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LETTER OF INTENTION

To: Members of the Electronics Experiments Committee

From: C. Bricman *, M. Ferro-Luzzi, J.M. Perreau (CERN)
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Re: Counter Experiment on $K^-p \rightarrow \bar{K}^0 n$ cross section from 1 to 2 GeV/c.

This is a letter of intentions, describing an experiment to be done with the CERN protonsynchrotron. The experiment is a measurement of the partial cross section for $K^-p \rightarrow \bar{K}^0 n$ as a function of the incident K^- momentum over the region from 1 to 2 GeV/c. A simple counter technique is envisaged. Reason for the experiment, description of the apparatus and rough estimate of the time necessary are presented below. A more detailed and formal proposal will soon follow.

Although it is not necessary to re-emphasize the importance of the physics of resonances, it is perhaps worth pointing out a few facts. By physics of resonances we mean the body of experiments which determine how many are these states, what is their mass, width and other quantum numbers. It goes by itself that no theory worth its name can afford to ignore the above information. The number of such states has recently grown to a large extent. Whereas a few years ago it would have seemed unjustified to undertake a large scale search of resonances, it is well evident now that such a systematic approach - involving ad hoc devices - will be more fruitful than the random search of the earlier studies. An example of this approach is the recent experiment at Brookhaven by Cool et al.(1). They measured the total K^-p and K^-d cross sections between 1 and 2.5 GeV/c. Here they uncovered a total of 5 new resonances. Considered a posteriori, the experiment was simple and obvious. Why then wasn't it done much earlier ? A possible explanation is that, until recently, resonances were considered as rare

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flowers, most of them already picked up. It is instead in a situation of resonance-inflation that the systematic approach becomes obvious.

This is a long story to say that many new resonances, in all likelihood, are still to be found, that a place where to look for them is the $\bar{K}N$ system and that a way of finding them is the one proposed here. Whereas it is certainly more appropriate to use bubble chambers in order to study the details of the interaction in the neighbourhood of the resonances, it appears instead that some partial cross sections are more conveniently, cheaply and quickly measured with a counter technique.

We propose to measure the cross section of the K^-p charge-exchange reaction (one of the two elastic channels of the $\bar{K}N$ system) because of the following specific reasons. A large scale systematic study of this reaction has never been attempted before. What is known at present is a mixed collection of data obtained by different experiments, mainly with bubble chambers. They are shown in Fig. 1. Many of the points here represent simply by-products of more general investigations aimed more towards the study of the mass spectra of final states in K^-p reactions than towards the careful evaluation of the cross sections. In spite of this, an interesting picture emerges from these data. The amplitudes of the process (measured by the ratio $\sigma/4\pi\bar{\lambda}^2$) appear to be made out of two distinct components. One is an approximately constant background at a level of $\sim$0.05 from 100 MeV/c all the way to 10 GeV/c. The second is the effect of the resonances, which clearly stand out over the flat background whenever enough measurements exist in the region. The process is ideal for detecting new peaks and studying the old. The high signal-to-background ratio present in this reaction is a very attractive feature that not many easily accessible processes can offer. The ratio, for example, is clearly larger than what one finds in the total cross sections (see ref. 1)

The most tempting region to investigate is where very little is known at present, either from this source or from other channels, i.e. the momenta above 2 - 3 GeV/c. However, we propose to examine first the interval between

1 and 2 GeV/c because (a) it so happens that a beam ("m_4") already exists at CERN, capable of yielding K^- with momenta in this range and with the necessary intensity; (b) the method must be tried in a region where some information already exists (from total cross section measurements of ref. 1 and sparse bubble chamber data of ref. 2) and (c) the detailed knowledge of this cross section can already help to solve a certain number of problems. In this region it is known that the following resonances exist: 1820 (at 1060 MeV/c), 1915 (at 1260 MeV/c), 2040 (at 1540 MeV/c), 2100 (at 1680 MeV/c) and 2260 (at 2060 MeV/c). Except for the first, none of these resonances has a well determined value of the elasticity. Spin assignments are tentative for 2040 and 2100, hypothetical for 1915 and unknown for 2260. Anomalous behaviour of the differential cross sections for many reactions has been noticed in the neighbourhood of 1150 MeV/c, i.e. for mass values between 1820 and 1915 (see ref. 3). This could correspond to a new resonance or to a different mass and width for 1915. The question is far from academic, in view of the conjectured identification of 1915 with the so-called Σ-recurrence[1,4]. Notice also that an accurate measurement of the elasticity of all these resonances could allow, when compared with the total cross section measurements of ref. 1, to derive unambiguously their spin.

