EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN/EP 87-99
2 June 1987

STRANGENESS AND DIQUARK SUPPRESSION FACTORS IN 360 GeV/c pp INTERACTIONS

EHS-RCBC Collaboration(*)

Bombay[1], Budapest[2], CERN[3], Chandigarh[4], Genova[5], Innsbruck[6], Japan-UG[7], Madrid[8], Mons[9], Moscow[10], Rutgers[11], Serpukhov[12], Tennessee[13] and Vienna[14] Collaboration

J.L. Bailly[9], S. Banerjee[1], W. Bartl[14], F. Bruyant[3], B. Buschbeck[14], C. Caso[5], H. Dibon[14], F. Diez-Hedo[8], B. Epp[6], A. Ferrando[8], F. Fontanelli[5], S.N. Ganguli[1], P. Girtler[6], I.V. Gorelov[10], A. Gurtu[1], P. Herquet[9], J. Hrubec[14], Yu. Ivanyushenkov[12], N. Khalatyan[12], E. Kistenev[12], S. Kitamura[7(a)], J.M. Kohl[4], V. Kubik[12], J.C. Marin[3], S. Matsumoto[7(b)], I.S. Mittra[4], L. Montanet[3], G. Neuhofer[3], P. Porth[14], R. Raghavan[1], T. Rodrigo[8], J.M. Salicio[8], J.B. Singh[3], S. Squarcia[5], K. Takahashi[7(c)], L.A. Tikhonova[10], U. Trevisan[5], T. Tsurugai[7(a)], T. Yamagata[7(a)], G. Zholobov[12] and S. Zotkin[10]

1. Tata Institute of Fundamental Research, 400005 Bombay, India
2. Central Research Institute for Physics, 1525 Budapest 114, Hungary
3. CERN, European Organization for Nuclear Research, Geneva, Switzerland
4. Panjab University, 160014 Chandigarh, India
5. University of Genova and INFN, 16146 Genova, Italy
6. Institut für Experimentalphysik, 6020 Innsbruck, Austria(*)
7(a) Tokyo Metropolitan University, 158 Tokyo, Japan
7(b) Chuo University, Tokyo, Japan
7(c) Tokyo University of Agriculture and Technology, Tokyo, Japan
8. Junta de Energia Nuclear, Madrid 3, Spain
9. Université de l'Etat, Faculté des Sciences, 7000 Mons, Belgium
10. Moscow State University, SU-117234 Moscow, USSR
11. Rutgers University,New Brunswick, NY 08903, USA
12. Institute for High Energy Physics, Serpukhov, SU-142284, Protvino, USSR
13. University of Tennesse, Knoxville, TN 37916, USA
14. Institut für Hochenergiephysik, 1050 Wien, Austria(*)

Submitted to Physics Letters B

(*) Supported by: Fonds zur Forderung der Wissenschaftlichen Forschung.

EP/3608P/LM/mk

ABSTRACT

From the measurements of the inclusive production ratios between π^-, K^- and $\bar{p}$ at Feynman x = 0 in 360 GeV/c pp interactions and using the predictions of the Lund Fragmentation Model, we determine the strangeness and diquark suppression factors and find $\gamma_{s,\ell} = 0.28 \pm 0.03$ and $\gamma_{D,\ell} = 0.063 \pm 0.011$.

A considerable effort has been dedicated to the experimental study of hadro-production hard processes in e^+e^- annihilations, deep inelastic lepton-hadron scattering and large p_T hadron collisions. The data were successfully analyzed within the framework of the quark-parton model and of the Perturbative Quantum Chromodynamics.

Contrasting with this situation, the knowledge on particle production in soft processes is much less complete although it represents the largest part of the total hadronic cross sections. This is largely due to the limited theoretical understanding of these processes but also due to the lack of detailed experimental data. The most recent developments of the quark models for soft particle production have been reviewed in refs [1-3].

In this letter we report on the measurement of the strange to light quark, as well as diquark to light quark production ratios ($\gamma_{s,\ell}$ and $\gamma_{D,\ell}$), studying the inclusive particle production ratios in pp collisions at 360 GeV/c beam momentum at x = 0. This is made possible by the use of the charged particle identification capabilities of the European Hybrid Spectrometer, which is particularly efficient for particles produced with Feynman $|x| \leq 0.1$. The ratios, at x = 0, are compared to the Lund Fragmentation Model expectations [4] for various production ratios from the vacuum of strange to ordinary quarks pairs, and diquark to quark pairs, using the Lund Monte-Carlo program [4] with standard parameters. The production ratios $\gamma_{s,\ell}$ and $\gamma_{D,\ell}$ are then compared with those obtained for other production processes.

