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Introduction

The 160 to 200 Mev released in the fission of uranium is sufficient to make the production of a pi-meson energetically possible. The process seems unlikely, however, and was not considered seriously until the event shown in Fig. 1 was discovered[1] in a uranium loaded plate exposed to cyclotron mesons.[2] Here is definitely a 5 Mev meson (a) coming from a fissioning nucleus and leaving the emulsion just before coming to rest. It is not possible to determine the charge of the meson since it does not end in the emulsion. Track (b), which stays in the emulsion for 2.4 mm, is a proton of energy 115 ± 20 Mev as determined by grain count and scattering measurements. A non-uniform development of the plate makes it impossible to say with certainty whether this proton was entering or leaving the fission.

If the proton was entering the uranium nucleus, then the meson must have been produced as a result of the fission since the threshold energy for direct production is greater than 150 Mev. If the proton was leaving the uranium nucleus, the event was probably caused by a fast neutron which ejected a meson and a proton from a nucleus which subsequently fissioned.

Following the discovery of this event, two experiments were performed to search for mesons produced in uranium fission.

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1 Found by J. Willat

2 S. G. Al-Salam, private communication

I For the first experiment, C2 and G5 emulsions were placed next to a 6 mm x 30 mm x 0.4 mm sheet of 94 percent U^{235} and exposed for 40 hours to neutrons from a Po-Be source, moderated by 7 inches of paraffin.[3] The source produced 1×10^6 neutrons per sec. Three normal ρ mesons and two faded ρ mesons, but no σ mesons or π-μ decays were observed in 340 mm^3 of emulsion. One other meson left the emulsion a few microns before coming to rest. All possible meson energies could have been detected in the emulsion.

Assuming a maximum of one π meson per 340 mm^3 (though the ρ mesons observed were almost certainly due to cosmic ray background), and assuming a flat distribution in range of the mesons coming from the U^{235} sheet, the probability for producing mesons is less than 8×10^{-7}. A cross section of 500 barns[4] for slow neutron fission of U^{235} was used for this calculation.

II The second experiment gave a much weaker limit on the cross section for meson production, but achieved high initial nuclear excitation by using the decay energy of π^- mesons. The total energy released is greater than twice the rest mass of a π meson. A high probability of meson production would be particularly significant in this case, since Al-Salam's measurements[2] indicate that every π^- meson captured in uranium results in fission. A beam of π^- mesons produced in a conventional channel arrangement inside the 184-inch Berkeley cyclotron was stopped in a 1/8 in. thick slab of ordinary uranium metal. Secondary mesons up to approximately 30 Mev produced in the slab could be observed in a C2 emulsion embedded in absorber beyond the uranium. The total meson flux into the uranium was computed by making runs of the same length, and counting the number of mesons stopping in an emulsion behind a triangular absorber. Background

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3 W. H. Barkas (private communication) had independently made a similar qualitative experiment using unseparated uranium.

4 B. Feld, in Science and Engineering of Nuclear Power. Editor, C. Goodman.

runs were made by replacing the uranium with lead, and by blocking the meson channel with a lead plug. Results are given in Table I.

Table I

Run		Primary	No. Mesons Secondary (all directions)			Secondary (from slab)			Area Scanned cm^2
			σ	π-μ	ρ	σ	π-μ	ρ	
1	U	$4440/cm^2$	4	3	7	0	0	0	5
2	Pb	$4440/cm^2$	2	5	10	1	0	1	5
3	channel blocked	---	2	2	8	0	0	0	5

It is evident that few if any of the secondary mesons were produced in the uranium, since none came from the direction of the uranium slab, and the number of randomly directed events was statistically no different from the background runs. Assuming that, at most, one of the mesons was produced via fission, it can be estimated that no more than one meson per 172 captured in uranium will produce a secondary meson with energy under 30 Mev.

It can be inferred that the original event observed was a "direct production" of a meson from a fast neutron striking a nucleon in uranium, and was not directly associated with the fission.

