Five Months of Experience with Liberas during PETRA III Commissioning

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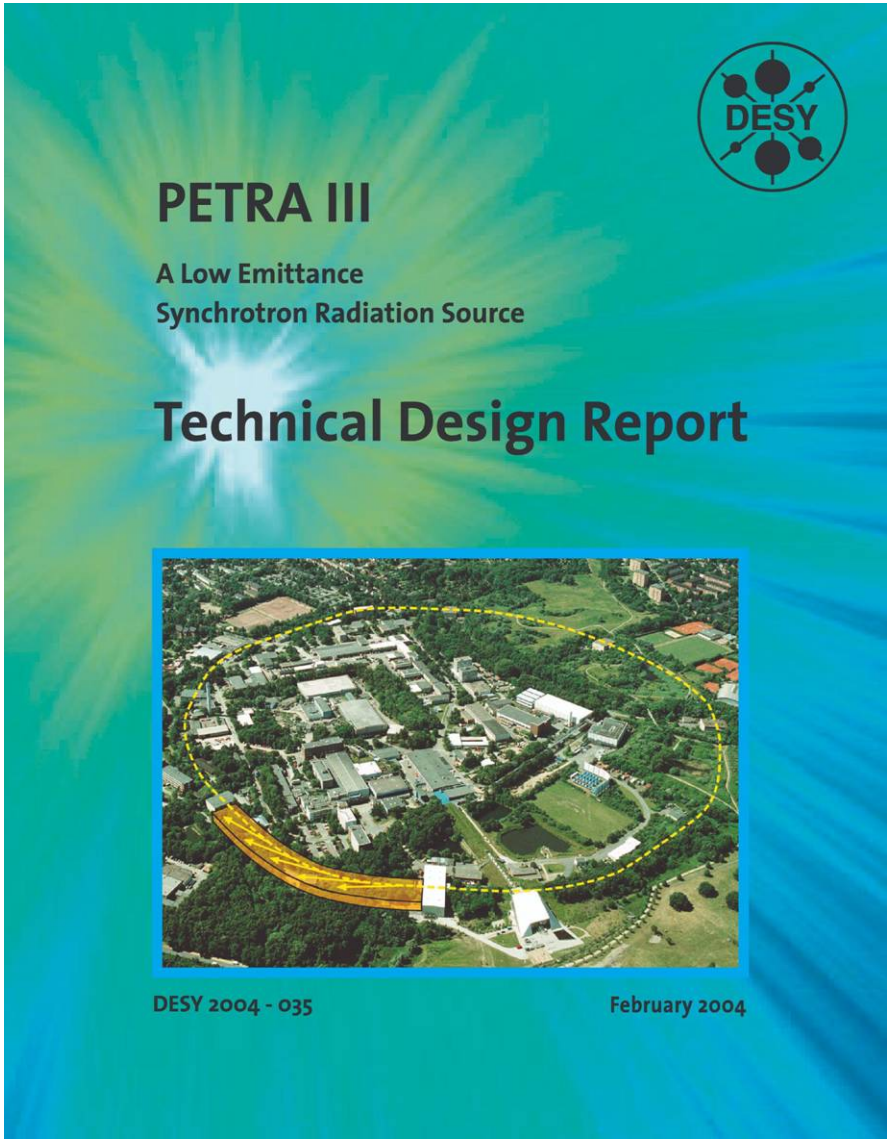
DESY / MDI

- Introduction
- BPM System
- Commissioning Experience
- Critical Issues

DESY

HELMHOLTZ
GEMEINSCHAFT

PETRA III @ DESY



Parameters:

- circumference: 2304 m
- energy: 6 GeV

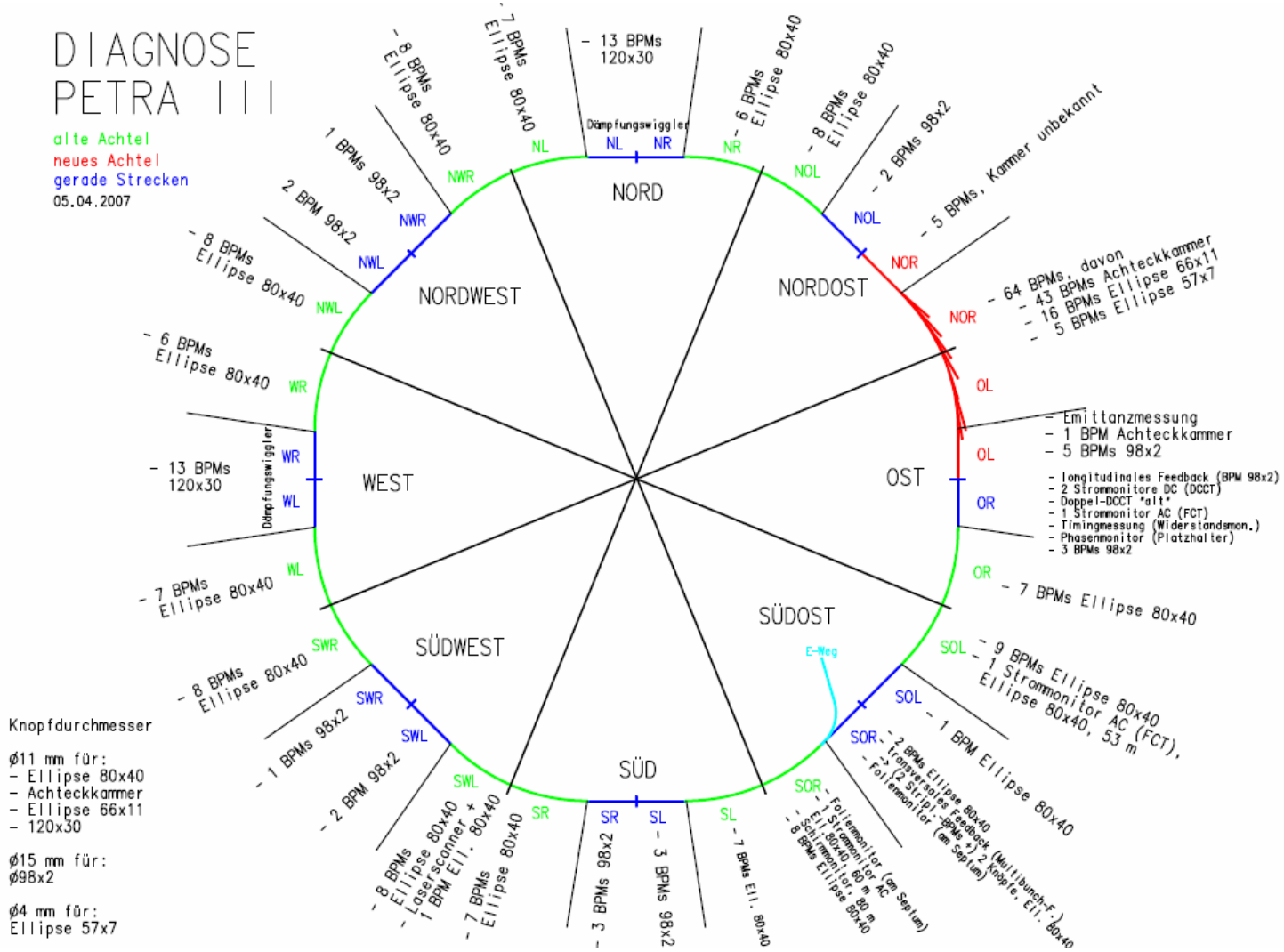
- emittance: 1 nmrad
- emittance coupling : 1% (10 pmrad!)

- 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!

PETRA III Diagnostics



PETRA III:

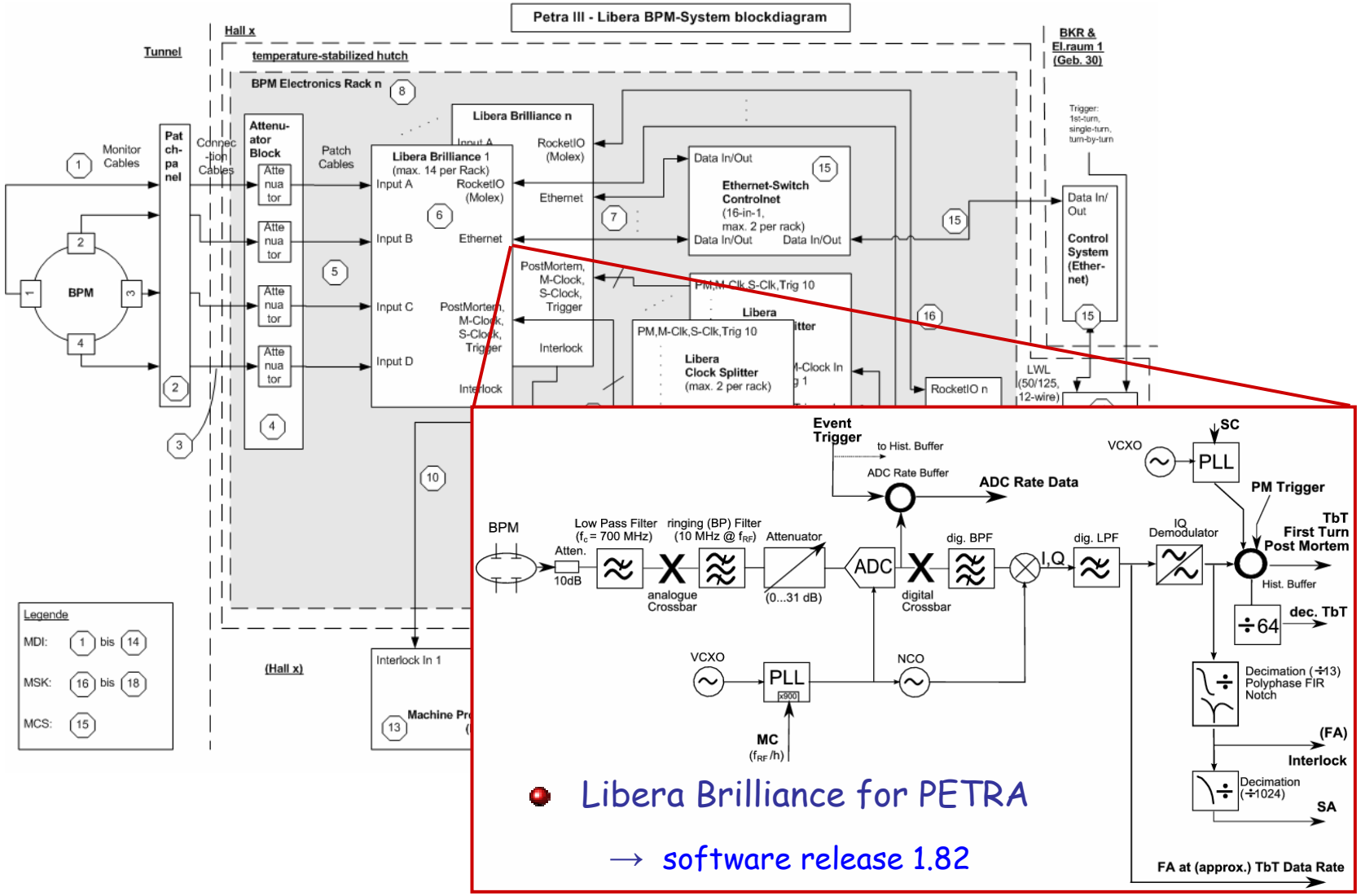
- 228 BPMs
  - → 226 for Orbit
  - → 227 Libera Brilliance
- 6 Current Monitors
- 2 Stripline-BPMs and 2 Button-BPMs for Multibunch Feedback
- 1 Button-BPM for longitudinal Feedback
- 1 Wall Gap Monitor
- 1 Laser-Wirescanner
- 2 Beamlines for Emittance Diagnostics
- 3 Screens

Transfer Lines:

- 20 BPMs
- 10 Current Monitors
- 4 Wall Gap Monitors
- 11 Screens

BPM System

- Overview

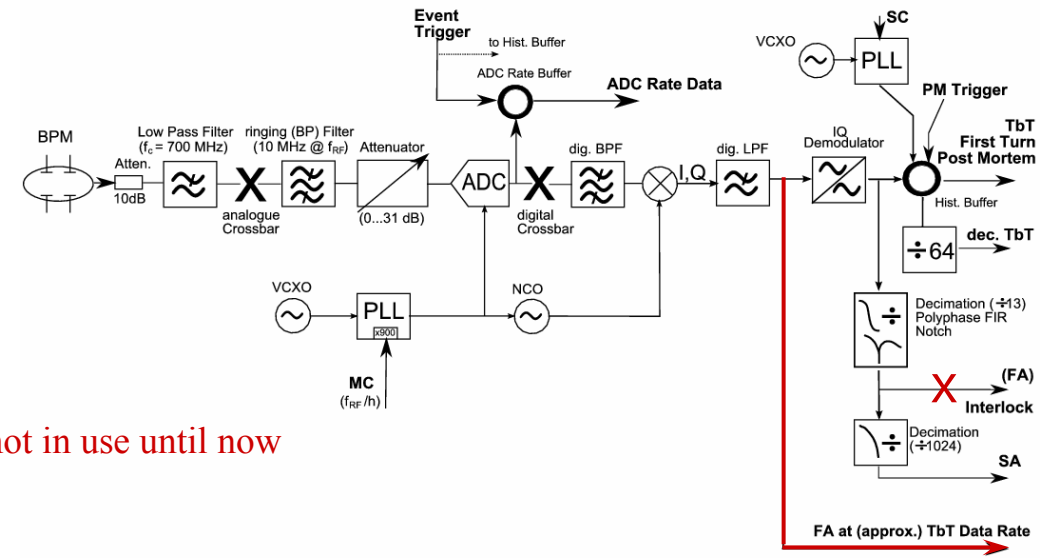


- Libera Brilliance for PETRA

→ software release 1.82

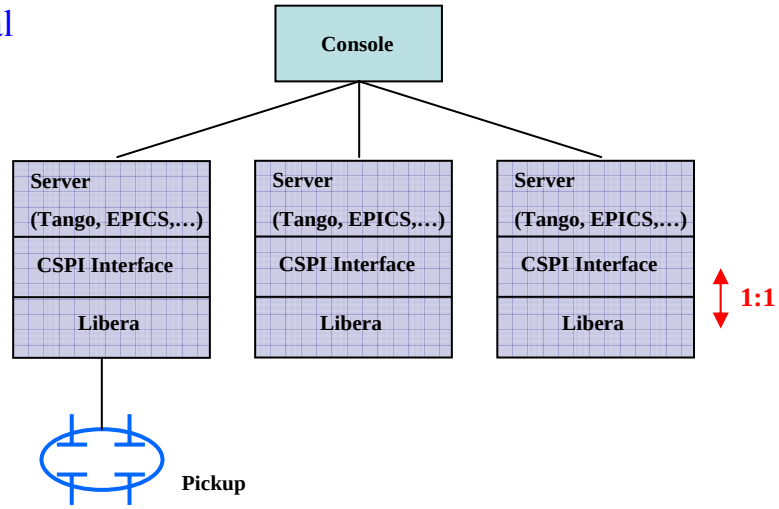
BPM System: Differences

- **Fast Data Stream (FOFB)**
  - latency of standard FA data stream
    → ∇(270 µsec)
  - new data output: Molex
    → reduced latency ∇(130 µsec)
    → in-house processing of raw data

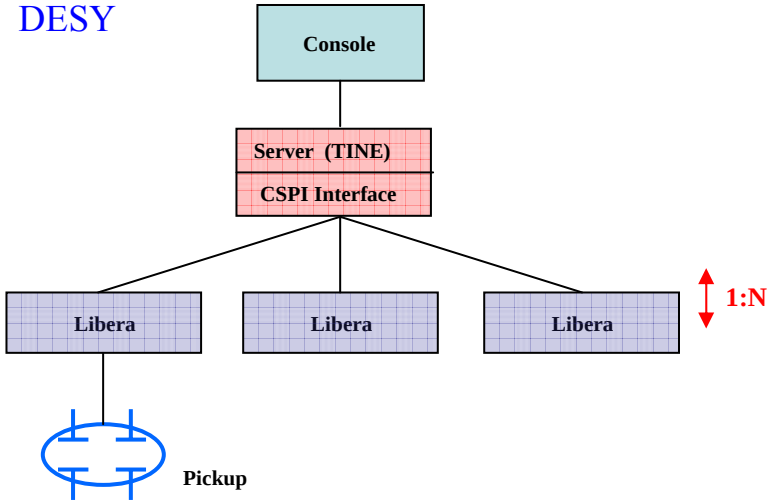


→ not in use until now

- **Server Architecture**
  - usual

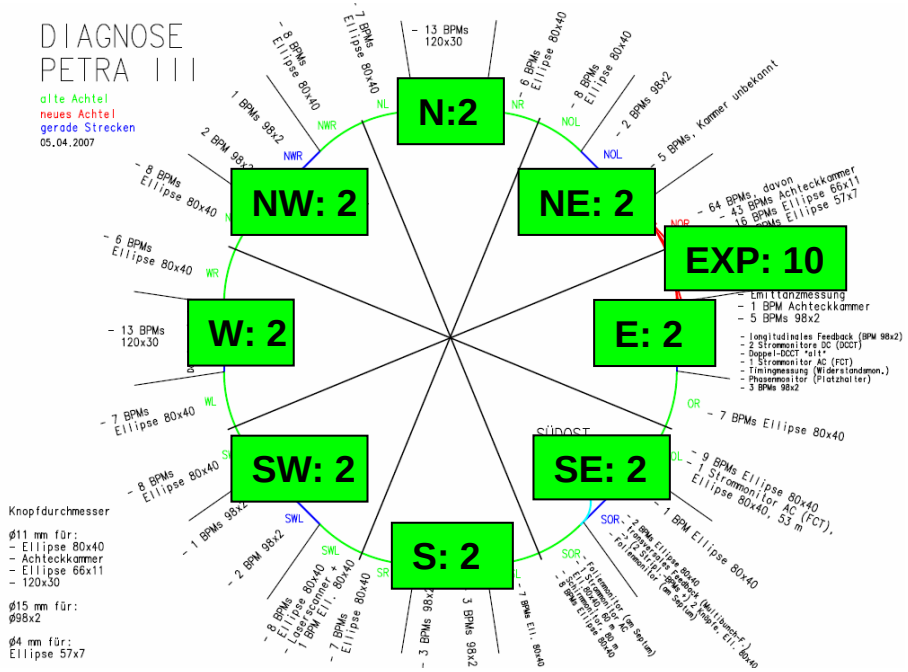


  - DESY



Accelerator Geometry: Implications

- accelerator sections
  - different vacuum chamber cross-sections
    - → 8 different pickup types
- large circumference
  - scattered infrastructure
    - → located in 8 „old“ experimental halls and the new experimental hall
  - cable lengths (10 m … 200 m)
    - → 3 different cable types for loss compensation (RFA 1/2´´-, 3/8 ´´-, 7/8´´-50)



number of racks in hall

→ 227 individual gain settings

Temperature Stabilization

- old 7 octants
  - Liberas in temperature-stabilized hutches (together with feedback electronics)

