L1 Trigger

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@
TRG/DAQ Workshop in Yonsei Univ.

TRG : Requirements and Strategy

- **Requirements (☑ = ok, □ = under study or unknown)**
  - ☑ **High efficiency** — **almost 100% for Upsilon 4S events**
    - No dead-time -> pipeline
    - Redundant and independent TRG logics -> 3 main TRG
  - □ **Max. average rate** — **30 kHz @ 8×10^{35} $cm^{-2}s^{-1}$**
    - Limited by DAQ
    - Good background reduction necessary
    - Flexible TRG logics to manage BG rates
    - Low level event reconstruction to identify BG
  - ☑ **Latency** — **4.400 usec**
    - Limit from SVD front-end
  - ☑ **Timing precision** — **less than 10 nsec**
    - Request from SVD front-end
  - □ **Event separation** — **200 nsec**
    - Request from DAQ
- **Belle-I triggering scheme is employed again**
  - Sub-Triggers + Global Decision Logic
  - Basic scheme is same, but each component was replaced with new tech

    Data flow : parallel -> high-speed serial

    Data rate : 16 Mbps -> 190 Mbps (CDC wire case)

    Logic : hard-coded -> FPGA

    #cables and modules : O(1000) -> O(100)

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Belle-II TRG System

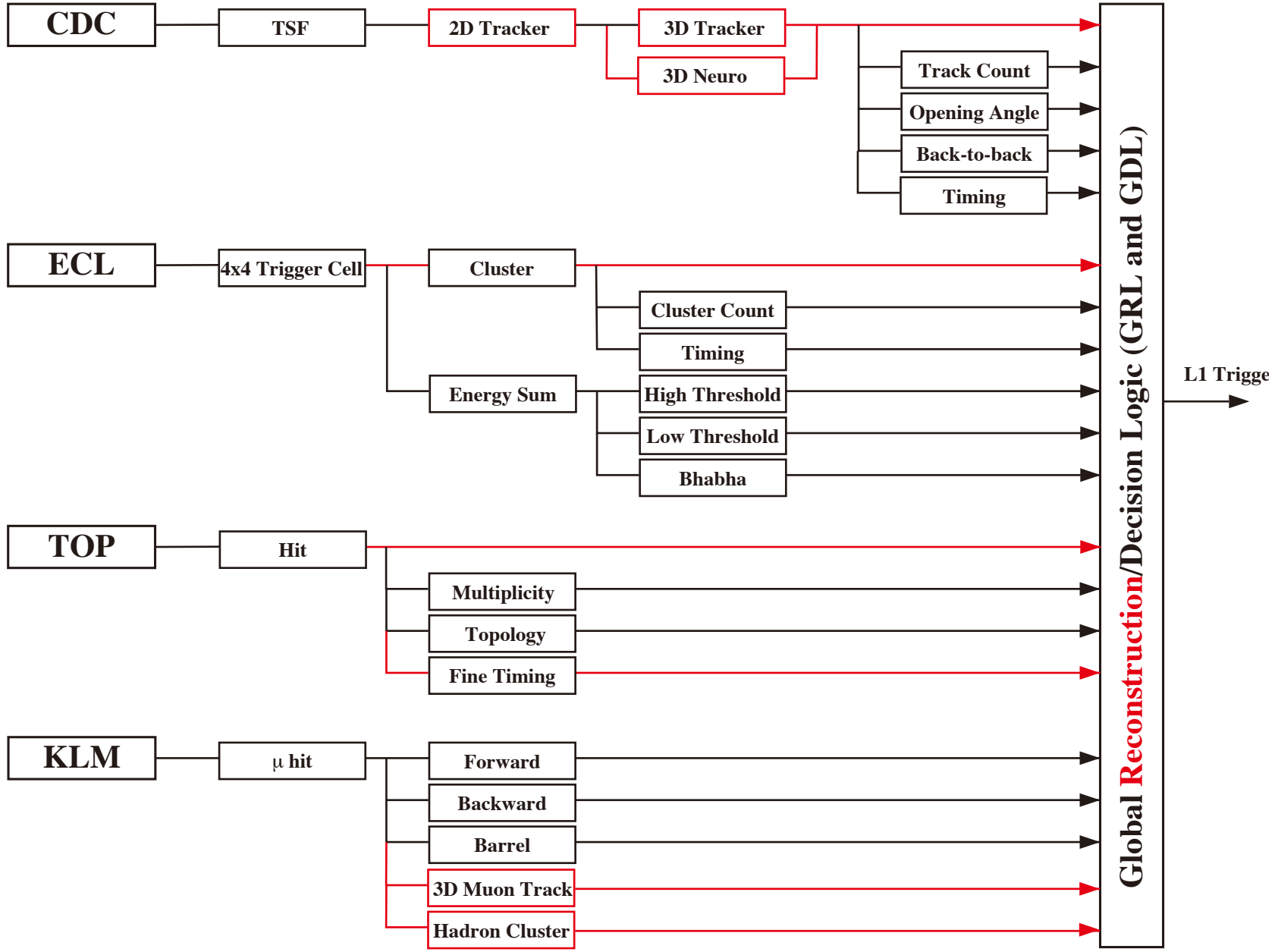
Korea U.
National Taiwan U.
Fu Jen Catholic U.
National United U.
KIT
TUM
KEK

