

ON A POSSIBILITY OF EXTRACTION OF TWO-NUCLEON  
INTERACTIONS IN d-C COLLISIONS AT 4.2 GeV/c PER NUCLEON

SNEŽANA DRNDAREVIĆ and DRAGAN KRPIĆ

*Faculty of Physics, University of Belgrade, 11000 Belgrade, Yugoslavia*

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An attempt to extract data on interaction where both deuteron nucleons interact in d-<sup>12</sup>C collisions is presented. The contribution of such interactions is established and used to estimate the appropriate mean positive and negative pion multiplicities. These expectations were in agreement with the experimentally established distributions and a model of independently interacting nucleons.

### *1. Introduction*

Pion multiplicity distribution in fast light-ion collisions are described in terms of models assuming independent interactions of projectiles nucleons with the target<sup>1,2</sup>). In the case of incident deuteron, there are three different possibilities:

- a) Neutron interacts and proton is a spectator.
- b) Only proton interacts, neutron being a spectator.
- c) Both nucleons interact with target nucleus.

The corresponding pion multiplicity distributions have to be different and it would be interesting to see if the third type reaction multiplicity can be estimated from the data for the first and second ones.

## 2. Experimental data and results

Experimental data have been obtained by 2 m propane bubble chamber in the Laboratory of High energies, JINR Dubna. The chamber was placed in a magnetic field of 1.5 T and exposed to beams of protons and deuterons from Synchrophasotron, with a momentum of 4.2 GeV/c per nucleon.

After scanning, measurement and geometrical reconstruction 6188 p-propane and 9010 d-propane events have been registered at DST, which lead to 4014 p-C and 5701 d-C events.

For this sample  $\pi^-$  and  $\pi^+$  multiplicity distributions, normalized to 1, are presented on Figs. 1a, b and Figs. 2a, b.

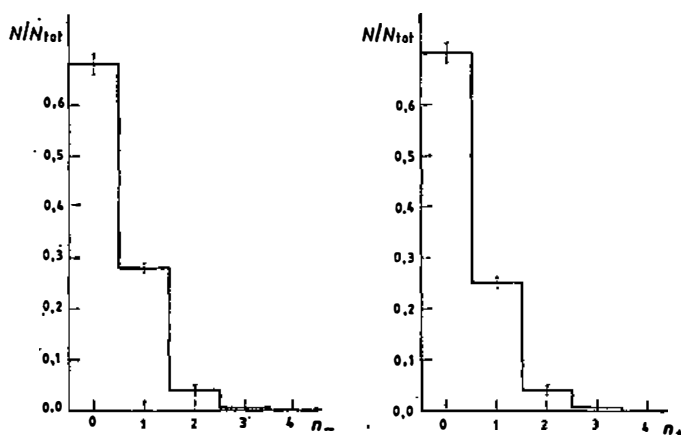


Fig. 1.  $\pi^-$  and  $\pi^+$  multiplicity distributions for p-C events (proton beam).

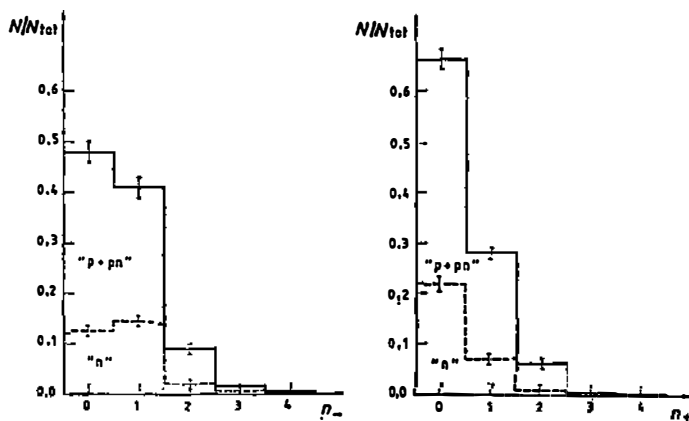


Fig. 2.  $\pi^-$  and  $\pi^+$  multiplicity distributions for deuteron beam.

Among the d-C events, we detected 1739 interactions where a track of a proton-spectator was clearly seen. (The criteria for the proton spectator, so called *stripping proton* were: momentum higher than 3 GeV/c and emission angle less than 4 degrees<sup>3,4</sup>.) These events correspond to the interaction of a neutron (type a) and we called them »n-events« (dotted line in Figs. 2a and 2b). The rest of distribution contains a mixture of interactions of protons (type b, »p-events«) and of interactions of a proton and neutron together (type c, »pn-events«).

In order to extract the contribution of pn-events we used a fact that  $(\sigma_{in})_{pC} = (\sigma_{in})_{nC}$ , which is the consequence of isospin symmetry and shown in Ref. 5, leading to equal numbers of n- and p-events, which gives us a total number of 2223 pn-events. Then, the relative contribution of pn-events, i.e. the portion of two-nucleon interaction among all d-C events is found to be:

$$\alpha = \frac{2223}{5701} = 0.39 \mp 0.02.$$

We also used a shape of  $\pi^-$  and  $\pi^+$  multiplicity distributions corresponding to p-C interactions (Figs. 1a, b) and after normalization we subtracted them from corresponding »p + pn« distributions. Results are presented on Figs. 3, a, b and in Table 1.

