Search for pair-produced vector-like quarks of charge -1/3 decaying to bH using boosted Higgs jet-tagging in pp collisions at $\sqrt{s}$ = 8 TeV

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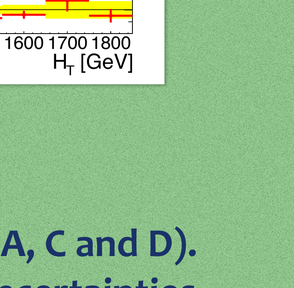
♠ 1. Introduction

- **Motivation**
  - The 4th generation quarks, t' and b' (charges +2/3 & −1/3), may represent an extra generation in SM, or consist of fermions with symmetric chiralities in SU(2) ("vector-like").
  - The VLQs mass is independent of coupling to the Higgs.
  - Solutions to the hierarchy problem in SM or various BSM models propose the existence of VLQs.
- **Strategy**
  - Fully-hadronic b'→bH decay has a much higher sensitivity as compared to searches in Higgs leptonic final states.
  - Use boosted Higgs-tagging to develop this analysis.
- **Boosted Higgs tag**
  - For the high-mass b', the Higgs boson decay to b jets has high Lorentz boost and results in a merged fat jet.
  - Fat jets with substructure are used to identify highly boosted $H\to b\bar{b}$ decay signature.

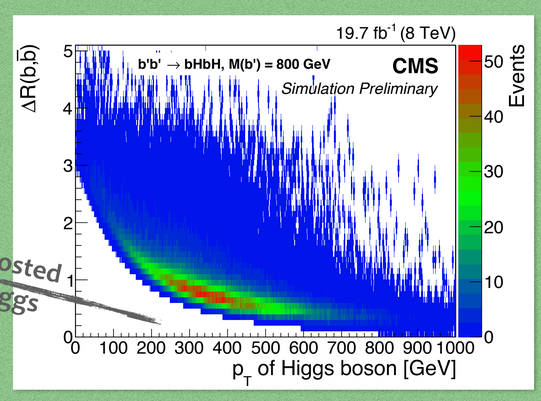


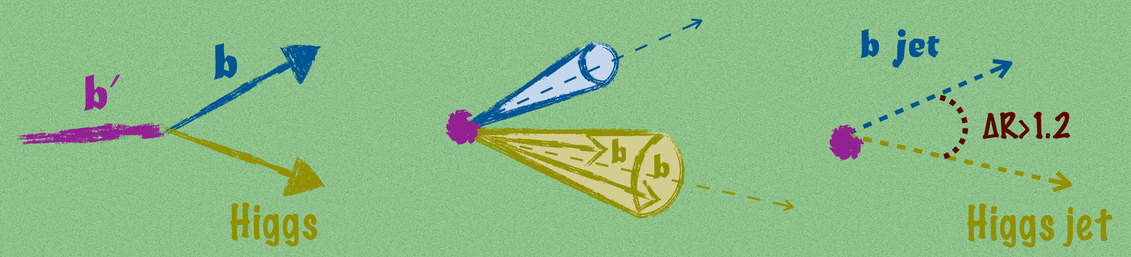
♠ 2. Signal and background assumption

- pp→b'$\bar{b}$' with BR(b'→bH) = 100%
- Background = multi-jet + t$\bar{t}$ jets

