Predictions for ttbar differential cross sections

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Cavendish Laboratory

Differential cross sections in the di-lepton channel

NNLO QCD calculations including top-quark decays (and corrections to those)

- so far leptonic decays only
- $\rightarrow$ comparisons to measurements in the di-lepton channel
  - fiducial cross sections
  - differential measurements of decay products: leptons and b-jets.

Setup:

- Narrow Width Approximation NWA @ NNLO QCD
- PDF set: *NNPDF31_nnlo_as_0118* (and NLO/LO version for lower orders)
- Dynamical renormalization/factorization scale $H_T/4$
- Top-quark mass: $m_t = 172.5$ GeV

Fiducial phase space definition

Following definition of 13 TeV CMS measurement [CMS, arxiv:1811.06625]:

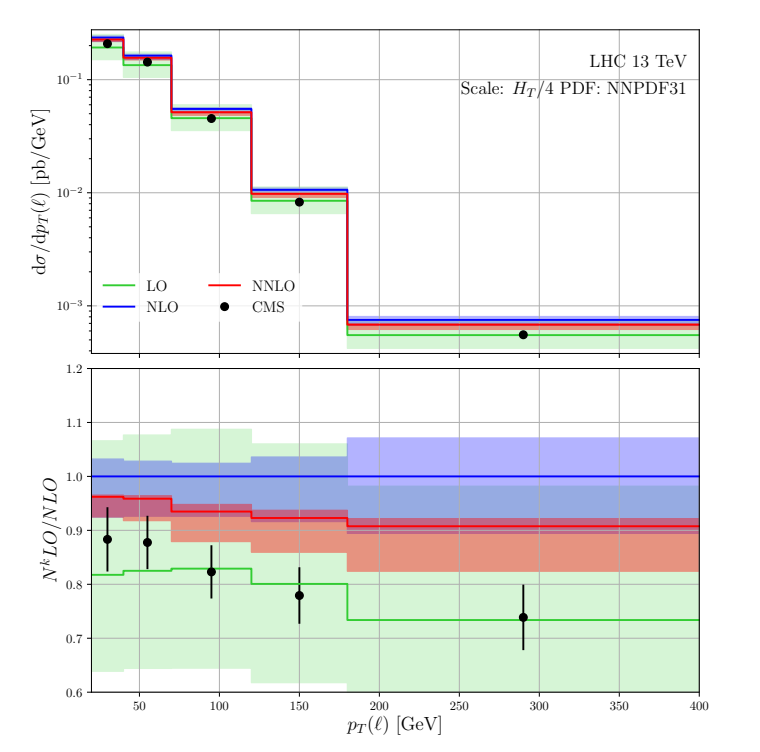
- 2 Leptons ($e^+e^-, \mu^+\mu^-, e^\pm\mu^\mp$): $p_T > 20$ GeV and $|\eta| < 2.4$, $m_{\ell\bar{\ell}} > 20$ GeV
- 2 b-tagged Jets : anti-$k_\perp$ with $R = 0.4$, $p_T > 30$ GeV and $|\eta| < 2.4$, $\Delta R(\text{jet}, \text{lepton}) > 0.4$.

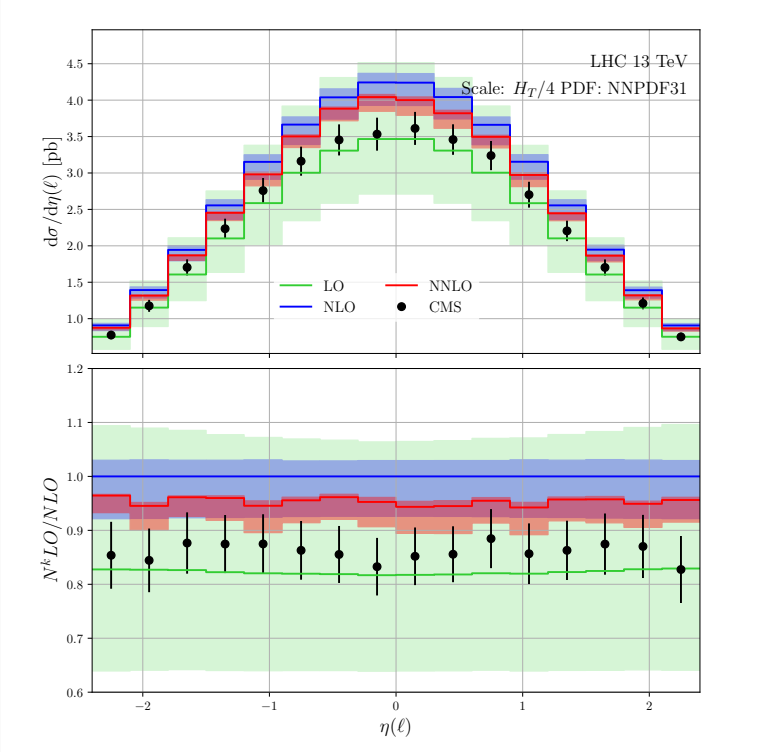
b-tagged jets:

- Clustered partons: gluons and massless quark flavours (including b-quarks)
- b-tag: evaluating 'bottomness' of jet, if larger 0 $\rightarrow$ b-tag
- Note for fixed order NNLO QCD: up to three partons form a jet.

