TRG operation status
2024/10/21
T.Koga

Motivation

-TRG operation status

-TRG rate/efficiency status and plan

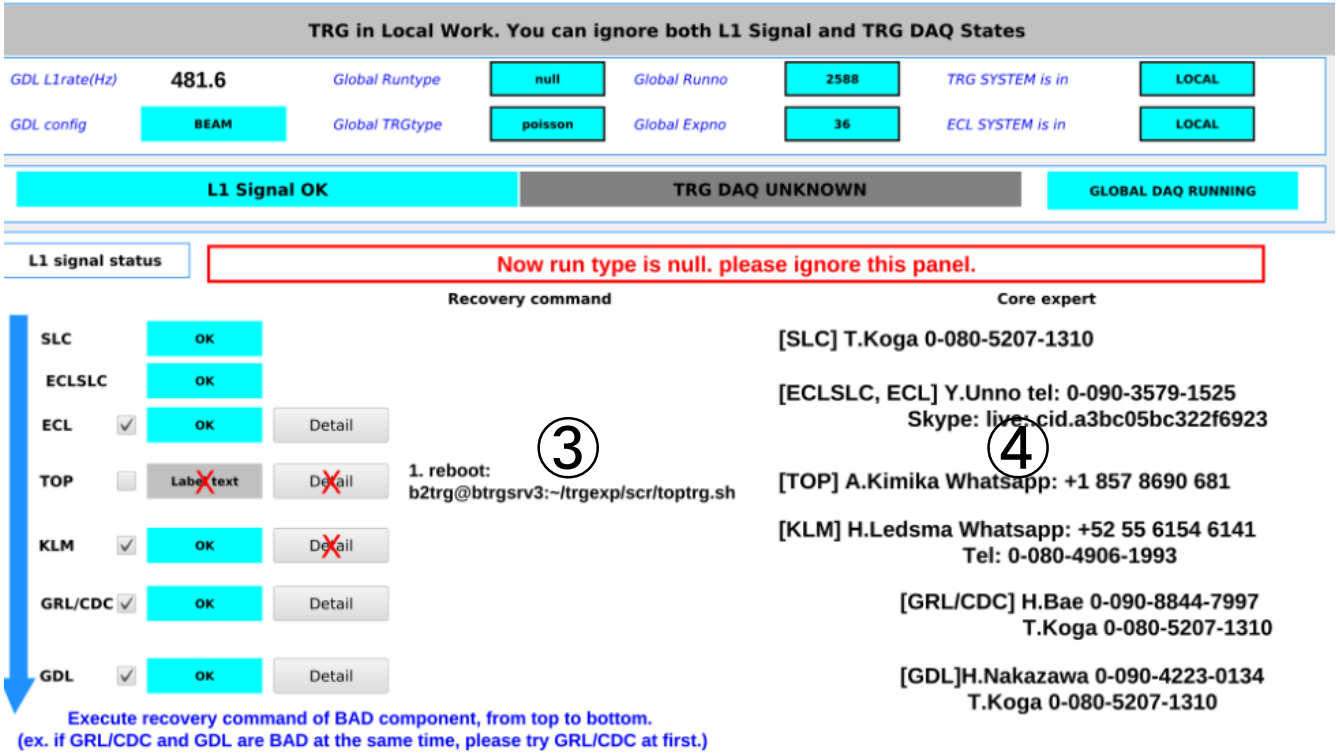
TRG operation

TRG operation: on-call trouble shooting

-TRG operation scheme since 2024ab, stably working:

- -① some errors are fixed by SALS automatically
- -② CR shifter call TRG expert
- -③ TRG expert initialize/reboot/mask module by pushing recovery button
- -④ TRG expert call core TRG expert

-From 2026ab(?), we are considering to ask CR shifter to do (part of) ③



TRG operation: deadtime

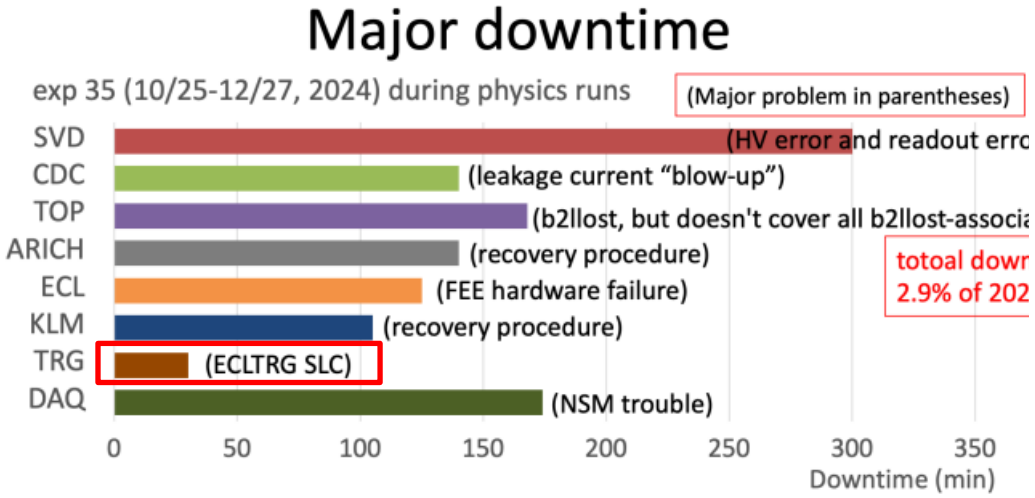
-~30minutes downtime: bug was implemented by update of SLC

