



# Interference studies for FCNC *tZu*

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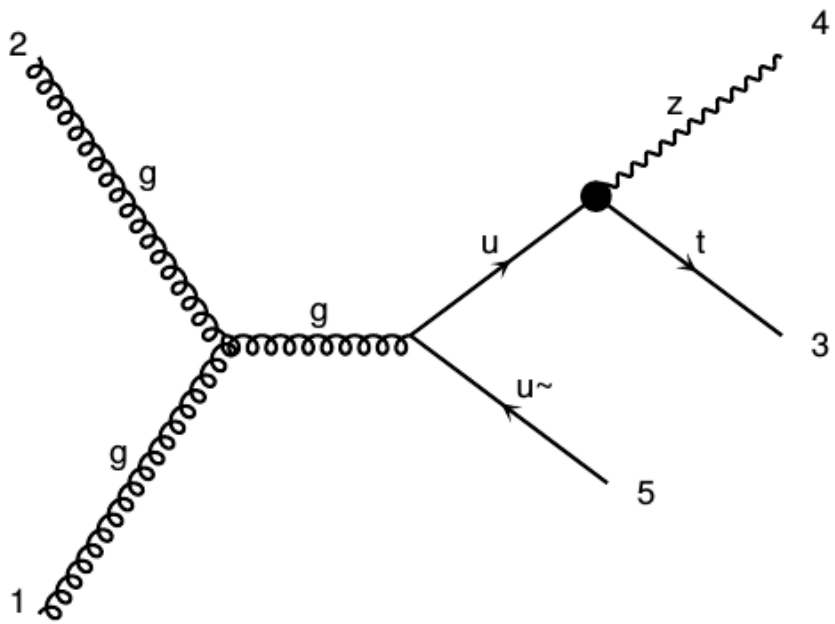
# MadGraph details

- **Version:** 2.6.1
- **Shower:** Pythia8
- **Detector:** Delphes
- **UFO Model:** TopFCNC with the restriction for just $utZ$ anomalous coupling
  Parameters consider the limit of the branching ratio of $2.2 \times 10^{-4}$
- **10000** events per process
- All samples generated with **MadSpin, Pythia8 and Delphes**

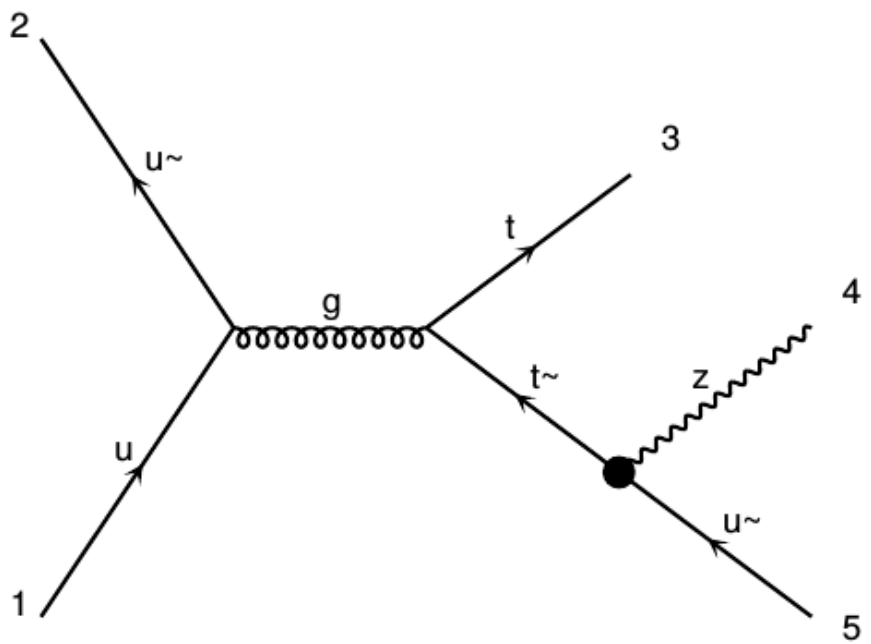
# Monte Carlo generation - Production

- generate p p > t z u~$$ t~
- add process p p > t~ z u $$ t
- **18** independent Feynman diagrams
- $\sigma = (0.01431 \pm 4.153 \times 10^{-5})$ pb



