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# PROPOSAL TO SEARCH FOR $K_2^0 \rightarrow 2\pi$ at 10 GeV/c

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Geneva, 6.9.1964

PS/4542/kl

# PROPOSAL TO SEARCH FOR $K_2^0 \to 2\pi$ at 10 GeV/c

## I. AIM OF THE EXPERIMENT

Recently, J.H. Christenson, J.W. Cronin, V.L. Fitch and R. Turlay1) have found evidence for the decay $K_2^0 \to 2\pi$ with a rate of $2 \cdot 10^{-3}$, as compared to all charged modes. J. Bernstein, N. Cabibbo and T.D. Lee2) have pointed out that CP invariance of all interactions and the apparent decay $K_2^0 \to 2\pi$ could be reconciled by introducing a new long-range weak field which produces a potential energy of equal magnitude but opposite sign for $K^0$ and $\overline{K^0}$. As a consequence of these assumptions, the decay rate for $K_2^0 \to 2\pi$ would increase linearly with the Lorentz factor $\gamma$ of the $K_2^0$.

The validity of these assumptions can be tested by a measurement of the decay rate $K_2^0 \to 2\pi$ at high momentum. This rate can then be compared with the rate found by Christenson et al1) at 1.1 GeV/c.

A spark chamber experiment is proposed here, to measure this rate at 10 GeV/c. Possible extensions of the experiment will be proposed later.

## II. EXPERIMENTAL METHOD

A decay region of 1 m length is sensed with a detector which accepts 2 charged decay particles in coincidence in a symmetric configuration of vector momentum. These particles may be emitted in the known three-body decays or in the decay $K_2^0 \to 2\pi$. A. Abashian et al3) have pointed out that $K_{\mu 3}$ decays, analysed as $K_{2\pi}$ decays, can give a pronounced forward peaking of the vector sum of the momenta of the two-decay particles for invariant masses near to the $K_2^0$ mass. To avoid mis-labelling of $F_{\mu 3}$ events, the three possible decay particles, e, $\mu$ and $\pi$ will be identified; e by a threshold Cerenkov counter and $\mu$ by absorption of $\pi$ in 1 m of iron (experimentally, rejection of $\pi$'s better than $10^{-3}$ have been obtained at 5 GeV/c). Having identified all masses, the momentum of the decaying $K_2^0$ can be determined in three-body decays as well.

The beam layout is shown in Fig.1, the experimental set-up in Fig.2. A trigger is derived from the coincidence $L_1 L_2 L_3 L_4$ with $R_1 R_2 R_3 R_4$. The two spark chambers in front of the magnet measure the angles of the $K_2^0$ decay secondaries, the two spark chambers behind the magnet measure their momenta.

## III. RESOLUTION IN INVARIANT MASS AT 10 GeV/c

Identification of the decay $K_2^0 \rightarrow 2\pi$ in a background of three-body decays is afforded by calculating the invariant mass. The resolutions required for a mean momentum of 10 GeV/c to obtain $\Delta m^* = \pm 5$ MeV are $\Delta \Theta_{1,2} = \pm 0.5$ mrad and $\frac{\Delta p_1}{p_1} = \frac{\Delta p_2}{p_2} = \pm 10^{-2}$. With this resolution, a ratio $\frac{K_2^0 \rightarrow 2\pi}{K_2^0 \rightarrow \text{all charged}} = 2.10^{-3}$ can be detected. Using 4-gap spark chambers at 2 m distance, the angles can be measured to ± 0.5 mrad. Using a 1 m standard bending magnet and a bending angle of 100 mrad gives $\frac{\Delta p}{p} = \pm 10^{-2}$.

## IV. GEOMETRY OF THE DETECTOR

The symmetric configuration shown in Fig. 2 favours detection of the decay $K_2^0 \rightarrow 2\pi$ and suppresses 3-body decays. To investigate this point, 2-body decays and various 3-body decays have been generated by a Monte-Carlo method$^{4)}$ and were sent from different points of the decay region to the detector. The solid angle for $K_2^0 \rightarrow 2\pi$ turns out to be about 10 times bigger than for 3-body decays. A preliminary value for the geometrical acceptance of $K_2^0 \rightarrow 2\pi$ decays is $2 \cdot 10^{-2}$. The final geometry will depend also on the measurements of neutron background (See VI).

