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RF Control interlocks correlation in EPICS/CS-Studio based on White Rabbit Technology. Post-mortem analysis and first results in LIPAc accelerator The innovative IFMIF

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Linear IFMIF Prototype Accelerator (LIPAc), located in Rokkasho, Japan is a linear accelerator whose objective is to validate the final IFMIF accelerators concept. LIPAc includes 18 RF power chains, distributed in a nine meters RFQ cavity with 8 chains, 2 buncher cavities with one chain per cavity and a superconducting cavity with the remaining 8 chains. In terms of beam power, LIPAc aims to reach a (9MeV, 1.1MW) deuteron beam at 125mA in CW. At present the project is finishing the commissioning of its second of four phases that consists in Injector + RFQ (Radio-frequency quadrupole) + MEBT (Medium Energy Beam Transport) + DPlate (Diagnostic plate) + LPBD (Low Power Beam dump).

One of the state-of-the-art features that this accelerator has is the distribution of RF, timing synchronization and precise diagnostic timestamp through White Rabbit technology. The utilization of White-Rabbit technology allows controlling each chain's frequency, amplitude and phase independently, simplifying significantly the facility commissioning and tuning operation.
White-Rabbit (WR) is a fully deterministic Ethernet-based network for general purpose data transfer and synchronization. It was born at CERN for time and frequency dissemination up to 1000 nodes, demonstrating the capability to provide synchronization accuracy better than 100ps and stability on frequency dissemination better than 2ps. It is self-calibrated and allows plug and play deployment due to a periodically temperature compensation.

The LIPAC LLRFs have been designed with the aim of being flexible and precise systems including multiple features in order to be as stable and accurate as possible. One of the new features is the possibility of correlating RF Control interlock between difference control systems using EPICS and CSS/BOY combined with WR. Using the PVs and the timestamps supplied by WR, it has been possible the creation of an interlock's management system for individual LLRF, which is an ordered way to represent the interlocks data. The aim is to obtain a correlate and time-structured historical of interlocks data for all RF control system. The data are timestamped with the precision of WR and can be displayed in a graphical way in CSS or stored for a post-analysis.

This feature allows the possibility of monitoring and correlating the interlocks occurred in the system working in stand-alone or as a complete system where all the LLRF are synchronized with a sub-nanosecond precision. Thereby achieving an improvement in the reliability of the system by providing frequent points of failure or vulnerable points in the accelerator, RF amplifiers, subsystems⋯.

The first LLRF synchronization results on the combined cavity using multiple outputs and preliminary results will be presented.

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