Tracking performance for long-lived particles at LHCb

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on behalf of the LHCb collaboration

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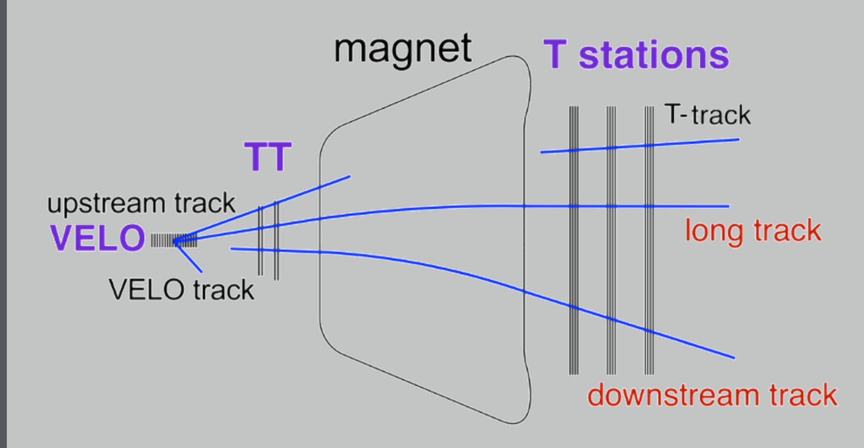
Track definition at LHCb



Long tracks

- Hits at least in VELO and T stations
- Excellent momentum resolution (0.5 %)
- Used in majority of analyses

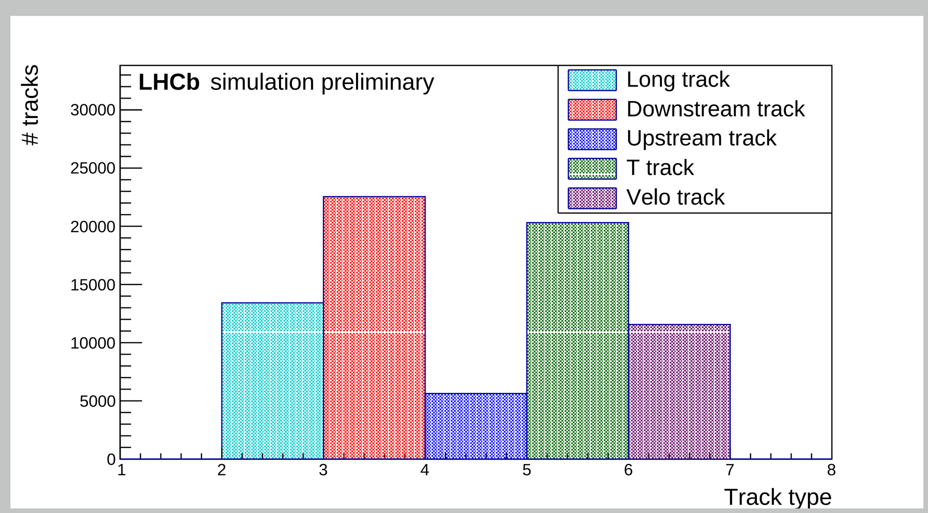
Downstream tracks

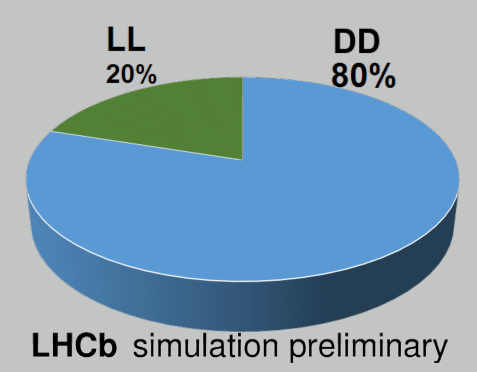
- Hits in TT and T stations (not in VELO)
- Lower momentum resolution (1%)
- **Decay products of long-lived particles**

Long-lived particles are important for many analyses:

- Λ frequently appear in b-baryon decays
- K_s are common in b-meson decays

Proportion of each track type in the $\Lambda \to p\pi$ decay (left) and $\Lambda_b \to \Lambda\gamma$ analysis (right):





