PH I/COM-71/35
23 July 1971

S.130

# LETTER OF INTENTION

# STUDY OF THE REACTION $K_L^0 p \rightarrow K_S^0 p$ IN THE MOMENTUM INTERVAL $4 \leqslant P_{K_L^0} \leqslant 16$ GeV/c

by

J.M. Abillon, P. Chavanon, M. Crozon, A. Diaczeck, T. Leray
J.P. Mendiburu, J. Tocqueville, J. Valentin

Laboratoire de Physique atomique et moléculaire
Collège de France, PARIS, France

G. Calvelli, S. Cittolin, P. De Guio, F. Gasparini
S. Limentani, P. Mittner, P. Posocco, L. Ventura, C. Voci

Istituto Nazionale di Fisica Nucleare, Sezione di Padova
Istituto di Fisica dell'Università, PADOVA, Italia

## 1. PHYSICAL INTEREST.

In the reaction $K_L^o p \to K_S^o p$ only the exchange of C=-1, natural spin-parity meson trajectories ($\rho,\omega,\phi$) is allowed in the t channel. One expects the $\omega$ trajectory contribution to dominate over the $\phi$, which is weakly coupled to the nucleon. On the other end, for t=0, the $\rho$ residue is thought to be $\sqrt{4}$ to $\sqrt{5}$ time smaller$^{(1)}$ than the $\omega$ residue (SU3 would give a factor of $\sqrt{3}$): its contribution, relatively well known, is expected to be limited. Thus, this reaction offers a unique possibility of exploring the poorly known $\omega$ exchange mechanism.

The following main features have been predicted for the angular distribution:

1) a forward peak for very small $|t|$ values, due to the dominance of the non-flip amplitude in $\omega$ exchange (in contrast with the spin-flip dominance in $\rho$ exchange);

2) a possible dip at $t \simeq 0.15$ (GeV/c)$^2$ connected with a zero in the $\omega$ trajectory (this feature has been advocated for some time to explain the cross-over phenomenon);

3) a dip at $t \simeq -0.6$ (GeV/c)$^2$ whose size would indicate the relative magnitude of the $\omega$ and $\rho$ spin-flip amplitudes.

By the use of a Regge pole model we will be hopefully able to determine the parameters of

$\alpha_\omega=\alpha_\omega(t)$ and this should allow some interesting tests of the theory.

## 2. EXISTING DATA.

A 800.000 pictures bubble chamber experiment has been performed at SLAC(1). A quarter of the pictures contains 571 $K^o_S$ events with $1.3 \leq p_{K^o_L} \leq 8$ GeV/c: of these, 78 events correspond to $4 \leq p_{K^o_L} \leq 8$ GeV/c. The results are displayed in fig. 1. Within their statistics, they are in agreement with the above mentioned 1 to 3 points and are well fitted by two different models containing either $\omega+\rho$ and $\omega'+\rho'$ or $\omega+\rho$ and strong cuts.

## 3. EXPERIMENTAL SET-UP.

A schematic view of the apparatus is shown in fig. 2. The hydrogen target (20 cm. long, 4 cm. diameter) is followed by a decay zone, 150 cm. long, and by a magnetic spectrometer, which analyze the forward scattered $K^o_S$, through the $2\pi$ decay; the direction of the pions are given by two sets of magnetostrictive chambers, each set consisting of nine gaps. The magnet gap dimensions are $165\times100\times60$ cm$^3$. We hope to use the "Venus" magnet now in Saclay. Should this not be possible, an

A.E.G. magnet would fit our needs.

The recoil proton detection is accomplished with multiwire proportional chambers aside the target. We are also planning to use a small magnet to analyze the proton momentum.

The trigger will be given by two sets of counters hodoscopes, one before and one after the magnet (in the position shown in fig. 2). An anticounter, in the forward region downstream the target, will discard the events with forward produced charged particles; the rest of the solid angle around the target is anticoincided by lead-plastic sandwiches.

A large amount of the instrumentation already exsists as part of the present running S86 experiment and of an experiment which is expected to be running in Saturne by the end of the year.

## 4. BEAM REQUIREMENT.

We need a small angle beam ($\Theta_{prod} \leq 40$ mrad) to get energetic $K^o_L$'s. Possible candidates are the present 0° $b_{16}$ beam in the South Hall, a (virtual) beam in the East Hall and a (virtual) beam in the West Hall, from the $\Omega$ target.

