TIME DETERMINATION OF PRIMARY VERTICES WITH THE ATLAS EXPERIMENT'S HIGH-GRANULARITY TIMING DETECTOR (HGTD)

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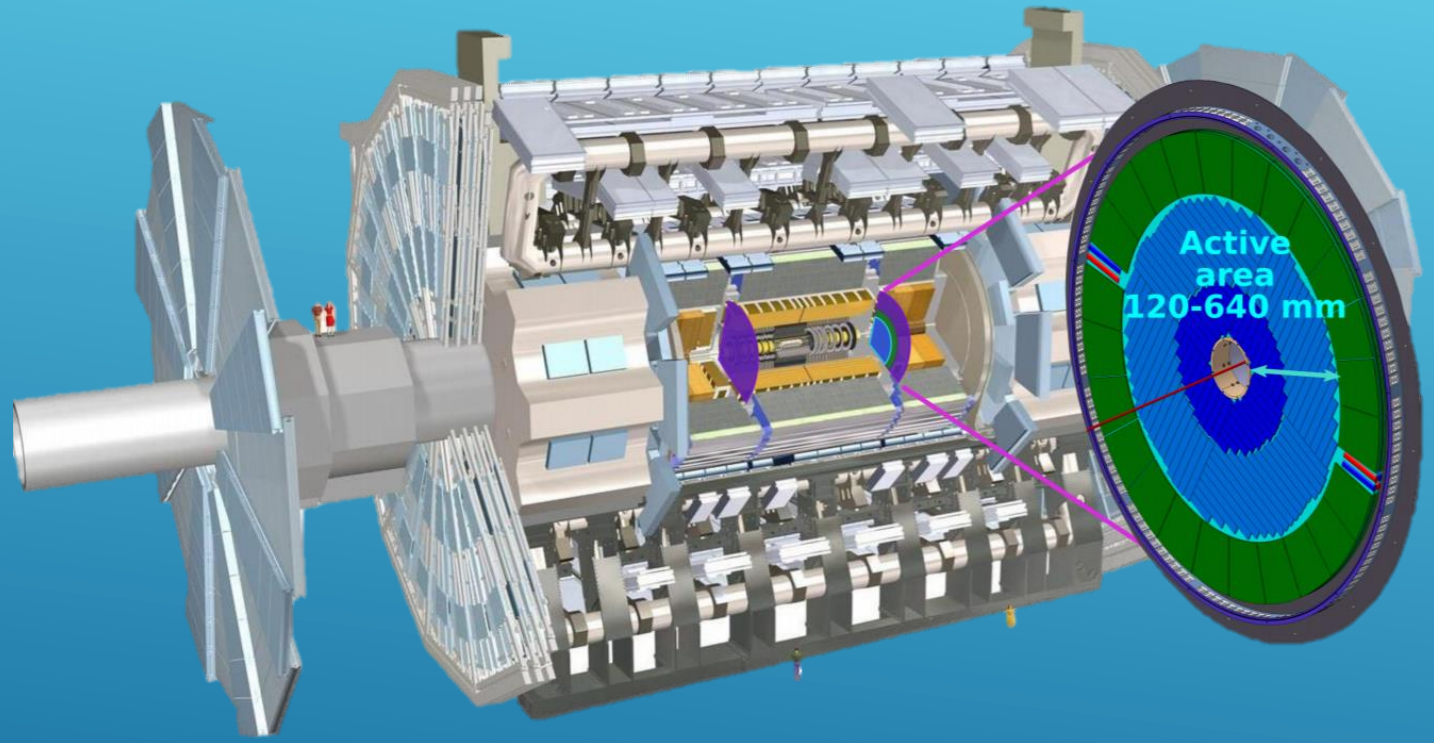
PROBLEM FORMULATION



- High Granularity Timing Detector (HGTD) being developed
- PU = Pile-up, HS = Hard-scatter
- Too many interactions in small space → Difficult to separate
- HGTD allows us, for the first time, to discern the interesting HS vertex from all the uninteresting pileup interactions in the time dimension
- Currently, 25% of clusters are not given a time at all while 5% are given a time solely based on PU tracks yielding an incorrect time. We want to improve this!

