VXD Rad.Mon. & Beam Abort Experience in Phase 2

S.Bacher, G.Bassi, C.La Licata, L.Vitale, L.L.

Belle II Italia Meeting - Torino, 24/05/2018

1. SuperKEKB - status and plans
2. Backgrounds studies - status
3. Radiation monitor system (highlights):
   - Initial settings
   - Dose rate measurements and beam aborts
4. Summary

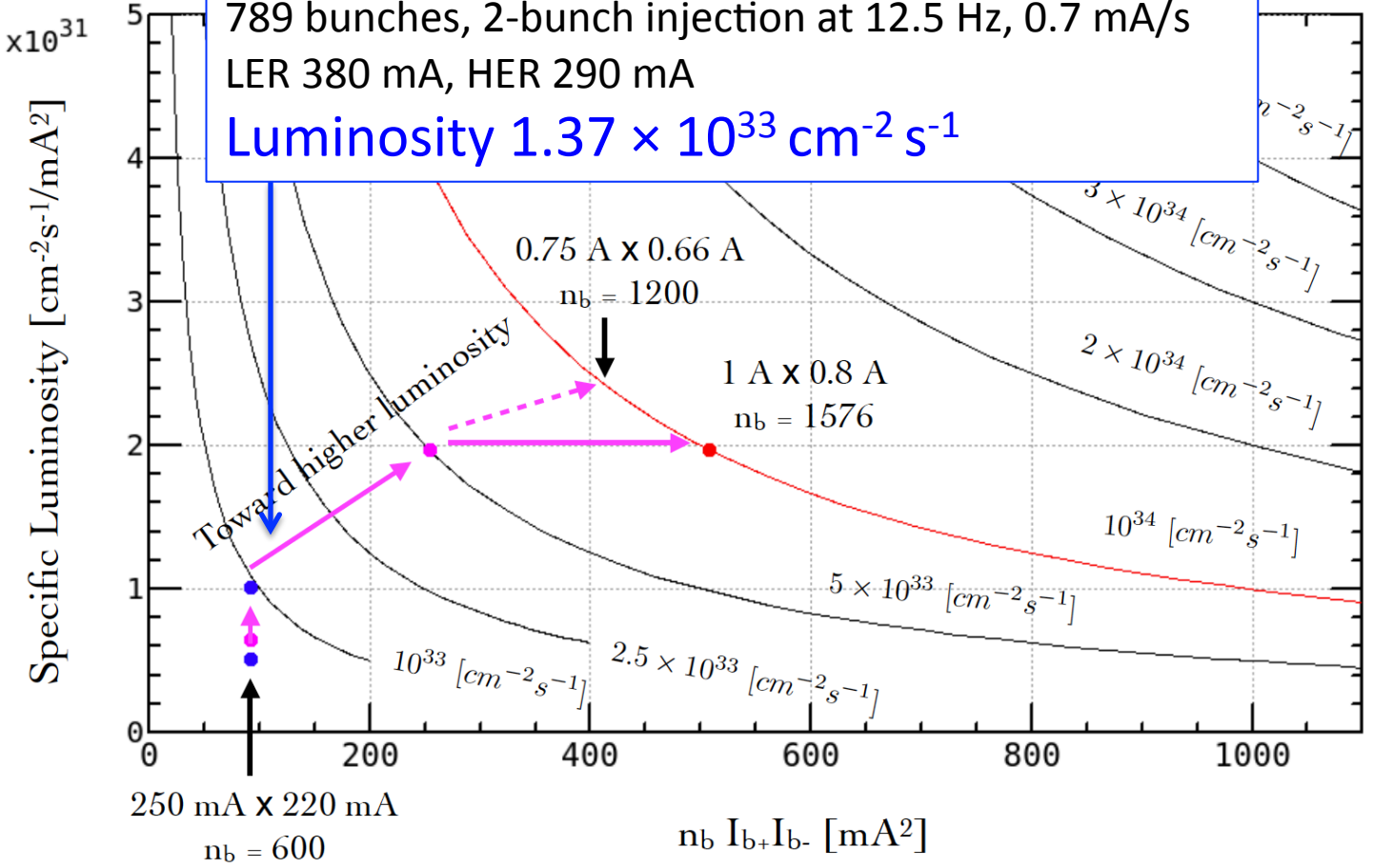
an efficient
Injection Inhibit
State Machine

SuperKEKB Status

Ohnishi-san, KCG meeting 22/05/2018, in “Today’s Schedule”

Travel Guide in Phase 2

23/05/2018, 20:00
789 bunches, 2-bunch injection at 12.5 Hz, 0.7 mA/s
LER 380 mA, HER 290 mA
Luminosity $1.37 \times 10^{33}\ cm^{-2}\ s^{-1}$



SuperKEKB Plans

Ohnishi-san, KCG meeting 22/05/2018, in “Today’s Schedule”

Machine Parameters

*1 assumption *2 35% larger than meas.

