P̄ANDA Collaboration Meeting 24/2
P̄ANDA FEE/DAQ Workshop

Nest DAQ

featuring conti. RO w/ FairMQ

and related topics

Content:

NestDAQ Over View

Development status from the test BM

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26.06.2024

SPADI Alliance

Signal processing and data acquisition infrastructure alliance

- Since ~2022.
- Developing a next generation DAQ/FEE system for nuclear/hadron physics experiments.
- Standardisation, in Japan and beyond.
- Participation from majority of nuclear/hadron physics institutes in Japan.
  - RCNP, KEK
- c.f. Collider Electronics Forum. OpenIT

- very active, relatively a small number of developers

https://www.rcnp.osaka-u.ac.jp/~spadi/

SPADI Alliance

Signal processing and data acquisition infrastructure alliance

WG1
Frontend Electronics

Streaming type
Charge ASD board
Voltage ASD board
WF Digitizer board
Control Firmware dev.

WG2
Clock synch. / Data Transfer

General Clock Synch.
High throughput
Intra-board transfer

WG3
Acquisition software framework (NestDAQ + …)

Streaming type
FairMQ-based Scalable DAQ
Sampling, Time frame build, Event build, Monitoring…
Format

WG4
Event processing

Acceleration using GPU/FPGA
Zero suppression
Calibration, Clustering, Tracking, PID,

WG5
User Interface

Control, Monitor, Configure,

Trial with
SlowDash

WG6
Computing infrastr.

High throughput
Large volume
Flow and Archive
Power consumption
Interconnect
Networking
…

WG7
Packaging

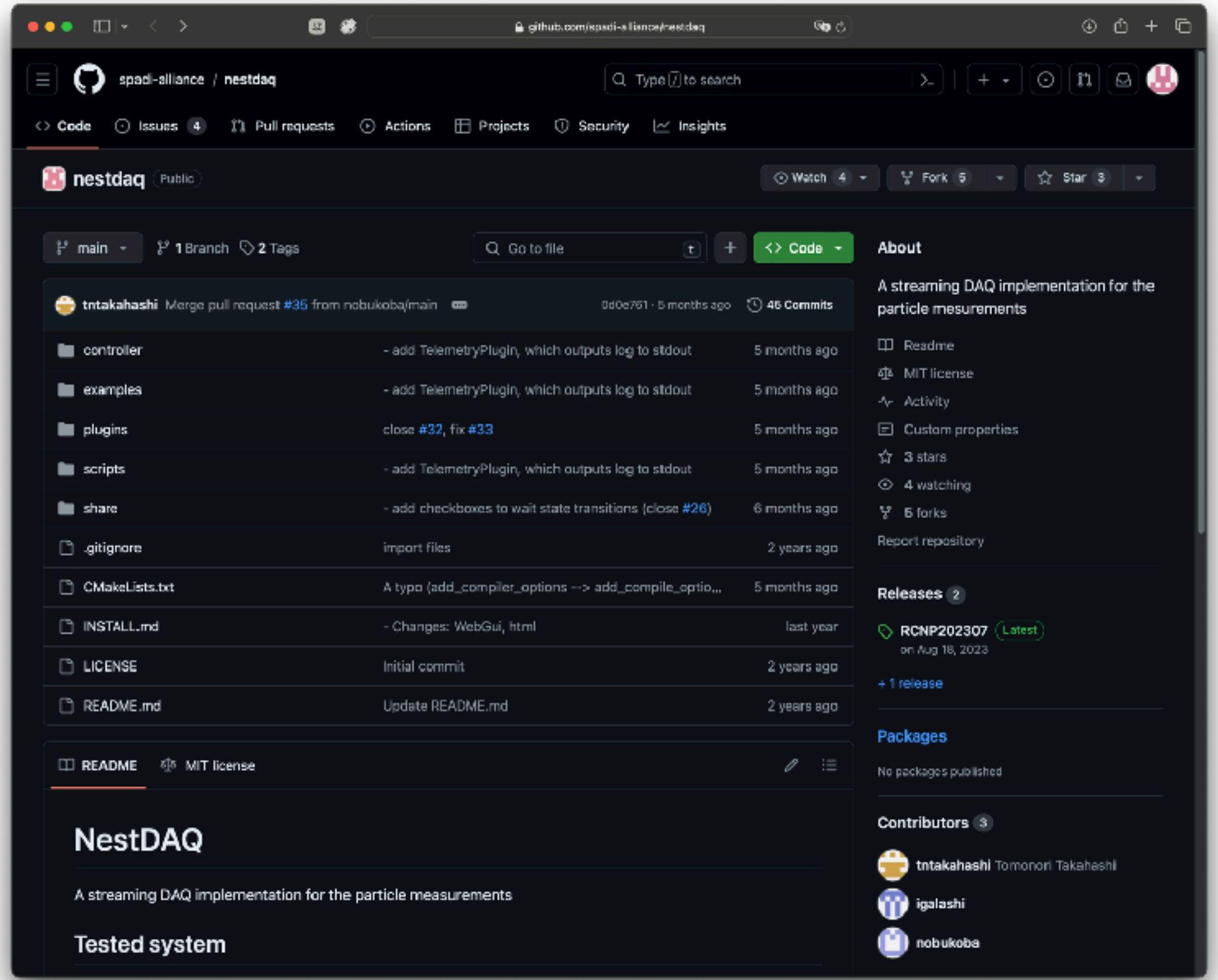
Standalone system
Popularization
Standardization
Market research
User feedback

Analysis

Trial with
Artemis

No ASIC Development (so far)

NestDAQ on GitHub



NestDAQ Dependencies

NestDAQ

A streaming DAQ implementation for the particle measurements

Tested system

System	Version	Compiler	CMake
CentOS	7	GCC 8.3.1 (devtoolset-8)	3.14.6 or later (epel: cmake3)

External packages used with NestDAQ

Packages	Version	URL
Redis	6.0.10	https://github.com/redis/redis/
Redis TimeSeries	1.4.18	https://github.com/RedisTimeSeries/RedisTimeSeries/
Grafana		

Dependencies to build NestDAQ

Packages	Version	URL
boost	1.72.0 or later	
FairLogger	1.9.0 or later	
FairMQ	1.4.26 or later	
hiredis	1.0.0	https://github.com/redis/hiredis/
redis-plus-plus	1.2.1 (recipes branch)	https://github.com/sewenew/redis-plus-plus

Streaming DAQ based on FairMQ

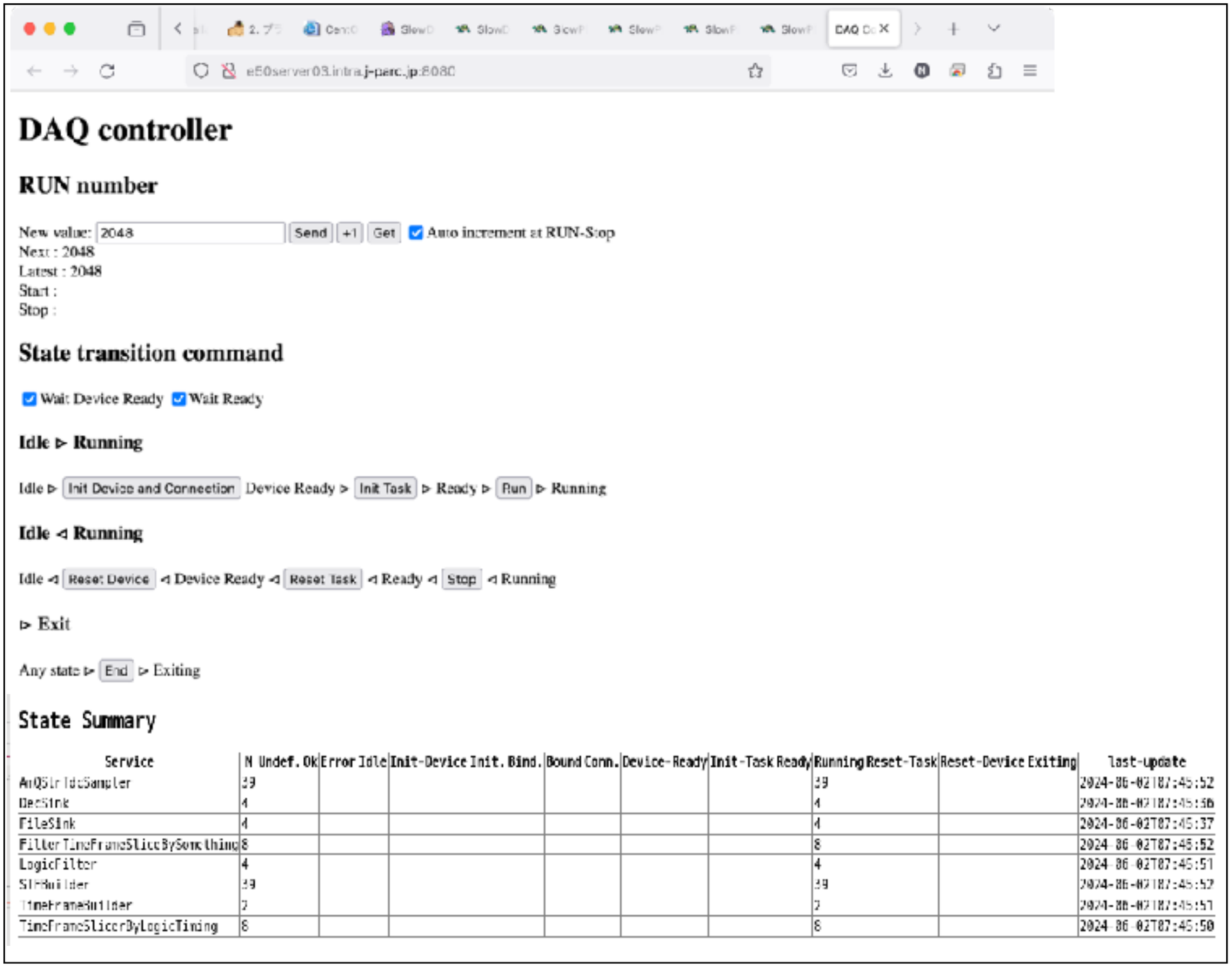
Redis on memory database

NestDAQ Features

- Continuous Readout (based on FairMQ)
- Scalable
- Clock synchronisation (MIKUMARI)
- Data transfer with SiTCP* (TCP implementation on FPGA)
  - 10 Gbps / 1 Gbps
- data stream, divided into a time interval, Heart-Beat-Frame (HBF)
  - 125 MHz, 16bit = 524.288 μs
- CPU/GPU
- Replayer

