

Weak effects in b -jet and di-jet production at Hadron Colliders

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Why weak effects in hadronic collisions ?

- Hadron Colliders
 - Provide high energy events
 - Many observables will be measured with 5-20% accuracy

Theory: NLO corrections

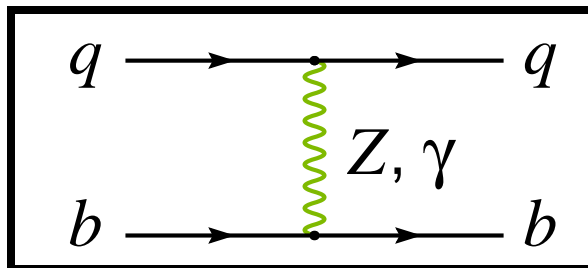
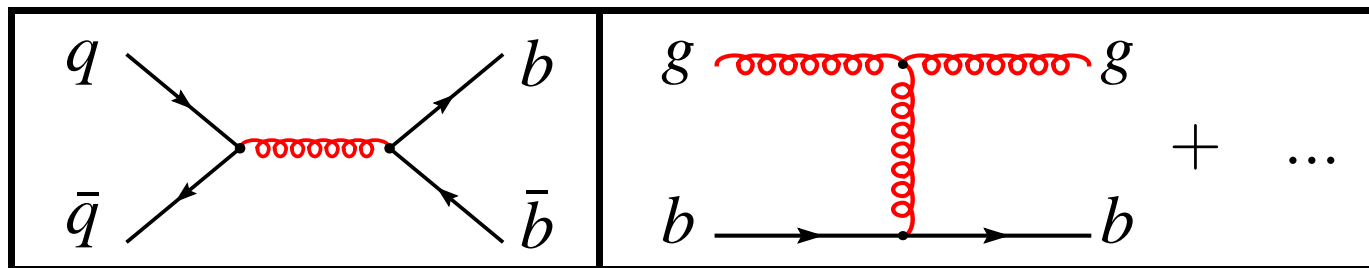
- QCD-corrections are important
- (Electro-) Weak corrections
 - Smaller coupling: $\alpha < \alpha_s$
 - Large logarithms: Sudakov Logarithms

$$\ln^2 \left(\frac{E_{cm}}{M_w} \right), \ln \left(\frac{E_{cm}}{M_w} \right)$$

(Sudakov 1954)
(Kühn, Penin, Smirnov 1999)
(Ciafaloni, Comelli 1999)
(Denner, Pozzorini 2001)

Bottom jet production

- Bottom-quark ($m_b = 0$)
 - Events with well separated partons ($p_T > 50$ GeV)
 - Background process ($t\bar{t}$, SUSY)
 - Testing the SM at high p_T
- b -jet production at Hadron Colliders



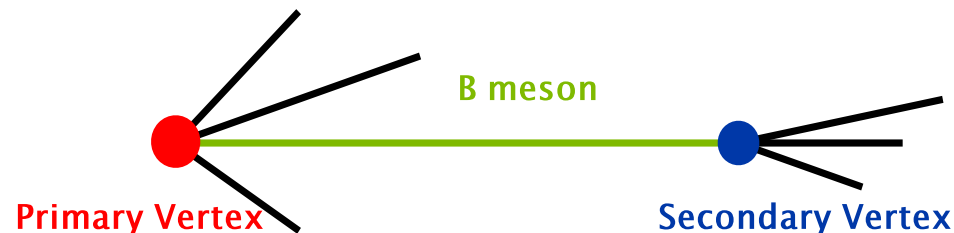
Bottom jet production

- QCD, Mixed and Electroweak contributions

initial state	single b -tag	
quark-induced	$qb \rightarrow qb, q\bar{b} \rightarrow q\bar{b}, \bar{q}b \rightarrow \bar{q}b, \bar{q}\bar{b} \rightarrow \bar{q}\bar{b}$	$q\bar{q} \rightarrow b\bar{b}$
gluon-induced	$gb \rightarrow gb, g\bar{b} \rightarrow g\bar{b}$	$gg \rightarrow b\bar{b}$
pure bottom-induced	$b\bar{b} \rightarrow b\bar{b}, bb \rightarrow bb, \bar{b}\bar{b} \rightarrow \bar{b}\bar{b}$	
	double b -tag	