	Achieved, May 9		Achieved, May 20		Phase 2.1		Phase 2.1.1	
	LER	HER	LER	HER	LER	HER	LER	HER
I_L, I_H [mA]	**250**	**220**	**275**	**220**	**250**	**220**	**250**	**220**
n_b	**600**		**600**		**600**		**600**	
β_x^* [mm]	200		200		200		200	
β_y^* [mm]	8		8		8		**6**	
$\varepsilon_y/\varepsilon_x$ [%]	**22**[*1]		**14**[*2]	**5**[*2]	**14**		**10**	
ξ_x	0.0038	0.0025	0.0051	0.0028	0.0039	0.0025	0.0040	0.0026
ξ_y	0.0147	0.0145	0.0349	0.0200	0.0184	0.0182	0.0189	0.0187
I_{bunch} [mA]	0.42	0.37	0.458	0.37	0.42	0.37	0.42	0.37
L [$cm^{-2}s^{-1}$]	4.7×10^{32}		9.3×10^{32}		5.9×10^{32}		8.1×10^{32}	
L_{sp} [$cm^{-2}s^{-1}/mA^2$]	5.2×10^{30}		10.1×10^{30}		6.4×10^{30}		8.8×10^{30}	

Background Studies

S.Vahsen, Report at the TB, 23/05/2018

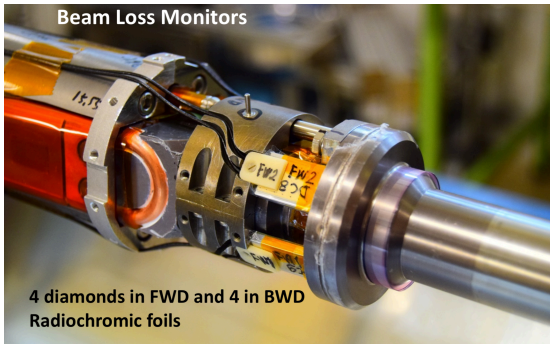
- Highlights from the last two weeks
  - Modification of IP orbits
  - Reduction in injection backgrounds
  - HER beam size study
- Status of beam backgrounds
- Next steps

Background Situation Now

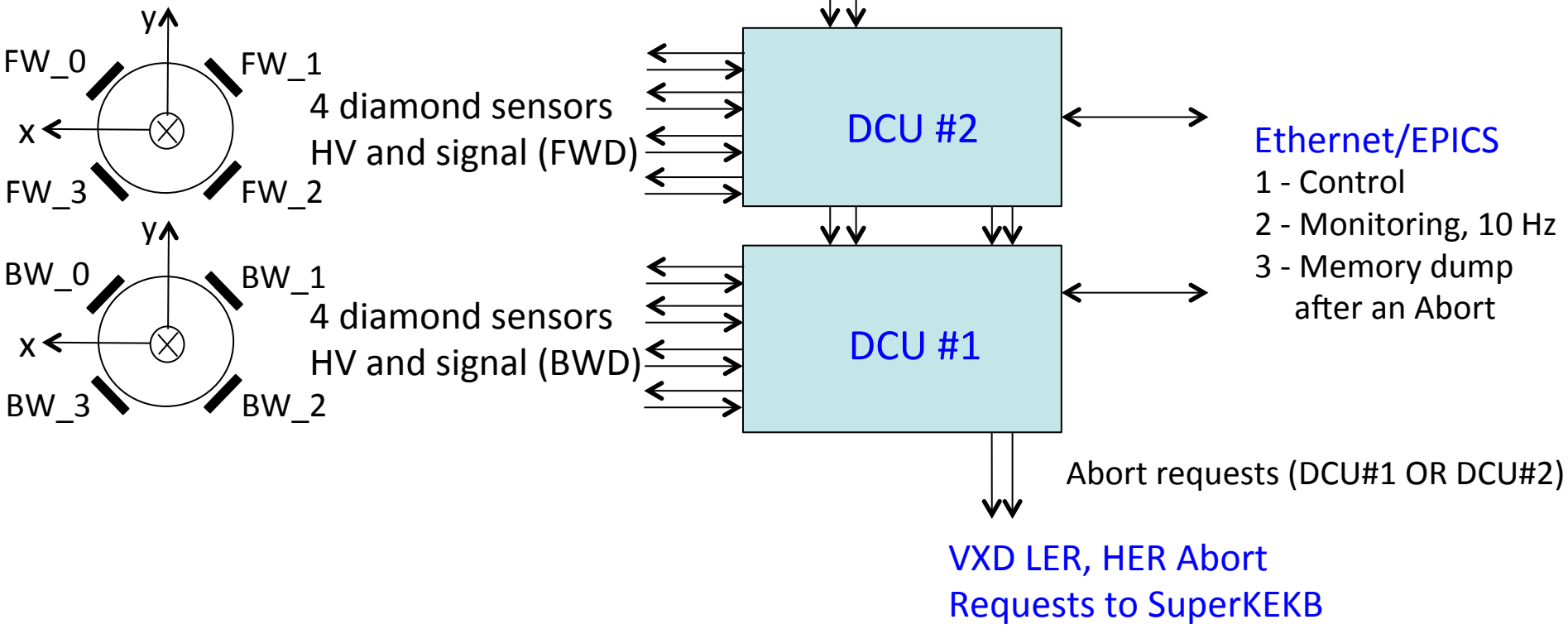
1. Beam gas (Coulomb scattering + bremsstrahlung): larger than simulation, due to high dynamic pressure, but continuously decreasing with vacuum scrubbing
2. Touschek: Now (with 601 bunch collision fill pattern) seems to be visible at IP for both LER and HER. Not a large fraction of total BG at IP, but currently limiting both LER and HER lifetime.
3. Luminosity backgrounds (e.g. Bhabbha): still need to be studied.
4. Injection backgrounds: Were intolerably large until recently, but substantially reduced May 19th. Working group formed to improve. Tanaka San is Belle II representative.
5. ~ 10 keV x-rays seen in FANGS and PXD: Source not yet fully understood. Are these SR and/or secondary artifacts from scraping beams?
6. Scraping beams: Major, unexpected background component. Not understood. Could change significantly as optics improve and beta* change.
7. Beam/beam backgrounds (colliding beams disturbing each other) : small, masked by background reduction due to beam blow up right now.

