READOUT (STATUS AND UPGRADE)  S. Yamada (KEK)
READOUT STATUS
### PXD Status – Short Overview

- Only ½ of PXD (20/40) modules installed
  - Two broken, damages on others
  - Only half of readout used (only ½ DHH and ½ of ONSEN powered off)
- Mostly stable data taking
  - 5kHz real data, 10kHz DAQ test, 35kHz with dedicated tests
  - Event selection on HLT (and ONSEN!) turned on now (event reduction to ~10%)
  - ROI selection tested in few runs (for half the modules → DHE order)
- Overlapping trigger firmware deployed during phase 3
- Only Belle 2 trigger veto for continuous injections, no gated mode (yet)

### Overview of Main Issues

- Long HLT startup time, long buffering and processing times for some events (up to 2 minutes!), challenge for ONSEN buffering → full → trigger busy at each run start
  - HLT does not clear buffers and/or worker nodes crash → for some events we never get triggers → still in memory at run stop
- NSM timeout EB/HLT → PXD seen as excluded (seems to be solved)
- “HLT before DHH” ← no data sent anymore from DHH (in most cases)
  - Firmware and/or ASIC issue
- Not all problem come from PXD even if PXD notices an error
- DHH firmware was updated/changed several times
  - PXD Busy and data corrupting happen with some versions
  - Different reasons → fixed with latest versions
- Lost 25% of data because of wrong trigger delay setting in early phase 3
- One optical link (of 80) went dead in June

Will be tested in September according to Igor-san’s talk
However, we found a couple of problems

1. L6.14.2 sensor current increase
2. SVD COPPER stuck due to large SVD data
3. FTSW APV trigger veto problem at high trigger rate

2. Data size limitation in FEE -> to be tested after IBBelle recovery
   HSLB firmware modification should be done for safe.

3. The cause was found. Considering a way to keep both data quality and high-rate processing.

We found the problem is related to a latency setting in APV25.
- Thanks for the great efforts of Takuto and Hikaru!
- By the beg of 2019 spring run: the latency setting was 4.967usec. (lat=158)
- During 2019 spring run: the latency was changed to 4.998usec. (lat=159)
- With lat=158 the error never happens, while with lat=159 the error appears.
  - lat=159 is cutting edge of the APV25 operational range.
  - No degradation seen in the SVD performance under a few kHz trigger rate.

<table>
<thead>
<tr>
<th></th>
<th>SVD data size [kB/event]</th>
<th>SVD data rate @ 15kHz [MB/s]</th>
<th>SVD data rate @ 30kHz [MB/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>COPPER</td>
<td>max. ~ 2.3</td>
<td>max. ~ 35</td>
<td>max. ~ 70</td>
</tr>
<tr>
<td>ROPC</td>
<td>max. ~ 11</td>
<td>max. ~ 170</td>
<td>max. ~ 350</td>
</tr>
<tr>
<td>EB1</td>
<td>~ 84</td>
<td>~ 1200</td>
<td>~ 2500</td>
</tr>
<tr>
<td>HLT/Storage</td>
<td>~ 84</td>
<td>HLT rate ~2.5kHz</td>
<td>HLT rate ~5.0kHz</td>
</tr>
</tbody>
</table>

~ 210 ~ 420
Extrapolation to high luminosity

- Data size was extrapolated to $10^{34}$ cm$^{-2}$s$^{-1}$ and $10^{35}$ cm$^{-2}$s$^{-1}$.

- Bottleneck due to 1Gbit ethernet cable is 125MB/s.

- Under high trigger rate =30kHz, bottleneck corresponds to about 4kB/event for each readout pc.

- When current data is extrapolated to luminosity= $10^{35}$ cm$^{-2}$s$^{-1}$, data size would be below 4kB/event.
  - If extrapolated to $8 \times 10^{35}$ cm$^{-2}$s$^{-1}$, data size>4kB/event.

