Eur. Phys. J. A **18**, 347–349 (2003)
DOI 10.1140/epja/i2002-10233-3

The European Physical Journal A

Hyperon production in proton-proton collisions at the time-of-flight spectrometer COSY-TOF

W. Schroeder[a]

For the COSY-TOF Collaboration
Physikalisches Institut, Universität Erlangen-Nürnberg, Erwin-Rommel-Str. 1, 91058 Erlangen, Germany

Received: 30 September 2002 /

Abstract. The associated strangeness production in elementary proton-induced reactions is studied exclusively at the external COSY beam using the time-of-flight spectrometer TOF. The complete measurement of all charged-particle tracks allows the extraction of total and differential cross-sections and Dalitz plots as well. Especially the analysis of the Dalitz plots of the reaction $pp \longrightarrow K^+\Lambda p$ shows a strong influence of N^*-resonances.

PACS. 13.75.Cs Nucleon-nucleon interactions (including antinucleons, deuterons, etc.) – 14.20.Jn Hyperons

1 Introduction

The main interest in the investigation of the associated strangeness production in the reaction $pp \longrightarrow K^+\Lambda p$ close to the reaction threshold is the insight in the dynamics of the $s\bar{s}$ production. The reaction mechanism can be described within meson exchange models. In these models the contribution of strange and non-strange exchange particles can be investigated as well as the influence of N^*-resonances. Moreover, measurements near threshold can give information about the role of the hyperon nucleon final-state interaction (FSI) [1].

2 Experiment

The external experiment COSY-TOF is a large angle, non magnetic spectrometer, with various start and stop detector components to measure the time of flight. The detector combines high efficieny and acceptance with a moderate energy and momentum resolution. The whole detector together with a tiny liquid-hydrogen target is installed inside a vacuum vessel (see fig. 1). This ensures a rather precise definition of the interaction point and a strongly reduced contamination from background reactions in air.

The outer detector, which gives the stop timing, consists of a huge cylindrical segmented scintillator barrel with about three meters length and diameter each and a circular endcap in the forward direction. The endcap is made of two seperate hodoscopes, a central one ("Quirl") with a diameter of one meter and a ring-like one with an outer diameter of three meters. Both consist of three segmented scintillator layers, one of wedge-like parts and two of left- and right-hand spirally formed elements.

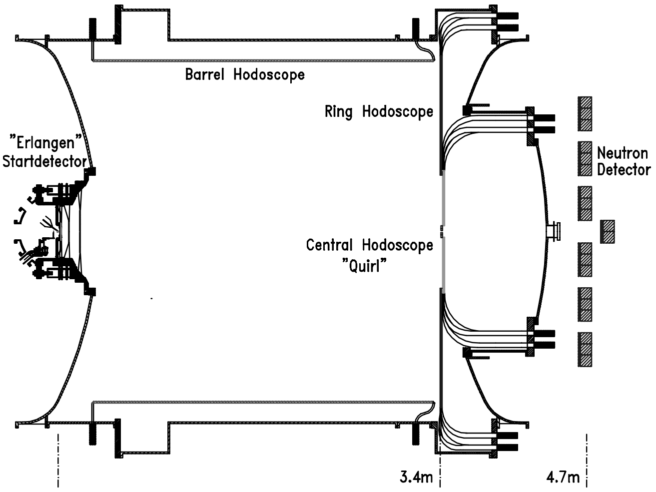

Fig. 1. Scheme of the TOF detector.

The inner detector, shown in fig. 2 together with a typical $K^+\Lambda p$ event, is optimized for track and vertex reconstruction. It consists of the "Starttorte", made of two layers of thin scintillators providing the start timing, a highly granulated double-sided silicon microstrip detector and two scintillating fibre hodoscopes. This system covers the whole angular range of the reaction products for the investigated hyperon production from threshold up to the

