

FIRST LARGE-SCALE REAL-TIME DRIFT COMPENSATION FOR LOW-LEVEL-RF-STATIONS AT THE EUROPEAN XFEL

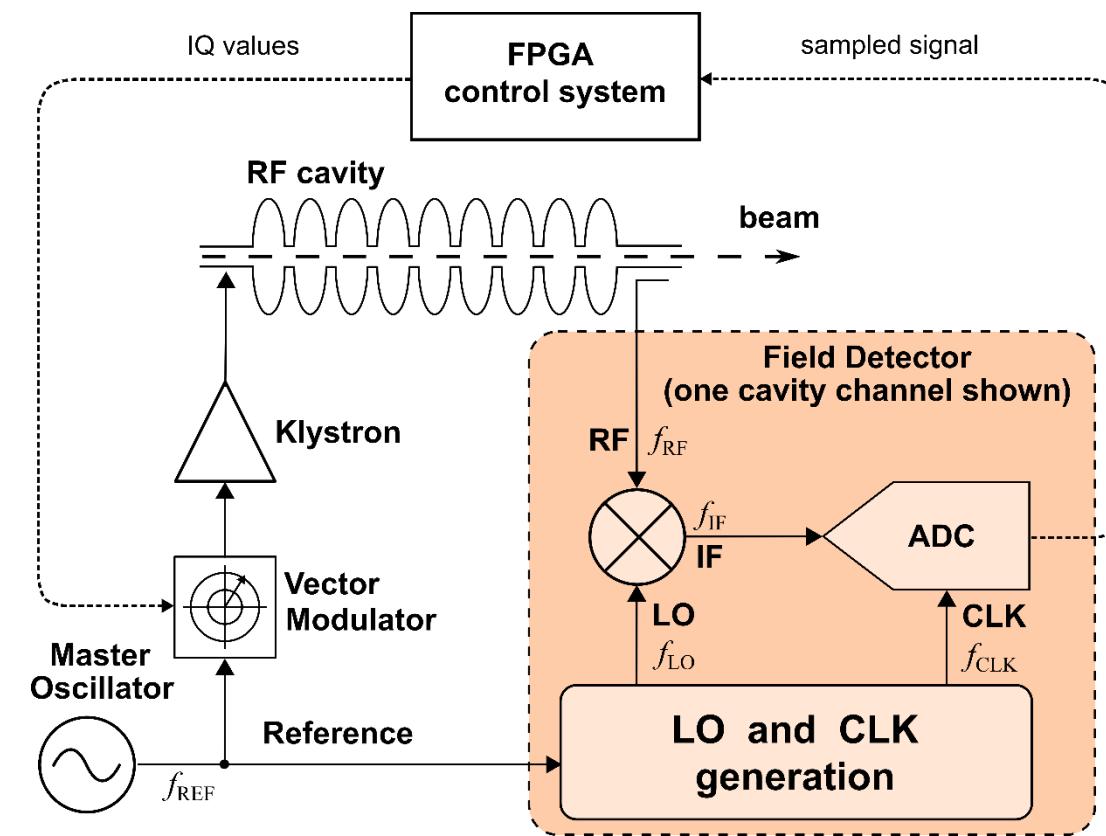


J. Piekarski, Ł. Butkowski, K. Czuba* – ISE, Warsaw University of Technology, Poland
 M. Hoffmann, F. Ludwig, G. Moeller, H. Schlarb, C. Schmidt, M. Uros and B. Yang – DESY, Hamburg, Germany
 * presenting author



Introduction

One of the key components of Low-Level RF systems (LLRF) in Free Electron Lasers (FELs) is the RF field detector that converts the detected cavity field signal to an intermediate frequency (IF) for digital sampling. For a reliable and robust operation of free-electron lasers with bunch-arrival time variations on the sub-10fs scale, the short-term and long-term RF stability of the cavity field is a crucial factor. Temperature and humidity changes cause amplitude and phase drifts of the RF field detectors.



