miscellaneous slides, status and comments on:

LHC (Beam 2) Commissioning

- BPM, Q, Q'
Instrumentation and Diagnostics -

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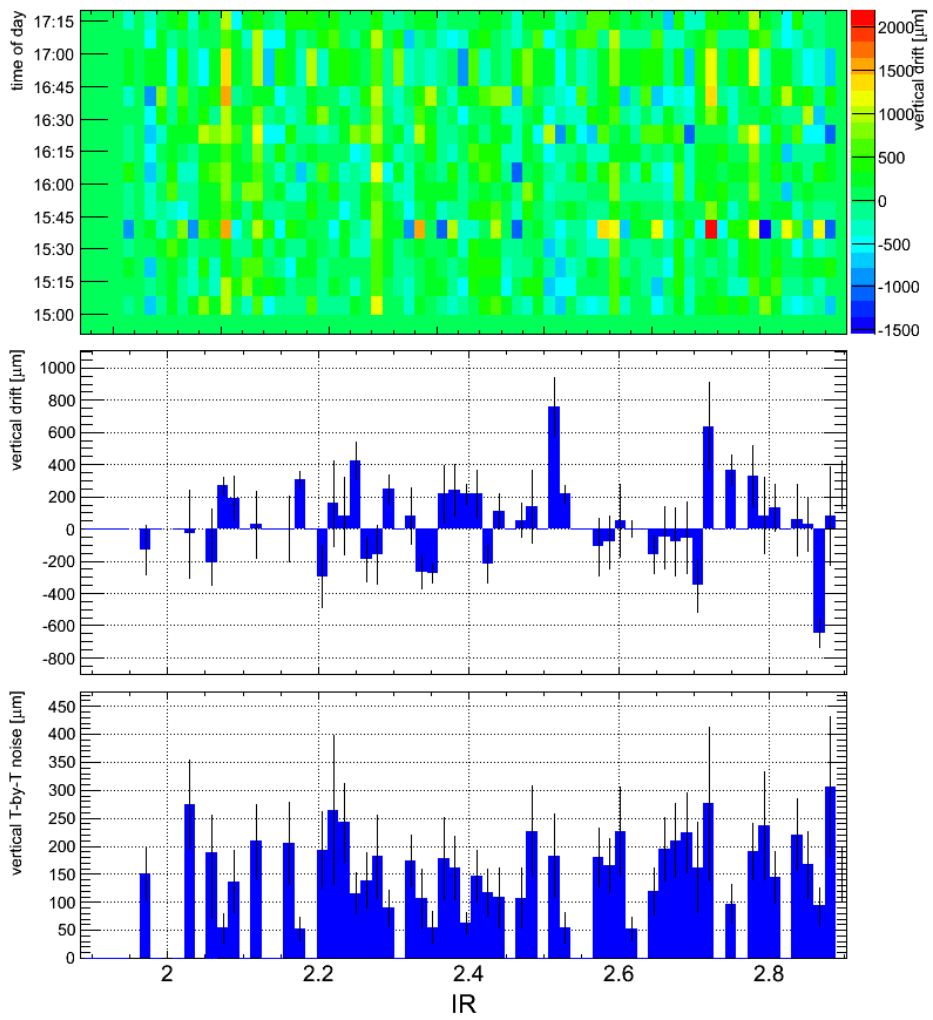
LHC Orbit Feedback Controller & Service Unit

- Tested data concentration of 120 front-end systems, mapping, etc....
  - Worst case latencies shown to be less than 20 ms (small cross-talk with LSA's CMW-get call)
- Tested first-order BPM error/fault detection scheme
- Now default data source for YASP (orbit, CODs, statuses) and 100k turn GUI (statuses)
- Example: B2 sector test – beam as seen/published by the OFC

LHC Beam Position Monitor – Turn-by-Turn Stability B1 - Injection Tests

- LHC Beam 1 injection test on 2008-08-10, vertical plane (hor. similar):



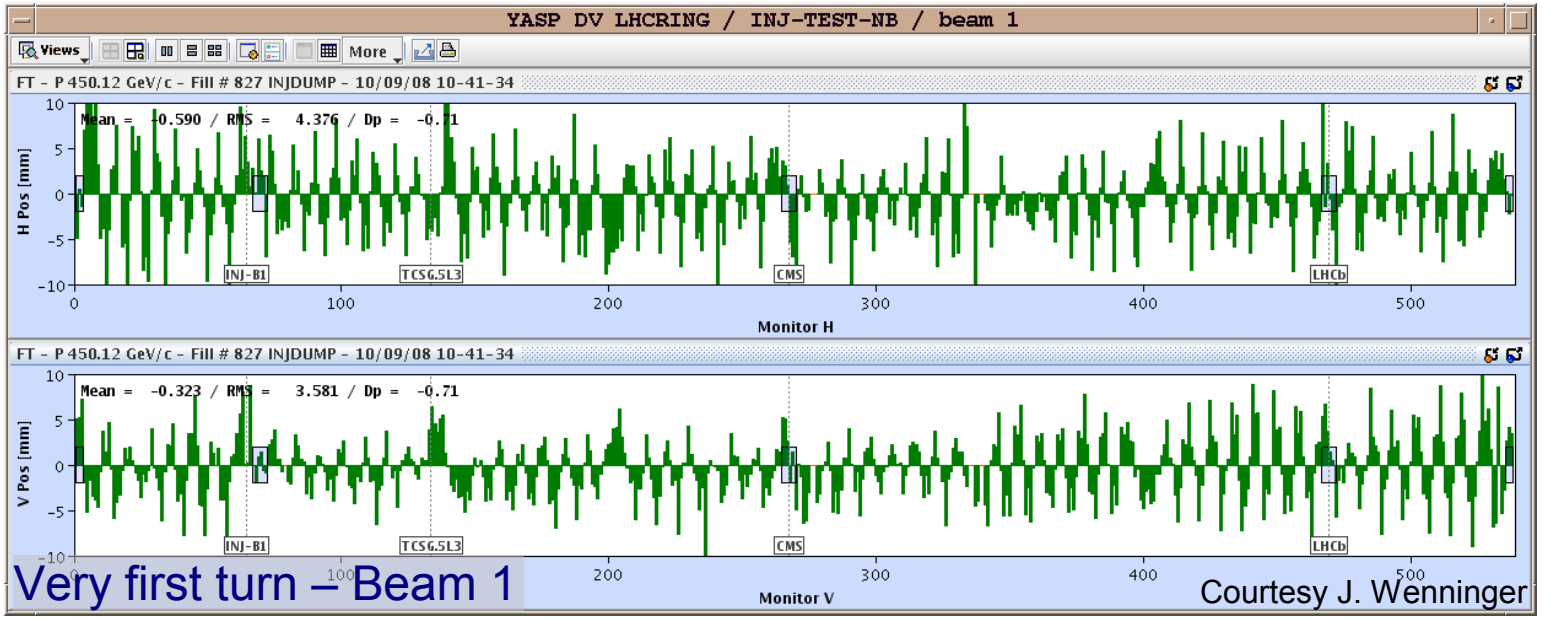
No obvious time structure from one injection to the next
→ dominated by the 'white noise' floor of the BPM acquisition electronic

