

For Publisher's use

v1.0 - 7th December 1998.Ω00
i00

CHARMED BARYONS PHOTOPRODUCED IN FOCUS AT FERMILAB

SERGIO P. RATTI*

Dip. di Fisica Nucleare and Sezione I.N.F.N. I27100 Pavia (Italy)

E-mail: ratti@pv.infn.it

FOCUS collected over 7×10^7 triggers and more than 10^6 fully reconstructed charm particles in a photoproduction experiment at Fermilab. The experimental setup is an upgraded version of a multiparticle spectrometer used in the previous experiment E687¹.

Data on charmed meson spectroscopy have been presented by F.L. Fabbri in this Section. Here data on photoproduction of charmed baryons are presented.

1 Σ_c : Mass Splitting and Widths

The selection of the $\Sigma_c \rightarrow \Lambda_c^+ \pi^\pm$ decays is performed on a sample of over 25,000 fully reconstructed $\Lambda_c^+ \rightarrow pK^- \pi^+$ baryons selected through a "candidate driven" algorithm¹. In this analysis we exploit a sample of $(12,410 \pm 180)$ Σ_c events requiring that the Λ_c^+ candidates have a momentum $P > 40 \text{ GeV}$ and a proper decay time less than 10 times the Λ_c^+ lifetime. The Σ_c baryons are reconstructed combining Λ_c^+ candidates with a mass within 2.1σ of the Λ_c^+ average mass, with a charged pion. As usual, to minimize systematic effects, we compute the invariant mass differences ΔM : $\Delta M^{\circ,++} = M(pK^- \pi^+ \pi^\pm) -$

Table 1. Mass difference $\Delta M(\Sigma_c) - m(\Lambda_c^+)$.

State	Exp	$\Delta(M)$
ΔM°	E791 ²	$167.76 \pm 0.29 \pm 0.15$
	CLEO II ³	$168.20 \pm 0.30 \pm 0.20$
	FOCUS	$167.38 \pm 0.21 \pm 0.13$
	PDG ⁴	167.31 ± 0.21
ΔM^{++}	E791 ²	$167.38 \pm 0.29 \pm 0.15$
	CLEO II ³	$167.10 \pm 0.30 \pm 0.20$
	FOCUS	$167.35 \pm 0.19 \pm 0.12$
	PDG ⁴	167.87 ± 0.20
$\Delta M =$ $M(\Sigma_c^{++})$ – $M(\Sigma_c^{\circ})$	E791 ²	$+0.38 \pm 0.40 \pm 0.15$
	CLEO II ³	$+1.10 \pm 0.40 \pm 0.10$
	FOCUS	$-0.03 \pm 0.28 \pm 0.11$
	PDG ⁴	0.66 ± 0.28

$M(pK^- \pi^+)$. The mass difference distributions $\Delta M^{\circ} = M(\Sigma_c^{\circ}) - M(\Lambda_c^+)$ (fig. 1a) and $\Delta M^{++} = M(\Sigma_c^{++}) - M(\Lambda_c^+)$ (fig. 1b) are shown in figs. 1. The results of the fits (also shown in figs 1) are compared to the results of other experiments in Table 1. We find no evidence of isospin splitting for the Σ_c baryons; our measurements do not support the conclusion that the doubly charged Σ_c is more massive than its neutral counterpart. The Σ_c isospin multiplet appears to be fully degenerate. This excludes a number of recent theoretical predictions⁵. On the same data Focus has preliminary estimates of the mass widths for the Σ_c baryons. By selecting two somewhat larger samples, a signal of $425 \pm 55 \Sigma_c^{\circ}$ (fig. 1c) and a signal of $540 \pm 59 \Sigma_c^{++}$ (fig. 1d) were obtained on which we

