EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN-EP/81-138
4 November 1981

THE INCLUSIVE MOMENTUM DISTRIBUTIONS IN (pp) REACTIONS COMPARED WITH LOW-ENERGY (e^+e^-) DATA IN THE RANGE $\sqrt{s}$ = 3.0-7.8 GeV

M. Basile, C. Cara Romeo, L. Cifarelli, A. Contin, G. D'Ali,
P. Di Cesare, B. Esposito, P. Giusti, T. Massam, R. Nania,
F. Palmonari, V. Rossi, F. Rohrbach, G. Sartorelli, M. Spinetti,
G. Susinno, G. Valenti, L. Votano and A. Zichichi

CERN, Geneva, Switzerland
Istituto di Fisica dell'Università di Bologna, Italy
Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali di Frascati, Italy
Istituto Nazionale di Fisica Nucleare, Sezione di Bologna, Italy
Istituto di Fisica dell'Università di Perugia, Italy
Istituto di Fisica dell'Università di Roma, Italy

ABSTRACT

Using the method of removing the leading protons, the inclusive fractional momentum distributions of particles produced in low-p_T (pp) interactions have been measured for effective hadronic energies, E_{had}, available for particle production, in the range corresponding to the very low (e^+e^-) c.m. energies $(\sqrt{s})_{e^+e^-}$ = = 3.0-7.8 GeV. The results are in good agreement with (e^+e^-) data. This shows that the similarity with (e^+e^-), already found at higher E_{had}, extends to the lowest energy range in (e^+e^-). The experiment was performed at $(\sqrt{s})_{pp}$ = 30 GeV, at the CERN Intersecting Storage Rings using the Split Field Magnet Facility.

(Submitted to Nuovo Cimento)

1. INTRODUCTION

One of the most significant discoveries in multihadronic systems produced in (e^+e^-) annihilation has been the dramatic rise observed at low fractional momentum of the rate of particles produced[1].

The new way of studying (pp) interaction, based on the subtraction of the "leading" proton effects, has shown an impressive series of analogies in the properties of the multiparticle systems produced in (pp) interactions and in (e^+e^-) annihilation[2-11]. One of these properties is the inclusive fractional momentum distribution of the particles produced[2].

So far, owing to technical reasons and the corresponding experimental bias in the effective hadronic energy, it was impossible in the (pp) case (because of the too high incident proton energies) to reach the same low value, for the effective hadronic energy, E_{had}, as for the low-energy (e^+e^-) case. Thus our observation of the same behaviour in the inclusive fractional momentum distributions could not be established down to the lowest energy range.

The purpose of this paper is to report on the inclusive fractional momentum distributions of multiparticle systems produced in (pp) interactions, at low effective hadronic energies, E_{had}, in such a way that, using (pp) data, it is possible to reproduce the total sequence from low to high E_{had}, corresponding to the (e^+e^-) case. This proves that the similarity in the inclusive fractional momentum distributions between (pp) and (e^+e^-) holds true all over the E_{had} range.

2. EXPERIMENTAL APPARATUS AND DATA TAKING

The experiment was performed at the CERN Intersecting Storage Rings with (pp) c.m. energy $(\sqrt{s})_{pp}$ = 30 GeV. A description of the apparatus has already been given elsewhere[12]. The set-up consisted mainly of a large-volume magnetic field, coupled to a powerful system of multiwire proportional chambers. The trigger of the events required, by means of a suitable wire chamber logic, two fast particles, one in the forward and one in the backward hemisphere, with respect to the beam direction. The purpose of this trigger is to obtain events with leading protons detected in the apparatus.

3. DATA ANALYSIS

The procedure of the analysis is the same as described in our previous papers[2-11]. For each hemisphere, the leading proton is determined as the fastest particle, with positive charge and $x \equiv 2|p_L|/\sqrt{s} \geq 0.4$ (p_L = longitudinal momentum). A momentum resolution $\delta p/p \leq 8\%$ is also required. The events with a leading proton detected in the apparatus are then analysed, in order to study the properties of the multiparticle systems produced in the same hemisphere as the leading proton. The available energy for hadron production is defined as

$$E_{had} = \frac{\sqrt{s}}{2} - E_{leading}$$

with $E_{leading}$ being the energy of the leading proton. The momentum distribution of the particles produced is studied in terms of the fractional variable $x_R^* = p/E_{had}$, with p being the momentum of the particle. Only tracks with an estimated momentum resolution of $\delta p/p \leq 30\%$ and a distance d from the vertex of $d \leq 5$ cm were retained in the analysis.

