RARE K-DECAY EXPERIMENTS*

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There have been a proposal (accepted - E777) and a letter-of-intent to search for rare K-decays at the AGS. E777 by Yale/Pittsburgh/BNL (Zeller) will search for $K^+ \to \pi^+\mu^+e^-$ to a branching ratio better than 10^{-11}. The letter [Yale/BNL (Schmidt)] proposes a search for $K^0 \to \mu^+e^-$ at a similar level. This motivation is to test different types of lepton number conservation--specifically, there is a boson in technicolor models which would allow such decays at a level around 10^{-10}. This note will discuss the Zeller experiment, their reasons for doing the experiment at the AGS, and the prospects for looking for even smaller branching ratios.

A level of B.R. < 4.8×10^{-9} (90% C.L.) for $K^+ \to \pi^+\mu^+e^-$ was achieved in a CERN experiment[1] designed to study Ke4 decay. That experiment used a separated 8×10^4/pulse K^+ beam with a PWC/spark chamber detector and no muon identification. E777 will use an unseparated beam with $2\times10^7 K^+$/pulse, PWCs, and muon identification. Cherenkovs will be designed to not misidentify particles, at a reduced efficiency. For example, two counters will be filled with H_2 gas at atmospheric pressure to identify electrons. This reduces delta-ray contamination, at a cost of reduced efficiency for identifying the electrons. They chose a K^+ momentum of 6 GeV/c (and, thus, to do the experiment at the AGS) for good particle identification.

The table below compares the two. The primary gain in E777 is the factor of 200 in beam intensity which will result in their reaching the sensitivity of the CERN experiment in 1-1/2 hours. This intensity, however, is a factor of 10 below an AGS limit--they require about 2×10^{11} protons/pulse. The AGS, at present, has about 10^{13}/pulse and 4×10^{12} protons could be delivered to a given target.

Comparison of a $K^+ \to \pi^+\mu^+e^-$ Experiment at CERN[1] and AGS Proposal 777.

Experiment	CERN	E777
K^+ rate/pulse	8×10^4	2×10^7
Total beam/pulse	3×10^5	5×10^8
Beam momentum	2.8 GeV/c	6 GeV/c
$\gamma c\tau$	21 meters	45 meters
Decay zone	5 meters	5 meters
Acceptance	5%	9%
Sensitive K^+/pulse	$7\times10^2\ K^+$	$1.6\times10^5 K^+$
Total sensitivity	$5\times10^8\ K^+$	$2\times10^{11} K^+$
Final branching ratio	$<4.8\times10^{-9}$	$<10^{-11}$

In any reasonable scenario for improving upon E777, one would first do that experiment, then learn from experience--i.e., turn up the throttle. There are several places where detector changes (after experience) might help:

1) They are concerned with limiting their singles rates in their chambers to a few $\times10^6$/second. One straightforward improvement here would be to add field wires between their 2 mm PWC signal wire spacing, as with a drift chamber.[2] This reduces drift time and, thus, the PWC strobe width. A strobe width of 30 ns (corresponding to 20 ns/mm drift velocity^{-1}) is conservative here versus a typical 75 ns for standard PWCs.

2) With $\gamma c\tau$ = 45 meters and a 5 meter decay zone, the 10% K^+ decays they use might be increased with larger aperture magnets and detector, giving a larger decay region. A factor of 2 might be gained here, with less increase in many backgrounds, since the beam is the same.

3) Their acceptance of 9% might be improved with a larger detector.

4) Moving the experiment back 20 meters would mean a loss of 30% of the K^+s but might help in rates in chambers caused by muons coming from the K production target. A jog could be introduced in the line to filter out muons from π decay.

Conclusion

The present proposals for searching for rare K decays, at a level of 10^{-11}, are still a factor of 10 under the present available AGS intensity. It seems possible to, eventually, use that factor of 10 after the experience of the present experiments. New ideas, which, typically, are likely, would be required to make use of another factor of 10 if the AGS intensity were increased. A more fundamental limit on rare K-decay branching ratios may be background which, as calculated for E777, comes in at a level of 3×10^{-12} for $K^+ \to \pi^+\pi^+\pi^-$, with $\pi^+ \to \mu^+\nu$, and the π^- misidentified as an electron. The experiments are particularly suited for the AGS energy range because they require excellent particle identification.

Footnote and References

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1. A.-M. Diamant-Berger et al., Phys. Lett. **62B**, 485 (1976).
2. This technique will be used at the AGS in E755.