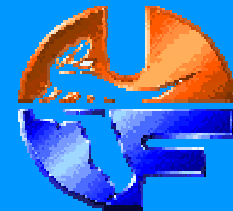
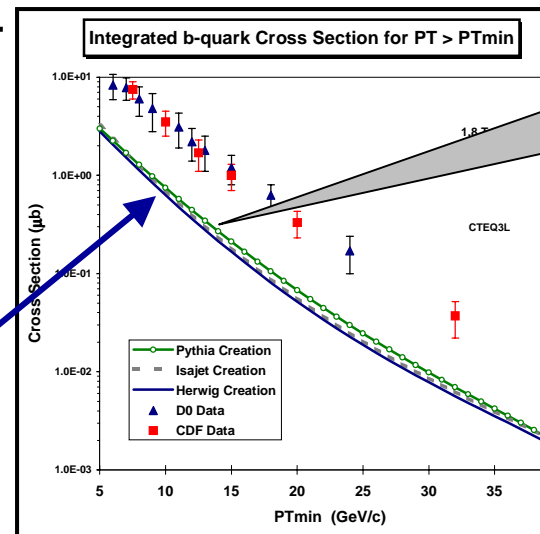




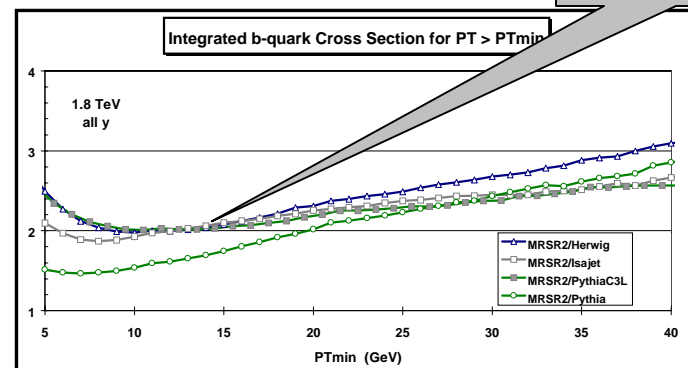
The Sources of b-quarks at the Tevatron



- ➔ Important to have good leading (or leading-log) order predictions of collider observables.
- ➔ If the leading order estimates are within a factor of two of the data, higher order calculations might be expected to improve the agreement.
- ➔ On the other hand, if the leading order estimates are not within roughly a factor of two of the data, one cannot expect higher order calculations to improve the situation.
- ➔ If a leading order estimate is off by more than a factor of two, it usually means that one has overlooked something.
- ➔ **“Something is goofy”** (Rick Field, CDF B Group Talk, December 3, 1999).
- ➔ <http://www.phys.ufl.edu/~rfield/cdf/>



Leading order “Flavor Creation” is a factor of **four** below the data!

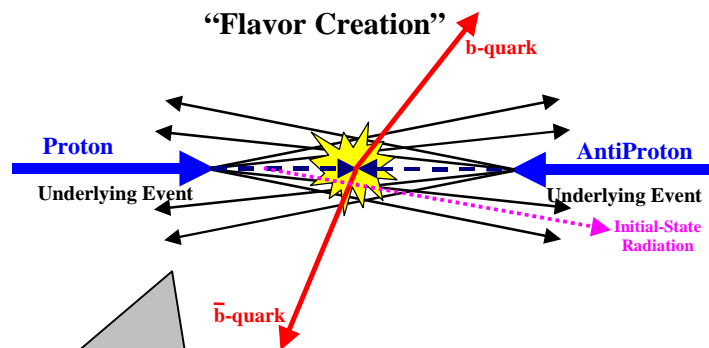
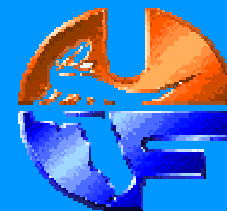


NLO/LO “Flavor Creation” is roughly a factor of **two**.

Today’s talk available at my WEBSITE.

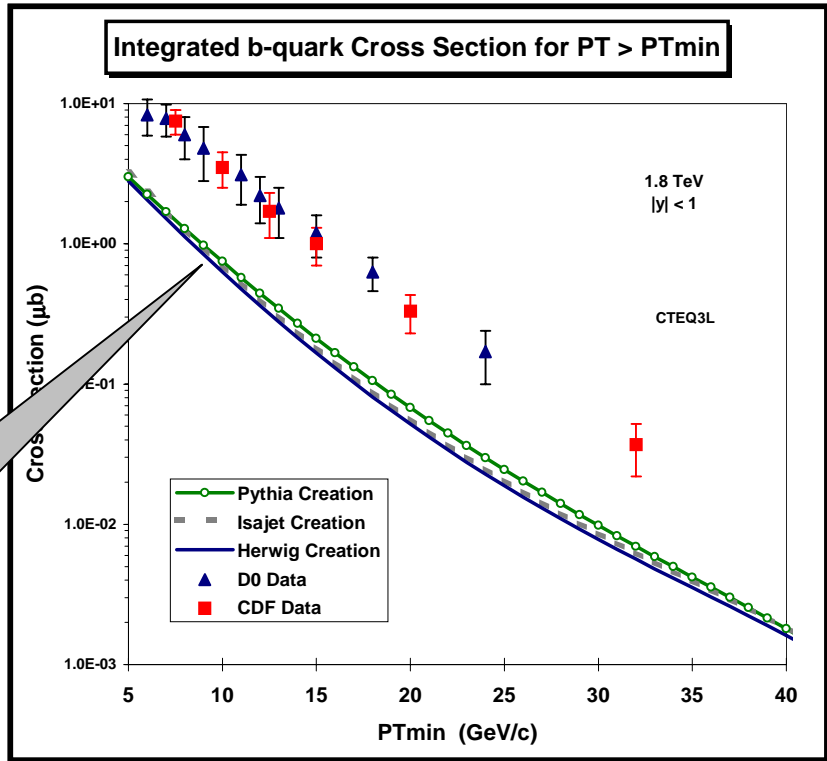


“Flavor Creation”



“Flavor Creation” corresponds to the production of a b - \bar{b} pair by gluon fusion or by annihilation of light quarks.

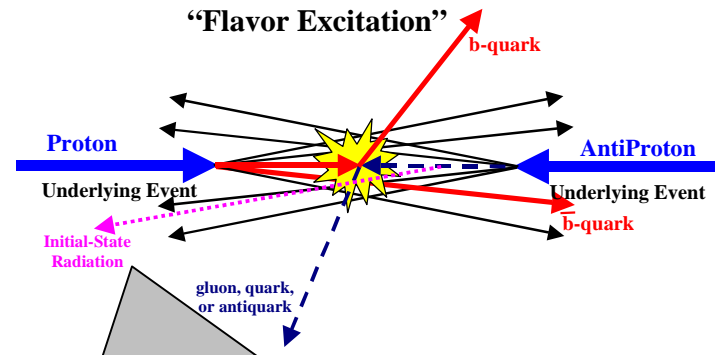
Leading-Log order “Flavor Creation” is a factor of **four** below the data!



