# SEARCH FOR SINGLE TOP-QUARK PRODUCTION VIA FLAVOR-CHANGING NEUTRAL CURRENTS AT 8 TEV WITH ATLAS

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"Physics at the Terascale"

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# OUTLINE

- Introduction:

  -Standard Model single top quark production
  -FCNC in Standard Model and beyond

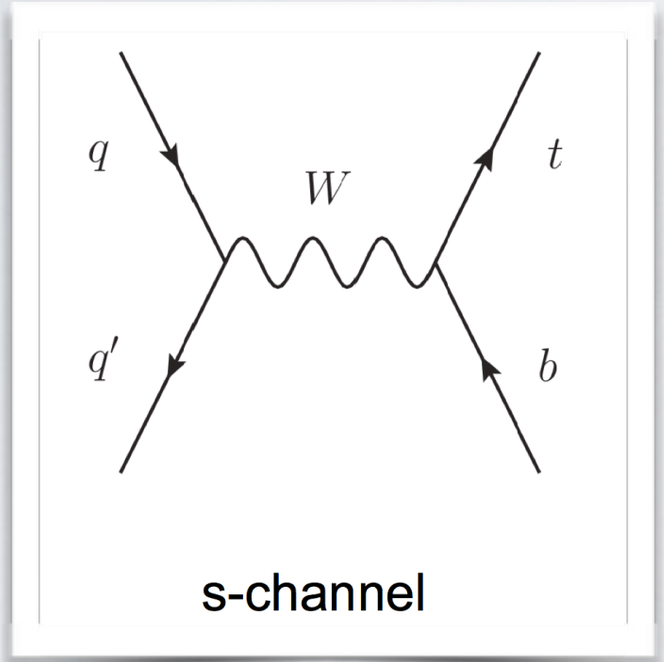
- 8 TeV ATLAS analysis strategy:

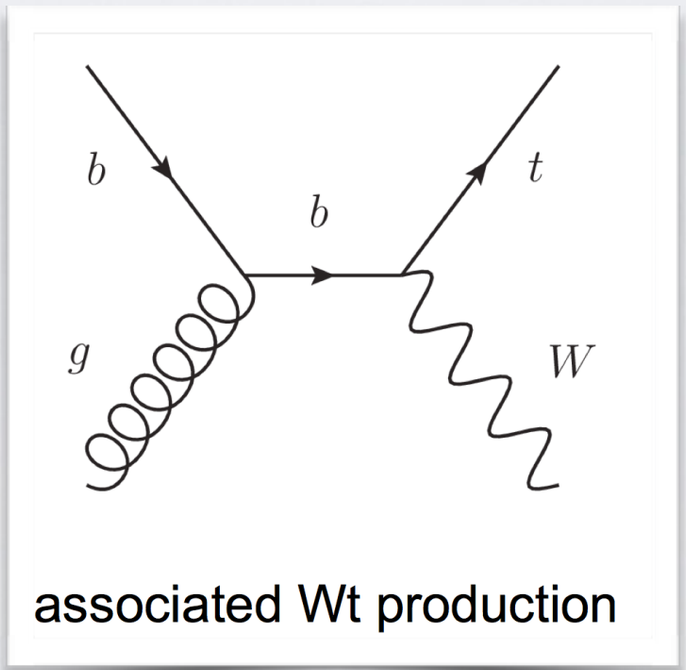
  -Event selection
  -Signal separation
  -Results

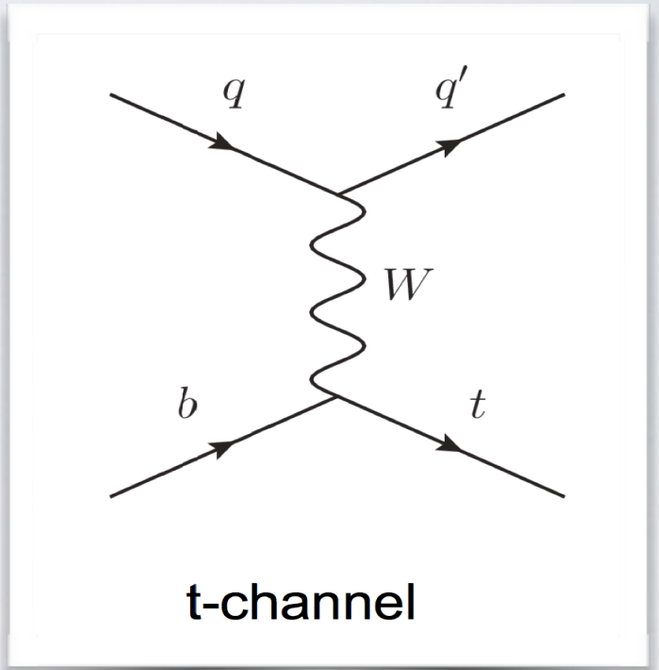
- Summary

# STANDARD MODEL SINGLE TOP PRODUCTION

Single top at LHC produced via 3 subprocesses & Wtb vertex.



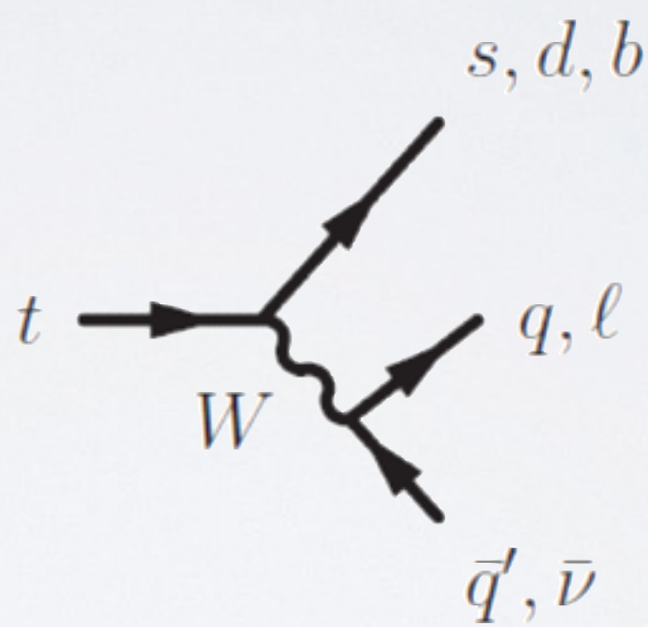




- Top quarks decay predominantly to Wb
  - Other qW widths are very small
  - Top quarks produced via FCNC assumed to decay like in SM