The $K^o_L$ spectrum as a function of $\Theta_{prod}$ is displayed in fig. 3; fig. 4 shows the ratio $K^o_L$/ neutrons$^{(3)}$. Absolute $K^o_L$ and neutron fluxes are computed under the assumption that $3 \cdot 10^{11}$ protons per burst interact in the target (for target 1 this is obtained with $1.5 \cdot 10^{12}$ circulating protons, 40% on target and an interaction probability of 0.5). The solid angle is $\sim 0.16$ μster ($20 \times 20$ mm$^2$ at 50 m.).

The neutron content of the beam, for the $K_L^o$ expected intensity (see table I) can be estimated as $\leq 5 \cdot 10^6$ neutrons/burst. It has been proved experimentally$^{(4)}$ that the secondary particles coming from neutron interactions in the target at such high fluxes do not disturb appreciably the spark chambers. However, we are still looking in more details into the problem of the choice of the angle from the points of view of $K_L^o$ intensities and neutron background.

## 5. TRIGGER RATES.

The trigger rate calculation is shown in table I. The cross sections are taken from ref.2 and the $K_L^o$ beam intensity from fig.3 (0° production and 50 m. path). An overall efficiency of 10% has been estimated mainly because of geometrical cuts.

The minimum $|t|$ is 0.1 (GeV/c)$^2$, which corresponds to a 300 MeV/c threshold in the recoil proton detection. The maximum |t| correponds to a production angle in the laboratory of ∿12°.

## 6. $K^o_L$ BEAM MONITOR.

In order to evaluate cross sections it is essential to monitor the flux of the incident $K^o_L$ beam as to determine its momentum spectrum. By a suitable logic we shall count the number of $K^o_L$ decaying into 3-bodies ($K_{\mu 3}$, $Ke_3$, $K_{\pi 3}$) within the "decay region" and for a fraction of them (a few for each burst) we shall measure the momenta of the two charged secondary particles. By the use of the well known branching ratios and decay correlations, the distribution of such momenta can univocally be related to the beam momentum spectrum (see, e.g., ref. 2). The rate expected for these decays is given in table I.

## 7. FURTHER DEVELOPMENTS.

Using essentially the same apparatus, with different logics, one can expect to measure various $K^o_L$ or neutron-induced reactions.

1) $K^o_L p \rightarrow K^+ n$ (with a suitable neutron detector)

2) $K^o p \to K^+ \pi^- p$ , $\overline{K^o} p \to K^- \pi^+ p$

3) $K^o_L p \to K^o_S \pi^+ p$ (forward $\pi^+$)

4) $K^o p \to \Lambda \pi^+$ (forward $\Lambda$)

5) $np \to pn$ (up to large t)

6) $np \to (p\pi^-)p$ .

If the recoil proton detection threshold can be made lower or if an acceptable trigger can be obtained with the forward $K^o_S$'s only, the structure at $|t|<0.1$ $(GeV/c)^2$ of the $K^o_L p \to K^o_S p$ angular distribution may be more reliably inferred from the data. This would also allow for a determination of the regeneration amplitude phase at 0°.

## 8. TIME SCHEDULE.

We estimate to be able to start assembling the apparatus on the beam by January 1973. After a reasonable amount of test time, we need 10 (five days) weeks to collect the amount of data listed in table I.

## REFERENCES

1. F.J. Gilman, $K_2^o p \to K_1^o p$ and the Regge trajectory of the meson, P.R. 171, 1453 (1968).

2. A.D. Brody et al., The reaction $K_L^o p \to K_S^o p$ from 1.3 to 8 GeV/c, SLAC-PUB-888, March 1971.
   W.B. Johnson et al., Interpretation of the reaction $K_L^o p \to K_S^o p$, SLAC-PUB-889, March 1971.

3. Figures 3 and 4 are derided from the report by J. Engler at the Meeting on Physics with the Ω spectrometer (19/6/1970).

