

Inclusive production of a Z boson in association with heavy quarks

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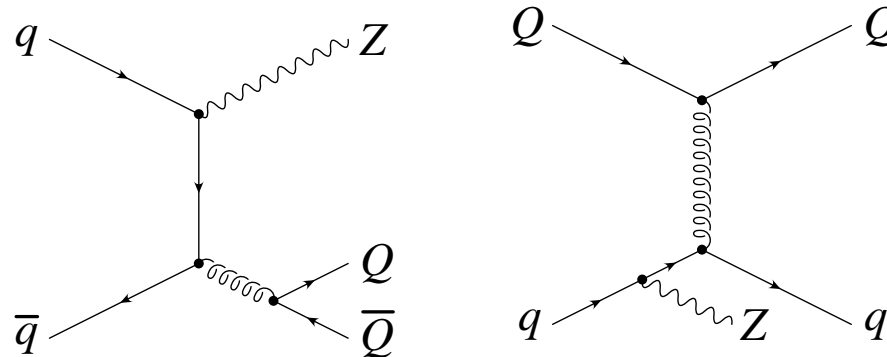
Based on F. Maltoni, T. M., and S. Willenbrock, [hep-ph/0505014](https://arxiv.org/abs/hep-ph/0505014)

Motivation

- $p\bar{p} \rightarrow hb\bar{b} + X$ may be an important process for SUSY Higgs discovery.
- We could require one or two high- p_T b -jets...
- ...but let's be more inclusive.
- We want the total cross section for all Higgs events with a b in the final state.
- This is equivalent to requiring a b in either the initial or final state of the partonic subprocess.

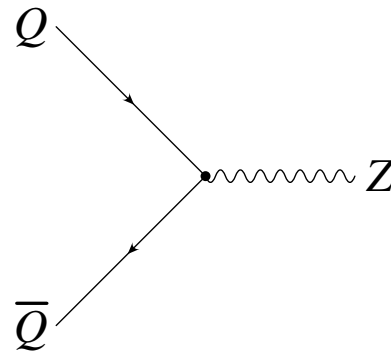
From Higgs to Z

- Let's use Z production as a testing ground for the Higgs.
- This is more complicated than $p\bar{p} \rightarrow h b\bar{b} + X$:
 - We must consider both $p\bar{p} \rightarrow Z b\bar{b} + X$ and $p\bar{p} \rightarrow Z c\bar{c} + X$.
 - Light quarks can masquerade as heavy quarks.
 - Some diagrams contributing to $q\bar{q} \rightarrow Z Q\bar{Q}$ and $qQ \rightarrow Z qQ$ have no analog in Higgs production.

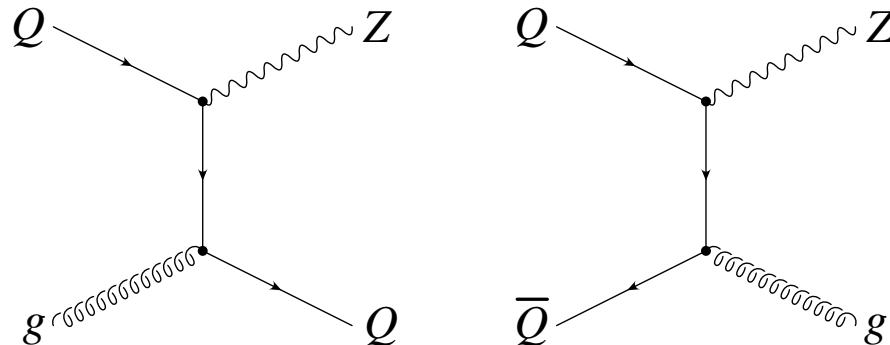


The Calculation

- Things are straightforward at LO:



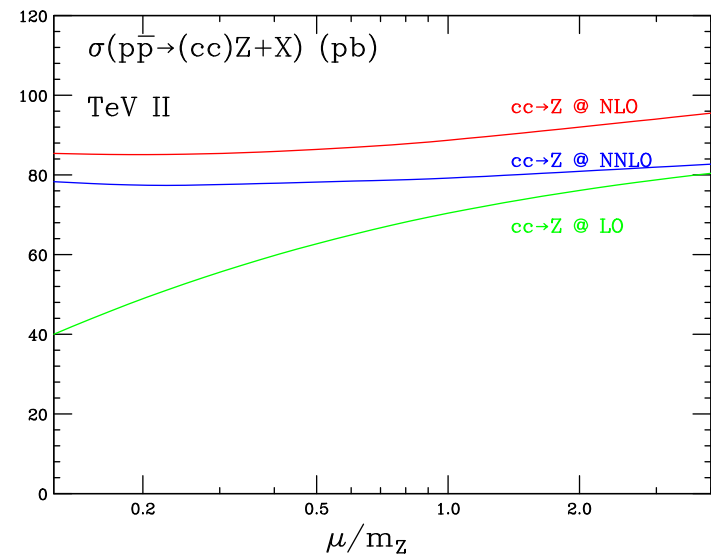
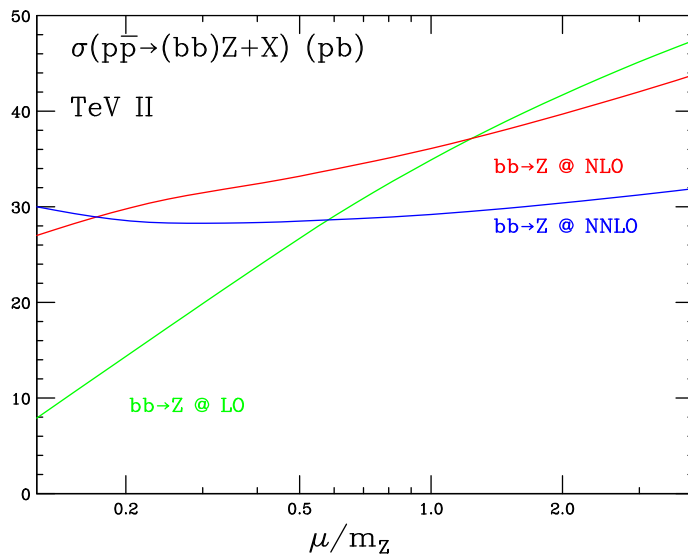
- and at NLO:



- At NNLO, things get interesting, due to diagrams with two quark lines.

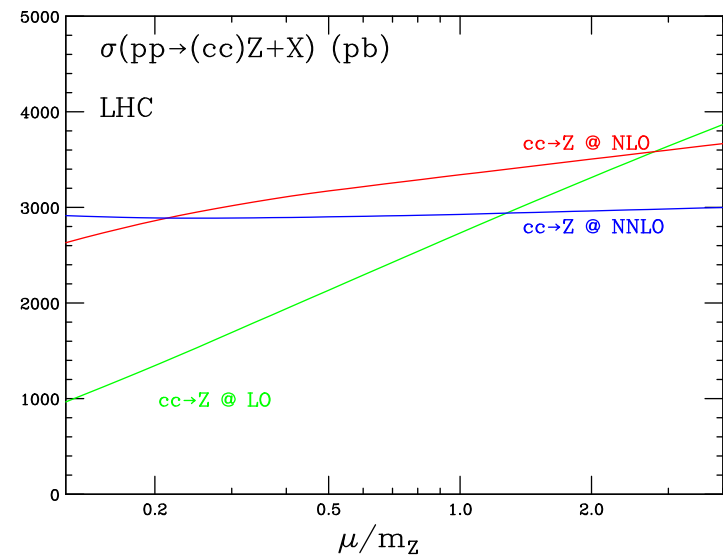
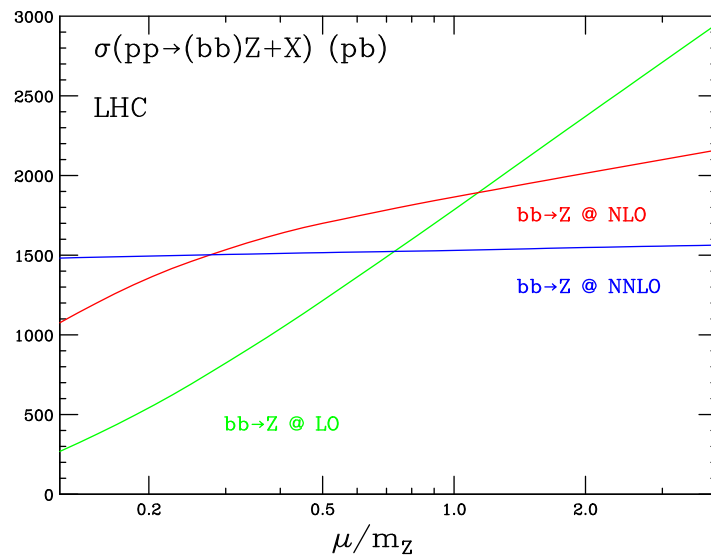
NNLO, Part 1

