# Level 3 Trigger: The story so far
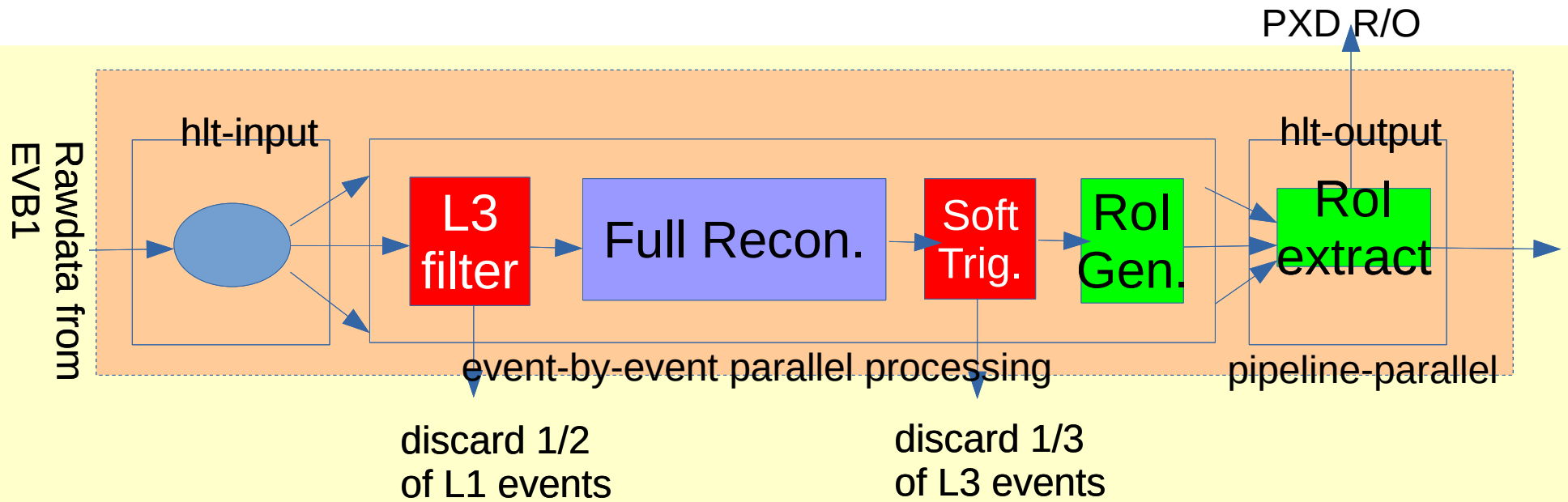
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1. Introduction

- Background event reduction before the HLT full reconstruction
  using the fast tracking + ECL clustring
  was planned in the original design of HLT so as to reduce
  the total CPU consumption for the cost reduction.
    -> Level 3 trigger

- In our experience in the former Belle experiment, ~50%
  reduction of background reduction was achieved by applying
    * track cut ($|z| < 15cm$ (?))
    * ECL energy sum > 1GeV

- The tracking/clustering was done using special codes which
  run faster than that in the usual reconstruction.
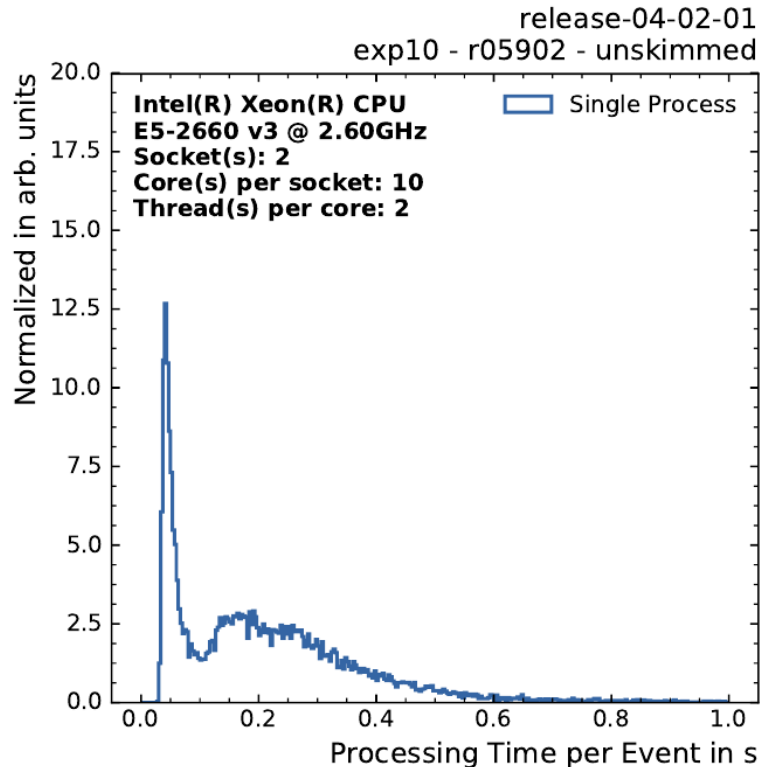
- Ave. time is > 0.3 sec./event/core.