    → ± 1° C

- new experimental hall
  - hall itself is temperature-stabilized

    → ± 0.1° C

Beam Steering

Conditions

- only one screen monitor behind injection

  → beam steering depends on reliability of BPM system

Strategy

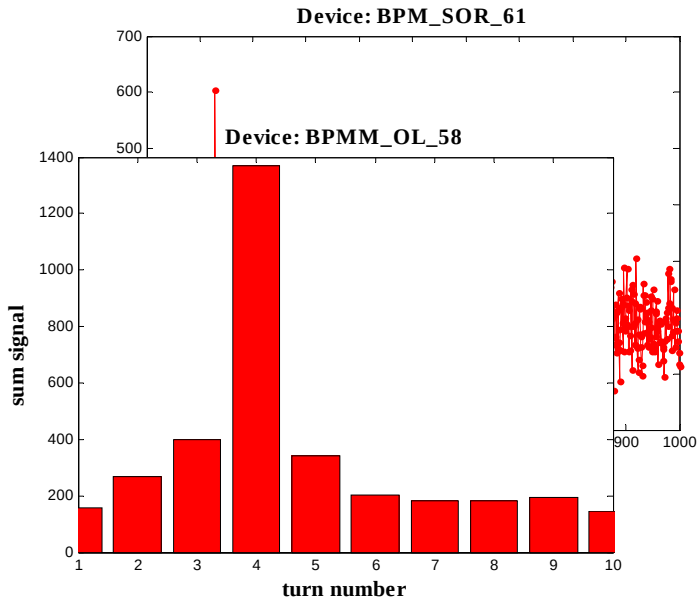
- triggered data on demand (DD) acquisition (→ injection trigger)
- observation of BPM sum signal

  → fix gain setting (-55 dBm), but AGC works well
- timing: adjust hardware trigger delay

  → maximum of sum signal appears in same turn

  → ADC signal in same channels
- fine tuning via machine time (MT) phase delay

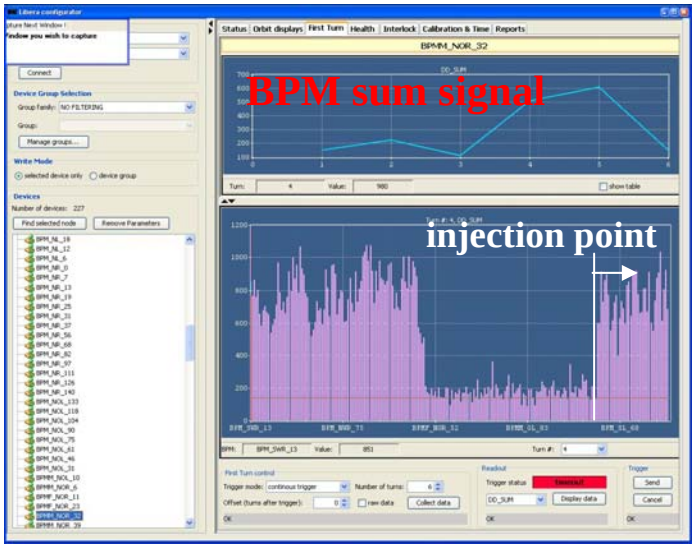
  → optimize intensity of sum signal wrt. neighbour turns

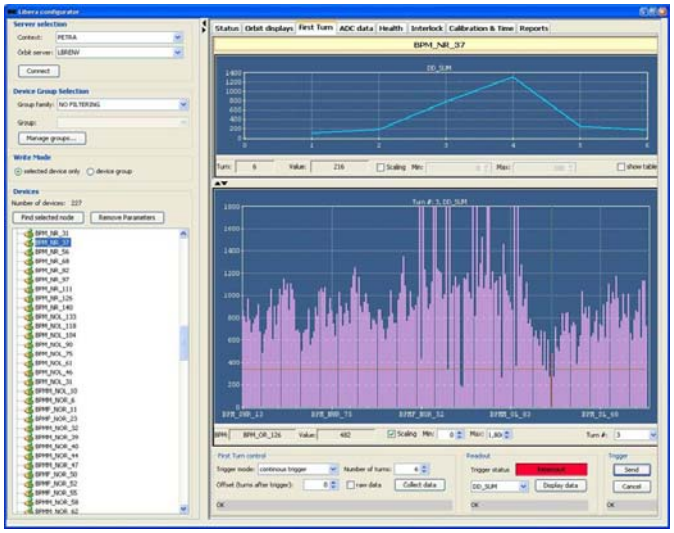


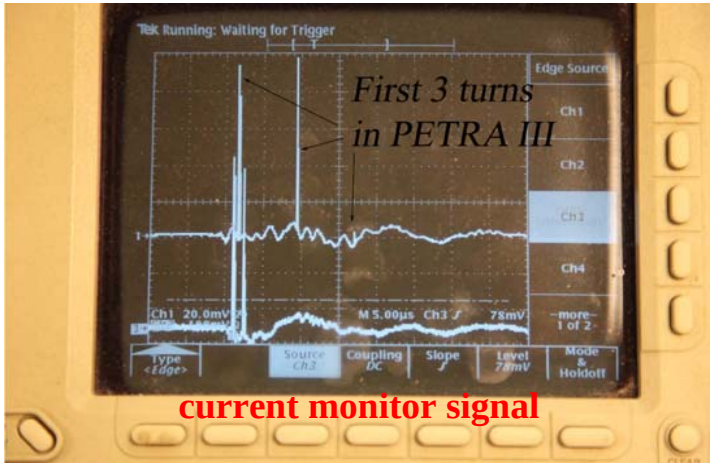
Beam Steering (2)

- Milestones
  - April 3: first beam in PETRA
  - April 10: all magnet power supplies available
  - April 12: first turns
  - April 13: first stored beam

    → single bunch, 20 µA (~ 10^9 particles)

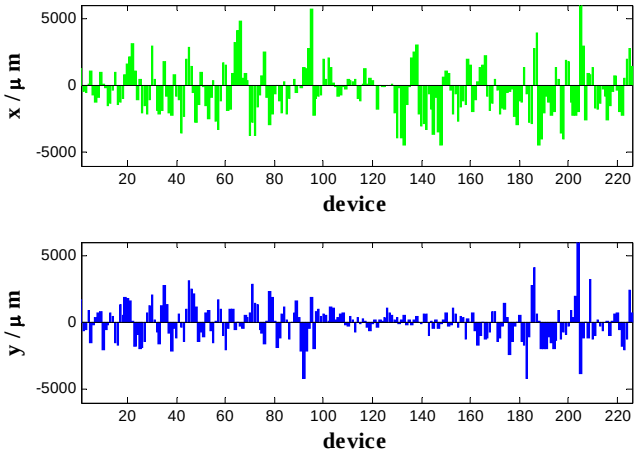




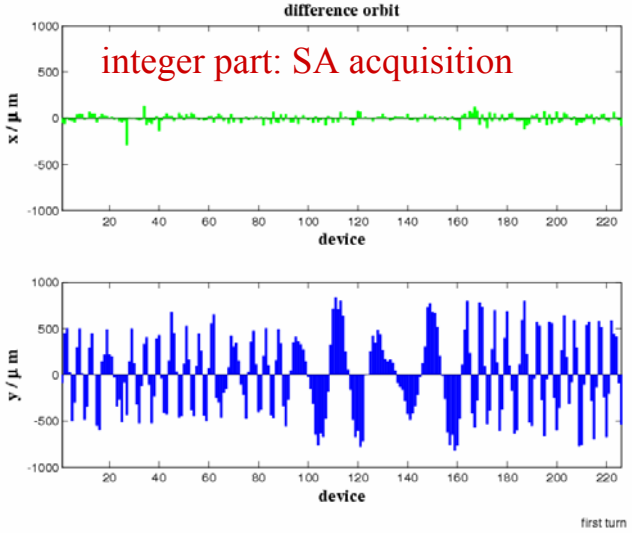


Commissioning

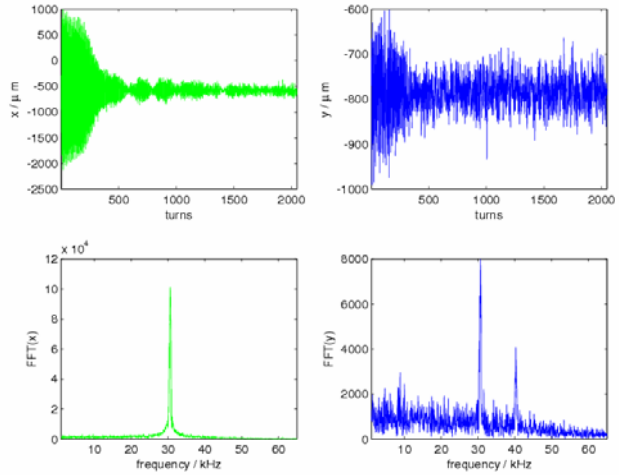
- correction of closed orbit
  - SA mode: AGC & DSC & switching on



