

MEASUREMENTS OF $\langle p_T^2 \rangle_{in}$ AND $\langle p_T^2 \rangle_{out}$ DISTRIBUTIONS
IN HIGH-ENERGY pp INTERACTIONS

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ABSTRACT

A study of the multiparticle systems produced in high-energy pp interactions shows evidence for planarity effects. These effects are measured via the study of the average transverse momentum squared distributions in the "out" and "in" planes defined in the standard way.

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The study of the structure of jet-like events has recently attracted much interest. The planar and three-jet structures observed at PETRA¹⁾ have prompted much work, both on the experimental and the theoretical side.

We have recently reported a remarkable similarity between inclusive hadronic production in e^+e^- annihilation and proton-proton interactions²⁾. This has been achieved by redefining the energy available for particle production E_{had} , so as to take into account the energy carried away by the leading baryon (proton). In this paper we want to extend the analysis to a more detailed aspect of multiparticle production in proton-proton collisions, i.e. the transverse momentum squared distribution of the particles produced.

The experiment was carried out at the Split-Field Magnet (SFM) facility of the CERN Intersecting Storage Rings (ISR). Details of the experimental apparatus can be found elsewhere³⁾. The analysis has been performed on a sample of "minimum bias events", i.e. low- p_T pp interactions, without any special requirement such as multiplicity or a special configuration of the final state.

THE ANALYSIS

The events have first been selected by requiring the ($x_F = 2p_L/\sqrt{s}$)^{*}) of the fastest positive charged particle to be in the range $0.44 \leq x_F \leq 0.84$. The estimated momentum error was $\Delta p/p \leq 8\%$. This particle was assumed to be a proton. According to previous inclusive studies⁴⁾, the π contamination remains below the 25% level. The knowledge of x_F has been used to redefine the hadronic energy E_{had} , which is available for particle production in the same hemisphere as that of the proton:

$$E_{\text{had}} = \frac{\sqrt{s}}{2} - E_{\text{proton}} \quad (1)$$

We have then studied all the charged particles in the same hemisphere as that of the identified proton, and performed a two-dimensional momentum tensor ellipsoid analysis⁵⁾ on the plane orthogonal to the proton-proton line of flight,

^{*}) p_L = longitudinal momentum; \sqrt{s} = total c.m. energy of the colliding protons.

in their centre-of-mass reference system. Such a tensor was, in our case, defined by:

$$M_{\alpha\beta} = \sum_{j=1}^N p_{j\alpha} \cdot p_{j\beta}, \quad (\alpha, \beta = 1, 2),$$

where j sums on the N particles in the same hemisphere as that of the proton. We then determined the two eigenvalues and eigenvectors of $M_{\alpha\beta}$, Λ_1 , Λ_2 and \vec{n}_1 , \vec{n}_2 , respectively, where

$$\Lambda_i = \sum_{j=1}^N (\vec{p}_j \cdot \vec{n}_i)^2, \quad (i = 1, 2).$$

Having ordered Λ_1 and Λ_2 so that $\Lambda_1 < \Lambda_2$, we defined

$$\langle p_T^2 \rangle_{\text{out}} = \frac{\Lambda_1}{N} = \frac{1}{N} \sum_{j=1}^N (\vec{p}_j \cdot \vec{n}_1)^2 \quad (2)$$

and

$$\langle p_T^2 \rangle_{\text{in}} = \frac{\Lambda_2}{N} = \frac{1}{N} \sum_{j=1}^N (\vec{p}_j \cdot \vec{n}_2)^2. \quad (3)$$

The quantities $\langle p_T^2 \rangle_{\text{out}}$ and $\langle p_T^2 \rangle_{\text{in}}$ are respectively the average value of the square of the momentum component, normal to the event plane (out), and in the event plane (in). The event plane is, in our case, the plane $\vec{n}_2 \hat{=} (\text{proton-proton line of flight})$. Planar events correspond to the case $\langle p_T^2 \rangle_{\text{in}} \gg \langle p_T^2 \rangle_{\text{out}}$.

Figures 1 and 2 show $(1/N)(dN/d\langle p_T^2 \rangle)$ versus $\langle p_T^2 \rangle$ for the quantities $\langle p_T^2 \rangle_{\text{out}}$ and $\langle p_T^2 \rangle_{\text{in}}$ and for two ranges of hadronic energies E_{had} of the systems of charged particles produced:

- i) $10 \leq 2E_{\text{had}} \leq 16$ (GeV) (Fig. 1);
- ii) $28 \leq 2E_{\text{had}} \leq 34$ (GeV) (Fig. 2).

