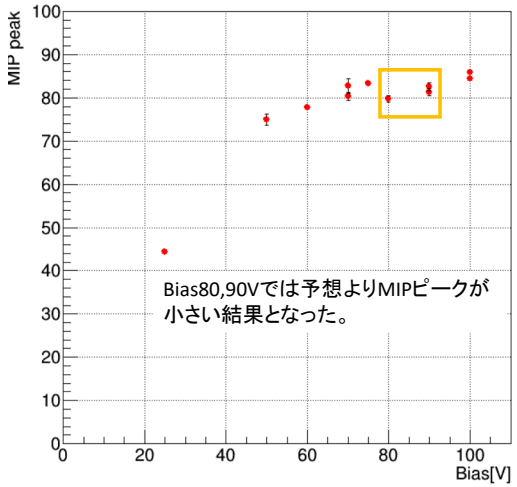
Commissioning Plan
~ Time-in INTT~

RIKEN/RBRC

Itaru Nakagawa

Preparation

- Beam 6x6 bunches.
- Once background is confirmed to be low, turn on thoroughly HV (Rachid). Can be done with one ladder, lowered voltage than 100V. The operation voltage required for the timing scan is > 50V minimum.
- Turn on LV/FPHX.
- Test GTM LV1 delay set command and readback functions (itaru)



	測定1	測定2
25V	44.31±0.31	—
50V	74.93±0.58	74.9±1.3
60V	77.72±0.63	—
70V	82.72±1.63	80.25±0.94
75V	83.24±0.42	—
80V	79.77±0.78	—
90V	82.53±0.88	81.3±0.8
100V	85.97±0.50	84.36±0.46

おおむねBias電圧に比例してMIPピークが大きくなることが確認できた。

https://indico2.riken.jp/event/4462/contributions/20872/attachments/11920/17288/20230412_sugiyama.pdf

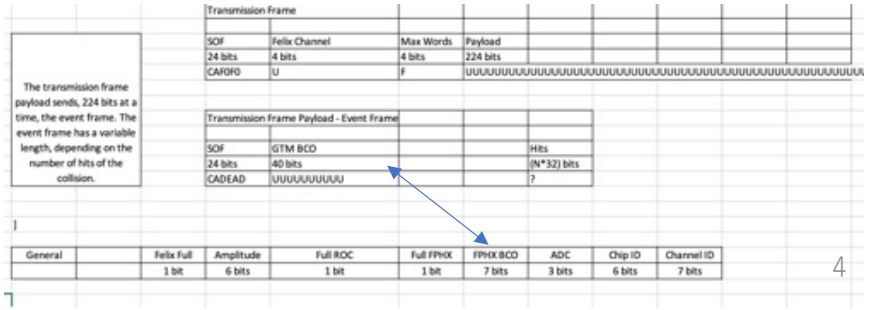
DAQ Setting

- Start with intt rcdaq standalone until Martin shows up.
- Trigger: clock trigger by every 120 cycles tuned to be trigger rate ~100Hz or so unless we know how to plug-in LVL1 accept of MBD from the GTM.
  - L1Delay=0, Felix delay=62, BCO time window=127, n_collision=127
  - DAC0 threshold=23
  - Mask channel list made for DAQ0 scan. (In order to focus on the first data taking with beam. Not to be bothered by noisy channels!)
- Attempt to operate 8 Felix servers from inttdaq using gRPC. If not successful, we run only with intt0.

Data taking Plan (1)

- Observation of collision related INTT hits.
  - L1Delay=0, Felix delay=62, BCO time window=80, n_collision=127
  - DAC0 threshold=23
  - 5~10 minutes : 30~60k events.
  - Analysis:
    - hit multiplicity vs BCO
    - hit multiplicity vs BCO-Full
    - Difference of “the least 7 bits of 40bits BCO-Full” – “7 bits FPHX BCO” for correlated hit BCO finding study (Cheng-Wei?) (if we can take data with MBDLVL1 trigger).

Run#7364, 7367



Data taking Plan (2)

- L1Delay Scan
  - Felix delay=62, BCO time window=80, n_collision*=2
  - DAC0 threshold=23
  - 5~10 minutes : ~4k events (10minutes)
  - L1Delay=4
  - 48, 50, 46, 52, 44, 54, 42, 56, 40, 58, 60 BCLKs, … (in the priority order)
  - Record start/stop time for normalization
  - Analysis:
    - Total hits/felix/run plotted as a function of L1Delay. (Genki)
    - Make a graph #hits vs L1Delay. (Mai, Manami)
    - For felix-to-felix, ladder-to-ladder variation to be analyzed by offsite crews.

ex) `phnxrc@operator1:~/operations$ gl1_gtm_client gtm_set_l1delay 3 360`
`phnxrc@operator1:~/operations$ gl1_gtm_client gtm_get_l1delay 3`
`360`
Or `phnxrc@opc0:~/INTT/commissioning_5_23$ ./l1delay3.sh 48`
(To be kept in l1delay3.log)

L1Delay Translation Table

[value]	[BCO]
240	40
252	42
264	44
276	46
288	48
300	50
312	52
324	54
336	56
348	58
360	60
372	62
384	64

GTM_DelayTranslator.xlsx

* We take 2BCO window this time, because the synchronization between felix servers can be off by 1BCO

