PRODUCTION OF MESON RESONANCES AS LEADING PARTICLES IN JETS
IN PROTON-PROTON COLLISIONS AT $\sqrt{s} = 62$ GeV AT THE CERN ISR

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ABSTRACT

The production of $\rho(770)^0$, $K^{*}(892)^0$, $\bar{K}^{*}(892)^0$ and $f_2(1270)$ mesons as leading particles in hadron jets ($\langle z \rangle \sim 0.7$) has been measured in deep inelastic pp interactions at the CERN ISR at $\sqrt{s} = 62$ GeV. The comparison of vector and pseudo-scalar meson production at the same transverse momentum provides a rather model independent way to determine the fragmentation parameter V/P . We determine $(V/P)_{u,d} = 1.66 \pm 0.18 \pm 0.63$ from the ρ/π ratio and $(V/P)_s = 0.90 \pm 0.13 \pm 0.27$ from the K^*/K ratio. For the $f_2(1270)$ production we find $f_2/\rho^0 = 0.30 \pm 0.08$.

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1. INTRODUCTION

A fundamental understanding of the parton fragmentation mechanism based on pure quantum chromodynamics (QCD) has as yet not been achieved. While the hard interactions of partons can be successfully treated with the methods of perturbation theory, the momentum transfers in the subsequent fragmentation process become too low to allow a similar approach. Theoretical models are therefore used to reduce experimental observations to a set of (hopefully) universal parameters and to distinguish dynamical and kinematical effects. Recently, approaches have been successful which treat at least the first stage of fragmentation as a coherent parton shower [1]. However, even these shower models have to rely on phenomenological assumptions concerning the way the colourless hadron states are finally formed.

Fragmentation models, in general, divide the hadronization of partons into two stages. In the first stage, a number of quarks, antiquarks and gluons is created out of the vacuum. The flavours of the new quarks are generated in a statistical process, which is governed by a set of probability parameters. In the second stage, these partons have to be recombined to form colourless hadron states. Since the quark content does not define a hadron state unambiguously, a second set of parameters is needed to determine spin and other quantum numbers of the created hadrons.

The relation between the probabilities to create a vector or a pseudoscalar meson within a jet is usually expressed by a free parameter V/P , which is defined as the ratio of the probabilities of a quark-antiquark pair to recombine into a vector or pseudoscalar meson. This parameter is not only important for the particle composition of the final state, it also governs the fraction of "indirect" pions and kaons, i.e. those coming from resonance decays. The knowledge of indirect production rates is essential for the determination of intrinsic fragmentation functions.

The least model-dependent way to obtain V/P is by comparing the vector and pseudoscalar meson cross sections at the same fraction $z = p_{\text{meson}}/p_{\text{parton}}$ of the fragmenting parton's momentum. In addition, by using a z value as large as possible one can use kinematics to minimize the "indirect" contributions to pion and kaon production coming from resonance decays. As a result, the ratios ρ/π and K^*/K at large z are more sensitive to V/P and need less model input in order to correct for indirect contributions. In this paper, we determine V/P from ρ/π and K^*/K ratios measured at $\langle z \rangle \sim 0.7$ [2].

2. THE EXPERIMENT

We used six data samples recorded with the Split Field Magnet (SFM) spectrometer at the CERN ISR at a centre of mass energy of 62 GeV. The event samples are characterized by a charged trigger particle at a polar angle θ of 10° , 20° and 45° and a transverse momentum of $P_T > 2, 3$ or 4 GeV/c. The trigger particle was identified using Cherenkov counters. The data have been taken with two different detector versions. We will refer to these detector versions as "set-ups A and B", and the data taken with them as "samples A and B". While in sample A the pion identification restricted the trigger transverse momentum to $P_T > 4$ GeV/c at $\theta = 45^\circ$, sample B was taken with an additional high pressure ball Cherenkov counter, which allowed pion identification down to a threshold of $P_T > 3$ GeV/c. The details of the experimental set-up have been discussed elsewhere [3]. We have shown previously that the high- P_T events have a four-jet structure [4] and that their origin is the hard scattering of proton constituents [5]. The trigger particle is created in the fragmentation of one of the scattered partons (fig. 1 (a)), with the trigger particle having on average a fraction $\langle z_{Tr} \rangle \sim 0.7$ of the fragmenting parton's energy [2].

