Status of the BEC

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JUNO EU meeting
2023-05-10

Status of the BEC

1. BECs location and usage

2. Tests in the SAB

3. TTIM 'repair' and its review

   - Mini-WR issue

   - Removing common mode choke

   - tests performed

4. BECs connected to GCU boxes

5. Commissioning data for the BECs

   - Analyzing commissioning data

1. BEC's location and usage

180 BEC boxes have been produced in total

- 160 BECs are used by the main JUNO detector
    - All have been installed and tested in elecRoom last November
    - + 4 backups are in eleroom as well
- 1 BEC is used for OSIRIS
    - Installed and working well now
- 2 BECs in EleRoom for combine test with GCU/DCS.
- 4 BECs in SAB are used for sPMT, LPMT, GCU box test
- 3 BECs as backup in JUNO surface storage.
- 6 BECs in 6 different places for various purposes

Where BEC are now	BEC amount
JUNO-detector	160
JUNO-backup-eleRoom	4
OSIRIS	1
EleRoom-test	2
SAB-test	2+2
JUNO-backup	3
Onsite Total	174
Tsinghua	~~2~~1
SJU	1 (from Tsinghua)
France	1
Belgium	1
IHEP	1
Italy(116)	1
Total	180

2. Tests in the SAB

- **BEC with GCU box test:**

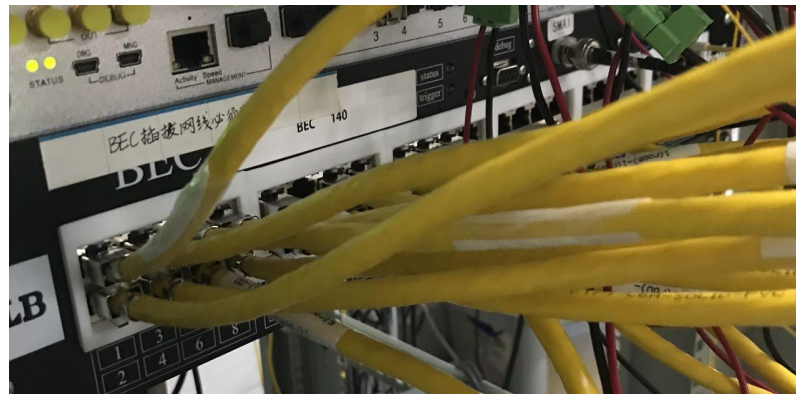 Transmission error test (PRBS error)

- **BEC with LPMT test:**

  Provide time/clock and trigger

  (external mode)

BEC using for LPMT test

- **BEC with sPMT test:**

  Provide time/clock
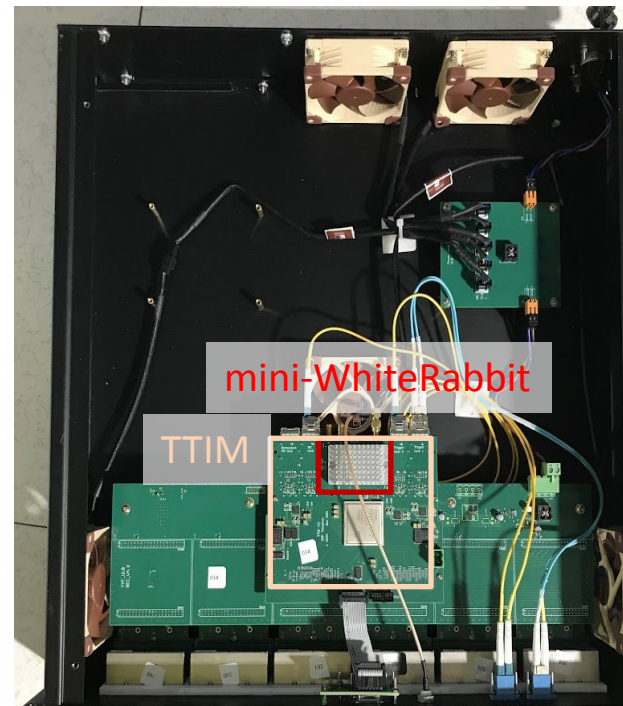
3. TTIM 'repair' and review

Mini-WR module issue:

Communication problem between WR switch and TTIM; it was found last year during the BEC test in eleRoom.
For some TTIM/BEC, clock from mini-WR may lose locking when large data is transferred.

Study from Jianmeng:
- The common mode (CM) choke produce a large voltage drop when the mini-WR is processing the network packet.
- Solution: removing the CM choke, no packet loss, no clock got unlock.

mini-WhiteRabbit

TTIM

TTIM 'repair' and review

Removing common mode choke (Reviews were done):

- Open BEC box and unscrew the unit of mini-WR and its heat sink from TTIM.

- Remove the common-mode choke coil and short-circuit the power supply pins

- Add spacer between heat sink and TTIM to avoid screwing force

Remove CM choke

mini-WhiteRabbit

2*1mm spacer

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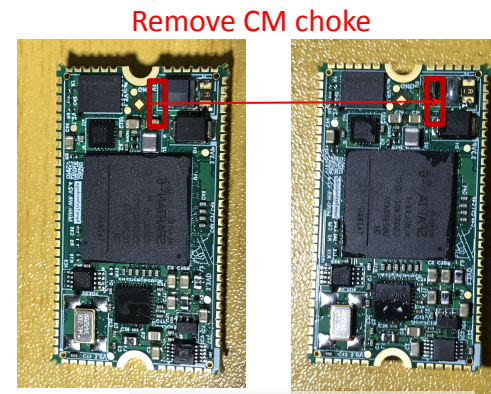
TTIM 'repair' and review

All BECs for JUNO detector have been repaired

Tests performed :

- Ping + Temperature reading check have been done
- Transmission error test (loop test) has not finished. BECs connected to the installed GCUs have passed the test. The rest will be tested before more GCUs are installed.

