UR-449

COO-3065-51
FERMILAB-PUB-73-152-E

Some Remarks Concerning K_S^o and Λ Production in High Energy Proton-Proton Collisions*

D. Cohen†

Department of Physics and Astronomy
University of Rochester
Rochester, N.Y. 14627

Contract Number AT (11-1) 3065

August 1, 1973

We observe that the topological cross sections for K_S^o and Λ production in high energy proton-proton collisions can be parameterized within the framework of the KNO semi-inclusive scaling prediction in the same manner as the charged-particle and π^o topological cross sections. We also note that the $K_S^o\pi^-$ and $\Lambda\pi^-$ correlations seem to exhibit a weaker energy dependence than the $\pi^o\pi^-$ correlations over a range of beam momenta extending from 69 GeV/c to 303 GeV/c.

To be published in Physics Letters.

*Research supported by the United States Atomic Energy Commission. The computer analysis was made possible through funds provided by The University of Rochester.

†Address after September 1, 1973: Nevis Laboratories, Columbia University, Irvington, N.Y.

Within the past year, bubble chamber exposures from Serpukhov and from the National Accelerator Laboratory (NAL) have provided physicists with a detailed look at proton-proton interactions in the 50-400 GeV/c energy range. Several aspects of these experiments have already been discussed in the literature[1].

One of the most striking phenomena observed in these high energy experiments has been the seeming regularity of the behavior of the topological cross sections. In particular, Slattery[2] has shown that the semi-inclusive scaling prediction of Koba, Nielsen, and Olesen[3] (KNO) for the charged-particle topological cross sections is extremely well satisfied by the data over a momentum range of from 50 GeV/c to 303 GeV/c. The KNO prediction is that

$$\langle n\rangle \frac{\sigma_n}{\sigma_{inel}} = \psi\left(\frac{n}{\langle n\rangle}\right) \qquad (1)$$

where σ_n is the topological cross section for the reaction $pp \rightarrow n$ charged particles at a particular value of the square of the center of mass energy, s, σ_{inel} is the total inelastic pp cross section, $\langle n\rangle$ is the mean number of charged particles produced at the particular value of s, and ψ is an energy independent function.

Dao and Whitmore[4] have recently derived a new form of KNO scaling which is applicable to the semi-inclusive reaction $pp \rightarrow \pi^o + n$ charged particles. The scaling law for semi-inclusive π^o production is

$$\frac{\langle n\rangle}{\langle n_{\pi^o}\rangle} \frac{\sigma_n(\pi^o)}{\sigma_{inel}} = \phi\left(\frac{n}{\langle n\rangle}\right) \qquad (2)$$

where $\langle n \rangle$ and $\langle n_{\pi^o} \rangle$ are the mean numbers of charged particles and π^o's, respectively, produced at a particular value of s, $\sigma_n(\pi^o)$ is the inclusive π^o cross section at a particular value of the charged-particle multiplicity, n, and ϕ is an energy independent function. This scaling law is also found to be in excellent agreement with the existing data on high energy π^o production in pp collisions[4].

We examine in this note the semi-inclusive reactions

$$pp \rightarrow K_S^o + n \text{ charged particles} \tag{3}$$

and

$$pp \rightarrow \Lambda + n \text{ charged particles} \tag{4}$$

within the framework of the KNO scaling prediction. The KNO prediction for the above reactions is given by equation (2), with π^o being replaced by either K_S^o or Λ. We note that the energy independent function $\phi(\frac{n}{\langle n \rangle})$ need not be the same for reactions (3) and (4) as it is for semi-inclusive π^o production. We wish to point out that the extension of equation (2) to strange-particle production is by no means guaranteed by the fact that it works for π^o production. The behavior of the K_S^o/π^o and Λ/π^o production cross section ratios as a function of the associated charged-particle multiplicity is not clear from presently available data. In particular, the data from 69 GeV/c to 303 GeV/c[5] indicate that the Λ/π^o ratio is strongly dependent upon the associated charged-particle multiplicity.

