The LHCb trigger

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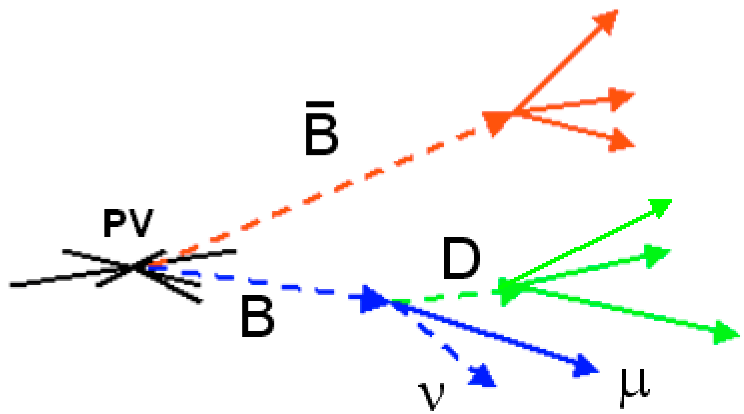
Thursday, 22 july 2010

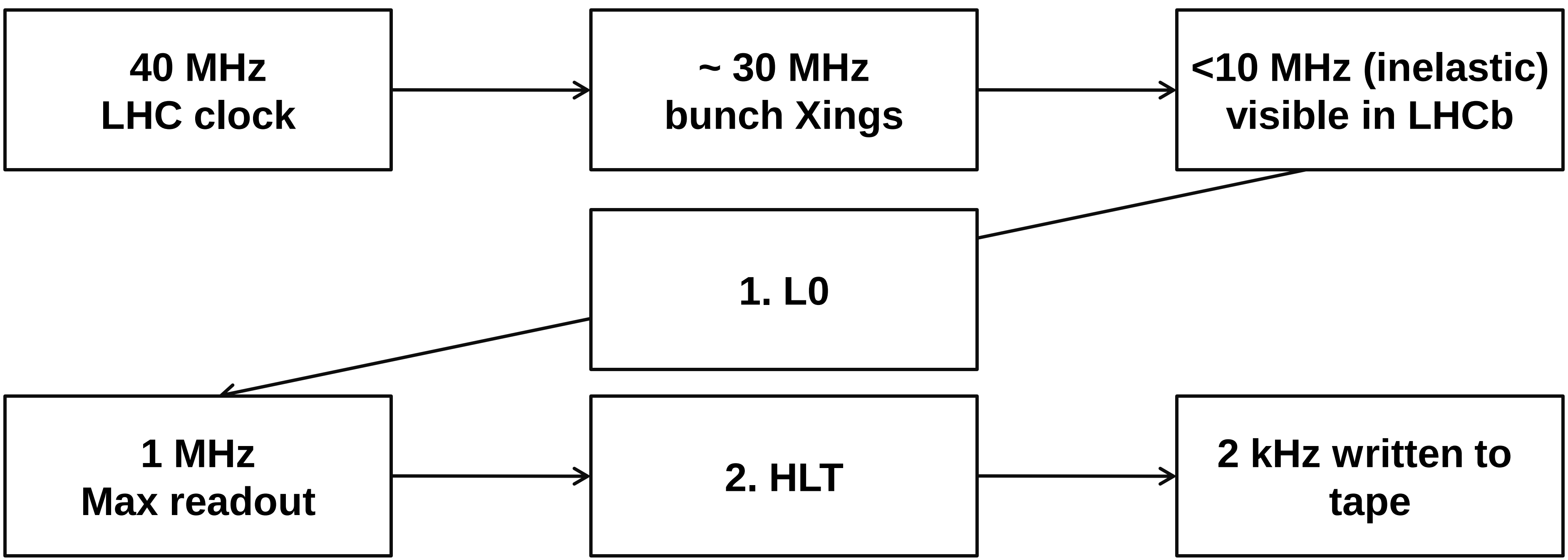
Aim of LHCb trigger

- Exploit finite lifetime & large mass of charm & beauty hadrons to distinguish heavy flavour from background in inelastic pp scattering
- Aim of trigger is to reject not interesting events as soon as possible
- Assume LHCb design luminosity $2*10^{32}$ $cm^{-2}s^{-1}$