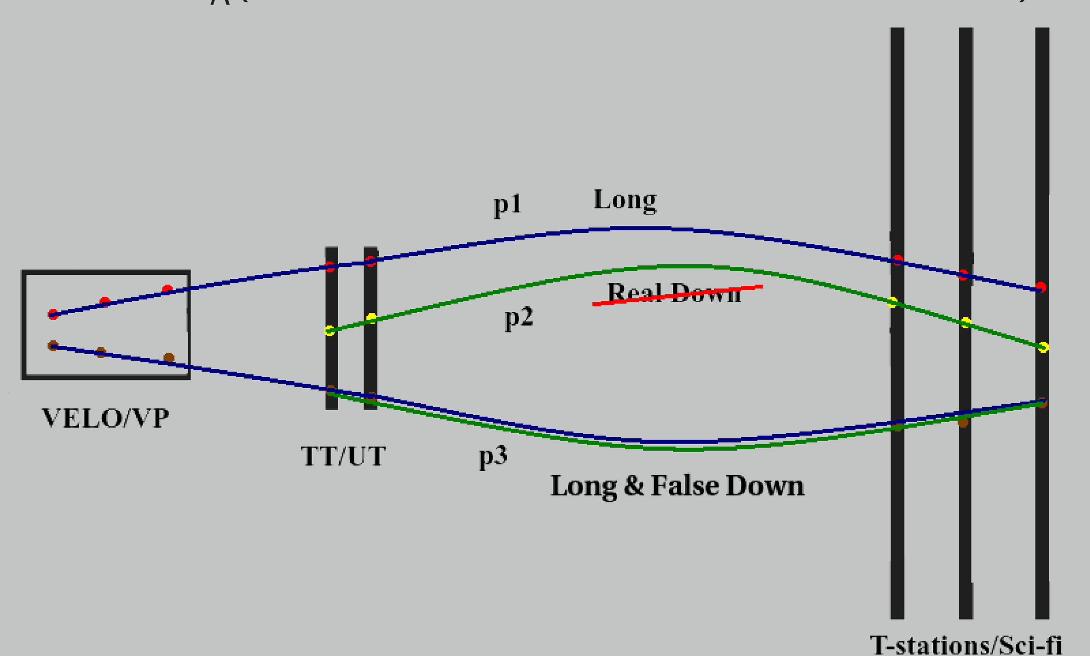
- Large proportion of Downstream tracks (30%)
- Only Long and Downstream tracks are used at analysis level
- In analysis, the proportion of events with downstream tracks can go up to 80%

Downstream tracking

- The steps in downstream tracking are:
  - Seeding: Create tracklets in the T-station
    - Algorithm (Run II): PatSeeding [1]
    - Algorithm (Run III): HybridSeeding [2]
  - Downstream tracking: Extend those tracklets to the TT
    - Algorithms: PatLongLivedTracking [3]
- **Why monitoring:** Need to check tracking performance, in particular the efficiency
- **New method:** The efficiency is computed as the number of downstream tracks reconstructed in a sample of Long tracks. The performance of downstream tracking algorithm is extracted using $\Lambda \to p\pi$:

1. Run Tracking algorithms keeping these track types:
   - L Long tracks
   - D Dowstream tracks
   - FD False Downstream tracks (Long tracks reconstructed as Downstream)
2. Reconstruct prompt Λ from Long and False Downstream tracks
3. Compute the efficiency using:

$$\epsilon = \frac{\#p_\Lambda^{FD}(hits^{VeLo/VP}, hits^{TT/UT}, hits^{Tstation/SciFi})}{\#p_\Lambda^{L}(hits^{VeLo/VP}, hits^{TT/UT}, hits^{Tstation/SciFi})}$$

