NLO simulation of $t\bar{t}V$, $V = W^{\pm}, Z$

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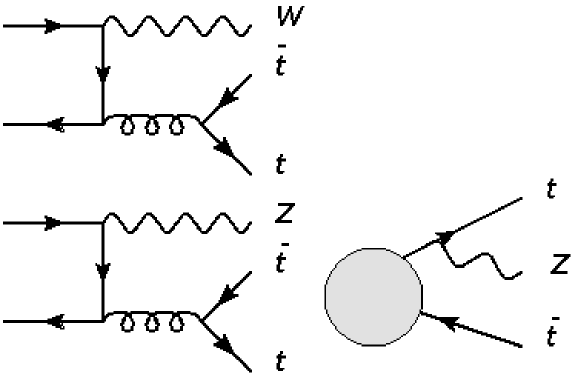
Overview

Backgrounds to multi-lepton decays of $t\bar{t}H$

The relevant irreducible background processes are:

- Irreducible - $t\bar{t}V$ with $V = W^{\pm}, Z, \gamma^*$
- $W^{\pm}Z$ and further V^n
- Further reducible backgrounds

$t\bar{t}V$



- $t\bar{t}W$ is quark initiated at LO
- $t\bar{t}Z$ includes Z radiation of top line

Matching to Parton Shower

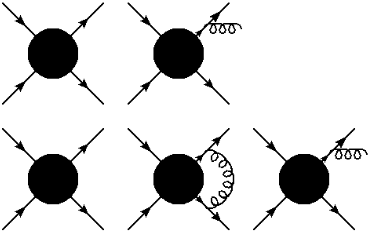
NLO ME

NLO matrix elements make parton shower matching harder as the ME can emit 0 or 1 additional parton.

- Matching algorithms allow the parton shower to be interfaced to the ME without double counting one emission.
- This is achieved by the first emmision being taken from the matrix element.
- Matching algorithms available: MC@NLO and POWHEG.
- MC@NLO was the proposed first, but POWHEG can be considered a generalisation of the MC@NLO method.

LO Merging

- Higher Multiplicity LO Matrix Elements can be merged together.
- This improves the modelling of jets, as the parton shower is a soft, collinear approximation.
- A merging procedure must be implemented in order to avoid double counting.



CKKW

- Introduce an unphysical merging scale, μ_q.
- Require that, above μ_q, emissions are described by the ME, and by the PS below.
- The probability of *n*-jet mulitplicity to be produced is given by $P_n = \frac{\sigma_n(\mu_q)}{\Sigma_N \sigma_i(\mu_q)}$
- Recluster a jet history, including the appropriate Sudakov form factors.
- Begin a parton shower from the external partons.

MEPS@NLO

MEPS@NLO is a full NLO calculation:

- Higher order MEs are calculated to NLO.
- The Sudakov form factor must be altered to subtract the double counted terms.
- On top of the NLO calculation, some LO calculations can be included.

Monte Carlo status of $t\bar{t}V$

- SHERPA+OpenLoops MEPS@NLO - NLO merged samples with up to 1 additional jet calculated at NLO.
- NLO MEs matched to parton shower with S-MC@NLO method.
- MC@NLO method as implemented in SHERPA

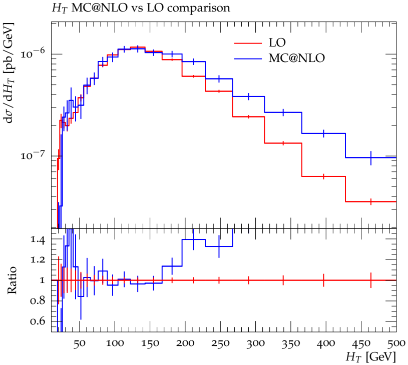
Calculation details

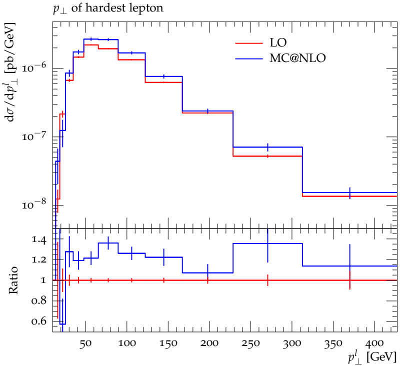
- $t\bar{t}V$ produced on-shell with 0,1 jet at NLO
- 2 jet contribution calculated at LO
- Heavy particle decays included as an afterburner
- LO accurate with spin correlations
- Can, in principle, calculate $t\bar{t}$+leptons