Residual min/max trajectory drift is compatible with BPM noise estimate (see below).

r.m.s. turn-by-turn noise: ≈ 200 µm
- as expected from lab and electronic design for the given intensity ($2 \cdot 10^9$ protons/bunch)

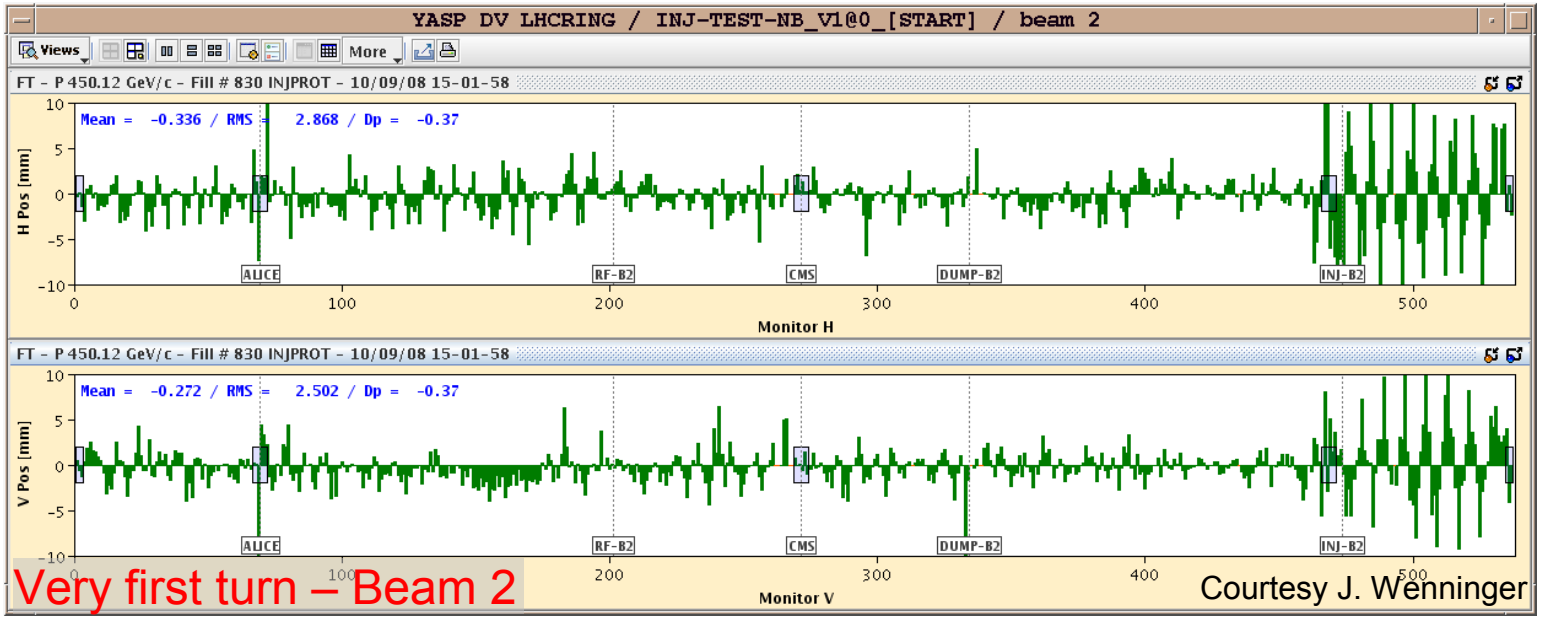
- Found 2 (B1)/ 12(B2) polarity/mapping errors – fixed immediately once spotted
  - no additional erroneous BPMs found with circulating beam (injection test paid off)

