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Till now all experimental investigations on a check of the charge invariance principle in pion production were made by comparing two charge-conjugated reactions the cross sections of which must be in a definite relation if the total isotopic spin is conserved. This concerns the reactions $p+p \rightarrow d+\pi^+$ and $n+p \rightarrow d+\pi^0$ studied at energies of 400 MeV[1,2] and 600 MeV[3,4] as well as the reactions $p+d \rightarrow t+\pi^+$ and $p+d \rightarrow He^3+\pi^0$ which were compared at energies of 340 MeV[5], 450 MeV[6], and 600 MeV[7].

However, a more direct method of checking the charge invariance principle, being free from any systematic errors, consists in establishing the degree of forbiddeness resulting from the conservation of an isotopic spin in the processes of meson production. So, for example, the forbiddeness due to this principle must take place in the reaction[8]

$$d+d \rightarrow \pi^0+He^4 \qquad (1)$$

The process above-mentioned makes it also possible to test the hypothesis of the existence of isotopically scalar neutral pion suggested by A.M. Baldin[9] in order to remove the discrepancies between the data on pion photoproduction near the threshold and Panofsky ratio. In the present paper are given the first data on this reaction which were obtained with the synchrocyclotron of the Laboratory of Nuclear Problems at a deuteron energy of 400 MeV. The measurements were made at an extracted deuteron beam with the intensity of about 3.10^{10} sec^{-1}. Secondary charged particles emitted from the targets of heavy polyethelene and carbon were selected by a brass collimator placed at an angle of 5.6° with respect to a deuteron beam, were deflected by a magnetic field at an angle of 27°, and passed through a steel collimator in the shielding concrete wall. The particles were registered by a telescope consisting of six scintillation counters (Fig. 1). The charged particles knock-knocked out of the target were identified by the effective momentum, specific ionization and the range The particles with a definite momentum were selected by means of an electromagnet to the poles of which a special form is given to improve their energy resolution. The particle separation by the magnitude of the specific ionization was made in each of the first five counters of the telescope independently. Such a method[10] enabled us to identify rare processes of the emission of high ionization particles in the presence of the background of the lower ionization radiation. The range of the particle was set by absorbers placed between the fifth and the sixth counters of the telescope. The latter counter was in anticoincidence with the first five to detect the particles in the given range interval. In the first five counters of the telescope the scintillators were used as films 0.5 mm thick providing for α-particle recording with the energy of more than 60 MeV. The discriminator was gauged with α-particle beams of the energies 800, 700, 460 and 370MeV. The apparatus was tested and the electomagnet was gauged in the units of MeV/c by recording the He^3 nuclei from the reaction $d + d \rightarrow He^3 + n$. In Fig. 2 is plotted the spectrum of masses or particles with an effective momentum $P/Z = 730$ MeV/c, which are emitted at an angle of 5.6° in the lab.system from the target of heavy polyethelene. In Fig. 3 are shown the counting response of the telescope depending on the discriminator threshold, the yield of He^3 nuclei depending on the current in the deflecting electromagnet for the target of heavy polyethelene, and also the counting difference

$CD_2 - C$ corresponding to the reaction $d+d \rightarrow He^3 + n$. Analogously the yield of α -particles with the effective momentum 635 MeV/c has been measured at the target made of heavy polyethelene. This yield of α -particles corresponded to the emergence of α -particles from reaction (1) for the angle 5.6° in the lab. system to which an isotropic angle in center-of-mass system (Fig. 4) corresponds approximately. In Figs 5 and 6 are given the conditions of recording these α -particles by the magnitude of specific ionization, by range, and by effective momentum. The absolute cross sections have been determined under the same conditions by detecting the deuterons from the reaction $p+p \rightarrow d+\pi^+$ the cross section of which is well-known now/11/. In Fig. 7 is given the counting response of the telescope in recording the deuterons from this reaction. It follows from the results of the first measurements that with a confidence limit of 90% the total cross section for reaction (1) is $\sigma_t(d+d \rightarrow \pi^0 + He^4) < 1 \cdot 10^{-31}$ см².

The upper limit obtained shows that the cross section for reaction (1) exceeds only a few times the cross section for the electromagnetic process $d+d \rightarrow \gamma + He^4$ which, according to the data on the inverse reaction $\gamma + He^4 \rightarrow d+d$ is about 10^{-32} cm², while the cross sections for these two processes may differ as much as 10^2 times if the forbidenness is absent.

