B-QUARK PRODUCTION AND ANOMALIES

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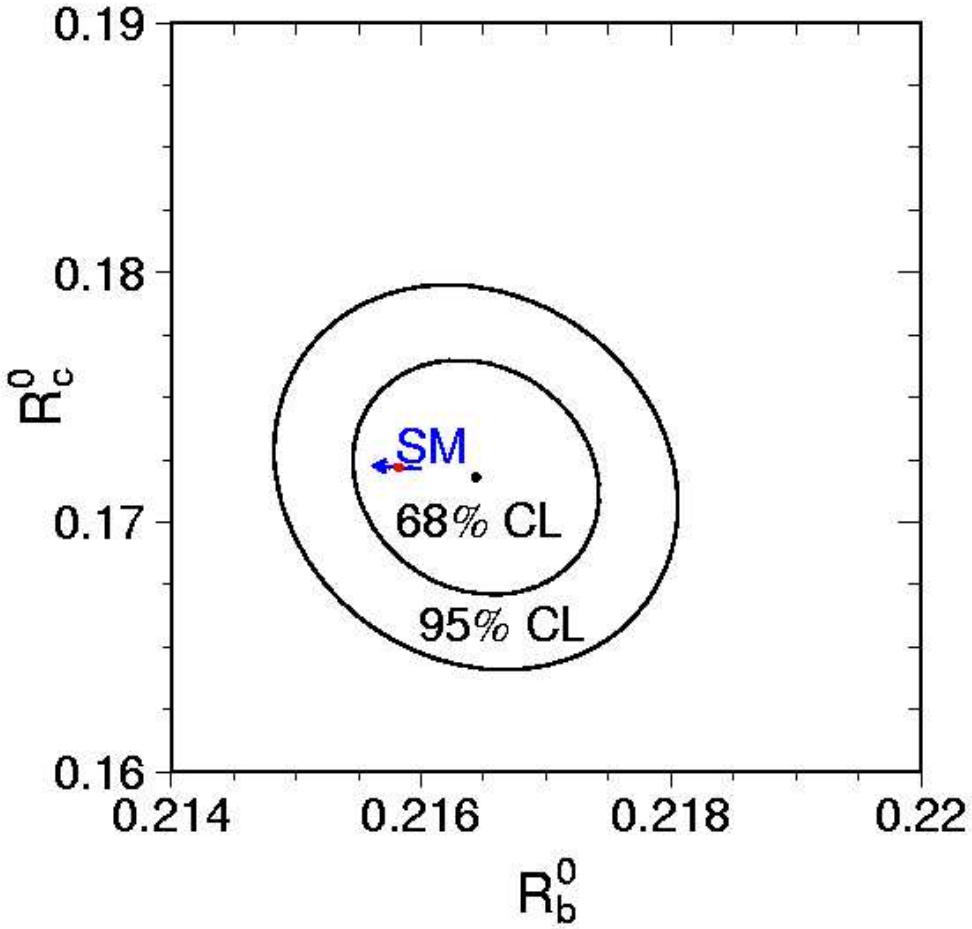
B-Physics data (excess production) appears to show discrepancies with predictions of the Standard Model.

Could be a signal for BSM physics,
(e.g. light gluinos and light b-squarks)
But we need to examine the evidence carefully

