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DEVELOPMENT AND VALIDATION OF AN X-BAND LLRF PROTOTYPE FOR THE *EuPRAXIA@SPARC_LAB* LINAC

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Instrumentation Technologies

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UK Research and Innovation

Instrumentation Technologies overview

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Est. 1998

45+ employees

7M EUR revenue in 2021

ISO 9001:2015 certified

Headquartered in Solkan, Slovenia

Company Business Areas

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INSTRUMENTATION TECHNOLOGIES

LIBERA

Beam Diagnostics and Control Instrumentation

- Particle Accelerators
- Nuclear Reactors

Company Business Areas

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INSTRUMENTATION TECHNOLOGIES

LIBERA

SOLUTIONS FOR INDUSTRIES

Beam Diagnostics and Control Instrumentation

- Particle Accelerators
- Nuclear Reactors

Development Services and Data Acquisition products

- Automotive Industry
- Test and Measurement
- IoT - connectivity

Company Business Areas

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INSTRUMENTATION TECHNOLOGIES

LIBERA

SOLUTIONS FOR INDUSTRIES

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Open-source general-purpose lab devices

- Universities
- Research
- Industry

LIBERA and Particle Accelerators

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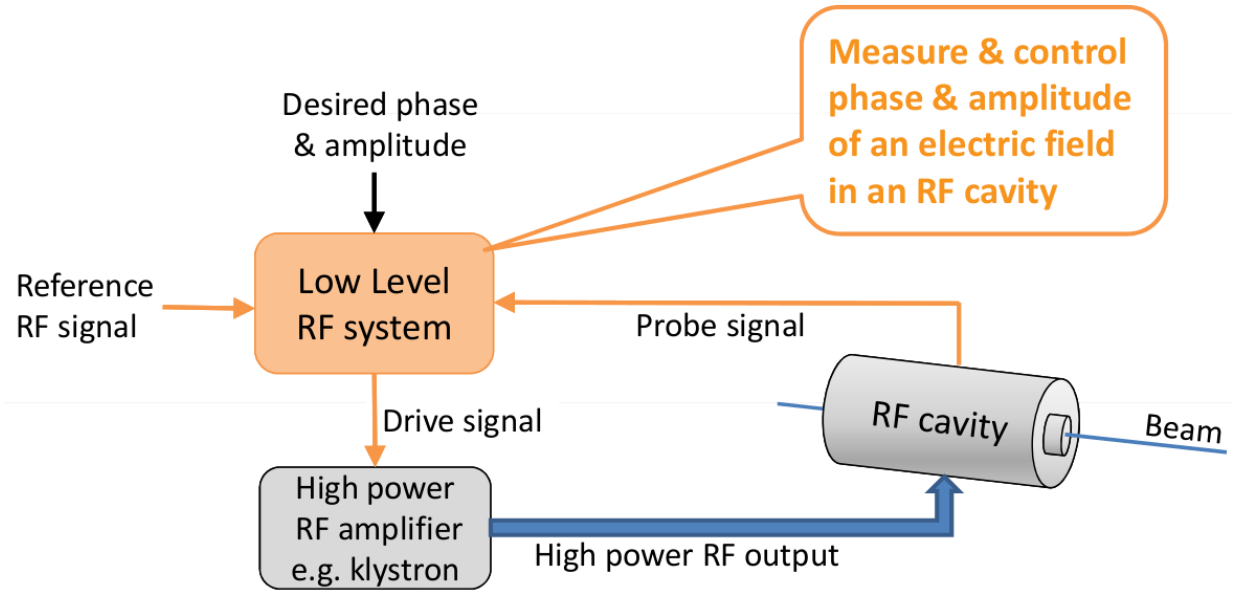
- Collaborative approach with accelerator laboratories and their needs: most LIBERA instruments are the results of these projects.
- Started with electron synchrotron Beam Position Monitoring electronics, later on expanded to other machines, particles and applications (Digital LLRF).

