THE ENERGY DEPENDENCE OF CHARGED PARTICLE

MULTIPLICITY IN p-p INTERACTIONS

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ABSTRACT

The average charged multiplicity in proton-proton interactions has been studied at $\sqrt{s} = 62$ GeV. A very good agreement with the average charged multiplicity measured in e^+e^- annihilation at different energies is obtained by redefining, in p-p, the correct energies available for particle production. This means that a p-p collision at $\sqrt{s} = 62$ GeV does in fact correspond to a large range of effective hadronic energies available for particle production.

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The energy dependence of charged particle multiplicity has been investigated by many authors [1]. The measurements performed to date show that the average charged multiplicity in p-p collisions differs and is in fact lower than in e^+e^- annihilation, as can be seen from fig. 1.

We have recently reported on a study of multiparticle production in p-p collisions, based on "minimum bias events". The key point in this study was the subtraction of the "leading" proton effects [2]. Once this is done, the fractional momentum distribution of hadrons produced in p-p interactions shows impressive similarity to the fractional momentum distribution of hadrons produced in e^+e^- annihilation.

In the present work, we want to extend the study to the problem of the charged particle multiplicity versus the hadronic energy available in p-p interactions. The most important point of our investigation is, as usual, that this total hadronic energy is not $\sqrt{s} = 2E$, where E is the proton beam energy in the c.m. system. It is, instead, the difference between the incident proton energy E_{inc} and the "leading" proton energy E_{lead} :

$$E_{inc} - E_{lead} = E_{had}.$$

Thus a p-p interaction with two colliding protons, each with $E_{inc} = 31$ GeV, will in fact produce a set of E_{had} which will cover a wide range, depending on the amount of energy taken by the leading proton. The energy E_{had} is the correct one to take, in order to compare the charged particle multiplicity in p-p and e^+e^- interactions: in fact $2E_{had} = E(e^+e^-)$.

Table 1 shows the range of $(2E_{had})$ values which are obtained in our data, via the selection of the "leading" proton.

The experiment was performed at the CERN Intersecting Storage Rings (ISR) at $s = \sqrt{62}$ GeV, using the Split Field Magnet (SFM) facility [3]. The detector [3] was operated in the simplest possible mode, i.e. the "minimum bias" mode [2]. A total of 40,000 events were analysed and gave about 4,000 events with a "leading proton"; this allows us to calculate E_{had} . The total number of tracks produced in the same hemisphere as that of the "leading proton" was measured via the multi-wire proportional chamber system [3].

No momentum resolution cut was applied, and the results were corrected for acceptance efficiencies via Monte Carlo simulation.

The results are reported in table 1 and plotted in fig. 1. A comparison with the e^+e^- data from PETRA [4] shows that the agreement is remarkable. Notice that the standard way to analyse p-p interactions would give only one point in fig. 1, namely the highest energy point corresponding to $\sqrt{s} = 62$ GeV. This is reported for comparison. In fact, it agrees very well with previous data. This point, as well as all previous ones obtained at lower p-p energies, would give a value of $\langle n_{ch} \rangle$ in disagreement with the data obtained in e^+e^- annihilation. In fact, according to our analysis the single point at $\sqrt{s} = 62$ GeV does correspond to a set of points, thanks to the effective hadronic energy E_{had} available in a p-p collision. In spite of the fact that this collision is generated by two protons, each with 31 GeV total energy, E_{had} depends on how much energy has been taken by the "leading" proton.

Once again, the analysis of "minimum bias" p-p events has produced a remarkable agreement with (e^+e^-) annihilation. We consider the agreement of our p-p data on $\langle n_{ch} \rangle$ with the data from e^+e^- annihilation as a further proof that multi-particle production follows the same mechanism in p-p collisions as in e^+e^- annihilation, provided that, in p-p collisions, the correct energy has been identified.

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Table 1

Average charged multiplicity
versus hadronic energy

$2E_{\text{had}}$ (GeV)	$\langle n_{\text{ch}} \rangle \pm \Delta \langle n_{\text{ch}} \rangle$
10-16	7.4 ± 0.5
16-22	9.1 ± 0.5
22-28	10.0 ± 0.5
28-32	10.5 ± 0.6
32-36	11.4 ± 0.6
36-40	11.5 ± 0.6
40-44	12.6 ± 0.6

Figure caption

Fig. 1 : The average charged multiplicity versus $2E_{\text{had}}$ is compared with data from e^+e^- annihilation. The dashed line is the proton-proton average charged multiplicity plotted versus the total p-p centre-of-mass energy ($\sqrt{s}$).

Fig. 1