*The co-authors are: J.M.Link, M.Reyes, P.M.Yager (UC DAVIS); J.Anjos, I.Bediaga, C.Gobel, J.Magnin, I.M.Pepe, A.C.Reis, A.Sánchez-Hernández, F.R.A.Simão (CPBF, Rio de Janeiro); S.Carrillo, E.Casimiro, H.Mendez, M.Sheaff, C.Uribe, F.Vasquez (CINVESTAV, México City); L.Cinquini, J.P.Cumalat, J.E.Ramirez, B.O'Reilly, E.W.Vaandering (CU Boulder); J.N.Butler, H.W.K.Cheung, I.Gaines, P.H.Garbcinius, L.A.Garren, S.A.Gourlay, P.H.Kasper, A.E.Kreymer, R.Kuschke (Fermilab); S.Bianco, F.L.Fabbri, S.Sarwar, A.Zallo (INFN Frascati); C.Cawfield, E.Gottschalk, K.S.Park, A.Rahimi, J.Wiss (UI Champaign); R.Gardner (IU Bloomington); Y.S.Chung, J.S.Kang, B.R.Ko, J.W.Kwak, K.B.Lee, S.S.Myung, H.Park (Korea University, Seoul); G.Alimonti, M.Boschini, B.Caccianiga, A.Calandrino, P.D'Angelo, M.DiCorato, P.Dini, M.Giammarchi, P.Inzani, F.Leveraro, S.Malvezzi, D.Menasce, M.Mezzadri, L.Milazzo, L.Moroni, D.Pedrini, F.Prelz, A.Sala, S.Sala (INFN and Milano); T.F.Davenport III (UNC Asheville); V.Arena, G.Boca, G.Bonomi, G.Gianini, G.Liguori, M.Merlo, D.Pantea, C.Riccardi, L.Viola, P.Vitulo (INFN and Pavia); A.M.Lopez, L.Mendez, A.Mirles, E.Montiel, D.Olaya, C.Rivera, W.Johns, Y.Zhang (Mayaguez, Puerto Rico); N.Copt, M.V.Purohit, J.R.Wilson (USC Columbia); K.Cho, T.Handler (UT Knoxville); D.Engl, M.Hosack, M.Nehring, M.Sales, P.D.Sheldon, M.Webster (Vanderbilt); K.Stenson (Wisconsin, Madison); Y.Kwon (Yonsei University, Korea).

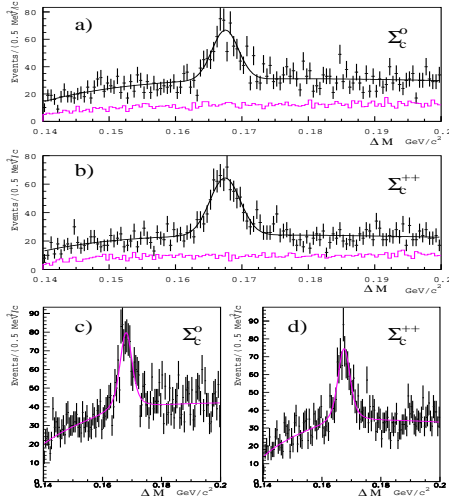


Figure 1. Mass difference distributions: a- Σ_c^0 ; b- Σ_c^{++} . The lower histograms in a,b, are from data in sidebands away from the Λ_c^+ signal; b,d- Σ_c^{++} . In c and d, larger samples for width measurements. The full lines are fit of a smooth background plus a Breit-Wigner.

fit the mass widths. The preliminary values of the fit are: $\Gamma(\Sigma_c^0) = 2.68 \pm 0.79$ MeV and $\Gamma(\Sigma_c^{++}) = 2.63 \pm 0.77$ MeV respectively for the two charged states. The experimental resolution is $\sigma \approx 1.5$ MeV. These values are well consistent with the recent results provided by the CLEO II collaboration.

2 Σ_c and Λ_c^+ Excited States

Expanding the ΔM distributions we find preliminary evidence of 593 ± 146 Σ^{*0} events above background, at a mass difference $\Delta M^0 = 232.7 \pm 1.2$ MeV and evidence of 1284 ± 225 Σ^{*++} events above background, at a mass difference $\Delta M^{++} = 234.2 \pm 1.5$ MeV, well compatible with the CLEO data reported in the 1998 P.D.G. Book ⁴, i.e.: $\Delta M^0 = 232.6 \pm 1.0 \pm 0.8$ MeV (504 events) and $\Delta M^{++} = 234.5 \pm 1.1 \pm 0.8$ MeV (677 events). The E687 investigation of the $\Lambda_c^{*+} \rightarrow \Lambda_c^+ \pi^- \pi^+$ has been extended to the improved statistics. The new preliminary signals consist of 100 ± 20 Λ_c^{*+} (2593) events at $\Delta M = 308.1 \pm 0.7$ MeV and 371 ± 32 Λ_c^{*+} (2593) events at $\Delta M = 314.6 \pm 0.3$. The

final analyses are still in progress.