The inclusive fractional momentum distribution, normalized to the number of events, $(1/N_{ev})(dN/dx_R^*)$, has been measured. The number of tracks, dN, is corrected for the acceptance of the apparatus, as determined by a Monte Carlo simulation. N_{ev} is the number of events, i.e. the number of multihadron systems with at least one charged particle produced. In order to take into account the fact that we observe only one hemisphere, we need to normalize each event to a full (e^+e^-) event. This is why the inclusive distributions are multiplied by a factor of two and the c.m. energies are compared in terms of $(\sqrt{s})_{e^+e^-} = 2E_{had}$.

4. RESULTS

Three hadronic energy bands in the SPEAR energy range have been studied: $2E_{had}$ = 3-4, 4-6, 6-9 GeV. The corresponding numbers of analysed events, with at least one charged particle detected, are 184, 488, and 897, respectively.

Our results for the inclusive fractional momentum distributions, $(2/N_{ev})(dN/dx_R^*)$, are shown in Figs. 1-3, where they are compared with the distributions $(1/\sigma)(d\sigma/dx_R)$ from the Mark I experiment[13] ($x_R = 2p/\sqrt{s}$).

The results show that also in the low-energy range there is a good agreement with (e^+e^-) data.

5. CONCLUSIONS

The study of the inclusive fractional momentum distributions of particles produced in low-p_T (pp) interactions, based on the method of removing leading protons, has been extended to the lowest range of the effective hadronic energies. The present results and our previous ones, relative to higher E_{had}, show that the similarity between (pp) interactions and (e^+e^-) annihilations, in the inclusive fractional momentum distributions of the particles produced, holds true all over the energy range investigated so far, i.e. $2E_{had}$ from 3 GeV up to 32 GeV. In particular, going from low to high energy, a similar rise in the rate of particles produced at low fractional momentum is observed in the (pp) as in the (e^+e^-) case.

REFERENCES

1) R. Brandelik et al. (TASSO Collaboration), Phys. Lett. 89B, 418 (1980) and references therein.

2) M. Basile, G. Cara Romeo, L. Cifarelli, A. Contin, G. D'Ali, P. Di Cesare, B. Esposito, P. Giusti, T. Massam, F. Palmonari, G. Sartorelli, G. Valenti and A. Zichichi, Phys. Lett. 92B, 367 (1980).

3) M. Basile, G. Cara Romeo, L. Cifarelli, A. Contin, G. D'Ali, P. Di Cesare, B. Esposito, P. Giusti, T. Massam, R. Nania, P. Palmonari, G. Sartorelli, G. Valenti and A. Zichichi, Phys. Lett. 95B, 311 (1980).

4) M. Basile, G. Cara Romeo, L. Cifarelli, A. Contin, G. D'Ali, P. Di Cesare, B. Esposito, P. Giusti, T. Massam, R. Nania, F. Palmonari, G. Sartorelli, G. Valenti and A. Zichichi, Nuovo Cimento 58A, 193 (1980).

5) M. Basile, G. Cara Romeo, L. Cifarelli, A. Contin, G. d'Ali, P. Di Cesare, B. Esposito, P. Giusti, T. Massam, R. Nania, F. Palmonari, G. Sartorelli, G. Valenti and A. Zichichi, Lett. Nuovo Cimento 29, 491 (1980).

6) M. Basile, G. Cara Romeo, L. Cifarelli, A. Contin, G. D'Ali, P. Di Cesare, B. Esposito, P. Giusti, T. Massam, R. Nania, F. Palmonari, G. Sartorelli, M. Spinetti, G. Susinno, G. Valenti and A. Zichichi, Phys. Lett. 99B, 247 (1981).

