luminosity, which is defined as the instantaneous luminosity integrated over the total time of the experiment. If more there is more than one bunch per beam, the number of bunch crossings at a given interaction point (i. e., for a single experiment) is increased by the number of bunches, N_b.

Of course for a useful number, we must account for any dead time of the experimental apparatus. In order to identify the B mesons in this experiment, the detector must identify the tracks of the particles from the decays of the B mesons. The detector takes a certain amount of time to accumulate and log the data, producing a period of time in which the detector is unable to identify a new event. This is called the dead time of the detector.

This type of event produces many daughter particles, and if there are two simultaneous events, the data is usually too confused to be useful. Because of this confusion, it is useless to have the average number of interactions per beam crossing greater than some value (usually one or less for most experiments.)

For an experiment with a single beam incident on a fixed target, the intensity is traditionally quoted as the number of beam particles hitting the target per second, rather than as a luminosity.

Two other terms used for defining intensities are used with synchrotron light sources: brightness and brilliance. Both are proportional to the number of photons hitting the target per second, but they have the added feature of being inversely proportional to the band width, or energy spread of the photon beam. Brightness is defined as the number dn, of photons per time interval dt, passing through a solid angle $d\Omega$, and divided by 0.1% of the bandwidth $d\lambda/\lambda$,

$$\Phi_\Omega = 1000\,\frac{d^4 n}{dt\,d\Omega\,(d\lambda/\lambda)}. \tag{1.5}$$

Brilliance is defined as the brightness per area, s, of the source,

$$B = \frac{d\Phi_\Omega}{ds}. \tag{1.6}$$

In the rest of this chapter we review some basic concepts and briefly discuss a few of the early types of particle accelerators, which illustrate the different techniques used to accelerate charged particles.

1.2 Direct–voltage accelerators

The simplest type of elementary particle accelerator is a source of electrons or ions, and a pair of electrodes, activated by a potential drop ΔV, as shown in Fig. 1.1.

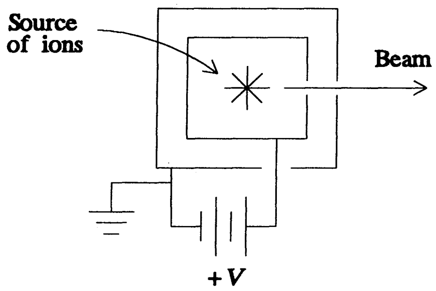

Figure. 1.1 A simple accelerator for charged ions of charge q. The kinetic energy of the beam is approximately qV.

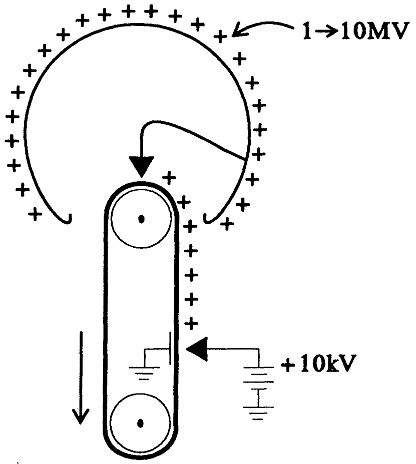

Figure. 1.2 A Van de Graaff generator. Electrons are pulled off the belt by a corona discharge at the bottom. The net positive charge moves up with the belt inside the dome, where electrons from the dome are pulled onto the belt through another corona discharge. As a result, the dome can reach a potential of several million volts relative to the lower corona points which are at ground.

Indeed such an apparatus is the prototype of a class of devices (cathode ray tubes, electron microscopes, etc.) which come under the branch of "Electron Optics." All direct current accelerators are variations on this theme, e. g., the electrostatic generator constructed by Van de Graaff[2] and the cascade generator developed by Cockcroft and Walton,[3] who first succeeded in disintegrating nuclei with accelerated particles.

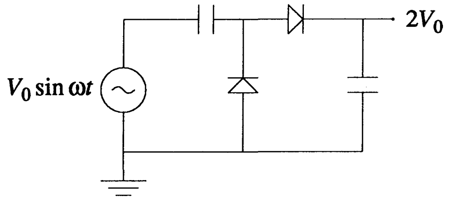

Figure. 1.3 A simple cascade circuit for doubling the voltage of an input generator.

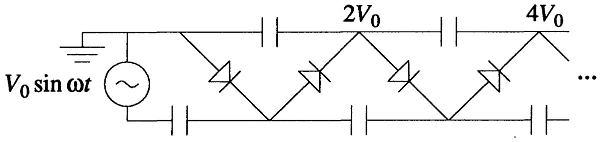

Figure. 1.4 A multistage cascade Cockcroft–Walton circuit, which rectifies and multiplies the input voltage.

Fig. 1.2 shows the sketch of the Van de Graaff electrostatic generator: a belt of insulating material runs between ground and a high-voltage generator ($\simeq$ 10 kV); corona discharge provides charge to the belt which, in its turn, induces electrostatic charges in the "hot" terminal (1—10 MV); another corona discharge neutralizes the belt. Notice how the drive of the engine is one of the best examples of electromotive force!

Mixtures of high pressure gases (N_2 and CO_2, for example) provide insulation and material for corona discharges. This machine can accelerate charged particles of either polarity.

A further improvement is the tandem generator, where negative ions are accelerated from the ground to the terminal, then are stripped of most of their electrons by a thin foil, hence the resulting positive ions are accelerated back to ground potential. In principle the energy gain can be increased (twice for protons) with respect to a simple acceleration.

The cascade generator is an extension of the doubling circuit, shown in Fig. 1.3, where two rectifying diodes and two capacitors, applied to an ac generator $V(t) = V_0 \sin \omega t$, give an almost dc voltage, $2V(t)$.

Fig. 1.4 shows a sketch of a multistage cascade generator, capable of reaching a few million volts of potential. In both these high voltage generators the voltage must be distributed along the accelerating tube via either capacitive or resistive partitions, in order to avoid electric disruptions.