chapter 6

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1 6.1

- spin : 1
- three quarks exist for every flavour
- 8 kinds of gluons

2 6.2

When $\sqrt{s} = 2.5$ R=2,$\sqrt{s} = 4$ $R = \frac{10}{3}$

3 6.3

(a)

$$\frac{pT}{p} = \frac{1}{\sqrt{s}} = 0.223607 \tag{1}$$

(b)

$$\frac{d\sigma}{d\Omega} \propto (1 + cos^2(\theta)) \tag{2}$$

So the rate is $\frac{4}{7}$

4 6.4

We use formula:

$$x = \frac{Q^2}{2\nu m_p} \tag{3}$$

$E^{'} = 33.37GeV$

5 6.5

$$
\begin{aligned}
x &= \frac{Q^2}{2(E-E')m_p} \\
E &= E^{'} + \frac{EE^{'}}{m_p}(1-cos\theta) \\
Q^2 &= 2EE^{'}(1-cos\theta)
\end{aligned} \tag{4}
$$

So $x = 1$, for the elastic scattering.

6 6.8

$$
\begin{aligned}
Q^2 &= 2xm_p(E - \frac{Q^2}{2E(1-cos\theta)}) \\
Q^2 &= \frac{2E^2(1-cos\theta)}{1+\frac{E}{xm_p}(1-cos\theta)}
\end{aligned} \tag{5}
$$

When $\theta = \pi$, Q^2 is maximum. $Q^2 = 37.48GeV^2$

7 6.9

$\sqrt{s} = 313.68GeV$

$$
E_{e,f} = 52448GeV \tag{6}
$$

- When x=0.4, $Q^2_{max} = 39356GeV^2$
- When x=0.01, $Q^2_{max} = 983GeV^2$
- When x=0.0001, $Q^2_{max} = 9.84GeV^2$

8 6.10

$$
\alpha_s(Q^2) = \frac{12\pi}{(33-2n_f)ln(Q^2/\Lambda^2_{QCD})} \tag{7}
$$

$\alpha_s((10GeV)^2)$=0.209, and $\alpha_s((100GeV)^2)$=0.132

$$
\alpha(Q^2) = \frac{\alpha(\mu^2)}{1-6.67\frac{\alpha(\mu^2)}{3\pi}ln(Q^2/\mu^2)} \tag{8}
$$

$\alpha((10GeV)^2)$=0.00757, and $\alpha((100GeV)^2)$=0.00776

9 6.15

$$
\begin{aligned}
R_{2GeV} &= \frac{\sigma(hadrons)}{\sigma(\mu)} = 2 \\
R_{20GeV} &= \frac{\sigma(hadrons)}{\sigma(\mu)} = \frac{11}{3} \\
R_{\mu} &= \frac{\sigma(2GeV)}{\sigma(20GeV)} = 100 \\
R_{hadrons} &= \frac{\sigma(2GeV)}{\sigma(20GeV)} = 100
\end{aligned} \tag{9}
$$

10 6.16

$$
E^{'} = \frac{E}{1 + \frac{E}{M}(1 - cos\theta)} = 4.75GeV \tag{10}
$$

$$
\begin{aligned}
&s = 2Em_p = (E_{CM} + \sqrt{m_p^2 + E_{CM}^2})^2 \\
&E_{CM} = 1.39GeV
\end{aligned} \tag{11}
$$

11 6.17

(a)

$$
R_i = 3.125 * 10^{12} s^{-1} \tag{12}
$$

(b)

$$
\Delta\Omega = \frac{1}{2500} \tag{13}
$$

(c)

$$
\frac{d\sigma}{d\Omega} = \frac{z^2 Z^2 \alpha^2}{16E^2} \frac{1}{sin(\frac{\theta}{2})^4} = 2.54 * 10^{-27} m^2 \tag{14}
$$

(d)

$$
Hit = \frac{10^3 R_i \rho N_A l}{A} \Delta\Omega \frac{d\sigma}{d\Omega} = 2.1 * 10^7 \tag{15}
$$

12 1.21

$$
Q_{max}^2 = \frac{4E^2}{1 + \frac{2E}{M_{Fe}}} = 15(GeV)^2 \tag{16}
$$

$\theta = \pi$

13 1.22

$$\frac{d\sigma}{d\Omega} \propto \frac{1}{sin^4 \frac{\theta}{2}} \tag{17}$$

So $\frac{\sigma_{\theta>90}}{\sigma_{\theta>10}} = 0.00765$

14 1.23

$$L = I\rho 10^3 l N_A / A = 5.9 * 10^{25} m^{-2} s^{-1} \tag{18}$$

$$\sigma = \frac{\pi z^2 Z^2 \alpha^2}{8E^2} \int_{0.1}^{\pi} \frac{sin(\theta)}{sin(\frac{\theta}{2})^4} d\theta = 4.5 * 10^{-25} m^2 \tag{19}$$

$$R = L\sigma = 26.5 s^{-1} \tag{20}$$

15 1.24

Scatter elastically have maximum energy:

$$E^{'} = 4.12 GeV \tag{21}$$

16 1.25

$$E^{'} = \frac{E}{1 + \frac{E}{M}(1 - cos\theta)} \tag{22}$$

$\theta = 21.6$

17 1.26

$$(\frac{d\sigma}{d\Omega})_{Mott} / (\frac{d\sigma}{d\Omega})_{Rutherford} = cos^2 \frac{\theta}{2} = \frac{1}{2} \tag{23}$$