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**A SEARCH FOR THE DEUTERON KNOCKOUT  
FROM CARBON NUCLEI  
BY 4.3 GeV/c PROTONS**

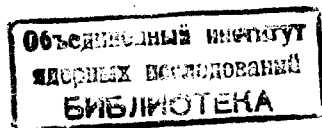
**1978**

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A SEARCH FOR THE DEUTERON KNOCKOUT  
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*Submitted to ЯФ*



Ажгирей Л.С. и др.

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Поиски выбивания дейтронов из ядер углерода протонами с импульсом 4,3 ГэВ/с

Представлены результаты поисков квазиупругого выбивания дейтронов из ядер углерода под углом 103 мрад протонами с импульсом 4,3 ГэВ/с. Найденное дифференциальное сечение составляет  $(3,4 \pm 2,4)$  мкбн/ср. В тех же условиях определены дифференциальные сечения реакций  $pp \rightarrow d\pi^+$  и  $pd \rightarrow dp$ , а также реакции  $p\langle N \rangle \rightarrow d\pi$  на нуклонах, связанных в ядрах дейтерия и углерода. Значение отношения дифференциального сечения выбивания дейтронов из ядер углерода вперед к сечению свободного  $p$ - $d$ -рассеяния сравнивается с результатами расчетов в квазиклассическом приближении.

Работа выполнена в Лаборатории вычислительной техники и автоматизации ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна 1978

Azhgirey L.S. et al.

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A Search for the Deuteron Knockout from Carbon Nuclei by 4.3 GeV/c Protons

The results of a search for the deuteron knockout from carbon nuclei at an angle of 103 mrad by 4.3 GeV/c protons are presented. The measured differential cross section for this process is  $(3.4 \pm 2.4)$   $\mu\text{b}/\text{sr}$ . The differential cross sections for the reactions  $pp \rightarrow d\pi^+$  and  $pd \rightarrow dp$ , and for the reaction  $p\langle N \rangle \rightarrow d\pi$  on nucleons bound in the deuterium and carbon nuclei have been determined under the same experimental conditions. The value of the differential cross section ratio of the quasielastic deuteron knockout from carbon to the elastic deuteron production in  $p$ - $d$  scattering in the forward direction is compared with the results of calculations of this ratio in the framework of the distorted density impulse approximation.

The investigation has been performed at the Laboratory of Computing Techniques and Automation, JINR.

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The quasielastic deuteron knockout from nuclei by 675 MeV protons was discovered more than twenty years ago <sup>/1/</sup>. However, so far, in spite of a series of additional experiments <sup>/2-4/</sup>, there is a lack in understanding the physical mechanism of this process <sup>/5,6/</sup>. Nevertheless, it is likely that short range nuclear pair correlations must play a noticeable role in the reactions of quasielastic deuteron knockout, and that a large part of the cross sections of these reactions is due to neutron pickup from the correlated clusters <sup>/7/</sup>. It appears that more intensive experimental investigations may give useful new information for further theoretical developments.

In the course of measurements of 4.3 GeV/c proton nuclear interactions we searched for the deuteron knockout from carbon nuclei. The experiments consisted in measuring, at an angle of 103 mrad by means of a single-arm magnetic spectrometer on-line with a computer <sup>/8/</sup>, the spectra of secondary particles emitted in the bombardment of  $\text{CH}_2$ ,  $\text{CD}_2$  and C targets by 4.3 GeV/c protons. Secondary protons and deuterons were separated by measuring their time of flight. The spectra of secondary protons with momenta in the interval from 3.6 to 4.3 GeV/c from the C target and those from D and H obtained by subtracting  $\text{CD}_2$ -C and  $\text{CH}_2$ -C are shown in *fig. 1*. In the present investigation we have analysed the most upper parts of these spectra where secondary particles with momenta greater than 4.34 GeV/c were contained, amongst which one might attempt to find quasielastically produced deuterons. *Figure 2* shows the mass distribu-

