COMPARISON OF HIGH- E_T PARTICLE PRODUCTION
IN PP AND $\overline{P}P$ INTERACTIONS AT THE CERN ISR

The Axial Field Spectrometer Collaboration

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ABSTRACT

We have measured the production of neutral and charged hadrons with transverse momenta in the range 2 GeV/c to 6 GeV/c at $\sqrt{s} = 63$ GeV. Data have been obtained under identical experimental conditions in pp and $p\bar{p}$ collisions. The comparison of the inclusive spectra shows no statistically significant difference over the p_T range studied.

With the advent of $p\bar{p}$ -interactions at the CERN ISR a new important tool became available for the study of hadron dynamics. We can now study, at the highest $\sqrt{s}$ values, interactions which are sensitive to the different quark content of the colliding nucleons. Comparison of pp and $p\bar{p}$ induced final states can be carried out under almost identical experimental conditions and hence usually with rather small systematic errors. The study of $p\bar{p}$ collisions at the ISR energy range is also of interest because it facilitates the extrapolation to and comparison with data obtained at the CERN SPS pp collider. We report here for the first time a measurement on high p_T hadron production. The data were obtained during a relatively short run of less than one day with modest luminosity ($L < 10^{27} \text{ cm}^{-2} \text{ s}^{-1}$). Future improved $p\bar{p}$ operation procedures are expected to result in luminosities close to $L = 10^{29} \text{ cm}^{-2} \text{ s}^{-1}$ and will launch an extensive $p\bar{p}$ high p_T programme.

The experiment was performed at the CERN-ISR using the Axial Field Spectrometer [1,2]. A fission compensated uranium hadron calorimeter covered 270° in azimuth. With this instrument unbiased triggering on electromagnetic and hadronic energy is possible. A novel calorimeter trigger system [3] permitted the parallel selection of a number of different final states, which were of interest for the physics analysis. As an example in the study of high p_T inclusive hadrons reported here we required localized (i.e. showers of a size typical for single particle induced showers) energy deposit above a threshold of $E_{th} = 2 \text{ GeV}$. The charged hadrons were in addition recorded in the vertex detector, a 1.4 m long drift chamber of the "bicycle wheel" configuration with 4° azimuthal segmentation [4]. The large solid angle covered by the calorimeter (Fig. 1) with its versatile trigger system combined with the drift chamber allowed us to select and record high p_T events even at the low luminosity of $L = 10^{27} \text{ cm}^{-2} \text{ s}^{-1}$ of this only pp run to date at $\sqrt{s} = 63 \text{ GeV}$. About 80,000 events were recorded and 13533 events were accepted by the off-line preselection and fully analysed. The integrated $p\bar{p}$ luminosity for this data sample was $4.37 \times 10^{31} \text{ cm}^{-2}$. For the comparison, a pp data sample at $\sqrt{s} = 63 \text{ GeV}$ was recorded with the same trigger conditions and thresholds. A somewhat larger sample of 17392 high p_T pp events was fully analysed, with the same set of analysis programs, corresponding to integrated luminosity of $5.28 \times 10^{31} \text{ cm}^{-2}$.

The principal systematic uncertainty in the comparison of the two data samples originated from the very different background conditions. Due to the low $p\bar{p}$ luminosity background from cosmic rays, which contributed about 50% of all triggers with $p_T > 5$ GeV/c, and beam-gas interactions diluted the $p\bar{p}$ sample to a much larger extent than the pp data set. From dedicated cosmic ray runs and operation of the ISR with the p-beam only we have found that these sources of background could be effectively suppressed by requiring that the events had a reconstructed vertex within the fiducial volume of the interaction region. We estimated that the contamination of the final sample was less than 5%.

The rapidity acceptance of our detector is uniform in $|y| < 0.8$. The calorimeter, in its present configuration, covers $\Delta\phi = 270^\circ$. The distributions presented here correspond to this geometrical acceptance. At this stage of the analysis absolute normalizations have relatively large uncertainties ($\sim 20\%$); systematic differences in the comparison of the pp and $p\bar{p}$ data, however, are small.

In Fig. 2 the hadronic "single shower" p_T spectra are shown as measured by the calorimeter alone. The corresponding electromagnetic p_T spectra are displayed in Fig. 3. The electromagnetic single particle trigger required a longitudinal energy deposition consistent with that induced by photons or electrons. These spectra are therefore expected to reflect predominantly the production of π^0 's. Above the trigger threshold the differences between the pp and $p\bar{p}$ induced p_T spectra are seen to be small up to 6 GeV/c. An important check was provided by the consistency of the energy measurement of the calorimeter showers and the momentum measured for the single high p_T particles by reconstructing the tracks in the drift chamber. We found that only 9.5% of all calorimeter showers were produced by more than one charged track. This confirms that the dominant contribution to the single shower p_T spectra is due to isolated high p_T hadrons.

Information on the particle content was obtained by comparing the track momentum with the energy deposit recorded in the drift chamber and with the dE/dx information provided by our drift chamber. We concluded that the positive tracks are almost all due to π^+ 's, whereas the negative tracks are a mixture of π^- 's, K's and p's. In Fig. 4 we compare the π^+ spectrum from pp collisions with the $p\bar{p}$ measurement.

Again, the spectra are very similar up to $p_T = 5$ GeV/c. Fig. 5 gives the p_T spectra for negative tracks, with an indication of more negative tracks in $p\bar{p}$ compared to pp .

The ratios of high p_T particle production is shown in Fig. 6. At the present level of limited statistical accuracy no significant differences are found.

In conclusion, the large solid angle covered by our calorimeter and drift chamber allowed us to trigger and record high p_T events even at the low luminosity of the initial $\sqrt{s} = 63$ GeV $p\bar{p}$ run in ISR. In the p_T range from 2 to 6 GeV/c the high p_T production in pp and $p\bar{p}$ is similar. With the large increase in luminosity expected in future $p\bar{p}$ runs these studies will be extended over a larger p_T range and more refined and significant comparisons will be possible.

We acknowledge with gratitude the dedicated efforts of the staff of the AA, PS and ISR which made the first $p\bar{p}$ run at $\sqrt{s} = 63$ GeV so successful.

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FIGURE CAPTIONS

- Fig.1 Cross section through the Axial Field Spectrometer, Phase I. The vertex detector for charged particles covers the full azimuth; the uranium hadron calorimeter covers $\Delta\phi = 270^\circ$; a lsr Cerenkov arm allows unambiguous particle identification in the 2 to 10 GeV/c momentum range.
- Fig. 2 The inclusive p_T distribution of single particle hadronic showers as measured with the hadron calorimeter alone. The trigger threshold was set to ~ 2 GeV.
- Fig. 3 The inclusive p_T -distribution of single particle electromagnetic showers as measured with the calorimeter. The trigger threshold was set to ~ 2 GeV.
- Fig. 4 Comparison of the p_T -distribution of positive pions produced in pp- and $p\bar{p}$ collisions. The solid line represents the inclusive π^0 -distribution produced in pp-collisions, to which our measurements were normalized.
- Fig. 5 Production of negative hadrons in pp and $p\bar{p}$ collisions, with the same normalization as was used in Fig. 4. The solid line represents the π^0 production in pp interactions.
- Fig. 6 Ratios of high- p_T particles produced in pp and $p\bar{p}$ interactions at $\sqrt{s} = 63$ GeV.

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6