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MEASUREMENT OF THE MASS AND LIFETIME OF THE CHARMED STRANGE BARYON Ξ_c^+

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ABSTRACT

We have observed six unambiguous decays of the charmed strange baryon Ξ_c^+ (or charge conjugate $\overline{\Xi}_c^-$) in the collision of 230 GeV/c negative pions or kaons on a copper target at the CERN SPS using silicon microstrip detectors and charge-coupled devices for vertex reconstruction. Three of them have been reconstructed through the decay chain $\Xi_c^+ \to \Xi^-\pi^+\pi^+$, $\Xi^- \to \Lambda^0\pi^-$, $\Lambda^0 \to p\pi^-$ and the other three through the decay chain $\Xi_c^+ \to \Sigma^+K^-\pi^+$, $\Sigma^+ \to p\pi^0$. We present our measurements of the mass, lifetime and production cross-section of the Ξ_c^+, as well as of the branching ratio for the two decay modes.

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1. INTRODUCTION

Four singly-charmed baryons are expected to decay weakly : Λ_c^+(cud), Ξ_c^+(csu), Ξ_c^0(csd) and Ω_c^0(css). Until a year ago there has been little experimental information on the last three states. The Ξ_c^+ had been first observed by a hyperon beam experiment at CERN in the reaction Σ^-(135 GeV/c)+Be → $\Lambda^0 K^- \pi^+ \pi^+$+X [1] and confirmed by an experiment at FNAL in the reaction n(~600 GeV/c)+W/Si/Be → Λ^0(or Σ^0)$K^- \pi^+ \pi^+$+X [2], with an average mass of 2460±19 MeV/c^2 [3]. The Ξ_c^0 had not been seen and the Ω_c^0 had been observed by the CERN hyperon beam experiment through three decays in the decay mode $\Xi^- K^- \pi^+ \pi^+$ whose masses cluster around 2740 MeV/c^2 [1]. In addition there appears to be a discrepancy between the two experiments for Ξ_c^+, as the second one sees two peaks in the $\Lambda^0 K^- \pi^+ \pi^+$ mass spectrum, while the first one only sees one peak.

Even for experiments using a precise vertex detector, charmed baryon decays involving a Λ^0 suffer from combinatorial background for it is generally impossible to decide which vertex the Λ^0 is coming from. This is not the case for decays involving a Ξ^- or $\Sigma^\pm$ hyperon, or a proton. In addition the baryon character of such decays can in general be better ascertained through a clean reconstruction of the characteristic decay of a Ξ^- or $\Sigma^\pm$ than through the identification of a proton with Cerenkov counters. Exploiting these ideas we reported a year ago the observation of two unambiguous decays of Ξ_c^+ into a new decay mode $\Xi^- \pi^+ \pi^+$ [4]. Then the CLEO Collaboration reported the first observation of Ξ_c^0 in the decay mode $\Xi^- \pi^+$ at a mass of 2471±3±4 MeV/c^2 [5] and we reported the observation of another new decay mode of $\Xi_c^+ \rightarrow \Sigma^+ K^- \pi^+$ [6]. Recently the CLEO Collaboration confirmed the decay $\Xi_c^+ \rightarrow \Xi^- \pi^+ \pi^+$ and, after reanalysing their $\Xi_c^0 \rightarrow \Xi^- \pi^+$ data, measured the isospin mass splitting of the Ξ_c system to be $m_{\Xi_c^+} - m_{\Xi_c^0} = -5 \pm 4 \pm 1$ MeV/c^2 [7]. In this letter we present our final results on the decay of Ξ_c^+ into the decay modes $\Xi^- \pi^+ \pi^+$ and $\Sigma^+ K^- \pi^+$. Results on the observation of Ξ_c^0 in this experiment will be reported in a forthcoming letter.

Our experiment was performed in 1985-1986 at the CERN SPS. Its main aim was the study of production and decay properties of charmed particles produced in hadronic collisions and decaying hadronically into final states containing a p-K^- or K^+-K^- pair. It was a continuation of the NA32 experiment [8] using the ACCMOR spectrometer, an improved vertex detector and a dedicated trigger. For the first time charge-coupled devices, CCDs [9], were used as vertex detectors. They provide high precision (~ 5 μm) space points on tracks close to the target. A modified version of the FAMP trigger [10] was used to trigger on events containing a pair of opposite charge kaons and/or protons. A total of 17 million triggers have been recorded.

