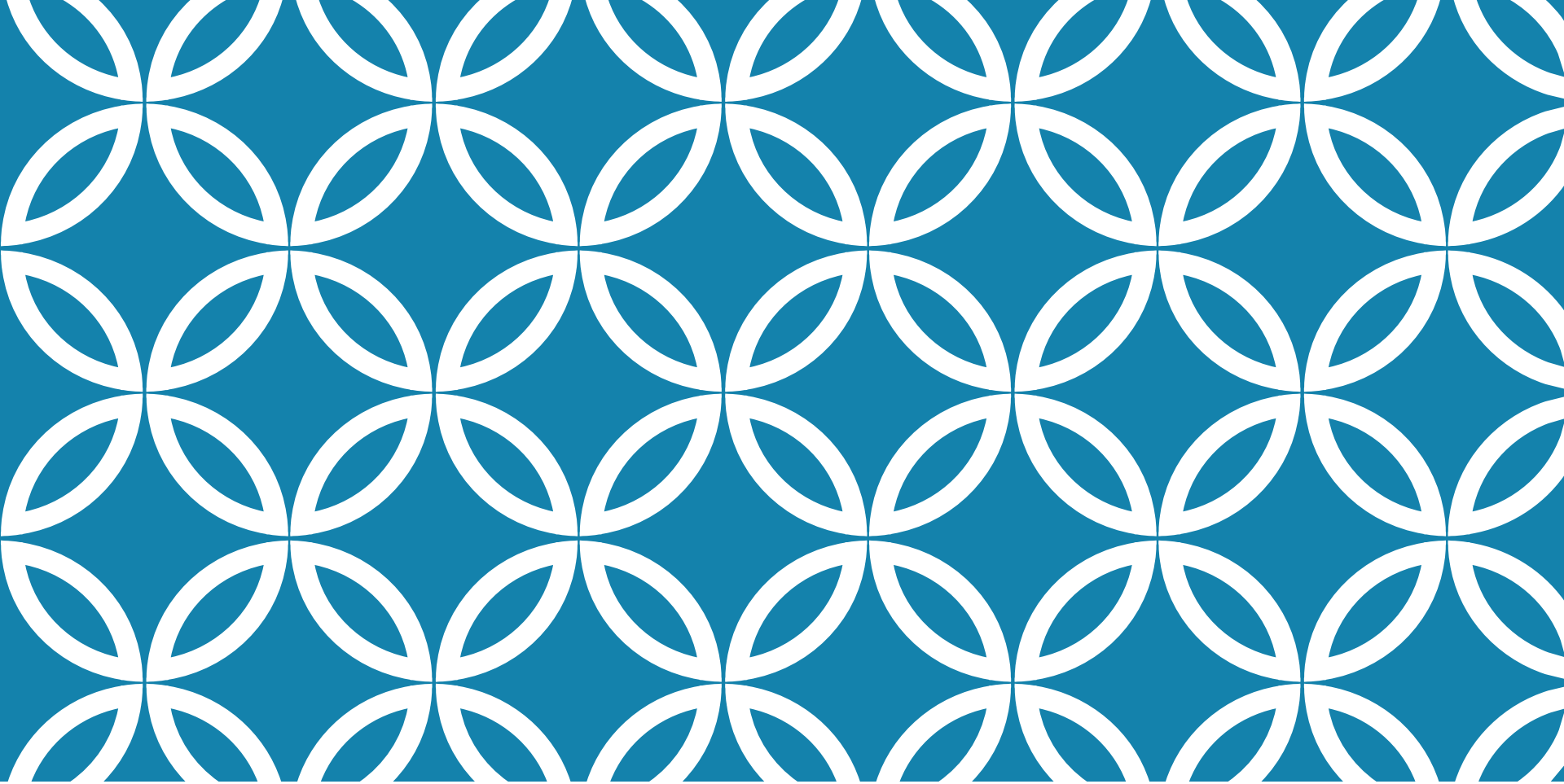