LHC Beam Position Monitor – LHC Day 1
The LHC BPM System at It's Best I/II



Very first turn – Beam 1

Courtesy J. Wenninger

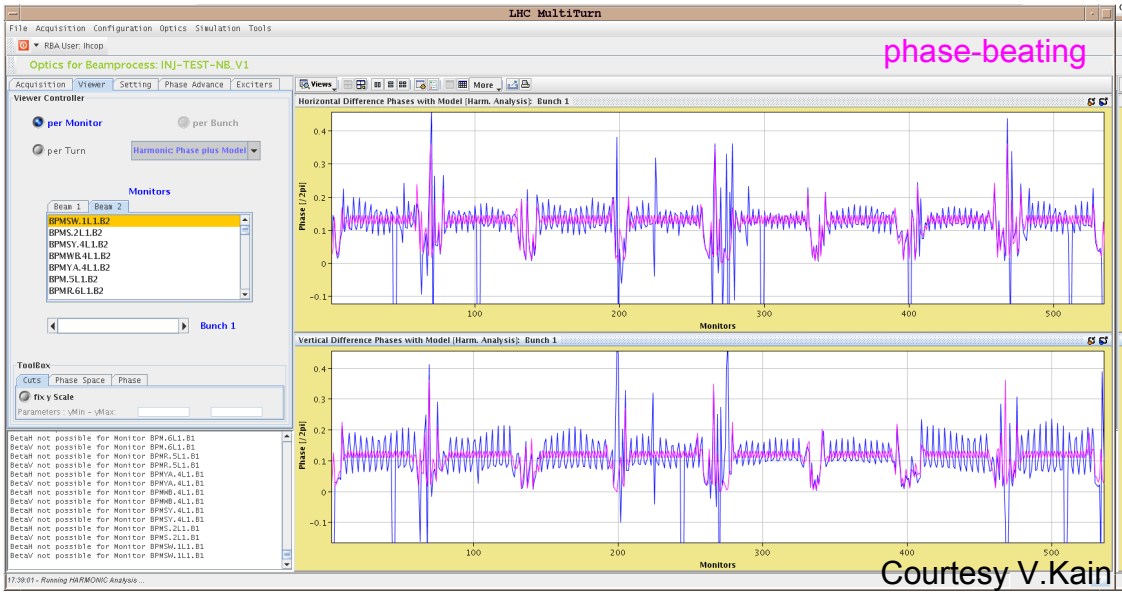


Very first turn – Beam 2

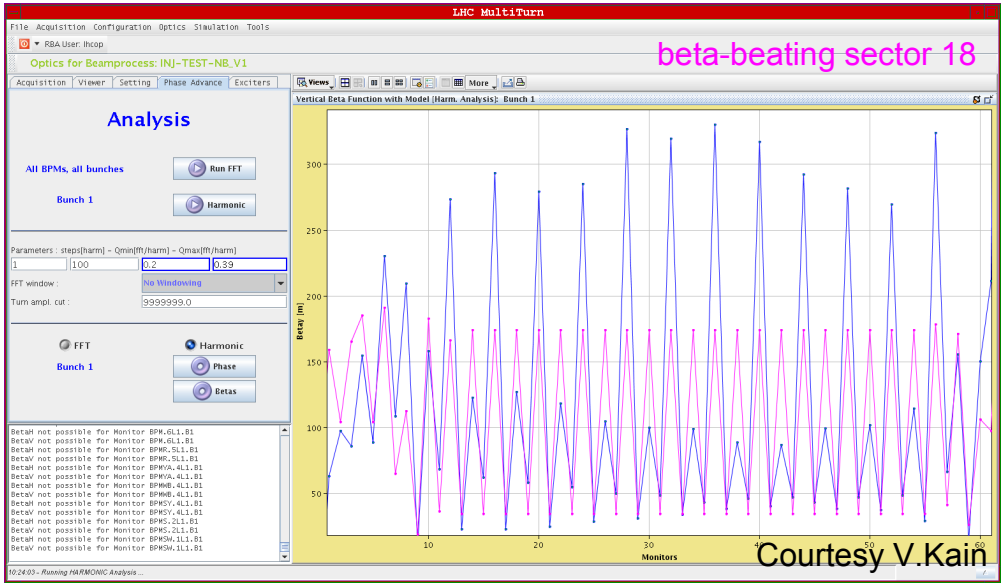
Courtesy J. Wenninger

LHC Beam Position Monitor – LHC Day 1
The LHC BPM System at It's Best II/II

- Could reconstruct LHC B1 optic on the few 10% level using only 50 turns

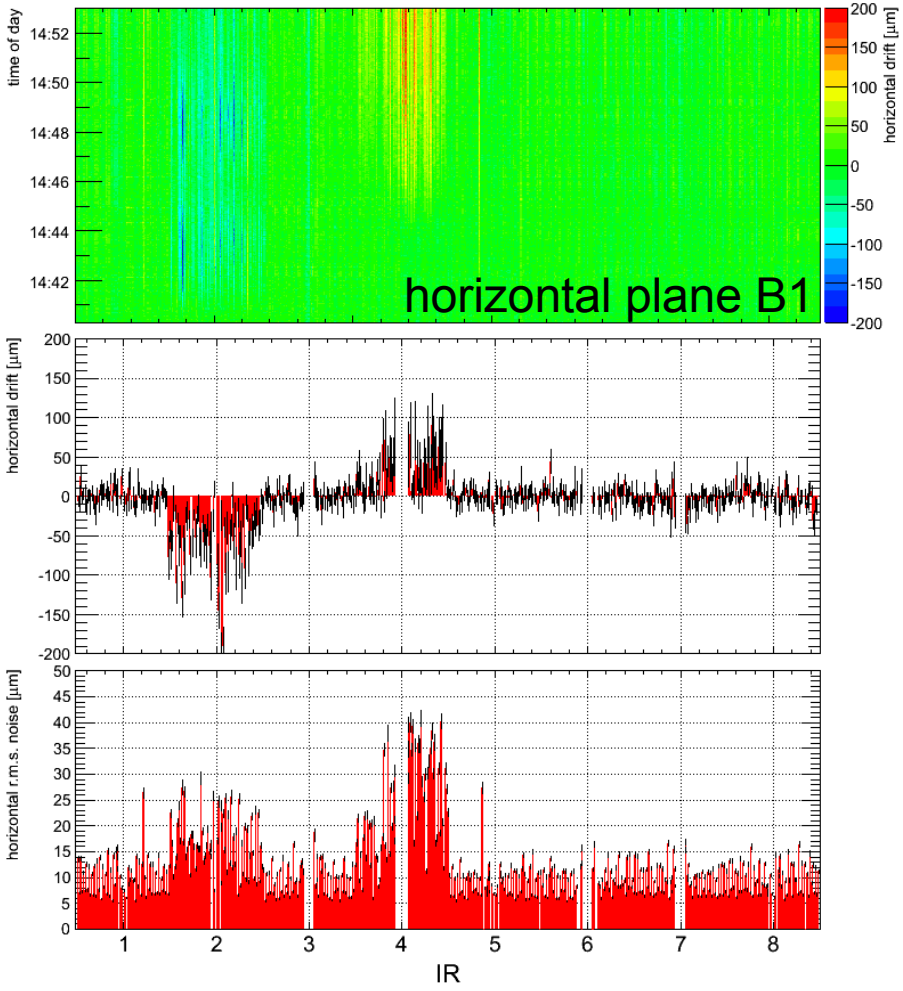


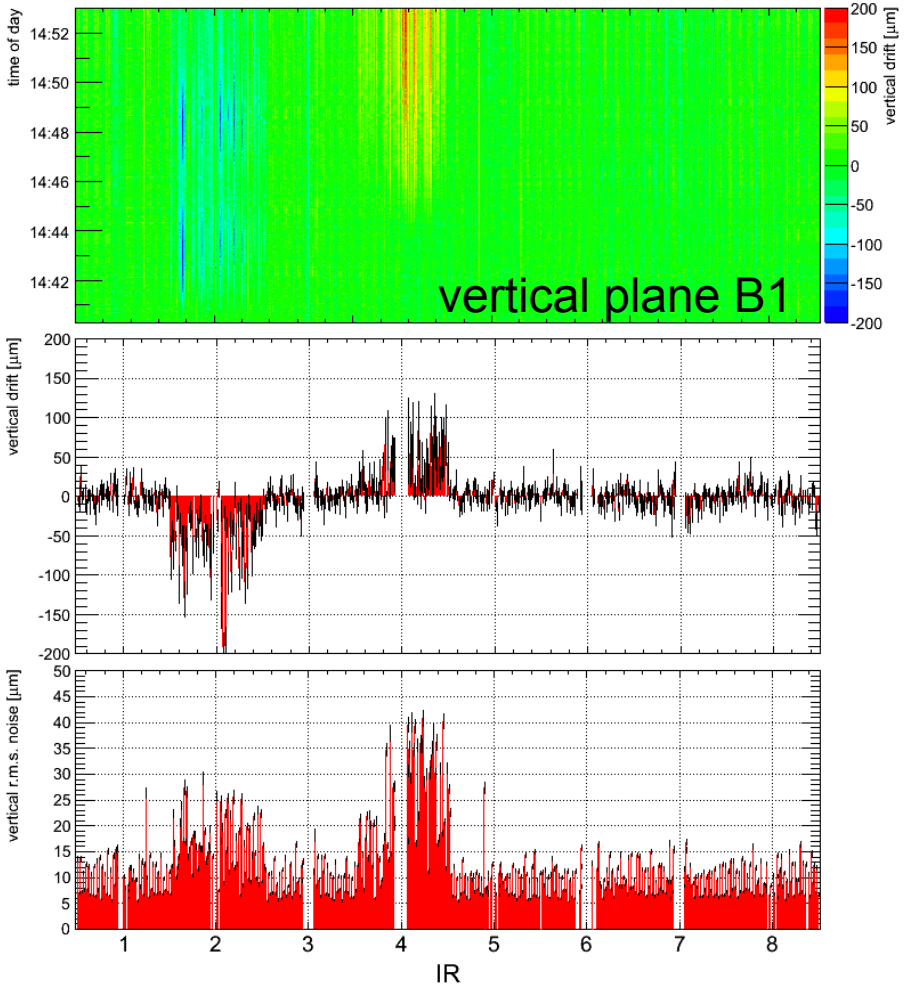
- Nearly all BPM triggered and gave useful readings
  - LSA concentrator hick-ups
    → relying on FIFO read-out using YASP
- Vertical beta-beat (blue) vs. model (pink)
  - Surprisingly large: 100%
  - further analysis/correction proposal pending (R. Tomas)