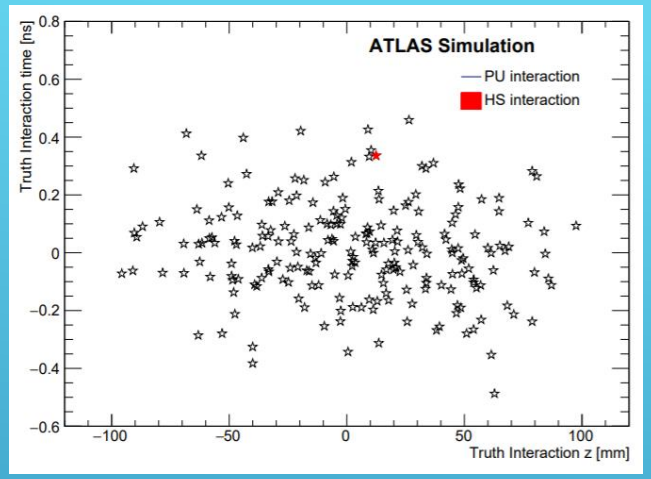


Figure 1: Visualisation of the truth interactions in a single bunch crossing in the z-t plane. Taken from HGTD Technical Design Report (TDR), 2020.

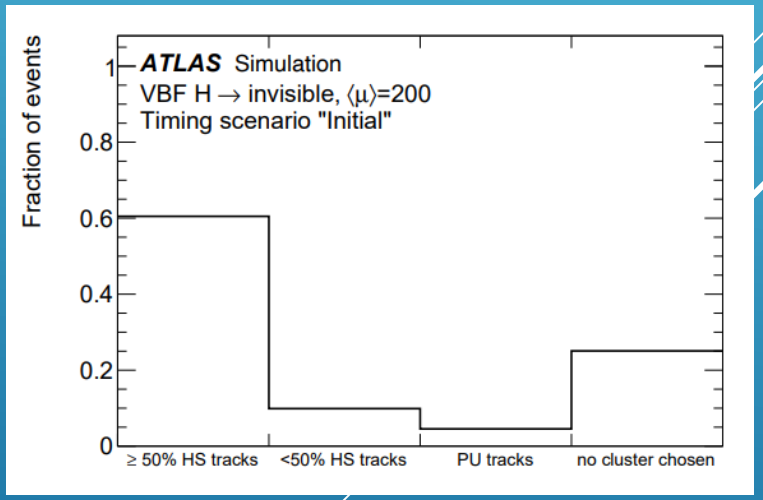


Figure 2: BDT results of predicted HS clusters for all trained events in the VBF H → invisible data set. Taken from HGTD Technical Design Report (TDR), 2020.

TDR available at: https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/UPGRADE/CERN-LHCC-2020-007/

ADDRESSING THE PROBLEM WITH MODERN ML TECHNIQUES

- *Examine if a more elaborate machine learning architecture can determine the times of the HS vertices more accurately than the present boosted decision tree model*
- We are applying a graph convolutional network (GCN)
- Graph representation captures the link between the reconstructed tracks and vertices
- Use the track information as features
- Nodes are tracks
- Edges are time and vertex links
- **Example of graph representation and prediction in figure 3**

