Transverse Damper in 2012

presented by W. Hofle

Special acknowledgements:

H. Bartosik, V. Lebedev, D. Valuch, V. Zhabitsky

BE-OP, BE-RF

Transverse Damper in 2012

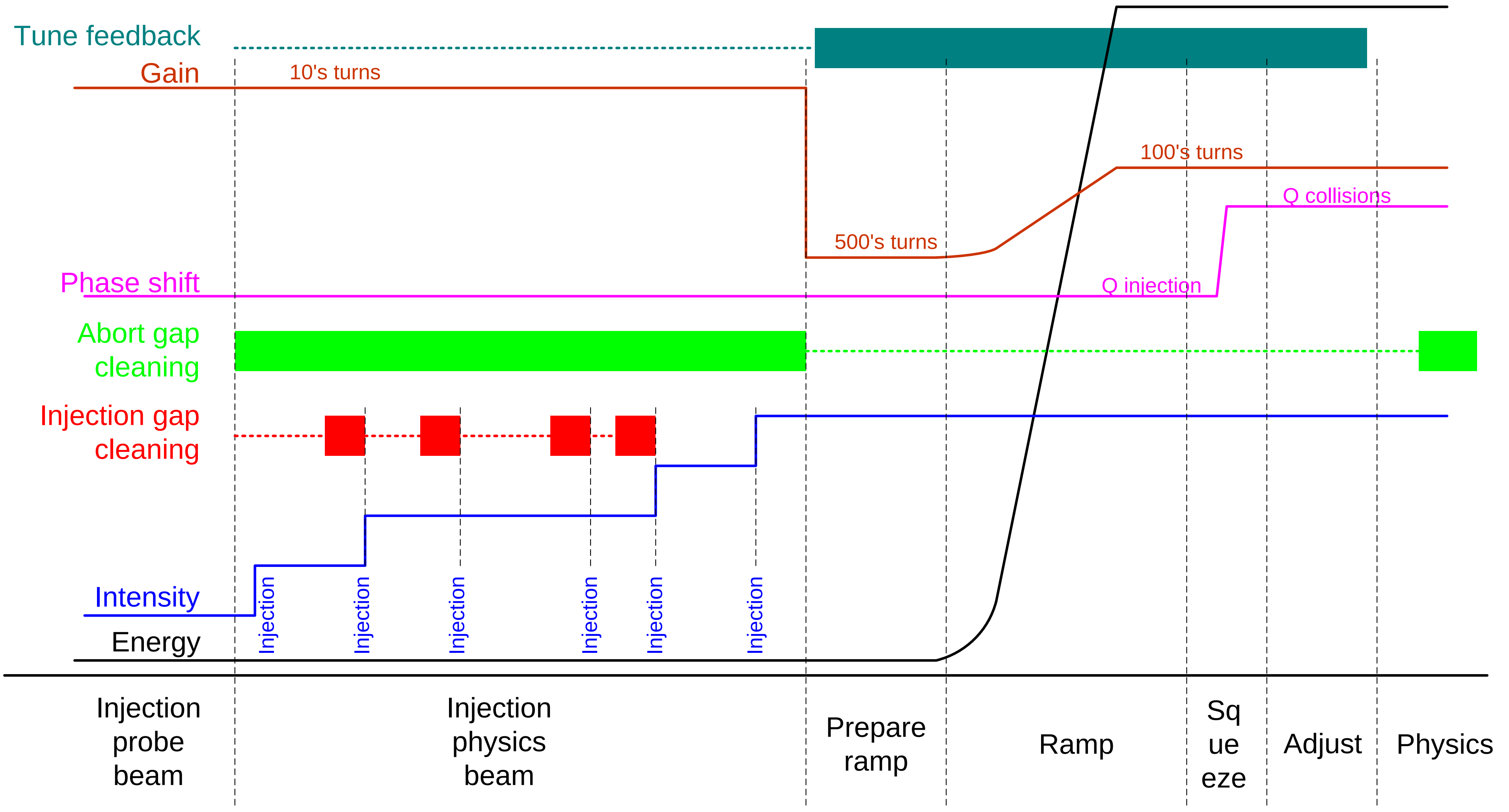
- where do we stand end of 2011
- plans for 2012 – new features
- performance with 25 and 50 ns
- what changes with increased energy
- running at higher gains in ramp
- noise: a feedback view
- tune measurement: feasibility and plans

Where do we stand end of 2011

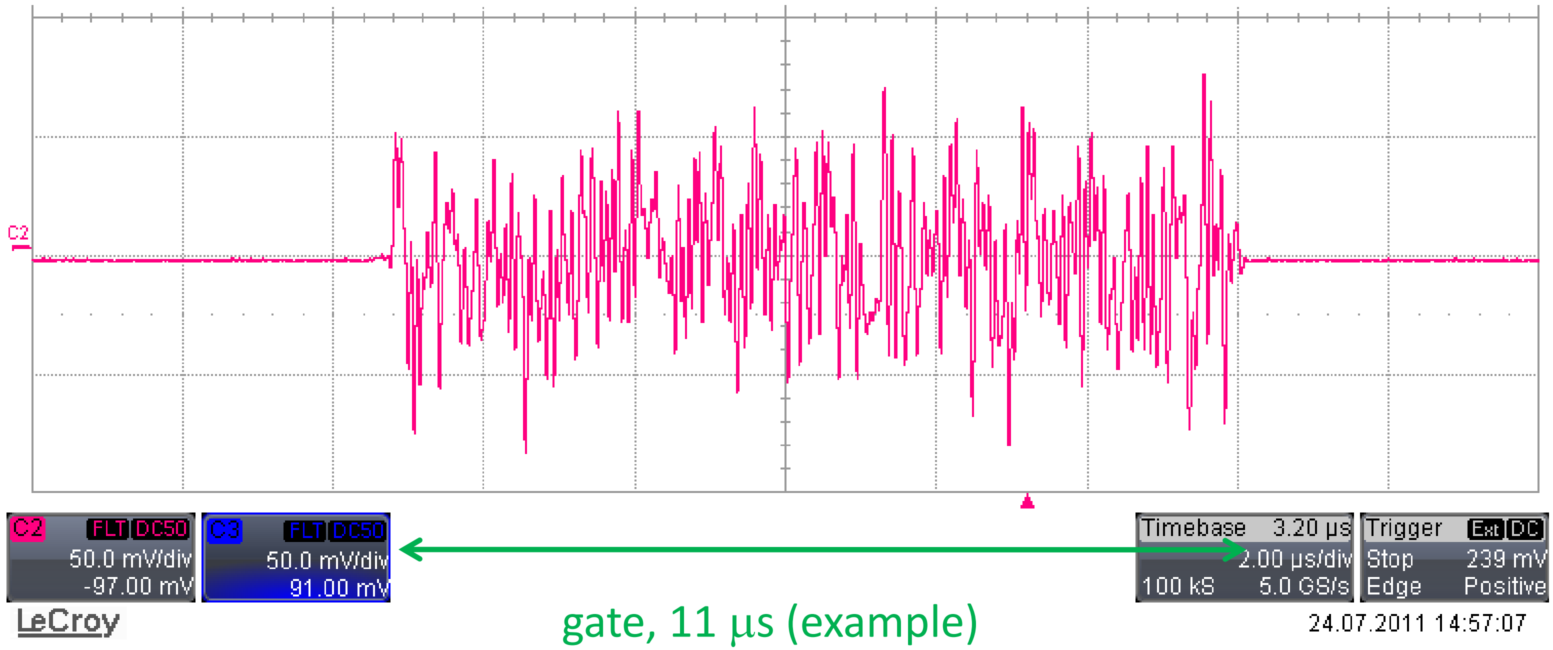
- procedures for setting-up well established & highly automized
- running with feedback on @50 ns spacings at all times
- tests with 25 ns spacing show criticality of set-up of delay
- abort gap cleaning and injection cleaning fully operational
- fine setting-up of feedback phase done, in line with expectations, but will re-visit in 2012
- contribution to noise from cabling identified, correction. i.e. re-cabling of pick-ups for one system (H.B2) done this stop.
- batch selective excitation demonstrated

→ see Evian talk by D. Valuch
→ also re-commissioning in 2012 see D. Valuch @Evian

