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Observation of Ξ_c^0 semileptonic decay

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Observation of the semileptonic decay of the charmed baryon Ξ_c^0 in the decay channel $\Xi_c^0 \to \Xi^- l^+ X$ has been made using the ARGUS detector at the e^+e^- storage ring DORIS II at DESY. The cross section times branching ratio was found to be $\sigma(e^+e^- \to \Xi_c^0 X) \cdot \mathrm{BR}(\Xi_c^0 \to \Xi^- l^+ X)) = 0.74 \pm 0.24 \pm 0.09$ pb.

Observation of the Ξ_c^0 baryon was first reported in 1989 [1], and subsequently studied in the decay channels $\Xi_c^0 \to \Xi^-\pi^+$, $\Xi_c^0 \to \Xi^-\pi^+\pi^+\pi^-$ and $\Xi_c^0 \to \Omega^- K^+$ [2–4]. In this paper, the first evidence for the semileptonic decay of the Ξ_c^0 baryon is presented, and its cross section times branching ratio is determined. The decay mode studied is $\Xi_c^0 \to \Xi^- l^+ X$ [#1] where l^+ is either an electron or muon, and X is any low mass neutral particle combination containing a neutrino. Because the neutrino cannot be detected, this decay channel is difficult to observe with many possible contributing background processes. The ARGUS collaboration has previously reported a measurement of the semileptonic decay $\Lambda_c^+ \to \Lambda l^+ X$ [5]. The work presented here is a continuation of this previous paper in which the decay $\Xi_c^0 \to \Xi^- l^+ X$ was observed as a source of background to the Λ_c^+ semileptonic decay channel.

There has been much effort lately given to theoretical calculations and experimental measurements of semileptonic decay rates of charmed and bottom mesons. The quark model has so far had reasonable success in describing these semileptonic processes [6]. From this work, one can eventually extract the corresponding Cabibbo–Kobayashi–Maskawa mixing angles and the quark structure of hadrons described by the various form factors. Thus, it is natural to extend this model to the decay of heavy quark baryons such as Λ_c^+, Ξ_c^0, Ξ_c^+, Ω_c^0 and Λ_b^0. Just as in the semileptonic D or B meson decay, the semileptonic decay of these heavy quark baryons is a spectator process where the Cabibbo-favored decay $c \to sl^+\nu_l$ or $b \to cl^-\bar{\nu}_l$ dominates. These processes occur, to a good approximation, independently of the spectator diquarks. Differences from semileptonic meson calculations arise in the hadronic wavefunction parametrization. Recent theoretical work [7–11] has estimated these heavy quark baryon semileptonic branching ratios to be a few percent, indicating that they should be clearly observable. Indeed, the semileptonic decay of the Λ_c^+ [6,12–14] and the Λ_b^0 [15] baryon has already been reported by various experiments. Thus, one should expect to be able to observe the semileptonic decay of the Ξ_c^0 charmed

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#1 In this paper, all references to a specific charge state imply the charge conjugate state also, unless otherwise stated.

baryon.

The data presented here was collected using the ARGUS detector at the e^+e^- storage ring DORIS II at DESY. The ARGUS detector is a 4π solenoidal magnetic spectrometer, described in detail elsewhere [16]. The data sample comprises an integrated luminosity of 495.0 pb^{-1} accumulated on the $\Upsilon(1S)$, $\Upsilon(2S)$, $\Upsilon(4S)$ resonances and the nearby continuum with an average center of mass energy of 10.4 GeV. Only multihadron events are selected, these being defined as having at least three charged tracks with either a common main vertex or a total energy deposit of at least 1.7 GeV in the shower counters. To suppress radiative Bhabha and beam gas events, we require $n_{ch} + n_\gamma/2 > 5$ where n_{ch} is the number of charged tracks and n_γ is the number of photons with momentum above 100 MeV/c. To eliminate poorly measured particles, charged tracks are required to have a minimum momentum transverse to the beam direction of 60 MeV/c and a polar angle, θ, with respect to the beam direction such that $|\cos\theta| < 0.92$. Charged particle identification is made on the basis of specific ionization (dE/dx) in the drift chamber, time of flight (TOF) measurements, shower counter and muon chamber information. This information is then used to calculate a likelihood ratio for all charged tracks. Only charged particles with a likelihood ratio greater than 1% for one of the mass hypothesis π, K, p, e or μ, are accepted [16].

