Higgs decay to WW* in Higgsstrahlung at 250 GeV

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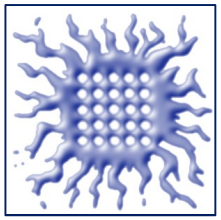
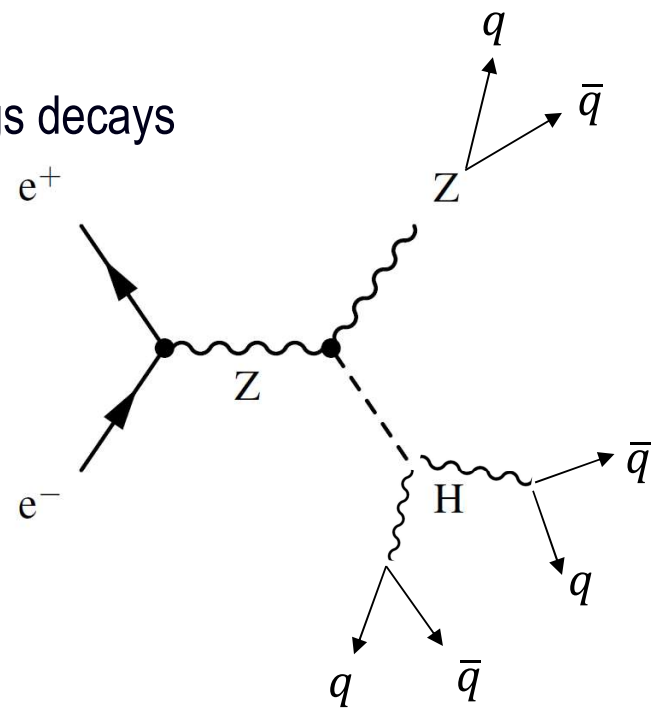


Introduction

- Analyzed HZ fully hadronic decay: $Z \rightarrow qq$, $H \rightarrow WW^* \rightarrow qqqq$
- HZ @250GeV $\sigma(e^+e^- \rightarrow HZ, Zqq) \sim 346$ fb
- $BF_{H \rightarrow WW} \sim 23.0\%$, $BF_{WW \rightarrow qqqq} \sim 45.7\% \Rightarrow \sim 10\%$ of Higgs decays
- $\sigma_{signal} \sim 36$ fb

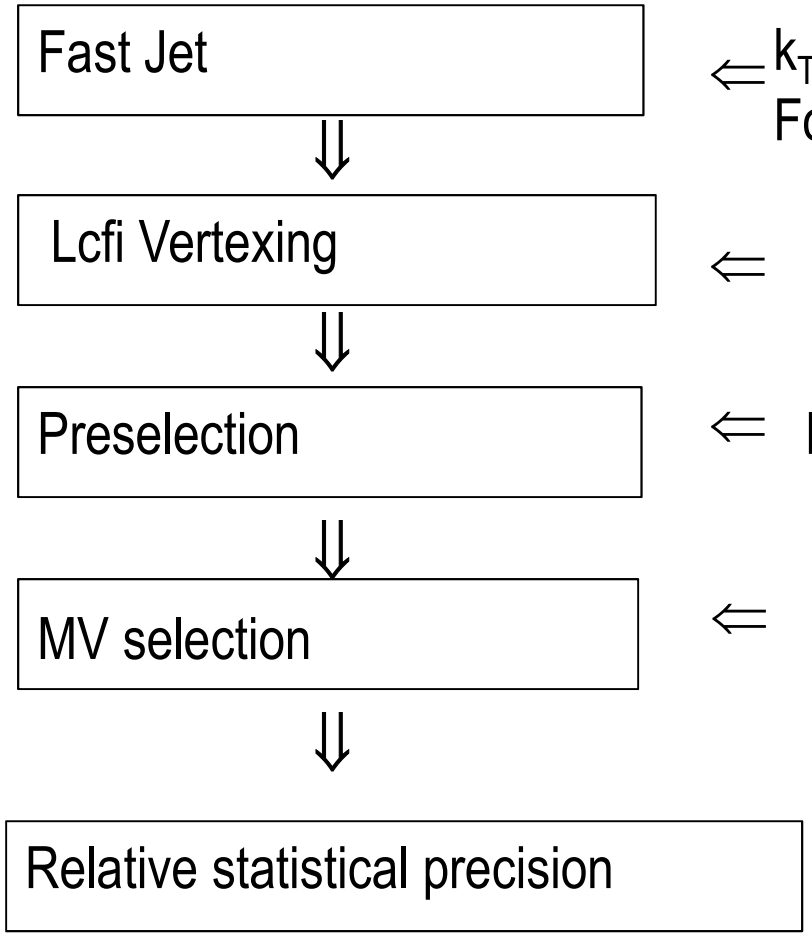


- Signal signature:

  6 wide central jets in the final state

- Considered luminosity scenario:
  - 500 fb^{-1} $P(e^-,e^+)=(-80\%,+30\%)$
- Goal of the analysis:
  - Calculate the statistical potential for the determination of the g_{hww} coupling

Analysis flow



⇐ k_T exclusive, PandoraPFO's
Force events into 6 jets , R=1.5

⇐ multijet hypothesis to apply btagging

⇐ Reduction of large cross-section background

⇐ BDTG

$$\frac{\Delta\sigma}{\sigma} = \frac{\sqrt{S+B}}{S}$$

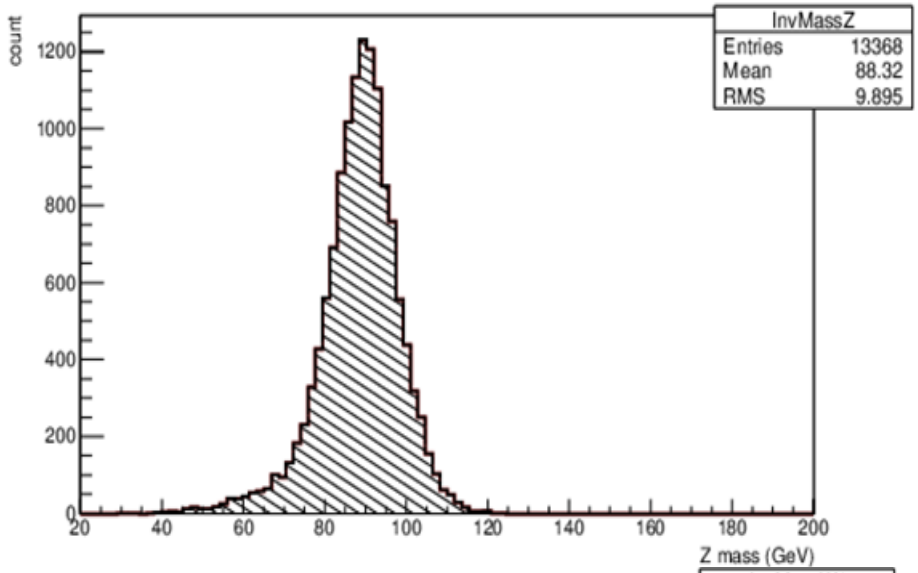
Higgs, Z, W boson reconstruction

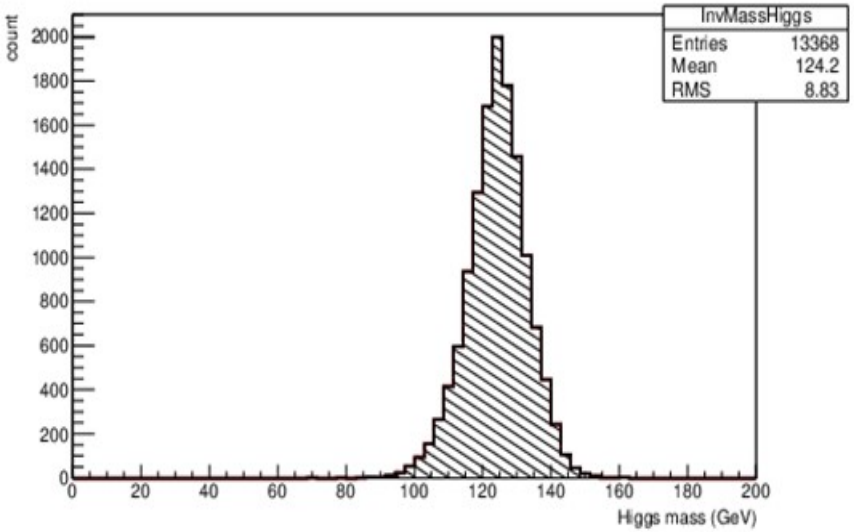
- The event is forced into 6 jets
- Obtained jets are grouped into pairs to form the Higgs, W, W* and Z bosons
- The combination which minimizes the χ^2 is chosen :