2. THE EXPERIMENT

A negative beam with a momentum of 230 GeV/c was used. Two CEDAR Cerenkov counters served for tagging incident pions and kaons (96% and 4% respectively). Hadronic charm decays into charged particles were fully reconstructed with the vertex detector and the large acceptance spectrometer [11] shown in Fig. 1. The vertex detector consisted of two parts : a beam telescope with 7 silicon microstrip detectors (MSDs) and a vertex telescope with 2 CCDs at 10 and 20 mm behind the target and 8 MSDs positioned from 65 to 185 mm behind the target. A short 2.5 mm Cu target was used so that decay vertices could be observed in vacuum close to the primary vertex. The spectrometer consisted of 2 magnets M1 and M2 and 48 planes of drift chambers arranged in 4 groups, DC_1 to DC_4. Three multicellular threshold Cerenkov counters, C_1 to C_3, were used to identify π,K,p in the momentum range 4-80 GeV/c.

The trigger had two levels, a hardware trigger and the FAMP trigger. They are described in Ref. [11]. Compared to a simple interaction trigger, this two-level trigger increased by a factor 5 the sensitivity of the experiment for decays with a pair of opposite charge K/p in the final state.While decays like $X \to \Sigma^+K^-\pi^+(\Sigma^+ \to p\pi^0)$ satisfy the trigger conditions by themselves, decays like $X \to \Xi^-\pi^+\pi^+$ ($\Xi^- \to \Lambda^0\pi^-$, $\Lambda^0 \to p\pi^-$) do not*). However kaons or protons from the primary vertex, or the kaon from the decay of the associated charmed partner, or accompanying pions, simulating kaons or protons, permit such reactions to fulfil the trigger conditions with a sizeable, though reduced, efficiency. Through this mechanism we have obtained substantial samples of $D^+ \to K^-\pi^+\pi^+$ and $D^0 \to K^-\pi^+$ or $K^-\pi^+\pi^+\pi^-$ in this experiment [12].

3. RECONSTRUCTION OF Ξ^- HYPERONS

We look for the cascade $\Xi^- \to \Lambda^0\pi^-$, $\Lambda^0 \to p\pi^-$ and, at the same time, $\Omega^- \to \Lambda^0K^-$, $\Lambda^0 \to p\pi^-$. In order to achieve a strong rejection of background, one ought to reconstruct the Ξ/Ω track and the three charged decay tracks, measure their momenta and identify them. On the other hand one would like to keep the acceptance as large as possible. We restricted the search for Ξ/Ω to decays in front of the onset of the magnetic field in M1 (70 cm downstream of the target) to avoid complications with the bending of the Ξ/Ω track in M1 (Fig. 1). We also restricted the search to decays beyond CCD_2 so that the Ξ/Ω track can always be reconstructed in the vertex detector. The asymmetric decay of the Ξ and of the Λ^0 frequently prevents either decay pion to reach DC_2. A reasonable compromise between background rejection and larger acceptance was to restrict the search to Λ^0 decays in front of DC_1 (285 cm

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*) Unless explicitly stated, particle symbols will be used throughout to denote particles and antiparticles.

downstream of the target) and to require the π/K from Ξ/Ω decay and the pion from Λ^0 decay to be detected in DC1. As a consequence i) the momentum of the π/K can always be measured, ii) the momentum of the pion from Λ^0 decay can be measured for most Λ^0 decays. The forward-going proton from Λ^0 decay is required to be detected in DC_1 and DC_2 so that its momentum can be determined from its deflection in M2. Under these conditions the background was found to be small and it was decided not to require particle identification in order not to decrease unnecessarily the acceptance.

