Neural networks for electron identification with DAMPE

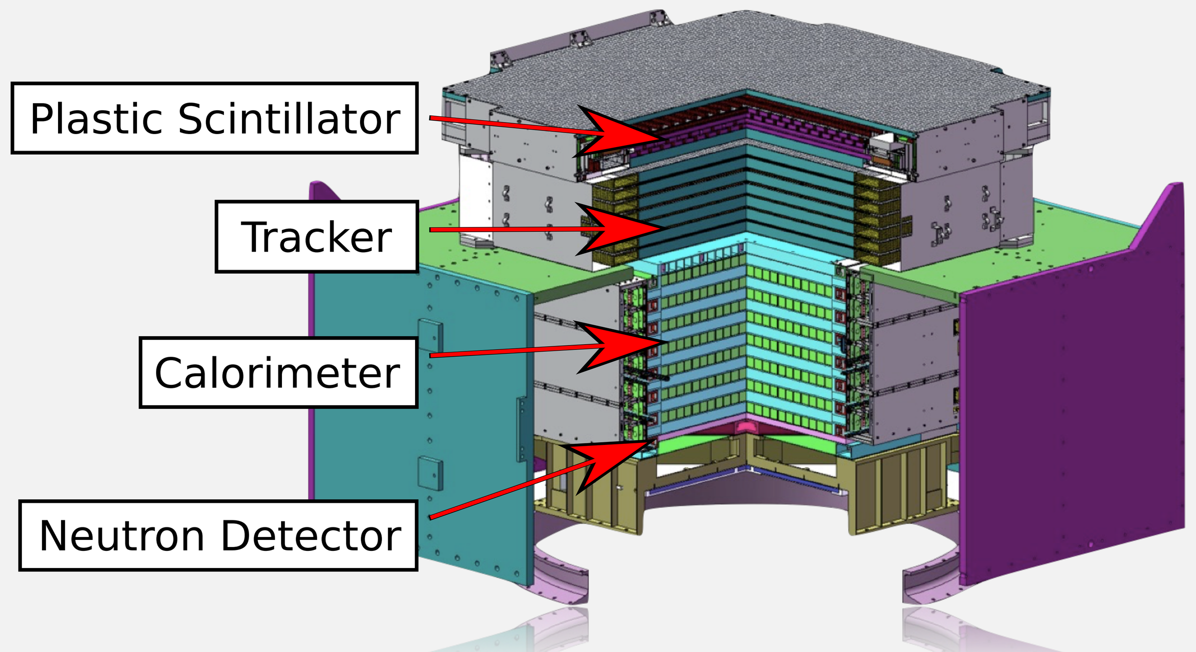
David DROZ (david.droz@unige.ch), A. TYKHONOV, M.Deliyergiyev, X. WU
Department of nuclear and particle physics, University of Geneva, 1211 Geneva, Switzerland

References
- Chang, J., et al. (2017) Astropart. Phys., vol. 95, pp. 6–24
- Ambrosi, G., et al. (2017). Nature, 552(7683), 63.
- **Droz, D., et al. (2021) accepted to JINST, arXiv:2102.05534.**

Software
- Keras: Chollet, F. & al. (2015). https://keras.io
- Theano: Theano dev.team (2016) arXiv:1605.02688

1. DArk Matter Particle Explorer

A cosmic ray space observatory in operations since December 2015. It is equipped with a deep calorimeter (32 X_0) able to detect electrons up to 10 TeV with a 1% energy resolution.

