Operation with Libera Brilliance at PETRA III
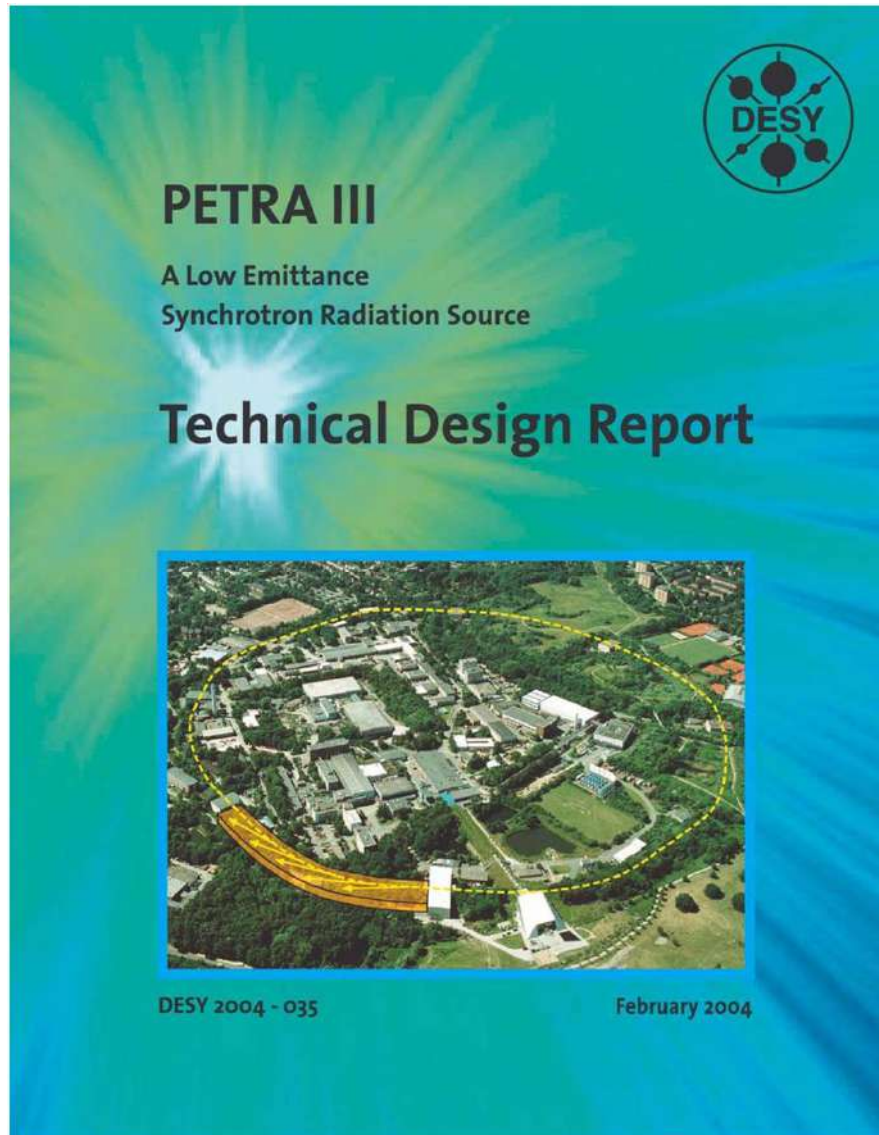
Frank Schmidt-Föhre