4. BECs # connected to GCU boxes (up to 2023-04-28)

elec room #1

	1R	2R	3R	4R	5R	6R	7R	8R	9R	10R
1排	61	33	41	46	144	51	142	95	78	58
	169	112	65	34	159	59	87	2	129	107
	12	86	82	44	72	120	125	40	103	83
2排	117	42	91	152	50	115	84	13	5	3
	122	128	168	155	127	64	23	38	4	35
	111	167	148	70	92	173	73		16	15
3排	31	135	174	176	123	137	24	53	85	
	132	179	170	43	71	146	172	164	141	
	10	163	109	80	57	14	62	49	79	

elec room #2

	1R	2R	3R	4R	5R	6R	7R	8R	9R	10R
1排	9	175	67	88	75	162	36	178	133	
	27	131	157	20	158	48	47	77	105	
	19	8	100	101	166	165	45	69	94	
2排	145	160	39	32	11	74	76	56	124	
	29	108	102	177	114	147	153			
	119		81	154	93	156	121			
3排	52	143	149	126	104	25	68	136	134	
	37	63	90	60	110	161	30	106		
	54	151	130	98	28	139	99	17		

Note	orange = CD 134	purple = VETO 21	blue = sPMT 5

GCU connected to 8+10 BEC

spmt electronics box 2 BEC

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Number of connected channels (LPMT) 2023-04-28

- Installed up to April, 18(8+10) BECs are used, 252 channel are connected.
- 252 channel pass the transmission error test, one failed due GCU's cable issue, the GCU has been replaced on April 28th.

position	dcs_no	bec_no	IP	trig_section	connected_chs	RMU	room	installed	remain ch
1-1-5-3	15	72	192.168.10.82	2	45	1	1	18	27
1-2-5-1	43	50	192.168.10.60	4	44	4	1	32	12
1-2-7-2	50	23	192.168.10.33	V6	44	8	1	1	43
1-2-7-3	51	73	192.168.10.83	V1	45	8	1	2	43
1-3-6-2	76	146	192.168.10.156	1	44	3	1	41	3
1-3-6-3	77	14	192.168.10.24	3	44	3	1	27	17
2-1-7-2	106	47	192.168.10.57	75	40	5	2	24	16
2-1-7-3	107	45	192.168.10.55	73	44	5	2	40	4
2-2-5-1	125	11	192.168.10.21	76	44	7	2	28	16
2-2-5-2	126	114	192.168.10.124	74	44	7	2	24	20
2-2-7-1	131	76	192.168.10.86	V17	47	8	2	1	46
2-2-7-3	133	121	192.168.10.131	V12	34	8	2	1	33

5. Commissioning data for the BECs:

> Commissioning global trigger: BEC-level trigger

> BEC-level trigger: for one BEC

- if the total nhits are over than the threshold, all GCUs of this BEC will be triggered.

Trigger mode	GCU trigger register	BEC+CTU	Description
GCU period trigger	0xC601	NO	Electronic noise data (random noise)
GCU self trigger	0x0613	NO	Dark noise data (check GCU+PMT waveform)
global trigger	0x0000	YES	normal working mode

JUNO docDB: 9522
https://jupyter.ihep.ac.cn/XTV9kwK7TciwBl8qe1uMDQ

The SYNC link between BEC and GCU

connection	description	connection check method
GCU→BEC	Slow control	BEC: ttc_error
GCU→BEC	Trigger request	-
BEC→GCU	Trigger accept	GCU: compare GCU/BEC triggered frequency(s)
BEC→GCU	clock	GCU: PLL lock information

- BEC didn't save any information, uplink no check
- Downlink PLL information : Error register
- Trigger accept : using timestamp data to check