3 Some Λ_c^+ Decays

A number of decay channels of the Λ_c^+ baryons are also under investigation. The statistics in FOCUS is about an order of magnitude better than in E687 and exceeds by a factor 2 the statistics of competing experiments.

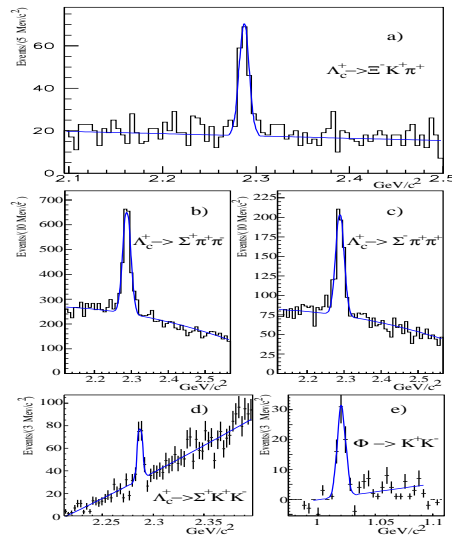


Figure 2. Mass distributions for Λ_c^+ search: a- $\Lambda_c^+ \rightarrow \Xi^- K^+ \pi^+$; b- $\Lambda_c^+ \rightarrow \Sigma^+ \pi^- \pi^+$; c- $\Lambda_c^+ \rightarrow \Sigma^- \pi^+ \pi^+$; d- $\Lambda_c^+ \rightarrow \Sigma^+ K^+ K^-$; e- the $\phi(K^+ K^-)$ signal for the events in the Λ_c^+ peak.

Fig. 2a shows our improved signal of 138 ± 14 events (signal/noise ratio ≈ 3) for the channel $\Lambda_c^+ \rightarrow \Xi^- K^+ \pi^+$, which more than double the evidence for this decay reported in 1998 P.D.G. Book⁴. Figs 2b,c show our improved signals for the decay channels $\Lambda_c^+ \rightarrow \Sigma^+ \pi^- \pi^+$ (1418 ± 63 events, fig. 2b) and $\Lambda_c^+ \rightarrow \Sigma^- \pi^+ \pi^+$ (728 ± 35 events, fig. 2c). The data of fig.s 2b,c might provide material for a Dalitz plot search for 2-body decays. From the data of fig.s 2d,e, we derive a very preliminar estimate of $R = N(\Sigma^+ \phi^0)/N(\Sigma^+ K^+ K^-) \approx 0.56 \pm 0.11$ that seems to be hardly compatible with a dominance of the quasi two-body decay channel. The measurement of the relative branching ratios for these channels are in progress.

4 Some Ξ_c^+ , Ξ_c^0 decays

We investigated also several decay channels of the strange-charmed baryons Ξ_c . Fig. 3 shows our final signal of 200 ± 39 event evidence for the Cabibbo suppressed decay $\Xi_c^+ \rightarrow pk^-\pi^+$. In order to extract the tiny signal from background (signal/noise ratio of 0.4 ± 0.1) we applied tight selection criteria for the vertex detachment ($l > 8.0\sigma(l)$, where l is the decay measured decay length) and for the proton and K Cerenkov identification. In this way the Λ_c^+ signal consists of about 7,000 events compared to over 25,000 in the initial fully reconstructed sample.

