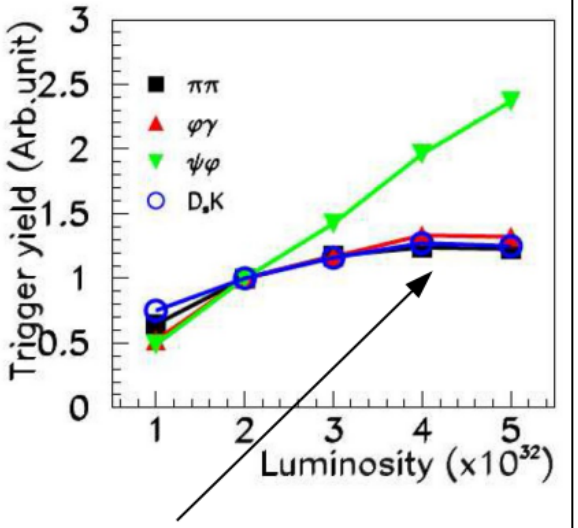
LHCb

Why we need to upgrade LHCb?

- Les paramètres de fonctionnement du LHC après le run2 impliquent une dose de radiation et un taux d'occupation trop élevés pour les sous-détecteurs actuels.

- On a besoin de collecter une large quantité de données pour avoir des mesures précises

Pour ces deux raison on prévois un upgrade du détecteur LHCb.

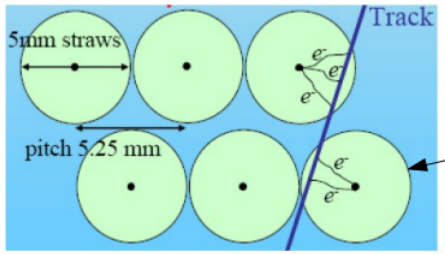


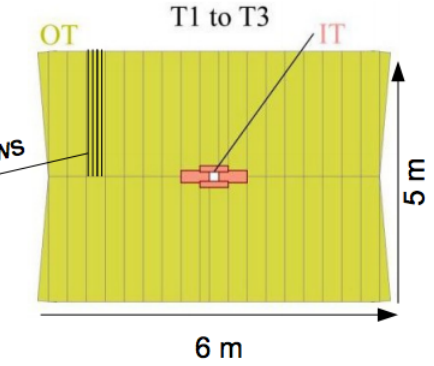
Saturation of hadronic modes with L0-hardware trigger

Detector Occupancy and Efficiency

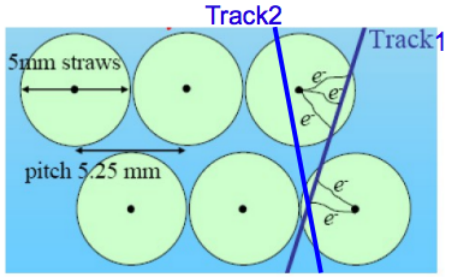
Outer Tracker = 5 mm straw gas drift tubes (2.5m long)
• Detector is insensitive to multiple tracks per tube (35ns drift time)

Good!!





BAD!!



Outer Tracker tracking efficiency decreases above 25% occupancy → 40% expected in the upgrade

