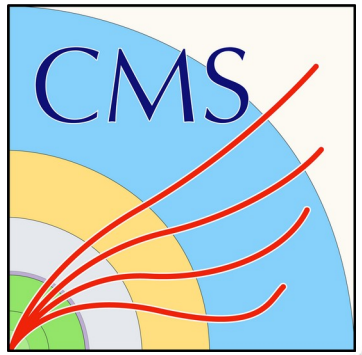


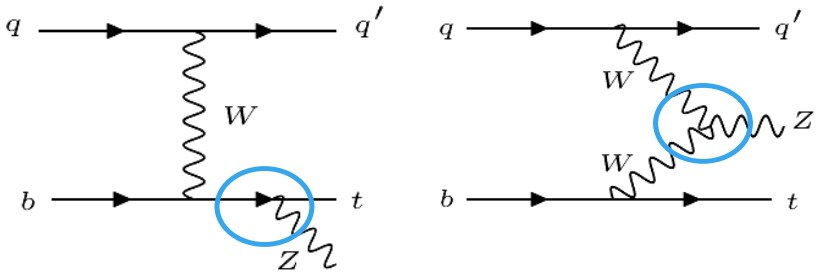
Search for tZq in 2ℓ final states

DPG - March 2021

Federica Colombina, Abideh Jafari, Andreas Meyer,
David Walter, Nicolas Tonon

Introduction

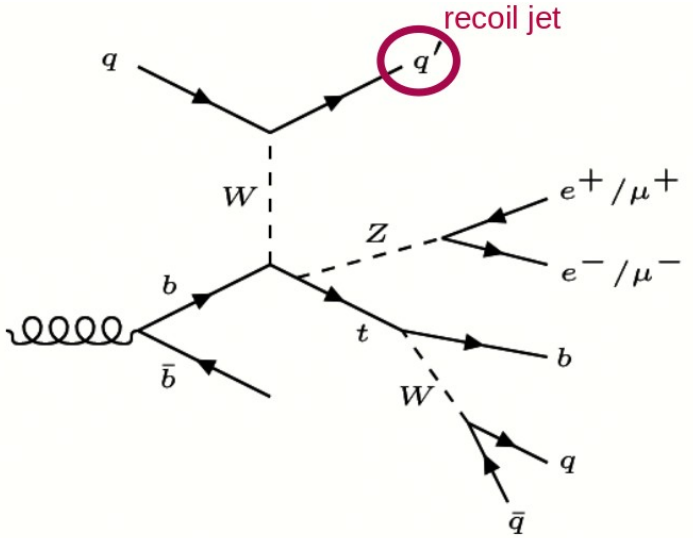
- tZq process sensitive to both top-Z and WWZ couplings → interesting for EWK studies



- Direct precision measurements of the top-Z coupling became possible for the first time with Run-2 data
- Observed in the 3ℓ channel from ATLAS and CMS

Purpose of the analysis:

- Study of tZq in the 2ℓ channel (not observed), to bring complementary information and increase the sensitivity

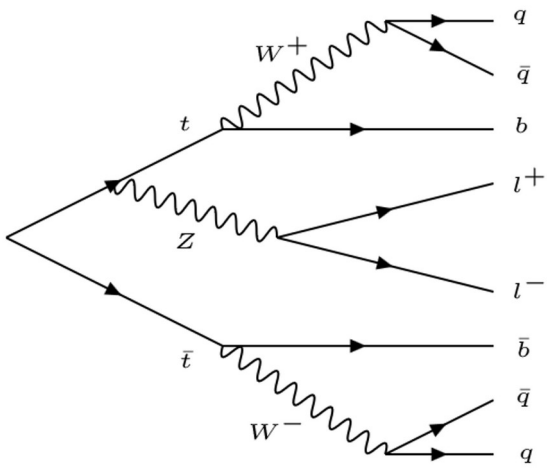


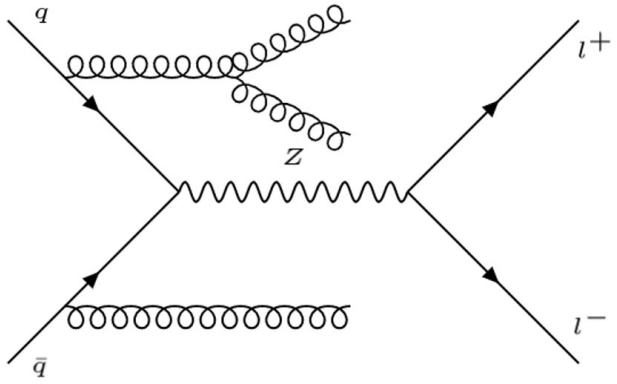
Main backgrounds

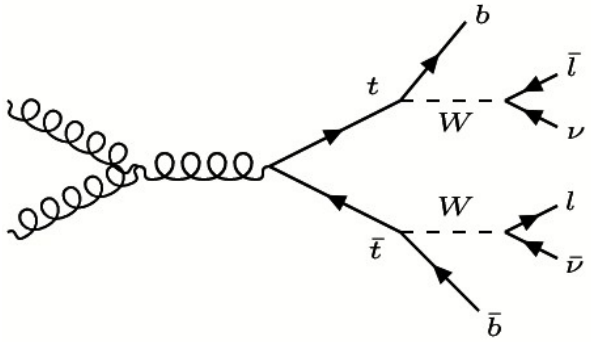
- Drell-Yan and $t\bar{t}$ → large cross-sections compared to that of tZq
- $t\bar{t}Z$ and tZq → comparable cross-sections, similar signatures

Cross-sections (2ℓ) [pb]

DY	6077.22
$t\bar{t}$	88
$t\bar{t}Z$	0.11
tZq	0.09







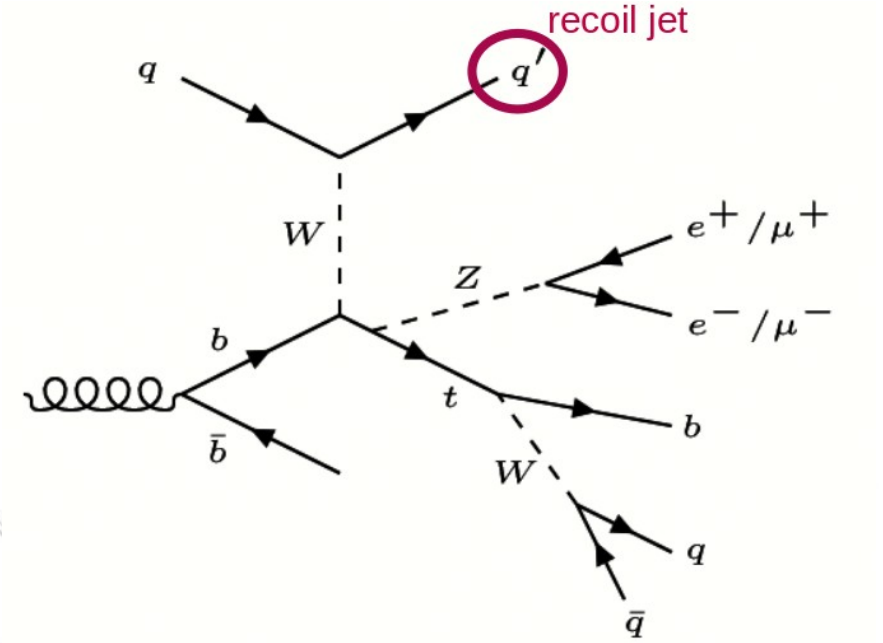
Event selection

Object identification:

- isolated leptons
- tight WP for b-jets (fake rate: ~0.1%)
- jets with p_T > 25 GeV and |η| < 5

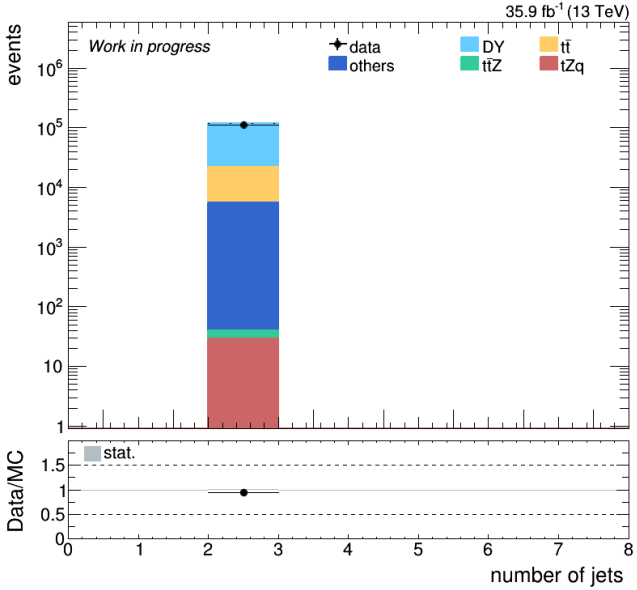
Signal Region:

- ≥ 4 jets, one of them b-tagged
- exactly 2 leptons ($e^{\pm}$, $\mu^{\pm}$), with:
  - opposite charge, same flavor
  - $|m_{\ell\ell} - m_Z| < 20$ GeV

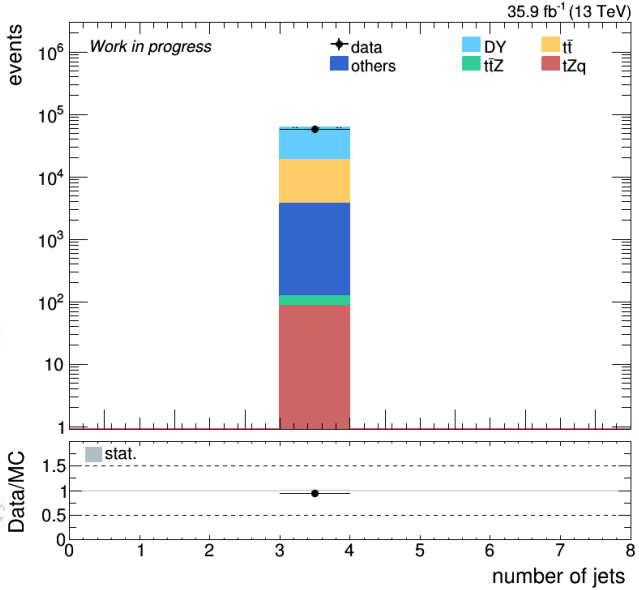


Control Regions and Signal Region

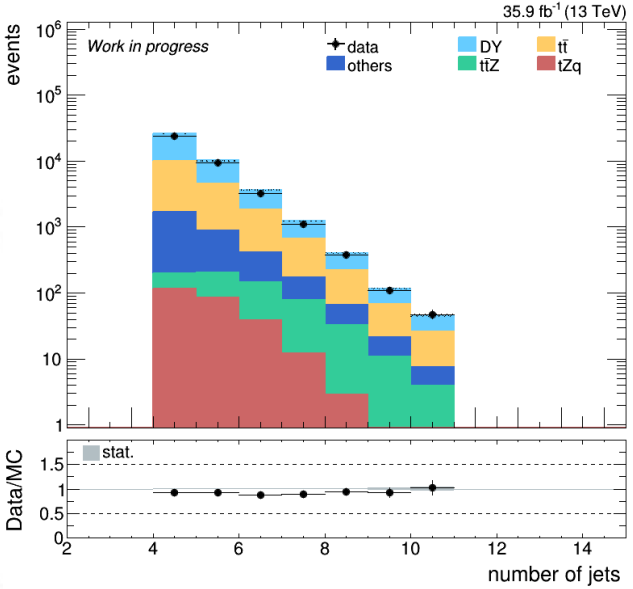
- 2 jets (CR):