7) M. Basile, G. Cara Romeo, L. Cifarelli, A. Contin, G. D'Ali, P. Di Cesare, B. Esposito, P. Giusti, T. Massam, R. Nania, F. Palmonari, G. Sartorelli, M. Spinetti, G. Susinno, G. Valenti, L. Votano and A. Zichichi, Lett. Nuovo Cimento 30, 389 (1981).

8) M. Basile, G. Cara Romeo, L. Cifarelli, A. Contin, G. D'Ali, P. Di Cesare, B. Esposito, P. Giusti, T. Massam. R. Nania, F. Palmonari, G. Sartorelli, M. Spinetti, G. Susinno, G. Valenti, L. Votano and A. Zichichi, Lett. Nuovo Cimento 31, 273 (1981).

9) M. Basile , G. Cara Romeo, L. Cifarelli, A. Contin, G. D'Ali, P. Di Cesare, B. Esposito, P. Giusti, T. Massam. R. Nania, F. Palmonari, V. Rossi, G. Sartorelli, M. Spinetti, G. Susinno, G. Valenti, L. Votano and A. Zichichi, Charged particles multiplicities in (pp) interactions and comparison with (e^+e^-) data, preprint CERN-EP/81-76, submitted to Nuovo Cimento.

10) M. Basile, G. Cara Romeo, L. Cifarelli, A. Contin, G. D'Ali, P. Di Cesare, B. Esposito, P. Giusti, T. Massam, R. Nania, F. Palmonari, V. Rossi, G. Sartorelli, M. Spinetti, G. Susinno, G. Valenti, L. Votano and A. Zichichi, The method of removing the leading protons in the study of high-energy (pp) reactions, compared with the standard analysis, preprint CERN EP/81-88, submitted to Nuovo Cimento.

11) M. Basile, G. Cara Romeo. L. Cifarelli, A. Contin, G. D'Ali, P. Di Cesare, B. Esposito, P. Giusti, T. Massam, R. Nania, F. Palmonari, V. Rossi, G. Sartorelli, M. Spinetti, G. Susinno, G. Valenti, L. Votano and A. Zichichi, The inclusive transverse-momentum distribution of hadronic systems produced in proton-proton collisions, Preprint CERN EP/81-102, submitted to Lett. Nuovo Cimento.

12) R. Bouclier, R.C.A. Brown, E. Chesi, L. Dumps, H.G. Fischer, P.G. Innocenti, G. Maurin, A. Minten, L. Naumann, F. Piuz, and O. Ullaland, Nucl. Instrum. Methods 125, 19 (1975).

13) J.L. Siegrist, Ph.D. Thesis, Report-SLAC 225 (1979).

Figure Captions

Fig. 1 : The inclusive fractional momentum distribution $(2/N_{ev})(dN/dx_R^*)$ $(x_R^* = |\vec{p}|/E_{had})$, for (pp) data at $2E_{had}$ = (3-4) GeV, compared with the distribution $(1/\sigma)(d\sigma/dx_R)$, $(x_R = 2|\vec{p}|/\sqrt{s})$ in (e^+e^-), at $(\sqrt{s})_{e^+e^-}$ = 3 GeV (Mark I).

Fig. 2 : The same distributions as in Fig. 1, at $2E_{had}$ = (4-6) GeV for (pp) data, and $(\sqrt{s})_{e^+e^-} \simeq 4.8$ GeV for (e^+e^-) data.

Fig. 3 : The same distributions as in Fig. 1, at $2E_{had}$ = (6-9) GeV for (pp) data, and $(\sqrt{s})_{e^+e^-}$ = (7.0-7.8) GeV for (e^+e^-) data.

