Status Update SuperKEKB and PXD

PXD Workshop and 23rd International Workshop on DEPFET Detectors and Applications

27.05.2019, Kloster Seeon

SuperKEKB

- January, cosmics and DAQ integration, DAQ tests
- March 08, Switch on solenoid
- March 11, Resume SuperKEKB operation, (HER injections)
- March 13, Resume SuperKEKB operation, (LER injections)
- March 25, Physics Run, colliding beams with 8mm optics, I_{LER}=200 mA, I_{HER}=150 mA, 789 bunches
- April 03, (swing shift): Fire next to LINAC => switch to cosmic runs & firmware development
- April 26, resume SuperKEKB operation
- May 14, continuous injection (consequences: see Bjoern's talk on Wednesday), collision data
- Maintenance days (access to top of Belle, no beam): 30.5, 13.6, 27.6
- Goal: 3 fb⁻¹ on May 30

Daytime (first weeks): machine study (vacuum scrubbing, injection tuning, luminosity tuning, optics correction, collimator studies, ...) Nighttime & weekend: physics runs Run plan: <u>https://confluence.desy.de/display/BI/Run+Plan</u>

Belle II

Targets:

- May 30: 3fb⁻¹
- June 6: 4fb⁻¹



SuperKEKB 24h Operation Summary



Belle II Operation/ Changes

- Massive efforts to stabilize Belle II Slow Control and DAQ
- Frequent restarts (SALS), requires around 5min (now: 2-3min)
- Stable DAQ operation, 5kHz, limited by HLT processing power (10kHz for DAQ tests)
- All sub-detectors are in operation, but still some issues

PXD Status

- 19/20 modules work (H1032 is broken) source current 120mA @ HV=-20V, contacts in Aluminum layer
- Participating most of the time in global runs
 - PXD DAQ *mostly* stable (overlapping trigger firmware)
 - ONSEN very stable
- Modules pre-optimized in lab
- Still remaining:
 - Different gains
 - Different source currents
 - Ring structure
- Re-optimization of offsets (see Florian's talk on Tuesday for details)
- Retuning gate-on voltages due to radiation damages
- Data Quality Monitoring (DQM)



Trigger delay problem (solved)

- PXD trigger consists mainly on one parameter:
 - DHP latency (look back in time in DHP memory)
 - 1 gate \triangleq ~100ns
- Readout length depends on two parameters
 - DHI trigger length (strobe length to DHP)
 - DHE trigger length (used by the firmware to build event)
- Latency depends on the trigger latency and timing of Belle2
 - DHP latency was ~50 in phase2
 - Was set to 5 in early phase3?
 - 45 gates off \rightarrow ~23% (=45/192) loss of efficiency!
- Finding correct timing only possible with "real" physic triggers (but low statistics with cosmics)
 - Need correct trigger gate (timing pixels) \rightarrow can tune "Start Gate emulator" on DHE, x-check
 - Need to know the readout frame the pixel is firing in (timing pixels), determine when next readout frame starts (per DHP!). Information is lost in overlapping firmware due to event building

Slow Control

- No mayor issues, problems (ONSEN, PS, DHH, Sequences, monitoring)
- Alarms / alarm panel implemented
- Archiver works
- Gateway
- Problem with high load during upload of pedestals/offsets solved
- HV state / sequences need some improvement



(A) Alarm Area Panel (red and green)(B) Alarms (use right click on the alarm(C) Acknowledged alarms



PXD problems (module side)

- Module emergency shutdown (=> ERROR) due to Over Voltage Protection (OVP)
- Partially huge Pedestal spread (dead gates, pre-irradiated, ...)
- Bias voltages (tuning of HV, bulk, clear-off)

Region of Interest (ROIs) Selection (Cabling / internal order of DHEs data sent to ONSEN)

PXD problems (DAQ side)

