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First studies towards a measurement of the Higgs width at TLEP (Draft_version, to_be_updated_later)

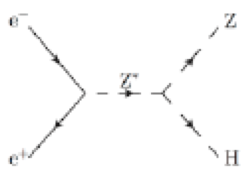
INTRODUCTION

TLEP is a circular e+ e- collider with high luminosity to study the Higgs Boson and physics at the electroweak scale. My project was to get started with a measurement of Higgs width at TLEP, using the e+ e- → WW → Hvv process and using the PFSim package, which is a particle flow simulation package developed at CMS. To achieve this I have learned ROOT and used python to write the analysis code.

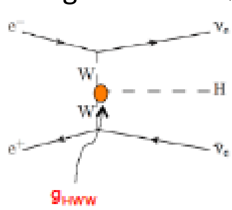
MEASUREMENT OF HIGGS WIDTH FROM Hvv FINAL STATE

I have considered two processes for the e+ e- collision (with Centre of Mass energy = 350 GeV) :

(i) The Irreducible background : e+ e- → ZH



(ii) The signal : e+ e- → WW → H



It is clear that both processes have the same final state Hvv. And, my goal was to distinguish between the two processes.

From the cross-section of WW → H and branching ratio of Higgs decaying into two W bosons i.e. σ(WW →H) and BR(H → WW), the total Higgs width can be calculated and is given by :

$$\Gamma \sim \sigma(WW \rightarrow H) \; / \; BR(H \rightarrow WW)$$

STRATEGY TAKEN

I have computed the missing mass and visible mass for both of the above mentioned processes, because computing these two quantities will help us to discriminate WW → H process from HZ process. I have imposed no requirements on the decay mode of the Z boson or Higgs. Also, I have not used jet reconstruction.

MISSING MASS

The missing mass of a process is an estimation of the mass of invisible particles in the final state. If the 4-momentum of beam and final state particles are denoted as, $\mathbf{P}_{beam}$, $\mathbf{P}_1$, $\mathbf{P}_2$ ... $\mathbf{P}_N$. Then, the "missing mass" is defined as: $\mathbf{M}^2 = (\mathbf{P}_{beam} - \sum \mathbf{P}_i)^2$.

VISIBLE MASS

The visible mass is the mass of all the reconstructed particles in the final state. For a particle, decaying into N particles, the "visible mass" of the decaying particle is: $\mathbf{M}^2 = (\sum \mathbf{P}_i)^2$

EVENT SIMULATION

I have generated events with HZHA and simulated with PFSim package. I have generated 20,000 events with cross-section 131 fb for HZ process and 5000 events with cross-section 30 fb for the WWH process.

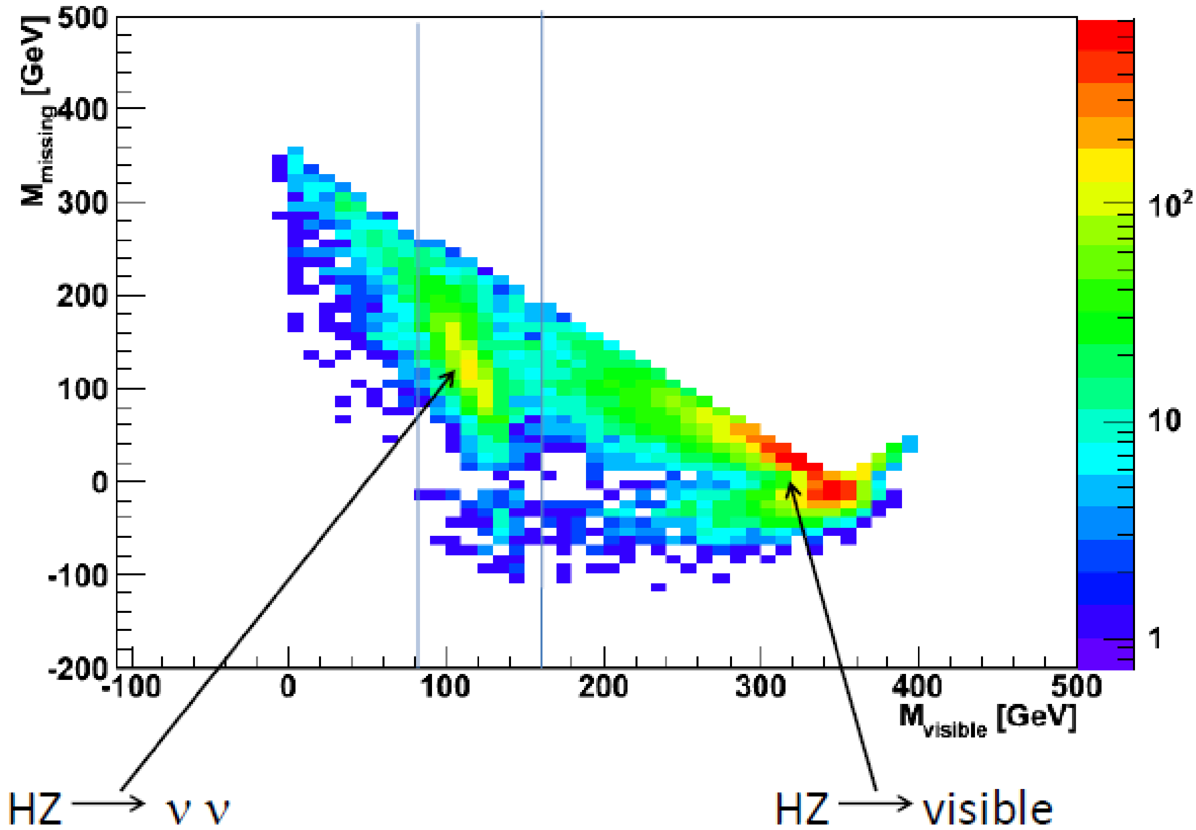
Time taken to generate and simulate events with HZHA and PFSim is approximately 20 ms/ event real time, which is dominated by HZHA. For PFSim with fastjet , the time required is only 2 ms/ event real time.

