Reconstruction at 30 MHz for the LHCb upgrade

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on behalf of the LHCb Collaboration

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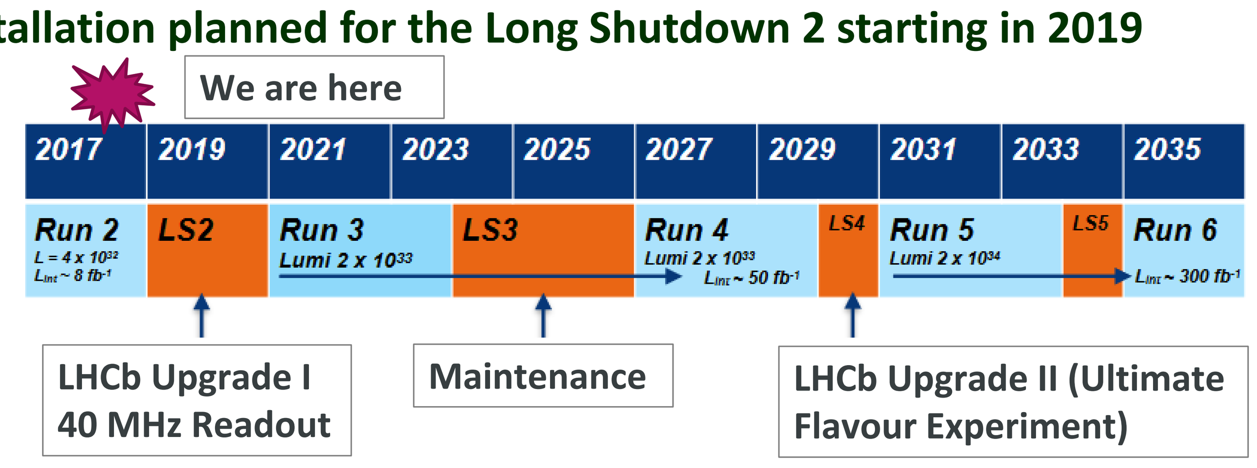
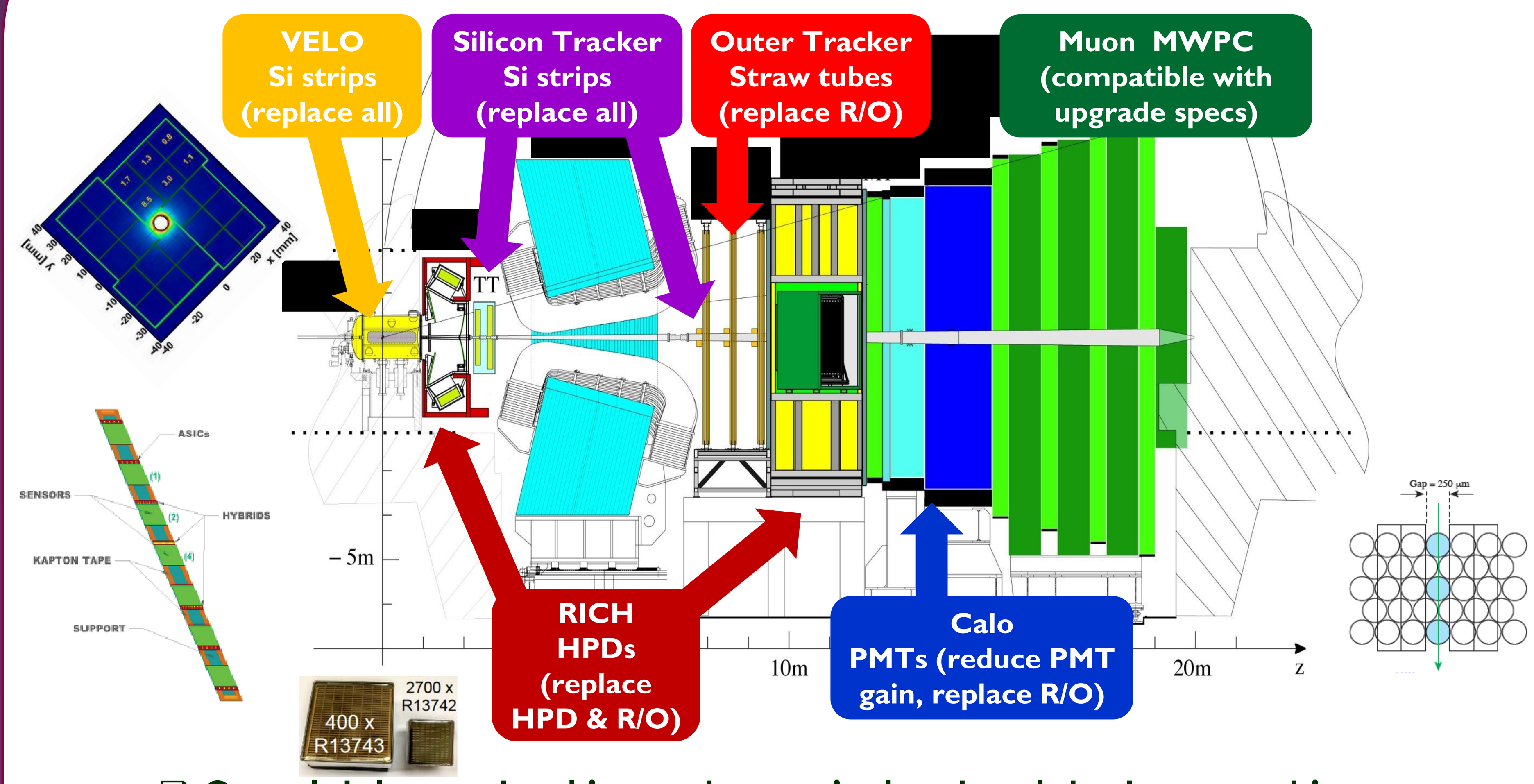
LHCb Upgrade Plan

