Preliminary results of the spin parameters study in the $\Lambda_c \to \Lambda\pi$ decay channel

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(By the E831 (FOCUS) Experiment)

Abstract

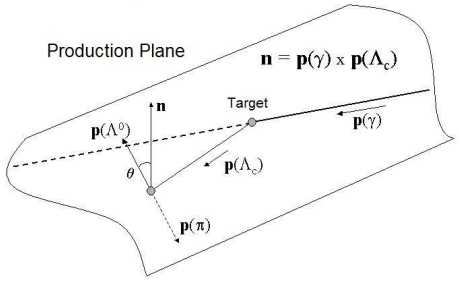
Using data from FERMILAB E831 (FOCUS) experiment we have done the first measurement of the polarization of Λ_c's produced in high-energy ($< E >= 180$ GeV) photon-nucleon interactions. For this we have analyzed the decay mode $\Lambda_c \to \Lambda\pi$. We have measured the product αP, where α is the weak decay asymmetry parameter, and, using the CP conservation hypothesis, we have gotten the polarization P. We have found that in photoproduction the Λ_c is produced with a small polarization, between 8% and 30%. As we have low statistics and the errors are large, the polarization is compatible with zero within 1σ. The results are preliminary.

For the decay of a spin-$\frac{1}{2}$ particle into a spin-$\frac{1}{2}$ + spin-0 particles, like the case of:

$$\Lambda_{c(1/2)} \to \Lambda_{(1/2)}\ \pi_{(0)} \tag{1}$$

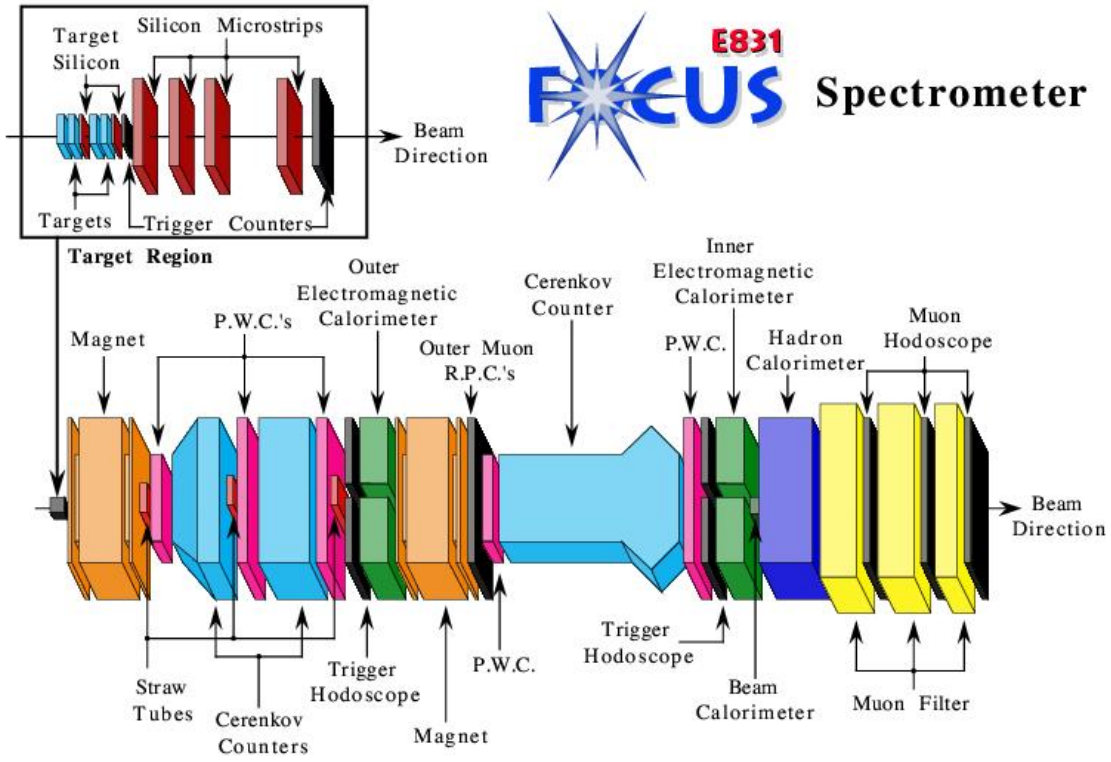
we can write the angular distribution of the daughter fermion in the parent fermion center of mass as:

$$\frac{\mathrm{dN}}{\mathrm{d}\cos\theta} = \frac{\mathrm{N_0}}{2}\ \left(1 + \alpha_{\Lambda_c^+}\mathrm{P}\cos\theta\right) \tag{2}$$



FOCUS EXPERIMENT

▷ The spectrometer:



◇ Located in Fermilab's Wide Band Laboratory, upgrade of experiment E687
◇ Large aperture fixed target multiparticle spectrometer
◇ $< 175 >$ GeV photon beam from bremmstrahlung of 300 GeV electrons and positrons
◇ Segmented berylium oxide targets
◇ Two systems of silicon microvertex detectors: 2 target stations + 12 planes
◇ High resolution separation of primary and secondary vertices
◇ 2 analysing magnets of opposite polarity.
◇ 5 stations of multiwire proportional chambers
◇ 3 multicell threshold Cerenkov counters identify e, π, K , p
◇ 2 electromagnetic calorimeters
◇ 1 hadron calorimeter consisting of iron and scintillating tile
◇ 2 muon systems: resistive plate chambers and scintillator hodoscope.

▷ The E831/FOCUS data sample:
◇ Collected during 1996-1997 fixed target run.
◇ Multiplicity trigger and loose transverse energy requirement in trigger.
◇ Fully reconstructed more than one million charm mesons.

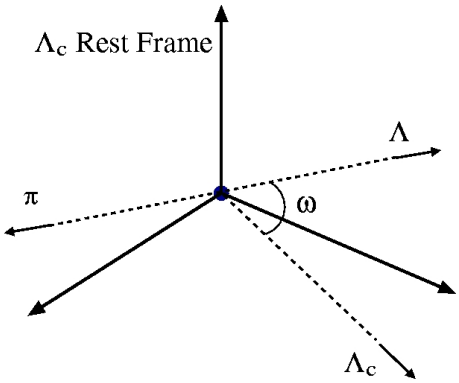
STEPS TO CALCULATE THE Λ_c^+ POLARIZATION

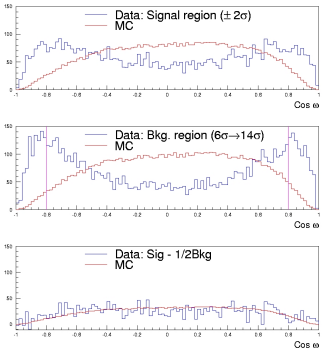
- ▷ Get the number of Λ_c^+ events by fitting the mass distributions divided into four equal intervals of cosine theta for particles and anti-particles.
- ▷ Fit the $\cos\theta$ distribution, normalized and efficiency corrected, by using a linear function to get $\alpha_{\Lambda_c^+}$P from each sample of particles and anti-particles.
- ▷ Calculate the polarization P for each sample assuming no CP violation ($\alpha_{\Lambda_c^+} = -\alpha_{\Lambda_c^-}$) and using $\alpha_{\Lambda_c^+}$ from PDG 2005 and FOCUS.

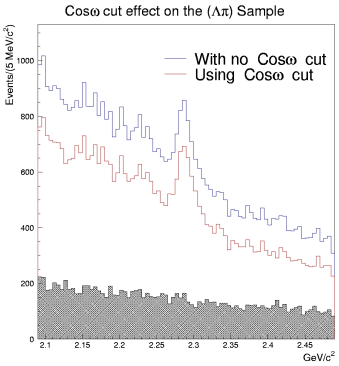
SELECTION CRITERIA

- ▷ Λ Selection:
  - ◇ Quality of tracks
  - ◇ $1.09 < \mathrm{M}(\Lambda) < 1.14$ GeV/c^2
  - ◇ Normalized mass of Λ^0: $\left|\frac{m_\Lambda - m_\Lambda(\mathrm{PDG})}{\sigma(m_\Lambda)}\right| < 7$;
    $m_\Lambda(\mathrm{PDG}) = 1.115683$ GeV/c^2
  - ◇ Čerenkov particle identification
- ▷ π from Λ_c^+:
- ▷ Primary:
  - ◇ $-10 < z_{\mathrm{prim}} < -3$