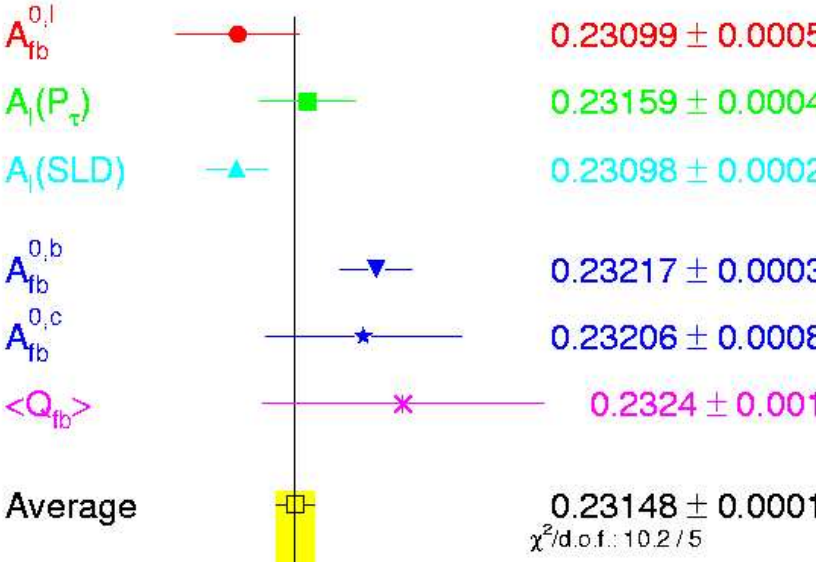
B Physics at LEP 1

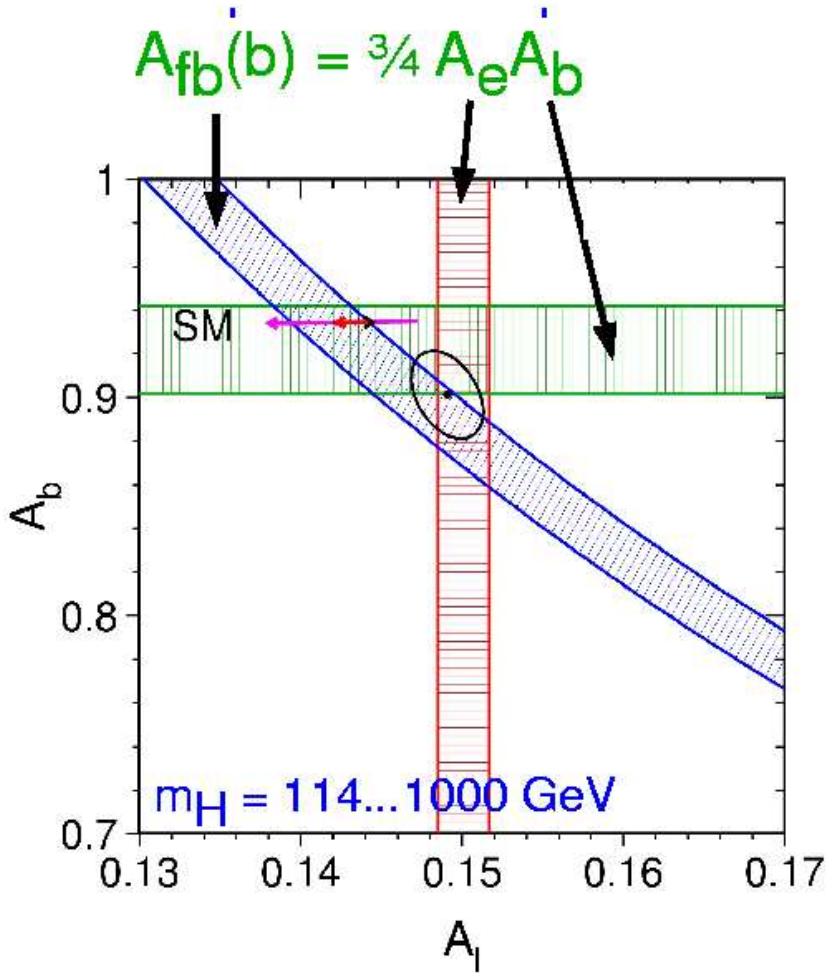
Overall B-production rate IS consistent with SM.



