LHCb real time analysis and tracking for Upgrade 2

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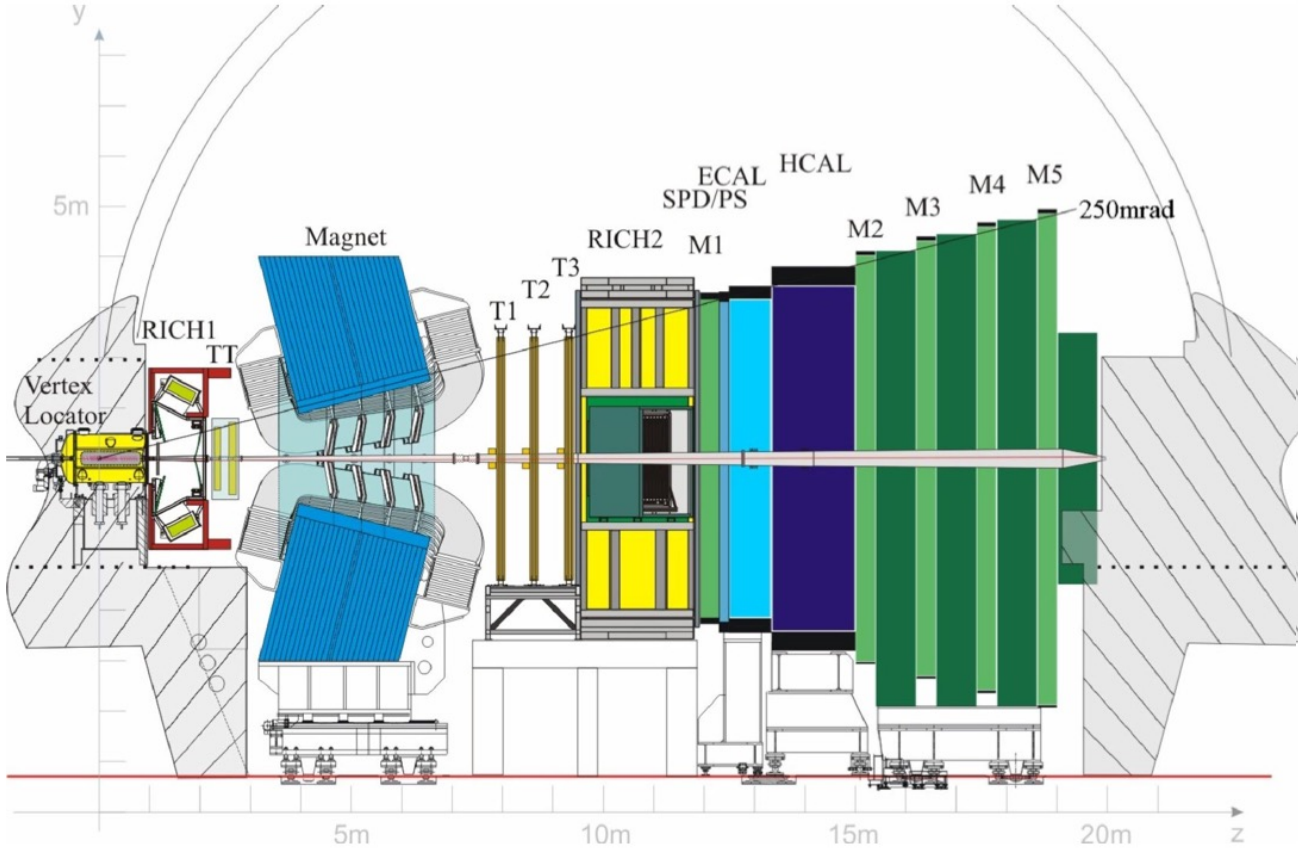
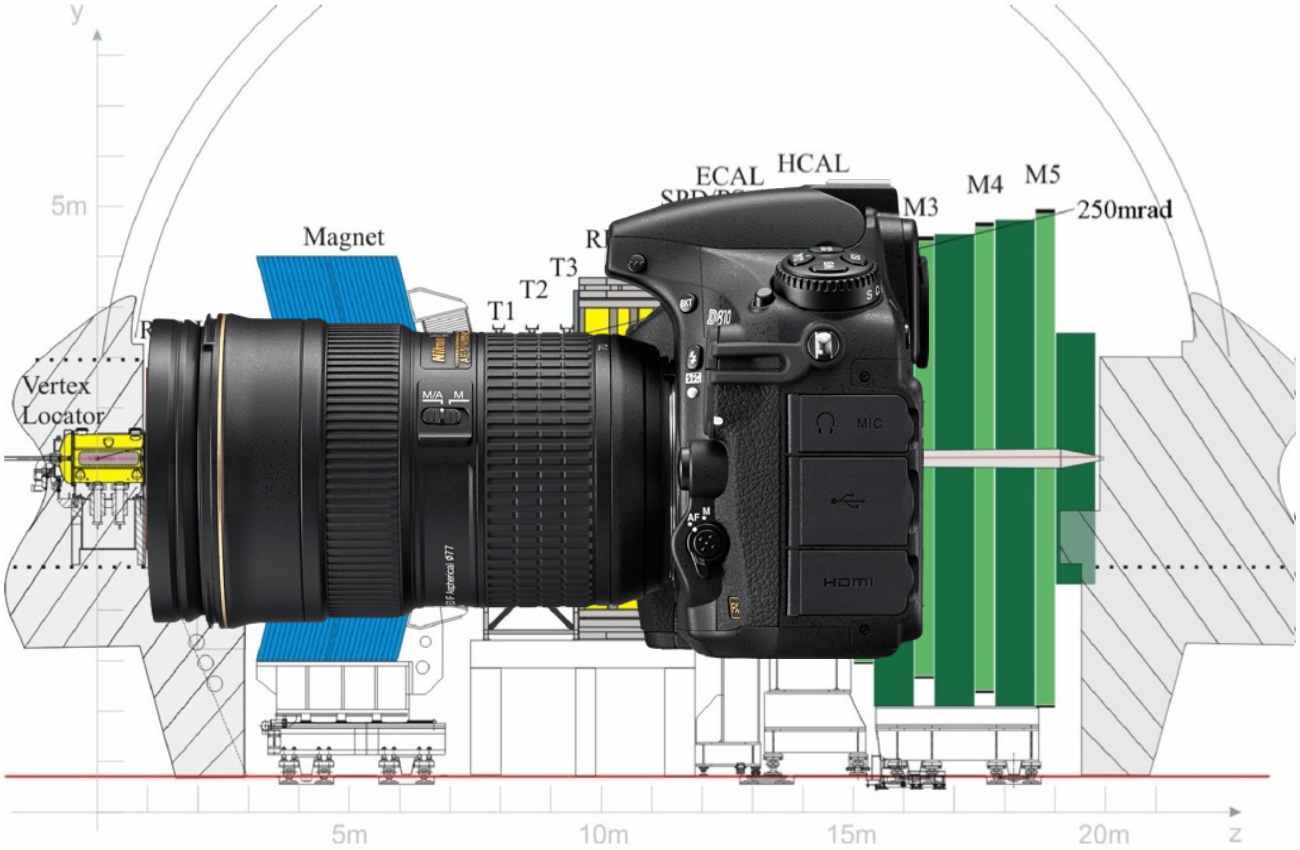
LHCb