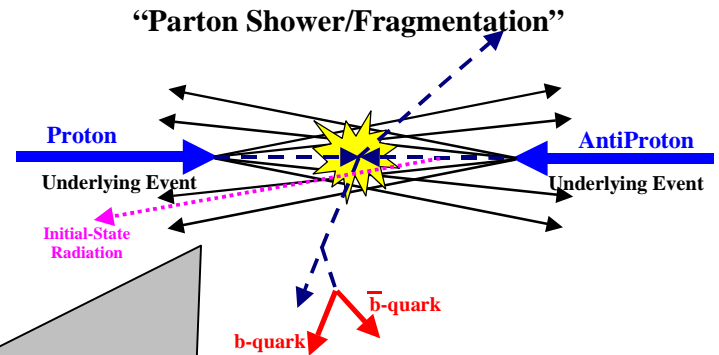
- ➔ Data from CDF and D0 for the integrated b-quark total cross section ($P_T > P_{Tmin}$, $|y| < 1$) for proton-antiproton collisions at 1.8 TeV compared with the QCD Monte-Carlo model predictions of HERWIG, PYTHIA, and ISAJET for the “flavor creation” subprocesses. The parton distribution functions CTEQ3L have been used for all three Monte-Carlo models. .



Other Sources of b-quarks

“Flavor Excitation” corresponds to the scattering of a b-quark (or bbar-quark) out of the initial-state into the final-state by a gluon or by a light quark or antiquark.

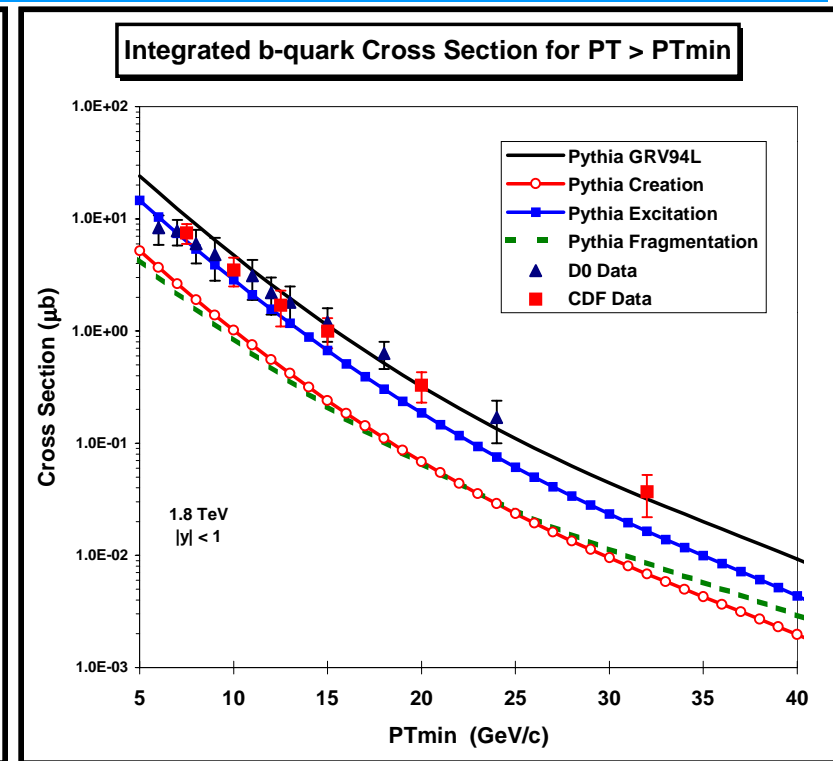
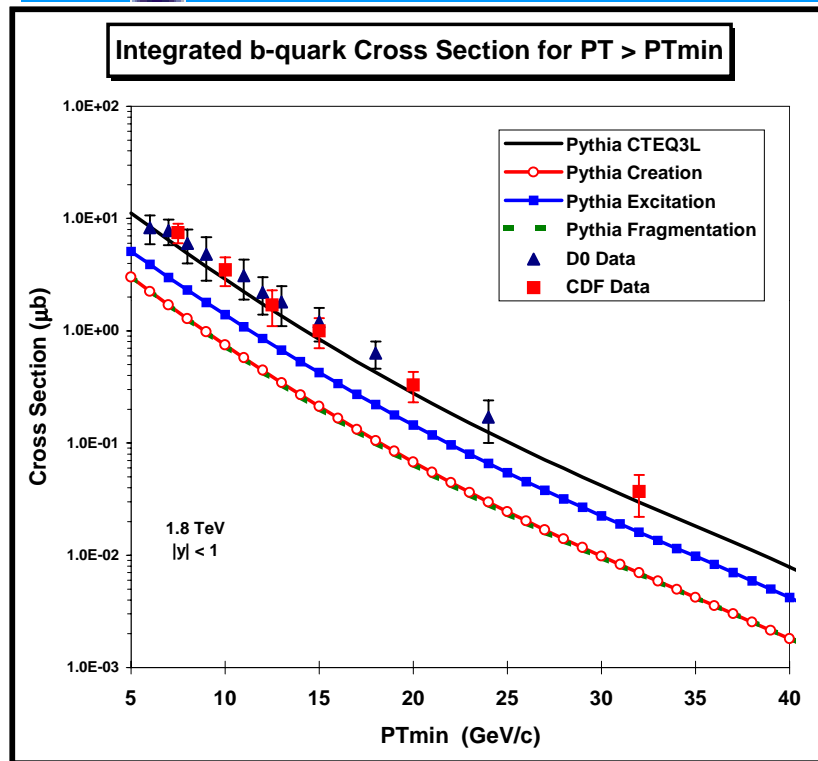


The b-bbar pair is created within a parton shower or during the fragmentation process of a gluon or a light quark or antiquark. Here the QCD hard 2-to-2 subprocess involves gluons and light quarks and antiquarks. This includes what is referred to as “gluon splitting”.

- ➔ “Flavor excitation” is, of course, very sensitive to the number of b-quarks within the proton (*i.e.* the structure functions).
- ➔ The Monte-Carlo models predictions for the “shower/fragmentation” contribution differ considerably. This is not surprising since ISAJET uses independent fragmentation, while HERWIG and PYTHIA do not; and HERWIG and PYTHIA modify the leading-log picture of parton showers to include “color coherence effects”, while ISAJET does not.