Beam bunch spacing will be 25ns in 2015+

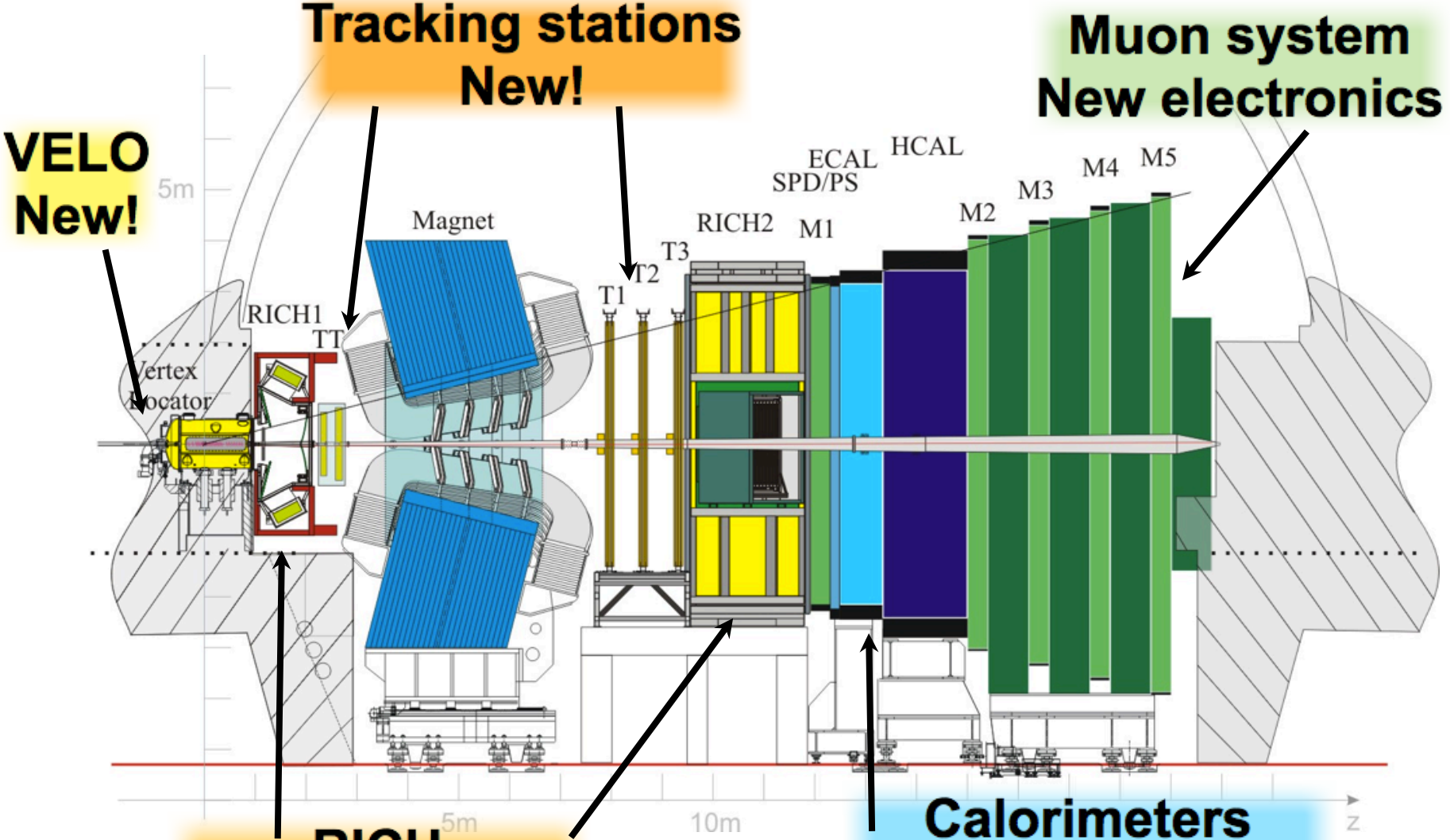
1

LHCb upgrade: overview

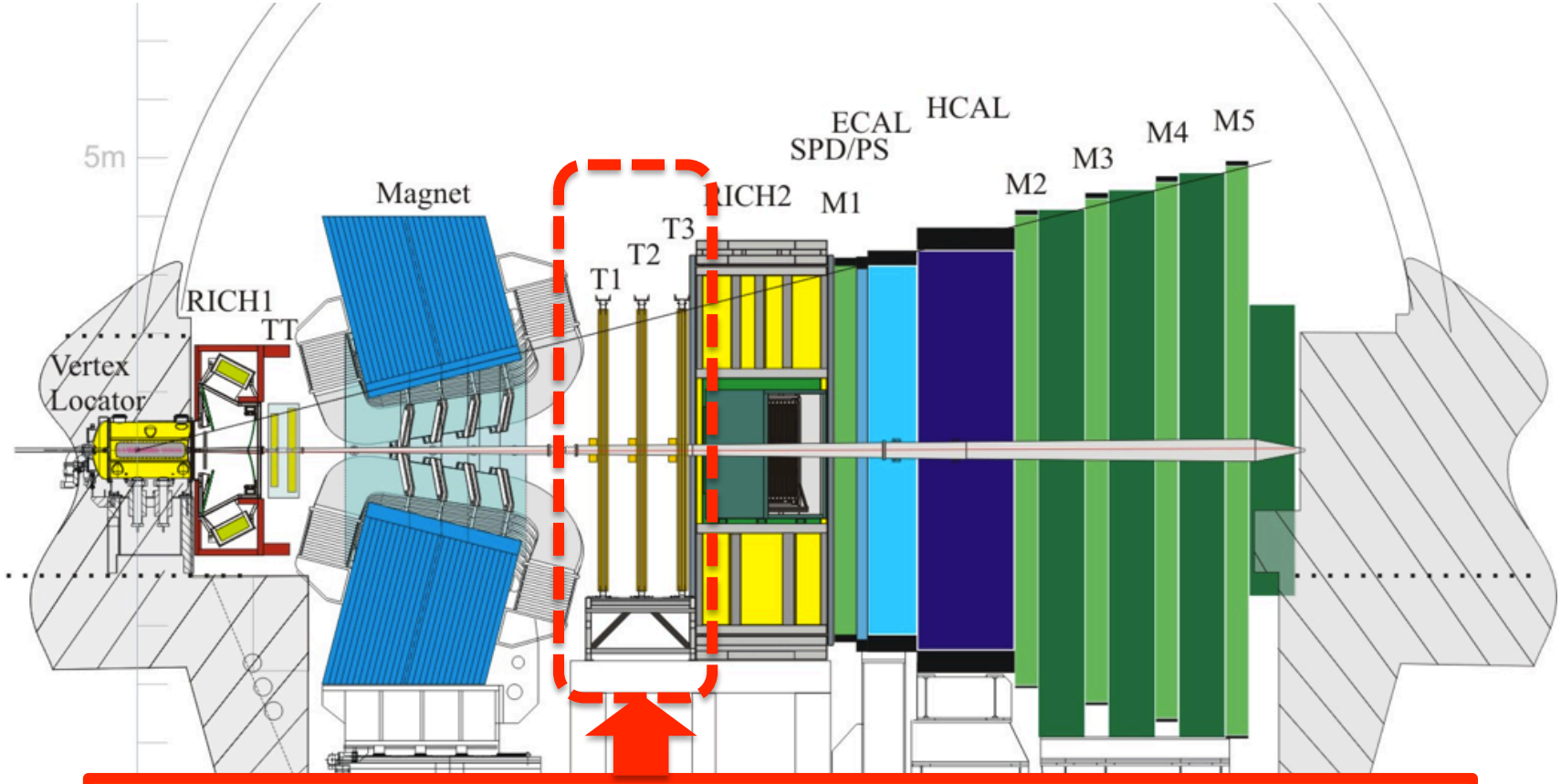
LHC running conditions		
Year	*2012*	***upgrade***
Energy	*8 TeV*	***13 - 14 TeV***
Bunch spacing	*50 ns*	***25 ns***
Colliding bunches		***2400***
Luminosity leveling	*$4x10^{32}$ cm^{-2} s^{-1}*	***$2x10^{33}$ cm^{-2} s^{-1}***
Pileup (interactions/bunch crossing)	*1.7*	***2.5 to 5***

- replace/overhaul several sub-detectors: VeloPixel, Trackers (UT, ***SciFi***), RICH
- replace readout electronics: readout rate at 40 MHz instead of 1 MHz
- Full software trigger

