

Small-x effects in heavy quark production

(coord: A.Dainese, H.Jung and R.Vogt)

- ◆ **GLR-MQ and BK**
 - ⊕ GLR-MQ (J. Qiu, G. Levin, M. Ryskin): small x and DGLAP, non-linear terms and factorization
 - ⊕ BK (G. Levin, J. Bartels, M. Lublinsky, K. Kutak, L. Motyka, K. Peters): non-linear terms and factorization
 - ⊕ Comparison of GLR and BK: understanding of gluon enhancement and suppression relative to the linear case (R. Vogt, A. Dainese, K. Peters)
- ◆ **Phenomenological Applications: Heavy Quark Production**
 - ⊕ non-linear effects at HERA (H. Jung et al.)
 - Heavy quark production in multiple interaction events
 - suppression of $D\bar{D}$ cross section at small p_t ?
 - ⊕ non-linear effects at LHC
 - Charm production (R. Vogt, A. Dainese, K. Peters)
 - Beauty production (K. Peters)
- ◆ **Perspectives for experimental observations at LHC (A. Dainese, R. Vogt)**
- ◆ **Factorisation and non-linear effects: effective factorisation at large p_t , estimates and predictions (K. Peters)**

GLR-MQ non-linear terms in DGLAP eq.

$$\frac{\partial xg(x, Q^2)}{\partial \log Q^2} = \frac{\partial xg(x, Q^2)}{\partial \log Q^2} \Big|_{\text{DGLAP}} - \frac{9\pi\alpha_s^2}{2Q^2} \int_x^1 \frac{dy}{y} y^2 G^{(2)}(y, Q^2)$$

$$x^2 G^{(2)}(x, Q^2) = \frac{1}{\pi R^2} [xg(x, Q^2)]^2$$

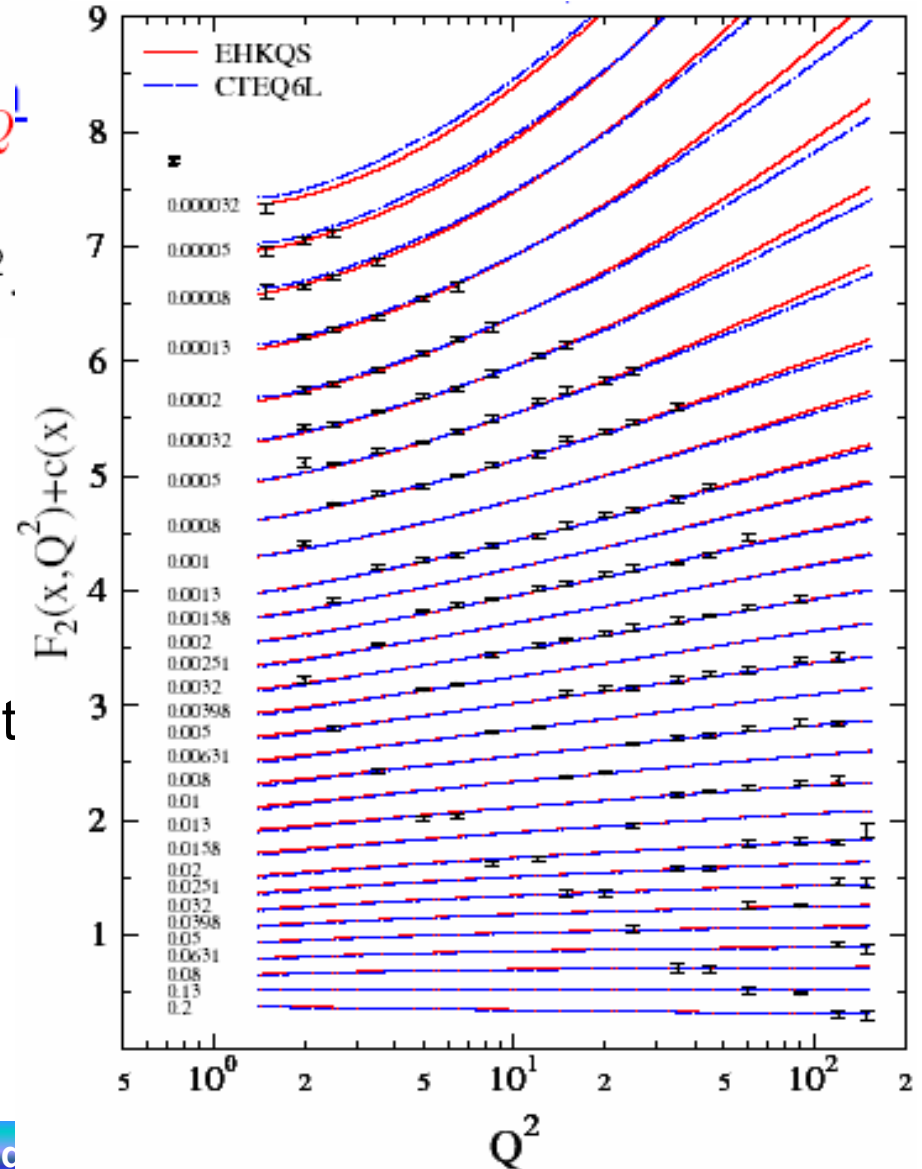
non-linear (quadratic) correction has “-” sign