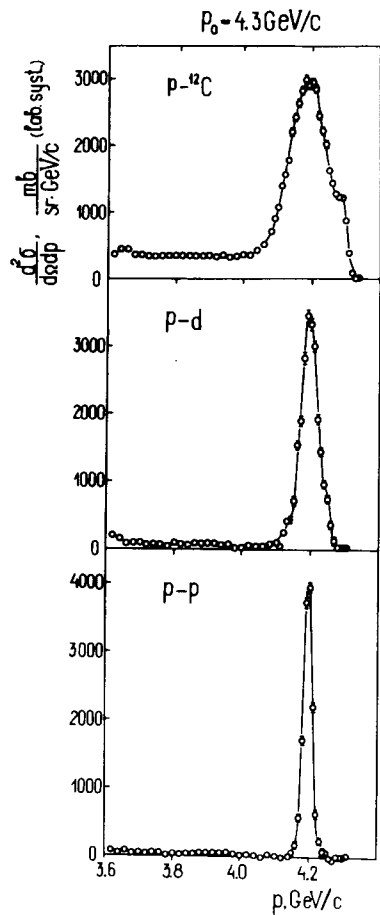


Fig. 1. Momentum spectra of protons detected at a lab. angle of 103 mrad in collisions of 4.3 GeV/c protons with H, D and C nuclei.

tion of the secondary particles detected in these spectrum parts, summed over all three targets. It is seen that the secondary protons and deuterons are clearly separated.

The spectra of protons and deuterons with momenta greater than 4.34 GeV/c summed over  $\text{CH}_2$ ,  $\text{CD}_2$  and C targets are shown in fig. 3. The proton spectrum is

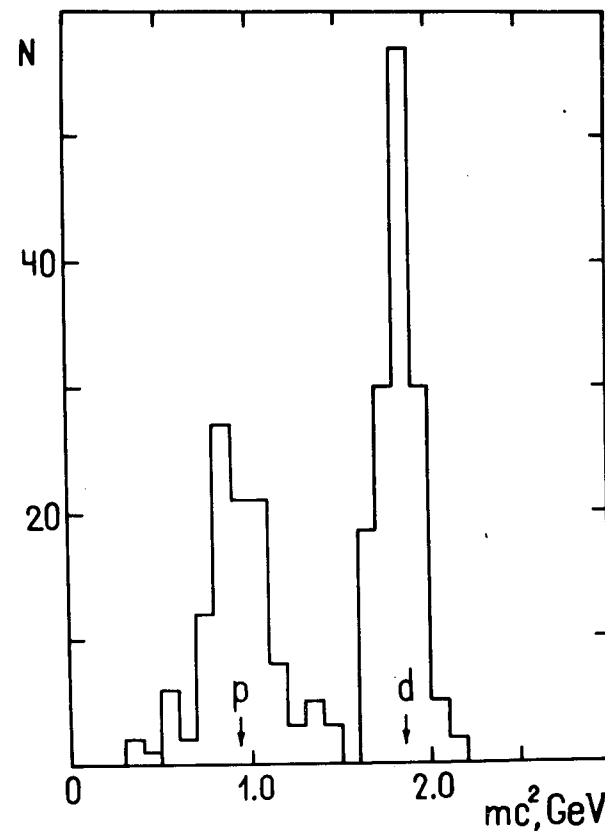


Fig. 2. Mass distribution of secondary particles with momenta greater than 4.3 GeV/c.

a tail of the distribution of protons scattered on carbon. In the deuteron spectrum at 4.46 GeV/c a peak from the reaction  $pp \rightarrow d\pi^+$  is seen. The peak is placed on the deuteron distribution from the process  $p\langle N \rangle \rightarrow d\pi$  on nucleons bound in C and D nuclei. Four events at about 4.77 GeV/c (one event from each of C and  $\text{CH}_2$  targets and two events from  $\text{CD}_2$  target) correspond kinematically to the elastic p-d scattering. The obtained data were normalized absolutely by using the differential cross section for the elastic P-P scattering. Its value