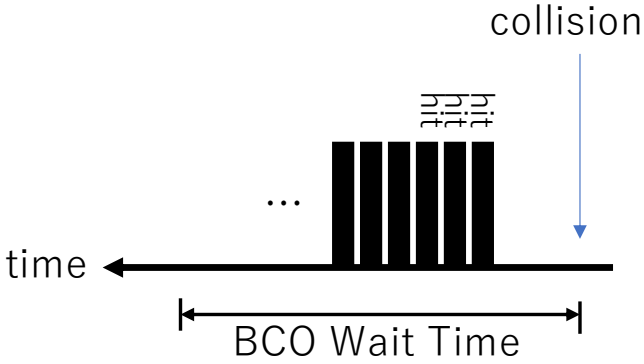
Data taking Plan (3) 5/25 2nd store

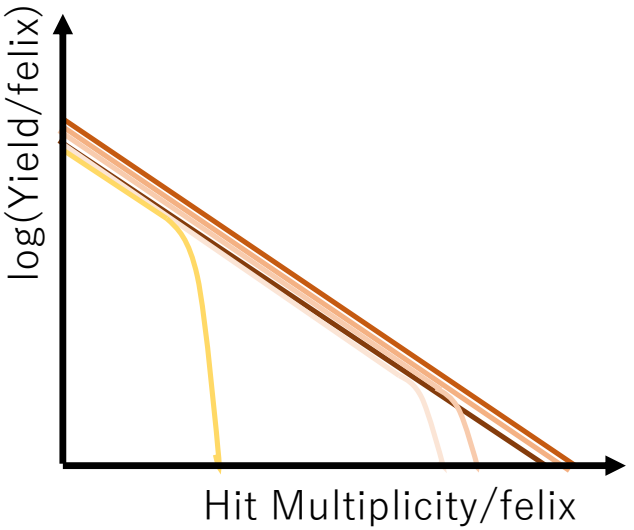
- Continue L1Delay Scan
  - 56x56 bunch collision
  - MBDL1 trigger ~ 5 kHz
  - n_collision=2
  - L1Delay=54, 52, 56, 50, 58, 48, 60, 46, 62, 44, 64
  - 5min/run (Otherwise >2000 events/run)
- 1BCLK Window Measurement
  - n_collision=0
  - L1Delay=52, 53, 54, 55, 56
  - 5min/run (Otherwise >2000 events/run)
- Analysis:
  - Hit rate/felix vs. L1Delay for all 8 felix

[value]	[BCO]
240	40
252	42
264	44
276	46
288	48
300	50
312	52
324	54
336	56
348	58
360	60
372	62
384	64

Felix BCO Wait Time Scan

- Start with the BCO wait time* sufficiently wide (60 BCLK=max depth of FIFO in ROC?) at the beginning.
- The scan is to be done for 80->30->20->10->9->8->7->6->5->4->3->2->1 BCLK window.
- 5 minutes/run
- Compare the hit multiplicity distribution/chip (tracklet/track multiplicity for further sophisticated analysis).
- Optimal window would be selected at the saturated point. (f.i, multiplicity of 30=20=10=9>8>7, then >10 is the optimal window).

