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H->ZZ* analysis at 3 TeV

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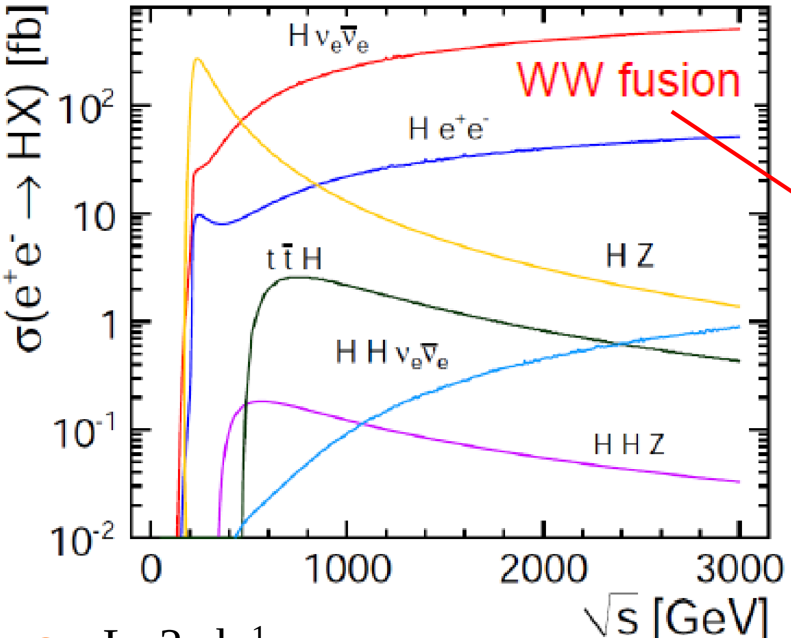
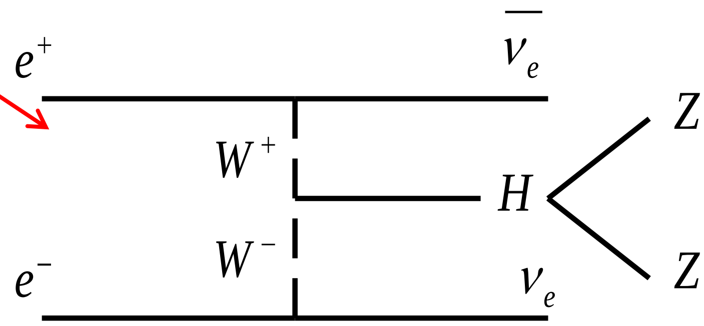
Overview

- Signal and background
- Simulation and reconstruction
- Analysis strategy
- Preselection
- MVA results
- Conclusions

Signal



Signal : 2 jets + 2 leptons (muons, electrons or taus) + missing energy

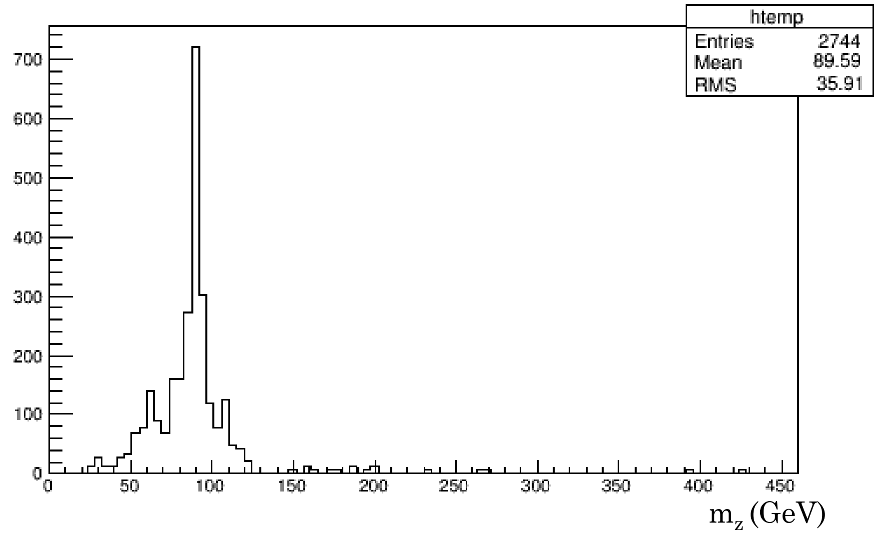


- L=2 ab^{-1}
- Signature: E_{miss} plus (2-jet+2l)
- σ(e+e -⟶ Hvv) ~ 415 fb
- BR(H→ZZ*) ≈2.89%
- BR(Z->qq) ≈70%, BR(Z->ll) ≈10%
- Ns~ 3400 events

