An update on ttbar dilepton fiducial distributions

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Outline

- ✓ Status of the comparison with CMS
  - ✓ Implications for top-pair production at threshold and m_{top} determination
  - ✓ A comment on spin correlations

NNLO QCD vs CMS data

CMS arXiv:1811.06625
Czakon, Mitov, Poncelet 2020 (to appear)

- ✓ First comprehensive comparison of fiducial differential distributions computed in NNLO QCD

- ✓ Amazing progress since Top2019!

- ✓ Special thanks for a very productive collaboration go to

  - the CMS TOP and LHCtopWG conveners
  - Mykola Savitskyi
  - Rene Poncelet

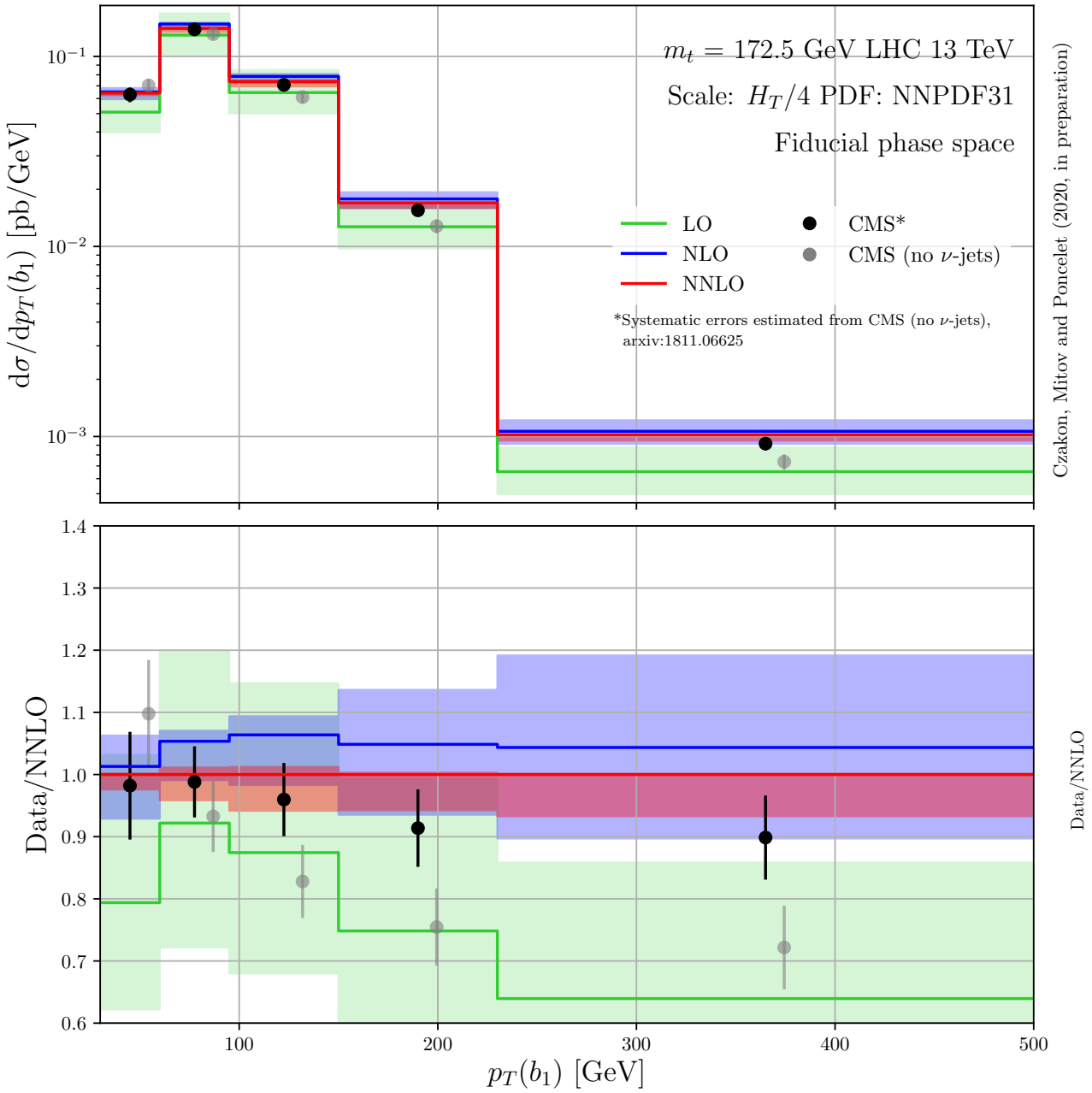
- ✓ As a result of our th+exp investigations two sources of differences were uncovered

NNLO QCD vs CMS data

- Source 1: [reported Nov19 TopWG] CMS uses "reconstructed" top, we used "true" top
  - Experimentally the top is reconstructed from the decay products
  - Initially we used the true top (which is known before the decay). Then switched to "reconstructed" top:
    - Assume neutrino momenta are known
    - Leptons + neutrinos give the two W's (minimizing the differences from the true W mass). This step is unambiguous for us
    - Combine the two W's with the two b-jets that minimize the difference between the reconstructed top masses and "true" mass. In our calculation we can have up to 4 b-quarks – so a potential difference
- Source 2: [NEW] Difference in b-jets: [See talk by Mykola Savitskyi]
  - In the CMS measurement the b-jets do not include neutrinos from semileptonic B-decays.
  - Our calculation is fully inclusive in QCD. Assuming no out-of-cone radiation, our calculation includes the neutrinos.
  - The updated CMS measurement includes these neutrinos. substantial numeric effect!

b-jet observables

NNLO QCD vs CMS data: b-jet observables



- b_1 and b_2: the two b-jets that best reconstruct the top pair
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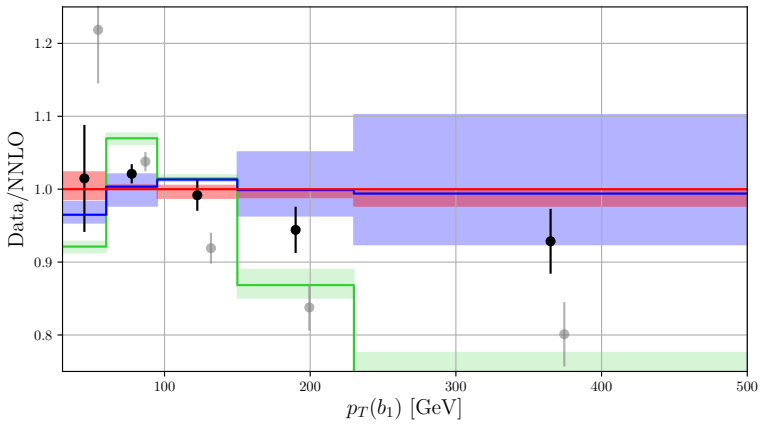

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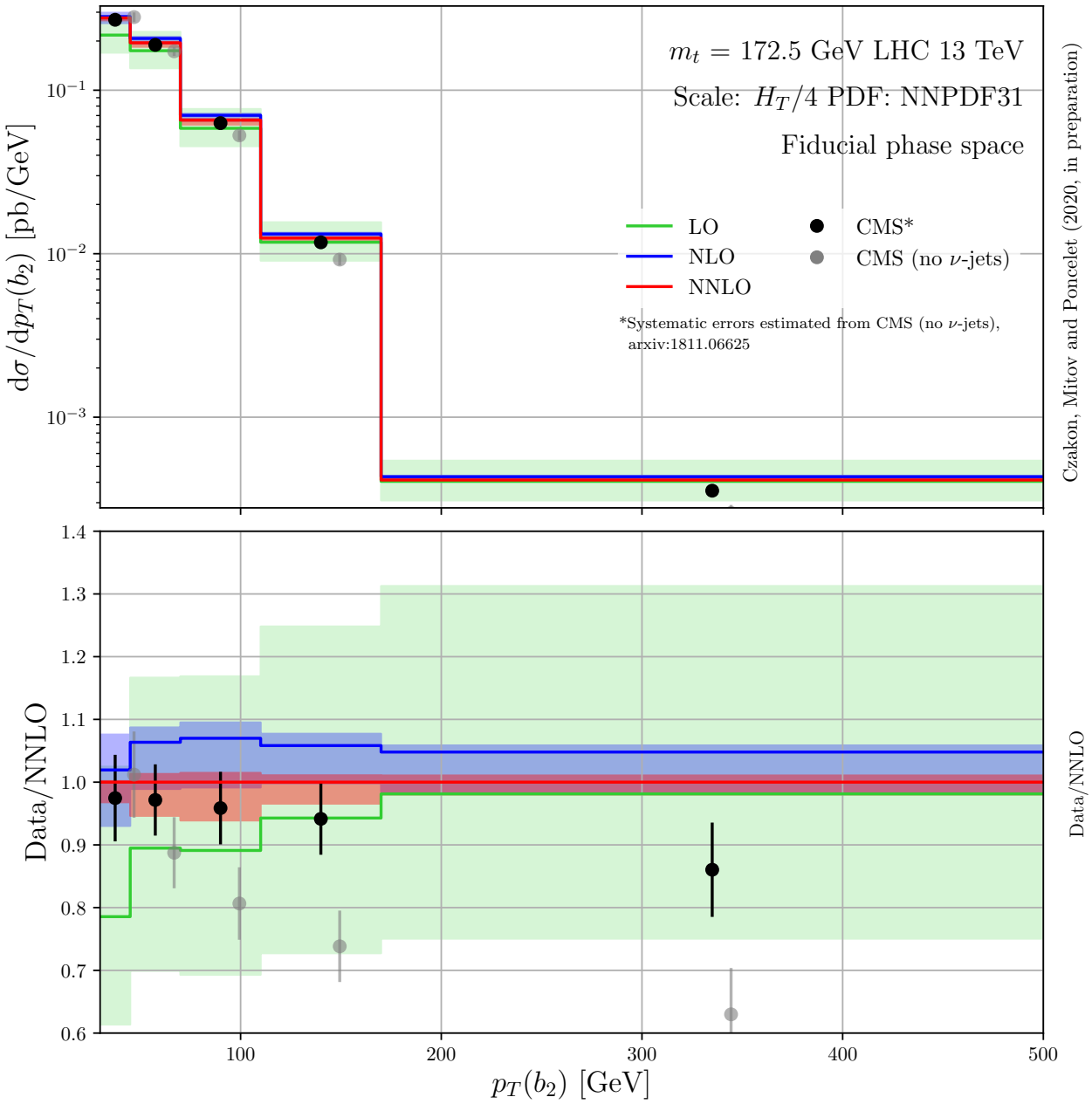