- Forward spectrometer
- Designed as the *b*-physics experiment at the LHC

LHCb



- Forward spectrometer
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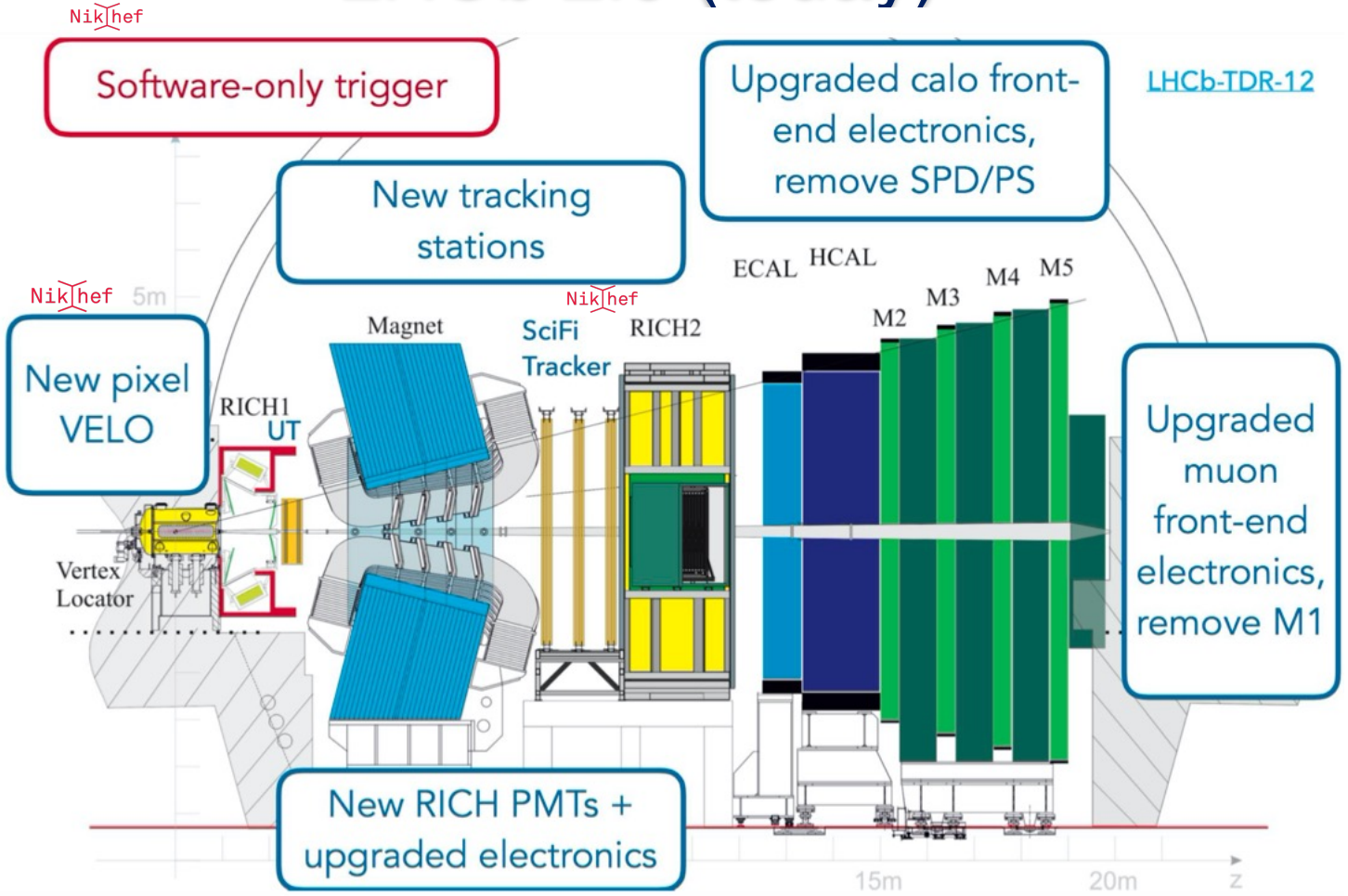
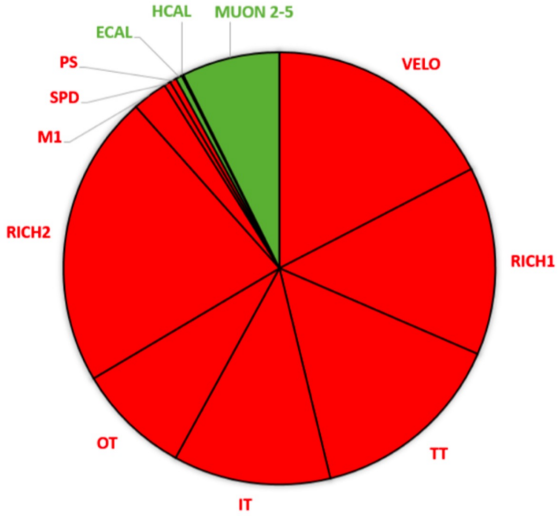
LHCb 2.0 (today)