Beam Position Monitor electronics

Digital Low-Level RF

Beam Loss Monitor electronics and detector

LLRF principle and Company Expertise



Main LLRF feedback control loop

LLRF principle and Company Expertise

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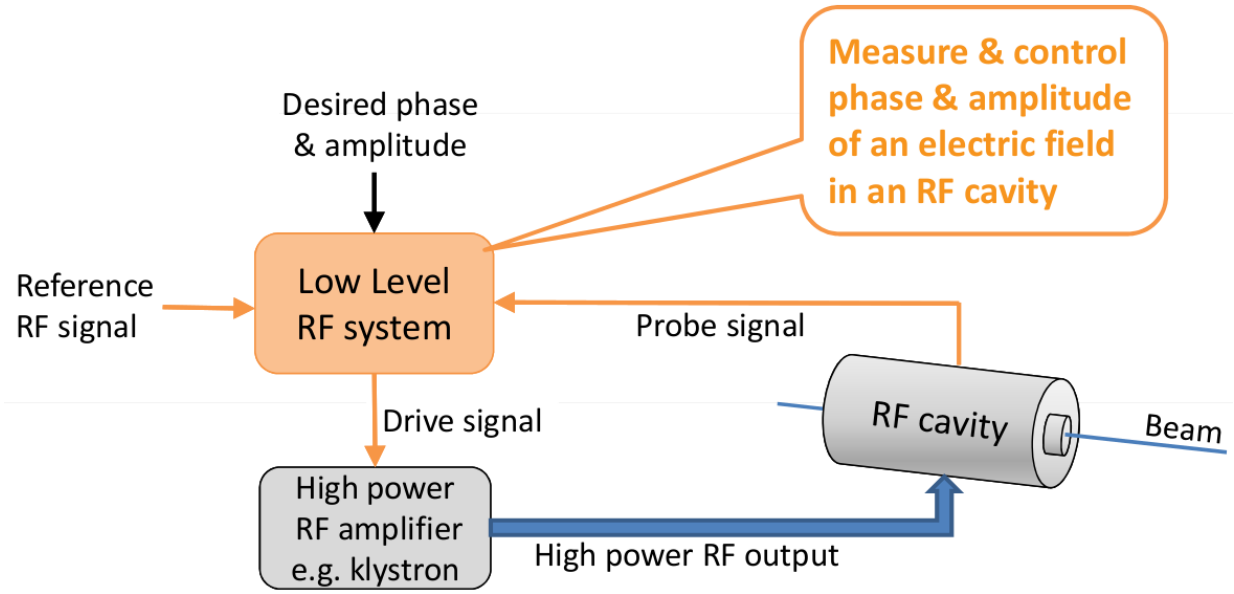
- High-frequency analog RF electronics
- Temperature stabilized RF design
- Digital Electronics design



Main LLRF feedback control loop

- FPGA real-time data processing and control
- SW processing and interfacing with Control System
- Product development and maintenance processes

LLRF challenges for X-Band electron LINACs

- The development of accelerator technology at higher frequencies up to X-Band allows higher accelerating gradients [MeV/m] and shorter accelerating structures -> more compact machines.

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- Controlling the RF pulse properties (amplitude and phase) at this high frequencies and for very short pulses (100ns) is a challenge.
- Temperature drifts influence the LLRF system stability even more at higher RF frequencies: need for temperature stabilized down-conversion.

LLRF challenges for X-Band electron LINACs

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- Controlling the RF pulse properties (amplitude and phase) at this high frequencies and for very short pulses (100ns) is a challenge.
- Temperature drifts influence the LLRF system stability even more at higher RF frequencies: need for temperature stabilized down-conversion.
- At the moment there is no commercial LLRF system working in X-band that meets the performance requirements of the future EuPRAXIA@SPARC-LAB LINAC

Project Structure and Research Goals

- Definition of the X-band LLRF prototype, tailored to the EuPRAXIA@SPARC_LAB LINAC requirements: LLRF concept, choice and verification of the components. Iterative process.

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- Definition of the X-band LLRF prototype, tailored to the EuPRAXIA@SPARC_LAB LINAC requirements: LLRF concept, choice and verification of the components. Iterative process.
- Implementation of the prototype and its characterization on a real test-bench in collaboration with INFN-LNF. Requirement verification and review.
- Future goal: prototype industrialization to make the X-band LLRF available for this and other projects.

Deliverables and Milestones

Assuming no previous experience with Digital LLRF, we identified the following project milestones and associated deliverables:

Milestones	Associated Deliverable(s)	Indicative Date
M1: definition of the final LLRF prototype architecture	**D1***:* Technical Description of the X-band Single-Channel LLRF prototype	T0 + 12 months
M2: confirmation of the components to be used in the prototype	**D2**: identified key-components	T0 + 18 months
M3: confirmation of the produced prototype (lab measurements)	**D3**: Report on the measurements performed in the lab	T0 + 24 months
M4: confirmation of the prototype on the INFN-LNF test-bench	**D4**: Report on the measurements performed at INFN-LNF test-bench	T0 + 30 months

Education and Secondments

Particle Accelerator Area

- Particle Accelerator Schools (JUAS, CAS, …)
- EuPRAXIA DN Schools and camps
- International Conferences and Workshops (IPAC, LLRF Workshop, …)

Specific to the project

- Introduction to the company products and specific LLRF training (working principles and building blocks,
- Establishment of a LLRF test-setup and execution of relevant tests
- Secondments: INFN-LNF, with more than one secondment at different project stages.

Contact and Further Project Details

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