- Installation planned for the Long Shutdown 2 starting in 2019



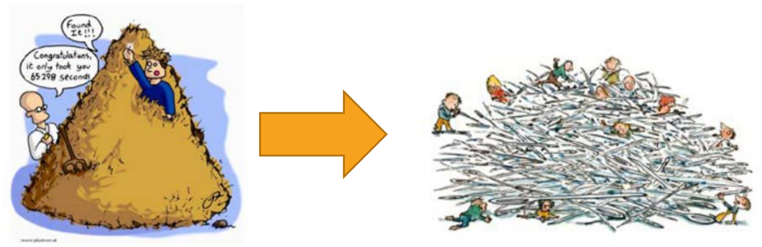
- Need to remove hardware trigger (L0), i.e., move from the full detector readout done @1 MHz to 40 MHz one
- The upgraded LHCb must cope with up to five times higher inst. luminosity relative to Run II ($\mathcal{L} = 2 \cdot 10^{33}\ \mathrm{cm^{-2}s^{-1}}$)
- Triggerless readout with the full software trigger that requires real-time calibration and alignment
- Offline-like reconstruction run in real time
- Use Run II trigger system as a testbed for new techniques for Run III
- **Huge Challenge, but we are on track!**

Our „new" detector



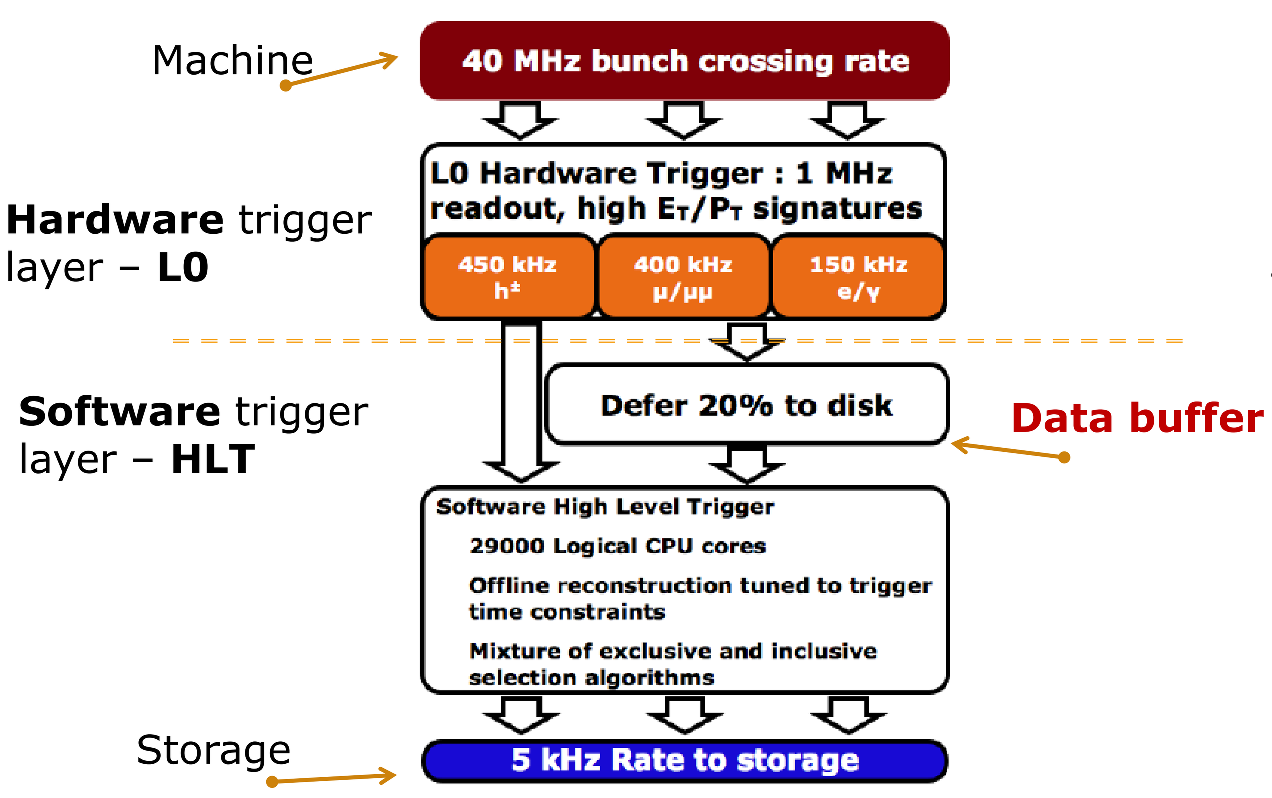
- Completely new tracking system – pixel vertex detector, new strip and scintillating fibre trackers
- New custom made electronics capable to process data on-detector at machine clock (40 MHz)