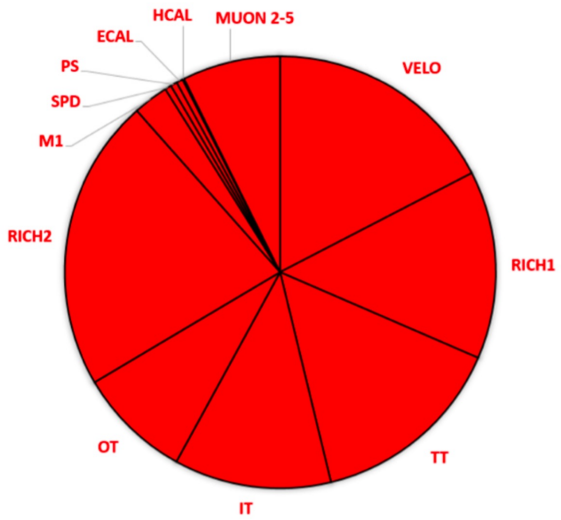


- Forward spectrometer
- Designed as the *b*-physics experiment at the LHC
- **Major detector upgrade for Run 3**

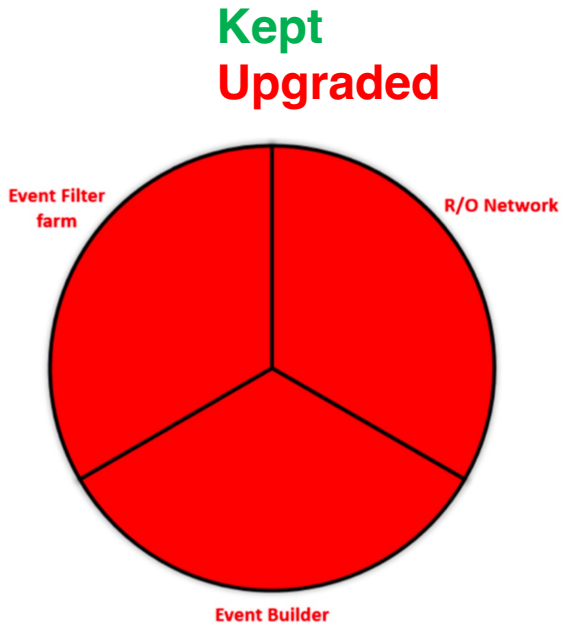
LHCb 2.0 (today)



Detector channels



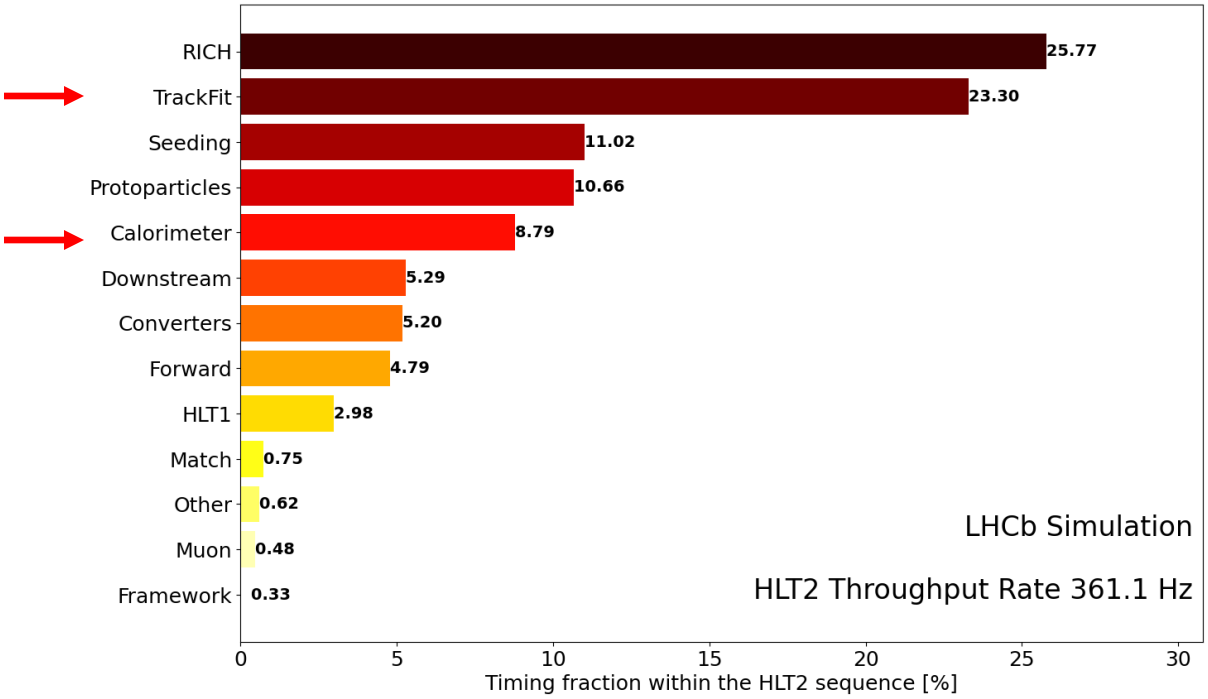
R/O electronics



DAQ

- No hardware trigger anymore
- **Fully software online trigger on GPUs: Allen project** Nikhef
- CPU-based second-level trigger HLT2