The search for Ξ/Ω was made in two phases : i) search for Ξ/Ω decaying between CCD_2 and plane MSD_7 of the vertex telescope (decay range = 16 cm), ii) search for Ξ/Ω decaying between MSD_8 and the onset of the magnetic field in M1 (decay range = 52 cm). In the first phase the π/K from Ξ/Ω decay can be detected in at least two MSD planes and the Ξ/Ω decay vertex can be precisely reconstructed, making the reconstruction of the Λ^0 originating from this point comparatively straightforward. In the second phase we had to use an iterative procedure, looking for that point on a Ξ/Ω track which minimizes the sum of the two χ^2s for the π/K and for the Λ^0 to originate from it. In both phases we require i) the invariant mass of either the $p\pi^-$ or the $\pi^+\bar{p}$ interpretation of a reconstructed V^0 to be within $\pm$ 20 MeV/c^2 of the Λ^0 mass, ii) the angle between the Ξ/Ω track and the sum of the momentum vectors of the π/K and of the Λ^0 to be less than about 2 mr.

As we do not use particle identification, each cascade can be interpreted either as a $\Xi^- \rightarrow \Lambda^0\pi^-$ candidate or as a $\Omega^- \rightarrow \Lambda^0K^-$ one. The small fraction of ambiguities is removed by requiring $|m_{\Lambda^0K^-} - m_{\Omega^-}| > 15$ MeV/c^2 for the Ξ^- candidates. Figure 2 shows the distribution of the $\Lambda^0\pi^-$ invariant mass as obtained from all triggers. The Ξ mass peak contains approximately 7500 Ξ^- and 5700 $\bar{\Xi}^+$. The tails of the $\Lambda^0\pi^-$ mass distribution reflect some distortion induced by the reconstruction procedure for the second range of the Ξ^- decay, in particular when the Λ^0 decays closely behind the Ξ^-.

4. THE DECAY MODE $\Xi_c^+ \rightarrow \Xi^-\pi^+\pi^+$

The analysis is similar to the one used for our Λ_c^+, D_s^+, D^+ and D^0 studies [12]. We first look for decay vertices, having a χ^2 probability of better than 1% between the track of a reconstructed Ξ^- and two other π^+ tracks. Then we require i) the effective mass of the $\Lambda^0\pi^-$ system to be within $\pm$ 25 MeV/c^2 of the Ξ^- mass, ii) all three tracks in a decay vertex to be incompatible with originating from the primary vertex, with a χ^2 probability less than 1%, in order to exclude topological ambiguities, iii) the decay vertex to be outside the target, in order to exclude secondary interactions, and to be upstream of CCD_2, so that all three tracks can be reconstructed in at least one CCD, iv) the total momentum vector of the decay vertex to be compatible with passing through the primary vertex with a χ^2 probability better than 1%.

Under these conditions three events were selected out of the total sample of 17 million triggers. The second requirement, stronger than the one used in Ref.[12], turned out to be very powerful in suppressing the background. Table 1 gives the characteristics of the three events. Their $\Xi\pi\pi$ effective masses cluster around 2465 MeV/c^2. Our Λ_c^+ studies already showed that the precision of the vertex detector allows the selection of clean decay vertices in vacuum and we found a background of only 7% under the mass peak in the decay mode $\Lambda_c^+ \rightarrow pK^-\pi$. Here in the $\Xi\pi\pi$ decay mode the presence of a Ξ^- in the final state gives an additional signature which reduces the background still further. As a cross-check, using the same selection criteria, we also looked for $\Xi\pi\pi$ decay vertices where the two pions have opposite charges and where no charmed particles are expected. No event was selected.

We therefore interpret the three events as decays of the Ξ_c^+ baryon . All three events have been produced by incident pions. One decay is a Ξ_c^+, the other two are $\overline{\Xi}_c^-$. Taking the Ξ^- mass to be 1321.32 MeV/c^2 [3] we find a weighted mean mass $m_{\Xi_c^+} = 2465.4 \pm 4.0$ MeV/c^2 in good agreement with the previous determinations [3,7]. As for our measurement of the Λ_c^+ mass [13], we estimate a systematic uncertainty of ± 1.2 MeV/c^2 on the Ξ_c^+ mass, after checking that the effect of the small distortion mentioned in section 3 is negligible.

