TECHNISCHE UNIVERSITÄT DRESDEN

FSP ATLAS Erforschung von Universum und Materie

ATLAS EXPERIMENT

Fakultät für Mathematik und Naturwissenschaften, Fachrichtung Physik, Institut für Kern und Teilchenphysik

Search for a light CP-odd Higgs boson decaying into a pair of taus with ATLAS

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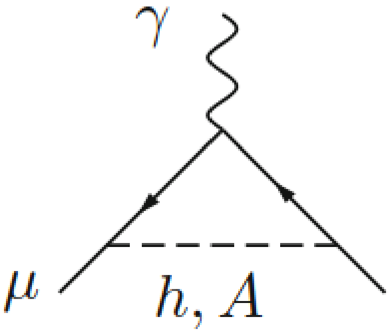
DPG Spring meeting Heidelberg
TH-21 , 23.03.2022

DRESDEN concept
Exzellenz aus Wissenschaft und Kultur

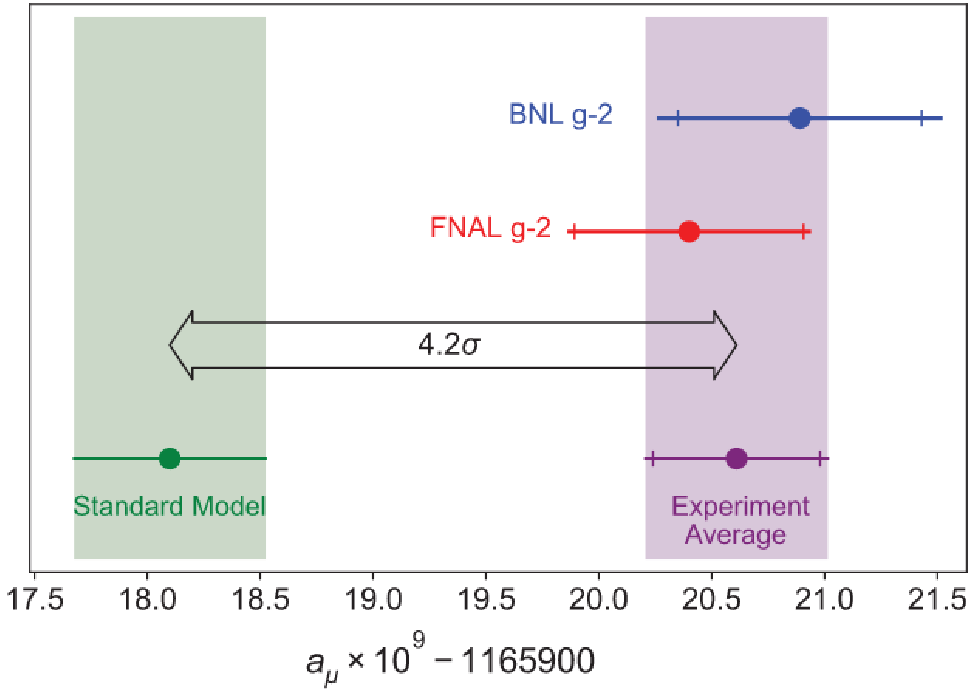
Motivation

- Experiments show deviation of the anomalous magnetic moment

  → loop contributions from a low-mass, chargeless CP-odd A-boson (2HDM)

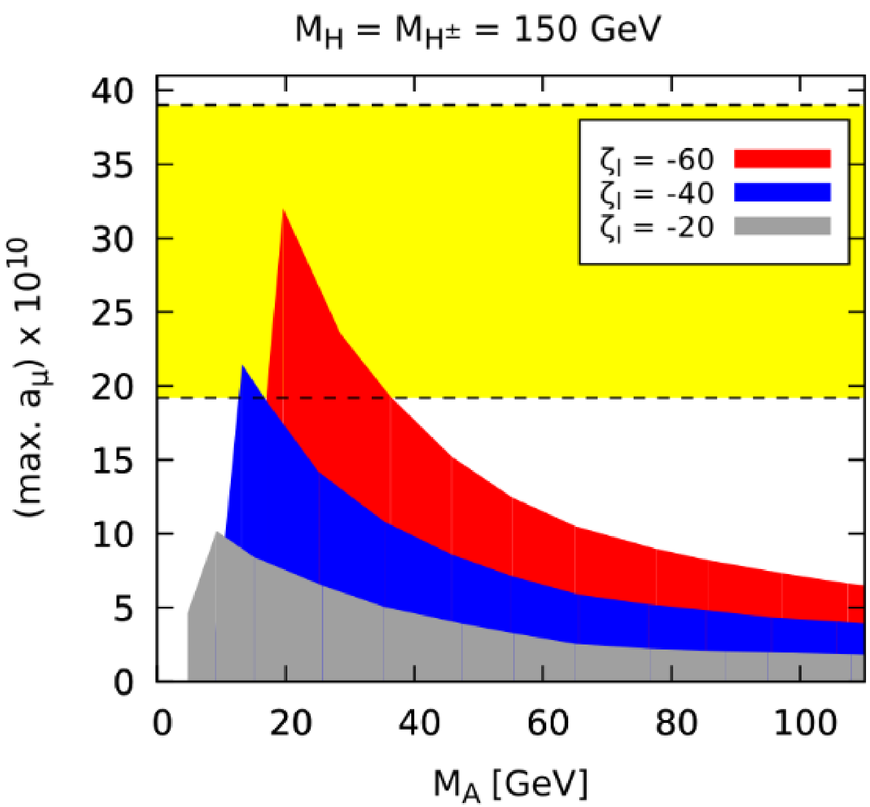


[F.Jegerlehner , “The anomalous magnetic moment of the muon”]