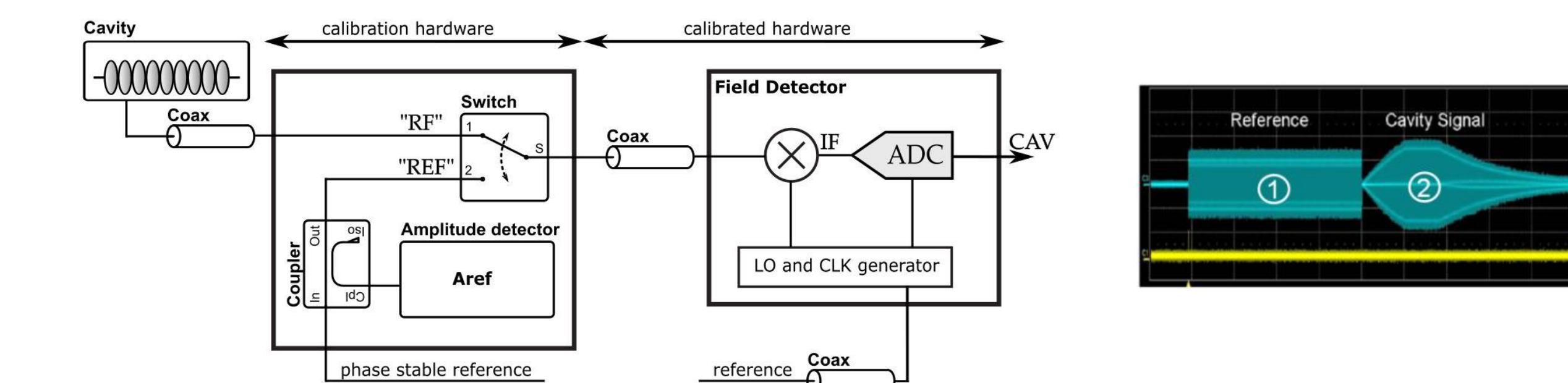
Example drift values of mixer based Field Detectors:
 $\Delta A = 0.2\% / {}^\circ C$
 $\Delta \phi = 0.2 {}^\circ C, \Delta \phi = 0.1\% / \% RH$

Required field stability for the European XFEL:
 $\Delta A = 0.01\%$
 $\Delta \phi = 0.01 {}^\circ$

For the European XFEL we used a drift compensation module operating at 1.3GHz to remove long-term amplitude and phase variations of the MicroTCA.4 Low-Level-RF control system on the fs-scale. The module showed excellent suppression of environmental temperature and humidity changes of about two magnitudes down to an amplitude and phase stability of 0.01%, respectively 0.01deg or 20fs (all peak-to-peak values). In the article we present the method, hardware, performance and operation of the module.

