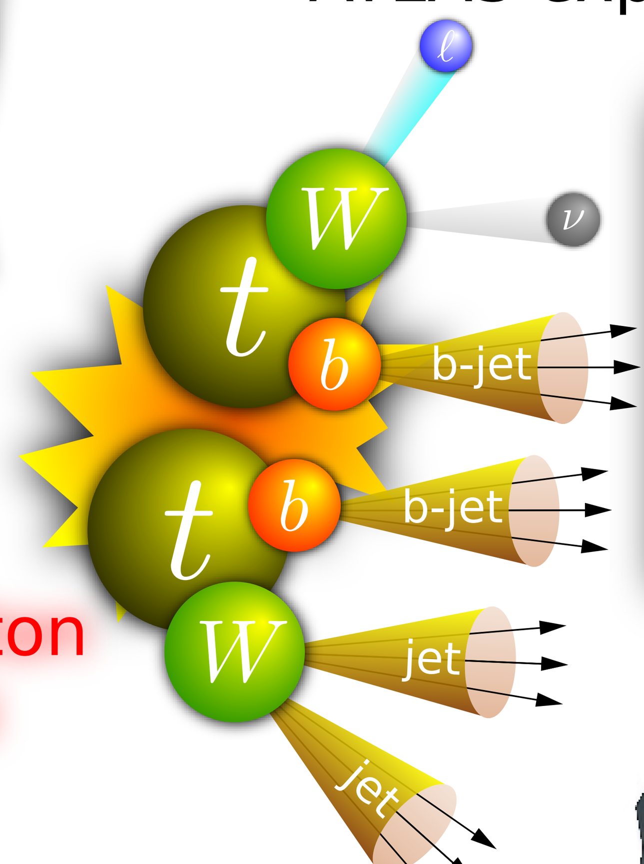
$t\bar{t}$ production cross section measurement at ATLAS

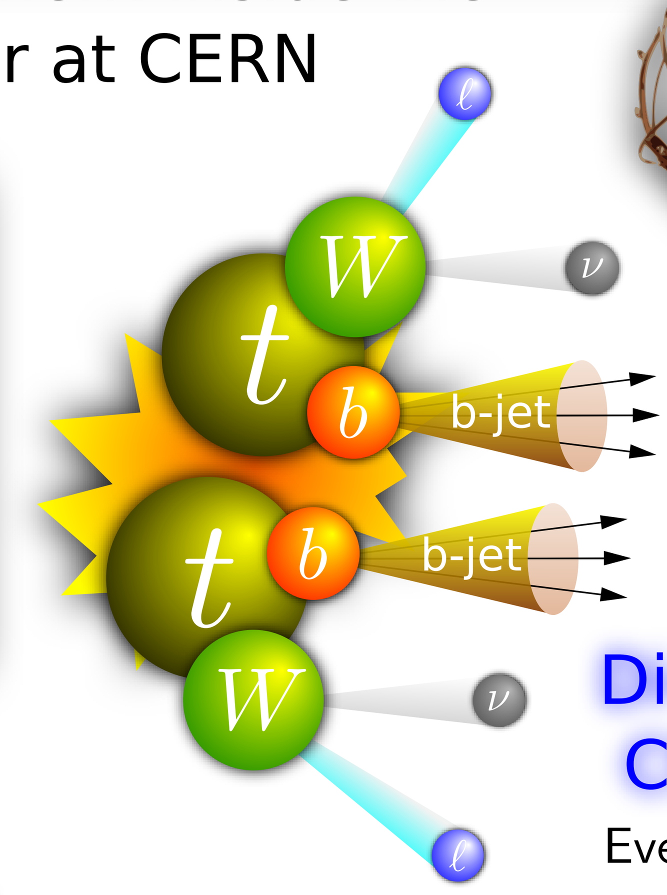
Analysis strategy for top-antitop cross section measurement inside the ATLAS experiment at the LHC proton-proton collider at CERN

(all numbers and plots are for 200 pb^{-1} at 10 TeV)

