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DIRECTION AND ENERGY DISTRIBUTION NEAR THRESHOLD OF FISSION FRAGMENTS

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ABSTRACT

Two experiments on fission fragments have been performed with neutrons from the Li (p n) reaction on the electrostatic generator in W.

A. No strong correlation was found between incident-neutron direction and fission-fragment direction.

B. No strong dependence of fission fragment energy distribution was found on bombardment of 37 by neutrons of various energies in the region of fission threshold.

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DIRECTION AND ENERGY DISTRIBUTION NEAR THRESHOLD OF FISSION FRAGMENTS

A. The correlation of fission fragment direction with the direction of the incident neutron.

The experimental setup is shown in Fig. 1. A 25 foil was irradiated with neutrons of 450-to 500 Kev energy from the Li (p n) reaction. The foil lay in a double ionization chamber originally built by J. M. Blair for back-to-back comparison of foils of fissionable materials placed on the high-voltage electrode common to both chambers. For this experiment holes were drilled in the high-voltage electrode and the foil was placed on one collector electrode. Fission fragments from the foil traversed one chamber, A, and those with directions nearly enough normal to the plane of the high-voltage electrode passed through the collimating holes and were counted in the farther chamber, B, also. The detector biases were set low so as to count almost all fragments. The chambers were each 5 mm deep and were operated at Los Alamos atmospheric pressure of air. The foil was 15 mm in diameter, and the collimating holes were 1/16" diameter in a 1/16" thick dural plate. Thus fragments at up to 45° to the normal were counted, although those at smaller angles had much more probability of passing through the collimator. When the foil was removed no counts were observed in either chamber.

The ratio of counts B/A was observed as a function of the angle O between the direction of the incident neutrons and the normal to the plane of the high-voltage electrode. No significant dependence of this ratio on was found for the three angles observed within the statistical error (Table I). Hence there is no strong correlation of 25 fission fragment direction with direction of incident neutrons for neutrons of these energies, at least with this poor angular resolution.

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TABLE I

θ	B/A
0°	.058 ± .003
90°	.050 ± .004
180°	.055 ± .004

B. The energy of fission fragments on bombardment of 37 with neutrons of energies around the fission threshold.

It was thought of interest to investigate whether the energy distribution of fission fragments changes with changing incident neutron energy in the region around the threshold of a fast "fisher". If the energy required for, say, the splitting into two particles of nearly equal energies is greater than for more asymmetric fission, then one might observe only the latter for neutron bombarding energies very near the fission threshold.

An electron-collection ionization chamber was constructed with an O. R. Frisch grid. The ionization pulse heights are proportional to the total energy of the single fission fragments coming off the thin (approximately 10 micrograms per cm^2) foil at all angles. The foil was prepared by Mr. D. Hufford. The single pulse height distribution is the familiar double peak of energies, which is very closely the inverse of the chemical mass distribution. The pulses were recorded with a Sands Model 500 Amplitude Analyzer, giving directly the differential curve of number per unit energy interval vs. energy in Figs. 3 and 4. The observations are of a part of the more energetic group of fragments only. Although there may be changing total energies of fission in such a way that a changing ratio of fragment energies would not show up in the high energy peak distribution

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alone, this was considered quite unlikely.

The linearity of response of the detector to the primary ionization was not investigated throughly because of lack of time. The depth of the minimum between the two peaks was taken as a rough criterion of resolution. With the chamber operated at very high collecting voltages (approximately 6 Kv) with or without the grid and at various pressures, and using unpurified tank argon, the minimum was about 20% of the high energy peak maximum for both 25 and 37. This compares with 13% for 25 and 22% for 49 measured by Deutsch[1)] with electron collection using a Frisch grid and collimating the fragments normal to the foil. Snyder[2)] observed the minimum to be zero for ion collection but not for electron collection, with uncollimated fragments as in the present case, and from a considerably thicker foil. It seems likely that the minimum does, in fact, go to zero, but that it is blurred over in this experiment. For this reason, and because of the poor statistics and finite channel with the present experiment cannot give any fine details on the fragment distribution, but it should show clearly any major change in the distribution.

The data are plotted in Fig. 2 and the 37 cross-section as a function of energy is shown in Fig. 3, showing the bombarding energies used. The absolute energy scale in Run #2 is from Deutsch's data, since the present data were taken on a relative energy scale only. Sample statistical root mean square errors are given. The different energies had about the same statistics in Run #1, but the 400 Kev data had considerably less than the 720 Kev in Run #2.

1) M. Deutsch, La-510

2) T. Snyder, LAMS - 299

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There appear to be no major changes within the present experimental resolution in the high-energy group distribution over the range of energies covered.

"Only after the deformation of the nucleus has exceeded the critical value, in fact, will there occur that rapid conversion of potential energy of distortion into energy of internal excitation and kinetic energy of separation which leads to the actual process of division.

