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OBSERVATION OF THE CHARMED STRANGE BARYON DECAY $\Xi_c^+ \to \Xi^-\pi^+\pi^+$

(ACCMOR Collaboration)

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ABSTRACT

We have observed 2 charmed strange baryon decays $\Xi_c^+ \to \Xi^-\pi^+\pi^+$, $\Xi^- \to \Lambda^0\pi^-$, $\Lambda^0 \to p\pi^-$ (and charge conjugate) in the data collected in 1985 and 1986 by the NA32 experiment using charge-coupled devices for vertex reconstruction and a trigger on a pair of opposite charge kaons and/or (anti)protons.

The still preliminary analysis gives for the Ξ_c^+ mass a value around 2465 MeV.

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1. INTRODUCTION

We studied inclusive Ξ/Ω hyperon production by 230 GeV/c π^-s incident on a copper target in the data collected in 1985 and 1986 with the ACCMOR spectrometer. This spectrometer is described in Ref.[1] and [2]. As a by-product of this study we found 2 events that we interpret as production of the charmed strange baryon Ξ_c^+ (csu) and its decay into $\Xi^-\pi^+\pi^+$, $\Xi^- \rightarrow \Lambda^0\pi^-$, $\Lambda^0 \rightarrow p\pi^-$ (and charge conjugate).

2. SEARCH FOR Ξ HYPERONS

The search for the cascade $\Xi^- \rightarrow \Lambda^0\pi^-$, $\Lambda^0 \rightarrow p\pi^-$ proceeds as follows. Events are selected containing at least one track seen only in the vertex detector ("Ξ" tracks). The search for Ξ decay is made by iterating along the "Ξ" tracks between the last plane of the vertex detector and the onset of the magnetic field in the first magnet M1 (Fig. 1). That corresponds to a decay range of 52 cm. For each iterative point on a "Ξ" track a good match is looked for with a track in the drift chambers and a search is made for a V^0 in the drift chambers, compatible with being produced from that point. All 3 tracks, i.e. π^- from Ξ decay, p and π^- from Λ^0 decay, should not be seen in the vertex detector. Since the proton from a Λ^0 decay takes most of its momentum, the V^0 is required to contain at least one forward-going track seen in the drift chambers in front of and behind the second magnet M2. No particle identification is used in the search and the invariant mass of the V^0 has to be within 20 MeV of the Λ^0 mass. In addition, the sum of the momentum vectors of the π^- from Ξ decay and of the Λ^0 should have an angle of less than about 2 mr with the "Ξ" track. Finally, the Ξ decay point is taken to be the point on the Ξ track which corresponds to the minimum of the sum of the χ^2 for the pion track from Ξ decay to originate from that point and of the χ^2 for the Λ^0 to originate from the same point. Figure 2 shows the invariant mass of the $\Lambda^0\pi^-$ system obtained from approximately $16 \cdot 10^6$ events (about 95% of the total data sample).

3. SEARCH FOR Ξ_c BARYONS

The decay mode $\Xi_c^+ \rightarrow \Xi^-\pi^+\pi^+$ can be recognized as a secondary vertex in the vertex detector, a few millimeters downstream of the primary vertex (Fig. 3). We looked for good vertices, having a probability of better than 99%, between the track of a reconstructed Ξ and 2 other tracks in the vertex detector after requiring that all 3 tracks are seen in at least one charge-coupled device (CCD) and that they are incompatible with originating from the primary vertex, with a probability less than 1%. Restricting ourselves to secondary vertices outside the target, a dozen events are found. Most of them correspond to secondary interactions in the vertex detector or to a confusion in the primary vertex reconstruction. If we further require that the total momentum sum of the secondary vertex points to the primary vertex with a probability better than 99%, two interesting events are found.

Figure 3 gives a sketch of the first one. It contains a $\Xi^-\pi^+\pi^+$ vertex 13 mm behind the target centre. All three tracks are seen in CCD2 and their impact parameters with respect to the primary vertex are 216 μm, 278 μm and 191 μm respectively (precision on the impact parameter of a track is ~ 7 μm).

