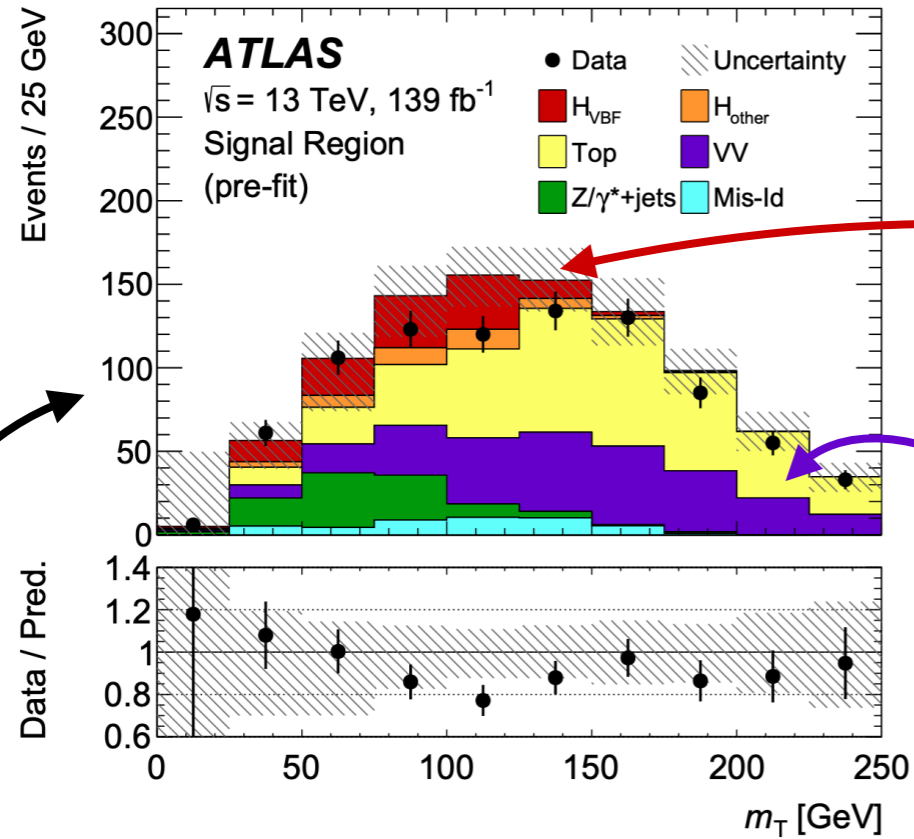


# Absolute Branching Fraction Normalizations Using VBF ( $H \rightarrow$ )WW

Elliot Lipeles

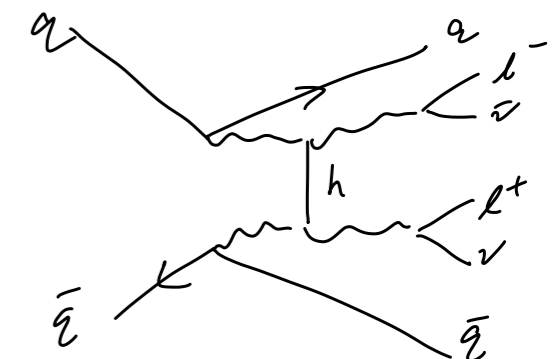
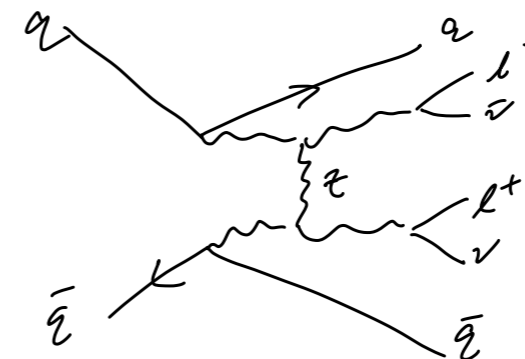
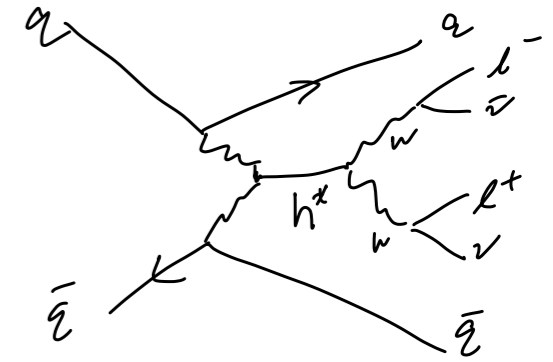
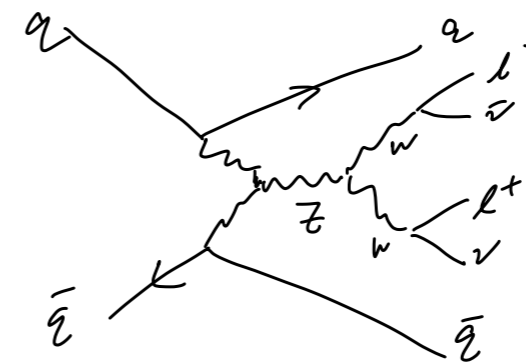
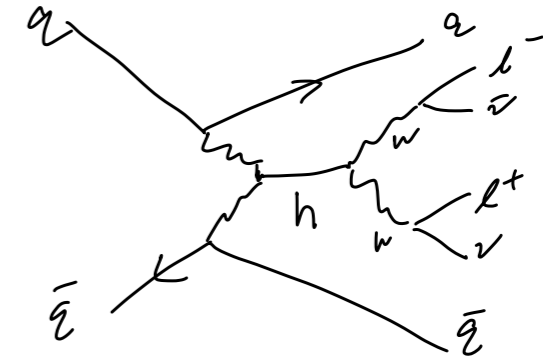
# Concept

<https://arxiv.org/pdf/2304.03053>



*VBF H → WW*

*VBF WW*



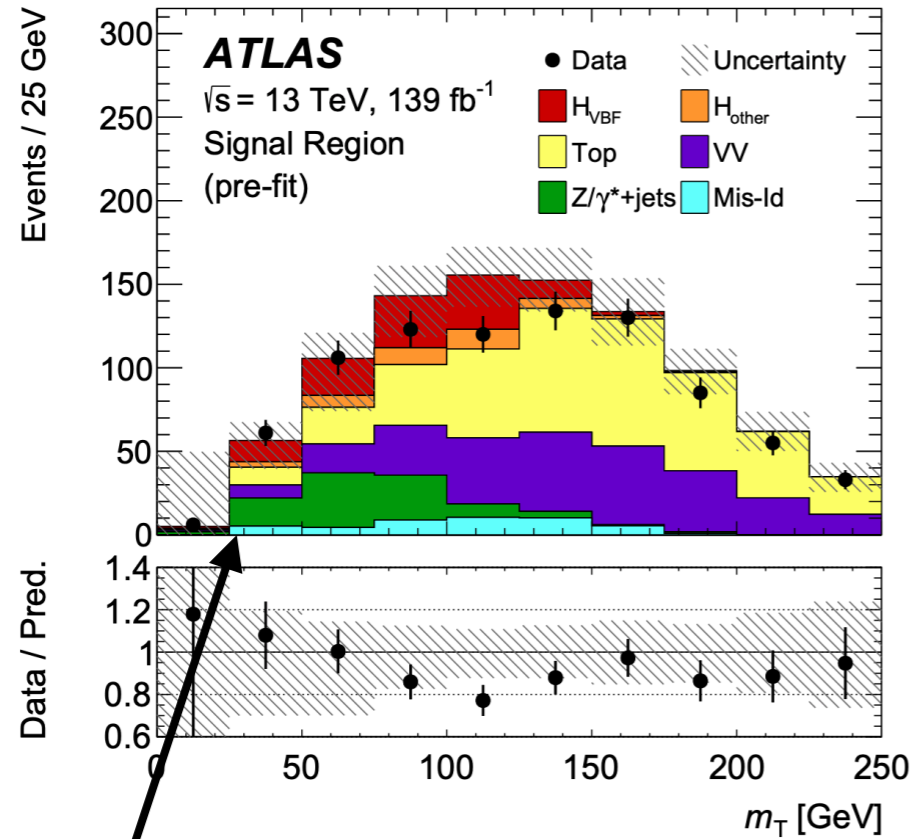
Fit this distribution for  $\frac{H \rightarrow WW}{VBF WW}$

VBF  $H \rightarrow WW$  and VBF WW (no Higgs) should have very similar pdf and QCD uncertainties

Result should give an absolute estimate of  $\kappa_w^2 / \Gamma_H$  with small theory uncertainties

Main experimental uncertainties also cancel to first order (lepton id, jet energy scale)