---

[a] e-mail: `schroeder@physik.uni-erlangen.de`

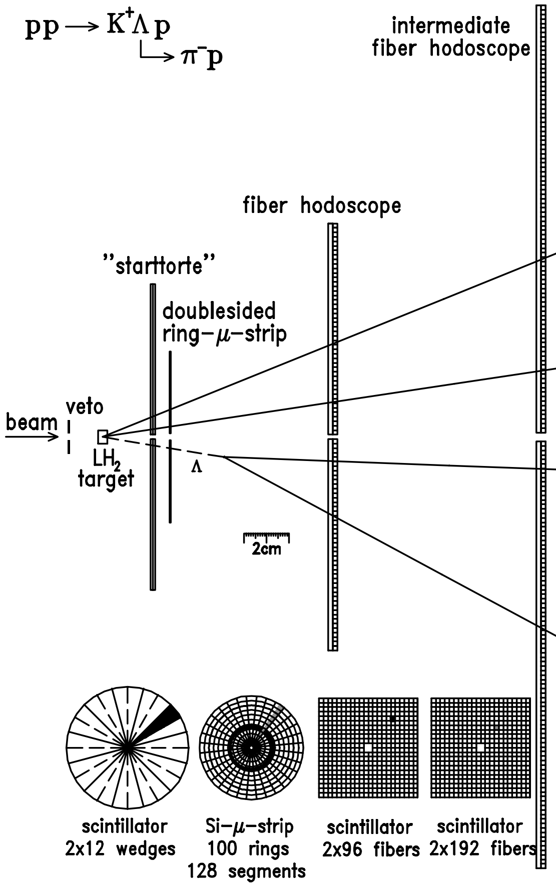

Fig. 2. Scheme of the Erlangen startdetector.

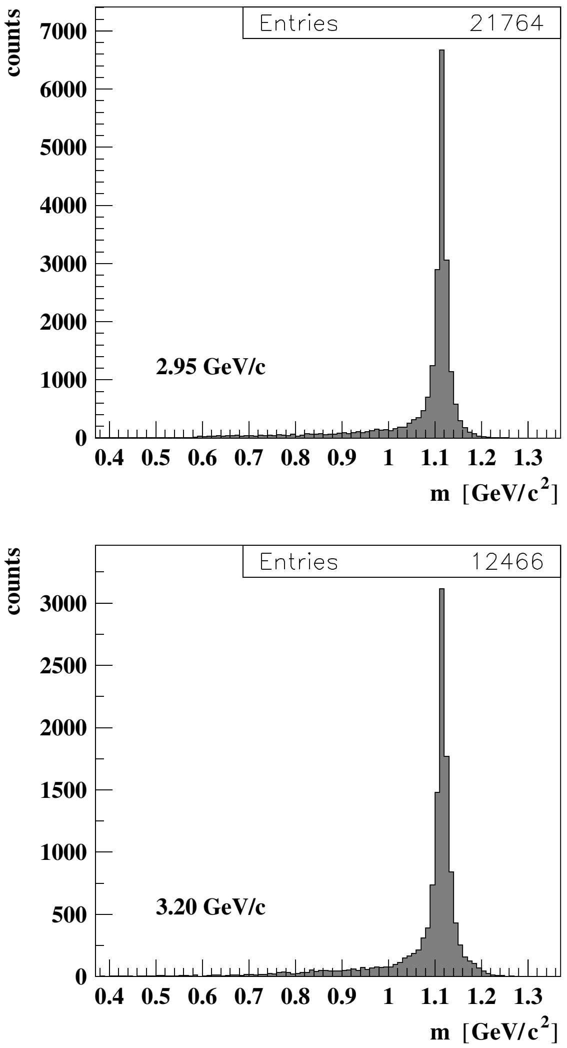

Fig. 3. Λ missing-mass distributions at 2.95 GeV/c (top) and 3.20 GeV/c (bottom).

COSY limit at 3.4 GeV/c. It allows the complete reconstruction of the $pp \longrightarrow K^+\Lambda p$ events including the precise measurement of the delayed decay of the Λ-hyperon in two charged particles.

3 Results and discussion

The reaction $pp \longrightarrow K^+\Lambda p$ has been investigated in detail between 2.5 GeV/c and 3.2 GeV/c beam momentum. For all measurements clean event samples on a very low background have been extracted. To demonstrate this, the missing-mass spectra of the reconstructed Λ-hyperons are shown in figs. 3 for the beam momenta of 2.95 and 3.2 GeV/c, respectively.

One big advantage of the TOF experiment is the coverage of the full phase space which allows to extract various exclusive observables model indepentently. A powerful tool to investigate the influence of N^*-resonances and the FSI is the analysis of Dalitz plots. In figs. 4 and 6 the squared masses of the subsystems $K\Lambda$ *versus* $p\Lambda$ are shown for the data at 2.95 and 3.20 GeV/c. A strong deviation from pure phase space is observed.

To investigate this in more detail, we use a meson exchange model of Sibirtsev *et al.* [2] where various contributions can be added in a coherent way. Besides a non-resonant meson exchange which leads to a uniform distribution of the Dalitz plots, the code allows to include the resonant exchange via the N^*-resonances at 1650, 1710 and 1720 MeV/c^2. The resonances are known to have a significant decay branch into the $K\Lambda$ system. Moreover, $p\Lambda$ FSI can be included.

