Status and Plan for Belle Trigger

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for Belle Trigger subgroup
(Y.Iwasaki,Y.Sakai,S.Nishida,Y.Ushiroda et al.)

BaBar−Belle Detector Workshop in Vancouver

Outline

1. Introduction
2. Level 1 trigger
   – subtrigger
   – global decision
   – trigger rate / performance
3. Level 3 trigger
4. Future Plan
5. Summary

1. Introduction

Expected rate of trigger @ $L=10^{34} cm^{-2} sec^{-2}$

Physics Process	Cross section (nb)	Rate (Hz)
$\Upsilon(4S) \to B\bar{B}$	1.2	12.
Hadron production from continuum	2.8	28.
$\mu^+\mu^- + \tau^+\tau^-$	1.6	16.
Bhabha ($\theta_{lab} \geq 17°$)	44.	4.4 [a]
$\gamma\gamma$ ($\theta_{lab} \geq 17°$)	2.4	0.24 [c]
2γ processes ($\theta_{lab} \geq 17°$, $p_t \geq 0.1$ GeV)	~ 15	~ 35 [b]
Total	~ 67	~ 96

Physics trigger : ~ 100Hz
Background : 100−1KHz??

Limitation from DAQ design

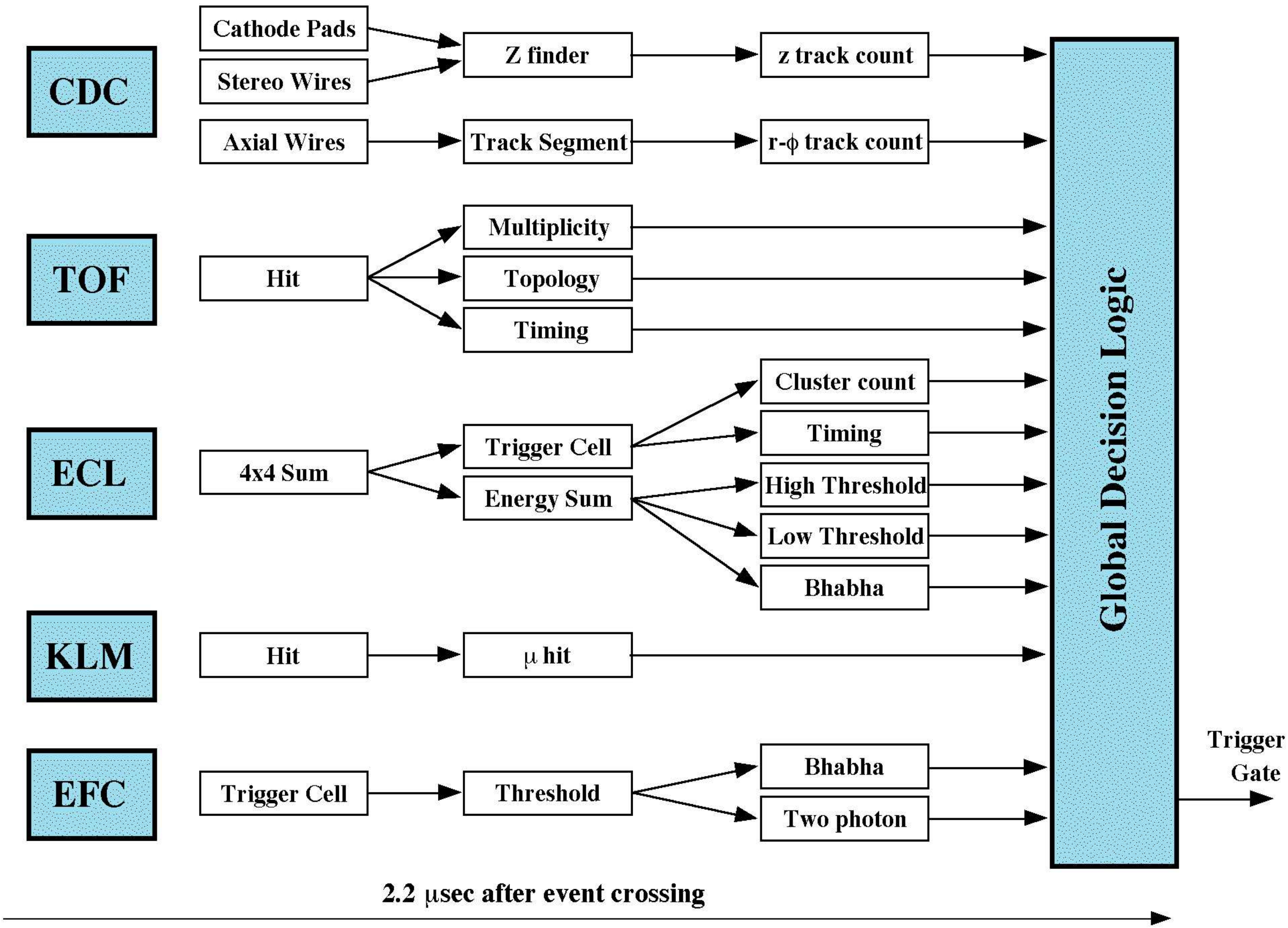
DAQ: non−pipelined system

−> readout deadtime ~ 150−200µsec/event => 10% @ 500Hz

Design(L1): typical rate = 200Hz
maximum = 500Hz

* Level 1 trigger + Level 3 trigger. No (hardware) Level 2 trigger

2. Belle Level 1 Trigger System



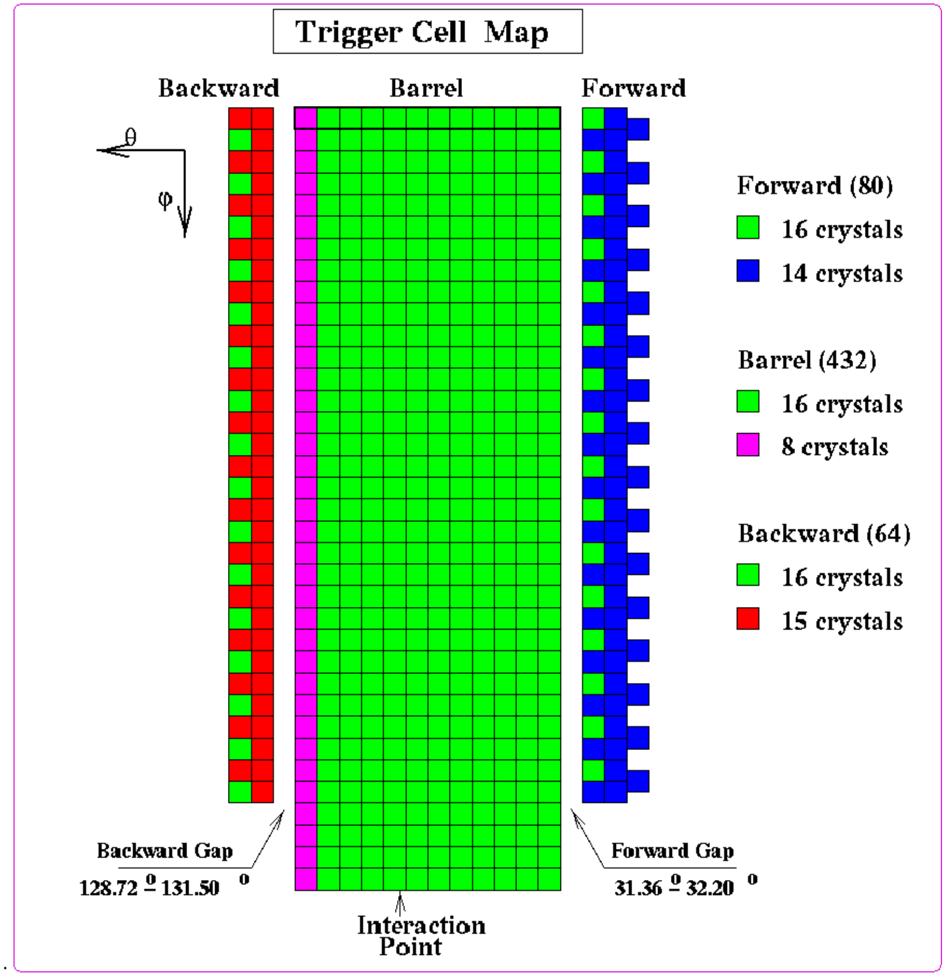
Detector		label	# Bits	comments
CDC	$r\phi$	$N_{CDR-Full}$	2	CDC Full Track (N = 1, 2, $\geq$ 3)
		$N_{CDR-Short}$	3	CDC Short Track (N = 1, 2, .. $\geq$ 7)
		CDC:B-B	1	CDC Back-to-Back Tracks (1-7/64)
		CDC:open	1	$\phi_{open} > 135°$
	Z	N_{CDZ}	2	CDC Z-track (N = 1, 2, $\geq$ 3)
TSC		Timing	1	"Timing" Trigger (N $\geq$ 2)
		N_{TSC}	2	# of TSC hits (N=1,2,$\geq$3)
		TSC:multi	1	$N_{TSC} \geq Min$ (=2 now)
		TSC:patt	1	TSC pattern (1-3 bacck-to-back now)
ECL		E_{Tot}	3	$E_{Tot} > E_1, E_2, E_3 (0.5, 1, 3 GeV now)$
(CsI)		N_{isl}	4	Number of Isolated clusters (0-7,$\geq$8)
		CsI:BB_{psc}	1	CsI Bhabha (prescaled)
		CsI:BB	1	CsI Bhabha (non-prescale)
		CsI:Cosmic	1	CsI Cosmic
		CsI:Timing	1	CsI Timing (cluster $\geq$ 1)
KLM		MU	3	Hits in KLM Fwd,Barl,Bwd
EFC		EFC:BB	1	EFC Bhabha
		EFC:Tag	1+1	Tag for two-photon + reserve
CALIB		Random	1	Random
		Revolution	1	Revolution
SVD_L0			1	SVD L0 (for flag,scaler)
		Total	34	+14 spare (= 48)