Higgs coupling: $\frac{g^2_{HWW} \cdot g^2_{HZZ}}{\Gamma_H}$

SIGNAL

- The reconstruction is based on the pair of jets or leptons with the mass closest to the mass of real Z, including both hadronic and leptonic Z decay modes.



“real” Z

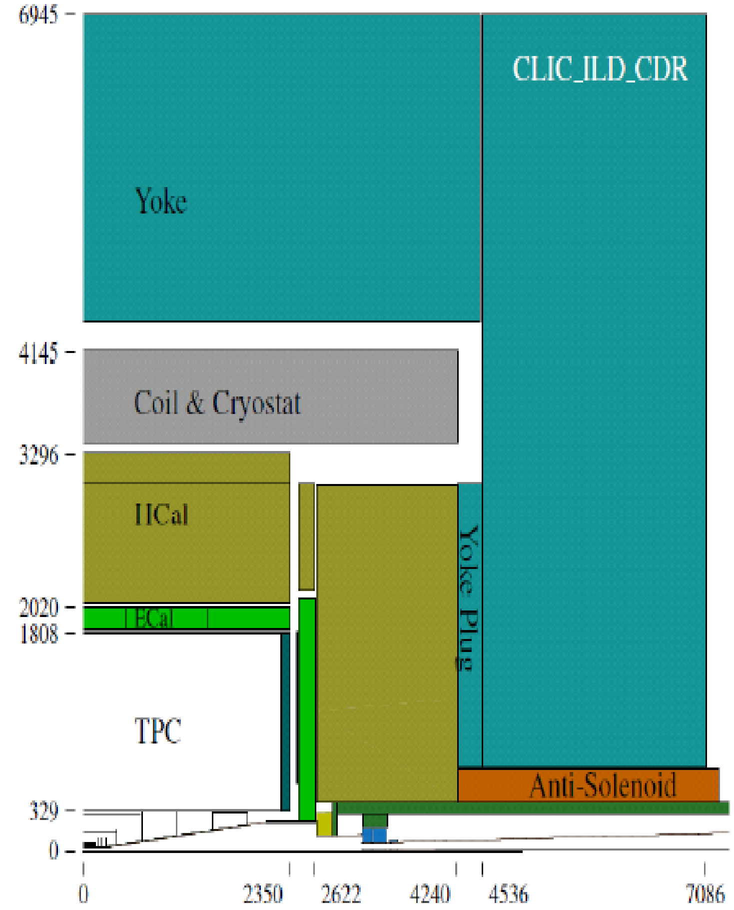
Signal and bck processes

Process	$\sigma[fb]$
$e^+e^- \to H\nu_e\overline{\nu_e}, H \to ZZ -> qqll$	1.7
$e^+e^- \to qq\nu_e\overline{\nu_e}$	1317.5
$e^+e^- \to H\nu_e\overline{\nu_e}, H \to WW$	96
$e^+e^- \to H\nu_e\overline{\nu_e}, H \to bb$	233
$e^+e^- \to qqll$	3319.6
$e^+e^- \to H\nu_e\overline{\nu_e}, H \to cc$	11.7
$e^+e^- \to H\nu_e\overline{\nu_e}, H \to gg$	35.2
$e^+e^- \to qql\nu$	5560.9
$H \to others$	37.4

Several processes with a large cross-section ⇒ will be removed after MVA.

