TABLE I. Total number, N_μ, of mesons in the energy interval 0.224 Bev $\leq E_\mu \leq 0.255$ Bev (from Table III and Fig. 2 of reference 2), and total vertical primary intensity N_p near the top of the atmosphere (reference 3) as a function of the geomagnetic latitude.

Latitude	0°	15°	30°	45°	60°
$N_\mu \times 10^6$ (cm² sec sterad Mev)⁻¹	1.97	2.07	2.59	3.32	3.73
$N_p \times 10^2$ (cm² sec sterad)⁻¹	2.6	2.8	4.5	11.5	29.0

The values of $\Delta N_\mu/\Delta N_p$ are shown in Fig. 1 as a function of the primary energy. While the absolute values may be seriously inaccurate, the increase in the multiplicity with increasing primary energy cannot be doubted.

However, the number of mesons produced per incident primary does not represent directly the number of mesons produced per collision, and it is the latter quantity which one would like to determine. Obviously our method favors high energy primaries; they may be able to retain, after one or several collisions, sufficient energy for further meson production. Moreover, their secondaries might also contribute, so that the actual variation of the multiplicities with the primary energy in the region shown above may be considerably smaller than the factor of about 20 indicated in Fig. 1. Still, the corrections do not invalidate the conclusions drawn. The contribution due to shower secondaries can be shown to be very small, and it follows then that also the later collisions of the primaries account for only a fraction of all the mesons produced.

To get a rough estimate of the contribution of the secondaries, we observe first from Fig. 1 that particles of energies below, say, 1 Bev are very inefficient in the production of hard-component mesons. We note, next, that the average multiplicity of relativistic secondaries to primaries of 12 to 14 Bev colliding with air nuclei is not very high; a figure between 4 and 6 is certainly not an underestimate (see Salant *et al.*[4]). We recall, finally, that the energy spectrum of shower secondaries, observed by Rochester and Butler[5] on their predominantly positive particles, shows only 2 out of 16 measured particles with a momentum exceeding 2 Bev/c, while the average primary energy selected in their experiment was probably 10 to 20 Bev (see the estimates of Piccioni[6] and of the author[7]). To assume that in these collisions in air an average of 1.5 particles with energies above 1 Bev are ejected is, therefore, a rather high estimate. Using for the multiplicity at this energy a value of 0.25×10^{-4} as suggested by Fig. 1, one finds that the secondaries of the first collision account for only about 7 to 8 percent of the multiplicity of 5.0×10^{-4} computed for the highest energy interval. Evidently, the contributions of the secondaries from subsequent collisions become completely negligible. The primaries themselves, descending with an energy reduced to about ½ per collision, will become entirely

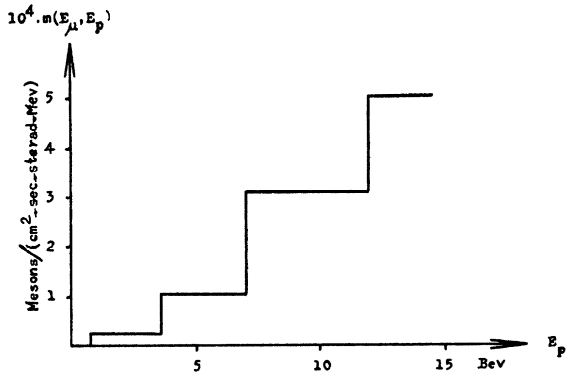

FIG. 1. The differential multiplicity, $m(E_\mu, E_p)$, defined as the number of mesons having energies in the interval 0.224 Bev$\leq E_\mu \leq$0.255 Bev at 30,000 ft, produced per primary of energy E_p.

inefficient in about 4 collisions. It follows that, if their multiplicity remained constant during the energy-degrading descent, the observed number of mesons could increase by as much as a factor of about 4, while the actual increase is about 4 to 5 times larger. In order to account for the experimental data, one must thus demand a rather strong energy dependence of the differential multiplicity, even for the comparatively low meson energies recorded in Conversi's experiment.

It should be noted that the values N_μ in Table I are not the total number of mesons produced, but the number of mesons reaching the 30,000-ft level. Corrections for decay in flight, analogous to the calculations of Sands,[8] can be made, based on specific assumptions on the "production spectrum" of the mesons. As it is doubtful whether an identical spectrum should be used for all primary energies, the calculations will not be reproduced here, but it is of interest to note that the total number of relativistic mesons computed in this manner, assuming Sands' production spectrum, for primaries of approximately 4 to 5 Bev (near 45°) is very small; less than 0.5 per incident primary.

