Design and Status of the MicroTCA.4 Based LLRF System for TARLA.

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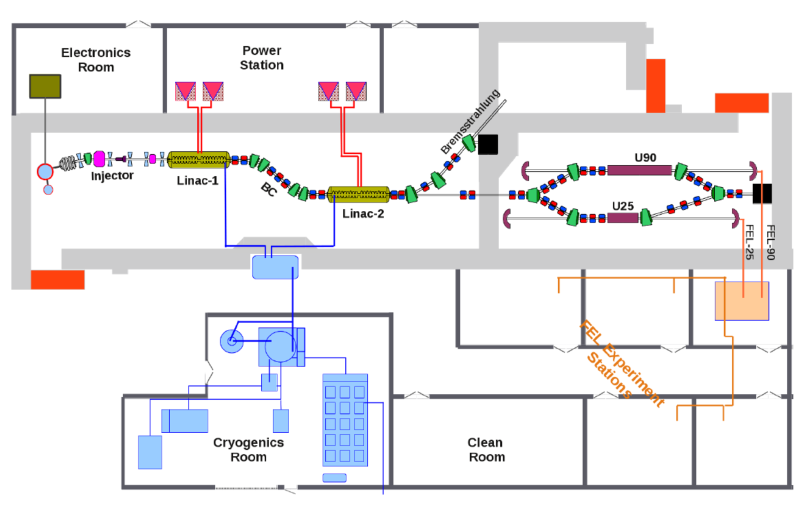
Abstract

The Turkish Accelerator and Radiation Laboratory in Ankara (TARLA) is constructing a 40 MeV Free Electron Laser with continuous wave RF operation. In order to control and monitor the four superconducting (SC) TESLA type cavities as well as the two normal conducting buncher cavities, a MicroTCA.4 based LLRF system is foreseen. This highly modular system is further used to control the mechanical tuning of the SC cavities by control of piezo actuators and mechanical motor tuners. This poster describes the system setup and integration to the existing accelerator environment with hardware and software components .

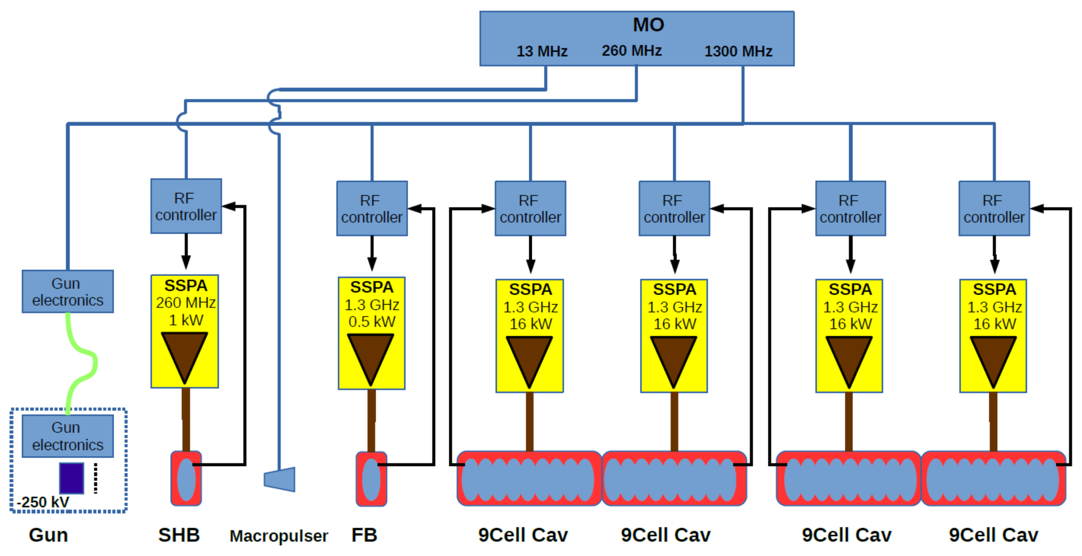
LLRF Regulation Requirements

Module		Jitter (RMS)		Drift (peak-to-peak)	
		Granted	Expected	Granted	Expected
260 MHz Sub-harmonic Buncher Cavity	Amplitude [%]	0.5	0.2	0.8	0.5
	Phase [deg]	0.2	0.15	0.8	0.2
1.3 GHz Buncher Cavity	Amplitude [%]	0.1	0.08	0.5	0.2
	Phase [deg]	0.1	0.08	0.25	0.1
1.3 GHz Superconducting Cavities	Amplitude [%]	0.1	0.05	0.25	0.1
	Phase [deg]	0.1	0.04	0.25	0.1