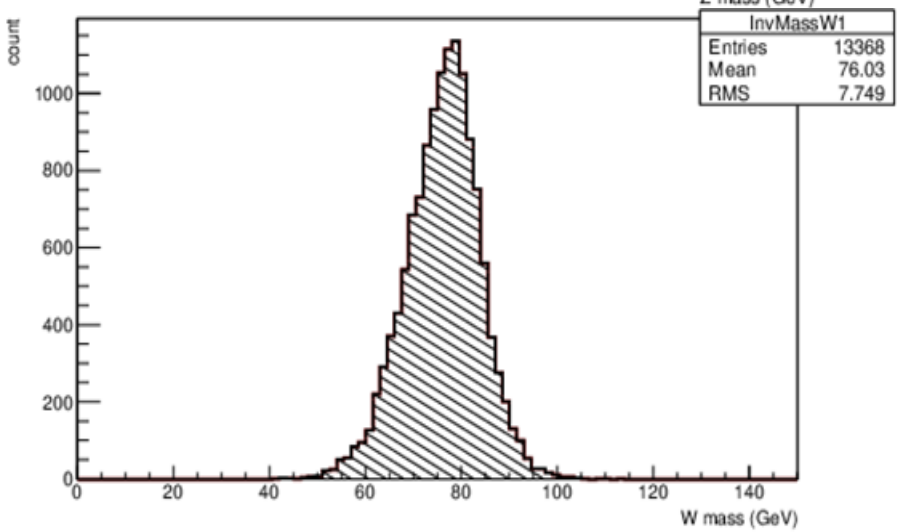
$$\chi^2 = \frac{(M_{ij} - M_W)^2}{\sigma^2_W} + \frac{(M_{kl} - M_Z)^2}{\sigma^2_Z} + \frac{(M_{ijmn} - M_H)^2}{\sigma^2_H}$$

