The LHCb trigger in Run II

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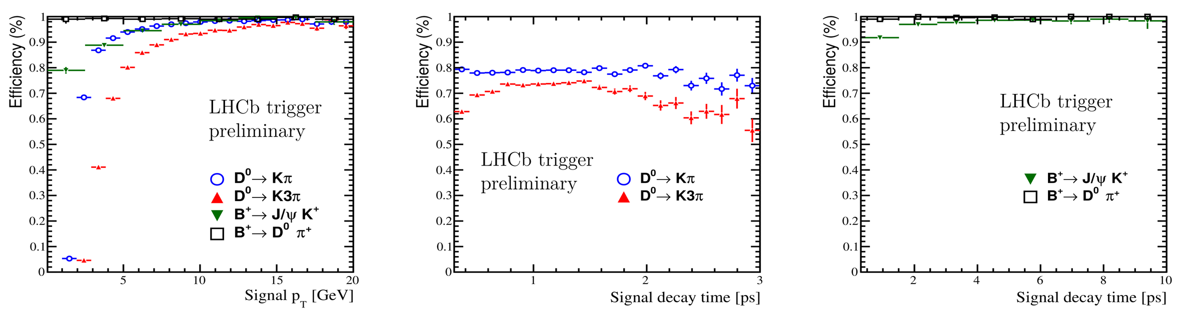
Improved LHCb trigger for Run-II: First ever High Energy Physics detector aligned, calibrated, and fully reconstructed in real-time, enabling real-time analysis directly in the trigger system.

HLT 1

The first software trigger level applies an inclusive selection based on multivariate techniques. Events with one or two tracks with a tranverse momentum greater than 500 MeV/c and detached from the primary vertex are selected.

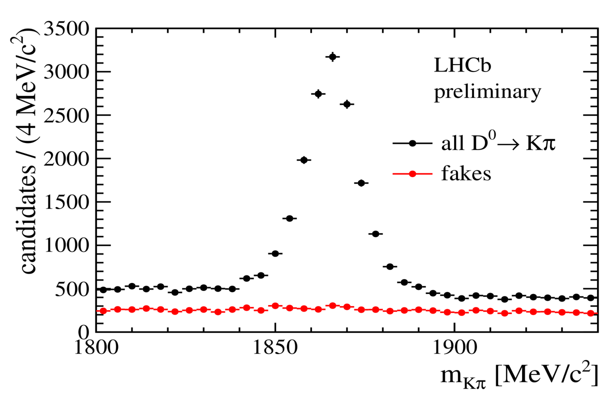


For the first time, lifetime unbiased charm and beauty exclusive selections are implemented.

HLT 2

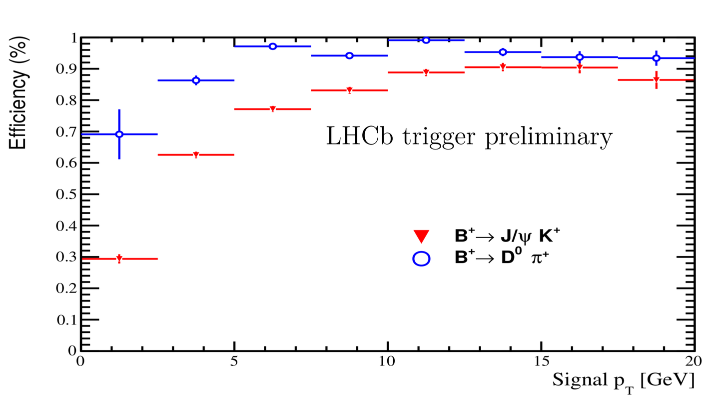
The events selected from the first level trigger are tranferred to the second lever trigger (HLT2) where a fully reconstruction occurs. Software improvements made the reconstruction much faster with respect to Run-I. This, the farm improvements and the real-time calibration allow for the off-line quality in the trigger.

New ghost track rejection and high quality particle identification information both decrease combinatorial time and increase signal purity.

