ggF subgroup: status report

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Outline

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- Summary

Introduction

In the ggF section of YR1 we presented inclusive cross sections:
we had to agree on a number with an uncertainty

→ it was nonetheless a non trivial task

In the ggF section of YR2 we are dealing with differential cross sections

We found impossible to compile numbers for the relevant differential distributions, which we think are too diverse to be presented

The goal is instead to identify and discuss the most relevant issues and to present possible solutions

Note however that these solutions are not carved in stone: they are subject to change as soon as new progress is achieved

Higgs p_T spectrum

D. de Florian, G.Ferrera, D. Tommasini, MG (2011)

One of the most important distributions is the Higgs p_T spectrum

The NNLL+NLO result computed with HqT is used to reweight results from MC event generators

HqT2.0 introduces some improvements:

- Exact value of second order hard-collinear coefficients

S.Catani, MG (2011)

- Value of $A^{(3)}$ for q_T resummation implemented

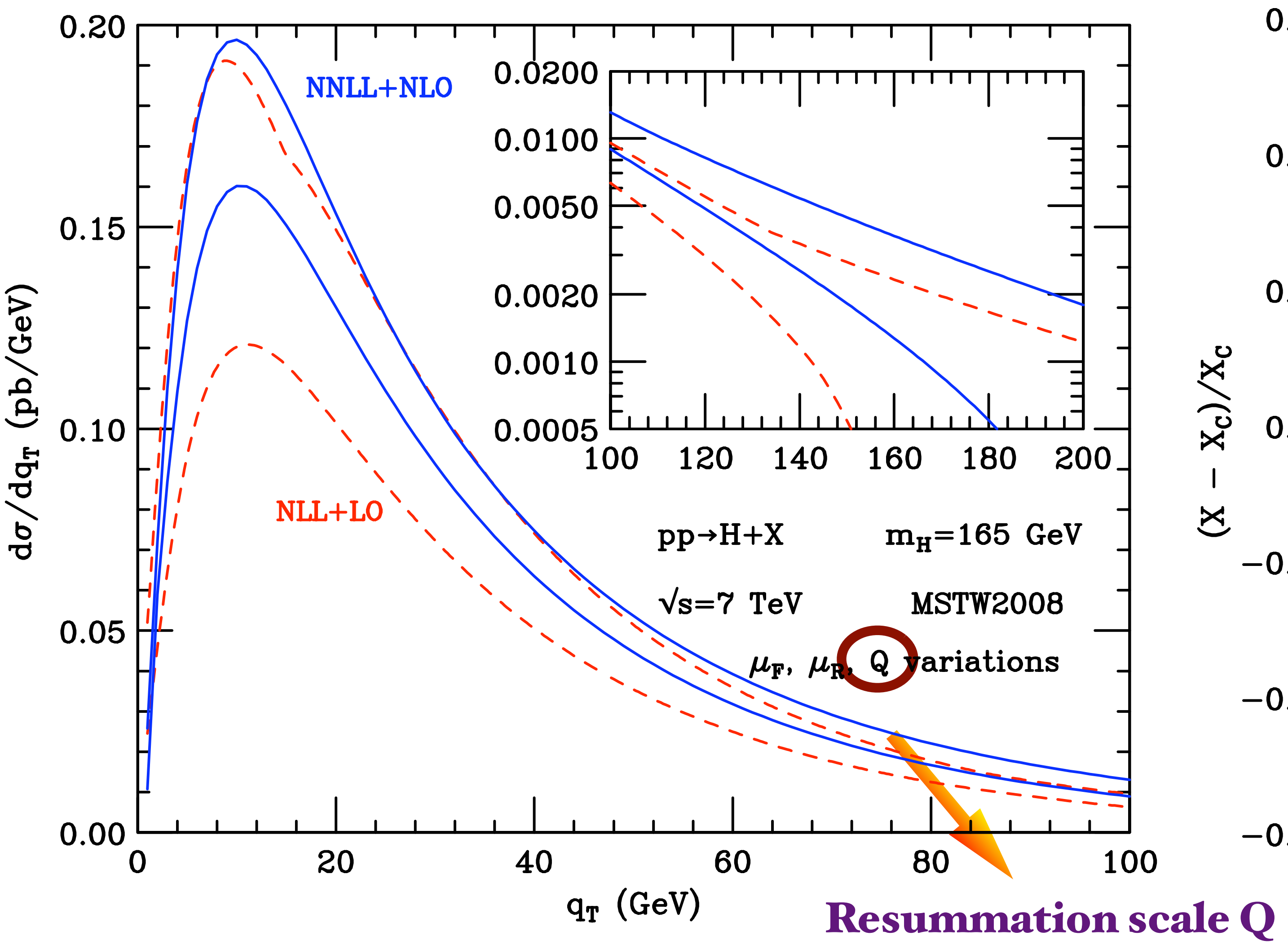
T.Becher, M.Neubert (2010)