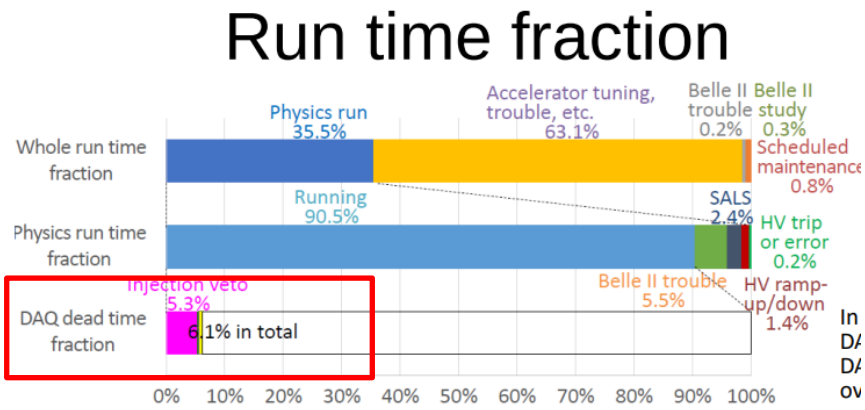
-Injection veto is largest deadtime

-active injection veto reduce deadtime 30~50%, but still large

-no further idea to improve it from TRG

link





-We caused ~2hour BAD run (next page 1. and 4.)

-ECLTRG: optical link instability

https://gitlab.desy.de/belle2/operations/run2_operation/2024c/badrun/-/issues/3

-KLMTRG: wrong initialization

https://gitlab.desy.de/belle2/operations/run2_operation/2024c/badrun/-/issues/11

https://gitlab.desy.de/belle2/operations/run2_operation/2024c/badrun/-/issues/15

TRG operation: major error to call core expert

-1. Optical link instability after rebooting

After CDCTRG/ECLTRG modules are rebooted,
sometimes optical link get unstable and cause additional errors
-> need to call core expert

-2. CDCFE recovery

CDCFE is damaged by radiation, and optical link get down.
Most of case it is recovered by masking by recovery button.
However, in rare case, optical link status get unstable and difficult to mask the problematic channel correctly by button
-> need to call core expert

1. and 2. need deep investigation of optical protocol etc.
-> it is time consuming work and not solved so far

TRG operation: major error to call core expert

-3. CR/TRG expert's quality is sometimes low and take time to recover

-> shift training is improved by Hanwook

-> it is essential to reduce number of errors.

solve reason of error fundamentally, or improve automatic recovery.

-4. KLMTRG SLC error detection is not enough

-we caused ~1hour BAD run due to wrong KLMTRG initialization

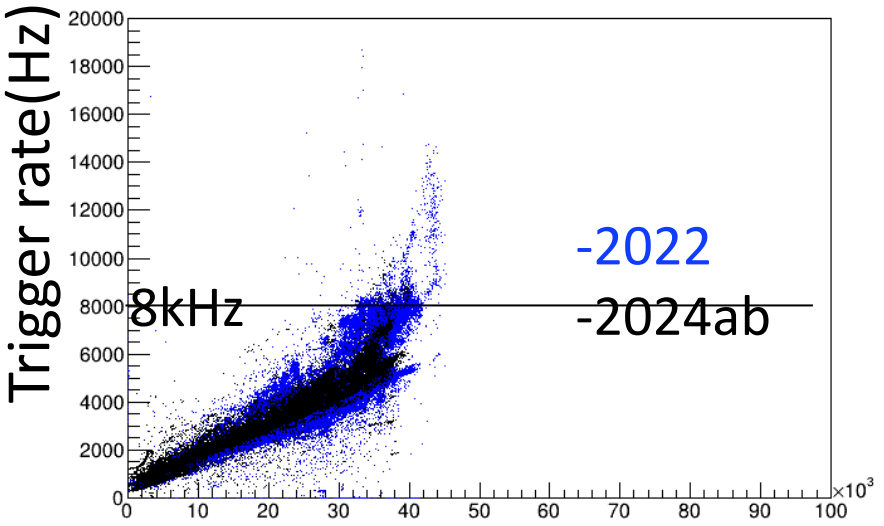
-> need to add error detection on SLC

TRG rate/efficiency status

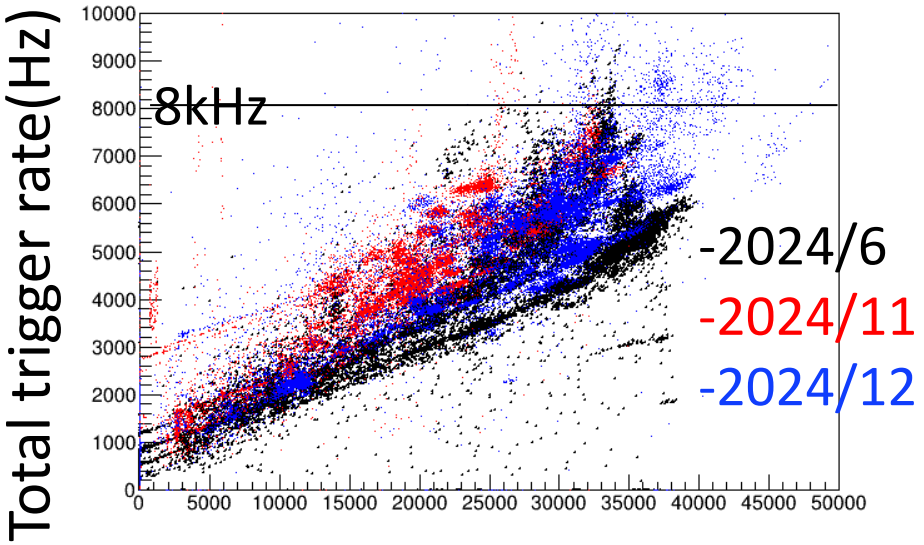
Trigger rate status in 2024

-Trigger rate is ~8kHz at maximum in 2024 @ L=~4 × 10^{34}cm^{-2}s^{-1}

-below DAQ limit of ~20kHz



Luminosity (× 10^{30}cm^{-2}s^{-1})