PLL lock/ErrorRegister of all GCU
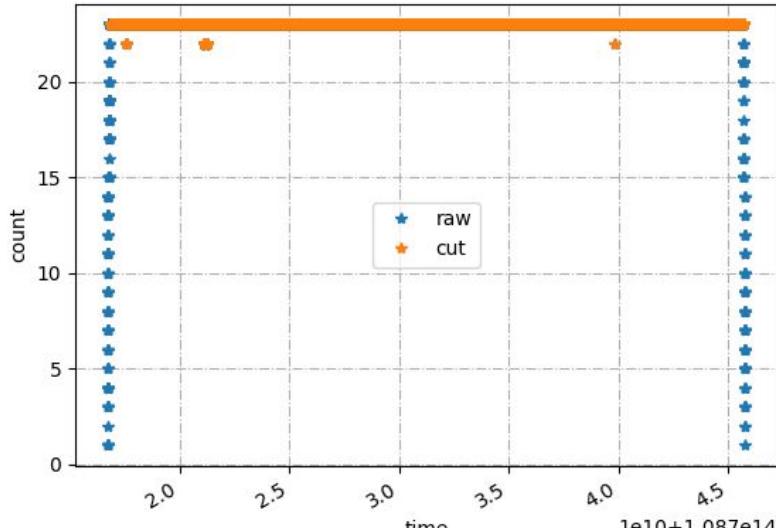

Clock link no problem!
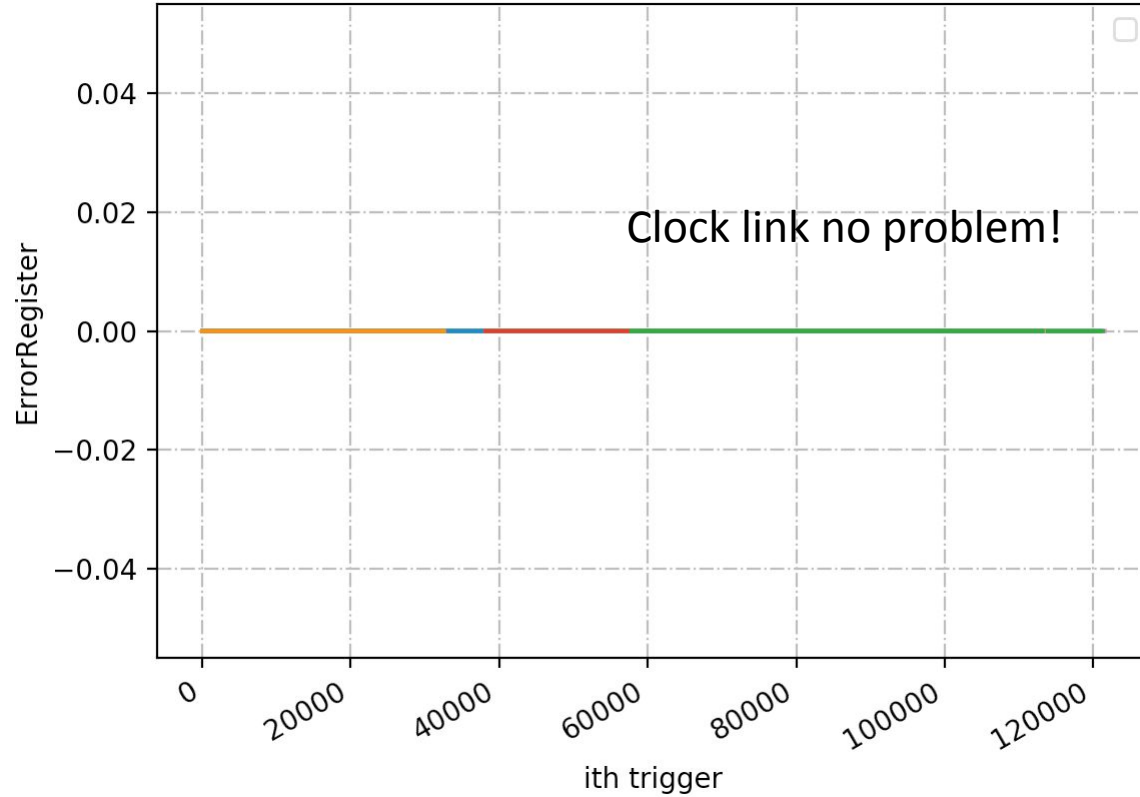
Check GCU's trigger information

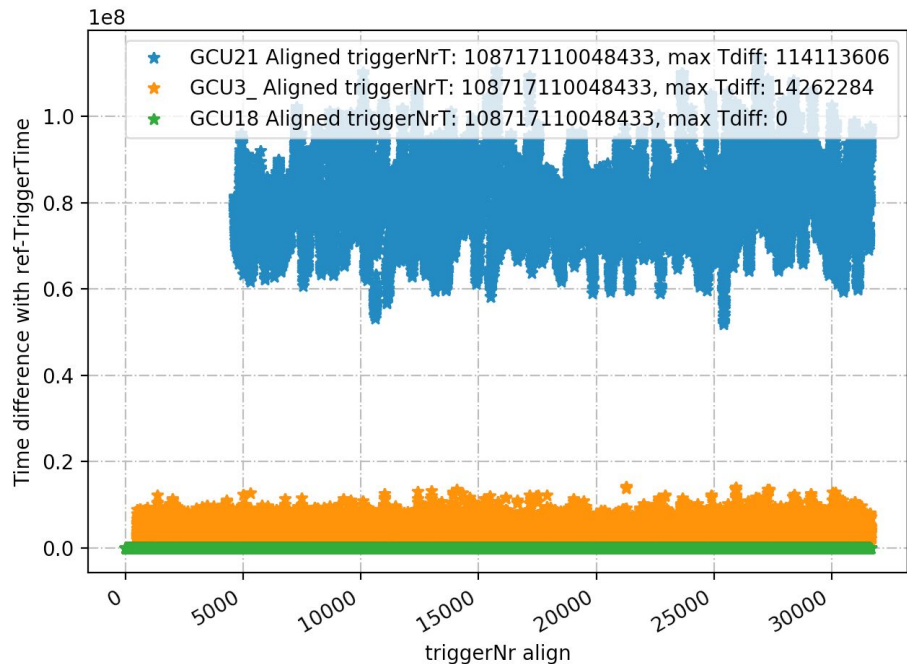Count the triggered GCU numbers at one trigger time.
- for example Run7866/BEC 47, at one time, it should have 23 triggered GCUs.
- if not：
    →GCU didn't receive trigger
    →DAQ lost data

The drop of two ends are due to the non-parallel launch order of the DAQ: not for analysis.
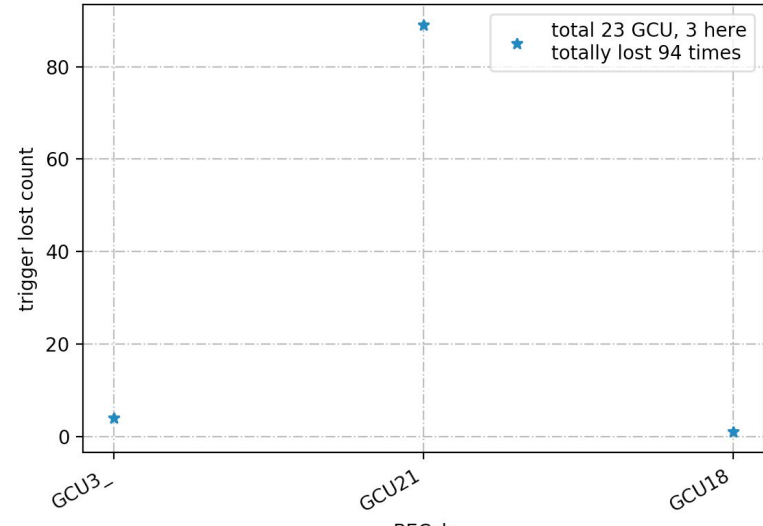
Check GCU's trigger information: local TriggerNr

GCUs with problem: no trigger or daq lost data:

a) Align all GCU's trigger time, pick this time's local triggerNr as 0th Trigger.
b) Compare the GCU which lost data with ref-GCU.