5/23/18 Sven Vahsen @ Technical Board Meeting 10

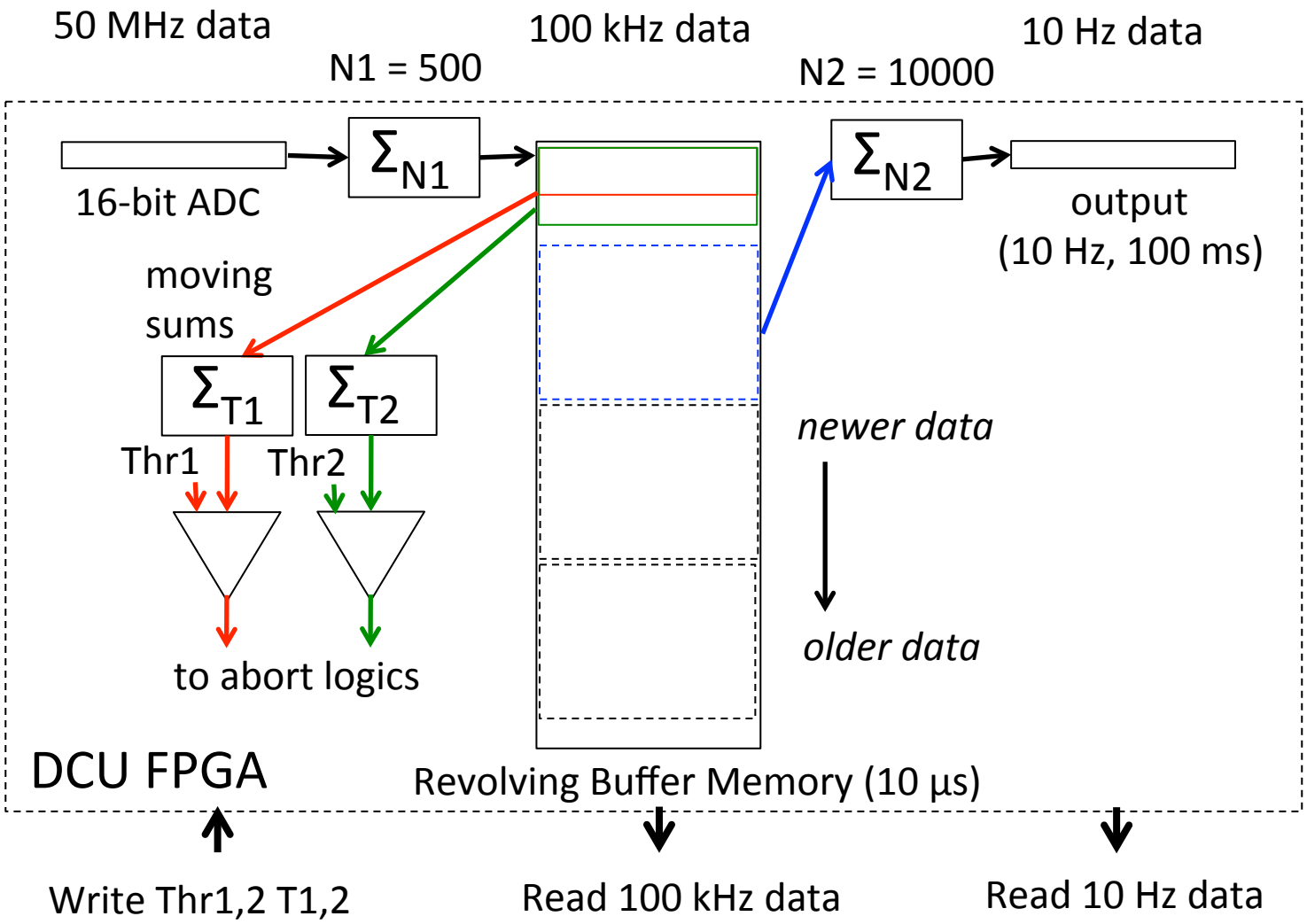
Diamond Sensors: Electronics



4 FWD and 4 BWD diamond sensors on the beam pipe



Read Out, Abort Thresholds

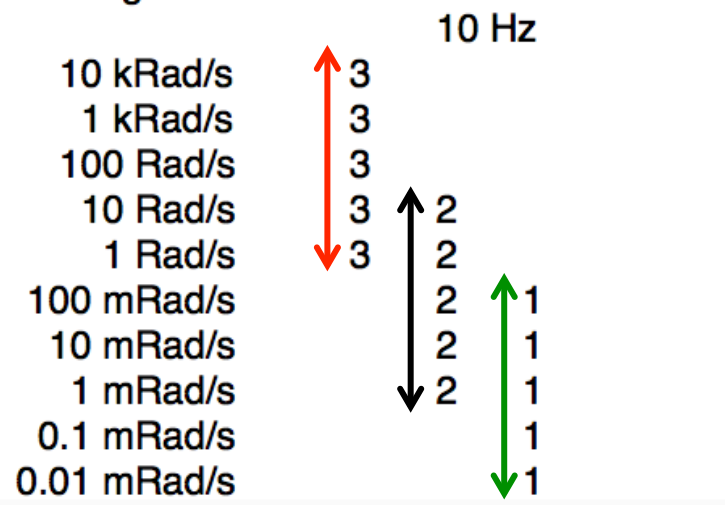


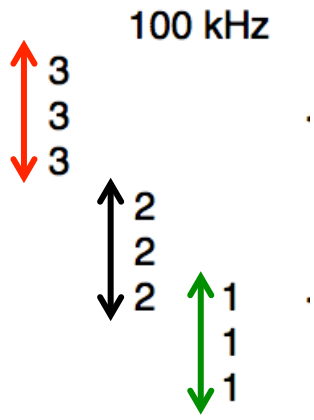
Diamond Control Units (DCU): Current Ranges

3 current measurement ranges and corresponding sensitivities (@100 kHz, 10 Hz)

	range	10 Hz	100 kHz
1	±10 nA	0.003 mRad/s - 100 mRad/s	0.3 mRad/s - 100 mRad/s
2	±1 µA	0.3 mRad/s - 10 Rad/s	30 mRad/s - 10 Rad/s
3	±1 mA	0.3 Rad/s - 10 kRad/s	30 Rad/s - 10 kRad/s