Hanyang U.
BINP

U. Pittsburgh
U. Hawaii

Virginia Tech
U. Hawaii
Indiana U.

National Taiwan U.
KEK



New in Belle II

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Expected TRG Rates

Phase3 Lum. Record (det. on)

Process	C.S. (nb)	R@L=6.1x10^{33} (Hz)	R@L=8x10^{35} (Hz)	TRG logic
Upsilon(4S)	1.2	7	960	CDC 3trk(fff) ECL high energy(hie) ECL 4 clusters(c4)
Continuum	2.8	17	2200	
μμ	0.8	5	640	CDC 2trk(ffo) etc
ττ	0.8	5	640	
Bhabha	44	268	350 *	ECL Bhabha(bhabha, 3D bhabha)
γ-γ	2.4	15	19 *	
Two photon	13	79	10000	CDC 2trk(ffo) etc
Total	67	397	~15000	

- **PS=1 for Bhabha in Phase3**

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TRG Condition in Phase 3

- **Physics (PS=1)**
  - **ffo : 2D track > 1 & opening angle > 90° & !Bhabha**
  - **fff : 2D track > 2**
  - **hie : energy > 1 GeV & !Bhabha**
  - **c4 : isolated cluster > 3 & !Bhabha**
- **Calibrations (PS>1)**
  - **ff(PS=20), c2(PS=150), bhabha(PS=1), 3D bhabha(PS=1), many others**
- **MC background overlay**
  - **Pseudo random(1Hz), revolution(1Hz)**
  - **Delayed bhabha logic had a bug (PS=0)**
- **Triggers for the dark sector**
  - **c1 & hie/lum, c3 & hie/lum, n1 & hie/lum, n3 & hie/lum**
- **Timing decision**
  - **ECL timing only**

