RCNP

SPADI Alliance

Signal processing and data acquisition infrastructure alliance
toward the standardization for sustainable developments

ePIC Software & Computing Weekly Meeting: Test-Beam Support

Wednesday Oct 29, 2025, 11:00 AM → 12:00 PM US/Eastern

Dmitrii Kalinkin (University of Kentucky), Markus Diefenthaler (Jefferson Lab), Torre Wenaus (BNL), Wouter Deconinck (University of Manitoba)

Towards Interfacing NestDAQ and JANA2/EICrecon | ARTEMIS

Nobu Kobayashi

Research Center for Nuclear Physics, the University of Osaka

Contents

- What is NestDAQ?
- Implementations of NestDAQ and experiences to use NestDAQ
- Towards Interfacing NestDAQ and JANA2/EICrecon | ARTEMIS
- Timeline of R&D

NestDAQ: Streaming DAQ and computing flamework
Why NestDAQ? Common issues in Japan

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Courtesy of S. Ota

Explosive increase of the data flow

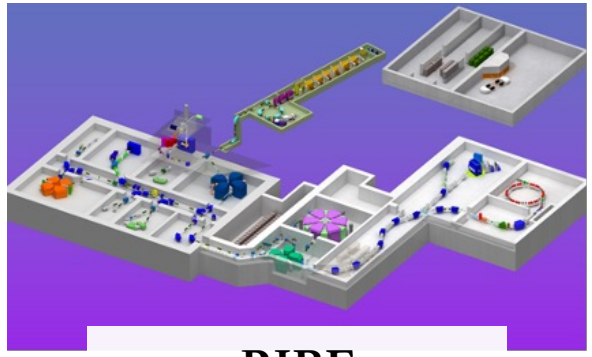
Quantum beam
10 times and more

×

High granularity
for the high resolution and high intensity

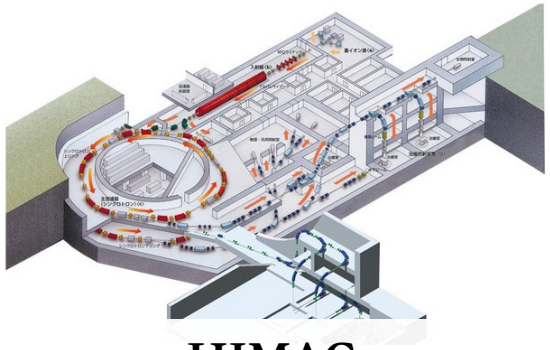
=

Quantum bigdata
1000 times larger amount data



RIBF

RCNP



HIMAC

J-PARC

Beyond the limitation of the present data acquisition and processing

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>140 researchers (23 institute)

Strategy committee
Chair : Shinsuke OTA
Vice-Chair: Ryotaro Honda and Hidetada Baba

Goals:
Common system
Standardization

→ Reducing manpower and costs to develop and construct the DAQ system

The streaming DAQ and computing system by SPADI Alliance

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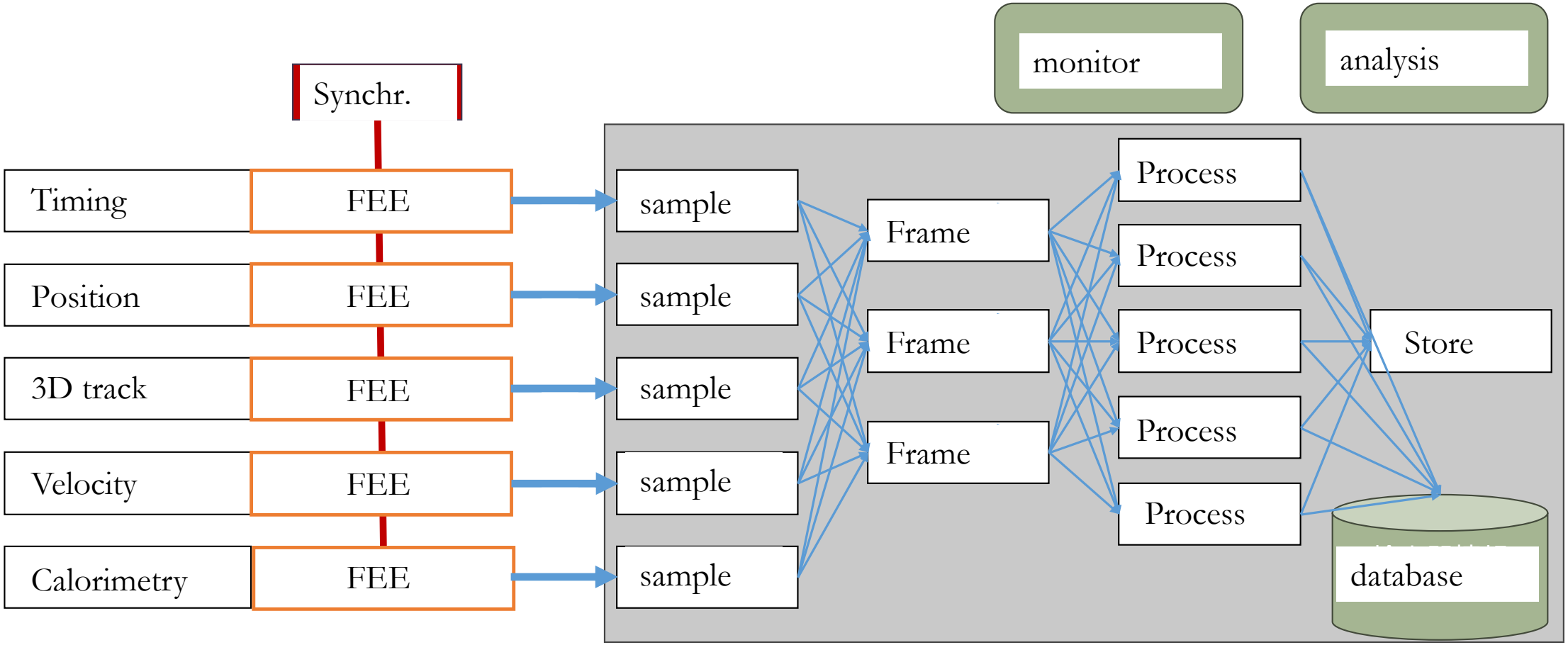