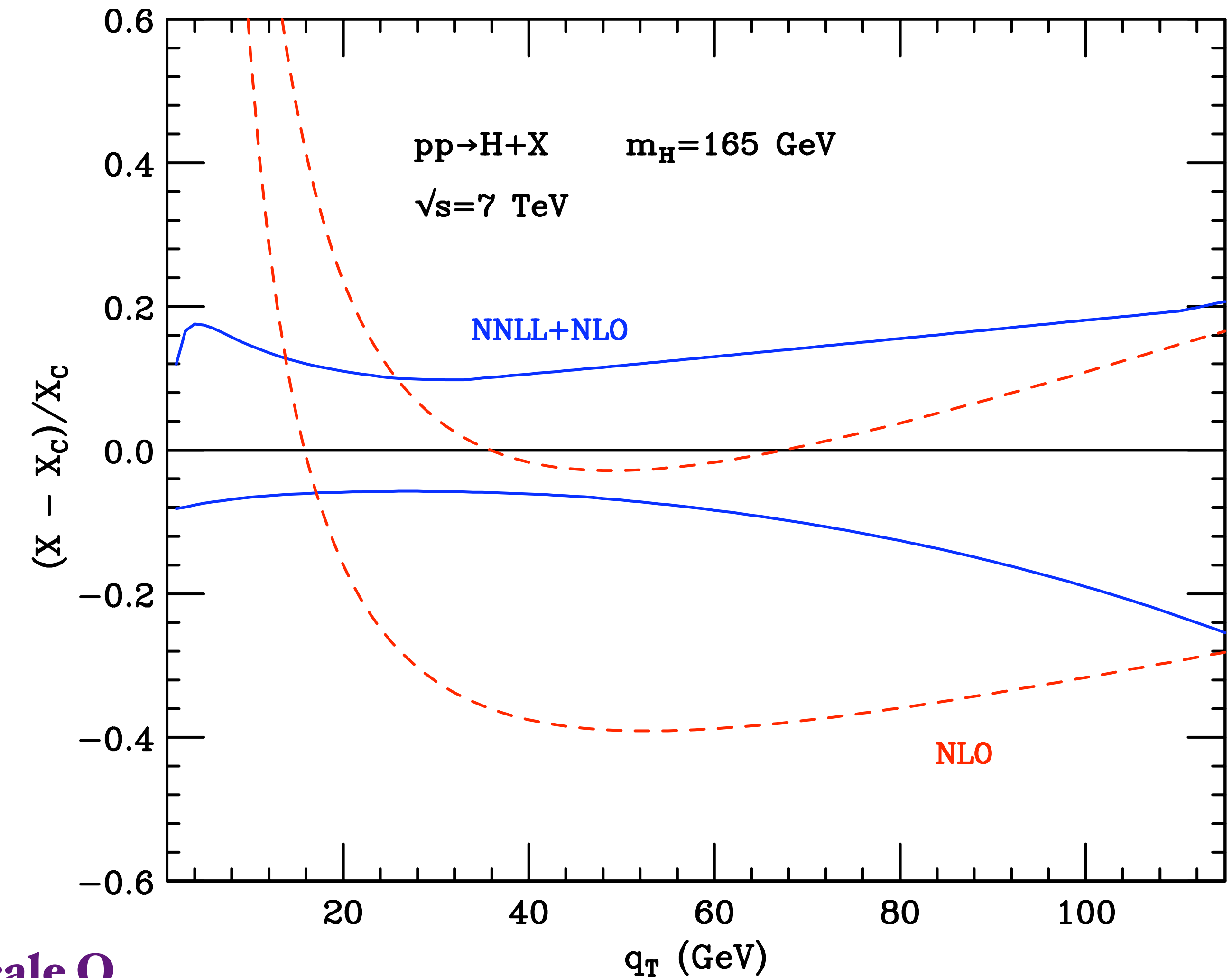
- Exact treatment of resummation scale

Allows to quantify uncertanties in the resummation procedure

- Interface with LHAPDF

Results





Scale uncertainty computed by independent variations of μ_F,μ_R and Q in the ranges 1/2 m_H < {μ_F,μ_R} < 2m_H and 1/4 m_H < Q < m_H with the constraints 1/2 < μ_F/μ_R < 2 and 1/2 < Q/μ_R < 2

Perturbative uncertainty at NNLL+NLO ranges from about ±10% at the peak to about ±8% at q_T=30 GeV to ±10% at q_T=60 GeV
At large values of q_T the resummed result looses predictivity: better to use NLO

Shape uncertainty

One of the issues that are currently debated is how to evaluate the uncertainty on the cross section after cuts

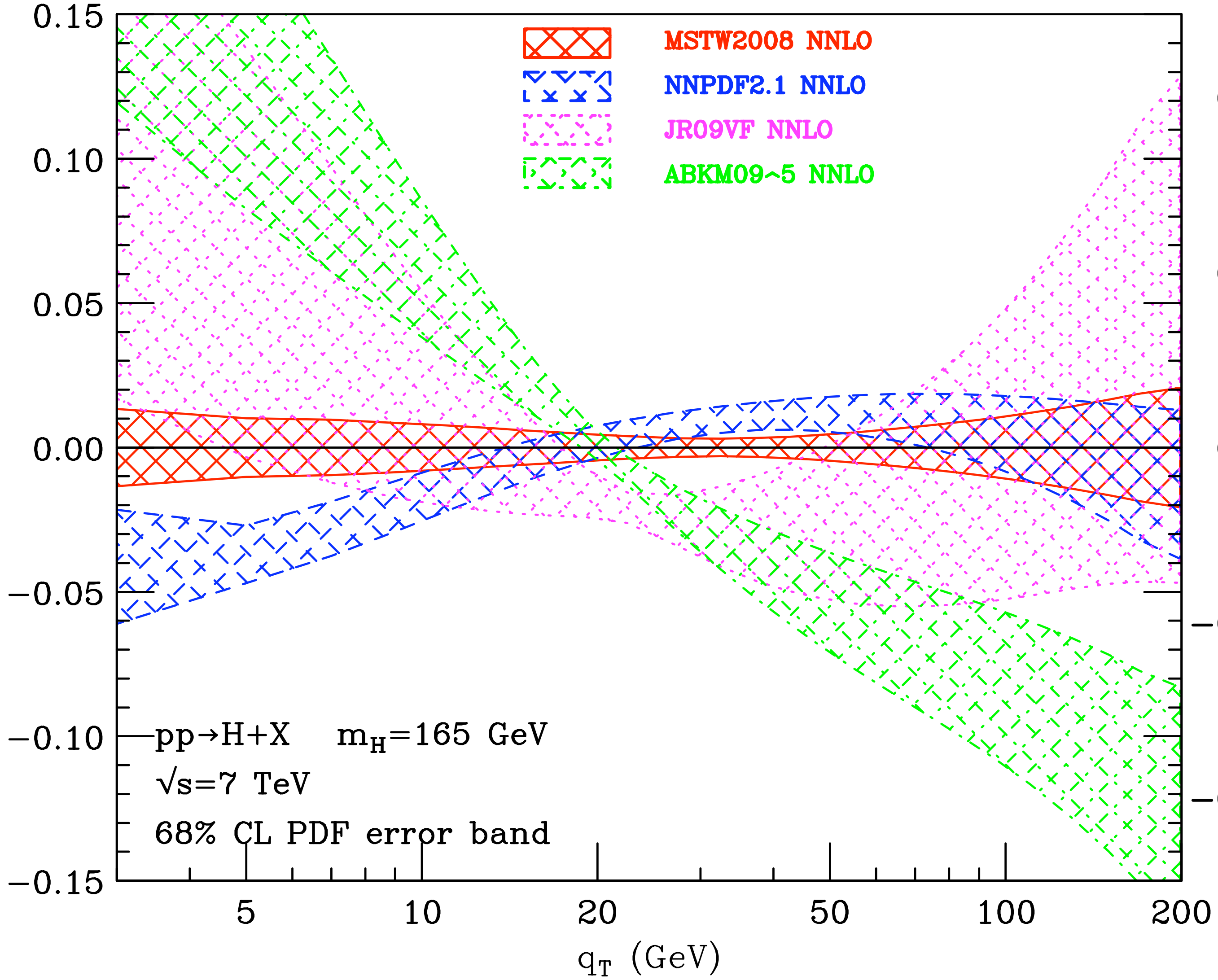
HqT is used to reweight the spectrum of MC event generators

