Top Quark Pair Production Cross-section at LHC with ATLAS

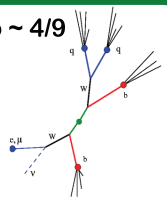
Alexander Doxiadis (adox@nikhef.nl)

Reconstructing top quark pairs is a big challenge for the **reconstruction** due to their complex final state. It involves jets, leptons and E_T^{miss}. Presented here are **commissioning analyses** for **√s=10TeV** that do not make use of b-tagging.

Single lepton

Branching ratio ~ 4/9

- 4 jets (2 b-jets)
- 1 lepton (e,μ)
- E_T^{miss} (1 neutrino)



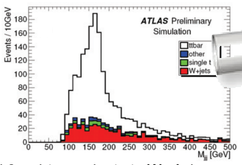
Cut & Count method

The hadronic topmass is reconstructed using the 3 jet invariant mass of the selected jets with the highest vector sum p_T. The cross section is then the number of **observed** events after selection minus the expected **background** events divided by the **selection efficiency** and the **luminosity**.

$$\sigma = \frac{N_{Sig}}{\mathcal{L}\times\varepsilon} = \frac{N_{Obs}-N_{Bkg}}{\mathcal{L}\times\varepsilon}$$

Selection Cuts:

- single high-p_T lepton trigger
- exactly 1 isolated lepton(e,μ), p_T > 20 GeV
- E_T^{miss} > 20 GeV
- 4 jets p_T > 20 GeV
- 3 jets p_T > 40 GeV
- $|M_W - M_{jj}|$ < 10 GeV

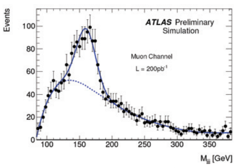


The main background for this analysis is **W+Jets**, which can be determined from data with **Z+Jets** events using the fact that the **W** to **Z ratio** is predicted with small uncertainties. After selection **S/B ~ 2**. Largest expected systematic uncertainty in the cross section estimate, ~10%, comes from the uncertainty in the Jet Energy Scale (JES).

Likelihood fit

The Likelihood method uses the same events as selected by the **Cut & Count** method. The M_{jjj} distribution is modeled by a **Gaussian** (correctly reconstructed signal) on top of a **Chebychev polynomial** (background & incorrect combination of jets). The cross section is then the number of events in the **peak** divided by the **efficiency** and the **luminosity**.

$$\sigma = \frac{N_{Peak}}{\mathcal{L}\times\varepsilon}$$



Largest expected systematic, ~13%, comes from the uncertainty in the amount of Initial and Final State Radiation (ISR & FSR).

Analysis: 200pb⁻¹

Expected Results (muon-channel)*

o Cut&Count:

$\Delta\sigma/\sigma$ = 3(stat) $^{+12}_{-15}$(syst) ± 22(lumi) %

o Likelihood:

$\Delta\sigma/\sigma$ = 15(stat) $^{+6}_{-15}$(syst) ± 20(lumi) %

o Variant Cut&Count:

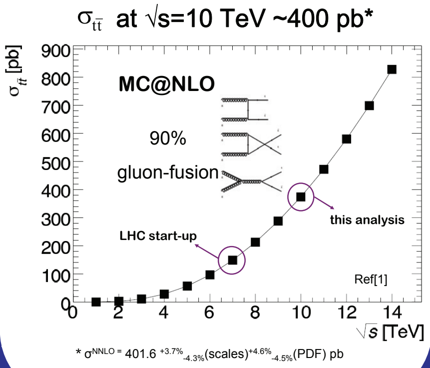
$\Delta\sigma/\sigma$ = 3(stat) $^{+20}_{-20}$(syst) ± 23(lumi) %

o Variant Template:

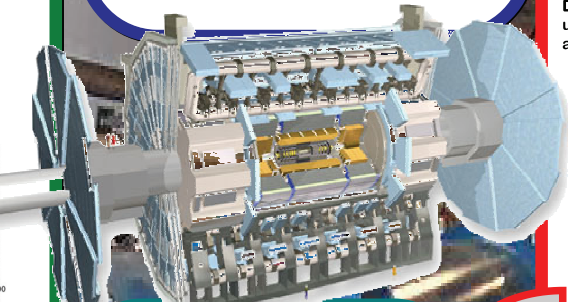
$\Delta\sigma/\sigma$ = 6(stat) $^{+9}_{-15}$(syst) ± 20(lumi) %