DESY / MDI

- Introduction
- Experience with BPM System
- Proceedings and open issues
- Petra III Upgrade
- Outlook
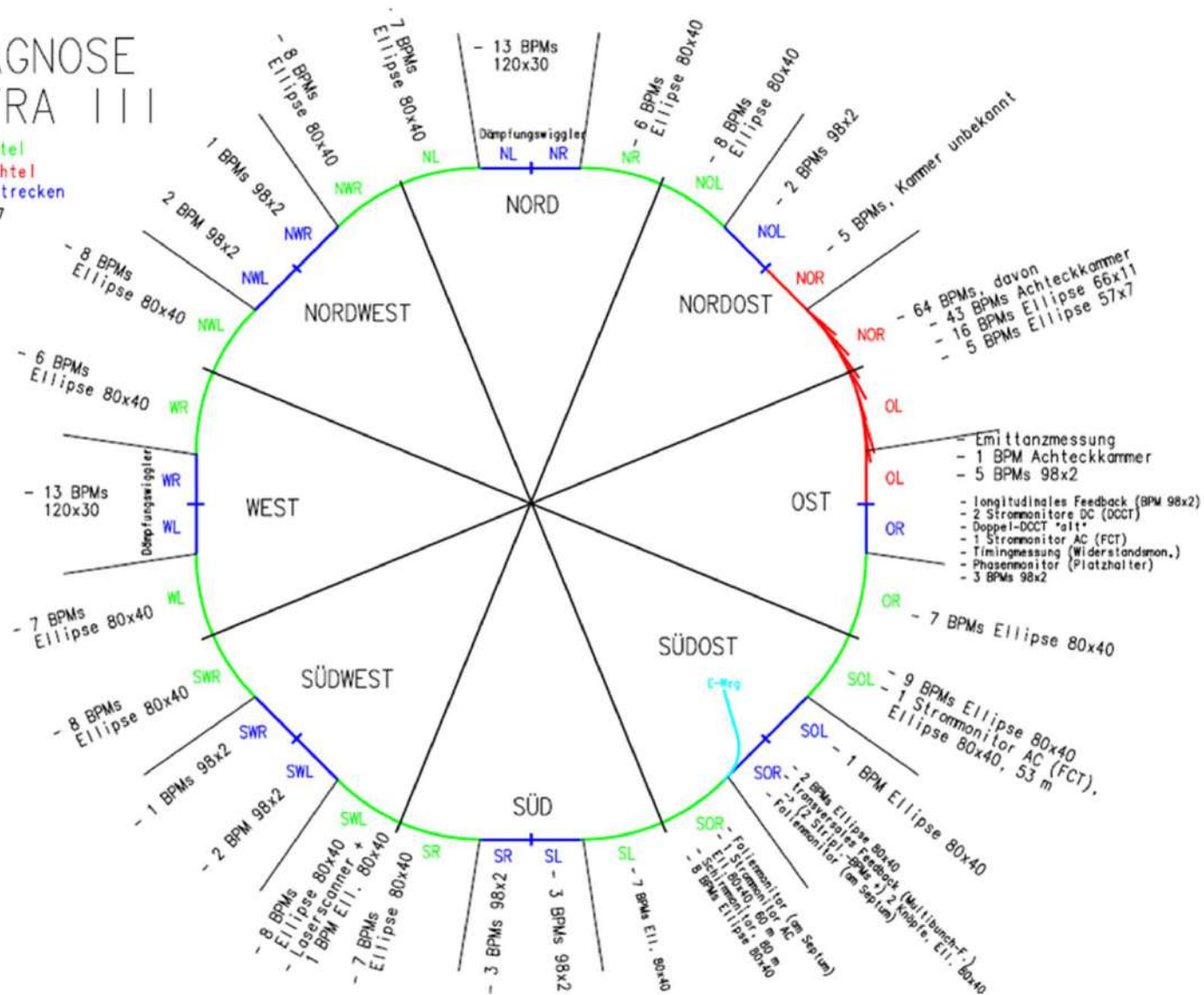
PETRA III @ DESY - Introduction

Parameters:

- circumference: 2304 m
- energy: 6 GeV ✓

- emittance: 1 nmrad ✓
- emittance coupling : 1% (10 pmrad!) ✓

- current: 100 (200) mA ✓
- # bunches: 40 / 960 ✓

- straight sections: 9 ✓
- undulators: 14 ✓
- undulator length: 2, 5, 10 (20) m ✓

- supplement to X-FEL (✓)
  ➔ cost effective!

BPM System Experience (Libera)

Libera Brilliance firmware version V1.87 currently operating at PETRA III

Many operational parameters and functions were tested, validated, clarified or fixed during the last 1-2 years …

🔴 Performance Tests & Measurements

⟩ Validation of performance of all necessary data paths for all of the 227 BPMs ➔ works fine

⟩ Validation of the necessary on-demand data streams
  (Turn-by-Turn (TbT), decimated TbT, Post-Mortem, ADC, orbit interlock functionality (FA))
          ➔ frequently used for recommissioning, machine studies, service & maintenance
          ➔ works fine (minor exceptions – see below)

⟩ TbT resolution: < 10µm rms (BW > 40 kHz)

⟩ SA resolution: < 100nm (1 σ, 10 Hz)

🔴 Optimization of transverse Fast Orbit Feedback (FOFB)

⟩ FOFB data stream with 130.1 kHz data rate,
          synchronous to machine revolution frequency

⟩ uses special DESY-type Molex output
          (I/Q raw data ➔replaces normal Libera Brilliance FA data output)

⟩ Low latency (130 µs) compared to normal FA output (270 µs)

⟩ Transverse Fast Orbit Feedback works now stable with design performance
          (minor exceptions – see below)

BPM System Proceedings (Libera)

Several Libera issues fixed or clarified in collaboration with I-Tech over the last 1-2 years …

🔴 Libera internal operation and Control System Interface related issues
(FPGA, firmware, CSPI, Libera Generic Server, TINE Libera Server)

› Libera Generic Server link-breakdowns fixed (Generic Server problem)

› AGC minor issue clarified ('switch after stop', Libera firmware)

› Libera mass reboot hangup clarified (Unix problem)

› Post-Mortem buffer readout crash fixed (TINE Libera Server problem)

