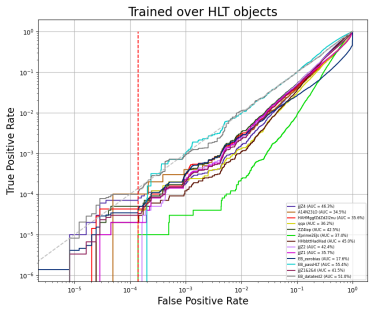
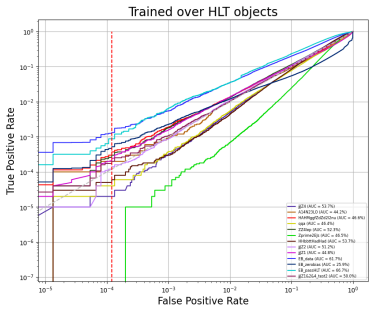
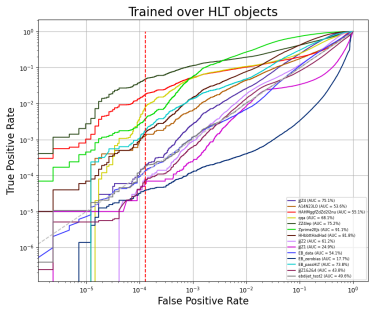
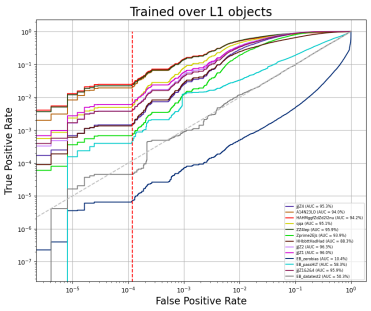
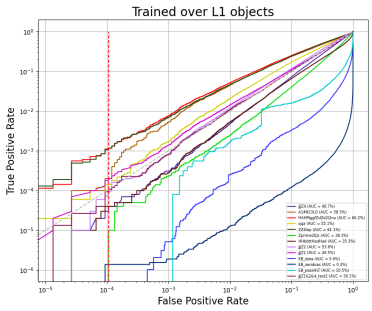
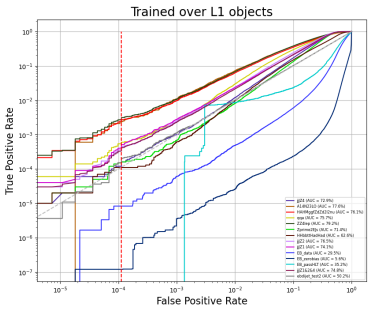
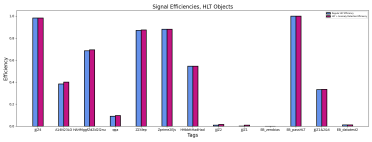
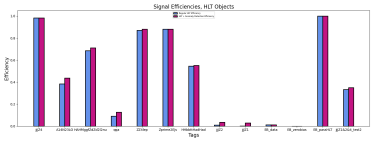
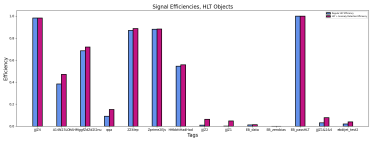
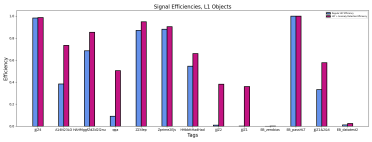
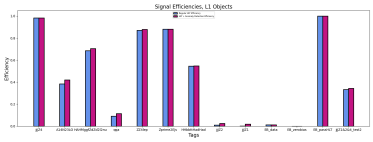
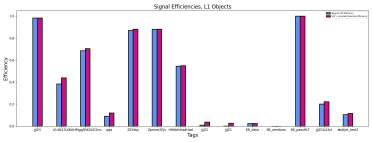
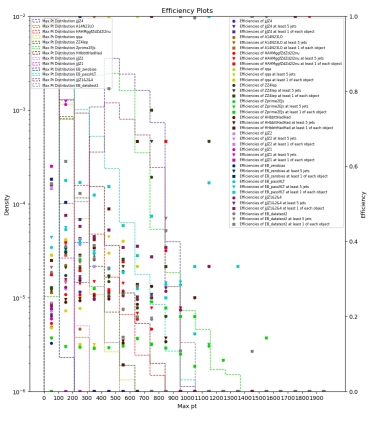
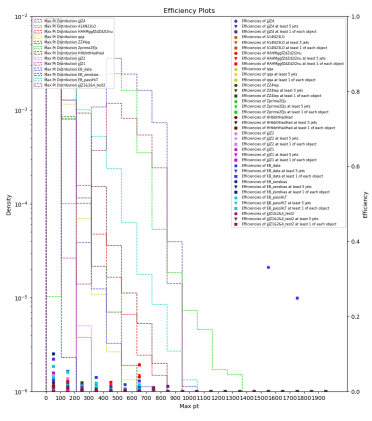
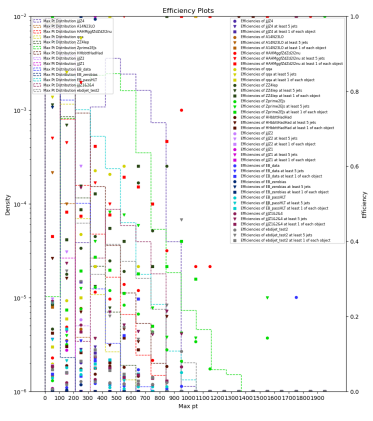
