Search for hadronic weak decay $\Lambda_c^+ \to \Sigma^{*+}\eta$

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HFP Group Meeting , Nov.16,2021

Outline

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- Data sample && MC simulation
- Event selection
- Signal MC

Motivation

Theory

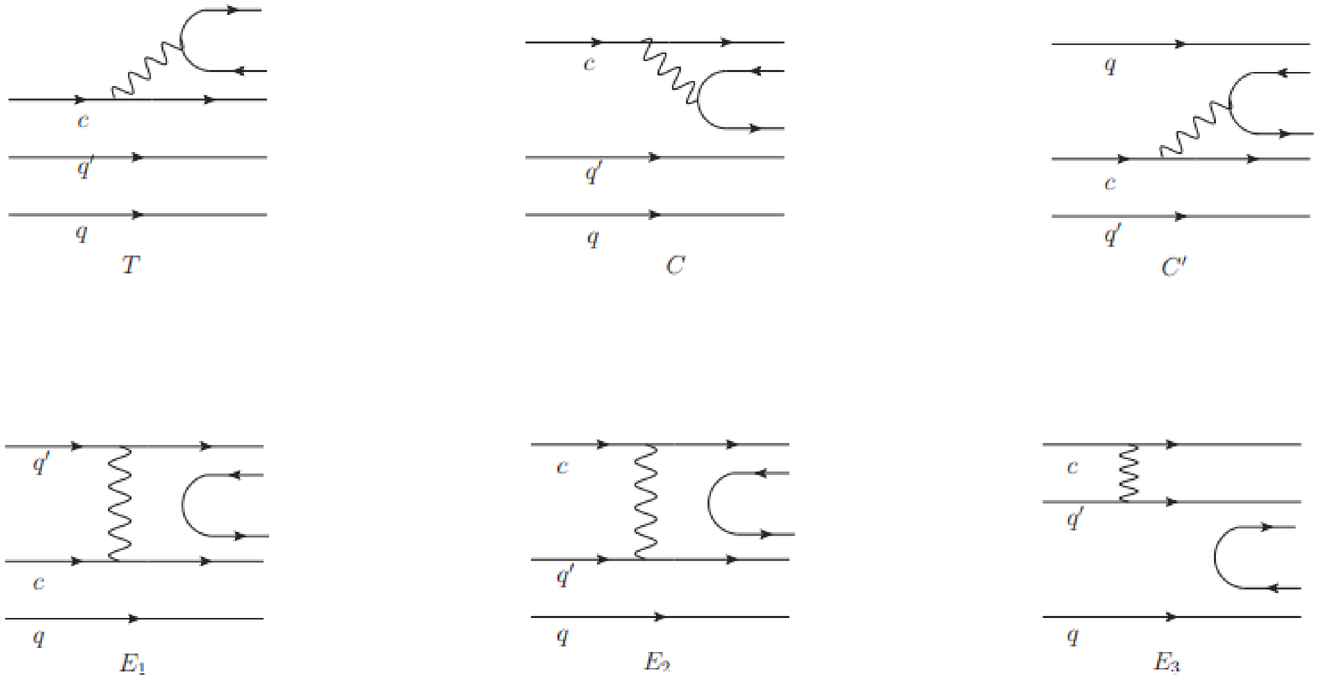


FIG.1 Topological diagrams contributing to $B_c \to B + M$ decay(with M being a pseudoscalar or vector meson): external W-emission T , internal W-emission C, inner W-emission C′, W-exchange diagrams E1, E2 and E3.

It is known empirically to be working reasonably well for describing the nonleptonic weak decays of heavy mesons.

But, this is not directly applicable to the charmed baryon.

Motivation

Theory

The experimental measurements of the decays $\Lambda_c{}^{+} \rightarrow \Sigma^0\pi^+$, $\Sigma^+\pi^0$ and $\Lambda_c{}^{+} \rightarrow \Xi^0 K^+$, which do not receive any factorizable contributions, indicate that W -exchange and inner W -emission indeed play an essential role in charmed baryon decays.

Motivation

Experiment

There were two major breakthroughs in recent charmed-baryon experiments in regard to the hadronic weak decays of $\Lambda_c{}^+$.

- Related to the absolute branching fraction of $\Lambda_c{}^+ \rightarrow \mathrm{p}K^-\pi^+$.

- In 2015 BESIII has measured the absolute branching fractions for more than a dozen of decay modes directly for the first time .

