# Matching $t\bar{t}W^{\pm}$ with Parton Showers

## Implementation in the Powheg Box

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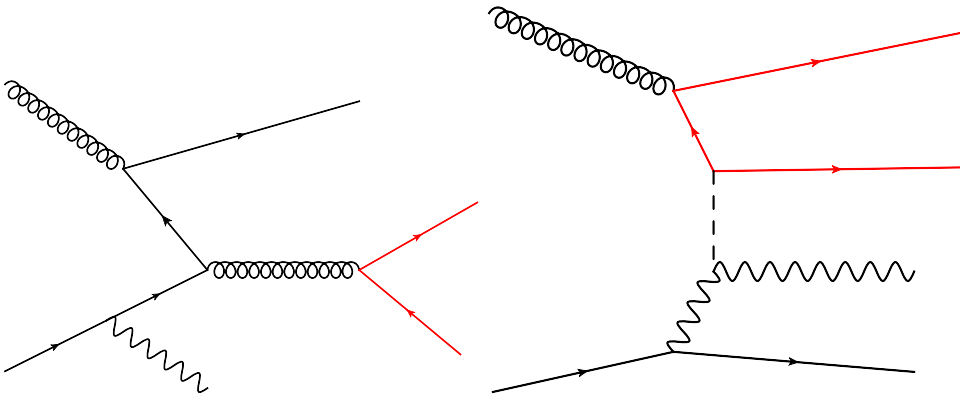
# Motivation

- Recent studies of $t\bar{t}W^{\pm}$ at NLO+PS based on MC@NLO.
  - [Maltoni, Mangano, Tsinikos, Zaro, arXiv:1406.3262] – aMC@NLO
  - [Frederix, Tsinikos, arXiv:2004.09552] – aMC@NLO
  - [Buddenbrock et al. arXiv:2009.00032] – aMC@NLO + FxFx
  - [ATL-PHYS-PUB-2020-024] – aMC@NLO + FxFx and Sherpa
- Implementation of $t\bar{t}W^{\pm}$ in the PowHel Framework.
  - [Garzelli et al. arXiv:1208.2665] (no spin-correlations)

**Goal:**

- Provide implementation of $t\bar{t}W^{\pm}$ in the Powheg Box.
- Provide **dominant** contributions at $\alpha_s^3\alpha$ and $\alpha_s\alpha^3$.
- Keep LO **spin-correlations** for unstable particles.

# Implementation in the POWHEG BOX



## Available processes:

- `pp_ttWp_QCD` – $t\bar{t}W^+$ @ $\alpha_s^3\alpha$
- `pp_ttWm_QCD` – $t\bar{t}W^-$ @ $\alpha_s^3\alpha$
- `pp_ttWp_EW` – $t\bar{t}W^+$ @ $\alpha_s\alpha^3$
- `pp_ttWm_EW` – $t\bar{t}W^-$ @ $\alpha_s\alpha^3$

- Decay modelling keeping LO spin correlations [`Frixione et al. hep-ph/0702198`]

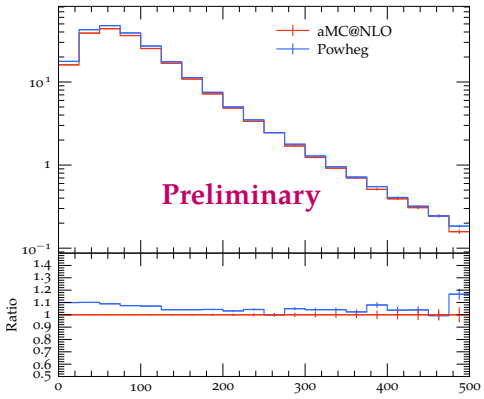
# Setup

- Signature: 2 same-sign leptons + jets
  - $p_T(\ell) > 15$ GeV, $|\eta(\ell)| < 2.5$
  - $p_T(j) > 25$ GeV, $|\eta(j)| < 2.5$ anti-$k_T$ with $R = 0.4$
  - $N_{b-jets} \geq 2$, $N_{jets} \geq 2$
- Comparing to results from aMC@NLO + MadSpin
- Using Pythia 8.303 – (No MPI, No Hadronization)

