# Mass Effects in $Wb\bar{b}$ Production at Hadron Colliders

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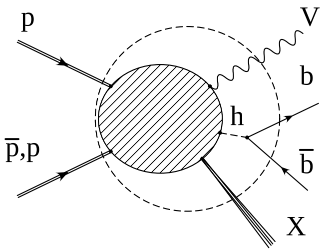
# Outline

- Motivation: Improving theoretical predictions of QCD backgrounds
- Brief review of the calculation of fully differential cross sections
- Results: comparison with massless approximation at LO and NLO: Theoretical uncertainties and distributions
- Summary

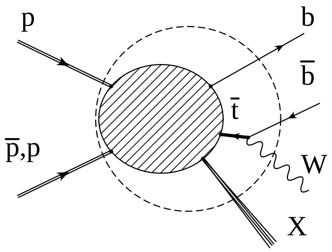
# Motivation

- $Wb\bar{b}$ @ hadron colliders is background to important processes:




Light SM-like Higgs boson production

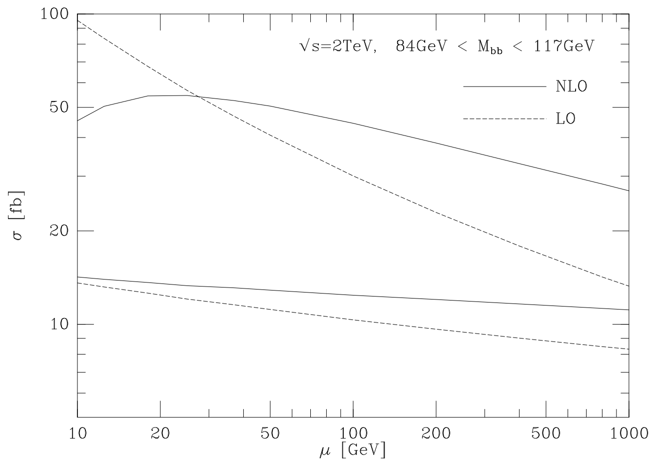
signal known @ NNLO




Single top production

signal known @ NLO

- Full massive calculation is only known @ LO. NLO calculation with $mb = 0$ approximation available in a Montecarlo program (MCFM `[J. Campbell and R.K Ellis]`): `[R.K Ellis et al hep-ph/9810489]`



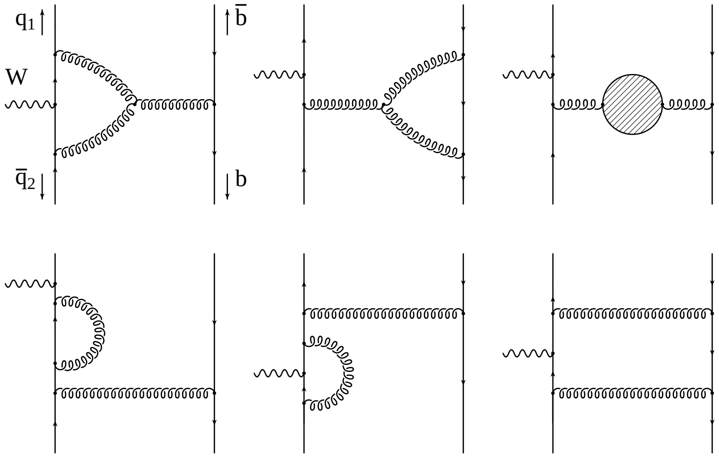
# Precision QCD calculation

Radiative corrections of order $\alpha_s$ to $d\sigma$

all divergences regularized using dimensional regularization

## Virtual

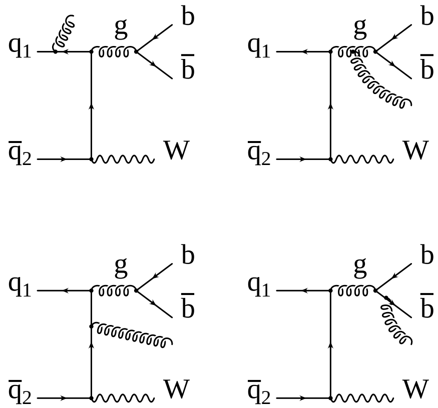
Sample of loop diagrams:




in $\overline{MS}$ renormalization scheme

## Real

Sample of diagrams with extra parton:




PSS used to extract IR divergences

Then, after convoluting the virtual plus real contributions with the renormalized parton distribution functions, we get the cancellation of all singularities

In the massless approximation kinematical cuts are imposed to simulate mass effects

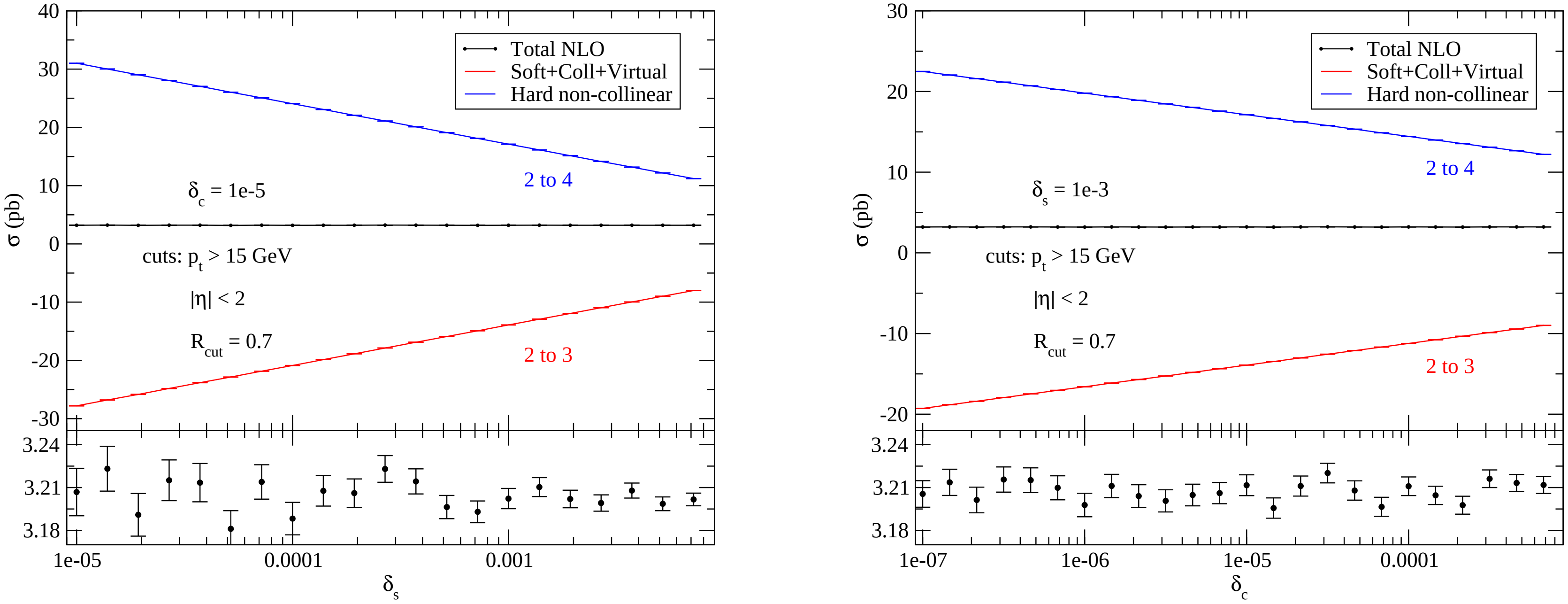
# Experimental cuts

Having a fully differential cross section allows to implement any experimental cut to calculate total cross sections and distributions. We have produced data for the Tevatron ($\sqrt{s} = 1.96$ TeV), with the following cuts:

- Transverse momentum of the b-quarks: $p_t > p_{t\ min}$ (15 GeV) for both $b$ and $\bar{b}$ quarks
- Pseudorapidity: $|\eta| < \eta_{max}$ (2) for both $b$ and $\bar{b}$ quarks
- kt-jet algorithm with $R_{cut} = 0.7$

# Check the total cross section independence of the PS-slicing parameters

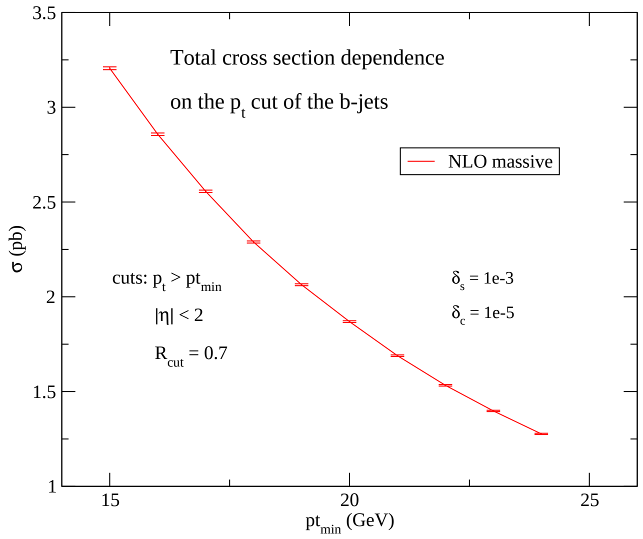
soft ($\delta_s$) and collinear ($\delta_c$) cuts