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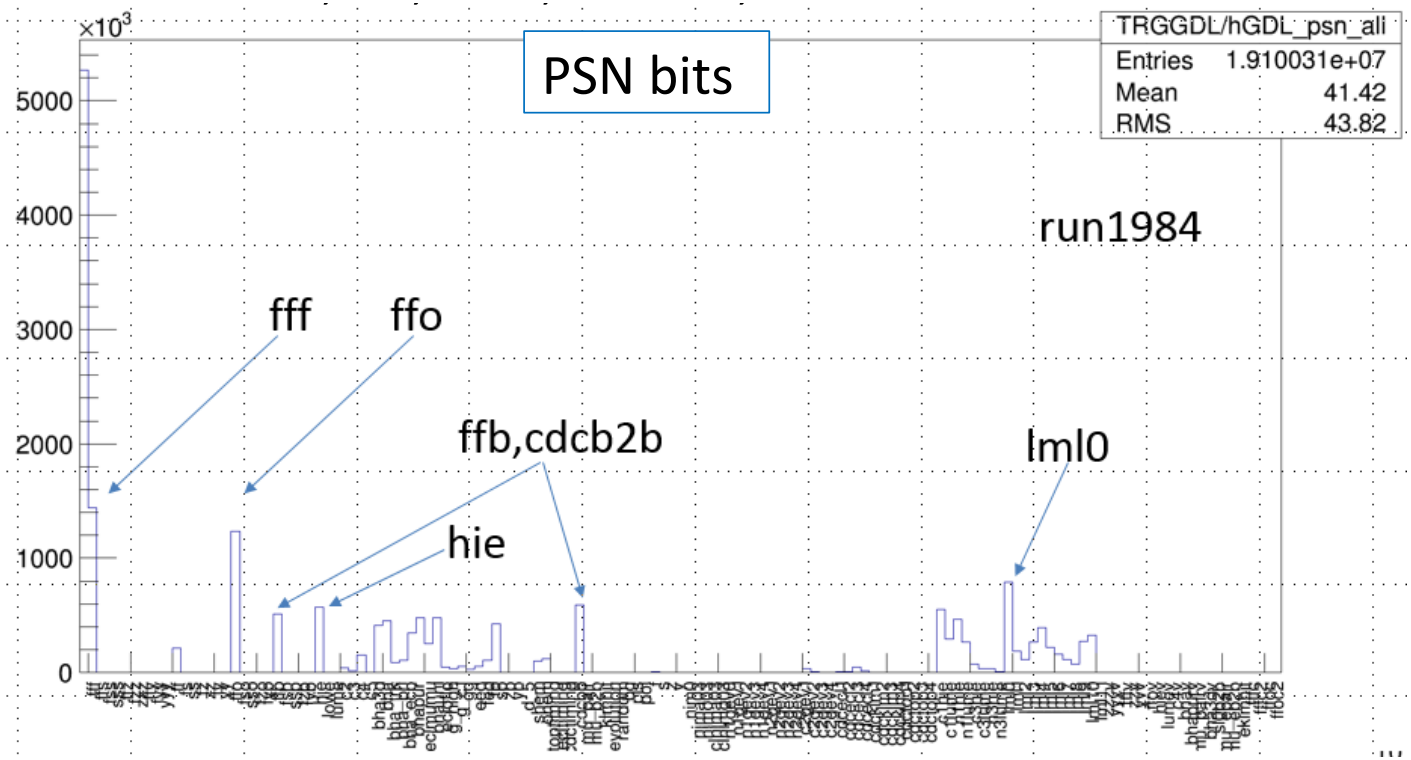
TRG Rate in Phase 3

- Beam currents : LER ~600mA, HER ~550mA
- Luminosity record : ~6 x10^{33}/cm2/s
- Average L1 rate : 2~3 kHz
- TRG condition was quite loose
  - Only ~10% of total rate were from physics
  - ~90% are from calibration triggers and beam BG