ADT through the cycle



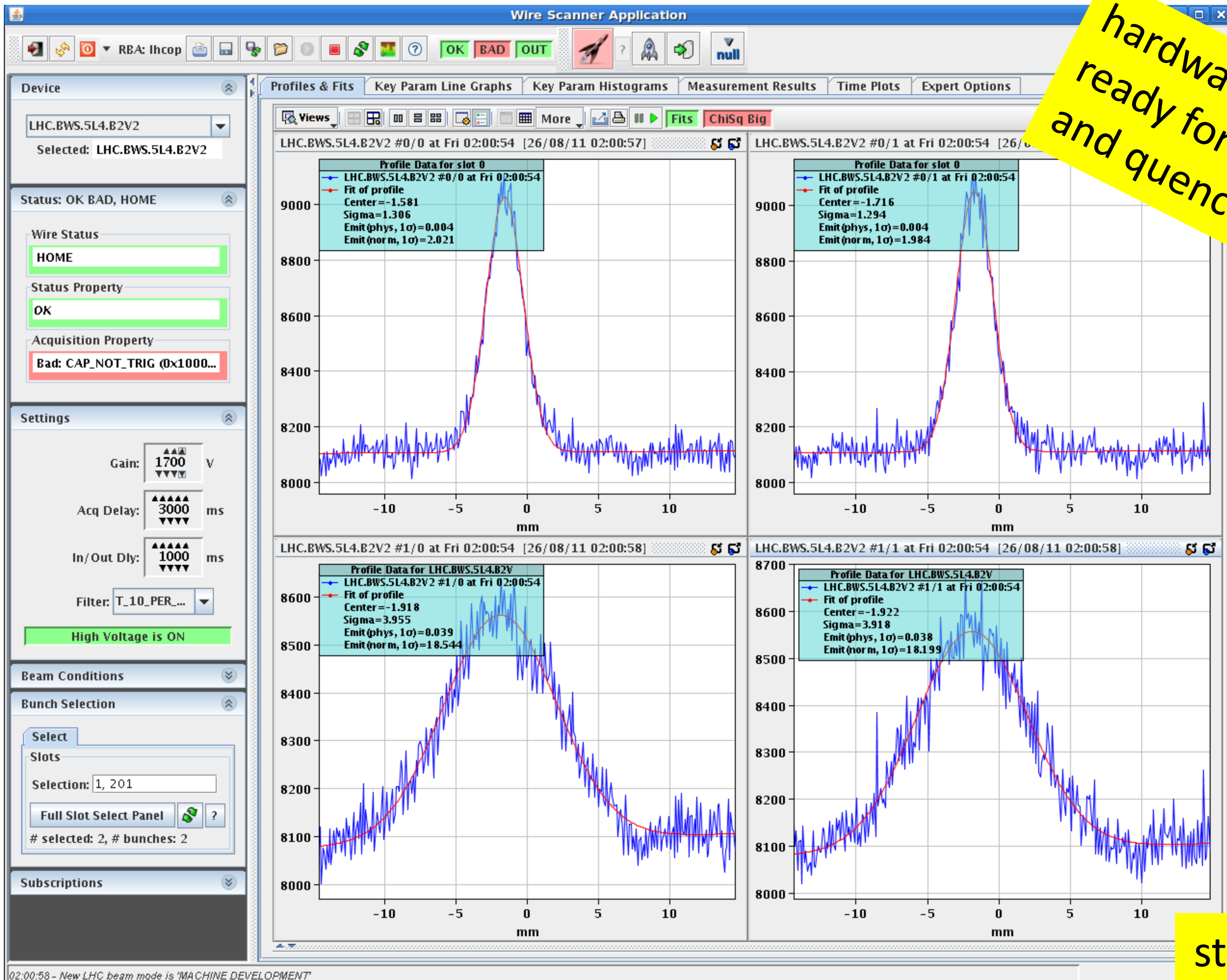
Gated excitation



- white noise generated on FPGA running at 40 MS/s
- after VME upgrade available for all dampers
- tested on all dampers of beam 2 (H and V plane)
- noise can be filtered by IIR lowpass filter

D. Valuch, M. Jaussi, D. Jacquet, T. Levens

Selective blow-up (2 pilots)



hardware / firmware ready for aperture tests and quench tests

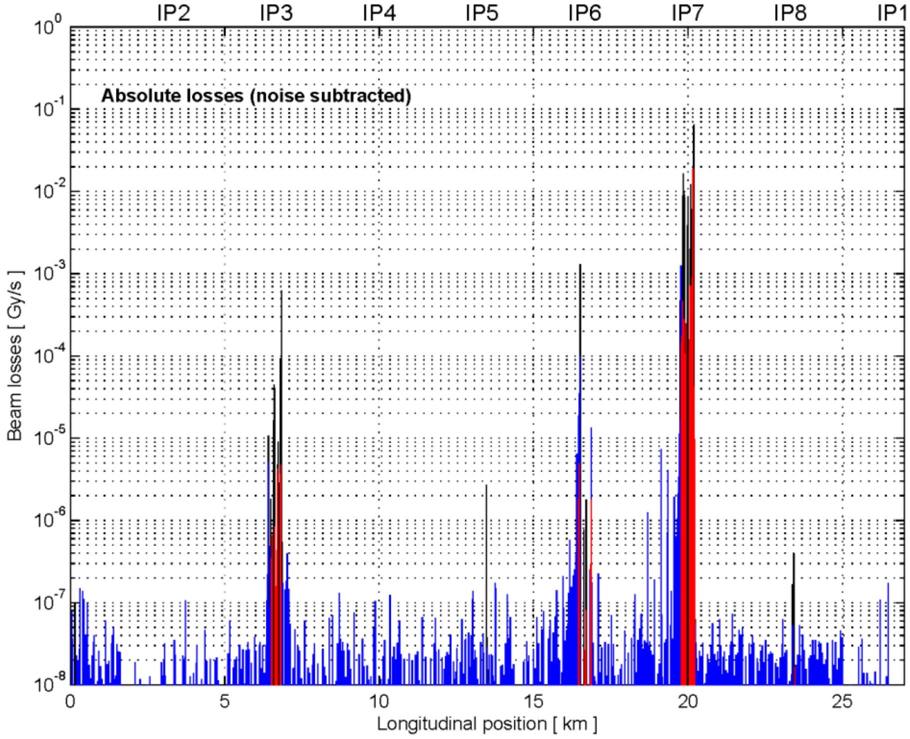
2 μm

18 μm

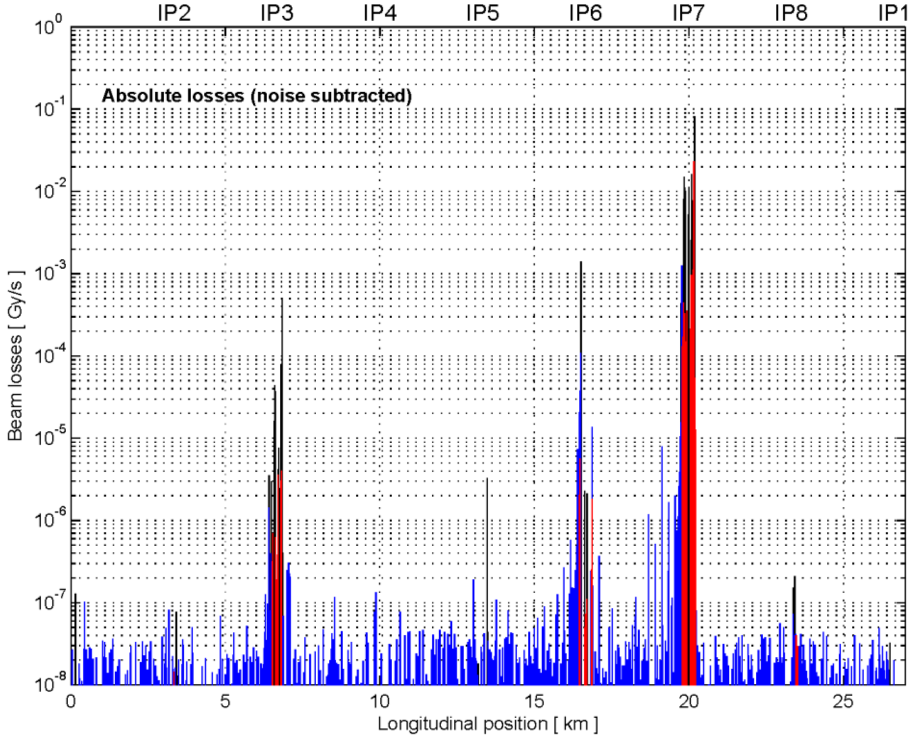
stops at 18 μm
→ aperture

Comparison loss maps

damper (ADT blow-up) loss map



3rd order resonance



S. Redaelli, R. Schmidt, D. Valuch, D. Wollmann, M. Zerlauth et al.

Plans for 2012 – new features (1)

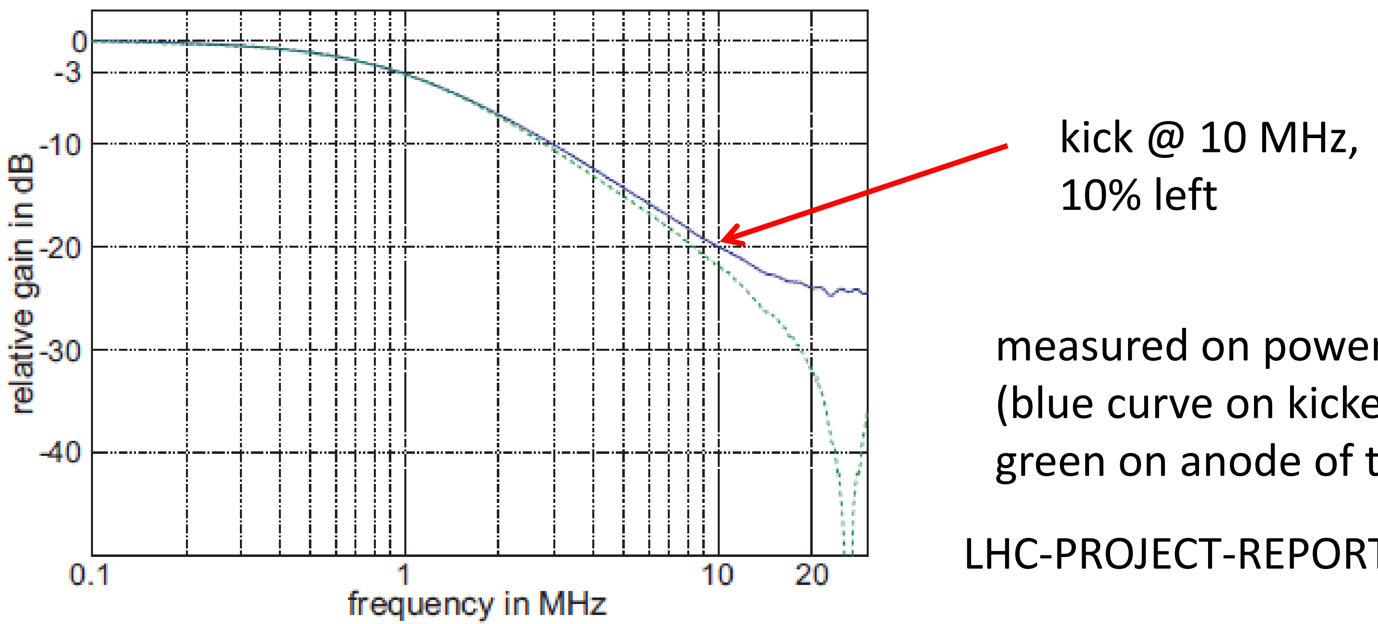
- user interface for loss maps (purely software effort), “expert” interface → later sequencer (?)
- observation of two selectable bunches in a continuous way for tune measurement with data streamed to software in packages of 4096 turns, tests for software interface pending
- for tune measurement: gain modulation within a turn to have lower gain for a witness bunches train (leading 12 bunches)
- “dead-band” / “dead-band” with commutation of FB sign later to be considered (“dead-band” → do not damp oscillation before it reaches x μm, x adjustable)
- tune measurement from witness bunch train (ADT data or BBQ)

Plans for 2012 – new features (2)

- bunch mask based observation (more than 8 bunches) permitting online injection quality checks along batch (current observation limited to 8 bunches)
- automatic setting of bunch intensity dependent gain, permitting observation of pilot bunches at injection: still some procedure to protect equipment to be defined
- post mortem data display for ADT to be commissioned