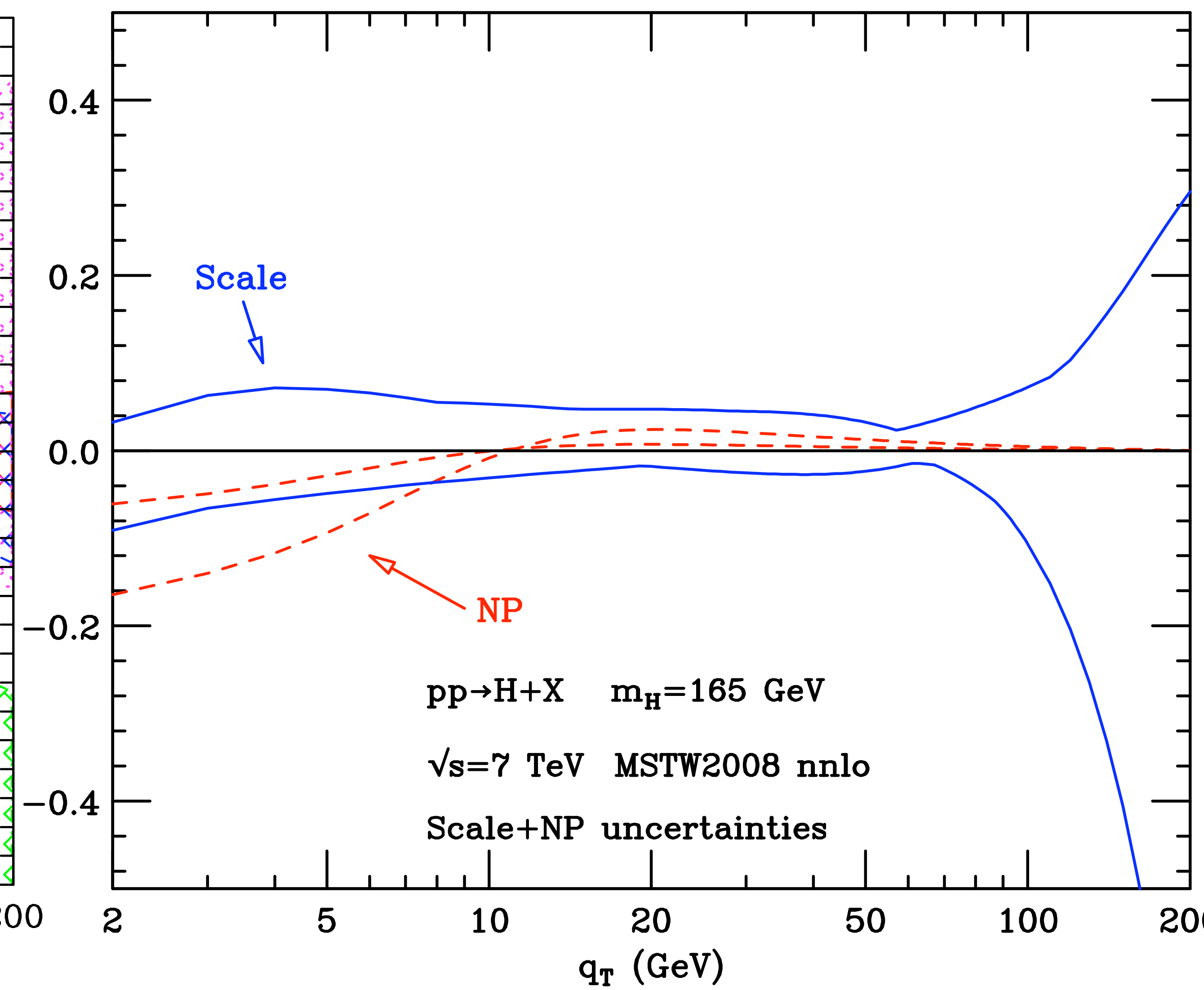
→ What matters is actually the uncertainty on the SHAPE of the q_T distribution provided by HqT

Sources of uncertainties:

- Scale dependence
- PDFs
- Non-perturbative effects
- Large m_{top} approximation ?

