Primary Vertex Reconstruction for Upgrade at LHCb

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My origins


Central Europe
SWEDEN
DENMARK
Baltic Sea
LITHUANIA
(RUSSIA)
North Sea
BELARUS
Berlin
Warsaw
POLAND
THE NETHERLANDS
GERMANY
BELGIUM
Prague
Krakow
UKRAINE
LUXEMBOURG
CZECH REPUBLIC
Tatra Mts.
SLOVAKIA
Black Forest
Munich
Vienna
FRANCE
Budapest
LIECHTENSTEIN
AUSTRIA
HUNGARY
ROMANIA
SWITZERLAND
Geneva
SLOVENIA
The Alps
Ljubljana
CROATIA
ITALY
250 kilometers
250 miles
Adriatic Sea
BOSNIA & HERZEGOVINA
SERBIA
BULGARIA

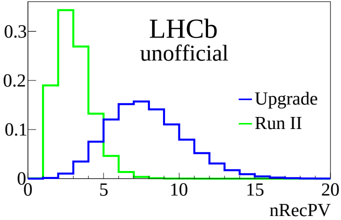
Upgrade LHCb Detector

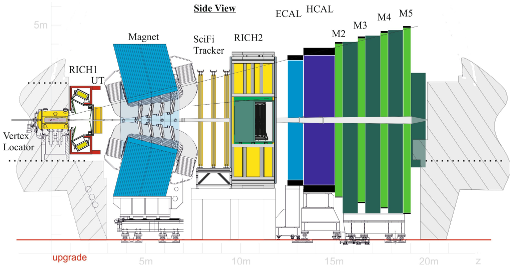
Main changes

- Software and hardware trigger → full software trigger
- VELO → VeloPix detector
- TT → Upstream Tracker
- T1-T3 stations → SciFi detector

Running conditions

	Energy [TeV]	Luminosity [$cm^{-2}s^{-1}$]	Bunchspacing [ns]	Data [fb^{-1}]
Run I (2010-2012)	7/7/8	$1/3.5/4 \cdot 10^{32}$	50	3
Run II (2015-2018)	13	$4 \cdot 10^{32}$	25	5
Upgrade (>2020)	14	$2 \cdot 10^{33}$	25	50

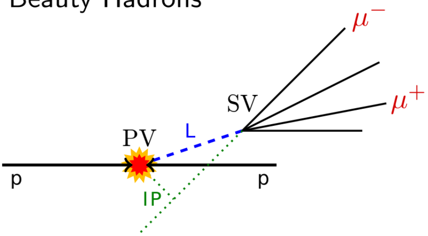


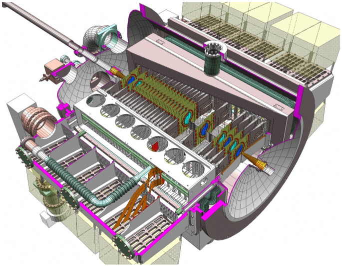


Definition

Position of the proton-proton collision inside the VELO (VErtex LOcator) detector at LHCb is obtained from the primary vertex reconstruction (PV) algorithms which use a set of input tracks. In order to make the best performing reconstruction a wide range of parameters is being studied.

Beauty Hadrons





Quality Parameters

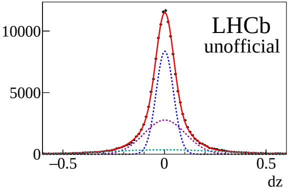


Figure 1 – The resolution for the z coordinate in Run II.

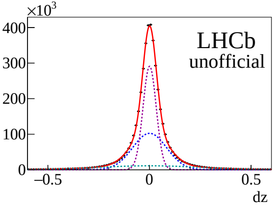


Figure 2 – The resolution for the z coordinate in Upgrade.

Definition

Resolution is defined as the difference between the fitted and generated position of the PV separately for each coordinate and is obtained as the averaged width of fitted triple Gaussian :

$$\Delta i = (i_{MC} - i_{fit})\ [\text{mm}], \qquad \text{where } i = \{x, y, z\}$$

Table 1 – The global resolution for the primary vertex reconstruction.

Par.	Run II	Upgrade
σ_x	0.013 ± 0.001	0.011 ± 0.001
σ_z	0.075 ± 0.001	0.062 ± 0.001

Quality Parameters

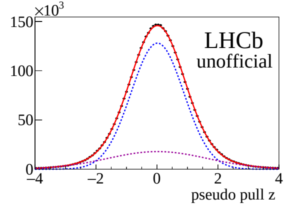


Figure 3 – The pseudo pull for the z coordinate in Upgrade.