→ Q^2 evolution is **slower**

Refit HERA F_2 data, reduces F_2 at low x a moderate Q^2

$xg(x, Q^2)$ at low Q^2 ($<10 \text{ GeV}^2$) and x ($<10^{-3}$) is larger than in DGLAP

from V.Kolhinen



Non-linear effects in BK equation

Nonlinear evolution equation for unintegrated gluon distribution.

$$f(x, k^2) = \tilde{f}^{(0)}(x, k^2) + K^1 \otimes f - K^2 \otimes f^2$$

$\tilde{f}^{(0)}(x, k^2) \rightarrow$ input

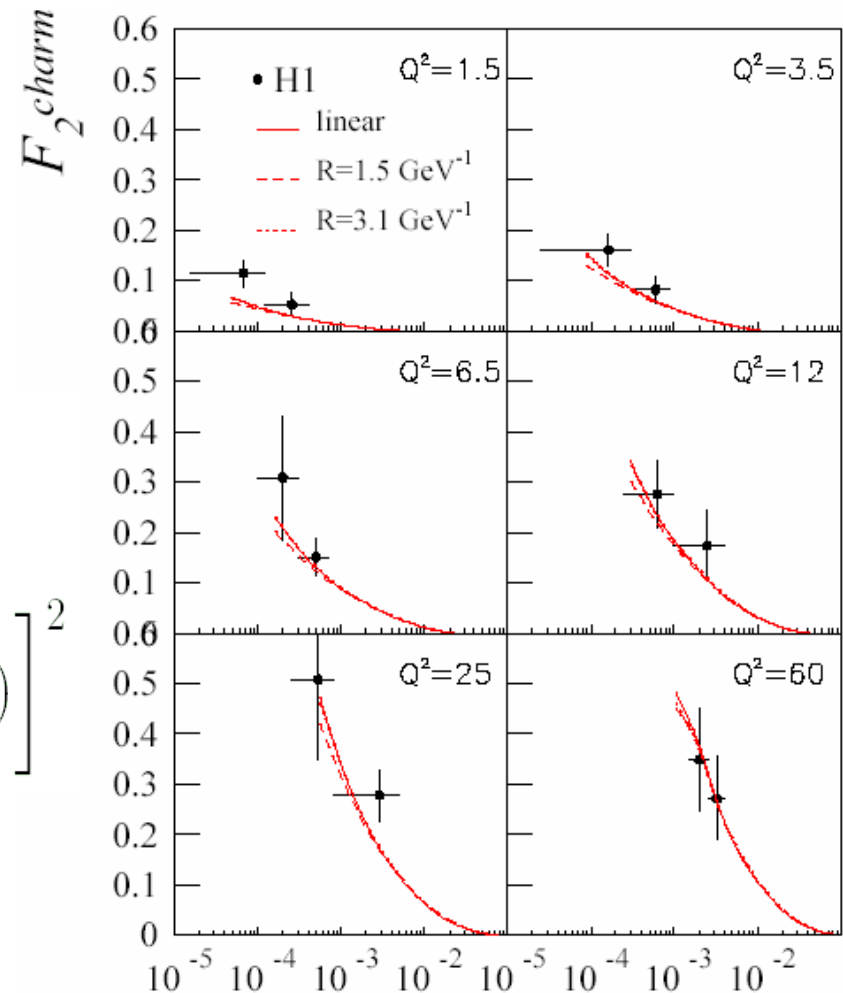
$$K^1 \otimes f \rightarrow \text{BFKL}$$