## V. BEAM AND RATES

The actual layout situation in the South Hall leaves the possibility of a neutral beam at 12.5 mrad derived from target 1. The beam will travel in vacuum for the last 12 m. The decay region is at about 50 m from target 1. The solid angle of a $10 \times 6$ cm$^2$ beam area is $2.4 \cdot 10^{-6}$ sr. The flux of $K_2^0$ of $(10 \pm 1)$ GeV/c per burst has been estimated from data on $K^+$ and $K^-$ production$^{5)}$ at $0^0$ and 19.2 GeV/c :

$$N_{K_2^0} = \left( \frac{d^2\sigma}{d\Omega dp} \right)_{K_2^0} \frac{1}{\sigma_{in}} \cdot \Delta\Omega \cdot \Delta p \cdot I_0 \cdot$$

$\sigma_{in}$ (Be) $= 170$ mb

$\left( \frac{d^2p}{d\Omega dp} \right)_{K_2^0} = 8 \cdot 10^{-27}$ cm$^2 \cdot$ sr (GeV/c)$^{-1}$

$\Delta\Omega = 2.4 \cdot 10^{-6}$ sr

$\Delta p = 2$ GeV/c

$I_0 = 5 \cdot 10^{11}$ protons/burst

By substituting we obtain:

$N_{K_2^0} = 1.1 \cdot 10^5$/ burst.

The decay probability inside the decay volume is $3 \cdot 10^{-3}$, giving

$N'_{(K_2^0 \to \text{all})} = 330$ ($K_2^0$ decays) / burst.

Using a geometrical acceptance of the trigger system of $2 \cdot 10^{-3}$ for 3-body decays and $2 \cdot 10^{-2}$ for $K_2^0 \to 2\pi$ decays, we expect

$T_{(K_2^0 \to \text{all})} = 0.7$ triggers from ($K_2^0 \to$ all)/burst.

and, using $\frac{K_2^0 \to 2\pi}{K_2^0 \to \text{all charged}} = 2 \cdot 10^{-3}$ ,

$T_{(K_2^0 \to 2\pi)} = 1.4 \cdot 10^{-2}$ triggers from ($K_2^0 \to 2\pi$) / burst.

## VI. BACKGROUND FROM NEUTRON CONTAMINATION

Based on results obtained during production measurements[5] (N5) the neutron flux at 0° is estimated to be 46 neutrons / sr / interaction. This gives a neutron flux in the decay region of $5.5 \cdot 10^7$/ burst. This figure is very uncertain and should be checked experimentally as soon as possible. In case the estimated flux is confirmed, we would expect to observe several accidental tracks per picture due to neutron stars. Therefore, we are prepared to cut holes for the passage of the beam into the foils of the spark chambers.

## VII. INSTALLATION

Installation of the 12.5 mrad neutral beam in the South Hall (beam hole, collimators, beam stopper, sweeping magnet, vacuum system) should start as soon as possible for measurements of the neutron contamination. The detection apparatus will be installed independently of the beam installation. A CERN 1 m bending magnet is requested for 15 September, for adjustment of the gap height and for field measurements. A monitor channel for target # 1 is requested.

## VIII. MACHINE TIME

A few percent of the internal beam on target # 1 is requested for background measurements after installation of the neutral beam before the next shut-down. The first run of the proposed experiment is planned for end November*). A more detailed time schedule and machine time request will be issued later.

## IX. ANALYSIS OF PHOTOGRAPHS

Photographs will be scanned at CERN and measured with a flying spot device, developed by our group in collaboration with the Institut de Radium, Orsay. This computer controlled device is operational and will enable us to analyse rapidly the photographs taken in the proposed experiment.

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*) All runs should be made at the same PS energy to keep the same $K_2^0$ spectrum.

