Electroweak corrections to b-jet and di-jet production

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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

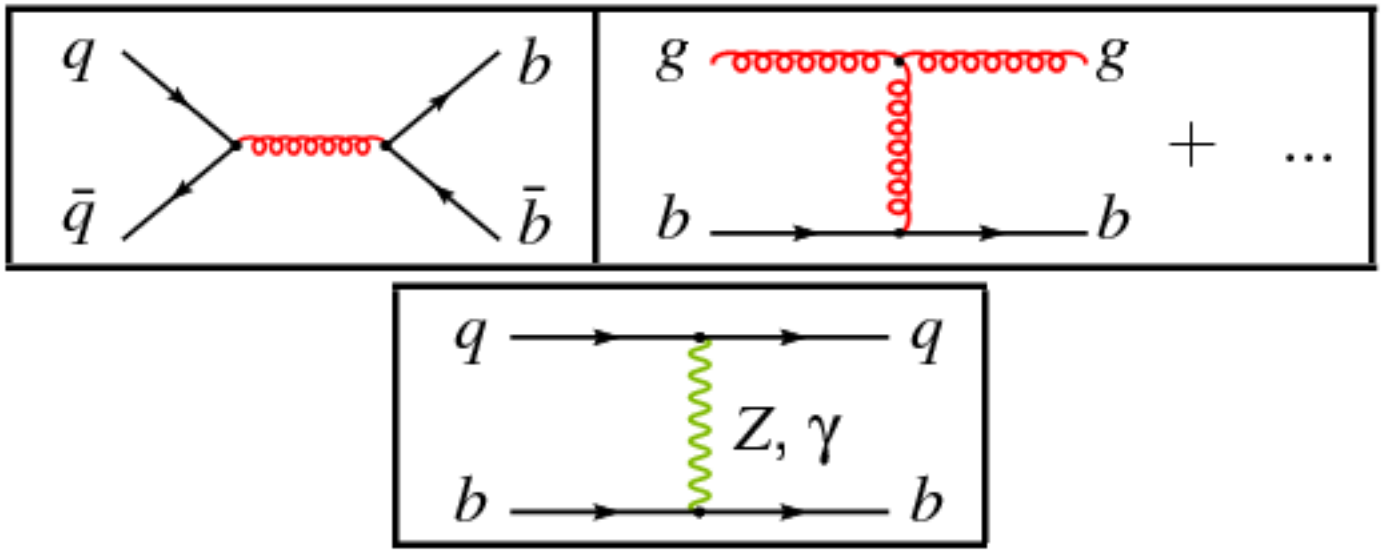
- QCD-corrections are important
- (Electro-) Weak corrections
  - Smaller coupling: $\alpha < \alpha_s$
  - Large logarithms: Sudakov Logarithms

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

(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)
  - Testing the SM at high p_T
  - New phyics search Z', SUSY ...
- b-jet production at Hadron Colliders



Bottom jet production

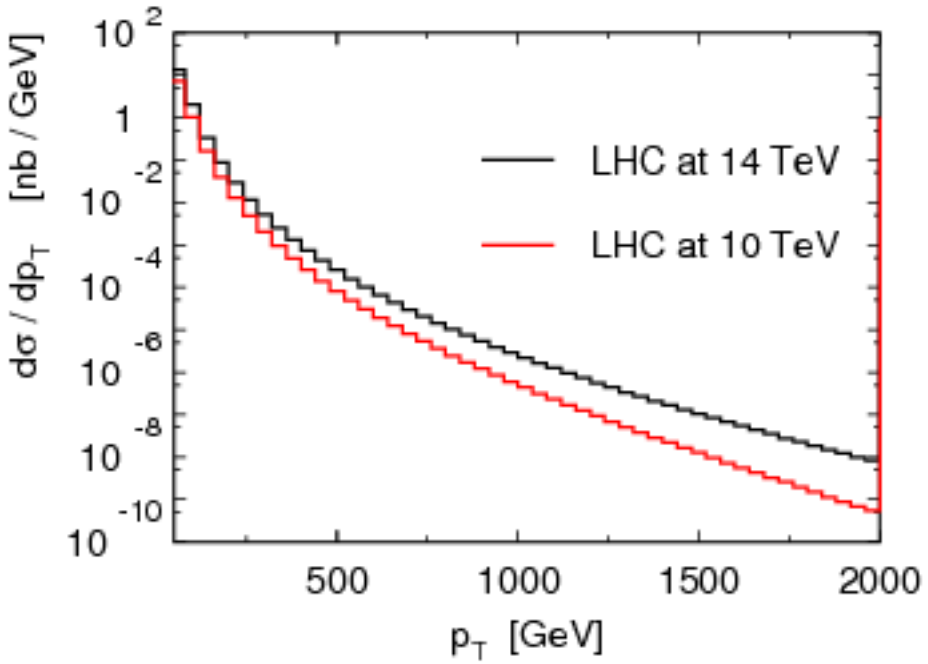
- QCD, Mixed and Electroweak contributions