- PXD stopped run for two main reasons:
 - DHH did not send data anymore (finally BUSY) ("HLT trigger ahead of DHH")
 - DHH send too many corrupted data
 - HLT did not send Triggers (anymore)
 - HLT did not send Triggers for too many events at the beginning of a run ("O02S4 ptr_lut_write_dhh: LUTW_OVERWRITE missed")
 - \rightarrow memory occupancy at end of run
 - PXD lab_framework: Misconfiguration or -operation (after pedestal taking, IOC crash, operator error)
- NSM timeout: HLT did not notice that PXD was included into run
 - NSM timeout of Event Builder (have observed that before...)
- Event Builder 2 crash \rightarrow link to ONSEN drop \rightarrow PXD ERROR

=> Problems not only on PXD side, even if PXD detects error

$Livetime in 24hrs(rough estimation) = 41.7 \ \% \ (33.8 \ \% \ w/ \ all subsystems) \\ While \ HV_permitted : 62.6 \ \% \ (53.4 \ \% \ w/ \ all subsystems) \\$

Links : last 12hrs last 7days all period VXD test

PXD ERROR

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Over Voltage Protection (OVP)

Triggered OVP in Nov 2018:

current limits for clear-off to close => increased current limits

• Triggered OVP in April 2019:

frequently: 1072, unit 80, but also other ones less frequent After update of DHI firmware / JTAG libraries reason still unclear => switched back to old version

- Still under investigation? (DESY long term test) https://agira.desy.de/browse/BIIPXDH-289
- How to handle PS when OVP happens: bring it into a save state, ramp up (recover) https://agira.desy.de/browse/BIIPXDH-259
- Retuning of gate-on voltages
 - Actual currents as current limit (1 week)

2019-04-26 22:53:55, H1012 ovp 2019-04-24 23:13:11, H1082 ovp 2019-04-26 18:10:33, H1082 ovp 2019-04-29 18:47:30, H1082 ovp 2019-03-29 04:31:56, H1032 ovp 2019-04-08 10:01:30, H1062 ovp 2019-04-24 11:13:48, H1072 ovp 2019-04-24 16:45:01, H1072 ovp 2019-04-27 17:37:56, H1072 ovp 2019-04-28 22:25:31, H1072 ovp 2019-04-29 09:38:33, H1072 ovp 2019-04-29 17:58:45, H1072 ovp

DHP "last gate" bug

- Some firing pixels are transmitted a few frames later
- Work around
 - 2 pixels of last gate (row 766) are permanent "on"
 - Mask complete last gate (lose 0.5%)

https://confluence.desy.de/display/BI/PXD+DHP+bugs

PXD data rates/occupancy and CommonMode

ONSEN										
					Occupancy	overview				
H1011	H1021	H1031	H1041	H1051	H1061	H1071	H1081	H2041	H2042	
0.0762 %	0.0214 %	0.0169 %	0.0792 %	0.0000 %	0.0755 %	0.0000 %	0.0318 %	0.0378 %	0.0603 %	
146 pix/evt	41 pix/evt	32 pix/evt	152 pix/evt	0 pix/evt	145 pix/evt	0 pix/evt	61 pix/evt	73 pix/evt	116 pix/evt	
146 0	41 0	32 0	152 0	0 0	145 0	0 0	61 0	73 0	116 0	
0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	
H1012	H1022	H1032	H1042	H1052	H1062	H1072	H1082	H2051	H2052	
0.0188 %	0.0222 %	0.0000 %	0.0757 %	0.0767 %	0.0775 %	0.0216 %	0.0000 %	0.0580 %	0.0580 %	
36 pix/evt	43 pix/evt	0 pix/evt	145 pix/evt	147 pix/evt	149 pix/evt	41 pix/evt	0 pix/evt	111 pix/evt	111 pix/evt	
36 0	43 0	0 0	145 0	147 0	149 0	41 0	0 0	111 0	111 0	
0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	
		ONSEN occu	ipancy (FW)	ONSEN occupancy (BW)						

