объединенный
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дубна

E1 - 12087

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Submitted to "Nuclear Physics"

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Энергетические спектры протонов, испущенных в случаях столкновения пионов с ядрами ксенона без множественного рождения частиц

Исследуются энергетические спектры протонов, испускаемых в таких столкновениях пионов с ядрами ксенона, в которых нет множественного рождения частиц. В спектрах наблюдаются нерегулярности.

Работа выполнена в Лаборатории высоких энергий ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна 1979

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Energy Spectra of Protons Emitted in Pion-Xenon Nuclei Collision Events Without Multiparticle Production

Energy spectra of protons emitted in pion-xenon nuclei collisions without multiparticle production are analysed. Irregularities are observed in these spectra.

The investigation has been performed at the Laboratory of High Energies, JINR.

Preprint of the Joint Institute for Nuclear Research. Dubna 1979

1. INTRODUCTION

We have shown that the high-energy pion-nuclei collision events exist in which intensive proton emission takes place without multiparticle production[1,2]; although, taking into account the total energy of the protons emitted, many secondary pions could be generated too. As it has been reported, we have ascribed to these events, in one of our experiments[2], the pion-xenon nuclei collisions without any secondary pion and with single one pion. Investigations were performed using the 180 litre xenon bubble chamber[3]. The registration conditions of the neutral and charged pions in this chamber allow us to state that not any more pion has been emitted in the class of the pion-xenon nuclei collision events being under investigation [2,4].

A question for consideration appeared then: how are the protons in such events to be emitted; what is the role of the multiparticle generation in the proton emission process?

After performing accurate analysis of this situation, it appears to be clear that monotonous braking of high-energy hadrons traversing the nuclear matter may exist, being accompanied by the intensive emission of the

fast protons observed[5]. This braking effect has been postulated and, a few weeks later, discussed in more detail[6]. An argumentation has been presented in favour of the existence of the monotonous energy loss which undergo high-energy hadrons traversing the atomic nuclei[6].

But, it has been pointed out that if we suppose this picture of the fast proton emission process to be corresponding to the reality, we may expect to find some irregularities in the proton energy spectra[6]. Such irregularities should be looked for in the most simple cases of the hadron-nuclei collisions, like these without multiparticle production[6].

Therefore, additional analysis has been done of the events which we have already written about[2]. In this paper we shall present the results of our investigations of the proton energy spectra.

2. METHOD OF INVESTIGATION

The pictures used for this analysis were taken in the 180 litre xenon bubble chamber exposed to the negative charged pion beam of 3.5 GeV/c momentum. They have been scanned for all the pion-xenon nuclei collisions registered within a small fiducial region localized in the central part of the chamber. The events were recognized to be the pion-xenon collision cases, if the tracks of the primary pions end or scatter at an angle of larger than 3°, being accompanied or not by some number of secondary particles outgoing from the interaction points.

The protons of kinetic energies (15--220) MeV, the negative charged pions of (10-150) MeV, positive charged pions of (0--150) MeV, and the neutral pions of energies larger than 0 MeV were recorded with the registration efficiency closed to 100% within the total 4π solid angle. The energy of protons emitted within the 60° cone and stopping inside the chamber is nearly 350 MeV. The neutral pions of all energy values are recorded by the observable negaton-positon conversion pairs and by the electron-photon cascades created by the gamma quanta appearing in the pion decay process. The positive pions stopped within the chamber are identified simply as decaying into muons, forming the visible tracks, and decaying, in ones turn, into well identificable electrons.

The accuracy of the proton energy estimation, using the range-energy relation, was 10% for the protons of 15 MeV kinetic energy and 1% for those of 200 MeV. The average error of the proton emission angle estimation was nearly 3°.

3. EXPERIMENTAL DATA

About 2800 pion-xenon nuclei collision events were carefully analysed; 35 events without secondary pions, 283 events with single one charged secondary pion, and 35 with single one secondary neutral pion were qualified to be these without multiparticle production in which the intensive nucleon emission takes place, however.