# Concept

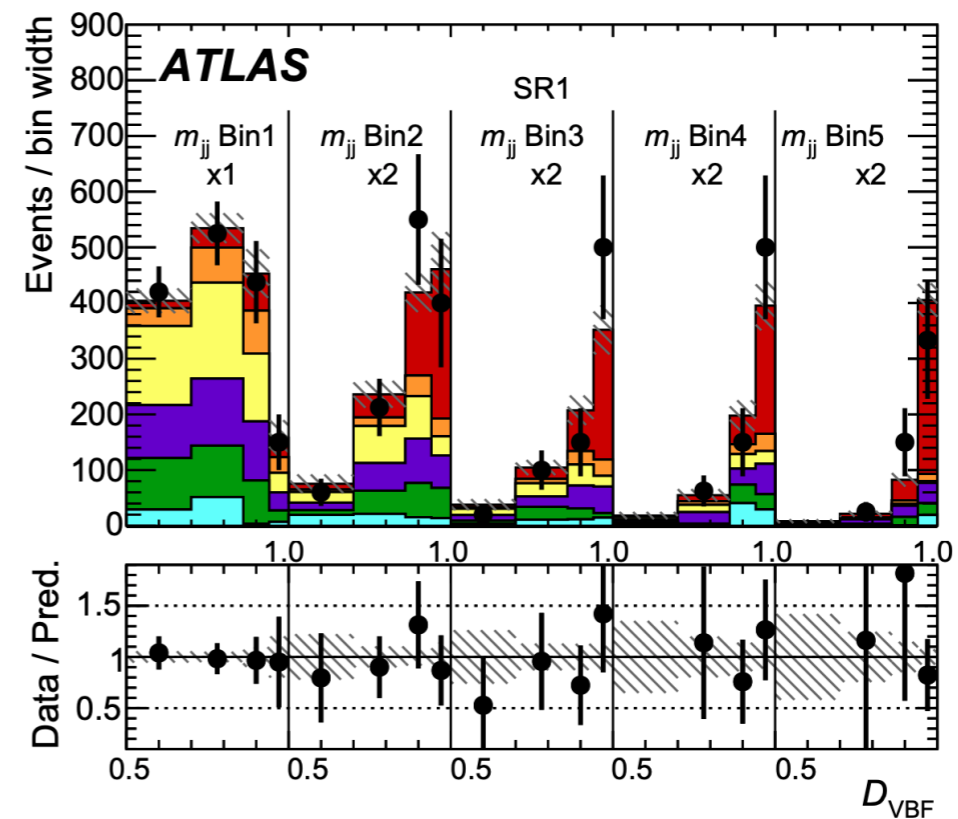


Fit this distribution for  $\frac{H \rightarrow WW}{VBF WW}$

VBF  $H \rightarrow WW$  and VBF  $WW$  (no Higgs) should have very similar pdf and QCD uncertainties

Result should give an absolute estimate of  $\kappa_w^2 / \Gamma_H$  with small theory uncertainties

Main experimental uncertainties also cancel to first order (lepton id, jet energy scale)



Top and  $Z \rightarrow \tau\tau$  backgrounds are significant

- 1) Cut tighter...
- 2) Lots of control regions

Also forward tracking and b-jet tagging (already at HL-LHC) may significantly suppress top

100 TeV and 30ab<sup>-1</sup> gives order 4000x more statistics

Maybe this ~20% uncertainty could be ~1%

Strategy = cut hard on VBF signature to demonstrate clean signal ... not so easy

First pass with privately generated Delphes (from FCChh LHE files)

- Very preliminary
- Working with Birgit on getting full set of official v07 samples

## Missing VBF WW (non-Higgs)

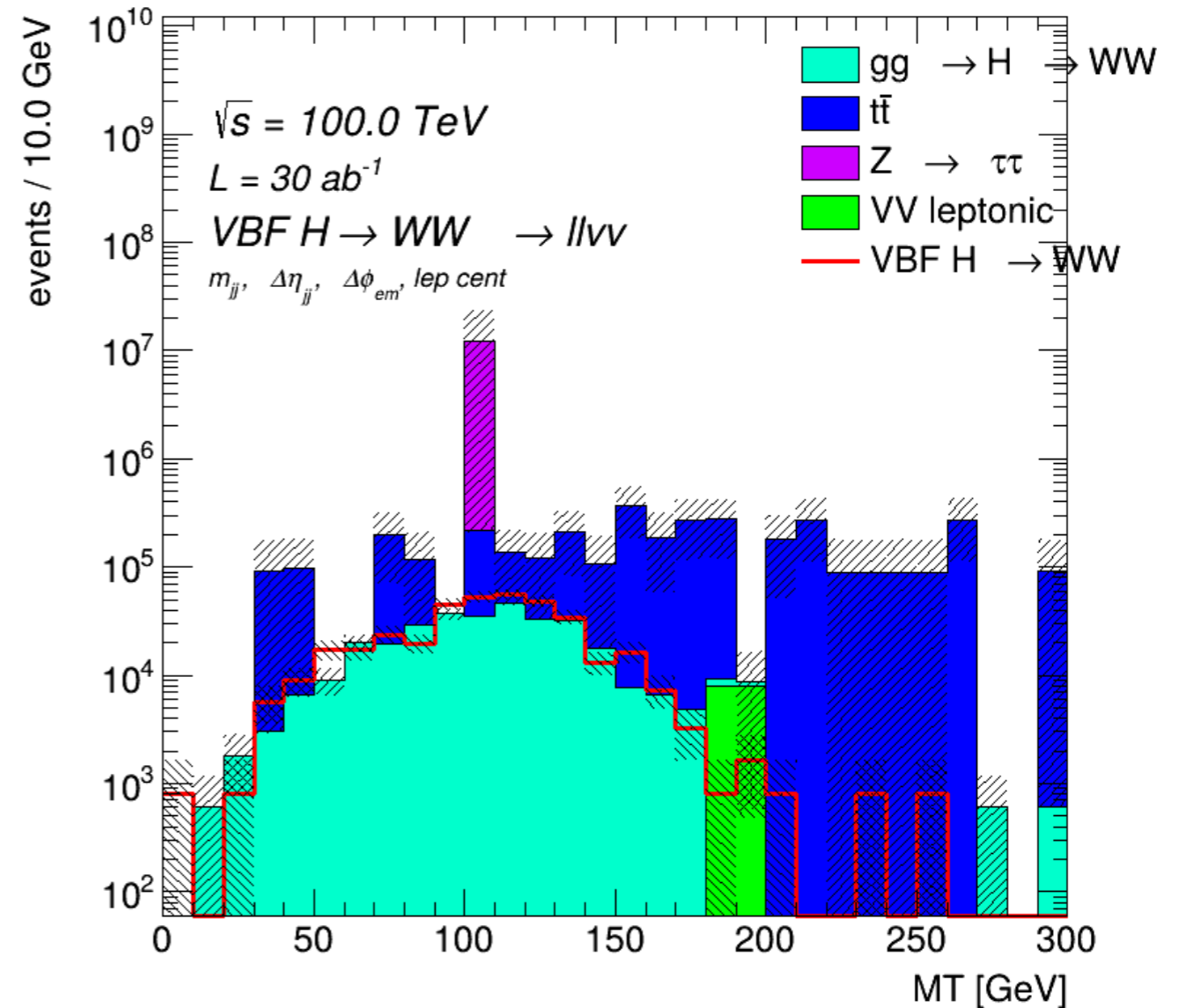
Low stats particularly in  $Z \rightarrow \tau\tau$

- New sample found that should improve this testing now
- No  $Z \rightarrow \tau\tau$  veto implemented yet

Double checking normalizations (e.g. k-factors are almost certainly wrong).

