

CDCTRG 2D status

2022/11/24

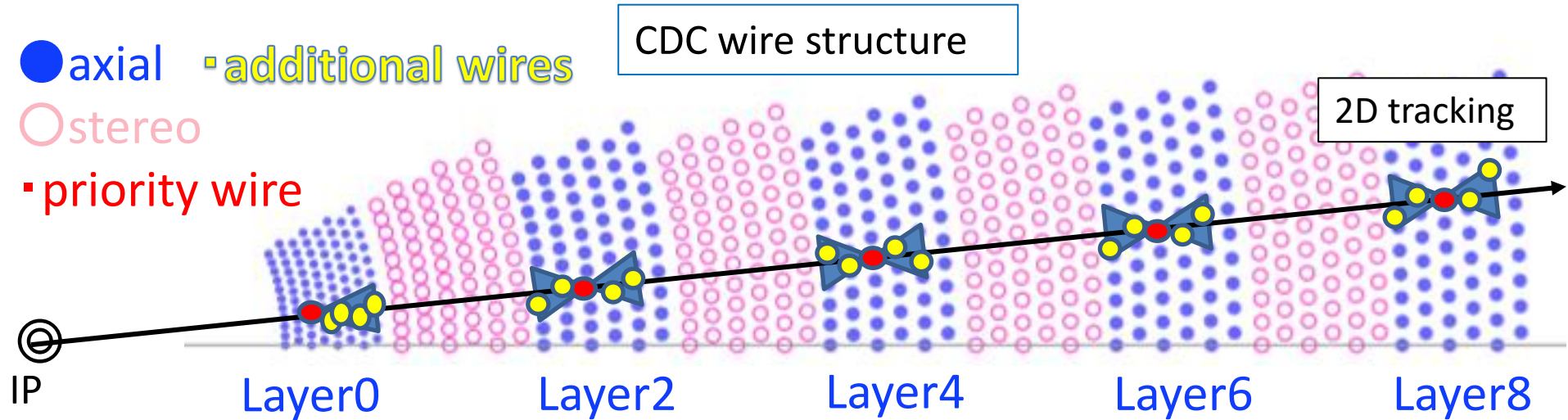
T.Koga

Motivation

- Status of new 2D firmware
- Performance evaluation with cosmic
- Simulation with collision data for further optimization

Fullhit 2D algorithm

-Modify 2D to count all layer hits inside TSF for hough mapping



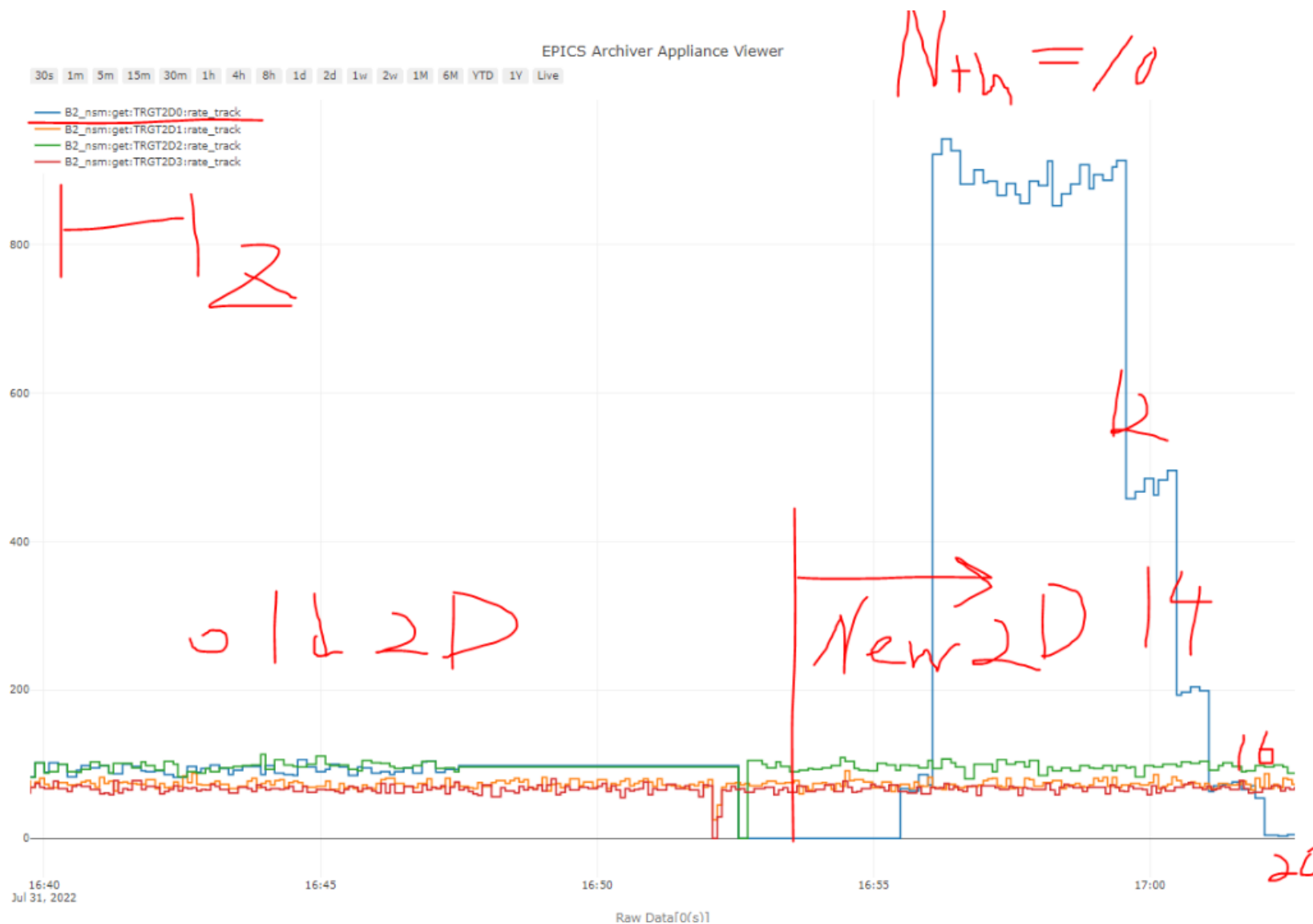
-Firmware development is finished by Ping,
and Koga takes over commissioning work for his graduation

