CEBAF Large Acceptance Spectrometer

Level 3 Trigger

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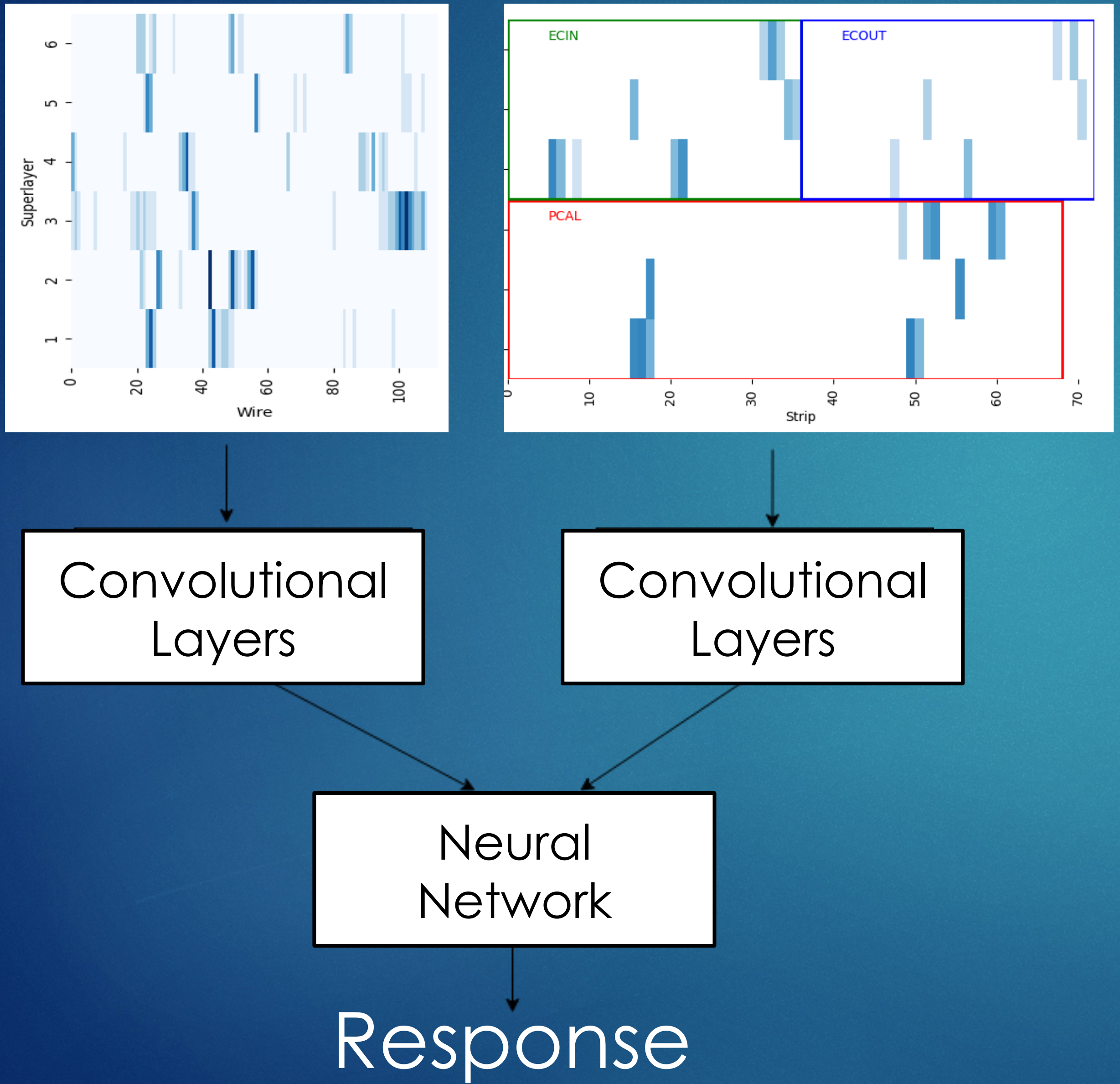
Level-3 Electron Trigger



- The level3 trigger employs a convolutional neural network to classify events with/without an electron.
- It uses information from the Drift Chambers (DC) and the Electromagnetic Calorimeters (ECAL).
- The idea is to run this online during data taking on a GPU to which data is streamed by the ET ring.

Electron Trigger Purity and Efficiency

- The conventional CLAS12 level-1 trigger efficiency is above 99.5%.
- At higher luminosities, higher occupancy means the level-1 trigger purity decreases.
- The aim of the level-3 trigger is to improve the purity especially at high luminosity.

Confusion Matrix	Electron in Sector	No Electron in Sector
Selected by Trigger	True Positive (TP)	False Positive (FP)
Rejected by Trigger	False Negative (FN)	True Negative (TN)

Table 1: The electron trigger confusion matrix.

