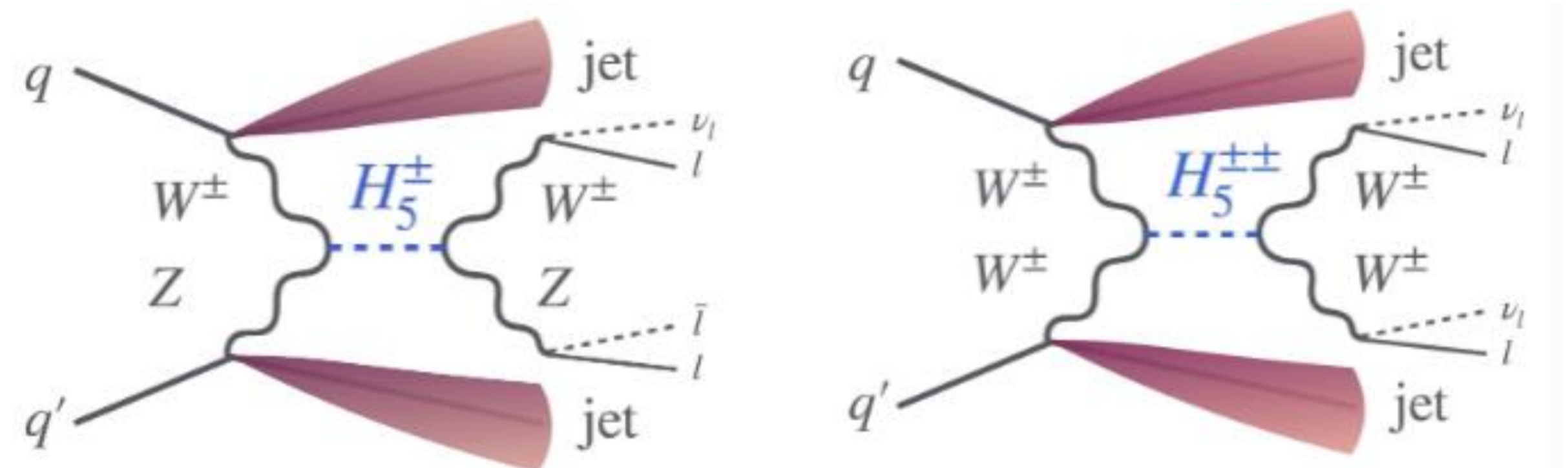


## Analysis Overview

- This analysis is a run-2 + partial run-3 search for a charged and doubly charged Higgs in the  $W^\pm Z$  and same-sign  $W^\pm W^\pm$  channel.
- Motivated by excesses seen in run-2.
- Aim is to add run-3 data and to optimize the analysis as a  $H^+$  and  $H^{++}$  search in the vector-boson fusion (VBF) channel.



## AF3 and FullSim

- Detector simulation with GEANT4 (FullSim) is accurate but requires significant CPU resources.
- AtlFast3 (AF3) uses parameterized shower simulation to save on CPU.
- AF3 has significantly improved modelling of substructure within jets compared to AF2.

## Event Selections

- Combined run-2 Monte Carlo campaigns.
- $H^+$  and  $H^{++}$  mass points from 450 GeV to 3000 GeV.

### WZ Channel

#### Control Region (CR):

Leading Z, subleading Z, and W lepton  $p_T > 25$  GeV  
 Leading (subleading) jet  $p_T > 65$  (35) GeV  
 Additional jet  $p_T > 25$  GeV  
 Event has 3 leptons with one same-flavour opposite-sign pair  
 Inclusive of all flavour combinations  
 Lepton pair with  $|m_{ll} - m_Z| < 20$  GeV  
 Jet  $|\eta| < 4.5$   
 $m_{jj} > 500$  GeV

$$|\Delta y_{jj}| < 3.5$$

$$E_T^{miss} > 25$$
 GeV

#### Signal Region (SR):

Same as CR with  $|\Delta y_{jj}| > 3.5$

### WW Channel

#### Low- $m_{jj}$ Control Region (CR):

Leading and subleading lepton  $p_T > 27$  GeV  
 Leading (subleading) jet  $p_T > 65$  (35) GeV  
 Additional jet  $p_T > 25$  GeV  
 Event has exactly 2 signal WW leptons with same charge  
 Jet  $|\eta| < 4.5$   
 $m_{ll} > 20$  GeV

