Novel Real-time Alignment and Calibration of the LHCb Detector in Run II
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Running Conditions from Run I to Run II
- Higher energy: $\sqrt{s} = 7$ TeV $\rightarrow$ 13 TeV.
- 15% increase in inelastic collision rate.
- 20% increase of multiplicity per collision.
- 80% increase of $v_T$ and $v_x$.
- Reduced bunch spacing: 50 ns $\rightarrow$ 25 ns.
- Similar instantaneouos luminosities: $4 \times 10^{34}$ cm$^{-2}$ s$^{-1}$.

LHCb Detector

LHCb Trigger Schemes

Advantages of Real-time Align. and Calib.
- Improves trigger selection.
- Minimises the difference between online and offline performances.
- Ensures the stability of the alignment quality.
- Enables physics analyses directly on the trigger output.

Degrees of Freedom for Alignment
- 3 translations and 3 rotations for each element.
- Number of elements to be aligned:
  - VELO: 86
  - TT: 135
  - IT: 64
  - OT: 496
- Constrained to nominal, survey or previously aligned position.

Alignment and Calibration Impact on Physics Performance
- The spatial alignment of the detector and the accurate calibration of its subcomponents are essential elements to achieve the best physics performance.
- An exclusive selection using hadron particle identification criteria relies on the complete calibration of the RICH detectors.

OT and RICH Calibration Strategy in Run II
- Online analysis task running on single CPU.
- New parameters evaluated from fits to monitoring histograms.

Global Time Alignment for OT
- Drift-time $t_{D}$ measurement: $t_{D} = \phi_{0} + \phi_{prop} + \phi_{reset}$, with $\phi_{0} = \phi_{collission} - \phi_{clock} + \phi_{initial}$.
- A single condition which accounts for the time alignment between the collision time and the LHCb clock.
- Run the job for every run and update the constant if above a certain threshold.

RICH Calibration
- Refractive index calibration (1040 constants): Depends on the gas mixture, temperature and pressure.
- Fits on the Cherenkov angle differences $\Delta \phi$.
- Corrections calculated and updated every run.
- HPD calibration (2 constants):
  - Electrostatic effect (probably) due to switching off the HV for every injection.
  - Fit a circle to the HPD image.
- Corrections calculated and updated every run.

CALO Calibration
- A relative calibration online using occupancy method.
  - Occupancy for each cell defined as $O(x,y,b) = \sum_{i,j} F(x,i,y,j)/\sum_{i,j} F(x,y,i,j)$.
  - Ratio of occupancies proportional to changes in hardware characteristics.
  - HV adjusted on a per fill basis based on the gain changes calculated from the occupancy profiles.

References

FRONTIER DETECTORS FOR FRONTIER PHYSICS - 13th Pisa Meeting on Advanced Detectors
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