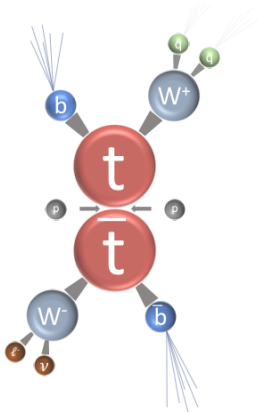
Measurement of the inclusive $t\bar{t}$ cross-section in the lepton+jets channel in p p collisions at $\sqrt{s}$ = 8 TeV with the ATLAS detector



Arwa Bannoura

On behalf of the ATLAS collaboration

BERGISCHE UNIVERSITÄT WUPPERTAL

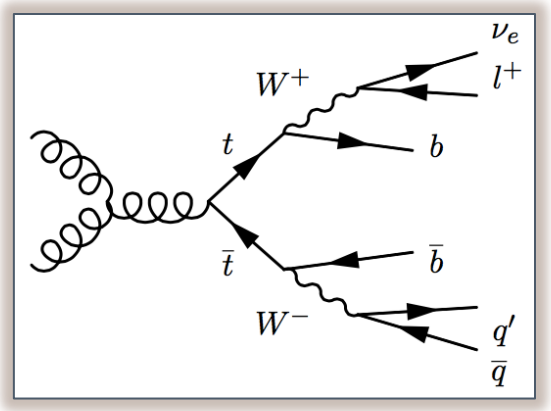
ATLAS EXPERIMENT

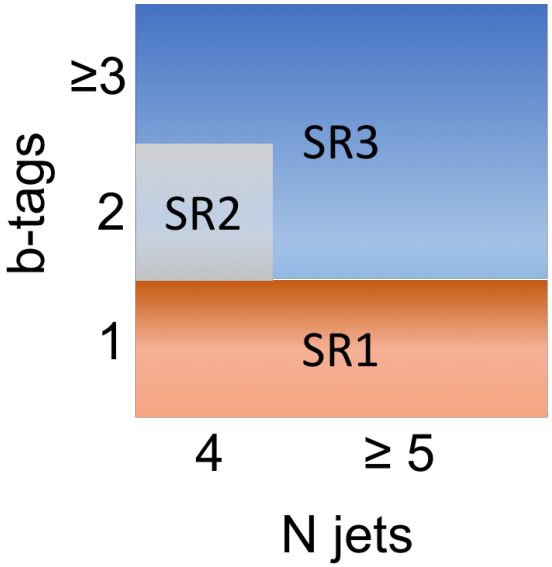
TOP2017 Braga, Portugal

10th International Workshop on Top Quark Physics

Analysis overview

- Split selected events into three signal regions
- Constrain uncertainties due to JES and b-tagging efficiency
- Simultaneous maximum-likelihood fit in the three regions
- Use $\mathbf{NN_{output}}$ as discriminating variable in SR1 and SR3
- Use $\mathbf{m_{jj}}$ distribution as discriminating variables in SR2 → sensitive to JES
- SR1: highest background fraction and highest number of signal events
- SR2 and SR3: small background fraction
- Ratio of 1 b-tag to 2 b-tags (SR1 vs SR2+SR3) is sensitive to b-tagging efficiency