LHC Beam Position Monitor – Orbit Stability B2 – LHC Day 1

- Residual injection orbit stability (orbit feedback/radial loop off)

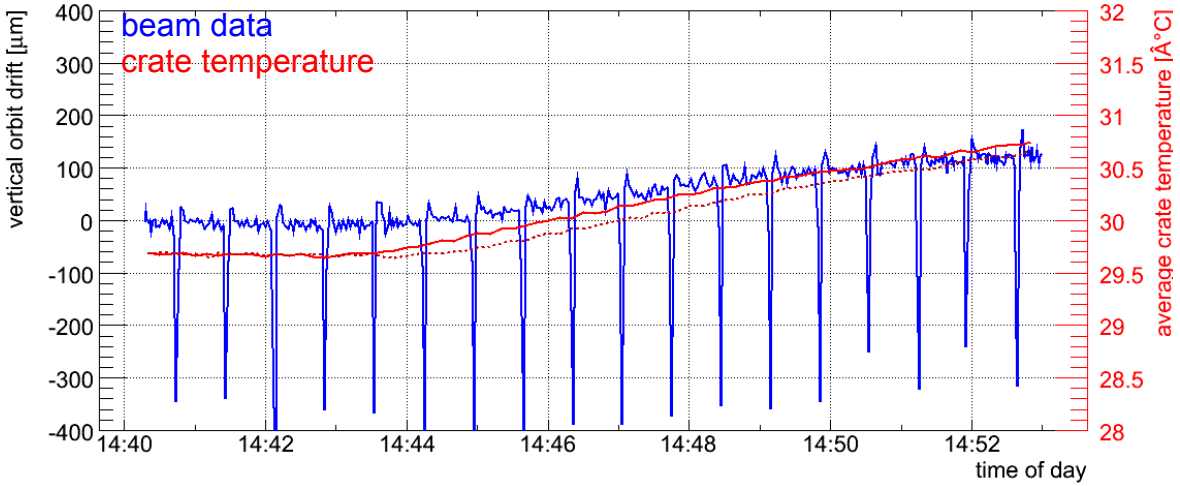


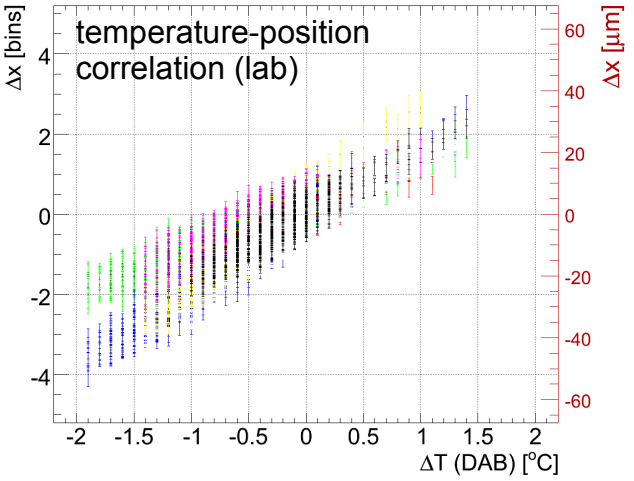


- Effective LHC B2 orbit stability about 5 um → understood (next slide)
- Small oscillations/drifts in point 2 and 4 → also understood (next slide)

LHC Beam Position Monitor – Orbit Stability B2 – LHC Day 1
Residual Noise Sources

- Effective LHC B2 orbit stability about 6 µm, two known sources:
  1. turn-by-turn noise predicition → orbit r.m.s.: ≈ 6 µm (150-200µm, 1024 turns average)
     - However: should be the same for all arc BPMs (same aperture)
  2. Residual noise of the COD power supplies, expectation: 5-10 µm orbit r.m.s.
- Small drifts in point 2 and 4 → thermal drifts (switched off SX4 climatisation)
  - Known from earlier lab measurements
  - Fix: 'somebody' gets a scarf for Christmas & local crate temperature control





- Source of the transient orbit spikes is till date unknown
  - lasts up to two seconds (→ too fast for an BPM electronics related spike)
  - a forgotten injection/tune/...? kicker magnet?

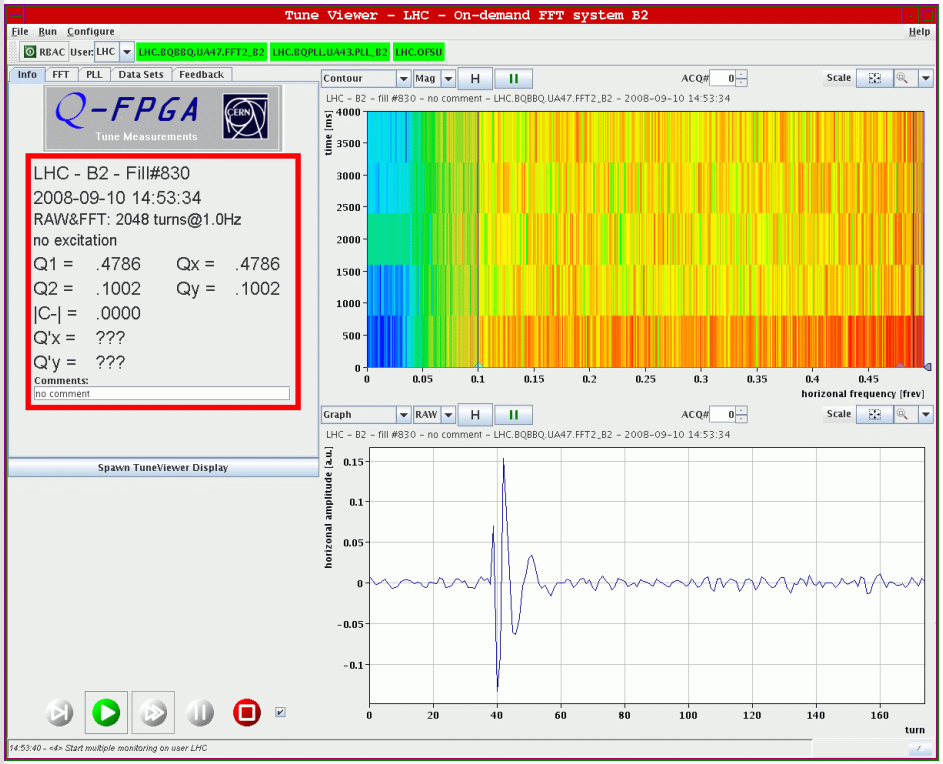
LHC Base-Line Q/Q' Diagnostics Overview – Q/C⁻ BBQ Use-Cases Abstraction