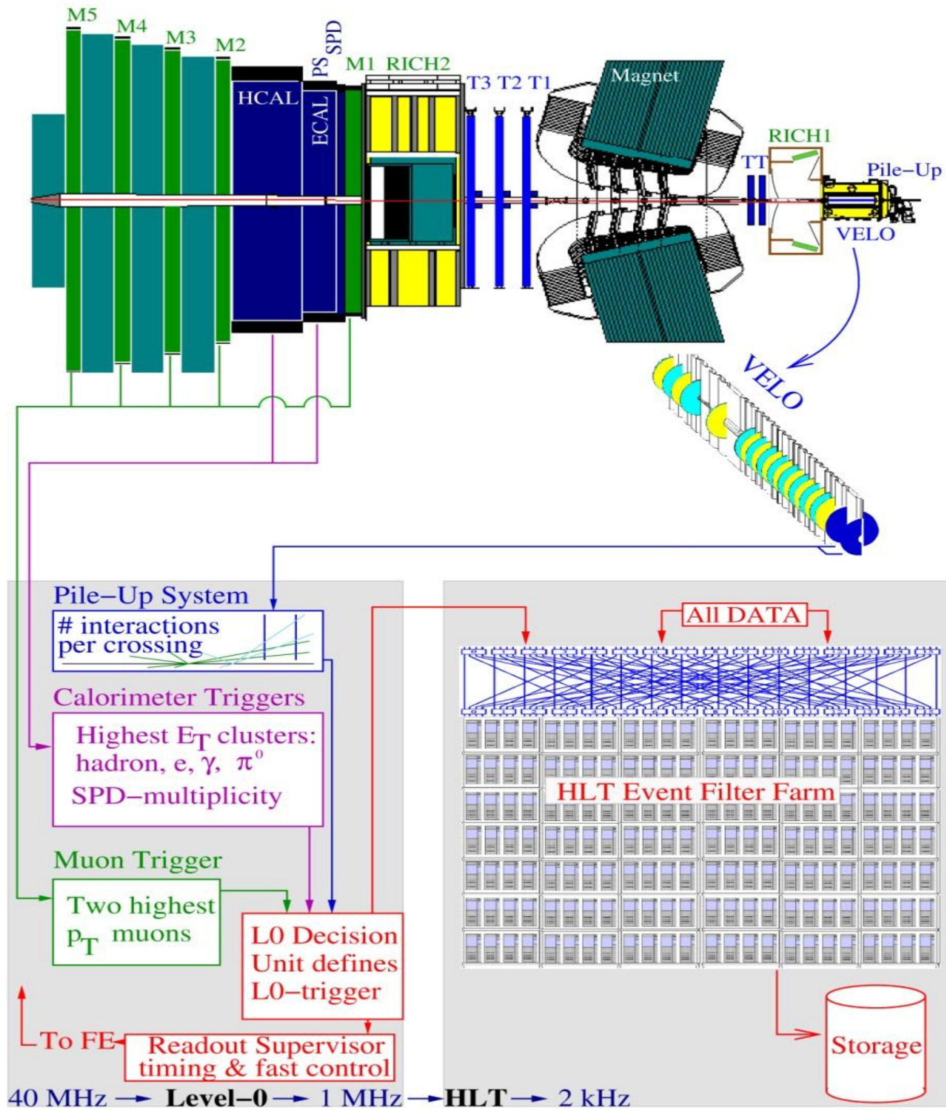
Structure of trigger

1. L0 is implemented in hardware. It reduces the visible (2 tracks in detector acceptance) interaction rate to a maximum of 1 MHz (nominal rate into LHCb)
2. HLT is a C++ application running on an Event Filter Farm composed of several thousand CPU nodes.

