Chapter 7

Comparison with the theoretical prediction

The theoretical prediction for the $R_{b\bar{b}}$ is obtained using the Monte Carlo simulator with the DL pomeron flux. `POMPYT 2.6` and `PYTHIA 5.7`(non-tuned) are used for the diffractive and the non-diffractive processes, respectively. We use EHLQ set-1 structure function [37] which has been confirmed [11] to give the correct underlying multiplicity in minimum bias $p\bar{p}$ scattering in a wide range of $\sqrt{s}$ including the typical $\sqrt{s}$ of the pomeron-proton scattering in the diffractive $b\bar{b}$ production, $\sqrt{s} \sim 300$ GeV. The results of the simulation are summarized in Table 7.1.

	$\sigma_{b\bar{b}}$ (μb)	N_{passed}/N_{gen}(%)	$R_{b\bar{b}}$(%)
non-diffractive	9.45×10^{-1}	0.26	-
Flat-Gluon	1.22×10^{-3}	0.21	10.4
Flat-Quark	1.35×10^{-4}	0.17	0.92
Hard-Gluon	1.26×10^{-3}	0.23	11.6
Hard-Quark	1.29×10^{-4}	0.19	1.02

Table 7.1: Theoretical Model prediction for the diffractive $b\bar{b}$ production

For the flat-gluon structure function of the pomeron we obtain $R_{b\bar{b}}^{\rm MC}$(FG) = 10.4 %, and for the flat-quark pomeron we obtain $R_{b\bar{b}}^{\rm MC}$(FQ) = 0.92%. The CDF data yields $R_{b\bar{b}}^{\rm DAT}$(FG) = 0.63 $\pm$ 0.24 (stat+syst)% for the flat-gluon pomeron, and $R_{b\bar{b}}^{\rm DAT}$(FQ) = 0.93 $\pm$ 0.36 (stat+syst)% for the flat-quark pomeron. This result favors the flat-quark pomeron, but the magnitude of $R_{b\bar{b}}$ depends on the model of the pomeron flux factor, which cannot be uniquely determined by the Regge theory.

The discrepancy of the flux factor between the data and the theory can be evaluated as a function of the gluon fraction, f_g, of the flat(or hard) component of the pomeron by comparing the experimental value of $R_{b\bar{b}}$ with the Monte Carlo predictions [10, 11, 41]. The discrepancy factor D is defined as,

$$D = \frac{R^{\mathrm{DAT}}}{R^{\mathrm{MC}}_{\mathrm{FG}} f_g + R^{\mathrm{MC}}_{\mathrm{FQ}}(1 - f_g)}. \tag{7.1}$$

D=1 means the DL flux is correct, i.e. the factorization of the pomeron flux is right. Figure 7.1(7.2) shows the measured D for various experiments as a function of the flat-gluon (hard-gluon) fraction f_g. The band in the plot shows the $\pm 1\ \sigma$ values of the measurements. The thick solid curve shows the $\pm 1\ \sigma$ limit of the diffractive b-quark measurements. In the calculation of the $R^{\mathrm{DAT}}_{b\bar{b}}$, we take account of the change in the gap acceptance according to the quark to gluon ratio. The measured curve of the D vs f_g for the "flat" structure pomeron (Fig. 7.1) is almost the same as for the "hard" structure pomeron as shown in Fig. 7.2. In other measurements, CDF diffractive-W production [11], CDF diffractive-dijet production [10] and ZEUS measurements (DIS + photo-jet production) [8], the "hard" structure function is used to calculate the discrepancy factor D. The diffractive W-boson production is observed using the electron from $W \to e\nu$ decay in the central rapidity region ($|\eta| < 1.1$), and the ratio of the diffractive to the non-diffractive W-boson production is measured as R_W=1.15±0.55% assuming the gap acceptance of the hard-quark pomeron. The diffractive dijet production is measured using the forward dijets with E_T >20 GeV in the rapidity region of 3.5> $|\eta|$ >1.8 and the ratio of the diffractive to non-diffractive dijet-production is measured as R_{jj}= 0.75 ± 0.05(stat) ± 0.09(syst) % assuming the gap acceptance of the hard gluon pomeron.