Max Trigger Time difference(max Tdiff) after aligning
1. if max Tdiff >0 , means GCU didn't receive trigger at least once.
2. if max Tdiff=0, means DAQ lost data

GCU21 and GCU3 didn't receive trigger at least once. GCU18 DAQ lost data.

Under discussion with Jun and Jianmen to understand better.

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Summary of the status of the BEC

- All BECs for JUNO have been installed and tested in elecRoom

- We removed the CM choke from the mini-WR, and partial tests have been done

- Installed GCUs's cable have been connected to BEC, except one cable's issue, all passed the combine test between GCU and BEC

- BEC attend the commissioning and performed a successful joint test with underwater electronics system

backup

commissioning global trigger mode

Commissioning global trigger is different with official mode, for one BEC
- if the total nhits are over than the threshold, all GCUs will be triggered.
- data taking time :3 minutes.

position	bec_no	connected GCUs	trigger window[ns]	threshold [pmt]	run
1-1-5-3	72	18	16 ns	6 pmt	7878
1-2-5-1	50	32	16 ns	5 pmt	7878
1-3-6-2	146	41	32ns	8 pmt	7882
1-3-6-3	14	27	32ns	6 pmt	7882
2-1-7-2	47	23	32 ns	7 pmt	7866
2-1-7-3	45	40	32ns	8 pmt	7869
2-2-5-1	11	28	32ns	7 pmt	7874
2-2-5-2	114	24	32ns	6 pmt	7874

https://juno.ihep.ac.cn/elog/Commissioning/26

Trigger/Timing System Scheme
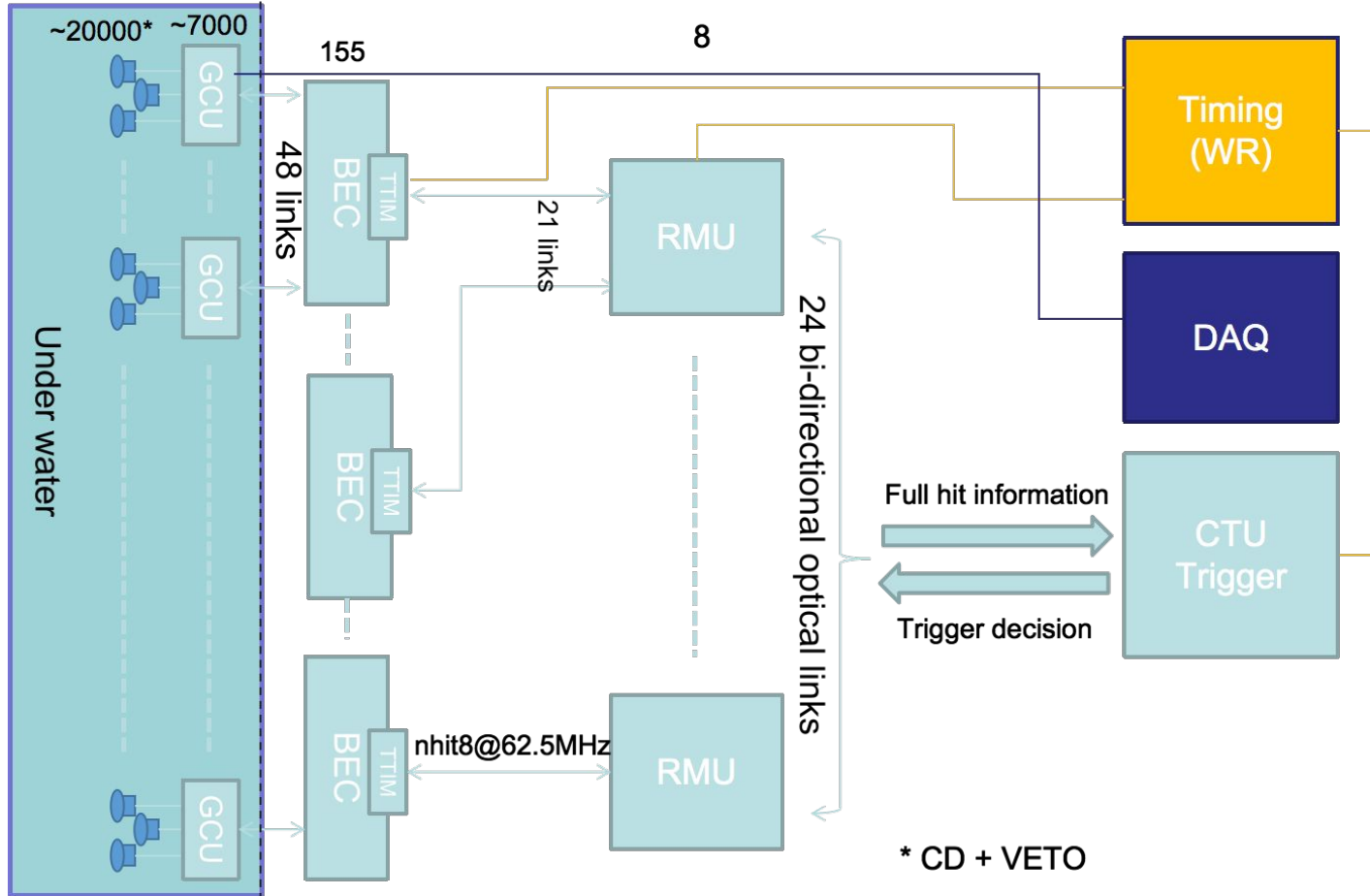
* GCU: Global Control Unit
* BEC: Back-End Card
* TTIM: Trigger/Timing Interface Mezzanine
* RMU: Reorganizing and Multiplexing Unit
* CTU: Central Trigger Unit
* WR: the White Rabbit system; provide sub-ns synchronization
* DAQ: the Data Acquisition system