TARLA Facility Layout



Facility organization (top view)



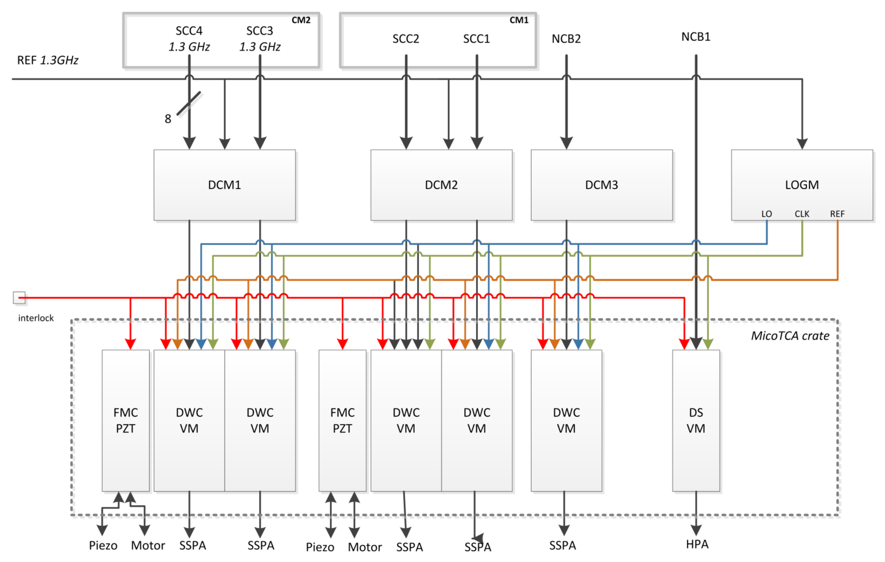
Schematic block diagram of the RF system layout

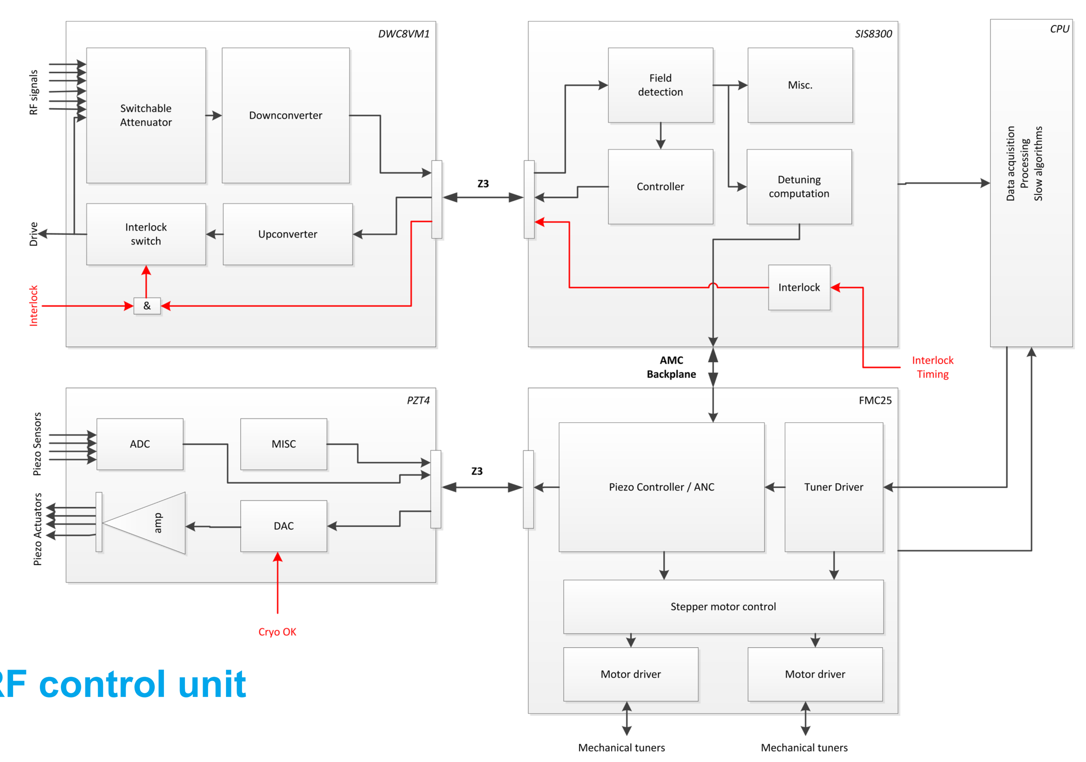
- Facility is located in Gölbaşı-Ankara, Turkey
- 3-250µm FEL, usage of Bremsstrahlung radiation and fixed target experiments
- Similar to ELBE (HZDR) design in terms of synergies in development and operation process
- Additional piezo control system for microphonic suppression
- Mechanical tuning system is also integrated in LLRF setup
- Stepwise preparation at DESY and final system commissioning on site component testing, integration tests and system assembly at DESY
- Coordination with on-site infrastructure preparation