Differential cross sections

Leptonic observables:





Differential cross sections

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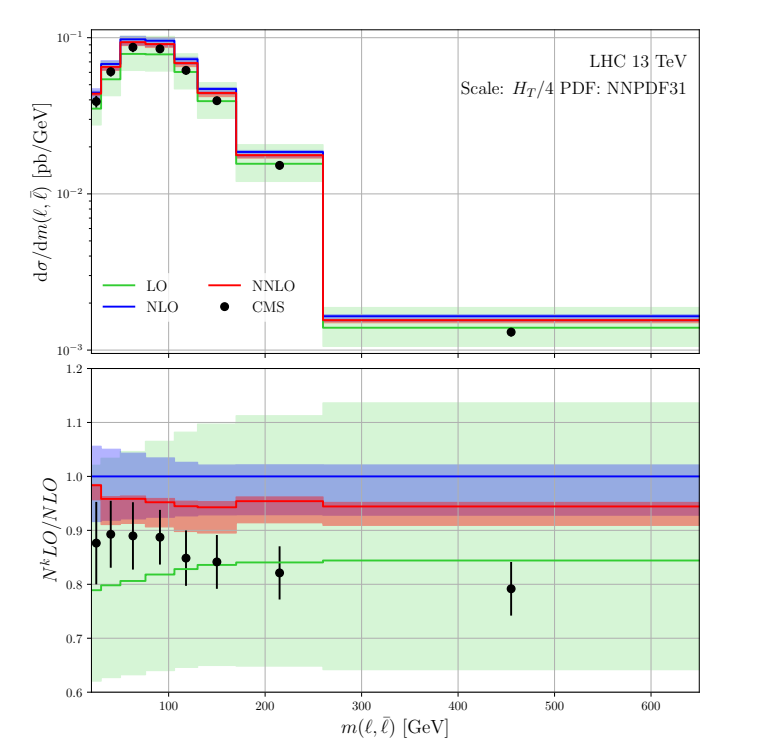
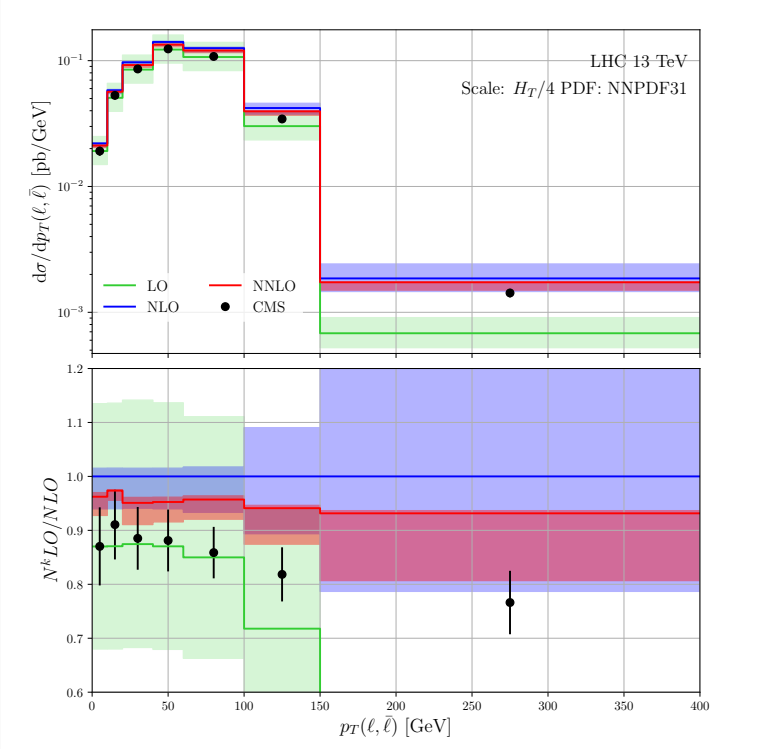
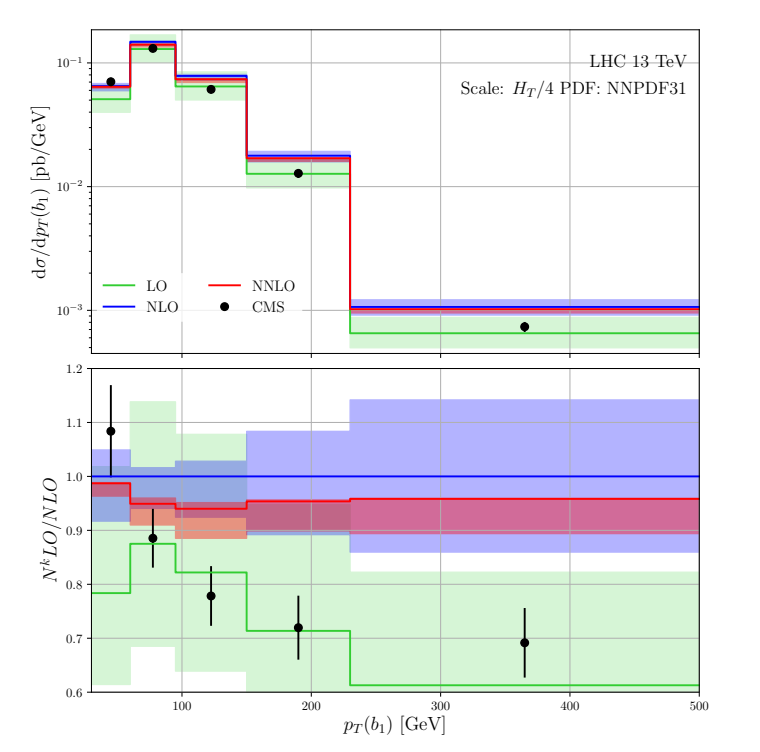
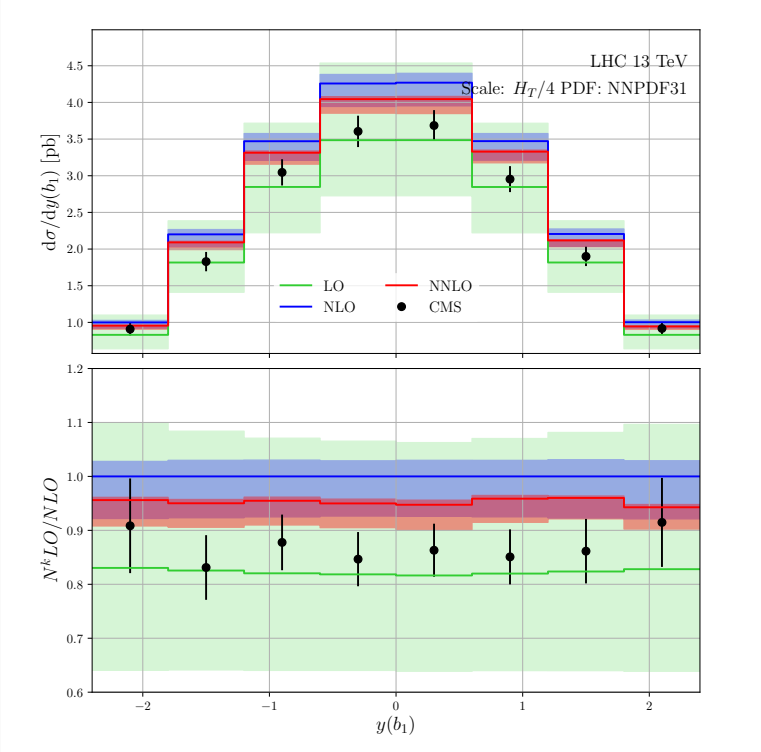




