# Search for excited doubly charmed baryons

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## Overview

Three weakly decaying doubly charmed baryons are expected:

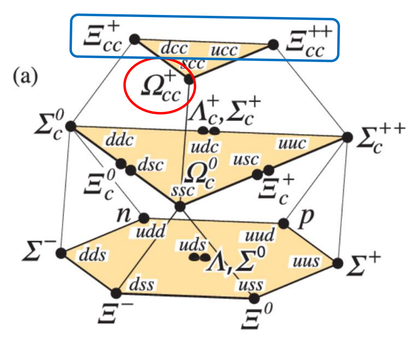
- $\Xi_{cc}$ isodoublet (ccu, ccd)
  → Similar masses (isospin symmetry)
- $\Omega_{cc}$ isosinglet (ccs)

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

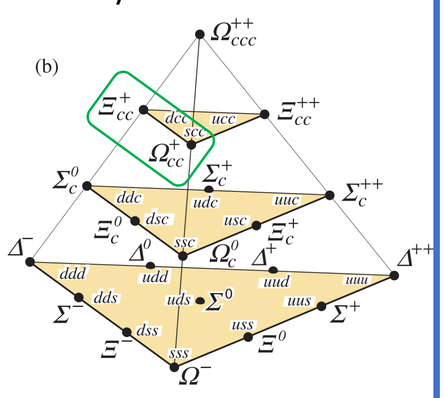
We study two excited states, looking for two spectra:

- $\Xi_{cc}^{**+} \rightarrow \Xi_{cc}^{++} \pi^-$
- $\Omega_{cc}^{**+} \rightarrow \Xi_{cc}^{++} K^-$

$J^P = 1/2^+$ ground states



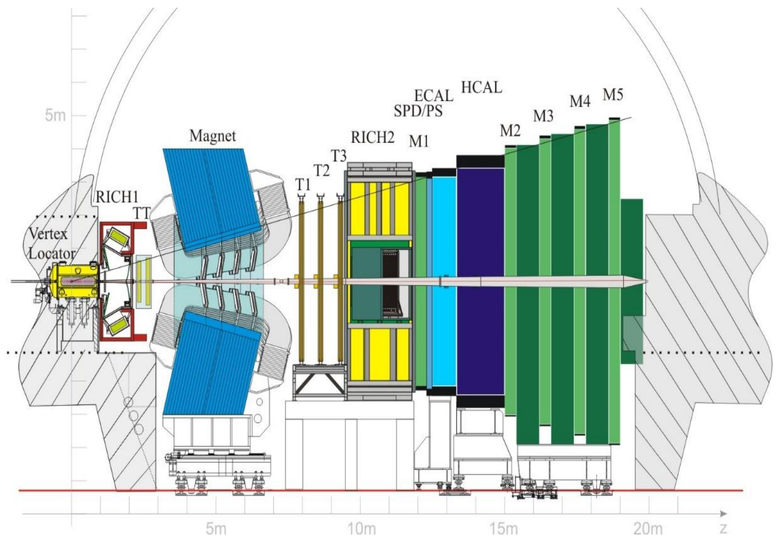

$J^P = 3/2^+$ excited states

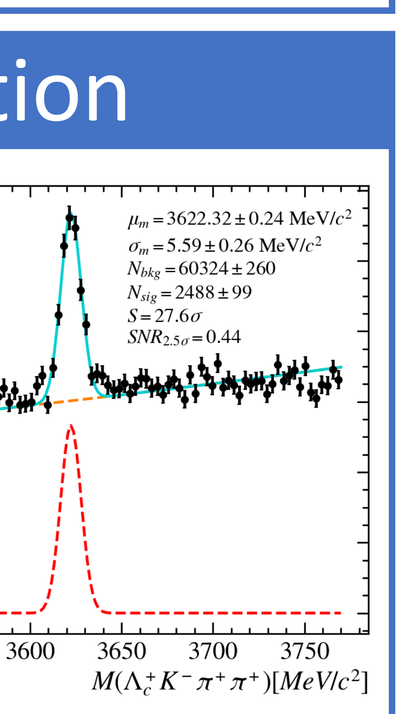



SU(4) 20-plets

## LHCb detector

- Single arm forward spectrometer
- Excellent tracking, particle ID and efficient trigger system

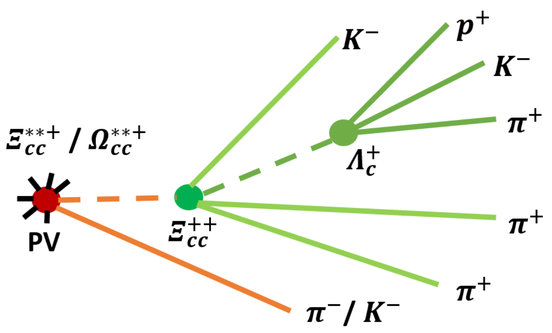



- LHCb is a superb laboratory for studies of $\Xi_{cc}$ decays

## Analysis approach

1. Reconstruct $\Xi_{cc}^{++}$ candidates
2. Combine those candidates to a $\pi^-/K^-$ to reconstruct $\Xi_{cc}^{**+}$/ $\Omega_{cc}^{**+}$ candidates




