CORRELATION BETWEEN TRANSVERSE AND LONGITUDINAL MOMENTA OF PHOTONS PRODUCED IN 9 GeV NEGATIVE PION INTERACTION WITH XENON NUCLEI

BY T. SIEMIARCZUK

Institute of Experimental Physics, Warsaw University*

(Received March 23, 1973)

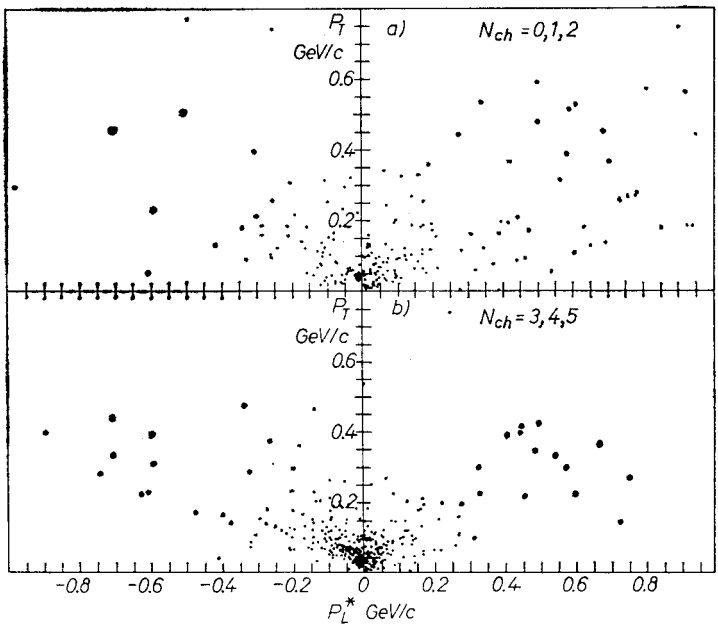
Photon production in π^--Xe interaction at 9 GeV is analysed from the point of view of the description suggested previously. A strong correlation between transverse and longitudinal momenta of photons is observed similar to that in π^--nucleon interactions.

In several papers (see [1] and references therein) concerning the study of π^--nucleon elementary interactions it was pointed out that the assumption of an absence of a correlation between transverse and longitudinal momenta of secondaries is not valid in the accelerator energy region. In Refs quoted in [1], a decrease of the average transverse momentum for small absolute values of longitudinal centre of mass momenta of charged pions, p_L^*, was observed. The shape of $\langle p_\perp \rangle = f(p_L^*)$ distribution for charged pions was found to be approximately symmetrical with respect to $p_L^* = 0$. The comparison of the experimental results with the phase space prediction shows that the phase space curves reflect rather well the shape of the distribution but give higher average values of transverse momenta [1].

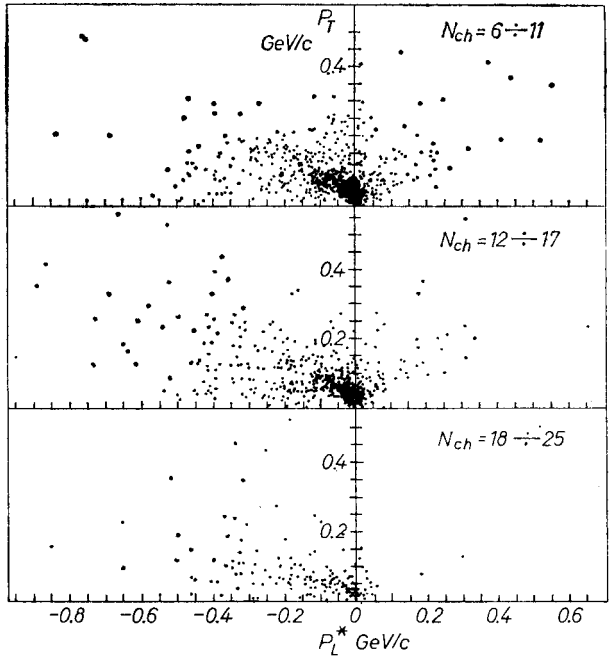
As yet, there is no evidence of the existence of $\langle p_\perp \rangle - p_L^*$ correlation in the centre of mass of the collision for particles produced in the interaction with complex nuclei. The definition of this centre of mass for the interaction with nucleus was introduced in Ref. [2] where the production of photons was studied in the collisions of 9 GeV negative pions with xenon nuclei. In the present work the results of a search for a correlation between average value of the transverse momentum and longitudinal momentum of photons are presented.

A sample of 3271 photons due mainly to the $\pi^0 \to 2\gamma$ decay [2] and originating in 1079 interactions of 9 GeV π^--mesons with xenon nuclei in the JINR xenon bubble chamber was analysed. For each electron-positron pair the statistical weight W_i was calculated

* Address: Instytut Fizyki Doświadczalnej, Uniwersytet Warszawski, Hoża 69, 00-681 Warszawa, Poland.



a



b

Fig. 1a, b. Peyrou plot of photons in π^--nucleon CMS for different number of charged secondaries N_{ch} in the final state

with the formula

$$1/W_i = 1-\exp(-\sigma_i(E_i)\cdot l_i),$$

where $\sigma_i(E_i)$ is the cross-section for the photon conversion, E_i-the energy of the photon and l_i-the potential length of the photon in the fiducial region of the chamber. The sum of the statistical weights of the recorded photons was found to be 3983 (for more details see Ref. [2]).