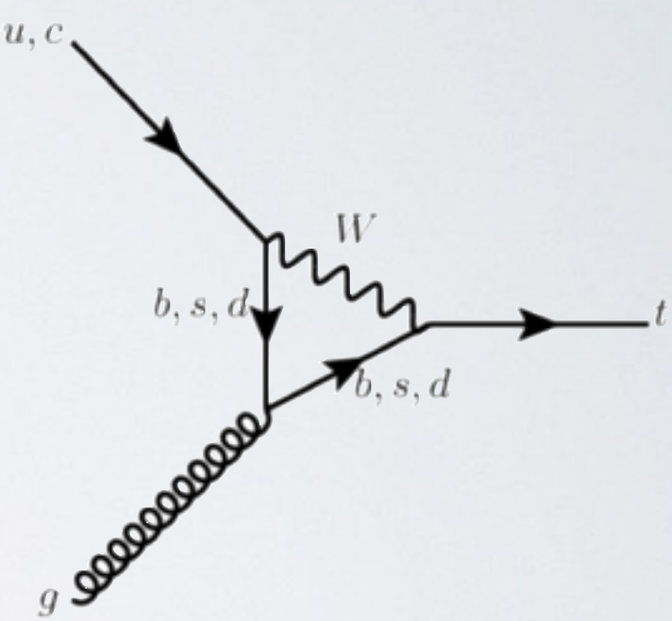
# FCNC IN THE STANDARD MODEL AND BEYOND

- In the SM, FCNC is absent at tree level but occur at higher order through loop diagrams.
- However they are highly suppressed by the GIM mechanism with a branching ratio into top quark: ~$10^{-13}$ - $10^{-14}$.

Top quark in the SM:




BR ~100% in SM




GIM mechanism:

BR ~$10^{-13}$ - $10^{-14}$ in SM

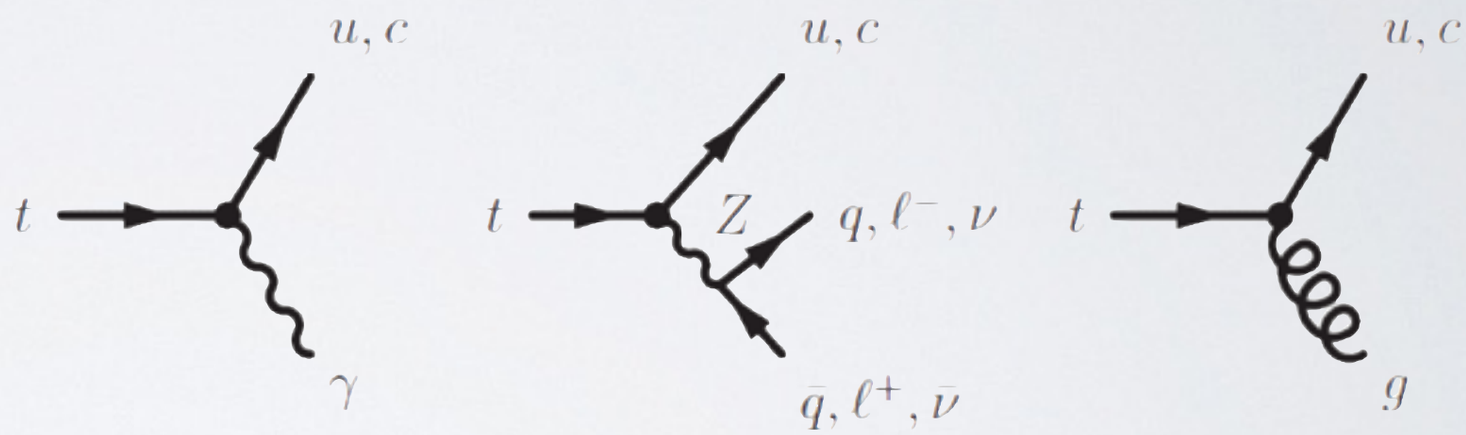
# FCNC IN THE STANDARD MODEL AND BEYOND

- Interesting process, predicted by many extensions of the SM with branching ratios up to ~$10^{-4}$ (MSSM). The existence of an FCNC signal involving top quarks would indicates new physics.

- It has been investigated by experiments at LEP, HERA, Tevatron and LHC.

- FCNC involving top quarks has not been observed yet.

FCNC Beyond SM:



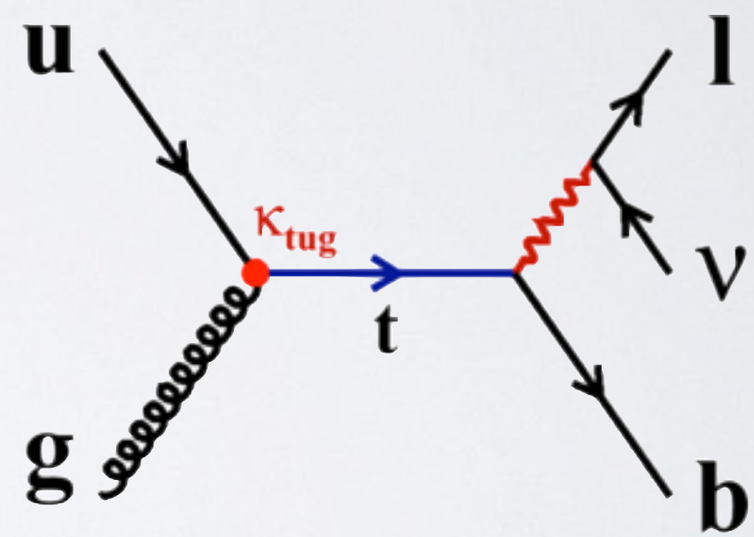

| | SM | 2HDM-III | MSSM | R-MSSM | TC2 |
|---|---|---|---|---|---|
| $t \to qg$ | $4{,}6\times10^{-12}$ | $10^{-4}$ | $10^{-4}$ | $10^{-3}$ | $10^{-5}$ |
| $t \to q\gamma$ | $4{,}6\times10^{-14}$ | $10^{-7}$ | $10^{-6}$ | $10^{-5}$ | $10^{-7}$ |
| $t \to qZ$ | $1\times10^{-14}$ | $10^{-6}$ | $10^{-6}$ | $10^{-4}$ | $10^{-5}$ |

J. A. Aguilar-Saavedra arXiv:hep-ph/0409342v4

# SEARCH FOR FCNC IN TOP PRODUCTION

[hep-ex/1509.00294] submitted to EPJC

- Latest ATLAS results use 20.3/fb data from 8 TeV pp collisions
- Event Selection:
  - One lepton: $p_T > 25$ GeV
  - One b-tagged jet: $p_T > 30$ GeV
  - $E_T^{miss} > 30$ GeV
  - $m_T(l\nu) > 50$ GeV