In this analysis we are interested only in Ξ_c^0 events from continuum $c\bar{c}$ production. To reduce $\Upsilon(4S)$ resonance events, and hence possible Ξ_c^0's produced from B meson decay, a topological cut is applied. The second Fox–Wolfram moment [17] is required to be larger than 0.35. Extensive Monte Carlo studies showed that this suppresses $(93 \pm 3)\%$ of the $\Upsilon(4S)$ resonance.

The Ξ^- is identified by its decay into $\Lambda\pi^-$. The subsequent Λ is reconstructed by a procedure similar to that reported in ref. [5]. Since the Λ and π^- come from the secondary decay of the Ξ^-, which has a relatively large $c\tau$ of 4.91 cm [18], their momentum vectors are not required to point back to the main vertex. To reduce combinatorial background, the cosine of the angle between the Λ and π^- momentum vectors is required to be greater than zero. This is justified since events from Ξ^- decay have a $\cos\theta_{\Lambda\pi^-}$ distribution peaked at 1.0, while background events have a flat distribution. Also, pions from reconstructed secondary vertices consistent with a Λ or K_s^0 mass hypothesis are not used in the Ξ^- reconstruction. Fig. 1a shows a plot of the mass for all $\Lambda\pi^-$ combinations from the data satisfying the above requirements. A signal near the Ξ^- mass is observed.

Electrons and muons are identified by a combined likelihood function which includes dE/dx, TOF, shower counter and muon chamber information [16]. Only those leptons having a combined likelihood ratio greater than 80% are accepted, with the further requirement that the muons must also have at least one hit in the outer muon chambers. Also, electrons and muons are required to have a momentum

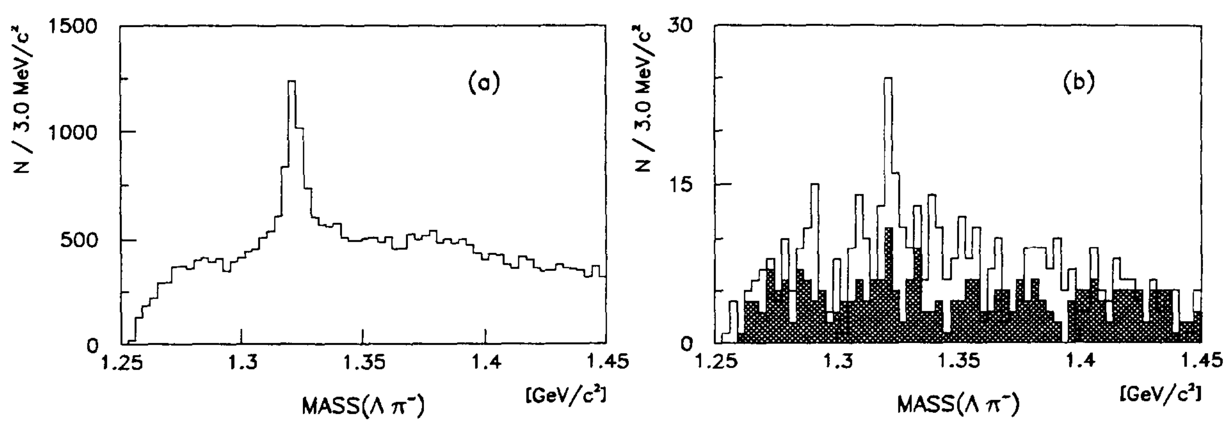


Fig. 1. Invariant mass of $\Lambda\pi^-$ combinations for: (a) all events and (b) those events with a right-sign lepton (open histogram) and a wrong-sign lepton (shaded histogram) with $x_p > 0$ and $M_{\Lambda\pi^- l^+} < 2.473$ GeV/c^2.

greater than 0.4 GeV/c and 0.9 GeV/c, respectively. This is where reliable lepton identification begins. Finally, electrons from photon conversion are removed from subsequent analysis. These are defined as e^+e^- combinations from the main vertex or from reconstructed secondary vertices which have an invariant mass less than 100 MeV/c^2. With these selections a high purity sample of leptons is obtained with only a (0.5 ± 0.2)% electron–hadron and (2.0 ± 0.6)% muon–hadron misidentification rate.

Fig. 1b shows the invariant mass distributions for $\Lambda\pi^-$ candidates that have a right-sign or a wrong-sign lepton [#2] in the same event and a combined $\Lambda\pi^-$ + lepton mass less than that of the Ξ_c^0 baryon [18]. The existence of a right-sign signal at the Ξ^- mass will be shown to be from the semileptonic decay of Ξ_c^0, while a signal in the wrong-sign distribution will be shown to be due to various background processes.

