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M. Basile et al. : DEEP INELASTIC SCATTERING AND SOFT (pp) INTERACTIONS: A COMPARISON

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Deep Inelastic Scattering and Soft (pp) Interactions: a Comparison.

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PACS. 13.90. – Other topics in specific reactions and phenomenology of elementary particles.

Summary. – A comparison between the average charged-particle multiplicities measured in (νp) deep-inelastic scattering (DIS) and in soft (pp) interactions shows that a remarkable agreement can be established between these two processes, so far considered drastically different. This agreement can be observed when soft (pp) data are treated in a way which is analogous to the (νp) DIS data. The (pp) data cover a W^2 range from 100 to 500 $(\text{GeV})^2$.

In previous papers [1-18] we have introduced a new method of analysis for (pp) interactions. The basic idea is to take into account the «leading effect» and therefore calculate the effective energy available for particle production.

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With this new method of analysis, striking similarities ([1-18]) were found between (pp) and (e^+e^-) interactions. In particular it was shown that the average charged-particle multiplicities $\langle n_{ch} \rangle$ in (pp) and in (e^+e^-) are in agreement ([3,8,14]). In the present paper this study is extended to the comparison with (νp) deep inelastic scattering (DIS) processes.

Let us first recall a well-known fact: the average charged-particle multiplicity measured in DIS ([19]) does not agree with (e^+e^-) data, as shown in fig. 1. On the other hand, the (e^+e^-) data, when compared with (pp) data, analysed removing leading protons, show a good agreement ([3,8,14]). In fig. 1 the dashed curve is a best fit to (e^+e^-) and (pp) data. It follows that DIS data and (pp) data cannot agree.

The purpose of this paper is to show that the disagreement, between the average charged-particle multiplicities measured in DIS, and in (pp) and (e^+e^-), is a consequence of the omitted subtraction of the leading proton in the analysis of the hadronic systems produced in DIS processes. In fact, in the analysis of DIS data, the leading proton in the backward hemisphere is not subtracted. This means that DIS data are analysed

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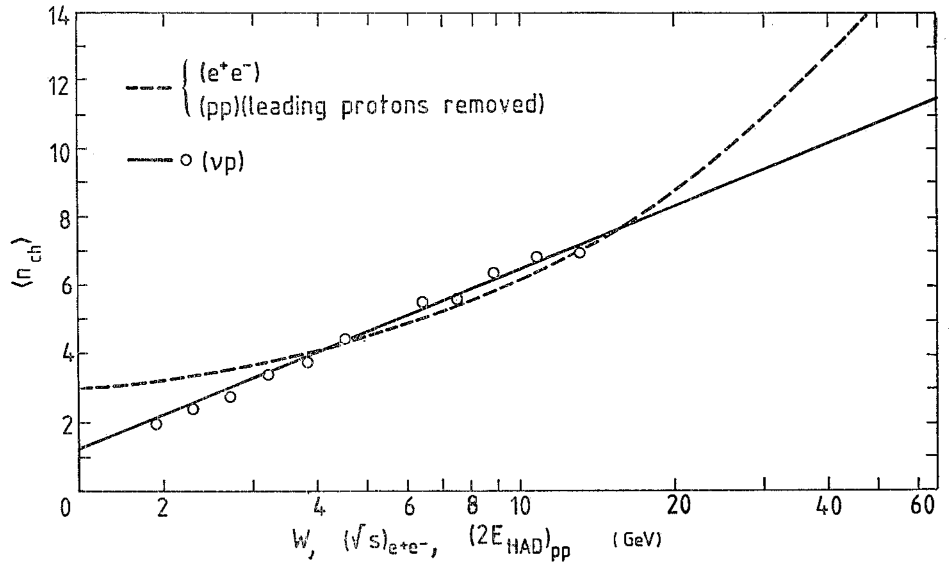

Fig. 1. – The dashed line is the best fit to $\langle n_{ch}\rangle$ measured, in (e^+e^-) *vs.* $(\sqrt{s})_{e^+e^-}$, and in (pp) removing leading protons *vs.* $2E_{had}$ (ref. ([8])). The points are the measurements of $\langle n_{ch}\rangle$ *vs.* W in (νp) deep inelastic scattering, and the continuous line is the best fit to these data (ref. ([19])).

without taking into account the « leading effect », which is present not only in hadron-hadron interactions, but also in lepton-hadron interactions, as proved by us in previous papers ([11,12]).

A direct comparison of our results with the DIS data is not possible, unless we modify our analysis to follow DIS.