$$R_b = \frac{\Gamma(Z \to b\bar{b})}{\Gamma_{TOT}(Z)}$$

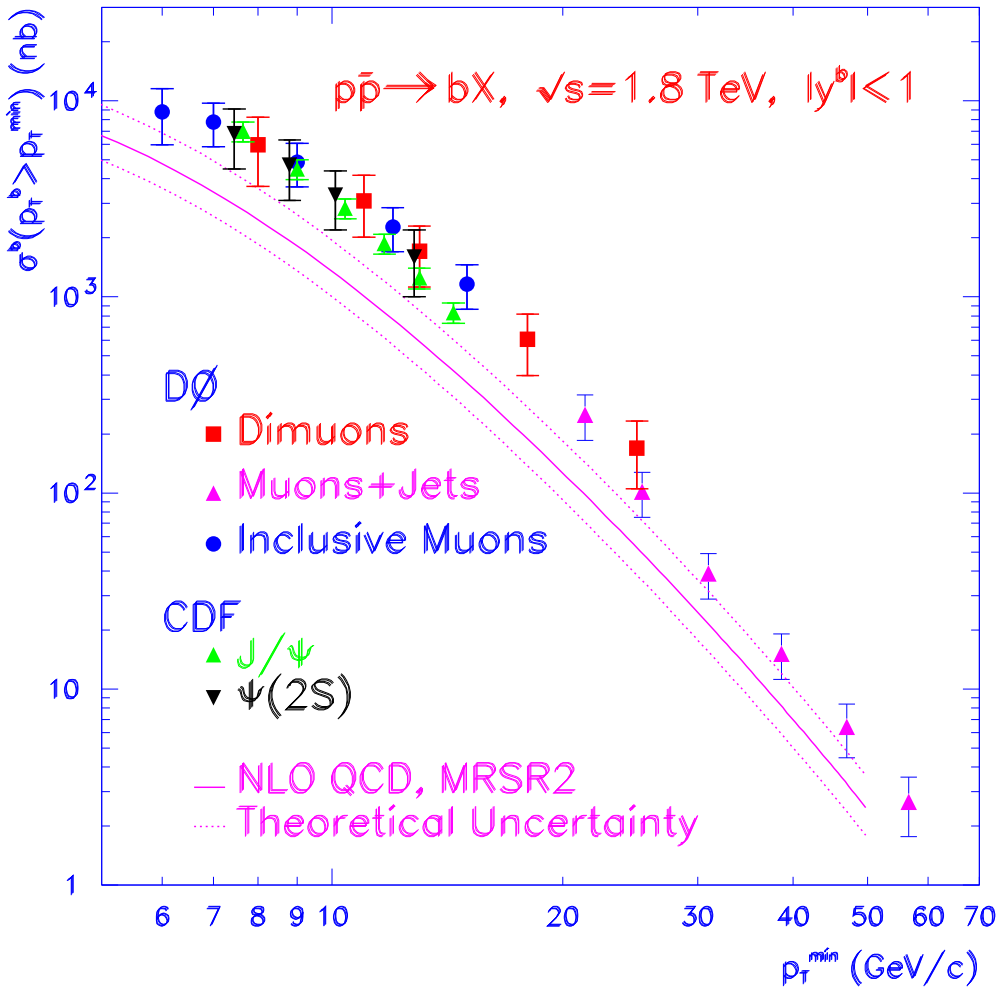
But angular distributions are cause for concern





$3\,\sigma$ discrepancy in $\sin^2\theta_W$ from $Z \to b\bar{b}$

Open b-quark production at TEVATRON



Excess over QCD calculation at NLO by about a factor of 2

NLO perturbative QCD calculation for final state consisting of a b and $\bar{b}$ quark only contains terms

$$\alpha_s^3 \ln\left(p_T^2/m_b^2\right),$$

(collinear divergences as $m_b \to 0$).

Cacciari et. al. have summed these logs and obtain a small enhancement in the predicted cross-section.

$$\frac{d\sigma/dp_T(\text{exp.})}{d\sigma/dp_T(\text{theor.})} \sim 1.8 \pm 0.5$$

$\uparrow$

(expt. and theor. uncertainties)

B-jet Production

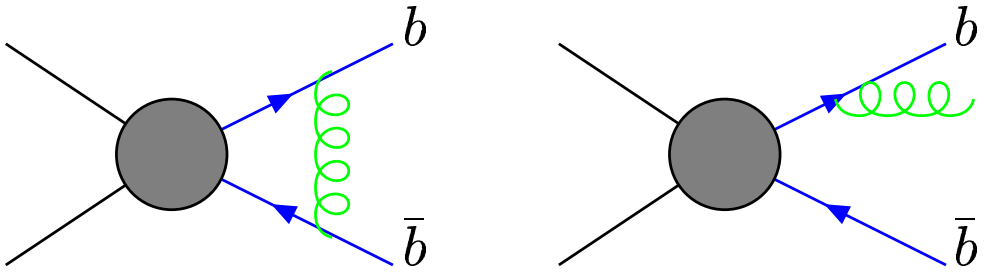
Experiment observes a jet containing a B-meson.

A MonteCarlo (ISAJET) is used to extract open b-quark production cross-section.

This is sensitive to parameters of jet fragmentation used in MonteCarlo.