- To manage 30kHz, one event must be processed in 0.000033 sec.

  => Needs large scale parallel processing with a granularity of O(10000).

- The required number of cores in HLT is estimated based on
  the experience of RFARM in Belle where a full event reconstruction
  was performed using the same offline software for all the events
  in real time.

- The estimated number of cores required at t=0 (L=2×10^{35}; 1/4 of full L)
   is 1400. One HLT unit is equipped with 320 and we will prepare 5
  units for t=0, 1600 cores.

- We will gradually add HLT units to keep up with the luminosity
  improvement. -> 6400 cores in total for the full luminosity.

- The requirement to the average processing time per core per event
  is about 0.33 sec(3Hz/core). It is the average time for all event types.

- Belle's experience shows the processing time for a hadronic event
  is around 1 sec. while 1/10 for other types of events.
      -> Average processing time was less than 0.3 sec / core
          considering the cross section and L1 trigger selection.

PXD R/O

Rawdata from EVB1

hlt-input

L3 filter

Full Recon.

Soft Trig.

RoI Gen.

hlt-output

RoI extract

event-by-event parallel processing

pipeline-parallel

discard 1/2 of L1 events

discard 1/3 of L3 events

* 1/2 rate reduction with "Level 3" filter
   - Based on fast CDC tracking + ECL clustering.
   - Cut in the track |z| position and ECL energy sum
* Full event reconstruction using all detector signals except PXD
* Software trigger using physics event skim codes
  (Hadronic/tau event selection....) + Monitor trigger
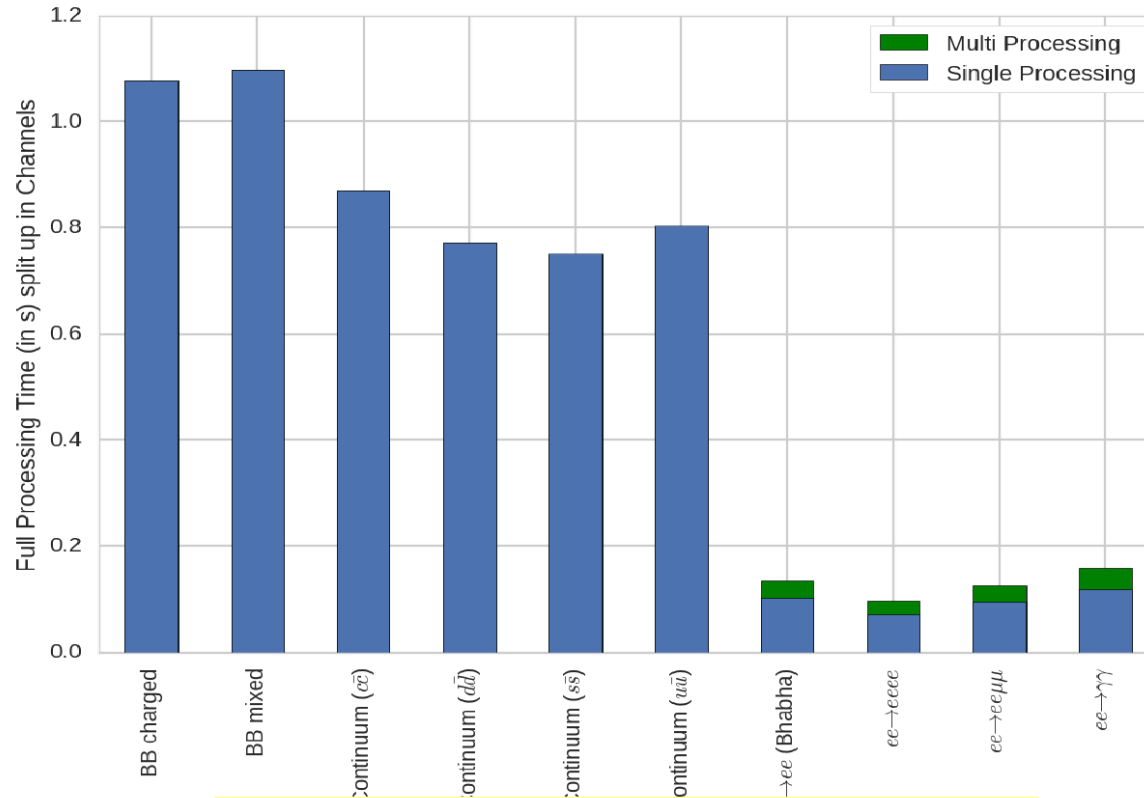
HLT Software Trigger Scheme (Level 3 vs. FastReco)