The Cerenkov hodoscopes identify the two π^+s as unambiguous pions and the proton from Λ^0 decay as being incompatible with a pion interpretation. We measure :

$$Mp\pi^- = 1109\ MeV$$

$$M_{\Lambda^0\pi^-} = 1320\ MeV$$

$$M_{\Xi\pi\pi} = 2469 \pm 6\ MeV$$

We have not yet calibrated the absolute mass scale of the spectrometer, but we estimate from our Λ_c and charmed meson results a systematic mass uncertainty not exceeding 2 MeV. The flight path of the Ξ_c corresponds to a proper lifetime of $13 \cdot 10^{-13}$s.

The second event contains a $\bar{\Xi}^+\pi^-\pi^-$ vertex 2.1 mm behind the target centre (distance from the target edge = 850 μm, precision on this distance ~130 μm). The impact parameters of the three tracks are 47 μm, 91 μm and 58 μm respectively. The Cerenkov hodoscopes identify one π^- as an unambiguous pion and the antiproton from $\bar{\Lambda}^0$ decay as being incompatible with a pion interpretation. We measure :

$$M_{\bar{p}\pi^+} = 1132\ MeV$$

$$M_{\Lambda^0\pi^+} = 1304\ MeV$$

$$M_{\Xi\pi\pi} = 2461 \pm 12\ MeV$$

The flight path of the $\bar{\Xi}_c^-$ corresponds to a proper lifetime of $3.7 \cdot 10^{-13}$s.
The invariant mass measured for the $\bar{\Lambda}^0\pi^+$ system is rather low and lies in the left tail of the distribution in Fig. 2. We are still investigating for possible sources leading to mass broadening in the V^0 reconstruction program.

The charmed strange baryon Ξ_c^+ has been seen in two experiments [3,4,5] in the final states $\Lambda^0K^-\pi^+\pi^+$ and $\Sigma^0K^-\pi^+\pi^+$. We observe two events from a new decay mode. They have a mass in very good agreement with the previous determinations, which are :

$$2460 \pm 15\ \ MeV$$

and

$$2459 \pm 5 \pm 30\ MeV\ .$$

REFERENCES

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Figure Captions

Fig.1 Top view of the ACCMOR spectrometer (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 ; V1-V8 : silicon microstrip detectors used together with CCDs for reconstruction of tracks and vertices ; M1,M2 : spectrometer magnets for momentum determination of charged particles ; DC1,2,3,4 : drift chambers for reconstruction of charged particle tracks ; C1,C2,C3 : Cerenkov hodoscopes for identification of charged particles.

Fig. 2 Invariant mass distribution of the $\Lambda^0\pi^-$ system from $16 \cdot 10^6$ events.

Fig. 3 Sketch of the first Ξ_c event.