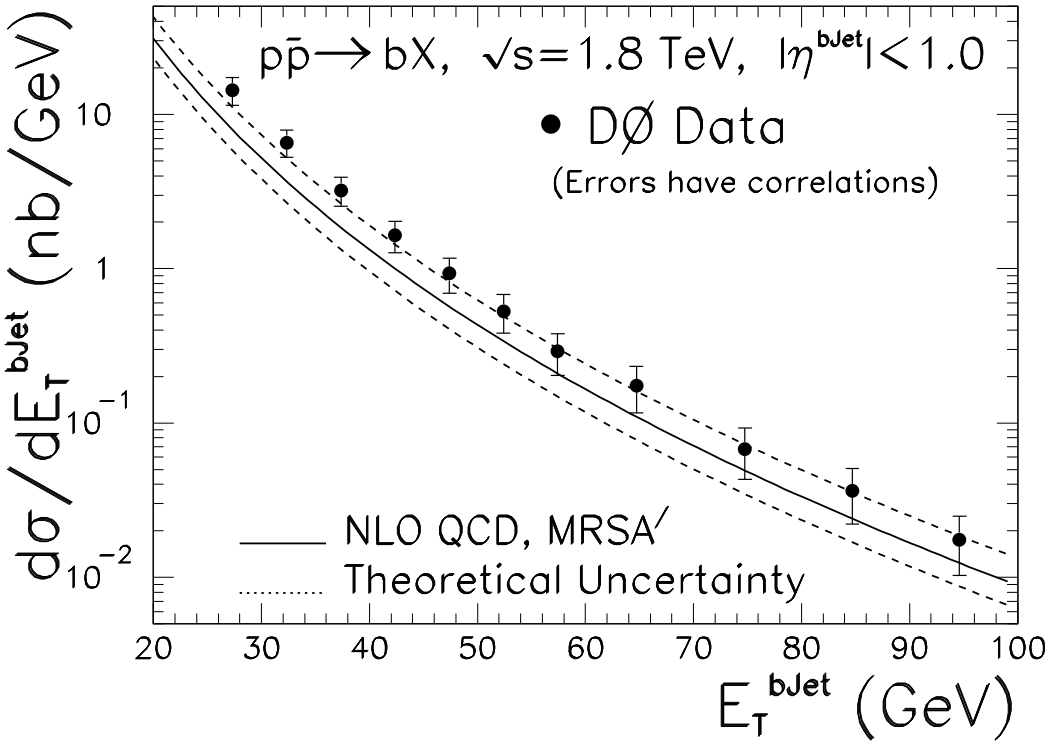
BUT in perturbative QCD, cross-sections into jets containing a $b-$quark do NOT have a $\ln(p_T^2/m_b^2)$ term.

Cancels when collinear gluon is included in the jet.)



Frixione & Mangano calculated the b-jet cross-section

(this is more stable)



WARNING:

Large theoretical uncertainties (obtained by changing factorization scale) should be viewed as a signal of instability of the perturbation expansion (it "borrows" part of the NNLO correction)

$$\frac{\text{Data}}{\text{Theory}} \sim 1.6 \pm .3\,(\text{exp.}) \pm .4\,(\text{theor.})$$

Partonic processes considered in perturbative calculation:

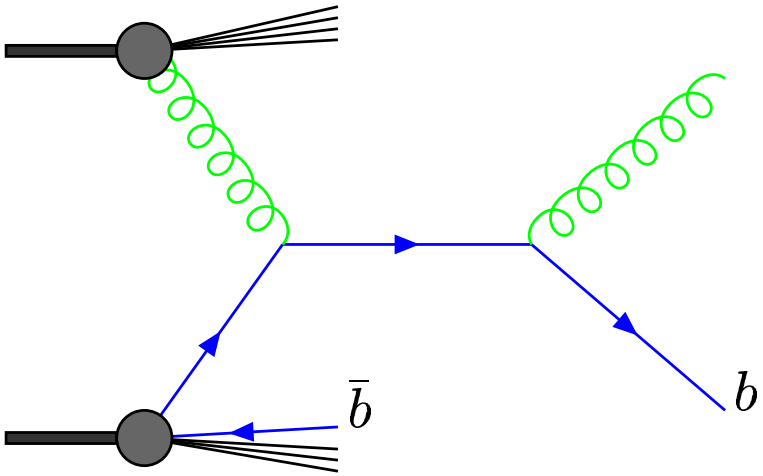
$$q\,\bar{q} \;\rightarrow\; b\,\bar{b}$$

