

AHCAL Test Update

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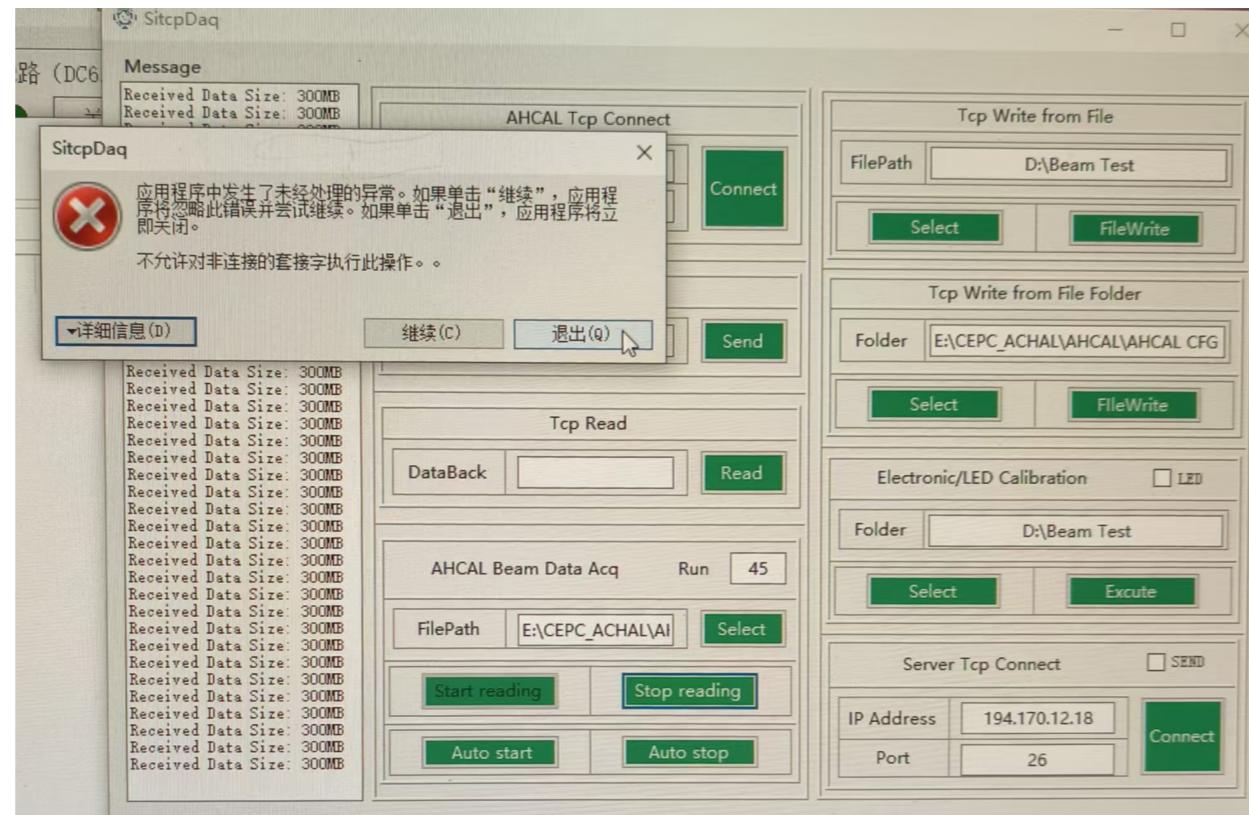
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Overview of Progress Over the Past Week

DAQ Software Stability

- Previously, the DAQ software would randomly disconnect.



- According to recent tests (Run83), if the temperature acquisition software is not run on the same laptop as the DAQ software, the DAQ remains stable for over 2 days.
- This stability is sufficient and potentially suitable for direct use at CERN.