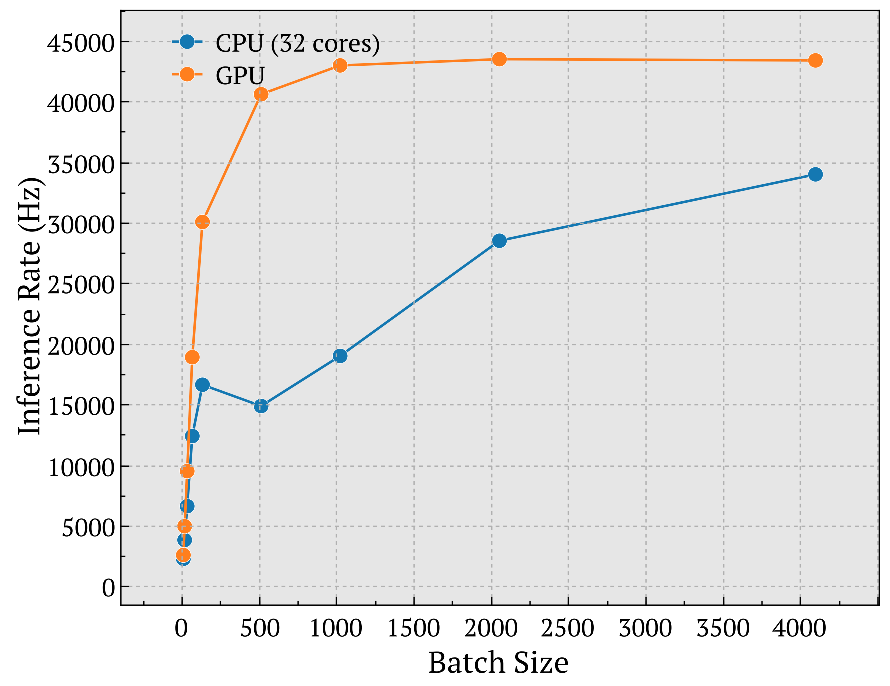
$$Purity = \frac{TP}{TP + FP}$$

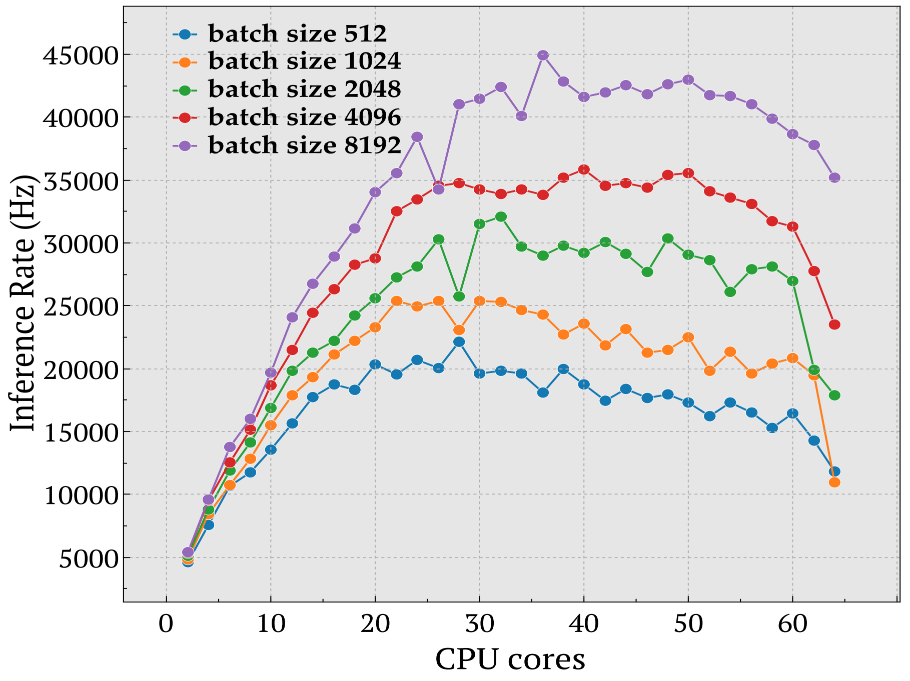
$$Efficiency = \frac{TP}{TP + FN}$$

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

Prediction Rate

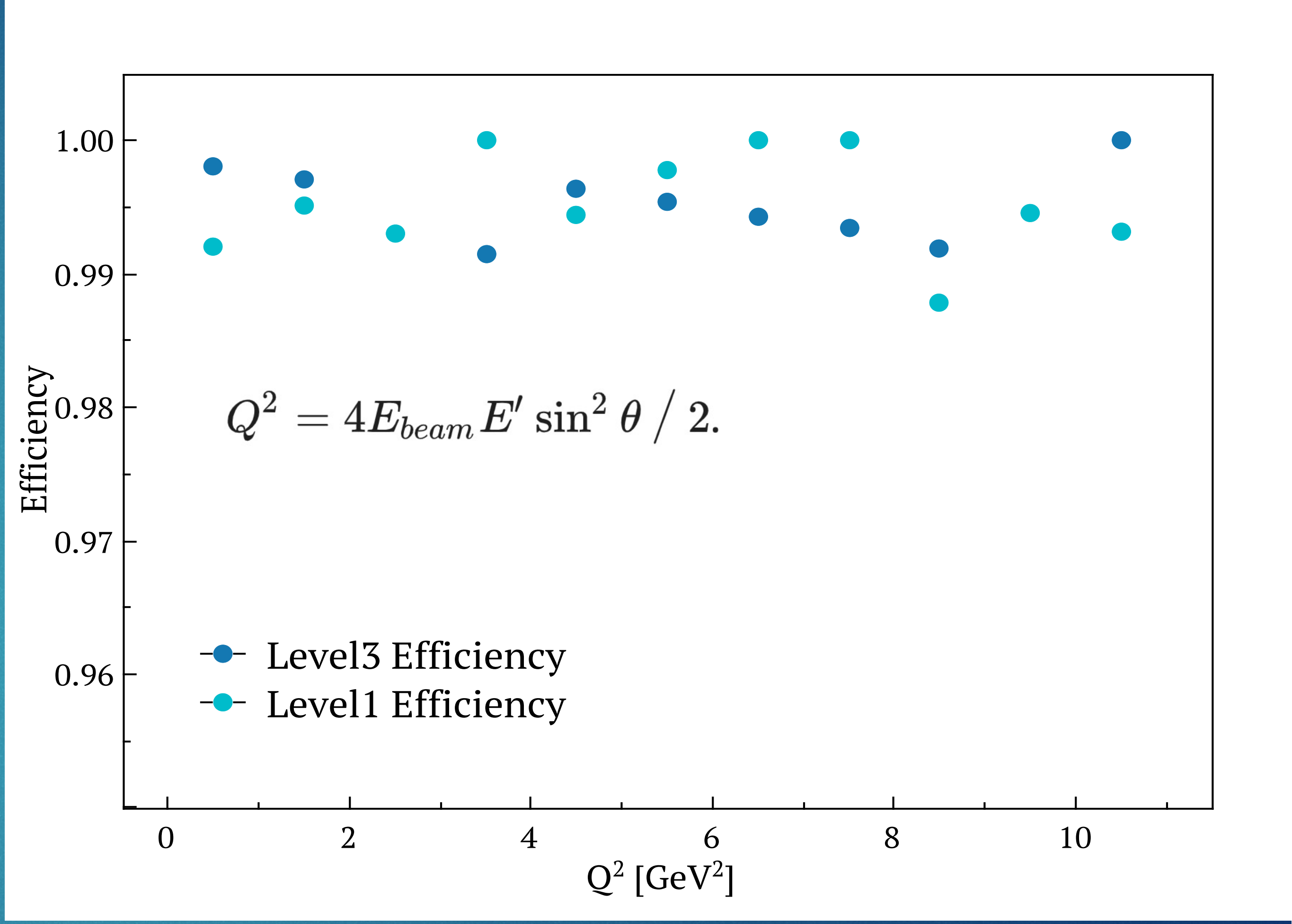
- Gagik ran the level3 trigger online, see his presentation for more details on online AI applications.
- Typical trigger rates at CLAS12 are on the order of ~20 kHz.
- We can also reach batch sizes of ~2000 sectors online.
- The CNN based level3 trigger is more than capable of keeping up with the rate of data taking on 1 GPU or 1 CPU with 30-50 cores.





