SVD DAQ phase-3 2019 spring run

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TRG/DAQ workshop

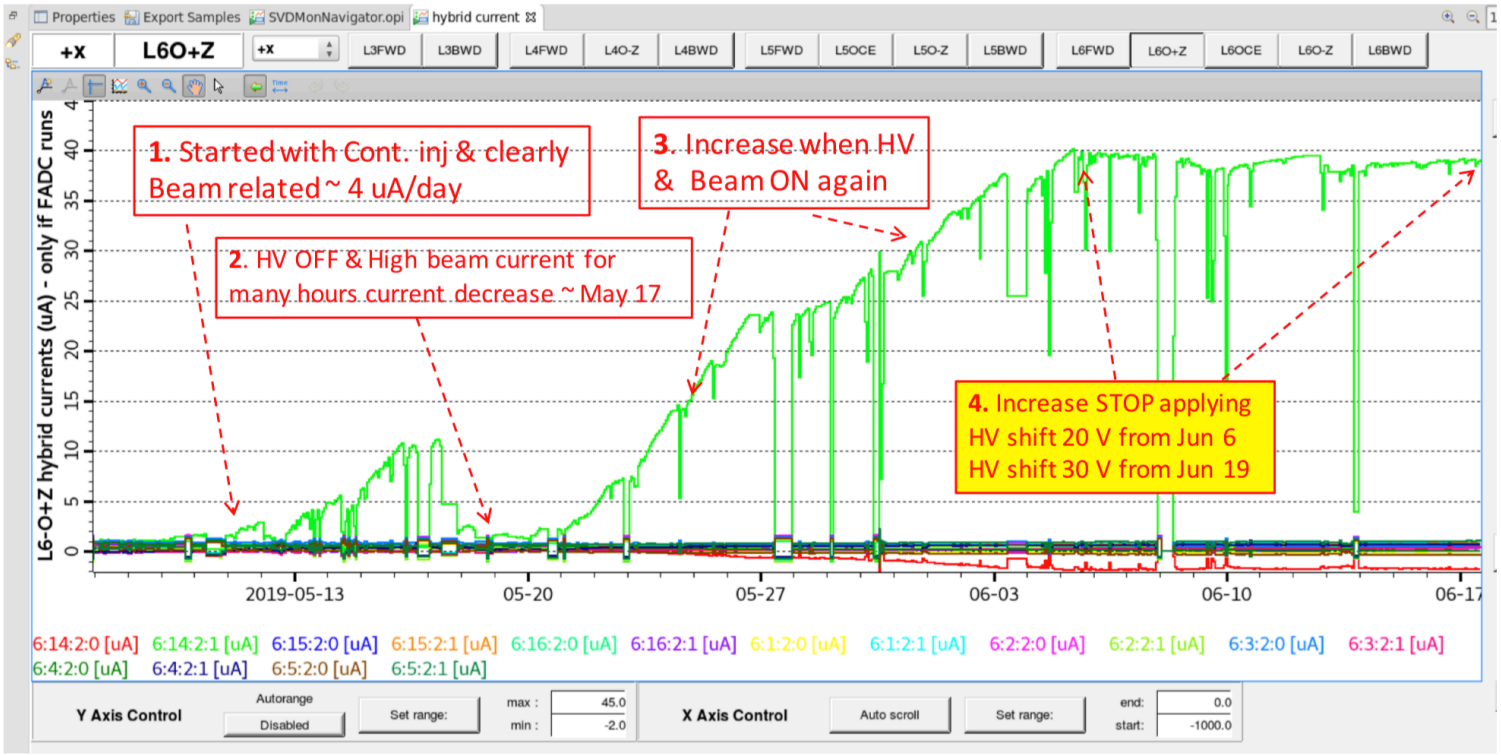
SVD DAQ summary in 2019 spring

- **SVD was one of the stable subsystem in 2019 spring run.**

- **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

From B2GM Jun 2019

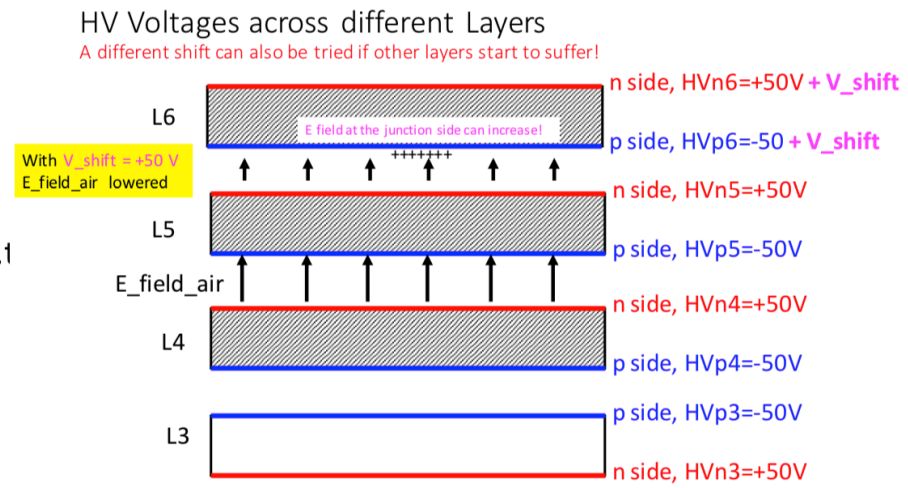
L6.14.2 sensor current increase



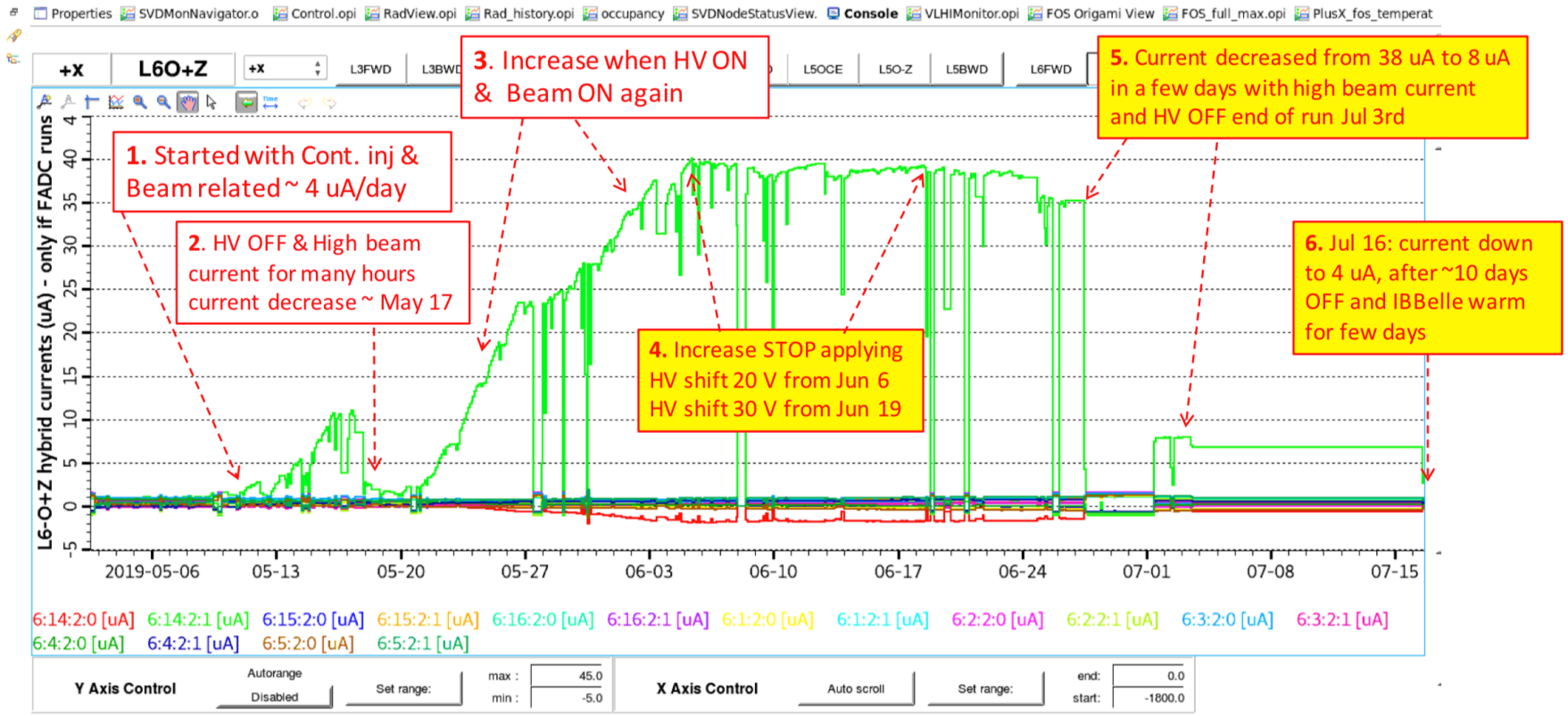
From B2GM Jun 2019

L6.14.2 sensor current increase

- After start of LER/HER continuous injection, the sensor leakage current on L6.14 started to increase, with slope beam related ~4uA/day
- Hypothesis: Surface charge accumulated on on L6 p-side and increase the electric field on the junction side and (together with a sensor defect) causes the increased current (driven by generation from impact in high E field)