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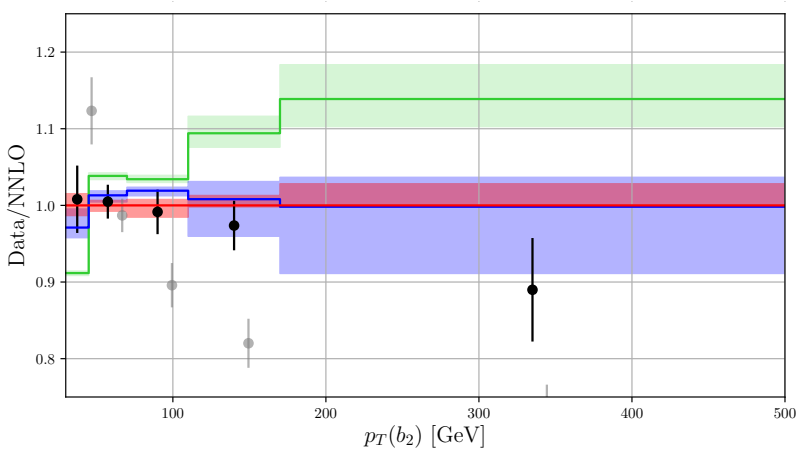

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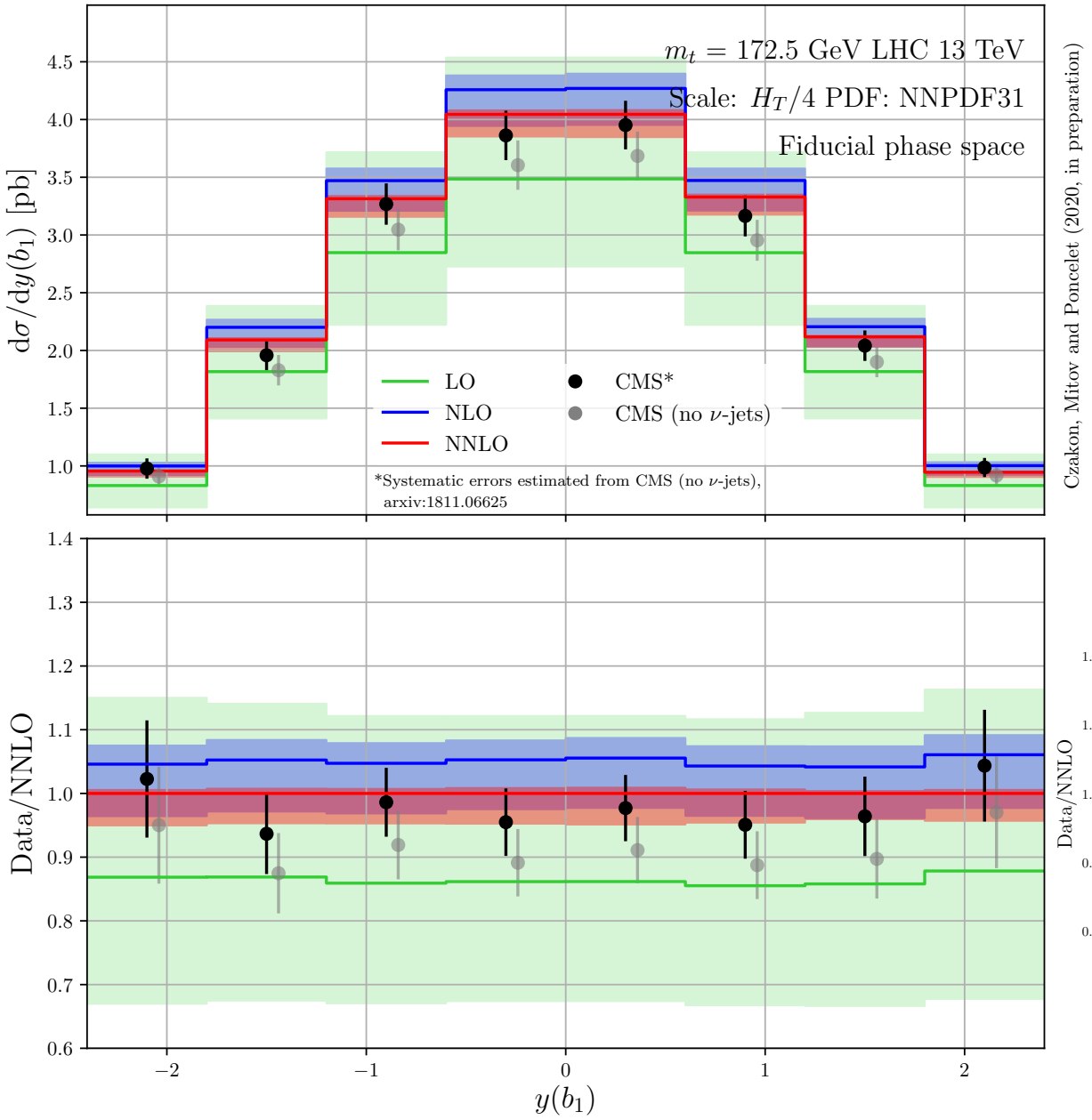

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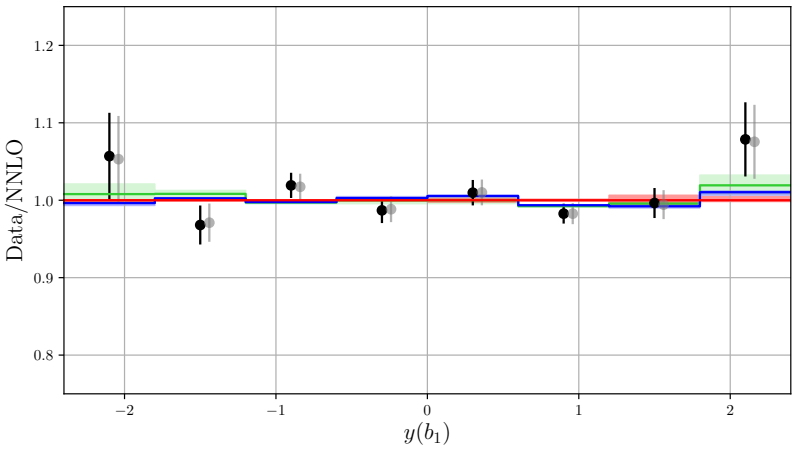

