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ENG-48

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STARS IN PHOTOGRAPHIC EMULSIONS. PART I. EXPERIMENTAL

Eugene Gardner and Vincent Peterson

December 1, 1947

Berkeley, California

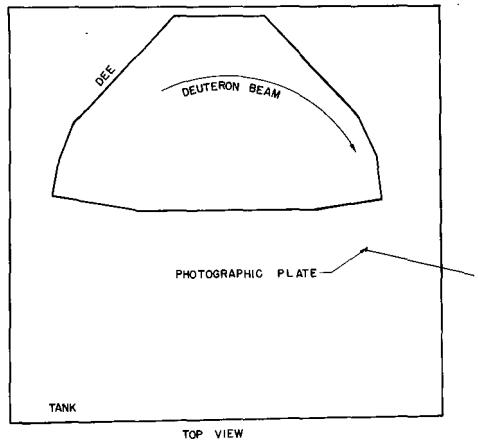
STARS IN PHOTOGRAPHIC EMULSIONS. PART I. EXPERIMENTAL

Eugene Gardner and Vincent Peterson

Radiation Laboratory, Department of Physics
University of California
Berkeley, California

December 1, 1947

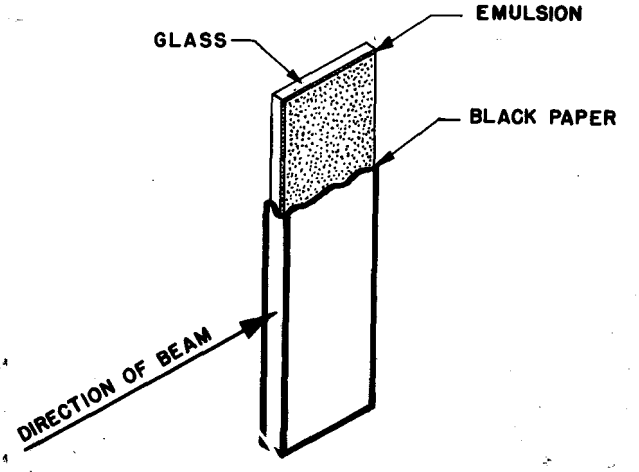
Photographic plates have been bombarded in the 184-inch Berkeley cyclotron for the purpose of studying stars initiated by deuterons and alpha particles. The first slide shows the position of the photographic plate in the cyclotron.



LOCATION OF PHOTOGRAPHIC PLATE FOR EXPOSURE TO CIRCULATING BEAM

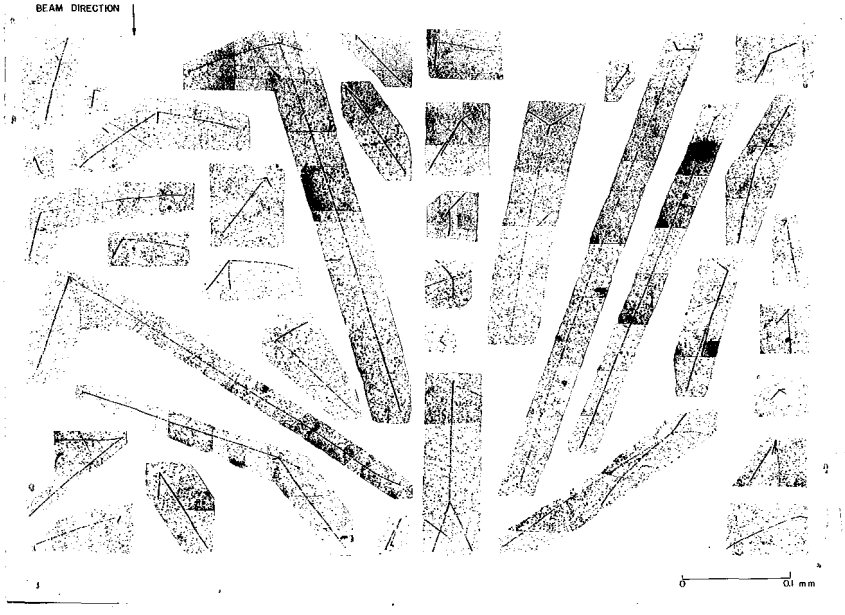
By placing the plate at various radii it is possible to bombard it with particles of various energies.