Shape uncertainty





MSTW and NNPDF in relatively good agreement

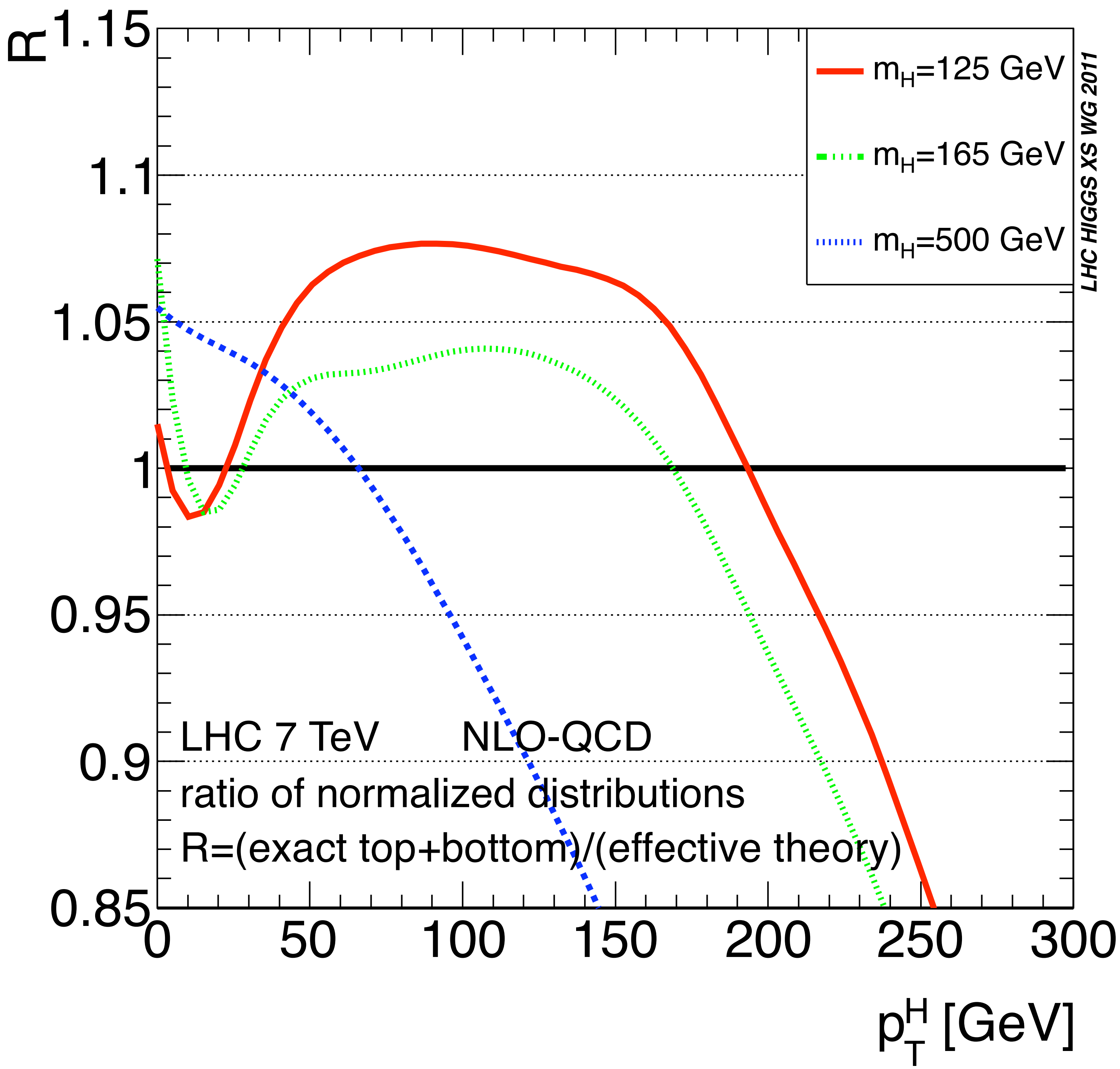
ABKM spectrum softer: at high q_T larger x are probed where ABKM gluon is lower than MSTW

Scale uncertainties at the level of about ±5%
NP effects estimated as in Bozzi et al. (2005)

They become important at small q_T

Heavy quark mass effects

E.Bagnaschi, P. Slavich,G. Degrassi, A.Vicini



NLO corrections known with the exact dependence of top and bottom masses

U.Baur, N.Glover (1990), M.Spira et al.(1995)
G. Degrassi et al. (2006)
C. Anastasiou et al. (2009)

