

CDCTRG major problem in 2022
2022/11/23
T.Koga

Motivation

-I would like to remind what is the major issues of CDCTRG in 2022ab, and needed counter measure in LS1

-Major issues:

- CDC gain drop

- decrease CDCTRG efficiency

- beamBG increase

- increase CDCTRG rate

Reminder: CDC gain drop

-CDC gain has been decreased, correlated with beamBG

-~20% gain drop at the end of 2022b

-Jira: <https://agira.desy.de/browse/BIIDP-5529>

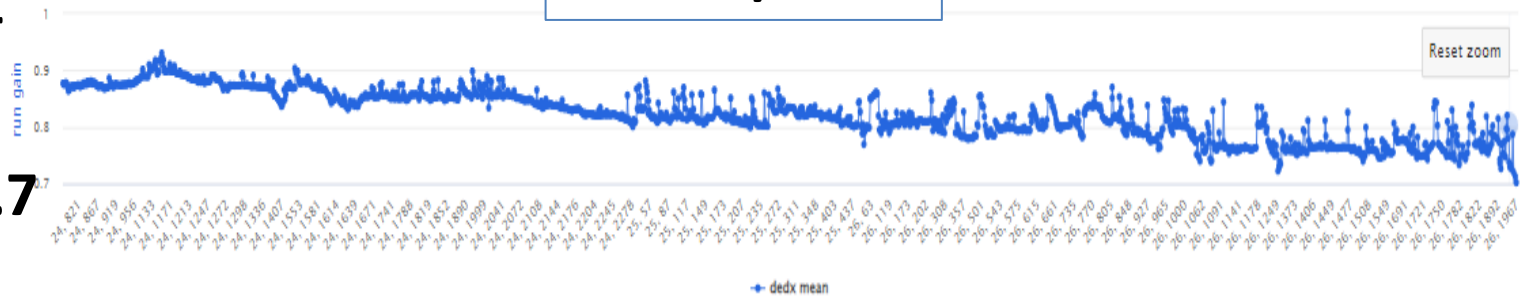
-[report](#) from Taniguchi-san at B2GM

a.u.

1

CDC dE/dx

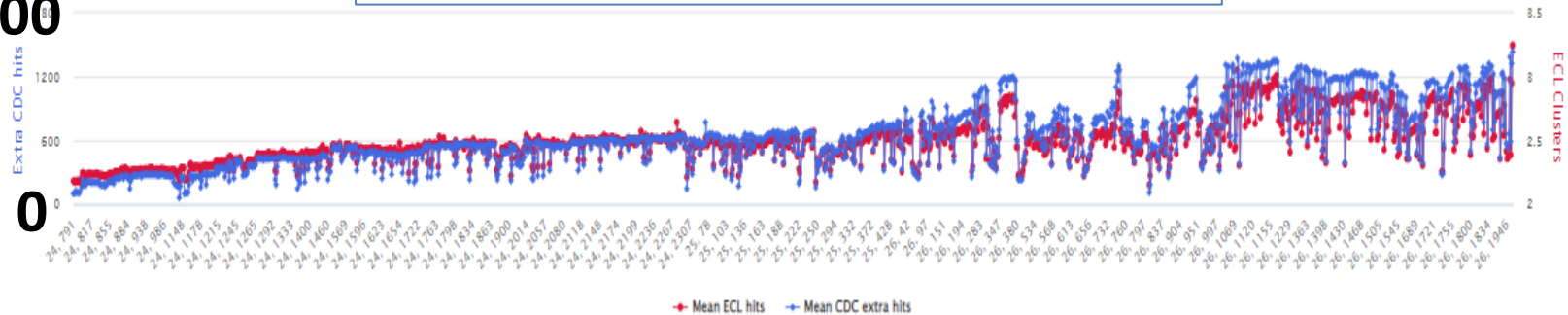
0.7



#hit

1800

CDC #extra hit in an event($\mu\mu$)



start of 2022a

end of 2022b

CDCTRG 2D efficiency 2021-2022

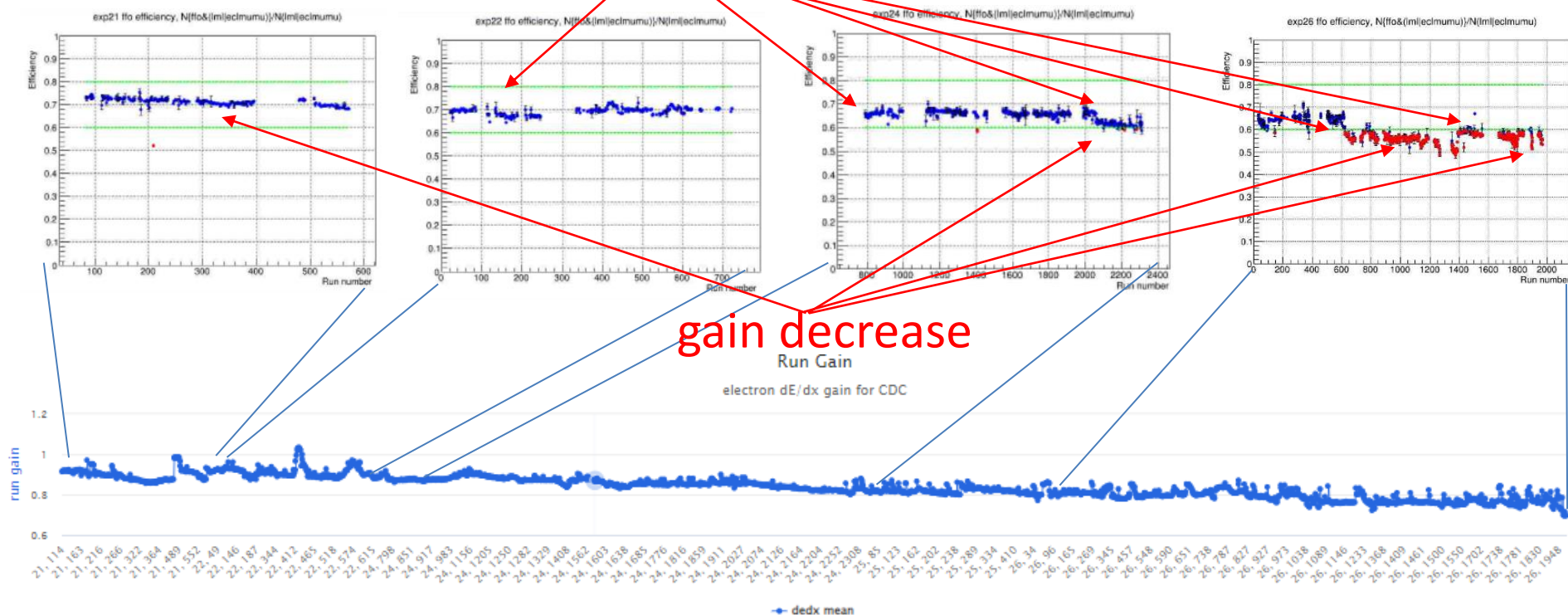
- 2D efficiency has correlated with CDC gain and dead channel
- step function like change: due to dead channel
- continuous change: due to gain
- At maximum ~20%(10%) change of two (single) track trigger efficiency

ffo efficiency with mumu_tight

2021c

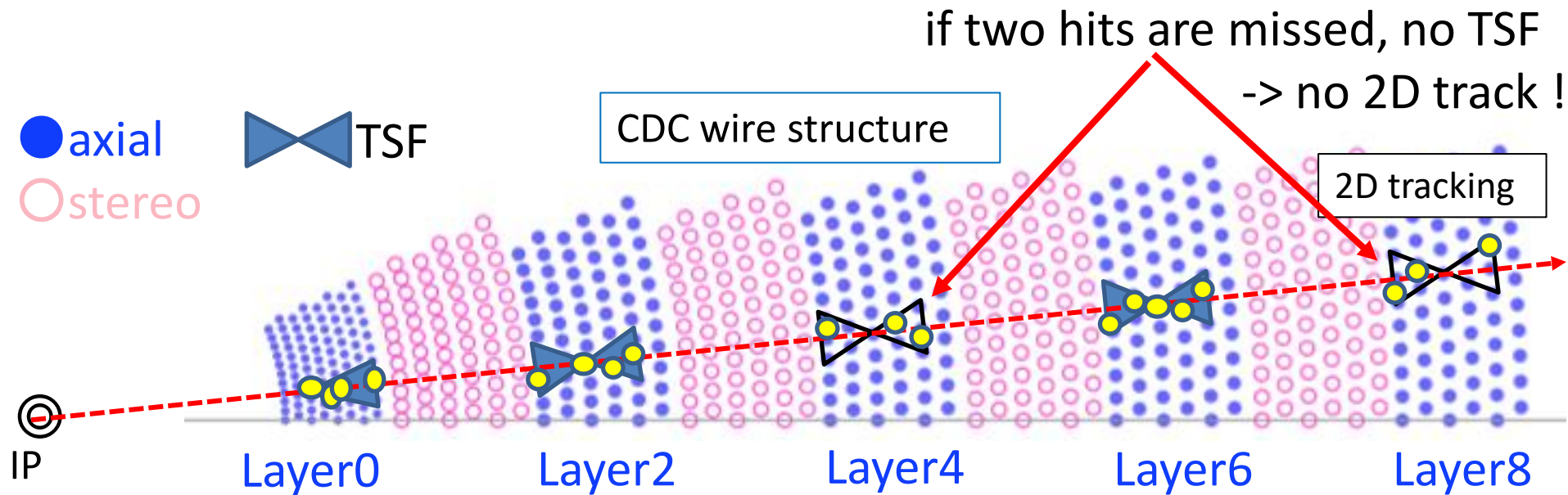
dead channel

2022ab



How to recover efficiency

-TSF algorithm requires 4 layer hits in 5 layers, 2D track require 4 TSFs.
This requirements are already too tight with low gain.