The present study is based on experiment NA23 performed at CERN using the Rapid Cycling Bubble Chamber (RCBC) and the European Hybrid Spectrometer (EHS) set-up. The RCBC, filled with liquid hydrogen, was exposed to a 360 GeV/c proton beam. Relevant details about the spectrometer performances and the trigger procedure are given elsewhere [5-9]. Results on inclusive particle production obtained from the same experiment can be found in refs [7,9].

For this analysis, we extract from the NA23 data, a sample of 8560 fully reconstructed events (all charged tracks have been successfully reconstructed). This sample is selected in such a way that it satisfies the known multiplicity distribution measured at this energy [5]. It therefore gives a good representation of the total inelastic cross section observed at this energy for proton-proton interactions.

To avoid the main effects due to the fragmentation of the incident protons, only negative hadrons are considered.

The sample consists of 30 151 negative tracks. 80.1% of the negative tracks lie in the $-0.1 \leq x \leq 0.1$ region (assuming they are all pions).

Particle identification was provided by ISIS [10,11]. ISIS is a $(4 \times 2 \times 5.12)m^3$ pictorial drift chamber, which identifies charged particles by ionization sampling. ISIS geometrical acceptance was calculated by Monte-Carlo simulation of π^-, K^- and $\bar{p}$ tracks propagated into the central ISIS plane perpendicular to the beam direction and located at 8.05 m from the center of RCBC. The production vertex coordinates were simulated according to the experimental distributions observed in RCBC. The simulation was repeated for various intervals of momentum of the secondary particles.

From ISIS information and from the ionization expected for a particle with a given mass and momentum, a χ^2 probability is calculated for each mass hypothesis. ISIS information is only used for tracks satisfying good measurability criteria [11]: 63.6% satisfy these criteria. This limitation does not affect $\pi^-/K^-/\bar{p}$ ratios in the momentum region considered here.

The statistical separation between different charged particles (π^-, K^- and $\bar{p}$), in various Feynman x intervals, is achieved by a maximum likelihood fit to the data. Since the logarithm of ionisation is normally distributed with different central values for different masses [12], we write the likelihood

$$\ell n\, L = \sum_{i=1}^{\text{tracks}} \ell n \left(\sum_{j=1}^{4} P_j^i N_j \right) - \sum_{j=1}^{4} N_j$$

with

$$P_j^i = \exp[-\tfrac{1}{2} (\ell n\, I_{th}^j - \ell n\, I_m^i)/\sigma_i^2].$$

$\sigma_i = 0.60/\sqrt{n_i}$; n_i: number of ISIS wires used

where

- $j = e, \pi, K, p$ mass hypothesis.
- I^i_m is the measured ionization of track i.
- I^j_{th} is the theoretical ionization for a mass hypothesis j.
- N_j is the fitted amount of tracks for a mass hypothesis j.

Only measurements having an ISIS probability larger than 1% for at least one mass hypothesis and a $\Delta p/p \leq 20\%$ were taken into account in the likelihood.

The resulting inclusive production differential cross sections as function of x in the region $-0.1 \leq x \leq 0.1$ for π^-, K^- and $\bar{p}$ are shown in figs 1(a) to 1(c) respectively. The errors in the negative x_F region reflect the low number of tracks which reach ISIS if produced at $x < 0$. These cross sections have been corrected for geometrical acceptance and ISIS inefficiency.

The data have been fitted (full line in the figures) to the form: $f(x) = A\,(1-|x|)^B$, as suggested by several quark models, obtaining for the exponent the values $B(\pi^-) = 20.83 \pm 0.55$, $B(K^-) = 13.35 \pm 2.45$ and $B(\bar{p}) = 6.36 \pm 3.11$.