- 3 jets (CR):

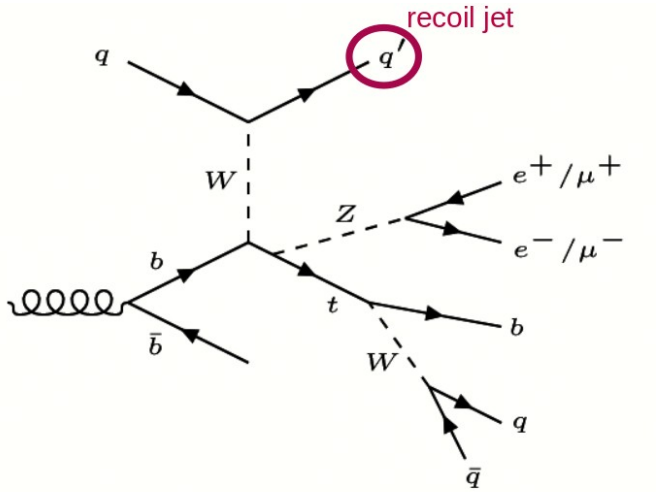


- 4 jets (SR):



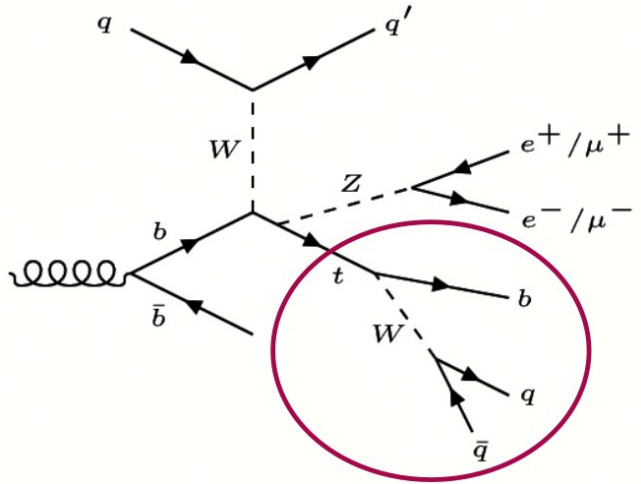
Event reconstruction: SR

- Recoil jet identification: choice based on a likelihood-ratio test which takes into account the |η| and p_T of the jets in the MC signal sample



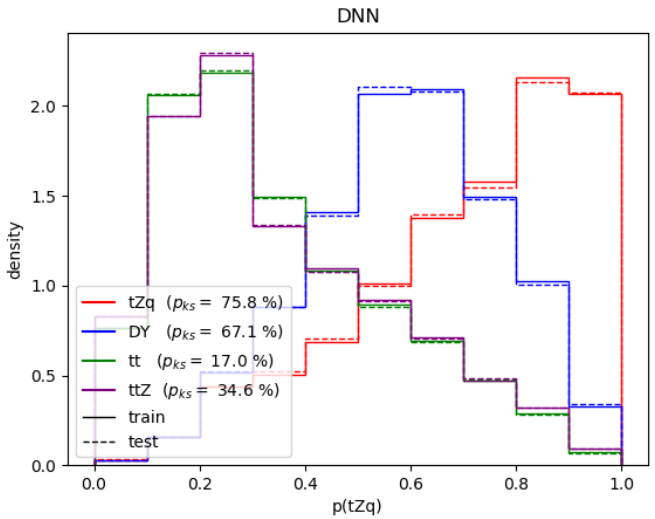
- Hadronic top reconstruction: combination of jets with best χ^2

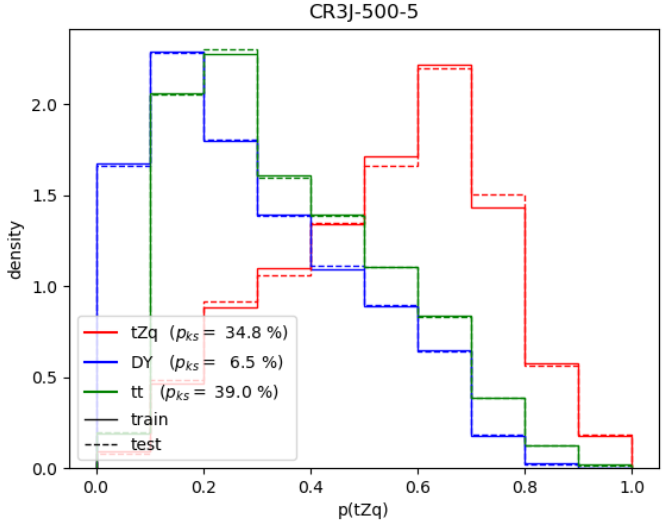
$$\chi^2 = \frac{\left(m_t^{gen} - m_t^{reco}\right)^2}{\Gamma_t^2} + \frac{\left(m_W^{gen} - m_W^{reco}\right)^2}{\Gamma_W^2}$$



DNN for S/B discrimination

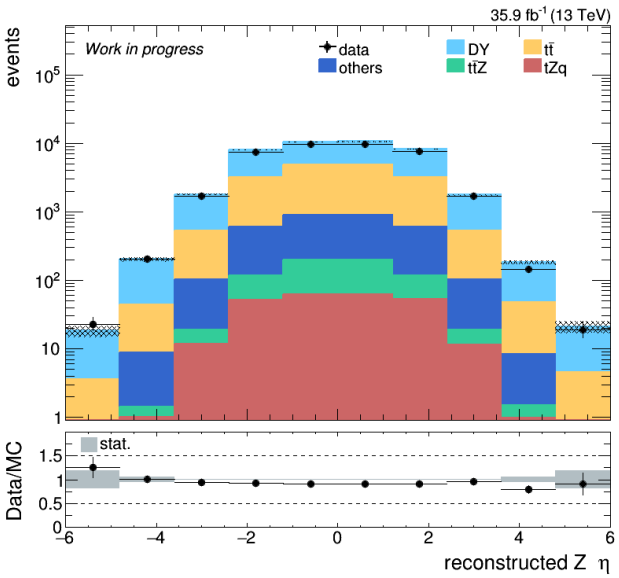
- Region with ≥ 4 jets:
  - input variables from both pre-selection and event reconstruction
  - 4 output nodes: tZq, DY, $t\bar{t}$ and $t\bar{t}Z$
- Region with 3 jets:
  - input variables from pre-selection
  - 3 output nodes: tZq, DY and $t\bar{t}$

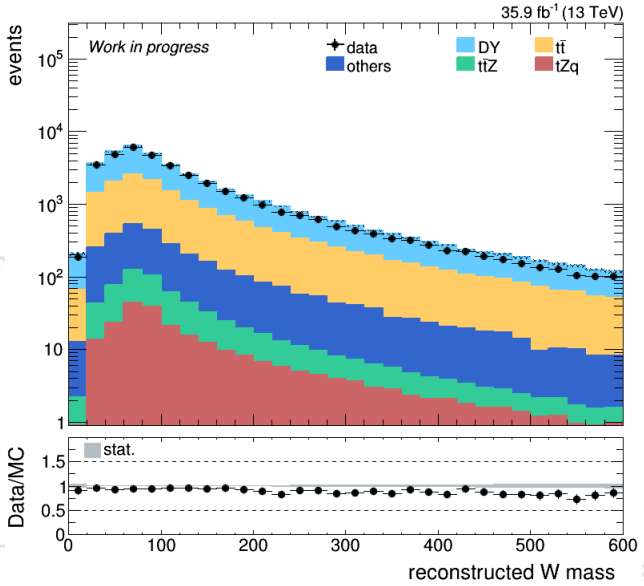


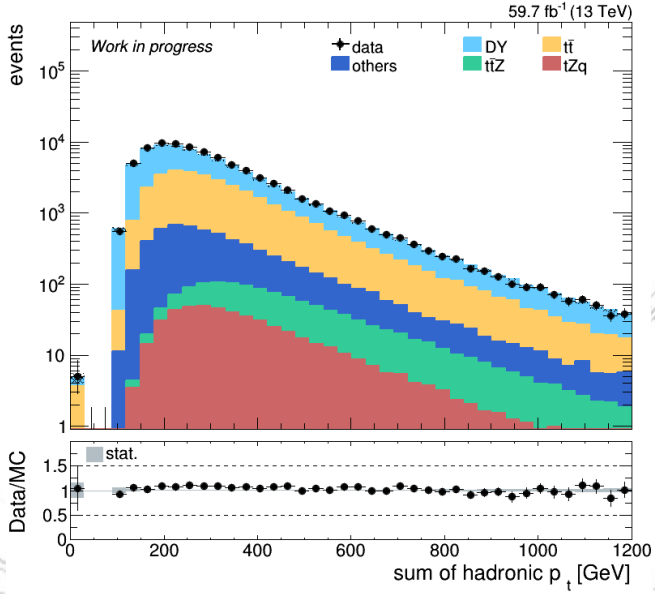


DNN: input variables (1/2)

- Only variables with a good data/MC agreement have been used in the training:

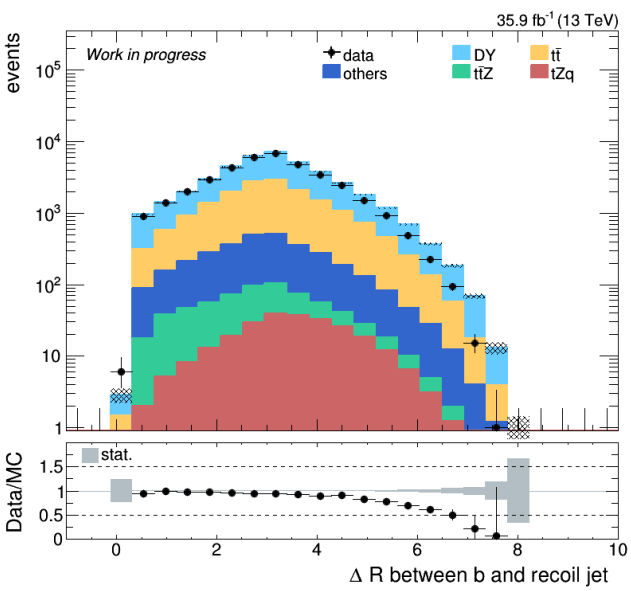


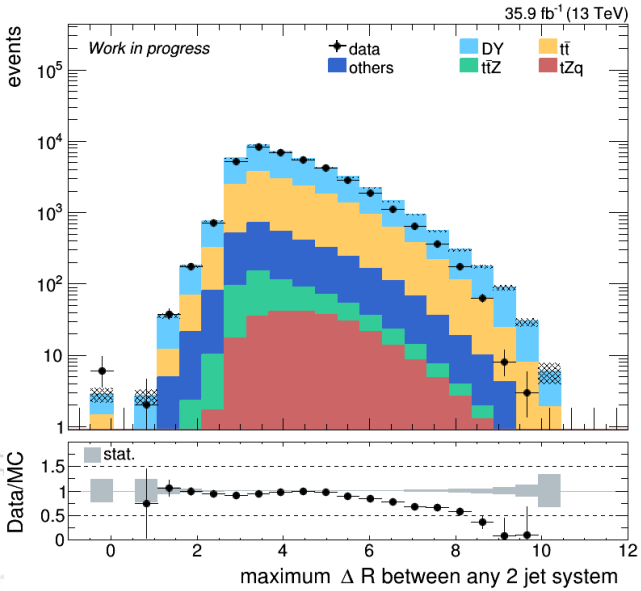


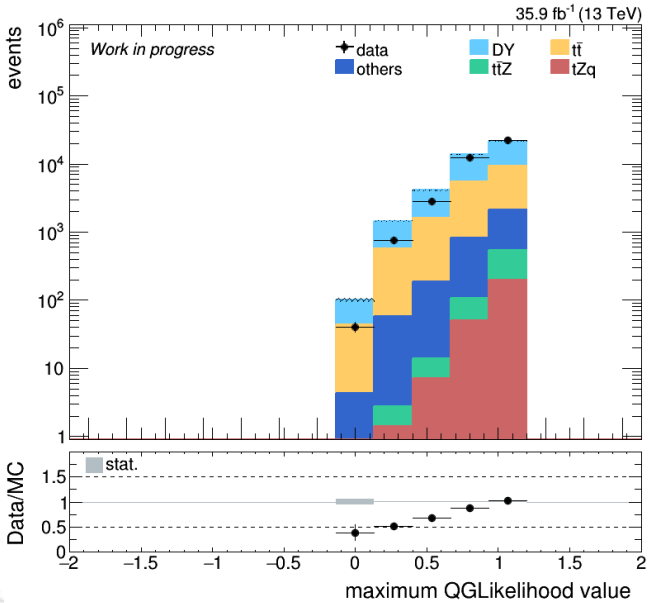


DNN: input variables (2/2)

- Variables with a strong disagreement have been excluded:

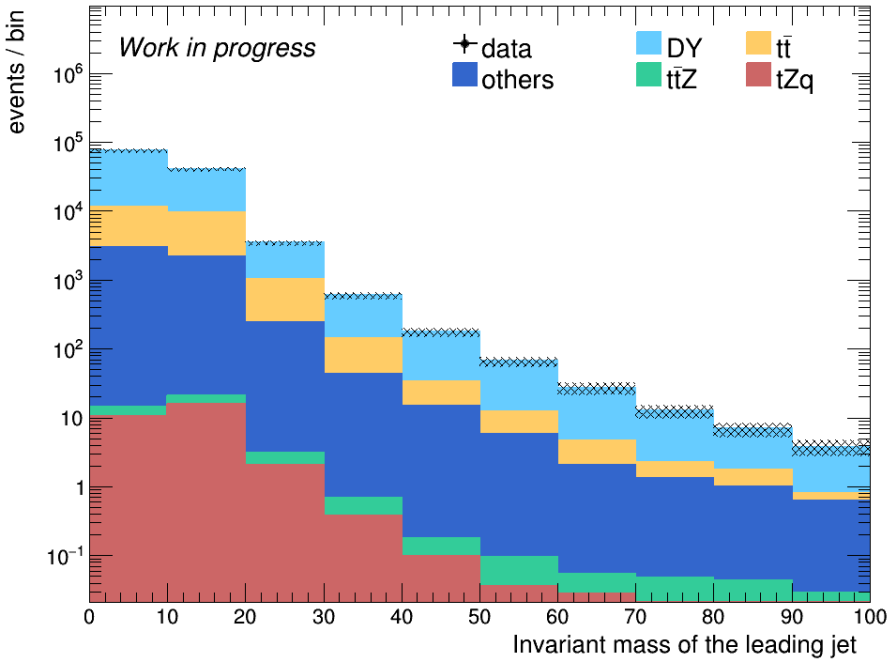




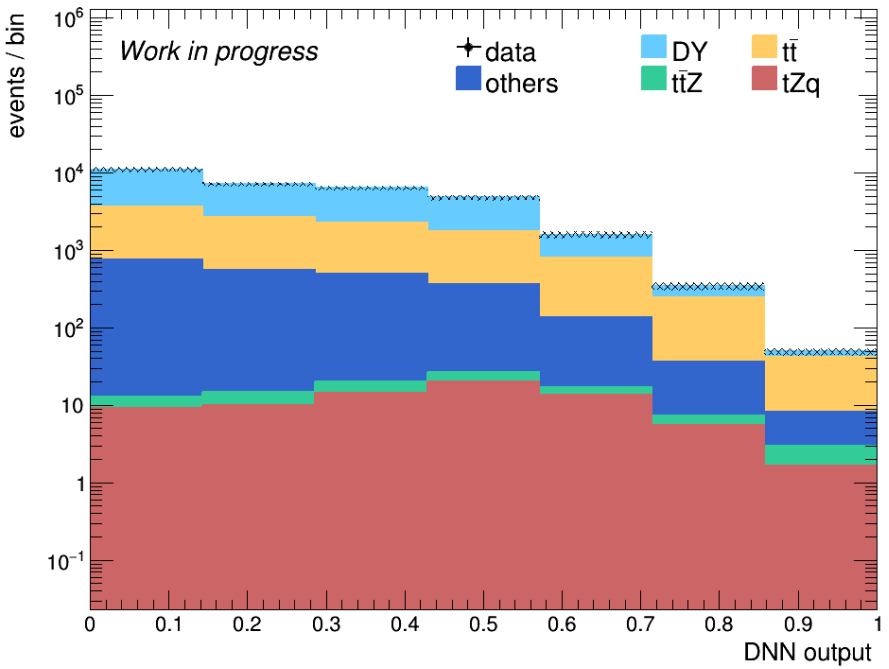


Pre-fit plots: CRs

- 2 jet region: invariant mass of the leading jet

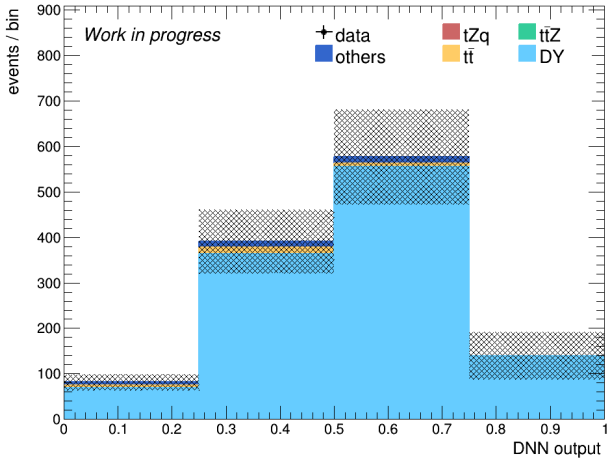


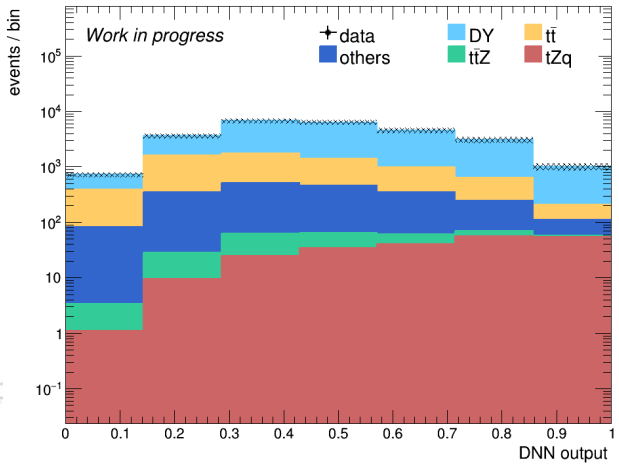
- 3 jet region: tZq output node

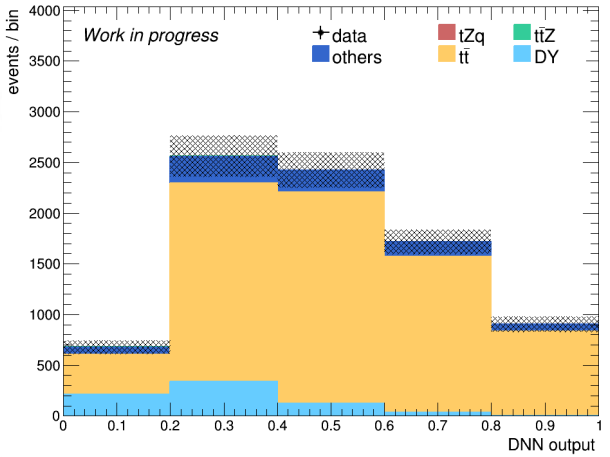


Pre-fit plots: SR

- tZq, DY and tt output: only events for which the value is the maximum among all nodes are included, in order to have orthogonal categories





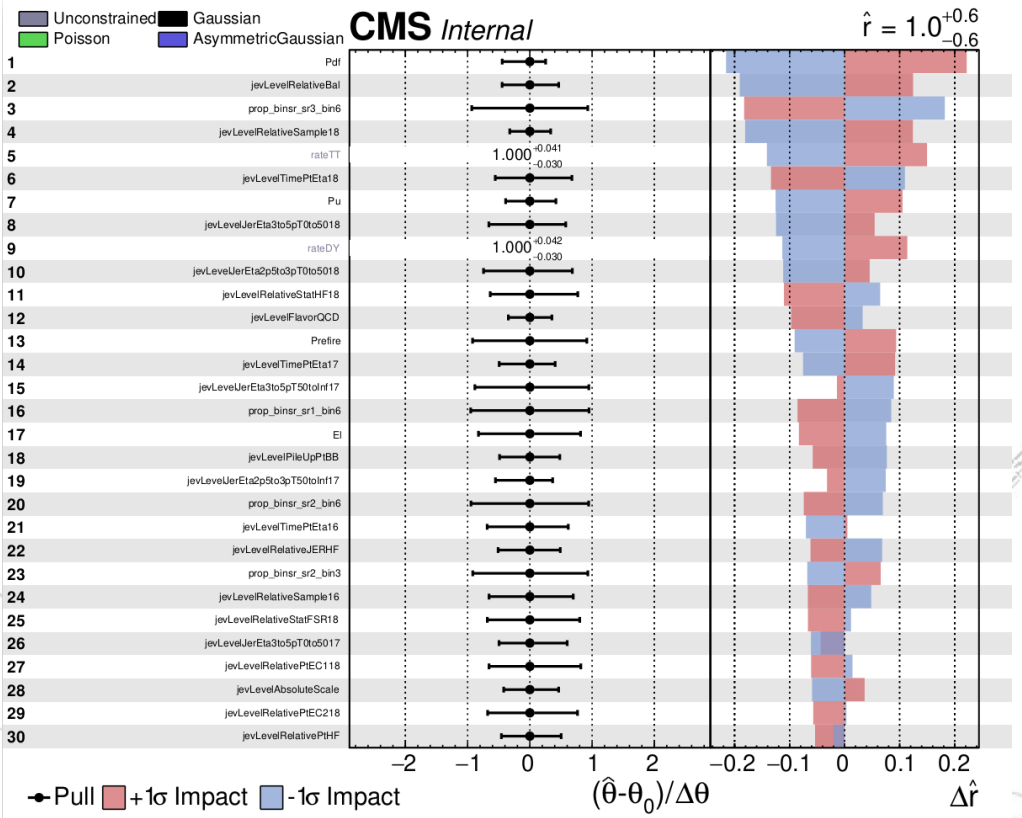


Uncertainties and fit results

- Statistical uncertainties
- Systematic uncertainties:
  - luminosity
  - trigger efficiency
  - normalization for $t\bar{t}Z$ and *others* (15%)
  - lepton and b-tag scale factors
  - pile-up weights
  - Jet energy and resolution
  - PS weights (tZq and $t\bar{t}Z$)
  - PDF, α_S and matrix element (tZq + main backgrounds)