*https://www.sitcp.net/

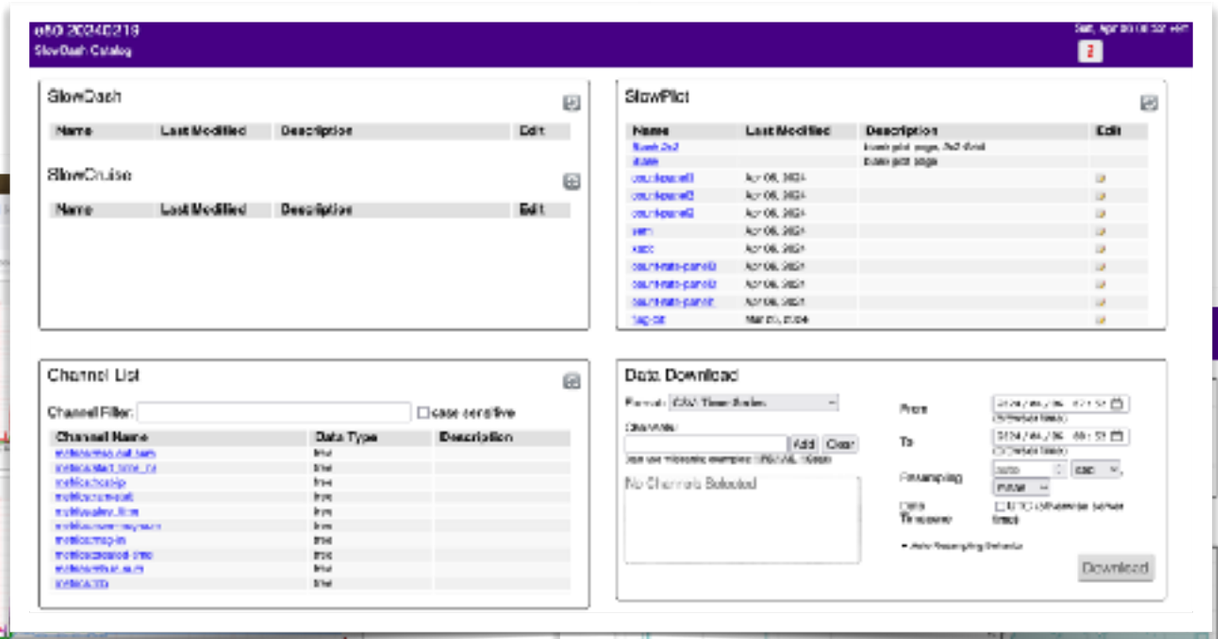
DAQ Controller

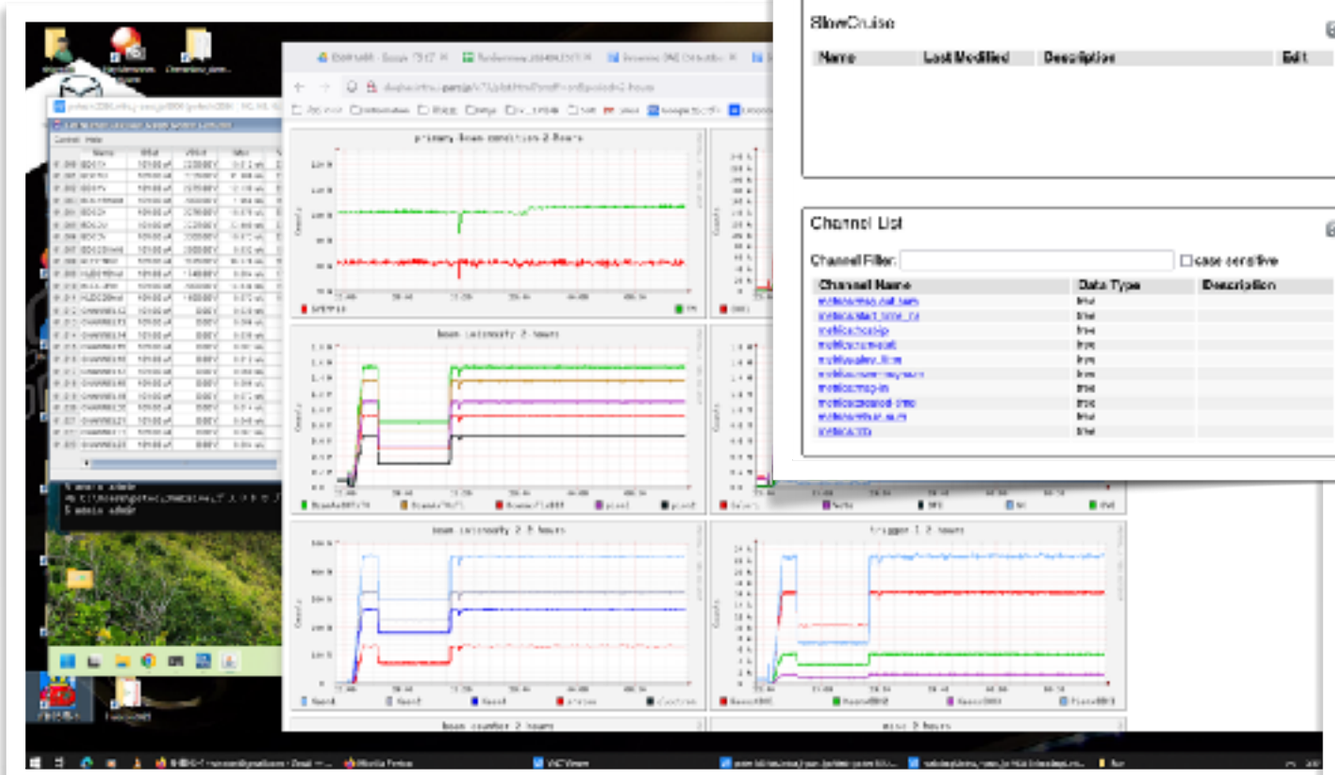


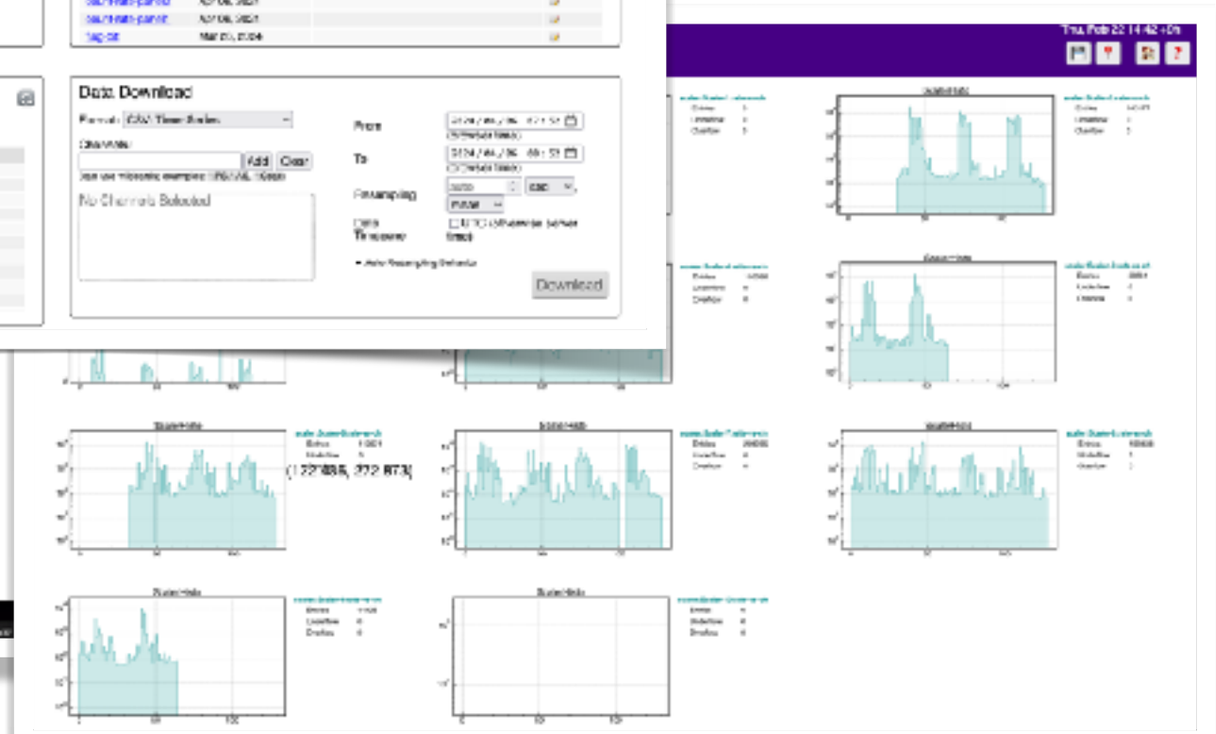
Service	N Undef. Ok	Error Idle	Init-Device Init. Bind.	Bound Conn.	Device-Ready	Init-Task Ready	Running Reset-Task	Reset-Device Exiting	last-update
AnQStrIdcSampler	39						39		2024-06-02T07:45:52
DecSink	4						4		2024-06-02T07:45:56
FileSink	4						4		2024-06-02T07:45:37
FilterTimeFrameSliceBySomething	8						8		2024-06-02T07:45:52
LogicFilter	4						4		2024-06-02T07:45:51
SlcBuilder	39						39		2024-06-02T07:45:52
TimeFrameBuilder	2						2		2024-06-02T07:45:51
TimeFrameSlicerByLogicTiming	8						8		2024-06-02T07:45:50