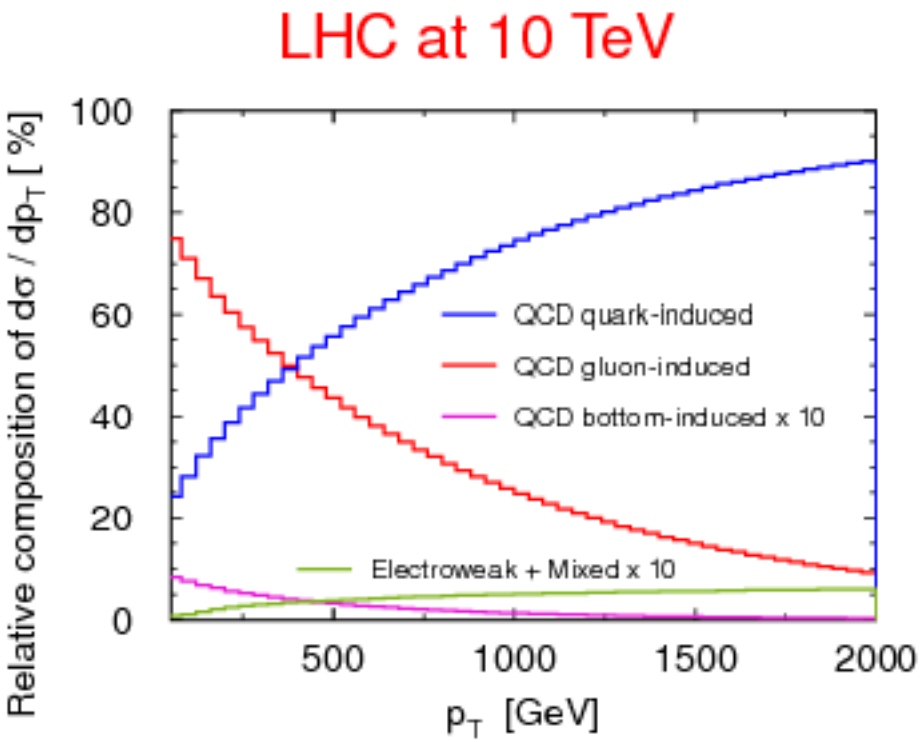
initial state	single b-tag	
quark-induced	$qb \to qb, q\bar{b} \to q\bar{b}, \bar{q}b \to \bar{q}b, \bar{q}\bar{b} \to \bar{q}\bar{b}$	$q\bar{q} \to b\bar{b}$
gluon-induced	$gb \to gb, g\bar{b} \to g\bar{b}$	$gg \to b\bar{b}$
pure bottom-induced	$b\bar{b} \to b\bar{b}, bb \to bb, \bar{b}\bar{b} \to \bar{b}\bar{b}$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

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

Bottom jet production at the LHC

- p_T-distribution at leading order: Single b-tag
  - Relative composition





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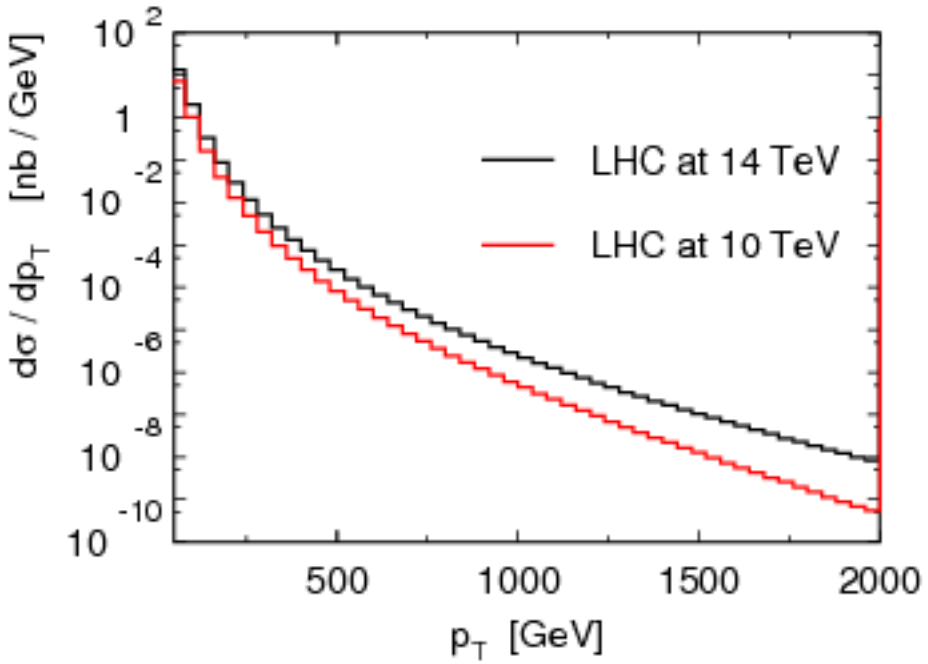

