Controlling RF gun and ACC1 with SimCon 3.1

Waldemar Koprek
in collaboration with
Elmar Vogel and Piotr Pucyk

FLASH Seminar at 23rd May 2006

Status of (some) activities with SimCon 3.1

Achievements from studies in March concerning the RF gun

- Proportional control
  latency reduction 3 to 1.2 μs for proportional fb gain increase 1 to 5
- Adaptive feed forward (AFF) working from RF pulse to RF pulse
  getting rid of repetitive (and drift) effects, decrease bunch to bunch (emission phase) spread

What remains open?

- Qualification measurements
  un-proper adjusted dark current kicker caused unwanted effects in measured values
  nevertheless: the improvements by SIMCON and the algorithms were visible

Achievements from studies in March concerning ACC1

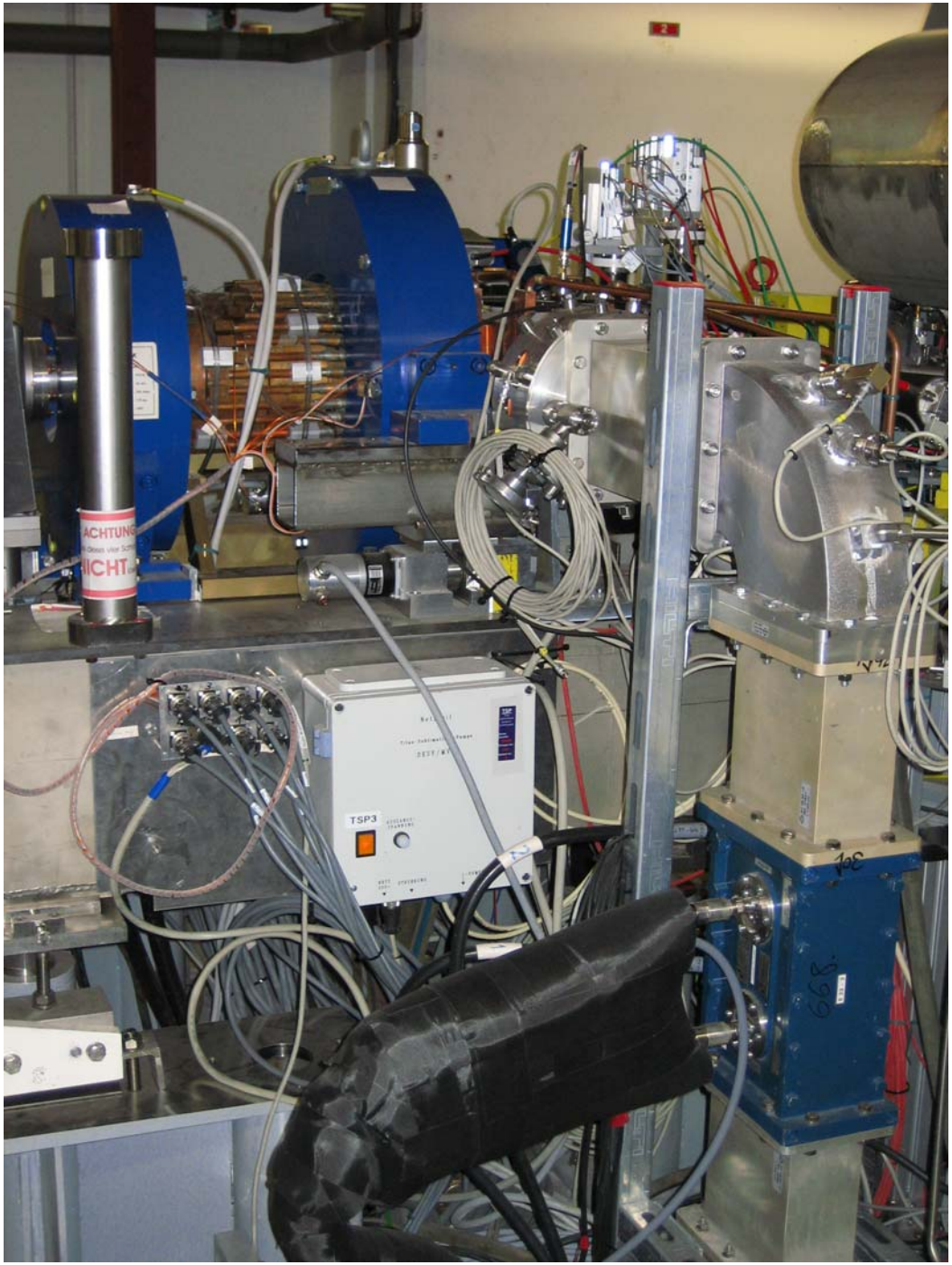
- Proportional control of vector sum
  latency reduction allows proportional fb gain increase by four
- Beam monitor signals taken by SimCon
  algorithm for charge proportional values tested successfully
  (collaborators: T. Traber, D. Nölle)

What remains to be done?

- Set up of DOOCs servers and control room displays for standard operation
- Using beam monitor (charge) signal for beam loading compensation
- Adaptive feed forward (AFF) working from RF pulse to RF pulse

TTF rf gun

- beam generated within the (1.3 GHz) RF gun by a laser
- filling time: typical 30 µs
- flat top time: up to 800 µs
- pulse repetition: up to 5 Hz
- high RF field: 40 MV/m
- FEL operation is sensitive to RF gun phase (0.5 deg)
- via the temperature the frequency is controlled (0.1 deg Celsius corresponds to 2.1 deg in RF phase)