Also reported for comparison in the figures are:

- i) the data points obtained in similar energy ranges by the TASSO Collaboration⁶⁾ at PETRA;
- ii) a "limited p_T " ($\langle p_T \rangle \approx 0.300$ GeV/c) phase-space Monte Carlo simulation.

Notice that our data show a very clear broadening of the $\langle p_T^2 \rangle_{in}$ distribution as expected for "planar" events. The broadening is present neither in the Monte Carlo prediction nor in the $\langle p_T^2 \rangle_{out}$ distribution. Moreover, our data are perfectly consistent with the e^+e^- data at similar energies.

CONCLUSIONS

The results of the present paper show that the "planarity" effects observed in the multiparticle systems produced in e^+e^- annihilations¹⁾ are also present in the multiparticle systems produced in pp interactions. This means that the analogy already reported between pp interactions and e^+e^- annihilation, i) in the inclusive X_R^* distribution²⁾ and ii) in the average charged particle multiplicity⁷⁾, does in fact hold also iii) for the "planarity" structure of the multiparticle systems produced.

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Figure captions

- Fig. 1 : The average transverse momentum squared distributions for "out" and "in" cases, in the "low-energy" range.
- Fig. 2 : The average transverse momentum squared distributions for "out" and "in" cases, in the "high-energy" range.