The beam strikes the emulsion "edge on" as shown in the next slide.

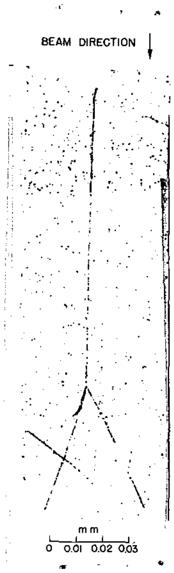


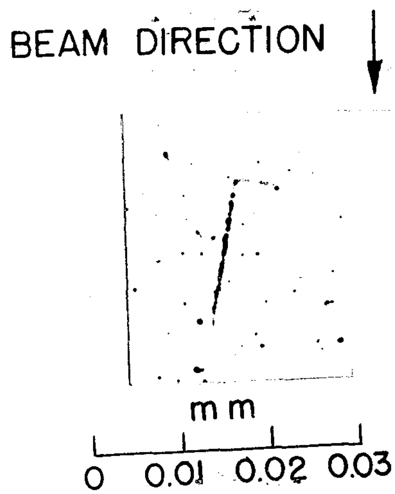
The next slide shows a group of stars as seen under the microscope.

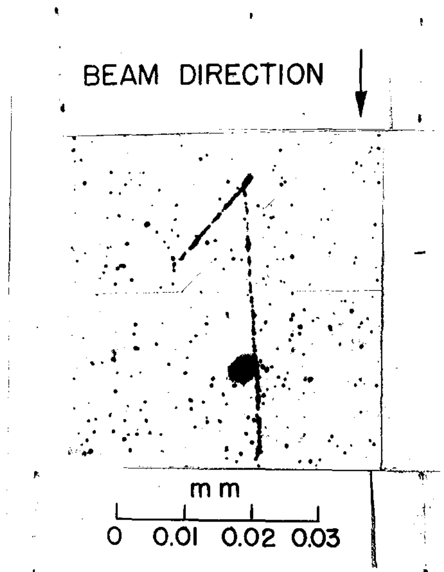
These stars were initiated by deuterons of energy 190 Mev (Ilford C.1 plates.)

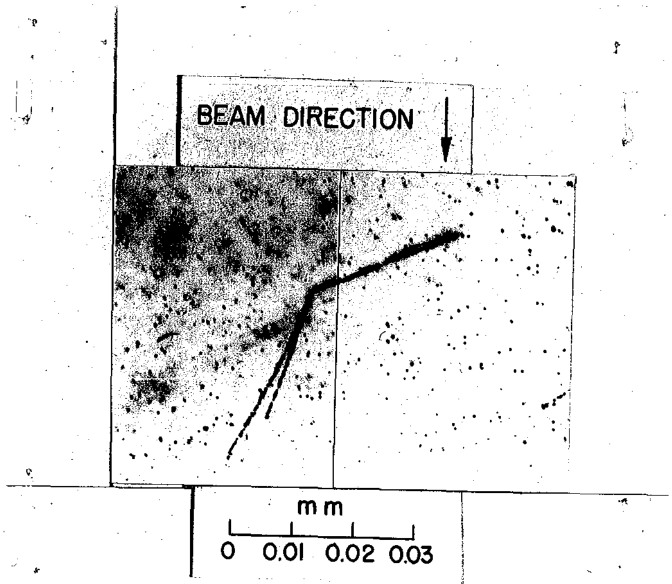


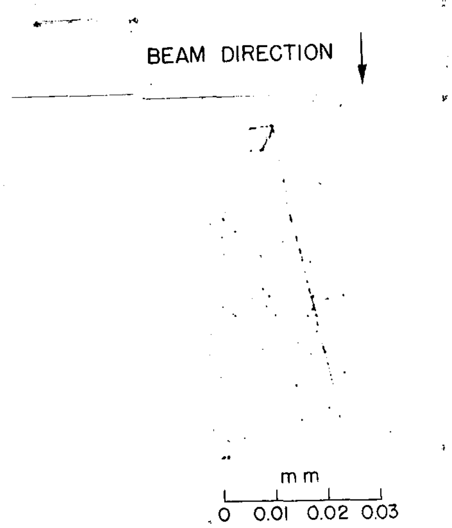
The following slides show individual stars from this group.

