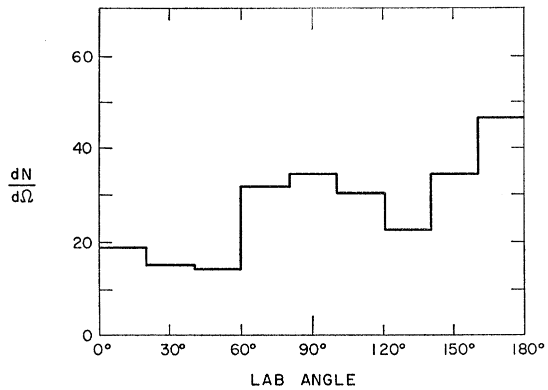

FIG. 11. Angular distribution of the light fragments with respect to the fission fragments.

respect to the fission fragments (Fig. 11) shows some peaking around 90°. The larger and variable mass of the light fragments makes the interpretation of these data somewhat uncertain. However, the results indicate a greater proportion of simultaneous emission of light fragments as compared with alpha particles.

CONCLUSION

Fission of medium weight elements differs from heavy element fission with respect to energetics. In heavy elements, the mass decreases by about 150 Mev, which is just about equal to the Coulomb energy and to the fragment kinetic energy. In the fission of medium weight elements the mass usually increases by 10–20 Mev. Since the Coulomb energy here is 40–50 Mev, there is a fission threshold of ~60 Mev.

The Monte Carlo nuclear cascade calculations[8] indicate that the mean excitation energy for all cascade products from the irradiation of Ru^{100} by 1.84-Bev protons is 270 Mev. Since the fission cross section increases very rapidly with energy,[3,7] it is reasonable to assume that the mean excitation energy is about 400 Mev for those cascade products which eventually undergo fission. Such high excitation may produce nuclear oscillations but it seems that these do not result in actual scission until the nucleus has had time to evaporate many particles. Since alpha particles are not observed to evaporate from the resulting fission fragments, and since the emission probability of alpha particles relative to nucleons seems to be almost independent of excitation energy[9,17] above 50 Mev, it is probable that, at most, only a few nucleons are emitted from the fission fragments.

An alpha particle or light fragment is frequently emitted simultaneously with the two heavy fragments. True ternary fission, in which three approximately equal fragments are produced, is very rare.

ACKNOWLEDGMENTS

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Altitude Dependence of the Longitudinal Distribution of Atmospheric Čerenkov Radiation*

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The longitudinal distribution of the Čerenkov radiation generated by the electron component of extensive cosmic ray air showers interacting with the earth's atmosphere was measured at −46 m and 3801 m elevation. Although the two distributions are similar, a somewhat larger number of showers with small Čerenkov radiation thickness at 3801 m suggests that those showers contain substantial light contributions from elevations where electron scattering is small.

THE Čerenkov radiation associated with the electron component of extensive cosmic ray air showers is produced along that portion of the electron paths in the atmosphere during which the electron velocities exceed the phase velocity of light. The subsequent detection of this radiation can provide unique information concerning the history of the electrons. In general, the light arriving at the detector first will have been produced early in the shower development since Coulomb scattering of the electrons will delay their longitudinal progress relative to the Čerenkov photons.

Thus the time dependence of the incident Čerenkov

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light intensity at any height will contain an approximate composite history of the shower electrons which have previously radiated into the acceptance cone of the detector. Due to the near unity refractive index of the atmosphere, the maximum angle of Čerenkov emission with respect to the electron path is very small, about 1.3° at sea level. Further, all levels of the shower may contribute approximately equal amounts to the detected light. The inverse square law decrease of intensity roughly compensates the increase with height of the shower area included within the detector acceptance cone up to the height at which the acceptance area becomes equal to the shower cross-sectional area. An analysis of the differences in the time dependence of the Čerenkov radiation at various elevations is expected to provide information on the development of the electron component of extensive air showers.

Previous experiments have clarified certain aspects of the Čerenkov radiation.[1–7] The purpose of this article is to describe a set of two observations of the time dependence of the Čerenkov radiation produced by a substantial number of showers at two different elevations. Measurements were made at Death Valley, California at −46 m elevation and at White Mountain Research Station, California at 3801 m.

The time dependence of the light intensity was measured using a simple, vertically-directed optical system in conjunction with a photomultiplier tube of low transit time spread and high current amplification coupled directly to the deflection plates of a cathode ray oscilloscope. The report of a separate experiment performed at 2070 m describes the detection system more completely and demonstrates that 95% of the showers detected by the arrangement used possessed shower fronts moving in directions within 5° of the zenith.[6] Thus, the light intensity distributions deduced from the detectors are closely representative of the longitudinal Čerenkov radiation distribution.

Pulse widths of the waveforms recorded from the oscilloscope were corrected for photomultiplier tube transit time spread, oscilloscope display rise time, dispersion caused by connecting signal cables, and oscilloscope sweep nonlinearity. The corrected pulse widths at half-maximum were selected as a measure of the light distribution.

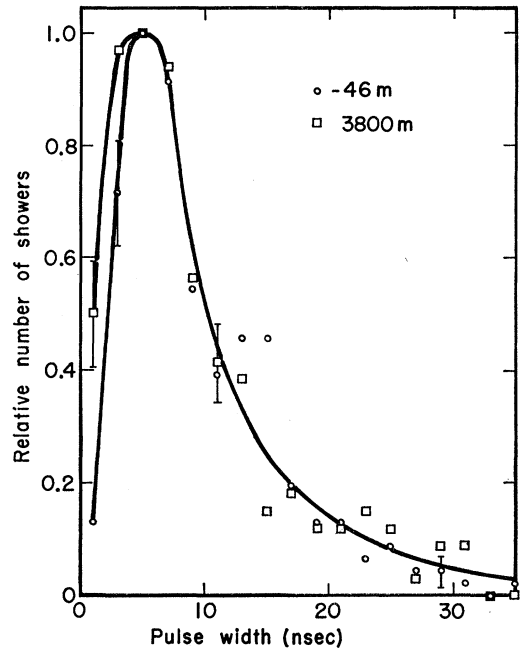

FIG. 1. Relative number of cosmic ray showers producing Čerenkov light pulses of various widths at −46 m and 3801 m elevation.

Figure 1 is a plot of the occurrence spectra of these pulse widths recorded at each elevation. The curves have been normalized to give equal maxima. A total of 248 showers are included in the −46 m data and 197 in the 3801 m data. Pulses included in Fig. 1 fulfilled a minimum amplitude requirement which corresponded very roughly to a minimum total shower energy of 2×10^{15} ev. Results due to Cudakov indicate that equal primary energies yield approximately equal amounts of light at sea level and mountain elevations.

The observed increase in the number of showers possessing Čerenkov light thicknesses less than 5×10^{-9} sec at the higher elevation suggests that relatively more showers detected at that elevation contain large light contributions from levels where electron Coulomb scattering is small. Aside from this effect, the two distributions are similar, in accord with the results of measurements of other electron component properties such as lateral distribution and energy spectrum at sea level and mountain elevations.[8]

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