

# Run24 Preparation

RIKEN/RBRC

Itaru Nakagawa

# sPHENIX Beam Use Proposal for Run24, 25

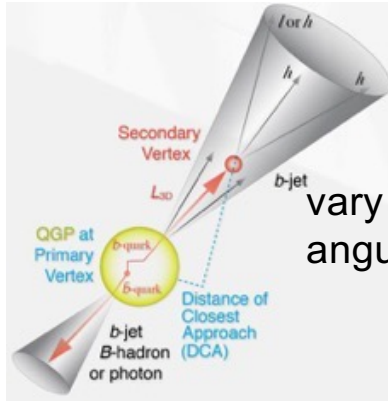
## Overview of updated run plan

- Run-2024: transversely polarized  $p+p$  running, with a few options for short Au+Au running
  - ➔ finish commissioning, ColdQCD  $p+p$  program, crucial reference data for AA program
  - ➔ the luminosity projections do not allow for a  $p+Au$  run in 2024 w/o jeopardizing the core science mission based on  $p+p$  and Au+Au data
- Run-2025: high-luminosity Au+Au running
  - ➔ measurements of jets and heavy flavor observables with unprecedented statistical precision

**Table 2.2:** Summary of the sPHENIX Beam Use Proposal for 2024 and 2025, as requested in the charge. The values separated by slashes correspond to different cryo-week scenarios (20/24/28 in 2024 and 24/28 in 2025). The 10%-*str* values correspond to the modest streaming readout upgrade of the tracking detectors.

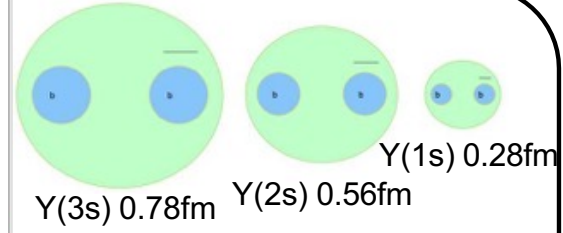
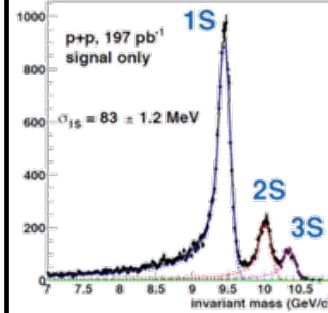
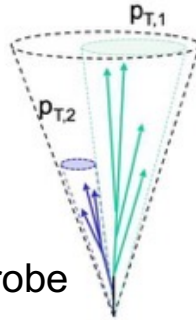
| Species  | $\sqrt{s_{NN}}$<br>[GeV] | Physics<br>Weeks | Min. Bias Rec. Lum.<br>$ z  < 10$ cm   | Calo. Trigger Lum.<br>$ z  < 10$ cm |
|--|--------------------------|------------------|--|-------------------------------------|
| Run-2024, Scenario A, 6 cryo-weeks Au+Au + 20/24/28 cryo-weeks $p+p$ |                          |                  |  |                                     |
| Au+Au  | 200                      | n/a              | n/a (Commissioning running)  |                                     |
| $p+p$  | 200                      | 13/17/21         | 0.34/0.44/0.54 pb <sup>-1</sup> [@ 5kHz]<br>2.3/3.1/3.9 pb <sup>-1</sup> [10%-str] | 23/31/39 pb <sup>-1</sup>           |
| Run-2024, Scenario B, 20/24/28 cryo-weeks $p+p$ + 6 cryo-weeks Au+Au |                          |                  |  |                                     |
| $p+p$  | 200                      | 9/13/17          | 0.23/0.34/0.44 pb <sup>-1</sup> [@ 5kHz]<br>1.5/2.3/3.1 pb <sup>-1</sup> [10%-str] | 15/23/31 pb <sup>-1</sup>           |
| Au+Au  | 200                      | 3                | 0.4 nb <sup>-1</sup> (3B events)   | not needed                          |
| Run-2025, 24/28 cryo-weeks   |                          |                  |  |                                     |
| Au+Au  | 200                      | 20.5/24.5        | 5.2/6.3 nb <sup>-1</sup> (35B/43B events)  | not needed                          |