**How to reconstruct candidates**

1. Events are filtered and candidates are reconstructed and selected centrally through the trigger
2. A cut-based pre-selection is applied
3. A multivariate selection is applied after training using simulation and background data
4. Clone and duplicated candidates are removed

## $\Xi_{cc}^{++}$ reconstruction

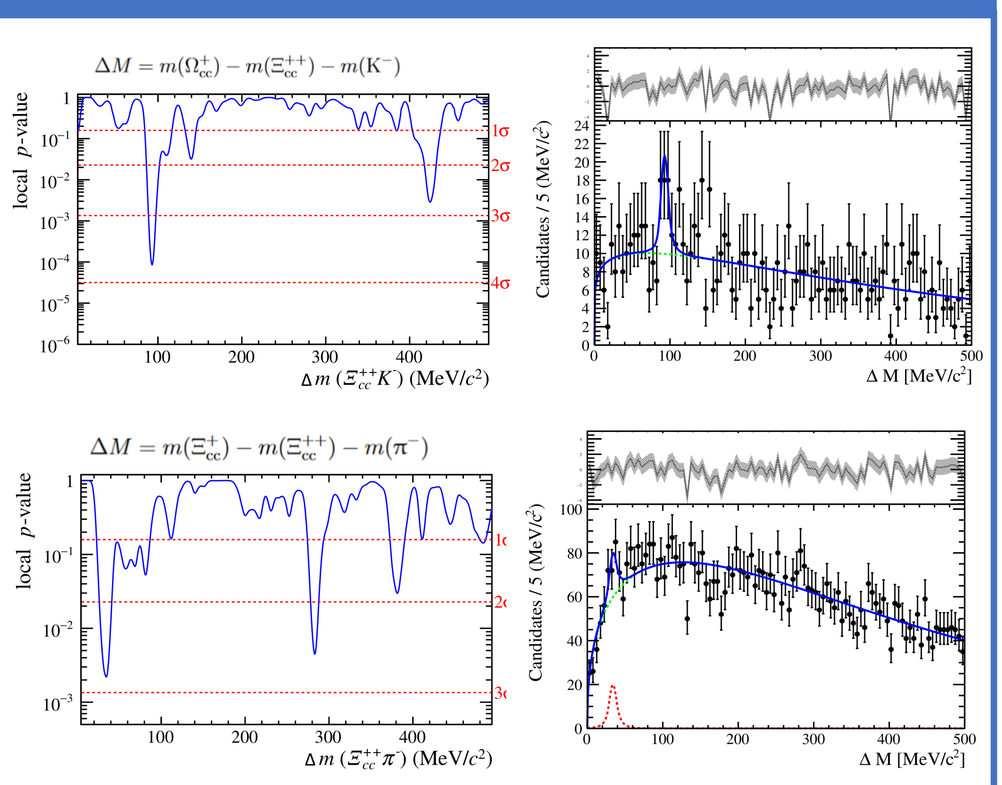
- Decay mode :
  $\Xi_{cc}^{++} \rightarrow \Lambda_c^+ K^- \pi^+ \pi^+$
- **~2500** candidates
- Local significance **> 27 σ**
- Resolution = **5.59 ± 0.30 MeV** (consistent with expected detector resolution)
- SNR = 0.44 (signal purity)




**m($\Xi_{cc}^{++}$) = 3622.32 ± 0.24 MeV**

## Excited states reconstruction

A search for both the $\Xi_{cc}^{**+}$ baryon through the $\Xi_{cc}^{++}\ \pi^-$ decay and the $\Omega_{cc}^{**+}$ baryon through the $\Xi_{cc}^{++}\ K^-$ decay are performed, using *pp* collision data collected by the LHCb experiment from 2016 to 2018 at a centre-of-mass energy of 13 TeV, corresponding to an integrated luminosity of 5.4 $fb^{-1}$. No significant signal is observed in the mass range of 0 to 500 MeV from the mass threshold.




## Future work

- Future searches by the LHCb experiment with upgraded detectors, improved trigger conditions, additional $\Xi_{cc}^{**+}$ and $\Omega_{cc}^{**+}$ decay modes, and larger data samples will further increase $\Xi_{cc}^{**+}$ and $\Omega_{cc}^{**+}$ signal sensitivity
- 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 :

- M. Gell-Mann, A schematic model of baryons and mesons, Phys. Lett. 8 (1964) 214
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