Searching for more ttbar suppression

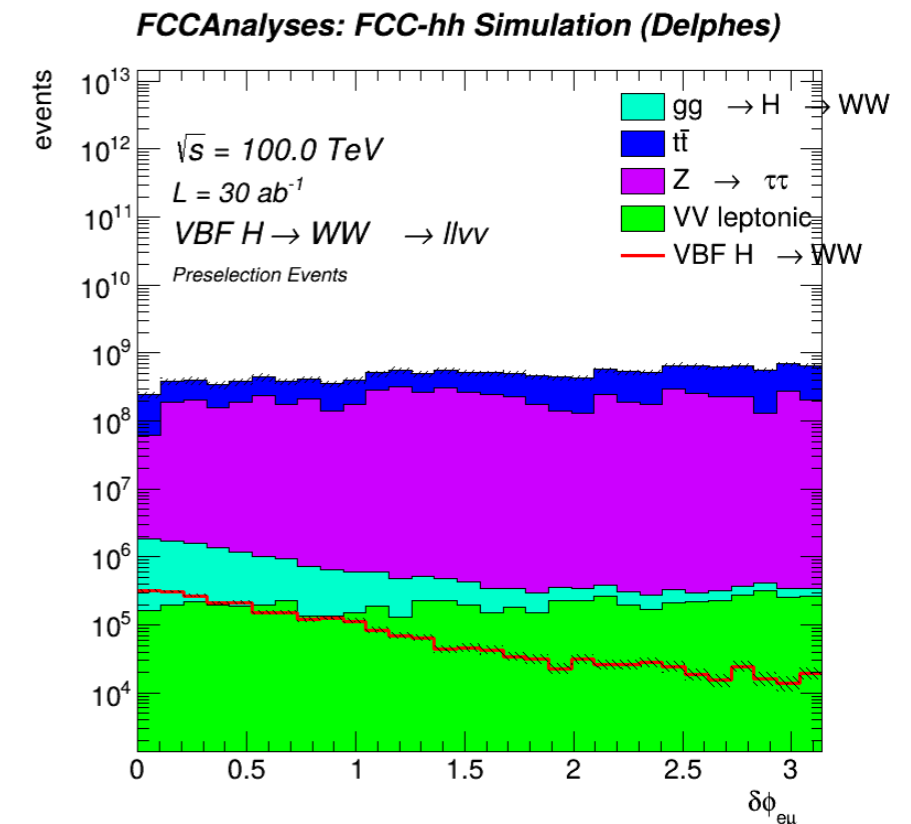
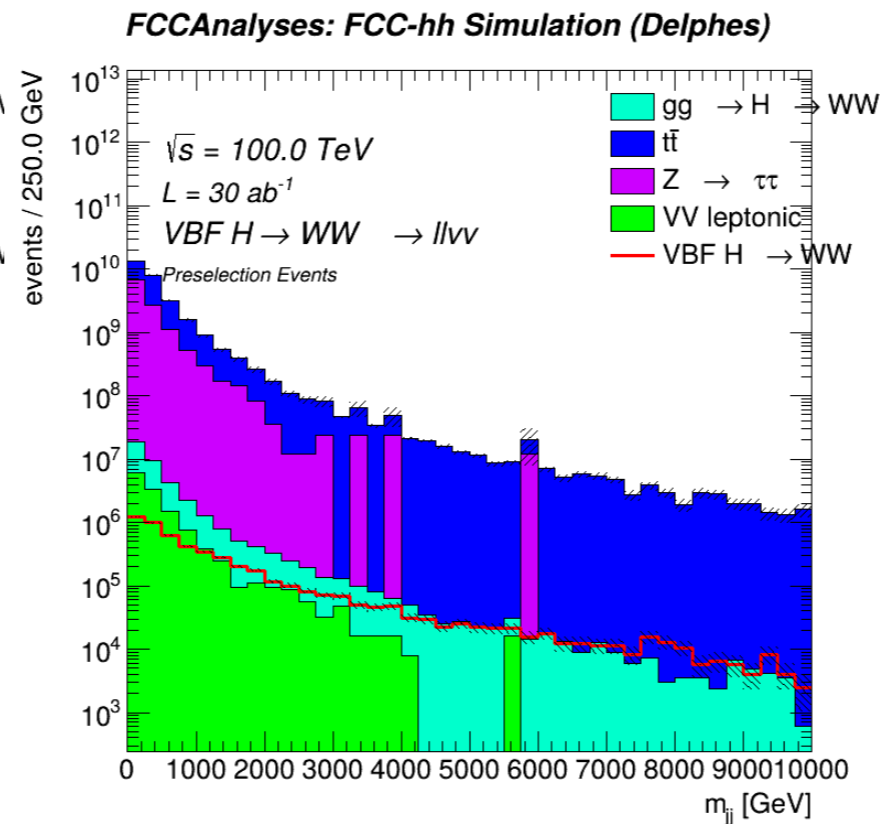
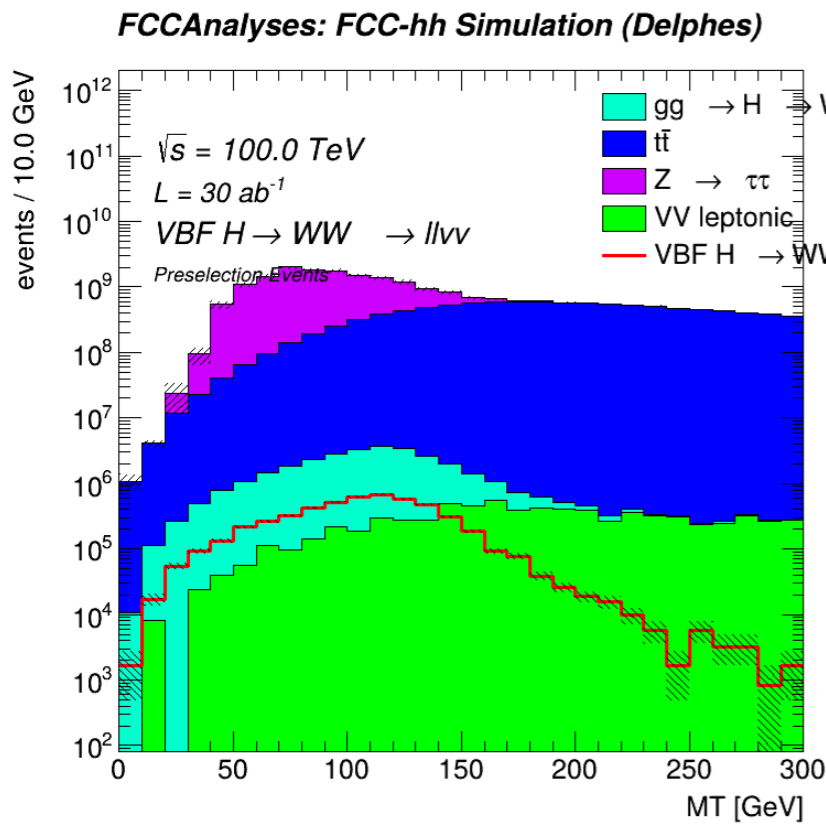
FCCAnalyses: FCC-hh Simulation (Delphes)



components of  $p_{e\mu}$  and  $\cancel{E}$  and assuming  $m_{\nu\nu} = m_{e\mu}$

# Selection

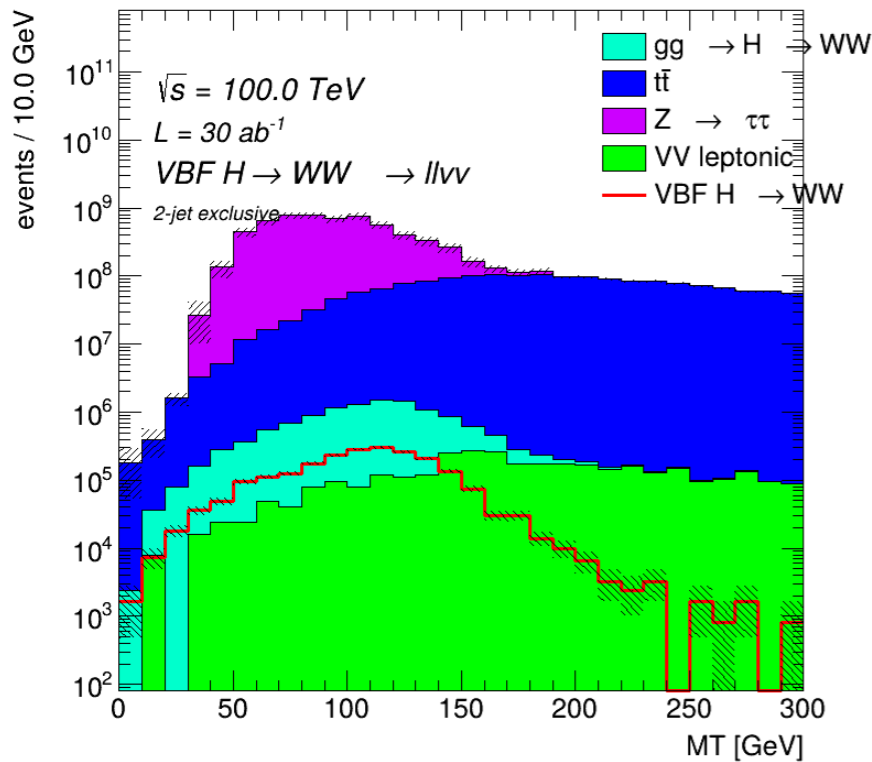
- One  $e$  and one  $\mu$
- At least two jets