# sPHENIX Physics Program



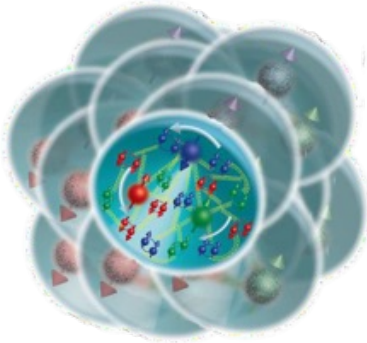
vary momentum & angular scale of probe

## Jet physics



vary size of probe

## Quarkonium spectroscopy



## Cold QCD

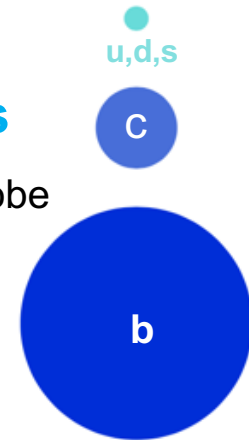
vary temperature of QCD matter

study proton spin, transverse-momentum, and cold nuclear effects

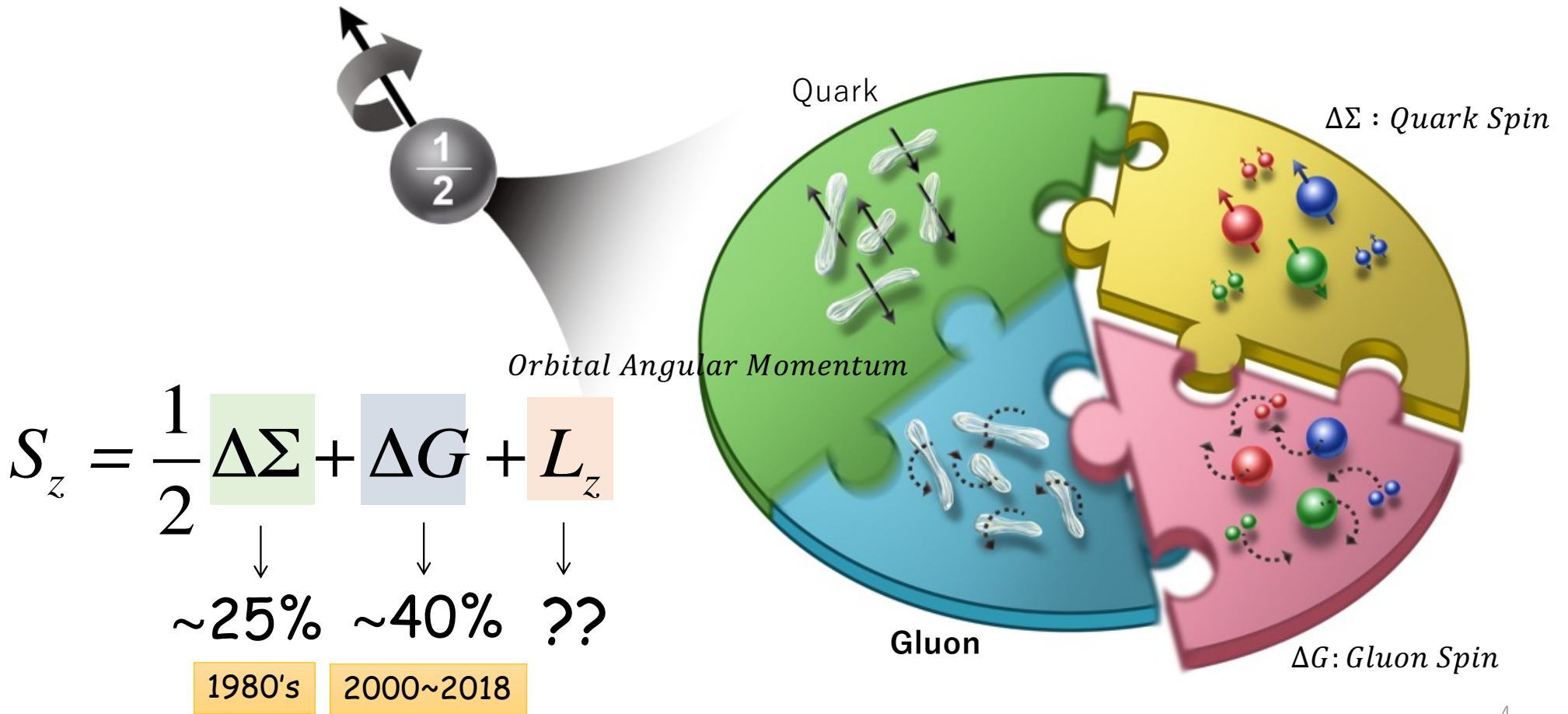
## Parton energy loss

vary mass & momentum of probe

photon  
gluon

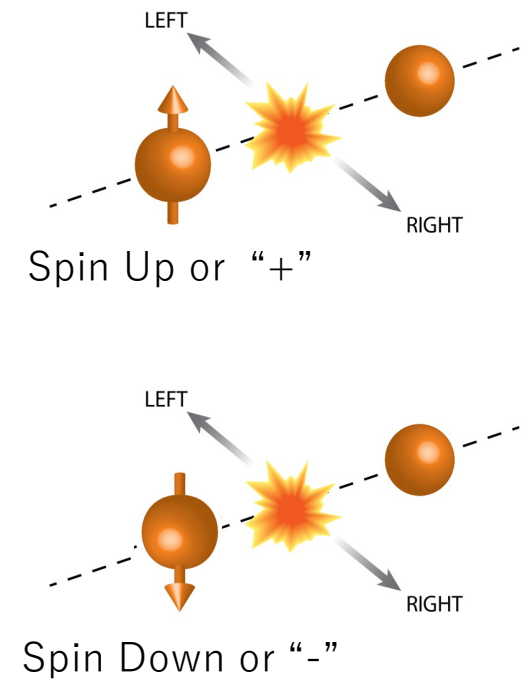
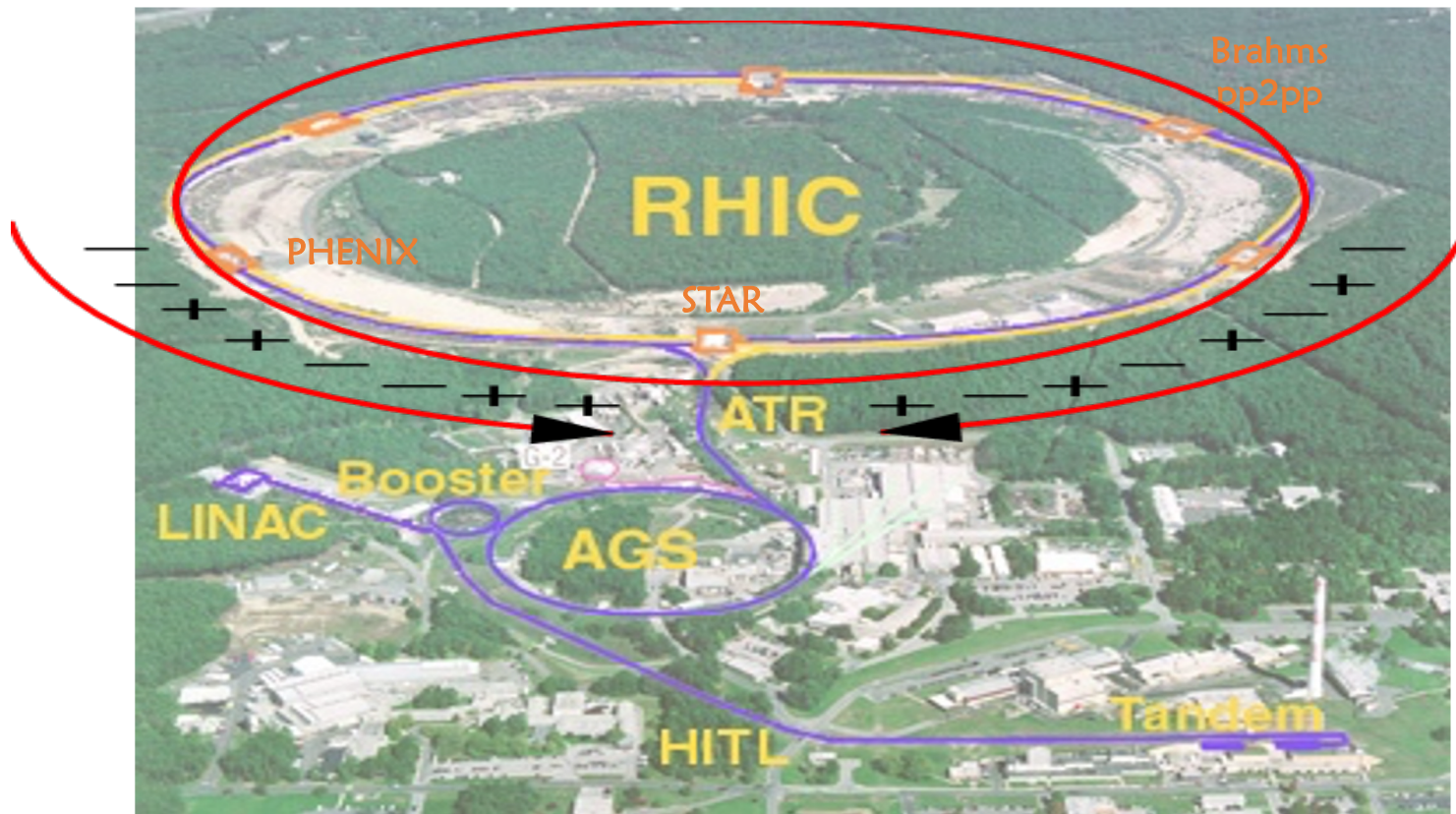


# Cold-QCD: Proton Spin Decomposition



# The role of INTT for RHIC Spin Program

1BCLK time resolution is crucial for Spin program



# Preparation for Run24

- DAQ Development (Mainly Raul's firmware, but need some feedback from us)
- Online/Semi-Online Software
- Hardware Preparation (Restore even better acceptance than Run23 after TPC repair work).

# DAQ Developments for Run24

# DAC Development Priority List (before)

1. Achieve 1BCLK timing resolution
2. Calibration capability with rcdaq
3. Stream Readout
4. Clone Hit Issue (May have nothing to do w/ Felix firmware)



# DAC Development Priority List (Updated)

1. Achieve 1BCLK timing resolution
2. Fix Mixed-Event Issue
3. Calibration capability with rcdaq
4. Stream Readout
5. Clone Hit Issue (May have nothing to do w/ Felix firmware)

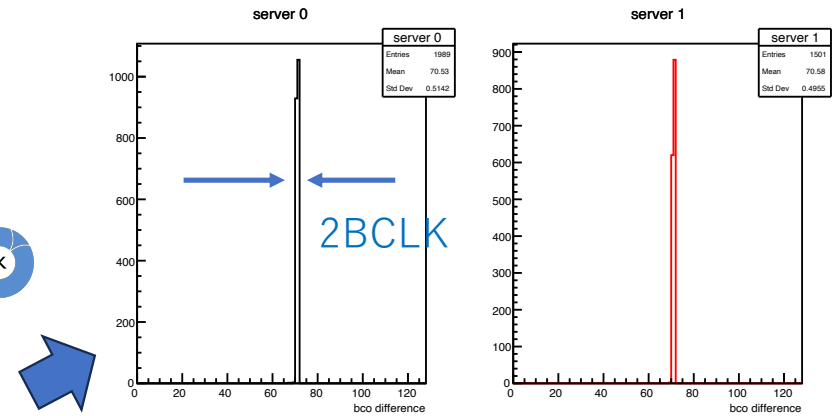
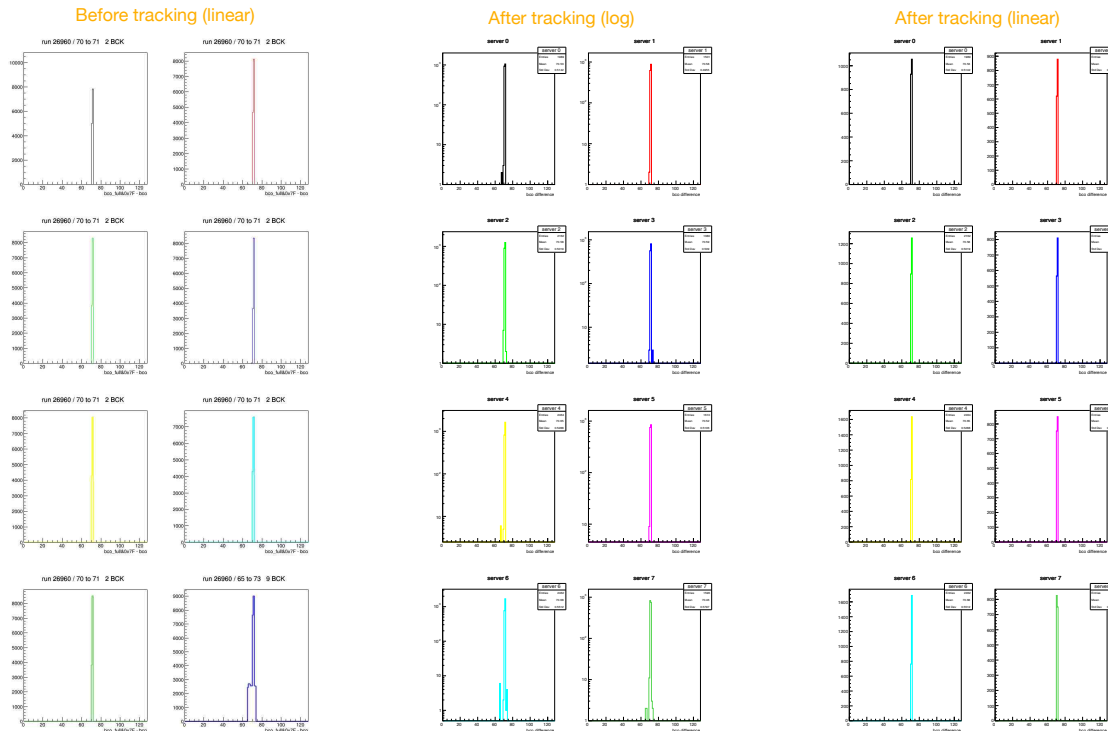
# 1. Timing Resolution

# 1. Timing Resolution

## BCO\_diff of good cosmic tracks



Cosmic run 26960



- Raul developed firmware to have the better control of clocks provided to FPHX.
- The latest cosmic run shows all felix shows the timing resolution of 2BCLKs.
- Although we cannot judge if 1BCLK resolution has been established or not, Raul is confident 1BCLK is already established.
- If Raul is correct, we happen to be sitting on the edge of the BCLK timing.