To reduce combinatorial background, which is observed to have a soft momentum spectrum, we only accept events with a scaled momentum $x_p = p/p_{\max} > 0.45$, where $p = |\boldsymbol{p}_\Lambda + \boldsymbol{p}_\pi + \boldsymbol{p}_l|$ and $p_{\max} = \sqrt{E^2_{\text{beam}} - M^2_{\Xi_c^0}}$. This selection is justified since Ξ_c^0's from the continuum have a hard momentum distribution [3]. Furthermore, with the $x_p > 0.45$ selection, most Ξ_c^0's from the $\Upsilon(4S)$ resonance are eliminated since the decay products from B decay are kinematically restricted to be less than 2.3 GeV/c (i.e. $x_p = 0.49$).

The resulting $\Lambda\pi^-$ mass distribution with $x_p > 0.45$ (see fig. 2) is fitted with a gaussian signal and a third order polynomial background with an exponential threshold factor at 1255.2 MeV/c^2 [19]. The fit to the right-sign $\Lambda\pi^-$ mass distribution yields a signal with a mass of 1322.2 ± 0.7 MeV/c^2, a width $\sigma = 2.2 \pm 0.6$ MeV/c^2 and 22.6 ± 5.8 $\Lambda\pi^-l^+$ events. Breaking this down into individual lepton channels, one finds 15.2 ± 4.8 $\Lambda\pi^-e^+$ and 7.4 ± 3.3 $\Lambda\pi^-\mu^+$ events. Fixing the fit to the above mass and width for the wrong-sign $\Lambda\pi^-$ mass distribution yields a signal of 2.1 ± 2.3 $\Lambda\pi^-l^-$ events.

To study the Ξ^- + lepton mass distribution, we define Ξ^- candidates to be all $\Lambda\pi^-$ combinations within 6.6 MeV/c^2 (3.0σ) of the Ξ^- mass. The resulting Ξ^- + lepton mass is shown in fig. 3 for both the right-sign signal and the wrong-sign + sideband background distributions, with $x_p > 0$ and $x_p > 0.45$. Here, the sideband represents the fake Ξ^- background and is defined as $\Lambda\pi^-l^+$ events which have a $\Lambda\pi^-$ mass above and below the Ξ^- signal region within the mass ranges 1309.0 to 1315.6 MeV/c^2 and 1328.8 to 1335.4 MeV/c^2. The number of wrong-sign events are determined from the above fit, and the number of sideband events are scaled to match the number

[#2] In this paper, such combinations as Ξ^-l^+ (Ξ^+l^-) are referred to as right-sign, whereas those combinations that cannot result from Ξ_c^0 semileptonic decay, Ξ^-l^- (Ξ^+l^+) are referred to as wrong-sign, and Ξ^- + lepton refers to both charged states.

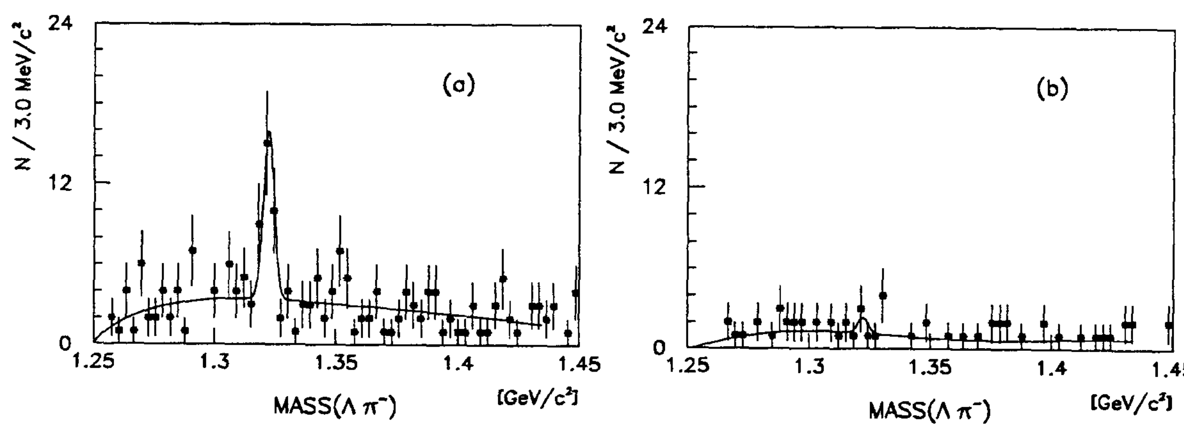


Fig. 2. Invariant mass of $\Lambda\pi^-$ combinations for events with: (a) a right-sign lepton and (b) a wrong-sign lepton, both with $x_p > 0.45$ and $M_{\Lambda\pi^-l^+} < 2.473$ GeV/c^2. The curves in (a) and (b) correspond to the fits described in the text.