RG-D

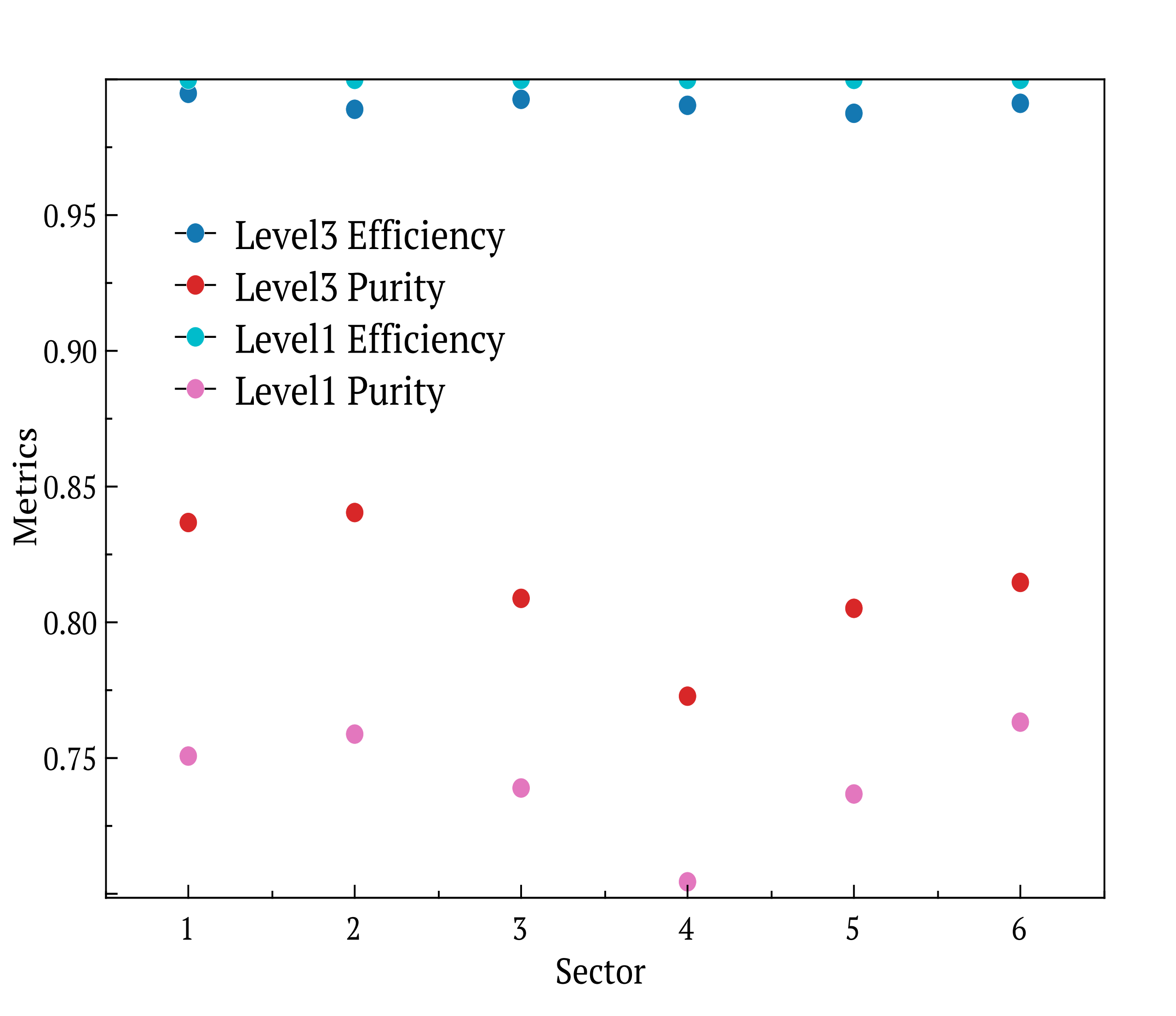
- We can apply the trigger directly online to data from the ET Ring or offline HIPO files. The code is available here.
- The difference in performance when compared to proof of principle tests is due to training/testing samples with different rates of various types of background to what is seen in the raw dataset.
- We also need to test the level 3 trigger on inbending data and at high beam current



Torus (50 nA)	L1 Efficiency	L3 Efficiency	L1 Purity	L3 Purity
Out	99.6 %	99.5 %	74.6 %	75.5 %