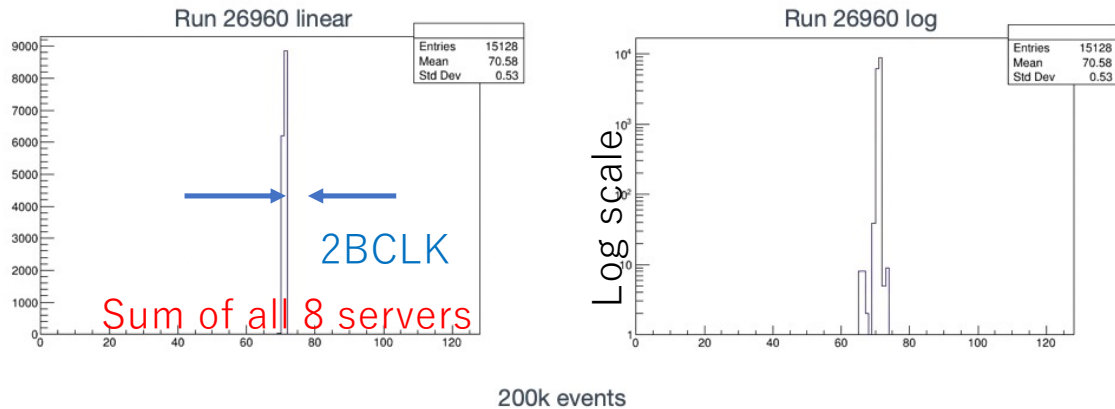
# 1. Timing Resolution

## The `bco_diff` of good cosmic tracks



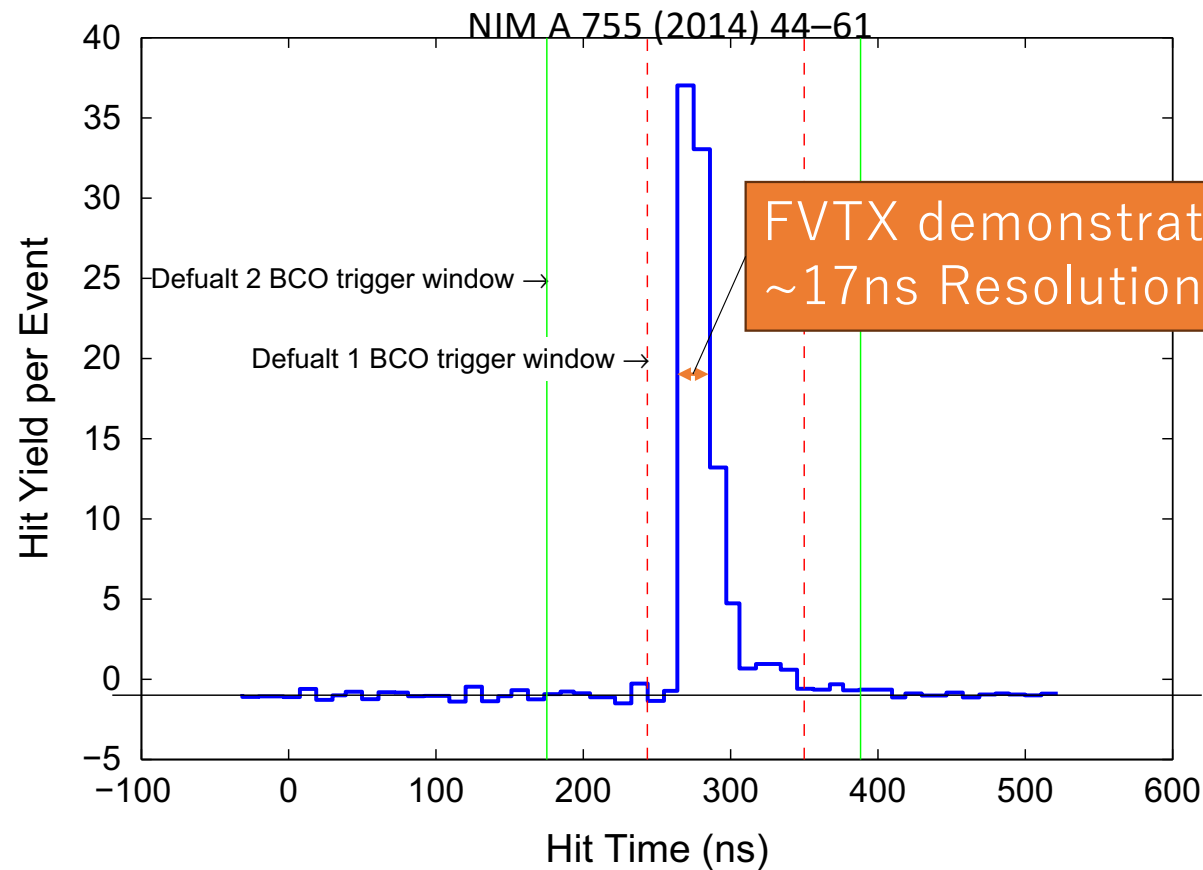
- Mask : INTT0\_1 & some hot channels
- Cluster size < 5 & single-hit cluster removed
- $N_{innerclu} > 1$  &  $N_{outerclu} > 1$
- $3 < N$  total clusters < 8
- Fitting reduced  $\chi^2_{xy} < 5$  & reduced  $\chi^2_{rz} < 5$
- Note : One cluster can have more than one `bco_diff`

- Synchronization between 8 FELIX has been established.
- The timing peak of total sum of 8 servers remain 2BLCK width.

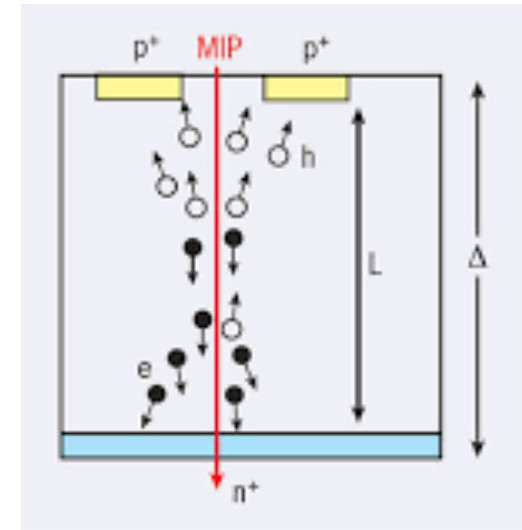


We are ready to move on to the phase scan. We can attempt it with cosmic data taking even before the Run24 beam in January ~ February 2024.

# 1. BCO Phase Scan



Mobility of e/h in silicon

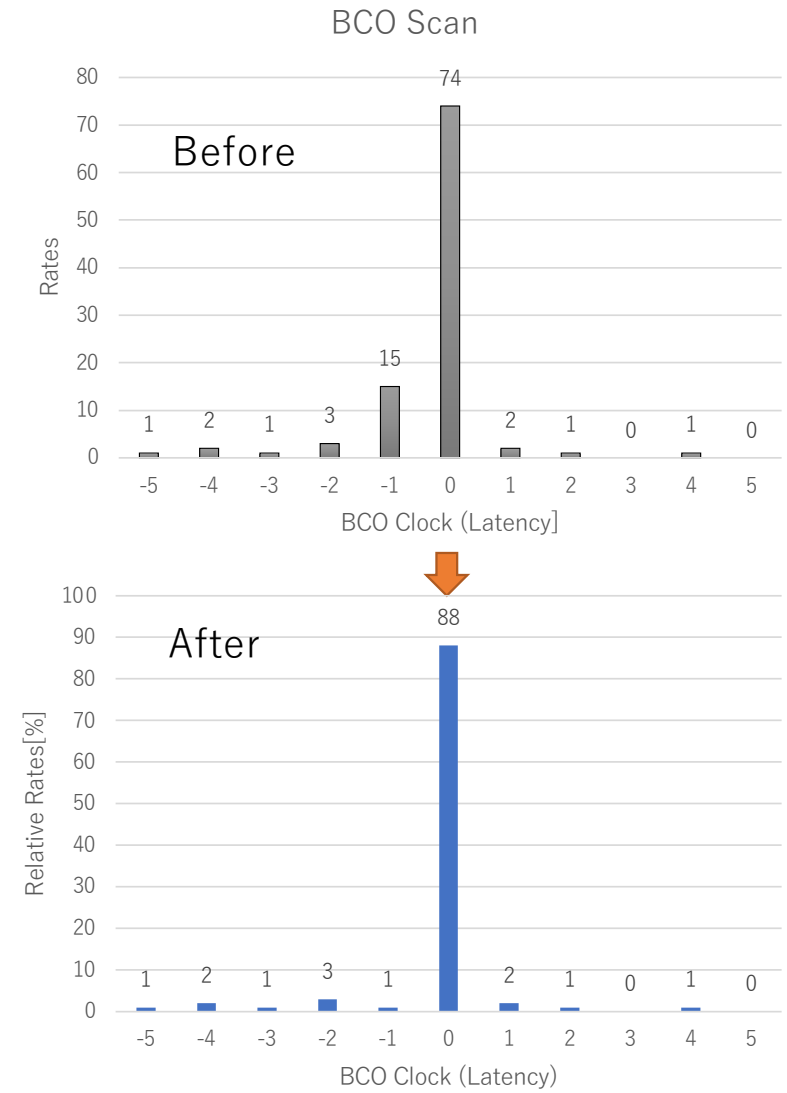
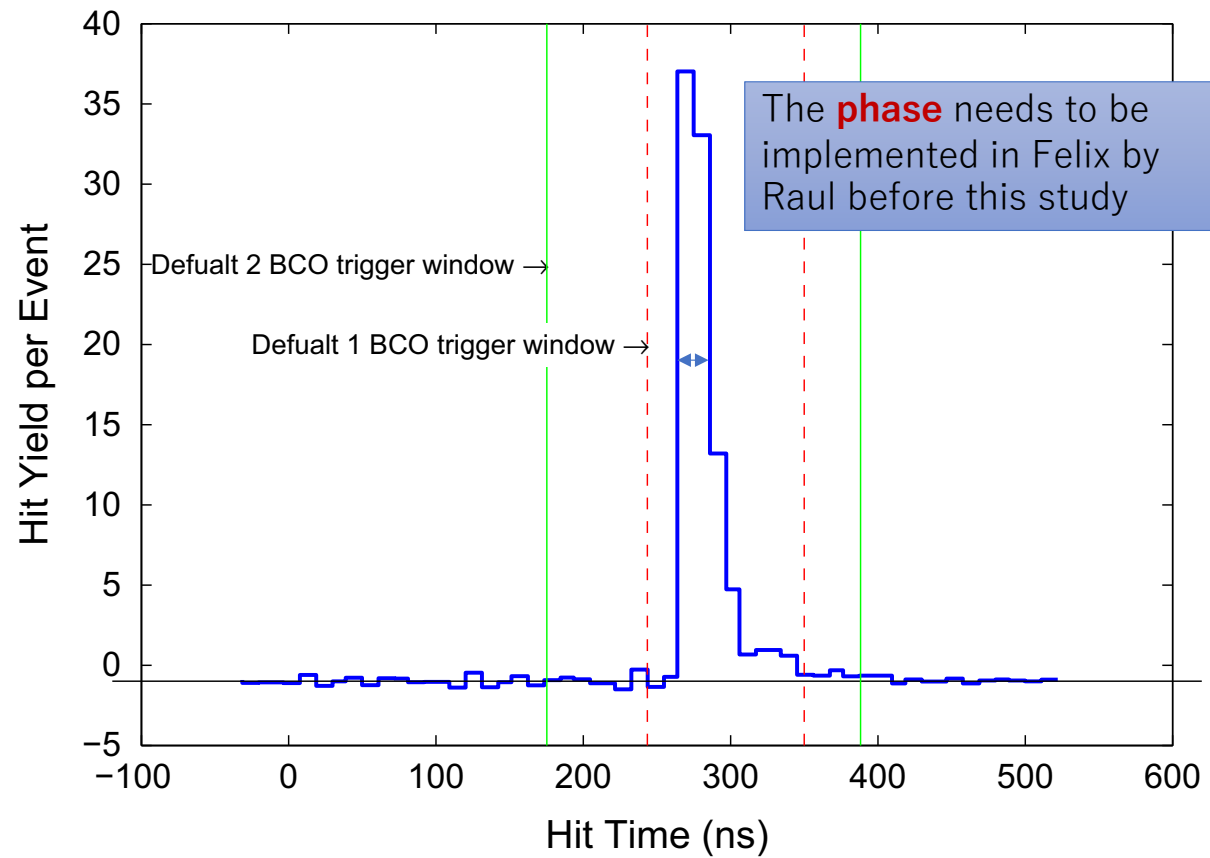


