PROCEEDINGS OF SCIENCE

Kaon multiplicities in SIDIS from COMPASS

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We present preliminary COMPASS results on kaon multiplicities produced in semi-inclusive deep inelastic scattering of 160 GeV muons off a pure proton (LH_2) target. The results constitute a large data set of more than 600 points for pions and 600 for kaons, covering a large x, Q^2 and z domain in a fine binning. The results from the sum of the z-integrated multiplicities $\mathscr{M}^{K^+} + \mathscr{M}^{K^-}$ and their ratio $\mathscr{M}^{K^+}/\mathscr{M}^{K^-}$ are presented versus x and compared to previous COMPASS results on deuteron and other experiments like HERMES.

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1. Introduction : Quark Fragmentation Functions

Quark Fragmentation Functions are non-perturbative objects that are needed to describe several processes. While light flavoured Quark Fragmentation Functions like up quark and down quark are well determined and constrained, the strange quark Fragmentation function is still not well known. Moreover the largest uncertainty in the Δs extraction from polarized SIDIS data comes from the bad knowledge of strange quark fragmentation function into kaons. The data available from e^+e^- and pp collisions are not sufficient and at too high Q^2 to allow a good determination of the strange quark Fragmentation Function.

In order to access the quark fragmentation functions in SIDIS, one measures the multiplicity of hadrons $lN \to l'hX$ where $h = \pi, K, p$. In the expression of the multiplicities, the Parton Distribution Functions (PDFs) and the quark Fragmentation Functions (FFs) are linked :

$$\frac{dM^h(x,y,z)}{dz} \overset{LO}{=} \frac{\sum_q e_q^2 q(x,Q^2) D_q^h(z,Q^2)}{\sum_q e_q^2 q(x,Q^2)},\ z = \frac{E_h}{\nu} = \frac{E_h}{E_\nu - E_{\nu'}} \tag{1.1}$$

One can access the quark FF assuming the PDF known. It has to be noted that while the PDFs depend on x, the FFs depend on z. When the kaon multiplicities are measured, one can constrain the product $s(x,Q^2).D_s^K(z,Q^2)$.

Thus, pion and kaon multiplicities allow to do global NLO QCD analyses to extract quark FFs and the strangeness contained in the kaons.

2. Data analysis

The multiplicities $M^{K^\pm}$ are calculated in bins x, y (the lepton energy fraction carried by the virtual photon), and z. The choice of the z and x variables is natural because multiplicities depend most strongly on these variables. The third variable is chosen to be y, since it is close to a laboratory variable, and thus it is well suited for the acceptance evaluation. It is preferred to Q^2, which is strongly correlated to x in COMPASS fixed target kinematics. The multidimensional binning used for the multiplicity extraction includes 9 bins in x and 5 bins in y, as shown in Fig. 1, as well as 12 bins in z. The expression of the multiplicities, $M^{K^\pm}$, is given by the kaon yield $N^{K^\pm}$ in (x,y,z) bins divided by the number of DIS events N^{DIS} in (x,y) bins, corrected by acceptance $A^{K^\pm}$, diffractive vector meson contamination $B^{K^\pm}$ and radiative corrections $\eta(x,y,z)$:

$$\frac{dM^{K^\pm}(x,y,z)}{dz} = \frac{1}{N^{DIS}(x,y)} \frac{dN^{K^\pm}(x,y,z)}{dz} \frac{B^{K^\pm} \cdot \eta(x,y,z)}{A^{K^\pm}} \tag{2.1}$$

2.1 Acceptance correction

The acceptance correction, $A^{K^\pm}$, takes into account the limited geometric and kinematic acceptance of the spectrometer and the efficiency of event reconstruction. It is evaluated using a Monte-Carlo (MC) simulation of muon-proton deep inelastic scattering processes. Events are generated with the DJANGOH [1] generator where the parton hadronisation mechanism is simulated using the JETSET package [2] with the tuning from reference [3]. To avoid introducing a strong dependence on the event generator used in the simulation, the extraction of kaon multiplicities from