› CSPI error message generation fixed (Libera firmware)

→ **but there are still some issues to be clarified and fixed in collaboration with I-Tech …**

BPM System Critical Issues (Libera)

● **DSC (digital signal conditioning) switching artefacts (TbT)**

› Switching artefact in all TbT-related data streams
→ switching effect increases with difference between momentary temperature
    and temperature level at which DSC coefficients were last learned (temperature drift)
→ depends on the position inside the machine
→ depends on momentary cooling conditions at the position inside the machine

› DSC coefficient degradation due to beam dump during ,DSC learning'-mode (see next page)
   (same effect expected on steep beam current gradients -> under investigation)

● **Libera Internal issues (FPGA, firmware)**

› Libera-internal task system pile-up (Libera firmware)

› Rarely sporadic hangups of DESY-type FOFB-interface (Libera FPGA)

› Rarely sporadic jumps in SA SUM data (Libera FPGA or firmware)

BPM System Critical Issues (DSC, 2)

- **DSC switching artefacts (TbT)**

  › Switching varies with time (Libera frontend issue)
    → impact of temperature on Libera RF frontend

  › Long-term measurement (12 h); ideal beam emulation

  › DSC coefficients learned, then DSC learning ‚off'

  › Health daemon ‚on' (fans regulated)

  › Averaged over 500 TbT samples
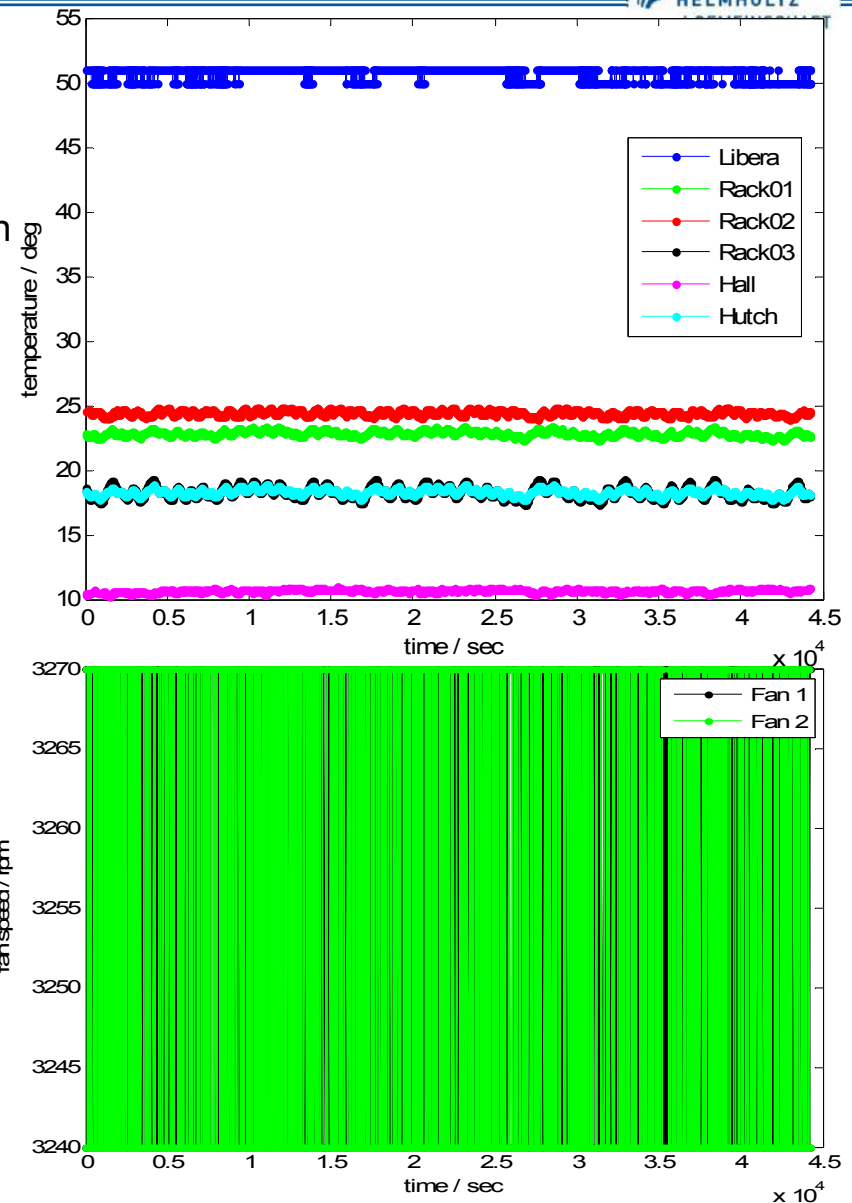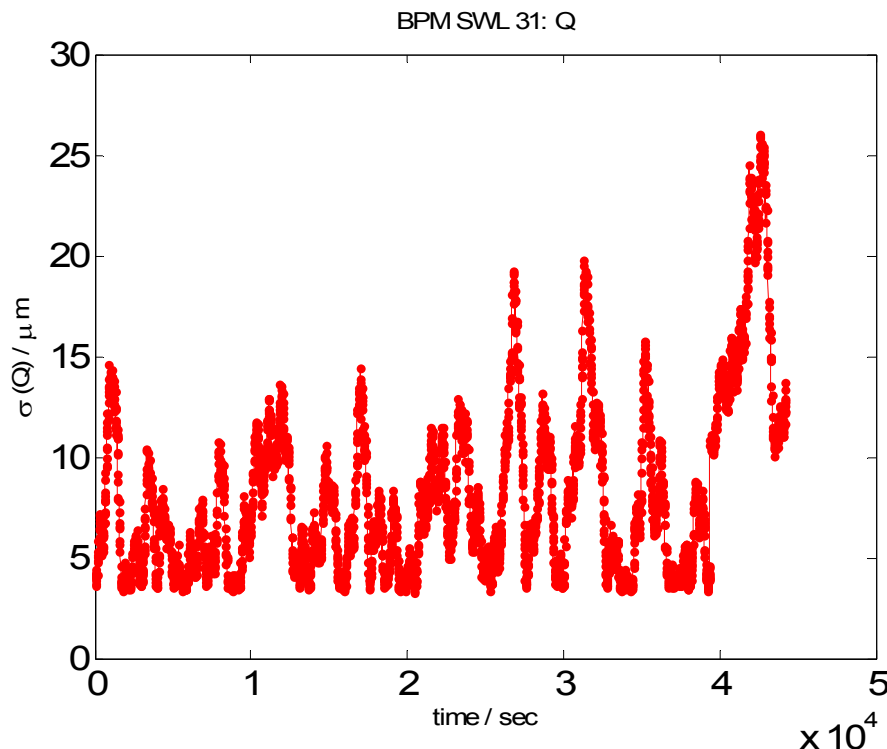
BPM System Critical Issues (DSC, 3)
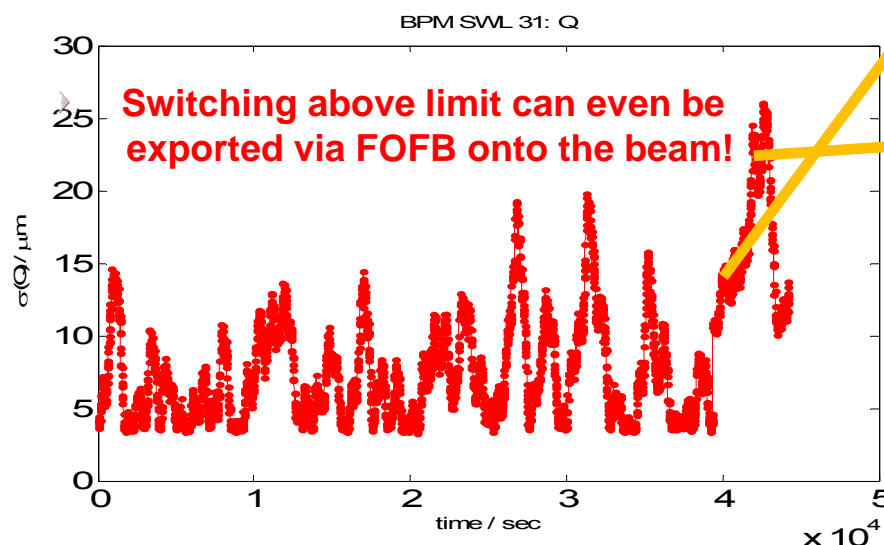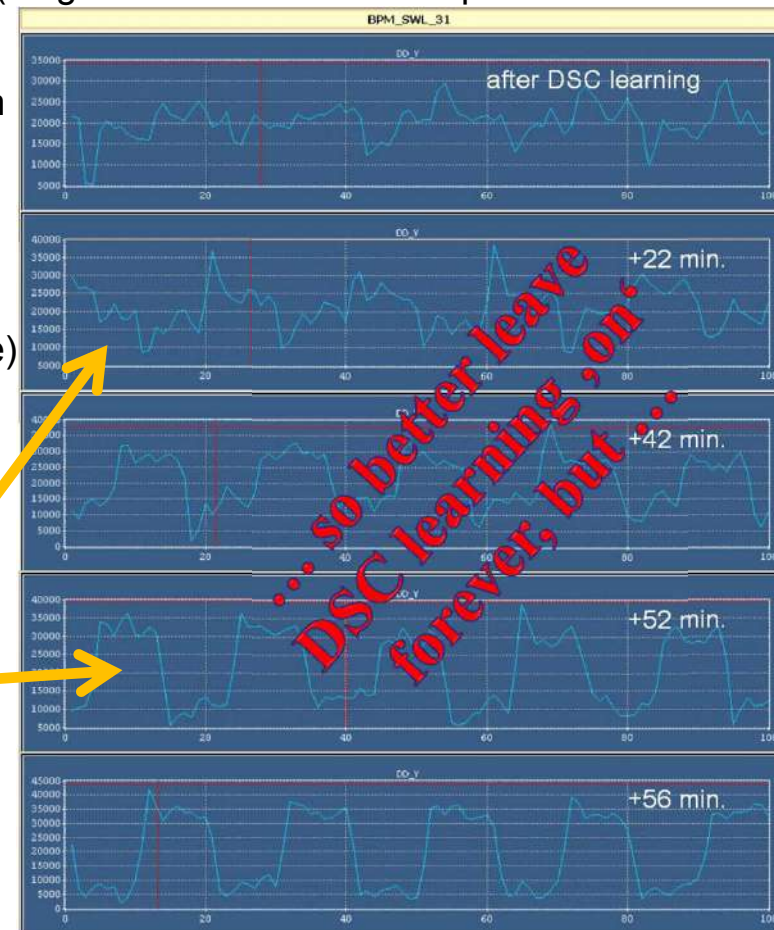
DSC switching artefacts (TbT; same BPM SWL-31)