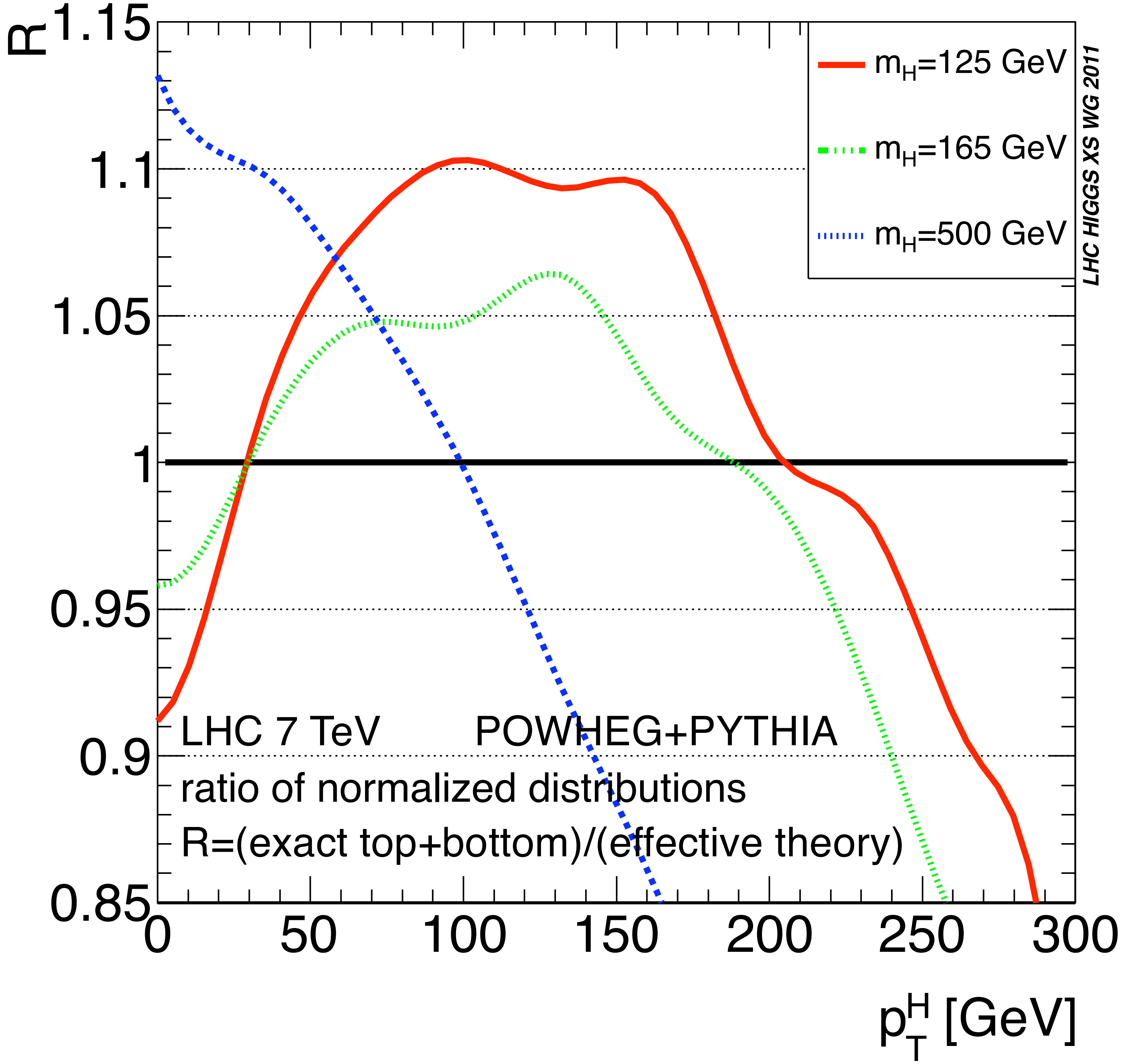
The impact on the shape of the spectrum is significant, expecially for a light Higgs (top-bottom interference)

At large p_T the result in the effective field theory fails

➡ Recoiling QCD radiation becomes sensitive to the heavy quark loop

Heavy quark mass effects

E.Bagnaschi, P. Slavich, G. Degrassi, A.Vicini



These effects have been implemented in POWHEG

POWHEG slightly amplifies the effect due to its process dependent Sudakov form factor

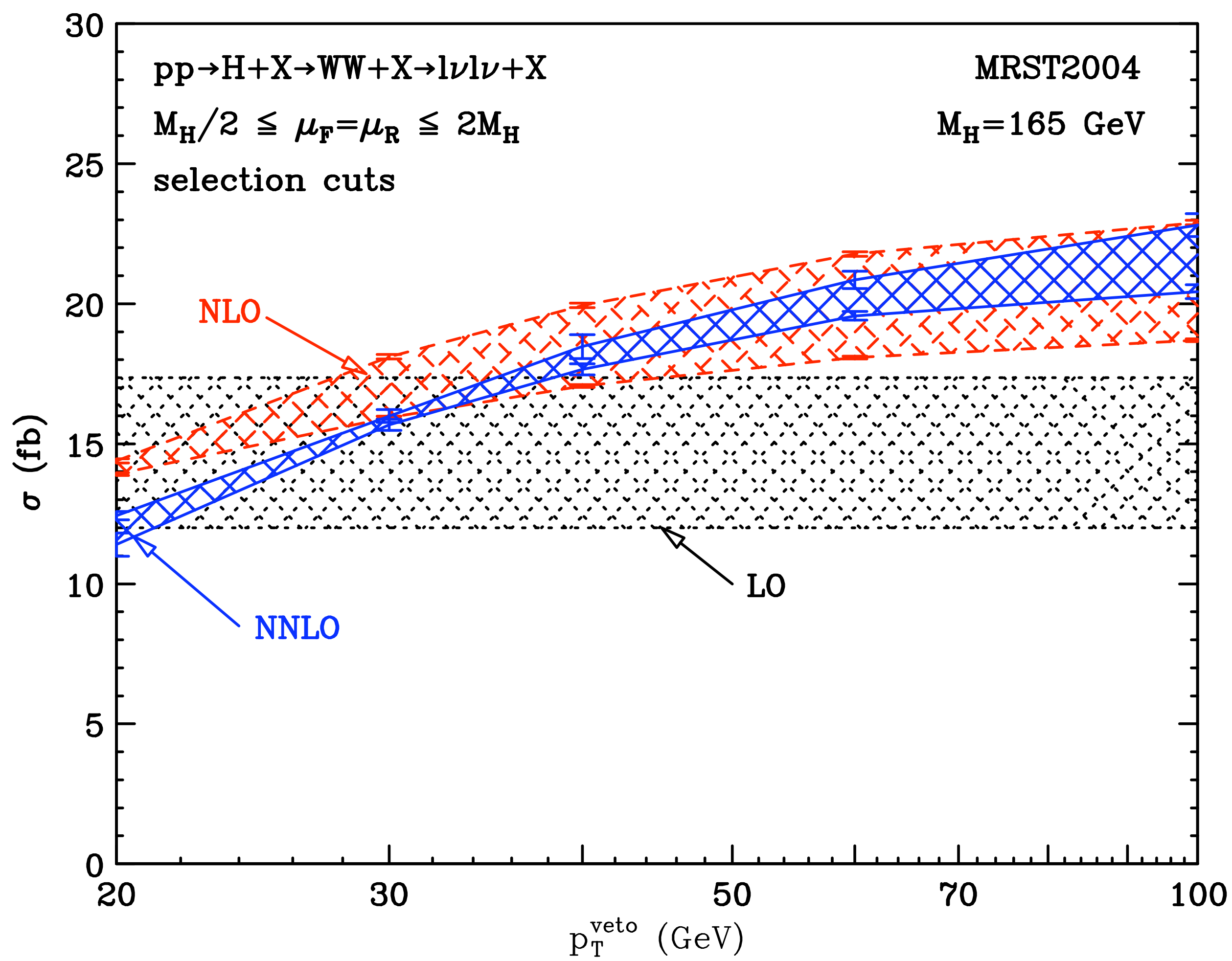
Mass dependence could be included in HqT up to NLL+LO