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check timestamp of all GCU(23) of one BEC, run 7866

start: 108721p.**129**09949

end: 108721p.**207**522647
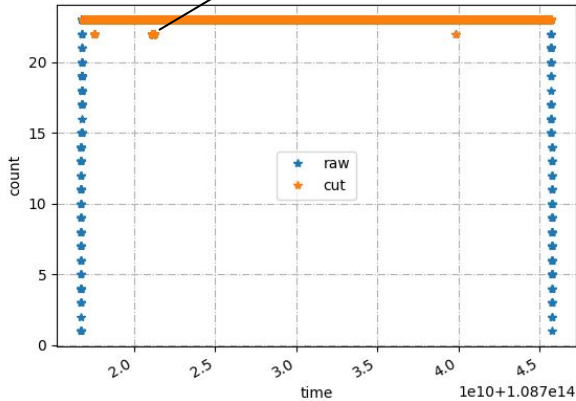
108721p.**129**90189   108721p.**208**064891

TriggerNr	mode	time	BEC_ch
9951	3	8659	0	108721129190189	21
9952	2	8660	0	108721208064891	21

BEC's 21st ch, trigger lost 89 times,
during this time, GCU's local triggerNr is continuous.
means: GCU didn't received trigger decision

commissioning's data package format
## - only timestamp from BEC

■ Global trigger data format

Header		Waveform······				Tailer	
805A	2d48	...	...	...	version	← Firmware version
Channel No.	2d45	...	...	...	Data type	← Data type from BEC
Data Length	2d46	...	...	...	Error register	← Error register value
local Trig counter	2d43	...	...	...	High voltage	← High voltage status
Trigger mode	2d41	...	...	...	(reserved)	
Timestamp[47:32]	2d40	...	...	...	(reserved)	
Timestamp[31:16]	2d44	...	...	...	GCU_BEC_port	← BEC port
Timestamp[15:0]	2d42	...	...	...	8069	← tailer marker

Head marker → 805A
0,1,2,3,4,5 → Channel No.
Window = (value-2)*8 ns
Pack size = value * 16 Byte → Data Length
Local counter only → local Trig counter
Trigger mode register value → Trigger mode
48 bits timestamp (8ns resolution) → Timestamp

Global trigger with waveform data

JUNO docDB: 9522

check timestamp of all GCU of 2 BEC, run [7878-BEC50]

position	bec_no	chs on BEC	Trg window	threshold	Trg rate[elog]	Trg rate[TrgNr/T]	run	lost times
1-2-5-1	50	32	16 ns	5 pmt	150 Hz	183.1Hz	7878	469
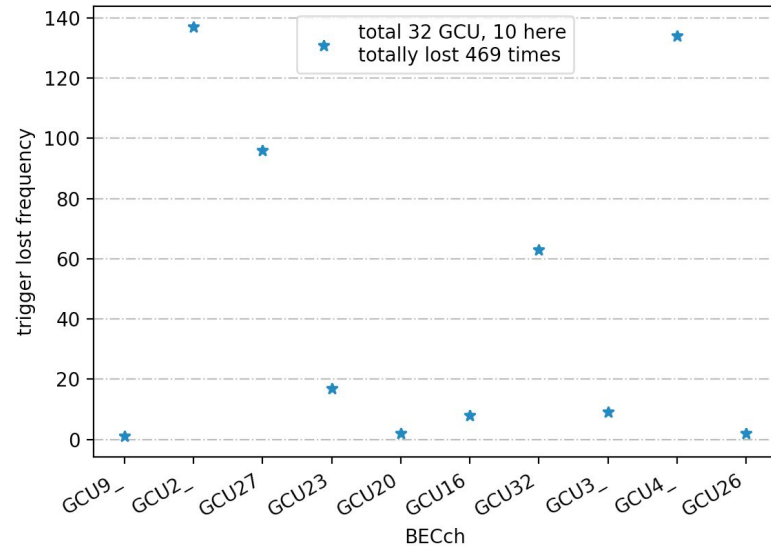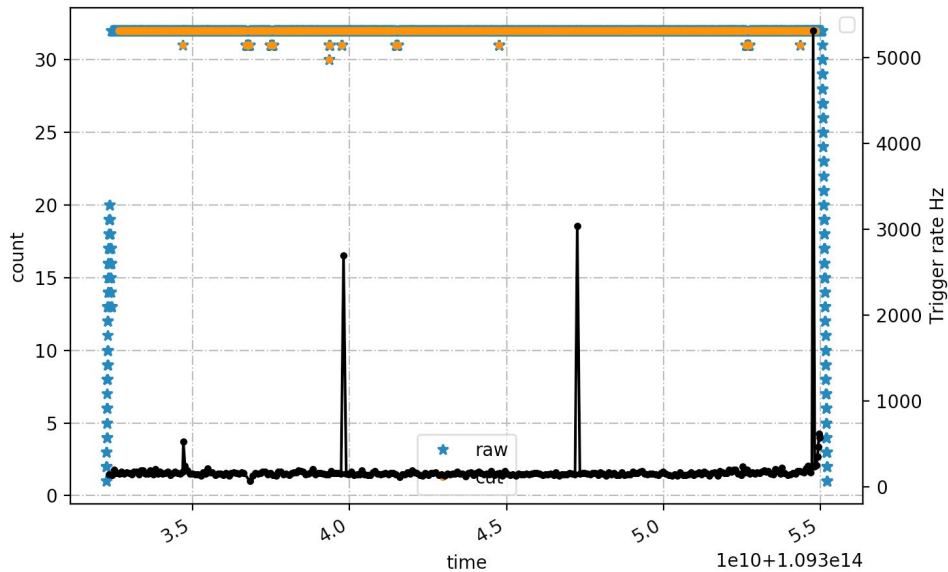
check timestamp of all GCU of 2 BEC, run [7878-BEC50]