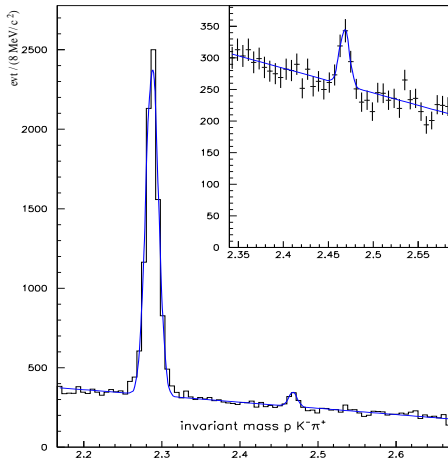


Figure 3. $M(pk^-\pi^+)$ distribution. Insert is the enlargement of the region around the Ξ_c^+ mass.

A preliminary value of the ratio $R = \Gamma(\Xi_c^+ \rightarrow pk^-\pi^+)/\Gamma(\Xi_c^+ \rightarrow \Xi^-2\pi^+) = 0.13 \pm 0.03 \pm 0.02$. is to be compared to SELEX⁶ $R = 0.20 \pm 0.04 \pm 0.02$.

Ξ_c signals have been detected in different Cabibbo allowed channels. In fig. 4 collects four decay channels of the Ξ_c^+ including the **first observation** of 25 ± 7 events of the channel $\Xi_c^+ \rightarrow \Omega^-K^+\pi^+$ (fig. 4d). The distributions of fig.s 4b,c ($\Xi_c^+ \rightarrow \Lambda^0K^-2\pi^+$ and $\Xi_c^+ \rightarrow \Sigma^+K^-\pi^+$ respectively) are still on partial statistics. All masses, with uncertainties of about 1.5MeV are consistent with $M = 2469\text{MeV}$, with σ 's 6-10 MeV.

Finally, the signals for the decay modes

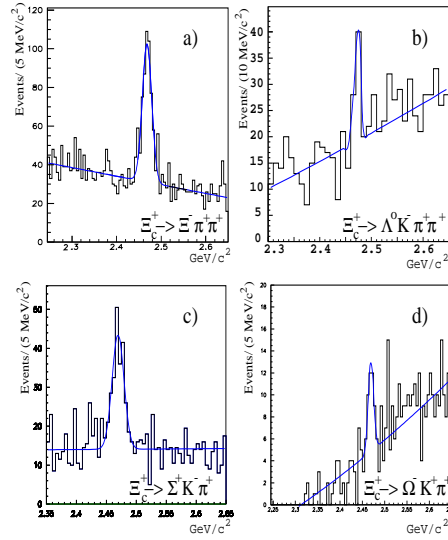


Figure 4. Ξ_c^+ masses: a- $M(\Xi^-2\pi^+)$, 320 ± 29 ev.; b- $M(\Lambda^0K^-2\pi^+)$, 31 ± 12 ev.; c- $M(\Sigma^+K^-\pi^+)$, 147 ± 15 ev.; d- $M(\Omega^-K^+\pi^+)$, 25 ± 7 ev.

$\Xi^- \pi^+$ (fig. 5a) and $\Omega^- K^+$ (fig. 5b) of the Ξ_c^0 baryon are collected in fig.s 5. The masses,

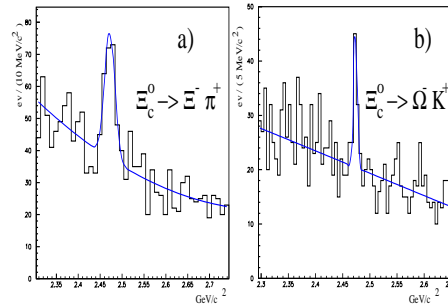


Figure 5. Ξ_c^0 mass distributions: a- $M(\Xi^- \pi^+)$, 117 ± 20 ev.; b- $M(\Omega^- K^+)$, 421 ± 11 ev.

measured with an error of about 2 MeV are very close to 2470 MeV.

References

1. E687 Coll., N.I.M. **A320**, 519 (1992);
2. E791 Coll., Phys.Lett **379B**, 292 (1996);
3. Cleo II Coll., Phys.Rev.Lett. **71**, 3259 (1993);
4. P.D.Group, Eur.Phys.J. **C3**, 1 (1998);
5. Focus Coll., Phys.Lett. **B488**, 218 (2000);
6. Selex Coll., Phys.Rev.Lett. **84**, 1857 (2000).