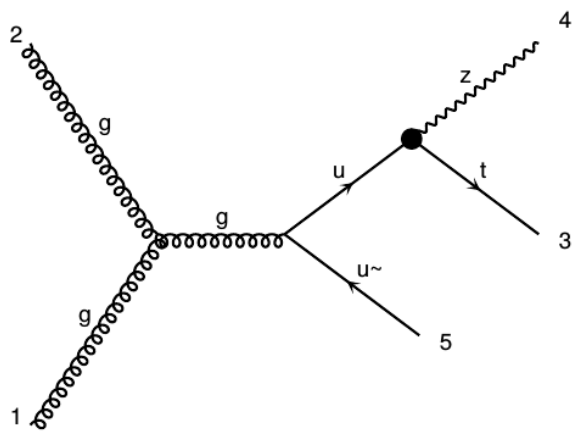
# Monte Carlo generation - Decay

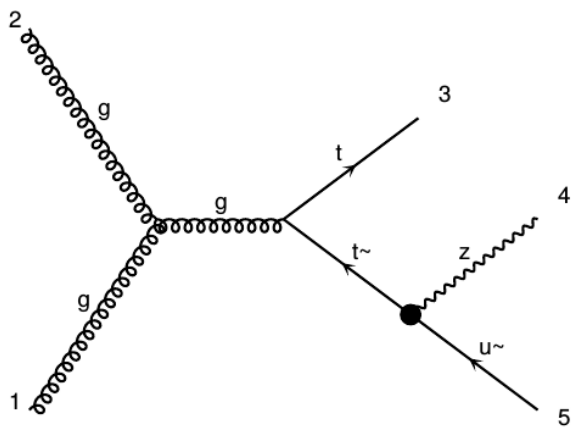
- generate p p > t t~ > b w+ z u~
- add process p p > t t~ > b~ w- z u
- **8** independent Feynman diagrams
- $\sigma = (0.1903 \pm 0.00035)$ pb



# Monte Carlo generation - Interference

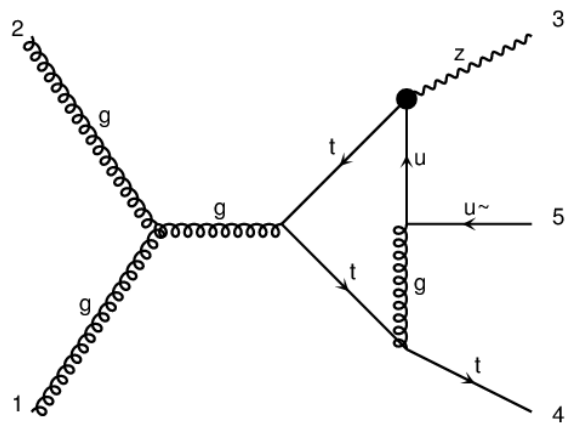
- generate p p > t z u~
- add process p p > t~ z u
- **28** independent Feynman diagrams
- $\sigma = (0.226 \pm 0.00048)$ pb

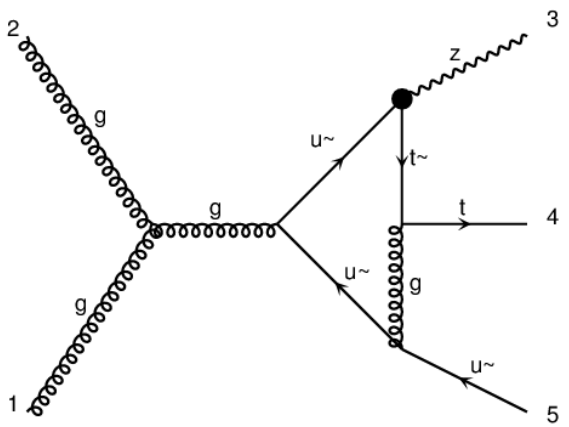


# Monte Carlo generation at NLO - Interference

- generate p p > t z $$ t~ [QCD]
- add process p p > t z u~ [QCD]



