Effective range parameters in the $p-Y$ system extracted from the hyperon production data.

P. Kowina and D. Grzonka for the COSY–11 collaboration

Final state interactions of a two body subsystem in a 3-body final state like pK^+Y influence the excitation function in the threshold region and its analysis allows to extract information on the effective range parameters (for a review see ref. [1]). A parametrization of the cross section which relates the shape of the threshold behavior to the effective range parameters is e.g. given by Fäldt and Wilkin [2]:

$$\sigma = const \cdot \frac{V_{ps}}{\mathrm{F}} \cdot \frac{1}{\left(1 + \sqrt{1 + \frac{Q}{\varepsilon'}}\right)^2} = C' \cdot \frac{Q^2}{\sqrt{\lambda(s, m_p^2, m_p^2)}} \cdot \frac{1}{\left(1 + \sqrt{1 + \frac{Q}{\varepsilon'}}\right)^2}. \quad (1)$$

The phase space volume V_{ps} and the flux factor F are given by [3]:

$$V_{ps} = \frac{\pi^3}{2} \frac{\sqrt{m_p\, m_{K^+}\, m_Y}}{(m_p + m_{K^+} + m_Y)^{\frac{3}{2}}}\, Q^2, \quad (2)$$

$$\mathrm{F} = 2\,(2\pi)^{3n-4} \sqrt{\lambda(s, m_p^2, m_p^2)}. \quad (3)$$

with $\lambda(x,y,z) = x^2 + y^2 + z^2 - 2xy - 2yz - 2zx$.

The solid lines in fig. 1 represent the results of χ^2 fits using the Fäldt and Wilkin parametrization to the available data for the Λ and Σ^0 hyperon production in the close-to-threshold energy range up to ~ 60 MeV. The dashed lines correspond to the fit considering only pure S-wave phase space distributions.

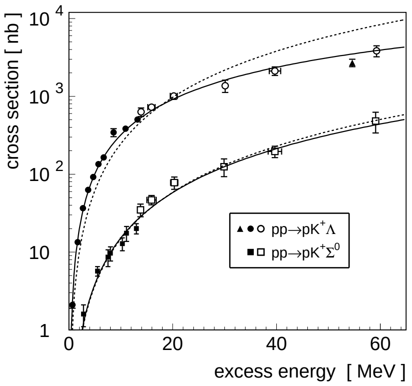

Fig. 1: Total cross sections for the $pp \to pK^+\Lambda$ and $pp \to pK^+\Sigma^0$ production (full symbols [4, 5], open symbols [6] and triangle [7]).

The parameter ε', which is related to the strength of the $p-Y$ final state interaction and the normalization constant C' were extracted by the fits performed for each reaction separately resulting in:

$$C'(\Lambda) = (98.2 \pm 3.7)\ \mathrm{nb/MeV^2}$$
$$\varepsilon'(\Lambda) = (5.51^{+0.58}_{-0.52})\ \mathrm{MeV}$$
$$C'(\Sigma^0) = (2.97 \pm 0.27)\ \mathrm{nb/MeV^2}$$
$$\varepsilon'(\Sigma^0) = (133^{+108}_{-44})\ \mathrm{MeV}.$$

Assuming only S-wave production, the $p-\Lambda(\Sigma^0)$ systems can be described using the Bergman potentials [8], where the scattering length $\hat{a}$ and the effective range $\hat{r}$ are given by:

$$\hat{a} = \frac{\alpha+\beta}{\alpha\beta}, \qquad \hat{r} = \frac{2}{\alpha+\beta}, \quad (4)$$

with a shape parameter β and $\alpha = \pm\sqrt{\varepsilon' 2\mu}$ where μ is the reduced mass of the $p-Y$ system. The negative value of α is chosen since (at least for $p-\Lambda$) an attractive interaction is expected [9, 10].

The parameters $\hat{a}$ and $\hat{r}$ are interdependent and only a correlation between them can be deduced. In fig. 2 the correlations obtained for both the $p-\Sigma^0$ and for the $p-\Lambda$ systems are represented by the solid and dashed lines, respectively. The error ranges are shown in the figure by the thinner lines.

The results obtained for the $p-\Lambda$ system are consistent with the value of the spin averaged parameters determined experimentally [11] and shown in fig. 2 by the cross symbol.

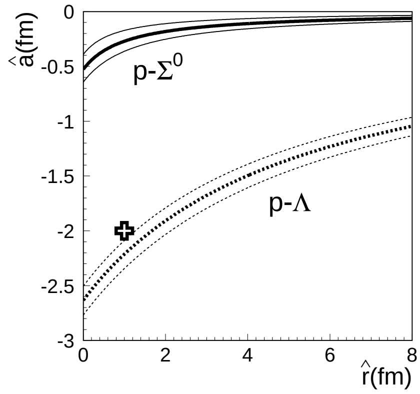

Fig. 2: Correlation between the $p-\Sigma^0$ (solid lines) and $p-\Lambda$ (dashed lines) effective range parameters. The cross symbol is the value of the $p-\Lambda$ effective range parameters extracted from a FSI approach in ref. [11].

It seems that the $p-\Sigma^0$ FSI is much smaller than the FSI for $p-\Lambda$. However, since transitions in the final state (like $n\Sigma^+ \to p\Sigma^0$) are possible, the use of the Fäldt and Wilkin parametrization allows only to obtain an estimation of the effective $N-\Sigma$ FSI and not directly the FSI in the $p-\Sigma^0$ channel [12]. Therefore, one should be careful when interpreting the result for the $p-\Sigma^0$ system.

References:

[1] P. Moskal, M. Wolke, A. Khoukaz and W. Oelert, Prog. Part. Nucl. Phys. **49** (2002) 1.
[2] G. Fäldt and C. Wilkin, Z. Phys. **A357** (1997) 241.
[3] E. Byckling and K. Kajantie, Particle Kinematics (John Wiley & Sons Ltd., 1973), ISBN 0 471 12885 6.
[4] S. Sewerin et al., Phys. Rev. Lett. **83** (1999) 682.
[5] J. Balewski et al., Phys. Lett. **B420** (1998) 211.
[6] P. Kowina et al., Submited to EPJ A (2003).
[7] A. Bilger et al., Phys. Lett. **B420** (1998) 217.
[8] R.G. Newton, Scattering Theory of Waves and Particles (Springer-Verlag, New York, 1982).
[9] B. Holzenkamp, K. Holinde and J. Speth, Nucl. Phys. **A500** (1989) 485.
[10] T.A. Rijken, V.G.J. Stoks and Y. Yamamoto, Phys. Rev. **C59** (1999) 21.
[11] J. Balewski et al., Eur. Phys. J. **A2** (1998) 99.
[12] J. Haidenbauer, IKP, FZ–Jülich, priv. com.