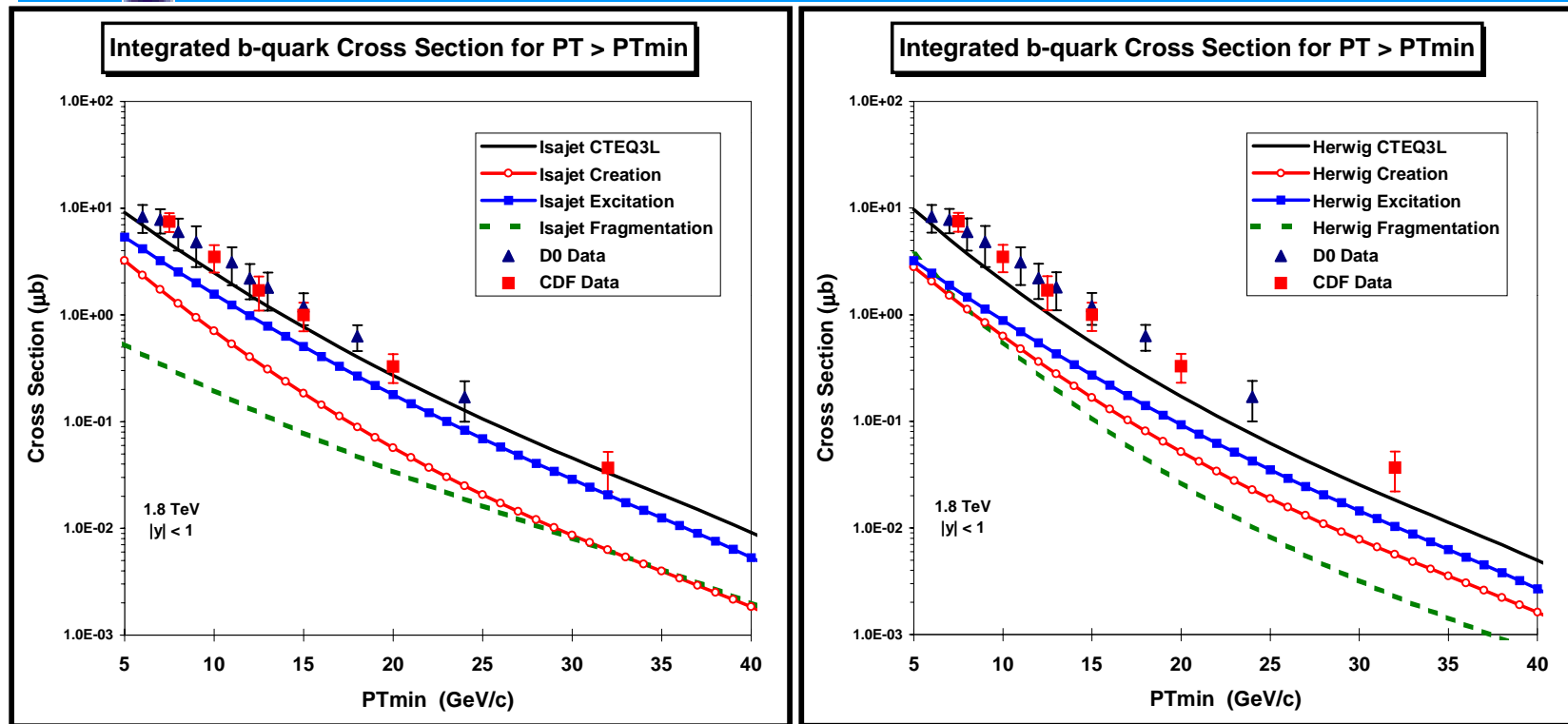
Inclusive b-quark Cross Section



- ➔ Data on the integrated b-quark total cross section ($P_T > P_{Tmin}$, $|y| < 1$) for proton-antiproton collisions at 1.8 TeV compared with the QCD Monte-Carlo model predictions of PYTHIA (CTEQ3L) and PYTHIA (GRV94L). The four curves correspond to the contribution from flavor creation, flavor excitation, shower/fragmentation, and the resulting total.



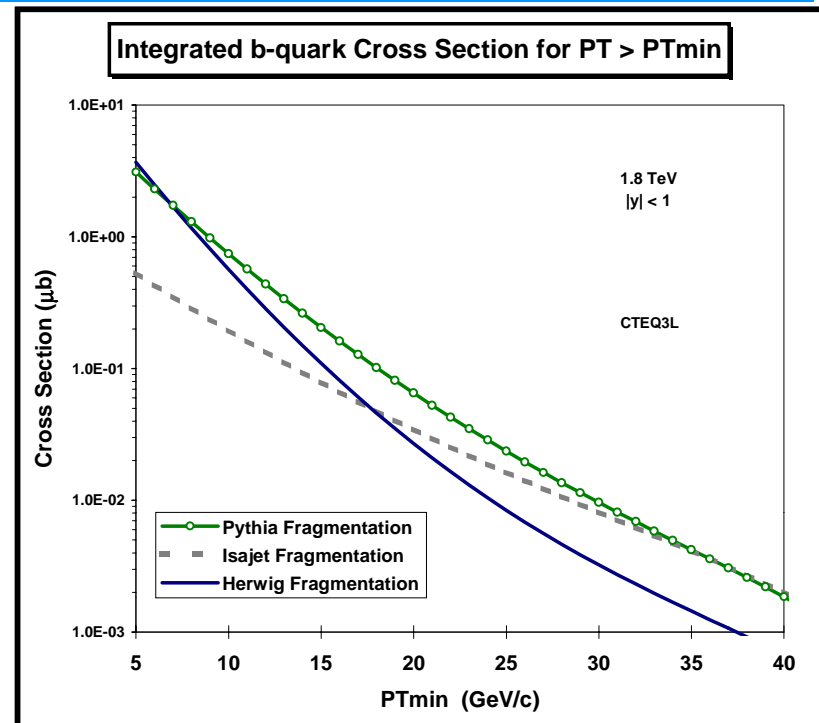
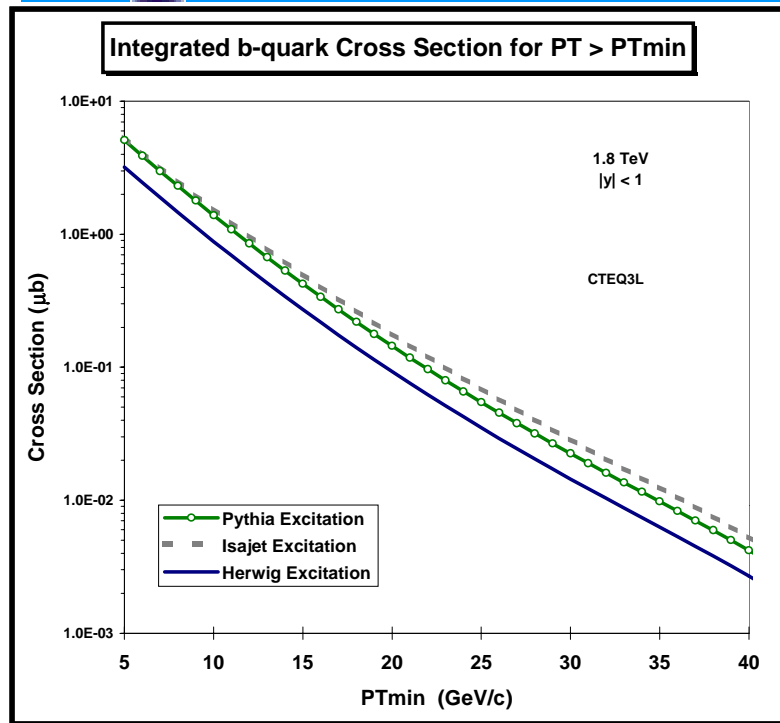
Inclusive b-quark Cross Section