5. RECONSTRUCTION OF Σ^+ HYPERONS

The Σ^+ hyperon decays almost equally into $p\pi^0$ and into $n\pi^+$. The Σ^- hyperon decays exclusively into $n\pi^-$. In order to achieve a strong rejection of the background we required a baryon to be identified in the decay products. Since our set-up was not detecting neutrons, we restricted the search to decays of Σ^+ into $p\pi^0$. Due to their comparatively short lifetime, most Σ^+s decay between the last plane of the vertex detector and the first plane of the drift chamber group DC_1. In addition the proton from Σ^+ decay is emitted forward, with an angle with respect to the Σ^+ direction which has to be less than the kinematical limit $\theta_{max} = 189/p$ mr, where p is the proton momentum in GeV/c. Its momentum can, therefore, be determined from its deflection in M2 and it can be identified in the Cerenkov counters.

In these circumstances a Σ^+ decay can be recognized as a kink between a track reconstructed in the vertex detector ("Σ" track) and a track reconstructed in DC_1 and DC_2 to DC_4 and identified as being that of a proton ("proton" track). A kink is accepted if a "Σ" track and a "proton" track pass each other within about 2.5 mm in the interval MSD_8 - DC_1 and if they have an angle larger than about 1 mr and less than about $(\theta_{max}+ 1)$ mr. Once a Σ^+ decay is recognized, the Σ^+ momentum can be determined from the proton momentum and from the kink angle with the well-known twofold ambiguity.

The strength of this procedure together with the cleanliness of the reconstruction of decay vertices in the vertex detector has been demonstrated in this experiment by the observation of 11 decays $\Lambda_c^+ \rightarrow \Sigma^+\pi^+\pi^-$ with a small background [12].

6. THE DECAY MODE $\Xi_c^+ \rightarrow \Sigma^+K^-\pi^+$

The analysis is very similar to the one described in section 4. We first look for decay vertices, having a χ^2 probability of better that 1%, between the track of a reconstructed Σ^+ and two other tracks, identified as kaon and pion respectively. Then we impose the conditions ii, iii and iv specified in section 4.

In total 12 events have been selected, seven with the charge state $\Sigma^+K^-\pi^+$ (Ξ_c^+), three with the charge state $\Sigma^+K^+\pi^-$ (Λ_c^+, Cabibbo disfavoured) and two with the "wrong" charge state $\Sigma^+K^-\pi^-$. To interpret these events we have to take into account the Σ momentum ambiguity as well as the rather frequent K/π identification ambiguity. In the charge state $\Sigma^+K^-\pi^+$, four decays have an unambiguous kaon, three of them having one of the two $\Sigma K\pi$ mass solu-tions clustering around $m_{\Xi_c^+}$, the fourth one having both mass solutions below 2060 MeV/c^2. The remaining three decays have ambiguous kaons but all may be interpreted as $\Lambda_c^+ \rightarrow \Sigma^+\pi^-\pi^+$ (m = 2290, 2284, 2277 MeV/c^2 respectively). Similarly, in the charge state $\Sigma^+K^+\pi^-$, all three decays may be interpreted as Λ_c^+, two $\Lambda_c^+ \rightarrow \Sigma^+K^+\pi^-$ (m = 2284 and 2278 MeV/c^2) and one $\Lambda_c^+ \rightarrow \Sigma^+\pi^-\pi^+$ (m = 2287 MeV/c^2).

Considering the low level of unexplained background (one event with charge state $\Sigma^+K^-\pi^+$, two with "wrong" charge state $\Sigma^+K^-\pi^-$) we interpret the first three $\Sigma^+K^-\pi^+$ decays as evidence for a new, Cabibbo favoured, decay mode of Ξ_c^+. Table 2 gives their characteristics. The first two events have been produced by incident pions, one decay is a Ξ_c^+, the other one a $\overline{\Xi}_c^-$. The third event has been produced by an incident kaon and the corresponding decay is a Ξ_c^+, containing an s-quark like the K^-. In addition the second event appears as a remarkable instance of hadronic production of a charmed baryon - charmed antibaryon pair, whose decays are fully reconstructed : $\pi^- + Cu \rightarrow X^- + \overline{\Xi}_c^- + \Lambda_c^+ +$ neutrals, $\overline{\Xi}_c^- \rightarrow \overline{\Sigma}^-K^+\pi^-$, $\Lambda_c^+ \rightarrow pK^-\pi^+$.