In order to test the scaling prediction of equation (2) for strange particles, we plot in Figs. 1 and 2 the available high energy pp data on K_S^o and Λ production[5], respectively, as a function of $\frac{n}{\langle n \rangle}$. The smooth

curves drawn on these distributions are the result of a least squares fit of the data to a function of the form $\phi(\frac{n}{\langle n\rangle}) = \exp(\sum_{j=0}^{3} a_j (\frac{n}{\langle n\rangle})^j)$. The coefficients a_j for the K_S^o and Λ fits are given in Table I. The χ^2 between these functions and the experimental data is 16.1 for 26 degrees of freedom for the K_S^o's, and 10.0 for 16 degrees of freedom for the Λ's. The K_S^o and Λ topological cross sections for the high energy pp data presently available can therefore be described by a functional form that depends only on $\frac{n}{\langle n\rangle}$, and hence are consistent with the semi-inclusive scaling prediction of equation (2). Thus, the strange-particle topological cross sections in high energy pp collisions from 69 GeV/c to 303 GeV/c can be parameterized in the same energy independent manner as the charged-particle and π^o topological cross sections.[6]

We have also investigated $K_S^o\pi^-$ and $\Lambda\pi^-$ correlations by examining the Mueller correlation parameter f_2.[7] For non-identical particles a and b, f_2 is defined as

$$f_2^{ab} = \langle n_a n_b\rangle - \langle n_a\rangle \langle n_b\rangle .$$

We plot in Fig. 3 $f_2^{\pi^- K_S^o}$ and $f_2^{\pi^-\Lambda}$ for the available high energy pp data. The errors on these quantities are relatively large, and several interpretations of the energy dependence of these f_2's are certainly possible. It appears, however, that these quantities do not exhibit as strong an energy dependence as $f_2^{\pi^-\pi^o}$ over the same energy range. This latter quantity is increasing approximately as $(\ln s)^{3/2}$ from 69 GeV/c to 303 GeV/c.[4]

I wish to thank T. Ferbel and P. Slattery for critically reading this note, and F.T.Dao and J. Whitmore for bringing their analysis to my attention.

Table I

Coefficients for Least Squares Fit to K_S^o and Λ Data

Coefficient	K_S^o	Λ
a_0	-2.38 ± 0.57	-1.13 ± 0.75
a_1	7.08 ± 1.67	4.59 ± 2.62
a_2	-4.95 ± 1.47	-3.39 ± 2.67
a_3	0.85 ± 0.39	0.45 ± 0.82

References

1. See, for example, Proceedings of the International Conference on Multiparticle Production, Vanderbilt University, Nashville, to be published.

2. P. Slattery, Phys. Rev. Letters 29, 1624 (1972) and Phys. Rev. D7, 2073 (1973).

3. Z. Koba, H. B. Nielsen, and P. Olesen, Nucl. Phys. B40, 317 (1972).

4. F. T. Dao and J. Whitmore, NAL Preprint NAL-Pub-73/47-EXP.

5. The data used in this paper are derived from the following sources:
69 GeV/c: French-Soviet Collaboration, Contribution to the International Conference on Multiparticle Production, Vanderbilt University, Nashville, (1973);
102 GeV/c: Michigan-Rochester Collaboration, to be published.
205 GeV/c: G. Charlton et al., Phys. Rev. Letters 30, 574 (1973).
303 GeV/c: F. T. Dao et al., NAL Preprint NAL-Pub-73/21-EXP and UCLA-1071.

6. Although the data presented here and in references 2 and 4 are consistent with the KNO prediction, we note that small systematic deviations from semi-inclusive scaling might be apparent in the more sensitive new data on charged-particle multiplicity distributions. See A. Wroblewski, Lecture given at the XIII Cracow School of Theoretical Physics, Zakopane, June, 1973, to be published in Acta Physica Polonica.

7. A. H. Mueller, Phys. Rev. D4, 150 (1971).

Figure Captions

1. $\frac{\langle n \rangle}{\langle n_{K_S^o} \rangle} \frac{\sigma_n(K_S^o)}{\sigma_{inel}}$ as a function of $n/\langle n \rangle$ for the reaction $pp \to K_S^o + n$ charged particles. The solid curve is the result of a fit to the data.

2. $\frac{\langle n \rangle}{\langle n_\Lambda \rangle} \frac{\sigma_n(\Lambda)}{\sigma_{inel}}$ as a function of $n/\langle n \rangle$ for the reaction $pp \to \Lambda + n$ charged particles. The solid curve is the result of a fit to the data.

3. (a) The correlation parameter $f_2^{\pi^- K_S^o}$ as a function of the beam momentum.