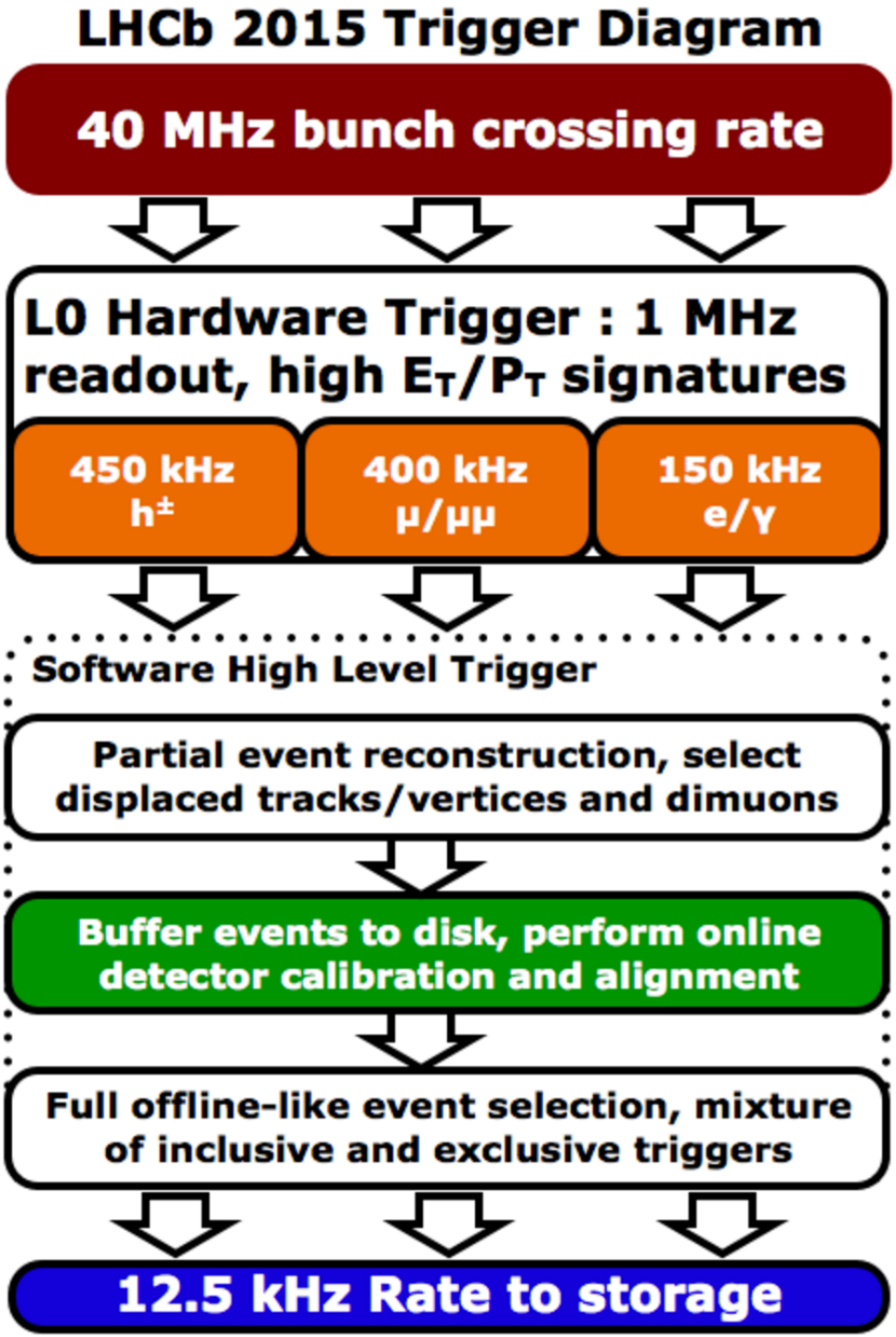
LHCb upgrade: overview

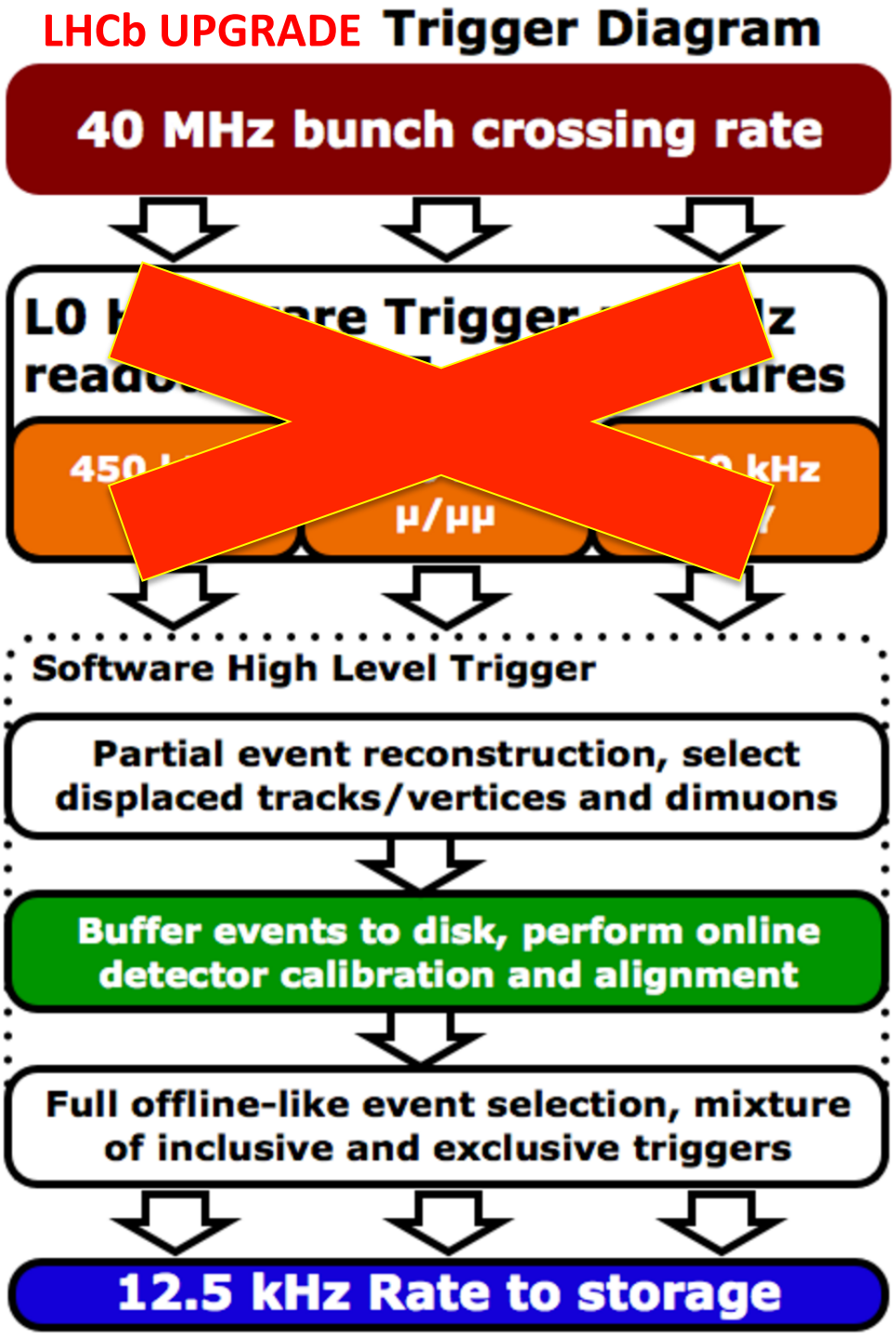


LHCb upgrade: overview



Nous sommes impliqués dans le Scintillating Fiber tracker (SciFi) qui va remplacer les stations de tracking après l'aimant


LHCb 2015 Trigger Diagram
40 MHz bunch crossing rate
L0 Hardware Trigger : 1 MHz readout, high E_T/P_T signatures
450 kHz $h^{\pm}$
400 kHz $\mu/\mu\mu$
150 kHz e/γ
Software High Level Trigger
Partial event reconstruction, select displaced tracks/vertices and dimuons
Buffer events to disk, perform online detector calibration and alignment
Full offline-like event selection, mixture of inclusive and exclusive triggers
12.5 kHz Rate to storage


LHCb UPGRADE Trigger Diagram
40 MHz bunch crossing rate
μ/μμ
Software High Level Trigger
Partial event reconstruction, select displaced tracks/vertices and dimuons
Buffer events to disk, perform online detector calibration and alignment
Full offline-like event selection, mixture of inclusive and exclusive triggers
12.5 kHz Rate to storage

