Summary on uTCA measurements and outlook

"no guarantee for completeness"

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for the LLRF team
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DESY

Outline

- System setup
  - Motivation
  - Procedure
- Measurement results from uTCA upgrade
  - Achieved field stability
  - Beam based measurements
- Summary
  - Lessons learned
  - Next steps

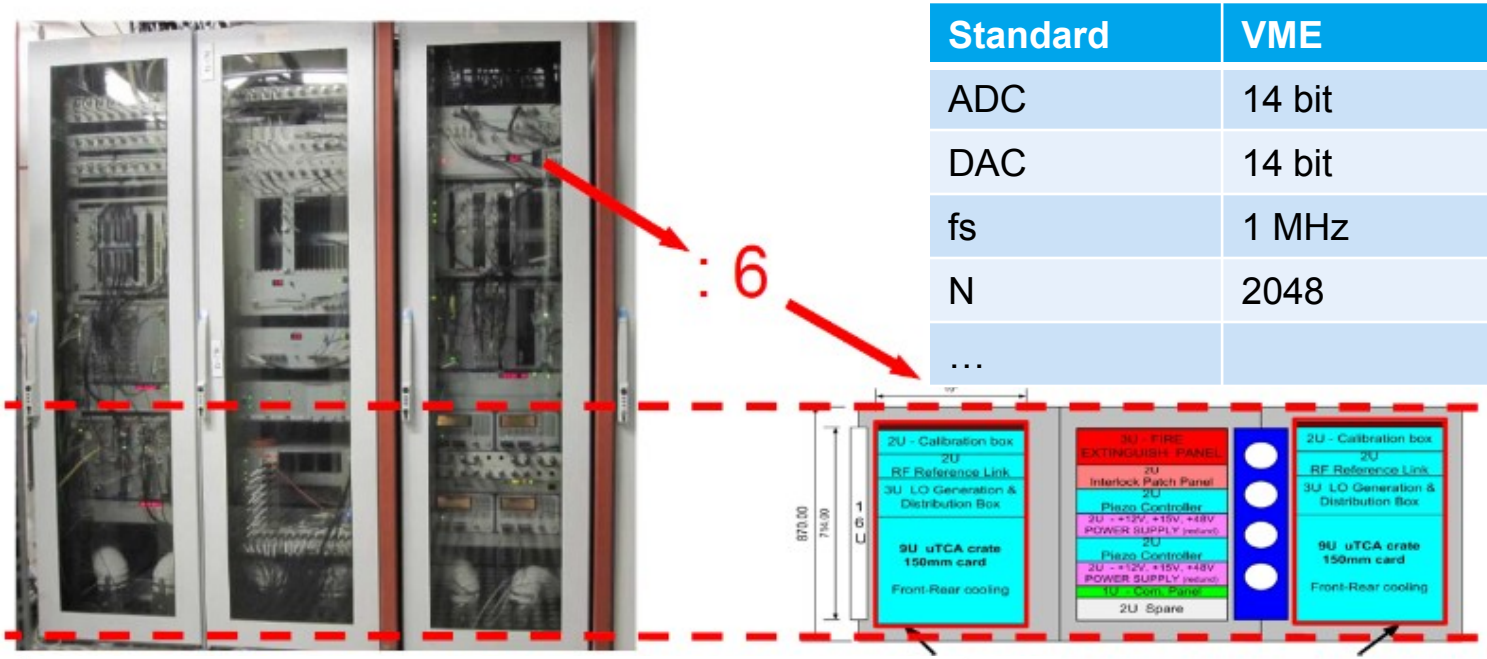
Motivation

- Keeping the controller structure equal to current VME based system
  - Has to be adapted for two different systems SC (FLASH, CMTB) and NC (REGAE)
  - Most of the features could be easily reused
  - Measurements could be compared to previous results
  - Procedures, e.g. LFF does work without any problems
  - Further developments are available for both systems
  - Restructuring seemed to be not necessary
- Procedure
  - Started with parasitic measurements due to parallel setup of uTCA system at ACC1
  - Eventually switched between VME system and uTCA (fast manual switch)
  - End of user run allowed to keep this system in use (Gun breakup)

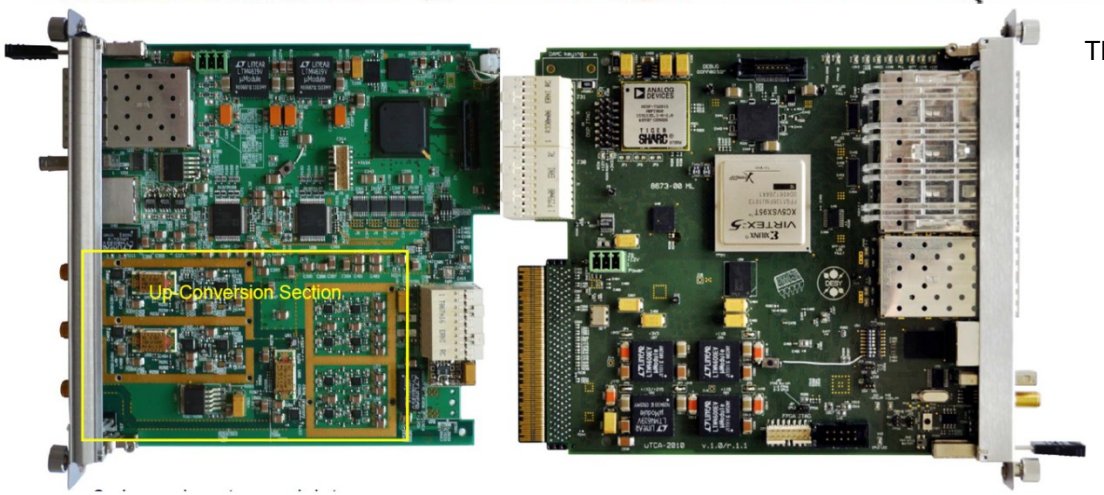
System setup at FLASH

- Parallel setup to VME installation at ACC1
  - Out of loop measurement
  - Relative system calibration
- Fast switchable solution for short term tests
  - Manual VM output switch
  - Keeping regular system always in state
- Used minimum setup only
  - DWC, ADC, uTC, VM
- Forw. and Refl. signals are not connected
  - Readable by different server

