# LHCb Upgrade Overview

ALICE, ATLAS, CMS & LHCb joint workshop on DAQ
Château de Bossey
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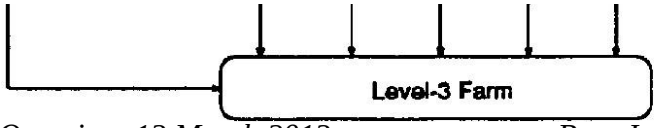
# Overview

- A little bit of Archaeology
  - The evolution of the LHCb DAQ system with time
- Upgrade motivation
  - More data
  - Trigger efficiencies
- The System after Upgrade

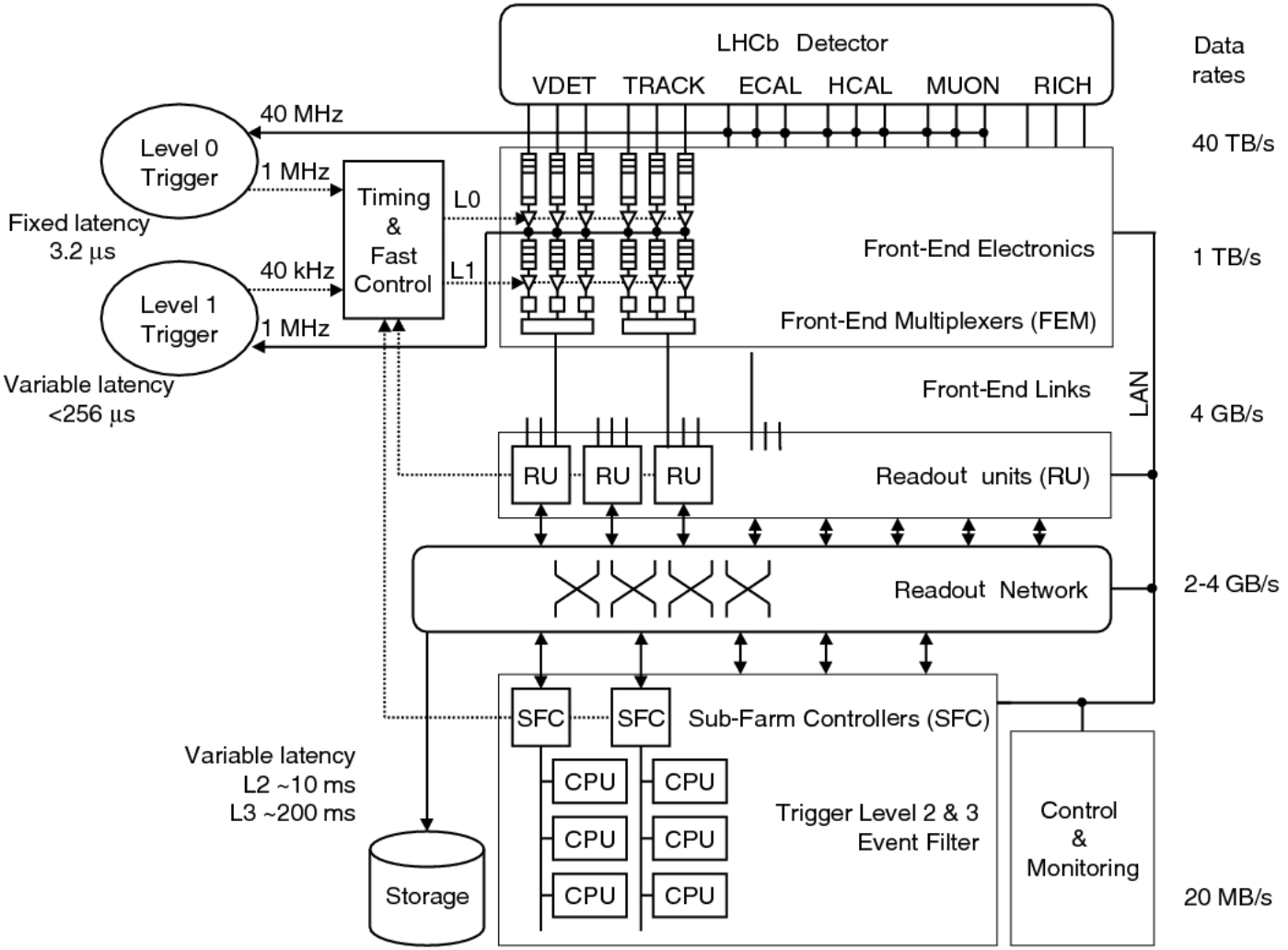
# Archaeology – LoI (1996)

