Studies of new trigger lines, dedicated to long-lived particle detection at the LHCb

Volodymyr Svintozelskyi *(1, 2)*
Mentors:
Arantza Oyanguren *(2)*, Brij Kishor Jashal *(2,3)*

(1) Taras Shevchenko National University of Kyiv
(2) Instituto de Física Corpuscular (IFIC), CSIC (ES), Univ. of Valencia
(3) TIFR, Tata Institute of Fundamental Research, Mumbai, India

01

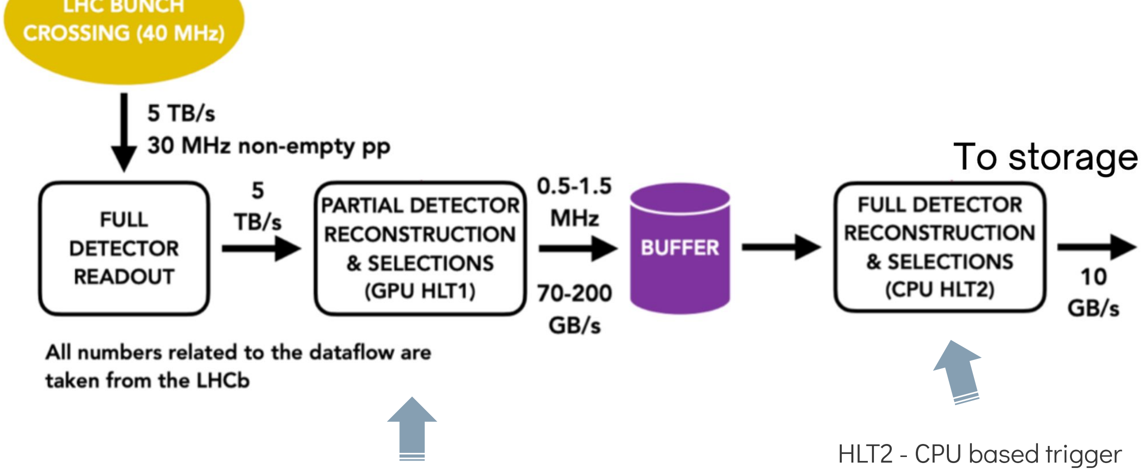
LHCB OVERVIEW

Trigger systems & LLPs

HIGH LEVEL TRIGGER

- LHC provides 40 million pp collisions per second (approx 5 TB/s of data)
- We're unable to save all the data from economic point of view
- One needs to "select" only interesting events - done with high level trigger system
- HLT1 & HLT2 - software triggers, able to reduce data flow down to 10GB/s

LHCB DATA FLOW SCHEME



HLT2 - CPU based trigger

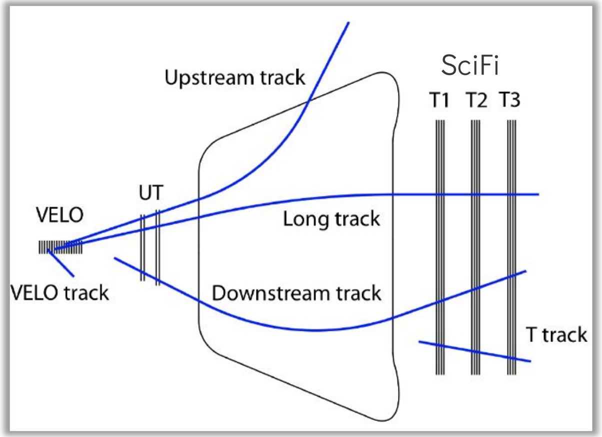
HLT1 - GPU based trigger (Allen)
Implemented on O(500) Nvidia GPU cards