on a log scale:





Range 3
for beam abort, high threshold

Range 1 (sometimes 2)
for precision measurements

Compromise: used alternatively for FWD, BWD

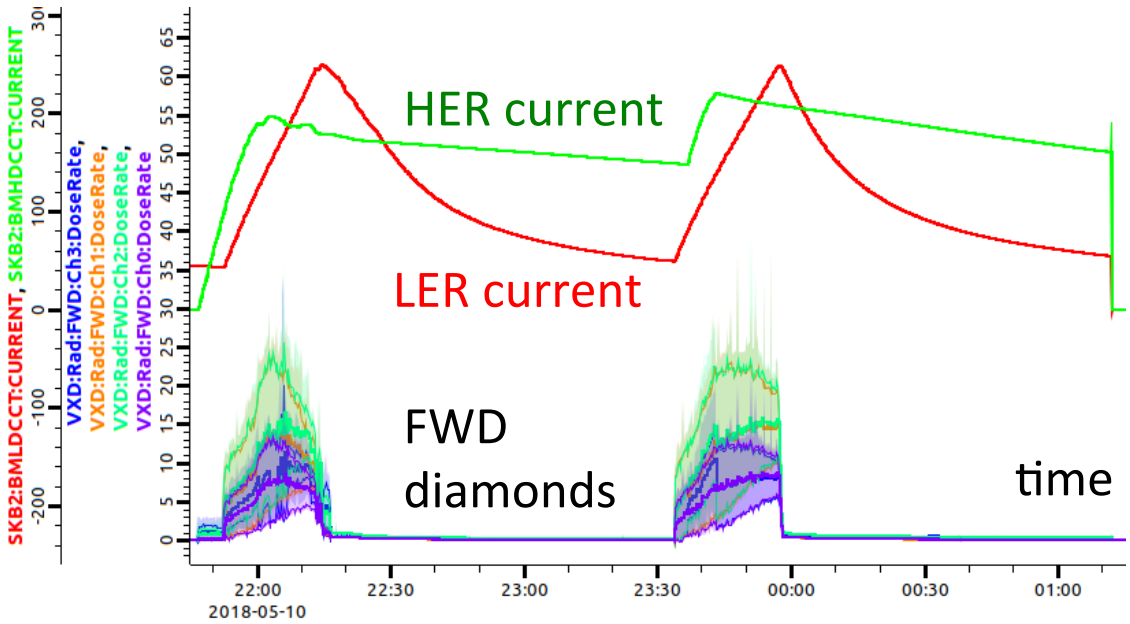
In many interesting studies diamonds are relevant, i.e.:

Collimators
Touscheck (beam size)
Beam steering at the IP
Collisions/no collisions
HER, LER emittance
Luminosity runs
Comparisons with simulations, SVD, PXD
… etc.

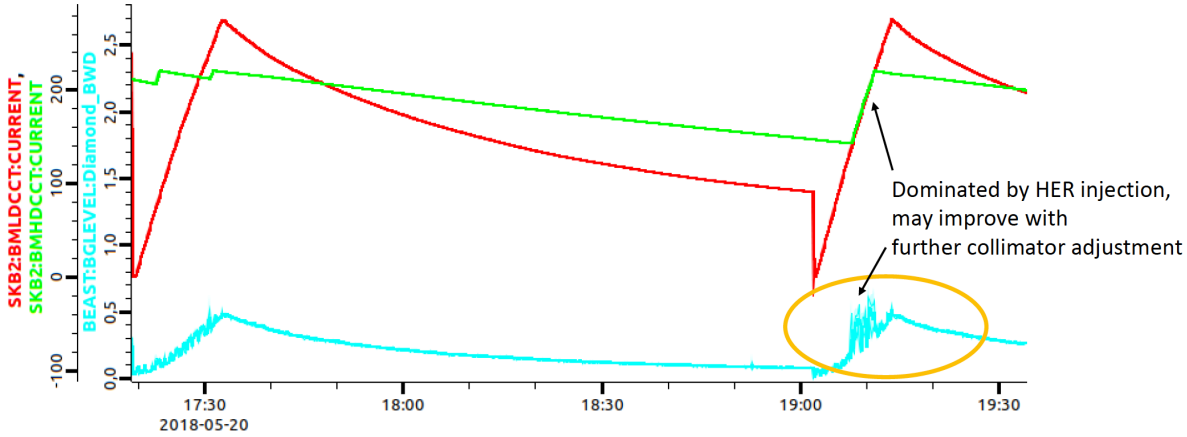
see reports by Chiara and Giovanni
at SVD and KCG, BCG/BEAST meetings
Here only some examples