If the trigger particle with a fractional momentum z_{Tr} is the decay product of a resonance (fig. 1(b)), the parent particle must have a fractional momentum $z \geq z_{Tr}$. This kinematical constraint, which is due to the fact that the momentum of the trigger particle is much larger than the Q value of the resonance decay, provides us with a means to detect resonances which are the leading particle of their jet. On the other hand, the high P_T threshold ensures that only a minor fraction of the charged pions and kaons, e.g. $\sim 30\%$ in the case of the π^+ trigger, are due to resonance decays. Hence, the ratios ρ/π and K^*/K depend sensitively on the parameter V/P . Possible contributions from three or more body decays are efficiently suppressed by the same mechanism.

3. EXTRACTION OF RESONANCE SIGNALS

3.1 $\rho(770)^0 \rightarrow \pi^+ \pi^-$

The $\pi^\pm$ trigger particles were combined with secondaries of opposite charge to which the pion mass was assigned. All tracks were required to have a relative momentum resolution $dp/p \leq 30\%$. For the analysis of the data taken at $\theta = 45^\circ$, the secondaries were required to have $P_T > 0.3$ GeV/c in the proton proton CMS. Secondaries in phase-space regions where the local detector acceptance was $\leq 50\%$ were rejected.

In the majority of the analyzed mass spectra the background itself shows a broad peak in the ρ mass region. Therefore, an event mixing technique was used to extract the resonance signal without the necessity of crucial assumptions on the shape of the background (for details see refs [6,7]). A further advantage of the event mixing method is that acceptance effects in the mass spectrum are automatically taken into account and do not lead to artificial structures. However, the event mixing subtraction results in a distorted resonance signal. In order to evaluate the resonance contribution, a special Monte Carlo procedure has to be used.

In this procedure, the $\rho(770)$ resonance was generated with the mass distributed according to a relativistic p-wave Breit-Wigner function [8]. The resonances were generated such that one of the decay particles met the high- P_T trigger requirements, and both decay particles satisfied the same cuts as in the real data. The decay products were appropriately weighted with the correct trigger and secondary particle acceptances. The event mixing method was then applied to the Monte Carlo events in a manner identical to that used for the real data, and the resulting curves were fitted to the background subtracted mass spectra. The relative factor obtained from the fit, times the number of resonances produced by the Monte Carlo calculation, gave the number of resonant events observed in the real data. The Monte Carlo calculation also provided the effective resonance acceptance. From this we finally obtained a figure proportional to the differential resonance cross section averaged over the considered phase-space interval. This method is discussed in more detail in ref. [7].

In order to determine the average resonance acceptance over given P_T intervals, we assumed that the shape of the P_T spectrum for the $\rho(770)$ resonance was similar to that of the π meson in the relevant range. In order to minimize the influence of this shape, reasonably small P_T bins have been chosen whenever statistics were sufficient.

The $\pi^-\pi^+$ invariant mass spectra are shown before (fig. 2(a)) and after (fig. 2(b)) the event mixing subtraction for sample A (as a convention, the first particle quoted, here π^- , corresponds to the trigger particle, while the second, here π^+ , means the mass hypothesis for the secondary particle; thus, $\pi^-\pi^+$ and $\pi^+\pi^-$ stand for different types of events). The spectrum features a clear $\rho(770)^0$ signal and an indication of a small signal in the K_S^0 mass region. The solid line in fig. 2(b) represents the fitted result of the Monte Carlo calculation, which corresponds to a number of ~ 2300

$\rho(770)^0$ mesons in this π^- trigger sample alone. Figure 2(c) shows the same distribution as fig. 2(b) after the correction for the distortion caused by event mixing has been applied. Combining these results with those from events with a π^+ trigger and the corresponding results from sample B, we arrive at a total of $\sim 9700 \rho(770)^0$ mesons at $\Theta = 45^\circ$. The $\rho(770)^0$ meson results are summarized in table 1.

The $\rho(770)^0$ meson yield was also determined at the smaller trigger angles of $\Theta = 10^\circ$ and $\Theta = 20^\circ$. At 10° , due to the kinematics at this CMS energy, the threshold Cherenkov counters allow us only to distinguish (anti)protons from non-(anti)protons, therefore the $\rho(770)$ and $K^*(892)$ signals had to be separated on a statistical basis. A detailed discussion of this procedure is given in ref. [7]. Figure 3 displays the event mixing corrected " $\pi^- \pi^+$ " spectrum at $\Theta = 10^\circ$ (the quotes as to remind of the K^- admixture), where the $\bar{K}^*(892)^0$ component is very weak, the strong peak is therefore almost entirely due to $\rho(770)$ mesons. The results of this analysis are summarized in table 2. The signal in the $1.2 \text{ GeV}/c^2$ mass region will be discussed in sect. 3.3.