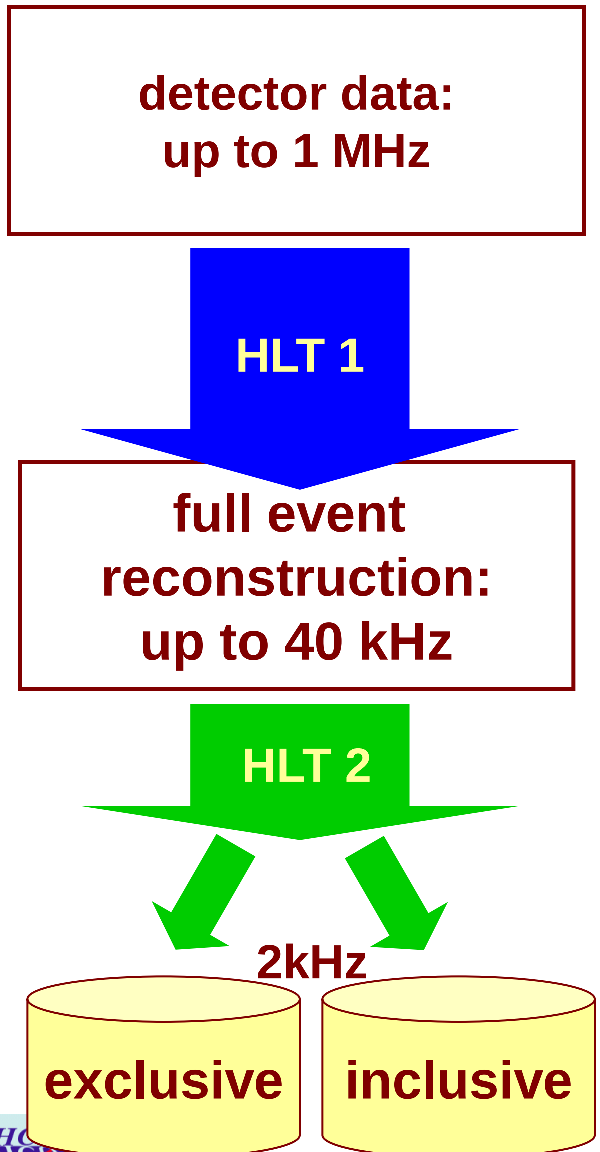


L0 trigger

- **Highest $E_T^{\text{hadron}} \geq 3.5$, $E_T^{e,\gamma,\pi^0} \geq 2.5$ GeV clusters in Calorimeters**
- **Highest $p_T^{\mu,\mu\mu} \geq 1$ GeV muons, in Muon Chambers**



HLT Trigger



- ## HLT first level (HLT1):
  - confirm L0 decision using tracking system
  - reconstruction in region of interest
  - trigger on simple signatures (pt, IP, ..)

  → increase fraction of ccbar and bbbar

- ## HLT second level (HLT2):
  - Use full detector information to produce a mixture of inclusive and exclusive channels