To make (pp) and DIS data comparable, we have to remove only one leading proton in the (pp) final state. The properties of the residual hadronic system are studied as a function of the invariant mass W:

$$W = \sqrt{(q_1^{inc} - q_1^{leading} + q_2^{inc})^2}\,,$$

where q_1^{inc}, q_2^{inc}, $q_1^{leading}$ are the four-momenta of the two incident protons and of the observed leading proton. In other words, in our experiment proton No. 1 is treated as the lepton is treated in DIS ([20]).

The quantity W corresponds to the invariant mass of the hadronic final state as defined in DIS analysis.

The experiment was performed at the CERN Intersecting Storage Rings (ISR) using the Split-Field Magnet (SFM) facility. A description of the apparatus and of data collection can be found elsewhere ([8,21]).

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The results reported here were obtained from 2813 events at $(\sqrt{s})_{pp} = 30$ GeV. These events were selected from a sample of « minimum bias » events, by requiring only one leading proton detected in the apparatus. For details concerning the definition of the leading proton, the event selection, and other information, we refer the reader to previous papers (1-18).

The results are shown in fig. 2, where the average charged-particle multiplicity $\langle n_{ch} \rangle$ is plotted *vs.* W^2 and compared with the (νp) DIS data. The (νp) DIS data are below $W^2 = 170\,(\text{GeV})^2$, while the (pp) data extend up to $W^2 = 500\,(\text{GeV})^2$. A good agreement is seen to exist with DIS data in the overlapping region of the W^2 range, $W^2 \approx (100 \div 200)\,(\text{GeV})^2$. It is furthermore very significant that the (pp) data are lying on the extrapolation to higher energies of the fit to the average charged-particle multiplicites measured in (νp) DIS.

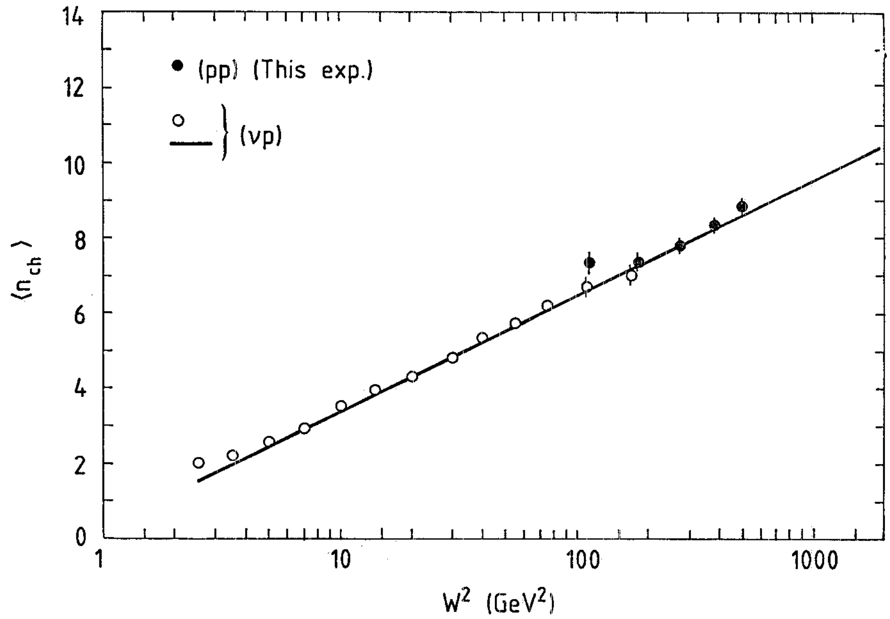

Fig. 2. – The average charged-particle multiplicites $\langle n_{ch} \rangle$ measured in (pp), at $(\sqrt{s})_{pp} = 30$ GeV, by using a DIS-like analysis, are plotted *vs.* W^2 (black points). The open points are the (νp) data and the continuous line is their best fit (ref. (19)).

The results reported in fig. 2 show that, if the analysis of (pp) data is done in the same way as for DIS data, *i.e.* without subtracting the leading proton in the « backward » hemisphere, the average charged-particle multiplicities in (pp) and DIS processes are the same. Notice that for one of the two colliding protons (called proton No. 1) the « leading effect » is taken into account; this proton is therefore treated as the lepton in DIS.

An interesting consequence of our study is that the ISR (pp) data make it possible to reach a W^2 range much higher than the one reached so far by the highest-energy (νp) DIS measurements. Our results, in the W^2 range from 200 to 500 $(\text{GeV})^2$, are therefore a firm prediction of what will be found by DIS measurements when these high W^2 values will be reached.