The energy distribution of 724 protons emitted in the sample of events with one secondary pion is presented in fig. 1 by the histogram; the smooth line superimposed on this histogram describes the experimental data according to the HBOOK Users Guide Programme[7].

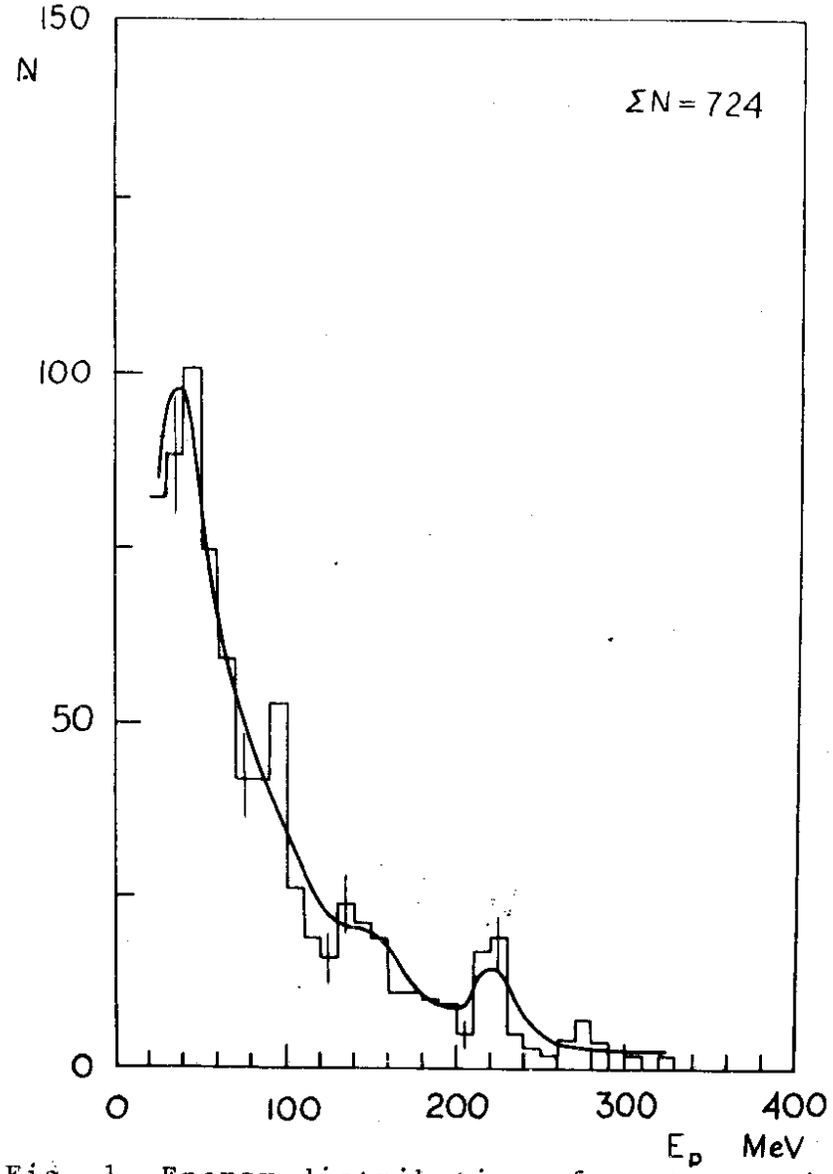

Fig. 1. Energy distribution of protons emitted in the pion-xenon nuclei collisions at 3.5 GeV/c without multiparticle production, with single one charged secondary pion. The smooth line presents the same distribution after applying the appropriate data processing procedure[7].

In order to facilitate the comparison of the proton energy spectra in different classes of collision events, we use later the representation of these experimental spectra by such smooth curves as shown in fig. 1.

