Firmware structure and adaptation for CW operation

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on behalf of the LLRF Team

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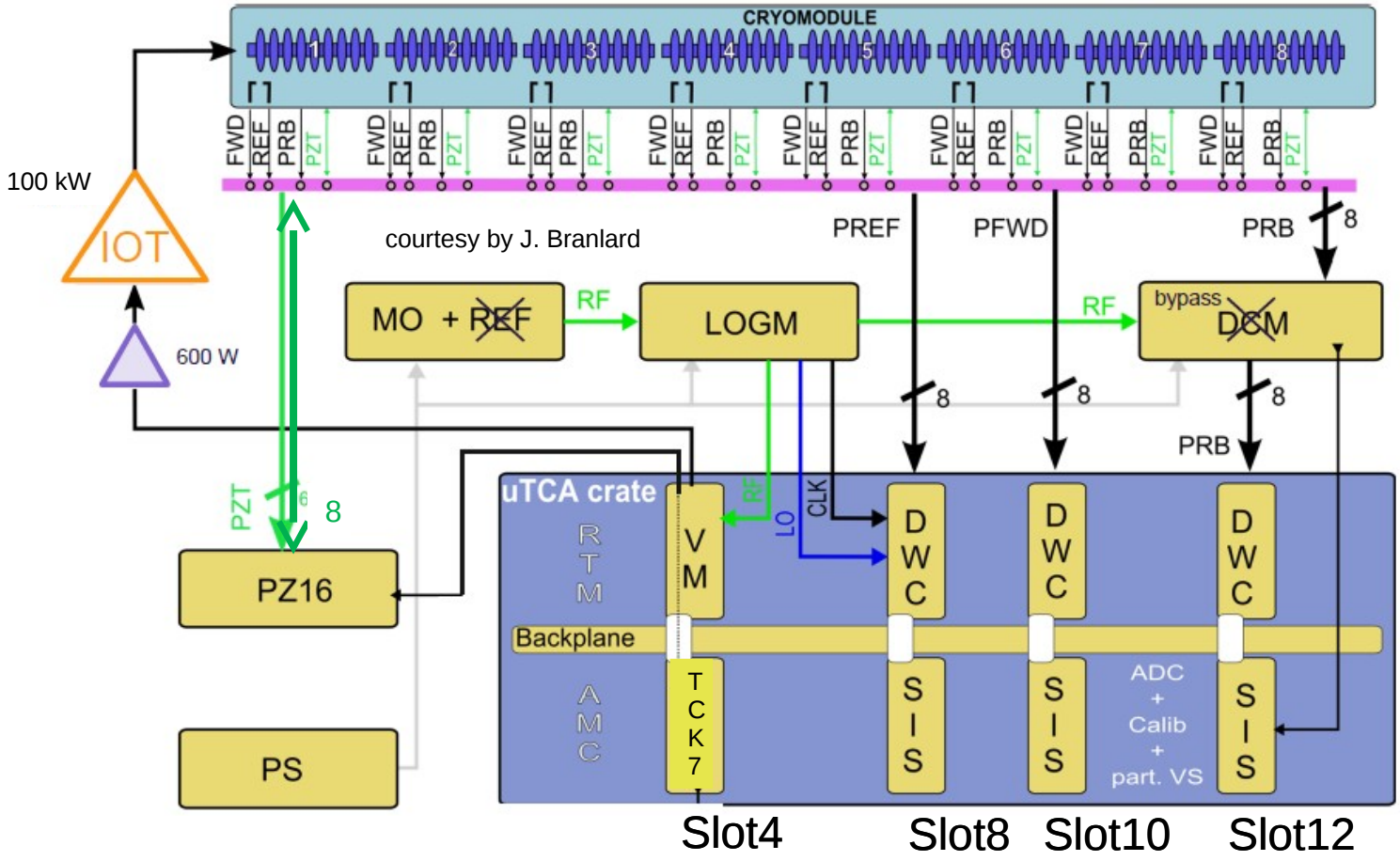
HELMHOLTZ ASSOCIATION