DIF & DAQ Board of Layer 0

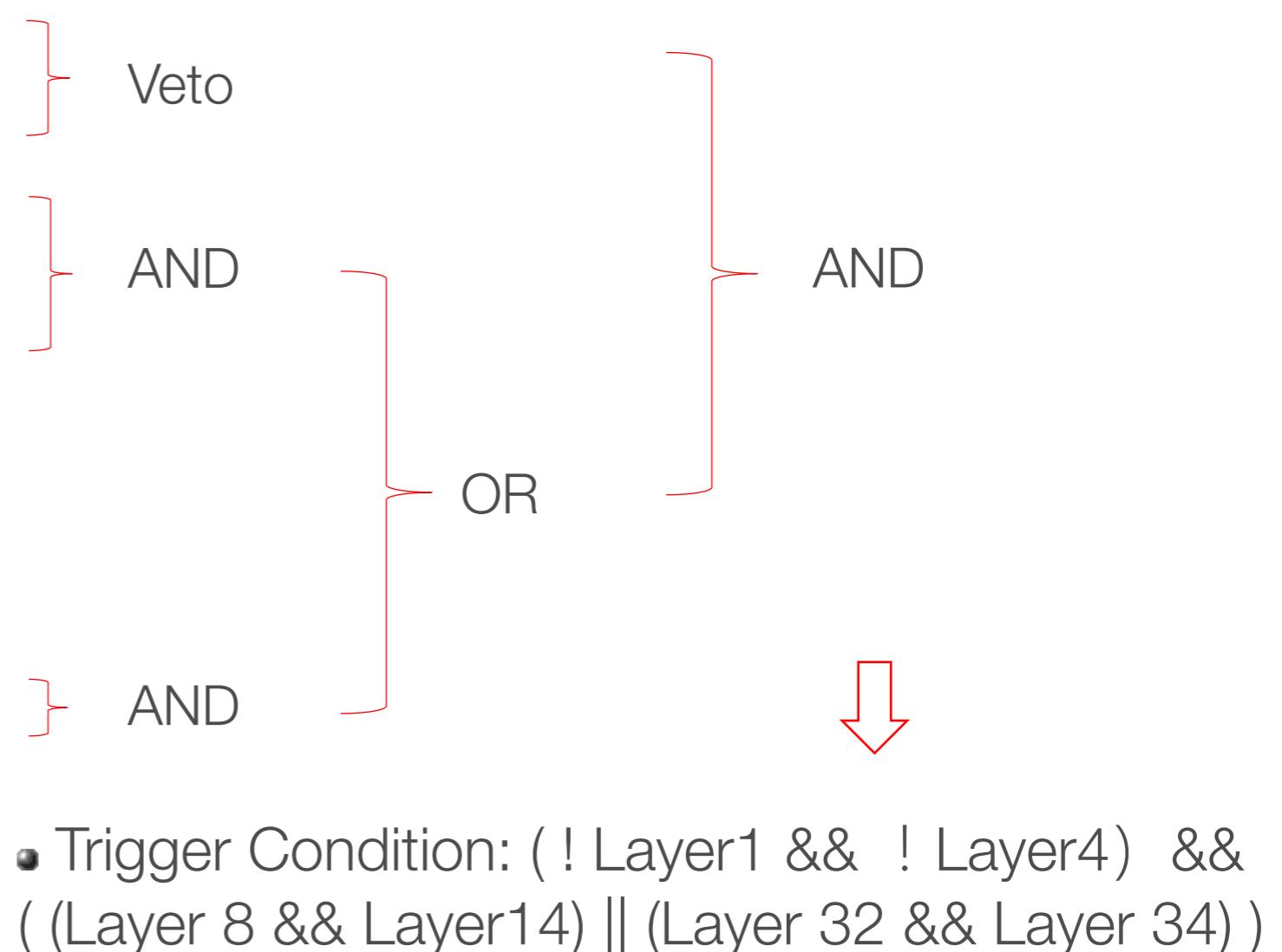
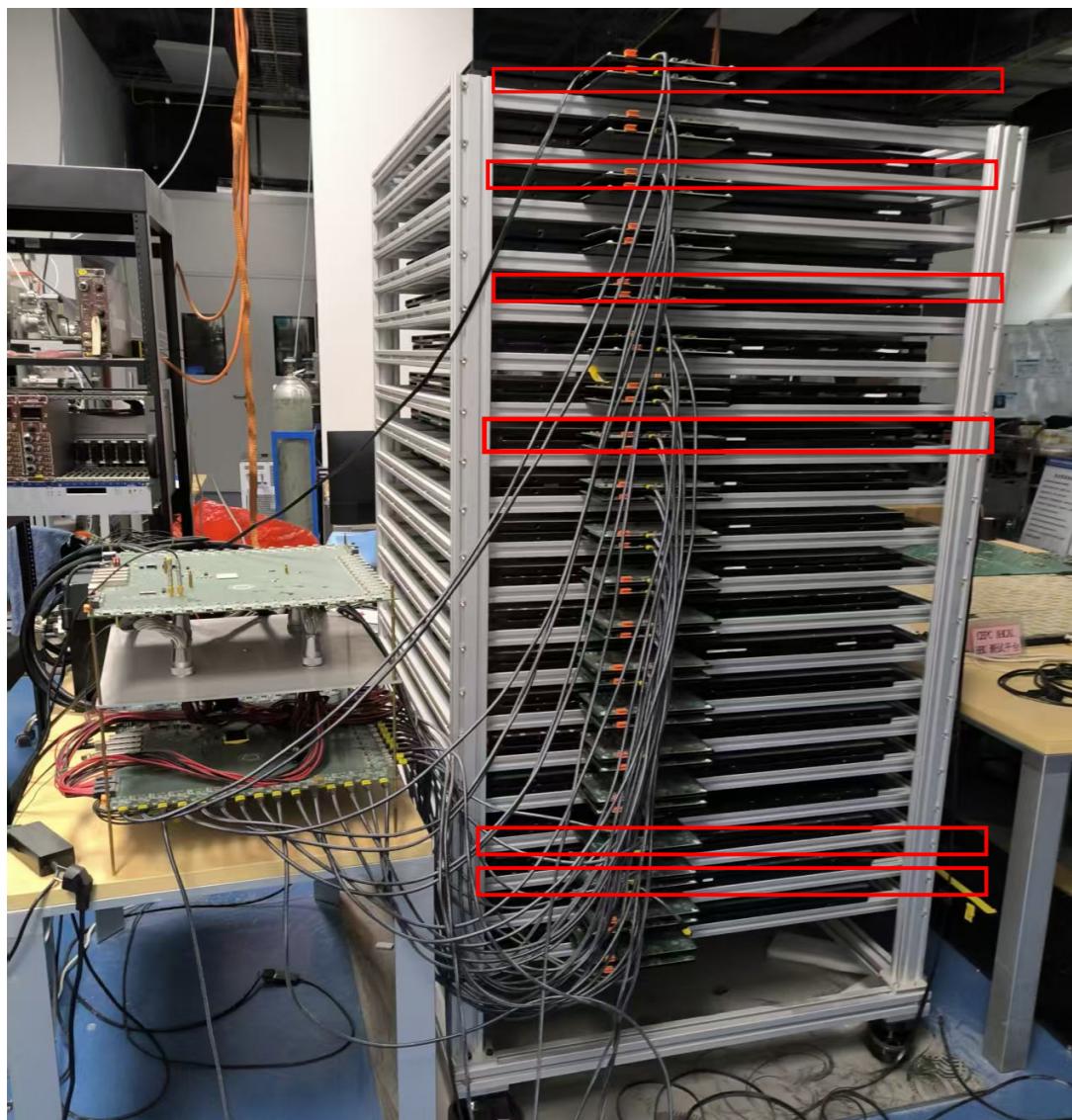
- Either the DIF board or the DAQ board channel corresponding to Layer 0 is malfunctioning.
- Exact faulty part is not yet confirmed, temporary solution is to exclude Layer0.



- Earlier:
 - Trigger rate was low (1–2 Hz).
 - Removing Layer 0 increases the rate to 4–10 Hz.
 - No triggers are observed when Layer 0 is used for triggering.

Trigger Logic

- In the future CERN tunnel setup, two veto layers will be added in front of AHCAL, and four internal layers will be used for triggering.
- For current testing (no veto layers), a simplified setup is used:
 - Veto Logic: $(\neg \text{Layer1} \ \&\& \ \neg \text{Layer4})$
 - Trigger Logic: $((\text{Layer8} \ \&\& \ \text{Layer14}) \ || (\text{Layer32} \ \&\& \ \text{Layer34}))$



Hardware Mapping

- Signals from Layer 1, 4, 8, 14, 32, 34 are connected to TLU Trigger Inputs 1–6, respectively.



$(\neg \text{Layer1} \&\& \neg \text{Layer4}) \&\& ((\text{Layer 8} \&\& \text{Layer14}) \parallel (\text{Layer 32} \&\& \text{Layer 34}))$

 In terms of TLU signals

Trigger = $(\neg \text{Input 1} \&\& \neg \text{Input 2}) \&\& ((\text{Input 3} \&\& \text{Input 4}) \parallel (\text{Input 5} \&\& \text{Input 6}))$

Trigger Command Implementation

- With appropriate trigger masks and TLU commands, this logic is implemented as:

$$\text{Trigger} = (\text{!Fire A \&& !Fire B}) \&& ((\text{Fire C \&& Fire D}) \parallel (\text{Fire E \&& Fire F}))$$

```
-- trigger#      1, timestamp #211592772,  Fire[A,B,C,D,E,F]: 0 0 1 1 1 0
-- trigger#      2, timestamp #211592806,  Fire[A,B,C,D,E,F]: 0 0 1 1 1 0
-- trigger#      3, timestamp #211592837,  Fire[A,B,C,D,E,F]: 0 0 0 0 1 1
-- trigger#      4, timestamp #213626241,  Fire[A,B,C,D,E,F]: 0 0 1 1 0 0
-- trigger#      5, timestamp #213626271,  Fire[A,B,C,D,E,F]: 0 0 1 0 1 1
-- trigger#      6, timestamp #213626296,  Fire[A,B,C,D,E,F]: 0 0 0 0 1 1
-- trigger#      7, timestamp #215659716,  Fire[A,B,C,D,E,F]: 0 0 1 1 1 0
-- trigger#      8, timestamp #217693184,  Fire[A,B,C,D,E,F]: 0 0 1 1 1 0
-- trigger#      9, timestamp #217693212,  Fire[A,B,C,D,E,F]: 0 0 1 1 0 0
-- trigger#     10, timestamp #217693214,  Fire[A,B,C,D,E,F]: 0 0 1 0 1 1
-- trigger#     11, timestamp #217693235,  Fire[A,B,C,D,E,F]: 0 0 0 0 1 1
-- trigger#     12, timestamp #219726660,  Fire[A,B,C,D,E,F]: 0 0 0 0 1 1
-- trigger#     13, timestamp #219726684,  Fire[A,B,C,D,E,F]: 0 0 1 1 1 0
-- trigger#     14, timestamp #221760137,  Fire[A,B,C,D,E,F]: 0 0 0 0 1 1
-- trigger#     15, timestamp #223793625,  Fire[A,B,C,D,E,F]: 0 0 1 0 1 1
-- trigger#     16, timestamp #223793656,  Fire[A,B,C,D,E,F]: 0 0 1 0 1 1
-- trigger#     17, timestamp #223793687,  Fire[A,B,C,D,E,F]: 0 0 0 0 1 1
-- trigger#     18, timestamp #225827109,  Fire[A,B,C,D,E,F]: 0 0 0 0 1 1
-- trigger#     19, timestamp #225827144,  Fire[A,B,C,D,E,F]: 0 0 1 1 1 0
-- trigger#     20, timestamp #227860582,  Fire[A,B,C,D,E,F]: 0 0 0 0 1 1
-- trigger#     21, timestamp #227860606,  Fire[A,B,C,D,E,F]: 0 0 1 1 1 0
-- trigger#     22, timestamp #229894051,  Fire[A,B,C,D,E,F]: 0 0 1 1 1 0
-- trigger#     23, timestamp #229894053,  Fire[A,B,C,D,E,F]: 0 0 0 0 1 1
-- trigger#     24, timestamp #229894076,  Fire[A,B,C,D,E,F]: 0 0 0 0 1 1
-- trigger#     25, timestamp #231927528,  Fire[A,B,C,D,E,F]: 0 0 0 0 1 1
-- trigger#     26, timestamp #231927557,  Fire[A,B,C,D,E,F]: 0 0 1 1 1 0
-- trigger#     27, timestamp #233961015,  Fire[A,B,C,D,E,F]: 0 0 0 0 1 1
-- trigger#     28, timestamp #233961046,  Fire[A,B,C,D,E,F]: 0 0 1 0 1 1
-- trigger#     29, timestamp #235994484,  Fire[A,B,C,D,E,F]: 0 0 0 1 1 1
-- trigger#     30, timestamp #238027976,  Fire[A,B,C,D,E,F]: 0 0 0 0 1 1
-- trigger#     31, timestamp #238028002,  Fire[A,B,C,D,E,F]: 0 0 0 0 1 1
-- trigger#     32, timestamp #240061447,  Fire[A,B,C,D,E,F]: 0 0 1 0 1 1
```

- Trigger Inputs 1–6 correspond to Fire A–F.
- So far, all test outputs meet expectations.
- Plan to collect data using this logic to evaluate impact on event quality.

Issues

Event Footer, Layer Footer, and Hit Loss Issue

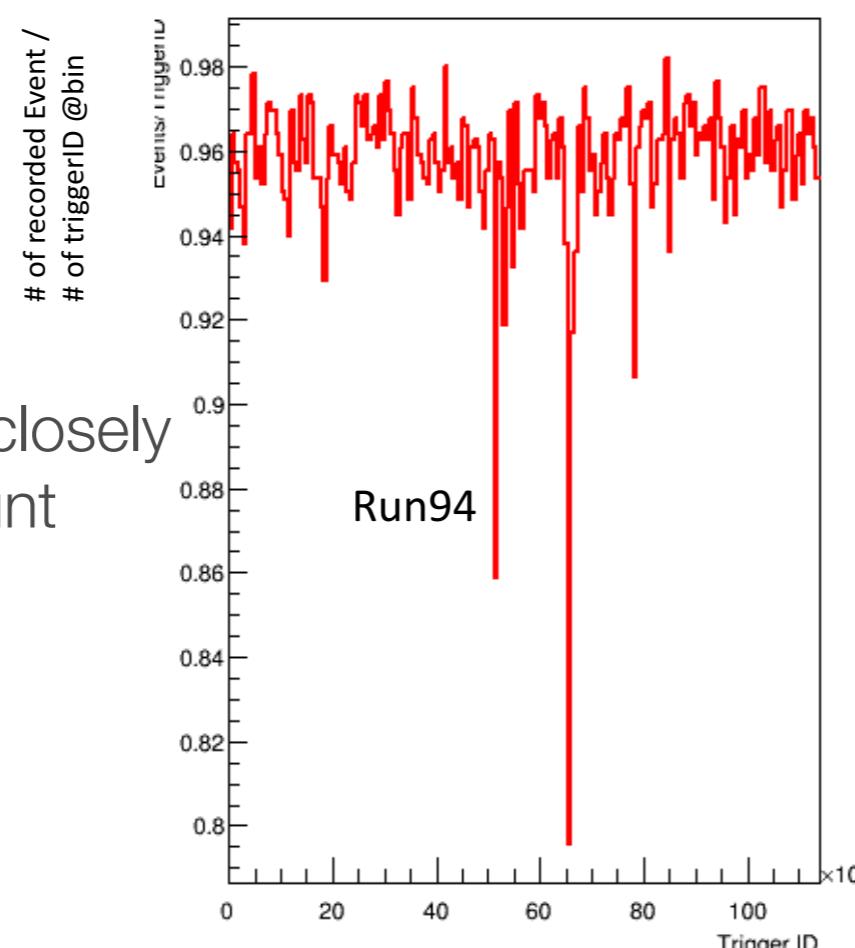
- The event footer and layer footer in the binary data are sometimes missing.
- Initially, by swapping Layer 38 and 39, and Cable 38 and 39, we observed that both event and layer footers are present as long as the combination is not the original.
- However, in a long run (Run 83), the event footer disappeared after 9000 seconds.
- In a short run (Run 84) afterwards, the event footer was still missing.
- Regarding DAQ39 hits: as long as DAQ39 is connected to Layer 39 instead of Layer 38, hits for DAQ39 are recorded.
- Comparison between Run 57 and Run 62 shows that simply swapping Cable38 and Cable39 can resolve the issue, which is quite strange.

Run number	DAQ period	Skip DAQ Channels	Trigger Logic	Note	Event Footer	DAQ 39 Footer	DAQ 39 Hit
57	5 min	not skip DAQ38	14 & 34	DAQ38-Cable38-Layer38, DAQ39-Cable39-Layer39	No	No	No
58	5 min	skip DAQ 38	14 & 34	DAQ38-Cable38-Layer38, DAQ39-Cable39-Layer39	Yes	Yes	Yes
59	5 min	not skip DAQ 38	14 & 34	DAQ38-Cable39-Layer39, DAQ39-Cable38-Layer38	Yes	Yes	No
60	5 min	skip DAQ 38	14 & 34	DAQ38-Cable39-Layer39, DAQ39-Cable38-Layer38	Yes	Yes	No
62	5 min	not skip DAQ 38	14 & 34	DAQ38-Cable39-Layer38, DAQ39-Cable38-Layer39	Yes	Yes	Yes
63	5 min	skip DAQ 38	14 & 34	DAQ38-Cable39-Layer38, DAQ39-Cable38-Layer39	Yes	Yes	Yes
64	5 min	not skip DAQ 38	14 & 34	DAQ38-Cable38-Layer39, DAQ39-Cable39-Layer38	Yes	Yes	No
65	5 min	skip DAQ 38	14 & 34	DAQ38-Cable38-Layer39, DAQ39-Cable39-Layer38	Yes	Yes	No
83	4h22min	skip DAQ 0 and 38	01 & 04	DAQ38-Cable38-Layer38, DAQ39-Cable39-Layer39	lost from 9000s	/	/
84	1h20min	Skip DAQ 0 and 38	01 & 04	DAQ38-Cable38-Layer38, DAQ39-Cable39-Layer39	No	/	/