The streaming DAQ and computing system by SPADI Alliance

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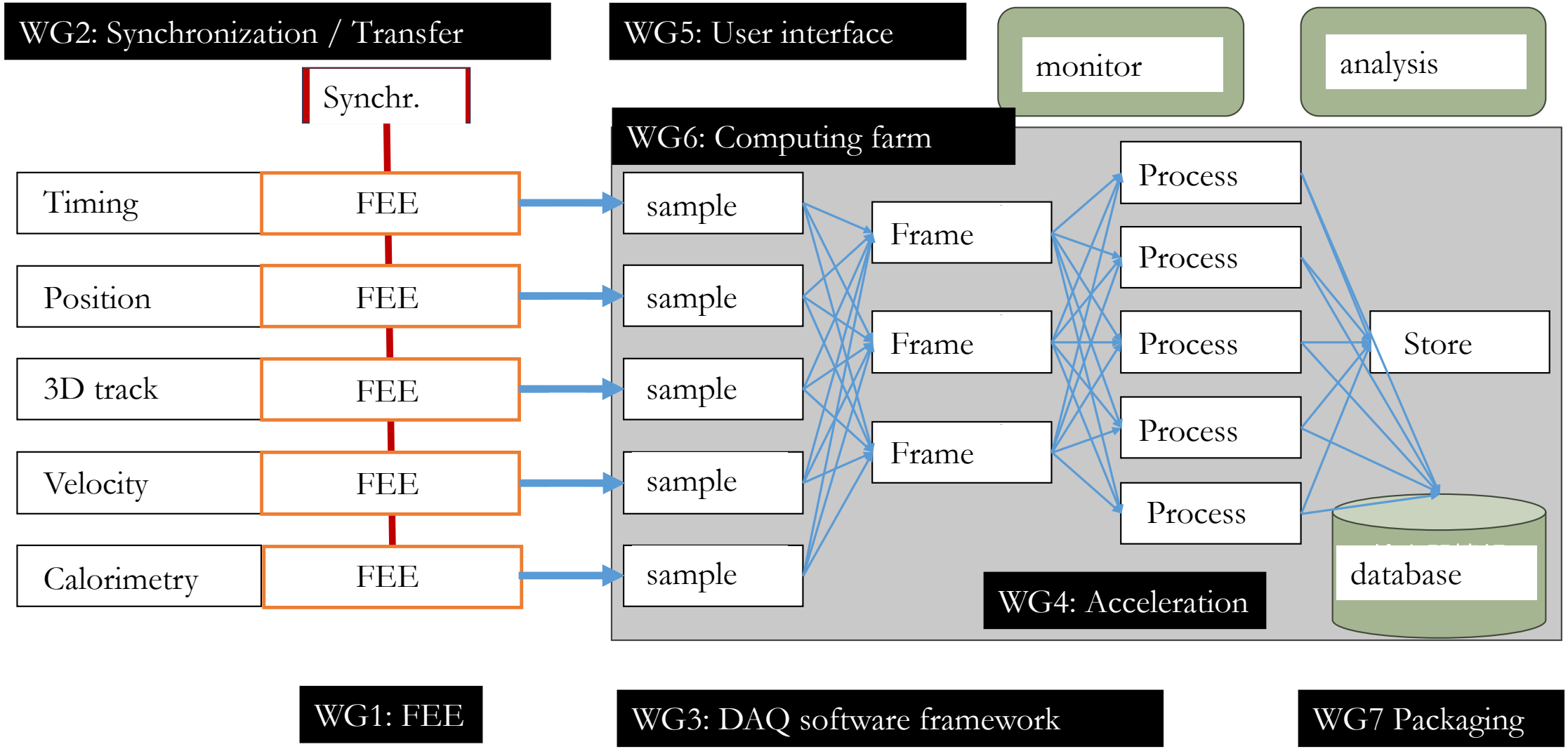

The streaming DAQ and computing system by SPADI Alliance

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Courtesy of S. Ota

WG2: Synchronization / Transfer

Synchr.

Timing

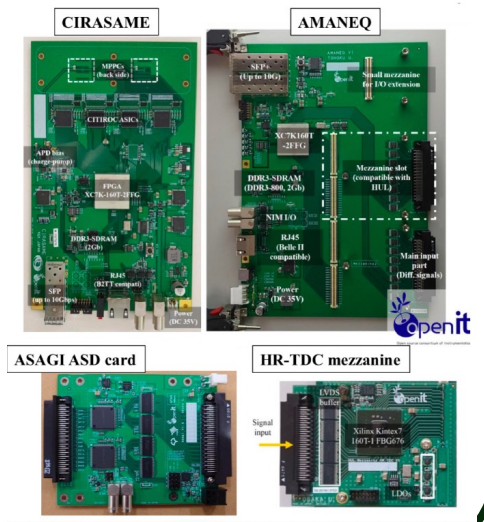
Position

3D track

Velocity

Calorimetry

ASIC & FEE



WG1: FEE

WG5: User interface

monitor

analysis

WG6: Computing farm

Computing framework

- WG3: NestDAQ Ver. 1 & Ver. 2
- WG4: Hardware acceleration
- WG4: Online processing
- WG5: Slow control / GUI
- WG6: Computing Infrastr.

WG3: DAQ software framework

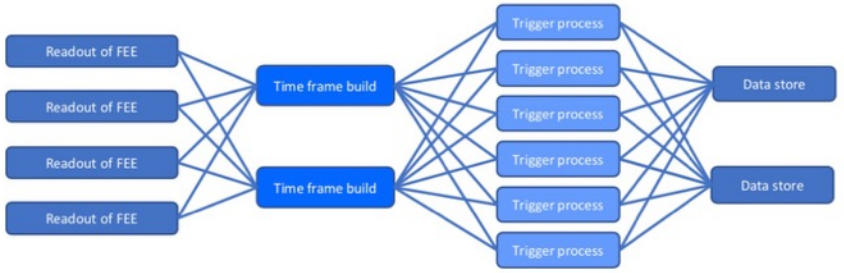
WG7 Packaging

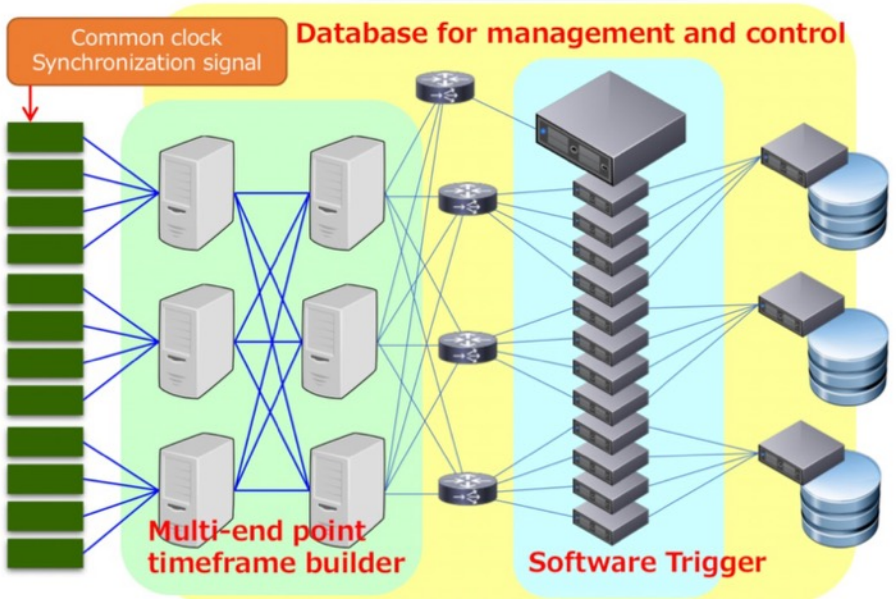
NestDAQ

Developed by T.N. Takahashi et al.

