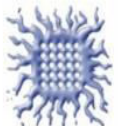




HEP & QCD VITTA



Higgs to ZZ^* at 1.4 TeV

status report

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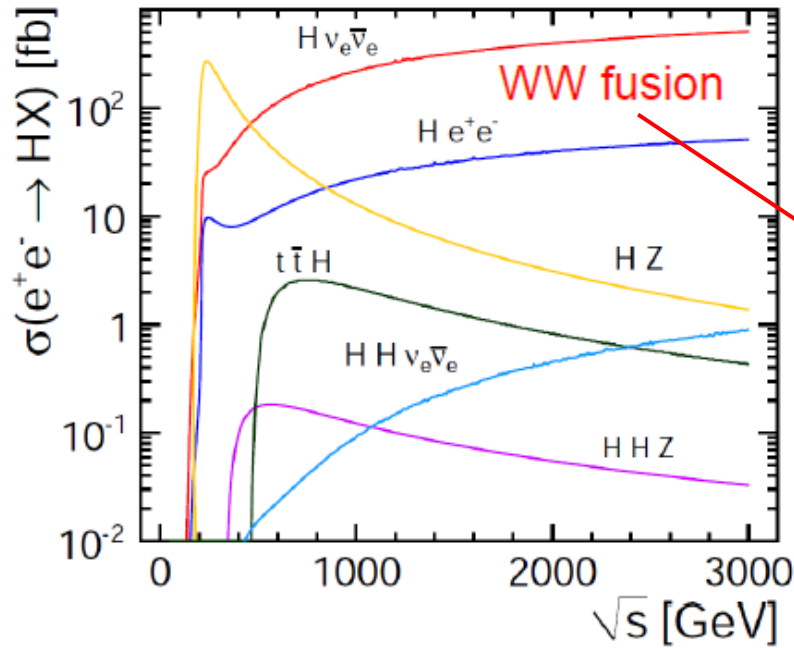


Overview

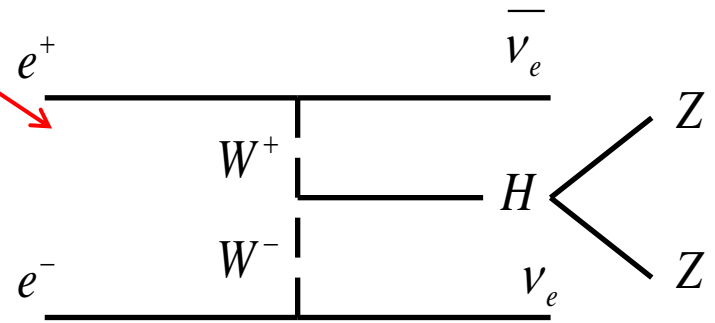
- Signal and background x-sec
- Analysis strategy
- MVA results
- Conclusion



Signal



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



Higgs coupling:

$$\frac{g_{HWW}^2 \cdot g_{HZZ}^2}{\Gamma_H}$$

$$\text{BR}(H \rightarrow ZZ^*) \approx 2.89\% \Rightarrow \sigma_{HWW} \times \text{BR} \approx 7.05 \text{ fb}$$

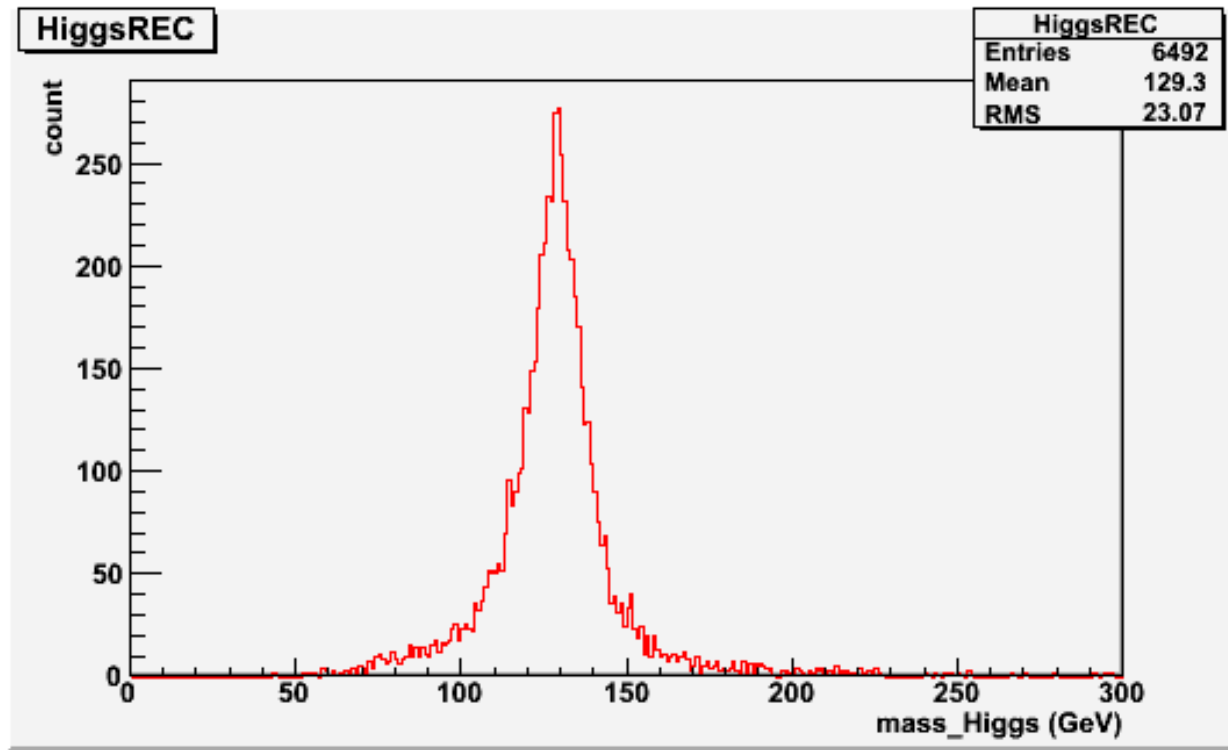
$$\text{BR}(Z \rightarrow e^+e^-, Z \rightarrow \mu^+\mu^-, Z \rightarrow \tau^+\tau^-) \approx 9.2\%$$