The overlap of the bands from the three CDF results shows the allowed range of the D and f_g at the 68% confidence level corresponding to 1σ. The bands slightly meet at their edges of $f_g \sim 0.5$ and $D \sim 0.2$. This result of the gluon fraction is consistent with the results from the ZEUS measurements, $0.3 < f_g < 0.8$. However, the discrepancy factor $D \sim 0.2$ is significantly smaller than the ZEUS results. The discrepancy of the pomeron flux between the CDF and the ZEUS (or DL flux) has already been seen for the diffractive W production and the diffractive dijet production. The CDF results suggest that there is a problem in the hypothesis of the factorization of the pomeron flux described in Chapter 1 [42].

There is a phenomenological model which predicts the break down of the factorization using the "renormalized" pomeron flux [42]. The renormalized flux is defined as the DL flux normalized, if its integral exceeds unity, to one pomeron per nucleon. The discrepancy factor predicted by the renormalized flux is $D_R = 1/(9\beta^{2\epsilon'}) \sim 0.13$, where we used $\beta = 0.5$ [42, 43]. Assuming the gluon fraction of the 70% measured for the diffractive W and the diffractive dijet productions, the discrepancy factor of the diffractive $b\bar{b}$ production is measured to be $D = 0.09 \pm 0.04$, which agrees with the prediction from the renormalized flux.

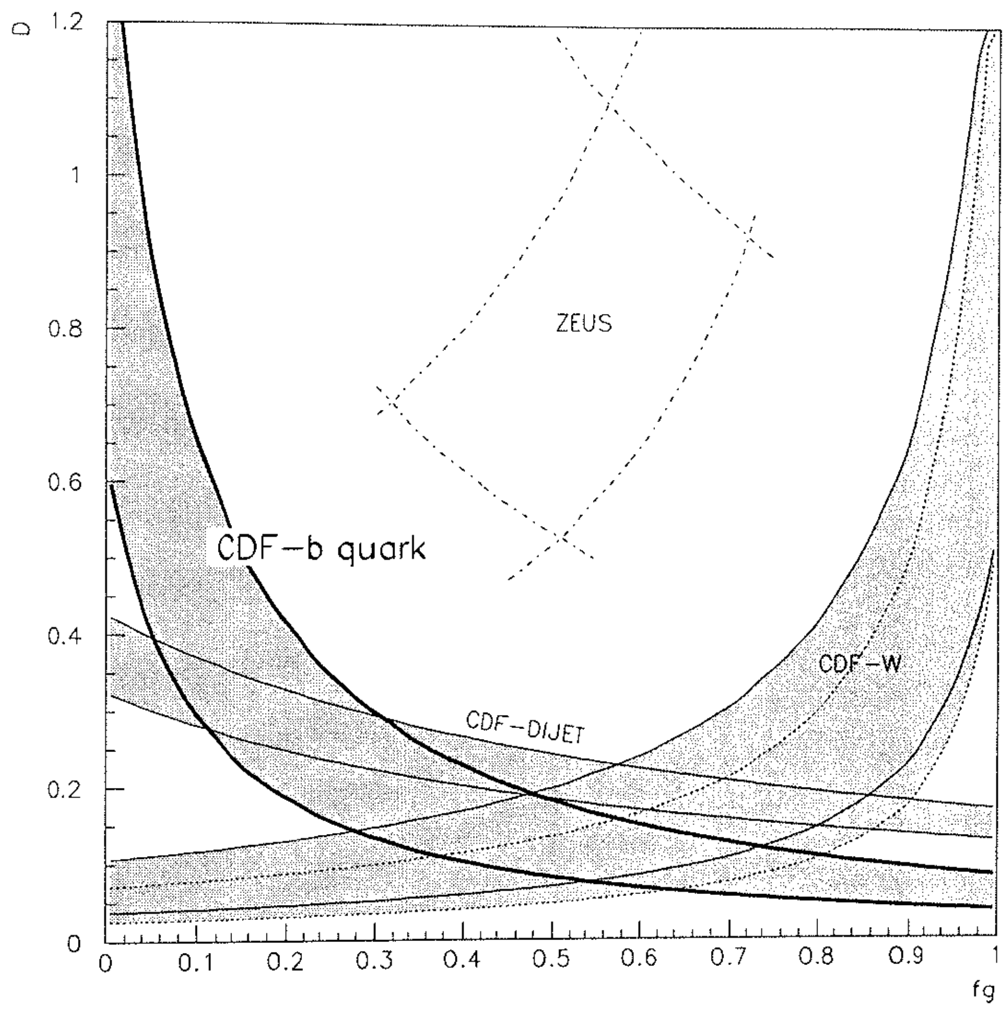

Figure 7.1: The flux discrepancy factor D versus gluon fraction f_g (see text). Results are shown for ZEUS (dashed-dotted), CDF-dijets, CDF-W and CDF-b quark measurements. **The "flat" structure function is used for the CDF-b quark measurement.** The "hard" structure function is used for all the other measurements. The CDF-W result is shown for two (dotted) or three (solid) light quark flavors in the pomeron. The shaded band shows the $\pm 1\sigma$ bounds of the measurements.

