The new strategy for particle identification samples in Run 2 at LHCb

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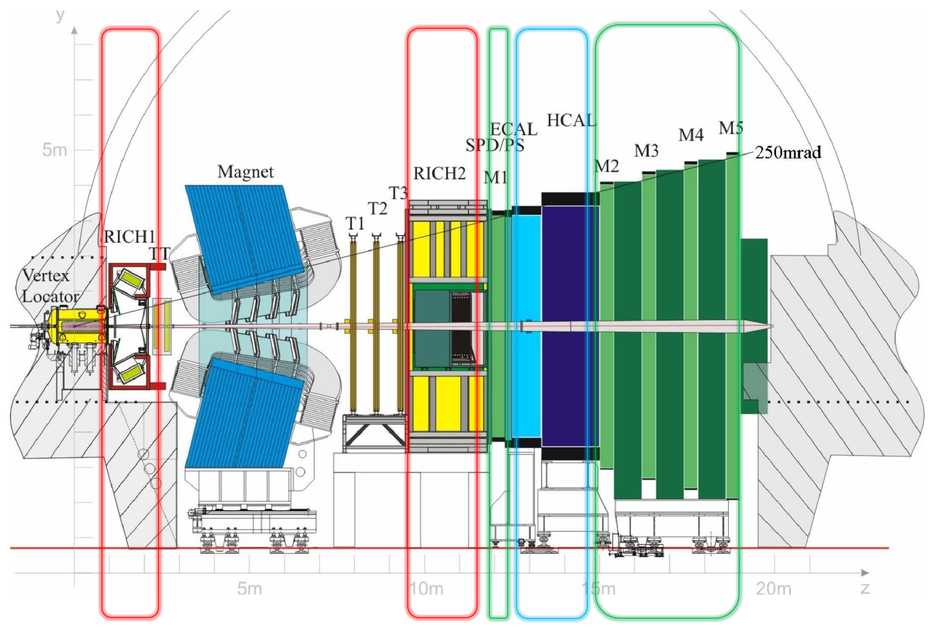
Introduction

- One of the major requirements in a flavour physics experiment is the ability to **distinguish kinematically similar decays** through Particle IDentification (PID) of final state tracks. PID also plays a crucial role in **tagging the flavour of neutral B mesons** at production.
- At LHCb [1], PID is provided by 3 groups of sub-detectors:
  - **Ring Imaging Cherenkov (RICH):** Consists of 2 detectors (RICH1 and RICH2), 2 radiators (C_4F_{10}, CF_4) and provides PID for $K^{\pm}, \pi^{\pm}$ & proton.
  - **Calorimeters (CALO):** Consists of Scintillation Pad Detector (SPD), Pre-Shower detector (PS), Electromagnetic CALO (ECAL) and Hadronic CALO (HCAL) and provides PID for e^{-}, γ and neutral hadrons.
  - **Muon chamber:** Consists of 5 tracking stations (M1-M5) and provides PID for muons ($\mu^{\pm}$) with high purity.
- Combining PID information from all these sub-detectors, **global PID variables** are built and used in physics analysis.



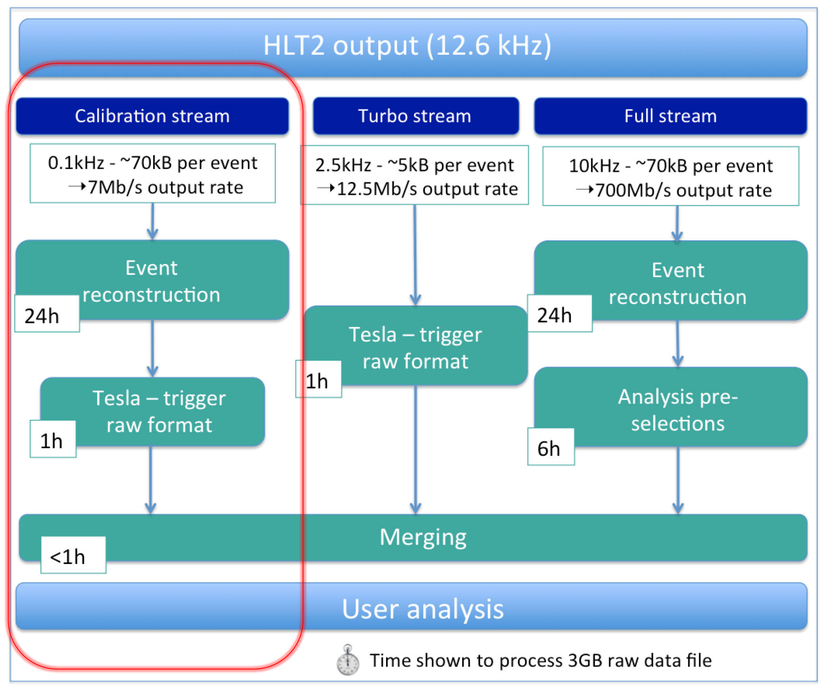
Calibration Samples

- The efficiency for a PID requirement is determined with a **data-driven method** by using calibration samples which:
  - Contain decay candidates with a topology which allows unambiguous identification of one daughter **without relying on its PID**-related variables.
  - Are low-multiplicity modes with **large branching fractions.**
  - Use **tag-and-probe method** (e.g. $J/\psi \to \mu^+\mu^-$).
- **New calibration modes and selections** have been included that improve the kinematic coverage of calibration samples.