Impact for the digital control loop



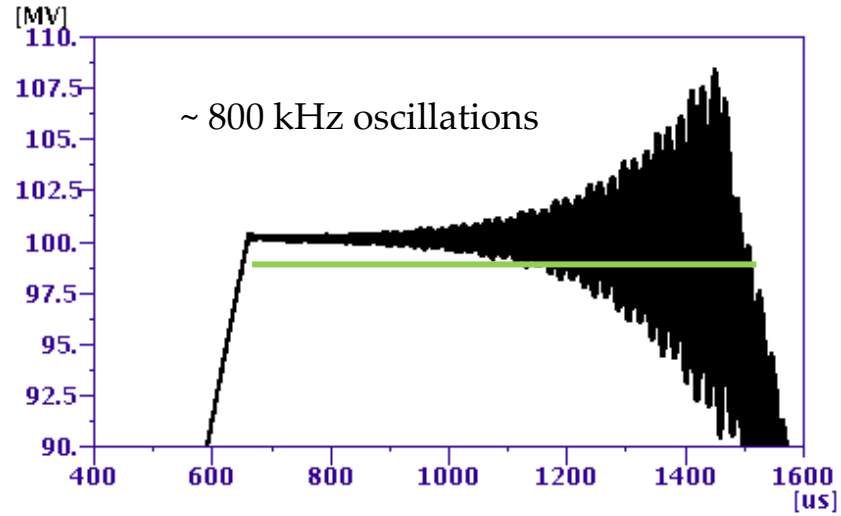
Standard	VME	uTCA
ADC	14 bit	16 bit
DAC	14 bit	16 bit
fs	1 MHz	9 MHz
N	2048	16384
…		

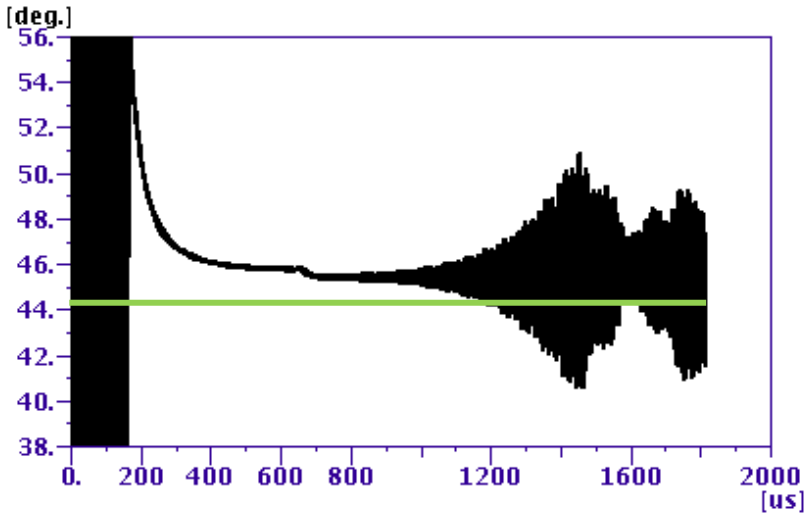


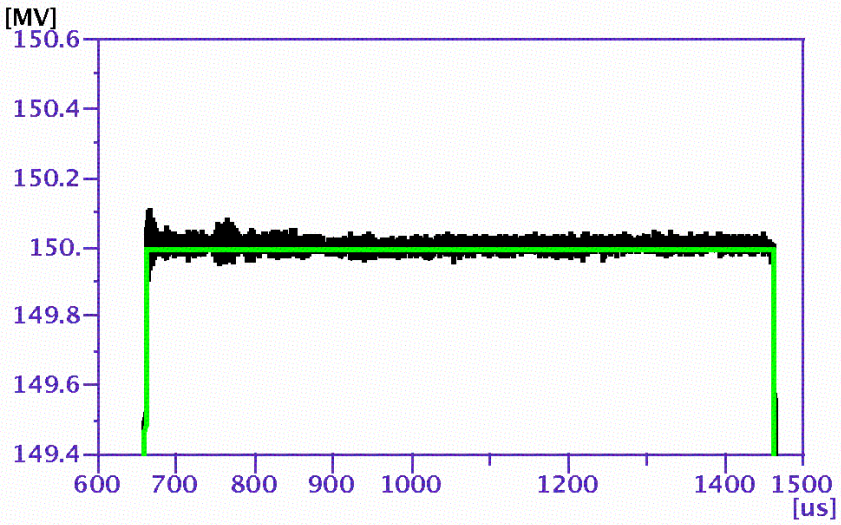
Thanks: F.Ludwig

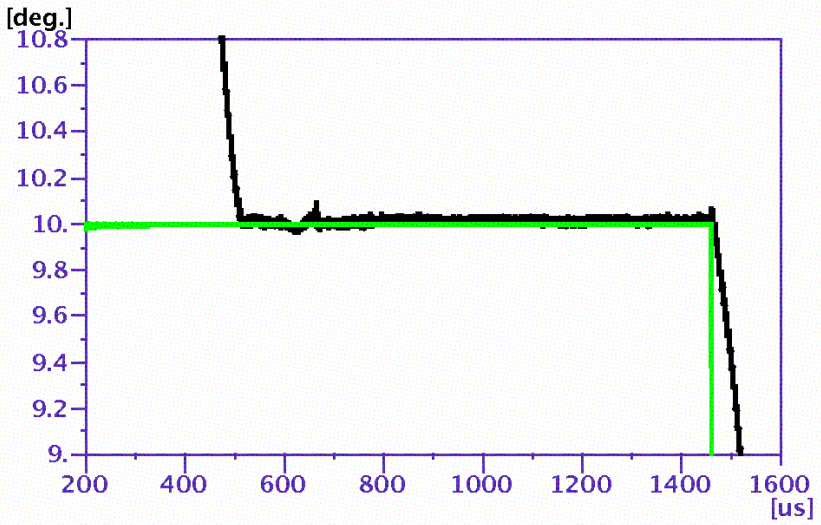
- Tunnel installation (XFEL)
- Drift compensation
- Scalability
- Non-IQ sampling
- …