Jet bin uncertainties

In the Higgs search at the Tevatron and the LHC data are divided into jet bins

This allows to optimize the analysis for H+one, two or more jets

Scale dependence in the 0-jet bin tends to be rather small



Independent scale variations do not significantly change the picture

→ NNLO scale uncertainty in the zero jet bin smaller than inclusive uncertainty: difficult to believe

Large positive corrections to the inclusive cross section partially cancelled by logarithmic terms in p_T^{veto}

Jet bin uncertainties

F.Tackmann, I.Stewart (2011)

Alternative procedure:

consider instead inclusive H+jet(s) cross sections

σ_{total} , $\sigma_{\geq 1}$, $\sigma_{\geq 2}$ ....

Treat them as uncorrelated and propagate the uncertainty on $\sigma_0 = \sigma_{total} - \sigma_{\geq 1}$

$\sigma_1 = \sigma_{\geq 1} - \sigma_{\geq 2}$

Note: this is an hypothesis based on the fact that σ_{total} , $\sigma_{\geq 1}$ and $\sigma_{\geq 2}$ start at different orders in α_S and have different logarithmic structure

σ_{total} has no log p_T/m_H whereas $\sigma_{\geq 1}$ does

Jet bin uncertainties

F. Tackmann, I. Stewart

Proceeding in this way the uncertainties become sensibly larger

For example: relative uncertainty on $f_0=\sigma_0/\sigma_{total}$

$$\delta(f_0)^2 = \left(\frac{1}{f_0} - 1\right)^2 (\delta^2_{\rm total} + \delta^2_{\geq 1})$$

The uncertainty on f_0 increases as f_0 decreases

At the Tevatron with f_0=0.52 we get $\delta(f_0)$ = 24%

For typical values of f_0 at the LHC
(m_H=165 GeV; veto at p_T=30 GeV, $|\eta|<3$, f_0=0.65)

$\delta(f_0)$ = 12%

Quite a reasonable number

Example in the public note of the LHC Higgs combination WG

Uncertainty on σ_{total} taken from YR, on $\sigma_{\geq 1}$ and $\sigma_{\geq 2}$ from HNNLO (or FEHIP or MCFM) at NLO and LO respectively

Jet bin uncertainties

A.Banfi, G.Salam, G.Zanderighi

NNLO definition of 0-jet fraction

Zero-jet cross section

$$f_0^{(a)}(p_T^{\rm cut}) \equiv \frac{\Sigma^{(0)}(p_T^{\rm cut}) + \Sigma^{(1)}(p_T^{\rm cut}) + \Sigma^{(2)}(p_T^{\rm cut})}{\sigma^{(0)} + \sigma^{(1)} + \sigma^{(2)}}$$

But there are other definitions that differ by N3LO terms

$$\sigma^{\rm NLO}_{\text{1-jet}}(p_T^{\rm cut}) = \sigma^{(1)} + \sigma^{(2)} - \left(\Sigma^{(1)}(p_T^{\rm cut}) + \Sigma^{(2)}(p_T^{\rm cut})\right)$$

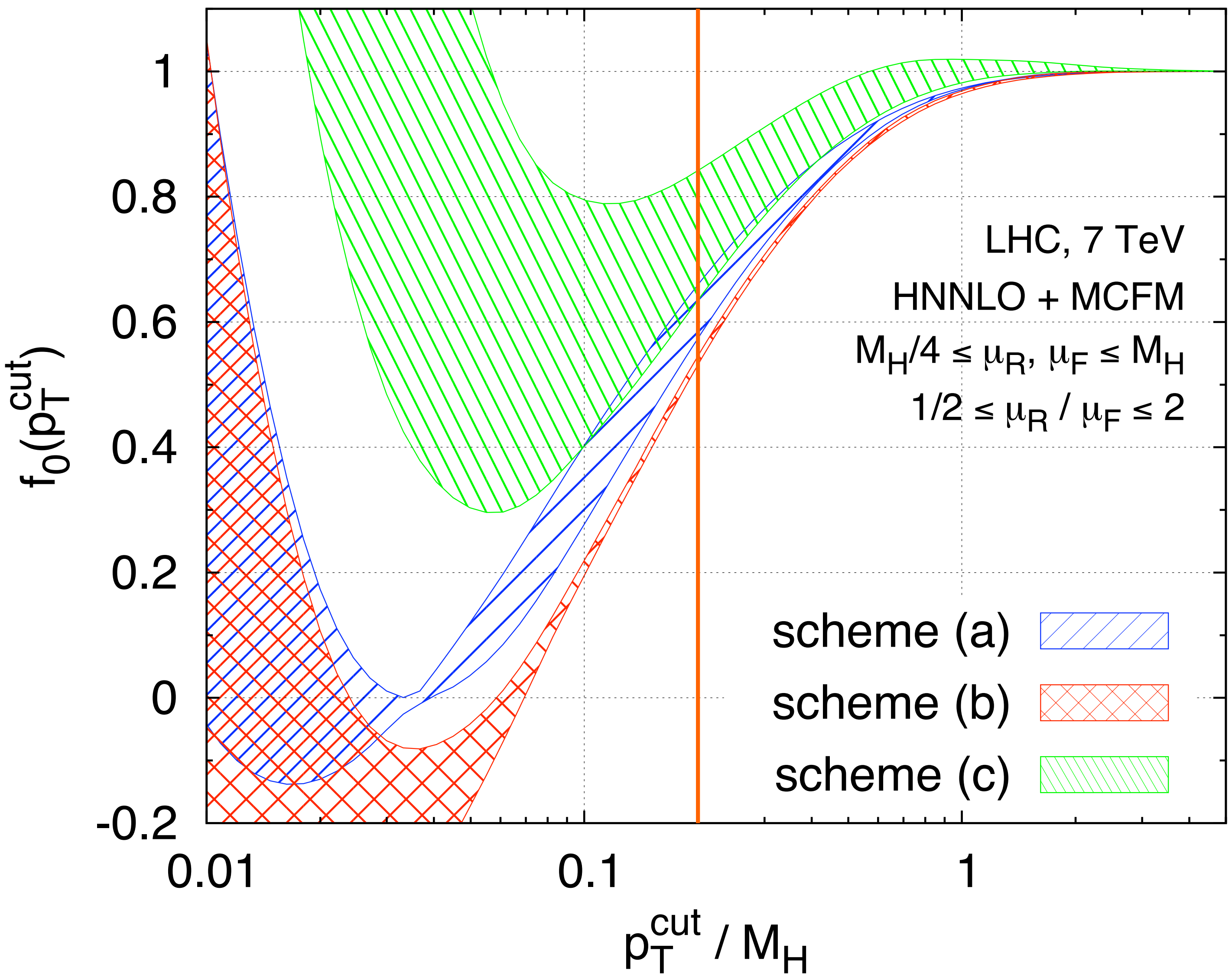
$$f_0^{(b)}(p_T^{\rm cut}) = 1 - \frac{\sigma^{\rm NLO}_{\text{1-jet}}(p_T^{\rm cut})}{\sigma^{(0)} + \sigma^{(1)}}$$