-Parameter of Hough is the same as present 2D, except for hit threshold

- Present 2D: the number of tracked TSF ≥ 4
- New 2D: the number of tracked hit ≥ 20 (Nth)

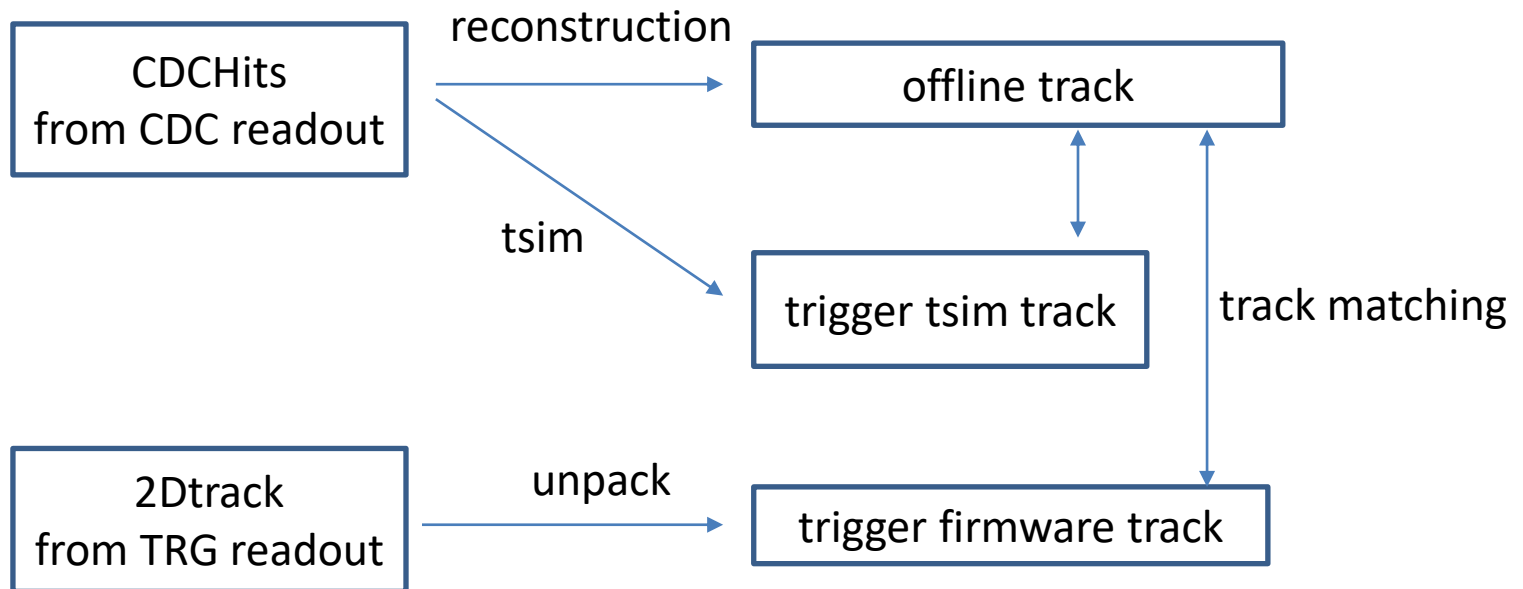
Commissioning with cosmic

- New firmware is installed and cosmic rate checked.
- With $N_{th} \geq 16$, rate is smaller than present 2D. Expected behavior.



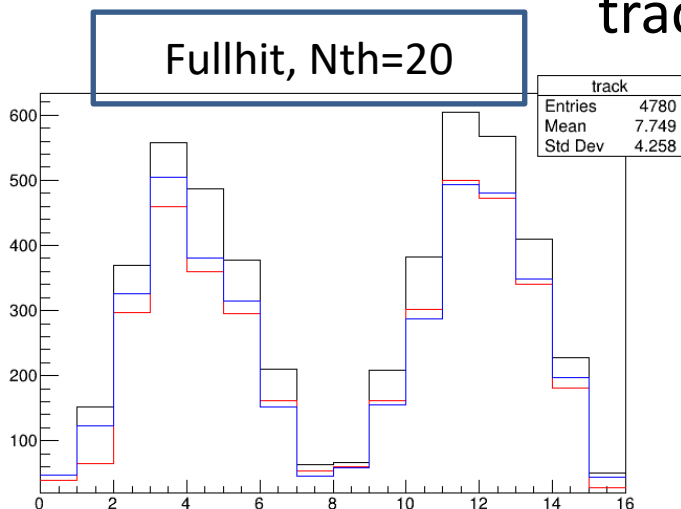
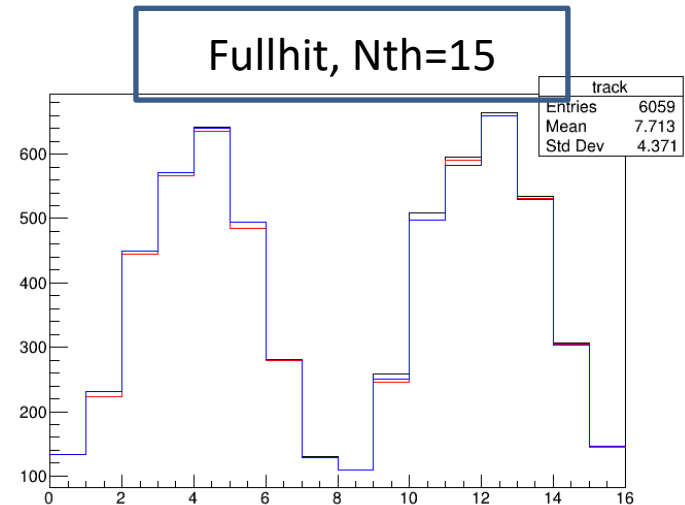
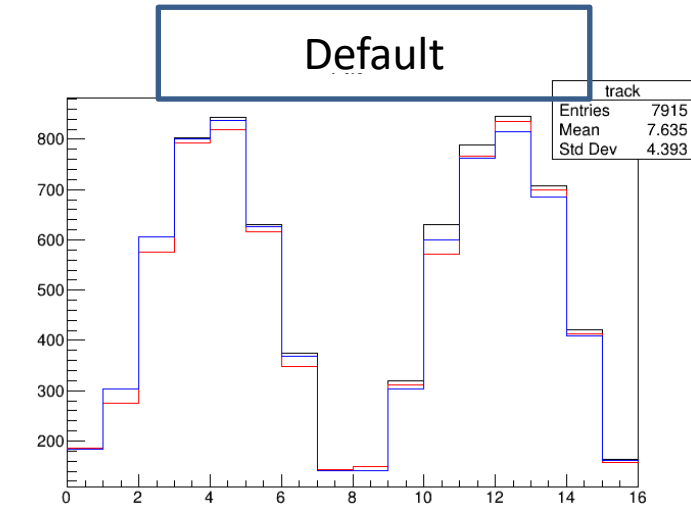
Cosmic analysis with offline track