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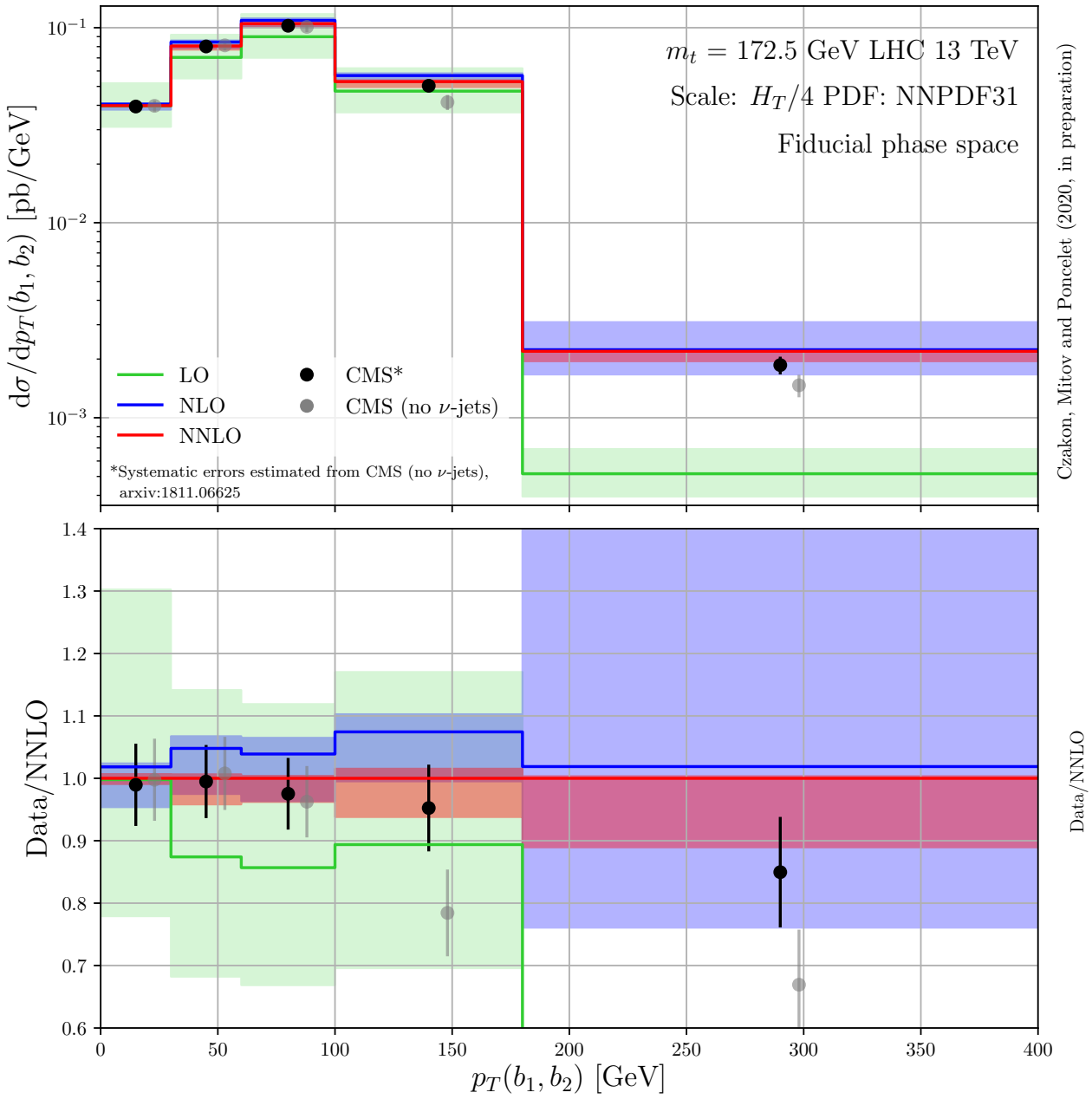

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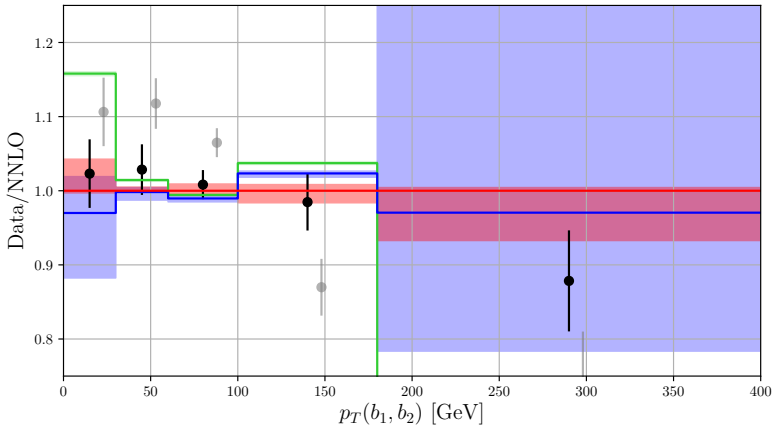

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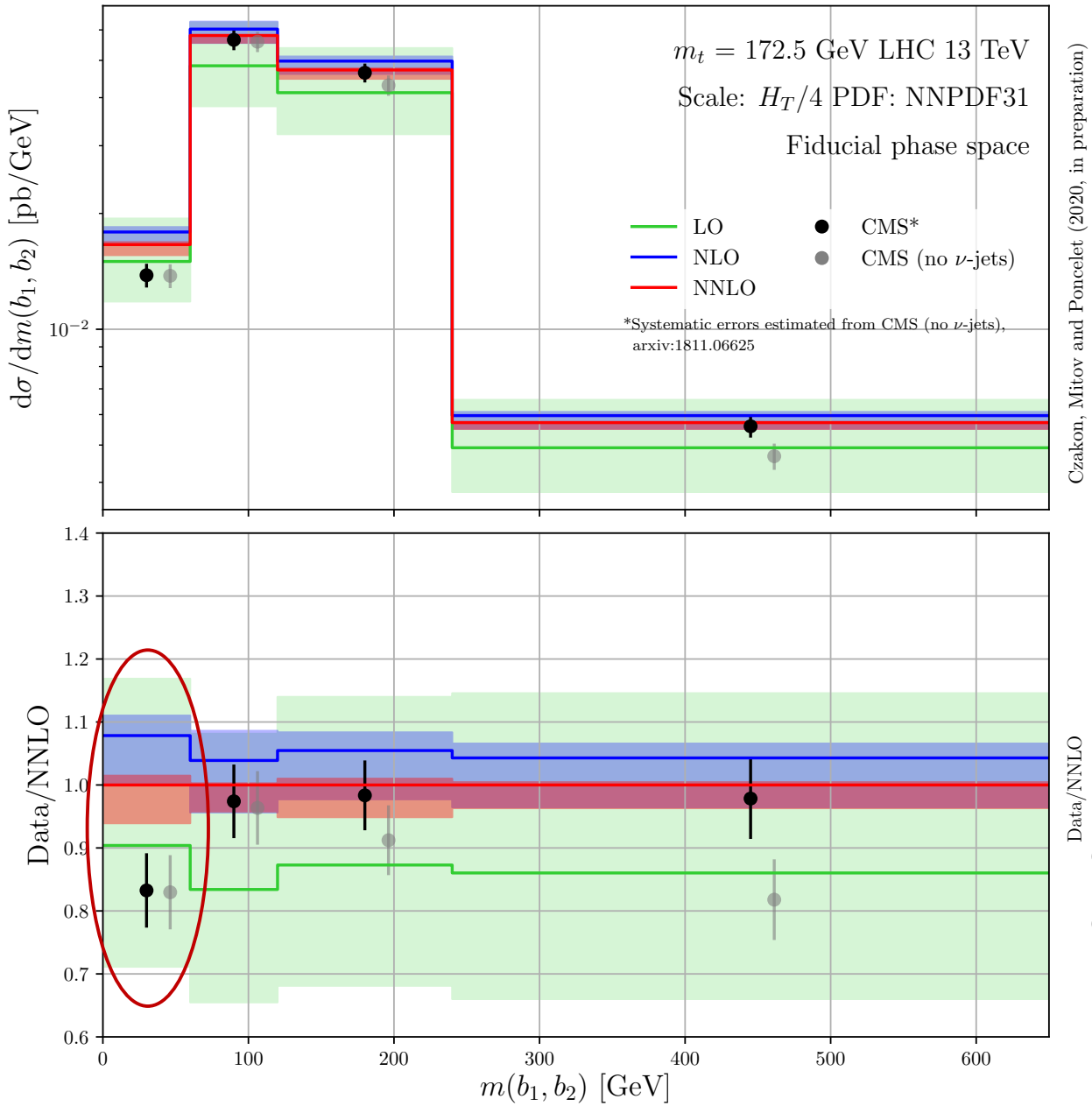

