^{8}Li Emission in 1.8 GeV/c K^--Meson Interactions in Nuclear Emulsion

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Out of about 16,000 stars found by an area scan of 1.8 GeV/c K^--meson interactions with emulsion nuclei, 120 'hammer tracks' have been collected. The corrected production rate is (1.30 ± 0.12) %. The forward to backward ratio indicates isotropic emission of ^{8}Li fragments. The emission of short recoils at the primary vertex shows a definite correlation with the ^{8}Li fragments.

I. Introduction

There have been quite a few experiments [1-9] on the emission of ^{8}Li fragments from K^- interactions with emulsion nuclei at various incident beam energies. The experiments are helpful in understanding the nuclear structure and also the mechanism of fragmentation. For studying fragments with a charge greater than that of the α-particle, ^{8}Li (also ^{9}Li, ^{8}B) fragments have been chosen because of their characteristic decay into two α-particles, usually known as 'hammer tracks'. The hammer tracks (HT) make the identification of ^{8}Li fragments very simple and unambiguous. In this paper we present the analysis on 120 HTs produced in the interaction of 1.8 GeV/c K^- with the emulsion nuclei. No effort, however, was made to distinguish between the ^{9}Li, ^{8}B and ^{8}Li fragments in the HTs.

II. Experimental Procedure

This work was done using a stack * consisting of 40 K-5 nuclear pellicles, each of size $20 \times 12 \times 0.06\ cm^3$ exposed to the K^- beam of momentum 1.8 GeV/c at Brookhaven National Laboratory. The background contamination is not exactly known, but it is estimated to be as high as 30% [10].

Approximately 16,000 K^- interactions were picked up by an area scan using 125× magnification. Each grey or black track which originated from a beam star was followed within the emulsion pellicle containing the primary star. The centre of each star was examined under a magnification of 2250× to detect the presence of a short HT or a recoil. All hammer tracks were assumed to be due to ^{8}Li fragments. Only those ^{8}Li fragments which decayed at rest into two colinear α-particles (Space angle should be 180 ± 10 degrees) were picked up. In this respect the production rate given below is a lower limit.

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* This stack is on loan from Prof. A. J. Herz, CERN, Switzerland.

III. Experimental Results

A) Emission frequency of HTs

Out of 16,000 stars found, 120 fragments were identified to be due to ^{8}Li decaying at rest. This gives a production rate of (0.75 ± 0.07)%. The following corrections were applied to get the corrected rate of production.

a) The loss of HTs passing to the neighbouring pellicle. The measured range spectrum (Fig. 1) of the ^{8}Li fragments gives a correction factor of 1.24.

b) The loss of HTs due to inconvenient orientation of α-particles. The HTs with α-particles oriented

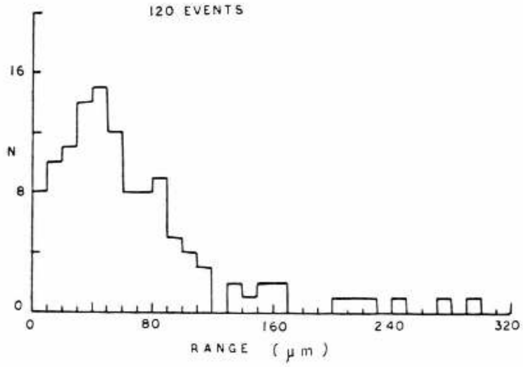

Fig. 1. Range distribution of ^{8}Li.

Table 1. Comparison of emission frequencies of ^{8}Li.

Incident K$^-$ momentum (GeV/c)	Type of the parent stars	Uncorrected production rate (%)	Corrected production rate (%)	Reference
0.8	—	0.20 ± 0.05	—	1
1.3	$N_h > 8$	0.38 ± 0.06	1.27 ± 0.20	2, 3
1.5	$N_h > 8$	0.38 ± 0.06	1.21 ± 0.18	2, 3
	$N_h > 6$	0.39 ± 0.03	0.98 ± 0.10	4
	All	0.46 ± 0.05	0.77 ± 0.19	5
1.8	All	0.75 ± 0.07	1.30 ± 0.12	Present work
3.0	$N_h > 6$	0.96 ± 0.10	2.06 ± 0.21	6
	All	0.80 ± 0.05	—	7
3.5	All	0.92 ± 0.10	1.55 ± 0.12	5
5.0	All	1.11 ± 0.05	—	7
	$N_h > 6$	1.83 ± 0.12	2.88 ± 0.30	8
10.1	All	1.17 ± 0.07	—	9

along the parent track or vertically upwards or downwards are missed in scanning. This introduces a correction factor of 1.4 [11].