♠ 3. Event selection

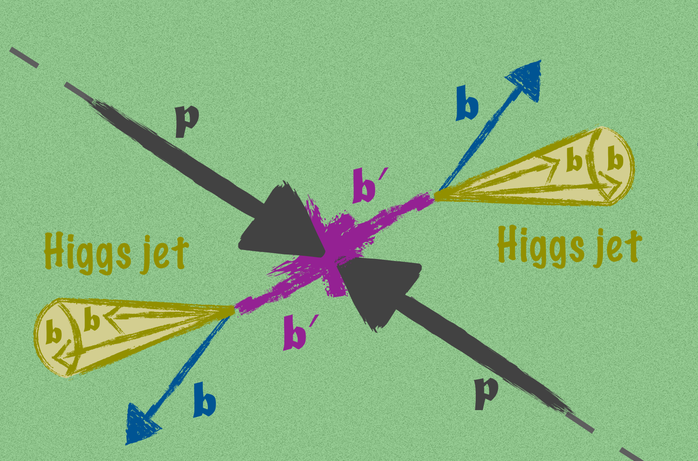
- Hight level trigger H_T > 750 GeV
- Good primary vertex
- $H_T = \Sigma|p_T(\text{AK5 jets})|$ > 950 GeV
- At least one b-tagged AK5 jet
- At least one Higgs-tagged CA8 jet
  - p_T > 300 GeV
  - 90 < Pruned mass < 140 GeV
  - N-subjettiness <0.5
  - b tagging in both subjets
- Separate two categories with multiplicities of b-tagged AK5 jet.
  - One and ≥ two b-tagged AK5 jets.



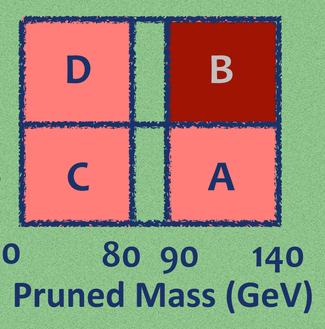


♠ 4. Background estimation

- Main background is multi-jets, the smaller background is t$\bar{t}$+jets.
- Estimate multi-jets from data with *ABCD* method.

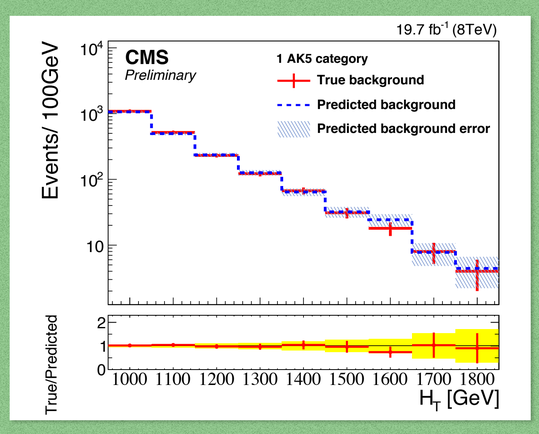


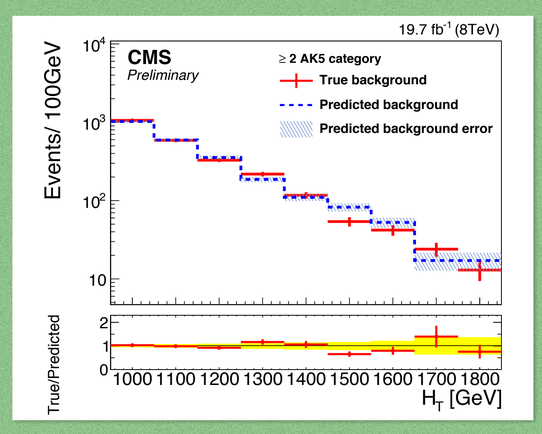
$$\frac{\text{A: Anti-Higgs, } 90 < \text{Pruned Mass} < 140 \text{ GeV}}{\text{C: Anti-Higgs, } 0 < \text{Pruned Mass} < 80 \text{ GeV}} = \frac{\text{B: Higgs, } 90 < \text{Pruned Mass} < 140 \text{ GeV}}{\text{D: Higgs, } 0 < \text{Pruned Mass} < 80 \text{ GeV}}$$



♠ 5. Background estimation closure test

- Use zero b jet data control sample.
- Good agreement in the predicted and true background H_T distributions.