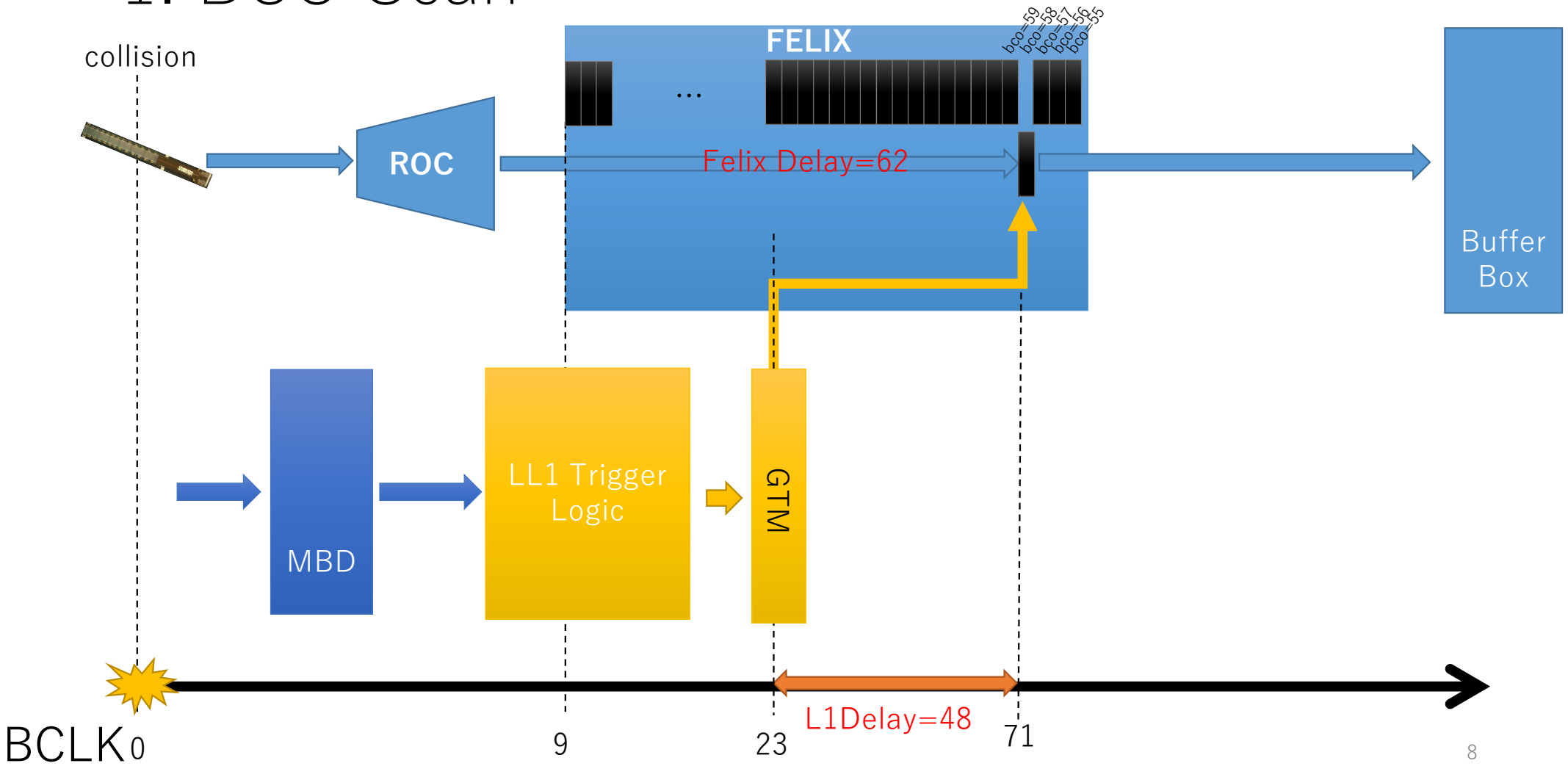




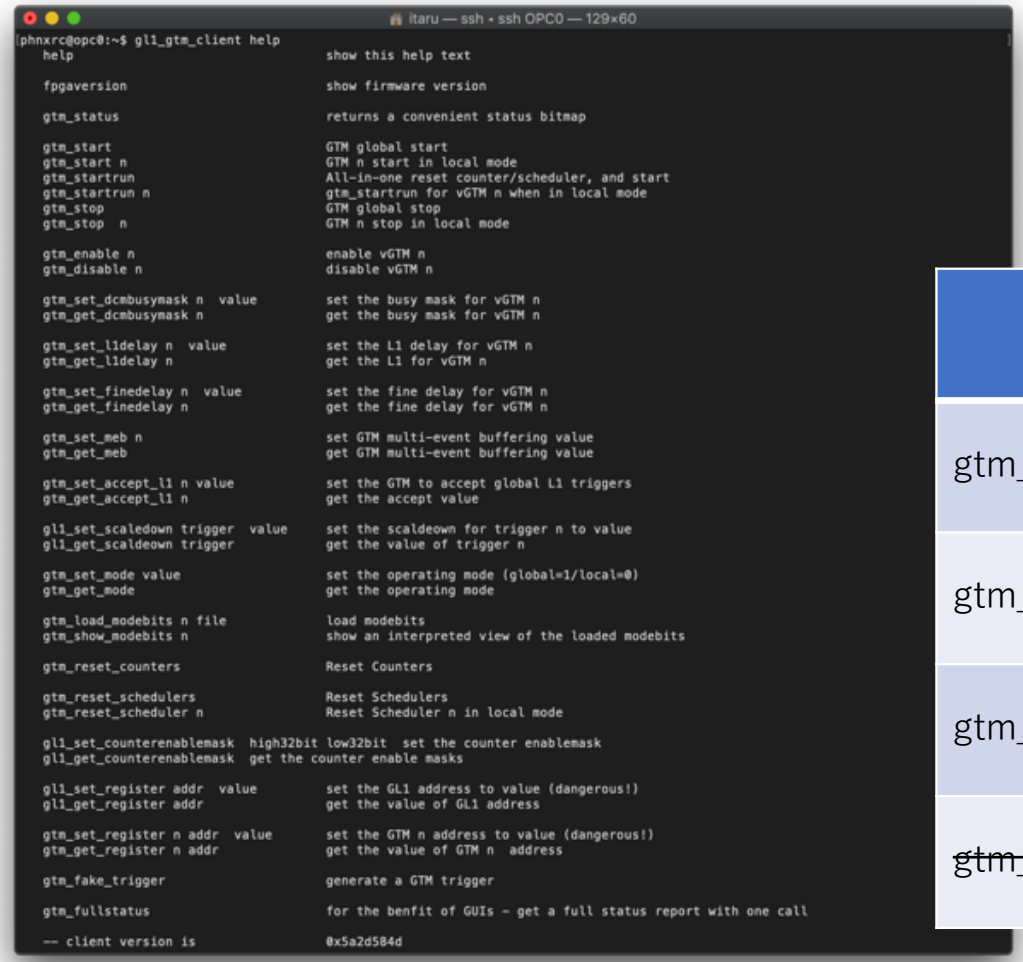
Software : hit multiplicity/felix distribution

*BCO wait time window has to be implemented as external parameter of Felix firmware by Raul
* Need to confirm with Raul if this wait time is equivalent with the "Busy" status to be sent to GTM based on the philosophy of the commissioning. (= no LVL1 trig while cumulating data of a given BCO.) See 230506_PacketStrategy.pptx

1. BCO Scan


collision
FELIX
bco=59
bco=58
bco=57
bco=56
bco=55
...
ROC
Felix Delay=62
Buffer Box
MBD
LL1 Trigger Logic
GTM
BCLK 0
9
23
71
L1Delay=48

Changing LV1 Delay from the command line



- No GUI is available
- Change the LV1 delay from command line

command	explanation
gtm_set_l1delay n value	set the L1 delay for vGTM n 17.76ns
gtm_get_l1delay n	get the L1 for vGTM n
gtm_set_finedelay n value	set the fine delay for vGTM n 80ps
~~gtm_get_finedelay n~~	~~get the fine delay for vGTM n~~

Data Saving and Logging

rcdaq mode : “calib”

- evt file: /bbox/commissioning/INTT/calib
- Root file and dedicated analysis tools : (Joseph, etc)