Several switching network implementations are, or will be, available in time for the running of LHC-B. These possibilities range from ring structures such as SCI[6] or Quickring to switching fabrics such as ATM or the InMos C104 to a network of DSPs ('C40s or AMD21060s) connected via their data-links. All of these switch implementations are driven by commercial applications and are developing rapidly. This assures us that a scalable, cost-effective solution can be found for LHC-B.

Somewhat Cute…

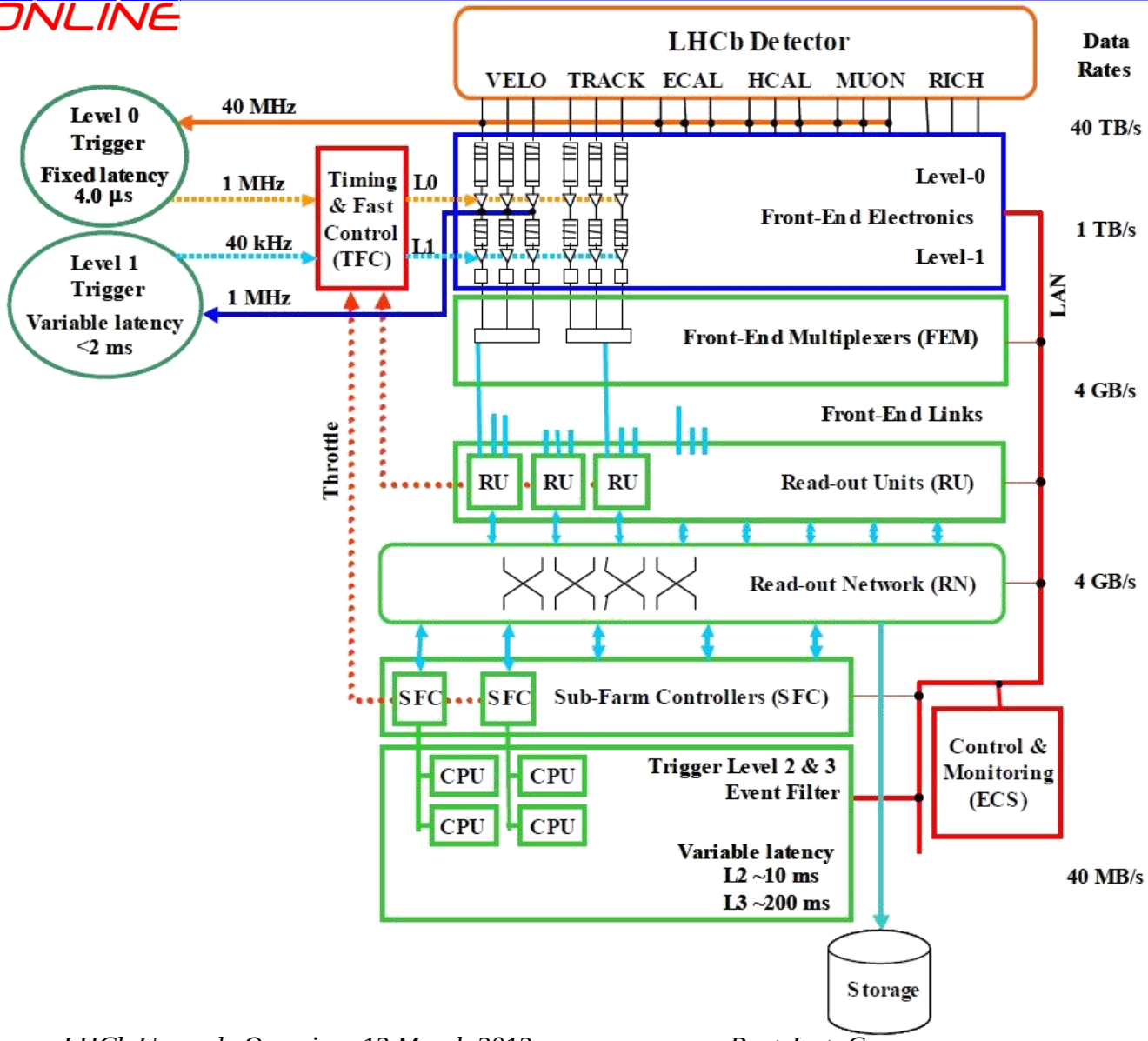


# Archaeology – Techn. Proposal (1998)



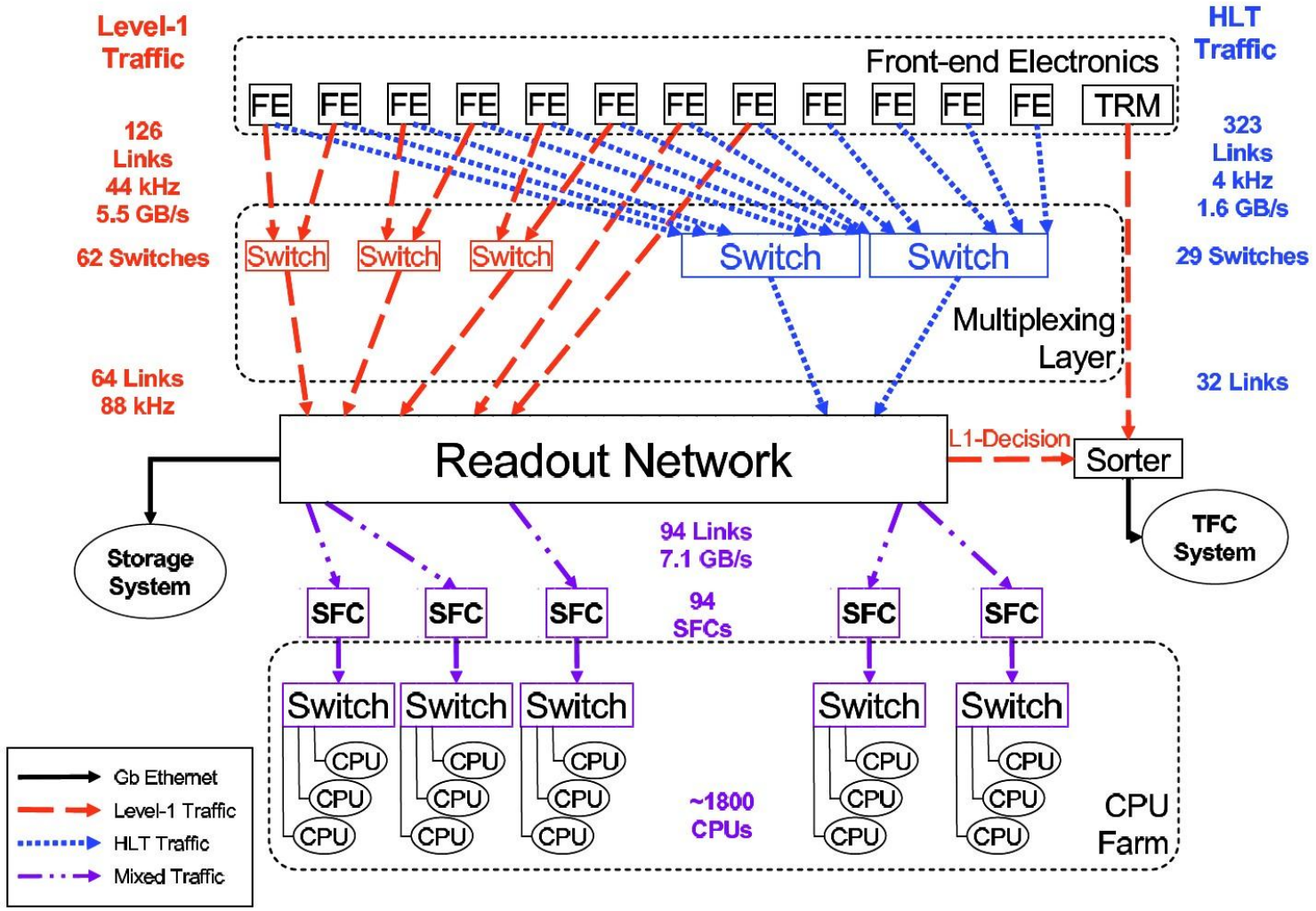

Still two protocols (Full readout/push vs. Phased Readout/pull)