# REFERENCES

1 J.H. Christenson, J.W. Cronin, V.L. Fitch, R. Turlay, Phys.Rev.Letters 13, 138 (1964).

2 J. Bernstein, N. Cabibbo and T.D. Lee, CERN Preprint 19.8.64.

3. A. Abashian, R.J. Abrams, D.W. Carpenter, G.P. Fisher, B.M.K. Nefkens, J.H. Smith, Phys.Rev.Letters 13, 243 (1964).

4. We are grateful to Mr. M.A. Pouchon of the CERN/ETH group for the programmes.

5. D. Dekkers et al., NP/Int. 64-5 (27.5.1964).

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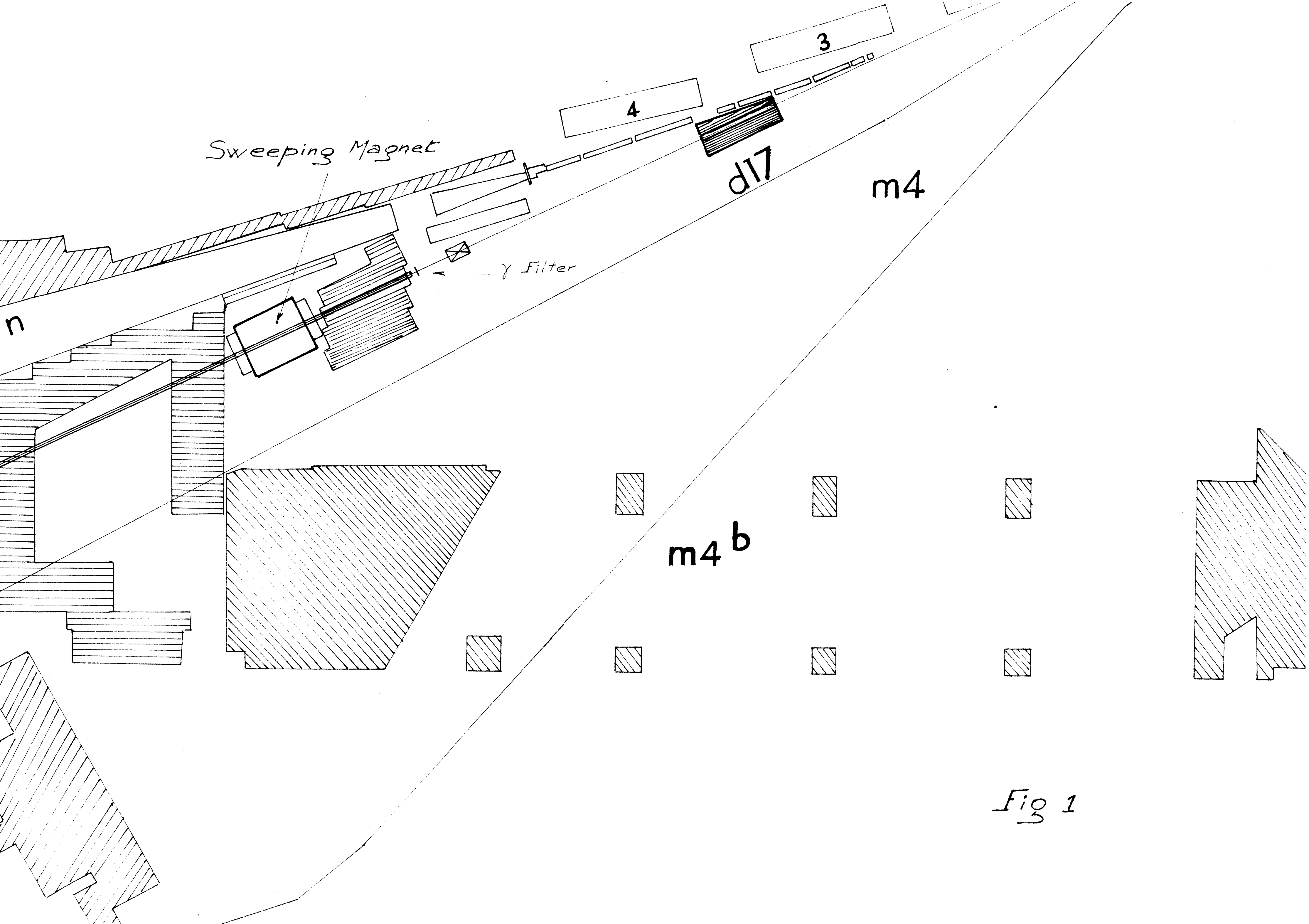
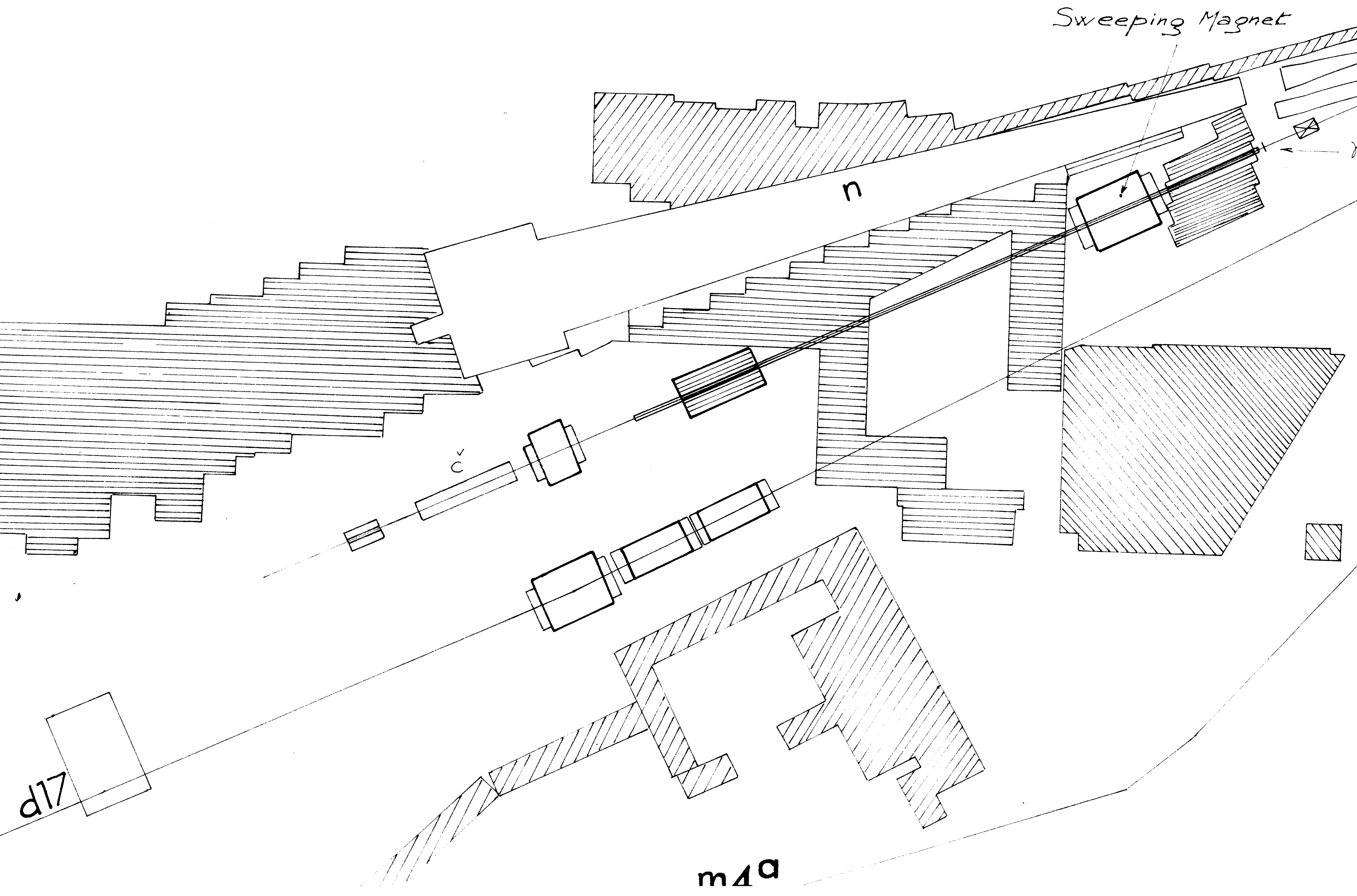


Fig 1


Sweeping Magnet
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γ
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d17
m4a

Fig. 2 Layout of detector for $K^0_2 \to 2\pi$