- tune settings

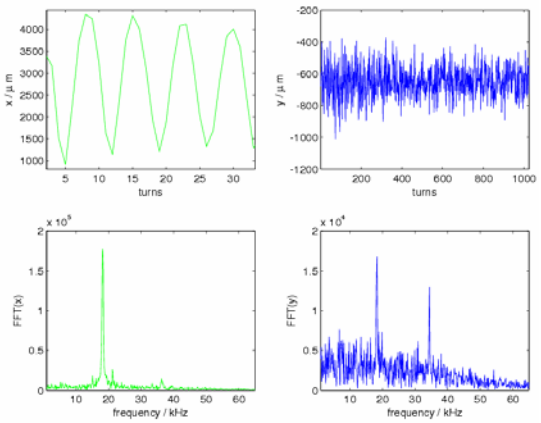


fractional part: DD acquisition



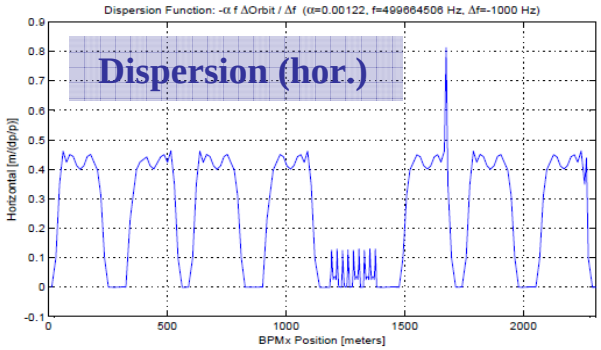
- adjustment of injection kicker strength
  - DD mode

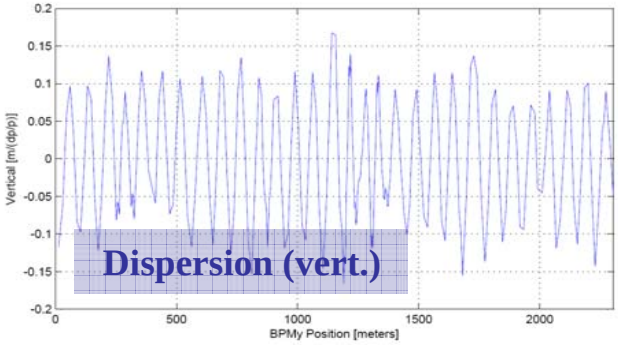
    → reduce oscillation amplitude

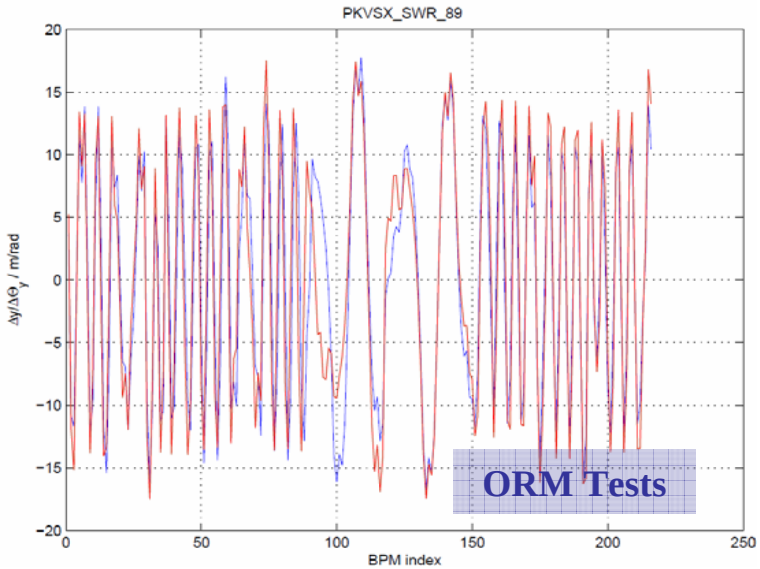


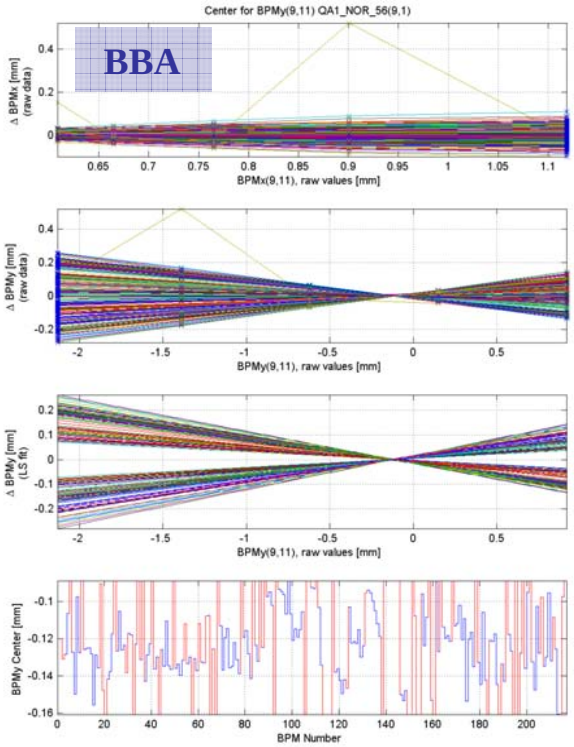
Commissioning (2)

- high level applications (examples)







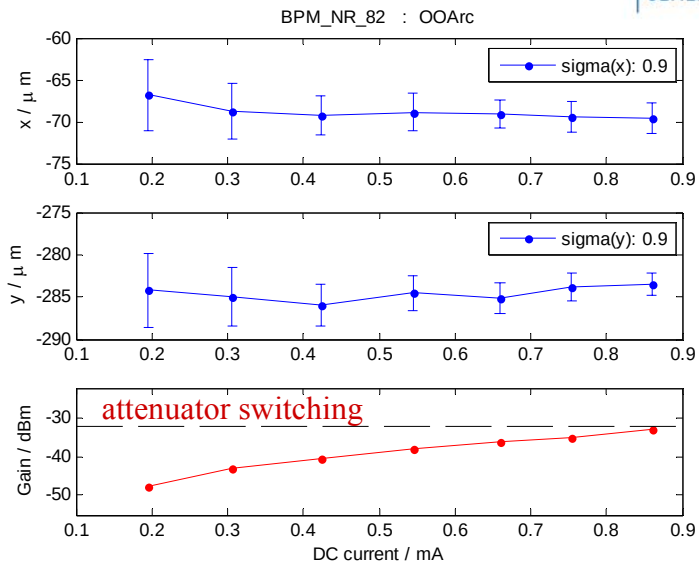


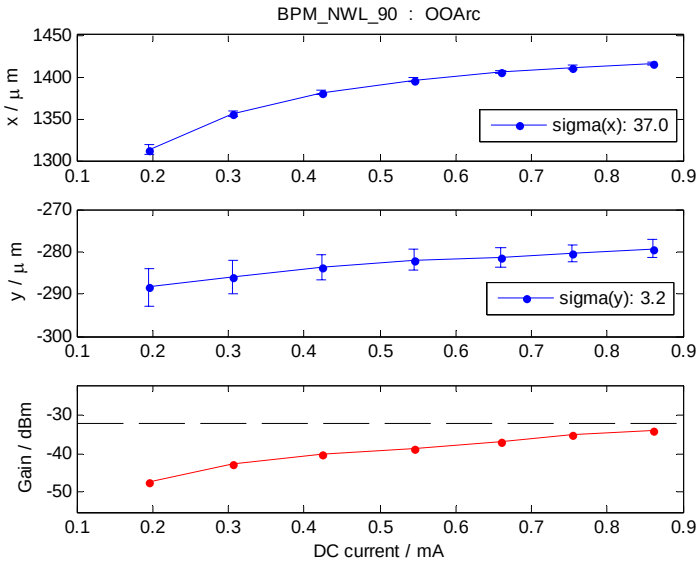
Beam Current Dependency

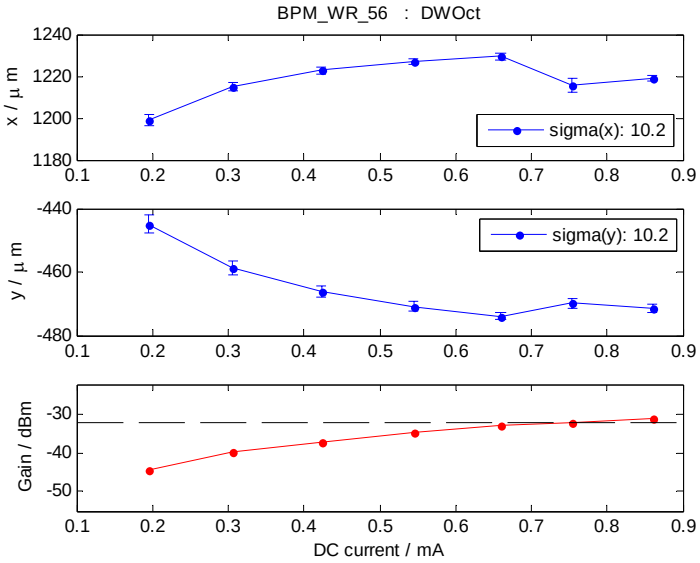
- dependency on position readout
  - single bunch (→ real beam)
  - SA acquisition:

    → DSC on, crossbar switching on
  - 100 samples for each bunch current

    → mean and variance of pos. readout

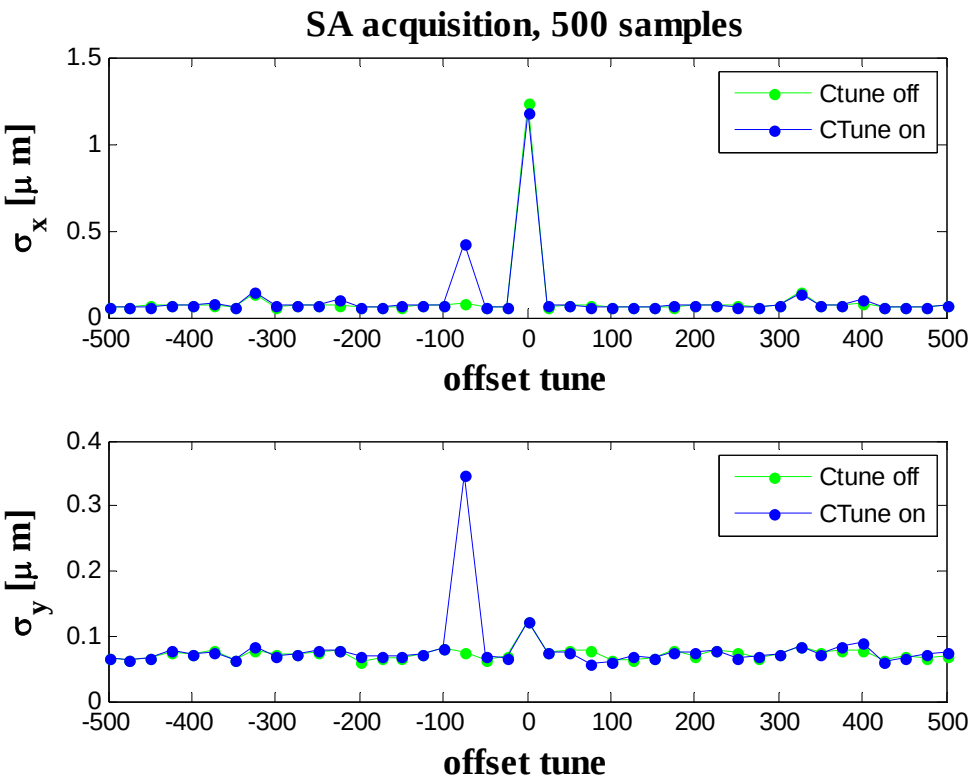


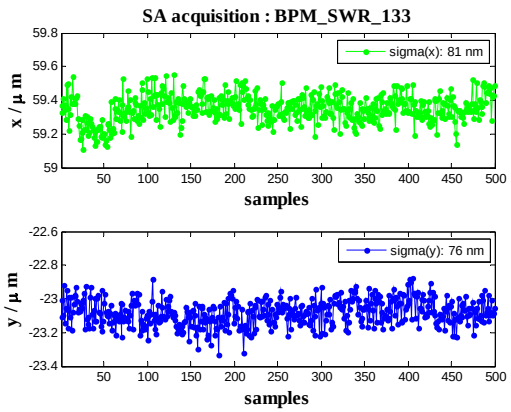




Offset Tune

- test measurement with „ideal" beam
  - 40 bunches, I ≈ 16-20 mA
    (with several re-injections)
  - AGC on
    → Gain: -37…-39 dBm
  - SA acquisition:
    → DSC on, crossbar switching on
  - compensation tune on/off
  - 500 samples for each offset tune
    → mean and variance of pos. readout

