Bell inequality violation detection with flavor entanglement of B0-B0bar pairs in LHC-ATLAS Run-3

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The Bell inequality is a principal touchstone of testing the local realism posited by Einstein at the time of the formation of quantum theory. We examine the feasibility of the Bell test, i.e., detecting a violation of the Bell inequality, through the flavor entanglement between pairs of the B mesons produced in pp collisions at the LHC. We propose a new measurement in LHC-ATLAS Run-3 taken in low-luminosity condition to suppress combinatorial backgrounds and with a low-pT di-muon trigger to increase signal efficiency. Our simulation study, including evaluation of background and systematic uncertainty, proved feasibility to detect a violation of the Bell inequality with 4.6 sigma significance with 1 /fb of low-luminosity data. The definitive factor for this promising result lies primarily in the fact that the ATLAS detector can measure the individual decay time of each B meson, which was not possible in the previous experiments, for instance Belle experiment.

This will be the first Bell test in high-energy domains, opening up a new arena for experimental studies of quantum foundations at high energy. This talk will present studies on optimizing low-pT muon trigger, developing an analysis method, for example a way to reconstruct existing particles of events, and those performances towards the measurement at LHC-ATLAS Run3.