- ➔ Data on the integrated b-quark total cross section ($P_T > PT_{min}$, $|y| < 1$) for proton-antiproton collisions at 1.8 TeV compared with the QCD Monte-Carlo model predictions of ISAJET (CTEQ3L) and HERWIG (CTEQ3L). The four curves correspond to the contribution from flavor creation, flavor excitation, shower/fragmentation, and the resulting total.



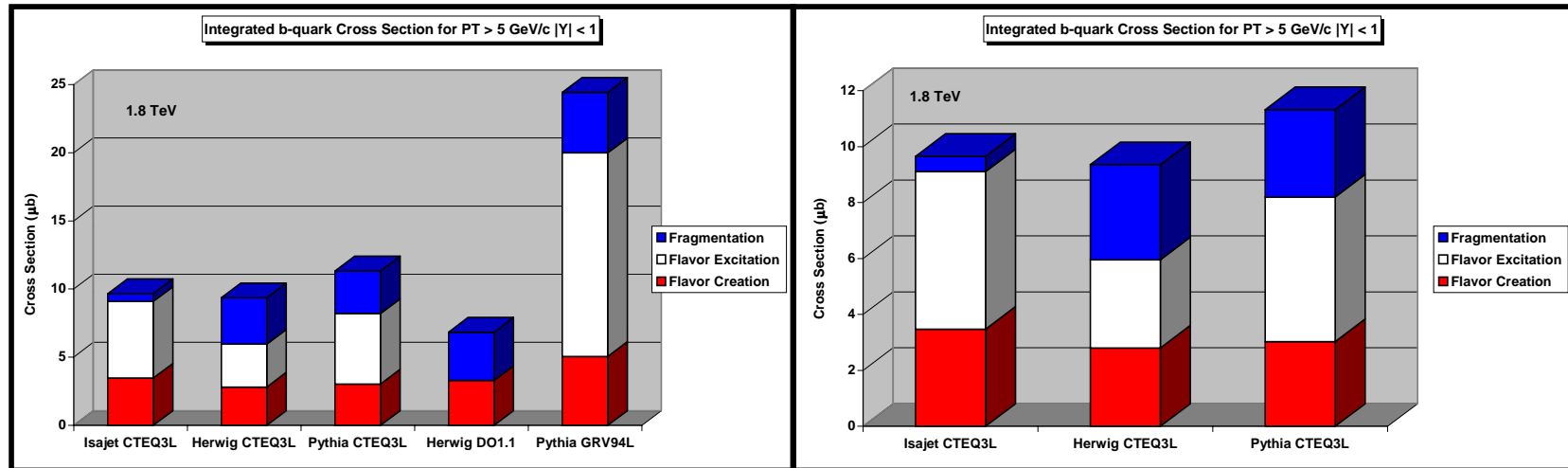
Inclusive b-quark Cross Section



- ➔ Predictions of HERWIG, PYTHIA, and ISAJET for the integrated b-quark total cross section ($P_T > P_{Tmin}$, $|y| < 1$) for proton-antiproton collisions at 1.8 TeV resulting from “flavor excitation” and “shower/fragmentation”. The parton distribution functions CTEQ3L have been used for all three Monte-Carlo models .



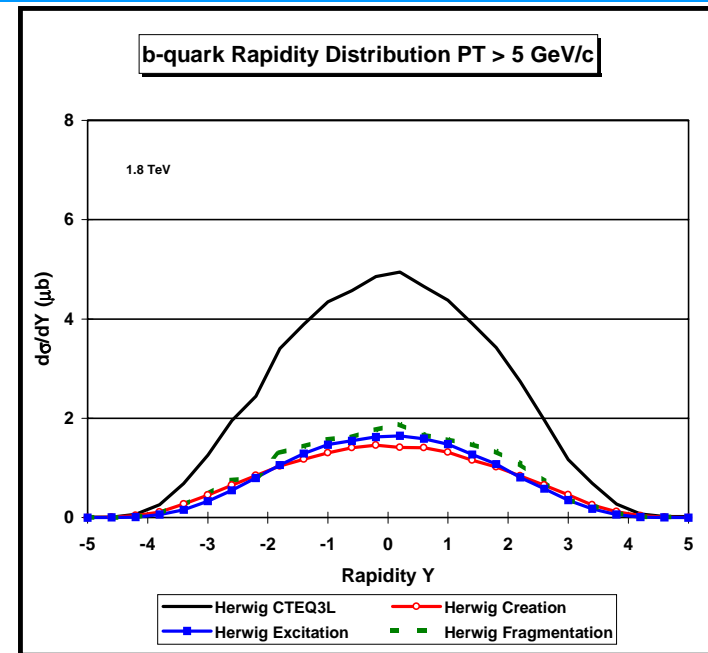
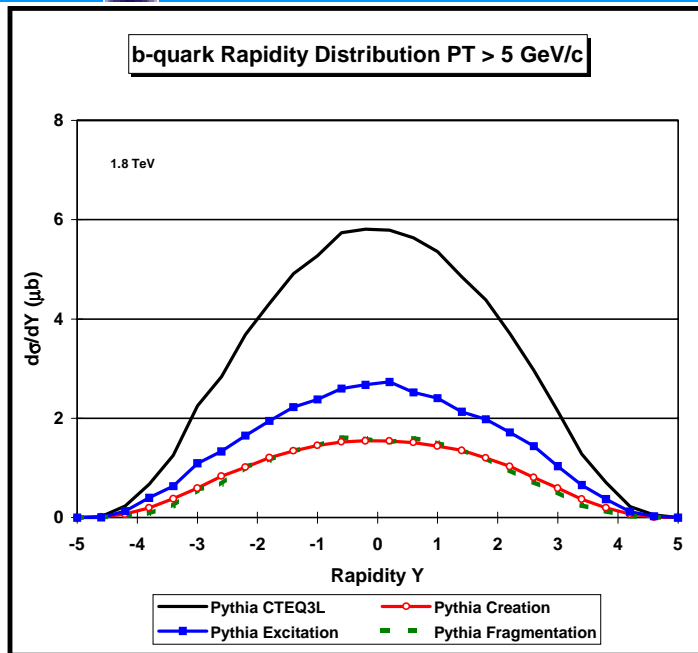
Inclusive b-quark Cross Section