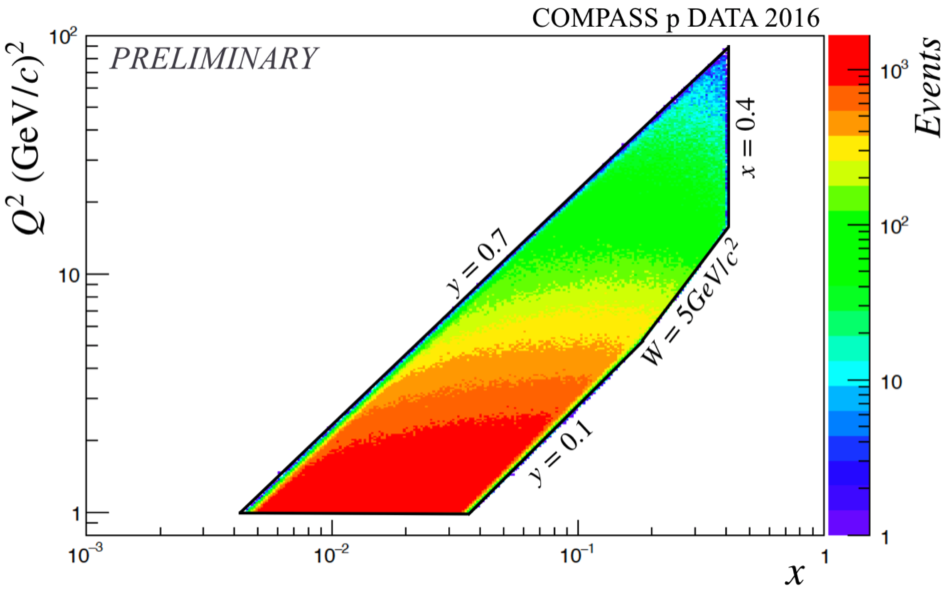

Figure 1: Kinematic variables for DIS events, Q^2 vs x. Solid lines indicate the x and y bin limits.

the MC is performed in narrow kinematic bins of x, y and z. The geometry of the spectrometer is simulated using the GEANT4 toolkits [4], and the MC data are reconstructed with the same software as the experimental data [5] taking detector efficiencies and resolutions into account. The acceptance is calculated from the ratio of the reconstructed multiplicities over generated multiplicities where the reconstructed events and particles are subject to the same kinematic and geometric cuts as the data, while the generated ones are subject to kinematic requirements only.

2.2 Diffractive vector meson contamination

Usually it is assumed that hadrons produced in SIDIS originate from lepton-parton scattering. However, the scattering of a lepton off a nucleon can also result in the diffractive production of vector mesons (DVM). These particles decay into lighter mesons that cannot be distinguished from the one resulting from the hadronisation of a quark originating from the target nucleon. The diffractive vector meson events can also lead to a contamination in DIS events. In this work, the two channels studied are diffractive ϕ and ρ^0. As mesons stemming from DVM decay cannot be separated from the ones resulting from SIDIS, the evaluation of their contribution to the multiplicities is estimated using MC. Separate cross section normalised MC samples are used, based on different generators (SIDIS using DJANGOH [1], and DVM events using HEPGEN++ [6]) and the same event reconstruction chain as described in the previous section is used. The fraction of DVM is calculated in the same binning as the multiplicities, and the resulting correction, $B^{K^\pm}$, is applied to the measured multiplicities as a multiplicative factor.

2.3 Radiative effects

The experimental multiplicities are affected by QED radiative effects, which introduces a systematic bias of the observed (measured) kinematics with respect to the true kinematics. The most important contributions at first order are the initial and final state radiation of a real photon by the incoming and outgoing lepton. The correction factor used to take into account these phenomena is defined versus x, y and z, calculated using the DJANGOH event generator [1]. This is the first time in the COMPASS collaboration that radiative corrections with a z-dependence are calculated.

3. Results

The final multiplicities with all corrections are shown in a multidimensional binning in x, y and z in Fig. 2. The data show a strong z dependence with a much weaker dependence in x and y. As expected due to u quark dominance M^{K^+} is greater than M^{K^-} as displayed in Fig. 3.