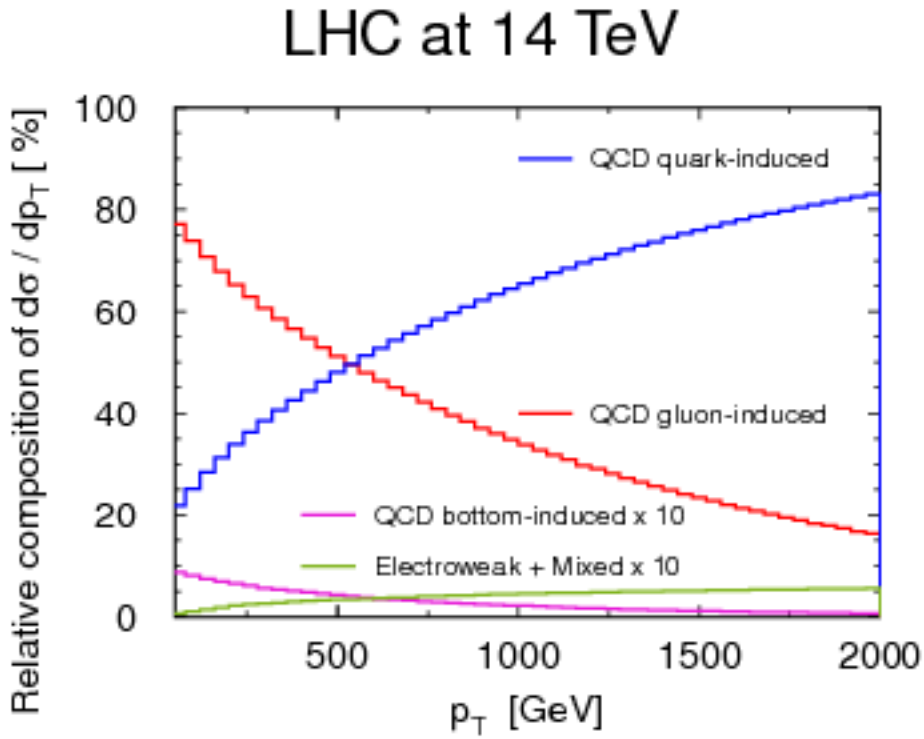

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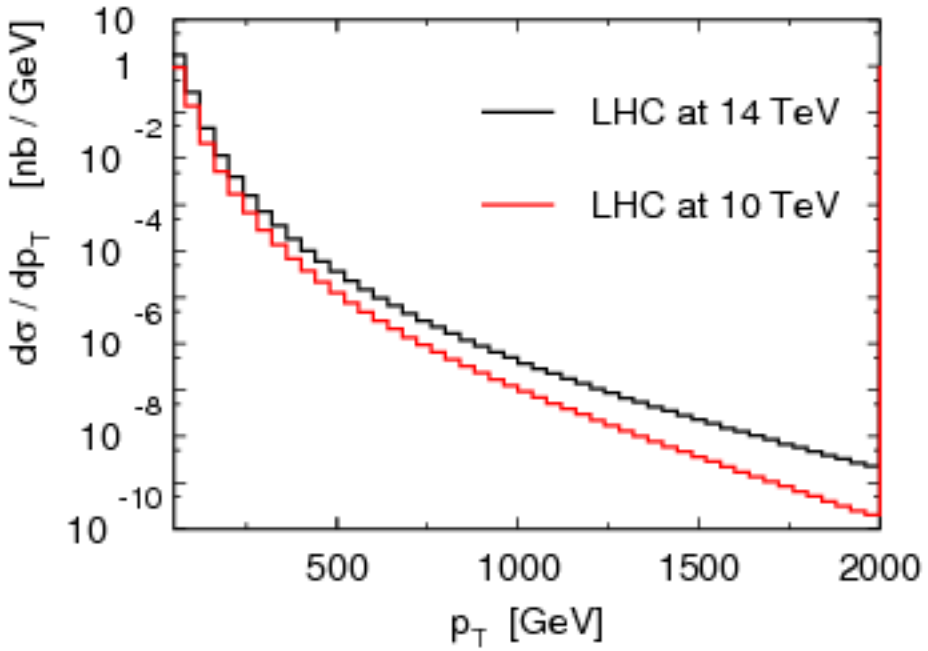
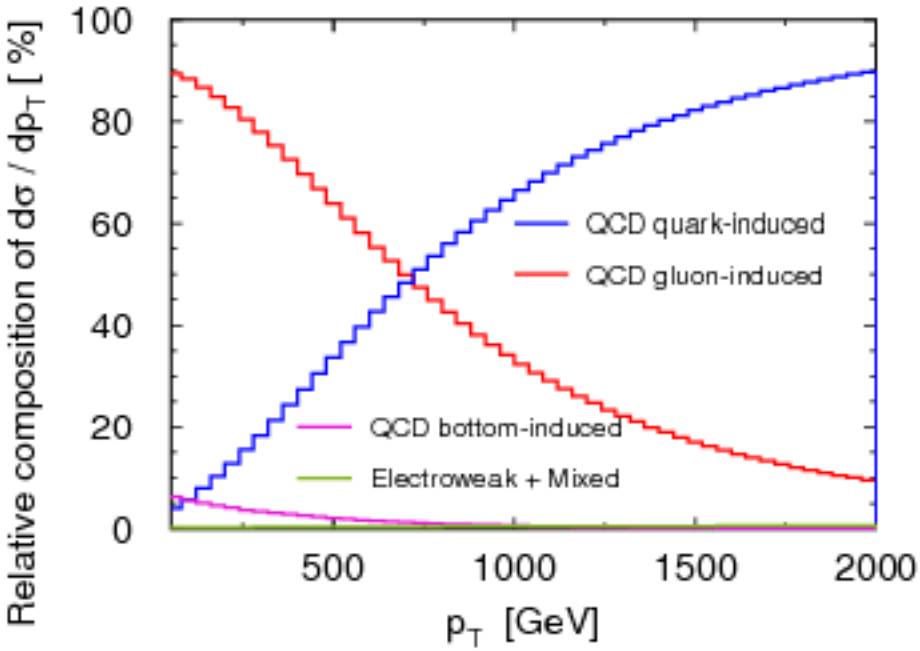


LHC at 10 TeV



