$\Xi_c(2645)$ and $\Xi_c(2815)$ production in ***pp*** interactions at the LHCb

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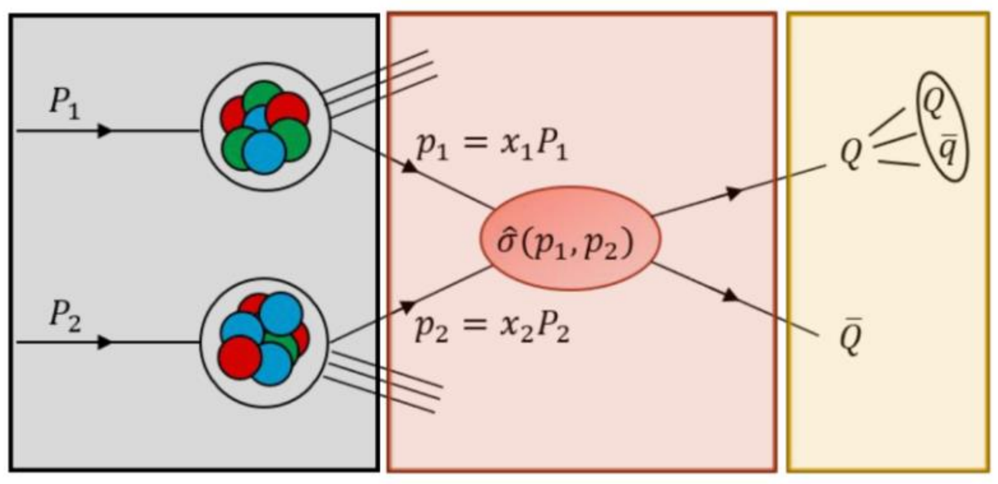
1. Introduction

The **factorization approach** is used to describe the cross-sections of hard processes. The approach implies the separation of the proton interaction process into **independent phases**, each of which is characterized by its own dynamics. The **factorization formula** well demonstrates the dynamics of each phase.



$$\frac{d\sigma}{dX} = \sum_{i,j} \int_X p_i(x_i, Q) p_j(x_2, Q) \frac{d\hat{\sigma}_{ij}(Q)}{d\hat{X}} f(\hat{X} \to X, Q)$$

Hadron differential cross-sections | **Parton** density functions | **Parton** differential cross-sections | **Fragmentation fractions**

The fragmentation processes are difficult to simulate. The information about them could be obtained by analyzing the so-called **fragmentation fractions.**

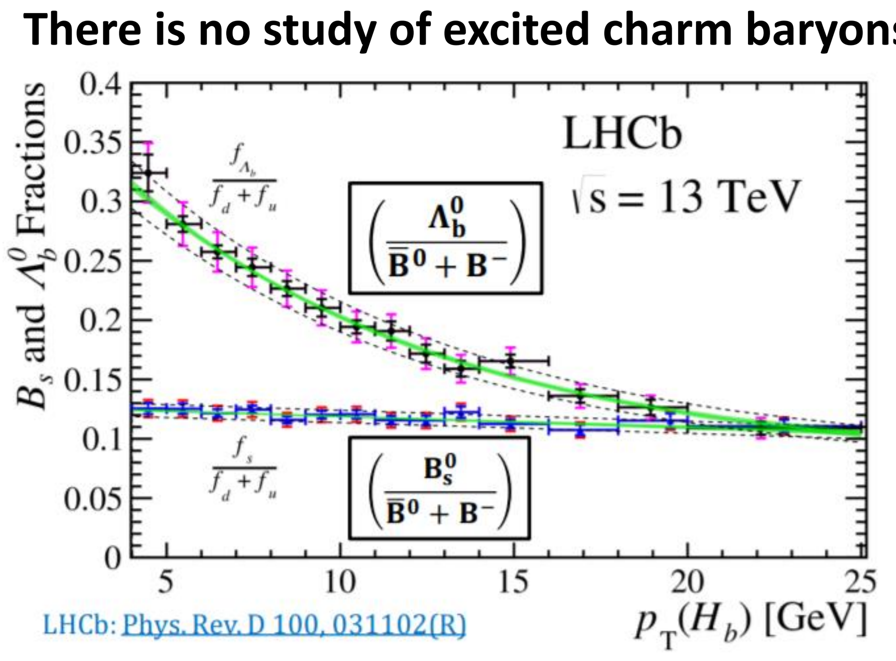
The fragmentation fraction – the probability of the **parton state** is hadronized to the corresponding observed **hadronic state**.