- Switching varies with time (Libera frontend issue)
  → impact of temperature on Libera RF frontend

- Long-term measurement (12 h); ideal beam emulation

- DSC coefficients learned, then DSC learning ‚off'

- Health daemon ‚on' (fans regulated)

- Right diagram shows snapshots of a signal behaviour
  like in the diagram below (switching variations vs time)

- Up to 30µm switching peak-peak seen here
  (even more switching can be seen depending
  on BPM position and several other conditions)

(diagram shows vertical TbTposition vs TbT sample)

Switching above limit can even be exported via FOFB onto the beam!

...so better leave DSC learning ‚on' forever, but...

(only principle shown
– data in both diagrams are not directly corrrelated)
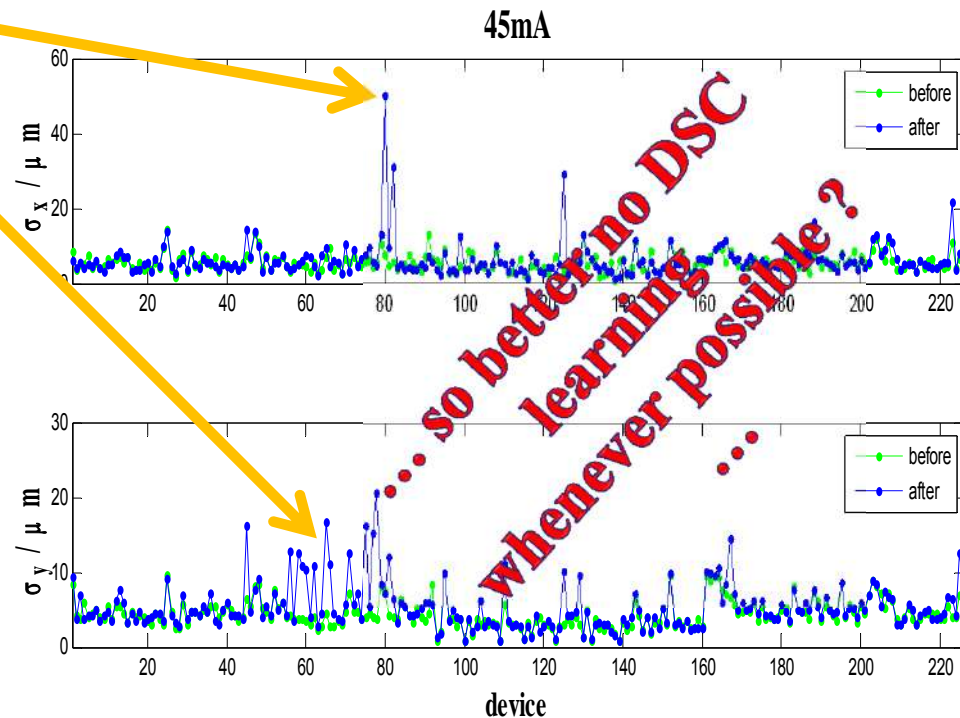
BPM System Critical Issues (DSC, 4)

🔴 ... but DSC learning can (at least) be affected by spontaneous beam losses !

› Calculation of incorrect DSC coefficients (amplitude, phase) based on noise signals shall be inhibited by ,MinTbTLearnLimit' parameter threshold detection (new: 40000 for Libera Brilliance at PETRA III)
→ does yet not work correctly

Test procedure used:

› Establish a certain beam current at absolute stable beam conditions (60 bunches, FOFB on etc.)