- ➔ Predictions of ISAJET (CTEQ3L), HERWIG (CTEQ3L), PYTHIA (CTEQ3L), HERWIG (DO1.1), and PYTHIA (GRV94L) for the integrated b-quark total cross section ($P_T > 5 \text{ GeV}/c$, $|y| < 1$) for proton-antiproton collisions at 1.8 TeV. The contributions from flavor creation, flavor excitation, and shower/fragmentation are shown together with the resulting sum (overall height of box).
- ➔ The differences in the flavor excitation contribution are due to the different ways the models handle the b-quark mass in this subprocess. However, it seems likely that at the Tevatron the flavor excitation contribution to the b-quark cross section is comparable to or greater than the contribution from flavor creation.
- ➔ The QCD Monte-Carlo predictions differ considerably for the “shower/fragmentation” contribution. However, at the Tevatron the fragmentation contribution to the b-quark cross section might be comparable to the contribution from flavor creation.



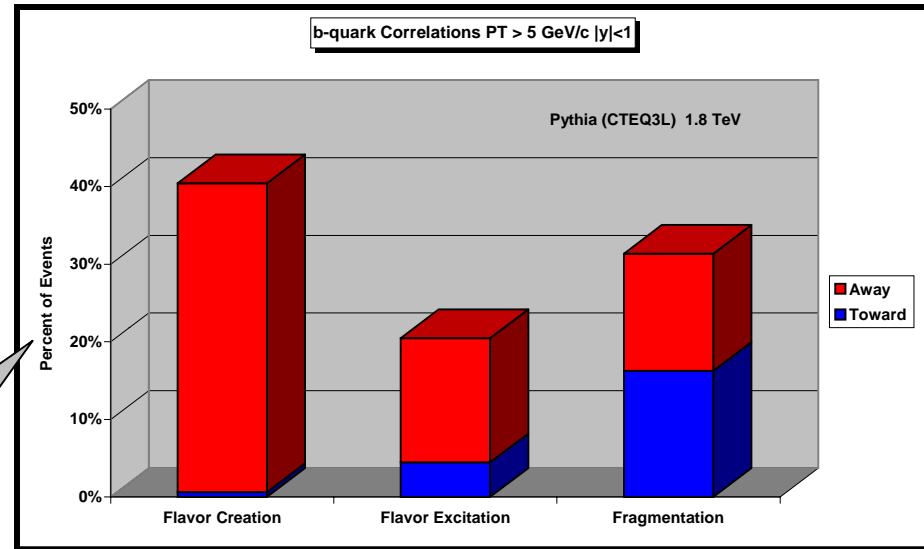
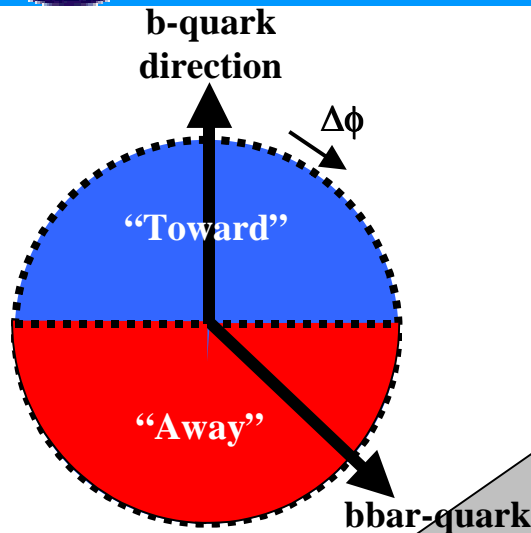
b-quark Rapidity Distribution



- ➔ Predictions of PYTHIA (CTEQ3L), and HERWIG (CTEQ3L) for the b-quark rapidity distribution ($P_T > 5 \text{ GeV}/c$) for proton-antiproton collisions at 1.8 TeV. The four curves correspond to the contribution from flavor creation, flavor excitation, shower/fragmentation, and the resulting total.



Simple Correlations

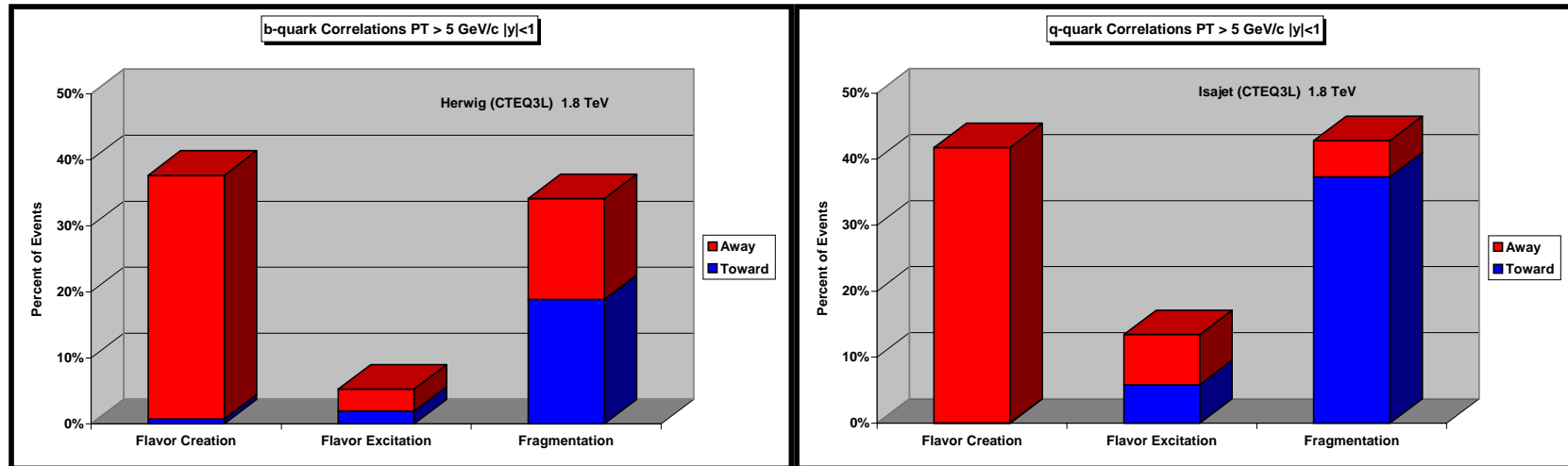


For events with a b-quark ($P_T > 5 \text{ GeV}/c$ $|y| < 1$), **probability of observing a b-bar-quark** ($P_T > 5 \text{ GeV}/c$ $|y| < 1$).