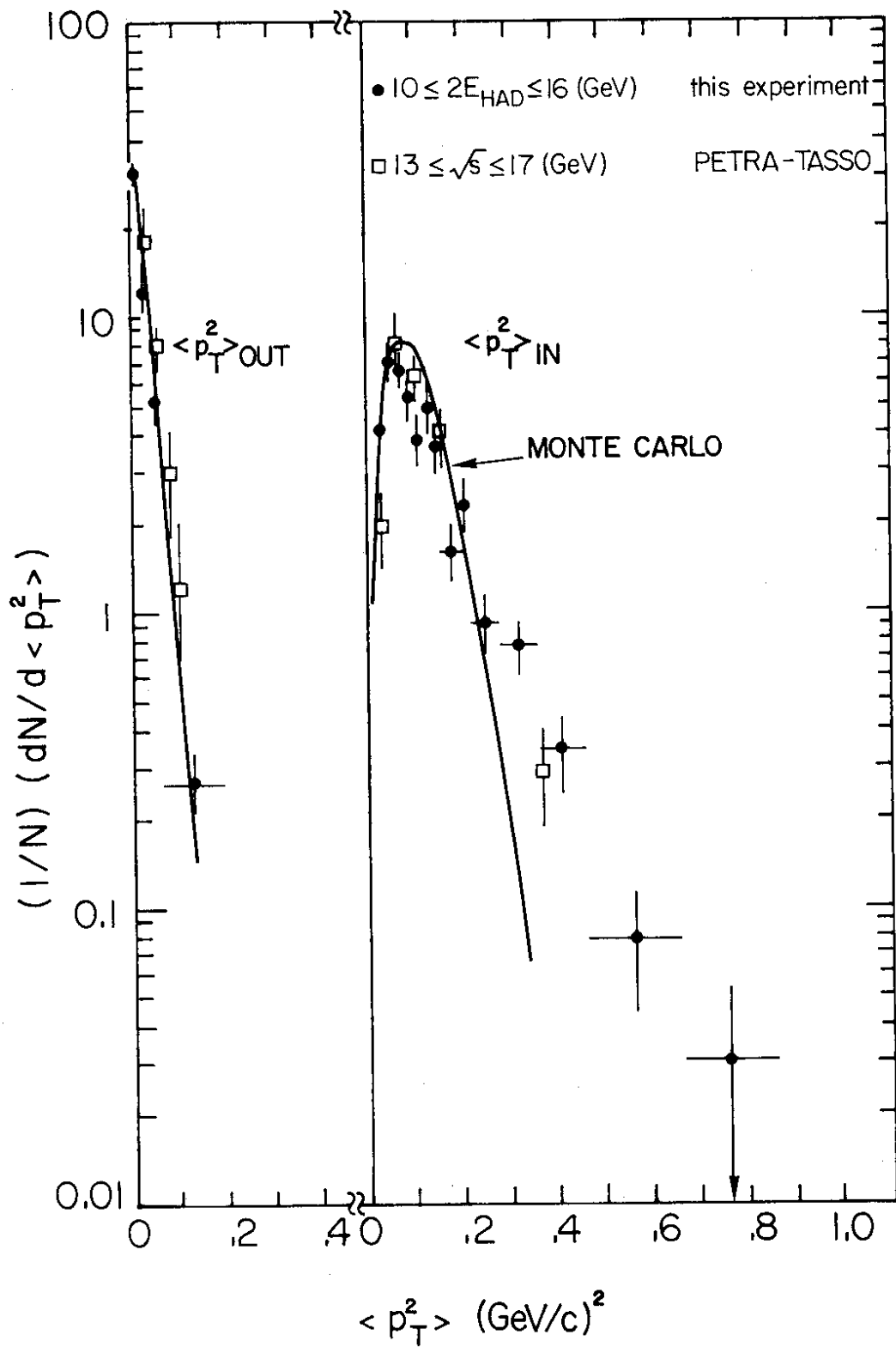


Fig. 1

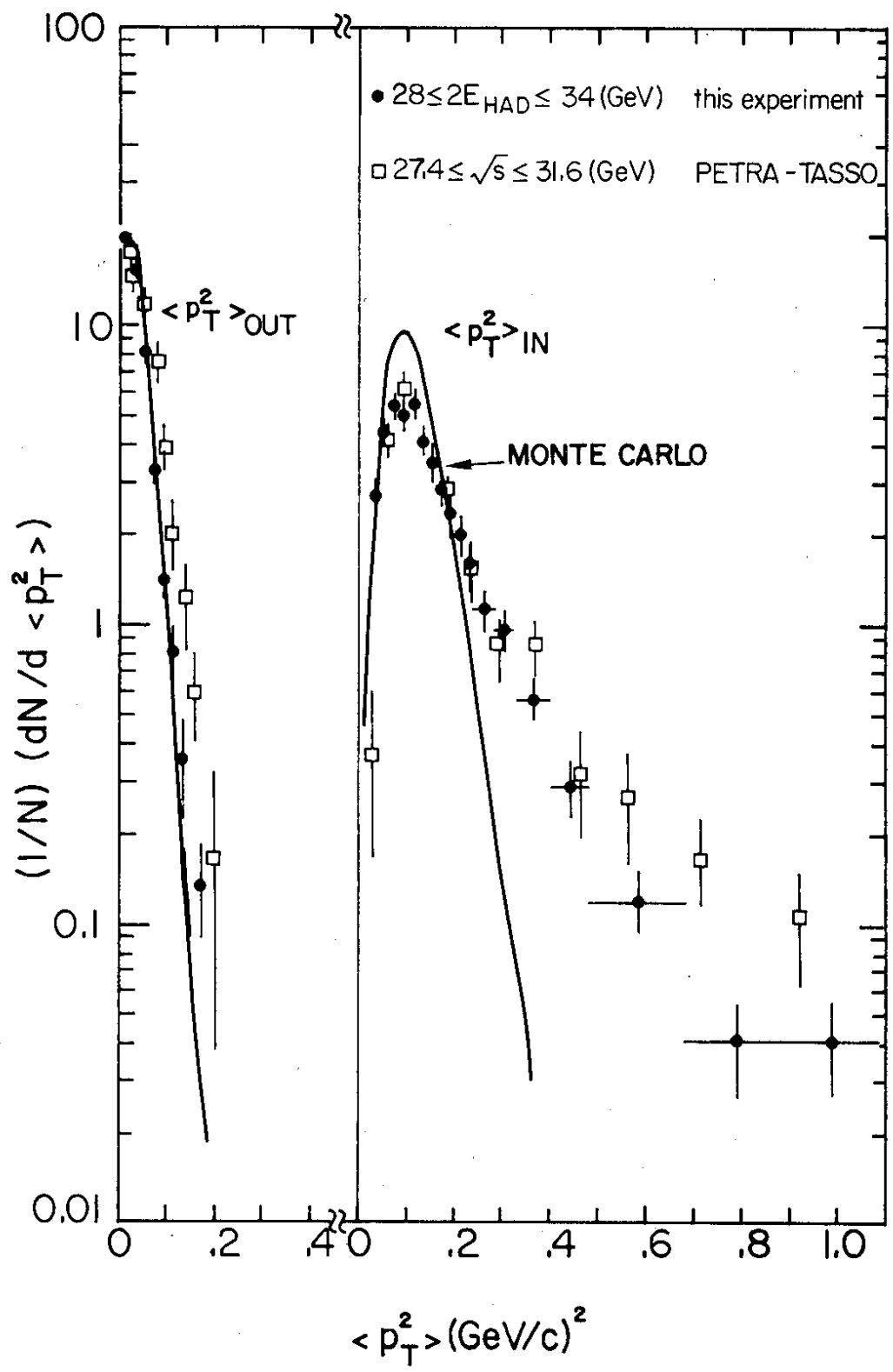


Fig. 2