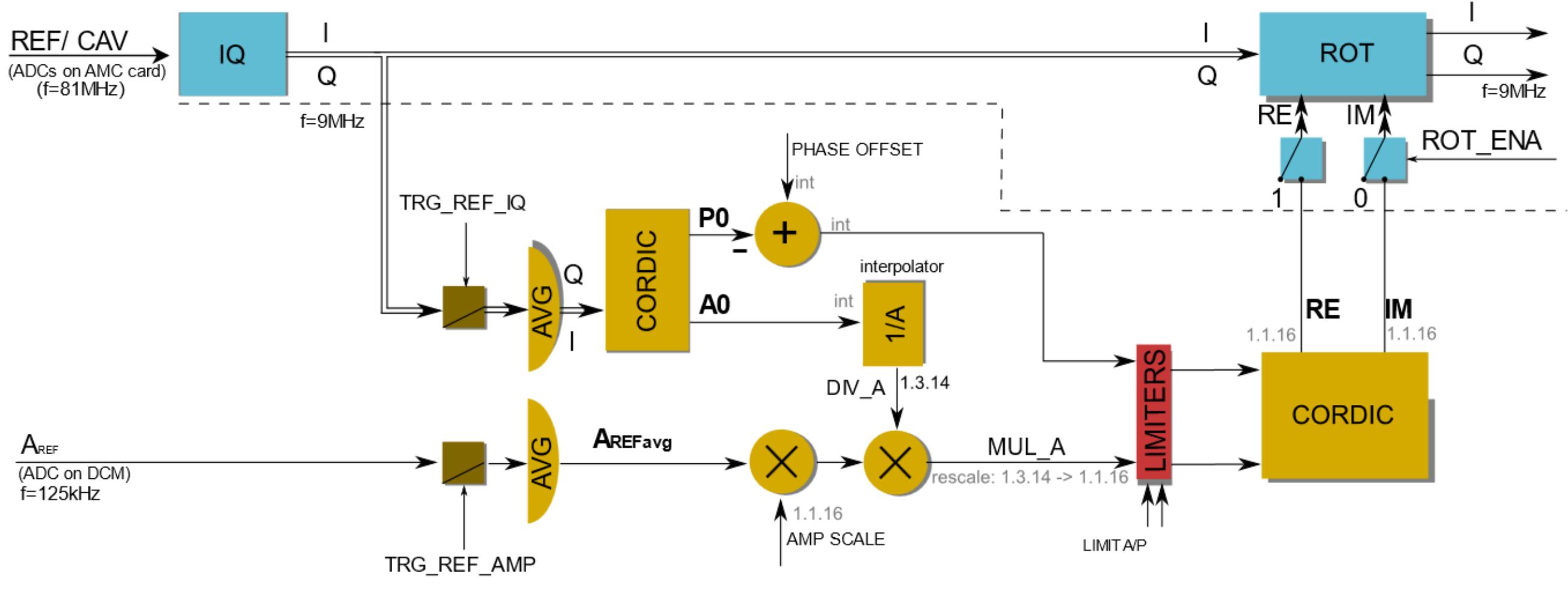
Concept

Reference injection (one cavity channel shown)



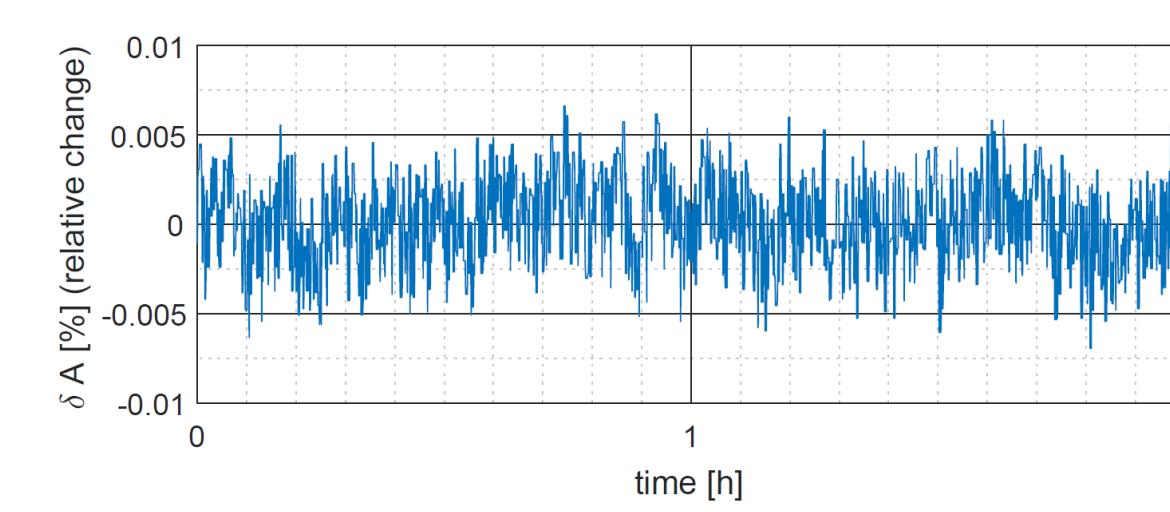
- RF switch used for selecting reference of the cavity signal (only for pulsed machines)
- compensation is done relative to the reference signal
- an accurate amplitude detector is required due to the reference signal amplitude instability
- for multichannel system a low drift reference signal splitter has to be added
- calibration hardware has to be temperature stabilized and hermetically sealed (environmental stabilization of one PCB board instead of the entire rack)

Drift Compensation (FPGA firmware)