Simulation and reconstruction

- Event generation with WHIZARD V57 , ISR, BS, beam recoil
- Particle reconstruction and identification using PFA approach
- Overlay of beam-induced background $\gamma\gamma \rightarrow$ hadrons



ANALYSIS STRATEGY

Lepton Isolation	Find 2 isolated electrons, muons or taus
⇓	
Fast Jet	Force events into 2 jets, kT exclusive, SELECTEDPFOs, R=0.8
⇓	
Lcfi Vertexing	helps to reduce $e^+e^- \to H\nu_e\overline{\nu}_e, H \to bb$
⇓	
Preselection	helps to reduce large x-sec background
⇓	
MVA selection	Multivariate BDT analysis
⇓	
Relative statistical uncertainty of $\sigma \times BR$	Higgs mass distribution is used to estimate statistical uncertainty $\frac{\sqrt{S+B}}{S} \times 100\%$

Isolated Lepton Finder

- Remove all tracks with E < 6 GeV
- Energy contained in a cone around the track: cos θ=0.995
- Cut at Impact Parameter : $d_0<0.2$mm, $z_0<0.3$ mm, $R_0<0.3$mm
- Ratio of track energy deposition in ECAL and HCAL

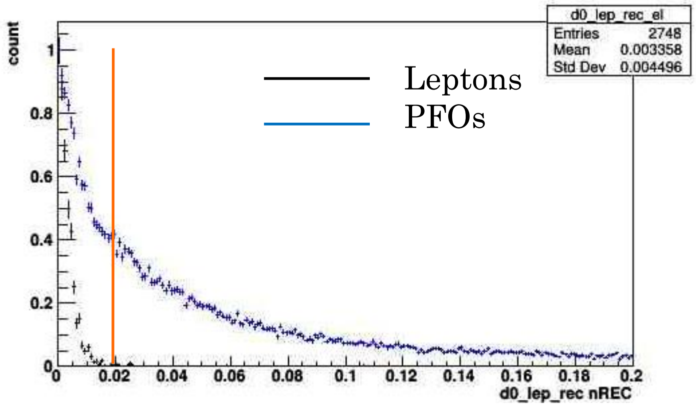
  0.02< μ E_{ECAL} to E_{HCAL} fraction <0.25

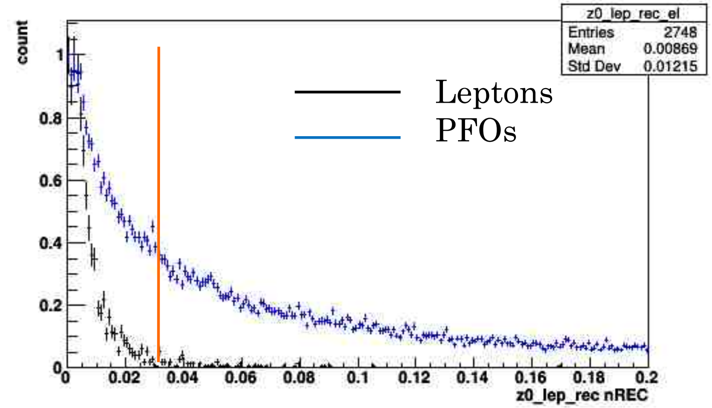
  e^- E_{ECAL} to E_{HCAL} fraction>0.94
- Apply isolation criteria

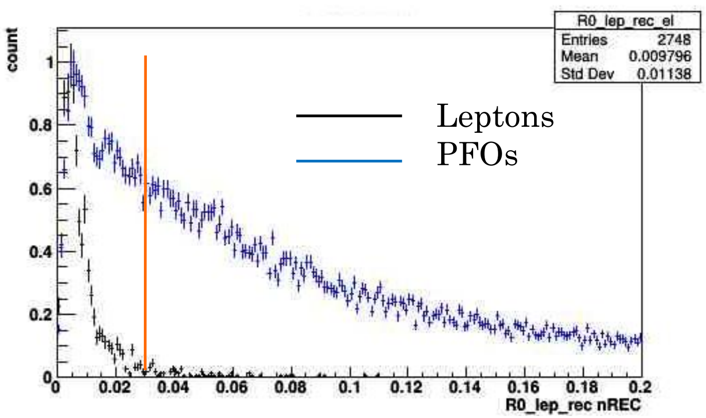
86% efficiency in reconstruction of the lepton (electron/muon) pair

