

Variable RF Parameters along European XFEL Bunch Trains.



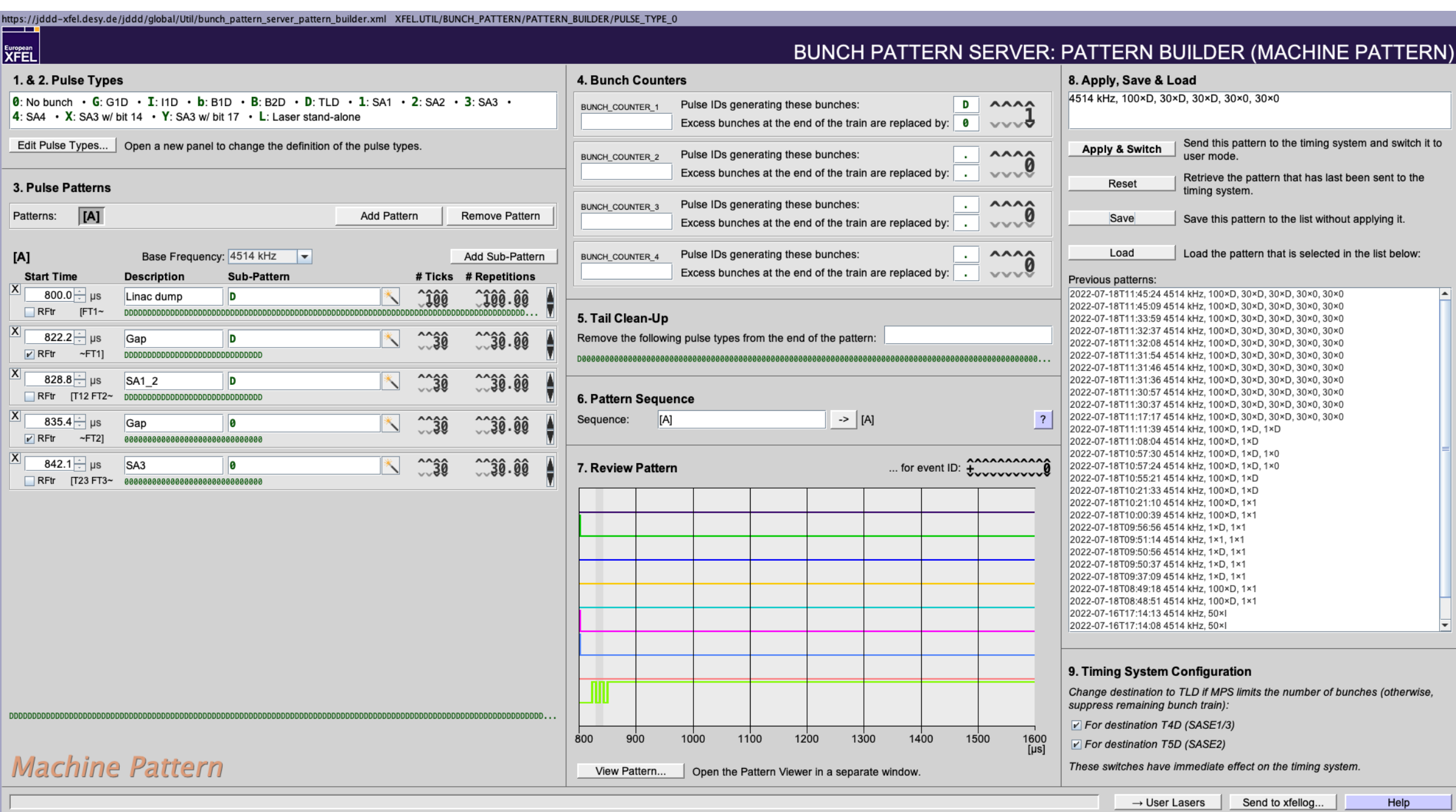
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On behalf of the DESY Beam Regions Team

Introduction

Superconducting RF allows for long RF pulses compared to warm normal conducting machines. At the European XFEL these pulses are used to transport up to 2700 bunches per pulse to the user stations.