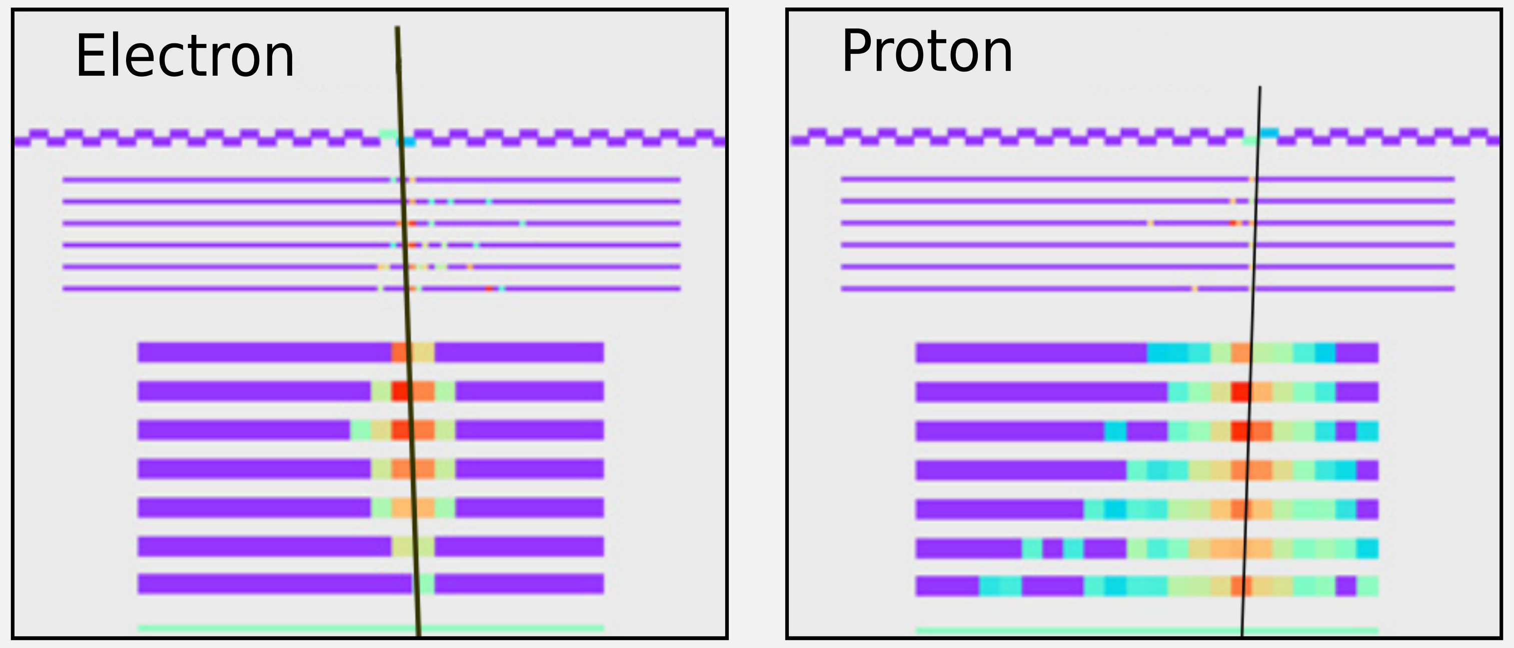


Electron identification is based on the interaction topology.
The classical method is to define such observable *[Ambrosi et al.]*

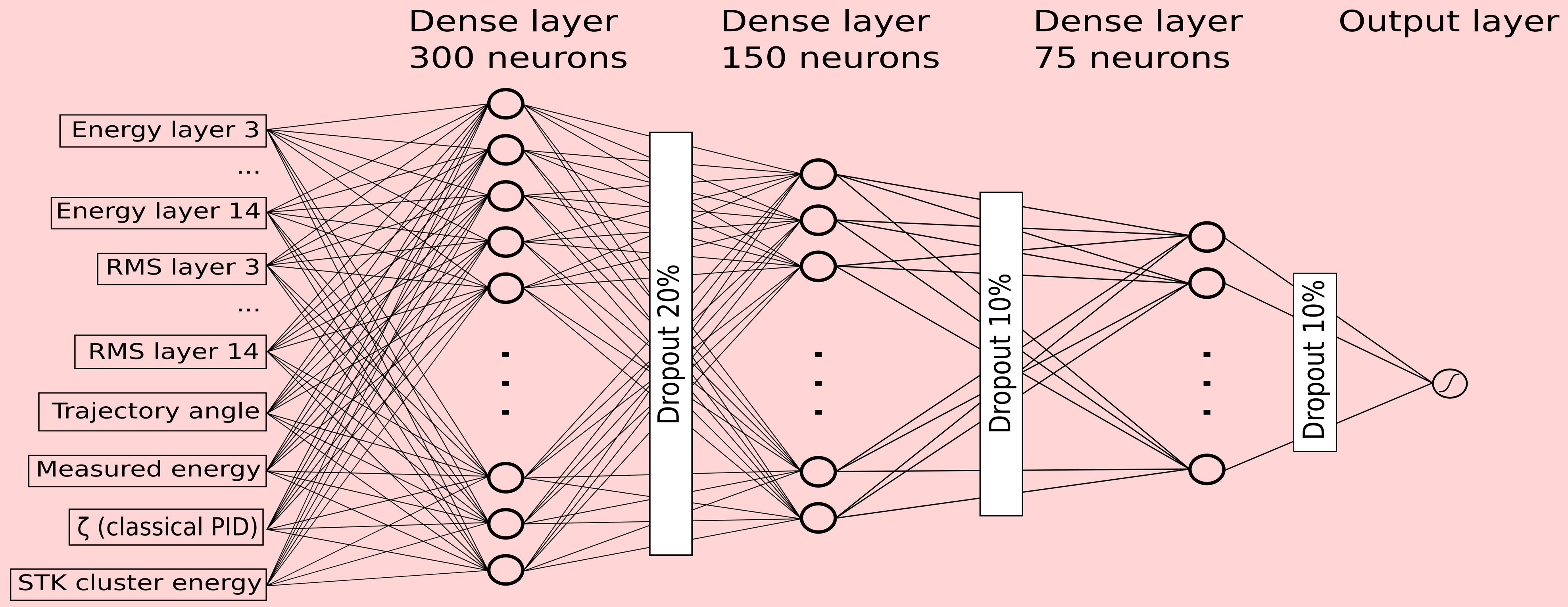
$$\zeta = \text{shower width} \times \text{shower depth}$$

