LIGHT PROTON THERAPY LINAC LLRF SYSTEM

B.Baričević, Instrumentation Technologies, Solkan, Slovenia
Y. Ivanisenko, AVO-ADAM, Meyrin, Switzerland

Abstract

Next generation proton cancer therapy, based on the LIGHT LINAC by Advanced Oncotherapy, offers beam energy control by means of accelerating gradient change paired with highly accurate dose delivery . A customized Libera LLRF system is in the core of the accelerator control providing the required high stability RF control and synchronization of modular accelerating units: a 750 MHz RFQ, 3 GHz SCDTLs and CCLs. Cavities are regulated based on Libera LLRF tune measurements. The system also provides flexibility in pulse shaping and includes RF Interlock functionality to avoid repeating breakdowns in the cavity. Libera provides a real-time interface to set up RF parameters at 200 Hz via a dedicated FPGA module.

LIGHT LINAC RF system

The LIGHT LINAC design consists of:

- a proton source at 40 keV providing currents up to 300 uA with pulses up to 20 us at 200 Hz repetition rate.
- an RFQ (Radio Frequency Quadrupole) at 749.48 MHz accelerating the protons up to 5 MeV, operated at the forth sub-harmonic of the 2997.92 MHz LINAC frequency. The RFQ RF system provides to the LLRF system, 4 cavity probe signals and 4 pairs of directional coupler forward and reflected signals.
- Two SCDTL (Side Coupled Drift Tube LINAC) high power RF units at 2997.92 MHz, delivering the beam at 37.5 MeV. Each SCDTL RF station provides 4 cavity probe signals and 3 pairs of directional coupler forward and reflected signals, as the klystron amplifier output is split between two accelerating structures.Ten CCL (Coupled Cavity LINAC) high power RF units at 2997.92 MHz accelerating beam up to 230 MeV. Five CCL units provide 2 RF probe signals and 2 pairs of directional coupler forward and reflected signals. In the other five CCL RF stations, 4 probes and 3 pairs of directional coupler signals are provided as the high-power drive is split among two accelerating structures.