- Offline track is selected from cosmic data
 - impact parameter $|d_0| < 1\text{cm}$: select cosmic through IP
 - first cdc layer < 5 , last cdc layer > 50 : select long track from SL0 to SL8
- Track matching is applied to trigger tracks, both tsim and firmware
 - $\Delta\phi < 20\text{deg}$.
 - (no pt requirement because magnetic field is off)



Comparison of track ϕ

- With Nth=15, good FW/TSIM/offline track agreement
- With Nth=20, FW efficiency is smaller than TSIM/offline
- > investigating with larger dataset taken in Oct.



track ϕ (slotID)

- offline track
- matched firmware track
- matched tsim track

Simulation with collision data

-TSIM is performed with collision data, in order to optimize the hit threshold

-Data set:

-3/21 exp24run1184, physics, beam_reco_filter

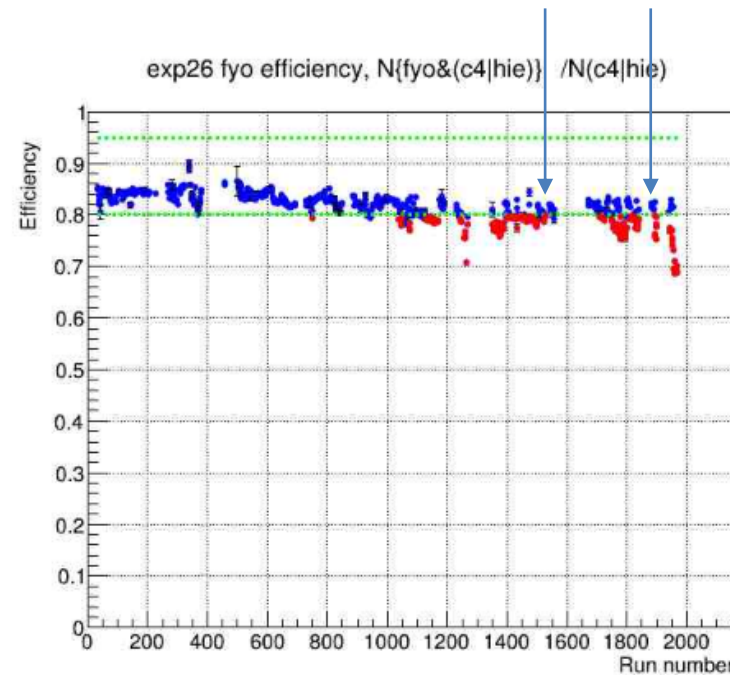
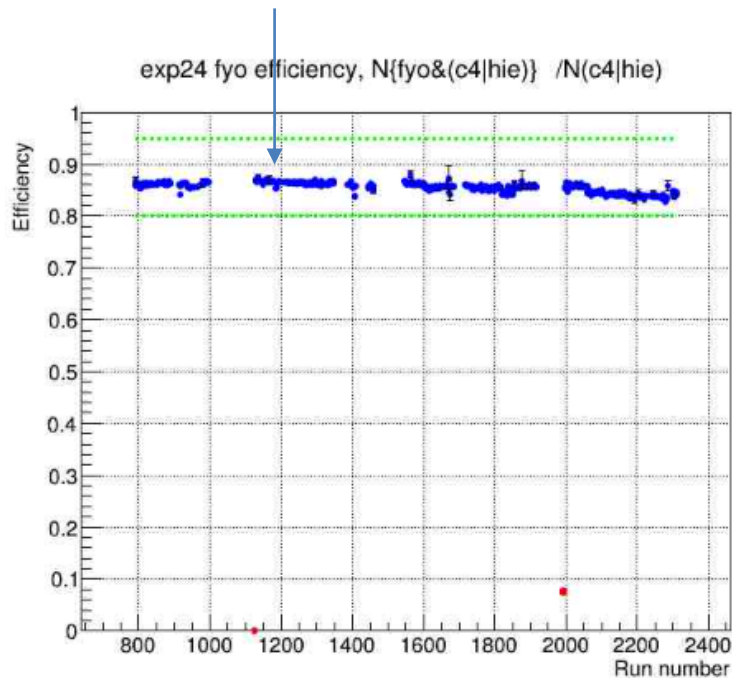
$L \sim 2.0 \times 10^{34}$, L1 rate ~ 3 kHz, CDC leak current $\sim 40 \mu\text{A}$

-6/13 exp26run1506, debug, beam_reco_filter, **lower TDC threshold -20mV**

$L \sim 3.5 \times 10^{34}$, L1 rate ~ 8 kHz, CDC leak current $\sim 200 \mu\text{A}$