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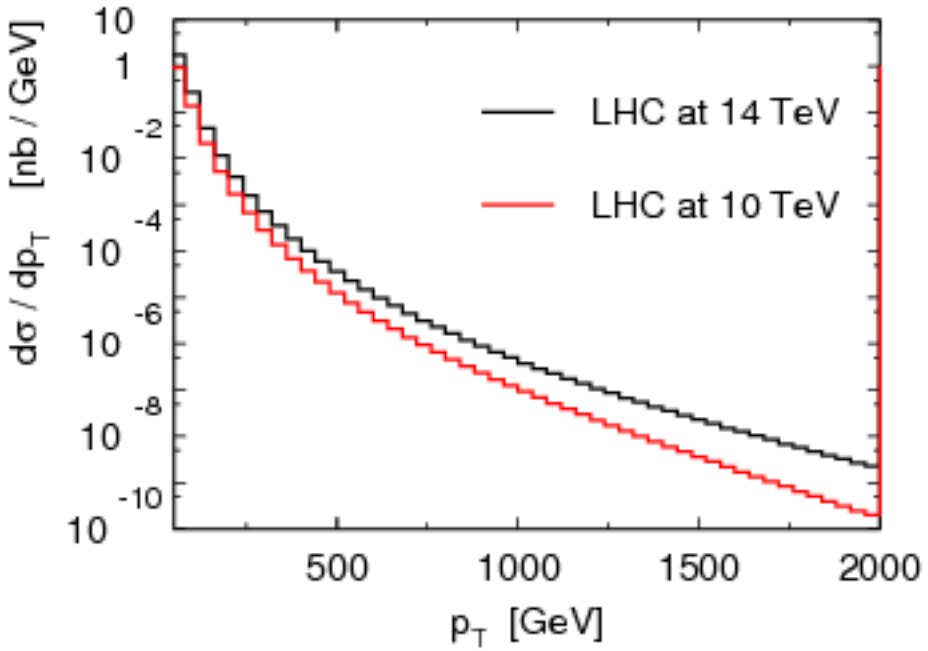
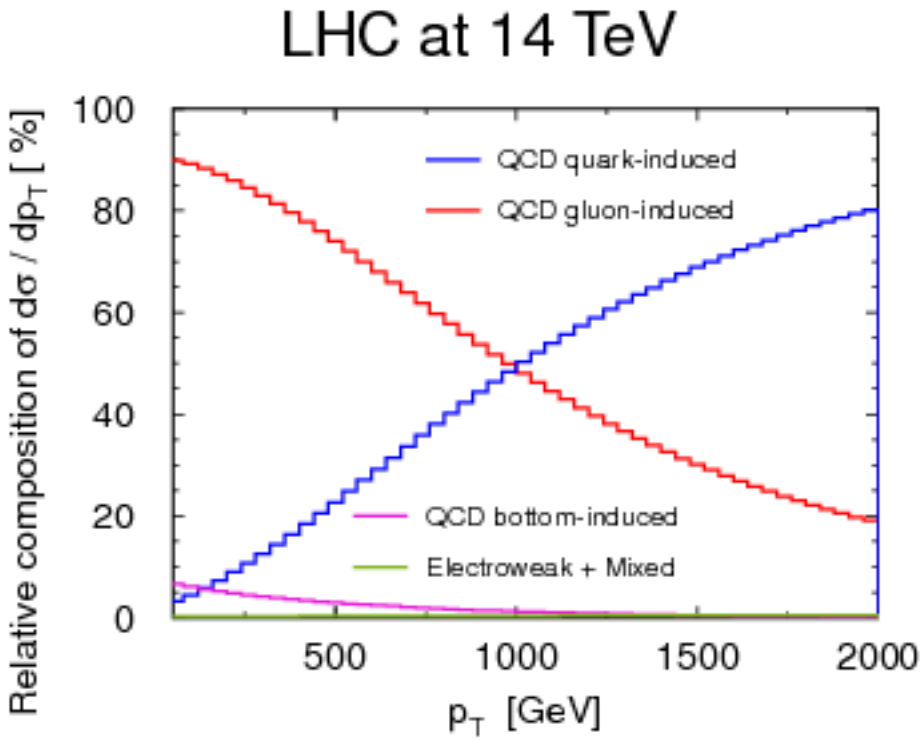
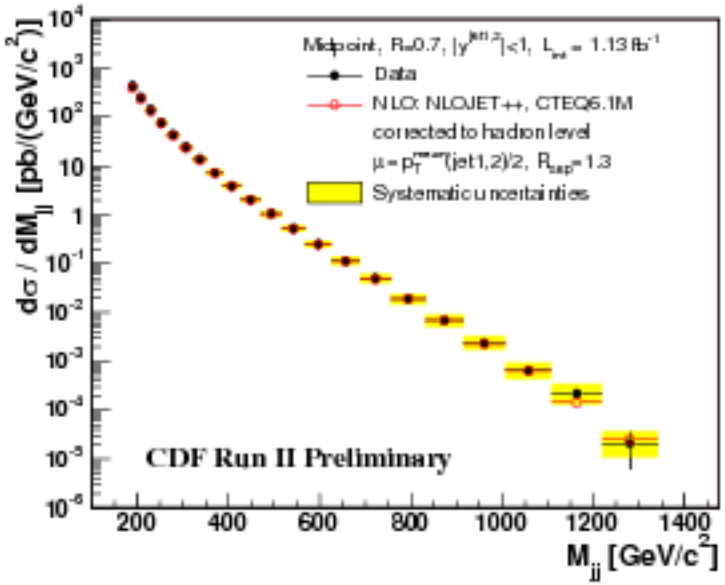