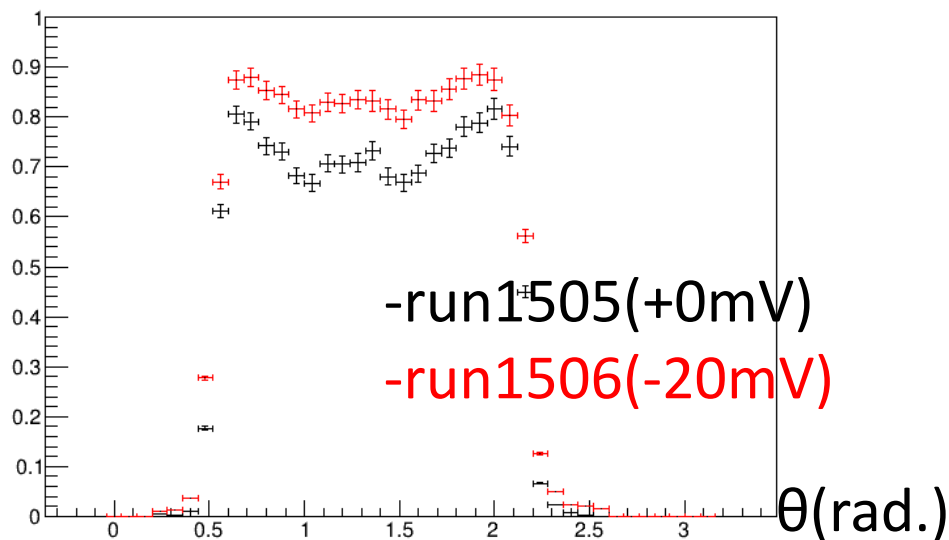
-In order to recover efficiency, it is needed to loosen the requirement.

- 1. decrease hit threshold of CDCFE (discriminator for TDC on CDCFE)
- 2. modify TSF (no good idea for now)
- 3. modify 2D/NN, 3Dhough

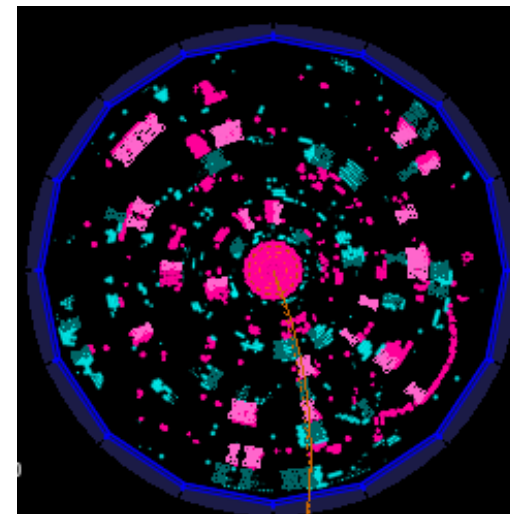
How to recover efficiency: change hit threshold

- Test run is took with lower discriminator threshold: from -10 to -50mV
 - At -20mV, ffo efficiency increased $\sim 10\%$ ($\sim 5\%$ per track) successfully.
 - However, trigger rate significantly increased due to higher BG
 - 20mV: ~ 1.5 times larger CDCTRG rate
 - 40mV: ~ 4 times larger CDCTRG rate
- It is difficult to lower the threshold simply while keeping trigger rate

fpo efficiency with dimuon



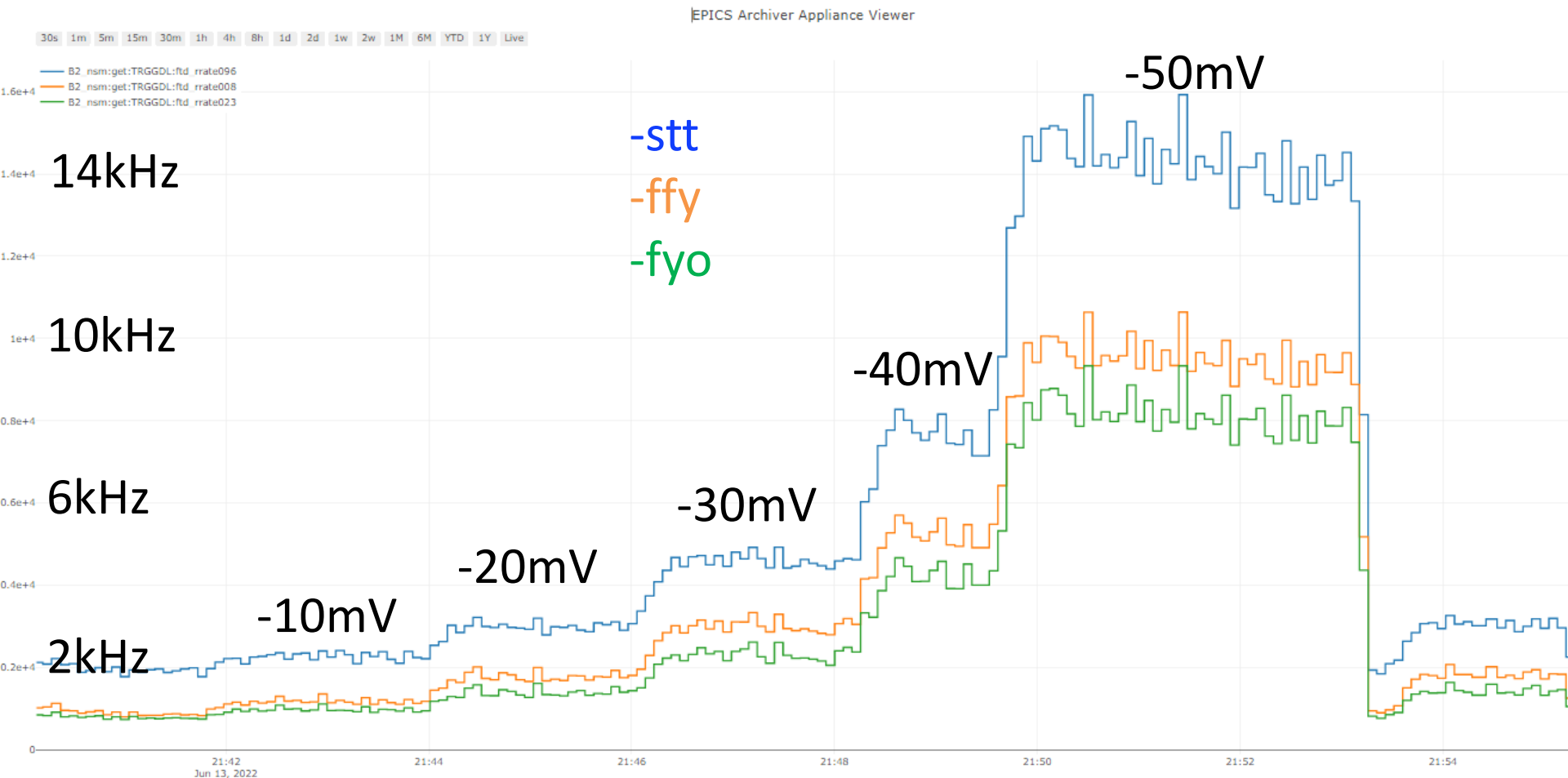
event display with -50mV threshold



many
fake tracks

CDCTRG rate with threshold scan

- CDCTRG rate dramatically increased by the threshold scan
- 20mV: ~1.5 times larger
- 40mV: ~4 times larger
- 50mV: ~8 times larger



How to recover efficiency: modify tracker

-2D: Koga's talk tomorrow

- tracker is modified to count the number of hit layers inside TSF
- With ADC cut, ~30% rate reduction is possible while lowering TDC threshold.

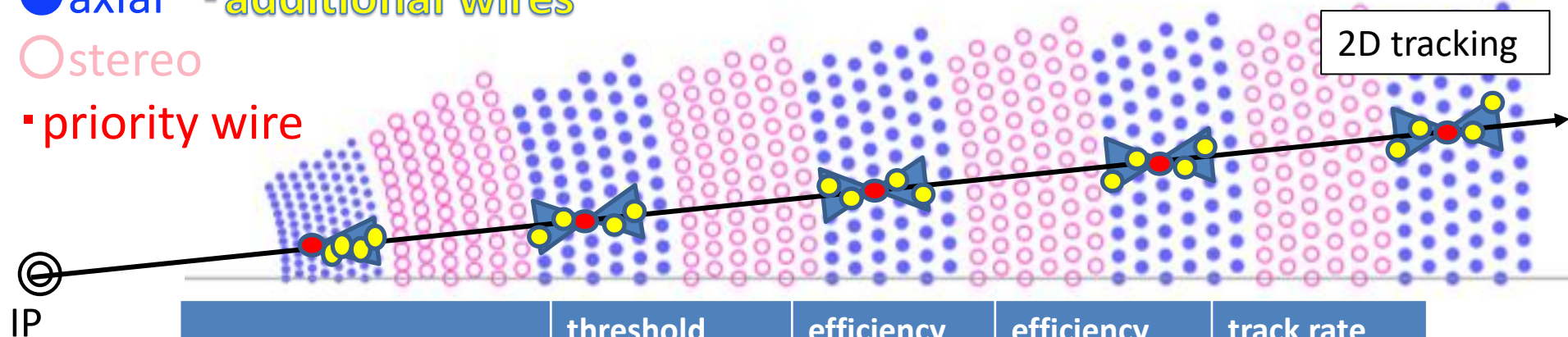
-3D, NN, 3DHough:

- 3D, NN: if efficiency decreases at 2D, maybe there is no much things to do
- 3DHough: should improve efficiency largely with loose TSF requirement