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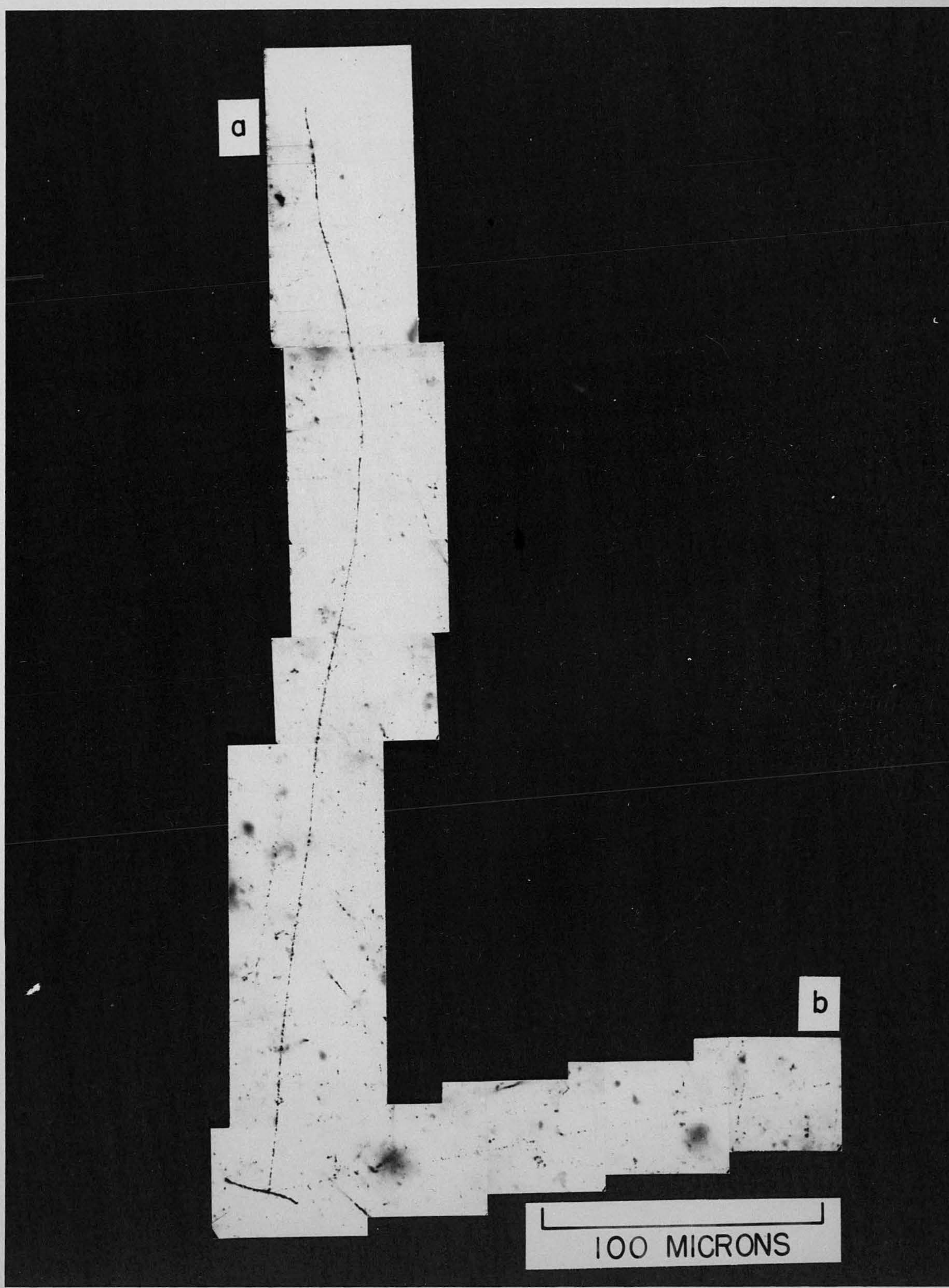

FIG. 1

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