Studying the role of multi-parton interactions in the production of doubly-heavy hadrons in proton-proton collisions

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The masses of the beauty and charm quarks are so large that their production at proton-proton colliders, such as the Large Hadron Collider, is dominated by perturbative Quantum Chromodynamics (QCD). As such, these heavy quarks can uniquely act as probes of the complex interactions within the proton that led to their formation. During a single proton-proton collision it is possible for multiple pairs of partons from the two protons to interact, commonly referred to as multi-parton interactions (MPIs). However, whether the quarks produced in different parton-parton interactions can then go on to form single hadronic states is as yet unknown.

Doubly-heavy hadrons are bound states of quarks containing two heavy quarks, including the B_c^+ meson ($c\bar{b}$) and Ξ_{cc}^{++} baryon (ccu). Their formation is generally assumed to be dominated by single-parton interactions (SPIs) in which additional heavy flavour pairs are produced by pertubative QCD as gluonic radiation during the event evolution. These hadrons constitute an ideal laboratory to test whether heavy quarks from *different* parton-parton interactions can become bound in a single hadron. The Monte Carlo event generator PYTHIA predicts a significant fraction of doubly-heavy hadrons are produced via MPI mechanisms [1], but experimental evidence of this is missing.

Ongoing studies capable of differentiating doubly-heavy hadron production from MPI or SPI mechanisms are currently being performed using data collected by the LHCb experiment.

[1] U. Egede, T. Hadavizadeh, M. Singla, P. Skands, M. Vesterinen, *The role of multi-parton interactions in doubly-heavy hadron production*, [arxiv:2205.15681]