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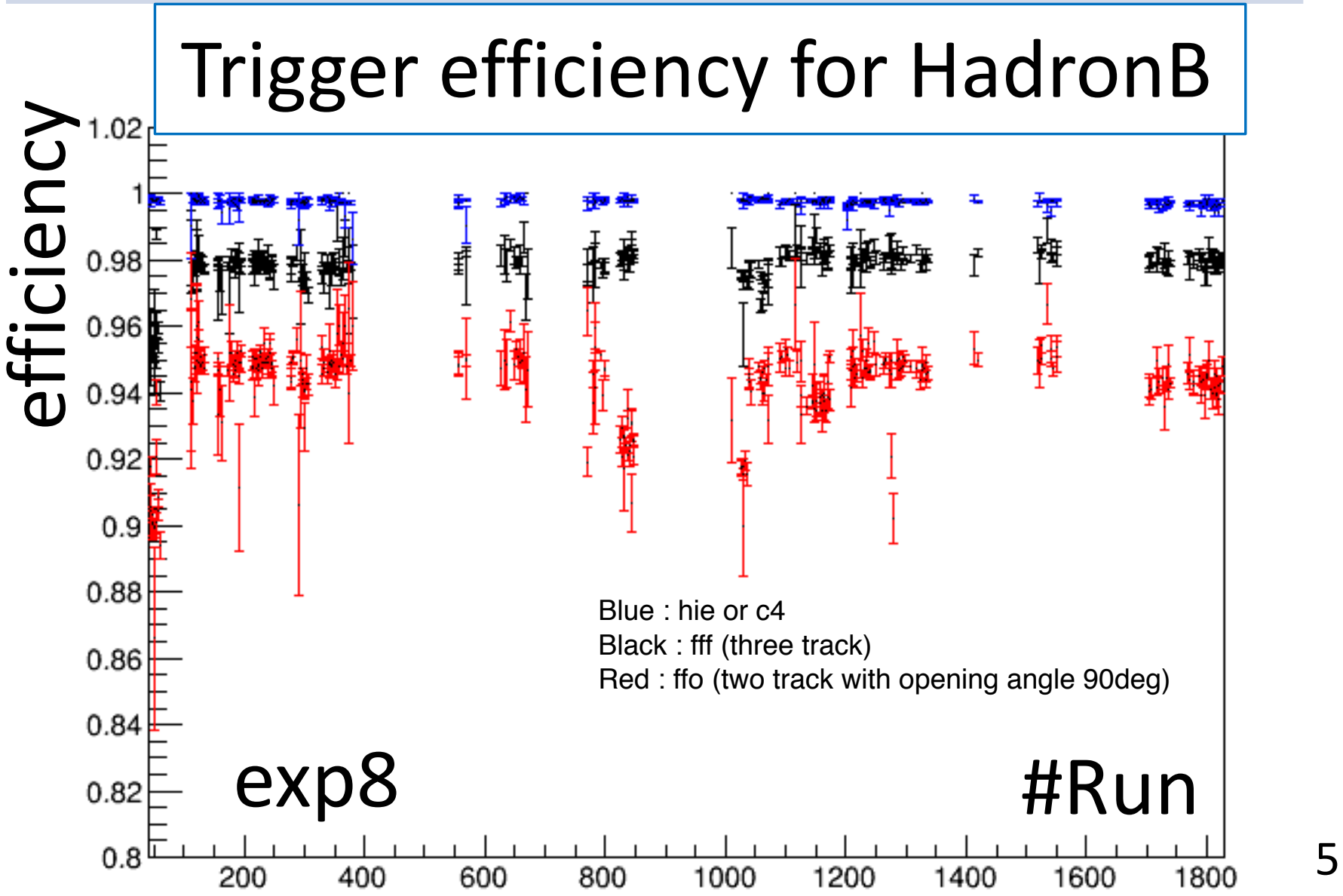
Trigger Efficiency in Hadronic Events



