NEW DATA ON THE Ω_c^0 FROM THE CERN HYPERON BEAM EXPERIMENT WA89

The WA89 Collaboration

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Abstract

Among the ground state charmed hadrons the Ω_c^0 is the least known particle. It has so far been observed in a few decay channels only and with low statistics. Using a data sample of 1993 from the CERN hyperon beam experiment WA89 the Ω_c^0 has been found in 7 decay modes which cover final states with Ω^-, Ξ^- and Λ. We present a measurement of the Ω_c^0 mass and its lifetime.

1 Introduction

The Ω_c^0(ssc) is the least well known weakly decaying charmed baryon. First found in the former hyperon beam experiment WA62 [1] it has been seen by Argus [2] and E687 [3]. These experiments found the Ω_c^0 in four different decay channels. In the following we present new data on the Ω_c^0 in seven decay modes obtained in the CERN hyperon beam experiment WA89.

The measured lifetimes of the three charmed baryons Λ_c^+(udc), Ξ_c^+(usc), Ξ_c^0(dsc) differ by almost a factor of 4. For the Ξ_c^0 decay the direct decay and the decay via internal W-exchange is possible, resulting in a short lifetime. For the Ξ_c^+ the internal W-exchange is not possible and the lifetime is the longest of the three measured charmed baryon lifetimes. If u or s quarks are already present in the initial charmed baryons additional differences between the lifetimes are caused by the overlap of identical quarks in the final state. This overlap is of crucial importance for the Ω_c^0 decay where three identical quarks are present in the final state. Thus the lifetime of the Ω_c^0 is of special interest to understand the hierarchy of the charmed baryon lifetimes.

2 The WA89 Experiment

WA89 uses a Σ^--beam at the Ω spectrometer magnet at CERN. The Σ^--beam passes a set of micro strip detectors and a 80 cm long transition radiation detector (TRD) before hitting the longitudinally segmented target consisting of a copper and three diamond slabs with 3 % interaction length in total. The TRD is used to suppress the pion content of the beam on trigger level. A silicon vertex detector, consisting of 29 silicon micro strip planes with pitch sizes of 25 μm and 50 μm follows after the target. The trigger selected interactions which occured in the target or in one of the first 12 silicon vertex detector planes.

Drift chambers and wire chambers with 1 mm wire spacing in a 7 meter long region between the target and the spectrometer are used to reconstruct the decays of short living strange particles. The superconducting Omega spectrometer magnet is located 13 m downstream of the target area. A ring imaging cherenkov counter (RICH) positioned downstream of the magnet provides particle identification. A detailed description and the apparatus and all its components can be found in [4].

3 Event Reconstruction and Selection

In the 1993 beam time 200 Million events were recorded. The reconstruction of these events was performed seperatly in the subdetectors. Finally the track segments from the spectrometer, the decay region and the vertex detector were linked together. The decays of Λ and K^0 in two charged particles were kinematically identified. The decays of Ξ^- and Ω^- were reconstructed by forming a vertex using the trajectories of a reconstructed Λ and tracks from negative particles. In addition it was requested that the reconstructed Ξ^- or Ω^- trajectory coincided with a track segment in the vertex detector which was not connected to a segment in the downstream detectors. To further reduce the background particle identification was applied where possible.

The decays of Ω_c^0 were isolated from the background by reconstructing the production and decay topology. All tracks with the correct charge combination for a given decay mode were combined and tested for a common vertex (decay vertex). Tracks not used for this candidate were assumed to come from the interaction point and were also fitted to a common vertex (production vertex). In the fit of the production vertex tracks not consistent with a common vertex were rejected [5].

Criteria applied for background rejection in the charm search were based on the quality of the two fitted vertices, the separation of the two vertices, the impact parameter of the charm candidate at the production vertex, and the impact of the tracks of the decay products at the production point. These cuts were adjusted to isolate events with two separated vertices. In decay modes with K^- particle identification was used to reduce the combinatorical background. In addition clearly identified pions were not used as kaons. Details of the applied cuts for all decay modes can be found in [6] and [7]. Figure 1 shows the signals obtained in the decay modes