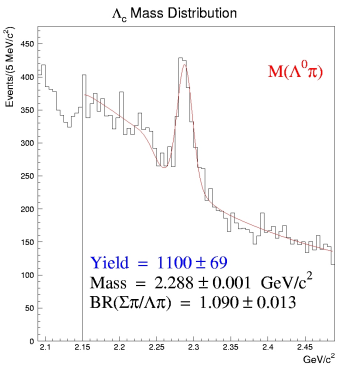
- ▷ Λ_c^+ Selection:
  - ◇ $2.09 < \mathrm{M}(\Lambda_c^+) < 2.49$ GeV/c^2
  - ◇ Detachment (L/σ): $L/\sigma > 4$
  - ◇ Λ_c^+ proper time: $t_{\mathrm{life}} < 5\,\tau_{\Lambda_c^+}$; $\tau_{\Lambda_c^+}$ 0.2 ps
  - ◇ Λ_c^+ momentum: $\mathrm{p}(\Lambda_c^+) > 40$ GeV/c .
  - ◇ C.L. on Secondary: CLS > 0.01
  - ◇ C.L. on Primary: CLP > 0.01
  - ◇ $|\mathrm{Cos}\ \omega| < 0.8$

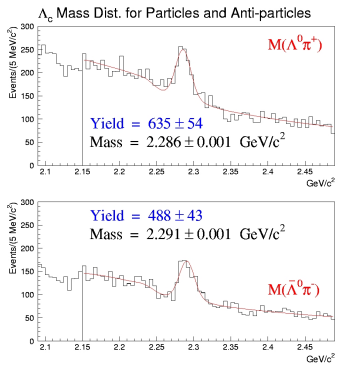






FITTED $\Lambda_c^+ \to \Lambda\pi$ MASS DISTRIBUTIONS





EFFICIENCY

The efficiency is defined as:

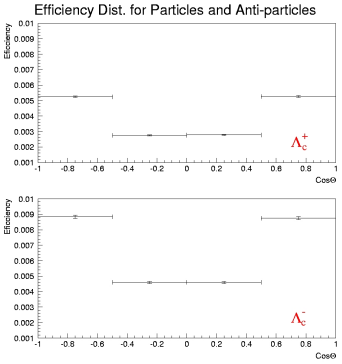
$$\epsilon = \frac{N_{rec}^{MC}}{N_{gen}^{MC}} \tag{3}$$

N_{rec}^{MC}: Number of MC reconstructed events.

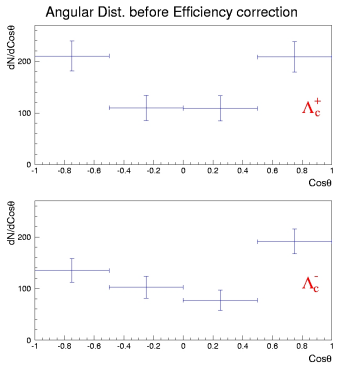
N_{gen}^{MC}: Number of MC generated events.