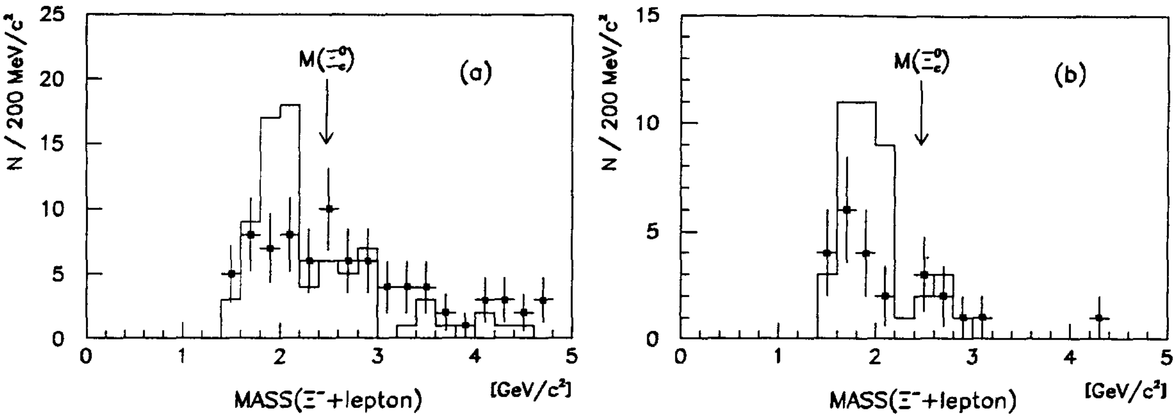


Fig. 3. Invariant mass of Ξ^- + lepton events for the right-sign (histogram) and wrong-sign + sideband (solid squares) distributions with: (a) $x_p > 0$ and (b) $x_p > 0.45$.

of fake Ξ^- events under the right-sign Ξ^- signal (see below). In fig. 3b, most right-sign events populate the $\Xi^- l^+$ mass region from 1255.2 MeV/c^2 up to the Ξ_c^0 mass, which is the kinematically allowed range for events from $\Xi_c^0 \to \Xi^- l^+ u_l$ decay. However, this mass region is large with many possible background processes contributing, as seen from the sizable wrong-sign + sideband $\Xi^- l^+$ mass distribution. Thus, the following sources of background have to be considered and then analyzed to check their effect:

(i) the chance coincidence of a real Ξ^- with a real lepton, each from a separate source (random correlation).

(ii) the chance coincidence of a fake Ξ^- with a real lepton.

(iii) the chance coincidence of a real Ξ^- with a fake lepton.

(iv) feeddown from other charmed baryon semileptonic decay modes.

These background processes are now discussed in detail. The first source of background considered are those events having a randomly correlated Ξ^- and lepton, each from a separate source. Examples of these are a Ξ^- from higher mass baryon decays or created in the primary $q\overline{q}$ fragmentation, and leptons from the semileptonic decay of D or B mesons. To estimate the size of this background, LUND Monte Carlo [20] studies similar to those described in ref. [5], were performed. From the continuum, $\Upsilon(1S)$, and $\Upsilon(2S)$, a data scaled background of 1.1 ± 0.2 right-sign $\Xi^- l^+$ events was observed for $x_p > 0.45$. Random correlations from Monte Carlo generated $B\overline{B}$ decays, including the second Fox–Wolfram moment cut, yields a small right-sign background of 0.4 ± 0.2 events. Thus, corrections are made by subtracting the background calculated above from the observed right-sign signal. Finally, it should be noted that the above Monte Carlo studies showed that randomly correlated wrong-sign events tend to have a Ξ^- and a l^- in the opposite quark jets and thus have a low combined momentum. Therefore, this background significantly populates the wrong-sign at low x_p and high mass. This can be seen from fig. 3a, where the wrong-sign + sideband mass distribution is larger than the right-sign above the Ξ_c^0 mass. Removing this background is one of the reasons for the high x_p cut. This is demonstrated in fig. 3b, where these two distributions are approximately equal above the signal region.