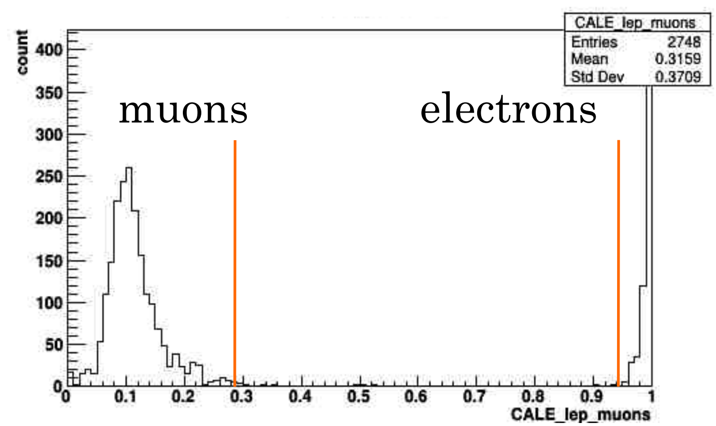
Isolated Lepton Finder

Impact parameters





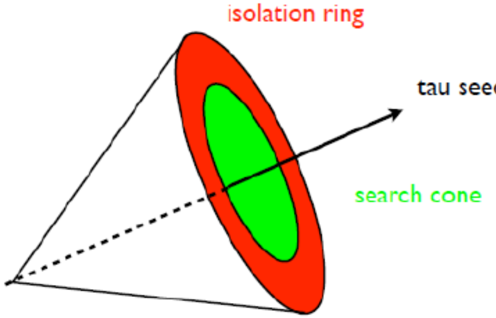




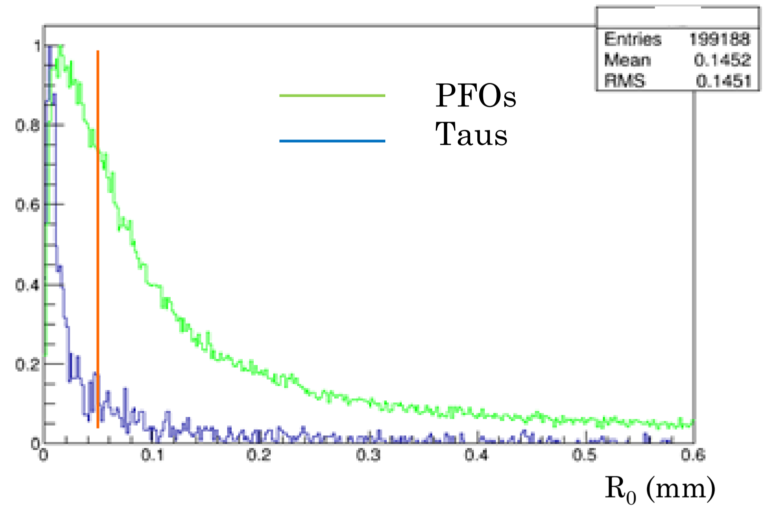
Ratio of track energy deposition in ECAL and HCAL

Tau Finder

- Steps to reconstruct a tau:
  1. Look for tau 'seed' (a high energy, charged track)
  2. Add all particles within search cone to seed
  3. Check number of charged tracks, isolation, tau mass



Initial p_T cut for all tracks > 2 GeV
p_T cut for seed > 10 GeV
Impact parameter R_0 : <0.06
Search cone angle < 0.15 rad
Isolation energy < 3 GeV
Ring particles < 8
Invariant mass < 2 GeV/c^2