Courtesy of T. Gunji

- **SPADI-Alliance has been developing the streaming DAQ framework.**
- **NestDAQ (network-based streaming DAQ)**
  - **overall management of dataflow and control**
  - **FairMQ**
    - **ZeroMQ as process communications**
      - One to many, many to one communication
      - Message queue works as a data buffer.
  - **Redis (key-value based DB)**
    - Memory-oriented and fast response
    - Key-space notification
    - Pub/Sub →It can be used for control.





NestDAQ in Japan

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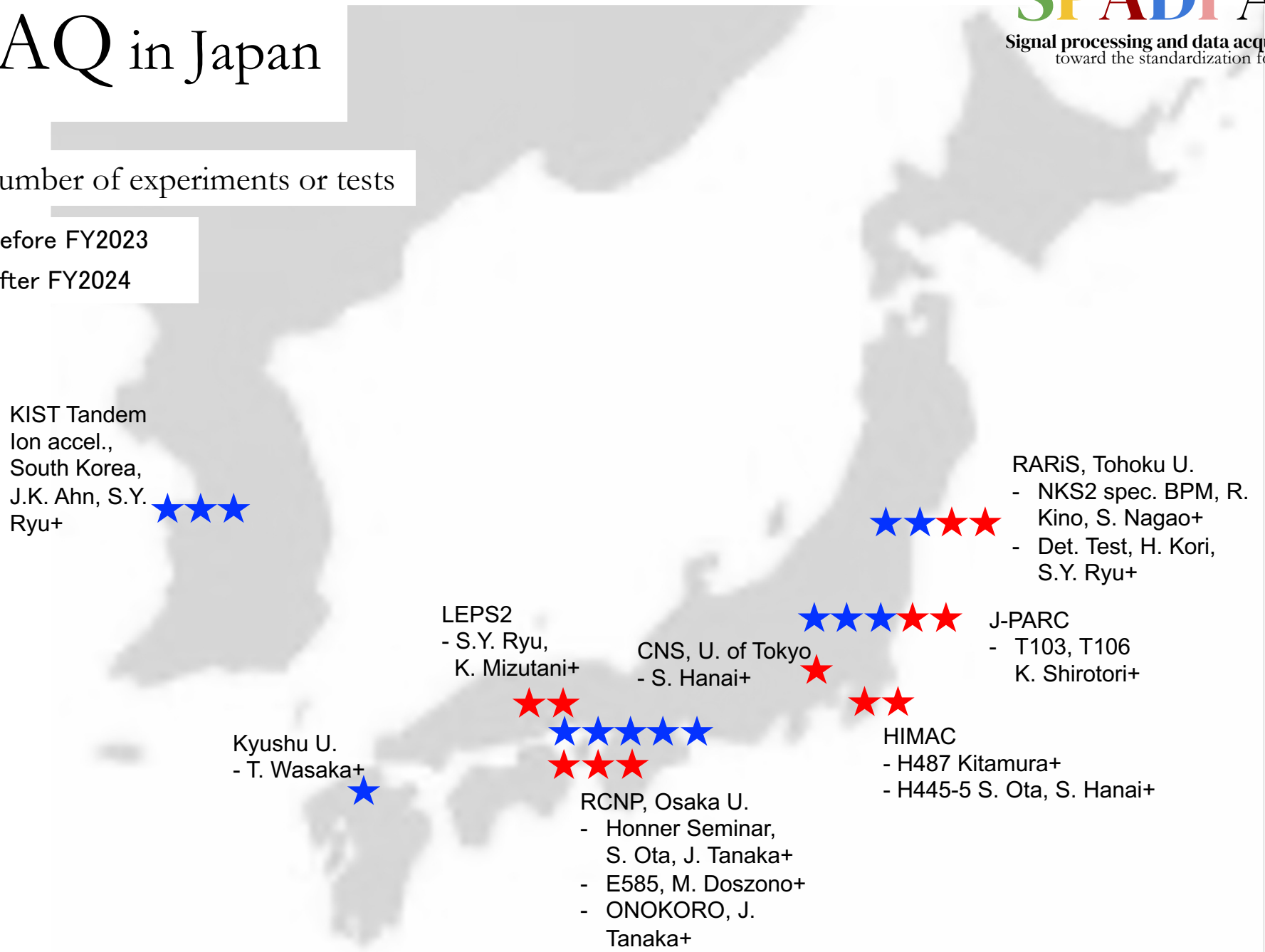
Stars: number of experiments or tests