Slow Dash

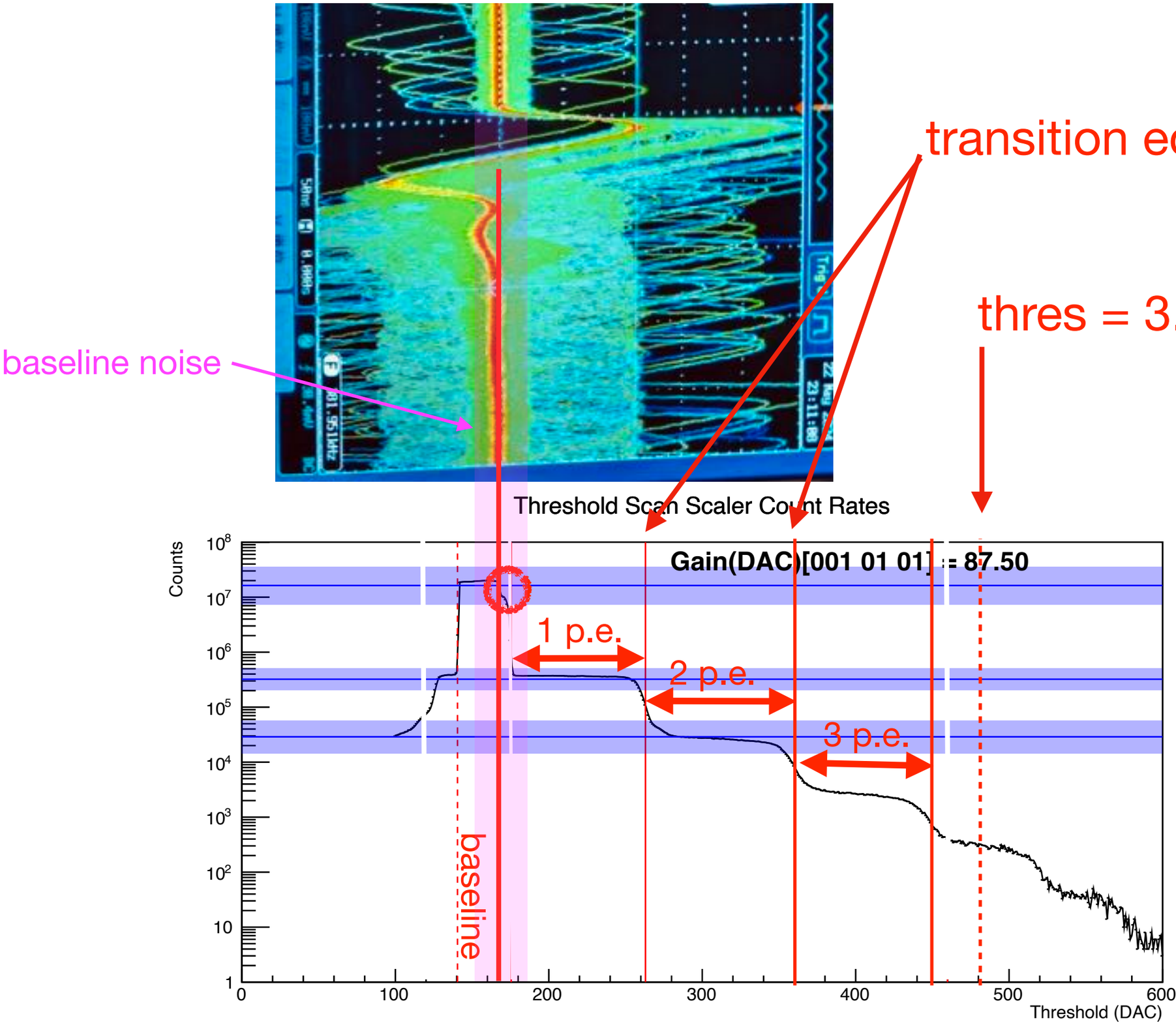
- “slow” communication with FEEs using RBCP
    - Remote Bus Control Protocol, a simple memory access protocol for SiTCP
- Get scaler information implemented on FPGAs, show data rate, hit patterns, time trends, **independently from DAQ**
- DCS







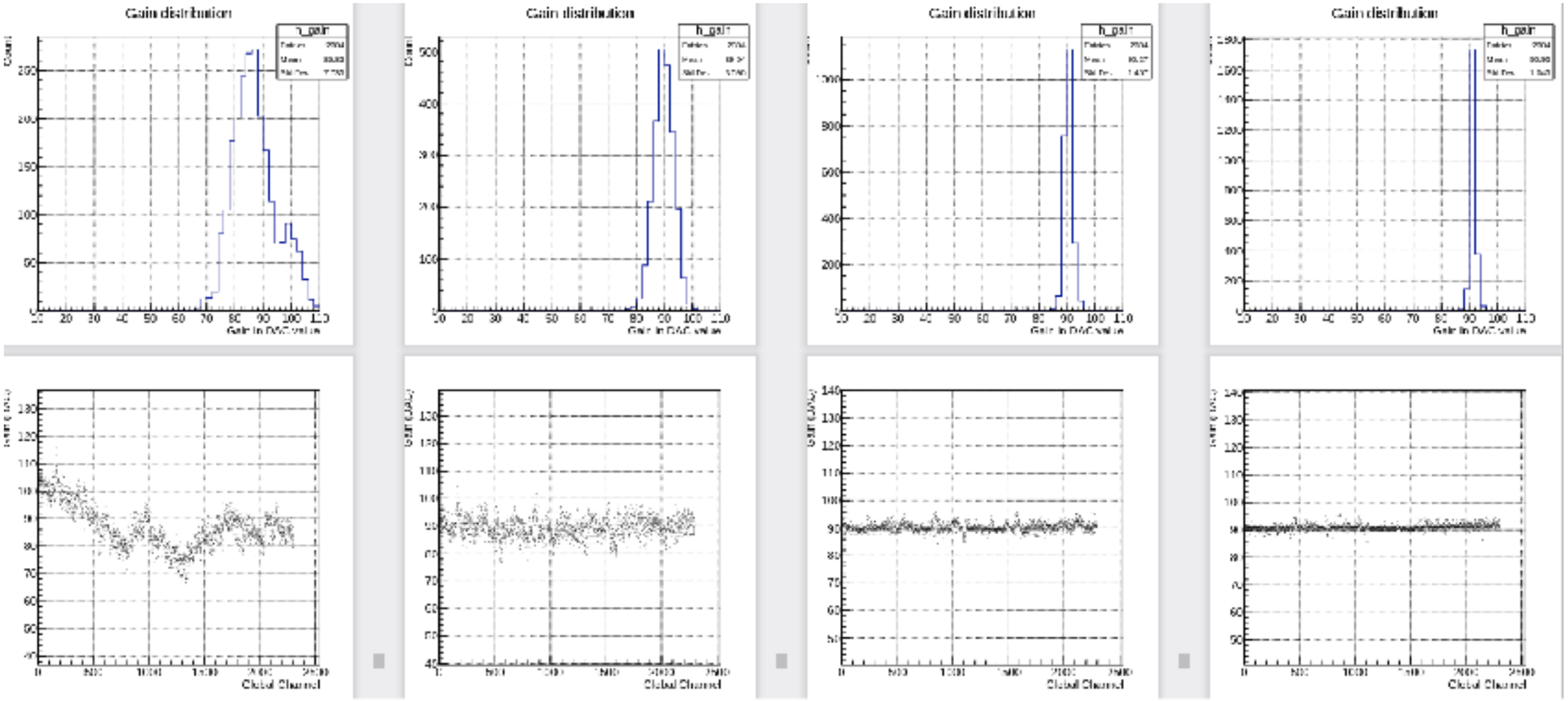
E.g. SiPM Gain Calib.



w/o DAQ

E.g. SiPM Gain Calib.

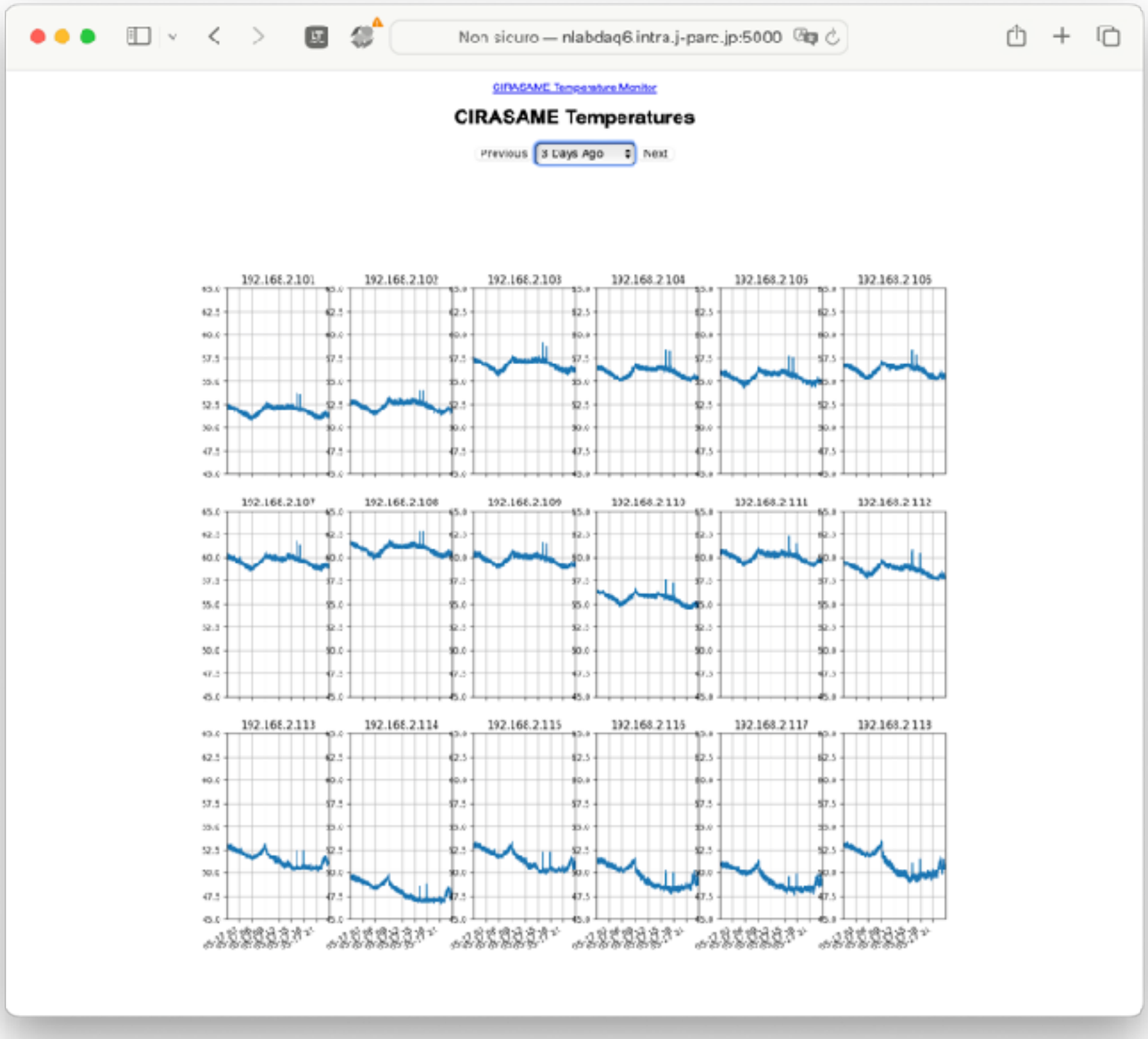
32ch (CITIROC) x 4 (on one FEE card) x 18 2304 ch.



initial status Fine bias adj. per ch.

Course bias adj. per ASIC (32ch) Fine bias adj. per ch. 2nd itr.