- ➔ Predictions of PYTHIA (CTEQ3L) for the probability of finding a b-bar-quark with $P_T > 5 \text{ GeV}/c$ and $|y| < 1$ for events with a b-quark with $P_T > 5 \text{ GeV}/c$ and $|y| < 1$ for proton-antiproton collisions at 1.8 TeV. The contribution from the “toward” ($|\Delta\phi| < 90^\circ$) and the “away” ($|\Delta\phi| > 90^\circ$) region of the b-quark are shown for flavor creation, flavor excitation, and shower/fragmentation.



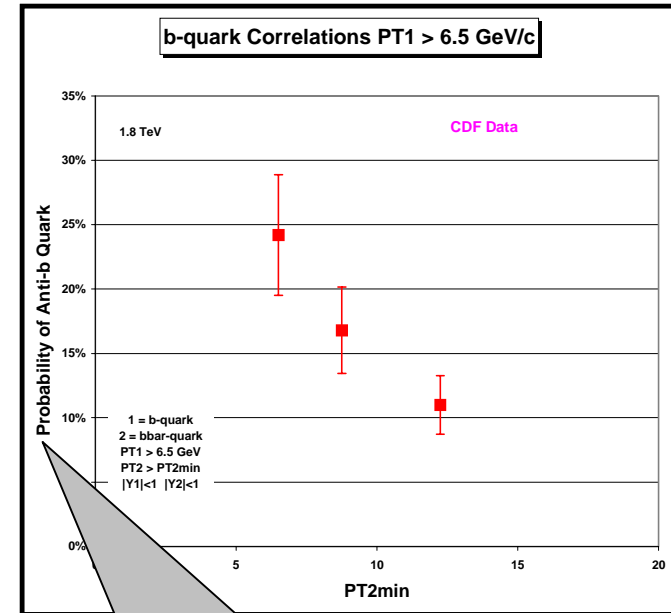
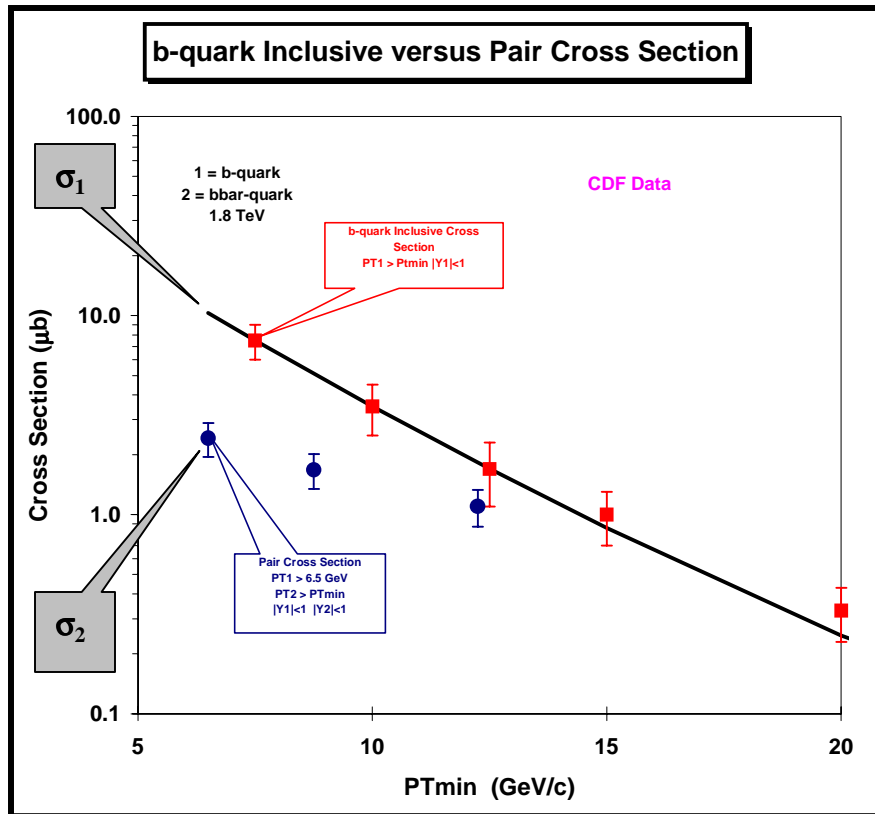
Simple Correlations



- ➔ Predictions of HERWIG (CTEQ3L) and ISAJET (CTEQ3L) for the probability of finding a $b\bar{b}$ -quark with $P_T > 5 \text{ GeV}/c$ and $|y| < 1$ for events with a b-quark with $P_T > 5 \text{ GeV}/c$ and $|y| < 1$ for proton-antiproton collisions at 1.8 TeV. The contribution from the “toward” ($|\Delta\phi| < 90^\circ$) and the “away” ($|\Delta\phi| > 90^\circ$) region of the b-quark are shown for flavor creation, flavor excitation, and shower/fragmentation.