- Three independent BBQ Tune/Coupling diagnostic chains available per beam:
  - PLL based acquisition - commissioning pending!
    - one measurement at high/reduced acquisition frequency, targets:
      - 100 Hz for feedbacks (driven by need to reduce feedback latencies)
      - 1 Hz for general purpose logging
    - expert: high frequency data that is event synchronised and buffered (post-mortem, PLL setup), typical length: 5 min ↔ < 1 MB of data
    - main use: monitoring/logging, feedbacks, fill-to-fill studies, ...
  - FFT based acquisition – 'periodic' (FFT1) – B2 fully commissioned
    - one measurement every 1 second starting from first-injection
    - intended use: monitoring/logging, (feedbacks), fill-to-fill studies, ...
  - FFT based acquisition – 'on demand' (FFT2) – B2 fully commissioned
    - n-measurements synchronised to an external event (BPM, BQ, ...)
    - intended use: expert diagnostics, detailed studies, ...

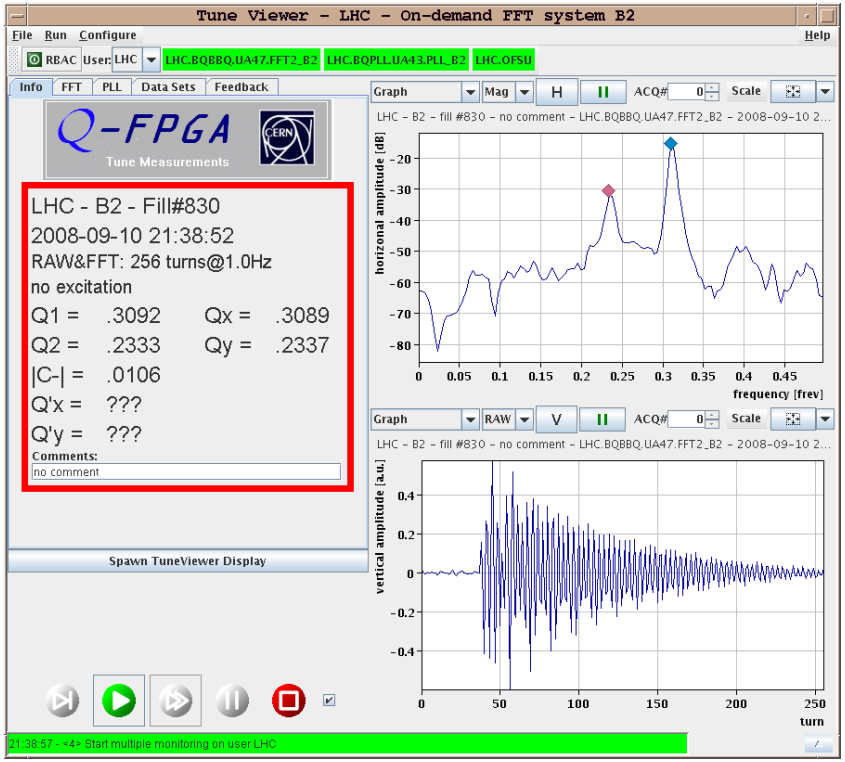
Present Commissioning State

- BBQ systems for B2 including excitation and correction fully commissioned!
  - One important stepping stone in getting the beams circulating

Very first turn B2 (B1 similar)!



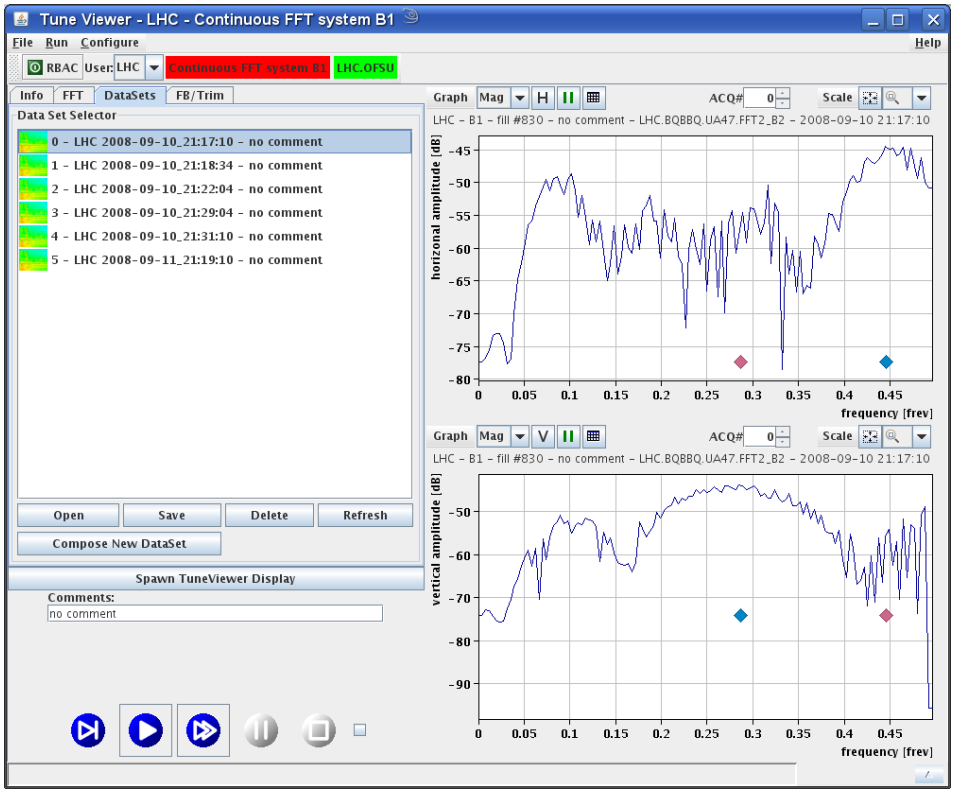
first circulating beam...

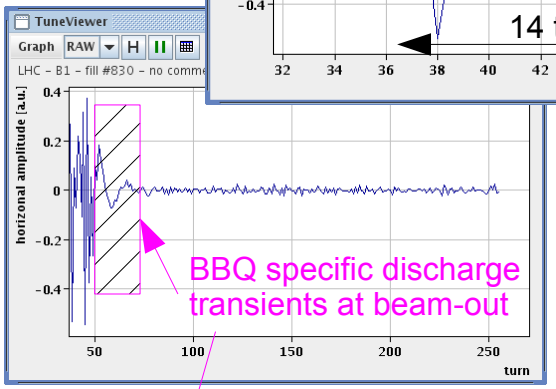


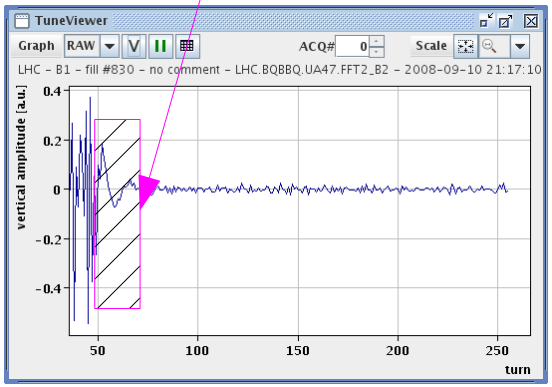
- Next few slides document how we got there...