Luminosity(× 10^{30}cm^{-2}s^{-1})

Trigger rate status in 2024

-Fraction of trigger rate @ Total L1 rate=~7kHz, Luminosity=~3.5×10^{34}

-injectionBG ~1kHz, storageBG/lumi.~6kHz

event triggered by upper bits are excluded in lower bits in table

Category	bit	Raw rate (kHz)	Exclusive rate (kHz)
CDC ~~B physics~~ standard bits	ffy: #full track>=3, |z|<20cm	0.60	0.60
	fyo: #full track>=2, Δϕ>90deg, |z|<20cm	0.89	0.48
ECL ~~B physics~~ standard bits	c4: #cluster>=4	0.40	0.21
	hie: Energy sum>1GeV	1.36	1.03
KLM τ/dark	klmb2b, eklmb2b, beklm: Back to back sector hits	0.46	0.40
	cdcklm, seklm, ecleklm: #CDC-KLM, ECL-KLM matching>=1	0.45	0.22
CDC τ/dark	stt: #full track>=1, |z|<15cm, p>0.7GeV	1.91	0.93
	syo: #full track>=1, #short track>=1, Δϕ>90deg, |z|<20cm	1.21	0.43
	fy30: #full track>=2, Δϕ>30deg, |z|<20cm	1.16	0.07
ECL τ/dark	lml: several combination of #cluster and energy	2.92	1.65
	eclmumu: back to back low energy hit	0.63	0.01
Calibration	PID	0.24	0.09
	other (Bhabha, γγ, random, trg)	1.87	0.92
Total L1	OR of all bits	7.0	7.0

~3kHz

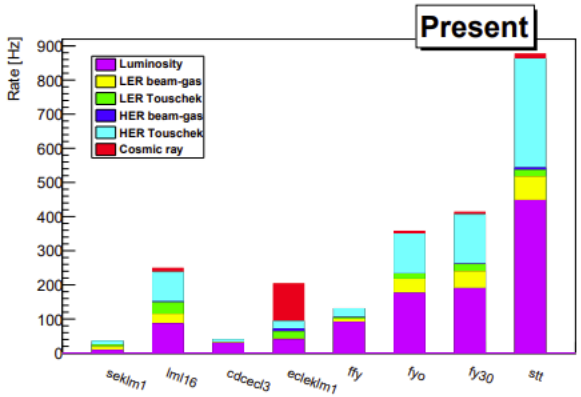
~0.6kHz

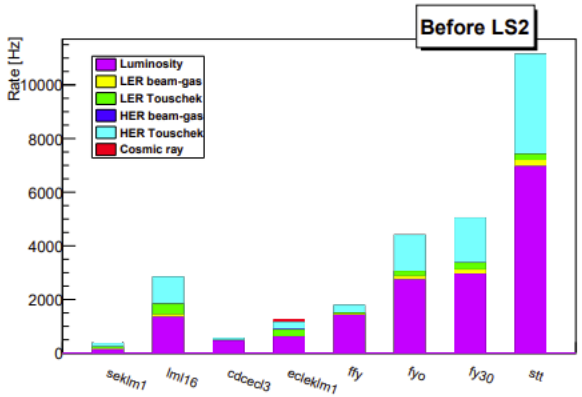
~3.4kHz

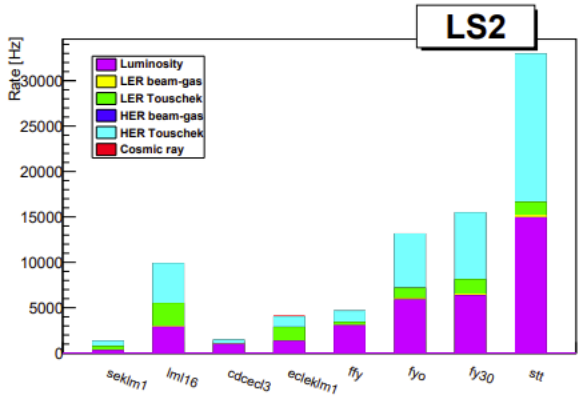
Trigger rate status in 2024

-Based on single beamBG run 2024, we have estimated fraction of trigger rate from collision and beamBG. extrapolated to designed lumi.
https://docs.belle2.org/files/451/BELLE2-NOTE-TE-2024-022/1/BELLE2-NOTE-TE-2024-022.pdf

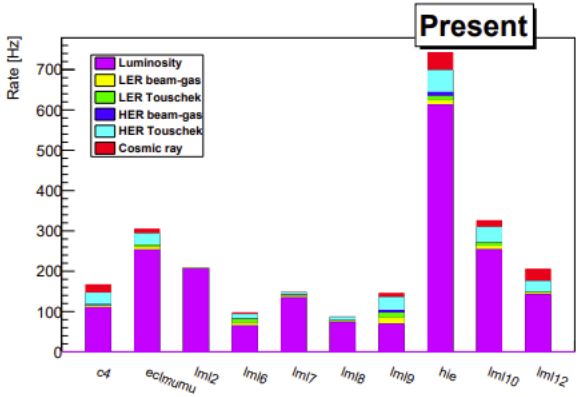
-CDCTRG bit rate: 20~40% beamBG, 60~80% luminosity BG

