Weak Strangeness Production at COSY

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Reactions with strangeness non-conserving Λ-production would allow the observation of a pure weak process not via interference effects but in a clean direct way. It has been proposed [1] to measure the strangeness violating weak Λ-production at COSY–TOF in the reaction $\mathrm{dp} \to \Lambda\mathrm{pp}$.

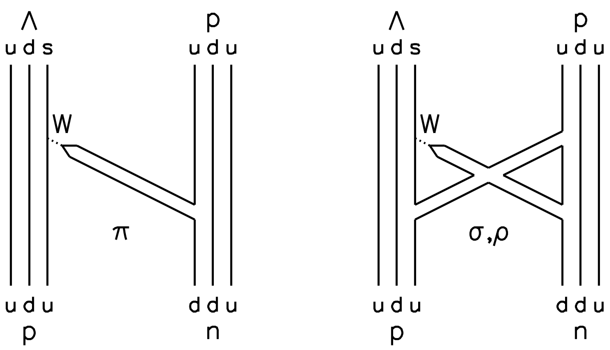

Figure 1: Quark line diagrams of weak Λ-production

Hypernuclei decay experiments are somehow the inverse. They have shown that a simple description of the underlying decay process is not sufficient: Λ decaying into nucleon and pion, with the pion interacting with a neighbouring nucleon. This simple model incorporates a spin and isospin dependence caused by the pion exchange, a dependene which is not seen in the experimental data. Additional processes have to be taken into account, for instance σ-, ρ-, ω-, or Kaon-exchange [2]. In order to obtain any experimental data about these decay modes which obviously cannot be seen in a free Λ-decay it would be favourable to have a reaction where this weak process could be seen isolated and not inside a nucleus. A solution seems to be the weak strangeness production in nucleon-nucleon scattering, i.e. Λ-production below any strangeness conserving energies.

The reaction has a very low cross-section. The branching ratio can be estimated from the ratio of typical time constants for hadronic and weak interaction to be $10^{-23}\mathrm{s}/10^{-10}\mathrm{s} \sim 10^{-13}$ (see also [2]). It is obvious that for a measurement an extremely clean environment is needed. This might be obtained by two conditions: first, a reaction which runs at an energy below any threshold of strangeness conserving strong Λ-production, second, the Λ-decay which is the main signature for strangeness identification must happen in vacuum in order to avoid background reactions which could fake a Λ-decay. The first condition is fulfilled by the reaction $\mathrm{dp} \to \Lambda\mathrm{pp}$. Its threshold of 1.5406 GeV/c is far below strong Λ-production even on heavy nuclei (1.726 GeV/c). The advantage of measuring d on p instead of $\mathrm{pd} \to \Lambda\mathrm{pp}$ is the fact that the emission angles of all particles (except the decay pion) are below $35°$ in the whole measurable momentum range. The second point is fulfilled by using the TOF-detector with its internal vacuum.

We want to begin these studies with the same setup like for $\mathrm{pp} \to \mathrm{pK}^+\Lambda$, a reaction which is already included in the experimental program of COSY for 1995 [3]. Here, the experiment consists of the liquid hydrogen target with a small start detector behind it. The following rectangular scintillator hodoscope in combination with the outer detector elements 'quirl', 'ring', and 'barrel' (all 3-layer scintillator hodoscopes) will allow a precise track reconstruction and time-of-flight measurement. A limit of $< 10^{-9}$ for the branching ratio should be rather easy to reach like this.

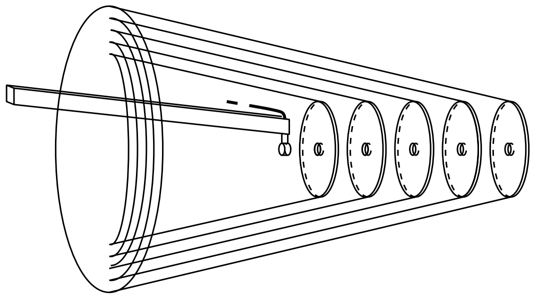

Figure 2: Target and decay spectrometer

For higher sensitivity we plan to improve the detectors step by step and finally use the experimental setup proposed for hypertriton lifetime measurement [4]. Following the liquid hydrogen target a stack of silicon counters (a decay spectrometer) with a 'quirl'-like surface structure is used for track and therefore decay vertex determination. These silicon disks with ~ 70 mm diameter will be mechanically and electrically supported by cones made of copper plated capton foils. A spherical scintillator hodoscope covering 2π in laboratory system surrounds the inner detector section. In conjunction with the outer scintillator hodoscopes it allows for precise track reconstruction and time-of-flight measurement also for decay pions. An additional energy detector behind the 'quirl' will improve energy resolution.

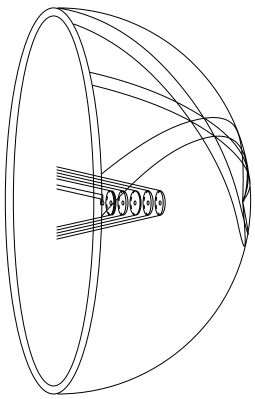

Figure 3: Spherical scintillator hodoscope containing target section

References:

[1] Letter of Intent 33 for the TOF-experiment at COSY
[2] Haidenbauer, Holinde, Thomas, this report
[3] Proposal 15 for the TOF-experiment at COSY
[4] Proposal 32 for the TOF-experiment at COSY