- Implemented mitigation (after many tests): L6 HV shift w.r.t L5 HV to reduce Efield in air and reduce/stop the charge accumulation on p surface
  - L6 HV shift 20V (Jun 6) stopped the increase
  - L6 HV shift 30V (Jun 19) still stable current (no decrease…)
- Even increasing the shift further will probably not reduce the current.
- Current is likely to go down when we have high beam current and HV OFF end of June→ restart in Sept with the HV shifted to keep the current low!



L6.14.2 sensor current history



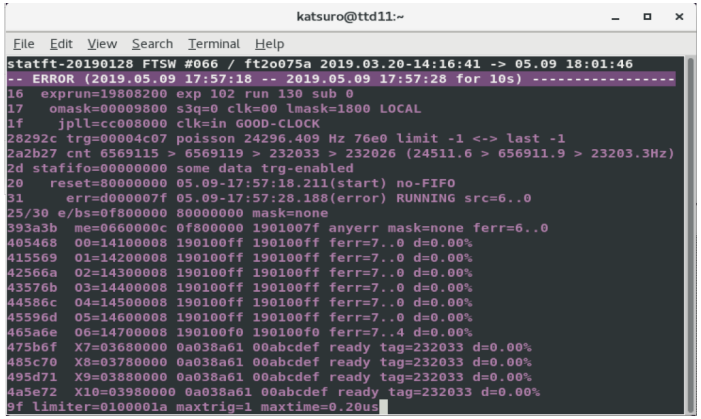
Problem 1: COPPER system stuck due to SVD large data

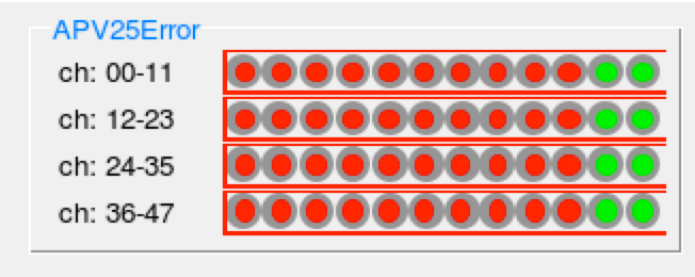
- **Symptom**
  - When SVD accidentally sends large data to COPPER, in the most cases the COPPER system gets stuck. (HSLB FIFO gets full)
  - Usually happens when:
    - SVD DAQ runs with HV OFF ,
    - Accidental big beam loss happens
    - But, does not happen during healthy luminosity-run operation
  - Once this happens, the SVD COPPER becomes BUSY and stops physics runs soon after start. This cannot be recovered with SALS.
- **Recovery**
  - In the most cases, it requires power-cycle of COPPER crates, and reconfiguration of slow-control and firmware.
  - This procedure itself will take about 15-20min. Including other investigation time, it could stop DAQ for more than 30min.
- **Possible solution**
  - FADC can set the limitation on the data size. A limitation of ~60% occupancy may avoid the problem. (to be confirmed)
    - The function is not used after we found a bug on the feature. The bug has already been fixed.

