сообщения
объединенного
института
ядерных
исследований
дубна

E1 - 12943

GENERAL FEATURES OF ^{4}He BREAKUP REACTIONS IN ^{4}Hep INTERACTIONS AT A ^{4}He INCIDENT MOMENTUM OF 8.56 GeV/c

Warsaw - Dubna - Košice - Moscow - Strasbourg - Tbilisi Collaboration

1979

Глаголев В.В. и др. **E1 - 12943**

Основные особенности реакций развала ^4He в ^4Hep-взаимодействиях при начальном импульсе ^4He 8,65 ГэВ/с

Приводятся результаты исследований событий, зарегистрированных при взаимодействии ядра ^4He (с импульсом 8,56 ГэВ/с) с протонами в однометровой водородной камере. Приведены топологические сечения. Получена некоторая информация о свойствах ядра ^4He и механизме нуклон-ядерных взаимодействий на основании изучения двух реакций развала $^4Hep \to {}^3Hpp$ и $^4Hep \to {}^3Hep$.

Работа выполнена в Лаборатории высоких энергий ОИЯИ.

Сообщение Объединенного института ядерных исследований. Дубна 1979

Glagolev V.V. et al. **E1 - 12943**

General Features of ^4He Breakup Reactions in ^4Hep Interactions at a ^4He Incident Momentum of 8.56 GeV/c

The results are presented of investigation of the events obtained in the interaction of the 8.56 GeV/c ^4He nucleus with protons in the one-meter hydrogen bubble chamber. The topological cross sections are presented. The information on the properties of the ^4He nucleus and the nucleon-nuclear interaction is obtained on the basis of the study of two decays $^4Hep \to {}^3Hpp$ and $^4Hep \to {}^3Hep$.

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

Communication of the Joint Institute for Nuclear Research. Dubna 1979

1. EXPERIMENTAL PROCEDURE AND CROSS SECTIONS

The data presented in this paper have been obtained in an exposure of the 1 m Dubna HBC an external beam of 8.56 GeV/c ^4He particles. Selection, measurement and identification of events have been performed independently in each laboratory of Collaboration by using common criteria. We have estimated the ^4He-p topological cross sections on approximately half the total available statistics (40 000 events). We also present some characteristics of ^4He breakup reactions into two and three charged particles obtained from 8263 events giving at least one kinematical fit. 87% FIT events have the only hypothesis. Results on ^4He-proton elastic scattering and on other two-prong final states have been published elsewhere [1].

The ^4He-proton topological cross sections are given in Table 1. The two-prong elastic cross section takes into account a 15 mb correction, while we assume that, due to our favourable kinematical conditions, no losses occur in inelastic reactions. The calculation of cross sections has

Table 1

Topological cross sections. The errors statistical only

Topology	Cross sections (mb)
2 prongs elastic	36. ± 3.
2 prongs inelastic	23.3±2.0
3 prongs	73.1±0.9
4 prongs	5.3±0.1
5 prongs	8.9±0.2

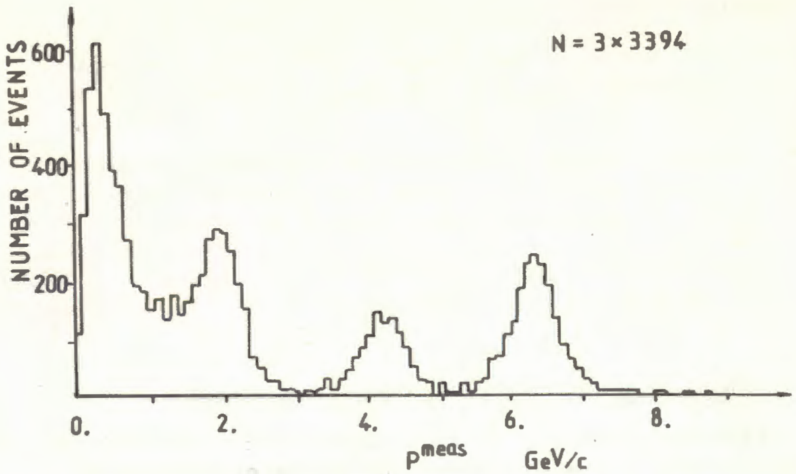

Fig. 1. Momentum distributions of secondary charged particles from 3394 three-prong events.

