PROCEEDINGS OF SCIENCE

Search for the Standard Model Higgs Boson produced in Vector Boson Fusion and decaying into tau pair in CMS with 1fb^{-1} of luminosity.

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A prospective analysis is presented on the observability of the Standard Model Higgs boson produced in the Vector Boson Fusion and decaying into tau-tau pair with the tau-tau->$\ell\nu\nu$+τ-jetν final state. The estimates of the upper limit on the cross section times branching ratio for 1fb^{-1} for the Higgs boson mass interval 115–145 GeV/c^2 are given.

XXth Hadron Collider Physics Symposium
November 16 – 20, 2009
Evian, France

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PoS(HCP2009)067

1. Introduction

The Standard Model Higgs boson decay to a tau-tau pair is an important channel in the search of the Higgs boson in the mass range 115–145 GeV/c^2. The vector boson fusion (VBF) process, with the second highest cross section at the LHC, provides a characteristic signature of two forward quark jets, which can be used to distinguish the Higgs boson signal from the background processes.

2. Mass reconstruction

The full di-tau mass can be reconstructed from two visible taus and $E_\mathrm{T}^\mathrm{miss}$. For high p_T taus the direction of the neutrinos from its decay is approximately collinear with the visible decay products. Thus, their energies can be retrieved by projecting $E_\mathrm{T}^\mathrm{miss}$ on visible taus. This collinear approximation provides a satisfactory mass resolution, but a fraction of the events is lost when the approximation results in negative neutrino energy. This may arise from a back-to-back event topology or from a poor reconstruction of $E_\mathrm{T}^\mathrm{miss}$. Another method, suited for early data-taking, is the di-tau mass reconstruction using only visible decay products. The method is independent on $E_\mathrm{T}^\mathrm{miss}$ reconstruction, but reconstructed mass is significantly underestimated (Fig. 1).

The dominant uncertainties of the full mass shape are expected to come from the modeling of $E_\mathrm{T}^\mathrm{miss}$. A method to model the di-tau mass shape from real $Z \to \mu\mu$ events has been developed. Firstly, muons are removed from the real event and not counted in $E_\mathrm{T}^\mathrm{miss}$ calculation. Secondly, taus with the real muons kinematics are generated and put into the real $Z \to \mu\mu$ event to form a di-tau event with fake taus. Finally, the di-tau mass are calculated for this event. Figure 2 shows the reconstructed di-tau mass distribution for the $Z \to \tau\tau$ events with real and fake taus [1].

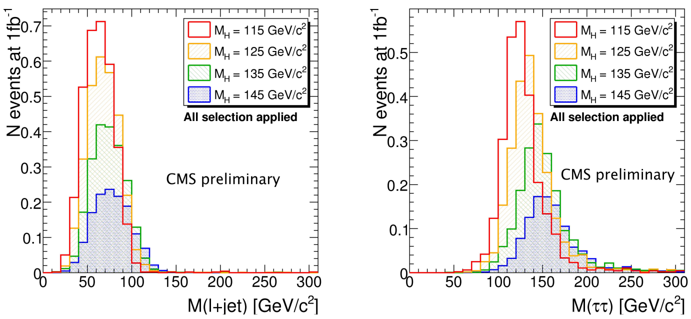

Figure 1: The reconstructed mass distribution using (left) visible decay products and (right) the collinear approximation, for VBF H $\to \tau\tau$ events.

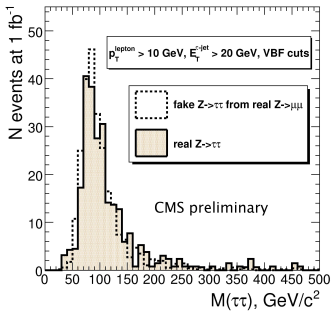

Figure 2: The di-tau mass distribution for $Z \to \tau\tau \to \ell\nu\nu + \tau_\mathrm{had}\nu$ events with real and fake taus.

3. Rapidity gap

A particular signature of VBF events is the rapidity gap between the two quark jets due to the absence of color exchange between the incoming quarks. A selection of the gap allows to reduce significantly background keeping a high efficiency for signal. Two methods of the central rapidity gap selection were studied:

• the Central Jet Veto (CJV) is requirement of non-existence of any jet in $p_T > p_T^{min}$ in the rapidity gap,

• the Track Counting Veto (TCV) is requirement of maximal number of tracks with $p_T > p_T^{min}$ in the rapidity gap.

Fig. 3 shows the efficiency of selecting the VBF $H \rightarrow \tau\tau$ signal with respect to the efficiency for the Z+jets background using CJV (left) and TCV (right). For details see in note [1].

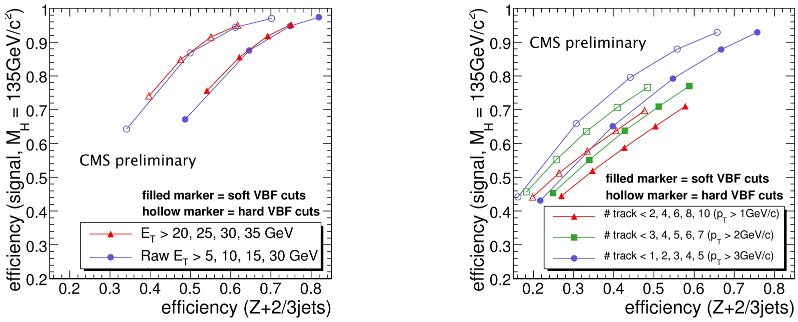

Figure 3: The signal efficiency (VBF H $\rightarrow \tau\tau$, M_H = 135 GeV/c^2) vs the background efficiency (Z+jets, $Z \rightarrow \ell\ell$) for CJV (left) and TCV (right).

4. Results

The di-tau mass distribution after all selections is shown in Fig. 4. No signal evidence is expected for 1fb^{-1}. The mass distribution for signal and background was used to evaluate the upper limit on the cross section times the branching-ratio in the Higgs mass range 115–145 GeV/c^2 (Fig. 5). For details see in note [2].

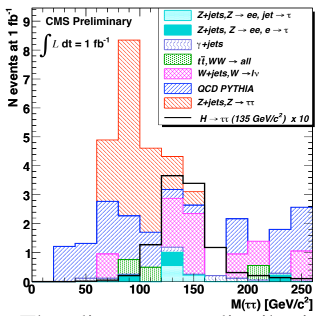

Figure 4: The di-tau mass distributions for the backgrounds expected for 1fb^{-1} after all selections. The signal mass distribution scaled by factor 10 is also shown for M_H = 135 GeV/c^2.

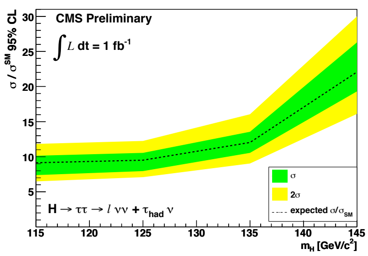

Figure 5: The 95% CL limit on the cross section times the branching ratio expected for 1fb^{-1} as a function of the Higgs boson mass. Systematic uncertainties taken into account. The 1σ and 2σ bands correspond with the statistical uncertainties.

References

[1] CMS Collaboration, *Towards the Search for the Standard Model Higgs boson produced in Vector Boson Fusion and decaying into a τ pair in CMS with 1fb^{-1}: τ identifications studies.*, CMS PAS HIG-08-001, 2008

[2] CMS Collaboration, *Search for the Standard Model Higgs boson produced in Vector Boson Fusion and decaying into a τ pair in CMS with 1fb^{-1}*, CMS PAS HIG-08-008, 2008