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Z.Strugalski, T.Pawlak, J.Pluta*

EXPERIMENTAL STUDY OF THE PION-XENON NUCLEUS COLLISIONS WITHOUT PARTICLE PRODUCTION AT 3.5 GeV/c MOMENTUM: Angular Distributions of Emitted Protons

* Institute of Physics of the Warsaw Technical University, Poland.

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1. INTRODUCTION

It was already communicated that such collisions of negatively charged pions of 3.5 GeV/c momentum with xenon nucleus exist in which "fast" protons, of kinetic energy from about 20 to about 400 MeV, are intensively emitted without particle production [1,2]. This sample includes about 11% of any type pion-xenon nucleus collisions; an argumentation exists [3] that the occurrence of such events is proper not only to the pion-xenon nucleus collisions under study but it is a general property of hadron-nucleus collisions at high energies. The observed fast proton emission should be regarded as an indication that fast neutrons are intensively emitted as well.

Investigations in details of various characteristics of the fast proton emission process, in collision events without particle production, may throw light on the connection between the nucleon emission process and the particle production process in hadron-nucleus collisions, and on the mechanism of the fast nucleon emission phenomenon. Various characteristics of the fast proton emission process were investigated, therefore, in this class of events, and the results were described in our former works [1,2,4,5]. The results obtained allow one to conclude that observed proton emission is not a result of a simple knocking-out of protons from the target nucleus by the incident hadron; probably, fast protons are emitted in result of decays outside of the target nucleus of some excited two or more nucleon systems that appeared in the target nucleus when incident hadron passes through it. The excitation may happen in result of absorption of slow pions by two or more nucleons. It was found necessaty to perform additional investigations in details of angular distributions of the emitted fast protons, therefore.

The subject matter in this paper is a presentation of results obtained in experimental studies of angular distributions of the fast protons, in pion-xenon nucleus collisions without particle production at 3.5 GeV/c momentum.

2. EXPERIMENT

Pion-xenon nucleus collisions were studied by means of the 180 litre xenon bubble chamber [6]. Characteristics of this chamber and detailed information about the experimental procedure can be found in our previous works [1-5].

Table

Characteristics of angular distributions of fast protons, of kinetic energy from about 20 to about 400 MeV, in pion-xenon nucleus collisions at 3.5 GeV/c momentum with $n_p \geq 1$ and $n_p = 1,2,\ldots,8,\geq 9$ emitted protons, without particle production. θ_p is the proton emission angle in degrees; ΣN_p ,number of protons at a given n_p.

n_p	ΣN_p	$\langle\cos\vartheta_p\rangle$	r.m.s.	skewness	kurtosis
≥ 1	2973	0.1976	0.5474	- 0.43	- 0.86
1	165	0.3575	0.4081	- 0.81	0.25
2	180	0.2009	0.5464	- 0.46	- 0.82
3	150	0.1868	0.5558	- 0.49	- 0.87
4	208	0.2040	0.5210	- 0.43	- 0.74
5	240	0.1543	0.5592	- 0.24	- 1.01
6	342	0.1849	0.5520	- 0.34	- 1.01
7	308	0.1983	0.5451	- 0.33	- 1.06
8	360	0.1872	0.5447	- 0.43	- 0.81
≥ 9	1020	0.1890	0.5595	- 0.44	- 0.90

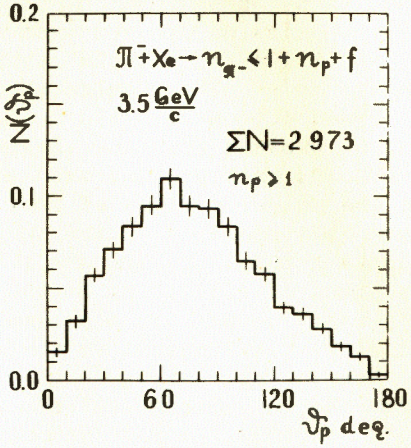

Fig.1. Angular distribution $N(\theta_p)$ of "fast" protons, of kinetic energy from about 20 to about 400 MeV, emitted in pion-xenon nucleus collisions without particle production at 3.5 GeV/c momentum. θ_p is the proton emission angle; n_π multiplicity of secondary pions; n_p ,multiplicity of the emitted protons; f, residual nuclear fragments; ΣN, number of protons in the histogram.

