Search for High-Mass Resonances Decaying to Z and Higgs Bosons

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Overview

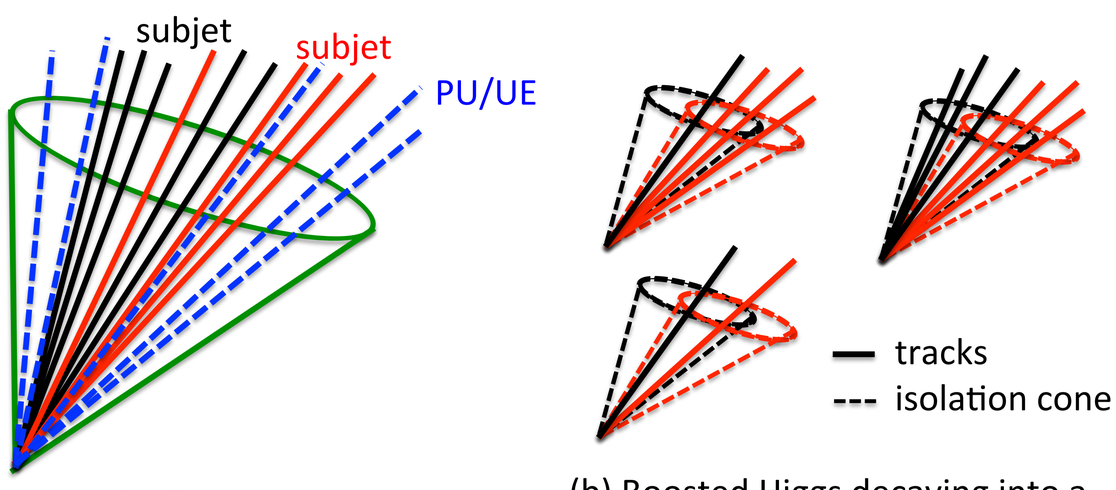
Several theories of physics beyond the standard model predict the existence of new TeV scale resonances that decay preferentially in dibosons. A search for resonances based on the reaction $q\bar{q} \to Z' \to Z\,H \to q\bar{q}\,\tau^+\tau^-$ is presented, where both Z and Higgs (H) bosons have high-p_T. Studies are based on proton-proton collisions at $\sqrt{s} = 8$ TeV with the CMS detector at LHC, analysing $19.7/\mathrm{fb}$ of integrated luminosity.

Boosted Topology

The signal events are caracterized by a Drell-Yan production of a narrow high-mass spin-1 resonance ($M_{Z'} >\sim 0.8$ TeV), which decays in a Z and H bosons with transverse momentum (p_T) close to half of the resonance mass. This feature implies that the final products of the two quarks or the two τ leptons, from the bosons decay, must be detected within a small angular interval:

$$\Delta R_{f\bar{f}} = \sqrt{(\Delta\eta_{f\bar{f}})^2 + (\Delta\phi_{f\bar{f}})^2} \sim \frac{2 \times M^{Z/H}}{p_T^{Z/H}} .$$

The boosted Z boson decaying in a pair of quarks is reconstructed using jet substructure techniques, which consider the 2-subjets-like configuration of the Z-jet and mitigate effects from pileup (PU) and underlying-event (UE). For the boosted H boson decaying into τ leptons, the decay products of the two τ leptons must be detected within a small angular interval. The constituents associated to one τ are removed when identifying the other candidate of the pair.



(a) Boosted Z decaying into a pair of quarks.

(b) Boosted Higgs decaying into a pair of taus (visible components).

Event Selection

The selection is optimized comparing signal simulations with backgrounds from simulations and observed events. In addition, it is used a baseline selection dedicated to the Z-jet identification and hadronic trigger threshold.

The signal efficiency regarding this selection depends on the mass of the resonance and the channel. It is observed higher efficiencies in all-leptonic category ($\tau_e\tau_e$, $\tau_e\tau_\mu$, $\tau_\mu\tau_\mu$), between 20 - 60%. In semileptonic ($\tau_e\tau_h$, $\tau_\mu\tau_h$) and all-hadronic ($\tau_h\tau_h$) categories the efficiencies vary between 20 - 40%.

Selection	$\tau_e\tau_e$, $\tau_e\tau_\mu$, $\tau_\mu\tau_\mu$	$\tau_e\tau_h$, $\tau_\mu\tau_h$	$\tau_h\tau_h$
E_T^{miss}	> 100 GeV	> 50 GeV	> 80 GeV
$p_{T,\ell}^{leading}$	-	> 35 GeV	> 50 GeV
$N_{b-tagged\ jet}$	$= 0$	$= 0$	-
$\Delta R_{\ell\ell}$	< 1.0	< 1.0	< 1.0
$m_{\tau\tau}$	-	-	105–180 GeV