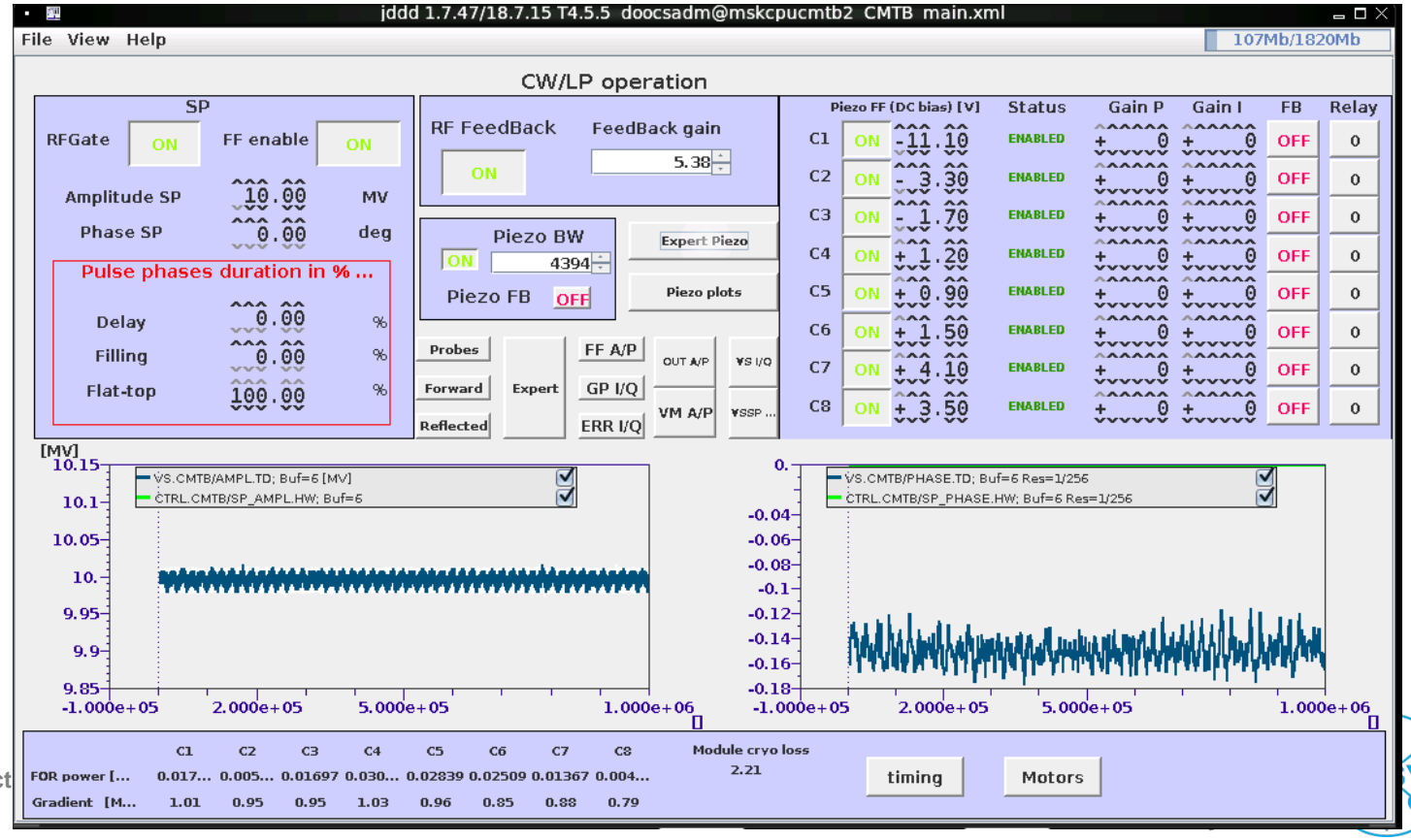
iSe DMCS DESY

CW@CMTB System overview



LLRF Requirements

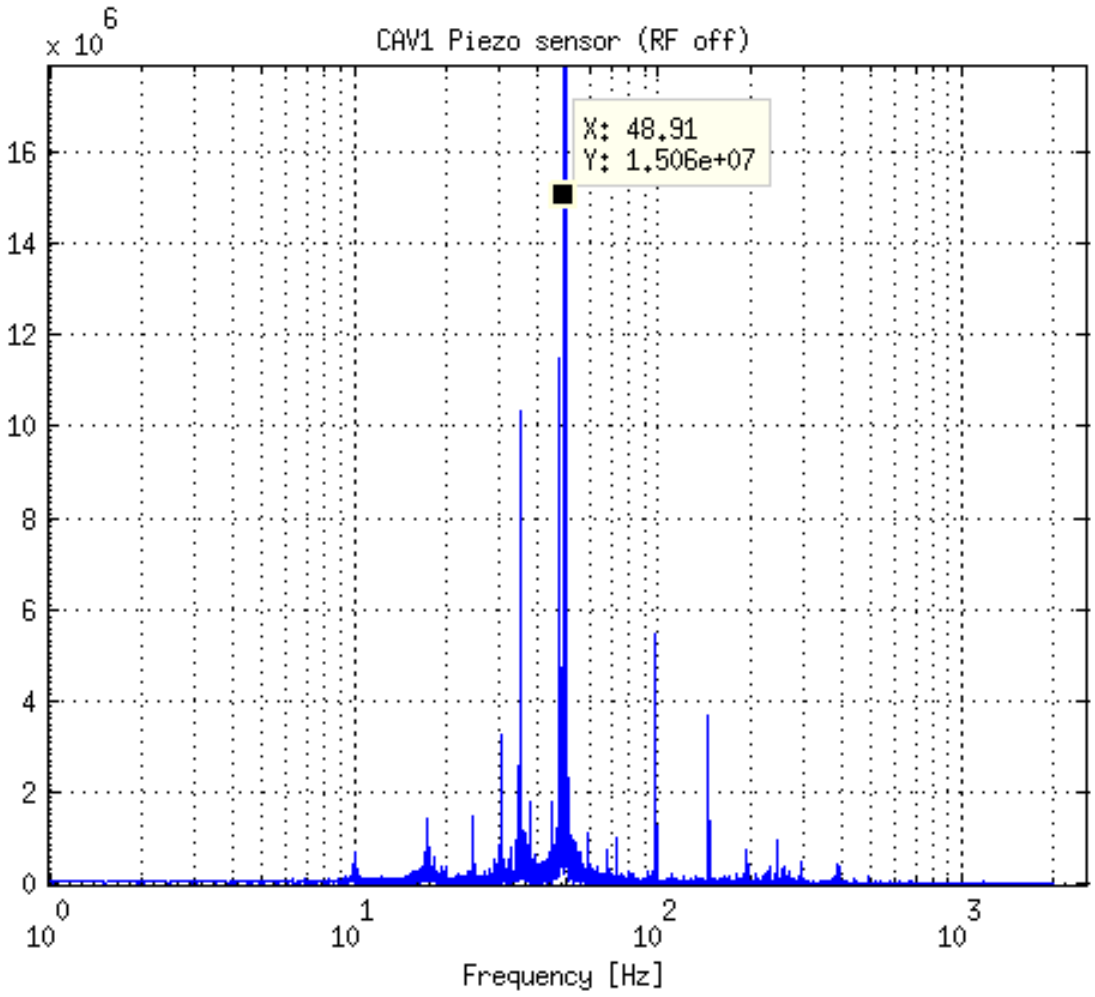
- Stabilize amplitude/phase of VS (RF Controller)
- Compensate for the microphonics noise, keep cavity at the resonance (Piezo Controller)
- Simultaneous stabilization of the RF and detuning compensation
- CW!