   (b) The correlation parameter $f_2^{\pi^- \Lambda}$ as a function of the beam momentum.

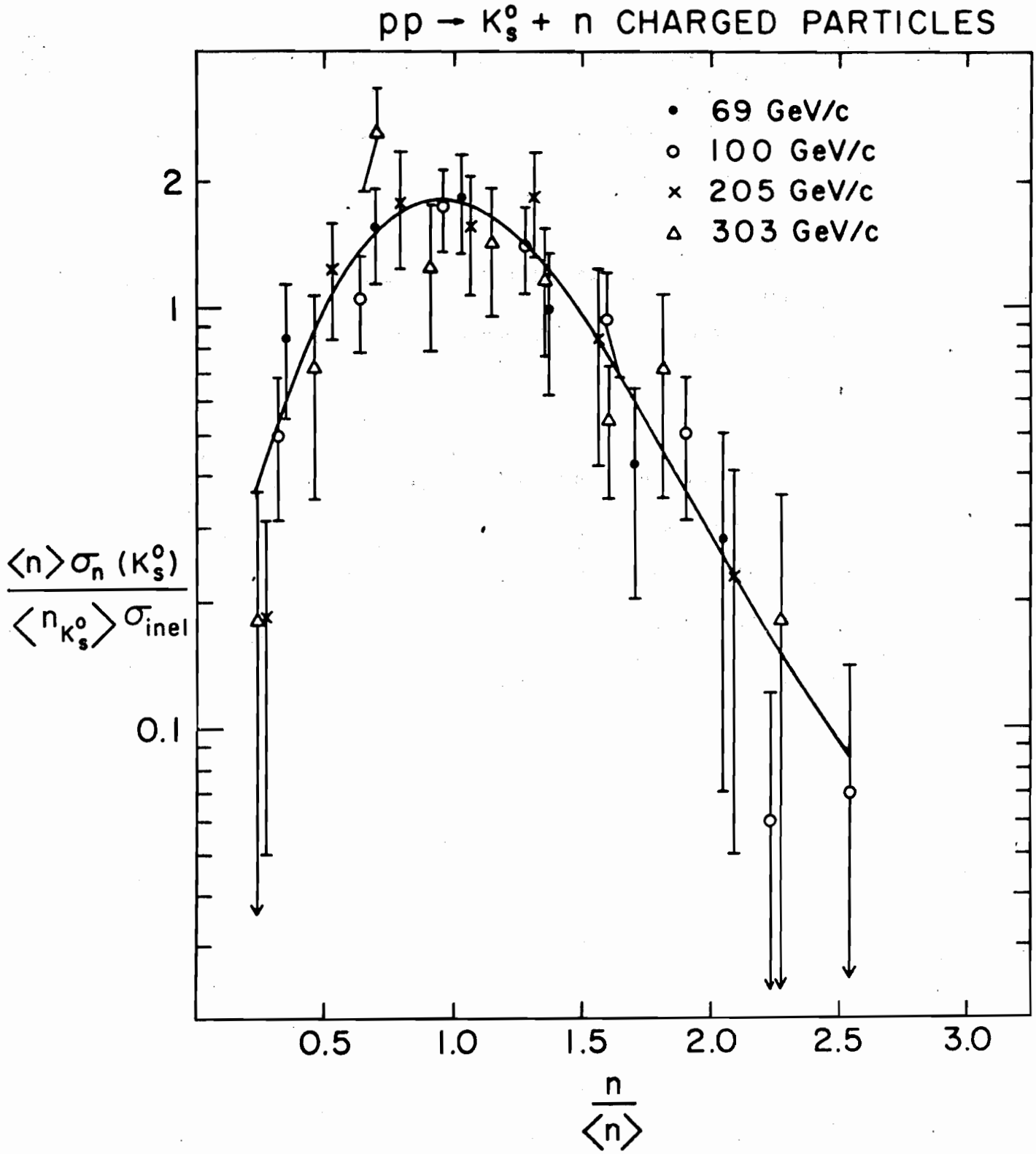
pp → K^0_s + n CHARGED PARTICLES
69 GeV/c
100 GeV/c
205 GeV/c
303 GeV/c
2
1
0.1
$\frac{\langle n \rangle \sigma_n (K^0_s)}{\langle n_{K^0_s} \rangle \sigma_{inel}}$
0.5
1.0
1.5
2.0
2.5
3.0
$\frac{n}{\langle n \rangle}$