Differential cross sections

b-jet observables:





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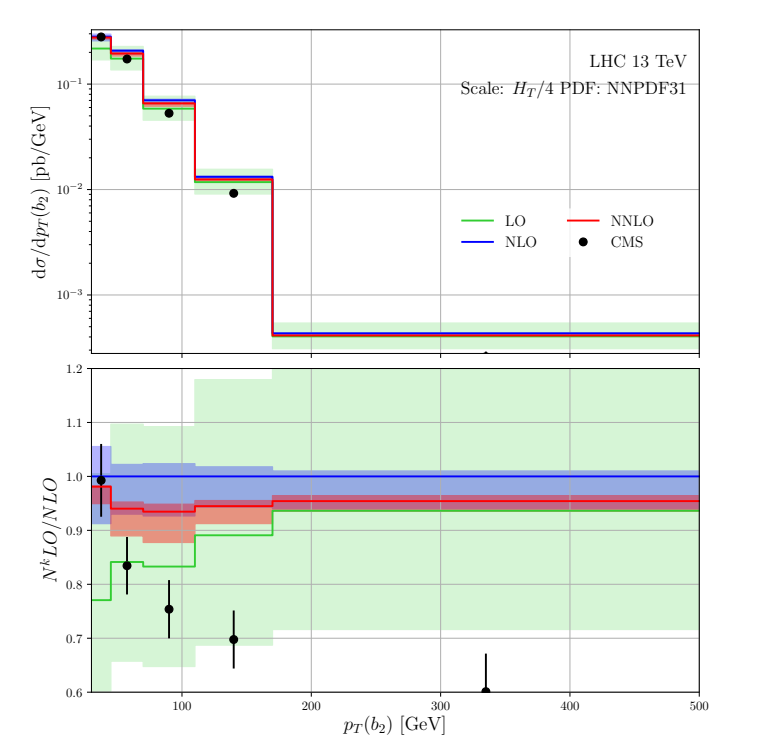