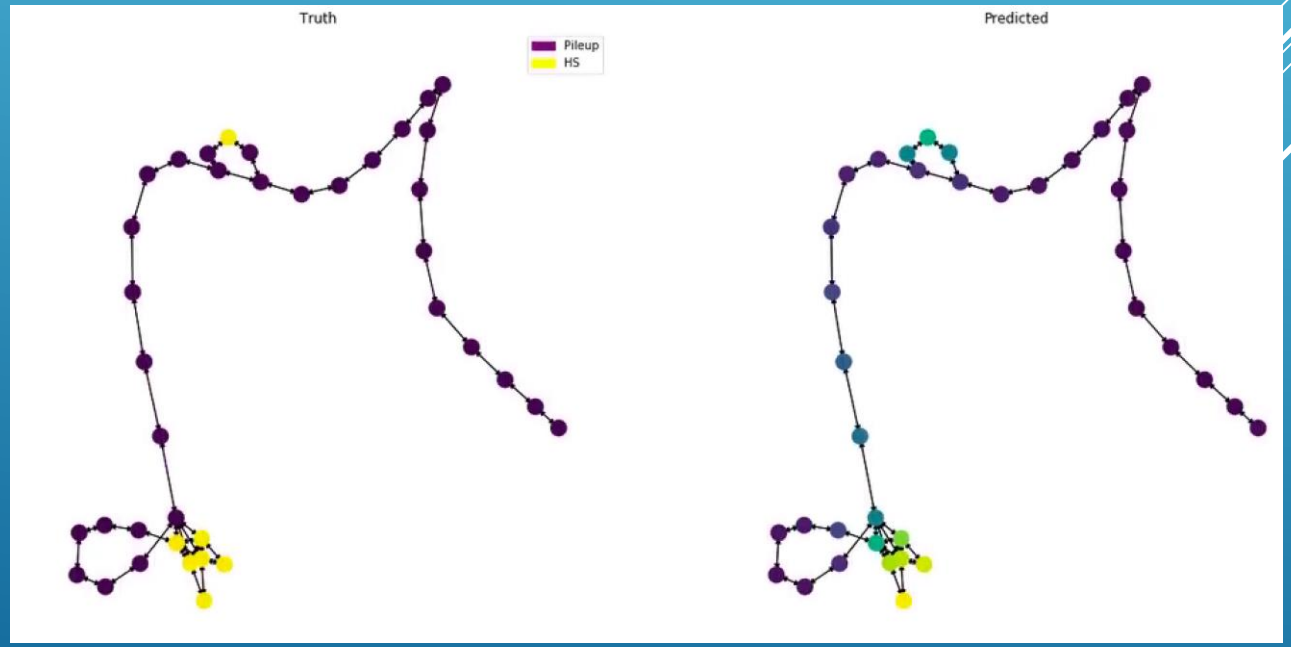


Figure 3: One event (bunch crossing), trained on a GCN, represented as a graph with the truth information on the left and the predicted graph representation on the right

PRELIMINARY RESULTS AND COMPARISON

- Preliminary results show good predictive ability when focused solely on precision (figure 4)
- When trained on 12500 events while prioritizing recall we got similar results to the BDT (figure 5 & 6)
- Next step is to train on more events, perform variable importance analysis, hyperparameter tuning and examine potential preprocessing alternatives

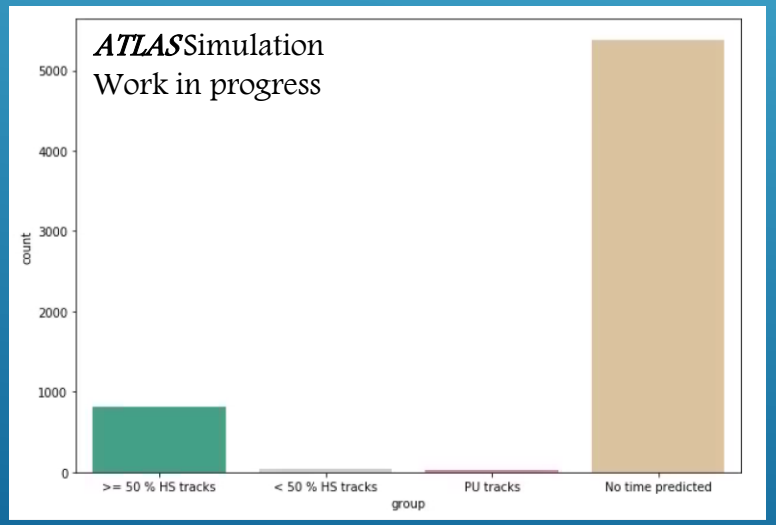


Figure 4: Correctly assigned vertices when prioritizing precision. Nuimber of events = 6250 (our results from the testdata)