3.2 $K^*(892)^0 \rightarrow K^+\pi^-$, $\bar{K}^*(892)^0 \rightarrow K^-\pi^+$ at $\Theta = 45^\circ$

The $K^*(892)$ mesons are accessible in a quite similar way by combination of an identified K^+ trigger particle with the negative secondaries, treated as pions, or a K^- trigger particle with the positive secondaries. Since the Cherenkov counters, in this experiment at 45° , allowed only the separation of pions from non-pions, the so-called kaon samples contain an admixture of protons and antiprotons. However, the level of contamination is known from separate measurements with an additional Cherenkov counter [9]. The experimental cuts were the same as for the $\rho(770)$ analysis. The $K^+\pi^-$ invariant mass spectrum is shown in figs 4(a-c). A clear $K^*(892)$ resonance signal is observed. From the shape of the signal, a significant contribution from $\Delta(1232)^0$ baryons can be excluded. A weak structure at $\sim 750 \text{ MeV}/c^2$ can be attributed to a reflection of the Λ hyperon in the $K^+\pi^-$ channel.

Combining the two data samples, in total $\sim 600 K^*(892)^0$ and $\sim 700 \bar{K}^*(892)^0$ mesons are observed. Table 3 shows the K^*/K ratios including the necessary corrections for branching ratios and for $p/\bar{p}$ contaminations.

3.3 $f_2(1270) \rightarrow \pi^+\pi^-$

The $\pi^-\pi^+$ mass spectrum at $\Theta = 10^\circ$ (fig. 3) reveals an additional signal around $1.2 \text{ GeV}/c^2$, which can be attributed to the $f_2(1270)$ tensor meson. The data at other

polar angles display only weak evidence for this resonance because of their inferior statistics. The production rate of $f_2(1270)$ mesons is determined by fitting a relativistic d-wave Breit-Wigner distribution, to which the event mixing procedure and experimental cuts have been applied, together with the corresponding shape from the $\rho(770)^0$ and the $K^{*-}(892)^0$ reflection to the data. While the width of the signal agrees with the accepted value, the mass of the resonance appears to be shifted from the standard value of $1274 \pm 5 \text{ MeV}/c^2$ to an observed value of $1245 \pm 10 \text{ MeV}/c^2$. Similar $f_2(1270)$ mass shifts have been observed in double pomeron [10] and $\gamma\gamma$ reactions [11].

The fit leads to an observed number of 1800 $f_2(1270)$ mesons. It is interesting to compare the acceptance corrected cross section with that of the $\rho(770)$ meson. Since both particles are expected to be dominantly produced directly in the fragmentation chain, their production ratio should reflect the underlying fragmentation features. We measure a ratio of $f_2/\rho^0 = 0.30 \pm 0.08$ (see also table 4).

4. INTERPRETATION OF THE RESULTS

4.1 Quantum chromodynamics (QCD) model calculations

A QCD model has been employed to derive the relationship between the fragmentation parameter V/P and the measured quantities $\rho/\pi^\pm$ and $K^*/K^\pm$. The QCD model described in ref. [12], which is based on a Feynman-Field approach, has been used since the inclusive particle spectra at large P_T are not sensitive to the colour string effects and other subtleties of hadronization included in other models [13]. In the following model calculations, the primary $\rho(770)^0$ and $\omega(783)$ mesons are assumed to emerge with the same probability, unless stated otherwise.

4.2 Determination of V/P

It is convenient to use the isospin symmetric ratio ρ^0/π^0 , with the denominator defined as $\pi^0 = (\pi^+ + \pi^-)/2$; it represents the harmonic average of ρ^0/π^+ and ρ^0/π^- . The ρ^0/π^0 as measured in our experiment is shown in fig. 5. The QCD model predicts only a slow rise with P_T , which is due to the decreasing resonance decay contribution in the $\pi^\pm$ production. A fit to this data (solid line in fig. 5) gives a value of

$$(V/P)_{u,d} = 1.66 \pm 0.18 \pm 0.63 ,$$

where the first error quoted is statistical and the second systematic. The systematic error originates mainly from the uncertainties in the detector acceptances and the slope of the resonance's P_T spectrum. Figure 6 shows the corrected ρ^0/π^+ and ρ^0/π^+ ratios along with model curves obtained with the parameter value above.