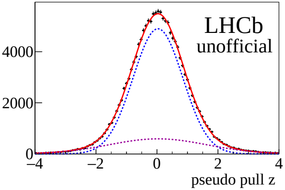


Figure 4 – The pseudo pull for the z coordinate in Run II.

Definition

Pseudo pulls are calculated as a resolution divided by reconstructed position uncertainty :

$$pull_i = \frac{\Delta i}{\sigma_i} , \qquad \text{where } i = \{x, y, z\}$$

Table 2 – The pseudo pulls for the primary vertex algorithms.

Par.	Run II	Upgrade
μ_x	-0.007 ± 0.003	0.002 ± 0.002
σ_x	1.031 ± 0.023	1.039 ± 0.005
μ_z	0.032 ± 0.002	0.016 ± 0.001
σ_z	1.017 ± 0.016	1.077 ± 0.004

Outcome

Good performance & stability

Radial Distance Optimization

Definition

r distance is defined as :

$$r = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

where (x_2, y_2) is PV position and (x_1, y_1) is the resolver position which for MC is equal to $(0, 0)$

Purpose

Optimal value of r distance must be found in order to minimise the false PV efficiency and maximise the true PV efficiency.

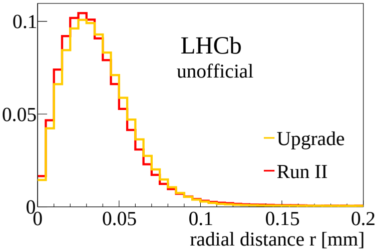


Figure 5 – Radial distance distributions for true PV.

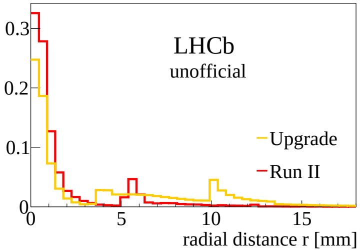


Figure 6 – Radial distance distributions for false PV.

Merits

FOM

The maximum of the *purity ∗ true PV efficiency* sets the optimal value of r distance to $r = 0.145$ mm, where in Run II it was equal $r = 0.18$ mm for min bias sample.

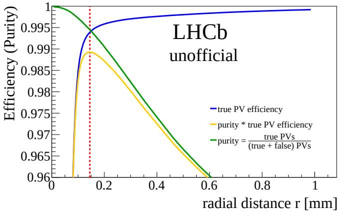


Figure 7 – FOM for upgrade

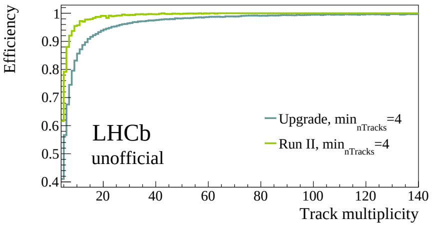


Figure 8 – The PVs reconstruction efficiency as the function of track multiplicity

Efficiency

For the upgrade we have to be able to reconstruct PVs consisting more tracks, although the total efficiency of PV's reconstruction for Upgrade which equals 93.88% is comparable to the Run II is 96.82%.

Thank you for your attention !

Any Questions ?

BACKUP

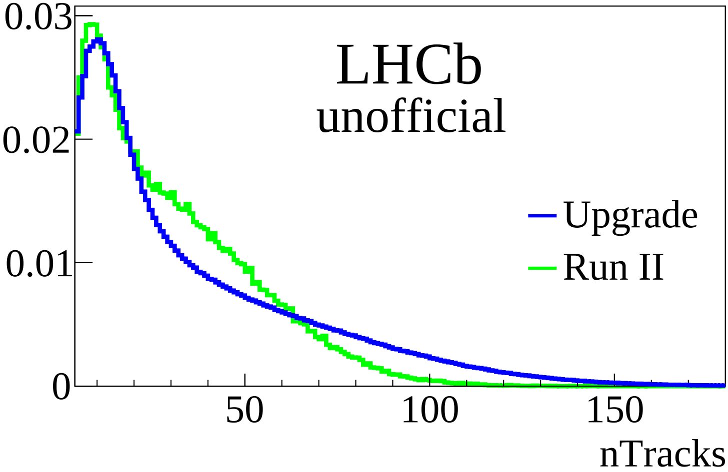


Figure 9 – Number of PVs per track multiplicity.