"For a classical liquid drop the course of the reaction in question will be completely determined by specifying the position and velocity in configuration space of the representative point of the system at the instant when it passes over the potential barrier in the direction of fission. If the energy of the original system is only infinitesimally greater than the critical energy, the representative point of the system must cross the barrier very near the saddle point and with a very small velocity. Still, the wide range of directions available for the velocity vector in this multidimensional space, as suggested schematically in Fig. 3, indicates that production of a considerable variety of fragment sizes may be expected even at energies very close to the threshold for the division process. When the excitation energy increases above the critical fission energy, however, it follows from the statistical arguments in Section III that the representative point of the system will in general pass over the fission barrier at some distance from the saddle point. With general displacements of the representative point along the ridge of the barrier away from the saddle point there are associated asymmetrical deformations from the critical form, and we therefore have to anticipate a somewhat larger difference in size of the fission fragments as more energy is made available to the nucleus in the transition state."[3]

3) Bohr and Wheeler, Phys Rev 56, pp 447-448, (1939)

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It is evident that the spread of fragment energies produced very near threshold is large compared to the increase in spread due to raising the bombarding energy up to 500 Kev above threshold. That is, the spread induced by the representative point crossing the barrier at the distances from the saddle point associated with 500 Kev excess energy is small compared with the spread resulting from the breakup after the representative point crosses the saddle point with even very little excess energy.