$$N_s(ZZ^* \rightarrow qqe^+e^-, ZZ^* \rightarrow qq\mu^+\mu^-, ZZ^* \rightarrow qq\tau^+\tau^-) \approx 1300/1.5 \text{ ab}^{-1}$$



Signal

The reconstruction is based on the pair of jets or leptons (muons, electrons or taus) with the mass closest to the mass of real Z.



Higgs mass



Signal and bck x-sec

Process	$\sigma[fb]$
$e^+e^- \rightarrow H\nu_e\bar{\nu}_e, H \rightarrow ZZ \rightarrow qqll$	0.895
$e^+e^- \rightarrow qq\nu_e\bar{\nu}_e$	788
$e^+e^- \rightarrow qqqq\nu_e\bar{\nu}_e$	24.7
$e^+e^- \rightarrow H\nu_e\bar{\nu}_e, H \rightarrow WW$	56.38
$e^+e^- \rightarrow qq$	4009.5
$e^+e^- \rightarrow qqqq$	1245.1
$e^+e^- \rightarrow qqqqll$	71.7
$e^+e^- \rightarrow qqqq\nu$	115.3
$e^+e^- \rightarrow H\nu_e\bar{\nu}_e, H \rightarrow bb$	136.94
$e^+e^- \rightarrow qqll$	2725.8
$e^+e^- \rightarrow H\nu_e\bar{\nu}_e, H \rightarrow ZZ \rightarrow qqqq / llll$	3.51
$e\gamma \rightarrow qq\nu$	29873.525
$e\gamma \rightarrow qqe$	16898.9
$\gamma\gamma \rightarrow qq$	76782.766



Analysis strategy

- **ISOLATED LEPTON FINDER + TAU FINDER**
- **FASTJET**: Force events into 2 jets, k_T exclusive, SELECTEDPFOs, $R=1.0$
- **b-TAGGING** (helps to reduce $e^+e^- \rightarrow H\nu_e\bar{\nu}_e, H \rightarrow bb$)
- **PRESELECTION** (two isolated electrons, muons or taus)
- **MVA SELECTION**
- **FINAL SELECTION**



Simulation - reconstruction lepton matching

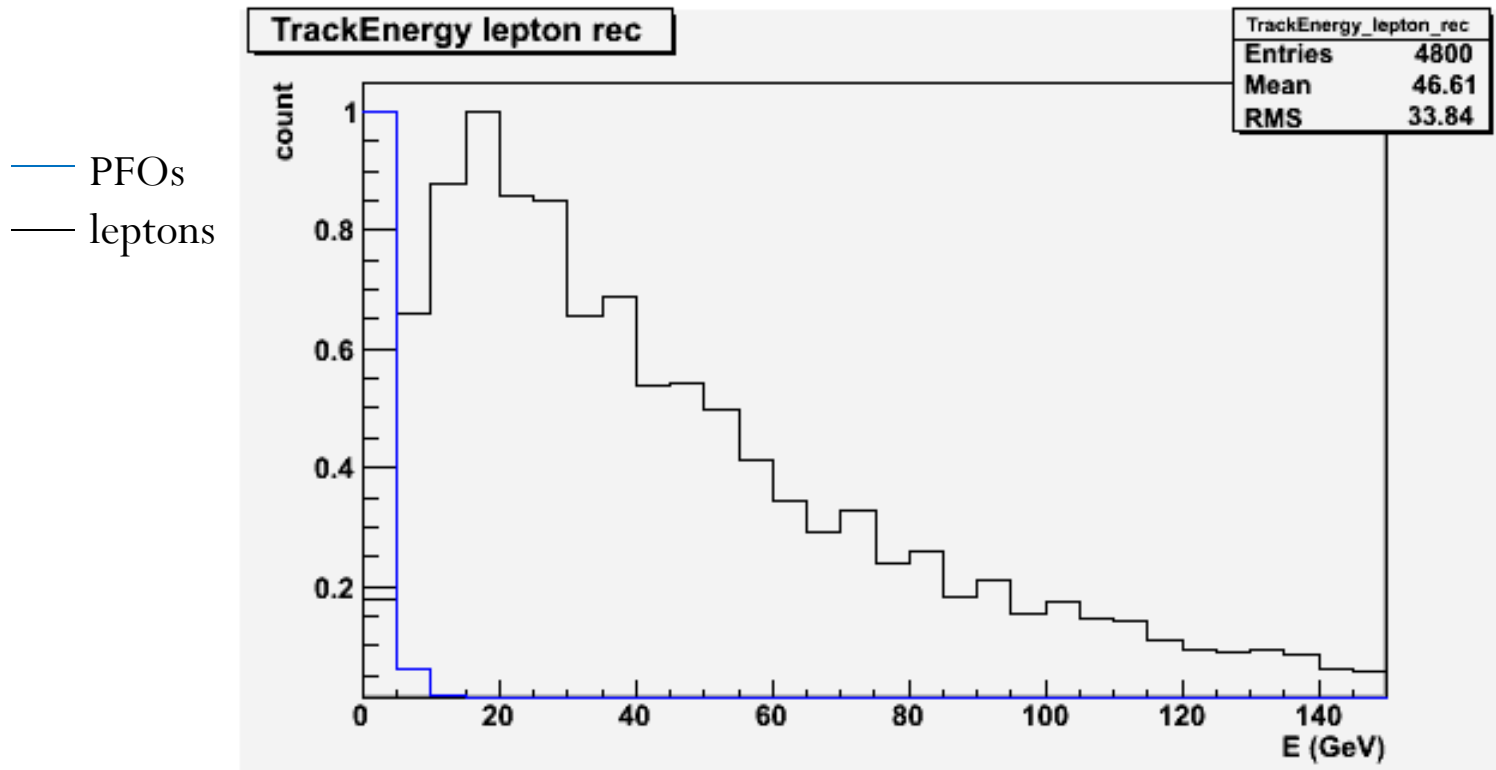
- Simulation-level information (RecoTruthLink) is used to exactly match generated particle to reconstructed particle.
- It gives better distinguish between reconstructed leptons and other reconstructed particles.
- Improvement in efficiency of finding two muons or electrons in Isolated Lepton Finder (74%→87%)