● axial ■ additional wires

○ stereo

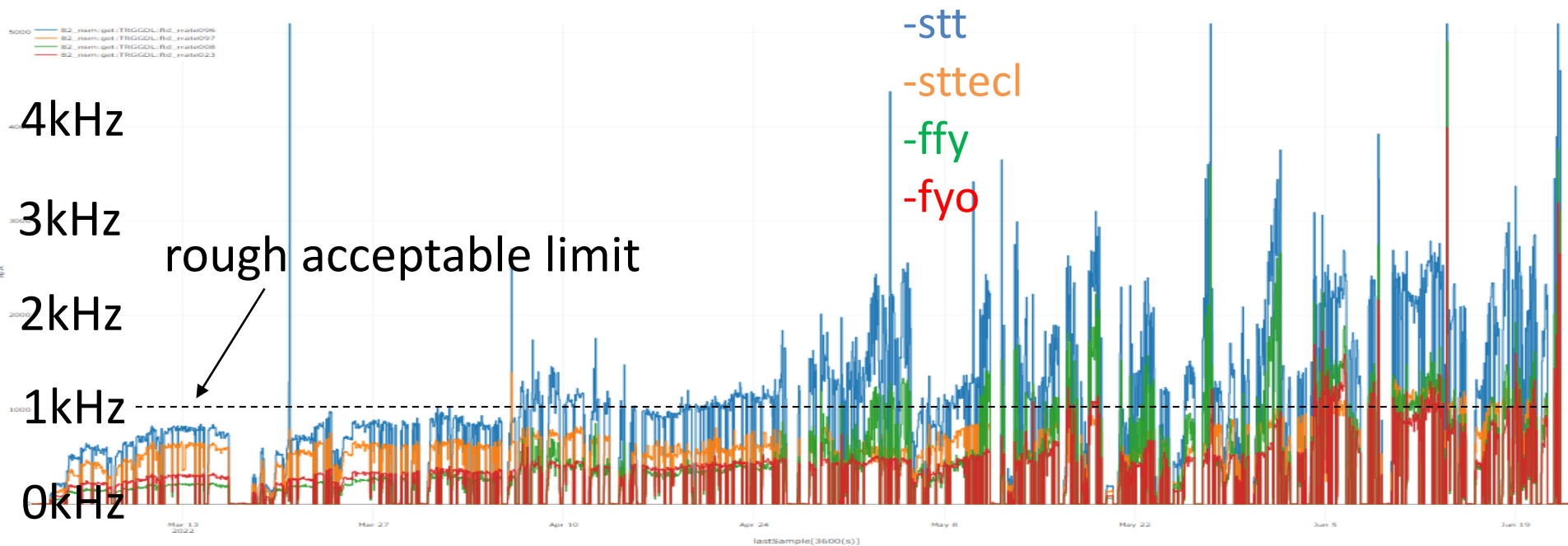
■ priority wire



	threshold	efficiency	efficiency with -20mV	track rate
original 2D	4(TSF)	0.857	0.893	3.4kHz
new 2D 10<ADC<700	15(hit in TSF)	0.872	0.904	2.9kHz
new 2D 20<ADC<400	15(hit in TSF)	0.843	0.875	2.4kHz

Reminder: CDCTRG rate in 2022ab

- CDCTRG rate has been increased during 2022ab due to high BG
- Need to reduce CDCTRG rate of ffy,fyo,stt ~50% during LS1
- luminosity will increase ~10 times: ~1kHz is allowed with present luminosity



How to reduce trigger rate: CDCFE, 2D, NN trackers

- CDCFE: modify crosstalk filtering

- 2D: Koga's talk tomorrow

 - The upgrade of full hit with ADC is useful to reduce trigger rate too.

- 3D, NN, 3DHough: Liu, Felix, Sudo-san, Christian's talk for recent progress

 - improvement of z resolution, and fake track reduction are crucial.

 - no dramatic improvement is seen so far: need further study and nice idea.

-Proposal of rate reduction goal in LS1

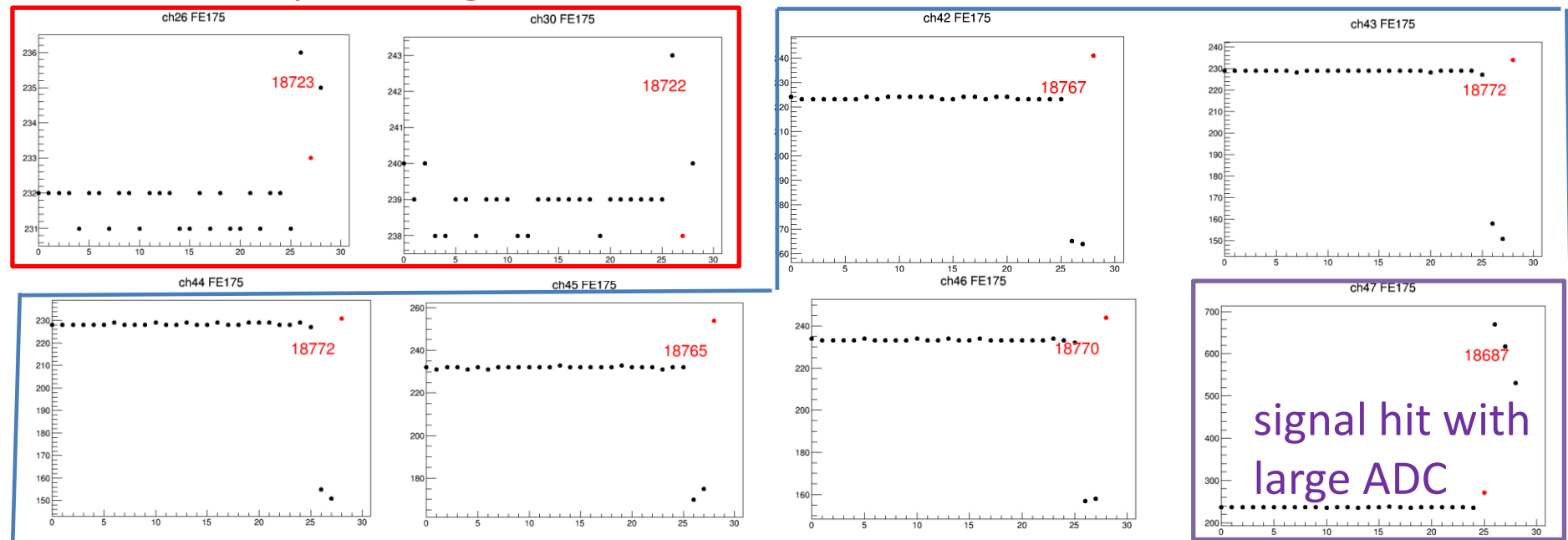
CDCTRG Modified Module	Required rate reduction to achieve 50% (status)
CDCFE crosstalk filter, ADC	~10% (not yet)
CDCTRG 2D	~20% (achieved by simulation)
CDCTRG NN, 3D, 3DHough	~30% (not yet)
Total	~50%
(CDC-ECL matching)	30~50% (achieved by data, not used)

How to reduce trigger rate: CDCFE crosstalk

- CDCFE: it is possible to modify cross talk suppression logic
 - for now, if more than 3 of 8 hits are detected in a asic within $\sim 16\text{ns}$, hit vetoed.
succeed to veto the **crosstalk in the same asic**.
 - however, it is failed to veto the **crosstalk between different asic**.
it is technically possible to modify the logic to veto the next asic.

crosstalk in the next asic,
20-40ns delay from signal, within 10ns

crosstalk in the same asic,
80ns delay from signal, within 10ns



How to reduce trigger rate: ADC in LS1

-R&D is on-going to use ADC information for CDCTRG for BG rejection and possible counter measure of gain degradation

-Advantage:

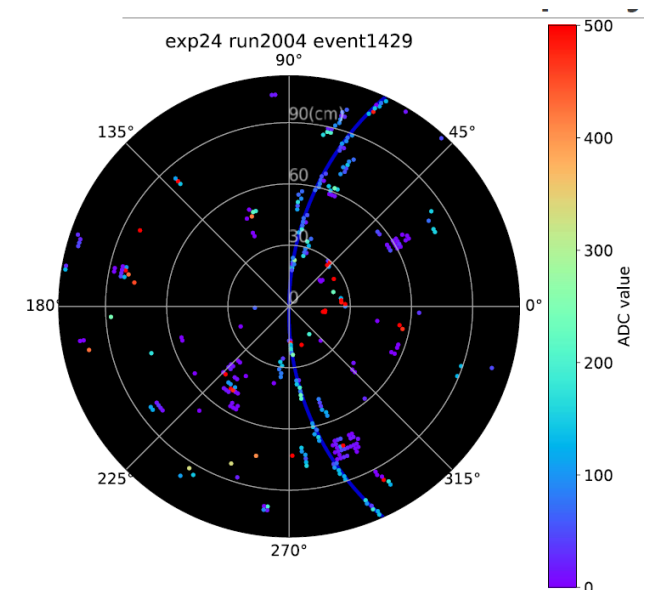
- lower TDC threshold
- improve eff. and BG rejection

-Disadvantage:

- latency increase $\sim 400\text{ns}$
- all CDCFE/CDCTRG FW modification
- degrade eventT0 resolution
(CDCFE bandwidth limit)

-Discussion is on-going with Yun-tsung for MGR FW modification and bandwidth increase

Event display with ADC



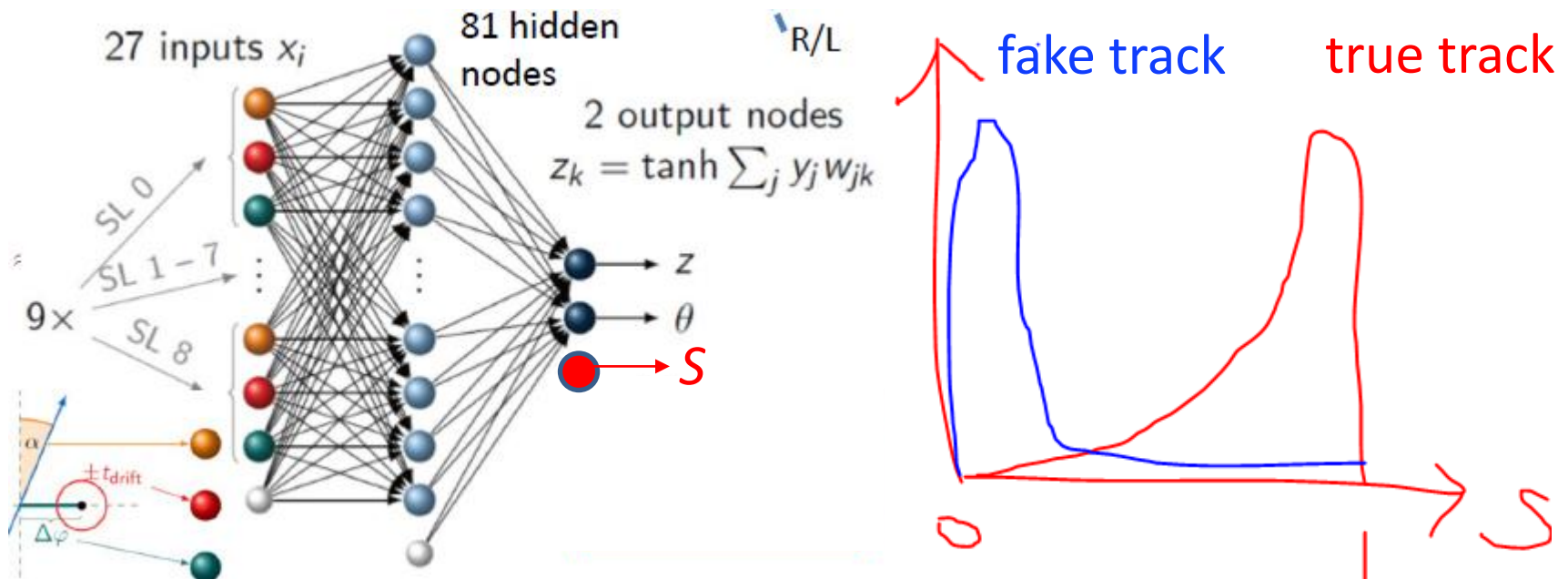
Idea of new logic: fake track identification on NN