The values of the fitted normalization parameters A give directly the production cross section at x = 0. Those values turned out to be

$$\sigma|(pp \to \pi^-)|_{x=0} = 1045.6 \pm 23.6 \text{ mb}$$

$$\sigma|(pp \to K^-)|_{x=0} = 54.9 \pm 4.9 \text{ mb}$$

$$\sigma|(pp \to \bar{p})|_{x=0} = 12.2 \pm 1.9 \text{ mb}$$

We then find

$$R_1 = \sigma(pp \to K^-)/\sigma(pp \to \pi^-)_{x=0} = 0.053 \pm 0.005$$

$$R_2 = \sigma(pp \to \bar{p})/\sigma(pp \to \pi^-)_{x=0} = 0.012 \pm 0.002.$$

R_1 and R_2 have also been estimated, using the Lund generation program JETSET V6.2 [4], with different values of $\gamma_{s,\ell}$ and $\gamma_{D,\ell}$. The ratios R_1 and R_2 being linear in $\gamma_{s,\ell}$ and $\gamma_{D,\ell}$ respectively a linear interpolation yields the following results:

$$\gamma_{s,\ell} = 0.28 \pm 0.03$$

and

$$\gamma_{D,\ell} = 0.063 \pm 0.011$$

We give in fig. 2 a comparison of the strangeness suppression factor observed for our experiment to those observed in other experiments [13]. Our point agrees well with the general trend of a slight increase of $\gamma_{s\ell}$ with the available energy W, in particular for hadron-hadron interactions.

The result found for $\gamma_{D\ell}$ is in good agreement with the value obtained in muon-nucleon interactions at 280 GeV/c [13](h), $\gamma_{D\ell} \simeq 0.065$, but it is significantly below the value needed to interpret the e^+e^- interactions [14], $\gamma_{D\ell} \simeq 0.09$.

REFERENCES

[1] P.D.B. Collins and A.D. Martin, Rep. Prog. Phys. 45 (1982) 335.

[2] K. Fialkowski and W. Kittel, Rep. Prog. Phys. 46 (1983) 1283.

[3] Proc. Europhysics study Conf. on Partons in soft hadronic processes, Erice, Ed. R.T. Van der Walle, Singapore: World Scientific (1981).

[4] B. Andersson et al., Phys. Rep. 97 (1983) 31.

We use JETSET V6.2 of the Lund Monte-Carlo computation for our analysis.

[5] J.L. Bailly et al., Zeitschr. für Phys. C23 (1984) 205.

[6] J.L. Bailly et al., Zeitschr. für Phys. C22 (1984) 119.

[7] M. Asai et al., Zeitschr. für Phys. C27 (1985) 11.

[8] T. Aziz et al., Zeitschr. für Phys. C30 (1986) 381.

[9] J.L. Bailly et al., TMU-HEL-8407.

[10] W.W.M. Allison and J.H. Cobb, Ann. Rev. Nucl. Part. Sci. 30 (1980) 253.

[11] W.W.M. Allison et al., Nucl. Instr. and Meth. 119 (1974) 499.

[12] L. Lyons and W.W.M. Allison, Maximum likelihood or extended maximum likelihood, Oxford Univ. Nucl. Phys. Lab. Ref 41/85.

[13] (a) I. Cohen et al., Phys. Rev. Lett. 40 (1978) 1614;

(b) V.V. Ammosov et al., Phys. Lett. 93B (1980) 210;

(c) E. Wittek, MPI-PAE/exp. El 138, presented at the XIth International Conference on Neutrino Physics and Astrophysics, Nordkirchen, June 1984;

(d) W. Bartel et al., Zeitschr. für Phys. C20 (1983) 187;

(e) P.V. Chliapnikov et al., Nucl. Phys. B176 (1980) 303;

(f) S. Banerjee et al., Zeitschr. für Phys. C31 (1986) 401;

(g) H. Kichimi et al., Phys. Rev. D20 (1979) 37;

(h) M. Arneodo et al., CERN EP 86/160 and F. Montanet, PhD, CPP Marseille, France.

(i) A. Breakstone et al., Phys. Lett. 135B (1984) 510;

REFERENCES (Cont'd)

(j) T. Muller, Proceedings of the XIVth International Symposium on Multi-particle Dynamics, Lake Tahoe (June 1983), World Scientific Publishing Co., Singapore 1984, p. 528;

[14] H. Aihara et al., Phys. Rev. Lett. 54 (1985) 274;

H. Aihara et al., Phys. Rev. Lett. 52 (1984) 577;

H. Aihara et al., Phys. Rev. Lett. 52 (1984) 2201;

H. Aihara et al., Phys. Rev. Lett. 53 (1984) 274.

FIGURE CAPTIONS

Fig. 1 Inclusive $d\sigma/dx$ distribution in the $-0.1 \leq x \leq 0.1$ region for:

(a) negative pions;

(b) negative kaons;

(c) antiprotons.