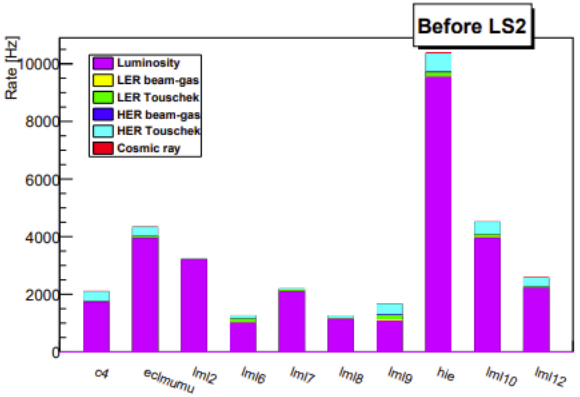


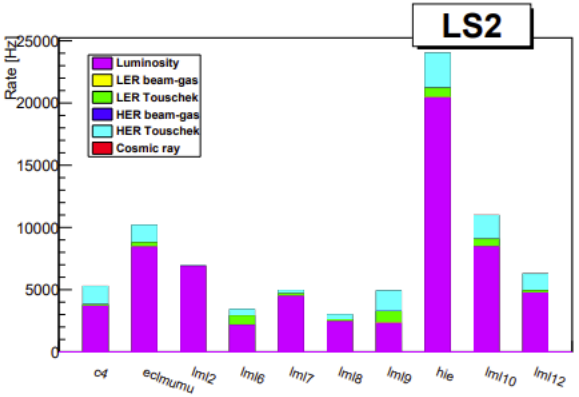




-ECLTRG bit rate: 10~20% beamBG, 80~90% luminosity BG (Bhabha)





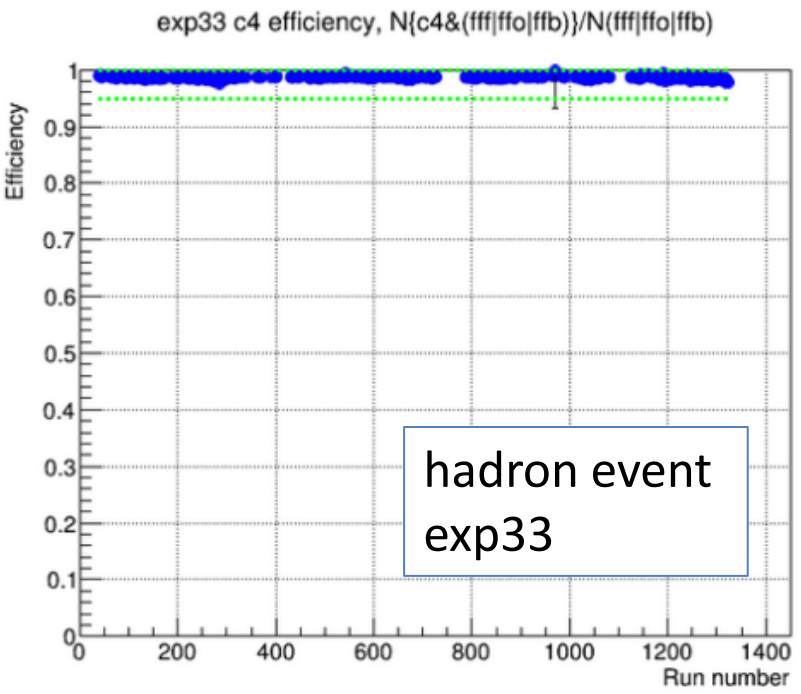


Trigger efficiency: hadron event

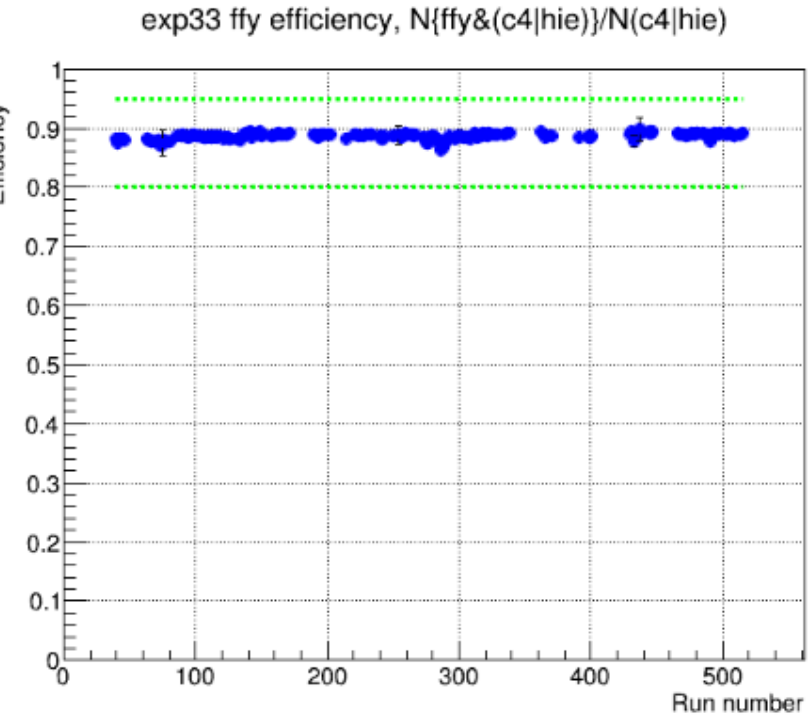
-efficiency for hadronic event is >~99%

- -~99%(ECLTRG), ~98%(CDCTRG) for hadronb2 skim
- -ECLTRG is very stably working
- -CDCTRG efficiency has been fluctuated by CDC gain drop issue -> next page