Since under the conditions of the given experiments α -particles from the reaction $d+d \rightarrow \pi^0_0 + He^4$ in which the isotopically scalar π^0 -meson is produced, could also be recorded an obtained upper limit of the total cross section for reaction (1) should be considered as an indication that an isotopically scalar neutral pion with the mass in the interval $(135 \begin{smallmatrix}+15\\-35\end{smallmatrix})$ MeV does not exist.

The differential cross section for the reaction $d+d \rightarrow He^3 + n$ has been measured in the present experiment for the angle 5.6° in the lab. system, which in the center-of-mass system is equal to $\frac{d\sigma}{d\Omega}(15{,}5°) = (3{,}8 \pm 0{,}5) \cdot 10^{-29}$ cm²/sterad.

In further experiments with this apparatus and the liquid deuterium target it would be apparently possible to go forward, at least, by a factor 10 in estimating the upper limit of the cross section for reaction (1), and, thereby, to compare directly the reactions

$$d+d \rightarrow \pi^0 + He^4 \quad \text{and} \quad d+d \rightarrow \gamma + He^4$$

under the same conditions.

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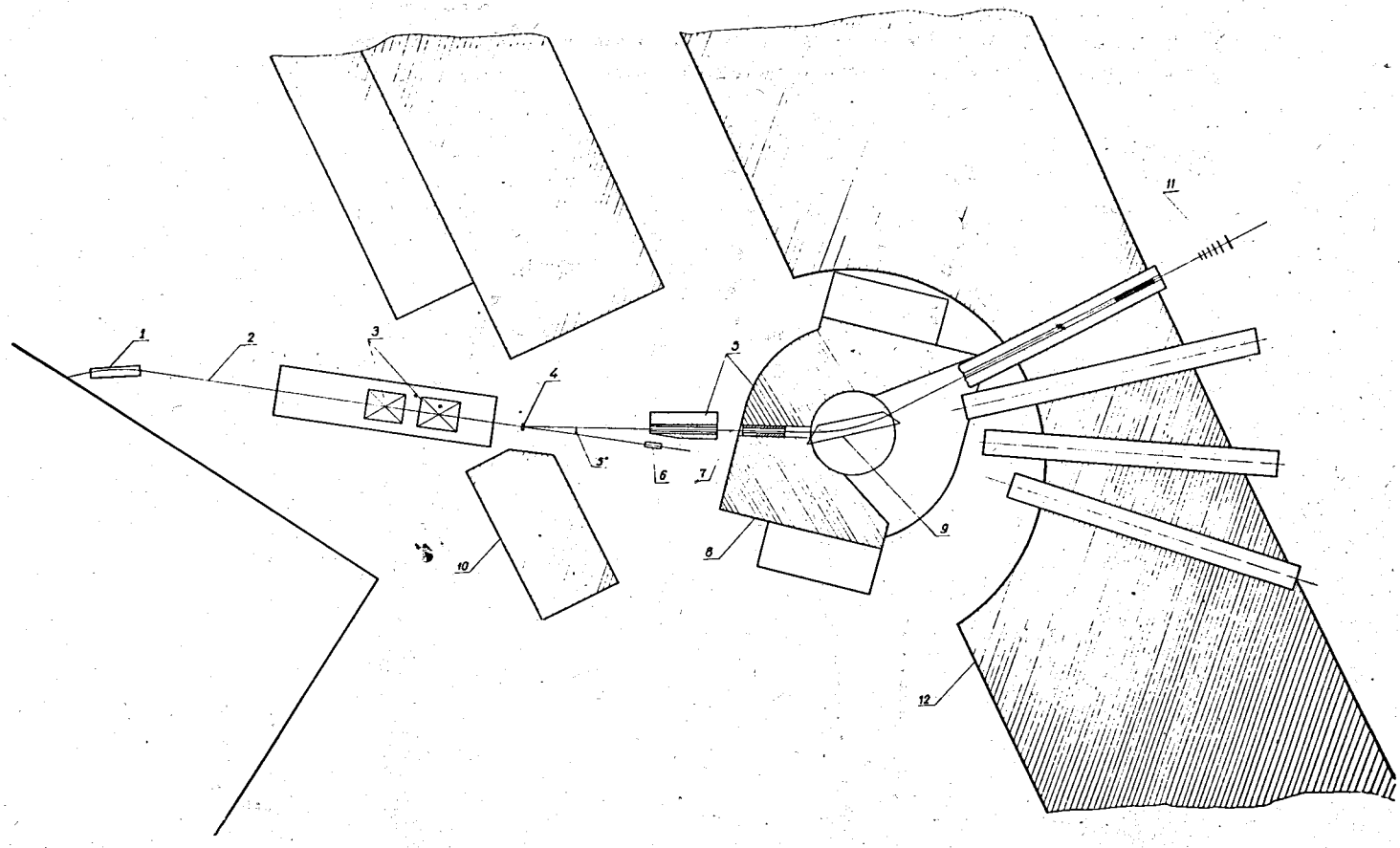

