Ξ_{cc} decays and properties

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LHCC 2018

Overview

Introduction

- Quark model within SM predicts the existence of quasi-stable doubly charmed baryons:

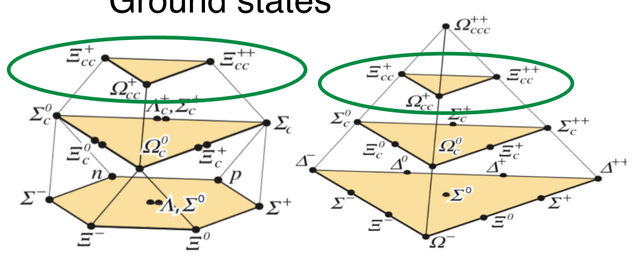
  Ξ_{cc}^{++}(ucc), Ξ_{cc}^{+}(dcc) and Ω_{cc}^{+}(scc)

$J^P = \frac{1^+}{2}$ Ground states

$J^P = \frac{3^+}{2}$ Excited states

Properties

- Excitations decay to ground states via Strong and EM interactions



Form SU(4) multiplets

- Ground states decay weakly via c → u/d/s transitions
- Production cross-sections are predicted with large uncertainties: 60-1800nb @13TeV LHC [1]
- Predicted lifetimes and mass show:

Production

$\tau(\Xi_{cc}^{++}) \in$ 200-700 fs, $\tau(\Xi_{cc}^{+}) \in$ 50-250 fs [2]

$m(\Xi_{cc}) \in$ 3.5-3.7 GeV [3]

- Dedicated heavy flavour generator GenXicc [4] used to produce initial hard processes leading to Ξ_{cc} production

Motivation

Gluon-gluon fusion dominate mechanism

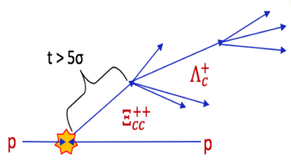
- They are great testing grounds for non-perturbative QCD techniques and are unexplored systems for CP violation

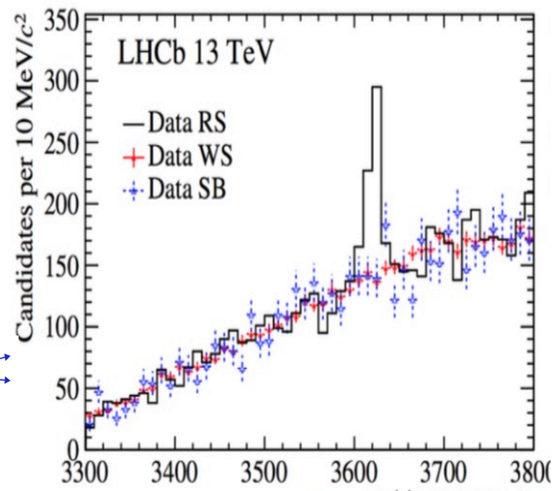
Ξ_{cc}^{++} discovery

- LHCb observed the first doubly charmed baryon, the Ξ_{cc}^{++} baryon, in $\Xi_{cc}^{++} \to \Lambda_c^+ K^- \pi^+ \pi^+$ decays

- Local significance **> 12σ**
- Resolution = **6.6 ± 0.8 MeV** (consistent with expected detector resolution)
- Decay vertex significantly displaced