THE TRIGGER CHALLENGE

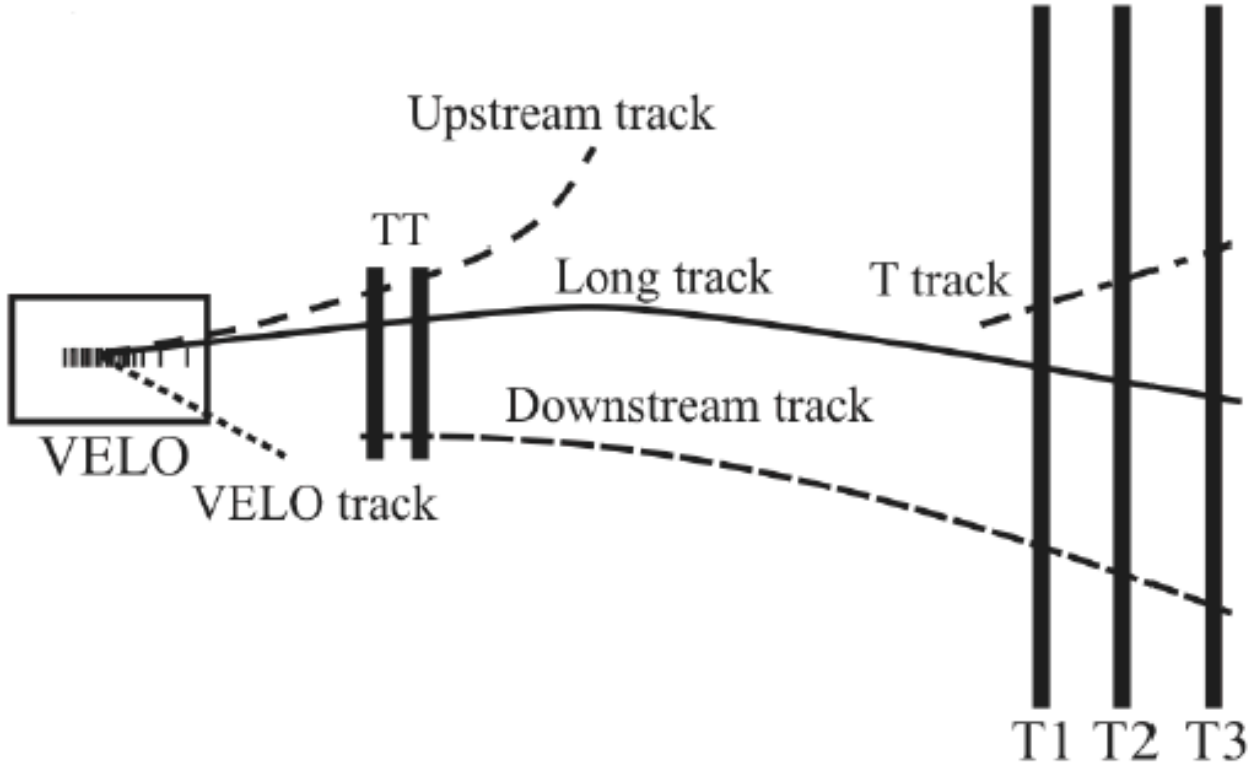
- The difficulty for Run III is to process **~100 times more data with ~1/2 the financial investment in the processing farm** (we have a roughly 3 MCHF budget compared to almost 6 MCHF spent on the current HLT so far)

- The major challenge is to **use the shared memory of the multi-core architectures more efficiently**, and eliminate waste due to cache misses etc. Therefore we have to pass from a quasi-parallelism in which each core gets a different event and basically acts as an independent processing unit, to a genuine multithreaded approach processing multiple events in parallel on each core and using accelerators (FPGA/GPU) where possible in an efficient way, which also requires the ability to efficiently send data around between these different processing architectures

- On the physics side, this will enable LHCb to not only achieve **optimal perfomance for B physics but also** to achieve **its full potential in charm physics, kaon physics, and low-mass dark matter (A', dark photon, etc) and exotic searches**. These "low momentum" or "soft" signatures critically depend on having the full reconstruction in the trigger.

TRACKING SOFTWARE

- The tracking is a key ingredient of the trigger. At LPNHE we are working on developing the **tracking algorithms for the new Scintillating Fiber Tracker** (SciFi) that will be installed in 2019 for the upgrade. We are in particular focused on the "seeding" algorythm, i.e. the one using exclusively informations from the SciFi (no Velo, no UT) important for the long lived particles. All performances have to be looked at: efficiency, ghost rate, speed! (parallelism…)



BIG DATA, MACHING LEARNING, ETC…

- We are also interested in following the developments in these fields, as we perform complex analyses on large sets of data, that requires sometimes a lot of time and in which improvements in the signal/background discriminating algorithms are very welcome