|              | FVTX              | INTT              |
|--------------|-------------------|-------------------|
| Thickness    | 320 $\mu\text{m}$ | 320 $\mu\text{m}$ |
| Bias Voltage | $\sim 70$ V       | 100 V             |
| Readout      | FPHX              | FPHX              |

In principle, INTT silicon is the dead copy of FVTX's. We expect similar to the timing resolution demonstrated by FVTX.

**Fig. 32.** Timing distribution of the FVTX hits relative to the RHIC beam clock.

# 1. BCO Phase Scan RateAnalyzer



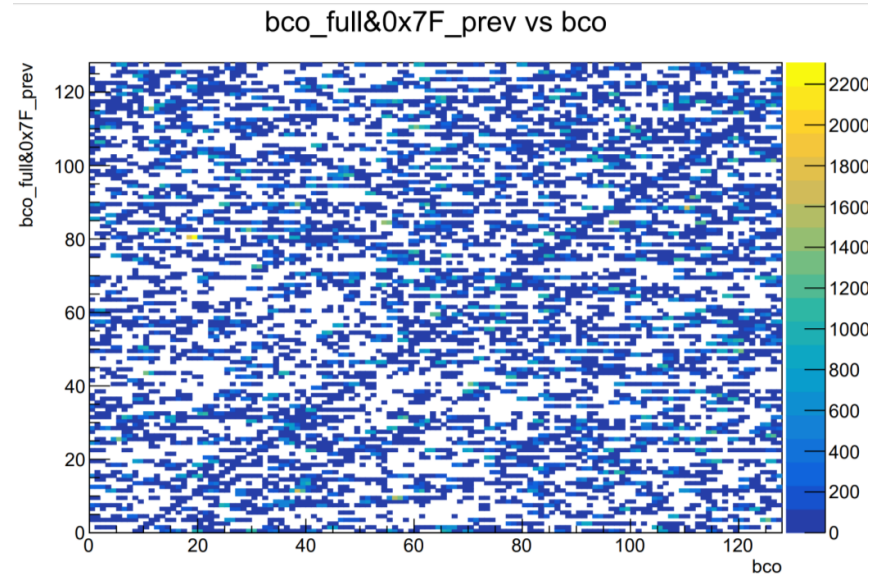
**Fig. 32.** Timing distribution of the FVTX hits relative to the RHIC beam clock.

Software: Average Rates/ladder vs. latency

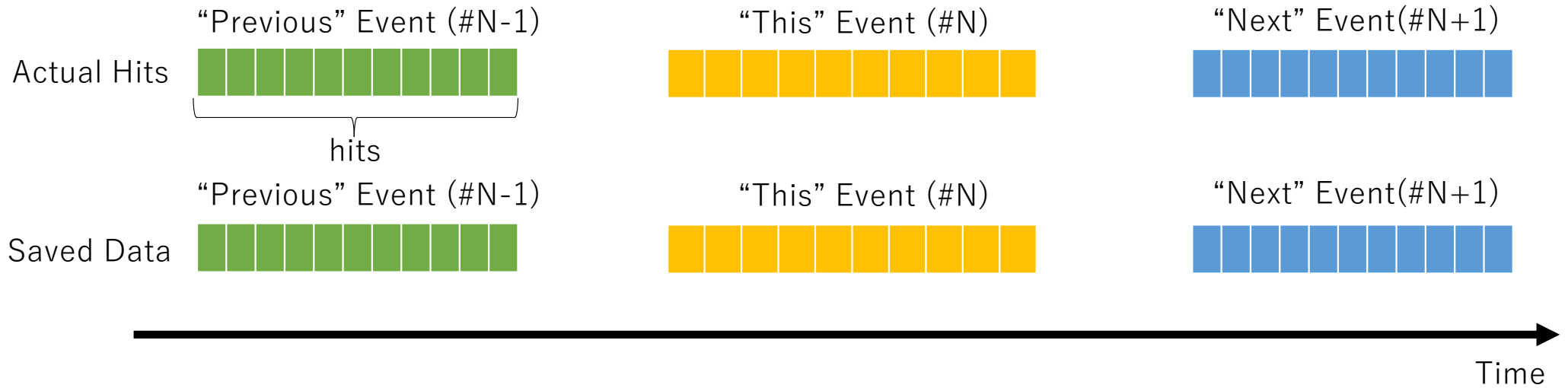
# 2. Event Mix-up

Based on the Analysis by Mai Kano

Previous event BCO\_Full &0x7F vs BCO

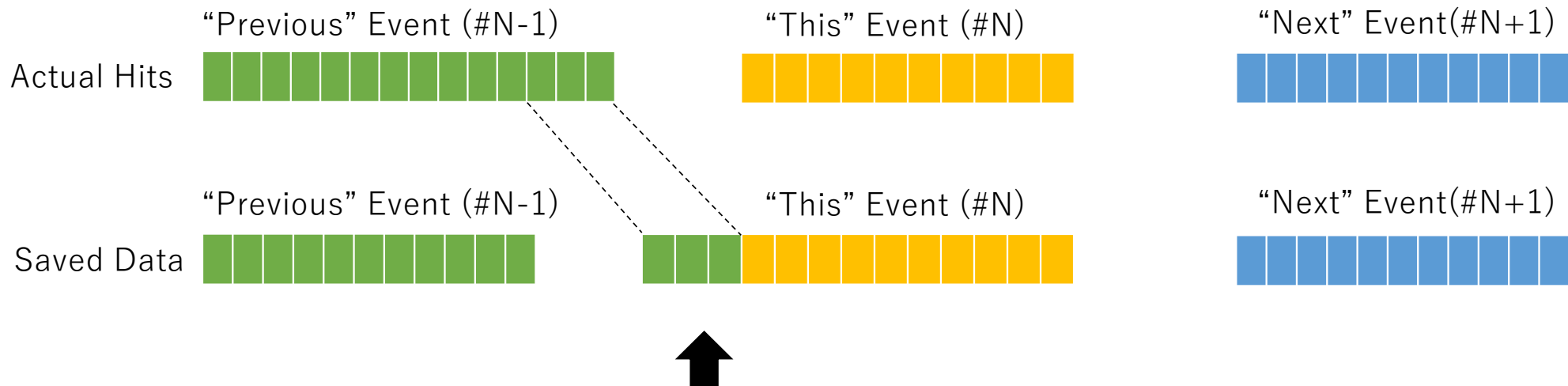


# Low Multiplicity



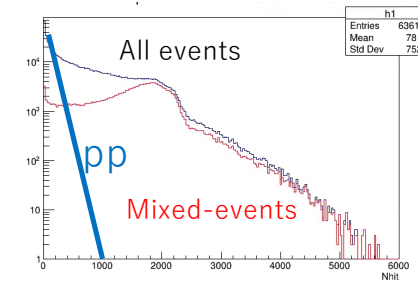
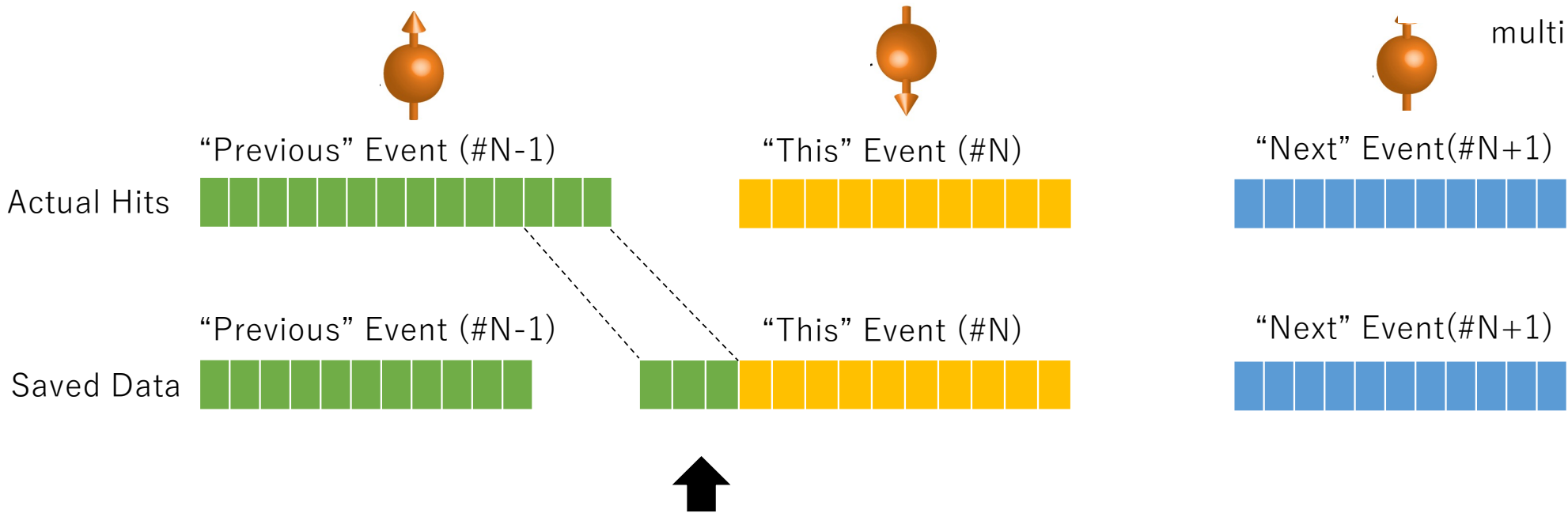


