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The possibility of μ^- -induced fission of U^{238} by nonradiative capture or by the nuclear capture of a negative meson has been discussed by Wheeler.¹ Galbraith and Whitehouse failed to observe fission by cosmic-ray mesons in an ionization chamber and set an upper limit of 0.25 on the fission -to-capture ratio.² W. John and W. F. Fry, using uranium-loaded nuclear emulsions, observed 7 μ^- fissions and a fission -to-capture ratio of about 0.15.³ Recently, Zaretsky has attempted to calculate the nuclear excitation from nonradiative capture into mesonic orbits in order to evaluate the possibility of fission catalysis by mesons.⁴ However, the results are not quantitative.

The preliminary results of an experiment performed to obtain the relative probabilities of the two meson-induced fission mechanisms are presented in this letter. A gas scintillation counter containing nine stainless steel discs 3-1/4 inches in diameter by 0.015-inch thick, coated on both sides with $0.85 \text{ mg/cm}^2 \text{ UF}_4$ (natural isotopic mixture), was filled to 45 psi above atmospheric pressure with a mixture of 80% A and 20% N_2 . The μ^- beam, obtained at the 184-inch cyclotron for studies of the neutron multiplicities from μ^- capture in various elements,⁵ was estimated to contain not more than one π^- per one thousand μ^- mesons.

An oscilloscope was triggered by a three-fold coincidence between the

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two photomultiplier tubes looking at the gas scintillator, and a 3.7×10^{-7} -second gate triggered by the coincidence-anticoincidence pulse. This pulse formed by simultaneous pulses in the plastic scintillators S_2 , S_3 , and S_4 , together with the absence of a pulse in the water Cherenkov counter C (Fig. 1). The absence of a prompt pulse in the last plastic scintillator, A, was not required for triggering the oscilloscope because of our concern about accidental pulses in A induced by mesonic x-rays or products of a prompt fission. Pulses from S_3 , S_4 , and A, as well as a sum pulse from the two gas-scintillator phototubes were displayed on the oscilloscope and photographed. A precision, 50-Mc oscillator was used to calibrate the sweep speed of the oscilloscope, and a weak Cf^{252} spontaneous-fission source was included in the chamber to permit frequent calibrations of the fission-fragment detection efficiency.

The zero-time calibration was obtained by photographing the pulses when a piece of plastic scintillator was placed in the fission chamber and also by photographing π^- -induced fissions. In both cases the uncertainty in the zero time was about 3×10^{-9} sec. The background counting rate when plates that were not uranium-coated were bombarded was completely negligible. The random fission background with uranium in the chamber was $2.4 \pm 0.8\%$ fissions per coincidence-anticoincidence trigger, presumably caused by the neutron flux from the accelerator. Pulses from A (usually quite small) were observed about 10% of the time. In nearly all of these cases they were in coincidence with the fission pulse and not with the other counter-telescope pulses. The few observed cases of an S_2S_3A coincidence were not associated with prompt fissions. They are included in the data.

The number of fissions per 1×10^{-8} -sec interval is shown in Fig. 2 as a function of the time elapsed after the stopping of the meson. The background has not been subtracted in the figure. It was considered possible that

a $\tau = 20 \times 10^{-8}$ -sec component^{6,7} might be created by fissions produced by neutrons from the nuclear capture of mesons in the stainless steel plates. In this case, Be plates might be necessary, but the counting rate for delays greater than a few mean lifetimes is consistent with that expected from the random background. Accordingly, the data, excluding the first time interval, were analyzed by the method of Peierls,⁸ and a total mean life of $(7.54 \pm 0.55) \times 10^{-8}$ sec was obtained. This value is slightly smaller than but consistent with the $(8.8 \pm 0.4) \times 10^{-8}$ -sec capture mean life obtained by Sens.⁶ It is also in agreement with the theoretical value of 7.4×10^{-8} sec calculated by Primakoff.⁹ The extrapolated number of fissions in the first time interval, 44.7 ± 3.0 , is to be compared with the experimental value of 62. We conclude that the percentage of fissions due to nonradiative atomic capture is $5.6 \pm 2.7\%$.

It appears that nonradiative capture is, at the most, responsible for a small fraction of the total U fissions induced by stopped μ^- mesons. An absolute fission probability cannot be given at this time, because of the uncertainty of the relative stopping power of the U at the end of the μ^- range.

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Figure Legends

- Fig. 1. Counter-telescope arrangement. Here S_1 , S_2 , S_3 , S_4 , and A are plastic phosphors, C is a water Cherenkov counter in anticoincidence to eliminate the small electron contamination in the beam, and G. S. is the gas scintillator containing the uranium-covered plates.
- Fig. 2. Histogram of μ^- -induced fission events before subtraction of 2.4% background.