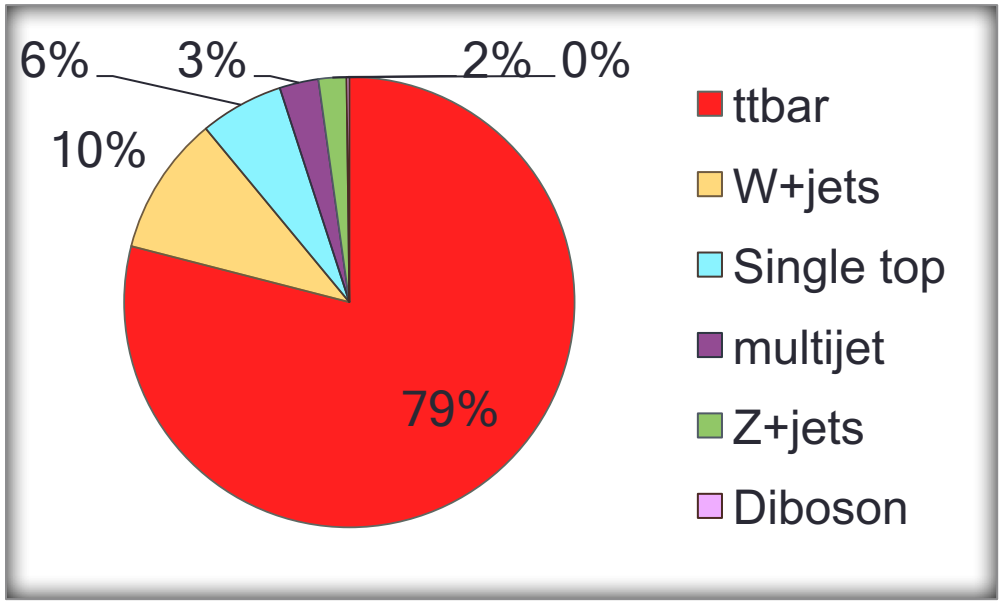




Event selection and background estimation and modelling

Object	Requirement
Jets	≥ 4 jets p_T > 25 GeV ≥1 b-tag
Leptons (e or μ)	Exactly 1 lepton p_T > 25 GeV
E_T^{miss}	> 25 GeV
$m_T(W)$	> 30 GeV

- **Single top, Z+jets, diboson:**
  - Normalised to their theoretical prediction
- **Multijet** background**:**
  - Templates fitted from data using control regions enriched with non prompt and fake leptons
- Main background **W+jets**:
  - Modelled by a data-driven method