LHCb Trigger (R)Evolution



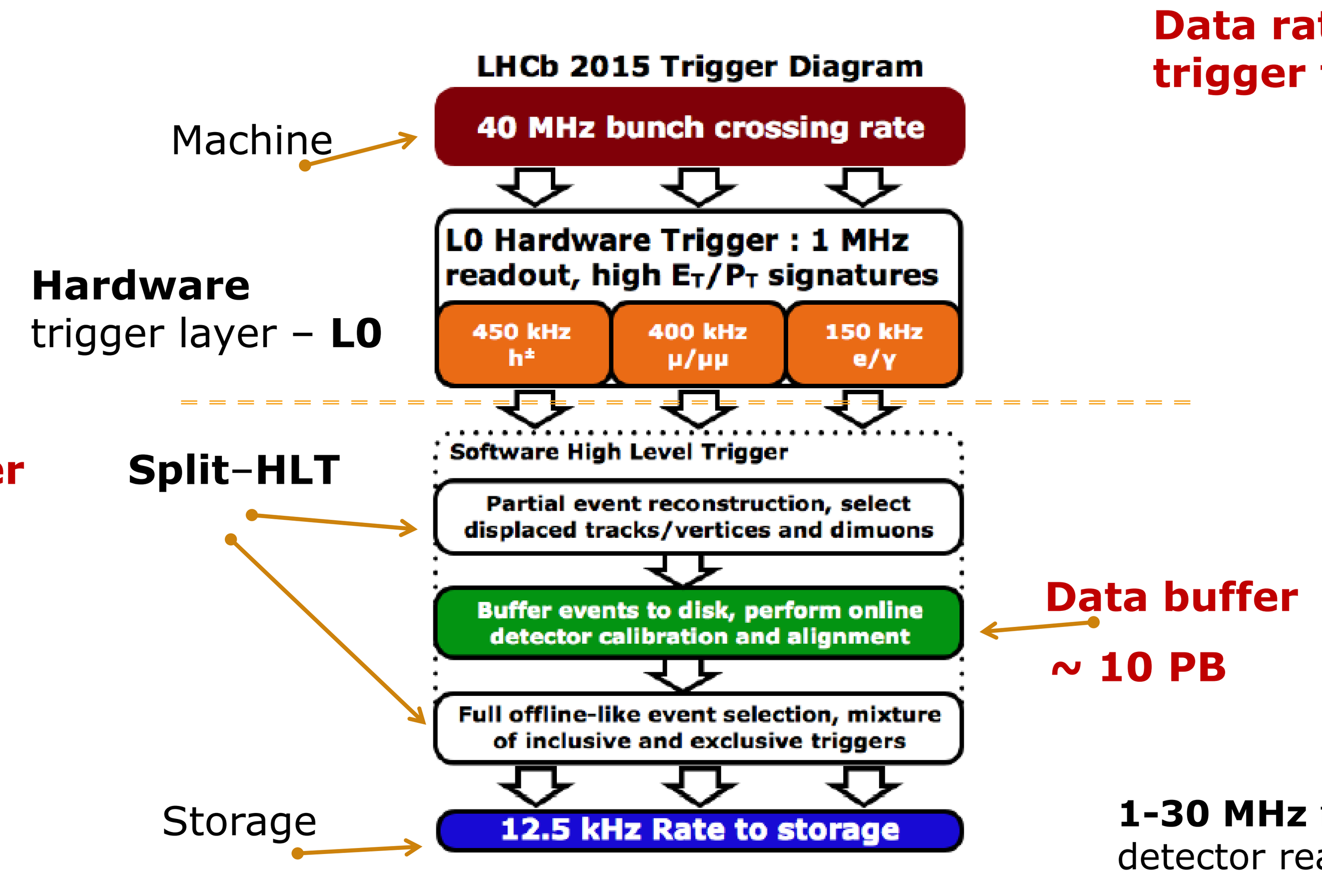
Upgrade luminosity means no trivial background rejection:
every event contains a beauty, charm or hyperon decay.
