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Possibility of obtaining secondary alpha beams at AGS

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POSSIBILITY OF OBTAINING SECONDARY ALPHA BEAMS AT AGS

No alpha particles were detected both in the early experiments[1,2] at the CERN Proton Synchrotron and in a recent measurement[3] at the Argonne ZGS. The measurements reported here show, however, that there are sizable fluxes of alphas produced at the Brookhaven AGS. Details of the experiment will appear in a later publication,[4] and only a brief description is presented here. This short note is intended primarily for a quick communication to potential users,[5] regarding the possibility of obtaining useful secondary alpha beams at the AGS for various experimentation.

The measurement was carried out at the AGS test beam. Secondary particles produced at $18^{o}48'$ from the 28.5 BeV internal protons incident on the BeO target at G10 were momentum analyzed by a bending magnet, and then classified according to their time-of-flight (TOF) and their energy loss (dE/dx) in a scintillator. The dE/dx analysis is essential for the alpha indentification, because He^{4++} has twice the momentum of the deuteron, and hence the same TOF. An example of the TOF spectrum at 1.4 BeV/c is shown in Fig. 1(a). Here the detection efficiencies of pions and protons were reduced purposely in order to display the peaks better. In Fig. 1 the data plotted in (a') is the same as (a) except that the vertical scale is expanded 8 times. Any portion of the TOF spectrum can be analyzed in terms of the energy loss of the particles involved. The dE/dx spectrum of the deuteron peak in Fig. 1(a) is shown in Fig. 1(b) and (b'). The data in (b) is the same as in (b') except that the vertical scale is expanded 128 times. Clearly, the deuteron peak in the TOF spectrum is decomposed into deuteron and alpha peaks in the dE/dx analysis. The scattered dots under the deuteron peak in Fig. 1(b) is purely instrumental; namely when (b') is expanded 128 times in the vertical direction, many channels in the deuteron peak go beyond the range of the oscilloscope display and somehow show up as the scattered dots. To confirm that the small peak is really due to alphas, the dE/dx system was calibrated by the protons and He^{3++}. Here, He^{3} has twice the momentum of the proton. The resulting dE/dx spectrum is shown in Fig. 1(c) and (c'). The data in (c) is the same as in (c') except that the vertical scale is expanded 104 times. Thus, the relative abscissas of the proton, deuteron, He^{3++} and He^{4++} peaks, and hence their relative energy losses establish the first unambiguous identification of the alpha production at the high energy accelerators.

The ratio of alpha to deuteron production is given in Fig. 2. The alpha production is of the order of 1% of the deuteron production in this momentum range. Preliminary data from our recent measurement[6] on secondary production at the AGS test beam show that the deuteron to pion ratio is about 1%. Thus, the ratio of alpha to pion production is of the order of 10^{-4} at the momentum range covered here, and this can be used as a "rule of thumb" for a rough estimate of the available alpha fluxes in the existing experimental beams at the AGS. From the consideration of transverse momentum distribution, it is probable that at larger production angles, the alpha to pion ratio can be even higher than 10^{-4} in the pion momentum range above 1 BeV/c. The absolute yield of alphas would of course be smaller.

An interesting application of the alpha beam is the measurement of the cross sections for $\alpha + \alpha \rightarrow D$ (or He^3) +--- below 1000 MeV/nucleon. Such cross sections are critical for the interpretation of the D, He^3 and He^4 composition of the cosmic rays, and are very valuable for the understanding of the origin and propagation of the primary cosmic rays in the interstellar space.[7] Such experiment now becomes feasible with the possible secondary alpha beams and the helium bubble chambers in operation at Argonne. A cloud chamber triggerable with electronic counter logics might even be preferable. A detailed discussion of this subject will be given in a separate paper.[8]

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Figure Captions

Fig. 1 (a) Time-of-flight spectrum of 1.4 BeV/c secondary particles produced at $18^{\circ}48'$ from 28.5 BeV protons incident on Be. The abscissa is the flight time and the ordinate is the relative abundance of the particles; both in arbitrary scales. Here, the detection efficiencies of pions and protons were reduced purposely in order to give a better balance in the height of the peaks.

(a') Data in (a') is the same as in (a) except that the vertical scale is expanded 8 times.

