

TRG General

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TRG/DAQ Workshop in BINP

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Physics Processes and TRG Logics

Process	σ (nb)	Rate (Hz) @ $L=8 \times 10^{35}$
Upsilon(4S)	1.2	960
Continuum	2.8	2200
$\mu\mu$	0.8	640
$\tau\tau$	0.8	640
Bhabha *	44	350
$\gamma\text{-}\gamma$ *	2.4	19
Two photon **	13	10000
Total	67	~15000

* Rate of Bhabha and $\gamma\text{-}\gamma$ are pre-scaled by factor 100

** Rates are estimated by the luminosity component in Belle L1 trigger rate

● Physics triggers

● Upsilon 4S + continuum

- Three-track
- Total energy
- Isolated cluster

● Tau pair

- Two-track (w/ Bhabha veto)

● Calibration triggers

● Bhabha

- Pre-scaled by Bhabha trigger (ECL)

● $\gamma\text{-}\gamma$

- Pre-scaled by $\gamma\text{-}\gamma$ trigger (ECL)

● Mu pair

- Two-track (w/ Bhabha veto)

● Random trigger

● Veto

● Bhabha

● Beam injection

● Two photon events if possible

- Low level reconstruction is necessary

Summary Triggers : CDC and ECL

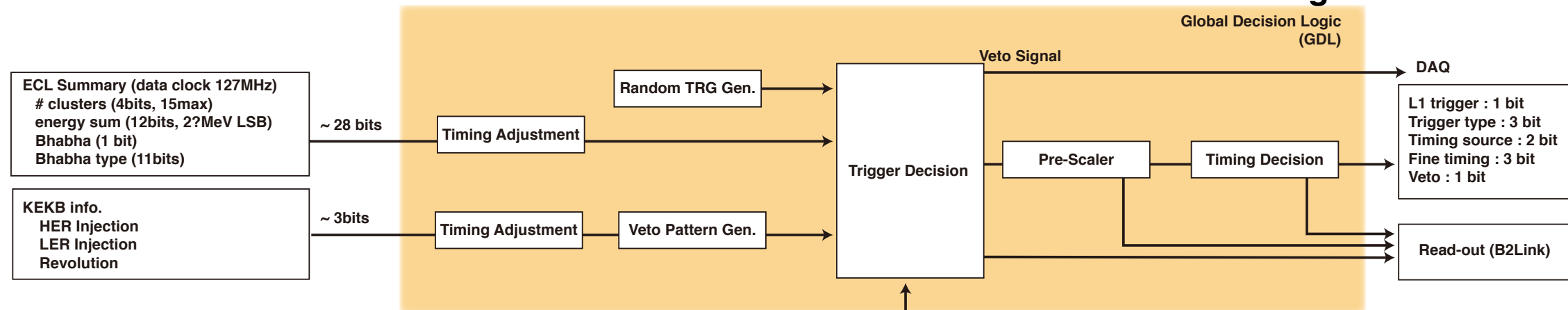
Sub-trigger	Type	Bit Width	Data Clock	Flow (Gbps)	Flow (Gbps)	Provider
CDC	# 3D full tracks	3	32 MHz	0.096	0.608	GRL
	# 3D short tracks	3		0.096		
	# 2D full tracks	3		0.096		
	# 2D short tracks	3		0.096		
	back-to-back	1		0.032		
	opening angle (45deg)	1		0.032		
	CDC timing active	1		0.032		
	timing (2ns LSB)	4		0.128		
ECL	E hi (1 GeV)	1	8 MHz	0.008	0.216	ETM
	E low (0.5GeV)	1		0.008		
	E lum (3GeV)	1		0.008		
	Bhabha	1		0.008		
	Bhabha type	11		0.088		
	# isolated clusters	4		0.032		
	ECL timing active	1		0.008		
	timing (1ns LSB)	7		0.056		

