**Abstract**

In order to preserve beam stability with nominal bunch intensity in the LHC, longitudinal emittance blow-up is performed during the energy ramp by injecting phase noise in the main accelerating cavities. The noise spectrum spans a small frequency band around the synchrotron frequency. It is generated continuously in software and streamed digitally into the Digital Signal Processor (DSP) of the Beam Control system where it is added to the pick-up signal of the beam phase loop, resulting in a phase modulation of the accelerating RF. In order to achieve reproducible results, a feedback system, using as input the measured bunch lengths averaged over each ring, controls the strength of the excitation, allowing the operator to simply set a target bunch length. The spectrum of the noise is adjusted to excite the core of the bunch only, extending to the desired bunch length. As it must follow the evolution of the synchrotron frequency through the ramp, it is automatically calculated by the LHC settings management software from the momentum ramp and RF voltage. The system is routinely used in LHC operation since June 2010. We present here the details of the implementation in software, FPGA firmware and DSP code, as well as some results with beam.

**Motivation**

- First attempt to ramp nominal intensity single bunch (Fig. 1).

**System overview**

- Feedback gain
- Feedback memory
- Target length
- Amplitude
- Frequencies
- LSA
- Feedback filter
- Noise generator
- amplitude correction
- write buffer
- Noise buffer
- BQM notification
- PESA
- 89 ns
- end of buffer
- Swap buffers
- buffer 1
- buffer 2
- FPG + DSP
- phase loop
- interpolate noise
- swap

The LSA layer can keep track of the settings and regenerate them if anything relevant changes. The PESA layer uses the settings sent by LSA to calculate on the fly the noise. It also talks with the FPGA to refill the noise buffer each time the DSP empties a buffer.

**Results**

- Without the longitudinal blow-up system, the LHC would not be able to ramp nominal bunches.
- Achieves reproducibility with a ±50 ps error[5].
- Reduces the spread of bunch lengths, see Fig. 7.
- Spread is about 60 ps after injection and is reduced to around 15 ps at flat top.
- Improvements are in the pipeline to increase the measurement rate of the mean bunch length done by the BQM (currently 5 s).
- Lower time constant means higher gain without instabilities.

**References**

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