Performance with 25 ns and 50 ns spacing

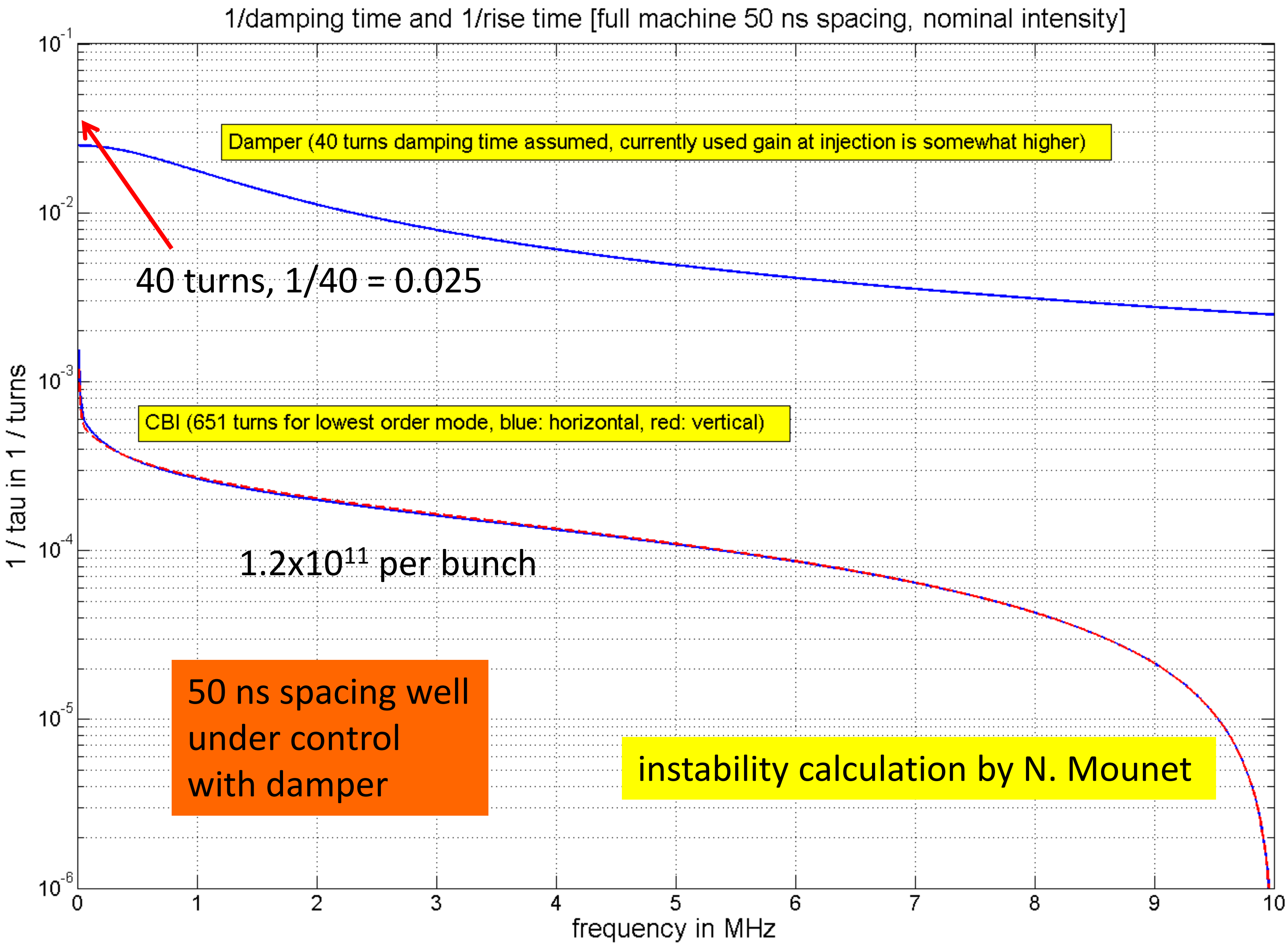
- 50 ns: 10 MHz bandwidth required and available
- 25 ns: 20 MHz bandwidth required more difficult set-up
- for 25 ns frequency response improvements under study (also important for abort gap cleaning): cable dispersion, and entire amplifier change under scrutiny



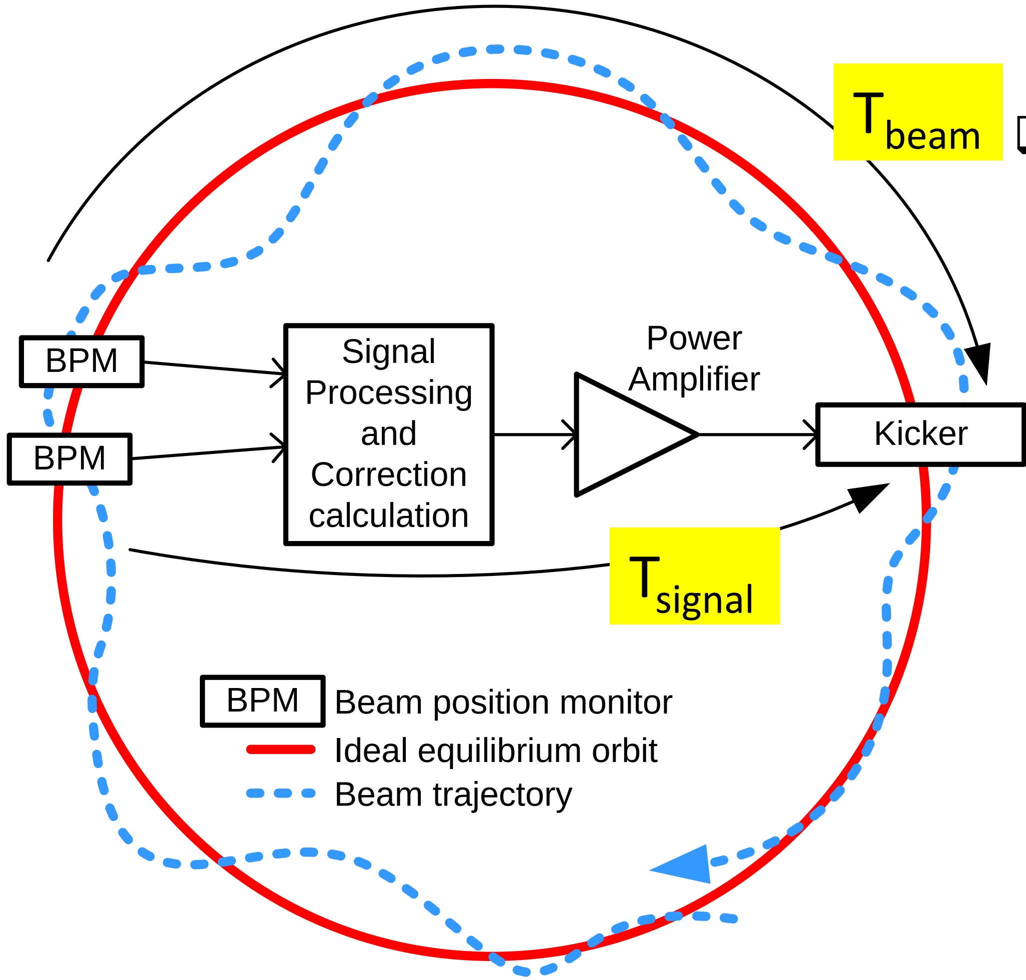
measured on power amplifier
(blue curve on kicker,
green on anode of tetrode)

LHC-PROJECT-REPORT-1148

50 ns spacing



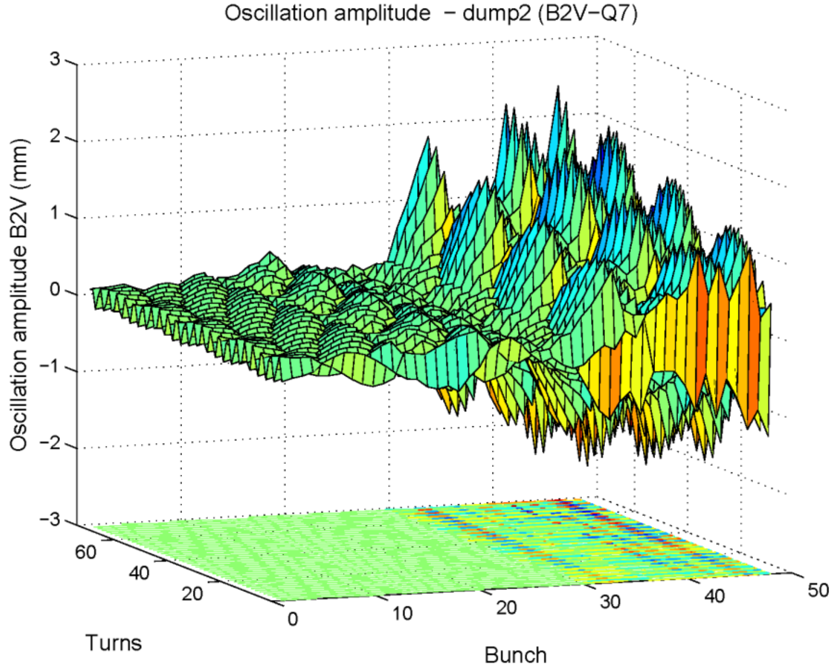
Transverse damper adjustments



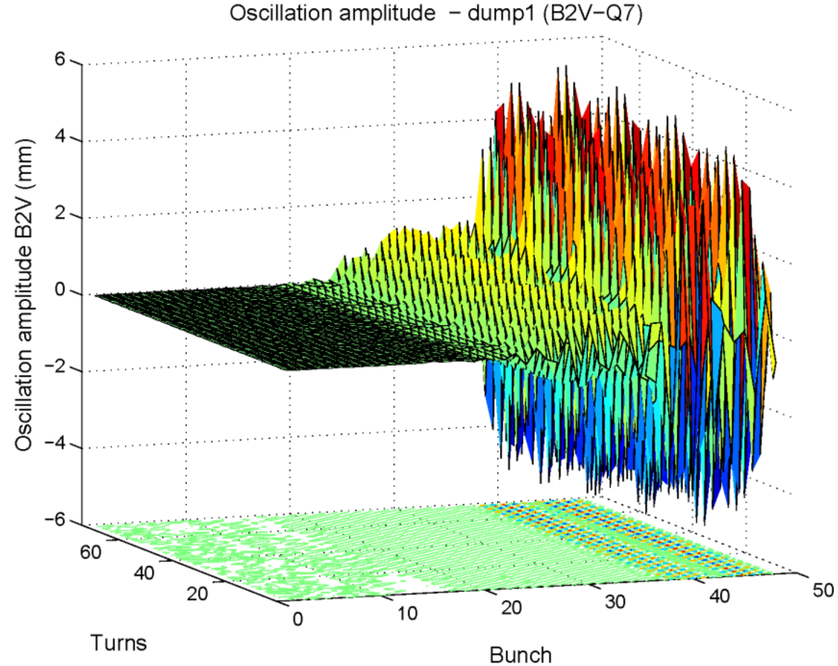
- Key elements:
  - beam position monitor(s)
  - signal processing system
  - power amplifiers
  - kickers (electric field)
- Key parameters:
  - Feedback loop gain
  - phase and
  - delay