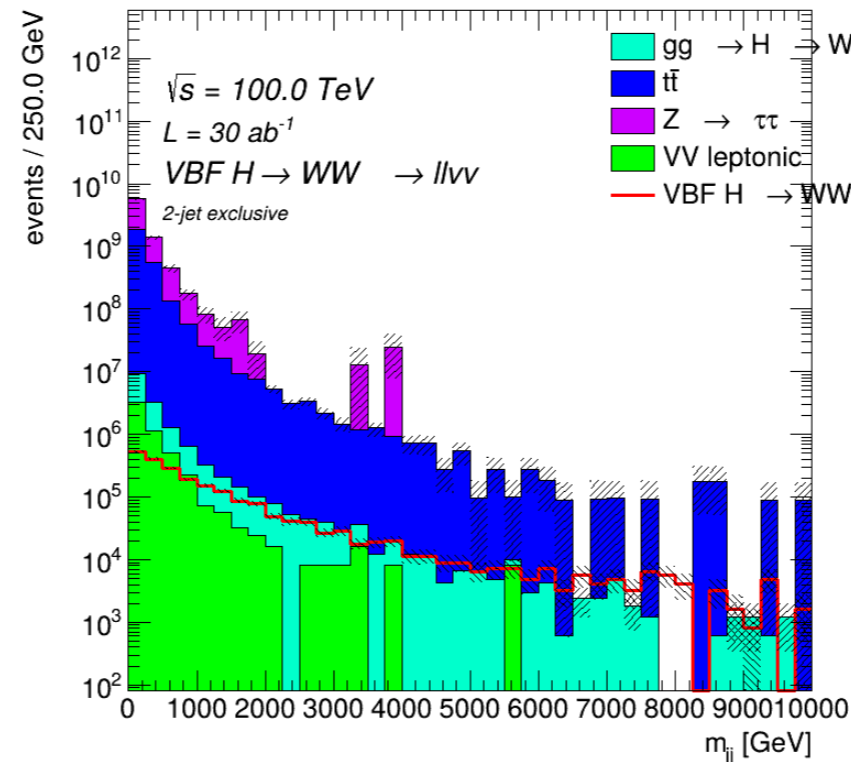
# Selection

- One  $e$  and one  $\mu$
- Exactly two jets

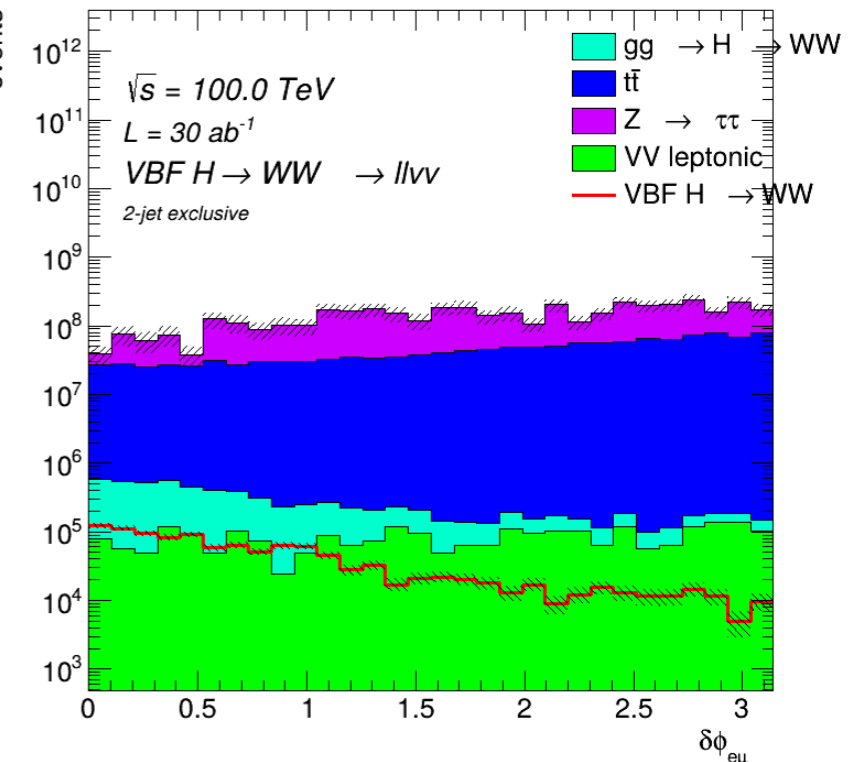
FCCAnalyses: FCC-hh Simulation (Delphes)



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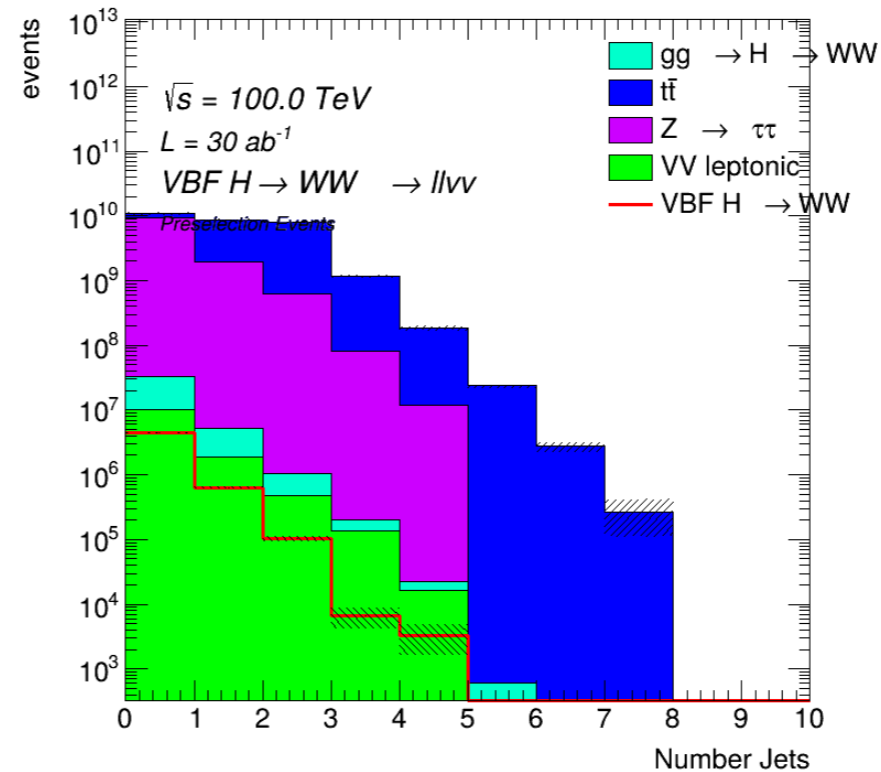




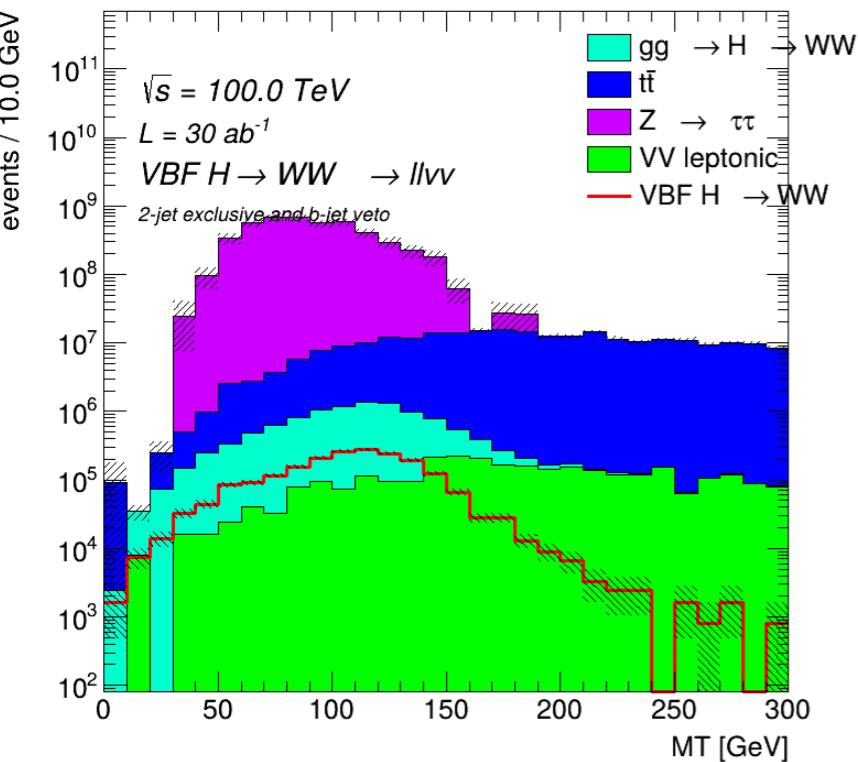
# Selection (con't)