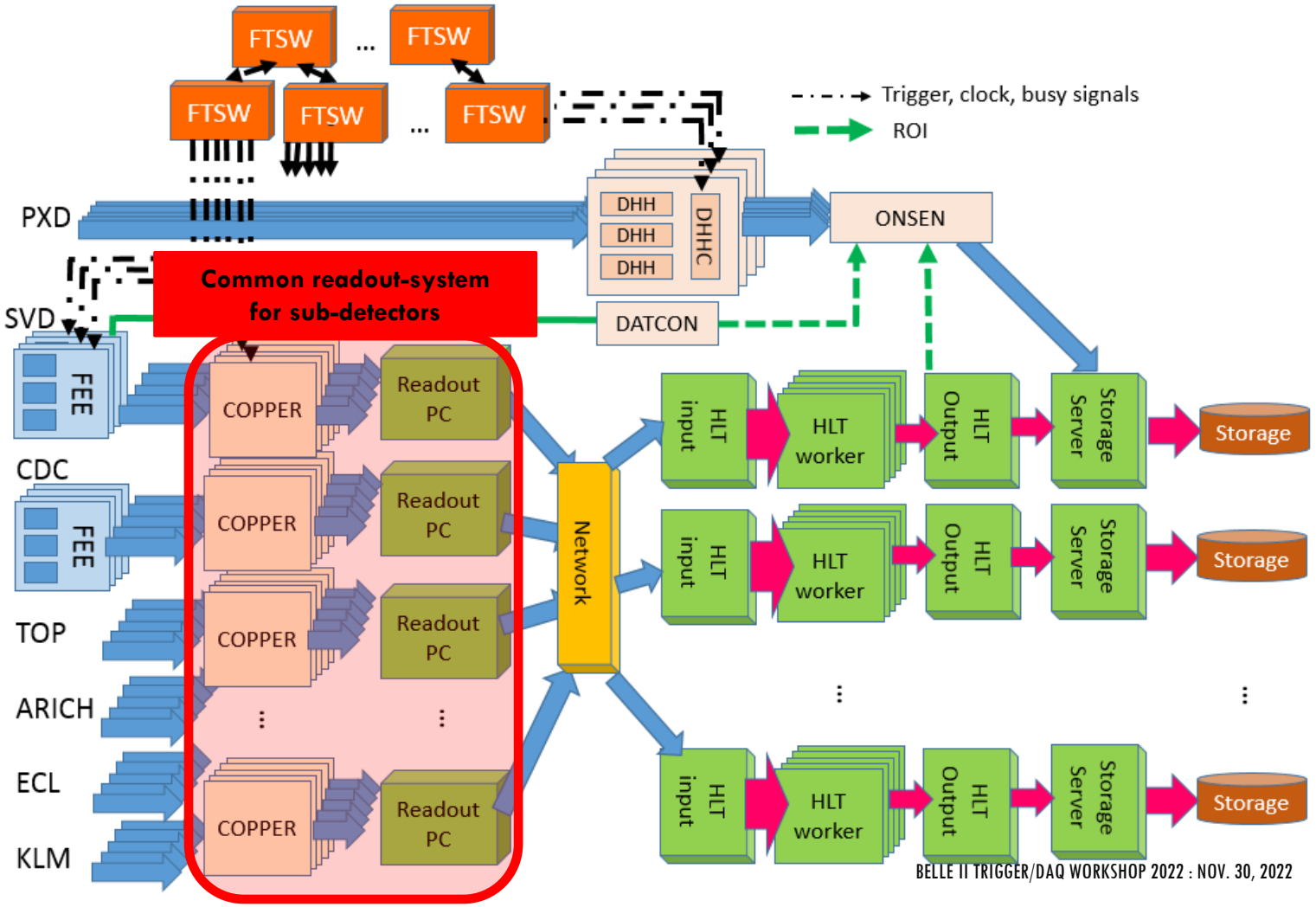