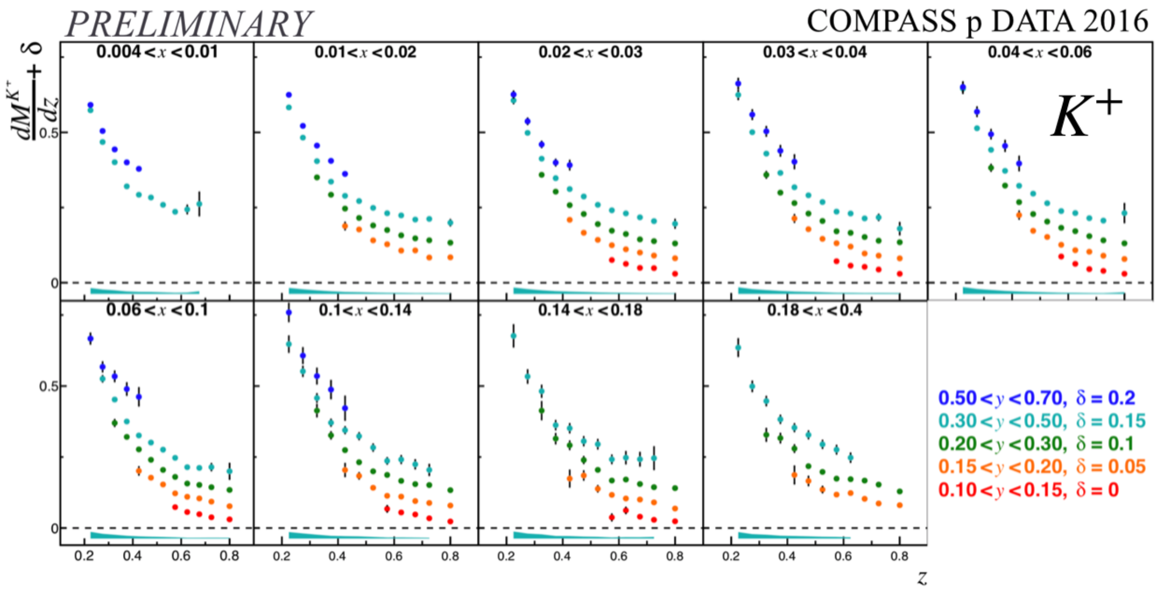

Figure 2: Final positive kaon multiplicities as a function of z in bins of x and scattered vertically with y. Diffractive vector meson, radiative corrections and acceptance corrections have been applied. Systematic errors are shown as bands for the y bin between 0.3 and 0.5.

3.1 Sum of charged kaon multiplicities $\mathscr{M}^{K^+}+\mathscr{M}^{K^-}$

One of the main goals of the kaon multiplicity analysis is the extraction of kaon strange fragmentation functions. These FFs allow for the extraction of the strange quark polarisation in the nucleon obtained from polarised SIDIS analyses. From this point of view, the sum of positive and negative charge kaon multiplicities integrated over z is of special interest.

For a proton target, the charged kaon multiplicities integrated over z can be expressed at LO pQCD as:

$$\mathscr{M}^{K^+}+\mathscr{M}^{K^-}=\mathscr{D}^K_{fav}+\mathscr{D}^K_{unf}+\left[\frac{(s+\bar{s})\left(\mathscr{D}^K_{str}-\mathscr{D}^K_{fav}\right)+(d+\bar{d})\left(\mathscr{D}^K_{unf}-\mathscr{D}^K_{fav}\right)}{4(u+\bar{u})+d+\bar{d}+s+\bar{s}}\right]. \tag{3.1}$$

At high value of x, the sea content of the nucleon can be neglected:

$$\mathscr{M}^{K^+}+\mathscr{M}^{K^-}=\mathscr{D}^K_{fav}+\mathscr{D}^K_{unf}+\left[\frac{d\left(\mathscr{D}^K_{unf}-\mathscr{D}^K_{fav}\right)}{4u+d}\right], \tag{3.2}$$

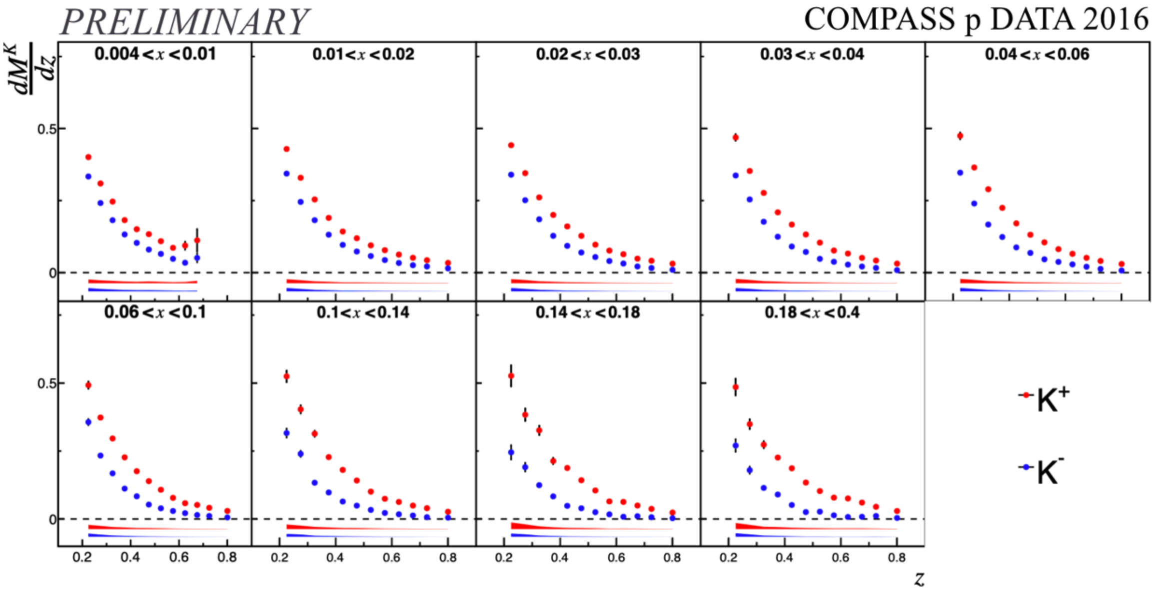

Figure 3: Final kaon multiplicities as a function of z in bins of x averaged over y (0.1 to 0.7). Diffractive vector meson, radiative corrections and acceptance corrections have been applied. Systematic errors are shown as bands.

