azimuthal plane between the cumulative pions and accompanying non-cumulative participant protons and pions in events with production of at least of one cumulative pion. For each reaction considered, we calculated the coefficient of azimuthal asymmetry $A = \frac{N\left(\varepsilon_{ij} < \frac{\pi}{2}\right) - N\left(\varepsilon_{ij} \geq \frac{\pi}{2}\right)}{N\left(0 \leq \varepsilon_{ij} \leq \pi\right)}$, where ε_{ij} – the angle in azimuthal plane between *i*-th cumulative pion and *j*-th accompanying participant proton with a momentum in the range p = 0.3 ÷ 1.2 GeV/c (or *j*-th accompanying pion with a momentum in the range $p \leq 0.7$ GeV/c), $N(\varepsilon_{ij} < \pi/2)$ – the total number of combinations with $\varepsilon_{ij} < \pi/2$, $N(\varepsilon_{ij} \geq \pi/2)$ – the total number of combinations with $\varepsilon_{ij} \geq \pi/2$, and $N(0 \leq \varepsilon_{ij} \leq \pi)$ – the total number of all the combinations.

Table. Coefficients of azimuthal asymmetry between the cumulative pions and accompanying participant protons ($A_{\pi p}$), and between cumulative pions and accompanying pions ($A_{\pi\pi}$).

Type, P_0 (GeV/*c*)	$A_{\pi p}$	$A_{\pi\pi}$
p^{12}C, 4.2	–0.106 ± 0.074	–0.079 ± 0.098
p^{12}C, 9.9	–0.090 ± 0.035	–0.0072 ± 0.0310
^{2}H^{12}C, 4.2 *A*	0.038 ± 0.058	–0.109 ± 0.071
^{4}He^{12}C, 4.2 *A*	–0.048 ± 0.033	–0.059 ± 0.036
^{12}C^{12}C, 4.2 *A*	–0.026 ± 0.021	–0.025 ± 0.020
^{12}C^{181}Ta, 4.2 *A*	0.014 ± 0.013	0.049 ± 0.018
π^{-12}C, 40	–0.079 ± 0.044	–0.037 ± 0.025

As seen from table, very week or almost none azimuthal correlations are observed between cumulative pions and accompanying participant protons as well as between cumulative pions and accompanying pions in hadron-nucleus and nucleus-nucleus interactions in the interval of initial energies from 4 to 40 GeV. For almost all the reactions considered, as seen from table, the coefficients of azimuthal symmetry $A_{\pi p}$ and $A_{\pi\pi}$ agree within two standard deviations with the zero value of A, which shows an absence of azimuthal correlations between cumulative pions and accompanying particles.

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AZIMUTHAL CORRELATIONS IN PRODUCTION OF CUMULATIVE PROTONS IN HADRON-NUCLEUS AND NUCLEUS-NUCLEUS COLLISIONS AT HIGH ENERGIES

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The importance of studying processes involving cumulative particle production stems from their direct relation to the formation of multiquark configurations, so called fluctons, in a nucleus due to nucleon-density fluctuations in which two or more nucleons occur at a distance shorter than 1 fm from one another [1,2]. Hence production of cumulative particles originates from collective phenomena in hadron-nucleus and nucleus-nucleus collisions at high energies. In the present study we examine the azimuthal correlations in production of cumulative protons in π^{-12}C-, p^{12}C-, ^{2}H^{12}C-, ^{4}He^{12}C-, ^{12}C^{12}C-, ^{12}C^{181}Ta-, ^{16}Op -, p^{20}Ne - collisions at primary energies range 3–300 GeV with the total experimental statistics of more than 100000 fully measured inelastic collision events. This work is a continuation of a series of our papers [3–6] on production of cumulative particles. The experimental data analyzed in this work were obtained with the help of 2-m propane (C_3H_8) and 1-m hydrogen (H) bubble chambers of the Laboratory of High Energies of Joint Institute for Nuclear Research (JINR, Dubna, Russia), and 30-inch neon-hydrogen bubble chamber of FNAL (Batavia, USA). All the charged secondary particles of the reactions were identified and their kinematical characteristics measured in conditions of 4π acceptance. For all the reactions, except ^{16}Op - interactions, the identification and measurement of kinematical characteristics of cumulative particles was done in the laboratory frame, i.e. in the rest frame of target nucleus. In case of ^{16}Op - interactions, an analysis was performed in the antilaboratory frame, i.e. in the oxygen nucleus rest frame. The criteria, similar to those of [3,4,6], were used to identify the cumulative particles. The proton was considered to be the cumulative one if its so-called cumulative number $\beta = \frac{E_p - p_l}{m_n}$ (E_p – the total energy of proton, p_l – longitudinal momentum of proton, m_n – the mass of the nucleon, taken to be equal to the proton mass) was higher than 1.2, its emission angle θ was greater than 90 deg., and its full momentum p was bigger than 300 MeV/c (spectator protons were excluded). The cumulative number β has a simple physical meaning – it is the minimal mass of the flucton (or part of the fragmenting nucleus), expressed in numbers of nucleons, required for the production of the cumulative particle. Note that in the present work we put even stricter restrictions on selection of cumulative protons than was previously done by us in [3,4,6]. In the present work we put higher threshold (p = 300 MeV/c) for excluding the spectator protons than (p = 200 MeV/c) in our previous works.