# High Multiplicity



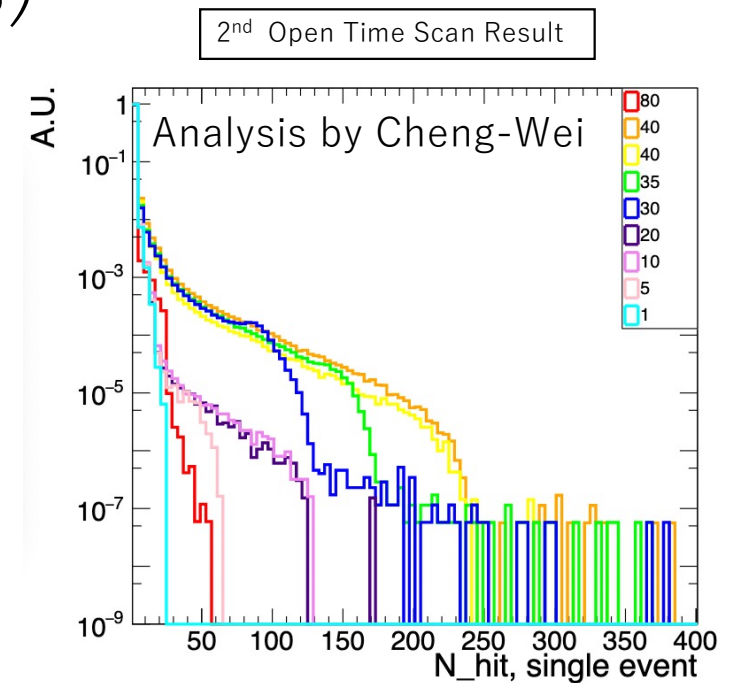
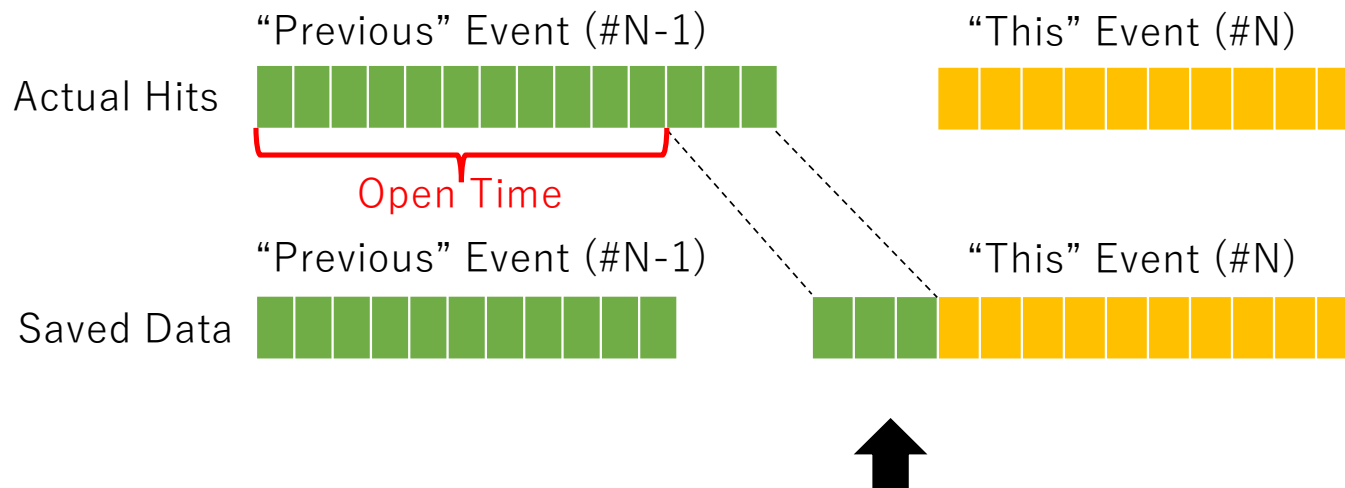
The hits of previous event are mis-classified to this event. The symptom has been already reported to Raul from Mai.

# High Multiplicity



Mixing up hits between events is fatal for the spin program. This has to be fixed before Run24 although the multiplicity of proton-proton collision is not as high as Au+Au.

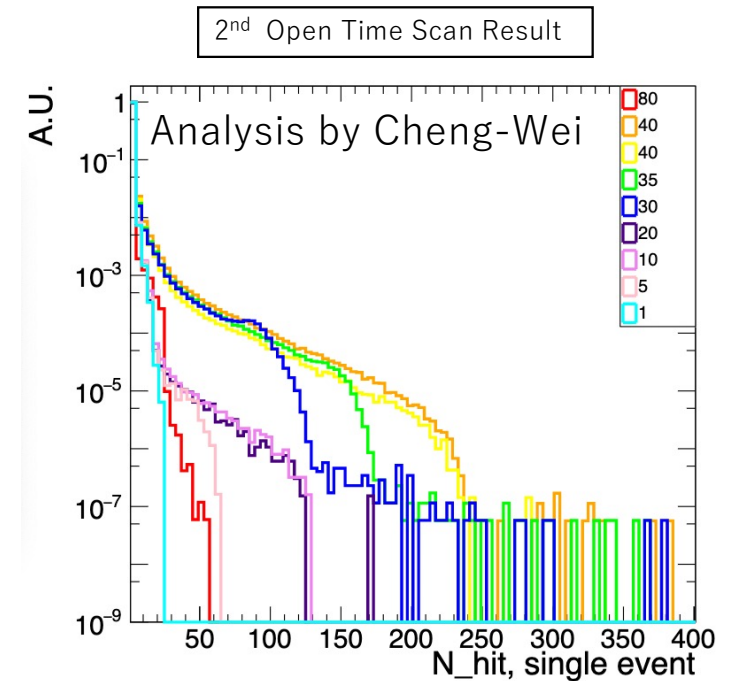
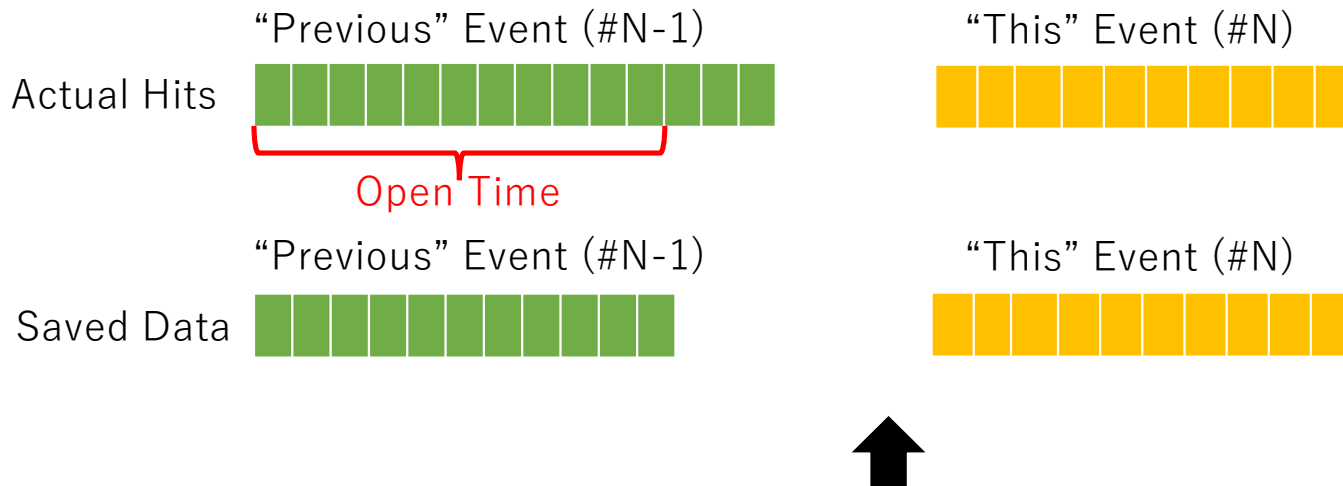
# Possible Cause? (My hypothesis)



“Open time“ is one of DAQ parameters which controls time window how long the felix would wait for hits to be received. The hits of previous event didn't make it may be mis-labeled as “this” event.

→ The fraction of mixed events should be significant for small open time data.