Figs 1a and 1b show the Peyrou plot of photons for interactions with different number of visible charged secondaries N_{ch} in the final state, formally presented in the centre of mass system of the incoming pion and one of the nucleons in the nucleus assumed to be at rest. It is seen that an increase in the number of N_{ch} corresponds to an increase in the

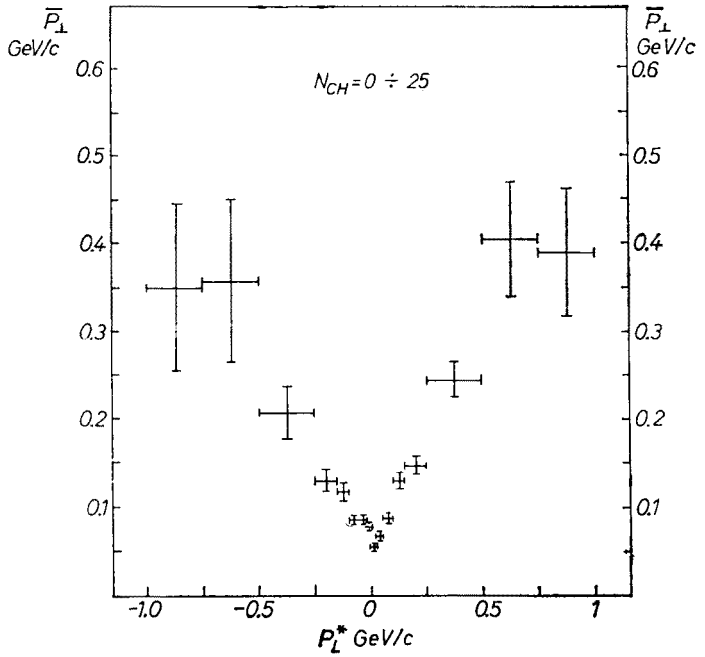


Fig. 2. Dependence of the average value of the transverse momentum of photons on their longitudinal momentum

fraction of photons emitted backwards and their number with increasing N_{ch} becomes much higher than that of photons emitted in the forward direction. This implies that the above formal transformation does not provide the proper rest frame for all the considered events because, as it is well known from elementary interaction data [1], the population of the Peyrou plot for pions is rather symmetrical with respect to $p_L^* = 0$. Inspection of Figs 1a and 1b shows that only for events with low values of N_{ch} (Fig. 1a) is the Peyrou plot close to that observed for pions in interactions with nucleons [1].

It has been shown previously [2] that all the features of photons observed in this experiment are consistent with the assumption that π^0 production takes place mainly in

a single act of interaction[1] of an incident pion with a nucleon or a group of nucleons. The contribution of the events where more than one nucleon is involved into the production process increases with increasing N_{ch}. On the assumption of a single production process, events with different values of N_{ch} were transformed to their centre of mass systems (which we call CMS of the collision) providing symmetrical angular distribution of photons. The overall $\langle p_\perp \rangle = f(p_L^*)$ dependence calculated after the transformation of photons to their centre of mass of the collision is presented in Fig. 2, where the average transverse momentum of photons is plotted against their longitudinal momentum. The pronounced dip at $p_L^* = 0$ is observed similar to that for charged pions in π^--nucleon interactions.

The author is indebted to the operating crews of the Dubna synchrophasotron and the Xenon Bubble Chamber. He would like to thank the measuring staff for careful measurements.

REFERENCES

[1] M. Bardadin, L. Michejda, S. Otwinowski, R. Sosnowski, *report INR* 511/VI, Warsaw 1864; E. Balea, O. Balea, V. A. Belyakov, E. N. Kladnitskaya, E. S. Kuznetsova, A. Mihul, M. Sabeu, *reports JINR* P1-2963, P-2773, 1966; A. A. Kuznetsov, N. N. Melnikova, B. Chadraa, E. Balea, O. Balea, A. Mihul, T. Ponta, C. Felea, *report JINR* P1-4912, 1970; B. P. Bannik, A. A. Kuznetsov, N. N. Melnikova, B. Chadraa, *Soviet J. Nuclear Phys.*, **9**, 1025 (1969); M. Bardadin-Otwinowska, T. Hofmokl, L. Michejda, S. Otwinowski, R. Sosnowski, M.Szeptycka, A. Wróblewski, D. Zimińska, W. Wójcik, *report INR* 1400/VI/PH, Warsaw 1972; to be published in *Phys. Rev.*; T. Siemiarczuk, *Nuclear Phys.*, **57**, 469 (1964).

[2] T. Siemiarczuk, *Acta Phys. Polon.*, **23**, 878 (1968).

[3] C. Bemporad, W. Beusch, A. C. Melissinos, E. Polgàr, D. Websdale, J. D. Wilson, J. P. Dufey, K. Freudenreich, R. Frosch, F. X. Gentit, P. Mühlemann, P. Astbury, J. Codling, J. G. Lee, M. Letheren, G. Bellini, M. di Corato, G. Vegni, *Nuclear Phys.*, **B33**, 397 (1971).

[4] L. Van Hove, *Nuclear Phys.*, **B46**, 75 (1972).

---

[1] The recent results of the CERN and the ETH Zurich experiment [3] seem to support in some respect this point of view. The analysis of the π^--nucleus diffraction dissociation data at 15 GeV/c by means of the optical model gives the total $\sigma(3\pi)$ and $\sigma(5\pi)$ cross-sections for the interaction with nucleus of the three and five pion systems very close to the pion nucleon cross-section at 15 GeV/c. The Van Hove modification of the Glauber theory [4] explains this observation by taking into account the fact that the dissociated system can oscillate between many internal states the the nucleus. The physical implication of the model is an increased transparency of the nucleus due to the fact that the pions exist mostly in a virtual state as they propagate through the nuclear matter. The treatment is general enough to be applied to any hadronic dissociation and extended to incoherent processes [4].