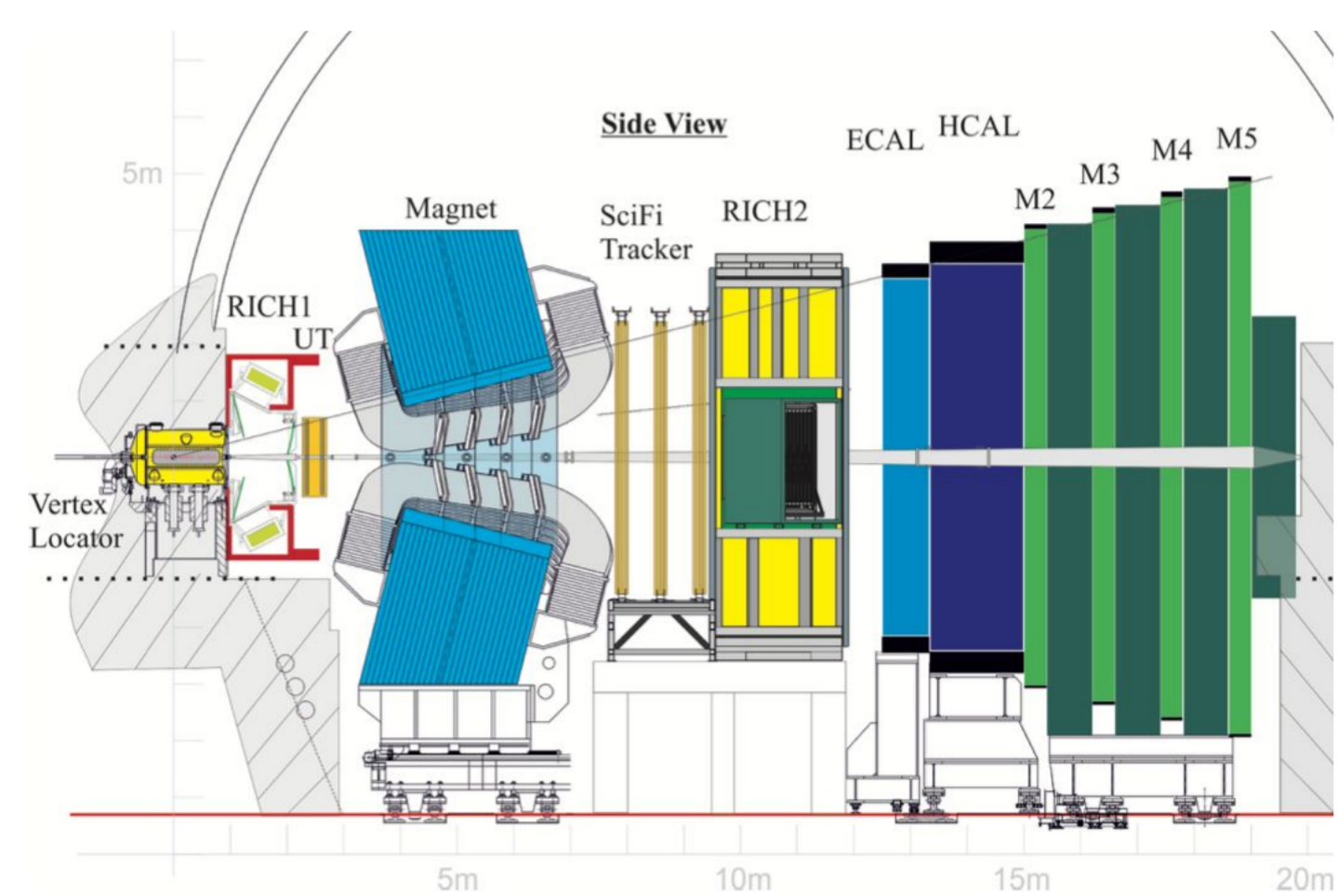


Tracking and vertexing *downstream* the LHCb magnet at the first stage of the trigger

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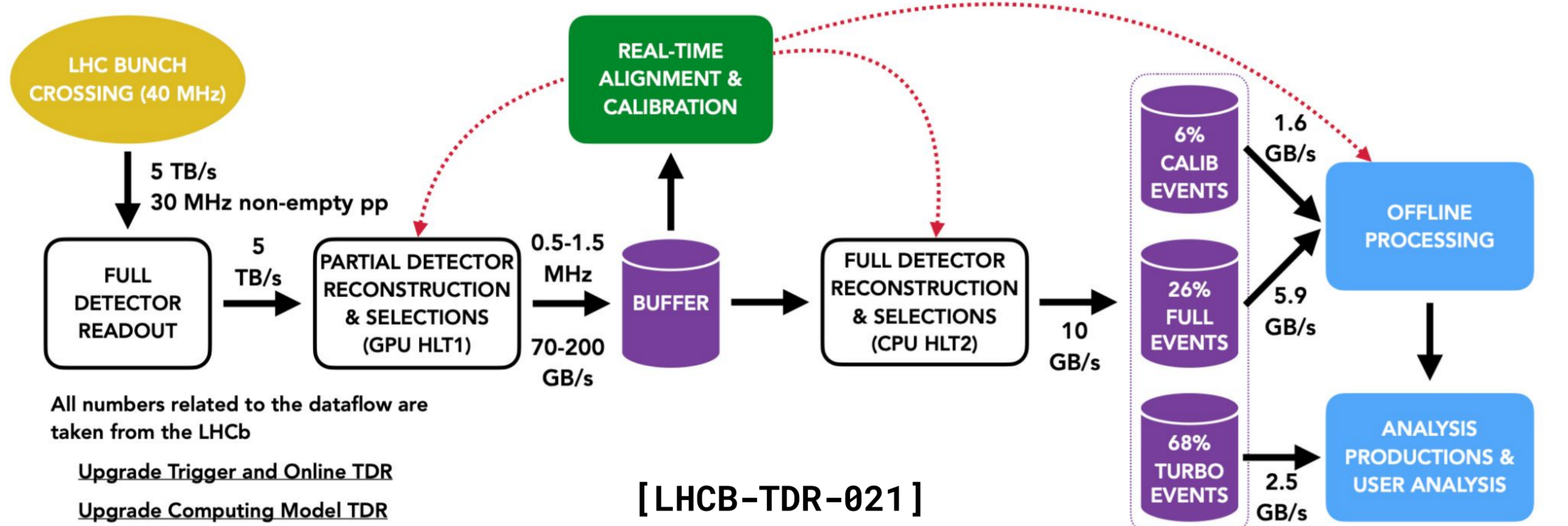
LHCb experiment for Run3



