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Positive π mesons have been detected by means of a delayed coincidence between a π^+ meson and its decay μ^+ meson. This method is similar to that of previous investigators[1,2,3] who have used the characteristic μ^+-β^+ decay for meson detection.

A polyethylene target bombarded by the photon beam of the Berkeley synchrotron provided a source of mesons. Two transtilbene crystals in the form of a counter telescope were placed 90° from the direction of the photon beam. The scintillations from the crystals were detected and amplified by 1P21 photo-multipliers. The photo-multiplier pulses caused by a π^+ meson passing through one crystal and stopping in the second open a gate of width 0.08 μsec. which is then delayed 0.025 μsec. If the μ^+ meson pulse arising from the decay of the stopped π^+ meson appears during the time the gate is open, the meson is counted. (Fig. 1.) The amplifiers and coincidence circuits are of a distributed type.[4] The gate generator is a non-symmetrical cathode coupled multivibrator using miniature tubes.

In order to determine the detection efficiency, the meson counting rate was measured as a function of pulse height for (1) the π^+ meson pulse in the first crystal, (2) the π^+ meson pulse in the second crystal, (3) the μ^+ meson pulse in the second crystal. Curves for the π^+ meson pulses are of the same type as those of Steinberger.[3] A plateau was obtained for the μ^+ meson pulse (Fig. 2) by varying the gain of the amplifier providing the signals for the π-μ coincidence circuit. This plateau shows that all μ^+ mesons which stop in the crystal during the time the gate is open are counted.

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With delayed coincidence detection the accidental background is proportional to the length of gate used. Since the ratio of the π^+/μ^+ mean lives is of the order of 0.01, the accidental background is reduced by going to the faster decay scheme. With the present apparatus the background is reduced only by a factor of 10 from that of reference 3. This is due to the larger ratio of pulse width to half-life and the difficulty of discrimination with narrower pulse widths. To lower the background further, a triple delayed coincidence involving π^+-μ^+-β^+ decay has been used. This requires that the μ^+-β^+ decay as well as the π^+-μ^+ decay must take place in the second crystal. The background and counting efficiency are both lower when the π^+-μ^+-β^+ detection scheme is used, but the ratio of counting efficiency to background is increased.

As an application of this method the π^+ meson mean life[5,6,7] was measured by varying the gate delay. The delay was increased and decreased in cycles to minimize the effect of beam fluctuations and detection sensitivity changes. In order to obtain the accidental delayed coincidences, the gate is delayed for a time long compared to a π^+ mean life. The finite length of the gate does not need to be taken into account, since this does not affect the slope of the curve. Calculations show that the effect of the decay of the μ^+ mesons into positrons may be neglected. This is due to the fact that only a small fraction of the positrons occur at each delay; in addition only about 30 percent or less of these positrons lose sufficient energy in the crystal to be counted.

Eight lengths of RG 63/U cable were used to provide the variable delay. The delay of each cable was measured, using a synchroscope, by photographing the reflections of pulses sent down the cable. Cable delays were measured to 2 percent.

The 5641 meson counts with a background of 398 at each of the seven points (Fig. 3) give for the mean life

$$\tau_m = 2.54 \pm 0.11 \times 10^{-8} \text{ sec.} \quad \text{(Standard deviation)}$$

The corresponding half-life is $\tau_{1/2} = 1.76 \pm 0.08 \times 10^{-8}$ sec. This value agrees with that of reference 5, but lies outside the standard deviations of previous measurements.[6,7]

We wish to thank Professor E. McMillan and Professor O. Chamberlain for their encouragement and advice. Thanks are due also to Dr. Leininger for kindly providing the crystals and to the synchrotron crew for aid in carrying out the bombardments.

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Figure Captions

Fig. 1 Block Diagram of Electronics

Fig. 2 Pulse 2B Plateau. Plot of delayed coincidence counting rate against the relative height of a pulse required to make a delayed coincidence. Obtained by counting the number of delayed coincidences for different gain settings of amplifier 2B.

Fig. 3 The number of π^+ mesons at each gate delay plotted against the gate delay.