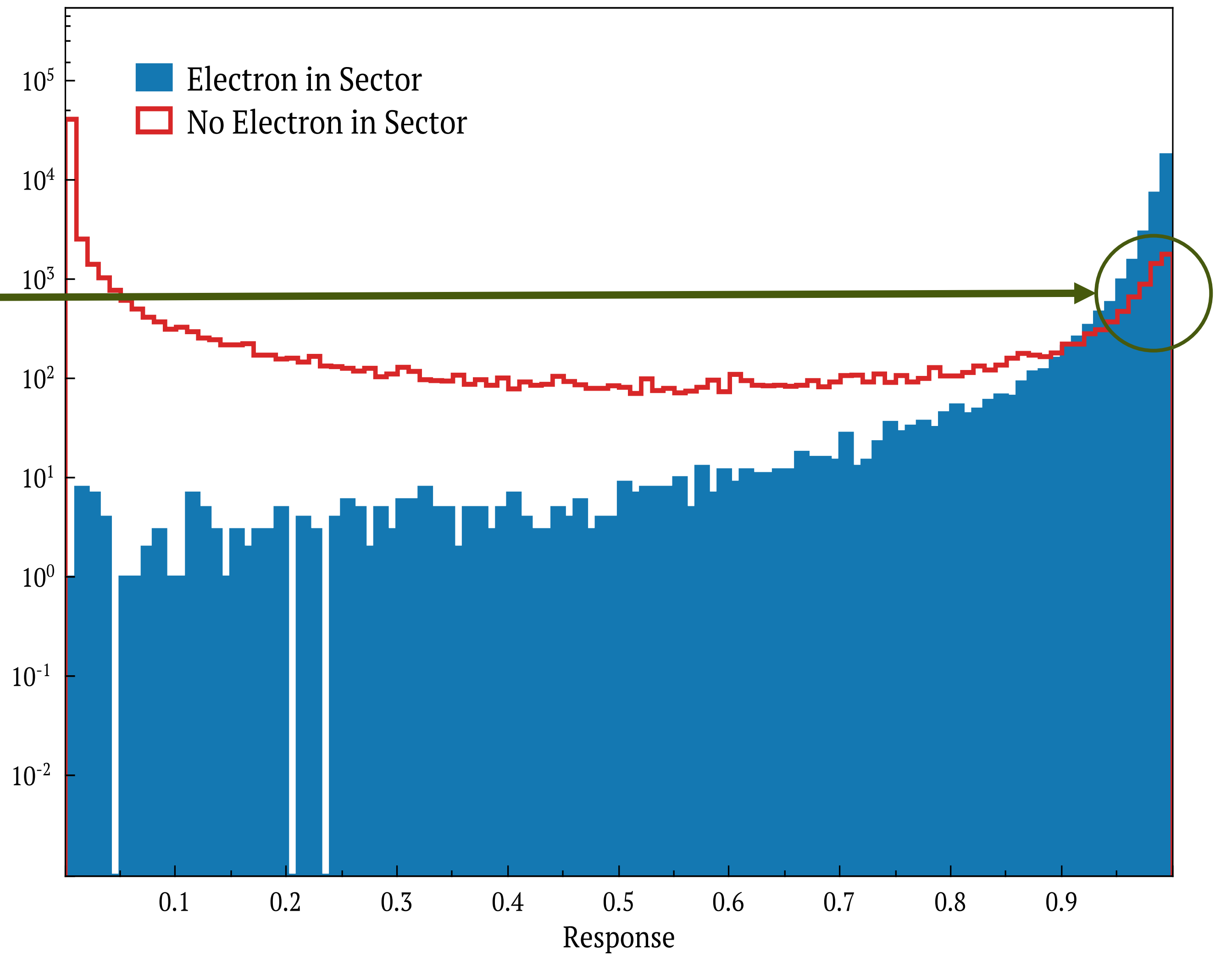
Second Pass

- The level3 trigger can be trained on negative events that the level1 trigger misidentifies.
- In this case the level3 trigger is filtering out background in the level 1 trigger.
- This improves the purity at a cost of efficiency.



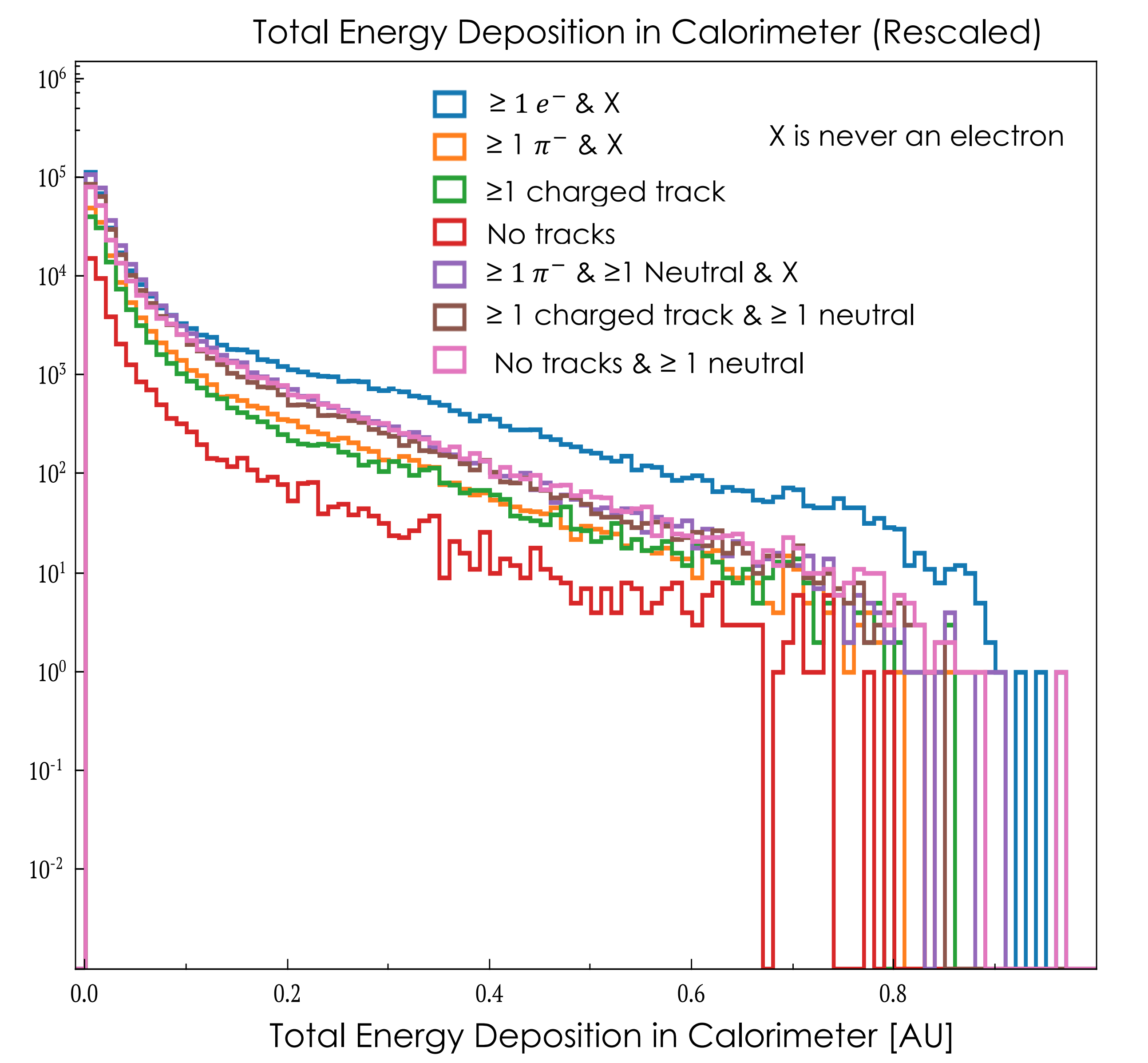
Where does the level 3 trigger fail?

