Search for tHq flavor-changing neutral current interaction in H→ $b\bar{b}$, lepton+jets channel with CMS Run2 data

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EPS-HEP Conference, July 26-30, 2021

Introduction

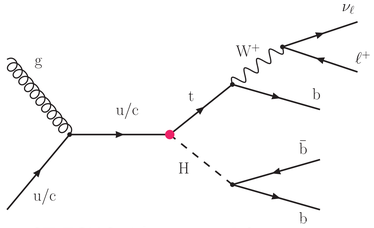
- FCNC in top-Higgs-quark (up or charm) interaction
  - ➢Highly suppressed in the SM due to GIM mechanism
  - ➢Branching fractions can be improved up to 10^{-3}~10^{-5} in BSM
  - ➢Good window to new physics considering large top quark mass and Yukawa coupling of Higgs boson and fermions
- Data taken by the CMS detector at LHC during Run2 (2017-8) are newly analyzed and combined with 2016 results [2]

Datasets and event selections

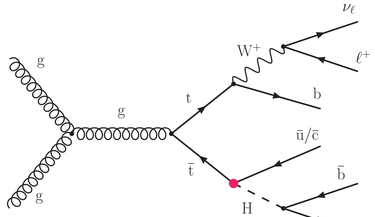
- Data: Final state with single muon or electron, 101 fb^{-1}
- SM backgrounds: $t\bar{t}$, $t\bar{t}V/H$, single top, V+jets, VV, QCD (V=W,Z)
- Signal: Single top (ST) and $t\bar{t}$ (TT) FCNC, H→ $b\bar{b}$ decay

$$\mathcal{L} = \sum_{q=u,c} \frac{g}{\sqrt{2}} \bar{t}\,\kappa_{Hqt}(f_{Hq}^{L}P_{L} + f_{Hq}^{R}P_{R})qH + h.c.$$

  - ➢Assuming anomalous coupling κ for Hut and Hct channel



ST FCNC, 1 lepton + 3 jets

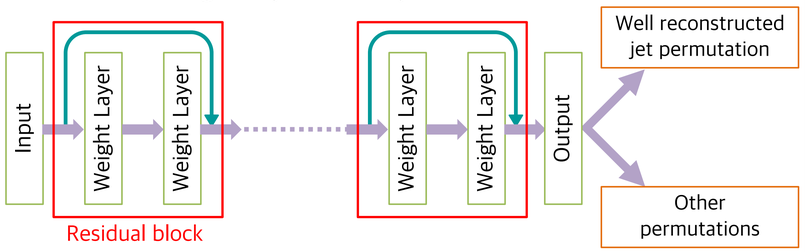


TT FCNC, 1 lepton + 4 jets

- Selection: 1 isolated lepton, ≥3 jets and ≥2 b jets
  - ➢Categorization: b2j3, b3j3, b2j4, b3j4, and b4j4

Event reconstruction (1)

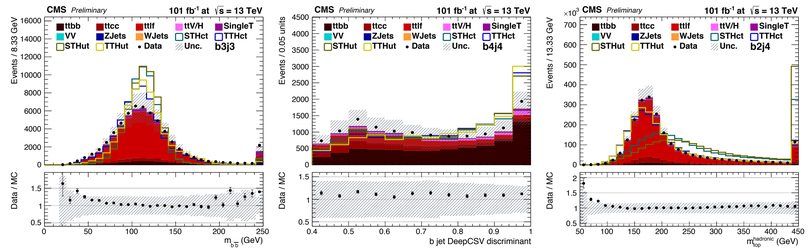
- Jet assignment with Deep Neural Network (DNN)
  - ➢Targeting ST, TTFCNC, and SM $t\bar{t}$ hypotheses
  - ➢Well reconstructed jet permutations vs all the other combinations, using MC samples
  - ➢Residual network [3]: Boost training and prevent loss of information when using many hidden layers



  - ➢Trained for all jet categories and additionally for b4j4 category to deal with small sample size

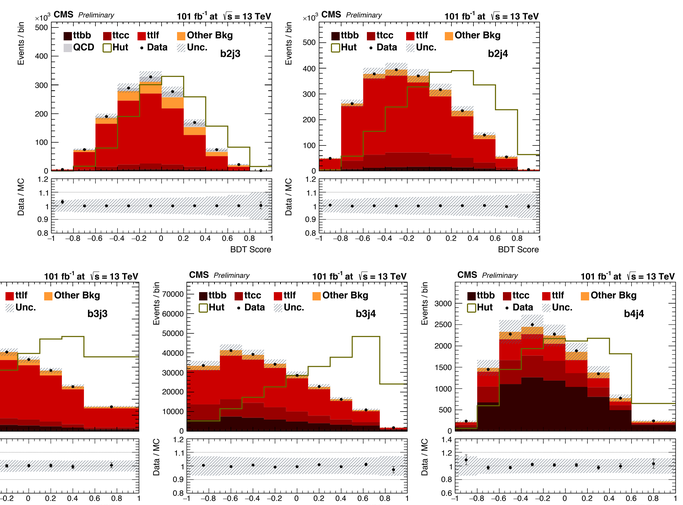
Event reconstruction (2)