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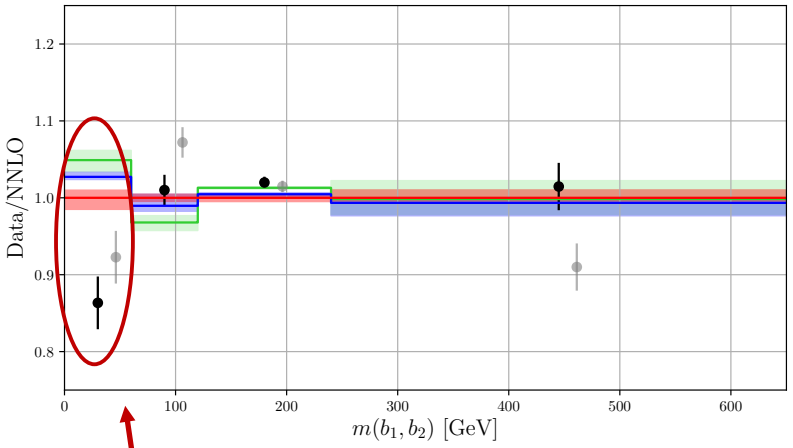
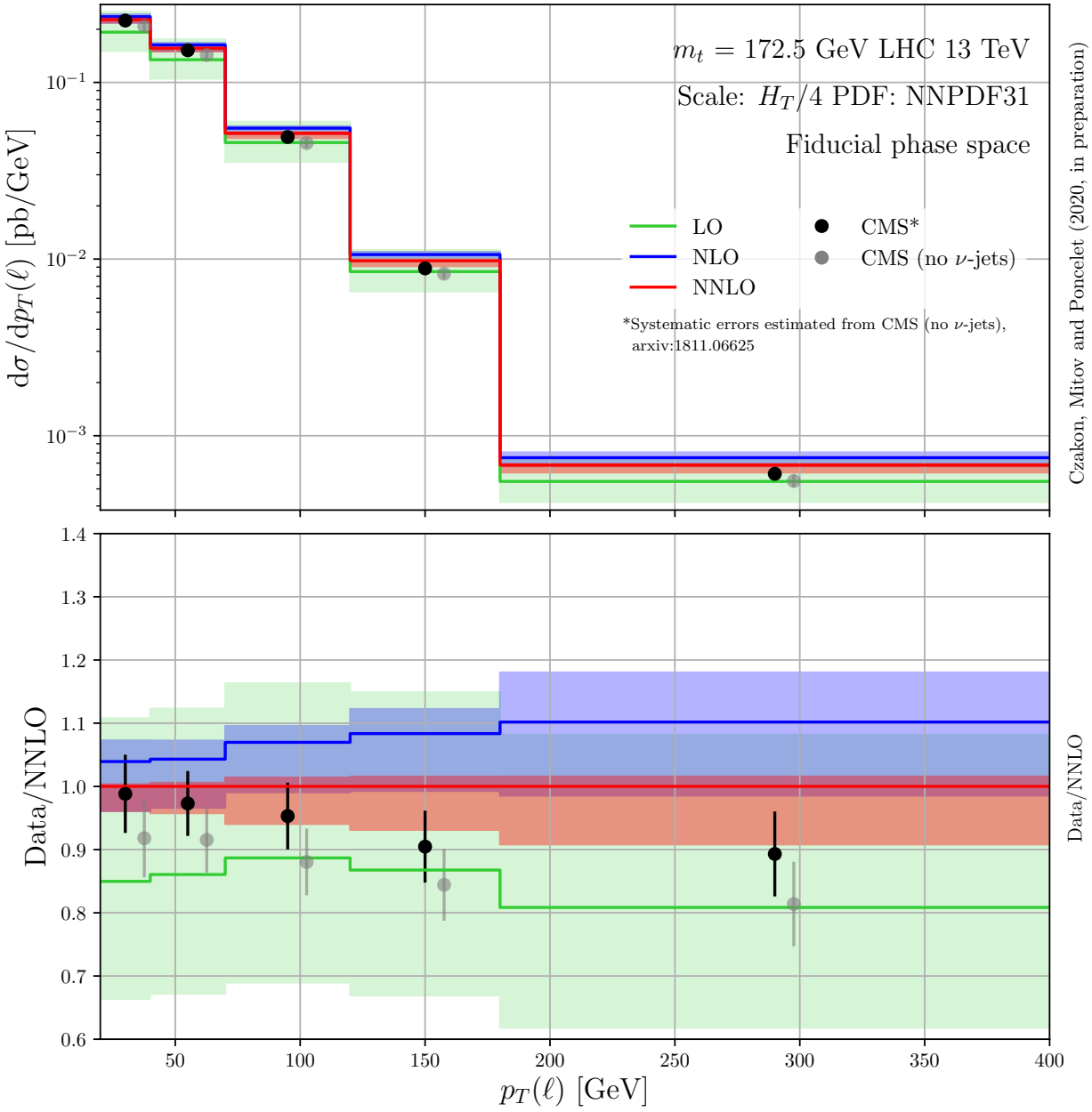


The only notably disagreeing bin for the b-jet observables

lepton observables

NNLO QCD vs CMS data: lepton observables



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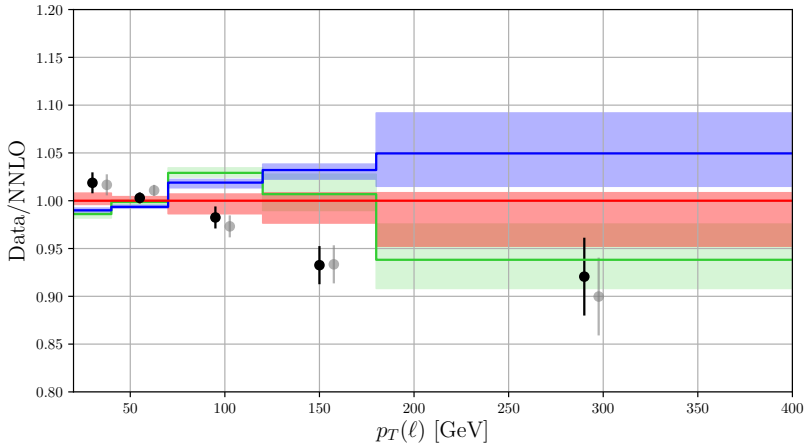
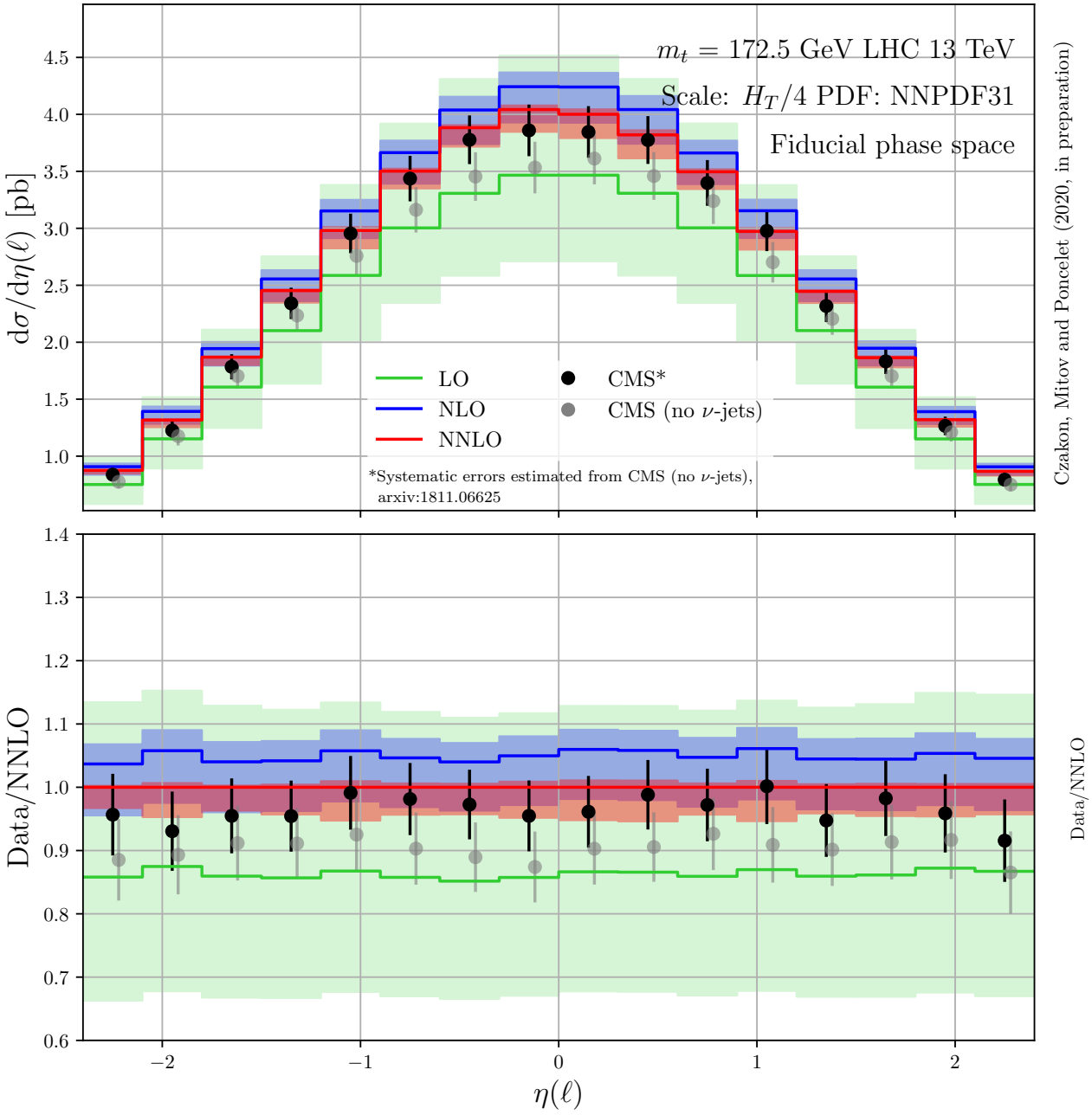


NNLO QCD vs CMS data: lepton observables



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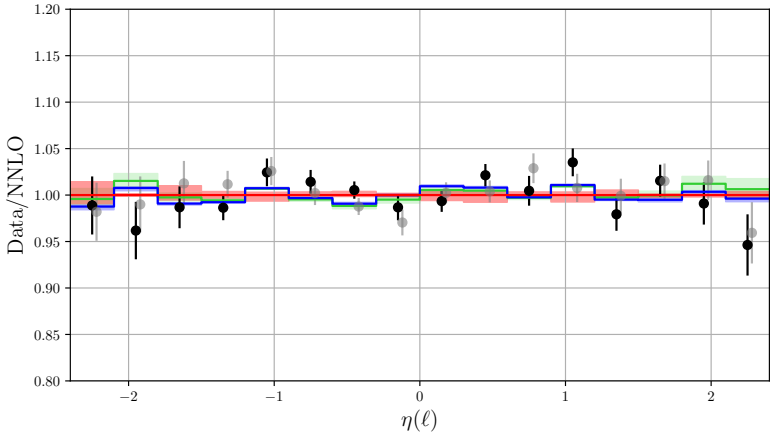