Comparison 8/9-Pi mode excited and suppressed



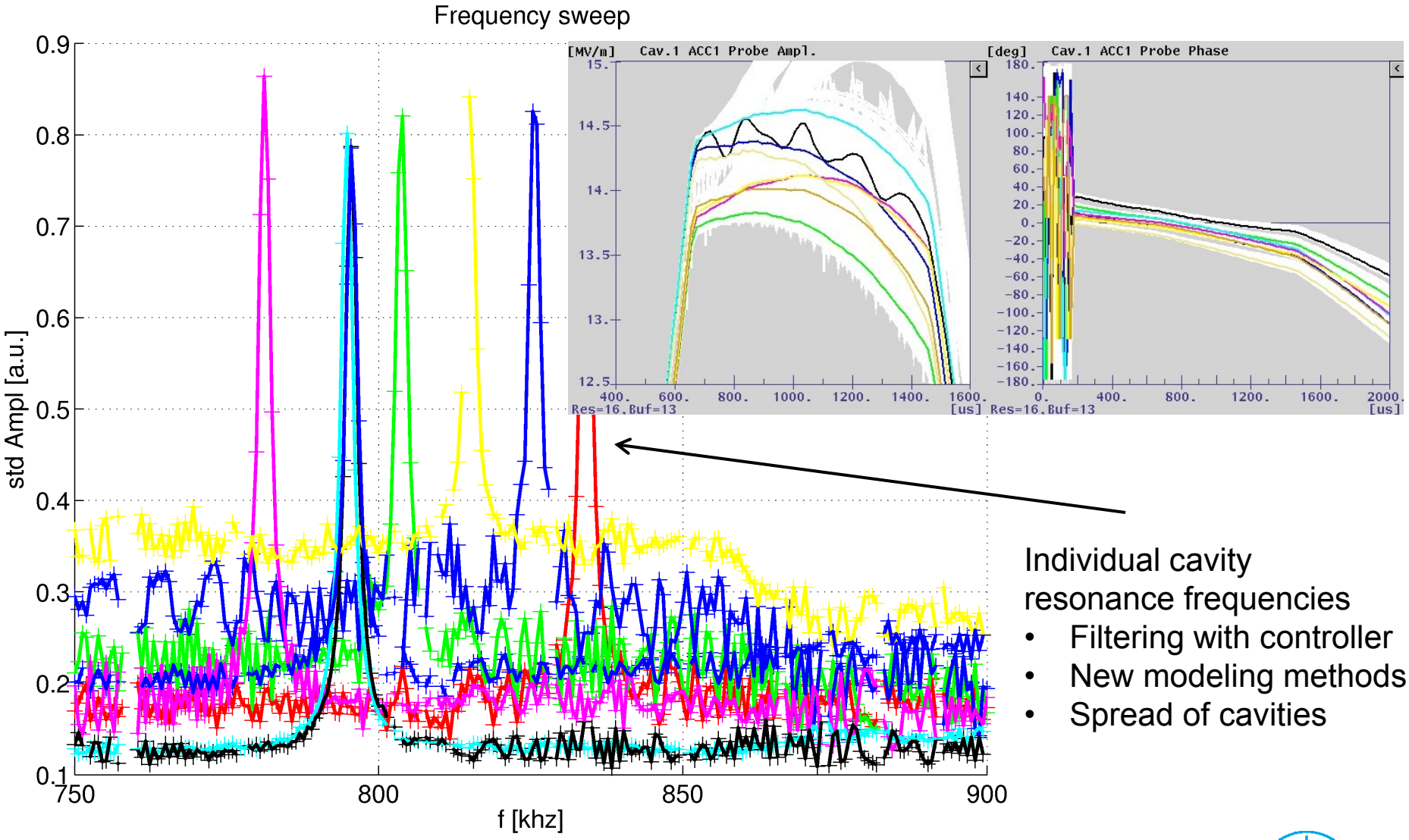






Controller settings are more critical due to higher sampling rate, filtering, averaging