Summary Triggers : TOP and KLM

Sub-trigger	Type	Bit Width	Data Clock	Flow (Gbps)	Flow (Gbps)	Provider
TOP	# hits	3	127 MHz	0.381	1.524	GRL
	back-to-back	3		0.381		
	TOP timing active	3		0.381		
	timing (1ns LSB)	3		0.381		
KLM	# clusters	4	127 MHz	0.508	0.889	GRL
	# tracks	3		0.381		

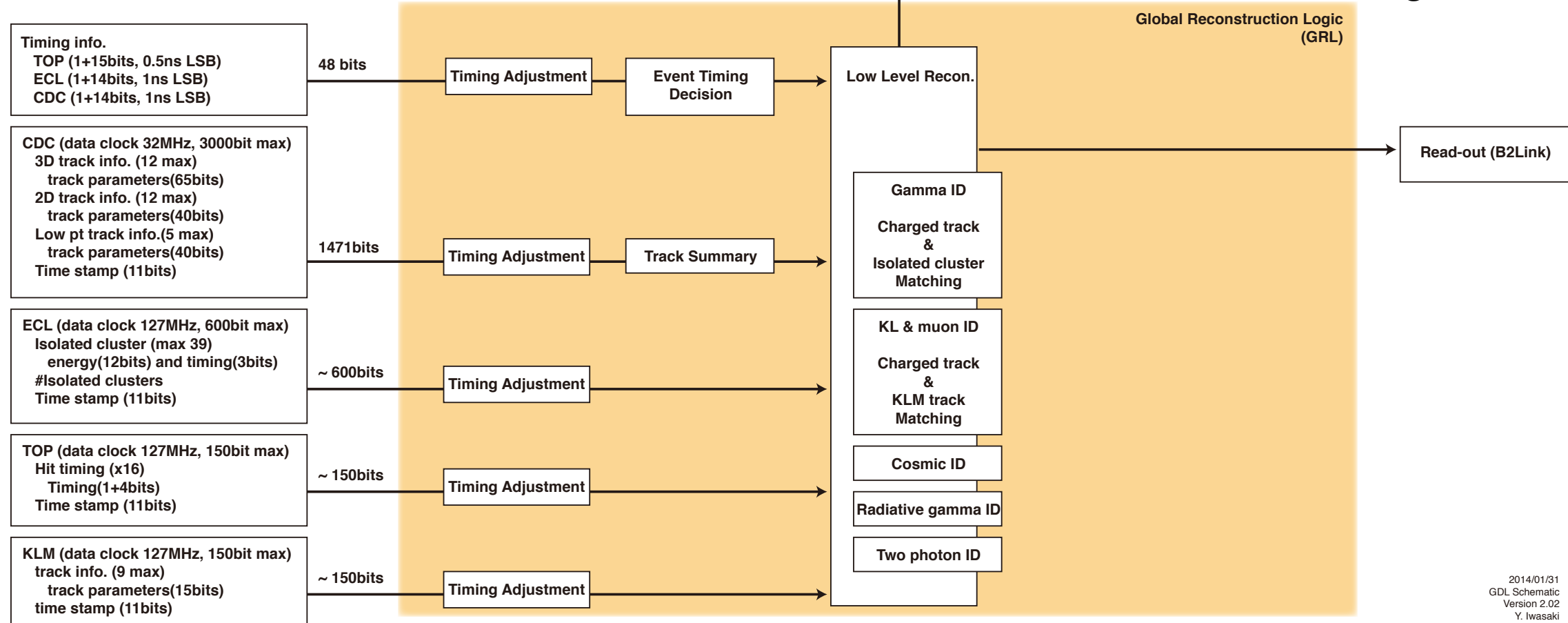
GDL and GRL

Global Decision Logic



Reconstruction Summary (data clock 64MHz, 600bit max)
Timing summary(1+15 bits, 0.5ns LSB)
Charged track summary(30bits)
Gamma summary(30bits)
Muon summary(30bits)
KL summary(30bits)