- Experimentally

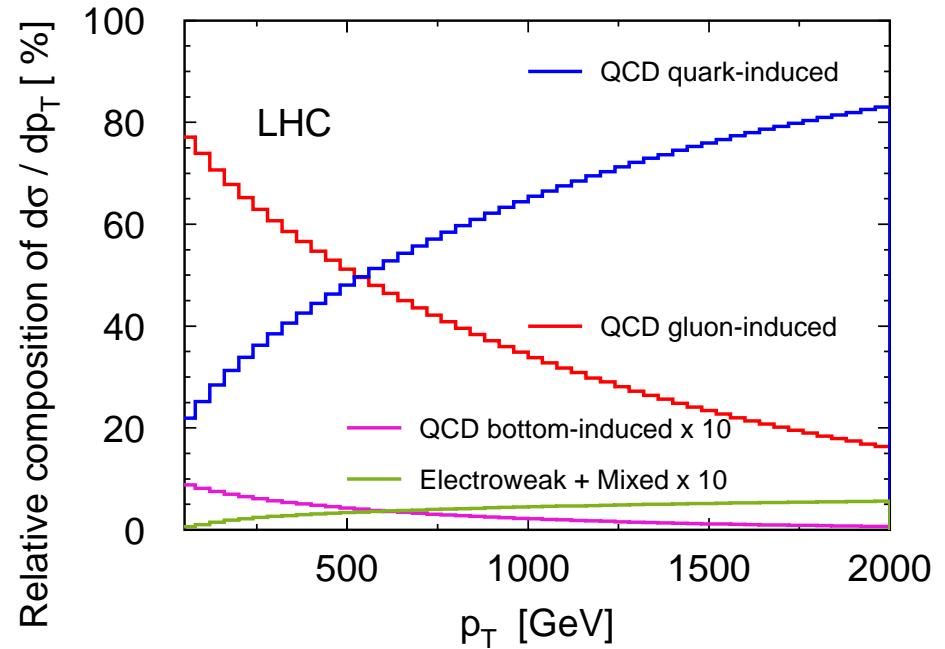
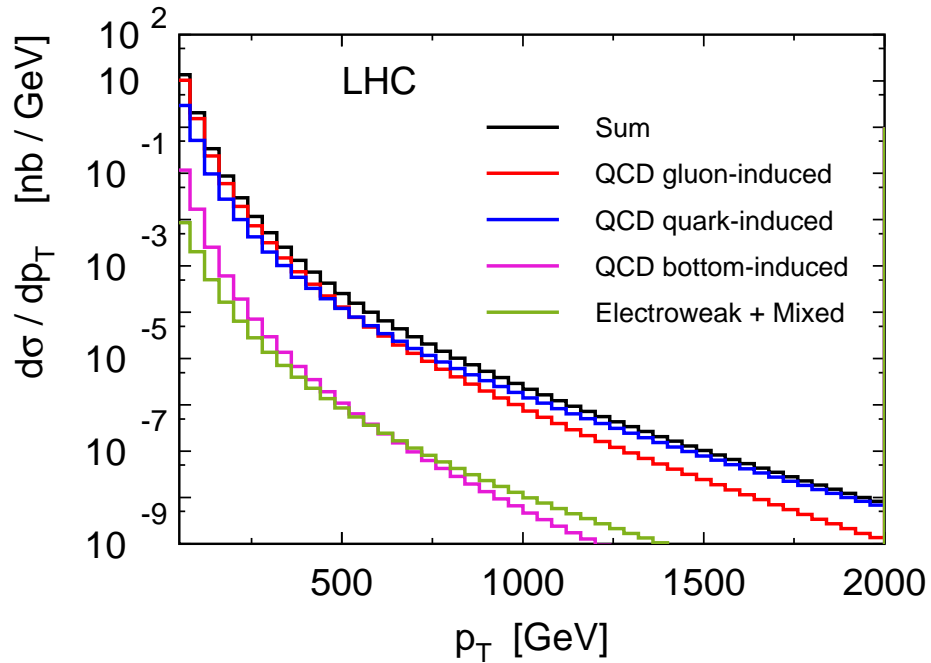
- Lifetime of B mesons $\propto 1.5 \times 10^{-12} s$
- Decay length allows b -jet identification