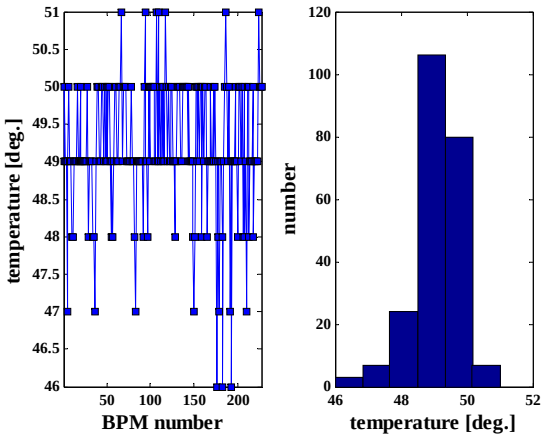


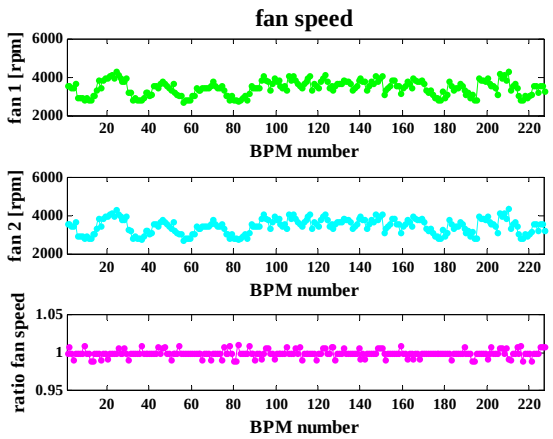


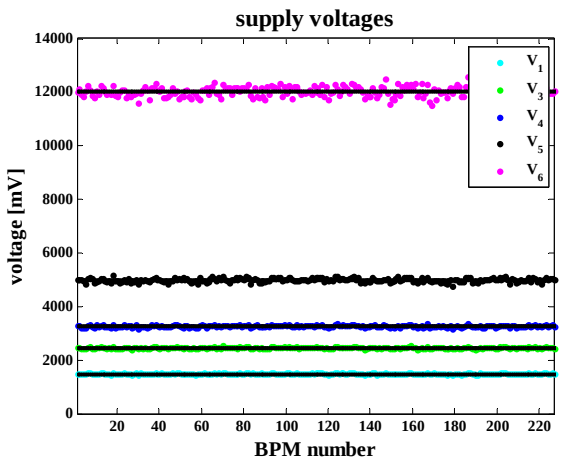
offset tune: +400

Reliability: Fault Finding

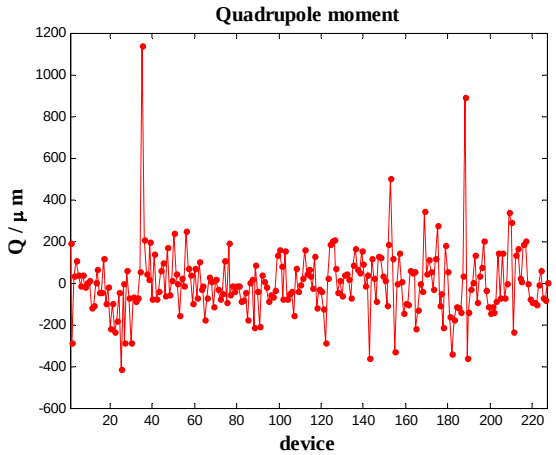
- monitoring of health parameters



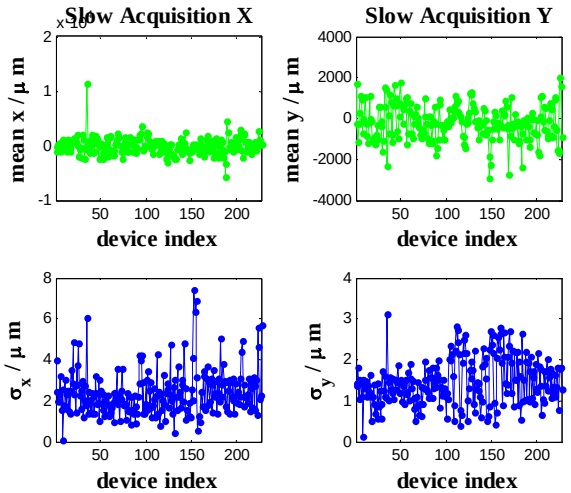




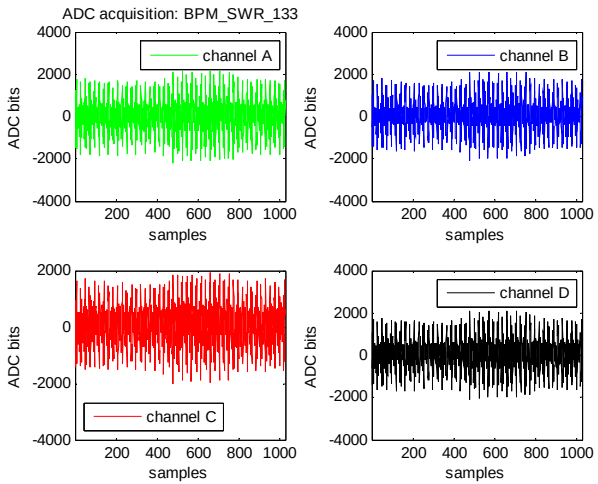
- q-value



- resolution

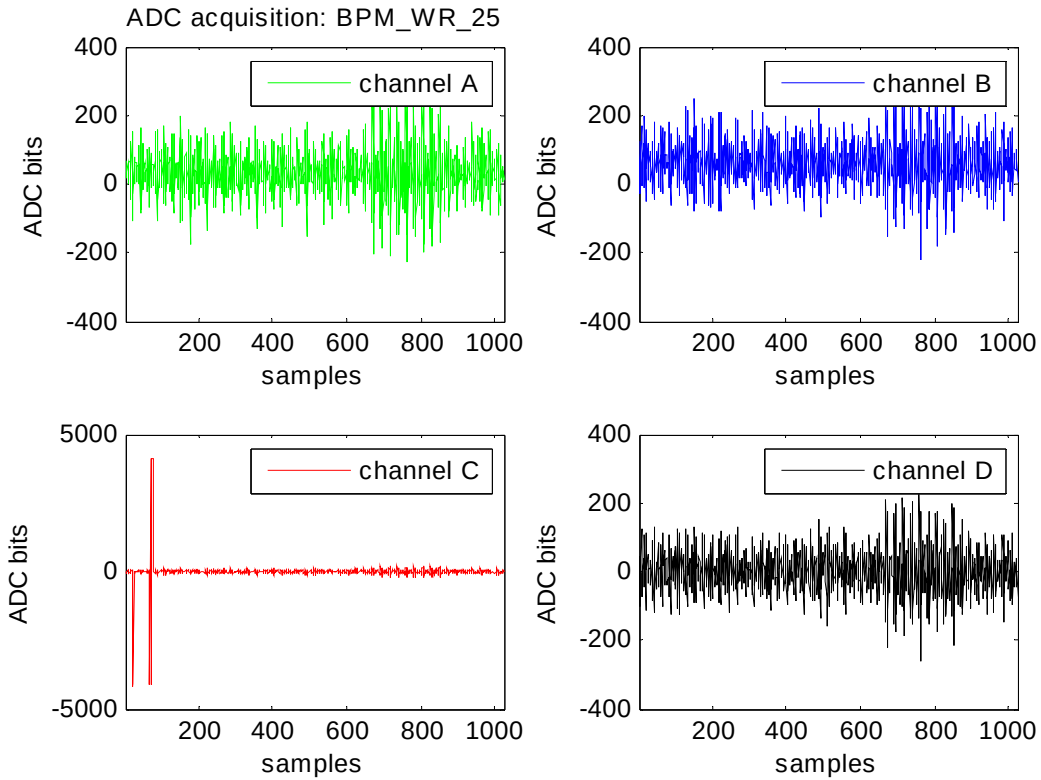


- ADC data

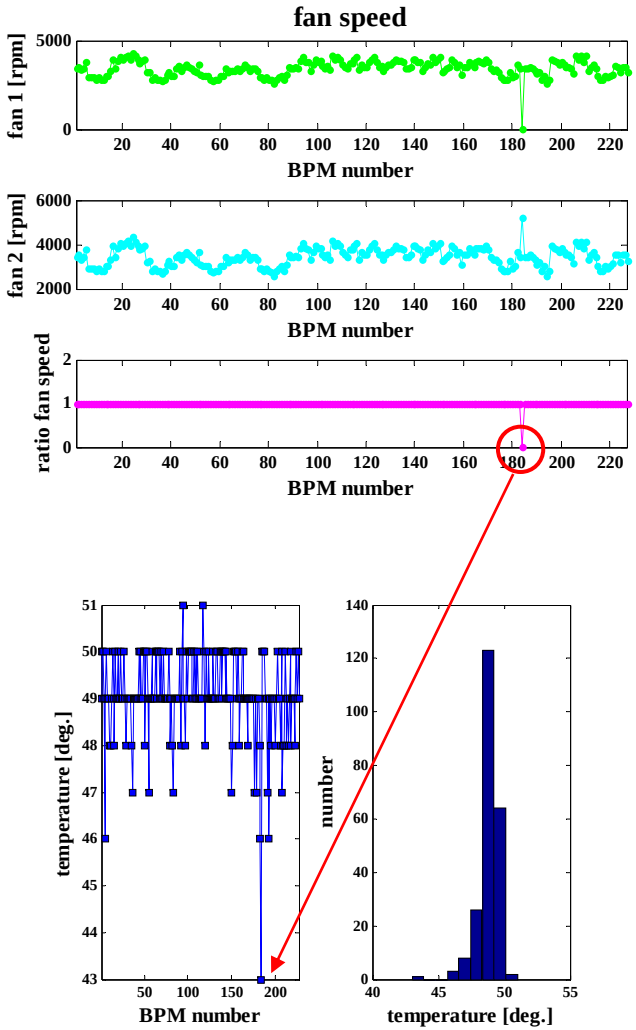


Fault Finding: Examples (1)

- defect bit on digital board

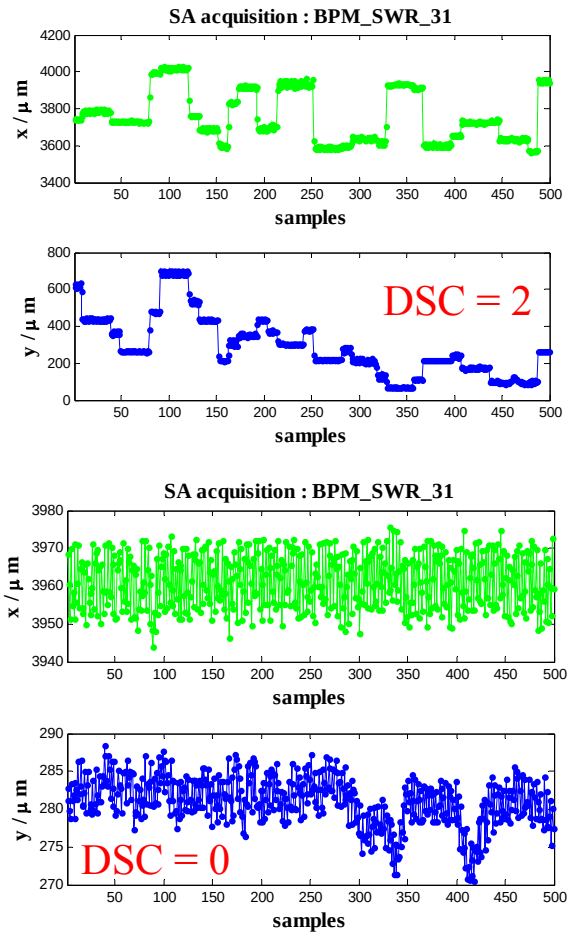


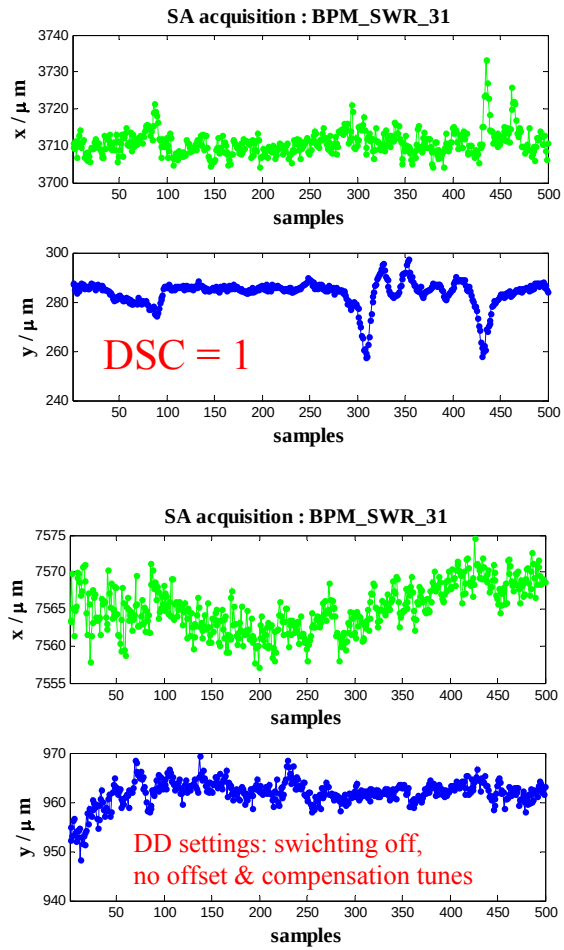
- defect fan



Fault Finding: Examples (2)