Experimental values of a_μ from the BŃL E821 (blue), FNAL (red) and the combined average (purple) compared to the SM prediction (green) [PhysRevLett.126.141801]

Motivation

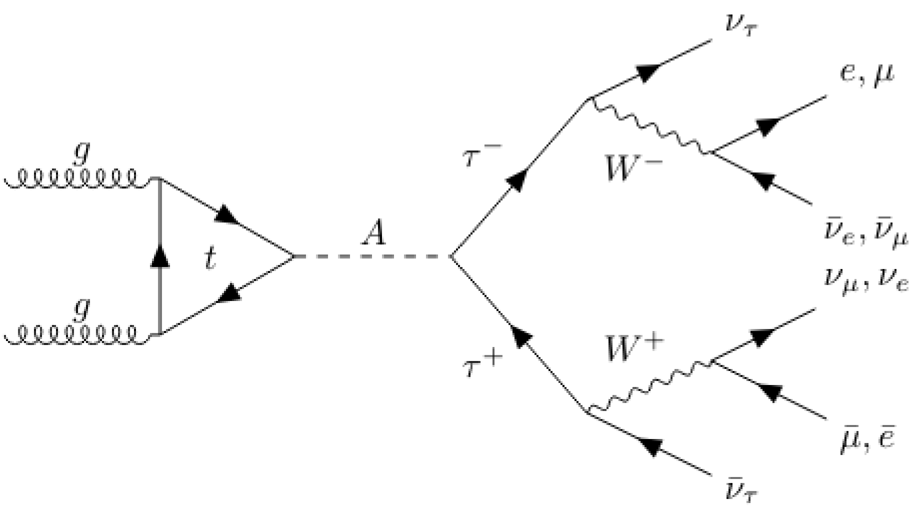


- High contribution for low A-Boson masses and high coupling parameters

  → this model can explain the deviation experimentaly observed for A-boson masses of ~25GeV and coupling parameter ~-60

Anomalous magnetic moment of the muon depending on the mass of the A-Boson
arXiv:1711.11567 [hep-ph]

Signal process



production and decay processes of the A boson at the ATLAS detector
[P. Moder, "Search for a light CP-odd Higgs boson decaying into a $\tau\,\tau$ pair"]

- only production channels are via gluon fusion and a top quark loop

- A boson decays only into a pair of τ-leptons
  → τ-leptons can decay leptonically
  or hadronically
- Measure leptonic decay into one electron one muon and four neutrinos
- Lepton decay allows for searches of low m_A

Event selection and Control regions

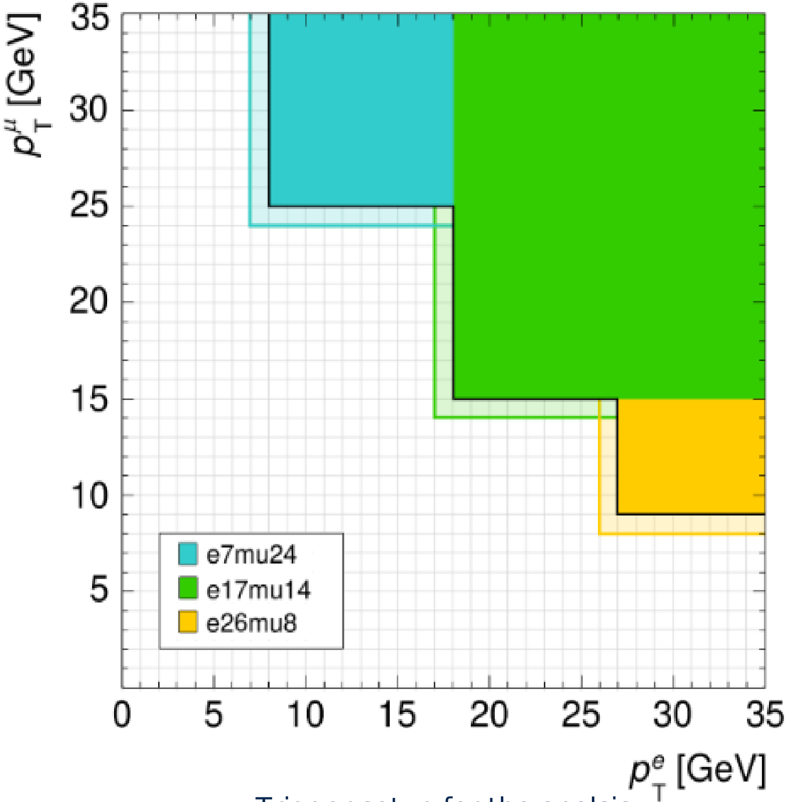
- Baseline selection:
  - Combination of electron and muon triggers
  - ID and Isolation selection
  - No b-jet
  - 1 electron and 1 muon with opposite charge
- Signal region:

  $m_T^{tot} < 65\,\mathrm{GeV}$ $\Delta R_{ll} < 1{,}0$

- $Z \rightarrow \tau\tau$ control region:

  $m_T^{tot} < 85\,\mathrm{GeV}$ $\Delta R_{ll} > 1{,}4$

- Top control region:
  - b-jet required



Trigger setup for the analsis

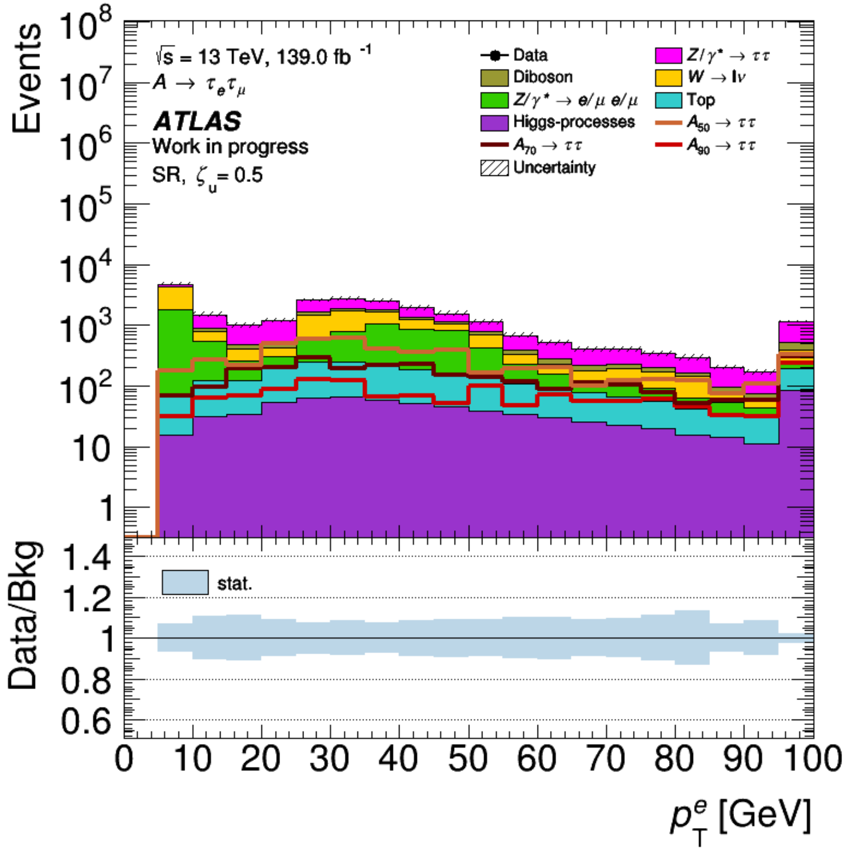
[X.Sonntag, “Optimized search for a light CP-odd Higgs boson decaying into two τ-leptons using the ATLAS detector“]

Monte-Carlo backgounds

- Most of the backgrounds are obtained via Monte-Carlo Simulation
- $Z \rightarrow \tau\tau$
- $Z \rightarrow \mu\mu$, $Z \rightarrow ee$ (heavily supressed)
- Top quark processes
- $W \rightarrow l\nu$
- Diboson processes
- Higgs processes
- QCD processes

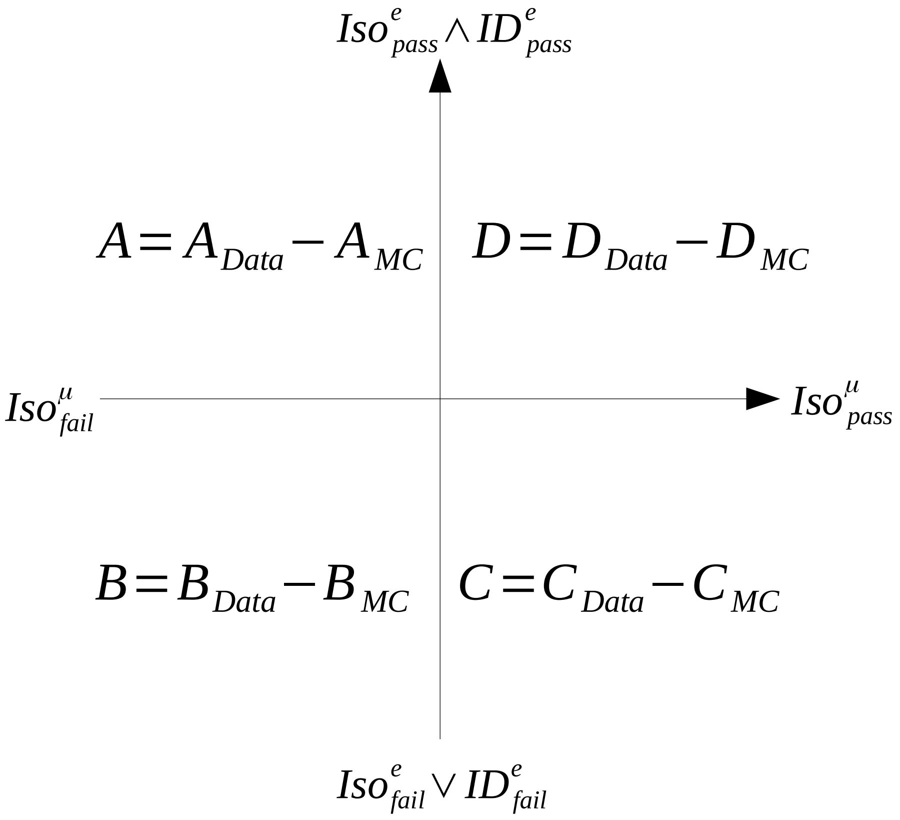
→ Monte-Carlo Simulation does not produce a reliable background