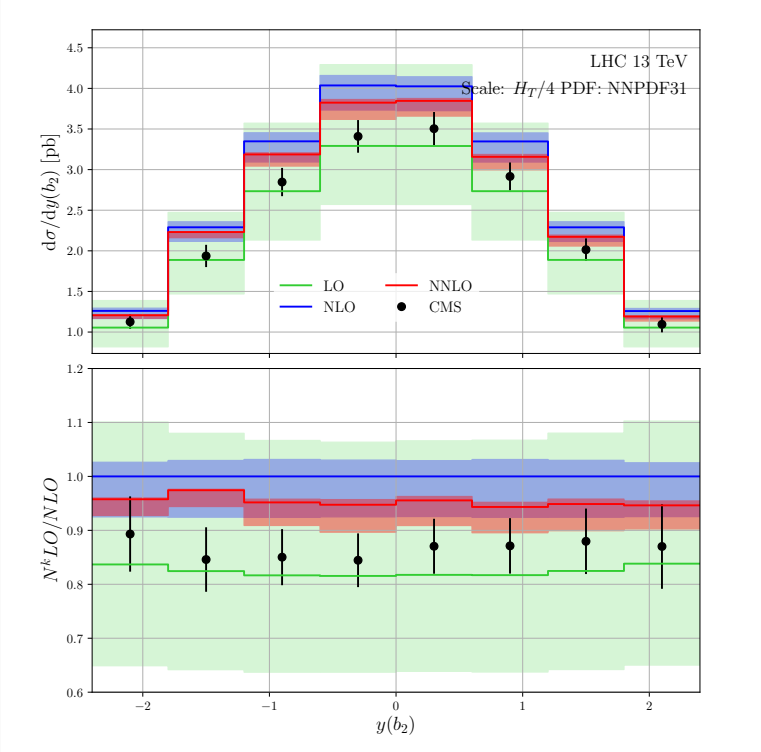

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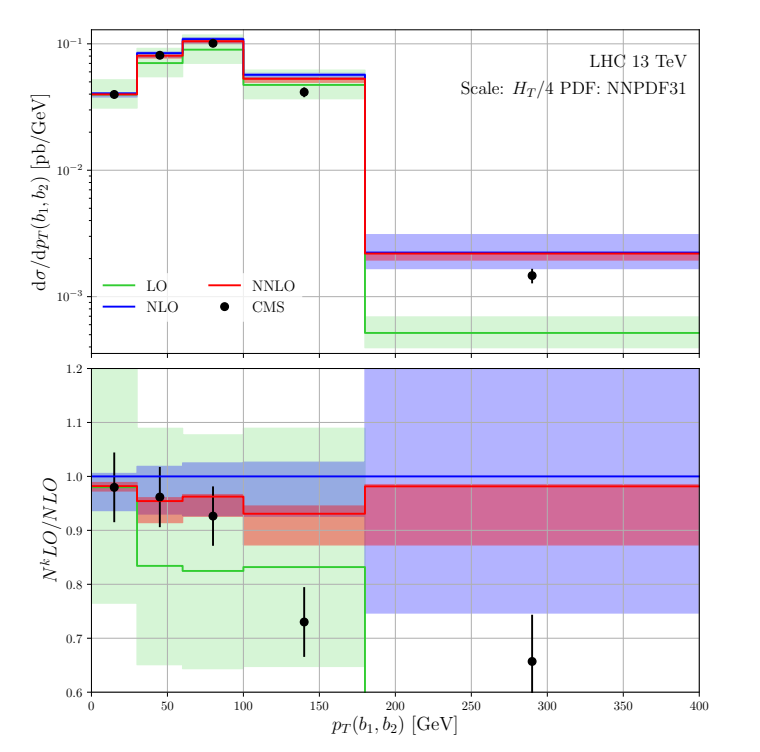
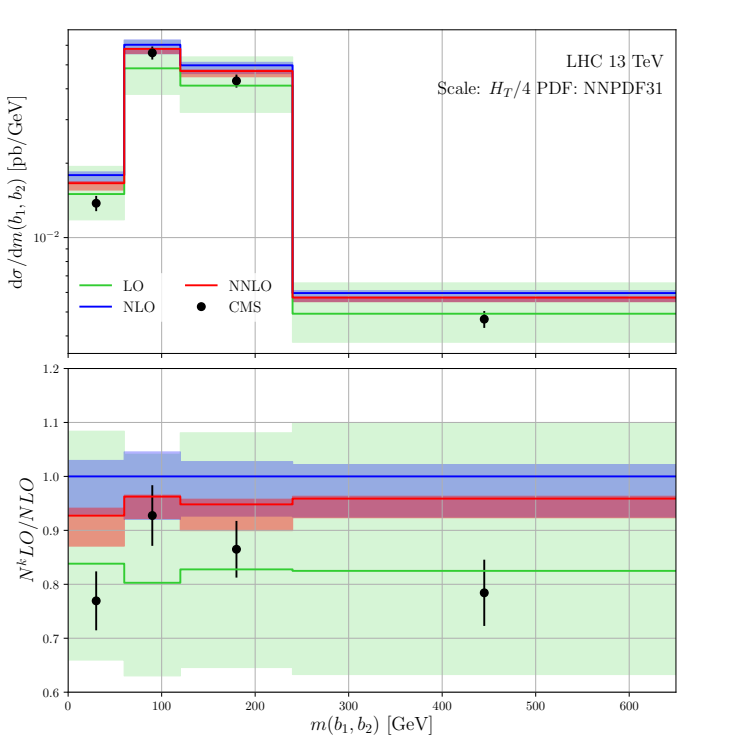




Differential cross sections

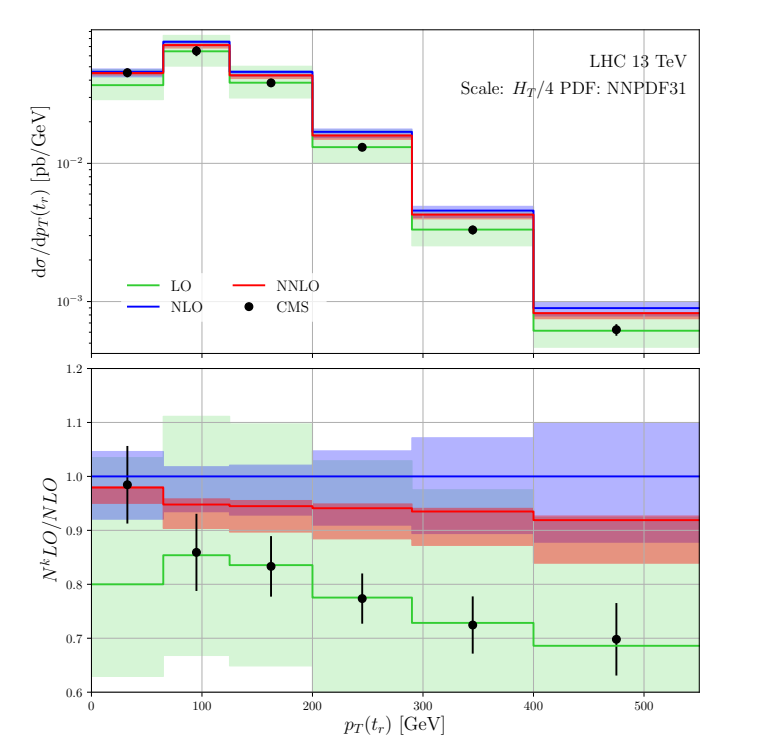
Top-quark observables:

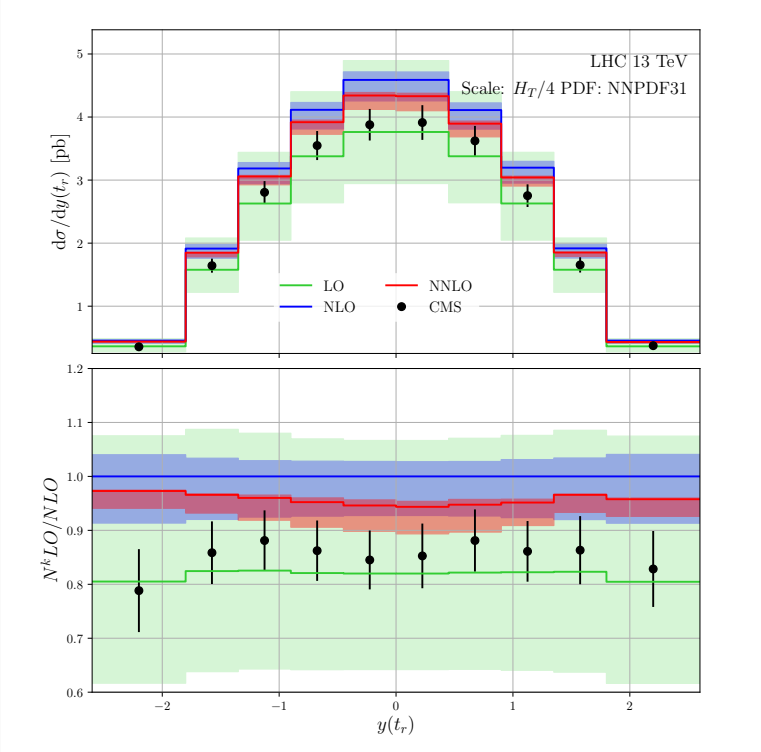
Top-reconstruction

- Neutrino + Lepton momenta $\rightarrow W^{\pm}$ momenta
- Match b-jets to minimize $\sum |m(p_W, p_{j_b}) - m_t|$

Differential cross sections

Top-quark observables:





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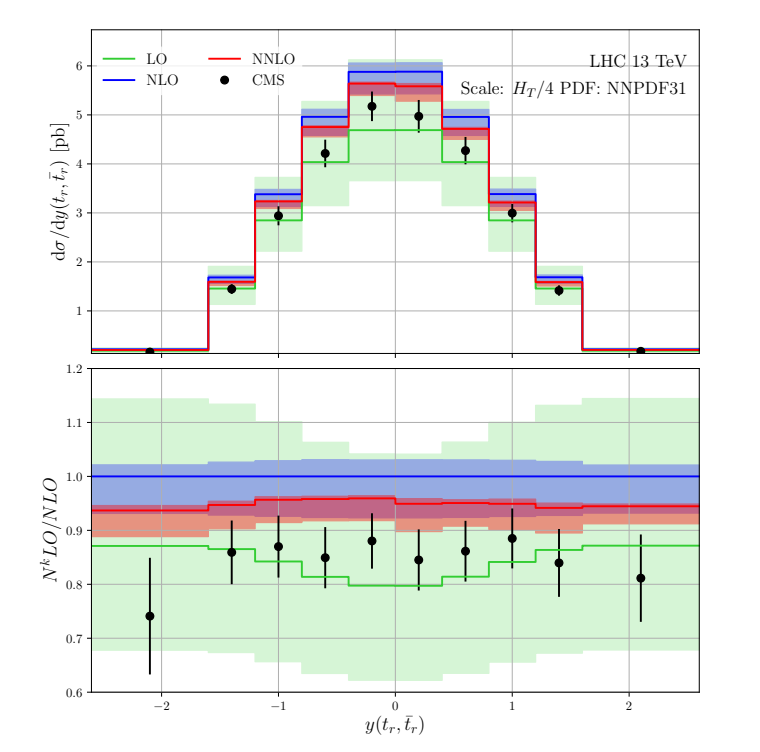
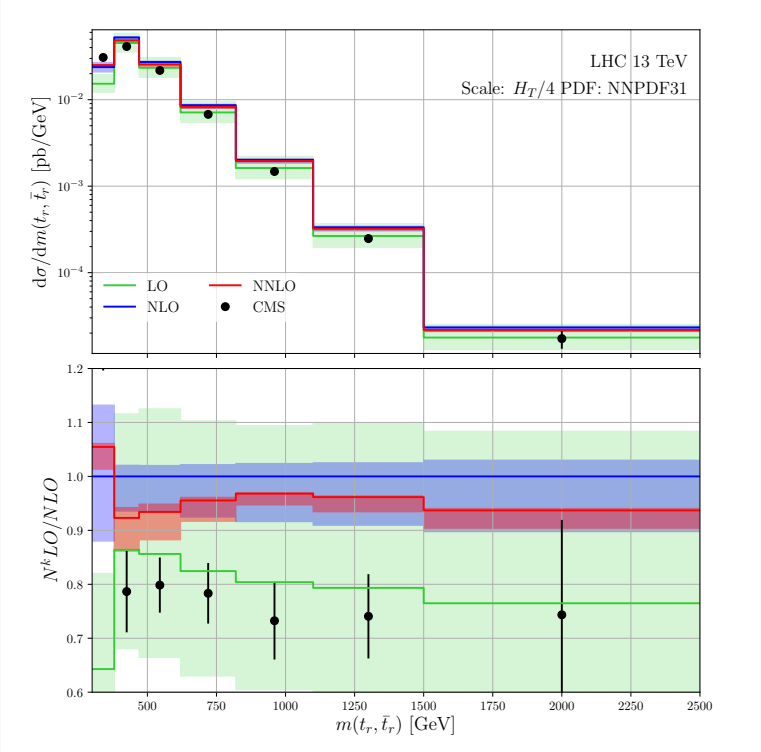
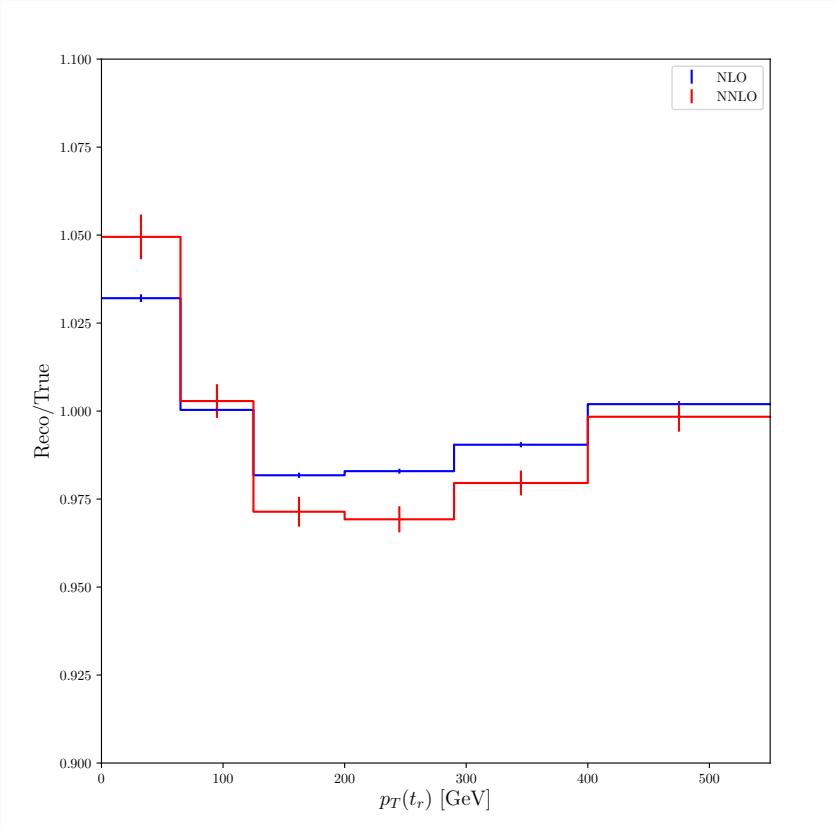