Fig. 1. A scheme of an experiment.
1- deflecting attachments, 2- unpolarized beam of deuterons, 3- magnetic quadrupole lens, 4- target of heavy polyethelene or carbon, 5- lead shielding, 6- monitor, 7- trajectory of secondary charged particles, 8- deflecting electromagnet, 9- focusing attachment , 10- concrete shielding, 11- telescope of six scintillation counters, 12- shielding wall.

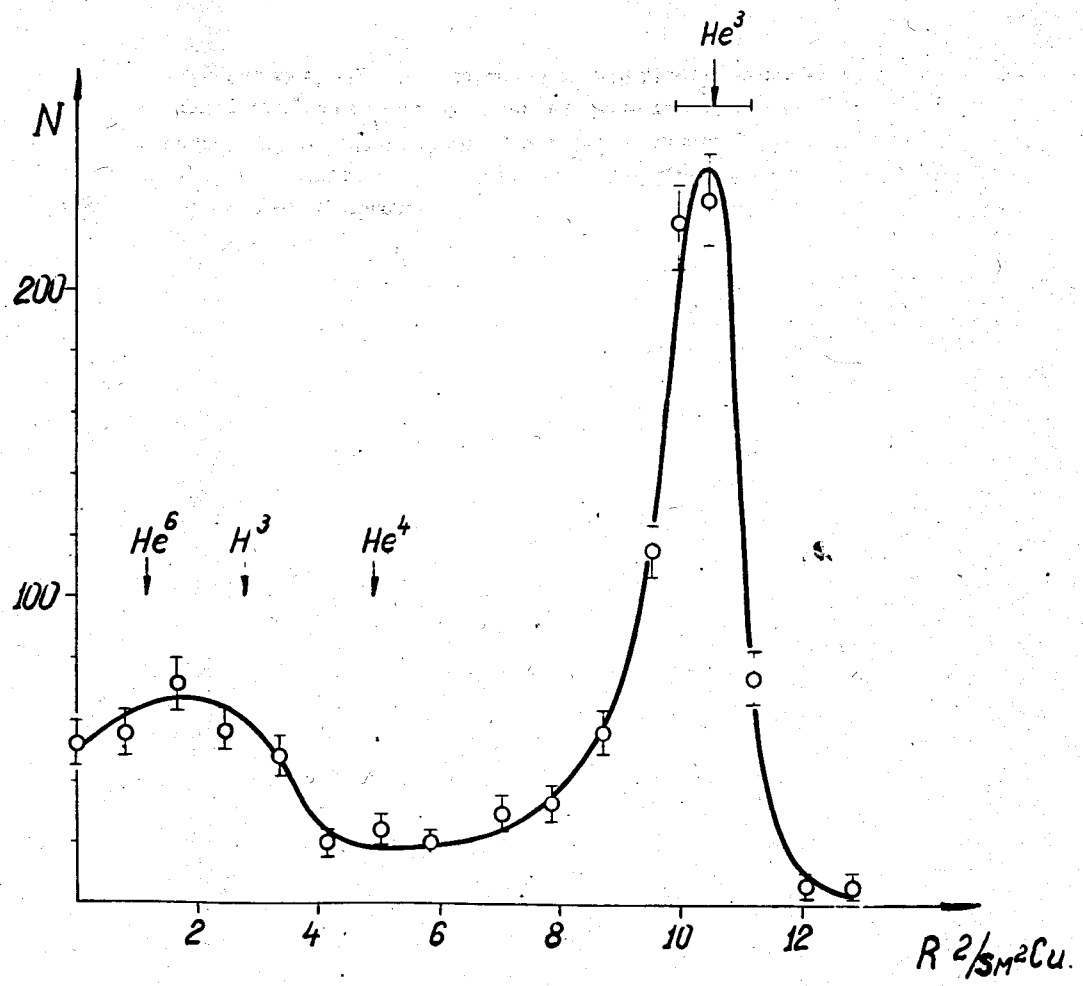

Fig. 2. Spectrum of masses of particles emitted at an angle of 5.6° in the lab.system from the collisions $d + CD_2$. The arrows indicate the calculation values of the mean ranges of different particles.