Scheme 1

30 kHz → **Level3 CDC+ECL** → 15 kHz → **Offline Rec. all detectors w/o PXD** → **Physics Trigger** → 10 kHz

Kakuno Hidekazu   Chunhua Li

Scheme 2

FastReco (Offline Rec. CDC+ECL) → **Offline Rec. the rest detectors** → **Physics Trigger**
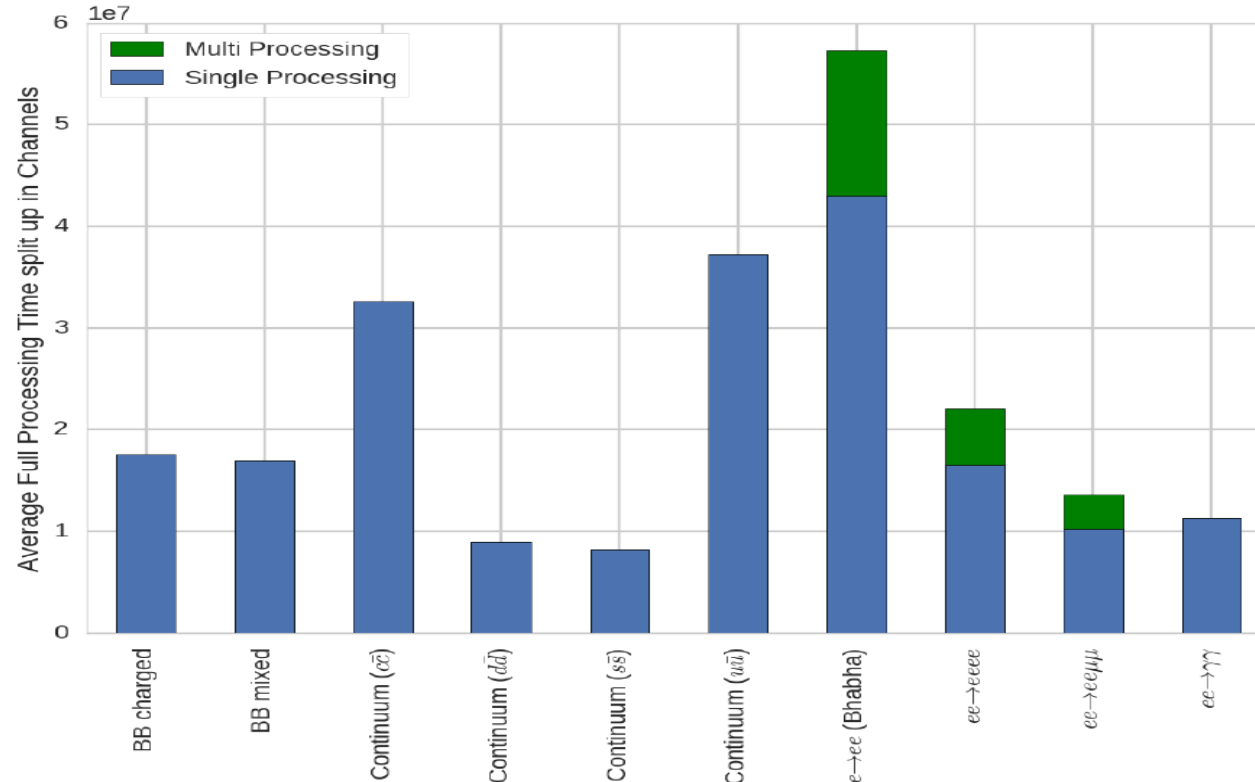
Nils Braun
Thomas Hauth   Chunhua Li

Measured processing time/core/event on HLT processing node

~ 1sec for hadronic events
~ 0.1 sec for low multiplicity events
        <= They are just as expected.

Processing time normalized by cross section+trigger rate of each channel

Thomas Hauth

* BG is not considered.

Taking into account the non-perfect scaling of low-multiplicity events, the average processing time is **0.24 s** (which correspond to a maximal rate of 26 kHz after Level1).
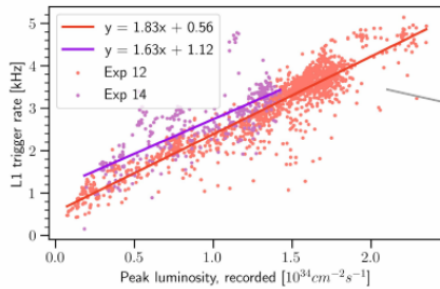
The time satisfies the requirement of <0.33 sec.

