Search for Heavy Resonances Decaying to Two Higgs Bosons in Final States with 4 b Quarks

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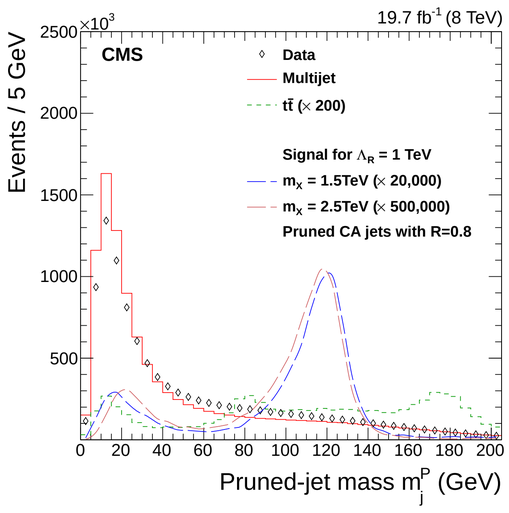
Overview

Several beyond the standard model studies postulate the existence of warped extra dimensions considering a scalar radion with mass in the TeV scale. In this analysis we search for a spin-0 radion X resonance analyzing a decay chain of $X \to HH \to b\bar{b}b\bar{b}$ with boosted Higgs bosons.

Boosted Topology

The present study considers predictions of warped extra dimensions with radion resonance of masses between 1 and 3 TeV. In a boosted regime, the Higgs bosons (H) in the topology $X \to HH \to b\bar{b}b\bar{b}$ have large momentum. The decay product of each H boson is a pair of b quarks, whose hadronization turns out to be jets very close to each other, being identified as a single large jet. Then the final state appears with 2, 3 or 4 jets, depending on how merged is each b-jet pair after the reconstruction of events.



Multijet and $t\bar{t}$ are the dominant backgrounds, but are significantly removed after selecting events based on the flavor of jets (from b-tagging technique, its mass and substructure. The spectrum of a single jet p_T for signal of radion appears in the failing tail of observed and background events.

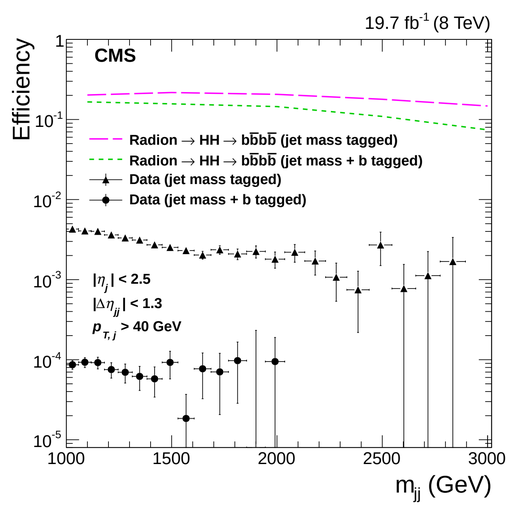
Selections

In order to remove background and enhance the signal of radion, selection of events are applied in the following order:

- good primary vertex
- at least 2 jets with $p_T > 40$ GeV
- jets with $|\eta| < 2.5$
- angular separation between two jets ($|\eta_{jj}| < 1.3$)
- invariant mass of two jets (dijet mass) is $m_{jj} > 1$ TeV
- jets mass with $110 < m_j < 135$ GeV
- 2 b-tagged jets and ≥ 1 double b-tagged jets

After requiring events with $|\eta| < 2.5$, $p_T > 40$ GeV for both jets and $|\eta_{jj}| < 1.3$, efficiencies as a function of the dijet mass appear to have dependence with:

- jet mass (110 – 135 GeV)
  - 12 to 9% in signal
  - 4 to 0.1% in data
- jet mass + jet b-tag
  - 9 to 4% in signal
  - ≈ 0.01% in data



Jets are classified as a function of their substructure (τ_{21}) depending on the probability to have one ($\tau_{21} \to 0$) or two jets ($\tau_{21} \to 1$):

- "high-purity" jets (HP) have $\tau_{21} < 0.5$
- "low-purity" jets (LP) have $\tau_{21} < 0.75$

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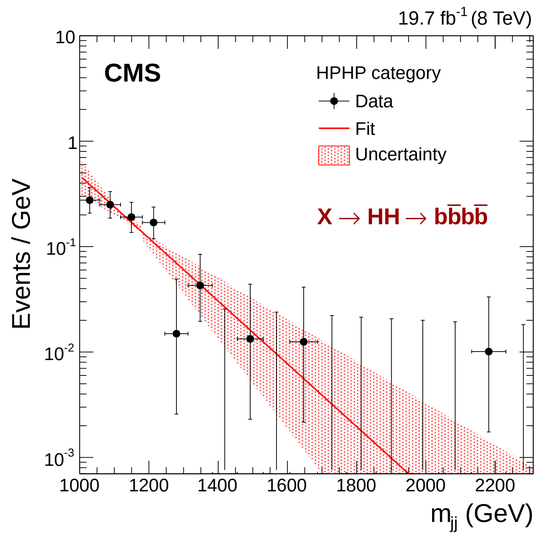
Background Modeling