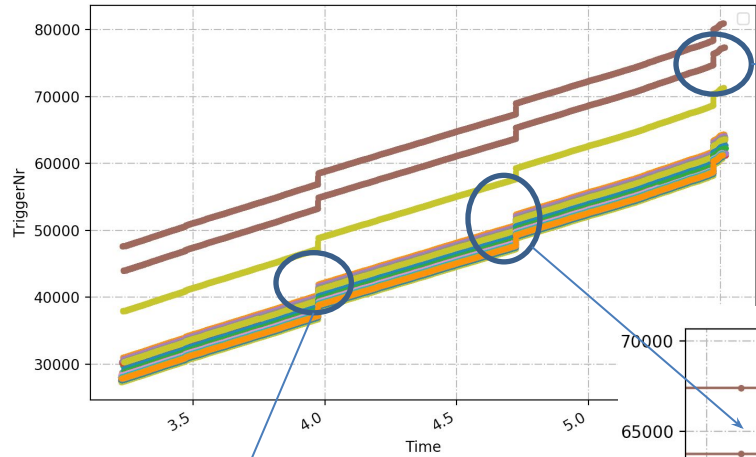| position	bec_no	chs on BEC	Trg window	threshold	Trg rate[elog]	Trg rate[TrgNr/T]	run	lost times
1-2-5-1	50	32	16 ns	5 pmt	150 Hz	183.1Hz	7878	469

if one of any GCU's aligned triggerNr not exit, all the triggerNr not plot here.
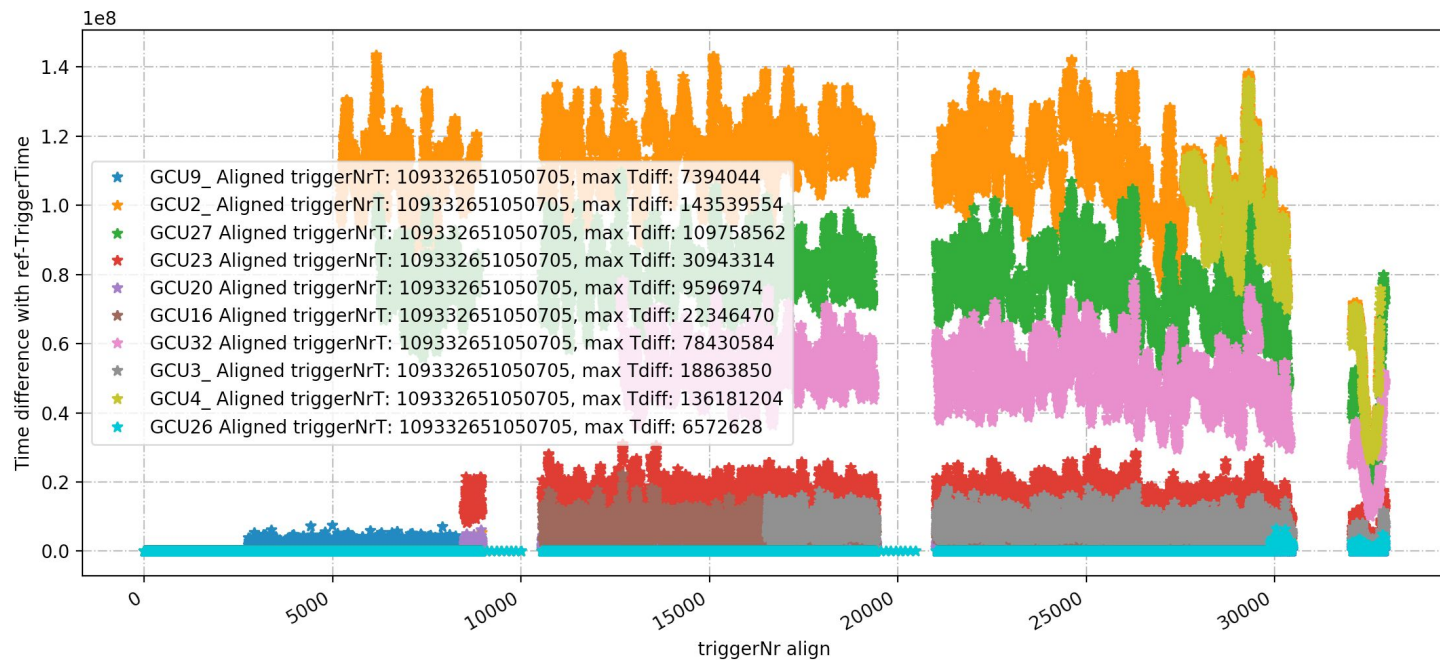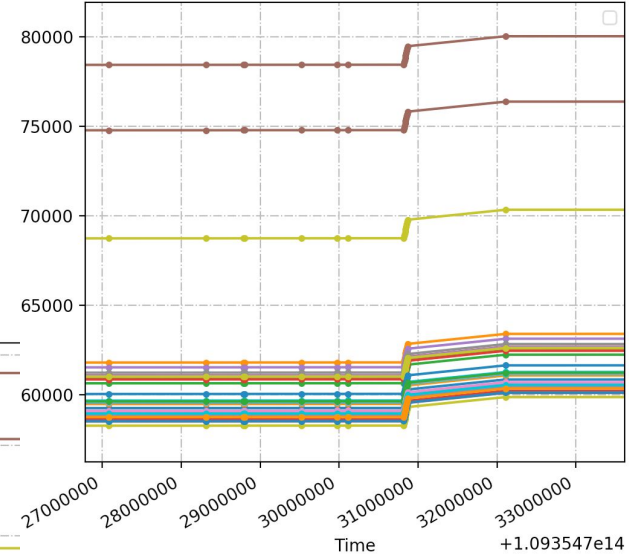

