Some opportunities and challenges for b-production dynamics studies

Charm and bottom quark production at the LHC
CERN, Dec 3 2010

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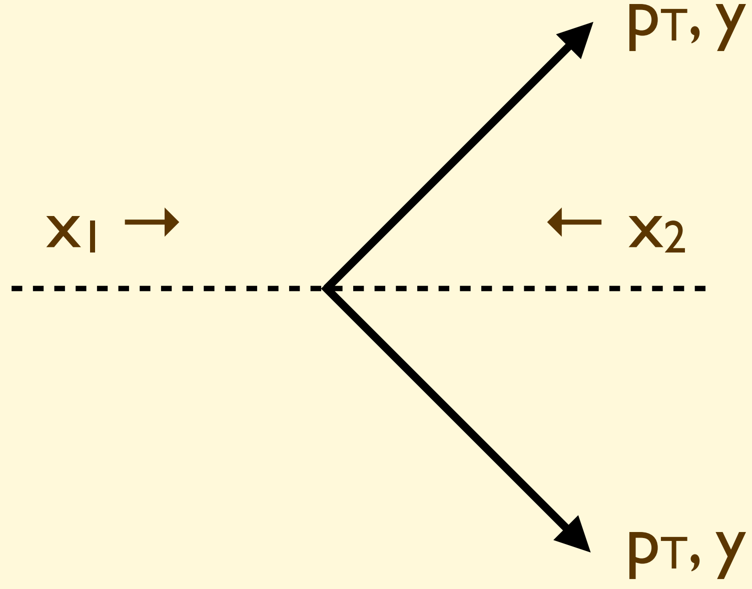
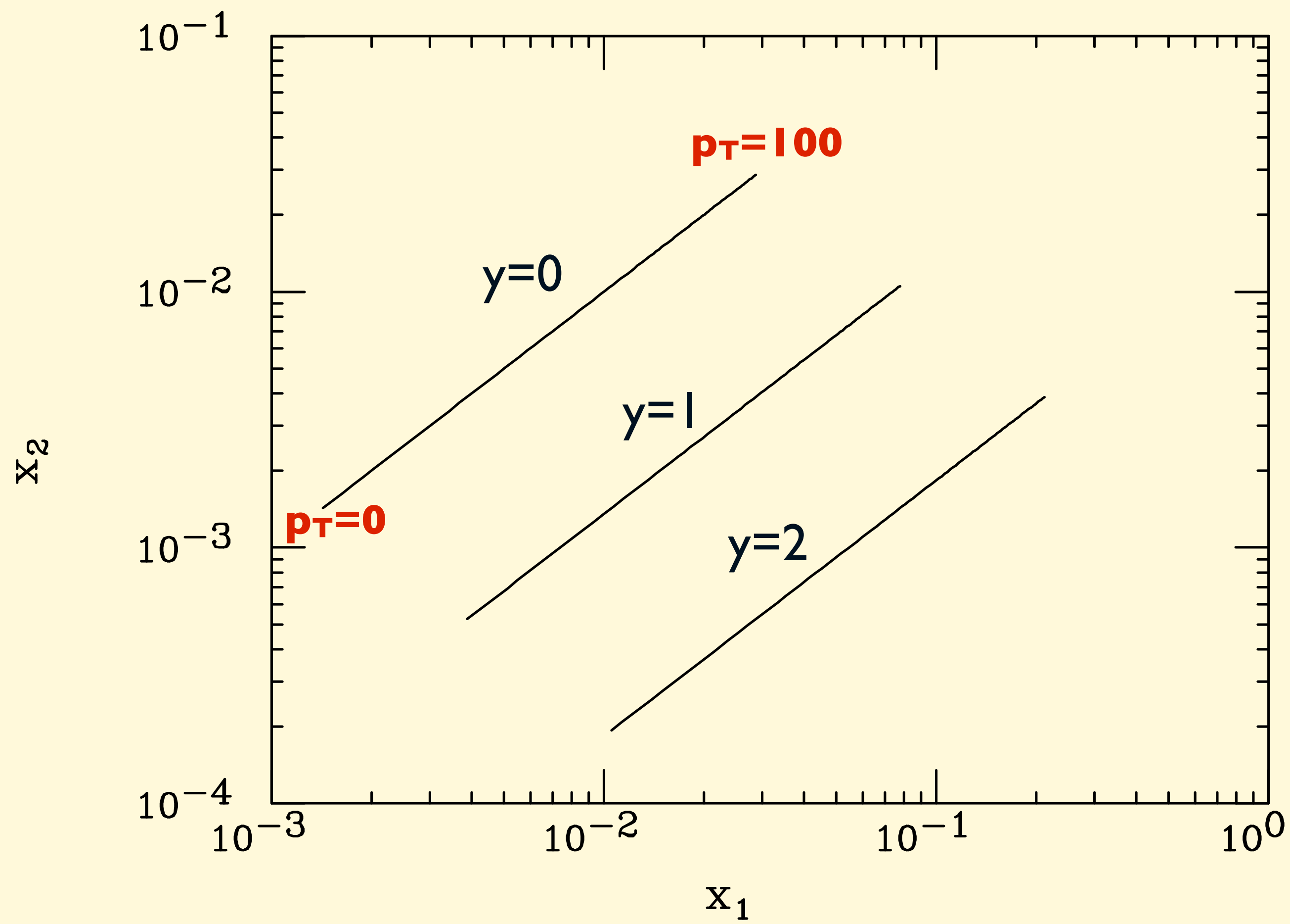
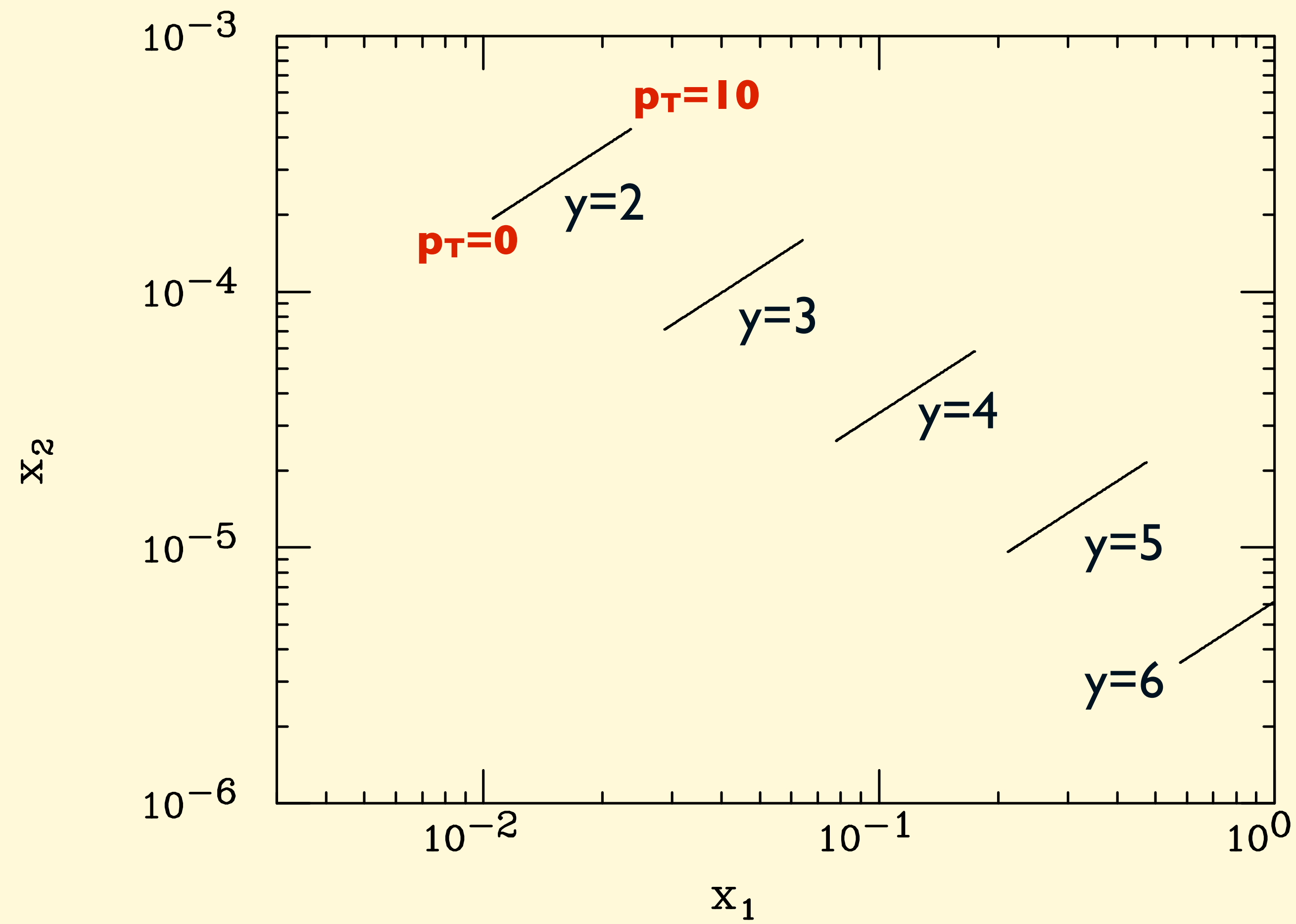
Kinematic reach