# Archaeology – Online TDR (2001)



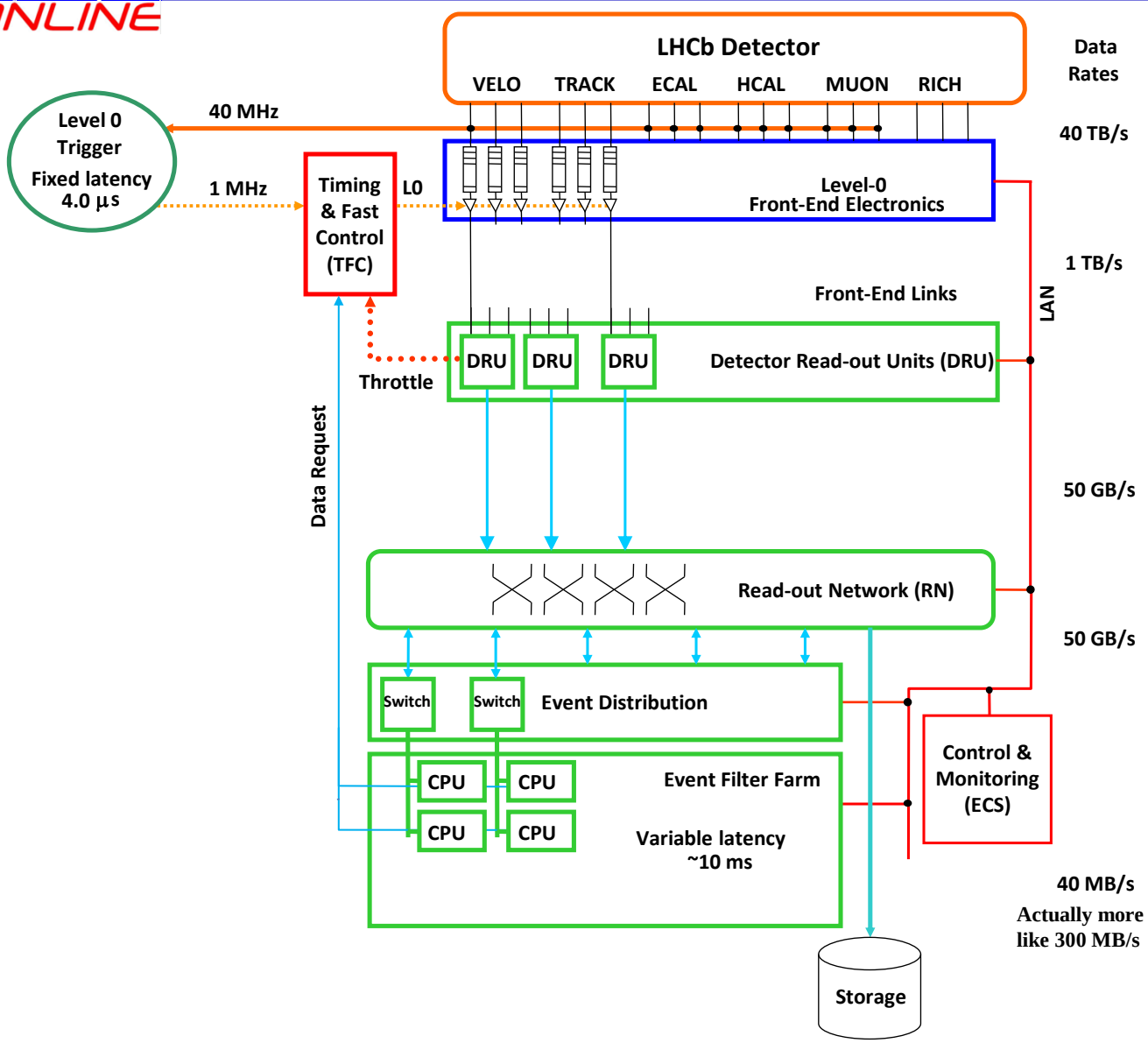

Level-1 Trigger physically a separate entity

# Archaeology – Trigger TDR (2003)




Level-1 Trigger integrated in the Overall HLT framework. Still logically a separate entity

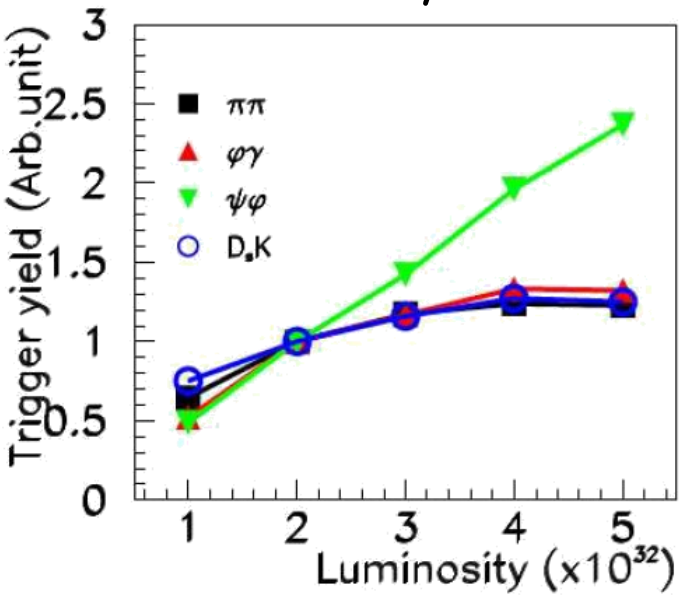
# Archaeology – The final design (2005)




Level-1 Trigger eliminated as a distinct entity.
The ultimate simplicity.
