Observation of Pontecorvo Reactions with Open Strangeness

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Annihilation reactions of antinucleons on atomic nuclei with only one meson in the exit channel (Pontecorvo reactions) demand the participation of more than one nucleon, due to conservation laws. So far, only $\bar{p}d$ Pontecorvo channels with strangeness zero products, such as $\pi^- p$, have been observed. The results did not allow a decision between the two-step and the fireball picture. The former assumes an ordinary annihilation of the antiproton on one of the nucleons into two mesons in the first reaction step and the absorption of one of these mesons on the other nucleon in the second step. In the latter model the 3 antiquarks and 6 quarks of the entrance channel form a compound system, the fireball, which decays statistically. The predictions of these models for channels with open strangeness differ by orders of magnitude.

The Crystal Barrel Collaboration has discovered the Pontecorvo reactions $\bar{p}d \to K^0\Lambda$ and $\bar{p}d \to K^0\Sigma^0$ [1,2]. The observation was made possible by installation of a Silicon microstrip detector [1,3] in the center of the Crystal Barrel Detector at LEAR (CERN) which incorporates a drift chamber and a CsI barrel as main components. The cylindrical set-up (Fig.1) of 15 partly overlapping microstrip modules, oriented in parallel to the beam axis, covers fully the solid angle of the drift chamber which measures charged particle momentum in a magnetic field of 1.5 Tesla. The combination of these two detectors provides a fast topological trigger on secondary decay vertices. Reactions with secondary $K^0_S \to \pi^+\pi^-$ or $\Lambda \to \pi^- p$ decays are enriched by this trigger by a factor of 100.

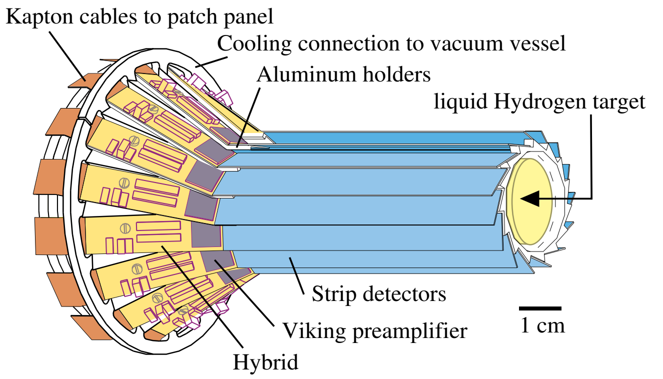

Fig. 1: Schematic overview of the silicon vertex detector and the front end electronic read-out installed in the Crystal Barrel detector [1,3].

Antiprotons from the LEAR facility were stopped in a liquid deuterium target in the center of the detector. A K^0_S- and Λ-enriched sample of events corresponding to 10^9 annihilations was recorded. An example from the on-line display (Fig.2) shows two secondary vertices outside of the Silicon detector and an isolated photon entry in the CsI crystal barrel in addition to the energy deposits that match with the charged particle tracks. Full kinematic reconstruction identifies this event as being of the Pontecorvo type $K^0_S\Sigma^0$ with successive $K^0_S \to \pi^+\pi^-$ and $\Sigma^0 \to \gamma\Lambda(\to p\pi^-)$ decays.

Samples of about 100 events were found in the final off-line data selection for each of the channels $K^0_S\Lambda$, $K^0_S\Sigma^0$, $K^0_L\Lambda$ and $K^0_L\Sigma^0$. The corresponding $\bar{p}d$ annihilation rates are $(2.35\pm0.45)\times10^{-6}$ and $(2.15\pm0.45)\times10^{-6}$ for the $K^0\Lambda$ and the $K^o\Sigma^o$ channels, respectively, with identical results for the K^0_S and the K^0_L versions. These rates exceed by orders of magnitude the expectations of the two-step model. In particular, the similarity of the two rates disagrees drastically with that model. On the other hand, our observations were expected as signals of a parton fireball [4]. Indeed, the B (baryon number) = 1 fireball was suggested to form the seed of a quark-gluon plasma phase in $\bar{p}$-nucleus interactions. With the present understanding of meson-baryon interactions, our observations of the open strangeness Pontecorvo channels are to be taken as evidence for deconfinement of the original nucleonic quark bags.

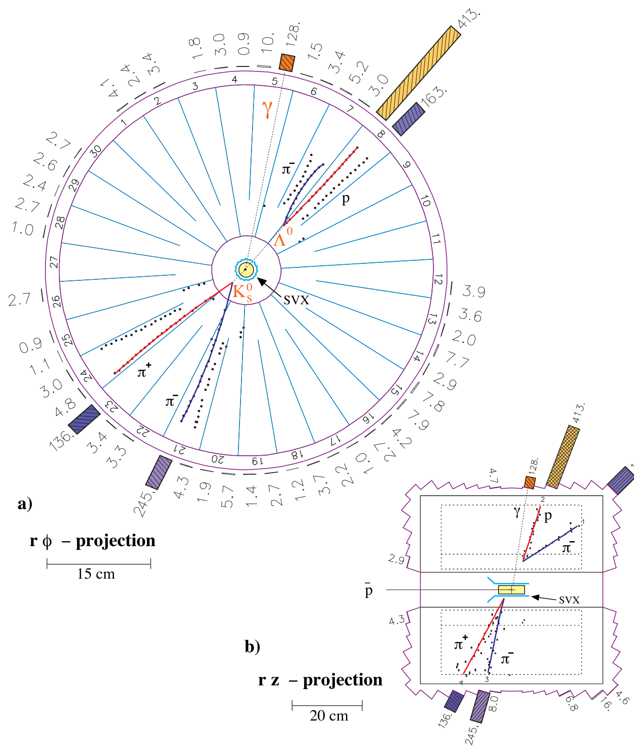

Fig. 2: An event of the Pontecorvo type with charged-particle multiplicities 0 in the Silicon counter (SVX) and 4 in the drift chamber, as recorded on-line. The transversal and longitudinal projections a) and b) show the complete signature of a $\bar{p}d \to K^0_S(\to \pi^+\pi^-)\Sigma^0(\to \gamma\Lambda(\to p\pi^-))$ event. Clockwise and anticlockwise curvatures in a) signify negative and positive charges, respectively. Energy deposits in the barrel-shaped CsI calorimeter are represented by bars of proportional length.

References

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