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P.Kozma, K.D.Tolstov, V.V.Yanovsky*

CROSS SECTIONS FOR THE PRODUCTION OF ^{11}C IN C TARGETS BY 3.65 AGeV PROJECTILES

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*On leave from the Leningrad Nuclear Physics Institute, Academy of Sciences of the USSR, 188350 Gatchina, USSR

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In previous paper [1] we described a monitoring system for relativistic particles and nuclei accelerated at the Dubna synchrophasotron. Using this system the cross sections of monitoring reactions of the type ^{27}Al (projectile, X) ^{24}Na at 3.65 AGeV have been measured[2]. In the present paper we report on cross section measurements for the production of ^{11}C in C targets by 3.65 AGeV protons, deuterons, ^{4}He- and ^{12}C-ions. A set of precise cross section values for the ^{12}C(projectile, X)^{11}C reactions is needed for absolute flux determinations by means of the well-known activation techniques. The above reactions are convenient for this purpose because the final nuclide ^{11}C is quite insensitive to production by secondary particles produced in nuclear reactions induced by high-energy particles and nuclei. Moreover, these cross sections could also provide information useful for various theoretical descriptions of high-energy collisions.

The cross section measurements were carried out in an external beam of the Dubna synchrophasotron in three stages. First, low intensity runs were made in which beam particles and nuclei were counted with a thin nuclear emulsion layer rotating in a beam and ^{11}C activity was produced in a 2.54 cm thick graphite block. Second, the ^{11}C activity induced in a 0.16 cm thin polystyrene target was measured relative to the standard fission chamber beam monitor [1,3] in high intensity runs. Finally, the ^{11}C activity in a thick target was also determined at high beam intensities relative to the fission chamber calibrated with nuclear emulsion counts. The appropriate cross sections were determined from these three runs. The experimental procedure of a beam flux measurement by means of the nuclear emulsion and fussion chamber KNT-8 used in this experiment was identical to that used previously in measuring ^{27}Al(projectile, X)^{24}Na cross sections. The ^{11}C activity produced in the polystyrene and thick graphite block was determined by counting annihilation radiation using a large ⌀15 cm x 15 cm NaI(Tl) and 3.2 x 3.2 x 15.0 cm^3 BaF_2 [4] detector from several counts covering a total time span of at least one ^{11}C half-life. In order to stop positrons, polystyrene targets were counted sandwiched between two thin copper discs.

Table

Cross sections for the ^{12}C (projectile, X)^{11}C reactions at 3.65 AGeV

Projectile	Cross section [mb]
protons	27.3±0.5
deuterons	35.2±0.7
^{4}He-ions	42.0±0.7
^{12}C-ions	58.5±1.1

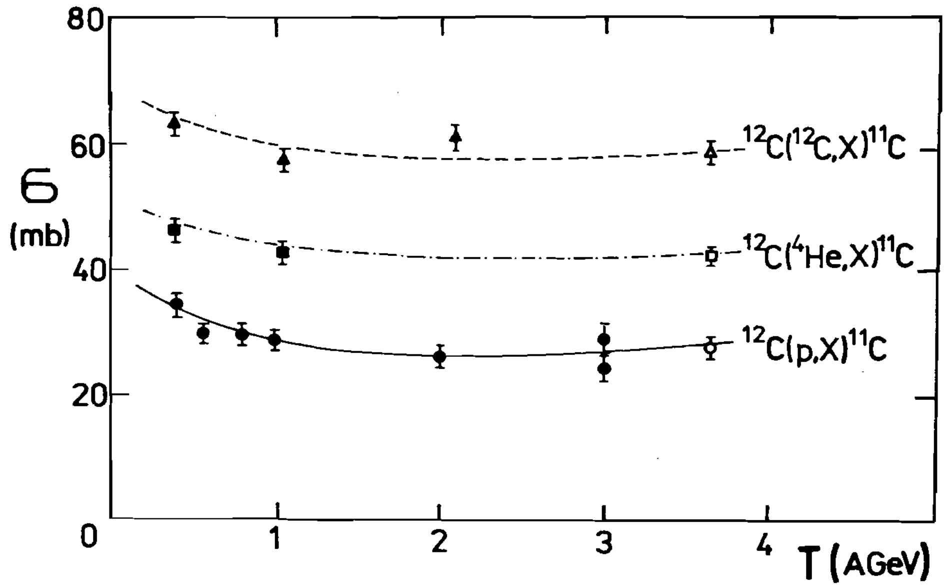

Fig. 1. Excitation functions for ^{11}C production by high-energy protons, ^{4}He- and ^{12}-ions on C targets. Our data are indicated by opened symbols; the appropriate lines are guides to the eye.