Di-jet production

- Gluon- & light quark-jets ($m_u = m_d = m_s = m_c = 0$)
  - Background for high-boosted $t\bar{t}$-pairs
  - New physics: Z'
- Experimentally
  - Tevatron: Di-jet-Masses up to 1 TeV
  - LHC: Di-jet-Masses up to several TeV

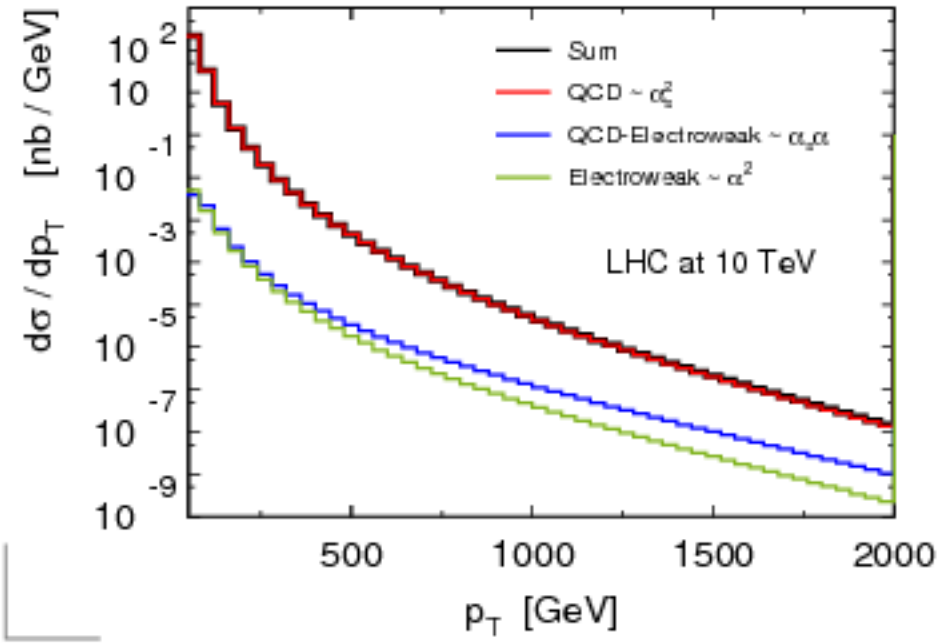


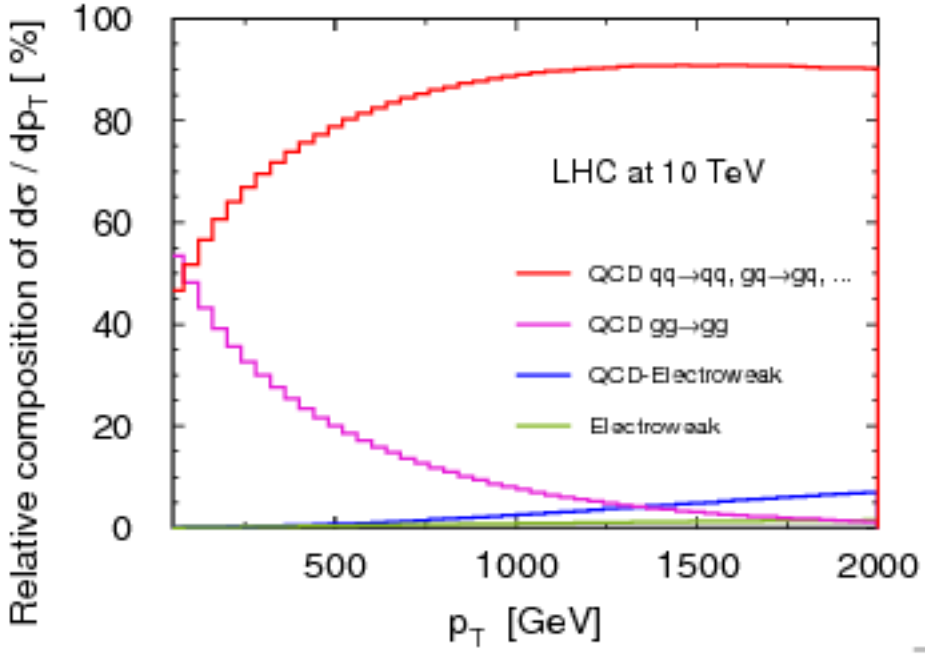
Di-jet production

- Partonic processes

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

- p_T-distribution at leading order





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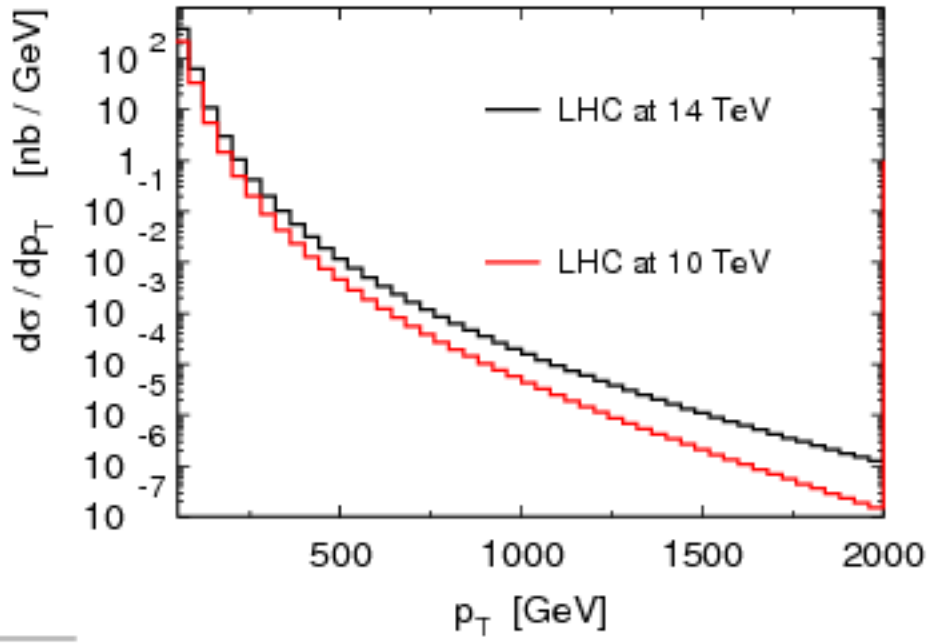
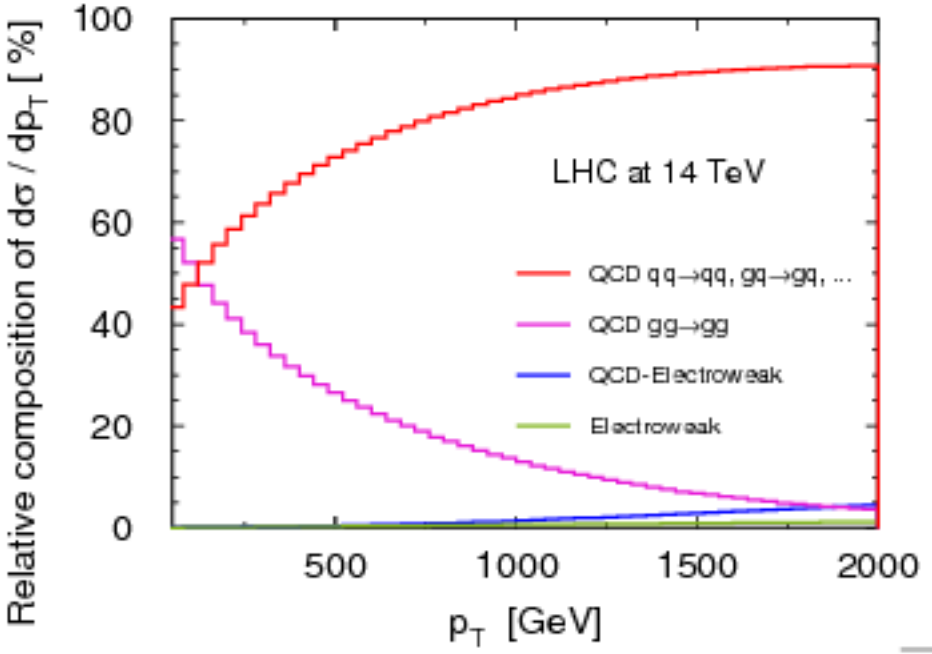
- p_T-distribution at leading order



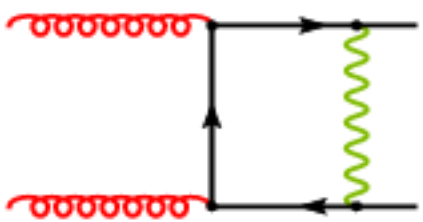


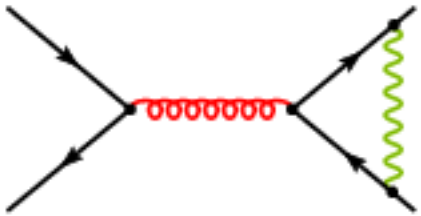
Status of NLO calculations

- b-jet production
  - QCD corrections $O(\alpha_s^3)$ (Dawson, Ellis, Nason 1988) (Beenakker, Kuijf, Neerven, Smith 1989) (Frixione, Mangano 1997)
  - $b\bar{b}$ production $O(\alpha_s^2\alpha)$ (Moretti et al 2003)
- Di-jet production
  - QCD corrections $O(\alpha_s^3)$ (Ellis, Sexton 1985) (Aversa et al 1988, 1991)
  - Weak corrections $O(\alpha_s^2\alpha)$ (Moretti et al 2006)