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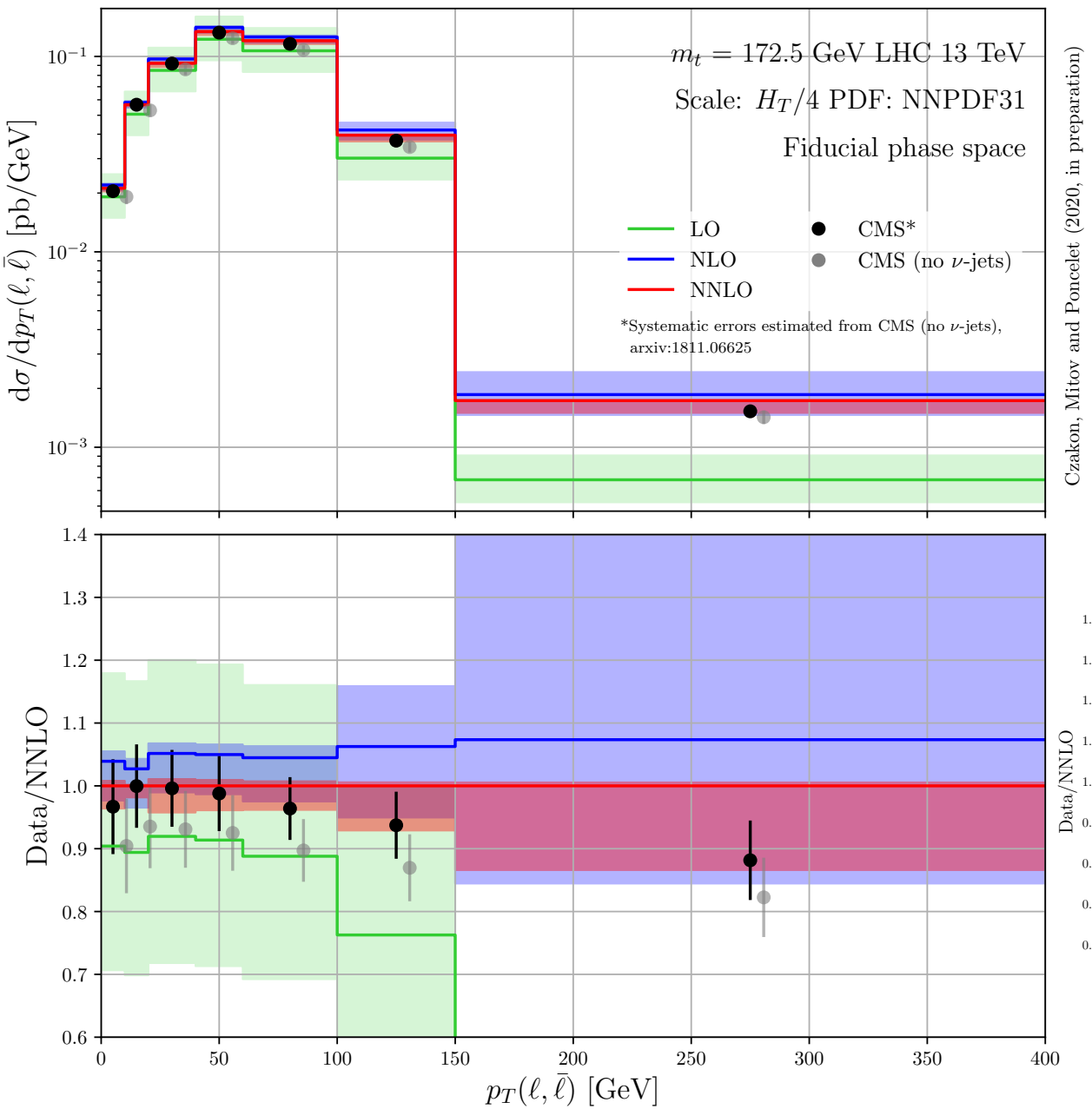

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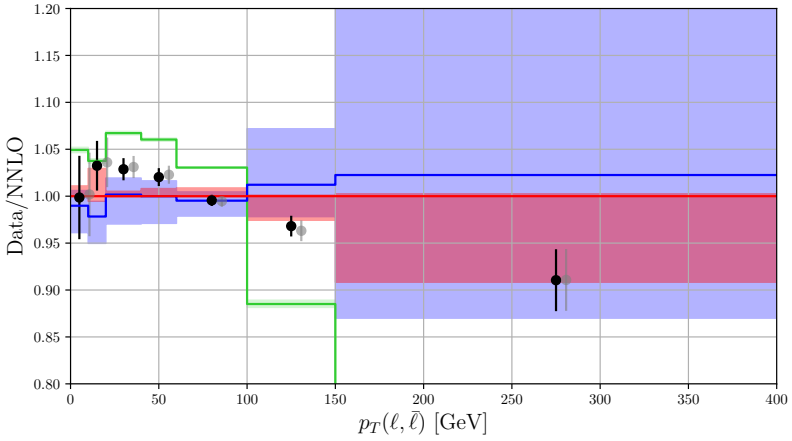

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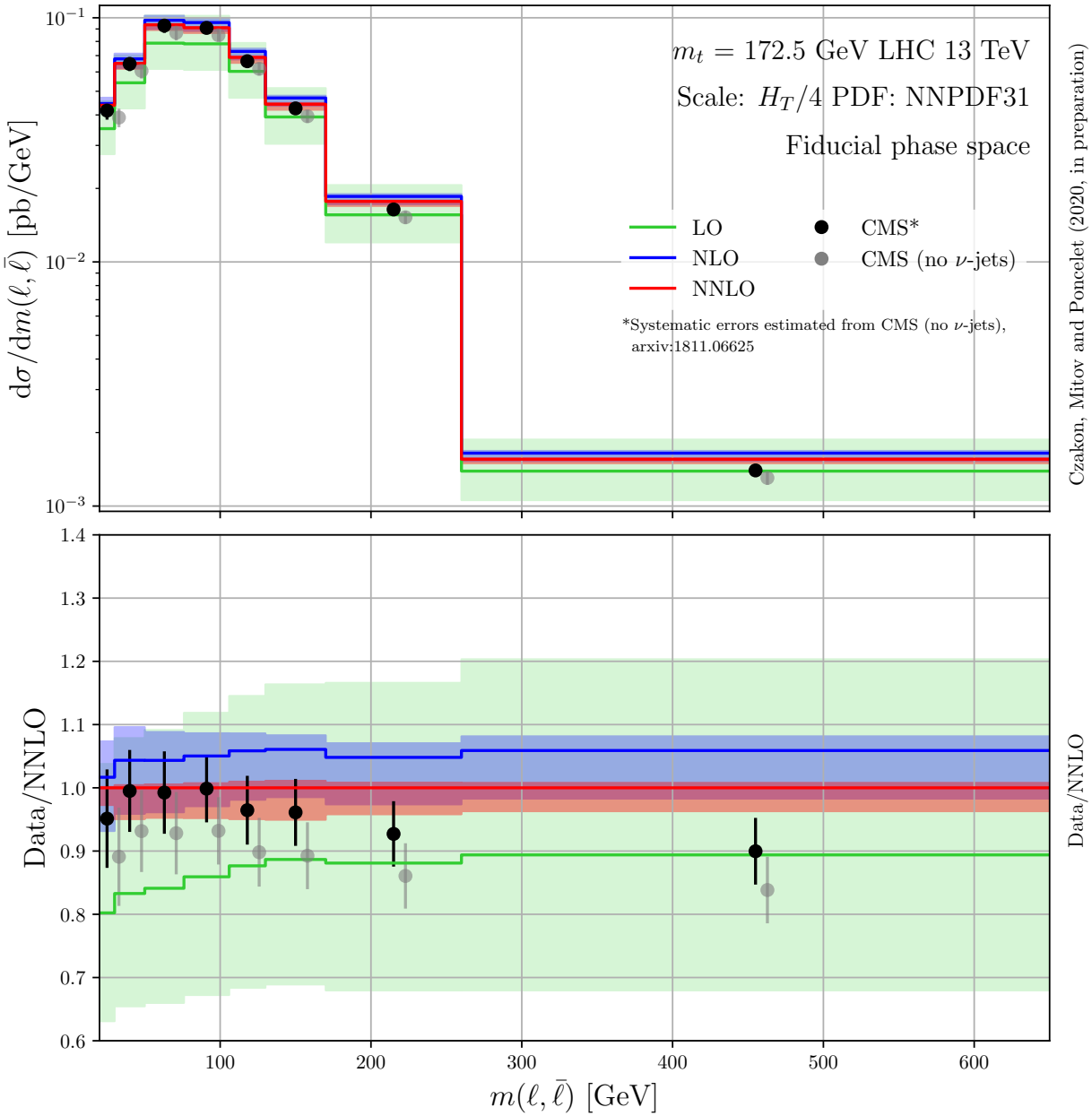