→ data-driven method



Electron transverse momentum in the signal region

Multijet (QCD) background



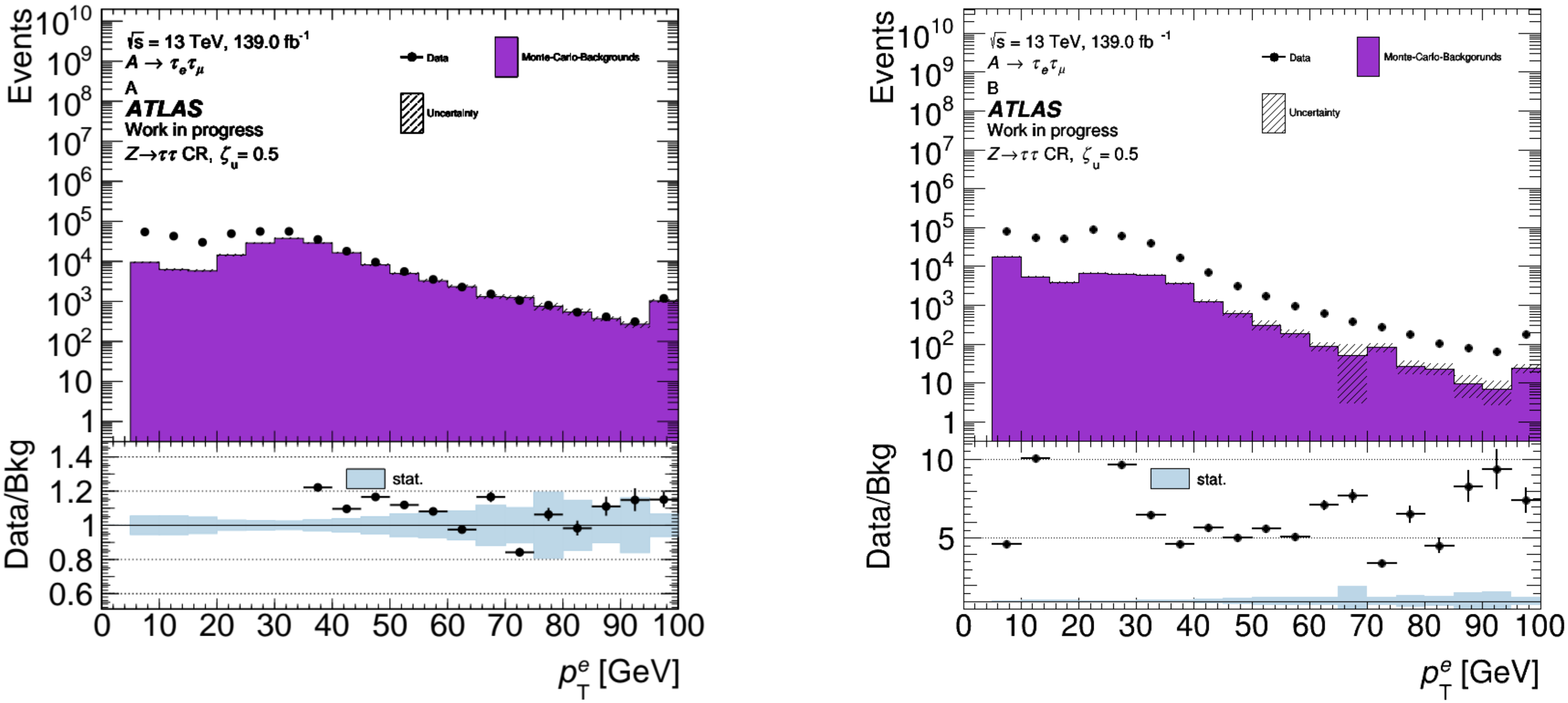
- Goal is an estimation for the QCD background in the „Signal“ Region D with fake factors ff

$$D = ff \cdot C$$

- Fake factors measured in the region, where the muon Isolation criteria is not met