Dose Rate Measurements: Examples - 1

high dose rate
during injection
(20-30 mRad/s)



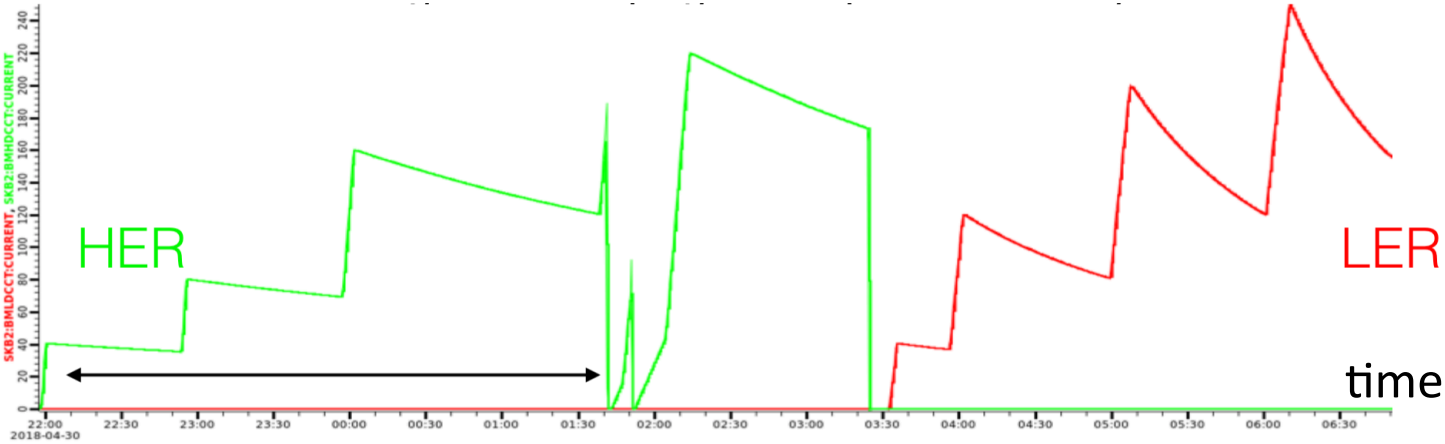
Improved injection



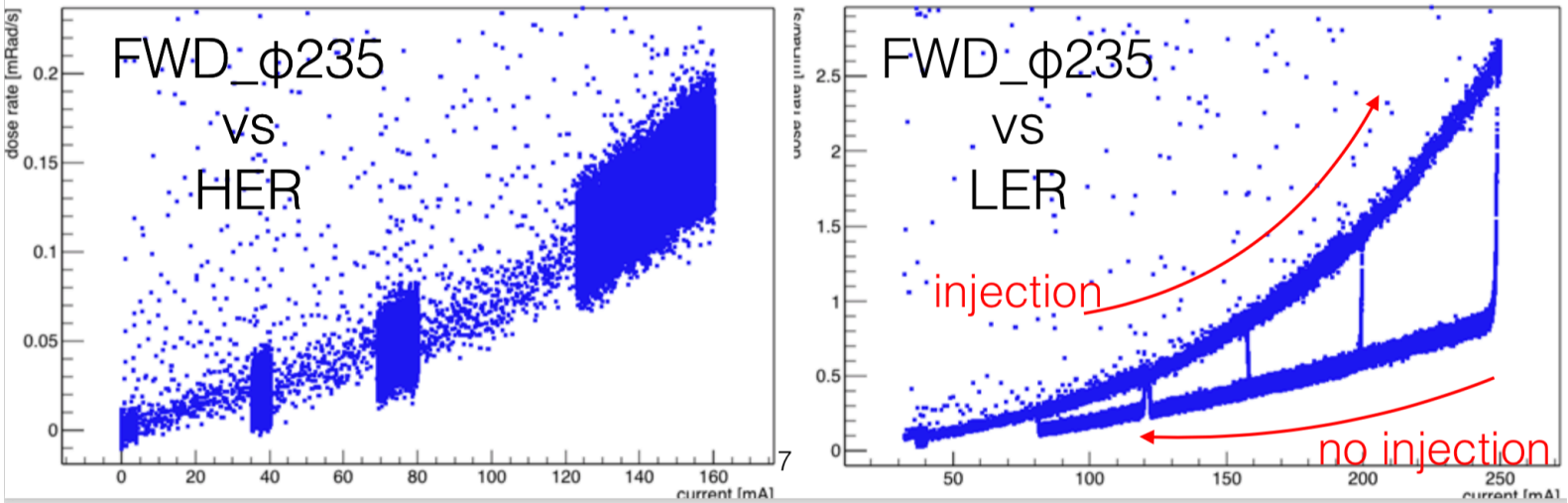
Dose Rates Measurements: Examples - 2

Dose rates vs beam currents: quadratic dependence

beam current [mA]