3. EXPERIMENTAL DATA

Experimental data on fast proton angular distributions, set forth below, are obtained in the analysis of 972 pion-xenon nucleus collision events without particle production singled out in the scanning of about 150000 chamber stereophotographs; this is the same sample of collisions, including events when

incident pion is absorbed inside the target nucleus or deflected in passage through it, general characteristics of which were analysed in our previous works [2,4,5].

Characteristics of fast proton angular distributions are presented in figs.1-4 and in the table containing parameters of distributions shown in fig.4.

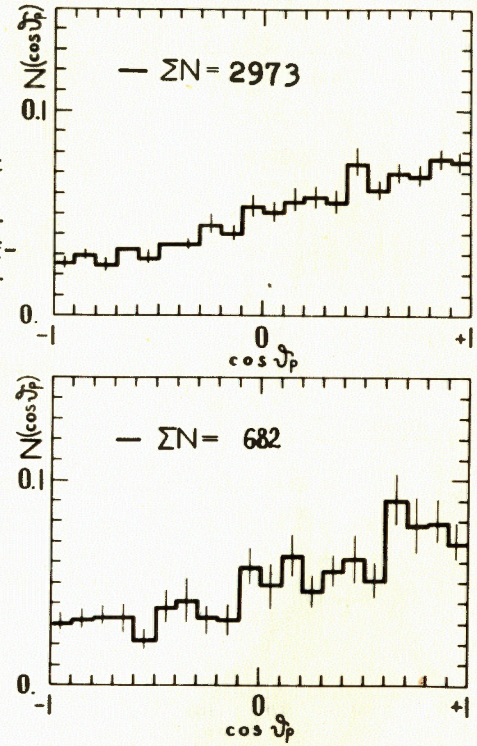

Fig.2. Angular distributions $N(\cos\theta_p)$ of fast protons, of kinetic energy from about 20 to about 400 MeV, emitted in pion-xenon nucleus collisions without particle production at 3.5 GeV/c momentum, in two classes of events: a) when incident pion is absorbed or deflected in the target nucleus - upper; b) when incident pion is absorbed inside the target nucleus - lower. θ_p is the proton emission angle, ΣN is the number of protons used in the histogram.

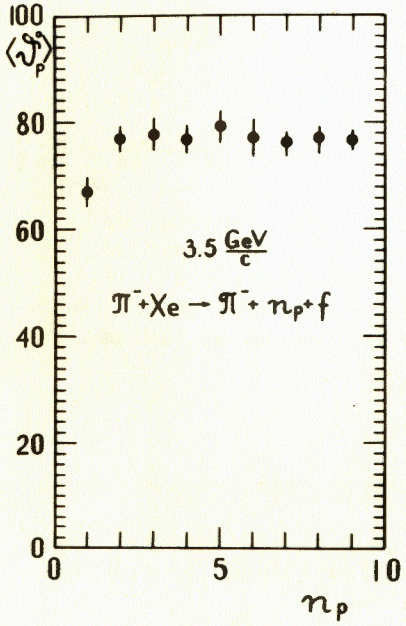

Fig.3. Dependence of the proton average emission angle $\langle\theta_p\rangle$ on the multiplicity n_p of emitted fast protons, of kinetic energy from about 20 to 400 MeV, in 972 pion-xenon nucleus collision events without particle production at 3.5 GeV/c momentum.

