

1 Luminosity

The intensity of collisions in a particle physics experiment is quantified through the *luminosity*. In a colliding beams experiment this is given by

$$\mathcal{L} = \frac{n_b}{2\pi} \frac{f_{\text{rev}} N_1 N_2}{\sigma_x \sigma_y} \quad (1)$$

when a total of n_b bunches are circulating in the collider with N_1 particles per bunch in bunches circulating in one direction and N_2 particles per bunch circulating in the opposite direction. f_{rev} is the circulation frequency of the bunches. σ_x and σ_y is the width (usually assumed to be Gaussian) of each bunch in the two directions transverse to the velocity when the bunches are in the collision region¹.

We can see from equation (1) that luminosity has the units of $1/(\text{area} \times \text{time})$. The conventional units to use are $\text{cm}^{-2}\text{s}^{-1}$. For instance, the peak luminosity obtained by LHC in the ATLAS in 2018 was

$$\mathcal{L}_{\text{peak}} = 21.0 \times 10^{33} \text{ cm}^{-2}\text{s}^{-1}.$$

This way of expressing the collision intensity makes it easy to calculate event rates. If the collision cross section is σ , then the event rate is

$$\frac{dN}{dt} = \sigma \mathcal{L}. \quad (2)$$

This expression holds independent on whether σ is the total collision cross section or the cross section for a specific process. Since cross section is usually expressed in units of barns ($1 \text{ b} = 10^{-28} \text{ m}^2$) it may be useful to express the luminosity in units of $\text{b}^{-1}\text{s}^{-1}$ using

$$10^{34} \text{ cm}^{-2}\text{s}^{-1} = 10^{10} \text{ b}^{-1}\text{s}^{-1} = 10 \text{ nb}^{-1}\text{s}^{-1}.$$

1.1 Integrated luminosity

The amount of data collected over a certain time is quantified through the integrated luminosity,

$$\int \mathcal{L} dt. \quad (3)$$

The integrated luminosity is given in units of inverse barn. With the amount of data collected by ATLAS, one usually have a number of fb^{-1} . Using equation (2) it is easy to calculate the expected number of events of a certain type given an integrated luminosity as long as one knows the relevant cross section.

¹Bunches are generally squeezed to have a much smaller transverse size in the collision region than in the rest of the machine.

A Natural units