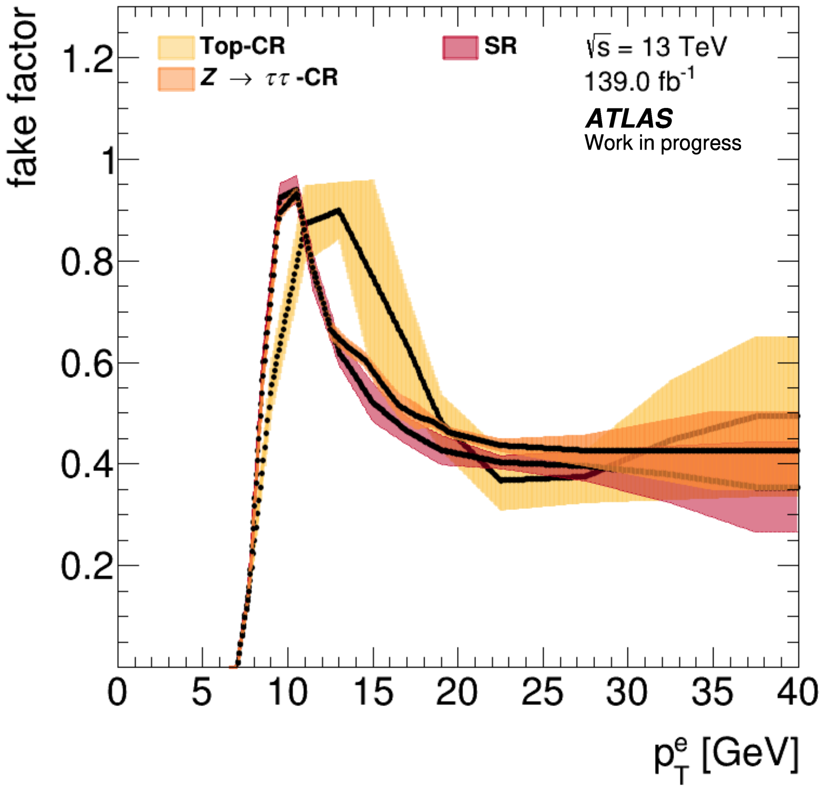
$$ff = \frac{A}{B}$$

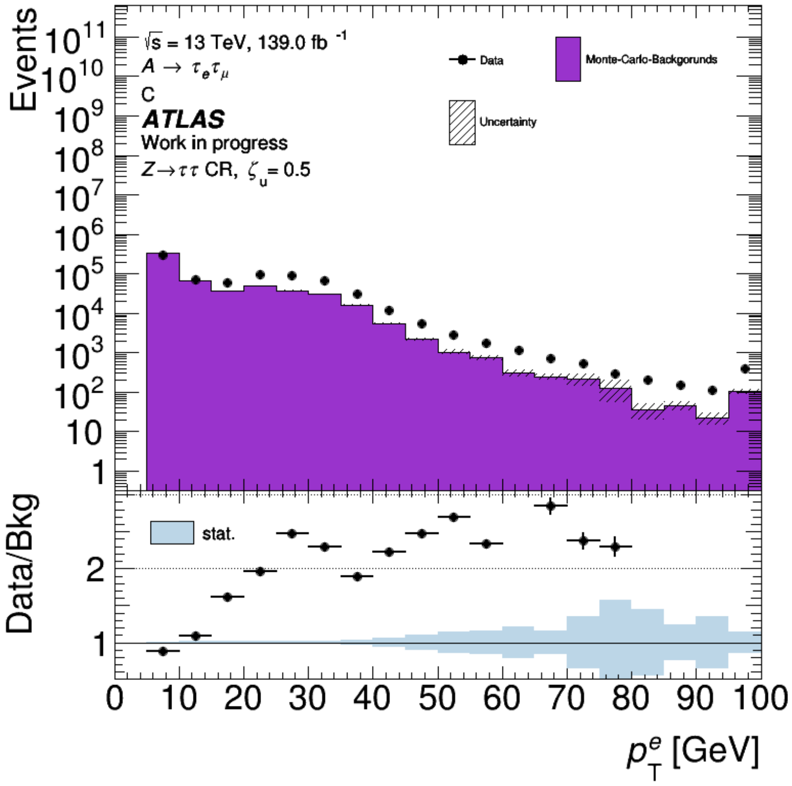
Multijet (QCD) background



Electron transverse momentum in in the Z→ ττ CR in the numerator region A (left) and denominator region B (right)

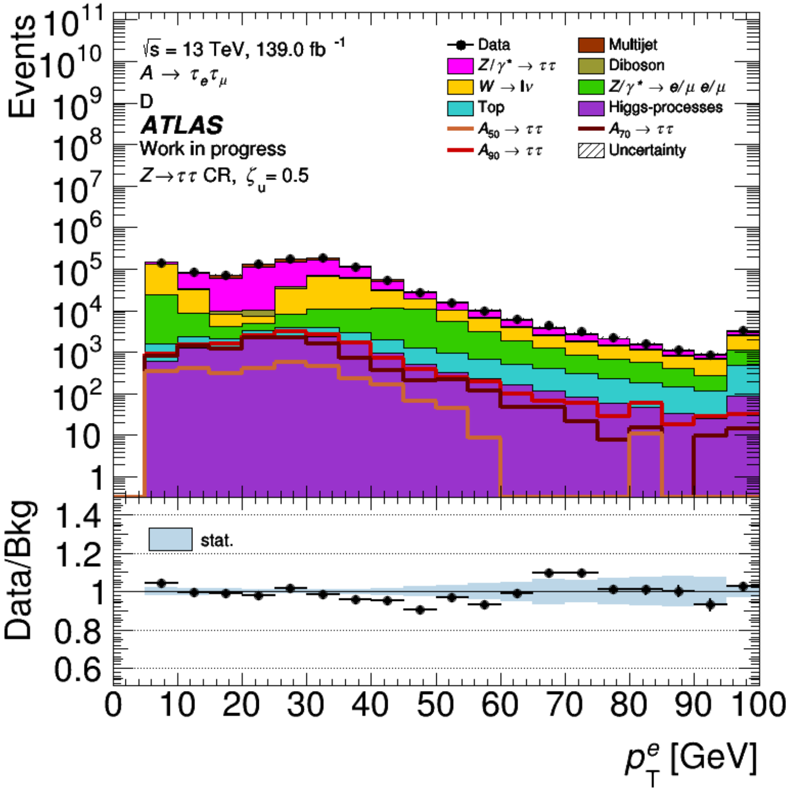
Multijet (QCD) background





Fake factors measured in electron transverse momentum (left)
and electron transverse momentum in the Z→ττ CR in the denominator region C

