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A POSSIBLE APPLICATION OF THE LOCAL AMPLIFICATION CHAMBER: SEARCH FOR THE DECAY MODE $K_2^0 \to \mu^+ + \mu^-$

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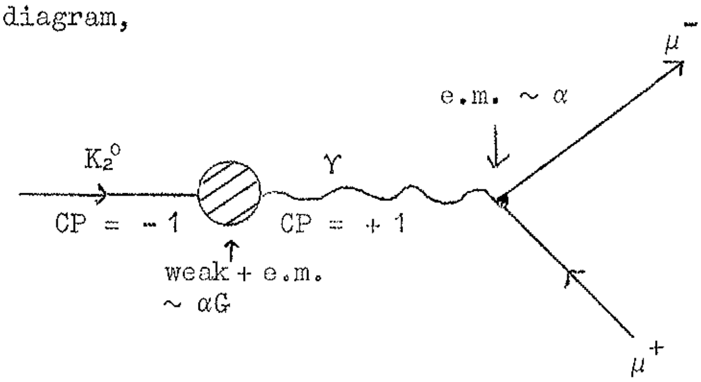
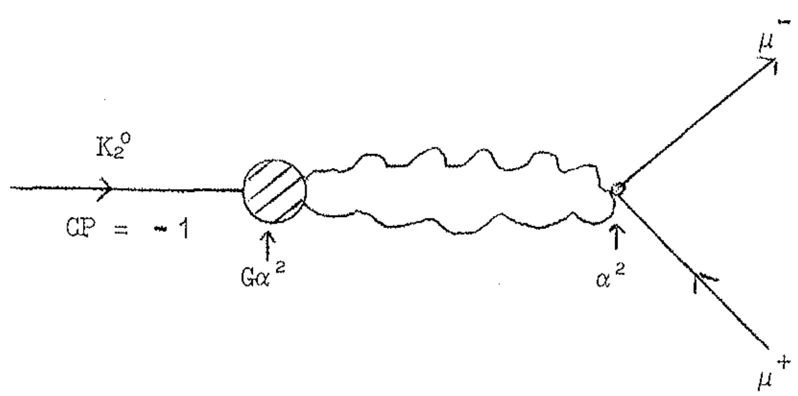
The decay process $K_2^0 \to \mu^+ + \mu^-$ is expected to occur if neutral current terms are present in the weak interaction Lagrangian. The converse is not true because this decay may arise from a combination of electromagnetic and weak interactions. However, the process is in this case particularly rare, owing to CP invariance. The lowest order diagram,



is forbidden and the first contributing term is the two-photon exchange



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giving a transition probability of the order $G^2\alpha^4 \sim 10^{-8}G^2$. Therefore, only if the process occurs with a branching ratio well in excess of 10^{-8} over the corresponding decay mode with $\Delta Q = 1$, $K^+ \to \mu^+ + \nu$, can it constitute proof for the existence of neutral currents in weak interactions*).

More explicitly, one can relate the decay $K^0 \to 2\mu$, to the decay $K^+ \to \mu^+ + \nu$ as follows:

$$\mathrm{rate}(K_2^0 \to \mu^+ + \mu^-) = \frac{G^2(\Delta Q = 0)}{G^2(\Delta Q = 1)} \times \mathrm{rate}(K^+ \to \mu^+ + \nu)$$

$$\times\ (\text{phase space ratio}) \times (\text{elicity terms, Pauli principle})$$

$$= 1.5 \times 10^8\ \mathrm{sec}^{-1} \times \frac{G^2(\Delta Q = 0)}{G^2(\Delta Q = 1)}\ .$$

The decay rate of $K_2^0 \to$ (all charged modes) is about 10^7 sec^{-1}. Therefore

$$\frac{\mathrm{rate}(K_2^0 \to \mu^+\mu^-)}{\mathrm{rate}(K_2^0 \to \text{charged particles})} = 15 \times \frac{G^2(\Delta Q = 0)}{G^2(\Delta Q = 1)}\ .$$

The principle of the experiment proposed is completely straightforward. A beam of high-energy K_2^0's (obtained by looking directly at the PS internal target) is crossing a decay volume, about 1 metre long, filled with helium gas operated as a discharge chamber in order to detect the V of the decay.

Both decay particles are required to cross a thick iron filter (~ 1.0 metre) and stop in a multiplate range chamber.

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*) No detailed calculation on the effect of this graph has yet been made, at least to our knowledge. In the case of the decay processes $K^+ \to \pi^+ + \mu^+ + \mu^-$ and $K^+ \to \pi^+ + e^+ + e^-$, Okun and Rudik[1]) have considered the first order graph (one-photon exchange, in our case forbidden). They conclude that analogies between the $K \to 2\pi$ and $K^+ \to \pi^+ + \gamma$ vertices seem to indicate a rate about 10^{-4} times the $K^+ \to \pi^+ + \pi^- + \pi^+$ decay rate.