Efficiency of #ECLTRG cluster >=4

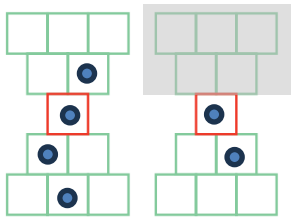


Efficiency of #CDCTRG track >=3



CDCTRG efficiency instability

wire hit
masked channel



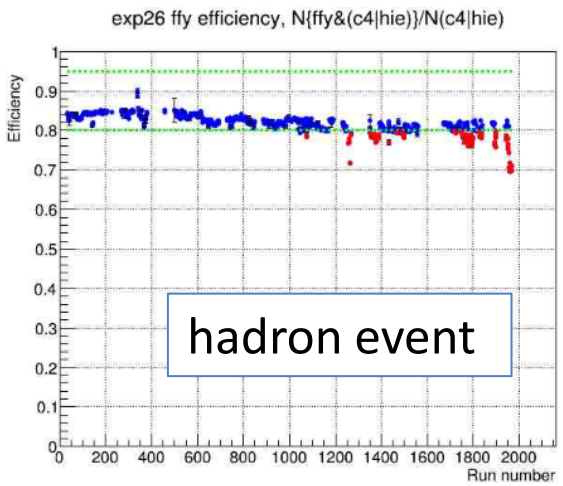
-CDC detector gain is fluctuated during experiment
->CDCTRG efficiency is affected

-Dead channel masking procedure is improved in 2022
  -loose TSF requirement (4/5 →2/3 layer hit) at the masked channel

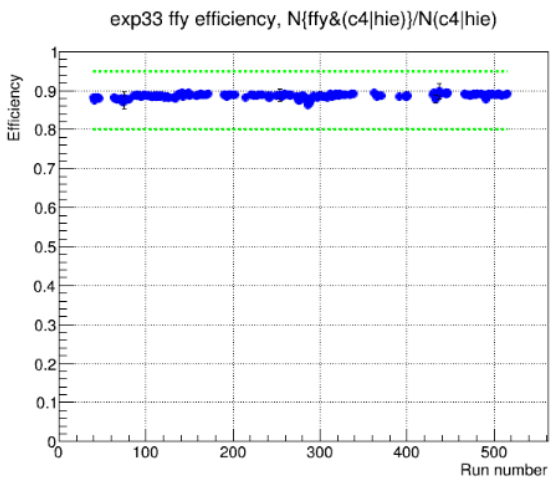
-At maximum, around ~5% efficiency decrease per track

Efficiency of #CDCTRG track >=3

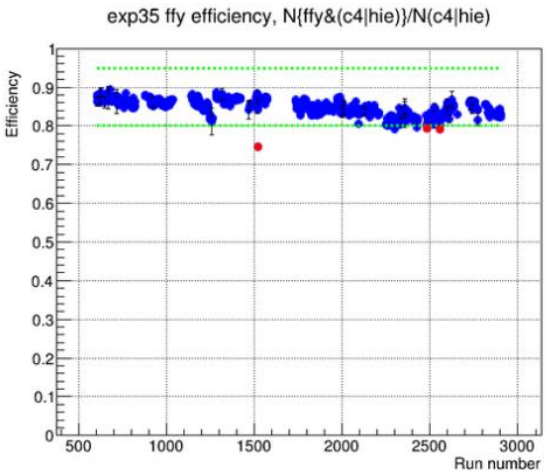
2022



2024ab



2024c



#run

Trigger efficiency: tau event

-Recently, tau group summarized trigger efficiency in each analysis (link) !
-high efficiency has been achieved for most of mode

mode	used trigger bit	TRG efficiency(MC)	TRG effienecy data/MC	trigger systematics
τ→evν, μνν (Zuzana)	ECL: lml0/12, lml2, lml4, lml6, lml7, lml8, lml9, lml10, lml13, hie CDC: fff, ffo, ffy, fyo	99%	1~0.998	0.01%
τ→3π (1x3)	hie, lml0, lml1, lml2, lml4, lml6,lml7, lml8, lml10, lml12,lml13	--	1.005	0.06 (0.14 total)
τ→Kπ0	ECL:hie|lml0|lml6|lml8|lml9|lml10|lml12 CDC:ffo|fyo|stt	99%(not final)	1.001(not final)	--
τ→μγ	lml2, lml6, lml7, lml8, lml9, lml10, lml12, hie	97%	0.991	--
τ→ℓπ0	fff, ffo, ffy, fyo, lml6, lml7, lml8, lml9, lml10, lml12, hie	98.3%(e) 98.8%(mu)	0.9992 0.9383	--
τ→ℓη	ffy, fyo, lml2, lml6, lml7, lml8,lml9, lml10, lml12, hie	0.991, 0.987, 0.995,0.988 (?)		--
τ→ℓα	ffo, fyo, lml1, lml2, lml4, lml6, lml7, lml8, lml9, lml10, lml12, hie	51%(e), 87%(mu) ?	0.979 1.010	2.8% 0.5%

Trigger efficiency: dark physics

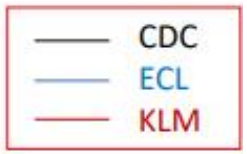
-Summary from TRGDAQ workshop 2022

-situation is not changed, but probably I missed something

-Trigger condition is not changed so far: keeping high efficiency

Triggers

Analyses	triggers
Z' invisibile, dark Higgs	fy30, cdcklm, stt
Z'→ττ, μμ	fff/ffy, cdcklm,stt (fy30, fyo)
A' invisible (single γ)	hie, lml6, lml16 (lml1, prescaled)
A' visible without γ	stt, fyo, hie
X17/ A' visible + γ	dpee (lml,,hie, c2hie)
ALP→ γ γ (3γ final state)	hie (high mass) , ggsel (low mass)
ALP→ γ γ fusion (ee → γ γ e)	lml2, hie (stt, lml1 barrel)
Single $\pi^0/\eta/\eta'$ (ee → γ γ e)	hie (stt)
μμ(γ) control sample (for invisible A' + …)	stt, beklm, cdcklm (fyo, syo)
IDM + Dark Higgs	hie (lml12, stt [stt4/5])
ππγ for HVP	hie, (ff, stt)
$\pi\pi\pi^0\gamma$ for HVP	hie, bha3d (lml1)
Dark showers	stt, stt-ecl, hie for electrons (displaced VTX)