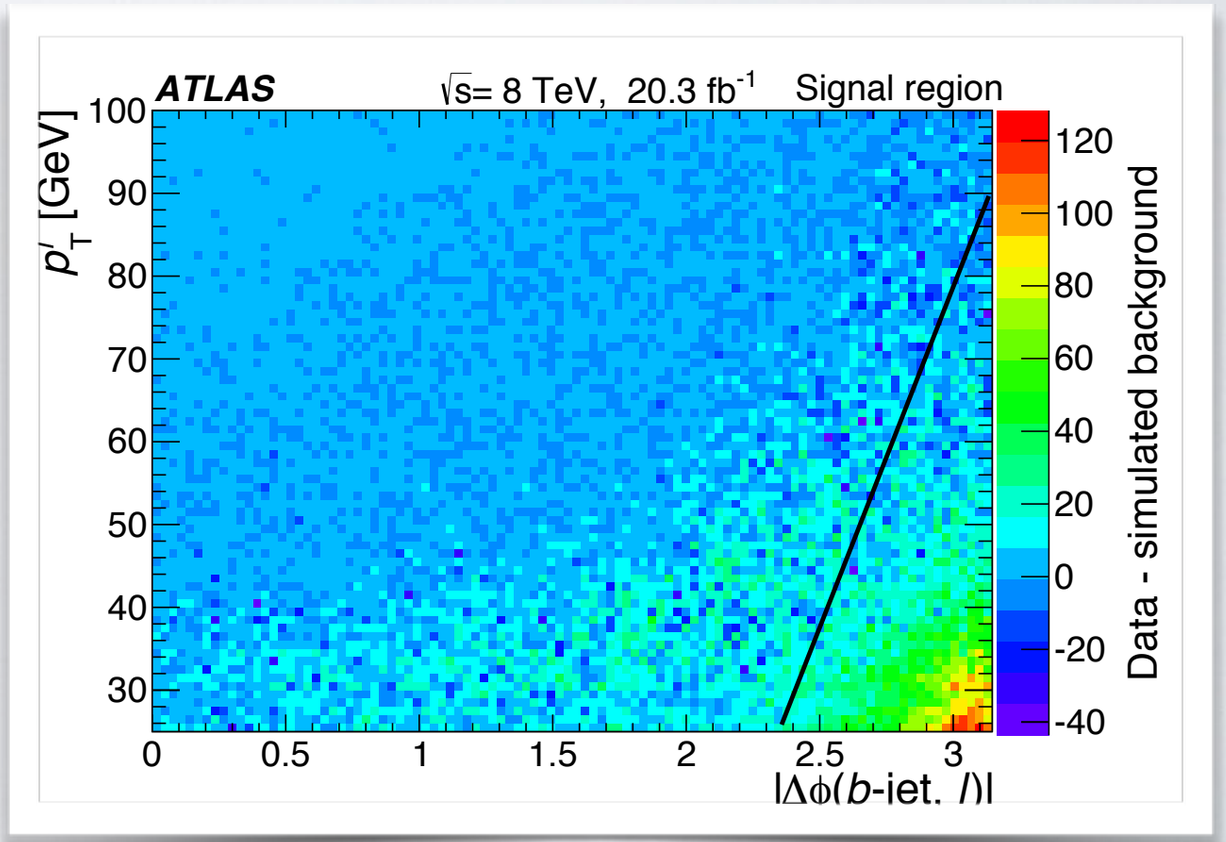


# SEARCH FOR FCNC IN TOP PRODUCTION

- An additional cut to further suppress the multi-jets background:

[hep-ex/1509.00294] submitted to EPJC

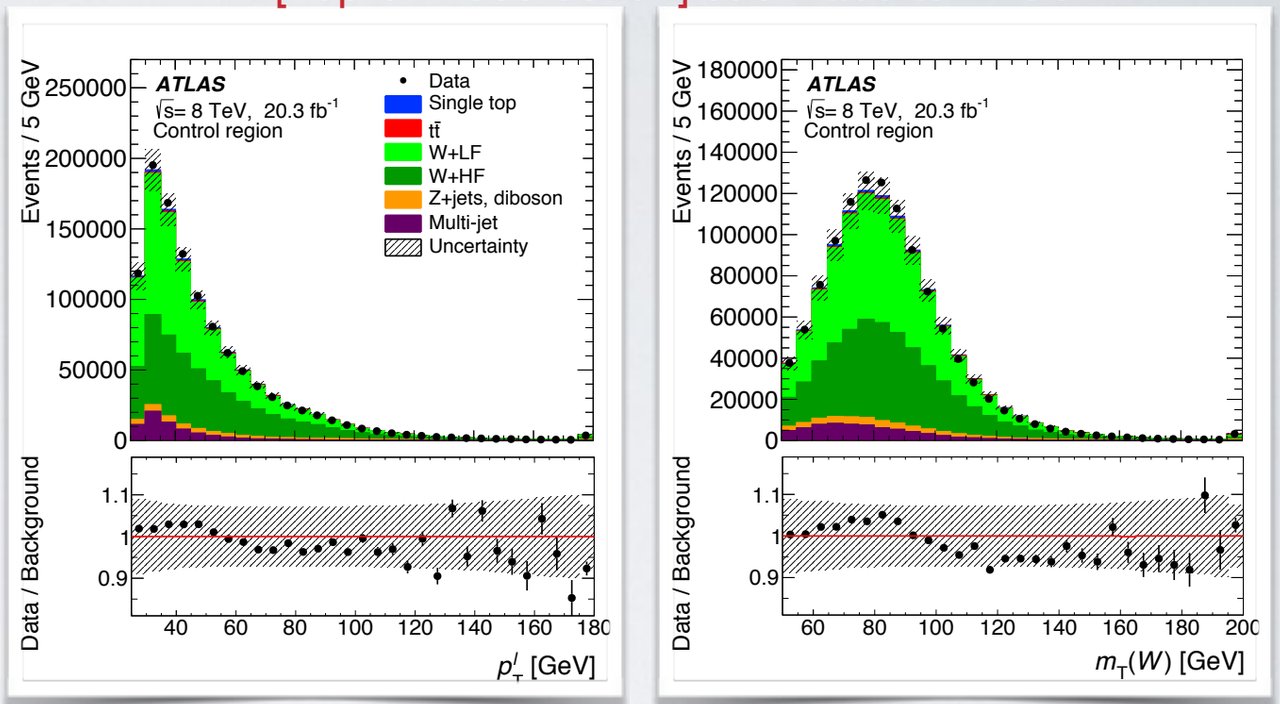
$$p_{\mathrm{T}}^{\ell} > 90\,\mathrm{GeV}\left(1 - \frac{\pi - |\Delta\phi(\ell, \mathrm{jet})|}{\pi - 2}\right)$$



# CONTROL DISTRIBUTIONS

[hep-ex/1509.00294] submitted to EPJC

- The dominant background is W+jets events
- Multijet events normalisation is obtained by a fit to the data