$$200 < m_{jj} < 500$$
 GeV

$$|\Delta y_{jj}| > 2$$

$$E_T^{miss} > 30$$
 GeV

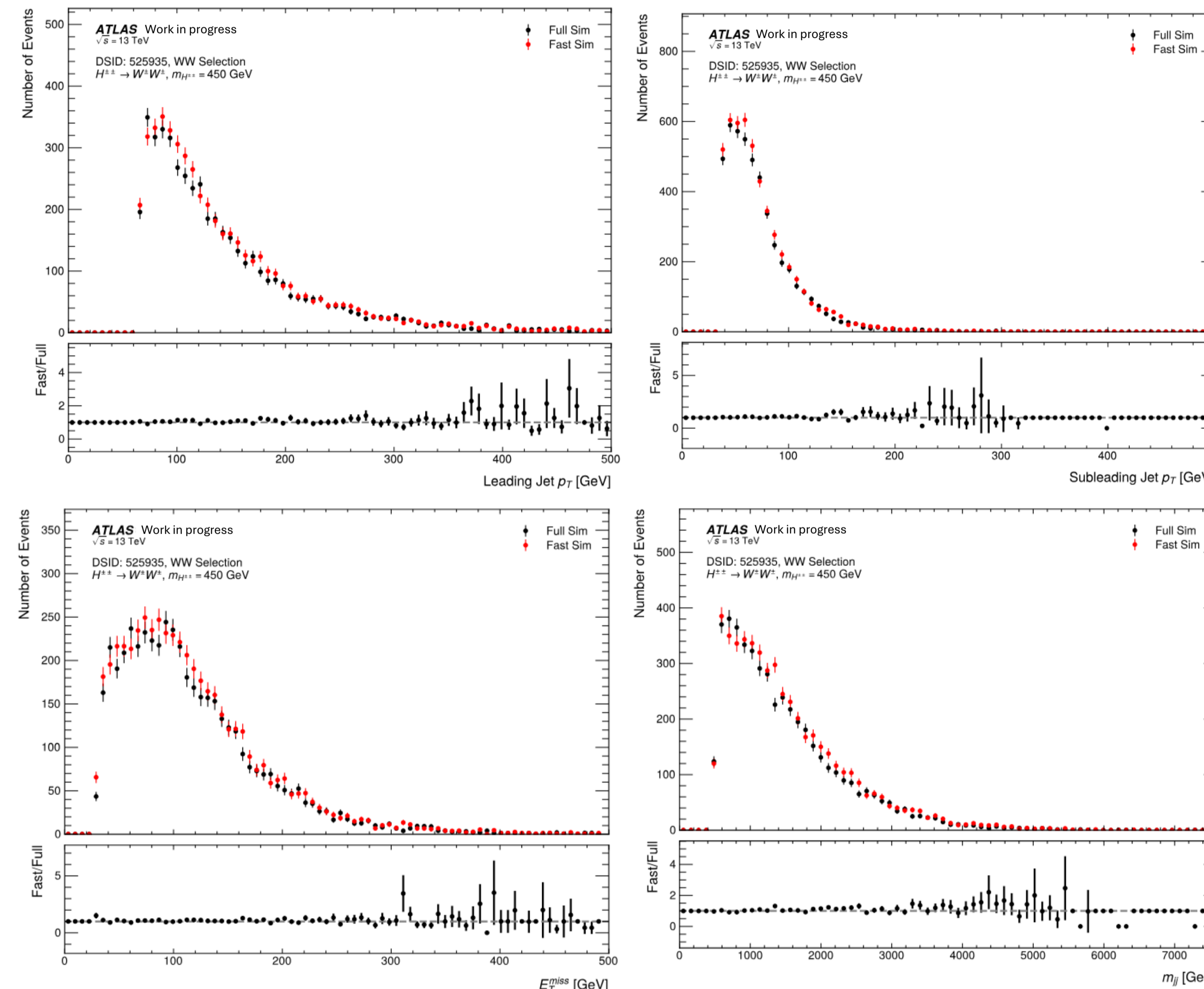
#### Signal Region (SR):