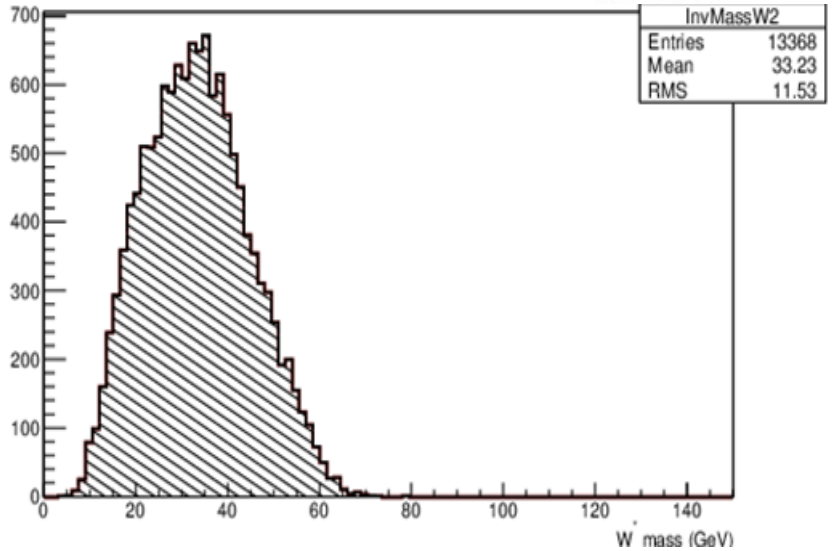
- For the $\sigma^2_{H,W,Z}$ - WA width

Reconstructed boson masses – signal









Event samples

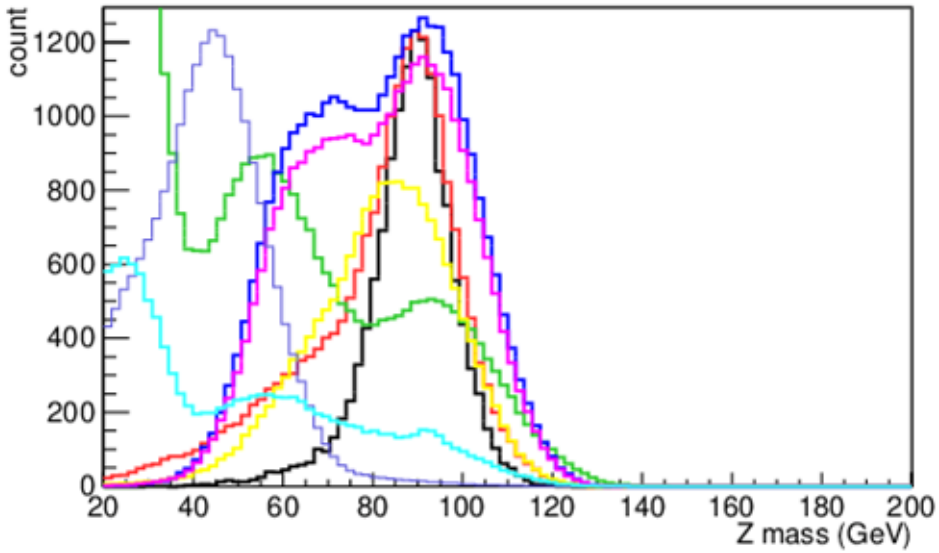
ILD preliminary

	σ[fb^{-1}] P(e^+,e^-)=(-80%,+30%)	expected #evts/500fb^{-1}
Signal	36.52	18 260
Non WW -qqqq Higgs decays	309,8	154 900
2f hadronic	129148,6	64 574 500
4f WW hadronic	14874,3	7 437 000
4f ZZ hadronic	1402,0	6 191 650
4f WW/ZZ hadronic	12383,3	701 000
4f WW semileptonic	18781,0	9 390 500
4f ZZ semileptonic	1422,1	711 000