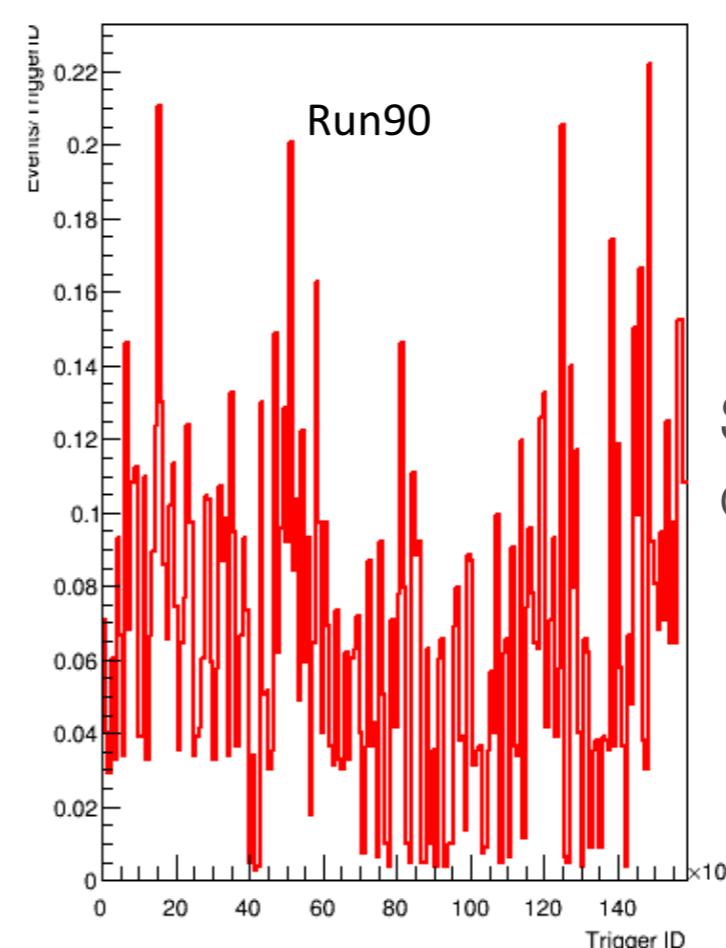
Trigger ID Loss Issue

- Trigger ID loss occurs either at the DAQ board or during transmission between the TLU and the DAQ.
 - The number of recorded events is smaller than the number of triggers issued by the TLU.
 - Good case: ~96% of triggers are recorded.
 - Bad case: Less than 10% of triggers are recorded.

Run number	DAQ period	Skip DAQ Channels	Trigger Logic	Trigger Recording Status
94	5 min	skip 00 & 06 & 38 & 39	01 & 04	GOOD
90	1h59min	skip 00 & 38 & 39	01 & 04	Trigger ID loss



Recorded events closely
match trigger count

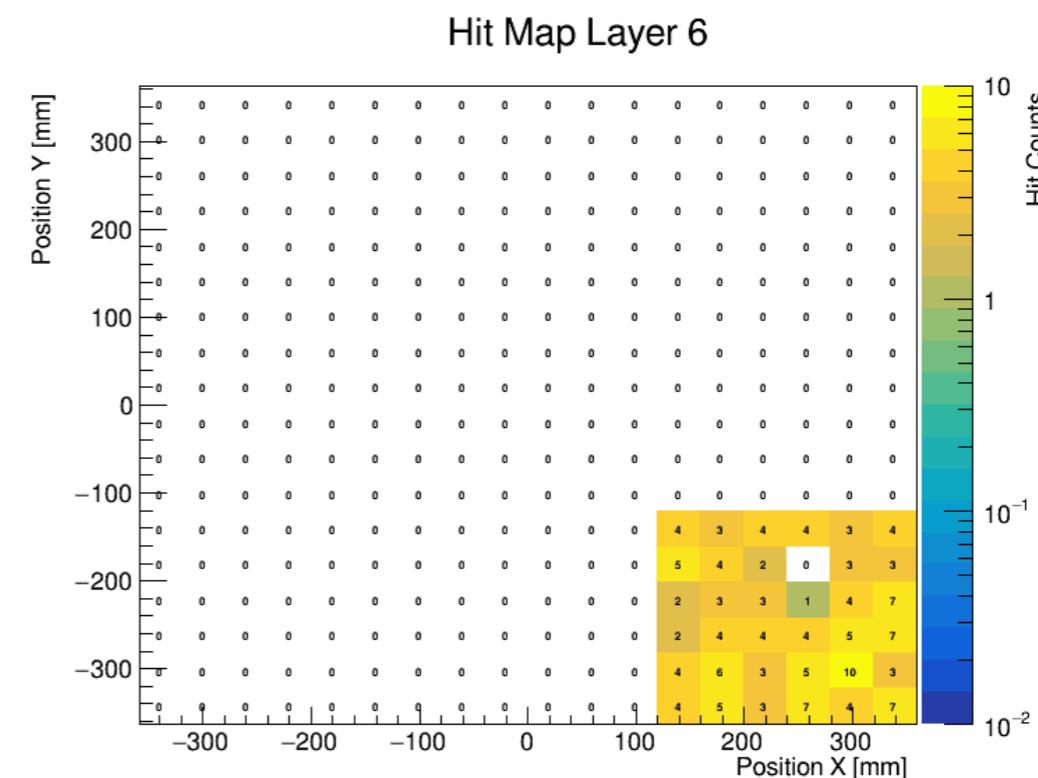
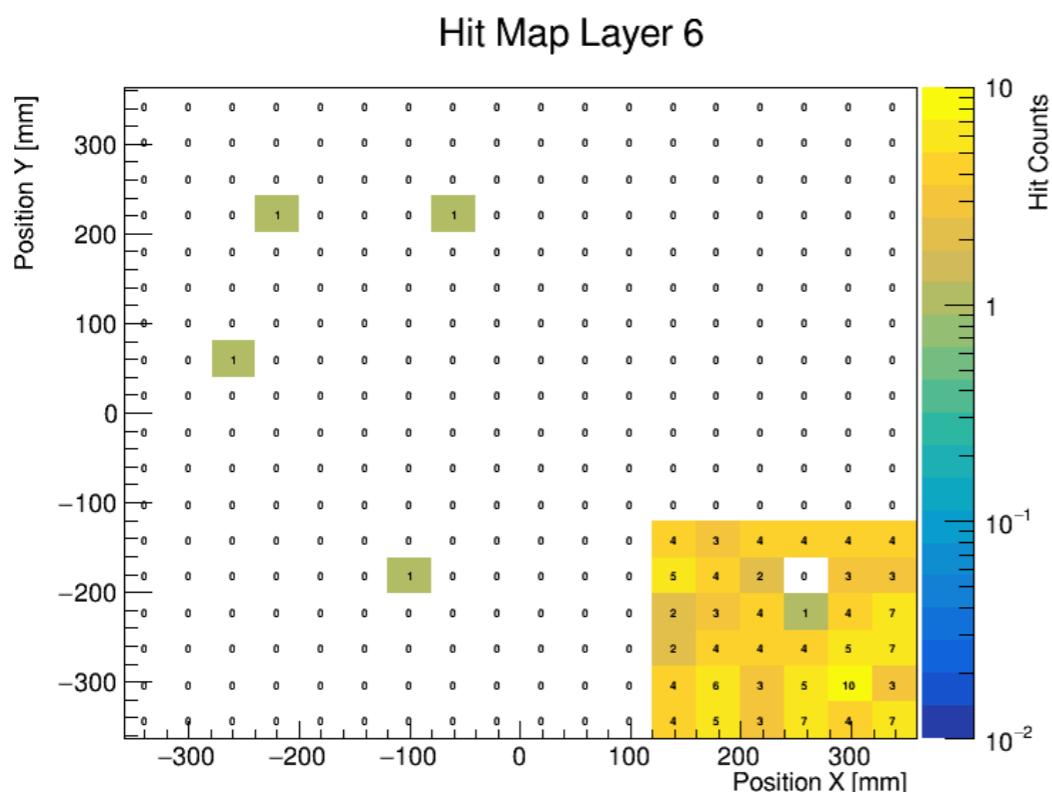


Severe trigger ID loss
observed

Hit Loss Issue in Some Runs

- In Run 86, no hits are recorded after 1 second except for Layer 6, Chip 6.
- In other layers, some hits are recorded within 1s, but no hits are observed after the first second.