Differences between numerical predictions
for a) b) and c) can give an idea of missing
higher order contributions

$$f_0^{(c)}(p_T^{\rm cut}) = 1 - \frac{\sigma^{\rm NLO}_{\text{1-jet}}(p_T^{\rm cut})}{\sigma^{(0)}} + \frac{\sigma^{(1)}}{(\sigma^{(0)})^2}\sigma^{\rm LO}_{\text{1-jet}}(p_T^{\rm cut})$$

Jet bin uncertainties

A.Banfi, G.Salam, G.Zanderighi



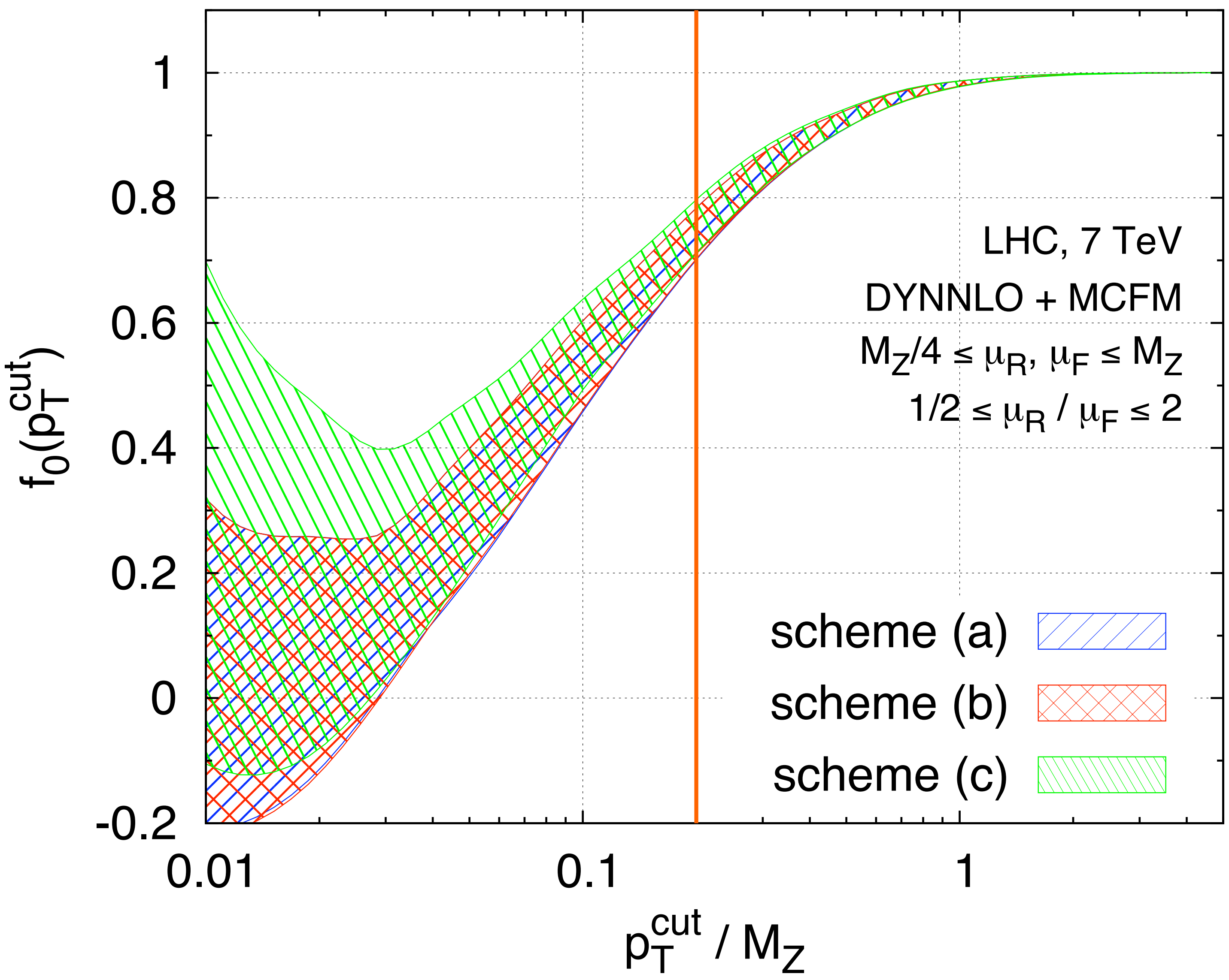
For $p^T_{cut} \approx 30$ GeV the uncertainties are rather large

