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J. Berbiere et al. : STUDIES OF TWO-PARTICLE CORRELATION IN RAPIDITY SPACE IN (pp) COLLISION AT  
( $\sqrt{s}$ )<sub>pp</sub> = 30, 44 and 62 GeV

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## Studies of Two-Particle Correlation in Rapidity Space in (pp) Collisions at $(\sqrt{s})_{pp} = 30, 44$ and $62$ GeV.

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PACS. 13.85. - Hadron-induced high- and superhigh-energy interactions, every  $> 10$  GeV.

*Summary.* - Two-particle correlations in rapidity space in (pp) collisions are reported, using the leading-proton subtraction method. The study is performed at different values of the nominal c.m. (pp) total energy  $(\sqrt{s})_{pp} = 30, 44$  and  $62$  GeV. The dependence of the correlation function  $R(y, y')$  at  $y = y' = 0$ , vs. the effective hadron energy available for particle production, is reported.

We have already reported <sup>(1)</sup> evidence for the same two-particle correlation in rapidity space in (e<sup>+</sup>e<sup>-</sup>) annihilation and in (pp) collisions, when the leading-proton effects are taken into account. The method of subtracting the leading-particle effects has already produced striking similarities between the properties of multiparticle systems produced in (e<sup>+</sup>e<sup>-</sup>) annihilation and in soft (pp) collisions <sup>(2-17)</sup>. The aim of the present

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<sup>(1)</sup> G. BONVICINI, G. CARA ROMEO, L. CIFARELLI, A. CONTIN, M. CURATOLO, G. D'ALÍ, C. DEL PAPA, B. ESPOSITO, P. GIUSTI, T. MASSAM, R. NANIA, G. NATALE, F. PALMONARI, G. SARTORELLI, G. SUSINNO, L. VOTANO and A. ZICHICHI: *Lett. Nuovo Cimento*, **36**, 563 (1983).

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work is to go further in the studies of two-particle correlations and to show that this important feature of the hadronization mechanism is related to the effective total hadronic energy available for particle production,  $\sqrt{(q_{\text{tot}}^{\text{had}})^2}$ , not to the nominal c.m. total energy of the two colliding protons  $(\sqrt{s})_{\text{pp}}$ . The definition of  $q_{\text{tot}}^{\text{had}}$  is

$$q_{\text{tot}}^{\text{had}} = q_1^{\text{inc}} + q_2^{\text{inc}} - q_1^{\text{leading}} - q_2^{\text{leading}},$$

where  $q_{1,2}^{\text{inc}}$  are the four-vectors of the incident protons and  $q_{1,2}^{\text{leading}}$  the four-vectors of the leading protons. Following the ( $e^+e^-$ ) method, the rapidity is calculated with respect to the sphericity axis, in the reference system, where the spacelike part of the four momentum  $q_{\text{tot}}^{\text{had}}$  is zero. For details on the analysis we refer the reader to our previous paper (1).

Only events with two identified protons and at least four charged tracks, besides the protons, are retained for the analysis.

The number of events, for each  $\sqrt{(q_{\text{tot}}^{\text{had}})^2}$  interval obtained at three different values of  $(\sqrt{s})_{\text{pp}}$  is shown in table I.