The K^*/K ratios can be interpreted in an analogous fashion. The requirement to describe both the K^{*0}/K^+ and $\bar{K}^{*0}/K^-$ ratios simultaneously with the model determines the parameter as

$$(V/P)_s = 0.90 \pm 0.13 \pm 0.27 .$$

Figure 7 shows the data as a function of the transverse momentum together with the model predictions for this parameter value. In fig. 8, the quantities $\alpha_V = V/(V + P)$ are compared with results from e^+e^- experiments [14-17]. The results are in good agreement with each other and underline the universality of jet production.

4.3 Discussion

The naive expectation for the V/P parameter from counting the available spin states regardless of dynamics would be $V/P = 3$. The results both from the $\rho(770)$ and the $K^*(892)$ give significantly lower values. Semiclassical calculations, which treat the formation of bound states in a linear colour field potential as a tunneling phenomenon, explain this observation by means of the spin-spin interaction between the recombining quarks, which results in an additional potential energy and therefore changes the tunneling probability in favour of the pseudoscalar mesons [18]. The agreement of our data with the results from e^+e^- experiments, where the average z of the resonances is much lower, excludes a strong z dependence of the V/P value. A less easily understood feature of our data is that the ρ/π ratios demand for a larger V/P than the K^*/K ratios. This could imply a flavour or a mass dependence of the V/P parameter. The approach in ref. [18], however, suggests that V/P increases with M_P/M_V , the ratio of the masses of pseudoscalar and vector meson. From this effect, a weak trend in the opposite direction is expected.

A value of the ω/ρ parameter, which governs the relative coupling of $\omega(783)$ and $\rho(770)^0$ meson to recombining $u\bar{u}$ and $d\bar{d}$ systems, different from $\omega/\rho = 1$ could also explain the observed difference between $(V/P)_{u,d}$ and $(V/P)_s$, since a relative suppression of the $\omega(783)$ would result in a larger $\rho(770)^0$ yield. The experimental data comparing $\omega(783)$ and $\rho(770)$ are scarce. A number of experiments have

determined the ω/π^0 production ratio using the channel $\omega(783) \rightarrow \pi^0 \gamma$. An ISR measurement [19] finds $\omega/\pi^0 = 0.87 \pm 0.17$, which should – after corrections for indirect π^0 's – be compatible with $\omega/\rho = 1$. Two experiments at FNAL [20,21] using hadron beams on beryllium targets at $\sqrt{s} \sim 15$ GeV report lower results of $\omega/\pi^0 \sim 0.44$. However, it is not clear how much these results have to be corrected for nuclear effects and for indirect π^0 contributions.

Figure 9 shows the fit results for $(V/P)_{u,d}$ and $(V/P)_s$ as functions of the ω/ρ parameter. If one assumes that V/P is a global parameter independent of parton flavours, an ω/ρ value around 0.5 is favoured rather than unity.

One can similarly discuss the ratio of tensor to vector meson production, T/V . From spin state counting one would expect $T/V = 5/3$. Our measured value of $f_2/\rho = 0.30 \pm 0.08$ can be compared to results from e^+e^- interactions, where an $f_2(1270)$ multiplicity of 0.11 ± 0.04 per hadronic event (with $x_E = p/E_{\text{beam}} \geq 0.1$) at $\sqrt{s} = 29$ GeV has been observed [22], in contrast to $\rho(770)^0$ multiplicities of $0.41 \pm 0.04 \pm 0.08$ [17] and $0.58 \pm 0.05 \pm 0.09$ [16] per hadronic event at $\sqrt{s} = 34$ GeV with $0.1 < x_E < 0.7$. These numbers lead to an f_2/ρ of 0.27 and 0.19, respectively, which is compatible with our result, especially if one regards the fact that the average z for the e^+e^- measurements is rather low, so that an indirect contribution from $\eta'(958)$, $a_1(1270)$ and $a_2(1320)$ decays to the $\rho(770)$ yield has to be considered.