The cross sections for the production of ^{11}C in C targets by 3.65 AGeV projectiles are listed in the Table. The errors quoted to the tabulated values are only of statistical nature. They are almost entirely from counting statistics of the ^{11}C activity measurements in thick graphite blocks and beam particles counting, as well. The results are compared (Fig. 1) with similar data for the $^{12}C(p, X)^{11}C$ [5], $^{12}C(^{4}He, X)^{11}C$ [6]

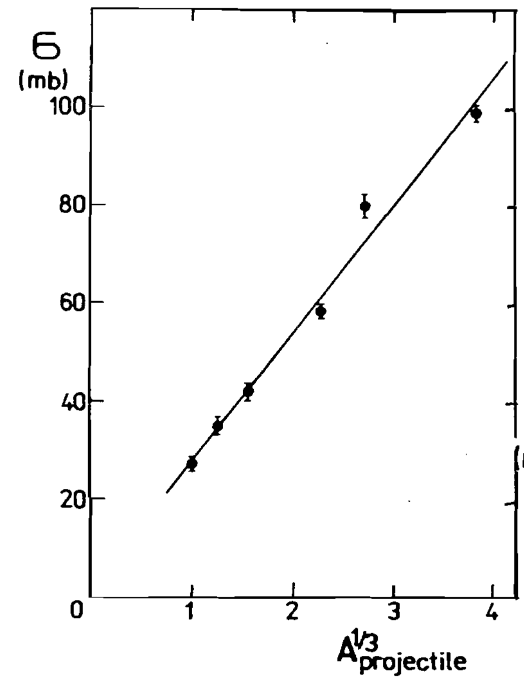

Fig. 2. Dependence of cross sections for ^{11}C production on projectile mass. Also shown for comparison are cross sections for production of ^{11}C from ^{20}Ne and ^{56}Fe projectiles at 1.05 and 1.7 AGeV, respectively. The solid line approximates the least-squares fit of $\sigma = 1.8 \pm 15.7\ A^{1/3}$.

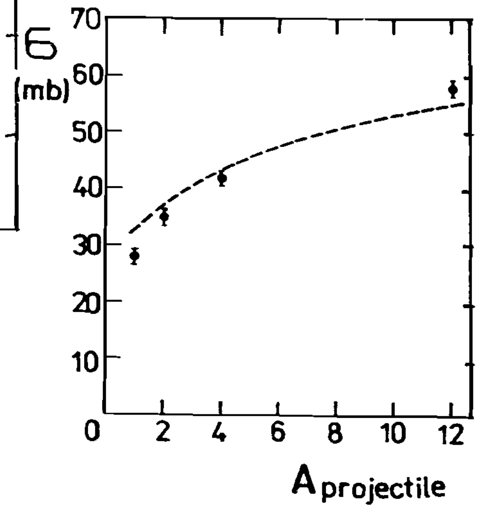

Fig. 3. Comparison of cross sections for ^{11}C production by 3.65 AGeV projectiles with Glauber theoretical calculations (dashed line).

and $^{12}C(^{12}C, X)^{11}C$ [7] reactions, respectively. As can be seen, cross sections of the appropriate reactions show a limiting behaviour at energies under study. This fact corresponds to the hypothesis of limiting fragmentation [8]. Following the concept of factorization (scaling) [9], the cross sections for the ^{12}C (projectile, X)^{11}C reactions for various projectiles should be proportional to $A^{1/3}$. This dependence is illustrated in Fig. 2. Here, cross sections [10] for the $^{12}C(^{20}Ne,X)^{11}C$ and $^{12}C(^{56}Fe, X)^{11}C$ reactions at 1.05 and 1.7 AGeV, respectively, are also included because of the validity of limiting fragmentation at these energies. Finally, in Fig. 3 we compare our data with simple Glauber theoretical calculations [7]. Good agreement between cross sections for the production of ^{11}C

in C targets by 3.65 AGeV projectiles and Glauber theory is evident.

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Козма П., Толстов К.Д., Яновский В.В. E1-89-745
Сечения образования ^{11}C в углеродных мишенях, облученных снарядами с энергией 3.65 ГэВ/нуклон

Измерены сечения образования ^{11}C в углеродных мишенях, облученных протонами, дейтронами, ядрами ^{4}He и ^{12}C. Аннигиляционное излучение от ^{11}C измерялось детекторами NaI(Tl) и BaF_2 больших объемов. Мониторирование потока проводилось посредством фотоэмульсии, вращающейся в пучке, и камерами деления. Настоящие результаты сравниваются с ранее полученными значениями сечений для углеродных мишеней, облученных снарядами высоких энергий, а также с предсказаниями по теории Глаубера.

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Cross Sections for the Production of ^{11}C in C Targets by 3.65 AGeV Projectiles

The absolute cross sections for the production of ^{11}C in C targets by 3.65 AGeV protons, deuterons, ^{4}He- and ^{12}C-ions were measured. Annihilation radiation from ^{11}C was counted using a large volume NaI(Tl) and BaF_2 detectors. The flux measurement technique based on registration of charged particles by means of a thin nuclear emulsion layer rotating in a beam as well as fission chamber was used. The results are compared with earlier measurements of the cross sections in carbon targets using high-energy projectiles and Glauber theoretical prediction, as well.

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

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