The energy spectra of protons emitted in the pion-xenon collision events with one secondary charged pion, without secondary pions, and with one secondary neutral pion are shown in fig. 2.

In order to find the dependence of the proton energy spectrum shape on the emission angle of the secondary pion, energy spectra were prepared for events with various pion emission angles θ_π : (0-30)°, (30-60)°, and (60-180)°, fig. 3.

The energy distributions of protons emitted in the forward direction and those emitted in the backward one are presented in figs. 4 and 5, for the collision events with single one secondary pion and without secondary pions.

4. RESULTS AND DISCUSSION

Irregularities are observed in the proton energy spectra; the shapes of these spectra are of similar character in various classes of the pion-xenon nuclei collision events: with single one secondary charged pion, with single one secondary neutral pion, and without secondary pions, fig. 2.

These irregularities are visible mostly in the class of collision events with the charged secondary pions emitted at the angle θ_π no larger than 30°. However, these are evident too in the sample of events in which the secondary pions escape at the angles larger than 30 , fig. 3. Similar picture we

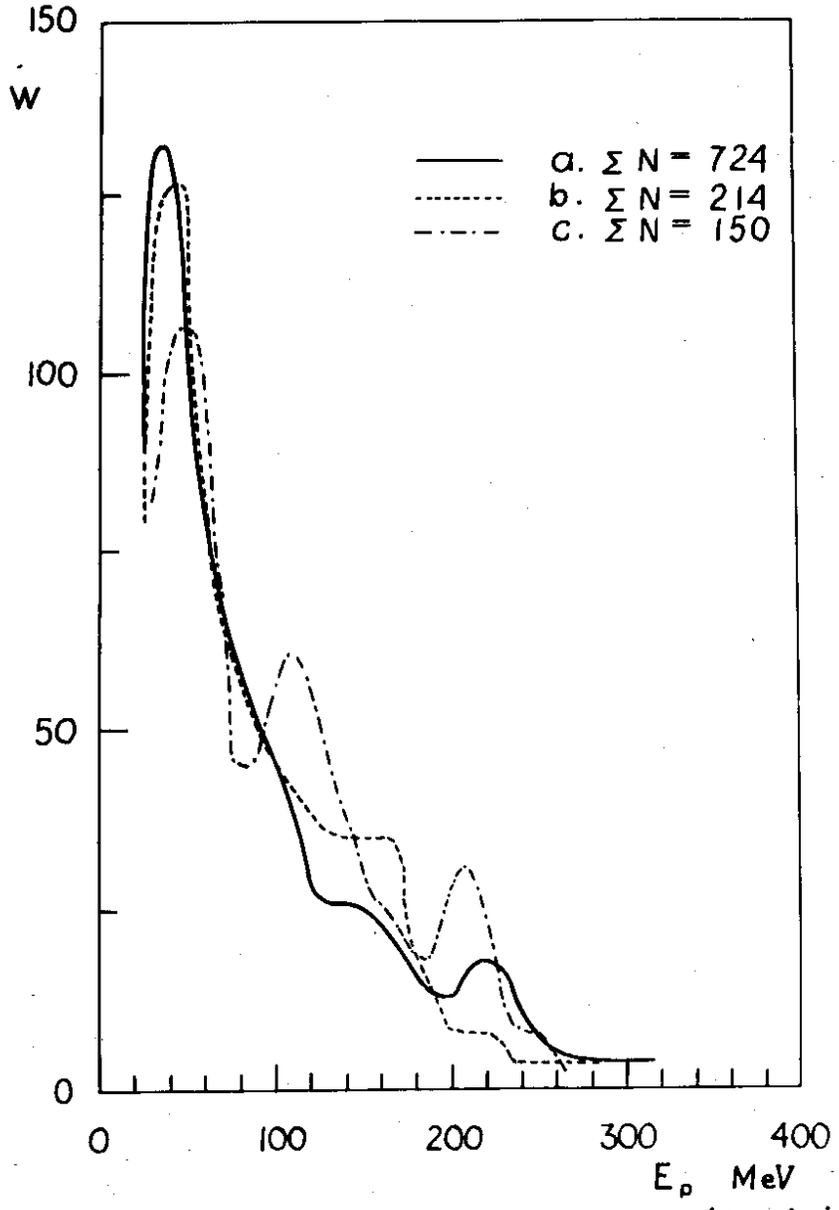

Fig. 2. Energy spectra of protons emitted in pion-xenon nuclei collisions at 3.5 GeV/c without multiparticle production: a)the event with single one charged secondary pion;b)the events without secondary pions;c)the events with one single neutral pion.

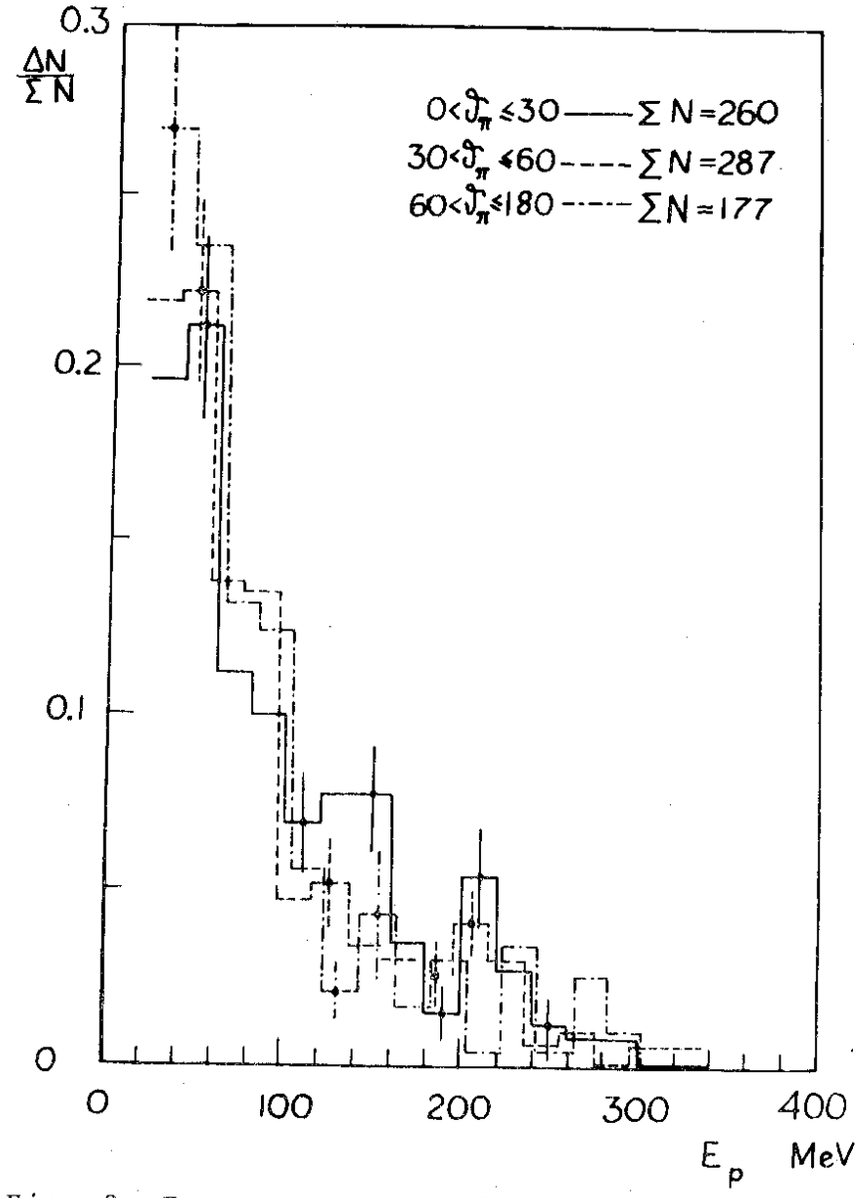

Fig. 3. Energy spectra of protons emitted in pion-xenon collision events at 3.5 GeV/c with one charged secondary pion emitted at various angles θ_π .