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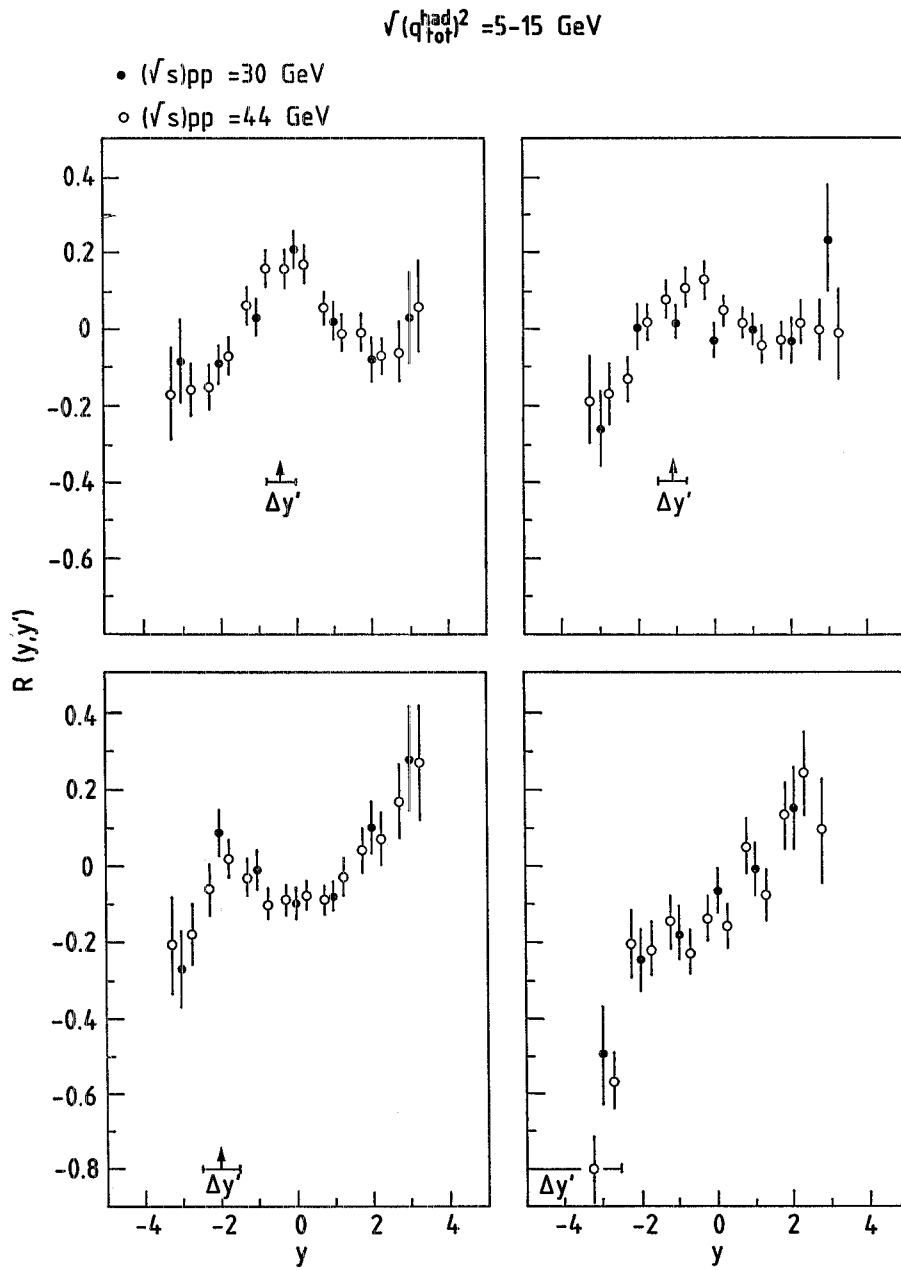


Fig. 1. - Correlation function  $R(y, y')$  measured in the  $\sqrt{(q_{\text{tot}}^{\text{had}})^2}$  range (5-15) GeV for two different values of  $(\sqrt{s})_{\text{pp}}$ . The results for  $(\sqrt{s})_{\text{pp}} = 44 \text{ GeV}$  are plotted as open circles; for  $(\sqrt{s})_{\text{pp}} = 30 \text{ GeV}$  as black points.