1st test with 48 bunches @25 ns spacing (1)

damper off, vertical plane



damper on, vertical plane



data from post mortem offline-analysis

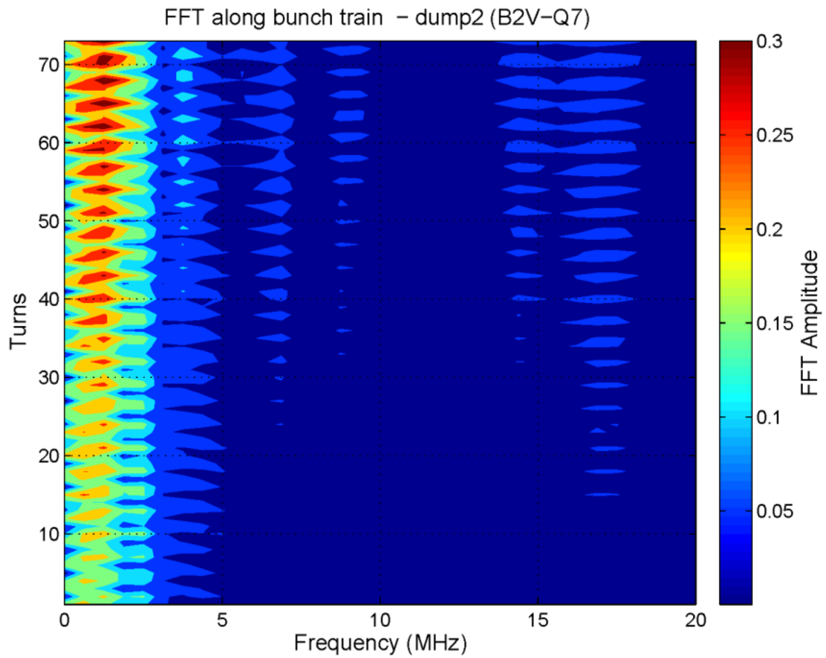
26th August 2011: two injection attempts at Q'=2, one with damper on, one with damper off; subsequent MDs with 25 ns done with high Q' (e-cloud instability)

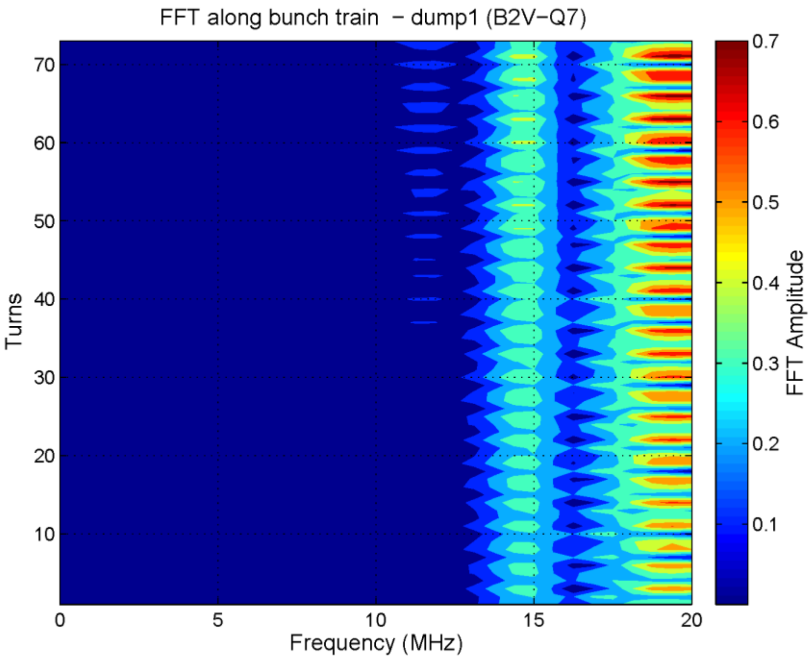
see MD note under approval, H. Bartosik, W.Hofle

1st test with 48 bunches @25 ns spacing (2)

damper off, vertical plane

damper on, vertical plane





damper off: frequencies of instabilities < 2.5 MHz
damper on: frequencies above 14 MHz unstable:
but delay was not yet correct

MD note under approval,
H. Bartosik, W.Hofle

What changes with increased energy ?

- impedance higher with collimators closer to beam
- physical beam size smaller, impact of noise higher
- marginal changes for 4 TeV, not an issue
- 7 TeV → reduction of noise advised (keep performance)
- 7 TeV, higher electronic gain required due to stiffer beam → means saturation, we run out of steam, re-shuffling of gain with some low power amplifiers needing re-design (for LS1)

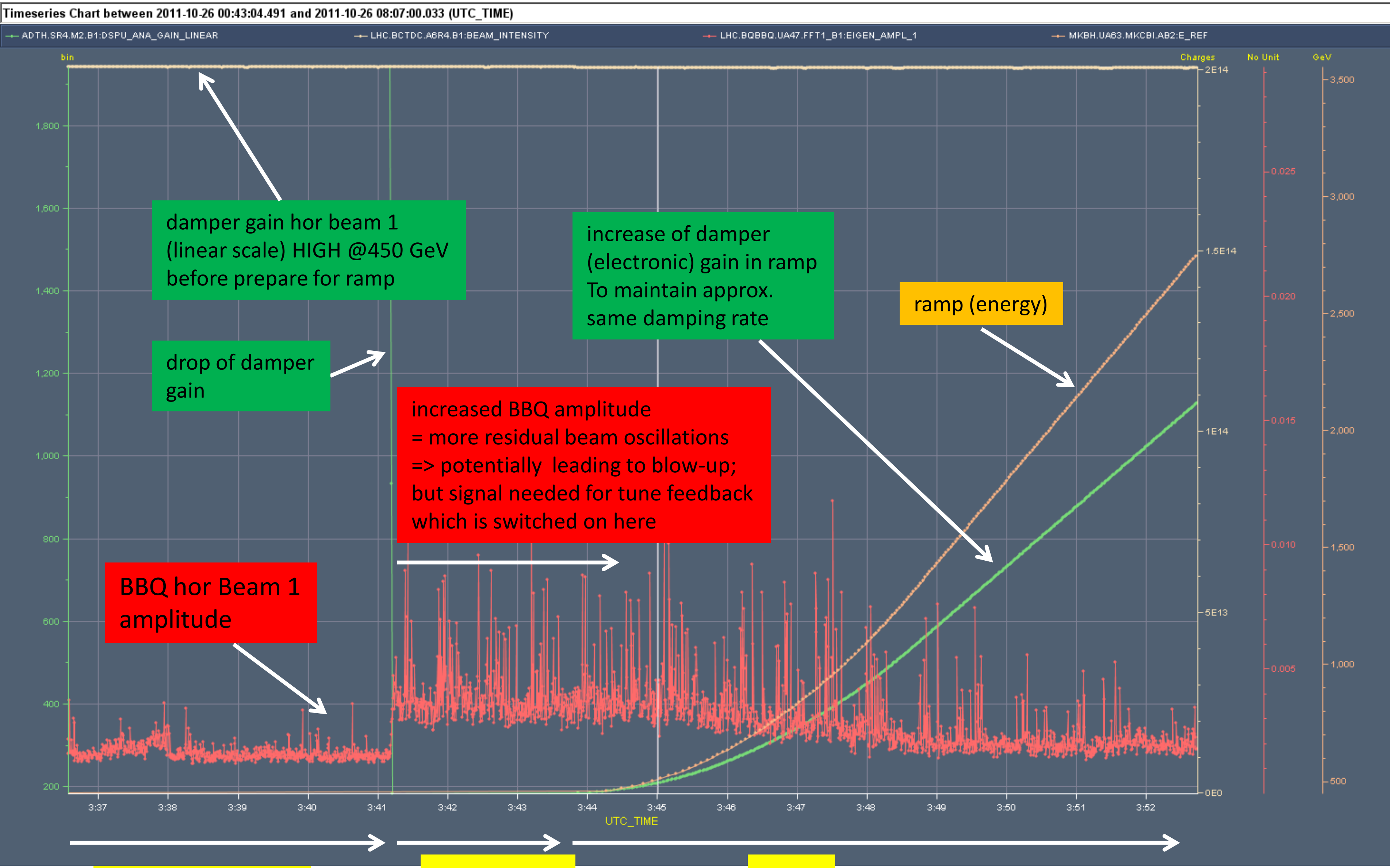
Running at higher gains in ramp

- maximum gain given by stability limits of feedback + beam
- impact of noise other than from damper pick-ups on emittance increase is reduced at high gain
- no dependence on gain of impact of damper pick-up noise on emittance
- higher gain and higher pick-up noise makes tune signal seen by BBQ noisier, i.e. noise floor outside tune rises