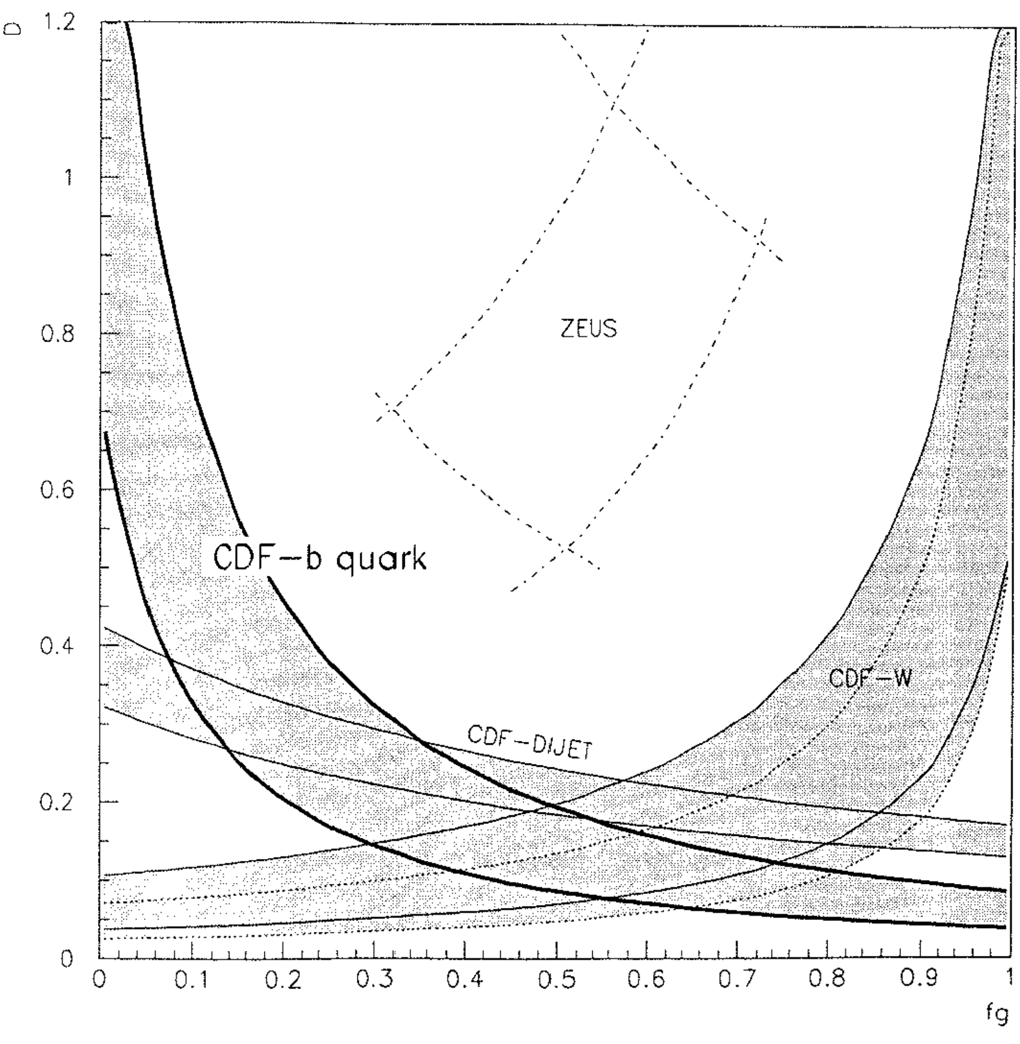

Figure 7.2: The flux discrepancy factor D versus gluon fraction f_g (see text). Results are shown for ZEUS (dashed0dotted), CDF-dijets, CDF-W and CDF-b quark measurements. **The "hard" structure function is used for the CDF-b quark measurement.** The "hard" structure function is used for all the other measurements. The CDF-W result is shown for two (dotted) or three (solid) light quark flavors in the pomeron. The shaded band shows the $\pm 1\sigma$ bounds of the measurements.