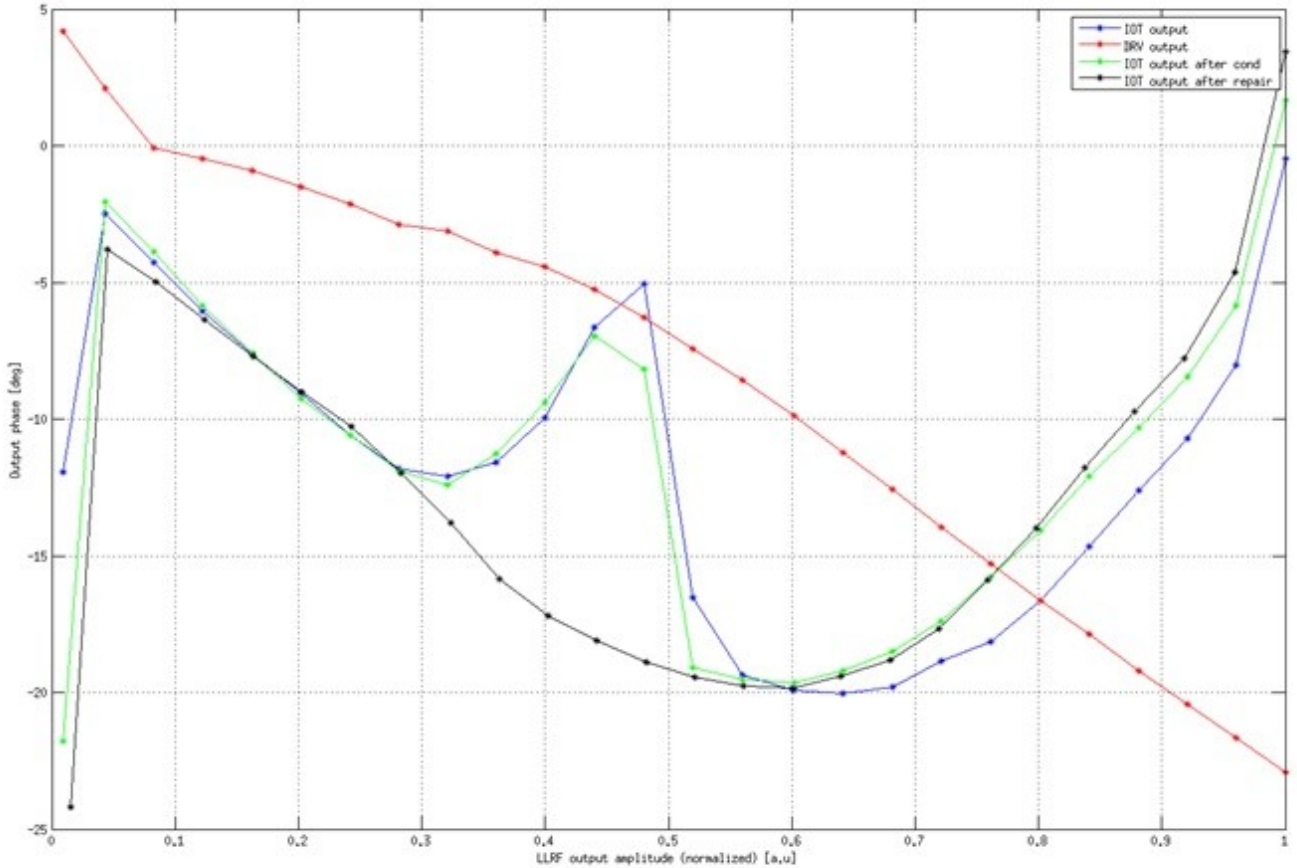
Comparison CW vs. Pulsed Mode

- High Loaded Q is used in CW mode
  - narrow bandwidth of the cavities (QL=3e6:433Hz, QL=1e7:130Hz)
  - higher influence of the microphonics on the field stability in open-loop
- Lorentz Force Detuning
  - LFD can be treated as time invariant and easily compensated
- Learning Feed Forward
  - currently used LFF is no applicable CW mode
  - is it needed?
- RF Controller design
  - PI controller can be effectively used
  - FF tables can be used In addition
- CW there is no time space for off line calculation
  - controller algorithms have to be implemented in the FPGA

Microphonics (RF off)