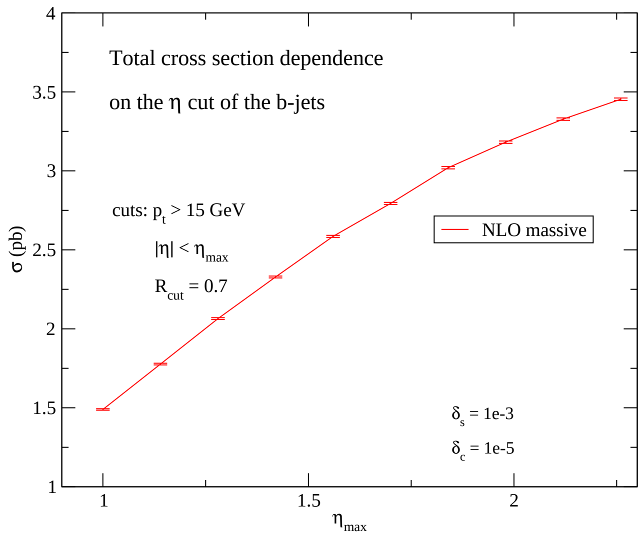

**Preliminary**

## Total cross section dependence in $p_{t\ min}$ and $\eta_{max}$ cuts

$$(\mu = M_W + 2m_b)$$




**Preliminary**

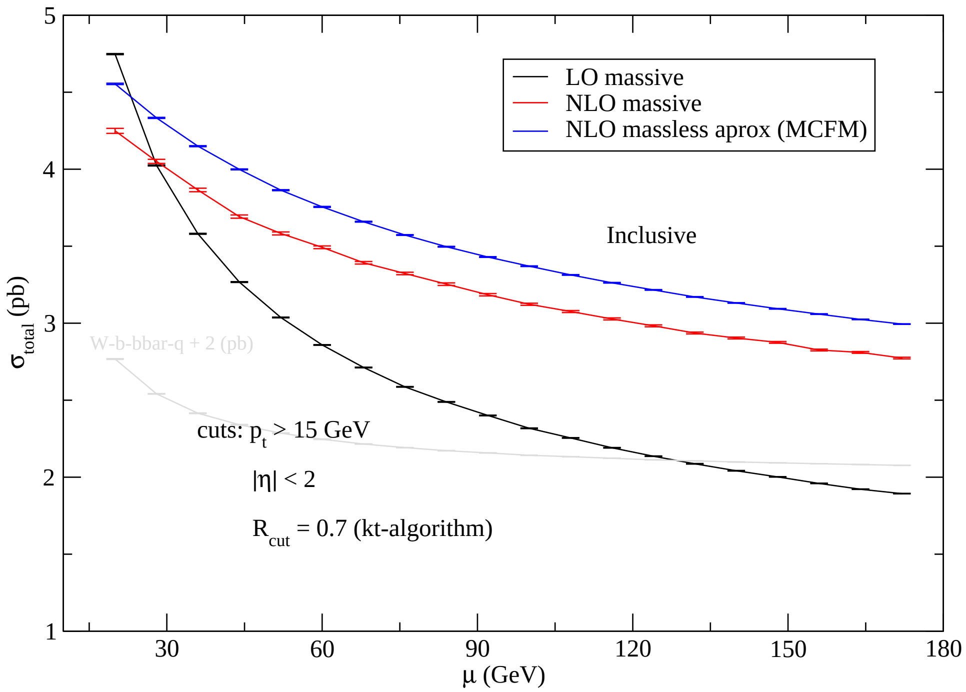


## Scale dependence and theoretical uncertainty

Using $\mu \in (\frac{1}{2}(M_W + 2m_b), 2(M_W + 2m_b))$

Inclusive case:

Real cross section integrated over all PS of the extra parton




LO $\sim$ 30%, NLO $\sim$ 15%

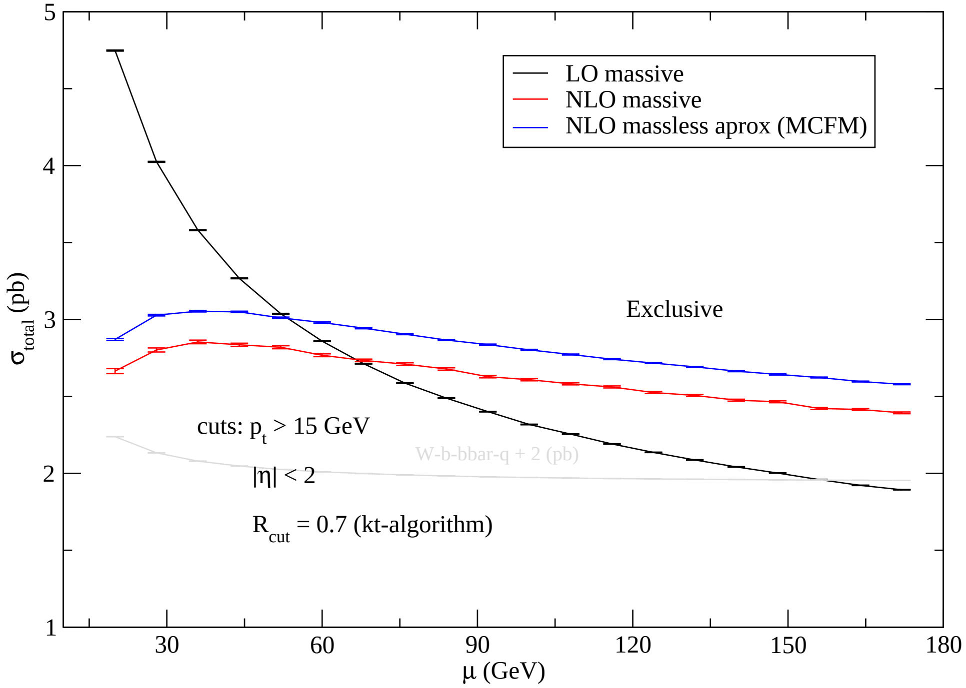
**Preliminary**

## Scale dependence and theoretical uncertainty

Using $\mu \in (\frac{1}{2}(M_W + 2m_b), 2(M_W + 2m_b))$

Exclusive case:

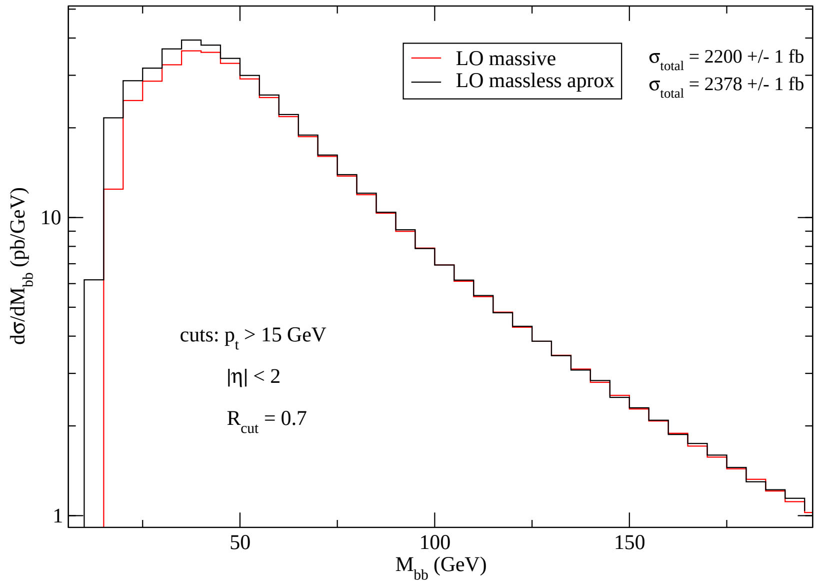
Real cross section integrated over PS when extra parton is not resolved