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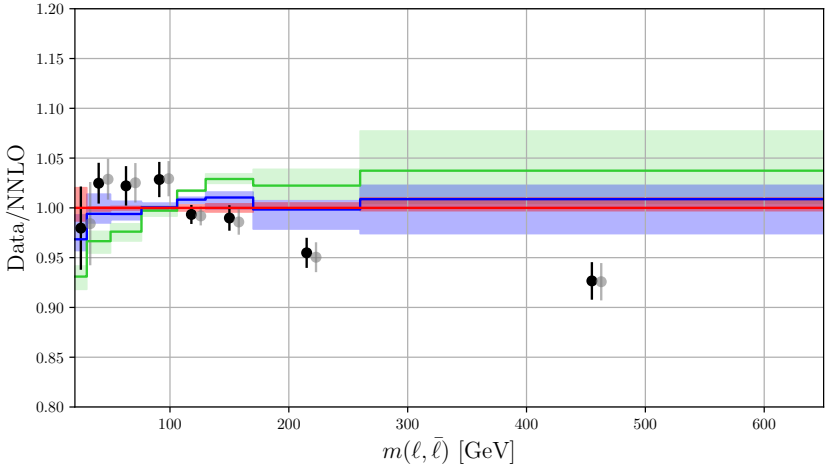


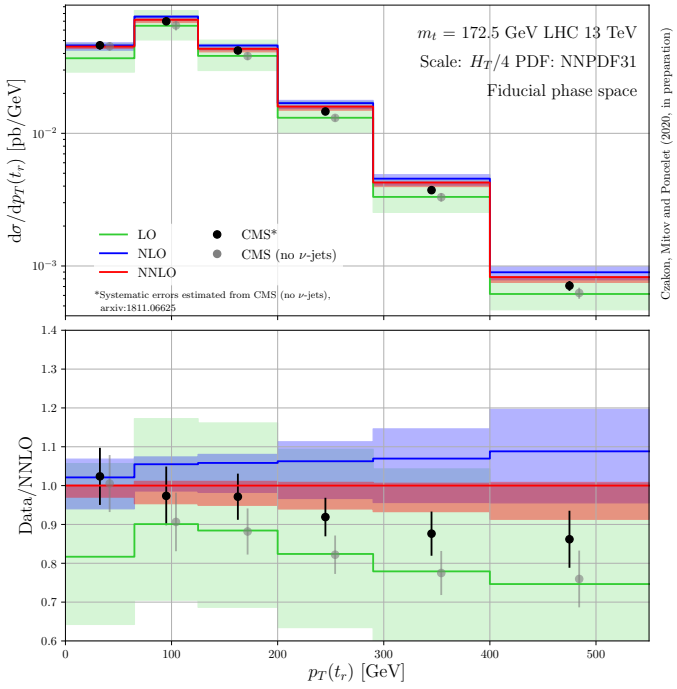
Top-quark observables

Note: there are 3 different top quarks that appear in the calculations

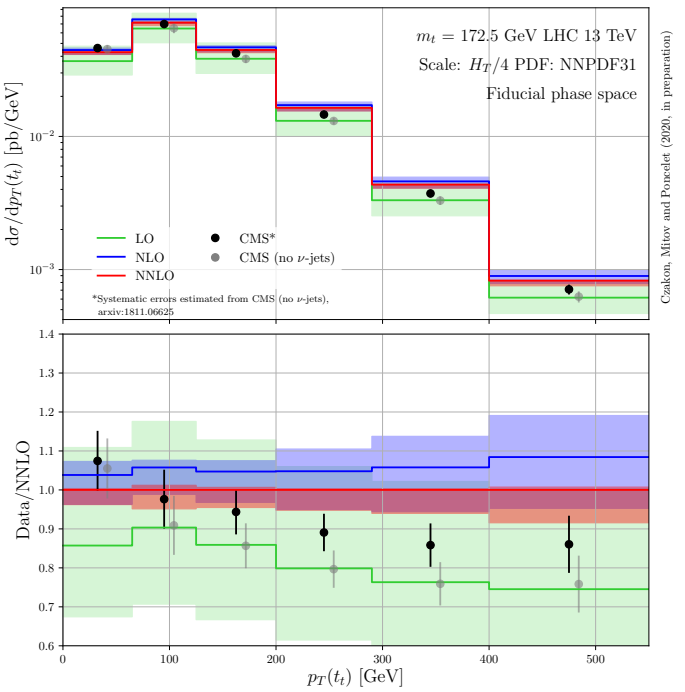
- reconstructed top t_r (fiducial volume)
- true top t_t (fiducial volume)
- inclusive top t (true top in inclusive phase-space)

NNLO QCD vs CMS data: top-quark observables

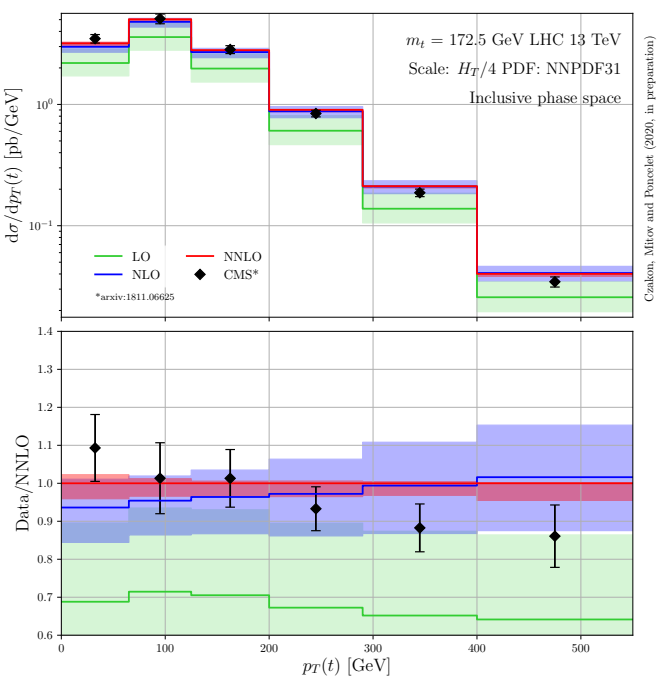
"Reconstructed" top (fiducial)



"true" top (fiducial)



Inclusive top



NNLO QCD vs CMS data: top-quark observables

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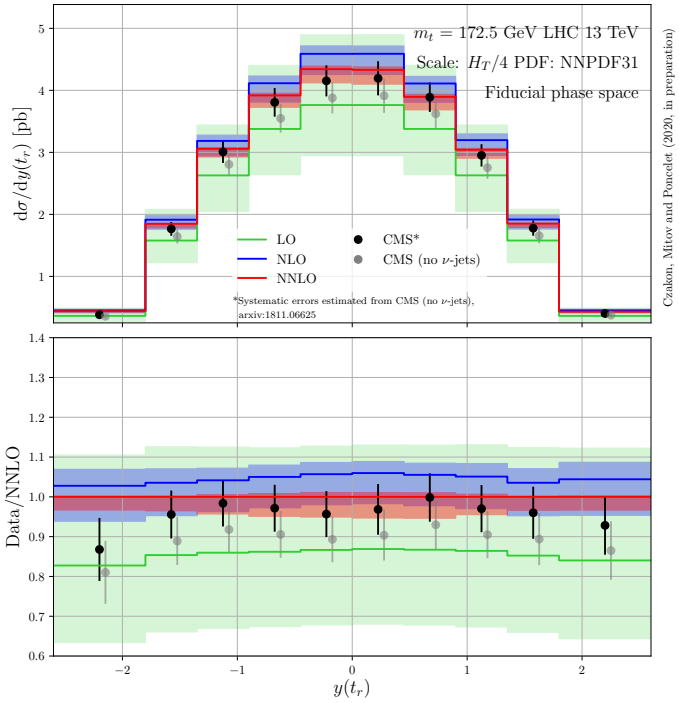

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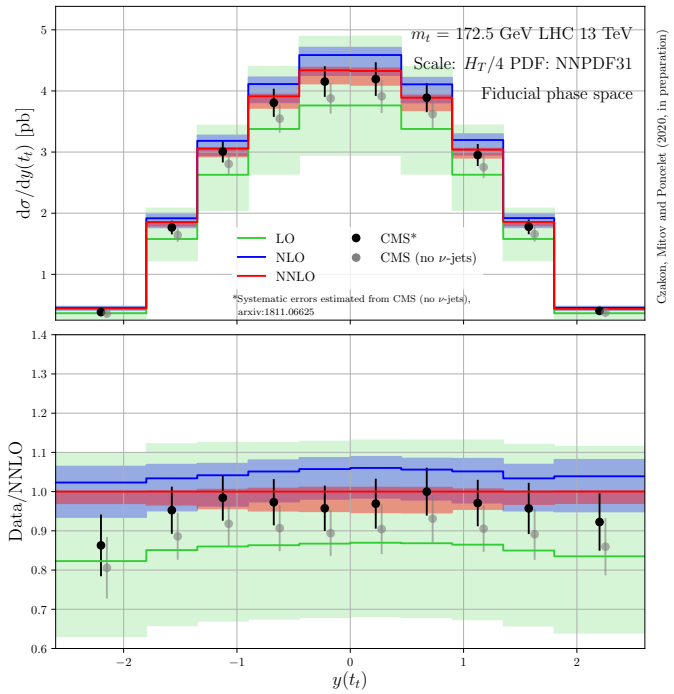