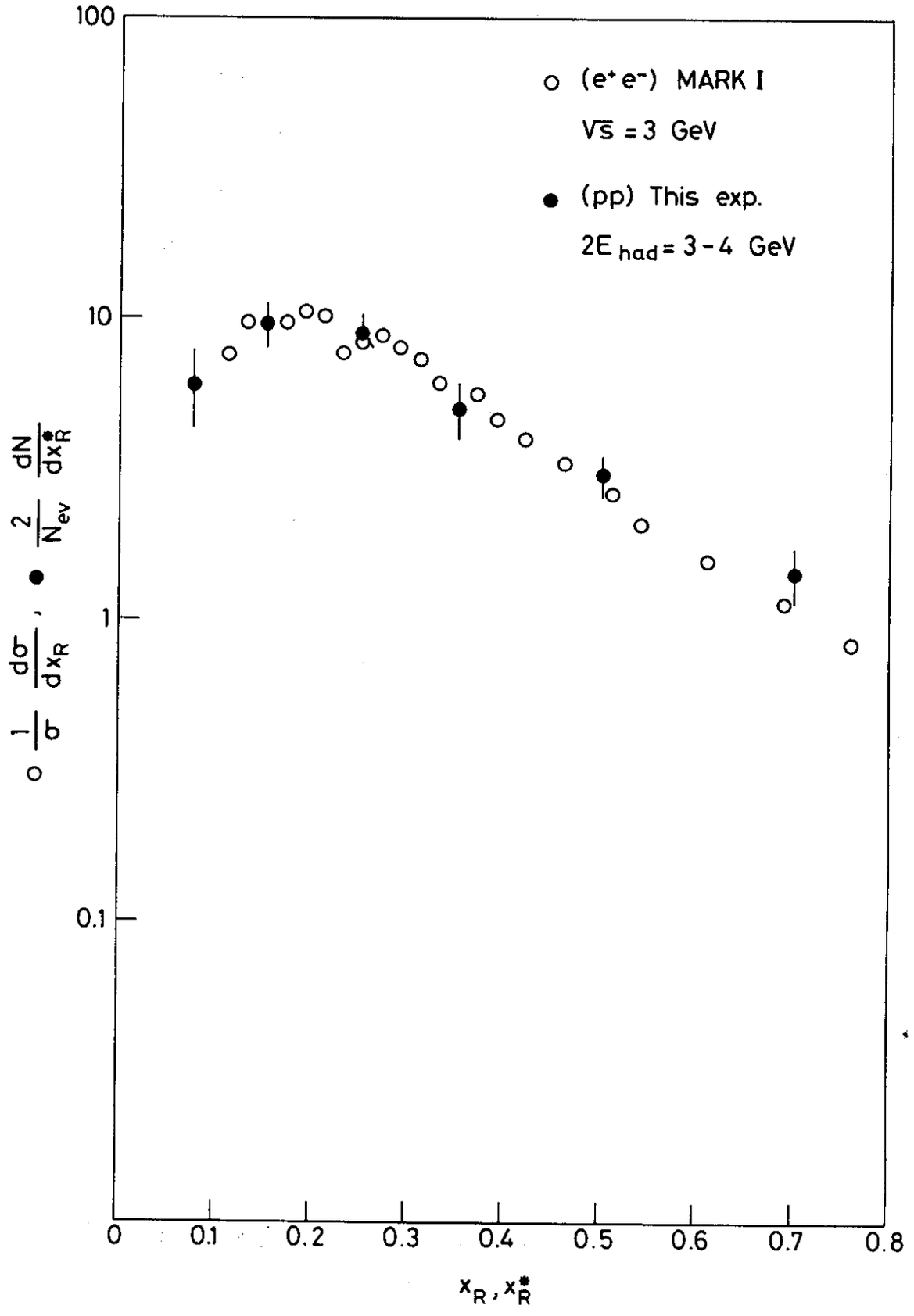
100
10
1
0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
○ (e⁺e⁻) MARK I
√s = 3 GeV
● (pp) This exp.
2E had = 3 - 4 GeV
○ 1/σ dσ/dx_R , ● 2/N_ev dN/dx*_R
x_R , x*_R

