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The near to continuous wave (CW) operation preparation and first test of X-FEL type module at CMTB

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Abstract

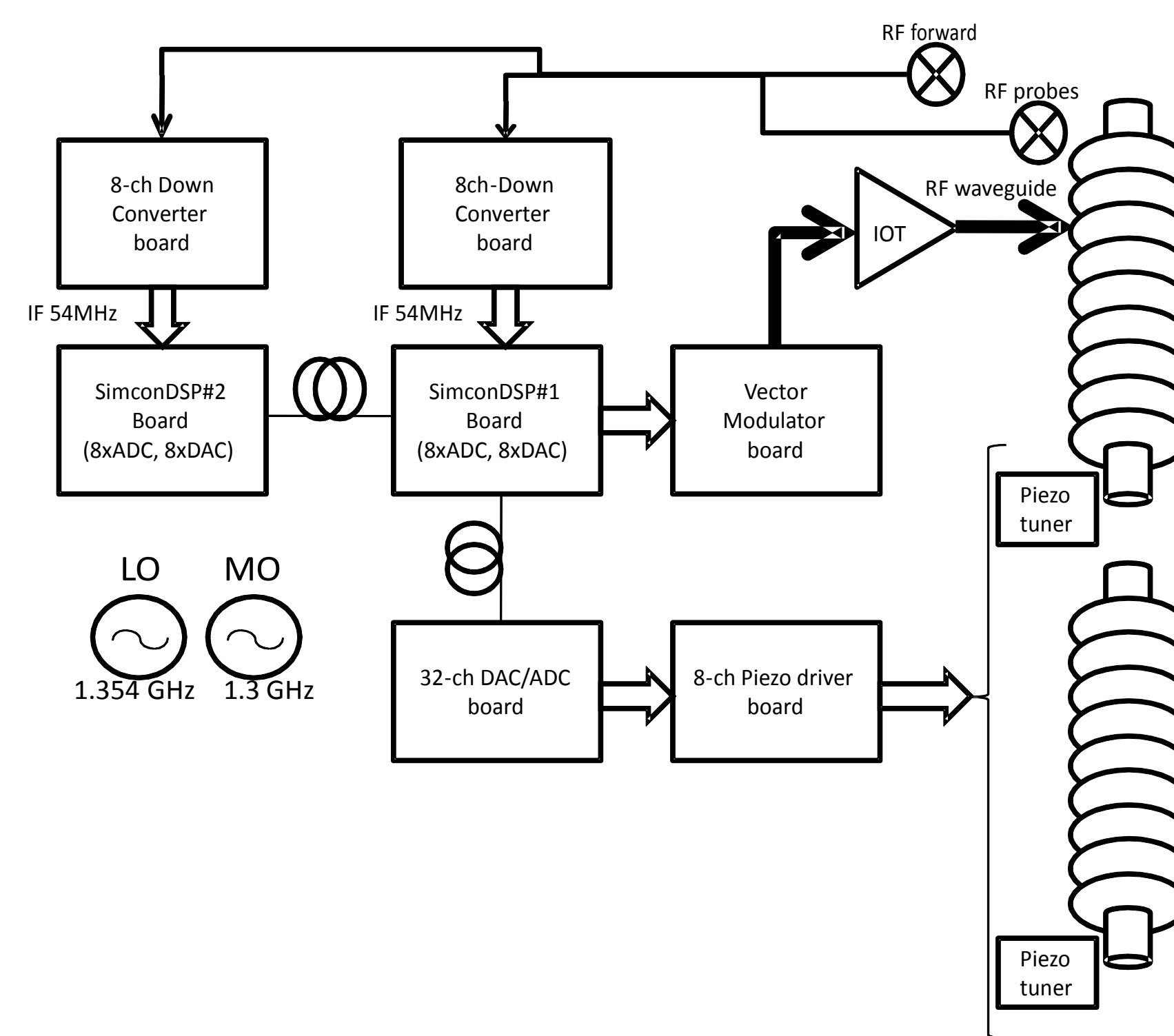
The continuous wave (CW) operation at FEL's becomes more and more attractive mode of operation for the future European XFEL. In order to evaluate this approach and identify opportunities and system limitations first test of CW operation of superconducting cavities module (one of XFEL type module) has been performed at Cryo-Module Test Bench (in DESY).

This contribution focuses on the software and hardware preparation phase for first LLRF tests in near CW operation mode. Using dedicated IOT amplifier and LLRF system that has been adjusted to long pulse operation (modified version of system used at FLASH) it was possible to operate cavities in 1Hz repetition rate and 100% duty cycle with low gradients.