HLT2 reconstruction

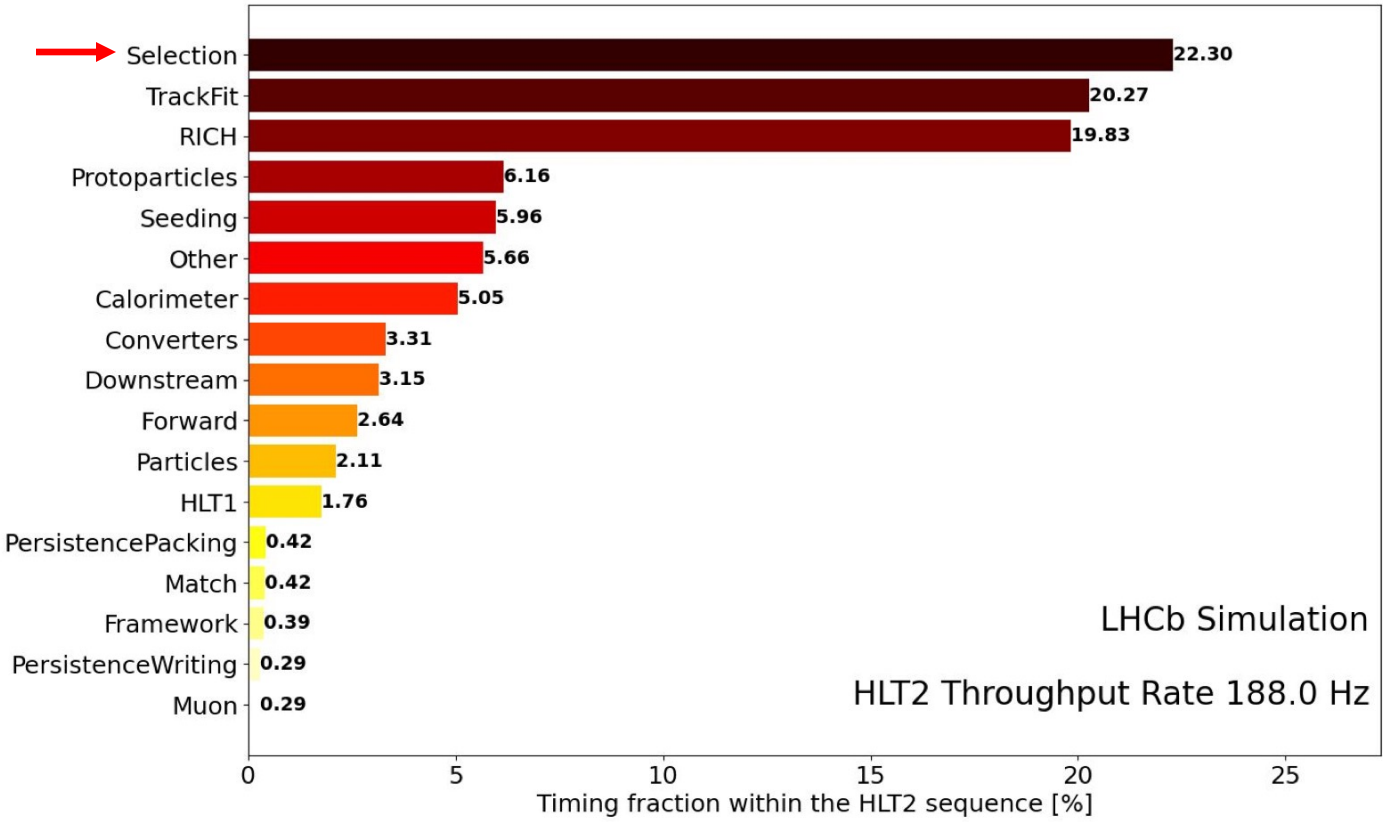


Overall **HLT2 reconstruction speed-up by *x2.5*** *(compared to 2021)*:

- track fit part got faster by *x3* Nikhef
- *x many* speed-up of calo reconstruction + electron ID Nikhef
- PV reconstruction Nikhef
- ML infrastructure Nikhef

Deployment, alignment, selections, persistency, offline analysis, data quality Nikhef

HLT2 today

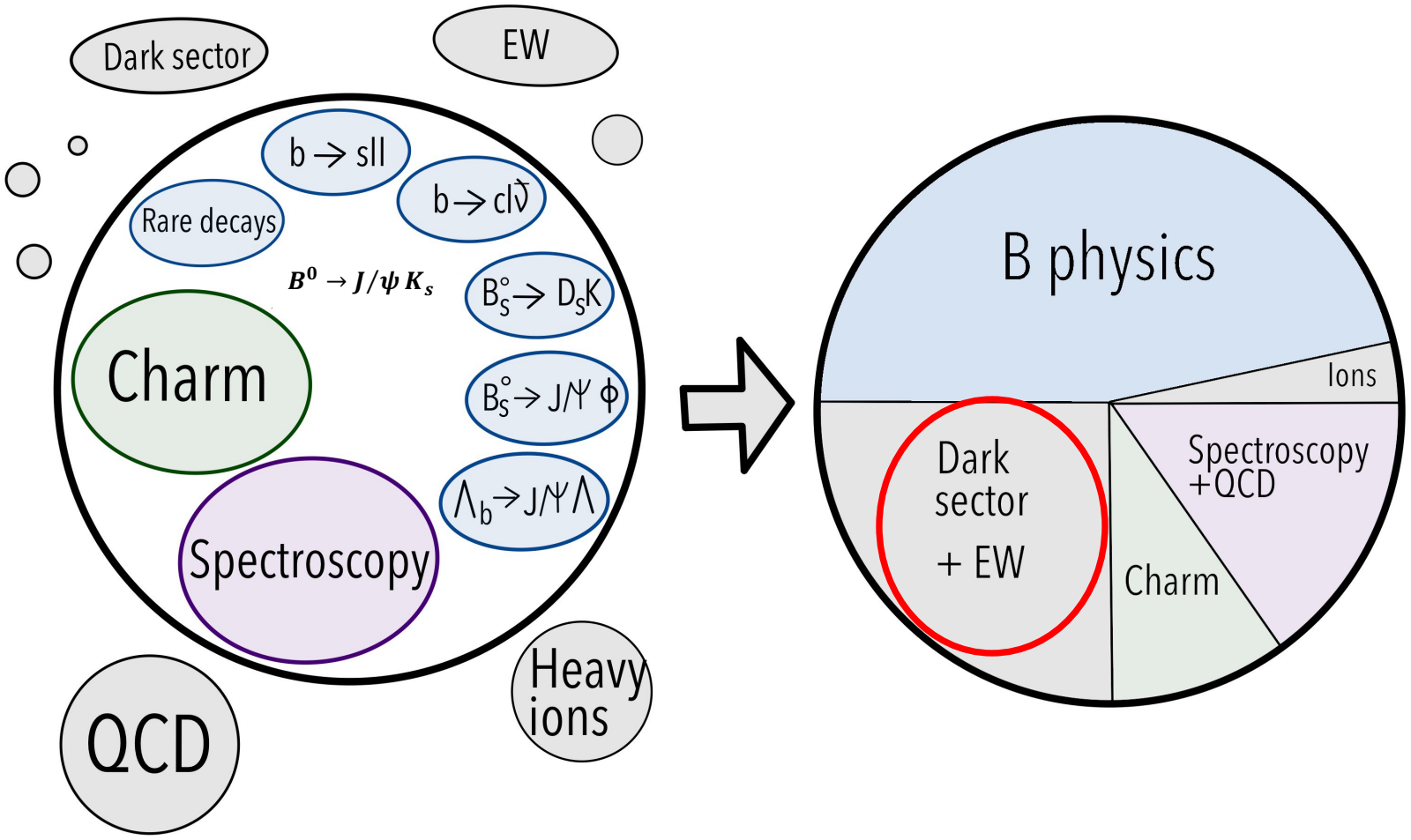


- Selection is the largest consumer at HLT2
- Getting as fast as the track fit and RICH reco