- However, one worry arises that the fast event selection using only CDC and ECL can introduce another systematics in the final physics selection (especially in the rare decay physics such as the dark matter search.)

- At the beginning of the experiment, the HLT processing power is enough to run full event reconstruction w/o L3 or FastReco (even without HLT selection = beam-reco-monitor).

- The HLT operation without L3 or FastReco has been kept so far until now (although HLT selection was turned on).

- Meanwhile, the effort to reduce the HLT processing time w/o L3/FastReco has been done.
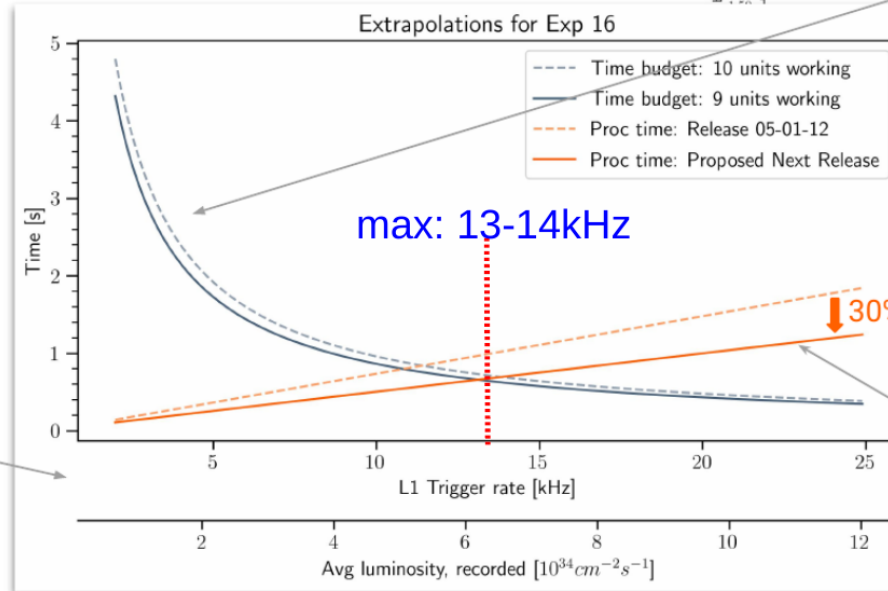

V.S.Vobbilisetti (IJCLab)
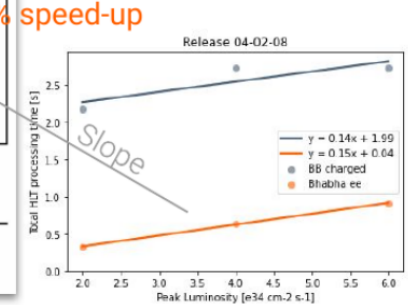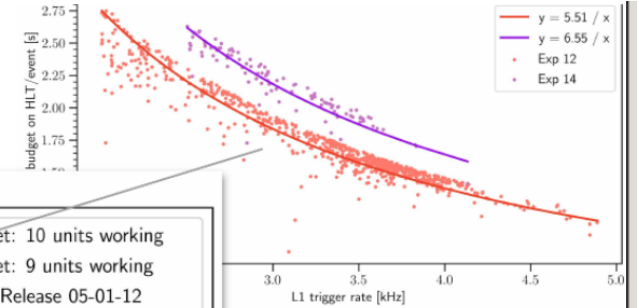
Estimates for 2021 a/b

- 2020 winter upgrade is included
- 9 out of 10 units working
- # processes is full, i.e., no out of memory problem
- No hardware under-performance (10% observed in Exp 14)

max: 13-14kHz

30% speed-up

Extrapolations for Exp 16

Time budget: 10 units working
Time budget: 9 units working
Proc time: Release 05-01-12
Proc time: Proposed Next Release

f the L1 trigger menu stays the same.

Should be safe for 2021 a/b

Generated samples at different luminosity (background conditions) to extrapolate processing time growth

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- However, the improvement is just for the current trigger condition.

- When the trigger rate drastically increases with the higher luminosity, it might be impossible to speed up the processing time only by this effort.

- Effort for trigger rate reduction = trigger tightening is necessary.

- As a part of the effort, re-implementation of Level3/FastReco might be necessary.

- Level 3 filtering is basically the same as what we expect for CDC 3-D trigger + ECL energy sum trigger, that can be managed in Level1 trigger.

- If such hardware trigger works as expected, it effectively behaves just like Level 3 trigger, and we don't need to implement the code in HLT processing.

-> What is the status of 3-D trigger?