Subtrigger Details

ECL (Calorimeter) trigger

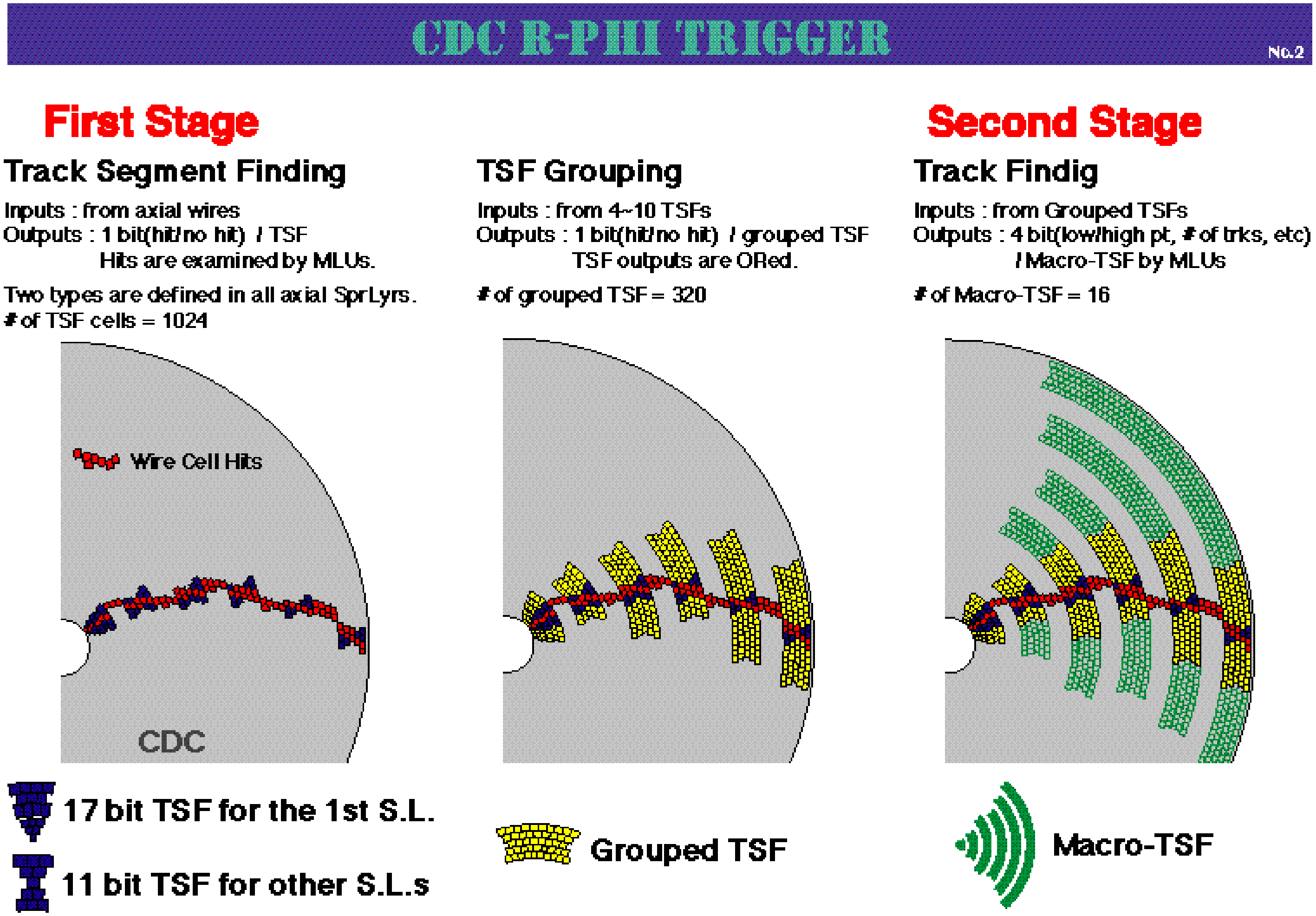
ECL trigger electronics provides

- Energy sum trigger
  3 thresholds
  (0.5, 1.0, and 3.0 GeV)
- No. of isolated clusters
  cluster counting logic
  –>gives timing
- Bhabha trigger
  back–to–back in ϕ–"ring"
- Cosmic veto



Track trigger

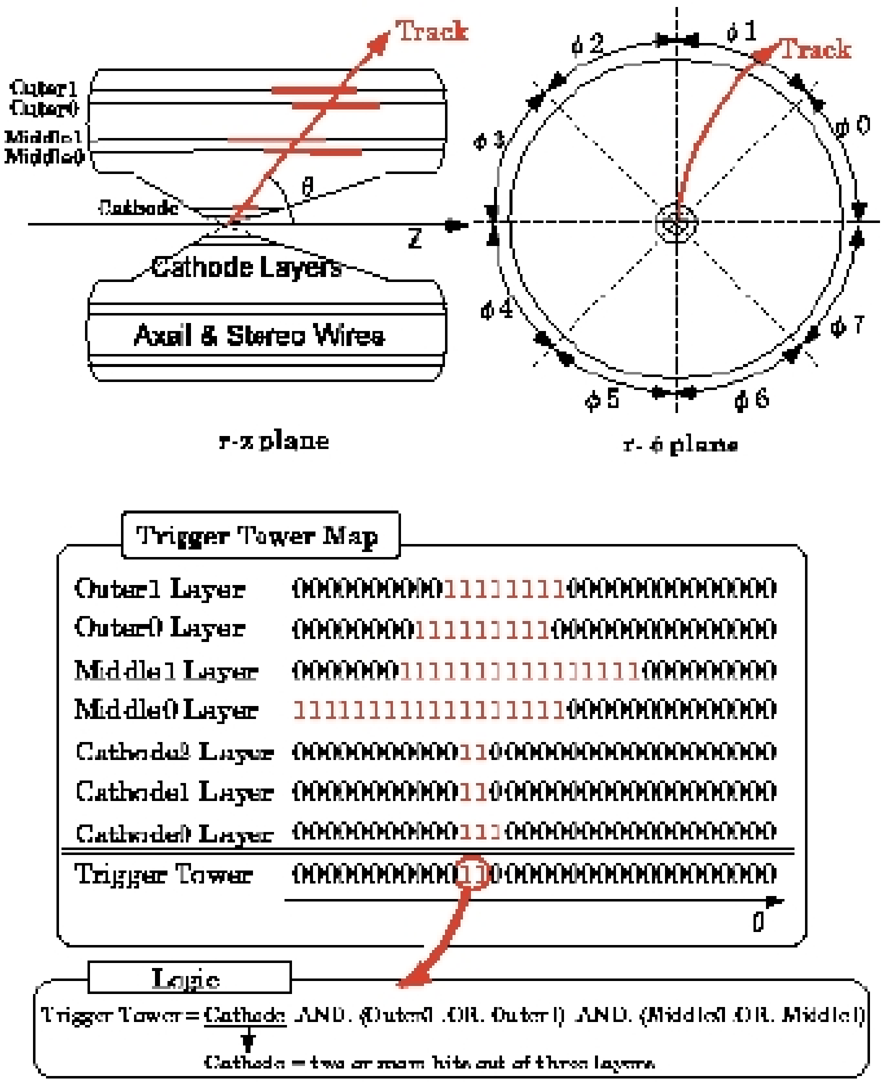
a) r–ϕ track finder



* No. of tracks (full/short)
* opening angle
* pattern (back–to–back)

"full track" = hits in all 6 layers; "short track" = hits in inner 3 layers
($p_T > 0.3$GeV/c) ($p_T > 0.2$GeV/c)

b) r–z trigger



– Divided into 8 sectors in r–ϕ

– Signals from
  * 4 stereo layers
  * 3 cathode strip layers
  are examined.