- Negative events at a high response are misclassified.
- A bump is indicative of events that are hard to distinguish from electrons.
- We can try and make it easier for the network to learn to ID these by separating these into different classes.

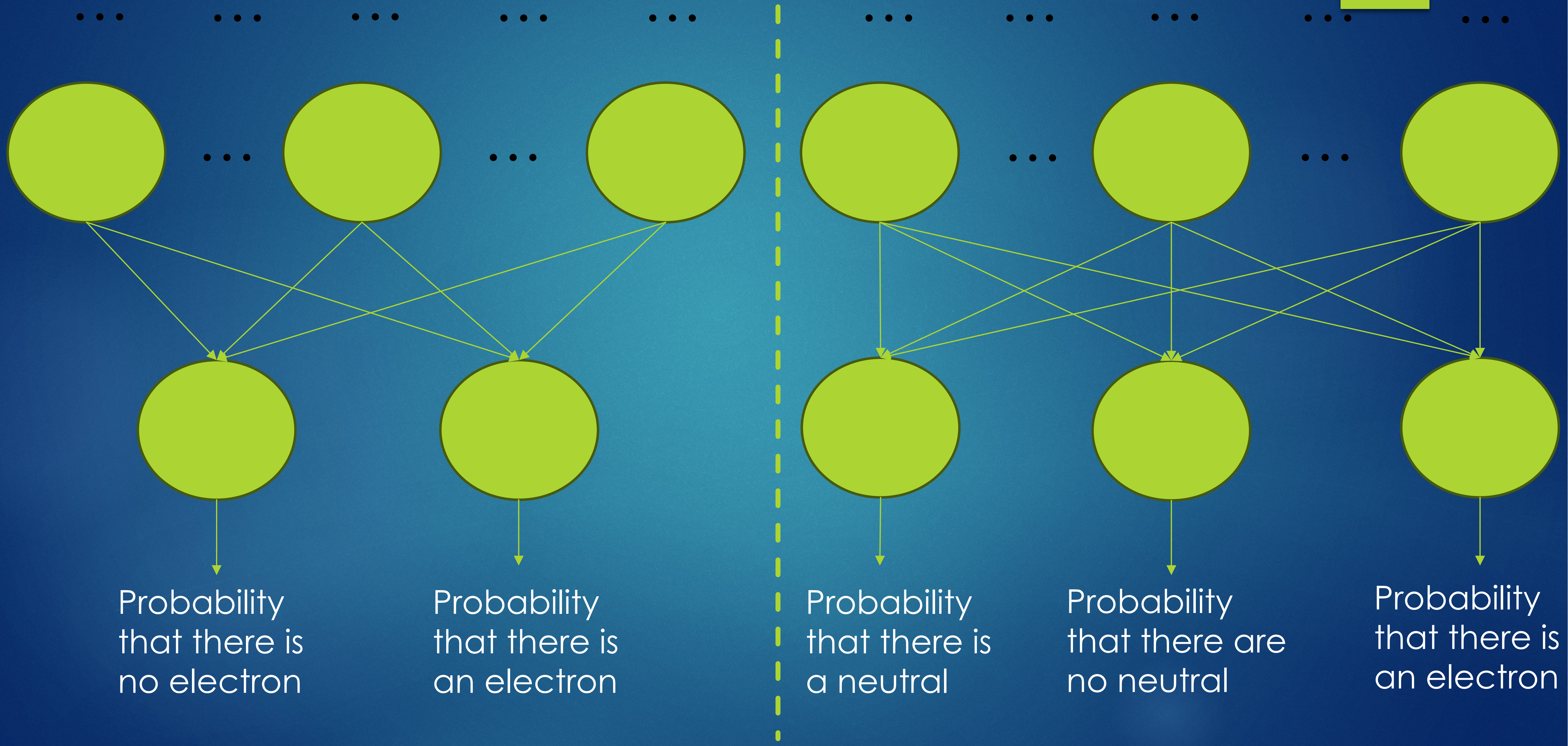


e- PID and Classes

- Electrons in calorimeter are identified by high energy deposition.