Methods: Overview

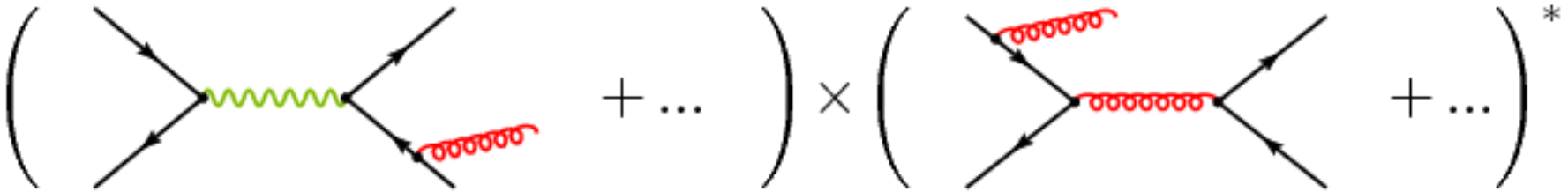
- Passarino-Veltman reduction
- Renormalisation
  - Weak corrections: Wave function only
  - QCD-corrections: $\overline{\mathrm{MS}}$ scheme
- Real corrections
  - Dipole Subtraction
  - Phase Space Slicing





(Catani, Seymour 1996)

(Harris, Owens 2002)



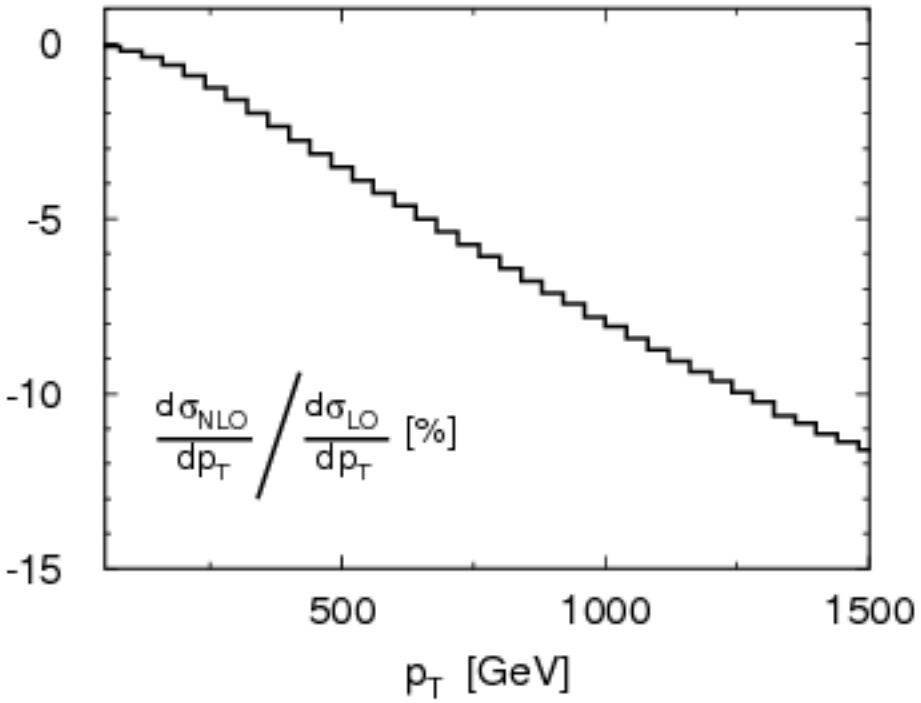
Consistency

- 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 (✓)