Bottom jet production

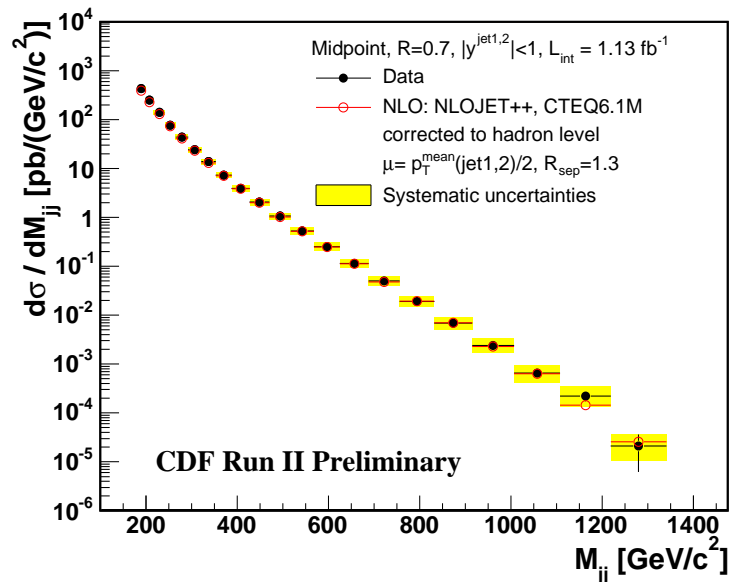
● p_T -distribution at leading order

● Single b -tag



Di-jet production

- Gluon- & light quark-jets ($m_u = m_d = m_s = m_c = 0$)
 - Well separated jets $p_T > 50$ GeV
 - Indirect new physics search, e.g. Z'
- Experimentally
 - Tevatron: Di-jet-Masses up to 1 TeV
 - LHC: Di-jet-Masses up to several TeV

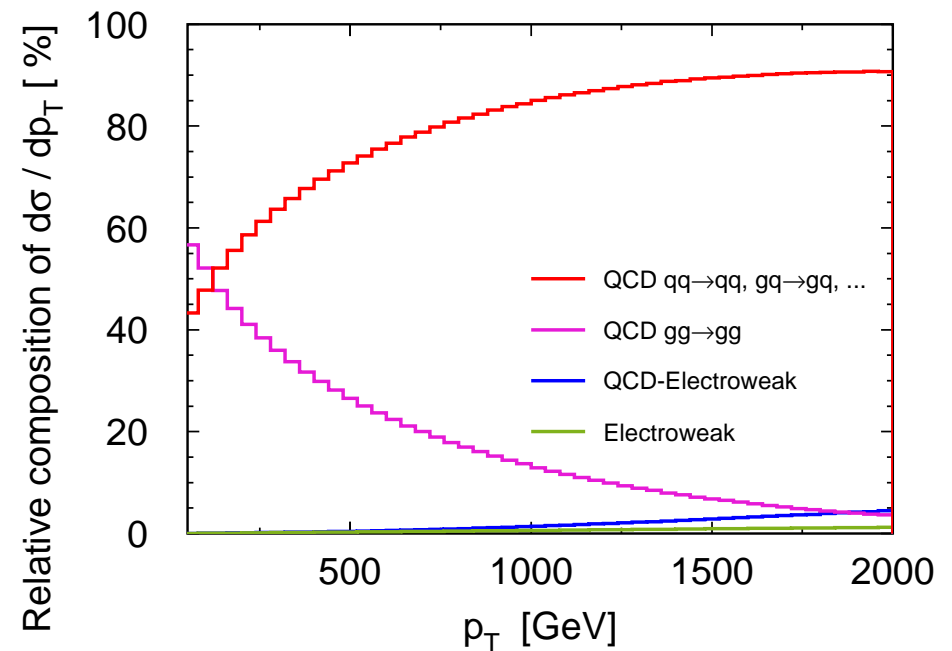
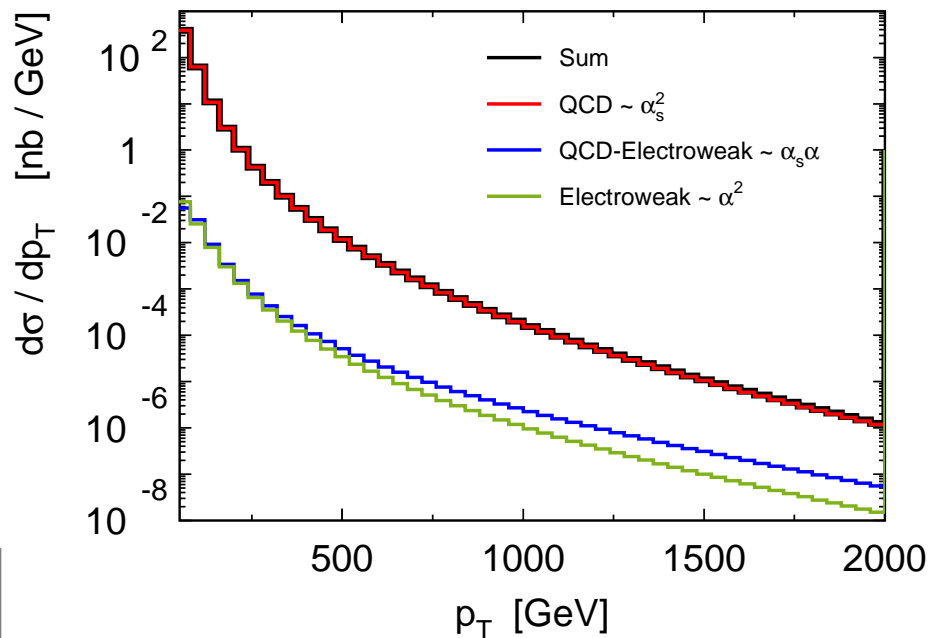


