6.1.5 The process $\gamma gg \rightarrow J/\psi$

In this approach, the $I\!P$ is modeled by a gluon ladder. Further more, the coupling of the gluon ladder with the proton is not described by the empirical function in Eq. (54), but from the proton structure function and form factor(see below). The two Feynman diagrams are shown in Figure 33(d). The bottom of the gluon ladder couples to the proton instead of the pomeron. The cross section is found to be

$$\frac{d\sigma_{\gamma p \rightarrow J/\psi p}}{dt} = \left[F_p^{2g}\left(t\right)\right]^2 \frac{\alpha_s^2 \Gamma_{ll} m_{J/\psi}^3 \pi^3}{3\alpha} \left[\bar{x} G\left(\bar{x}, \bar{q}^2\right) \frac{2\bar{q}^2 - p_t^2}{\left(2\bar{q}^2\right)^3}\right]^2 \left(1 + \frac{Q^2}{m_{J/\psi}^2}\right) \quad (60)$$

$$\bar{q}^2 = \frac{m_{J/\psi}^2 + Q^2 + p_t^2}{4}; \quad \bar{x} = \frac{m_{J/\psi}^2 + Q^2 + p_t^2}{s_{\gamma p}} \quad (61)$$

where $\bar{x} \approx q \cdot I\!P / q \cdot p$ is the fraction of the proton momentum carried by the pomeron, $\bar{q}^2$ is a hard scale, $G(\bar{x}, \bar{q}^2)$ is the gluon distribution function associated with the proton, and F_p^{2g} is a two-gluon form factor which characterizes correlation between two gluons inside the proton. $F_p^{2g} = 1$ at $t = 0$. In Monte Carlo studies, the electromagnetic proton structure function $F_p^{em}(t) = (1 - \frac{t}{0.71\mathrm{GeV}^2})^{-2}$ is used as F_p^{2g}, although it is an unknown function and should be measured experimentally, strictly speaking.

6.2 Monte Carlo generators

Four MC event samples were used in this analysis. Three events samples EPJPSI 11, EPJPSI 12 and EPJPSI 13 were generated by EPJPSI(version 3.3)[71]. One event sample DIPSI was generated by DIPSI(version 1)[73].

EPJPSI can be used to generate J/ψ produced in a variety of beams and via various mechanisms. In our study, EPJPSI was used to generate events for the following processes:

(1) $ep \to epJ/\psi$ using two gluon ladder model(IPSI=13).

(2) $ep \to epJ/\psi$ using the pomeron and the CS model(IPSI=12).

(3) $ep \to epJ/\psi$ using the pomeron and the Open Charm model(IPSI=11).

DIPSI can be used to simulate elastic vector meson($\rho, \phi, J/\psi, \Upsilon$) production in ep collisions via the two-gluon ladder interaction. In our study, DIPSI is used to generate events for $ep \to epJ/\psi$ using the two-gluon ladder model, which is the same as IPSI=13 process by EPJPSI generator, but with a different parametrization of the proton structure.

The three event samples EPJPSI 11, EPJPSI12, EPJPSI 13 were generated with isotropic decay. In DIPSI sample, the decay angular distribution is derived according to

$$f(\theta) = \frac{1 + \alpha \cos^2 \theta}{2 + 2\alpha/3} \tag{62}$$

where α is about 0.85.

The interesting measurements are $s_{\gamma p}$-dependence and t-dependence of the cross section. $s_{\gamma p}$-dependence is sensitive to the gluon distribution inside the pomeron and the gluon distribution inside the proton(depending on which model is used). For IPSI=12, the $p\mathbb{P}p$ vertex and structure function of the pomeron were fixed in the generator. For IPSI=11, the pomeron structure function can be chosen by the user. EPJPSI 12 sample was generated with a simple scaling function(Q^2 independent) $xG(x) = 6(1-x)$, assuming the pomeron consists of two hard gluons. For IPSI=13, the gluon distribution function xG can be chosen by the user. DIPSI is based on the same model as EPJPSI IPSI=13. The DIPSI sample was generated with the simple scaling $\bar{x}G(\bar{x}) = 3(1-\bar{x})^5$, assuming the gluons inside the pomeron are as soft as inside the proton.