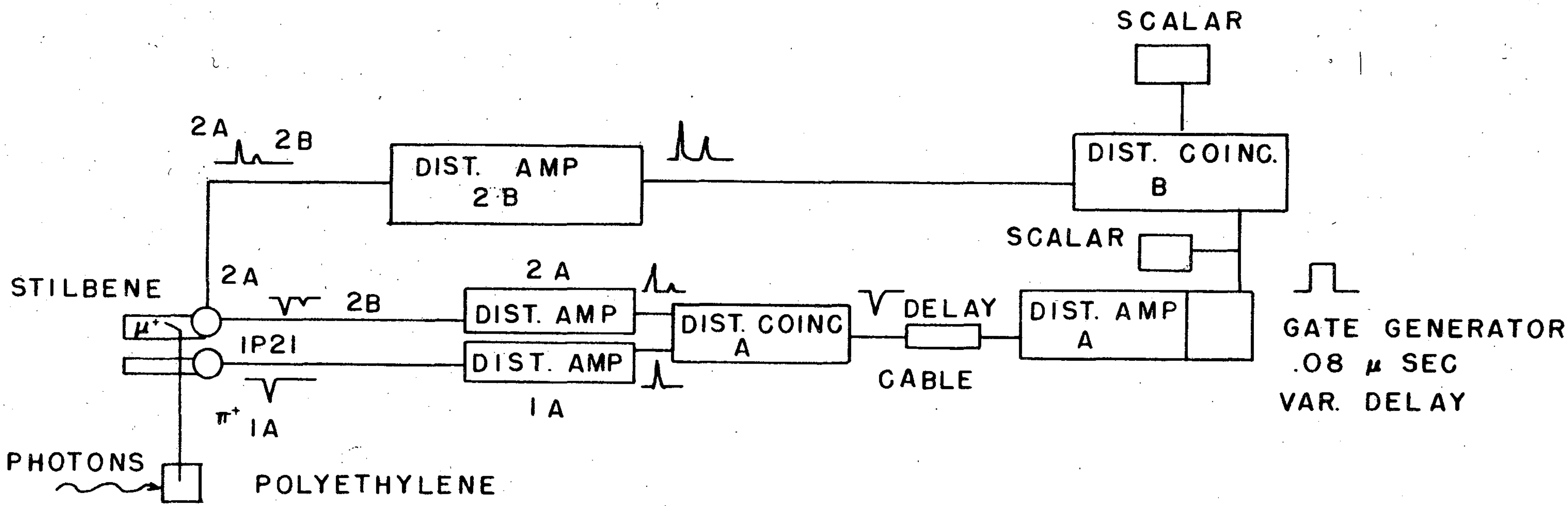

FIG. 1

BLOCK DIAGRAM OF ELECTRONICS

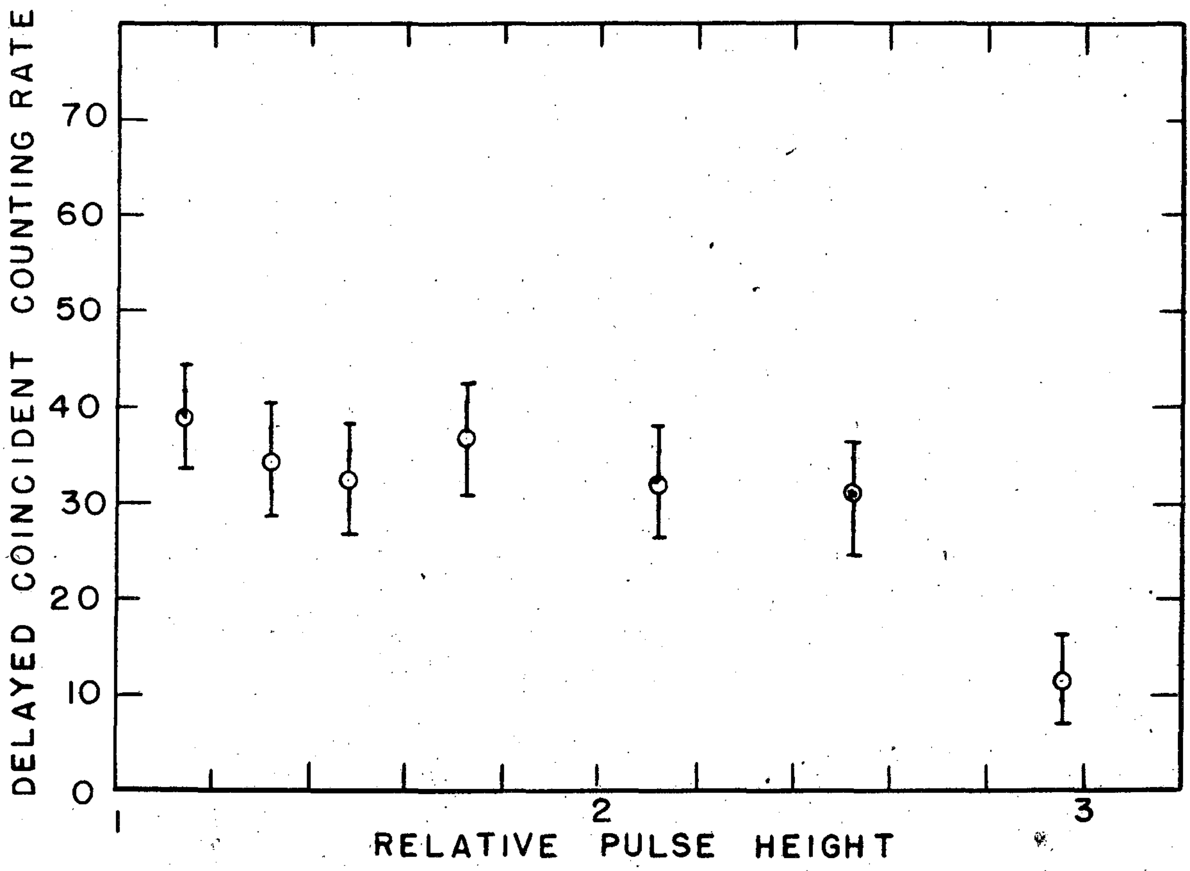

FIG. 2

PULSE 2B PLATEAU

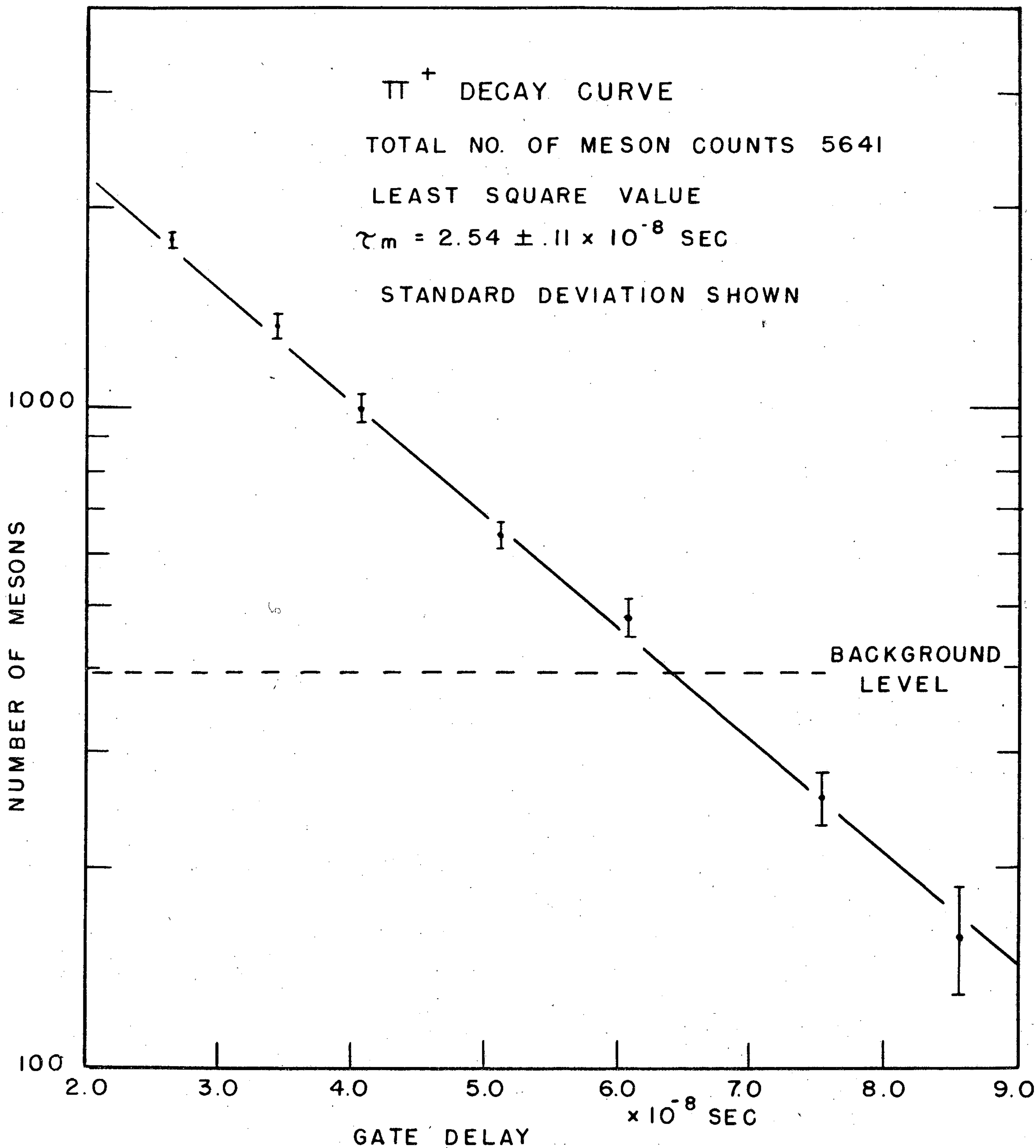
π⁺ DECAY CURVE
TOTAL NO. OF MESON COUNTS 5641
LEAST SQUARE VALUE
$\tau_m = 2.54 \pm .11 \times 10^{-8}$ SEC
STANDARD DEVIATION SHOWN
BACKGROUND LEVEL
NUMBER OF MESONS
1000
100
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
$\times 10^{-8}$ SEC
GATE DELAY

FIG. 3