ATLAS EXPERIMENT

TEL AVIV UNIVERSITY

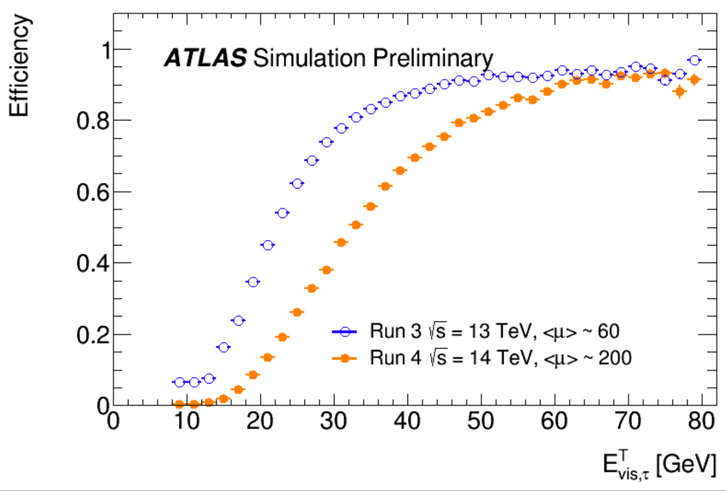
erc

Neural Network Algorithms For HL-LHC Tau Trigger In ATLAS

Yuval Frid For The ATLAS Collaboration

Motivation

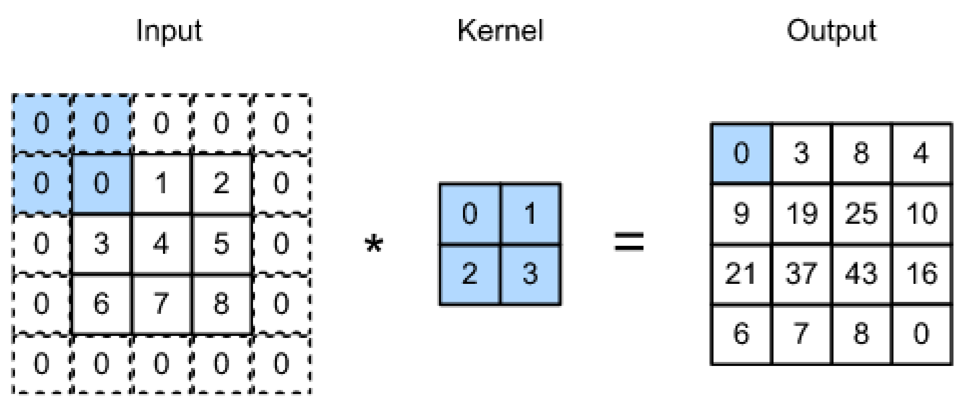
- In 2027 LHC will be upgraded to High Luminosity LHC known as Run 4.
  - Increase in pile up (<μ>) complicates signal and background discrimination and increases fake rate.
  - Level 1 trigger will have access to full calorimeter granularity, allowing more complex models.
- In the low energy range, hadronically decaying τ leptons have a very similar signature to QCD jets.
- Current trigger uses a window algorithm, where selected energy deposits in the ROI are summed and a threshold is used to determine if the object passes the trigger.
  - Keeping the current fake rate requires a higher threshold value, greatly degrading signal detection efficiency.



Comparison of window algorithm efficiency on Run 3 and Run 4 samples using the same fake rate.

Convolutional Neural Networks (CNN)

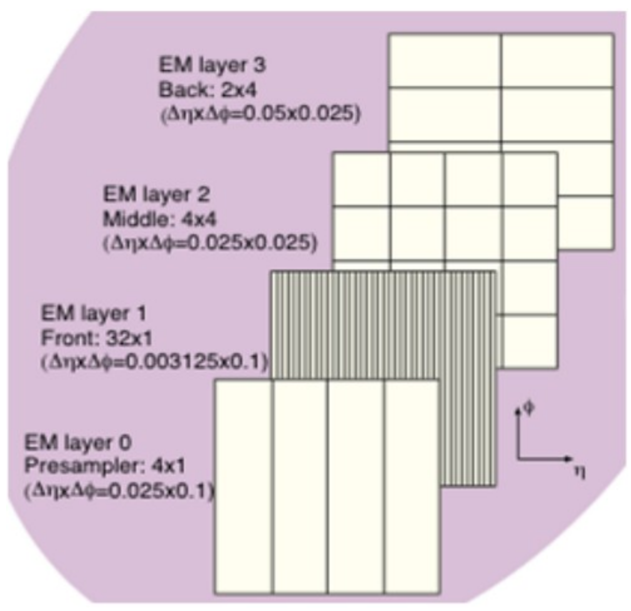
- Common method for image classification.
- Each TOB is treated as a 3x12 sized image with 5 filters.
- Each layer has many 2 dimension convolutions with 3x3 weights matrices, known as kernels.
- After several layers the tensor is flattened, and linear layers are used resulting in a score between 0 and 1.
- A threshold value is used to classify between the two options, signal and background.