HISTORY OF COPPER BASED READOUT

S. Yamada (KEK)

READOUT SUBSYSTEM IN BELLE II DAQ

- Readout data from FEEs of six sub-detectors
  - Receive data from FEE
  - Formatting, data-checking and partial event-building
  - Send data to event builder(eb1) and HLT

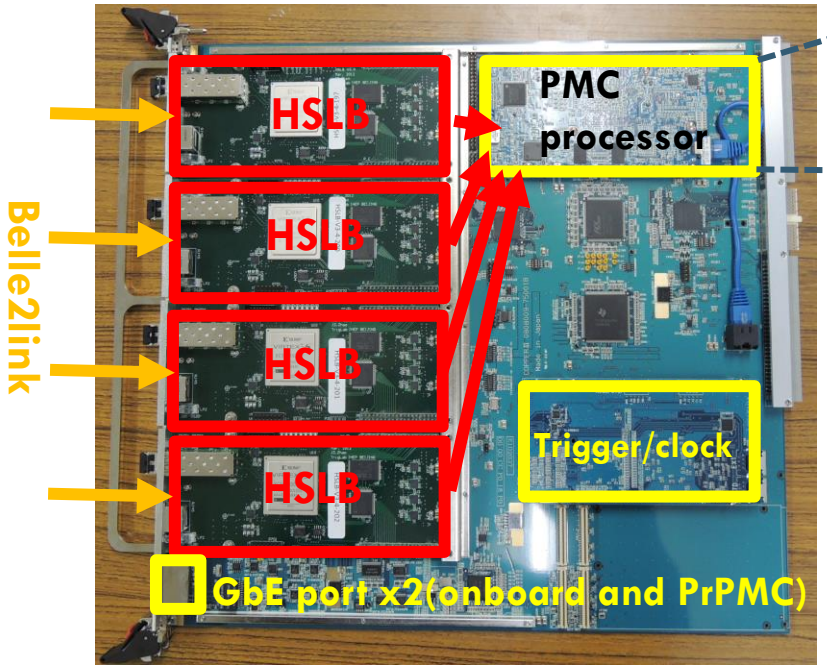


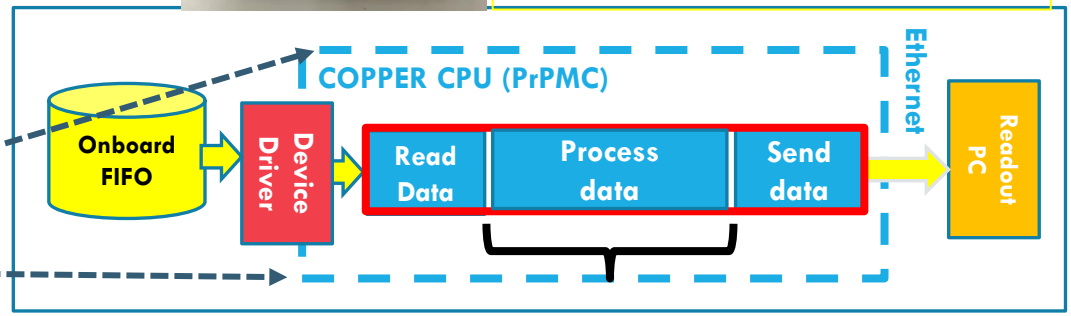
DATA PROCESSING ON COPPER READOUT BOARD

- Readout board : COPPER (COmmon Pipelined. Platform for Electronics Readout)
  - Versatile DAQ board developed at KEK
  - can be equipped with various I/O cards and CPU card
    - HSLB : Data receiver
    - TTRX : communicate with the trigger timing distribution system
    - PrPMC : Data processing

- CPU: Intel Atom 1.6GHz Z530P
- DDR2 SDRAM 512MB
- PXE boot from ROPC
- Gigabit Ethernet x1

COPPER board

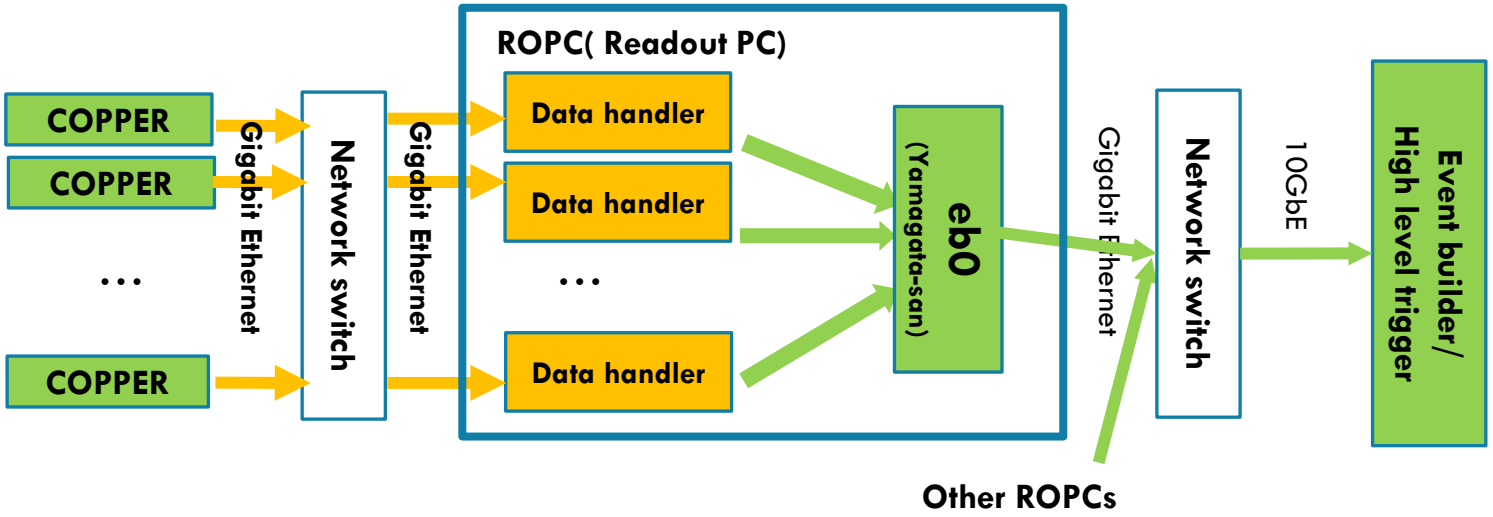




- **Data processing on COPPER CPU**
  - Data formatting (Add header and trailer to raw data)
  - Plain data check
    - Event # incrementation, check magic word etc.
  - Add XOR checksum
  - Report data-flow status to slow control