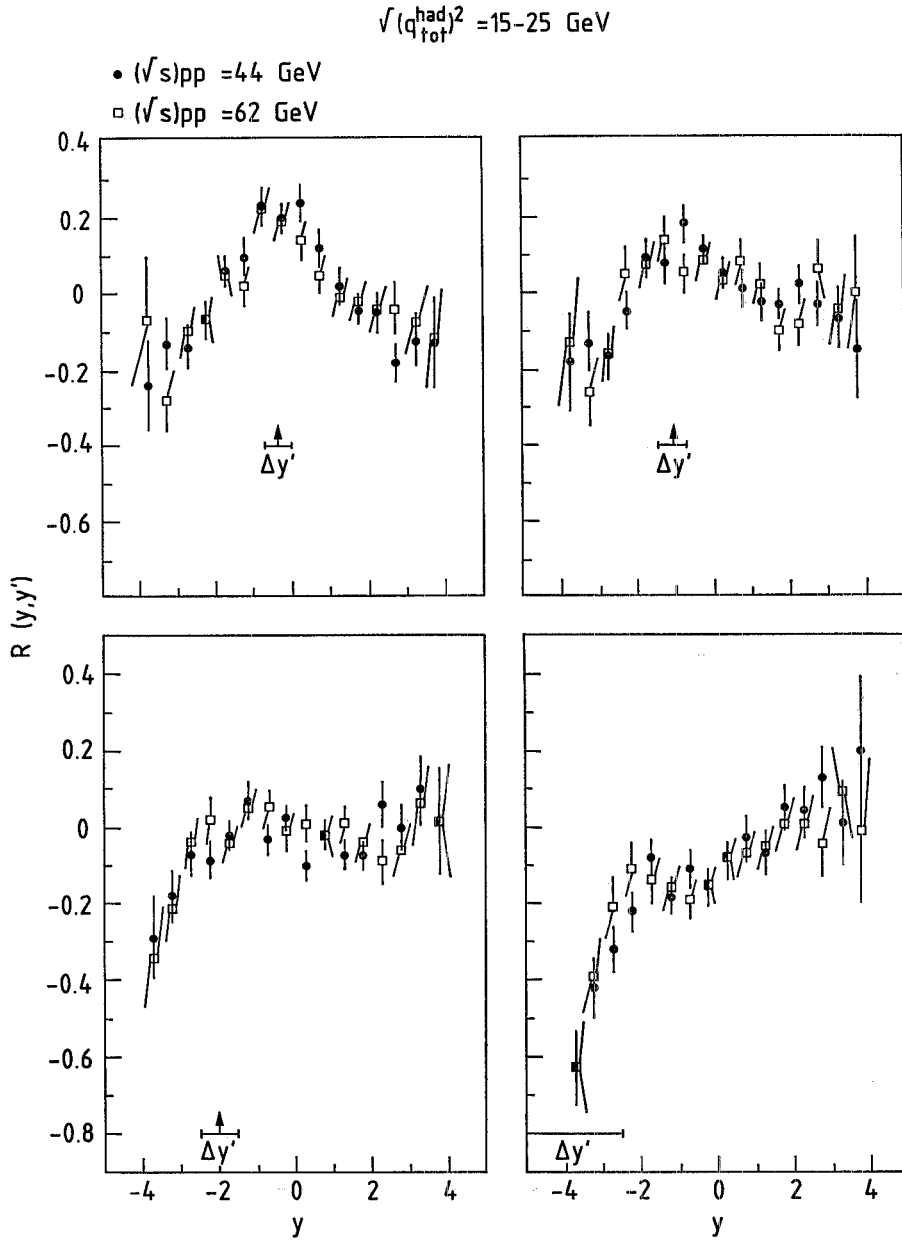


Fig. 2. - Correlation function  $R(y, y')$  measured in the  $\sqrt{(q_{tot}^{had})^2}$  range  $(15 \div 25) \text{ GeV}$  for two different values of  $(\sqrt{s})_{pp}$ . The results for  $(\sqrt{s})_{pp} = 62 \text{ GeV}$  are plotted as open squares; for  $(\sqrt{s})_{pp} = 44 \text{ GeV}$  as black points.