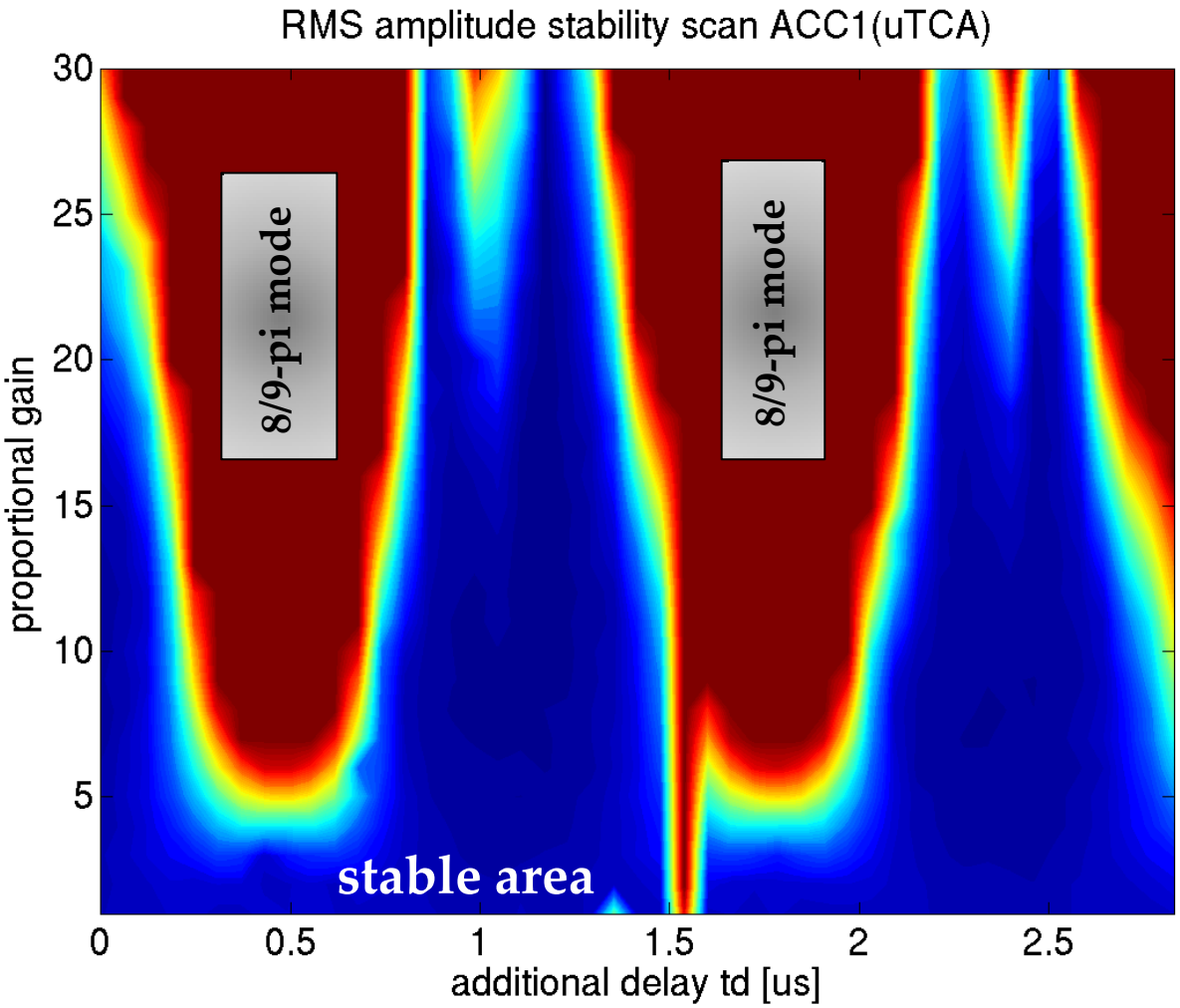
Excitation of the 8/9-Pi mode



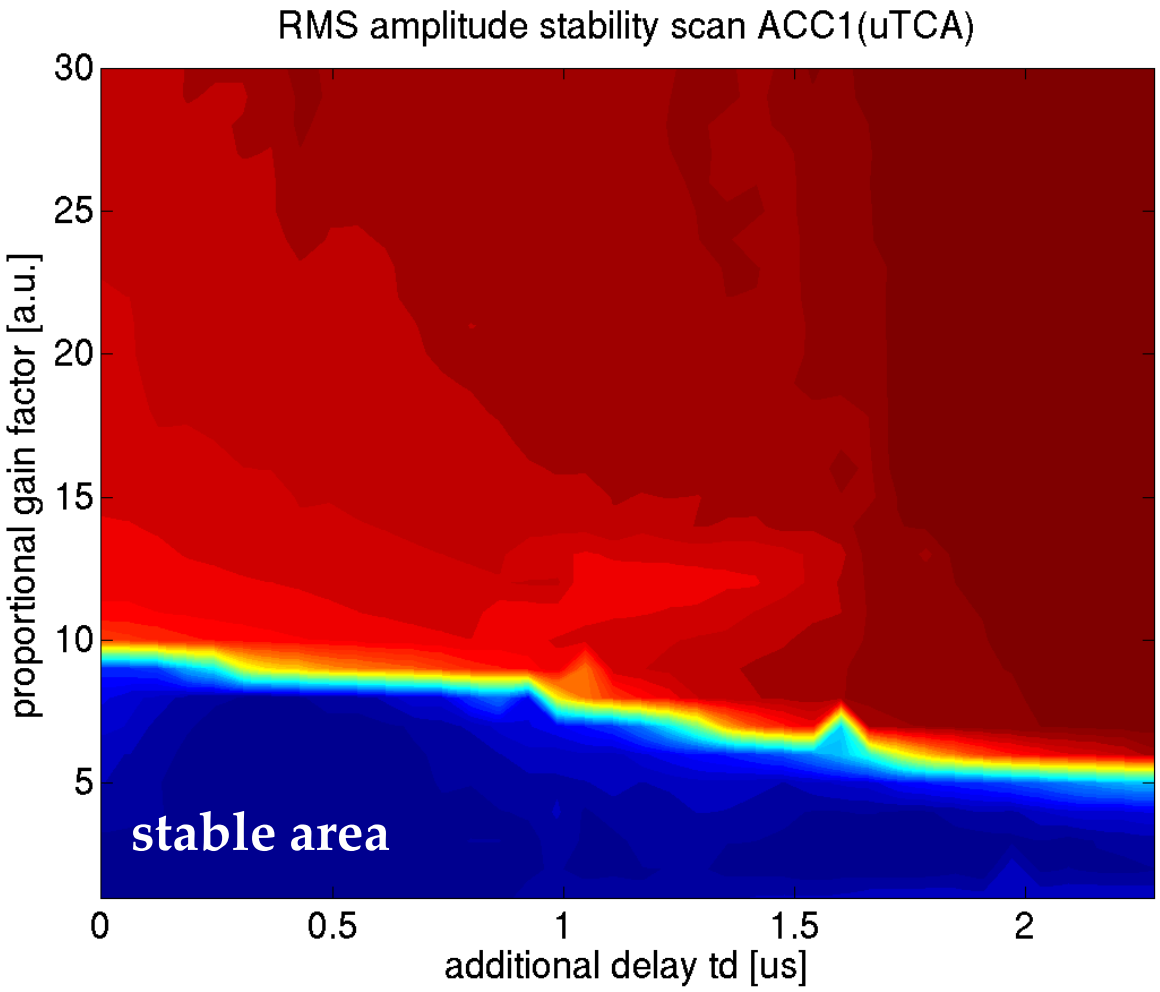
Individual cavity resonance frequencies