The piezo tuners control system and its performance, which play a crucial role in adjusting of the resonance frequency of cavities (with high QI factor) is also discussed.

The poster describes additionally the results from this first study and future plans for upcoming (2011/2012) CW operation tests at CMTB with next generation of LLRF system (based on uTCA).

LLRF system structure and components



LLRF controller modifications

The controller configuration has been changed (from this used at FLASH) in order to support 54MHz IF signal processing (81MHz sampling and IQ detection). Additionally controller tables approach has been modified in order to fulfill 1Hz repetition rate operation with adjustable duty factor.

Dedicated DOOCS controller server

Dedicated DOOCS front-end server has been developed. The new implementation allowed for better integration with modified field controller and easy management of operation conditions settings. Additionally the data storage functionality has been proposed and implemented.

Introduction

The long-pulse operation is one of the possible upgrade for European XFEL facility that is being build at DESY. The main advantages of this approach are: increasing of intra-bunch distances between bunches (less complex detectors needed) and possible few kilohertz repetition rate of photon burst with high bunches quantity (per second) and high average brilliance.

In order to provide the near-CW (long pulse) operation of XFEL some of the designed linac subsystems has to be modified. First of all cryogenic plant (the system capacity has to be increased by 30 %), additionally new SRF gun has to be designed and installed and finally a RF power source for supplying cryomodules has to have CW operation capability.

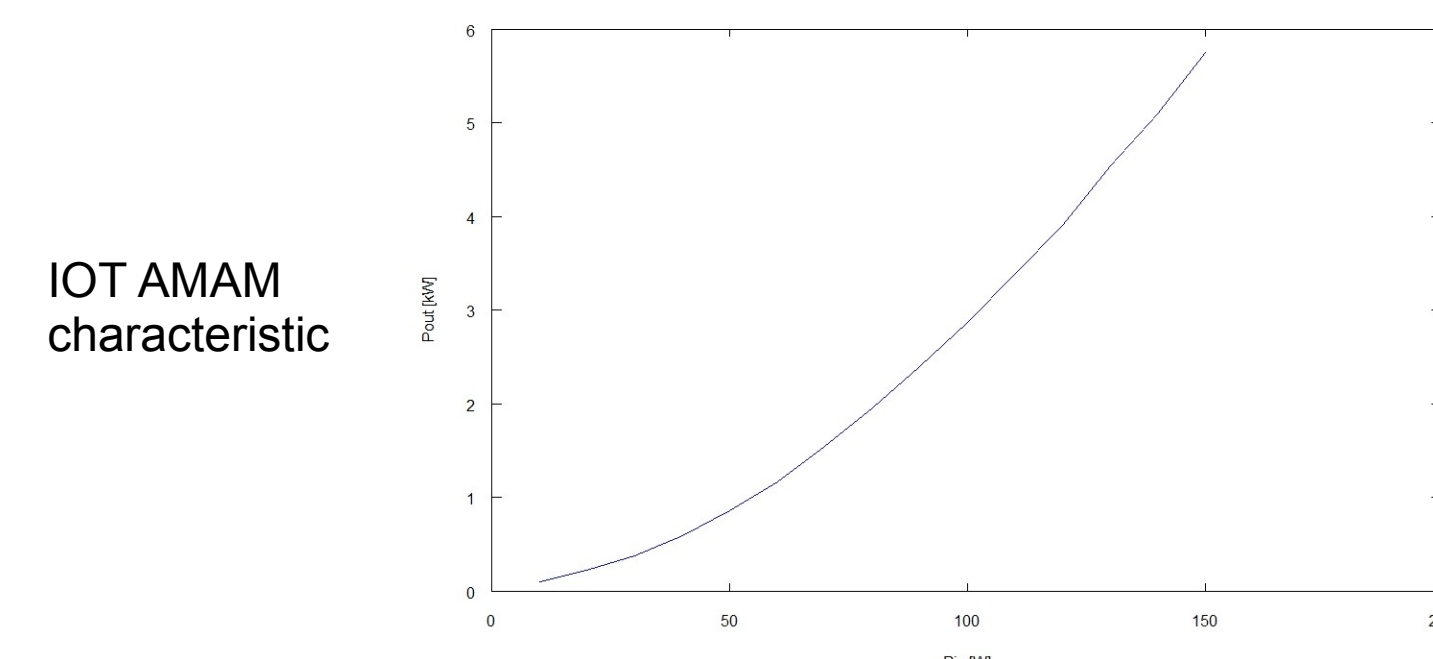
The near to CW operation tests at CMTB are dedicated to verify possibility and performance of cavities field parameters control in case of long pulse operation of resonators with loaded quality factor of $\sim 2e7$. Additionally this study is dedicated to evaluation of performance of a new RF source (IOT) prototype and estimation of heat load limitations for X-FEL cryomodules.