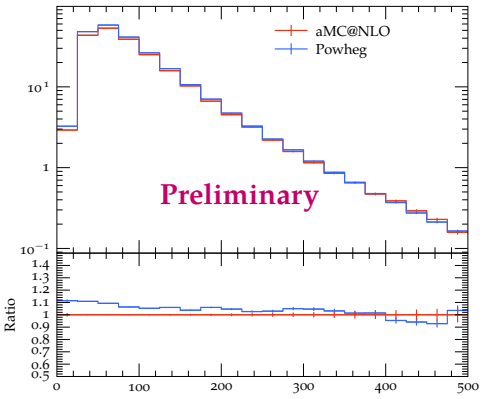
**Preliminary results**

# $pp \to t\bar{t}W^+ \ @ \ \alpha_s^3\alpha$

# pp_ttWp_QCD - Leptonic Observables

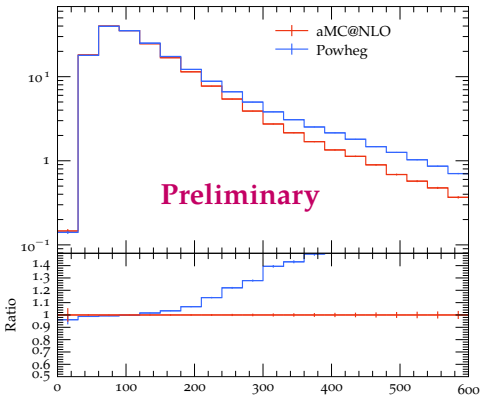



$p_T^{miss}$

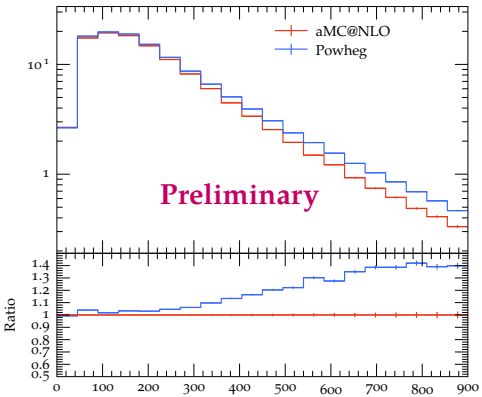



$p_T(\ell_1)$

- Good agreement between aMC@NLO and Powheg Box

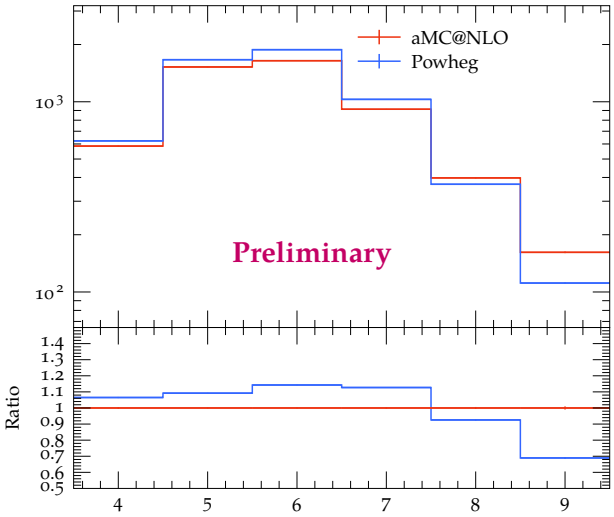



$p_T(j_1)$




$M_{jj}$

- Light jets are considerable harder in the POWHEG BOX
- Currently investigating origin of these large corrections

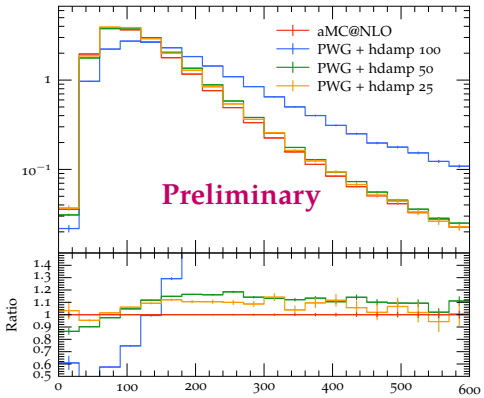



Number of light and b jets

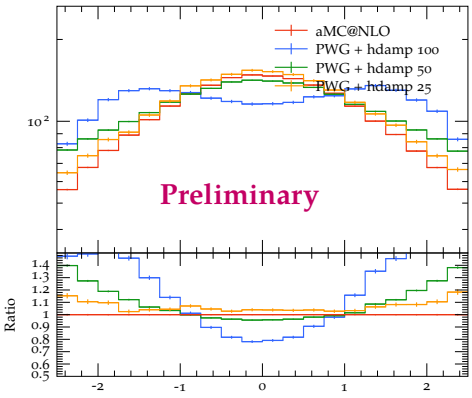
- Remarkely agreement over (±15%) up to 8 jets
- POWHEG BOX spectrum slightly softer

# $pp \to t\bar{t}W^+ \ @ \ \alpha_s\alpha^3$

- Big impact on the fiducial cross sections.




$p_T(b_1)$




$y(j_1)$

- Currently investigating origin of the dependence in detail.

# Summary

# Summary

**POWHEG BOX implementation on the way**

- Implementation of $pp \to t\bar{t}W^{\pm}$ @ $\alpha_s^3\alpha$ and $\alpha_s\alpha^3$ ready
- Investigating differences between the POWHEG BOX and aMC@NLO results
- More detailed study of QCD effects in the modelling of $t\bar{t}W^{\pm}$ signatures
- Will be made public soon.