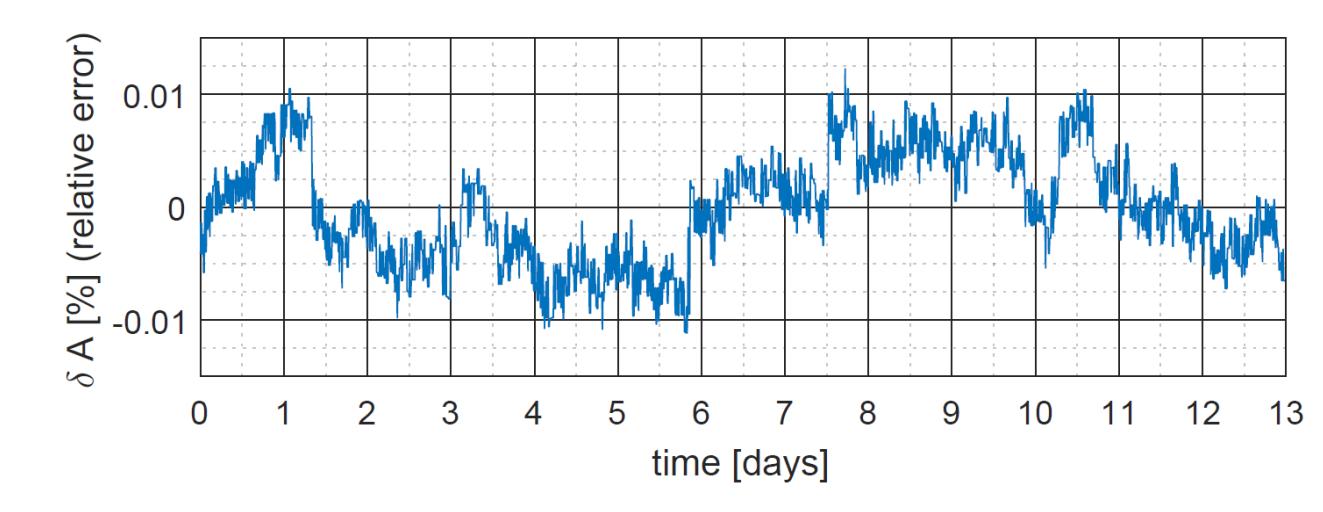


Performance (laboratory)