$$g\;g \rightarrow\; b\,\bar{b}$$

but NOT

$$g\,b \rightarrow b\,g,$$

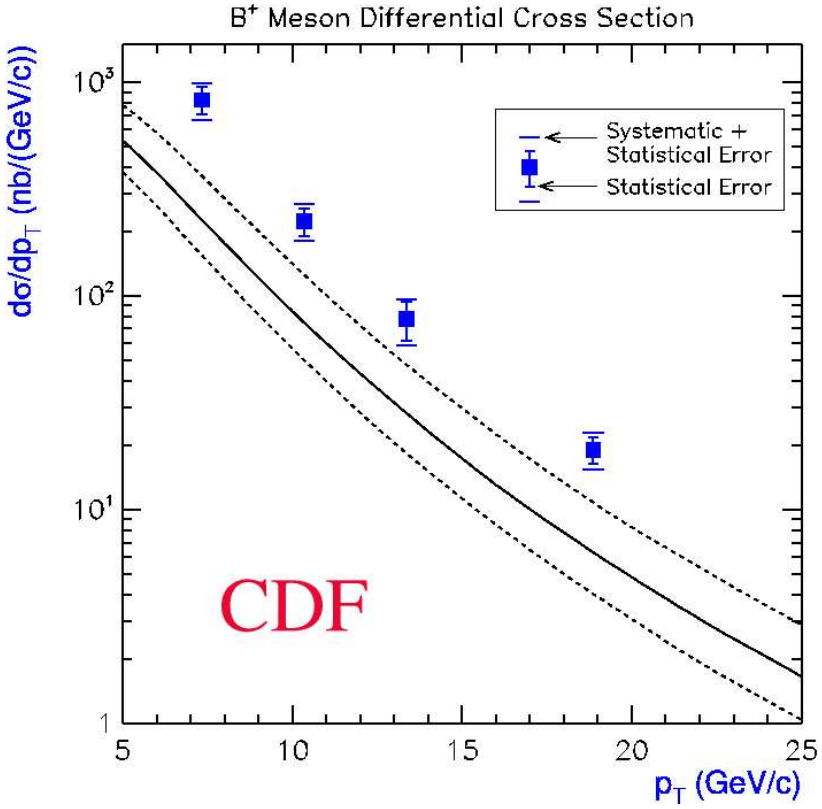
involves b-content of proton (for sufficiently large P_T)

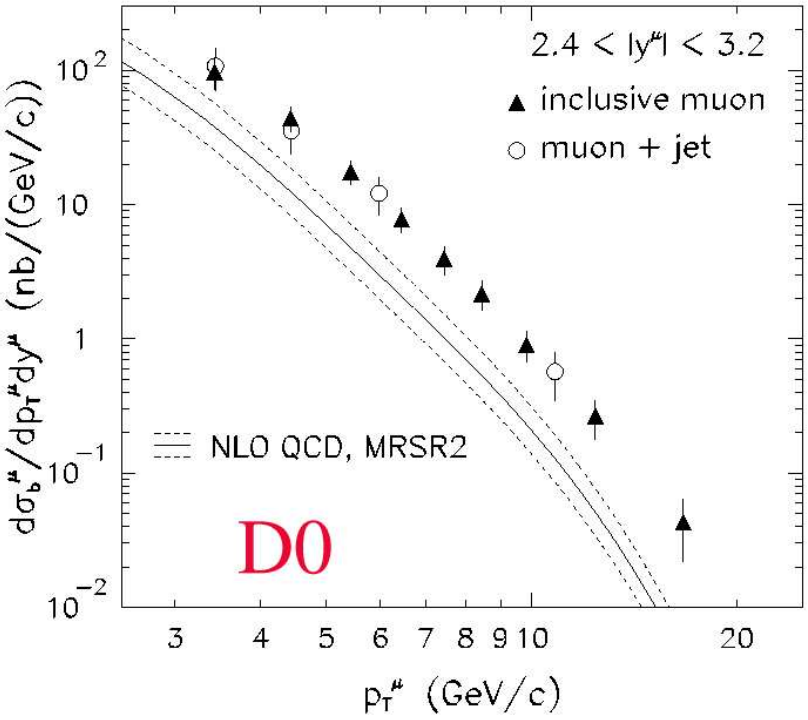


Away jet does NOT contain a $\bar{b}$-quark.

Field has performed MonteCarlo simulations and shown that these "flavour excitation" processes can give rise to substantial contributions to the total B production cross-section.
(but results are highly dependent on which Monte Carlo is used.)