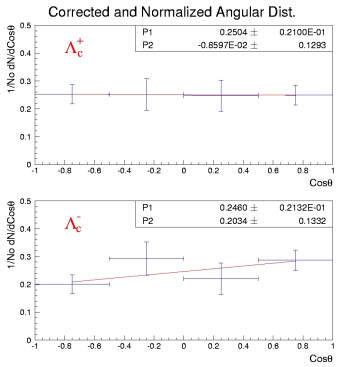
The error in the efficiency is given by:

$$\sigma(\epsilon) = \sqrt{\frac{\epsilon\,(1-\epsilon)}{N_{gen}^{MC}}} \tag{4}$$



ANGULAR DISTRIBUTION



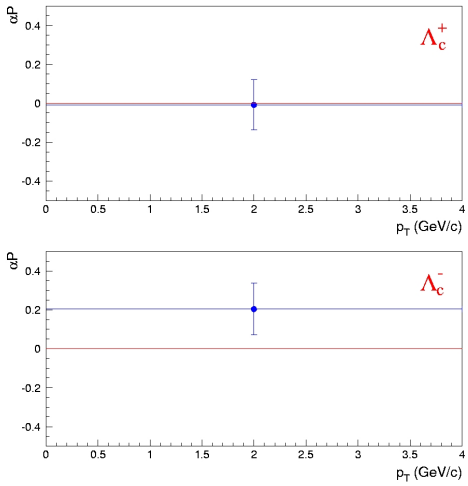


0.32

VALUES

The values of $(\alpha_{\Lambda_c^+}\mathrm{P})$ for Λ_c^+ and Λ_c^- integrated over all p_T are:

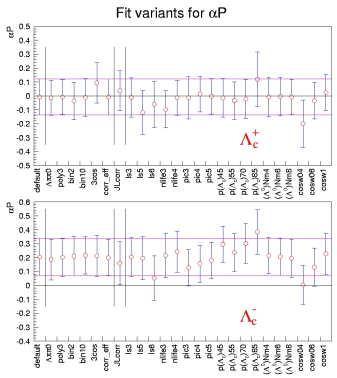
	$(\alpha_{\Lambda_c}\mathrm{P})$
Λ_c^+	-0.009 ± 0.130
Λ_c^-	0.203 ± 0.133



SYSTEMATIC ERROR STUDIES FOR $(\alpha_{\Lambda_c^+}\mathrm{P})$

We perform many checks in order to determine the systematic error in the measurement of $(\alpha_{\Lambda_c^+}\mathrm{P})$ varying the the cuts and the fitting conditions in a reasonable way.

- ▷ 1st Category: By changing the fit technique
- ▷ 2nd Category: By changing the way to reconstruct the sample
- ▷ 3rd Category: By changing the selection cuts



Category	Syst. errors on $(\alpha\mathrm{P})_{\Lambda_c^+}$
1st	0.046
2nd	0.032
3rd	0.066
Total	0.086

Category	Syst. errors on $(\alpha\mathrm{P})_{\Lambda_c^-}$
1st	0.011
2nd	0.031
3rd	0.088
Total	0.094

PRELIMINARY RESULTS

▷ The final values for ($\alpha_{\Lambda_c^+}$P) integrated over all p_T are:

Particle	$(\alpha_{\Lambda_c} P)$
Λ_c^+	$-0.009 \pm 0.130 \pm 0.086$
Λ_c^-	$0.203 \pm 0.133 \pm 0.094$

▷ To calculate the polarization we assume no CP violation ($\alpha_{\Lambda_c^+} = -\alpha_{\Lambda_c^-}$) and we use the $\alpha_{\Lambda_c^+ \to \Lambda\pi}$ weak assymetry parameter from PDG 2005 and FOCUS:

$\alpha_{\Lambda_c^+} = -0.98 \pm 0.19$ (PDG)
$\alpha_{\Lambda_c^+} = -0.78 \pm 0.16 \pm 0.19$ (Boca)

▷ The polarization values we get are:

α_{PDG}	$P_{\Lambda_c^+}$	0.009 ± 0.133
	$P_{\Lambda_c^-}$	0.207 ± 0.142
α_{FOCUS}	$P_{\Lambda_c^+}$	$0.012 \pm 0.167 \pm 0.110$
	$P_{\Lambda_c^-}$	$0.260 \pm 0.179 \pm 0.136$

CONCLUSION

▷ We found that in photoproduction the Λ_c^+ is produced with a small polarization, between 1% and 26%.
▷ As we have low statistics and the errors are large, the polarization integrated over all p_T is **compatible with zero** within 2σ.

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