-Interest of new logic on NN:

could we add **a flag to identify fake or true track** to output of the NN ?
(idea: reject fake tracks with bad χ^2 .)

-Training with matched offline track existence:

- NN track with offline track (=true track): $S=1$
- NN track with no offline track (=fake track): $S=0$



-Could Christian, Felix and Liu try this primary idea ?

Summary

-I would like to remind what is the major issues of CDCTRG in 2022ab, and needed counter measure in LS1

-Major issues

- CDC gain drop → decrease CDCTRG efficiency
- beamBG increase → increase CDCTRG rate

-Proposal of rate reduction in LS1

-could we add **a flag to identify fake or true track** to output of the NN ?

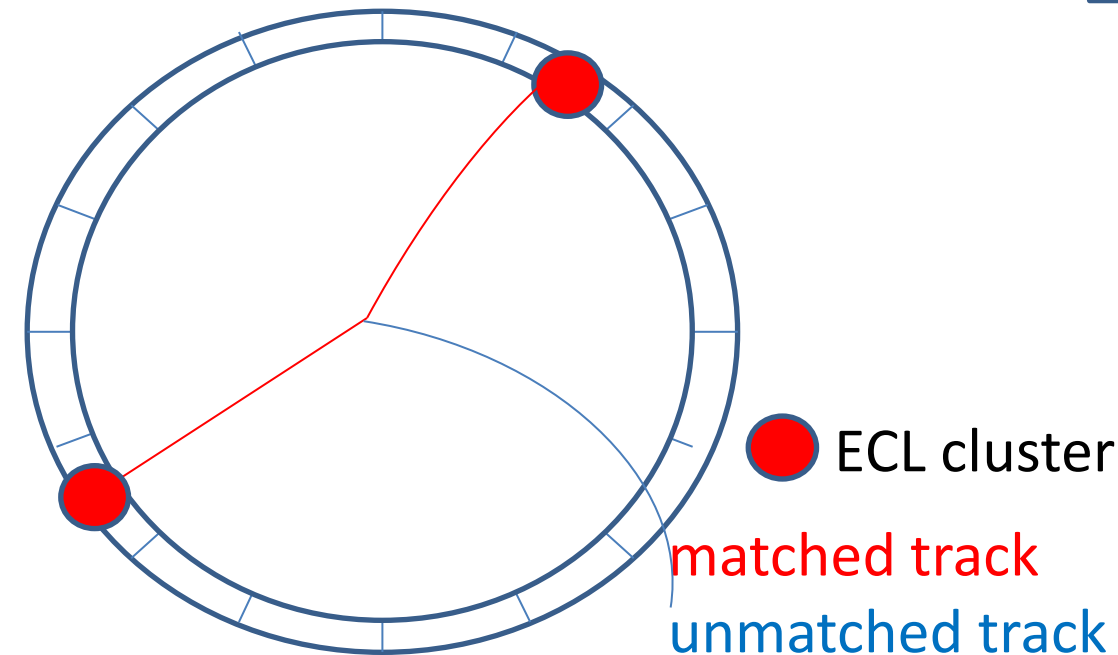
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Total	~50%
(CDC-ECL matching)	30~50% (achieved by data, not used)

backup

How to reduce trigger rate: matching with ECL

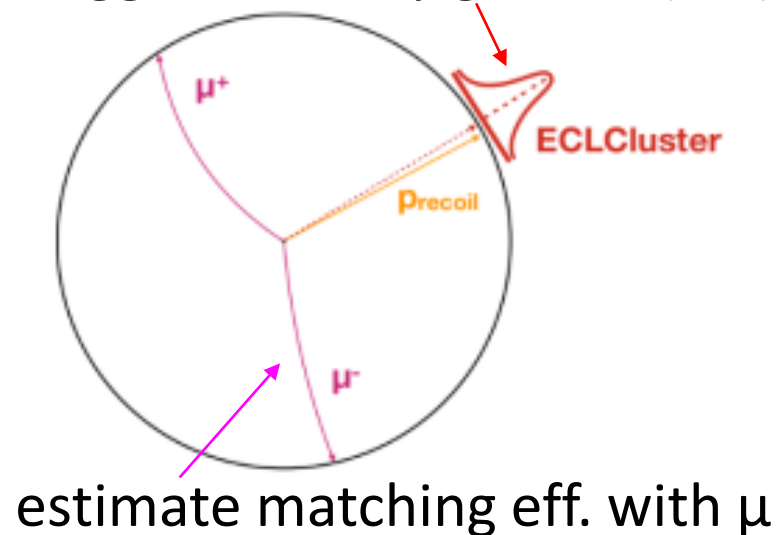
- ϕ Matching with ECL has been a strong option
- matching has been used at Belle
- trigger rate will reduce $\sim 50\%$ while keeping high ($\sim 99\%$) efficiency
- need to estimate trigger efficiency with control sample like $\mu\mu\gamma$, to ensure independence of CDC and ECL \rightarrow Joon will work on
- [example of Koga's study](#)

CDCTRG and ECLTRG ϕ map



Estimation of matching efficiency

trigger event by gamma (hie)



How to recover efficiency: loosen TSF requirement

- It is difficult to simply loose TSF requirement too, due to high BG
 - if we require 3 of 5 hits, too many fake tracks are detected
 - simple ADC cut does not improve situation

CDCTRG NN efficiency 2021-2022

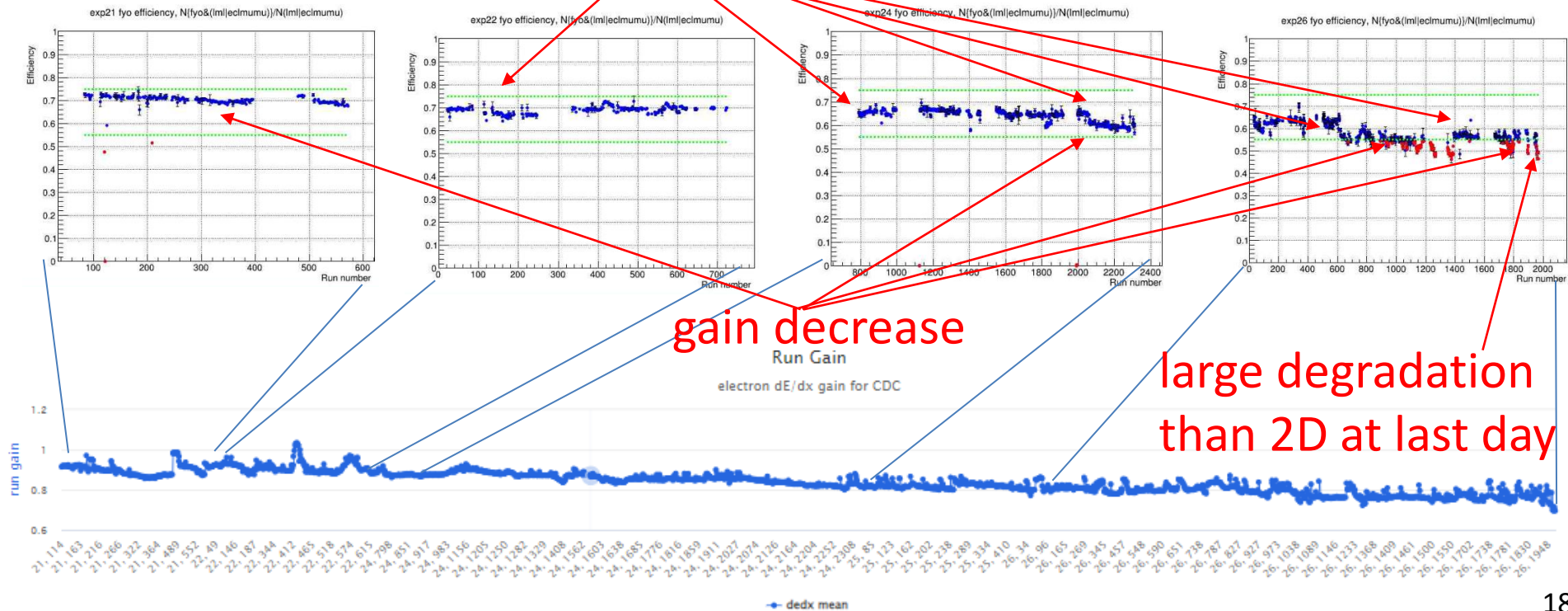
- NN efficiency has correlated with CDC gain and dead channel
- step function like change: due to dead channel
- continuous change: due to gain
- At maximum ~20%(10%) change of two (single) track trigger efficiency