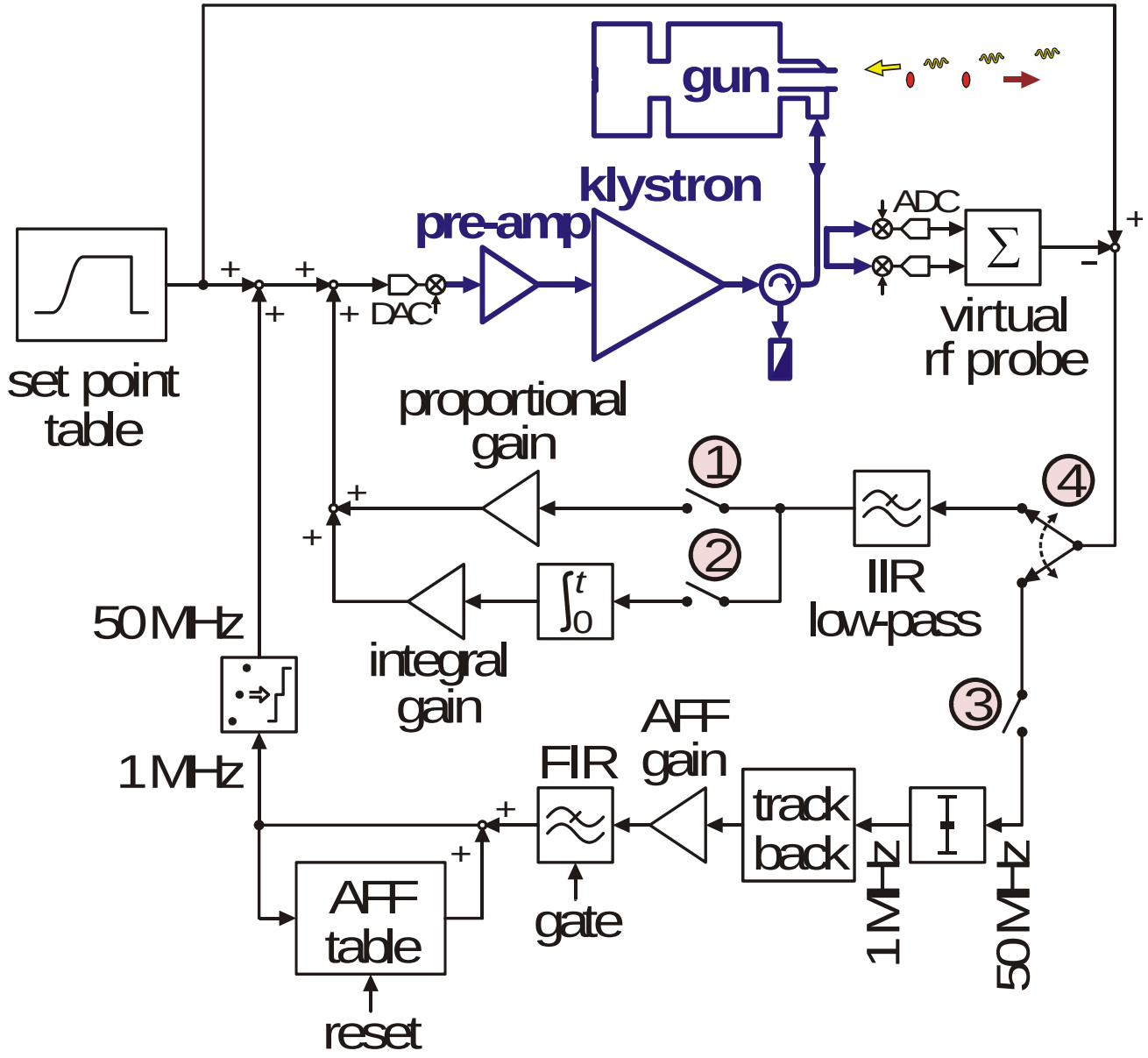
Rf gun control by SimCon 3.1 an some new algorithms

Implications of missing probe:

- calculation of probe form forward and reflected rf
- calibration is an issue, e.g. be done by temperature scans

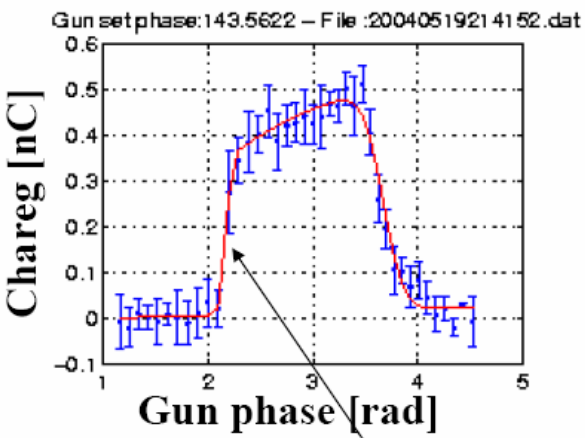
Algorithms:

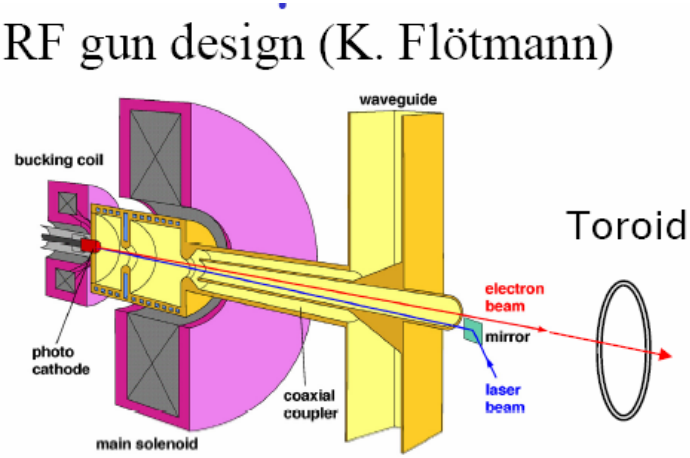
- P(I) control with recursive 20 kHz low-pass (IIR) for stability at high gain (>5)
- Adaptive feed forward (AFF) from rf pulse to rf pulse