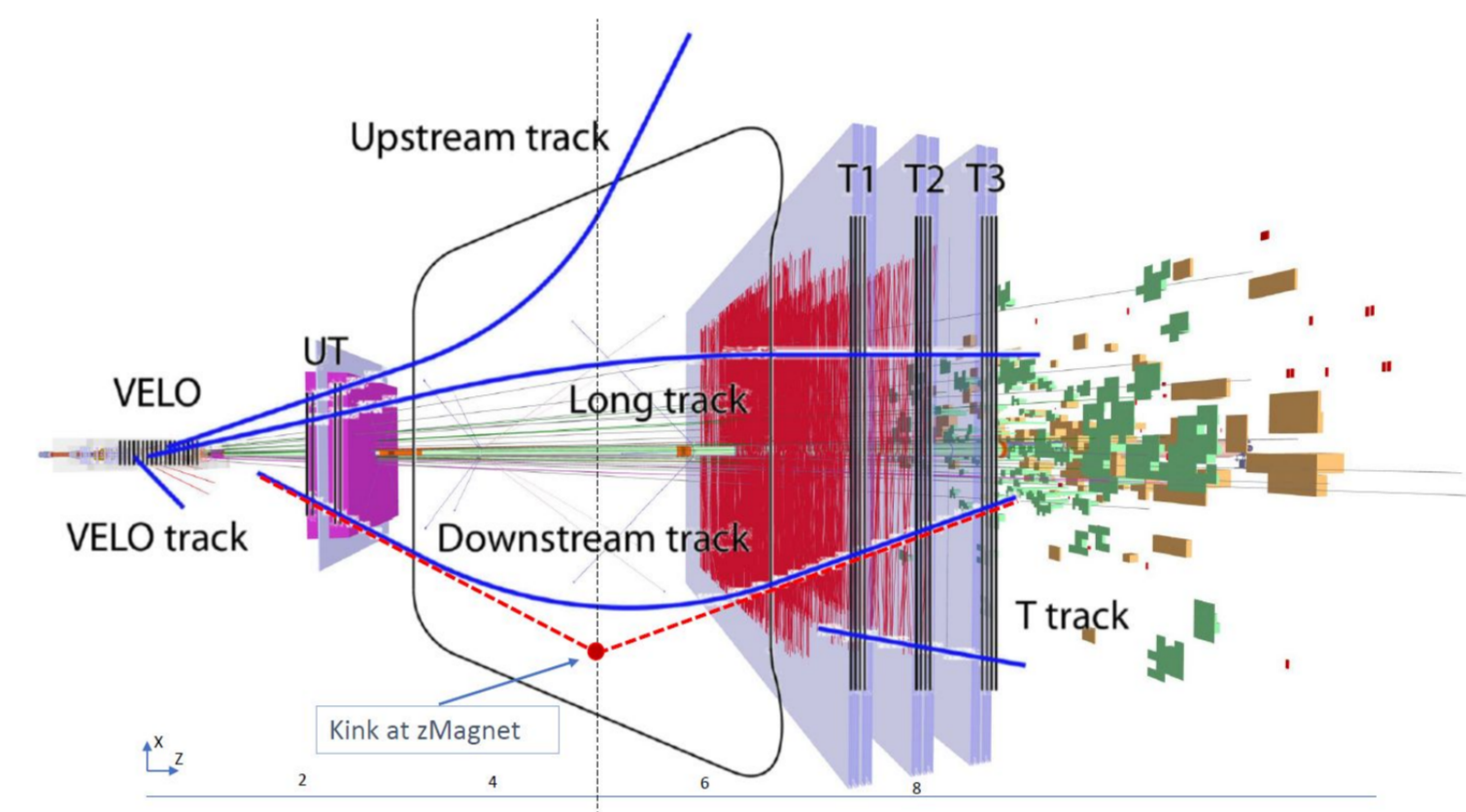
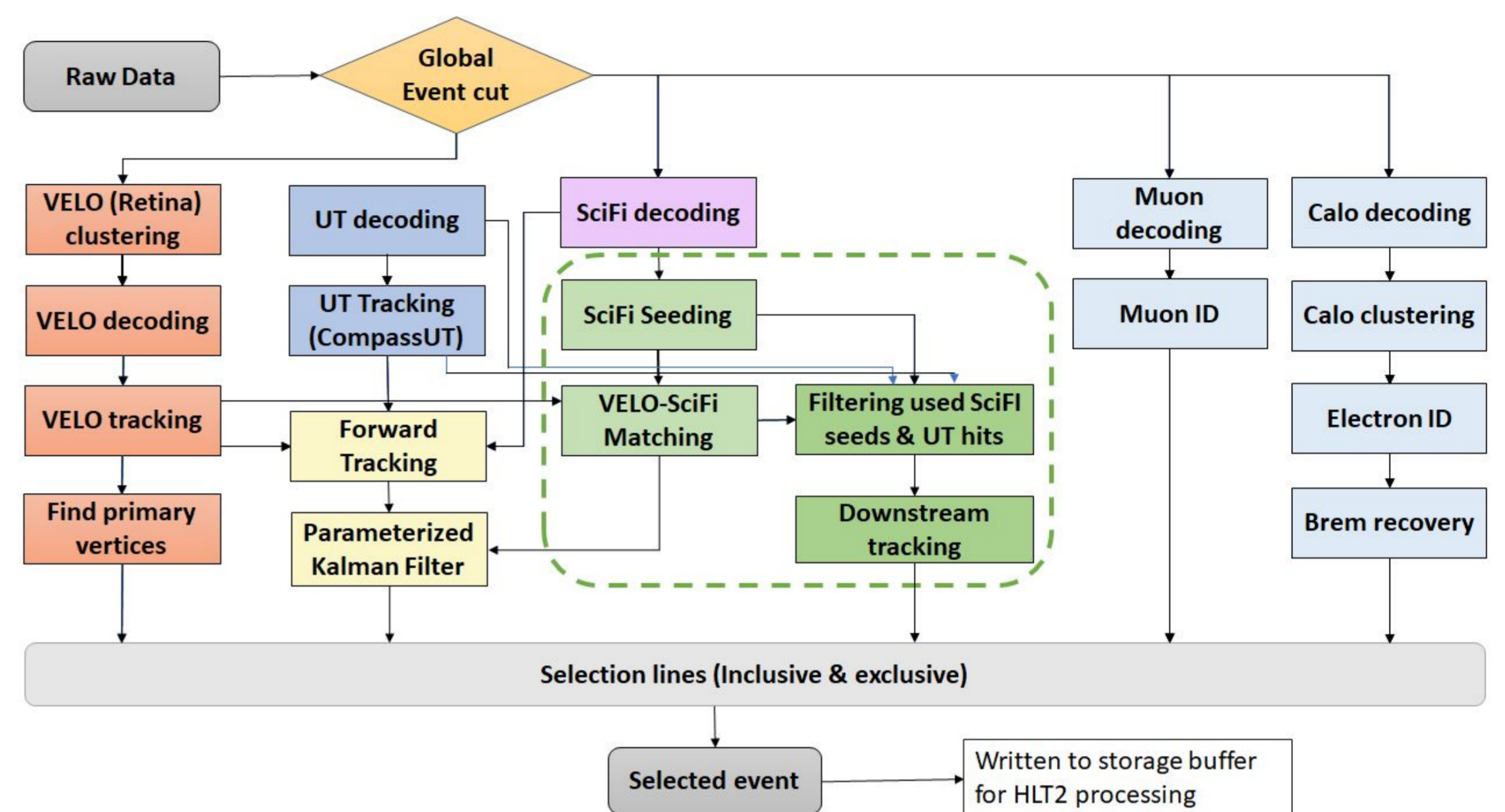
- Run at $\mathcal{L}_{inst.} = 2 \cdot 10^{33} cm^{-2} s^{-1}$ (x5 increase compared to Run2) with $\langle \mu \rangle = 5.2$.
- A new set of tracking detectors (VELO, UT, SciFi) designed to handle larger track multiplicity and radiation damage.
- All sub-detectors feature triggerless readout electronics operating at 40MHz.