4. CERN-KARLSRUHE group.

## TABLE I

| $p_{Lab}$ | I | $\sigma(\mu b)$ | trigger rate | events (10 weeks) | $\|t\|_{min}$ | $\|t\|_{max}$ | $K^o \rightarrow$bodies/burst |
|---|---|---|---|---|---|---|---|
| 4 | $5.7 \cdot 10^3$ | 85 | $27 \cdot 10^{-3}$ | 34000 | 0.1 | 0.6 | 33 |
| 7 | 5.4 | 26 | 8 | 10000 | 0.1 | 1.9 | 21 |
| 10 | 3.6 | 12 | 2.4 | 3000 | 0.1 | 3.5 | 9 |
| 13 | 2.0 | 7 | 0.8 | 1000 | 0.1 | 5.8 | 5 |
| 16 | 1.0 | 5 | 0.3 | 375 | 0.1 | 8.1 | 1 |

total flux $45 \cdot 10^3$, total trigger rate $74.5 \cdot 10^{-3}$, total number of events $\sim 9.10^4$

typical day $25 \cdot 10^3$ burst, typical week $125 \cdot 10^3$ bursts.

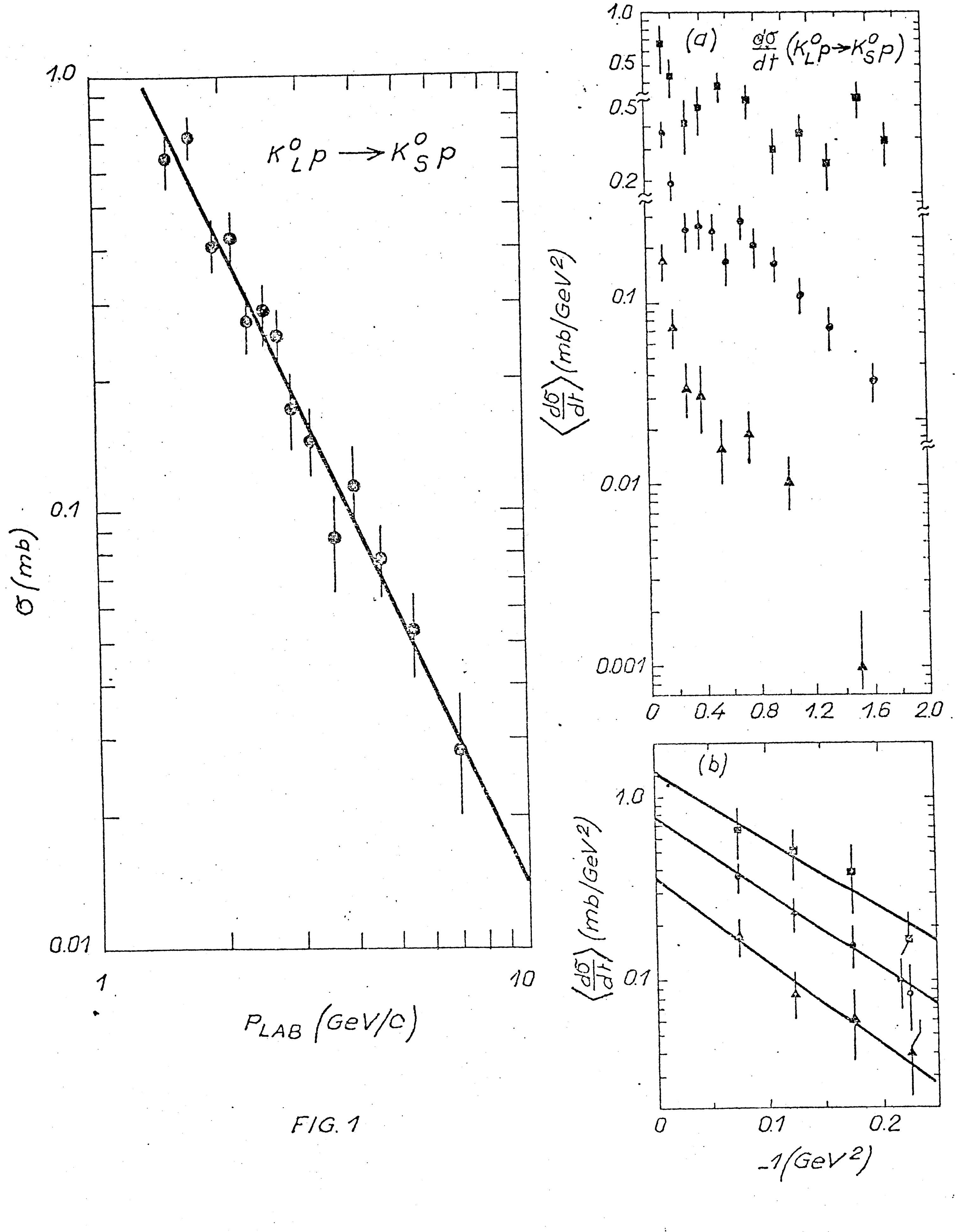
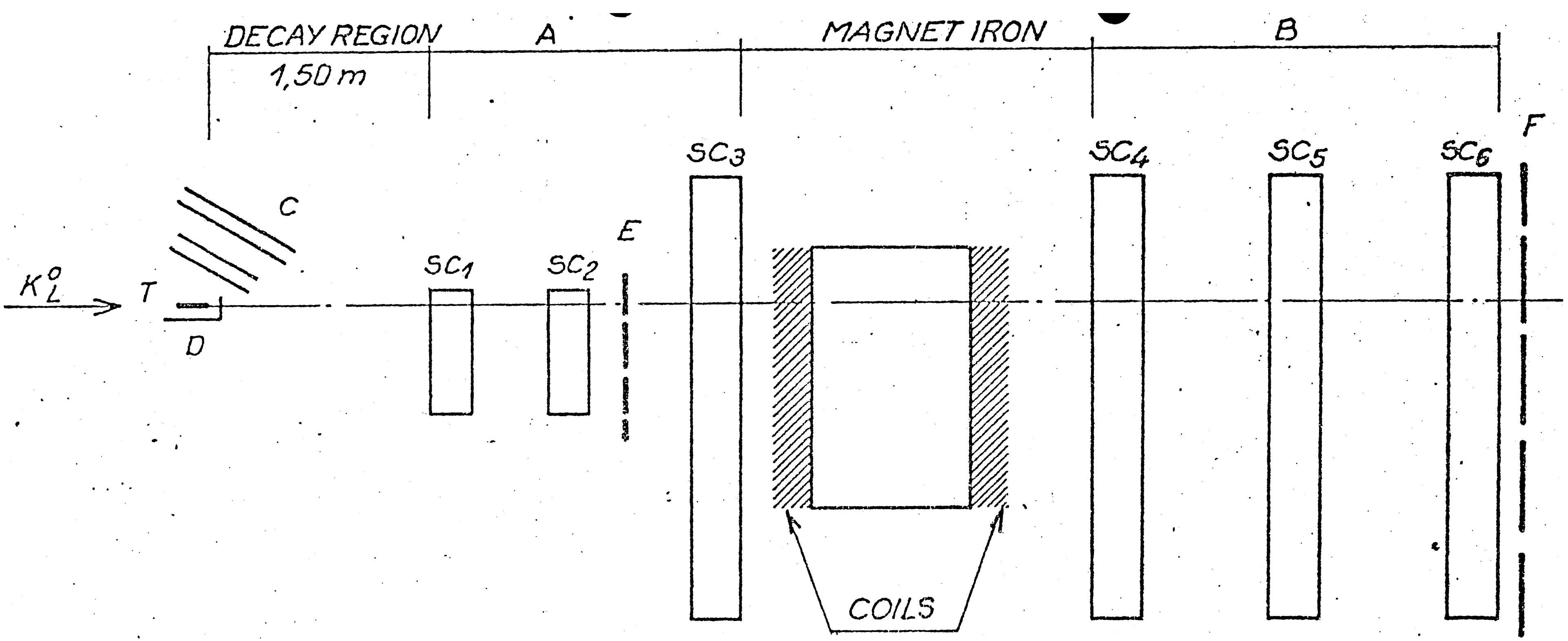

