Inclusive and differential cross-sections measurements in the single top tW eμ channel with CMS

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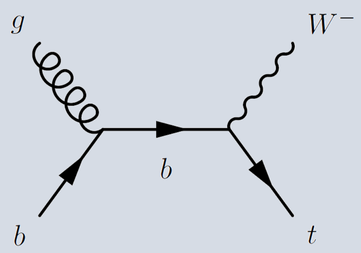
Reference: CMS-PAS-TOP-21-010

Motivation

- The tW process includes the most massive elementary particle of the SM, the top quark → $m_t = 172.5$ GeV (PTEP 2020 (2020) 8).
- It has the second biggest cross section of single top production at the LHC.

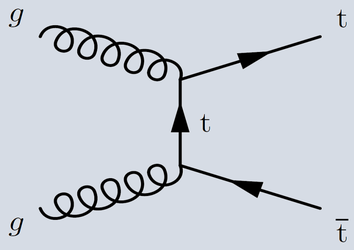
Challenge: background dominates signal!

Signal → tW



Electroweak production

Main background → $t\bar{t}$



Strong production

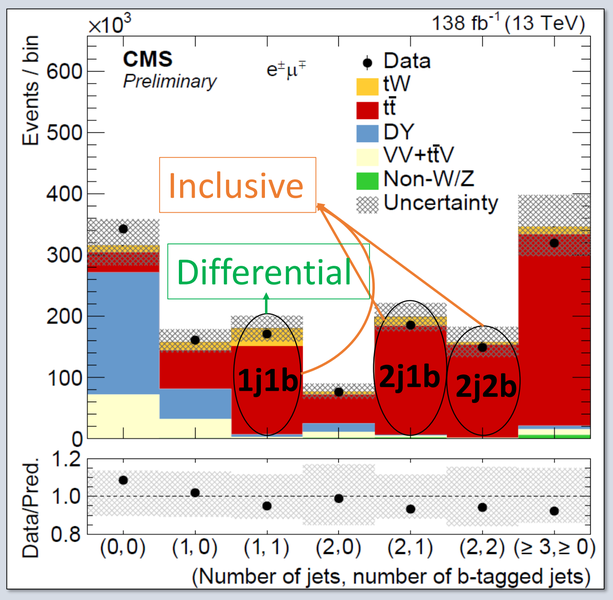
- Interference between $t\bar{t}$ and tW at NLO in QCD.
- Two schemes are defined to avoid double counting:
  - **DR**: all doubly resonant diagrams are removed from the ME calculation.
  - **DS**: a gauge invariant term is introduced in the ME calculation that locally cancels the doubly resonant diagrams.

Measurement performed using the full dataset recorded with the CMS detector during Run 2 at $\sqrt{s}$ = 13 TeV in pp collisions

Baseline event selection

- The two first leading leptons must be an electron and a muon of opposite charge.
- Leading lepton $p_T > 25$ GeV.
- The invariant mass of the dilepton pair must be greater than 20 GeV.

Different regions for the inclusive and differential measurements are defined based on the number of **jets** and **b-tagged jets**.



Inclusive cross section measurement

Methodology

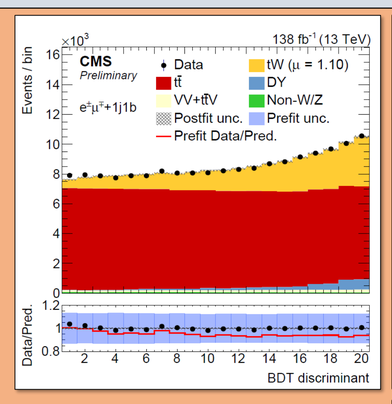
- BDT used to disciminate tW from $t\bar{t}$.
- The **2j2b** region is used as a $t\bar{t}$ control region.
- To extract the signal, a ML-fit is performed using the two BDT output and the subleading jet p_T in the 2j2b region.