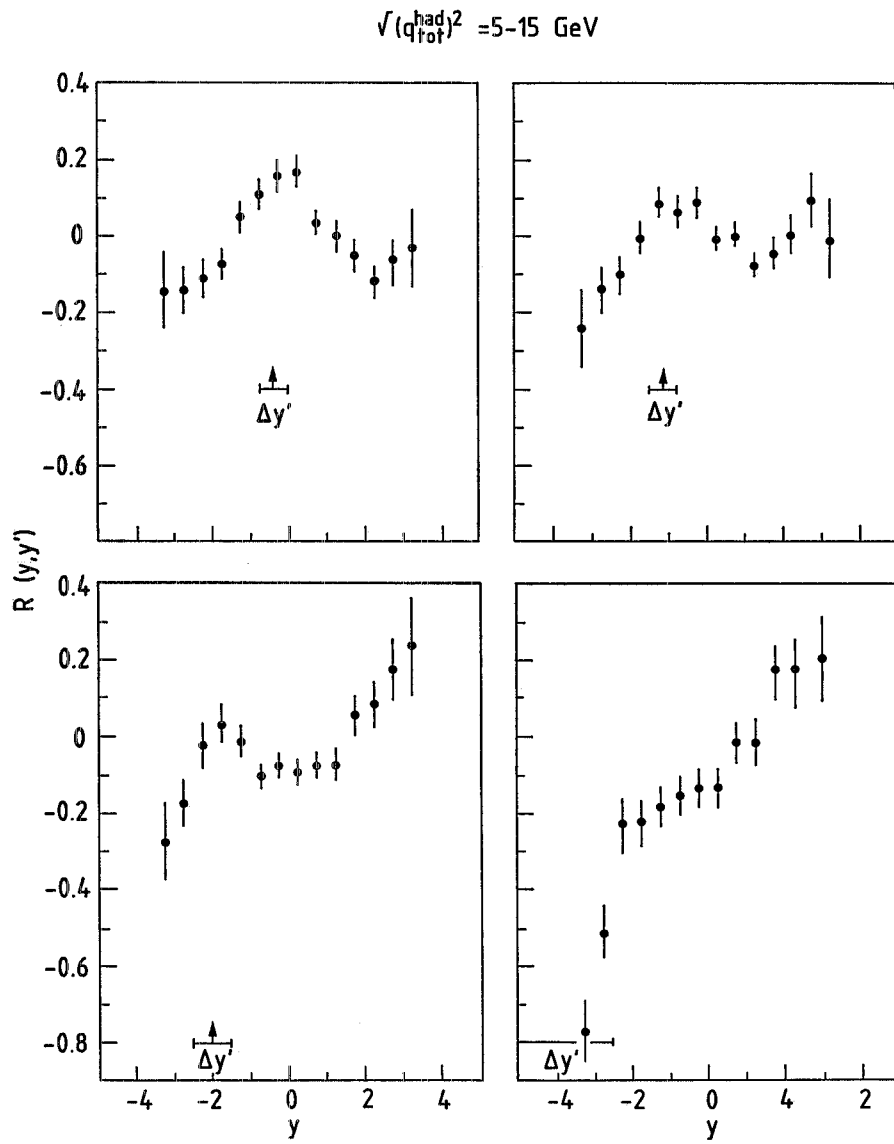


Fig. 3a. - Correlation function  $R(y, y')$  measured for the range  $5 \leq \sqrt{(q_{tot}^{had})^2} \leq 15 \text{ GeV}$ , adding the contributions from the data taken at  $(\sqrt{s})_{pp} = 30, 44$  and  $62 \text{ GeV}$ .