The three selected $\Sigma K\pi$ masses of Table 2 have widely varying associated errors, rapidly increasing when the kink angle approaches the limit θ_{max}. This effect is the strongest for the third event which, being the only one where the Σ^+ decays inside the magnetic field of M1, also suffers from the uncertainty on the position of the Σ^+ decay vertex. The error calculations being strongly non-linear for kink angles close to θ_{max}, we prefer to ignore this event. Taking the Σ^+ mass to be 1189.37 MeV/c^2 [3], we find from the first two events $m_{\Xi_c^+} = 2467.5 \pm 3.7$ MeV/c^2, in good agreement with our determination of section 4. As before, we estimate a systematic uncertainty of ± 1.2 MeV/c^2 on this result.

7. RESULTS

Combining our mass measurements from the two decay modes we find $m_{\Xi_c^+}$ = 2466.5±2.7±1.2 MeV/c^2 in very good agreement with the CLEO measurement of 2467±3±4 MeV/c^2 [7].

To measure the Ξ_c^+ lifetime, we have to correct the observed decay lengths for the acceptance of the selection criteria [14]. For each event with a decay length ℓ and Ξ_c momentum p_{Ξ_c}, we determine the minimum detectable decay length ℓ_{min} and calculate the corrected proper time $\Delta t = (\ell - \ell_{min})\, m_{\Xi_c}/cp_{\Xi_c}$. The correction for the loss of decays beyond CCD_2 is negligible. Since similar selection criteria were used for the two decay modes, we combine the six events and find a lifetime $\tau(\Xi_c^+) = (2.0^{+1.1}_{-0.6}) \cdot 10^{-13}$s somewhat smaller than the previous measurement of $(4.3^{+1.7}_{-1.2}) \cdot 10^{-13}$ [3], but very close to our measurement of $\tau(\Lambda_c^+) = (1.96^{+0.23}_{-0.20}) \cdot 10^{-13}$s [13].

There are two calculations of the lifetimes of the four weakly-decaying charmed baryons based on a spectator diagram, W-exchange and quark interference with QCD effects [15,16]. While the first process leads to equal lifetimes, the W-exchange between c and d quarks shortens the lifetime of Λ_c^+ and Ξ_c^0. The constructive interference between the s quark from the $c \rightarrow su\bar{d}$ decay and the s quark in the initial state shortens the lifetimes of Ξ_c^+, Ξ_c^0 and even more that of Ω_c^0, while the destructive interference of the u quarks lengthens the lifetimes of Λ_c^+ and Ξ_c^+. Guberina et al. [15] predict $\tau(\Omega_c^0) \approx \tau(\Xi_c^0) < \tau(\Lambda_c^+) < \tau(\Xi_c^+)$, whereas Voloshin and Shifman [16] predict $\tau(\Omega_c^0) < \tau(\Xi_c^0) < \tau(\Lambda_c^+) \approx \tau(\Xi_c^+) < \tau(D^0) \approx \tau(D_s^+) < \tau(D^+)$. Both authors also give estimates of the lifetimes but they stress that, while these estimates are subject to large uncertainties, the predicted lifetime hierarchies are much more reliable. In particular Voloshin and Shifman indicate that each inequality in their predicted hierarchy represents a factor 1.5-2.0. Our measurement of $\tau(\Xi_c^+)$, together with the more precise measurements of the lifetimes of Λ_c^+, D^0, D_s^+ and D^+ [13,3] supports their predictions, while the previous measurement of $\tau(\Xi_c^+) = (4.3^{+1.7}_{-1.2}) \cdot 10^{-13}$s [3] agrees better with the hierarchy of Guberina et al. More statistics are needed to decide between these interesting predictions.