Reconstruction of top-quark

- Differences between 'true' top-quark and reconstructed top-quark at fixed order
- significant but small



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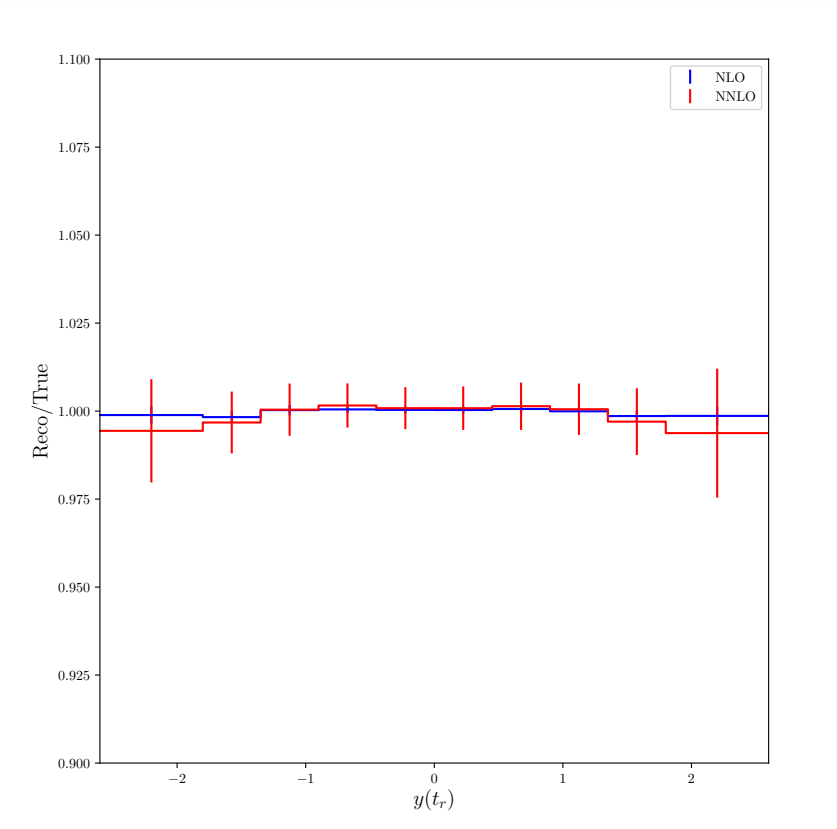

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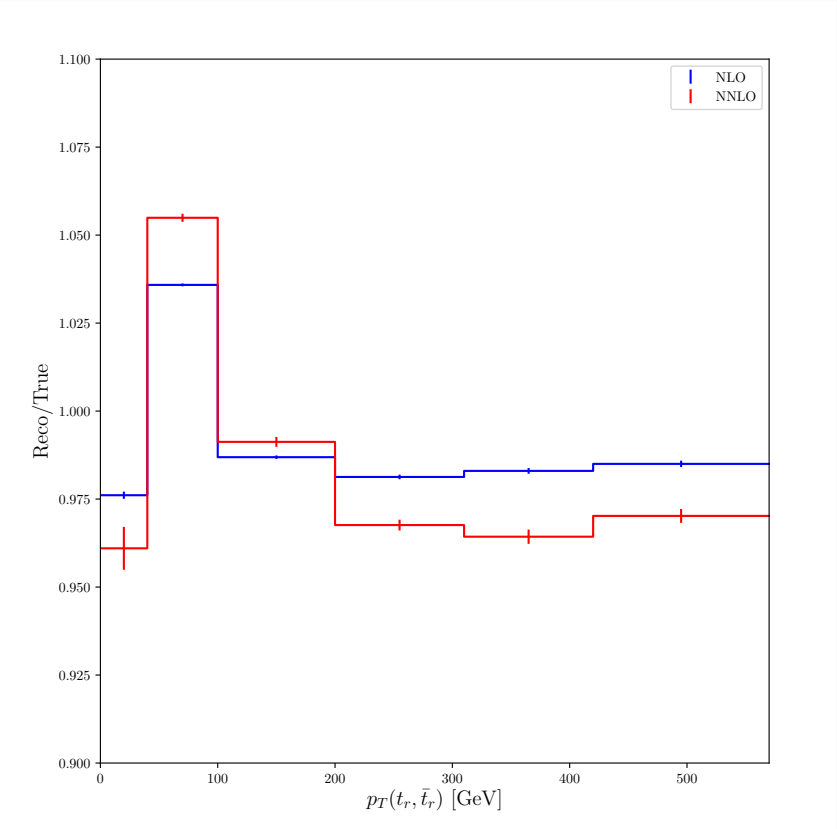