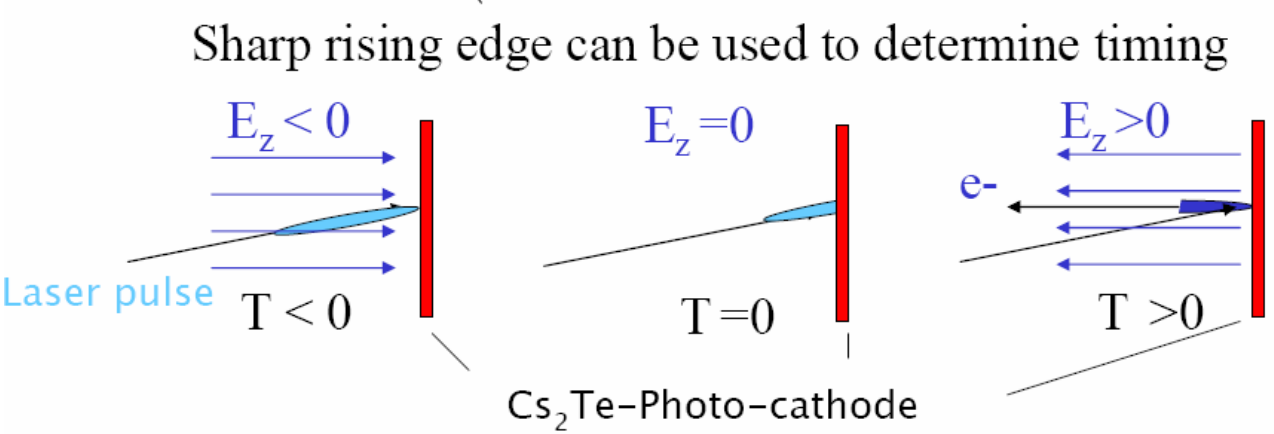


Emission phase stability measured with beam (H. Schlarb)

- indirect rf phase measurement
- bunch charge depends on rf phase at 'edge'
- measurement resolution: ± 0.1°
  ⇒ to be improved!