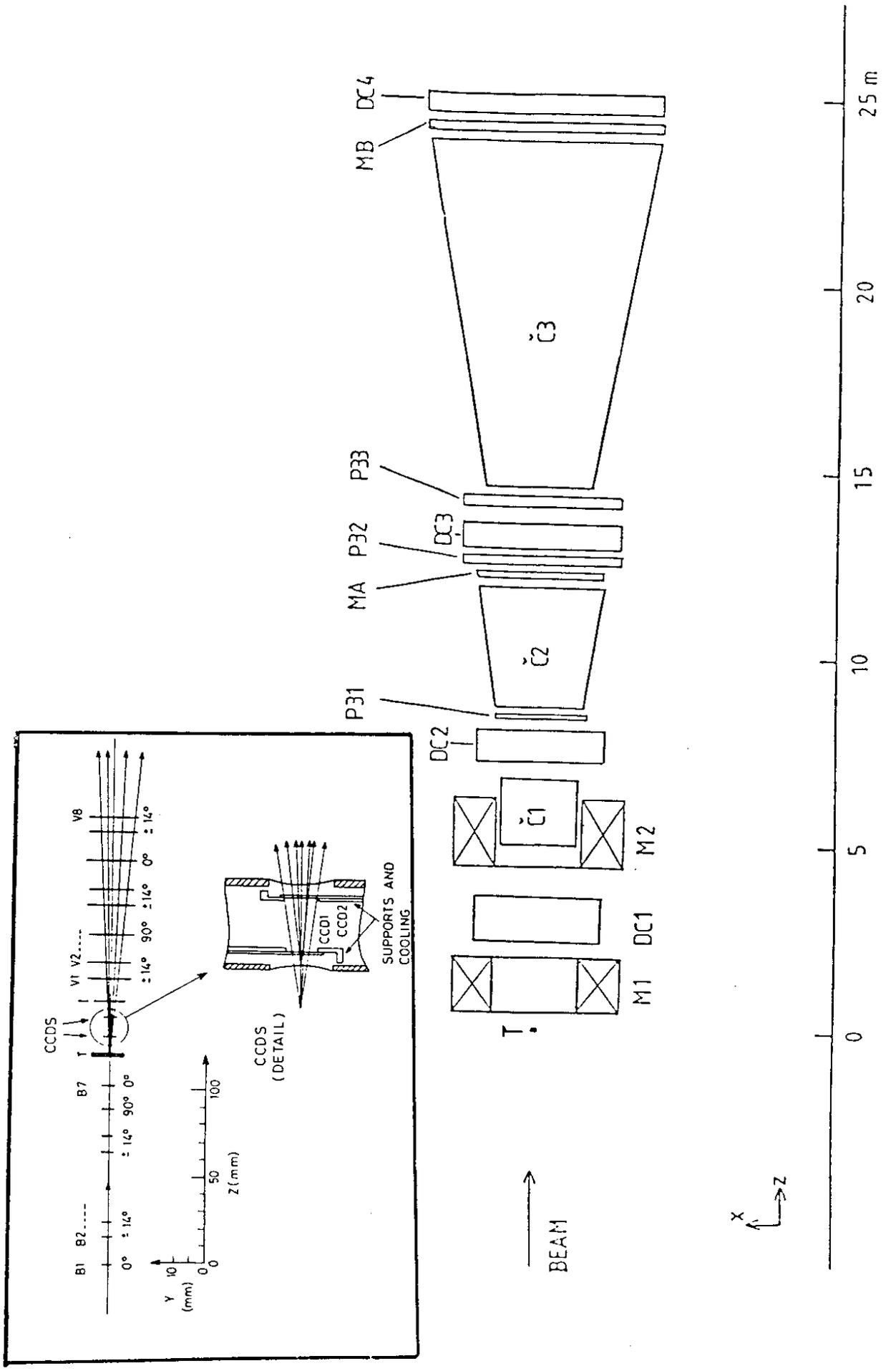
CCDS
V1 V2
V8
B1 B2
B7
0° ±14° 90° ±14° 0°
Y (mm)
Z (mm)
CCDS (DETAIL)
CCD1
CCD2
SUPPORTS AND COOLING
T
M1
DC1
C1
M2
DC2
P31
C2
MA
P32
DC3
P33
C3
MB
DC4
BEAM
X
Z
0
5
10
15
20
25 m