MISSING MASS vs. VISIBLE MASS FOR HZ PROCESS

I have plotted "visible mass" along the X-axis and "missing mass" along Y-axis. It can be seen from the plot, that, we get a peak for which missing mass is in between 90 GeV and 150 GeV, and visible mass is around 100 GeV. This peak is identified with HZ → νν process, since the ν's here come from a Z – resonance and therefore the missing mass in this case corresponds to the Z boson mass which is ~ 90 GeV and the visible mass corresponds to the Higgs boson mass ~ 125 GeV.

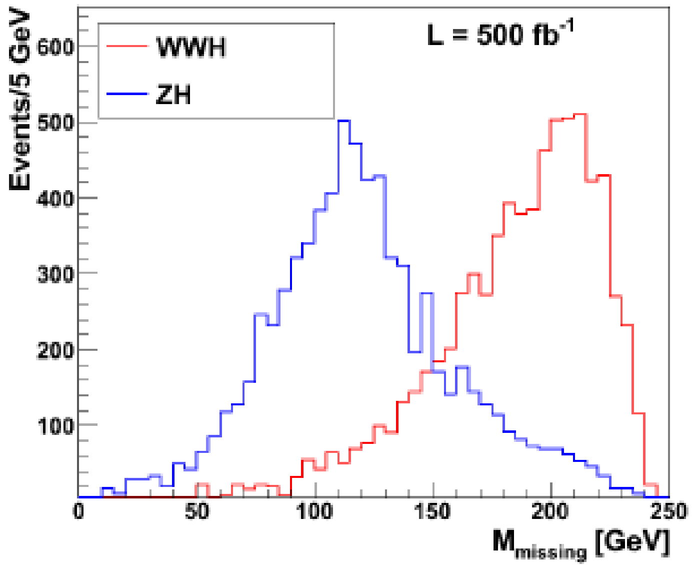
There is however another peak with visible mass ~ 330 GeV and very very small missing mass. This peak can thus be identified with the process of HZ → visible particles.

But, since I wanted only Higgs in our final state, so I applied a cut on visible mass between 90 – 150 GeV to select only those events that contains Higgs in final state.



DISTINGUISHING WWH PROCESS FROM ZH PROCESS

Applying the above mentioned cut on the visible mass I have plotted the normalized event distribution (up to 500 fb^{-1} Luminosity) of the missing mass of the two processes. The ZH process is identified with the distribution, which has a peak around 100 GeV i.e. around Z boson mass, because in this process the two neutrinos come from a Z – resonance. And the WWH process can be identified with the distribution which has peak at a higher value of missing mass i.e. around 200 GeV. This is expected because the neutrinos in this process were generated away from the resonance and therefore correspond to a higher missing mass value.



Obtained with a CMS-like detector modeled
in the PFSim, neglecting ee->qq background

FUTURE PLANS

In future, we will be trying to finalize the analysis by including the e+e- → qq background, which we neglected in this simulation. And, also to include b-tagging and set up template fits. We will update the simulation with more adequate PFSim package and compare with results obtained with CMS fast sim. We will also use the PFSim to investigate the effect of detector performance on the analysis.