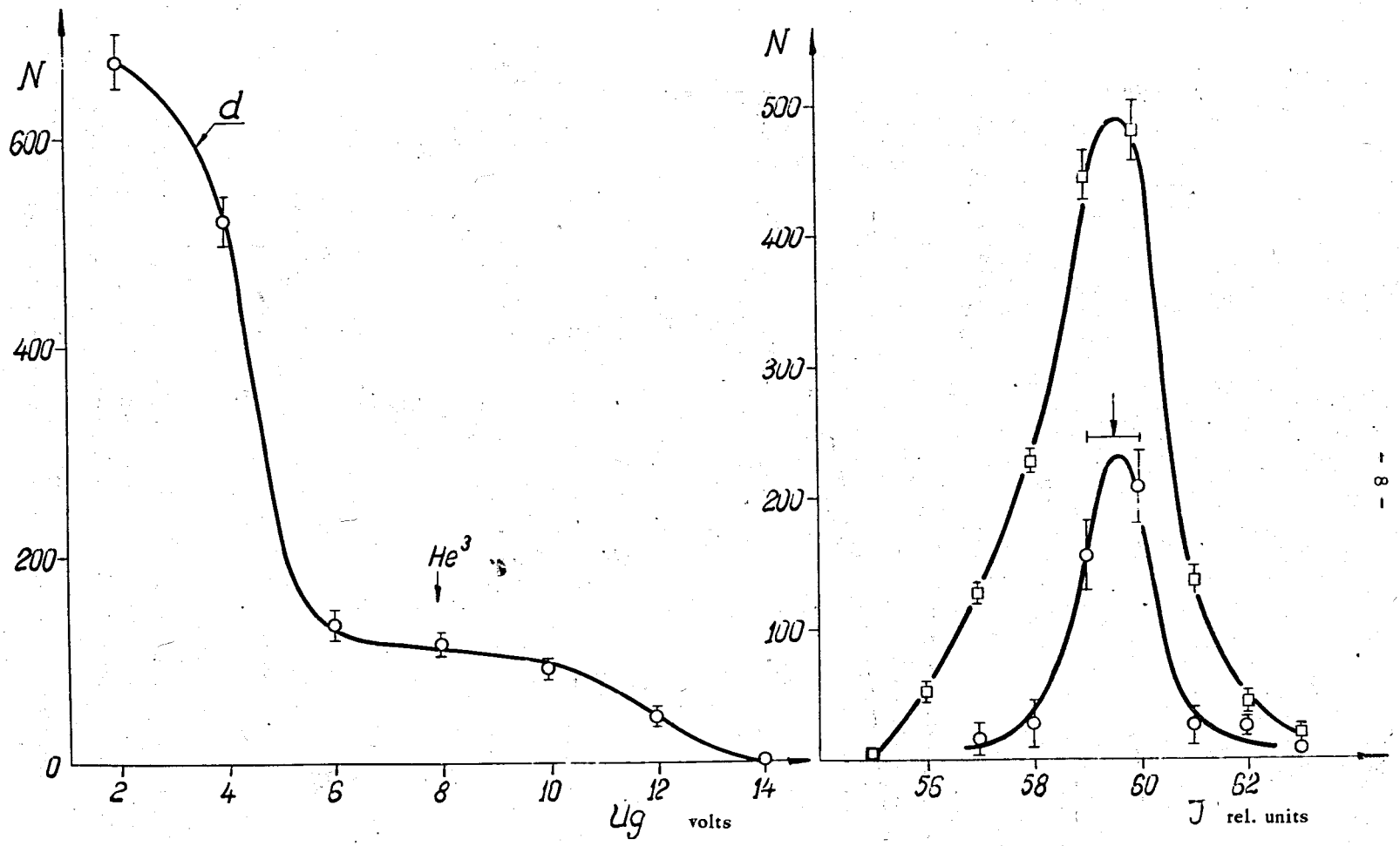

Fig. 3. The counting response of the telescope with the anticoincidence counter, the thickness of the absorber being 10.5 g/cm^2 Cu, depending upon the discriminator threshold in recording the He^3 nuclei from $d+CD_2$ collisions and the yield of He^3 nuclei depending upon the electromagnet current, ⊟ - from the target of heavy polyethelene; ⊙ -is the difference CD_2–C. The arrow indicates the calculation value of the peak of He^3 nuclei from the reaction $d + d \rightarrow He^3 + n$.