$$K^2 \otimes f^2 = \left(1 - k^2 \frac{d}{dk^2}\right)^2 \frac{k^2}{R^2} \times$$

$$\int_x^1 \frac{dz}{z} \left[\int_{k^2}^{\infty} \frac{dk'^2}{k'^4} \alpha_s(k'^2) \ln\left(\frac{k'^2}{k^2}\right) f(z, k'^2) \right]^2$$

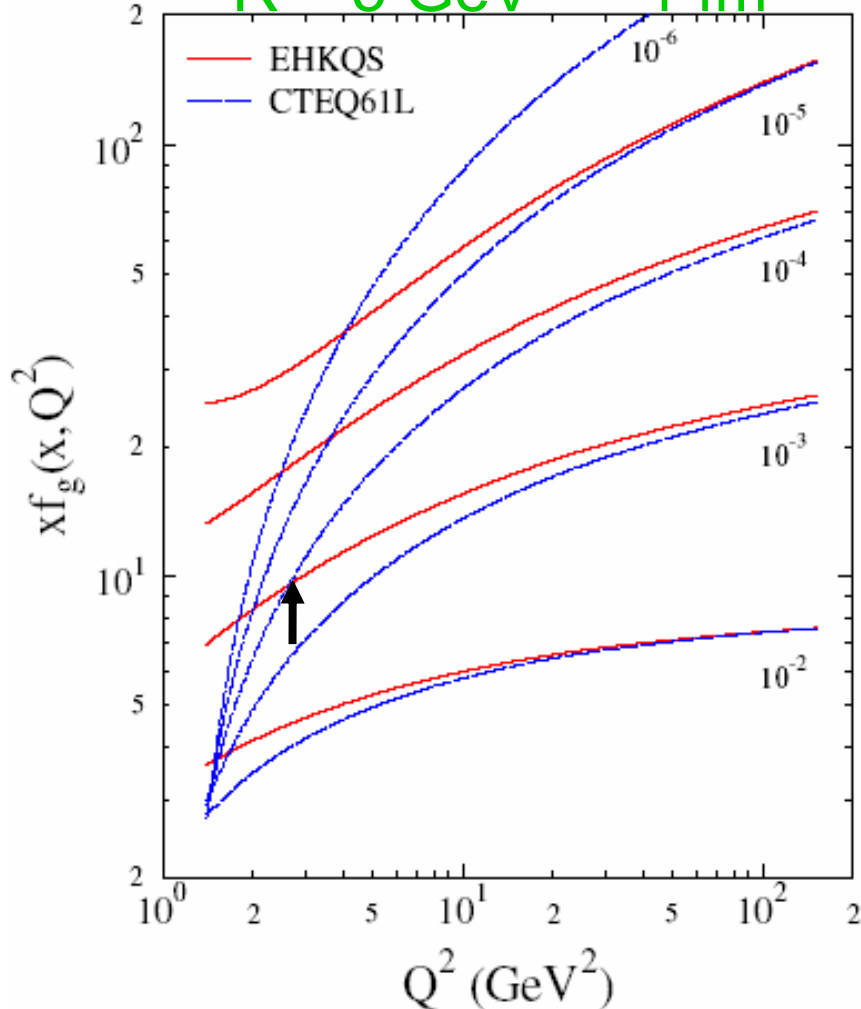
Non-linear part has no impact in the kinematical region of HERA