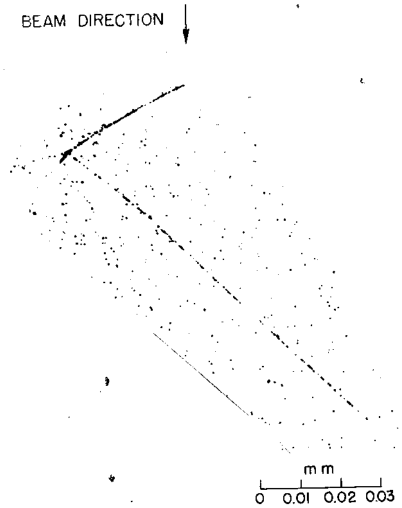








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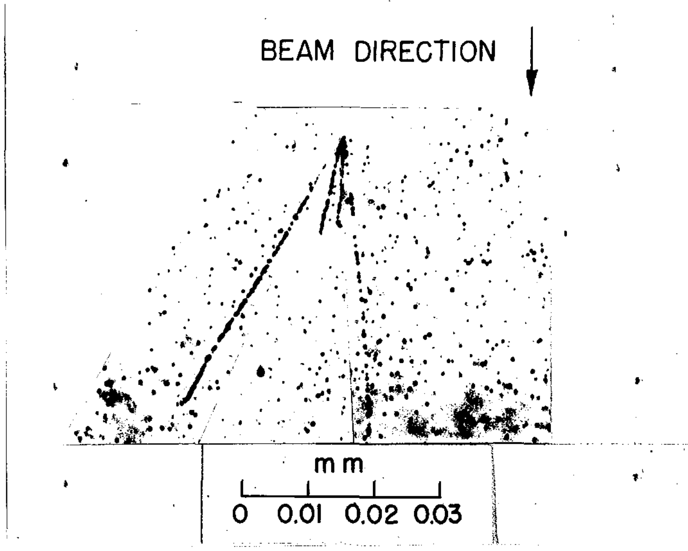
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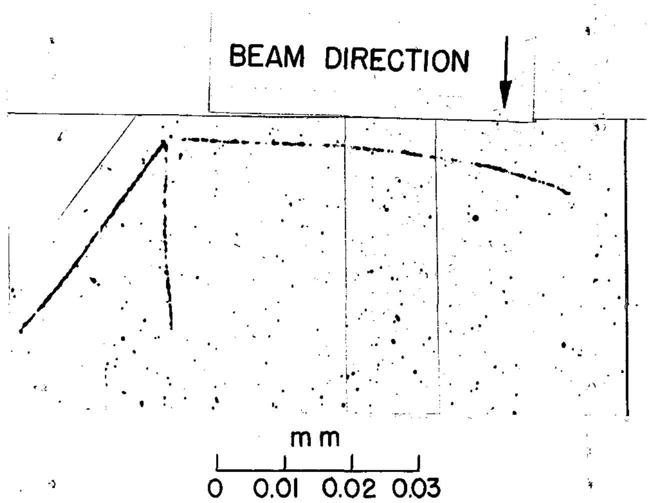
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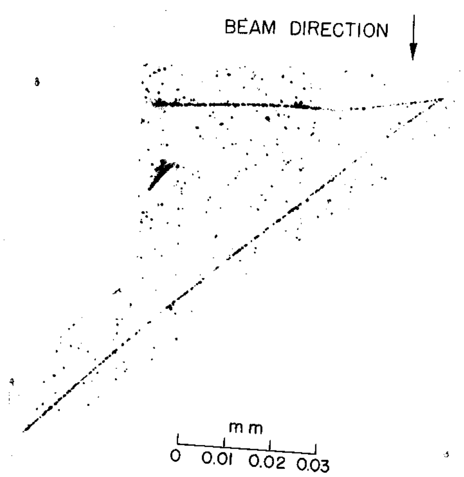
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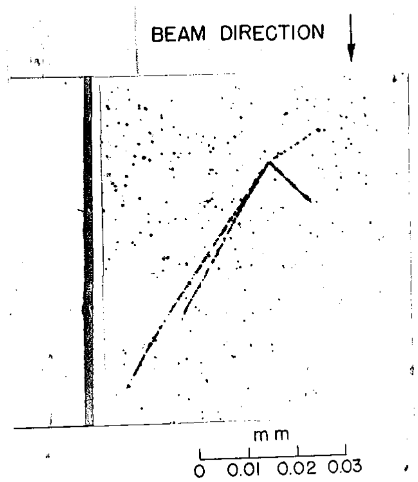
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For stars of this type it is not ordinarily possible to find out what type of nucleus is responsible for the disintegration. Furthermore, we do not know how many deuterons are given off or in which directions, so it is not possible to make a momentum or an energy balance. Thus it appeared that a detailed study of individual stars would not yield results which could be interpreted very easily. One can, however, tabulate average properties of the stars such as the number of prongs (i.e., the number of tracks making up the star). The experimental observations of these quantities can then be compared with theoretical predictions. The experimental results will be given in this paper, and the theoretical interpretation will be given in the following paper by Mr. Horning.