› Let AGC settle the gain level

› Let DSC learn

› take 1st measurement („before")

› Keep gain level (AGC off)

› Dump the beam (80% → 20% in 70μs)

› Turn DSC off (keep AGC off)

› Reestablish the former beam current level

› Take 2nd measurement ("after")

› (repeat sequence for other beam currents … →similar results found at different other beam currents)

(similar effect expected on steep beam current gradients due to DSC coefficients calculation
-> currently under investigation)

... so better no DSC learning whenever possible ?

BPM System Critical Issues (DSC, 5)

➔DSC suggestions:

- optimal solution: replacement for generic Libera 'ldscd' with adapted Diamond 'ldscd' concept ➔ apply newly calculated DSC coefficients only, if result of calculation shows better performance (otherwise discard these coefficients)
➔ see Michael Abbott's talk (Diamond)

- slim solution (not fully sufficient ➔ preliminary):

- Discard DSC coefficients, that were acquired during a period
  with a Post-Mortem trigger (usually correlated with a beam loss or beam dump)
  ➔should be user configurable

- Present AGC input level shall be acquired and compared before and after
  acquisitions for calculation of new DSC coefficients
  ➔discard coefficients acquired between different input levels

=> PETRA III needs a workaround at TopUp mode up to now …

BPM System Critical Issues (DSC, 6)

DSC TopUp workaround currently used at PETRA III:

- an automatic parameterized DSC learning scheme was invented
  and integrated into the so-called TopUp-engine

- it launches DSC learning cycles on a regular basis
  only in periods without TopUp charge injections and constant input power level

- scheme optimized in two ways:
  - minimize periods of active DSC learning
    → minimize danger of beam losses during DSC learning phases
  - maximize frequency of DSC learning
    just to keep the DSC coefficients at an optimized level

- watchdog-timeout-counter scheme implemented (forced DSC learning cycles even
  overriding TopUp injection periods) to overcome danger of long phases without
  DSC learning due to bad beam lifetime
  (DSC coefficients acquired during TopUp injections are even better than freely
  drifting TbT switching artefacts over a long period of time).

- drawbacks:
- functionality highly dependent on current beam lifetime
  →needs manual intervention e. g. on bunch pattern changes
- software mechanism outside Libera – DSC coefficient degradation is not faught
  against inside(!) Libera (i. e. at the source of the problem!)

PETRA III Upgrade Project
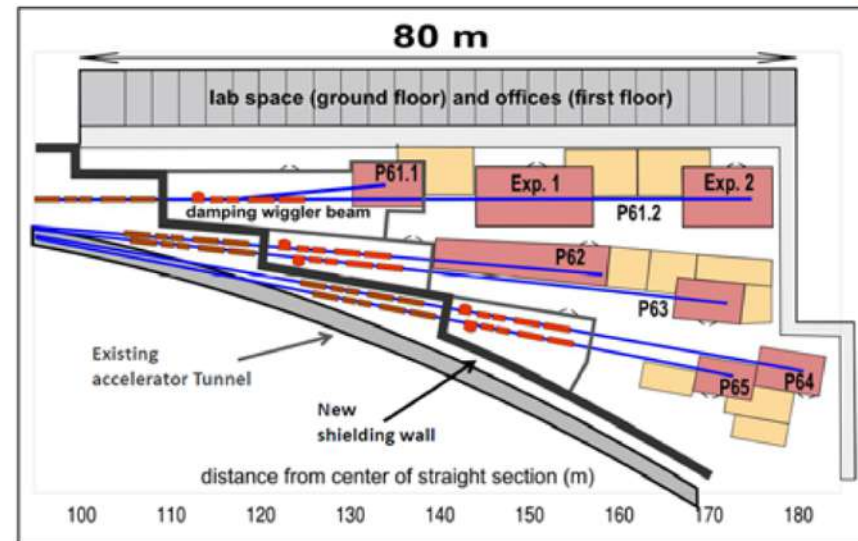
PETRA III Upgrade plans and example: new hall 'North' (for details see 'PETRA III UPGRADE', K. Balewski et al., IPAC 2011)

⟩Number of PETRA III beamlines to small to fulfill the users request for beam time

⟩Even more beamlines needed due to shut down of old DORIS III synchrotron at end of 2012

➔PETRA III Upgrade planned …

⟩Two new halls will be built with 5 new beamlines each (wigglers & undulators)

⟩Existing accelerator tunnel will be reused

⟩FODO cell structures will be replaced with canted DBA cell structures at new hall sections for ID implementation

⟩Existing FOFB will be enhanced

⟩Libera BPM system will be enhanced →Libera Brilliance+ under test at DORIS III

⟩Upgrade planned between spring and autuum 2013 → commissioning of new beamlines at 2014

