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Thread-safe N-tuple Writing in Gaudi with TTree and Migration to RNTuple

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The software framework of the Large Hadron Collider Beauty (LHCb) experiment, Gaudi, heavily relies on the ROOT framework and its I/O subsystems for data persistence mechanisms. Gaudi internally leverages the ROOT TTree data format, as it is currently used in production by LHC experiments. However, with the introduction and scaling of multi-threaded capabilities within Gaudi, the limitations of TTree as a data storage backend have become increasingly apparent, marking it as a non-negligible bottleneck in data processing workflows.

The following work introduces a comprehensive two-part enhancement to Gaudi to address this challenge. An initial focus is given to optimizing the current n-tuple writing infrastructure to be thread-safe within the constraints of the existing TTree backend, thus maintaining compatibility for users and downstream applications. This phase is then followed by the migration of the n-tuple storage backend from TTree to RNTuple, ROOT's next-generation I/O subsystem for physics data storage. This migration aims at leveraging the thread-safe, asynchronous capabilities of the new data format, thus making Gaudi fit to handle the requirements of HL-LHC computing and beyond.

Keywords: LHCb; Gaudi; ROOT; TTree; RNTuple; thread-safety

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