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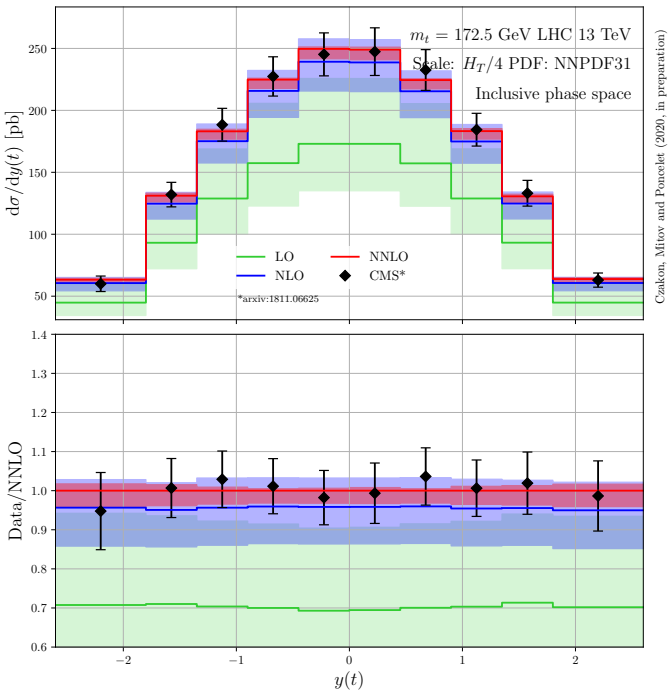

NNLO QCD vs CMS data: top-quark observables

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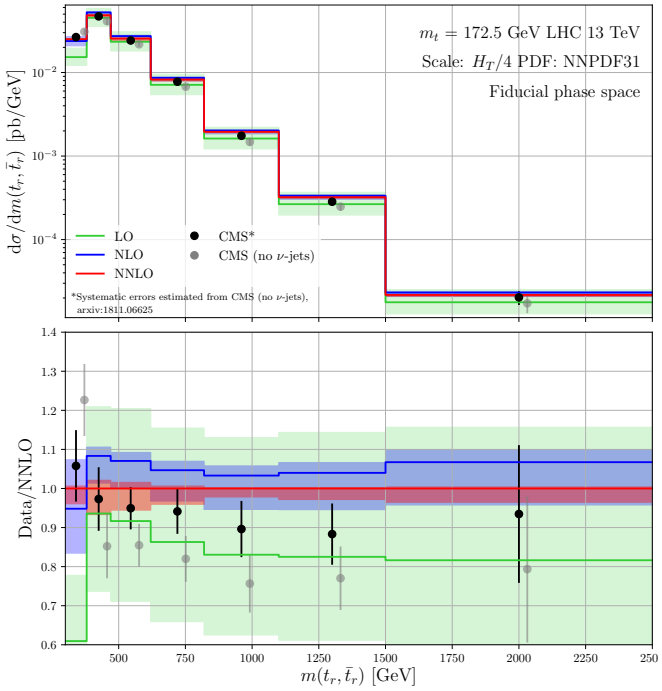

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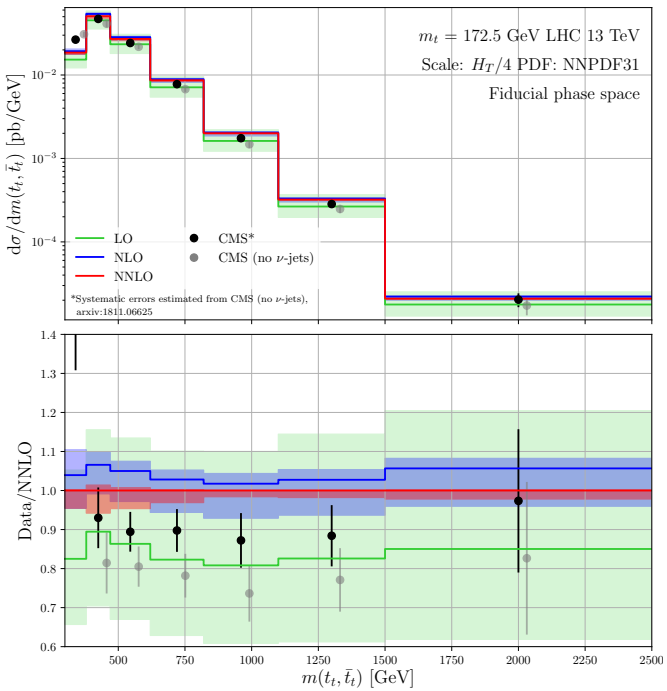

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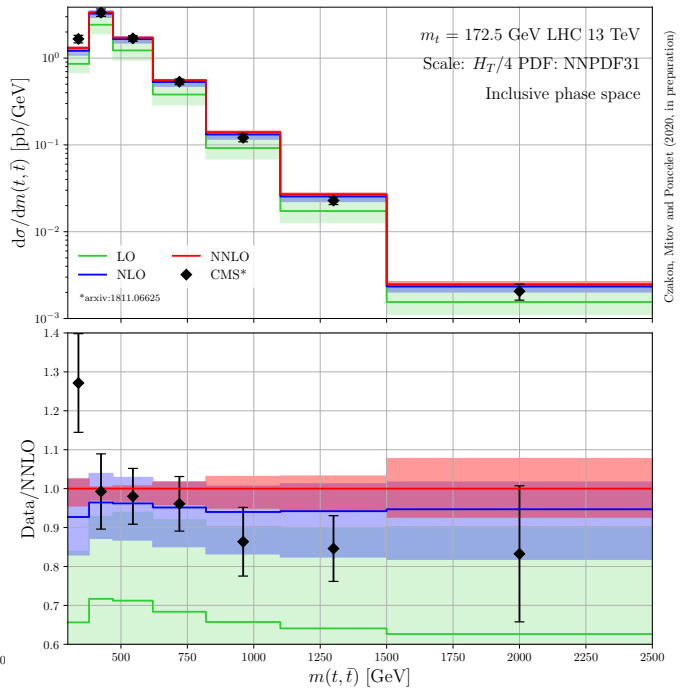


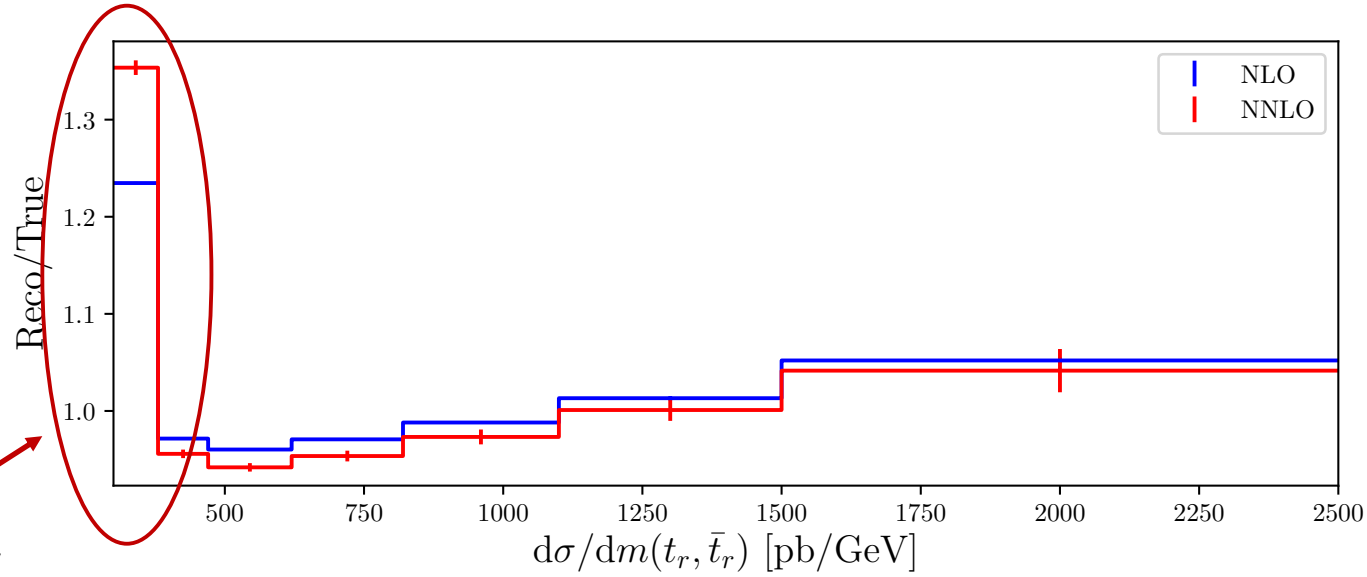
Modeling of top-production may have major impact on m_{top} determination at threshold!

- reconstructed vs true vs inclusive top are all very different
- the neutrino component of b-jets has significant impact
- MC's, too, do not seem to describe well the fiducial measurement at threshold?