# Possible Cause? (My original understanding)



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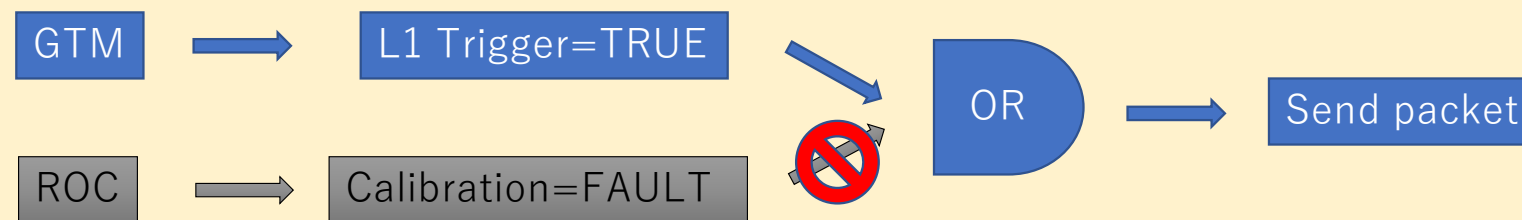
→ The fraction of mixed events should be significant for small open time data.

# 3. Calibration Capability w/ RCDAQ

# A) Triggerless Symptom Issue

- Intt1 has been barely operational since it tends to become triggerless (see below flow chart). Noisy condition of intt1 server has been a suspect, but no obvious abnormal grounding was found by Rachid within 6/21 access.
- The same symptom appeared to intt0 on 6/22 and all ROCs in 6/29 owl shift.
- Raul implemented new firmware which disables the trigger thru SC link from ROC in all felix servers on June 29<sup>th</sup> around 23o'clock. So far so good.
- We should watch if intt1 won't gets exploded with the new firmware.
- The trade off is no calibration capability for these servers.

"Triggerless Mechanism" in the present felix firmware

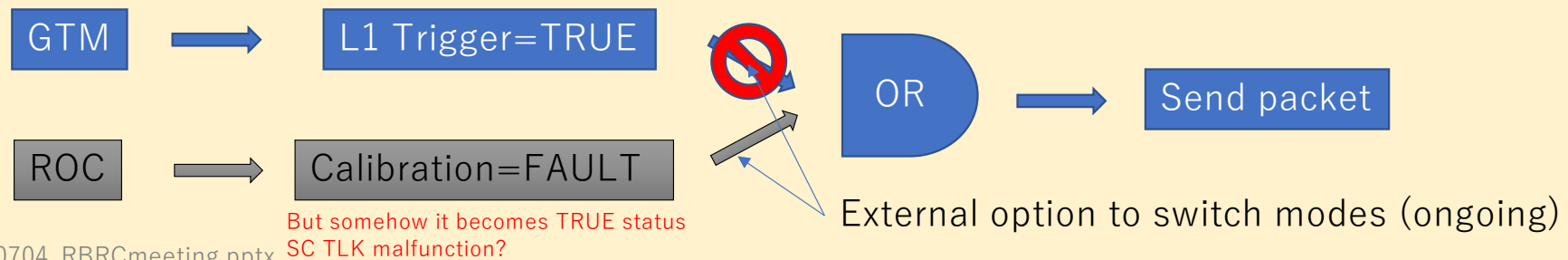


But somehow it becomes TRUE status  
SC TLK malfunction?

# A) Triggerless Symptom Issue

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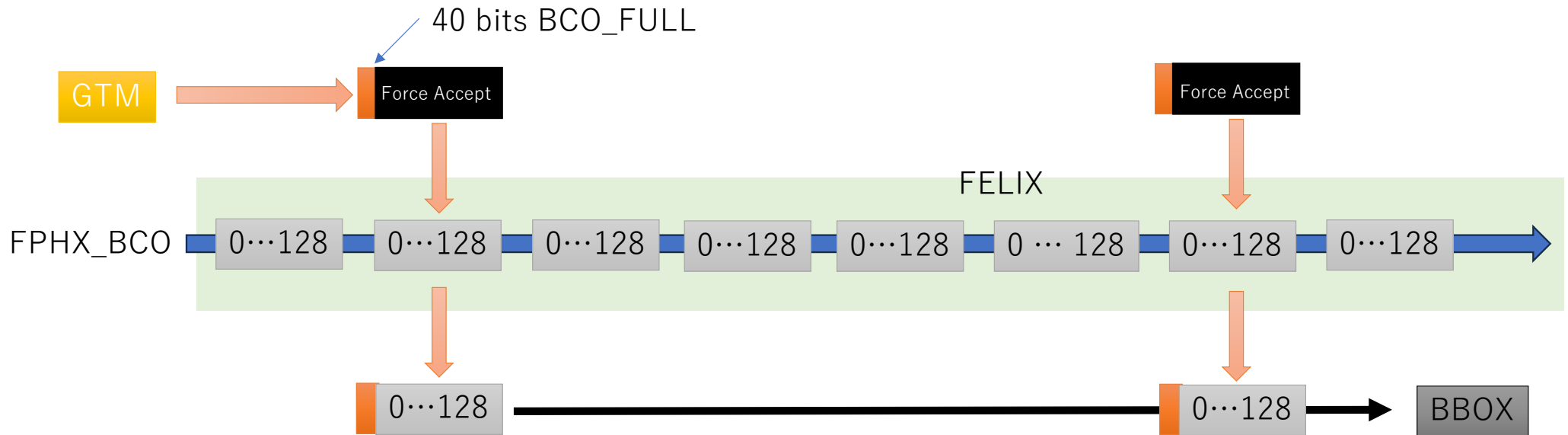
"Triggerless Mechanism" in the present felix firmware



# 4. Stream Readout



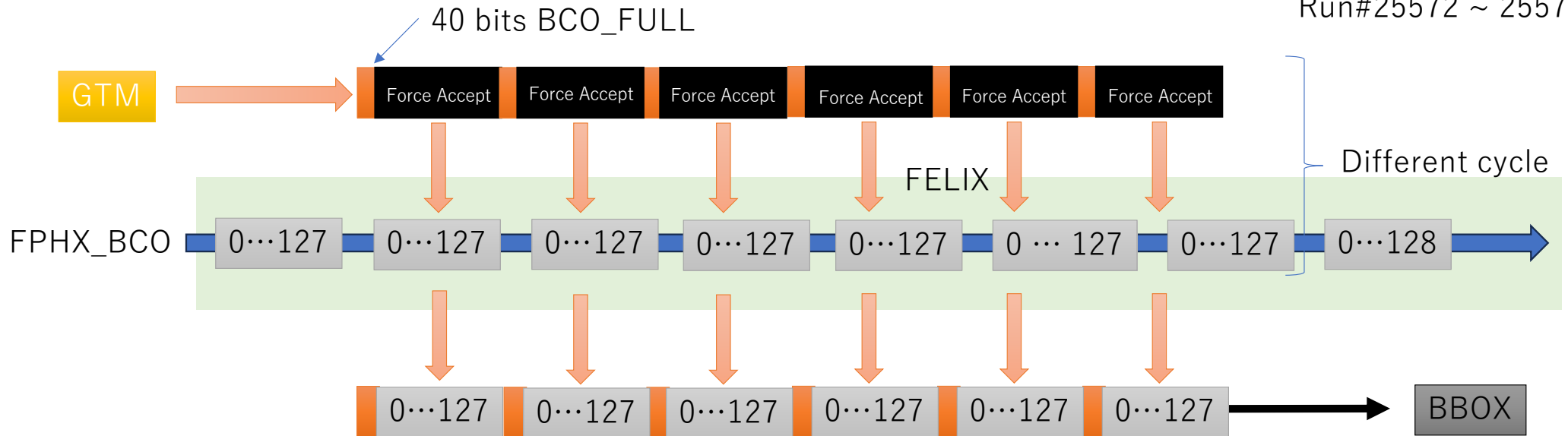
# Triggered Readout Data Taking Mode



# Stream Readout Data Taking Mode

75kHz

Run#25572 ~ 25573



```
phnxrc@operator1:~/operations/INTT$ cat intt_cosmics_streamed_75KHz.scheduler
# modegrp repeat jump target modebitfile
# modebit default value is 0:0x36;95:0x35; (9 August 2023)
0      0      0      0
1      0      0      0      0:0x36;95:0x35;
2      0      1      2      0:0x100
```

Every 120 bunch cycle instead of 128

# Status and Roadmap towards stream readout

- The switch between trigger and stream readout modes can be done by loading corresponding scheduler file to GTM. This mode change was confirmed to be smooth.
- No hung in the stream readout mode.
- Need custom operation conditions for trigger and stream readout modes, respectively.
  - Tighter hot channels masks
  - Higher DAC0 thresholds
- Stream readout data have to be confirmed if all hits are tagged by correct BCO\_FULL tag.
  - Synchronization between MVTX hits based on BCO\_FULL tag.