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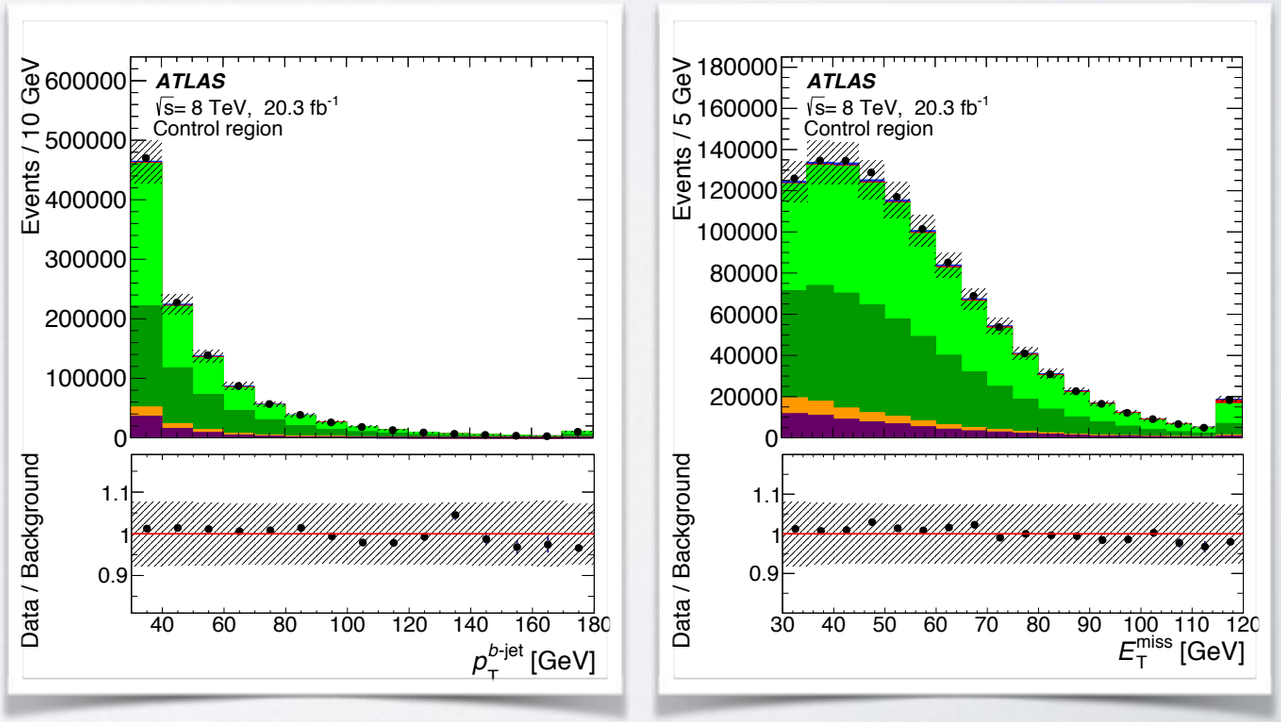
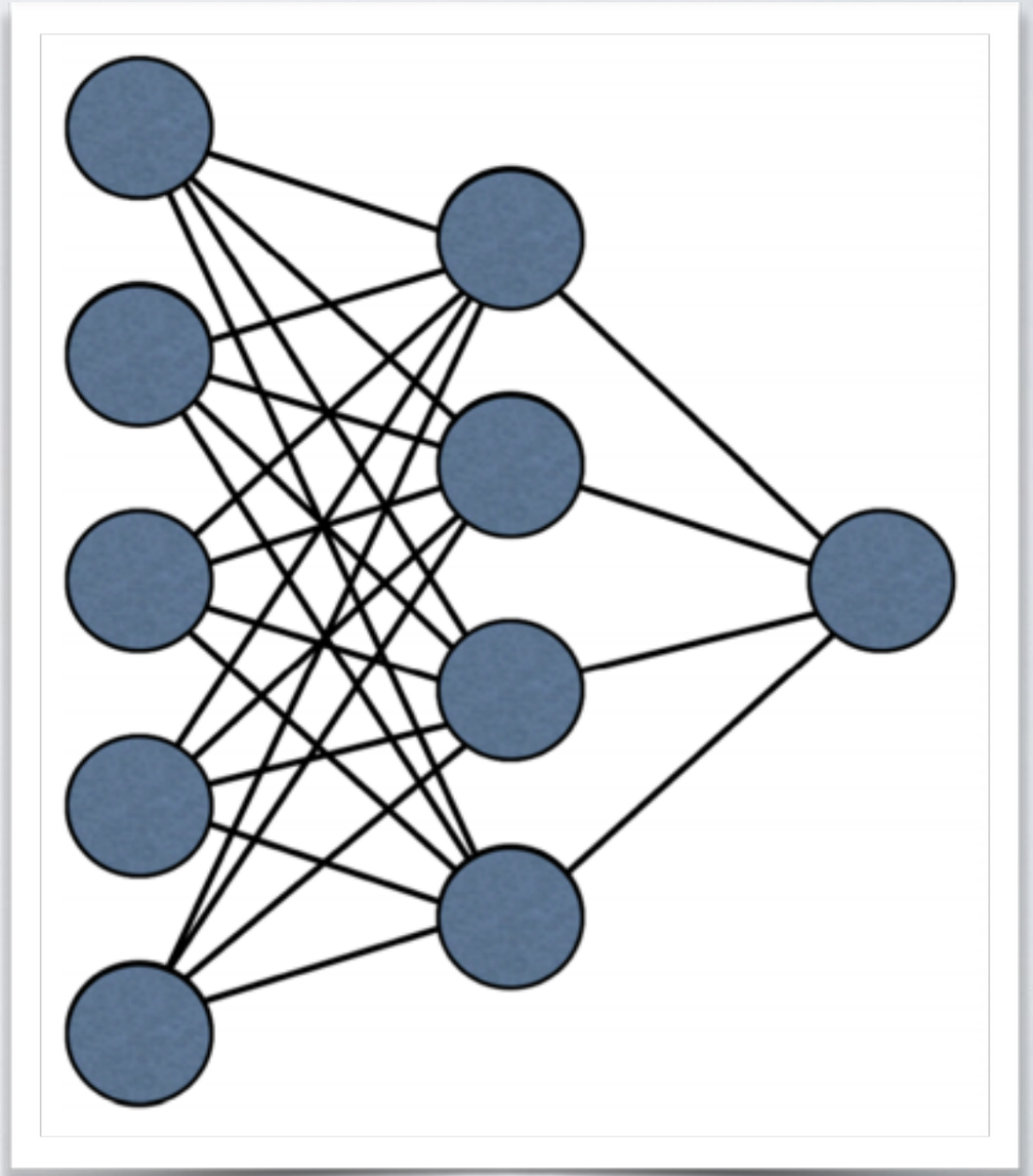



Control region is defined by inverting the b-tag requirement

# SIGNAL SEPARATION

- No single discriminating variable has a sufficient separation power, therefore a multivariate technique is adopted.