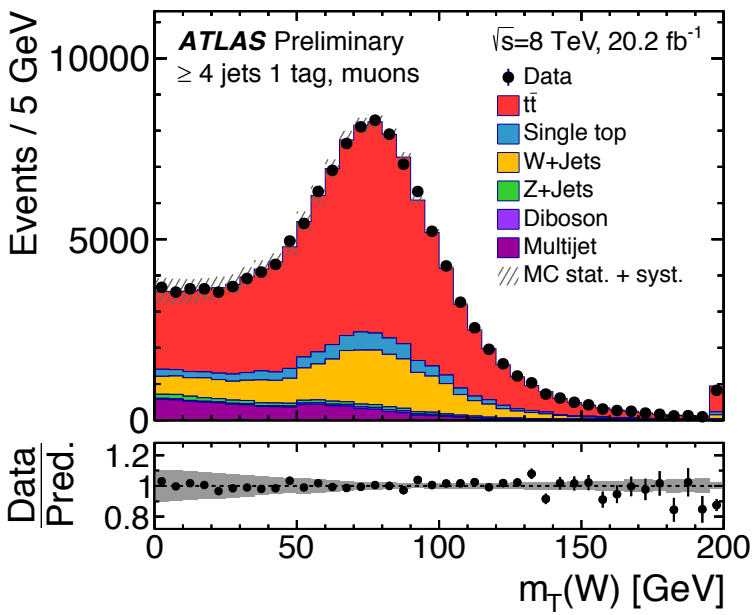


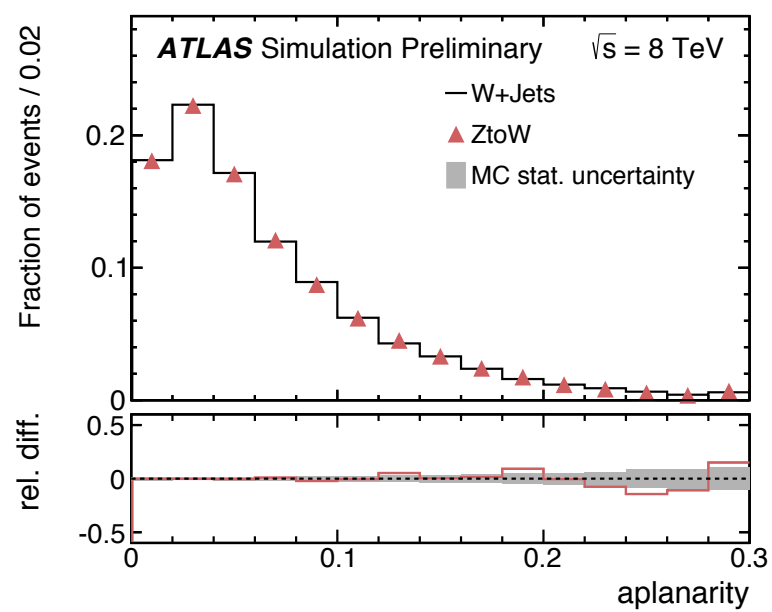
For the three signal regions together

Backgrounds estimation and modelling

- **Multijet** background:
  - Electron channel: template from jet-lepton method (select jet as a lepton)
  - Muon channel: Template from anti-muons method (change ID cuts)
  - Estimate normalisation: fit on $E_{\mathrm{T}}^{\mathrm{miss}}$ or $m_{\mathrm{T}}(\mathrm{W})$ distributions

- Main background **W+jets**:
  - Use Z+jets events selected from data
  - Scale momentum of leptons by m_W/m_Z
  - Select one of the leptons randomly and drop it
  - Recalculate the missing E_T of the event





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Discriminating observable in SR1 and SR3

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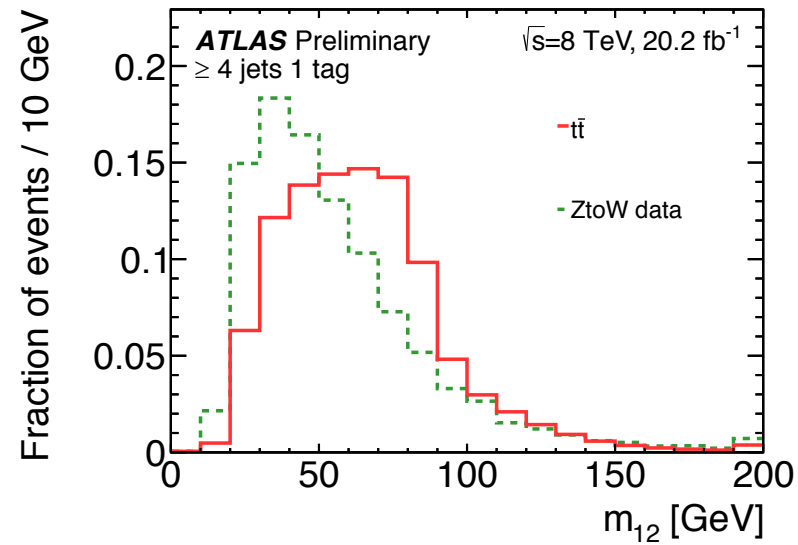
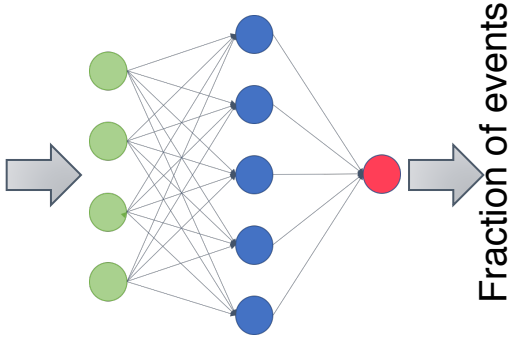
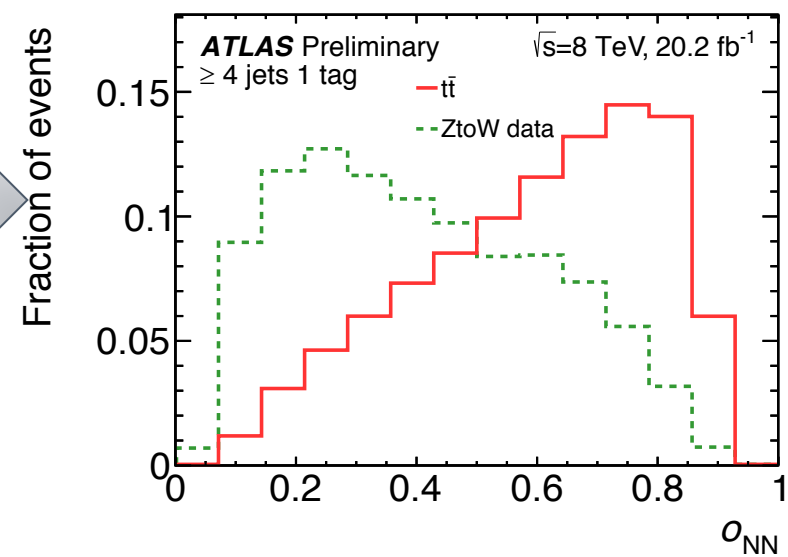
- Train a neural network
- Use equal number of $t\bar{t}$ events and ZtoW from data