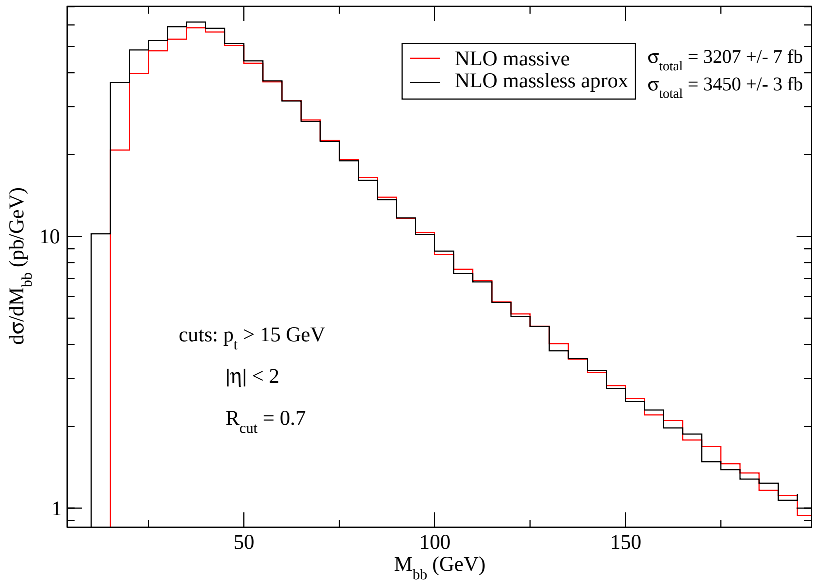



LO $\sim 30\%$, NLO $\sim 8\%$

**Preliminary**

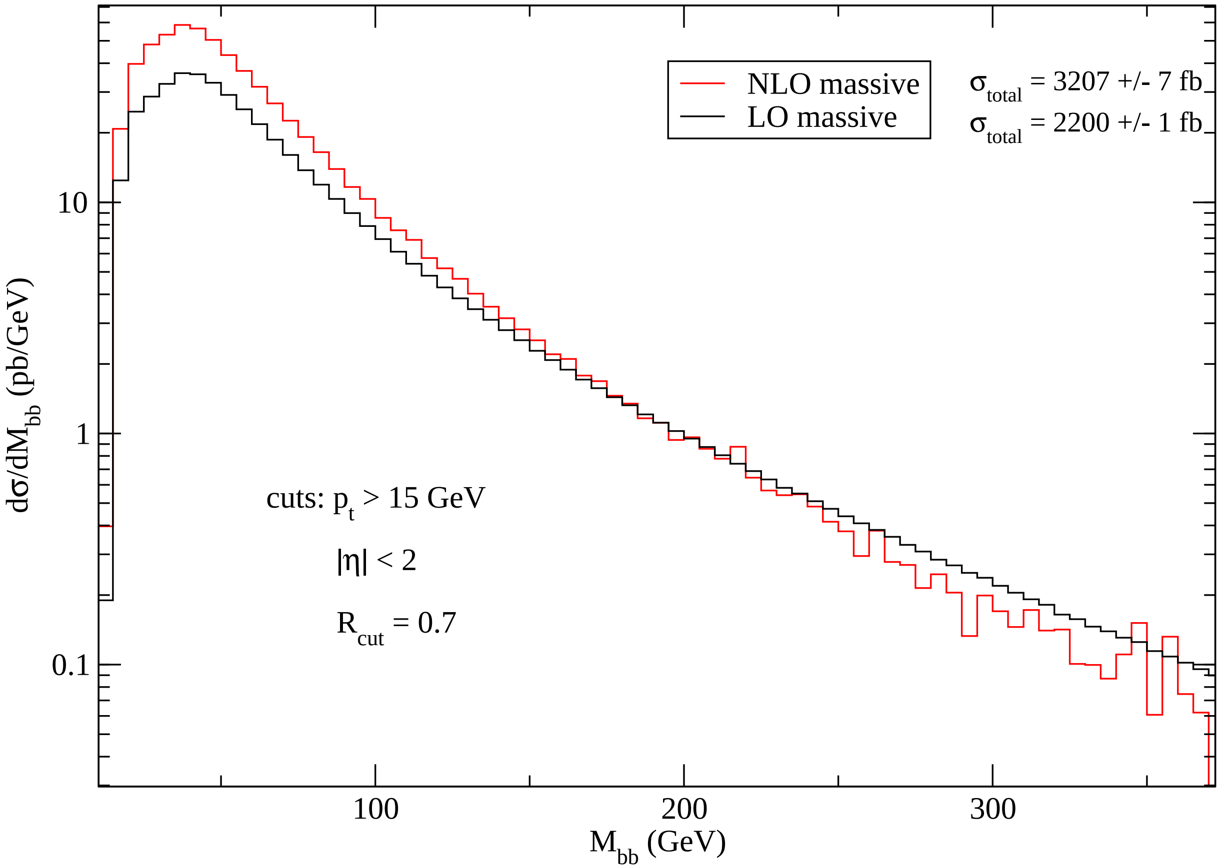
## LO and NLO distributions in the invariant mass of the $b - \bar{b}$ pair




**Preliminarily**, using this cuts, we have found a difference of around 7% between the massless NLO calculation and our NLO result, mostly coming from regions with small invariant mass of the $b - \bar{b}$ pair

# LO and NLO comparison of massive distributions




**Preliminary**

# Summary

- We have calculated the NLO QCD radiative correction to the production of a $W$ with two massive jets. We observe considerable reduction of the theoretical uncertainty on the total cross section with respect to the LO calculation, allowing for better predictions of backgrounds to important processes like vector boson associated Higgs production and Single Top production.
- Mass effects are relevant only for small invariant mass of the $b - \bar{b}$ pair (below 60 GeV).
- Because of the difference with LO distribution is important to use NLO distributions for Light Higgs searches.
- We are working to produce the $Z + b\bar{b}$ counterpart of this calculation.