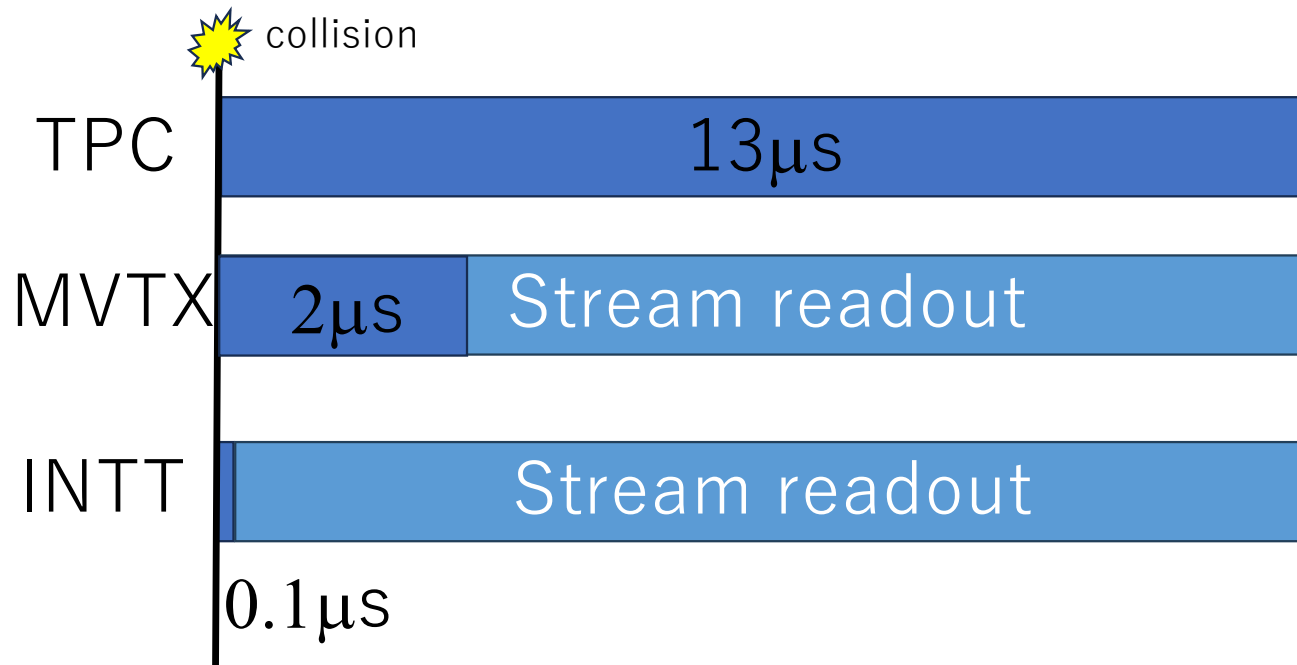
# MVTX Readout

- Operated at LHC clock : 40 MHz (4.2553 x 9.4MHz)
- Strobe defines the time window for the charge integral (5~10  $\mu$ s).
- The strobe is given by the clock regularly (can be given by MBDL1).
- The tail of the charge can be split into two hits data with different time stamp. To be distinguished by INTT tracks.
- No timing information from the sensor upto Felix. The BCO full will be injected into the data stream at Felix.
- In stream readout mode, the empty packets are to be sent out to downstream

# Drift/Integration Time for Trackers



# Stream readout to save TPC tracks



To be extended MVTX readout by  $(13-2)=11\mu\text{s}$ , INTT readout  $13-0.1=12.9\mu\text{s}$  in order to make use of recorded TPC tracks in data.

# Proposed by Tony

## Introduction - what does offline need?

The goal is to present the data to the offline reconstruction in a form that allows the **event-based F4All** processing scheme to use it.

For that purpose a “**trigger frame**” replaces what F4All considers to be an event. All data readout is assumed to be associated with a level 1 trigger.

### A trigger frame contains:

#### For Au+Au we have a MB trigger from the MBD

- TPC is streamed for 13  $\mu\text{s}$  (maximum drift time)
- MVTX is strobed every 5  $\mu\text{s}$  (maximum charge collection time 2.5  $\mu\text{s}$ )
- INTT is read out immediately (can resolve a bunch crossing)

#### For p+p with 7 $\mu\text{s}$ extended readout we have various level 1 triggers

- TPC is streamed for 7+13  $\mu\text{s}$
- MVTX is streamed for 7  $\mu\text{s}$  + charge collection/strobe time
- INTT is streamed for 7  $\mu\text{s}$

## Why is pp done this way?

The extended readout scheme is designed to allow us to collect MB data **for 7  $\mu\text{s}$  following each trigger**.

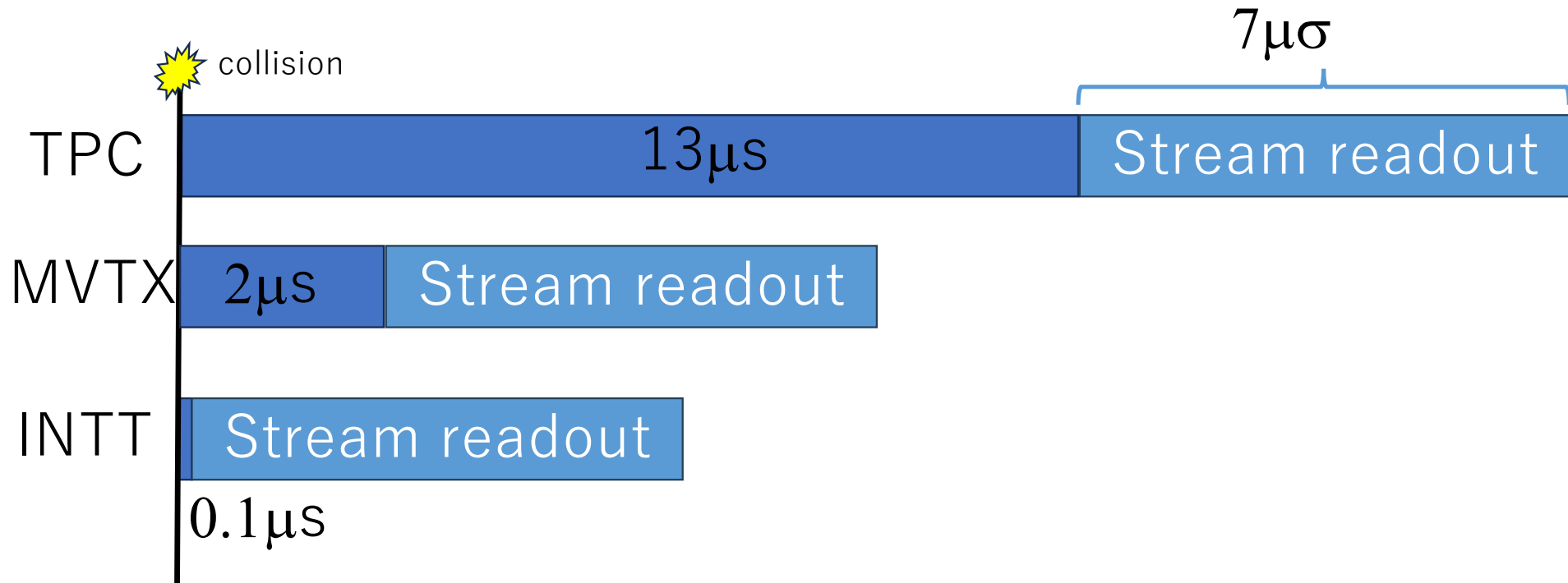
At 3 MHz, there are  $\sim 20$  pp collisions in the 7  $\mu\text{s}$  interval following a level 1 trigger

- Only the INTT can tell which bunch crossing a hit came from.
- The TPC z cannot be calculated until a bunch crossing is assigned.
- The bunch crossing for the TPC and MVTX is assigned by geometrically forming complete tracks (ignoring TPC z), and assigning the bunch crossing to all hits in the track using the INTT crossing number.

So for pp running the “event” processing loop in F4All must process **all** hits associated with a level 1 trigger together, and sort out which tracks to assign to which collision during the processing.

- Hence we feed to F4All all hits following a level 1 trigger, rather than what we would normally consider to be an event (i.e. a collision).
- That is what we are calling a trigger frame.

# Stream readout proposed by Tony?



To me, this doesn't make maximal use of TPC track in disk. What am I missing?

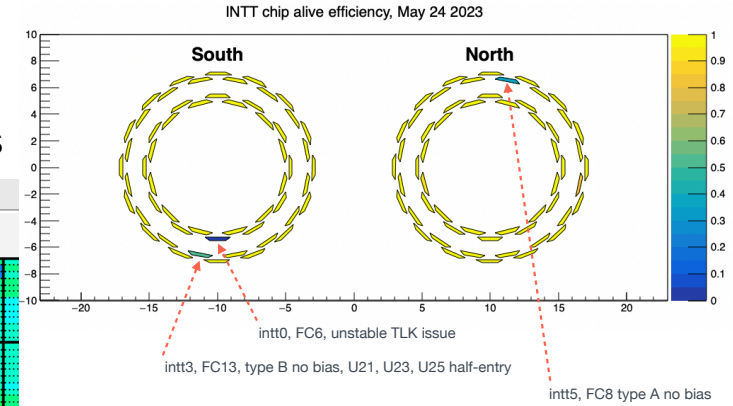
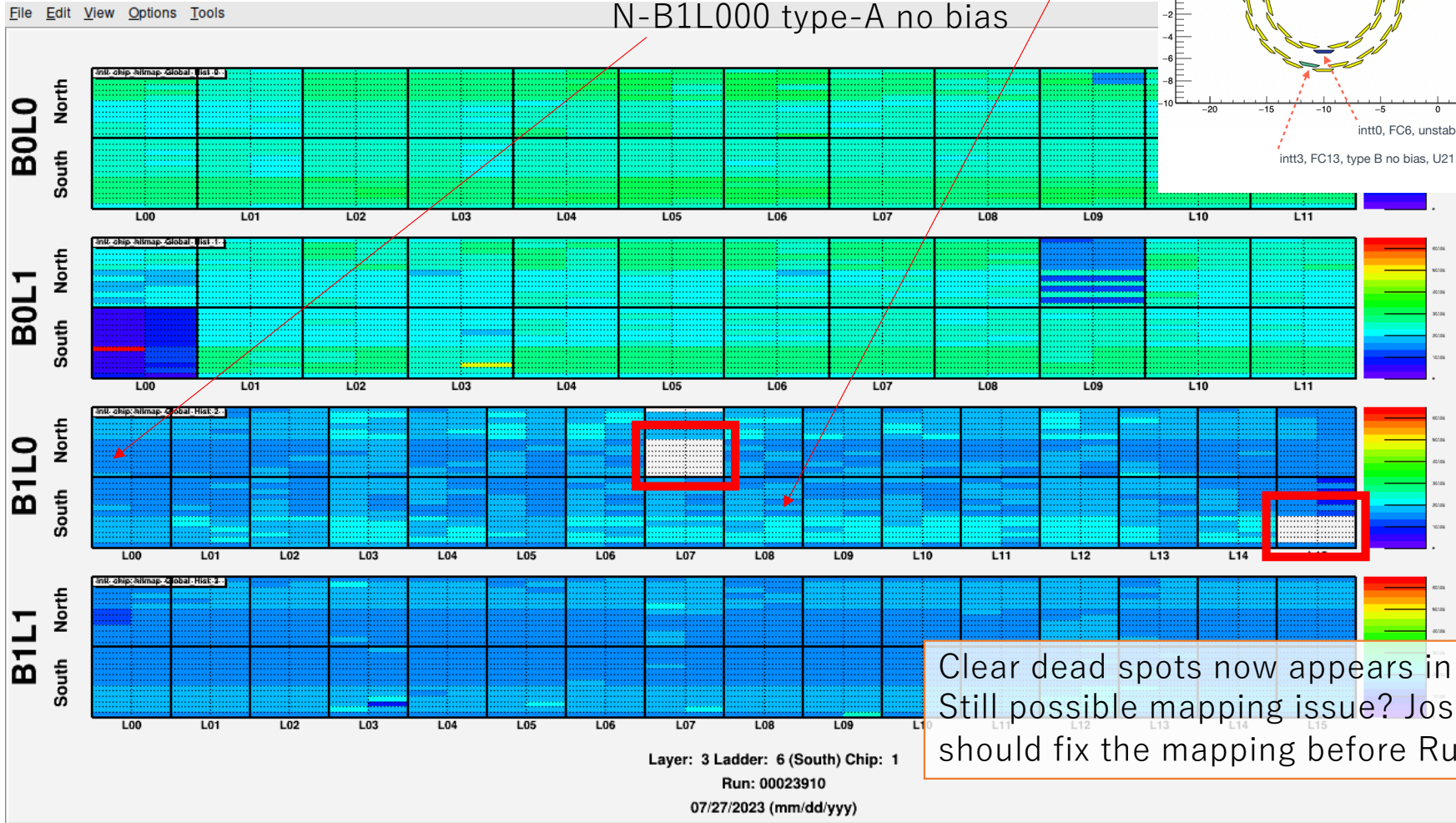