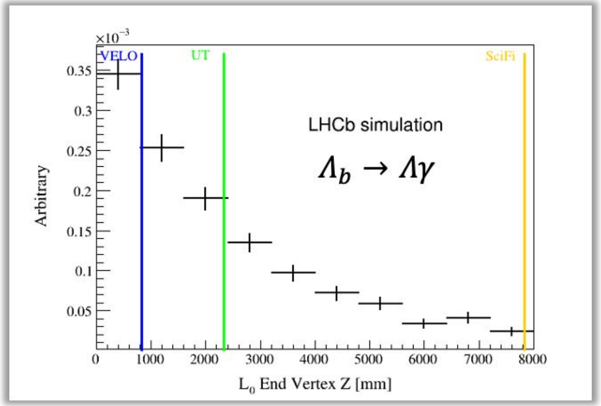
Long-lived particles

Large fraction decays outside of VELO:
For $\Lambda b \rightarrow \Lambda\gamma$ channel, the distribution of Λ decay vertices z leads to:

- 51% - daughter hits UT & SciFi
  (downstream tracks)
- 37% - daughter hits SciFi only
  (t-tracks)

To reconstruct most of the Λ (as well as others LLPs), one needs downstream & t-track reconstruction and vertexing algorithms





02
Previous projects

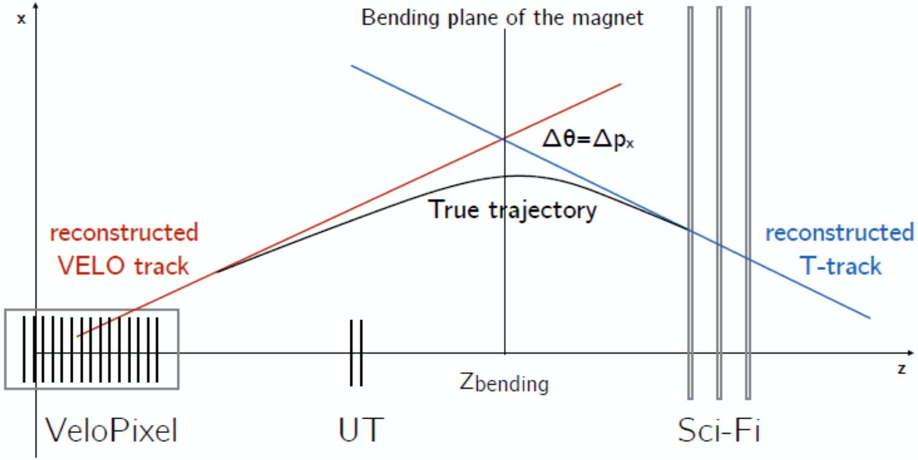
Optimization of long track reconstruction, downstream vertexing

MATCHING ALGORITHM AT HLT1

One of the reconstruction algorithms for long tracks - matching algorithm:

- Take track segments from VELO and SciFi
- Extrapolate segments to the bending plane (estimated for each track separately)
- Evaluate “quality” of each VELO-SciFi pair

Eleven constant parameters used in quality estimation. The values initially were took from HLT2 algorithm.



Optimization of these parameters for HLT1 - objective of one of my previous IRIS-HEP projects

Results after optimization:
- Efficiency: -0.36% (within errors)
- Ghost rate: 1.56%

Presented on: RTA-WP2, IRIS-HEP final talks
Allen merge request !989

DOWNSTREAM VERTEXING AT HLT1

For HLT1 LLP selection it's crucial to have downstream vertexing & selection algorithms.