Global Reconstruction Logic



Global Reconstruction Logic

Bit definition is under discussion

Sub-trigger	Type	Type	Bit	Data Clock	Flow (Gbps)	Flow (Gbps)	Provider
GRL	particle ID	electron	3	127MHz	0.381	1.524	GRL
		gamma	3		0.381		
		muon	3		0.381		
		KL	3		0.381		
	event ID	Bhabha	4		0.508	3.048	
		mu pair	4		0.508		
		tau pair	4		0.508		
		hadronic	4		0.508		
		radiative gamma	4		0.508		
		two photon	4		0.508		

Strategy for TRG Commissioning : GCRT

- Use standard trigger logics for physics
- Add some calibration triggers if requested by detector groups
 - If you need ad-hoc triggers, you have to contact TRG group in advance
- TRG group should have priority to develop TRG logic in early period
 - Cosmic run may be stopped during 13:00 - 16:00

Strategy for TRG Commissioning : Phase II

- **1st stage : establish the basic logics**
 - CDC 2D, total energy, isolated clusters, Bhabha, injection veto, random trigger : (very similar to the Belle-I basic triggers)
 - Efficiency for physics may not be the best
 - If the trigger rate is too high
 - Keep logic independency as much as possible
 - Use large pre-scale factors to maintain the trigger rate (1st stage only)
- **2nd stage : establish a minimum setup for physics**
 - Try to get best performance (efficiency and rate) for hadronic events
- **3rd stage : test new trigger performance**
 - Bits to be tested (firstly with large pre-scale values)
 - CDC 3D (conventional and neuro)
 - GRL event bits
 - Low multiplicity events requested by HLT group

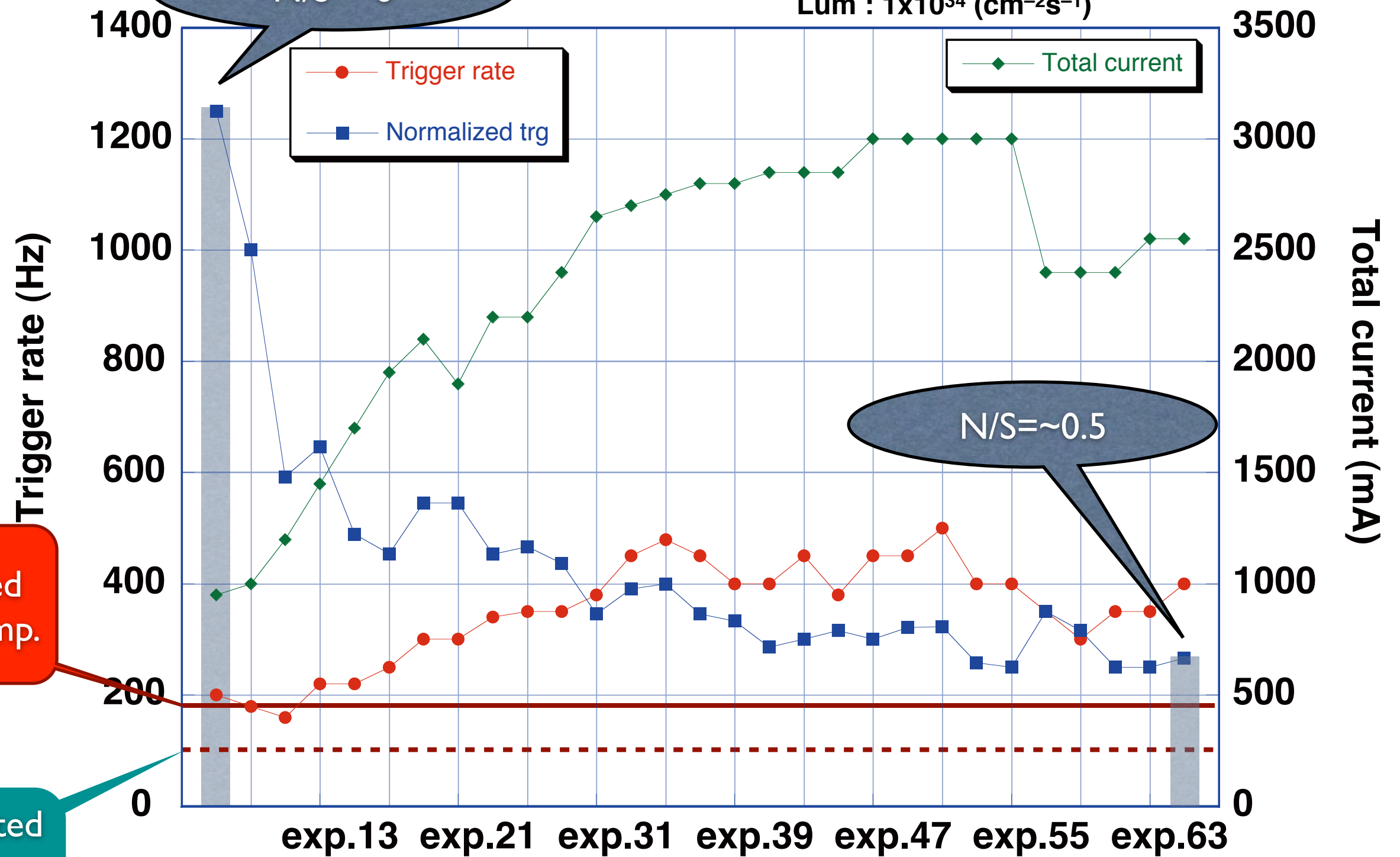
<https://docs.belle2.org/record/314/files/BELLE2-NOTE-PH-2015-011.pdf>
 - Use new bits with small pre-scale values after tests