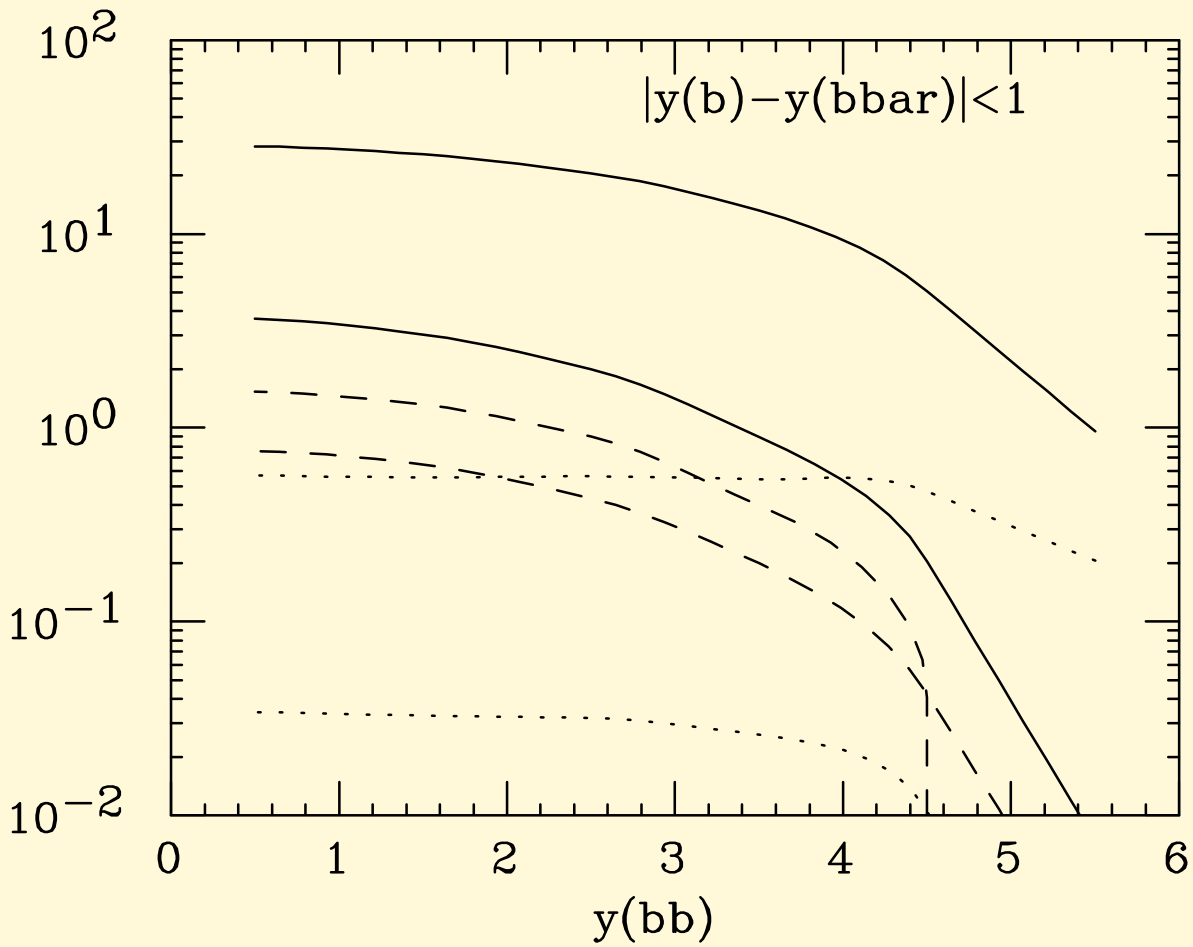


$$x_{1,2} = \frac{m_T}{E_b}\, e^{\pm y}$$





Initial state composition:



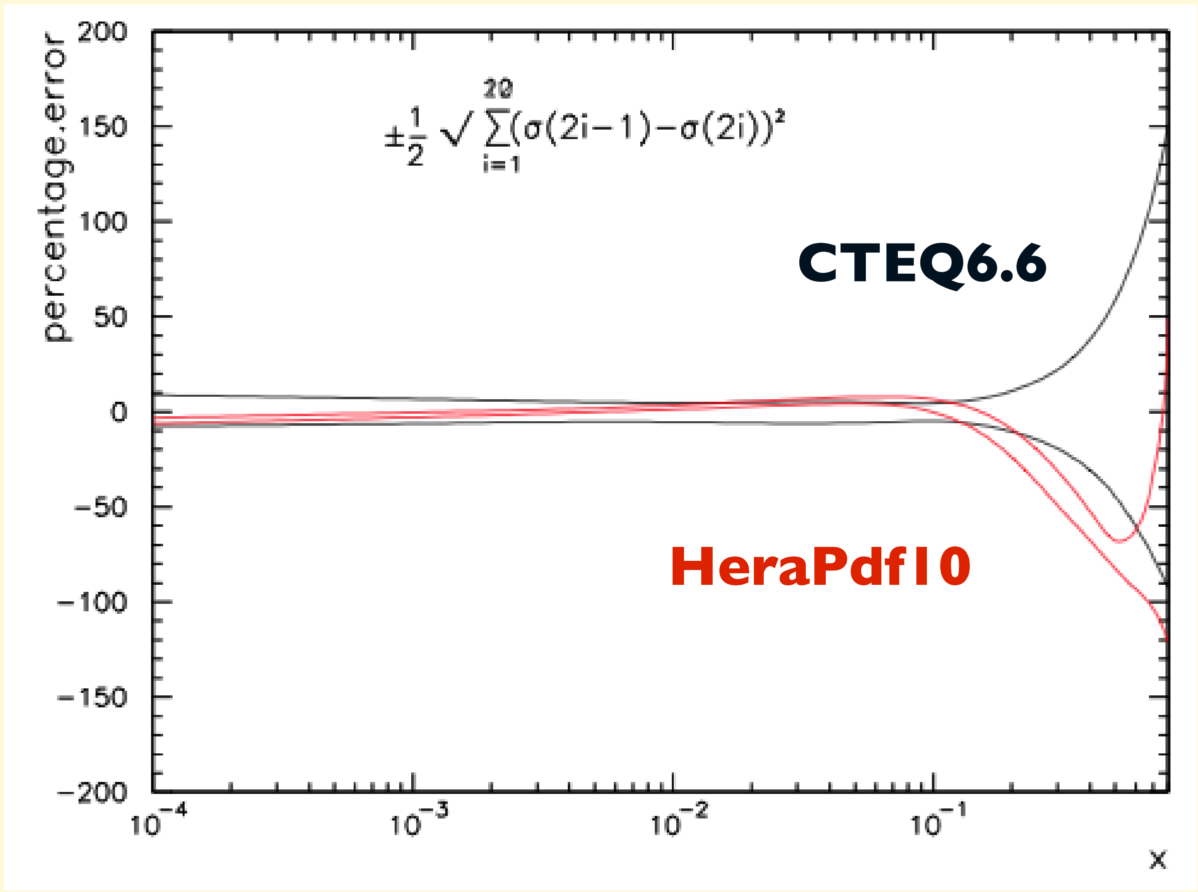
gg

qg

qqbar

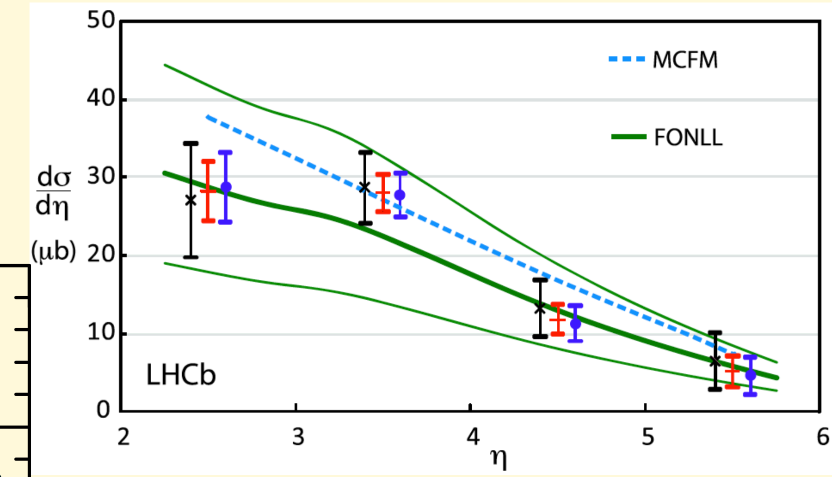
Upper curves: p_T>0

Lower curves: p_T>12 GeV



Dominated by gg initial state, possibly sensitive to gluon PDF

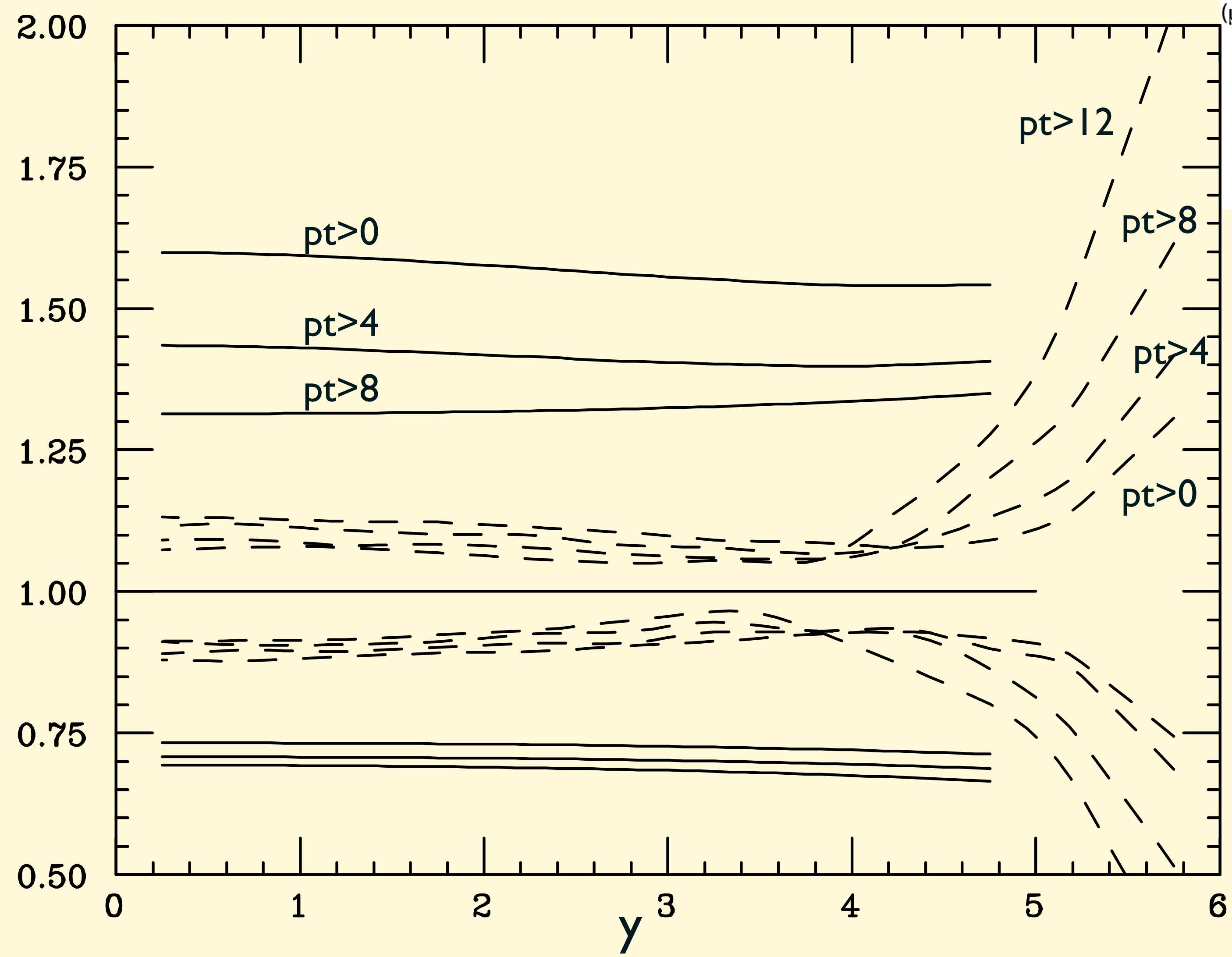
Scale vs PDF systematics



Solid lines:
scale/mass
systematics

$$\frac{\frac{d\sigma}{dy}(\mu_R^{max}, \mu_F^{max}, m_b^{max})}{\frac{d\sigma}{dy}(\mu_R^0, \mu_F^0, m_b^0)}$$

$$\frac{\frac{d\sigma}{dy}(\mu_R^{min}, \mu_F^{min}, m_b^{min})}{\frac{d\sigma}{dy}(\mu_R^0, \mu_F^0, m_b^0)}$$