In order to allow for flexible control of beam properties along the pulse the LLRF system was modified. In this software architecture we are no longer limited to three "flat-tops". Instead, amplitudes, phases, and feedback targets can be controllable via fine-grained tables of setpoints in up to 16 beam regions. The advantage of the BRs is that we can not only add slopes on the RF amplitudes



High Level Control

Beam regions are defined together with the definition of the bunch train. Certain parts of the train can be set as “transition”. These bunches are not used in the undulator lines and the LLRF system has basically no boundary conditions here.

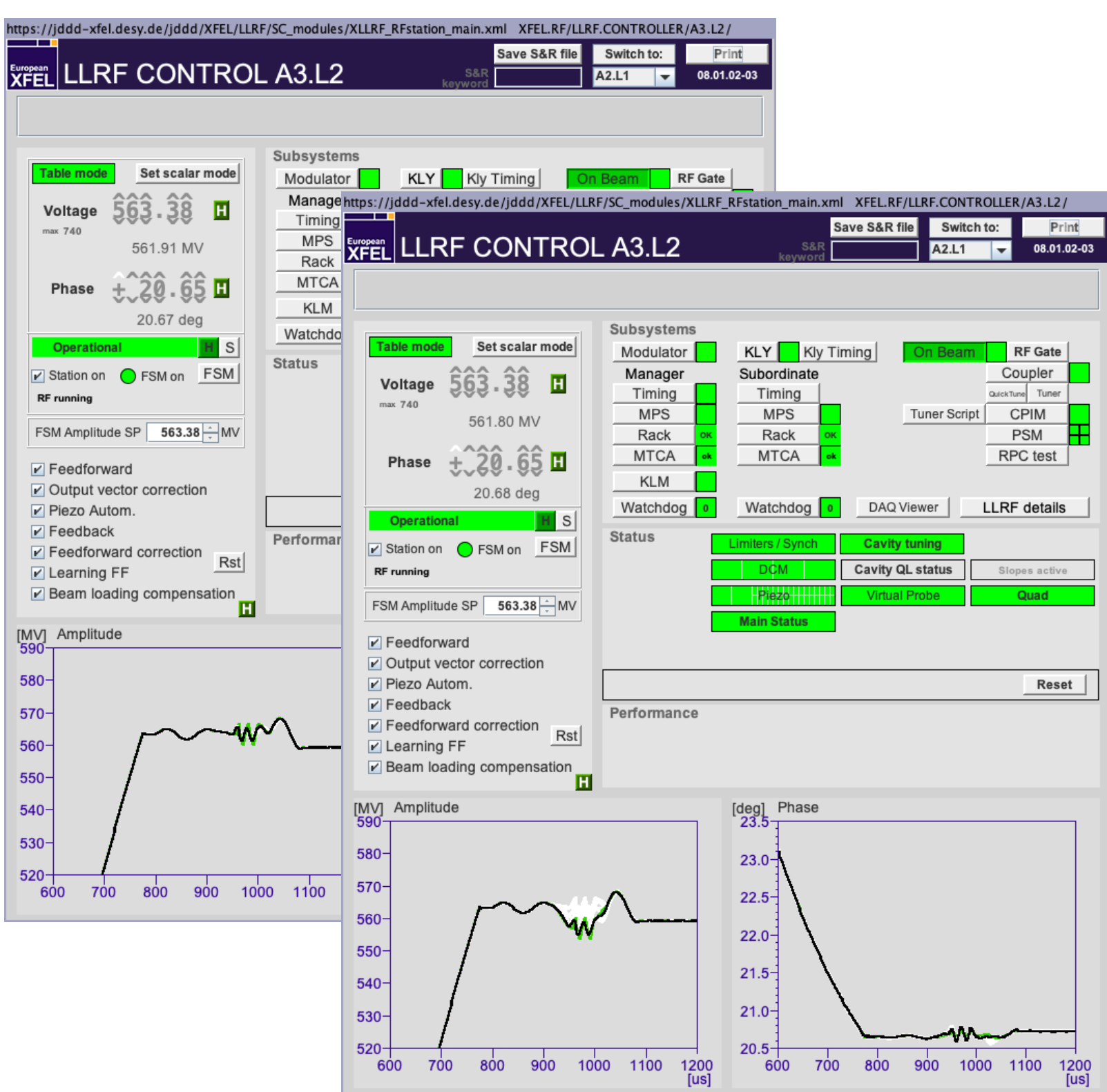
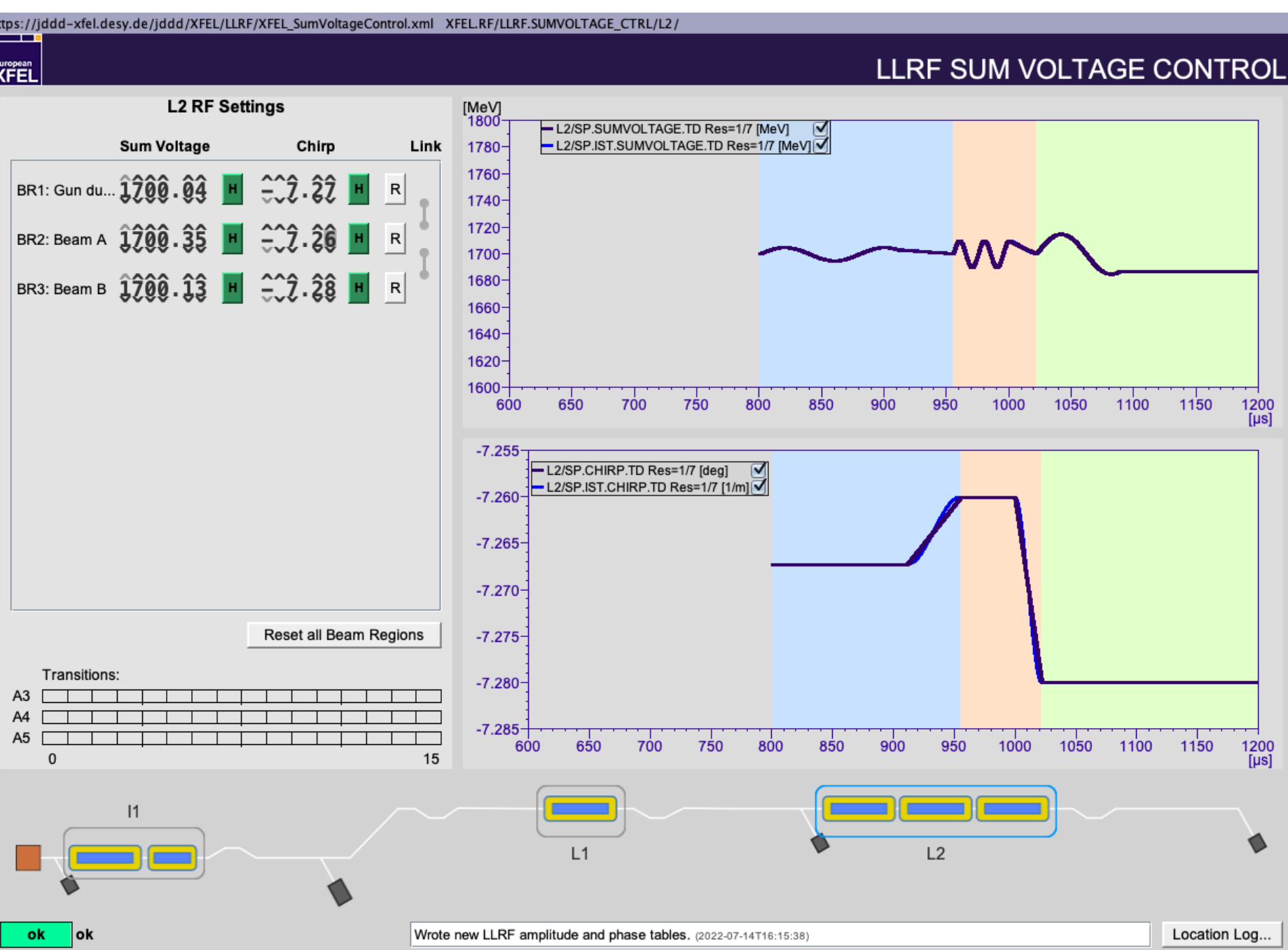
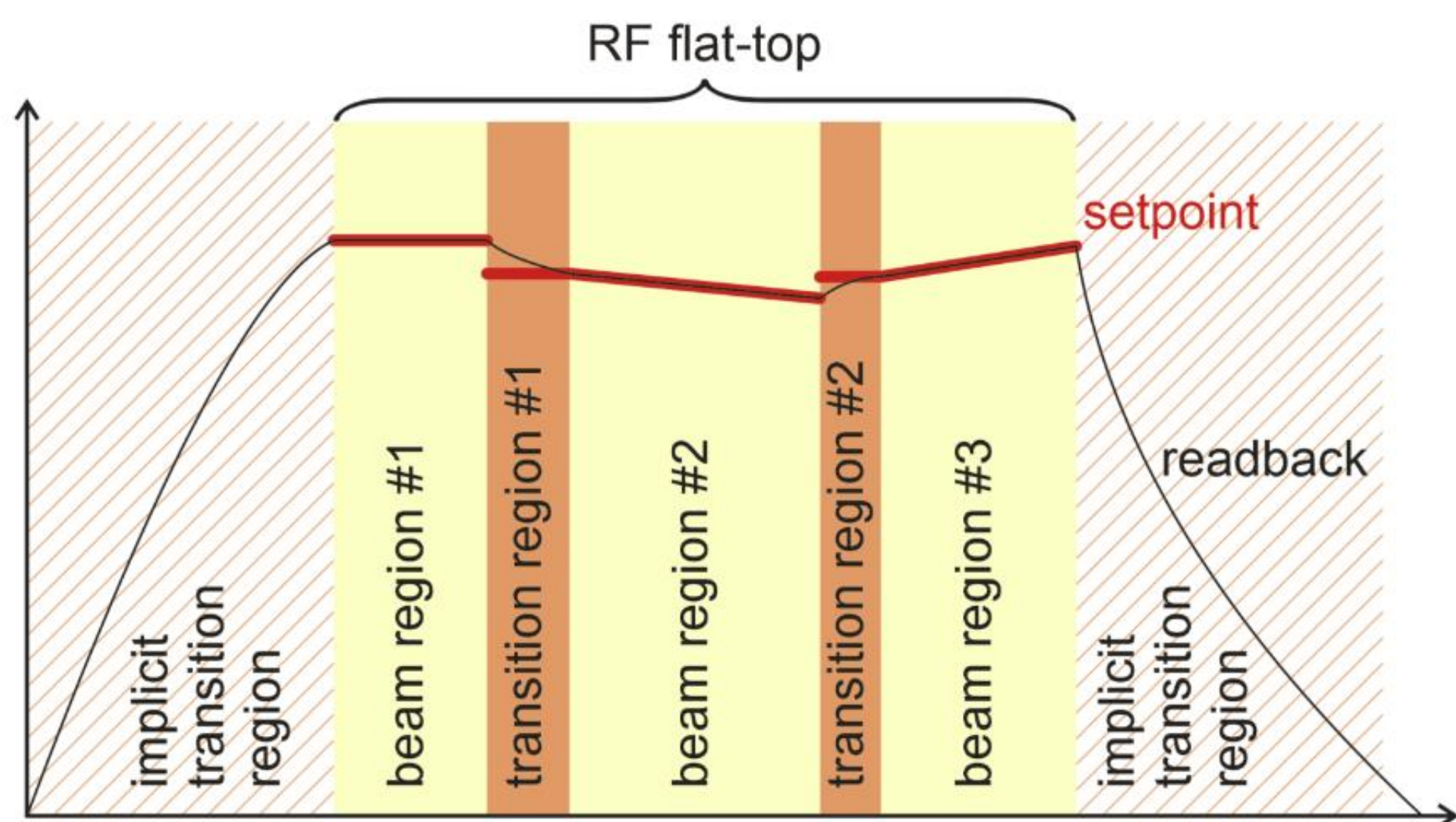
Each transition section defines a new beam region which starts after. These beam regions are dynamically created and available to control in the sum voltage server.