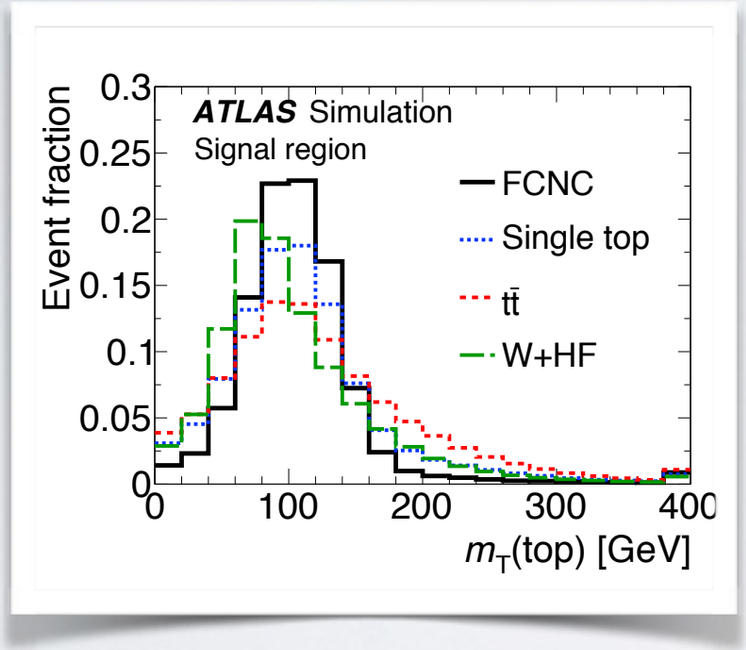
- Neural Network by NeuroBayes sort variables by their separation power (13 variables used)
  apply trained NN to data and MC



# NEURAL NETWORK VARIABLES

Significant variables and NN output shape distribution

[hep-ex/1509.00294] submitted to EPJC

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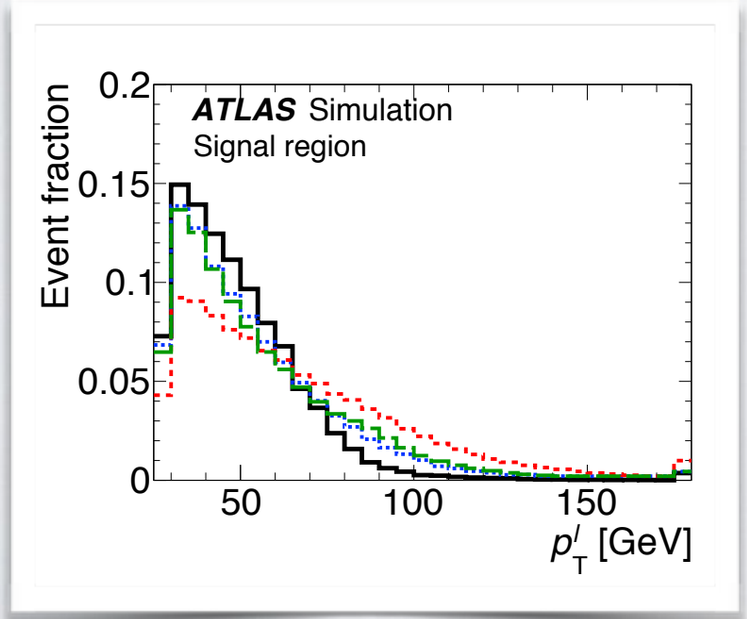


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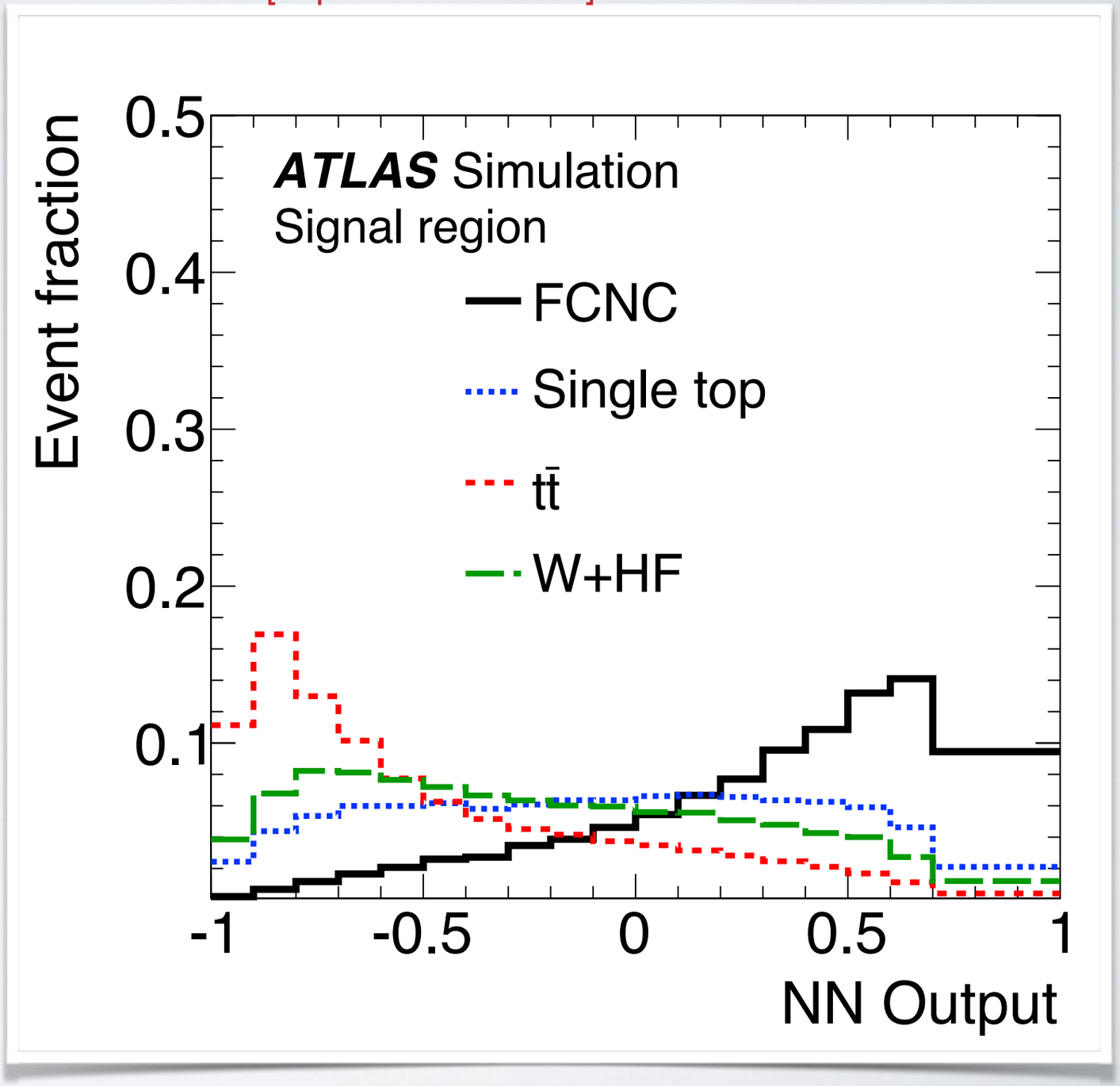