- One  $e$  and one  $\mu$
- Exactly two jets
- Veto loose b-jets

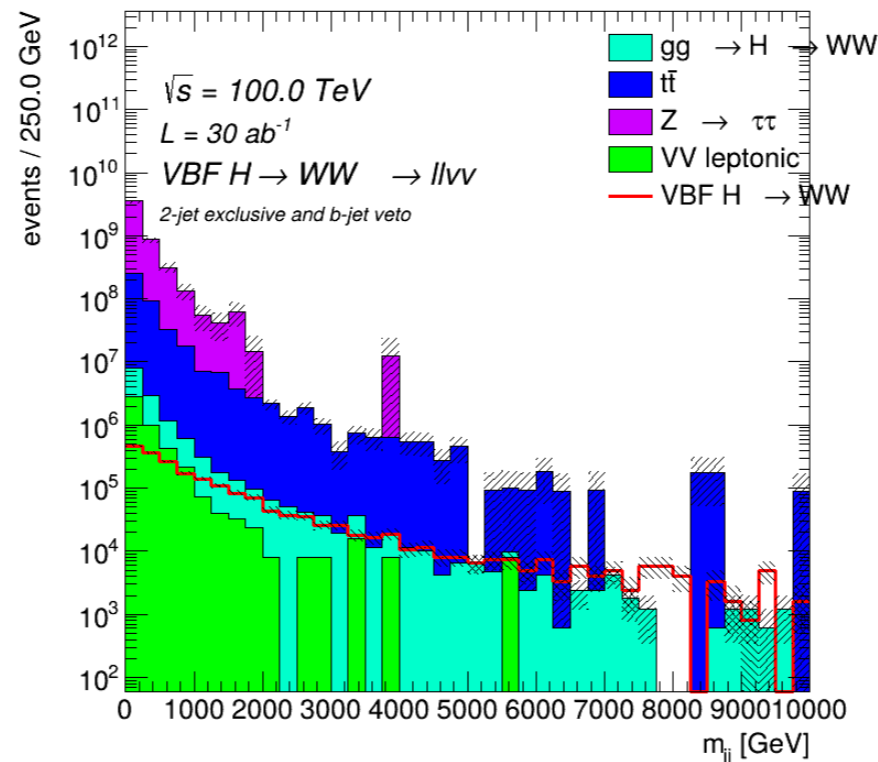
FCCAnalyses: FCC-hh Simulation (Delphes)



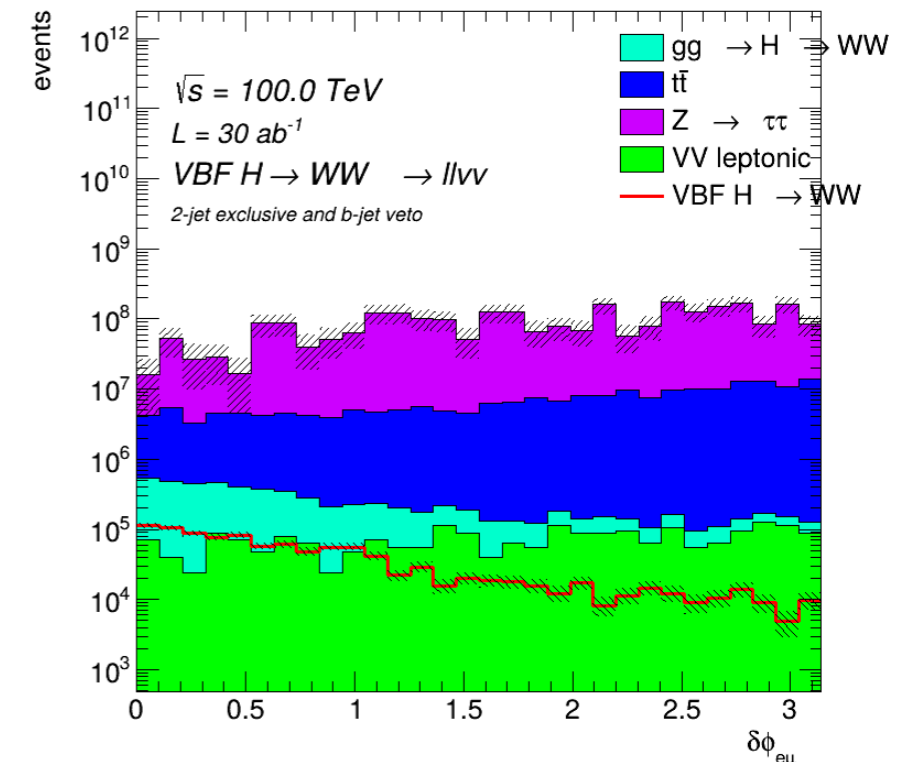
FCCAnalyses: FCC-hh Simulation (Delphes)



FCCAnalyses: FCC-hh Simulation (Delphes)



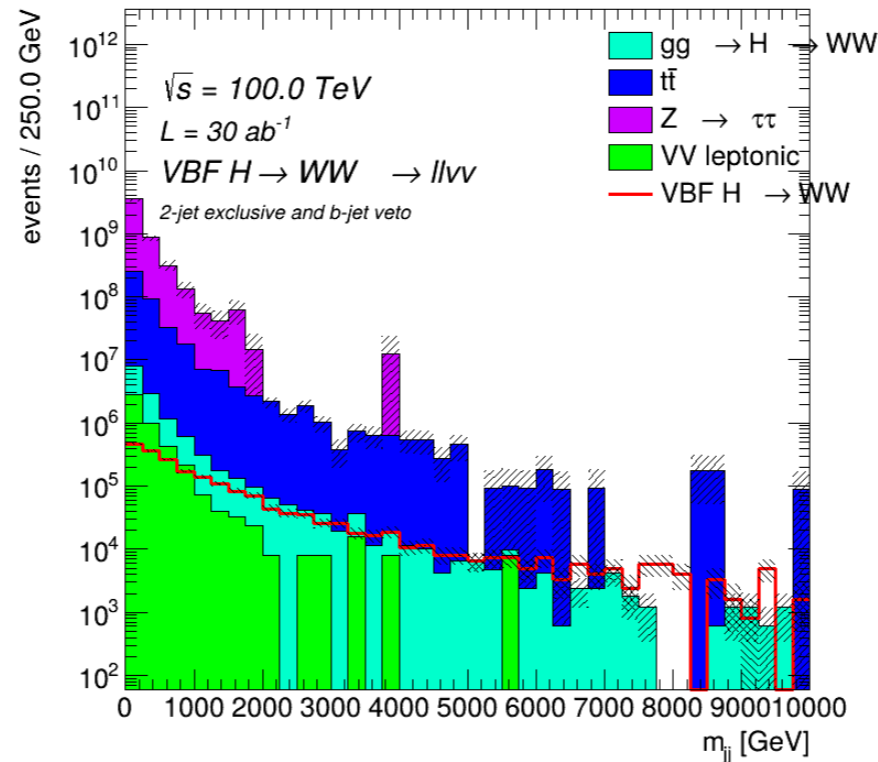
FCCAnalyses: FCC-hh Simulation (Delphes)



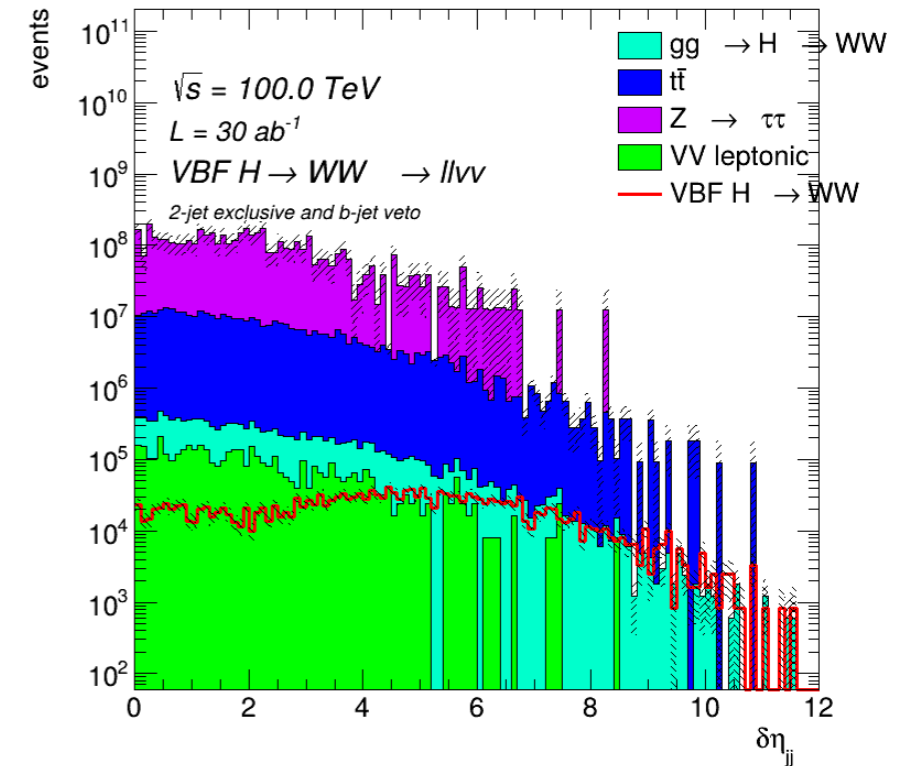
# Selection (con't)

