Bose–Einstein correlations in pp and pPb collisions at LHCb

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Introduction

Bose–Einstein correlations (BEC) emerge from quantum statistics describing a system of identical bosons:

- enhanced production of identical bosons with similar four-momenta q_1, q_2 (using a variable $Q = \sqrt{-(q_1 - q_2)^2}$)
- **correlation radius** R and **chaoticity parameter** λ can be measured (they provide information on properties of the particle-emitting source)
- often studied in different bins of the event **charged-particle multiplicity** N_{ch}, **average pair transverse momentum** k_T and rapidity.

Motivation

Small systems

Study of the BEC effect in pp and pPb collisions is of particular interest, due to different predictions of the theoretical models [1, 2] on the size of the particle-emitting source in those systems. A direct comparison of those two measurements performed with a single detector can contribute to the development of the theoretical models.

Forward region

The LHCb detector [3] can provide results in an acceptance region which is unique among other LHC experiments. It is a single-arm spectrometer that covers the forward region of pseudorapidity between $2.0 < \eta < 5.0$.

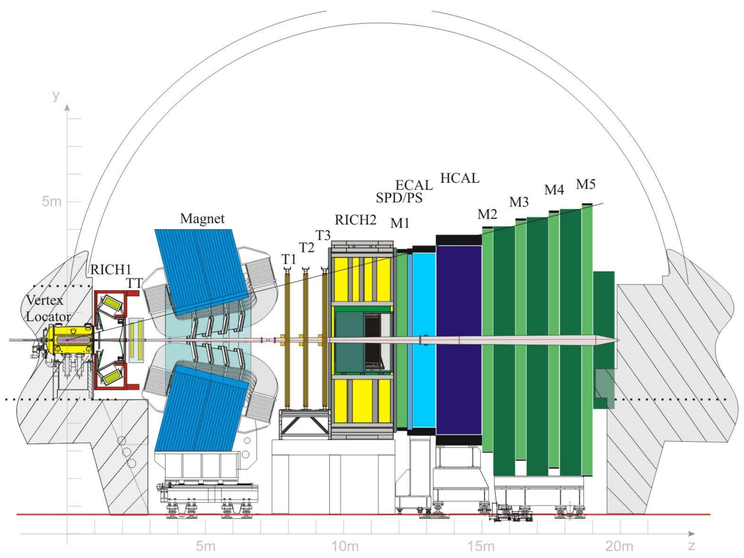

Figure 1: View of the LHCb detector [3].

Analysis method

Signal pairs are constructed from **same-sign charged pions** (originating from a single primary vertex) collected in pp and pPb collisions at $\sqrt{s} = 7$ TeV and $\sqrt{s_{NN}} = 5.02$ TeV, respectively.

Correlation function

Correlation function is defined as a ratio of Q distributions for the signal and reference pairs:

$$C_2(Q) = \frac{N_{ref}}{N_{sig}} \frac{N_{sig}(Q)}{N_{ref}(Q)}, \tag{1}$$

where the reference sample is constructed by **mixing particles from different events**, hence the Bose–Einstein correlations are not present. The BEC effect is studied using a **Bowler–Sinyukov formalism** [4], assuming a **Lévy-type source** (with α fixed to unity):

$$C_2(Q) = N[1 - \lambda + \lambda K(Q) \times (1 + e^{-RQ})] \times \Omega(Q), \tag{2}$$

where $\Omega(Q)$ corresponds to a **non-femtoscopic background** (*e.g.* mini-jets, long-range correlations) and $K(Q)$ provides a correction for final-state **Coulomb interactions** in the signal pairs.

In the pp study, a simulated sample is used to construct a double-ratio function, which significantly limits contributions from the non-femtoscopic background (see Fig. 2) and allows to use a simplified version of Eq. (2). **For the pPb collisions, a fully data-driven approach is taken.**

Data-driven approach

In the pPb analysis, the non-femtoscopic contributions are determined using pairs of **opposite-sign charged** pions from the data (see *e.g.* the study from CMS [6]). The obtained background parameters are then used in the fits to the signal pairs.