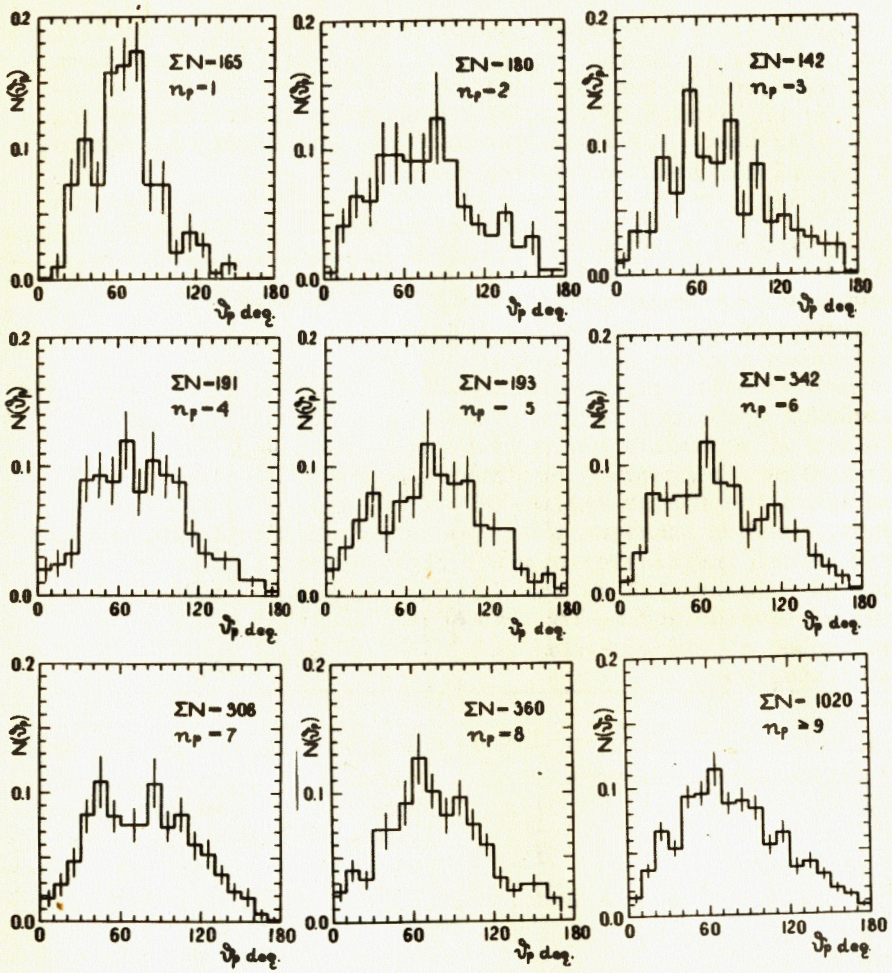

Fig. 4. Angular distributions $N(\theta_p)$ of fast protonts, of kinetic energy from about 20 to about 400 MeV, emitted in pion-xenon nucleus collisions without particle production but with $n_p = 1, 2, 3, \ldots 8, \geq 9$ protons, at 3.5 GeV/c momentum. ΣN, number of protons in histogram.

4. RESULTS

From angular distributions presented in figs.1-4 and in the table, one can conclude that:

1) Proton emission angles occur from 0 to 180 degrees, fig.1.

2) There are not evident irregularities in fast proton angular distributions, figs.1,2.

3) There is not significant evidence of any difference between the proton angular distributions in both two sub-classes of events without particle production - a) in the sub-class containing events in which incident pion is absorbed or deflected in passage through the target nucleus and b) in the sub-class of events in which incident pion is absorbed inside the target nucleus, fig.2.

4) The average emission angle $\langle\theta_p\rangle$ does not depend on the multiplicity n_p of emitted protons, when $n_p \geq 2$, fig.3.

5) The shapes of the fast proton angular distributions do not depend practically on the multiplicity n_p of emitted protons, fig.4 and table.

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Экспериментальное исследование столкновений пион-ксенон без рождения частиц при импульсе 3,5 ГэВ/с: угловые распределения испущенных протонов

Исследовались угловые распределения быстрых протонов с кинетическими энергиями от ~20 до ~400 МэВ, испущенных в столкновениях пион-ксенон при импульсе 3,5 ГэВ/с. Можно заключить, что: 1/ встречаются углы испускания протонов в интервале углов от 0 до 180 градусов; 2/ в угловых распределениях нет нерегулярностей; 3/ средний угол испускания протонов не зависит от кратности испускания протонов, когда эта кратность больше 1; 4/ формы угловых распределений протонов не зависят от кратности испущенных протонов.

Работа выполнена в Лаборатории высоких энергий ОИЯИ.

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Strugalski Z., Pawlak T., Pluta J. E1-83-234

Experimental Study of the Pion-Xenon Nucleus Collisions without Particle Production at 3.5 GeV/c Momentum: Angular Distributions of Emitted Protons

Angular distributions of fast protons, of kinetic energy from about 20 to about 400 MeV, emitted in pion-xenon nucleus collisions without particle production at 3.5 GeV/c momentum are studied. It can be concluded that: 1/ Proton emission angles occur from 0 up to 180 degrees; 2/ There are not evident irregularities in angular distributions; 3/ The average proton emission angle does not depend on the multiplicity of emitted protons, when its multiplicity is larger than 1; 4/ The shapes of the proton angular distributions do not depend on the multiplicity of emitted protons.

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

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