Introduction

• Quark model within SM predicts the existence of quasi-stable doubly charmed baryons: \( \Xi_{cc}^{\pm}(ucc), \Xi_{cc}^{\mp}(dcc) \) and \( \Omega_{cc}^{\pm}(sc) \).

Properties

• Excitations decay to ground states via Strong and EM interactions.

• Ground states decay weakly via \( c \to u/d/s \) transitions.

• Production cross-sections are predicted with large uncertainties: \( 60-1800 nb \) @13 TeV LHC [1].

• Predicted lifetimes and mass show:

  \[ \tau(\Xi_{cc}^{\pm}) = 200-700 \text{ fs}, \quad m(\Xi_{cc}^{\pm}) = 3.5-3.7 \text{ GeV} \] [3].

Production

• Dedicated heavy flavour generator GenXicc [4] used to produce initial hard processes leading to \( \Xi_{cc} \) production.

Motivation

• They are great testing grounds for non-perturbative QCD techniques and are unexplored systems for CP violation.

\( \Xi_{cc}^{++} \) discovery

• LHCb observed the first doubly charmed baryon, the \( \Xi_{cc}^{++} \) baryon, in \( \Xi_{cc}^{++} \rightarrow \Lambda_{cc}^{+} K^{-}\pi^{+}\pi^{+} \) decays.

  ➢ Local significance \( > 12 \sigma \)

  ➢ Resolution \( = 6.6 \pm 0.8 \text{ MeV} \) (consistent with expected detector resolution).

  ➢ Decay vertex significantly displaced \( \Rightarrow \) weakly decaying.

• Consistent with \( \Xi_{cc}^{++} (ccu) \) state.

\[ m(\Xi_{cc}^{++}) = 3621.40 \pm 0.72 \text{ (stat)} \pm 0.27 \text{ (syst)} \pm 0.14(\Lambda_{cc}^{+}) \text{ MeV} \]

LHCb detector

• Excellent tracking, particle ID and efficient trigger system.

  ➢ IP resolution: 20 \( \mu \text{ m} \)

  ➢ \( \tau \) resolution: 45 fs.

  ➢ Efficient K/πp separation (95%).

Analysis approach

• Using Run1 and Run2 data.

• Searches for both \( \Xi_{cc} \) isospin partners are done blindly.

• Selections built around simulated decays and data with an unphysical combination of charged tracks.

• Candidates for these analyses are reconstructed at trigger level (Turbo).

  ➢ LHCb can perform full detector alignment and calibration in real-time.

• Started searching for doubly charged state in \( \Xi_{cc} \rightarrow \Lambda_{cc}^{+} K^{-}\pi^{+}\pi^{+} \) decays.

  ➢ \( Br(\Xi_{cc}^{++} \rightarrow \Lambda_{cc}^{+} K^{-}\pi^{+}\pi^{+}) \) expected to be highest of all modes.

• Use cut-based selections and MVAs to reduce combinatorial background.

Future work

• Searching for \( \Xi_{cc}^{++} \) state in additional decay modes:

  \[ \Xi_{cc}^{++} \rightarrow \Xi_{cc}^{+} \pi^{+} \]

  \[ \Xi_{cc}^{++} \rightarrow D^{+} p K^{-} \pi^{+} \]

• Searching for \( \Xi_{cc}^{++} \) and \( \Omega_{cc}^{+} \) in larger data sets, in multiple channels and with improvements in triggering.

  ➢ Measure lifetimes, masses, quantum numbers and production cross sections of all states.

• LHCb aims to build an accurate and concise picture of doubly charmed baryons as a whole.

References