Fig. 1

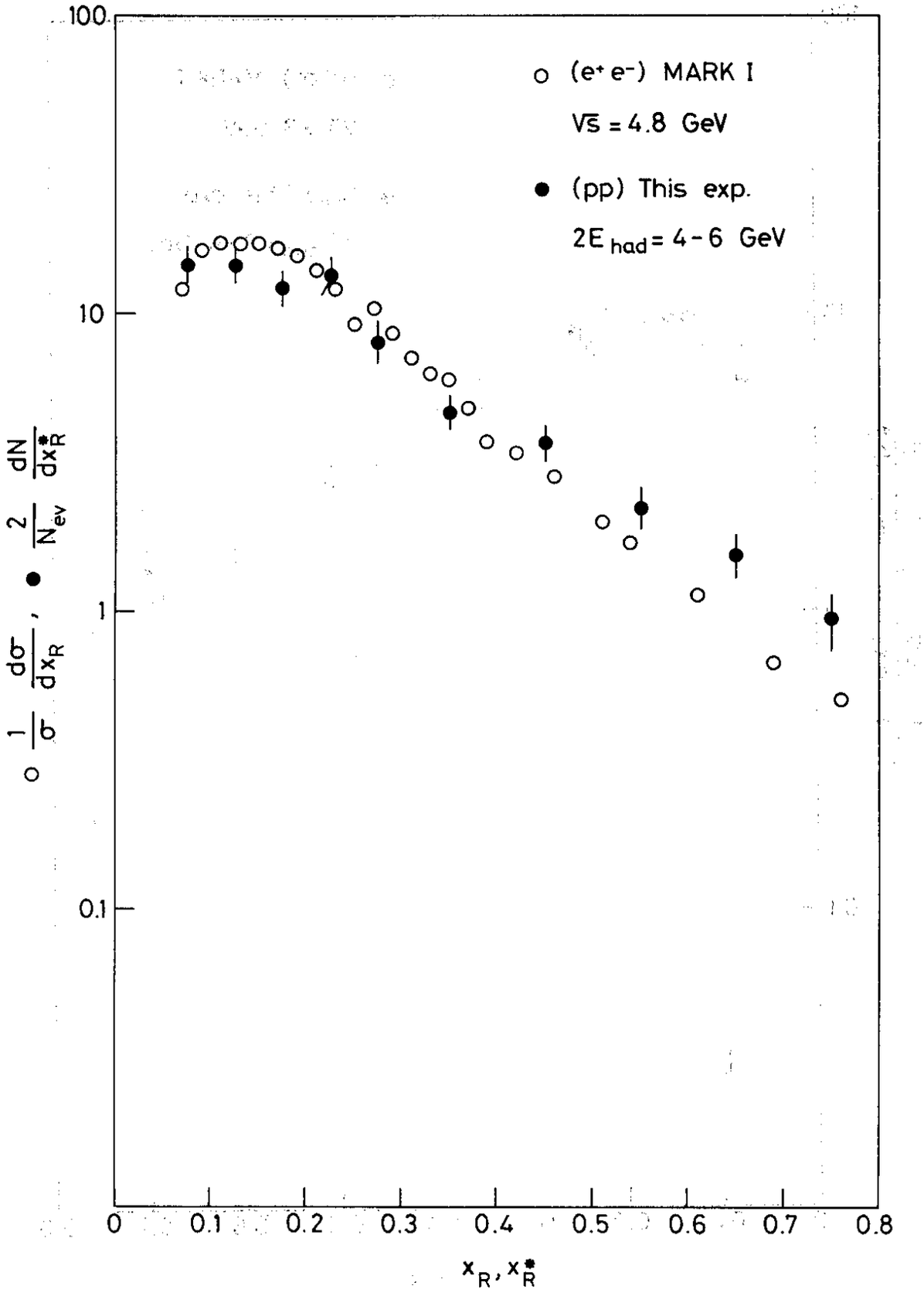
100
10
1
0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
○ (e⁺ e⁻) MARK I
√s = 4.8 GeV
● (pp) This exp.
2E had = 4 - 6 GeV
○ 1/σ dσ/dx_R , ● 2/N_ev dN/dx*_R
x_R, x*_R