Exclusive B-meson Production at TEVATRON



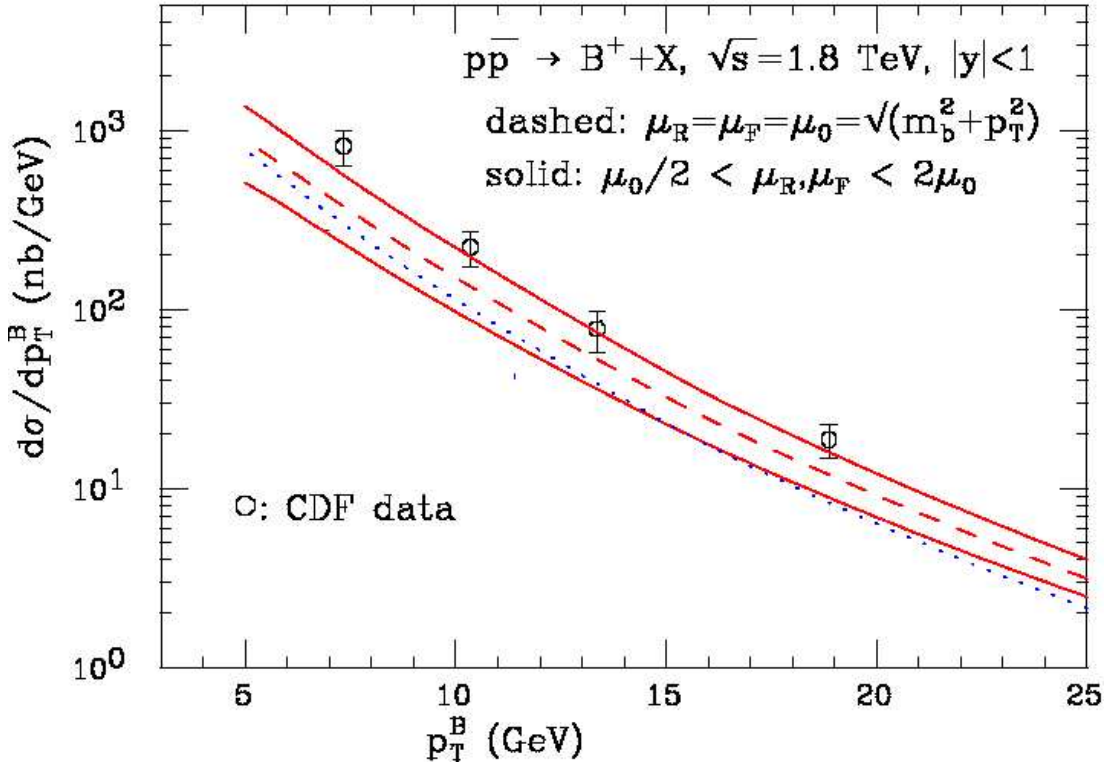


$$\frac{\text{Data}}{\text{Theory}} \sim 3 - 5$$

$$d\sigma(p\bar{p} \to B^+ X) \;=\; f_i^P \otimes f_j^{\bar{P}} \otimes d\sigma_h(ij \to bX) \otimes D^{B^+}$$