Gains

- higher signal efficiency
- long-lived tracking
- better electron ID
- better muon ID

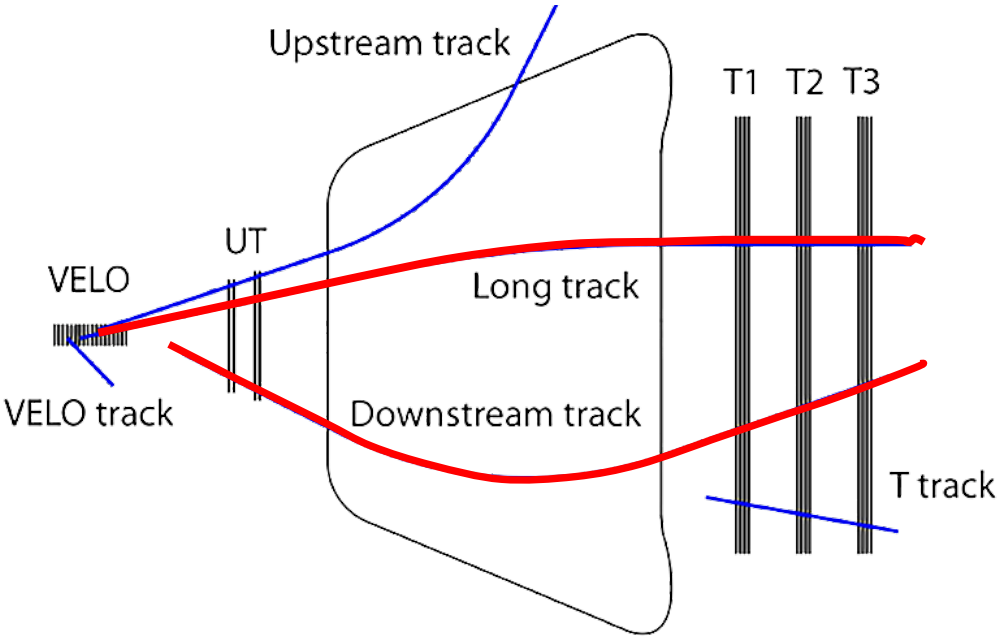
LHCb physics coverage



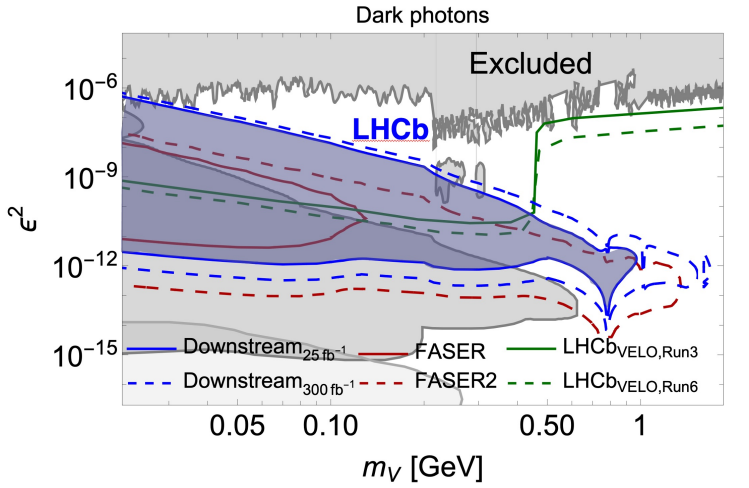
LHCb 1.0

LHCb 2.0

Long-lived tracking



- **Physics track types supported online:**
  - Long
  - Downstream
    (new in Run 3)
  - special cases for T-tracks
    (new in Run 3)