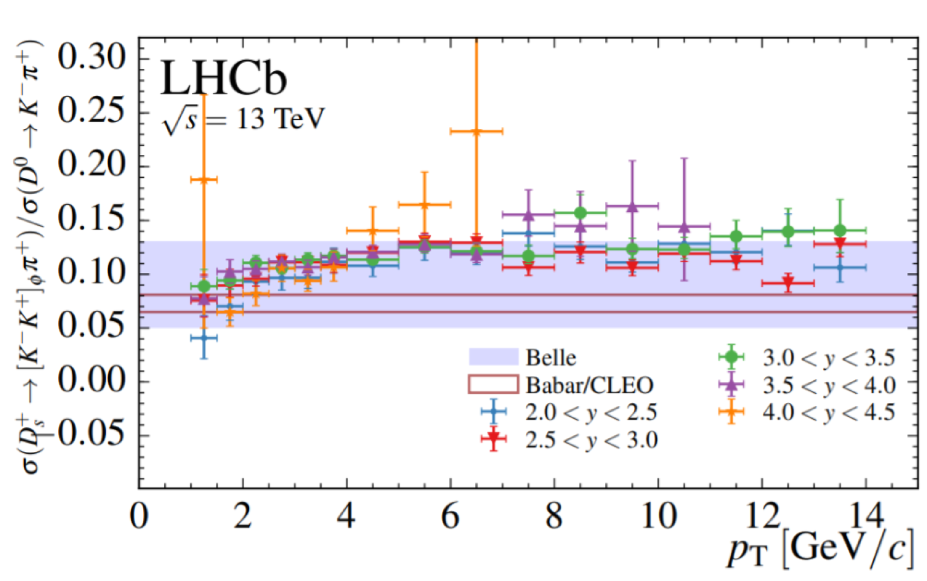
2. Motivation

The fragmentation fractions can be evaluated using the **relations between differential production cross sections.** The dynamics of fragmentation fractions is poor studied. It is interesting to understand fragmentation fraction universality in:

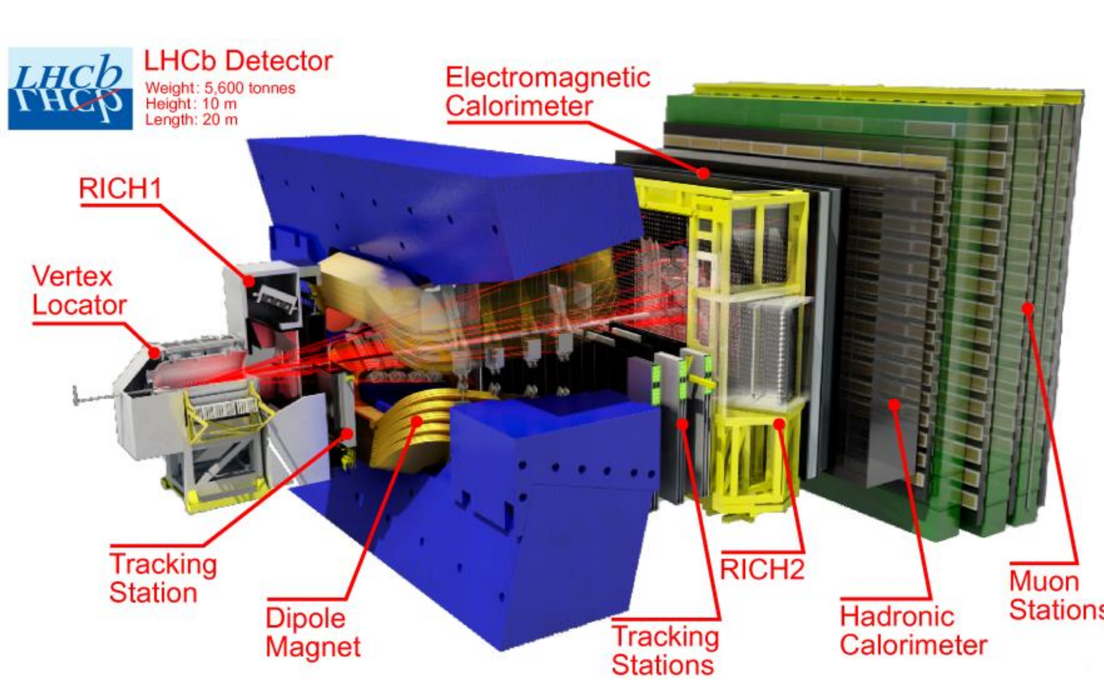
- Different types of interacted systems;
- Different system's centrality;
- **Different pT-y intervals.**

There is no study of excited charm baryons fragmentation fractions.





3. Why the **LHCb**?



- A single-arm forward spectrometer;
- The production cross-section of *cc*-pairs at 7 TeV: 6.10 ± 0.93 mb;
- **LHCb** acceptance → 1 fb^{-1} corresponds to 10^{12} decays of *c*-hadrons;
- High precision vertex detector;
- Unique ability of a particle identification.

4. Main steps of the analysis

To measure the relation of differential cross-section values (***R***) for Ξ_c**(2645)**, Ξ_c**(2815)** to its ground state, using data collected by the LHCb detector at 7 TeV (1 fb^{-1}) and 8 TeV (2 fb^{-1}):

$$R_{Y_c} = Br(Y_c \to \Xi_c) \frac{d^2\sigma_{Y_c}/dp_T dy}{d^2\sigma_{\Xi_c}/dp_T dy} \approx \frac{f(c \to Y_c)}{f(c \to \Xi_c)}$$

- Measurements of ***R*** uncorrected;
- Resolution evaluation;
- Optimization of the requirements;
- Estimation of systematic uncertainties;
- Calculation of the corrected ***R***.

$$\Xi_c^+ \to pK^-\pi^+$$
$$\Xi_c(2645)^0 \to \Xi_c^+\pi^-$$
$$\Xi_c(2815)^+ \to \Xi_c(2645)^0\pi^+$$