Isolated Lepton Finder

Lepton track energy

- Remove all tracks with $E < 6$ GeV

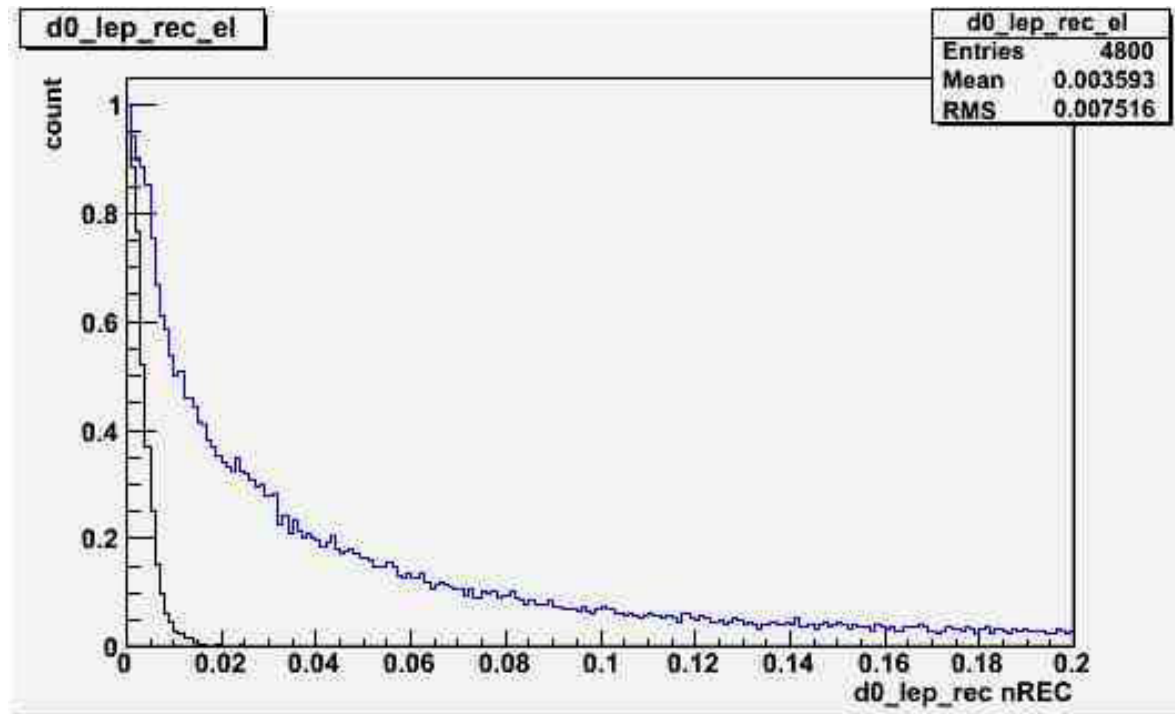




Isolated Lepton Finder

Impact parameters

- Cut at $IP < 0.02$

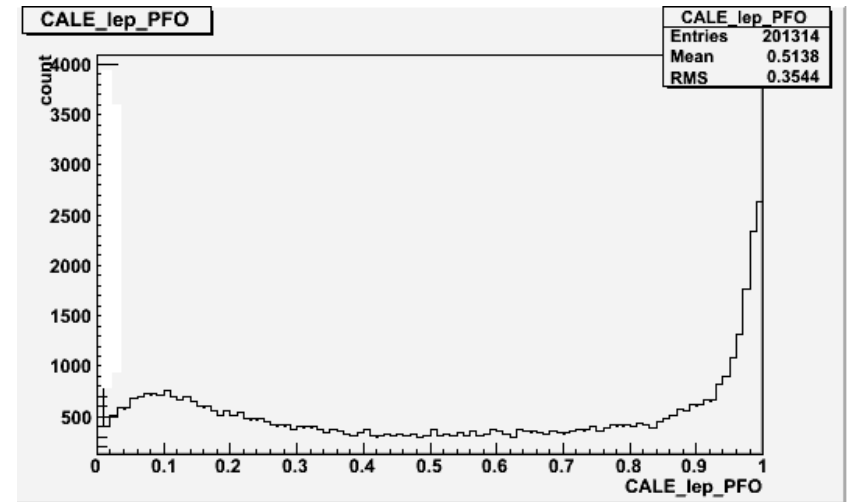
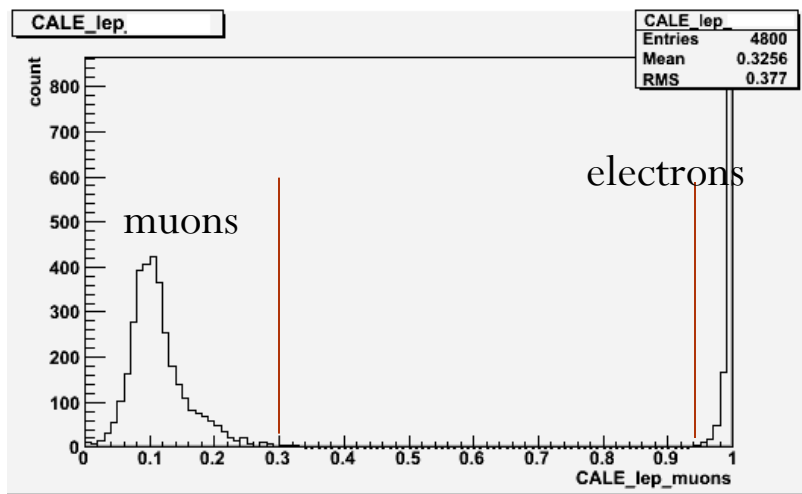