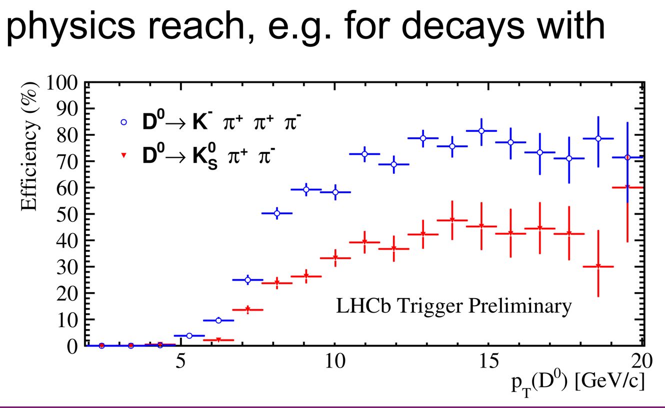


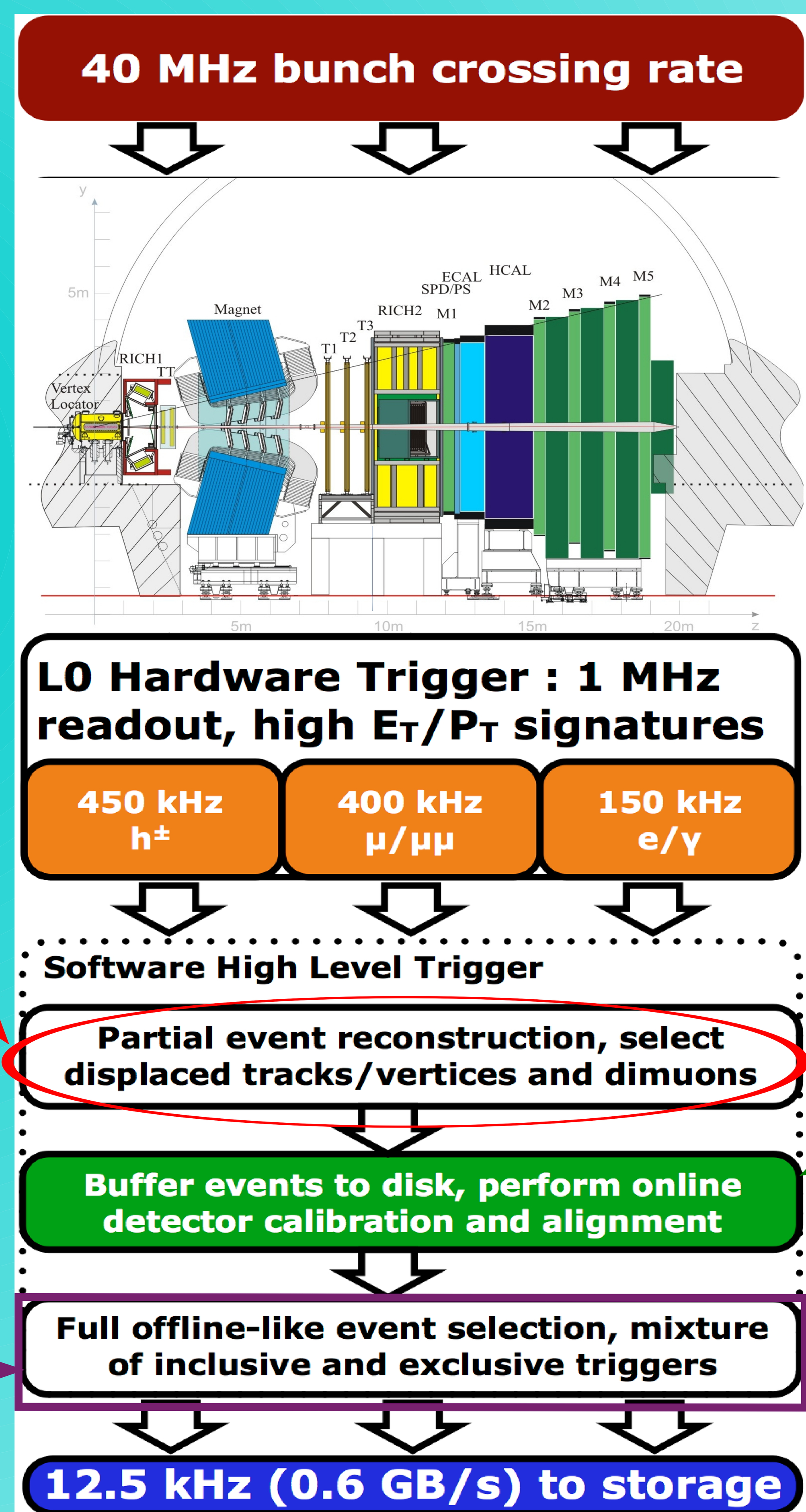
This additional information allows selections that are less biasing in decay time and phase space of multibody decays, reducing systematics.