Results (expected):

- 1.72 σ



Summary

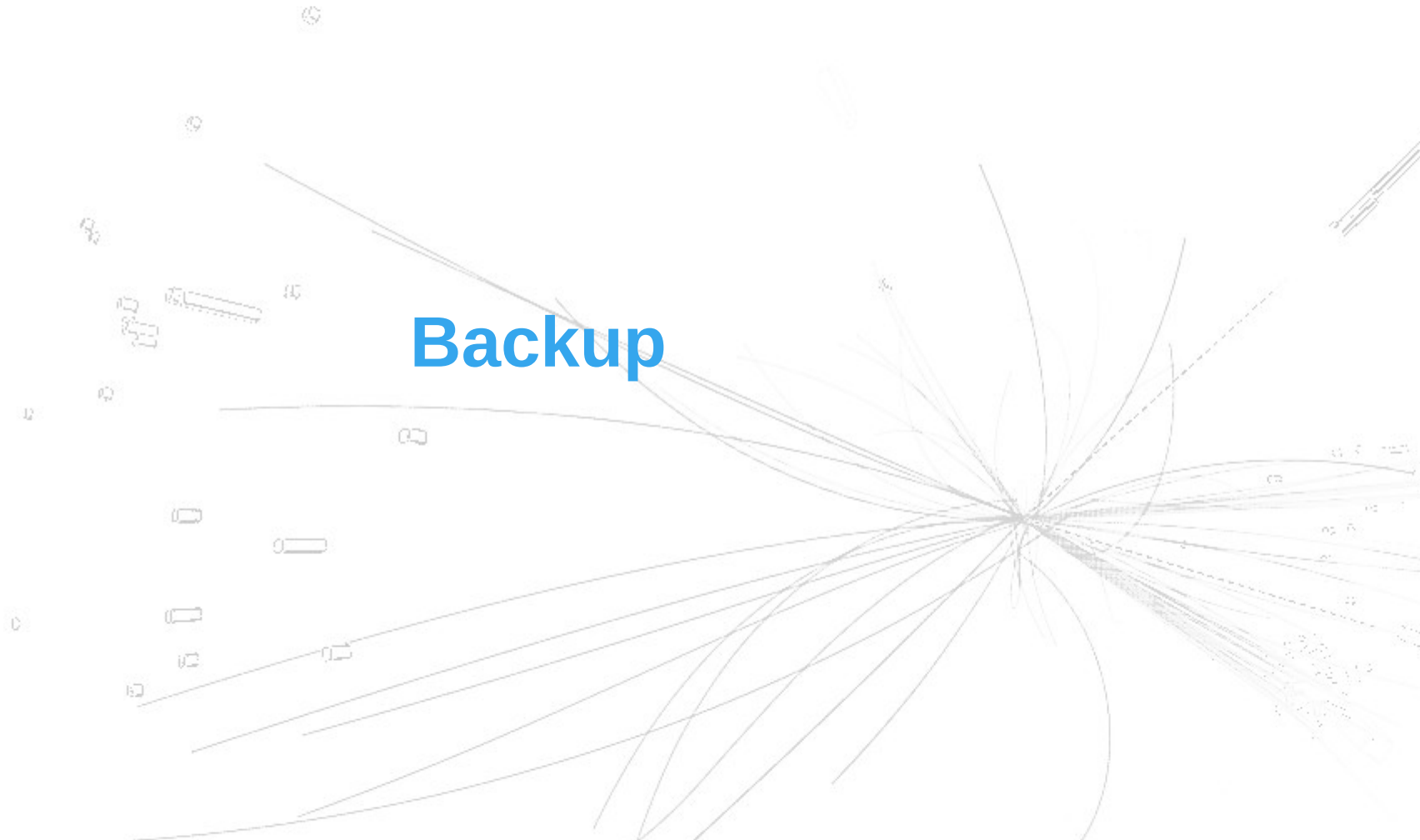
- We set up an analysis for tZq in the 2ℓ final state:
  - two DNN have been trained in order to separate tZq from the main backgrounds
  - a statistical fit is performed simultaneously on 3 different regions, depending on jet multiplicity
  - an expected significance of **1.72 σ** is reached, data have not been included yet

Next steps:

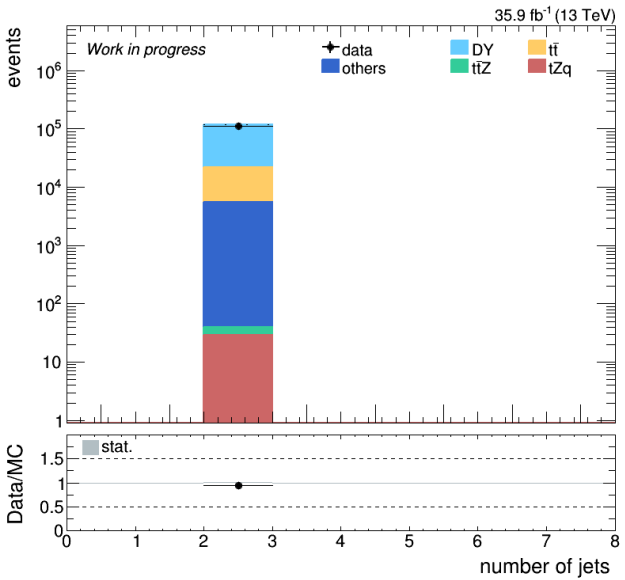
- Partial unblinding of the analysis
- Ask for total unblindig and public result

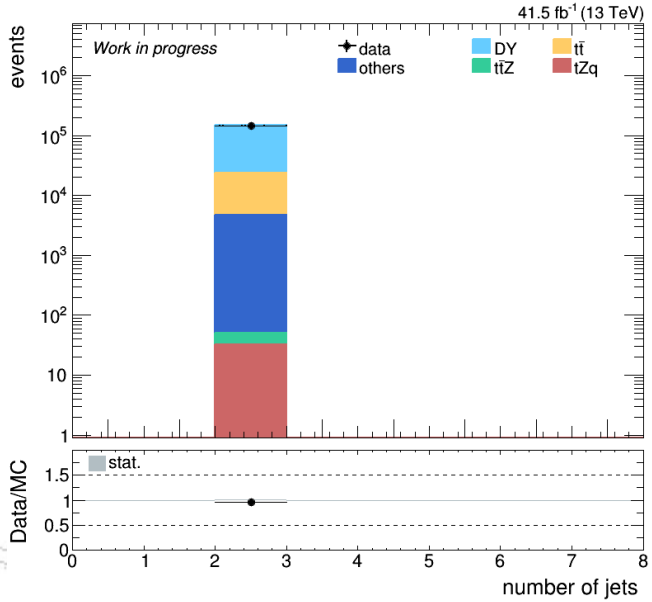
Thank you!

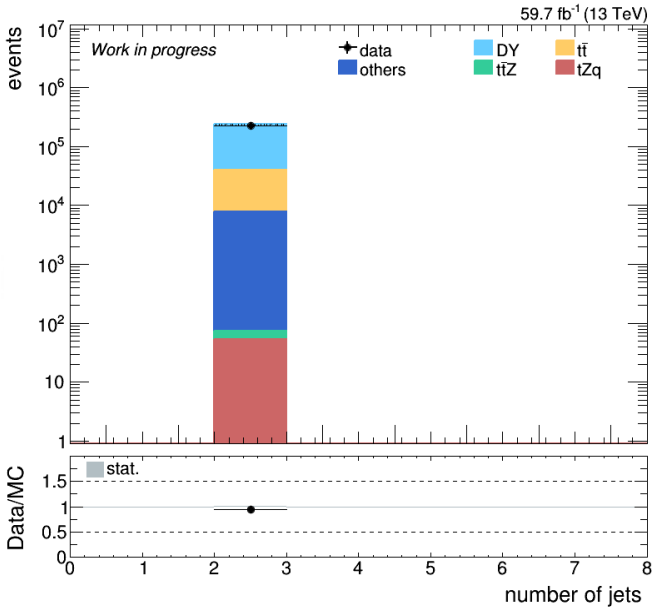
Backup



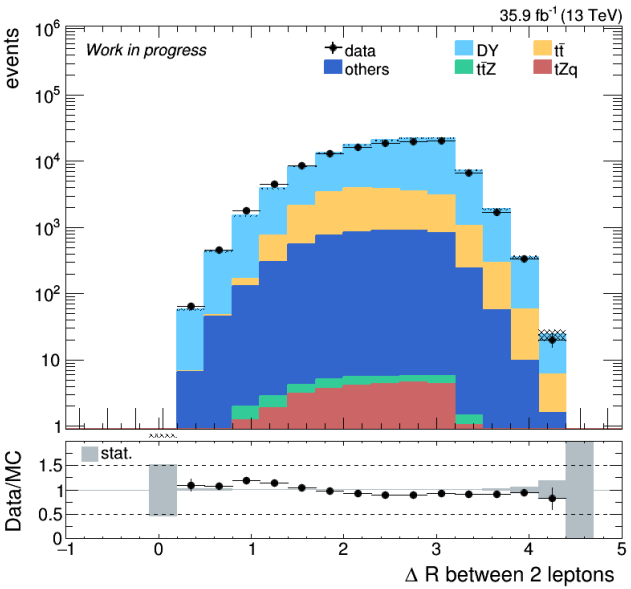
Control Plots: CR (2 jets)