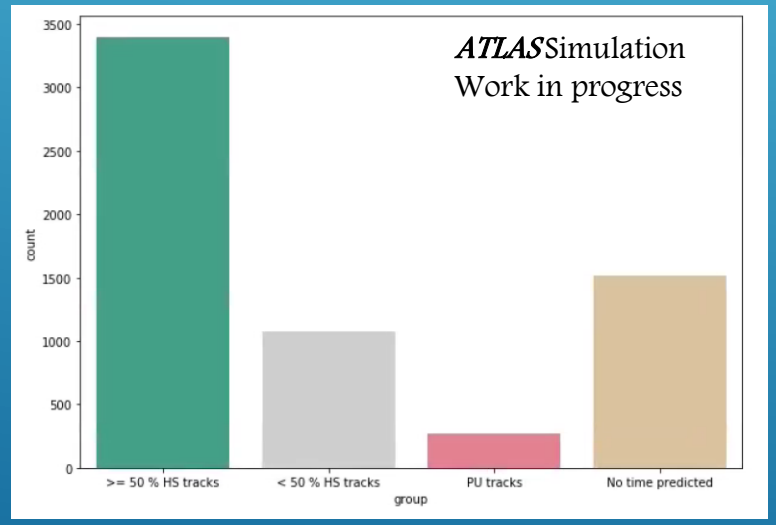


Figure 5: Correctly assigned vertices when prioritizing recall. Number of events = 6250 (our results from the testdata)

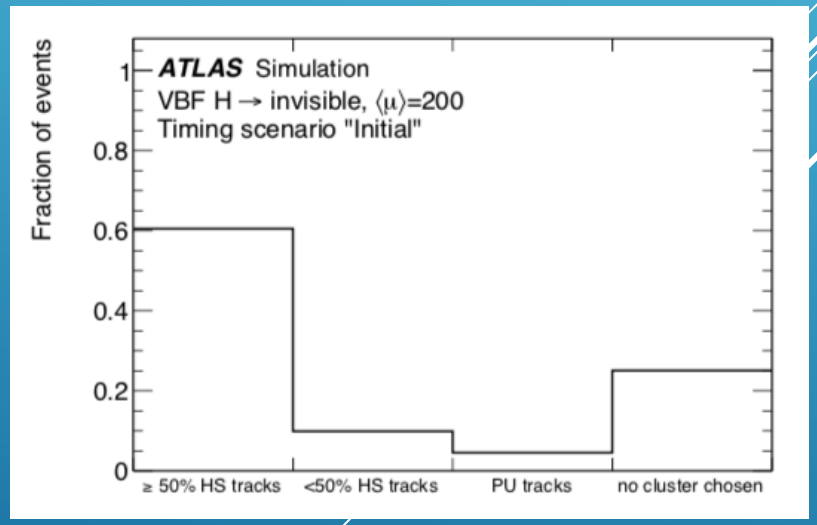


Figure 6: BDT results of predicted HS clusters for all trained events in the VBF H → invisible data set (TDR results)

TDR available at: https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/UPGRADE/CERN-LHCC-2020-007/