# NEURAL NETWORK VARIABLES

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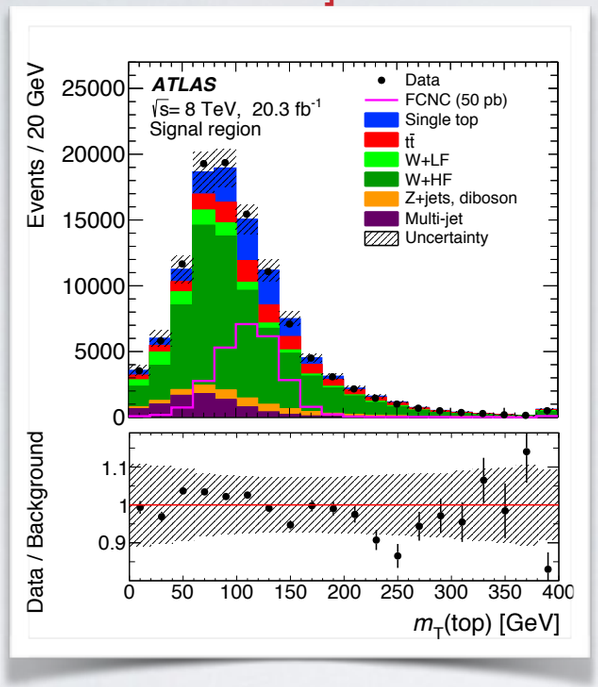


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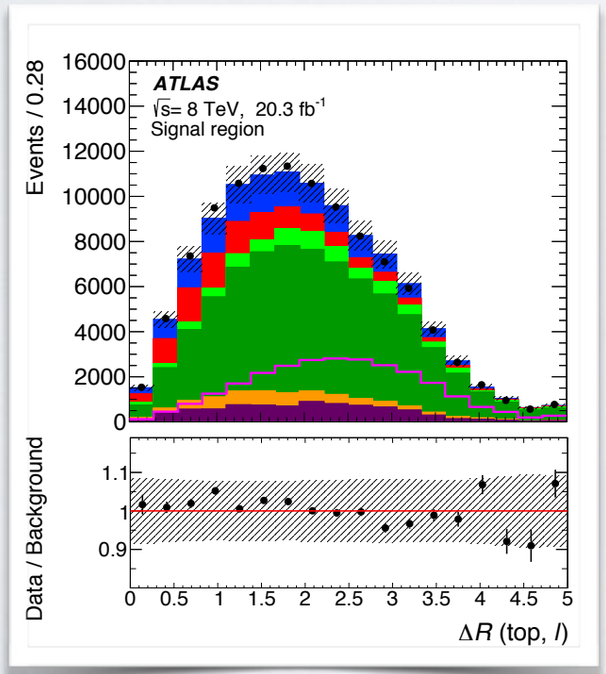


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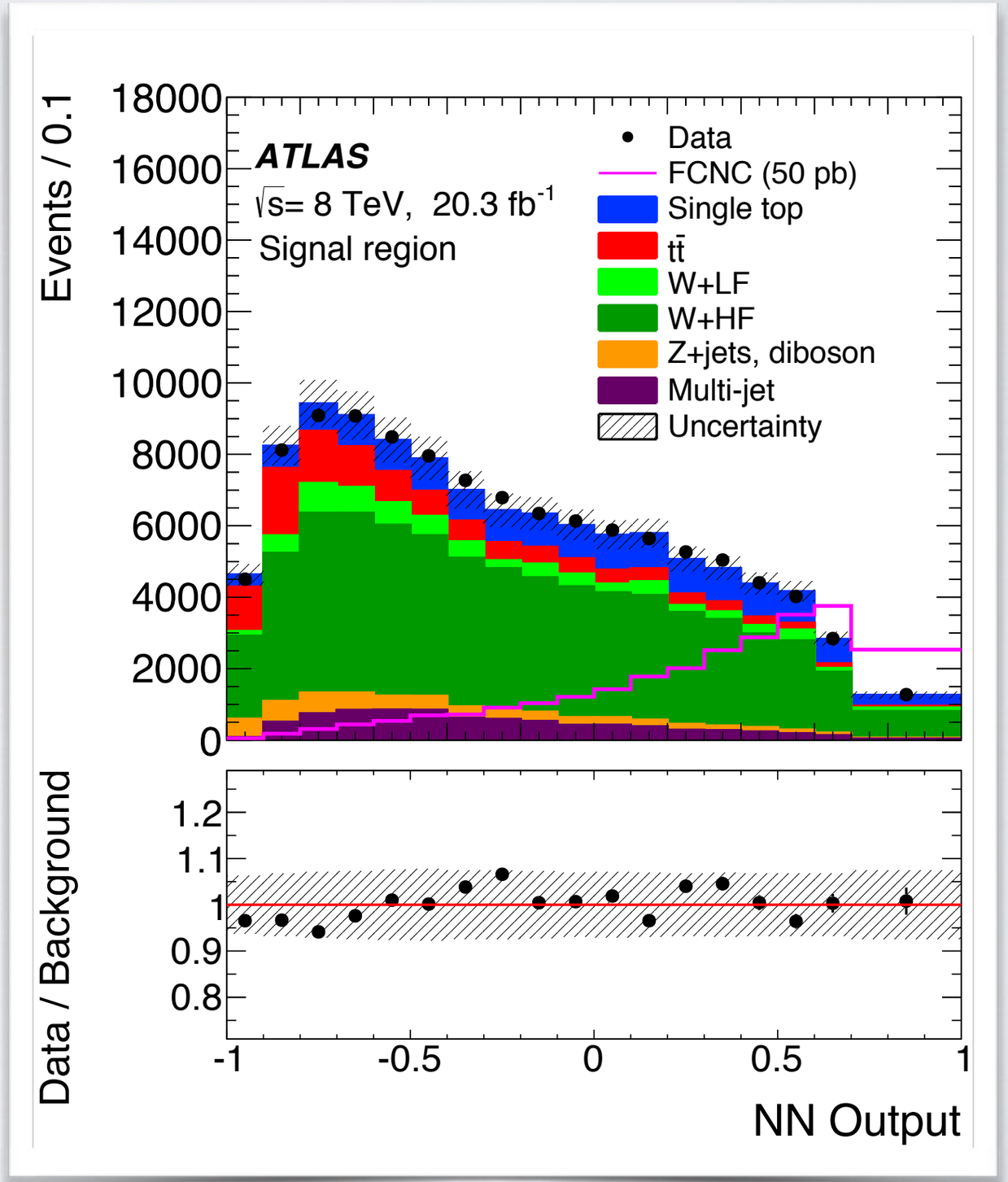


# RESULTS

No sign of a signal is observed, therefore upper limits on the cross-section of FCNC involving strong production of top quarks is set.

The observed 95% confidence level (C.L.) limit on the production cross-section multiplied by the $t \rightarrow bW$ branching fraction is $\sigma_{qg\rightarrow t} \times \mathcal{B}(t \rightarrow bW) < 3.4$ pb and the expected 95% C.L. limit is $\sigma_{qg\rightarrow t} \times \mathcal{B}(t \rightarrow bW) < 2.9$ pb.

