

Truth-level comparison between
 $H \rightarrow Z\gamma$ and $ZH \rightarrow l\gamma\gamma$

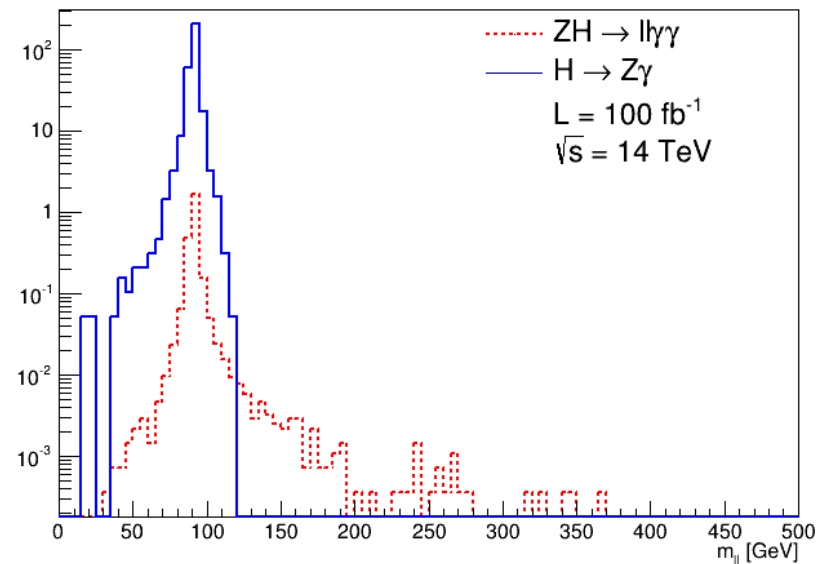
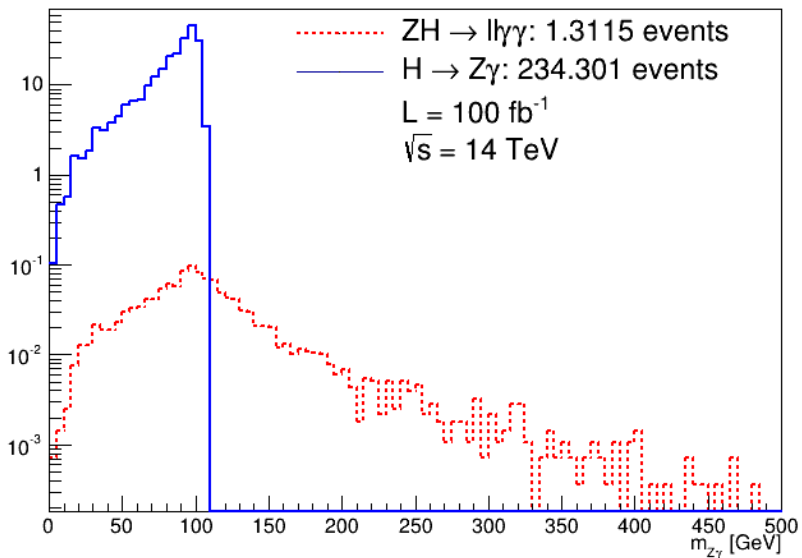
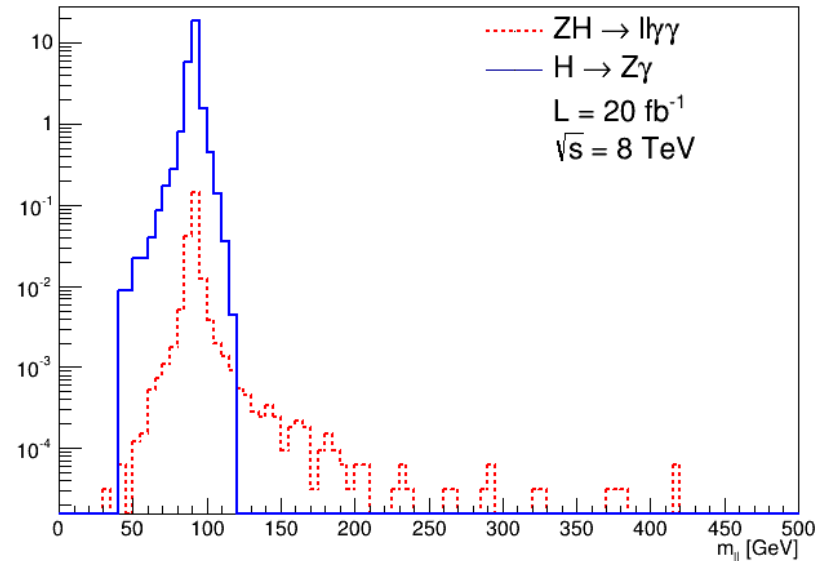
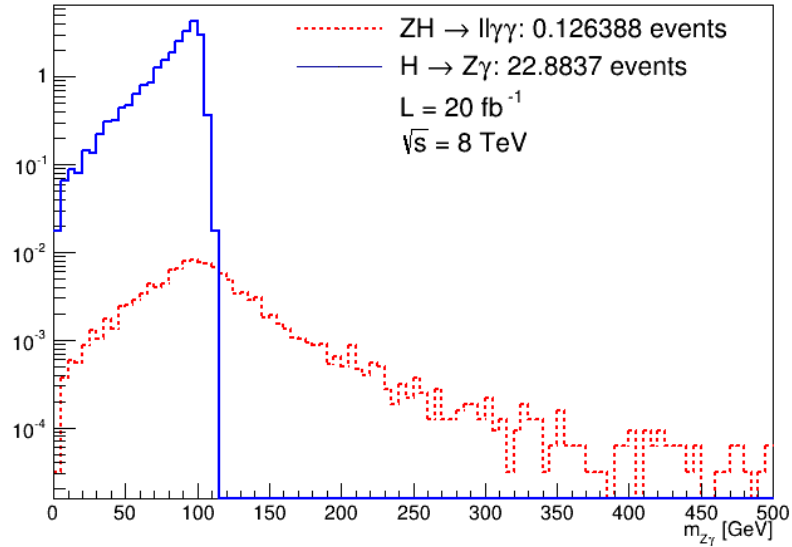
Event generation

