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# Standard setup for the calculation of tTV (V=Z,W+,W-) at NLO QCD

## General framework

We propose to present a comparison among existing NLO QCD tools. EW corrections will be discussed in a separate section, where the impact of heavy-boson radiation (tTVV) will also be briefly discussed.

We propose to compare results from:

- MG5\_aMC@NLO 2.3.2
- Powhel
- Sherpa2.2.0+Openloops1.2.3

We propose to limit the comparison to the fixed order NLO QCD calculations and postpone a full NLO QCD+PS study to the future activity of this working group.

We also suggest to postpone presenting results for tT+photon to future studies that would also include multiple photon emission, radiative top decays, and a study of QED showers.

## Setup

All input parameters should be chosen in compliance with the official Higgs HXSWG note <https://cds.cern.ch/record/2047636/files/LHCHXSWG-INT-2015-006.pdf> unless otherwise necessary. Small deviations from the recommendation are possible if they are not likely to substantially affect the results. In particular we recommend:

### Specific input parameters and PDFs

- consider  $\sqrt{s}=13$  TeV;
- use  $M_H=125$  GeV and  $m_t=172.5$  GeV (see recommendation);
- electroweak parameters should be computed in the Gmu scheme, i.e. using Gmu and the on-shell W and Z masses as input parameters
- use NLO PDF4LHC15;
- 5F scheme.

### QCD scales and variations

- calculate total cross sections using both fixed (with central value  $\mu_0=m_t+MV/2$ ) and dynamical (with central value  $\mu_0=HT/2$ ) renormalization/factorization scale, where  $HT=\text{sum of } t,T,V \text{ transverse energies (ignoring extra jet emissions)}$
- calculate distributions using dynamical renormalization/factorization scale  $\mu_0=HT/2$ .
- estimate the scale uncertainty with the usual independent factor-2 variations of  $(\mu_R,\mu_F)$  excluding antipodal variations.

## Analysis

We propose to keep the final-state particles (tTV) stable (no decays) and to consider the following observables:

- total cross section
- pT of t,T,V (20 bins from 0,500 GeV)
- eta of t,T,V (20 bins from -4,4)

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- pT of tTV and tT system (20 bins from 0,500 GeV)
- pT of 1st light jet (non-b jets) with R=0.4 anti-kT algorithm and eta<2.5 (20 bins from 25,525 GeV)
- geometric average of t,T,V transverse energies (20 bins from 0,1000 GeV)
- HT=sum of t,T,V transverse energies (ignoring extra jet emissions) (20 bins from 400,1000 GeV)

The analysis is the same we proposed for tTH without decays (see wiki), and with no PS, and the same Rivet routine can be used.

### Rivet analyses

The Rivet routine that implements the above analysis (as well as example plots) can be found at this URL [↗](#)

- hxsWG\_ttV\_stable = generic analysis for tTV+X final states with V=Z,W+,W- (stable top quarks and bosons)

### ttV recommended cross sections at 13 TeV using fixed scale (mt+mV/2)

Process	XS [fb]	scale	pdf	alpha_S
ttZ	839.3	+ 9.6% -11.3%	±2.8%	±2.8%
ttW+	397.6	+12.7% -11.4%	±2.0%	±2.6%
ttW-	203.2	+13.3% -11.7%	±2.1%	±2.9%
ttW- + ttW+	600.8	+12.9% -11.5%	±2.0%	±2.7%

Correlation effects are consistently included in the uncertainties of the combined ttW- + ttW+ cross section.

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