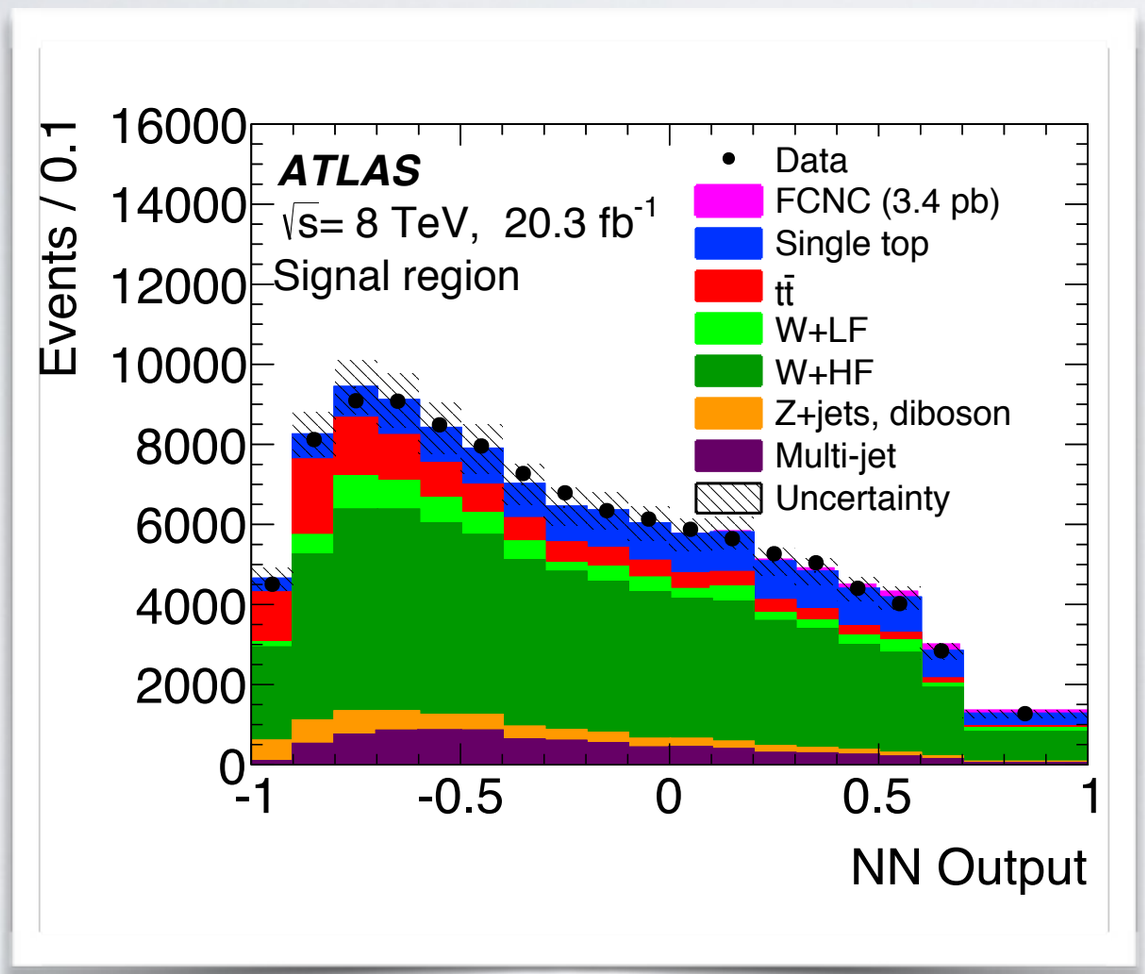
| Effect of syst. uncertainties | Expected limits (pb) |
|---|---|
| Normalisation & MC statistics | 1.5 |
| $E_T^{miss}$ modeling | 1.9 |
| Jet energy resolution | 1.9 |
| Multi-jet norm. and modeling | 1.8 |

The effect of a single systematic uncertainty in addition to the cross-section normalisation and Monte Carlo (MC) statistical uncertainties alone.

# RESULTS

FCNC signal cross section is scaled to the observed upper limit and stacked on top of the background.