- One  $e$  and one  $\mu$
- Exactly two jets
- Veto loose b-jets
- $m_{jj} > 1000$  &&  $|\Delta\eta| > 4.5$

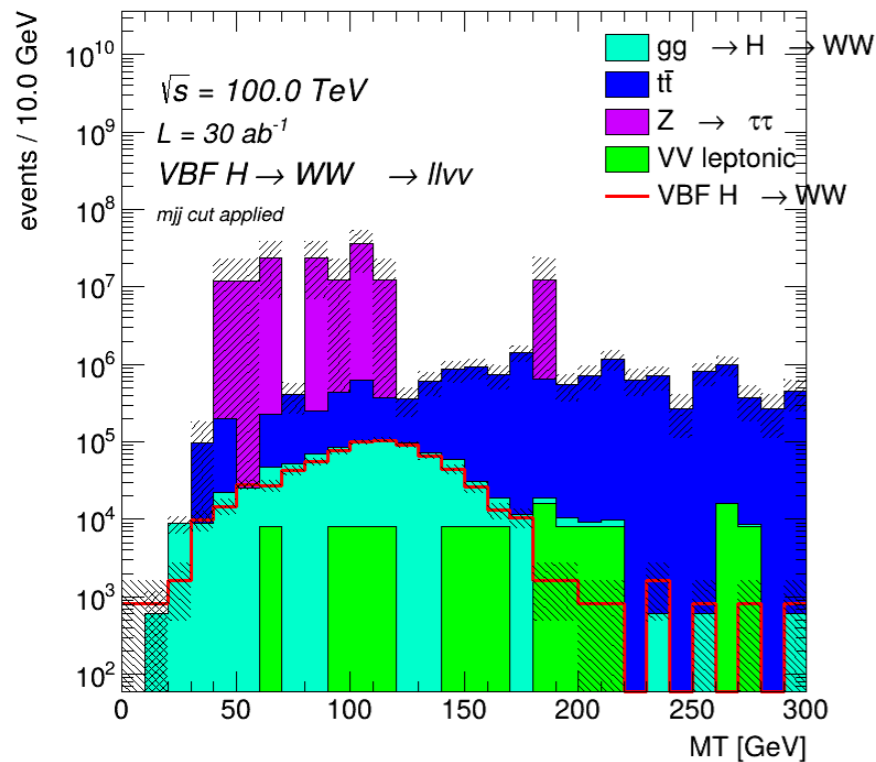
FCCAnalyses: FCC-hh Simulation (Delphes)



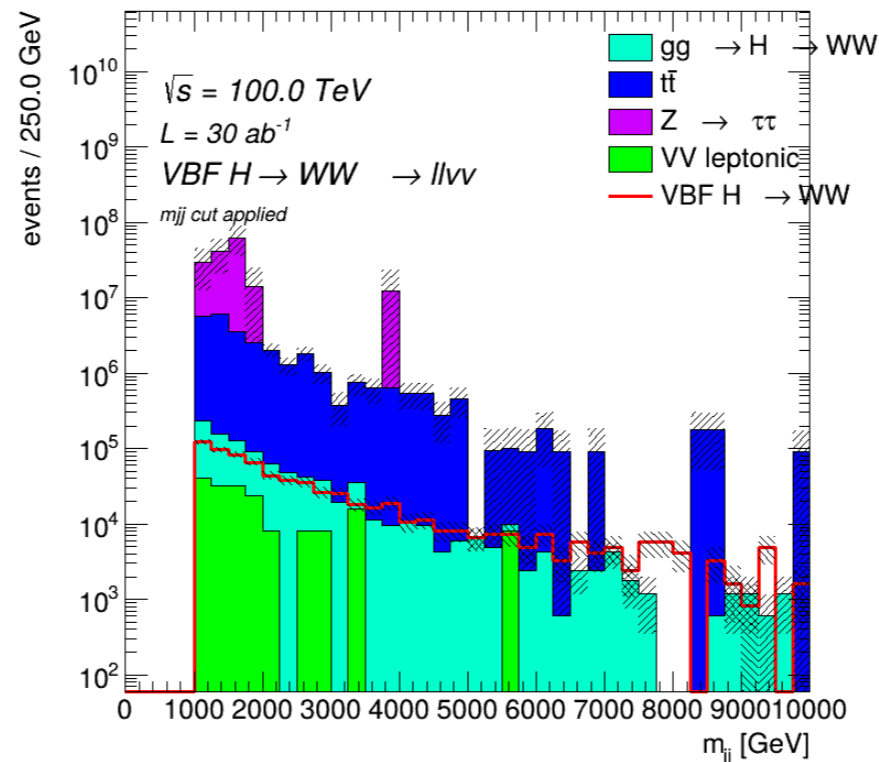
FCCAnalyses: FCC-hh Simulation (Delphes)



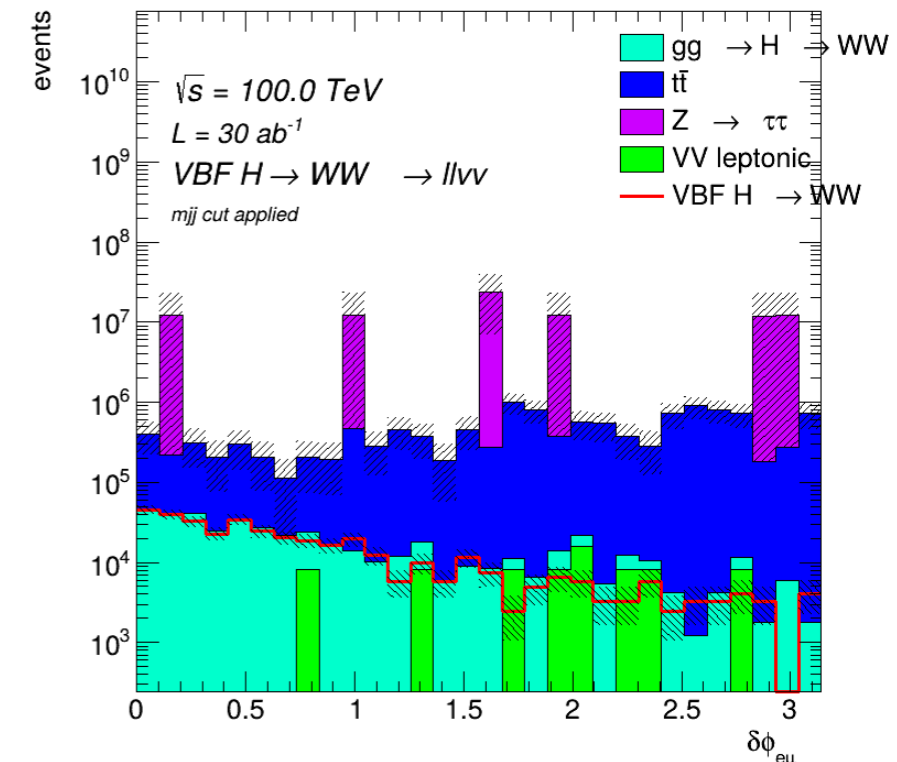
FCCAnalyses: FCC-hh Simulation (Delphes)



FCCAnalyses: FCC-hh Simulation (Delphes)



FCCAnalyses: FCC-hh Simulation (Delphes)





# Selection (con't)

- One  $e$  and one  $\mu$
- Exactly two jets
- Veto loose b-jets
- $m_{jj} > 1000$  &&  $|\Delta\eta| > 4.5$
- lepton centrality  $< 0.4$  &&  $\Delta\phi_{e\mu} < 0.75$