– Match in "trigger tower"
  |Δz| <~ 10cm
  –> identified as a "z–track"

=> No. of z–tracks

TOF/TSC trigger

– Timing trigger (Nhit >= 1)
– Number of hits
– Hit patten (back–to–back, 1–to–3/5/7)

KLM trigger

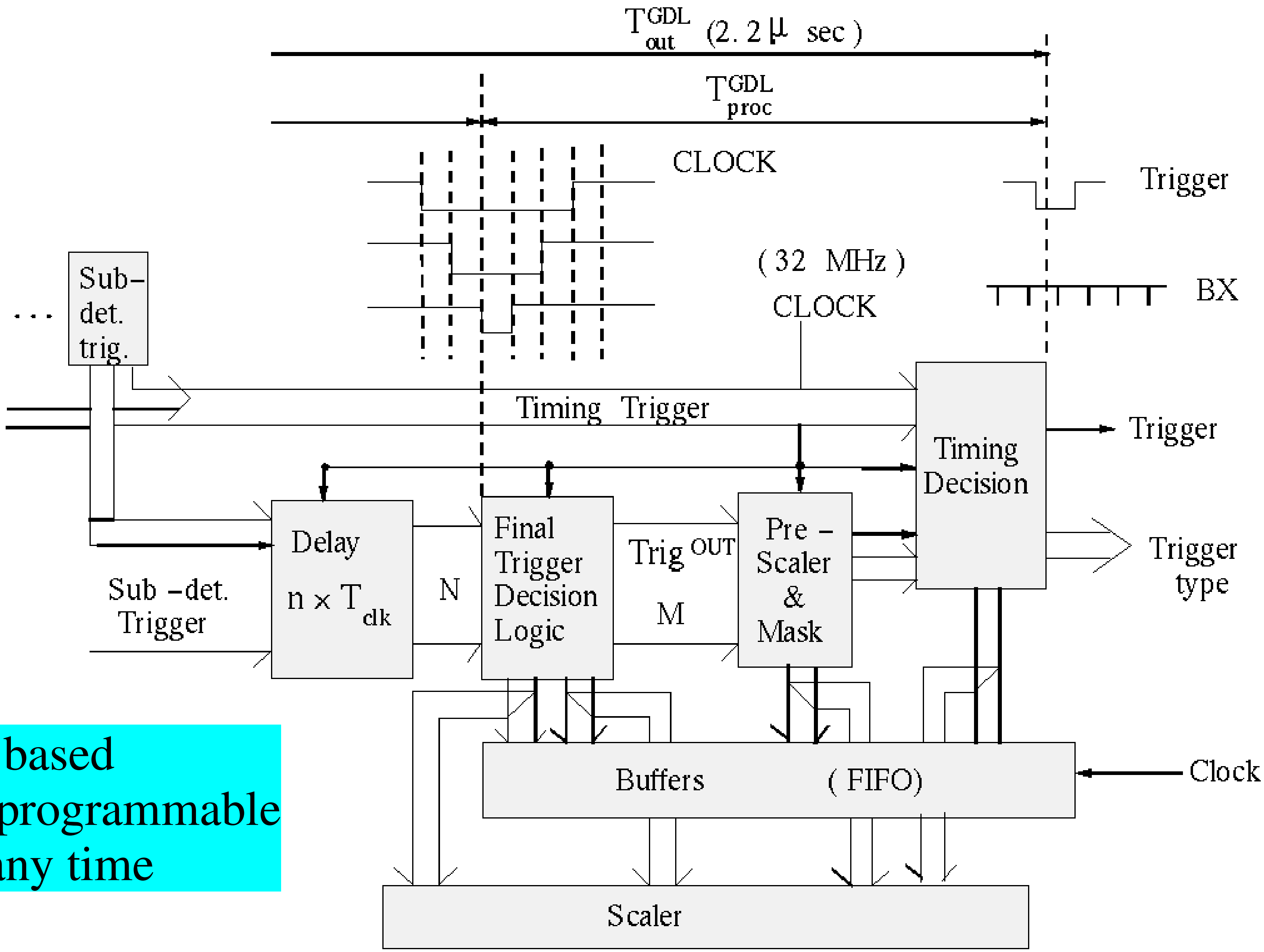
– any hit in barrel/forward/backward

Calibration trigger

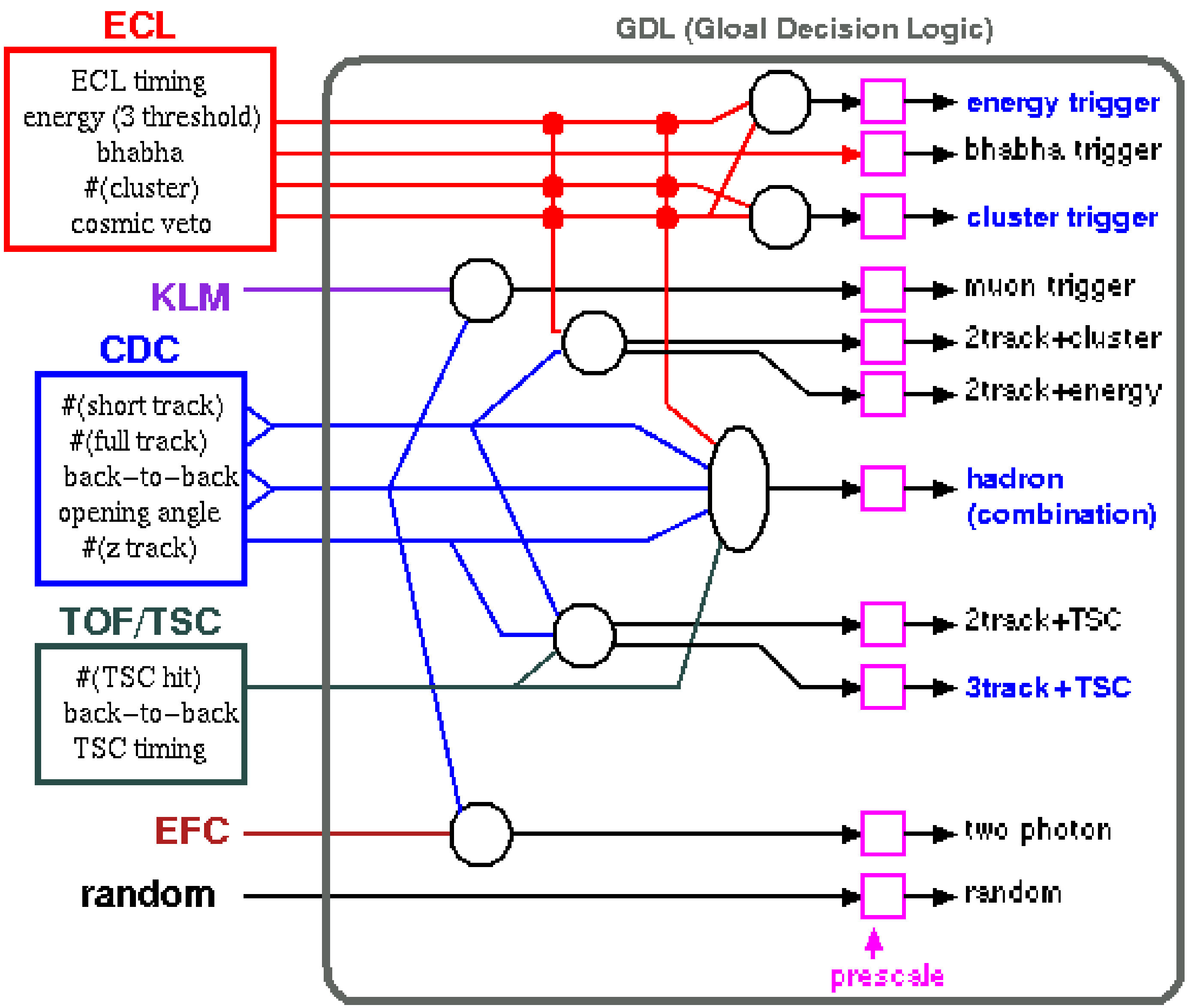
– random trigger
– revolution trigger

Global decision

global decision logic (GDL)