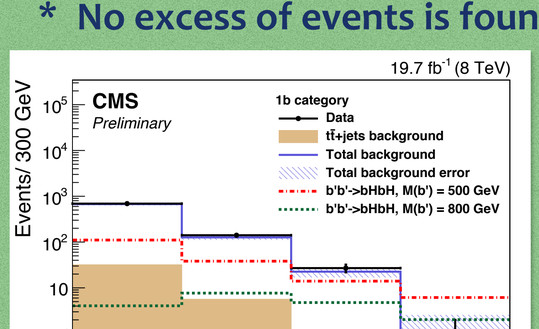


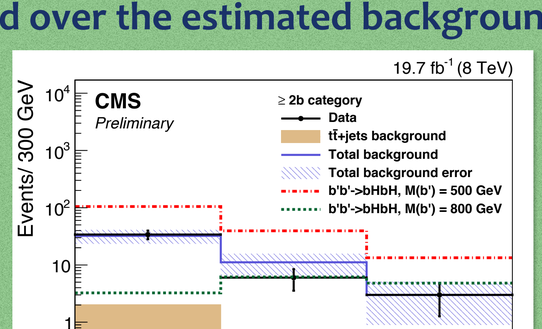
♠ 6. Systematic uncertainties

- Background estimation uncertainties
  - — Propagate from statistics of sideband region (A, C and D).
  - — Include t$\bar{t}$+jets MC statistical and systematic uncertainties.
- MC samples systematic uncertainties
  - — Jet energy corrections.
  - — b-tagging sale factors.
  - — CA8 jets selection scale factors.
  - — t$\bar{t}$+jets : Q^2, matching scale factor and top quark p_T weighting.
  - — PDF, pile up and luminosity.

♠ 7. Results of data and background

- Multi-jet is from data driven ABCD method, t$\bar{t}$+jets is from MC.
- Background = $(N^A_{Data}-N^A_{t\bar{t}jets})*N^D_{Data}/N^C_{Data} + N^B_{t\bar{t}jets}$ = multi-jets + t$\bar{t}$ jets
- Good agreement in event yields and H_T distribution.
- No excess of events is found over the estimated background.

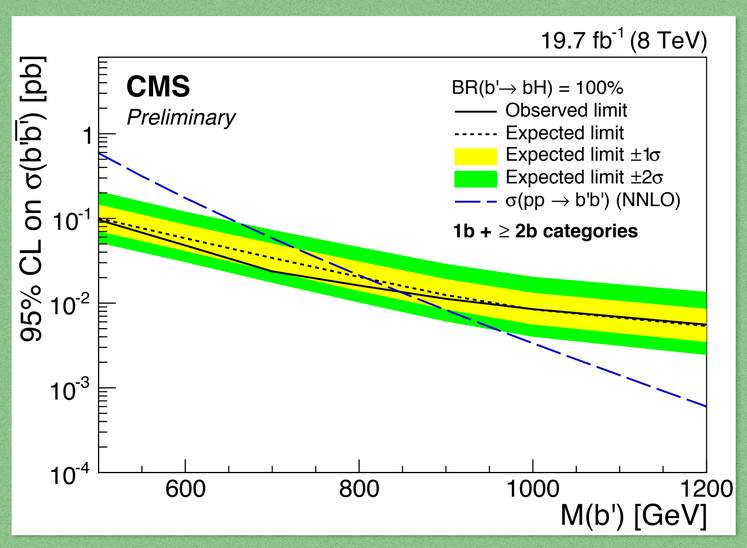




Process	Yields after full selection	Yields in 1 b-tagged category	Yields in ≥ 2 b-tagged category
Data-driven bkg.	871.67 (+49.12/-54.62)	824.92 (+46.96/-51.74)	46.35 (+4.46/-11.30)
Data	903	860	43

♠ 8. Upper limit

- Use "Higgs package" with binned likelihood fit H_T shape and the Bayesian algorithm.
- Include all systematic uncertainties in each different mass of signal MC and background.



♠ 9. Conclusion

- Boosted Higgs-tagging has enhanced sensitivity in high b' mass.
- The multijets background is evaluated entirely from the data while the t$\bar{t}$+jets background is obtained from MC simulations.
- Cross section limits on the pp→b' $\bar{b}$', BR(b'→bH) = 100% , $\sqrt{s}$ = 8TeV
  - — Exclude b' quarks for masses below 846 GeV at 95% CL.
  - — Expected upper limit is 81 1GeV.

♠ 10. Reference

* CMS-PAS-B2G-14-001

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