Two-body decays $K_2^0 \to \mu^+ + \mu^-$ are identified by coplanarity, range, and angles of decay of both μ mesons. Mu mesons are the only particles which have a sizeable probability of crossing the iron filter without interacting. The most serious background effect is the decay process

$$K_2^0 \to \pi^{\pm} + \mu^{\mp} + \nu$$
$$\hookrightarrow \mu^{\pm} + \nu \quad \text{(decay in flight probability} \sim 10^{-2}\text{)},$$

giving rise to two muons which can easily pass the iron shield. It appears that coplanarity, ranges, and decay angle relationships are sufficient to reduce this background to a level of at least 10^{-6} of the decays $K_2^0 \to$ (charged particles). A more precise evaluation of such a background is on its way. Conservative estimates appear to indicate a rate of about 1 event $K_0^2 \to 2\mu/10^5$ bursts for a branching ratio $K_0^2 \to 2\mu/K_2^0 \to$ (charged particles) $= 10^{-5}$. A test on neutral currents at the level $G^2(\Delta Q = 0) \lesssim 10^{-6}\ G^2(\Delta Q = 1)$ is then possible with about one week of data taking.

One might set up the experiment on the same spot after completion of the Ξ^- parity experiment. The neutral beam will be completely parasitic and will not effect the operation of any of the existing beams of target 1.

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REFERENCE

1) Okun and Rudic, Soviet JETP 12, 442 (1961).

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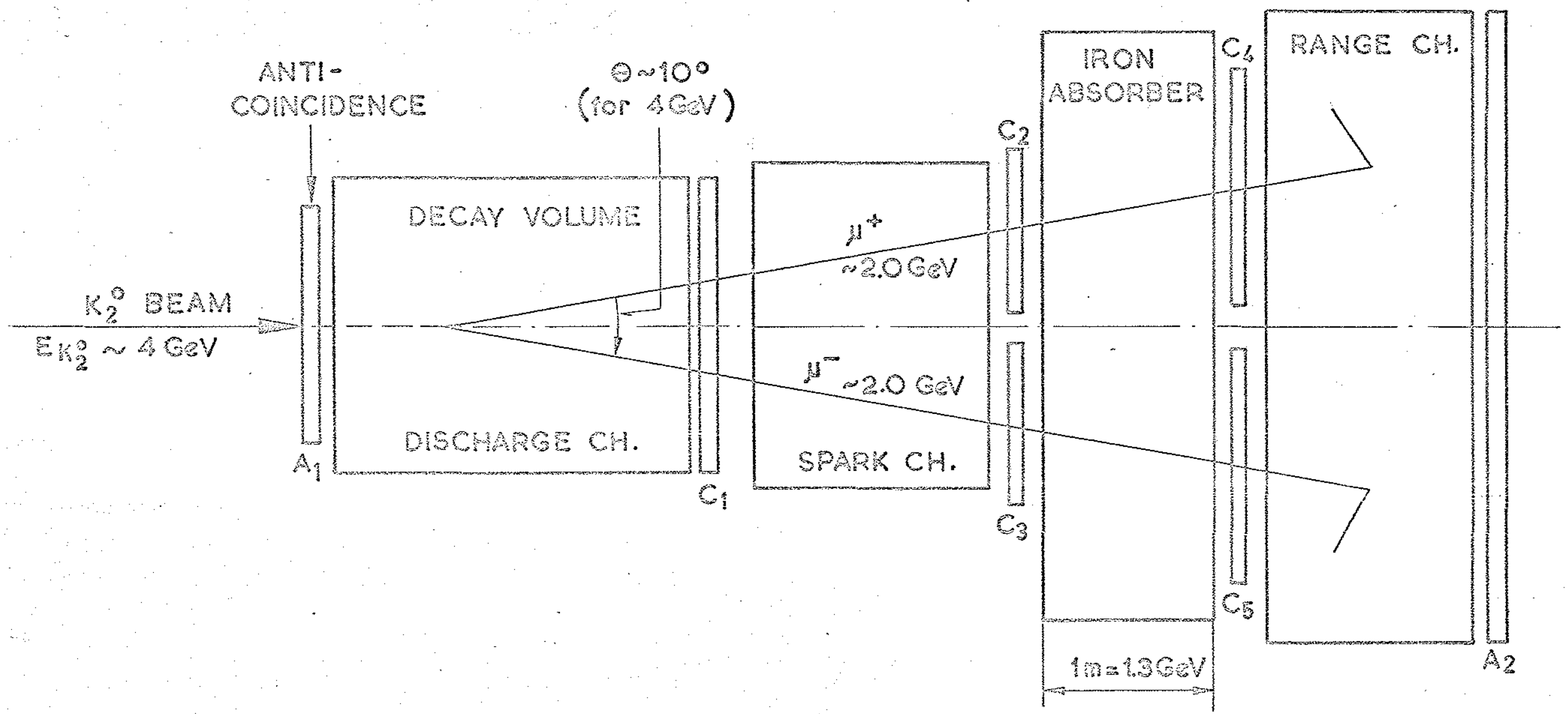

TRIGGER: $C_1 C_2 C_3 C_4 C_5 \bar{A}_1 \bar{A}_2$