- Generated $gg/ff \rightarrow H \rightarrow Z\gamma$ and $ff \rightarrow ZH \rightarrow ll\gamma\gamma$
 - Pythia 9.176
 - $\sqrt{s} = 8 \text{ TeV}$ and $\sqrt{s} = 14 \text{ TeV}$
 - $m_H = 125.5 \text{ GeV}$ $m_t = 173.07 \text{ GeV}$
 - 50k events $qq \rightarrow ZH$ with $Z \rightarrow ll$ and $H \rightarrow \gamma\gamma$ at 8 and 14 TeV
 - 10k events $gg \rightarrow H + \text{VBF}$ with $H \rightarrow Z\gamma$ at 8 and 14 TeV
- From LHC Higgs XS Working Group:
<https://twiki.cern.ch/twiki/bin/view/LHCPhysics/CERNYellowReportPageBR3>
- NLO cross sections and branching ratios:
 - $\sigma (gg \rightarrow H + \text{VBF}) = 20.69 \text{ pb (8TeV); } 49.13 \text{ pb (14TeV)}$
 - $\sigma (qq \rightarrow ZH) = 0.4102 \text{ pb (8TeV); } 0.9574 \text{ pb (14TeV)}$
 - $\text{BR} (H \rightarrow Z\gamma) = 1.58 \times 10^{-3}$
 - $\text{BR} (ZH \rightarrow ee + ZH \rightarrow \mu\mu) = 0.067$
 - $\text{BR} (H \rightarrow \gamma\gamma) = 2.28 \times 10^{-3}$