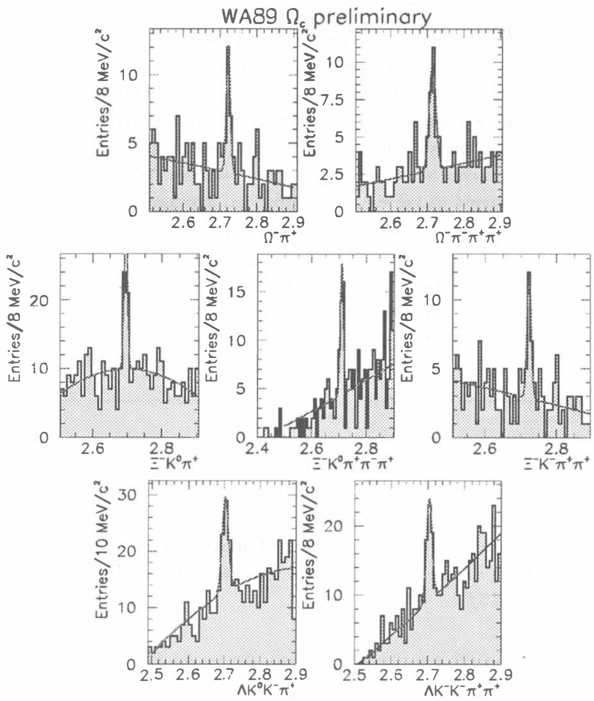

Figure 1

$\Omega^-\pi^+$ (10 ± 3.6 events found) . $\Omega^-\pi^+\pi^+\pi^-$ (20.3 ± 6.2) , $\Xi^-K^-\pi^+\pi^+$ (70.0 ± 11.0), $\Xi^-K^0\pi^+$ (29.3 ± 7.0), $\Xi^-K^0\pi^+\pi^+\pi^-$ (24.7 ± 7.4), $\Lambda K^0K^-\pi^+$ (22 ± 7.5) and $\Lambda K^-K^-\pi^+\pi^+$ (22 ± 6.2). The decay modes in $\Omega^-\pi^+$,$\Omega^-\pi^+\pi^+$ and $\Xi^-K^-\pi^+\pi^+$confirm the observation of WA62, Argus and E687. The other four decay modes were seen for the first time.

4 Measurement of Mass and Lifetime of the Ω_c^0

In total 198 ± 19 decay candidates were found. From the fits of a Gaussian plus a polynomial for the background in the different channels we obtain a preliminary value for the Ω_c^0 Mass

$$M(\Omega_c^0) = 2707 \pm 1(stat)\ \mathrm{MeV}/c^2 \quad (preliminary).$$

As an preliminary estimate for the systematic errors we obtain a value of ± 4 MeV/c^2. The study of the mass reconstruction systematics is not yet finalised.

The Lifetime of the Ω_c^0 was measured using the decay modes $\Omega^-\pi^+\pi^+\pi^-$,$\Xi^-K^-\pi^+\pi^+$, and $\Xi^-K^0\pi^+$. The most significant signal in the the channel $\Omega_c^0 \rightarrow \Xi^-K^-\pi^+\pi^+$ was splitted in three subsamples of events stemming from the copper target, the carbon targets and from interactions in the silicon planes. For the determination of the lifetime we chose samples from the signal regions in the mass distributions. The contribution from the background was studied by taking events from two sidebands away from the peak. To extract the lifetime we used a non binned maximum likelihood method. We minimised the likelihood function $L(t) = \eta f(t, \tau_s) + (1-\eta) f(t, \tau_b)$ where t are the measured (reduced) lifetimes $t = d_v - d_{min} \cdot / \gamma\beta$ (d_v being the measured vertex separation and d_{min} being the minimal allowed distance). τ_s and τ_b are the fitted lifetimes of signal and background events. The fitted function f was an exponential convoluted with a Gaussian to account for individual errors on the decay length. The weights between background and signal η were obtained in fits to the mass distributions. Details of the fitting method can be found in [6]. The obtained lifetimes together with their statistical errors are summarised in table 1. The weighted average lifetime is

Decay mode	Signal Lifetime (preliminary)	Background lifetime (preliminary)
$\Xi^- K^- \pi\pi$ (Copper target)	65^{+22}_{-15} fs	23 ± 5 fs
$\Xi^- K^- \pi\pi$ (Diamond target)	78^{+23}_{-17} fs	27 ± 10 fs
$\Xi^- K^- \pi\pi$ (Silicon target)	54^{+18}_{-13} fs	6 ± 2 fs
$\Omega^- \pi^- \pi^+ \pi^+$	100^{+33}_{-24} fs	40 ± 47 fs
$\Xi^- K^0 \pi^+$	56^{+19}_{-14} fs	25 ± 25 fs

Table 1

$$\tau(\Omega_c^0) = 70^{+9.3}_{-8.1}(stat.) fs \quad (preliminary)$$

This constitutes the first measurement of the Ω_c^0 lifetime and the shortest lifetime of a weakly decaying charmed particle measured so far. The systematic errors for this measurement are still under study. The main sources of systematic uncertainties studied up to now lead to a systematic error of about $\pm 15 fs$.

5 Conclusion

The charmed strange baryon Ω_c^0 was found in seven decay modes. In total 198 ± 19 decay candidates were observed. Using this data sample we measured the mass of the Ω_c^0 to be $2707 \pm 1(stat)$ MeV$/c^2$. The lifetime of the Ω_c^0 was measured to be $66^{+8.3}_{-7.2}(stat.) fs$. This measurements fully establishes the lifetime hierarchy of weakly decaying charmed hadrons for the first time. The extremely short lifetime of the Ω_c^0 underlines the importance of the hadronic effects in the decay amplitudes.

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