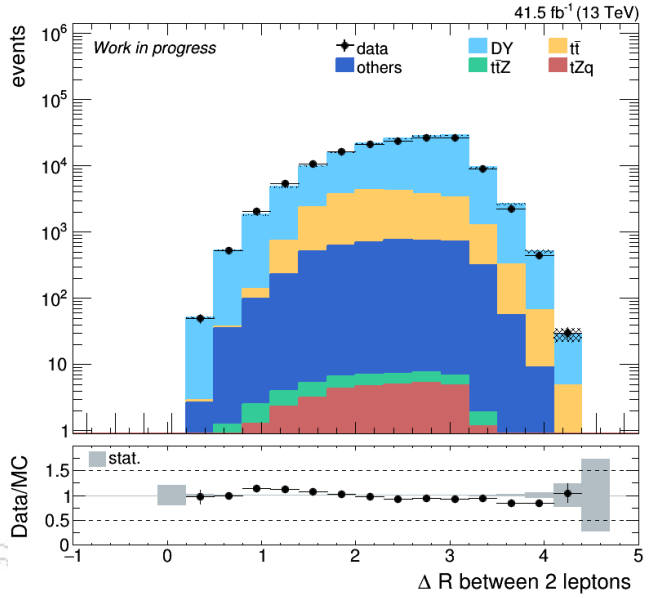


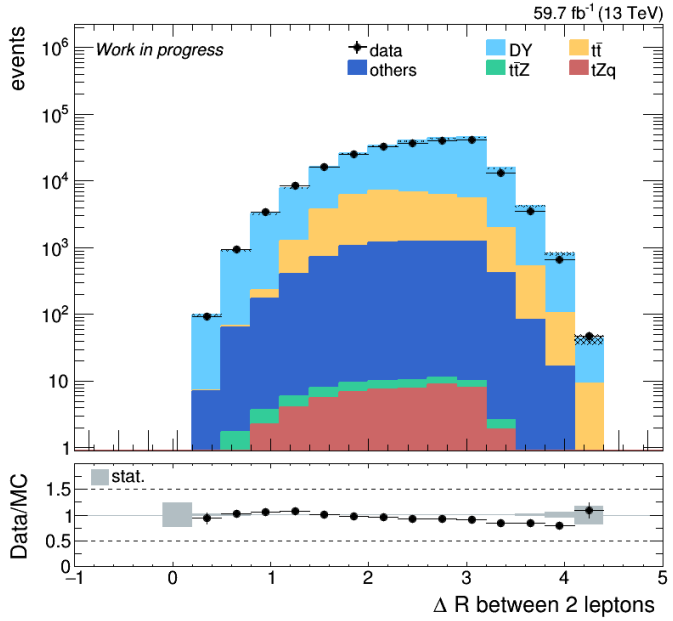




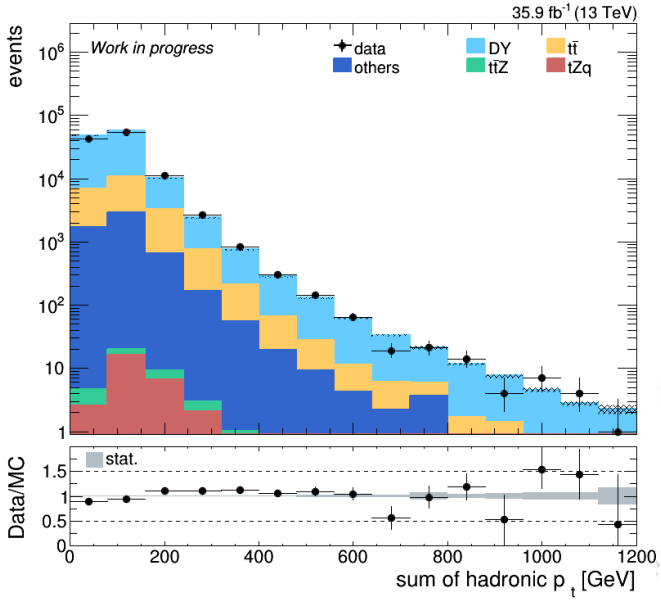
Control Plots: CR (2 jets)

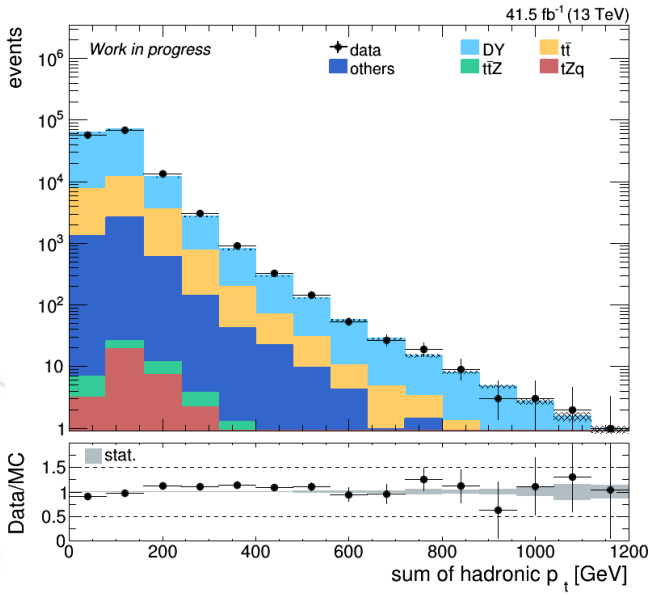


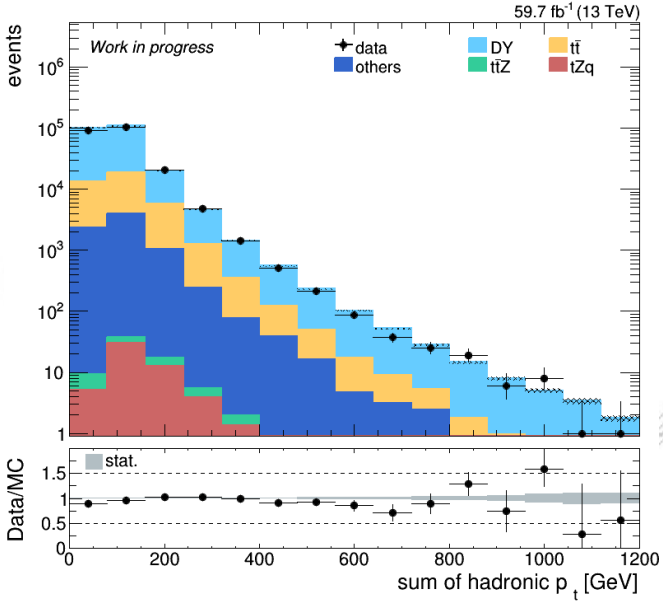




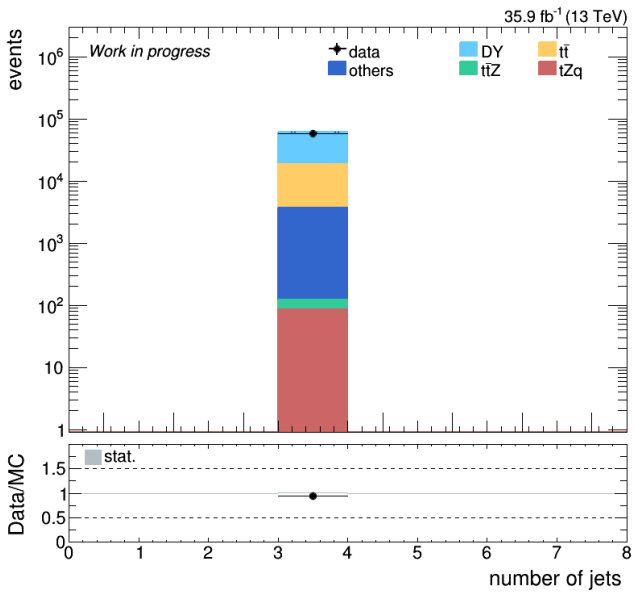
Control Plots: CR (2 jets)

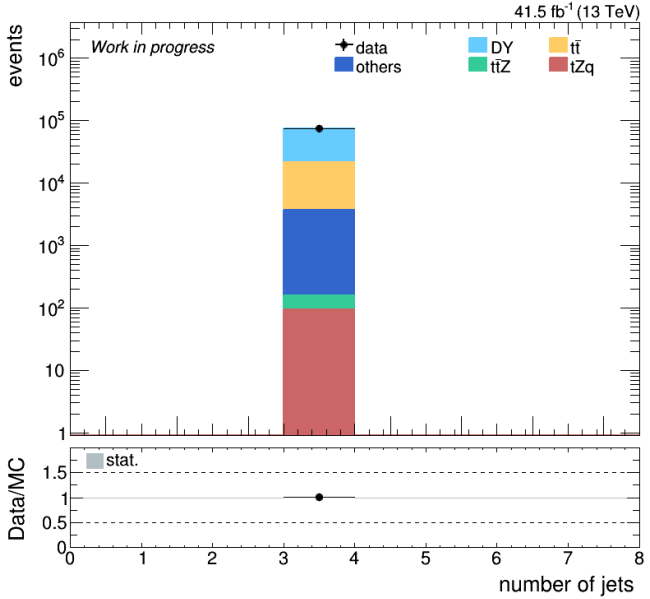


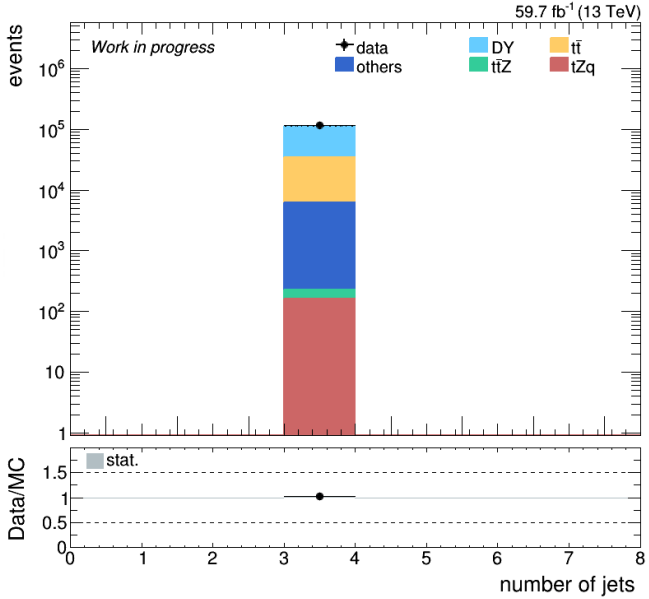




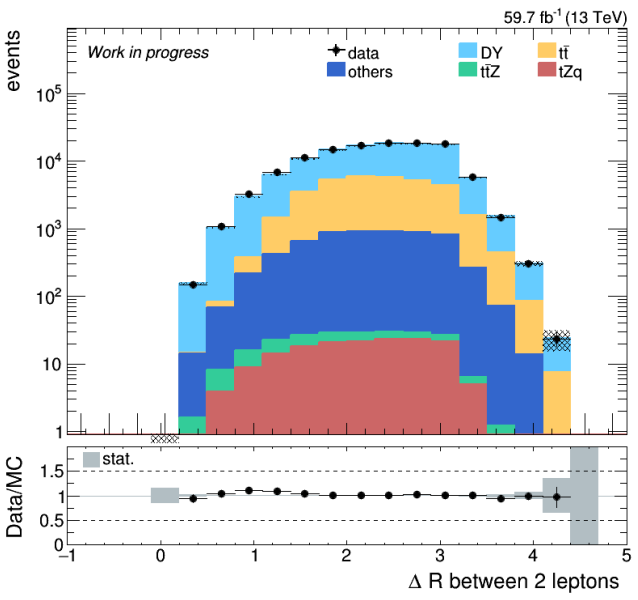
Control Plots: CR (3 jets)