E.g. temperature monitor

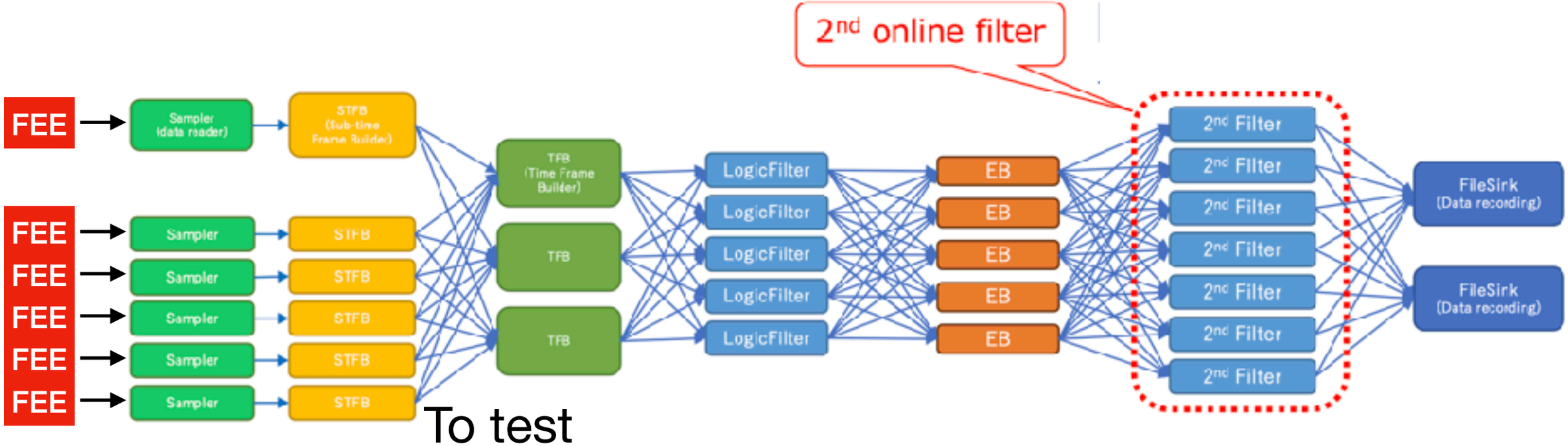


Test with the MARQ Spectrometer@J-PARC

Apr.-May 2024

- Full version @π20 beam line
  - 30 MHz 20 GeV/c π^- beam,
  - (7 MHz 6 GeV/c $\bar{p}$ beam)
  - ~25k channel (future)
- Test @K1.8BR beam line
  - K^- beam (<1 MHz)
  - ~5k channel (now)
  - 4.2s spill, 2.0 extraction

<u>Highest requirements among anticipated NestDAQ use cases</u>



To test

- Improved clock/timing system
- Improved communication format
- higher-level online filtering

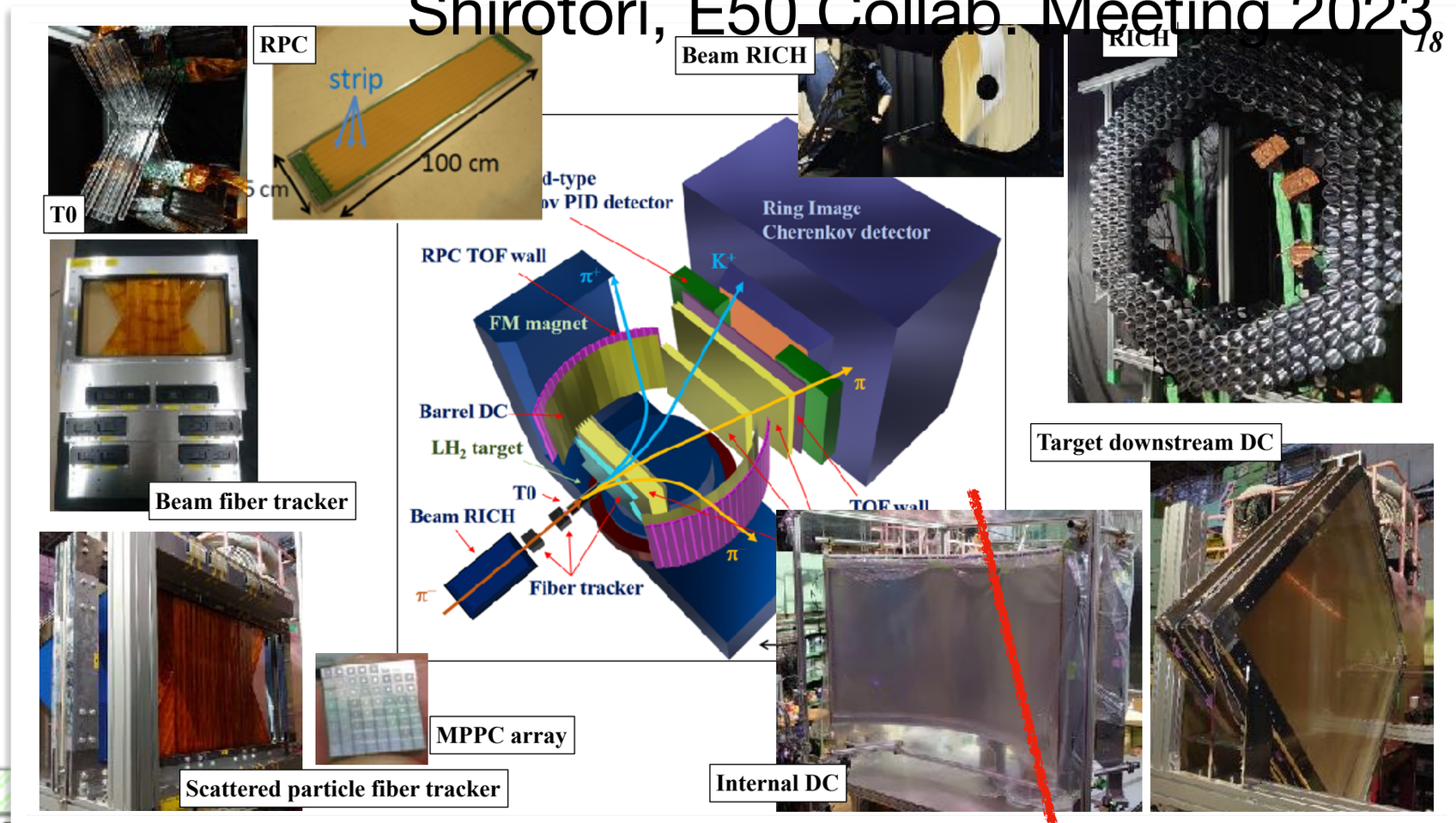
The MARQ Spectrometer in future

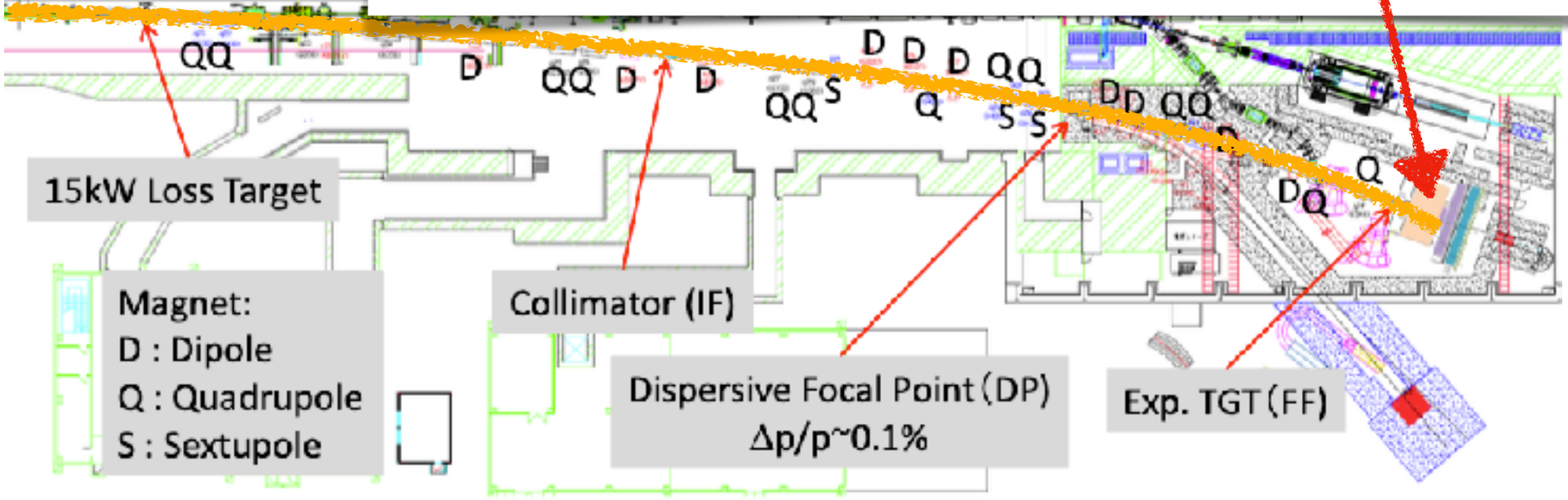
Shirotori, E50 Collab. Meeting 2023

MARQ-E50: charmed baryon spectroscopy, internal structure of charmed baryon, diquark correlations

$$\pi^- + p \rightarrow Y_c^{*+} + D^{*-}$$

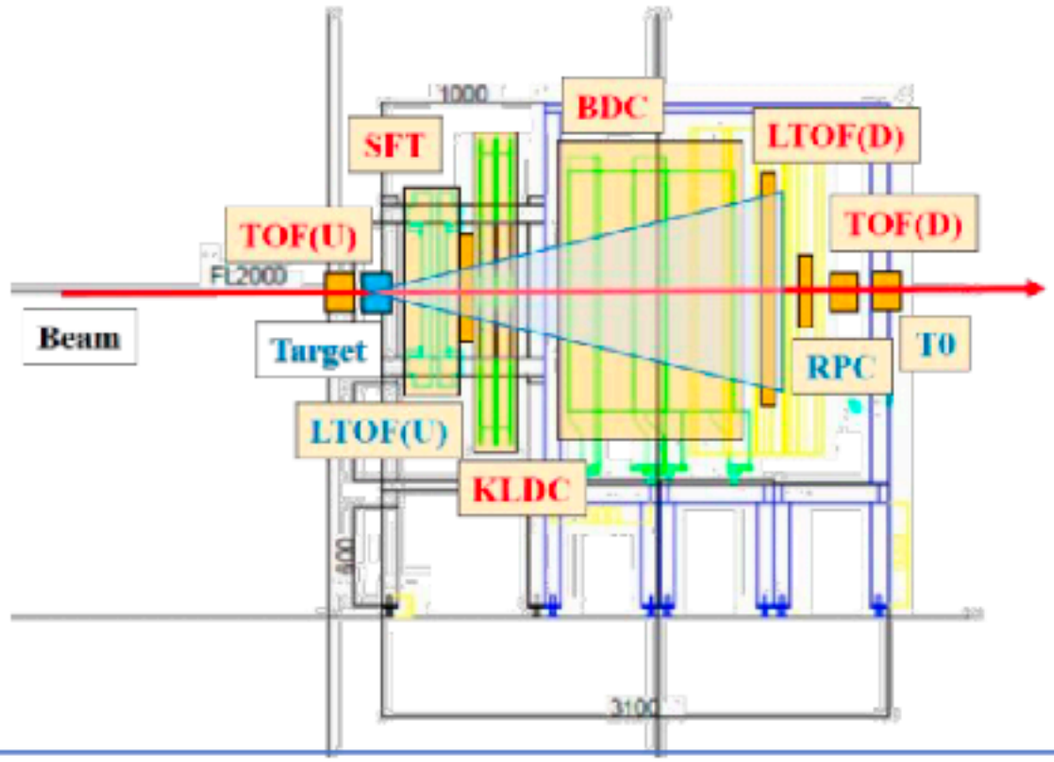
20 GeV/c π⁻ beam (30 MHz)