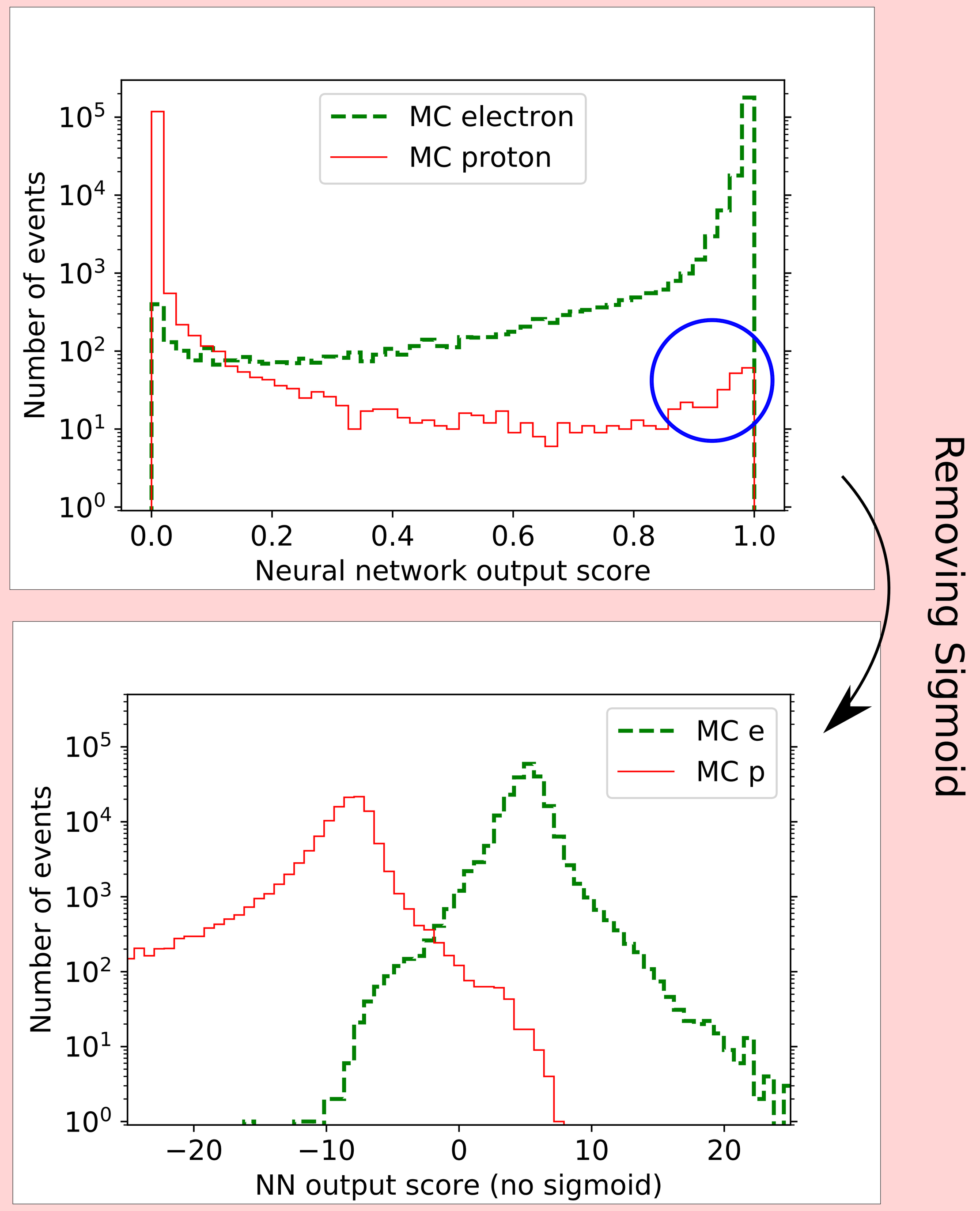
Electrons have a lower ζ than protons and nuclei.