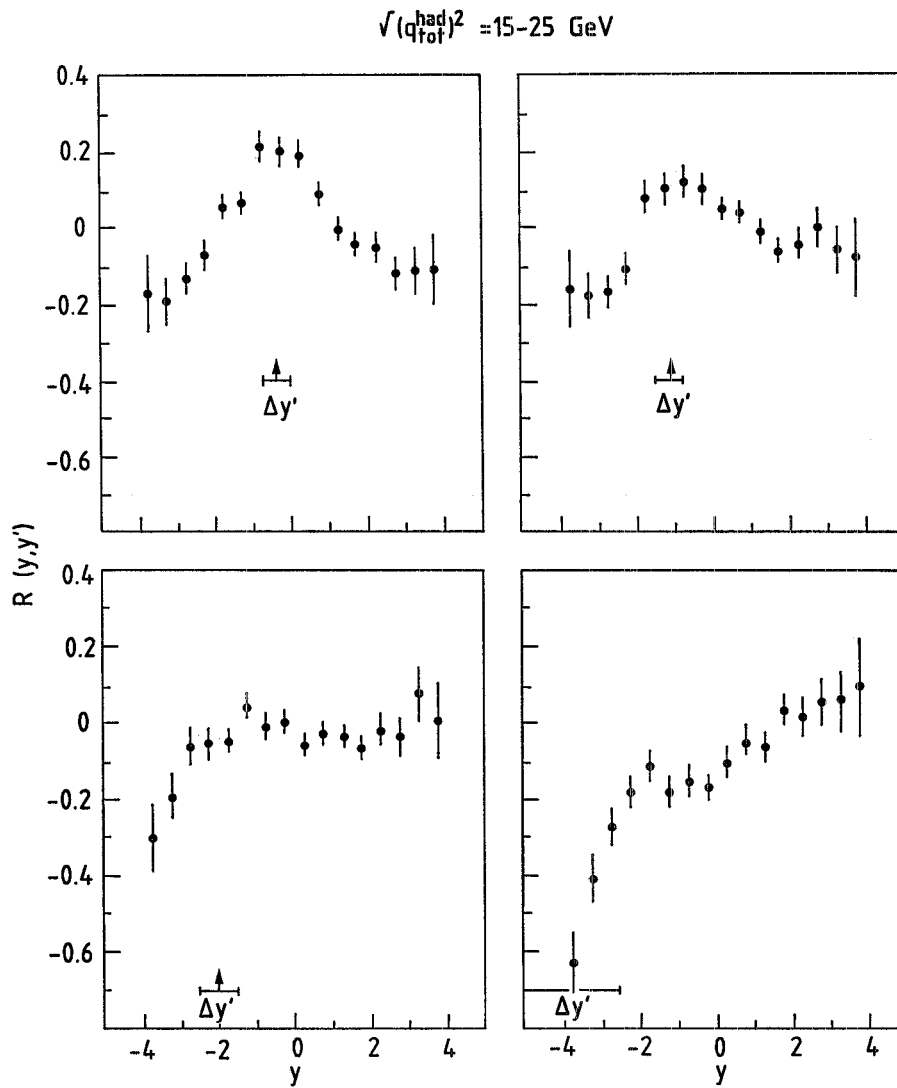


Fig. 3b. - Correlation function  $R(y, y')$  measured for the range  $15 \leq \sqrt{(q_{\text{tot}}^{\text{had}})^2} \leq 25 \text{ GeV}$ , adding the contributions from the data taken at  $(\sqrt{s})_{\text{pp}} = 30, 44 \text{ and } 62 \text{ GeV}$ .

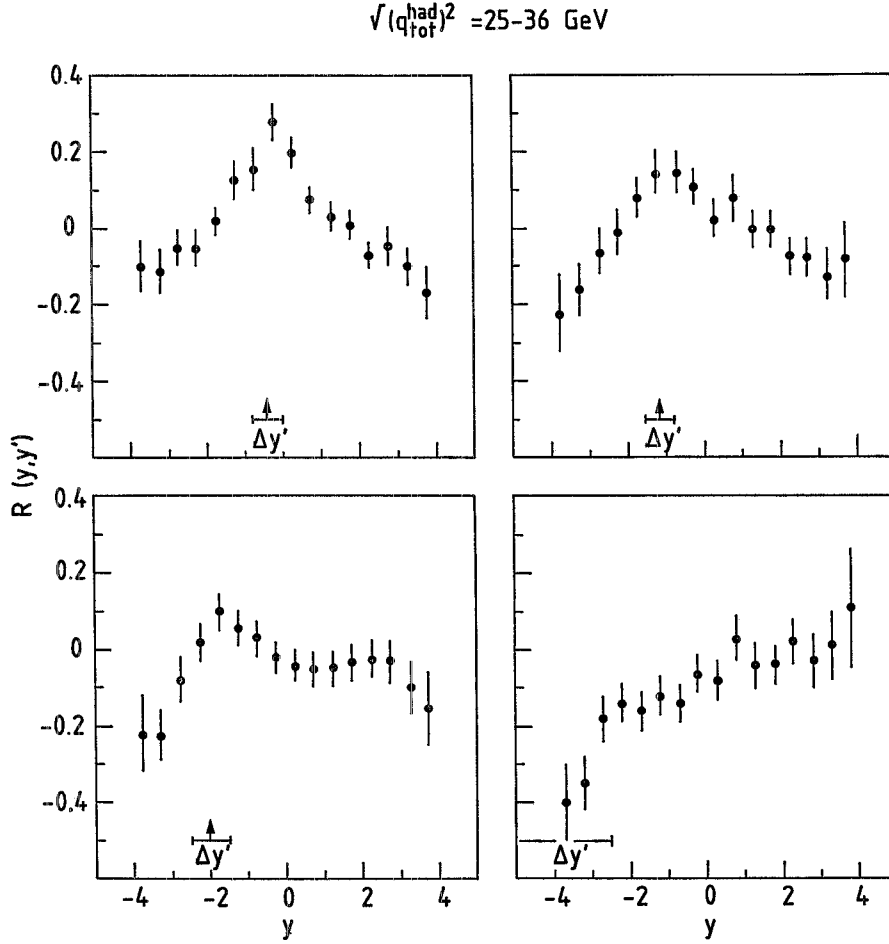


Fig. 3c. - Correlation function  $R(y, y')$  measured for the range  $25 \leq \sqrt{(q_{\text{tot}}^{\text{had}})^2} \leq 36 \text{ GeV}$ , adding the contributions from the data taken at  $(\sqrt{s})_{\text{DP}} = 30, 44$  and  $62 \text{ GeV}$ .

TABLE I - Number of events for different intervals of  $(\sqrt{s})_{\text{DP}}$  and  $\sqrt{(q_{\text{tot}}^{\text{had}})^2}$  (both in GeV).

