

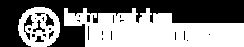
Libera

Libera LLRF

Gašper Jug, Libera Workshop, 14 October 2010, Solkan, Slovenia

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Overview

- General LLRF systems
- General digital LLRF system
- Libera LLRF short description
- Functionalities of Libera LLRF
- Tests of Libera LLRF
- Libera LLRF major configurations

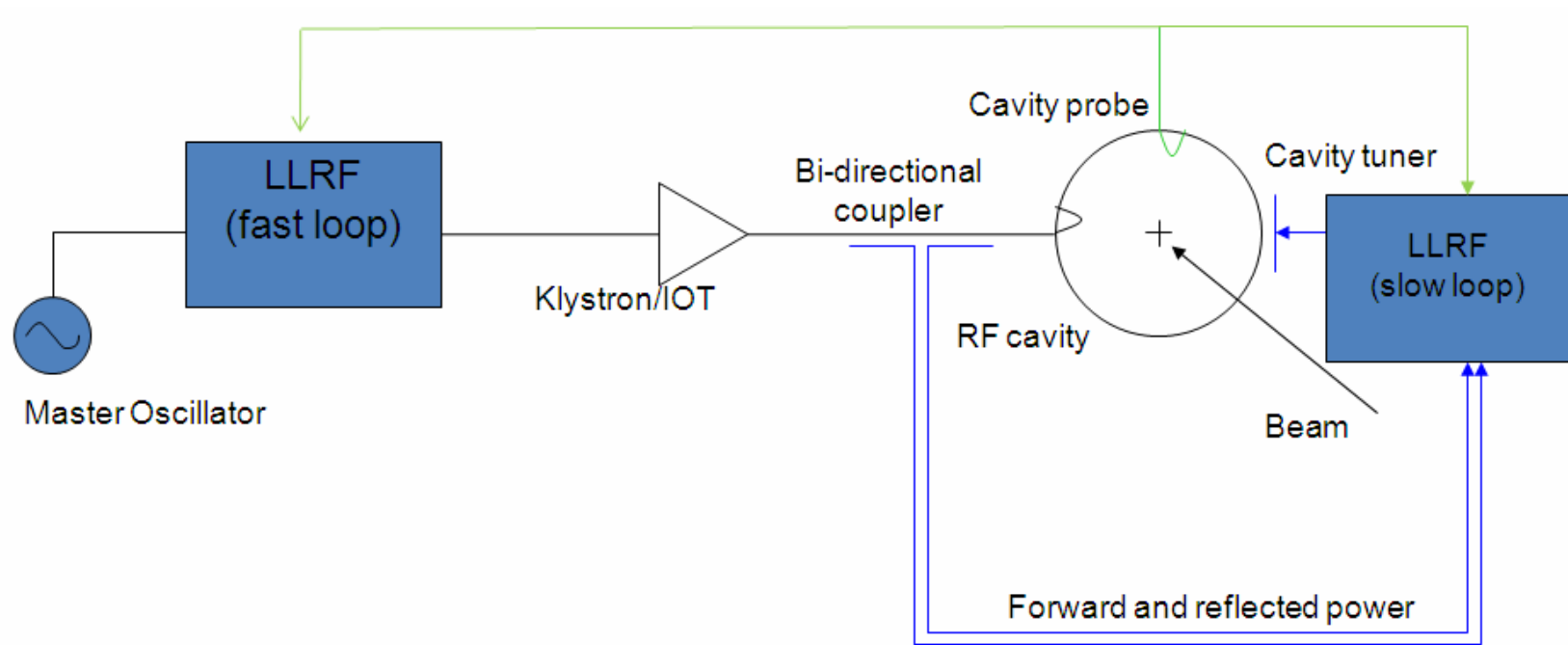
LLRF System - General

- Used to stabilize the accelerator's RF field
- Control loop is employed to set and stabilize the:
 - RF amplitude
 - RF phase
- Output of the LLRF system drives the preamplifier
- Currently mostly analog systems are used