Fig 1

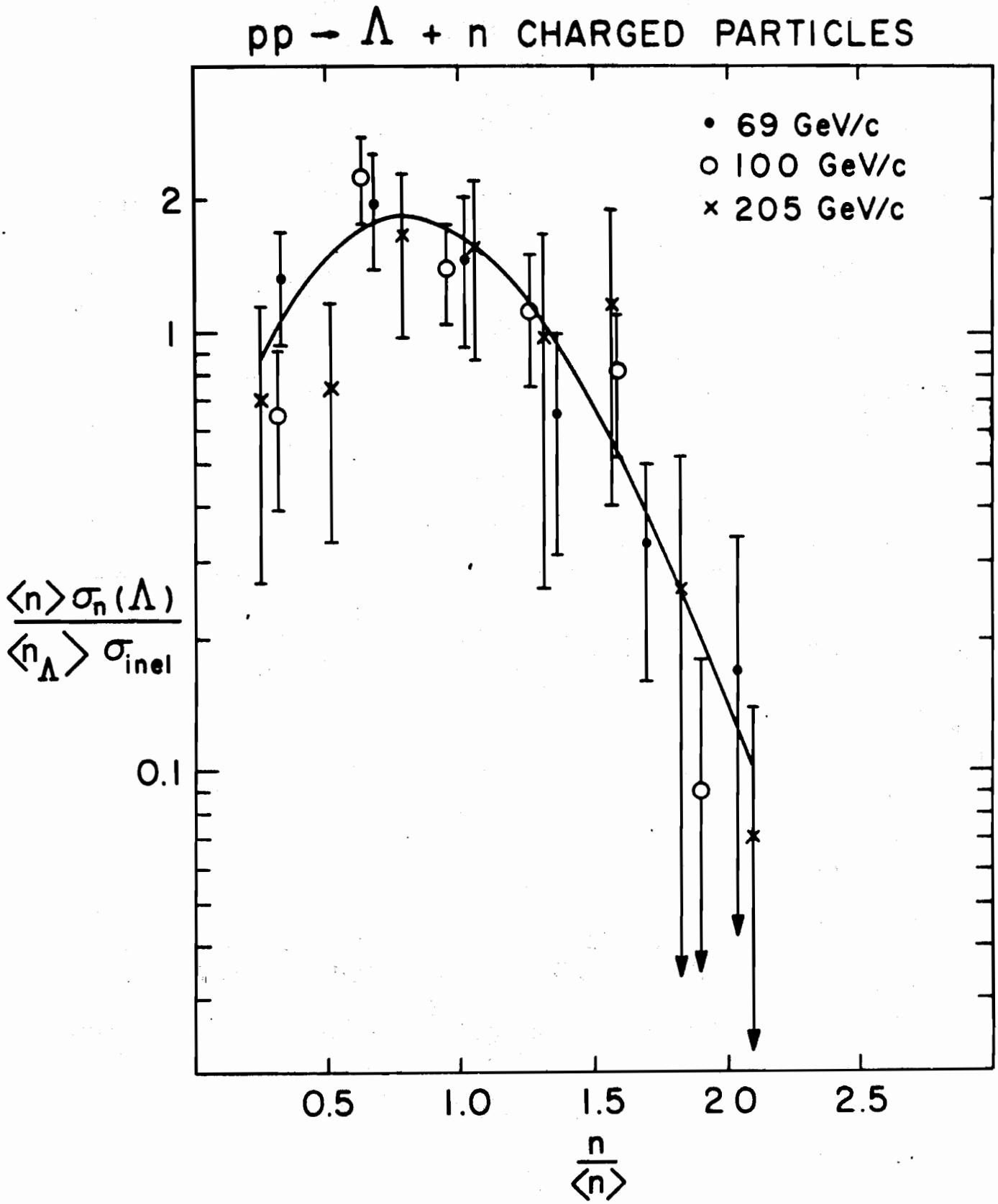
pp → Λ + n CHARGED PARTICLES
• 69 GeV/c
○ 100 GeV/c
× 205 GeV/c
2
1
0.1
$\frac{\langle n \rangle \sigma_n(\Lambda)}{\langle n_\Lambda \rangle \sigma_{inel}}$
0.5
1.0
1.5
2.0
2.5
$\frac{n}{\langle n \rangle}$