Truth-level analysis

- ATLAS $H \rightarrow Z\gamma$ analysis: ATLAS-CONF-2013-009
- Approximated analysis cuts by requiring:
 - Leptons (e or μ only):
 $p_T > 10$ GeV, $|\eta| < 2.5$ (same for e and μ)
 - One photon within detector acceptance:
 $p_T > 15$ GeV, $|\eta| < 2.37$
 - Reconstructed mass using truth lepton and photon momenta: i.e. includes ISR/FSR
 - Normalized to 20 fb^{-1} at 8 TeV
- At 8TeV:
 - Efficiency after cuts: $\epsilon(H \rightarrow Z\gamma) = 64\%$; $\epsilon(ZH \rightarrow ll\gamma\gamma) = 14\%$

Invariant mass of Z and of Z- γ system

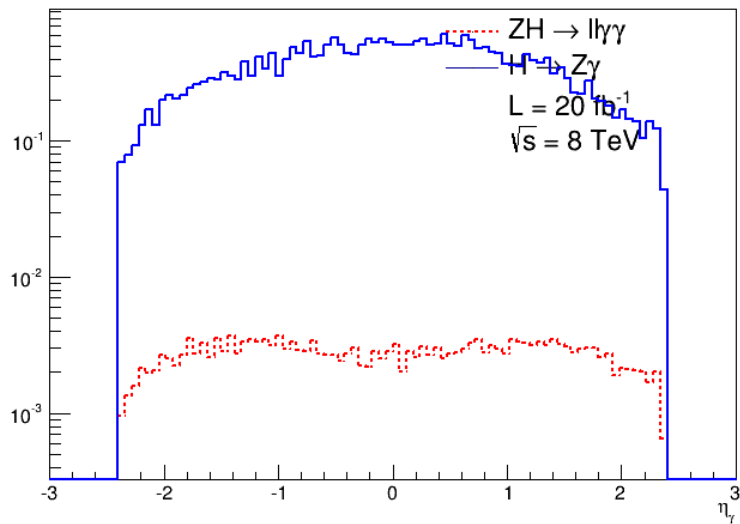
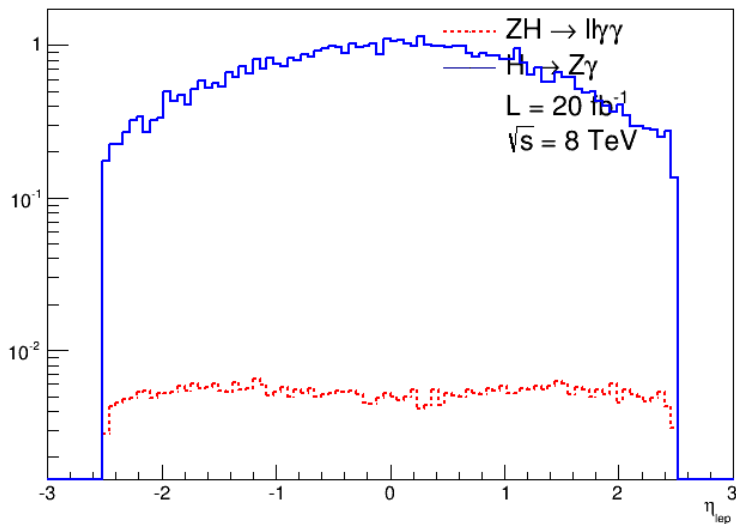
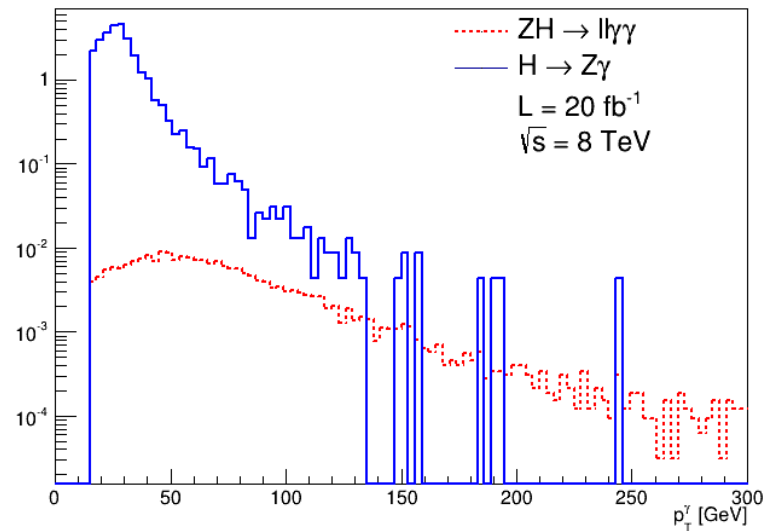
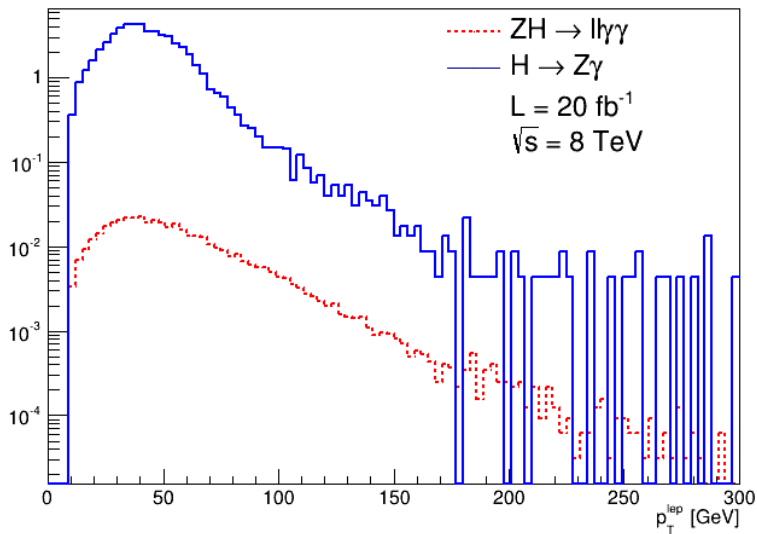