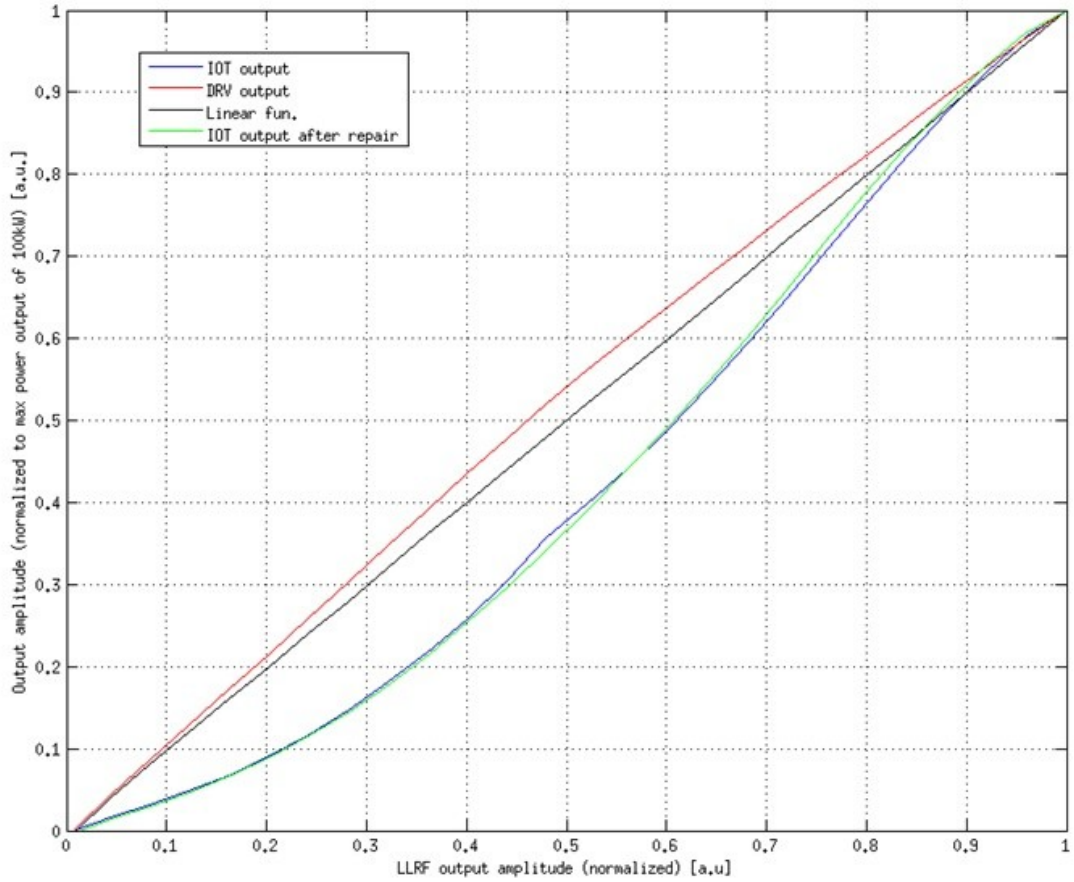


IOT Phase vs LLRF output



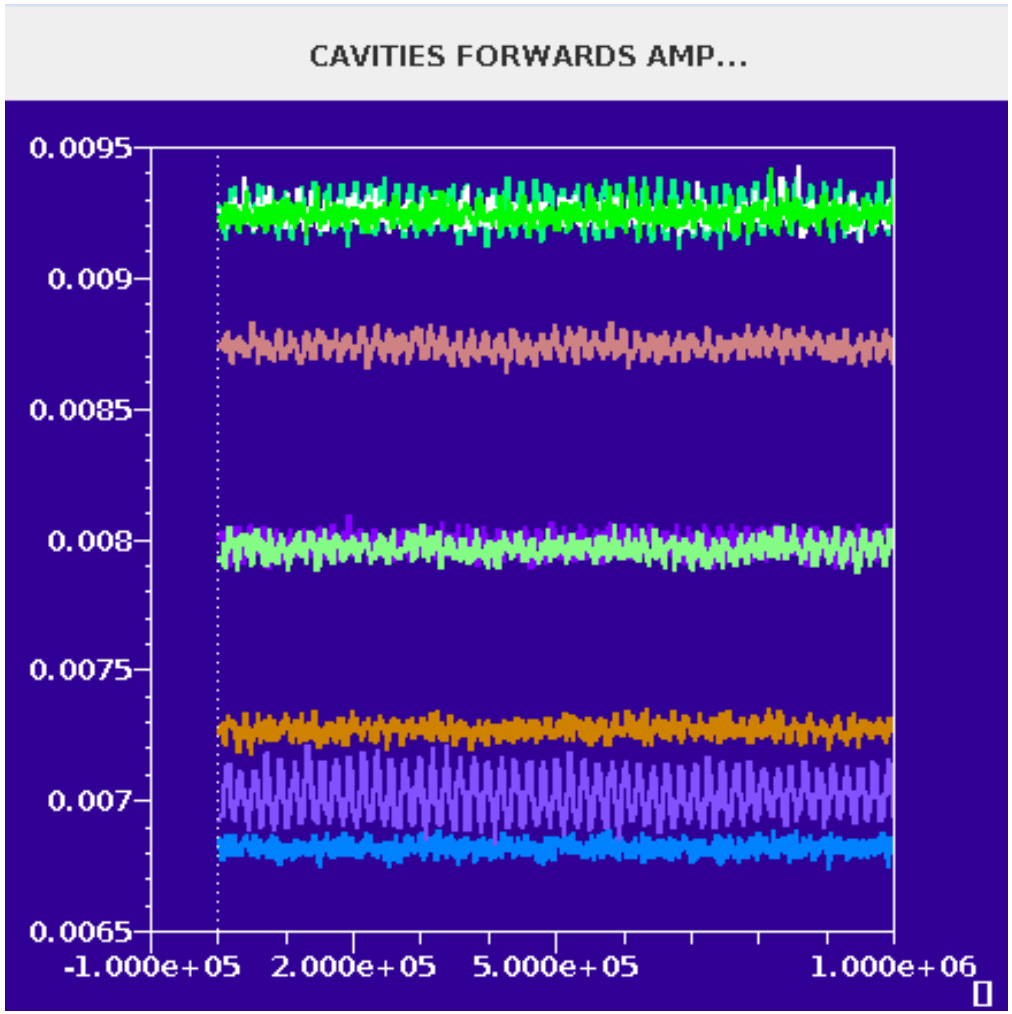
courtesy by W. Cichalewski

IOT Amplitude LLRF output



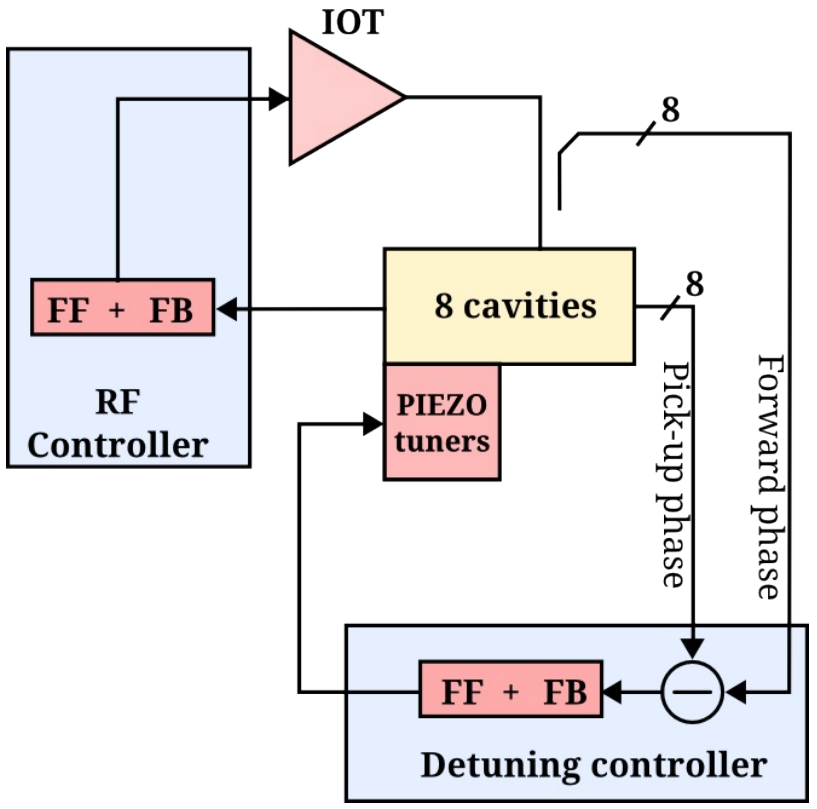
courtesy by W. Cichalewski

IOT noise (FB off)



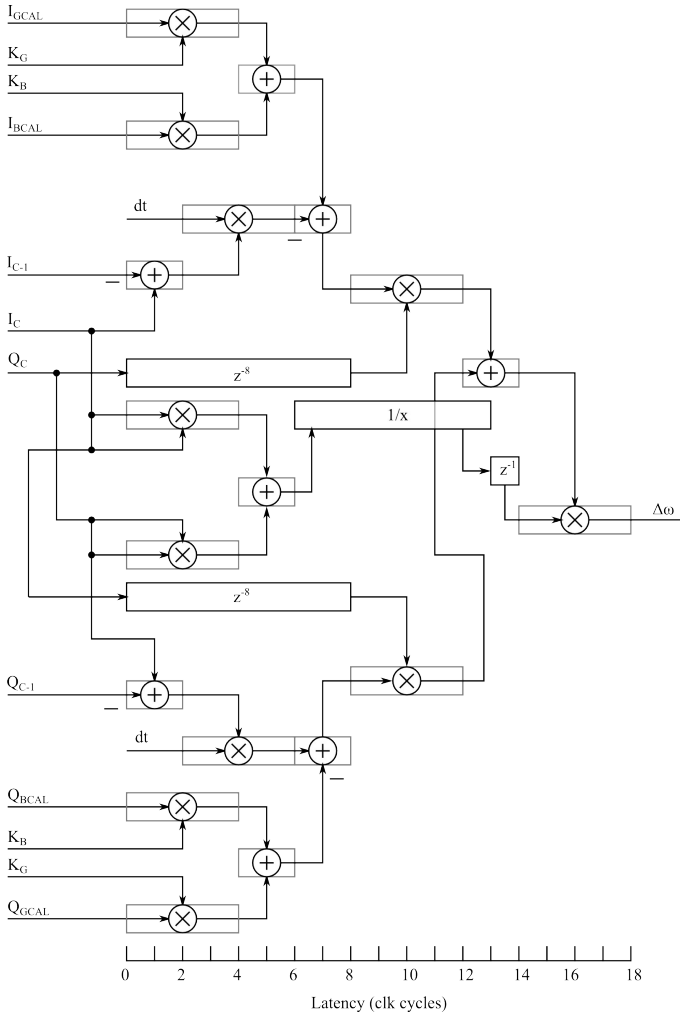
Current experiences

- PI controller for the RF field
  - works correctly
  - nonlinear behavior of the IOT + noise observed
- Piezo controller
  - simplified detuning estimate
  - PI controller
  - feedback is not very effective (2xsuppression)
- Piezo and RF controllers fighting with each other
  - IOT, noise, nonlinearities
  - detuning computation