Parameter	Unit	Base Value	Upgrade Value
Beam Energy	MeV	0 - 40	0 - 40
Max Bunch Charge (@13 MHz)	pC	77	115
Max Average Beam Current	mA	1	1.5
Horizontal Emittance	mm mrad	<15	<15
Vertical Emittance	mm mrad	<12	<12
Longitudinal Emittance	keV ps	<85	<85
Bunch Length	ps	0.4 - 6	0.3 - 6
Bunch Repetition	MHz	13	0.001-104
Macro pulse Duration	μs	10 - CW	10 - CW
Macro pulse Repetition	Hz	1 - CW	1 - CW

Basic machine and beam parameters

LLRF Hardware Setup

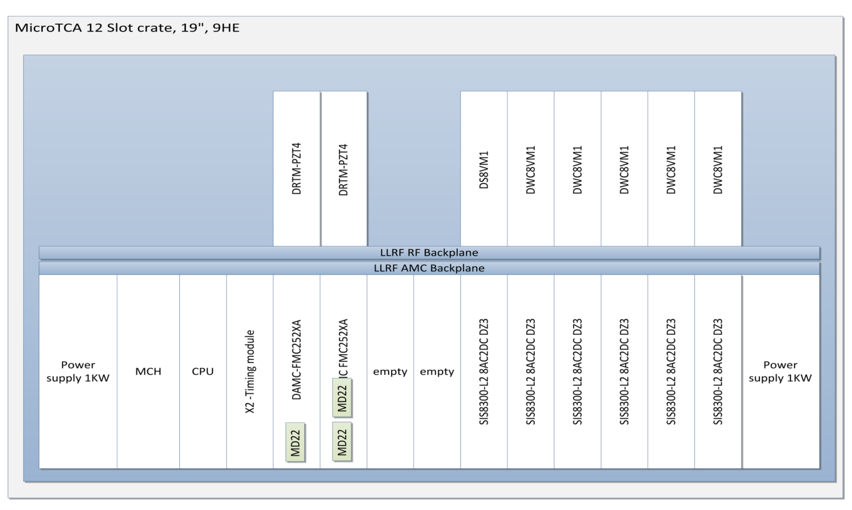




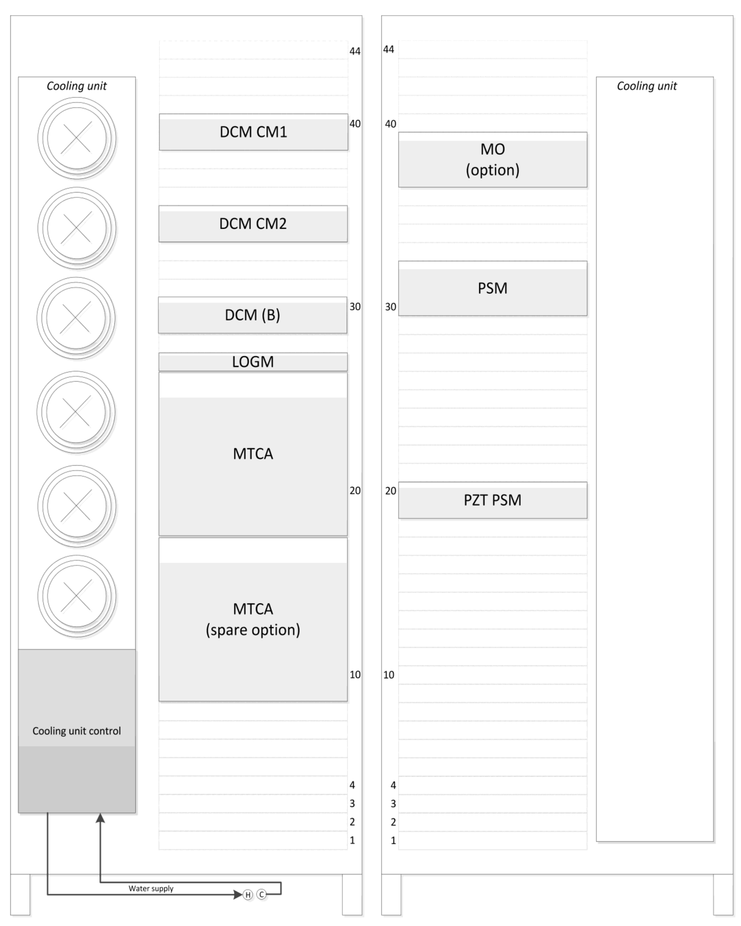
Simplified block diagram for a single LLRF control unit