Species	Soft (low p and p_T)	Hard (high p and p_T)
$e^{\pm}$	–	$J/\psi \to e^+e^-$
$\mu^{\pm}$	$D_s^+ \to \phi(\mu^+\mu^-)\pi^+$	$J/\psi \to \mu^+\mu^-$
$\pi^{\pm}$	$K_S^0 \to \pi^+\pi^-$	$D^{*+} \to D^0(\to K^-\pi^+)\pi^+$
$K^{\pm}$	$D_s^+ \to \phi(K^+K^-)\pi^-$	$D^{*+} \to D^0(\to K^-\pi^+)\pi^+$
p or $\overline{p}$	$\Lambda \to p\pi^-$	$\Lambda \to p\pi^-, \Lambda_c^+ \to pK^-\pi^+$

Run II Selection

- The novel real-time detector alignment & calibration [2] allows **offline quality information to be used in second level software trigger** (HLT2).



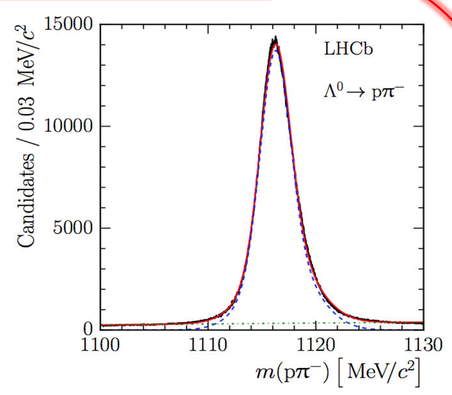
- **Calibration samples are selected directly at HLT2 with TURCAL stream** [3, 4, 5], which allows to calculate efficiencies for both the online (Turbo) and offline (Full) streams.

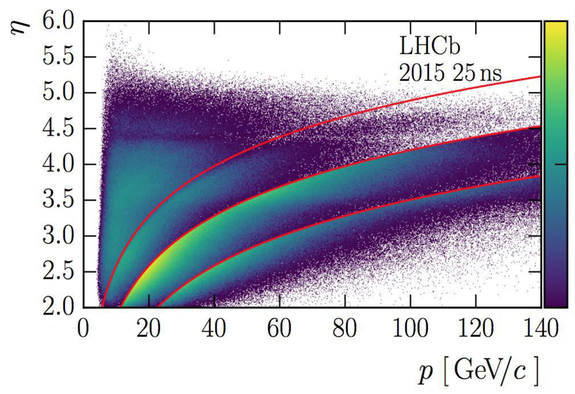
Run II Production

- For samples selected at HLT2, there is an additional production step in which **background subtracted calibration samples** are made available to analysts via CERN EOS and PIDCalib package [6].

Example proton PID sample

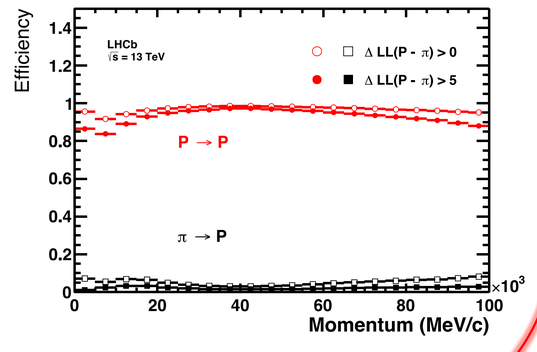
Invariant mass distribution of high transverse momentum (p_T) proton calibration sample ($\Lambda \to p\pi^-$) in 2015, MagDown data [5].





Distributions of proton calibration track pseudorapidity (η), and momentum (p) for 2015 data. The **red lines** correspond to p_T thresholds of 1.5, 3 and 6 GeV/c. The z-axis units are arbitrary [5].

Proton ID efficiency (**red points**) and pion mis-ID (**black points**) rate as measured using 2015 data as a function of track momentum. Results are shown for two different requirements on the global PID variable delta log-likelihood, $\Delta LL(P - \pi)$ [5].



References

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[3] R. Aaij, Tesla : an application for real-time data analysis in High Energy Physics, Comput. Phys. Commun. 208 (2016) 35-42.
[4] L. Anderlini et al., Computing strategy for PID calibration samples for LHCb Run 2, LHCb-PUB-2016-020.
[5] L. Anderlini, V. V. Gligorov, O. Lupton and B. Sciascia, Calibration samples for particle identification at LHCb in Run 2, LHCb-PUB-2016-005.
[6] L. Anderlini et al., The PIDCalib package, LHCb-PUB-2016-021.