Di-jet production

Partonic processes

	α_s^2	$\alpha_s \alpha$	α^2
Processes with external Gluons			
$gg \rightarrow gg, gg \rightarrow q\bar{q}, gq \rightarrow gq, g\bar{q} \rightarrow g\bar{q}, q\bar{q} \rightarrow gg$	✓	—	—
Processes with external Quarks only			
$q\bar{q} \rightarrow q'\bar{q}', q\bar{q}' \rightarrow q\bar{q}', qq' \rightarrow qq', \bar{q}'\bar{q} \rightarrow \bar{q}'\bar{q}$	✓	✓	✓
$q\bar{q} \rightarrow q\bar{q}, qq \rightarrow qq, \bar{q}\bar{q} \rightarrow \bar{q}\bar{q}$	✓	✓	✓

p_T -distribution at leading order



Status of NLO calculations

● b -jet production

- QCD corrections $O(\alpha_s^3)$
- $b\bar{b}$ production $O(\alpha_s^2\alpha)$

(Dawson, Ellis, Nason 1988)

(Beenakker, Kuijf, Neerven, Smith 1989)

(Frixione, Mangano 1997)

(Moretti et al 2003)

● Di-jet production

- QCD corrections $O(\alpha_s^3)$
- Weak corrections $O(\alpha_s^2\alpha)$

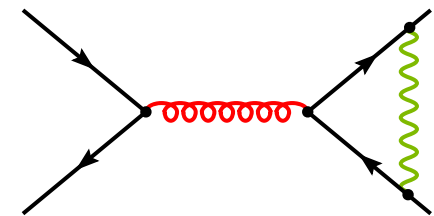
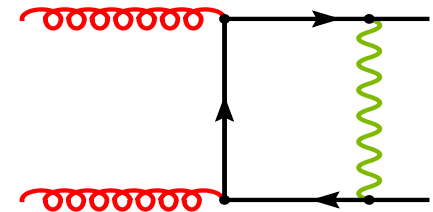
(Ellis, Sexton 1985)

(Aversa et al 1988, 1991)

(Moretti et al 2006)

Methods: Overview

- Passarino-Veltman reduction
- Renormalisation
 - Weak corrections: Wave function only
 - QCD-corrections: $\overline{\text{MS}}$ scheme
- Real corrections
 - Dipole Subtraction
 - Phase Space Slicing



(Catani, Seymour 1996)

(Harris, Owens 2002)

$$\left(\text{tree-level diagram} + \dots \right) \times \left(\text{loop-level diagram} + \dots \right)^*$$

Consistency

● b -jet production

- Cancellation of the IR and UV poles, ... ✓
- Crossing symmetries ✓
- Comparison between Slicing- and Dipole-Method ✓