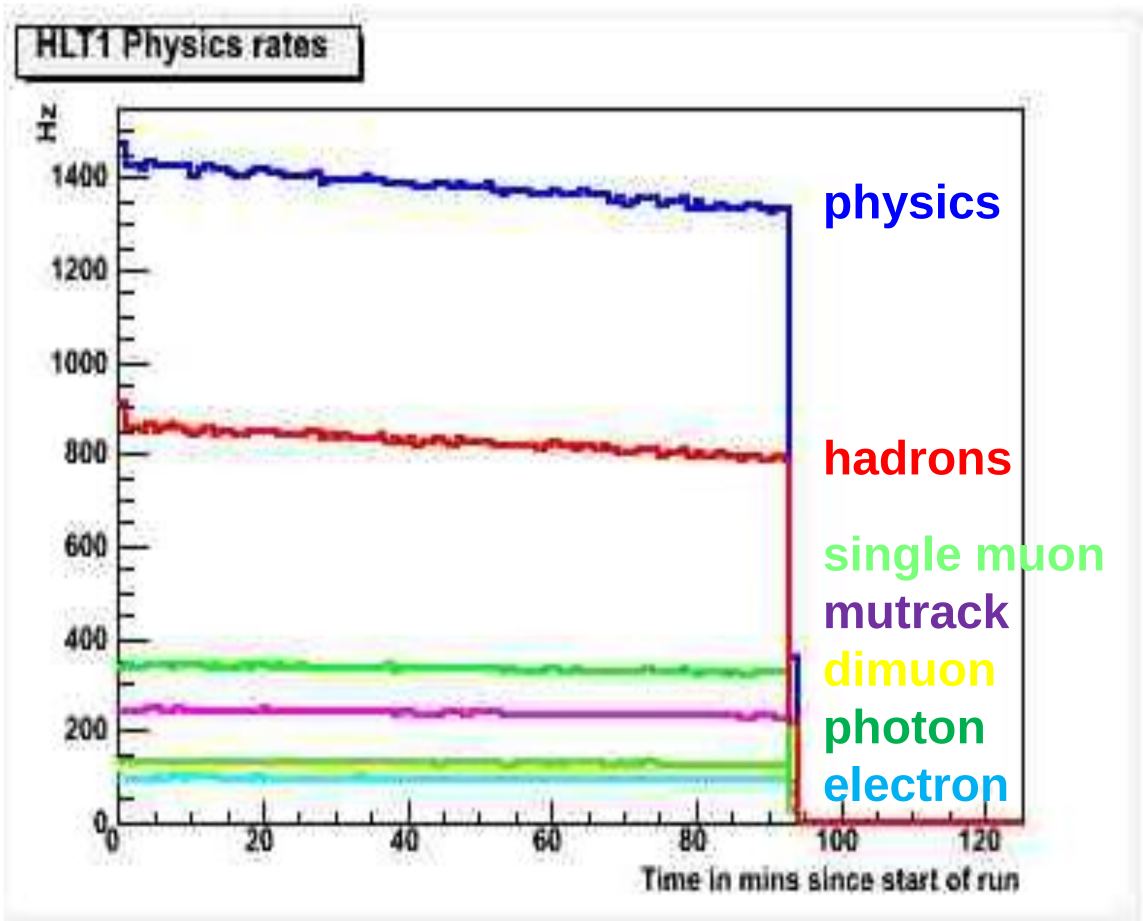
  → selection of interesting ccbar, bbbar and other

Commissioning

- L0 used cosmics to commission; running smoothly from day 1 last year
- HLT: prepare/test offline using MC and also new "unbiased" data
- Inject MC and real data into EFF to test new online versions of HLT
- Benchmarks:
  - Configuration time
  - Time per event
  - HLT1 & 2 rejection rates
- If all ok, put new version in production

Monitoring

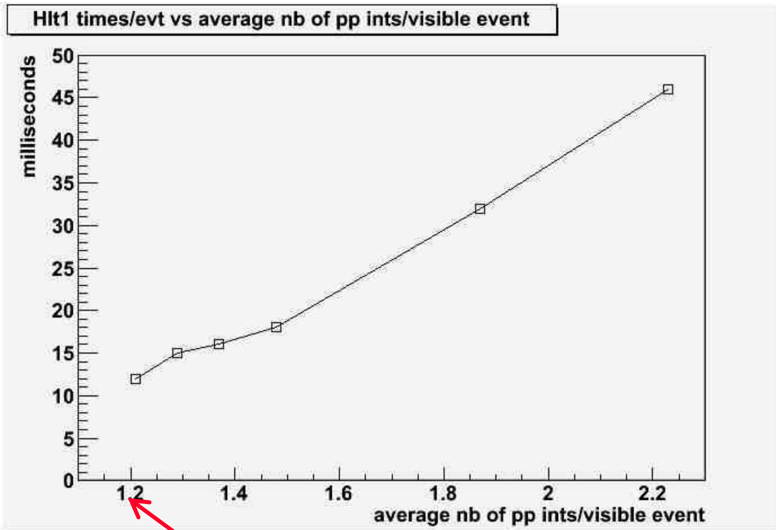
- HLT/L0 rate trend plots, e.g.