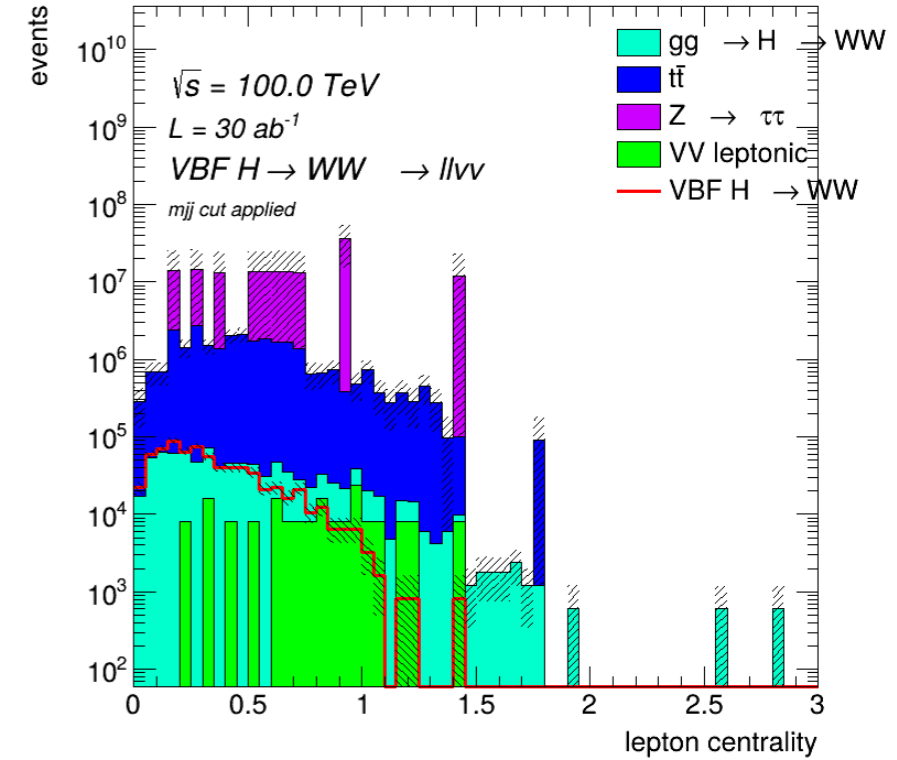
$$lep\ cent = \left| \frac{\eta_e - \bar{\eta}_{jj}}{\Delta\eta_{jj}} \right| + \left| \frac{\eta_\mu - \bar{\eta}_{jj}}{\Delta\eta_{jj}} \right|$$

where

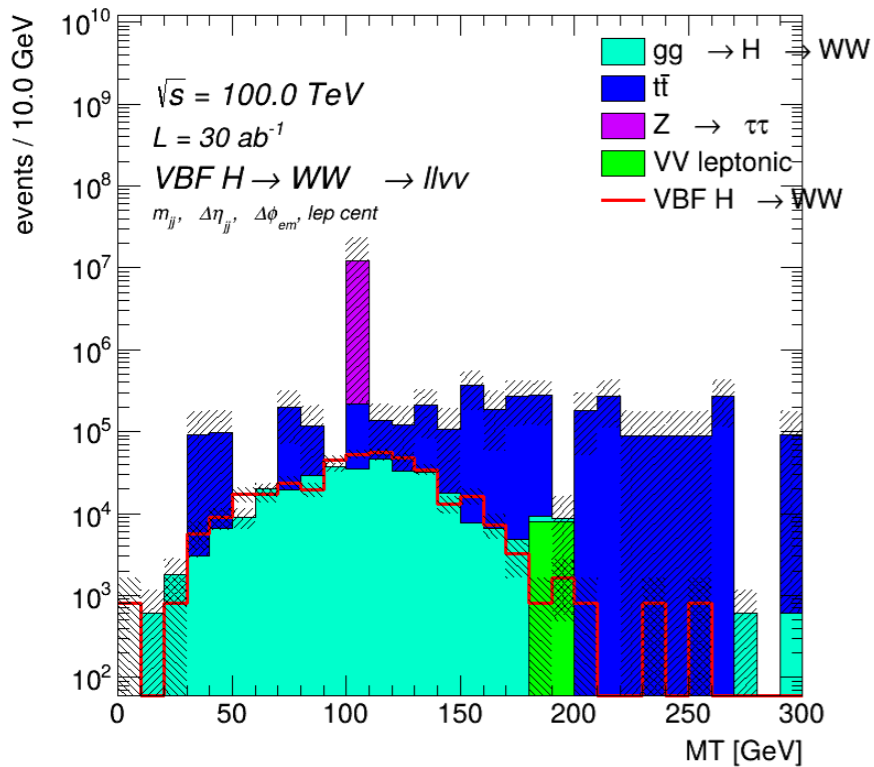
$$\bar{\eta}_{jj} = \frac{\eta_{j1} + \eta_{j2}}{2}$$

$$\Delta\eta_{jj} = \eta_{j2} - \eta_{j1}$$

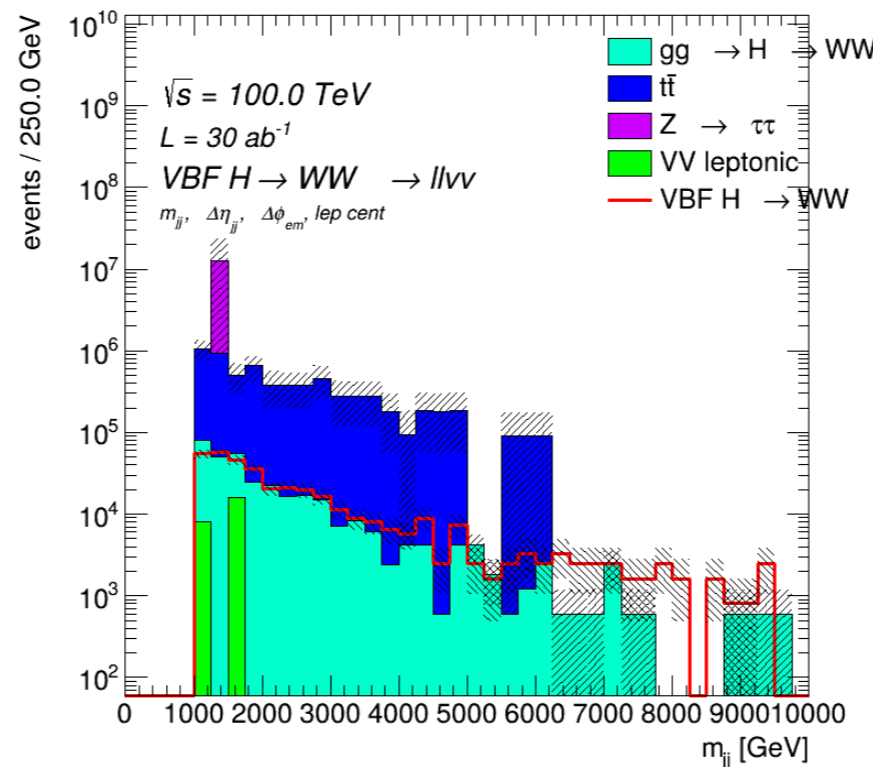
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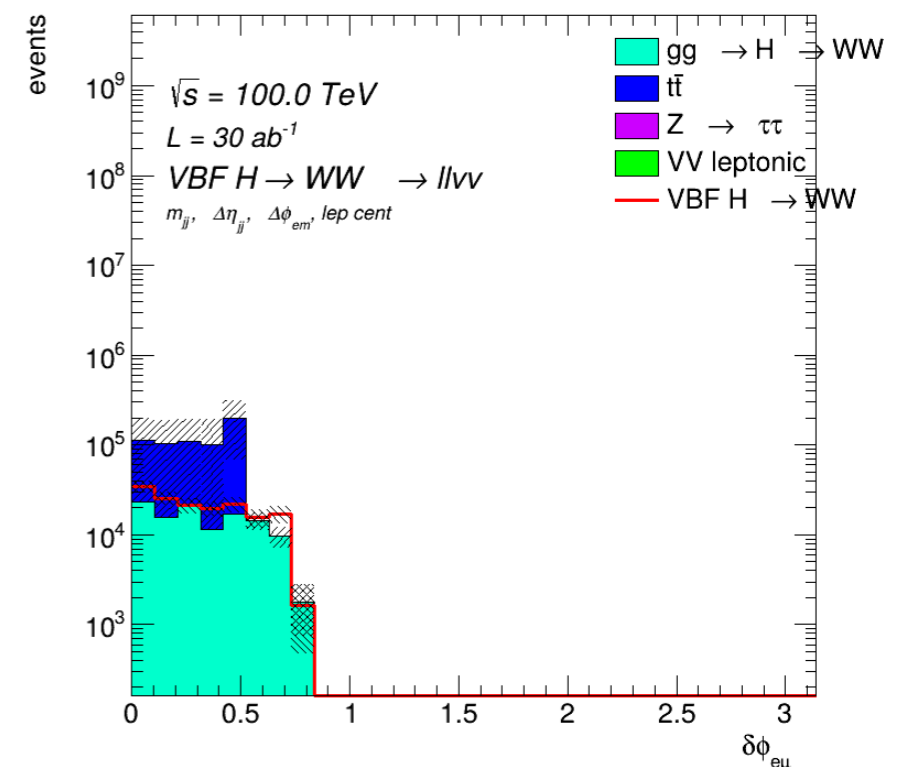
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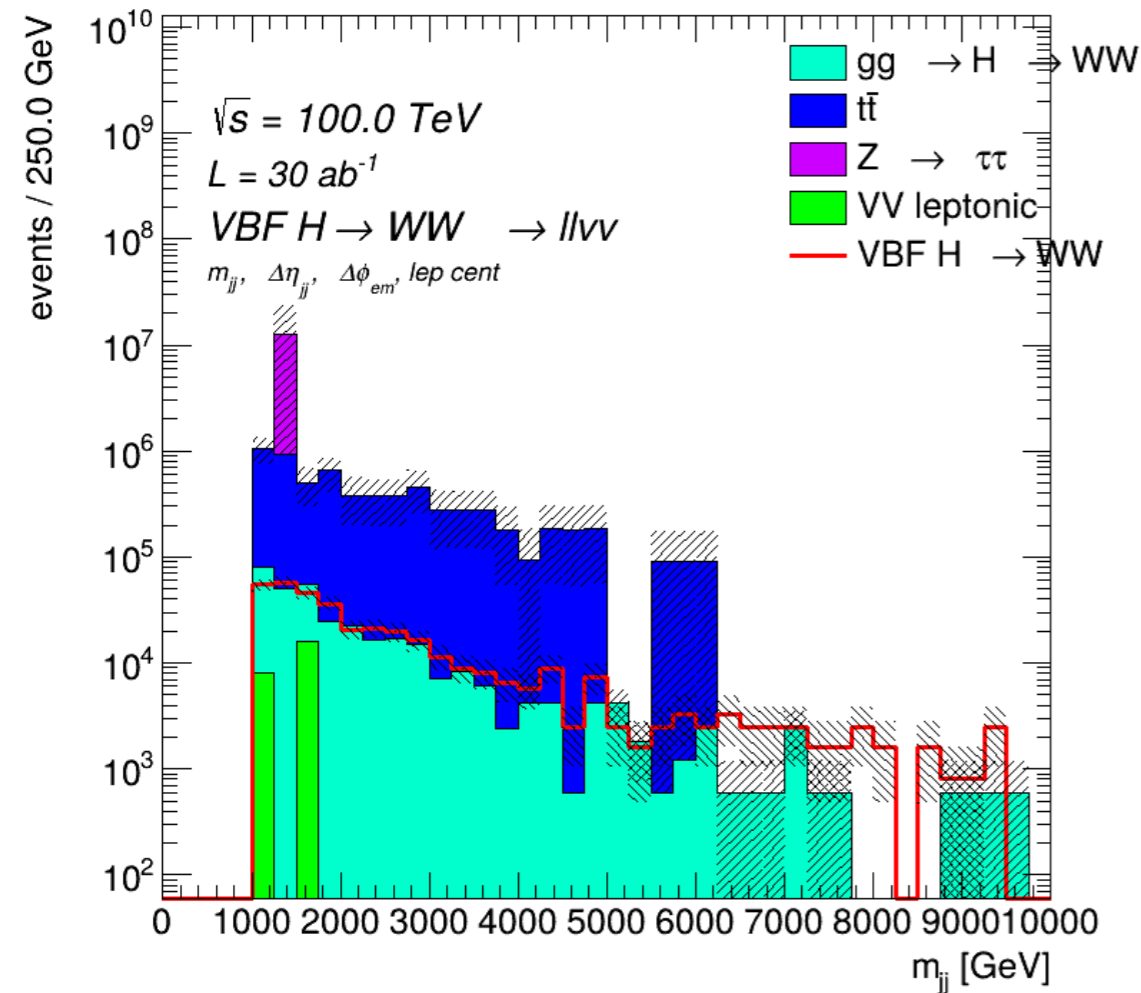