Fig. 2 The strangeness suppression factor for various experiments as function of $\sqrt{s}$ minus the mass of projectiles and targets.

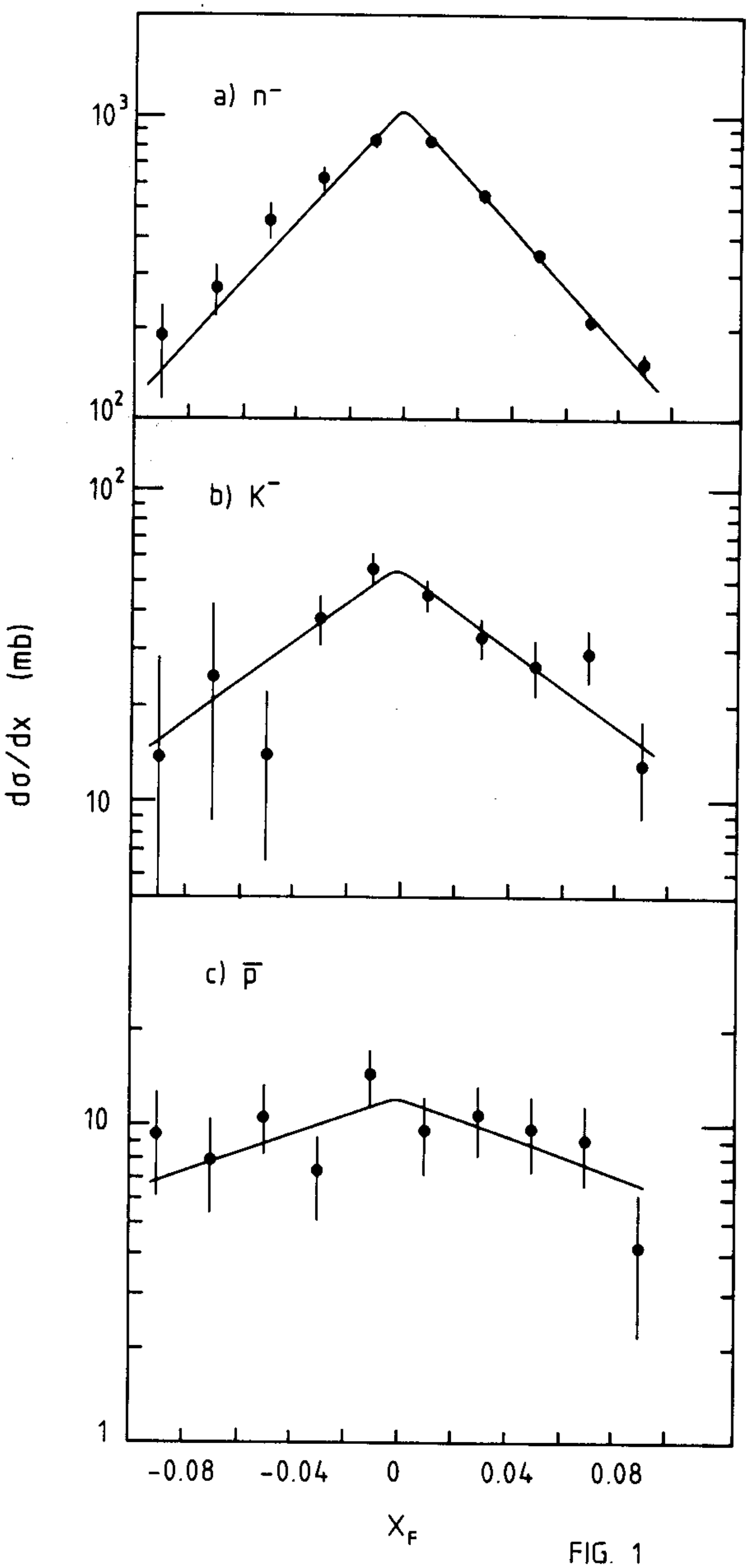