Seven input variables (ordered by their discriminating power)
$\mathbf{m_{12}}$: smallest invariant mass between jet pairs
$\mathbf{\cos(\theta^*)_{bjj}}$: angle between hadronic top quark momentum and beam direction in $t\bar{t}$ rest frame
$\mathbf{m(\ell\nu b)}$: mass of the semileptonically top-quark
Aplanarity: event shape variable related to the smallest eigenvalue of sphericity tensor
m(bjj): mass of the hadronically decaying top-quark
$\mathbf{m_{\ell 1}}$: smallest invariant mass between a jet and the lepton
$\mathbf{m_{23}}$: second smallest invariant mass between jet pairs







Discriminating observable in SR2

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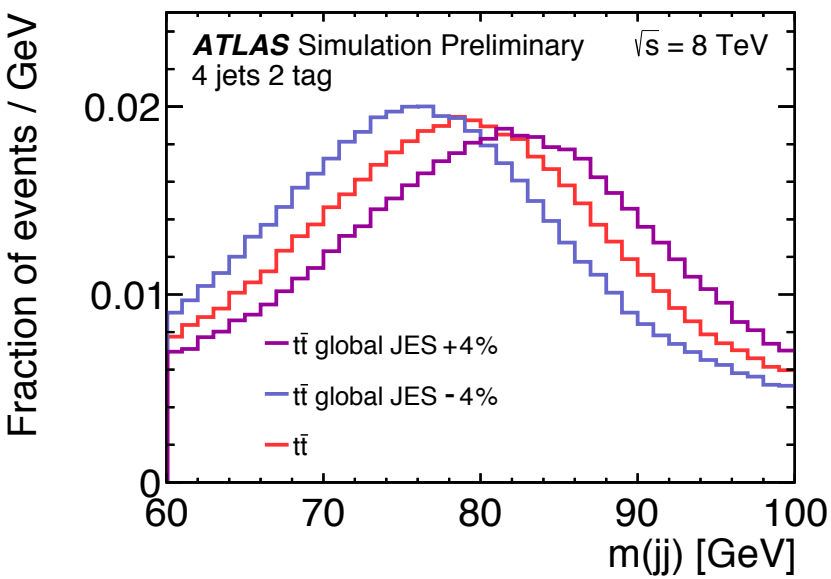
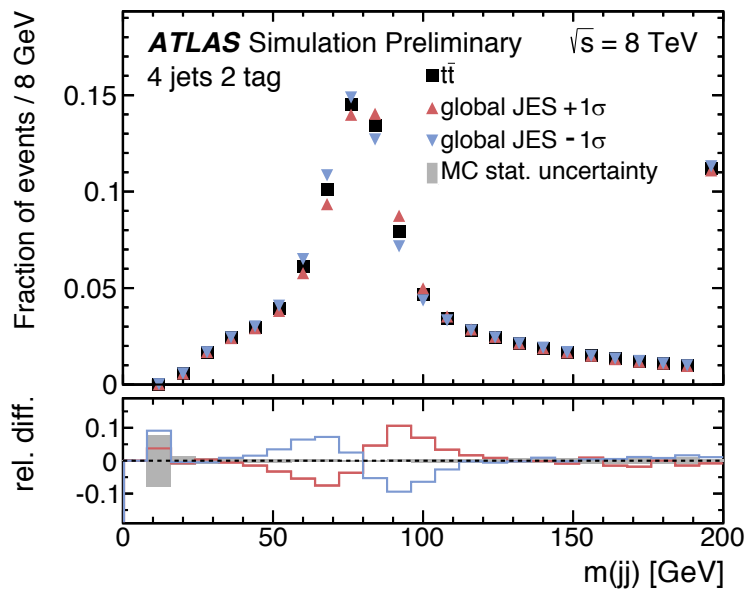
- Use the invariant mass of the two untagged jets m(jj) in SR2
- Utilised in top-quark mass measurements
- m(jj) shows sensitivity on the JES
  - Sensitivity to the peak position