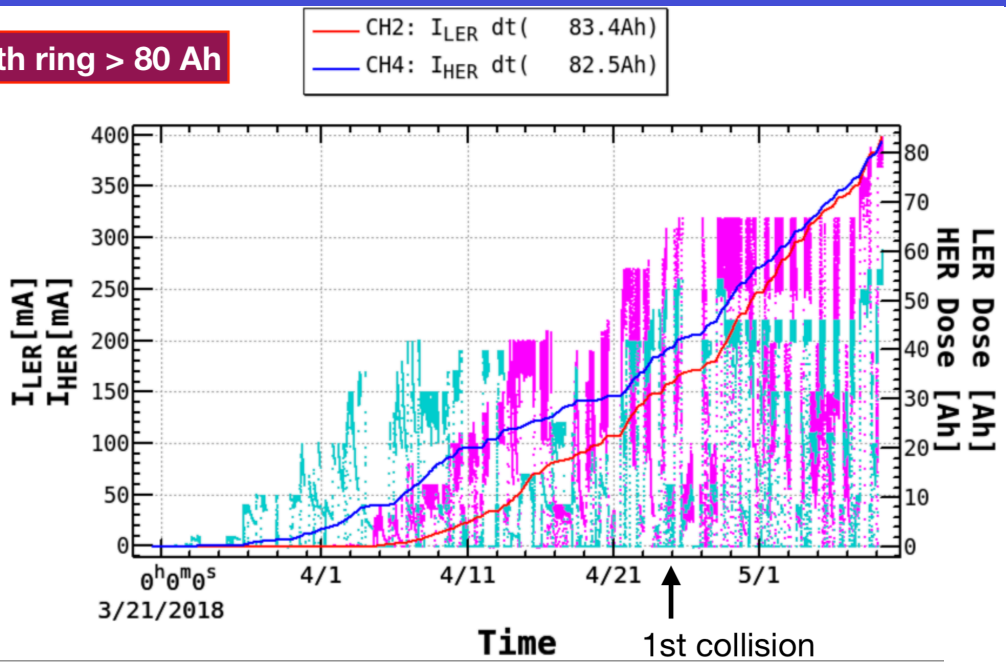
dose rate [mRad/s]



beam current [mA]

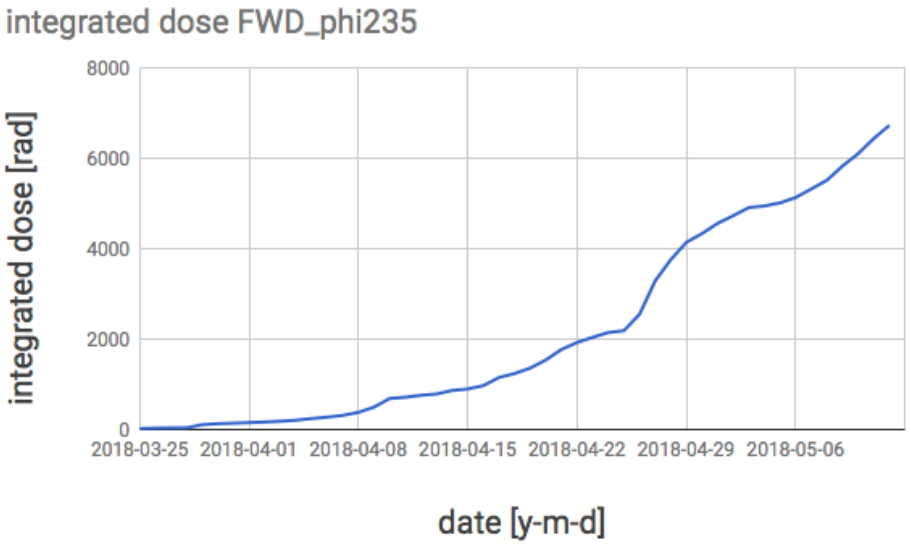
Integrated dose

Both ring > 80 Ah



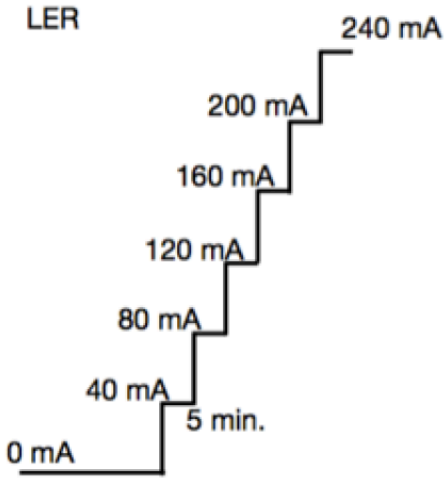
Beam charge (beam “dose”) [Ah]

PXD claims much larger dose seen from radiation damage (?)