As far as the connection of this experiment with those already proposed, the situation is the following. There are two experiments planned by other groups in the same momentum region.

The first is a bubble chamber study of the complete $\bar{K}N$ interaction, proposed by the CERN-Heidelberg-Saclay group of ref. 3 as an extension to higher momenta of their present study between 0.8 and 1.2 GeV/c. The purpose of this experiment is different and much more ambitious than ours. All channels open to K^-p and K^-d interactions will be examined, angular distributions and polarizations measured and, eventually, a partial wave analysis performed. On the other hand the statistical accuracy on any single channel will necessarily be limited and far below that foreseen in our experiment. Thus our results not only will serve as an independent check on theirs, but will also be of considerable help at the stage of the final analysis.

The second experiment with long-range claims to this region is the present polarized-target study of K^-p elastic scattering near 1 GeV/c (Sens et al.). The project is for more analysis of the same type, i.e. differential cross sections and polarizations, and does not envisage measurements of absolute cross sections. Thus our experiment will be complementary to this and, if conducted in a coherent fashion with it, could provide the latter with hints on the places where its analysis would be most useful.

Passing now to the technical part, the basic idea is that if one detects only those interactions of K^- in hydrogen which result in long-lived ($\sim 10^{-8}$ sec) neutral particles, the number obtained will be one half the rate of the $\bar{K}^o n$ reactions. Indeed, with the only exception of $K_2^o n$, all final states produced in $K^- p$ collisions end up with at least one of the following situations: (a) charged particles, (b) short-lived neutrals, (c) γ-rays. Fig. 2 shows schematically how one can anti-coincide all reactions falling in the above cases. The 4π counter is at a distance from the target large enough to allow the decay of short-lived neutrals ($\sim 10^{-10}$ sec) and short enough to permit the majority of long-lived neutrals to escape. The counter is made of an inner shell of scintillators to detect the charged particles and an outer shell consisting of lead-scintillator sandwiches so as to convert and detect the γ-rays (directly produced and coming from π^o-decays). That the idea makes sense and indeed can be used has been demonstrated by the early experiment of ref. 5.

The time necessary to the experiment can be estimated as follows. With a 60 cm target and 10^4 K^- per pulse there will be $\sim 10^4$ K_2^o per hour at 1.5 GeV/c. In order to obtain a good picture of the reaction one needs a momentum spacing between measurements of at least 25 MeV/c. The $\bar{K}^o n$ cross section goes from ~8 mb at 1 GeV/c to ~1 mb at 2 GeV/c. Thus some 50 hours are necessary to cover the whole region. This number must then be multiplied by 3 to allow for empty-target measurements. The overall running time comes to about 150 hours. To this, of course, one should add some more time in order to set up and test the apparatus. The latter can be ready to run by the Summer of 1967.

References

1. R.L. Cool et al., Phys. Rev. Letters 16, 1228 (1966).
2. C.G. Wohl et al., Phys. Rev. Letters 17, 107 (1966).
3. R. Armenteros et al., Paper presented at the International Conference on High Energy Physics at Berkeley, 1966.
4. W.M. Smart et al., Phys. Rev. Letters 17, 556, (1966).
5. V. Cook et al., Phys. Rev. 123, 320 (1961).