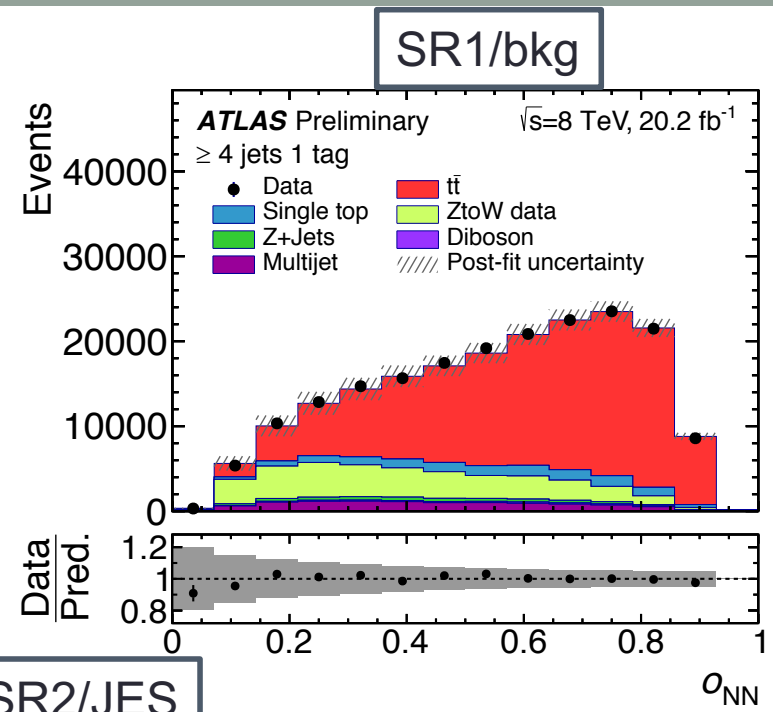
- Full distribution is used
- Global JES (±1 σ)