High momentum resolution Δp/p~0.1% with dispersion analysis

Test assembly for the 2024Apr BT



Detector	Front-end electronics	Number of modules	Number of channels
	Clock/time system (MIKUMARI)	4	128
TOF	FPGA HR-TDC (AMANEQ)	2	128
Drift chamber	FPGA TDC (AMANEQ)	15	1920
Fiber tracker	MPPC readout FEE (CIRASAME)	18	2304

Key Components

Front-End-Electronics (FEE)

∗ Total detector channel ~25,000 ch

⇒ Streaming DAQ: Only timing data (TDC)
- FEE: 1G/10Gbps network (Optical link)
- Timing synchronization (MIKUMARI)

- MPPC detector: ~20,000 ch
  - Scintillating fiber trackers
  - RICH, Beam-RICH, Vth AC

⇒ CIRASAME (ASIC: CITIROC)
- 128 ch Low-resolution TDC (ΔT_{LSB} ~ 1 ns)

- Timing detector: ~1,000 ch
  - T0, RPC, TOF: Amp/PMT + Discriminator

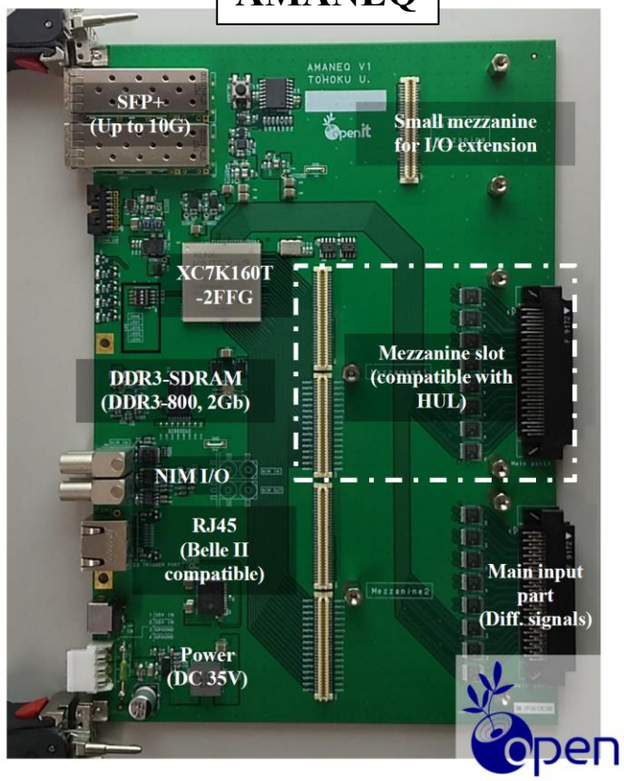
⇒ AMANEQ (HR-TDC mezzanine)
- 64 ch High-resolution TDC (ΔT_{LSB} ~ 20 ps)

- Drift chamber: ~4,000 ch

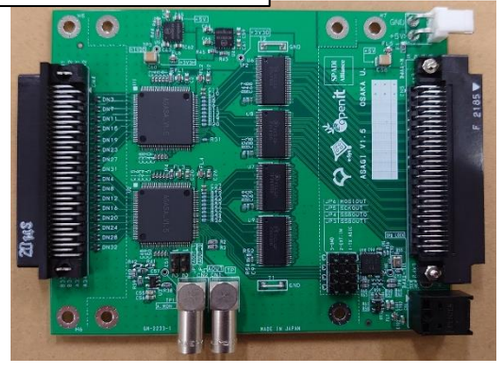
⇒ ASAGI(ASD) card + AMANEQ (DC mezzanine)
- ASD card 32 ch → TDC 128 ch
- Low-resolution TDC (ΔT_{LSB} ~ 1 ns)

CIRASAME

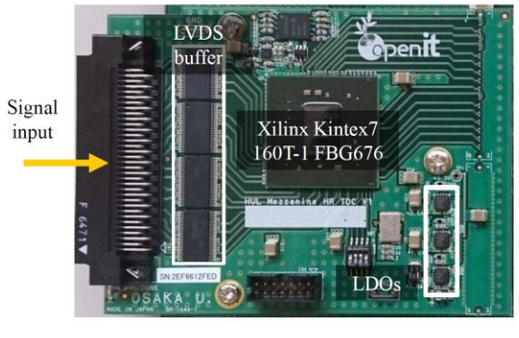
AMANEQ



ASAGI ASD card



HR-TDC mezzanine

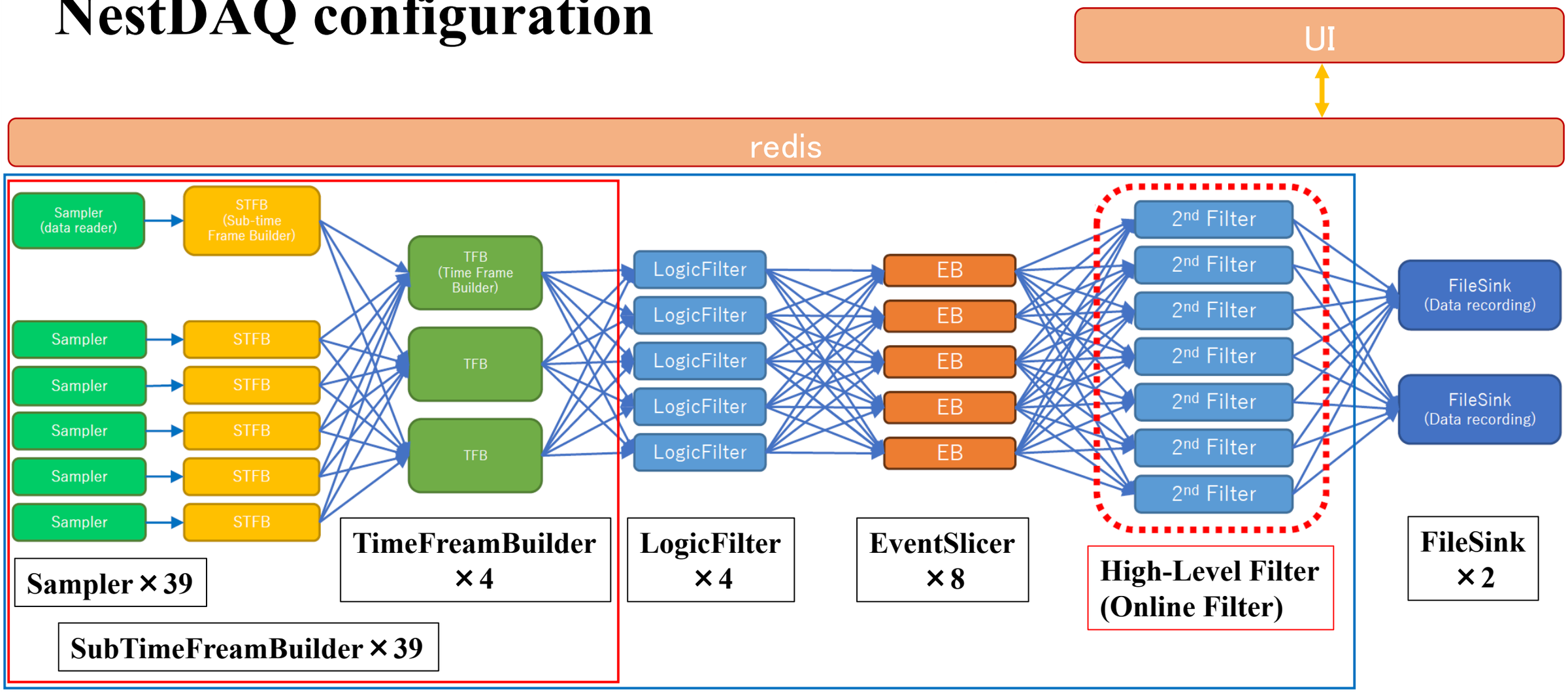


Other key components

- ? RAYRAW
- TPC readout w/ SAMPA chip (SAMIDARE)
- No-delay-cable QDC
  - Slow ADC -> TDC
  - LPF and slow WF digitiser
- WF digitiser

DAQ

NestDAQ configuration



- **No Filter: Sampler → STFB → TFB → FileSink**
- **Filtered: TFB → LogicFilter → EventSlicer → High-level Filter → FileSink**