Run number	DAQ period	Skip DAQ Channels	Trigger Logic	Status
86	3h23min	skip 00 & 38 & 39	01 & 04	No hit after 1s



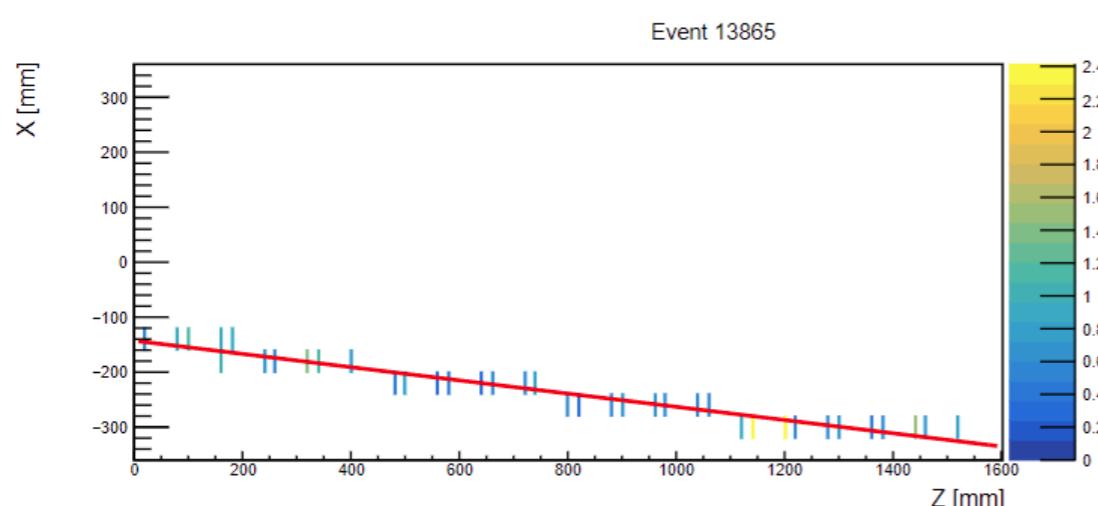
Hit Map of Layer 6
(Including hits from the first second)

Hit Map of Layer 6
(Excluding hits from the first second)

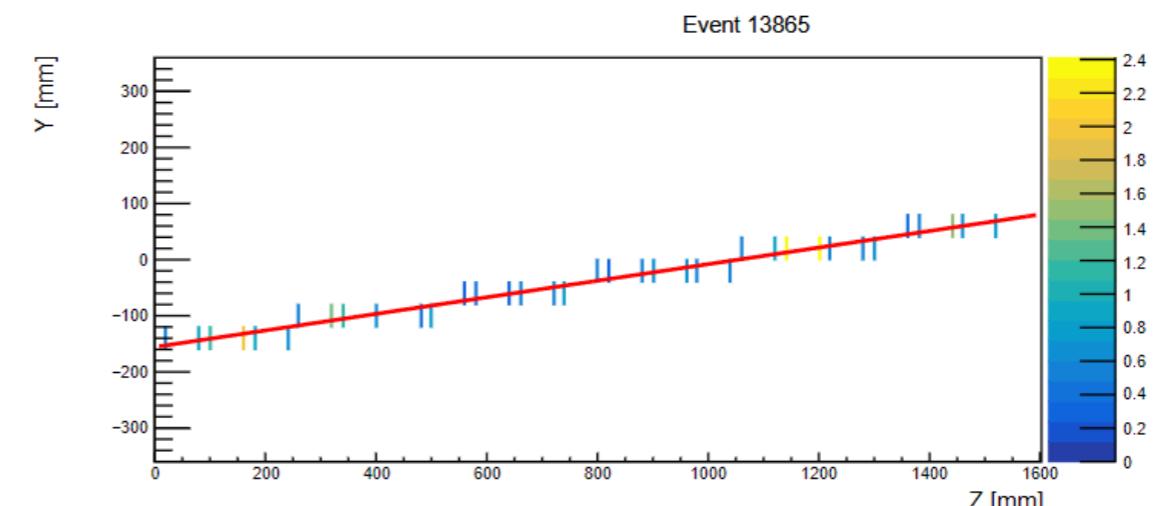
Muon Track Observed in a Good Run (Run18)

- Muon candidate selection: the event has an energy deposit greater than 0.5 MIP in both trigger layers.

Run number	Skip DAQ Channels	Trigger Logic	Data Status
18	No skip	08 & 32	Good



X-Z Projection View



Y-Z Projection View

Component Status

Most components are now ready:

- The installation for all 40 absorber layers has been completed.
- Mr. Tang has located the drawings to re-manufacture the grounding copper plates.
- DAQ structure is being redesigned by Mr. Tang.
- Aluminum brackets for DAQ mounting will also be produced by Mr. Tang.

Next steps

- Fix the event footer and layer footer issues, Trigger ID loss and No hit after 1 second.
- Collect data using the new trigger logic and monitor for any changes in event quality.
- Adjust thresholds and bias voltages as necessary.
- Perform LED calibration.
- Test the new cable recently sent by Brian to USTC.
- Once data quality is confirmed, prepare to ship the sensitive layers to the factory.
- In parallel, measure the dimensions of all components, finalize the design of the flight case, and place the order.

Thank You

Back Up

Updated Timeline

Zhen proposed to move sensitive layers to factory from July 21st to 25th , which is quite urgent.

Event Footer Missing Issue

- The event footer in the binary data is sometimes missing:
 - Initially, by swapping Layer 38 and 39, as well as Cable 38 and 39, we found that as long as the setup is not the original combination of DAQ38–Cable38–Layer38 and DAQ39–Cable39–Layer39, the event footer is present.
 - However, during a long run (Run 83), the event footer suddenly disappeared after 9000 seconds.
 - In a subsequent short run (Run 84), the event footer remained missing.