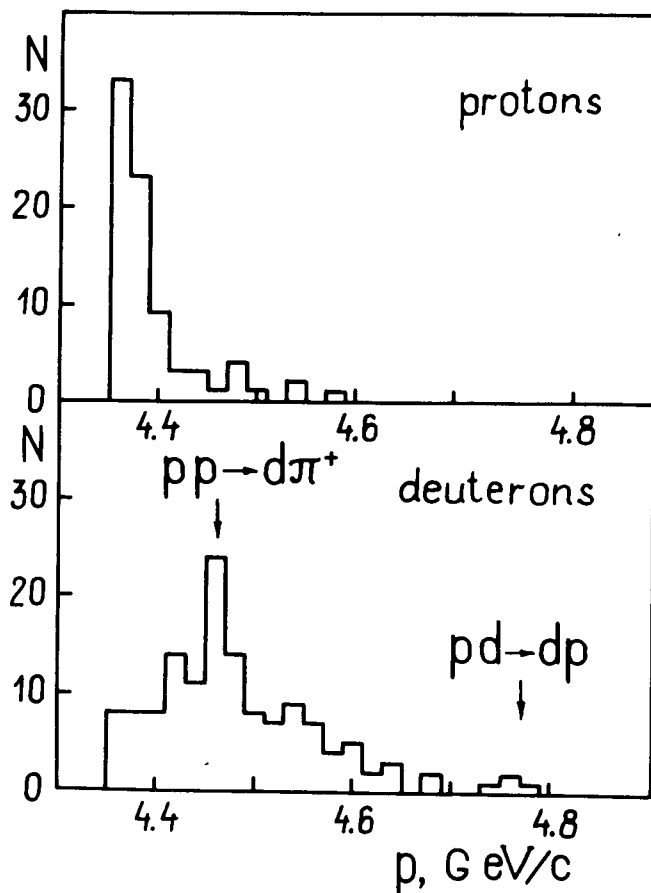


Fig. 3. Momentum spectra of protons and deuterons (summed over  $\text{CH}_2$ ,  $\text{CD}_2$  and C targets) with momenta greater than  $4.34 \text{ GeV}/c$  detected at a lab. angle of  $103 \text{ mrad}$  in nuclear interactions of  $4.3 \text{ GeV}/c$  protons.

for the present experimental conditions was taken to be  $(134 \pm 6) \text{ mb}/\text{sr}^{10}$ . Differential cross sections for the reactions of the fast deuteron production on H, D and C nuclei by  $4.3 \text{ GeV}/c$  protons, obtained from the analysis of the spectra, are given in the table.

Table

Differential cross sections for the reactions of fast deuteron production by  $4.3 \text{ GeV}/c$  protons on H, D and C nuclei at a lab. angle of  $103 \text{ mrad}$ , in  $\mu\text{b}/\text{sr}$

A	Reaction	$d\sigma/d\Omega$	Reaction	$d\sigma/d\Omega$
H	$pp \rightarrow d\pi^+$	$28 \pm 8$		
D	$p\langle N \rangle \rightarrow d\pi$	$57 \pm 15$	$pd \rightarrow dp$	$2.1 \pm 2.9$
C	$p\langle N \rangle \rightarrow d\pi$	$85 \pm 26$	$p\langle 2N \rangle \rightarrow dN$	$3.4 \pm 2.4$

The measured values of the differential cross sections for the reactions  $pp \rightarrow d\pi^+$  and  $pd \rightarrow dp$ , as seen from figs. 4 and 5, are in reasonable agreement with the recent results of measurements of the angular distribu-