In each beam region a table can be defined by the user – in addition the first entry in each table is exposed with tuning “knobs” which would shift the whole BR to allow efficient FEL tuning.

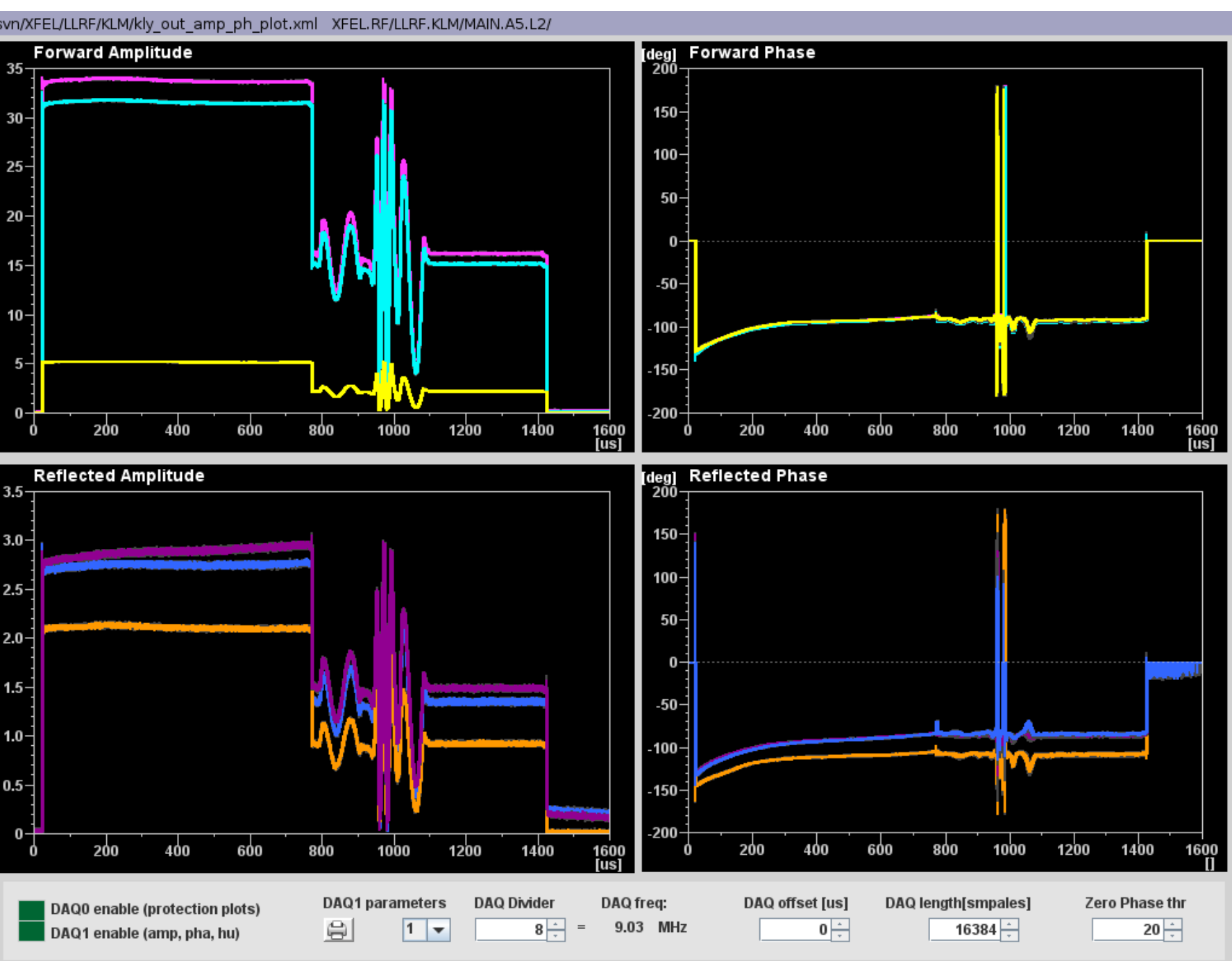
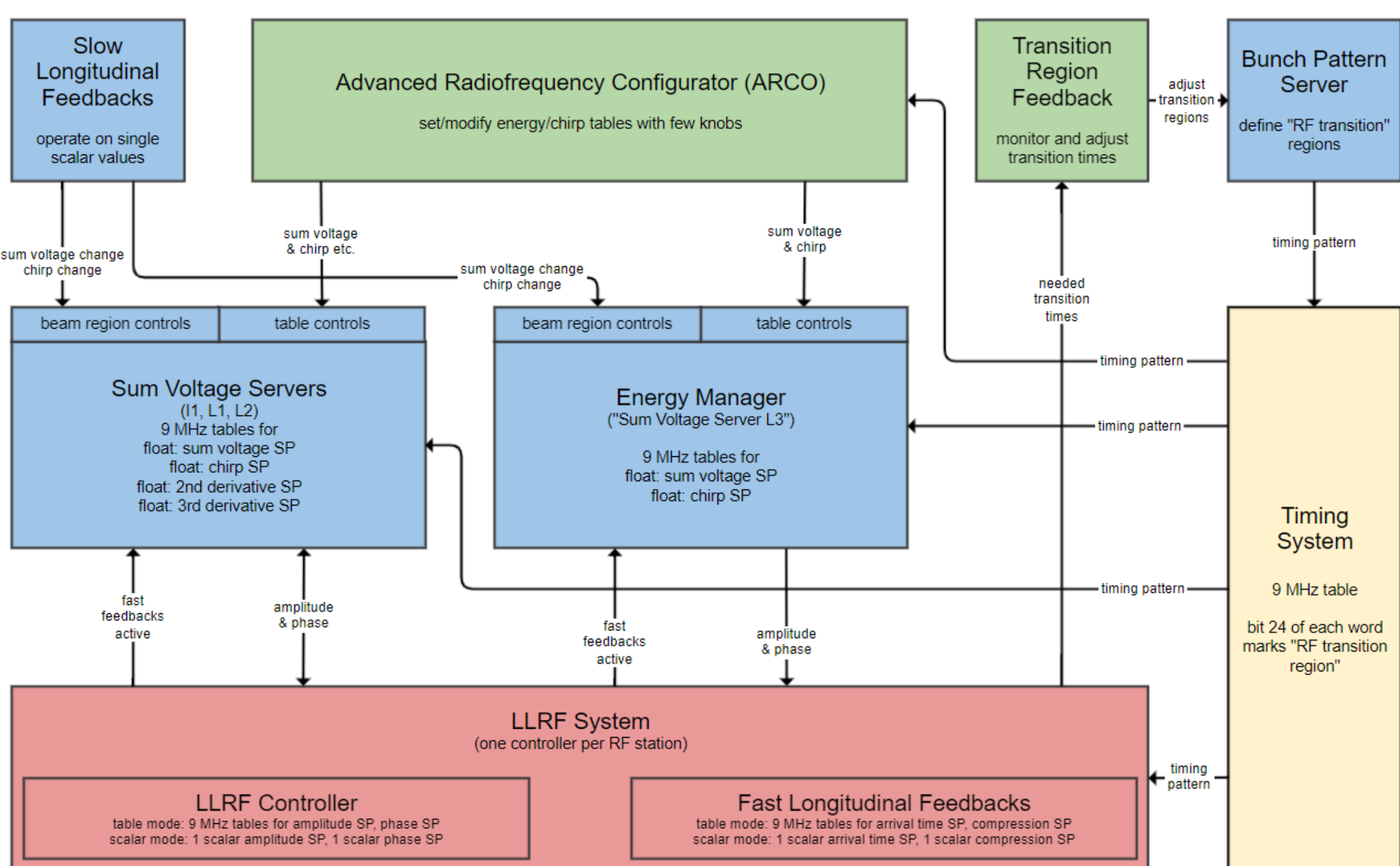
If the requested variation is exceeding the limits of the RF system the table is rejected by the server and a warning is indicated on the user interface. A soft limit “slew rate” is used to prevent RF limiter action.

and/or phases but basically any function or table within the cavity bandwidth. This allows for correction of intra train distortions or novel FEL modes.

RF stations are driven either in the “legacy” “scalar-mode” with direct control of voltage and phase e.g. for maintenance purposes like on-crest phase scans or in the preferred “table mode” which only allows control in physical parameters like chirp or energy gain. Table mode allows for arbitrary tables of these parameters.



Controls Concept Overview



Correction Concept

If desired energy or compression profiles deviate from the measured correction tables can be generated automatically.

Rate of change is limited by cavity bandwidth and RF station performance. Bunches in the transition regions are dumped upstream of the undulator lines.

European XFEL

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