APPENDIX

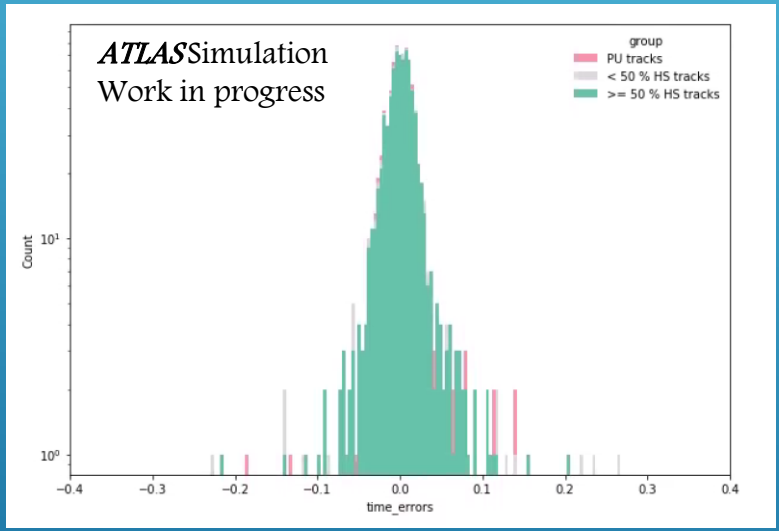


Figure 7: Time deviation between predicted HS interaction and true HS interaction when prioritizing precision. Number of events = 875 (our results from the testdata that have a time)

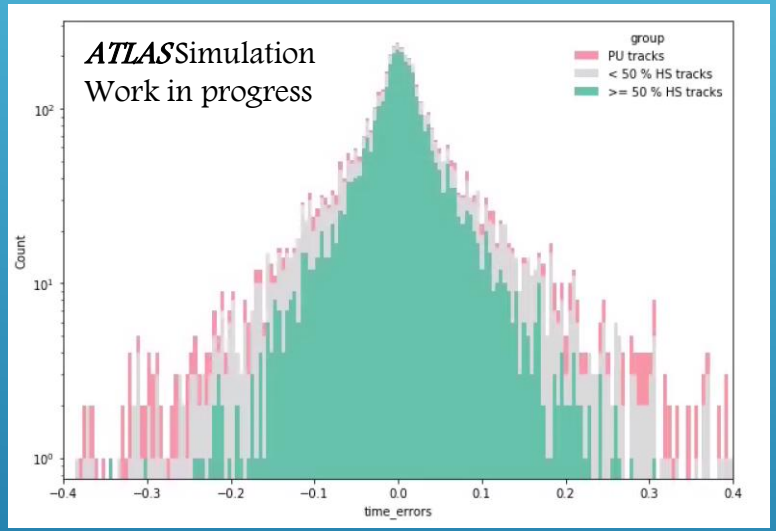


Figure 8: Time deviation between predicted HS interaction and true HS interaction when prioritizing recall. Number of events = 4735 (our results from the testdata)

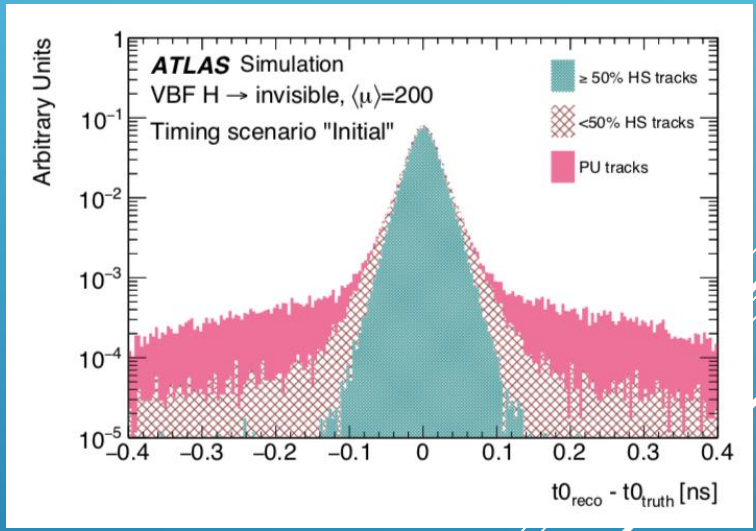


Figure 9: BDT results of predicted times for HS interactions and true HS interactions for all trained events in the VBF H → invisible data set (TDR results)

TDR available at: https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/UPGRADE/CERN-LHCC-2020-007/