* Supported in part by the AEC.
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The Disintegration of As^{77}

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As^{77} has a period[1,2] of 40 hr and is formed from the decay of both isomers[1,2] of Ge^{77}, *viz.*, the 59-sec and the 12-hr. Since a metastable state of Se^{77} exists,[3-5] whose period is 17.5 sec, there is always the possibility that the beta-ray transition of As^{77} might lead to the metastable rather than the ground state of Se^{77}. Mandeville, Woo, Scherb, Keighton, and Shapiro[6] state that As^{77} emits no gamma-rays. The beta-ray end point, measured by absorption, is given[7] as 0.8 Mev. Nordheim,[8] on the basis of the shell model, classifies the beta-ray transition of As^{77} as $p_{3/2}-p_{1/2}$ on the assumption that the transition is to the metastable rather than the ground state of Se^{77}. Since the transitions of As^{77} are important in order to give information on the correctness of the shell model, the radiations of As^{77} have been investigated.

A source of Ge^{77} containing its daughter As^{77} was obtained by the irradiation of GeO_2 in the Oak Ridge pile for one month. The arsenic was separated from the germanium by a procedure similar to that of Arnold and Sugarman,[2] in which $GeCl_4$ in HCl solution was distilled in an atmosphere of chlorine. The remaining arsenic was reduced to $AsCl_3$ and distilled from an HCl solution. Finally, the arsenic was precipitated as sulfide and sources were prepared from this material.

A beta-ray source of As^{77} was prepared and investigated in a magnetic lens spectrometer. Particular care was taken to search for internal conversion lines which might be attributed to Se^{77m}. *No internal conversion lines were found.* A Fermi plot was made of the data from the beta-ray spectrum and the results are shown in Fig. 1. The end point comes at 0.700±0.007 Mev and the spectrum appears to have an allowed shape.

In addition an absorption curve was taken on a source of As^{77} and no internal conversion lines or gamma-rays were found.

From the results of these experiments it is clear that As^{77} is not the parent of Se^{77m} and that the transition takes place from the ground state of As^{77} to the ground state of Se^{77}. The value of $\log_{10}(ft)$ is 6.1.

The results of this experiment are of interest in the light of the shell model. Mayer[9] points out that for N or Z lying between 29 and 37 spins of 3/2 are measured for every odd number with

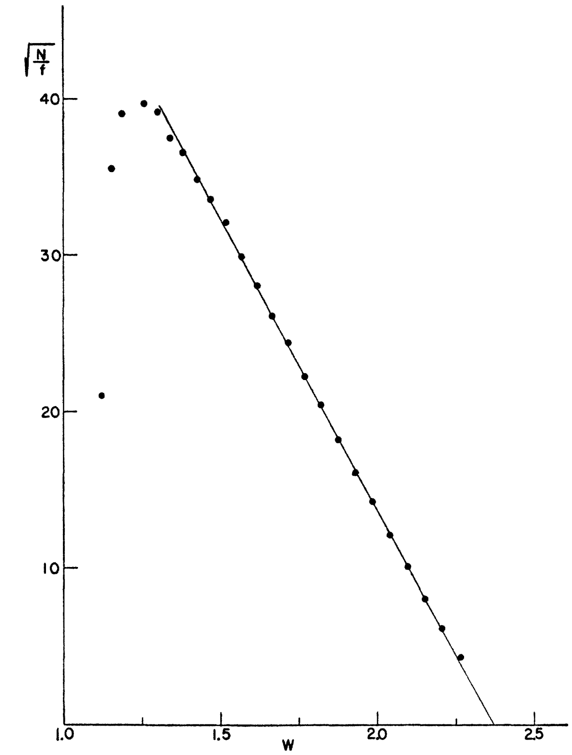

FIG. 1. Fermi plot of beta-ray spectrum of As^{77}.

the exception of $_{37}Rb^{85}$ and $_{30}Zn^{67}$ which show $f_{5/2}$ orbits. For example $_{33}As^{75}$ has a spin of 3/2 and it is presumed that the odd proton is in a $p_{3/2}$ orbit. On these grounds it is supposed that $_{33}As^{77}$ will likewise have a configuration $p_{3/2}$. In the region from 38 to 50, $p_{1/2}$ and $g_{9/2}$ configurations have nearly the same energy. For example $_{32}Ge^{73}$ has a $g_{9/2}$ orbit and spin of 9/2. If one assumes that As^{77} is a $p_{3/2}$ configuration, these experiments show that the ground state of $_{34}Se^{77}$ is $p_{1/2}$ rather than $g_{9/2}$. This follows since no internal conversion line is seen and the *ft*-value indicates an allowed transition. The evidence on the spin of Se^{77} is confusing.[10] There is conflicting evidence showing a spin of 1/2 or one of 7/2. The present experiments lend support to the view that in Se^{77} the $p_{1/2}$ state lies lower than the $g_{9/2}$ state.

