Diboson and top quark pair production cross section measurements at 5.02 TeV in CMS

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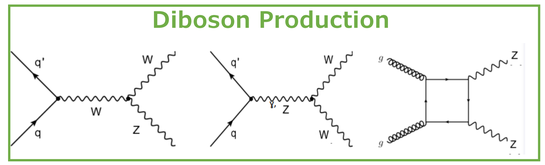
Introduction

Aim to explore a **new energy regime ($\sqrt{s}$ = 5 TeV)** for the **WW, WZ and ZZ** production (Diboson) as well as for **the top pair production** ($t\bar{t}$).

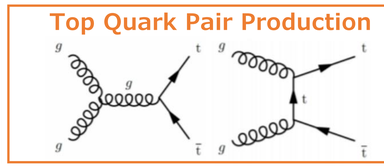
Dataset contains pp collisions collected during 2017 by CMS, at a relatively **low pile-up conditions** (only ~2 pp interactions per bunch crossing). The total amount of data corresponds to an **integrated luminosity of 304 pb^{-1}**.

Motivation: these processes are used to **test the SM** and are **irreducible backgrounds in searches BSM**

Diboson Production



Top Quark Pair Production



Diboson Production

Selection:

- Final states with multiple leptons used, **precise lepton identification** is achieved by using an MVA (**Lepton MVA**) to discriminate leptons coming from W and Z bosons with respect non-prompt leptons.
- **Five signal regions** defined to distinguish WW, WZ and ZZ production:

WZ (3l)
$p_T(l)$ > 8 GeV & OSSF ≥ 1
Leptons reconstructed as coming from W or Z:
- $|m(l_z, l'_z) - M_z| < 30$ GeV
- $p_T(l_W)$ > 20 GeV
- $m(3l)$ > 100 GeV

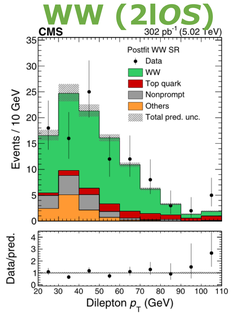
WZ($2\mu SS$)
1st(2nd) $p_T(\mu)$ > 20 (10) GeV
High quality of charge
0 Jets
MET > 25 GeV

ZZ (4l)
$p_T(l)$ > 8 GeV
✚
$|m(l,l') - M_z| < 10\ GeV$
0 Jets
MET projection on the $p_T(Z \to ll)$ axis >50 GeV

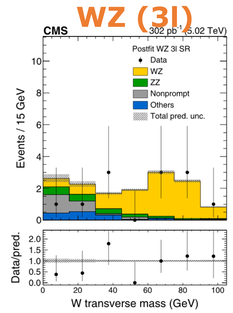
ZZ($2l2\nu$)
1 OSSF
1st(2nd) $p_T(l)$ > 20 (10) GeV

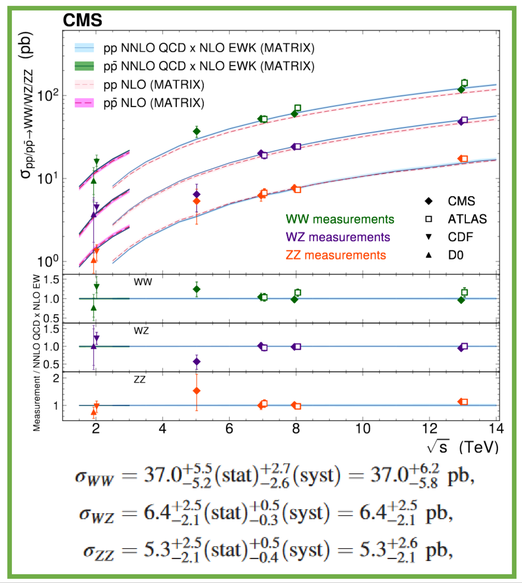
WW ($2lOS$)
1st(2nd) $p_T(l)$ > 20 (10) GeV
$\Delta\Phi(l,l) < 2.8$
MET > 20 GeV
0 Jets

WW ($2lOS$)



WZ (3l)





$$\sigma_{WW} = 37.0^{+5.5}_{-5.2}(\text{stat})^{+2.7}_{-2.6}(\text{syst}) = 37.0^{+6.2}_{-5.8}\ \text{pb},$$
$$\sigma_{WZ} = 6.4^{+2.5}_{-2.1}(\text{stat})^{+0.5}_{-0.3}(\text{syst}) = 6.4^{+2.5}_{-2.1}\ \text{pb},$$
$$\sigma_{ZZ} = 5.3^{+2.5}_{-2.1}(\text{stat})^{+0.5}_{-0.4}(\text{syst}) = 5.3^{+2.6}_{-2.1}\ \text{pb},$$

Backgrounds:

- Dominant background differs in each category.
- Backgrounds involving **non-prompt** leptons are estimated with a **data-driven approach.**
- Other backgrounds estimated with MC.

