Motivation

- Two dominant diagrams for $tHq$ production in SM, probing different Higgs boson couplings
- Destructive interference in SM \( \Rightarrow \sigma = 18.3 \text{ fb at } 8 \text{ TeV} \) [JHEP 05 (2013) 22]
- But with Yukawa coupling $y_t = -1$, the interference turns constructive, and $\sigma = 234 \text{ fb (13 enhancement)}$
- The $y_t = -1$ case is allowed by experimental data [JHEP 06 (2013) 103]
- New particles in $H\gamma\gamma$ and $Hgg$ loops

Two searches

- Performed searches for $tHq$ in full $8 \text{ TeV}$ dataset
  - Focused on the $y_t = -1$ case
- Two decay channels considered
  - $H \rightarrow \gamma\gamma$
    - Pure but low statistics
    - Additional $2.4 \text{ increase}$ in $B_{\ell \ell}$ due to interference
    - Cut-based analysis
  - $H \rightarrow \bbbar$
    - Largest branching ratio
    - Suffers from large background (mostly $t\bar{t}$)
    - Complex analysis using neural networks (NN)
- Last-week results in $H \rightarrow WW/\tau\tau\bbbar$ channel are not discussed [HIG-14-026]

Resonant backgrounds

- Backgrounds with a Higgs boson contribute to the $m_{\gamma\gamma}$ peak
  - $t\bar{t}H$ (dominant), VH, $H +$ jets
- A likelihood product discriminator (LD) is used to distinguish $tHq$ from $t\bar{t}H$
  - Variables: $m(t, \ell), m(q'), \Delta R(t, q'),$ lepton charge $Q(t)$
  - A cut on LD is added to the event selection

Non-resonant bkg are smooth in $m_{\gamma\gamma}$
- $\gamma + \text{jets}, \gamma + \text{jets}, t\gamma\gamma, \ell\gamma\gamma, \ldots$
- Their spectrum in data is fitted with an exponential function
  - Extract ratio $\alpha$ from control regions with inverted b-tagging requirement and nominal or inverted photon ID
  - Exploit ratio $\alpha$ to estimate bkg in the mass window from $m_{\gamma\gamma}$ sidebands

- Found zero events in signal region and $m_{\gamma\gamma}$ sidebands
- Observed (exp.) 95% $CL_s$ upper limit: $4.1(4.1) \times \sigma_{bkg}^{H_{\gamma\gamma}} < 5.2 \text{ fb}$

Event preselection:
- Two photons
- Exactly one muon or electron
- At least one $b$-tagged jet
- An untagged jet with $|y| > 1$
- Mass window for signal region $122 < m_{\gamma\gamma} < 128 \text{ GeV}$

Signal selection efficiency

CL$_s$ limit, $\sigma_{95\%}/\sigma_{bkg}^{H_{\gamma\gamma}}$

- Obs. 7.6
- Exp. 5.1

- Absolute value: $\sigma_{bkg}^{H_{\gamma\gamma}} < 1.0 \text{ pb}$

Electron channel
- 3T region
- $m = 125 \text{ GeV}$
- MVA output
- 0 0.5 1

Muon channel
- 4T region
- $m = 125 \text{ GeV}$
- MVA output
- 0 0.5 1

Simulation Preliminary: $5 \text{ TeV}$

CMS Simulation Preliminary: $8 \text{ TeV}$

Signal selection efficiency

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