*the electron results are similar

Top Pair Production



* σ^{NNLO} = 401.6 $^{+3.7\%}_{-4.3\%}$(scales) $^{+4.6\%}_{-4.5\%}$(PDF) pb



Variant Analysis

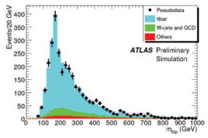
The variant analysis does not use the E_T^{miss} variable to select events, since it might not be fully understood at start-up. A Cut & Count method can be applied to extract the cross section. Alternatively the method uses 3 **templates** to fit the **data** in M_{jjj}.

$$D_{data} = A\times\mathcal{D}_{t\bar{t}} + B\times\mathcal{D}_{W,QCD} + C\times\mathcal{D}_{other}$$

where D_{W+QCD} is the weighted sum of W+Jets and QCD and D_{other} includes single top and Z+Jets.

Selection Cuts:

- 1 isolated central lepton (e,μ)
- p_T(e) > 40 GeV, p_T(μ) > 30 GeV
- HT2 > 160 GeV (scalar sum of p_T lepton, 2nd, 3rd and 4th jet)
- 4 jets p_T > 20 GeV
- 3 jets p_T > 40 GeV



The biggest systematic uncertainty, ~12%, comes from the JES.

Conclusion

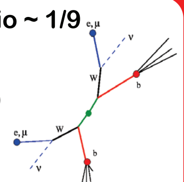
It has been shown that with a luminosity of **200 pb⁻¹** it is possible to measure the top quark pair production cross section with complementary analyses without making use of optimal performance of the detector, both in the single lepton and dilepton channel.

Understanding top quark production is a stepping stone towards understanding the **ATLAS detector**, the **standard model** and finally **new physics**.

Dilepton

Branching ratio ~ 1/9

- 2 b-jets
- 2 leptons (ee, eμ, μμ)
- E_T^{miss} (2 neutrinos)

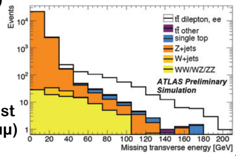


Cuts

The main backgrounds to the dilepton channel are events with **real** leptons and **fake** E_T^{miss} and events with **fake** leptons. The selection cuts remove most of the **Drell Yan**, any remaining contribution will be estimated using **data-driven methods**. Fake leptons from jets will also be estimated using **data-driven techniques**.

Selection Cuts:

- single high-p_T lepton trigger (OR of muon and electron trigger in eμ-channel)
- 2 oppositely charged isolated leptons (e,μ) p_T > 20 GeV
- $|M_Z - M_{l+l-}|$ > 5 GeV (ee, μμ)
- E_T^{miss} > 35 GeV (ee, μμ)
  E_T^{miss} > 20 GeV (eμ)
- 2 jets p_T > 20 GeV

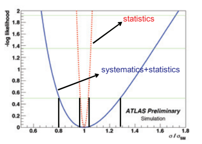


After selection **S/B ~ 4 – 6** and the largest background is **Z+Jets** (μμ) and **fake leptons** from jets (ee,eμ).

Cross section estimate

The method is a simple **Cut & Count**, where the resulting cross section will be extracted using a maximum likelihood estimate of the familiar formula:

$$\hat{\Delta}_{sig} = \frac{N^{obs} - \sum_{k\in\{bkg\}} N_k^{exp}}{\mathcal{L}\sum_j \Delta_{j,sig}}$$



All the uncertainties are combined through a likelihood function for each channel. They were fit and the final sensitivity was obtained from a **profile likelihood ratio**.

For ee,eμ-channel the largest expected systematic uncertainty, ~6-10% ,is coming from the uncertainty in the fake rate.

In the μμ-channel it's the muon efficiency and the uncertainty in the signal generator that give rise to the largest systematic uncertainty: ~ 5% each.

Expected Results

o ee-channel:

$\Delta\sigma/\sigma$ = 8(stat) $^{+14}_{-13}$(syst) $^{+26}_{-17}$(lumi) %

o μμ-channel :

$\Delta\sigma/\sigma$ = 6(stat) $^{+10}_{-9}$(syst) $^{+26}_{-17}$(lumi) %

o eμ-channel:

$\Delta\sigma/\sigma$ = 4(stat) $^{+10}_{-9}$(syst) $^{+26}_{-17}$(lumi) %

o **combined:**

$\Delta\sigma/\sigma$ = 3(stat) $^{+10}_{-9}$(syst) $^{+26}_{-17}$(lumi) %

[1] S.Frixione and B.R.Webber, JHEP, 06:029, 2002