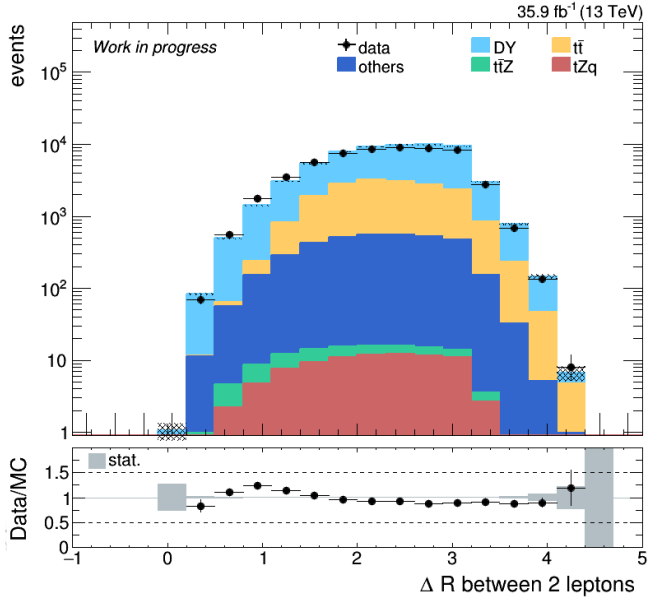


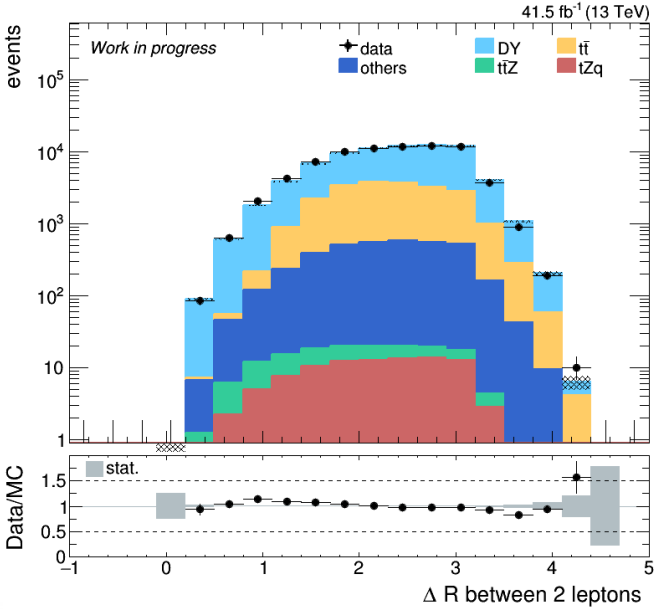




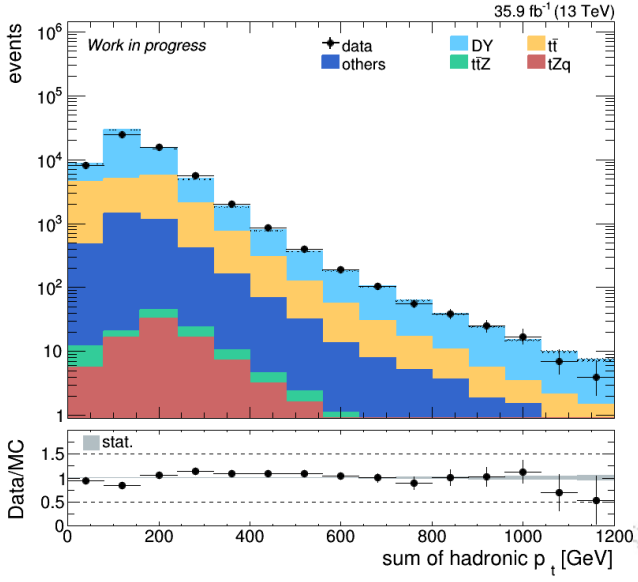
Control Plots: CR (3 jets)

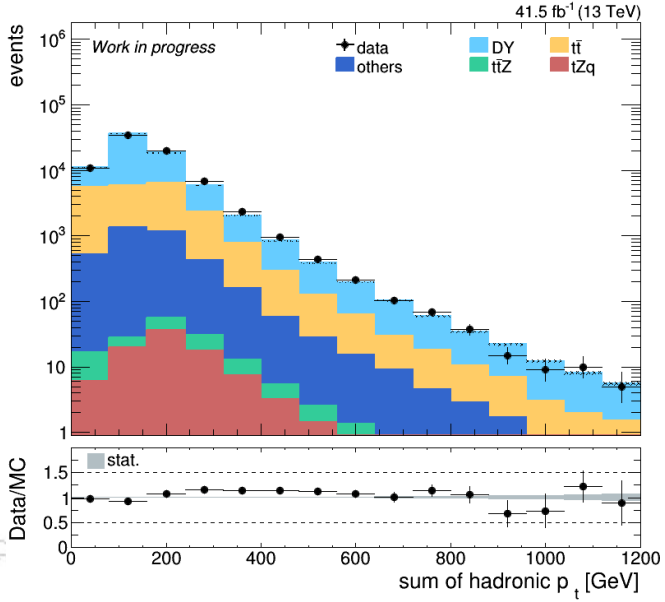


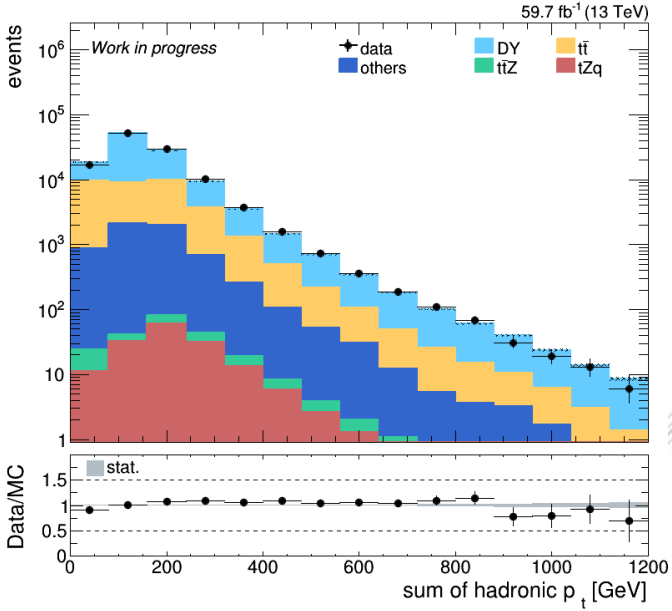




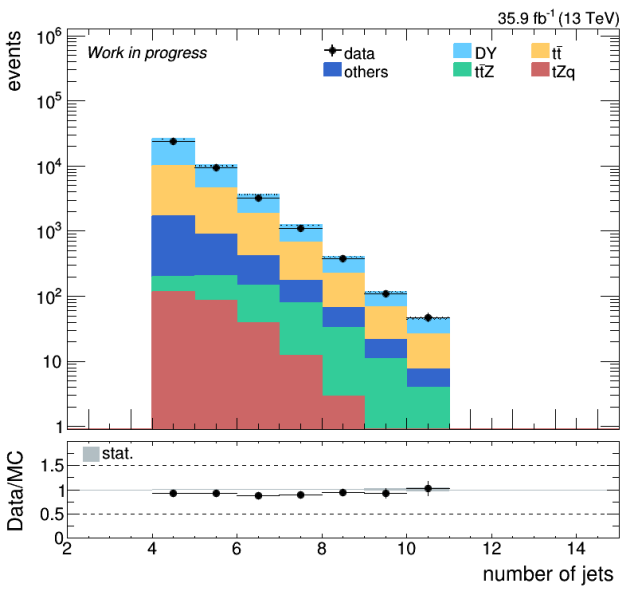
Control Plots: CR (3 jets)