– FPGA based
<– re–programmable
at any time

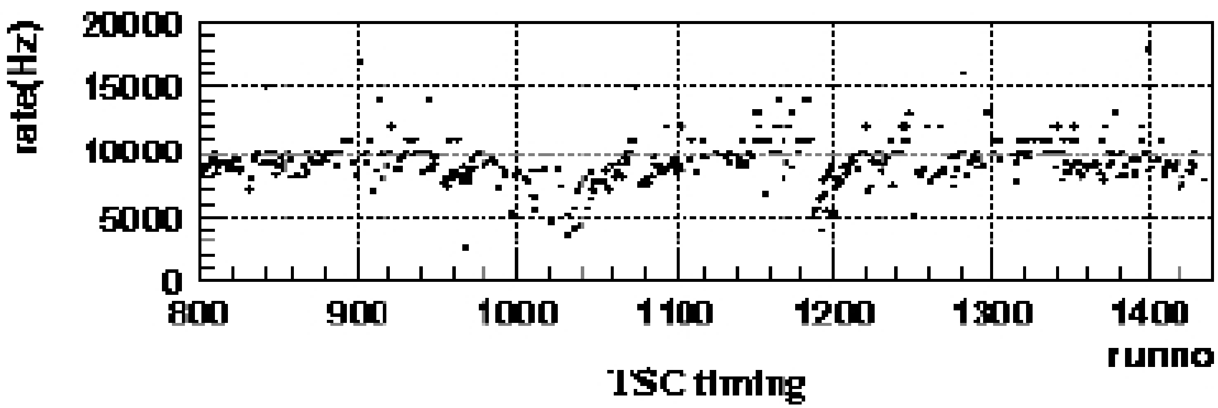

ECL
ECL timing
energy (3 threshold)
bhabha
#(cluster)
cosmic veto
GDL (Gloal Decision Logic)
energy trigger
bhabha trigger
cluster trigger
KLM
muon trigger
2track+cluster
2track+energy
CDC
#(short track)
#(full track)
back-to-back
opening angle
#(z track)
hadron
(combination)
TOF/TSC
#(TSC hit)
back-to-back
TSC timing
2track+TSC
3track+TSC
EFC
two photon
random
random
prescale

3. Performance

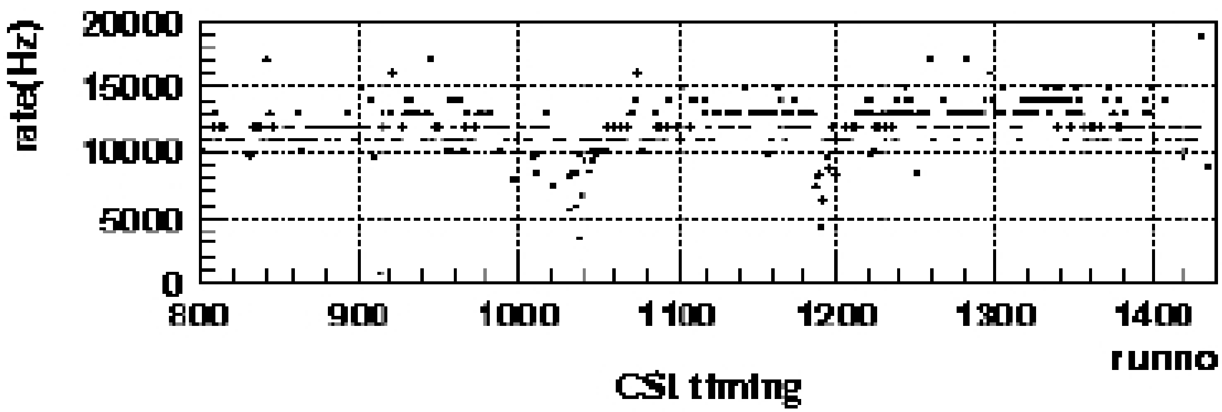
Trigger rate (under current beam condition : L~ 5.0 x $10^{33}cm^{-2}sec^{-1}$)

Timing trigger:

TOF/TSC timing trigger : ~ 10 KHz
ECL timing trigger : ~ 13 KHz

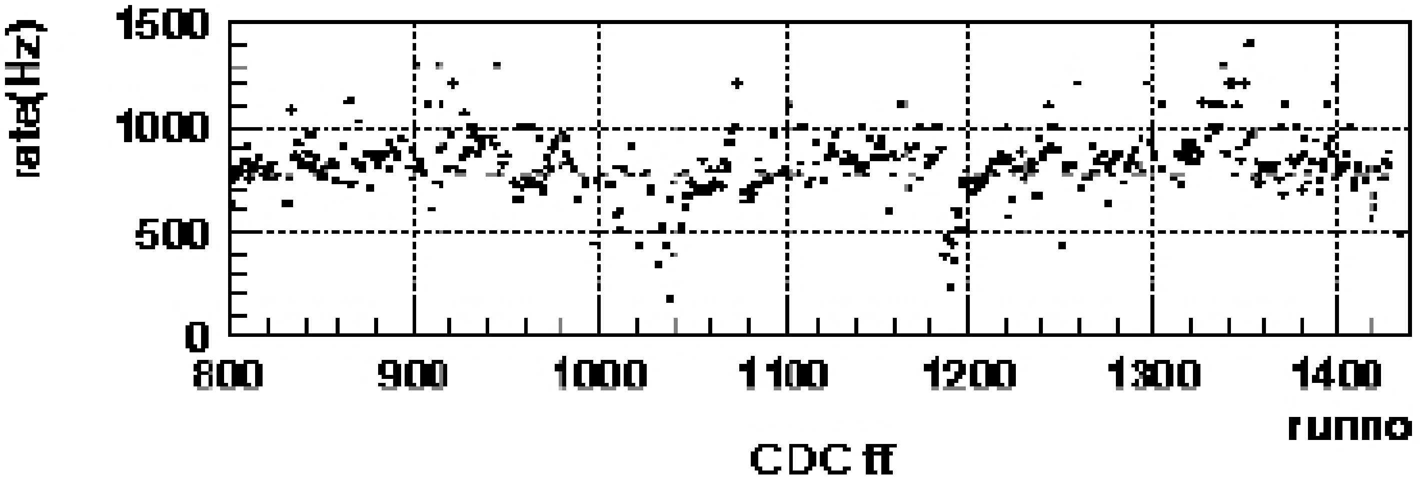


Nov.–Dec. 2001



Track trigger

– single "full" track trigger : ~ 5KHz
– two "full" track trigger : ~800Hz



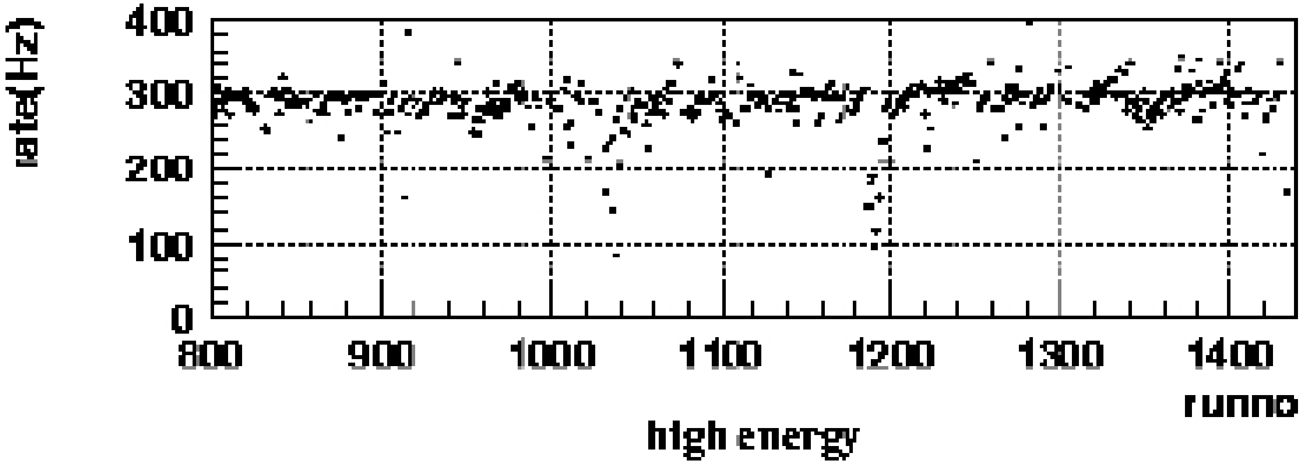
"full" track : track segments are found in all 6 layers
"short" track: track segments are found in 3 innner layers