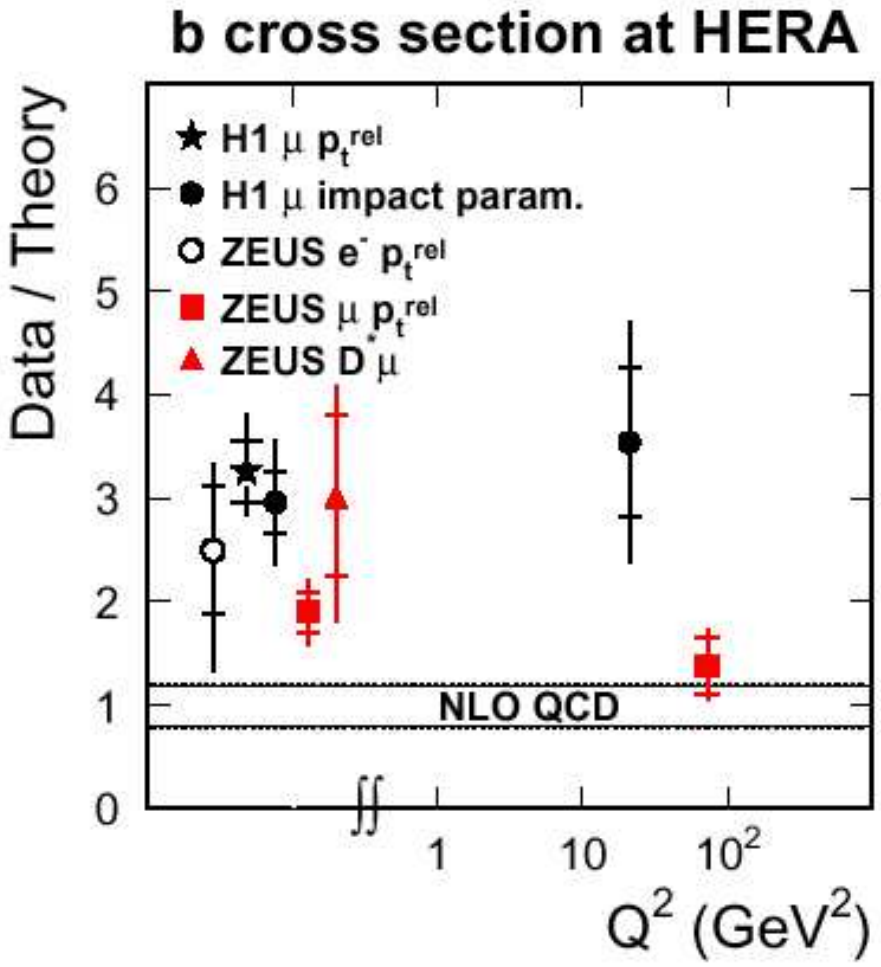
Sensitive to parameters used for fragmentation function, D^{B^+}.

If these parameters are matched to B-meson production at LEP the fit improves:
(Cacciari - preliminary)



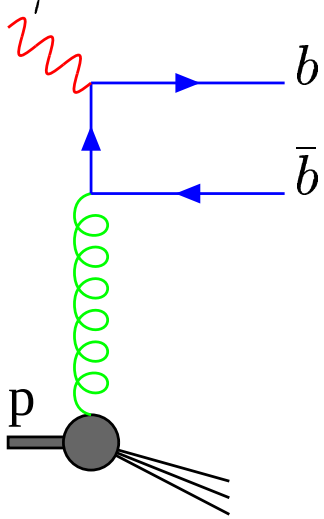
$$\frac{\text{Data}}{\text{Theory}} \;\sim\; 1.7 \pm .5\,(\text{exp.}) \;\pm .4(\text{theor.})$$

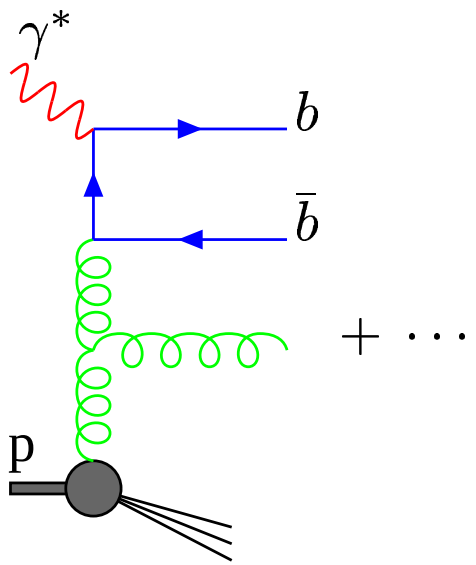
B-meson Production in DIS (HERA)



Excess also seen in charm production.

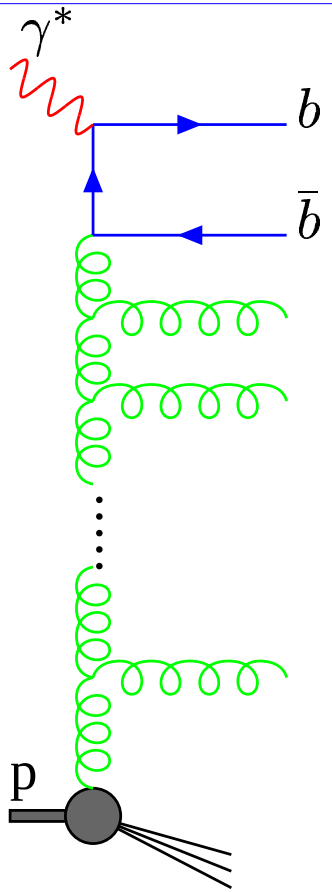
Fixed Order perturbative QCD:

LO: 

NL0: 