DATA PROCESSING ON READOUT PC

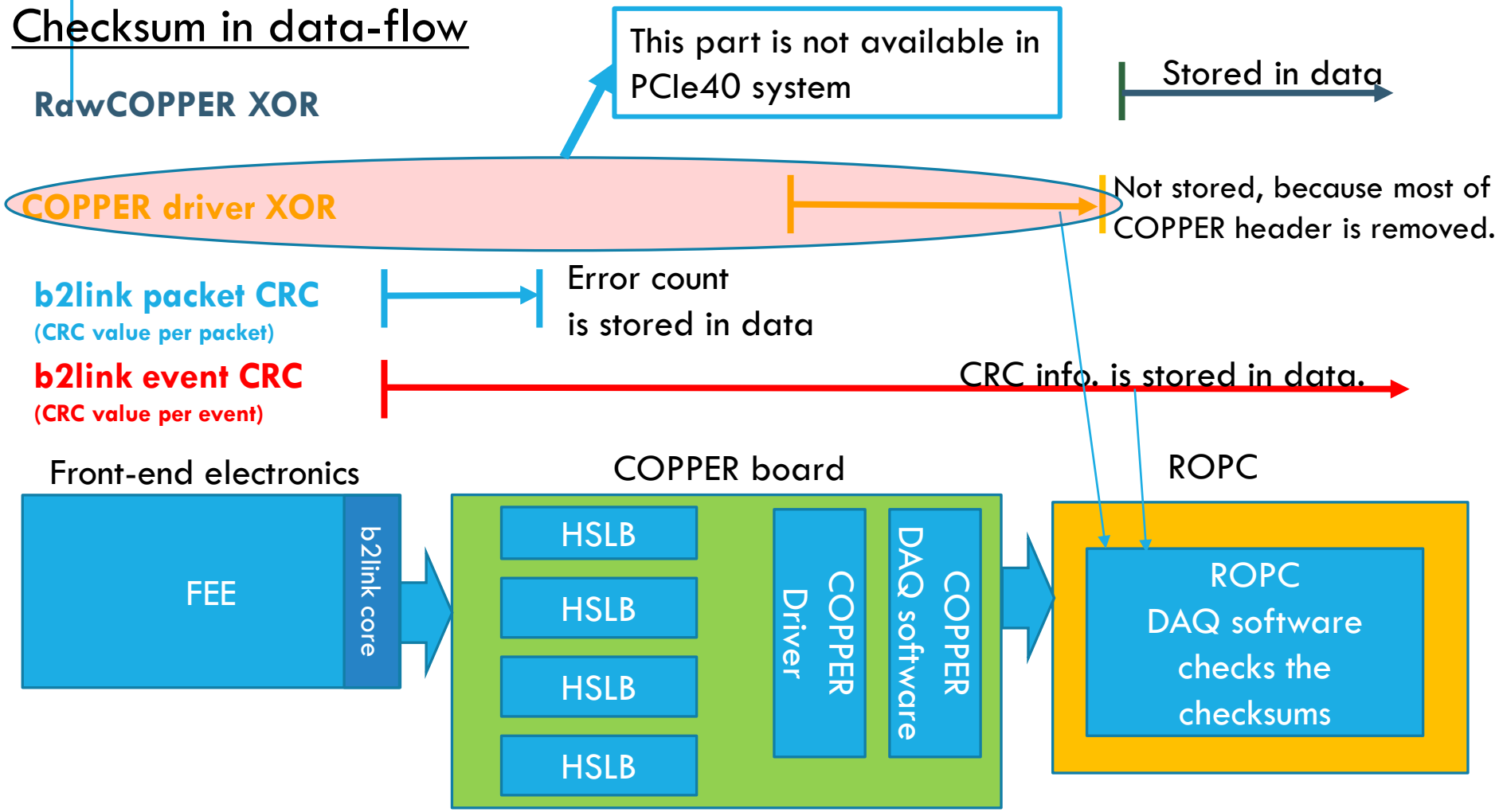
- Several COPPER boards are connected with a ROPC(readout PC) via Ethernet
- DAQ process for each COPPER data stream is running and doing the following;
  - data check
    - Calculate CRC16 and compare CRC value attached by FEE
    - XOR checksum calculated by software on COPPER
  - Data size reduction
    - merging redundant header/trailer attached by b2link and COPPER
    - Reduction by 15MB/s/ROPC at 30kHz trigger rate(<- 5COPPERs/ROPC, 4HSLB/COPPER)
- Eb0(event builder 0) performs partial event-building and send data to an input node of HLT.