Signal categorisation instead of background rejection.

Run I evolution from 2 to 5 kHz



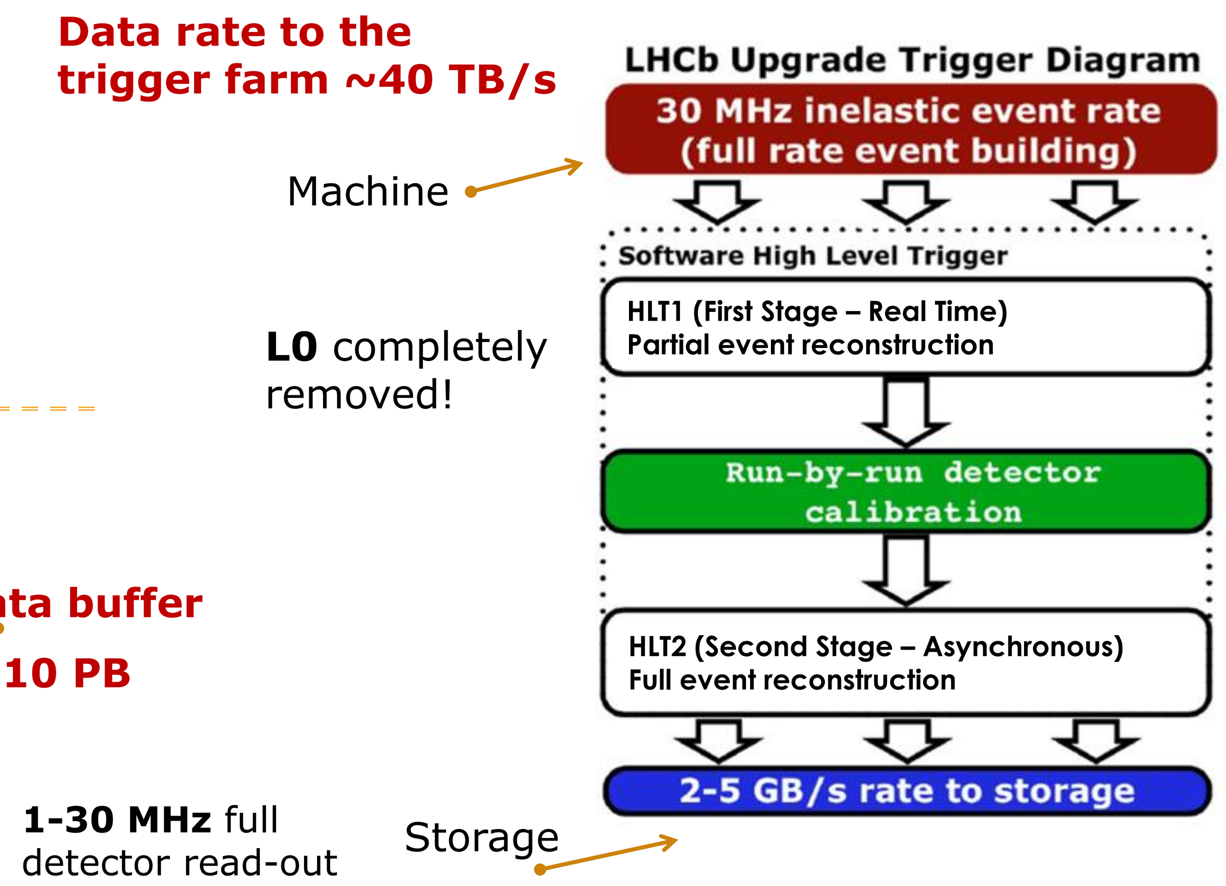
- **1.1 MHz** full detector read-out
- Data partially defered

