

1 CERN and the Large Hadron Collider

The European Council for Nuclear Research (in French *Conseil Européen pour la Recherche Nucléaire*), also known as CERN, is the site of an accelerator complex hosting the Large Hadron Collider (LHC). The LHC consists of a 27-kilometer ring of superconducting magnets with accelerating structures to boost the energy of particles, which collide at a center-of-mass energy of up to 14 TeV. The beams inside the LHC are made to collide at four locations around the accelerator ring, at the locations of four particle detectors: ATLAS, CMS, ALICE, and LHCb.

The number of events generated per second at the LHC collisions is given by $N_{event} = \mathcal{L}\sigma_{event}$, where σ_{event} is the cross-section for the event under study, and \mathcal{L} the machine luminosity. The machine luminosity depends only on the beam parameters, and can be written for a Gaussian beam distribution as:

$$\mathcal{L} = \frac{N_b^2 n_b f_{rev} \gamma_r}{4\pi \epsilon_n \beta^*} F \quad (1)$$

where N_b is the number of particles per bunch, n_b the number of bunches per beam, f_{rev} the revolution frequency, γ_r the relativistic gamma factor, ϵ_n the normalized transverse beam emittance, β^* the beta function at the collision point, and F the geometric luminosity reduction factor due to the crossing angle at the interaction points. Luminosity is measured in units of $\text{cm}^{-2} \text{s}^{-1}$. Thus the exploration of rare events in the LHC collisions requires both high beam energies and high beam intensities.