- Begin with only diagrams where Z couples to Q .
- This is completely analogous to $b\bar{b} \rightarrow h$.
- At the Tevatron:



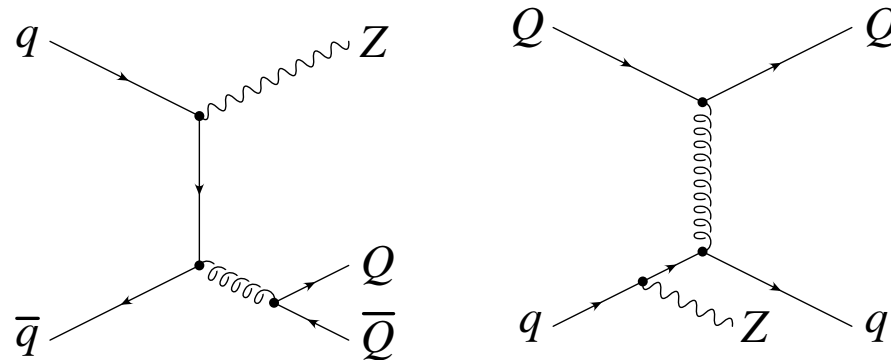
NNLO, Part 1

- Begin with only diagrams where Z couples to Q .
- This is completely analogous to $b\bar{b} \rightarrow h$.
- At the LHC:



NNLO, Part 2

- But what about those other diagrams?



- We must keep m_Q nonzero to regulate collinear singularities.
- With nonzero m_Q , these diagrams are known only at LO.
- Factors of $\ln(M_Z/m_Q)$ are not resummed.

Results

(cross sections in pb)

Process		Tevatron	LHC
$Z(b\bar{b})$	$b\bar{b} \rightarrow Z$ (NNLO)	28.3	1500
	$q\bar{q} \rightarrow Zb\bar{b}$ (LO)	19	120
	$qb \rightarrow Zqb$ (LO)	5.9	430
$Z(c\bar{c})$	$c\bar{c} \rightarrow Z$ (NNLO)	77.7	2890
	$q\bar{q} \rightarrow Zc\bar{c}$ (LO)	69	430
	$qc \rightarrow Zqc$ (LO)	21	1200
Inclusive Z		7510	56700

Conclusions

- Processes involving heavy quarks account for 3% of the inclusive Z cross section at the Tevatron (12% at the LHC).
- Desiderata:
 - Higher-order calculations of $q\bar{q} \rightarrow ZQ\bar{Q}$ and $qQ \rightarrow ZqQ$
 - Experimental measurements!