– Effect of Z trigger : ~ 20–30% reduction of total trigger rate

ECL trigger

– Energy sum trigger (>1.0GeV) : ~ 300Hz
– No. of isolated cluster > 3 : ~ 50Hz
– Bhabha trigger : ~ 50Hz(barrel) ~300Hz(forward/backward)

Energy sum >1.0GeV

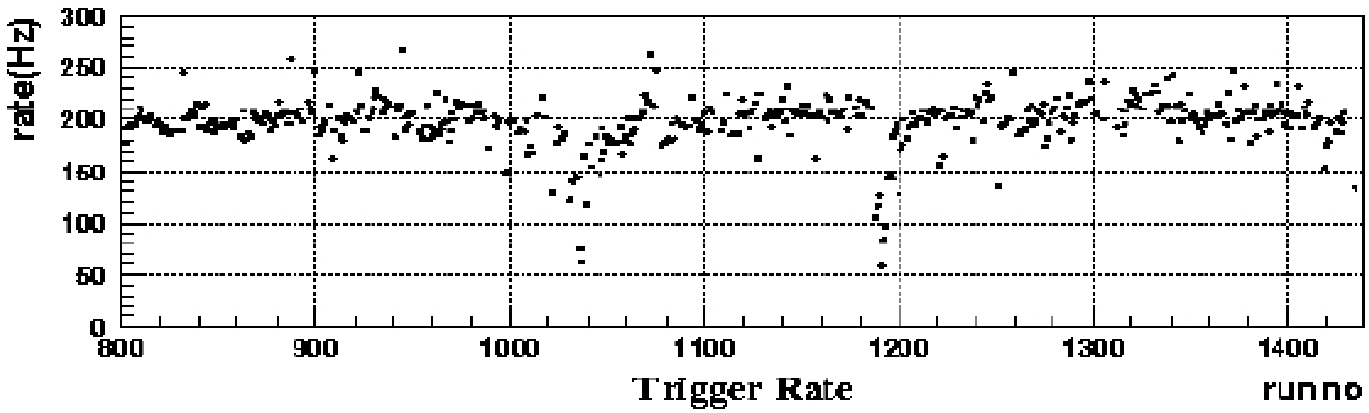


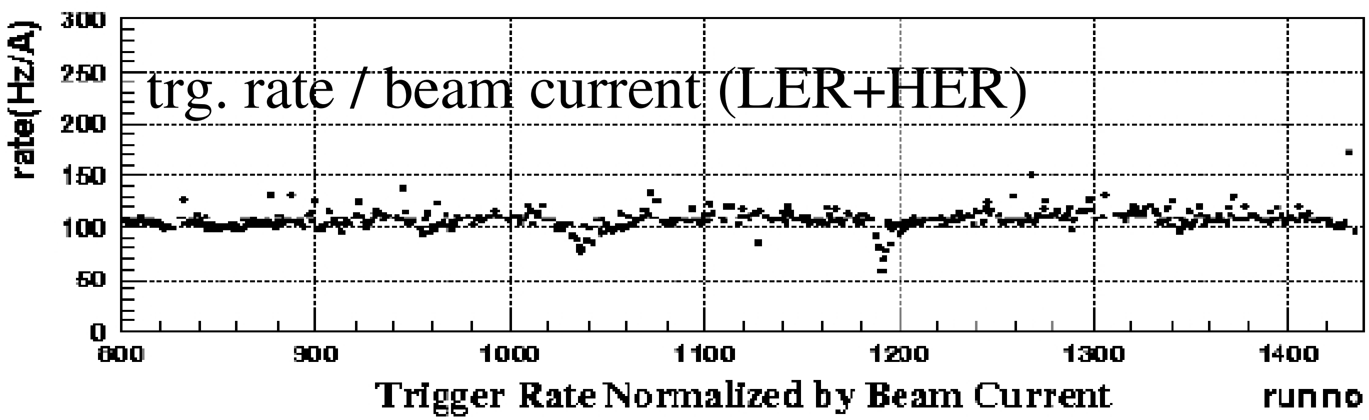
Other triggers

- KLM trigger : ~ 5KHz (barrel), ~800Hz(forward/backward)
- EFC "tag" trigger : ~ 3KHz
- Random trigger : ~20Hz

Some of the triggers are prescaled before global decision

Trigger after global decision

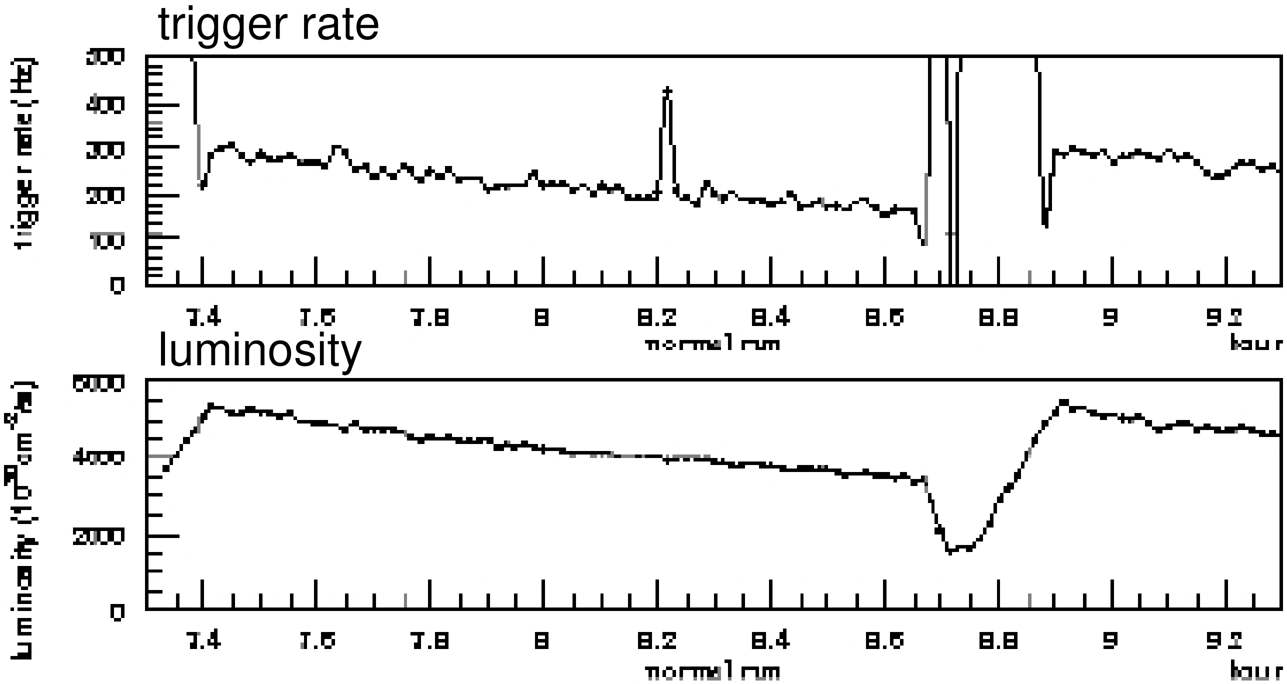




~ 200Hz (Ave.)
(Nov.–Dec. 2001)