Results:

The number of events in the SR is measured in a counting experiment in regions with high signal purity. Total cross section:

$$\sigma = \frac{N^{\text{SR}}_{\text{signal}}}{\mathcal{BR}(\text{V} \to XX)\mathcal{BR}(\text{V} \to XX)\epsilon\mathcal{L}'}$$

- **Good agreement with predictions at NNLO QCD x NLO EWK**
- Overall uncertainty **dominated by statistical** component.
- Reducing the gap between Tevatron and LHC measurements.

Top Quark Pair Production

Selection:

- Final states with opposite electric charge $e\mu$ and at least two jets.
- Lepton MVA used to select prompt leptons (from W/Z decay).
- Leading lepton p_T>20 GeV.
- Dilepton invariant mass greater than 20 GeV.

Backgrounds:

- **tW and VV:** estimated with MC.
- **DY:** estimated from data using $R_{out/in}$ method.
- **Non-prompt:** supressed by lepton selection, residual contribution estimated with $t\bar{t}$ and W+Jets MC.

Results:

- tt production cross section is obtained by a **counting experiment:**

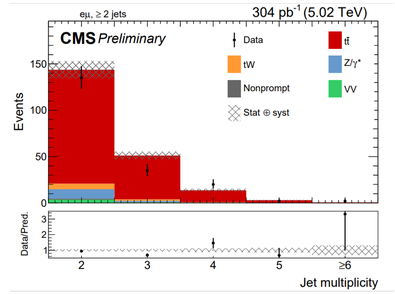
$$\sigma_{t\bar{t}} = \frac{N - N_{\text{bkg}}}{\varepsilon\mathcal{ABRL}}$$

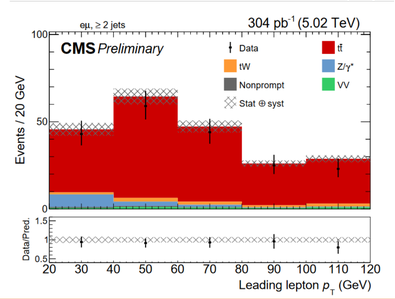
$$\boldsymbol{\sigma_{t\bar{t}} = 60.3 \pm 5.0\ (stat) \pm 2.8\ (syst) \pm 0.9 (lumi)\ \text{pb}}$$

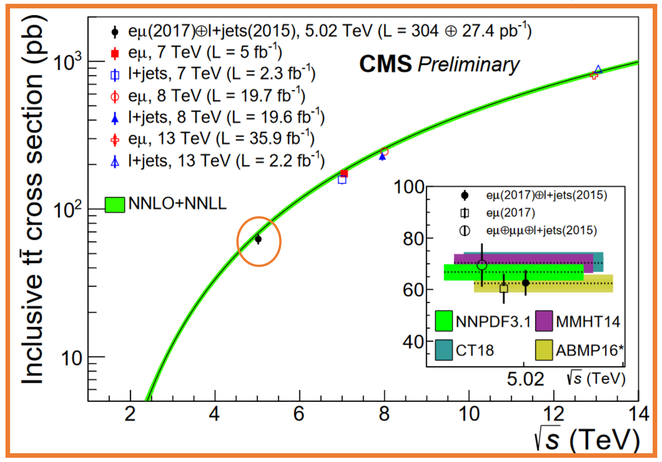
- To reduce the statistical limitation of the presented measurement, the result is **combined with that obtained in the l+jets decay channel*:**

$$\boldsymbol{\sigma_{t\bar{t}} = 62.6 \pm 4.1\ (stat) \pm 3.0\ (syst + lumi)\ \text{pb}}$$

- Overall uncertainty is still **dominated by statistical uncertainty**
- Measured cross section in **good agreement** with the NNLO in QCD including soft-gluon resummation at NNLL predictions







*JHEP 03 (2018) 115

- The CMS Collaboration. Measurements of the electroweak diboson production cross sections in proton-proton collisions at √s = 5.02 TeV using leptonic decays. Physical Review Letters 127, 191801 (2021)
- The CMS Collaboration. Measurement of the inclusive tt production cross section in pp collisions at √s = 5.02 TeV. CMS-PAS-TOP-20-004, CERN, 2021