Table 1 gives the corrected production rate for the present experiment. Results of some previous experiments at different incident K$^-$ beam momenta are also shown for comparison.

B) Characteristics of the parent stars

Figure 2 a shows the black- and grey-prong (N_h) distribution for the stars with a HT emission. From this distribution it can be seen that 83% of the HTs are issued from stars with $(N_h) > 6$, i.e. created in heavy nuclei. On the other hand from the N_h distribution (Fig. 2 b) for a randomly chosen sample of stars, it is seen that only 60% of the stars are due to interactions on heavy nuclei. The weighted mean value $\bar{N}_h$ is 10.4 for the stars with HT, whereas $\bar{N}_h$ is 7.9 for the random sample of stars. It is clear (as in the previous experiments) that HTs are produced primarily in interactions with heavy emulsion nuclei where the energy available for evaporation is comparatively large.

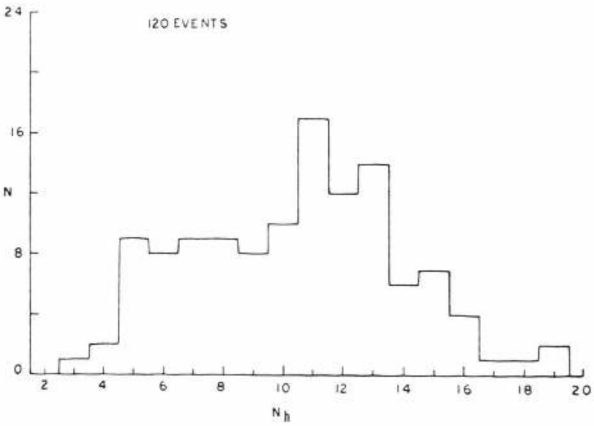

Fig. 2 a. N_h distribution of ^{8}Li sample.

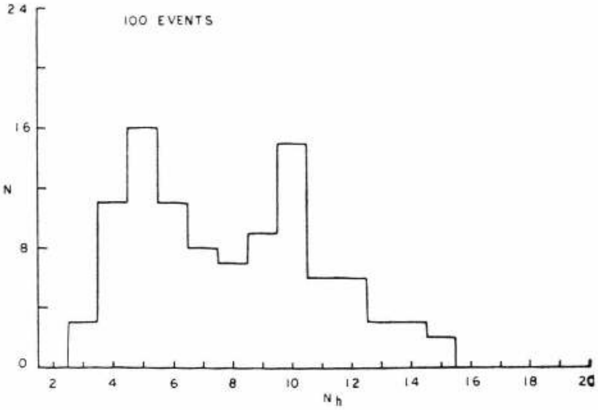

Fig. 2 b. N_h distribution of random sample.

C) ^{8}Li energy and angular distribution

Figure 1 shows the residual range distribution of HTs. The angular distribution of HTs with respect to the incident beam is given in Figure 3. The F/B ratio calculated from Fig. 3 is 0.88 ± 0.16 which indicates that the distribution is more or less isotropic. No data on HT emission at 1.8 GeV/c K$^-$ momentum are available. But this result is a little lower than the results obtained in previous experiments at 1.5 GeV/c beam momentum [4, 5]. Dhawan and Gaur [5] reported a value of 1.34 ± 0.27 and the F/B ratio obtained by Harmsen et al. [4] is 1.70 ± 0.28. The latter result is for HTs with energy smal-

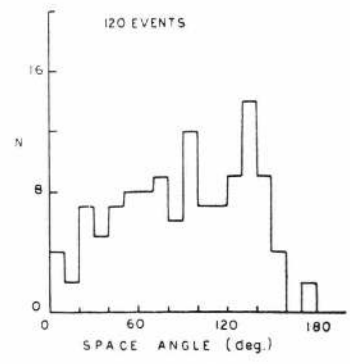

Fig. 3. Angular distribution of ^{8}Li fragments w.r.t. beam.

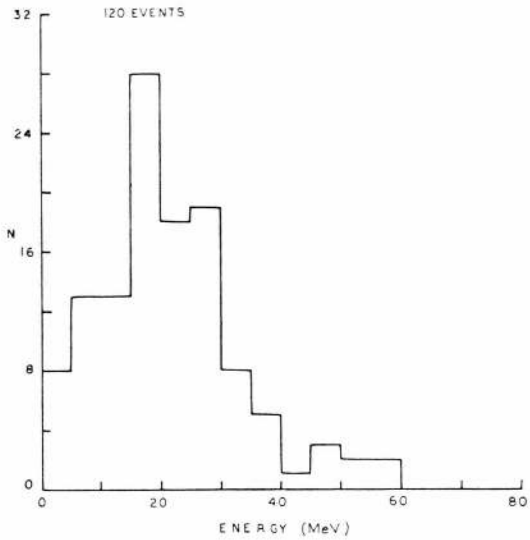

Fig. 4. Energy distribution of ^{8}Li fragments.