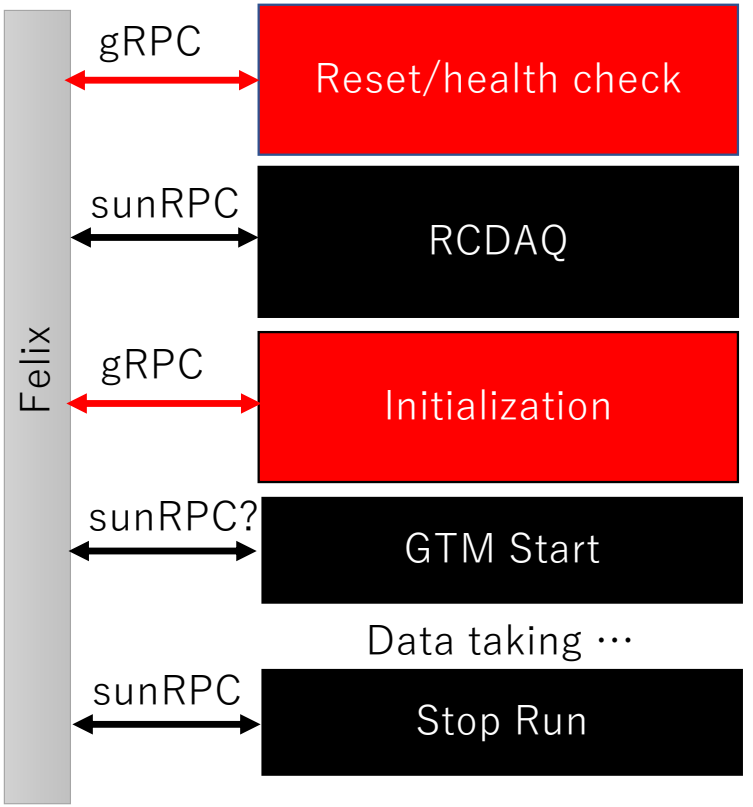
  `/home/phnxrc/INTT/commissioning_5_23`

- Run list: https://docs.google.com/spreadsheets/d/1dkvDEc5iUQd_xskGzAvR5JQ_HzxxxeJfPXEdy0TMKas/edit#gid=0
- INTT E-log: https://sphenix-intra.sdcc.bnl.gov/WWW/elog/INTT/
- RCDAQ comments:
  - Type in run conditions like LV1Delay value, etc as long as it is available by Raul
- Run23 e-log
  - Make a summary entry (Itaru)

Advanced Plan

top_pedestal.sh

- cold_start(d)
- start_rcDAQ.sh
  - sh ~/operations/INTT/intt_setup.sh
  - rcdaq_client daq_set_runtype calibration
  - rcdaq_client daq_open
  - rcdaq_client daq_begin
- macro_pedesetal()
- Start GTM
- Stop_rcDAQ.sh
  - sh ~/operations/INTT/intt_setup.sh
  - rcdaq_client daq_set_runtype calibration
  - rcdaq_client daq_open
  - rcdaq_client daq_begin
- Any end of run routines?

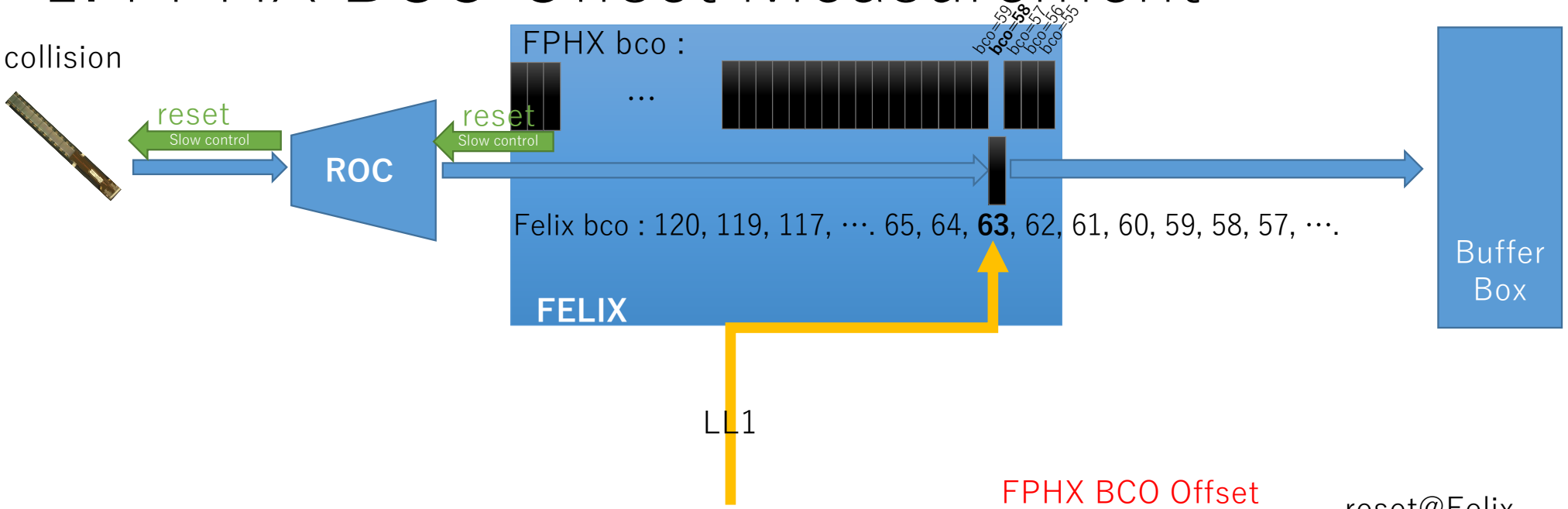


Raul's python script

Timing Parameters

- L1Delay
- Felix Delay (Equivalent to L1Delay after all)
- Wait Time
- FPHX BCO Offset
- n_collision

1. FPHX BCO Offset Measurement



7-bit BCO counters

FPHX BCO Offset

reset@Felix

FPHX	…	5	4	3	2	1	0	Slow control				
Felix				…	7	6	5	4	3	2	1	0

FPHX BCO Offset Measurement

Transmission Frame								
SOF	Felix Channel	Max Words	Payload					
24 bits	4 bits	4 bits	224 bits					
CAF0F0	U	F	UUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU					

The transmission frame payload sends, 224 bits at a time, the event frame. The event frame has a variable length, depending on the number of hits of the collision.

Transmission Frame Payload - Event Frame				
SOF	GTM BCO			Hits
24 bits	40 bits			(N*32) bits
CADEAD	UUUUUUUUUU			?