→ this is an undesired effect for the measurement of the tune

MDs planned for 2012

How we ran in 2011 with 50 ns beam

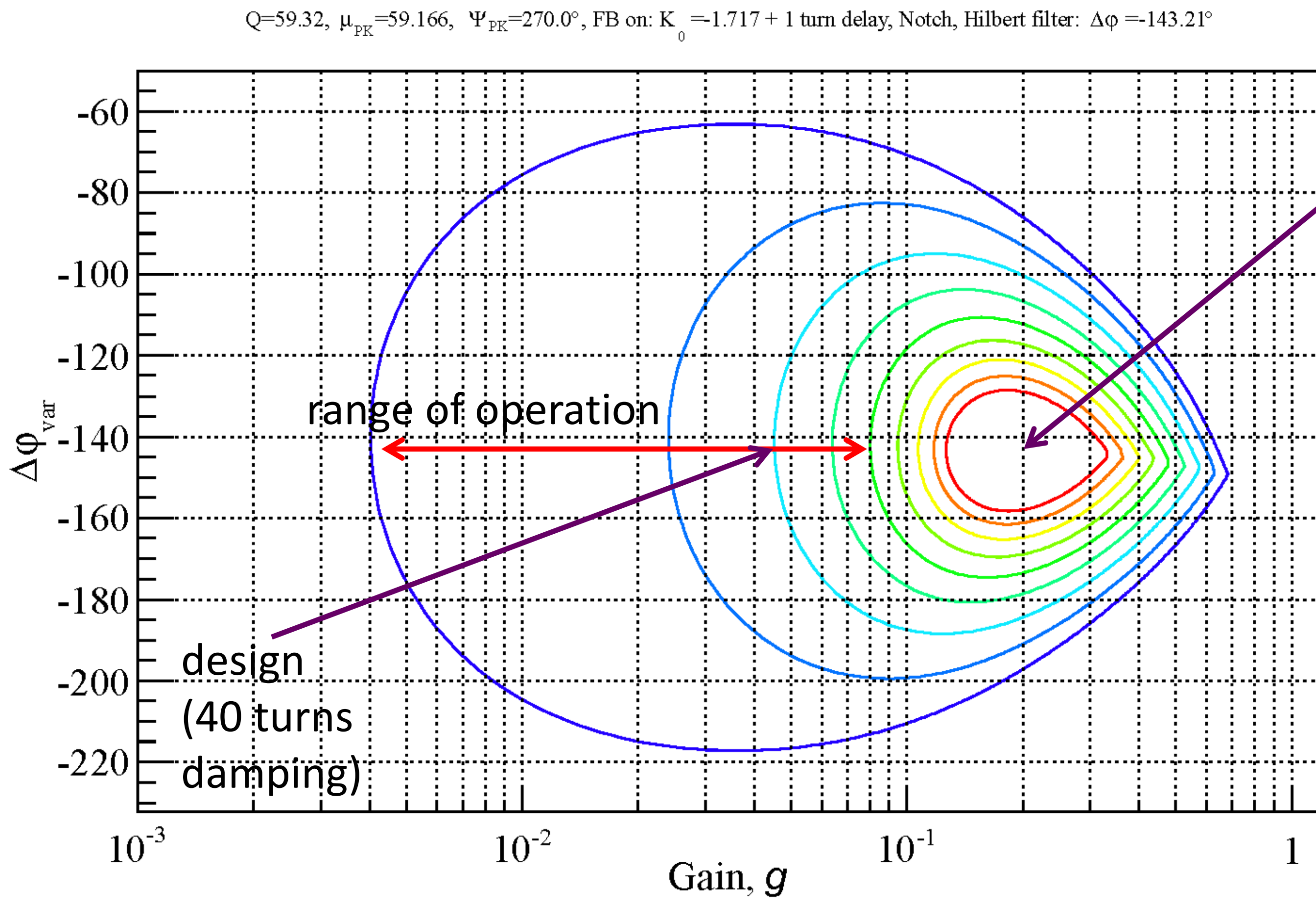


Injection plateau

prepare for ramp

ramp

Gain limit from stability



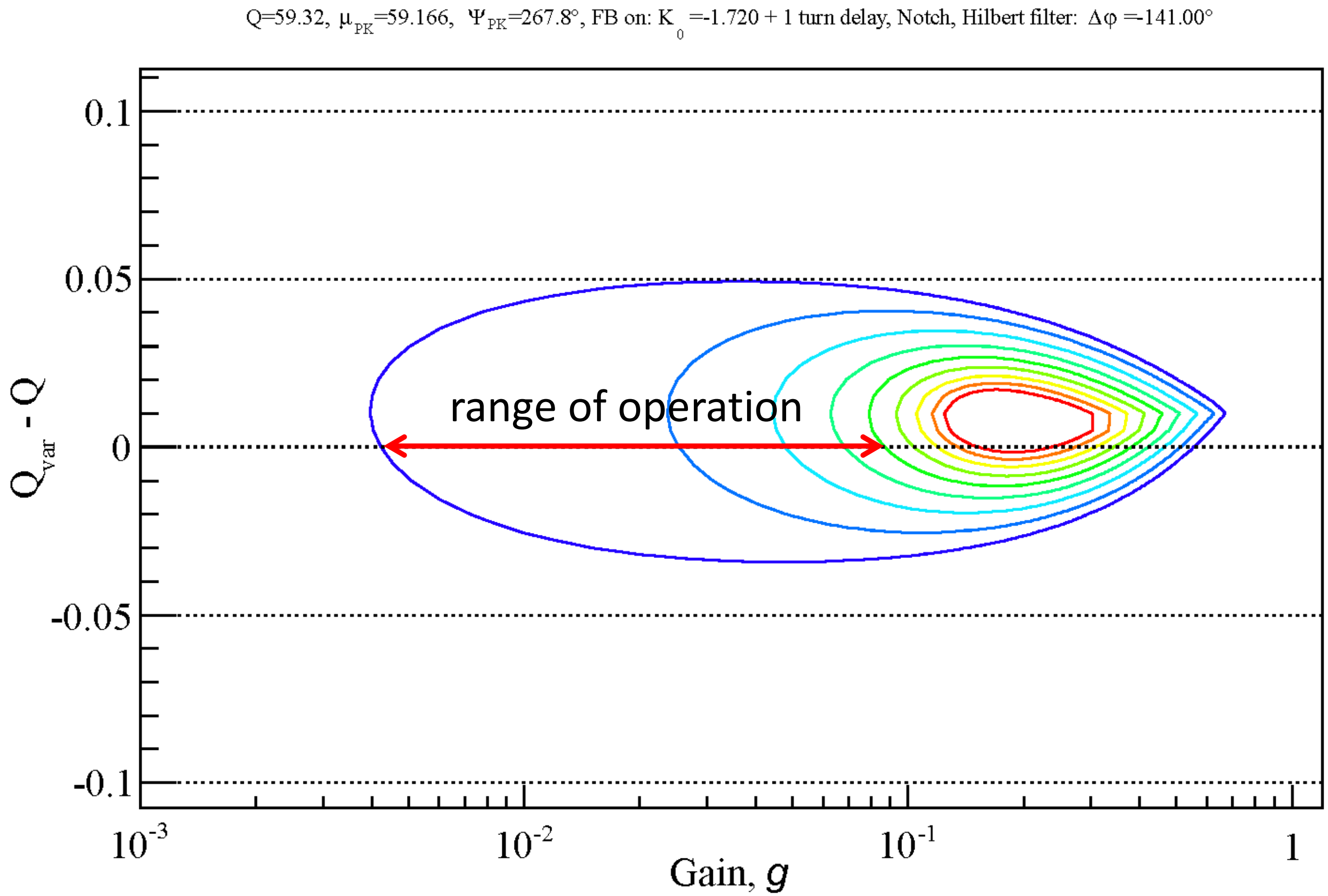
faster than 10 turns damping

contour lines at n/80 turns n=1…8 and 0.002 (1/τ)

gain is the fraction of detected oscillation that is corrected in a single turn

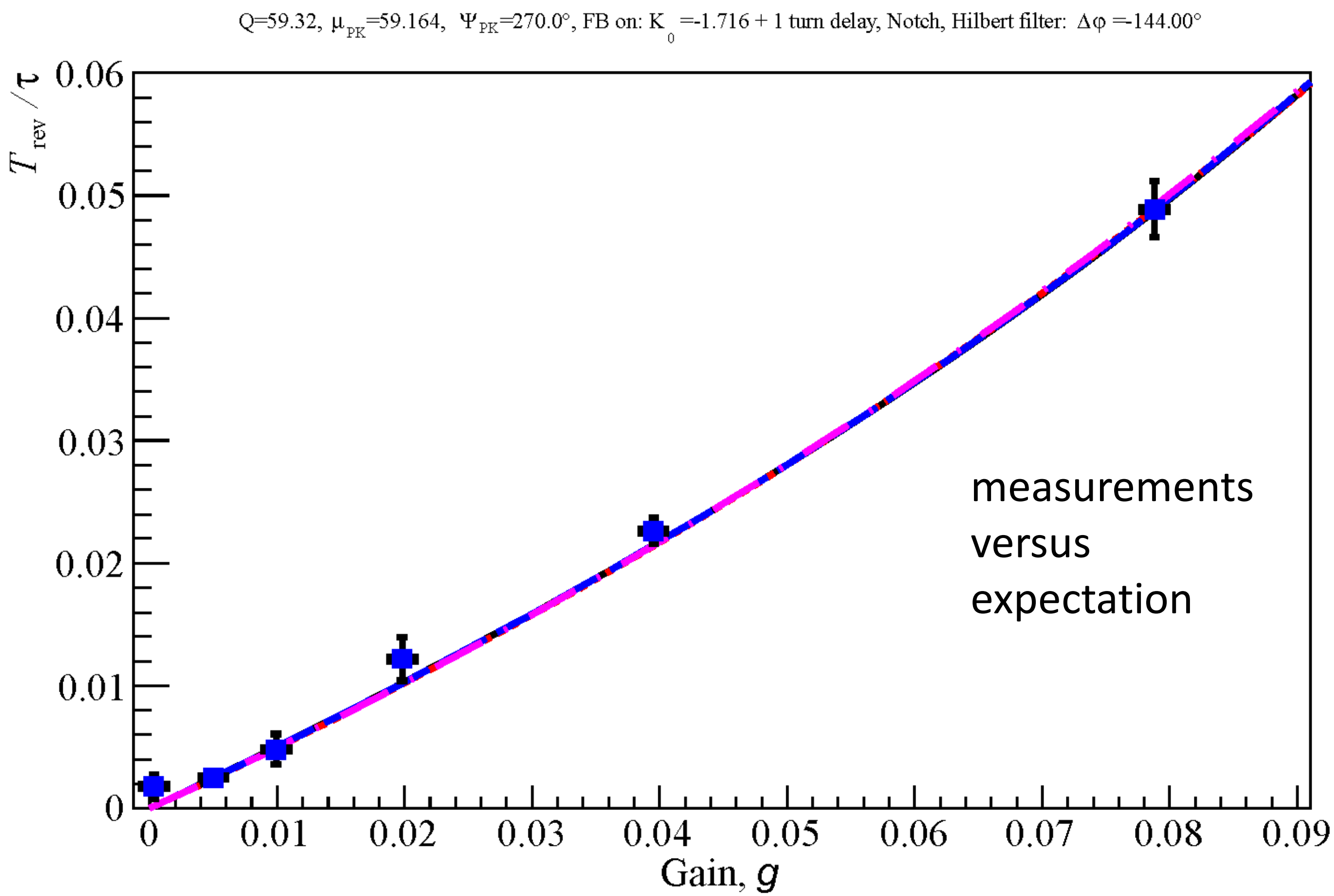
V. Zhabitsky et al.

Damping : variation with tune



report in preparation, looked at 8 pick-ups, injection and collision
some small optimizations possible, like in plot above
consider beam-beam tune shift for future (pi-mode !)