and taking as approximation $u = 2d$:

$$\mathscr{M}^{K^+} + \mathscr{M}^{K^-} = \frac{8\mathscr{D}^K_{fav} + 10\mathscr{D}^K_{unf}}{9}. \tag{3.3}$$

From the proton target result for $\mathscr{M}^{K^+} + \mathscr{M}^{K^-}$ at high x ($x \sim 0.25$) we extract $8\mathscr{D}^K_{fav} + 10\mathscr{D}^K_{unf} \approx 1.22 - 1.30$. This differs from the earlier DSS fit result at $Q^2 = 3$ (GeV/c)^2 , $8\mathscr{D}^K_{fav} + 10\mathscr{D}^K_{unf} \approx 0.35$, which was mainly based on HERMES results.

As can be clearly seen from Fig. 4, HERMES results [8] and COMPASS results are not compatible as it was already observed between HERMES results and COMPASS results [7] on isoscalar target. Our multiplicities are above those of HERMES in the full x range. A possible explanation for the discrepancy comes from the fact that HERMES was operating at a lower ν than in COMPASS and it was found that there might be phase space limitation effects which may be larger in the case of HERMES than in COMPASS, while it is already seen for $z > 0.75$ data for COMPASS [9]. Another explanation to reconcile the results is to look for hadron mass correction [10], which reduce the apparent large discrepancy between the measurements.

4. Summary and conclusions

We have presented multiplicities of positive and negative charge kaons measured from SIDIS of muons off an isoscalar target at COMPASS. Data are shown in bins of x, y and z. They cover the kinematic range $1 < Q^2 < 50$ (GeV/c)^2, $0.1 < y < 0.7$, $0.004 < x < 0.4$ and $0.2 < z < 0.85$. The sum of positive and negative charge kaon multiplicities integrated over z is also presented. Finally, compared to HERMES results, the multiplicity sum shows a significantly different x dependence as well as an overall higher value but explanations are brought to reconcile the two results.

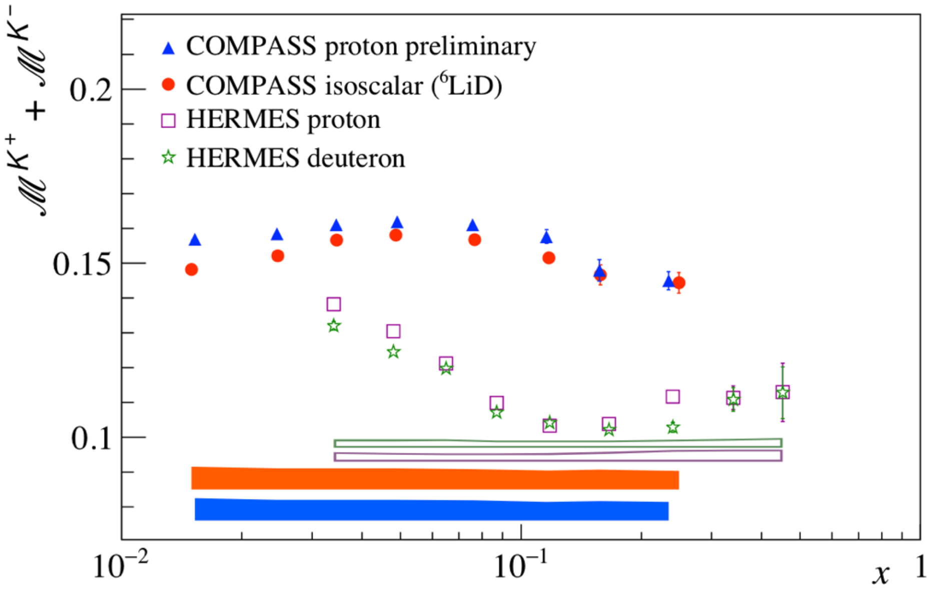

Figure 4: $\mathscr{M}^{K^+} + \mathscr{M}^{K^-}$ versus x for COMPASS data (blue triangles for proton target, orange points for isoscalar target [7]) averaged over y (0.1 to 0.7) and integrated over z (0.20 to 0.85) and for HERMES data (violet squares for proton target, green stars for deuteron target [8]) integrated over z (0.20 to 0.80). Systematic errors are shown in the bands.

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