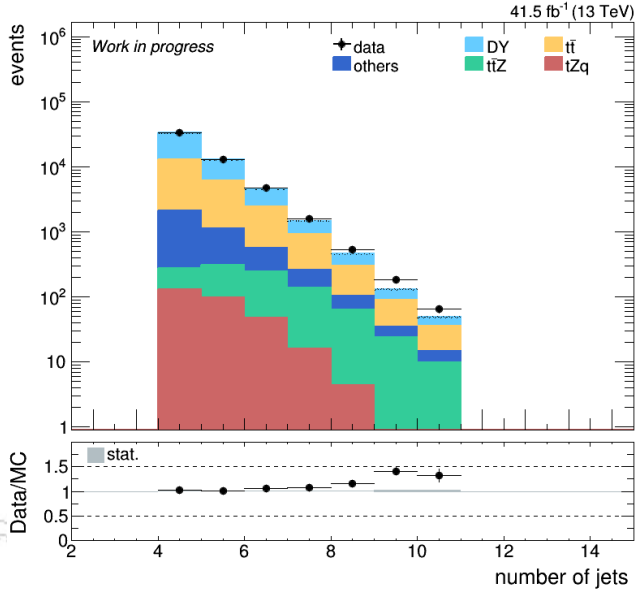


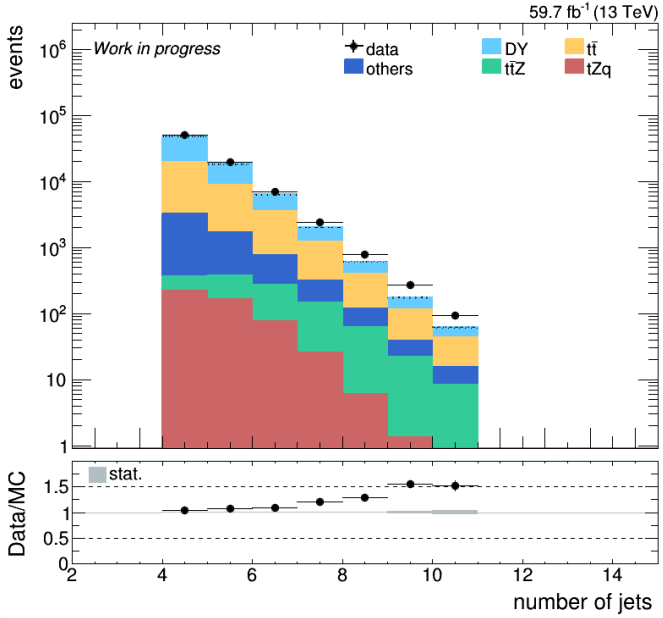




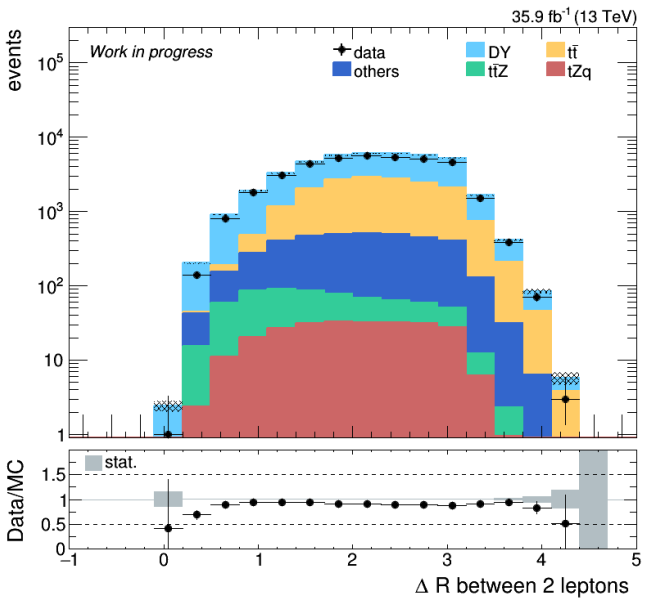
Control Plots: SR

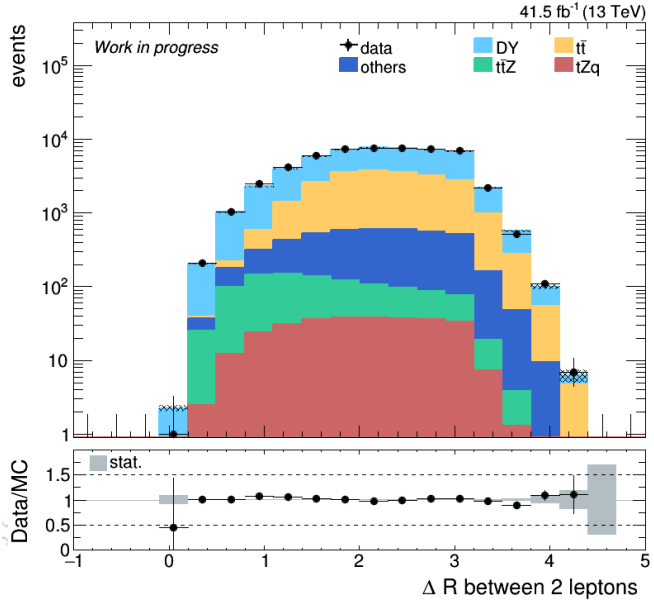


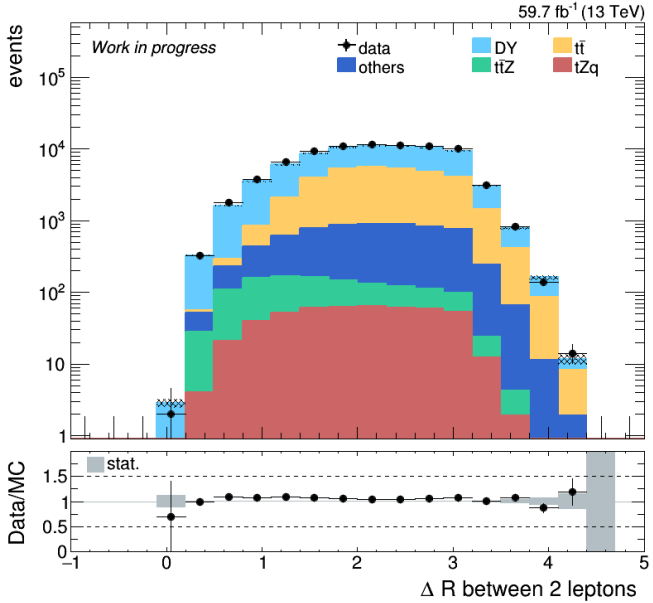




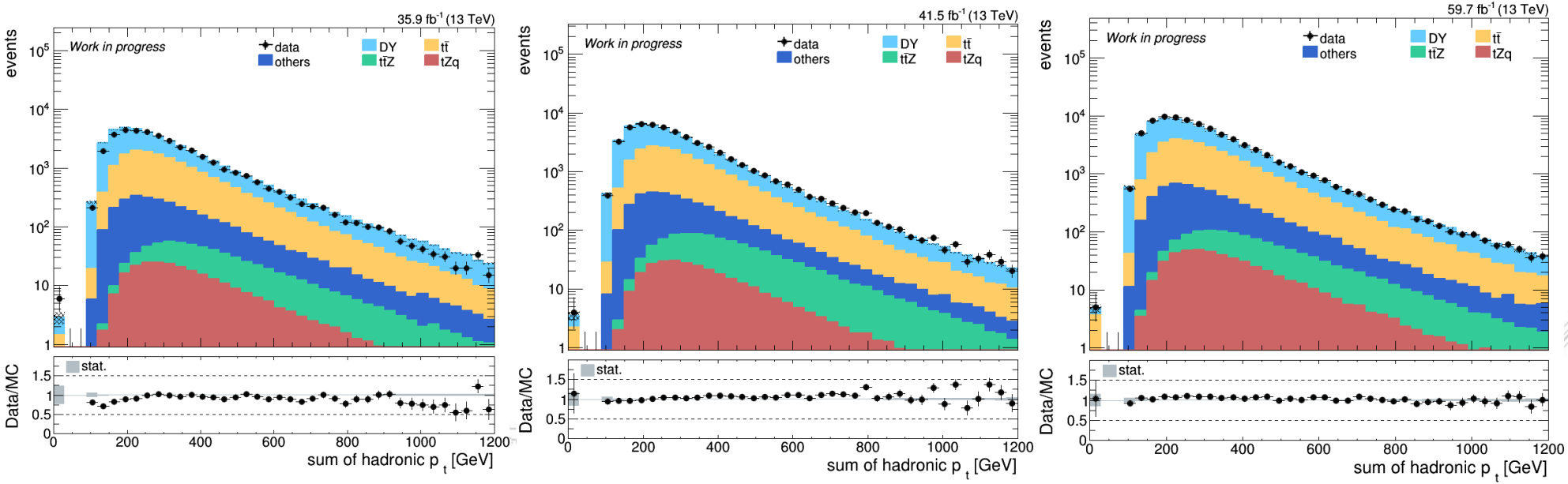
Control Plots: SR



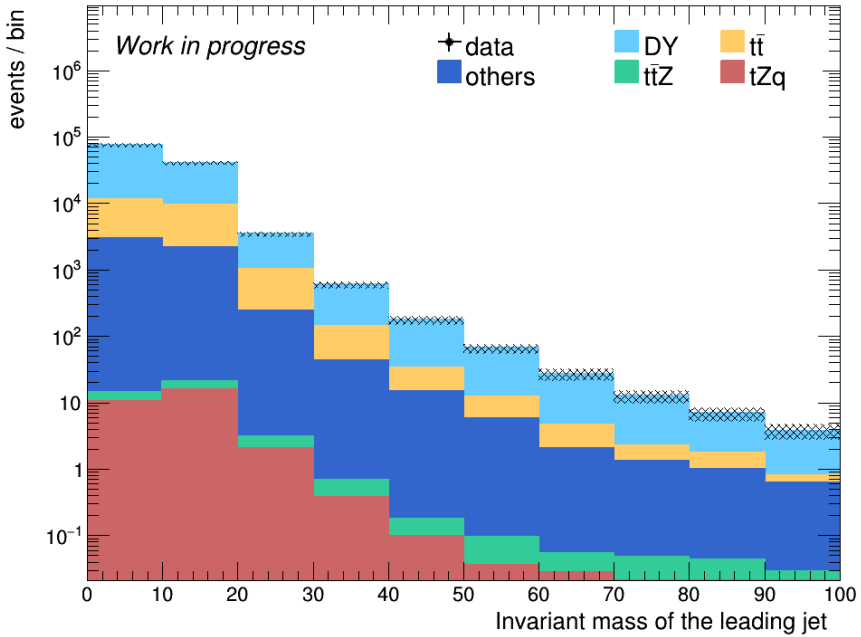


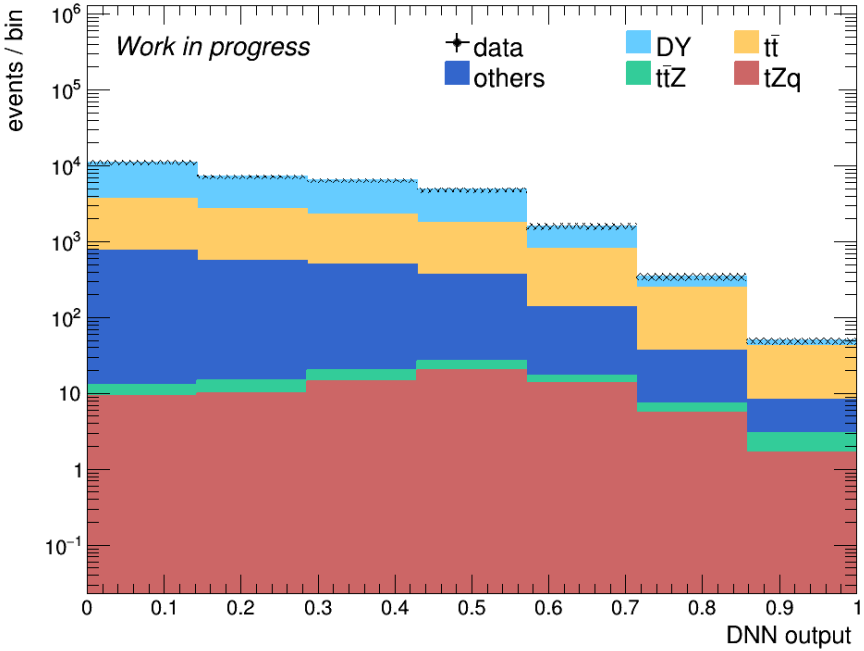


Control Plots: SR

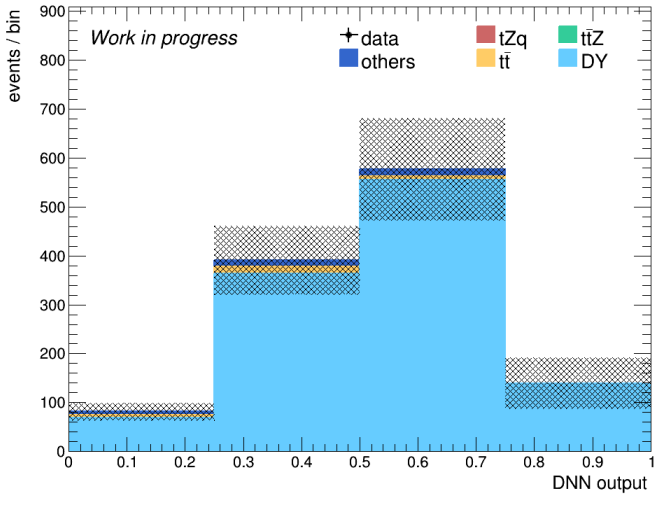


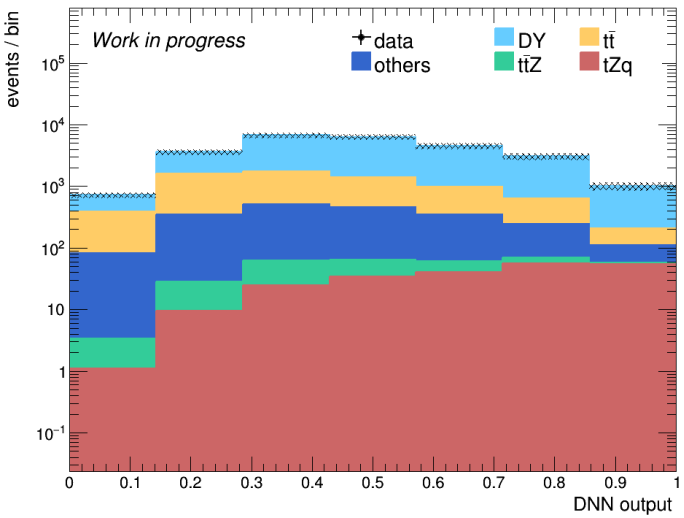
Pre-fit plots: CRs (2016)

