alize that the tire-road interaction consists of at least two parts: a "frictional" part, which embodies the classic function studied in general physics courses, and a "mechanical resistance" part, which does retardation work on the vehicle when rubber particles are stripped from the tire and deposited on the road as a skidmark. The mechanical resistance offered by the road to the skidding tire is at its maximum when the rubber is cool, such as at the beginning of a skidmark. The visual appearance of the skid at this point is that of an almost imperceptible polish or scuffmark, and great care is needed to determine the point of beginning. As the skid progresses, however, the tires have time to heat and soften. Larger globs of rubber are transferred to the road with smaller amounts of retardation work being done. Thus the "coefficient of friction" is not constant during the skid[5] and indeed averages to lower values as initial speed, and hence skid length, is increased. For example, traveled asphalt surfaces provide friction coefficients in the range 0.6–0.8 for initial speeds below 30 mph, and 0.55–0.7 for higher speeds.[6]

The best counterexample to the classic tire model is the elapsed time posted by drag racers over a quarter mile run, starting from rest. Runs as short as 6 s have been made, which corresponds to an average friction coefficient of

$$\mu = 2s/gt^2 = 2.3.$$

These runs are made with wheels smoking and spinning furiously with no attempt on the driver's part to maintain a static relation between tires and road. This indeed is one of the places where the "real world" deviates most from the general physics classroom.

A related question is the role of tread on automobile tires. According to conventional general physics wisdom, the presence of tire tread only changes the contact area between tire and road surface, which should not affect the maximum braking force available. The only conventional effect of tread is therefore to provide channels for road water to escape, thus preventing the hydroplaning action depicted so vividly in advertisements.

In fact, tread plays at least two contradictory roles on dry surfaces. The leading edges of lateral grooves offer increased mechanical resistance,[7] and in addition provide a wiping action to clear the surface of loose dust and dirt. On the other hand, more tread means less rubber in road contact and hence less distributed mechanical resistance. The latter effect seems to predominate since there is evidence[8] that a smooth tire will stop a car on dry pavement in less distance than tires with good tread.

It should be clear that the automobile tire offers a poor, in fact misleading, example of static and sliding friction in practice. At the same time, the automobile and its parts contribute so much to "Americana" that we as physics instructors need to deal with the subject at some level. Probably the best solution is to discuss it, with all its attendant problems, as a separate topic following the general textbook treatment of friction coefficients.

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[7]Reference 4, p. 255.
[8]Reference 3, p. 184f.

Simple technique for determining the mean lifetime of the cosmic ray μ meson

A. Owens[a)] and A. E. Macgregor
Department of Physics and Physical Electronics, Newcastle upon Tyne Polytechnic, Newcastle upon Tyne, England
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INTRODUCTION

In the conventional experimental technique,[1] mesons stopping in the equipment are recognized by a multidetector coincidence/anticoincidence array, and the time taken to decay is measured by a delayed coincidence technique. However, this type of system suffers from several distinct disadvantages. Probably the most serious of these is the relatively low rate of recording decay events, which almost invariably occurs due to only mesons incident within a small solid angle being recognized.

The experimental arrangement described here employs only one scintillation detector which results in the following advantages: (a) 4π geometry resulting in greater detection rates being achieved; (b) high detection efficiency for decay events since the scintillator is used as both detector and absorber; (c) simple and inexpensive with automatic recording of the decay events.

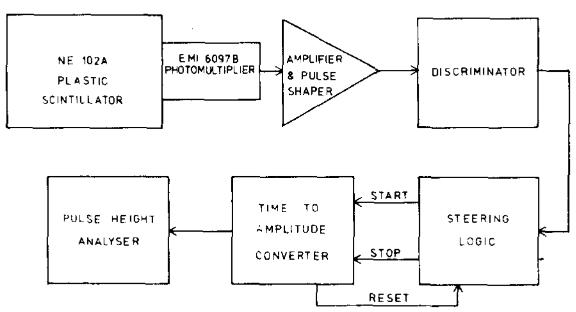

Fig. 1. Block diagram of the detector and electronics.

EXPERIMENTAL

A cross-sectional view of the counter system used and a block diagram of the principal circuits are shown in Fig. 1.

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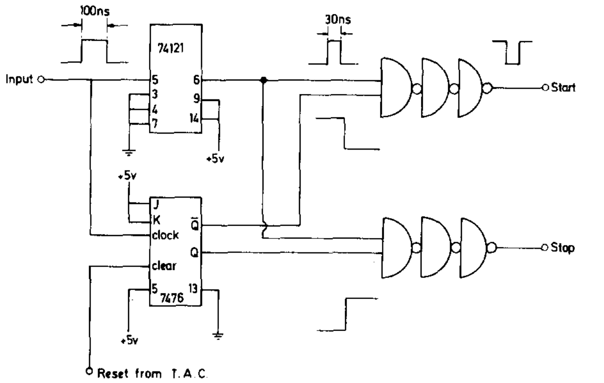

Fig. 2. Circuit diagram of the pulse steering logic.