- Remove **L0 hardware trigger** \rightarrow Necessitates software triggers (HLT1 and HLT2) to manage a higher throughput of events compared to Run2.
- **HLT1 operates on GPUs** with the Allen project at a frequency of 40MHz.

[10.1007/s41781-020-00039-7]



HLT1 Downstream tracking

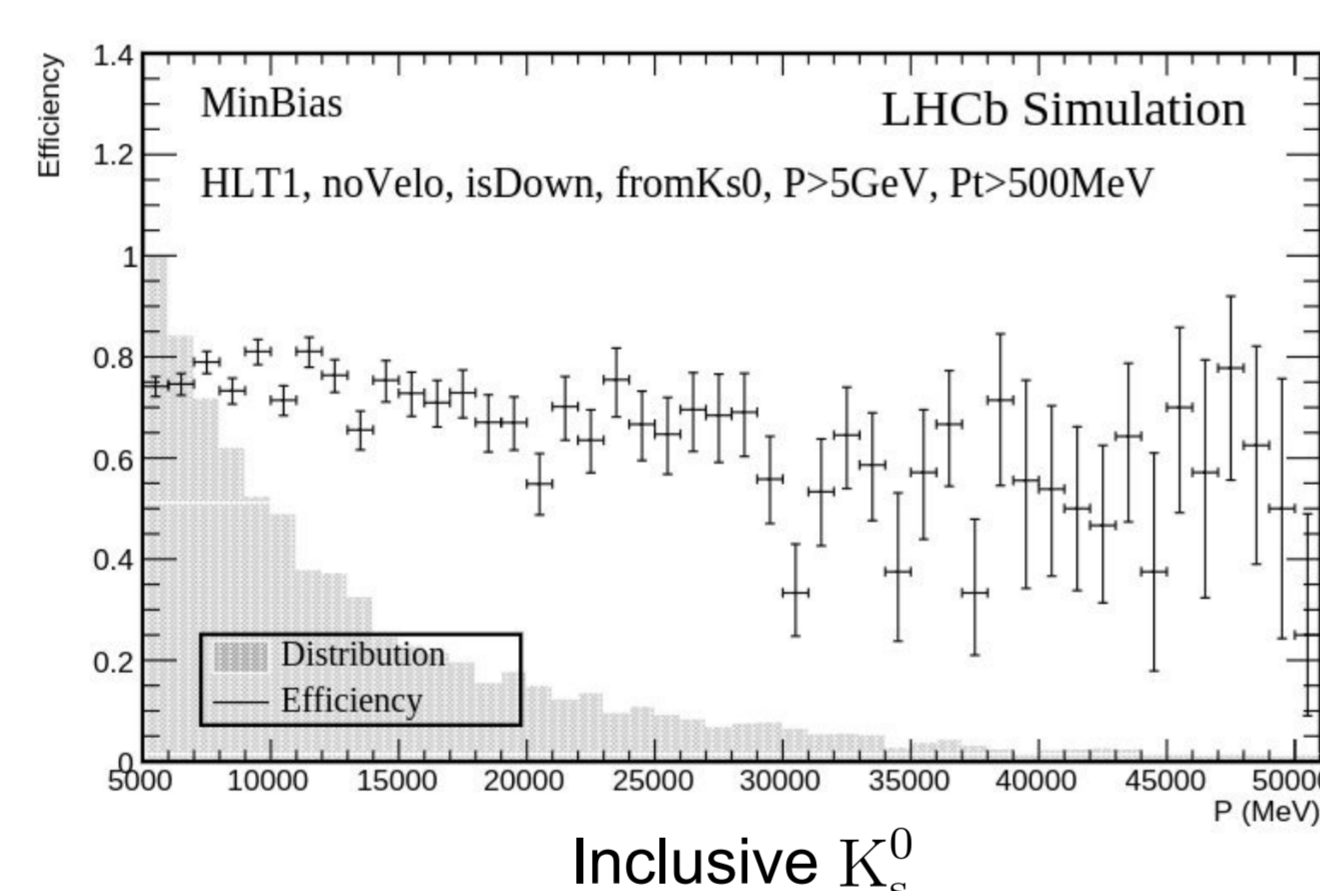