Dashed lines:
PDF systematics
(CTEQ6.6)

$\mu_{\mathbf{F,R}}^{\mathbf{max,min,0}}$, $\mathbf{m_b^{max,min,0}}$ parameter values at **maximum, minimum and central** values of the cross-section

- great stability of the y distribution vs scale/mass variations
- scale systematics fully correlated in y, so **y shape is robust**
- scale dependence at the ±30% level dominates over mass-dependence for $p_T \gtrsim m_b$
- PDF systematics affects the shape of the y distribution well beyond the effects of scale variations, once y>4 => **PDF sensitivity**
- **theory issues:** $x_1 \sim 1$ => Sudakov logs? $x_2 \sim 10^{-5}$ => small-x logs?

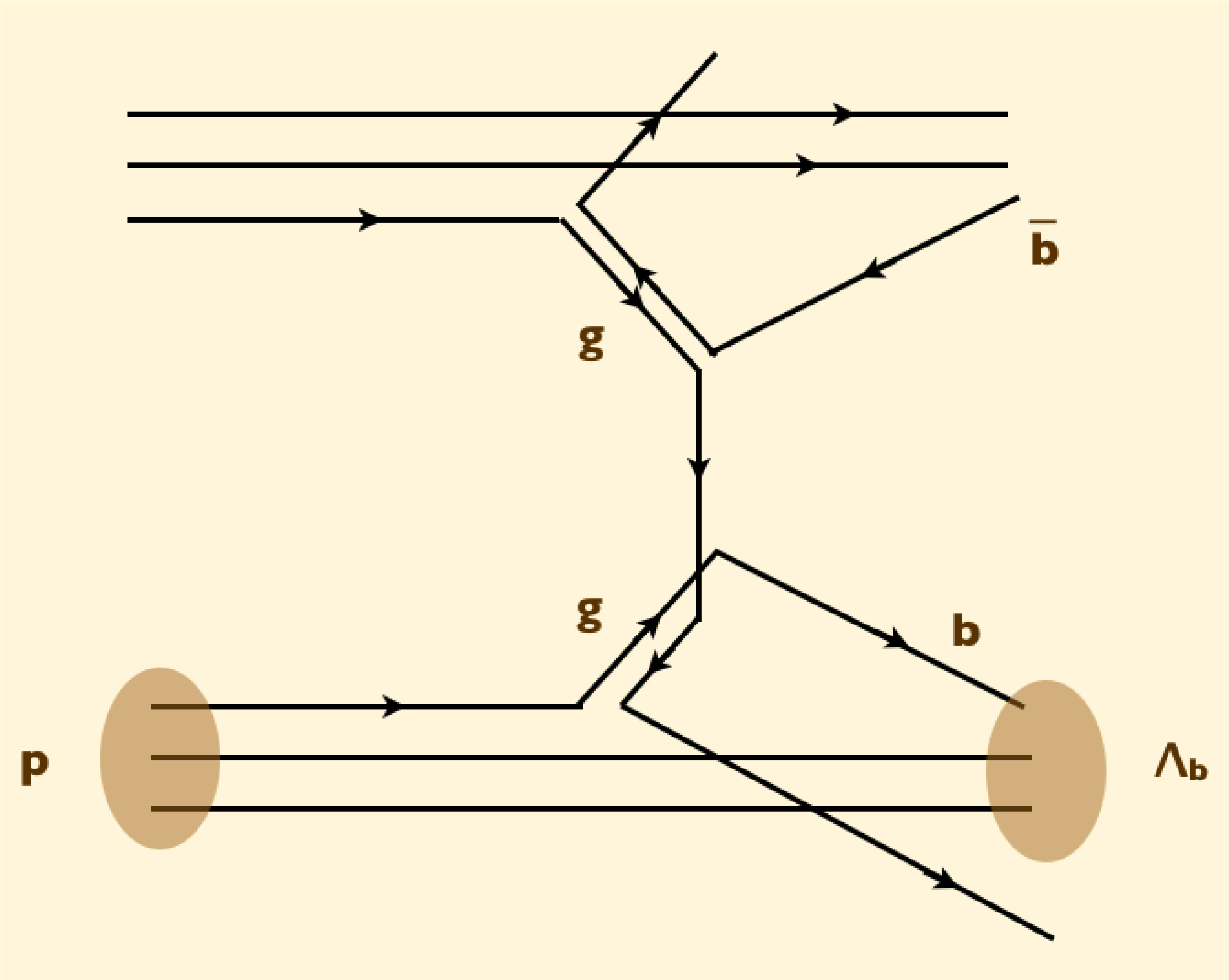
non-pQCD issues

b → H_b fragmentation fractions:

Species	Z^o fraction (%)	Tevatron fraction (%)
B^-	40.3±0.9	33.3±3.0
B^0	40.3±0.9	33.3±3.0
B_s	10.4±0.9	12.1±1.5
Λ_b	9.1±1.5	21.4±6.8

- **Needs clarification!**
- **To the least it points to — not unexpected — deviations from factorization**
- **In view of the CP non-invariance of the initial state, and of the forward kinematics of LHCb, each individual fraction will have to be measured very accurately**

Example



gg → $\bar{b}$ Λ_b

gg ↛ b $\bar{\Lambda}_b$

$$\frac{N(B^0)}{N(\bar{B}^0)} = \frac{1 - f(b \to \Lambda_b)}{1 - f(\bar{b} \to \bar{\Lambda}_b)}$$

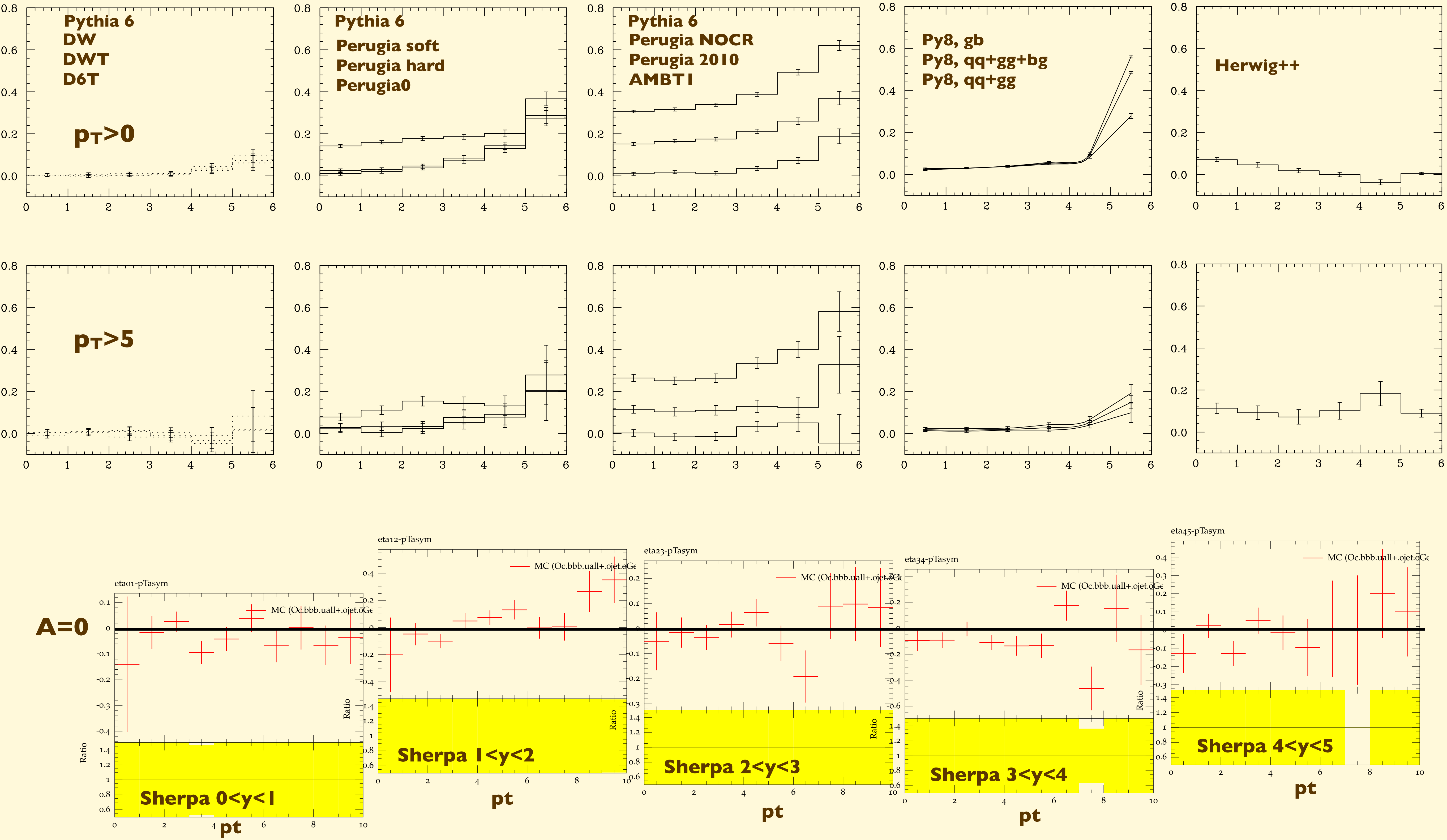
$$A(y) = \frac{dN(\Lambda_b)/dy - dN(\bar{\Lambda}_b)/dy}{dN(\Lambda_b)/dy + dN(\bar{\Lambda}_b)/dy}$$