Dose for one diamond [rad]

Beam Abort Test: thresholds

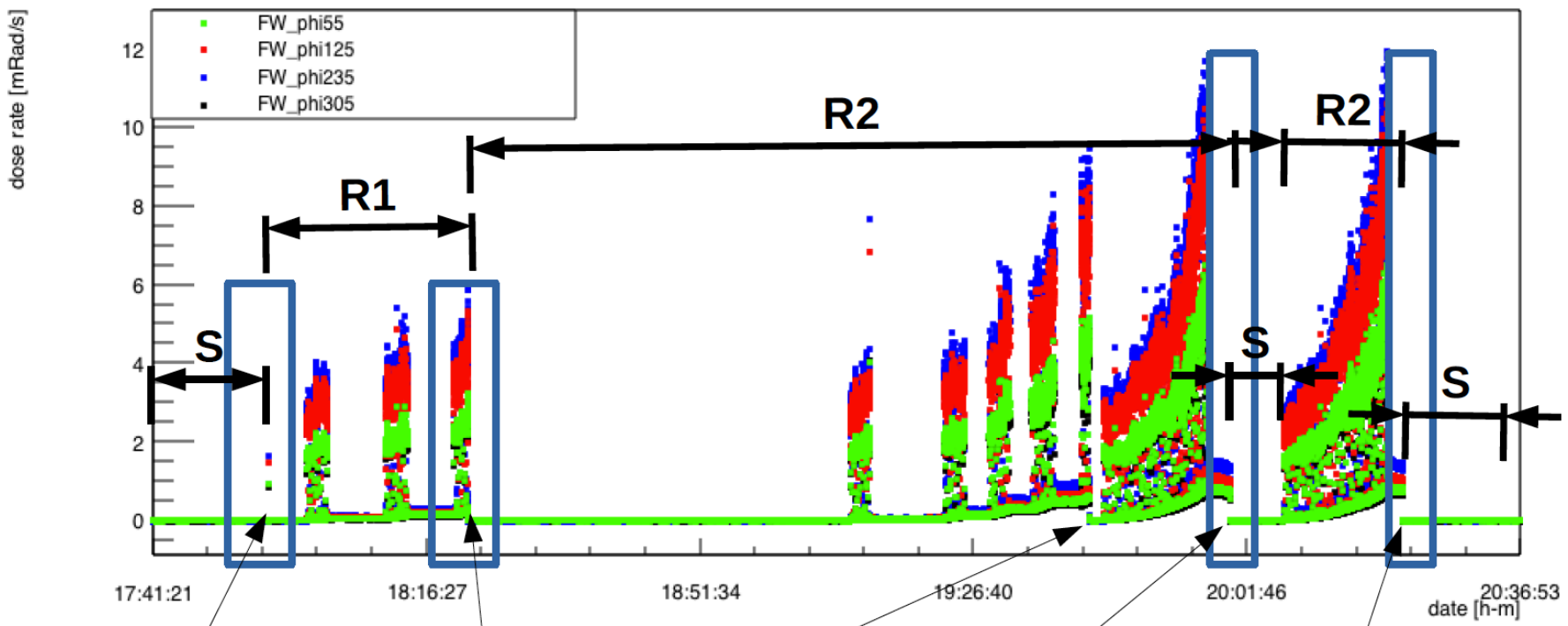


Beams pattern:
- only LER.
- from 0 mA to 240 mA in 40 mA steps.
- at each step wait a couple of minutes.

Diamond threshold settings:

- **STRICT** threshold: (**S**) 0.001 mRad integrated in 1 ms → 1 mRad/s.
- **RELAXED** thresholds : (**R1**) 0.5 mRad integrated in 10 ms → 50 mRad/s.
  (**R2**) 5 mRad integrated in 100 ms → 50 mRad/s.
- In both cases **at least 2** diamond signals have to exceed the thr to deliver an abort
- Relaxed thrs are used during injection to avoid to deliver abort, R1 was too low so we introduced R2.
- STRICT and RELAXED thrs are implemented in the **same configuration file**, they are **alternative** and we can **switch** between the two.

