The LHC Luminosity Control Stack

The LHC luminosity control software stack controls and optimizes the Luminosity at the LHC Interaction Points (IP). This is achieved by adjusting the beam separation, crossing angle, or squeeze factor ($\beta^*$) at an IP.

**Luminosity at an IP** (Gaussian beams):

$$ L = \frac{f_{rev}N_{11}\times n_{bunches} \times Y}{4\pi\beta^* e} G S $$

... where:

- $f_{rev}$: revolution frequency
- $N_{11}$: bunch intensities in beam 1 and beam 2
- $n_{bunches}$: number of colliding bunches
- $\beta^*$: squeeze (function) at the IP
- $e$: relativistic factor
- $e$: normalized transverse emittance

**Luminosity Optimization**

Scan the beam separation while acquiring the luminosity signal to find the beam head-on position giving maximum luminosity.

**Automatic Calibration Scans**

Perform separation scans synchronized with the experiments of arbitrary patterns, defined in a Domain Specific Language, to calibrate the absolute luminosity measurement using the van-deer-Meer method.

**Crossing Angle Changes & More**

Orchestrate multiple systems (e.g. power converters, orbit feedback, collimators) to smoothly adjust machine parameters like the crossing angle or $\beta^*$ while the beams are in collision.

For example with decreasing beam intensities, the crossing angle can be decreased. This is used operationally at the LHC in 2017.

**Separation Luminosity Levelling**

Keep the luminosity constant at an IP around a target value by adjusting the crossing angle and the beams are in collision. This is in particular used for the two low-luminosity experiments (ALICE and LHCb) at the LHC.

**LHC Luminosity Server**

For development and testing, the LHC Luminosity Server can run in full simulation mode without accessing the LHC control system or any device. For dry-runs and tests e.g. of the LHC-experiment communication (DIP), it can run in partial simulation (“wonderland”) mode where every aspect and signal can be individually switched between its real and simulated counterpart.

**References**