Isolated Lepton Finder

Lepton PID information

- Ratio of track energy deposition in ECAL and HCAL



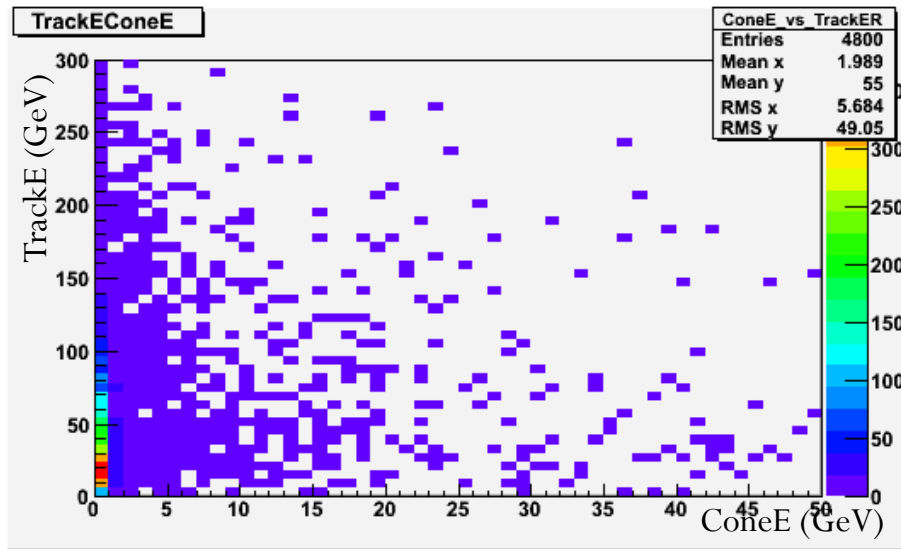
$0.02 < \mu$ ECAL to HCAL fraction < 0.3
 e^- ECAL to HCAL fraction > 0.94



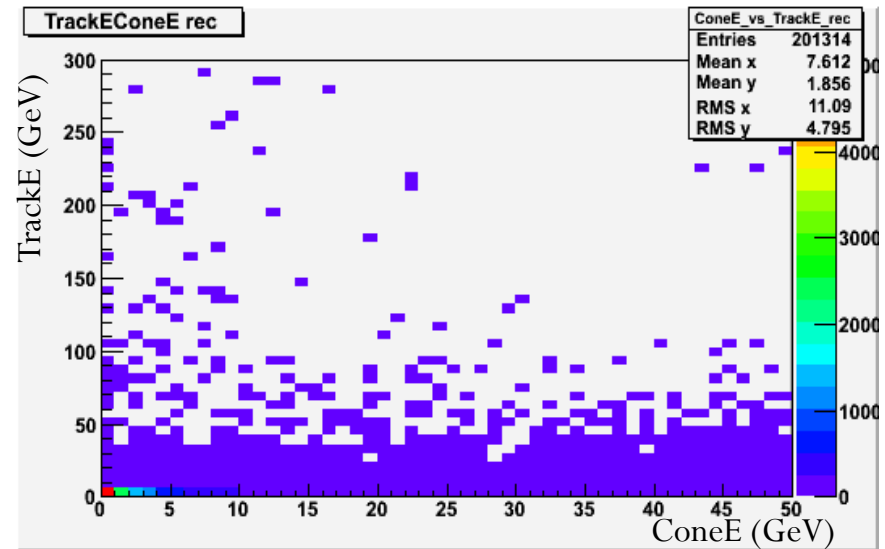
Isolated Lepton Finder

Isolation criteria

- Use cone energy to find isolated leptons
- Consider cone energy as a function of track energy