from K.Kutak

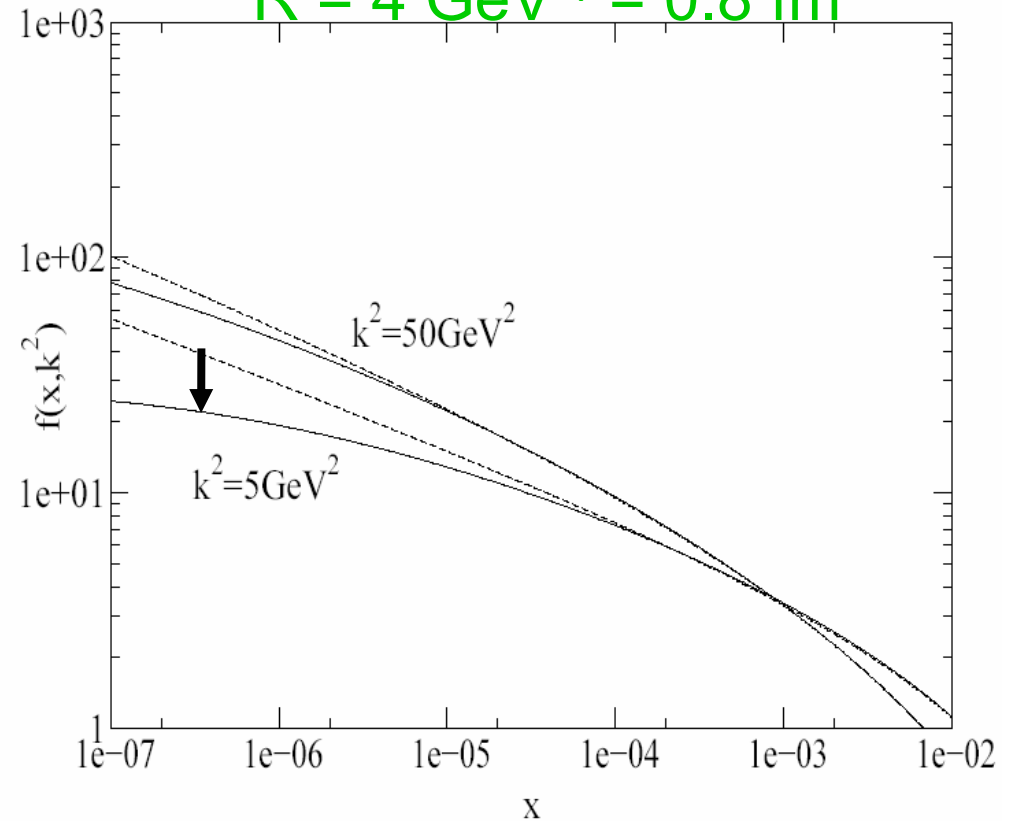


GLR-MQ vs BK: gluons

$R = 5 \text{ GeV}^{-1} = 1 \text{ fm}$



$R = 4 \text{ GeV}^{-1} = 0.8 \text{ fm}$

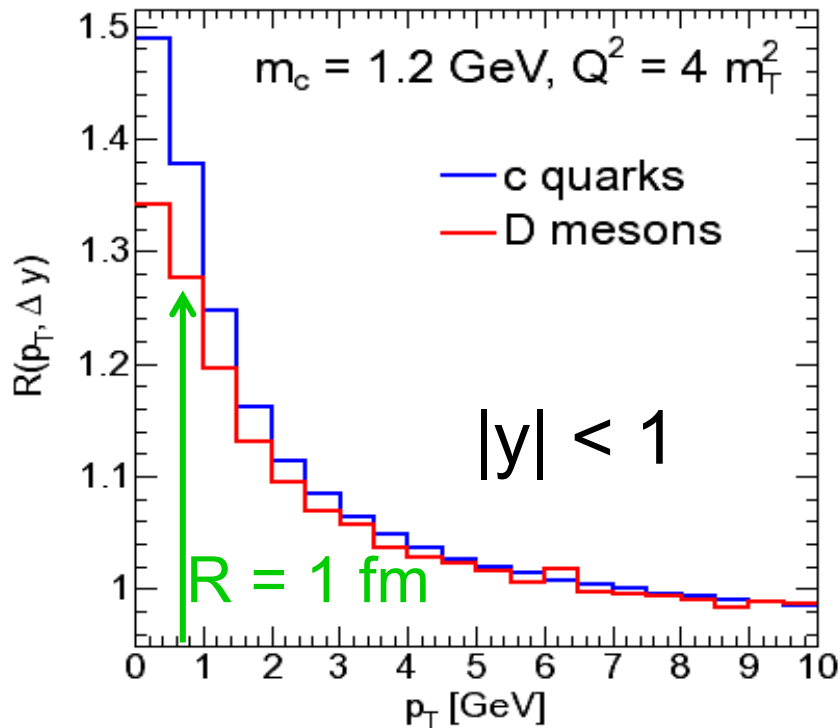


Non-linear effects at HERA