Multijet (QCD) background

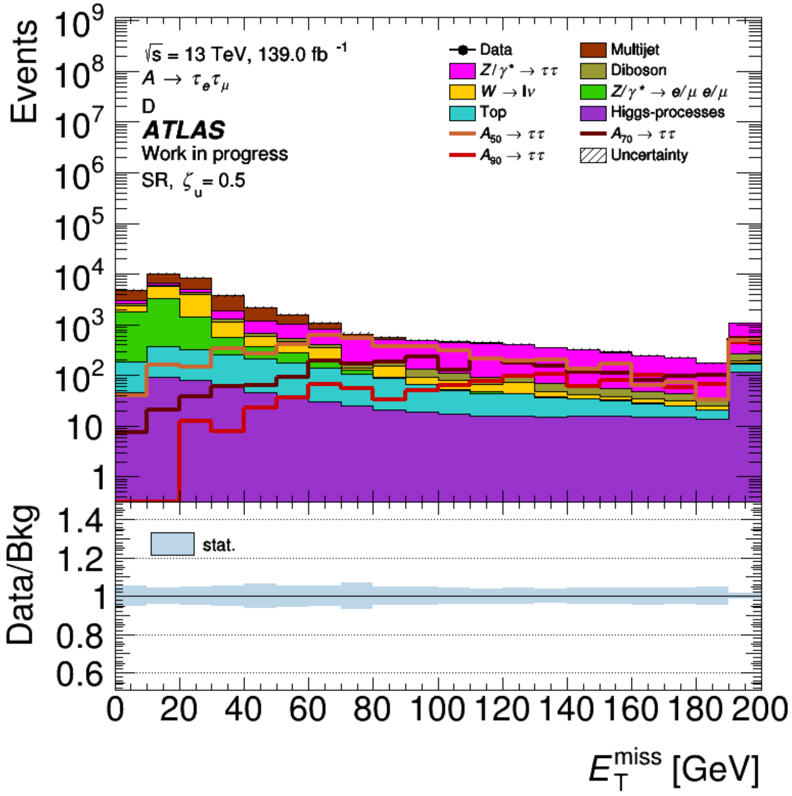


electron transverse momentum in the Z→ττ CR
with Multijet (QCD) background

- Fake factor method reduces data overshoot in the control regions
- QCD background is present in all regions

→ Fake factor method estimates the QCD background well

Summary and Outlook



Missing transverse energy in the signal region

- Implementation of fake factor calculation and application
- Estimates QCD background correctly

→ studies on systematc uncertainties
→ MVA studies to improve signal to background ratio in the signal region

Thank you for your attention

Backup

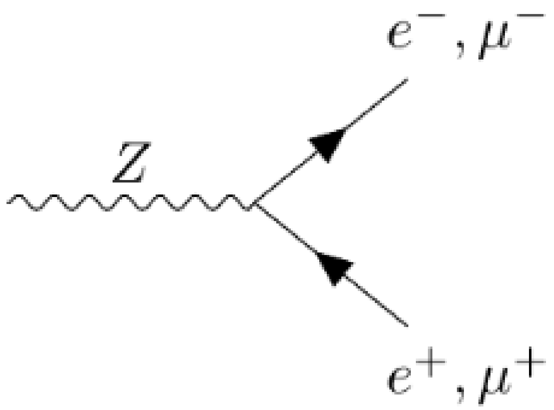


FIG.X. Feynman diagram of the Z → ll decay [3]

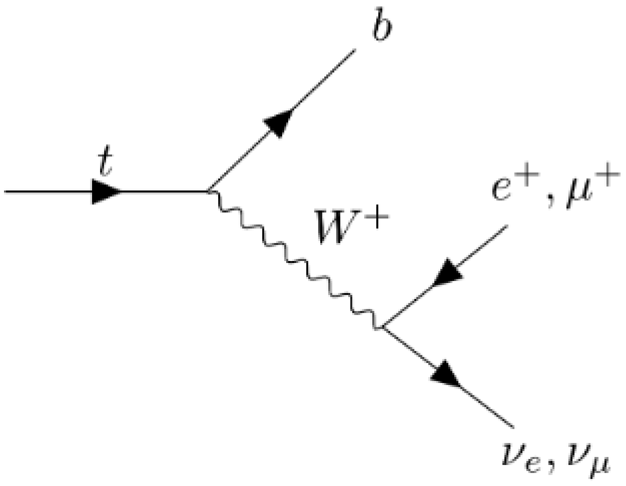


FIG.X. Feynman diagram of the leptonic Top quark decay [3]