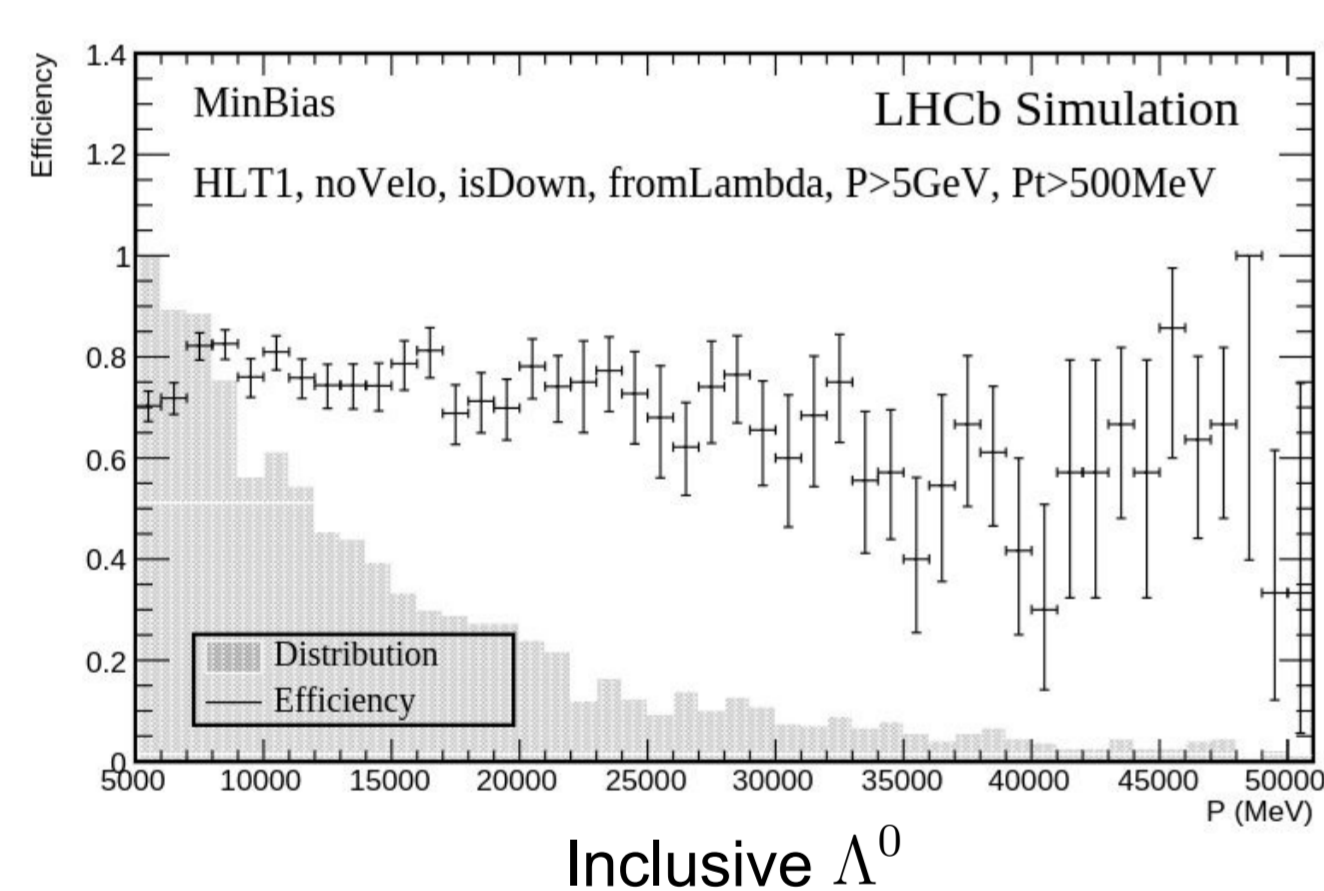


- Expand the existing HLT1 sequence to incorporate the reconstruction of **Downstream tracks**, utilizing only hits from **UT** and **SciFi**.
- Excluding SciFi seeds and UT hits that have already been used to construct long tracks.
- Primarily targeting long-living particles (LLP) that decay post-VELO detector.