Motivation

Cabibbo-allowed two-body decays

Decay	$\mathcal{B}$	Decay	$\mathcal{B}$	Decay	$\mathcal{B}$
$\Lambda_c^+ \to \Lambda\pi^+$	1.30 ± 0.07	$\Lambda_c^+ \to \Lambda\rho^+$	< 6	$\Lambda_c^+ \to \Delta^{++}K^-$	1.08 ± 0.25
$\Lambda_c^+ \to \Sigma^0\pi^+$	1.29 ± 0.07	$\Lambda_c^+ \to \Sigma^0\rho^+$		$\Lambda_c^+ \to \Sigma^{*0}\pi^+$	
$\Lambda_c^+ \to \Sigma^+\pi^0$	1.25 ± 0.10	$\Lambda_c^+ \to \Sigma^+\rho^0$	< 1.7	$\Lambda_c^+ \to \Sigma^{*+}\pi^0$	
$\Lambda_c^+ \to \Sigma^+\eta$	0.44 ± 0.20	$\Lambda_c^+ \to \Sigma^+\omega$	1.70 ± 0.21	$\Lambda_c^+ \to \Sigma^{*+}\eta$	0.91 ± 0.20
$\Lambda_c^+ \to \Sigma^+\eta'$	1.5 ± 0.6	$\Lambda_c^+ \to \Sigma^+\phi$	0.39 ± 0.06	$\Lambda_c^+ \to \Sigma^{*+}\eta'$	
$\Lambda_c^+ \to \Xi^0 K^+$	0.55 ± 0.07	$\Lambda_c^+ \to \Xi^0 K^{*+}$		$\Lambda_c^+ \to \Xi^{*0}K^+$	0.43 ± 0.09
$\Lambda_c^+ \to pK_S$	1.59 ± 0.08	$\Lambda_c^+ \to p\bar{K}^{*0}$	1.96 ± 0.27	$\Lambda_c^+ \to \Delta^+K_S$	

TABLE I : The measured branching fractions of the Cabibbo-allowed two-body decays of Λ_c^+(in units of %) taken from 2021 Particle Data Group .

Data and MC sample

- **Real Data Sample:**

  Integrated luminosity of 980.6 fb^{-1}

  Collected by Belle detector at the e^+e^- asymmetric-energy collider
- **Signal MC sample (1000000 events)**

  $e^+e^- \rightarrow \Upsilon(4S) \rightarrow c\bar{c}, {\Lambda_c}^+ \rightarrow {\Sigma^*}^+\eta, {\Sigma^*}^+ \rightarrow \Lambda_0\pi^+, \Lambda_0 \rightarrow p^+\pi^-, \eta \rightarrow \gamma\gamma$

  100w signal MC samples for each decay mode
- **Inclusive MC for resonance**

A generic MC simulation sample corresponding to an integrated luminosity of 950.7 fb^{-1} was used to study the possible peaking backgrounds of our decays.