If A(y)≠0 ⇒ N(B)≠N(Bbar) ⇒ apparent CP violation!

Modeling

Thanks to P.Skands, T.Sjostrand, D.Grellsheid, J.Winter for providing these predictions

A(y) predictions from various MC codes and tunings:



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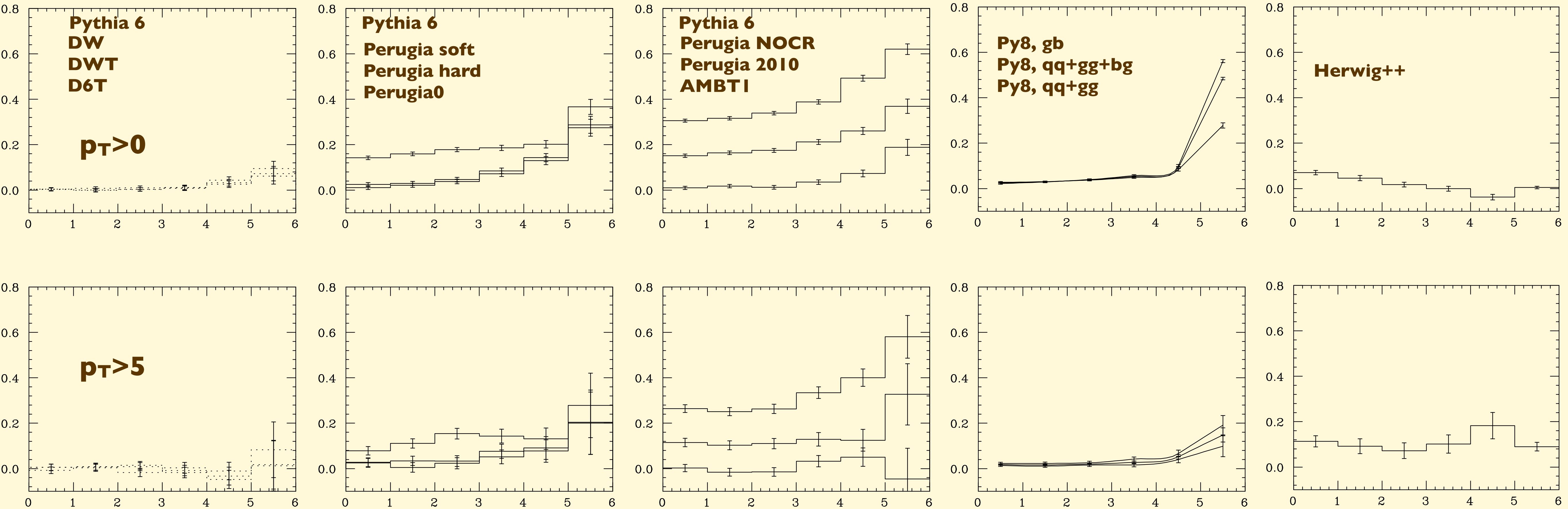

- Very broad range of "predictions", no robust benchmark
- Strong dependence on modeling of perturbative part: more/less gluon radiation will reduce/increase the color-coupling of the b with the proton diquark fragment
- Expect correlation with the modeling of strange and charmed baryons
- Looking forward to LHCb data!