Search for heavy resonances in the X→HH→ $\tau^-\tau^+$ $b\bar{b}$ final state at CMS

Camilla Galloni on behalf of the CMS collaboration

University of Zurich[UZH]

Abstract

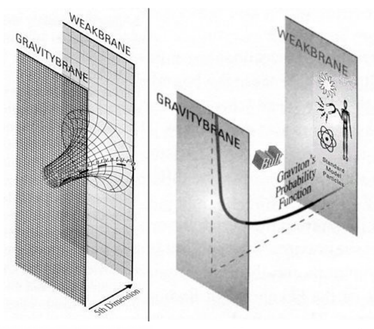
A search for a massive resonance decaying into a pair of Higgs bosons with τ leptons and b-quarks in the final state is presented. The search is performed using 19.7 fb^{-1} of pp collisions at $\sqrt{s} = 8$ TeV recorded with the CMS detector at LHC.

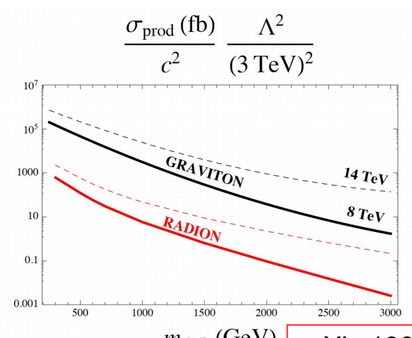
Theoretical motivation

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.

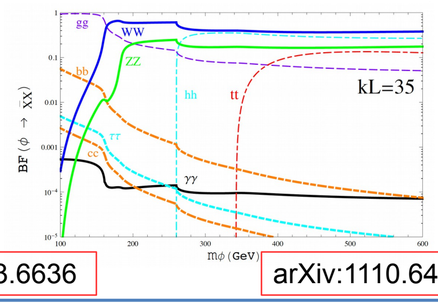
This model proposes the existence a 5th dimension that links the gravity brane and the electroweak brane.

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





arXiv:1303.6636

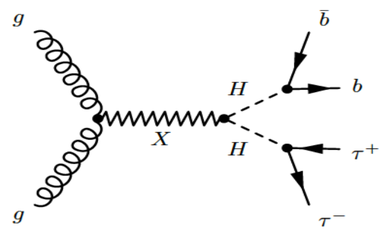


arXiv:1110.6452

Bulk scenario:

- EW fields spread in the 5th dimension
- High branching ratios to heavy boson (W_L,Z_L,H)

Signal: Radion → HH → $b\bar{b}\tau^-\tau^+$

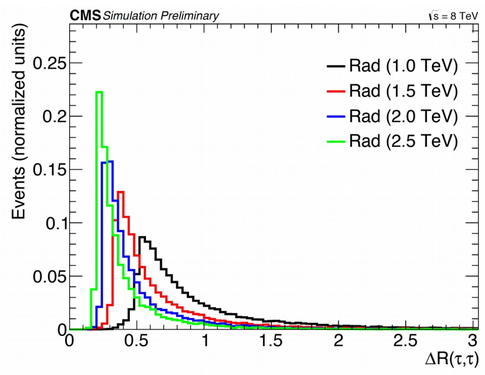


First search for heavy resonances into a pair of highly energetic Higgs bosons with τ leptons and b-quarks in the final state.

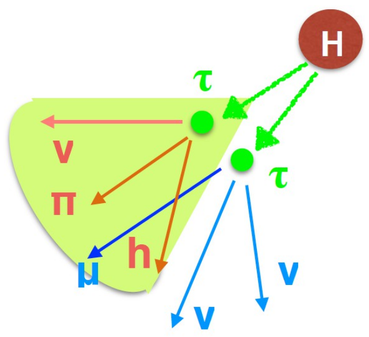
Boosted regime

Final products very collimated

- H → ττ (semi-leptonic final state): challenges in the lepton identification
- H → bb: reconstructed through jet substructure



H → ττ identification

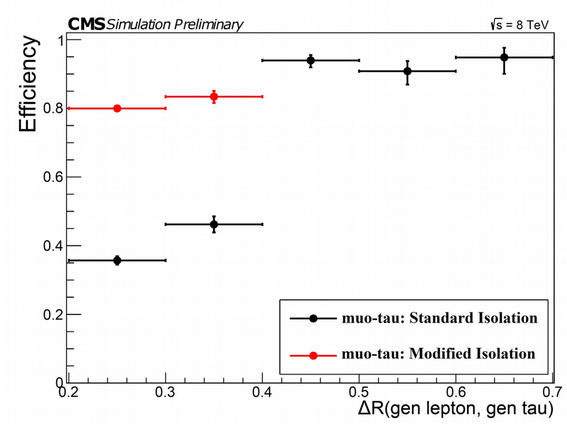


hadronic taus:

- jet cleaning procedure:
  - identified leptons are removed from jet cones
  - cleaned jets used as seed for particle flow tau reconstruction
- discriminants are applied for tau decay mode compatibility, isolation and electrons and muons rejection

muons and electrons:

- the decay products of the identified tau are removed from the isolation deposits

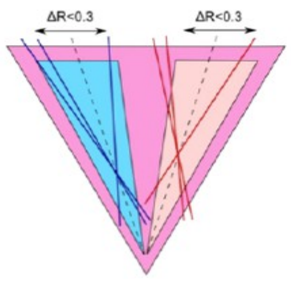


CMS-PAS-EXO-13-007

H → bb identification

The hadronization products of the two bottom quarks are reconstructed as a single merged Cambridge-Aachen fat jet (R = 0.8) jet:

- Pruning technique: 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 sub-jets ($\tau_{21} = \tau_2/\tau_1$)
- Higgs-b-tagging:
  if ΔR(sj1,sj2)>0.3: both sub-jets b-tagged
  if ΔR(sj1,sj2)<0.3: fat jet b-tagged

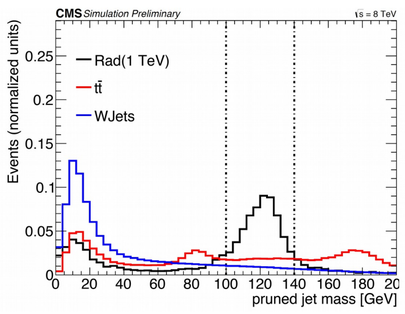


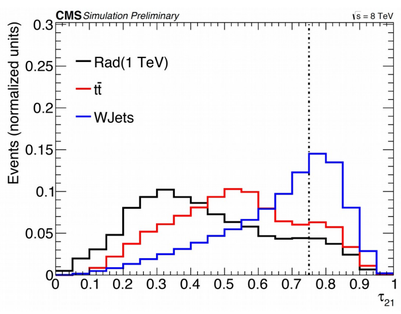
CMS-PAS-BTV-13-001

Event selection

Signal events are selected requiring:

- An isolated tau with p_T > 35 GeV
- An isolated electron or muon with p_T > 10 GeV
- A jet of p_T > 400 GeV, pruned mass ∈ [100,140] GeV, τ_{21}<0.75 and Higgs-b-tagged





Background estimation

Backgrounds are estimated from simulation with **data-to-simulation Scale Factors** (SFs):

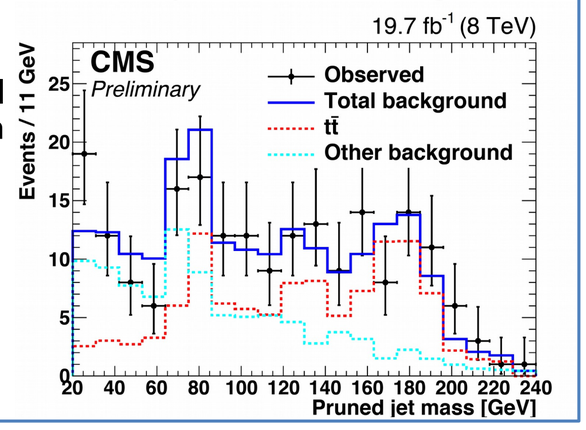
SFs are derived by simultaneously fitting simulated distributions in dedicated control regions, selected by loosening tau isolation and b-tagging requirements

Channel	Background	SF_{SR}
$\mu - \tau_h$	$t\bar{t}$	0.91 ± 0.24
	other	0.69 ± 0.19
$e - \tau_h$	$t\bar{t}$	1.05 ± 0.28
	other	0.65 ± 0.22

$$SF_{SR} = SF^{Untagged}_{IntermediateIso} * SF^{b-tagged}_{InvertedIso} / SF^{Untagged}_{InvertedIso}$$

Main background contributions:

- $t\bar{t}$
- W+jets and DY (other backgrounds)



Results

Main systematic contributions:

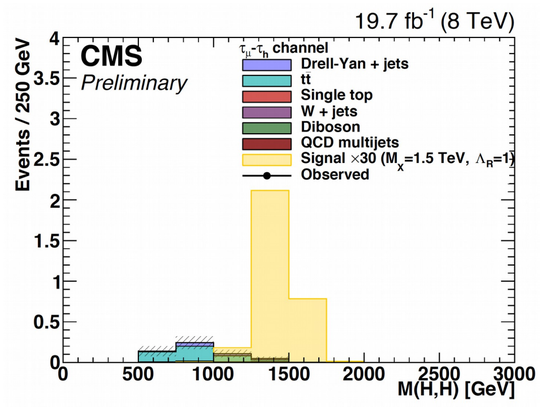
- Background estimation (40%)
- Lepton identification (20%)
- Higgs-jet identification (15%)

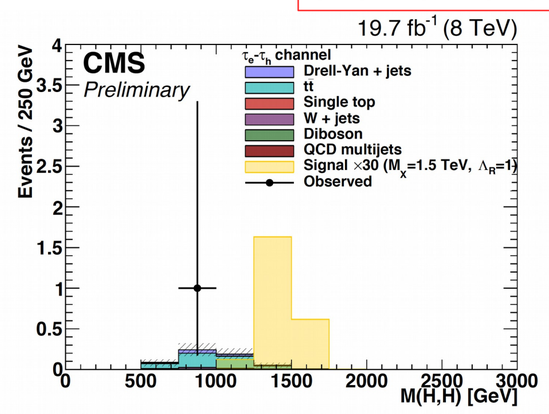
Signal efficiencies (%) after full selection

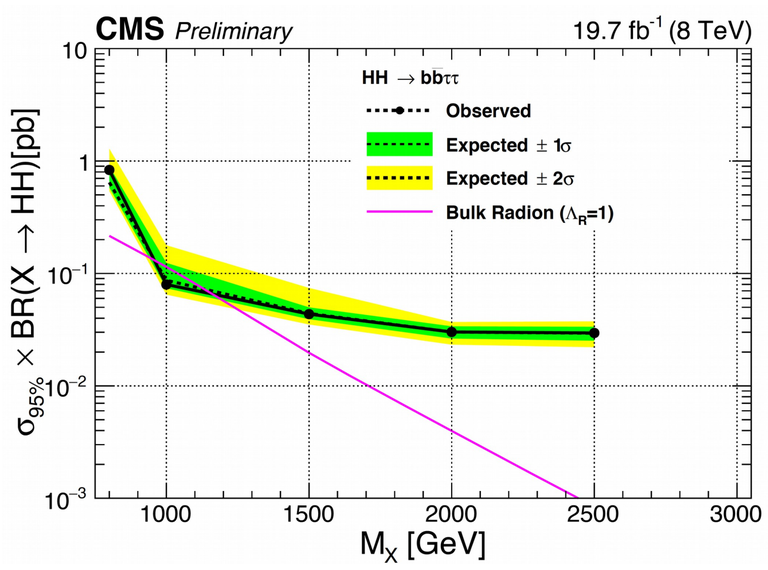
Mass (TeV)	$\tau_e\tau_h$	$\tau_\mu\tau_h$
0.8	0.14 ± 0.03(stat) ± 0.03(syst)	0.19 ± 0.03(stat) ± 0.03(syst)
1.0	1.10 ± 0.07(stat) ± 0.20(syst)	1.70 ± 0.09(stat) ± 0.31(syst)
1.5	2.44 ± 0.11(stat) ± 0.48(syst)	3.16 ± 0.13(stat) ± 0.63(syst)
2.0	3.95 ± 0.15(stat) ± 0.91(syst)	5.07 ± 0.17(stat) ± 1.17(syst)
2.5	2.60 ± 0.11(stat) ± 0.88(syst)	4.02 ± 0.14(stat) ± 1.09(syst)

Distribution for the expected background processes in the resonance invariant mass spectrum

CMS-PAS-EXO-15-008







Expected 95% C.L. upper limits on the production cross section of a heavy spin 0 particle decaying into a pair of Higgs bosons

Conclusions

A search for massive resonances decaying into a pair of Higgs bosons with b-quarks and τ leptons is performed in the final state where one tau decays hadronically and the other leptonically.

The analysis sets 95% C.L. upper limits on the cross section of a spin 0 resonance ranging from 850 to 30 fb for resonance masses between 800 and 2500 GeV and radions with Λ_R = 1 TeV are excluded between 950 and 1150 GeV.

(*)cgalloni@cern.ch