[hep-ex/1509.00294] submitted to EPJC

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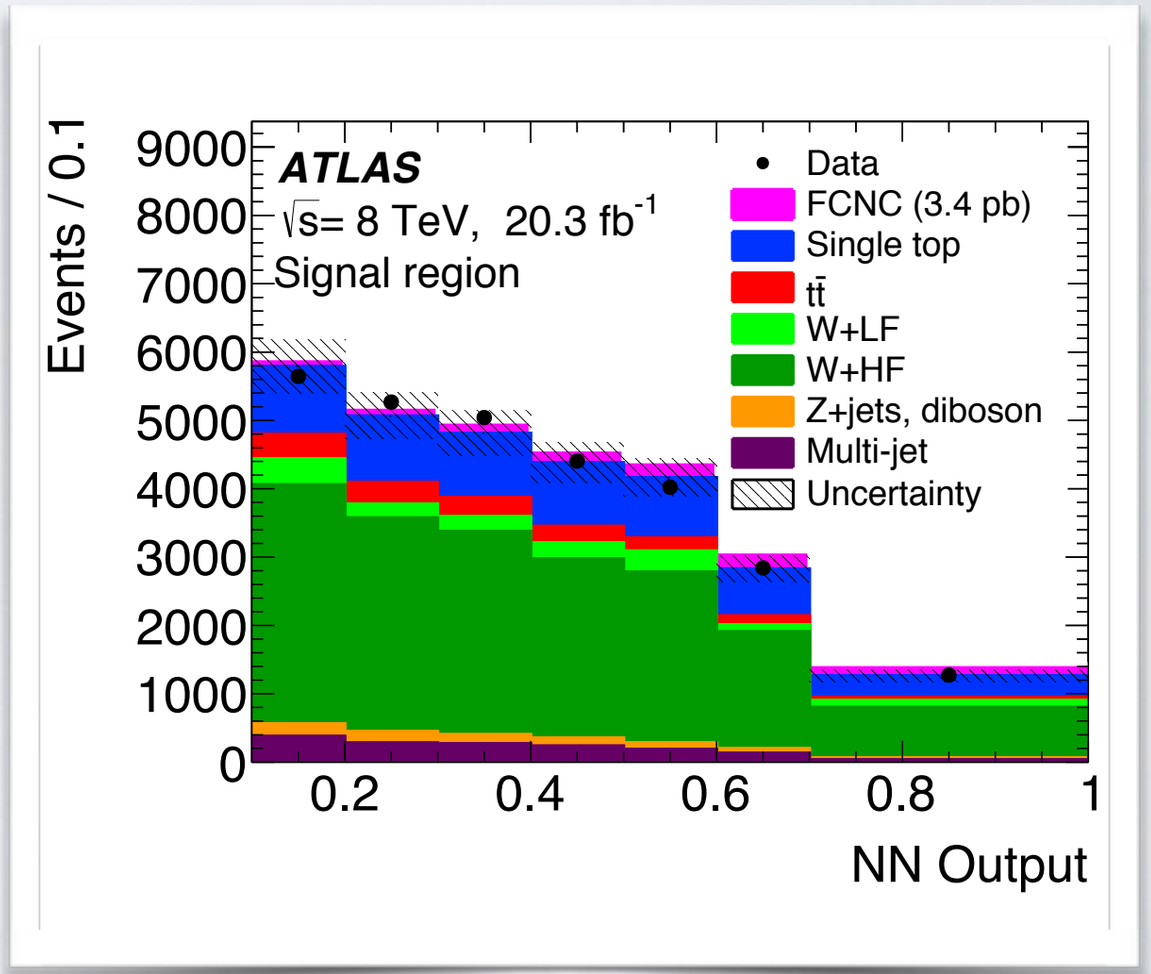
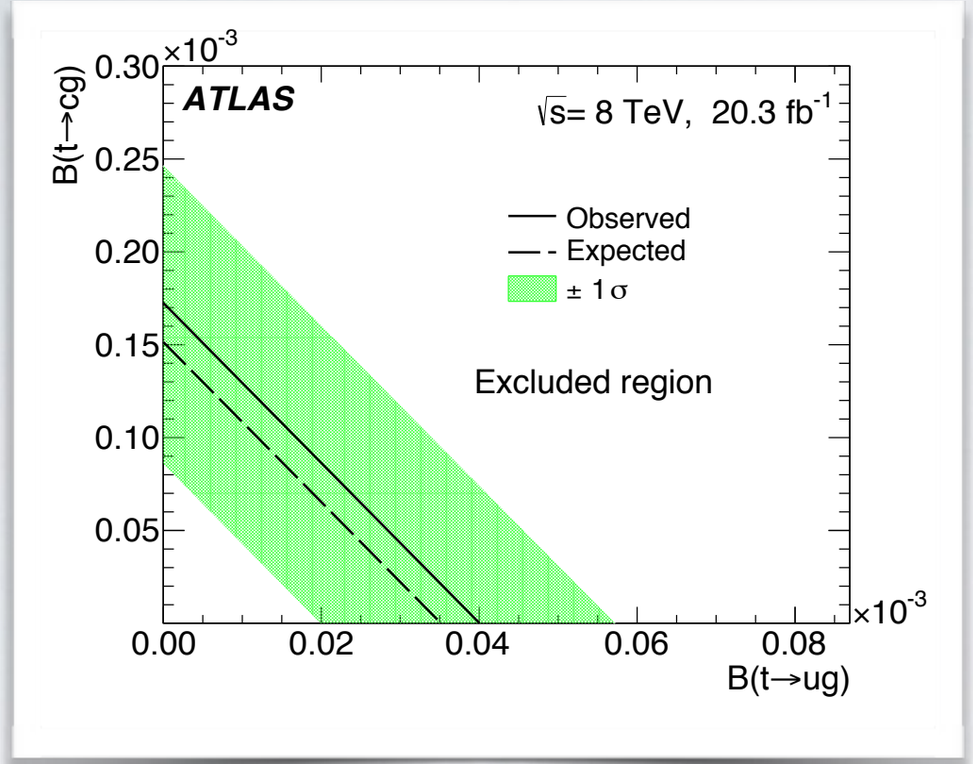


# UPPER LIMITS ON THE COUPLING CONSTANTS AND BRANCHING FRACTIONS

[hep-ex/1509.00294] submitted to EPJC

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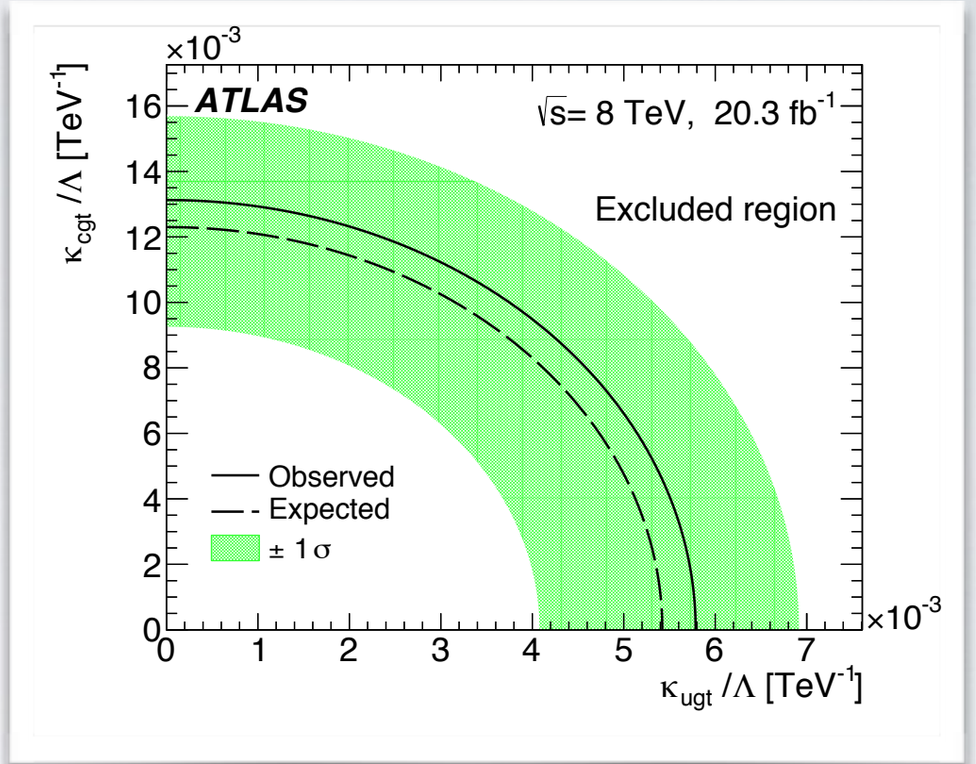


The observed limit is interpreted as upper limits on the coupling constants of the FCNC interactions divided by the scale of new physics:

$$\kappa_{ugt}/\Lambda < 5.8 \times 10^{-3}\ \mathrm{TeV}^{-1} \text{ assuming } \kappa_{cgt}/\Lambda = 0,$$
$$\kappa_{cgt}/\Lambda < 13 \times 10^{-3}\ \mathrm{TeV}^{-1} \text{ assuming } \kappa_{ugt}/\Lambda = 0.$$

Limits on the coupling constants are also interpreted as limits on the branching fractions:

$$\mathcal{B}(t \to ug) < 4.0 \times 10^{-5} \text{ assuming } \mathcal{B}(t \to cg) = 0,$$
$$\mathcal{B}(t \to cg) < 17 \times 10^{-5} \text{ assuming } \mathcal{B}(t \to ug) = 0.$$

# SUMMARY

- Search for FCNC in single top production using 8 TeV ATLAS dataset is presented.
- A neural network is used to separate the signal from the background.
- No sign of a signal is observed.
- Expected and observed limits are determined.

| Expected limits (pb) | Observed limits (pb) |
|---|---|
| 2.9 | 3.4 |

This is the most stringent limit published.