Search for heavy resonances into a boson and a higgs boson (WH,ZH,HH) in the jet + ττ final state

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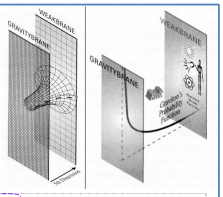
Abstract

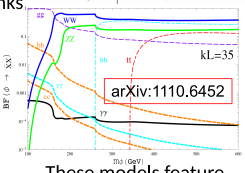
A search for a massive resonance decaying into a Higgs boson decaying to τ leptons and another standard model boson decaying hadronically (WH/ZH → qq ττ, HH → bb ττ) is presented. The search is performed using 35.9 fb^{-1} of pp collisions at $\sqrt{s}$=13 TeV recorded with the CMS detector at the LHC.

Theoretical motivation

Why is gravity 10^{32} times weaker than the weak force in nature?
This is one of the big unanswered questions of particle physics. New physics scenarios based on the idea of warped extra dimensions by Randall and Sundrum aim to address this problem, proposing a 5th dimension that links the gravity brane and the electroweak brane.



The existence of new neutral particles, i.e. Kaluza-Klein excitations of both spin-0 (radion) and spin-2 (graviton), is predicted.



Composite and little Higgs theories predict new particles of spin-1 (V'): charged W' and neutral Z'.

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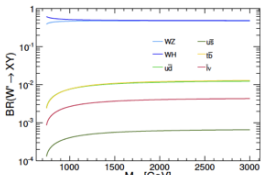
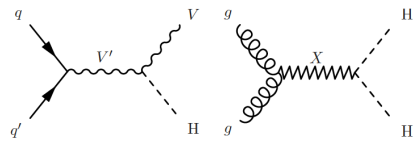


These models feature scenarios in which the new physics couples preferably
- to light fermions (HVT model A)
- to standard model boson (W_L,Z_L,H) (HVT model B)

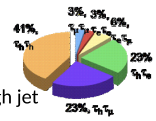
Signals

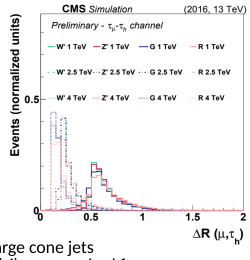


First search for heavy resonances into a pair of highly energetic bosons:
- H→ τ leptons
- W, Z (V) or H → q/b- quarks

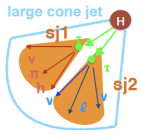
Boosted regime

Final products very collimated
- H → ττ : challenges in the lepton identification
- V/H → jet : reconstructed through jet substructure





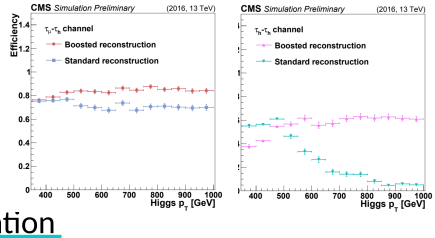
H → ττ identification



hadronic taus:
- start from large cone jets
  - 2 subjets (sj) are searched for :
    - p_T>10 GeV
    - max(m(sj1,sj2))/m(jet) <2/3
  - used as seeds for tau reconstruction
- discriminants are applied for tau decay mode compatibility and isolation

muons and electrons:
- the decay products of the identified tau are removed from the isolation deposits

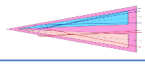
CMS-DP-2016/038



V/H → jet identification

The hadronization products of the two quarks are reconstructed as a single merged large cone jet (R = 0.8) :

- Grooming: removes the soft and large angle emitted radiation inside the jet
- N-subjettiness (τ_N): geometric distribution of constituents is analyzed to characterize the tendency of the jet to be composed of N subjets ($\tau_{21}=\tau_2/\tau_1$)
- Higgs-b-tagging: b-tagging applied to subjets



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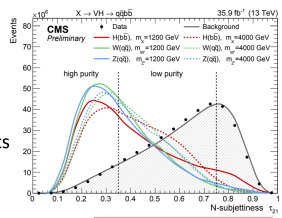
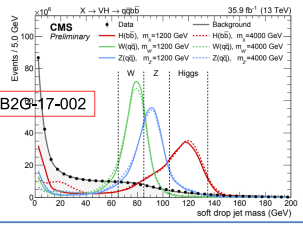


