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EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

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PROPOSAL TO SEARCH FOR INTERFERENCE IN $K_2^0 \to 2\pi$ and $K_1^0 \to 2\pi$

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I. Aim of the experiment

First results[1] of our experiment, designed to search for the two-pion decay of K_2^0 at 10 GeV/c, indicate a branching ratio in agreement with the result of Christenson et al. [2] . This excludes the possibility of reconciling CP invariance and the observed two-pion decay of K_2^0 by the hypothesis of soft hyperphotons [3][4][5]. The obvious question to ask next [4][6] is then : do the states $K_1^0 \to 2\pi$ and $K_2^0 \to 2\pi$ interfere and if yes, what is there relative phase[7] We propose to insert an absorber of Be or C into a neutral beam and to measure the intensity of K° decays into two pions as a function of the distance from the regenerator. The momentum of each K° parent is determined and used to express the decay distance in units of the mean decay length, $x' = x/\Lambda 1$. The intensity is expected to have the distribution

$$I_{2\pi}(x')dx = |\langle 2\pi|H_w|K_1^0\rangle|^2 \Big\{ |A_1(0)|^2 e^{-x'} + |\lambda|^2 |A_2(0)|^2 + 2|A_1 A_2 \lambda| \cos(\delta x' + \phi) \times e^{-x'/2} \Big\}$$

Here A_1 (o) and A_2 (o) are the amplitudes of K_1^0 and K_2^0 at the end of the regenerator, $|\lambda| = |\epsilon| \sqrt{3\tau_1/2\tau_2}$, $|\varepsilon|^2 = \Gamma_{K_2^0 \to 2\pi} / \Gamma_{K_1^0 \to 2\pi}$, δ

is the K_1^o - K_2^o mass difference and ϕ is composed of three phases,

$$\phi = \phi_\lambda - \phi_{A_1} + \phi_{A_2}$$

If the states $K_1^0 \to 2\pi$ and $K_2^0 \to 2\pi$ differ only in mass (δ) and by a constant phase (ϕ_λ), the interference will be observed and can be made large by appropriate choice of $|A_1(0)|$. We propose to observe two-pion decays over six mean decay lengths. The mass difference δ can then be determined without any further knowledge of nuclear parameters; to extract the phase ϕ_λ from the observed sum ϕ, the phase of A_1 (o) has to be known as well. It is defined by the ratio $^{Re A_1}/_{Im A_1}$, which is unknown on light nuclei. It can be determined, however, from a comparison of the elastic forward differential cross section of $K^\pm$ with the corresponding total cross sections.

The observed intensity distribution is weighted with the detection probability, $\Omega_{2\pi}(p_{K^o}, x)$. It has been calculated using Monte-Carlo methods and can be checked experimentally by placing a regenerator at different positions. We can take advantage of the variation of solid angle $\Omega_{2\pi}$ along the decay region. Depending on the value of ϕ, different parts of the interference pattern can be "amplified" by appropriate choice of the regenerator position with respect to the decay region as seen by the detector.

II. Experimental set-up

An absorber followed by a counter in anticoincidence is placed in the neutral beam. K^o decays are detected by a system of five spark chambers and a bending magnet. We propose to use the detector which proved to be successful in the first experiment$^{1)}$ (fig. 1). Counters N_{1-4} and P_{1-4} accept two charged particles in coincidence, preferentially in a symmetric configuration of vector momenta; their apex is confined to a decay region in vacuum of six mean decay lengths. This detector was designed to favour detection of two-pion decays over the more abundant three-body decays and to suppress detection of $K\pi_3$. To achieve this, use is made of the simple fact that in two-body decays each decay trajectory can be brought to a separate momentum focus after deflection in a bending magnet, roughly independent of the K° parent momentum and decay position. Counters N_4 and P_4 are placed in these foci, outside the neutral beam. In this way a rejection of three-body decays by $5 \cdot 10^{-2}$ and a mean solid angle of $\Omega_{2\pi}/4\pi = 2 \cdot 10^{-2}$ were achieved in the first experiment. Accepted three-body decays can either be labelled by $\check{C}$ (e) and N_5, P_5 (μ) or vetoed. No mislabelling effects were found in the first experiment.

This detector, orginally designed for a mean kaon momentum of 10 GeV/c can easily be adapted to lower Kaon momenta by Lorentz-contracting the part in front of the bending magnet.