# Monte Carlo generation at NLO

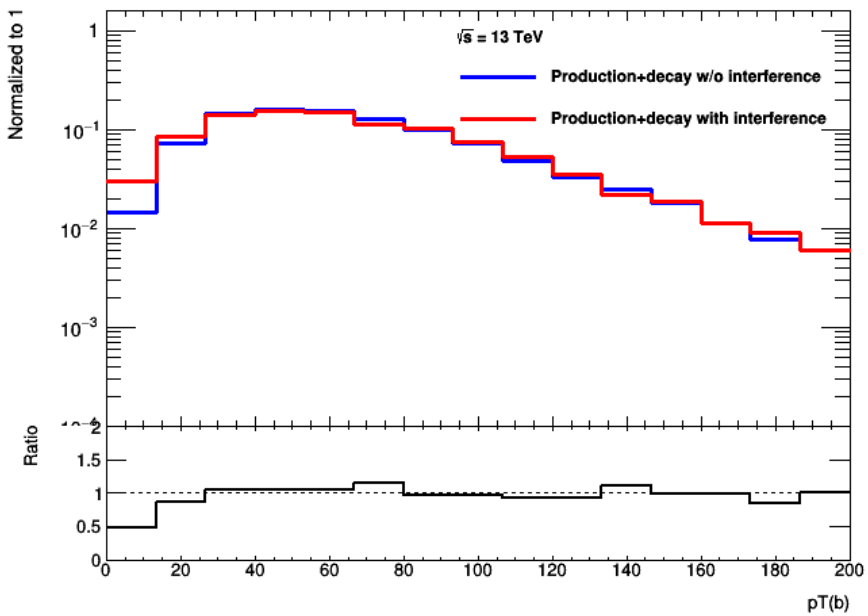
**Answer from Cen Zhang:** *the second process includes both production and decay, and the full NLO cannot be done automatically with MG. Since the t∼ resonance is present, the top width cannot be set to zero, which means the other t also has to be decayed. You'll have to generate a bWuZ final state at NLO, which is too difficult. (...) I think the most realistic way so far is to generate the first process as it is, but the second one only as a production process, pp>tt at NLO, and then decay the tops by using MadSpin with the FCNC model. (...) If you do pp>tZj at LO, by turning on/off the resonant diagrams you should be able to get the resonance. Are you proposing adding extra jets and do a merging? I think that should be correct and doable. But I'm not so sure if you really need to do it, because even without the jet, the interference is already one between the NLO of pp>tZ and the LO of pp>tt>tZu. Adding more jets corresponds to NNLO of pp>tZ interfering with NLO pp>tt. I'm not sure if this is helpful, if pp>tZ itself is computed only at NLO. But maybe you have a reason... Btw, if you look at 1607.05862, using "$$ t∼" corresponds to "diagram removal 1" which means no interference, but the authors also managed to do "diagram removal 2", i.e. including interference, using the same set up with MG. You will need to edit the matrix_*.f files, but you can maybe contact them for help, if you find this interesting.*