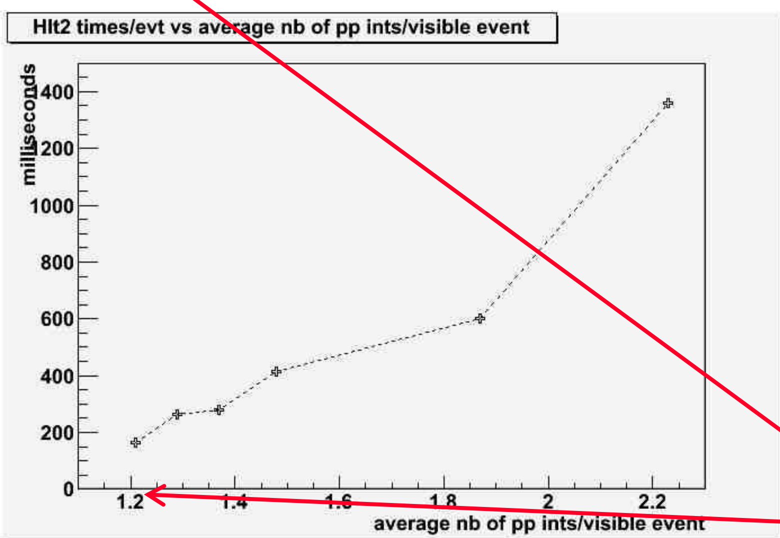


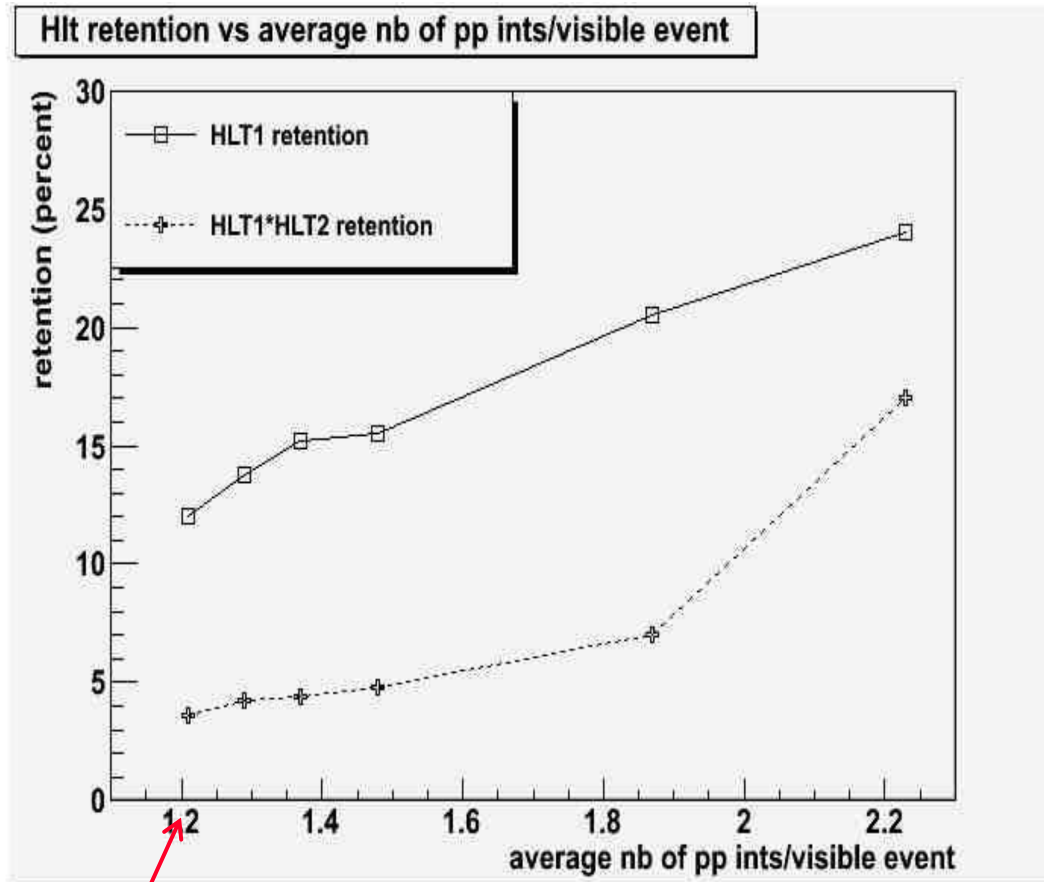
Experience with early data taking

- Running conditions: factor 100 lower than design luminosity
- Relaxed cuts for efficiency, maximizing charm while exploiting 2kHz output rate
- However, increased luminosity per bunch due to lower β^* (3.5 m instead of 10 m) means we have a higher average number of pp interactions per visible event (1.5 instead of 1.2, but we even saw 2.3)
- CPU increases dramatically