The contribution of the N^*-resonances without FSI leads to horizontal bands in the investigated Dalitz plots corresponding to their masses and widths. The FSI together with a non-resonant contribution without resonances shows up in an enhancement at low $p\Lambda$ masses. As shown in figs. 5 and 7, the experimental result can only be explained by a coherent addition of both FSI and N^*-resonances. Together with the data at 2.85 GeV/c which are not presented here, the analysis shows a clear and unique result concerning the influence of the N^*-resonances discussed. There is a strong energy dependence; whereas at 2.85 GeV/c only the $N^*(1650)$ is relevant, at 2.95 GeV/c in addition there is already a significant contribution of the $N^*(1710)$. At 3.20 GeV/c the amplitudes of both resonances are equal within the precision of the analysis. This behavior is in good agreement with the prediction of Shyam [3].

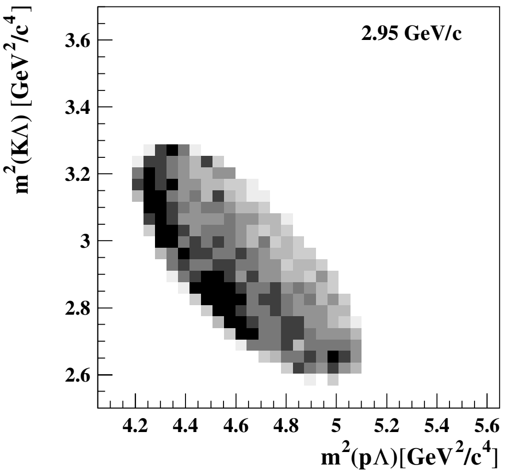

Fig. 4. Dalitz plot at 2.95 GeV/c.

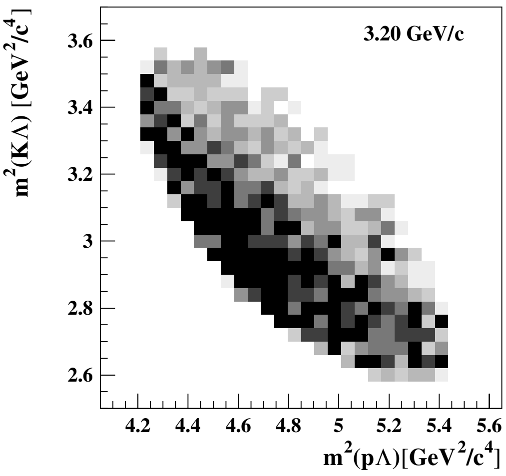

Fig. 6. Dalitz plot at 3.20 GeV/c.

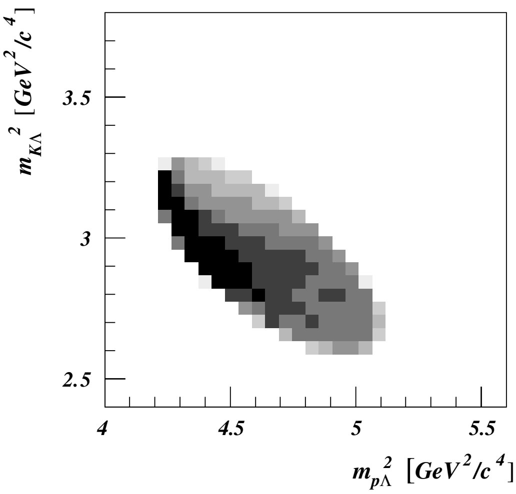

Fig. 5. Result of model calculations at 2.95 GeV/c.

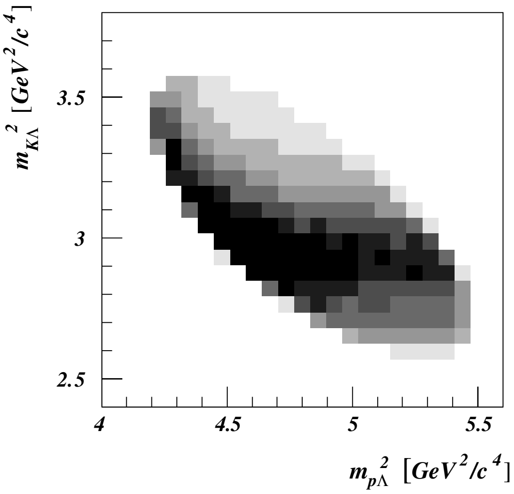

Fig. 7. Result of model calculations at 3.20 GeV/c.

4 Conclusion

The analysis of the Dalitz plots of the COSY-TOF data show for the first time in a clear way the strong influence of N^*-resonances in the Λ production in proton-proton collision close to threshold.

In a further step this method will be extended to the Σ production especially in the channel $pp \longrightarrow K^0\Sigma^+p$ for which first data could already be extracted in the COSY-TOF experiment.

Moreover, the use of a polarized beam will provide additional information for a more detailed analysis including exclusive spin observables.

This work was supported by German BMBF and FZ Jülich.

References

1. A. Bilger *et al.*, Phys. Lett. B **420**, 217 (1998).
2. A. Sibirtsev, private communication (2002).
3. R. Shyam, Phys. Rev. C **60**, 055213 (1999),