fy0 efficiency with mumu_tight

2021c

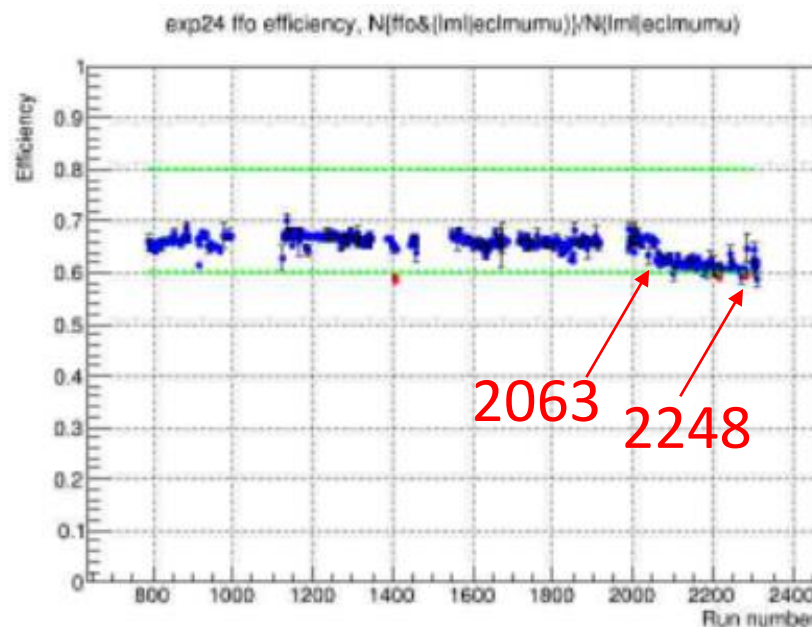
dead channel

2022ab



Trigger efficiency measurement with dimuon

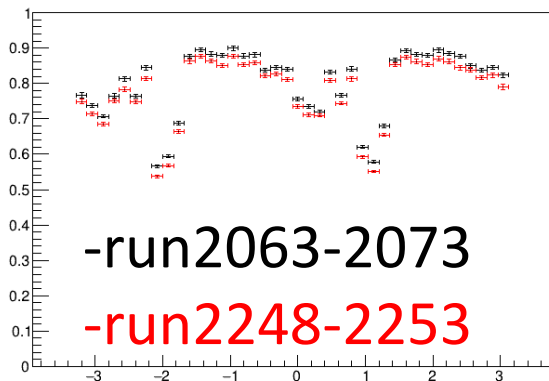
- Check ffo, stt efficiency with offline dimuon selection before/after the change of gain and efficiency (run2063 and run2248)
- Offline event selection:
 - HLT mumutight skim
 - Two offline tracks ($pt > 0.3\text{GeV}$, $|dr| < 2\text{cm}$, $|dz| < 4\text{cm}$)
 - Both two tracks are filled to histogram in an event



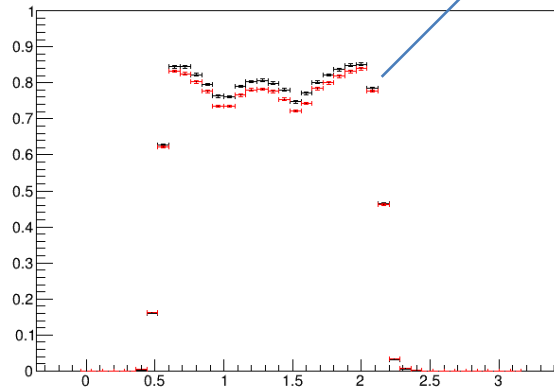
two track trigger (ffo) efficiency: run2063 vs run2248

- Definition of efficiency: $\#(\text{ffo \& lml fired events})/\#(\text{lml fired events})$
- Efficiency decrease $\sim 4\%$ relatively around $\theta=90.\text{deg}$
- It indicates dE/dx decreases
- similar behavior when gain drop in 2021ab (backup)

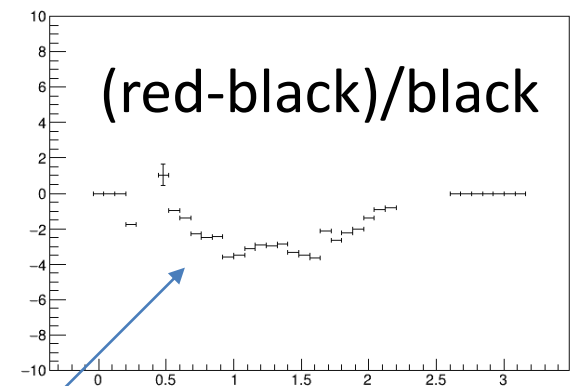
ffo eff. (ϕ)



ffo eff. (θ)



ffo eff. (pt)



%

ffo eff. (θ) relative difference

GeV

two track trigger (ffo) efficiency: time from injection

-Effect from injection BG is checked with “time from injection”

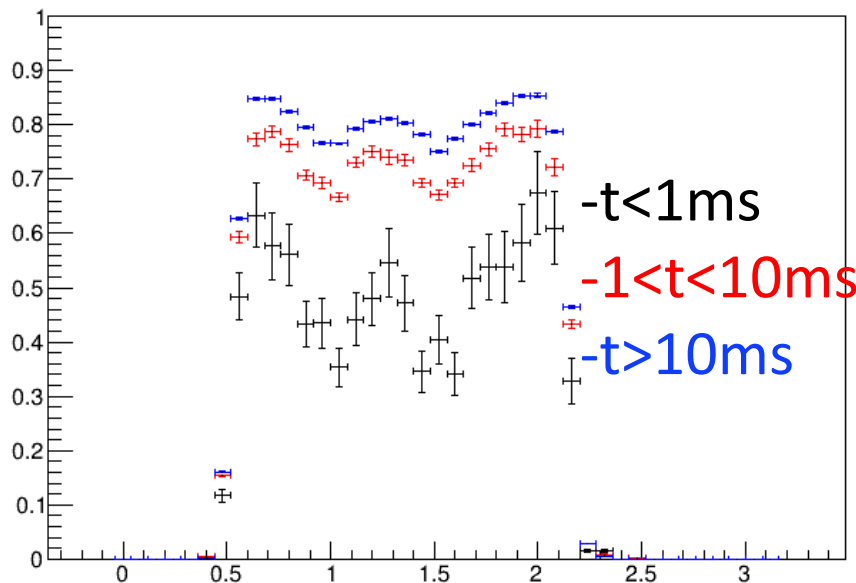
- $t=0$: beam is injected

- $t=0\sim 20\text{ms}$: BG is significantly increased due to the injection

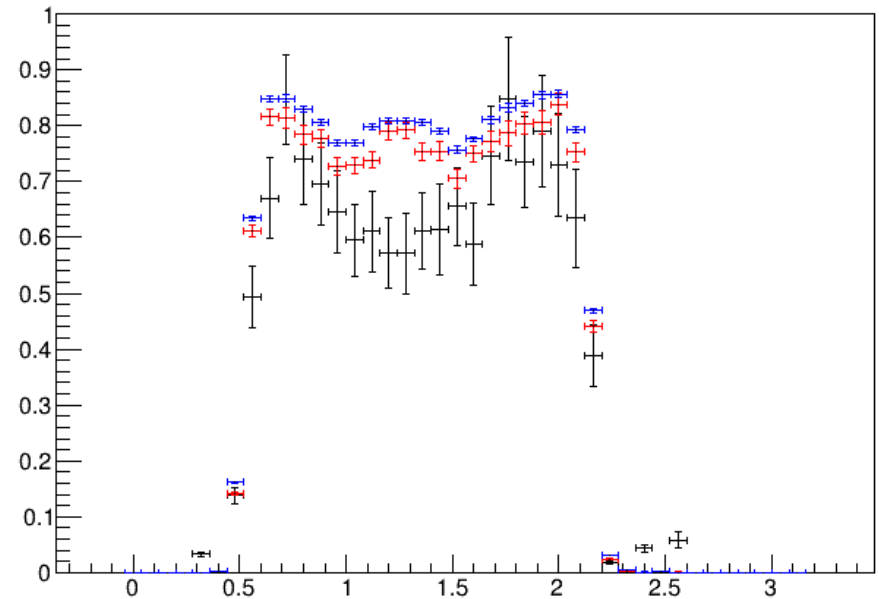
-Clear dependence of time from injection

-event variable of “injectionInHER” and “timeSinceLastInjectionMicroSeconds” are used

ffo eff. (θ) LER injection



ffo eff. (θ) HER injection



two track trigger (ffo) efficiency: TDC threshold scan

-Special run is taken with lower hit threshold on CDCFE

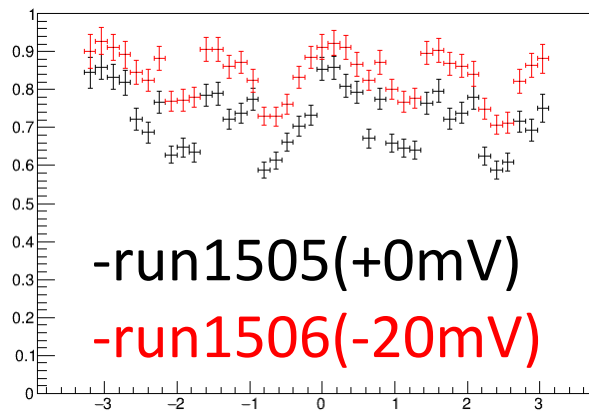
-ffo Efficiency recovered $\sim 10\%$!

- $\sim 5\%$ per a track

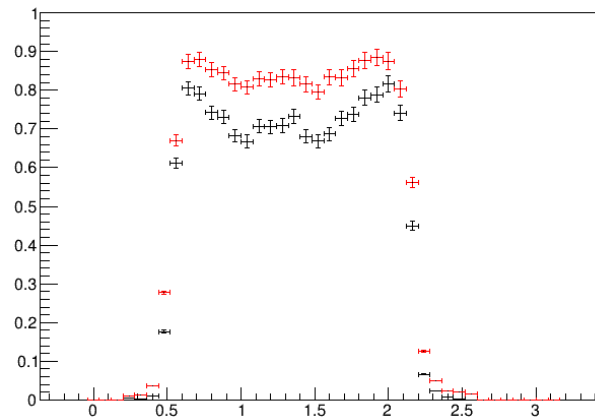
-If problem not solved in LS1, need to decrease threshold -20mV or more, against to increase of $\sim 1.5\text{times}$ increase of trigger rate.

