TABLE VI. Values of W in different gas mixtures.

	H_2-N_2	H_2-He-N_2
H_2 partial pressure	1400 psi	900 psi
N_2 partial pressure	30 psi	10 psi
He partial pressure	...	400 psi
Two γ events	57	28
W	0.97 ± 0.15	0.50 ± 0.23

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Determination of the τ^+ Branching Ratio*

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The branching ratio for the τ^+ decay mode ($K^+ \to \pi^+\pi^+\pi^-$) has been obtained from 2332 τ^+ decays in a bubble chamber containing C_3F_8. We find that $(5.54\pm0.12)\%$ of all K^+ decay by this mode. Combining this result with four previous measurements gives a weighted "world mean" of $(5.46\pm0.09)\%$.

INTRODUCTION

THE τ decay mode of charged K mesons ($K^\pm \to \pi^\pm + \pi^+ + \pi^-$) is easily recognized in most visual detectors. For this reason its branching ratio is widely used as a calibration of total K flux in measurements of cross sections and other K-decay mode branching ratios. Because of unresolved discrepancies in previous measurements[1–5] of the τ^+ branching ratio, we have undertaken a new measurement of substantially higher statistical accuracy.

The measurement was performed with K^+ in a separated beam from the bevatron, brought to rest in the Lawrence Radiation Laboratory 30-in. heavy-liquid bubble chamber. The chamber contained C_3F_8 at a density of 1.22 g/cm^2, radiation length 28 cm. In this liquid, no τ^+ decay secondary from a K^+ at rest has a range of over 8.8 cm, and at least two secondaries stop in the chamber in every τ^+ decay.

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SCANNING

The scanning was done by the three authors. An along-the-track scan was used, following each K from where it entered a chosen fiducial volume until it either decayed or left the volume. Events were classified as to whether they decayed in flight or at rest as determined by visual analysis of the K^+ ionization. Cases where the K^+ had undergone a nuclear interaction (projected angle of scatter greater than 15°) before decay were recorded separately. These categories were chosen as a check on the result, in anticipation of difficulties due to π contamination of the beam; they are combined in the final quoted rate. The results are shown in Table I.

It is necessary to include both decays at rest and in flight in the sample of data because τ decays in flight are usually kinematically obvious, while only ionization information is available for most of the other

TABLE I. Results of scanning.

τ decays		Other K^+ decays	
Rest	1765	Rest	30 818
Flight	195	Flight	2274
Interaction[a]	372	Interaction[a]	5982
	2332	Ambiguous	179
			39 253

[a] K undergoes nuclear scattering before stopping.

modes. It may be noted from the data that a larger fraction of τ decays were classified as "in flight" than was the case for the other modes; the τ figure more nearly represents the true probability of decay in flight.

The τ data in Table I includes the results of two additional area scans for τ's alone. This has brought the final scanning efficiency to essentially 100%. About $\frac{1}{4}$ of the film was rescanned to evaluate our scanning efficiency for other K^+ decays. This proved to be $(98.5\pm0.5)\%$.

The ambiguous category includes events which could be either "rest" or "interaction" events. They are mostly decays with short secondaries indistinguishable from a K scattering followed by K_{e3} decay at rest. The distinction need not be made in our final analysis, as all categories are combined.

The principal background in this experiment comes from the pion contamination of the beam, which is between 1 and 5%. The muon contamination is of no significance, because most muons either cross the fiducial volume without interacting, or decay at rest, in which case they are easily recognized both by ionization and by curvature in the last few centimeters of track. Pions which undergo nuclear scattering in the fiducial volume can be mistaken for K^+ decays in flight. Most of these, however, are eliminated by comparing the ionization of the primary and secondary tracks. All K^+ entering fiducial volume have at least 1.5 times minimum ionization, and a K^+ decay secondary that leaves the chamber must be minimum ionizing at its origin. Approximately 200 events listed in Table I (0.5% of our sample) could not be unambiguously interpreted by these criteria. We have arbitrarily assigned half of these as decays in flight. The uncertainty introduced by this assignment is negligible in the final result. A more reasonable estimate could be made if the pion contaminations could be measured more accurately.

The number of K decays in flight where the angle between the primary and secondary is too small to see should be less than 0.15%, assuming a 7° projected angle cutoff. Since we feel this criterion is conservative, we have not corrected for it.

TABLE II. Comparison with previous measurements.

	Branching ratio (%)
Birge *et al.* (Ref. 1)	5.56±0.41
Alexander *et al.* (Ref. 2)	6.77±0.43
Taylor *et al.* (Ref. 3)	5.2 ±0.3
Roe *et al.* (Ref. 4)	5.7 ±0.3
Shaklee (Ref. 5)	5.13±0.23
This experiment	5.54±0.12
Weighted mean (Ref. 2 excluded)	5.46±0.09

RESULTS

Adding to the number of K^+ decays the 1.5% for scanning efficiency, the number of τ's, and subtracting 100 ambiguous in-flight events, we obtain: No. of K^+ decays $=39\,253+(589\pm196)+2332-(100\pm50) = 42\,074\pm246$. The branching ratio is therefore

$$\frac{\text{No. of } \tau\text{'s}}{\text{No. of } K^+ \text{ decays}} = \frac{2332\pm46.9}{42\,074\pm246} = 0.0554\pm0.0012\,.$$

Table II compares this result to those of some previous experiments.

DISCUSSION

It is clear from Table II that it is possible to reconcile all existing measurements, except that of Ref. 2, on statistical grounds alone. The weighted mean excluding Ref. 2 is $(5.46\pm0.09)\%$. The authors feel that this probably represents the best value of the branching ratio.

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