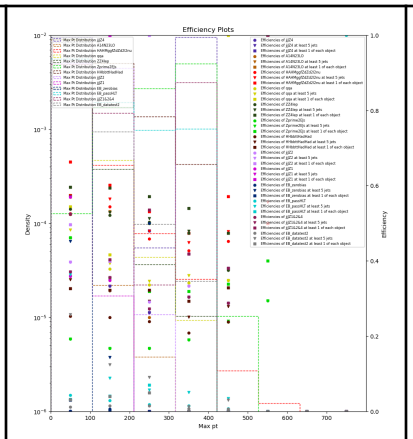
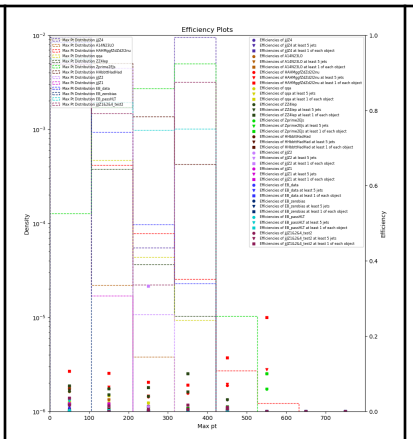
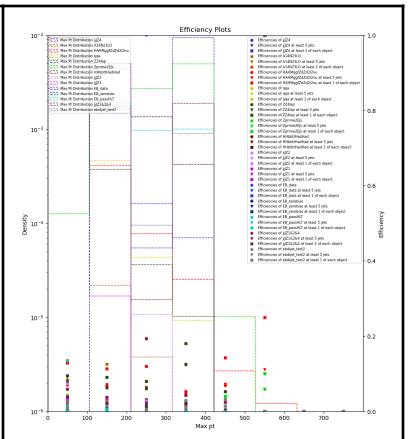
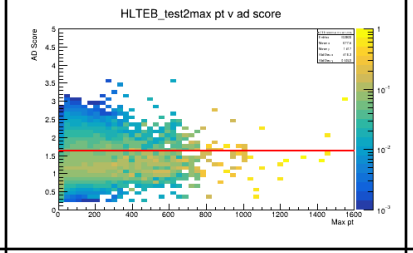
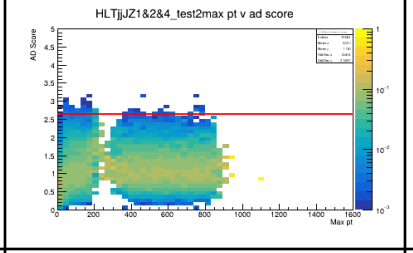
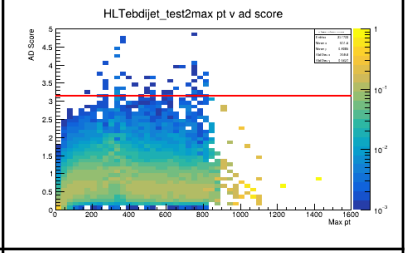
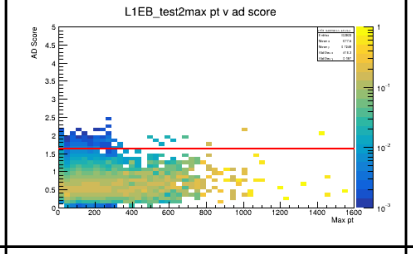
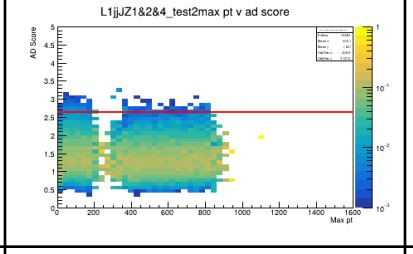
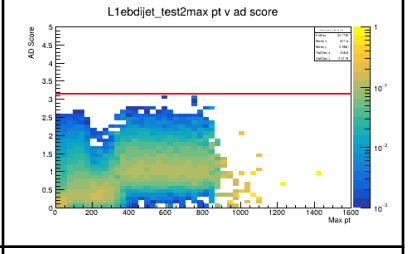
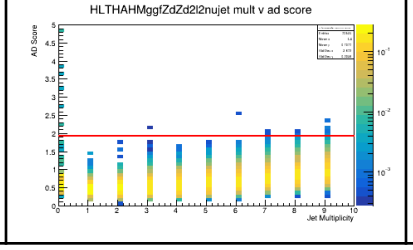
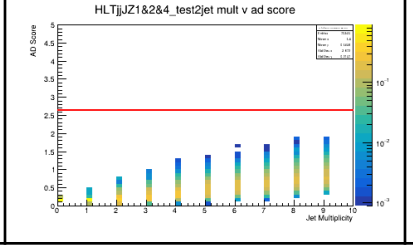
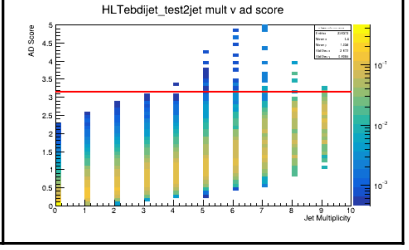
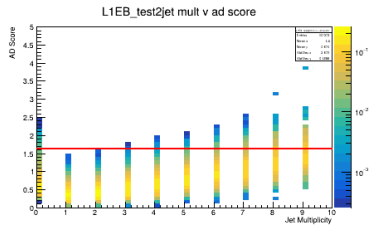
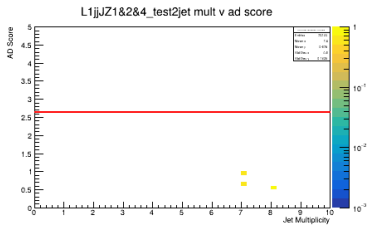
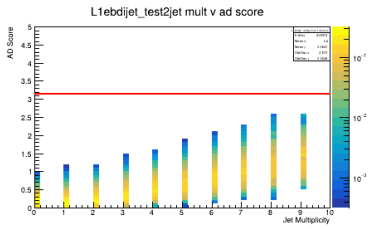
Summary

