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Study of heavy hyperons production in DIS at COMPASS

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Abstract. The yields of heavy hyperons and antihyperons have been studied in deep inelastic scattering at the COMPASS experiment at CERN. The data were collected in 2003-2004 using a 160 GeV polarised muon beam scattered off a large polarised ^{6}LiD target. Signals from $\Sigma^+(1385)$, $\Sigma^-(1385)$, $\Xi^-(1321)$ and their antiparticles were reconstructed. The ratios of $\Sigma^\pm/\Lambda$, $\bar{\Sigma}^\pm/\bar{\Lambda}$, Ξ^-/Λ and $\bar{\Xi}^+/\bar{\Lambda}$ were determined. These ratios were used to tune parameters of the LEPTO generator. Comparison with the yields of the heavy hyperons at low Q^2 - region was done.

1 Introduction

It is important to measure the yields of heavy hyperons and antihyperons in deep inelastic scattering (DIS) for for understanding the quark hadronization models. The decays of the heavy hyperons are also important for Λ and $\bar{\Lambda}$ production and polarization. It is known [1] that a significant part of the Λ hyperons in DIS is produced indirectly, via decays of heavy hyperons such as $\Sigma^0, \Sigma(1385), \Xi$ etc. The polarization of these indirect Λ hyperons may influence on the Λ polarization. On the other hand, the role of the indirect $\bar{\Lambda}$ hyperons, forming in the decays of heavy antihyperons, is not known. No measurements of the heavy antihyperon yields in the DIS exist before. Our measurements are also demonstrated similar hyperon and antihyperon yields in DIS of muons. The yields of the heavy hyperons in the neutrino DIS were measured by the NOMAD collaboration [2]. They have found strong deviation of the measured yields from the Monte Carlo predictions. The experimental yields were used to tune the parameters of the LEPTO generator.

2 The experimental set-up

COMPASS (COmmon Muon and Proton Apparatus for Structure and Spectroscopy) is the fixed target facility at CERN. The COMPASS spectrometer is designed to reconstruct the scattered muons and the produced hadrons in wide momentum and angular ranges. It is divided in two stages with two dipole magnets, SM1 and SM2. The first magnet, SM1, accepts charged particles of momenta larger than 0.4 GeV/*c*, and the second one, SM2, those larger than 4 GeV/*c*. The angular acceptance of the spectrometer is limited by the aperture of the polarised target magnet. For the upstream end of the target it is ±70 mrad. To match the expected particle flux at various locations in the spectrometer, COMPASS uses various tracking detectors. The identification of charged particles is possible with a RICH detector, although in this paper we have not utilised the information from the RICH. The data recording system is activated by various triggers indicating the presence of a scattered muon and an energy deposited by hadrons in the calorimeters. More information on the COMPASS spectrometer can be found in [3].

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3 The data analysis

The data used in the present analysis were collected in 2003-2004 using a 160 GeV polarised muon beam scattered off a large polarised ^{6}LiD target. The beam intensity is $2{\times}10^8$ muons per spill. The event selection requires a reconstructed interaction vertex defined by the incoming and the scattered muon located inside the target. DIS events are selected by cuts on the photon virtuality ($Q^2 > 1$ (GeV/c)^2) and on the fractional energy of the virtual photon ($0.2 < y < 0.9$). The data sample consists of $8.67 \cdot 10^7$ DIS events from the 2003 run and $22.5 \cdot 10^7$ DIS events from the 2004 run.

We studied following decays of heavy hyperons and antihyperons:

$$\mu^+ + d \rightarrow \mu^+ + \Sigma^{\pm}(1385) + X \;\; (\Sigma^{\pm} \rightarrow \Lambda + \pi^{\pm}) \;\; (1) \;\; \text{and} \;\; (\bar{\Sigma}^{\pm} \rightarrow \bar{\Lambda} + \pi^{\pm}) \;\; (2)$$
$$\mu^+ + d \rightarrow \mu^+ + \Xi^{-}(1321) + X \;\; (\Xi^{-} \rightarrow \Lambda + \pi^{-}) \;\; (3) \;\; \text{and} \;\; (\bar{\Xi}^{+} \rightarrow \bar{\Lambda} + \pi^{+}) \;\; (4)$$

Main selection criteria for reactions (1) and (2) require that the outcoming pion track is from the primary vertex and the vector of the $\Lambda(\bar{\Lambda})$ momentum is pointing to the primary vertex. However, in the weak hyperon (antihyperon) decays, reactions (3)-(4), a heavy hyperon decays in a secondary vertex. For these weak decays neither the pion track comes from the primary vertex nor the $\Lambda(\bar{\Lambda})$ momentum points to the primary vertex.