Same as CR with  $m_{jj} > 500$  GeV

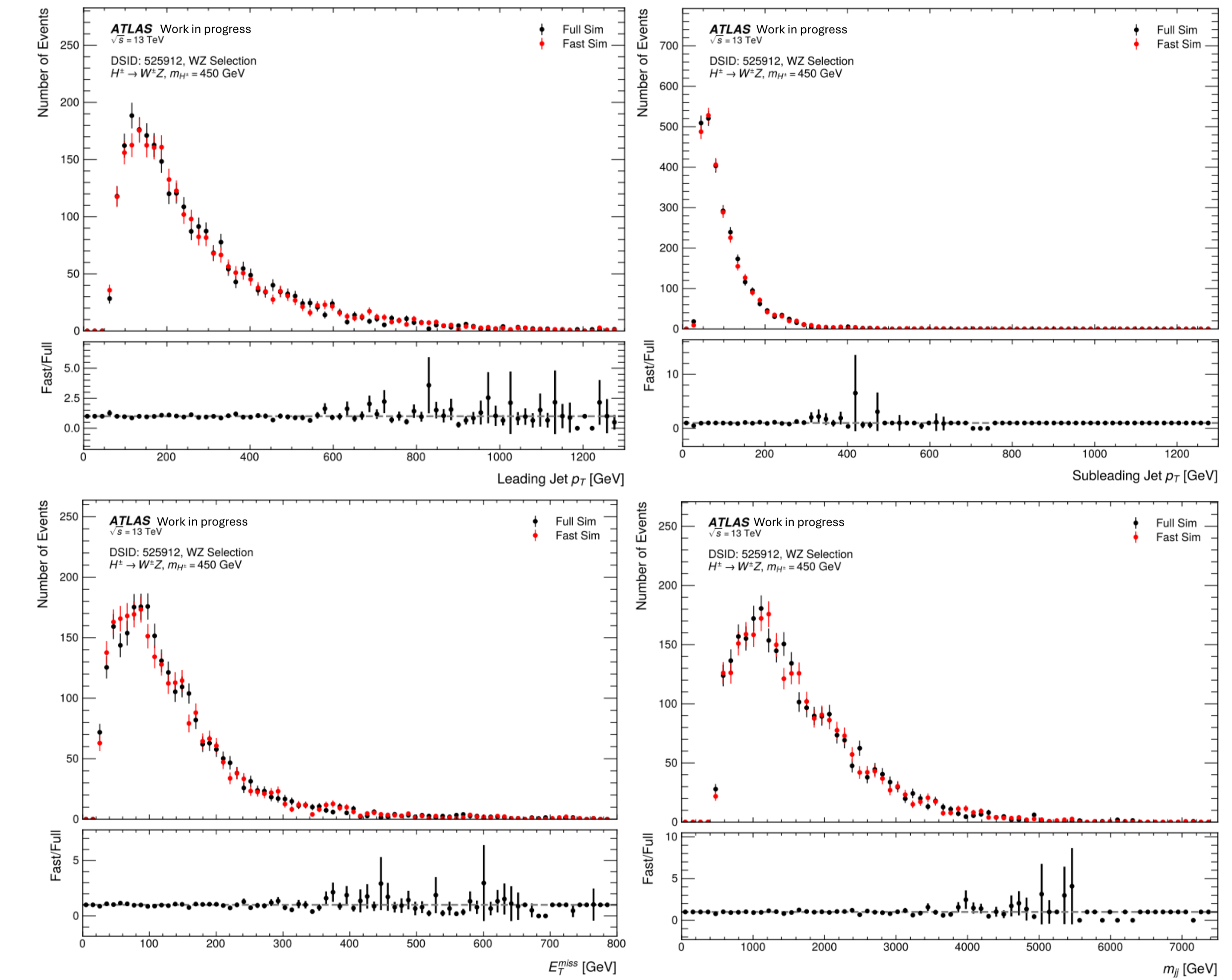
## Simulation Comparisons

- Modelling looks consistent with good agreement between AF3 and FullSim for both CR and SR comparisons.
- Sample SR plots for  $m_{H^{\pm\pm}} = 450$  GeV and  $m_{H^\pm} = 450$  GeV for leading and subleading jet  $p_T$ ,  $E_T^{miss}$ , and  $m_{jj}$ :