III Resolution

A resolution of ± 6 MeV in invariant mass was achieved at 10 GeV/c, corresponding to angular resolution of $\Delta\Theta_{12} = \pm 0.5$ mrad and momentum resolution of $\Delta p/p = \pm 10^{-2}$. The total resolution will improve at lower K° momentum.

IV. How to run the experiment.

We propose to proceed with this experiment in two steps.

Tests during March 1965 with the apparatus set up for 10 GeV/c K_2^0 in the beam b_7 will enable us to put some restrictions on the value of the composed phase ϕ. However, the high neutron flux in this beam puts severe limitations on the thickness of absorber which can be placed in it and thus limits the expected number of events beyond the level required in such an experiment.

The rough information on ϕ which we hope to gain nevertheless, will enable us to choose the final parameters of the detector to obtain optimum sensitivity in the second, final phase of the experiment. This is proposed to be conducted, after the shut-down, in a new neutral beam, derived at larger angle ($\sim$ 100 mrad), which contains a factor 100 less neutrons than b_7. The proposed K_2^0 momentum is around 4 GeV/c.

V. Time table

Analysis of the test run in March can be done in one month. Our data handling system, including automatic flying spot measuring device and programmes is operational.

Installation in the new beam in the East Experimental Area should start in June. A 2 m sweeping magnet is requested. All spark chambers, mirror optics and counters are existing. The gap width of a 1 m bending magnet has to be enlarged.

Parasitic running time (20 $^{\circ}/_{\circ}$ of the PS intensity) is requested, starting after the shut-down. The total running time is estimated to three periods of two weeks.

References

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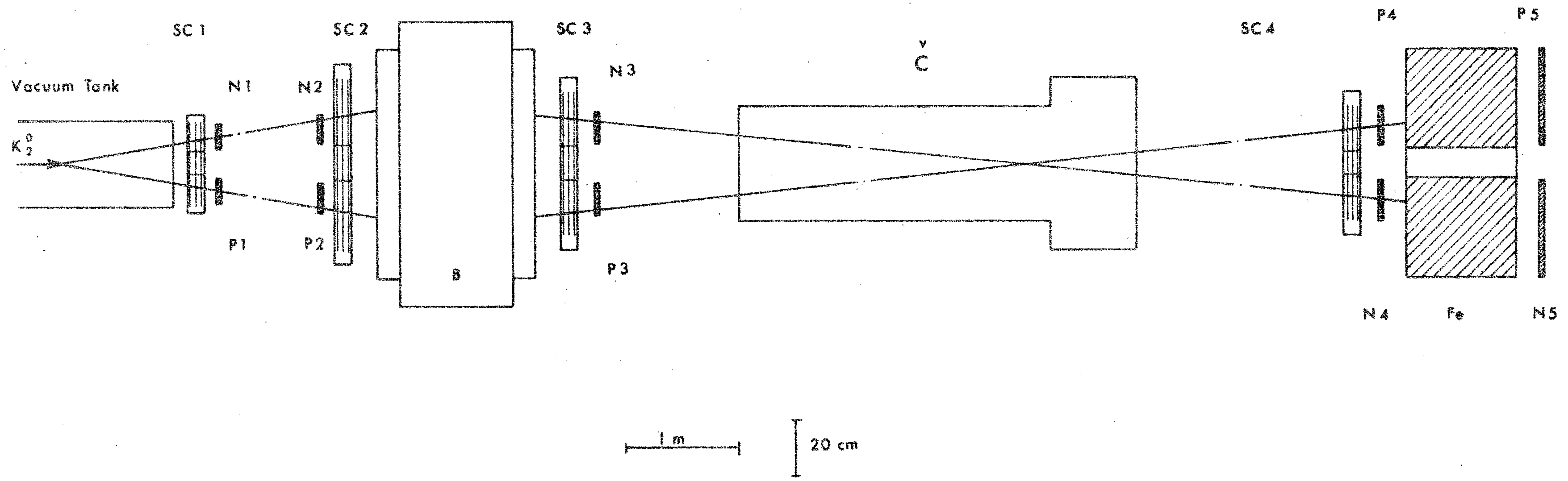
DIA 22.174


Vacuum Tank
K_2^0
SC 1
N 1
P 1
SC 2
N 2
P 2
B
SC 3
N 3
P 3
Č
SC 4
P 4
N 4
Fe
P 5
N 5
1 m
20 cm