- Photons will also create showers in the calorimeter and have a high energy deposition.
- We therefore split the negative sample into 3:
  - Events with at least one neutral with energy > 1 GeV
  - Events with at least a charged track
  - Events with no tracks and no neutrals

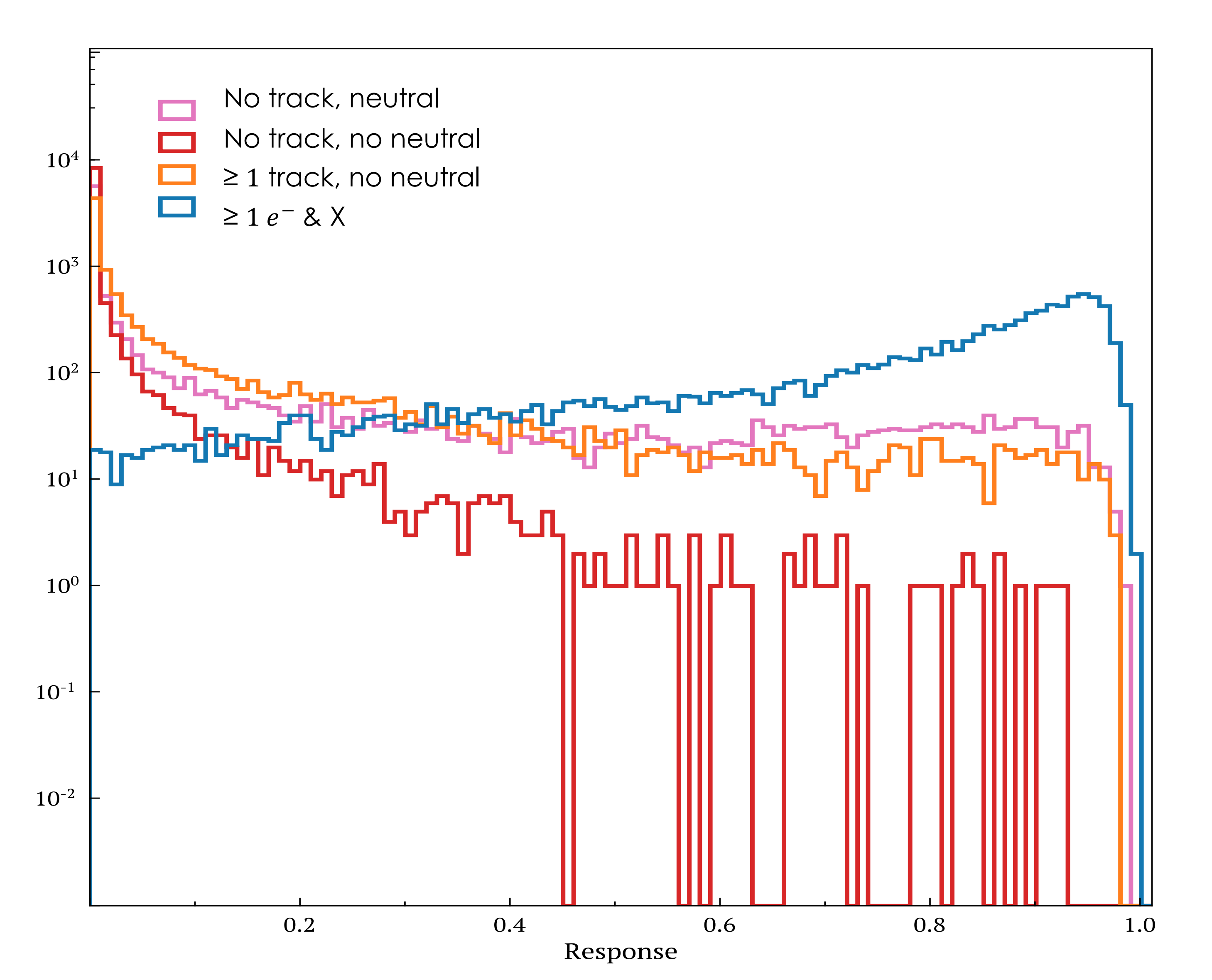


How does this work?