- significant influence of DSC & switching on SA data signal integrity …

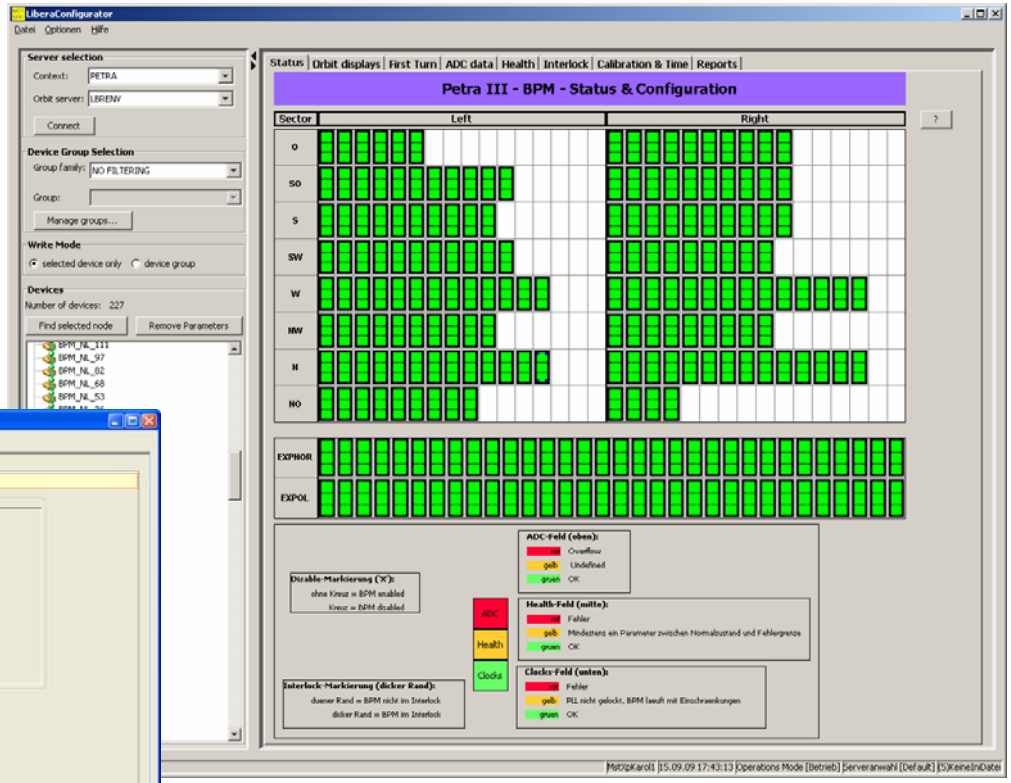


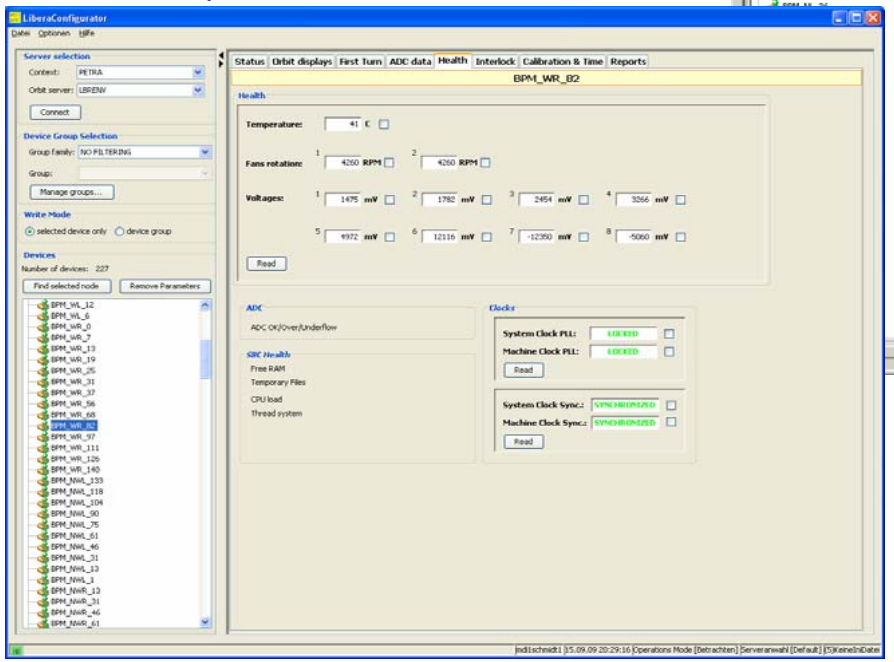


BPM_SWR_31, 08.06.2009
40 Bunche, ~17 mA → Gain ~ -36dBm

Libera Configurator (1)

- Libera client software integrated in Petra III control system offers …
- access to all important Libera device- & control-system parameters
- important control-room operator tool for commissioning
- different modes for operators and experts

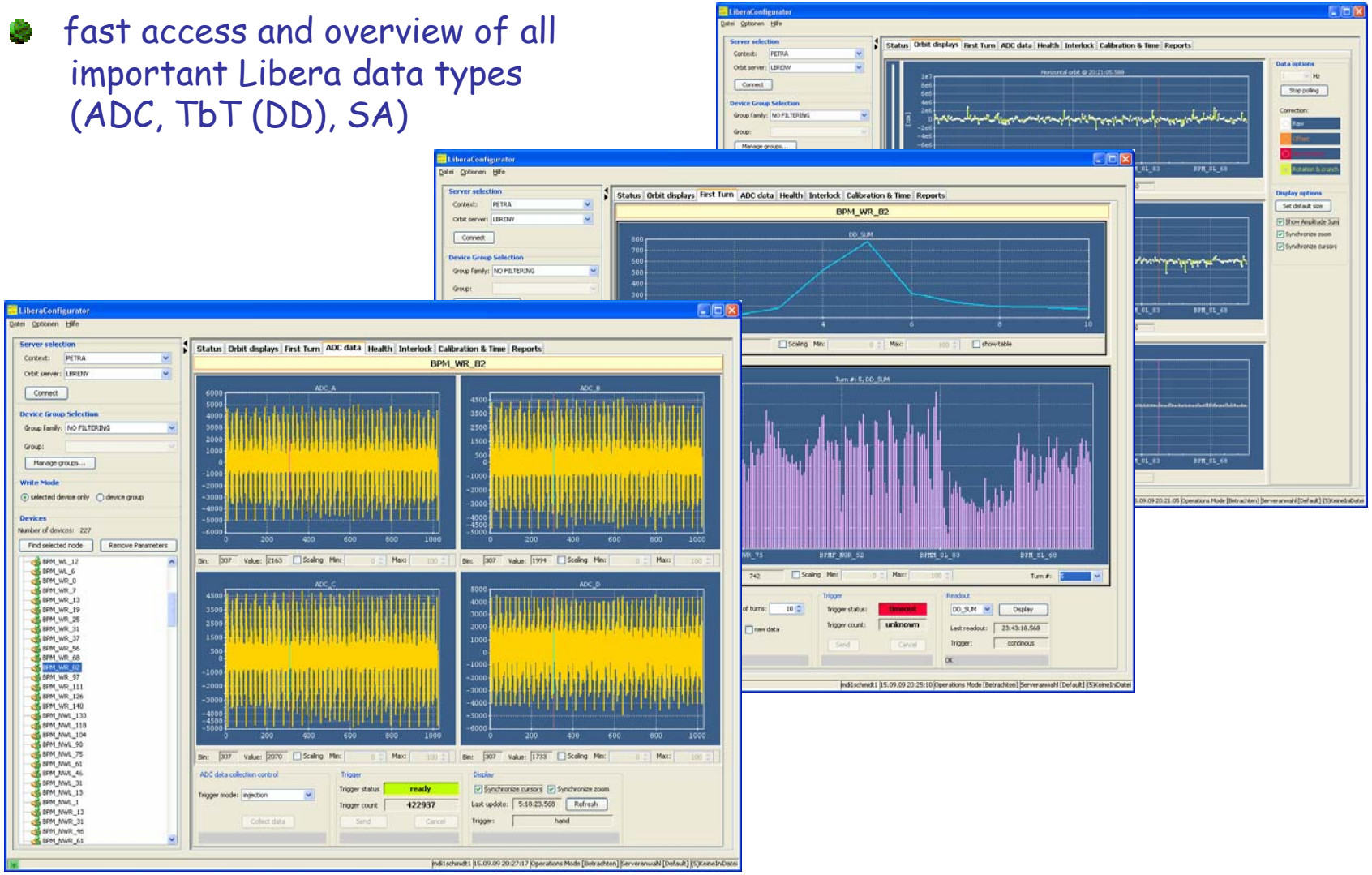




- … fast Libera status overview

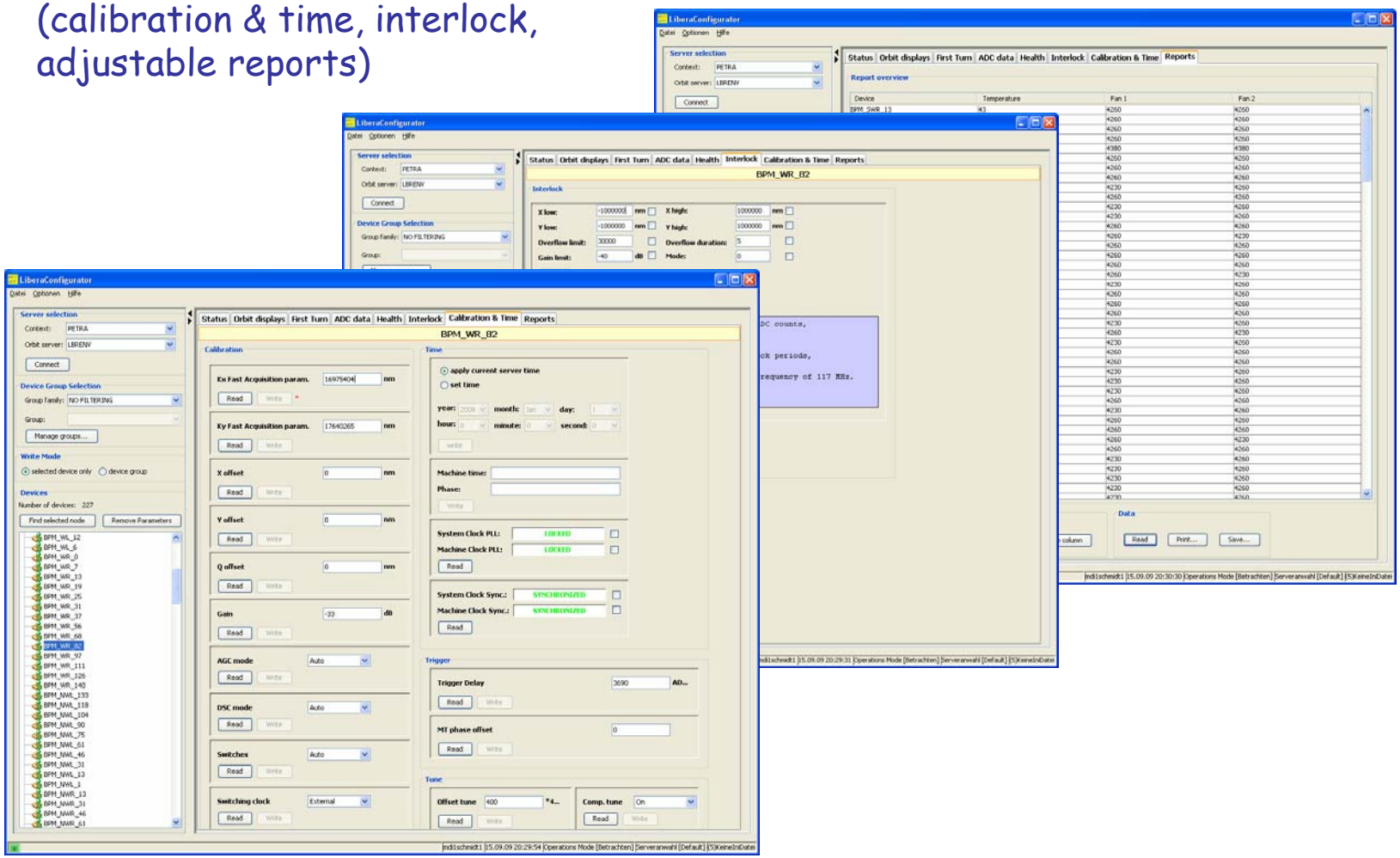
Libera Configurator (2)