1.0
0.1
0.01
1
10
σ (mb)
$P_{LAB}$ (GeV/c)
$K^0_L p \rightarrow K^0_S p$
(a)
$\frac{d\sigma}{dt}(K^0_L p \rightarrow K^0_S p)$
1.0
0.5
0.5
0.2
0.1
0.01
0.001
0
0.4
0.8
1.2
1.6
2.0
$\left\langle \frac{d\sigma}{dt} \right\rangle$ (mb/GeV$^2$)
(b)
1.0
0.1
0
0.1
0.2
$\left\langle \frac{d\sigma}{dt} \right\rangle$ (mb/GeV$^2$)
-t (GeV$^2$)

FIG. 1



T =TARGET

A =WIRE SPARK CHAMBER TELESCOPE (3 x 3 GAPS) / $SC_1, SC_2$ : $80 \times 40\,cm^2$

B = Idem (3 x 3 GAPS) / $SC_3, SC_4, SC_5, SC_6$ : $280 \times 150\,cm^2$

C =MULTIWIRE PROP. CHAMBERS

D =ANTICOINCIDENCE SHIELD (LEAD-PLASTIC SCINTILLATION COUNTERS)

E,F=SCINTILLATION COUNTERS HODOSCOPES .

FIG.2

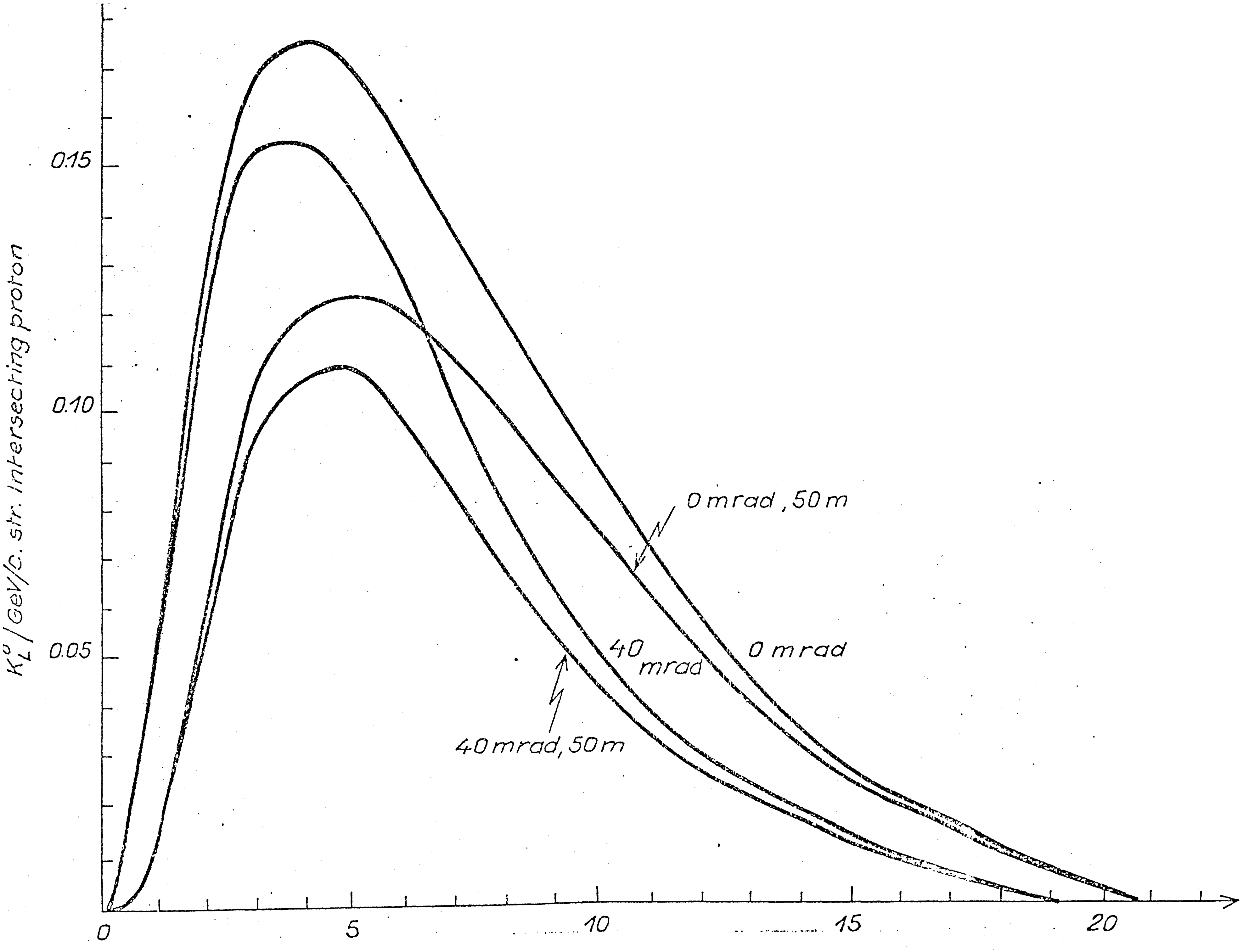
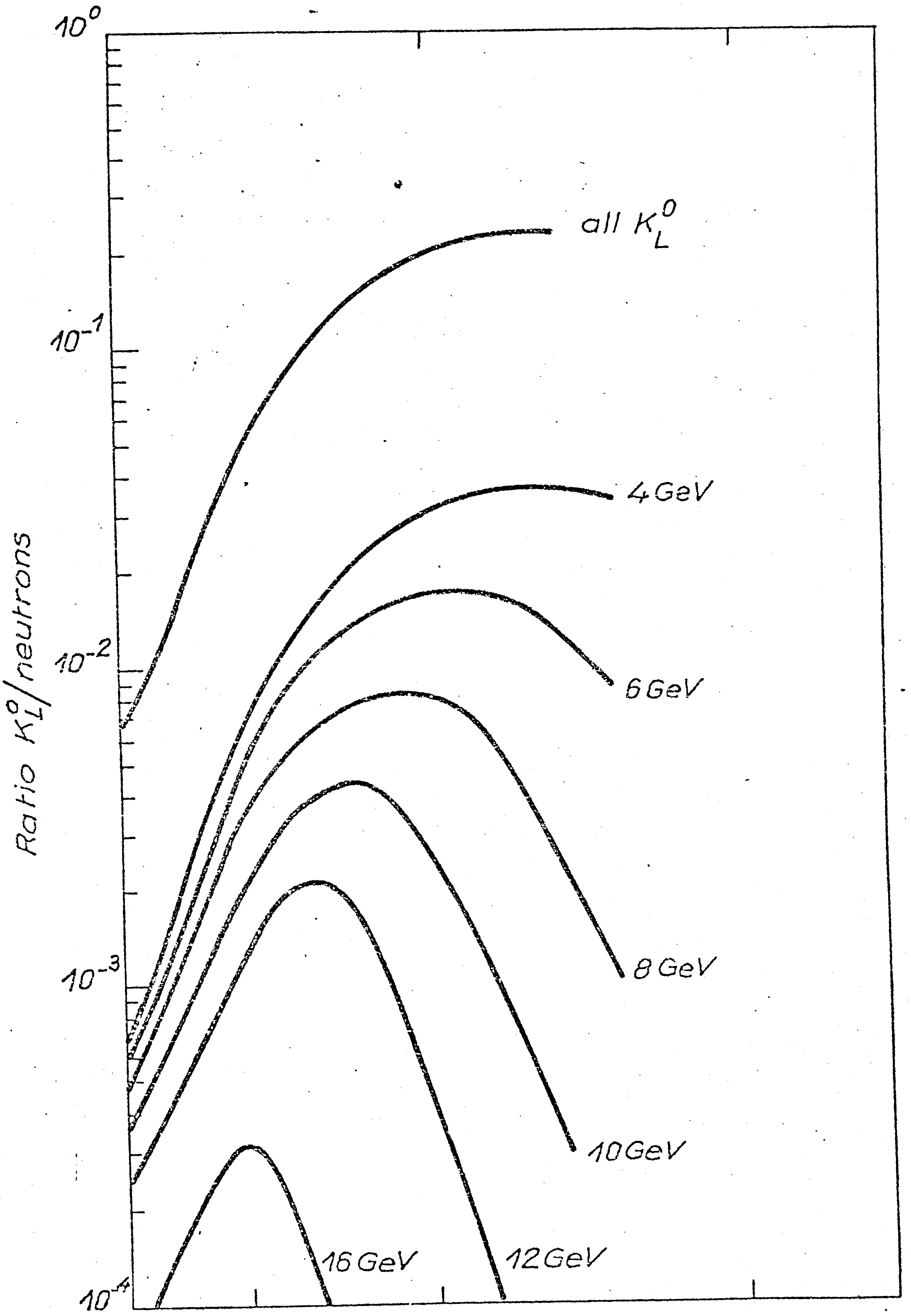

K°_L / GeV/c. str. Intersecting proton
0.15
0.10
0.05
0
5
10
15
20
0 mrad , 50 m
0 mrad
40 mrad
40 mrad, 50 m

FIG. 3



$10^0$
$10^{-1}$
$10^{-2}$
$10^{-3}$
$10^{-4}$
Ratio $K_L^0$/neutrons
all $K_L^0$
4 GeV
6 GeV
8 GeV
10 GeV
12 GeV
16 GeV
40
100
200
PRODUCTION ANGLE [milliradians]

FIG. 4