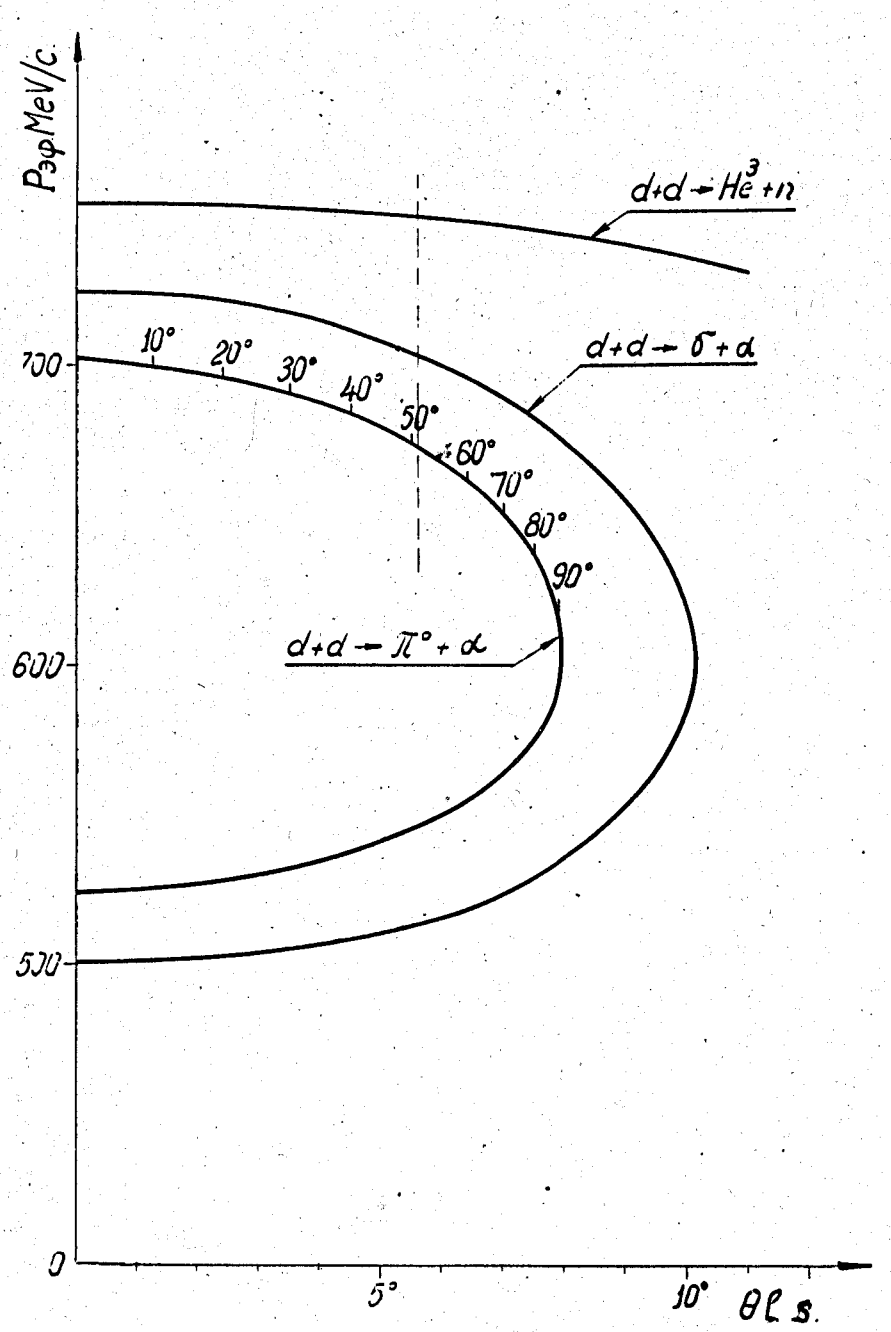

Fig. 4. Some kinematic characteristics of the reactions $d+d \rightarrow He^3+n$ $d+d \rightarrow \gamma+\alpha$ and $d+d \rightarrow \pi^0+\alpha$. The abscicca axis is the direction of emergent heavy charged particles in the lab.system, the ordinate axis is the effective momentum of particles P/Z, where Z is the charge of a particle. The digits of the inside 'loop' indicate the angles of α -particle emergence in the c.m.s. for the reaction $d + d \rightarrow \pi^0+\alpha$.

