Leibniz Universität Hannover

DESY.

Studying tWZ production at CMS for it's sensitivity to new physics

Quantum Universe Attract Workshop

Kim Richert

Personal background

- Started physics in 2017 at LUH with an interest in Astronomy/Astrophysics
- Bachelor's thesis on measurement of C-14 and H-3 in the context of radioactive waste management:
  - Simulation of immission from storage facility on environment
  - Taking environmental samples, C-14 from tree trunks, H-3 from groundwater
  - Measurement of C-14 by AMS and H-3 by LSC

Personal background

- Master's → Focus on theoretical physics:
  QFT, particle physics, gravitational physics, GR

- Particle physics → R. Kogler → Master's thesis at DESY
  studying tWZ + jet production

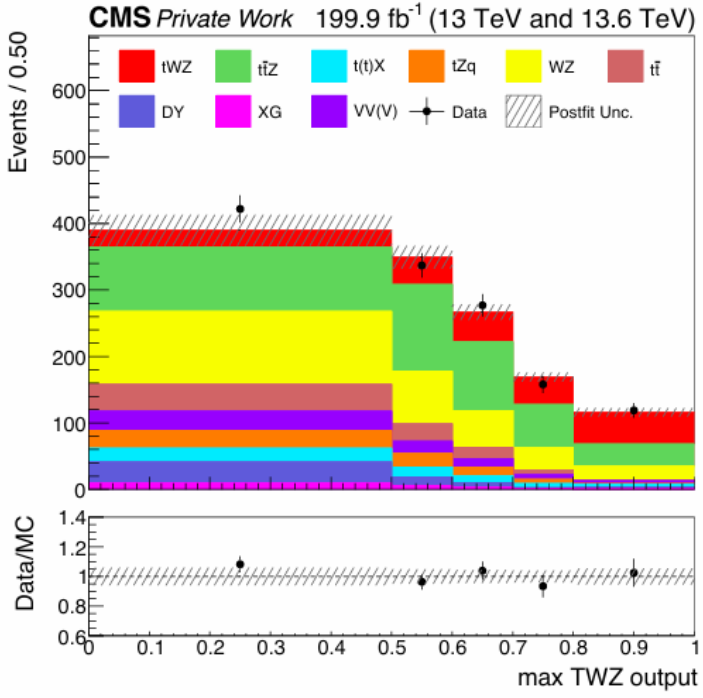
Motivation for tWZ

- Questions about matter/ antimatter symmetry and dark matter are still unanswered

  → related to electro-weak symmetry breaking scale
  → W, Z, t and Higgs Boson reside there

- Studying their properties and coupling is therefore of great interest (SMEFT)
- Weak coupling of top quark weakly constrained → room for new physics

Results from tWZ analysis

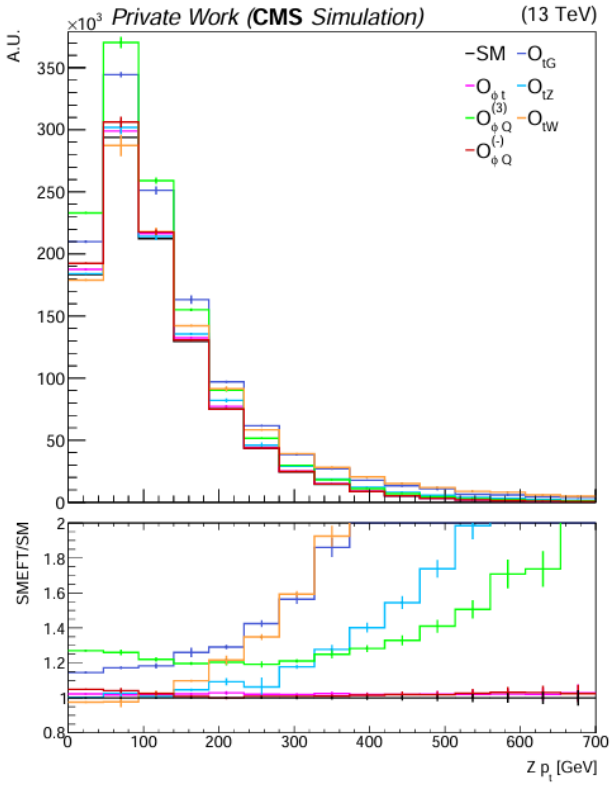


See A. Belvedere [2]

- Cross section:
  354 ± 54(stat) ± 95(syst)fb
- Observed tWZ process for the first time with more than 5 sigma significance
- observed cross section is 2 σ higher than predicted cross section from SM
- Main background contribution is ttZ