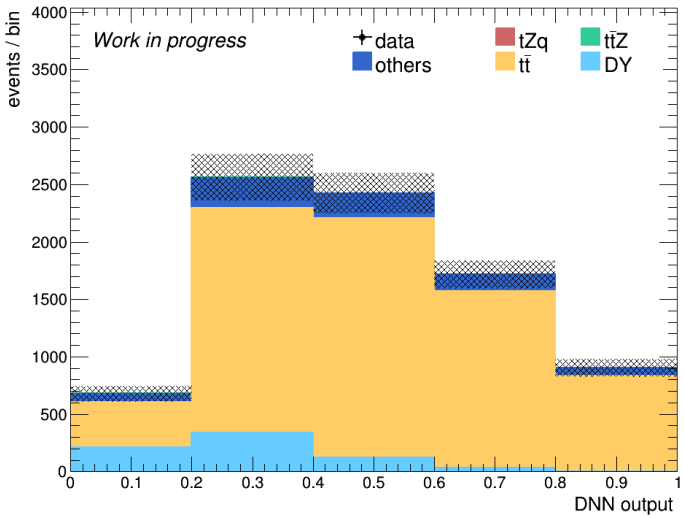




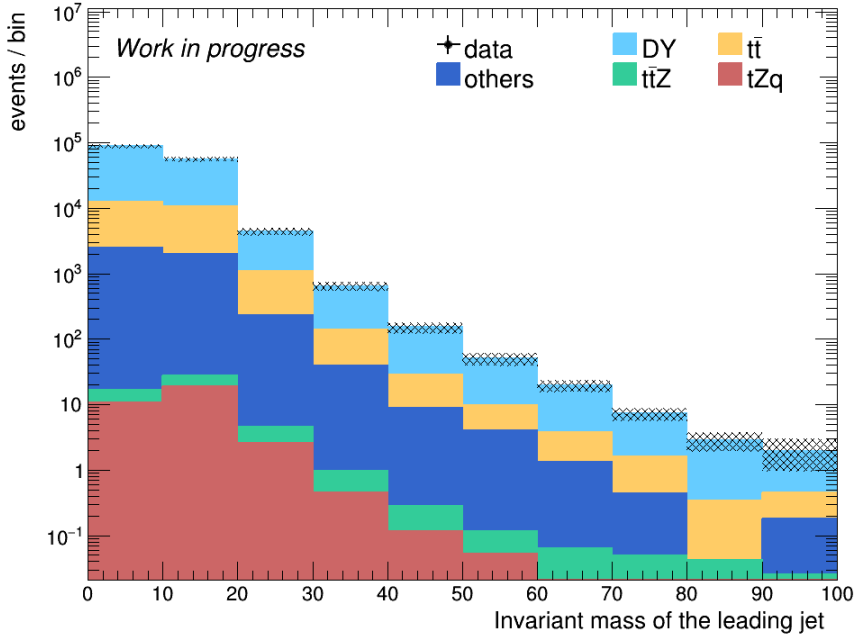
Pre-fit plots: SR (2016)

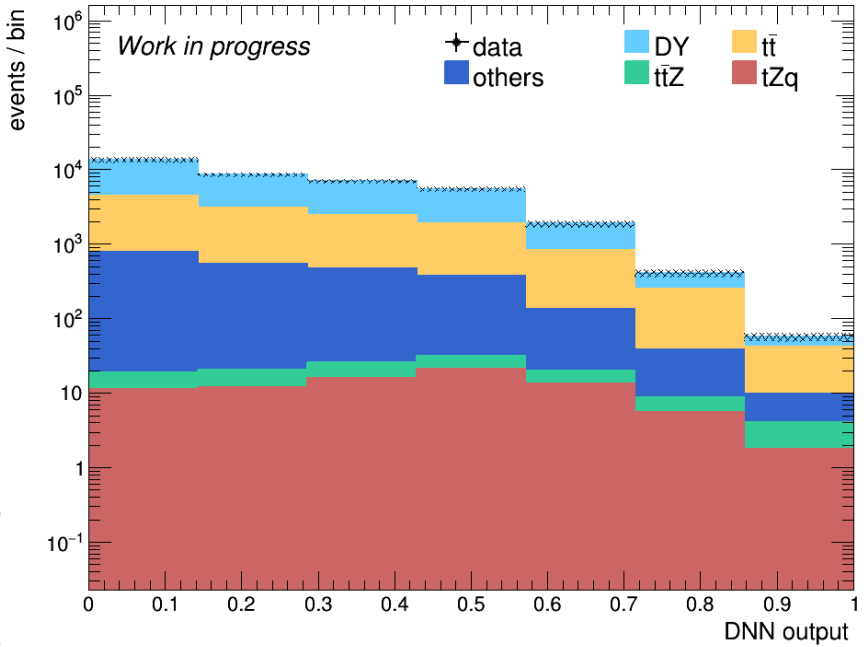




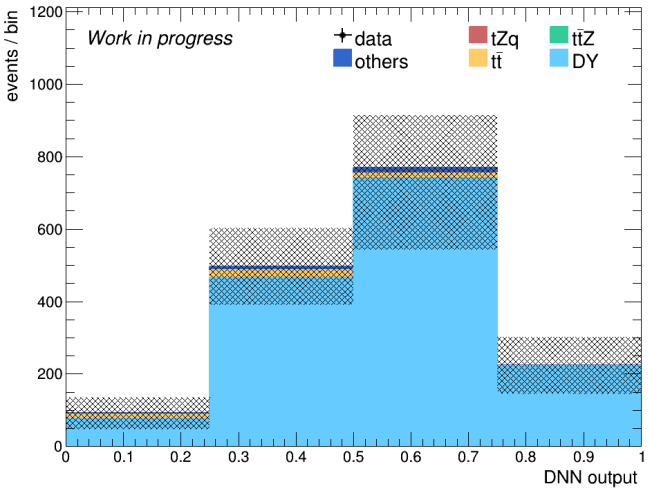


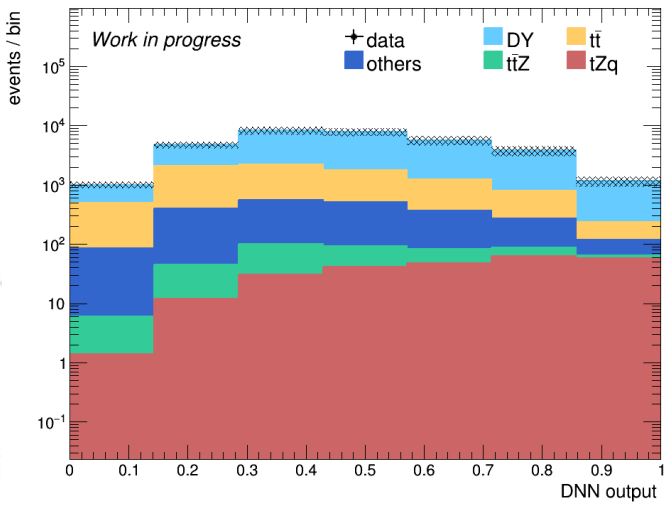
Pre-fit plots: CRs (2017)

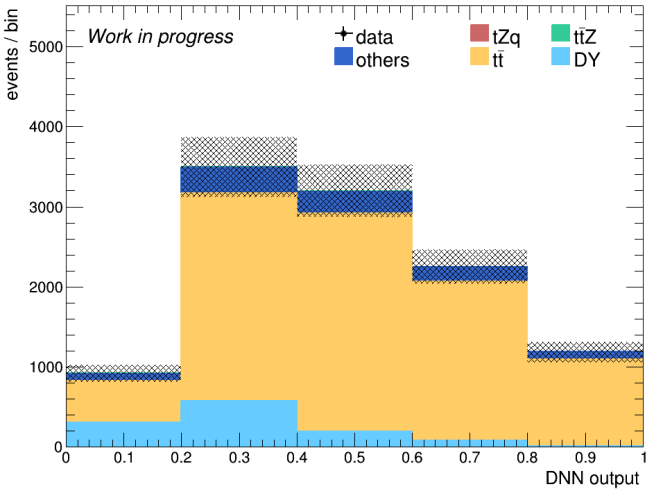




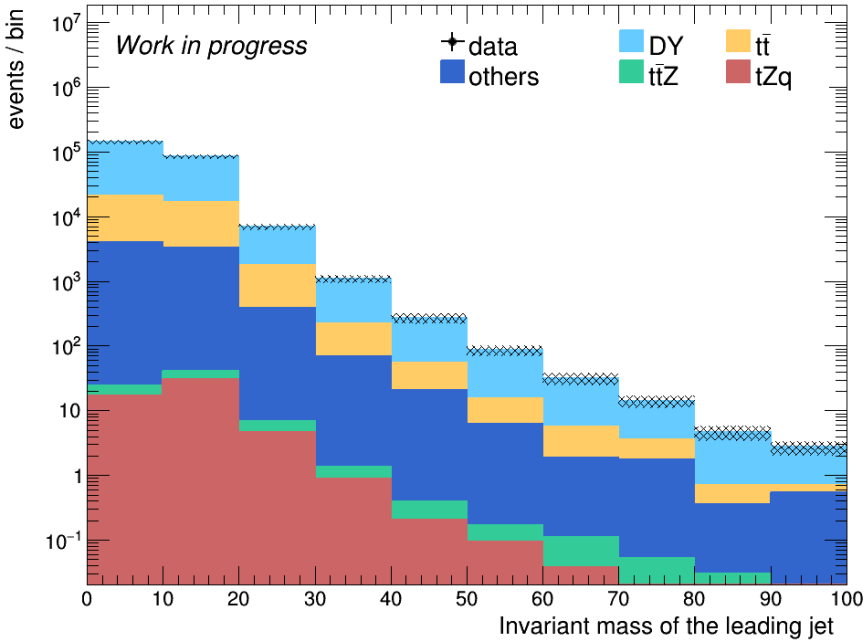
Pre-fit plots: SR (2017)

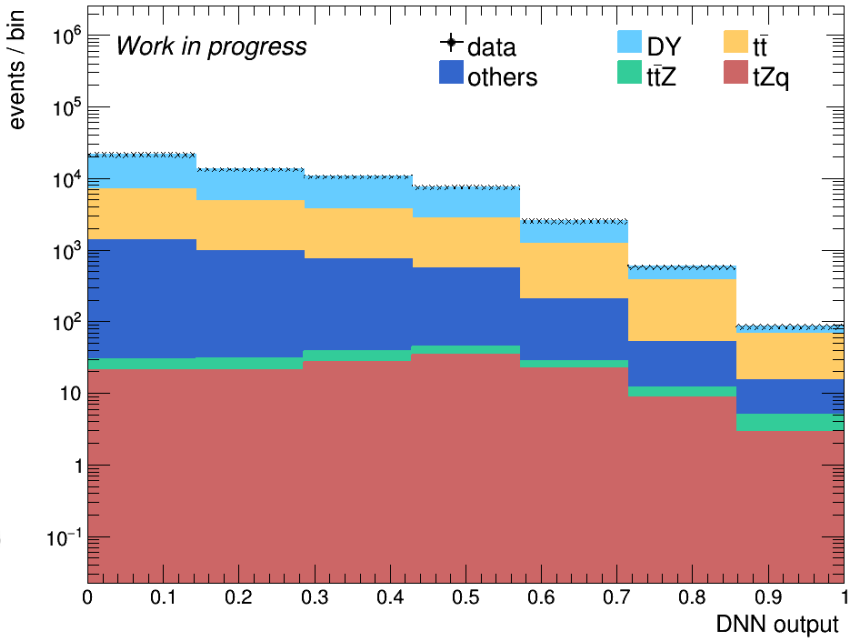






Pre-fit plots: CRs (2018)





Pre-fit plots: SR (2018)