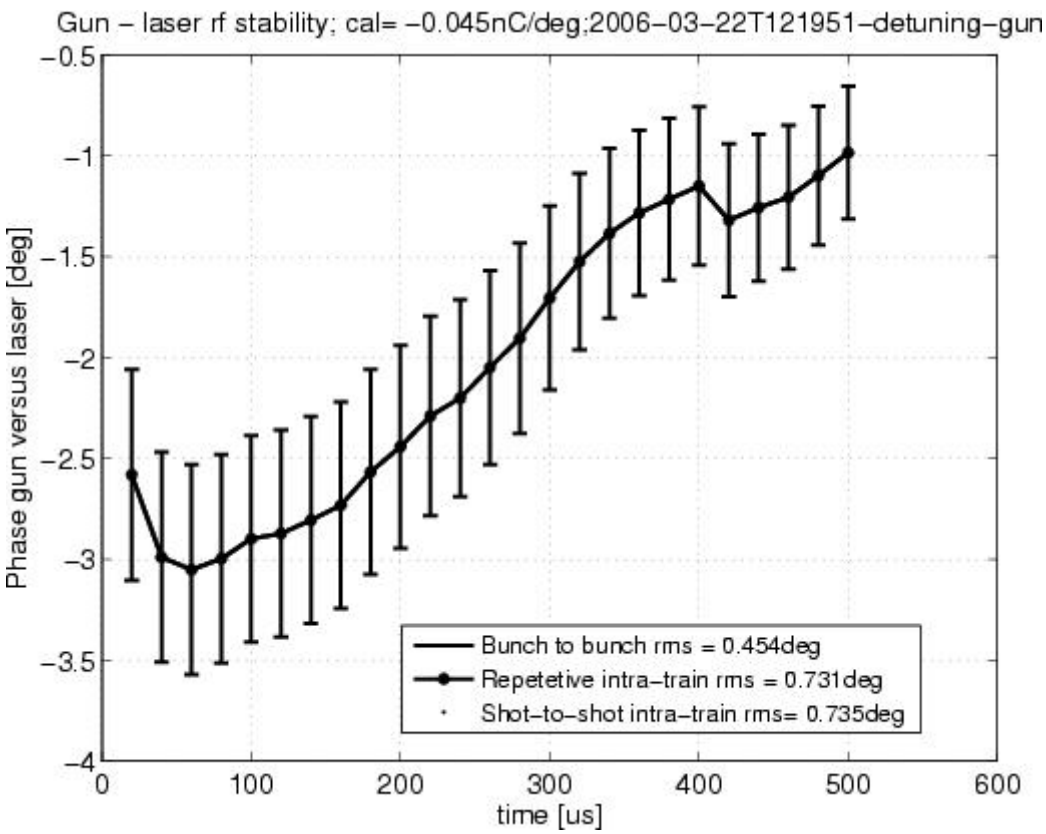






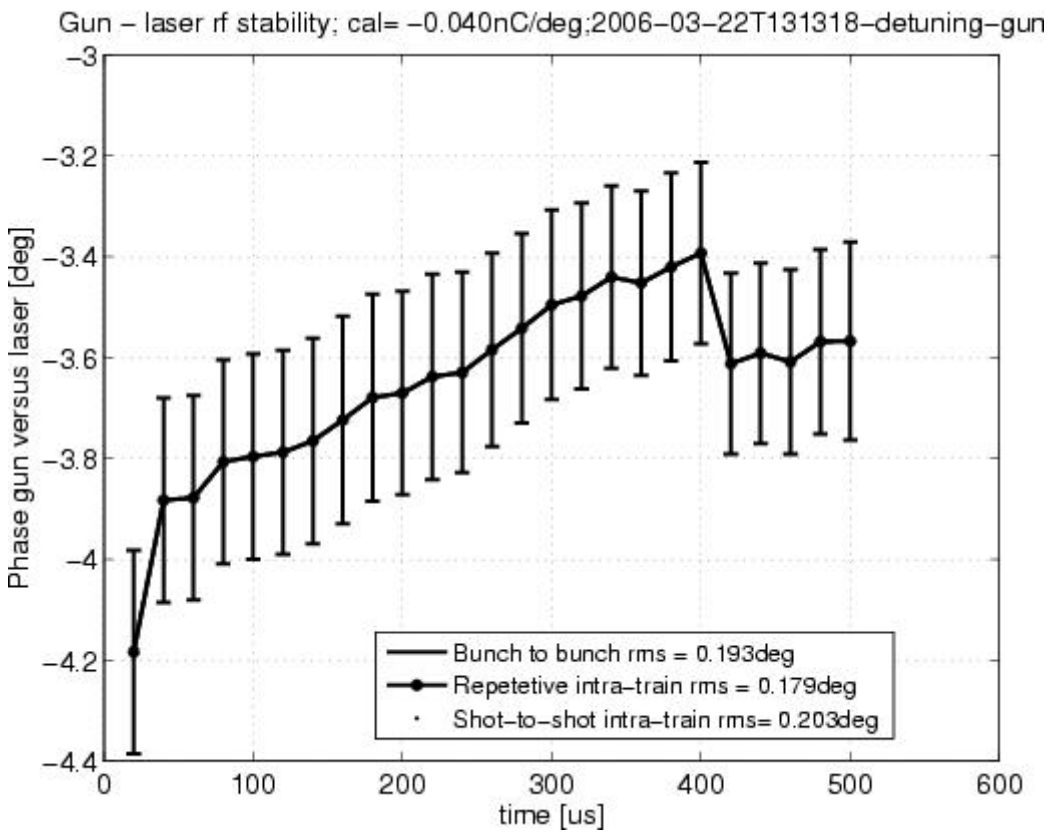
Bunch to bunch stability

RF drive only / similar to DSP



- resonance frequency change due to gun temperature change within pulse
- step caused by dark current kicker

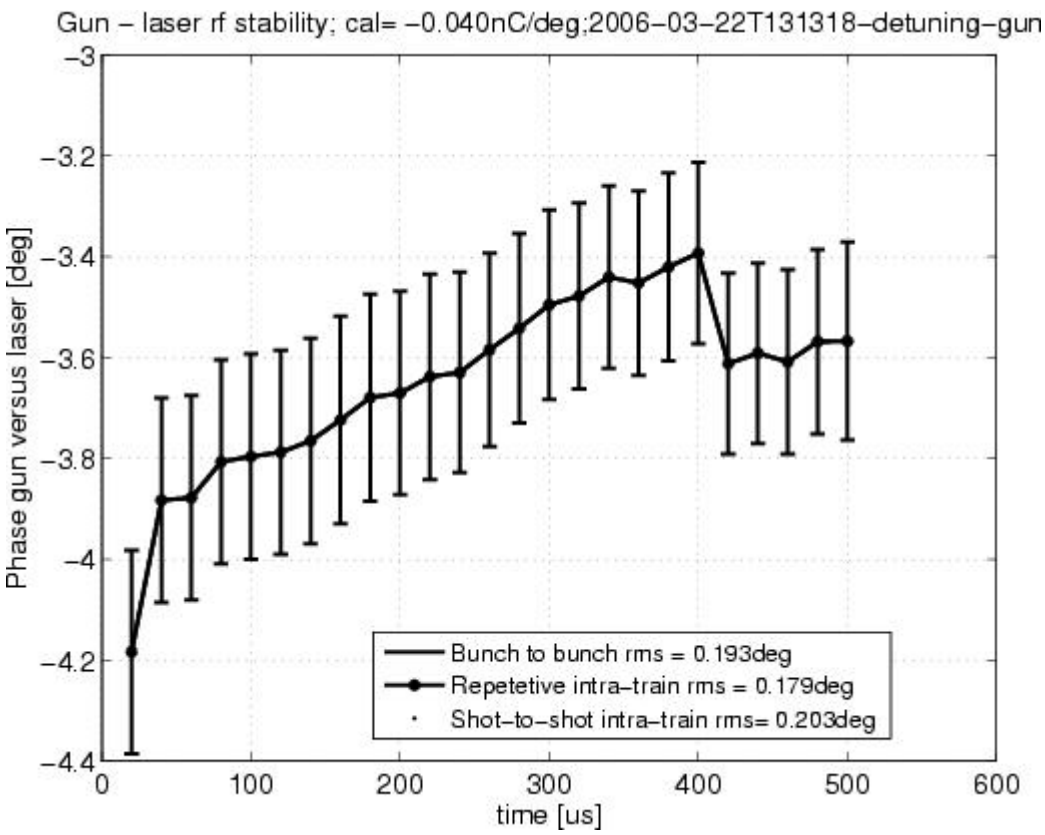
PI control



- error suppression by about 5 (= gain)