Digital LLRF System - General

- In addition to the analog system it offers:
 - Different control algorithms
 - Easier change of functionality
- Straight-forward integration into the control system
- Can be viewed as a separate and almost autonomous control system

Concept



Libera LLRF

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Libera LLRF



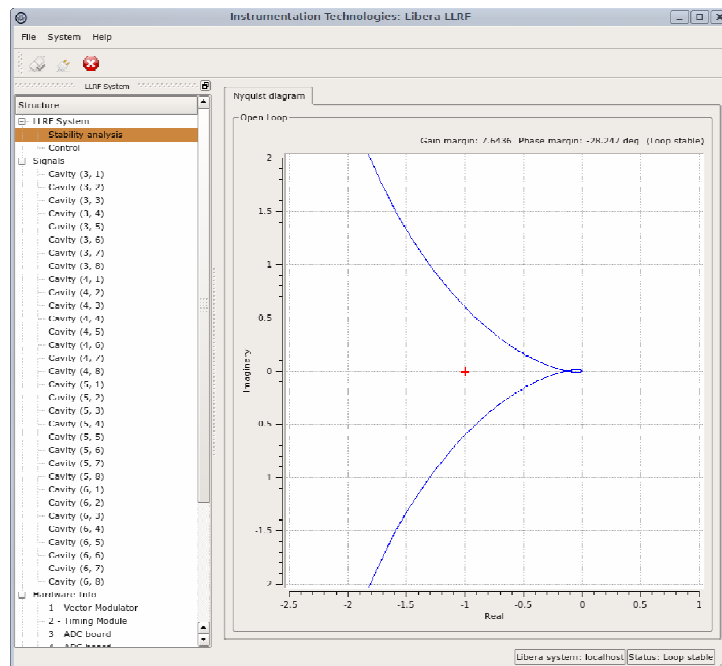
- Digital LLRF system
- Small 19" 2U form factor
- Drives 1 klystron
- Up to 32 RF inputs
- μ TCA based
- Low latency: approx. 300 ns
- EPICS ready
- All-in-one (HW, SW and FPGA)

Where Libera LLRF Can Be Used?



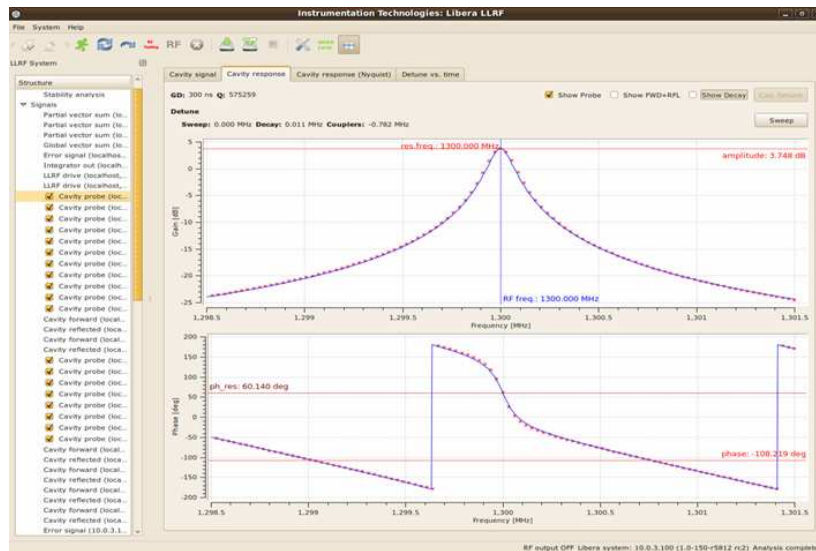
- 3rd generation light sources (synchrotrons)
- 4th generation light sources (FELs and ERLs)
- Hadron Accelerators

Libera LLRF – Functionalities (1)