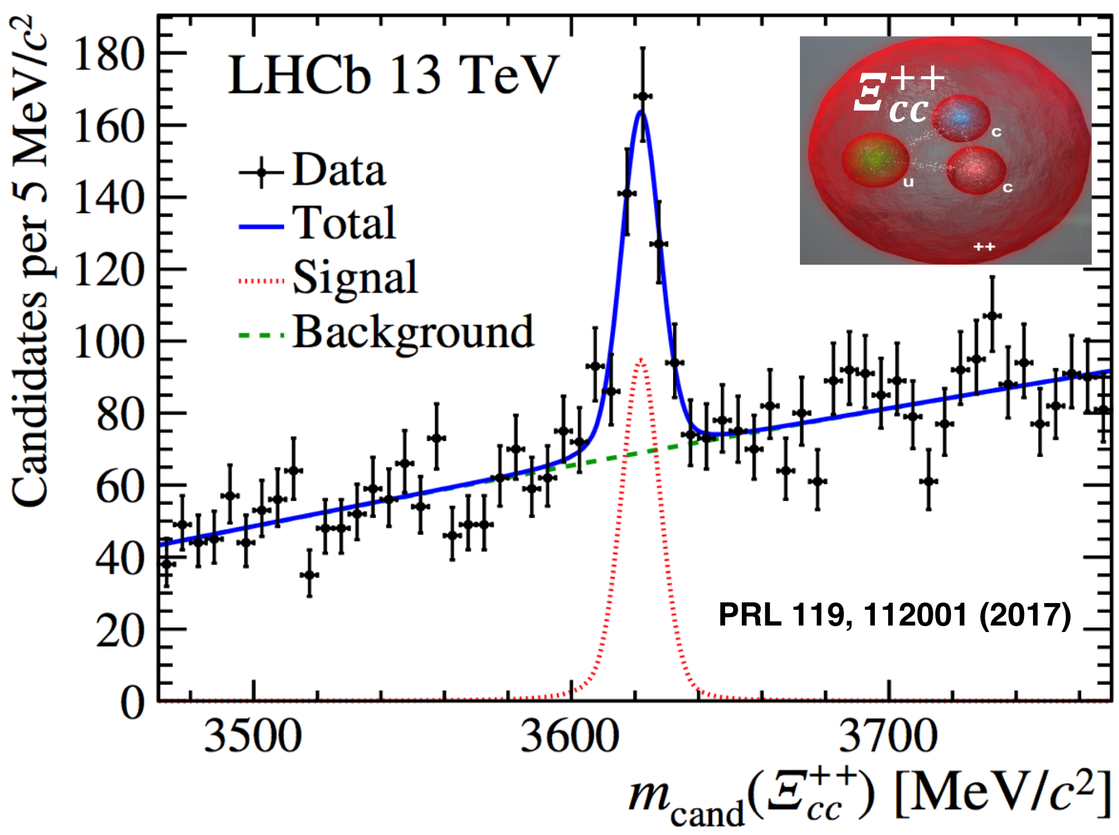
  ⟹ **weakly decaying**





- Consistent with Ξ_{cc}^{++}(ccu) state

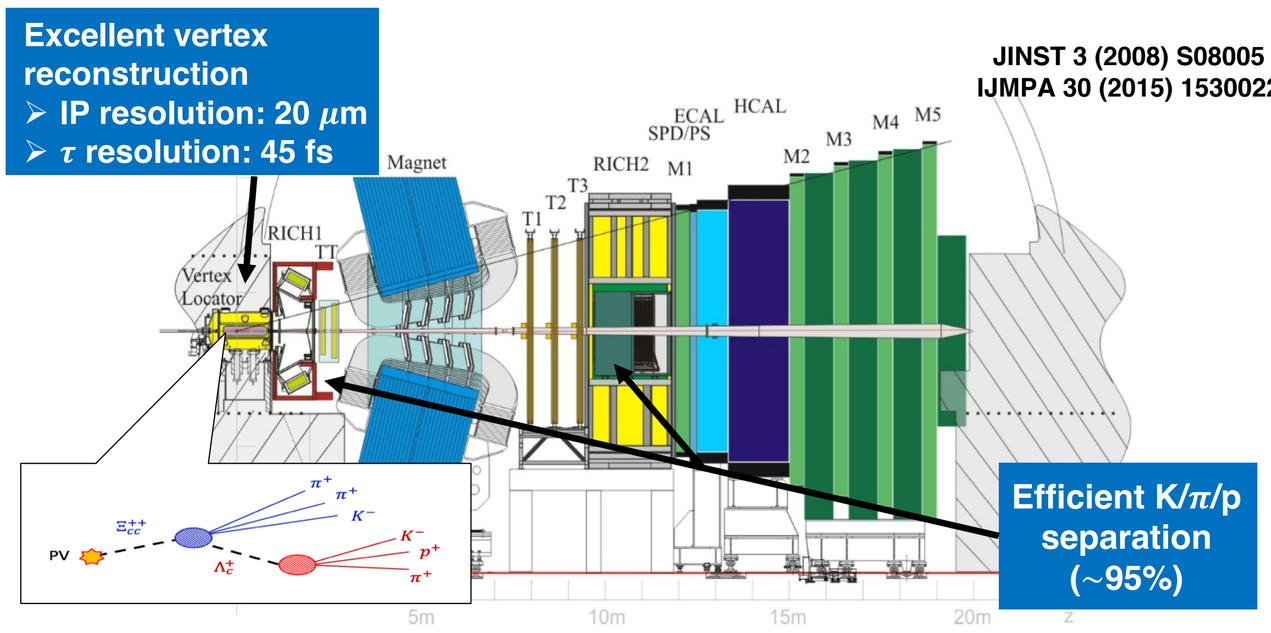
$M(\Xi_{cc}^{++})$ = 3621.40 ± 0.72 (stat) ± 0.27 (syst) ± 0.14(Λ_c^+) MeV