Fig. 1

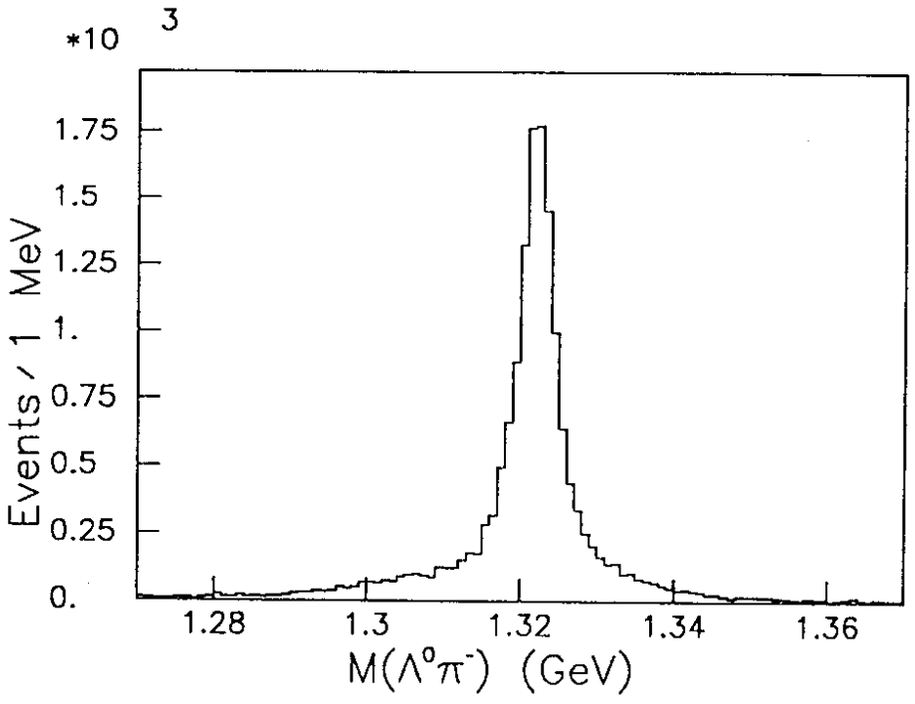
*10 3
1.75
1.5
1.25
1.
0.75
0.5
0.25
0.
Events / 1 MeV
1.28
1.3
1.32
1.34
1.36
M(Λ°π⁻) (GeV)

Fig. 2

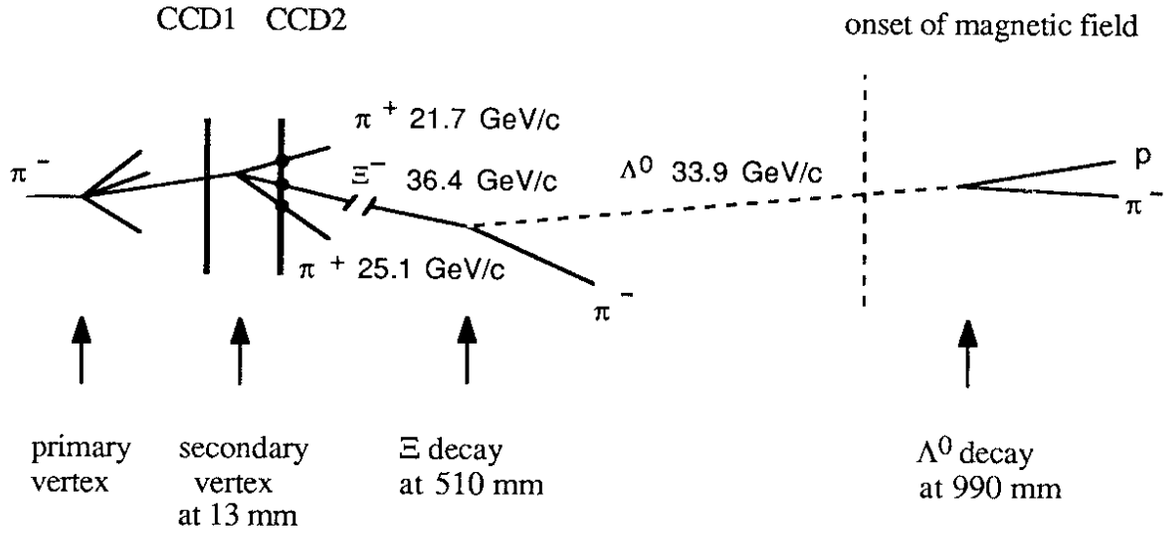
CCD1 CCD2
onset of magnetic field
π + 21.7 GeV/c
π -
Ξ− 36.4 GeV/c
Λ0 33.9 GeV/c
p
π -
π + 25.1 GeV/c
π -
primary vertex
secondary vertex at 13 mm
Ξ decay at 510 mm
Λ0 decay at 990 mm

Fig. 3