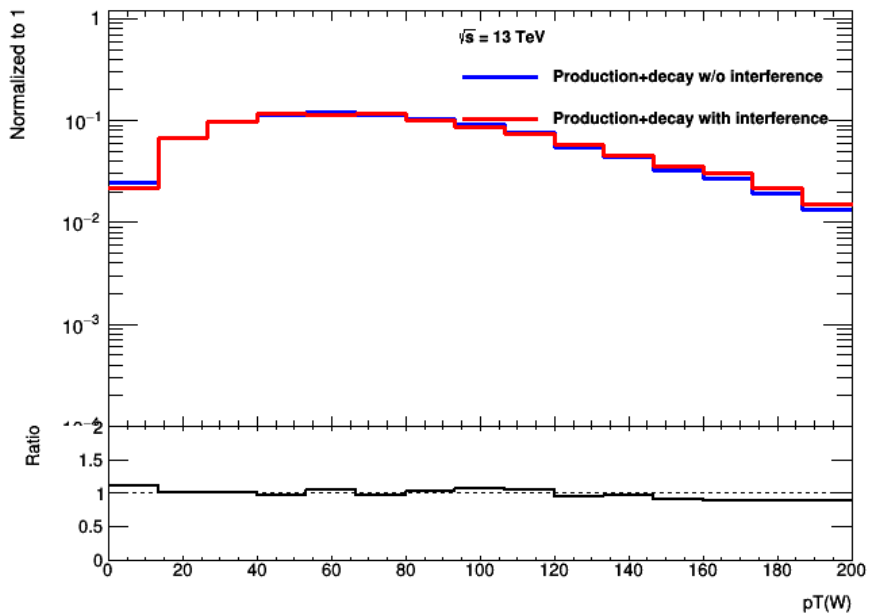
# MadAnalysis details

- **Version:** 1.5
- Looking at the kinematic and angular distributions of the objects in the final state

# Transverse Momentum

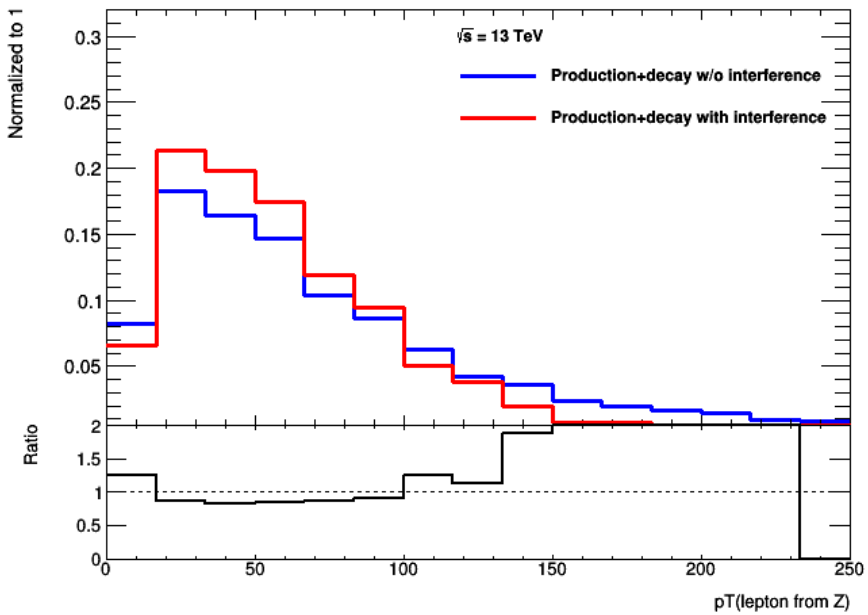
- Transverse momentum of the bottom quark and W boson