for indicating data losses within the given row CommonMode

The value 63 is reserved







PXD occupancy and beam currents



Possible work arounds for occupancy drops

- Increase veto length after injection
 - This reduced the problem already, but increasing it further means losing more luminosity (especially when the injections reaches 50 Hz in LER and HER)
 → A short term solution but freak events during normal beam conditions could also lead to these problems
- Apply the gated mode
 - This will also reduce the effect of occupancy spikes after the injections but possible freak events are not covered
 → Gated mode is another layer of complexity and needs more testing before we can apply it at KEK
- Apply a reset during the run
 - This is currently not possible with the DHC firmware but implementation should be possible
 → Would be a good solution to record as much luminosity as possible now. Even if it takes several seconds to recover the synchronization, this is little compared to aborting and starting a new run
- Longer trigger hold-off
 - Tests with 2,10 and 20 µs have been conducted and longer hold-off times increased the stability o the system
 - To reduce the data loss coming from a longer hold-off time, a discussion with Mikihiko Nakao was started
 - With firmware changes of the FTSW it should be possible to increase the hold-off time only shortly after beam injection



Radiation Dose

- Retuning of gate-on voltages
 - 08.04.2019, 09.05.2019, 20.05.2019
 - No defined strategy when to do re-calibration

Source currents

[P1011] = 90	[P1012] = 75
[P1021] = 102	[P1022] = 110
[P1031] = 99	
[P1041] = 96	[P1042] = 98
[P1051] = 107	[P1052] = 101
[P1061] = 109	[P1062] = 112
[P1071] = 102	[P1072] = 85
[P1081] = 90	[P1082] = 68
[P2041] = 80	[P2042] = 73
[P2051] = 85	[P2052] = 55



Optimization of Modules (voltages)

Some values from optimization did not reach the config DB:



➔ Besides of rings we also have a rectangular structure

Optimization of Modules (voltages)

• Lab-optimized modules



=> Use moving stage for all voltage scans for PXD2020

27.05.2019

Modules

- Keep track about noise maps, voltages, optimization, behavior ... <u>https://agira.desy.de/browse/BIIPXDH-253</u> Only manual update, no automatization yet
- Re-adjustment of voltages, elog

TO DO for PXD @ KEK

- Each module, how many unconnected gates and columns
 => not seen from pedestals map, only from hitmap
- Masks of pixels/gates over time
- Voltage sweep / IOC for voltage scans
- High Voltage control
 - Move to save state not to block injection after Over Voltage Protection
 - Recovery of single modules
 - Safety issue: >1 modules can be unfollowed => masked => PEAK state during injection (like H1051 on May 24)
- Further Firmware Development
 - DHC load balancing
 - Reorder of data input to ONSEN from DHH for Region of Interest selection
- Gated Mode
- Iteration of DQM plots (see Bjoern's talk)

PXD Organization

- Many big meetings
 - Monday meeting 10:30 (weekly)
 - Run meeting (10:00) (daily, also weekend and holidays)
 - PXD offline software & analysis meeting (weekly, Monday)
 - PXD commissioning & analysis meeting (weekly, Tuesday)
 - DEPFET meeting (weekly, Thursday)
 -

PXD Shifts

- Problems very similar to phase 2
- Most shifts taken by "local" experts, weekend and owl shifts leak coverage
- Development/Improvements/Debugging versus Shifting
- Training not covering new development issues (not final system yet)
- 3 shifts per day (0:00-8:00 (Europe), 8:00-16:00 (Japan), 16:00-0:00 (Euro/Japan) JST)
- Operation manual, shifter trainings and shadow shifts are available
- Elog and shift reports work quite well
- New task by Belle II Management: shifter should qualify runs by quality
- Pedestal procedure: not well defined when to take pedestals (high data rate)
- Settings, recalibration of gate-on voltages
- Audio Alarm for Shifter (not implemented yet)