TRGDAQ workshop

Present trigger menu for physics

-https://xwiki.desy.de/xwiki/short/344da

-All Trigger bits without prescale are listed

Trigger bit category	trigger bit name	simplified condition (see TriggerBitTable in more detail)
run number (exp run)		
CDC standalone	fff or ffy	#track>=3 (ffy: same efficiency as fff but small trigger rate with z vertex cut)
	ffo or fyo	#track>=2, Δφ>90degree
	ff30 or fy30	#track>=2, Δφ>30degree
	stt	#track>=1, p>0.7GeV
ECL standalone	c4	#cluster>=4
	hie	clusters energy sum >1GeV
	eclmumu	two back to back low energy clusters
	lml2	cluster energy > 2GeV at endcap
	lml6	only one cluster energy > 1GeV at barrel, no other anywhere
	lml7	only one cluster energy > 1GeV at endcap, no other anywhere
	lml8	two back to back low energy clusters
	lml9	two back to back low energy clusters
	lml10	two back to back low energy clusters
	lml12	three cluster, at least one cluster energy>0.5GeV

Present trigger menu for physics

-https://xwiki.desy.de/xwiki/short/344da

-All Trigger bits without prescale are listed

Trigger bit category	trigger bit name	simplified condition (see TriggerBitTable in more detail)
ECL + CDC veto	lml13 or lml16	lml13: only one cluster energy > 0.5GeV at barrel, no other anywhere lml16: lml13 with no cdc track
	ggsel	ecl bhabha with no cdc track
KLM stanalone	klmb2b	#klm sector>=2, back to back at barrel
	eklmb2b	#klm sector>=2, back to back at endcap
	beklm	#klm sector>=1 at endcap, #klm sector>=1 at barrel
CDC+KLM matching	cdcklm1,2,3,4	#cdc-klm matched track at barrel>=1
	seklm1,2	#cdc-klm matched track at endcap>=1
CDC+ECL matching	cdcecl3,4	#cdc-ecl matched track at barrel >=3
ECL+KLM matching	ecleklm1	#ecl-klm matched track at barrel >=1

When trigger rate reach DAQ limit

-When trigger rate reach DAQ limit, we will change trigger condition. plan is here .

-agreed with physics group in 2021, but most of you might forget..

-①Activate new DNN 3D trigger

-~30% CDCTrigger rate reduction with better z resolution

-track trigger efficiency is same or ~1% smaller

-②Change prescale of physics trigger bits at next pages

-30~40% total trigger rate reduction

-endcap photon efficiency decrease, but no physics impact for most of channel

-③Change prescale of prescaled calibration bits in backup proportional to luminosity.

-present prescales were set when Luminosity was ~2×10^{34}

-for example, increase prescale 5times, if Luminosity will be ~1×10^{35}

trigger menu for L=1~2 × 10^{35}

-②Change prescale of trigger bits

Trigger bit category	trigger bit name	simplified condition (see TriggerBitTable in more detail)
run number (exp run)		
CDC standalone	fff or ffy	#track>=3 (ffy: same efficiency as fff but small trigger rate with z vertex cut)
	ffo or fyo	#track>=2, Δφ>90degree
	ff30 or fy30	#track>=2, Δφ>30degree
	stt sttecl	#track>=1, p>0.7GeV + ecl matching not planned but if really needed (high trigger rate)
ECL standalone	c4	#cluster>=4
	hie hie4	clusters energy sum >1GeV + new Bhabha veto (page12)
	eclmumu disable	two back to back low energy clusters
	lml2 prescale 2~10	cluster energy > 2GeV at endcap
	lml6	only one cluster energy > 1GeV at barrel, no other anywhere
	lml7 disable	only one cluster energy > 1GeV at endcap, no other anywhere
	lml8	two back to back low energy clusters
	lml9 disable	two back to back low energy clusters
	lml10	two back to back low energy clusters
	lml12	three cluster, at least one cluster energy>0.5GeV

trigger menu for L=1~2 × 10^{35}

-②Change prescale of trigger bits

Trigger bit category	trigger bit name	simplified condition (see TriggerBitTable in more detail)
ECL + CDC veto	lml13 or lml16 prescale by 10	lml13: only one cluster energy > 0.5GeV at barrel, no other anywhere lml16: lml13 with no cdc track
	ggsel prescale ?	ecl bhabha with no cdc track not planned but if really needed (high trigger rate)
KLM stanalone	klmb2b	#klm sector>=2, back to back at barrel
	eklmb2b	#klm sector>=2, back to back at endcap
	beklm	#klm sector>=1 at endcap, #klm sector>=1 at barrel
CDC+KLM matching	cdcklm1,2,3,4 ycdcklm1,2,3,4	#cdc-klm matched track at barrel>=1 + |z|<15cm by CDCTRG 3D track(y)
	seklm1,2	#cdc-klm matched track at endcap>=1
CDC+ECL matching	cdcecl3,4	#cdc-ecl matched track at barrel >=3
ECL+KLM matching	ecleklm1	#ecl-klm matched track at barrel >=1

Summary

-TRG operation status

-remained major task:
optical link instability after rebooting, CDCFE recovery, shift scheme etc.