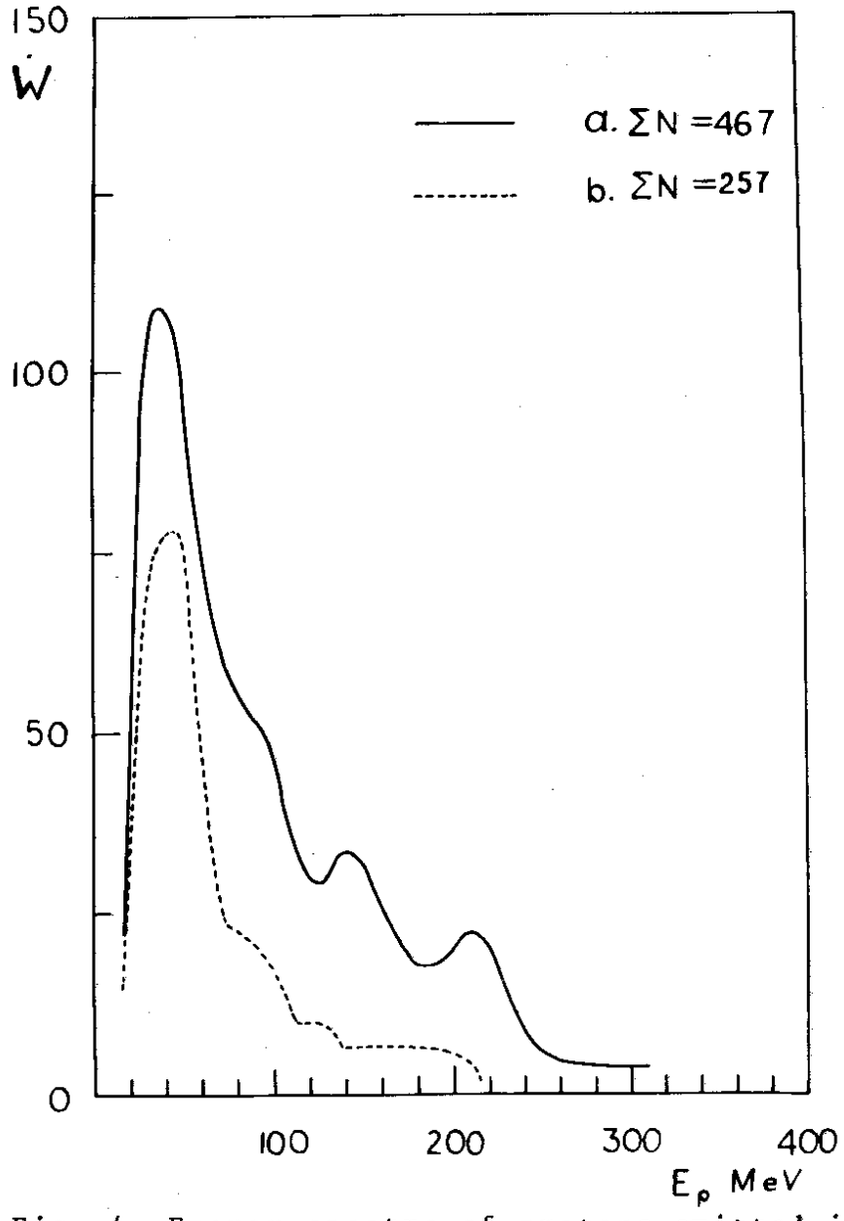

Fig. 4. Energy spectra of protons emitted in pion-xenon collision events with single one secondary pion: a) of protons emitted in the forward direction; b) of protons emitted in the backward direction.