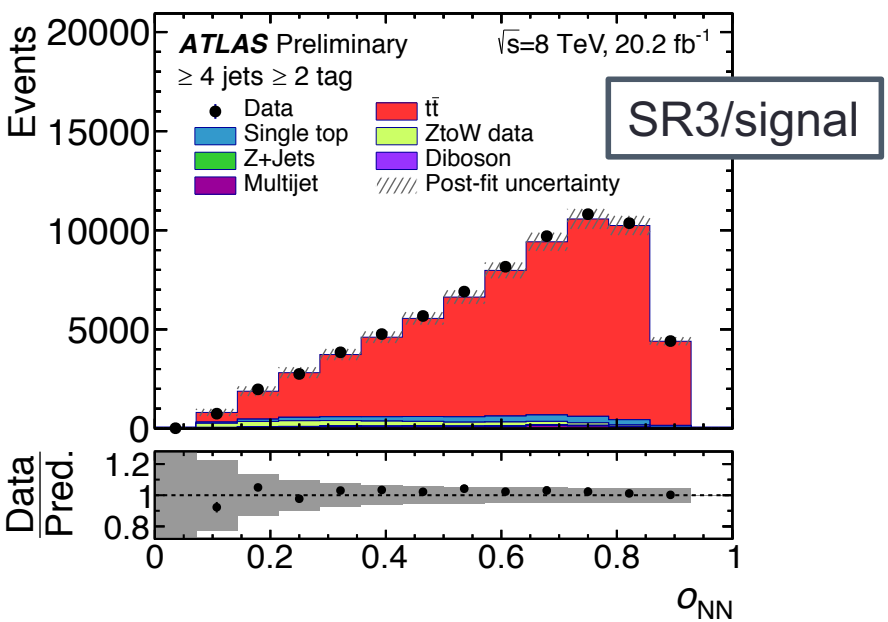
Extracting $t\bar{t}$ cross-section

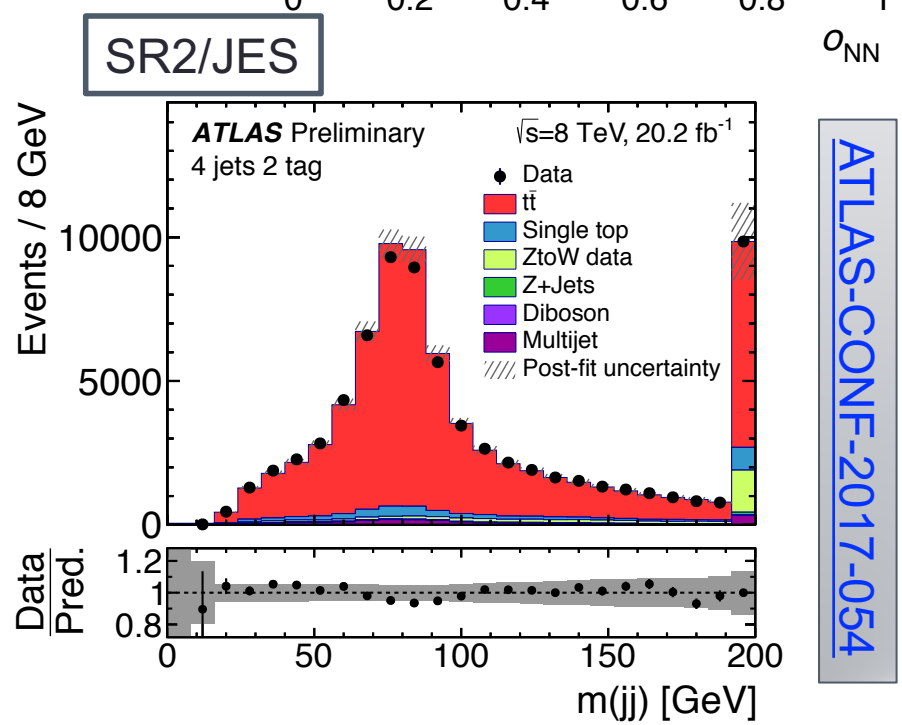
- Simultaneous binned maximum likelihood fit in the three signal regions

$$L(\beta^{t\bar{t}}, \beta^{W_1}, \beta^{W_{2,3}}, \delta_{b-\text{tag}}, \delta_{\text{JES}}) = \prod_{k=1}^{M} \frac{e^{-\mu_k} \cdot \mu_k^{n_k}}{n_k!} \cdot G(\delta_{b-\text{tag}}; 0, 1)$$

- One parameter for $t\bar{t}$: $\beta^{t\bar{t}}$
- Two parameters for W+jets: β^{W1}, $\beta^{W2,3}$
- Two nuisance parameters for:
  - Jet energy scale correction factor δ_{JES}
  - B-tagging efficiency correction factor $\delta_{b\text{-}tag}$







Systematic uncertainties

- Using 100k pseudo-experiments
- Shape and acceptance effects are considered
- Total uncertainty: systematic effects varied simultaneously
- Taking into account correlations
- Largest uncertainties: PDF and MC modelling of $t\bar{t}$ process
- **Total uncertainty (including lumi.): 5.7%**

Main sources of systematic uncertainties

Source	$\Delta\sigma/\sigma$ [%]
Jet energy scale	± 1.1
Lepton identification	± 1.4
Lepton trigger	± 1.3
NLO matching	± 1.1
Scale variation	± 2.2
Parton shower	± 1.3
PDF	± 3.0
ZtoW modelling	± 1.1
Luminosity	± 1.9
Total (sys. + stat.)	**± 5.7**

Final result

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Measured inclusive cross-section at $\sqrt{s}$ = 8 TeV :

$\sigma_{t\bar{t}}$ = 248.3 ± 0.7 (stat.) ± 13.4 (syst.) ± 4.7 (lumi.) pb

- **Most precise cross-section measurement from ATLAS in the lepton+jets channel: total uncertainty 5.7%**
- **Improves significantly** previous ATLAS measurement in the lepton+jets channel (total uncertainty 9.4%)
- **Close to most precise** dilepton channel ATLAS measurement (total uncertainty 3.2%)
- **More precise** than CMS measurement in the lepton+jets channel (total uncertainty 6.8%)

Thank you for your attention