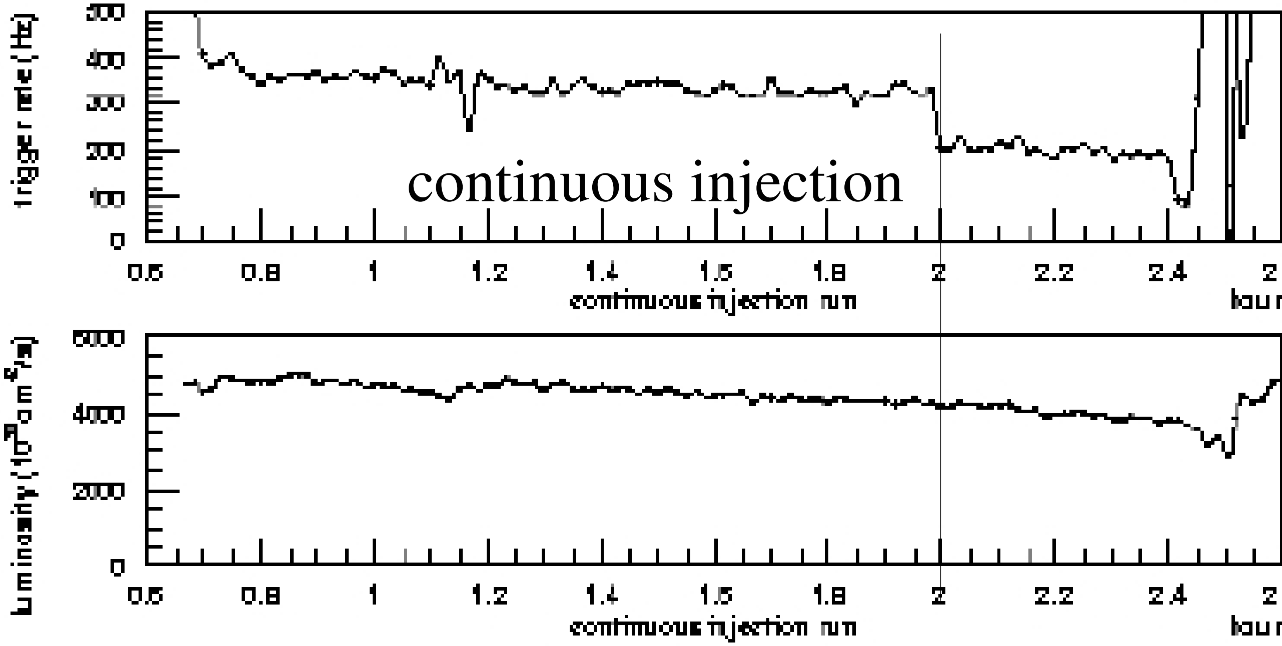
>250Hz
(this week)

Trigger rate in one run



Normal Run

Trigger rate
~ 300Hz at the beg
–> reduced to ~ 170Hz



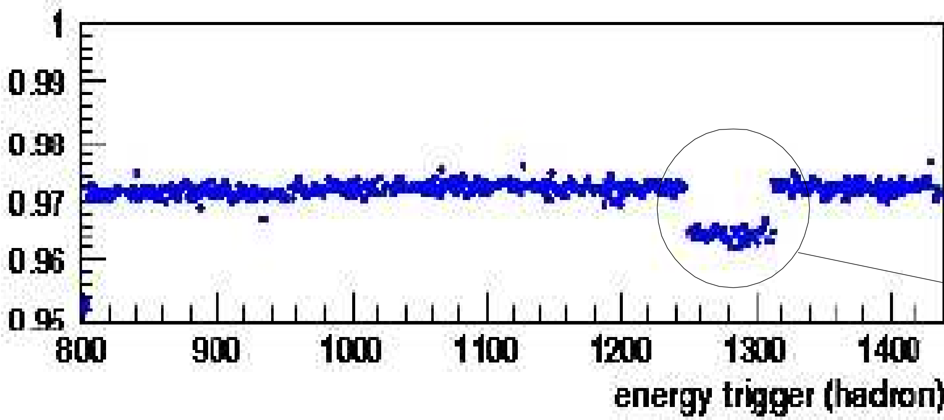
Continuous Injection

Trigger rate ~ 350Hz

Monitor of trigger efficiency

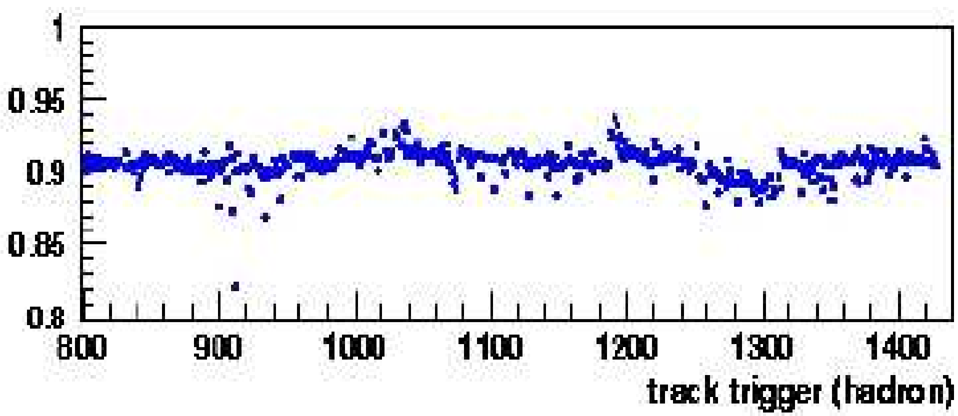
Efficiency for hadronic event : >98.5% (redundant trigger!)

Trigger efficiency of subtrigger components are studied in offline using physics−skim data sets to monitor the trigger performance.