Result for f_0 range from about 0.55 to about 0.82

➡ It confirms the very large NNLO uncertainties found with Stewart Tackmann procedure

Jet bin uncertainties

A.Banfi, G.Salam, G.Zanderighi



Note that this is not the case for the Drell-Yan process

Scheme a), b) and c) give almost identical results

➡ The large uncertainties in the Higgs case are mainly due to the poor convergence of the perturbative series for the total cross section

Insights from resummation

F.Stoeckli, F.Tackmann, I.Stewart,
W. J. Waalewijn (2011)

Use beam thrust variable

$$\mathcal{T}_{\rm cm} = \sum_k |\vec{p}_{Tk}| e^{-|\eta_k|} = \sum_k (E_k - |p_k^z|)$$ rapidity weighted version of H_T

as a prototype of jet-veto (small T_{cm} roughly equivalent to small p_T^{veto})

Same argument can be used for Higgs p_T spectrum (small Higgs p_T roughly equivalent to small p_T of recoiling jets) but it is only valid at relative $O(\alpha_S)$

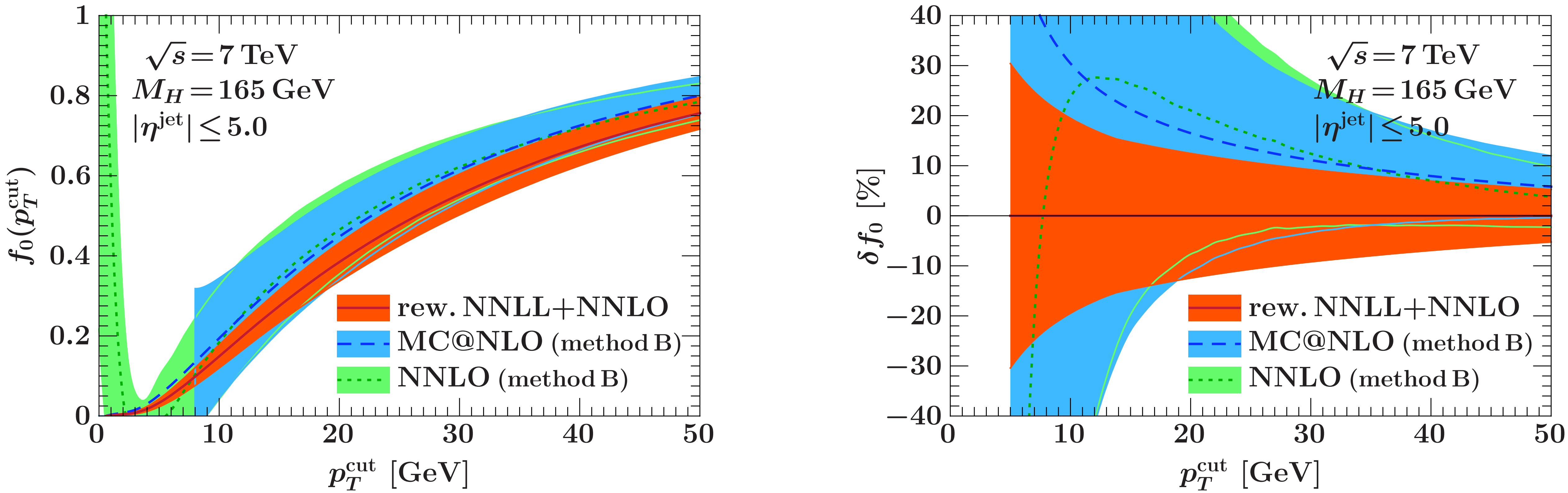
Use NNLL+NLO resummed result for beam thrust variable to reweight MC@NLO

What can we learn ? Contrary to Higgs p_T (which has the same definition at parton and hadron level) beam thrust is a shape variable

➡ sensitive to hadronization effects

Insights from resummation

F.Stoeckli, F.Tackmann, I.Stewart,
W. J. Waalewijn (2011)



Central value of NNLO and MC@NLO rather close

→ confirms previous studies

C.Anastasiou, G.Dissertori, F.Stoeckli, B.Webber (2008)
C.Anastasiou, G.Dissertori, F.Stoeckli, B.Webber, MG (2009)

Reweighted NNLL+NLO lower but compatible and with smaller uncertainty

Summary

- The ggF section of YR2 includes recent interesting theoretical progress in some key issues like: Higgs p_T spectrum and jet bin uncertainties

- Higgs p_T spectrum:

  - Latest version of HqT allows a more consistent study of theoretical uncertainties

  - Scale uncertainties in the shape of the spectrum amount to about ±5%

  - Finite heavy quark masses affect the Higgs pt spectrum in a non negligible way: this was known but should not be forgotten

  - New POWEG implementation of such effects shows differences up to O(10%) in the low p_T region

  - Such effects could be implemented in a future version of HqT

Summary

- Jet bin uncertainties

  - At present we have a procedure suggested by Tackmann and Stewart that, at NNLO, has been proven to provide more reliable uncertainties than naive scale variations

  - We should not forget that acceptances are evaluated through MC: an (approximate) resummation of the large logarithmic terms is effectively performed

  - It may be that the current prescription based on Stewart-Tackmann procedure leads to an overestimation of scale uncertainties

  - Nevertheless we think we can keep using this procedure until a resummed calculation for the jet-veto logs will be completed