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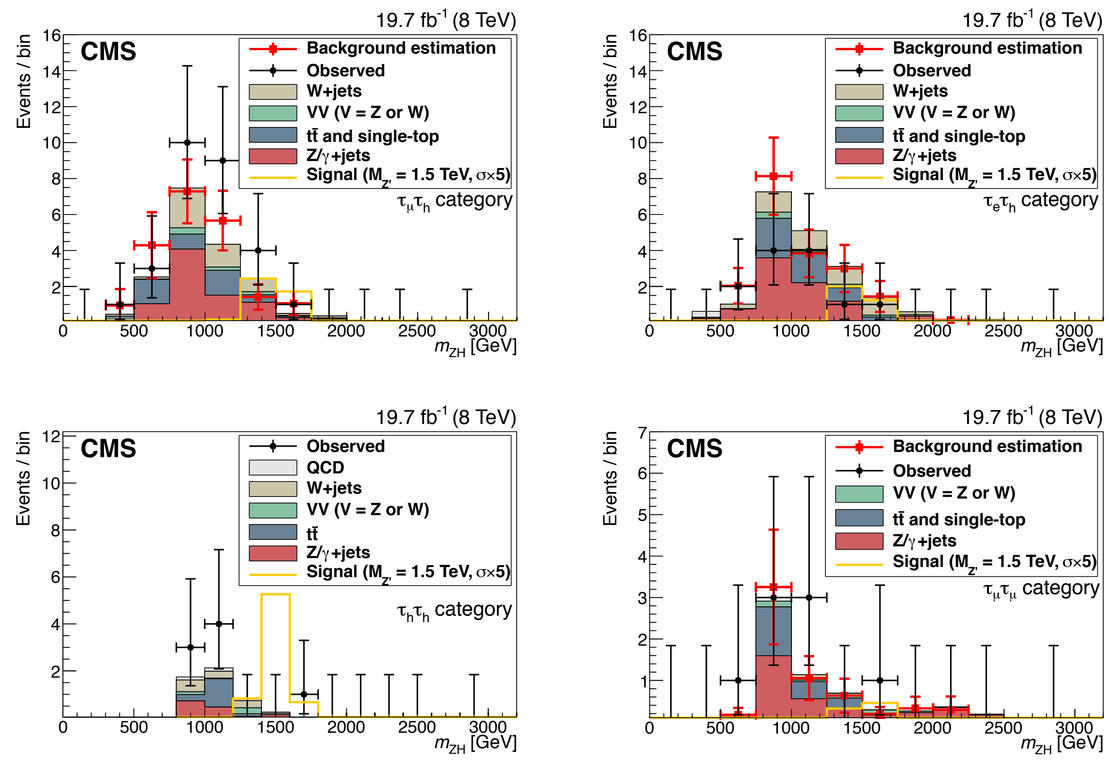
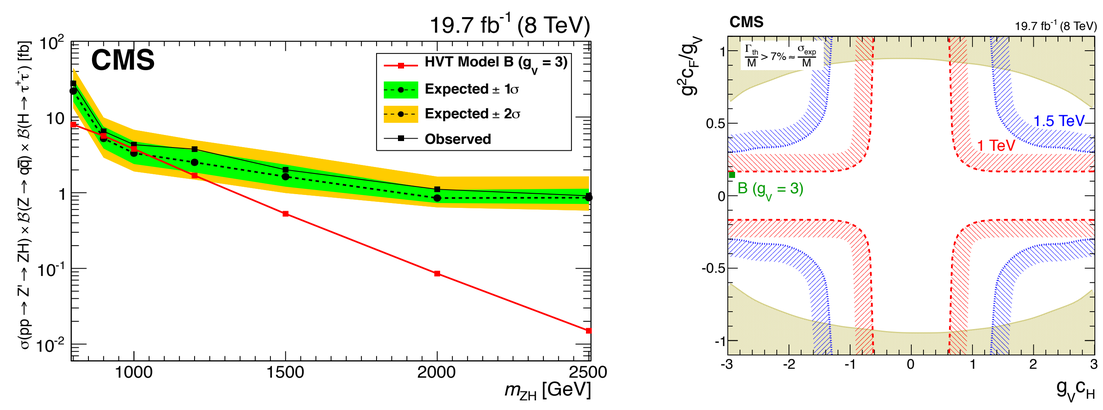
Background Modeling

The expected background is compared to observed events in the resonance mass variable (m_{ZH}) after full selection. Monte Carlo simulations are produced to describe the main background components: Z/γ + jets, W + jets, $t\bar{t}$, QCD, single-top, and VV. The simulation is not used in the direct comparison with observed events, but it helps in the validation of the background estimation method that considers mainly observed events. Similar methods for all the channels are used to estimate the background in the signal region (full selection) using observed events in a kinematical control region.



Results

Limits are set in the coupling parameters of a phenomenological Lagrangian that can be interpreted in the context of composite Higgs models. In this Lagrangian, a heavy $SU(2)_L$ vector triplet containing neutral and charged spin-1 states is introduced. For a fixed mass, the cross sections (σ) and branching fractions ($\mathcal{B}$) of the resonances decay are caracterized by three parameters: the strength of the couplings to fermions c_F, to the Higgs c_H, and the self-coupling g_V.



References

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