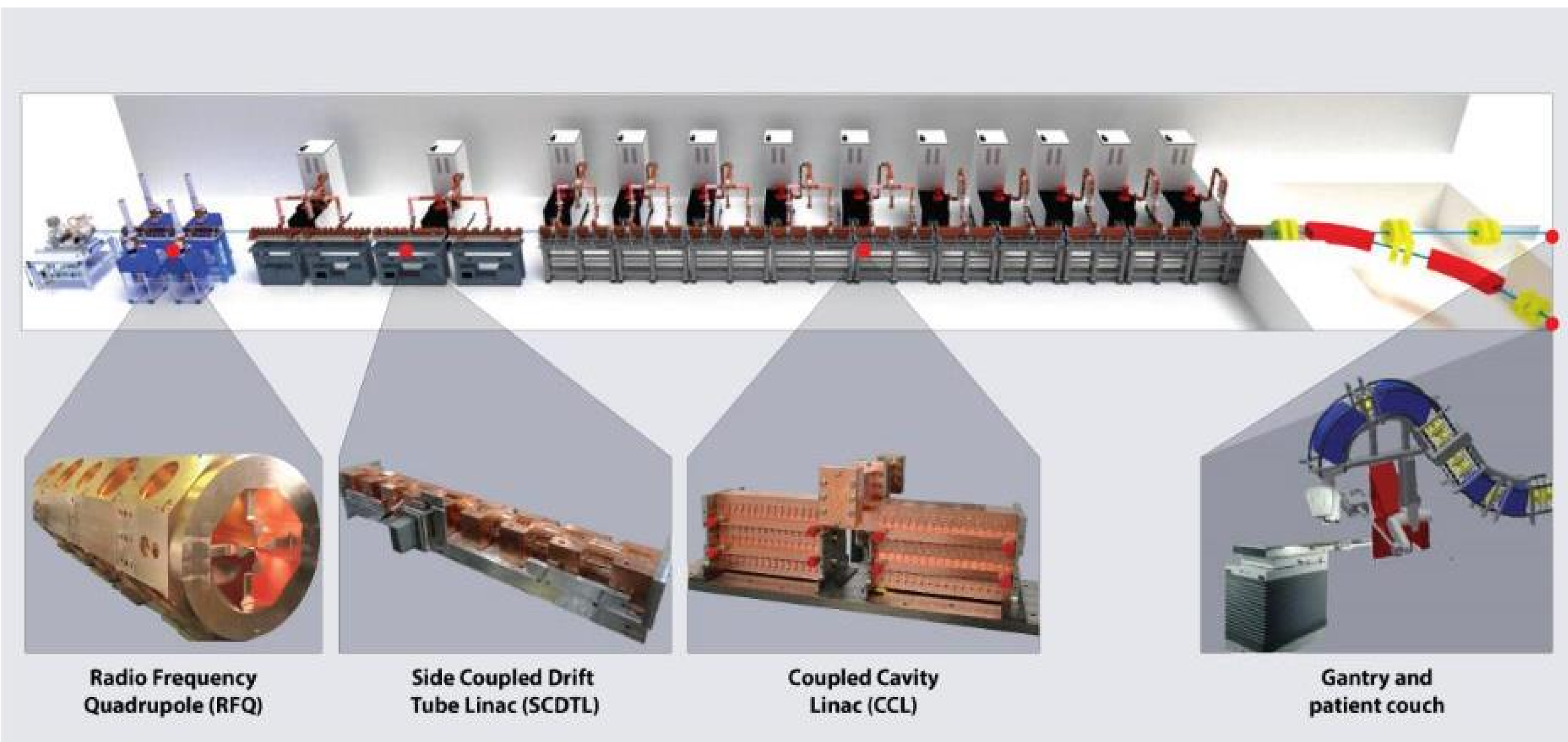

Figure 1: The scheme of the LIGHT proton accelerator..

Requirements

Parameter	Values
RF frequencies:	• RFQ: 749.48 MHz (+/- 1MHz conditioning) • SCDTL, CCL: 2997.92 MHz (+/-4 MHz conditioning)
RF pulse parameters:	• RFQ: 20 us • SCDTL, CCL: 7 us • Repetition rate: 200 Hz
Additional requirements:	• Dynamic range: 20 dB • MO distribution stability: +/-0.1° • Cavity tuning Modbus interface • Failure tolerant interlock logic • RF signal archiving functionality (UDP streaming over dedicated network) • Direct real-time FPGA RF pulse amplitude and phase shape configuration (at 200 Hz rate)

Stability requirements

Parameter	Requirement	Signal level
RMS amplitude stability	< 0.05 %	0 dBFS
RMS phase stability	< 0.05 °	0 dBFS
RMS amplitude stability	< 0.1 %	> -20 dBFS
RMS phase stability	< 0.1 °	> -20 dBFS

Figure 2:The LIGHT LLRF system implemented in the Libera LLRF platform..

Figure 3:The LIGHT Master Oscillator and temperature stabilized distribution amplifier.

