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Charge-exchange processes $\pi^{\pm}A \rightarrow \pi^0_L$ + ... in gamma-families formation

T. S. Yuldashbaev and Kh. Nuritdinov

Physical-Technical Institute of Academy of Sciences, 700084 Tashkent, Uzbekistan

Abstract. In the paper presents the results of comparative analysis of black spots shapes created by gamma-quanta, single hadrons and family hadrons in the carbon X-ray emulsion chambers. On the basis of such analysis the probability of charge-exchange processes $\pi^{\pm}A \rightarrow \pi^0_L$ + ... at the hadron energies $E_h = 10 - 100$ TeV is obtained.

1 Introduction

In the inelastic charge-exchange processes $\pi^{\pm}A \rightarrow \pi^0_L$ + ... the gamma-quanta energies from decay of leading π^0_L - mesons essentially exceed of the other quanta. Owing to power low Primary Cosmic Rays (PCR) spectrum and high energy threshold of γ-quanta registration in X-ray Emulstion Chambers (XREC) $\pi^{\pm}$-mesons charge-exchange processes play an important part in gamma-families formation.

Large difference in partial inelasticy coeffisient $K_\gamma = \frac{\sum E_\gamma}{E_0}$ (where $\sum E_\gamma$ - energy of secondary quanta, E_0 - primary energy) for pion-nucleus πA and nucleon-nucleus NA interactions is explained by important role of charge-exchange processes.

According to obtained experimental data, the charge-exchange probability of $\pi^{\pm}$-mesons with $X_L = \frac{E_{\pi^{\pm}}}{E_0} > 0.5$ into π^0_L W equal ~ 0.20 and one remain almost constant in the energy region $E_0 = 7 - 400$ GeV (L.A.Didenko, 1973; S.A.Azimov, 1975; A.M.Abdullaev, 1982).

2 Method of analysis

It is suppossed that majority of the family hadrons are $\pi^{\pm}$-mesons, while single hadrons consist os the nucleons mixed with $\sim 30\%$ $\pi^{\pm}$-mesons at the mountain level. In charge-exchange processes $\pi^{\pm}A \rightarrow \pi^0_L$ + ... instead of charge pions appear leading π^0_L-mesons with average energy $\overline{E}_{\pi^0} \sim 0.75\ E_{\pi^{\pm}}$. As a result in the XREC films it will be produced a concentrate black spots analogous to shape created by gamma-quanta. On the other hand, black spots created by hadrons in usual pionisation processes will have diffus, structural shape.

In the paper it is proposed the method of distinguish dark spots created in Carbon Emulsion Chamber films by hadron in pionisations and charge exchange processes. For that purpose it is necessary to perform the comparative analysis of dark spots distribution measured by different photometer diaphragm.

It is considered gamma-hadron families and single hadrons registered in XREC of Pamir Collaboration with number of particles $n \geq 4$ minimal energies γ-quanta $E_\gamma \geq 4$ TeV.

Value of darkness is obtained by expression:

$$D = lg(\frac{I_0}{I}),$$

where I - light flux after penetration through the dark spot, I_0 - one out of dark spot region. The dark spots in XREC films have a look as irregular, with a large density gradient in radial direction darkness. In connection with, for the distinguish of "gamma-like", compactable, concentrated to central part dark spots created by γ-quanta from structural, "hadron-like" spots it is proposed the parameter

$$L = \frac{I_{140} - I_{84}}{I_{48}},$$

where I - light flux measured by diaphragm with radius r : 140, 84 and 48. When it is measured the light flux penetrating through "gamma-like" spots by the smallest diaphragm $r = 48$ mm, value of I_{48} will be less than one penetrating through ring square limited by diaphragm 140 mm and 84 mm : $S_r = S_{140} - S_{84}$. In other case of "hadron-like" spots measurement the light fluxes penetrating through diaphragm with radius $r = 48$ I_{48} and through ring square S_r I_r will be not much differ with each other.