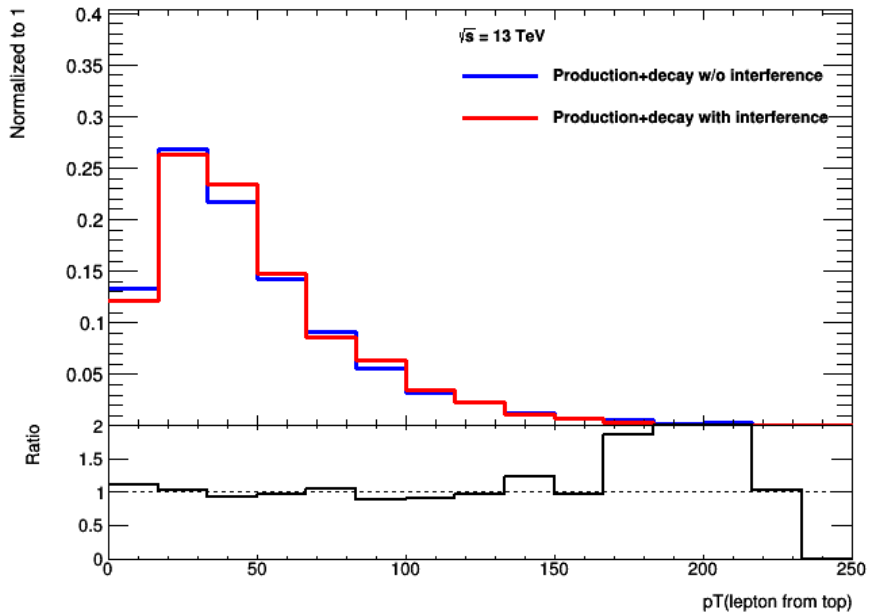


# Transverse Momentum

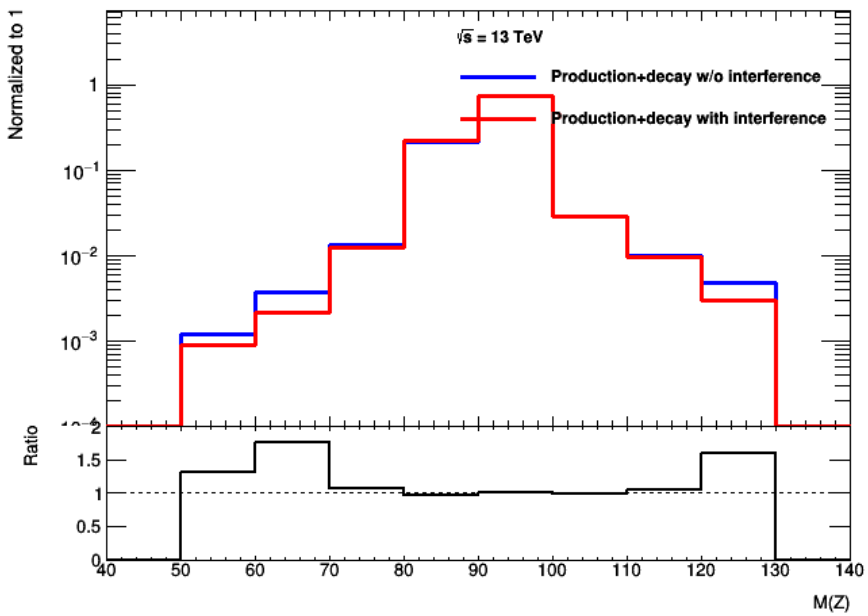
- Transverse momentum of the leptons coming from the Z boson and top quark