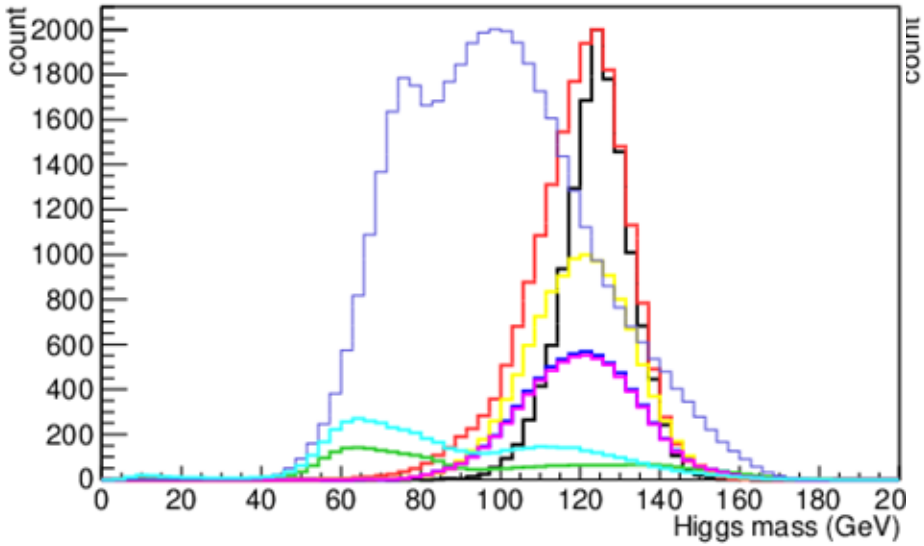
Sensitive observables

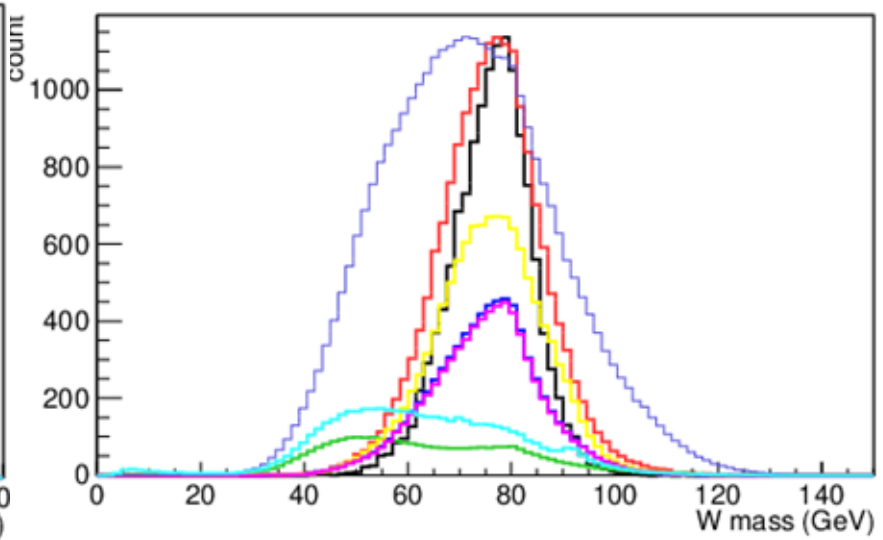
- Invariant masses: m_Z m_{Higgs} m_W m_{W^*}
- Number of particle flow objects NPFO, Evis
- Transverse momentum:
  - Jet P_t
  - Higgs jets $P_{tHiggsJets}$
- Event shape variables: thrust, aplanarity, oblateness, sphericity
- Jet transitions: y_{12} y_{23} y_{34} y_{45} y_{56} y_{67}
- b,c tagging applied on 2 and 6 jets
- Angles:
  - Z: $ThetaZ_{qq}$
  - W: ThetaWqq
  - Higgs:(WW*)