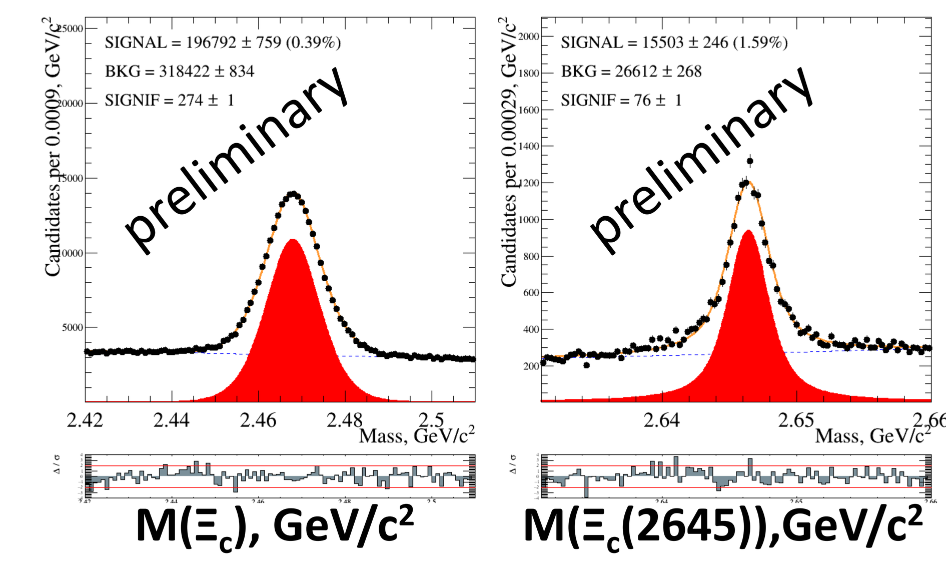
5. Mass spectra and resolution

The probability density functions to approximate the mass spectra:

- ground state: Ξ_c – Apollonious2;
- excited states: Ξ_c**(2645)**, Ξ_c**(2815)** – Breit-Wigner (BW);
- background part: 1-st order Bernstein polynomial.

To estimate the resolution:

- Merge 7 TeV and 8 TeV datasets;
- Fix BW and background parameters on Particle Data Group values;
- Maximum likelihood fit by BW convoluted with Gaussian with free sigma-parameter.

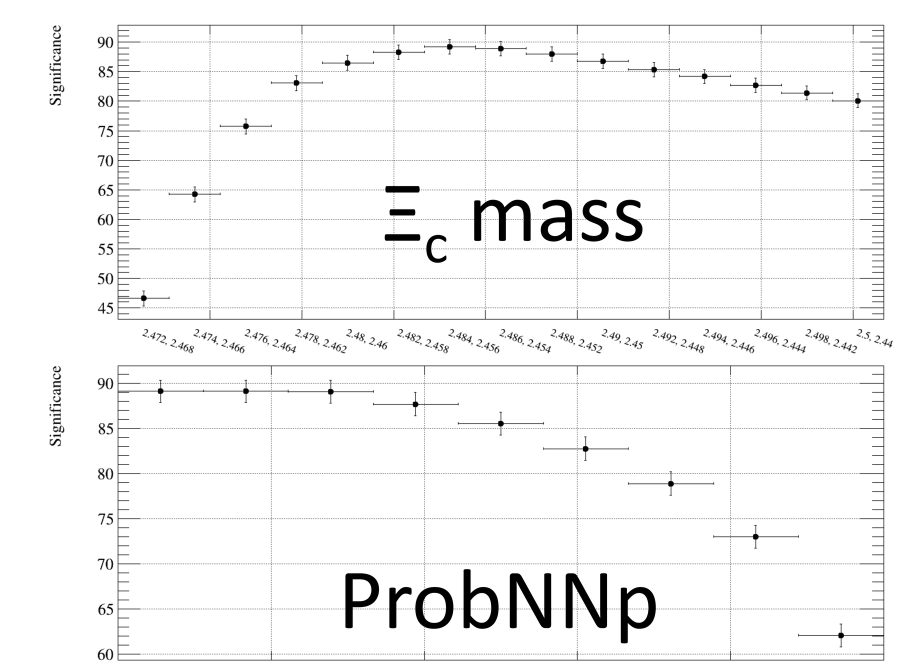


Energy resolution results:

Res(Ξ_c(2645)) = **817 ± 35 keV**;
Res(Ξ_c(2815)) = **1114 ± 101 keV**.