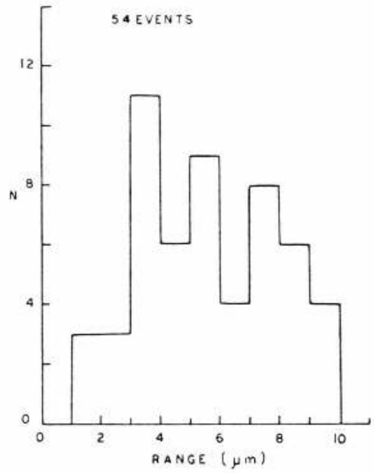

Fig. 5 a. Range distribution of recoils in ^{8}Li sample.

ler than 40 MeV. However, in our sample almost all HTs (93%) have energies $\leqq 40$ MeV (Figure 4).

D) Recoils

Any short black prong of length $\leqq 10\ \mu$ was considered to be a recoil. The recoils are thought to be the tracks of the residual nuclei left after the spallation process and are mainly responsible for the production of short range hyperfragments. During the de-excitation process, each particle while coming out gives an impulse to the remaining nucleus and as a result the residual nucleus acquires a large enough momentum to have a detectable track in the emulsion. ^{8}Li being massive imparts a large impulse to the remaining nucleus. Thus the average length of the recoils associated with ^{8}Li production is expected to be large, compared to the case of the recoils associated with a randomly chosen sample of stars. Figure 5 a shows the length distribution of the recoils for the HT sample, and a similar distribution for the random sample is shown in Figure 5 b. It is quite evident from these distributions that the average length of the recoils in Fig. 5 a is greater than that in Figure 5 b. The angular distribution (projected angle measured w.r.t. the direction of emission of HTs) of the recoils is shown in Figure 6. The backward clustering in Fig. 6 clearly indicates a correlation between the emission of ^{8}Li and the recoils.

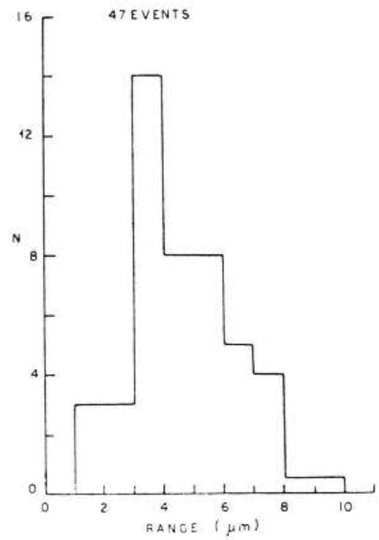

Fig. 5 b. Range distribution of recoils in the random sample.

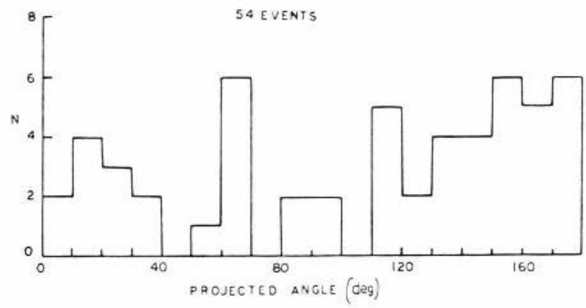

Fig. 6. Projected angle (w.r.t. ^{8}Li) of recoils.

IV. Conclusion

Table 1 shows that the rate of production of ^{8}Li fragments in K^- interactions with emulsion nuclei increases with the incident beam energy. The rate of increase in yield is quite large below the incident momentum of 5 GeV/c, and above that the experimental data are meagre. There should be some more experiments at K^- beam momentum above 5 GeV/c to find at what incident momentum the yield of ^{8}Li reaches a plateau, as in the case of pion interactions with emulsion nuclei [12].

All the experimental studies on ^{8}Li emission in K^- interactions with emulsion nuclei in general suggest that the majority of the ^{8}Li fragments is produced in the interactions with heavy Ag or Br nuclei. The studies also show that the emission is more or less isotropic when the energy of emitted ^{8}Li is not very large (<40 MeV).

The present work indicates that there exists a correlation between the short recoils at the primary star and the emitted HTs.

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