FCCAnalyses: FCC-hh Simulation (Delphes)

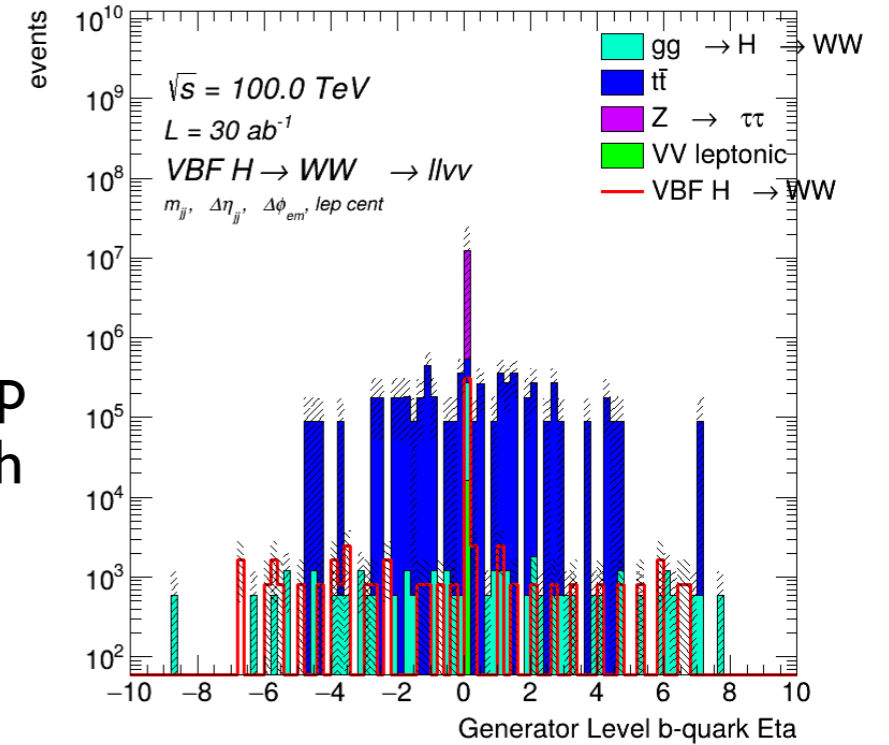


# Just cutting harder on $m_{jj}$ doesn't look good...

FCCAnalyses: FCC-hh Simulation (Delphes)

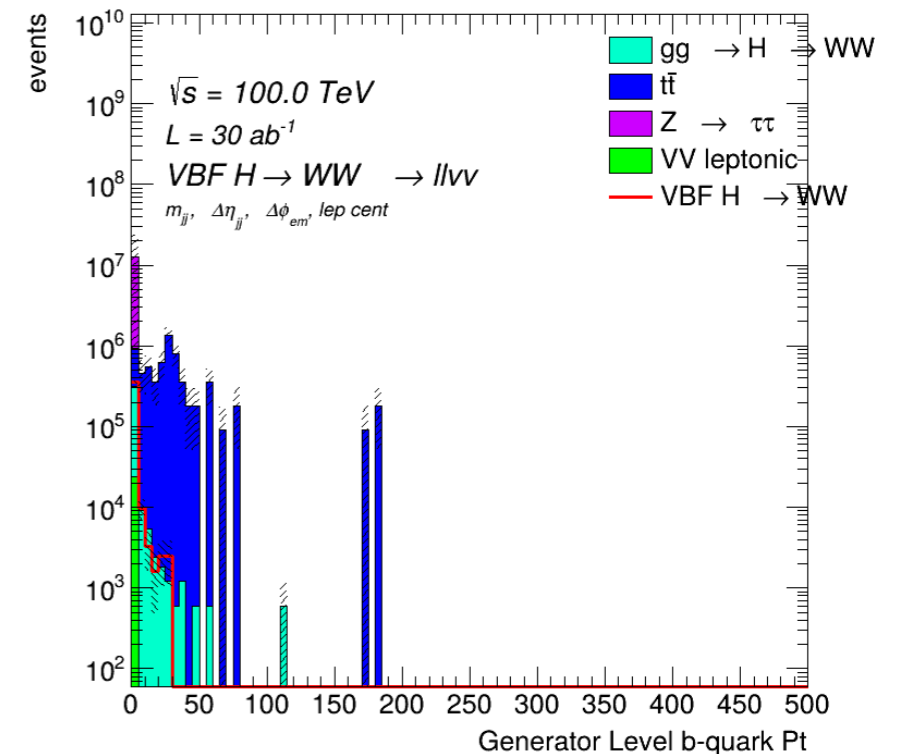


FCCAnalyses: FCC-hh Simulation (Delphes)



b-partons from top are reasonably high  $p_T$  and central

FCCAnalyses: FCC-hh Simulation (Delphes)



Might get rid of  $Z \rightarrow \tau\tau$  though (needs more stats)

# Summary

Selection looks “okay”

- Need to implement  $Z \rightarrow \tau\tau$
- $t\bar{t}$  is a bit high for comfort (need to check b-tag assumptions vs current LHC state of the art)

Sample Generation

- Working on high stats sample
- Missing VBF  $WW$  sample (in progress)
- Will transition to standard v07 samples

Convergence

- Plan to do a simple fraction fit to assess statistical power
- Are there simple reweights for experimental systematics?
- PDF reweights for additional energies?
- No plan for theory systematics
  - Backgrounds: control regions would “sufficient”?
  - Signal: would require dedicated calculation, but unlikely to be limiting factor in  $\sim 30+$  years

# Selection (con't)

- One  $e$  and one  $\mu$
- Exactly two jets
- Veto loose b-jets
- $m_{jj} > 1000$  &&  $|\Delta\eta| > 4.5$
- lepton centrality  $< 0.4$  &&  $\Delta\phi_{e\mu} < 0.75$
- MT cut