]

General		Felix Full	Amplitude	Full ROC	Full FPHX	FPHX BCO	ADC	Chip ID	Channel ID
		1 bit	6 bits	1 bit	1 bit	7 bits	3 bits	6 bits	7 bits

If (Physics mode){

XXXXXX?
Felix BCO

} else {
amplitude
}

Inject Felix the 6 most significant bits out of 7 bits. This way we will know the offset within 2BCO precision
FPHX_BCO_Offset = Felix_BCO – FPHX_BCO
The final offset is to be made by another measurement with 6 least significant bit injection to data stream.

2. BCO Timing Scan

Nuclear Instruments and Methods in Physics Research A 755 (2014) 44–61

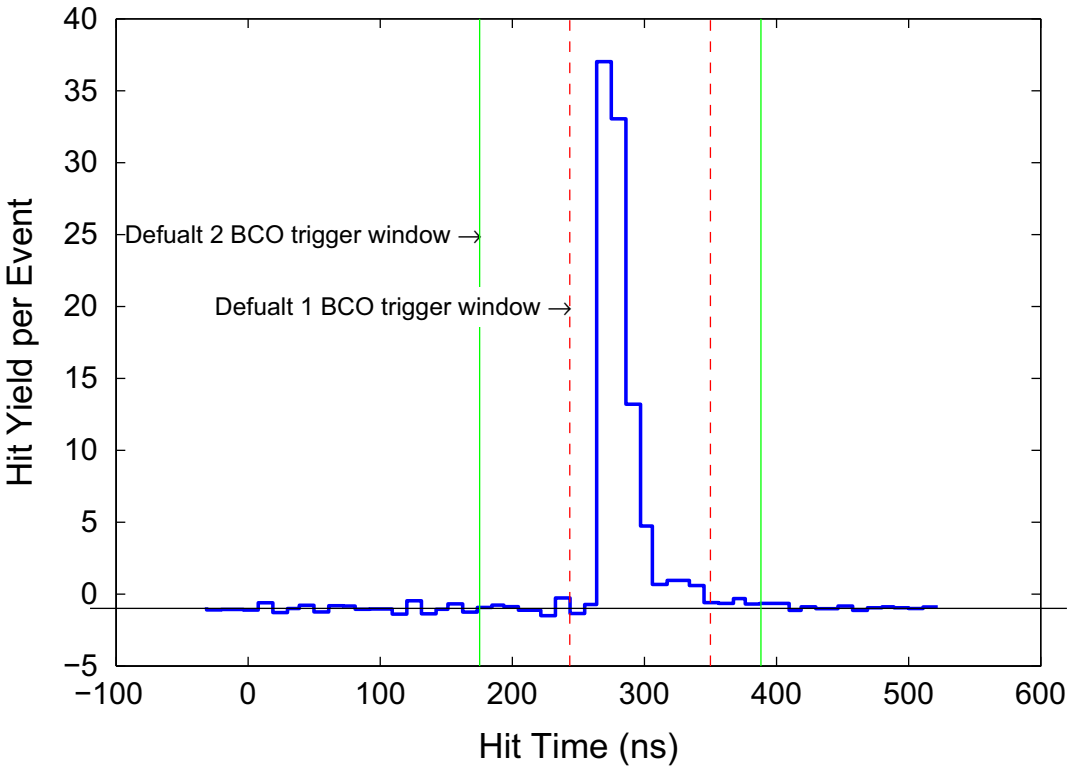


Fig. 32. Timing distribution of the FVTX hits relative to the RHIC beam clock.

Software: Average Rates/ladder vs. latency

6.1. Timing

The distribution in time of FVTX hits is studied relative to the RHIC collision time by comparing the hit rate at different FVTX delay values relative to the RHIC beam clock. The timing distribution for two sectors of wedges in the south arm is shown in Fig. 32. Most hits fall in a window ∼30 ns wide.

Two standard trigger timing configurations were used during FVTX operation, as shown by the vertical lines in Fig. 32: during relatively low trigger rate running (in heavy ion systems) hits arriving in a time window two RHIC beam clocks (BCO) wide (1 BCO∼106 ns) are accepted. In high trigger rate p+p running, a 1 BCO-wide window is used to avoid recording accidental hits from neighboring beam crossings (1 BCO apart).

On 2023/01/12 22:22, Huang, Jin wrote:

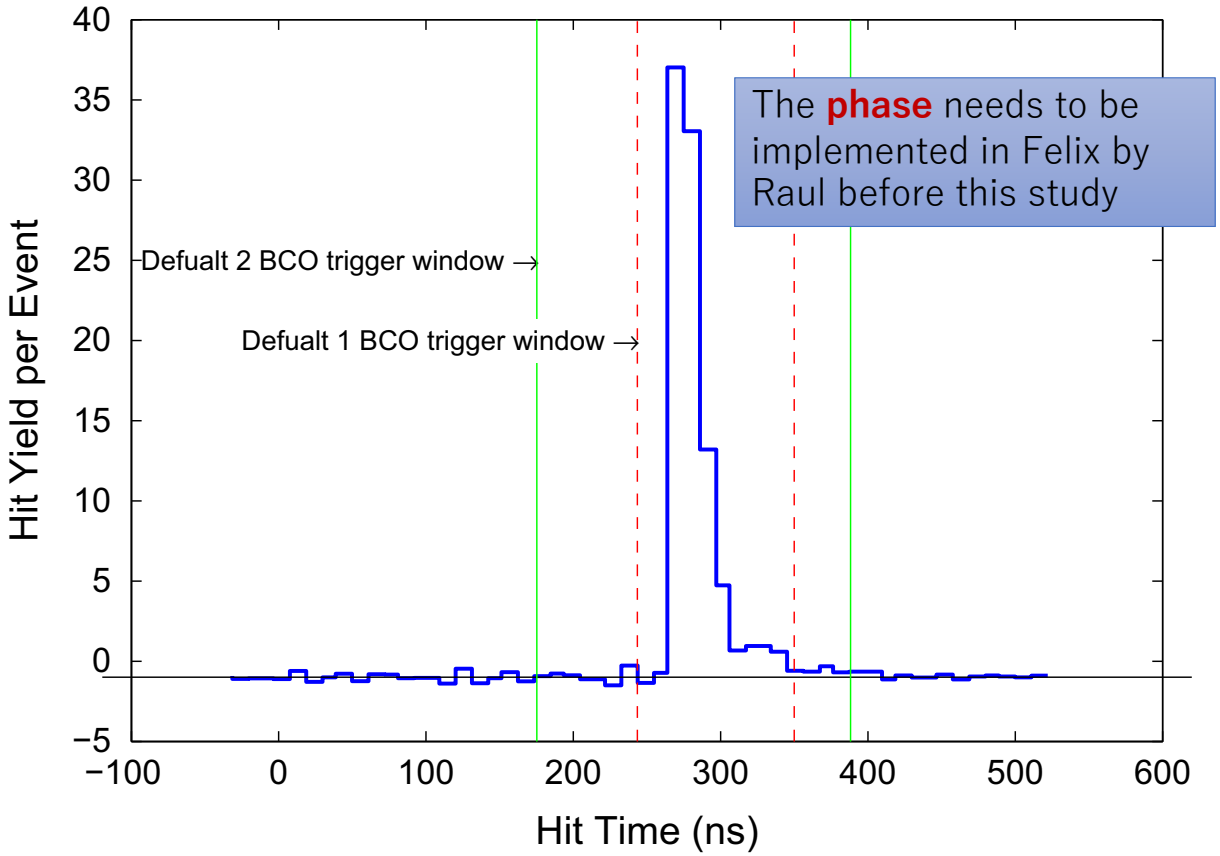
That was exactly how it was done and highly recommended for intt too. It took few hours of a special low bunch fill to perform this scan, shifting BCO phase 19-20ns at a time. That appears the only way to set timing for the sub-bco delay
Jin

n_collision parameter is to be started with 2~3 or 127. **n_collision**=0 setting may not relevant until Raul resolve the asynchronous clock issue between felix servers.

L1Delay=0 & n_collision=127 DAC0=23

2. BCO Phase Scan

RateAnalyzer



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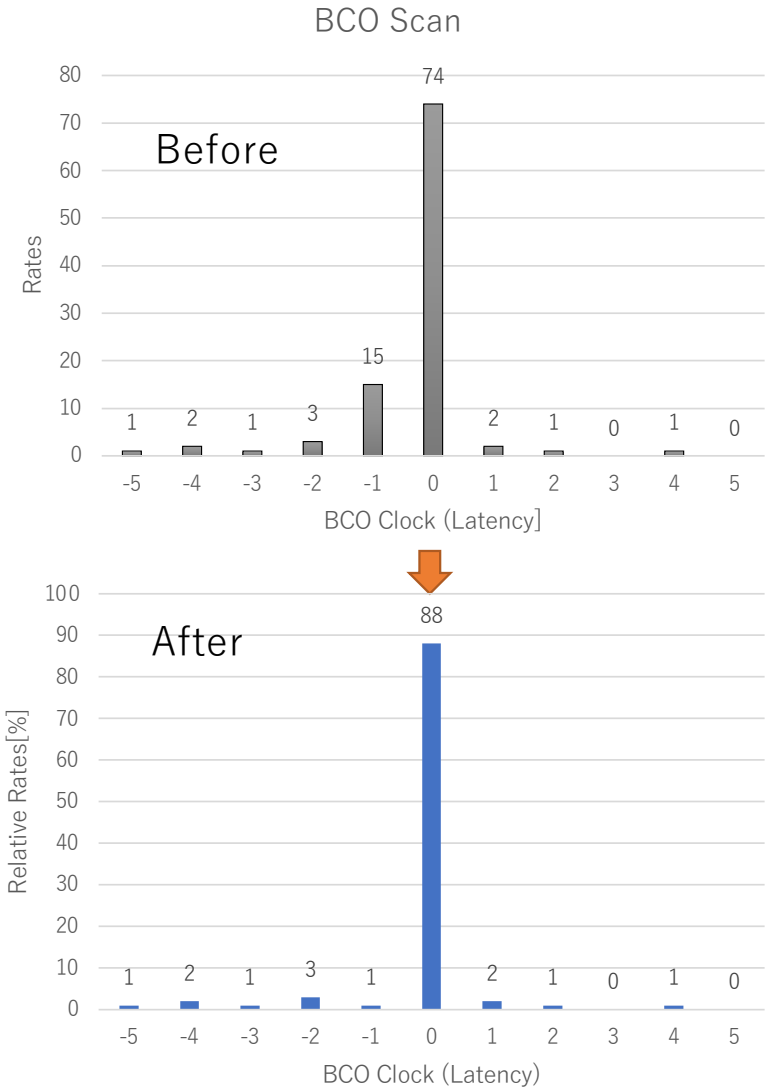
Software: Average Rates/ladder vs. latency



2. BCO Phase Scan

- Set n_collision=0
- Set BCO time window = 1
- Set optimized L1Delay – 2BCO
- Set finedelay value to the values as right table
- 3 minutes run at 100Hz each setting (50 runs, 3 hours total)
- Start with index 20 ~ 30 sets (expected peak) first.

- Hit Yield/Chip, Rates/half ladder
  - Evaluate jitters between chips and ladder

BWSel Dependence?