A group of about 1200 stars initiated by deuterons was observed, and average properties were tabulated. The group included about 300 stars at each of four deuteron energies. Table I gives the number of stars having a given number of prongs. There is some uncertainty in the number of 2-prong stars since it is often impossible to tell whether an event is a 2-prong star or a deflection in a single track. When it is reasonably clear that an event is a 2-prong star it is listed as "probable", and if it is impossible to tell whether it is a star or a deflection it is listed as "questionable". In some cases it is clear that the event is a deflection of a single track, and these cases do not appear in the tabulation at all.

Table I. Number of Stars Having a Given Number of Prongs

(Deuteron - Initiated)

Type of Star	Number of Stars			
	35 Mev	90 Mev	130 Mev	190 Mev
2-Prong (probable)	60	63	41	59
2-Prong (questionable)	27	44	60	40
3-Prong	155	153	121	122
4-Prong	56	52	68	71
5-Prong	2	9	8	10
6-Prong	0	1	3	0
All types:	300	322	301	302

Average Number of Prongs: 3.0

Another property of the stars which lends itself to statistical study is the direction of the star prongs with respect to the beam study. Although the star prongs lie in various directions in three dimensions, the microscope shows most clearly the projection of the prongs on a two-dimensional surface. The directions used are directions on the two-dimensional projection. The surface is divided into 60° sectors, and the number of prongs in the various sectors is tabulated. The angular distribution of star prongs for the group of 1200 deuteron stars is given in Table II. In Table III are given the number of prongs and lengths of prongs in the forward 60° sector.

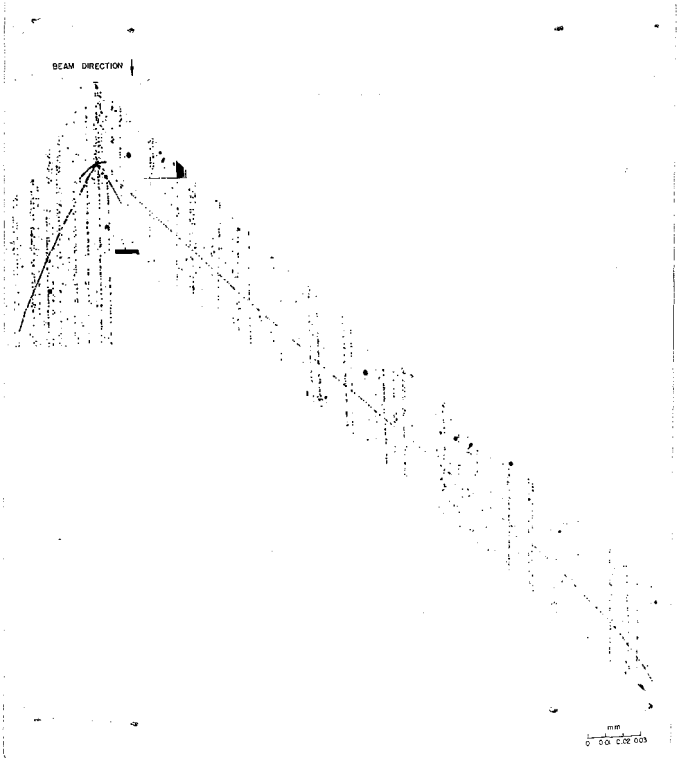
For stars initiated by alpha particles it is possible to obtain information similar to that given for deuteron-initiated stars, and, in addition, one can find the cross section for formation of stars.