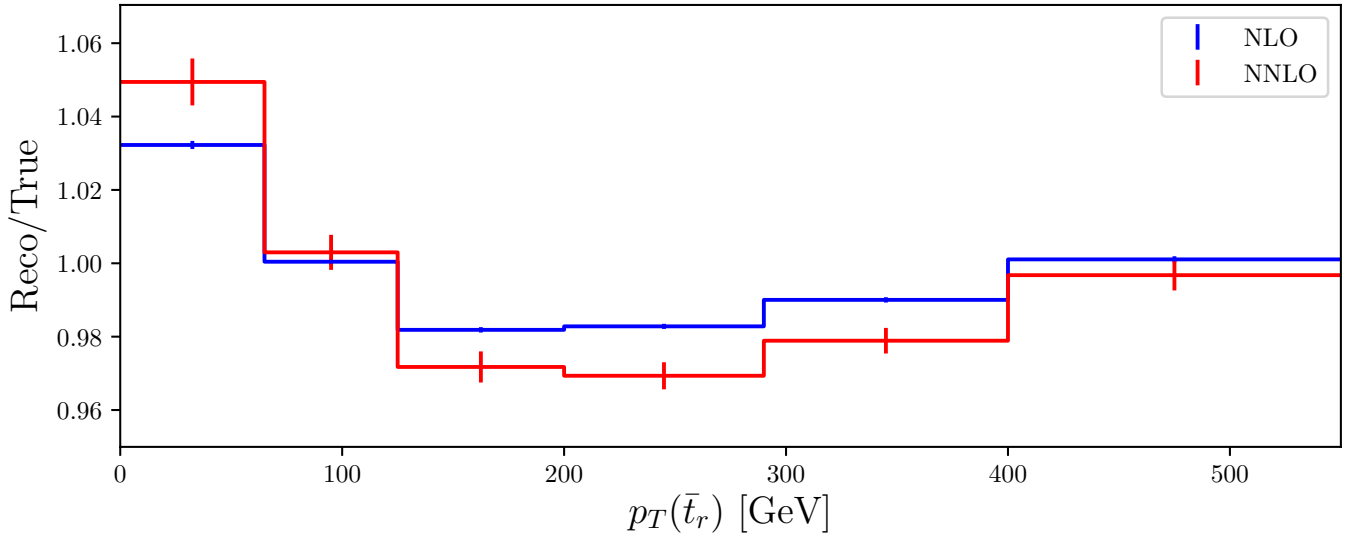
[See talk by Mykola Savitskyi]

NNLO QCD vs CMS data

✓ Ratio between the true and the constructed tops at NLO and NNLO (CMS selection)



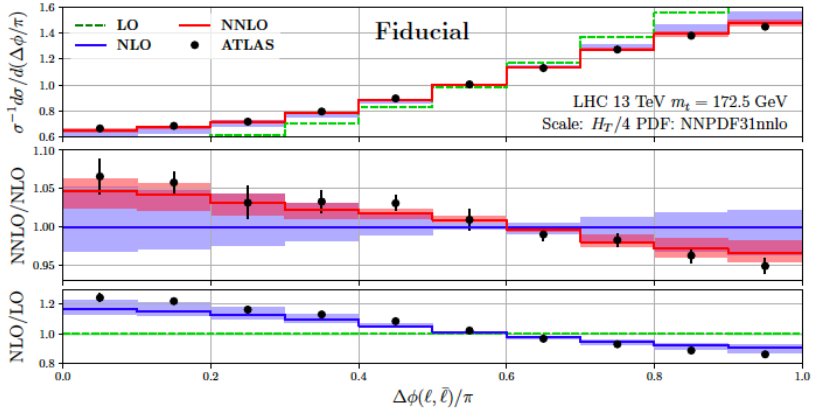
Notice this bin;
Huge effect

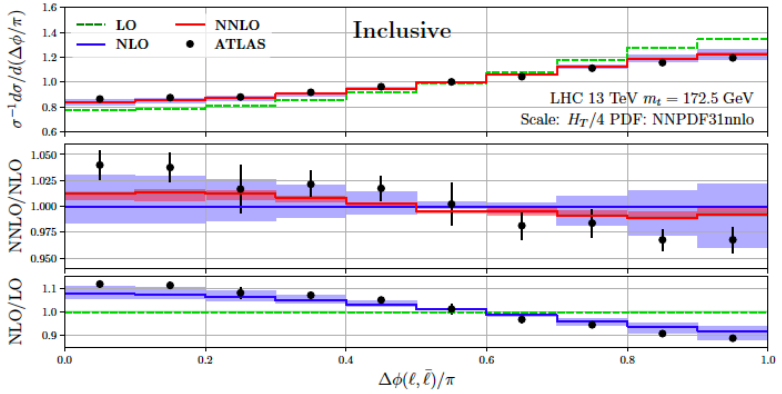


A comment on spin-correlations in Delta(Phi)

✓ NNLO QCD corrections to top pair spin-correlations waere found to agree with ATLAS at fiducial level and disagree at inclusive

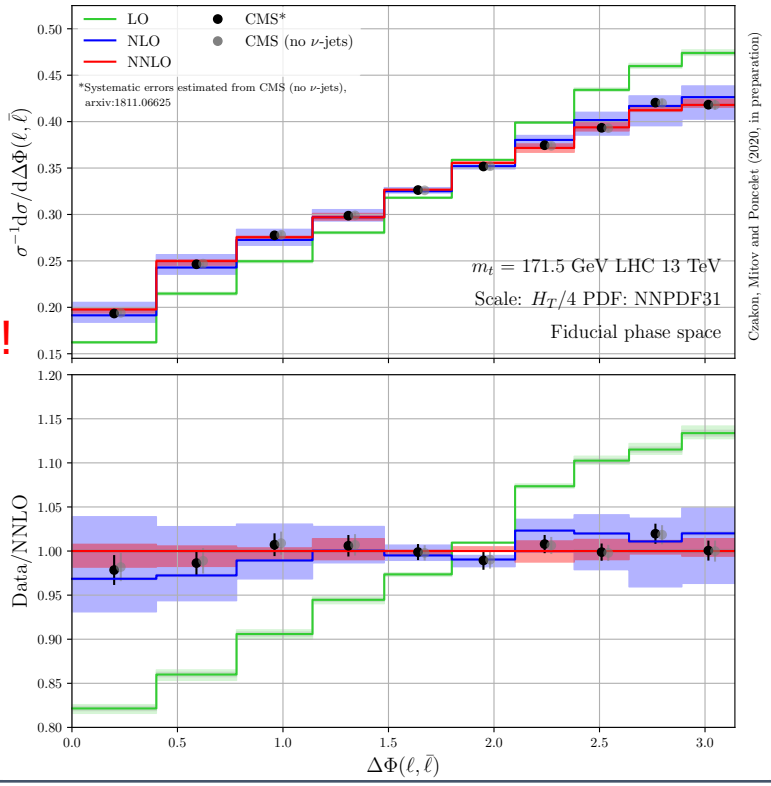
Behring, Czakon, Mitov, Papanastasiou, Poncelet arXiv:1901.05407

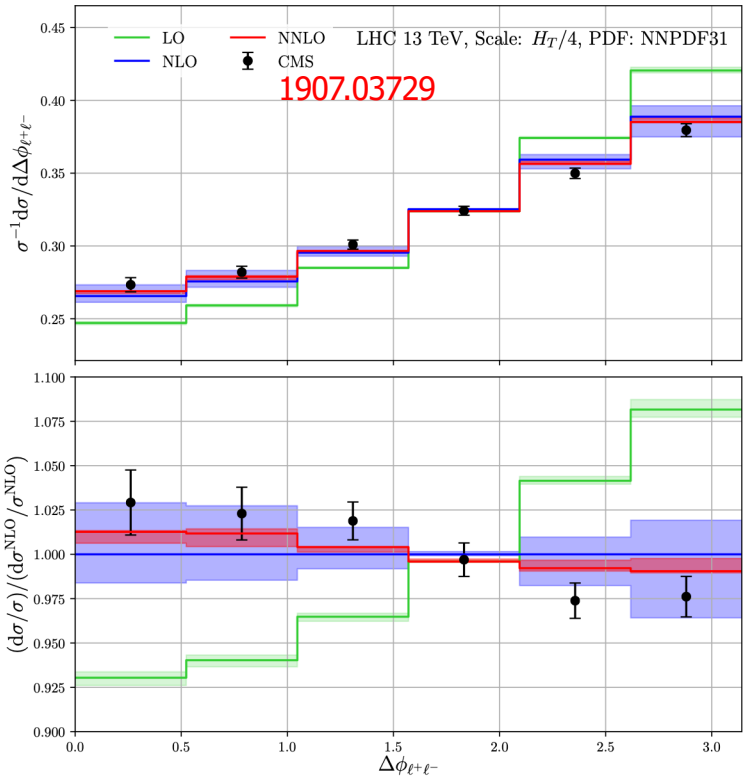




✓ The same feature (agreement in fiducial, not as much in inclusive) persists with CMS!

NEW!





Conclusions

- ✓ First comprehensive check of ttbar differential fiducial distributions with NNLO QCD
- ✓ Once calculations are done with reconstructed tops and b-jets are inclusive of neutrinos from semileptonic decays, an impressive agreement is found across all distributions
- ✓ We have checked (not shown) what happens if m_{top} = 171.5 GeV: improved normalized distributions
- ✓ Overall, description of differential distributions in NNLO QCD is good for inclusive selections (shown in the past for ATLAS) as well as for fully fiducial ones.
- ✓ These predictions, and more, will soon be made public Czakon, Mitov, Poncelet 2020 (to appear)
- ✓ The effects seem to have outsize impact close to ttbar threshold: significant impact on m_{top} determination, among others.
- ✓ The fiducial Delta(phi) NNLO predictions agree well with both ATLAS and now with CMS. Perhaps it is time to move beyond inclusive selection in this observable?
- ✓ Going forward: many of the questions related to differences in b-jets can be circumvented if data is published (also) for jets at parton level?