$\sqrt{(q_{\text{tot}}^{\text{had}})^2}$	$(\sqrt{s})_{\text{DP}}$		
	30	44	62
5 ÷ 15	817	1543	247
15 ÷ 25	71	1890	1226
25 ÷ 36	—	24	1264



The correlation function  $R(y, y')$  is defined as

$$R(y, y') = \frac{\rho_2(y, y')}{f \rho_1(y) \rho_1(y')} - 1,$$

where  $\rho_1(y)$  is the rapidity single-particle density

$$\rho_1(y) = \frac{1}{\sigma_{in}} \frac{d\sigma(y)}{dy}$$

and  $\rho_2(y, y')$  is the rapidity two-particle density

$$\rho_2(y, y') = \frac{1}{\sigma_{in}} \frac{d\sigma(y, y')}{dy dy'}.$$

The correct normalization is granted by the parameter  $f = \langle n_{ch}(n_{ch}-1) \rangle / \langle n_{ch} \rangle^2$ .

In fig. 1 the comparison of two-particle rapidity correlations for two different values of  $(\sqrt{s})_{pp}$  30 and 44 GeV, but with the same  $\sqrt{(q_{tot}^{had})^2}$  in the range (5 ÷ 15) GeV is reported.

The same comparison in the  $\sqrt{(q_{tot}^{had})^2}$  range (15 ÷ 25) GeV at two different values of  $(\sqrt{s})_{pp}$  44 and 62 GeV is shown in fig. 2.

The agreement between two-particle correlations measured at different  $(\sqrt{s})_{pp}$ , but with the same  $\sqrt{(q_{tot}^{had})^2}$  is very satisfactory.

These results show that we can add all the contributions from different  $(\sqrt{s})_{pp}$  and evaluate the two-particle correlations in rapidity space for three different  $\sqrt{(q_{tot}^{had})^2}$  intervals. The results are reported in fig. 3a-c).

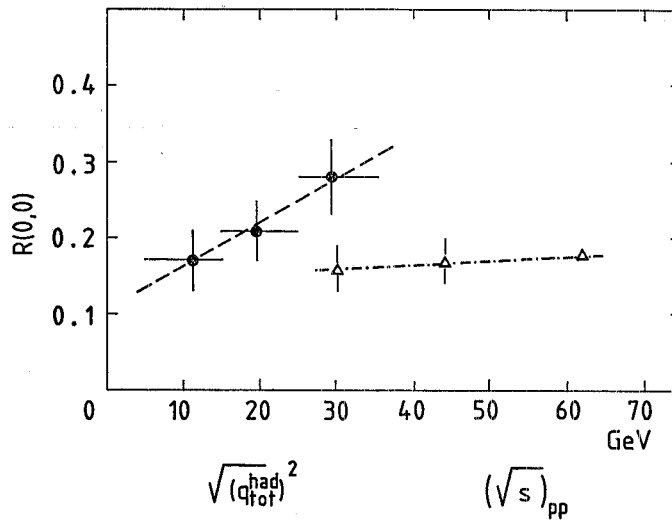


Fig. 4. - Correlation function  $R(y, y')$  measured at  $y = y' = 0$ , vs.  $\sqrt{(q_{tot}^{had})^2}$ . The data are indicated as black points. The broken line is the best fit. For comparison, the open triangles show  $R(0, 0)$  vs.  $(\sqrt{s})_{pp}$ . In this case the analysis of the final state is made without subtracting the leading-proton effects. The dash-dotted line is the best fit to these data. Notice that the abscissa for the black points is  $\sqrt{(q_{tot}^{had})^2}$ ; for the open triangles, it is  $(\sqrt{s})_{pp}$ .

An interesting result of these measurements is that the maximum of  $R(y, y')$  at  $y = y' = 0$  is increasing with increasing  $\sqrt{(q_{\text{tot}}^{\text{had}})^2}$ . How  $R(0, 0)$  varies with  $\sqrt{(q_{\text{tot}}^{\text{had}})^2}$  is shown in fig. 4. For comparison, in the same fig. 4, we have reported the values of  $R(0, 0)$  measured for final states of (pp) collisions *without* the subtraction of the leading-proton effects. In this case the energy variable is  $(\sqrt{s})_{\text{pp}}$ . The results show no variation of  $R(0, 0)$  vs.  $(\sqrt{s})_{\text{pp}}$ .

These studies are a further confirmation of the fact that the relevant quantity in describing high-energy and soft (pp) interactions is the effective total hadronic energy  $\sqrt{(q_{\text{tot}}^{\text{had}})^2}$  available for multiparticle production, and not the nominal c.m. total energy  $(\sqrt{s})_{\text{pp}}$  of the colliding protons.