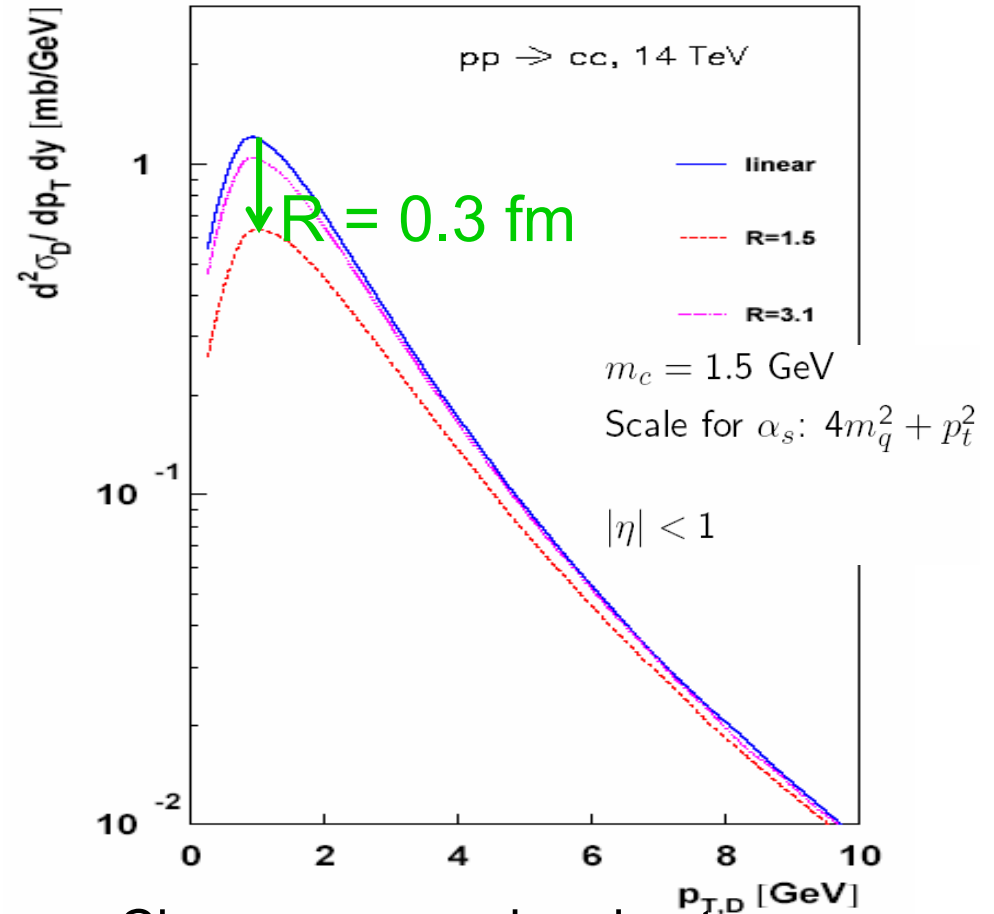
- ◆ Input from H. Jung:
 - ⊕ Total xsection F_2
 - ⊕ diffraction
 - ⊕ multiple scatterings
 - also in heavy quark production
 - ⊕ final state signatures ?
 - ⊕ heavy quark correlations