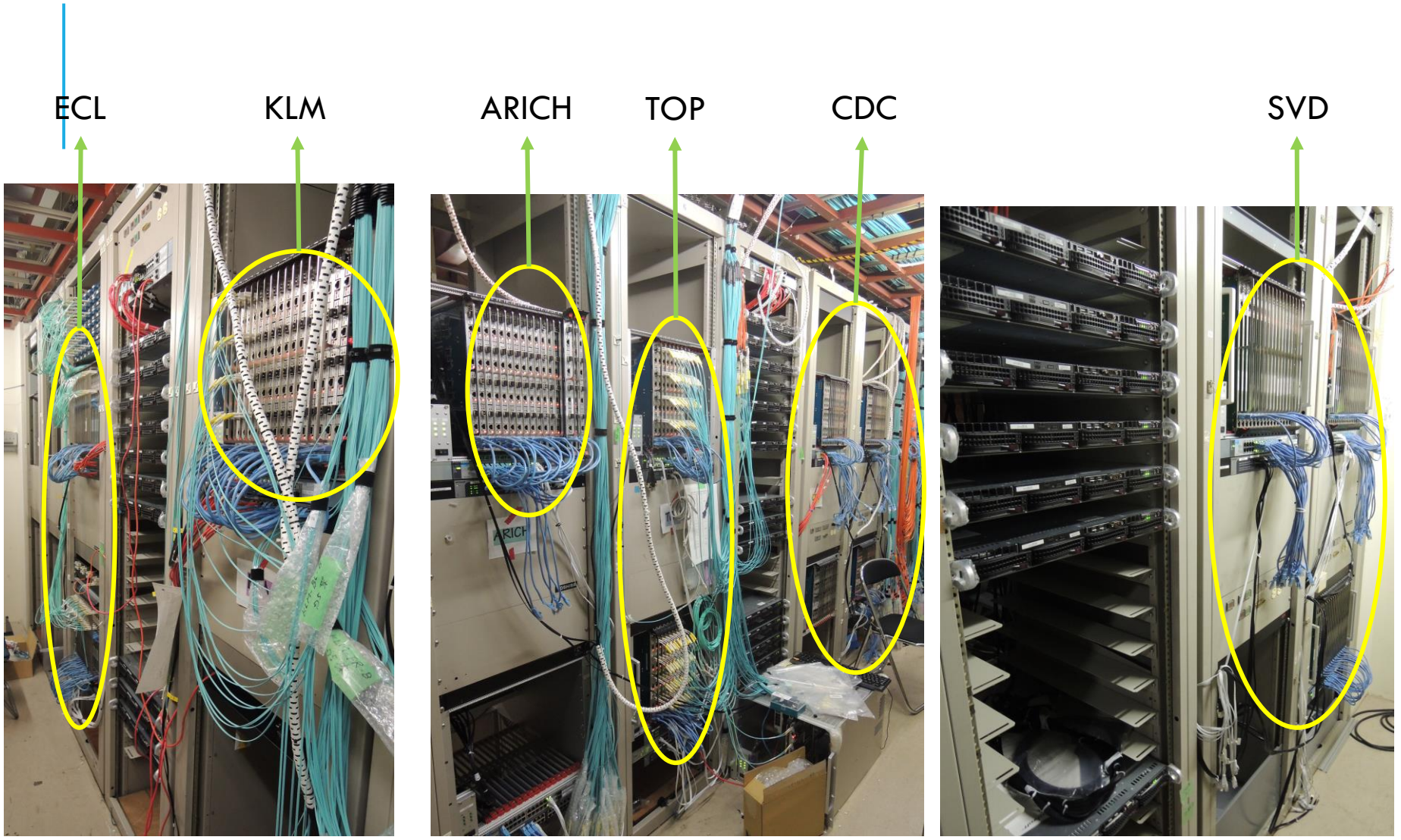
DATA VALIDITY CHECK ON READOUT-SUBSYSTEM

Data corruption after b2link is checked by readout system.

