G. K. O'Neill : THE STUDY OF K° MESON DECAYS BY COLLIDING BEAMS.
G. K. O'Neill (Palmer Physical Laboratory, Princeton University): *THE STUDY OF K^0 MESON DECAYS BY COLLIDING BEAMS.*

Electron-positron storage rings have been built at Frascati, Orsay and Novosibirsk for the study of problems in the strong and electromagnetic interactions: electromagnetic coupling constants to vector mesons, the timelike photon propagator, form-factors of strongly-interacting particles and the properties of strongly-decaying resonances.

The purpose of this note is to point out that these storage rings can also be applied to at least one significant problem in weak interaction physics: the branching-ratios and lifetime of the long-lived neutral K-meson, K^0. Further, given sufficiently high performance of the Frascati storage ring, it seems not out of the question that unusually clean experiments on the CP-violation parameters $\gamma_{+-}$ and $\gamma_{00}$ could be performed by colliding beams.

The special property of e^+e^- storage rings which should make this possible is that they can produce the $\phi$ resonance in a precisely known way, at rest, and free of all other particles. The $\phi$, in turn, has the special properties that its production cross-section is very high, its branching ratio to neutral K-meson pairs is also high (31 ± 2%), and it is so near the 2K^0 threshold that K^0 mesons from the decay of $\phi$'s at rest are slow, and therefore have a high probability of decay in an experimental apparatus even of modest size. The $\phi$ has I-spin zero, spin 1, odd parity and is odd under C. Its neutral kaon decay is therefore into the $K^0_SK^0_L$ combination either K^0 then serving as a signature for the production of the other.
The production graph for the $\Phi$ is given in fig. 1, and its principle radiative correction\(^{(1)}\) graph in fig. 2.

![Diagram of K_S^0 and K_L^0 decay](image)

**FIG. 1**

**FIG. 2**

Note that the dominant real-photon emission is in the initial state, from an $e^+$ $e^-$ line; however, if such emission is of more than about one MeV the energy is shifted well off the very narrow $\Phi$ resonance; this suppresses radiative processes relative to the non-radiative principal diagram, and has the effect of insuring that the $K_L^0$ and $K_S^0$ are nearly always colinear and of equal, known momenta.

Considering realistic detection apparatus, it is assumed that the useful decay length for $K_L^0$ is 50 cm, that only those $K_S^0$ which accompany $K_L^0$ decaying by the $\pi^+\pi^-$ mode are usable, and that there is a 50% chance of measuring all four charged tracks from a 4-prong event within the fiducial volume. The expected rate is then the product of the following numbers:

- Luminosity of Adone storage ring (nominal): 0.7(10)\(^{33}\)/cm\(^2\)-hour
- Measured peak\(^{(1)}\) cross-section for $\Phi$: 3.9 x 10\(^{-30}\) cm\(^2\)
- Branching ratio\(^{(1)}\) of $\Phi$ to $K_SK_L^0$: 0.312 ± 0.016
- Probability of decay of a 107 MeV/c $K_L^0$ in 50 cm: 0.14
- Branching ratio of $K_S^0$ into $\pi^+\pi^-$: 2/3
- Probability of measuring all 4 charged products: 0.50
- B.R. = branching ratio of $K_L^0$ into the mode of interest.

This product is 40(B.R.) per hour. In 400 hours of data-taking the expected numbers of particular $K_L^0$ decays, each one tagged by a

\(^{(1)}\) - Measured by the ACO group, as reported by Perez-y-Jorba at the 1968 Vienna Conference on High-Energy Physics. An earlier calculation by Gatto gave 8.5 x 10\(^{-30}\) cm\(^2\) for the peak cross-section; the Sept. '67 LRL table quotes 0.40 ± .03 for the branching ratio for $\Upsilon \rightarrow K_SK_L^0.$
The experimental conditions and the freedom from background which characterize events made by $e^+e^-$ annihilation with a four-prong signature suggest that this sort of experiment can considerably improve knowledge of the $K_S^0$ lifetime and branching ratios, and given above-minimum performance of Adone, may also serve as a useful check on the controversial $\eta_{oo}$ parameter.

Studies of $K_L^0$ leptonic-decay charge asymmetries and of the $\Delta S/\Delta Q$ rule are not accessible to the present generation of storage rings; they require a luminosity which can only be reached by the use of a new technique (low-beta sections) which has not yet been applied in practice.

REFERENCE -

(1) - G. Pancheri, LNF-68/26 (1968) and earlier references listed the rein.