

Cluster Counting Technique



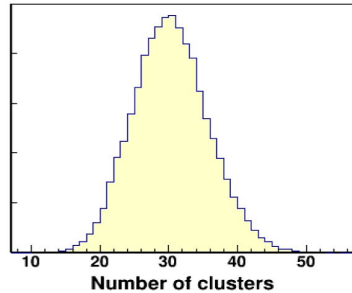
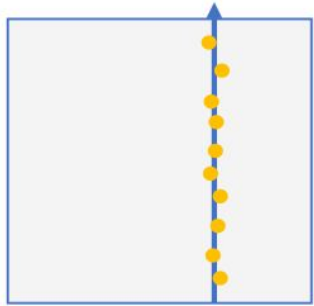
Muhammad Numan Anwar
Department of Physics
Polytechnic University of Bari
INFN, Italy

Outline

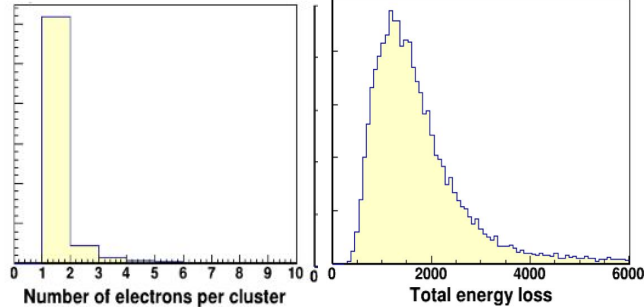
- 1. Cluster Counting**
- 2. Peak Finding Algorithm**
- 3. Long Short Term Memory (LSTM) Model**
- 4. Clusterization**
- 5. Convolution Neural Network (CNN) Model**
- 6. Future Planning**

Cluster Counting vs dE/dx

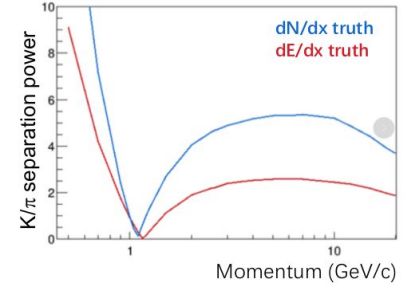
Primary Ionization



Secondary Ionization



K/p separation power dN/dx vs dE/dx

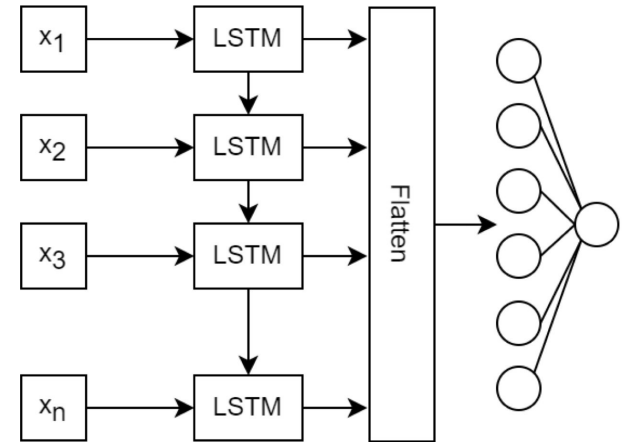
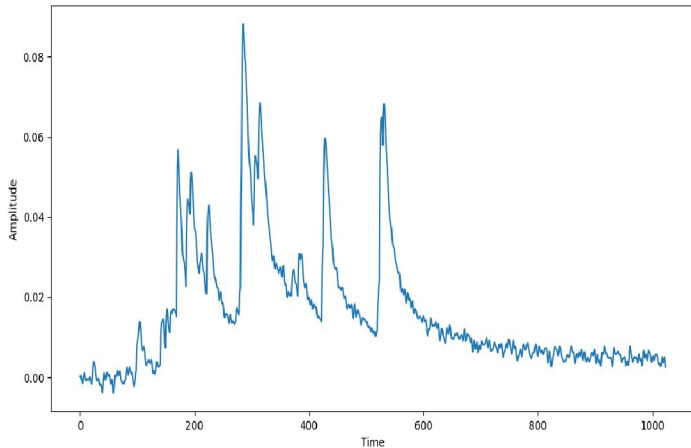


- Energy loss per unit length, Landau distribution, large fluctuation
- Number of primary ionization clusters per unit length, Poisson distribution, small fluctuation → Cluster Counting Technique