Invariant masses of the reconstructed bosons



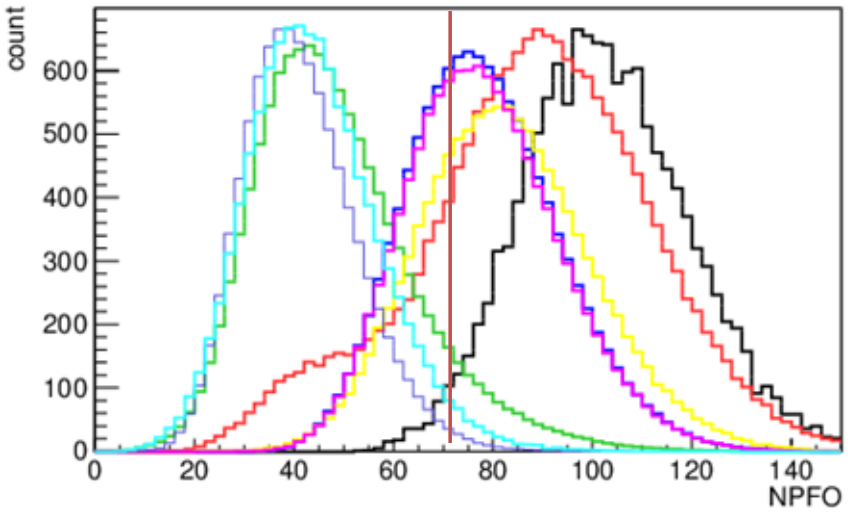
*Shape comparison

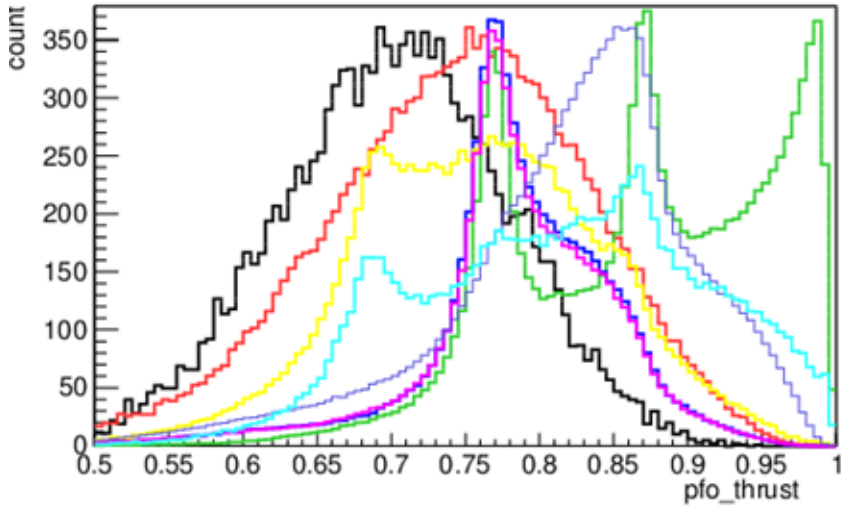


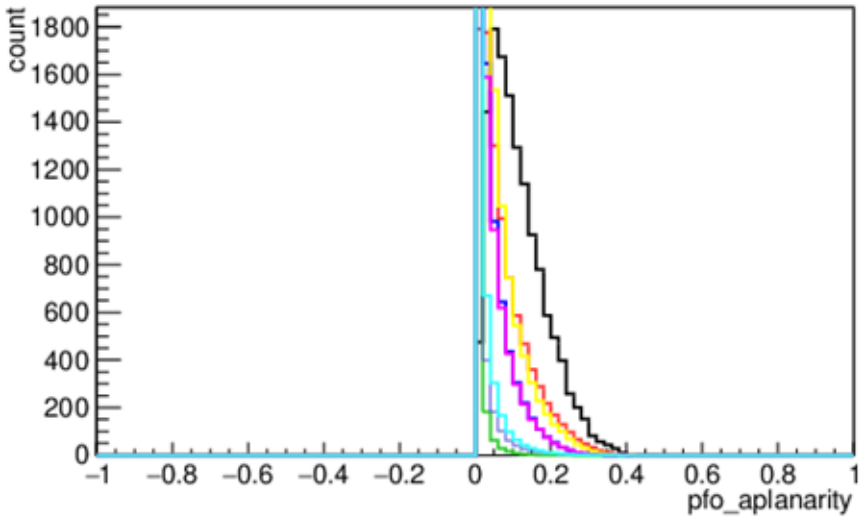


Input variables

- Number of particle flow objects NPFO

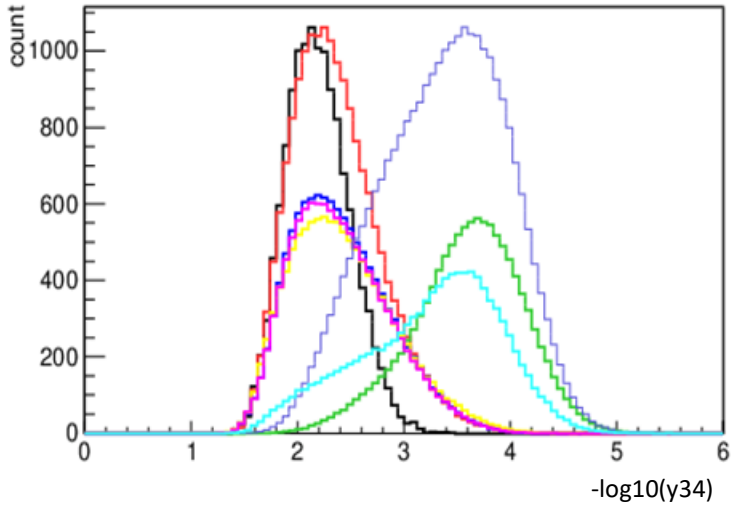


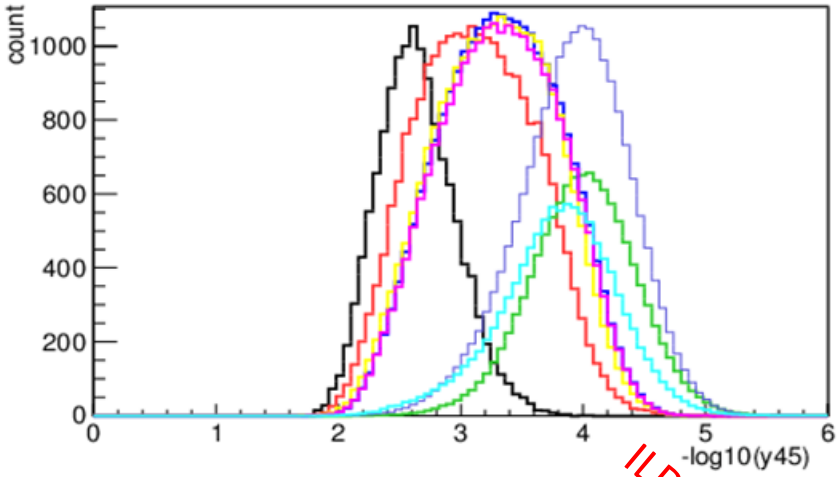


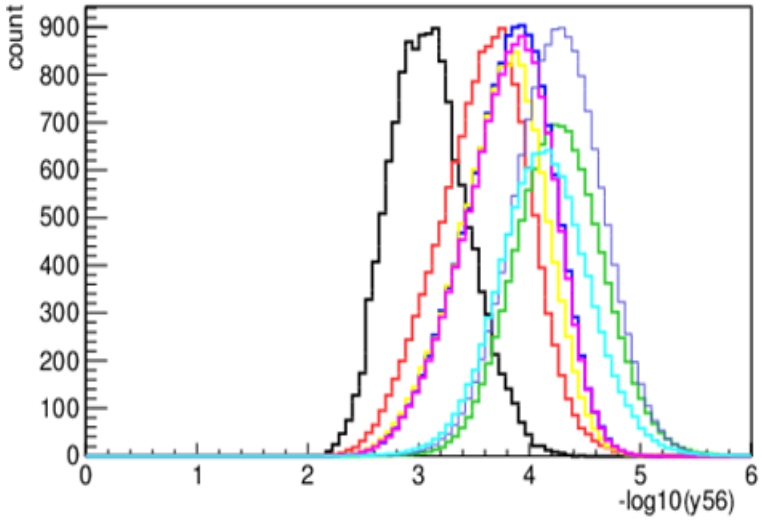


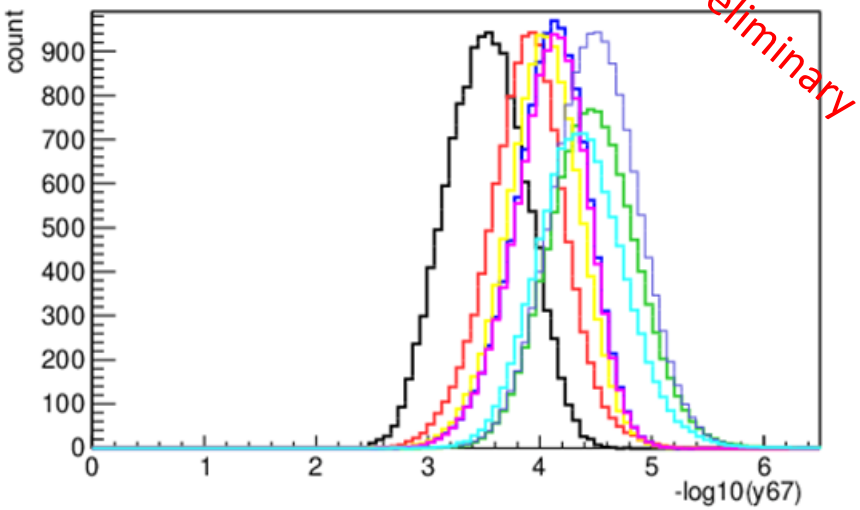
Input variables

- Jet transition probabilities a kt value at which number of jets transits from i number of jets to j, y_{ij}









ILD preliminary

Static cut selection

- m_Z >70. m_H >100 m_W>60
- number of particle flow objects NPFO>70 Visible energy >200 GeV ptJet<20
- thrust<0.90
- y12 < 2.2 y23 < 3.0 f_y34 < 3.5 y45 < 4.0 y56 < 4.0 y67 < 4.5

	#evts / 500fb^{-1}	Kinmatic Cut Eff	#evts After Kine cuts
Signal	18260	89.2	16287
Non WW Higgs decays	154 900	54.66	84668
2f	64 574 500	1.47	950863
4f WW hadronic	7 437 000	33.5065	2491878
4f WW/ZZ hadronic	6 191 650	33.8011	2092845
4f ZZ hadronic	701 000	42.9216	300880
4f WW semileptonic	9 390 500	0.00536228	503
4f ZZ semileptonic	711 000	0.50039	3557

Multivariate analysis BDTG

The training on five hadronic backgrounds (nonWW Higgs decays, 2f hadronic, 4f hadronic –WW,ZZ,Mix ZZ/WW)

- Invariant masses: m_Z m_{Higgs} m_W
- Number of particle flow objects NPFO
- Transverse momentum of;
  - Highest P_t jet in the event
  - Higgs jets $P_{tHiggsJets}$
- Event shape variables: thrust, aplanarity, oblateness, sphericity
- Jet transitions: y_{12} y_{23} y_{34} y_{45} y_{56} y_{67}
- 2jet hypothesis applied flavor tagging: second highest btag2, ctag2
- Angle between jets
  - Z: ThetaZqq
  - W: ThetaWqq

Variable set is optimized - disgarded variables: Evis, m_{W^*}, thetaW*$_{qq}$, thetaHiggs(WW*), single jet p_t, b, c tag for 6 jets hypothesis