3 Experimental results

It is analysis gamma-hadron families with energies $\sum E_\gamma$ = 100-300 TeV. Electron-photon cascades with energies

Correspondence to: T. S. Yuldashbaev
(toymas@uzsci@net)

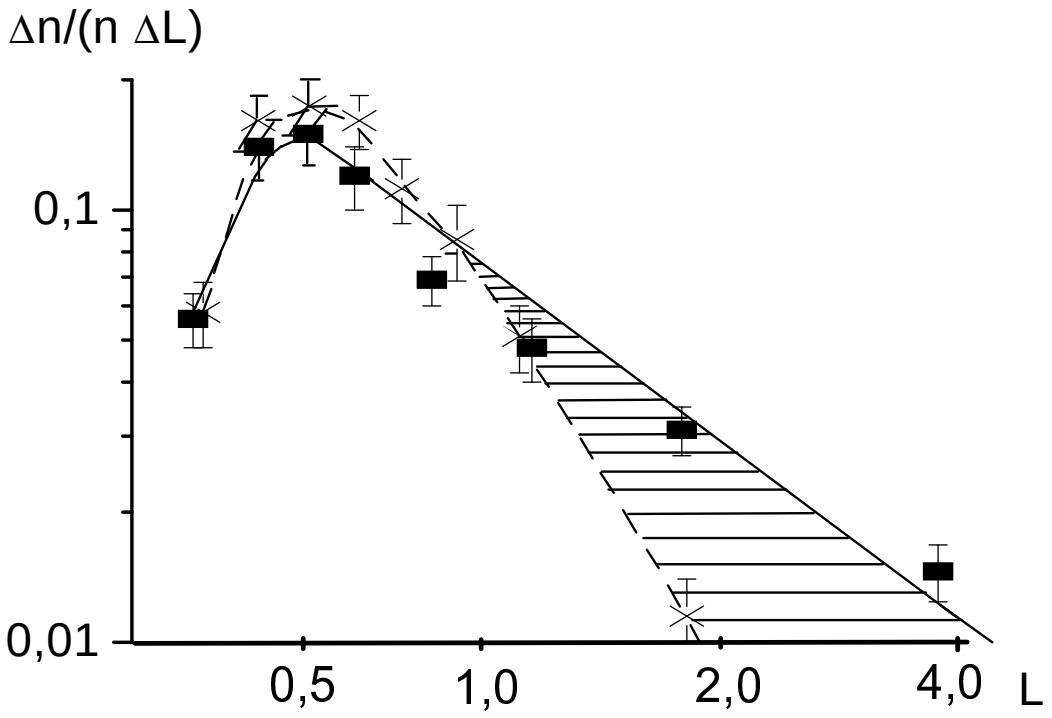

Fig. 1. The distribution of parameter L = (I_{140} - I_{84}) / I_{48}
x - single hadrons;
■ - family hadrons;
— - family gamma-quanta.

Fig. 1. See text.

$E_h^\gamma > 4$ TeV produced by hadrons correspond to hadron energy $E_h > \frac{E_h^\gamma}{K_\gamma} = 12$ TeV, where $K_\gamma = 0.3$ - effective partial incelasticity coefficient.

Fig. 1 presents the parameter L distributions for gamma-quanta, single hadrons and family hadrons. As can see from obtained results, essetial differece between the distributions of spots created by γ-quanta and single hadrons are observed. According to fig. 1 the fraction of "gamma-like" spots with $L \geq 1.0$ for the single hadrons is less than for γ-quanta. That is explained by large fraction of nucleus between single hadrons which do not create the γ-quanta in the charge-exchange processes. As the incident pions fraction between single hadron consist ~ 0.3 the fraction of "gamma-like" events formed in charge-exchange processes (with probability $W \sim 0.2$) will be consist of $\sim 6\%$ for single hadrons.

On the other hand, for the family hadrons mainly consisting from $\pi^\pm$-mesons the fraction of "gamma-like" spots created in exchange processes $\pi^\pm A \rightarrow \pi_L^0$ + ... will be much more than for single hadrons. The excess os such events consist of $\sim 20\%$.

4 Conclusion

In the paper the method of direct determination of the charge-exchange processes $\pi^\pm A \rightarrow \pi_L^0$ + ... is proposed. The selection criteria

$$L = \frac{I_{140} - I_{85}}{I_{48}}$$

sensitive to "gamma-like" and "hadron-like" dark spots produced in the charge-exchange and usual pionisation processes allows to evaluate the probability W of process $\pi^\pm A \rightarrow \pi_L^0$ + ... Considerable excess of "gamma-like" dark spots created by family hadrons in the comparison with single one points to essential probability $W \sim 0.2$ charge-exchange processes at the energies $E_0 = 10 - 100$ TeV.

References

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