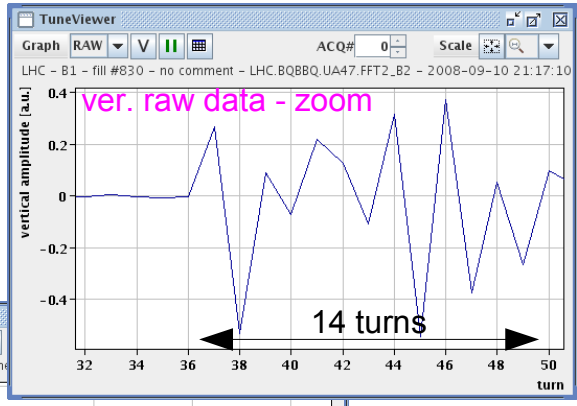
Sep. 10thBeam 2 Injection Tune – 14 Turn Data

- After adjusting first two turns (no RF, $Q_H \approx .44$, $Q_V \approx .28$)
  - Transient in raw (turn-by-turn) data:
    BBQ intrinsic discharging once beam is gone





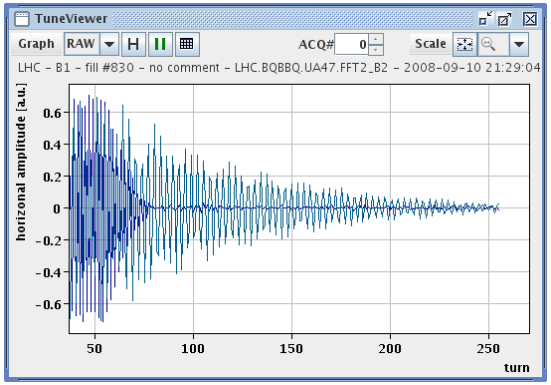


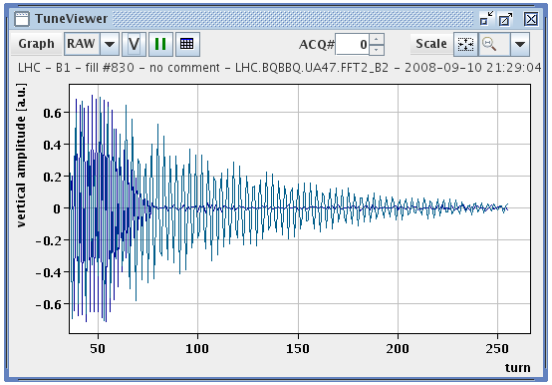


- Observations: only 14 turns – could the big spectra 'humps' indeed by the injection Q's?
  - vertical spectra is cleaner → decided to trim 'Δq_v=-0.1' and observe change

Beam 2 Injection Tune – 14 Turn Data – Q_v Trim

- no RF capture , $Q_H \approx .5 \rightarrow .315$, $Q_V \approx .24$, observation:
  - Programmed 'ΔQ_H=-0.2' seen as expected (LSA bug fixed, courtesy M. Lamont)
  - Moving from the half-integer resonance → 300+ turns (still no RF capture)