been made using the ^4He-proton total cross section $\sigma_{tot} = (148 \pm 7)$ mb estimated in ref.[1] by interpolating our experimental elastic differential cross section. This value is in good agreement with $\sigma_{tot} = (147 \pm 1)$ mb at a 17.9 GeV/c ^4He incident momentum obtained in a counter experiment[2]. We obtain therefore an average number of charged particles $\langle n \rangle = 3.00 \pm 0.02$ and a dispersion $D = 0.762 \pm 0.007$.

2. GENERAL CHARACTERISTICS OF ^4He BREAKUP REACTIONS

The use of ^4He incident beam permits the study of the ^4He fragmentation with a high efficiency of the identification of the emitted particles. This can be seen from figure 1 which presents the measured laboratory momenta of the outgoing particles for three-prong events. One observes two well-separated bumps centered at ~ 4 GeV/c and ~ 6.5 GeV/c which are due to deuterium and tritium tracks, respectively. The enhancement at ~ 2 GeV/c corresponds to fast protons while contributions to the first bump may arise from pions and slow protons. The separation of competing hypothesis is then easily achieved by applying the cuts resulting from figure 1; further cuts on the χ^2 probability and missing mass squared lead to a clean sample of events. The cross sections for the studied channels are presented in Table 2.

Table 2

Channel cross sections

Channel	Cross sections (mb)
$^4Hep \to pp\,^3H$	10.2±0.5
$\to {}^3Hepn$	11.0±0.5
$\to ddp$	1.2±0.2
$\to dppn$	9.9±0.5
$\to {}^3Hp\pi^+n$	11.4±0.5
$\to {}^3Hpp\pi^0$	2.6±0.3
$^4Hep \to {}^3H_s pp$	8.8±0.4
$\to p_s\,^3Hp$	1.4±0.1
$\to {}^3He_s pn$	9.3±0.4
$\to n_s\,^3Hep$	1.3±0.1
$\to p_s\,^3Hen$	0.42±0.02

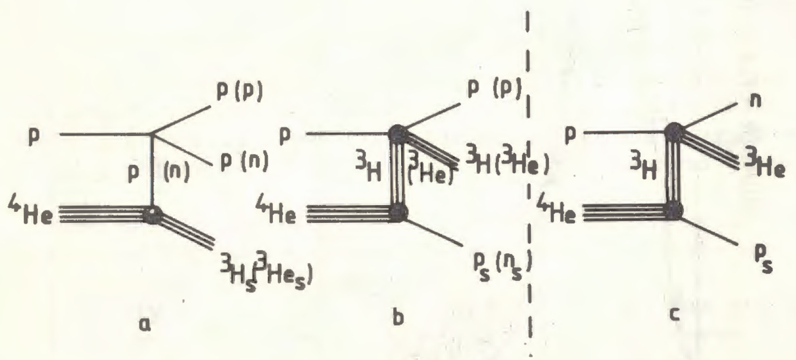

Fig. 2. Schematic representation of the reactions $^4Hep \to {}^3Hepn$ and $^4Hep \to {}^3Hpp$.

As in reference[3], one observed that the cross sections for the $^4Hep \to {}^3Hepn$ and $^4Hep \to {}^3Hpp$ reactions have large values which are close one to another as predicted by charge independence invariance. Nevertheless, a large difference occurs for the $^4Hep \to {}^3Hpp\pi^0$ and $^4Hep \to {}^3Hpn\pi^+$ processes; this difference is similar to that observed in the $pp \to pp\pi^0$ and $pp \to pn\pi^+$ reactions (4).