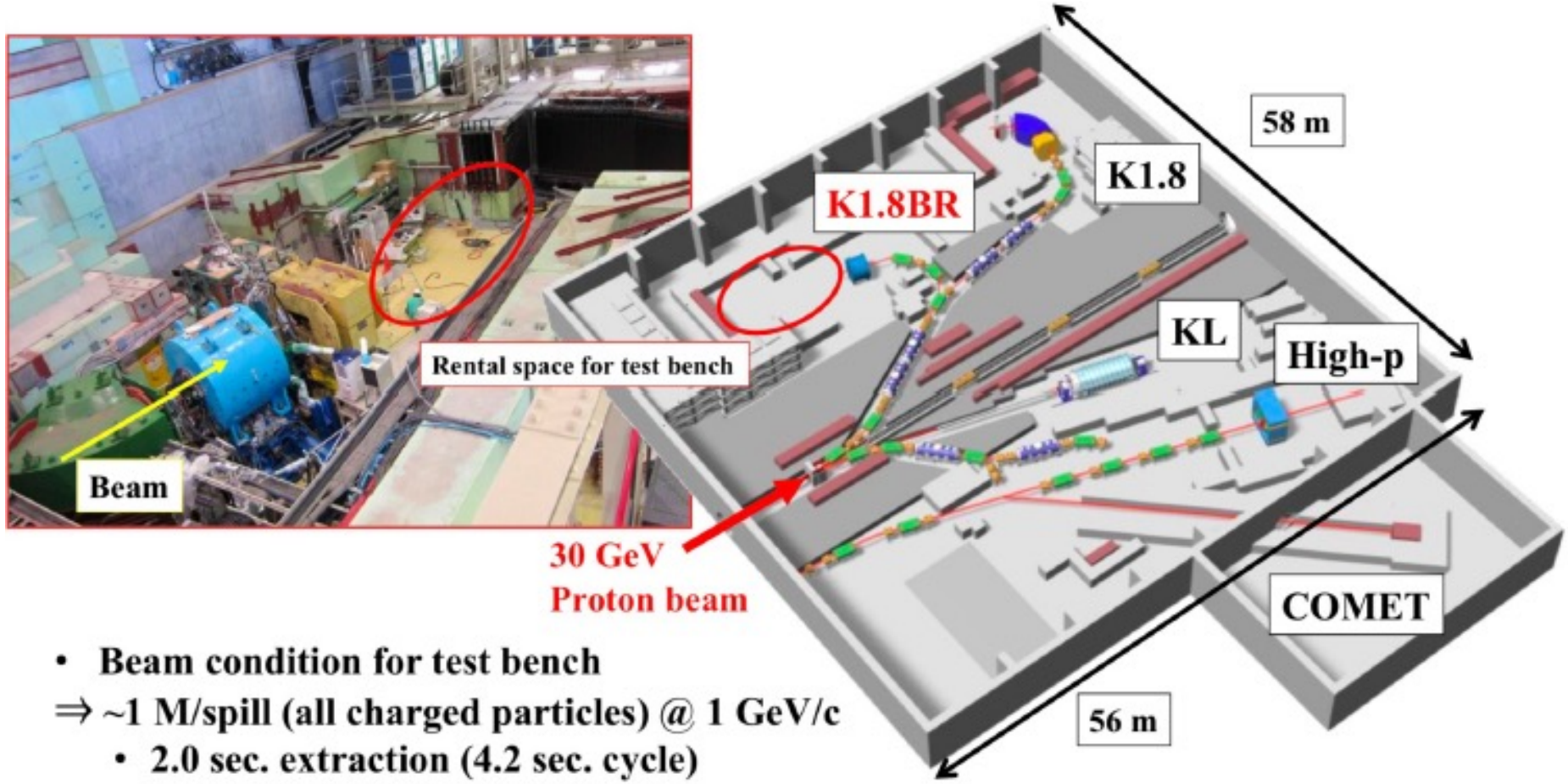
★ Before FY2023
★ After FY2024



NestDAQ

Courtesy of Sirotori et al.

Resent test at J-PARC: Testbench of streaming DAQ development



- **Beam condition for test bench**

⇒ **~1 M/spill (all charged particles) @ 1 GeV/c**

- **2.0 sec. extraction (4.2 sec. cycle)**

NestDAQ

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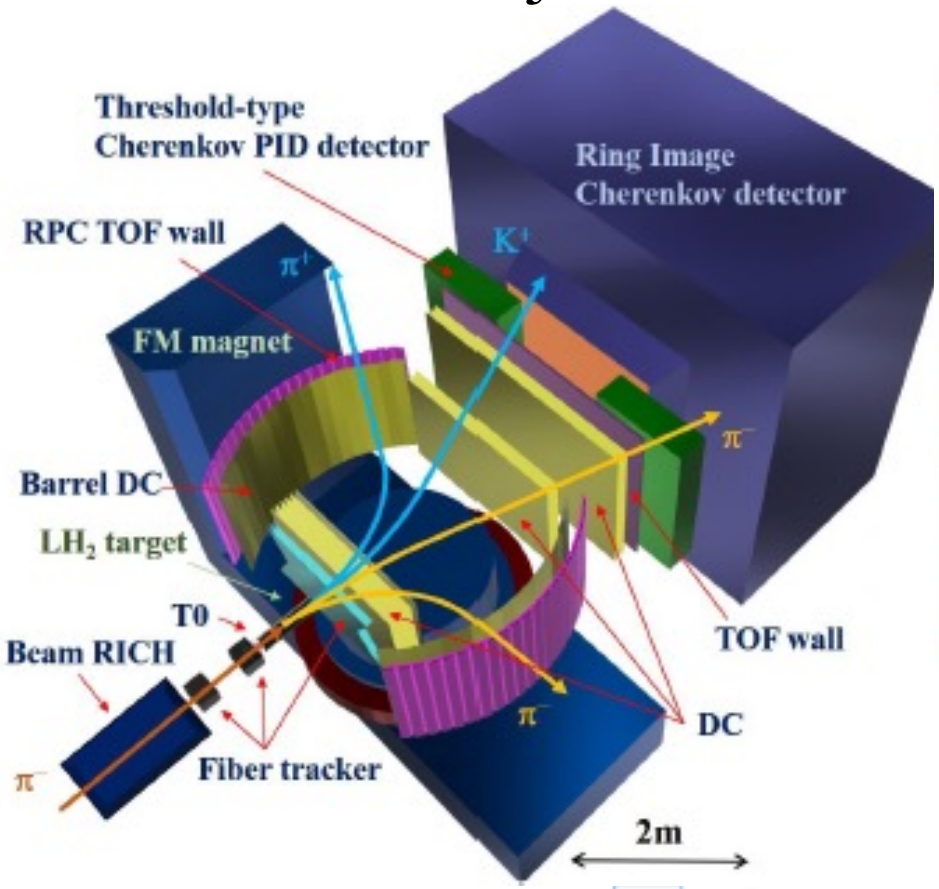
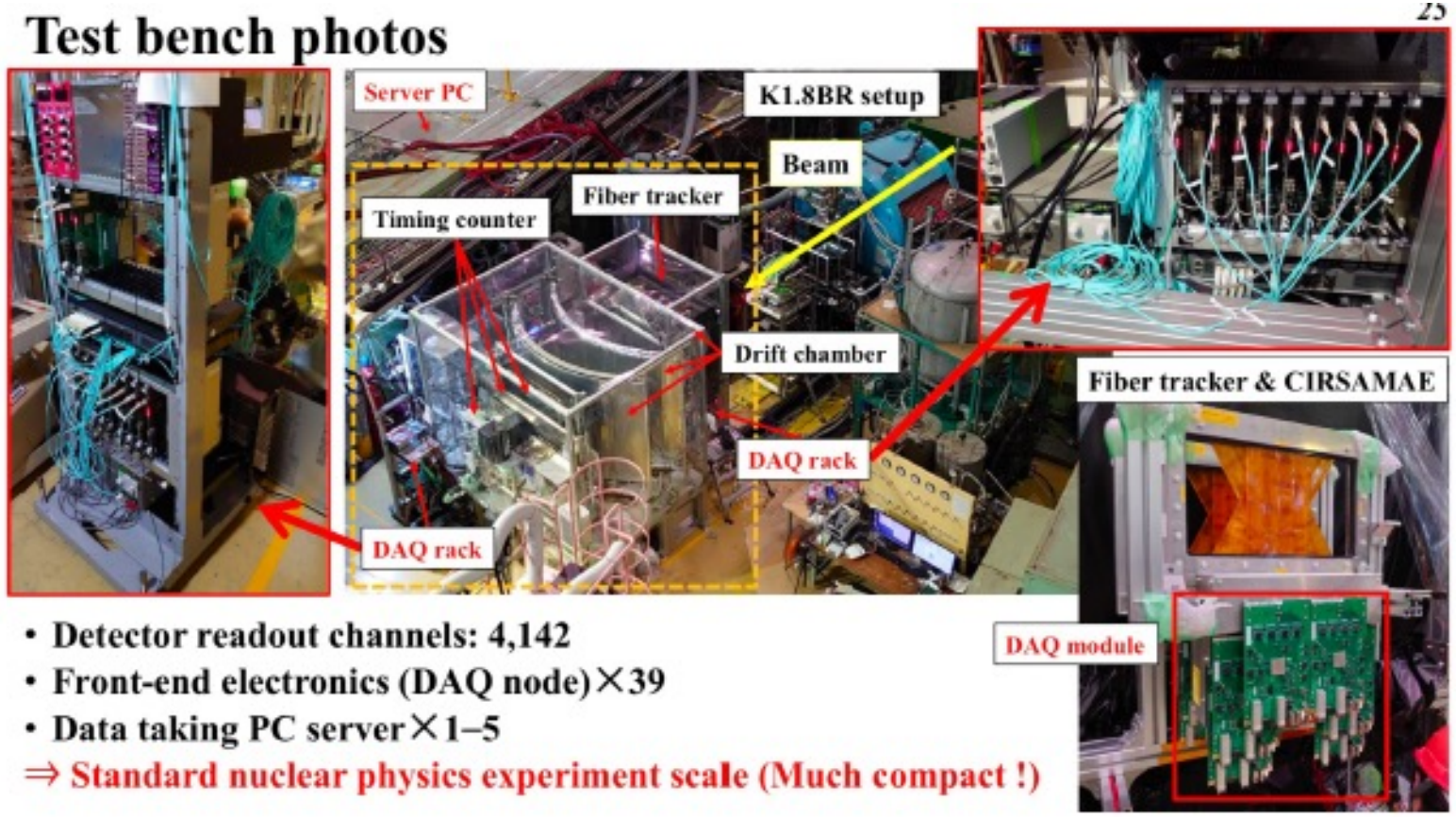
Courtesy of Sirotori et al.