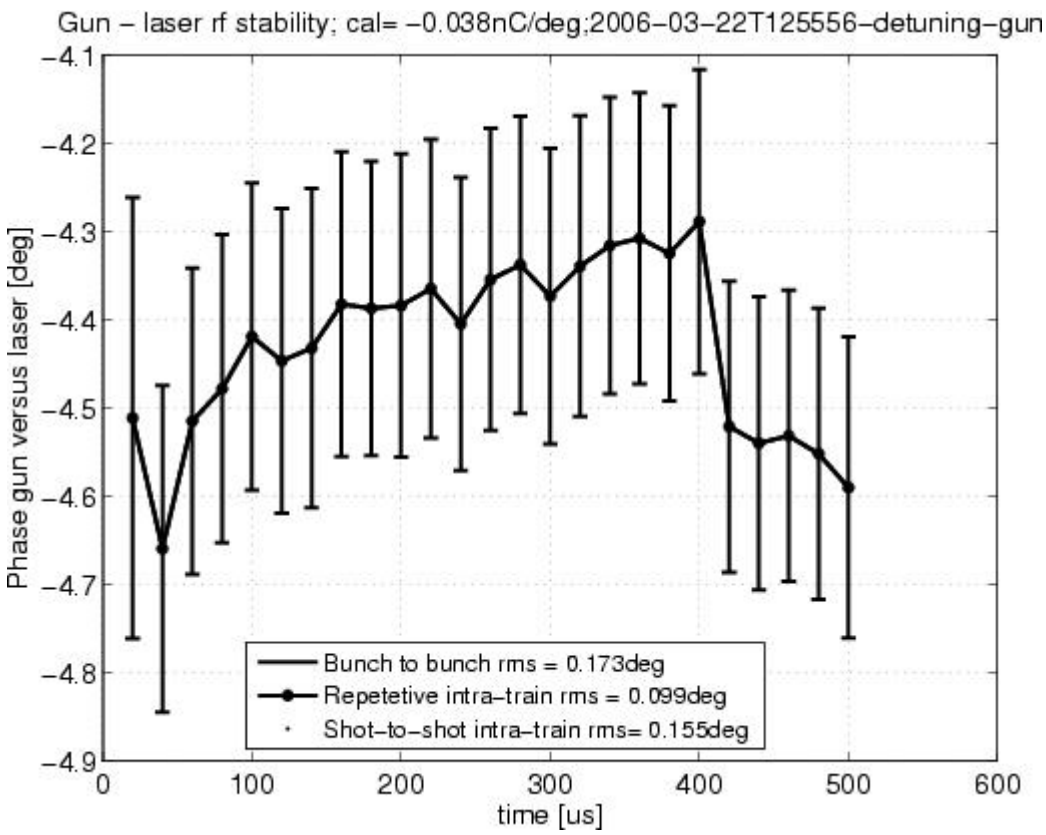
Bunch to bunch stability (continued)

PI control (repeated)



- error suppression by about 5 (= gain)