The analysis is started from the reconstruction of the vector of the momentum of the $\Lambda(\bar{\Lambda})$ hyperon. A detailed description of the selection cuts is given [4]. The total number of events after all selection cuts are $N(\Lambda) = 99667 \pm 385$ and $N(\bar{\Lambda}) = 60056 \pm 322$. This is much more then in all previous experiments on Λ and $\bar{\Lambda}$ production in DIS [1,2,5].

The $\Sigma^{\pm}(1385)$ and $\bar{\Sigma}^{\pm}(1385)$ resonances decay into the $\Lambda\pi^{\pm}$ and $\bar{\Lambda}\pi^{\pm}$ in the primary vertex. The invariant mass distributions of $\Lambda\pi^{\pm}$ and $\bar{\Lambda}\pi^{\pm}$ from the experimental data are shown in Fig. 1, 2. In Fig. 2 the broad peak on the right corresponds to the $\Sigma^{-}(1385)$ and $\bar{\Sigma}^{+}(1385)$ hyperons. The narrow peak on the left is a part of the $\Xi^{-}(1321)$ and $\bar{\Xi}^{+}(1321)$ weak decays (3-4) passed through the selection criteria.

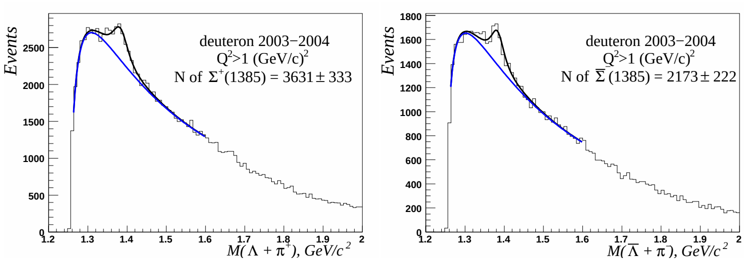

Fig. 1. Invariant mass distributions of $\Lambda\pi^+$(left) and $\bar{\Lambda}\pi^-$ (right) in the primary vertex.

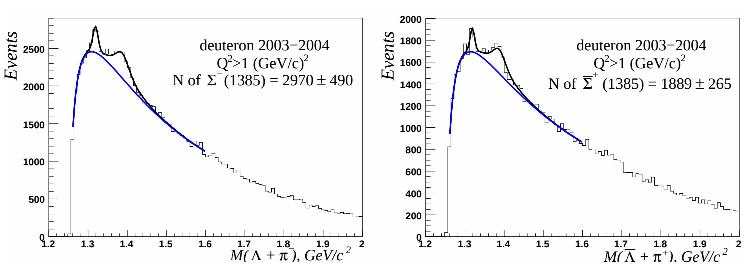

Fig. 2. Invariant mass distributions of $\Lambda\pi^-$(left) and $\bar{\Lambda}\pi^+$ (right) in the primary vertex.

The numbers of events after the fit were found to be $N(\Sigma^+) = 3631 \pm 311$, $N(\Sigma^-) = 2970 \pm 490$, $N(\bar{\Sigma}^-) = 2173 \pm 222$ and $N(\bar{\Sigma}^+) = 1889 \pm 265$.

To select the weak hyperon decay reactions (3-4) the collinear cut for $\Lambda(\bar{\Lambda})$ hyperons is no longer used. For this reason the collinearity cut $\theta_{col} < 0.01$ rad was omitted. It was substituted by the two dimensional Closest Distance of Approach (CDA) procedure. The $\Xi^-(1321)$ and $\bar{\Xi}^+(1321)$ resonances decay into the $\Lambda\pi^-$ and $\bar{\Lambda}\pi^+$ in the secondary vertex. The invariant mass distributions of $\Lambda\pi^-$ and $\bar{\Lambda}\pi^+$ from experimental data are shown in Fig. 3.

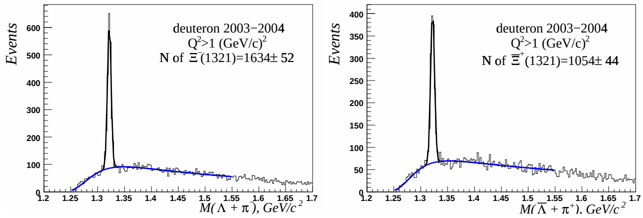

Fig. 3. Invariant mass distributions of $\Lambda\pi^-$(left) and $\bar{\Lambda}\pi^+$ (right) in the secondary vertex.

