Abstract The efficiency for multi-strange hyperon reconstruction and the detection strategy for basic kinematic parameters are described using experimental data of p+C interaction at 10 GeV/c. The efficiency for Λ hyperon reconstruction is equal to 16%. The Σ(1385) and Σ(1620) resonances are observed in the reconstructed Λπ+ mass spectrum.

Keywords Hyperon · multistrange · resonance · multi-vertex · acceptance

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1 Introduction

The CBM experiment at FAIR will investigate the QCD phase diagram at high baryon densities[1], [3]. Energy densities above GeV/fm³ appear at $E_{lab} > 5A GeV$ and exist during the time interval less than 5 fm/c. Baryon densities above $10n_0$ (normal baryon density) can be reached at $E_{lab} > 10A GeV$ in heavy A+A collisions[2]. One of the signatures of this new state is the enhanced production of strange particles, therefore hyperon reconstruction is essential for the understanding of the heavy ion collision dynamics. The experimental $A/\pi^+$ ratio in the p+C reaction is approximately two times larger than this ratio in pp reactions at the same energy [3]. The study of multi-strange hyperon and exotica production will be one of the major projects of the CBM experiment.

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2 Experimental data

2.1 Λ identification

The experimental information of more than 700,000 stereo photographs is used to select events with decays of neutral strange particles (V0 topology). The GEOFIT based on the GRIND-CERN program is used to measure the momentum vectors associated with the tracks in terms of depth $tg_\alpha = y/(\sqrt(x^2 + z^2))$ and azimuth angle $\beta = \arctg(z/x)$ if the beam direction is the z axis. The events with $V^0$ (Λ and $K^0_s$) were identified using the criteria given in [3]. The momentum resolution of Λ is equal to 2%. The mass of the identified 9838-events with Λ hyperon is consistent with their PDG values. The total inelastic cross sections for pp and pC interactions at momentum of 10 GeV/c are equal to 30 mb and 260 mb [3], respectively. The contribution from $p+p\rightarrow \Lambda X$ in $p+p_C$ interactions is less than 12%.

2.2 Input data

These experimental data consist of 9838 preselected events with Λ- hyperons from $10^6$ inelastic interaction had transformed in the ascii format as an input data for CBMROOT framework.

310k central (b = 0) p+C at 10 GeV events were simulated with UrQMD generator. The following cuts described in [4] have been used for Λ hyperons reconstruction: $\chi^2_{prim}(p, \pi^-) > 3\sigma$, $\chi^2_{geo}(\Lambda) < 3\sigma$, $Z_{vertex} > 3\text{cm}$ downstream of the target.

3 Λ and Σ+(1385) hyperons reconstruction

The number of reconstructed experimental and UrQMD events with Λ by CBMROOT is equal to 1689(without $\chi^2_{geo}$ cut) and 313 with all selection criteria, respectively. The mass and width for identified Λ hyperons from experimental data for CBM acceptance is equal to $M_\Lambda=1117$ and $\Gamma=7$ MeV/$c^2$, respectively(Fig.1a). The evolution of experimental and URQMD events for Λ hyperons shows Table 1. Fig.1b,c shows the scattering ($\theta < 0$, $\cos(\theta) = P_z/P$) and azimuth ($\phi \sim 0$, $tg(\phi) = P_y/P_x$) angles distributions in spherical system coordinates for the experimental data with CBM acceptance/the red dashed histogram). P and $P_x$, $P_y$, $P_z$ is total momentum and x,y,z projections, respectively. The beam direction is the z axis.

The curve(Fig.1d is the sum of the background by 8 order polynomial and 2 Breit-Wigner function ($\chi^2/N.D.F. = 43/38$). The small peaks are observed in mass range of $\Sigma^+(1385)$and $\Sigma^+(1620)$ with $\approx 3\sigma$. 
Table 1 The evolution of experimental and URQMD events for $\Lambda$ hyperons with acceptance for CBM.

| Type of data for p+C reaction | The number of collisions | The all number of $\Lambda \rightarrow \pi^- p V^0$ topology | All events with criteria for $\Lambda$ |
|------------------------------|--------------------------|-------------------------------------------------------|-----------------------------------|
| Exp. data                    | $10^6$                   | 9838                                                  | 1742                              | 1634                              |
| URQMD                        | $3.1 \times 10^5$        | 5310(7 mb)                                           | 1599                              | 313                                |

4 Conclusion

The $\Lambda$ and $\Sigma^+(1385)$ hyperons signals reconstruction efficiency is about 16% and $\approx 7\%$ for the p+C reaction at 10 GeV/c (Table 1), respectively. The obtained results show that the study of hyperons in high statistics experiments with the CBM facility at FAIR have a high scientific potential.

![Graphs](image1)

Fig. 1 The invariant mass distribution for identified $\Lambda$ hyperons(a). The experimental $\Lambda$ hyperons distributions for the scattering angle $\theta$ (b), azimuth angle $\phi$ (c) and $\Lambda\pi^+$ invariant mass spectrum with bin size 19 MeV/c$^2$ (d). The black solid histograms(b,c) are $\Lambda$ hyperons from all experimental data. The red dashed histograms are identified $\Lambda$ hyperons from experimental data by CBMROOT. The dashed red curve is the background by the polynomial method.

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