Current Run II trigger system



- **1.1 MHz** full detector read-out
- HLT is split, real-time calibration and alignment
- Offline-like quality tracking and selections in trigger

Run III (upgraded) trigger

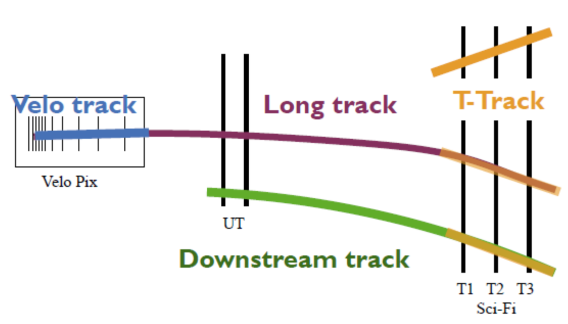


- **30 MHz** full detector read-out
- Full-software system
- Time constraints crucial!

Latest developments for upgrade Trigger

HLT1

- Partial event reconstruction only
  - Data preparation for tracking (unpacking/reformatting)
  - Track reconstruction
  - Initial pre-selection to reduce the rate to 500 – 1000 kHz



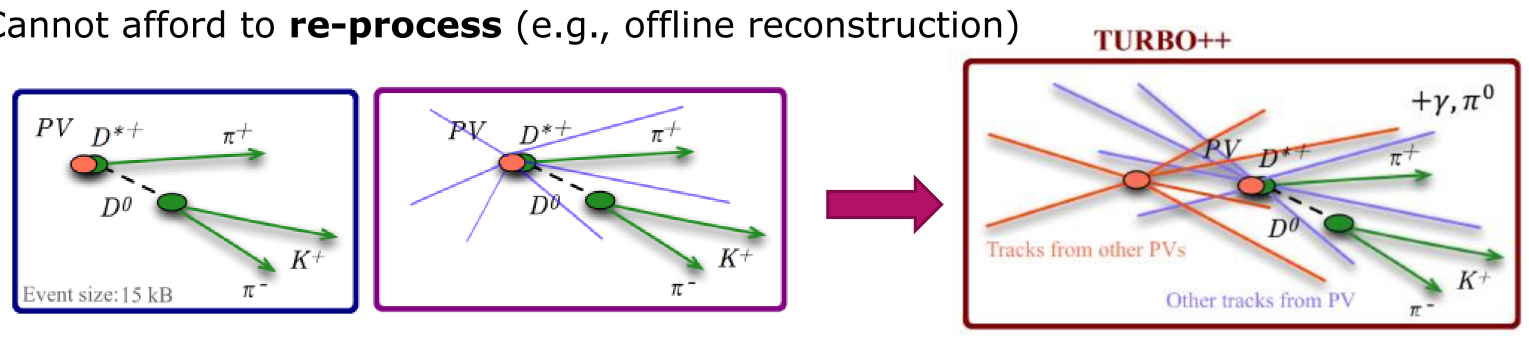
HLT2

- Full event reconstruction
  - Tracking performance with the offline quality
  - Particle identification information available based on fill-by-fill calibration – background rejection
  - Offline quality event selections

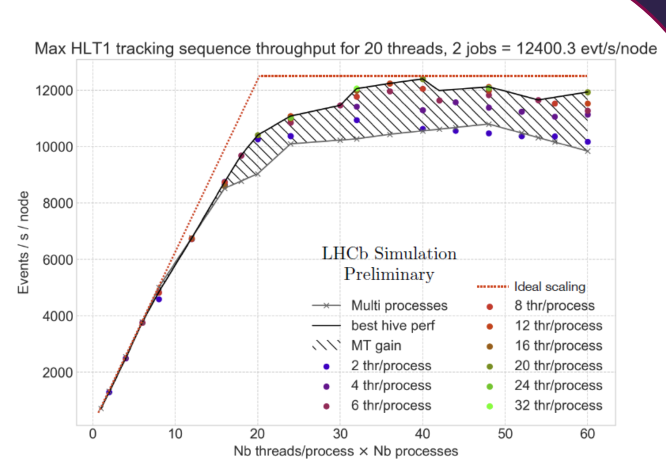
- **Calibration proces takes $\mathcal{O}$(minutes)**
- **Data stored in the buffer can be parked for $\mathcal{O}$(days)**

TURBO

- Facing the inevitable – finite budget for computing resources – TURBO data stream