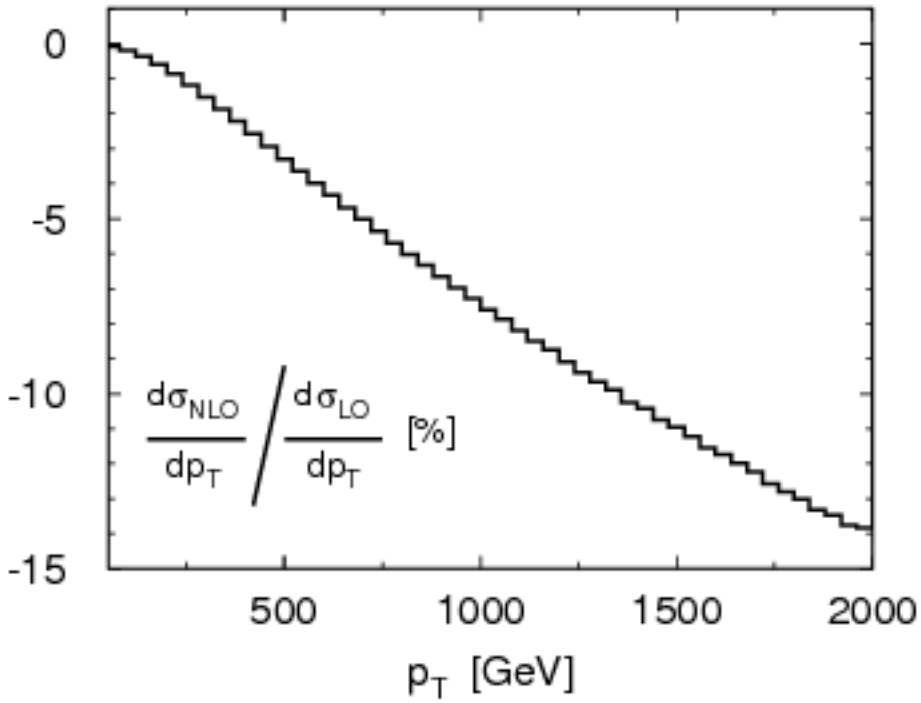
b-jet production at the LHC

- Relative corrections to p_T: Single b-tag

LHC at 10 TeV



LHC at 14 TeV

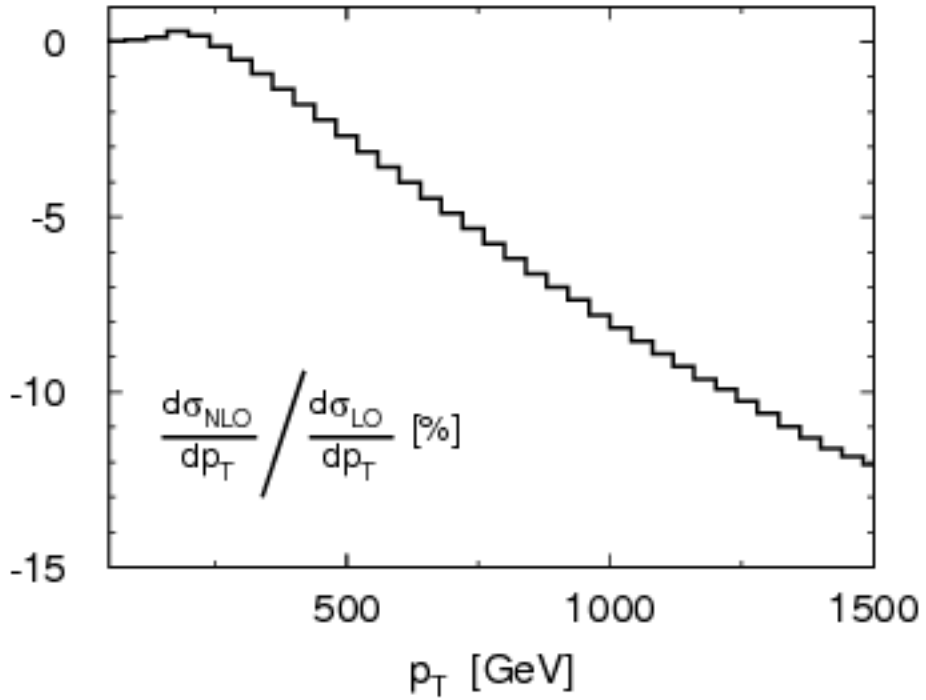


b-jet production at the LHC

- Relative corrections to p_T: Double b-tag
  - Comparison between massive and massless calculation

(Kühn, A.S., Uwer 2006)

LHC at 10 TeV



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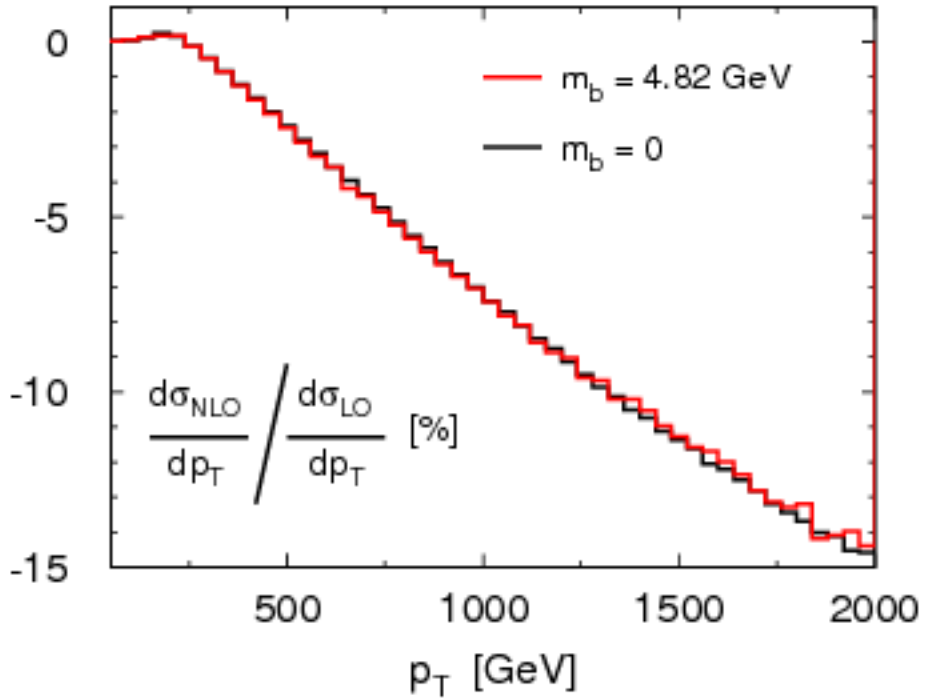
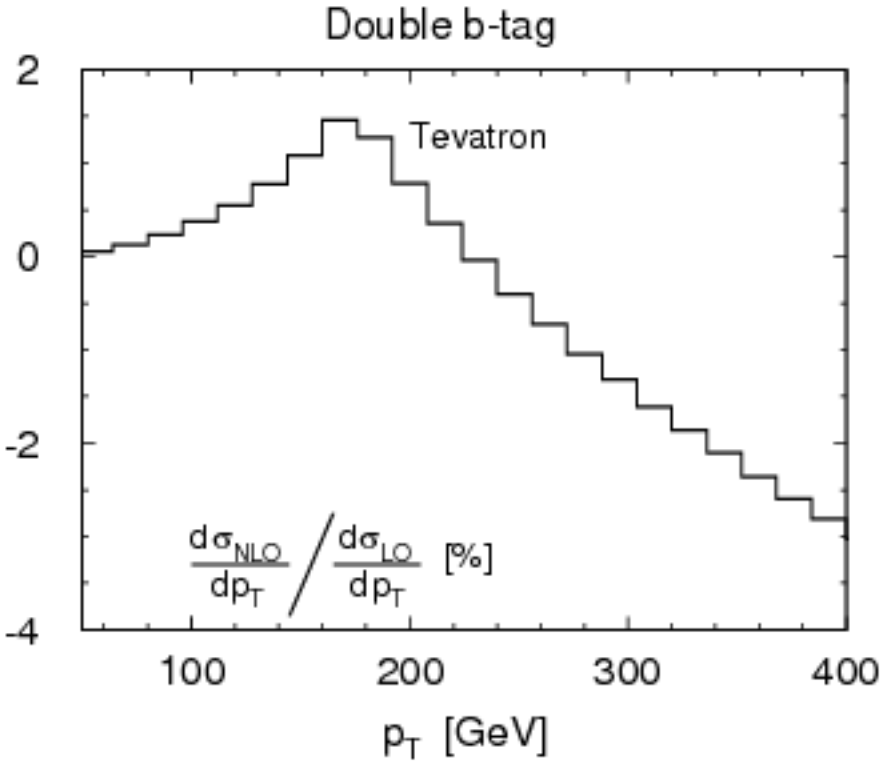
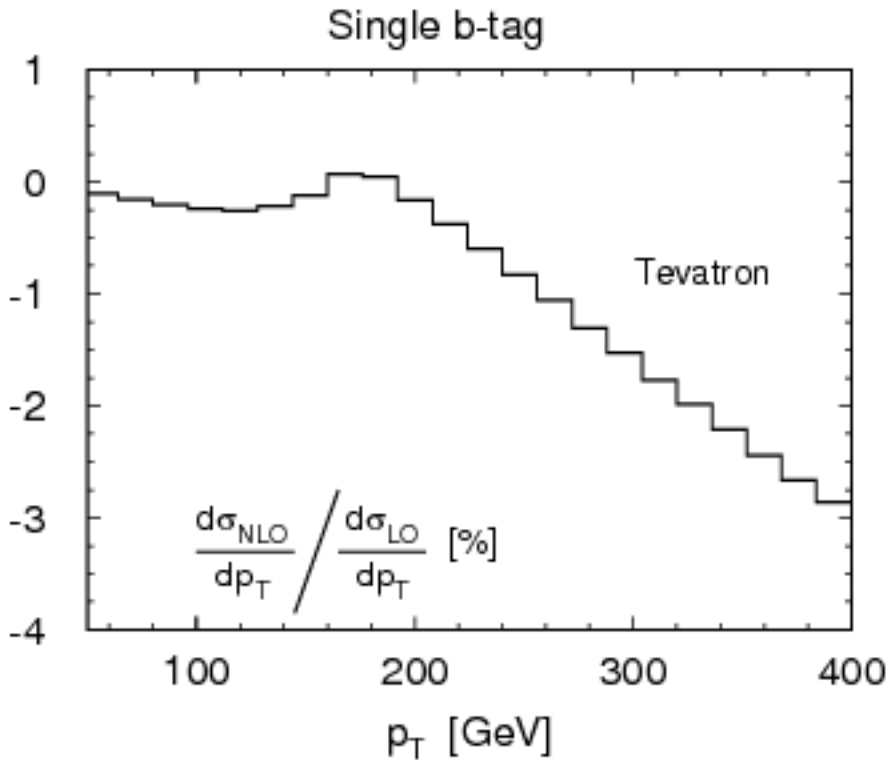