The main selection for the b physics is realized through an inclusive search of 2, 3 and 4 body vertices exploiting multivariate techniques [3]. These topological triggers have been reoptimized for the Run-II.

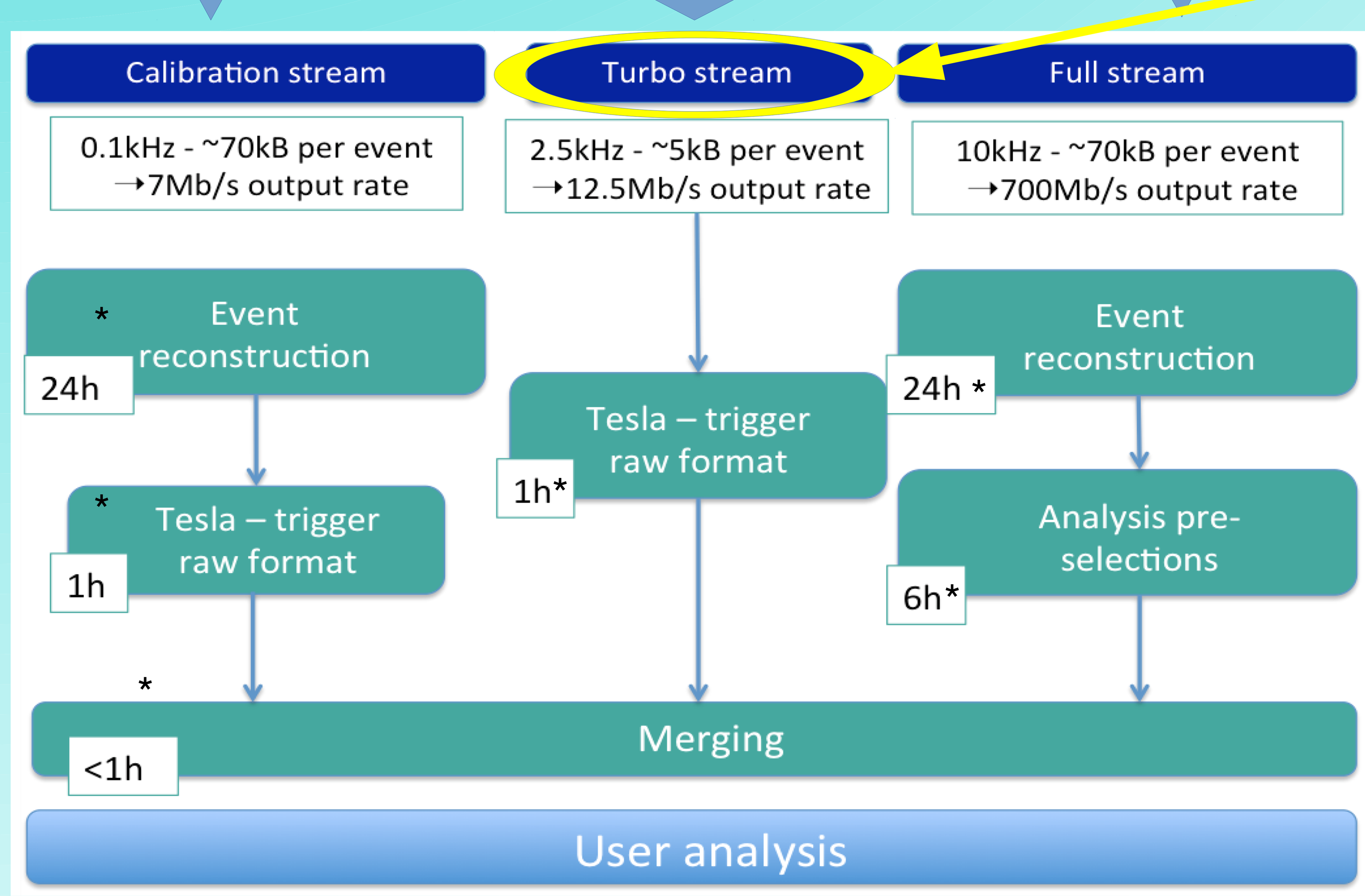


For the c physics, beyond the many exclusive selections in the Turbo stream, a MVA-based inclusive selection has been implemented. Inclusive selection is extremely challenging because of the high charm cross section, but it allows to greatly enhance the physics reach, e.g. for decays with neutral particles.





Based on the different selections, events are processed in different streams