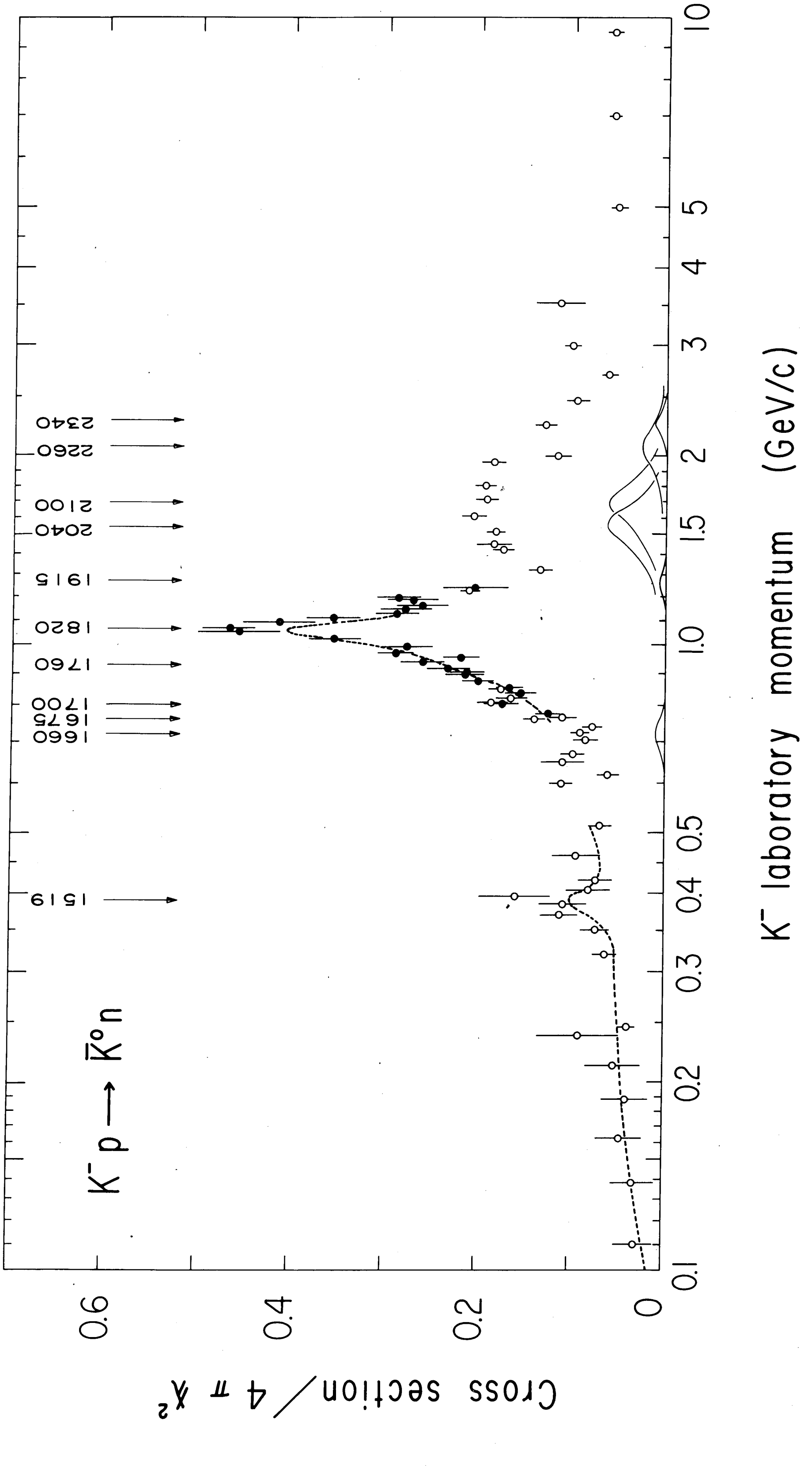

FIG. 1

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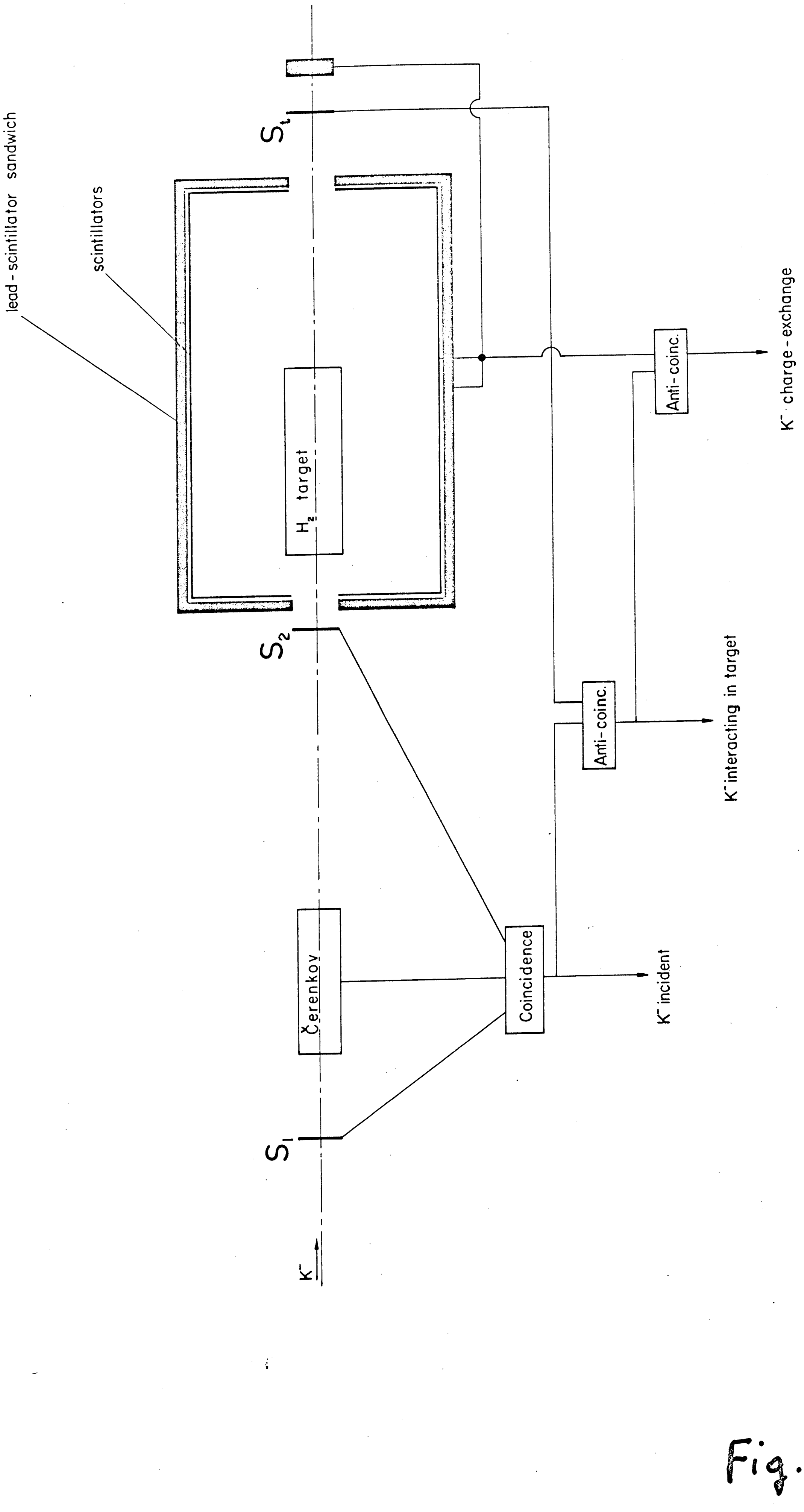
lead-scintillator sandwich
scintillators
S_t
H_2 target
S_2
Čerenkov
S_1
K^-
Coincidence
K^- incident
Anti-coinc.
K^- interacting in target
Anti-coinc.
K^- charge-exchange

Fig. 2