Non-linear effects at LHC: charm

pp @ 14 TeV



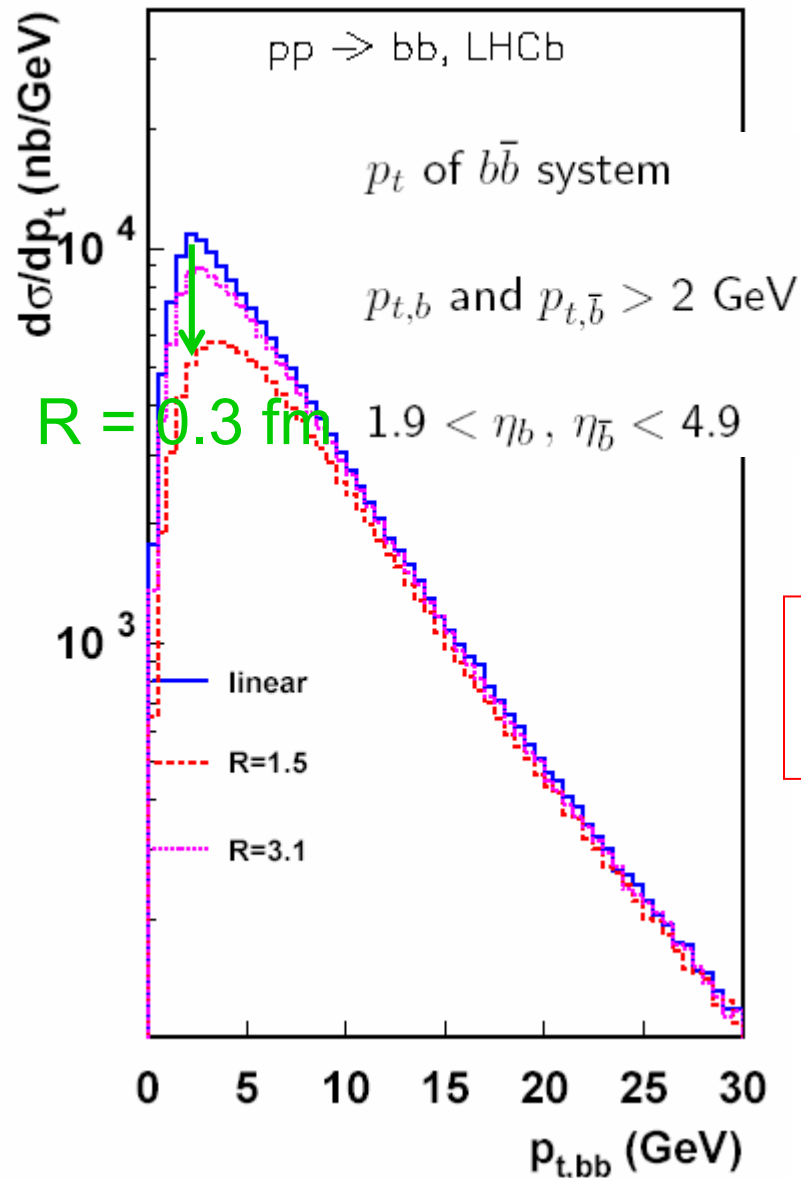
Charm enhancement due to non-linear effects in GLR-MQ



Charm suppression due to non-linear effects in BK (will be shown as ratios)

IMPORTANT TO-DO: compare at same R!