We have looked for possible resonant components in the Ξ_c^+ decays. For the 6 $\Xi^-\pi^+$ combinations in $\Xi_c^+ \rightarrow \Xi^-\pi^+\pi^+$ decays, we find the following effective masses : (1963,1887), (1965,1912) and (1928,1939) MeV/c^2. These values are incompatible with $\Xi(1530)^0$. For the mass of the $K^-\pi^+$ system in the three $\Xi_c^+ \rightarrow \Sigma^+K^-\pi^+$ decays, we find 936, 908 and 828 MeV/c^2 respectively, which may be interpreted as $\bar{K}^*(892)$. Using a quark model calculation, Körner et al. [17] have given predictions for the decay rates of charmed baryons into various two-body and quasi-two-body final states, in particular the partial width for $\Xi_c^+ \rightarrow \Xi(1530)^0\pi^+$ to vanish and the one for $\Xi_c^+ \rightarrow \Sigma^+\bar{K}^{*0}$ to be large. Our results are compatible with these predictions.

In order to determine the total production cross-section of Ξ_c^+ by pions we have assumed a production mechanism similar to what we have observed for Λ_c^+ [18]. In a Monte Carlo simulation the Ξ_c^+ is produced with the usual distribution $d^2\sigma/dx_F dp_T^2 \propto (1-x_F)^n \exp(-bp_T^2)$ (x_F, p_T = Feynman variable and transverse momentum of Ξ_c^+) in conjunction with a mixture of 67% $\bar{D}^0$ and 33% D^-. We take $n = 3$, $b = 1\ \mathrm{GeV}^{-2}$, $\tau(\Xi_c^+) = 2.0 \cdot 10^{-13}$s. Decay tracks from Ξ_c^+ and D decays are merged with additional tracks from real events. The Monte Carlo program includes the geometrical acceptance of our set-up, the simulation of the trigger and the simulation of the off-line selection. The total acceptance is found to be 0.25% for the decay chain $\Xi_c^+ \to \Xi^-\pi^+\pi^+$, $\Xi^- \to \Lambda^0\pi^-$, $\Lambda^0 \to p\pi^-$ and 2.3% for the decay chain $\Xi_c^+ \to \Sigma^+K^-\pi^+$, $\Sigma^+ \to p\pi^0$. Assuming a linear A dependence we measure from the three $\Xi^-\pi^+\pi^+$ events the Ξ_c^+ production cross-section times branching fraction of $\Xi_c^+ \to \Xi^-\pi^+\pi^+$ to be $0.13 \pm 0.08 ^{+0.05}_{-0.08}$ μb per nucleon for $x_F > 0$. The first error is statistical, the second one is systematic and reflects mainly the uncertainties on the Ξ_c^+ lifetime, on the value of n and on the trigger simulation (for n we assume an uncertainty $\Delta n = \pm 2$). From the above total acceptances and the 5 pion-induced Ξ_c^+ events we measure the branching ratio of the two decay modes to be $\Gamma(\Sigma^+K^-\pi^+)/\Gamma(\Xi^-\pi^+\pi^+) = 0.09 ^{+0.13}_{-0.06} {}^{+0.03}_{-0.02}$, with the same remark as before on the two errors.

8. CONCLUSIONS

We have observed six unambiguous decays of Ξ_c^+ in the two decay modes $\Xi_c^+ \to \Xi^-\pi^+\pi^+$ and $\Xi_c^+ \to \Sigma^+K^-\pi^+$. We measure the mass of Ξ_c^+ to be $2466.5 \pm 2.7 \pm 1.2\ \mathrm{MeV}/c^2$ and its lifetime to be $(2.0^{+1.1}_{-0.6}) \cdot 10^{-13}$s. Assuming a production mechanism of Ξ_c^+ by pions similar to the one for Λ_c^+, we determine the Ξ_c^+ production cross-section times branching fraction of $\Xi_c^+ \to \Xi^-\pi^+\pi^+$ to be $0.13 \pm 0.08 ^{+0.05}_{-0.08}$ μb per nucleon for $x_F > 0$. We also determine the branching ratio of the two decay modes to be $\Gamma(\Sigma^+K^-\pi^+)/\Gamma(\Xi^-\pi^+\pi^+) = 0.09 ^{+0.13}_{-0.06} {}^{+0.03}_{-0.02}$.