The second, and largest, source of background is from the chance coincidence of a real lepton with a fake Ξ^-, which can come from the random correlation of a real/fake Λ with a real/fake pion. Background from fake Ξ^-'s are modelled by extrapolating from the sideband region to the signal region under the Ξ^- mass. Performing fits to the $\Lambda\pi^-$ mass distribution in fig. 2a, as described previously, yields a fake Ξ^- contribution of 14.9 ± 1.4 events within 6.6 MeV/c^2 of the fitted Ξ^- mass. Thus, the fake Ξ^- background has been statistically identified and eliminated in this analysis. Finally, it should be noted that the $\Lambda\pi^-$ mass distribution for wrong-sign events is not at the same level as that for the right-sign (compare figs. 2a and 2b). This can be explained by the fact that a large number of right-sign fake Ξ^- events come from the semileptonic decay $\Lambda_c^+ \to \Lambda l^+ \nu_l$, coupled with a random π^-. This process does not populate the wrong-sign, thus accounting for the difference between these two distributions. Furthermore, this background is not expected to show any enhancements in the Ξ^- signal region. The previous arguments are demonstrated in fig. 4. It shows the $\Lambda\pi^+$ mass distribution from $\Lambda\pi^+ l^+$ events which are representative of the background from Λ_c^+ semileptonic decays. This mass distribution is found to be at the same level as the right-sign $\Lambda\pi^-$ mass distribution, and with no statistically significant signal observed at the Ξ^- mass. Thus, confirming the above expectations.

The third source of background is the chance coincidence of a real Ξ^- with a track that is misidentified as a lepton. Examples of this are electrons from misidentified hadrons, fake muons from hadron punch-throughs and muons from π or K decay. This background can be calculated by multiplying the lepton–hadron misidentification rates, given above, with the hadronic track multiplicity per Ξ^- event and the appropriate kinematical efficiencies. This yields a fake lepton background of 3.0 ± 0.9 right-sign and 1.7 ± 0.5 wrong-sign events. The difference between these two numbers is attributed to fake leptons from the observed decays $\Xi_c^0 \to \Xi^-\pi^+$, $\Xi_c^0 \to \Xi^-\pi^+\pi^+\pi^-$, $\Xi_c^+ \to \Xi^-\pi^+\pi^+$ and $\Lambda_c^+ \to \Xi^- K^+\pi^+$ [2,3,21], which predominantly populates the right-sign. The fake lepton background from this source is calculated to be 1.8 ± 0.5 events, which is consistent with the above difference. Furthermore, the observed wrong-sign $\Xi^- l^-$ signal for $x_p > 0.45$ can be attributed to fake lepton events since its magnitude is consistent with the above wrong-sign calculation. Thus, the fake lepton background is understood, and corrections can be made by subtracting its contribution from the right-sign $\Xi^- l^+$ signal.

The final source of background considered is contributions to the right-sign signal from the decay $\Xi_c^+ \to \Xi(1530)^0 l^+ \nu_l$, where subsequently $\Xi(1530)^0 \to \Xi^-\pi^+$. This background was examined by selecting $\Xi^- l^+$ events as above and combining these with a random π^+. The resulting $\Xi^-\pi^+$ mass distribution is fitted with a gaussian and a first order polynomial background curve. The mass is fixed to its nominal value [18] and the sigma is fixed to 7.6 MeV/c^2 which is its nominal width [18] convoluted with the detector resolution. This yields a $\Xi(1530)^0$ signal of 1.7 ± 1.7 events atop a background of 1.6 ± 0.5 events. This small background is accounted for by removing all $\Xi^-\pi^+$ events from subsequent analysis that are within 3.0σ of the $\Xi(1530)^0$ mass. The observed $\Xi^- l^+$ signal quoted previously already includes this subtraction. Also, contributions from the non-resonant mode $\Xi_c^+ \to \Xi^-\pi^+ l^+ \nu_l$ was analyzed by looking at the difference between the signal $\Xi^-\pi^+ l^+$ and background $\Xi^-\pi^- l^+$ mass distribu-