Ultimately we want 1/1000 data reduction

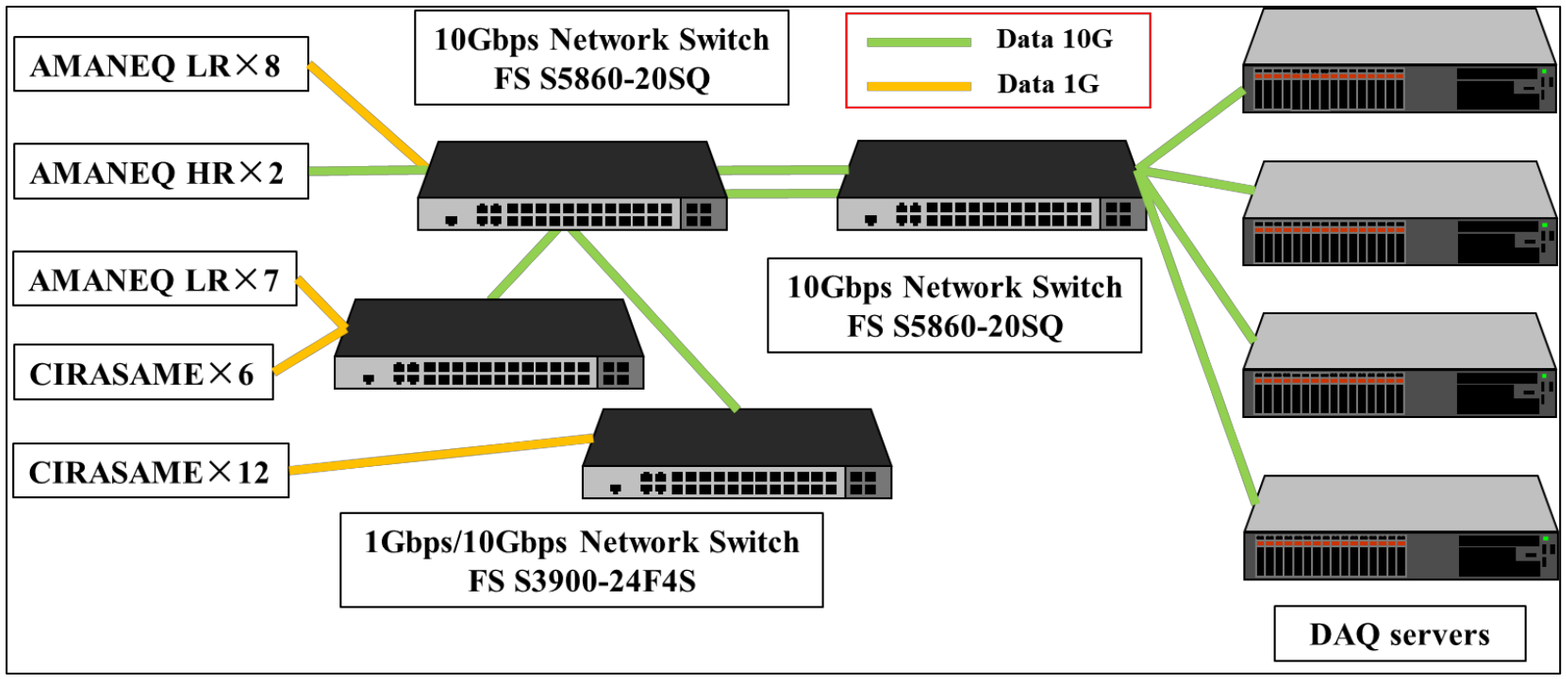
Shirotori, SPADI Meeting June 2024

General HPC nodes

Multiple PC study: DAQ Server performance

From Y. Igarashi

- DAQ PCs
  1. e50server03 (192.168.2.51)
     - AMD EPYC 74F3 24-Core Processor
     - 64 GB Memory
  2. eyst-daq01 (192.168.2.54)
     - AMD EPYC 7313P 16-Core Processor
     - 64 GB Memory
     - Intel 82599ES 10-Gigabit SFI/SFP
     + Network Connection (rev 01)
  3. e50server01 (192.168.2.55)
     - Intel(R) Xeon(R) CPU E5-2630 v4 @ 2.20GHz
     - 20-Core
     - 24 GB Memory
  4. e50server05 (192.168.2.53)
     - Intel(R) Xeon(R) CPU E5-2640 v4 @ 2.40GHz
     - 10-Core
     - 32 GB Memory
  5. nlabdaq5 (192.168.2.20)
     - AMD Ryzen 9 3900XT 12-Core Processor
     - 16 GB Memory



DAQ Server performance (Passmark bench CPU)

- DAQ PCs
  - e50server03 (192.168.2.51)
    - AMD EPYC 74F3 24-Core Processor
    - 64 GB Memory
  - eyst_daq01 (192.168.2.54)
    - AMD EPYC 7313P 16-Core Processor
    - 64 GB Memory
    - Intel Corporation 82599ES 10-Gigabit SFI/SFP+ Network Connection (rev 01)
  - e50server01 (192.168.2.55)
    - Intel(R) Xeon(R) CPU E5-2630 v4 @ 2.20GHz
    - 20-Core
    - 24 GB Memory
  - e50server05 (192.168.2.53)
    - Intel(R) Xeon(R) CPU E5-2640 v4 @ 2.40GHz
    - 10-Core
    - 32 GB Memory
  - nlabdaq5 (192.168.2.20)
    - AMD Ryzen 9 3900XT 12-Core Processor
    - 16 GB Memory

	AMD Ryzen 9 3900XT	AMD EPYC 74F3	AMD EPYC 7313P	Intel Xeon E5-2630 v4 @ 2.20GHz	Intel Xeon E5-2640 v4 @ 2.40GHz
Price	$379 - BUY	$2585.04 - BUY	$1204.21 - BUY	$14.99 - BUY	$174.9 - BUY
Socket Type	AM4	SP3	SP3	FCLGA2011-3	FCLGA2011-3
CPU Class	Desktop	Server	Server	Server	Server
Clockspeed	3.8 GHz	3.2 GHz	3.0 GHz	2.2 GHz	2.4 GHz
Turbo Speed	Up to 4.7 GHz	Up to 4.0 GHz	Up to 3.7 GHz	Up to 3.1 GHz	Up to 3.4 GHz
# of Physical Cores	12 (Threads: 24)	24 (Threads: 48)	16 (Threads: 32)	10 (Threads: 20)	10 (Threads: 20)
Cache	L1: 768KB, L2: 6.0MB, L3: 64MB	L1: 384KB, L2: 3.0MB, L3: 32MB	L1: 1,024KB, L2: 8.0MB, L3: 128MB	L1: 640KB, L2: 2.5MB, L3: 25MB	L1: 640KB, L2: 2.5MB, L3: 25MB
TDP	105W	240W	155W	85W	90W

CPU Mark Rating

As of 1st of June 2024 - Higher results represent better performance

AMD Ryzen 9 3900XT	32,727
AMD EPYC 74F3	60,666
AMD EPYC 7313P	42,032
Intel Xeon E5-2630 v4 @ 2.20GHz	11,663
Intel Xeon E5-2640 v4 @ 2.40GHz	12,374

PassMark Software © 2008-2024

CPU Single Thread Rating

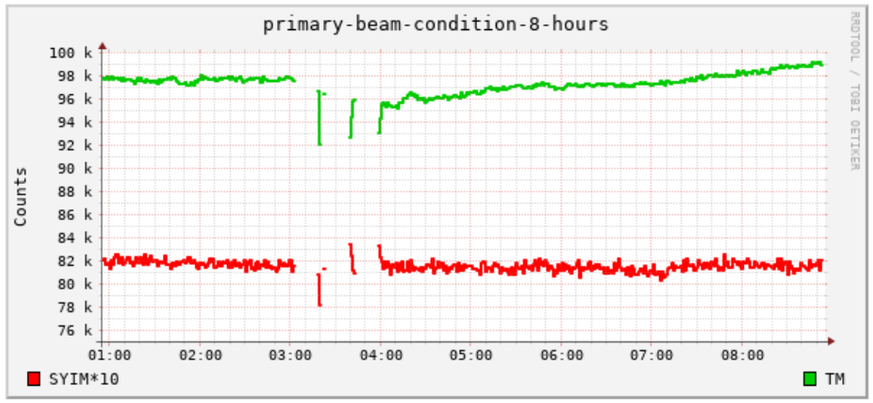
As of 1st of June 2024 - Higher results represent better performance

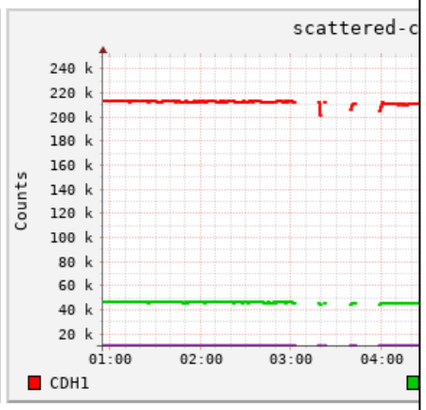
AMD Ryzen 9 3900XT	2,749
AMD EPYC 74F3	2,942
AMD EPYC 7313P	2,704
Intel Xeon E5-2630 v4 @ 2.20GHz	1,744
Intel Xeon E5-2640 v4 @ 2.40GHz	1,932