Fig. 2

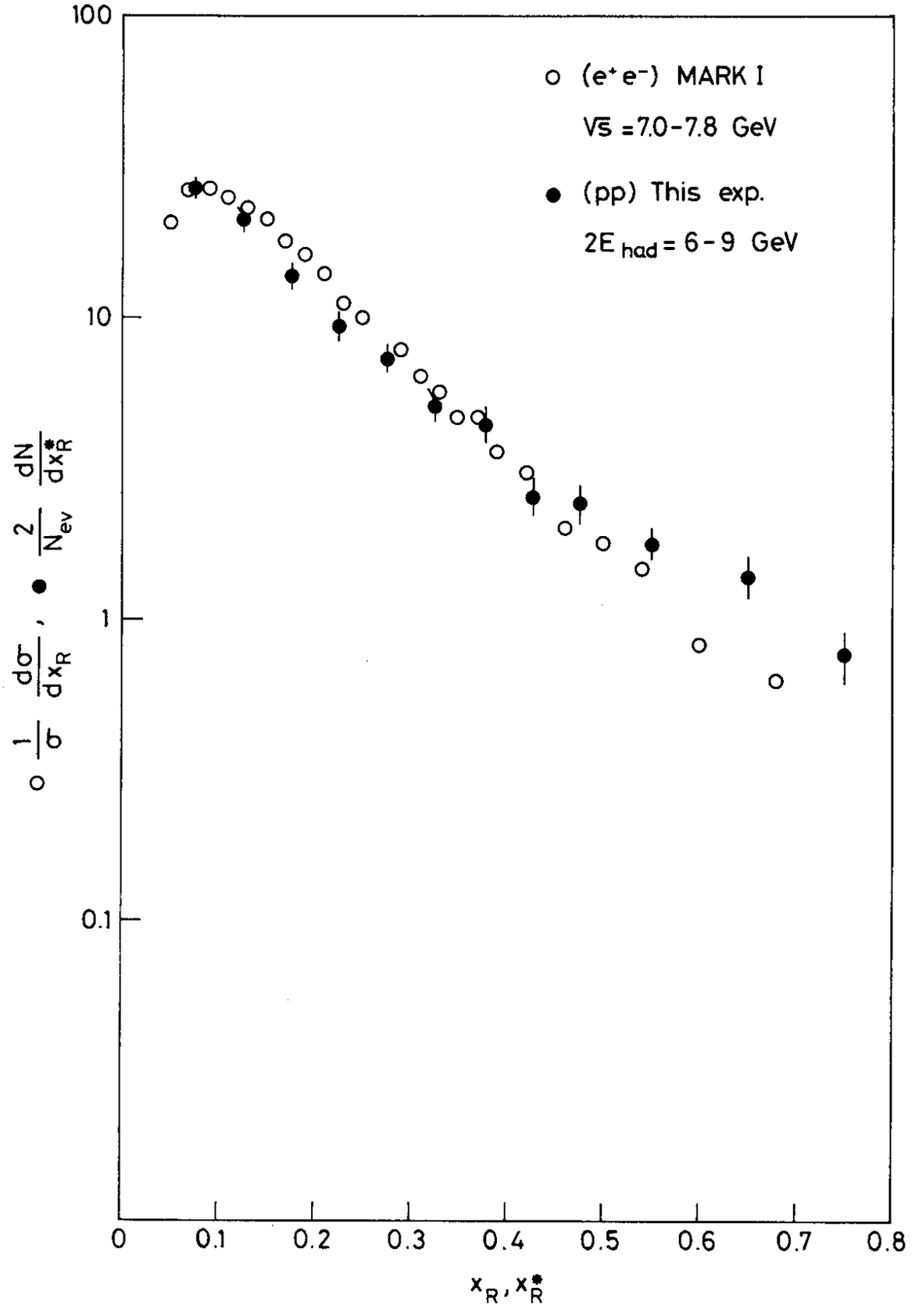
100
10
1
0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
○ (e⁺e⁻) MARK I
√s = 7.0-7.8 GeV
● (pp) This exp.
2E had = 6-9 GeV
○ 1/σ dσ/dx_R , ● 2/N_ev dN/dx*_R
x_R , x*_R

Fig. 3