However ζ is limited at several TeV. A better method is required.



2. Deep Learning classifier





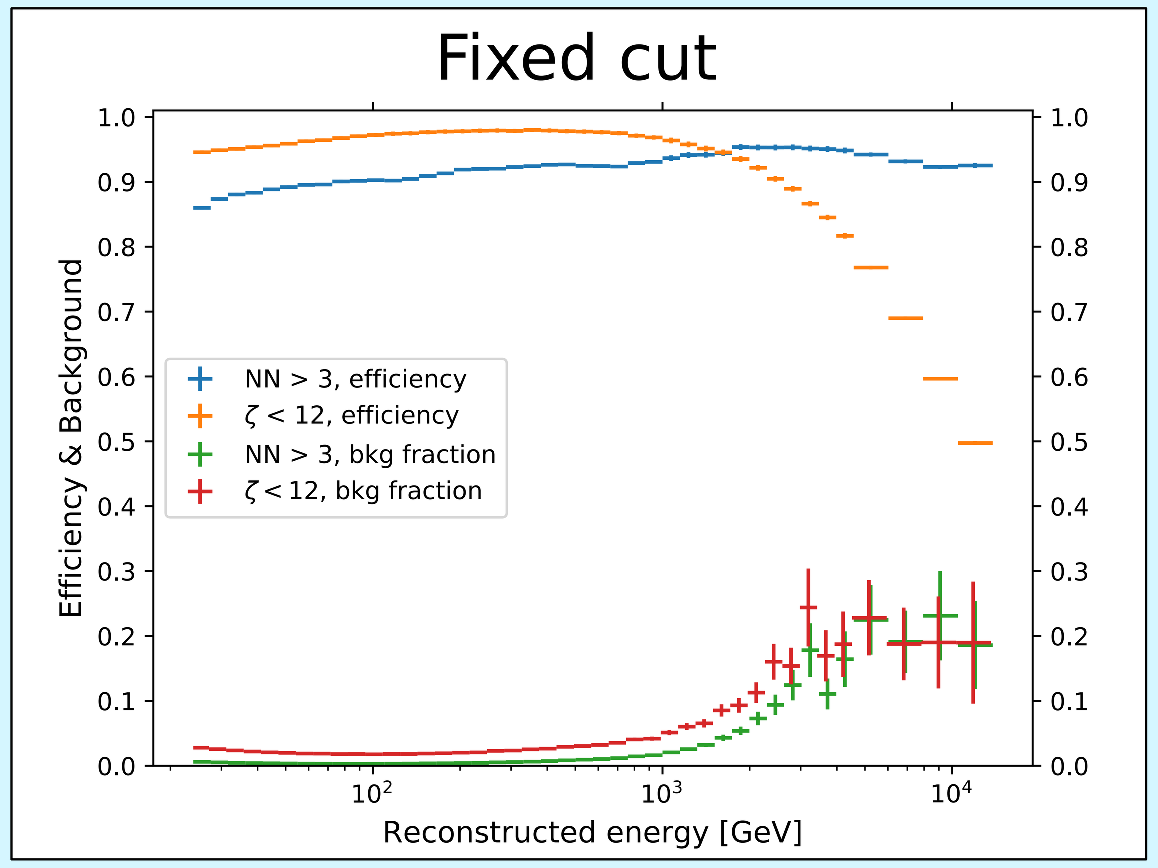
An artificial neural network is trained on Monte Carlo data, taking as input 28 observables quantifying interaction topology and event characteristics.

