Upgrade of SAMURAI DAQ

1. TDC upgrade: higher trigger rate
2. QDC upgrade: support for slow trigger
3. Offline circuit tuning system

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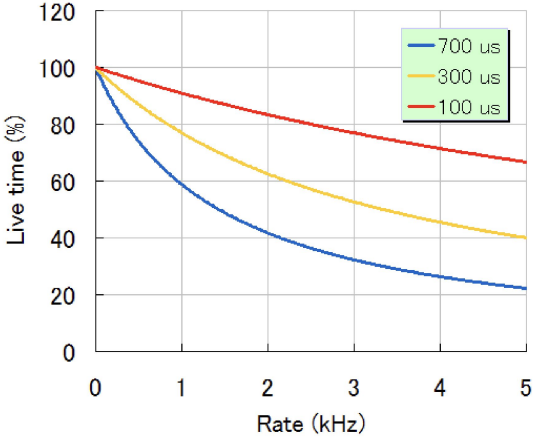
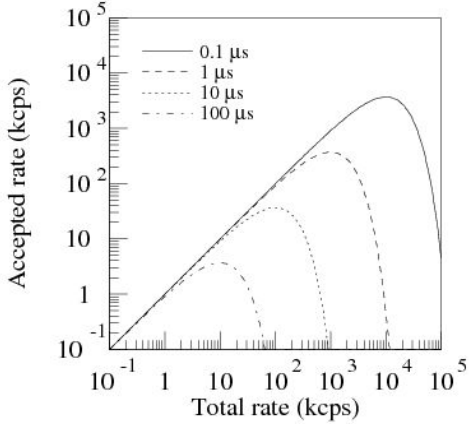
Higher trigger rate: 10 kHz trigger





J. Gao et al., NIM A **1035**, 166823 (2022).

Table 2
DAQ subsystems in the SAMURAI30 experiment.

Subsystem	Modules		Deadtime
Beam scintillators	1 1	Mesytek MQDC-32 Mesytek MTDC-32	~ 80 μs
Beam drift chamber (BDC)	4	AMSC AMT-TDC	~ 200 μs
Forward drift chamber 0 (FDC0)	4	AMSC AMT-TDC	~ 170 μs
HodoF24	2 2	Mesytek MQDC-32 Mesytek MTDC-32	~ 60 μs
HodoP	1 1	CAEN V792 QDC CAEN V775 TDC	~ 50 μs
NEBULA-Q	10	CAEN V792 QDC	~ 200 μs
NEBULA-T	10	CAEN V775 TDC	~ 120 μs
PANDORA	3	CAEN V1290 TDC	~ 50 μs
Proton drift chamber (PDC)	14	AMSC AMT-TDC	~ 175 μs

Live time = N'/N = 1/(1+N*t)

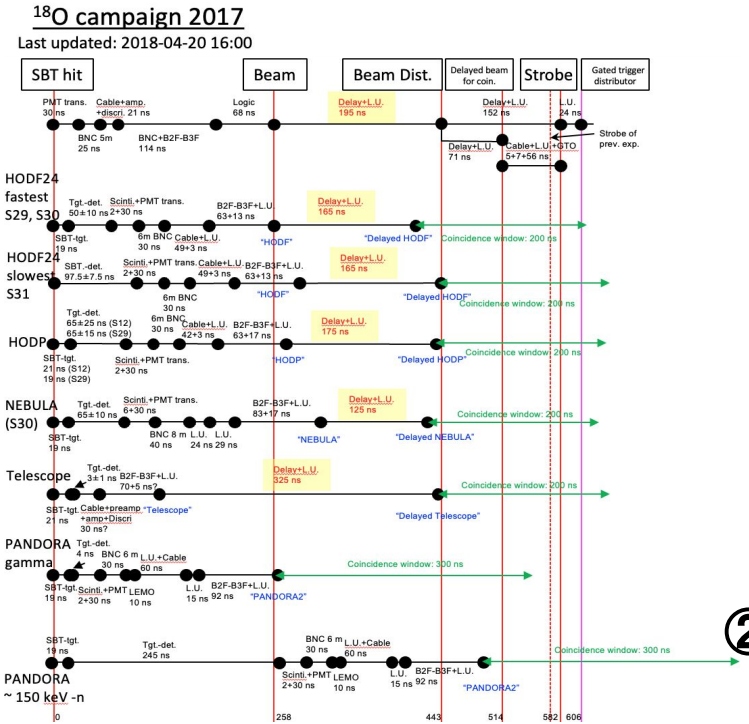
- N' = total trigger rate
- N = accepted trigger rate
- t = transaction time (dead time)

AMSC AMT-TDC ~200 μs
→ Fit (TDC) + MPV ~15 μs

VME readout ~ 60 μs
→ MPV readout ~15 μs

- t ~ 300 μs (FDC2)
  → 77% for **1-kHz** trigger
- t ~ 80 μs (VME bus)
  → 71% for **5-kHz** trigger
- t ~ 15 μs
  → 87% for **10-kHz** trigger

☹ Long cable delay for QDC



① Deterioration of the wave form

F3 pla. (<100 ns delay)

F13 pla. (~μs delay)

2024 Spring campaign

② Limitation of waiting for slow trigger (<~500 ns)