Detection of μ^- Meson
Induced Fission in Uranium
with a
Noble Gas Scintillator

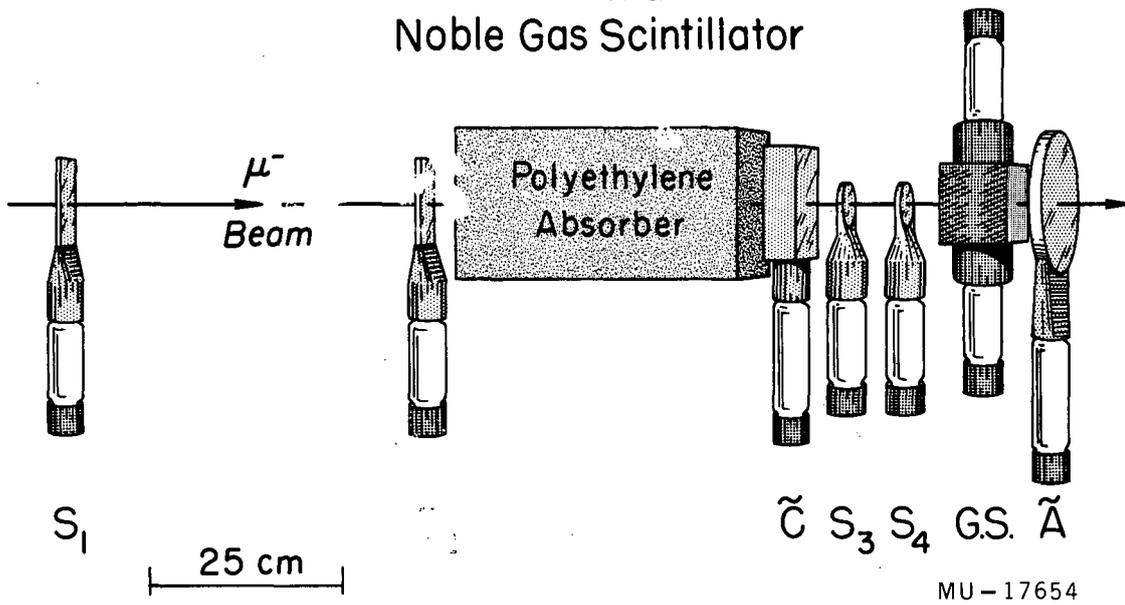
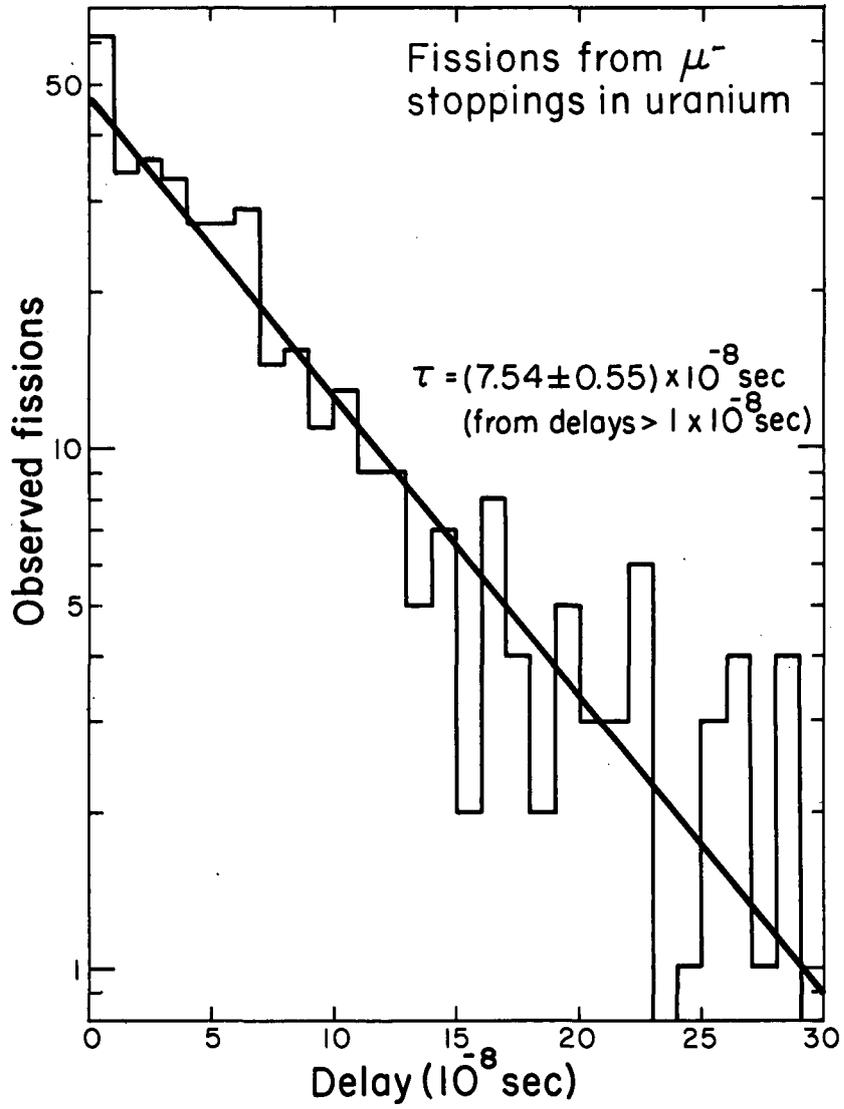


Fig. 1



MU-17674

Fig. 2

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