What is new for LHCb in Run 3?

The LHCb detector has undergone a big upgrade for the new data-taking period:

- The instantaneous luminosity is ~5 times larger than in Run 2: \( \mathcal{L} \approx 4 \times 10^{32} \text{cm}^{-2}\text{s}^{-1} \) compared to \( \mathcal{L} \approx 2 \times 10^{33} \text{cm}^{-2}\text{s}^{-1} \)

- All components of the LHCb tracker (VELO, UT, and SciFi) are new

- The read-out electronics and data acquisition system have been upgraded to cope with the larger event rate

- New full-software trigger system

Track-based alignment in short

Idea: use reconstructed tracks to extract information about the position of the detector and compute the necessary corrections

The optimal values of the alignment constants are found by minimizing the global track

\[
\chi^2 = \sum \chi_i^2(x_i, \alpha) = \gamma(x_i, \alpha) \chi_i \Gamma(x_i, \alpha)
\]

Alignment of the VELO

- The tracking alignment is not sensitive to the position of the VELO global motion system, it is evaluated offline from a material scan

- The position of VELO modules and module sensors is also evaluated offline during the commissioning period since they are not expected to move

- The real time alignment updates the constants corresponding to rotations and translations of the two VELO halves

The alignment is monitored in real-time, studying the difference between the position of primary vertices reconstructed independently from each of the two VELO halves

Impact on mass distributions

Early alignment

Improved alignment

Early commissioning Run 3 results already show a factor ~2.5 increase in the signal yield of \( \Lambda_c \to \pi \pi \) and \( \Lambda_c \) reconstructed candidates with a clear improvement in the mass resolution between two preliminary alignment versions. The main difference between the two versions is the inclusion of the alignment constants to correct the position of the SciFi mats. Further improvements on momentum and mass resolution are expected when the UT is commissioned and included in the reconstruction sequence.