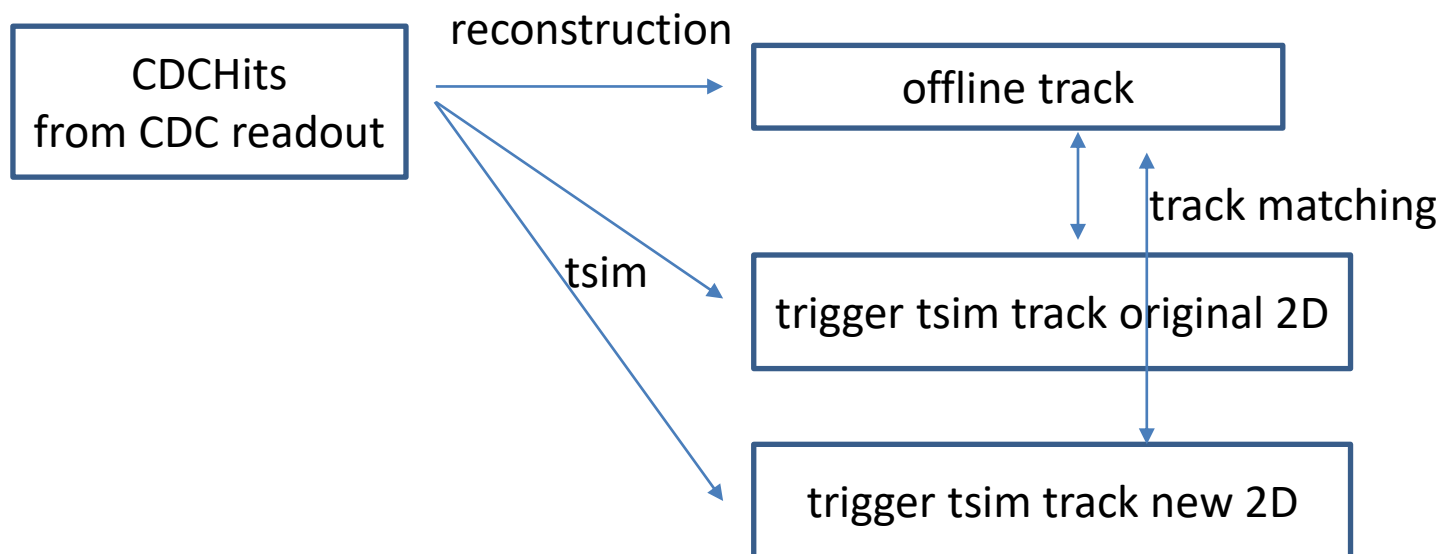
-6/18 exp26run1893, physics, beam_reco_filter

$L \sim 3.0 \times 10^{34}$, L1 rate ~ 5 kHz, CDC leak current $\sim 200 \mu\text{A}$



Analysis with offline track

- Offline dimuon track is selected from collision data
 - impact parameter $|d_0| < 1\text{cm}$, $|z_0| < 1\text{cm}$: select cosmic through IP
 - first cdc layer < 5 , last cdc layer > 50 : select long track from SL0 to SL8
 - HLT skim = mumutight
- Track matching is applied to trigger tracks, both tsim and firmware
 - $\Delta\phi < 20\text{deg}$.
 - $\Delta p_t <$
- Compare efficiency and trigger rate



track matching efficiency

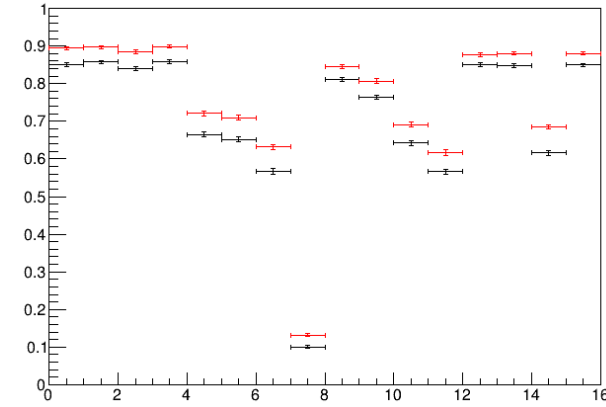
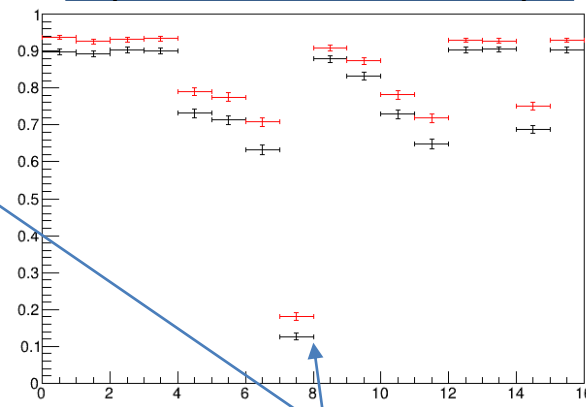
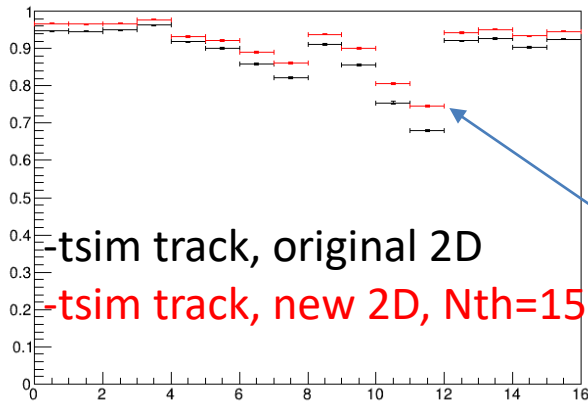
- Full-hit2D Hit threshold = 15
- Better efficiency than the original 2D.

matching efficiency

3/21 exp24run1184

6/13 exp26run1506
(lower TDC threshold)

6/18 exp26run1893



track $\phi(\text{slotID})$ Dips due to CDC readout dead channel (not CDCTRG)

track matching efficiency

-Full-hit2D Hit threshold = 15-19

-Efficiency decreases due to low hit efficiency

-due to low gain, which is not simulated and seen on data only

Efficiency at slot0

	Nth	exp24run1184	exp26run1506	exp26run1893
original 2D	4	0.946	0.893	0.857
	5	0.614	0.448	0.369
new 2D	15	0.966	0.926	0.897
	16	0.943	0.886	0.850
	17	0.910	0.846	0.799
	18	0.856	0.776	0.713
	19	0.776	0.666	0.599

optimal

track matching efficiency: Add ADC information

-2D code is modified on TSIM to use ADC information

- TSF: no ADC is used
- 2D: only CDChits with $\text{ADC}=[10,600]$ is used for Hough mapping.