b-jet production at the Tevatron

- Relative corrections to p_T

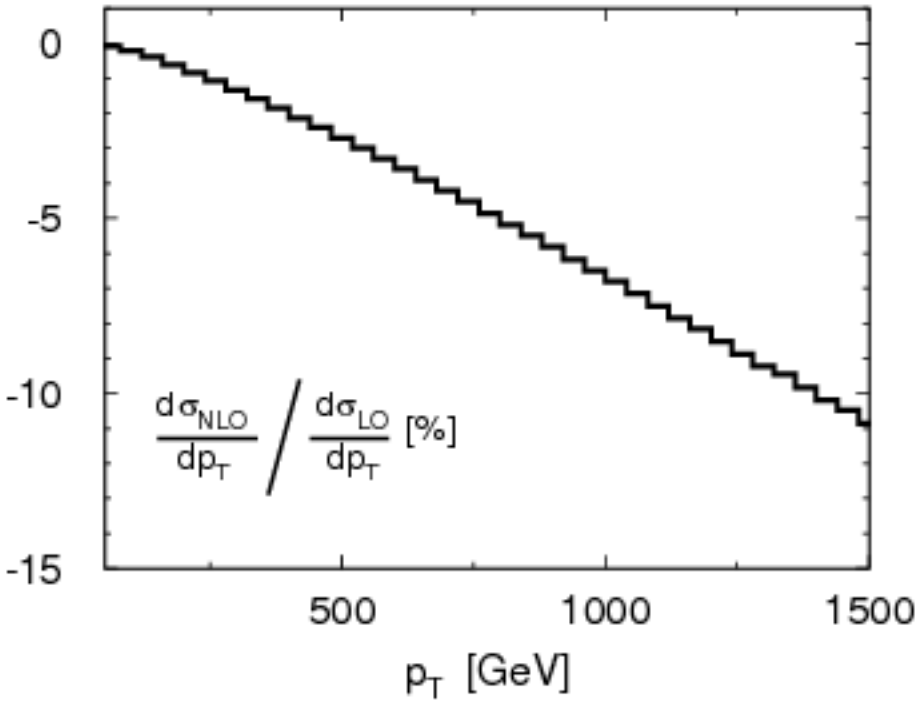




Di-jet production at the LHC

- Preliminary Result

LHC at 10 TeV



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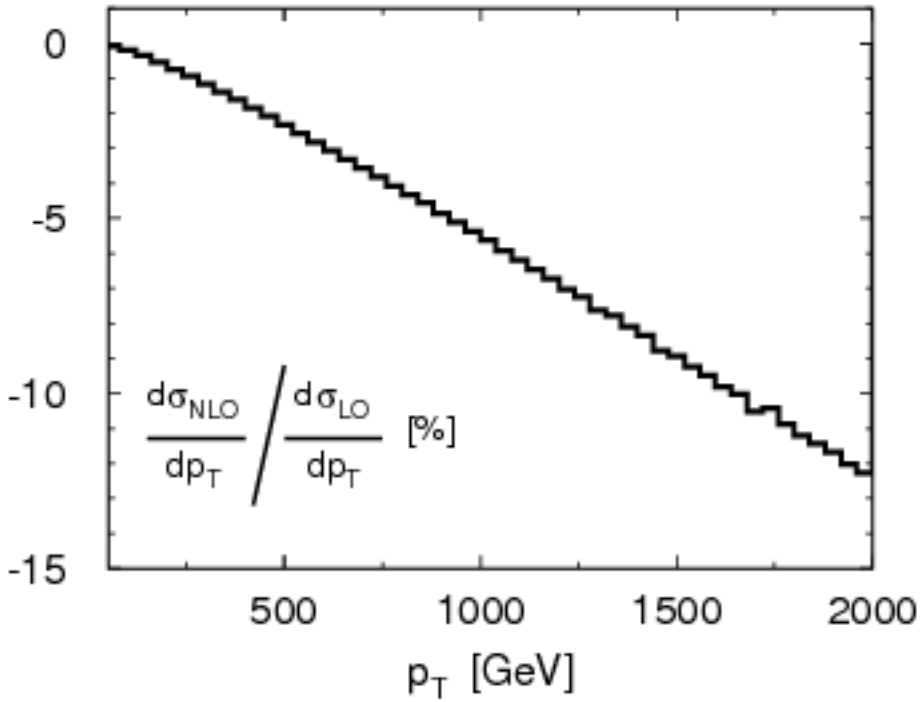

Conclusion

- 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