PassMark Software © 2008-2024

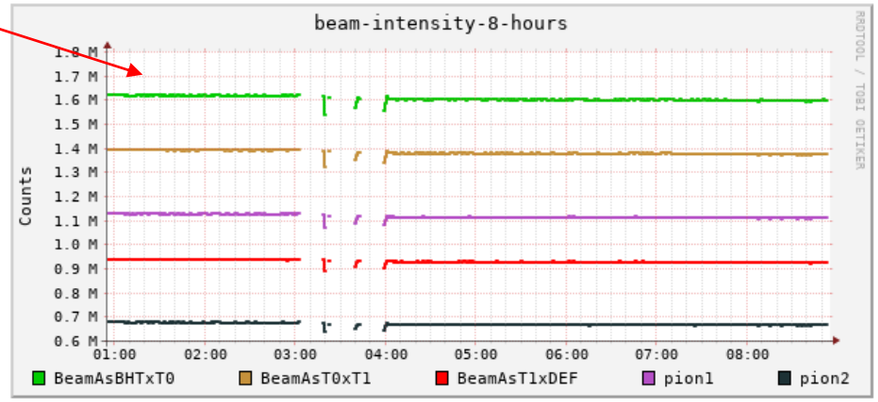
Beam

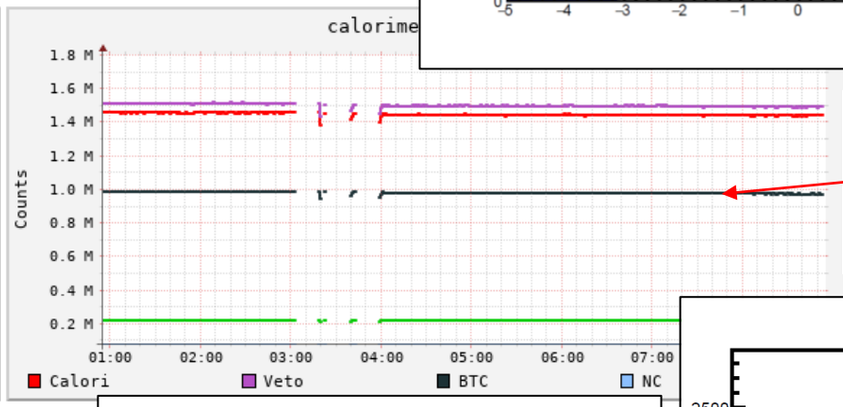
Beam flux: K1.8BR scaler information



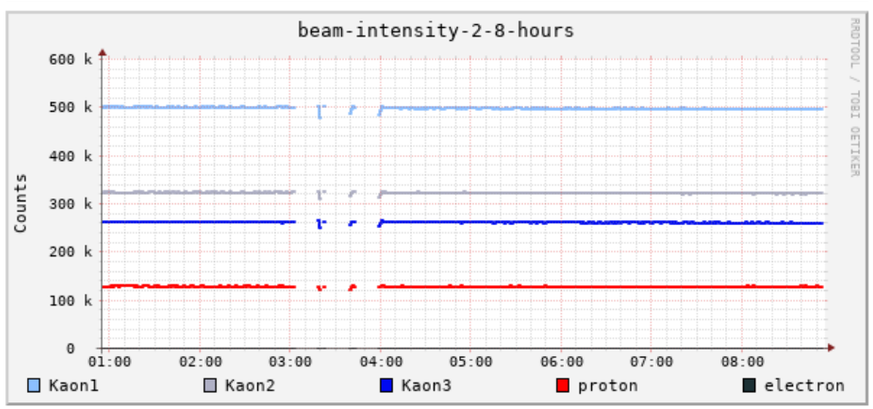


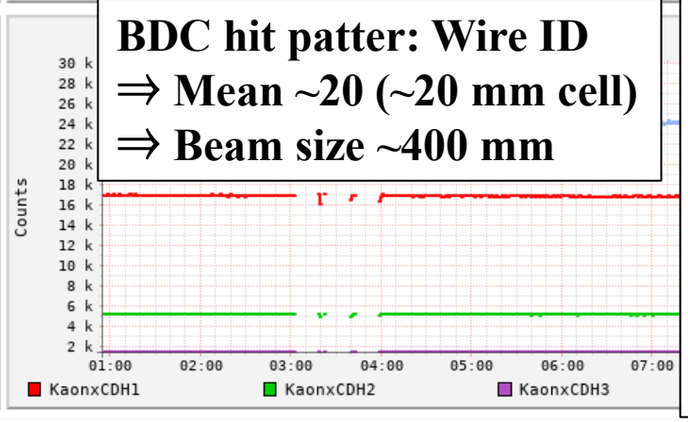
All charged
~1.6 M/spill



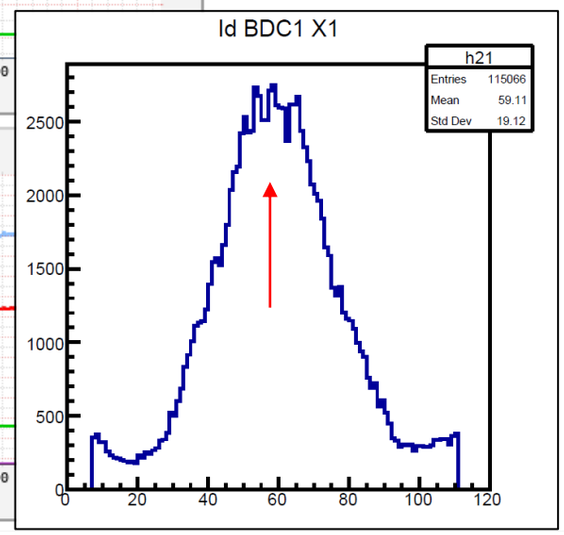


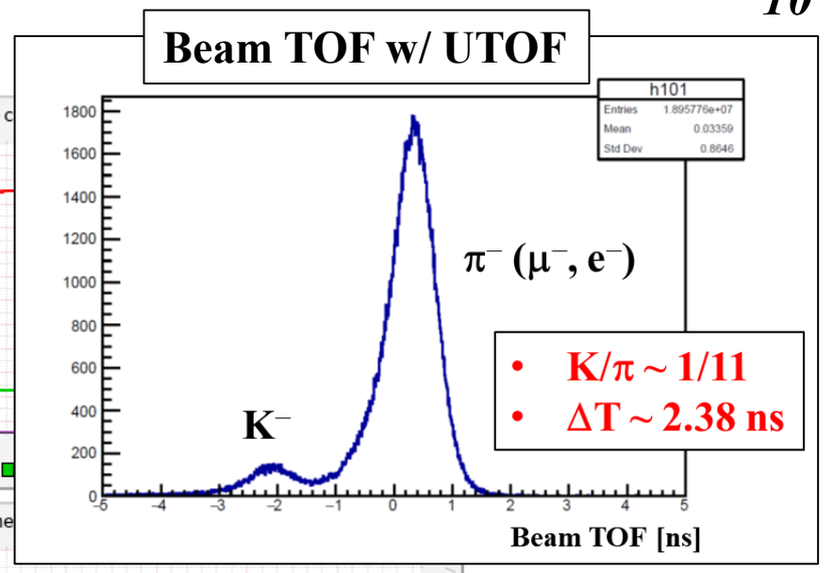
Counting rate
After calorimeter
~1.0 M/spill





BDC hit patter: Wire ID
⇒ Mean ~20 (~20 mm cell)
⇒ Beam size ~400 mm



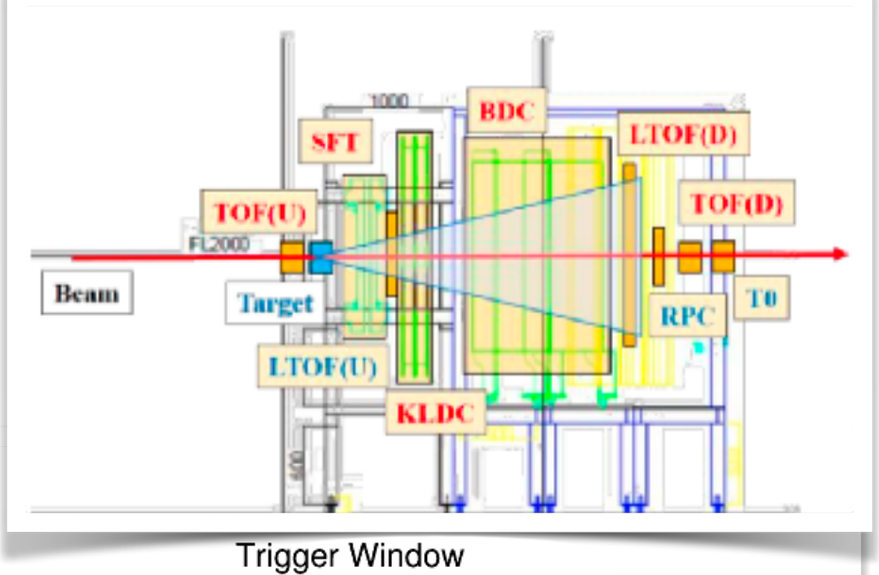


- K/π ~ 1/11
- ΔT ~ 2.38 ns

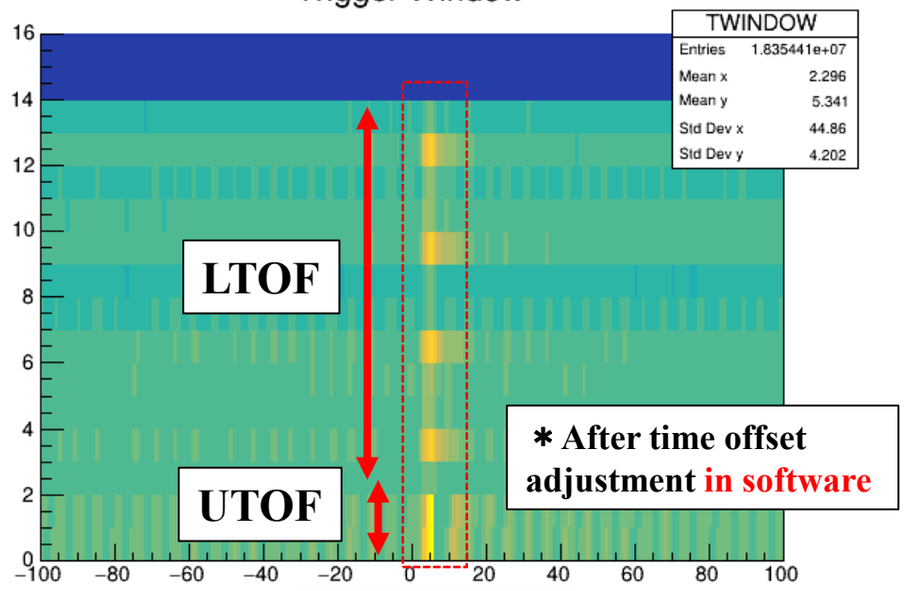
NestDAQ process implementation

- **TFB: Reconstruction of time frame from HBF**
  - **Free streaming data (w/o reduction by any selections)**
    - **All 1-M/spill data can be taken.**

⇒ **LogicFilter: Timing coincidence**
- **"Trigger timing" generated w/o reduction**
  - **UTOF × LTOF timing**
  - **Coincidence rate: ~200 k/spill (Reduced by detector size)**