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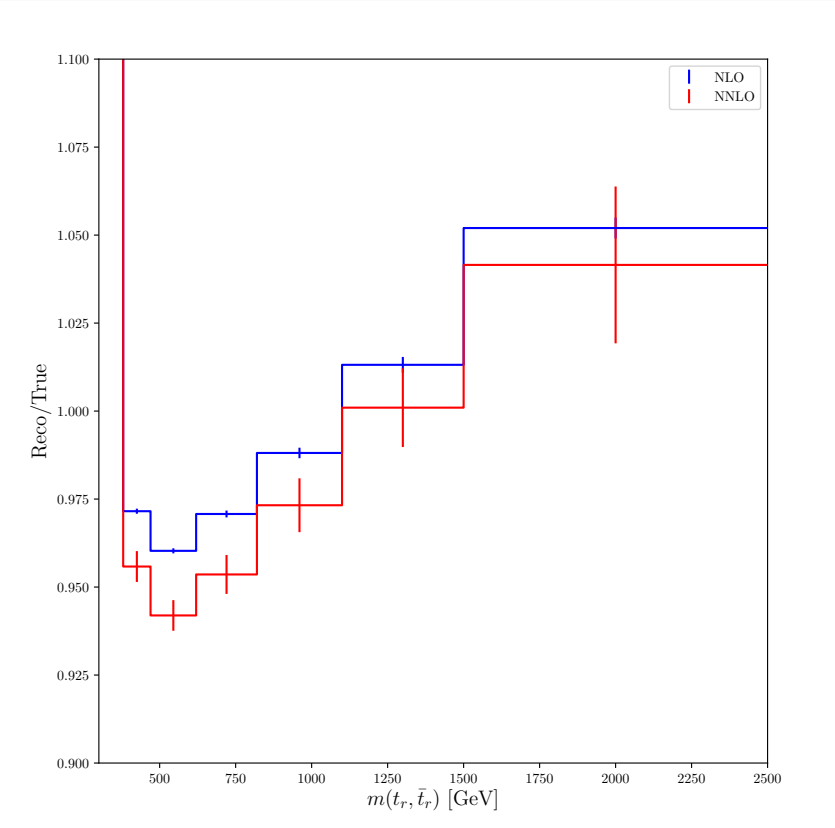
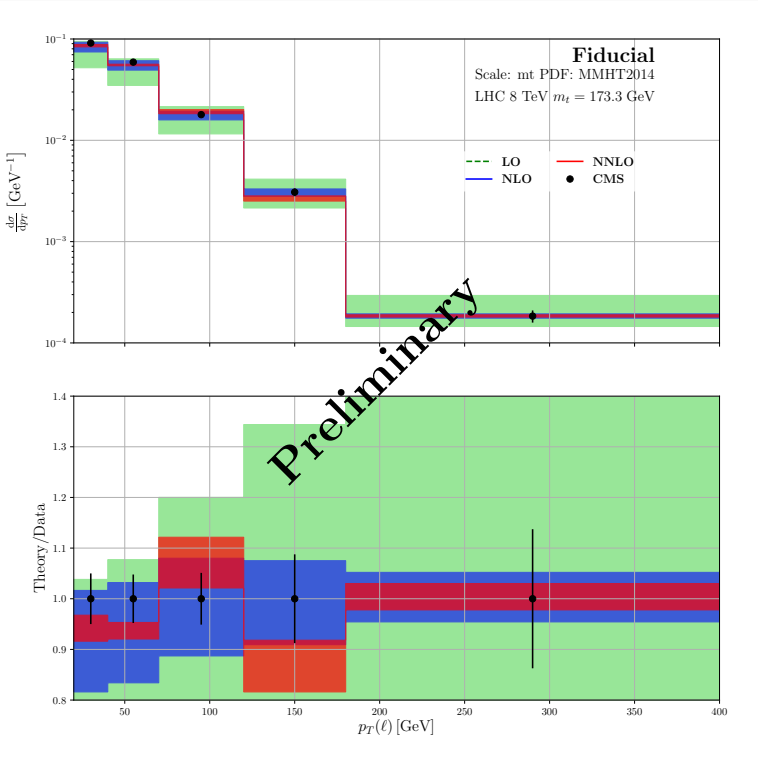
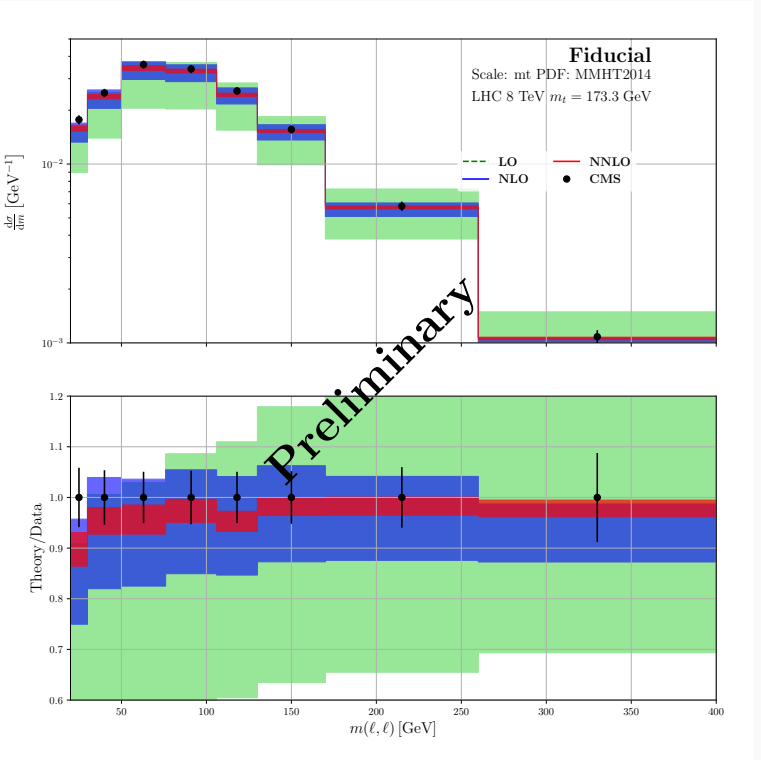