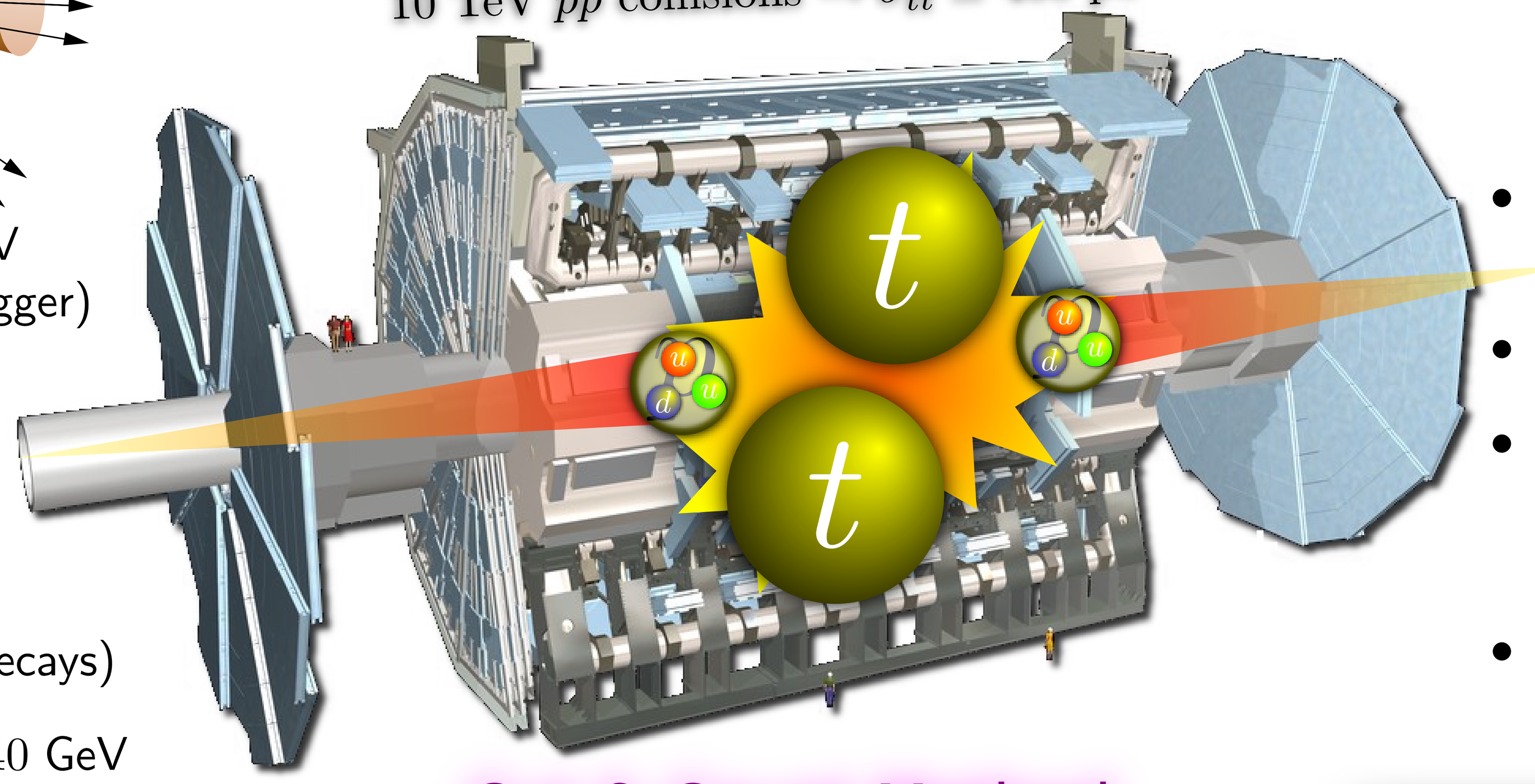


Measuring the $t\bar{t}$ production cross section is important:

- direct comparison with theoretical calculations
- $t\bar{t}$ events are background for new physics and Higgs
- understanding the experimental signatures of top events involves most parts of the ATLAS detector and is essential for claiming discoveries



