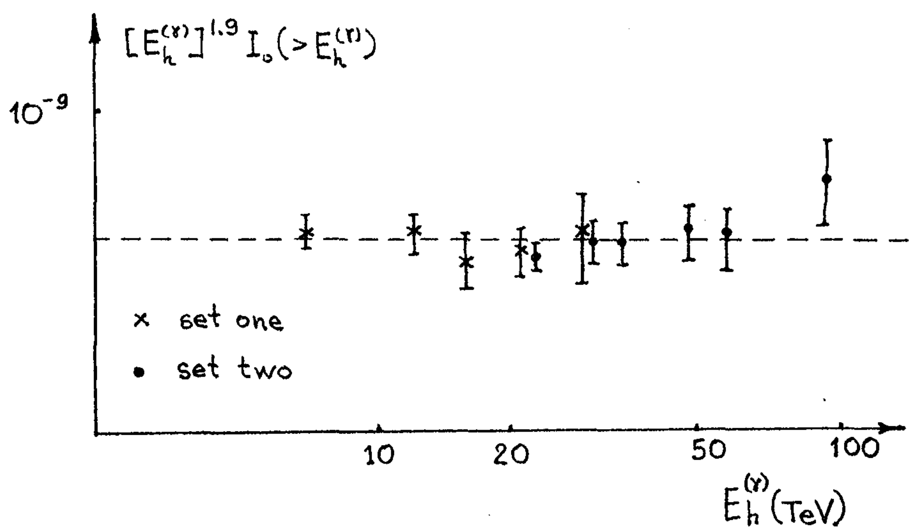
$$I_0(E_h^{(\gamma)} \geq 5\ \mathrm{TeV}) = (2.7 \pm 0.1) \cdot 10^{-10}\ \mathrm{cm^{-2} s^{-1} sr^{-1}} \qquad (4)$$

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

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:

$$I_0(>E_h) = (1.4 \pm 0.1)\cdot 10^{-10} \left(\frac{E_h}{20\ \mathrm{TeV}}\right)^{-(1.9\pm0.1)} \mathrm{cm^{-2}s^{-1}sr^{-1}} \quad (6)$$

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	$I_0(E_h^{(\gamma)} \geq 5\ \mathrm{TeV})$ ($\mathrm{cm^{-2}s^{-1}sr^{-1}}$)	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

REFERENCES

1. Trudy FIAN, v.154, p.39 (in Russian)
2. Wlodarzcik et al. (in press)
3. Pamir collaboration, 18th ICRC v.11, p.122, 1983
4. Mt.Fuji collaboration, 18th ICRC v.11, p.57, 1983.
5. China-Japan collaboration, 18th ICRC v.5, p.411, 1983