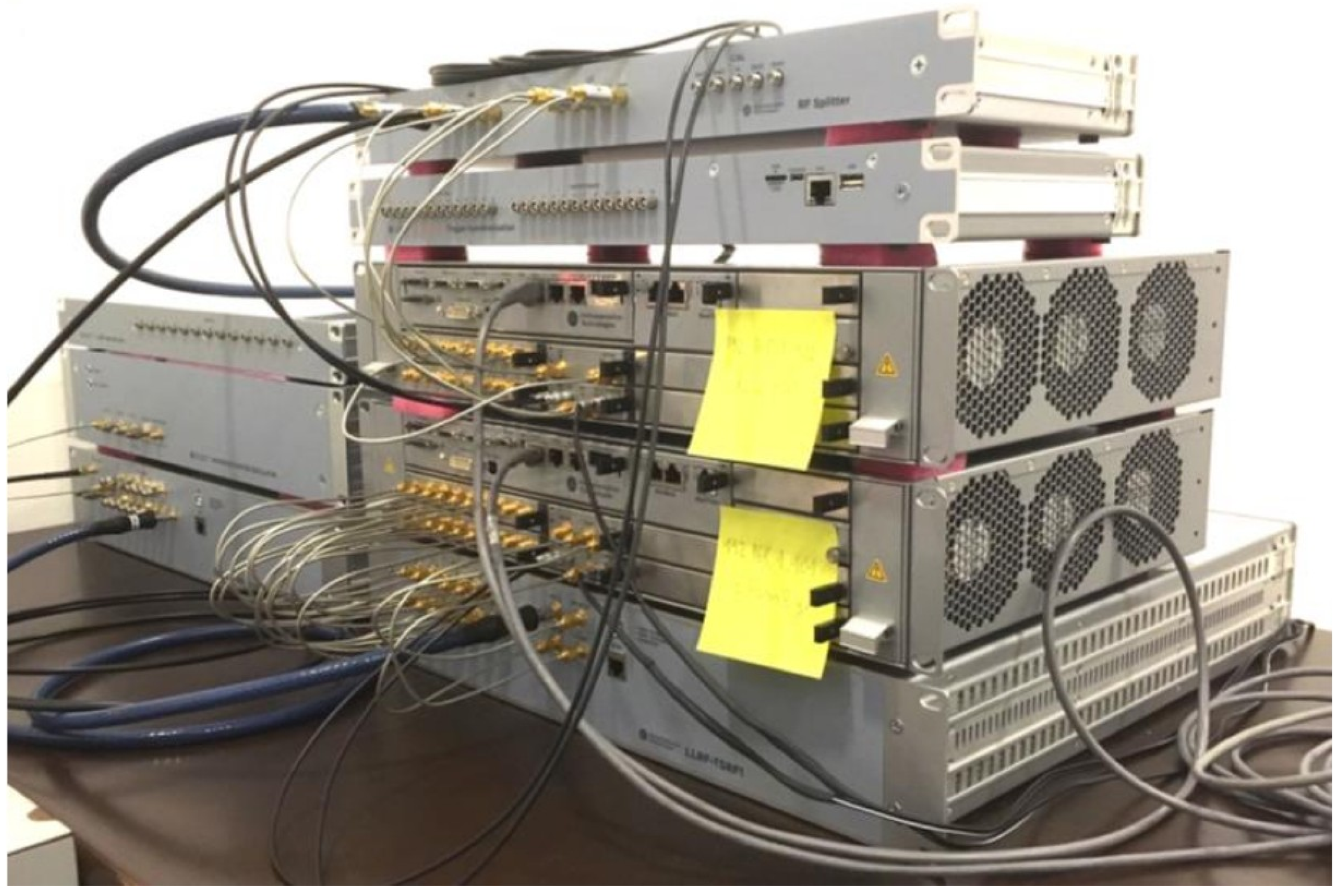

Figure 4: LIGHT LLRF system during SAT at AVO-ADAM

Conclusion

The LIGHT LLRF system has been delivered to AVO-AVAM in all sub-systems including Master Oscillator, trigger synchronization, RF amplifier and SAT was successfully completed. It became possible as a result of a strong collaboration between AVO-ADAM and Instrumentation Technologies teams, as both companies are building up their positions in industrial accelerator applications. The innovative LLRF solution for LIGHT, based on the versatile Libera platform, ensures the performance for a successful accomplishment of this challenging medical accelerator project.

References

[1] ADAM/AVO website: https://www.avoplc.com/
[2] B. Baricevic et al. “LIGHT proton therapy LINAC LLRF system development”, LINAC18, Beijing, September 2018
[3] A. Degiovanni et al. “Status of the commissioning of the LIGHT prototype”, IPAC'18, Vancouver, April 2018
[4] ADAM/AVO, Private Communication.
[5] G. De Michele et al.,”Commissioning status of the LIGHT development machine”, LINAC'18, Beijing, September 2018
[6] L. Piersanti et al., “Review of the ELI-NP-GBS Low Level RF and synchronization systems”, IPAC'18, Vancouver, April 2018
[7] D. Angal-Kalinin et al., “Commissioning of front end of CLARA facility at Daresbury Laboratory”, IPAC'18, Vancouver, April 2018
[8] R. Cerne et al., “Temperature stabilized LLRF control for new generation linear accelerators”, LLRF'17, Barcelona, October 2017

ADAM an ADVANCED ONCOTHERAPY company

Instrumentation Technologies, d.o.o. / Velika pot 22 / SI-5250 Solkan / Slovenia
P: +386 5 335 26 00, F: +386 5 335 26 01, E: info@i-tech.si, W: http://www.i-tech.si

INSTRUMENTATION TECHNOLOGIES