- Filtering with controller
- New modeling methods
- Spread of cavities

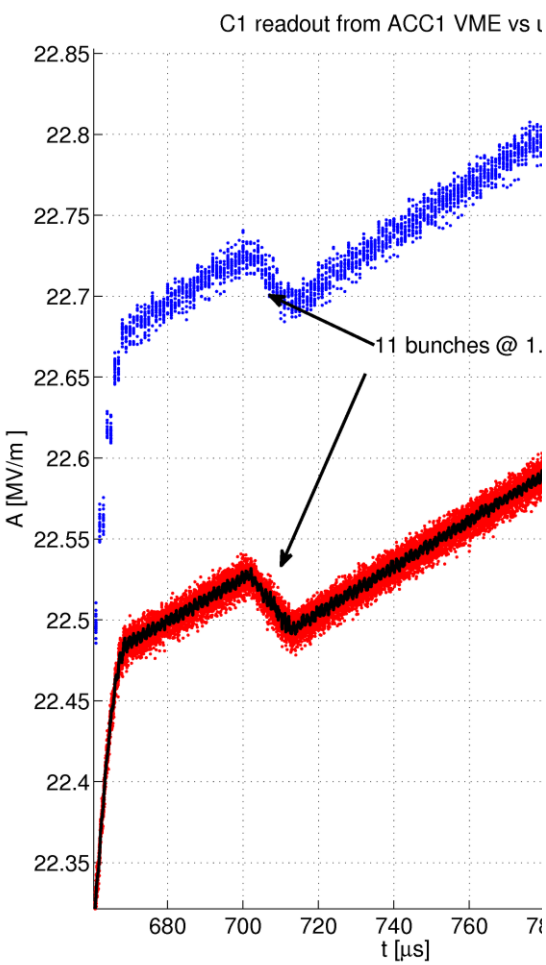
Amplitude stability as function of controller delay