- Access to lifetimes up to *10ns*
- New sensitivity for New Physics searches

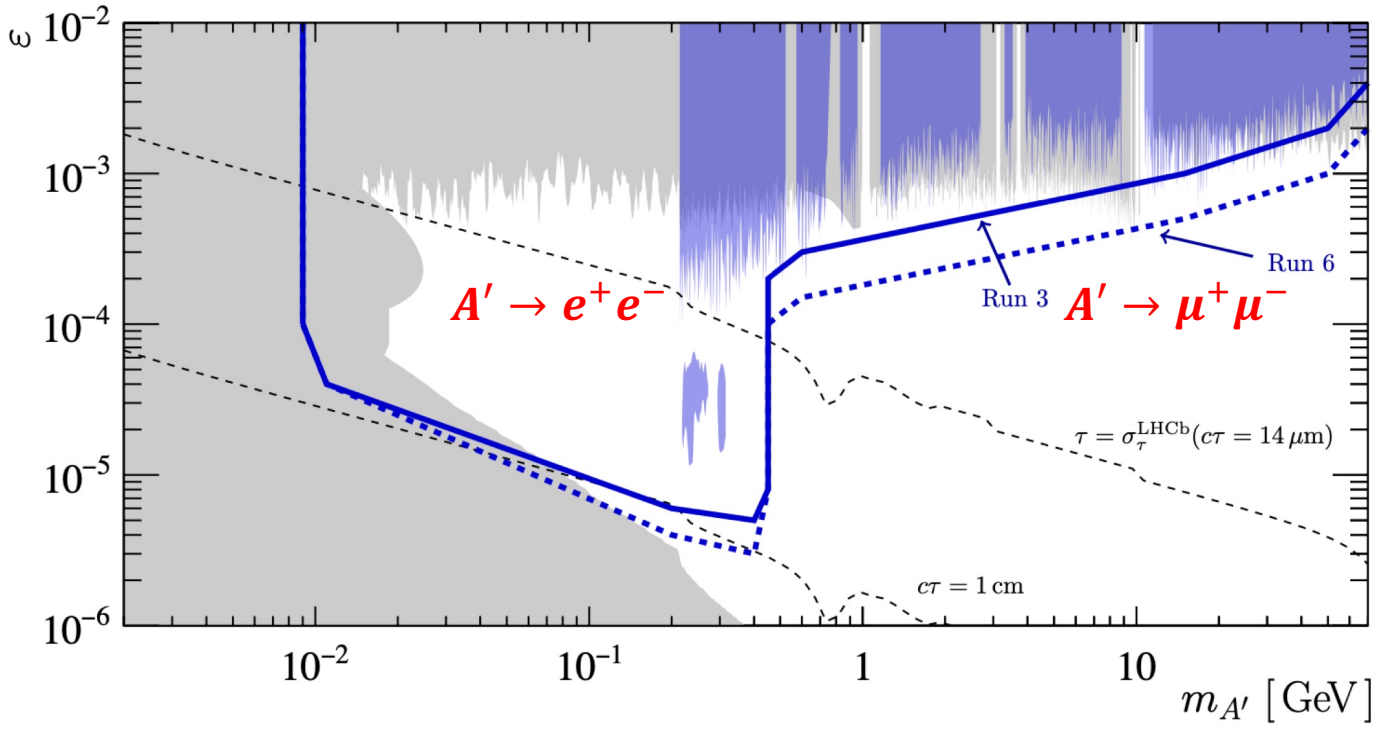
strong competitor to (potential) FASER2

Muons + electrons : dark photons

- Better tracking-based **muon ID**, *to be changed with NN soon?*

  - dramatic improvement at low momentum

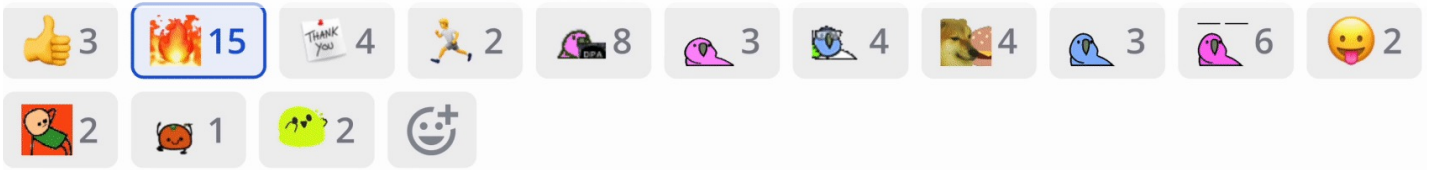
- Smooth and fast Lipsitz NN for **electron ID**

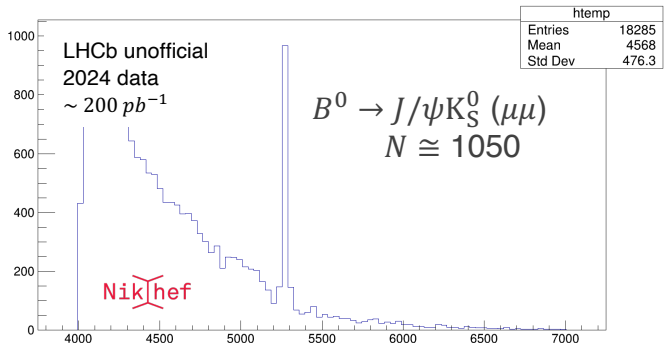


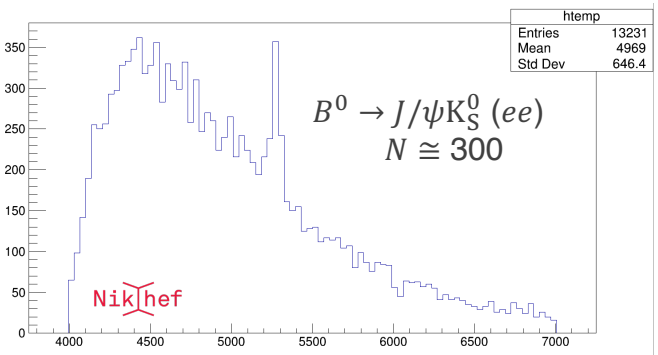
- **Becoming a major player in light dark photon searches**
- *Similar coverage for other models*

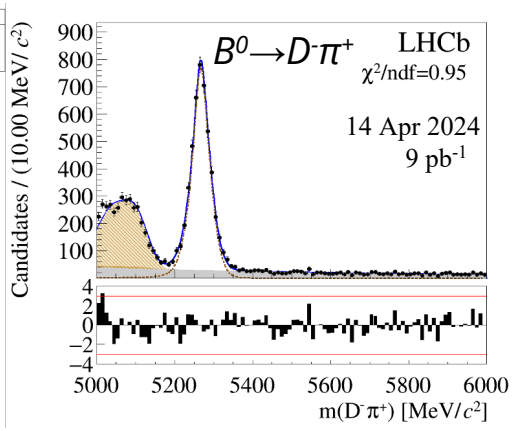
Run 3 in full swing

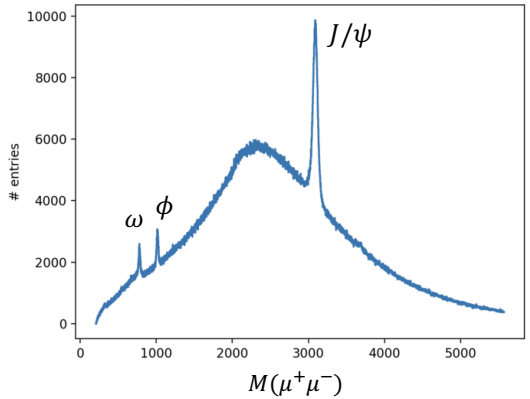
Exclusive Sprucing on the FULL stream will be available soon with ETA of Thursday and it should catch up to TURBO and TURCAL quickly.