A single LLRF control setup includes:

- LLRF controller consisting of Up/Downconverter (RTM) + digital processing stage (AMC)
- Mechanical controller consist of piezo driver/sensor (RTM) + digital processing stage with additional stepper motor control
- External interlocks are routed through MicroTCA.4 backplane or external RTM inputs
- 2 SC RF control units share one mechanical tuner setup
- Communication between RF and mechanical controller are done through AMC backplane using low latency links
- CPU over PCIe communication with firmware for both system parts



Crate setup with defined MicroTCA.4 components. Control of all NC and SC RF stations housed in one crate. Further mechanical and piezo actuators are in same setup. Detuning information for piezo control is transferred over backplane from RF field detection components to piezo control and driver board.



Planned rack layout. Next to the MicroTCA .4 based LLRF system there is further external modules like the Drift compensation module (DCM) and external local oscillator and clock generation module (LOGM). Further power supply and IT infrastructure is required. In addition to the running system there is a second setup for development and spare components.

Current System Tests at DESY

System integration test at DESY & preparation for final rack assembly

- Individual component tests at DESY – Hardware Checking
- System integration, testing of inter-board communication
- Setting up operating system, servers, firmware and cabling
- In rack integration, inner-rack cabling
- Final checks, ready for shipment
- On-site integration to infrastructure (machine protection, timing, synchronization)
- System commissioning, final RF control, performance measurements

Software

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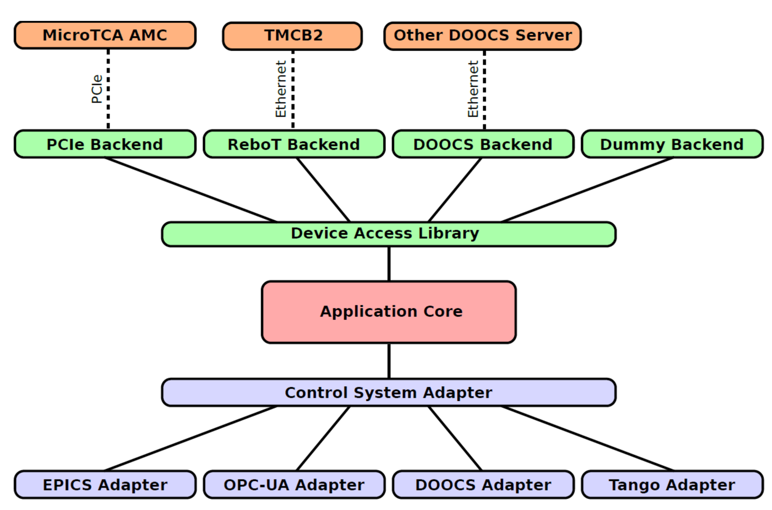
- Startup using basic DESY software using DOOCS servers
- Migration to the TARLA control system which is based on EPICS4 using control system adaptor
- Further system development can be done by ChimeraTK applications containing: Python and MATLAB bindings
- Stepwise integration of higher level applications and automation routines
  - Soft ramp up, auto-tuning and piezo tuner relaxation



Conclusion and Outlook

- Goal is to build a complete LLRF system at DESY
- Ready to use system will be shipped to Ankara
- System commissioning performed on site.
- Integration of control system
- Final upgrades using beam based information:
  - Beam loading compensation
  - Beam based feedbacks to further stabilize is foreseen for the future

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Low Level Radio Frequency Workshop
Barcelona, Spain,
October 16-19, 2017

TARLA Turkish Accelerator and Radiation Laboratory in Ankara