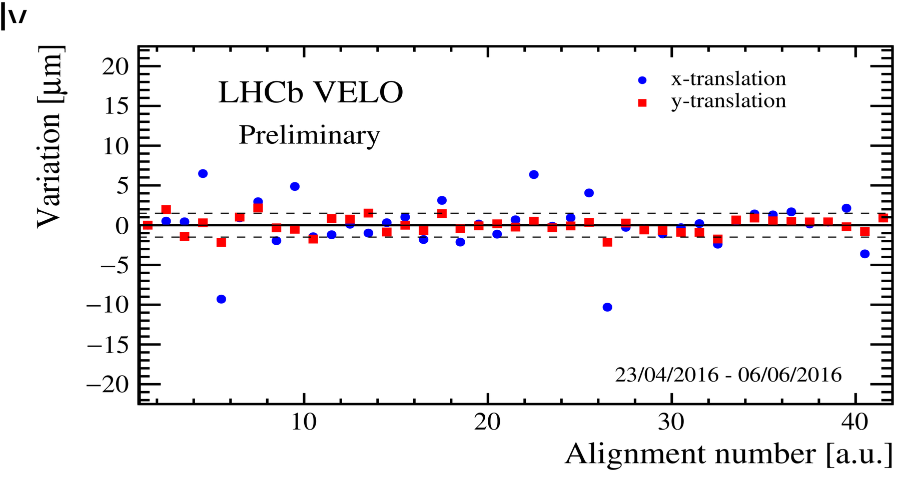
* Time shown to process 3 GB raw data file

Real-time calibration and alignment

The trigger farm has been optimized and extented [2] and now consists of 27000 physical cores. Every node is equiped with a memory disk (for a total disk buffer of 5 PB) on which the first HLT1 reconstruction is temporarily stored. This allows about 150 hours of data taking before the HLT2 has to be executed.

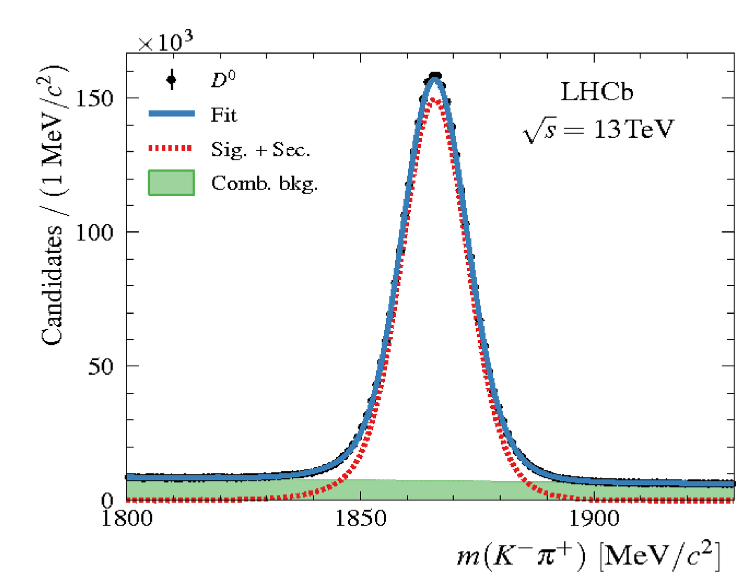
These improvements have allowed the development of an on-line procedure for the calibration and the alignment of the various subdetectors [1].