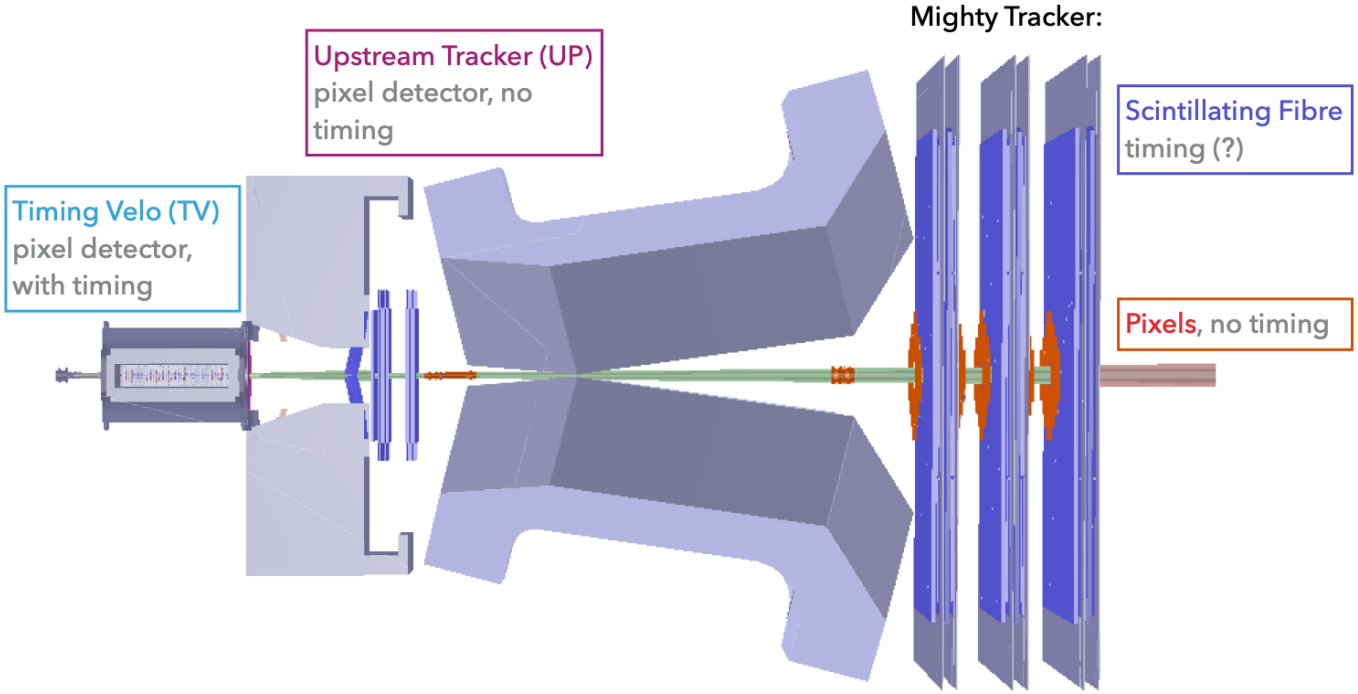




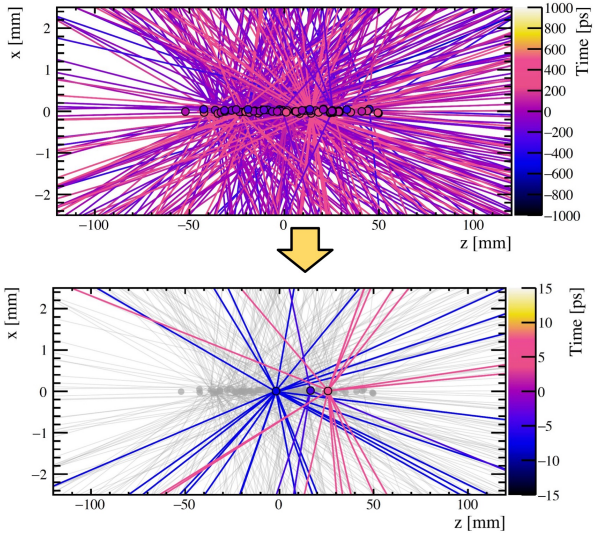


(some) tracking for Upgrade 2

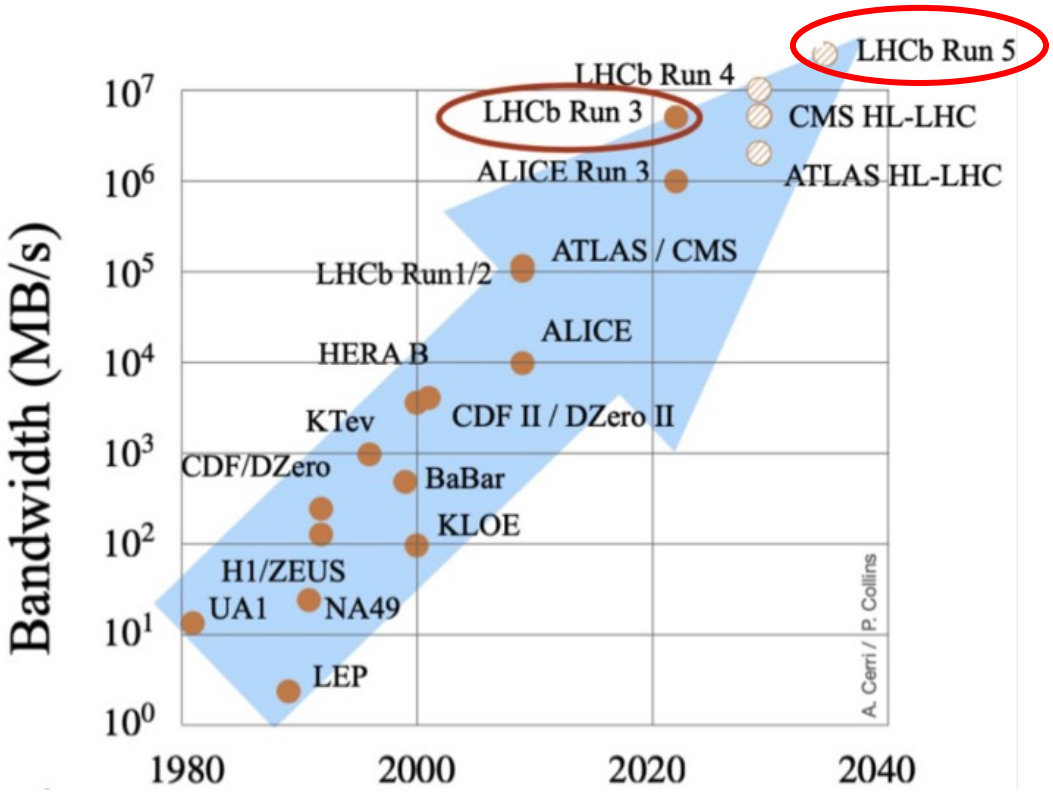
LHCb at high-lumi LHC



- Velo:
  - **timing in all hits**
  - **thin RF foil**
- UT : **pixels** instead of strips
- T stations : **pixels** in the middle,
  SciFi in outer region