All data read out at hardware trigger speed.
1MHz Readout.

# Why upgrade??

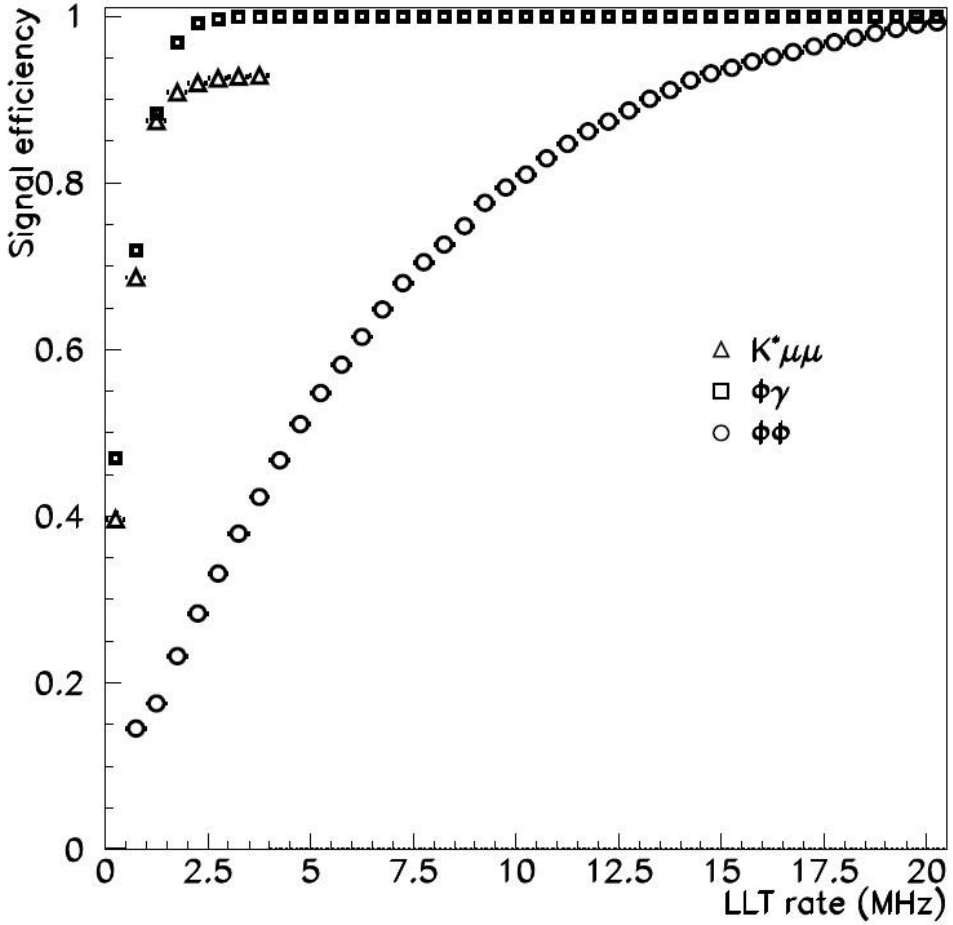
- After LS2 we want more data (factor ~10) of same or better quality i.e. more signal events
  - Need to run at higher luminosity (currently $4 \cdot 10^{32}$ cm$^{-2} \cdot$s$^{-1}$)
  - Aim is to operate at luminosity of $10\text{-}20 \cdot 10^{32}$ cm$^{-2} \cdot$s$^{-1}$
  - BUT