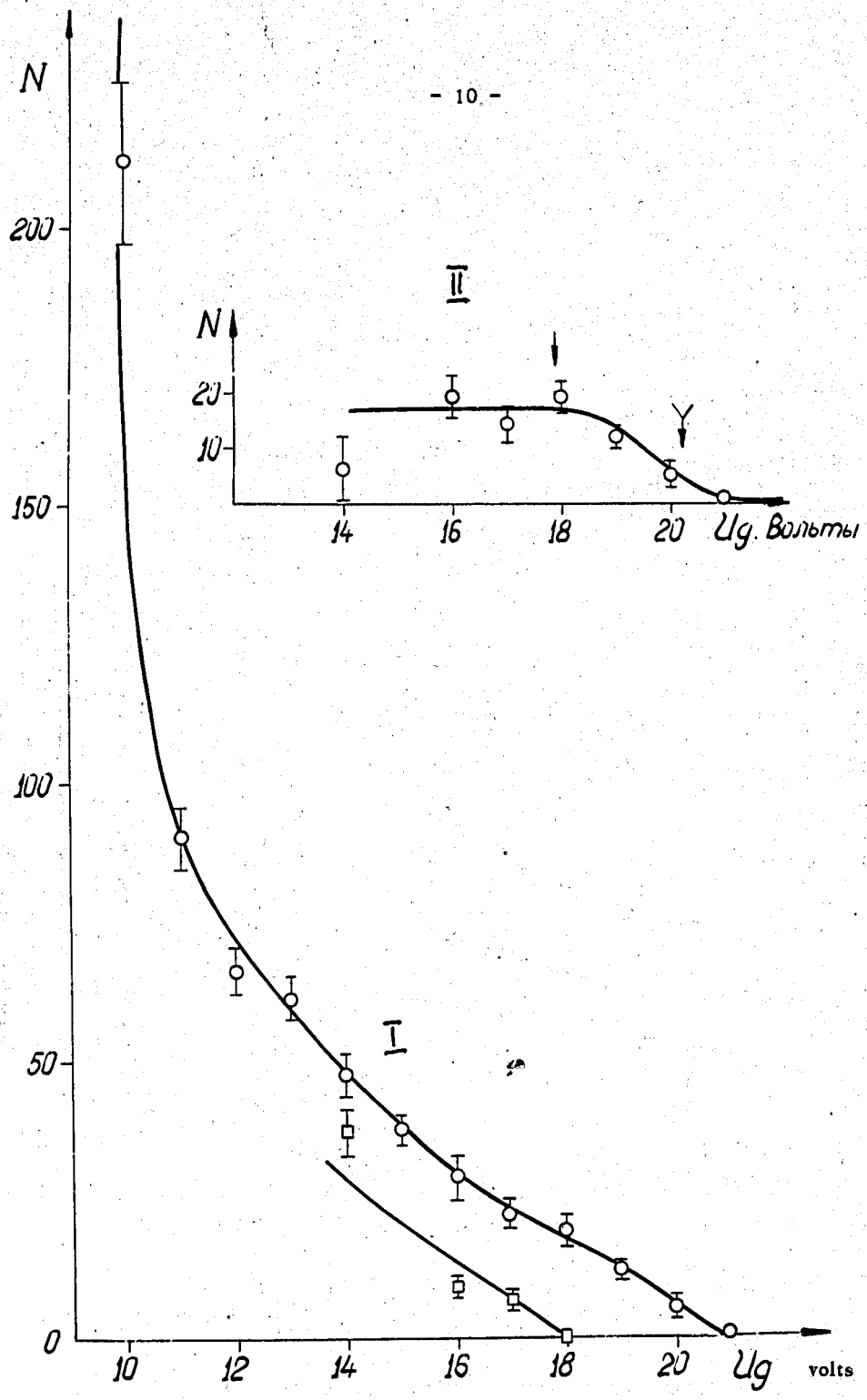

Fig. 5. Adjustment of the apparatus for recording α -particles from the reaction $d + d \rightarrow \pi^0 + He^4$. Curve I is the counting response of the telescope from $d + CD_2$ collisions, the thickness of the absorber being; $\frac{1}{2}$ - R = 0.5 sm Al; $\frac{1}{4}$ - R = 1.0 sm Al.

Curve II is the difference of counting N(R = 0.5) - N(R = 1.0) corresponding to α - particles with the effective momentum 635 MeV/c. The arrow indicates the calculation value of the discriminator threshold for α -particles with the momentum 635 MeV/c.