Two-Step Reconstruction Algorithm

Step 1: Peak Finding

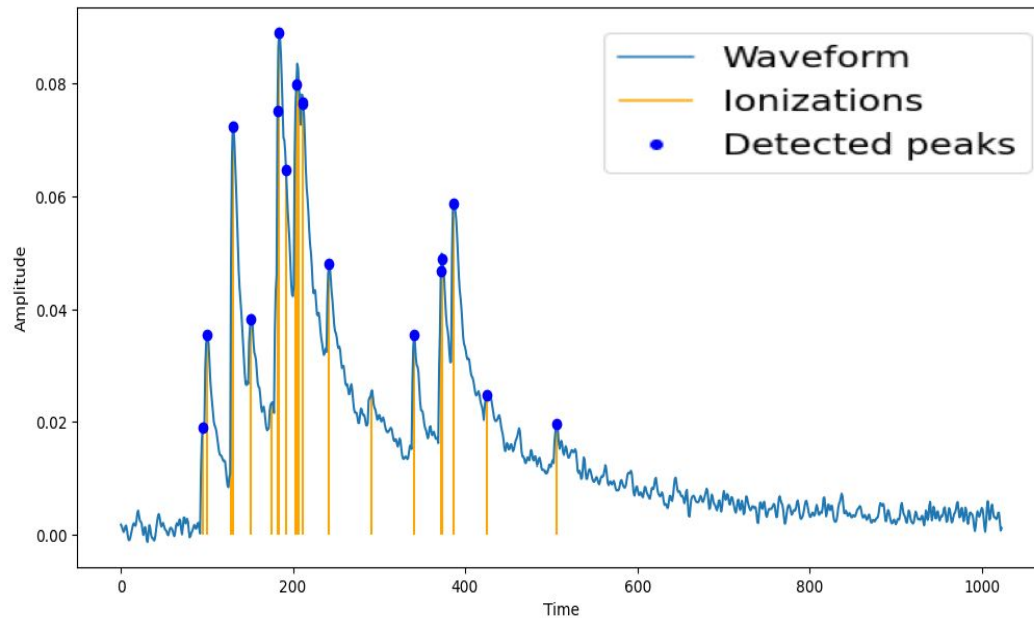
Waveform



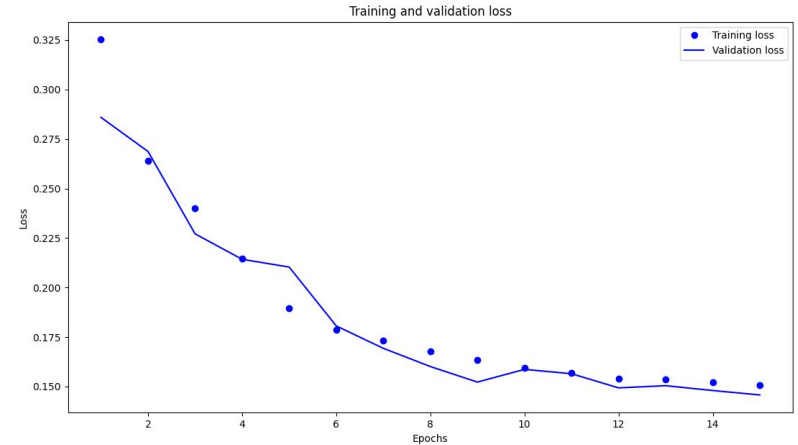
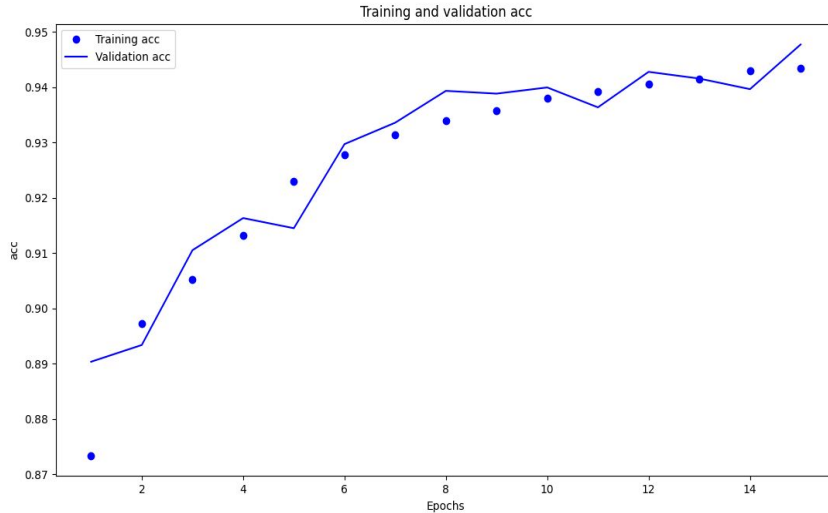
- **Discriminate peaks (both primary and secondary) from the noises (classification problem)**