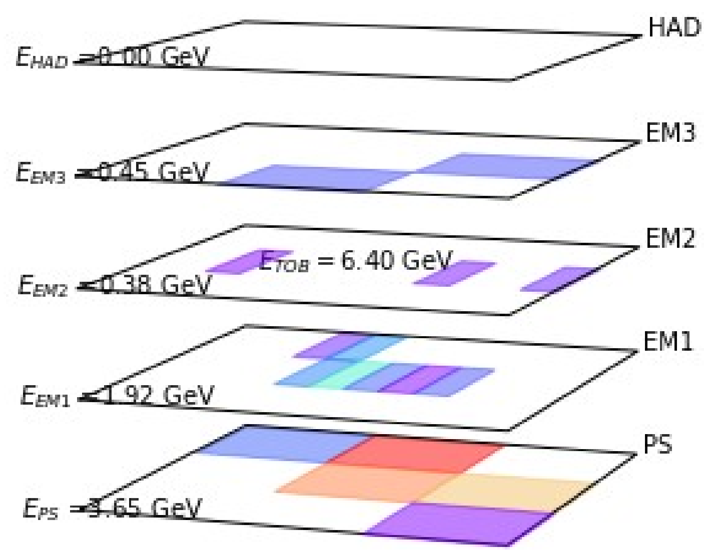
Example for a CNN layer in 2 dimensions.

Sample Processing

- Using information only from ECal and HCal calorimeters.
- Using Z to ττ for signal, QCD dijets for background.
- Trigger Objects (TOB) are seeded using FPGA based modules.
- Each TOB is 0.3x0.3 in ηxφ space.
- Less granular layers are split in η, resulting in a 3x12x5 tensor for each TOB sample.



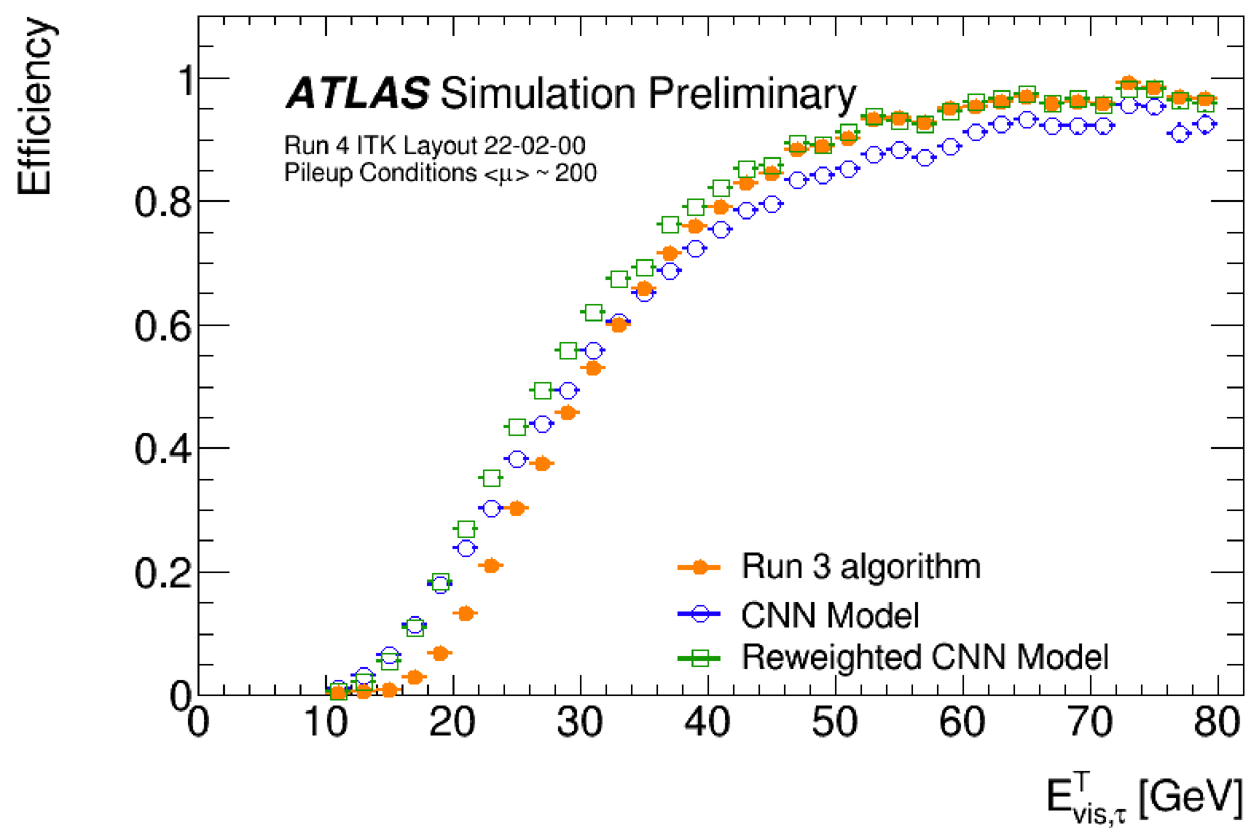
Cell granularity for EM Layers.



Signal TOB before splitting layers.

Results

- The trained network has a total of 7 layers with 12821 parameters.
- Training set limited to TOBs with |η| < 1.5, and transverse TOB energy > 5 GeV.
- Below 40 GeV, improvement of up to 15% in efficiency can be achieved for equal fake rate.



Conclusions

In Run 4 of LHC, <μ> will increase by a factor of 3, complicating triggering for low energy particles. For the hadronically decaying τ lepton this causes a big degredation trigger efficiency at energies below 60 GeV. Some of this loss can be recovered by using CNN models instead of the current window algorithms.

While improving the efficiency in the region below 30 GeV, the neural network fails at higher energies. An option to counteract that is by multiplying the CNN score by the transverse energy of the TOB, giving a bias towards the samples in the higher energy range.

Future steps in this research include measuring the model's latency, optimizing hyperparameters (number of layers, size of layers), trying different NN architectures, and multiplying the NN score by other available parameters, similarly to the shown case of transverse TOB energy.