Normalisation cross check at 8 TeV

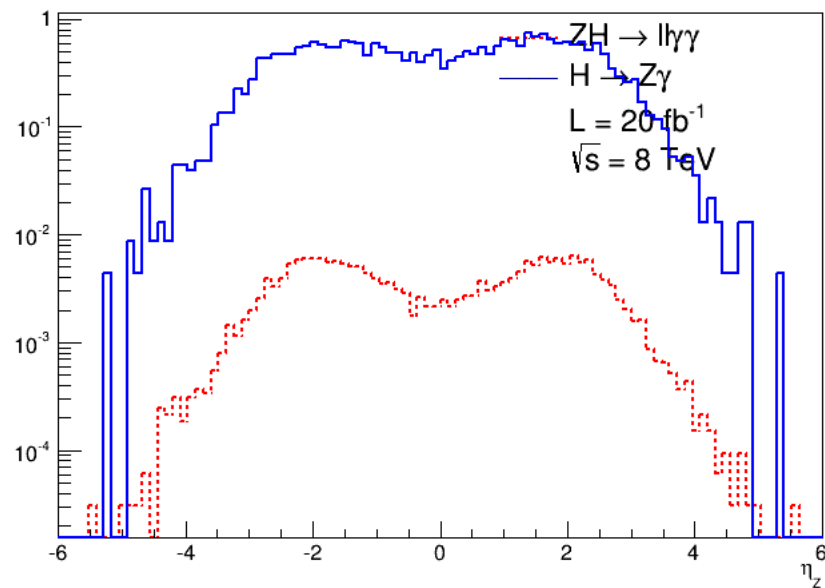
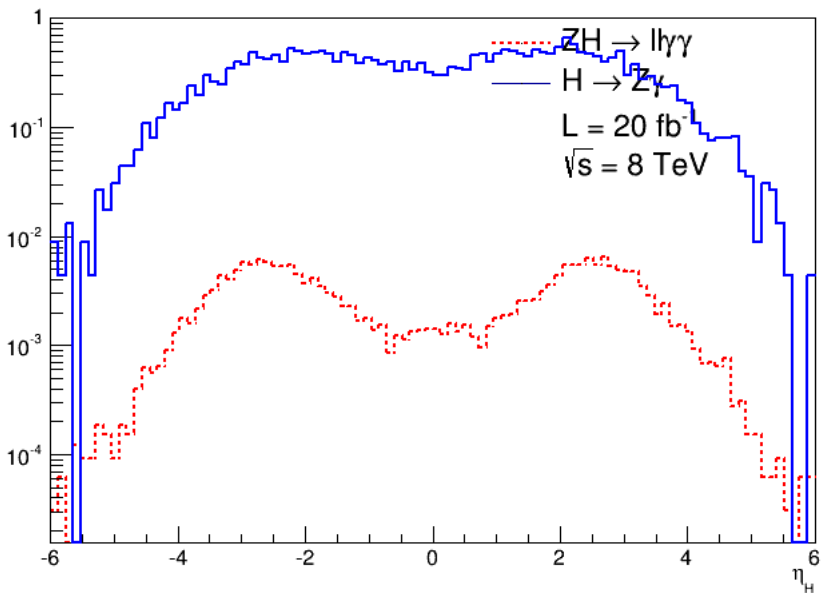
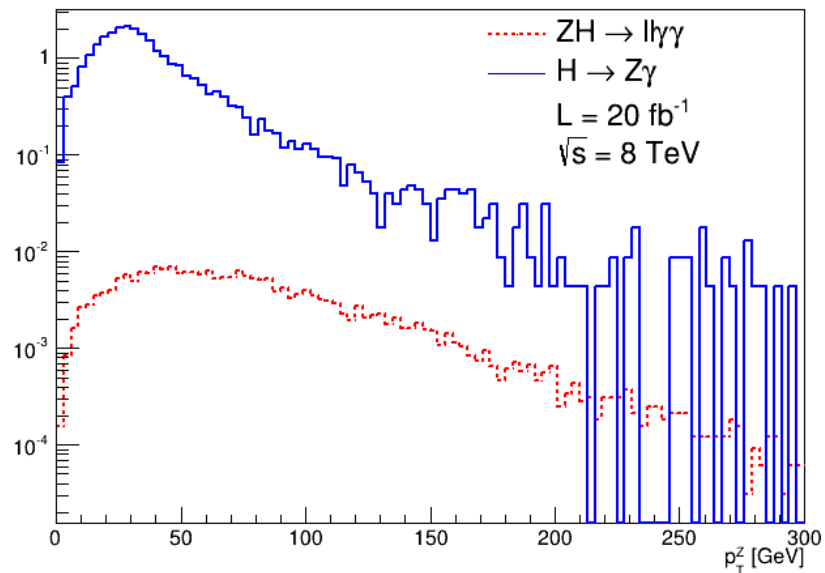
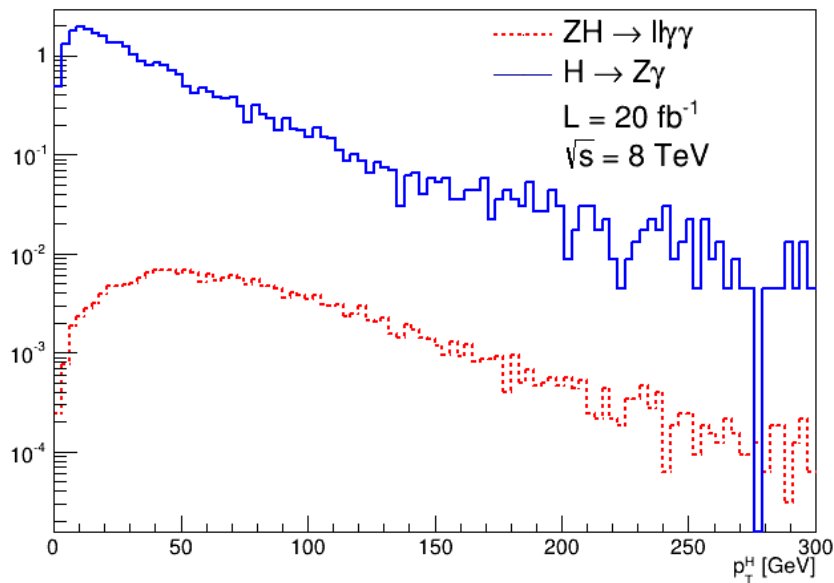
- $\sigma (gg \rightarrow H + \text{VBF}) = 20.69 \text{ pb (8TeV)}$
- $\sigma (qq \rightarrow ZH) = 0.4102 \text{ pb (8TeV)}$
- $\text{BR} (H \rightarrow Z\gamma) = 1.58 \times 10^{-3}$
- $\text{BR} (ZH \rightarrow ee + ZH \rightarrow \mu\mu) = 0.067$
- $\text{BR} (H \rightarrow \gamma\gamma) = 2.28 \times 10^{-3}$