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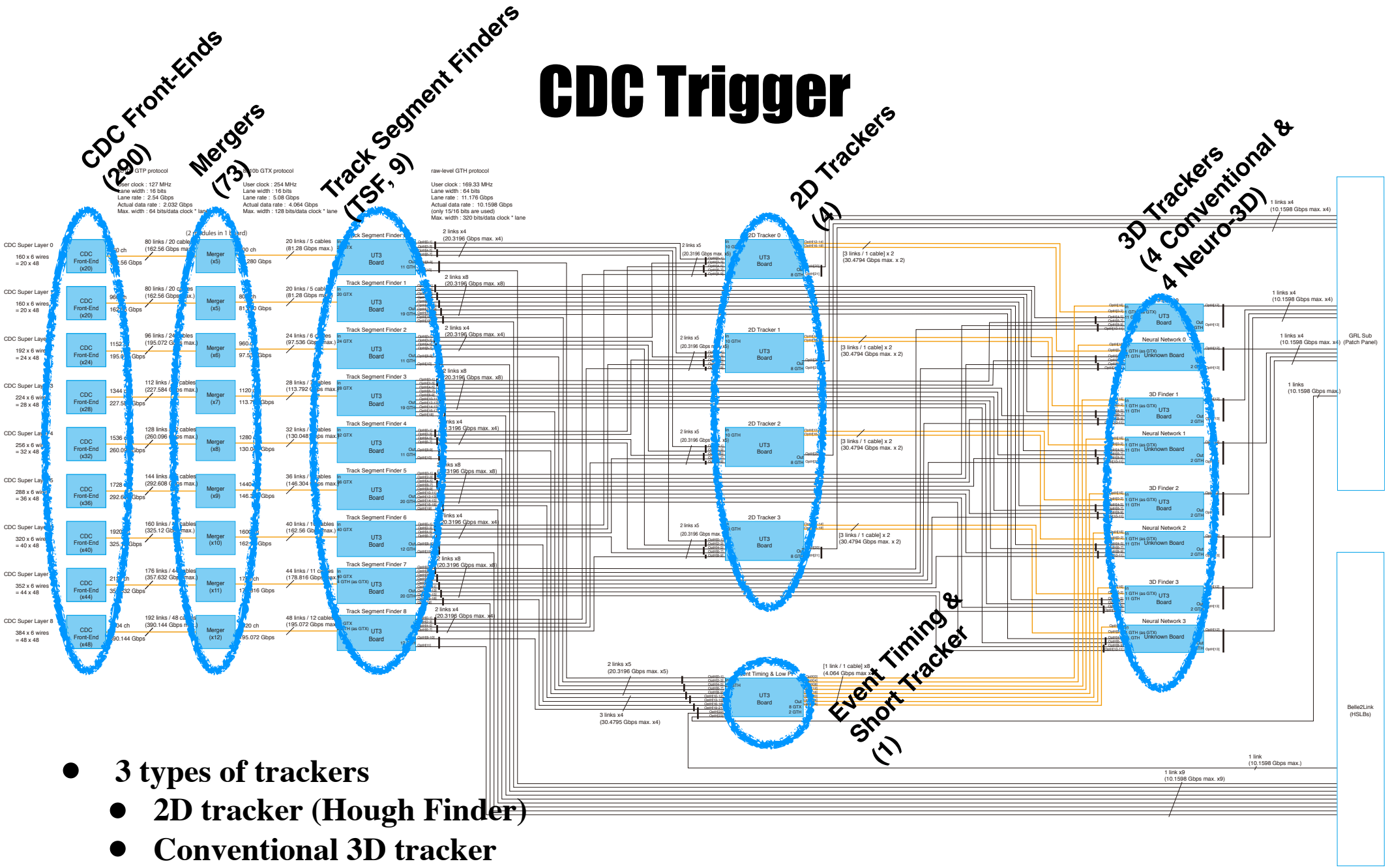
CDC Trigger