Eff(ECL Esum)
for hadonic events

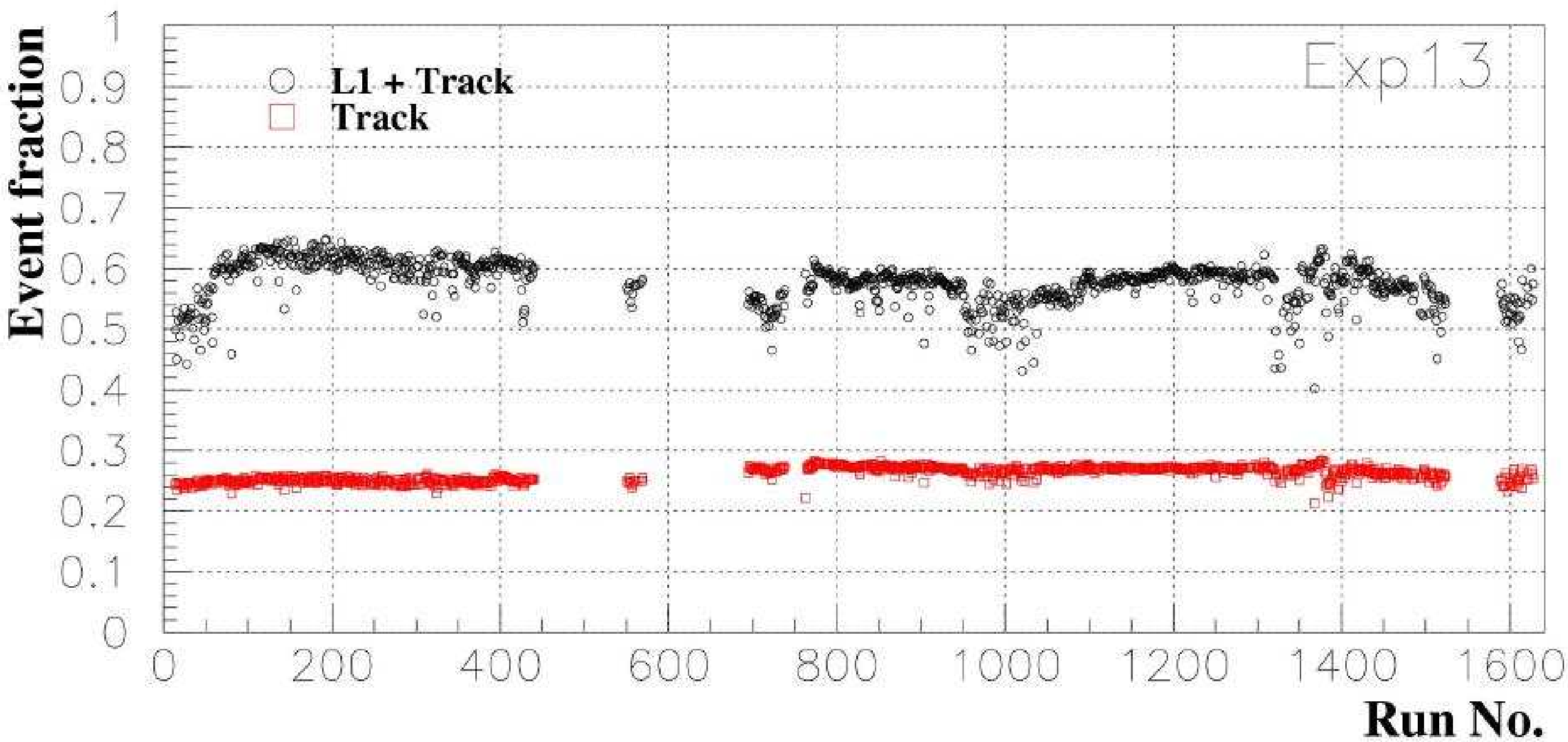
off−resonance runs



Eff(track trigger)
for hadonic events

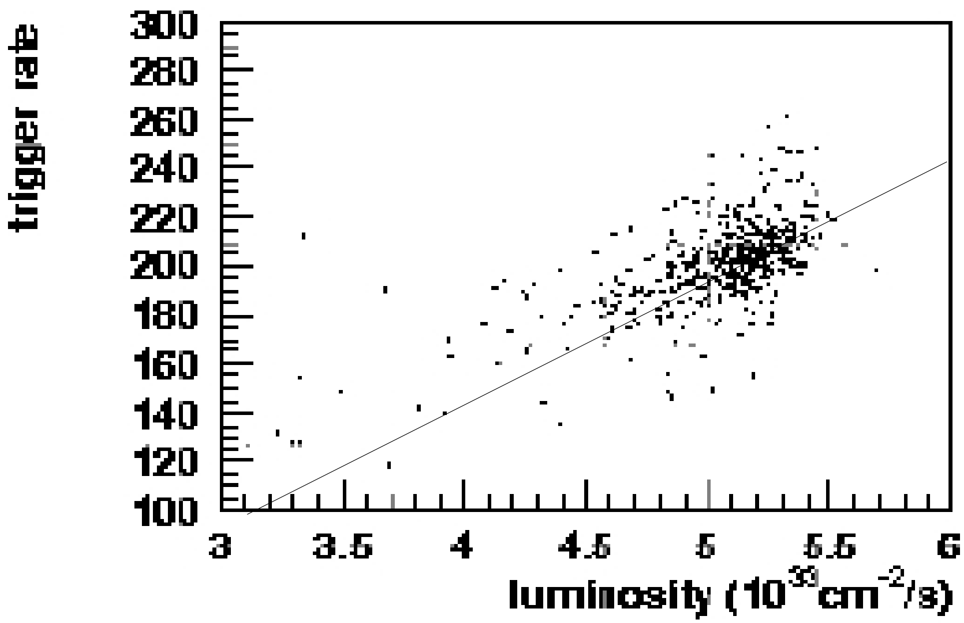
4. Level 3 trigger

– Level 3 trigger : software trigger
  * track finding using CDC r–f trigger cells
  * track fitting using drift time information (assuming simple x–t)
  * ECL energy trigger info is OR'ed
– The program is executed in event–building farm.
– >99% efficiency for hadronic event
– reduction factor : ~ 1/2



5. Future plan

a) Prospects for full luminosity ($L=10^{34}cm^{-2}sec^{-1}$)



expects:

> 500Hz ave. trig rate
@ $L=10^{34}cm^{-2}sec^{-1}$

may increase more.....

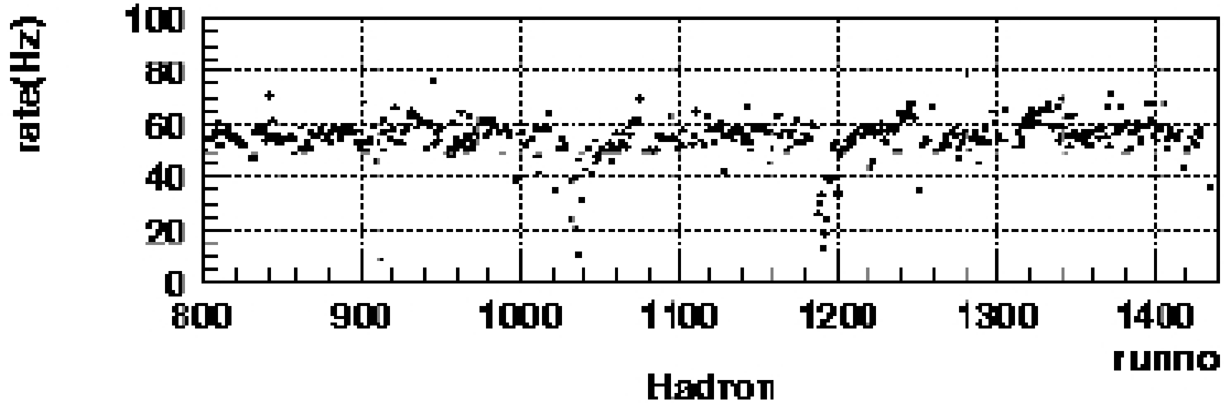
– Tightening trigger condition: (we have many "knobs" to tune!)
 * raise threshold of energy trigger (current 1GeV)
 * tighten track trigger (require 3 "full" tracks) or raise P_T threshold
 * "hadron trigger" only (emergency option)
 –> efficiency loss in hadronic events should be small
 –> effect on other channels ($\tau\tau$,2photon) / rare B decays should be carefully studied.

– Improvement of DAQ: reduce deadtime to a half => DAQ talk

"hadron trigger"

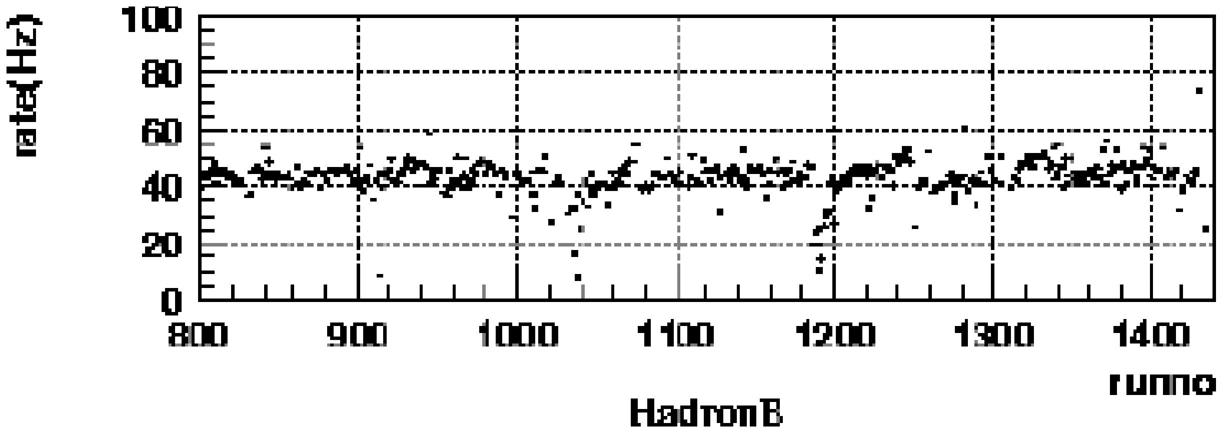
- (No. of "short" tracks > 2) AND
- (ECL energy sum > 0.5 GeV) AND
- (No. of ECL clusters > 1) AND
- (No. of TSC hits > 1)