  - Thus, increasing the luminosity (keeping the trigger rate at 1 MHz) doesn't help the hadron channels

→ need to increase the L0 trigger rate

# What trigger rate for upgrade?




- ~20 MHz seems sufficient
- interaction rate 30 MHz
- Bunch crossing rate 40 MHz
- → design for 40 MHz (maximum) to stop all discussions

# 40 MHz Readout – Implications

- New front-end electronics (Readout chips) for (almost) all detectors
  - Basically only detectors involved in the trigger have to change to a lesser degree (basically modernisation)
- To limit number of data links from detector to event building, Zero suppression has to happen at/near the detector
- 40 times more trigger rate → 40 times more data rate (after ZS)
  - Big challenge for readout network
  - Assuming event size 100 kB → 4 TB/s aggregate bandwidth
    - Actually: as only 30 MHz interaction rate → ~3 TB/s
  - ~40 more CPU power needed (compared to now)
- To cope with (prob.) staged farm installation need a LLT (Low-Level Trigger)
  - Similar to current L0 trigger, but with relaxed cuts to adjust for available CPU power

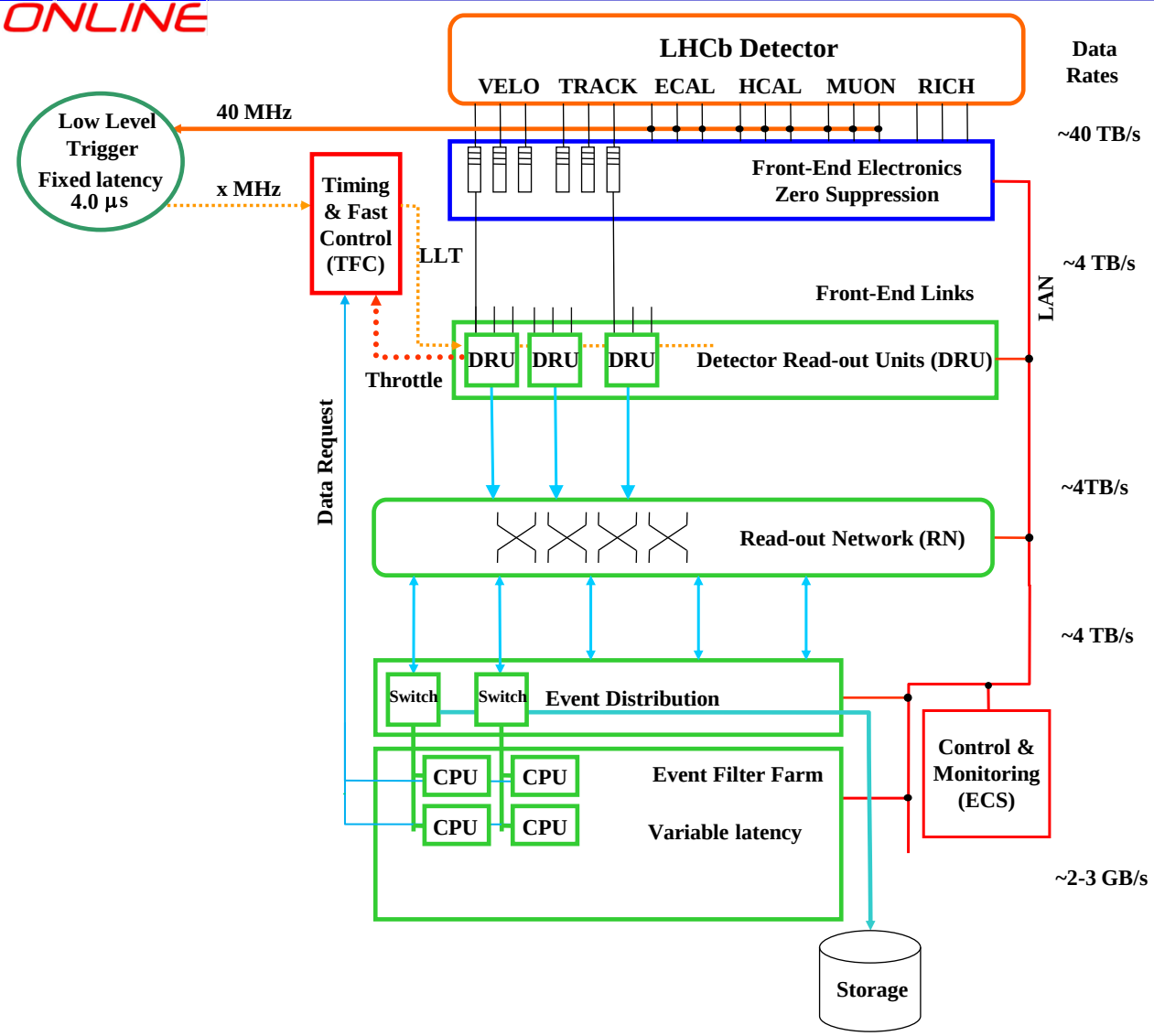
# Mitigation of the challenges

- Minimize Number of readout links
  - Zero suppression at detector
    - Rad tolerant/hard FPGAs to implement the necessary algorithms
  - Faster readout links