PETRA III Upgrade – Libera tests

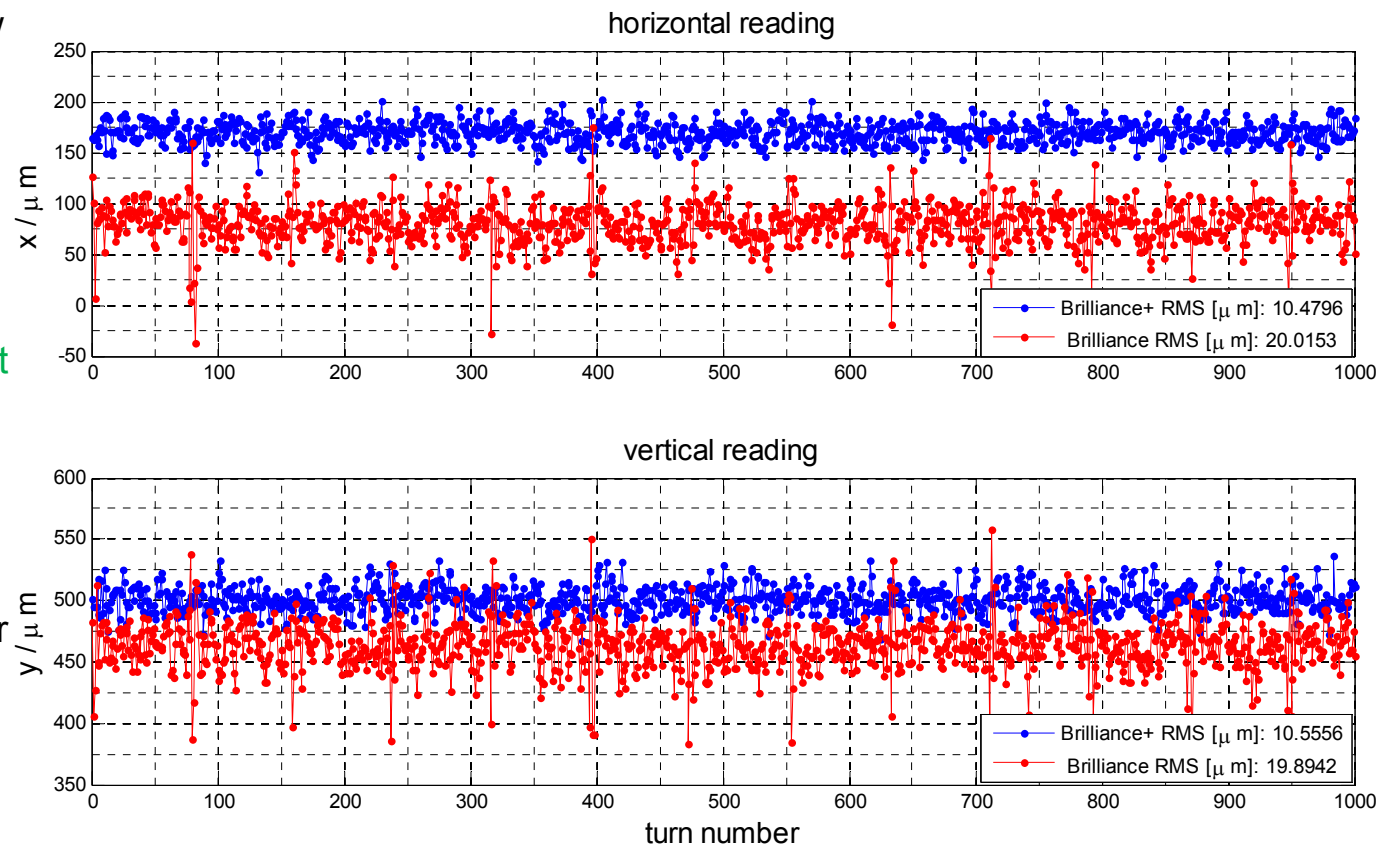● **Comparative tests of Libera Brilliance vs Libera Brilliance+ at DORIS (23.9.2011)**

› Libera Brilliance+ was equipped with 2 identical BPM channels (up to 4 possible per unit)

› Identical splitted RF-input signals for a single BPM channel at both units each

› Beam conditions: 10 bunches @ 130mA , Orbit-Feedback switched on

› Comparable configurations: DSC auto, AGC on, Spike Removal off, Kx = Ky = 10mm

› diagrams below show first comparative measurements of commonly triggered TbT data

› First raw tests show resolution advantage for Brilliance+ against Brilliance of roughly factor 2

› Reproducable results (several tests done)

› More tests needed for reliable statements

horizontal reading

Brilliance+ RMS [μ m]: 10.4796
Brilliance RMS [μ m]: 20.0153

vertical reading

Brilliance+ RMS [μ m]: 10.5556
Brilliance RMS [μ m]: 19.8942

turn number

PETRA III Upgrade – Libera tests (2)

- **First tests of Libera Brilliance+ functionality and system structure at DORIS (23.9.11)**