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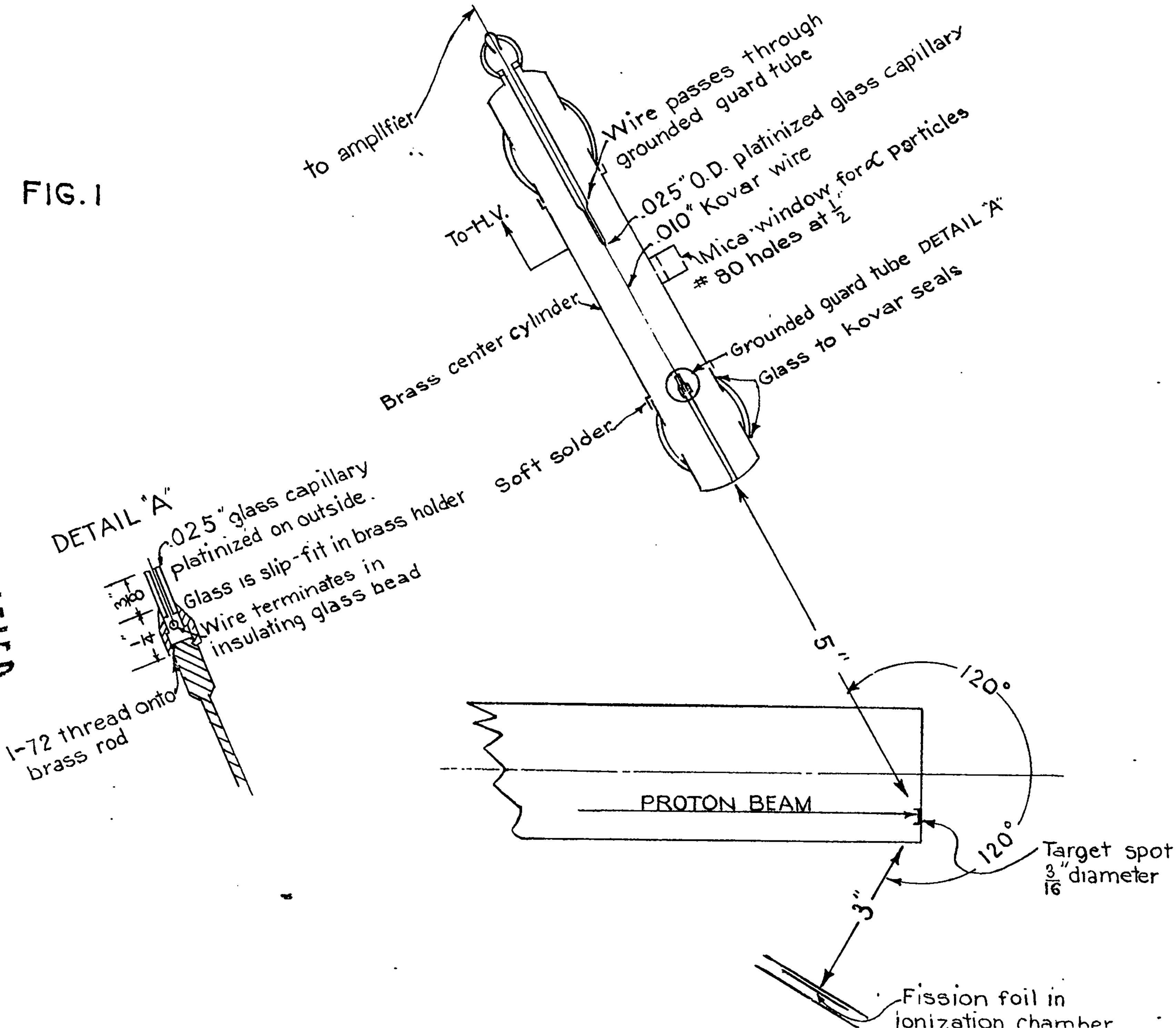
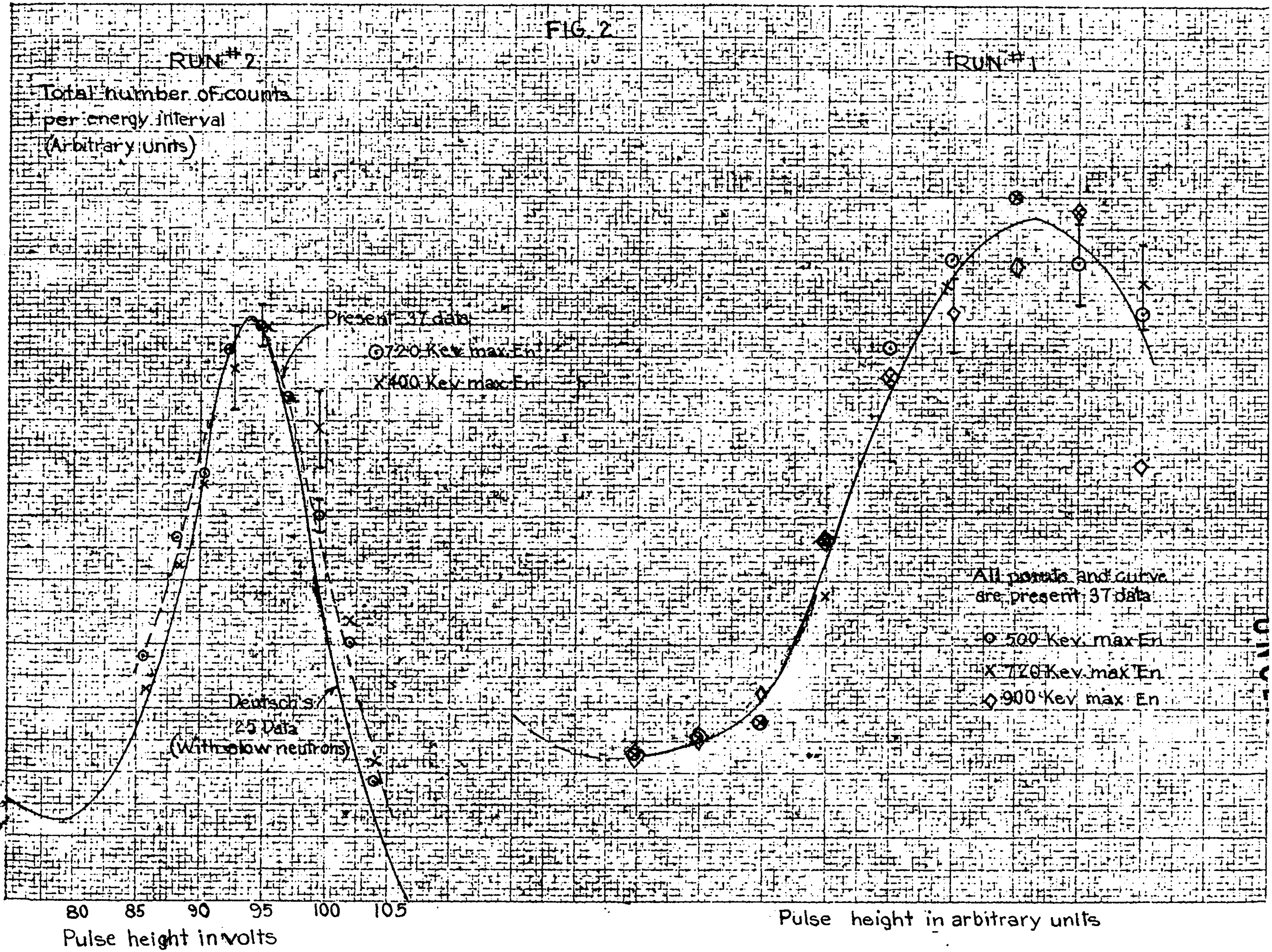
FIG. 1



to amplifier
Wire passes through grounded guard tube
.025" O.D. platinized glass capillary
.010" Kovar wire
Mica window for α particles
80 holes at 1/2"
To H.V.
Grounded guard tube DETAIL "A"
Glass to kovar seals
Brass center cylinder
Soft solder
DETAIL "A"
.025" glass capillary platinized on outside.
Glass is slip-fit in brass holder
Wire terminates in insulating glass bead
1-72 thread onto brass rod
5"
120°
120°
PROTON BEAM
Target spot 3/16" diameter
3"
Fission foil in ionization chamber

FIG. 2



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