The poster describes structure and functionality of the LLRF system used for mentioned study and first experiences of setup conditioning and initial module measurements.

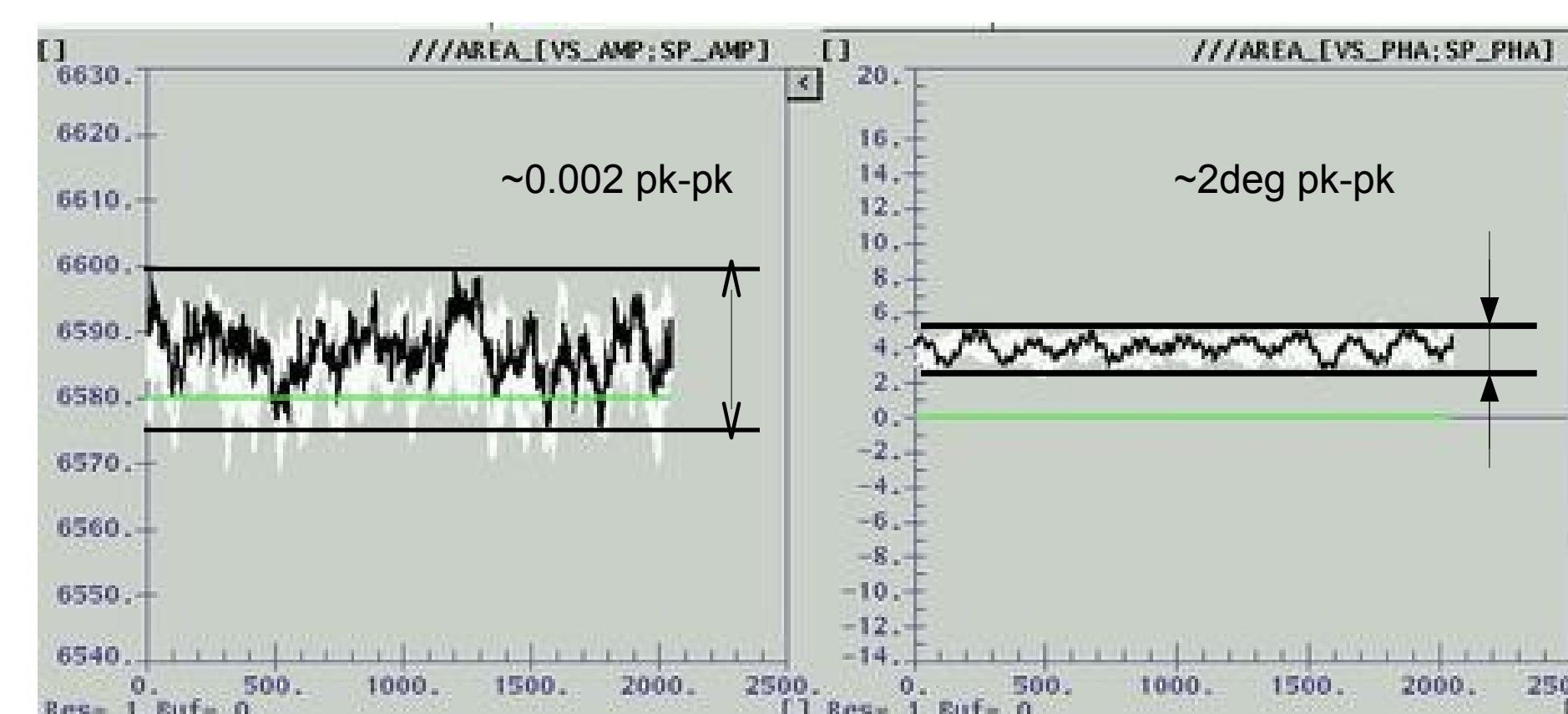
Initial tests experience

Test conditions:

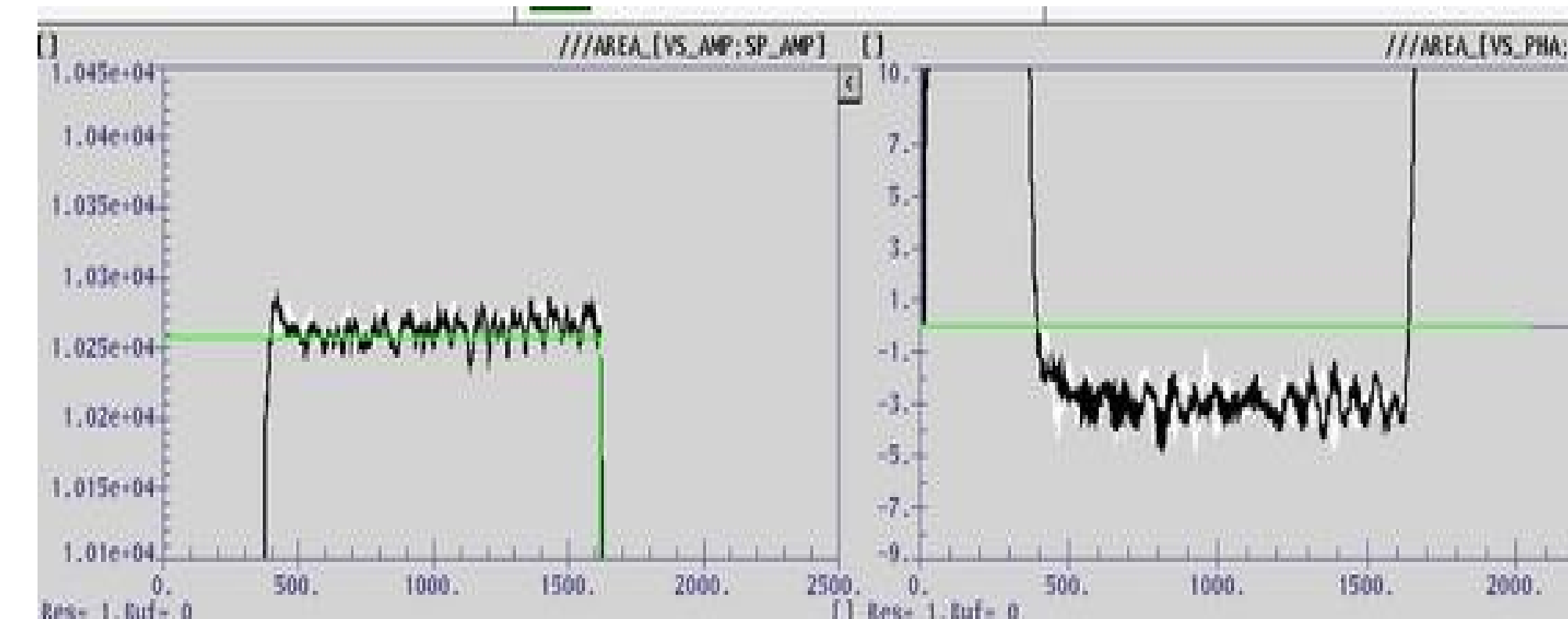
- six cavities with QI $\sim 1.6e7$
- CW and various pulse DF,
- gradients 5-12MV/m



CW operation



Long pulse operation



LLRF system for near CW

IOT & input driver amplifier

The prototype of Inductive Output Tube (IOT) has been installed in the test facility in order to provide the RF power for single (8 cavities) X-FEL type cryomodule.



Parameter	Unit	Spec	Measured at CPI and (DESY)
F	[MHz]	1300	1300
Output P	[kW]	60-120	85 (80)
Gain	[dB]	>21	22.3
Efficiency	[%]	>60	54
Voltage	[kV]	36-50	45-48

The device has been integrated with existing wave-guide distribution system and equipped with electronic protection systems. The RF control signal has been supplied to the IOT from 600W input driver amplifier.

Conclusions and future plans

Basing on the hardware components from the regular FLASH LLRF system the dedicated set-up for CW operation study has been established. The operation results gave starting point for further tests and system limitations investigation. The tests revealed unknown facts not only about LLRF system performance and piezo control accuracy but also about the IOT operation characteristics (AMAM and AMPM nonlinearities, range of output signal phase deviation due to supply the HV change) and near-CW operation influence on the measured cryo heat load. All that points are taken into account during preparation for upcoming study.

Acknowledgments

Authors are very grateful for the cooperation and support of the colleagues from DESY groups MSK, MKK, MHF-e. The initial successful test were possible only thanks to theirs participation in the installation and commissioning process.