35% efficiency in reconstruction of the tau pair

Preselection

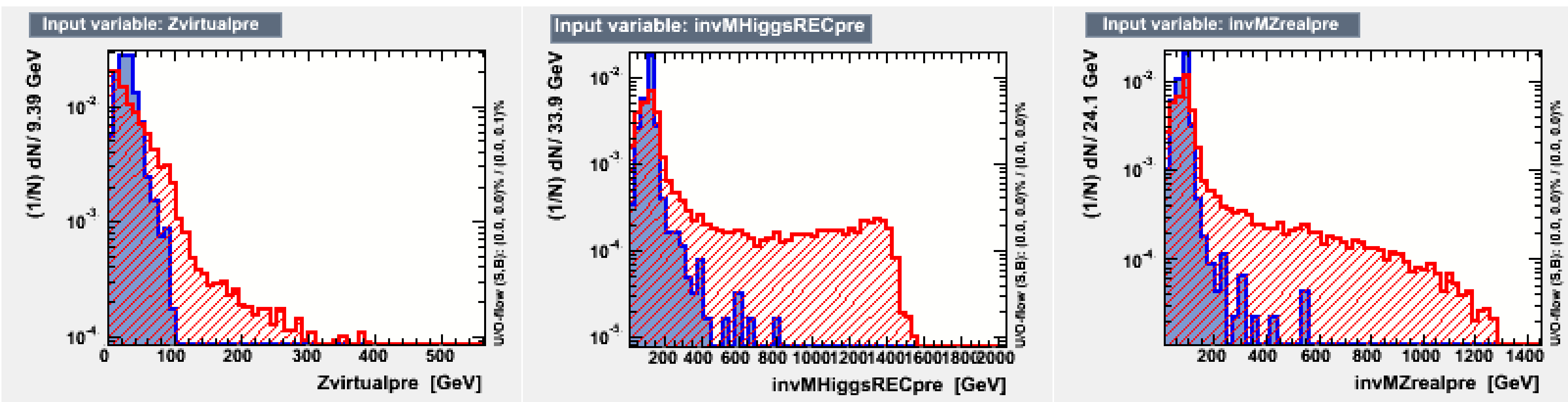
Preselection: find two isolated leptons.

Process	ε_{pre}
$e^+e^- \to H\nu_e\overline{\nu_e}, H \to ZZ^* -> qqll$	61%
$e^+e^- \to qq\nu_e\overline{\nu_e}$	13%
$e^+e^- \to H\nu_e\overline{\nu_e}, H \to WW$	30%
$e^+e^- \to H\nu_e\overline{\nu_e}, H \to bb$	20%
$e^+e^- \to qqll$	11%
$e^+e^- \to H\nu_e\overline{\nu_e}, H \to cc$	22%
$e^+e^- \to H\nu_e\overline{\nu_e}, H \to gg$	24%
$e^+e^- \to qql\nu$	20%
$H \to others$	48%

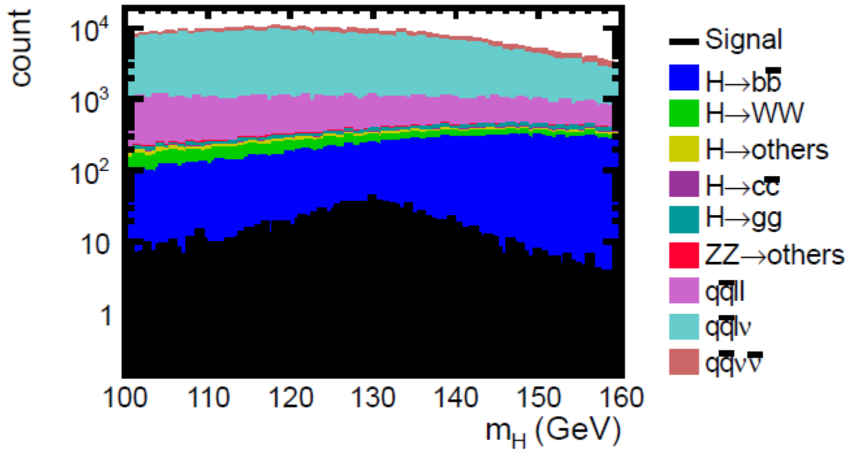
Main aim of the preselection is to reduce large x-sec background.