### WW Channel

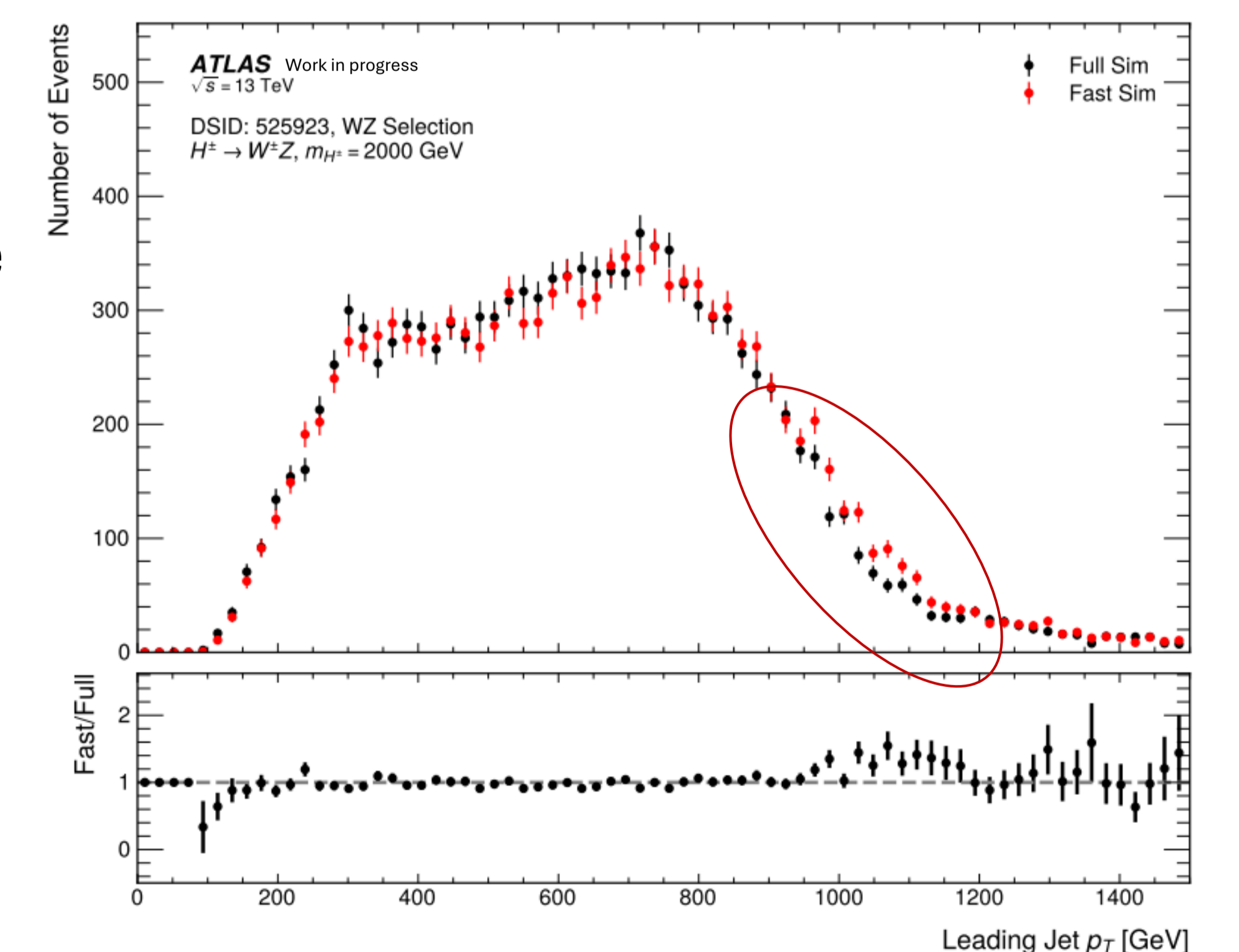


### WZ Channel



## WZ Channel Deviations

- All kinematic distributions agree well with the largest difference seen in jet  $p_T$  in bins 900-1200 GeV in the WZ channel.
- This does not show any correlation with other observables, such as  $\eta$ .
- Sample CR plot of leading jet  $p_T$  for  $m_{H^\pm} = 2000$  GeV:



## Conclusions

- Small deviation in leading jet  $p_T$  for the WZ channel.
- Overall,  $H^+$  and  $H^{++}$  events in the VBF channel see no significant disagreement between AF3 and FullSim.