TRG History in Belle

Normalized Trg Rate = Trg Rate / Lum

Rate : Hz

Lum : $1 \times 10^{34} \text{ (cm}^{-2}\text{s}^{-1}\text{)}$



TRG Rate Estimation

Based on Belle History

- **No reliable estimation even now**
 - for the beam induced background
 - Precise trigger simulator is not available
- **If history repeats,**
 - Early stage : lower currents with bad vacuum $\rightarrow N/S = \sim 6 \rightarrow 13 \text{ kHz}$
 - Final stage : high currents with good vacuum $\rightarrow N/S = \sim 0.5 \rightarrow 23 \text{ kHz}$
- **Tighten the TRG conditions if BG is serious**
 - New tools : CDC 3D tracking, low level reconstruction for BG reduction
 - Suppress two-photon events : these are the signal in Belle

Lum ($\text{cm}^{-2}\text{s}^{-1}$)	Lum. Comp.	N/S= ~ 0.5		N/S= ~ 6	
		BG	Total	BG	Total
1×10^{34}	190 Hz	100 Hz	290 Hz	1100 Hz	1300 Hz
1×10^{35}	1.9 kHz	1.0 kHz	2.9 kHz	11 kHz	13 kHz
8×10^{35}	15 kHz	8 kHz	23 kHz	88 kHz	100 kHz

Summary

- **GDL/GRL is ready to accept sub-triggers**
- **Final trigger decision (FTD) is prepared**
 - Present version : 0.02
 - Will be frequently updated
 - Ad-hoc triggers should be included
 - Acceptable signal : NIM, LVDS, optical serial link
- **GRL logic detail should be finalized soon**
 - Bhabha, mu-pair, tau-pair, hadronic, radiative gamma, etc
 - Unique trigger bit ID will be given if different PS is used
 - Only some of them will be provided in early stage
 - Trigger requests from HLT group will be prepared on GRL
 - Unique trigger bit will be given