Backup

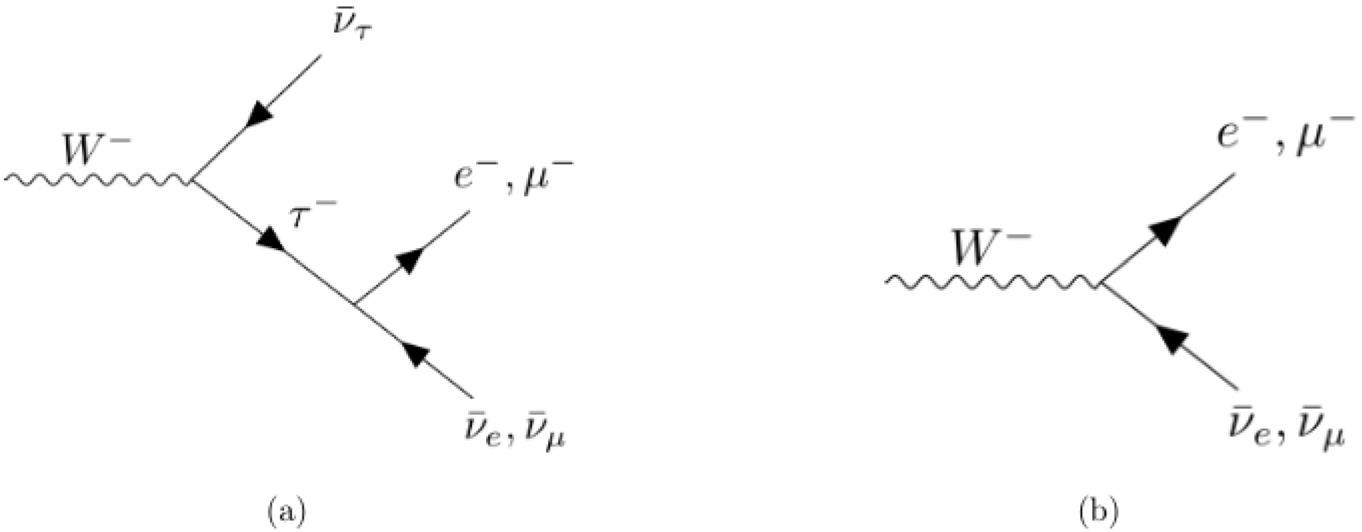
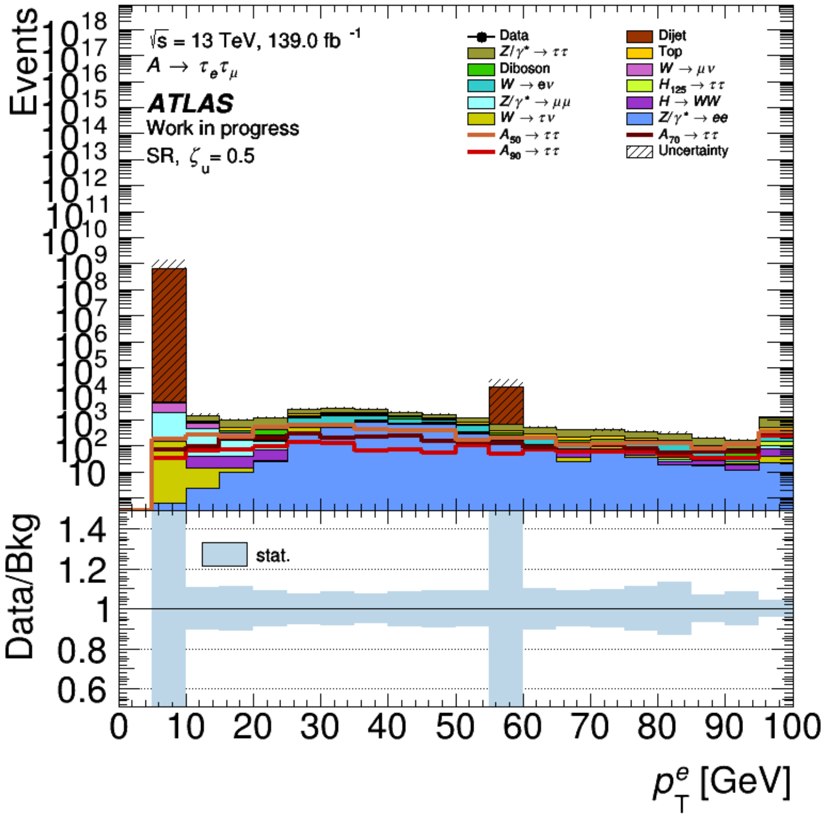
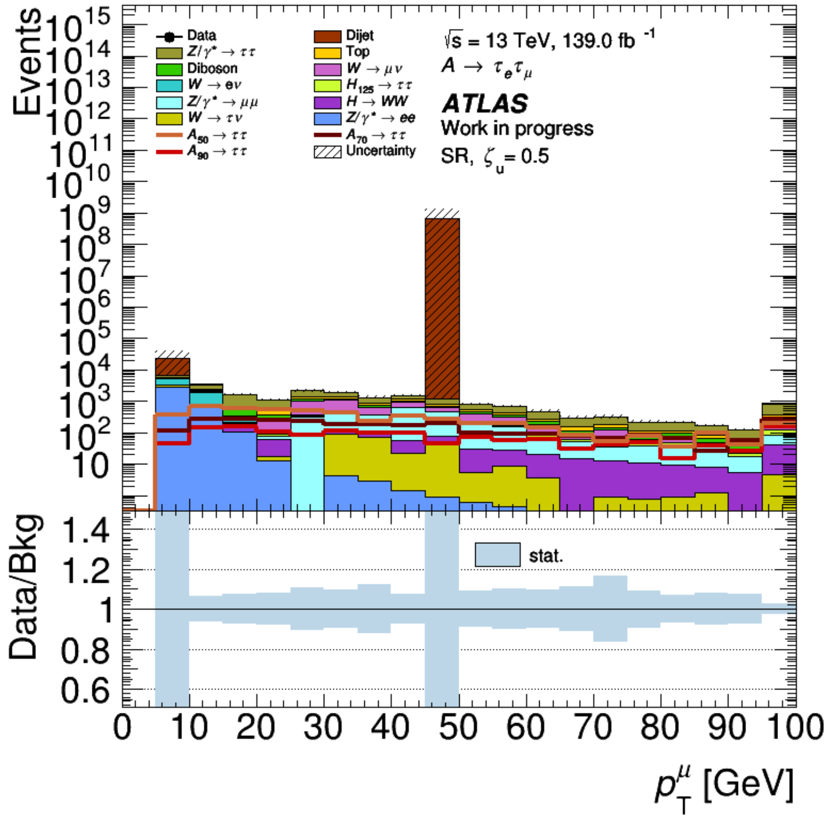