● Di-jet production

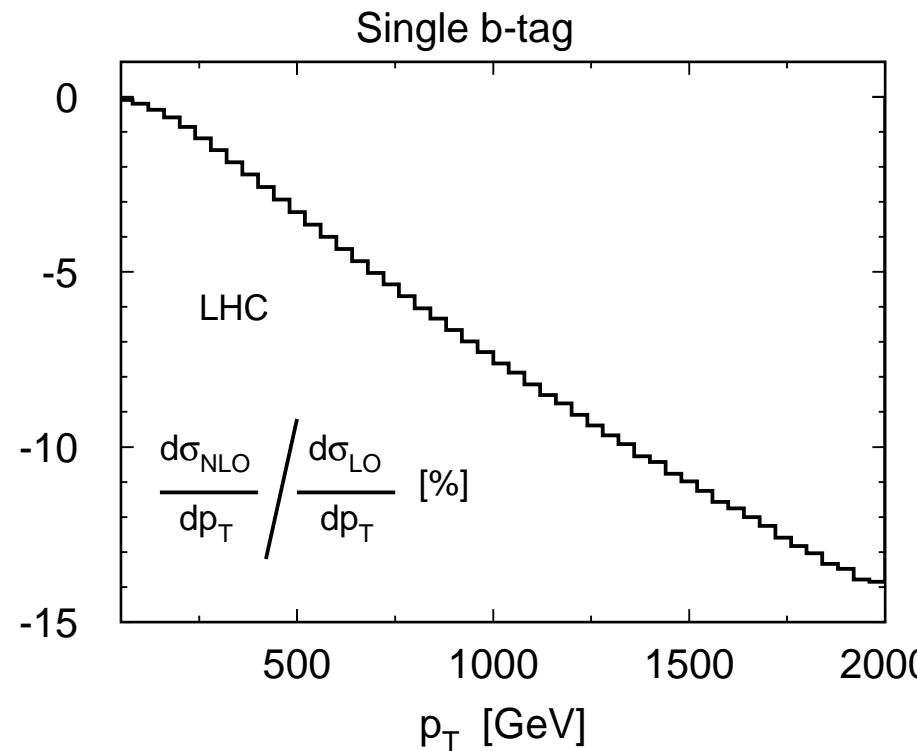
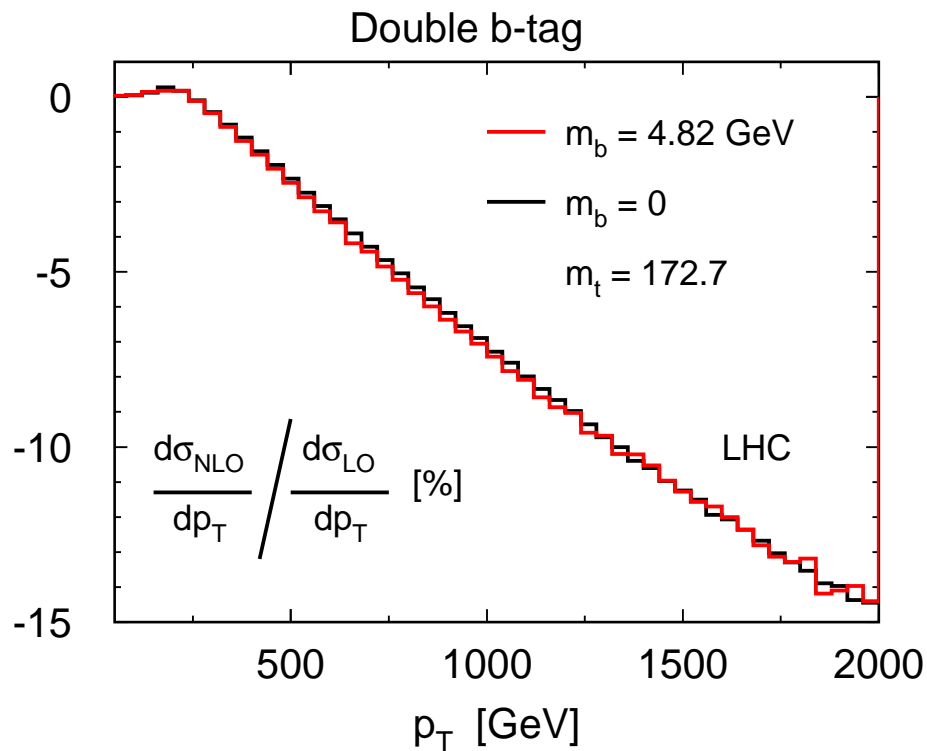
- Cancellation of the IR and UV poles, ... ✓
- Crossing symmetries ✓
- Comparison between Slicing- and Dipole-Method (✓)