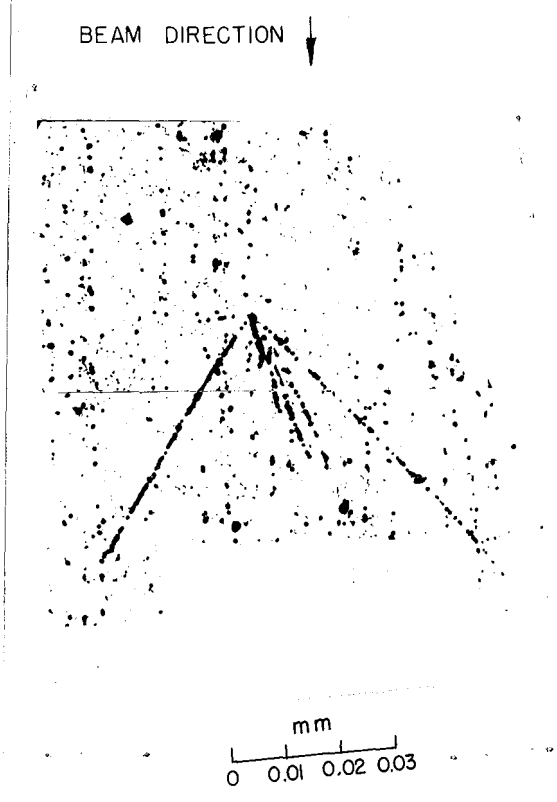
For stars initiated by deuterons it is ordinarily not possible to see the track of the initiating particle with the emulsions that we were using. Alpha particles, however, ionize more heavily, and we were able to see the tracts of the initiating particles for energies up to about 70 per cent of the maximum output from the cyclotron.

The following slides show stars initiated by alpha particles.

(Eastman NTA plates)

(10 stars initiated by alpha particles)