Checksum in data-flow



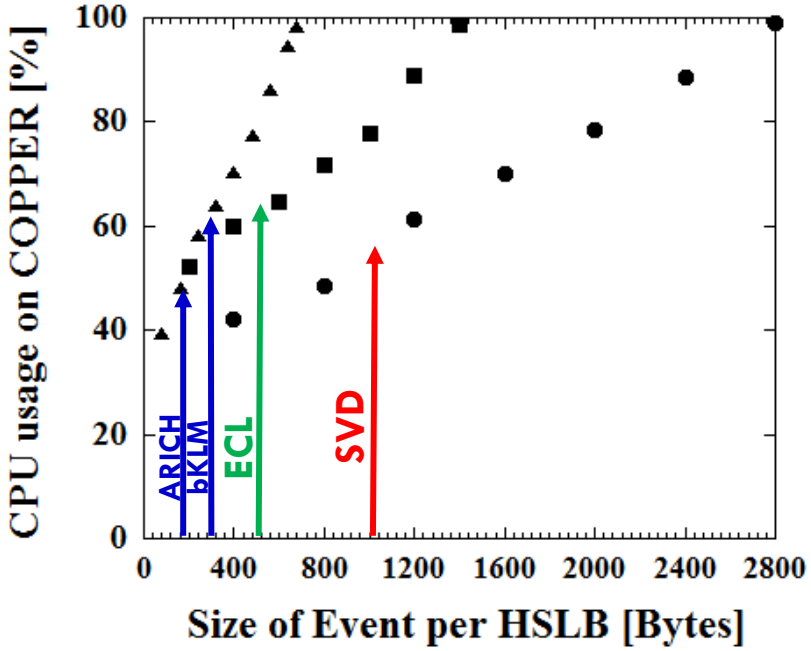
COPPER modules in E-hut



Performance of COPPER readout system

Trigger rate = 30kHz

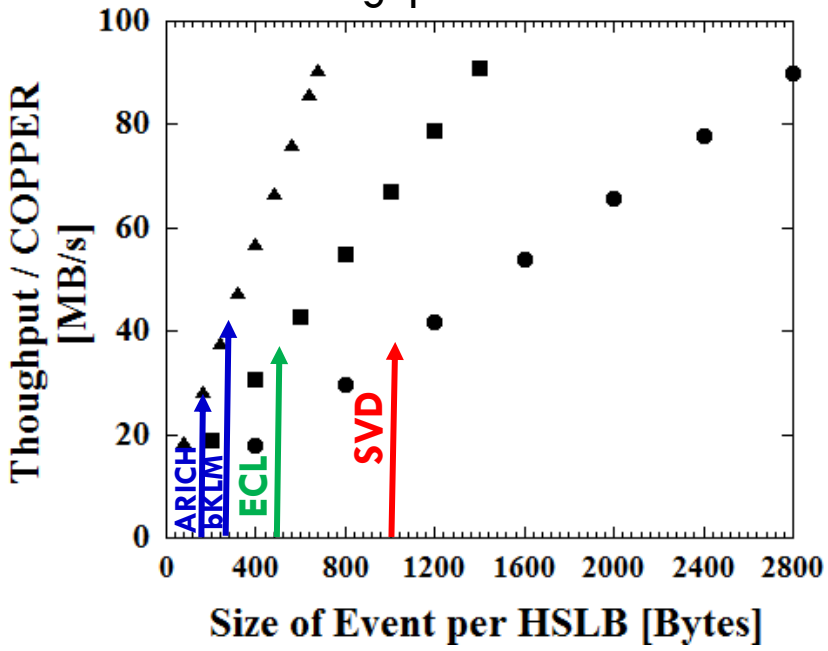
COPPER CPU usage



(w/o DAQ overhead)

Trigger rate = 30kHz

Throughput on COPPER



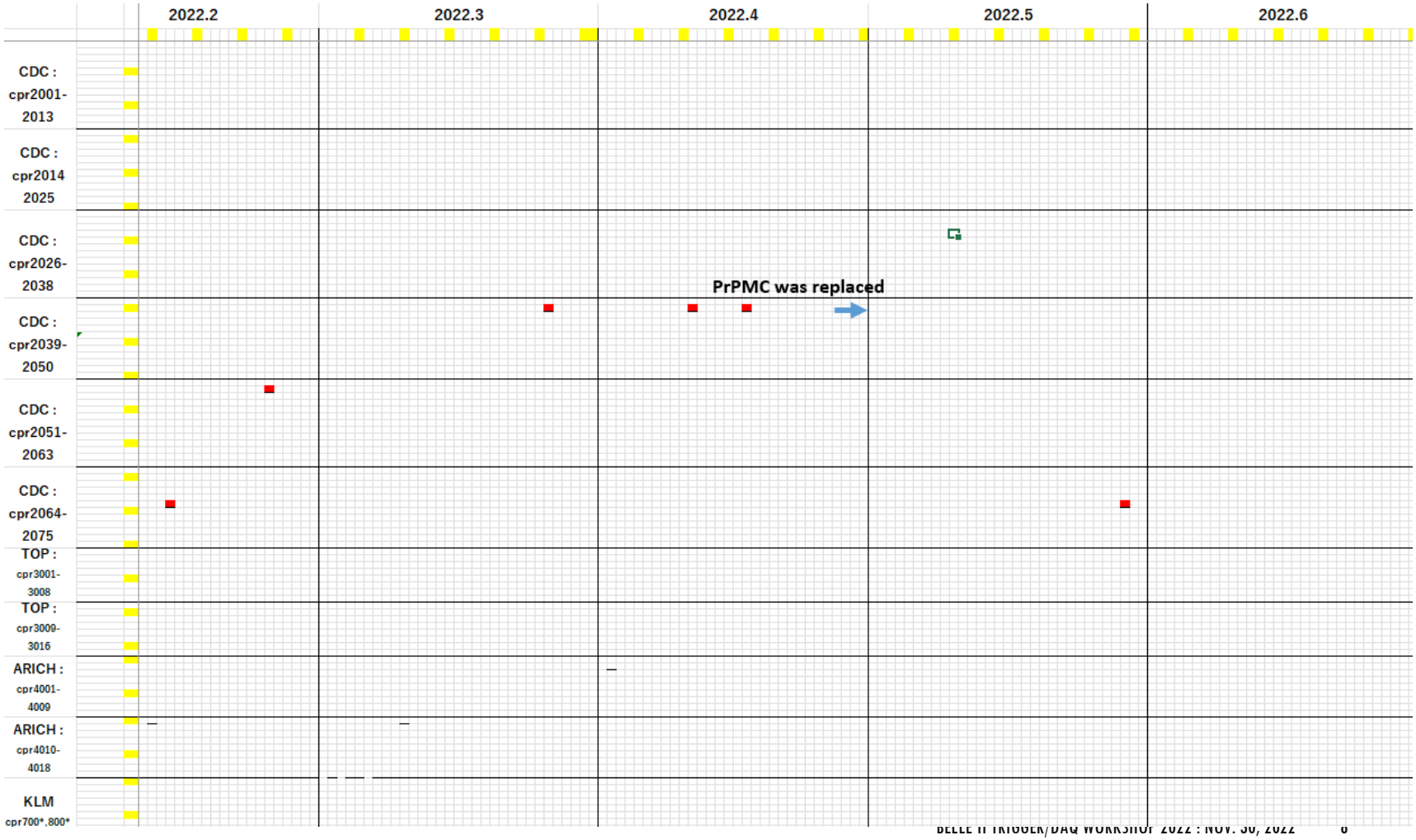
(w/o DAQ overhead)