b-jet production at the LHC

● Relative corrections to p_T

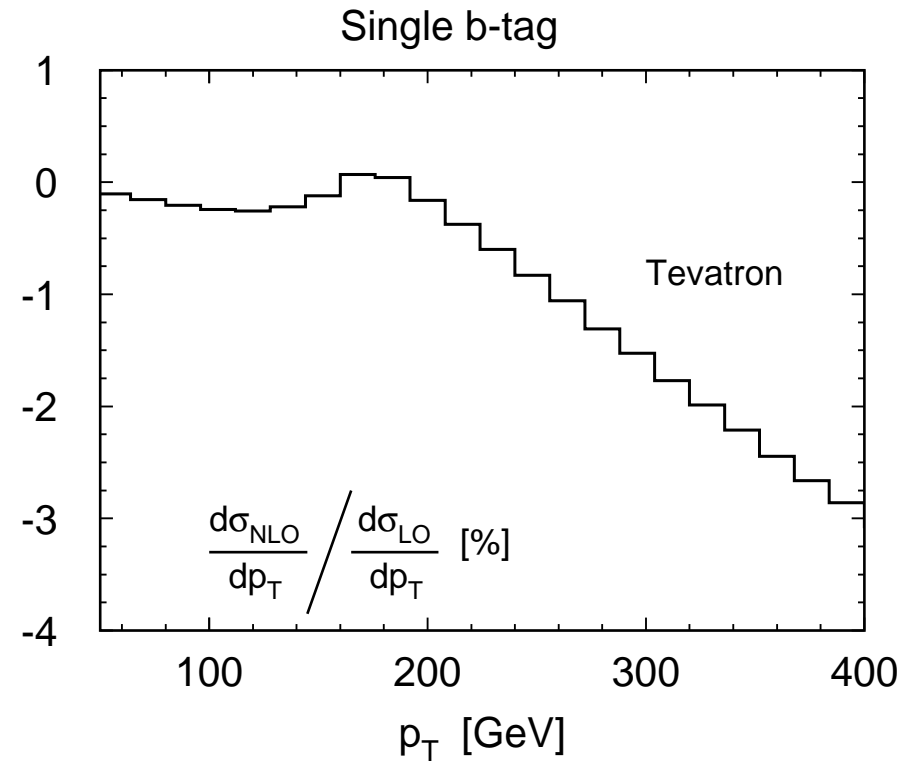
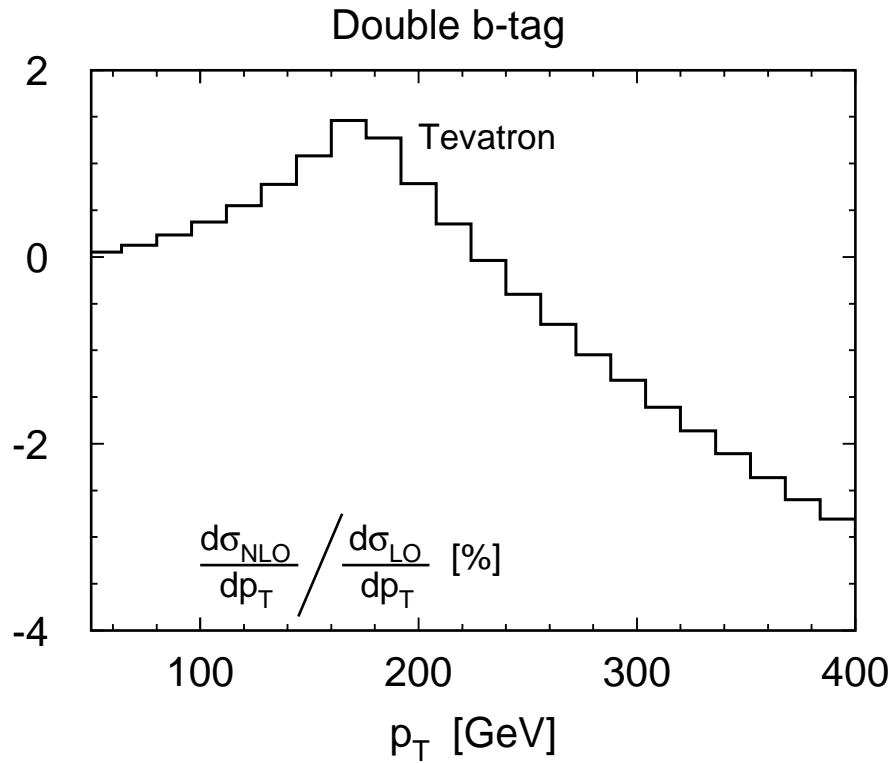
- **Double *b* tag:** Comparison between massive and massless calculation