Special data samples from the first trigger level are automatically analyzed to evaluate calibration and alignment constants for all sub-detectors. The frequency depends on the sub-detector, e.g. the Velo is aligned every fill as it is moving. Other detectors are monitored only

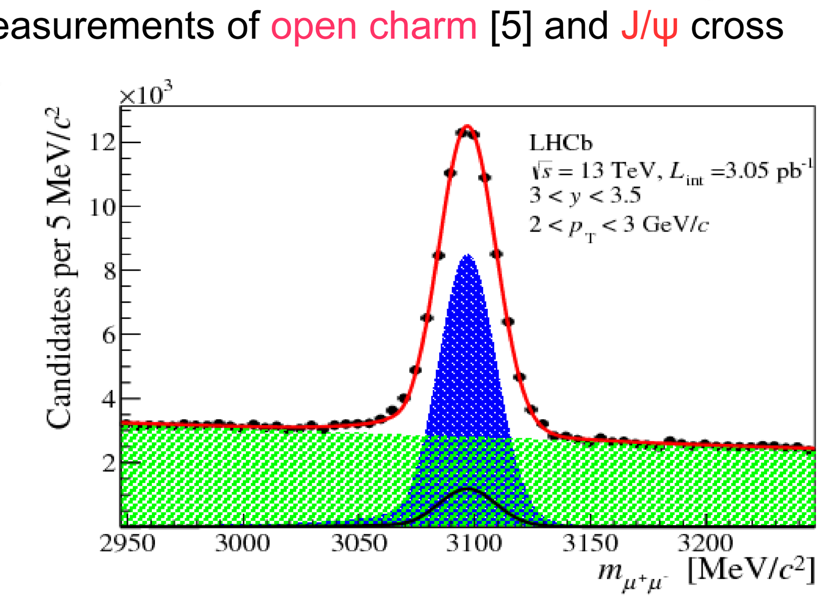


Turbo stream, real-time analysis

The Turbo stream [4] is one of the main novelties introduced for Run-II. Thanks to the high quality calibration and reconstruction there is no need for a further off-line reconstruction. The new approach taken by the Turbo stream is to save directly the particle candidates reconstructed in the HLT2. A clear advantage of the Turbo stream is that the event size is an order of magnitude smaller than the standard approach as all sub-detector information may be discarded.
Higher rate, more Physics!



First LHCb 13 TeV results have been obtained using this stream: measurements of open charm [5] and J/ψ cross section [6].



In 2015 Turbo was only used for exclusive selections. In 2016 more reconstructed objects can be saved to enhance physics possibilities.

References

[1] G. Dujany and B. Storaci, Real-time alignment and calibration of the LHCb Detector in Run II, J. Phys. Conf. Ser. 664 (2015) 082010
[2] M. Frank et al., Deferred High Level Trigger in LHCb: A Boost to CPU Resource Utilization, J. Phys. Conf. Ser. 513 (2014) 012006
[3] T. Likhomanenko et al., LHCb Topological Trigger Reoptimization, J. Phys. Conf. Ser. 664 (2015), arXiv:1510.00572.
[4] S. Benson, V. V. Gligorov, M. A. Vesterinen, and J. M. Williams, The LHCb Turbo Stream, J. Phys. Conf. Ser. 664 (2015) 082004.
[5] LHCb collaboration, Measurements of prompt charm production cross-sections in pp collisions at √s=13 TeV. ArXiv:1510.01707.
[6] LHCb collaboration, Measurement of forward J/ψ production cross-sections in pp collisions at √s=13 TeV, JHEP 10 (2015) 172.

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