Detuning computation comparison

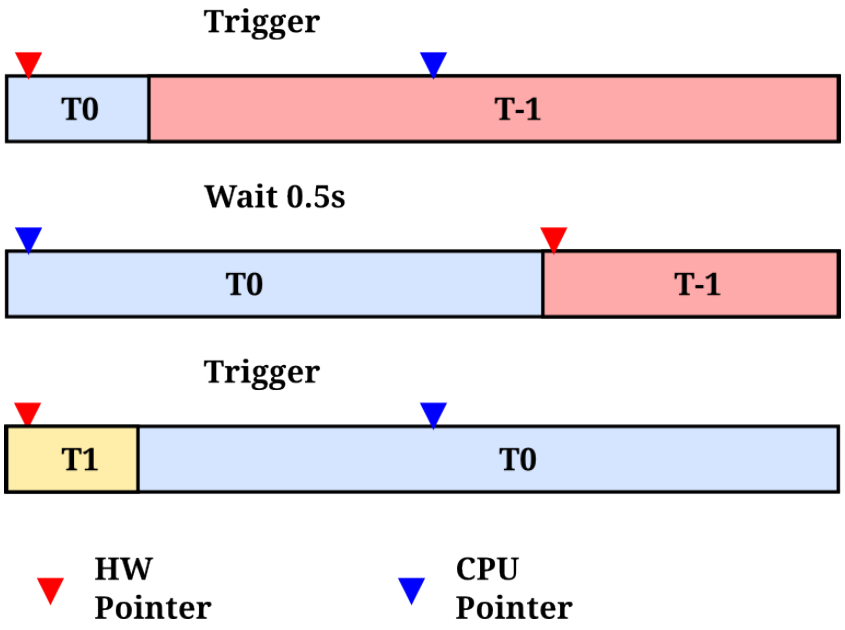
- Phase difference method
  - sensitive to the forward phase changes
  - simple
  - only forward/probe phases needed
- Model based estimation
  - not sensitive to the IOT nonlinearities
  - more complicated algorithm
  - input signals calibration needed
  - forward/reflected/probe signals needed
  - verified at FLASH for one cavity at time