- The ATLAS Group is experimenting with anomaly detection methods of machine learning to filter out data from the Large Hadron Collider.
- The goal is to train autoencoders on real and simulated data that are able to distinguish properties of physics among various types of particle collisions.
- For the most part, high energy collisions have a higher probability of leading to new particle discoveries than low energy collisions like dijet events.
- Thus, we hope that autoencoder classifies simulated dijets and real data from collider (which is mostly made up of low energy dijets) appear as background, while classifying higher energy collisions as anomalous, so the trigger disproportionately saves them.

	Base EB Trainer	**Base Dijet Trainer**	**Improved Trainer**
SPECS	Dimensions: 60 → 32 → 8 → 2 Pt normalized to 1	Dimensions: 60 → 32 → 8 → 2 Pt normalized to 1	Dimensions: 60 → 100 → 100 → 64 → 32 → 4 Trained on mix of EB and Dijets - jjJZ4 down weighted - EB downweighted to have similar emphasis as dijet Removed zero padding from loss function HLT: Pt normalized to 100 - Jets below 50 pt Gev zeroed out because suspected as pileup/noise L1: Pt normalized to 1
HLT ROC Curve (10HZ)			

L1 ROC Curve (10HZ)			
HLT Signal Efficiencies (1000HZ)			
L1 Signal Efficiencies (1000HZ)			
Efficiency Plot (HLT)			

Efficiency Plot (L1)			
HLT max pt v ad score			
L1 max pt v ad score			
HLT jet multiplicity v ad score			

L1 jet multiplicity v ad score			

- HLT Model:
    - Performance improved significantly. The model now distinguishes between signals, classifying low energy jets and enhanced bias data as background and high energy signals like HAHMggf and ZZ4Lep as anomalous
    - Low energy jets, especially in the trigger, have a lot of noise and uncertainty, because there tends to be more pile up (particles and jets originating from a different proton-proton collision) at low energies. To reduce the effect of this noise, all jets below 50 pt GeV were zeroed out.
    - The base autoencoders seemed to be picking up more on patterns in the data as opposed to actual physics. The 2D histogram comparing max pt and anomaly scores showed a stronger correlation under the improved model. This was likely caused by increasing the size of the network, which allowed the autoencoder to learn more features of the data.
- L1 Model:
    - The base L1 models were much better than the HLT and zeroing out low energy jets did not improve performance, suggesting the data didn't have as much pile up.
    - The changes did not significantly improve performance, but did increase the correlation between anomaly score and max pt of each event, suggesting more physics features of the data were learned.