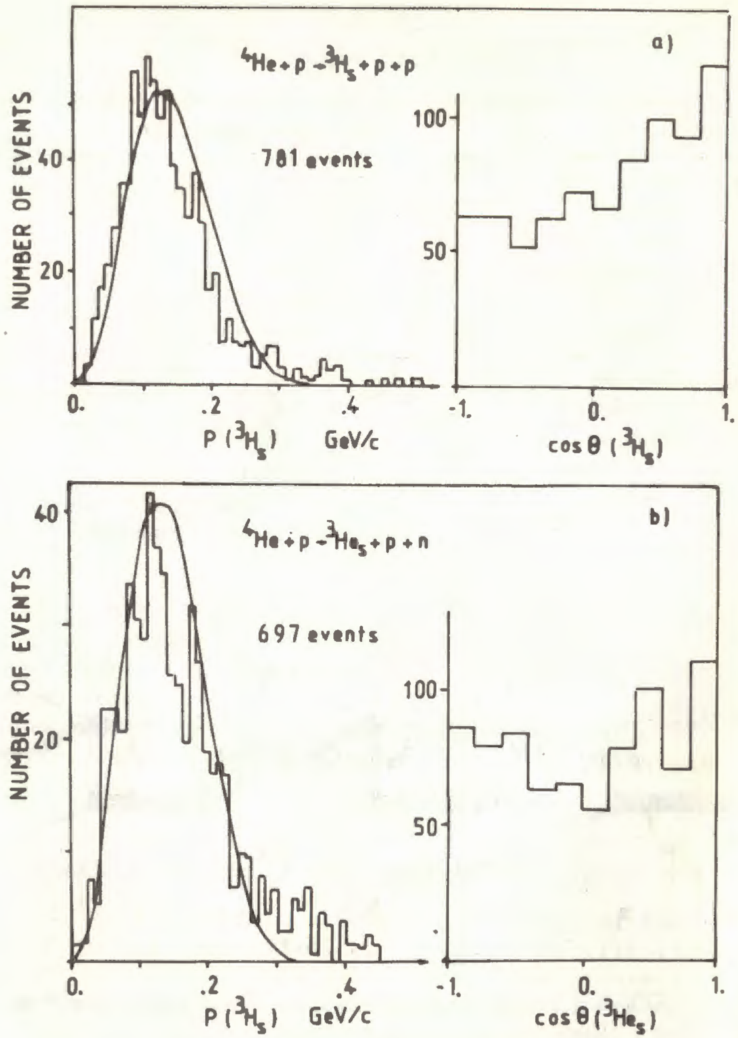

Fig. 3. Momentum and angular distributions of spectators in rest frame of nucleus.

The two break-up reactions ^3Hpp and ^3Hepn permit us to obtain some information on the properties of the ^4He nucleus and the mechanism of N-nuclei interactions. In the framework of the spectator model it is possible to interpret these reactions by using the various diagrams shown

in Figure 2. To this end we have defined the so-called spectator particle as a particle of the slowest momentum in the ^4He rest frame. Using this procedure, we are able to study the following subchannels

$$\begin{aligned} {}^4He\,p &\to {}^3He_s\,p\,n \\ &\to n_s\,{}^3He\,p \\ &\to {}^3He_s\,p\,p \\ &\to p_s\,{}^3H\,p\,, \end{aligned} \qquad (1)$$

where the index "s" denotes the spectator particle. Figure 3 presents some momentum distributions of the spectators and also the corresponding angular distributions with respect to the proton incident direction. One observes that these distributions are characteristics of the spectator scheme, namely the spectators are emitted rather isotropically and with a small momentum. The momentum distributions peak around 120 MeV/c which can be compared with the characteristic value $\alpha = (2\ mb)^{1/2} = 169$ MeV/c, where m is the reduced mass of a $n - {}^3He$ or $p - {}^3H$ system and B is the corresponding binding energy. The curves in figure 3 present the results of the calculation made in ref.[5] based on the Bessel-Wilkin wave function of the ^4He particle. These curves are in relatively good agreement with the experimental data; however, an excess of events is observed at high momenta.