1. Amplitude detector performance



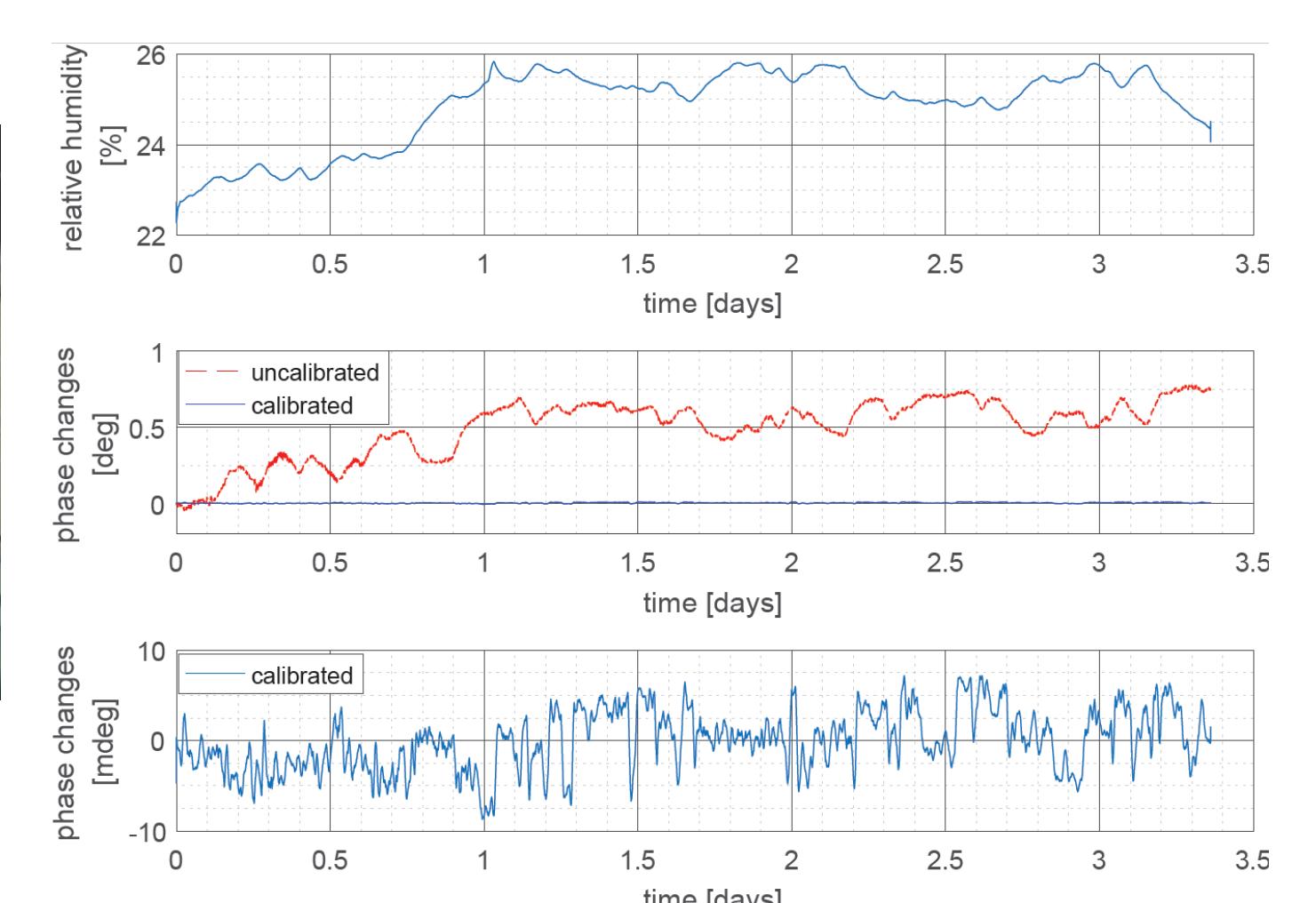
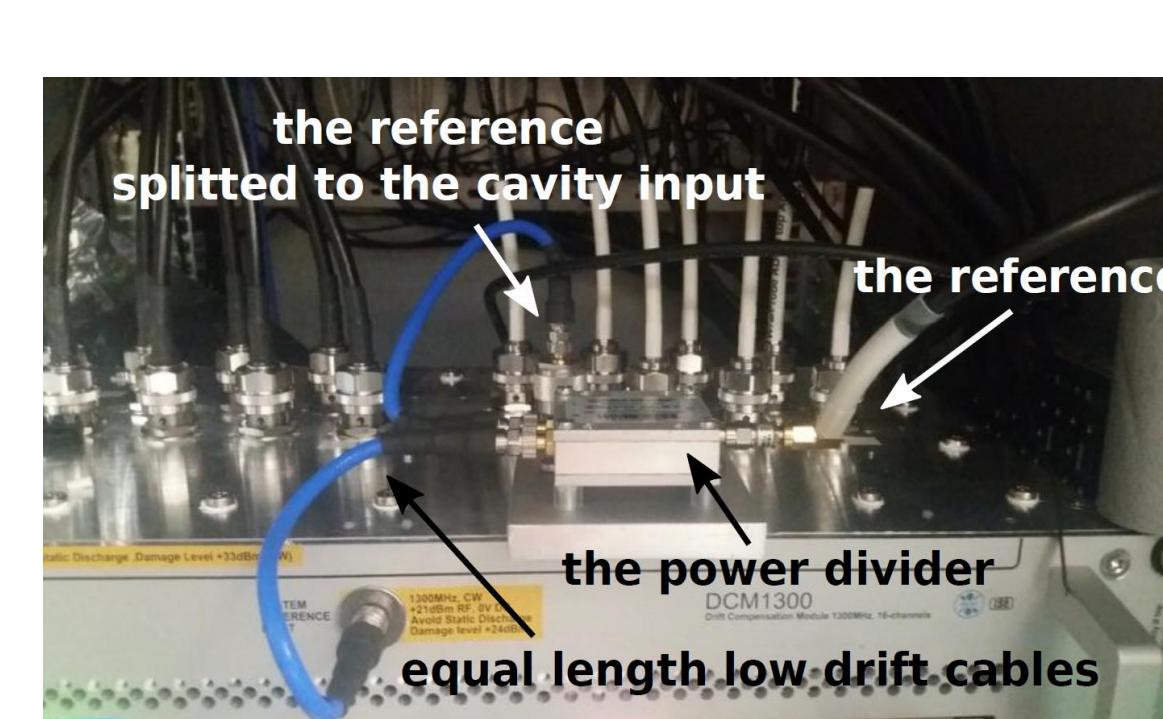
Short-term stability



Long-term stability

Amplitude of the reference signal has been measured with two detectors: internal DCM peak detector and external RMS detector, both values have been compared.