MultiClass Response

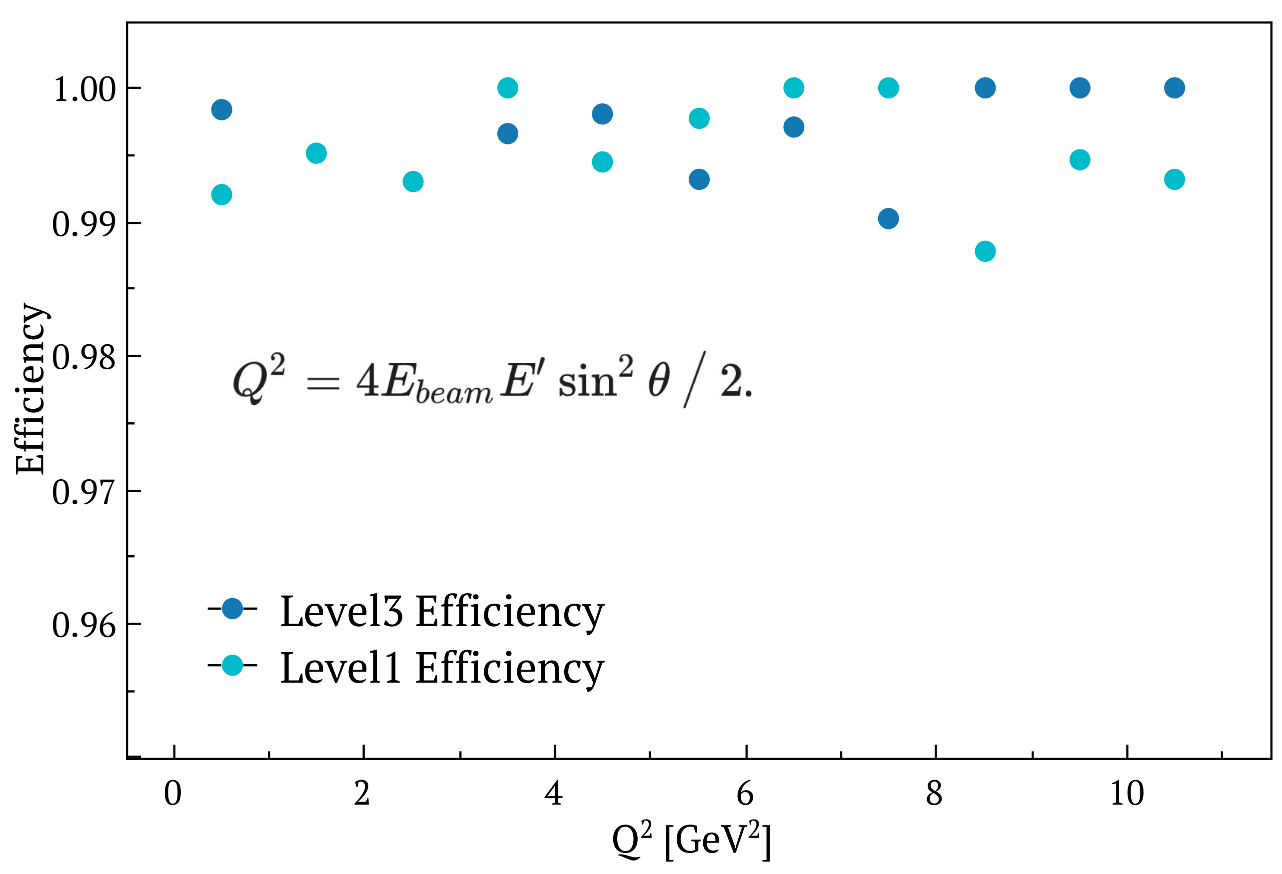
- It's easier for the network to ID background without neutrals or charged particles.
- We apply a cut on the probability that there is an electron (response) to select electrons.



MultiClass

- This will be investigated in more detail as we also expand the number of classes.

- We could expand the trigger to:
  - Muons for J/ψ
  - Pions/Kaons for MesonEx
  - …



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Future Tests

- We want to test the level 3 trigger on inbending data, as a function of beam current and as a function of electron kinematics.
- To fully understand where the network fails we need to develop simulations. This will allow us to cleanly distinguish scenarios that are hard for the network to ID
- We also need to test the stability of the network over time, and figure out how to deal with changes in the configuration or running conditions ie:
  - target change
  - beam current
  - detector response varying over time...
- We can continuously retrain online to adapt to running conditions. This is achievable with auto pass0, we need to develop code and tests to see how this would work.

Conclusion

- Main focus so far has been to run the level3 trigger online. This is now the case with the code to deploy and train model available and tested.
- Level 3 trigger achieves necessary prediction rates for online, matches level 1 efficiency at ~99.5% and purity.
- Purity is not as high as we want it to be. Performance will improve, please be patient.
- We're exploring the possibility of adding more classes than just electron or not. This will allow for:
  - Improved performance of the trigger
  - Trigger for wide variety of experiments (J/ψ, MesonEx, …)
- We need to test the level 3 trigger as a function of beam current and evaluate its stability in online deployment.