- Luminosity is not high in experiment 8.
  - Is extrapolation valid for high luminosity?
B2link error

- 7 FEIs are masked during phase-3 physics run
  - #247,204,218 (b2lllost): fixed once ~2 years ago, but appear again
  - #37,193 (b2lllost): new
  - #97, 115 (ttlost/crc error/b2link error): new. It was occurred when we had resumed operation with Belle solenoid turned ON

- Zhou-san and Nanae-san investigated link status with IBERT.

Error signal from FEE

- Operation with included in GLOBAL (Apr. 1 - June 30)
- Errors
  - rerr x13
  - fifoerr x9
  - semmbe(multi bit error) x1 (20190503, ~14:00), FE#20

- Mostly occurred inner part?
- Study for relation with radiation is ongoing
  - Background level measured by diamond sensor and neutron detectors
Swing test result

- The b2llost links show bad eye diagram, while the b2lerror links show normal eye diagram.
- By swapping the fiber on HSLB side, RX of fiber data transmission on the HSLB is working well.

FEE -> HSLB direction. -> Clearly worse than the normal link.
Establish a way to check link condition, by measuring stable range in delay-scanning.
Readout Status

- SCROD CPU crashes at ~1 BS/day
  - Recover by powercycle of the frontend (~20min)
  - Strong dependence on background conditions: happens more often when background rates are high and “spiky”
  - Don’t the know the exact reason, difficult to debug, cannot reproduce reliably
  - Maybe SEUs? Implementing SEU detection cores and DDR error checking into FW now. (but issue also happens in null runs without beam, though very rarely)
- Some ASICs self-masking in some runs (no response from ASIC within timeout)
  - Negligible hit loss, mostly recovered on run restart/SALS
DAQ Problems in phase3: initialization

- In cold-start, we need to booths (re-programming HSLB) after re-configuring Merger.
  - Otherwise, 8-bit data shift problem will happen.
  - As far as I confirmed, only ARICH needs it. (CDCFE is also virtex-5 GTP)

- When the data shift happens, FIFO will stop being filled. 00ff is the pattern taken from an empty FIFO inside HSLB.
**ttlost problem**

(ttlost happened for crate #4 just after power cycle or collector firmware reload.
After several ttlost the connection became stable.
After cable unplug/plug the problem has disappeared.
We continue to monitor the stability)

**Beam burst problem**

- If no ADC data recorded – no problem
- If steady run with ADC data record – no problem
- In case of bad injection or beam burst +ADC data record – ECL busy

Block ADC data when FIFO is still not almost empty. ->

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Run #1131 with ADC record was taken
- The described algorithm was implemented + scale to 30 kHz trigger
- The lost of the ADC data ~1.2% at 30 kHz
• RPC readout and (simple) scintillator readout basically running stably

Back-end Issues

• Intermittent BUSY from KLM COPPERs
  - When not recovered by SALS, requires rebooting all HSLBs to restore
  - Observed about once every 2 or 3 weeks
• Intermittent problems with HLT_KLM (e.g. elog/KLM/37)
  - Once at beginning of phase 3, turned out that old node or port numbers were being used
  - Once at end of Spring run, had to restart HLT_KLM
• Intermittent lock-up of COPPERs (e.g. elog/KLM/49)
  - Can’t ssh into one or more (usually one) of them
  - Requires restarting of COPPER
  - Observed at least twice in Spring run

• Power cycling COPPER crate does not automatically bring up FINESSE
  - Have to reboot ttrx/HSLBs
  - Observed near end of Spring run
Troubles during phase III
- Bug of event suppression logic for CDCTRG  
  Fixed
- B2L error of ETF  
  Masked
- Bit shift of B2L data from GDL  
  Fixed
- May 2019: VME parameter error  
  Temporal solution
- May 2019: LVDS connection error btw. GDL and GRL  
  Fixed
- BUSY from GDL  
  Reason is unknown
- Ttlost  
  Reason is unknown
- CDCTRG dataflow is down due to CDCFE or merger  
  Reason is unknown
- GDL lost signal from ETM.  
  Reason is unknown

GDL full readout plan in Autumn run

- GDL readout data is time integrated at present.  
  4bit(127MHz) -> 1bit(32MHz) to reduce data size.
- Full readout will be added in debug mode in Autumn run  
  - 4 B2L lines from one UT3 board
  - 4 more HSLB (cpr15003ab,4ab), 2 or more ropc, and 4 more FTSW are needed
  - firmware is being tested
  - apply scale factor to reduce dataname
Hardware task in COPPER/ROPC : todo before the fall run

Additional nodes
- TRG COPPER : 2 COPPERs (4 links)
  - Installation was done.
- TRG ROPC : Add trg03 (+trg04)
  - Installation of trg03 was done.
-> SLC setup is not yet done.