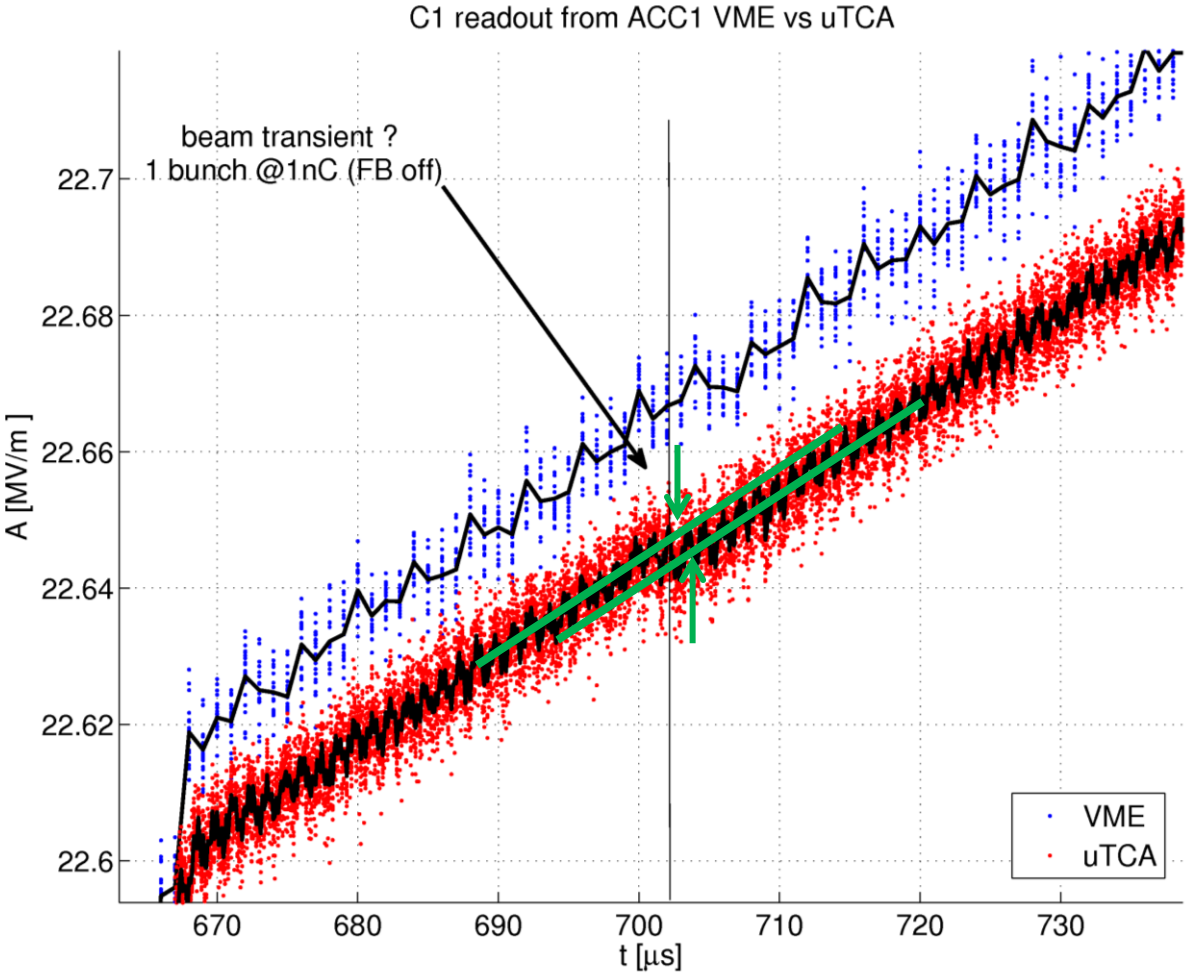


Filtering with MIMO FB controller



Measurements of beam induced transients



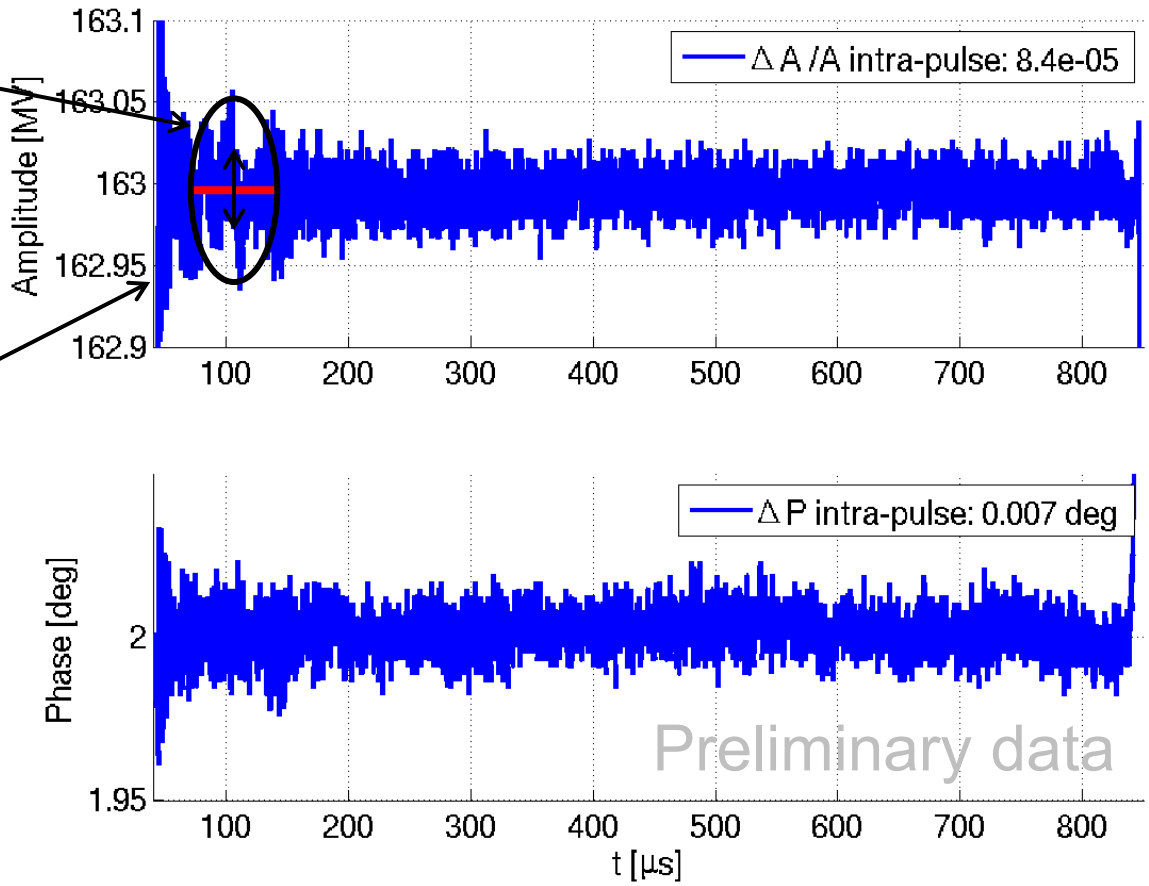


Possible advancement of vector sum calibration in terms of accuracy and machine setup requirements (currently 3nC with 30 bunches)