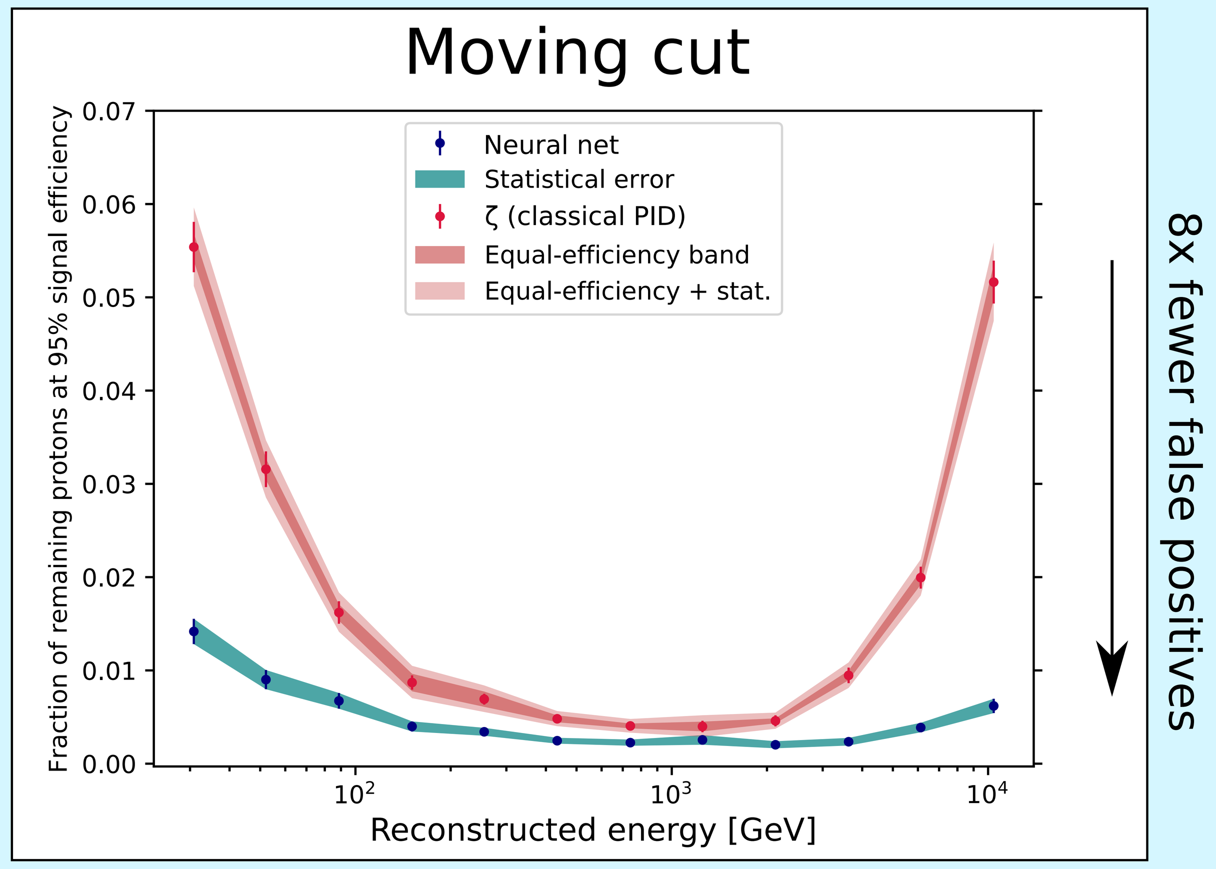
In a regular neural network, the output is compressed to the [0;1] range by a sigmoid function. This results in a peak of false-positives in the signal region. Removing the output activation recovers a monotonic distribution, allowing e.g. interpolation methods for background estimation.

3a. Performances

The neural network classifier features a much flatter efficiency than the classical method for a fixed cut, yielding at 10 TeV the same contamination for twice the signal efficiency.

For a 1-to-1 comparison, a moving cut is set such that both methods have the same efficiency. With a 95% efficient cut, the background rejection of neural nets is up to 8x better.





3b. MC validation

MC is scaled to the real data, to verify there are no biases and to confirm the reliability of the method.