-Track matching efficiency is checked again
-keeping high efficiency

Efficiency at slot0

	Nth	exp24run1184	exp26run1506	exp26run1893
original 2D	4	0.946	0.893	0.857
	5	0.614	0.448	0.369
new 2D $10 < \text{ADC} < 700$	10	0.998	0.995	0.988
	15	0.952	0.904	0.872
new 2D $20 < \text{ADC} < 400$	10	0.997	0.990	0.985
	15	0.937	0.875	0.843

optimal

Track rate reduction

- Check #2D tracks and 2D track rates with original 2D and new 2D
 - exp26run1780, beam_reco_monitor
 - $L \sim 4.0 \times 10^{34}$, L1 rate $\sim 8\text{kHz}$, CDC leak current $\sim 250\mu\text{A}$
- Even with rough idea,
2D track rate reduce $\sim 30\%$, while keeping efficiency with $20 < \text{ADC} < 400$.
 - further optimization is possible

	Nth	event rate of #2D track>0 exp26run1780	dimuon efficiency exp24run1184
original 2D	4	3.4kHz	0.946
new 2D	16	3.1kHz	0.943
new 2D $10 < \text{ADC} < 700$	15	2.9kHz	0.952
new 2D $20 < \text{ADC} < 400$	15	2.4kHz	0.937

Further modification with fine hough mesh

- Try to increase Hough binning of $\phi \times pt$ for better BG rejection
 - 160 $\times$ 34: OK $\leftarrow$ tested, same as nominal 2D
 - 320 $\times$ 34: OK $\leftarrow$ will be tested with cosmic
 - 320 $\times$ 68: BAD
- Optimization of logic design is needed to reduce LUT resource usage

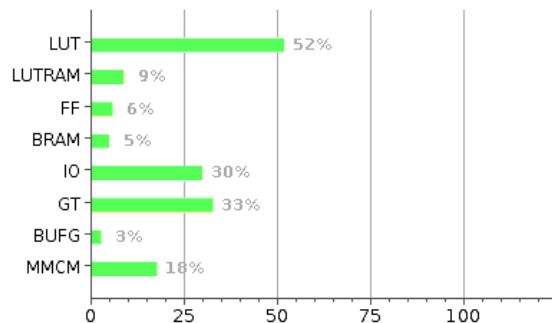
160 $\times$ 34

320 $\times$ 34

320 $\times$ 68

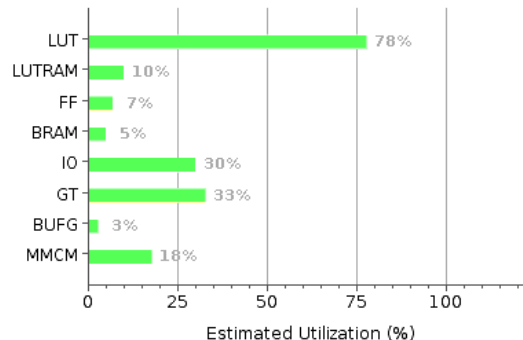
Utilization Post-Synthesis | Post-Implementation

Graph | Table



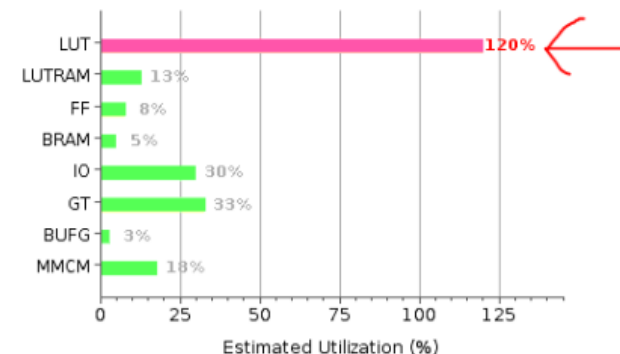
Utilization Post-Synthesis | Post-Implementation

Graph | Table



Utilization Post-Synthesis | Post-Implementation

Graph | Table



Summary

- Status of new 2D firmware
 - full-hit algorithm is successfully compiled. Trying fine Hough mesh too.
- Performance evaluation with cosmic
 - cosmic rate is checked and looks OK
 - #CDChits of FW is smaller than TSIM about ~ 1 hit per track.
Need further investigation with large data taken in Oct.
- Simulation with collision data for further optimization
 - 2D track rate reduce $\sim 30\%$, while keeping efficiency with $20 < \text{ADC} < 400$.

	Nth	event rate of #2D track>0	dimuon efficiency
original 2D	4	3.4kHz	0.946
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new 2D $10 < \text{ADC} < 700$	15	2.9kHz	0.952
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backup

Track finding efficiency: #hit dependence with TSIM

-Change Nth of TSIM for comparison.

Impact to efficiency is large, even with small changes of the Nth.

-It seems #CDChits of FW is smaller than TSIM about ~ 1 hit per track.

-offline track

-matched firmware track

-matched tsim track

data-MC agreement

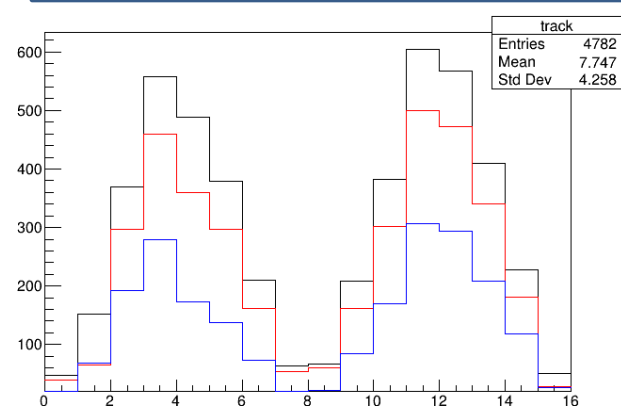
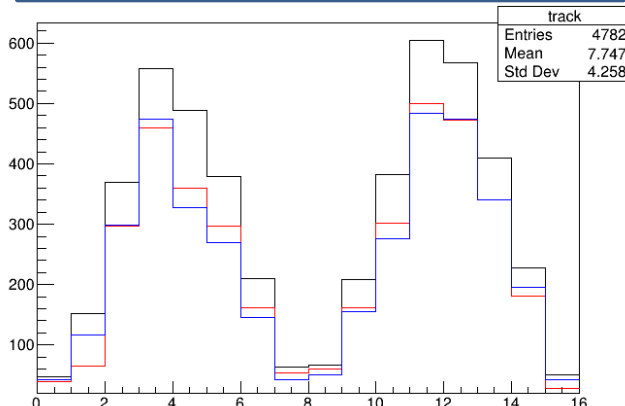
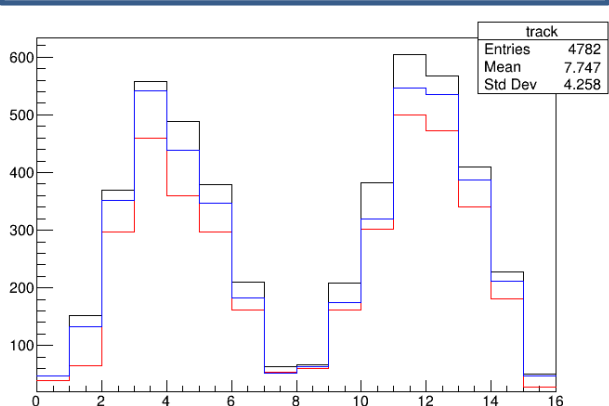
improved with Nth=21(TSIM)



