Σ^0 Hyperon Production in p + Nb at E_{kin} = 3.5 GeV*

L. Fabbietti[1,2], J. Friese[1] and T. Kunz[†1,2] for the HADES collaboration

[1]Physik Department E62, Technische Universität München, D-85748 Garching; [2]Excellence Cluster 'Origin and Structure of the Universe', D-85748 Garching

The production of Λ^0 – baryons (M = 1115.7 GeV/c^2) has been investigated by the HADES collaboration in various collision systems ranging from p + p to Au + Au at SIS energies. In this context it is of interest, to which amount feeding from Σ^0 (M = 1192.6 GeV/c^2) decays via the processes $\Sigma^0 \rightarrow \Lambda^0\gamma$ (BR = 100 %) and $\Sigma^0 \rightarrow \Lambda^0 e^+e^-$ (BR = 0.005 %) contributes to the observed Λ yields [2]. While at low collision energies close to the NN threshold the production cross sections $\sigma_\Lambda/\sigma_\Sigma \approx 10$ [1] suggest a feeding of ~ 10% it is expected that at energies around 1 GeV above threshold this contribution increases to ~30% [3]. For even higher energies it may reach up to 50%.

We have therefore started an attempt to identify Σ^0 – decays in the reaction p + Nb at E_{kin} = 3.5 GeV ($\epsilon \approx 0.67$ GeV). In the collected data sample of 4.21$\cdot$ 10^9 events Λ particles have been reconstructed through their weak decay $\Lambda \rightarrow p\pi^-$ utilizing momentum, dE/dx and track vertex information [4]. Coincident γ detection is achieved through conversion pair $\gamma \rightarrow e^+e^-$ identification, due to the absence of an electromagnetic calorimeter. However, the design of the HADES detector is optimized for low conversion probability. Furthermore, the momentum measurement for electrons is limited to $p_e \geq 50$ MeV/c because of the strong magnetic field between the two tracking stations MDCI/II and MDCIII/IV. GEANT simulations show that the conversion probability for γ´s (E_γ ~ 80 MeV) from Σ^0 decays is only ~3.0%.

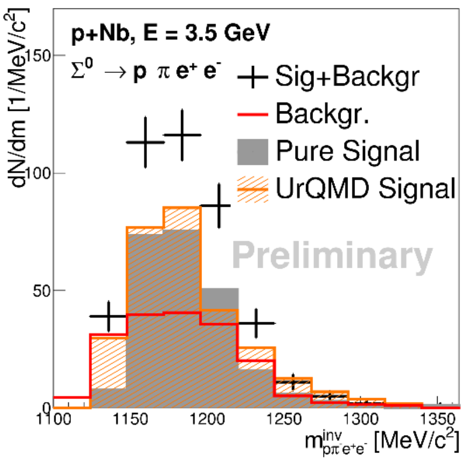

Figure 1: Invariant mass of the proton, pion and one di-electron pair for the selected Σ^0 candidates. The reconstructed events (black) are plotted together with background (red), extracted signal (grey) and UrQMD simulations (orange).

In the present analysis we require for each event with Λ content at least the momentum vector of one fully reconstructed electron or positron with a good quality RICH ring. For the identification of the converted photon we search for a second electron/positron candidate characterized by at least a RICH signal with hits in the inner tracking detectors only. The momentum of the latter is then determined by an event hypothesis method.

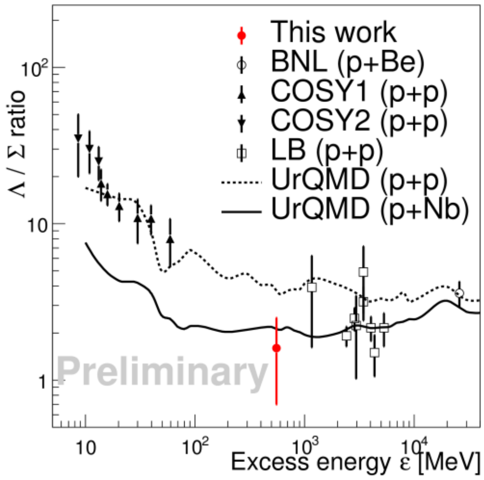

Figure 2: Invariant mass distribution for all $p\pi^-ee$ candidates with combinatorial backgrounds from mixed event and sideband analysis.

The reconstructed four particle invariant mass spectrum is presented in fig. 1. The background has been determined via a sideband analysis technique. Around 220 Σ^0 candidates become visible and are reasonably reproduced by a full scale simulation using UrQMD events as an input. After acceptance and efficiency correction the signal has been extrapolated to the uncovered p_t region using Boltzmann functions. The differential cross section is extracted to $\frac{d\sigma}{d\Omega}(\Sigma^0) = 2.3 \pm (0.2)^{stat} \pm (^{+0.6}_{-0.6})^{sys} \pm (0.2)^{norm}$ within the rapidity region of $0.5 < y < 1.1$. An extrapolation based on UrQMD predictions and measured Λ^0 rapidity distributions yields a total cross section of $\sigma^{tot}_{p+Nb}(\Sigma^0) = 5.8 \pm (0.5)^{stat} \pm (^{+1.4}_{-1.4})^{sys} \pm (0.6)^{norm} \pm (2.9)^{expol}$. The ratio $\frac{\Lambda}{\Sigma^0} = 1.6 \pm (0.1)^{stat} \pm (^{+0.5}_{-0.5})^{sys} \pm (0.7)^{expol}$ compares to the world data as shown in fig. 2.

[1] P.Kowina et. al, Eur. Phys. J. A 22, 293-299 (2004)
[2] K.A. Olive et al., Chin. Phys. C, 38, 0900001 (2014)
[3] H.Landolt, R.Börnstein, Landolt-B.12, (1988)
[4] G.Agakishiev et. al, Eur. Phys. J. A 50 (2014) 81

* Work supported by BMBF 05P15WOFCA, GSI TMLFRG 1316
† tobias.kunz@tum.de