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Real-time track reconstruction with FPGAs in the LHCb Scintillating Fibre Tracker beyond Run 3

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Finding track segments downstream of the magnet is an important and computationally expensive task, that LHCb has recently ported to the first stage of its new GPU-based trigger of the LHCb Upgrade I. These segments are essential to form all good physics tracks with precision momentum measurement, when combined with those reconstructed in the vertex track detector, and to reconstruct long-lived particles, such as K-short and strange baryons, decaying after the vertex track detector.
LHCb is currently developing a project for a new real-time tracking device based on distributed system of FPGAs, dedicated to the reconstruction of track primitives in the forward Scintillating Fibre tracker detector at the full LHC collision rate. The aim is to accelerate reconstruction in Run 4, and to develop this new technology in view of the higher instantaneous luminosity conditions foreseen for Run 5 (Upgrade II). In this talk we report the first detailed study of the reconstruction performance expected from this device, based on an accurate simulation of its architecture at the bit level.

Significance

This is the first complete public report of the performance expected from a new ambitious project of FPGA-based real-time reconstruction aimed at LHCb Upgrade-2, that is obtained from a realistic, detailed simulation of the envisioned device at the bit-level. It is a significant advancement over the initial study on the subject, that was based on a behavioral simulation (see ref. below), and in its current form is part of an official LHCb enhancement proposal, due for submission to the LHCC committee in Feb.2024. The device object of this study is the first tracking device envisioned to have a native throughtput matching the full event rate of LHC collision (averaging 30 MHz) without any time-multiplexing.

References

An initial study on this subject was presented at ACAT19:
https://arxiv.org/abs/2006.11067
A preliminary, incomplete version of the current work was shown at Connecting the Dots 2023:
https://indico.cern.ch/event/1252748/contributions/5521497/
while the current talk covers the final, full result.

Experiment context, if any

LHCb (Real Time Analysis project)

Primary authors: XU, Ao (Universita & INFN Pisa (IT)); LAZZARI, Federico (Universita di Pisa & INFN Pisa (IT)); TERZUOLI, Francesco (Università di Siena & INFN Pisa (IT)); PUNZI, Giovanni (Universita & INFN Pisa (IT)); TUCI, Giulia (Heidelberg University (DE)); ZHUO, Jiahui (Univ. of Valencia and CSIC (ES)); PICA, Lorenzo

(SNS & INFN Pisa (IT)); MARTINELLI, Maurizio (Universita & INFN, Milano-Bicocca (IT)); MORELLO, Michael J. (SNS and INFN-Pisa (IT))

Co-authors: CONTU, Andrea (INFN); DE OYANGUREN CAMPOS, Arantza (Univ. of Valencia and CSIC (ES)); Dr JASHAL, Brij Kishor (IFIC, Univ. of Valencia, CSIC (ES) and Tata Institute of Fundamental Research (TIFR)); MENDOZA, Diego (Instituto de Física Corpuscular - CERN); BASSI, Giovanni (SNS & INFN Pisa (IT)); HE, Jibo (University of Chinese Academy of Sciences (CN)); SHI, Qi (University of Chinese Academy of Sciences (CN)); FANTECHI, Riccardo (Universita & INFN Pisa (IT)); KOTRIAKHOVA, Sofia (Universita e INFN, Ferrara (IT)); BALDINI, Wander (Universita e INFN, Ferrara (IT))

Presenter: XU, Ao (Universita & INFN Pisa (IT))

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