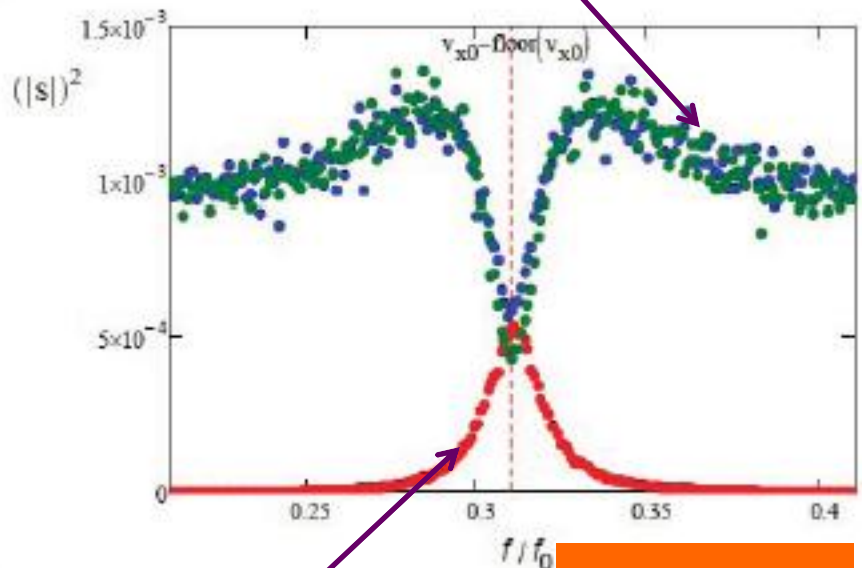
Damping time : variation with gain



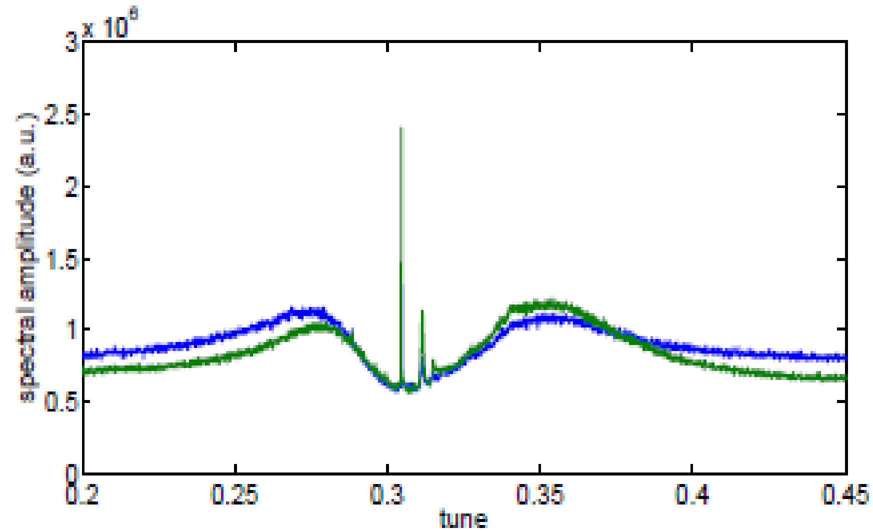
vertical, beam 2 @3.5 TeV

Tune from residual damper signal

PU signals with noise



simulated

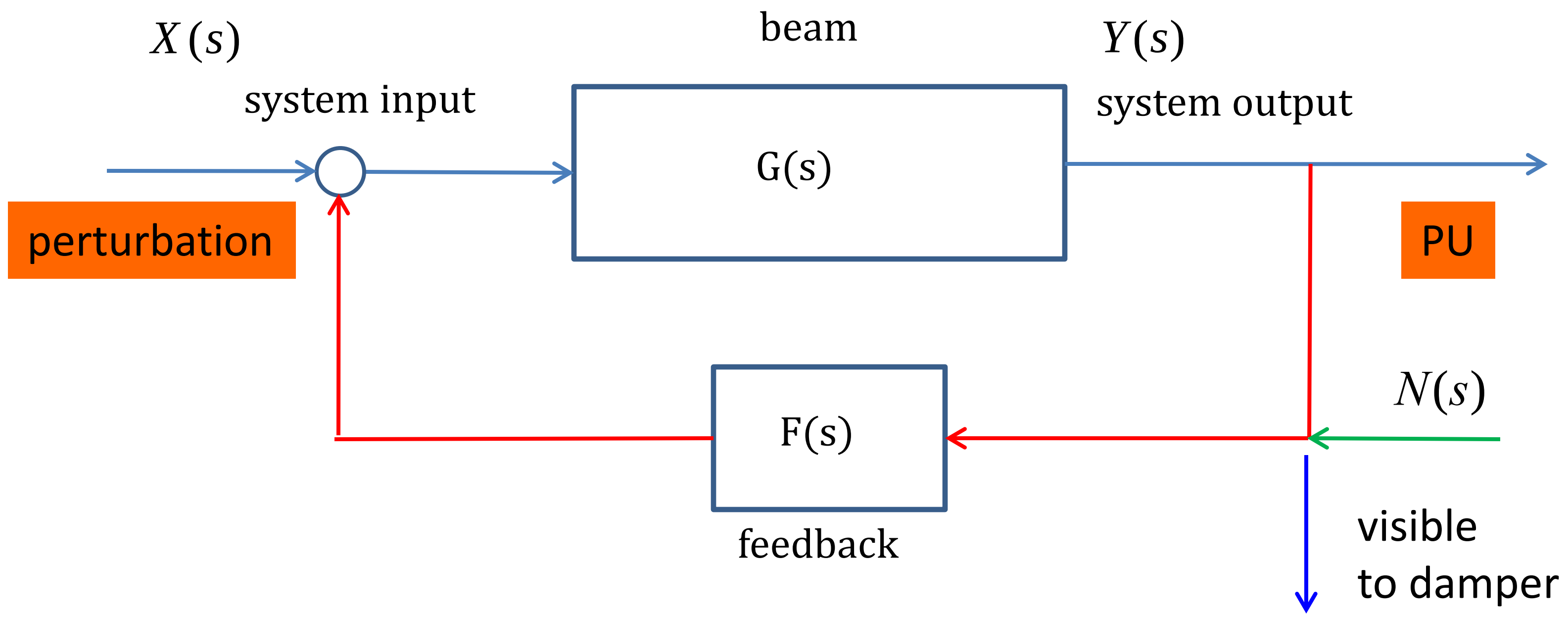


measured (2 PU signals)

beam motion below
damper detection level
i.e. not visible for damper

V. Lebedev, W. Hofle, D. Valuch
et al. IPAC 2011

Closed loop transfer function N(s)→Y(s)