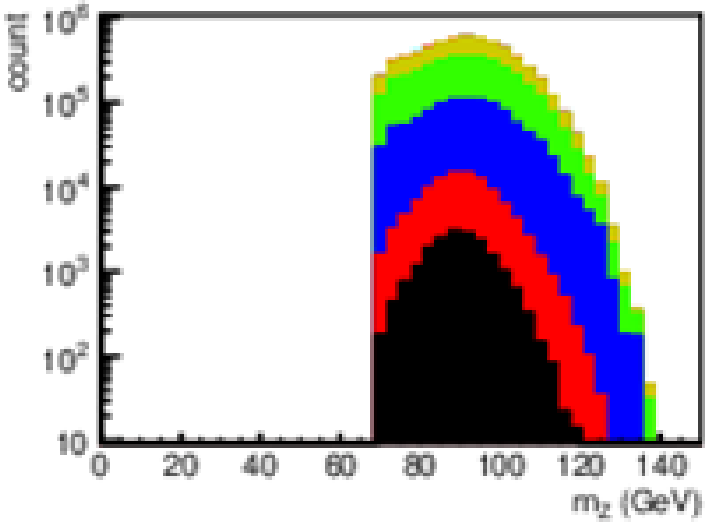
Final cut table

preliminary

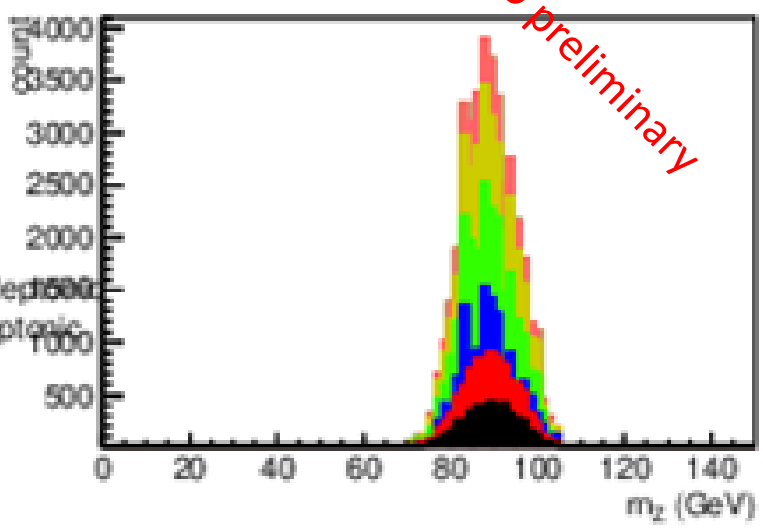
	σ[fb^{-1}]	#evts / 500fb^{-1}	#evts after Kinematic cut 500 fb^{-1}	ε_{BDT} [%]	ε_{total} [%]	#evts BDT 500 fb^{-1}
Signal	22.6	18260	16287	35.7	30	5600
Non WW Higgs decays	323.4	154 900	84668	7.5	4.1	6338
2f hadronic	129148.6	64 574 500	950863	0.6	0.008	5410
4f WW hadronic	14874.3	7 437 000	2491878	0.6	0.2	14961
4f WW/ZZ hadronic	12383.3	6 191 650	2092845	0.6	0.2	13340
4f ZZ hadronic	1402.0	701 000	300880	0.6	1.0	7178
4f WW semileptonic	18781.0	9 390 500	503	/	/	/
4f ZZ semileptonic	1422.1	711 000	3557	1.4	0.007	49
				$\frac{\Delta\sigma}{\sigma} = \frac{\sqrt{S+B}}{S}$		**4.1 %**

Event selection using multivariate analysis

After preselection



After TMVA



- The result was obtained by optimization of significance
- The kinematic cuts prior to multivariate analysis almost completely reduce semileptonic backgrounds
- The training of the multivariate methods has been performed on the hadronic backgrounds
- The dominant background after final selection are 4f hadronic and 2f hadronic due to the extremely large cross section backgrounds 10^5
- 2f hadronic can fake the signal six central jet signature

Summary

- Fully hadronic decay of H→ WW* analyzed
- Relevant background included – the considered backgrounds with $\sigma \geq \sigma_S$
- Semileptonic backgrounds largely reduced on the preselection level
- Final background reduction performed MVA (BDTG)
- Minimization of the observable set done
- The preliminary result of relative statistical uncertainty is 4.1 with the corresponding signal efficiency of 30%

N_S	5600
$\frac{\Delta\sigma}{\sigma} = \frac{\sqrt{S+B}}{S}$	4.1 %
ε_{sig} [%]	30

preliminary

BACKUP

Event Topology driven jet pairing

- $\vartheta \mathrm{I} o \xi \nu \nu$

Type equation here.

$$\chi^2 = \frac{\left(M_{ij} - M_W\right)^2}{\sigma^2_W} + \frac{\left(M_{kl} - M_Z\right)^2}{\sigma^2_Z} + \frac{\left(M_{ijmn} - M_H\right)^2}{\sigma^2_H}$$

Siignal efficiency vs. background reduction

- Applying looser kinematic cut selection leads to the slight increase in the final result but with ~10% gain in signal efficiency
- Allows the optimization of the significance/signal efficiency

	250 GeV 500fb-1	
Preselection criteria		
N_S	5600	7679
$\frac{\Delta\sigma}{\sigma} = \frac{\sqrt{S+B}}{S}$	4.1%	4.5%
ε_{sig} [%]	29	37