Fig 2

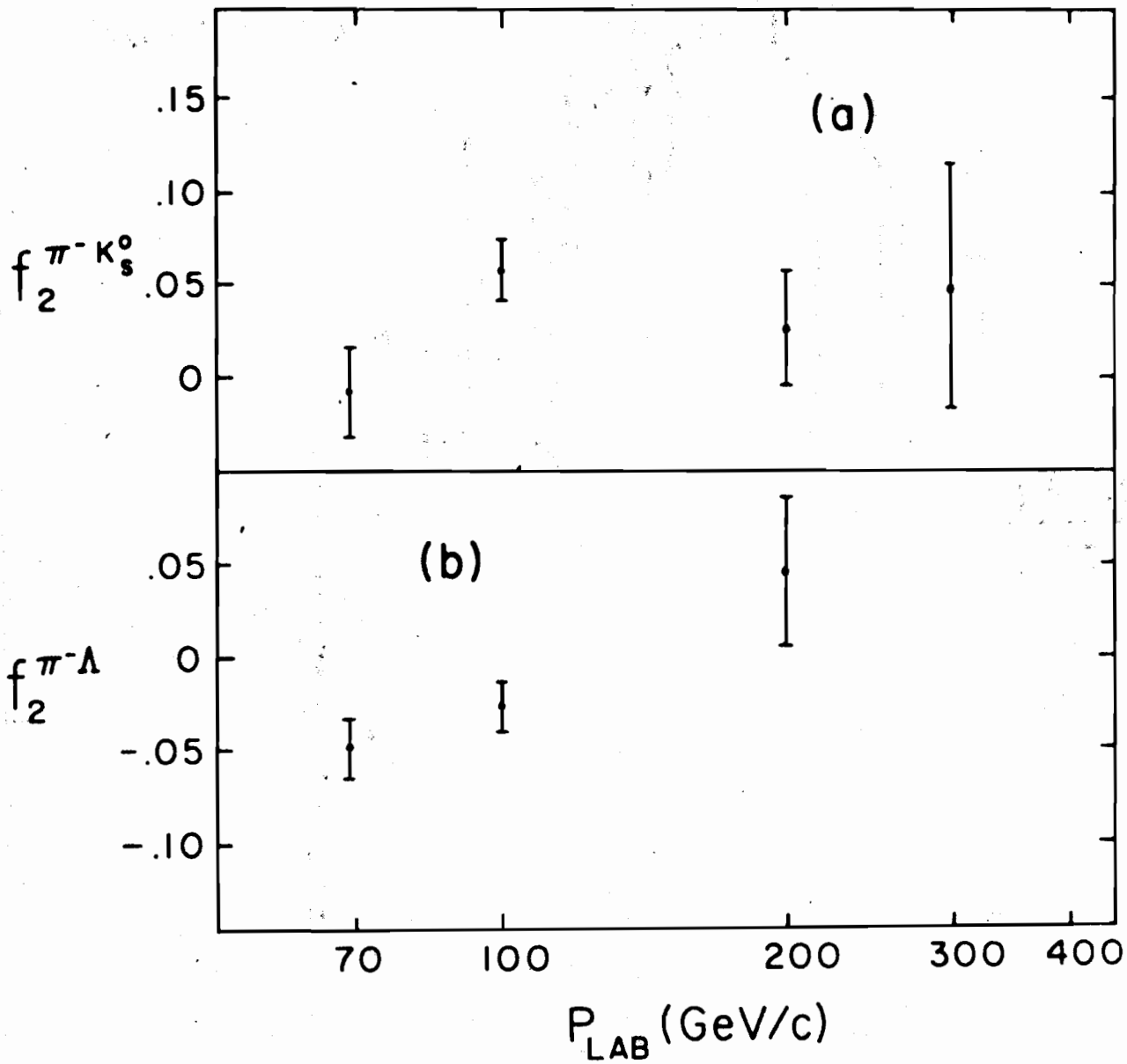
(a)
(b)
.15
.10
.05
0
-.05
-.10
$f_2^{\pi^- K_s^0}$
$f_2^{\pi^- \Lambda}$
70
100
200
300
400
P_{LAB} (GeV/c)

Fig 3