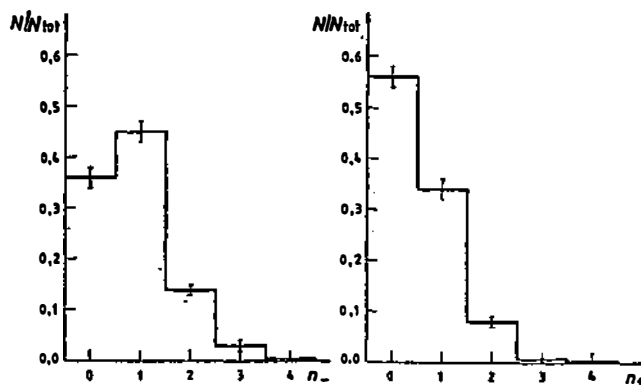


Fig. 3.  $\pi^-$  and  $\pi^+$  multiplicity distributions for »pn« events extracted from d-C interactions.

TABLE 1.

| Type of interactions | No. events. | $\pi^-$ | $\pi^+$ | $\langle n_- \rangle$ | $\langle n_+ \rangle$ |
|----------------------|-------------|---------|---------|-----------------------|-----------------------|
| p-C (p beam)         | 4014        | 1414    | 1399    | $0.352 \mp 0.015$     | $0.349 \mp 0.015$     |
| d-C                  | 5701        | 3802    | 2331    | $0.667 \mp 0.019$     | $0.409 \mp 0.014$     |
| n-C (d beam)         | 1739        | 1135    | 511     | $0.676 \mp 0.039$     | $0.294 \mp 0.020$     |
| pn                   | 2223        | 1930    | 1205    | $0.873 \mp 0.038$     | $0.542 \mp 0.030$     |

Pion multiplicities for p-C and d-C interactions.

The average values of positive and negative pion multiplicities in pn events are close to the lower limit of the sums of the corresponding values of p-C and n-C interactions. However, our value of  $\alpha$  makes it possible to estimate the mean pion multiplicities in pn-interactions from the simple relation:

$$\langle n_{\mp} \rangle_d = \alpha \langle n_{\mp} \rangle_{pn} + 0.5(1 - \alpha) \langle n_{\mp} \rangle_p + 0.5(1 - \alpha) \langle n_{\mp} \rangle_n,$$

where  $\langle n_{\mp} \rangle_d$ ,  $\langle n_{\mp} \rangle_p$  and  $\langle n_{\mp} \rangle_n$  are directly experimentally established. These estimations give:

$$\langle n_{-} \rangle_{pn} = 0.90 \mp 0.10 \quad \text{and} \quad \langle n_{+} \rangle_{pn} = 0.55 \mp 0.06$$

that are in good agreement with the values expected by the model.

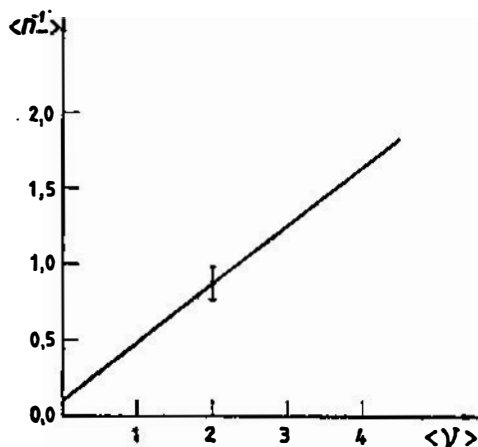


Fig. 4. Linear relation  $\langle n_{-} \rangle = a + b \langle \nu \rangle$ . Our point corresponds to  $\langle \nu \rangle = 2$ .

In a work of H. N. Agakishiyev et al.<sup>6)</sup> the relation between  $\langle n_{-} \rangle$  and the number of the nucleons of projectile interacting with carbon nucleus,  $\langle \nu \rangle$  for incident  $p$ ,  $d$ ,  $\alpha$  and  $C$  has been experimentally established:

$$\langle n_{-} \rangle = a + b \langle \nu \rangle,$$

where  $a = 0.09 \mp 0.04$  and  $b = 0.38 \mp 0.03$  (Fig. 4). Our point for  $\langle n_{-} \rangle = 0.9$  that is in good agreement with  $\langle \nu \rangle = 2$ , confirming that both deuteron nucleons took part in the interactions.

### 3. Conclusions

In deuteron-carbon interactions at 4.2 GeV/c per nucleon about 40% of d-C events are due to interactions of both nucleons of the projectile.

For these interactions, average multiplicities can be estimated from the corresponding values for d-C, p-C and n-C interactions.

These procedure is justified by comparison with Agakishiyev's relation.

#### References

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### MOGUĆNOST IZDVAJANJA DVONUKLEONSKIH INTERAKCIJA U d-C SUDARIMA NA 4,2 GeV/c PO NUKLEONU

SNEŽANA DRNDAREVIĆ i DRAGAN KRPIĆ

*Fizički fakultet, Univerzitet u Beogradu, 11000 Beograd*

UDK 539125.

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U ovom radu pokušali smo da izdvojimo među svim d-C interakcijama one u kojima su učestvovala oba nukleona iz upadnog jezgra. Procenat ovih interakcija je određen i iskorišten za procenu srednjeg multipliciteta  $\pi^-$  i  $\pi^+$  mezona nastalih u sudaru. Ova procena se dobro slaže sa eksperimentalnom raspodelom multipliciteta i modelom nezavisno interagujućih nukleona.