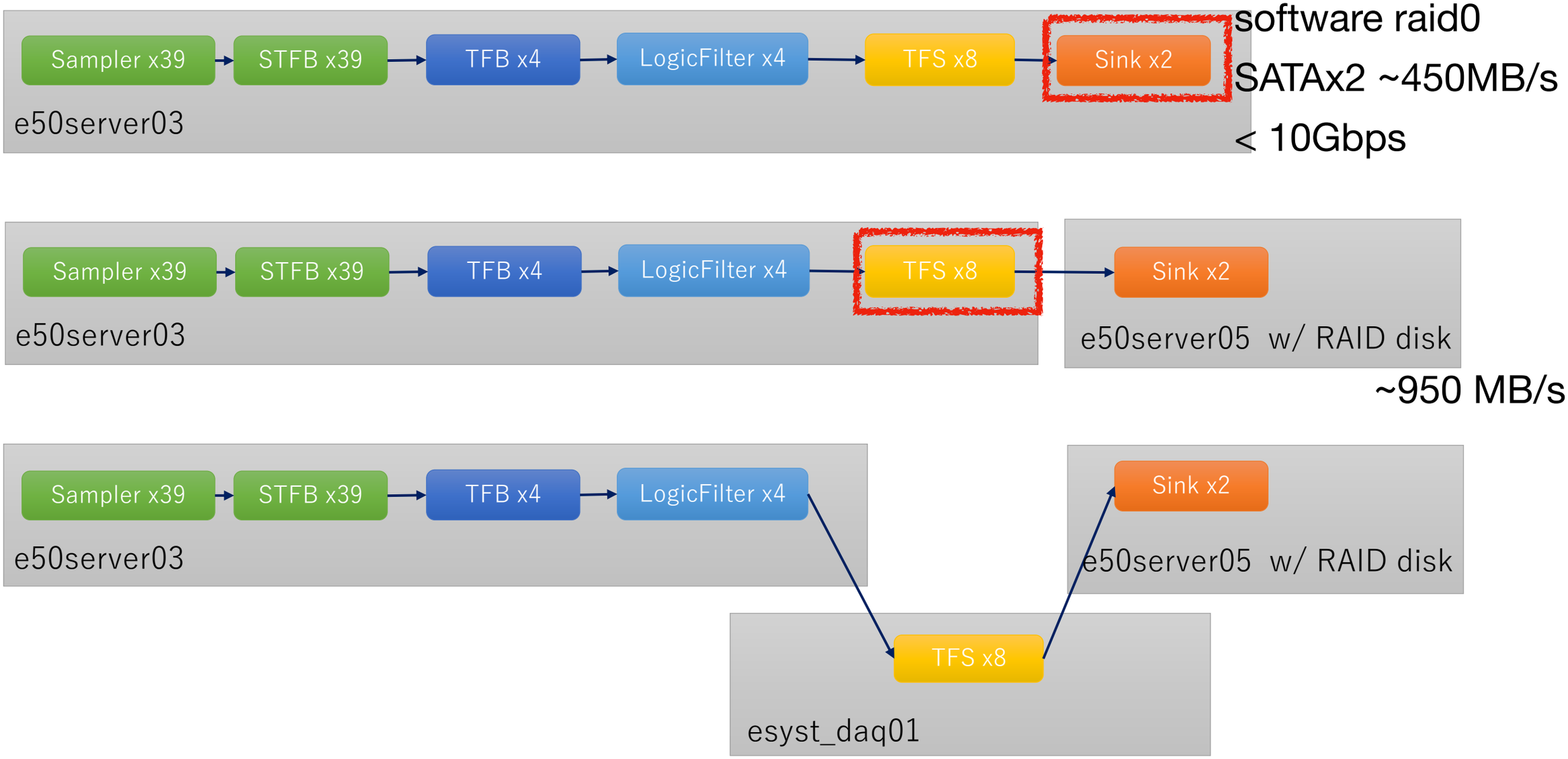
Trigger Window



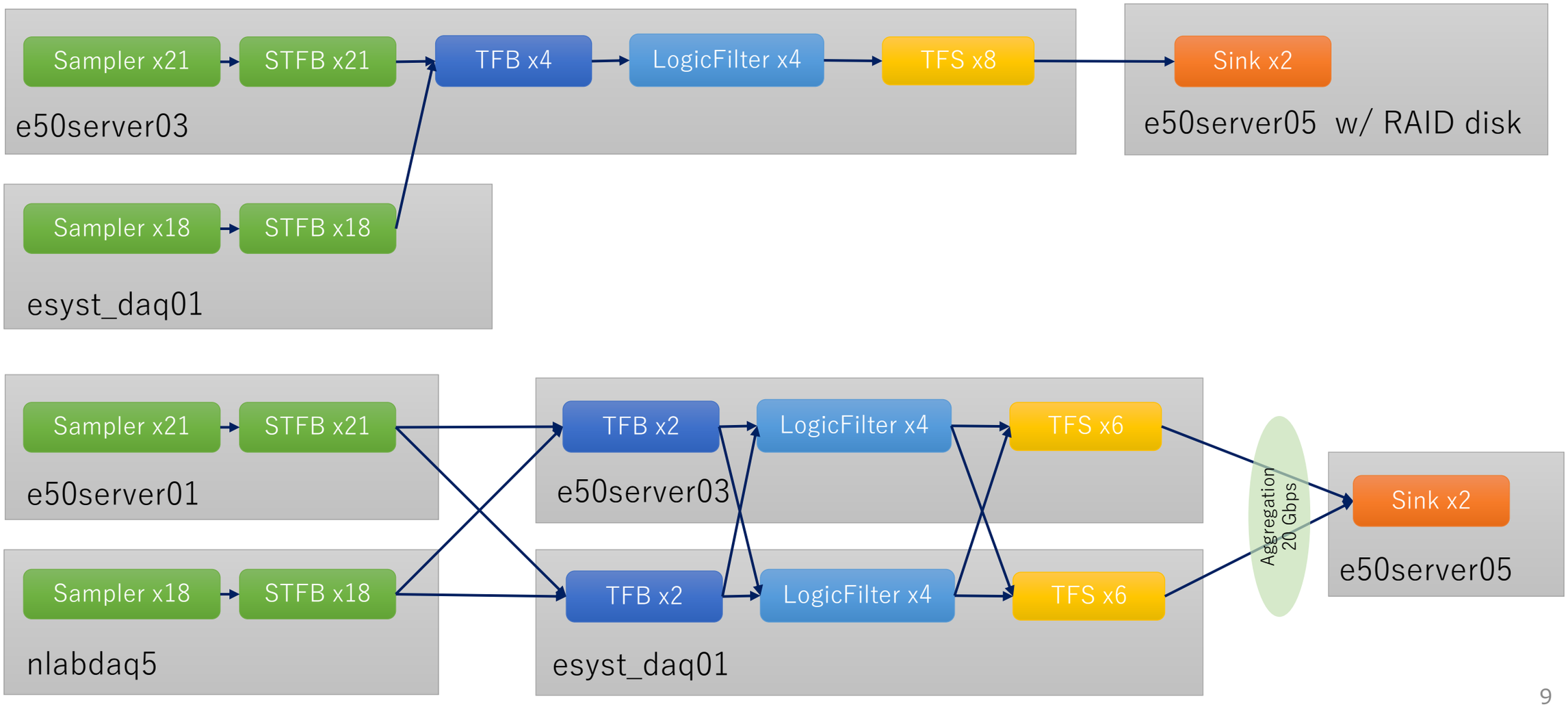
⇒ **EventSlicer: Event finding from "Trigger timing"**
- **Slicing window applied according to "Trigger timing": ±1000 ns**
  - **"Trigger timing" is used as reference timing.**
- **Timing group in Slicing window = "Event" generated w/ reduction**

⇒ **High-level Filter: Event selection using "Event"**
- **Event selection like an off-line analysis can be performed.**
  - **Beam TOF filter: K beam selection using ($T_{T1:MeamTime} - T_{UTOF:MeamTime}$)**

Data flow with multiple computers



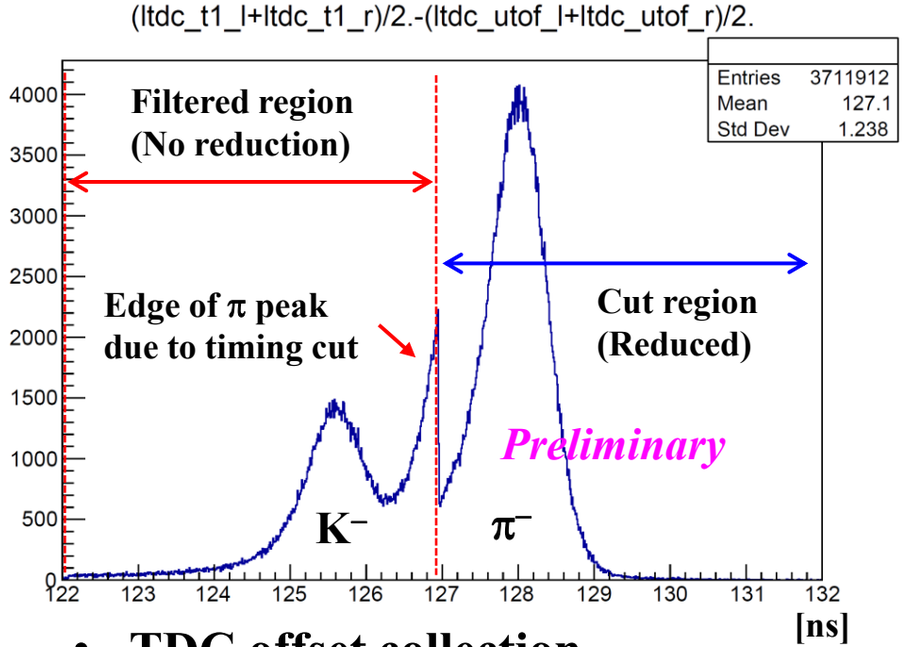
Data flow with multiple computers



High-level Filter status ⇒ To be reported by Furukawa-kun

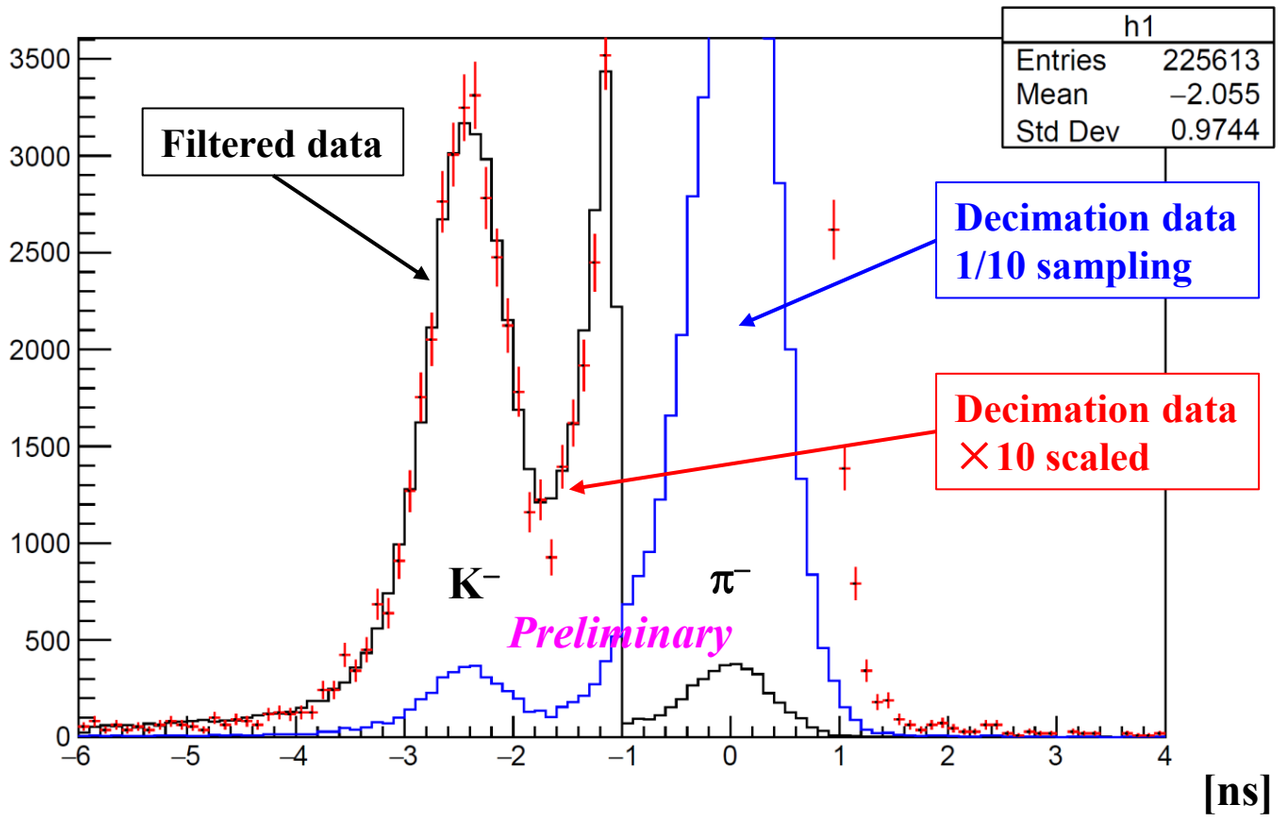
- **Beam TOF filter: K beam selection using ($T_{T1:MeamTime} - T_{UTOF:MeamTime}$)**
  - **All timing combinations in "Event" (Timing in Slicing window) are used.**
- **Correct Beam TOF selection ⇒ High-level filter worked well !**

"Raw" data: $T_{T1:MeamTime} - T_{UTOF:MeamTime}$



- **TDC offset collection**
- **TDC timing cut**
- **1st hit selection**

Beam TOF: $T_{T1:MeamTime} - T_{UTOF:MeamTime}$



Summary

- NestDAQ under active development by the SPADI alliance
- Just had a test BT with MARQ spectrometer (with the highest demands)
    - Gained a lot of experiences to run a continuous readout in practice
    - Flexible and scalable system
    - low/high level online filtering
- Next steps:
    - higher-level filtering, GPU, full system (x5), storage (CfphFS/SSD caching)