Matched leptons

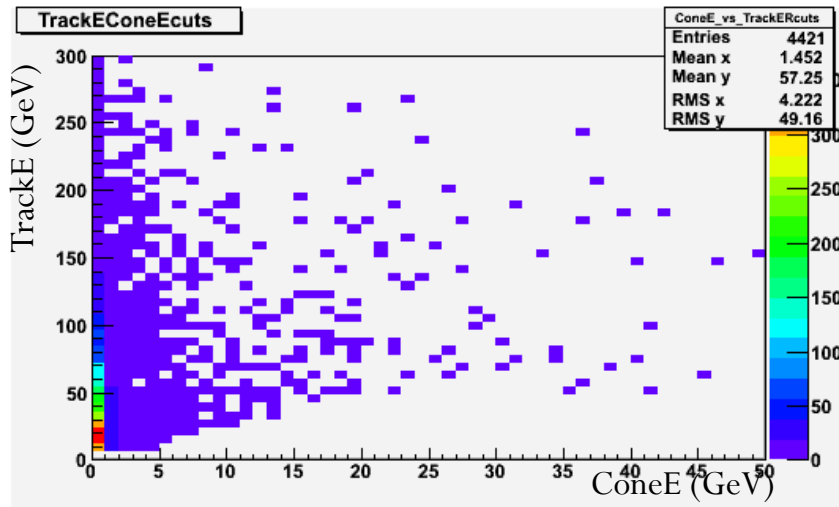


Other PFOs

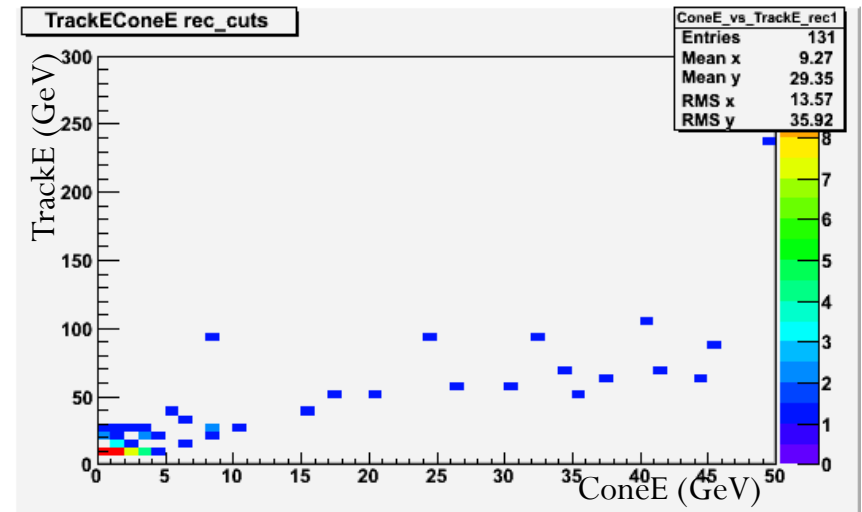


Isolated Lepton Finder

After track energy, IP cuts, lepton PID and isolation applied



Matched leptons



Other PFOs

87% efficiency in reconstruction of the lepton pair

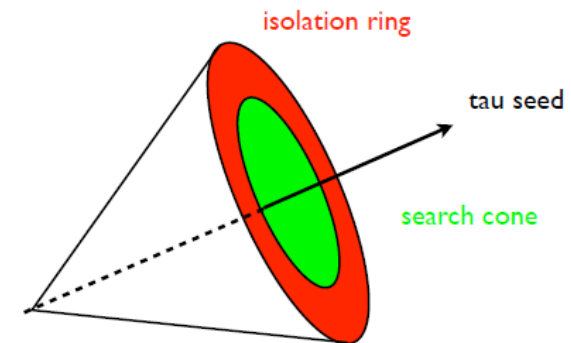


Tau Finder (NEW)

- Tau events look different to electron/muon events
- We search for them in a different way
- TauFinder: a Marlin processor written by Astrid Muennich

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





Tau Finder

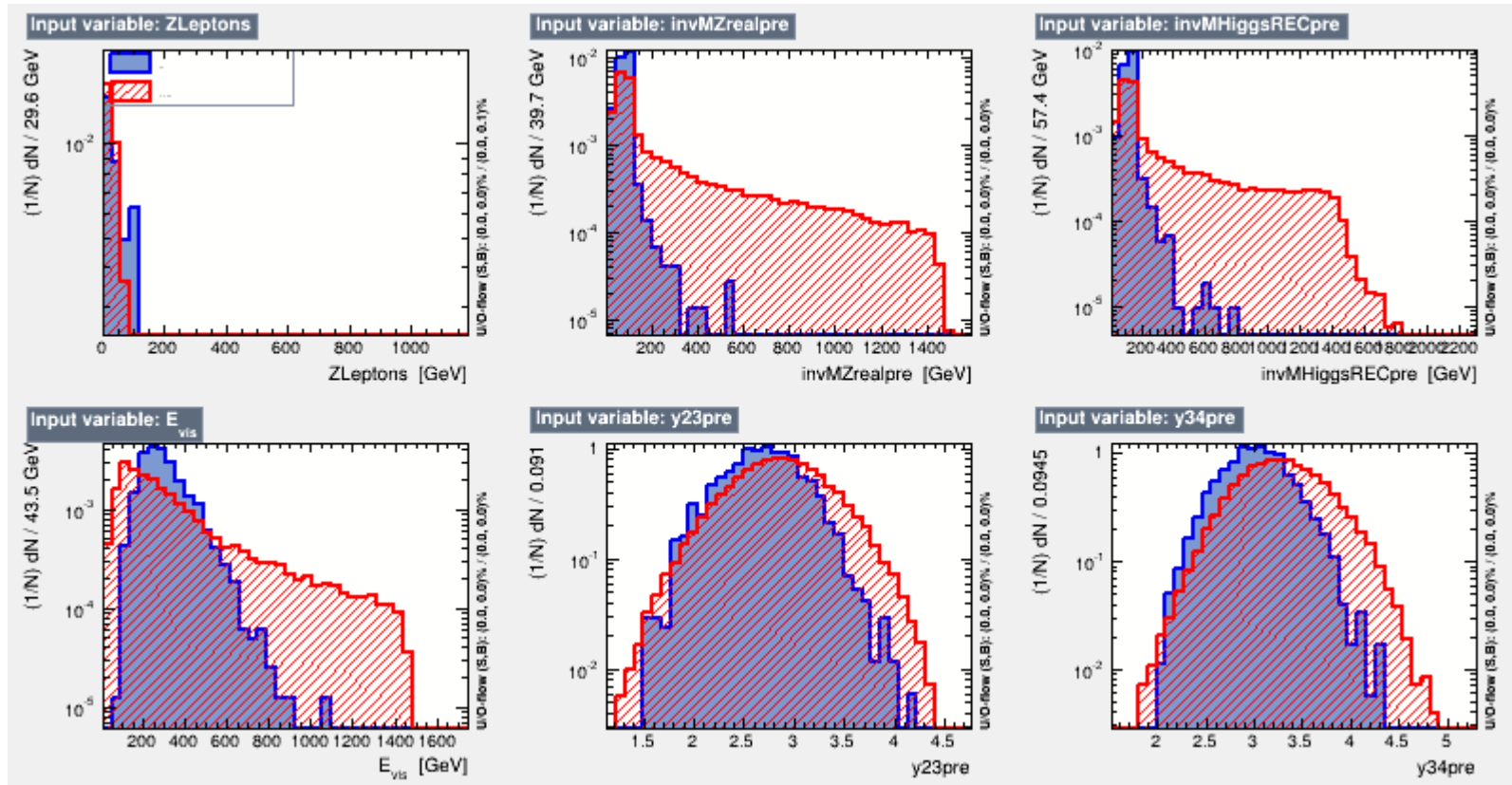
- Many parameters to tune
- Initial pT cut for all tracks $> 4 \text{ GeV}$
- pT cut for seed $> 10 \text{ GeV}$
- Impact parameter R0: 0.01 - 0.5
- Search cone angle $< 0.15 \text{ rad}$
- Isolation energy $< 3 \text{ GeV}$
- Ring particles < 5
- Invariant mass $< 2. \text{ GeV}/c^2$