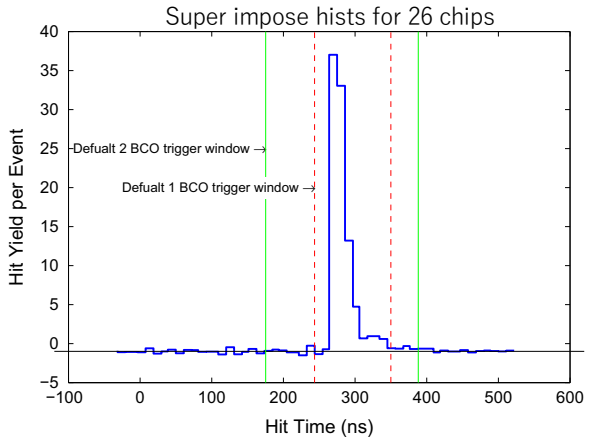


Fig. 32. Timing distribution of the FVTX hits relative to the RHIC beam clock.

Index	Fine Delay [value]	Fine Delay [ns]	index	Fine Delay [value]	Fine Delay [ns]
1	132	10.6	26	3432	274.6
2	264	21.1	27	3564	285.1
3	396	31.7	28	3696	295.7
4	528	42.2	29	3828	306.2
5	660	52.8	30	3960	316.8
6	792	63.4	31	4092	327.4
7	924	73.9	32	4224	337.9
8	1056	84.5	33	4356	348.5
9	1188	95.0	34	4488	359.0
10	1320	105.6	35	4620	369.6
11	1452	116.2	36	4752	380.2
12	1584	126.7	37	4884	390.7
13	1716	137.3	38	5016	401.3
14	1848	147.8	39	5148	411.8
15	1980	158.4	40	5280	422.4
16	2112	169.0	41	5412	433.0
17	2244	179.5	42	5544	443.5
18	2376	190.1	43	5676	454.1
19	2508	200.6	44	5808	464.6
20	2640	211.2	45	5940	475.2
21	2772	221.8	46	6072	485.8
22	2904	232.3	47	6204	496.3
23	3036	242.9	48	6336	506.9
24	3168	253.4	49	6468	517.4
25	3300	264.0	50	6600	528.0

Felix BCO Wait Time Scan

- Start with the BCO wait time* sufficiently wide (60 BCLK=max depth of FIFO in ROC?) at the beginning.
- The scan is to be done for 80->30->20->10->9->8->7->6->5->4->3->2->1 BCLK window.
- 5 minutes/run
- Compare the hit multiplicity distribution/chip (tracklet/track multiplicity for further sophisticated analysis).
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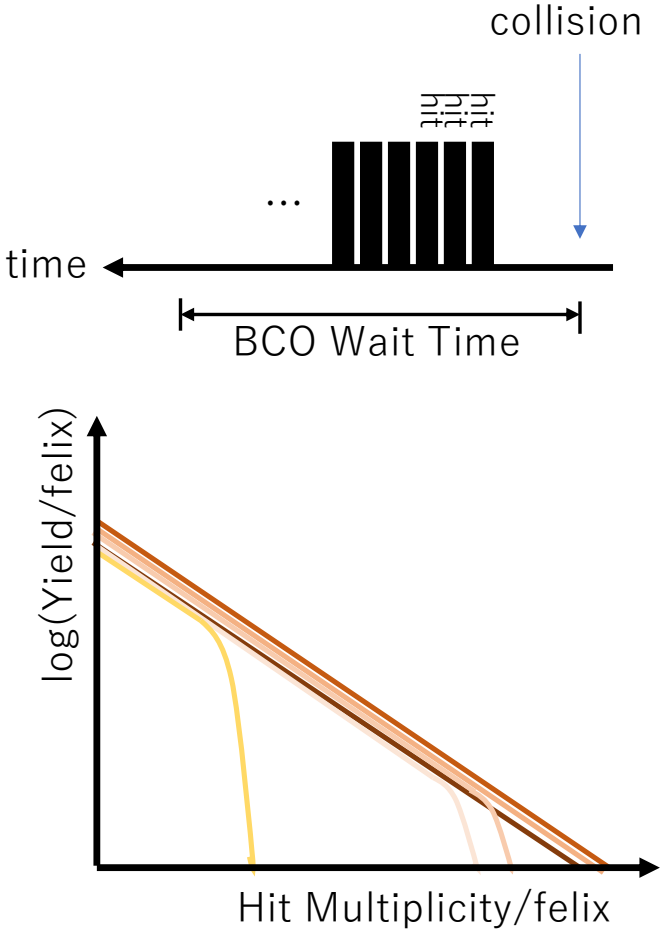

Software : hit multiplicity/felix distribution

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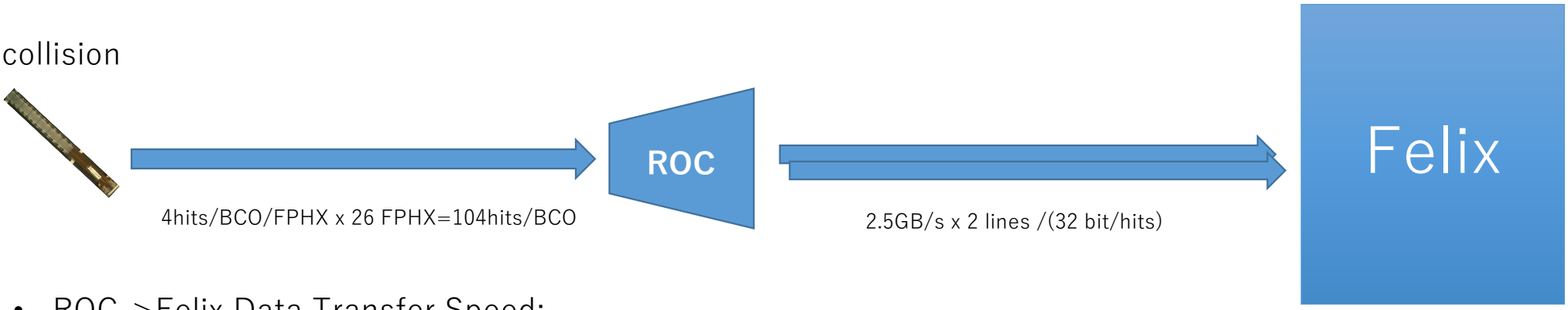
Data Transmission Speed



- ROC->Felix Data Transfer Speed:

$$\frac{2\times 2.5\ GB/s}{32\ Bits/hit} = 1.56\times 10^{8}\ hits/s = 15.6\ hits/100\ ns \sim 15\ hits/BCO$$

- Total time for the maximum 104 hits to be transferred to Felix (if all hits are ready to be transmitted at same time)

$$\frac{104\ hits}{15\ hits/BCO} \sim 7 \text{ or } 8 \text{ BCOs}$$

In reality, the last hits are received 4BCO later from the first hit, which may cause further stretch in the above transmission time. In addition, can there be more than 4 hits/BCO to be sent from FPHX?