-TRG rate/efficiency status and plan

-trigger rate is ~8kHz at maximum at 2024.
plan to change trigger menu when trigger rate reach DAQ limit.

-physics efficiency is very high.
CDCTRG efficiency has been fluctuated due to CDC detector condition.

backup

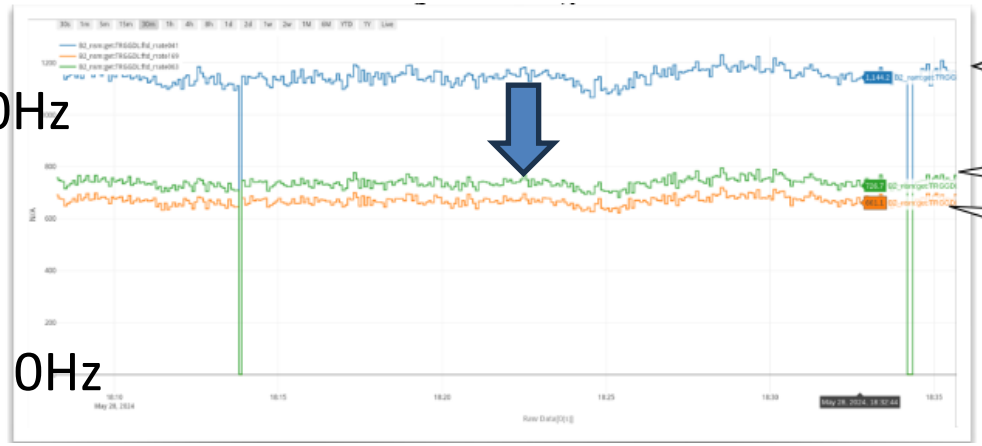
ECLTRG

-new ECL energy sum 1GeV trigger(hie3,4) is ready: ~40% rate reduction

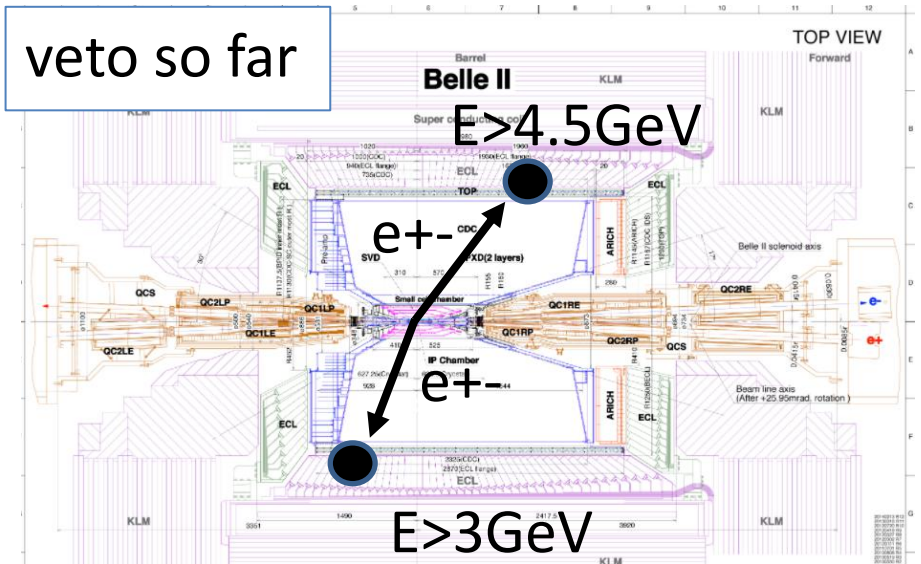
-original Bhabha veto: [E1>4.5GeV, E2>3.0GeV, $160<\Delta\phi_{CM}<200$deg, $165<\Sigma\theta_{CM}<190$deg]

-additional veto: (#cluster==1 at endcap) OR (#cluster==2, lower energy at endcap)

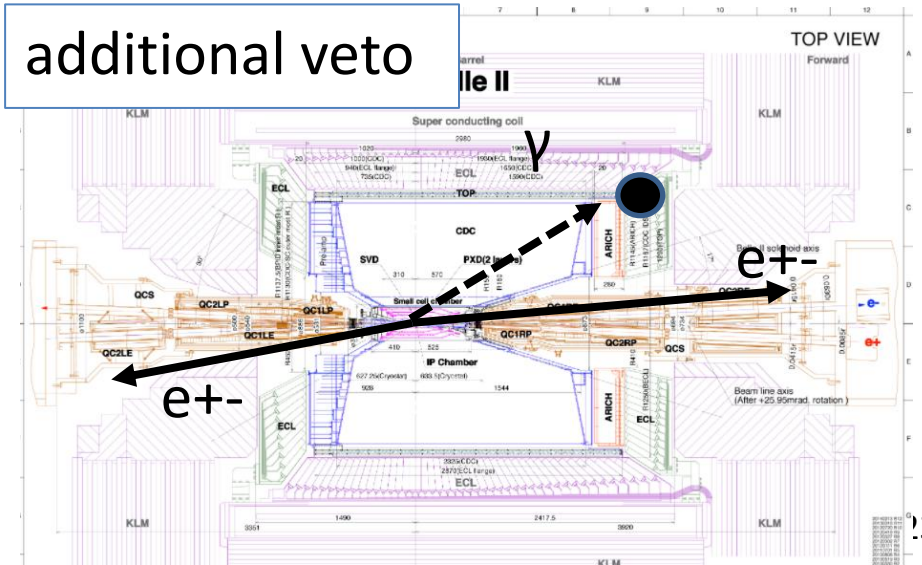
->Activate it if trigger rate reaches DAQ limit.