37% efficiency in reconstruction of tau pair
Overall signal efficiency 62%



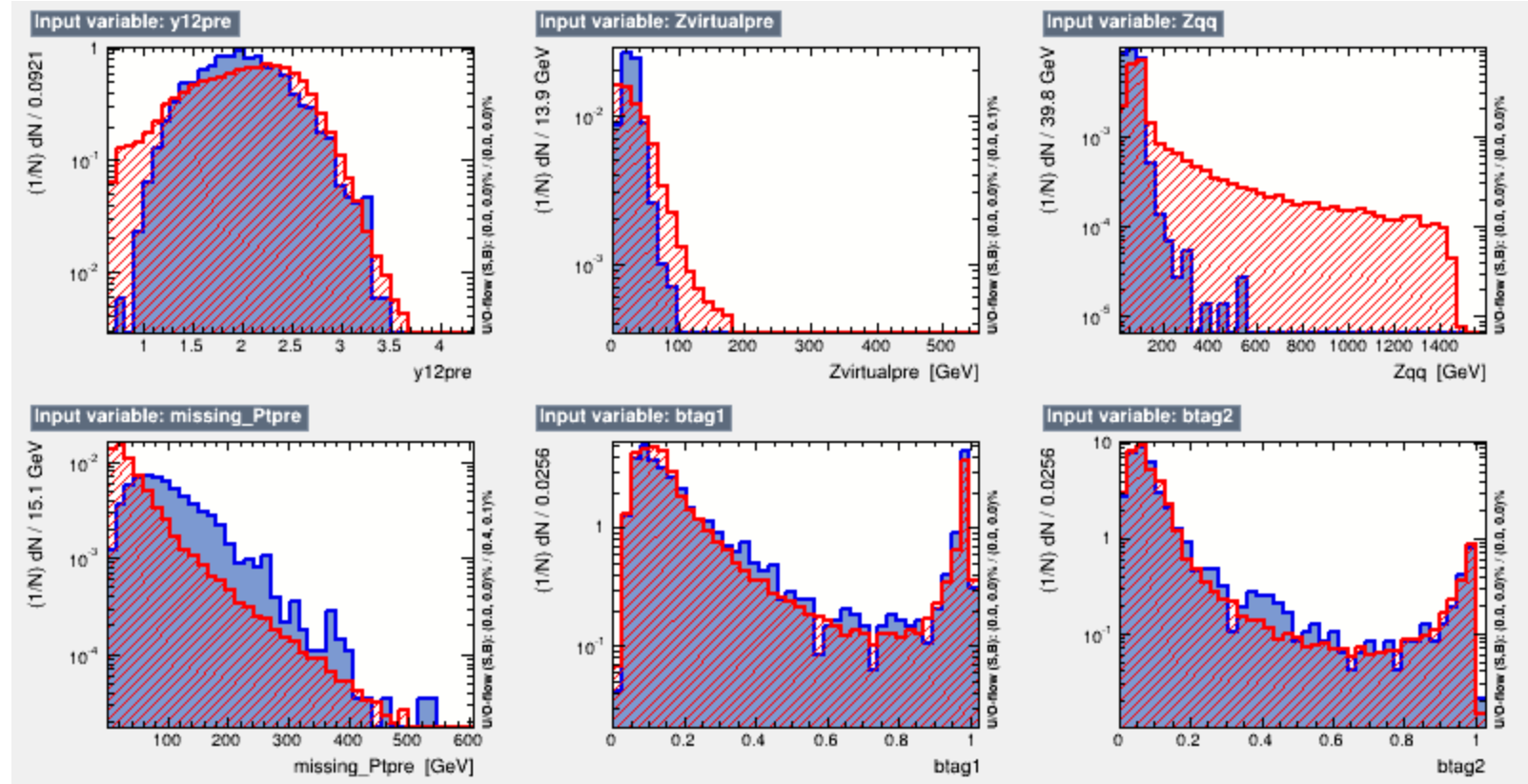
MVA analysis

- TMVA trained with 17 variables (m_{Z1} , $-\log(y_{34})$, $-\log(y_{23})$, $-\log(y_{12})$, $P(b)^{\text{jet}1}$, $P(b)^{\text{jet}2}$, $P(c)^{\text{jet}1}$, $P(c)^{\text{jet}2}$, E_{vis} , missing_Pt , Higgs_angle , m_{H} , Z_{leptons} , Z_{qq} , $E_{\text{vis}1}$, NPFOS) on total background