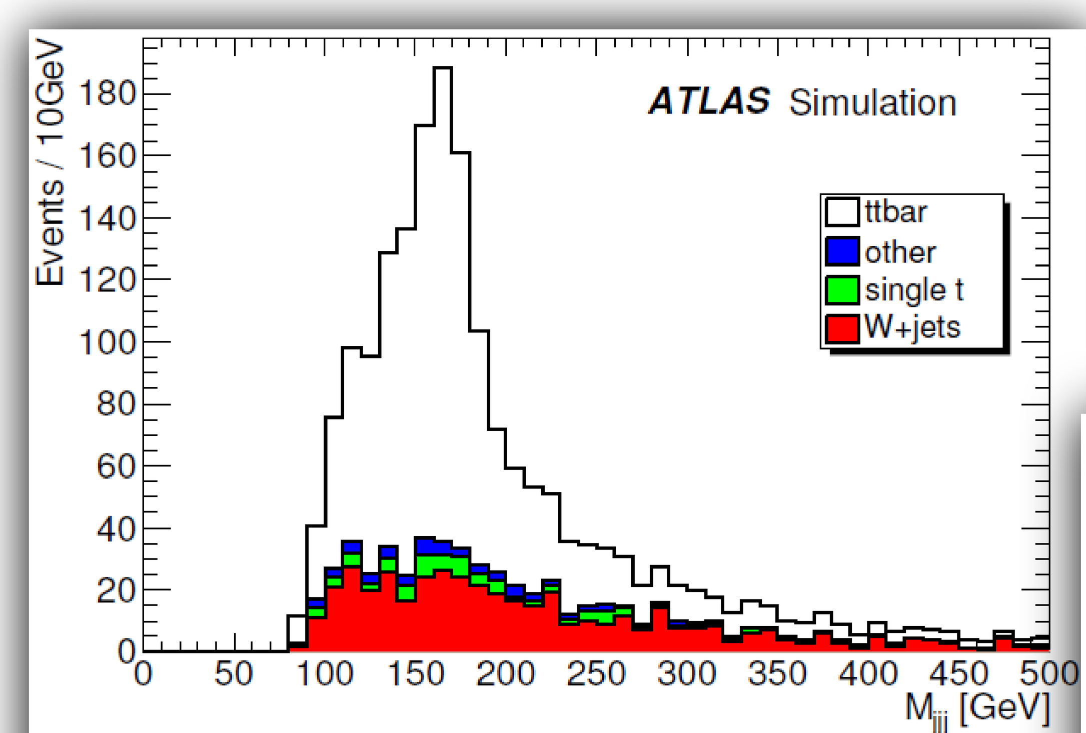
10 TeV pp collisions $\rightarrow \sigma_{t\bar{t}} \simeq 400$ pb^{-1}



Single Lepton Channel

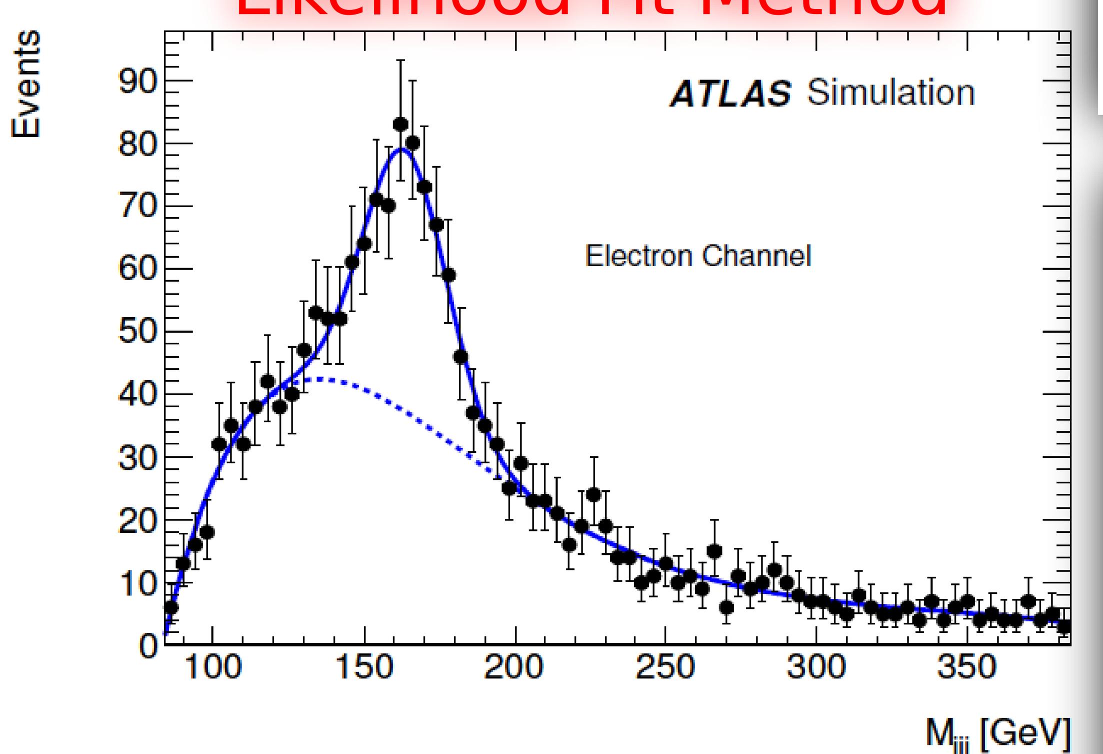
Event selection:

- 1 lepton (e or μ) with $p_T > 20$ GeV (which gives the isolated lepton trigger)
- $\not{E}_T > 20$ GeV (associated to ν coming from the leptonic W)
- at least 4 jets with $p_T > 20$ GeV (2 coming from the hadronic W and 2 b-jets coming from t and $\bar{t}$ decays)
- of which at least 3 jets with $p_T > 40$ GeV
- at least one 2-jets combination with invariant mass in a 10 GeV m_W window



Expected distribution for the invariant mass of the 3-jet combination with the highest p_T - defining the "top candidate" - in $t\bar{t} \rightarrow e$+jets events and the main backgrounds

Likelihood Fit Method

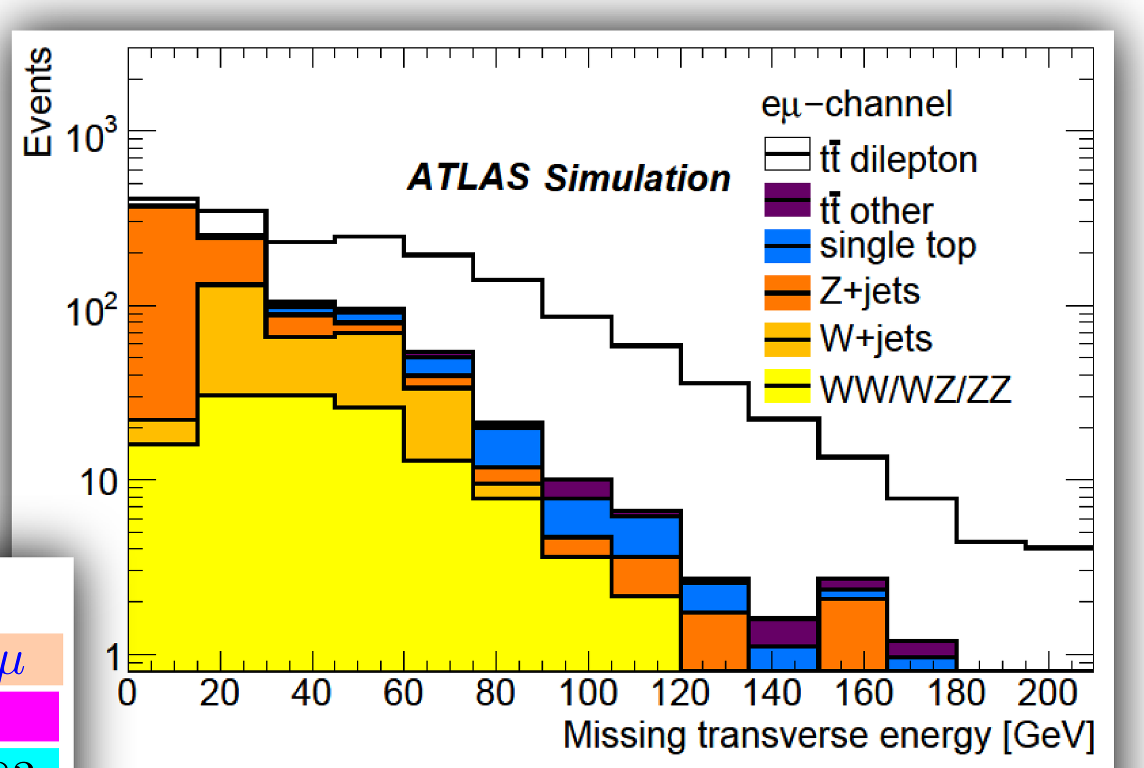


Likelihood fit on the "top candidate" mass distribution, to extract the $t\bar{t}$ cross section. The fit method is able to extract both signal and background from data, but needs more statistic.

Di-Lepton Channel

Event selection:

- 2 opposite sign isolated leptons (e and/or μ) with $p_T > 20$ GeV (with e or μ trigger)
- $\not{E}_T > 20$ GeV (associated to the two ν)
- at least 2 jets with $p_T > 20$ GeV (for $\mu\mu$) or > 35 GeV (for ee and $\mu\mu$) (associated to the two b produced in t and $\bar{t}$ decays)
- $|m_Z - m_{\ell\ell}| > 5$ GeV (for ee and $\mu\mu$ channels only, to reject the $Z \rightarrow \ell\ell$ background)



$\not{E}_T$ distribution for expected $t\bar{t} \rightarrow e\mu$+jets signal and the main backgrounds, after requiring 2 opposite signed ℓ