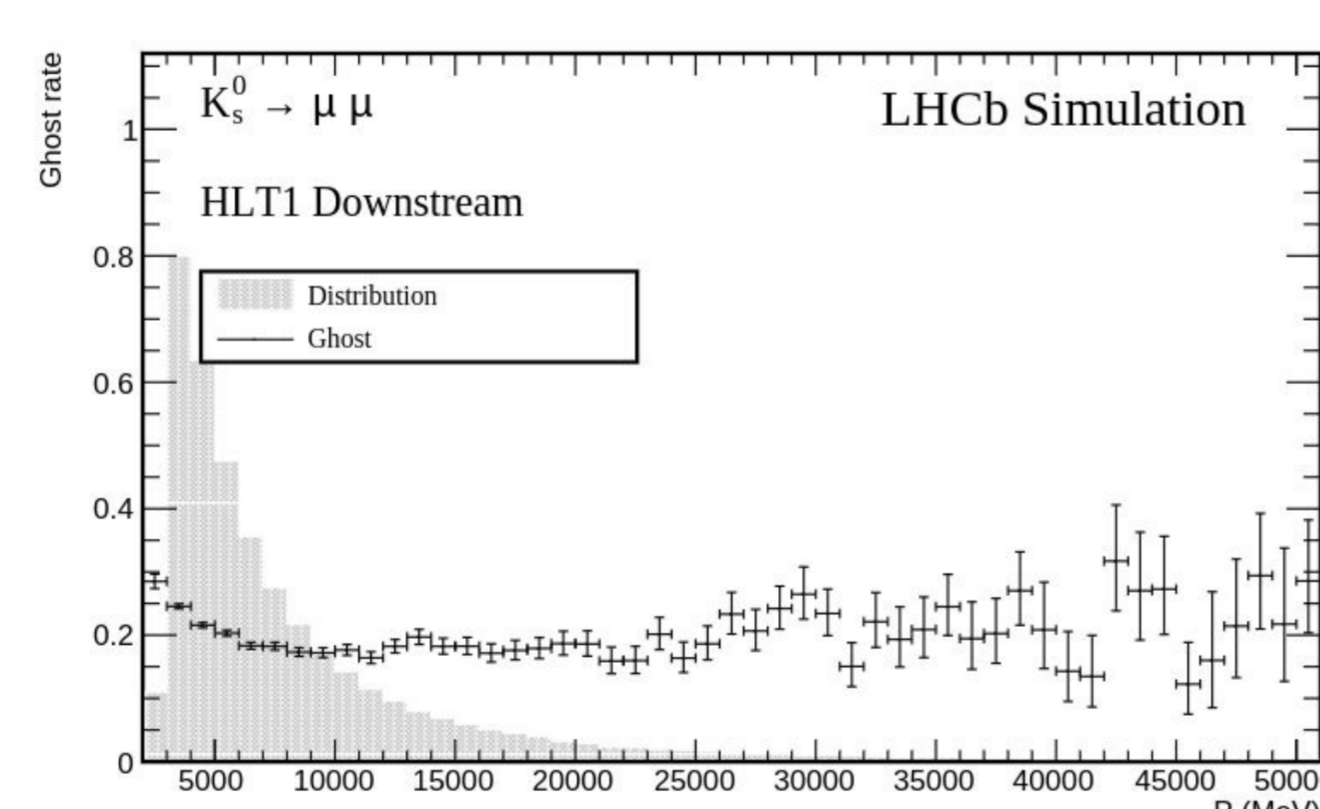
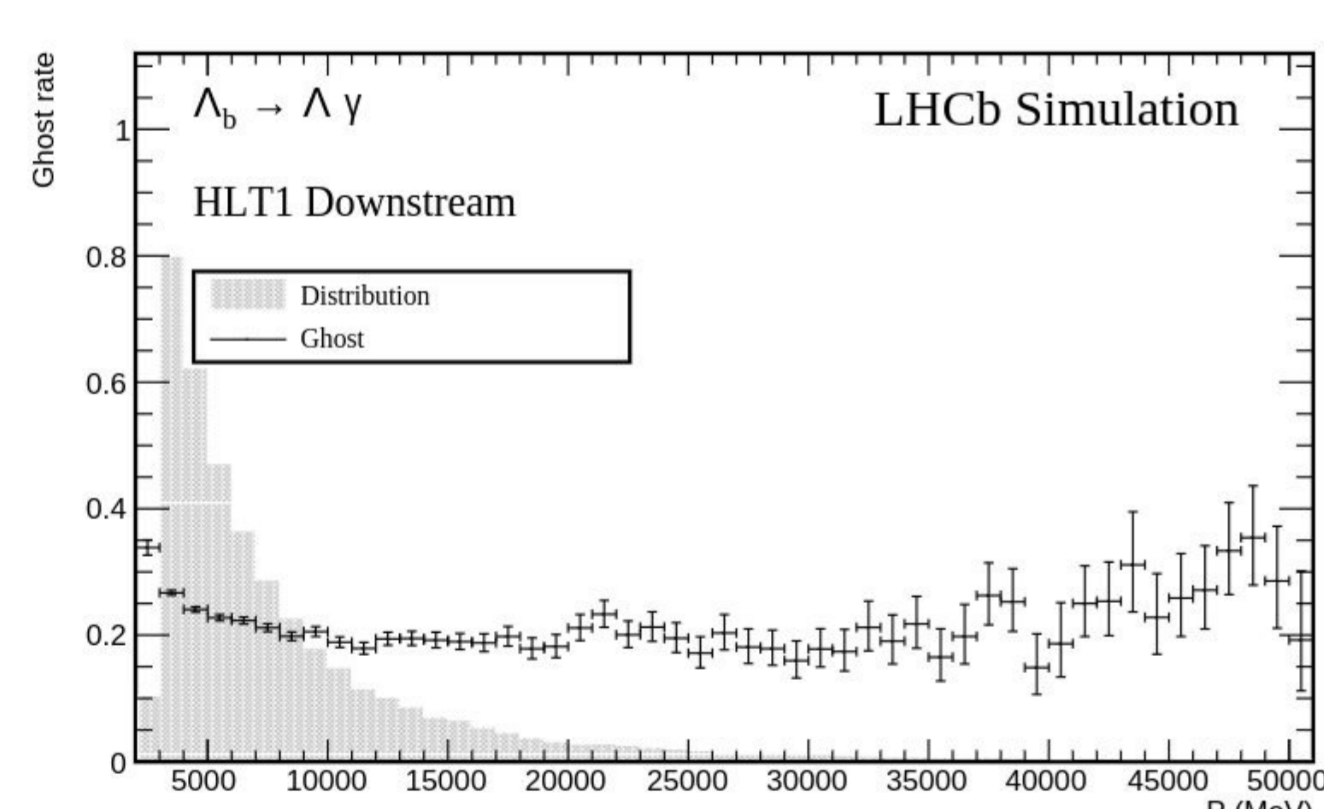
HLT1 Downstream tracking performance

[LHCb-FIGURE-2023-028]