-At present, the increase of the trigger rate is not acceptable..

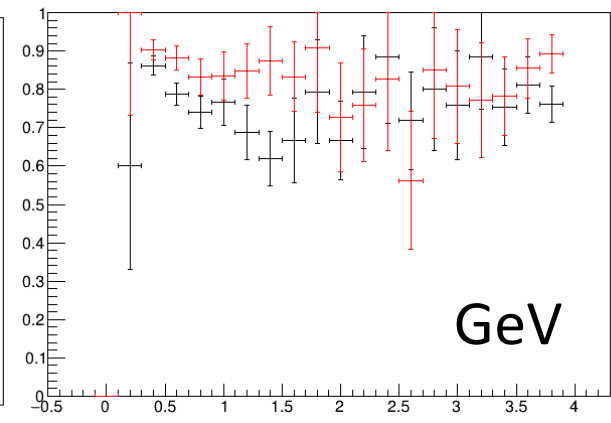
ffo eff. (ϕ)



ffo eff. (θ)



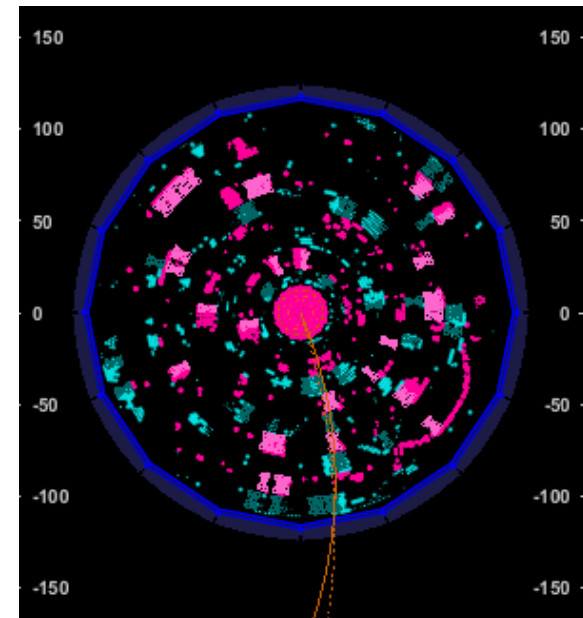
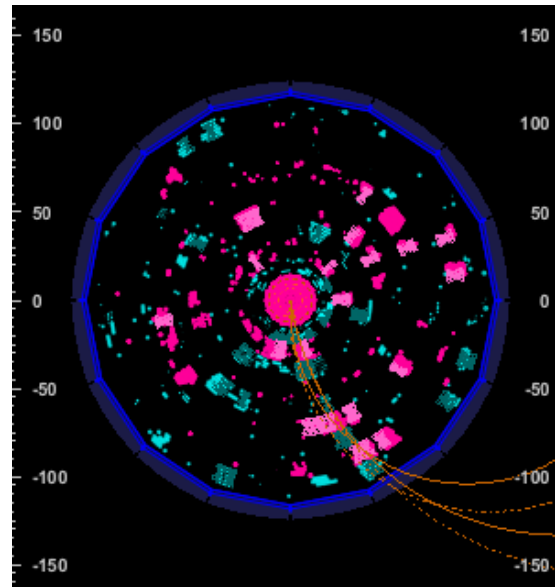
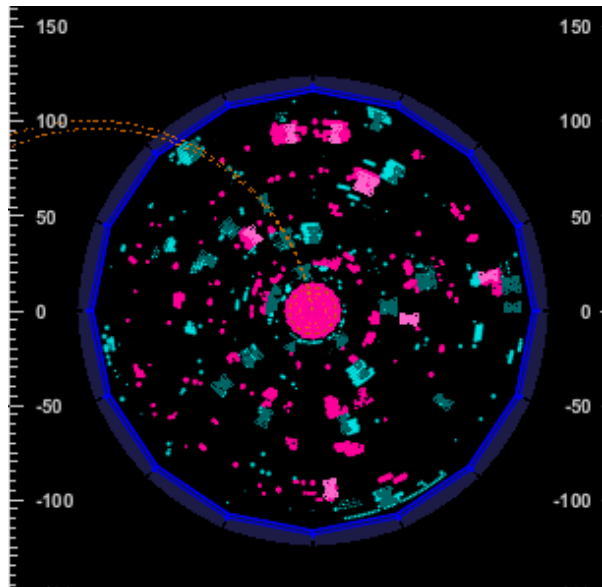
ffo eff. (pt)



Example of event display with lower threshold

23

- CDCTRG 2D TSIM is applied to e26r1507(-50mV)
- With event display, many fake tracks are seen with many noise
- Possible improvement of firmware during LS1 ?
 - New 2D with full hit (Ping, Koga)
 - New NN with improved training for fake track rejection ??
 - Improvement of crosstalk filter ??



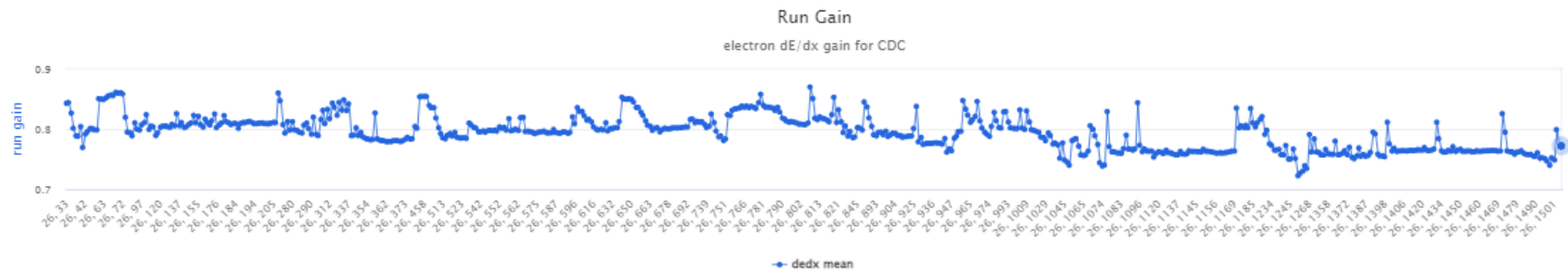
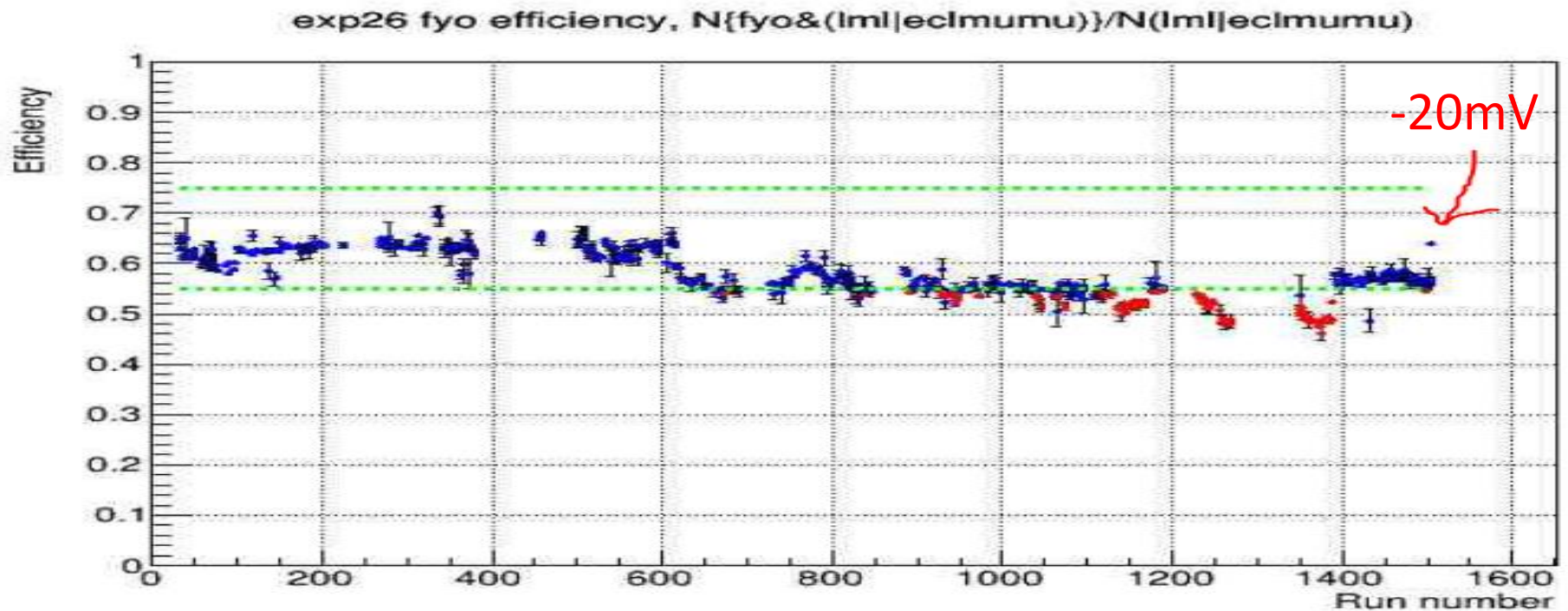
TDC threshold decrease test

- CDCTRG efficiency and CDC gain has been decreased
 - reason is not clear but related to beamBG
 - CDC TDC threshold is scanned to check efficiency and trigger rate
 - ① scan threshold from 0mV to -50mV
 - ② take data with -20mV (30min.) and -40mV (10min.)
 - exp26run1505: nominal setting
 - exp26run1506: -20mV
 - exp26run1507: -40mV
- /group/belle2/TMP/Data/Raw/e0026/r1507/

LER=1200mA, HER=960mA, $L \sim 3.4 \times 10^{34}$.