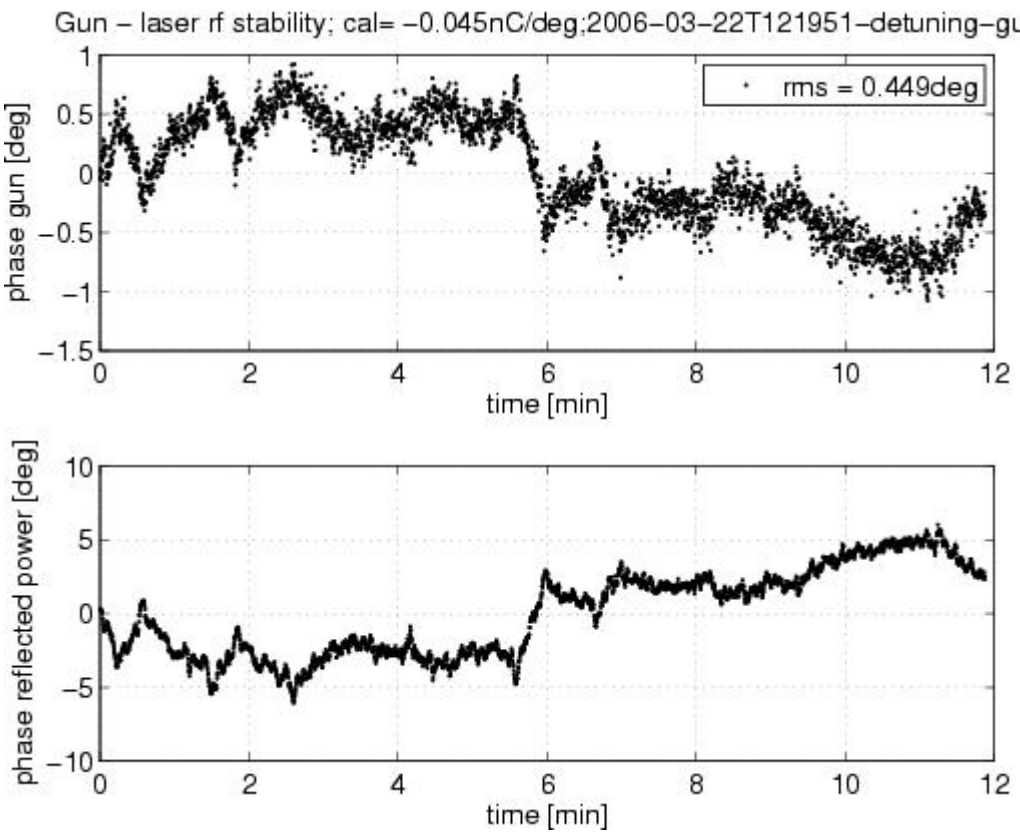
Alternating AFF and PI control



- gun temperature slope decreased by an other factor of 2

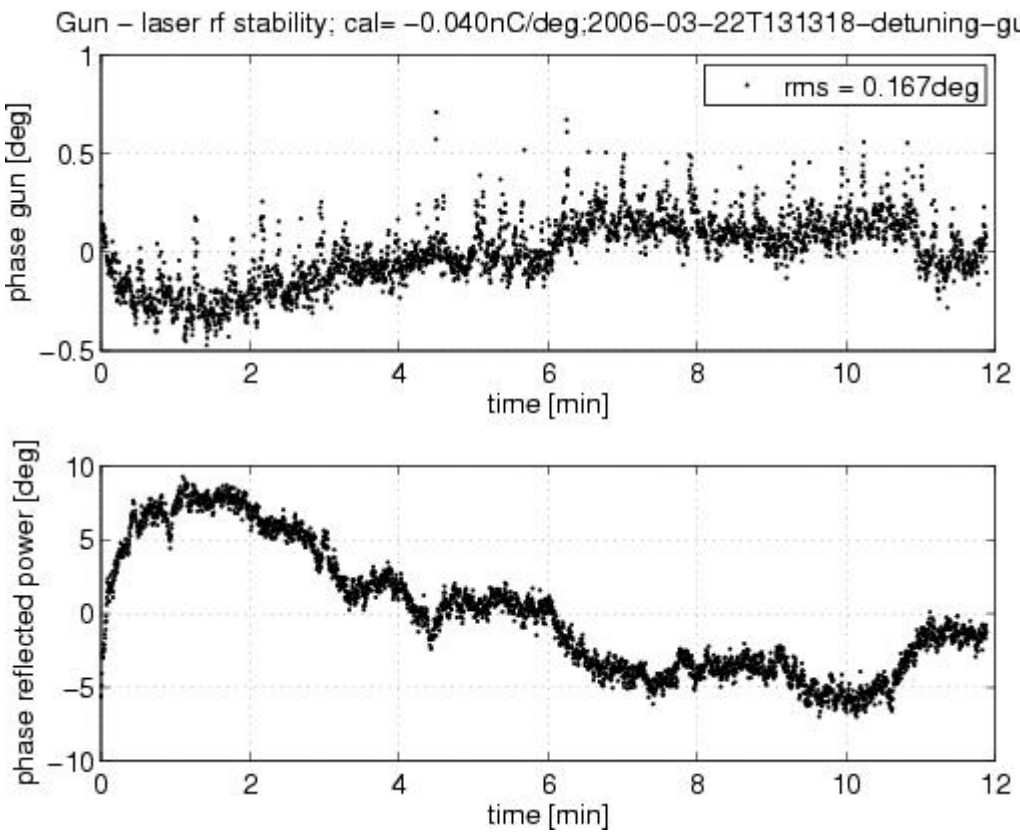
Rf pulse to rf pulse stability

RF drive only / similar to DSP



- resonance frequency changes together with the rf gun temperature
- the emission phase changes

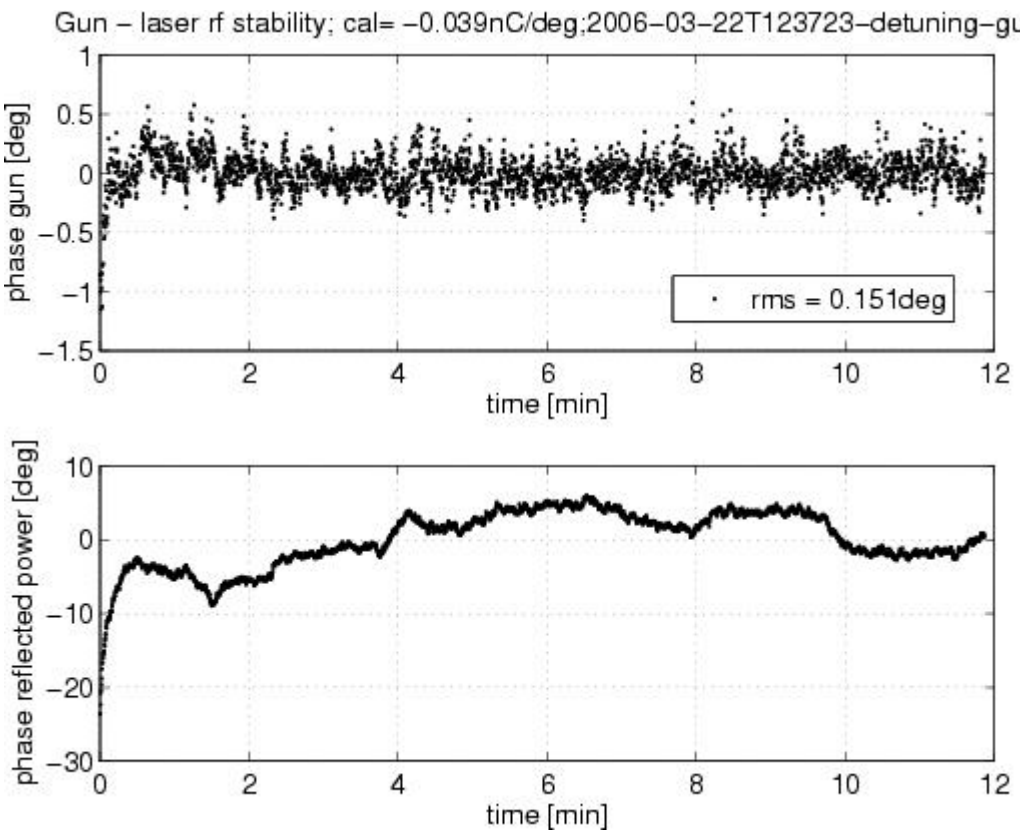
PI control



- error suppression by about 3 (< gain)