  - Cannot afford to **store all raw data offline**
  - Cannot afford to **re-process** (e.g., offline reconstruction)



Being fast and smart

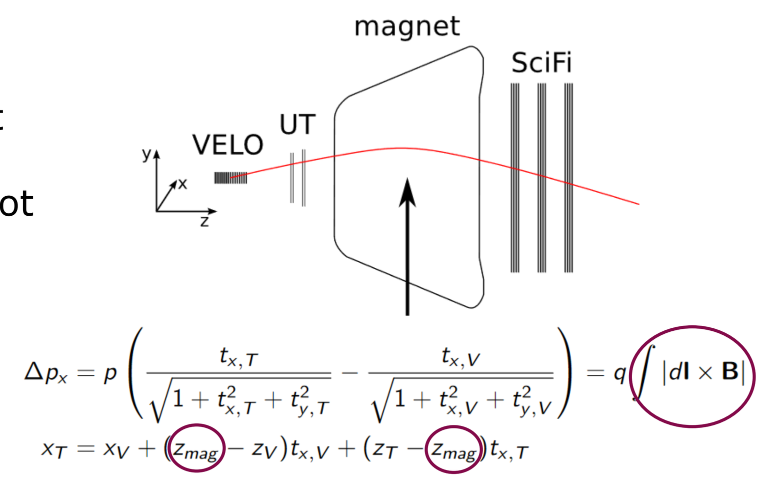


Concurrent s/w framework

- Multi-threaded framework using task-based model
  - Use commercially available multi-core CPU architectures
  - Better scalability in memory usage
  - Initial tests show ~20% extra speed-up in the reconstruction

Parametrised Kalman Fitter

- Kalman filter approach for tracking very successful, but
  - Very CPU intensive matrix algebra (can be sped-up)
  - Material locator still remains – memory intensive, cannot be easily reduced
  - The possible solution is **parametrised** Kalman
  - Reduce complicated field propagation and material lookup using a handful of parameters $\mathcal{O}(20)$



Simplified Geometry

- The full detector model is very complex **$\mathcal{O}(10^6)$ volumes**
  - Navigating through such structure can be very slow
  - Provide much simpler model (**$\mathcal{O}(30)$ volumes**) with large volumes filled with mixed materials that give the same multiple scattering and energy loss