Nth=20(data), Nth=20(TSIM)

Nth=20(data), Nth=21(TSIM)

Nth=20(data), Nth=22(TSIM)

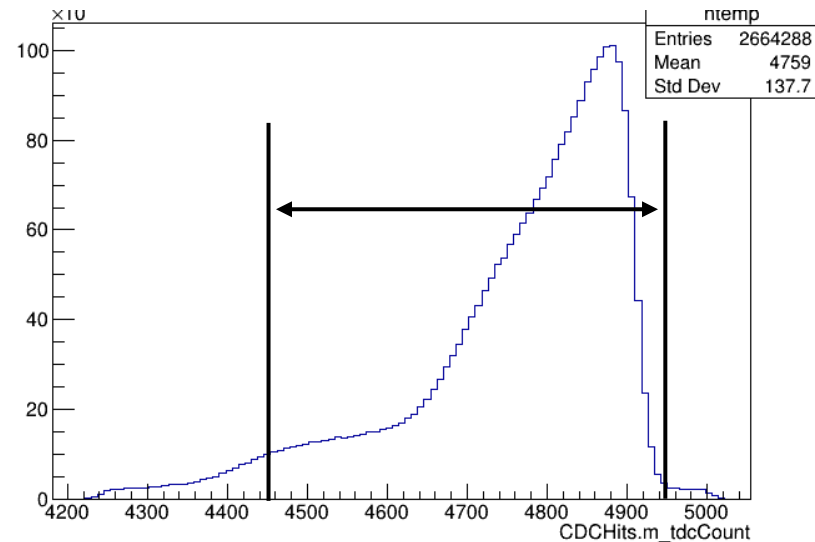


TSIM modification

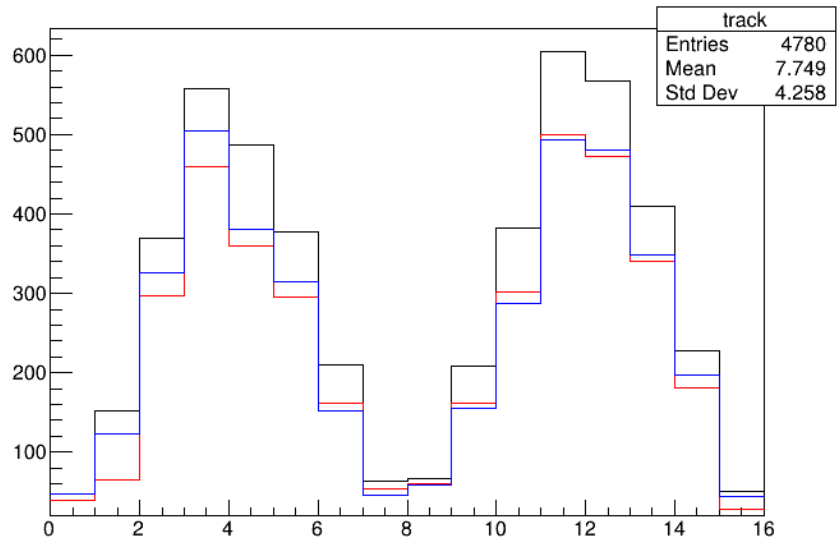
- TSIM is modified to use the same timing window as firmware
 - tdc=4450--4950

- Data-MC agreement is improved but not perfect. Asymmetry is seen.
 - Need further investigation with large data taken in Oct.