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Table 1

Summary of properties of the three $\Xi^-\pi^+\pi^+$ decays

Event	1	2	3
Mass of $(p\pi)$ from Λ^0 (MeV/c^2)	1132	1115	1108
Mass of $(\Lambda^0\pi)$ from Ξ^- (MeV/c^2)	1302	1320	1323
Mass of $(\Xi\pi\pi)$ system (MeV/c^2)	2461.0±8.8	2462.5±7.0	2468.5±5.2
Total charge and momentum (GeV/c)	- 34.2	- 58.0	+ 83.5
Distance of total momentum vector to primary vertex and its error (μm)	9.1 (4.0)	5.0 (7.5)	9.6 (4.8)
Distance of decay vertex from target edge (standard deviations)	10	6	52
Decay length ℓ (mm)	1.61	3.14	13.5
ℓ_{min} (mm)	1.49	2.50	4.12
Corrected lifetime (10^{-13}s)	0.27	0.91	9.2

Table 2

Summary of properties of the three $\Sigma^+K^-\pi^+$ decays

Event	1	2	3
Angle (Σ,p) in mr	7.7	7.1	6.3
Momentum of proton (GeV/c)	16.7	24.2	29.1
Mass of ($\Sigma K\pi$) system 2 solutions (MeV/c^2)	2467.2±3.8 2452.7±5.1	2474.6±18 2393.2±7.3	2446.5±20 2408.0±26
Total charge and momentum for first solution (GeV/c)	+ 47.3	- 46.3	+ 60.4
Distance of total momentum vector to primary vertex and its error (μm)	5.4 (3.2)	5.0 (5.4)	7.5 (4.2)
Distance of decay vertex from target edge (standard deviations)	2.6	27	9
Decay length ℓ (mm)	2.78	1.98	1.63
ℓ_{min} (mm)	2.66	1.29	1.52
Corrected lifetime (10^{-13}s)	0.22	1.23	0.16

Figure Captions

Fig. 1 Schematic view of the ACCMOR spectrometer with the details of the vertex detector in the inset. B1-B7 : silicon microstrip detectors for beam track reconstruction; T : 2.5 mm Cu target; CCDs : charge-coupled devices; I : interaction counter; MSD1-MSD8 : silicon microstrip detectors used together with CCDs for reconstruction of tracks and vertices (underneath are shown strip orientations with respect to horizontal plane).

Fig. 2 Invariant mass distribution of the $\Lambda^0\pi^-$ system for the $\Xi^-/\overline{\Xi}^+$ sample.