- **The data of waveform is time sequence data, which is suitable for LSTM**

Evaluation by Waveform



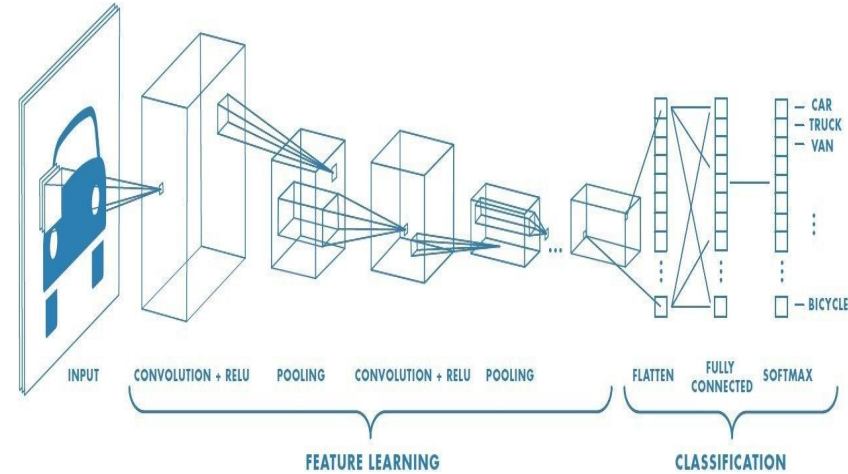
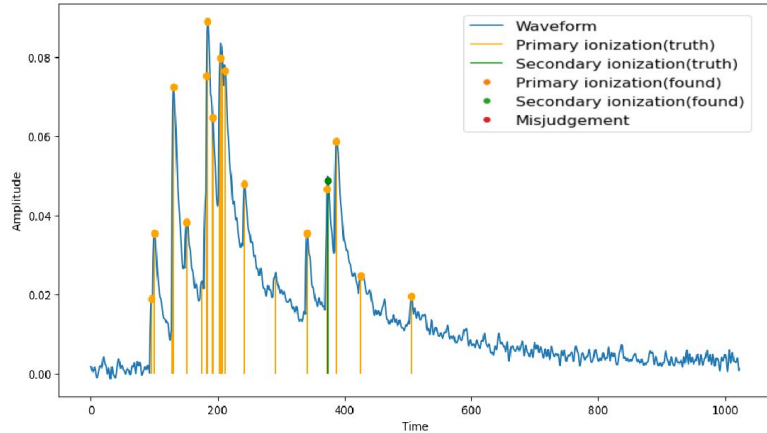
Performance of the Model



The above plot Accuracy VS epoch show us that the training and validation Accuracy increases over the epochs

The above plot loss VS epoch show us that the training and validation loss decreases over the epochs