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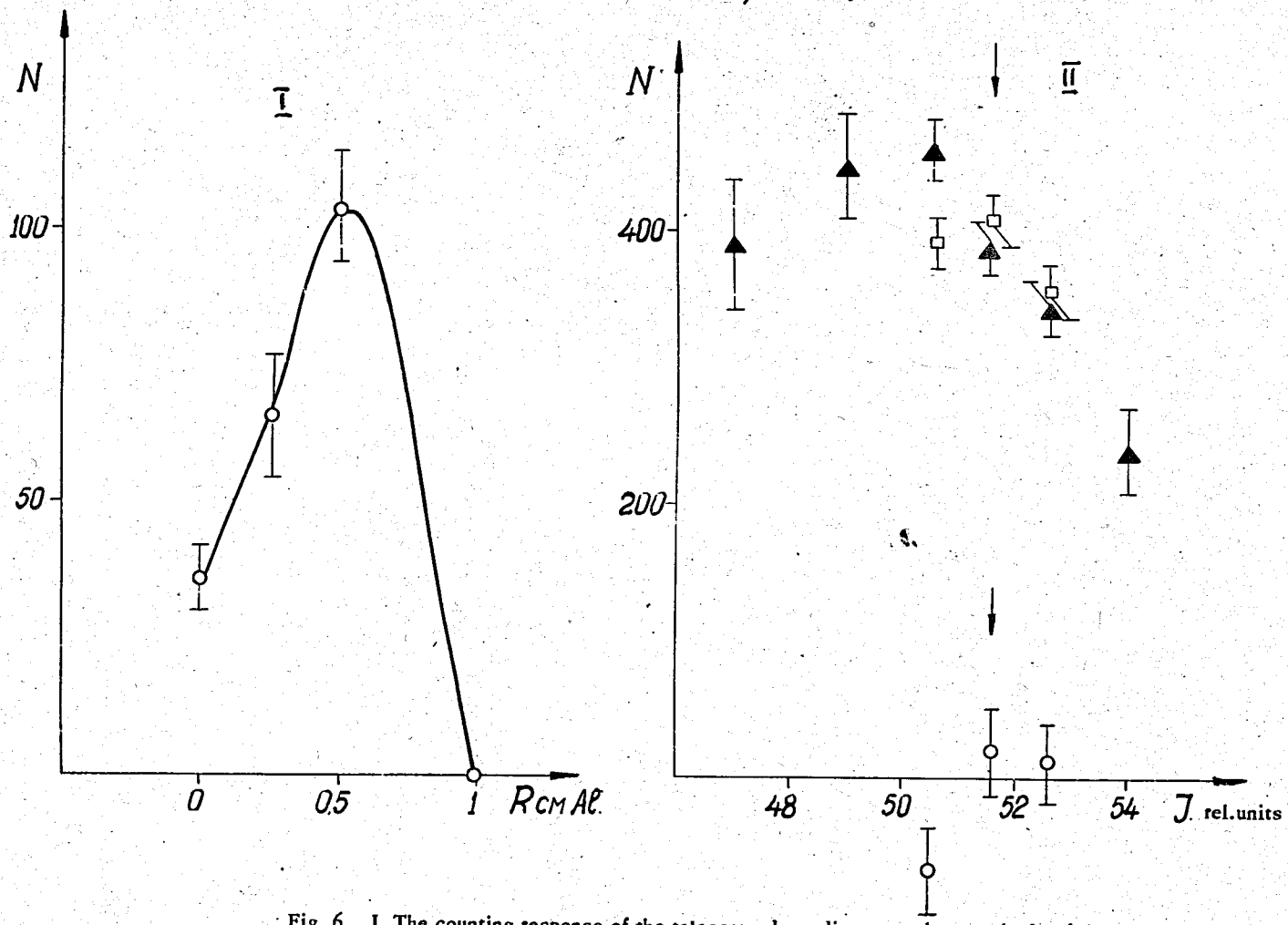

Fig. 6. I. The counting response of the telescope depending upon the magnitude of the stopping filter for α -particles from $d+CD_2$ – collisions with the momentum 635 MeV/c.
II. The results of measurements of the reaction $d+d \rightarrow \pi^0 + He^4$ obtained with a telescope tuned to α -particles from this reaction, emitting at an angle of 5.6° in the lab.system. $\overline{\overline{\Phi}} - CD_2$; $\overline{\Phi} - C$; $\overline{\overline{\Phi}} -$ the counting difference $CD_2 - C$. The arrow shows the value of the electromagnet current calculated by the peak of the He^3 nuclei from the reaction $d + d \rightarrow He^3 + n$. This value corresponds to α particles from the reaction $d + d \rightarrow \pi^0 + He^4$.