  › Libera Brilliance+ was equipped with 2 identical BPM channels (up to 4 possible per unit)

  › 1st BPM channel (blue) gets RF-input signals from DORIS BPM with beam

  › Beam conditions: 10 bunches @ 130mA , Orbit-Feedback switched on (as above)

  › Configurations: DSC auto, AGC on, Spike Removal off, Kx = Ky = 10mm

  › RF-inputs of 2nd BPM channel (red) were terminated (50Ω) without input signal

› diagrams below show first orientational measurement of commonly triggered TbT data (2nd channel scaled to 1/200 for visibility purposes)

› First raw tests show no visible crosstalk between the two Brilliance+ BPM channels

› Reversed channel arrangement shows identical behaviour

› More tests needed for reliable statements
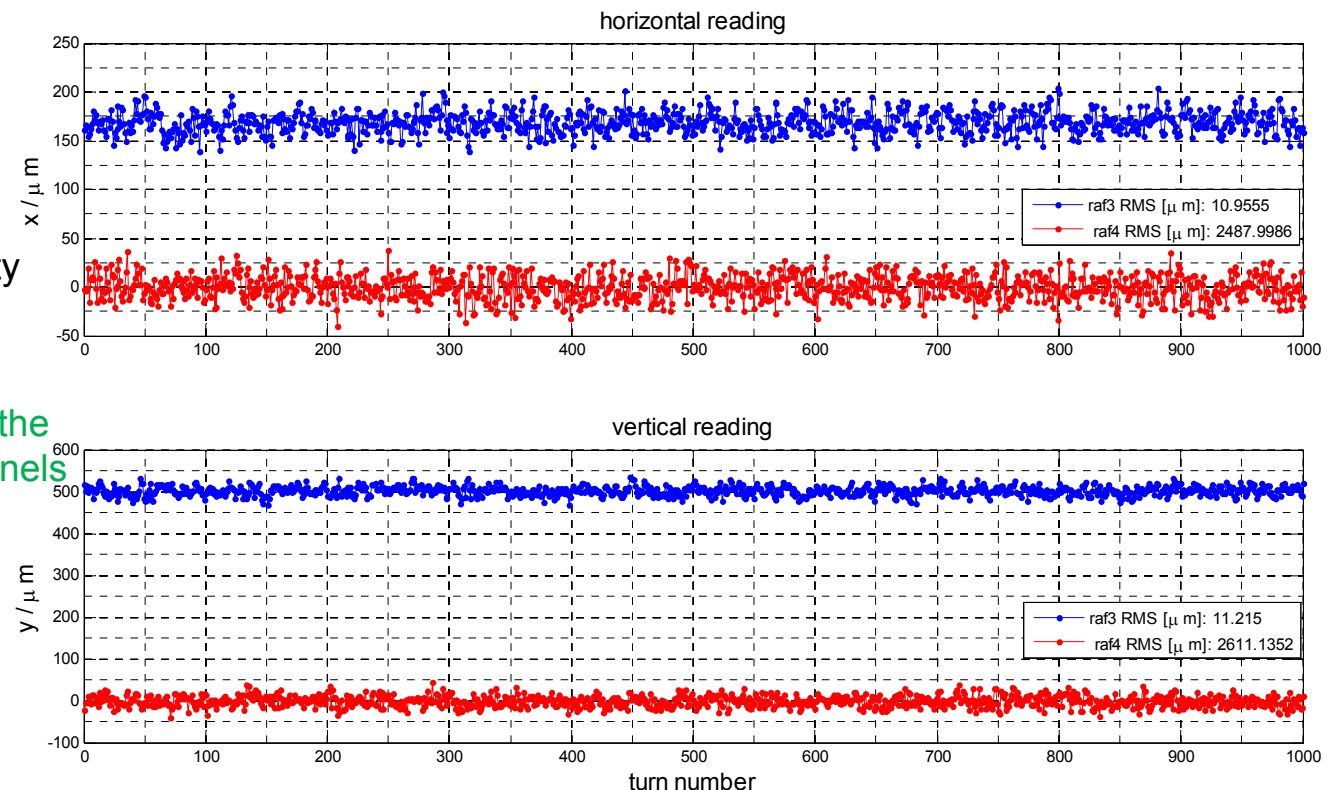
Summary & Acknowledgment

Summary …

- PETRA III achievements & proceedings shown
- PETRA III – BPM system works quite well, but still needs workarounds
- BPM system achievements & proceedings shown
- Open Libera issues described
- PETRA III upgrade project shown
- First comparative measurements of Libera Brilliance+ vs Brilliance done

Thanks …

… to Klaus Balewski and the whole PETRA III team for valuable hints and beamtime

… to Kees Scheidt (ESRF) and Günther Rehm (Diamond) for fruitful discussions and important hints concerning Libera functionality and operational experience.

… to the collegues from I-Tech for their comprehensive support .

Thank you for your attention!