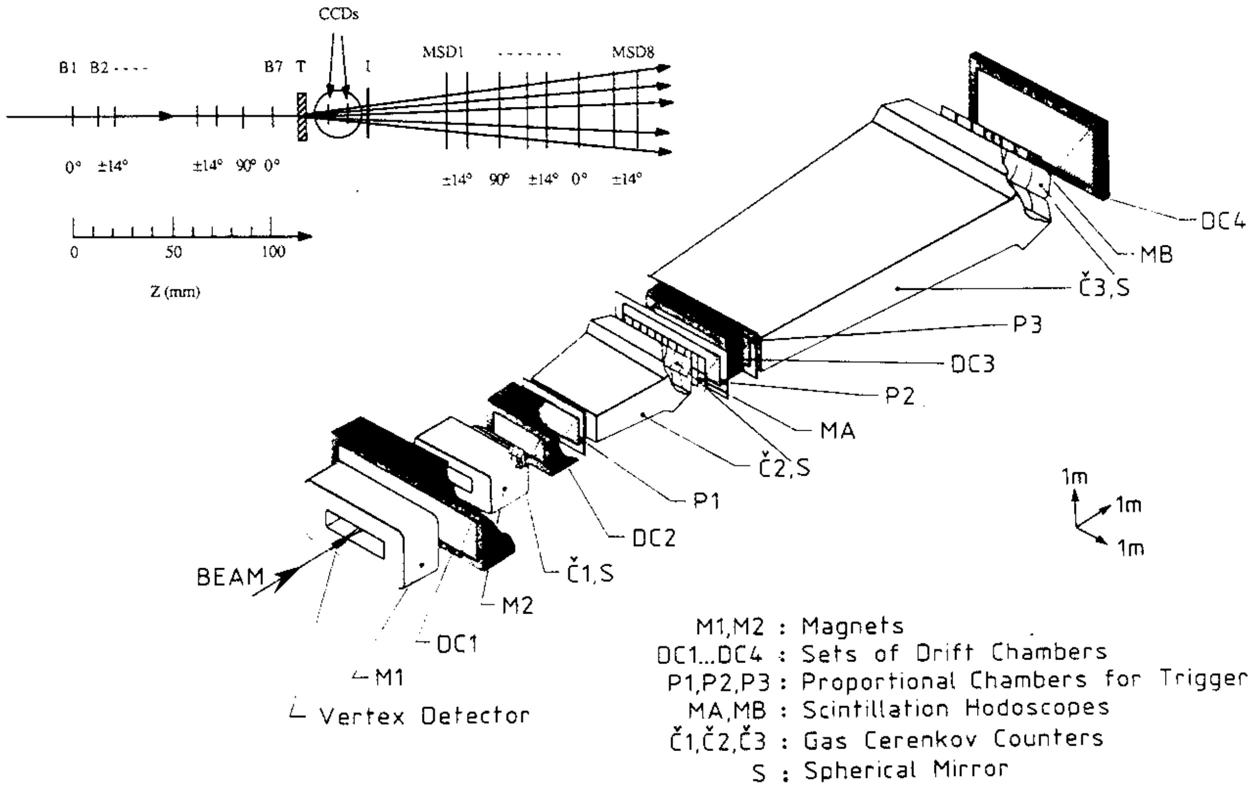
CCDs
B1 B2 ----
B7 T
I
MSD1 .... MSD8
0° ±14° ±14° 90° 0°
±14° 90° ±14° 0° ±14°
0 50 100
Z (mm)
DC4
MB
Č3,S
P3
DC3
P2
MA
Č2,S
P1
DC2
Č1,S
M2
DC1
M1
Vertex Detector
BEAM
1m
1m
1m
M1,M2 : Magnets
DC1...DC4 : Sets of Drift Chambers
P1,P2,P3 : Proportional Chambers for Trigger
MA,MB : Scintillation Hodoscopes
Č1,Č2,Č3 : Gas Cerenkov Counters
S : Spherical Mirror

Fig. 1

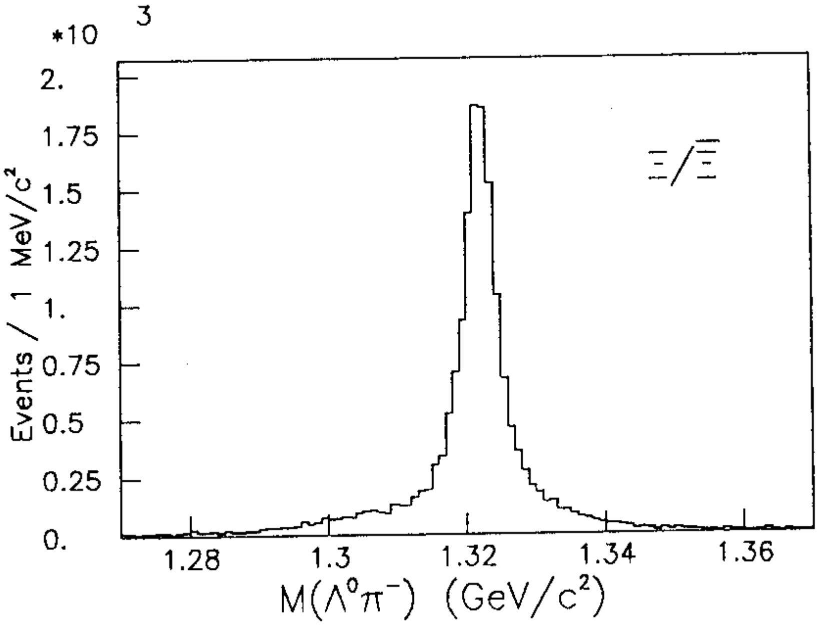
*10 3
2.
1.75
1.5
1.25
1.
0.75
0.5
0.25
0.
Events / 1 MeV/c²
1.28
1.3
1.32
1.34
1.36
M(Λ⁰π⁻) (GeV/c²)
Ξ/Ξ̄

Fig. 2