- $gg \rightarrow H + \text{VBF}$ with $H \rightarrow Z\gamma$ and $Z \rightarrow ll$:
 - $N = 20 \text{ fb}^{-1} \times 20690 \text{ fb} \times 0.067 \times 1.58 \times 10^{-3} \times 64\% \text{ (eff.)} = \mathbf{27.1}$ events
- $qq \rightarrow ZH$ with $H \rightarrow \gamma\gamma$ and $Z \rightarrow ll$:
 - $N = 20 \text{ fb}^{-1} \times 410.2 \text{ fb} \times 0.067 \times 2.28 \times 10^{-3} \times 14\% \text{ (eff.)} = \mathbf{0.175}$ events

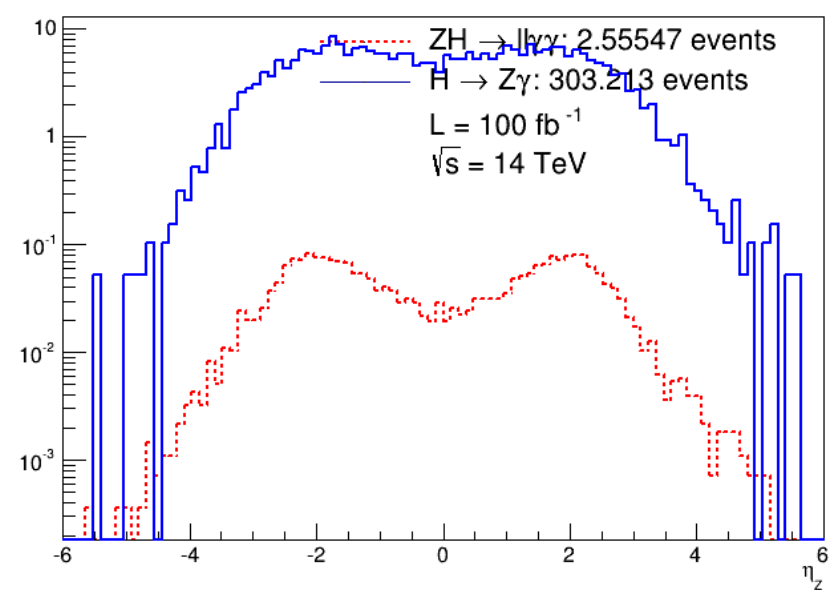
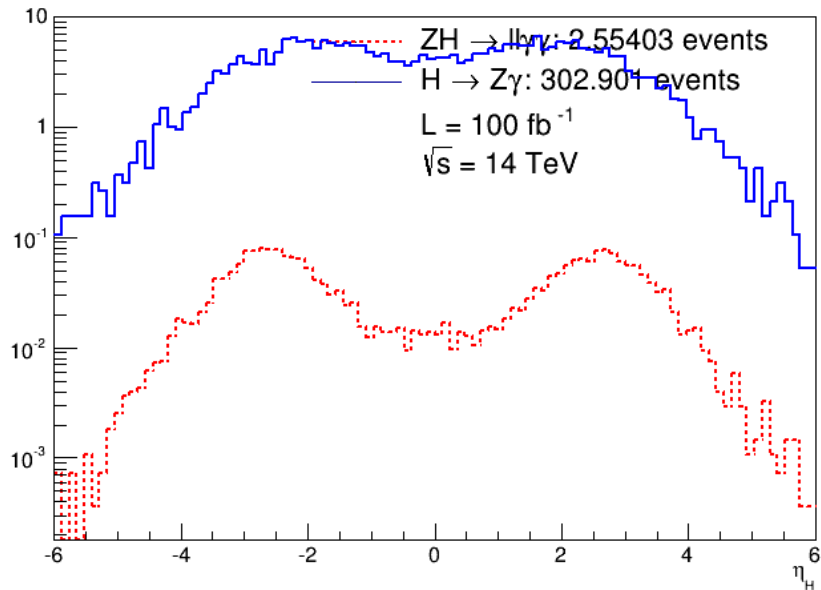
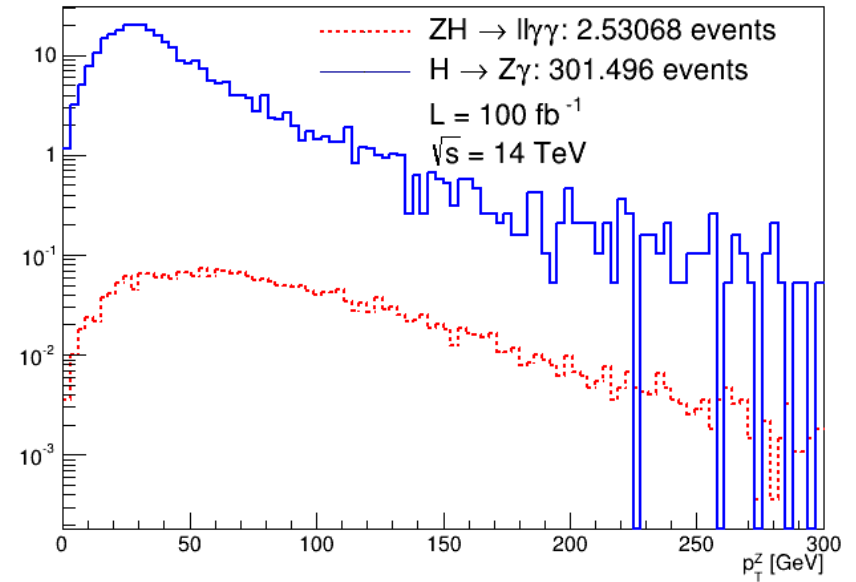
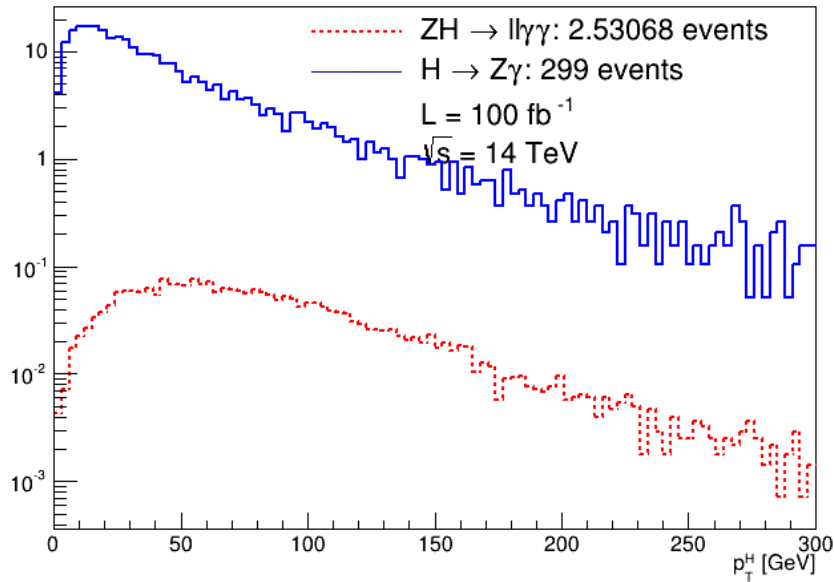
8 TeV plots: leptons and photons



8 TeV plots: Z and H kinematics



14 TeV plots: Z and H kinematics



Conclusions

- This was a quick study at truth level only
- $ZH \rightarrow l\bar{l}\gamma\gamma$ is a very small background for $H \rightarrow Z\gamma$