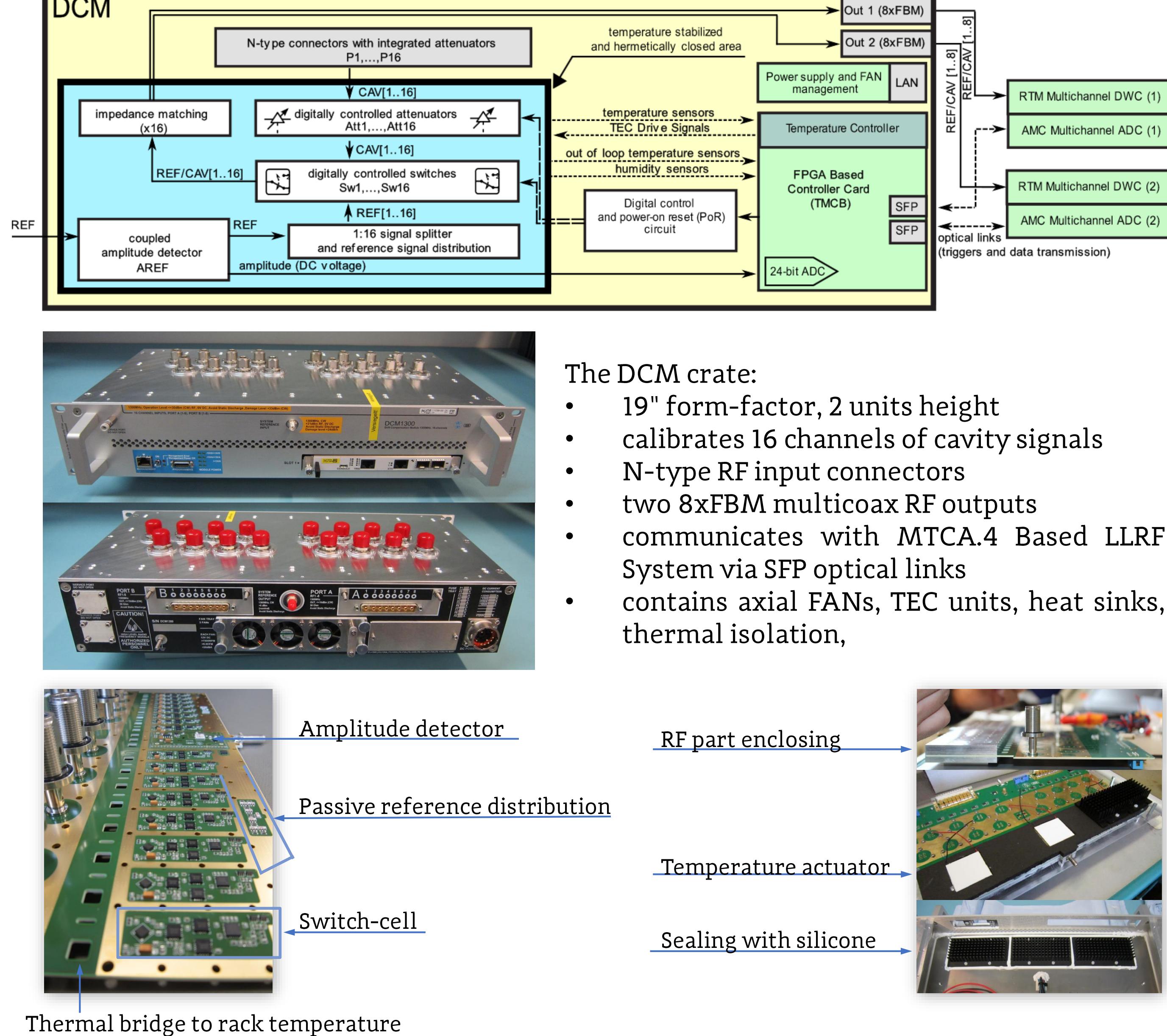
2. Phase performance



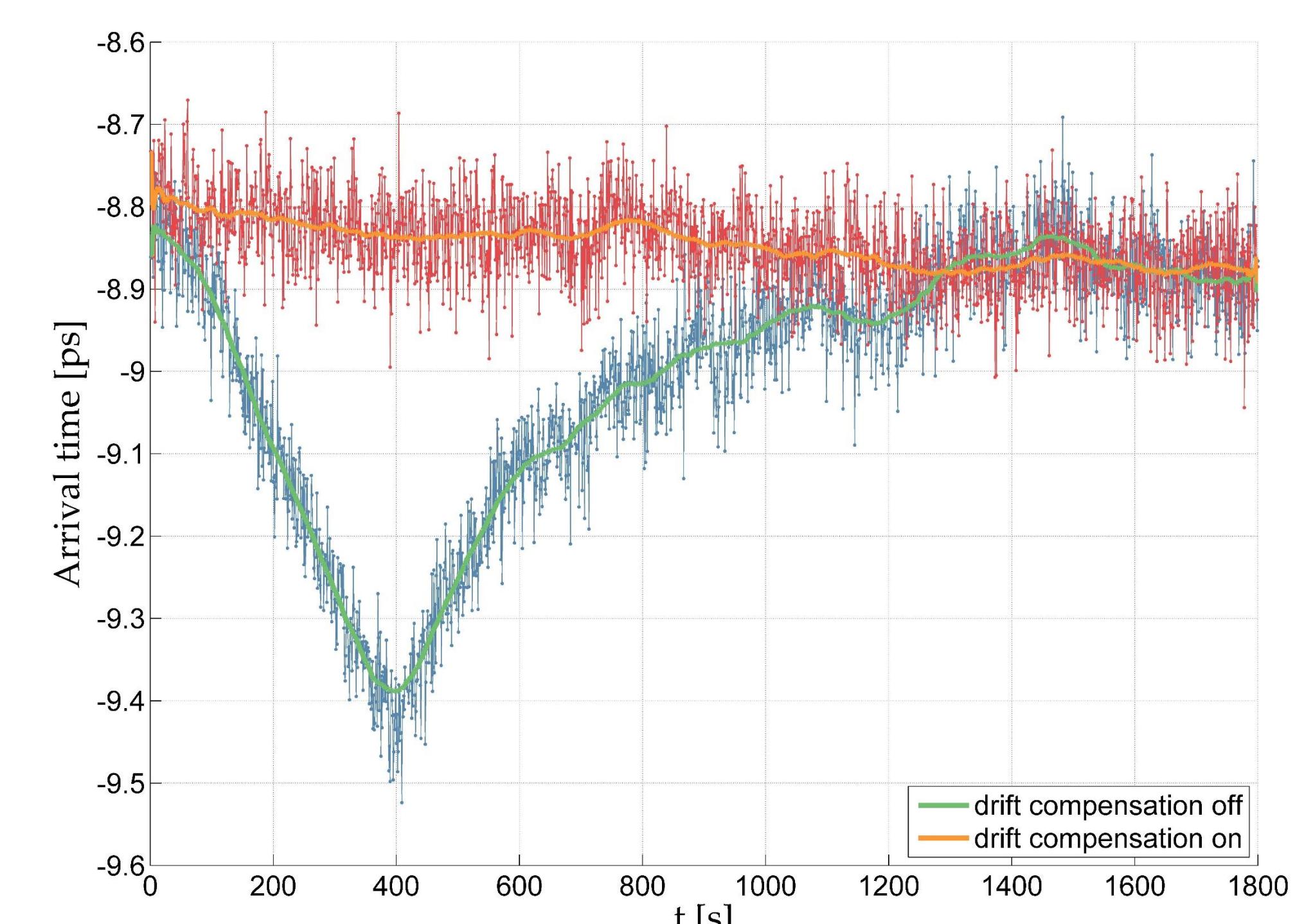
The measurement setup:

- reference signal provided symmetrically to the DCM REF and RF inputs
- accuracy defined as a difference between measurements in both switch states

Drift Compensation Module



Operation of the module



Improvement on beam arrival time stability due to the drift compensation, measured with 2°C induced rack temperature change at FLASH

Acknowledgment

Research supported by Polish Ministry of Science and Higher Education, funds for international co-financed projects for year 2017.

Contact

j.piekarski@elka.pw.edu.pl
 kczuba@elka.pw.edu.pl

References

- S. N. Simrock, V. Ayvazyan, A. Brandt, M. Hning, W. Koprek, F. Ludwig, P. Pucyk, K. Rehlich, E. Vogel, H. C. Weddig, M. Grecki, T. Jezynski, and W. Jalmuzna, "Conceptual LLRF design for the Euro-pean XFEL"
- F. Ludwig, C. Gerth, K. Hacker, M. Hoffmann, W. Jalmuzna, G. Moller, P. Morozov, C. Schmidt, "Drift calibration techniques for future FELs"