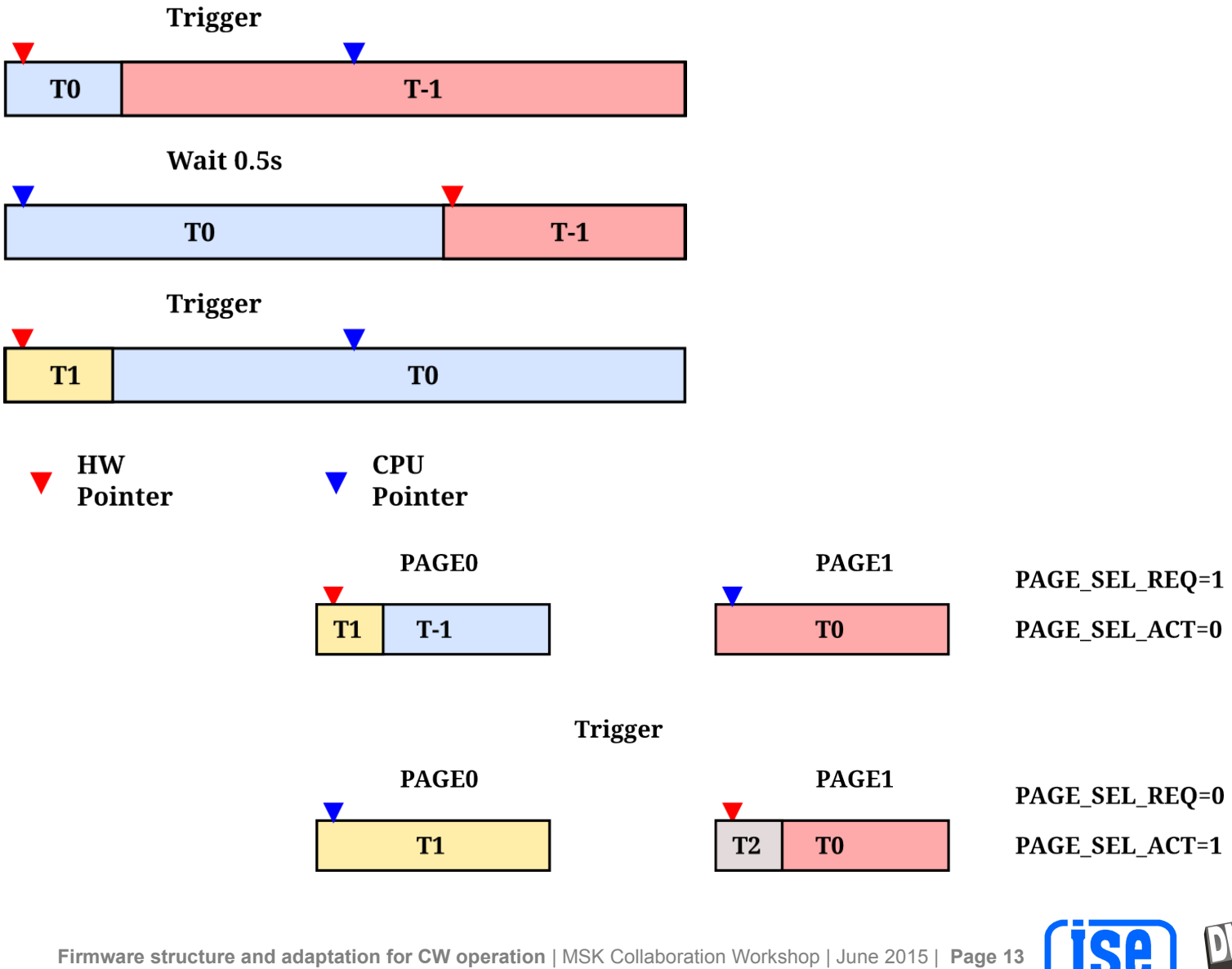
Firmware modifications for the June 2015 CW tests

- I, Q, Phase are sent from the SIS boards to the TCK7 via LLL
  - 1MHz
  - Prefiltered
- DAQ memory is extended to the 32 channels and 256k points
  - First 8 channels same as in pulsed FW
  - 16 is used for the detuning computation with the simple method and from the model
  - last 8 channels for the on-line halfbandwidth monitoring
  - additional memory page is provided so that no data is lost
- Memory for the Piezo identification
  - 32kx16bits
  - double buffered, switching synchronized with main trigger so v. long identification sequences are possible
  - switchable output (one or many outputs)

DMA readout for CW

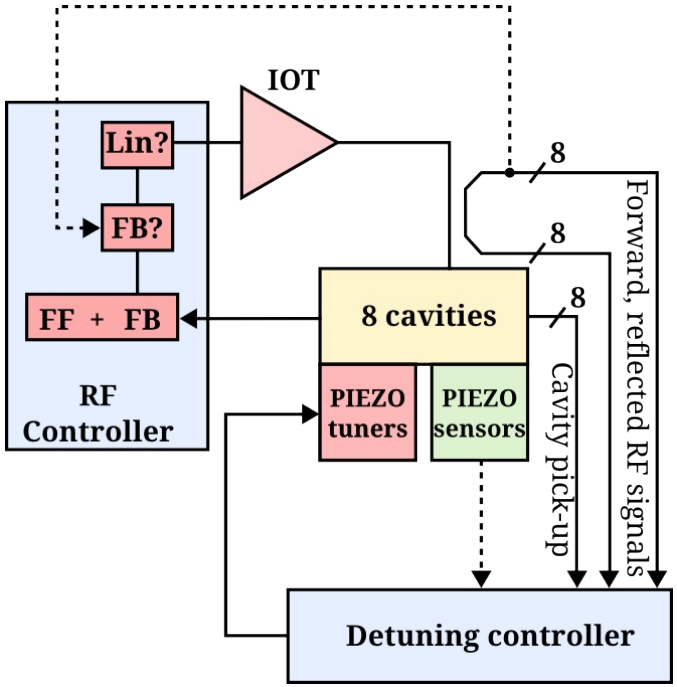


DMA readout for CW



Proposed features of the firmware

- RF Controller
  - linearizion of the IOT
  - feedback on the forward signals (nonlinearities, 50Hz noise)
- Detuning controller
  - should be based on cavity model detuning computation
  - more advanced controller should be used for detuning
    - modeling needed
  - Piezo sensor information should be considered



Thanks for attention!

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