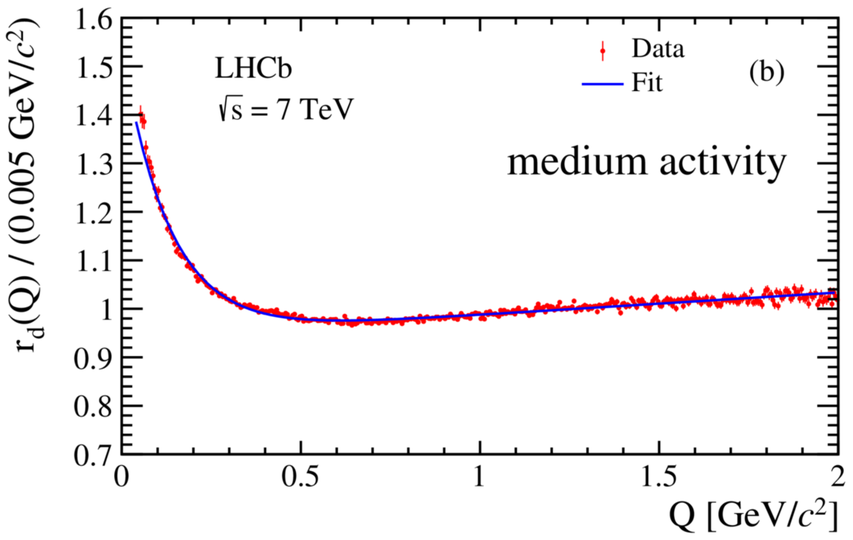

Figure 2: Double-ratio function obtained in the pp study at LHCb (example) [5].

Summary

- BEC effect studied in N_{ch} bins for pp (**published**) and (N_{ch}, k_T) bins in pPb (**ongoing**).
- Unique acceptance covering the **forward region** (potential to add information on rapidity dependence).
- **Direct comparison of pp and pPb** systems with a single detector (input for theoretical models).

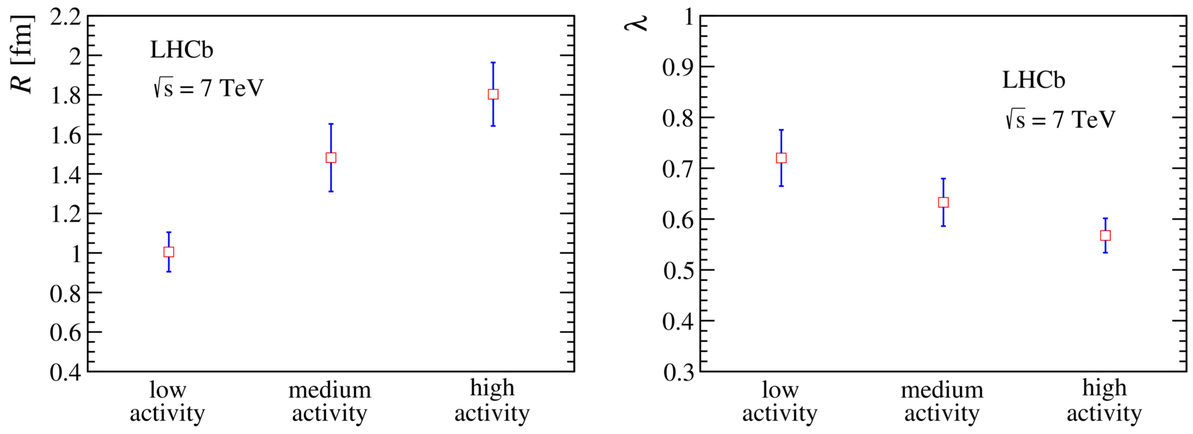

Figure 3: Correlation parameters measured at LHCb in the pp system (higher activity corresponds to higher N_{ch}) [5].

References

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Acknowledgements

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