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THE TRANSVERSE MOMENTUM DISTRIBUTIONS OF PARTICLES
PRODUCED IN pp REACTIONS AND COMPARISON WITH e^+e^-

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ABSTRACT

Following our previous work, the comparison of the properties of multihadron systems, produced in high-energy pp reactions, with hadron jets produced in e^+e^- annihilation, is further extended through the study of the inclusive distributions in the "reduced" variable $p_T/\langle p_T \rangle$.

A good agreement with e^+e^- data is found.

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INTRODUCTION

We have recently reported¹⁻⁷⁾ the results of a new method for studying the multiparticle production properties in pp reactions and comparing them with e^+e^- annihilation. The basic point was to remove the leading particle effect. This analysis has shown that multiparticle systems produced in pp reactions have remarkable similarities with multiparticle systems produced in e^+e^- annihilation.

In this paper the comparison with e^+e^- is further extended to the study of the inclusive transverse momentum distributions. Recently⁸⁾ the inclusive p_T distributions in e^+e^- hadronic final states have been measured in terms of the "reduced" variable $p_T/\langle p_T \rangle$, where p_T is the transverse momentum of the particle produced, and $\langle p_T \rangle$ is the average transverse momentum of all charged particles produced, defined as follows:

$$\langle p_T \rangle = \frac{1}{N} \sum_{i=1}^N \langle p_T \rangle_i ,$$

with N being the total number of particles. The experimental study⁸⁾ of multiparticle systems produced in e^+e^- annihilation has shown that the distributions in the "reduced" variable $p_T/\langle p_T \rangle$ at different e^+e^- c.m. energies ($\sqrt{s} = 9.4$ GeV and $\sqrt{s} = 30$ GeV) are the same.

The occurrence of this scaling was recently shown to be a consequence of QCD⁹⁾. This means that the particle distribution in this "reduced" variable $p_T/\langle p_T \rangle$ is a basic property of the hadronization processes.

The purpose of the present paper is to study these distributions when multiparticle systems are produced in pp reactions.

EXPERIMENTAL APPARATUS AND DATA ANALYSIS

The experiment was performed at the CERN Intersecting Storage Rings (ISR) with pp total c.m. energy, $\sqrt{s} = 62$ GeV. A description of the apparatus and data collection has already been given elsewhere^{1-7,10)}. The set-up consisted mainly of a large-volume magnetic field, coupled to a powerful system of multiwire proportional chambers (MWPCs). This set-up was used in the simplest possible mode, i.e. with a "minimum bias" trigger¹⁻⁷⁾.

As in our previous papers¹⁻⁷⁾, where a more detailed description of the method can be found, events with a leading proton detected in the apparatus are selected out of a sample of "minimum bias" events. The systems of particles produced in the same hemisphere as that of the leading proton are studied for different intervals of the hadronic energy $E_{\text{had}} = \frac{1}{2}\sqrt{s} - E_{\text{leading}}$ (where $E_{\text{leading}} \equiv$ energy of the leading proton).

The transverse momentum p_T of the particles produced is evaluated with respect to the direction of the missing momentum $\vec{p}_{\text{miss}} = \vec{p}_{\text{beam}} - \vec{p}_{\text{leading}}$ (where $\vec{p}_{\text{leading}} \equiv$ momentum of the leading proton). In order to be considered for the analysis, the particles of a given event had to satisfy the very simple conditions: i) to fit the event vertex to within ± 5 cm; ii) to have a momentum resolution $\delta p/p < 30\%$. Corrections for the acceptance of the apparatus have been applied using Monte Carlo simulation.

RESULTS

The results are presented in Fig. 1 for two energy bands ($8 \text{ GeV} \leq 2E_{\text{had}} \leq 16 \text{ GeV}$ and $24 \text{ GeV} < 2E_{\text{had}} < 32 \text{ GeV}$).

The analysis is based on 1255 events for the range $8 \text{ GeV} \leq 2E_{\text{had}} \leq 16 \text{ GeV}$, and on 2705 events for the range $24 \text{ GeV} \leq 2E_{\text{had}} \leq 32 \text{ GeV}$.

In Fig. 1 the e^+e^- data are reported for comparison. The corresponding e^+e^- energies are $\sqrt{s} = 9.4 \text{ GeV}$ and $\sqrt{s} = 30 \text{ GeV}$, respectively. The agreement with e^+e^- data is remarkable.

CONCLUSIONS

The comparison between properties of multiparticle systems produced in high-energy pp reactions, and e^+e^- annihilations, has been extended to the inclusive $p_T/\langle p_T \rangle$ distributions. The conclusion is that, also in this transverse momentum property, the multiparticle hadronic systems produced in pp interactions show a remarkable agreement with e^+e^- annihilation.

REFERENCES

- 1) A. Zichichi, Evidence for a close link between pp and e^+e^- in Proc. "Ettore Majorana", Int. School of Subnuclear Physics; 18th Course: The high-energy limit. Erice, 1980. To be published by Plenum Press.
- 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, F. 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, Nuovo Cimento Lett. 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, G. Valenti and A. Zichichi, Study of basic properties of low p_T multiparticle systems produced in p-p collisions removing leading protons, Proc. of the 20th Int. Conf. on High-Energy Physics, Madison, Wis., USA, 17-23 July 1980. To be published by the American Inst. of Physics.
- 8) Ch. Berger et al. (PLUTO Collaboration), preprint DESY 80/111 (1980).
- 9) G. Pancheri-Srivastava and Y. Srivastava, Phys. Rev. D 21 (1980) 95.
- 10) R. Bouclier, R.C.A. Brown, E. Chesi, L. Dumps, H.G. Fischer, P.G. Innocenti, G. Maurin, A. Minten, L. Naumann, F. Piuze and O. Ullaland, Nucl. Instrum. Methods 125 (1975) 19.

Figure caption

Fig. 1 : Renormalized $(1/\sigma)$, differential cross-section versus the "reduced" variable $p_T/\langle p_T \rangle$. These distributions allow a comparison of the multiparticle systems produced in e^+e^- annihilation and in pp interactions in terms of the "reduced" transverse momentum properties.

Fig. 1