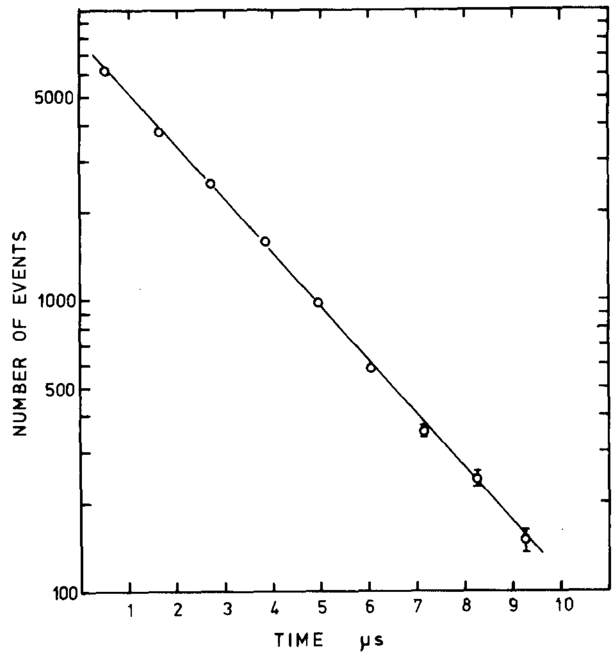

Fig. 3. Distribution of the decay times for a total of 18 000 μ meson events.

The decay events are detected by a cylinder 15-cm diam. by 15-cm long of NE 102A plastic scintillator. A 2-in. EMI 6097B photomultiplier tube is optically coupled to one end of the scintillator which is then wrapped with aluminum foil and made light-tight. The entire detector assembly was surrounded by a 10-cm thickness of lead. This was to remove the soft component of the cosmic rays and filter out negative μ mesons. The absorption probability for negative μ mesons varies at Z^4, thus decay events in the scintillator can be considered to be due to positive μ mesons only and so no correction need be applied to the observed lifetime to allow for nuclear interaction. The lead also had the advantage of increasing the number of mesons which entered the scintillator almost at the end of their range and so improved the rate of collection of data.

The signals from the photomultiplier are first amplified and shaped and then fed into the discriminator. The steering logic sorts the pulses from the discriminator into the start and stop pulses for the time to amplitude converter which is connected to a pulse height analyzer. The time to amplitude converter (TAC) used was a commercially available model (Nuclear Enterprises Model 4645) featuring a variable range time from 0.1 to 100 μs and is self-reseting if the range time is exceeded after the initial start pulse. A range time of 0–10 μs was chosen for this experiment.

The first pulse at the input of the steering logic generates a "start" pulse at the input of the time to amplitude converter. If a second pulse arrives within the 10-μs range time of the TAC, a "stop" pulse is generated by the steering logic and the resulting output pulse of the time to amplitude converter is received by the pulse height analyzer. If, however, a second pulse is not received by the time to amplitude converter within this range time, then an internal over-range discriminator resets the TAC and the steering logic and no output pulse is produced by the TAC. Under the conditions of the experiment the probability is small that two random events at the discriminator output will be within 10 μs of each other. Thus if any output is obtained from the TAC, the start pulse was almost certainly due to a μ meson entering the scintillator and the stop due to its subsequent decay.

The circuit diagram of the steering logic is shown in Fig. 2. TTL logic was used for economy and simplicity. The rising edge of the first input pulse triggers the monostable, the output pulse being steered by the gates to start the TAC. The falling edge of the input pulse clocks the flip-flop, so that a second input pulse will result in a monostable pulse being steered to stop the TAC. The falling edge of the second pulse will also reset the flip-flop. Three NAND gates were used in series on the start and stop outputs to ensure clean pulses. The TAC resets itself automatically if its range time is exceeded and its internal reseting pulse is also used to reset the steering logic via a logic level shifter which is not shown. Therefore, if the second input pulse is not received within the range time of the TAC, the TAC resets itself and the steering logic automatically. If it is not possible to easily extract a reset pulse from the TAC then another monostable, triggered by the first pulse could be used to define the range time and reset the steering logic.

The total count rate observed in the detector was about 6/s. The rate of recording decay events (signals within 10 μs of each other) was 50/h. Less than 2% of the decay events will therefore be due to random processes.

The distribution of the decay times for a total of 18 000 events is shown in Fig. 3. A least-squares fit to the points gave a mean lifetime of 2.32 μs. This should be compared with an accepted value of 2.22 μs. Drift in the TAC rather than statistical effects was the main cause of error in the experiment. Therefore a more sophisticated analysis of the data was not worthwhile. The effect of drift on TAC calibration accuracy was estimated to produce a total error of 5%. No correction has to be made for relativistic effects since for μ mesons decaying in flight the μ meson and electron pulse will appear simultaneously.

CONCLUSIONS

We have shown that a single scintillation counter is sufficient for determining the lifetime of cosmic ray μ mesons. Using a relatively small volume of scintillator about a hundred events can be recorded within a couple of hours, which enables a resonable estimate of the lifetime to be made.

[a]Now at the Dept. of Physics, University of Durham, England.

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