The numbers of events after the fit were found to be $N(\Xi^-) = 1634 \pm 52$ and $N(\bar{\Xi}^+) = 1054 \pm 44$. The ratios for the yields of the heavy (anti)hyperons production to $\Lambda(\bar{\Lambda})$ yields are the following:

$$\Sigma^+(1385)/\Lambda = 0.055 \pm 0.005 \pm 0.005 \quad (5) \qquad \bar{\Sigma}^-(1385)/\bar{\Lambda} = 0.047 \pm 0.006 \pm 0.005 \quad (6)$$

$$\Sigma^-(1385)/\Lambda = 0.056 \pm 0.009 \pm 0.007 \quad (7) \qquad \bar{\Sigma}^+(1385)/\bar{\Lambda} = 0.039 \pm 0.006 \pm 0.006 \quad (8)$$

$$\Xi^-(1321)/\Lambda = 0.037 \pm 0.003 \pm 0.002 \quad (9) \qquad \bar{\Xi}^+(1321)/\bar{\Lambda} = 0.046 \pm 0.004 \pm 0.002 \quad (10)$$

Where the first error is statistic and second is systematic. These ratios are corrected on the experimental acceptance evaluated using the MC data.

The experimental relative yields (5)-(10) were used to tune the parameters of the LEPTO generator. The COMPASS Monte Carlo code is based on the LEPTO 6.5.1 generator [6] providing DIS events which are passed through a GEANT-based apparatus simulation programme and the same chain of reconstruction procedures as the experimental events. It turns out that the experimental yields of Λ and $\bar{\Lambda}$ hyperons differ from the MC ones by a factor of about 2. The yields of heavy hyperons and antihyperons are also different for the data and the MC. That was the reason to tune the LEPTO parameters to describe the present data. The parameters tuning are described in detail in [7,8].

It is important to know how the yields of hyperons change if one release the DIS cuts ($Q^2 > 1$ (GeV/c)^2 and $0.2 < y < 0.9$). After removal of these cuts the data sample increased by a factor of 10. The total number of N was found to be $N(\Lambda) = 1208413 \pm 1312$ and $N(\bar{\Lambda}) = 654387 \pm 1067$. However, no changes in the ratios Σ/Λ, $\bar{\Sigma}/\bar{\Lambda}$, Ξ/Λ and $\bar{\Xi}/\bar{\Lambda}$ was found within the statistical errors.

Summarizing, the yields of the $\Sigma(1385)$, $\bar{\Sigma}(1385)$, $\Xi(1321)$ and $\bar{\Xi}(1321)$ hyperons are measured in DIS induced by the muon beam. The percentage of the indirect Λ from the decays of $\Sigma(1385)$, $\Xi(1321)$ in the total Λ sample is similar to the percentage of indirect $\bar{\Lambda}$ from decays of $\bar{\Sigma}(1385)$, $\bar{\Xi}(1321)$. The measured hyperon yields were used to tune the LEPTO generator parameters. After the removal of the DIS cuts the ratios of the Σ/Λ, $\bar{\Sigma}/\bar{\Lambda}$, Ξ/Λ, and $\bar{\Xi}/\bar{\Lambda}$ yields stays unchanged within the statistical errors.

References

1. HERMES Collaboration, A. Airapetyan *et al.*,, Phys. Rev. **D74** (2006) 072004.
2. NOMAD Collaboration, P. Astier *et al.*, Nucl.Phys. **B621** (2002) 3.
3. COMPASS Collaboration, P.Abbon *et al.*, Nucl. Instrum. Meth. **A577** (2007) 455.
4. COMPASS Collaboration, M.Alekseev *et al.*, Eur. Phys. J. *C64* (2009) 171.
5. E665 Collaboration, M.R.Adams *et al.*, Eur. Phys. J. **C17** (2000) 263.
6. A.E.G.Ingelman, and J.Rathsman, Comp. Phys. Commun. **101**, 10.
7. T. Sjöstrand, Comp. Phys. Commun. **82** (1994) 74.
8. COMPASS Collaboration, N.Rossiyskaya *et al.*, Nucl.Phys. B (Proc.Suppl.), (2011) 39-42.