Overview and system requirements for SARAF-LINAC LLRF systems

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Introduction

CEA is committed to the design, construction and commissioning of a Medium Energy Beam Transfer line and a superconducting LINAC for SARAF accelerator in order to accelerate 5mA beam of either protons from 1.3 MeV to 35 MeV or deuterons from 2.6 MeV to 40 MeV.

The Low Level RF (LLRF) is a subsystem of the CEA control domain for the SARAF-LINAC instrumentation. The cavities of the SARAF LINAC are independently driven according to the following simplified schematic, where green blocs represent CEA deliverables, blue blocs are for SNRC deliverables and interfaces are indicated with arrows. The general diagram of the LLRF system is described in Figure 3.

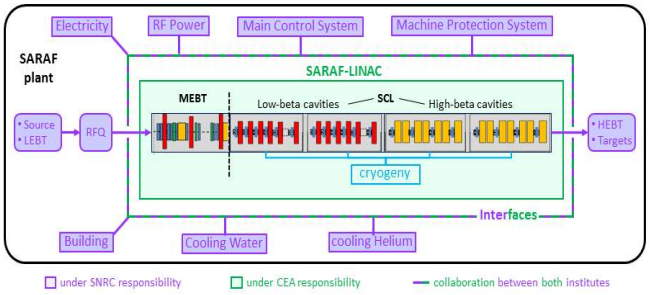

Figure 1. General diagram of one SARAF LLRF channel

General organization of the LLRF

The LLRF channels required in the frame of the SARAF-LINAC contract shall drive rebunchers and accelerating cavities. Figure 2 shows the connection between the LLRF cabinets and the rebunchers or cryomodules.

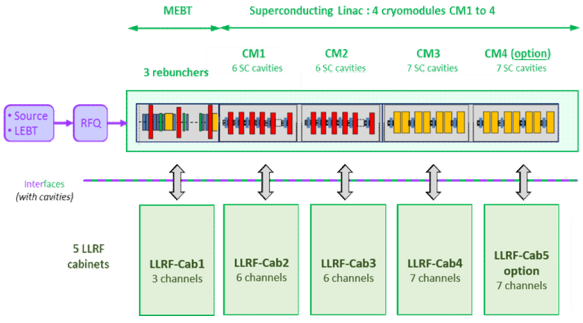

Figure 2: General organization of the LLRF cabinets.

The typical quality factor of the rebuncher cavities with their power couplers is close to 6000. The accelerating cavity for SARAF-LINAC are made of niobium at superconducting temperature. The typical quality factor of these cavities is around $1 \cdot 10^9$ and the external quality factor of their power couplers is close to $1 \cdot 10^6$.

Cavity field regulation requirements

Requirements for amplitude and phase field control were determined by the study of beam dynamic: 1% and 1°. Considering the error during calibration of the system and the other sources of instability during operation (amplifiers, cables, etc.), the requirements for the LLRF regulation are:

- **Amplitude stability < 0.1%**
- **Phase stability < 0.1%**

The specification for the LLRF electronic are being evaluated, based on these stability requirements and a Matlab/Simulink cavity control model[1].

SARAF LLRF channel

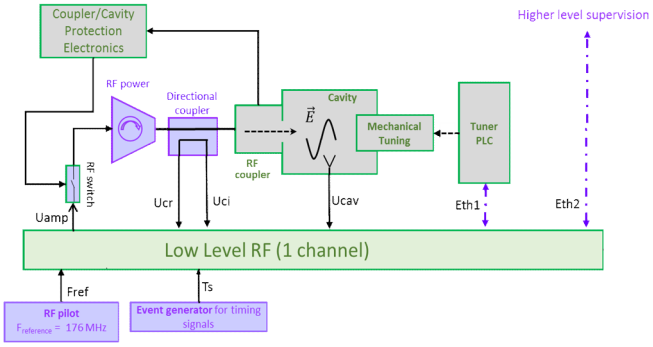

Figure 3. General diagram of one SARAF LLRF channel

Functional specifications of the LLRF system

The LLRF system implements the following functions:

Conditioning:
- **In open-loop**
- **Continuous or pulsed mode**

Regulation:
- **In closed-loop**
- **Continuous mode only**

Buffer :
- **Analyze post-mortem**
- **Real-time measurement**

Note: The safety of the cavity is managed by a specific electronic card, not by the LLRF itself.

Schedule:

- **Call for interests: on–going with ref. 17B3457-CB.**
  (link: https://www.marches-publics.gouv.fr)
- **Call for tender: end 2017 – mid 2018.**
- **Prototype tests: 2019.**
- **Commissioning: 2020-2022.**

SARAF : Soreq Applied Research Accelerator Facility
CEA: Commissariat à l'énergie atomique et aux énergies alternatives

[1] Michel, L., & Piquet, O. (2007). *RF control system modeling*.
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