Using this definition, we have extracted the cross sections for subchannels (1) with a spectator particle and have included them in Table 2.

Similarly to the $dp \to ppn$ reaction (6) and our previous study of the $^4Hep \to {}^3Hepn$ reaction (1), one observes some correlation between the outgoing particles and the spectator in the $^4Hep \to {}^3Hpp$ reaction. Figure 4 presents a diagram of the asymmetric in Treiman-Yang angular distributions as a function of spectator momentum. This angle is defined as the angle in the initial proton rest frame between the normal to the production plane and the plane containing the incident ^4He and the spectator.

One can see in Fig. 4 that the asymmetry of the Treiman-Yang angular distributions in both reactions increases with increasing spectator momentum. In analogy with the reaction $dp \to ppn$ [6], this may give evidence for a remarkable contribution of final state interaction between $p - {}^3H$ and $n - {}^3He$ particles.

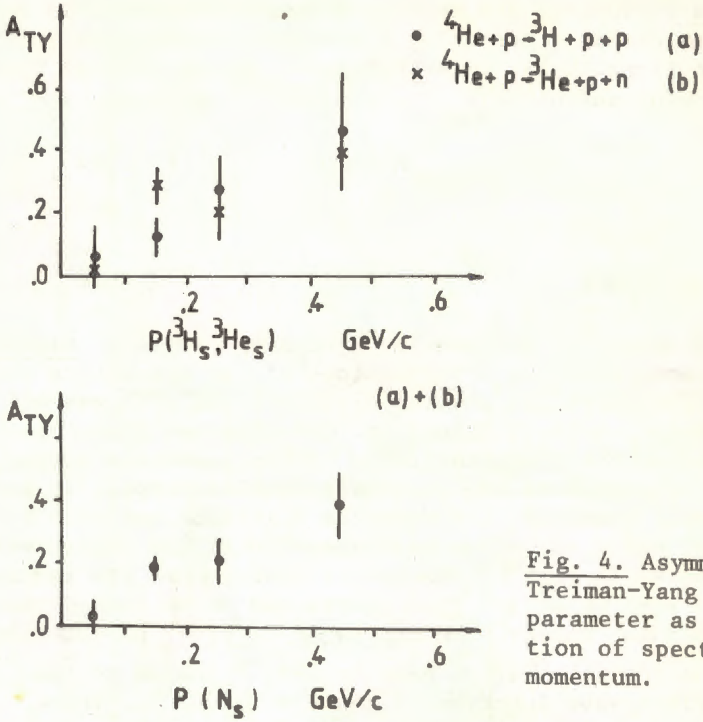

Fig. 4. Asymmetry Treiman-Yang angle parameter as a function of spectator momentum.

CONCLUSION

We have performed an analysis of some ^{4}He breakup reactions by using a ^{4}He beam and detecting the emitted particles with good accuracy. The application of the spectator scheme has allowed us to study NN interactions in an original way and may lead to a better understanding of the mechanisms of $^{4}He-p$ interaction.

REFERENCES

1. Glagolev V.V. et al. Phys.Rev., 1978, C18, p.1382.
2. Ableev V.G. et al. JINR, P1-10565, Dubna, 1977.
3. Bizard G. et al. Nucl.Phys., 1977, A285, p.461.
4. Alexander G. et al. NN and ND Interactions. A Compilation. UCRL 20 000 NN, 1970.
5. Kopeliovitch B.Z., Potashnikova I.K. Yad. Fiz., 1971, 13, p.1032.
6. Aladashvili B.S. et al. J.Phys. G., 1977, 3, p.7.

Received by Publishing Department
on November 11 1979.