Results from tWZ analysis

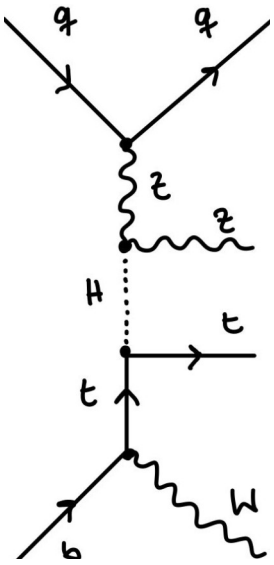
- SMEFT: tWZ sensitivity to $O_{\phi Q}$, O_{tZ}, O_{tW}, O_{tG} at higher energies
  → holds for **tWZ+jet** as well?
- $O_{\phi t}$ enters at NLO for tWZ
  → should have much larger effect on tWZ+jet
- Operator is least well known, least constrained



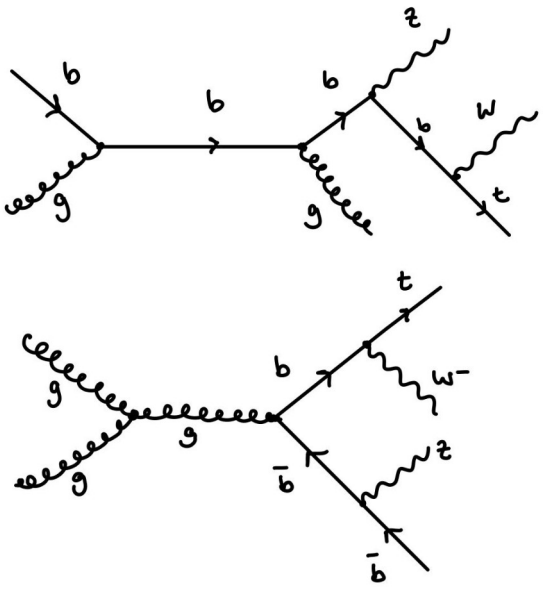
See A. Belvedere [2]

Thesis on tWZ+jet

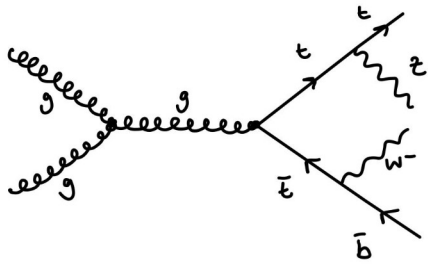
- **What we want to look at**



- tWZ at NLO



- ttZ final state



*For demonstration purpose: interference only if initial and final states are the same

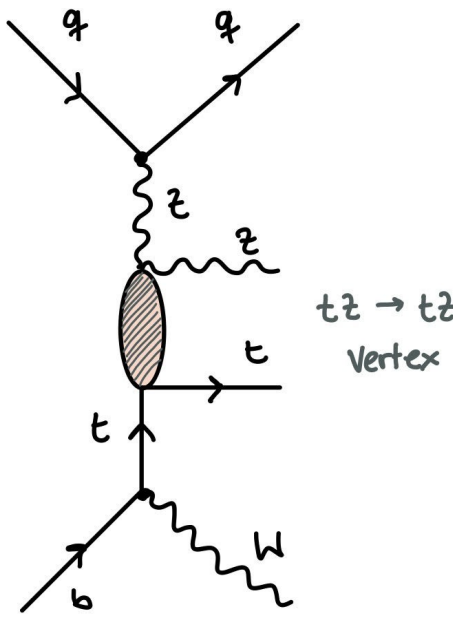
Thesis on tWZ+jet

Regarding SMEFT:

- tH vertex is interesting to study

  → Operator pulls together Ht and HZ
  → top + Z incoming to top + Z outgoing

- In SM → Higgs exchange
  but in SMEFT it could be operator $O_{\phi t}$
  so that this interaction can be enhanced



Thesis on tWZ+jet

- Generate tWZ+jet in MadGraph
- Expected cross section with QCD near tWZ (138fb) without QCD expected to be around 10 fb
- Got 0.014509 ± 5.06e-05 (pb) (~14 fb)*
- Then reconstructing mother particles for jet candidates

References

[1]*Evidence for tWZ production in proton-proton collisions at √s =13TeV in multilepton final states*, CMS Collaboration, 2024

[2]*Single top production in association with a WZ boson pair at the CMS experiment,* Alberto Belvedere, 2025

[3]*Single top production in association with a W Z pair at the LHC in the SMEFT,* Faham, Maltoni, Mimasu, Zaro, 2022

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Thanks for your attention

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