Comparison @ 8 TeV





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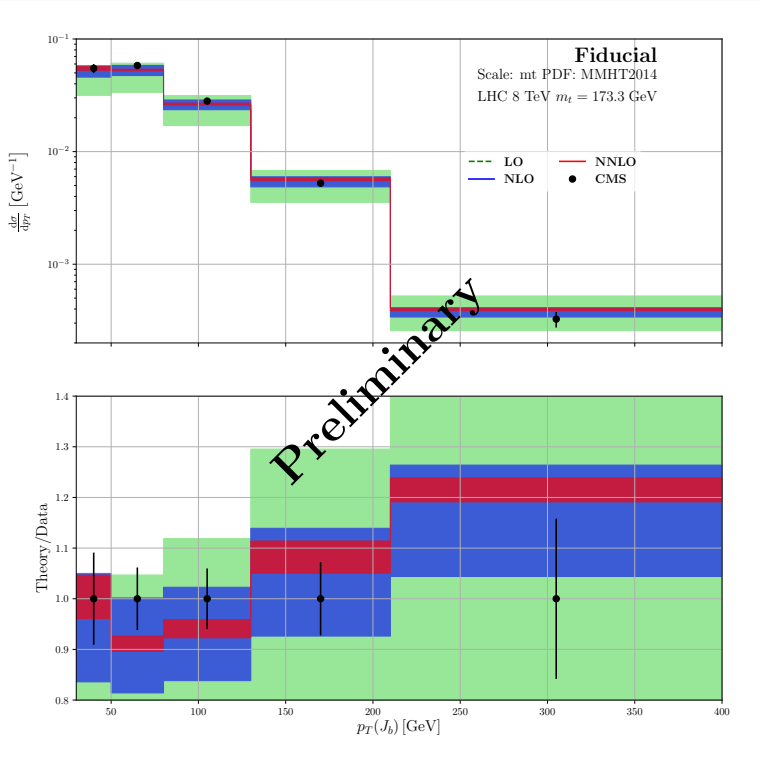

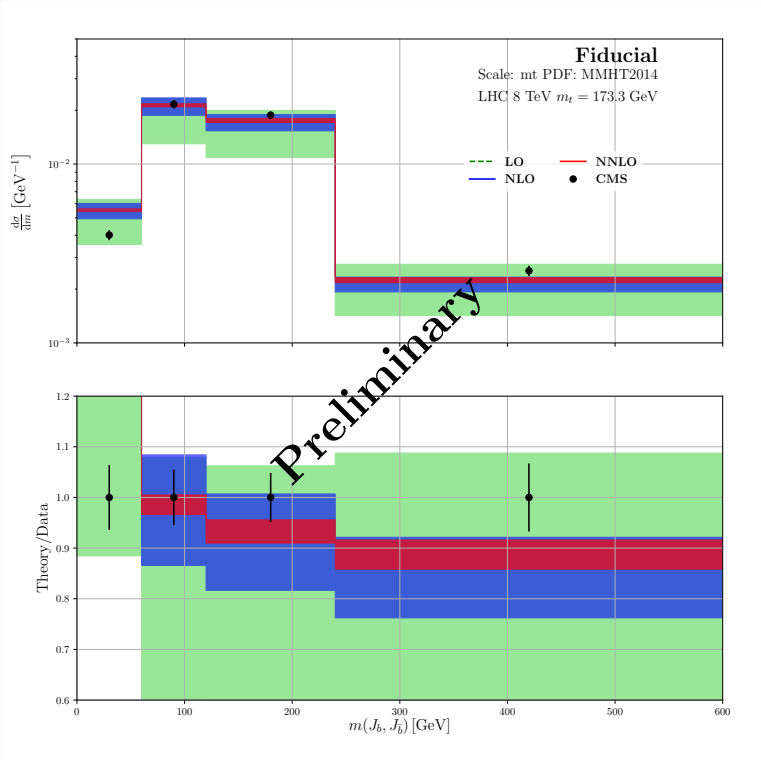

Summary/Outlook

- NNLO QCD predictions for fiducial phase space and comparison 13 TeV CMS measurement
- Obvious differences: normalization, shapes in b-jet and top-quark distributions $\rightarrow$ better understanding of the phase space definition needed!
- First steps to clarification: true vs. reconstructed top-quark $\rightarrow$ differences, but do not cover discrepancies