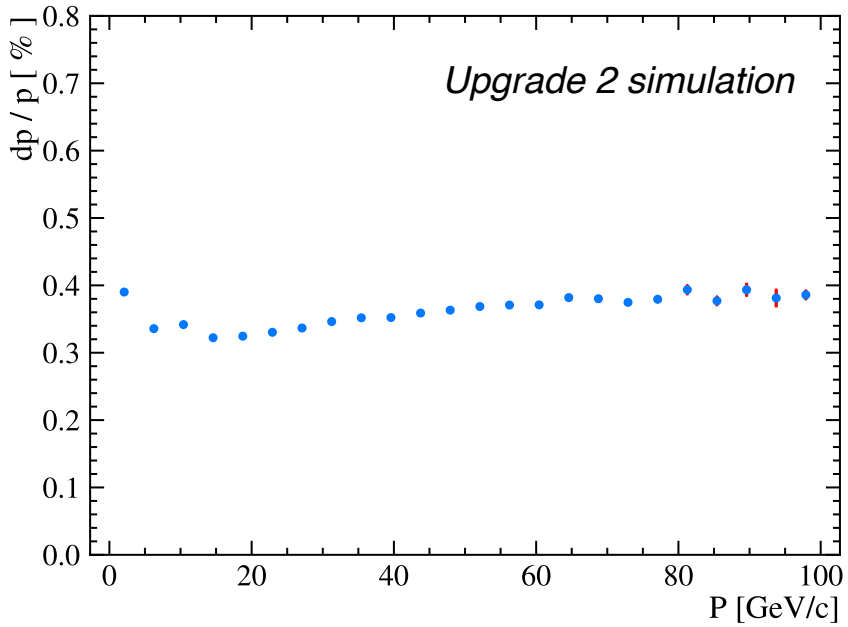
LHCb bandwidth



- Exponential growth in the bandwidth
- Requires redesign of both hardware and software
- Tracking is the key
- **Upgrade 2 is a massive challenge for reconstruction**

Track fit: momentum resolution

- Digesting new detector geometries: *material, pixel errors vs physics performance*
- Momentum resolution ***dp / p*** for **cheated long tracks**



- Preliminary: achieving momentum resolution below 0.4%

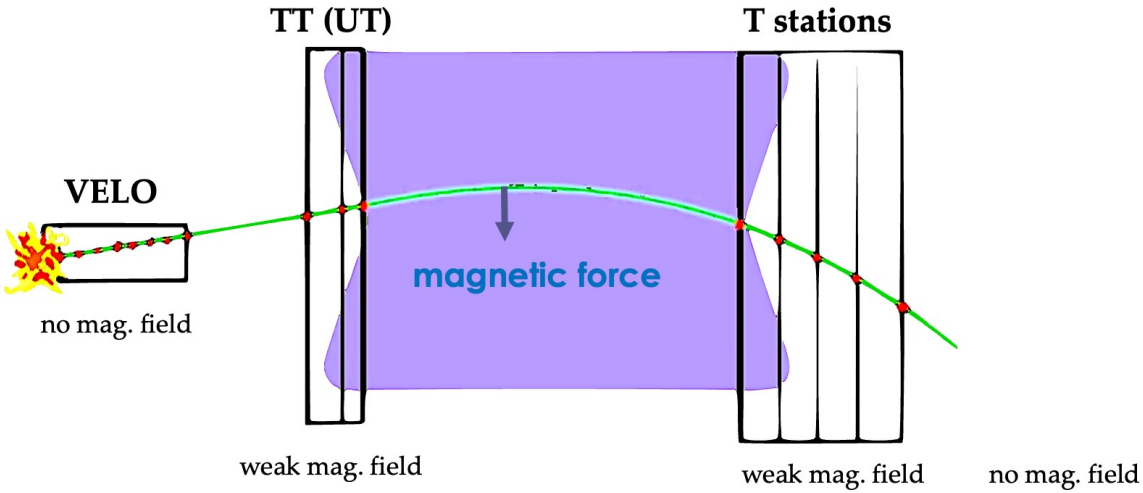
  - better compared to expected in Run 3

- *In agreement with standalone estimates → improvement in inv. mass resolution*

**equivalent to ~40% increase in statistics*

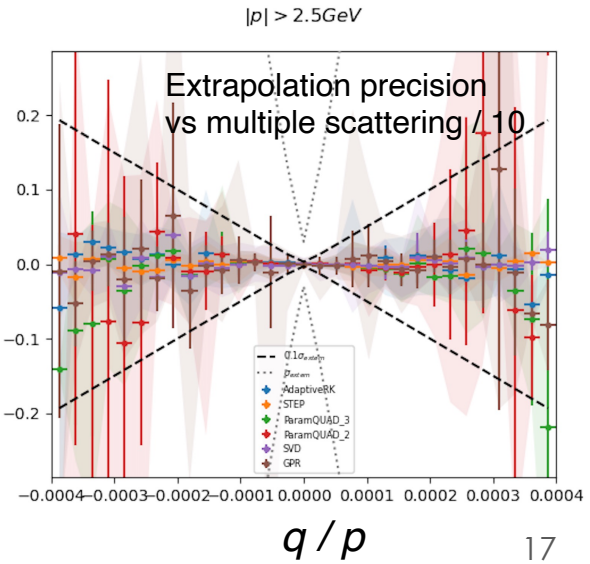
Track propagation in magnetic field

- Propagating track in complicated magnetic field, also CPU-expensive
- So far was needed only in the track fit



- Tried bunch of ML methods
- Pack results with *Singular Value Decomposition*
  - precision up to ~50 microns
  - *x25 less terms than exact parameterisation*
- Can be fast:

  promising for **Upgrade 2 pattern recognition**



Instead of summary

- Run 3 is in full swing for LHCb 2.0 with many advantages from real time analysis:
  fully software trigger, lepton ID, long-lived particles

- Tracking studies for Upgrade 2 have been prepared
  next: full realistic track reconstruction