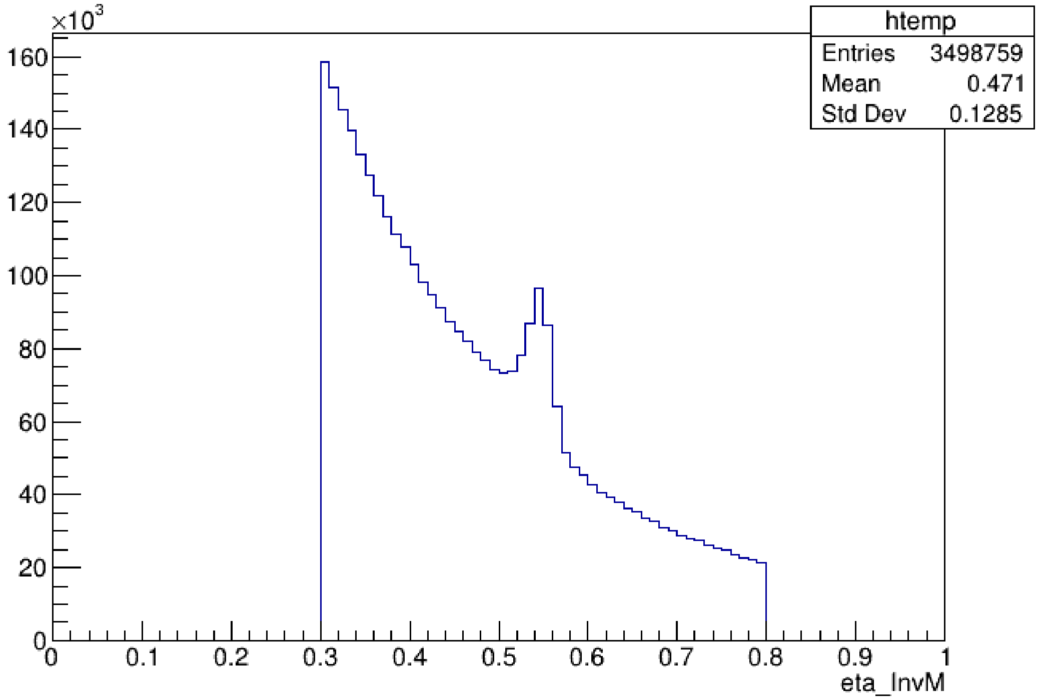
Event selection

Selection Type	Quantity	Selection Condition
PID(K)	$\mathcal{R}(K\|\pi)$	>0.9
	$\mathcal{R}(p\|K)$	<0.6
PID(p)	$\mathcal{R}(p\|\pi)$	>0.9
	$\mathcal{R}(p\|K)$	>0.9
Lepton PID	$\mathcal{R}(e)$	<0.9
Gamma energy	clusterE9/E25	>0.8
	E	>250MeV
Impact parameter for all particles	d(r)	<0.1
	|d(z)|	<0.2
Number of SVD hits for all particles	nSVDHits	>0

TABLE II : Event selection criteria for $\Lambda_c^+ \to \Sigma^{*+}\eta$ decay

In addition, we have a quality constraint for $\gamma\gamma$. Because both π^0 and η can decay to two photons, we need to remove the effect of the decay $\pi^0 \to \gamma\gamma$ on the η mass distribution. As shown in Figure 1, 2 .

Signal MC



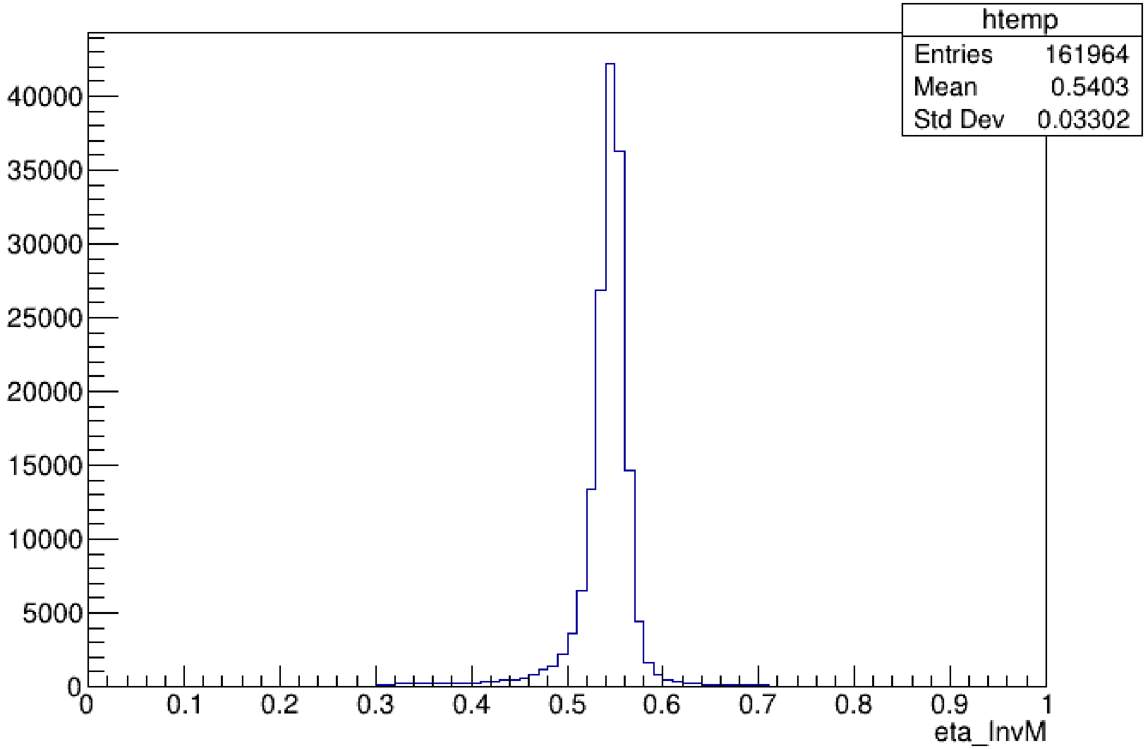


Figure 1, 2: FIG. 1 shows the mass distribution of η that does not match the case selection condition, and FIG. 2 shows the mass distribution selected by the case selection condition.