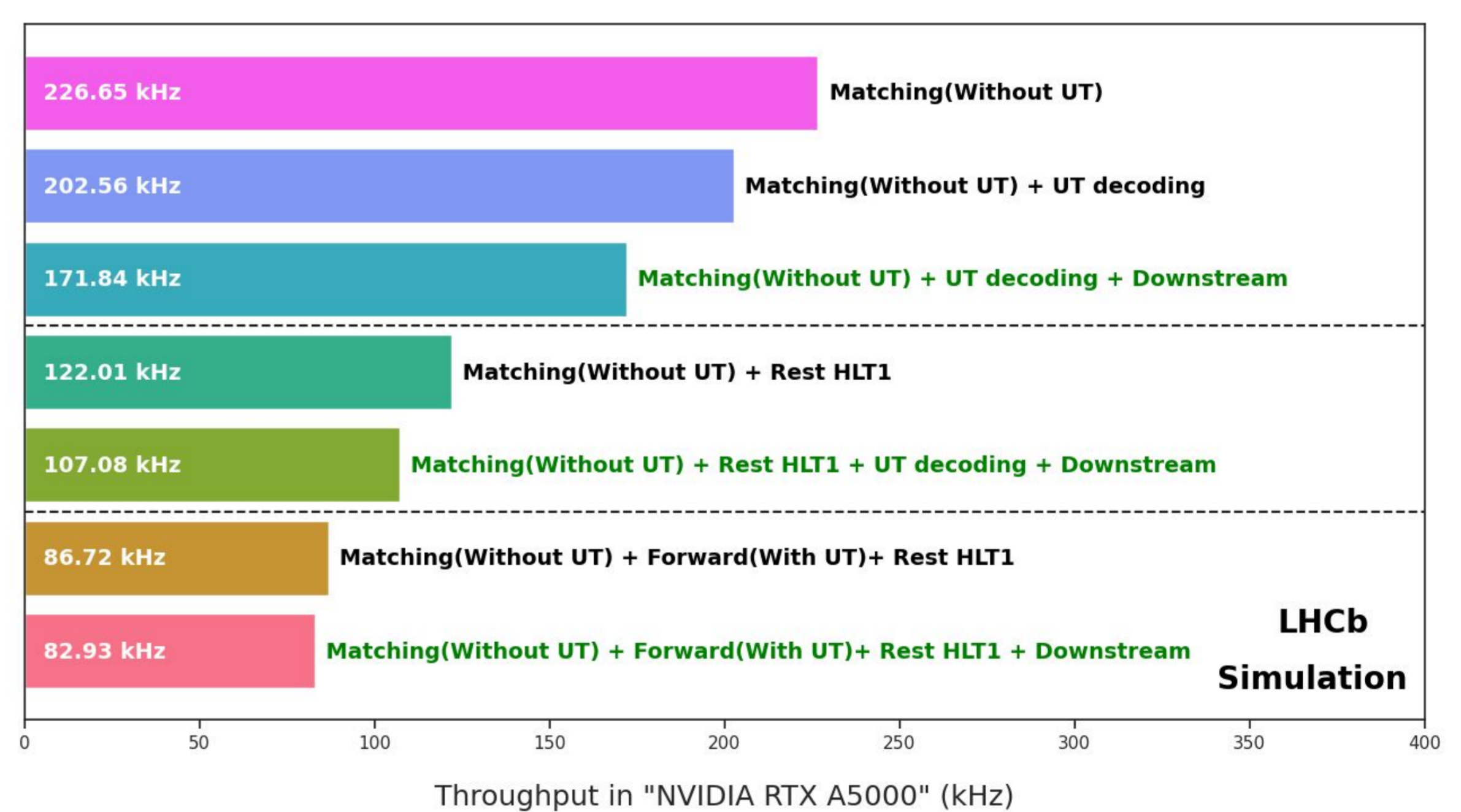
Tracking efficiency:



Tracking ghost rate:



Algorithm throughput impact:



- The **HLT1 downstream tracking** algorithm maintains consistent tracking efficiency and ghost rate for Λ^0 and K_s^0 , regardless of decay type.
- Throughput analyses on the **NVIDIA RTX A5000** reveal that the algorithm and UT decoding contribute equally to throughput impacts. Integration of this algorithm into the main sequence induces a **minimal effect on throughput**, evidenced by a modest reduction from **87kHz to 83kHz**.

HLT1 Downstream vertexing

[LHCb-FIGURE-2023-028]