LHCb detector

- Excellent tracking, particle ID and efficient trigger system

Excellent vertex reconstruction
- **IP resolution: 20 μm**
- **τ resolution: 45 fs**



JINST 3 (2008) S08005
IJMPA 30 (2015) 1530022

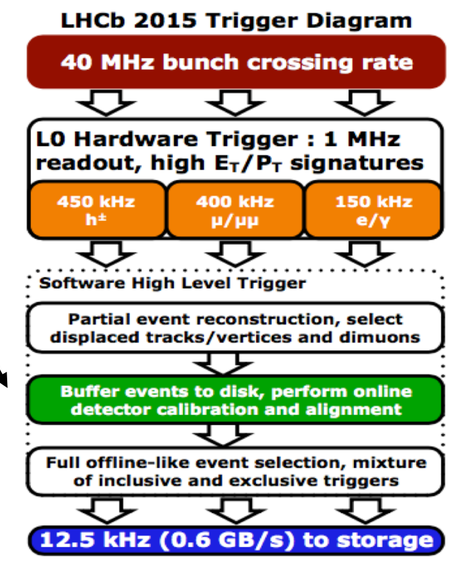
Efficient K/π/p separation (~95%)

- LHCb is a superb laboratory for studies of Ξ_{cc} decays

Analysis approach

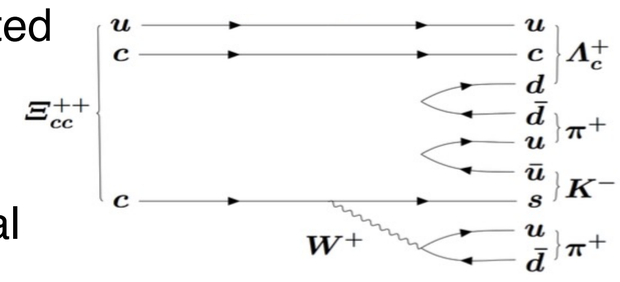
- Using Run1 and Run2 data
- Searches for both Ξ_{cc} isospin partners are done blindly
- Selections built around simulated decays and data with an unphysical combination of charged tracks
- Candidates for these analyses are reconstructed at trigger level (Turbo)

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



arXiv:1604.05596

- Started searching for doubly charged state in $\Xi_{cc}^{++} \to \Lambda_c^+ K^- \pi^+ \pi^+$ decays
- *Br* ($\Xi_{cc}^{++} \to \Lambda_c^+ K^- \pi^+ \pi^+$) expected to be highest of all modes
- Use cut based-selections and MVAs to reduce combinatorical background

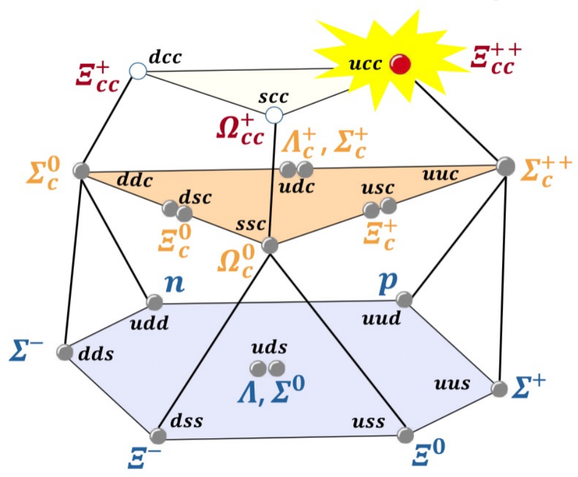


Future work

- Searching for Ξ_{cc}^{++} state in additional decay modes:

$$\Xi_{cc}^{++} \to \Xi_c^+ \pi^+$$
$$\Xi_{cc}^{++} \to D^+ p^+ K^- \pi^+$$

- Searching for Ξ_{cc}^{+} and Ω_{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
[1]: J.-W. Zhang et al., Hadronic production of doubly heavy baryon at LHC: Phys. Rev. D 83, 034026
[2]: B. Guberina and H. Stefancic, Lifetimes of doubly charmed baryons: Eur.Phys.J.C9:213-219,1999
[3]: M. Karliner and J. L. Rosner, Baryons with two heavy quarks: Phys. Rev. D 90, 094007 (2014)
[4]: C.-H. Chang, J.-X. Wang, and X.-G. Wu, GENXICC2.0: Comput.Phys.Commun.181:1144-1149,2010