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The Neutron Capture Cross Section of Am^{241}

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THE 16-hr Am^{242} (Am^{242m}) produced by neutron capture in Am^{241} decays by β-emission to Cm^{242}, by orbital electron-capture to Pu^{242}, and by an isomeric transition to a long-lived ground state (Am^{242} g.s.). Presumably Am^{242} g.s. may also be formed directly. Although a tentative decay scheme of Am^{242m} has recently been published,[1] the relative amounts formed of the various end products are not known accurately.

In a series of irradiations in the NRX pile we have measured the amount of curium produced and, for two of the samples, the amount of americium destroyed.

The samples of Am^{241} for irradiation were deposited on disks of aluminum by evaporation in vacuum from a tantalum filament. Thus, thin deposits were obtained, so that the amount of Am^{241} before and after the irradiation, and the amount of Cm^{242} formed, could be measured accurately by α-pulse analysis, using a low geometry proportional α-counter[2] and a 30-channel pulse analyzer. Since the α-activity of Cm^{242} after the heavier irradiations was about 100 times as great as that of the Am^{241}, accurate estimations of the latter could be achieved in only very thin sources. A typical α-pulse analysis is shown in Fig. 1.

The amount of Am^{241} destroyed was measured with any precision for only the two most heavily irradiated samples (Nos. 3 and 7), since only these would give results of sufficient accuracy. In all cases the Cm^{242} produced was measured and compared with the initial Am^{241} activity.

The measurement of the residual Am^{241} was complicated by the formation of Pu^{238} from the decay of Cm^{242}. The α-particles of Pu^{238} are almost identical in energy with those of Am^{241}; and, therefore, a correction for Pu^{238} has to be made.

A comparison of the Cm^{242} produced with the Am^{241} destroyed gives a value for f, the ratio of the partial cross section of Am^{241} for Cm^{242} production to the total cross section σ_1 for Am^{241} destruction. No knowledge of the neutron flux during the irradiation is required for this estimation of f. Samples 3 and 7 gave values of f equal to 0.66 and 0.62, respectively. The amounts of Am^{241} destroyed were 18 and 25 percent for these two samples, while the Pu^{238} corrections were 15 and 30 percent of the Am^{241} disintegration rates, respectively. Weighing these two results equally gives a value of 0.64 for f. The various errors which may accumulate are difficult to assess, but we feel that this value is correct within ± 10 percent.

By measuring the Cm^{242} produced in all the samples, we obtain a value for the partial cross section of Am^{241} for curium production, i.e., $f\sigma_1$, using the known integrated neutron flux for each sample. This was obtained from the pile operating log and the absolute neutron flux distribution in the pile.[3] The values of the partial cross section are given in Table I. The mean value is 568 barns. The deviations from the mean are within the over-all experimental error, and the absence of any trend toward lower values at high irradiation levels demonstrates that there is no appreciable neutron destruction of Cm^{242}.

This value of $f\sigma_1$, combined with the value of f obtained above, gives for σ_1, the total cross section for Am^{241} destruction, a value of 887 barns.

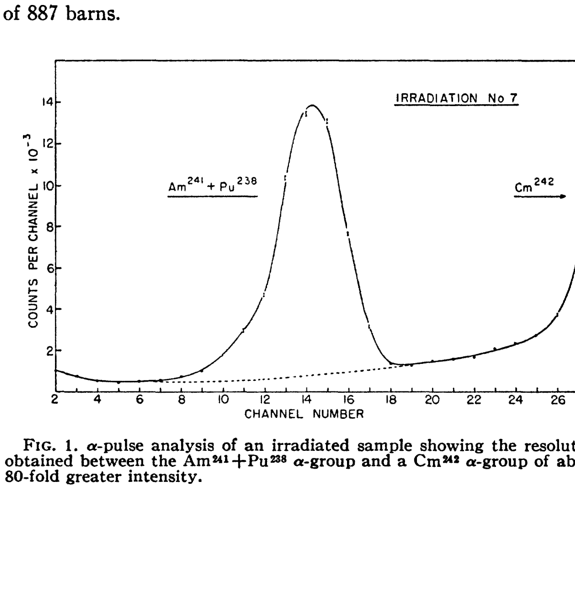

FIG. 1. α-pulse analysis of an irradiated sample showing the resolution obtained between the $Am^{241}+Pu^{238}$ α-group and a Cm^{242} α-group of about 80-fold greater intensity.