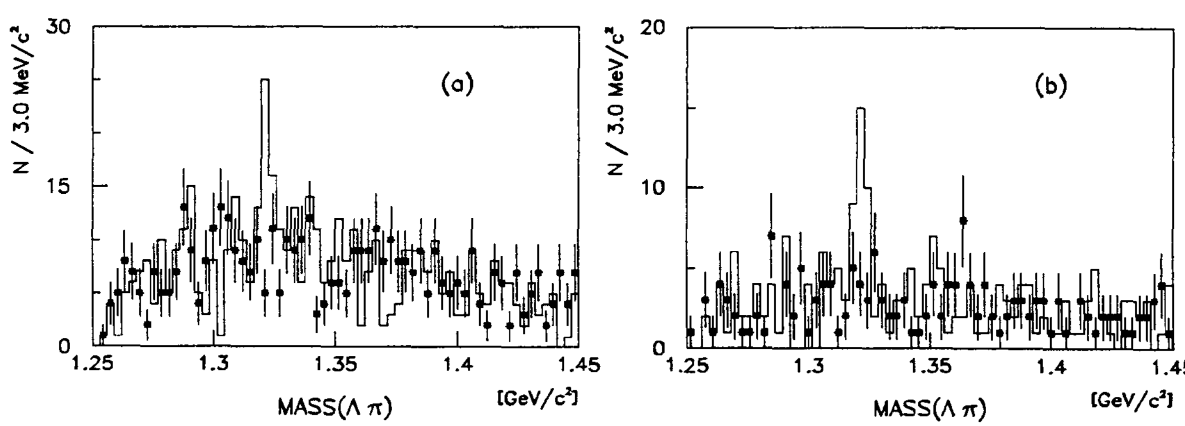


Fig. 4. Invariant mass of $\Lambda\pi$ combinations for $\Lambda\pi^- l^+$ events (histogram) and $\Lambda\pi^+ l^+$ events (solid squares) with: (a) $x_p > 0$ and (b) $x_p > 0.45$.

tions. No excess of signal over background events below the Ξ_c^+ mass was observed. A similar analysis for the decay $\Lambda_c^+ \to \Xi^- K^+ l^+ \nu_l$ also found no excess of signal $\Xi^- K^+ l^+$ over background $\Xi^- K^- l^+$ events. Therefore, these background processes are assumed to be negligible.

The Ξ_c^0 semileptonic signal is obtained by subtracting the background contributions from the fitted right-sign signal which already excludes contributions from the fake Ξ^- background (see table 1). After this subtraction there remains a net signal of 18.1 ± 5.9 events above a total background of 19.4 ± 1.7 events (the sum of 14.9 ± 1.4 fake Ξ^- events and the background summarized in table 1). Fig. 5a shows the $\Xi^- l^+$ right-sign mass distribution after wrong-sign + sideband background subtraction. As a comparison, fig. 5a also shows the Monte Carlo [#3] generated $\Xi^- l^+$ mass distributions from $\Xi_c^0 \to \Xi^- l^+ \nu_l$ decay, normalized to the data. The agreement between the experimental and Monte Carlo distributions, given the low statistics, is reasonable. As a further check of our results, fig. 5b shows the $\Xi^- l^+$ right-sign x_p spectrum after wrong-sign + sideband background subtraction. Also shown is the Monte Carlo generated $\Xi^- l^+$ x_p spectrum where again the agreement with the data is reasonable. Thus, our assumptions regarding the background subtraction and the parametrization of the Ξ_c^0 momentum spectrum (see footnote 3) are reasonable.

To calculate $\sigma(e^+e^- \to \Xi_c^0 X) \cdot \mathrm{BR}(\Xi_c^0 \to \Xi^- l^+ X)$ we first have to correct the Ξ_c^0 signal for detector efficiency including the topological and kinematical selections. Monte Carlo studies of the decay $\Xi_c^0 \to \Xi^- l^+ \nu_l$ (see footnote 3) determined the efficiency to reconstruct $\Xi^- e^+$ and $\Xi^- \mu^+$ events to be $(3.48 \pm 0.13)\%$ and $(1.29 \pm 0.07)\%$, respectively. The errors quoted here are statistical. Given an effective total luminosity of $511.4\ \mathrm{pb}^{-1}$, which includes the enhanced continuum cross section from the electromagnetic decay of the $\Upsilon(1S)$ and $\Upsilon(2S)$ [23], one finds for the individual lepton channels,

$$\sigma(e^+e^- \to \Xi_c^0 X) \cdot \mathrm{BR}(\Xi_c^0 \to \Xi^- e^+ X) = 0.71 \pm 0.28 \pm 0.09\ \mathrm{pb},$$

$$\sigma(e^+e^- \to \Xi_c^0 X) \cdot \mathrm{BR}(\Xi_c^0 \to \Xi^- \mu^+ X) = 0.83 \pm 0.50 \pm 0.11\ \mathrm{pb}.$$