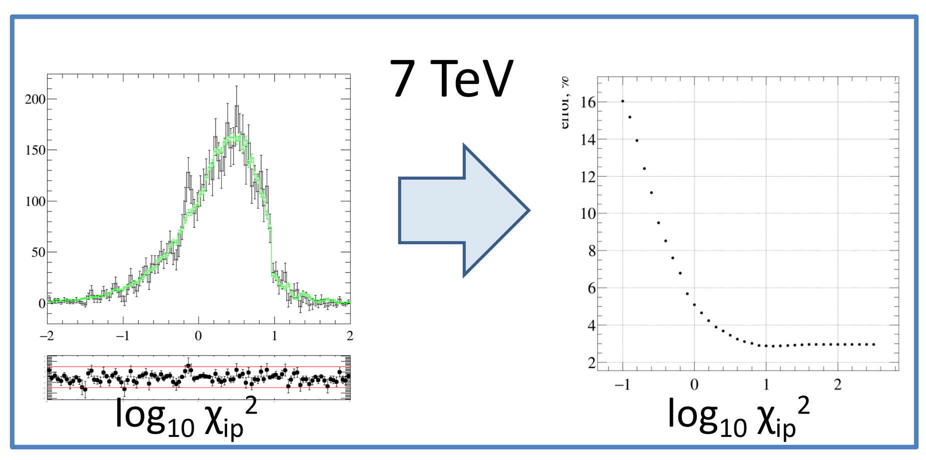
6. Requirements

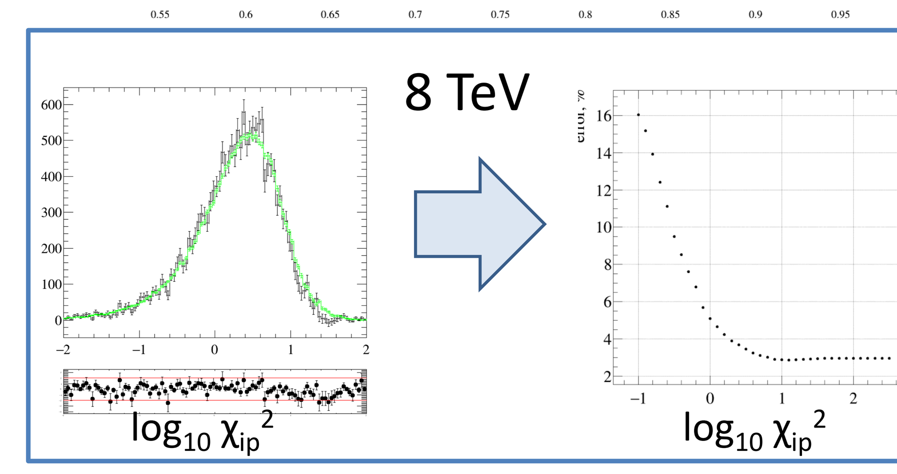
- The mass of ground state;
- The response of Neural Networks (***PID***);
- The $\log_{10}\chi^2_{ip}$ - requirement.



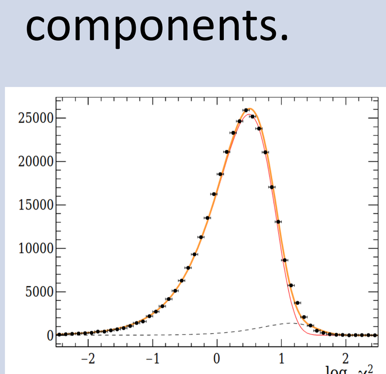
Does the $\log_{10}\chi^2_{ip}$ cut changes the ***R***?

- Fit mass spectra;
- Apply ***sPlot*** and take into account the signal part;
- Normalize and compare.





7. Systematic uncertainties

From chosen model of signal and background	From model parameters	From width fixing	From non-prompt events
Applied an approximation with alternative model and calculate the relation of difference to the number of events in mass spectra.	• Covariance matrix of fit • Randomize parameters by the covariance matrix • Refit with alternative parameters and get number of events .	• Generate MC-width based on PDG width of the resonance • Fit with fixed MC-width • Got the result-distribution's Sigma/N events.	Simultaneous fit of Ξ_c-mass spectra's prompt and non-prompt components.  (LHCb-ANA-2016-072)

8. Results

- The ***R*** is measured in kinematic bins for Ξ_c baryons;
- The systematic uncertainties related to fit models and prompt fraction are estimated;
- The significant deviation from the universality hypothesis is not observed.