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Λ_c^+ physics at BESIII

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Summary. — The charmed baryons offer a unique outlook into the study of the light-/heavy-quark interactions, and it is complementary with respect to the one given by charmed mesons. The lightest charmed baryon Λ_c^+ is the perfect laboratory since in effective field theory can be described as a light diquark (u-d) coupled to the heavier charm quark. In this way, the properties of Λ_c^+ are directly connected to the dynamics of the charm quark. However, until 2014 the study on the charmed baryon was very limited. In 2014 BESIII has started its physics program thanks to an upgrade of the beam energy from 2.1 to 2.3 GeV, exactly above the $\Lambda_c^+\bar{\Lambda}_c^-$ baryon threshold. In this contribution we will discuss one example of the BESIII possibilities in the Λ_c^+ studies.

1. – Introduction

Λ_c^+ is the lightest charmed baryon. Based on the Heavy Quark Effective Field Theory [1], it can be described by the dynamics of the quark charm. All the other charmed baryons will eventually decay into a Λ_c, so it is extremely relevant to study with high precision its properties. A dedicated data taking was performed by the BEijing Spectrometer III (BESIII) in 2014, with four data set in four energy values above the $\Lambda_c^+\bar{\Lambda}-_c^-$ baryon threshold for a total of roughly 620/pb. BESIII is a multi-purpose central detector optimized for flavor physics, and is hosted in the Beijing Electron Positron Collider II (BEPCII), at the Institute of High Energy Physics in Beijing, PRC.

The BESIII detector is composed by several sub-detectors, that are described in detail in ref. [2]. Most of the studies on charmed baryons come from B-factories, but BESIII offers the possibility to completely close the kinematics, reconstructing both sides of an event. This allows BESIII to search for final states in which there is a neutral particle (neutron, neutrino) as a peak in the missing mass of the event. The first observation of $\Lambda_c^+ \to nK_s\pi^+$ [3] is a good example of the possibilities of BESIII.

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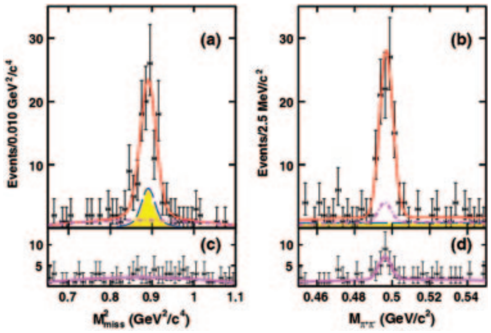

Fig. 1. – Projection of the 2D fit. The upper part is the signal region, while the bottom part is the sideband region to constrain the background. The yellow histogram represents the $\Lambda_c \to \Sigma(n\pi)\pi\pi$ background.

2. – Observation of $\Lambda_c^+ \to nK_s\pi^+$

The search for a final state with a neutron was one of the missing pieces in the PDG's [4] list in Λ_c^+ decays. Moreover, it is possible to test the isospin relation:

$$\mathcal{A}(n\bar{K}^0\pi^+) + \mathcal{A}(pK^-\pi^+) + \sqrt{2}\mathcal{A}(p\bar{K}^0\pi^0) = 0. \tag{1}$$

This analysis profits from a strategy that is called *Double-Tag* technique. First, 11 $\bar{\Lambda}_c^-$ decay modes are reconstructed and are called Tag-modes. Please refer to ref. [3] for the entire list. Then, among all pre-selected events the signal of interest is chosen.

The final state is reconstructed by selecting three pions. Two pions must have a secondary vertex well separated from the interaction point to identify the K_s. The remaining pion information are used to extract the missing mass:

$$M^2_{miss} = E^2_{miss}/c^4 - |\overrightarrow{p}_{miss}|^2/c^2, \tag{2}$$

where $E_{miss} \equiv E_{beam} - E_{K^0_s} - E_{\pi^+}$ and $\overrightarrow{p}_{miss} = \overrightarrow{p_{\Lambda_c^+}} - \overrightarrow{p}_{K^0_s} - \overrightarrow{p}_{\pi^+}$. The total number of events is extracted by a bi-dimensional fit of the squared invariant mass of the $\pi^+\pi^-$ pair and of the squared missing mass defined as in eq. (2). The resulting fit projections are shown in fig. 1.

The observed number of events is used to extract the total branching ratio $BR(\Lambda_c^+ \to nK^0_s\pi^+) = (1.82 \pm 0.23 \pm 0.11)$, where the first error is statistical and the second is systematical. This is the first measurement of a final state with a neutron. With the branching ratio we found the triangular relation of eq. (1) and thus isospin is confirmed.

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