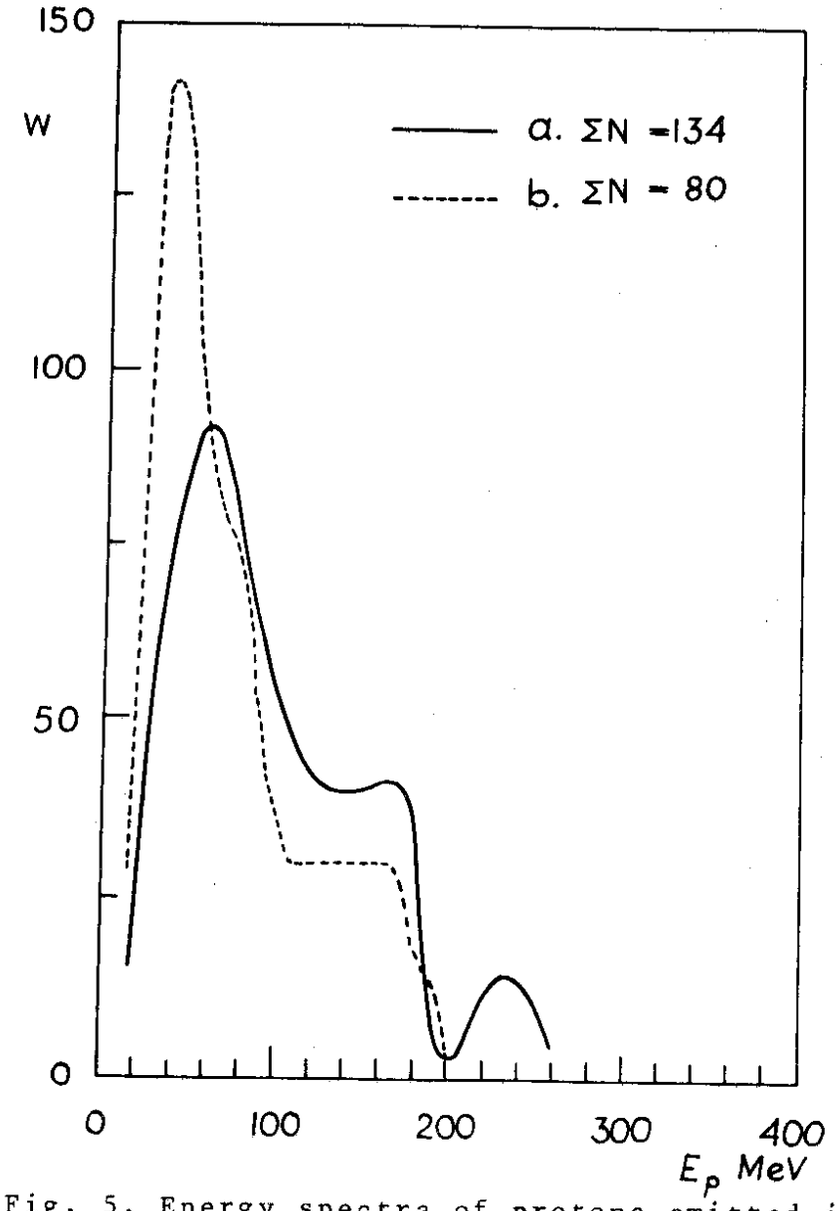

Fig. 5. Energy spectra of protons emitted in pion-xenon nuclei collision events without pions: a) of protons emitted in the forward direction; b) of protons emitted in the backward direction.

observe, if the proton spectra are prepared in the classes of protons emitted in the forward and the backward directions separately (figs. 4 and 5).

The irregularities observed appear as wide peaks in the proton energy spectra mainly at energy values lying nearly 40, 140 and 220 MeV. They may occur as a result of decay of some systems of nucleons.

An indication that irregularity in the proton spectrum in the pion-carbonium nuclei collisions exists has been presented too in other work[8].

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Received by Publishing Department
on December 15, 1978.