  Confirmation of above solutions is to be done in the summer shutdown.
  - Recovery of COPPER just with SALS is also necessary for the stable operation. Yamada-san is testing the COPPER system receiving large FTB dummy data.
    - Still the problem is not well understood.

Problem 2: FTSW APV-trigger veto

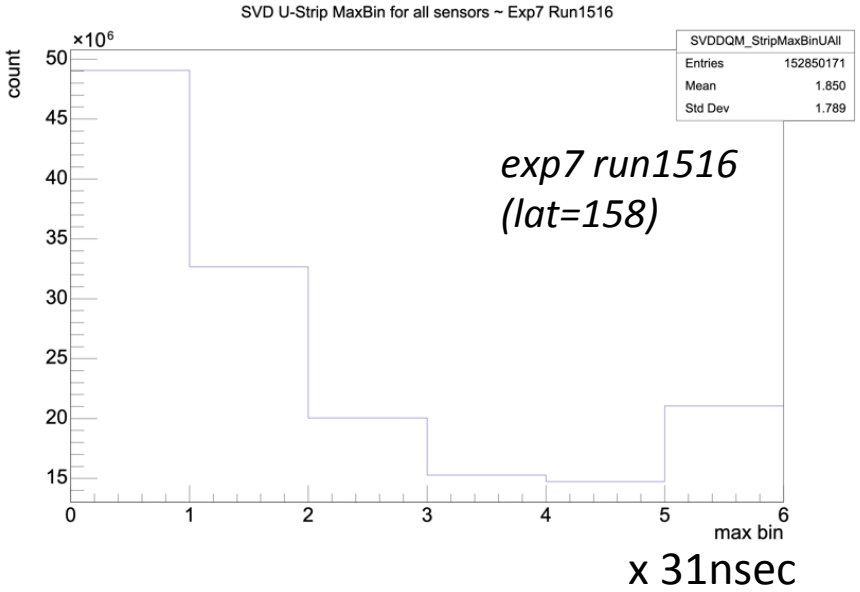
- **APV25 errors appeared at high trigger rate.**
  - At a rate above 23kHz, the run immediately stopped due to the APV25 error.
  - If the APV trigger-veto firmware works properly the APV25 error must not happen.
- **We found the problem is related to a latency setting in APV25.**
  - Thanks for the 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.





APV25 latency setting

SVD signal: max-ADC sample dist.
(= signal peak-timing distribution)



x 31nsec

latency changed from exp7 run1650

SVD signal: max-ADC sample dist.
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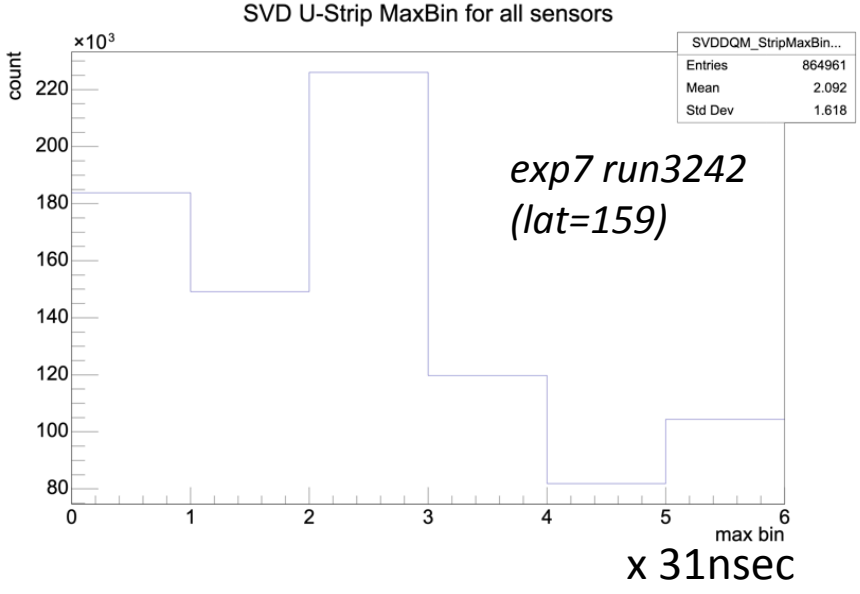

x 31nsec

- **Earlier trigger timing (=larger latency) effectively improves the separation btw physics and BG.**
- **However, as shown in the previous slide, lat=159 causes APV error under the nominal APV trigger-veto setting.**