- 3 types of trackers
  - 2D tracker (Hough Finder)
  - Conventional 3D tracker
  - Neuro 3D tracker
- Tracker output (track parameters) are sent to GRL
  - GRL is a master of CDC trigger

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Issues in CDC TRG

- **Sources of high 2D rate**
  - **CDC FE cross-talks**
  - **2D track over count**
  - **Beam-gas interactions (off IP tracks)**
- **CDC FE cross-talk treatment**
  - **Possible to put ADC cuts in TRG output of FE**
  - **200 - 300 ns latency required : quite marginal in latency budget**
- **2D track over count**
  - **Possible to put logic to merge two tracks into one in near momentum space in GRL**
- **Beam-gas treatment**
  - **2D tracker is sensitive even for off-IP tracks**
  - **3D tracker is desired**
- **Event Timing Finder couldn't work with beams**
  - **Because of high hit rate of TSF**
  - **Better algorithm is necessary**

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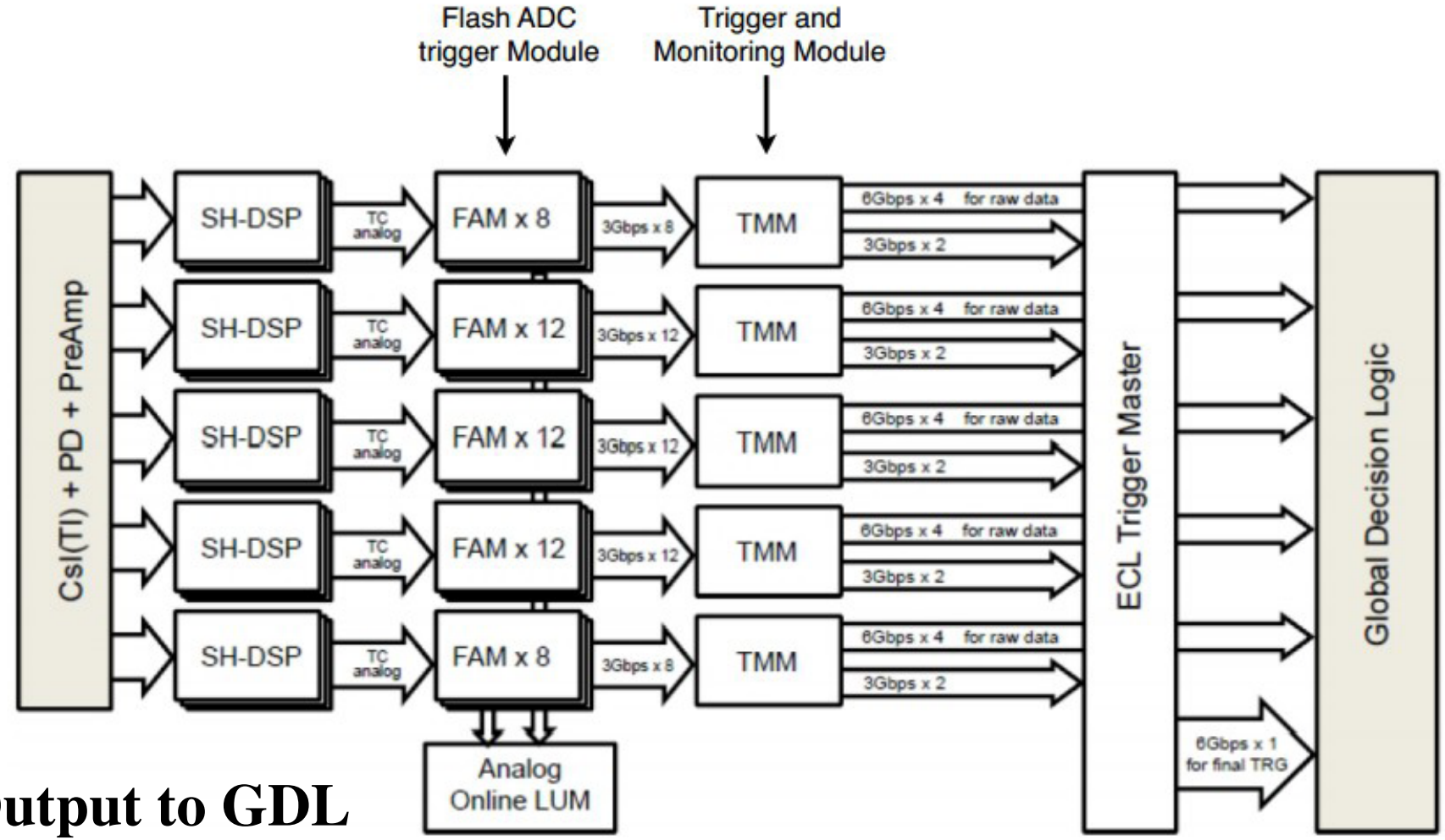
ECL Trigger



- **Output to GDL**
  - **Energy sum**
  - **Cluster info. with energy and position (6 clusters at most)**
  - **Bhabha (Belle-I type and 3D)**
  - **Event timing**
  - **Low-multi. related bits**

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Issues in ECL TRG

- **Designed logics were implemented already**
  - **3D Bhabha, low multiplicity bits, etc**
- **Timing precision is worse than expected**
  - **Careful calibration is necessary to improve**
- **Healthiness of present logic with high currents is unknown**

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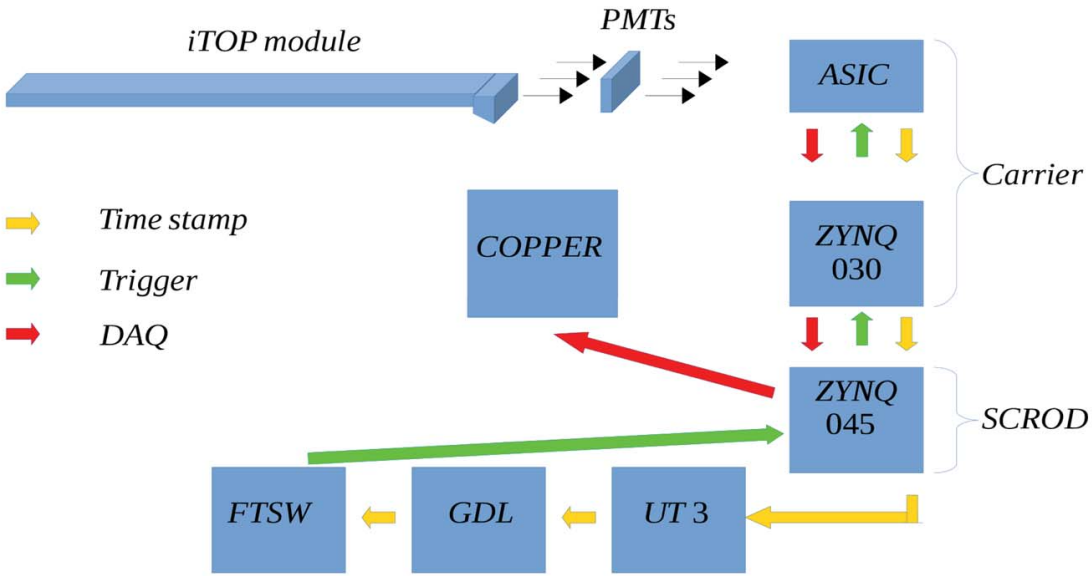
TOP TRG and Issues