All these results suggest that the spin suppression for tensor mesons is still stronger than for vector mesons. This behaviour could be a direct consequence of the relative angular momentum of the quarks inside the tensor meson, which might manifest itself as an angular momentum barrier term in the potential.

4.4 Rapidity dependence of V/P

The ρ/π ratio has been determined in three different rapidity intervals. Figures 10 and 11 show the results for the ratios $\rho^0/\pi^\pm$ and ρ^0/π^0 as a function of rapidity. The transverse momenta for the three rapidity intervals differ slightly, but the effects on the ρ/π ratio should be negligible within the statistical errors. The increasing difference between the ratios ρ^0/π^+ and ρ^0/π^- with increasing rapidity can be explained by the increase of Bjorken- x of the scattered quarks, which leads to a dominance of valence u -quarks over valence d -quarks in the proton structure functions, because the latter quarks are known to have a softer spectrum. This effect cancels in the flavour symmetric ratio ρ^0/π^0 , which therefore shows no significant rapidity dependence.

5. CONCLUSIONS

The production ratios ρ/π and K^*/K have been measured at $\langle z \rangle \sim 0.7$ in a jet. Assuming $\omega/\rho = 1$, we derive $(V/P)_{u,d} = 1.66 \pm 0.18 \pm 0.63$ and $(V/P)_s = 0.90 \pm 0.13 \pm 0.27$. The ρ/π ratio shows no apparent rapidity dependence. For the $f_2(1270)$ tensor meson, we obtain $f_2/\rho^0 = 0.30 \pm 0.08$.

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TABLE CAPTIONS

- Table 1 Observed numbers of ρ mesons and acceptance corrected ρ/π ratios at $\Theta = 45^\circ$, shown separately for different regions of transverse momentum, different trigger charges Q and the two detector set-ups A and B (for details see ref. [7]).
- Table 2 Observed numbers of ρ mesons and acceptance corrected ρ/π ratios for three different polar angles Θ and different trigger charges Q .
- Table 3 Observed numbers of $K^*(892)$ mesons and acceptance corrected K^*/K ratios at $\Theta = 45^\circ$ for two different regions of transverse momentum and detector set-ups A and B.
- Table 4 Observed numbers of $f_2(1270)$ tensor mesons and acceptance corrected f_2/ρ^0 ratio at $\Theta = 10^\circ$ polar angle.

TABLE 1

P_T [GeV/c]	S	Q	Number of $\rho(770)^0$ seen	$\rho^0/\pi^\pm$	$\rho^0/\pi^+\pi^-$
3-4	A	+ -	- -	- -	- -
	B	+ -	1254 ± 580 2263 ± 766	0.72 ± 0.20 0.82 ± 0.23	0.77 ± 0.15
4-5	A	+ -	380 ± 85 686 ± 115	0.90 ± 0.12 1.06 ± 0.14	0.97 ± 0.13
	B	+ -	987 ± 238 1140 ± 300	0.76 ± 0.14 0.94 ± 0.17	0.84 ± 0.11
5-6	A	+ -	511 ± 72 1095 ± 101	0.98 ± 0.08 1.28 ± 0.17	1.11 ± 0.09
	B	+ -	357 ± 84 338 ± 99	0.88 ± 0.16 1.22 ± 0.23	1.02 ± 0.17
6-7	A	+ -	138 ± 62 367 ± 83	0.81 ± 0.18 1.22 ± 0.23	0.97 ± 0.20
	B	+ -	- 153 ± 43	1.17 ± 0.35 1.91 ± 0.58	$1.45^{+0.28}_{-0.37}$

TABLE 2

" θ "	$\langle Y \rangle$	$\langle P_T \rangle$ [GeV/c]	Q	Number of $\rho(770)^0$ seen	$\rho(770)\pi^\pm$	ρ^0/π^0
45°	0.75	3.5	+ -	1254 $\pm$ 580 2263 $\pm$ 766	0.72 $\pm$ 0.20 0.82 $\pm$ 0.23	0.77 $\pm$ 0.15 $\pm$ 0.22
20°	1.8	3.1	+ -	1681 $\pm$ 325 2160 $\pm$ 340	0.64 $\pm$ 0.11 0.93 $\pm$ 0.19	0.76 $\pm$ 0.10 $\pm$ 0.17
10°	2.4	2.8	+ -	619 $\pm$ 277 3698 $\pm$ 473	0.37 $\pm$ 0.16 1.72 $\pm$ 0.21	0.61 $\pm$ 0.22 $\pm$ 0.19