HLT1 & 2 times/evt and retention rates



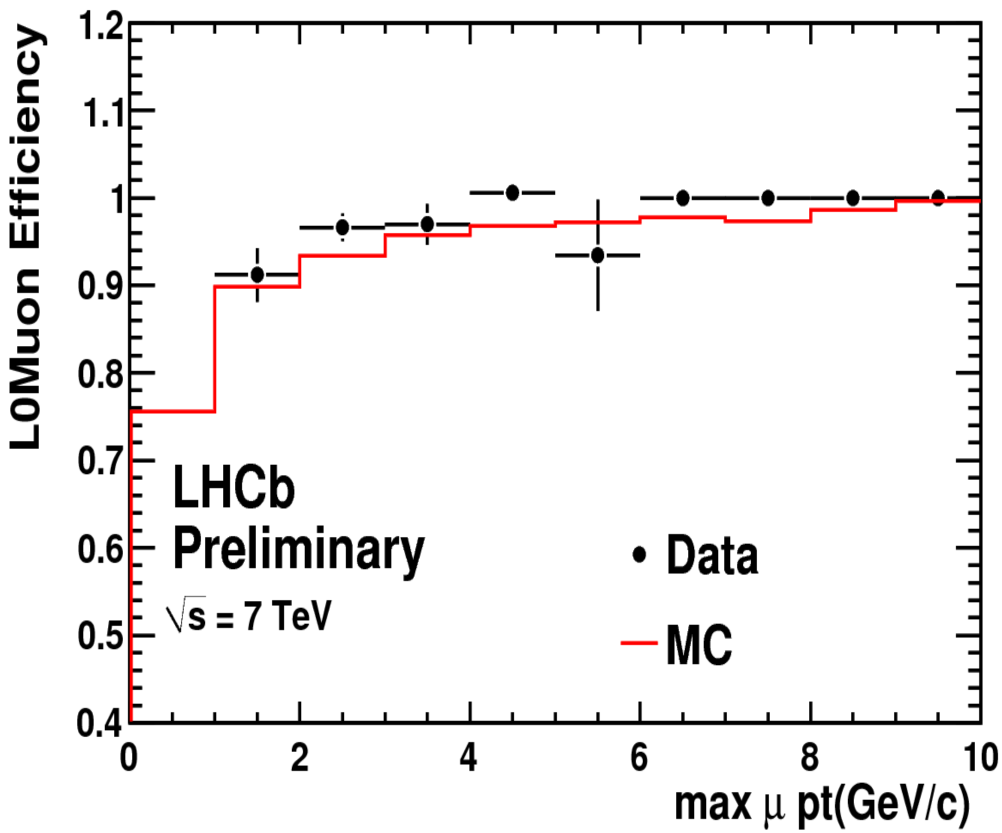




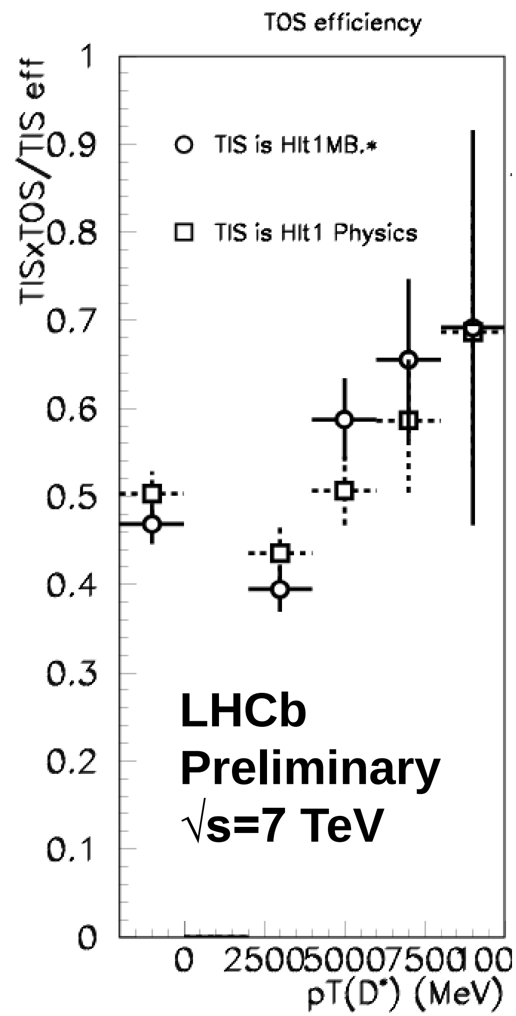
nominal running conditions with relaxed cuts

Trigger performance

L0 Muon trigger efficiency to select J/ Ψ events as a function of p_T of the muon coming from J/Ψ



HLT efficiency in D^{*+} p_t



Conclusions

- **The full trigger is operational in the experiment**
- **Efficiencies are as expected**
- **At low luminosity we are running with much relaxed thresholds, and quickly adapting to more challenging than nominal conditions**
  - **higher average # of pp ints/visible event**

Backup slides

Trigger Configuration Key (TCK)

- Allows selecting and keeping track of trigger conditions of data
- A running HLT job can change to a new TCK (in the same family) on the fly (“fast run change”)
- Can follow luminosity evolution, lower thresholds without reloading code in the Event Filter Farm

Operational constraints

- **Storage:**
  - Nominal design conditions (ave pp ints/vis xing = 1.2)
  - L0 accept rate: 1 MHz. Evt size: 35 kb. HLT accept rate: 2 kHz. Thru-put to storage: 70 MB/s.
  - Now (13/7/2010) higher pileup makes events bigger:
  - For 12b_8_8_8 bunches, L0 rate: 53 kHz, ave pp ints/vis xing 1.5. HLT rate 1.9 kHz, evt size 52 kb, thru-put to storage: 100 MB/s.
  - Theoretical limit: 500 MB/s
- **CPU:**
  - L0 rate 60 kHz: current (=1/5 of final) farm can handle 73 ms/evt. With current ave pp ints/vis xing (1.5, 50 kHz) : 45 msec/evt.
  - CPU usage increases exponentially with higher pileup and L0 rate
  - Complete (increase factor 5 in power) planned for november