veto so far



additional veto



Change of prescale

List of high-rate physic trigger bits

discarded bit name	alternative bit name	Change of logic	Raw rate reduction (kHz)	Exclusive rate reduction (kHz)	Physics target
stt	sttecl	apply CDC-ECL matching	2.0->1.0	1.0->0.4	tau
cdcklm seklm	ycdcklm ecleklm	require NN track	1.1->0.53	0.83->0.36	single μ(barrel) single μ(endcap)
syo, syb	syoecl, sybecl	apply CDC-ECL matching	1.8->0.40	0.46->0.10	tau, PID
yioiecl1	--	disable	0.5->0	0.3->0	endcap two track
hie	hie3	additional Bhabha veto to endcap	2.0->1.2	1.5->0.8	B, τ, single photon with E>1GeV
lml2	--	prescale by 10	0.61->?	0.34->?	γ with wide θ range
lml7	--	disable	0.38->0	0.25->0	single photon sideband
lml9	--	disable	0.67->0	0.49->0	ALP
lml10	eclmumu	acceptance affected	1.1->0.63	0.70->0.51	μμ
lml13		disable			
lml16	--	prescale by 10	1.0->0.1	0.66->0.6	single photon with E>0.5GeV

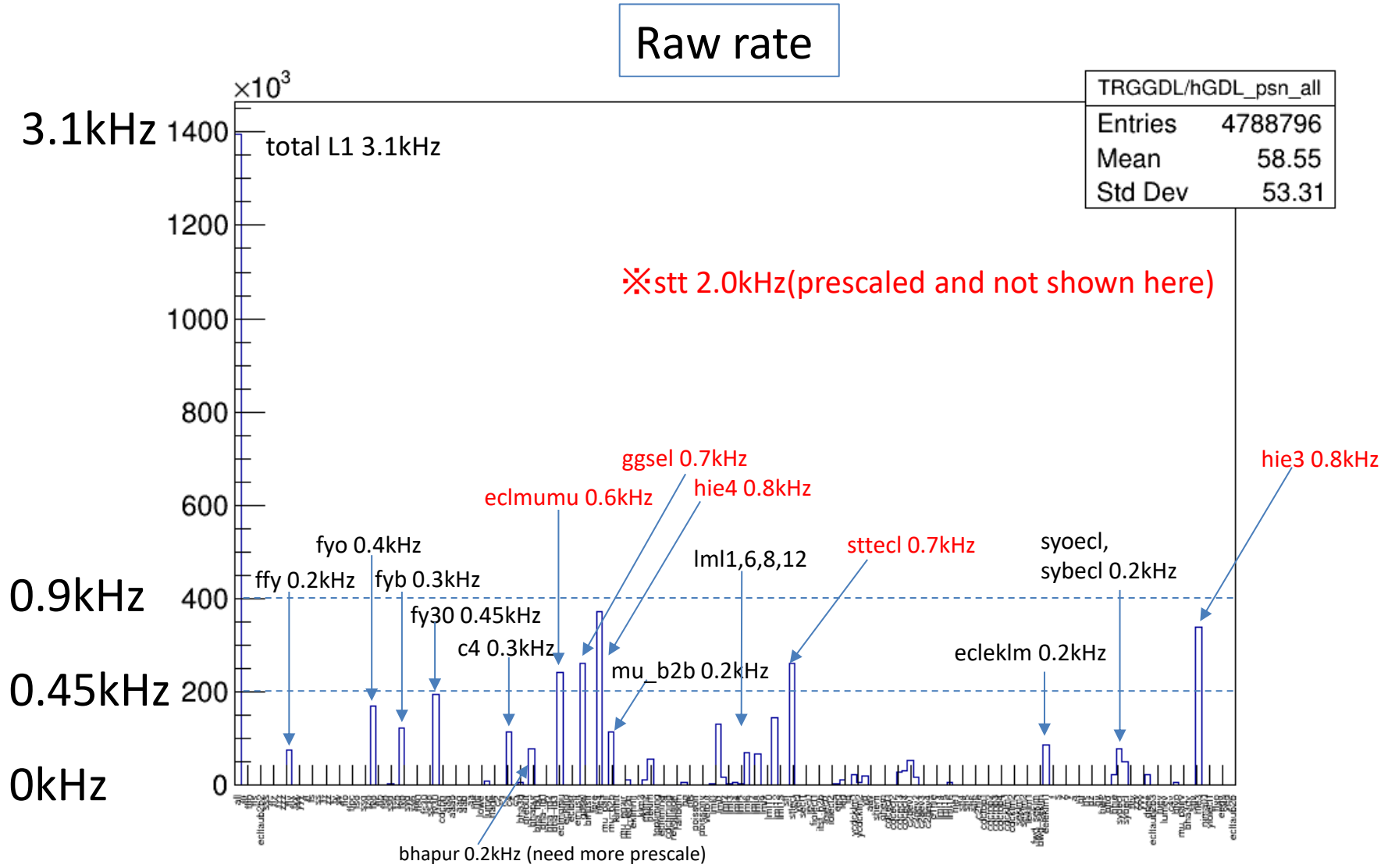
CDC-ECL matching

new Bhabha veto

Trigger bit fraction with tighter configuration

-Luminosity = ~3.8×10^{34}

-Total L1 rate: 3.1kHz



Trigger bit fraction with tighter configuration

-Luminosity = ~3.8×10^{34}

-Total L1 rate: 3.1kHz

Exclusive rate

bins in left side are priority