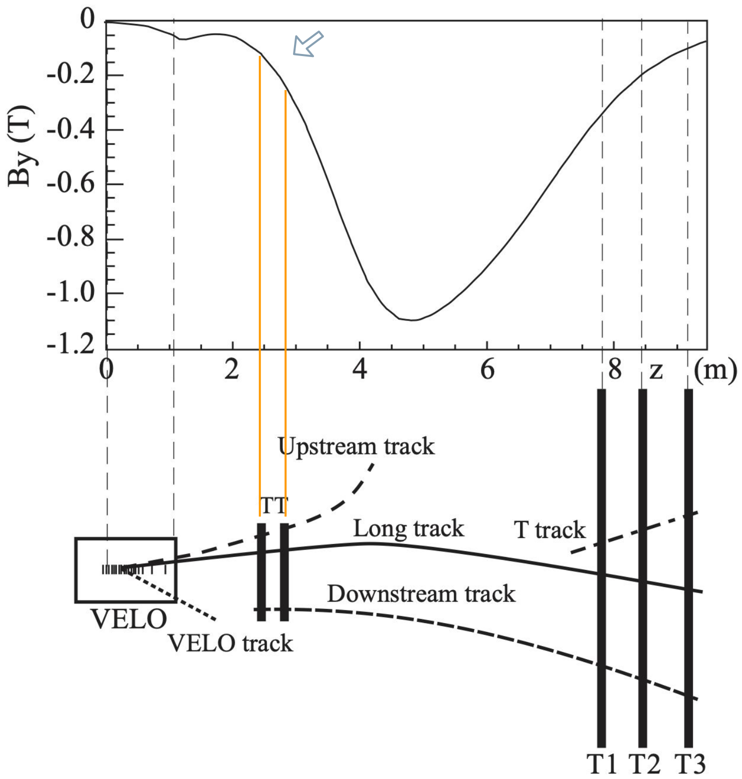
The development of such algorithms was an objective of my second IRIS project

Because of non-negligible magnetic field the corresponding track parameterization was developed:

$$x(z) = x_0 + t_x(z - z_{UT}) + \gamma(z - z_{UT})^2$$

$$y(z) = y_0 + t_y(z - z_{UT})$$

Where $\gamma = \gamma(\frac{q}{p})$ (magnetic correction)



DOWNSTREAM VERTEXING AT HLT1

Next steps in downstream vertexing:

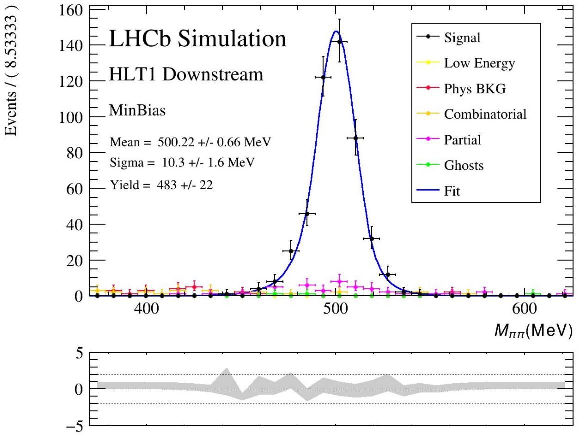
1. Estimated z position of point of closest approach between any two tracks
2. Extrapolated two tracks to the found point
3. Performed a linear vertex fitting using extrapolated states

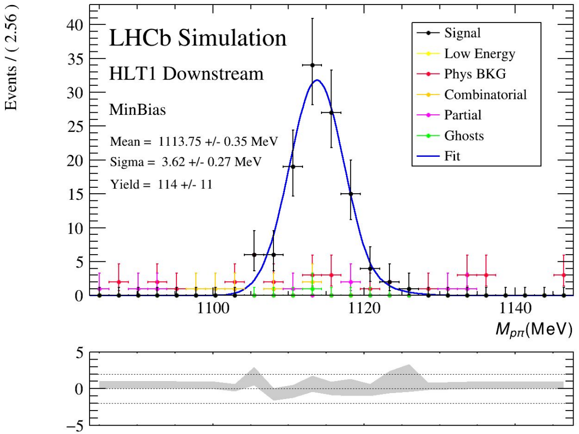
Two monitoring trigger lines, based on downstream vertexing: $K_s \to \pi\pi \quad \Lambda^0 \to p\pi$

- Neural network for selection
- One hidden layer with 7 nodes (throughput requirements)
- 12 input variables

Presented on: RTA-WP3
Allen merge request !1198

Results:
(preliminary)





03
CURRENT PROJECT

T-Track vertexing

T-Track Vertexing at HLT1

Current project is development of Two T-track trigger line for selection of LLPs

There are a number of problems here:

- Significant magnetic field between origin vertex and SciFi stations
- Tight throughput constraints - no RK
- Limited momentum information (SciFi hits displacement, error ±10%)
- Limited selection information, as due to magnetic field it's very hard to associate PV for mother tracks and estimate IP

Majority of vertices are here