TABLE 3

Sample	$\langle P_T \rangle$ [GeV/c]	Particle	Number of K^* (892) seen	Ratio	K^*/K
A	5.5	K^{*0} $\bar{K}^{*0}$	141 $\pm$ 27 137 $\pm$ 26	K^{*0}/K^+ $\bar{K}^{*0}/K^-$	0.53 $\pm$ 0.12 0.79 $\pm$ 0.16
B	3.6	K^{*0} $\bar{K}^{*0}$	421 $\pm$ 129 578 $\pm$ 138	K^{*0}/K^+ $\bar{K}^{*0}/K^-$	0.56 $\pm$ 0.18 0.80 $\pm$ 0.20

TABLE 4

" θ "	$\langle Y \rangle$	$\langle P_T \rangle$ [GeV/c]	Q	Number of $f_2(1270)$ seen	f_2/ρ^0
10°	2.4	2.8	-	1815 $\pm$ 456	0.30 $\pm$ 0.08

FIGURE CAPTIONS

- Fig. 1 Creation of a large P_T trigger particle in the fragmentation of a hard scattered quark ("direct trigger", left), in comparison to the creation of a large P_T resonance in the fragmentation of a hard scattered quark, where one of the decay particles forms the large P_T trigger ("indirect trigger", right).
- Fig. 2 (a) Invariant $\pi^-\pi^+$ mass spectrum at $\Theta = 45^\circ$. The transverse momentum P_T of the combination is required to be > 4 GeV/c.
(b) Same as (a), after event mixing subtraction.
(c) Same as (b), after correction for event mixing distortion.
- Fig. 3 Invariant $\pi^-\pi^+$ mass spectrum at $\Theta = 10^\circ$ after event mixing subtraction and distortion correction. The transverse momentum P_T of the combination is required to be > 2.3 GeV/c.
- Fig. 4 (a) Invariant $K^+\pi^-$ mass spectrum at $\Theta = 45^\circ$. The transverse momentum P_T of the combination is required to be > 4 GeV/c.
(b) Same as (a), after event mixing subtraction.
(c) Same as (b), after correction for event mixing distortion.
- Fig. 5 Cross section ratio ρ^0/π^0 at $\Theta = 45^\circ$ as a function of P_T for the two samples A and B, where $\pi^0 = (\pi^+ + \pi^-)/2$. The full line represents the QCD model prediction for $V/P = 1.66$ (statistical errors only).
- Fig. 6 Cross section ratios ρ^0/π^+ and ρ^0/π^- at $\Theta = 45^\circ$ as a function of P_T , averaged over the samples A and B. The full line represents the model prediction [12] for $V/P = 1.66$ (statistical errors only).
- Fig. 7 Cross section ratios K^{*0}/K^+ and $\bar{K}^{*0}/K^-$ at $\Theta = 45^\circ$ as a function of P_T . The full line represents the QCD model prediction [12] for $V/P = 0.90$ (statistical errors only).
- Fig. 8 Comparison of $\alpha_V = V/(V + P)$ from this experiment with results from HRS [14], TPC [15], JADE [16] and TASSO [17]. The error bars shown represent the statistical and systematic error, added in quadrature.

- Fig. 9 Constraints on the fragmentation parameters V/P and ω/ρ from the ρ/π (curved bands) and the K^*/K (straight bands) measurements assuming that $(V/P)_s = (V/P)_{u,d}$. The hatched bands correspond to one standard deviation of the statistical error, the full bands enclose the region inside one standard deviation of the combined statistical and systematical error (added in quadrature).
- Fig. 10 Cross section ratios ρ^0/π^+ and ρ^0/π^- as functions of the rapidity Y (statistical errors only). The lines are to guide the eye.
- Fig. 11 Cross section ratio ρ^0/π^0 as a function of the rapidity Y . The average transverse momenta P_T for the three data points are slightly different, their values are quoted in the figure (statistical errors only).

Fig. 1

Fig. 2(a)

Fig. 2(b)

Fig. 2(c)

Fig. 3

Fig. 4(a)

Fig. 4(b)

Fig. 4(c)

Fig. 5

Fig. 6

Fig. 7

Fig. 8

Fig. 9

Fig. 10

Fig. 11