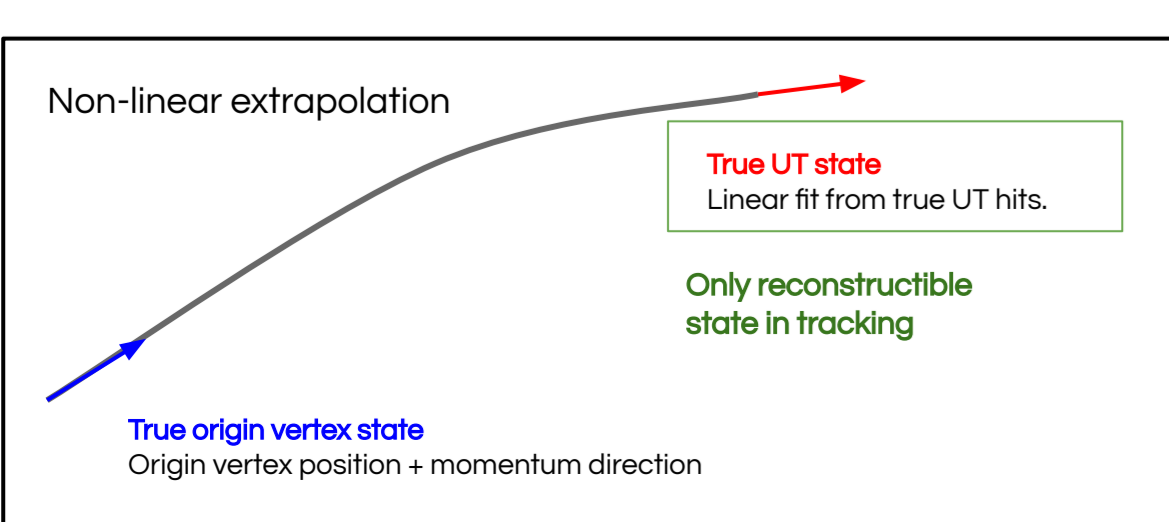
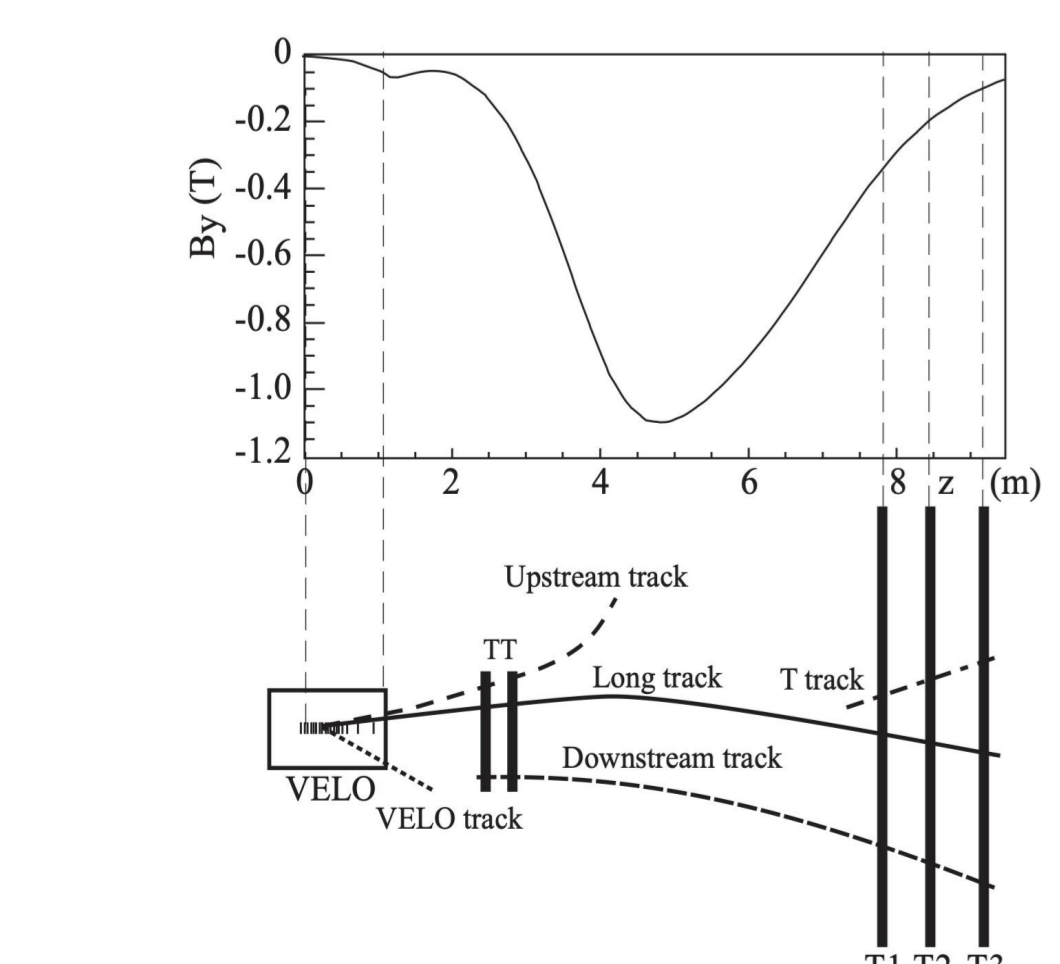
- Vertex reconstruction of two *downstream* tracks requires extrapolating from **UT to the origin vertex**, a process rendered **non-linear** due to the significant magnetic field between VELO and UT.
- A **second-order polynomial** is employed to describe the track trajectory, accounting for this magnetic effect:

$$x(z) = x_0 + t_x(z - z_0) + \gamma(z - z_0)^2$$

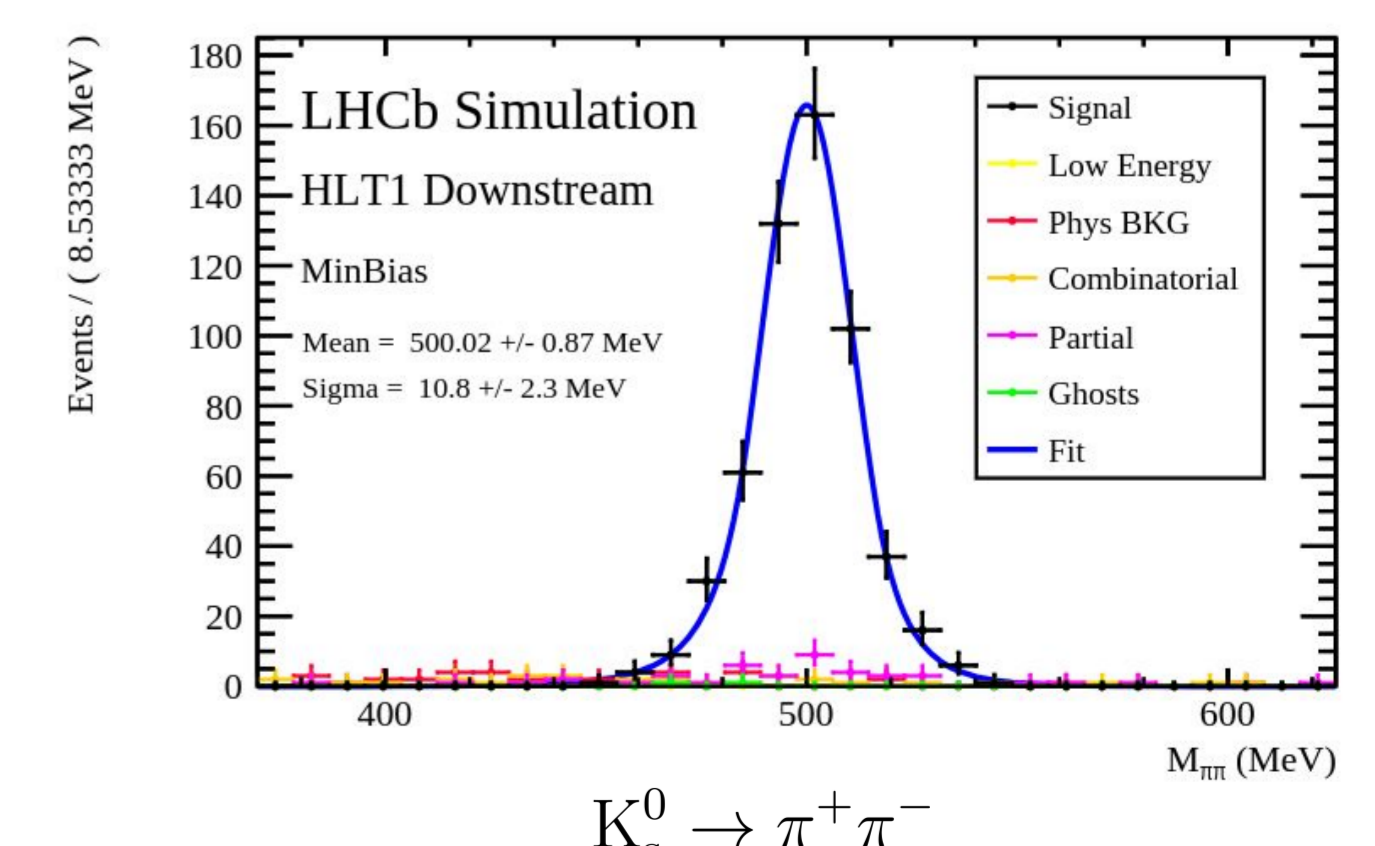
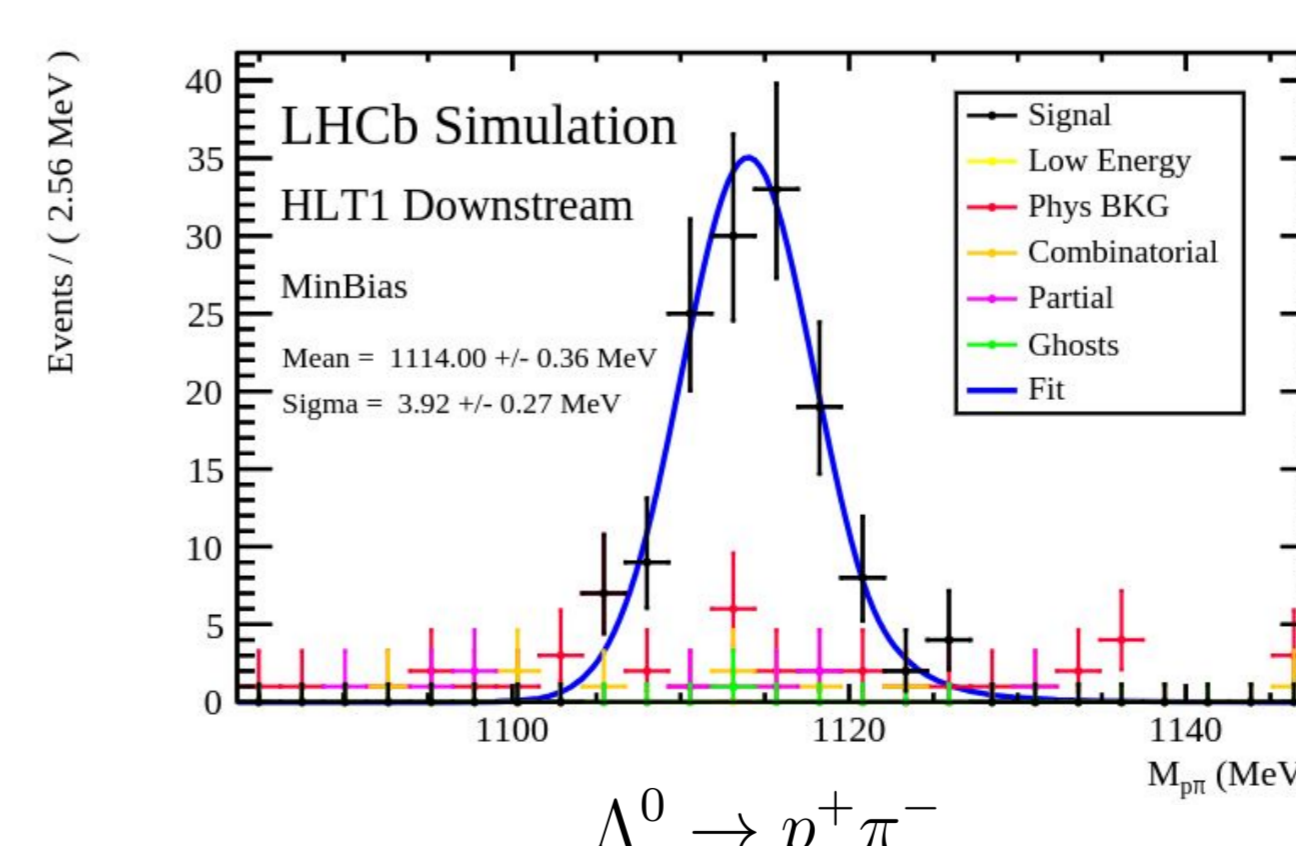
- The additional coefficient (γ) can be derived from estimating the charge and momentum of the *downstream* track:

$$\gamma = \gamma(q/p)$$

- A **Kalman filter-based** vertexing algorithm is implemented to reconstruct the vertex of two *downstream* tracks in HLT1.



Reconstructed mass:



- The **HLT1 downstream vertexing algorithm** successfully reconstructs the mass distribution of Λ^0 and K_s^0 utilizing two *downstream* tracks in HLT1, facilitating UT commissioning and online calibration.
- The HLT1 trigger, utilizing *downstream* tracks, is now prepared for Run3.