If a vertex constraint is applied at the origin of the track, the coefficient under the radical becomes 320.

The contribution due to multiple Coulomb scattering is approximately

$$\delta k_{\mathrm{ms}} \approx \frac{(0.016)(\mathrm{GeV}/c)z}{Lp\beta\cos^2\lambda}\sqrt{\frac{L}{X_0}} \ , \tag{12.19}$$

where $p =$ momentum (GeV/c)
$z =$ charge of incident particle in units of e
$L =$ the total track length
$X_0 =$ radiation length of the scattering medium (in units of length; the X_0 defined elsewhere must be multiplied by density)
$\beta =$ the kinematic variable v/c.

More accurate approximations for multiple scattering may be found in the section on Passage of Particles Through Matter (Sec. 10 of this *Review*). The contribution to the curvature error is given approximately by $\delta k_{\mathrm{ms}} \approx 8s^{\mathrm{rms}}_{\mathrm{plane}}/L^2$, where $s^{\mathrm{rms}}_{\mathrm{plane}}$ is defined there.

12.9. Superconducting solenoids for collider detectors

12.9.1. ***Basic (approximate) equations***: In all cases SI units are assumed, so that B is in tesla, E is in joules, dimensions are in meters, and $\mu_0 = 4\pi \times 10^{-7}$.

Magnetic field. The magnetic field at the center of a solenoid of length L and radius R, having N total turns and a current I is

$$B(0,0) = \frac{\mu_0 NI}{\sqrt{L^2 + 4R^2}} \ . \tag{12.20}$$

Stored energy. The energy stored in the magnetic field of any magnet is calculated by integrating B^2 over all space:

$$E = \frac{1}{2\mu_0}\int B^2 dV \ . \tag{12.21}$$

For a solenoid with an iron flux return in which the magnetic field is $< 2T$, the field in the aperture is approximately uniform and equal to $\mu_0 NI/L$. If the thickness of the coil is small, (which is the case if it is superconducting), then

$$E \approx (\pi/2\mu_0)B^2R^2L \ . \tag{12.22}$$

Cost of a superconducting solenoid [46]:

$$\text{Cost (in M\$)} = 0.523\,[(E/(1\ \ \mathrm{MJ})]^{0.662} \tag{12.23}$$

Magnetostatic computer programs. It is too difficult to solve the Biot-Savart equation for a magnetic circuit which includes iron components and so iterative computer programs are used. These include POISSON, TOSCA [47], and ANSYS [48].