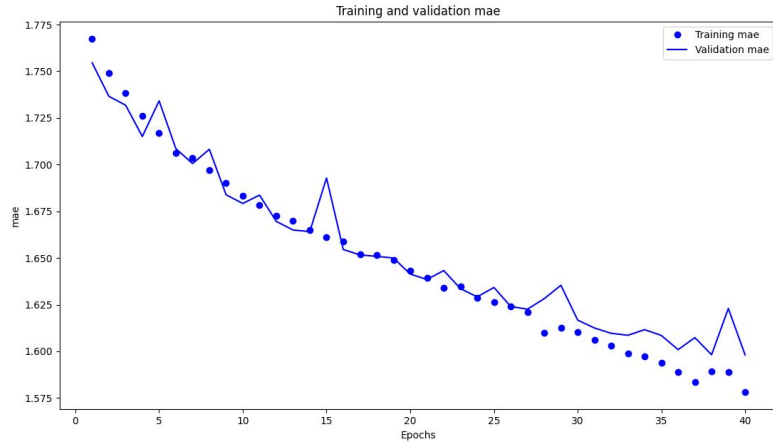
Step2: Clusterization



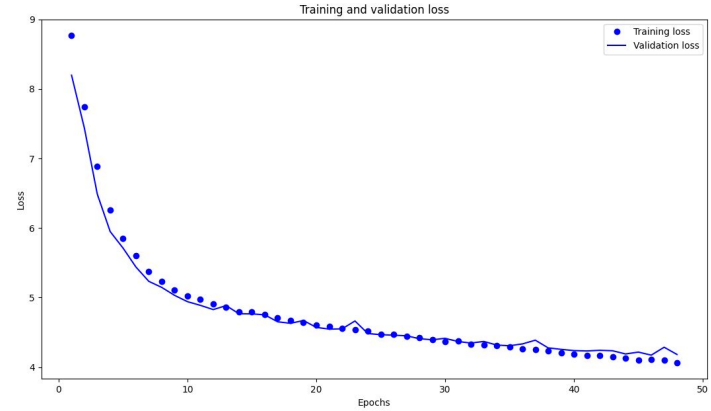
- **Determine the number of clusters from the detected peaks (Regression Problem)**

- **Extracting features from input**
- **1D CNN can handle sequence data**

Performance of the Model



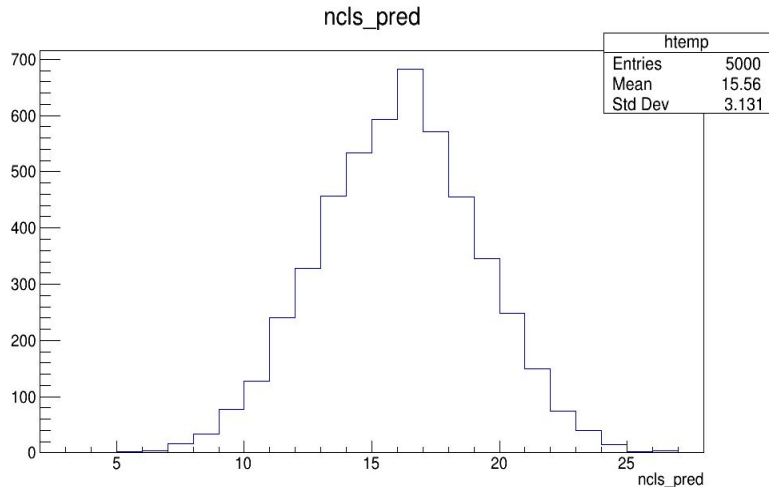
The above plot mean absolute error VS epoch show us that the training and validation mae decreases over the epochs



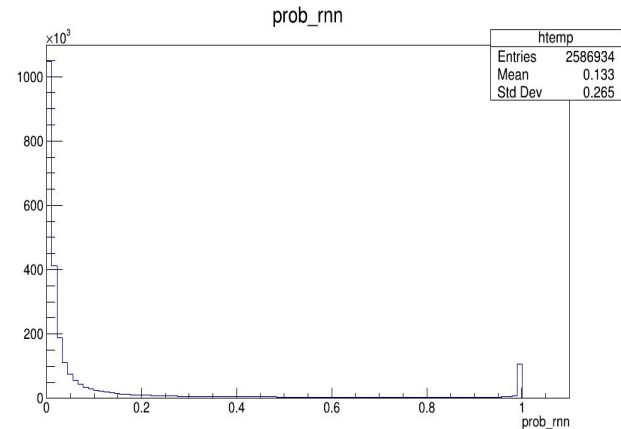
The above plot loss VS epoch show us that the training and validation loss decreases over the epochs

Predictions of the Two Models

Number of clusters predicted by CNN Model



Prob of the LSTM Model to
Classify Signal and
Background



12/12/2023

Future Planning

Now, we aim to enhance the performance of these models by using:

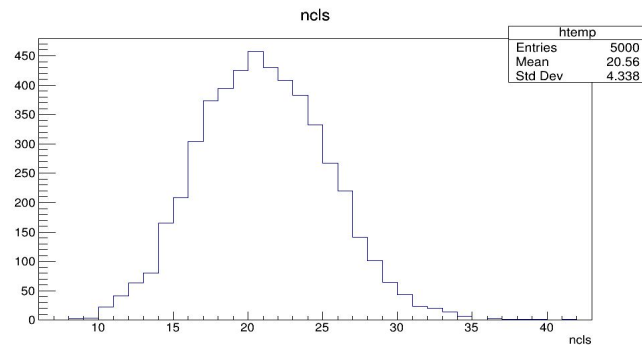
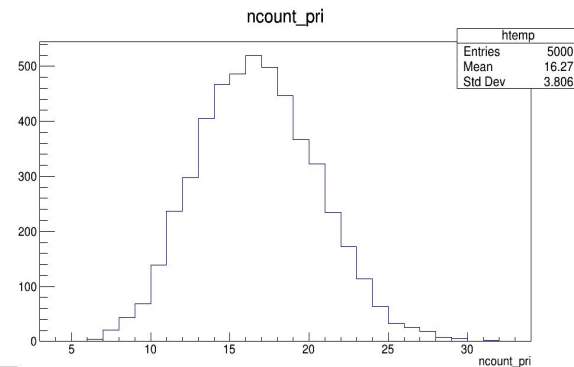
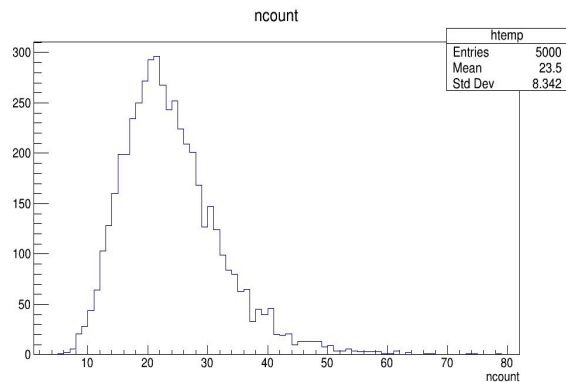
- **Different loss and activation functions**
- **Adding more layers**
- **Adjusting the number of training epochs etc.**
- **Once we achieve the best performance, we will apply our model to the test beam data.**

Thank
you



Plots for the Discussion

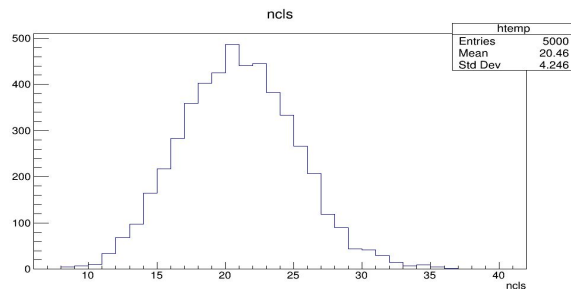
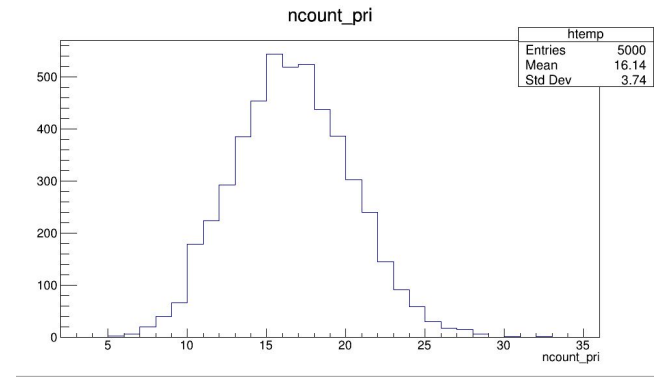
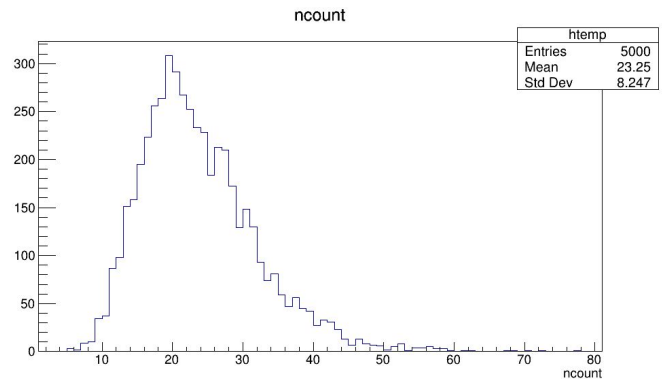
Peak Finding Train Root



12/12/2023

Plots for the Discussion

Peak Finding Test Root



Plots for the Discussion

Counting Test Root