CDCTRG efficiency

- fyo efficiency increase $\sim 10\%$ with mumutight skim
- detail offline analysis will be done



Comparison with offline track

- Check ffo, stt efficiency with offline dimuon selection before/after the change of gain and efficiency (run2063 and run2248)
- Offline event selection:
 - HLT mumutight skim
 - Two offline tracks ($pt > 0.3\text{GeV}$, $|dr| < 2\text{cm}$, $|dz| < 4\text{cm}$)
 - Both two tracks are filled to histogram in an event

two track trigger (ffo) efficiency: -20mV

-Definition of efficiency: $\#(\text{ffo fired events})/\#(\text{all selected events})$

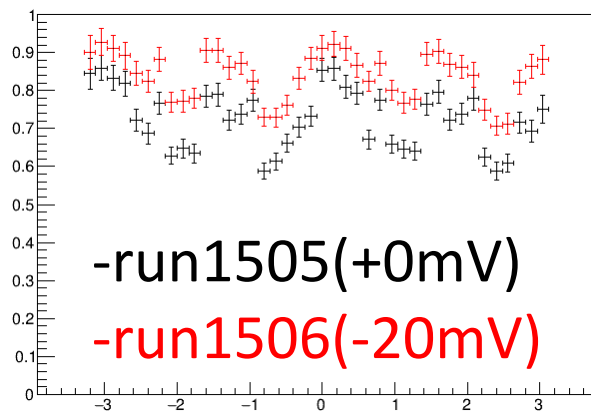
-Efficiency recovered $\sim 10\%$!

- $\sim 5\%$ per track

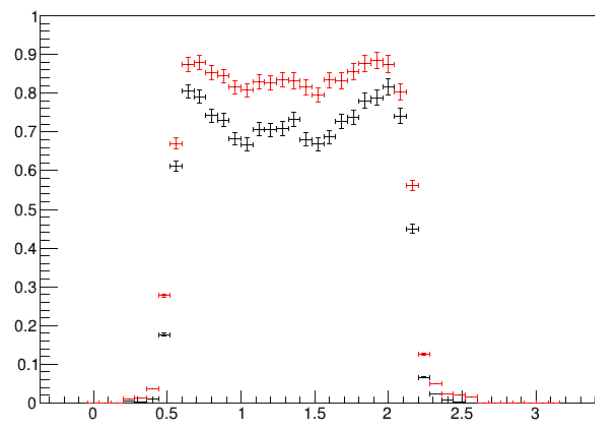
-If problem not solved in LS1, need to decrease threshold -20mV or more

-new CDCTRG 2D will help to reduce CDCTRG rate with lower threshold
(backup)

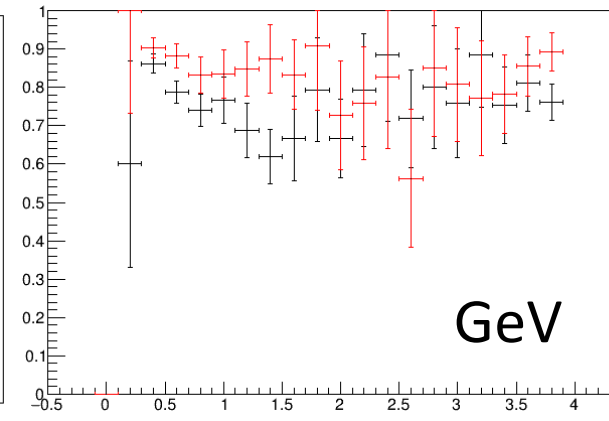
ffo eff. (ϕ)



ffo eff. (θ)



ffo eff. (pt)



two track trigger (ffo) efficiency: exp20 and 18

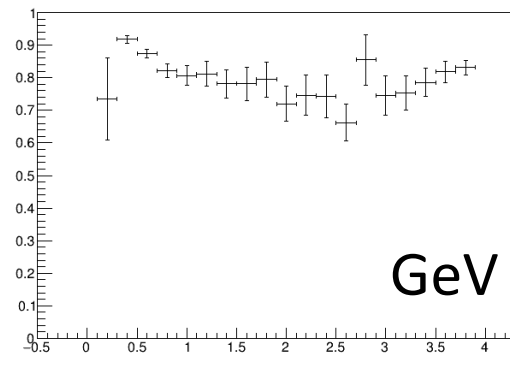
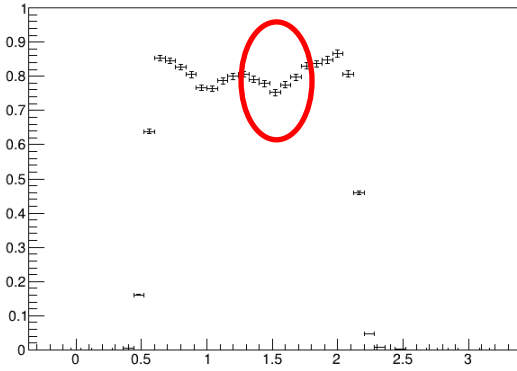
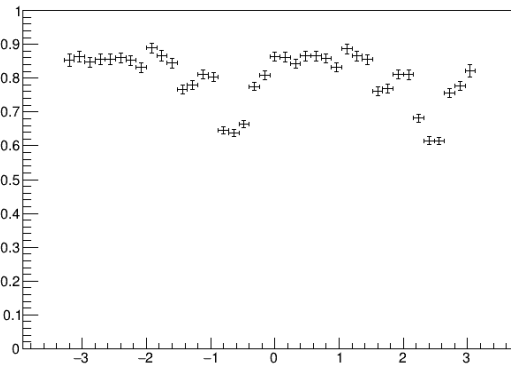
- Definition of efficiency: $\#(\text{ffo fired events})/\#(\text{all selected events})$
- Efficiency of ffo in exp20 is higher than exp18
 - Especially around $\theta=90\text{deg}$.
 - recovered by CDC gain increasement

ffo eff.(ϕ)

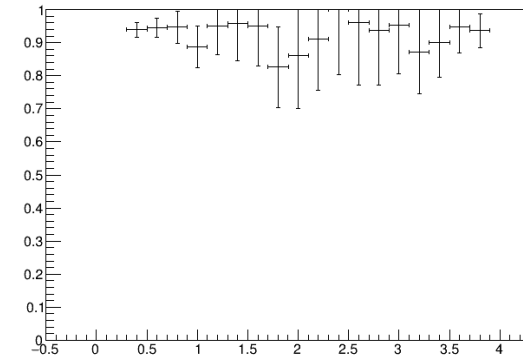
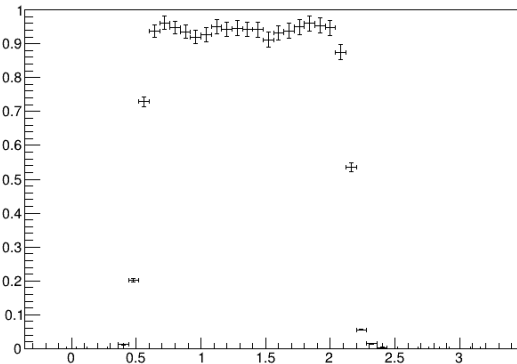
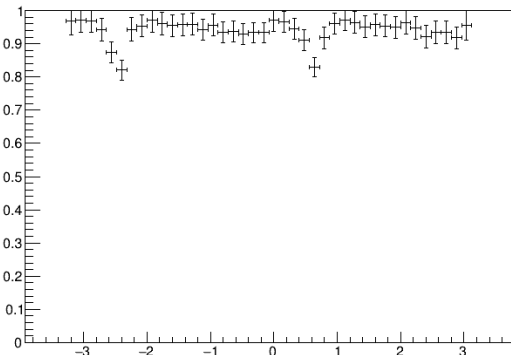
ffo eff. (θ)

ffo eff. (pt)

2021b
exp18
run1334-
1336



2021c
run625-632



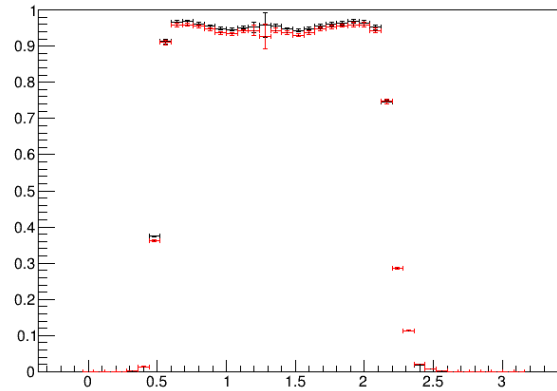
single track trigger (stt) efficiency

- Definition of efficiency: $\#(\text{stt fired events})/\#(\text{all selected events})$
- No significant effect for stt

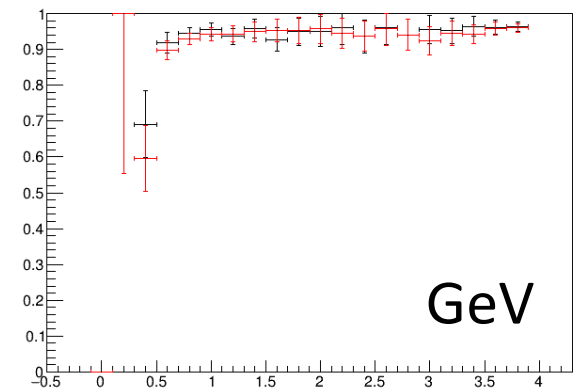
stt eff. (ϕ)



stt eff. (θ)



stt eff. (pt)



Comparison with offline track

-Check if ffo, stt are fired or not with offline dimuon selection

-Offline event selection:

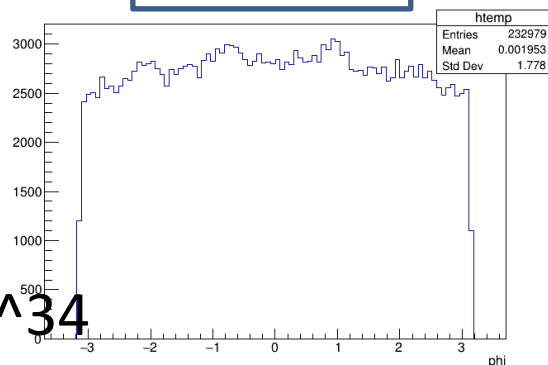
-HLT mumutight skim

-Two offline tracks ($pt > 0.3 \text{ GeV}$, $|dr| < 2 \text{ cm}$, $|dz| < 4 \text{ cm}$)