To reveal the azimuthal correlations in production of cumulative protons, we analyzed the angles in azimuthal plane between the cumulative proton and accompanying non-cumulative participant protons as well as accompanying pions in events with production of at least of one cumulative proton. For each reaction considered we calculated the coefficient of azimuthal asymmetry $A = \frac{N\left(\varepsilon_{ij} < \frac{\pi}{2}\right) - N\left(\varepsilon_{ij} \geq \frac{\pi}{2}\right)}{N\left(0 \leq \varepsilon_{ij} \leq \pi\right)}$, where ε_{ij} – the angle in azimuthal plane between i-th cumulative proton and j-th accompanying participant proton with a momentum in the range p = 0.3 ÷ 1.2 GeV/c (or j-th accompanying pion with a momentum in the range $p \leq$ 0.7 GeV/c), $N(\varepsilon_{ij} < \pi/2)$ – the total number of combinations with $\varepsilon_{ij} < \pi/2$, $N(\varepsilon_{ij} \geq \pi/2)$ – the total number of combinations with $\varepsilon_{ij} \geq \pi/2$, and $N(0 \leq \varepsilon_{ij} \leq \pi)$ – the total number of all the combinations with $0 \leq \varepsilon_{ij} \leq \pi$. If the coefficient A equals zero, this shows an absence of azimuthal correlations between the cumulative protons and accompanying particles. If A is greater than zero, it shows that the cumulative protons and accompanying particles tend to be emitted at the same direction in the azimuthal plane. If A is smaller than zero, then the cumulative protons and accompanying particles tend to be emitted at the opposite directions in the azimuthal plane.

Table. Coefficients of azimuthal asymmetry between the cumulative protons and accompanying participant protons (***A_{pp}***) and between cumulative protons and accompanying pions (***$A_{p\pi}$***). (* – Here the coefficient of azimuthal asymmetry for π^{-12}C-interactions at 40 GeV/c is calculated for cumulative protons with $p \geq 0.2$ GeV/c and participant protons in the range of p = 0.2 ÷ 1.2 GeV/c).

As seen from table, for the most reactions considered for the fragmenting nuclei from ^{12}C to ^{181}Ta and initial energies from 3 to 300 GeV, the coefficient of azimuthal asymmetry ***A_{pp}*** is significantly smaller than zero. This is especially the case for hadron-nucleus collisions and nucleus-nucleus collisions with a mass number of the projectile nucleus $A_p \leq 4$.

Type, P_0 (GeV/c)	***A_{pp}***	***$A_{p\pi}$***
p^{16}O, 3.275	–0.156 ± 0.035	–0.124 ± 0.057
p^{12}C, 4.2	–0.195 ± 0.044	–0.063 ± 0.055

p^{12}C, 9.9	–0.116 ± 0.024	–0.072 ± 0.020
^{2}H^{12}C, 4.2 *A*	–0.167 ± 0.036	–0.094 ± 0.042
^{4}He^{12}C, 4.2 *A*	–0.121 ± 0.024	–0.031 ± 0.024
^{12}C^{12}C, 4.2 *A*	–0.042 ± 0.017	–0.009 ± 0.016
^{12}C^{181}Ta, 4.2 *A*	–0.0023 ± 0.0048	–0.025 ± 0.006
π^{-12}C, 40	–0.017 ± 0.040	–0.074 ± 0.022
π^{-12}C, 40*	–0.100 ± 0.026	–0.031 ± 0.018
p^{20}Ne, 300	–0.086 ± 0.034	---------------------------

With an increase of the mass number of the projectile nucleus (^{12}C^{12}C collisions at 4.2 *A* GeV/*c*) or/and of the mass number of the target nucleus (^{12}C^{181}Ta collisions at 4.2 *A* GeV/*c*), the absolute value of the coefficient of azimuthal asymmetry decreases approaching to zero. This can easily be understood in terms of the number of participant protons. In case of an increase of the mass numbers of projectile or/and target nuclei, the number of participant protons increases. This in its turn leads to an increase in the number of combinations of uncorrelated pairs of cumulative and accompanying participant protons, and consequently the azimuthal correlations between cumulative protons and correlated accompanying participant protons are smeared out and hidden. Compared to significant azimuthal correlations between cumulative and accompanying participant protons, weak or almost none azimuthal correlations are observed between cumulative protons and accompanying pions, as seen from the values of $\boldsymbol{A_{p\pi}}$ in table.

From an analysis of data in table we can conclude that the significant azimuthal correlations between cumulative protons and accompanying participant protons are observed: the cumulative protons and accompanying participant protons tend to be emitted at the opposite directions in the azimuthal plane. This fact along with our previous results [3,4,6] on cumulative protons suggest that the cumulative protons and correlated participant protons most likely originate from the same source, namely the flucton. Thus the azimuthal correlations observed in the present work for hadron-nucleus and nucleus-nucleus collisions at wide range of primary energies from 3 to 300 GeV confirm that cumulative protons are most likely produced via the interaction of an impinging hadron (nucleus) with a flucton of the nucleus.

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ИЗОМЕРНЫЕ ОТНОШЕНИЯ ВЫХОДОВ И СЕЧЕНИЙ РЕАКЦИЙ ^{20}Te(γ,n)^{119m,g}Te и ^{130}Te(γ,n)^{129m,g}Te В ОБЛАСТИ ЭНЕРГИЙ 20-35 МэВ

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Изучение изомерных отношений позволяет выяснить характер спиновой зависимости плотности ядерных уровней и лучше понять механизм ядерных реакций. Значительная часть опубликованных работ относится к изучению изомерного отношения в реакции, инициируемых частицами. Процесс взаимодействия фотонов с ядрами исследован в меньшей степени.

В данной работе методом наведенной активности исследована зависимость изомерного отношения выходов $d=Y_m/Y_g$ реакций ^{120}Te(γ,n)^{119m,g}Te и ^{130}Te(γ,n)^{129m,g}Te от максимальной энергии тормозного излучения $E_{\gamma max}$ в области энергий 15÷35 МэВ с шагом $\Delta E_{\gamma max}$= 1 МэВ. Впервые методом на-