b-quark Inclusive versus Pair Cross Section

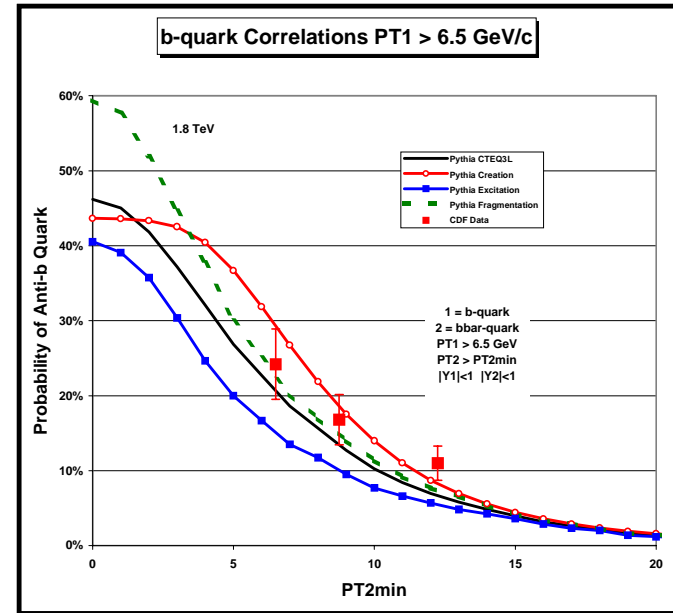
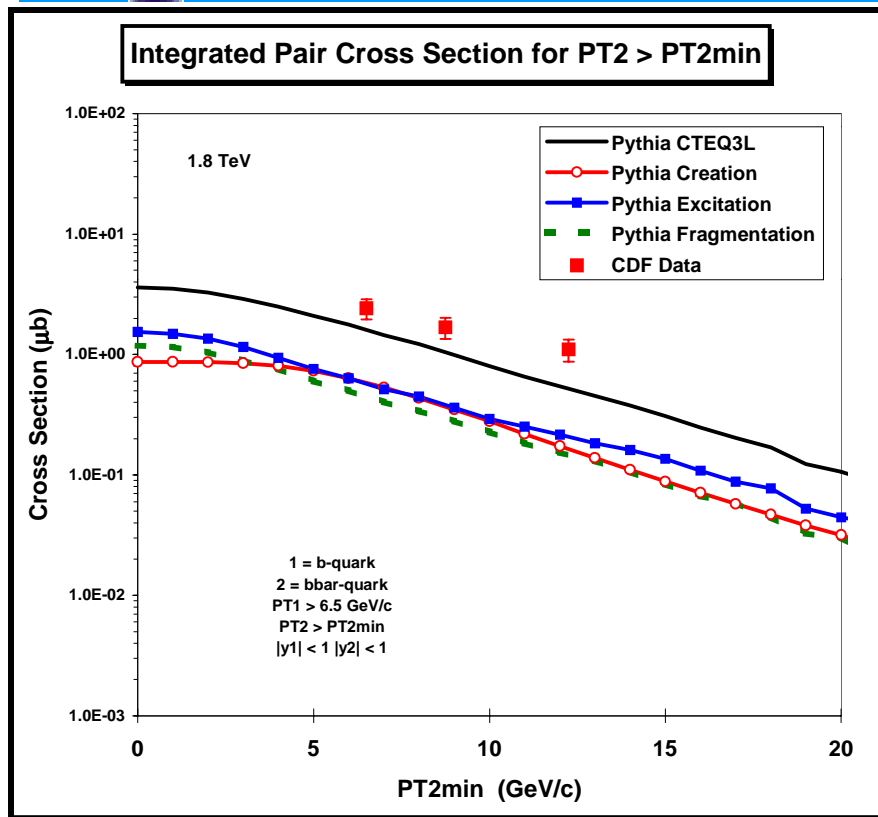


Divide the pair cross section σ_2 by the single inclusive cross section σ_1 .

➔ Data from CDF on the single b-quark inclusive cross section and the b-bbar pair cross section at 1.8 TeV.



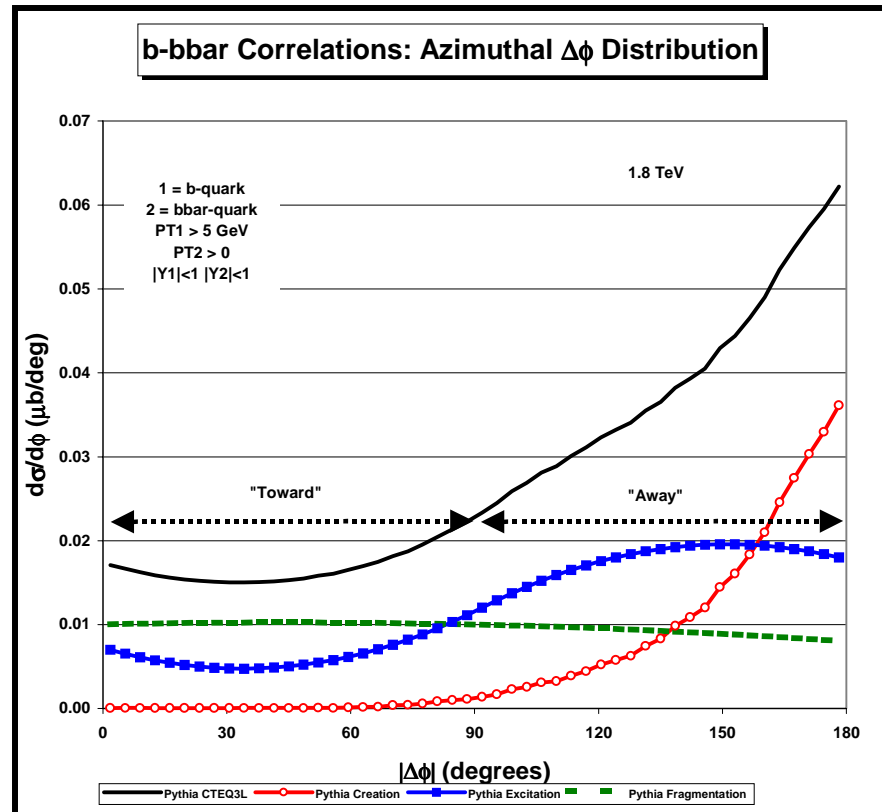
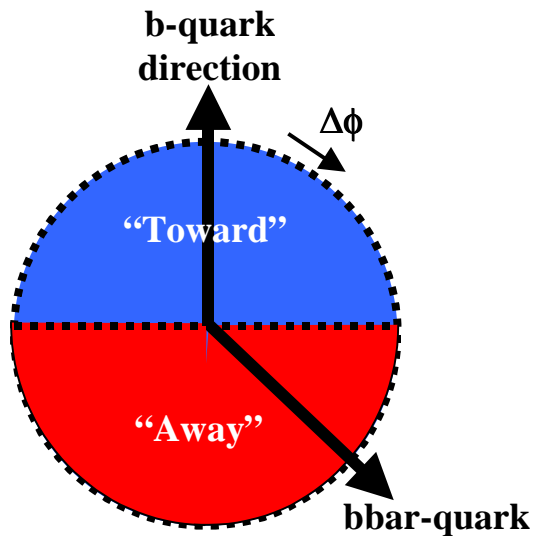
Integrated Pair Cross Section



➔ Data from CDF on the b-bbar pair cross section and the b-bbar probability at 1.8 TeV compared with the QCD Monte-Carlo predictions of PYTHIA (CTEQ3L). The four curves correspond to the contribution from flavor creation, flavor excitation, shower/fragmentation, and the resulting total.