Resent test at J-PARC: Subset of E50 detectors in the Testbench (MARC T103)



- Missing mass method: $\pi^- + p \rightarrow Y_c^{*+} + D^{*-}$
  - 20 GeV/c π^- beam @ 30 Mcps
  - $\rightarrow K^+ \pi^- \pi^-$



- Detector readout channels: 4,142
- Front-end electronics (DAQ node)×39
- Data taking PC server×1–5

⇒ Standard nuclear physics experiment scale (Much compact !)

- Tracking detectors: BFT, SFT(Fiber tracker), KLDC, BDC(Drift Chamber)
- Timing detectors: UTOF, LTOF, DTOF, T0, (UTOF used as target), T1 from E73

Online filters in NestDAQ

Courtesy of Sirotori et al.

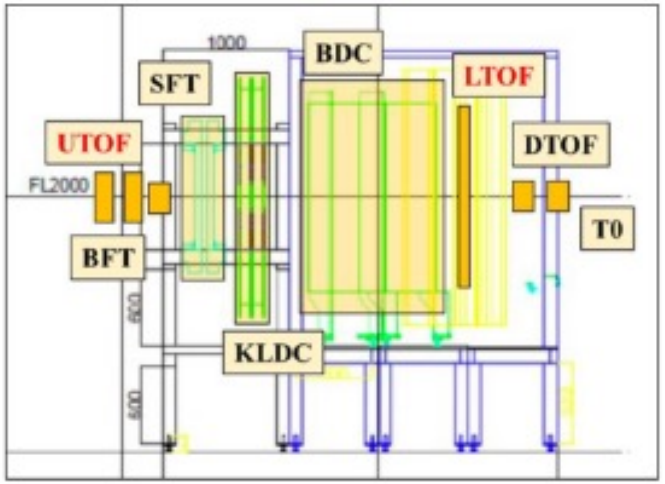
T103 at J-PARC

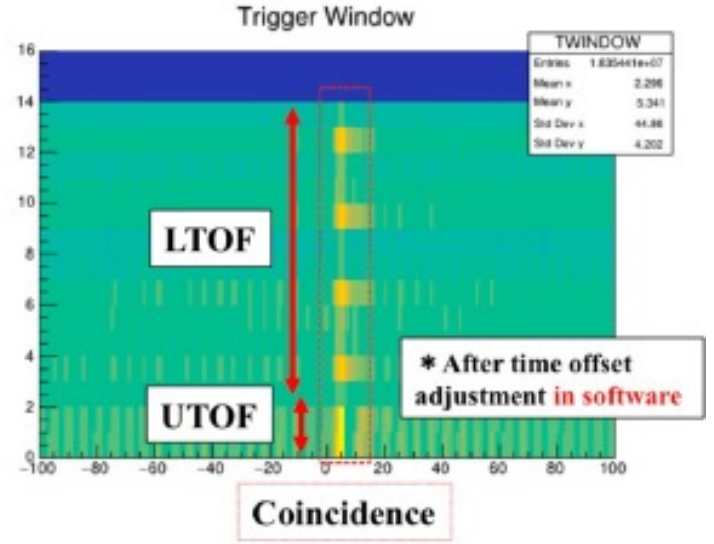
- **TFB: Reconstruction of time frame from HBF**
  - ✱ **Free streaming data taking**
  - **~100% efficiency and stable operation @ ~1 M/spill**
  - **Averaged data rate in 4.2 sec. spill: ~130 MB/s**
  - **Decimation data: Pre-scaled no bias data**

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

⇒ **EventSlicer: Event finding from "Trigger timing"**
- **Slicing window from "Trigger timing": ±1000 ns**
- **Timing group in Slicing window = "Event" generated**

⇒ **High-level Filter: Event selection using "Event"**
- **"Event selection like an off-line analysis" can be performed.**