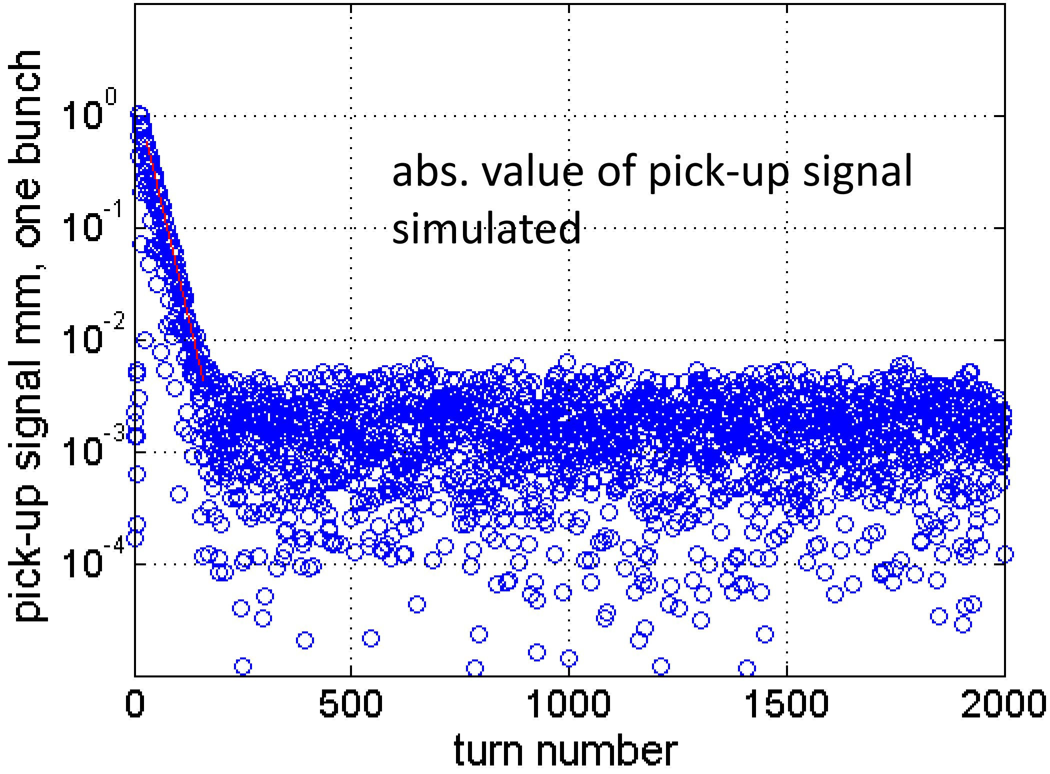


open loop $Y(s) = G(s)F(s)N(s)$

output of closed loop $Y(s) = -G(s)F(s)N(s) - G(s)F(s)Y(s)$

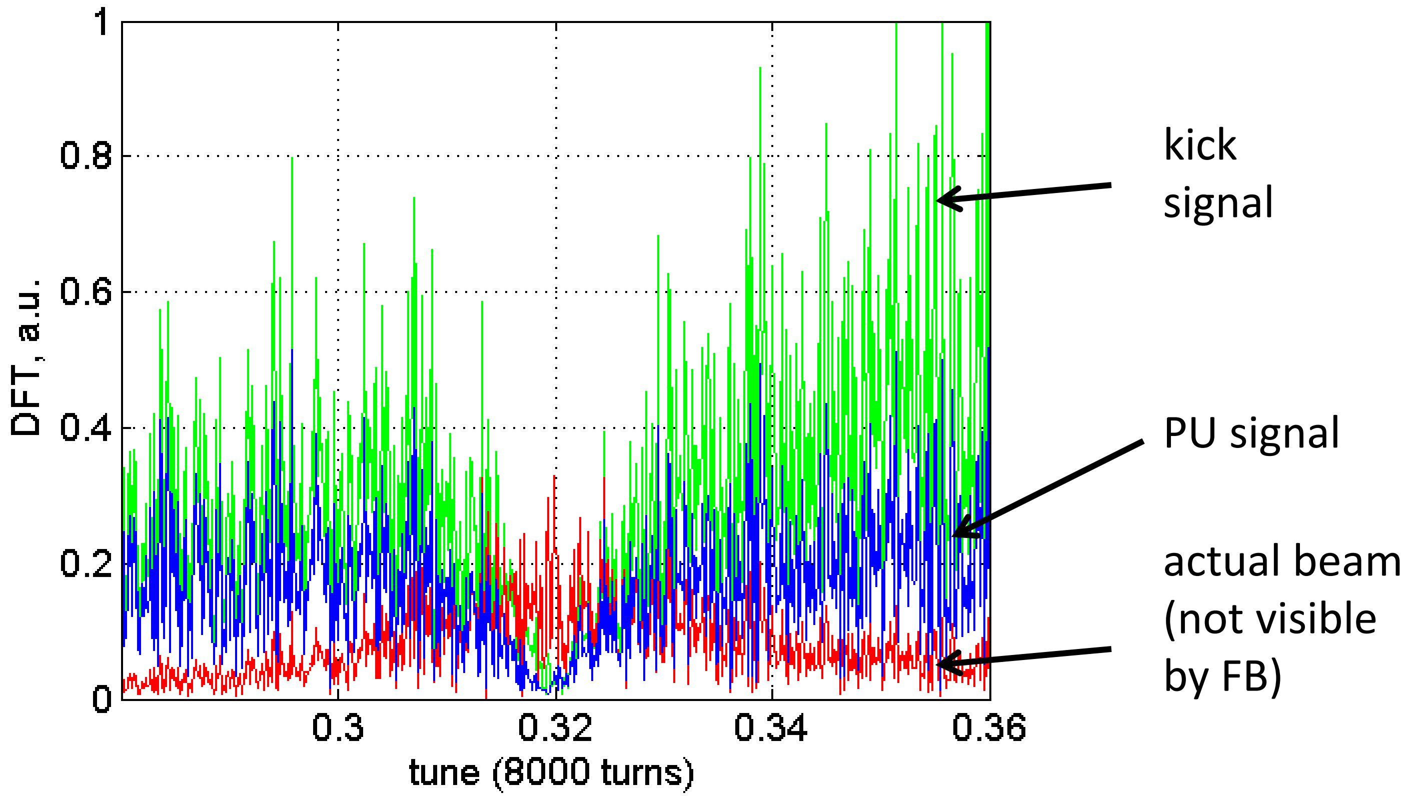
closed loop transfer function $G_{\mathrm{CL,N}}(s) = \dfrac{Y(s)}{N(s)} = \dfrac{-G(s)F(s)}{1+G(s)F(s)}$

Tune Measurement: feasibility and plans



damping of 1 mm error, and simulated noise floor matching observed fluctuation on PU signals (2 μm rms, 5 μm peak)

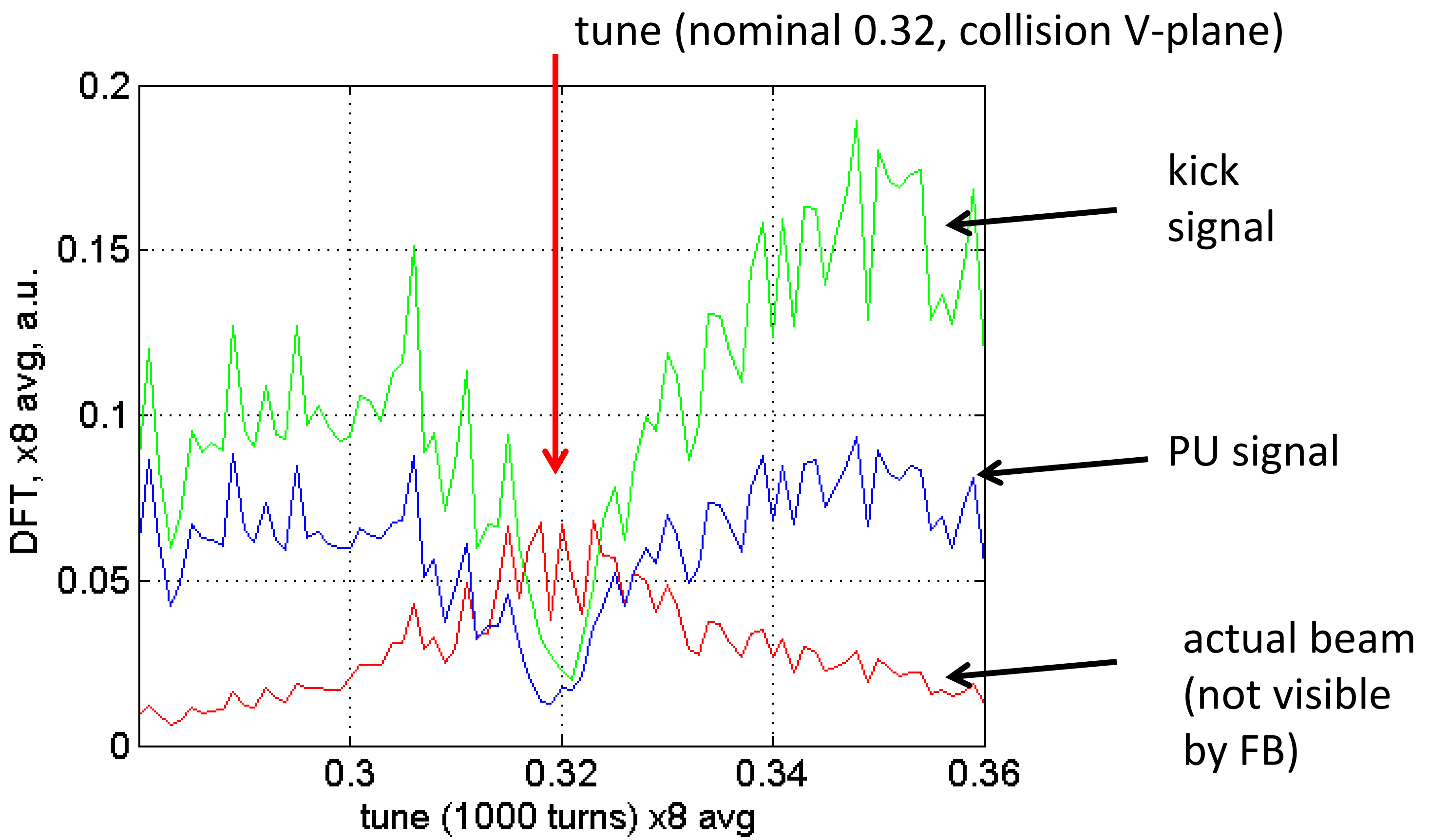
Tune Measurement: feasibility and plans



numerical simulation with correctly adjusted feedback phase

8000 turn FFT → relatively noisy

Tune Measurement: feasibility and plans

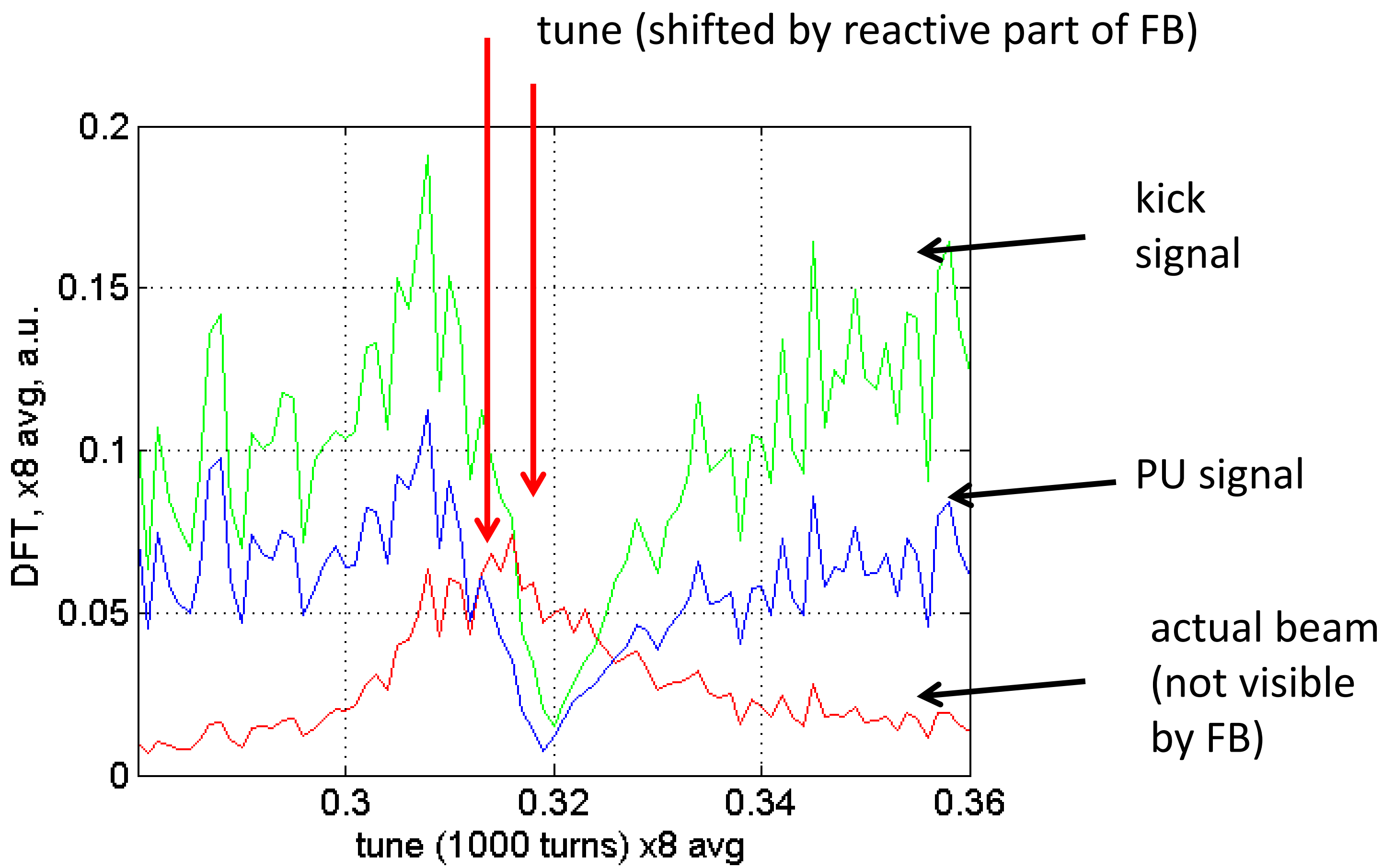


numerical simulation with correctly adjusted feedback phase

average of eight 1000-turn FFT from a set of 8000 turns,

one bunch, minimum of PU signal gives tune

Tune Measurement: feasibility and plans



numerical simulation with badly adjusted feedback phase (30° off)

average of eight 1000-turn FFT from a set of 8000 turns,

one bunch, minimum of PU signal gives un-shifted tune !