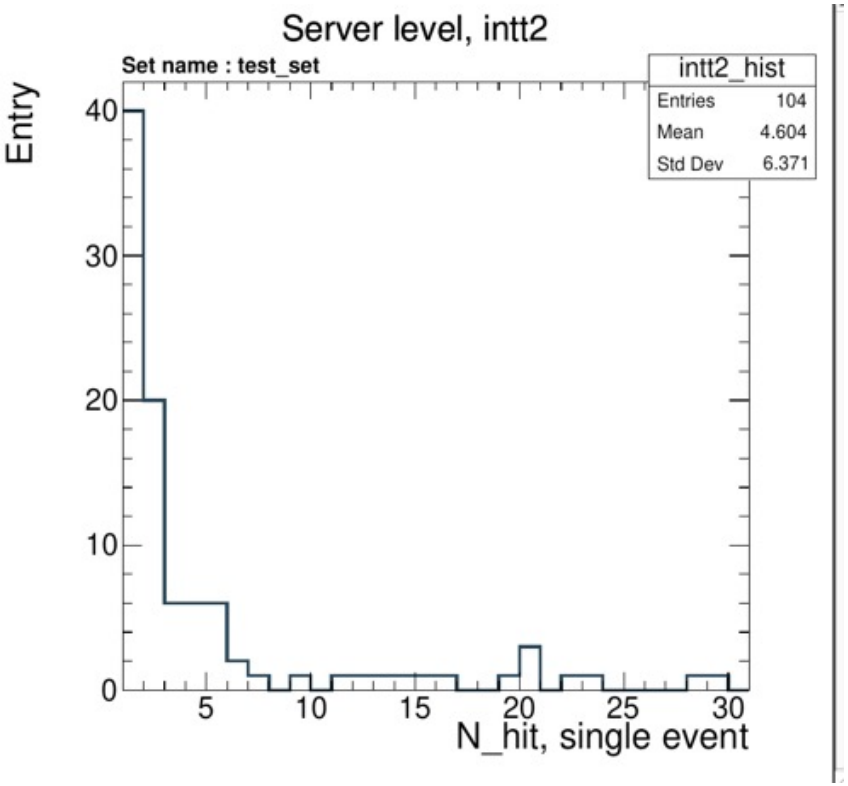
Panels to be prepared

- 9 panels (8 hit multiplicity/felix + total hit multiplicity)
- Load multiple data files for each window setting.
- Plot different color histograms for different window setting

Pedestal data for multiplicity distribution hists development (some multiplicity events are included)

181	calib_packv5_051123_1909_intt7_LVDS_Scan_8_all_FC.npy	intt7	Calibration		15	LVDS Scan	No channel mas
182	/home/phnxrc/INTT/josephb/evt_to_root/intt_intt0-00000029-0000.root	intt0	Pedestal	10		Raul's GTM test	RCDAQ Trigger
183	/home/phnxrc/INTT/josephb/evt_to_root/intt_intt1-00006402-0000.root	intt1	Pedestal	10		Raul's GTM test	RCDAQ Trigger
184	/home/phnxrc/INTT/josephb/evt_to_root/intt_intt2-00006403-0000.root	intt2	Pedestal	10		Raul's GTM test	RCDAQ Trigger
185	/home/phnxrc/INTT/josephb/evt_to_root/intt_intt3-00006406-0000.root	intt3	Pedestal	10		Raul's GTM test	RCDAQ Trigger
186	/home/phnxrc/INTT/josephb/evt_to_root/intt_intt4-00006405-0000.root	intt4	Pedestal	10		Raul's GTM test	RCDAQ Trigger
187	/home/phnxrc/INTT/josephb/evt_to_root/intt_intt5-00006404-0000.root	intt5	Pedestal	10		Raul's GTM test	RCDAQ Trigger
188	/home/phnxrc/INTT/josephb/evt_to_root/intt_intt6-00006407-0000.root	intt6	Pedestal	10		Raul's GTM test	RCDAQ Trigger
189	/home/phnxrc/INTT/josephb/evt_to_root/intt_intt7-00006408-0000.root	intt7	Pedestal	10		Raul's GTM test	RCDAQ Trigger

Multiplicity Distribution Software



- Thanks to Cheng-Wei, the analysis code is available by now.
- Mai succeeded the code to execute, and possible upgrades.

backup

New event types to be included in evt file

Raul

- DAC values
- Comments
- Hot channel maps
- Delay values
- Masked channels

INTT Timing Scan Readiness

- FPGA/Felix script wise ready (Raul).
  - Install all 8 felix in progress.
- Get LV1-Acccept ready thru GTM in RCDAQ Standalone or clock trigger (Raul)
- Execution of cold_start() & macro_pedestal() thru gRPC
  - Request to John H. to upgrade gRPC library from 1.42.0 to 1.54.2.
- SQL database for INTT
- Need to install gRPC and python libraries to DAQ computer.
  - Attempted last Friday, but not prepared well. List of necessary library.
  - To be attempted this week again.

Expert GUI Design in 1008