- ref:GCU1_
- max Tdiff >0 , means those 10 GCU didn't receive trigger at least once.

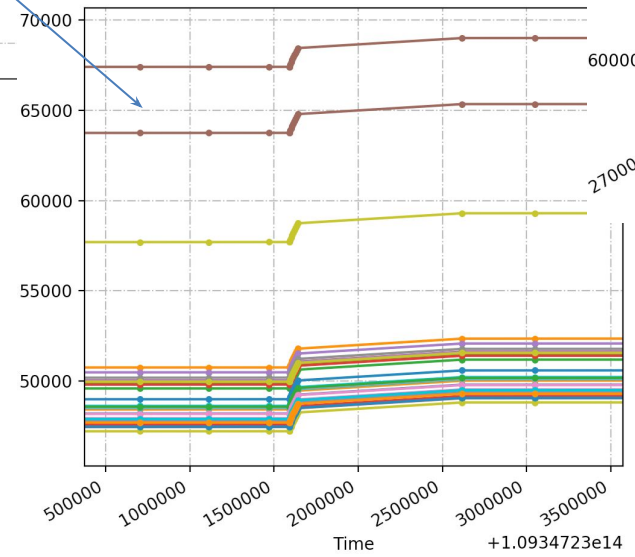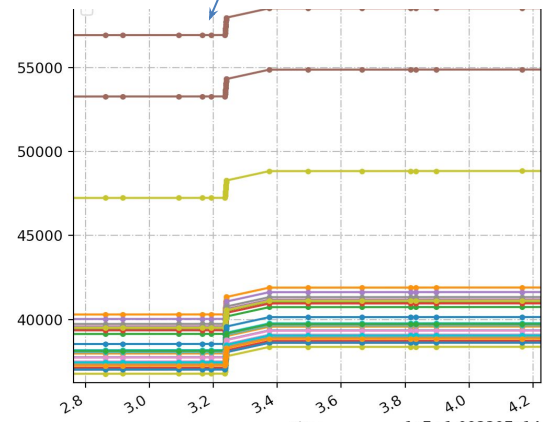# check timestamp of all GCU of 2 BEC, [7878-BEC50]
------check if the triggerNr increase smoothly along time

NO

the TriggerNr jumps around 1500 in a short time.
along the jump line, trigger density higher than normal.

position	bec_no	chs on BEC	Trg window	threshold	Trg rate[elog]	Trg rate[TrgNr/T]	run	lost times	lost ch	lost due to trigger	jump
1-1-5-3	72	18	16 ns	6 pmt	300 Hz	359.26 Hz	7878	236	18	18	0
1-2-5-1	50	32	16 ns	5 pmt	150 Hz	183.1Hz	7878	469	10	10	1
1-3-6-2	146	41	32ns	8 pmt	120 Hz	152.2Hz	7882	516	41	33	1
1-3-6-3	14	27	32ns	6 pmt	140 Hz	125.71Hz	7882	68	1	1	0
2-1-7-2	47	23	32 ns	7 pmt	130 Hz	138.6 Hz	7866	94	3	2	0
2-1-7-3	45	40	32ns	8 pmt	260 Hz	268.4	7869	2790	40	40	1?
2-2-5-1	11	27	32ns	7 pmt	260 Hz	203.08Hz	7874	260	4	4	0
2-2-5-2	114	24	32ns	6 pmt	260 Hz	249.7 Hz	7874	875.895k	24	24	1

Note: Trg rate[TrgNr/T] is calculated by GCU1's ch1. TrgNr/T=$\frac{TrgNr[-1]-TrgNr[0]}{Time[-1]-Time[0]}$

lost ch: the total number of GCU whose trigger information is lost at one trigger time compare to other GCUs

lost due to trigger: the total number of GCU which didn't revive trigger at least once!

- Trg[elog] not equal to Trg rate[TrgNr/T], most is similarly, not for 2-2-5-1/2 elog >TrgRate, 1-3-6-2/3 rever
- red line: all GCUs didn't receive trigger for at least once!