APV25 latency setting

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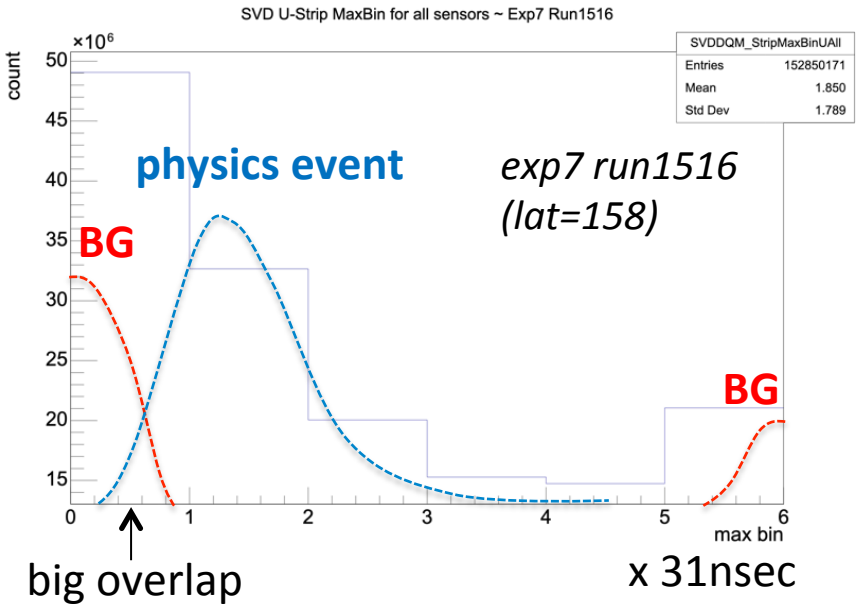

latency changed from exp7 run1650

SVD signal: max-ADC sample dist.
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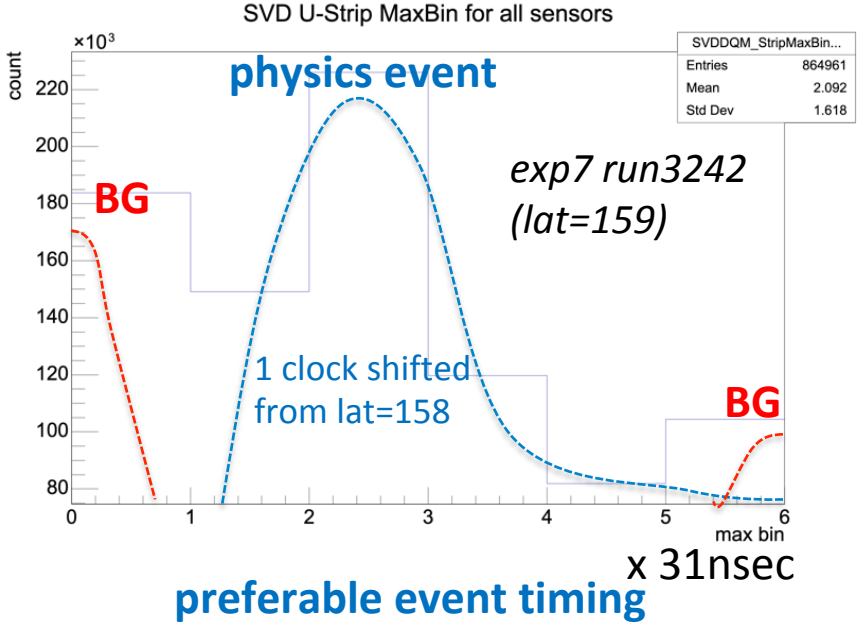


