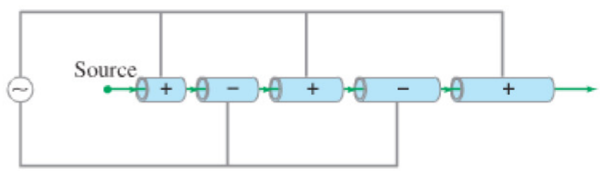
Linear Accelerators

Linac In a **linear accelerator** (linac), electrons or ions are accelerated along a straight-line path, Fig. 32–4a, passing through a series of tubular conductors. Voltage applied to the tubes is alternating so that when electrons (say) reach a gap, the tube in front of them is positive and the one they just left is negative. At low speeds, the particles cover less distance in the same amount of time, so the tubes are shorter at first. Electrons, with their small mass, get close to the speed of light quickly, $v \approx c$, and the tubes are nearly equal in length. Linear accelerators are particularly important for accelerating electrons because of the absence of synchrotron radiation. The largest electron linear accelerator is at Stanford (Stanford Linear Accelerator Center, or SLAC), Fig. 32–4b. It is about 3 km (2 mi) long and can accelerate electrons to 50 GeV. Many hospitals have 10-MeV electron linacs that strike a metal foil to produce γ ray photons to irradiate tumors.



(a)


(b)

FIGURE 32–4 (a) Diagram of a simple linear accelerator. (b) Photo of the Stanford Linear Accelerator (SLAC) in California.

Colliding Beams

Colliders High-energy physics experiments can be done by allowing a beam of particles from an accelerator to strike a stationary target. But to obtain the maximum possible collision energy from a given accelerator, two beams of particles are accelerated to very high energy and are steered so that they collide head-on. One way to accomplish such **colliding beams** with a single accelerator is through the use of **storage rings**, in which oppositely revolving beams can be repeatedly brought into collision with one another at particular points. For example, in the experiments that provided strong evidence for the top quark (see Chapter opening photo and Section 32–9), the Fermilab Tevatron accelerated protons and antiprotons each to 900 GeV, so that the combined energy of head-on collisions was 1.8 TeV.

The largest collider will soon be the Large Hadron Collider (LHC) at CERN, with a circumference of 26.7 km (Fig. 32–5), scheduled to be completed about 2007. The two colliding beams will each carry 7-TeV protons for a total interaction energy of 14 TeV.

FIGURE 32–5 The large circle represents the position of the tunnel, about 100 m below the ground at CERN (near Geneva) on the French-Swiss border, which will house the LHC. The smaller circle shows the position of the Super Proton Synchrotron that will be used for accelerating protons prior to injection into the LHC.