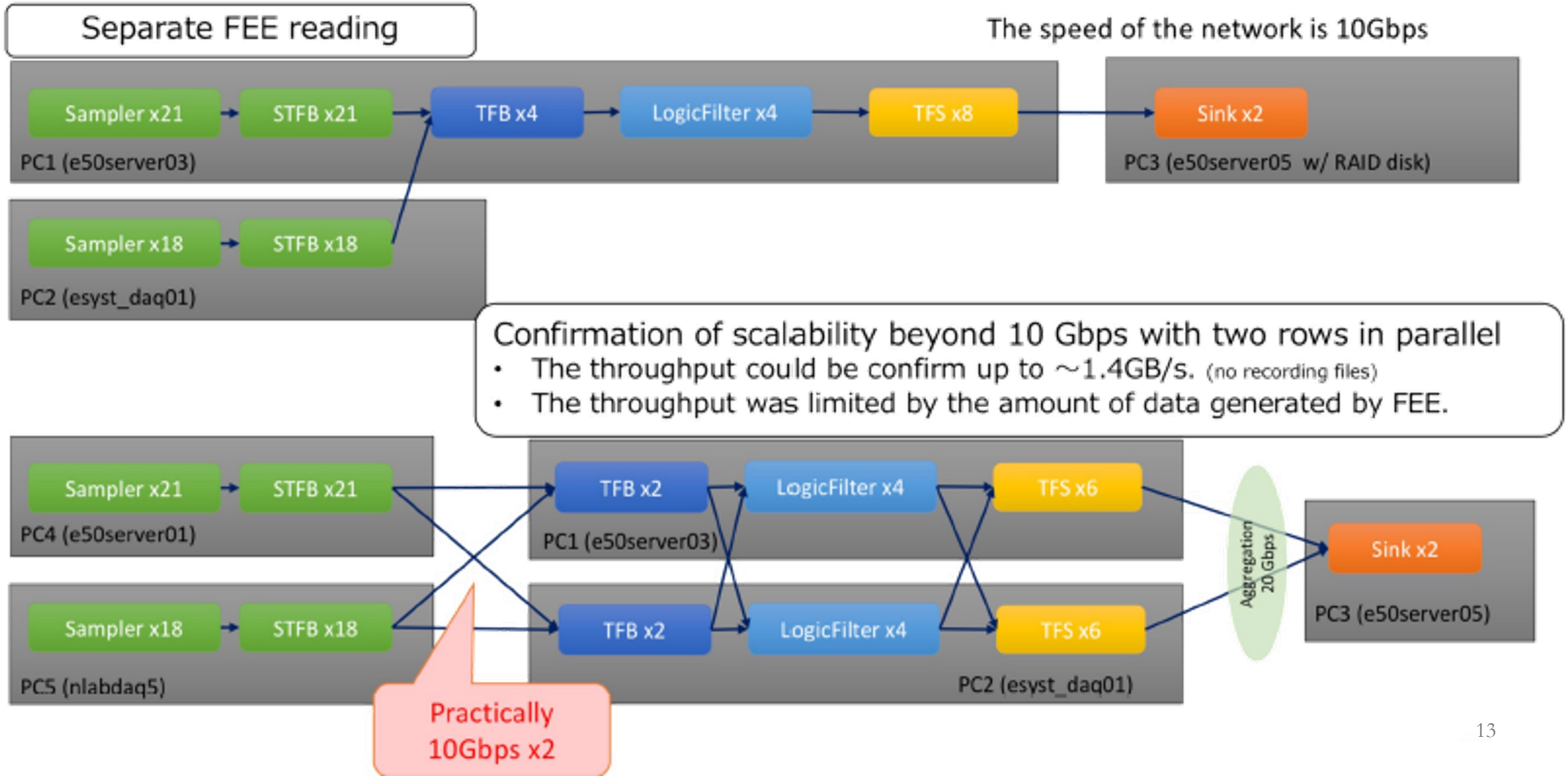




Scalability tests of NestDAQ

T103 at J-PARC

Multi-PC setup (2:1:1, 2:2:1) and stress tests with >10Gbps



Interfacing NestDAQ and ARTEMIS

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ARTEMIS: software framework to analyze the physics data

- ✓ CERN ROOT base
- ✓ Parallel processing
- ✓ A lot of convenient routines

NestDAQ provides FairMQ (ZeroMQ) interface

- ARTEMIS was easily connected

Towards Interfacing NestDAQ and JANA2/EICRecon?

- If the data format and protocols are decided, JANA2/EICRecon would be naturally connected
- RCNP group plans to have discussion with Kumaoka-san from QNSI/U-Tokyo, who is working on the streaming reconstruction using JANA2/EICrecon.

Next plans for ePIC

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- Development of NestDAQ for ePIC
  - Interface with DAM and GTM
  - Interface with SC system and DB
  - Interface with Calibration and EICRecon framework

- How to make contributions?
  - Now following up discussion in EIC and ePIC collaboration
  - Tomonori Takahashi from RCNP stays at BNL
  - Several server computers have been already prepared
  - Ready to develop the mini-echelon2 in Japan

In order to proceed,

Let us discuss the plans with you!

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NestDAQ Ver. 2.0

Developed by WG3: T. N. Takahashi et al.,

Majer updates toward large-scale system

- Process management
- Orchestration
- WWS: Workflow management System
- DDM: Distributed data management
- Observability
- Online filtering using accelerators (GPU, FPGA)

Other minor things

- Including waveform digitizer (FADC)
- Improving (Sub)Time-frame building
  - Incomplete (Sub)Time-frame building
  - Dynamical plug-in/out for auto-recovery
- Adequate data discarding to reduce back-pressure