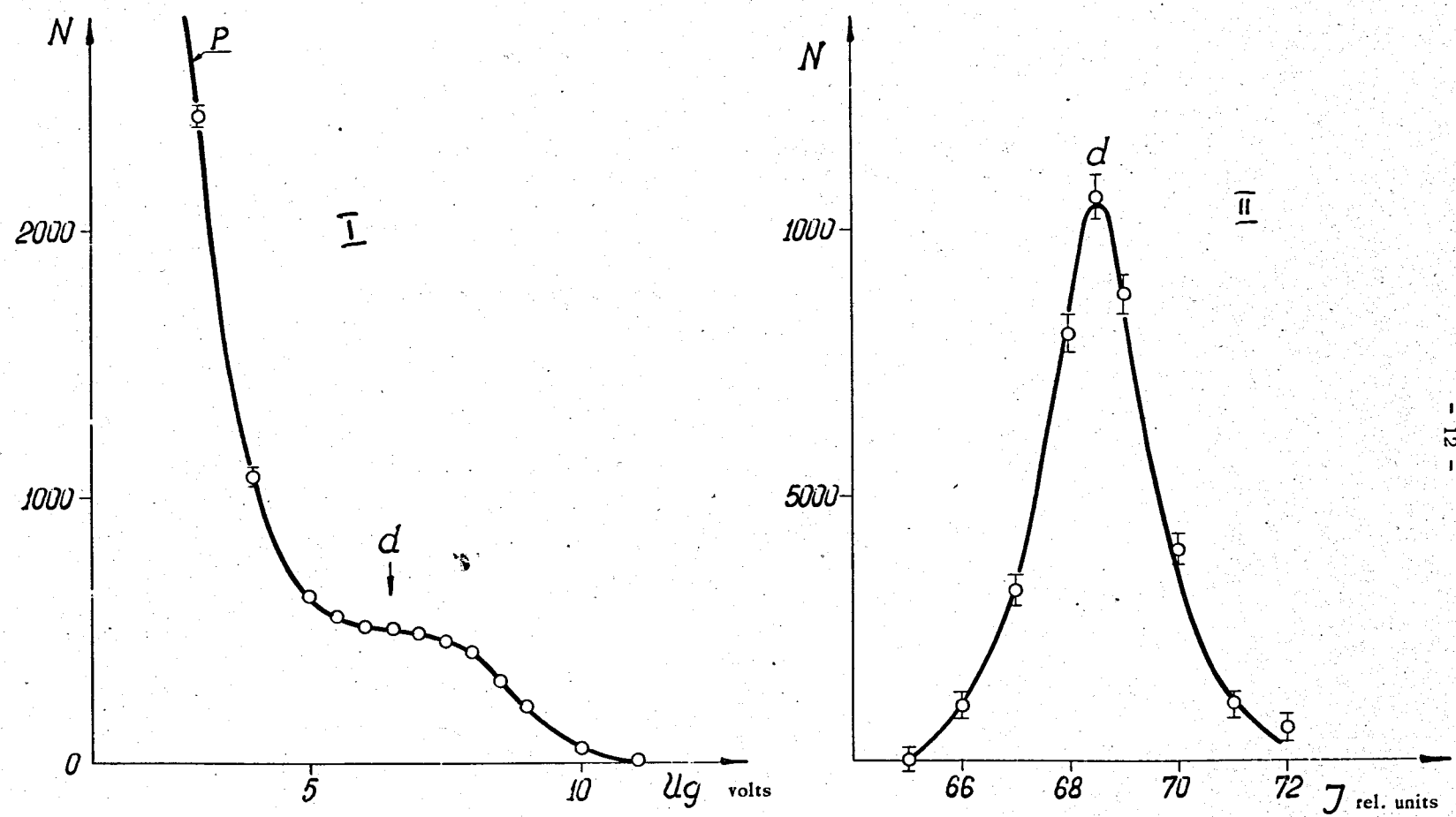

Fig. 7. Adjustment of the apparatus in recording the deuterons from the reaction $p + p \rightarrow d + \pi^+$.
Curve I - the counting response of the telescope depending upon the discriminator threshold.
Curve II - the telescope counting response depending upon the electromagnet current.