TDC of CDCHits



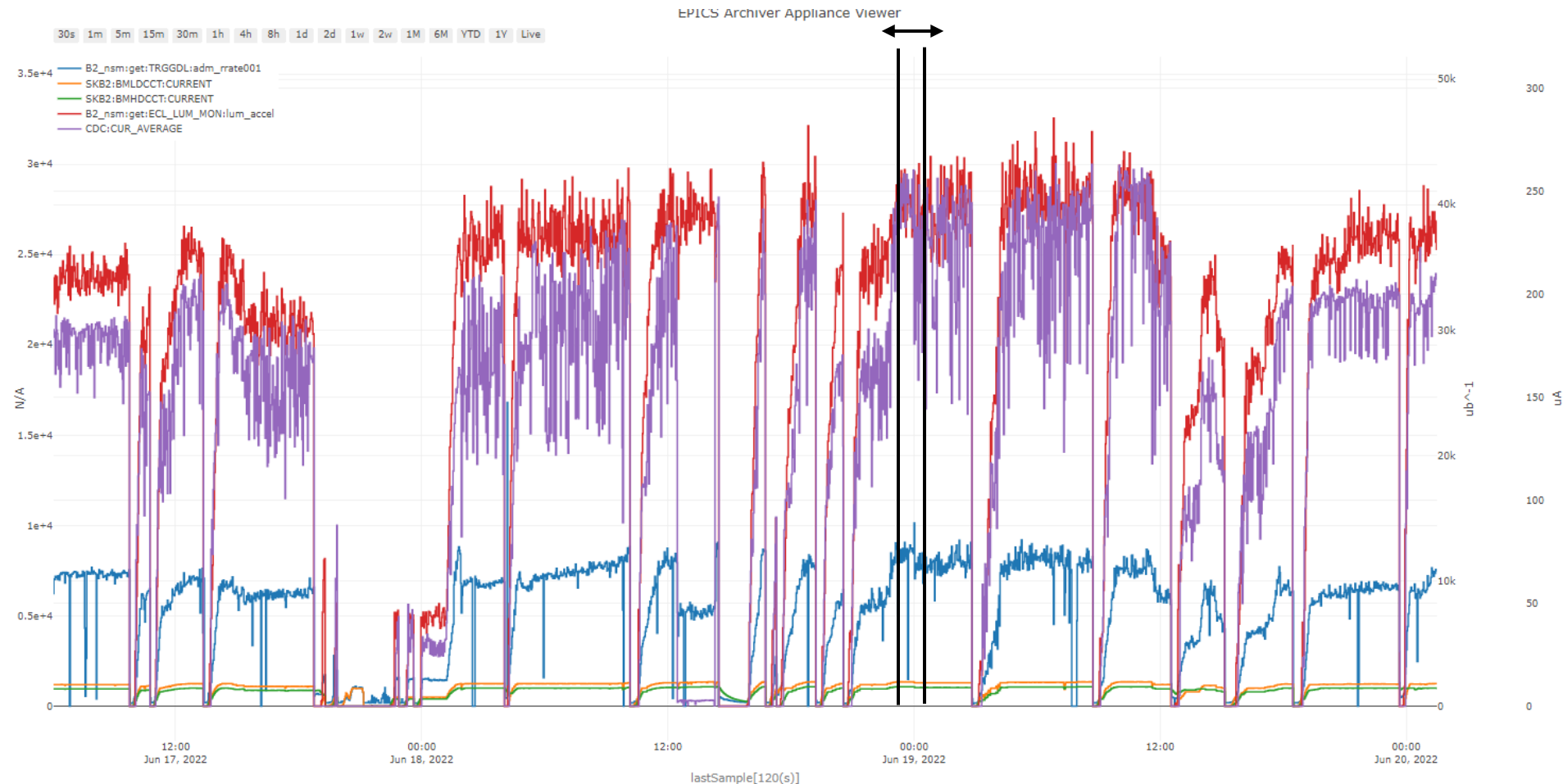
Fullhit, Nth=20 after modification



trackφ(slotID)

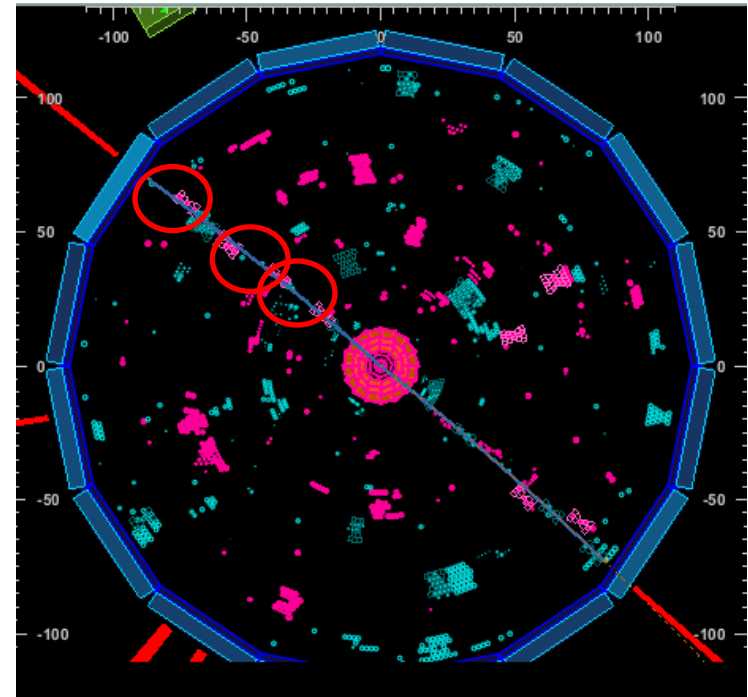
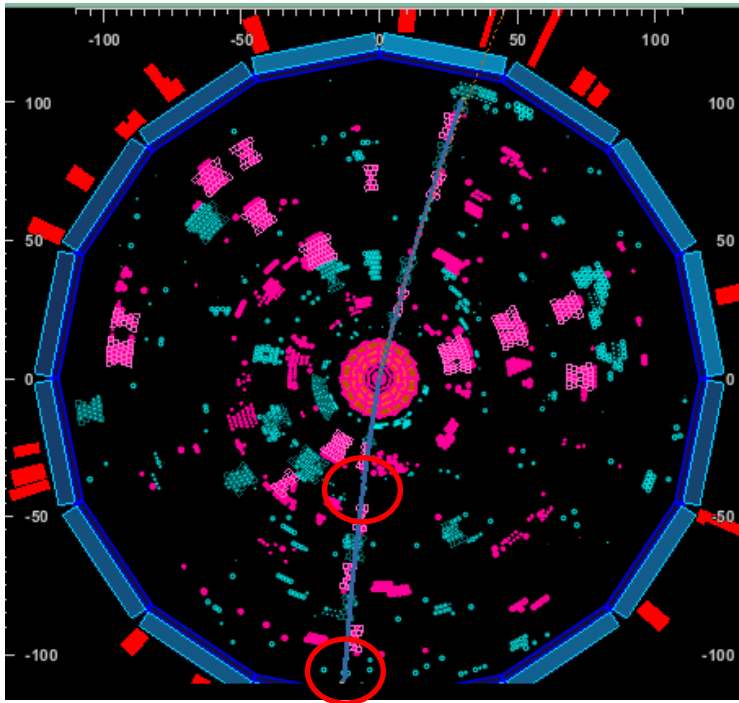
Dataset

-exp26run1780, physics, beam_reco_monitor
- $L \sim 4.0 \times 10^{34}$, L1 rate $\sim 8\text{kHz}$, CDC leak current $\sim 250\mu\text{A}$



Example of bad events

-TSF is missing due to low gain and hit efficiency



Track finding efficiency: #hit dependence with TSIM

-Change Nth of TSIM for comparison.

Impact to efficiency is large, even with small changes of the Nth.

-It seems #CDChits of FW is smaller than TSIM about ~ 1 hit per track.