(b) The dE/dx spectrum the deuteron peak in (a) is decomposed into deuteron and alpha peaks. The abscissa is the energy loss and the ordinate is the relative abundance corresponding to particular energy losses; both in arbitrary scale. The dots under the deuteron peak are due to overflows of corresponding channels in an expanded display of the pulse height analyzer. (See text)

(b') Data in (b') is the same as in(b) except that the vertical scale is reduced 128 times. Note the alpha peak does not show up even as a kink.

(c) The dE/dx spectrum of protons and He^3, used to calibrate the dE/dx system.

(c') Data in (c') is the same as in (c) except that the vertical scale is reduced 128 times. Note the relative abscissas of proton, deuteron, He^3 and He^4 peaks. Also note that the He^3 peak does not show up even as a kink. Here the detection efficiency of protons was not reduced as in (a).

Fig. 2 Ratio of alpha to deuteron production as a function of secondary momentum per nucleon. The solid line is drawn to guide the eyes.

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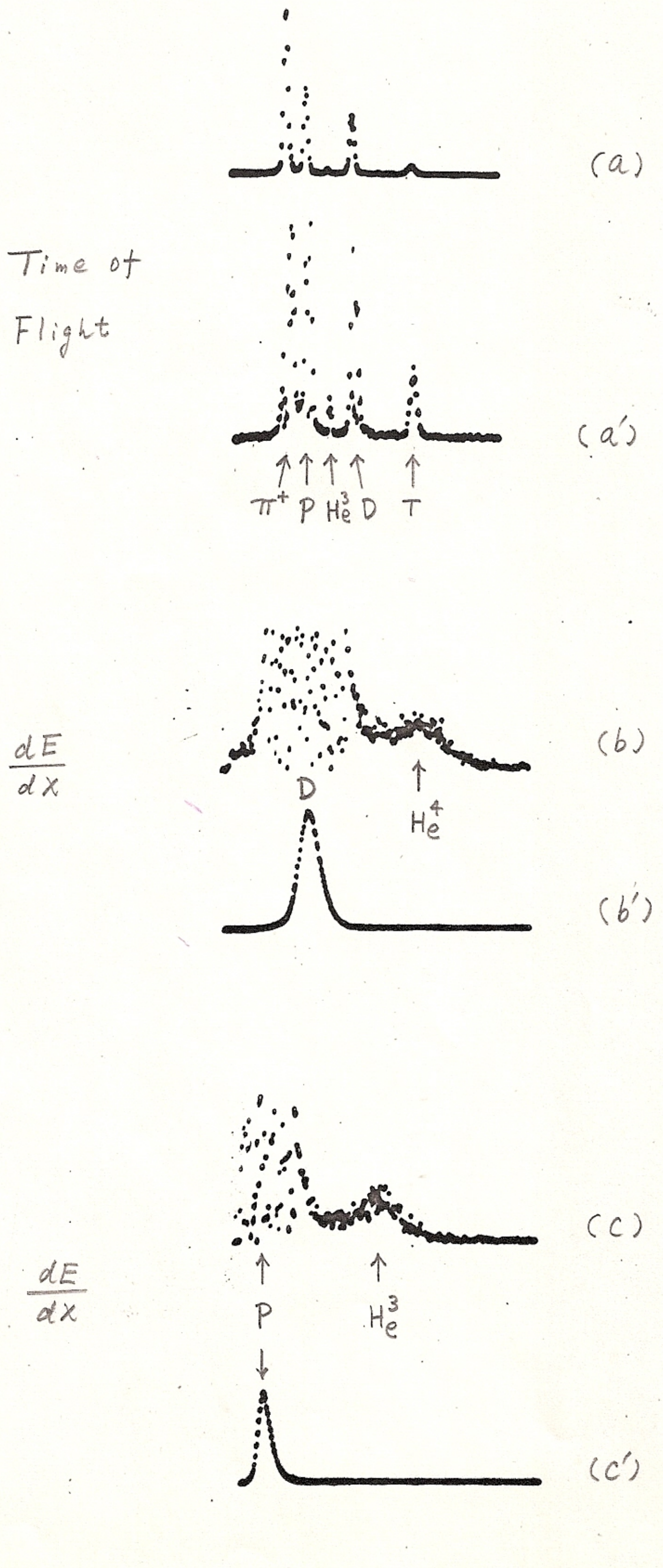

Fig. 1

Fig. 2