Run number	DAQ period	Skip DAQ Channels	Trigger Logic	Note	Event Footer
57	5 min	not skip DAQ38	14 & 34	DAQ38-Cable38-Layer38, DAQ39-Cable39-Layer39	No
58	5 min	skip DAQ 38	14 & 34	DAQ38-Cable38-Layer38, DAQ39-Cable39-Layer39	Yes
59	5 min	not skip DAQ 38	14 & 34	DAQ38-Cable39-Layer39, DAQ39-Cable38-Layer38	Yes
60	5 min	skip DAQ 38	14 & 34	DAQ38-Cable39-Layer39, DAQ39-Cable38-Layer38	Yes
62	5 min	not skip DAQ 38	14 & 34	DAQ39-Cable38-Layer39, DAQ38-Cable39-Layer38	Yes
63	5 min	skip DAQ 38	14 & 34	DAQ39-Cable38-Layer39, DAQ38-Cable39-Layer38	Yes
64	5 min	not skip DAQ 38	14 & 34	DAQ38-Cable38-Layer39, DAQ39-Cable39-Layer38	Yes
65	5 min	skip DAQ 38	14 & 34	DAQ38-Cable38-Layer39, DAQ39-Cable39-Layer38	Yes
83	4h22min	skip DAQ 0 and 38	01 & 04	DAQ38-Cable38-Layer38, DAQ39-Cable39-Layer39	lost from 9000s
84	1h20min	Skip DAQ 0 and 38	01 & 04	DAQ38-Cable38-Layer38, DAQ39-Cable39-Layer39	No

Temporary Storage of Sensitive Layers at CERN

- After disassembly, the sensitive layers cannot be stacked directly and require careful placement during storage and transfer.
- Does CERN currently have equipment or facilities that can accommodate all 40 sensitive layers safely during this intermediate stage?
- If not, Mr. Tang has proposed two possible solutions:
 - Option 1: Wooden Storage Boxes
 - Construct 4–5 custom wooden crates, each capable of holding 10 sensitive layers.
 - Large volume increases air freight cost significantly.
 - Option 2: Horizontal Storage Racks
 - Build 2 custom metal racks, modeled after the current lab storage system.
 - Design: Rotate the lab rack horizontally, split it in half, and add a base for stability.
 - Each rack can hold 20 sensitive layers.
 - Advantage: More compact and cost-effective for shipping.
 - Disadvantage: Requires on-site assembly and slightly more handling.
- Which storage method is more suitable for CERN's conditions and transportation logistics?

Transportation Plan (USTC → CERN)

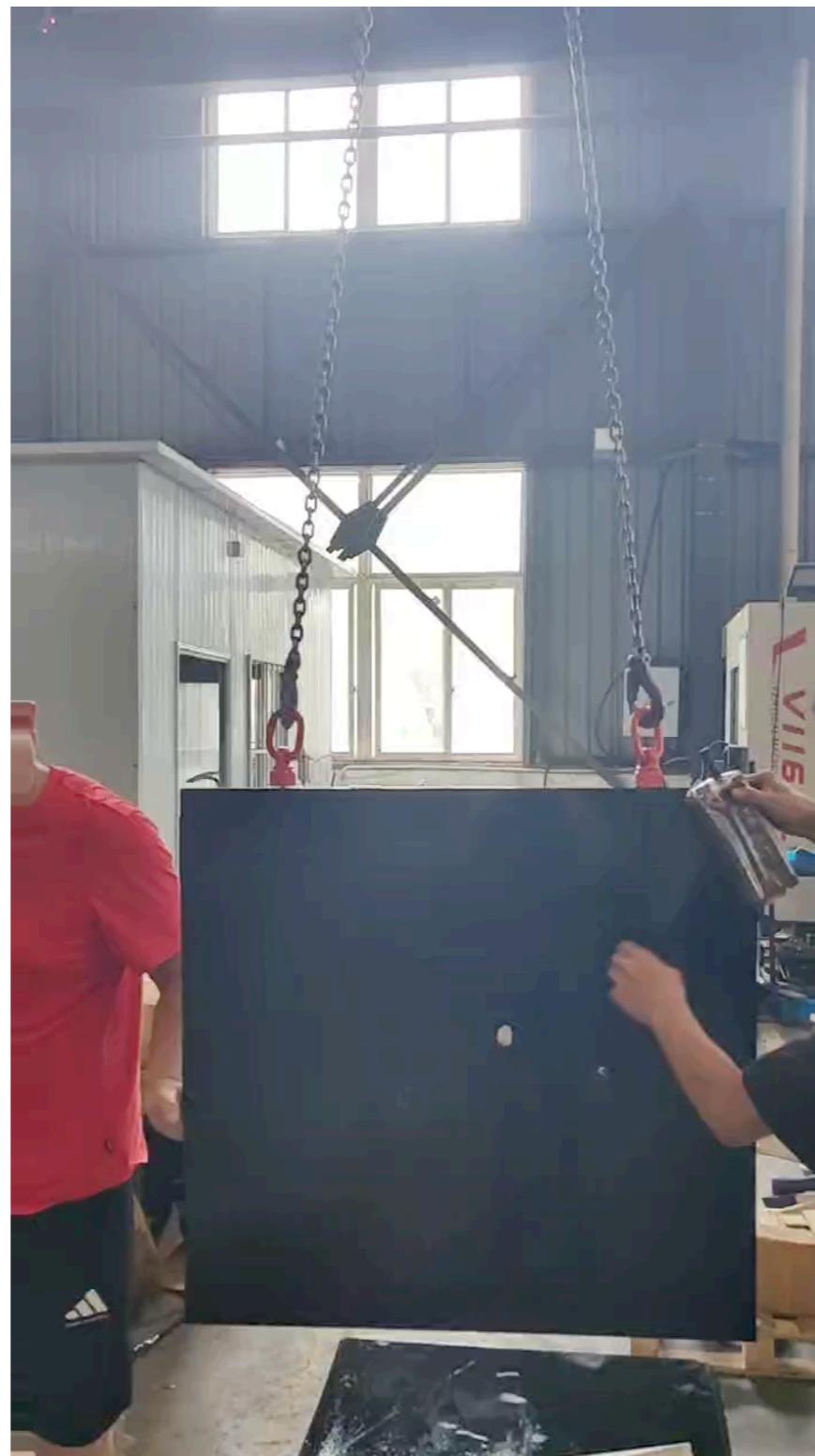
- Most components are now ready.
- Packing plan:
 - Wooden crate: AHCAL detector, lifting rings, copper plates
 - Flight case: Power supplies, DAQ, TLU, mounting brackets, support brackets, cables, screws, etc.
- Still to purchase: Allen wrenches and an electric wrench.



- After gathering all items, dimensions will be measured and sent to the flight-case company.

Current Status of Absorber Layers

- The installation for all 40 absorber layers has been completed.