As expected from lepton universality in weak decay, the electron and muon channel branching ratios are in good agreement. Averaging these two results gives

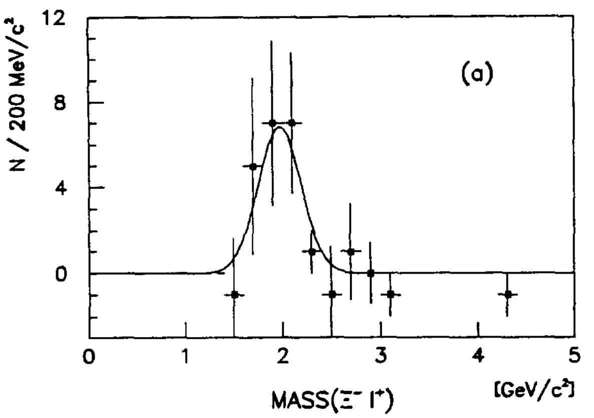
$$\sigma(e^+e^- \to \Xi_c^0 X) \cdot \mathrm{BR}(\Xi_c^0 \to \Xi^- l^+ X) = 0.74 \pm 0.24 \pm 0.09\ \mathrm{pb}. \quad (1)$$

The systematic error in the measurement of $\sigma \cdot \mathrm{BR}$ arises from a number of sources. The value of the collected luminosity is known to a 1.8% accuracy. The efficiency for the reconstruction of four tracks in the drift chamber is known within 4.0%. The Monte Carlo lepton identification efficiency is known to within 4.0% and 6.0% for the electrons and muons, respectively. The error in the parametrization of the back-

[#3] Monte Carlo calculations involve the generation of $\Xi_c^0 \to \Xi^- l^+ \nu_l$ events with the LUND program (ref. [20]). The program parameters are set to include QED radiative and second order QCD corrections and simple weak decay matrix elements. Also, the Ξ_c^0 momentum spectrum was generated using a Peterson fragmentation function (ref. [22]) with the fragmentation parameter determined by ARGUS (ref. [3]). These events were then processed through the full detector simulation and reconstruction program (ref. [16]). The above procedure is used for all $\Xi_c^0 \to \Xi^- l^+ \nu_l$ Monte Carlo calculations described in this paper.

Table 1
Sources of $\Xi^- l^+$ signal and background events, with $x_p > 0.45$ and $M_{\Xi^- l^+} < 2.473\ \mathrm{GeV}/c^2$.

Sources of Ξ^- + lepton events	$N_{\Xi^- l^+}$	$N_{\Xi^- e^+}$	$N_{\Xi^- \mu^+}$
(a) Right-sign signal	22.6 ± 5.8	15.2 ± 4.8	7.4 ± 3.3
(b) Fake lepton	3.0 ± 0.9	1.5 ± 0.7	1.5 ± 0.5
(c) Random correlations	1.5 ± 0.3	1.1 ± 0.3	0.4 ± 0.1
Net $\Xi^- l^+$ signal (a) − (b) − (c)	18.1 ± 5.9	12.6 ± 4.9	5.5 ± 3.3



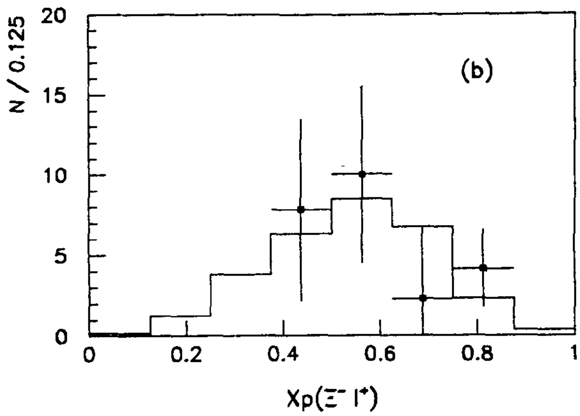


Fig. 5. (a) The $\Xi^- l^+$ right-sign invariant mass distribution after background subtraction (solid squares), and the $\Xi^- l^+$ Monte Carlo generated invariant mass from $\Xi_c^0 \to \Xi^- l^+ u_l$ decay (solid line), both distributions with $x_p > 0.45$. (b) The $\Xi^- l^+$ right-sign x_p spectrum after background subtraction for $x_p > 0.375$ (solid squares), and the $\Xi^- l^+$ Monte Carlo generated x_p spectrum from $\Xi_c^0 \to \Xi^- l^+ u_l$ decay (solid line), both with $M_{\Xi^- l^+} < 2.473$ GeV/c^2.