Efficiency for hadronic events ~ 95%



~ 60Hz @

4.5–5 x $10^{33}cm^{-2}sec^{-2}$



+ No. of Z trk > 0 AND
No. of "full trk" > 0

< 50Hz

b) New Z trigger

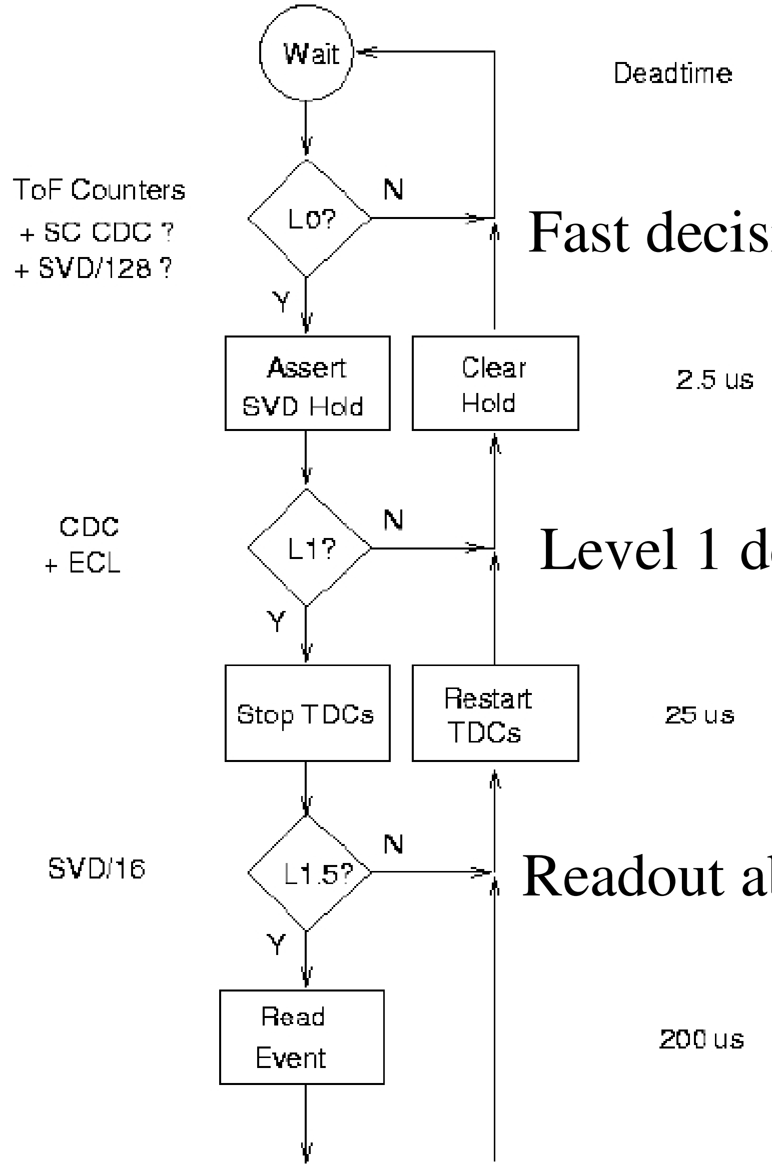
– Implementation of new SVD is planned next summer
– We will lose CDC–Z trigger (cathode readout) by this upgrade
    –> potential increase of trigger rate by ~20–30% or more.
– New beam pipe with smaller radius can also increase background.
    –> may increase trigger rate up to 1KHz or more.

↓

New Z trigger is required for background reduction

* Level 0 trigger using trigger output from VA1TA chip
  (new SVD readout chip)
* Upgrade of Level 1 trigger using VA1TA output
  (matching with L1 CDC tracks required)
* Level 1.5 trigger using SVD analog readout
  –> implemented to "abort" DAQ readout sequence
  in the middle

–> trigger rate is expected to be kept < 500Hz



Fast decision by Level 0

Level 1 decision

Readout abort by Level 1.5

65

Figure 50: Flowchart showing the various trigger stages and the amount of deadtime incurred by each.

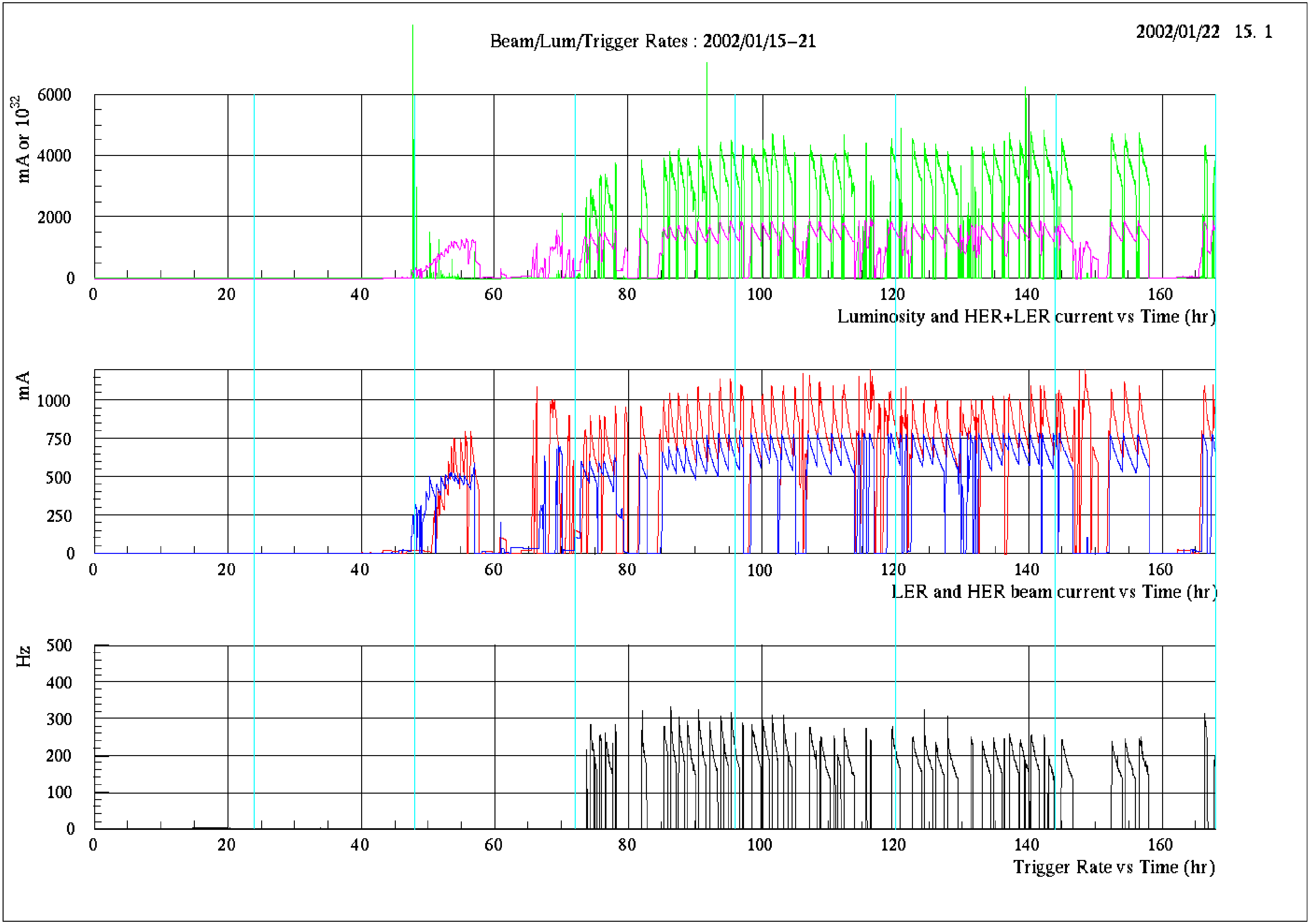
6. Summary

- The Belle Trigger System is working fine under the current beam condition with typical trigger rate at ~ 250Hz(L1).

- Flexible trigger decision logic using FPGA is very useful to keep up with the change in the beam condition. (i.e. increase in luminosity / background).

- The tightening of trigger conditions might be necessary for the coming luminosity increase
  ... we have many "knobs" to tune!
  ... new Z trigger will be effective to reduce trigger rate

Trigger for Super KEKB .... just started to think about



Beam/Lum/Trigger Rates : 2002/01/15–21
2002/01/22 15. 1
mA or 10^{32}
6000
4000
2000
0
0
20
40
60
80
100
120
140
160
Luminosity and HER+LER current vs Time (hr)
mA
1000
750
500
250
0
LER and HER beam current vs Time (hr)
Hz
500
400
300
200
100
Trigger Rate vs Time (hr)

Trigger rate vs. beam current

HER

LER