Summary

problem exist:
1. DAQ lost data(known issue from Chao Chen)
2. some GCU didn't revive the trigger
   - run 8 BECs, all BEC+GCU meet this problem
   - worst one is BEC 114, lost count is 875.895k during running.
3. GCU's local triggerNr jumps in short time, happen on almost all GCUs connected to one BEC
   - run 8 BEC, 4 BEC meet this problem.

|		Bit 1 Bit 2	Reset counter for backend error Reset DDR test error
Counter of back end transmission error	72	Read only	Counter of Bec input clock loss
	73	Read only	Counter of Prbs error
	77	Read only	Counter of TTC single bit error
	78	Read only	Counter of TTC double bit error
	79	Read only	Counter of TTC command bit error
	7a	Read only	Counter of L1 MMCM loss ，same as 0x7200
	7b	Read only	Counter of L2 external PLL loss
	7c	Read only	Counter of L3 MMCM loss
GCUid	F4	0-47	The port of BEC connected
Firmware version	75	Read only	Firmware version
Error code	7F	Read only	L1 buffer overflow（3bits） Trigger stun Adc initialization（3bits） Pll initialization（3bits） L3 MMCM lock L2 external PLL lock L1 MMCM lock

Number of connected channels (LPMT) 2023-04-28

- Installed up to April, 12 BECs are used, 239 channel are connected.
- 238 channel pass the transmission error test, one failed due GCU's cable issue, the GCU has been replaced on April 28th.

position	dcs_no	bec_no	IP	trig_section	connected_chs	RMU	room	installed	remain ch
1-1-5-3	15	72	192.168.10.82	2	45	1	1	18	27
1-2-5-1	43	50	192.168.10.60	4	44	4	1	32	12
1-2-7-2	50	23	192.168.10.33	V6	44	8	1	1	43
1-2-7-3	51	73	192.168.10.83	V1	45	8	1	2	43
1-3-6-2	76	146	192.168.10.156	1	44	3	1	41	3
1-3-6-3	77	14	192.168.10.24	3	44	3	1	27	17
2-1-7-2	106	47	192.168.10.57	75	40	5	2	24	16
2-1-7-3	107	45	192.168.10.55	73	44	5	2	40	4
2-2-5-1	125	11	192.168.10.21	76	44	7	2	28	16
2-2-5-2	126	114	192.168.10.124	74	44	7	2	24	20
2-2-7-1	131	76	192.168.10.86	V17	47	8	2	1	46
2-2-7-3	133	121	192.168.10.131	V12	34	8	2	1	33

check timestamp of all GCU(23) of one BEC, run 7866
------what might cause this lost?

- trigger rate in short time? seems No
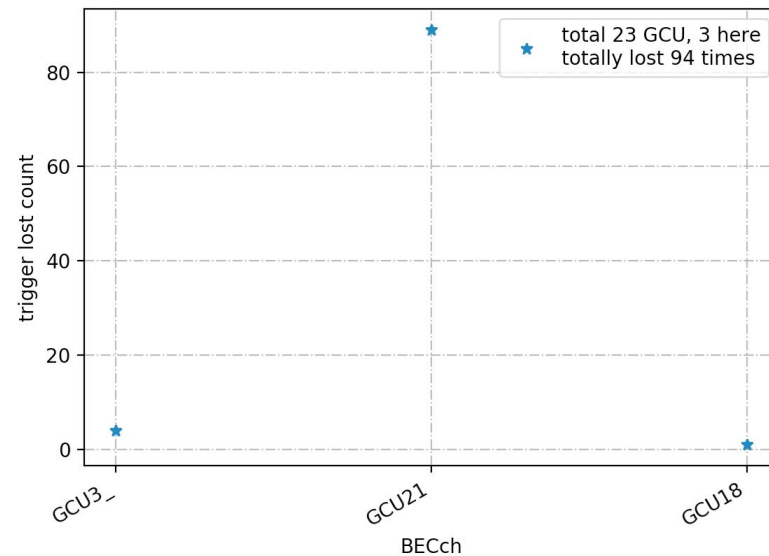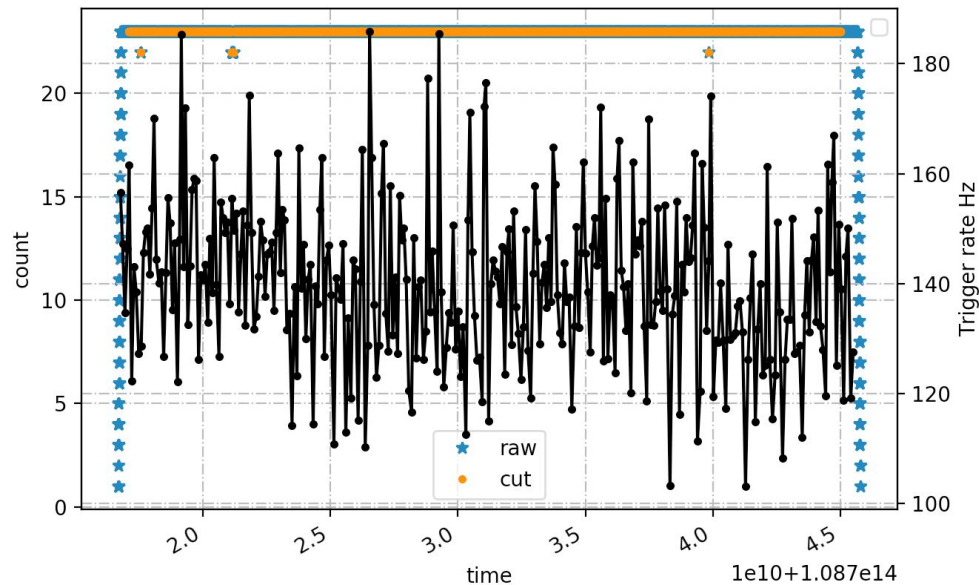
position	bec_no	chs on BEC	Trg window	threshold	Trg rate[elog]	Trg rate[TrgNr/T]	run	lost times
2-1-7-2	47	23	32 ns	7 pmt	130 Hz	138.6 Hz	7866	94