    - Currently GOL (1.6 Gb/s) → GBT (3.x Gb/s)
    - Helps reducing number of links (estimated ~12000)

    →new receiver card aggregating the detector links and interfaces to the DAQ
- Readout Network Bandwidth
  - Faster link technology
    - Currently GbEthernet → 10/40/100 GbEthernet or 56 GbInfiniband
    - Main questions
      - Port density in switches/routers
      - Buffering capabilities in switches/routers

    → which data transfer protocols?
- CPU power
  - Total need typically factor 30-40 more
    - Factor ~10 Moore's law
    - Factor 3-4 more boxes
- Low-Level Trigger
  - Basically re-use the current trigger system with thresholds adapted to the rate desired
- New TFC (TTC→GBT)
- New interfaces (GBT) for Controls and Monitoring of FE Electronics

# The System after LS2




- Only a very high-level architectural picture
- Still hope to keep a simple data transfer protocol

# Summary

- The upgrade of the LHCb Online system is driven by the physics request for more/better quality data
  - Limitation is hardware trigger at given max. readout rate
- The 40 MHz readout is a natural evolution of the system, but implies a lot of work/money
  - ZS at detector
  - Faster links
  - New readout Boards
  - Bigger network
  - Bigger farm
- In general, as always, time is on our side ☺…