- Libera client software integrated in Petra III control system offers …
- fast access and overview of all important Libera data types (ADC, TbT (DD), SA)



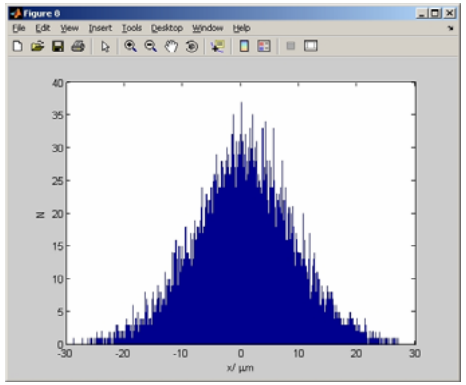
Libera Configurator (3)

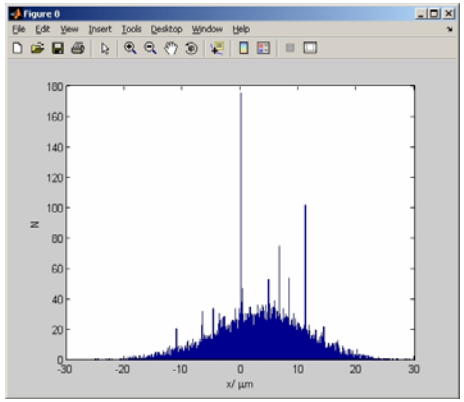
- Libera client software integrated in Petra III control system offers …
- detailed adjustment & report features (calibration & time, interlock, adjustable reports)

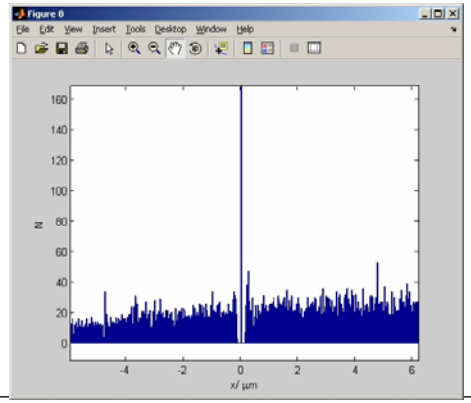


Mysteries in Libera Commissioning (1)

- decimated turn-by-turn (TbT, data-on-demand) data of pure noise signal …
  (readout of 16384 decimated-TbT data)
- corresponding TbT data histogram shows typical gaussian plot, but …
- => DD_X and DD_Y raw data show zeroes in regular intervals ???
- => histogram of decimated-TbT data shows …
  1. shifted center of gaussian plot and
  2. some bins (especially zero) are extremely more populated than others ???
- supposition: effect due to granularity of ADC sampling extremely low noise level
- … but, if TbT data show correct histogram, decimated TbT looks like a bug!!
- (decimated-TbT-data not used nowadays
  => to be investigated lateron)



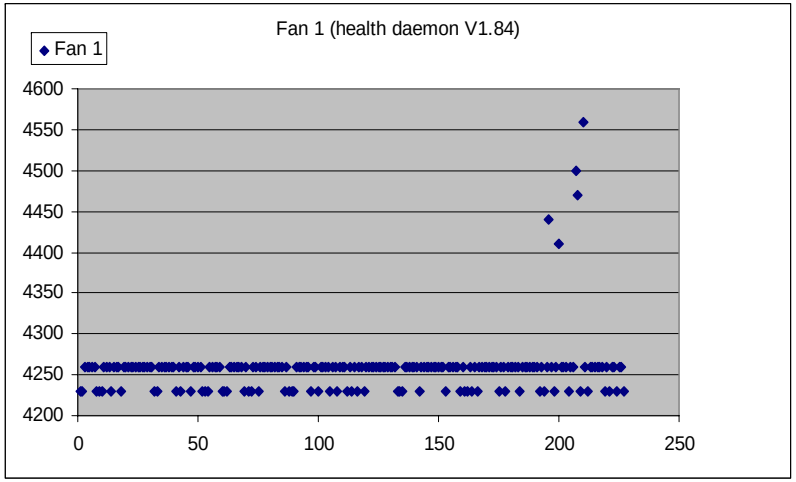


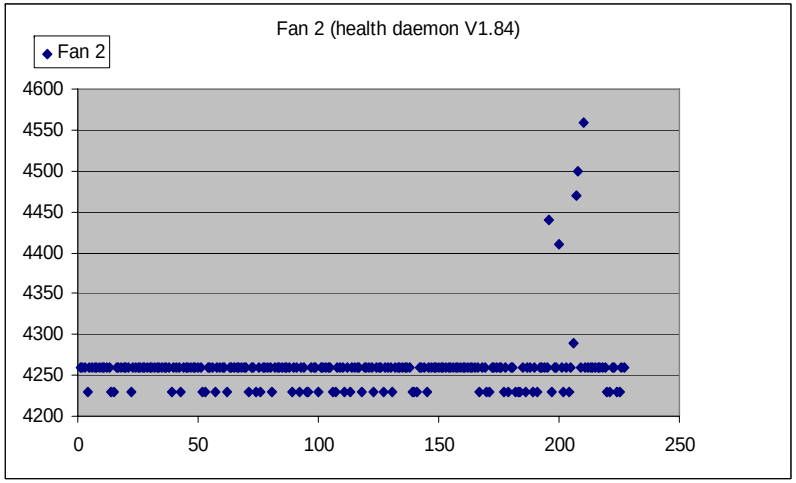


courtesy J. Keil

Mysteries in Libera Commissioning (2)

- several faulty fans (11)
- most of them (7) due to fan driver breakdown
- reason: fans are operated in a control-loop in V1.82 of health-daemon, which drives fans to speeds below critical limit (~4300rpm)
  => this kills driver transistor due to exceeded power dissipation!
- solution (step 1): fan speed is clipped at 4300rpm in control-loop of new health-daemon V1.84



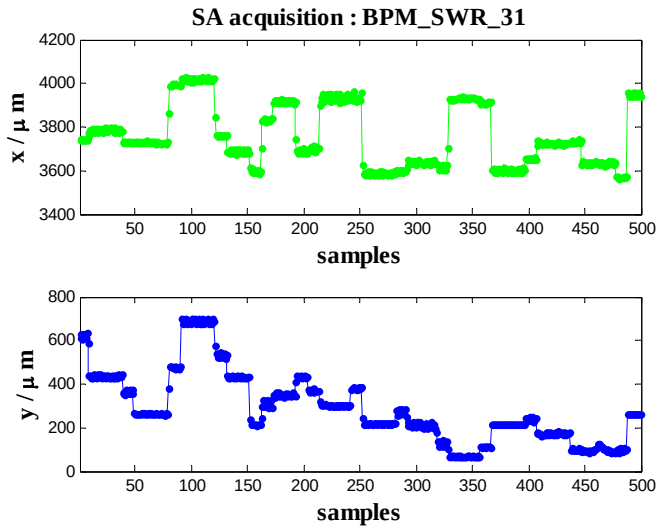


- probably more pre-damaged fan-drivers to come … ??
  (=> solution (step 2): hardware upgrade action planned)

Mysteries in Libera Commissioning (3)

- DSCD_MINTBT_LEARN_LIMIT boottime parameter upgrade

- DSCD_MINTBT_LEARN_LIMIT boottime parameter upgrade
- => reason: steps in SA data, after beam dumps
- => principle: inefficient DSC-coefficients (amplitude & phase for all 4 switch-channels) were calculated in a low inputlevel range due to noisy input signals (decaying beam)
- => solution: upgrade increases DSC learn limit boottime parameter (3900 -> 15000), so that DSC coefficients are calculated in a range of stable inputsignal signal-to-noise (> 30dB)
- => results: increased SA step performance (still under investigation)



Summary & Acknowledgment

- description of PETRA III – BPM system
- machine commissioning worked well & straight forward

  → extensive use of TbT capability
  in combination with high precision in SA mode

- fine tuning of monitor resolution together with investigation of resolution dependent influences recently started
- unexpected high failure rate

  → 13.4% (33 out of 246 devices)!

- Libera control system integration (GUI)
- some Libera mysteries during commisioning

- thanks

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

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

Libera Brilliance

Thank you for your attention!