# Data Quality Monitors

# D) Online Monitor (Latest)

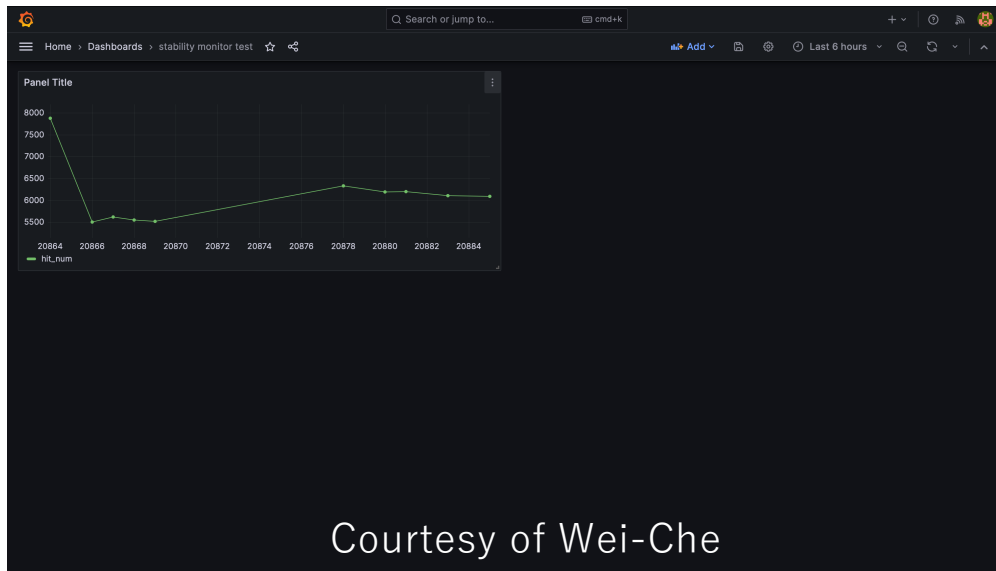
S-B1L008 type-B no bias

N-B1L000 type-A no bias



Clear dead spots now appears in the display. Still possible mapping issue? Joseph/Akitomo should fix the mapping before Run24.

# Stability Monitor



## To be added

- Hit Rates, Average ADC, S/N ratio, etc (Wei-Che)
  - Per North/South of (B0,B1) barrels
  - Per ladder
- DAQ
  - Timing Peak Width (Jaein)
  - Clone Hit Fraction/Run (Genki)
  - Event Mixup Fraction/Run (Mai K.)
  - etc ...
- Calibration results (Undergrad volunteer?)

Important to keep monitoring key quantities essential to keep high quality data semi-realtime. If we find any change in these key quantities during data taking, the stability monitor will tell us when it occurred. It helps us to debug the cause of the change.

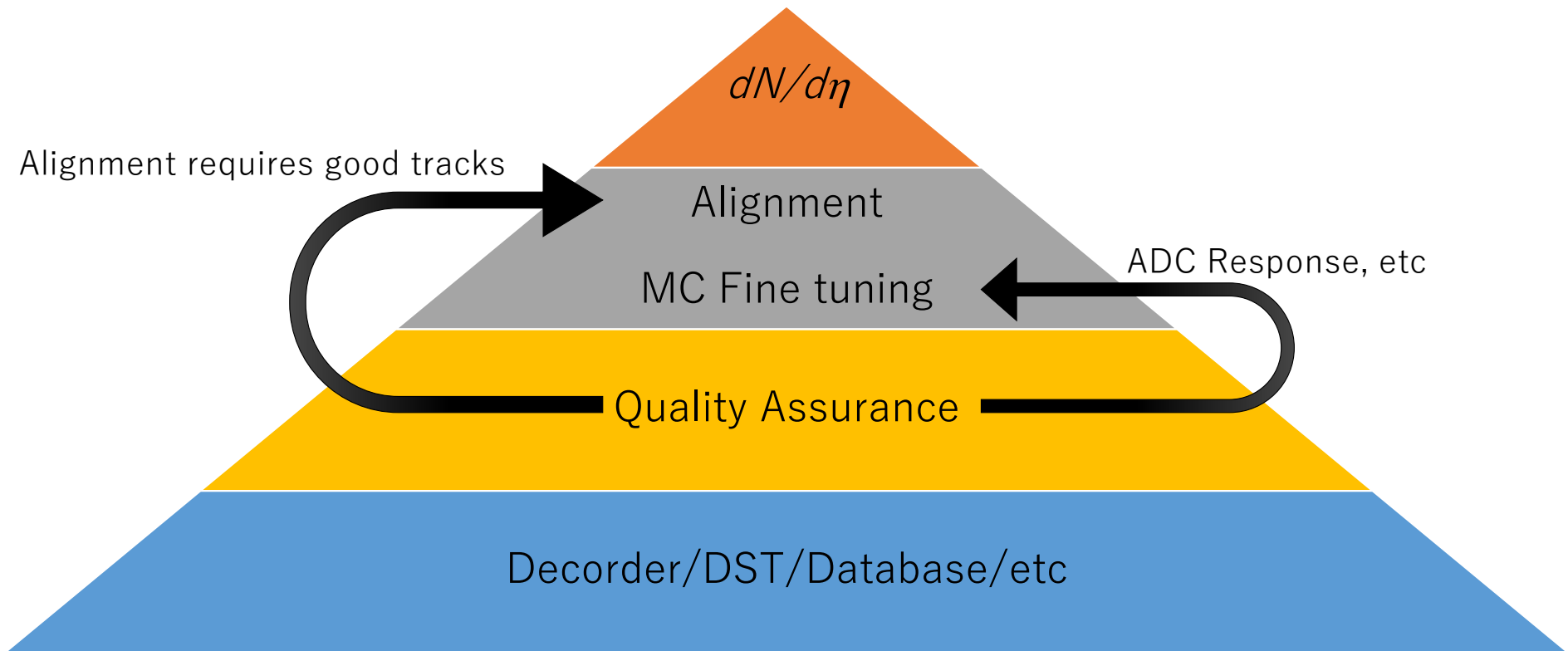
# Expert GUI

- Geometry bug have been fixed during Run23 (Tomoya).
- Initial parameters are already saved in sphnxdb master. It is ready to update new parameters.
- Python Library version mismatch in 1008 computer cluster needs to be resolved to run expert GUI in these machines.

Akitomo Enokizono  
(榎園昭智)



# Roadmap to Physics from INTT data



# Data Production & Database

| Project  | Personnel        |
|----------|------------------|
| Decorder | Joseph / Takashi |
| DST      | Takashi          |
| Run Log  | Ryota            |
|          |                  |
|          |                  |
|          |                  |

# Quality Assurance

| Topics                               | Personnel               |
|--------------------------------------|-------------------------|
| Clone hit removal                    | ? / (Genki / Cheng-Wei) |
| Hot/dead map finder                  | Joseph / Yuka / Jaein   |
| Beam on/off background & noise study | Ryota                   |
| Cluster counting                     | Misaki / Tomoya         |
| Tracklet algorithm                   | Genki / Wei-Che         |
| Detector QA                          | Maya                    |

Each tasks are to be automated and plug into Fun4All framework so that these modules can semi-online feedback

# dN/deta

| Project                        | Personnel   |
|--------------------------------|---|
| Detector Alignment Fine Tuning | Cheng-Wei/?                                       |
| Tracklet algorithm             | Wei-Che, Hinako (Takashi/Cheng-Wei), Mai Watanabe |
|                                |   |
|                                |   |
|                                |   |
|                                |   |



# Towards Run24

| Project                  | Personnel                             |
|--------------------------|---------------------------------------|
| Timing Resolution        | Raul / Mai Kano / (Cheng-Wei / Genki) |
| Stream Readout           | Raul / Genki / Akitomo?               |
| Calibration Run on RCDAQ | Raul                                  |
| Event Mixup              | Mai Kano                              |
| Stability Monitor        | Wei-Che                               |
| Event Display (Done)     | Manami                                |
| Expert GUI               | Akitomo / Genki / (Tomoya)            |
| Online Monitor           | Joseph / Akitomo                      |
| Spare ROC Testing        | Kazuma / Takashiro / Akitomo          |