FIG.X. Feynman diagrams for the single W boson decays W → tn (a) and W → en / W → mn (b) [3]

Backup (Dijet Plots)





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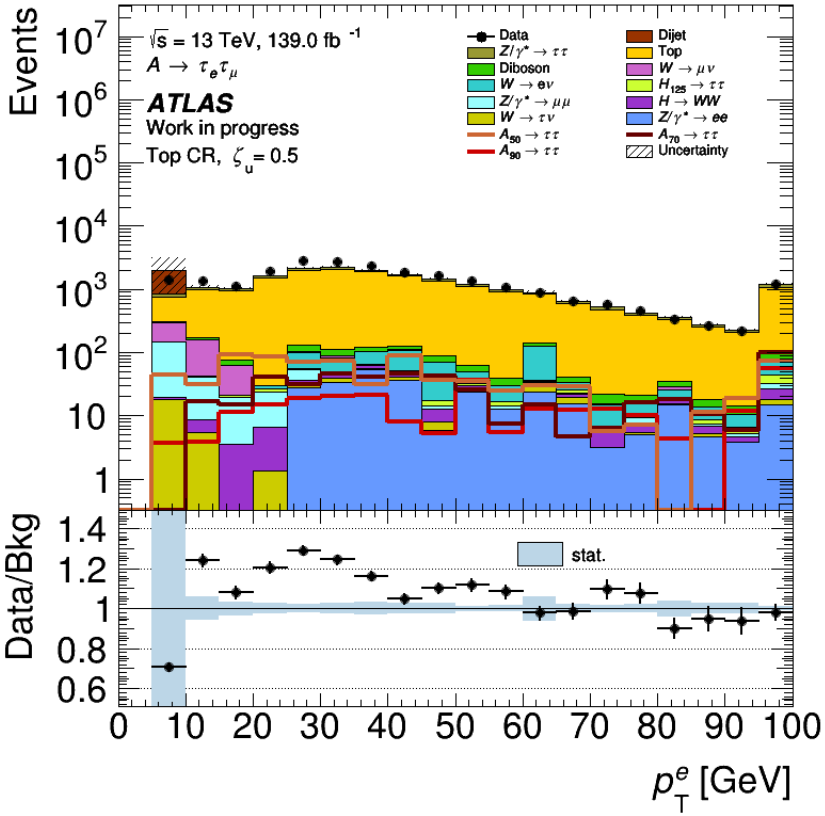

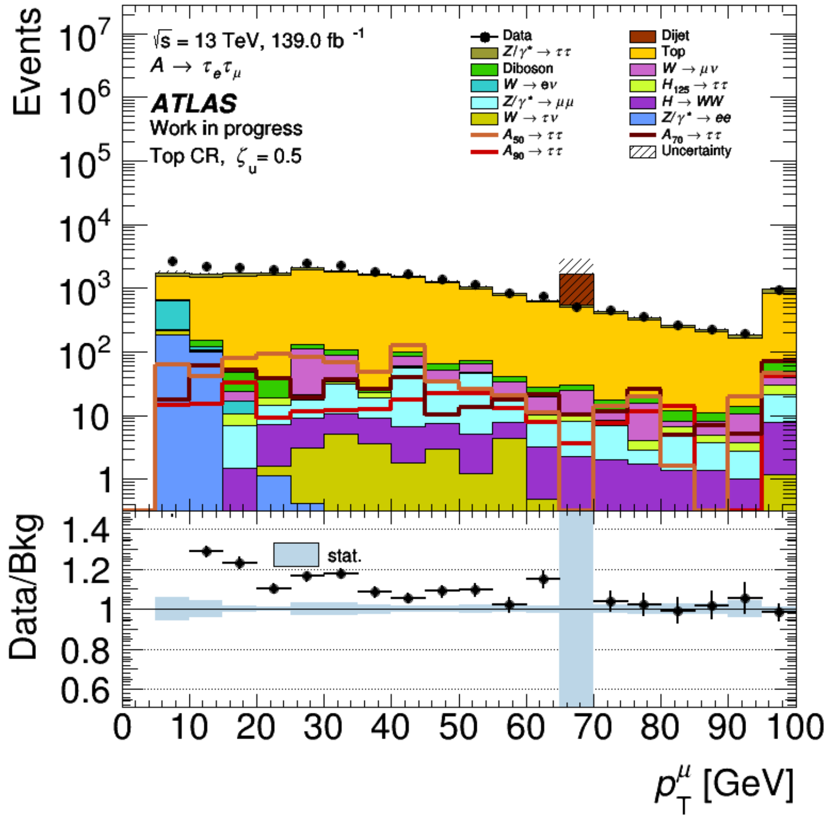

Backup (Dijet Plots)