No Clear Pattern

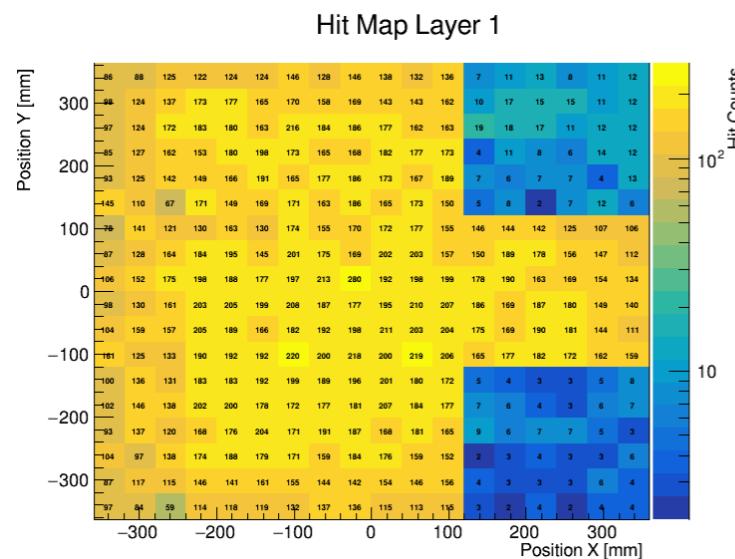
Run number	DAQ period	Skip DAQ Channels	trigger logic	trigger rate (begin)	trigger rate (end)	Note	Data status
83	4:22:00	skip 00 & 38	01 & 04	10Hz			DAQ39's layer footer and event footers lost later from 9000s.
84	1:20:00	skip 00 & 38	01 & 04		4.25Hz		DAQ39's layer footer and event footers lost
85	14:17:00	skip 00 & 38	01 & 04	20Hz	40Hz		Trigger Loss at DAQ
86	3:23:00	39	01 & 04	25Hz	2.77Hz		No hits after 1s (Layer6 chip6 only has some hits at >1s) / And layer footer of DAQ 37 is not send later from 214s
87	6:57:00	skip 00 & 38 & 39	01 & 04	21Hz			Trigger Loss at DAQ
88	10:31:00	skip 00 & 38 & 39	01 & 04	10Hz	16Hz	Shut down and reboot, disconnected Cable39, at ~9:30 am, the light is turned on.	Good (except for 9:10)
89	1:57:00	no skip 04 & 14	04 & 14	10Hz	12Hz	Disconnected Cable39, charger for TLU PC disconnected at 12:09 to 12:16	No hits after 1s
90	1:59:00	skip 00 & 38 & 39	01 & 04	22Hz	22Hz	Disconnected Cable39.	Trigger Loss at DAQ
91	0:34:00	skip 00 & 38 & 39	01 & 04	21Hz	21Hz	Reboot everything, disconnected Cable39	No hits after 1s
92	1:09:00	skip 00 & 38 & 39	01 & 04	7Hz	13Hz	Reboot DAQ, disconnected Cable39	GOOD
93	0:35:00	skip 00 & 06 & 38 & 39	01 & 04	21Hz	22Hz	Reboot everything, disconnected Cable39	No hits after 1s
94	1:55:00	skip 00 & 06 & 38 & 39	01 & 04	8Hz	16.5Hz	Reboot everything, disconnected Cable39	GOOD
95		skip 00 & 01 & 38 & 39	04 & 14	11Hz		Reboot everything, disconnected Cable39	Trigger Loss at DAQ

No Clear Pattern

Run number	DAQ period	Skip DAQ Channels	trigger logic	trigger	trigger	Data status
				rate (begin)	rate (end)	
101		skip 00 & 38 & 39	01 & 04			No hits after 1s
102	5 minutes	skip 00 & 38	01 & 04			Trigger Loss at DAQ
103	5 minutes	skip 00 & 38	01 & 04			No hits after 1s
104	~1 hours	all layers skip except for 14 & 34	14 & 34			No hits after 1(2)s

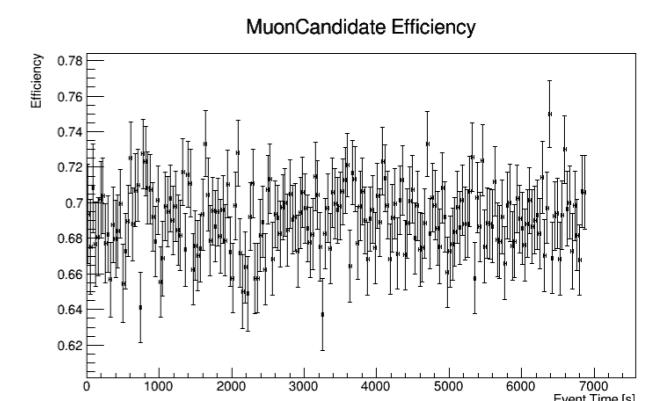
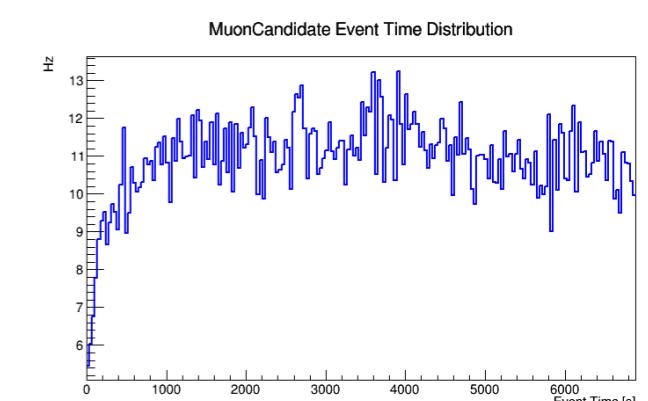
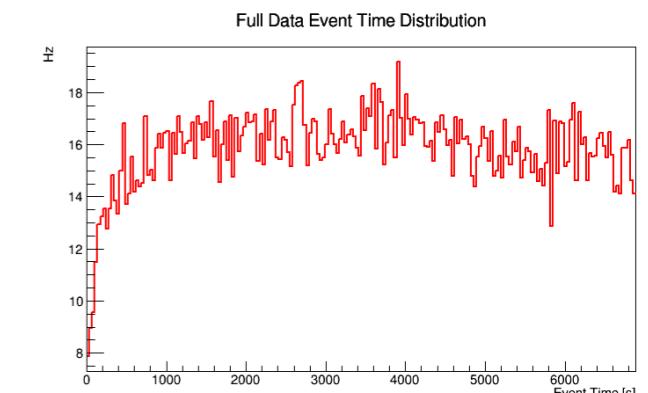
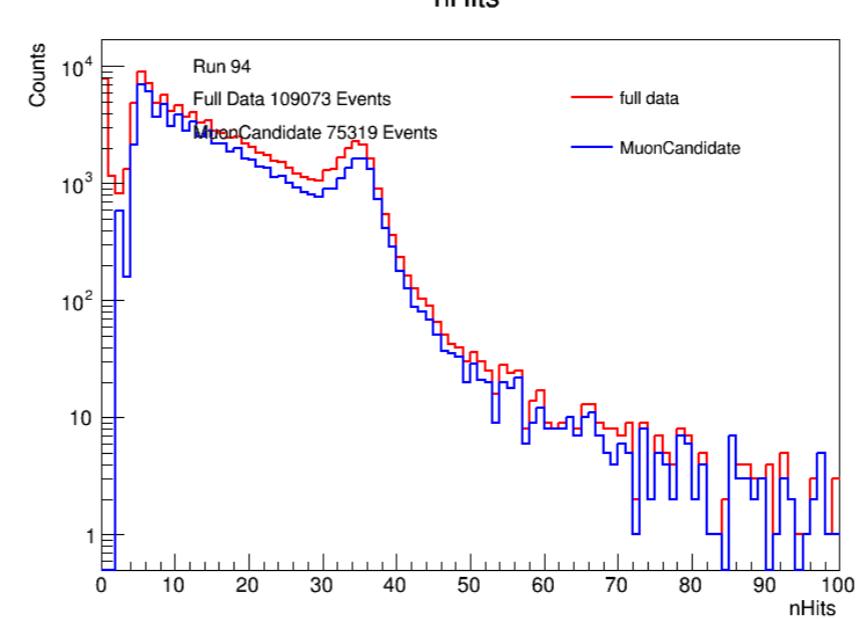
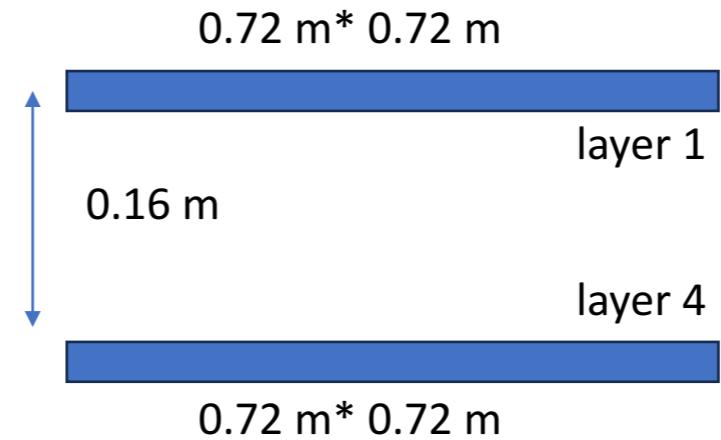
Muon candidate rate with the different trigger layer