CMS-PAS-B2G-17-002

Event selection

Signal events are selected requiring:
- An isolated tau with p_T > 20 GeV
- An isolated electron, muon or tau
- A missing momentum > 200 GeV
- T_{21} HP and LP categorization
- 1 or 2 b-tagged subjets
- No additional b-tagged jets

CMS-PAS-B2G-17-002



Background estimation

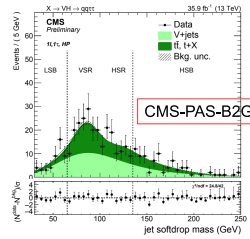
Backgrounds are estimated with a hybrid data-simulation approach:

-tt is estimated in dedicated control regions, selected by inverting the b-tagging requirements

τ_{21} LP	τ_{21} HP	1 b-tagged subjet	2 b-tagged subjets
0.96 ± 0.04	1.06 ± 0.06	1.00 ± 0.06	1.11 ± 0.15

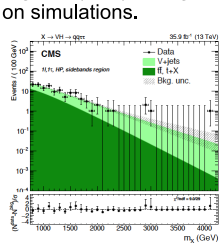
-V+jets is extrapolated from data events in the jet mass sideband regions (SBs), using predictions based on simulations.

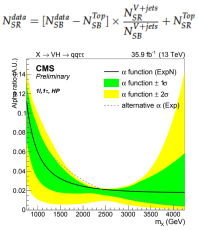
Main background contributions:
- tt
- V+jets (W+jets, DY, other backgrounds)

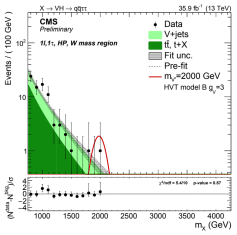


CMS-PAS-B2G-17-006

$$N_{SR}^{data} = [N_{SB}^{data} - N_{SB}^{Top}] \times \frac{N_{SR}^{V+jets}}{N_{SB}^{V+jets}} + N_{SR}^{Top}$$







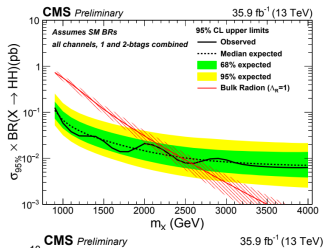
Results

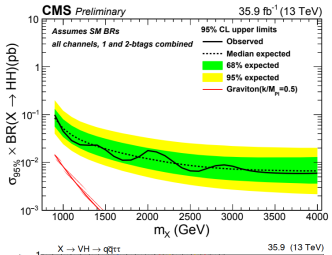
No significant excess with respect to the expected background events is observed in data:

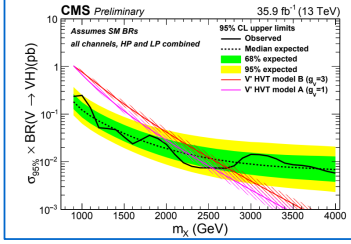
→ Expected 95% CL upper limits on the σ·BR for a resonance of spin 0, 1 ,or 2.
→ Constrains on the coupling parameters of the V' simplified model

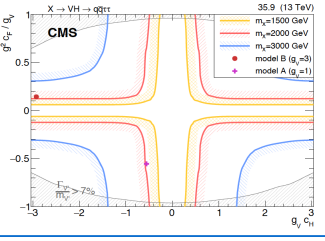
Main systematic contributions:
- Background estimation (60%)
- Lepton identification (30%)
- Jet tagging (18%)

CMS-PAS-B2G-17-006









Conclusions

A search for massive resonances decaying into a Higgs bosons decaying to τ leptons and another boson that can be a W, Z, or a Higgs decaying hadronically is performed in the data collected by CMS in 2016.
The analysis sets 95% C.L. upper limits on the cross section of a spin 0, 1, or 2 resonance decaying to diboson final states ranging from 250 to 6 fb for resonance masses between 900 and 4000 GeV.

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