

Brief remarks on $t\bar{t}$ -spin correlations from the perspective of the NNLO result

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Current status of NNLO results

✓ All is computed:

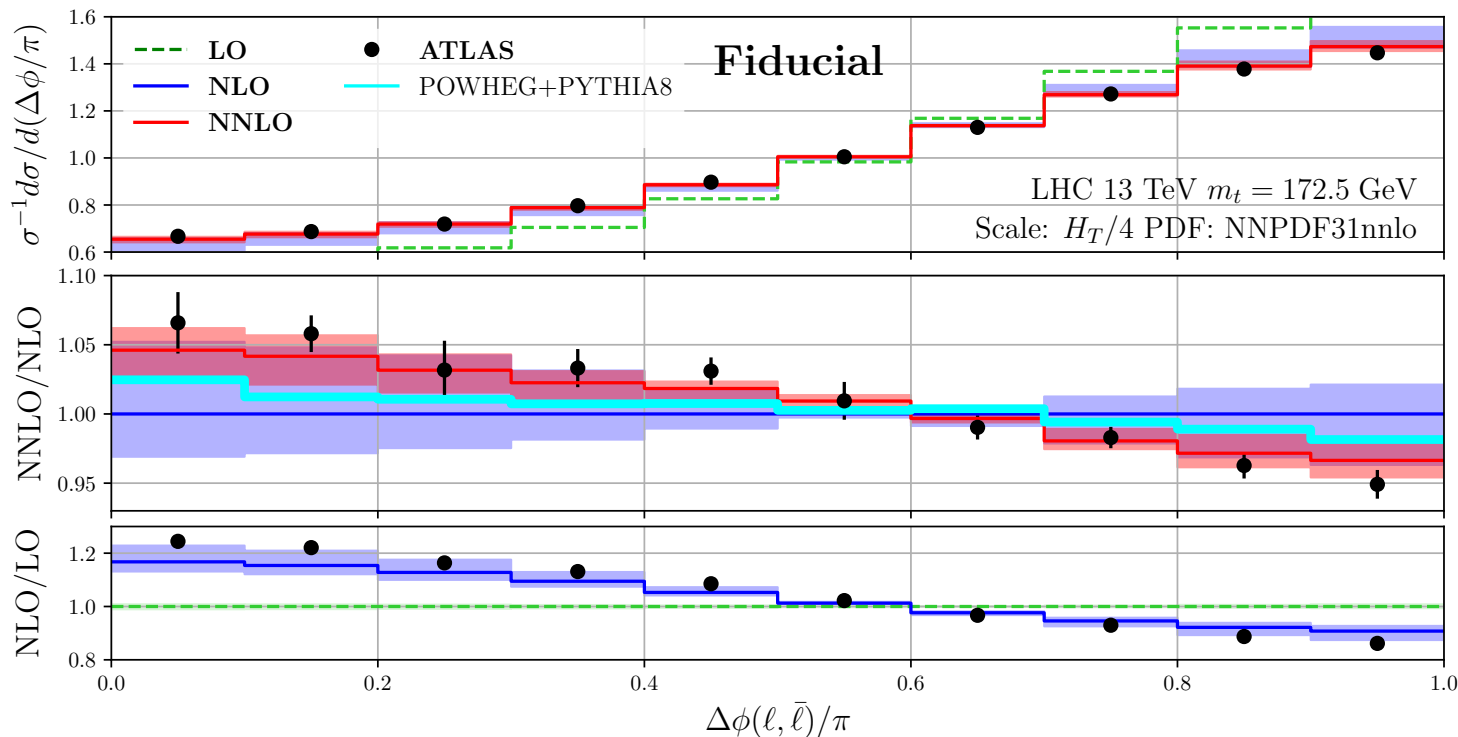
Behring, Czakon, Mitov, Papanastasiou, Poncelet arXiv:1901.05407

- ✓ Several scales
- ✓ In a realistic setup

✓ Nothing is missing at this point; no clearly missing contribution that need to be included.

✓ Our calculation in the fiducial volume makes sense:

- ✓ NLO agrees with POWHEG+PY8
- ✓ POWHEG+PY8 in between our NLO and NNLO.



POWHEG+PY8
prediction taken
from the plots of
the ATLAS paper
arXiv:1903.07570

Current issues in top spin correlations

- ✓ Clearly there is something that needs to be understood in the th/exp comparison when switching between fiducial and inclusive setups
- ✓ Following the ATLAS publication, we identify two “talking points”
 1. Definition of fiducial volume as used in the FO (NNLO) calculation and by ATLAS
ATLAS: [arXiv:1903.07570](#)
 2. Contributions from EW corrections
See talk by Zongguo Si

1. Definition of the fiducial volume

- ✓ Comparison at fiducial level is clearly preferable over the inclusive level
- ✓ Yet there are concerns if the definition of the fiducial level adopted by us in the FO calculation are the same (i.e. compatible) as the ones used in the ATLAS measurement. In other words do we compare apples to apples?
ATLAS: arXiv:1903.07570
- ✓ Our fiducial volume: at least two jets, at least one of which is a b-jet + cuts (just like ATLAS)
- ✓ Two aspects here:
 - B-identification: it is perfect in our case; not so in the measurement.
 - The “contents” of b-jets in our calculation vs. in MC’s
- ✓ The issue if b-jets are the same in both cases is clear: they are not but this is OK! Our calculation works with b-jets (not b-quarks) which are consistently defined with some jet algorithm (specifically anti-kT, $R=0.4$). All cuts are applied on jets.
 - ✓ Our jets include up to two emissions (exactly)
 - ✓ MC’s contain higher order soft/collinear + NP.
 - ✓ The important point is both are correct to the accuracy claimed by each
- ✓ Note: The definition of fiducial volume can be verified/estimated with MC’s

2. Inclusion of EW corrections

- ✓ Our NNLO calculation does not include any EW effects.
- ✓ However, we did a very rough estimate of the effect of EW corrections to the fiducial prediction by comparing to an existing calculation (with a different setup!)
Denner, Pellen arXiv:1607.05571
- ✓ We concluded that the EW and/or off-shell effects are small
- ✓ In the ATLAS publication NLOQCD + EW prediction in the inclusive case is shown. It seems to have large effect nearly agreeing with the inclusive data.
Bernreuther, Heisler, Si arXiv:1508.05271
- ✓ This is a puzzling situation which needs further investigation.
- ✓ To clarify it, we propose:
 - ✓ Ask Denner and Pellen for NLO QCD + EW predictions for a specific setup (presumably the one of ATLAS); if possible by separating off-shell corrections vs NWA; EW effects.
 - ✓ Ask also Bernreuther, Si and collaborators for tuned predictions at both inclusive and fiducial levels.
 - ✓ Comparing between these two groups, as well as with the NNLO and with MC's will hopefully clarify this.

Conclusions

- ✓ No plans from NNLO side for further calculation for the ATLAS measurement at this point.
- ✓ What needs to be clarified are the following issues
 - ✓ Role played by phase space definition in FO calculations and in MC's
 - ✓ Size of off-shell/EW effects in, separately, fiducial and inclusive cases
- ✓ Our future plans include computing differential distributions at particle level (including the spin-density matrix).
- ✓ In case there are any other comments, suggestions or requests please just let us know!