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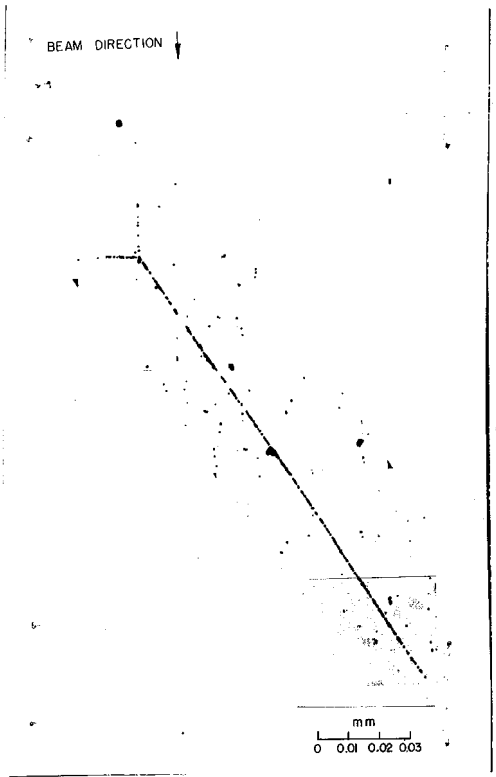
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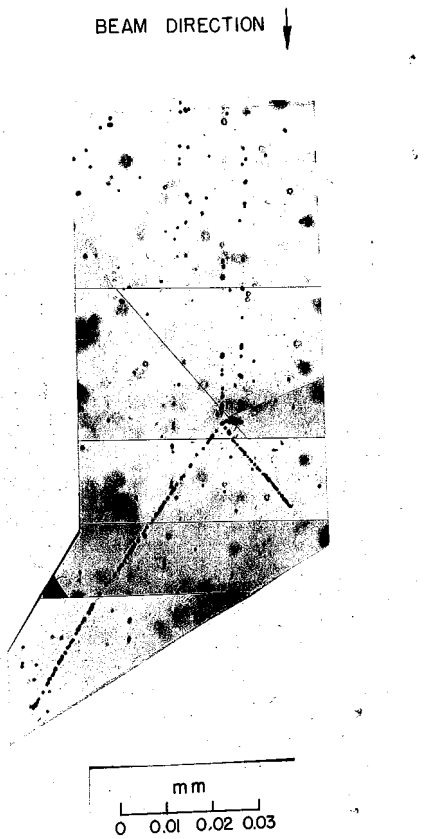
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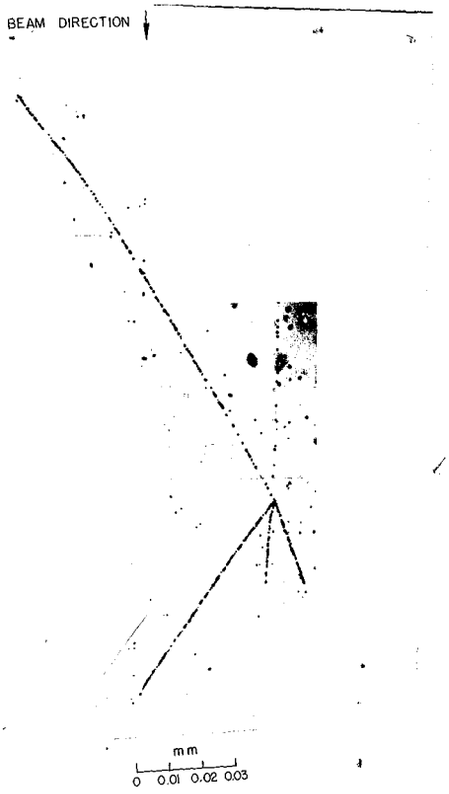
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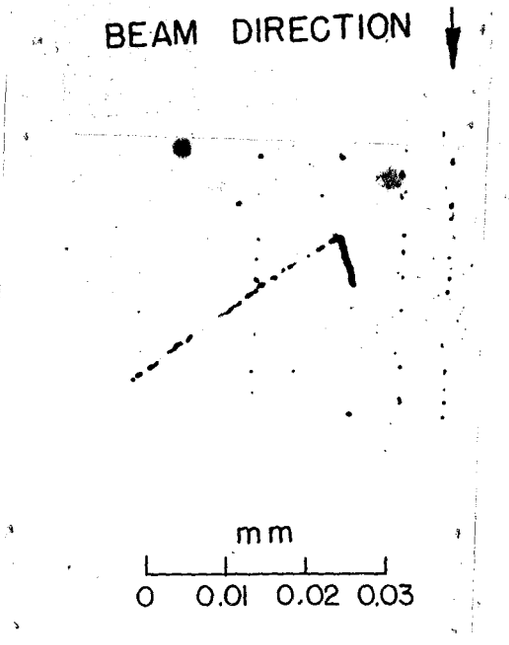
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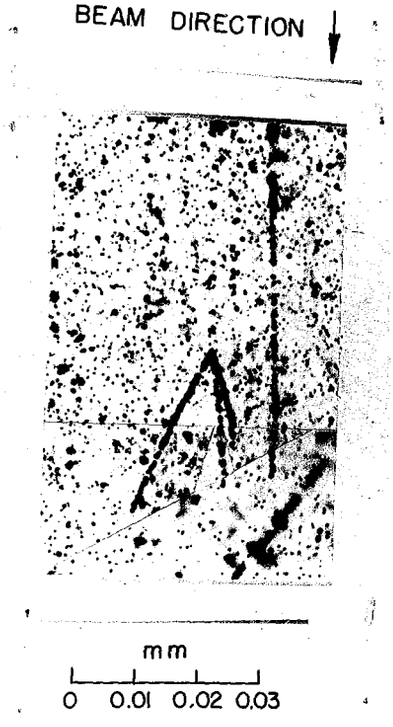
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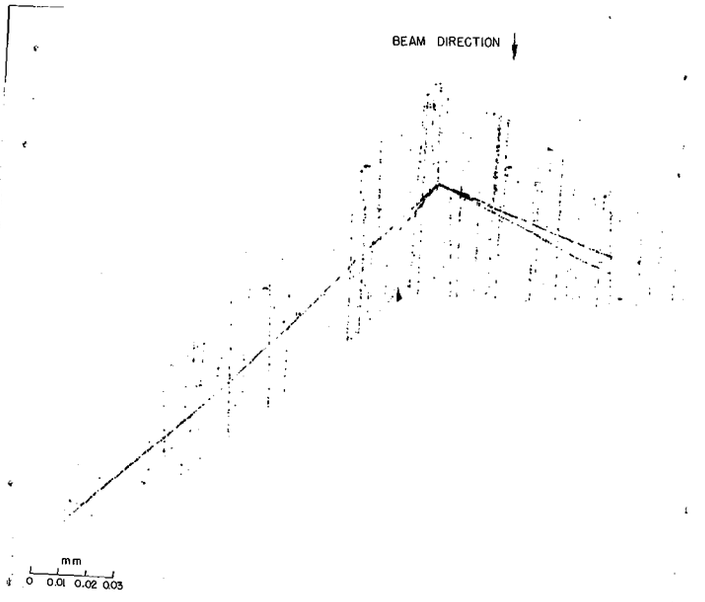
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Table II. Angular Distribution of Star Prongs