Summer Shutdown Plans

- July 20-25 IBBelle Maintenenace
- July 26-Aug 5, e-hut shutdown
- Aug 3-5 Power Shutdown at KEK
- Resume SuperKEKB operation at mid of October ?
- DAQ will run over summer
- CDC moisture problem: 1 week after stop in July & 1 week before start in October
- Meeting with SVD on June 6./7.
- Cosmics plan?
- Mechanical work BWD QCS will be extracted in middle of Aug. for Bellows pipe replacement
- Cooling required for firmware tests

Backup

Missing data - Observation

- DQM Plots CM63 observed The value 63 is reserved for indicating data losses within the given row
- Occupancy drop to lower values or to 0, i.e., no data flow DHP state machine gets stuck ?
 DHP ↔ DHH: Out of synchronization Resolved by issuing a reset (currently: Restart run, takes ~5min)
- <u>https://confluence.desy.de/pages/viewpage.action?pageId=131381651</u>



May 24,

• vFull(HER) = 100 us, trigger hold off = 2 us

run 1186 - 16 modules showed occupancy drop at the first injection. 15 were in sync with the DHE (DHE first frame vs. DHP first frame). For H1051, DHP and DHE not in sync anymore. DHP ahead of DHE by 1 frame.

• vFull(HER) = 100 us, trigger hold off = 20 us

run 1188 - no drops, run stopped because on TOP busy, no HER injections run 1190 - no drops, 5 HER injections

- vFull(HER) = 100 us, trigger hold off = 10 us run 1191 - no drops, 2.5 HER injections. Run stopped due to TRG BUSY
- vFull(HER) = 100 us, trigger hold off = 2 us run 1192 - 1 HER injection, then LER abort, then 1 HER injection. 4 modules showed occupancy drop during the last HER injection

SuperKEKB – Belle II organization (overview attempt)

- Daily Run Meeting at 10:00 JST in Tsukuba Hall, B3 Machine status, sub-detector report of last 24h <u>https://speakapp.link/to/Myf5-Q</u> password: rm4b2p3
- Weekly Monday Meeting at 10:30 JST in 3-go-kan, room 325 weekly report, SuperKEKB status, run plan for next week https://kds.kek.jp/indico/category/566/
- Run Plan: <u>https://confluence.desy.de/display/BI/Run+Plan</u> rough overview, details are in rocket chat on short announcement
- Rocket Chat, https://b2rc.kek.jp/
- Currently on Shift: https://confluence.desy.de/pages/viewpage.action?pageId=120132782
- Shift Tables (book shifts): https://shift.belle2.org
- Operation Manual for PXD shift: <u>https://confluence.desy.de/display/BI/Operation+Manual+for+PXD+shift</u>

Gated Mode

• KEK: verification of Injkick Signal at DHH from FTSW



- <u>https://confluence.desy.de/display/BI/PXD+Gated+Mode</u>
- https://confluence.desy.de/display/BI/DHH+gated+mode+tests
- => see gated mode talk

H1032

- Power supply's Over Voltage Protection (OVP) trigger occurred often (→ increase current limits & modify power up sequence => rarely triggered)
- Module 1032 (L1, module 3, BWD)

source current ↑ (source 140mA @ 5 V) - module does not provide reasonable data





Resets DHH / DHP

- DHI reset will fix internal issues in the DHP but the data will arrive completely asynchronous at the DHE and thus will be discarded
- reset is not a save procedure as we also reset buffers by that and will corrupt data by that hold off may help, but we are still not sure which values are reasonable. felix.johannes.mueller and me performed some tests at DESY and we can somehow reproduce the issue but we don't see all the systematics yet
- Twice drops / shift, most frequent: 1051, 1021
- * Verify consistency of DHE FrameID and DHP FrameID
 * Verify all triggers are coming and none was skipped
 - * Verify for no Hit without Row in beginning of ZS frame

May 14, continuous injection