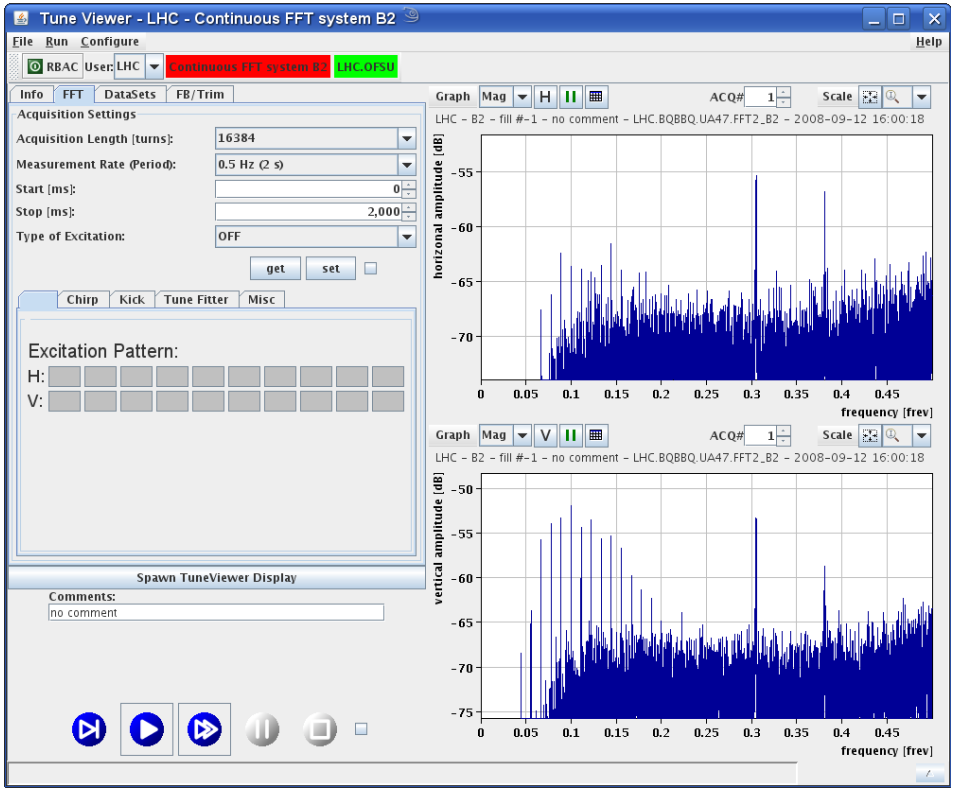




- LSA Settings (= deviation from reference): ΔQ_H = - 0.05, ΔQ_V = - 0.2

Beam 2 - Typical Circulating Beam Spectra

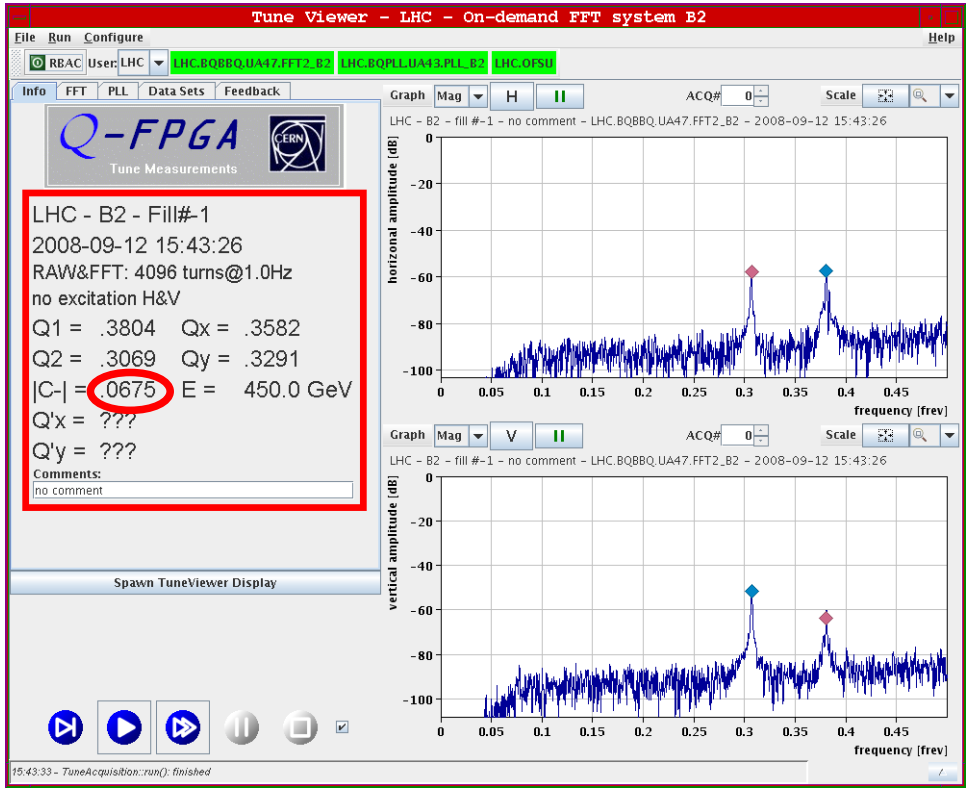
- Horizontal and vertical tunes were usually seen without further excitation
  - Typical signal-to-noise: 10-20 dB
    - FFT1 (continuous system, logging) was slightly more sensitive (+ ~ 5 dB)
  - Sufficient for monitoring & steering for the given beam configuration (single pilot)

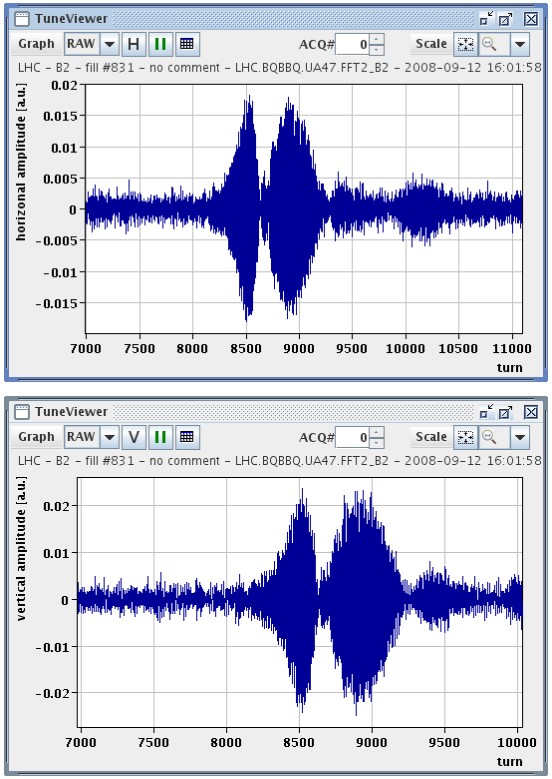


- Coupling measurement benefited from the chirp excitation using the exciter of the RF transverse damper (see next slide)

Present Commissioning State
... lots of first: coupling measurement

- Measured coupling |C-| ≈ 0.07
  - Compatible with the assumed magnetic field error model at that time (0.06)

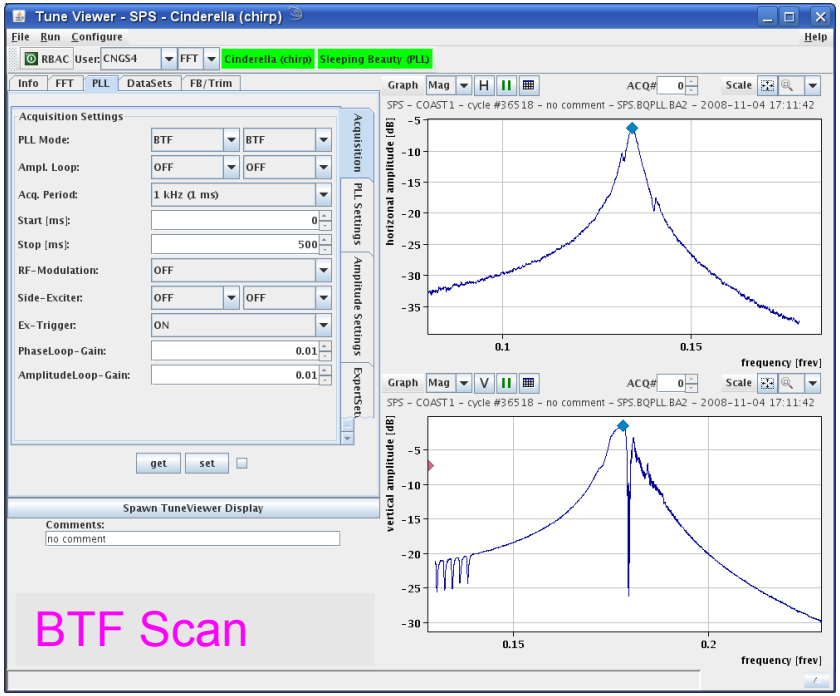


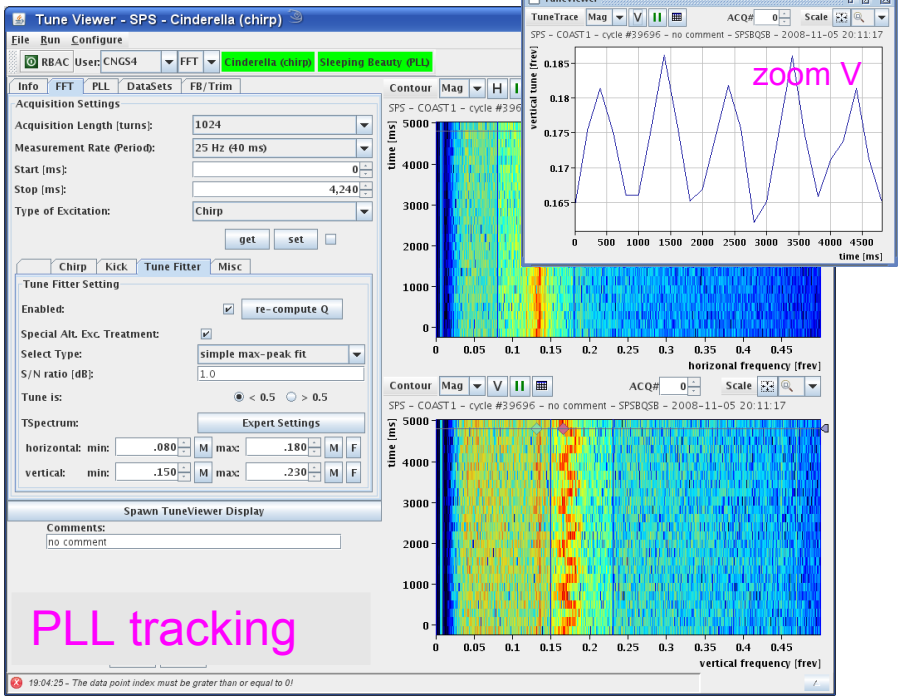


- Q-PLL and Q/Q' feedbacks commissioning would have been next, if not ...