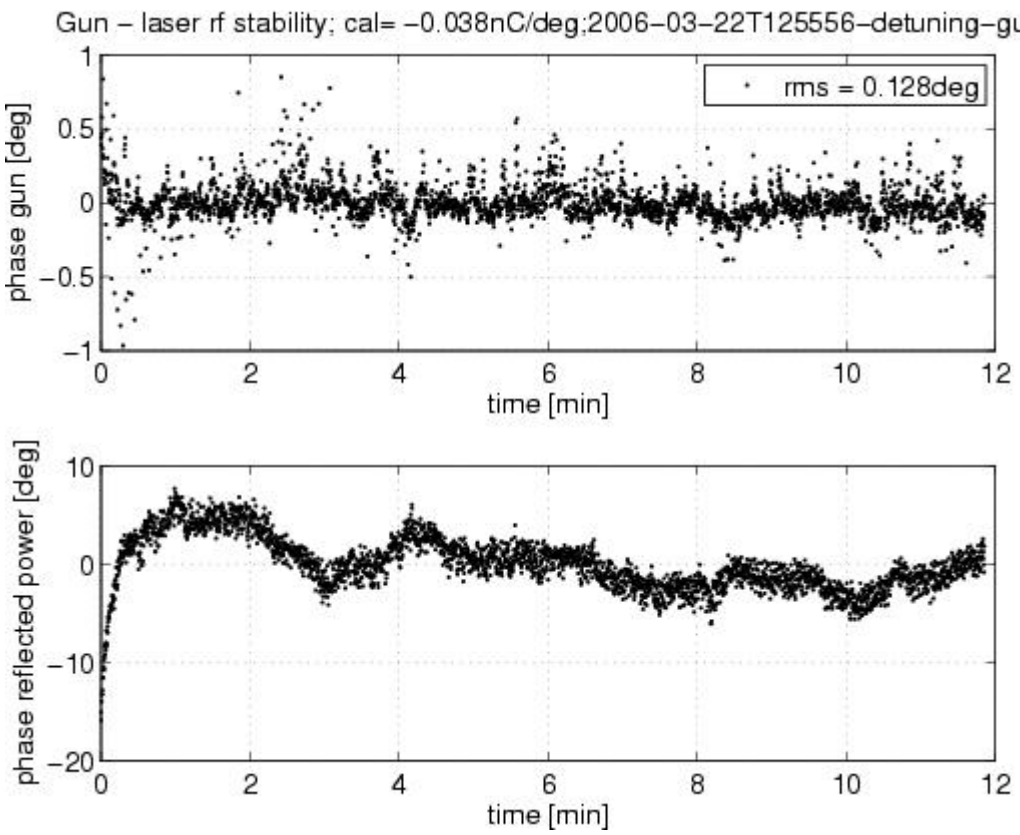
Rf pulse to rf pulse stability (continued)

AFF only



- error suppression by about 5 (= gain)

Alternating AFF and PI control



- gun temperature slope decreased by an other factor of 2

Summary: rf gun control with SimCon 3.1

Rf gun control with DSP:

- insufficient processing power for virtual probe (forward - reflected)
- only forward power was regulated
- field stability > 2°
  < 0.5° required for SASE

Rf gun control with SimCon 3.1:

- sufficient processing power for virtual probe
- sufficient processing power for rf pulse to rf pulse AFF
- field stability obtained: rms ~ 0.15°
  fine for SASE at VUV-FEL

What remains open?

Repetition of qualification measurements:

- without dark current kicker problem
- also for AFF & P-control

Toroid monitor signals for beam loading compensation

Ideas / motivation:

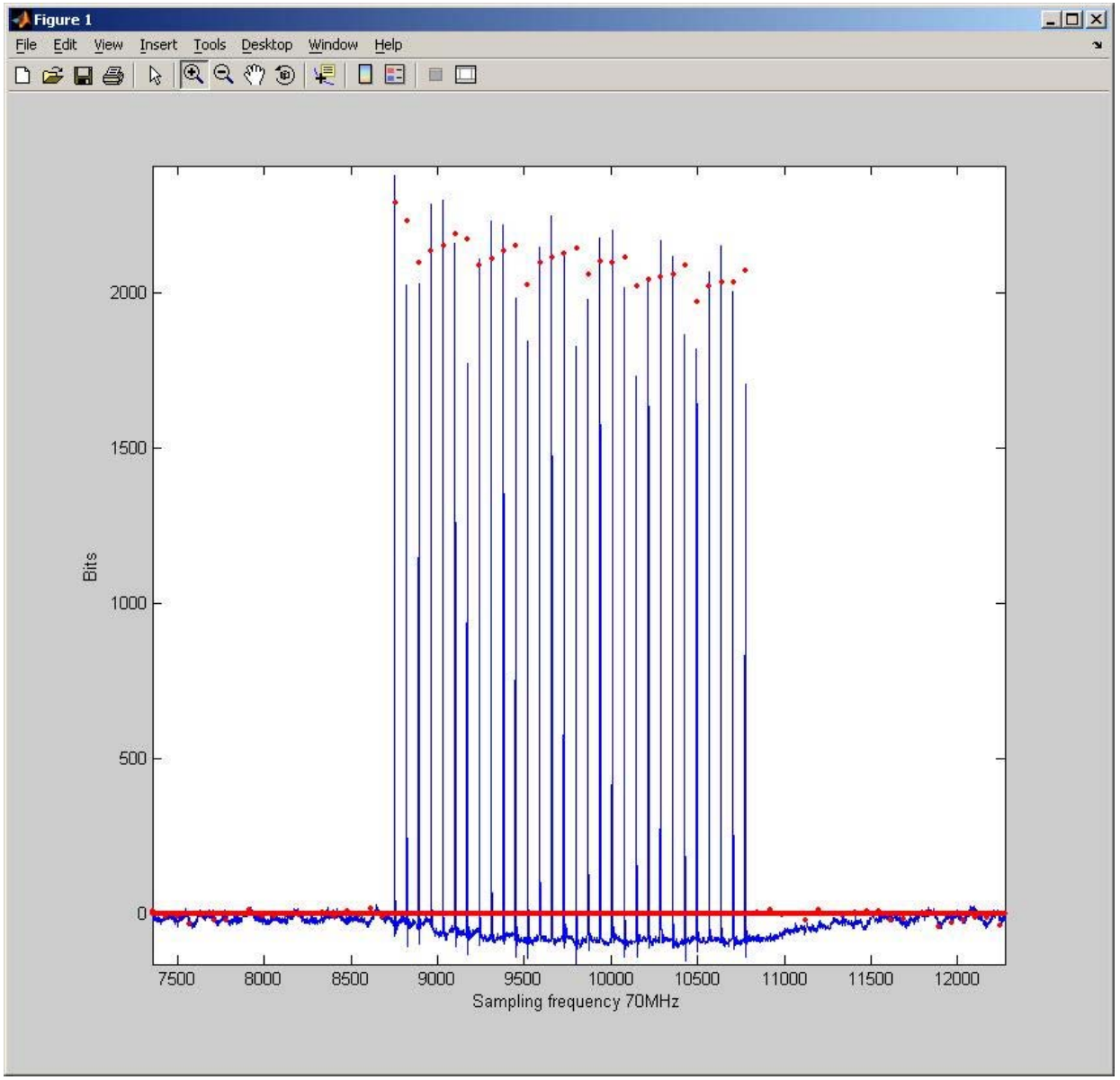
- overcoming band widths limitations within AFF algorithms
- operation less sensitive when beam is switched on and off