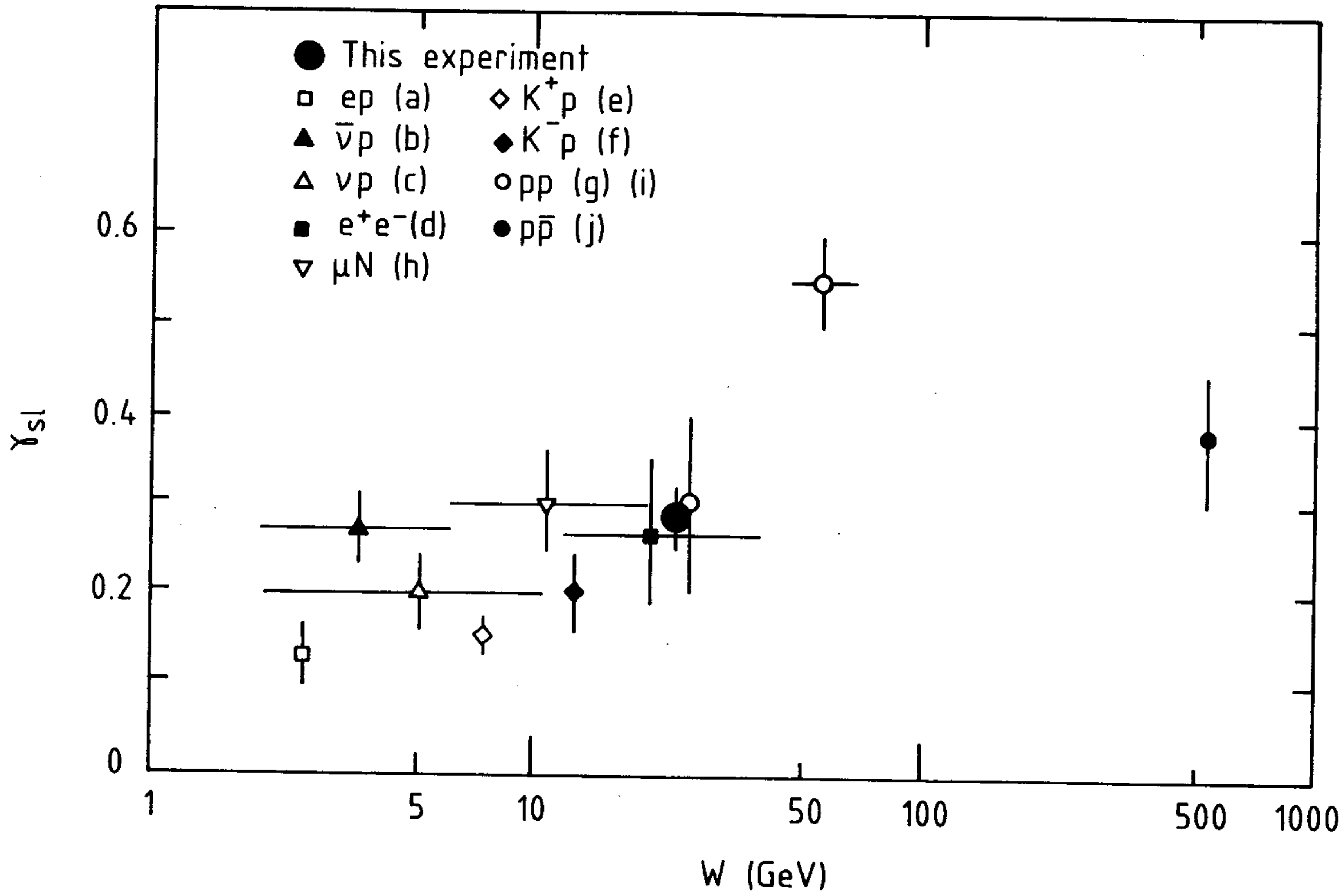


FIG. 1



This experiment
ep (a)
$\bar{\nu}$p (b)
νp (c)
e^+e^-(d)
μN (h)
K^+p (e)
K^-p (f)
pp (g) (i)
p$\bar{p}$ (j)
0.6
0.4
0.2
0
γ_{s}l
1
5
10
50
100
500
1000
W (GeV)

FIG. 2