Present Commissioning State
... Tune Phase-Locked-Loop Commissioning

- … made the best of the absence of beam in the LHC → used the LHC-PLL installation in the SPS for further tests
  - same interfaces/controls/server/operational GUI as LHC
  - Verified Beam-Transfer-Function (BTF) measurement and PLL logic

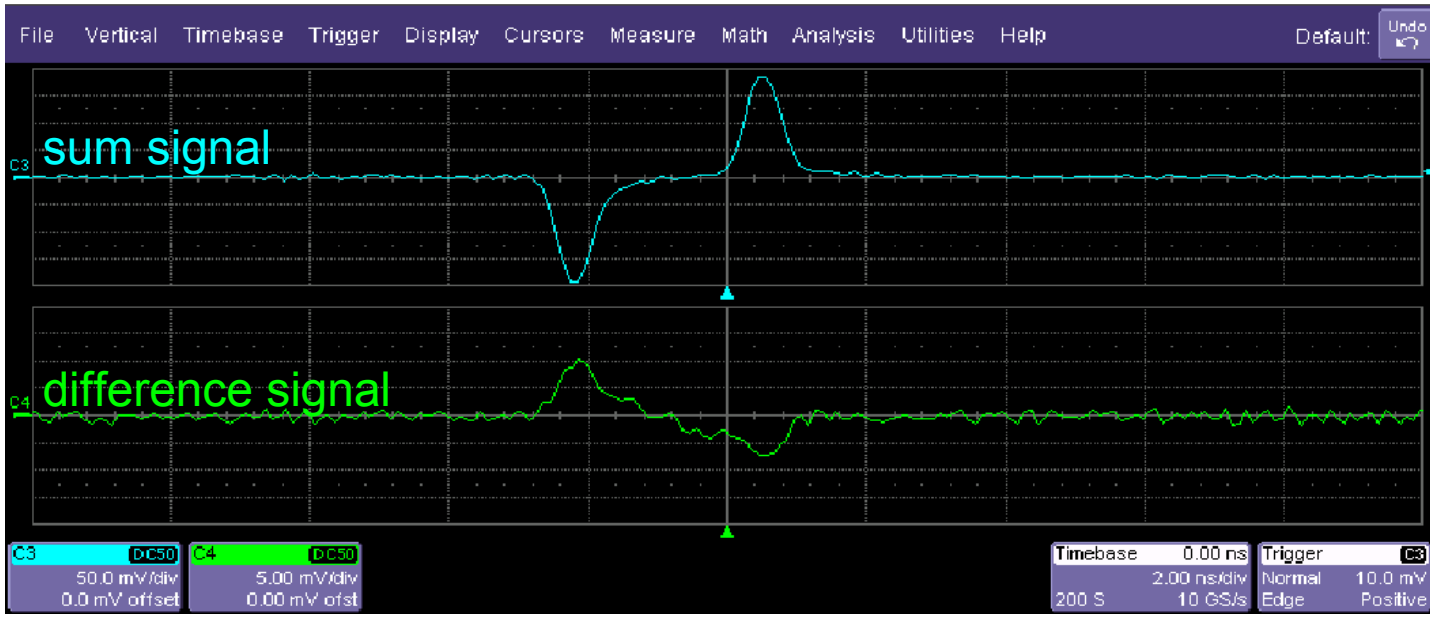




- To be tested: real-time display for PLL, LHC-RF interfaces (radial modulation)
- Since BBQ HW is fine for B2 (B1) and that the logic is correct (SPS test): remaining PLL commissioning should take less than one shift/beam.

BI's Wall-Current and Head-Tail Monitor

- Tested that detectors are alive and trigger on given timing event
  - Some software tests/adjustments pending
    - one full acquisition presently results in about 1 GByte of data
    - optimisations in the pipe-line
      - optimised memory usage (Java/JDataViewer)
      - optimised/simplified GUI for the WCM
    - Otherwise: same functionality/state as SPS Head-Tail system (bunch length, intensities, HT modes, chroma estimates, ...)



Conclusions I/II – Things done

- Base-line FFT tune acquisition commissioned for B2
  - used to establish circulating beam (tunes were off by up to 0.5)
  - tested polarities, gains, timing
  - tested RF damper polarities, rough amplitude calibration

    (used about 10% of one out of two damper driver modules)
    - Now LHC's baseline exciter for Q measurements
  - tested semi-automatic Q and Q' correction schemes (via LSA)
  - tested MKQ trigger & kicker response (synchro-delay adjustments pending)

- BPMs/Orbit Feedback:
  - good BPM readings, permitting fast commissioning of circulating beam
    - practically all BPM triggered with intensities down to ≈$2 \cdot 10^9$ protons
    - noise floor: COD power supplies (5-10 um), residual BPM 'white noise' (6 um), thermal BPM drifts (~35 um/°C, to be fixed)
    - Only few calibration & mapping errors found after injection tests!
      - We are lucky and should probably play the lottery more often!
      - Few noisy pick-ups electronic chains remain to be check/replaced
  - Data concentration and error/fault filter operational
  - Commissioned/tested about 250/1060 CODs with beam (ongoing)

Conclusions II/II
- Things to be (Re-) Done

- Full commissioning of B1 FFT1 & FFT2 BBQ systems
  - first turn works (all detectors alive), plane pending
  - otherwise same procedure as for B2:
    - damper polarities, amplitude calibration, ...
- Full commissioning of B1 and B2 BBQ Phase-Locked-Loop Systems
  - pre-requisite for first ramp! However: if no surprises: < shift/beam
- Test of (semi-) automated Q' & C^- measurement and correction procedures
  - after SPS tests: LHC-RF radial modulation
- Feedbacks
  - 750/1060 COD polarity and optic checks with beam pending
  - Quadrupole & sextupole circuit mapping/polarity checks with beam
  - test of > 1300 power-converter real-time inputs (AB/PO)

  → Semi- (or even fully) automated FB on Q/C^- is probably fastest/easiest to setup
- Training of LHC operators & EIC's

(ongoing, some have never seen/measured/corrected Q/Q' and even less C-)