Network throughput
- SVD : Done before phase 3 (x2GbE)
- ECL : to do before the fall run

Replacement
- Cdc06 : frequent disk? Trouble
  - Replace with a new server
DAQ UPGRADE
MoU: Replacement timescale

- This schedule doesn’t reflect long summer shut-down in 2020 (TOP MCP-PMT replacement, other work)

|------|------|------|-----------|------|------|------|------|------|------|------|

- Proposal deadline
- Decision

- Could be shortened depending on budgetary situation and integration results.

- COPPERs are replaced detector by detector during summer shutdown period in 2020, 2021, and 2022.
- Short winter shutdown might be utilized for additional work.

- Implies requirement for recommment operation
- It seems that 3months shutdown is not enough for full replacement
  - readout test at test bench for all-subdetector might be also difficult, if delivery of new hardware will be near the summer shutdown in FY2020.
  - So, support for installation/commission length will be extended to JFY2021.
  - But, anyway some sub-systems should be replaced in FY2020 (which subsystem ? TOP(KLM)+SVD+CDC ? )
    -> Discussion : will see the commission status at the test bench to decide
    - Co-exists with the current COPPER system
    - Then, In my idea, the longer shutdown can be used for the replacement of the rest of sub-detectors.
Tentative installation plan

- 2020 Summer shutdown (3months)
  - TOP(KLM) : the 1st choice
  plus
  Depending on the commissioning status at test bench.
  - SVD, CDC or others ?
It is better to operate with multiple systems, because it can provide some information when some trouble happen.
  - Coexists COPPER and new system

- 2021 Possible longer shutdown (6month? From January earliest ?)
  Still keep COPPER for the moment for roll-back option
LIAISON WITH DAQ-UPGRADE PROJECT

- The impact of modification is minimize in sub-detector side.
  - use belle2link -> no update for FEE firmware
  - update of SLC software -> previous talk.
- But, as for commission, we need to work together with sub-detector DAQ experts.
  - Building a test bench (KEK or home-institute?)
  - How to configure FEEs

<table>
<thead>
<tr>
<th></th>
<th>Candidates</th>
<th>Test bench</th>
</tr>
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<tbody>
<tr>
<td>SVD</td>
<td>Katsuro-san ?</td>
<td>Tsukuba B4</td>
</tr>
<tr>
<td>CDC</td>
<td>Nanae-san (O.K.)</td>
<td>Tsukuba B4</td>
</tr>
<tr>
<td>TOP</td>
<td>Oskar/Martin ?</td>
<td>Tsukuba B4, Hawaii</td>
</tr>
<tr>
<td>ARICH</td>
<td>Yun-tsung ?</td>
<td>KEK ? Kitasato ?</td>
</tr>
<tr>
<td>ECL</td>
<td>Mikhail (for now)</td>
<td></td>
</tr>
<tr>
<td>KLM</td>
<td>New UH post-doc ?</td>
<td>Hawaii</td>
</tr>
<tr>
<td>TRG</td>
<td>Koga-san (O.K.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FTSW preparation</td>
<td>Nakao-san/Kunigo-san?</td>
</tr>
</tbody>
</table>
SUMMARY

➢ Readout status during the phase III was basically stable.
➢ A lot of efforts to investigate the troubles are on-going towards the autumn run

➢ DAQ Upgrade plan
➢ The 1st replacement of COPPER boards will happen in the next summer shutdown.
➢ Schedule of each sub-system’s replacement will be confirmed as commissioning is on-going. TOP(KLM) could be the 1st choice.
➢ Asking to have liaison from each sub-detector group for the upgrade project.