Correction $\sim \alpha_s^2 \ln(s/m_b^2)$

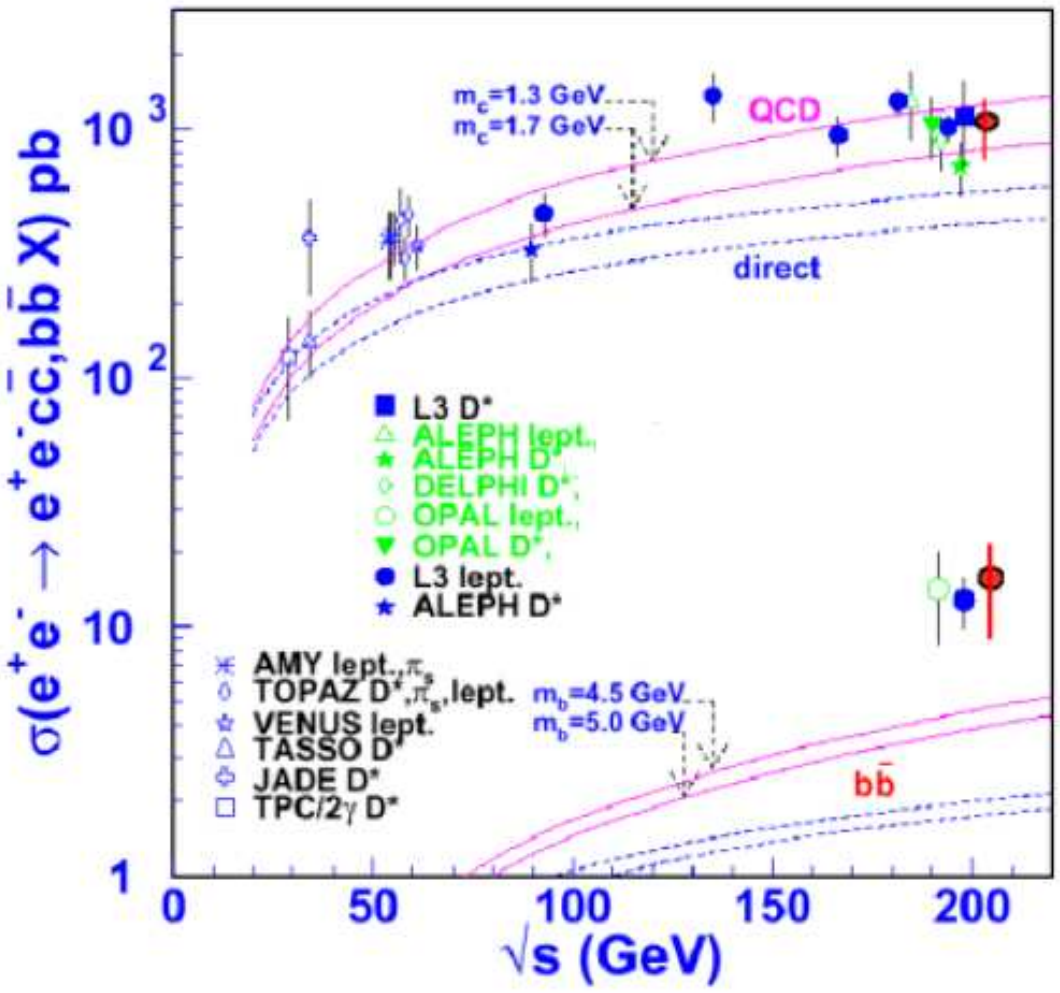
- t-channel gluon can be soft (diffractive production)



BFKL sums these leading logs to all orders:

Parton shower MonteCarlo's and BFKL contributions yield substantially different theoretical predictions.

B Production in $\gamma\gamma$ Scattering



Charm production fits theory well.

B-production exceeds theoretical prediction by 2 - 3

SUMMARY

- B production in $p\,\bar{p}$, $e\,p$, $\gamma\,\gamma$
  ALL show an excess over theoretical predictions.
- These excesses are substantially reduced by considering uncertainties in perturbative QCD and/or parametrization of MonteCarlo used to extract data.
- Most robust discrepancy is A_{FB} from LEP1 - SLD.
- There is certainly a strong hint of a discrepancy between B physics and the SM predictions,
  but by NO MEANS can this be taken as a clear signal for BSM Physics.
- More data RUN 2, LHC
  NNLO QCD corrections, weak interaction corrections,
  will help to resolve this.