ground curve to the fit of the $\Lambda\pi^-$ mass leads to an error of 2.0%. The error in the Monte Carlo simulation of the randomly correlated $\Xi^- l^+$ background has been estimated at 3.0%. Finally, the error on the parametrization of the x_p spectrum for the production of Ξ_c^0 results in an uncertainty of 9.8%. Adding all of these sources of error in quadrature, gives a total systematic error of 12.3% for the combined lepton channel, and 12.0% and 12.8% for the electron and muon channels, respectively.

The nature of X in $\Xi_c^0 \to \Xi^- l^+ X$ is to be considered here. Contributions to X can come from other exclusive Ξ_c^0 semileptonic decay modes such as $\Xi^- \pi^0 l^+ \nu_l$ and $\Xi^{*-} l^+ \nu_l$, where subsequently $\Xi^{*-} \to \Xi^- \pi^0$. These modes are difficult to observe which makes it hard to determine their contributions. However, excluding the π^0 from these modes shifts the mean $\Xi^- l^+$ mass down by 135 MeV/c^2. Fitting the $\Xi^- l^+$ mass distribution in fig. 5a with two gaussians which have a mean mass difference of 135 MeV/c^2 indicates that the $\Xi_c^0 \to \Xi^- l^+ u_l$ mode dominates, but the large statistical errors makes this argument inconclusive. Therefore, possible contributions from this and other sources are indicated by quoting $\sigma \cdot$ BR for $\Xi_c^0 \to \Xi^- l^+ X$.

The branching ratio in eq. (2) cannot be calculated since there are no measurements of Ξ_c^0 continuum production near the center of mass energy of 10.4 GeV. However, it is useful to compare the above results with measurements of other charmed baryon hadronic and semileptonic decays. Dividing a previous ARGUS measurement of $\Xi_c^0 \to \Xi^- \pi^+$ and $\Xi_c^0 \to \Xi^- \pi^+ \pi^+ \pi^-$ [3] into eq. (2) yields the ratios

$$\frac{\mathrm{BR}(\Xi_c^0 \to \Xi^- l^+ X)}{\mathrm{BR}(\Xi_c^0 \to \Xi^- \pi^+)} = 0.96 \pm 0.43 \pm 0.18\,, \qquad (2)$$

and

$$\frac{\mathrm{BR}(\Xi_c^0 \to \Xi^- l^+ X)}{\mathrm{BR}(\Xi_c^0 \to \Xi^- \pi^+ \pi^+ \pi^-)} = 0.29 \pm 0.12 \pm 0.04\,. \qquad (3)$$

Averaging the ARGUS measurements of $\sigma \cdot$ BR for the decay modes $\Lambda_c^+ \to \Lambda e^+ X$ and $\Lambda_c^+ \to \Lambda \mu^+ X$ [5], one finds $\sigma(e^+e^- \to \Lambda_c^+ X) \cdot \mathrm{BR}(\Lambda_c^+ \to \Lambda l^+ X) = 4.11 \pm 1.08 \pm 0.77$ pb. Dividing this into the average from eq. (2) one finds

$$\frac{\sigma(e^+e^- \to \Xi_c^0 X) \cdot \mathrm{BR}(\Xi_c^0 \to \Xi^- l^+ X)}{\sigma(e^+e^- \to \Lambda_c^+ X) \cdot \mathrm{BR}(\Lambda_c^+ \to \Lambda l^+ X)} = 0.18 \pm 0.08 \pm 0.04\,, \qquad (4)$$

where some of the common systematic errors cancel in the above ratios. A knowledge of the charmed baryon continuum production ratio would allow a determination of the ratio of experimental semileptonic rates from eq. (5) and a direct test of the various theoretical semileptonic decay models [7–11].

In summary, the first observation of the decay $\Xi_c^0 \to \Xi^- l^+ X$ has been made. The sources of background have been studied and the data subsequently corrected, leaving only $\Xi^- l^+$ events that are attributed to Ξ_c^0 semileptonic decay. This allowed a determination of $\sigma(e^+e^- \to \Xi_c^0 X) \cdot \mathrm{BR}(\Xi_c^0 \to \Xi^- l^+ X) = 0.74 \pm 0.24 \pm 0.09$ pb.

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