The background is estimated fitting the dijet mass of observed events using a modified exponential function with normalization N_B considering $100 < m_j < 135$ GeV and slope a based on $60 < m_j < 100$ GeV:

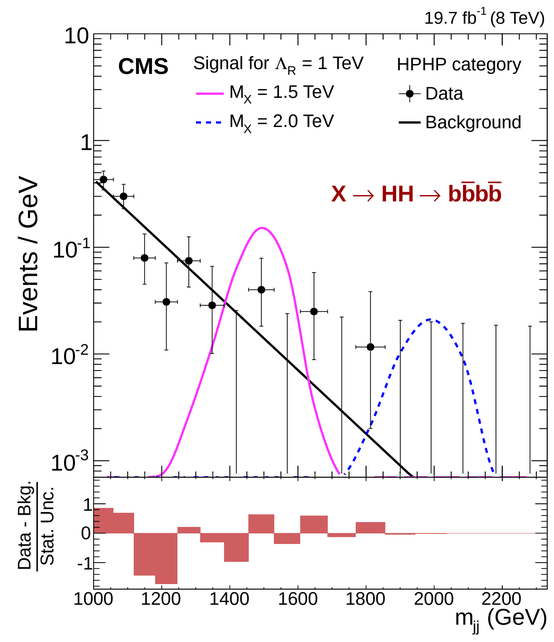
$$\frac{\mathrm{dN_{Background}}}{\mathrm{dm_{jj}}} = N_B\, a\, e^{-a(m_{\mathrm{jj}} - 1000GeV)}$$

Events are categorized according to the "jet-purity":

- HPHP: two "high-purity" jets
- HPLP and LPHP: one "high-purity" jet



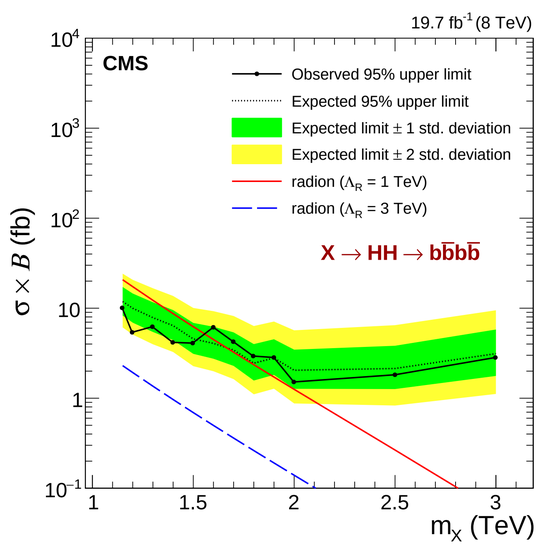
Jet mass: $60 < m_j < 100$ GeV

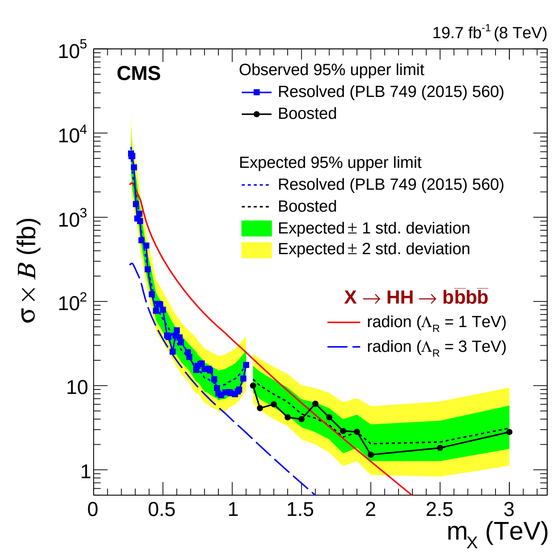


Jet mass: $100 < m_j < 135$ GeV

Results

No excess of data is found. Exclusion limits at 95% confidence level on the production cross section are computed for m_X between 1.15 and 3.0 TeV, extending significantly beyond 1.5 TeV the reach of previous searches. A radion with scale parameter Λ_R = 1 TeV decaying into HH is excluded for $1.15 < m_X < 1.55$ TeV for the first time in direct searches.





References

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[3] Thaler, Jesse and Van Tilburg, Ken, "Identifying Boosted Objects with N-subjettiness", *JHEP 03 (2011) 015*.