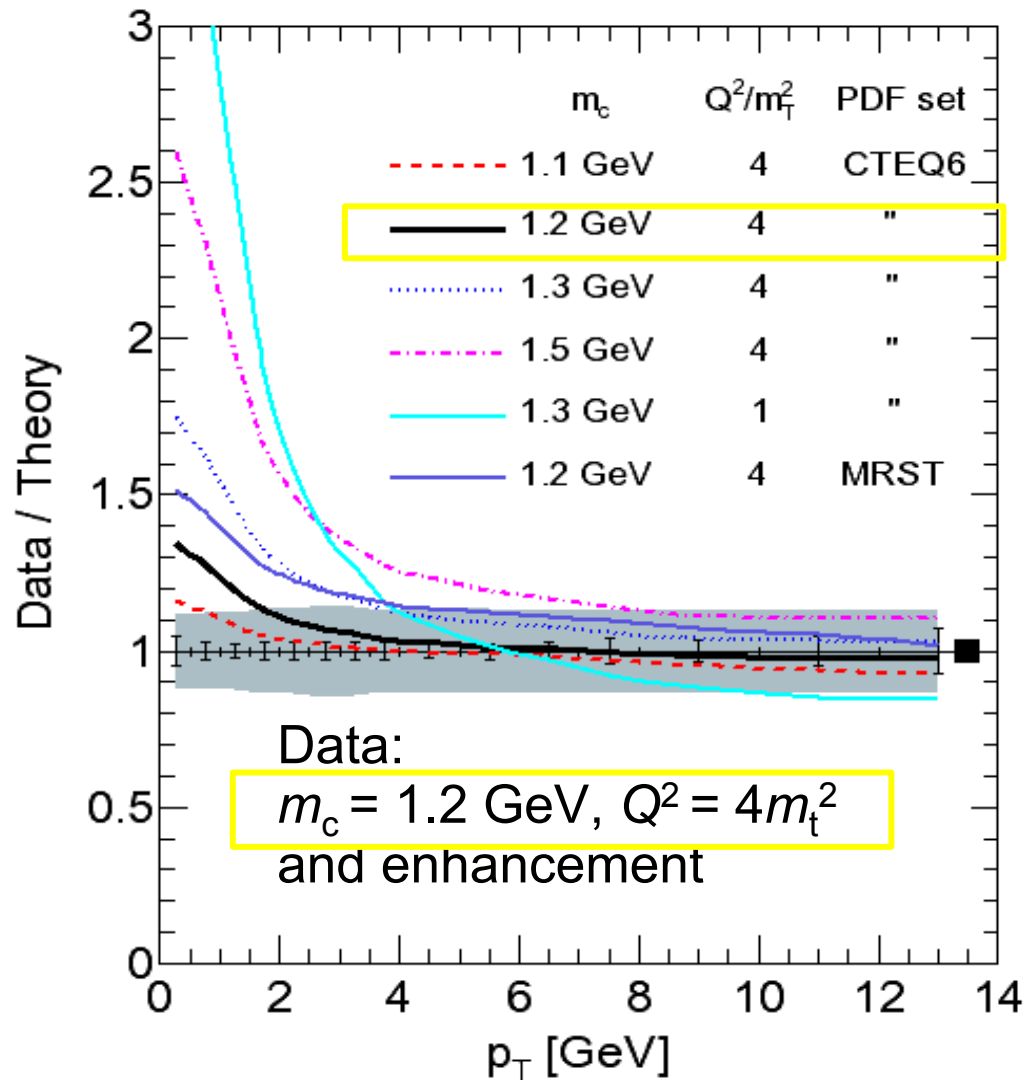
Non-linear effects at LHC: beauty



$b\bar{b}$ suppression due to non-linear effects in BK

GLR-MQ gives small effect ($< 15\%$) for beauty production, due to the larger scale of the process, relative to charm production

Perspectives for exp. obs. with ALICE



Ratio of simulated ALICE data for D^0 production (with GLR-MQ non-linear enhancement) to linear DGLAP results with several sets of parameters.