- **Earlier trigger timing (=larger latency) effectively improves the separation btw physics and BG.**
- **However, as shown in the previous slide, lat=159 causes APV error under the nominal APV trigger-veto setting.**

APV25 trigger-veto module

- Lat <= 158
  - APV behavior can be emulated with common 3 parameters
  - Seems the designed behavior
- Lat = 159
  - Observed on the test bench that parameter3 changed from Lat<=158.
  - With a special setup, the changed parameter measured, however, APV emulator does not work for real operation (high rate random trigger) with the measured parameter.
  - By relaxing the parameter from the measured value, it worked at least 3.5h in total without any error with 50kHz random trigger in the phase2 setup.
    - Mechanism not understood -> SVD data quality to be validated ASAP
- Lat = 160 - 168
  - In addition to the change of parameter3,
  - Effectively, fifo depth become shorter with larger latency
    - Lat 160 : depth 31, 161:30,…
  - Not preferable region

Hikaru's study in 2017

- **With lat≤158, APV behaves as expected. With lat=159, it shows unexpected behaviors.**
- **But even with lat=159, relaxing a parameter in the AVP trigger-veto from a nominal value, we can operate SVD at least for 3.5h.**
  - "Somehow" working without APV error
- **Concerns: 1. long-term stability, and 2. SVD performance at high trigger rate (~30kHz).**
  - They have to be confirmed in this summer shutdown.s

Possible solutions

The strange behavior of Lat=159 is a concern,
on the other hand we like to keep the current signal-to-BG separation.

Solution-1

- **Go back to lat=158, but reduce the trigger propagation time in the SVD cables and firmware.**
  - Cables can be shorten by 2.7m. (Installed already)
    - 2.7m x about 5nsec/m = 13nsec.
  - Propagation time in firmware is well optimized, but hopefully 7.8 nsec might be reducible (to be tested).
  - In total, about 20nsec. Not sure if this is enough.

Solution-2

- **Confirm the performance under lat=159 at high trigger rate (~30kHz). If the performance could be validated, we can keep using lat=159.**
  - Cosmic data taking with 30kHz poisson triggers is necessary for the performance evaluation. Enabling HLT filter, we can select the cosmic events.
  - SVD hit efficiency and timing resolution to be confirmed.

Summer shutdown DAQ plan

COPPER stuck study

- **Study of COPPER stuck due to large SVD data size**

CDC timing trigger performance test

- **Cosmic ray data taking with CDC timing trigger**
  - the trigger latency of the CDC timing to be verified

Lat=159 study

- **Long-term stability test**
  - Running DAQ with 30kHz poisson for a couple of days
- **Cosmic ray data taking with 30kHz poisson mixed triggers**
  - SVD performance to be confirmed

- **However, currently IBBelle (CO2 cooling system) has a leak problem and cannot work. Before the SVD operation, we have to wait for the IBBelle recovery, but the schedule is not clear yet.**
  - Only FTB dummy data can be provided to DAQ without IBBelle.

Expected SVD data size

	SVD data size [kB/event]	SVD data rate @ 15kHz [MB/s]	SVD data rate @ 30kHz [MB/s]	Limit on data rate [MB/s]
COPPER	max. ~ 2.3	max. ~ 35	max. ~ 70	~ 85
ROPC	max. ~ 11	max. ~ 170	**max. ~ 350**	~ 250
EB1	~ 84	~ 1200	**~ 2500**	~ 2500 (sum of all subsystems except PXD) Could be double with final HLT system
		HLT rate ~2.5kHz	**HLT rate ~5.0kHz**	
HLT/ Storage	~ 84	~ 210	~ 420	~ 1800(*) (sum of all subsystems)

- **Evaluated data rates are assuming 3% layer-3 occupancy, which is at the SVD operation limit due to tracking performance.**
- **Operation at 15kHz trigger rate should be OK, while operation at 30kHz can require future reinforcement of ROPC**
  - SVD data reduction with 3-sample instead of 6-sample
  - Increase the number of ROPCs or output network ports
  - COPPER upgrade project