Measured amplitude and phase stability

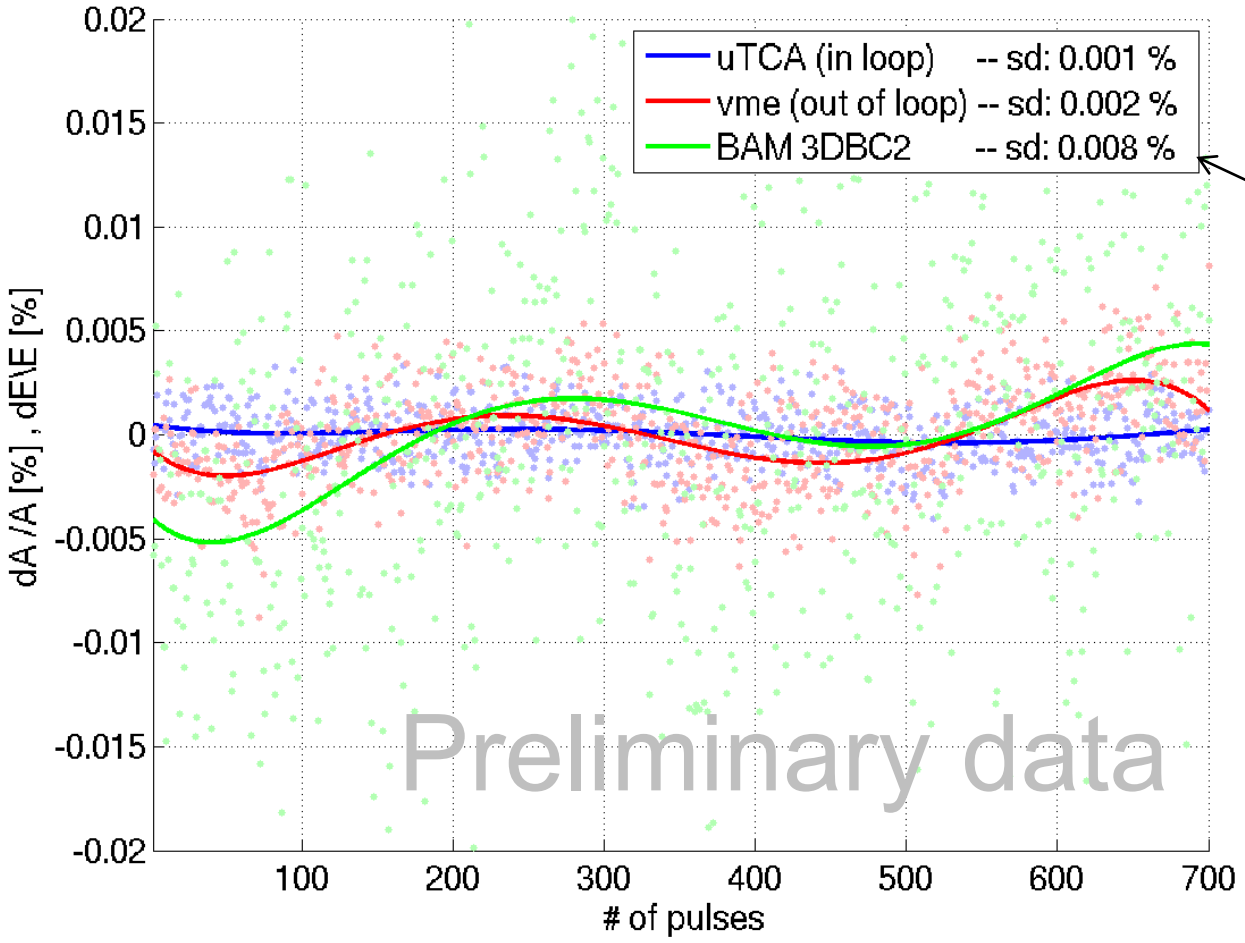
Pulse to pulse variation

Oscillations after filling transition



- uTCA System in control loop, with LFF and MIMO-Feedback
- Higher bandwidth compared to VME, In-loop measurements fulfill XFEL specifications

Amplitude pulse to pulse variation

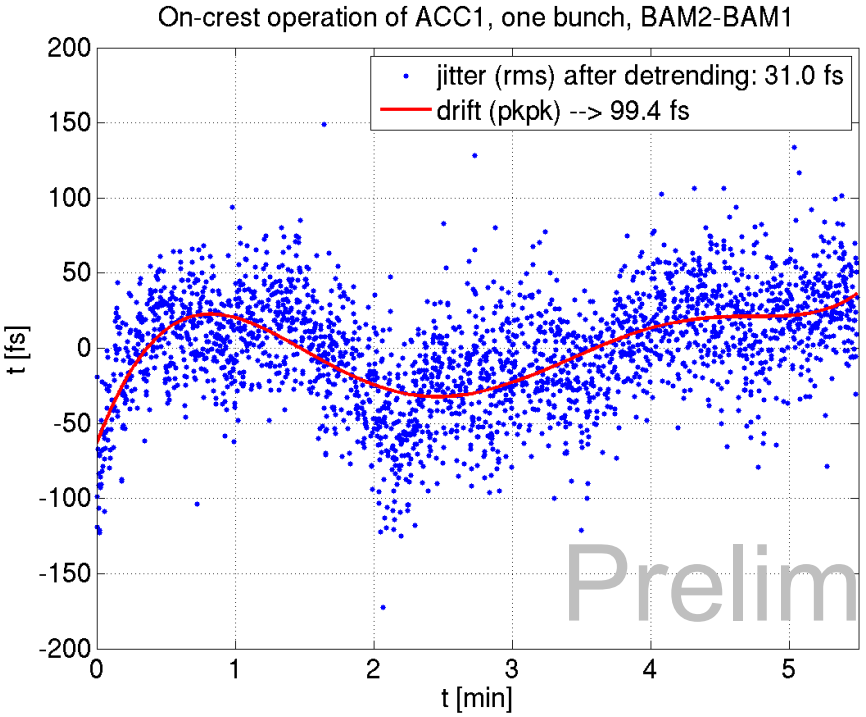


Approx. 30 % improvement

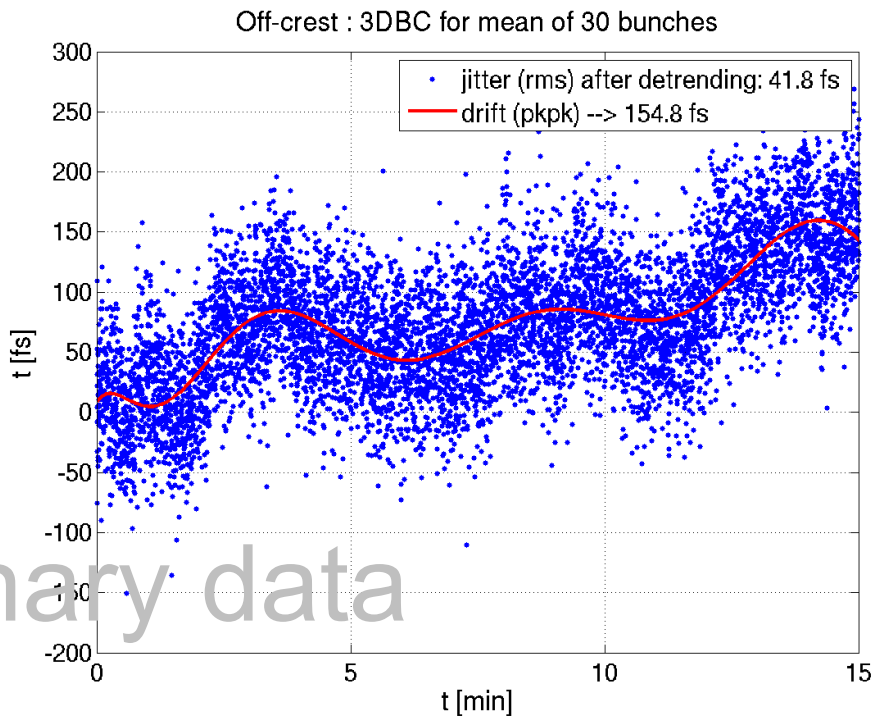
- Difference between out of loop measurement and beam based data probably due to link to optical synchronization system