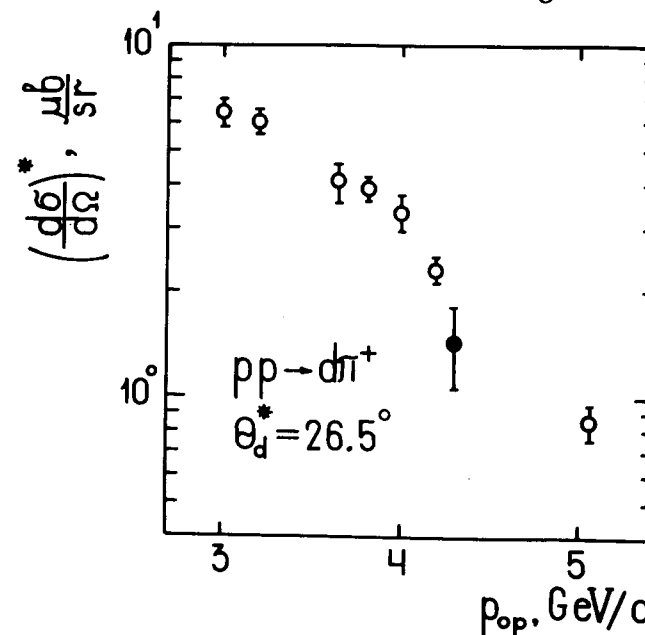


Fig. 4. Differential cross section of the reaction  $pp \rightarrow d\pi^+$  for a deuteron emission angle  $\theta_d^* = 26.5^\circ$  (in cms) versus the incident proton momentum.  $\circ$  - ref. <sup>10</sup>,  $\bullet$  - present work ( $\theta_d^* = 26.7^\circ$ ).

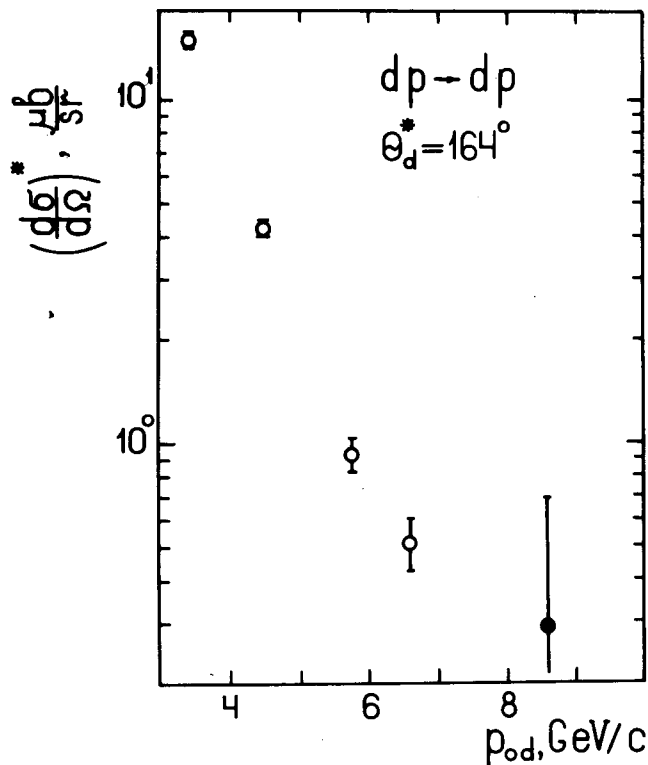


Fig. 5. Differential cross section of the reaction  $dp \rightarrow dp$  for a deuteron emission angle  $\theta_d^* = 164^\circ$  (in  $cm^2$ ) versus the incident deuteron momentum,  $\circ$  - ref. /11/,  $\bullet$  - present work.

tions of deuterons from the reaction  $pp \rightarrow d\pi^+$  in the interval from 3.0 to 5.0  $GeV/c$  /10/ and  $d-p$  backward elastic scattering in the interval of the incident deuteron momentum from 3.43 to 6.60  $GeV/c$  /11/.