- SVD arrow uses the largest event fragments over 48 FEEs (-> layer3).
- Other sub-detectors arrows uses averaged value over all FEEs.

➢ Actually, the bottleneck is usually the bandwidth from ROPC(GbE) to HLT.

REMAINING TROUBLE : FREEZING COPPER-CPU

- This issue only happens in CDC, TOP, ARICH and KLM.
  - Their COPPER board is equipped with 4 HSLBs
    - SVD : 1 HSLB, ECL and TRG : 2 HSLB
    - So, it might be related with power-consumption ?



HISTORY OF THE COPPER-FREEZING ISSUE

2013 : kernel? -> fixed

- CPU froze when processing high-rate data.
- Fixed by installing light-weight Linux kernel (disable unnecessary options)

2016 : high temperature -> fixed

- CPU automatically reboots sometimes.
- CPU temperature rose more than 70degree. Air-flow in racks was changed to cool COPPERs and the problem is gone.

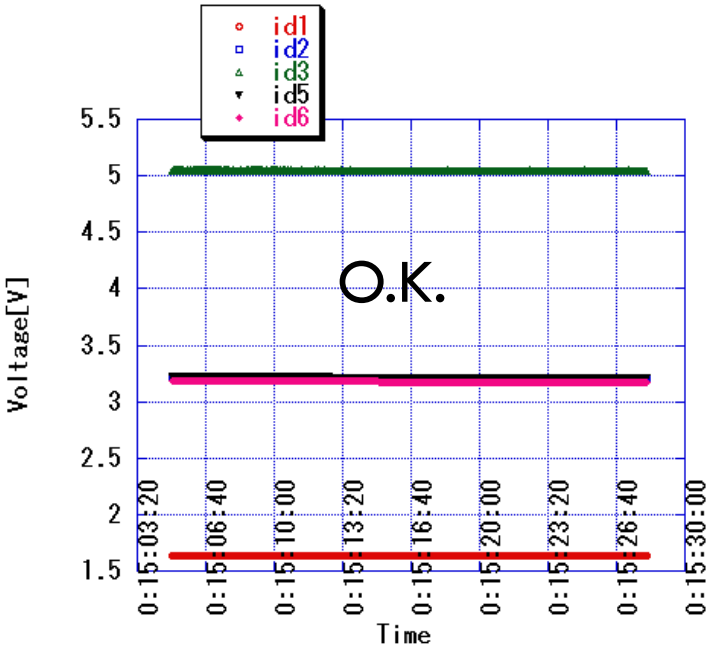
REINFORCING POWER-SUPPLY OF COPPER CRATE

CPU freezes when the following conditions are fulfilled.