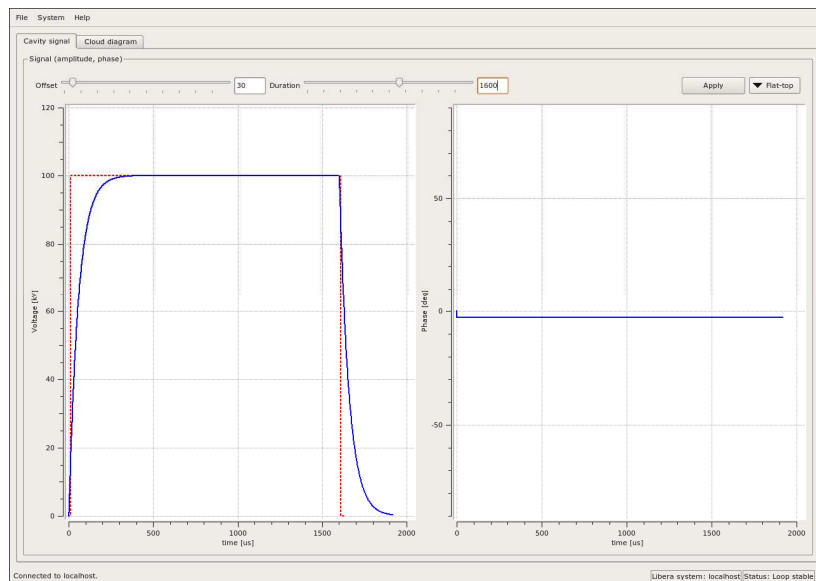
- Sets and stabilizes RF field in the cavities
- Characterizes the RF system
- For pulsed and CW machines
- Various RF frequencies supported
- SC / NC cavities
- EPICS interfacing data
- Interlocks

Libera LLRF – Functionalities (2)



- **Stabilization of RF field:**
 - **PI feedback**
 - **Feedforward**
 - **Pulse-by-pulse feedback**
- **Characterization of RF system:**
 - **Sweep analysis**
 - **Stability analysis (Nyquist)**
- **Temperature drift calibration**

Libera LLRF – Functionalities (3)



- **RF frequencies:**
 - **HW enables from few MHz up to 12 GHz**
- **EPICS (currently)**
- **Interlocks:**
 - **Measured signals out of set limits**
 - **External interlock signals**
 - **Reaction time within 5 µs**
- **Remote operation**
- **Graphical User Interface**

Libera LLRF – Additional Functionalities

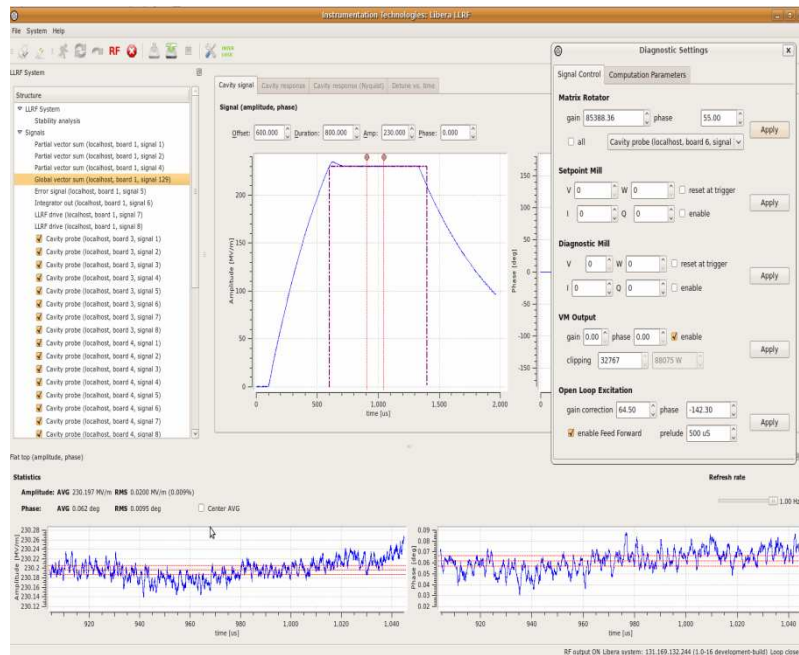
- **Tunes the cavities**
- **Controls:**
 - **Resonance frequency of cavities**
 - **Phase offsets of cavities**
 - **Equalization of amplitude of RF field in cavities (when more cavities are driven by one klystron)**
- **Master – Slave operation**
- **Possible additional control algorithms:**
 - **Adaptive feedforward**
 - **RF pulse shaping**