Cut & Count Method

The total cross section is obtained counting the number of events surviving the selection and subtracting the expected number of background events:

$$\sigma = \frac{N_{sig}}{L \times \epsilon} = \frac{N_{obs} - N_{bkg}}{L \times \epsilon}$$

(L: integrated luminosity, ϵ: signal selection efficiency)

Expected numbers for different channels:

	e+jets	μ+jets	ee	$\mu\mu$	$e\mu$
	number of events				
S	1286	1584	214	327	683
B	598	799	54	87	123
S/B	2.1	2.0	3.9	3.8	5.6
	relative uncertainties (%)				
	cut&count / fit		cut&count		
statistic	3.0 / 14	3.0 / 15	8.5	6.6	4.3
systematic	14.5 / 10.5	13.5 / 10.5	13.3	9.8	9.1
luminosity	22 / 20	22 / 20	22	22	22
TOT	27 / 27	26 / 27	27	25	24

Using b-tagging for event selection:

For the di-lepton channel, no selection strategy includes b-tagging:

- the statistical uncertainty would increase too much
- di-lepton $t\bar{t}$ events will be used to calibrate b-tagging

For the single lepton channel, one can use the b-tagging requirement:

- the S/B ratio will increase: ~ 7 (1 b-tag), ~ 15 (2 b-tag)
- the error coming from W+jets will decrease significantly
- a new syst. uncertainty is introduced (b-tagging efficiency)

Work in progress to use b-tagging in $t\bar{t} \rightarrow \ell$+jets for first 7 TeV data.

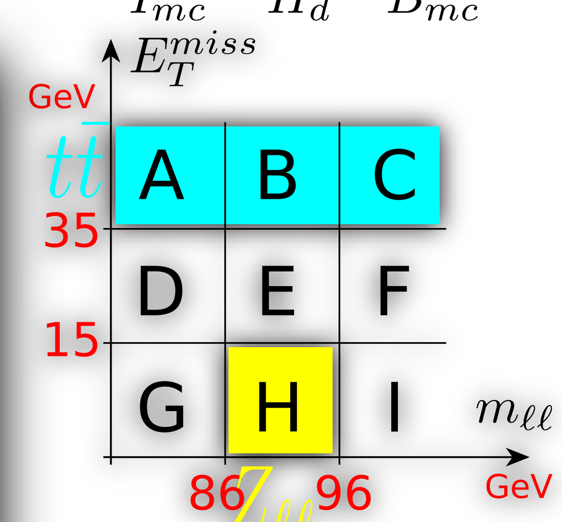
Systematic Uncertainties

- Background estimation: shape only for likelihood fit, normalization & shape for cut&count (data-driven methods needed)
- Jet Energy Scale: important for all the channels and methods
- Initial and Final State QCD Radiation modelling : affects the predictions for jet energy and multiplicity
- LHC Luminosity: expected to be 20% in the initial period of LHC run

Drell-Yan with E_T^{miss} vs $m_{\ell\ell}$ regions:

$$A_{est} = G_d \left(\frac{A_{mc}}{G_{mc}}\right)\left(\frac{B_d}{H_d}\right)\left(\frac{H_{mc}}{B_{mc}}\right)$$

$$C_{est} = I_d \left(\frac{C_{mc}}{I_{mc}}\right)\left(\frac{B_d}{H_d}\right)\left(\frac{H_{mc}}{B_{mc}}\right)$$



Data-Driven Background Estimation

W/Z ratio method for W+jets:

Count the number of Z+jets (easier to discriminate from $t\bar{t}$) and obtain the number of W+jets by rescaling it:

$$W_{4jets} \simeq Z_{4jets} \times \frac{W_{1jet}}{Z_{1jet}}$$

W_{1jet} and Z_{1jet} are counted in the 1jet control region.

Matrix Method for jets faking leptons rate:

Define a *loose* and a *tight* selection for leptons, with ϵ^{real} and ϵ^{real} = probability for a *loose* ℓ to pass the *tight* selection (for *real* and *fake* ℓ), count N_{loose} and N_{tight}, and have 2 equations with 2 unknowns:

$$\begin{aligned} N_{loose} &= N^{fake}_{loose} + N^{real}_{loose} \\ N_{tight} &= \epsilon_{fake} N^{fake}_{loose} + \epsilon_{real} N^{real}_{loose} \end{aligned}$$

(same method for $W + jets$ and single lepton $t\bar{t}$ background in di-lepton)

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on behalf of the ATLAS collaboration