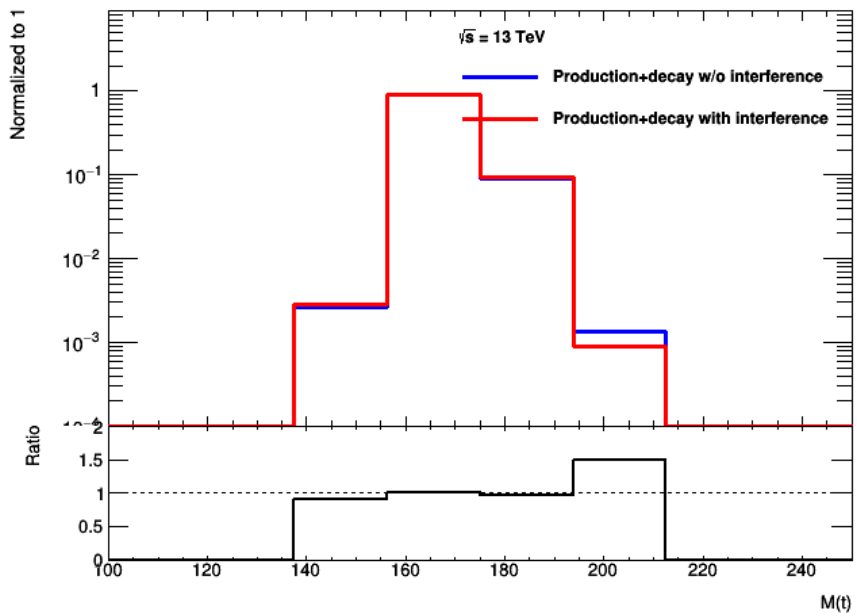


# Invariant Mass

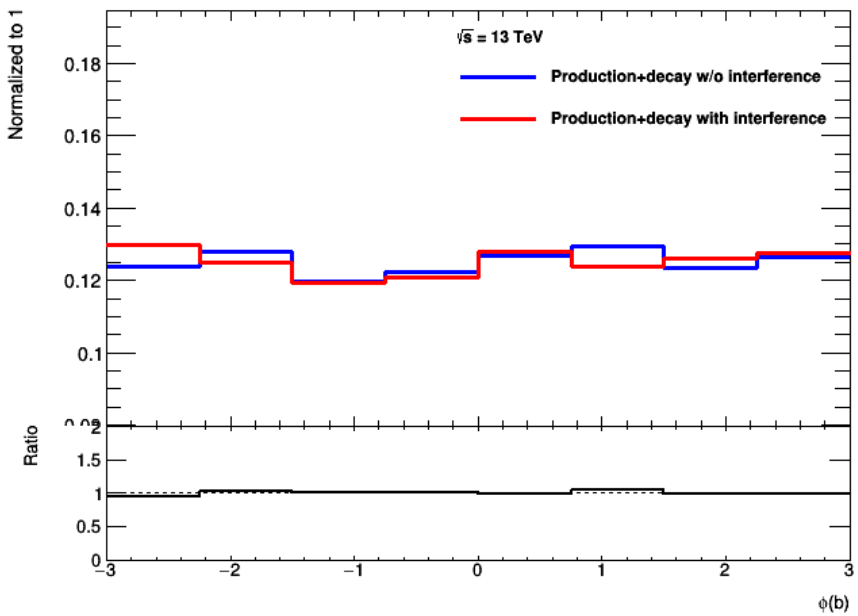
- Z boson and top quark masses

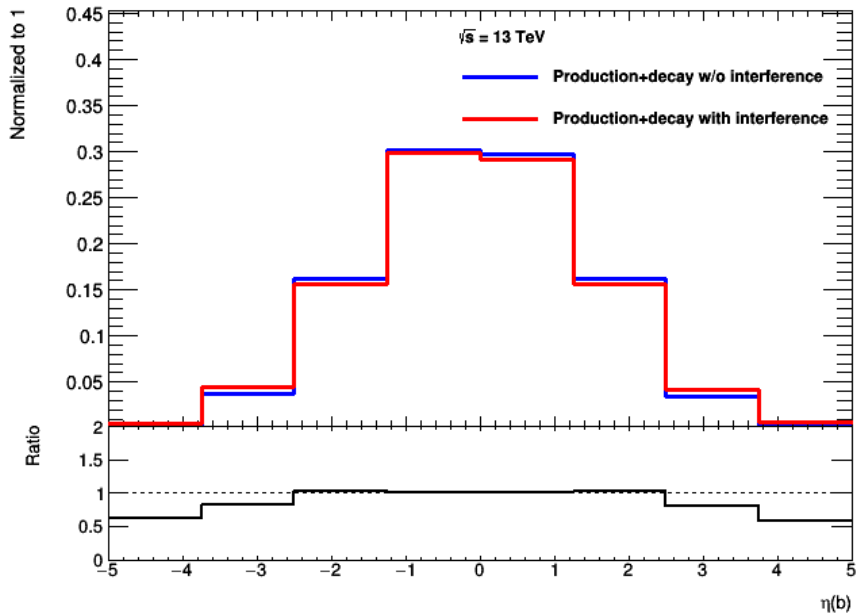


# Phi and pseudo-rapidity

- Phi and pseudo-rapidity of the bottom quark



# Next steps

- Optimistic prediction since we did not included the $tZ$ final state yet
- Still needed to study the output of the generation after Delphes
- A study about the dependence of the couplings is also necessary