Actual status of the algorithm:

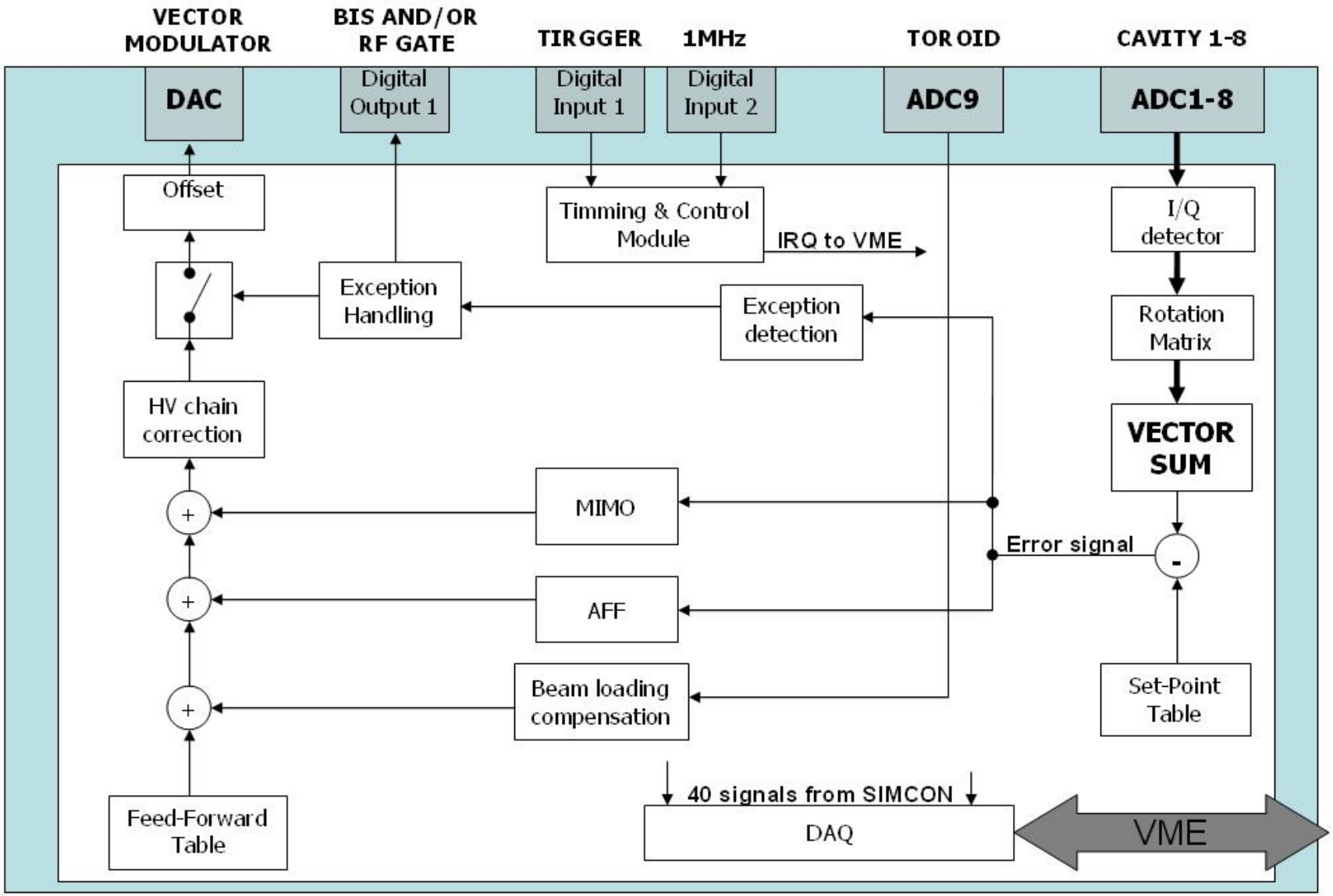
- from bunch to bunch a change proportional value is calculated in real time in SimCon 3.1

What remains to be done?

- first tests of beam loading compensation with the values calculated in real time



Block diagram of VHDL software in ACC1 controller



Features of ACC1 controller

- MIMO controller (includes simple proportional controller)
- AFF – the same like in RF-Gun
- Readout of 40 signals from internal structure of SIMCON from each pulse
- Beam loading compensation
- Vector sum error detection and handling
- Correction table for HV chain
- Alternative pulses scheme (2 schemes)
- DOOCS server

• Question: Improvements expected by exchanging the DSP system with SimCon in ACC1

…directly for operation:

- reducing the latency form 5 us to 1.3 us we can run a four times higher gain
  ⇒ rms of amplitude and phase will go down accordingly
- pulse to pulse AFF will decrease (but not elliminate) the sensitivity on phase drifts in reference signals

…for rf control development:

the FPGA hardware has sufficient processing power for testing new algorithms

- see the treatment of our colleagues from TUHH
- beam loading compensation (without and with beam monitor signals)
- new intermediate frequency – improvements of the sensors / down converters
- and so on

Discussion …