MVA ANALYSIS

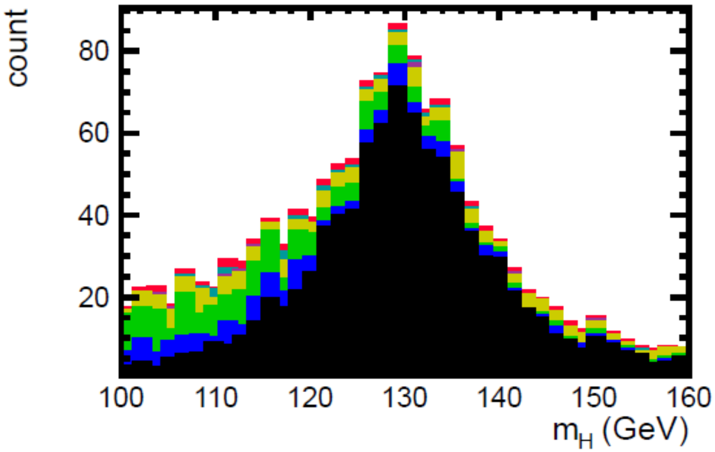
- TMVA trained with 17 variables (m_{Z*}, $-\log(y_{23})$, $-\log(y_{12})$, $P(b)^{jet1}$, $P(b)^{jet2}$, $P(c)^{jet1}$, $P(c)^{jet2}$, E_{vis}, pT_{miss}, θ_H, m_H, m_{ll}, m_{qq}, N_{PFO}, $m_{Zvirtual}$, $E_{vis} - E_H$) on total background.



RESULT



Preselection efficiency 61%



Overall efficiency 29%

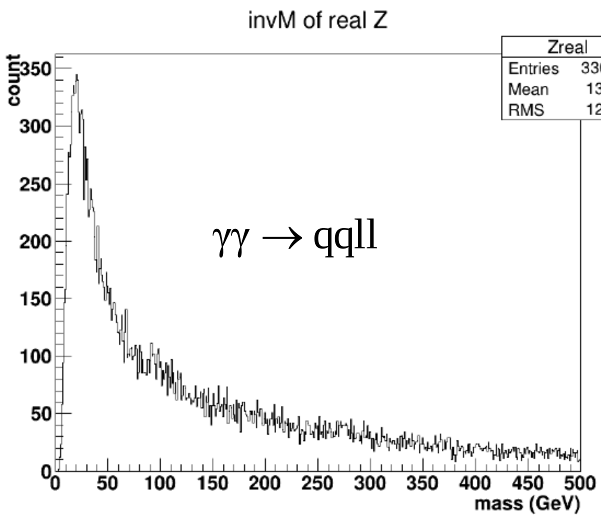
$$\frac{\Delta\sigma}{\sigma} = \frac{\sqrt{S+B}}{S} * 100\% \sim 4.4\%$$

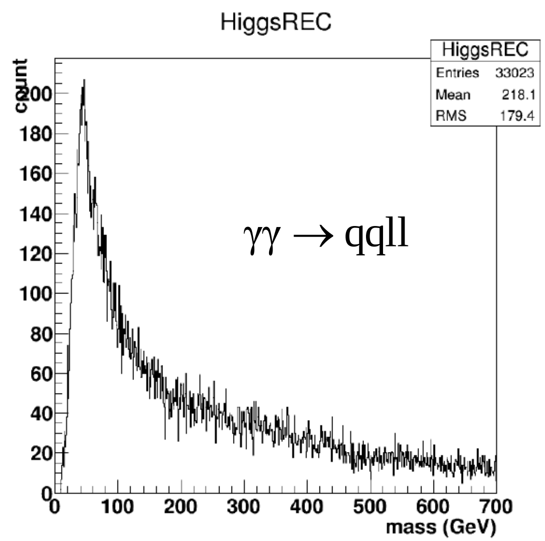
Next steps

Include background processes, also with EPA:

$e^{\pm}\gamma \rightarrow qq\nu$ $e^{\pm}\gamma \rightarrow qqe$ $\gamma\gamma \rightarrow qq$ $\gamma\gamma \rightarrow qqll$

At 1.4 TeV all these processes were fully removed after MVA.





- Systematic uncertainties

CONCLUSION

- The status of the $H \rightarrow ZZ^* \rightarrow qqll$ analysis at 3 TeV is being presented. All relevant background processes are included except γ_{BS} and γ_{EPA} interactions.
- Overall signal efficiency is 29% due to large number of signal-like background processes which are coming from the other Higgs decays and have similar kinematic properties as the signal.
- Statistical uncertainty is found to be 4.4%.
- H->ZZ* analyses at 1.4 TeV and at 3 TeV will be prepared for the publication.

THANK YOU!