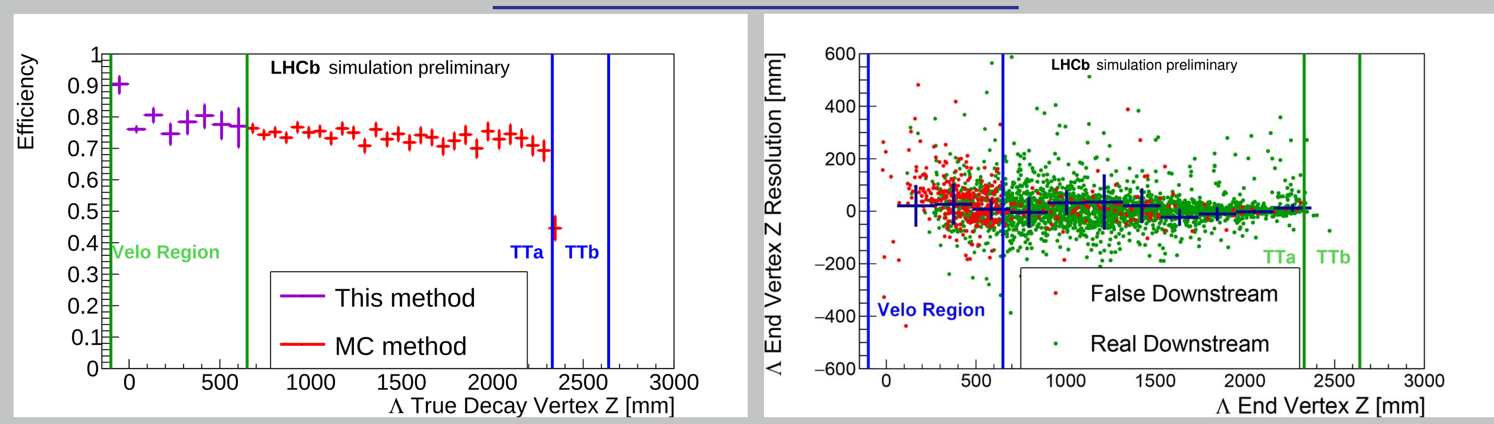


Proof of principle

This method work if the efficiency extracted:

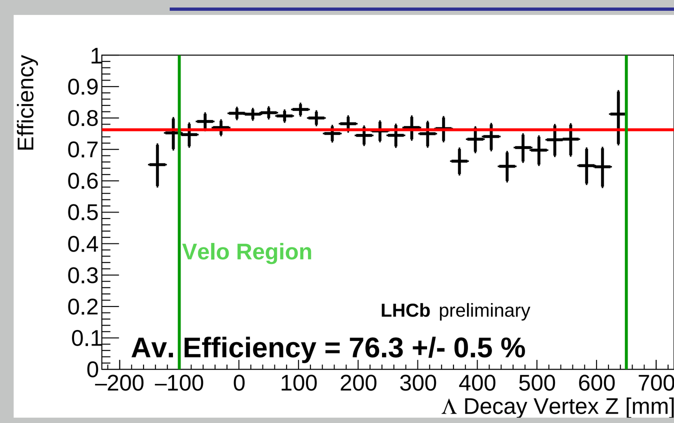
- Does not depend on Z (track length)
- Coherent results outside the VELO
- Downstream algorithms should be able to reconstruct tracks from VELO region

Simulation Run II

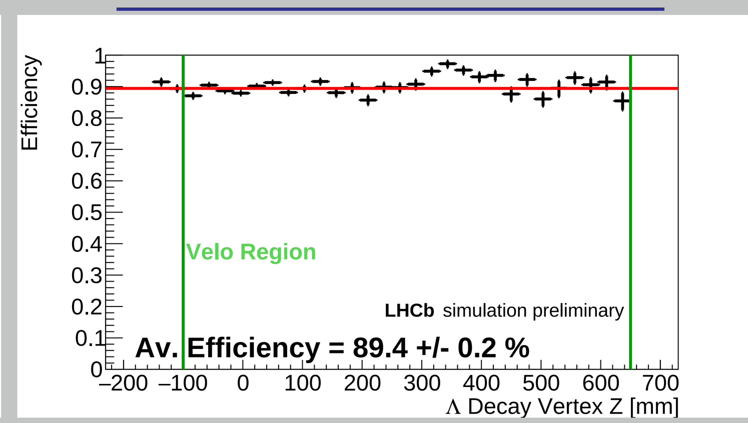


The independence with the z position can be checked in Real Data and Simulation Run III:

Real Data Run II



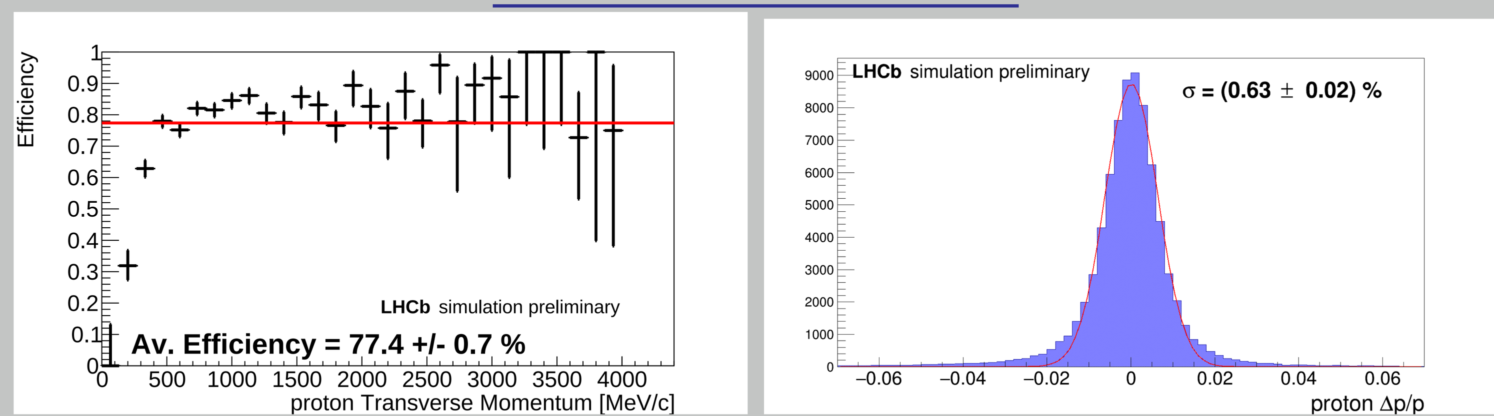
Simulation Run III



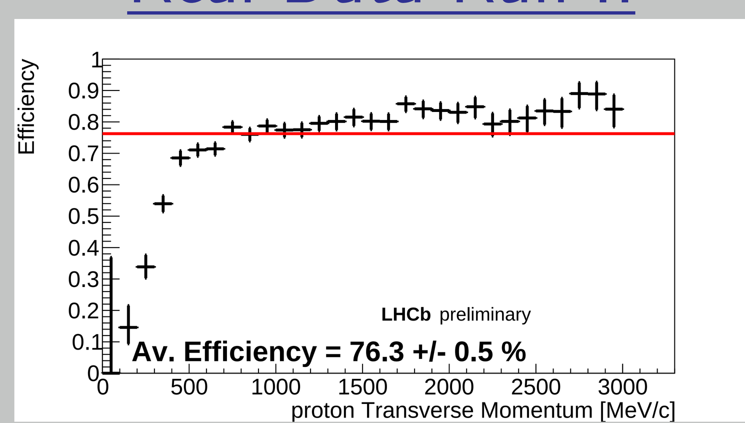
Results

The performance can be expressed as function of other variables to look for possible sources of inefficiency:

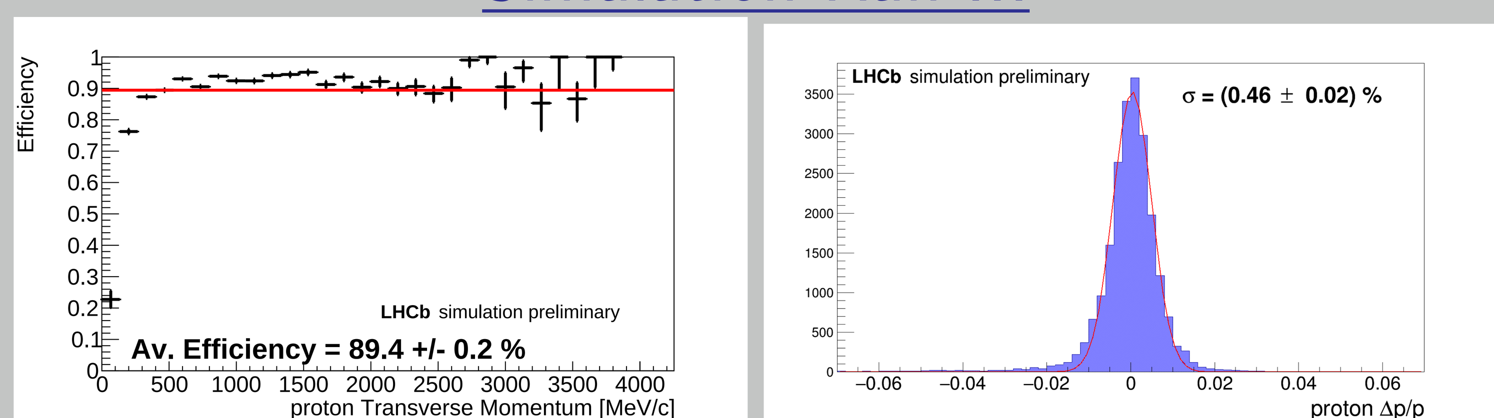
Simulation Run II



Real Data Run II



Simulation Run III



The new algorithms for the downstream tracking Run III has improve the efficiency and the momentum resolution [4]

Conclusions

- A new method has been developped to check the performance of downstream tracking at LHCb. **It allows to calibrate the algorithms with real data**
- Results are compatible between simulation and real data
- Coherent with other monitoring methods
- Table with efficiencies extracted from several data samples:

	Efficiency (%)	
	This method	MC Info
Simulation Run II	**77.4 ± 0.7**	74.5 ± 0.3
Real Data Run II	**76.3 ± 0.5**	–
Simulation Run III	**89.4 ± 0.2**	89.7 ± 0.1[4]

[1] LHCb-2008-042
[2] LHCb-PUB-2017-018
[3] LHCb-PUB-2017-001
[4] CERN-THESIS-2017-254