Beam Abort Test: History of Aborts



Abort 1
at ~ 17:56
strict thr S
exceeded
during
injection

Abort 2
at ~ 18:21
relaxed thr R1
exceeded
during
injection

SKEKB loss
monitor

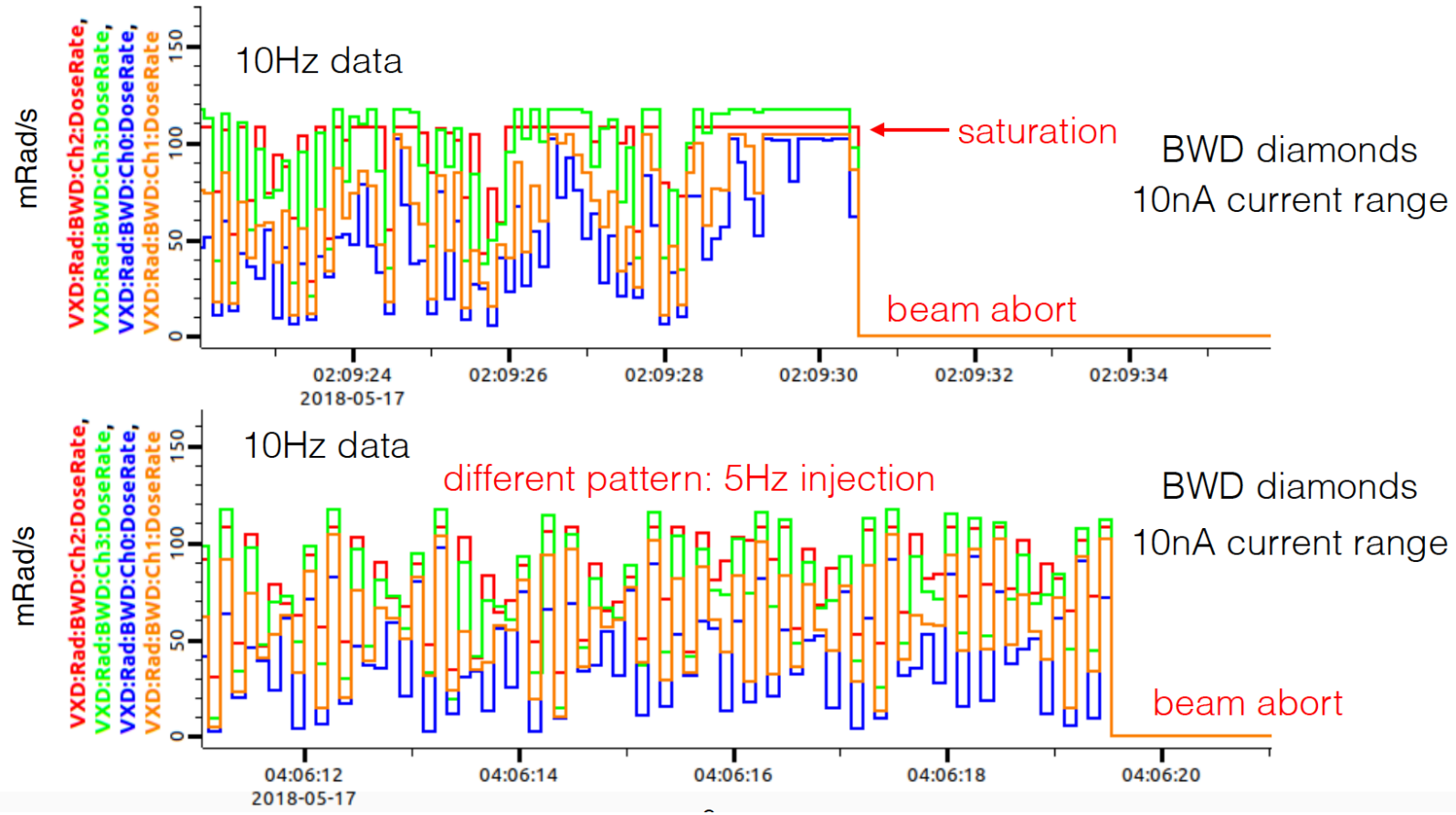
Abort 3
at ~ 19:59
manual change
from relaxed
R2 to strict S
during storage

Abort 4
at ~ 20:21
manual change
from relaxed
R2 to strict S
during storage

Preventing QCS Quenches?

QCS quenches (17 May)

During the night of 17 May we had two QCS quenches by beam directly hitting the magnet.
These quenches were due to optics and collimator settings that are still not well set.



Preventing QCS Quenches? Lower Thresholds!

Present abort threshold: **10 Rad** integrated in **1 ms**

Proposed new threshold: **fast** = **10 mRad** integrated in **1 ms**
slow = **200 mRad** integrated in **1 s**

Would the new threshold have aborted before recent quenches? YES, 15 out of 19

Time	Configuration FWD - BWD	Abort?	Time	Configuration FWD - BWD	Abort?
4/1/2018 20:55	10 nA – 1 mA	No abort	4/11/2018 18:45	1 uA – 1 mA	Slow/Fast
4/2/2018 19:29	10 nA – 1 mA	No abort	4/11/2018 20:23	1 uA – 1 mA	Fast
4/9/2018 17:31	1 uA – 1 mA	No abort	4/11/2018 21:15	1 uA – 1 mA	Slow/Fast
4/9/2018 20:06	1 uA – 1 mA	Fast	4/20/2018 14:33	10 nA – 1 mA	Fast
4/9/2018 20:53	1 uA – 1 mA	Fast	4/21/2018 0:22	10 nA – 1 mA	Fast
4/9/2018 21:40	1 uA – 1 mA	Fast	5/6/2018 11:28	10 nA – 1 mA	Fast
4/10/2018 17:44	1 uA – 1 mA	No abort	5/13/2018 2:45	10 nA – 1 mA	Fast
4/10/2018 21:56	1 uA – 1 mA	Slow/Fast	5/17/2018 2:09	1 mA – 10 nA	Fast
4/11/2018 14:21	10 nA – 1 mA	Fast	5/17/2018 4:06	1 mA – 10 nA	Fast
4/11/2018 15:25	10 nA – 1 mA	Fast			

Summary

- Good progress of SuperKEKB towards 10^{34} cm^{-2} s^{-1}
- Backgrounds improved recently, more work needed:

  Diamond doses vs PXD, SVD? synchrotron radiation? Scraping?

  Comparisons with simulations?
- Radiation monitoring system based on diamond sensors

  Stable, always on up to now, performing well

  Monitors the background levels, contributes to the understanding of backgrounds, and can abort the beams

  Abort thresholds to be lowered, to help preventing QCS quenches

  Readout system OK but limited in dynamic range; optimization or upgrade needed for Phase 3, based on the experience in Phase 2