NestDAQ updates

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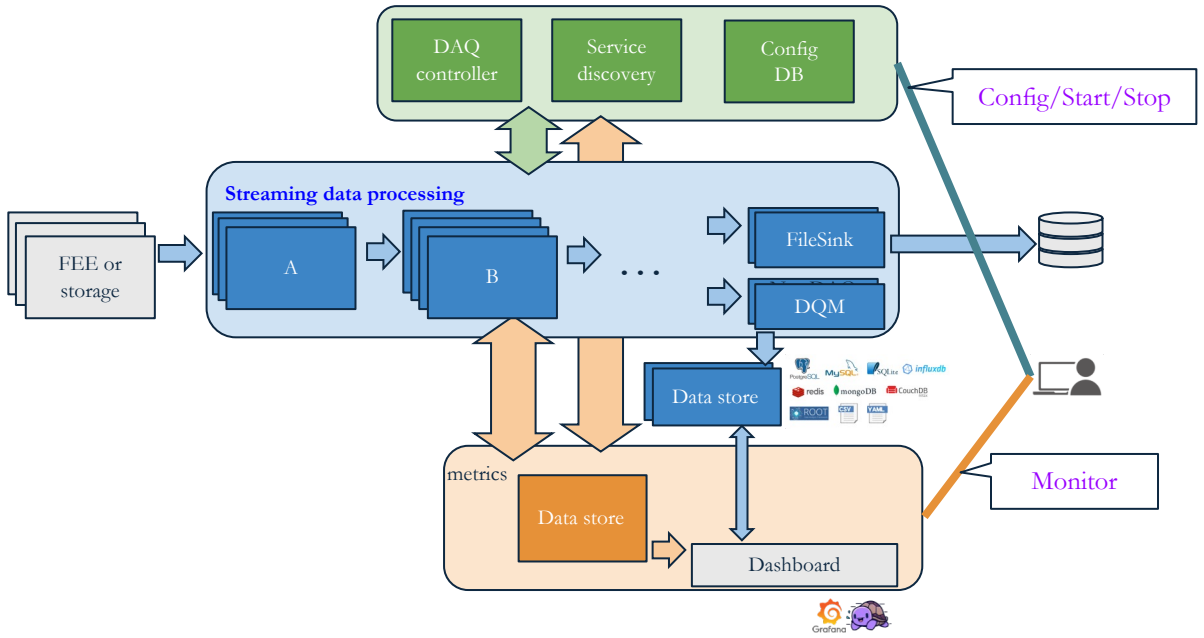
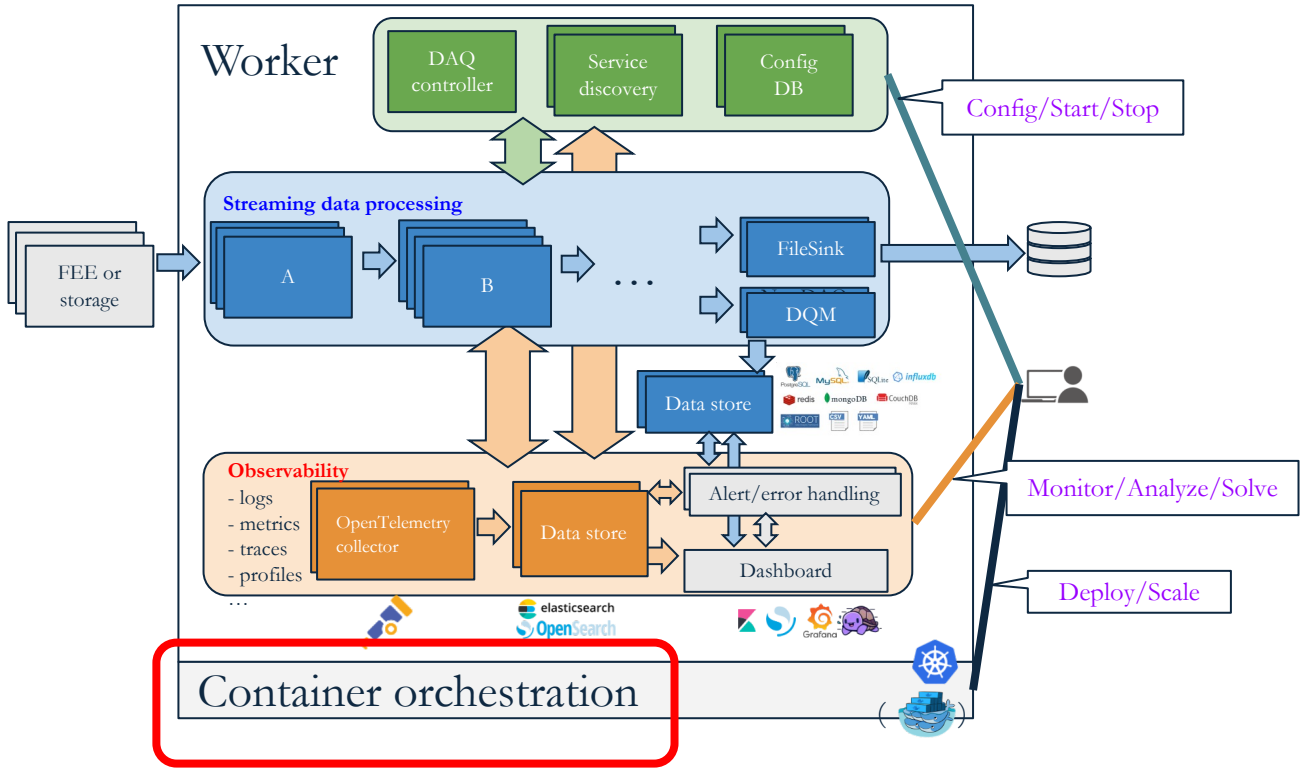
Ver. 1 vs. Ver 2.0