☹ Modern FPGA-based system takes ~μs

Workarounds

(1) Mira QDC → Baba-san's talk

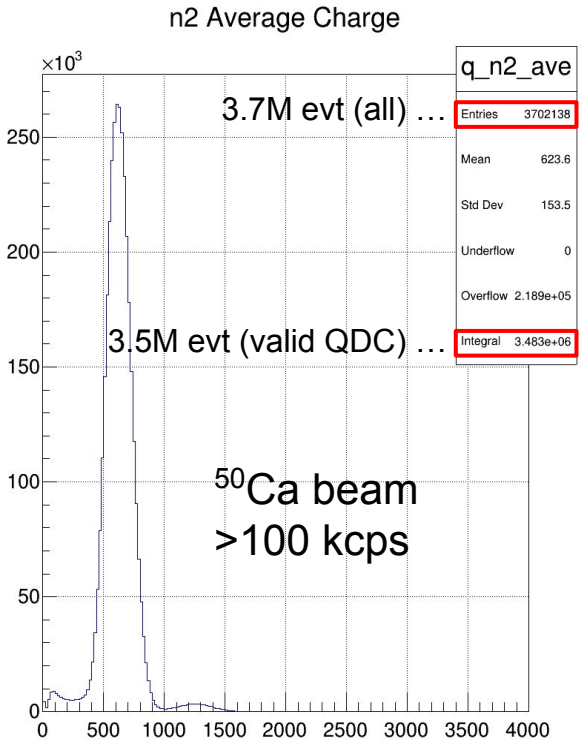
- ☺ Software adjustable delay → free from long cable delay
- ☹ #ch = 12
  - OK beamline plastics (<12ch: F3, F5, F7, F13A, F13B, SBV)
  - NG HODF24 (48ch) and HODP (32ch)

(2) "Delayed gating" operation of MQDC-32

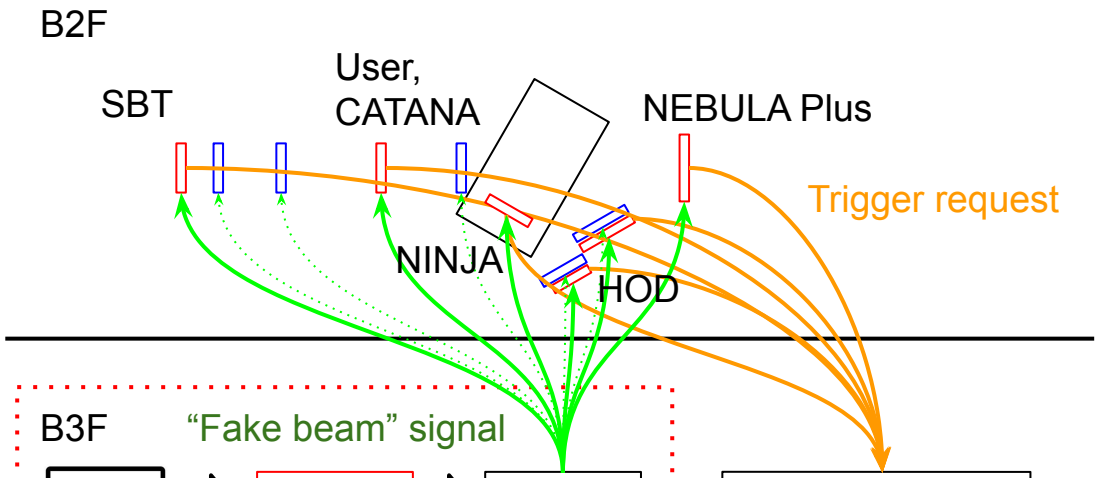
- ☺ Local (self) trigger → minimum (<100 ns) cable delay
- ☺ No new circuits needed
- ☺ >90% live time for 400-kHz rate (according to the manual)
  - → Confirmed: 94% live time for >100-kHz beam
- ☹ Timing adjustment of "experiment trigger" and QDC gate
  - → Needs for offline trigger tuning system

➔ Free from long cable delay

➔ Slow trigger signal (>μs) can be accepted



Offline circuit tuning system



B3F "Fake beam" signal

GTR → AWG → Trigger circuit

- Beam velocity
- Energy loss
- Response of "User" detector
- (Full simulation)

Procurement

- ✓ GTR (x2)
- ✓ Arbitrary waveform generator
  - ✓ Siglent SDG6022X (x4)
  - ✓ Digital detector emulator CAEN NDT6800 (x1)
- Octal 2-in 4-out linear FIFO
  - Real signal & fake signal

Implementation … Autumn 2024

Plan of machine study (Autumn 2024)

- Will be proposed to the coming MT committee meeting
- No preference on primary beam.
- Cocktail secondary beam (w/ different *Z*) is preferred.
- Intensity: 100 cps (tuning) ~ 1 Mcps (dead time measurement)
- Beam time request: 0.5 days
  - Assumption: SAMURAI is ready
  - 3 h: Evaluation of the offline trigger tuning system
  - 3 h: Mira QDC evaluation (SBT)
  - 3 h: Fit TDC evaluation (BDC, FDC)
  - 3 h: MQDC-32 “delayed gating” evaluation (HOD)

Summary

1. TDC upgrade: “Fit” for drift chambers
    - 87% live time for 10 kHz trigger
2. QDC upgrade: “Mira” or “delayed gating” of MQDC-32
    - Free from cable delays, deterioration of the signals
    - Slow trigger can be accepted (>μs)
3. Offline trigger tuning system
    - Saving precious and expensive beam time

- Machine study (0.5 days) will be proposed