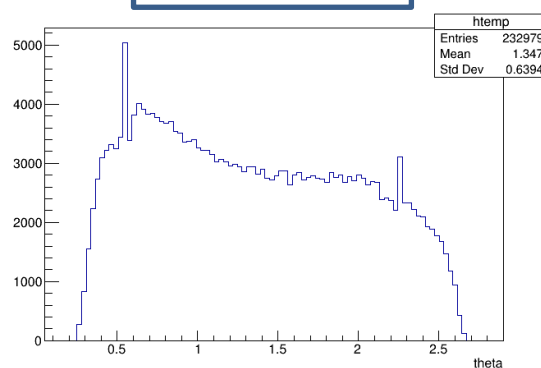
-Both two tracks are filled to histogram in an event

2021b
exp18
run1334-
1336

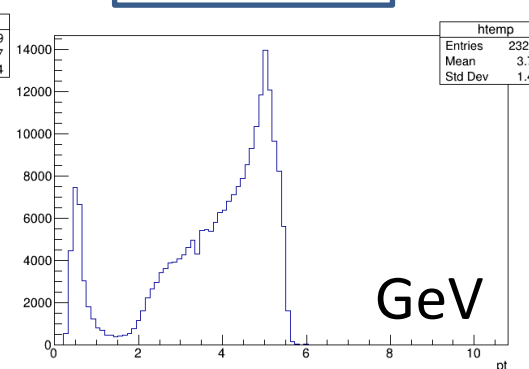
ϕ



θ



pt

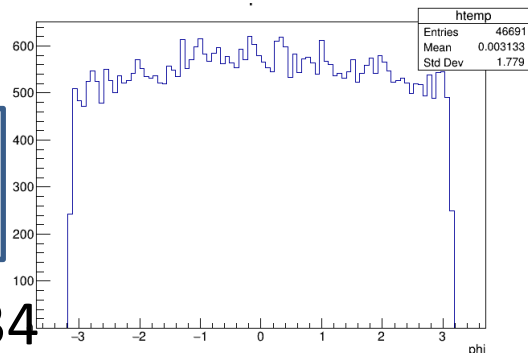


GeV

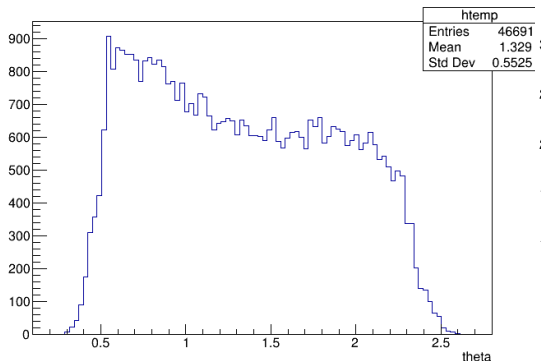
$L = 2.5 \times 10^{34}$

2021c
run625-632

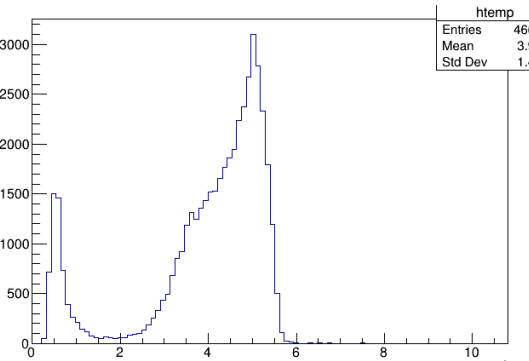
ϕ



θ



pt



fff efficiency (fake track rate)

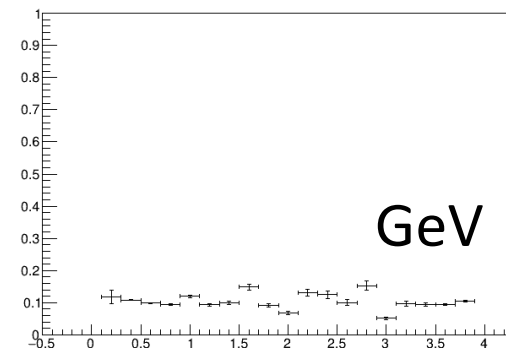
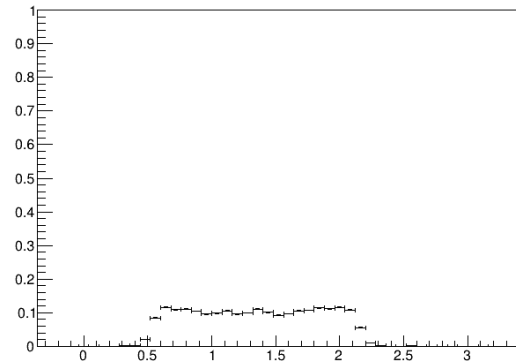
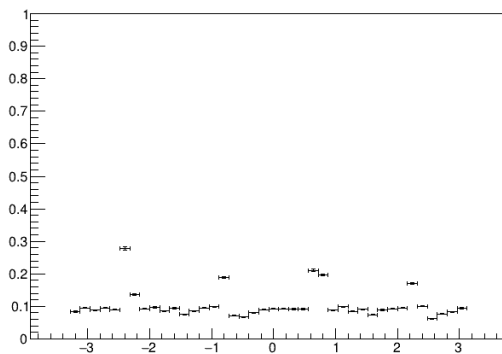
- Definition of efficiency: $\#(\text{fff fired events})/\#(\text{all selected events})$
- Fake track of fff in exp20 is higher than exp18
 - No tendency in ϕ, θ, pt

fff eff. (ϕ)

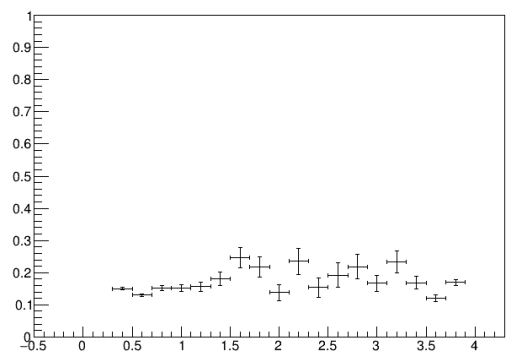
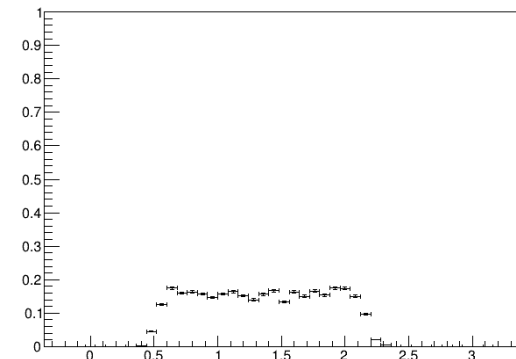
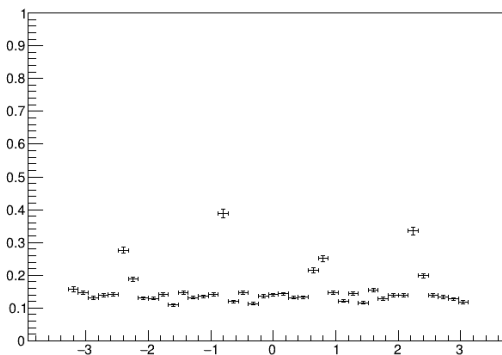
fff eff. (θ)

fff eff. (pt)

2021b
exp18
run1334-
1336



2021c
run625-632



fff,aaa efficiency (fake track rate)

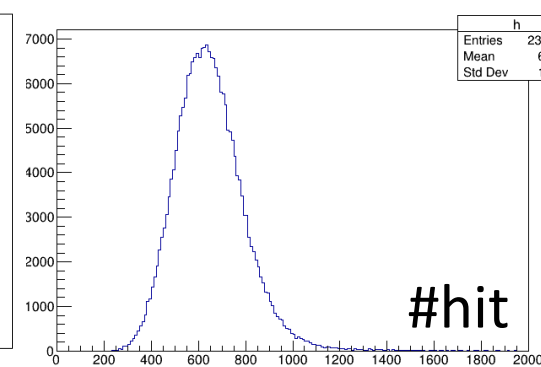
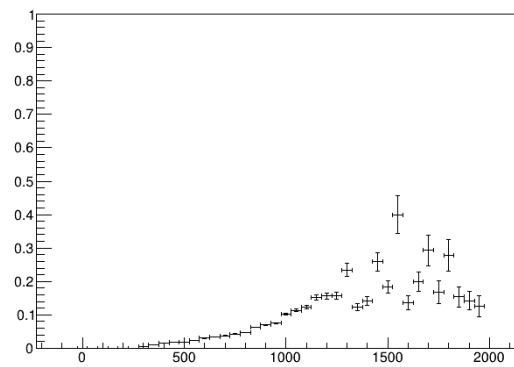
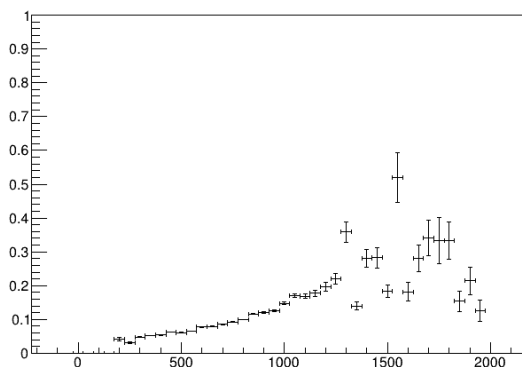
- Definition of efficiency: $\#(\text{fff fired events})/\#(\text{all selected events})$
- Fake track of fff, aaa in exp20 is higher than exp18
 - higher fake track with higher nExtraCDCHits
(#CDCHits not used for tracking)
 - Even with same nExtraCDCHits, fake track rate is higher

fff eff.(nExtraCDCHits)

aaa eff.(nExtraCDCHits)

nExtraCDCHits

2021b
exp18
run1334-
1336



2021c
run625-632