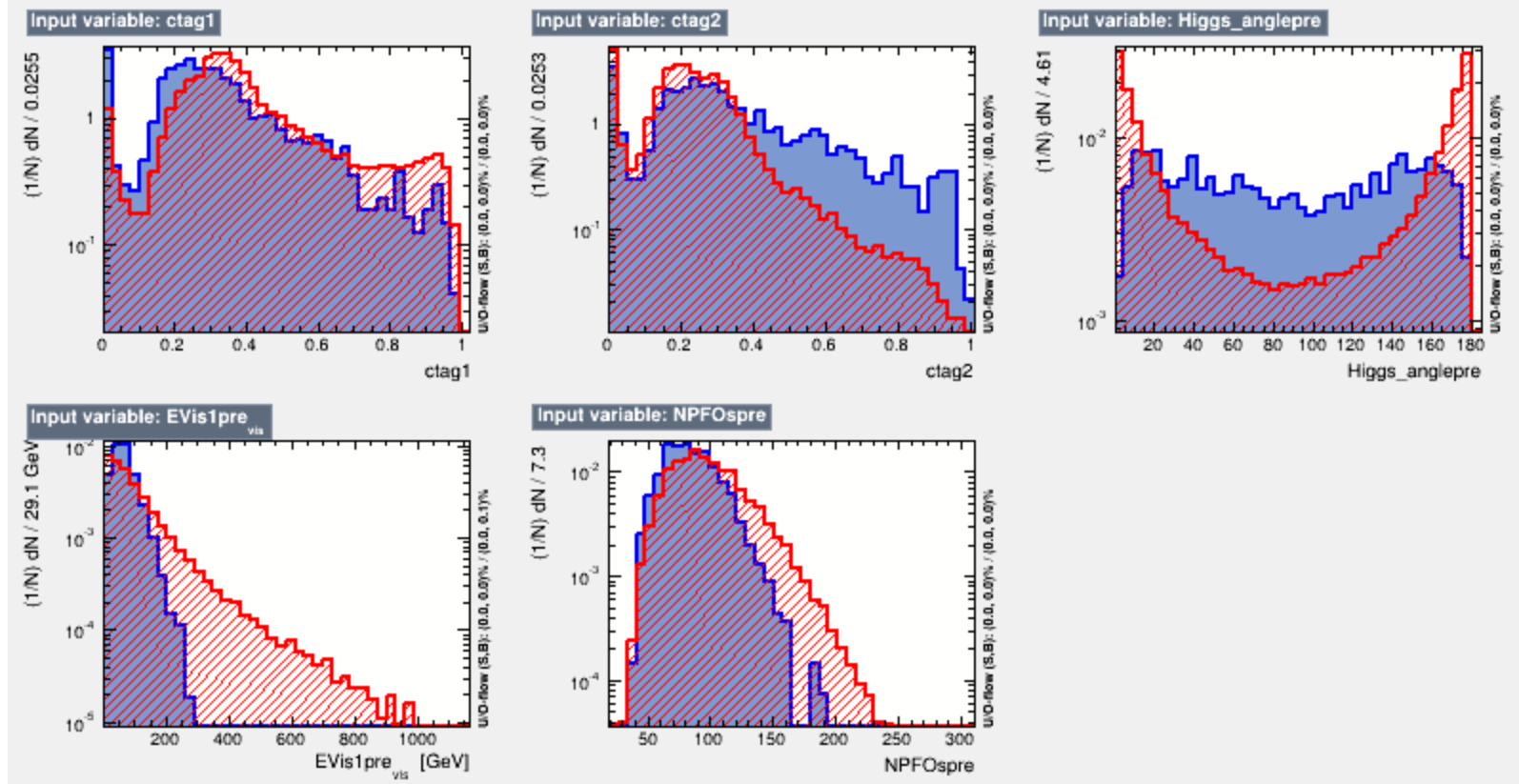


MVA analysis



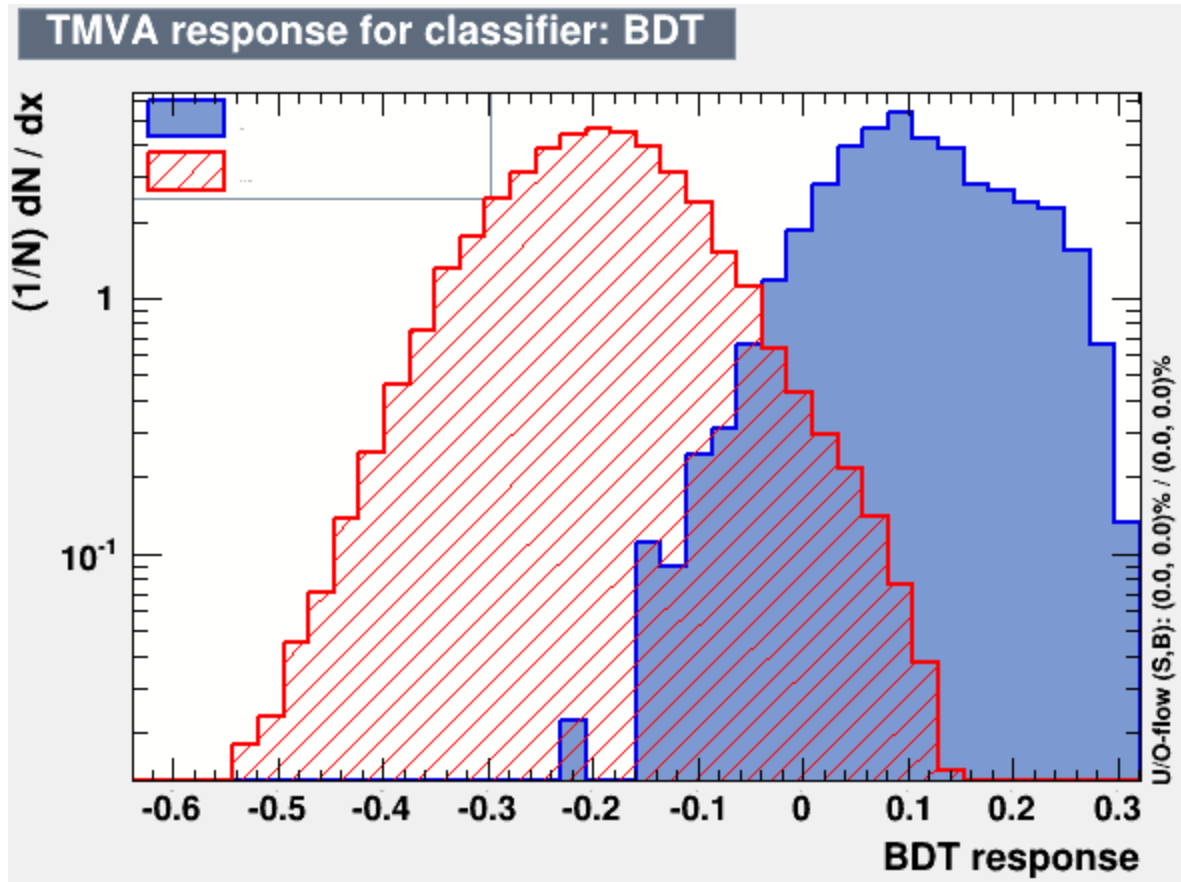


MVA analysis





MVA analysis



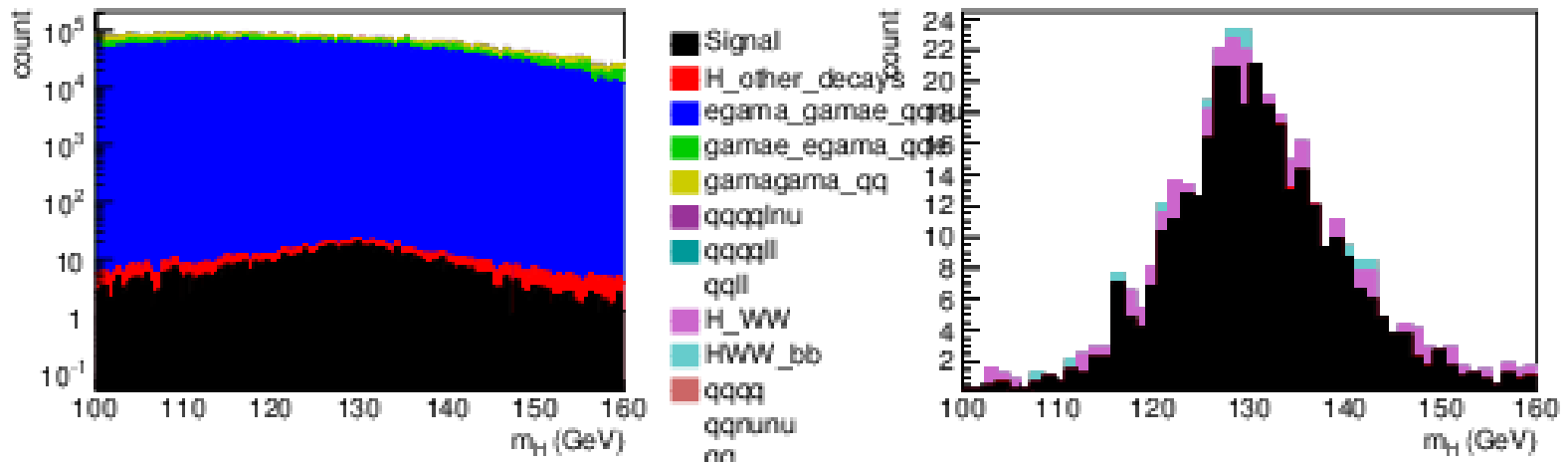
BDT > 1.6



Final selection

missing_Pt < 500 GeV
 Evis1 < 220 GeV
 40 < NPFOs < 160

Final selection helps to slightly reduce H->WW and H->bb background and has no impact on the signal efficiency.



Overall signal efficiency 29%

$$\frac{\Delta\sigma}{\sigma} \sim 5.6\%$$



Conclusion

- Results with tau leptons included are presented.
- Inclusion of tau improved statistics for 30%.
- Limited efficiency in tau pair reconstruction reduces the overall gain in statistics.
- Final statistical uncertainty is 5.6% (slight gain w.r.t to 6.1% for only muons and electrons pairs).
- “Stable” statistical uncertainty of approximately 6% in regard to several refinements of the analysis ($e\gamma \rightarrow qq\nu$, $e\gamma \rightarrow qqe$, $\gamma\gamma \rightarrow qq$ inclusion, MCMatching, TAU FINDER).