(*) limit due to data transfer to KEKCC

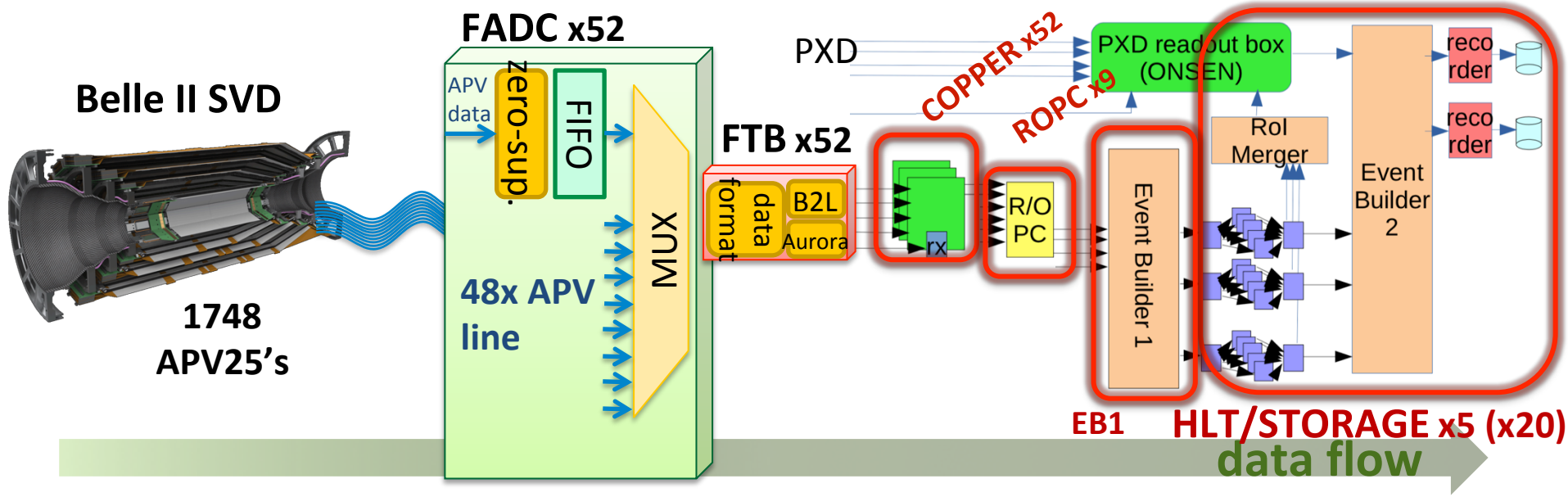
Summary

- Countermeasures for COPPER stuck issue to be prepared.
- APV performance at the cutting edge of operational range (lat=159) is will be investigated. Also we are trying possible trigger latency reduction.
- Currently SVD cannot be operational due to the IBBelle leak problem.
- Operation at 15kHz trigger rate should be OK, while operation at 30kHz can require future reinforcement of ROPC

backup

Expected SVD data size

SVD data rate
Possible data speed bottleneck



- **Possible bottleneck on the DAQ data speed**
  - COPPER : max. ~85MB/s per COPPER
  - ROPC : max. ~250MB/s per ROPC
  - EB1 : Currently max. ~2.5GB/s, but will improve with the increase of the HLT units
    - Data rate summed up all sub-detectors expect PXD
  - HLT/STORAGE, offline data transfer : max. ~1.8GB/s (agreement with offline data group)
    - Data rate summed up all sub-detectors after the high-level-trigger selection