(Kühn, A.S., Uwer 2006)



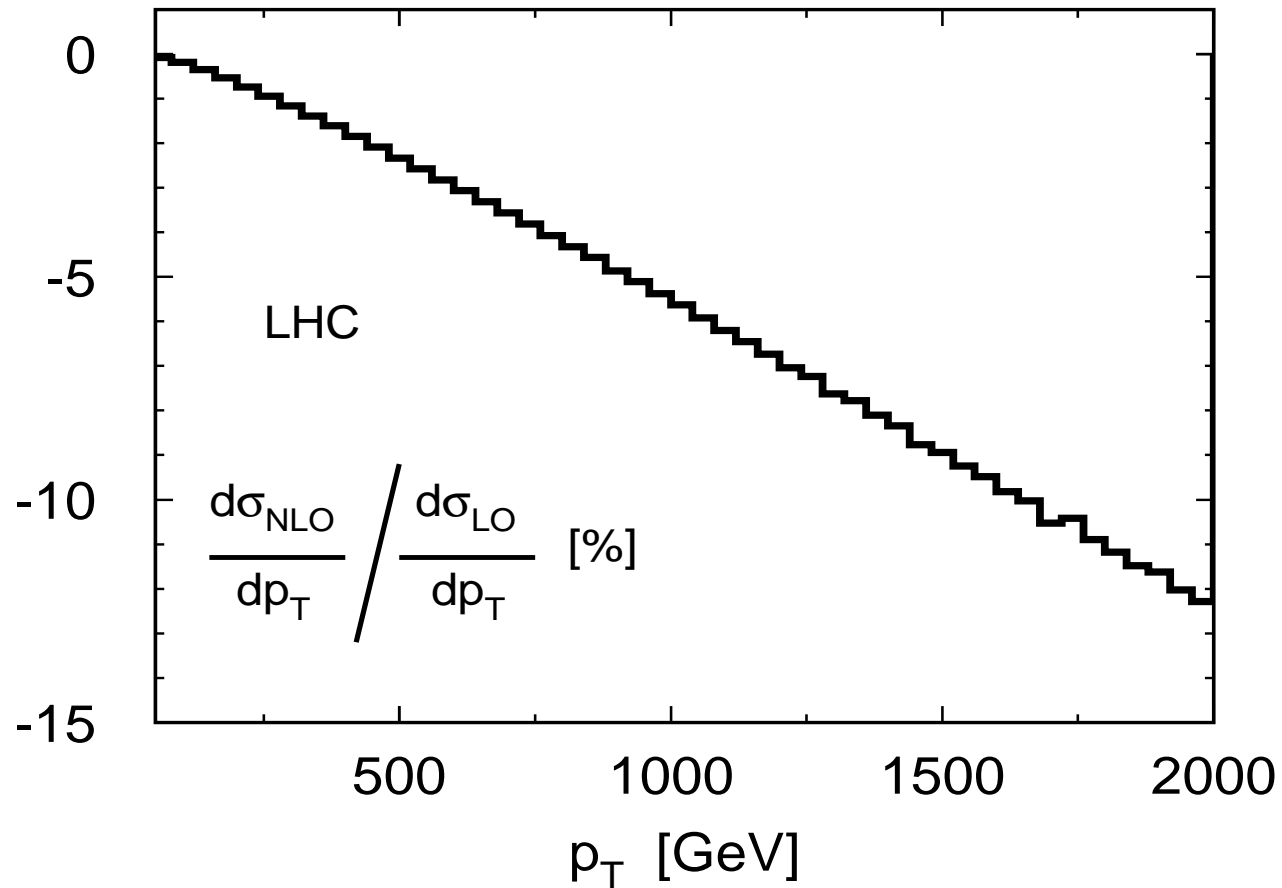
b-jet production at the Tevatron

● Relative corrections to p_T



Di-jet production at the LHC

● Preliminary Result



Conclusion

- Weak corrections have impact to p_T -distribution
 - b -jet production: $\propto 10 - 15\%$
 - di-jet production (preliminary): $\propto 8 - 12\%$
 - Analytic results for further studies