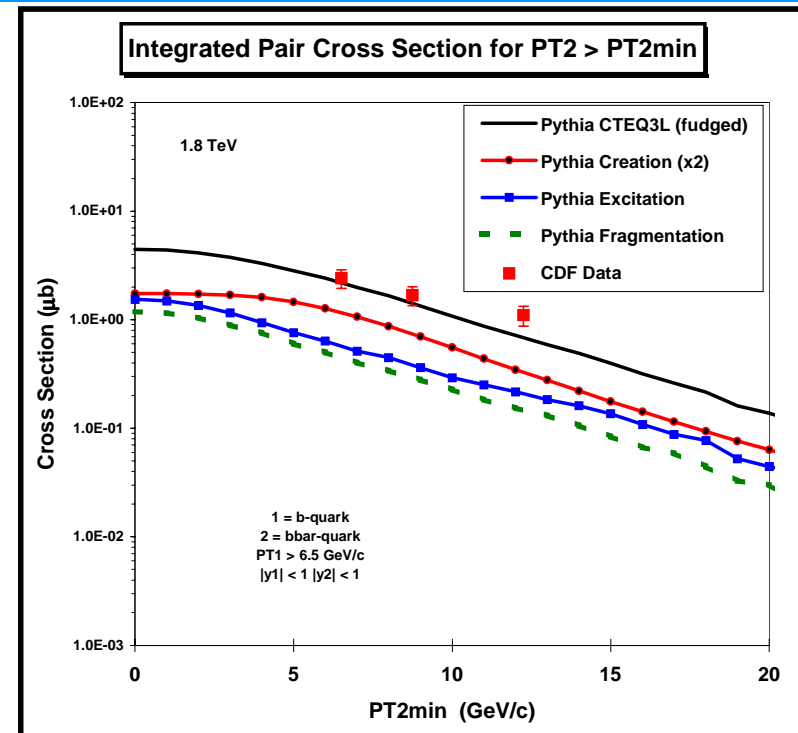
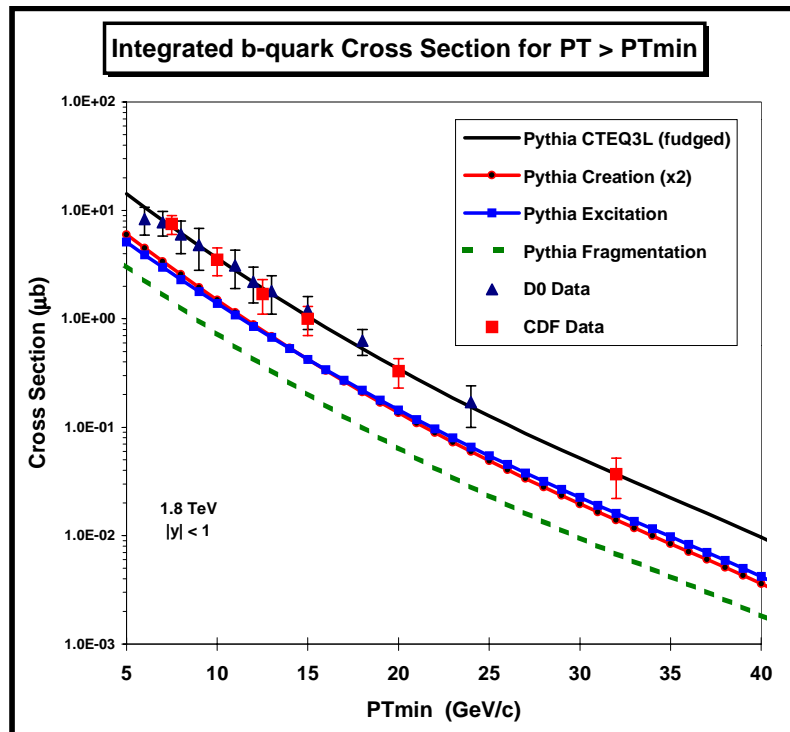
Azimuthal Correlations



➔ QCD Monte-Carlo predictions of PYTHIA (CTEQ3L) for the b - b pair azimuthal cross section $d\sigma/d\phi$ for $|y| < 1$. The four curves correspond to the contribution from flavor creation, flavor excitation, shower/fragmentation, and the resulting total at 1.8 TeV.



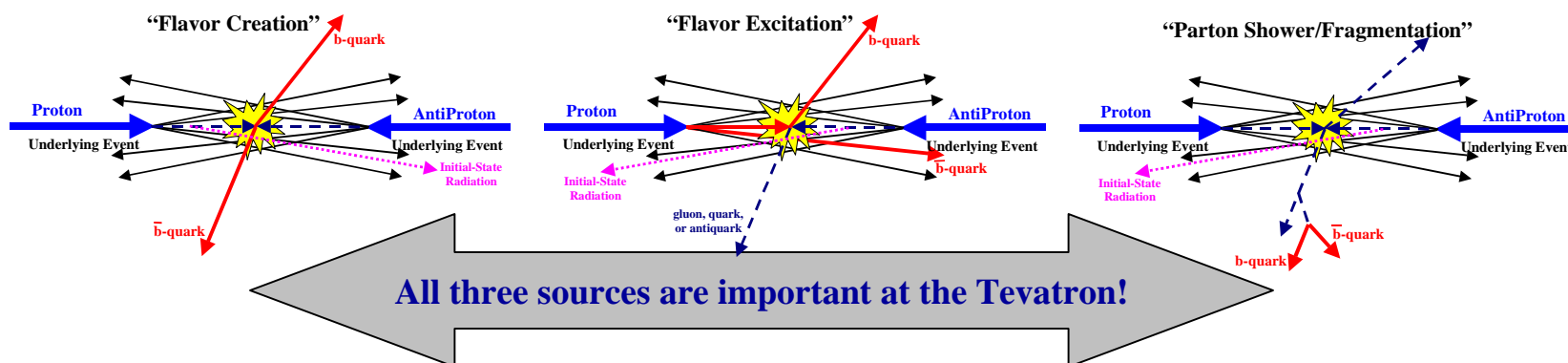
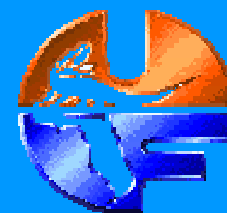
b-quark Inclusive versus Pair Cross Section



- ➔ Data from CDF on the single b-quark inclusive cross section and the b-bbar pair cross section at 1.8 TeV compared with the QCD Monte-Carlo predictions of PYTHIA (CTEQ3L) where the flavor creation term has been multiplied by a factor of 2 to take into account higher order corrections.



Summary & Conclusions



- ➔ One should not take the QCD Monte-Carlo model estimates of “flavor excitation” and “shower/fragmentation” too seriously. The contributions from these subprocesses are **very uncertain** and more work needs to be done. There are many subtleties!
- ➔ However, it seems likely that all three sources are important at the Tevatron.
- ➔ In Run II we should be able experimentally to isolate the individual contributions to b-quark production by studying b-bbar correlations in detail.