(Deuteron - Initiated)

Angular Range	Angle from Beam Direction to Center of Sector	Number of Star Prongs			
		35 Mev	90 Mev	130 Mev	190 M
-30° to $+30^{\circ}$	0°	326	335	295	267
$+30^{\circ}$ to $+90^{\circ}$ and -30° to 90°	60°	385	366	339	388
$+90^{\circ}$ to $+150^{\circ}$ and -90° to -150°	120°	128	166	184	187
$+150^{\circ}$ to -150°	180°	42	55	58	66
	Total:	881	922	876	908

Forward/Backward: 3.05

Table III. Star Prongs in Forward 60° Sector

(Deuteron - Initiated)

	35 Mev	90 Mev	130 Mev	190 Mev
Total Number of Prongs in Foward Sector:	326	335	295	267
Prongs Ending in Emulsion in Forward Sector:	243	213	139	108
Average Prong Length of Prongs Ending in Emulsion (microns):	22	36	35	49
Length of Longest Prong Observed:	110	750	525	625

A group of 276 stars initiated by alpha particles in Eastman NTA plates has been studied. Tables IV and V give summaries of numbers of prongs and angular distribution prongs. For stars initiated by alpha particles the presence of the track of the initiating particle removes the

confusion between 2-prong stars and deflections in a single track. The cross section for formation of stars by alpha particles has been measured by counting sections of tracks made by alpha particles and the stars originating on these tracks. A summary of the mean path length for formation of stars is given in Table ~~IV~~ III.

Table IV. Number of Stars Having a Given Number of Prongs (Alpha Particle-Initiated)

Energy Percent of 380 Mev)	2-Prong	3-Prong	4-Prong	5-Prong	6-Prong	7-Prong	Total
20-30	3	4	7	1			15
30-40	13	8	7	2			30
40-50	28	48	31	6	2		115
50-60	29	40	23	5	1	1	99
60-70	4	5	5	3			17
	77	105	73	17	3	1	

Average No. of Prongs: 3.15

Table V. Angular Distribution of Star Prongs (Alpha Particle-Initiated)

Energy (Percent of 380 Mev)	Number of Star Prongs				
	0°	60°	120°	180°	Total
20-30	18	27	5	1	51
30-40	39	35	12	2	88
40-50	164	156	24	20	364
50-60	126	120	48	11	305
60-70	28	18	10	2	58

Forward/Backward: 5.4

Table VI. Mean Path Length for Formation of Stars

(Alpha Particle-Initiated)

Energy (Per cent of 380 Mev)	Total Track Length (cm)	Total No. of Stars	Mean Path Length cm/star
10-16	460	0	
20-30	1270	15	84.7
30-40	1840	30	61.4
40-50	7650	115	66.5
50-60	9500	99	96.
60-70	2320	17	136.

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