Arrival time variation

- On-crest setup
- 1 bunch (high frequent oscillations)
- Differential measurement
  BAM 3DBC2 – 1UBC2



- Off-crest (SASE conditions)
- 30 bunches averaged (f < 30 kHz)
- Absolute meas. BAM 3DBC2



Correlated errors from optical synchronization system are subtracted

Imperfections between optical synchr. and RF are not excluded

Lessons learned from this measurements

- Issues
  - Communication server to firmware
  - DAQ like table readouts
  - MIMO controller only worked for 4.5 MHz sampling rate
  - Transmission bandwidth between ADC board and uTC
  - …
- Couple of minor bugs and not tested functions
  - Server programming structure (VME optimized)
  - jddd user interface to be optimized
  - Need of uniform firmware structure (facility switchable)
- Acceptance from regular machine operation
- Overall surprisingly good progress, compared to the limited measurement time

Next steps for uTCA development

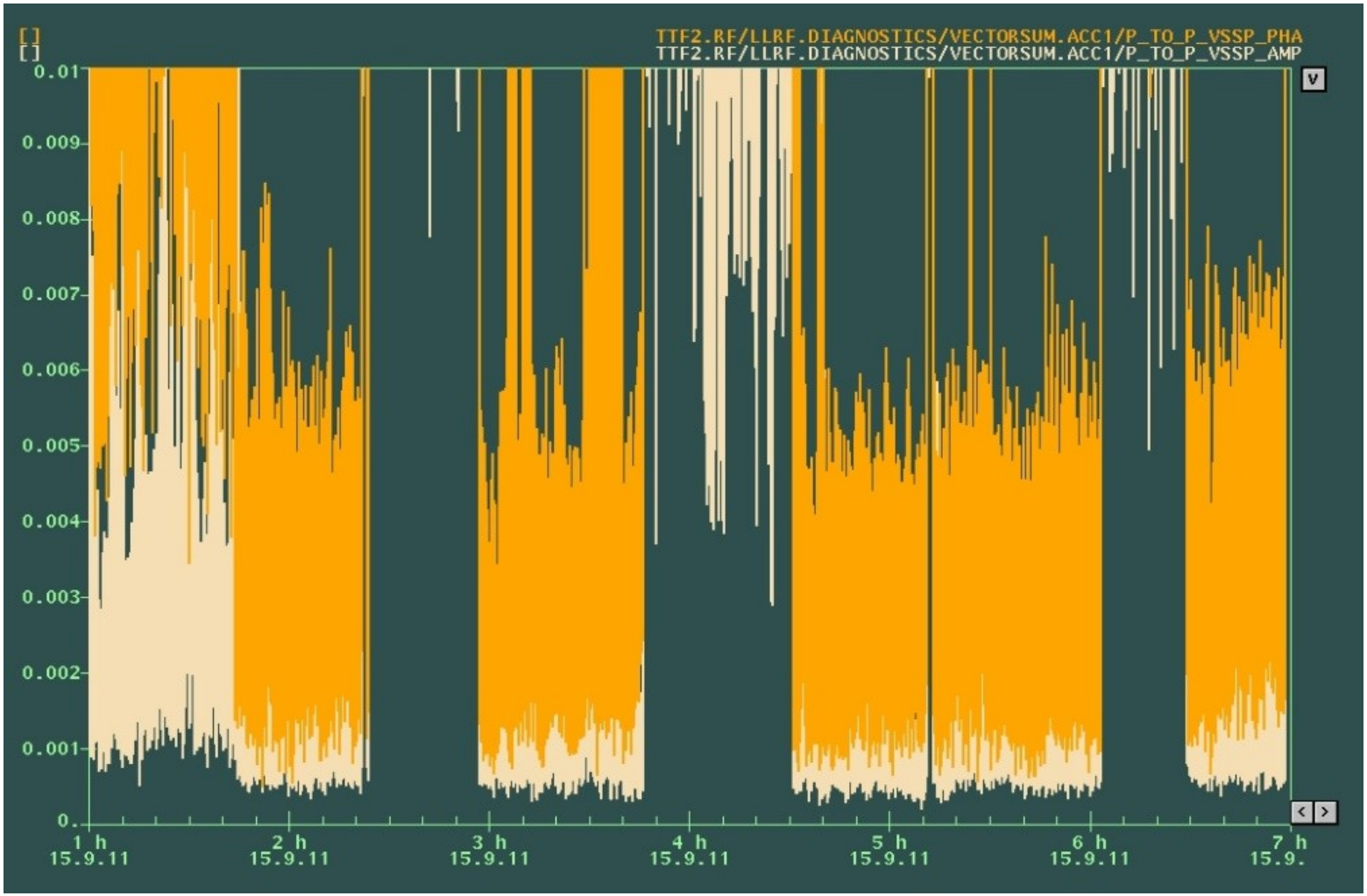
- Full system setup test
  - 3 ADC cards and one uTC based controller
  - Communication bandwidth, data transfer and handling, server communication
  - Online calibration of forward and reflected signals
- FLASH reassembling and functionality test
  - Beam based VS calibration
  - MIMO controller reimplementation and performance benchmark
  - Beam based feedback integration and upgrade
  - Panel renovation, …
- REGAE uTCA setup
  - Integration of learning FF and modeling system (GUN and Buncher cavity)
  - Possible feedback implementation
- Additional systems to be equipped with uTCA
  - EBPM, ACC39, tunnel installations, …

Summary

- Upgrade to uTCA Standard
  - Hardware development in first iteration stage
  - First measurement results at FLASH successful
  - Planned full upgrade to FLASH as test bed for XFEL
- Upcoming measurements and tests
  - Full system test to be done on CMTB
  - Beam based feedback integration
  - Calibration techniques
  - Additional system installations

Thanks for your attention

Measurement VME system with uTCA regulation



> dA / A ~ 0.001 % , dP ~ 0.002 deg