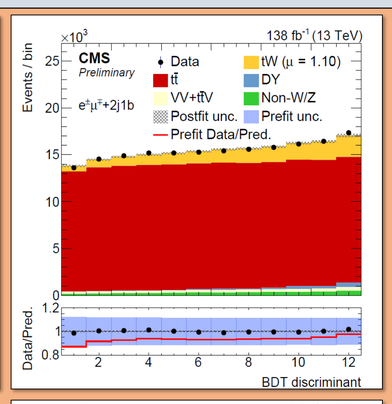
Results

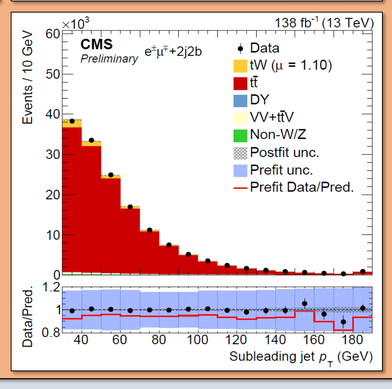
- The measured cross section is:

$\sigma_{tW} = 79.2 \pm 0.8\,(\text{stat}) \pm^{7.0}_{7.2}\,(\text{syst}) \pm 1.1\,(\text{lumi})$ pb

  - Measurement dominated by **systematic** uncertainties being the jet energy corrections, the matrix element μ_R and μ_F scales, and the modelling of the final state radiation for tW and $t\bar{t}$, the most important ones.







$\text{aNNLO(QCD)}: \quad \sigma^{\text{SM}}_{\text{tW}} = 71.7 \pm 1.8\,(scale) \pm 3.4\,(\text{PDF})$ pb (PoS DIS2015 (2015) 170)

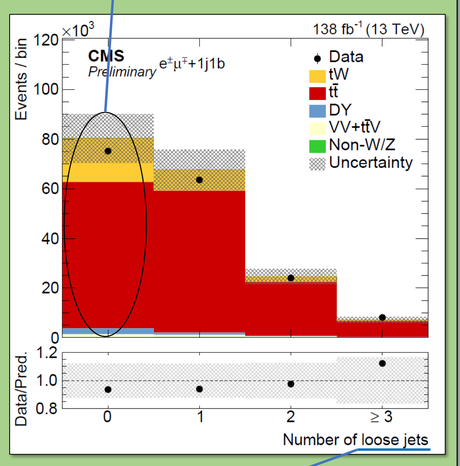
$\text{aN}^3\text{LO(QCD)}: \quad \sigma^{\text{SM}}_{\text{tW}} = 79.5 \pm^{1.9}_{1.8}\,(scale) \pm^{2.0}_{1.4}\,(\text{PDF})$ pb (JHEP 2021, 278 (2021))

Differential cross section measurements

Methodology

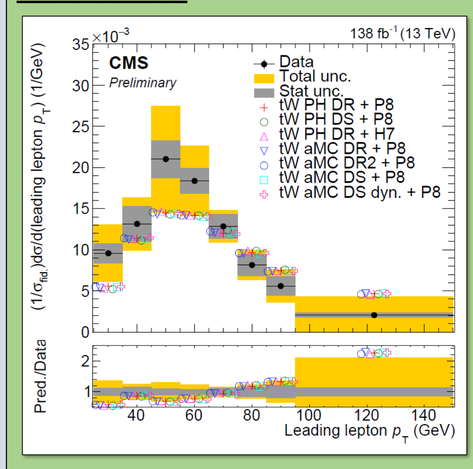
- The **1j1b** region with a veto on the number of loose jets is chosen as the signal region.
- The differential cross sections are measured as a function of the leading lepton p_T, jet p_T, $\Delta\varphi(e^{\pm},\mu^{\mp})$, $p_z(e^{\pm},\mu^{\mp},j)$, $m(e^{\pm},\mu^{\mp},j)$ and $m_T(e^{\pm},\mu^{\mp},j,p_T^{\text{miss}})$.
- Signal extraction and unfolding to a fiducial region in particle level (defined to mimic the signal region) are done at the same time in a maximum likelihood fit.
- The results are normalised to the fiducial cross section.

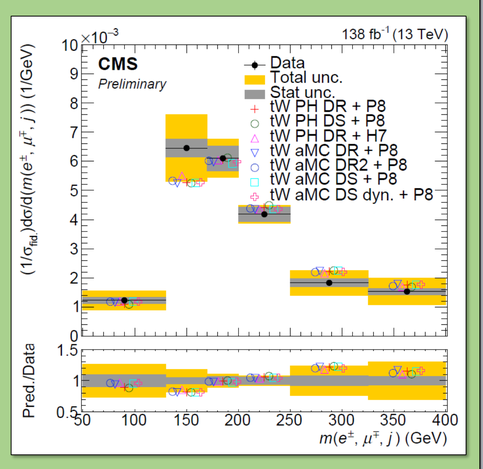
Signal Region



Jets with $p_T \in [20,30]$GeV

Results





- Overall agreement between data and expectations within uncertainties.
- Compatible results between the DR and DS schemes.