It seems to be interesting to consider the momentum dependence of  $R$ , the differential cross section ratio of the quasielastic deuteron knockout from carbon to the elastic deuteron production in  $p-d$  scattering in the forward direction. The expression for  $R$  was obtained in ref. /7/ in the framework of the distorted density impulse approximation, and it was used successfully in

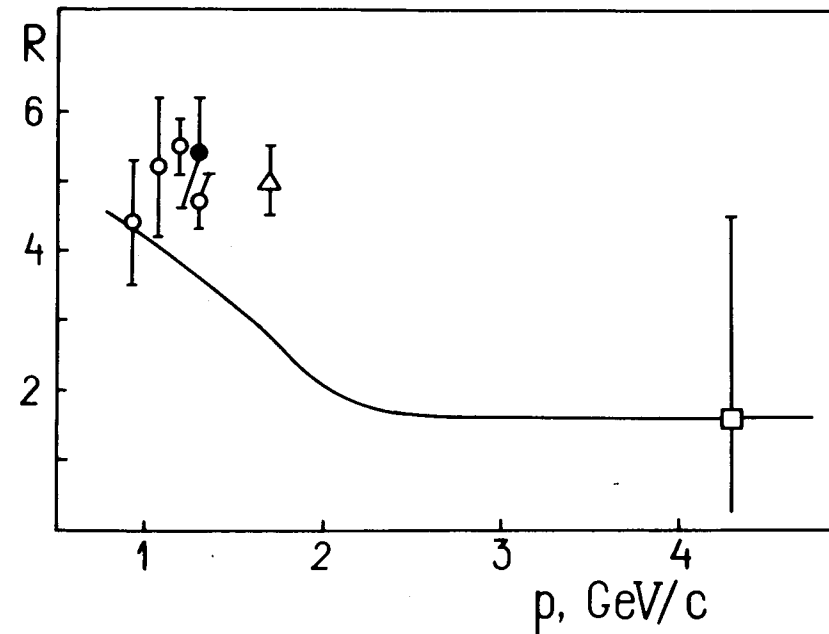


Fig. 6. The lab. initial momentum dependence of  $R$ , the differential cross section ratio of the quasielastic deuteron knockout from carbon to the elastic deuteron production in  $p-d$  scattering at  $0^\circ$ , calculated according to ref. /7/. The experimental points are:  $\circ$  - ref. /4/,  $\bullet$  - ref. /3/,  $\Delta$  - ref. /2/,  $\square$  - present work.

ref. /7/ to describe the experimental data on quasielastic deuteron knockout from nuclei by protons with initial momenta from 1.2 to 1.7  $GeV/c$ . In ref. /7/ it has been shown also that, in accordance with the experimental results /2,3/, ratio  $R$  for the fixed value of the incident proton momentum depends slightly on an angle in the interval from 0 to 0.2  $rad$ .

Figure 6 shows the dependence of the ratio  $R$  at  $0^\circ$  for protons on carbon versus incident proton momentum, that has been calculated according to ref. /7/, and  $R = 1.6 \pm 2.9$  obtained in the present experiment. It is worth noting that the differential cross section for the quasielastic deuteron knockout from nuclei in the forward di-

reaction decreases about a hundred times in the interval of the incident proton momentum from 1.3 to 4.3 GeV/c. At the same time the change of  $R$ , due to the behaviour of the amplitudes and cross sections of N-N interaction in the momentum interval under consideration, is limited to a factor of three.

#### REFERENCES

1. Azhgirey L.S. et al. *JETP*, 1957, 33, p.1185.
2. Sutter R.J. et al. *Phys.Rev.Lett.*, 1967, 19, p.1189.
3. Azhgirey L.S. et al. *Nucl.Phys.*, 1972, A193, p.581.
4. Komarov V.I. et al. *Nucl.Phys.*, 1976, A256, p.362.
5. Friedman W.A. *Phys.Rev.Lett.*, 1968, 21, p.1696.
6. Futami Y., Miyazima T. *Prog.Theor.Phys.*, 1971, 45, p.776.
7. Remler E.A., Sathe A.P. College of William and Mary report, Williamsburg, 1977.
8. Azhgirey L.S. et al. *Yad.Fiz.*, 1978, 27, p.1027.
9. Benary O. et al. UCRL-20000 NN, 1970.
10. Anderson H.L. et al. *Phys.Rev.*, 1974, D9, p.580.
11. Dubal L. et al. *Phys. Rev.*, 1974, D9, p.597.

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