-offline track

-matched firmware track

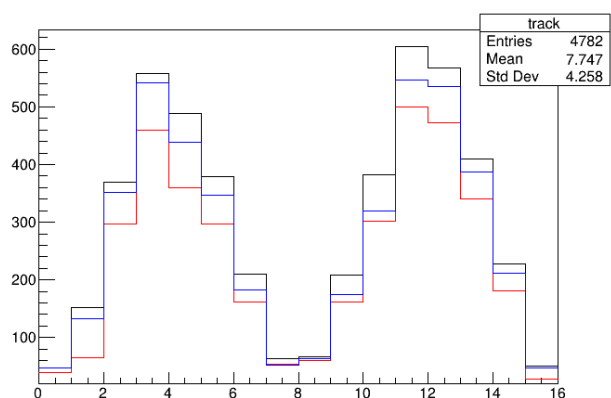
-matched tsim track

data-MC agreement

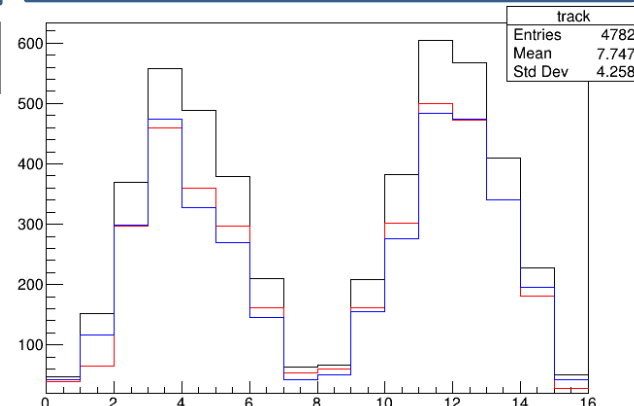
improved with Nth=21(TSIM)



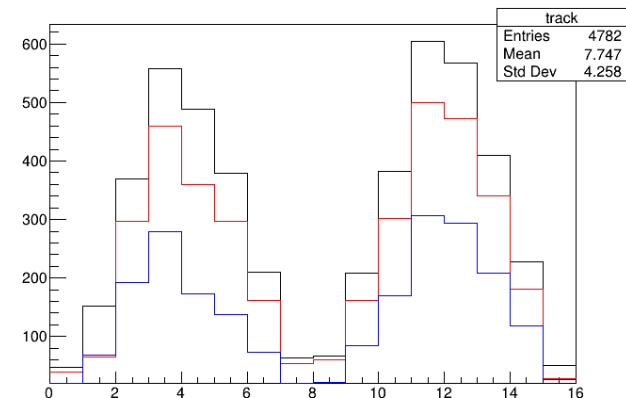
Nth=20(data), Nth=20(TSIM)



Nth=20(data), Nth=21(TSIM)



Nth=20(data), Nth=22(TSIM)

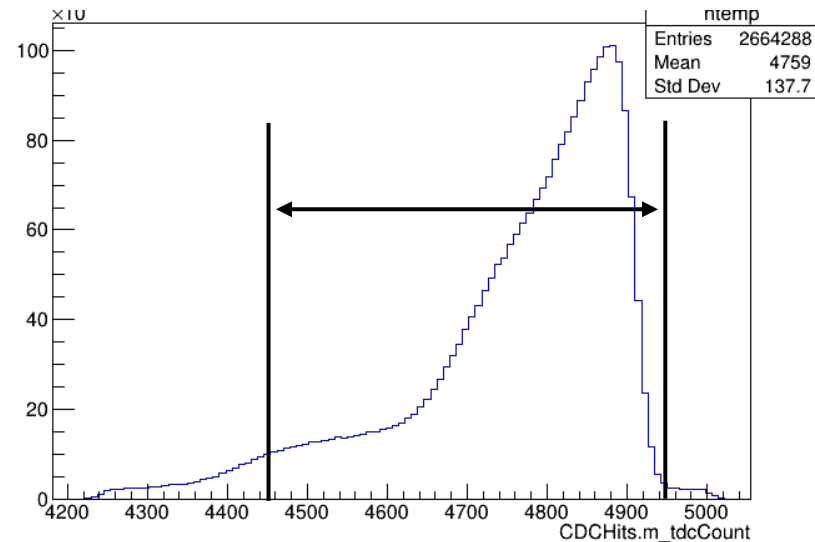


TSIM modification

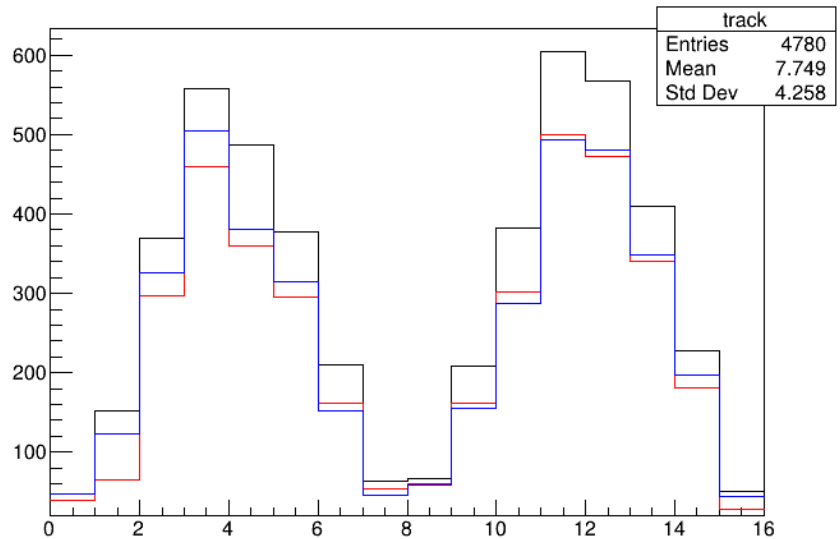
- TSIM is modified to use the same timing window as firmware
 - tdc=4450--4950

- Data-MC agreement is improved but not perfect. Asymmetry is seen.
→ Need further investigation

TDC of CDCHits



Fullhit, Nth=20 after modification



trackφ(slotID)

Summary

- Performance evaluation of new 2D firmware with full-hit algorithm by using cosmic
- It seems #CDChits of FW is smaller than TSIM about $\sim 0.5(?)$ hit per track.
→Need further investigation.
- Next:
 - study fake track rejection performance with collision data in 2022b, optimize Nth and other Hough parameters.