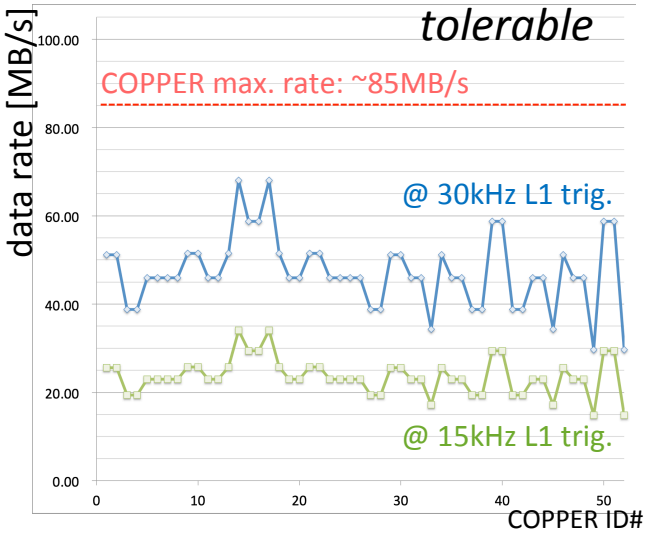
SVD data rate at layer-3 3% (1)

- **We evaluate the data rate in the DAQ components at layer-3 occupancy of 3%.**
  - The layer-3 occupancy should be kept below 2-3% limit from the tracking performance. 3% is the current maximum.
  - We check the margin or limitation on the DAQ components under the 3% occ. data size.

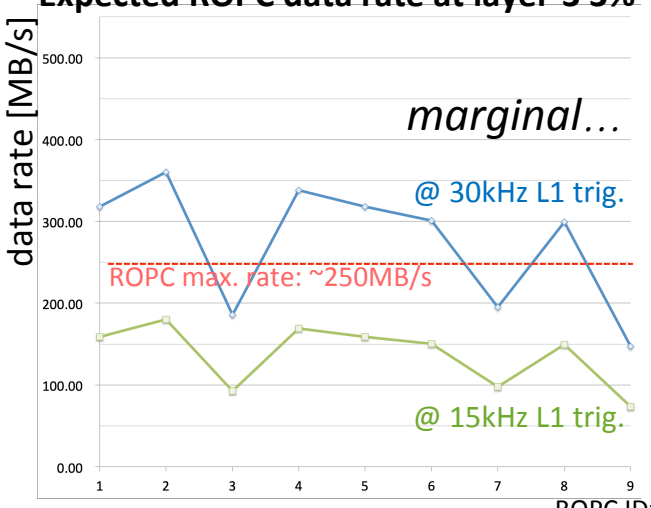
DAQ data rates estimated under layer-3 3% occ.

- **COPPER data rate would be tolerable**
  - Even at 30kHz trigger rate, the data rate ~70MB/s or less is expected
    - COPPER data rate limitation: ~85MB/s.
- **ROPC data rate is also OK at 15kHz**
  - At 15 kHz trigger rate, the data rate ~150MB/s is expected.
    - ROPC data rate limitation: ~250MB/s.
- **In future when we achieve 30kHz,**
  - At 30kHz trigger rate, the data rate will reach ~350MB/s, over the ROPC limitation.
  - **Possible countermeasures**
    - SVD data reduction with 3-sample instead of 6-sample
    - Increase the number of ROPCs or output network ports
    - COPPER upgrade project

Expected COPPER data rate at layer-3 3%



Expected ROPC data rate at layer-3 3%



SVD data rate at layer-3 3% (2)

DAQ data rates estimated under layer-3 3% occ.

- **EB1/HLT data rates are tolerable at 15kHz trigger rate:**
  - Expected total SVD data size is ~83kB/event .
  - EB1: Expected total SVD data rate is ~1.2GB/s at 15kHz trig.
    - Limitation on EB1 data rate (sum of all subsystems except PXD): Now ~2.5GB/s, and will be higher at 2021.
  - HLT/Storage/transfer: Expected total SVD data rate is ~0.21GB/s at 2.5kHz high-level trigger.
    - Offline data transfer rate (sum of all subsystems): ~1.8GB/s
- **In future when we achieve 30kHz, rates would be still OK**
  - EB1: Expected total SVD data rate is ~2.5GB/s at 30kHz trig.
    - Limitation on EB1 data rate: Now ~2.5GB/s, and could be double with the final HLT system.
  - HLT/Storage/transfer: Expected total SVD data rate is ~0.42GB/s at 5kHz high-level trigger.
    - Offline data transfer rate: ~1.8GB/s
- **The upgraded COPPER system will allow us to go above 3% occupancy. The hardware limitation with this upgrade is still to be evaluated.**