- Input features
  - ➢p_T, η, mass of jet (j), dijet (jj), trijet (jjj), top quarks
  - ➢ΔR, $\Delta\phi$, $\Delta\eta$ between (j, j) (jj, j), (jjj ,lepton), etc.
  - ➢b tagging discriminator values
- Reconstruction efficiency
  - ➢81-86% (STFCNC), 76-79% (TTFCNC), 78% (SM $t\bar{t}$)
  - ➢Improved by 5-15% compared to kinematic fit [1]
- Example kinematic distributions for STFCNC (left), TTFCNC (middle) and SM $t\bar{t}$ (right) hypothesis



Signal extraction and Systematic uncertainties

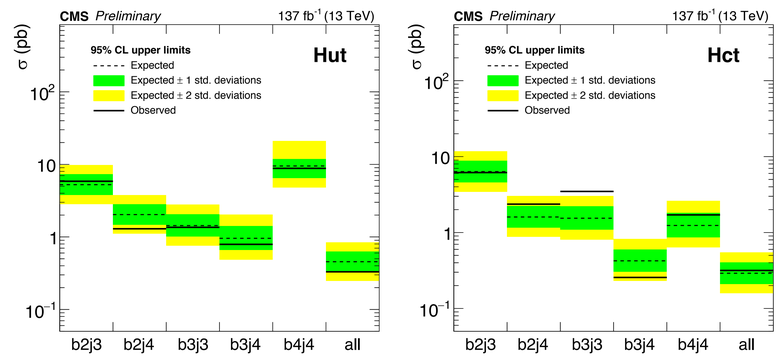
- Used BDT to distinguish FCNC and the SM backgrounds
  - ➢Trained for each of coupling / jet category / year
  - ➢Reconstructed distributions from jet assignment are used
- Post-fit BDT score distributions in Hut channel:



- Systematic uncertainties
  - ➢Leading uncertainties: b tagging and matrix element scale
  - ➢Total uncertainty: 13-34%, depending on jet category

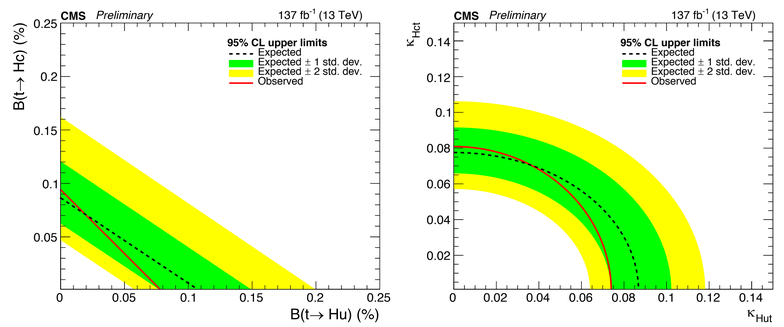
Results

- No significant excess from the SM prediction is observed
- Exclusion limits are set
  - ➢Result of 2017-18 datasets are simultaneously fit to data in the combination with 2016 results taken from [1]



- Observed (expected) limits on branching fraction (95% C.L.)
  - ➢**$\mathcal{B}(t\to Hu) < 7.9 \times 10^{-4}$ (1.1×10^{-3})**
  - ➢**$\mathcal{B}(t\to Hc) < 9.4 \times 10^{-4}$ (8.6×10^{-4})**
- 1D limits are interpolated by assuming linear relationship between branching fractions

$$\kappa_{Hqt}^{2} = \mathcal{B}(t\to Hq)\frac{\Gamma_t}{\Gamma_{Hqt}} \qquad \frac{\mathcal{B}_{Hut}^{Interpol}}{\mathcal{B}_{Hut}^{1D}} + \frac{\mathcal{B}_{Hct}^{Interpol}}{\mathcal{B}_{Hct}^{1D}} = 1$$



- Limits are improved by factor 3-6 compared with 2016 results
- The most stringent limits on tHq FCNC, H→ $b\bar{b}$ channel
- Reaches similar order of limits compared to H->$\gamma\gamma$ channel [4]

References

[1] CMS Collaboration, CMS-PAS-TOP-19-002
[2] CMS Collaboration, JHEP 06 (2018) 102
[3] K. He, X. Zhang, et al., arXiv:1512.03385
[4] CMS Collaboration, CMS-PAS-TOP-20-007