Cuts for the analysis

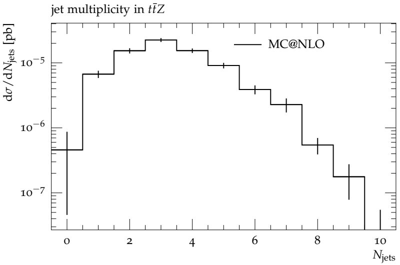
- trilepton analysis
- dR=0.4 jets
- 20GeV p_T jet cut
- 10GeV lepton p_T cut
- $E_{T\ \mathrm{miss}} > 50$GeV

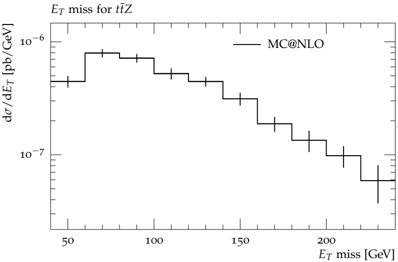
$t\bar{t}W^{\pm}$ MC@NLO vs LO





$t\bar{t}Z$ MC@NLO

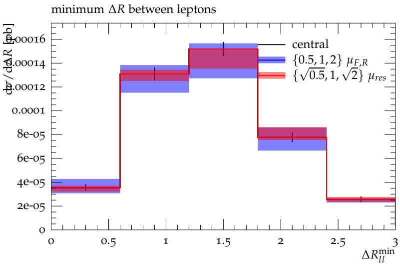


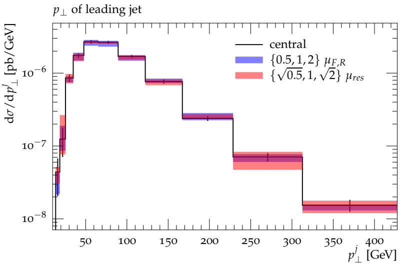


Scale Uncertainties

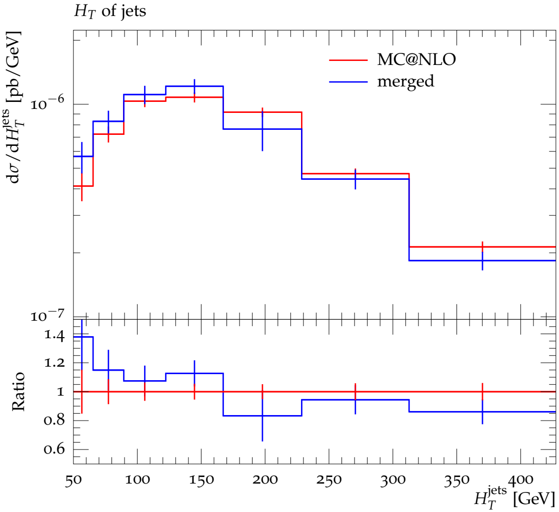
- Factorisation, renormalisation scale uncertainties - fixed order scales
- $\mu_{F,R}$ varied by a factor of 2
- Parton shower starting scale from matching
- μ_{res} varied by a factor $\sqrt{2}$
- Merging scale runs over reasonable values

$t\bar{t}W^{\pm}$ MC@NLO scale uncertainties

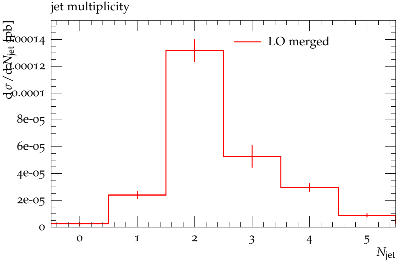


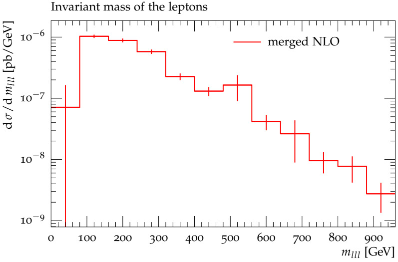


$t\bar{t}W^{\pm}$ MC@NLO vs MEPS@NLO



$t\bar{t}W$ merged





Conclusions to $t\bar{t}V$

- $t\bar{t}V$ gives an irreducible background to ttH.
- Currentle in SHERPA+OL can include multiple jets, up to one at NLO
- Can include V width effects in ME or with LO afterburner.
- Process has large scale uncertainties