Summary tune measurement

1) lower ADT gain for first bunch train of 12 bunches
2) implement in ADT observation of two selectable bunches
3) observe results of lower gain, incl. on BBQ (gated BBQ ?)
4) check practical feasibility of tune from residual damper signal
5) implement final solution in LS1

Summary

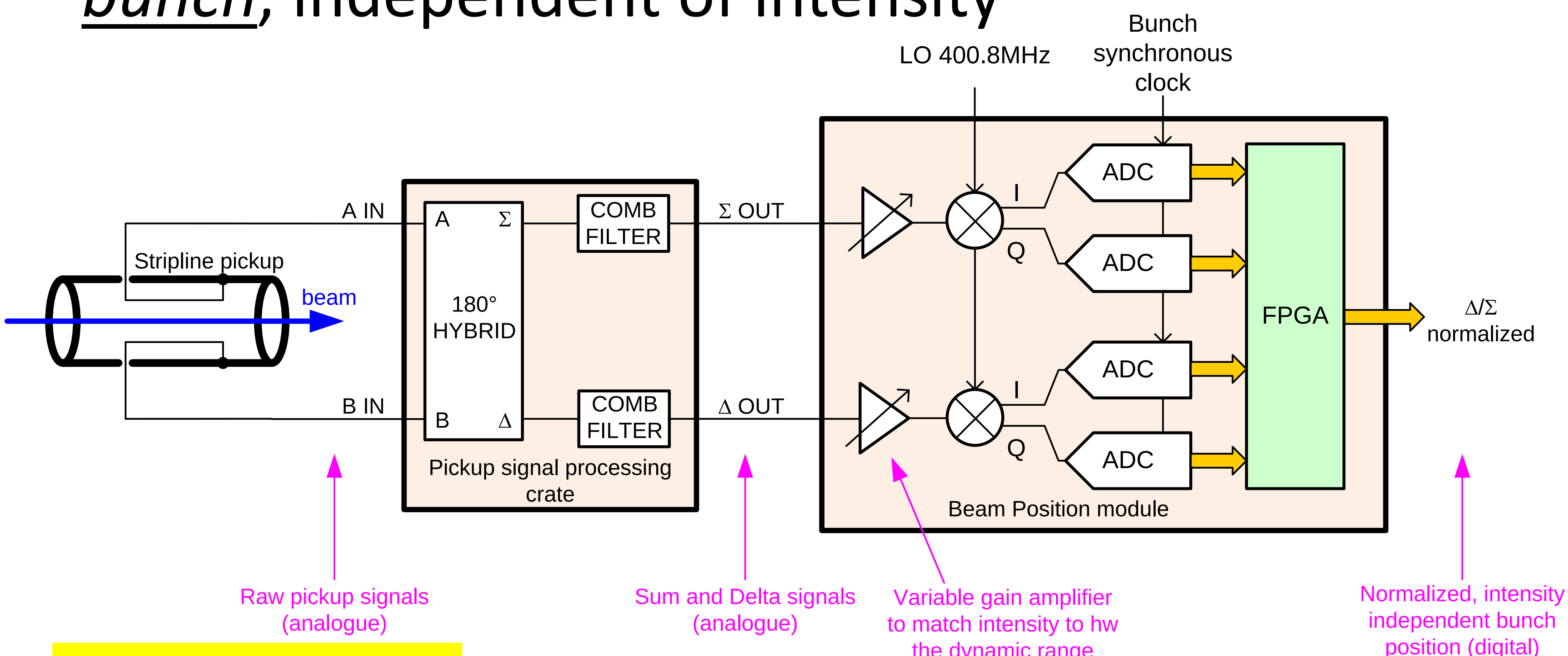
- a number of new features under development
- 50 ns well under control
- 25 ns requires attention for setting-up
- improvements for lower noise under way
- improvements for frequency response under way
- compatibility with tune measurement system

  to be tackled with witness bunches for 2012 run

Spare slides

Beam Position module (Bpos)

Calculates normalized beam position ***bunch by bunch***, independent of intensity

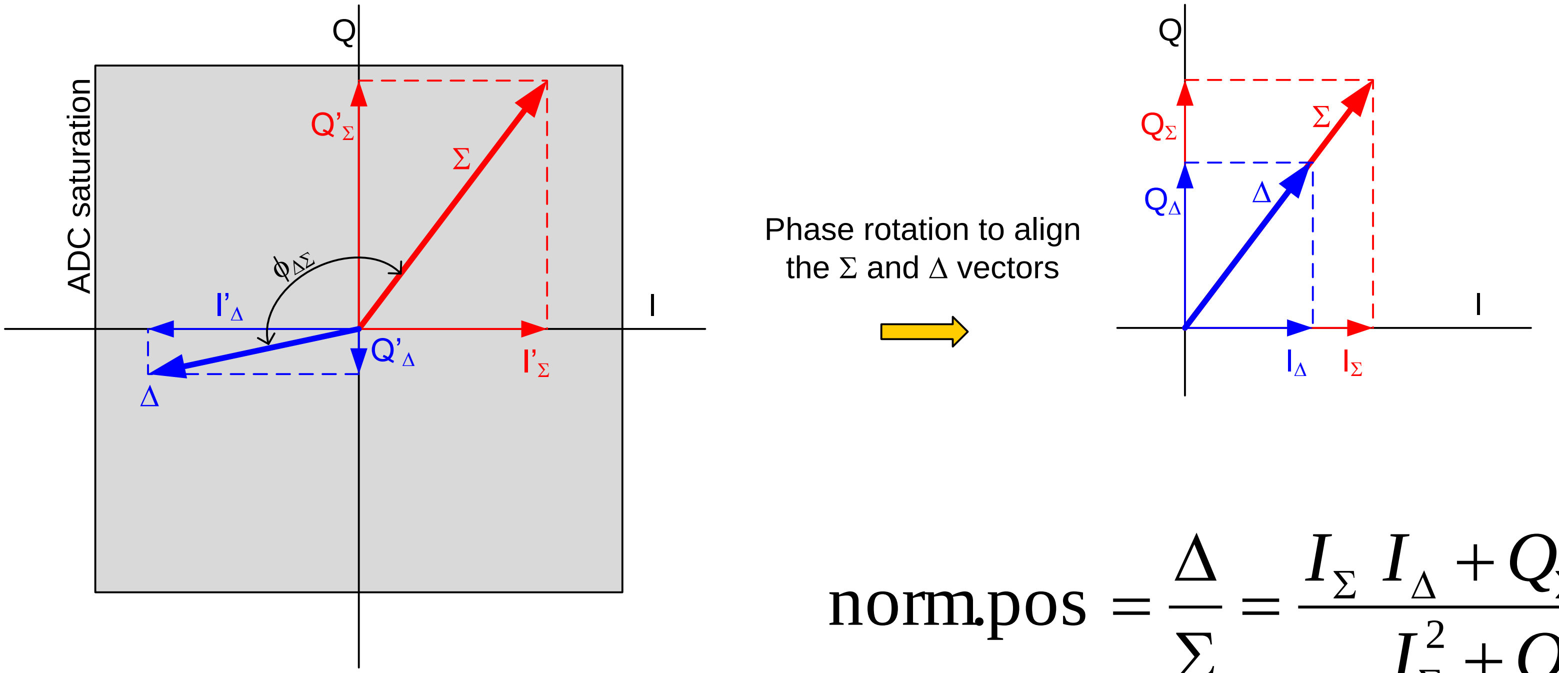


many different sources contribute to noise

16 bit ADCs

Beam Position module (Bpos)

Normalized bunch position calculation



$$\text{norm.pos} = \frac{\Delta}{\Sigma} = \frac{I_\Sigma\ I_\Delta + Q_\Sigma\ Q_\Delta}{I_\Sigma^2 + Q_\Sigma^2}$$

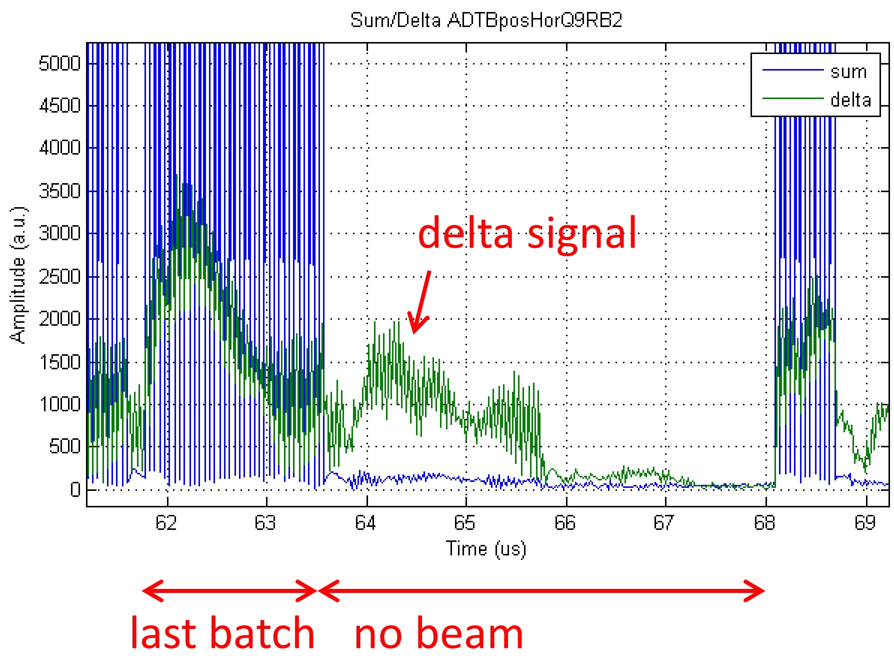
angle $\phi_{\Delta\Sigma}$ determined during setting-up, different settings required for different gains in pre-amplification chain

propagation of noise from 4 ADCs to final beam position measurement

Plans for TS 2011 and 2012 run

recabling of one system:

- 7/8” coaxial cable damage during the initial installation.
- Evaluation of a new typ of cable without corrugation.



noise contribution from cable the first to eliminate