- **TOP trigger is necessary to get good event timing**
- **However, performance of provided event timing was not good**
  - **Efficiency was low**
  - **Timing resolution was not good as expected**
- **Operation was stable**
- **Logic improvement is necessary**

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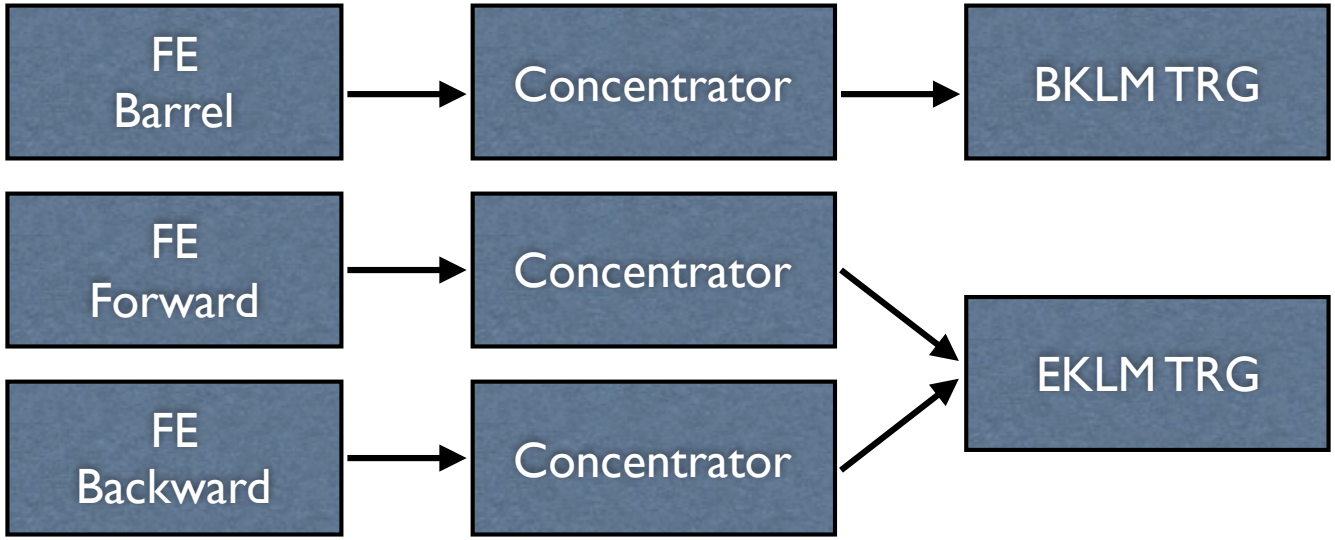
KLM Trigger and Issues



- **KLM trigger operation was stable**
- **Fully functional firmware was implemented for barrel and endcaps**
- **KLM trigger hit time jitter was quite large**
  - **Jitter shortening is under study**
- **Long term item**
  - **Track fitter**

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Issues of Other L1 Components

- **Stability of B2L readout**
  - **GDL and CDC UT3**
  - **ECL B2L was quite stable**
- **Stability of GDL VME access**
- **Stability of TRG slow control processes**
- **Trigger SIMulator (TSIM)**
  - **Fast simulation update**
  - **Firmware simulation implementation**
- **UT4 implementation**

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Summary

- **TRG was operated without L1 rate crisis in phase3**
- **L1 rate may be an issue when we have higher luminosity and currents**
- **We like to discuss present issues and possible options for future high current operations in this workshop**

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