- Layer 1 & Layer 4
→ $\frac{dN_\mu}{ds} \sim 25.5 \text{ Hz}$ by MC calculation
- Muon candidate rate $\sim 11 \text{ Hz}$
→ a little bit small?
- Due to the fail of
 - triggering at chip0 and chip6 of layer1
 - Selection of MuonCandidates



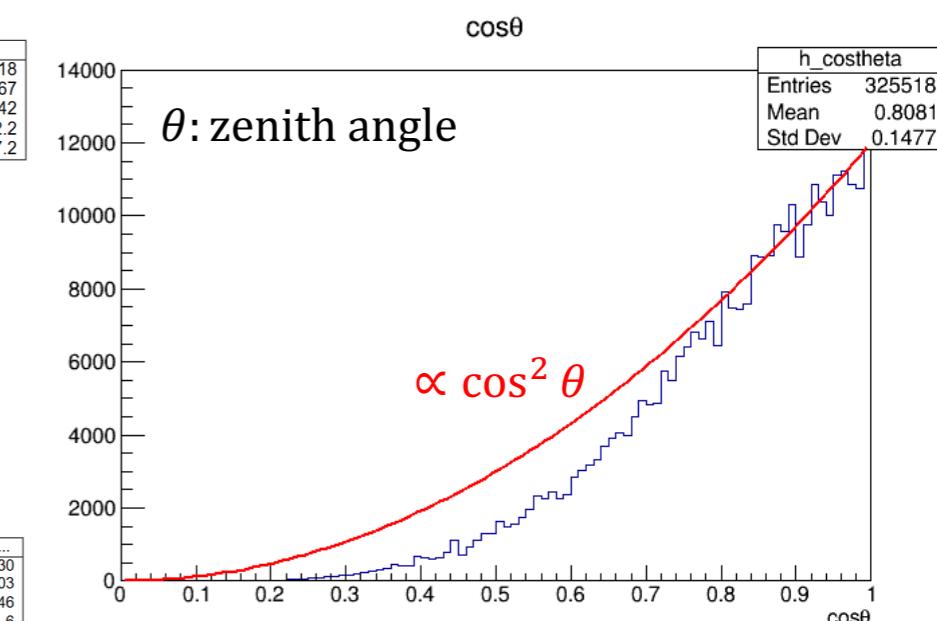
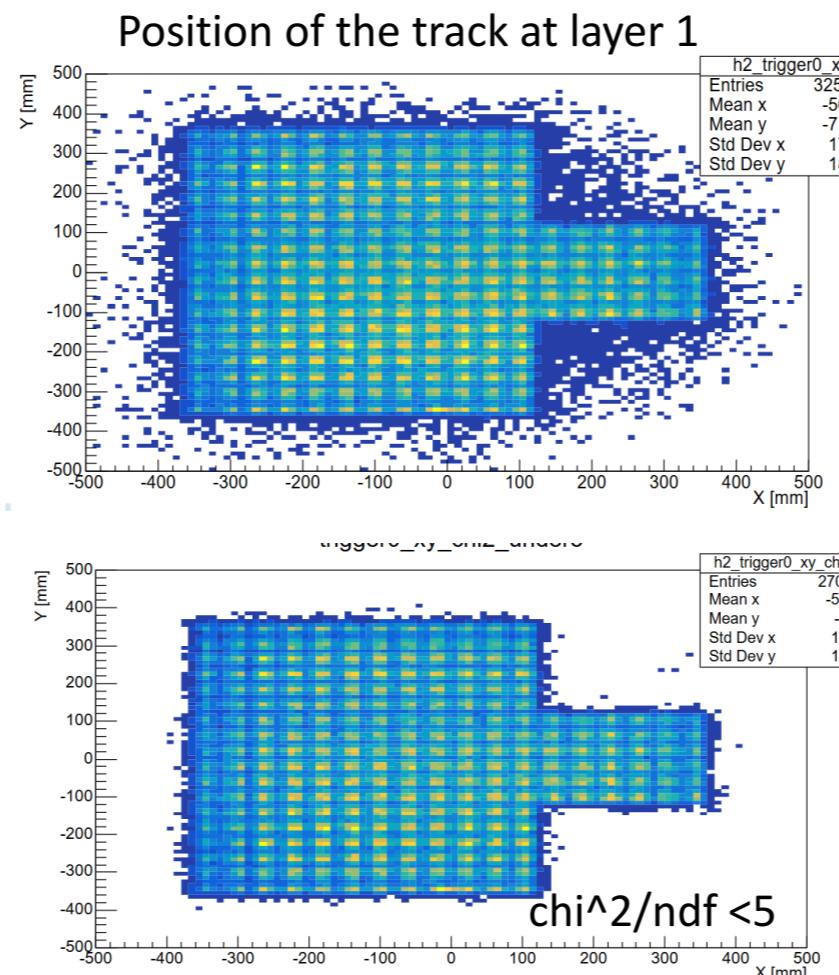
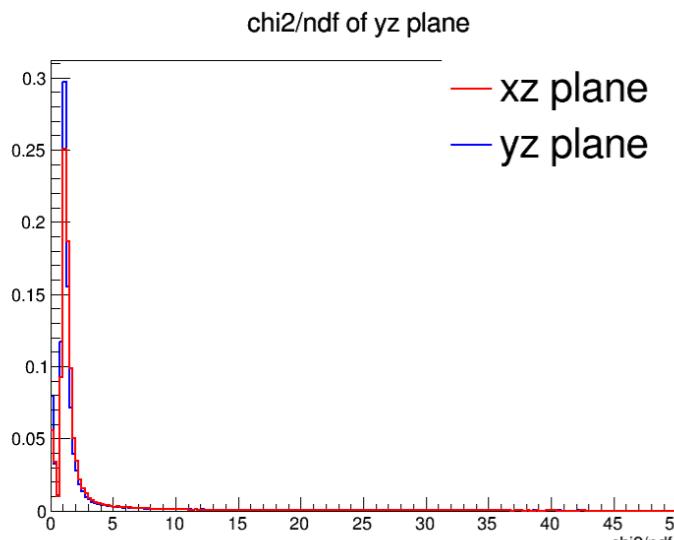
8 July 2025

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Cosmic muon profile



- chi²/ndf < 5 has a good track.

- Considering the acceptance of the detector at low $\cos\theta$, it seems reasonable

- Layer 1 chip 0 and chip 6 don't act as trigger channels.
- However, the good track is inside the sensitive region
- The center of the channel has a higher density
→ Due to the tracking algorithms, or unable to catch the edge of the scintillator cell?