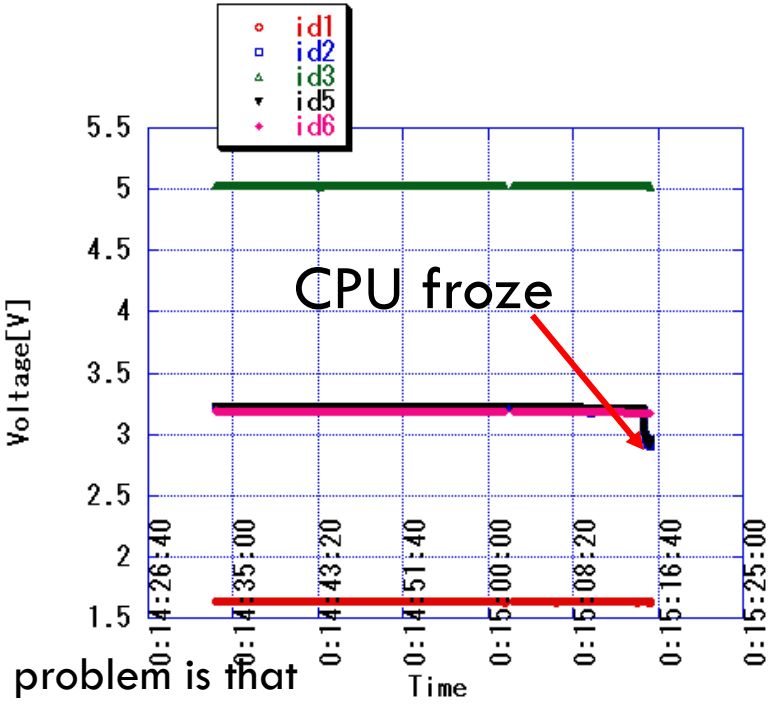
- # of COPPERs in a VME crate is larger than 13. (For some crate, the number is 12.)
- Each COPPER board is equipped with 4 HSLBs.
- HSLB firmware is downloaded.

When monitoring the voltage input to a PrPMC, 3.3V becomes unstable after downloading firmware.

# of COPPER = 13, 4HSLBs/COPPER



# of COPPER = 15, 4HSLBs/COPPER



Even after that, this happens time to time. The problem is that recently the error rate seems to be rising.

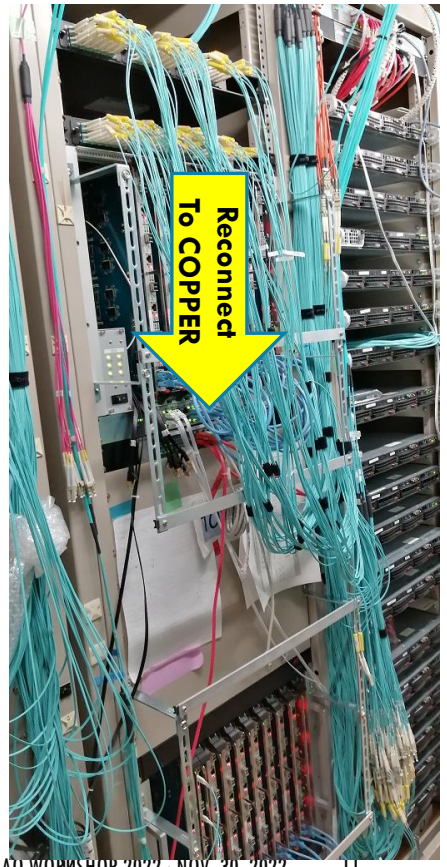
COPPER SYSTEM AS BACKUP (1)

- Switching between PCIe40 and COPPER
  - It was frequently done on maintenance days for a readout test of PCIe40 system.

- Procedures
  - Switching fibers on PCIe40 patch panels to COPPER boards
  - Turn off slow-control processes in PCIe40 ROPCs and Turn on SLC in COPPER ROPCs
  - Restart HLT software with COPPER configuration for eb1rx connection
  - Switch run-control GUI

- Switching during physics run
  - During the 2021c physic run, we rolled back to TOP COPPER system when TOP slow-control error happened.
  - PCIe40 -> COPPER : about 4hours
  - COPPER -> PCIe40 : about 2hours on a maintenance day

TOP COPPER rack



COPPER SYSTEM AS BACKUP (2)

- Currently, we keep the COPPER system for every sub-system in E-hut
- COPPER boards : ～210
  - HSLB -> spare boards < 10
  - Atom CPU
  - TTRX board

We still have some tens of spare cards except for HSLB.

- COPPER Readout PCs : 43
  - disk troubles : HDD will be replaced in LS1
    - Sep. 27 : svd01
    - Oct. 15 : klm01
- We have not decided how long we will keep the COPPER system as backup.

SUMMARY

- COPPER based readout system has been used for Belle II DAQ since 2018 beam run.
- It has been stably running was not a bottleneck so far.
  - Remaining issue is CPU freezing problem.
- Replacement with PCIe40 based system is ongoing.
  - All readout system except for PXD will be replaced in LS1.
- Keep COPPER system in E-hut as backup
  - maintenance of hardware is needed.
  - It is not decided how long we will keep the system.