Manually restart a process if it die

Key feature in Ver 2.0
→ Automatic process / workflow management

Interfacing NestDAQ and FEEs

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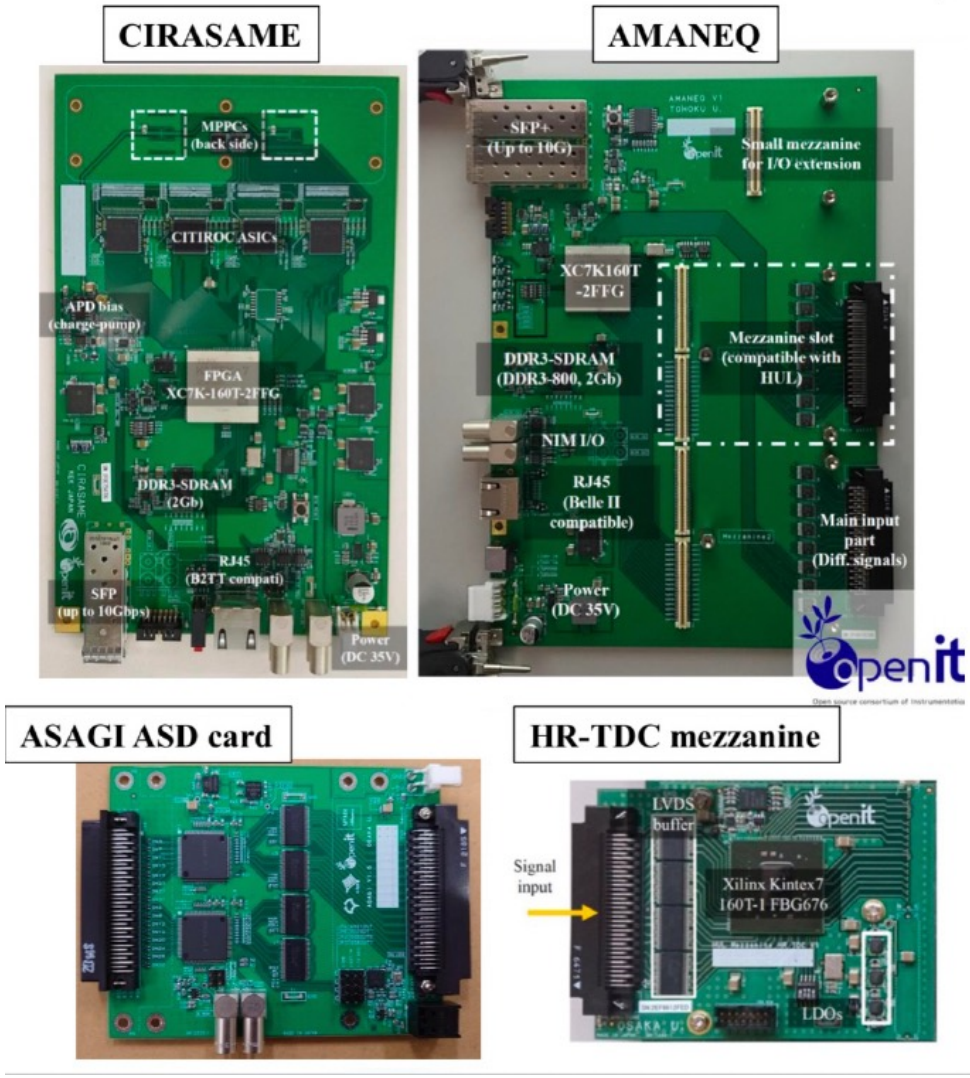
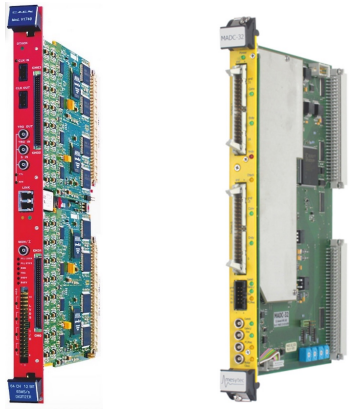


- ✓ Already we have experiences to use variety of FEEs developed in Japan
- ✓ Combination of NestDAQ and conventional triggered DAQ with commercial base FEEs
  - ✓ CAEN dizitizers
  - ✓ Mesytec VME modules



- ▶ NestDAQ has capability to interface FEEs
  - ▶ Collaboration with detector groups in EIC-Japan?

Timeline

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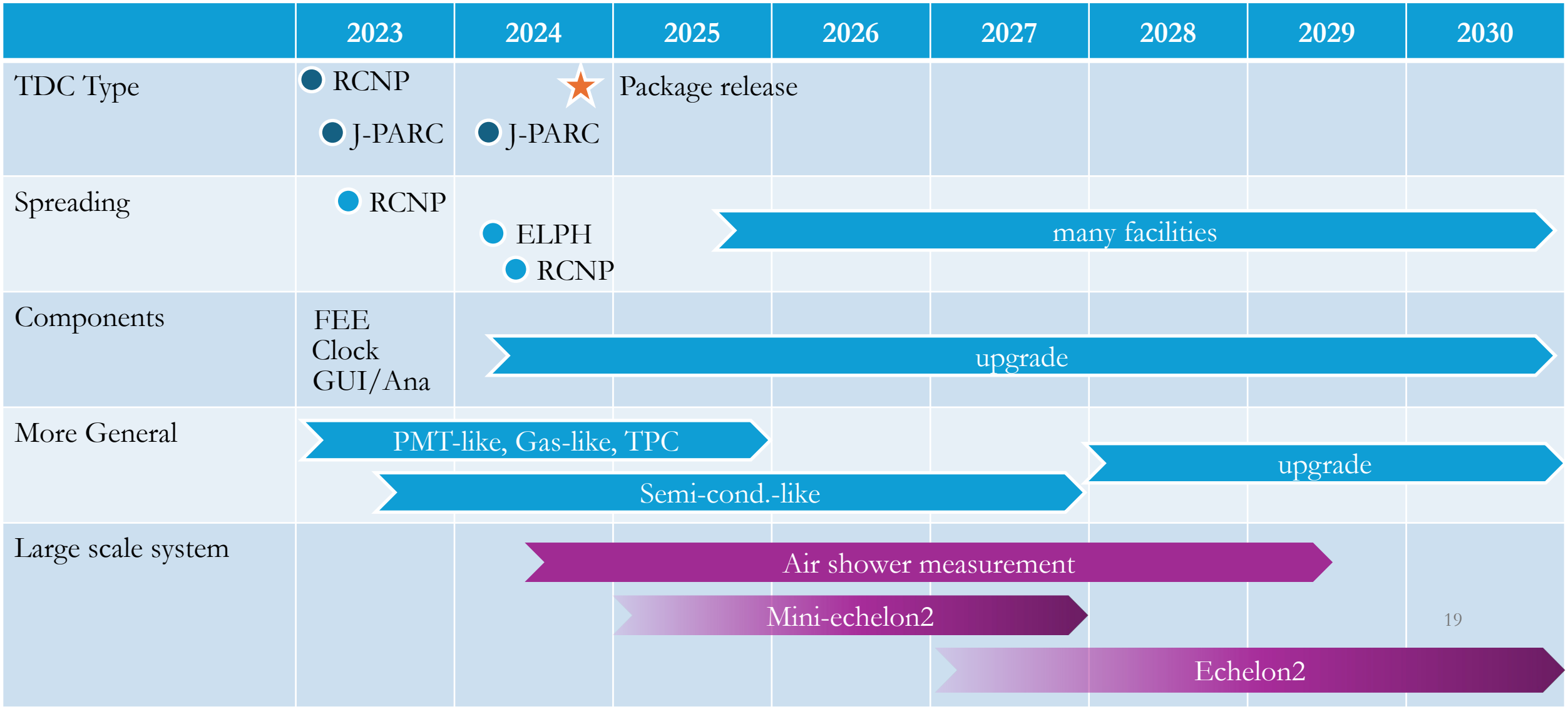

Summary and outlook

- ✓ NestDAQ developed by SPADI Alliance
  - ✓ Good performance
    - more than **40 times faster** event rate
  - ✓ A lot of experiences
    - ✓ Used in many physics experiments and worked well

- ✓ Toward large scale system
  - ✓ NestDAQ ver. 2 is under development
  - ✓ Interfacing JANA2/EICrecon, ARTEMIS, and other softwares

- ✓ EIC-Japan and SPADI-A
  - ✓ NestDAQ can interface also FEEs
    - → Collaboration with detector groups in EIC-Japan?

Thank you for your attention!