Tests

- **EMMA (currently being commissioned)**
 - **FLASH**
 - **FERMI@Elettra**
 - **FLASH 3.9 GHz**
- **Setting up the system within a day!**



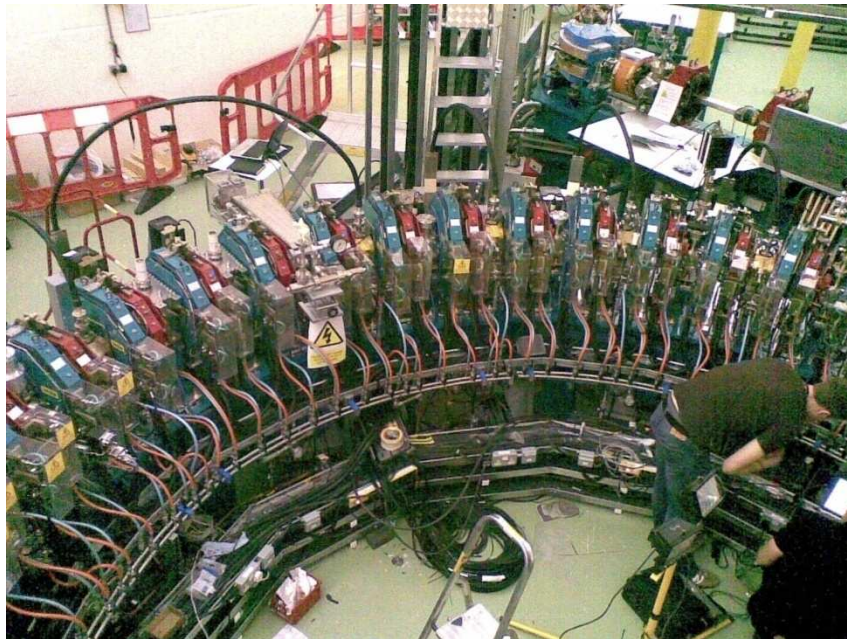
Performances



- Best achieved stability during EMMA and FLASH tests at 1.3 GHz:
 - Amplitude: 0.0090 % RMS
 - Phase: 0.0095 ° RMS
- FERMI@Elettra at 3 GHz (pulse-by-pulse feedback):
 - Amplitude: 0.027 % RMS
 - Phase: 0.033 ° RMS

BANDWIDTH!

Libera LLRF @ EMMA



- EMMA – Electron Machine Of Many Applications
- NS FFAG – Non Scaling Fixed Field Alternating Gradient proof of concept accelerator
- Master-Slave configuration
- 19 NC cavities, 59 RF input signals
- Currently under commissioning

Libera LLRF

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Libera LLRF – Features



- PI feedback
- Feedforward
- Pulse shaping
- Adaptive feedforward
- Stepper motor tuning
- Piezzo tuning
- CW & pulsed mode
- RF system analysis
- Advanced RF system analysis
- FPGA development kit
- SW development kit
- Customer requests

Libera LLRF – Major Configurations



- **Libera LLRF**

Core: very affordable 500 MHz basic version

- Storage Rings

- **Libera LLRF**

Injector: 500 MHz pulsed basic version

- Linacs, Boosters

- **Libera LLRF**

Customizable unit

- FELs, other (EMMA)