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

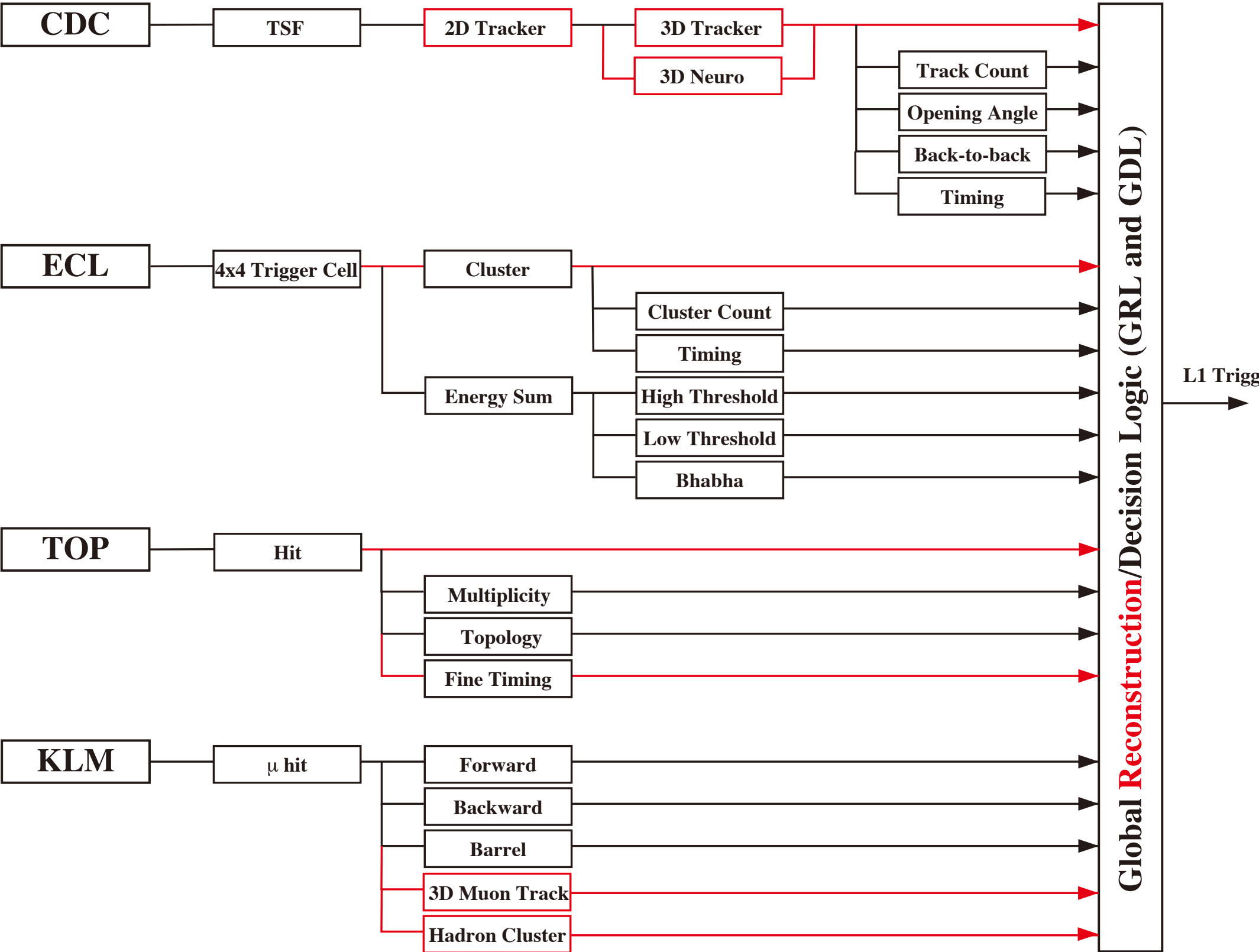
Belle-II TRG System

National Taiwan U.
KEK

Hanyang U.
BINP

U. Pittsburgh
U. Hawaii

Virginia Tech
U. Hawaii
Indiana U.



Sub-Triggers

- **CDC : for charged tracks (barrel only)**
 - Momentum measurements : 2D and 3D
 - Impact parameter : dz (no dr)
 - Track counting : up to 12 tracks / charge
 - Event timing : jitter $\sim 30\text{ns}$
 - Event topology : back-to-back, opening angles, etc
- **ECL : for neutral and charged tracks**
 - Energy sum
 - Position and energy measurements : cluster by cluster
 - Cluster counting
 - Event timing : jitter $\sim 30\text{ns}$
 - Bhabha event ID
- **TOP : for timing for charged tracks (barrel only)**
 - Event timing : jitter $< 10\text{ns}$
- **KLM**
 - Muon tracking

TRG Schedule in 2016

