GNN for Water Cherenkov Detector Charge Distribution Simulation in Loss Function

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Generating Random Throws from Fit

- Key idea: $Q_{throw} = \mu + N(0,1) \cdot \sigma$

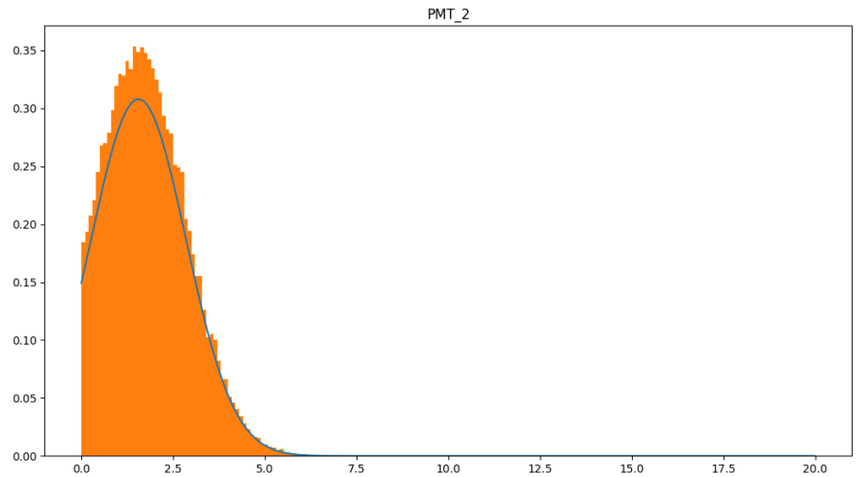
- For multiple Gaussians, decide by the relative probability:
  - First generate a random number from uniform distribution in (0, 1)
  - Define the probability threshold (for 2 Gaussian case) by:
    - $p_{threshold} = \frac{A_1}{A_1 + A_2}$, where A's are the coefficient of each Gaussian component
  - If the generated random number from (0,1) is smaller than this threshold then throw from the first gaussian, otherwise the second.

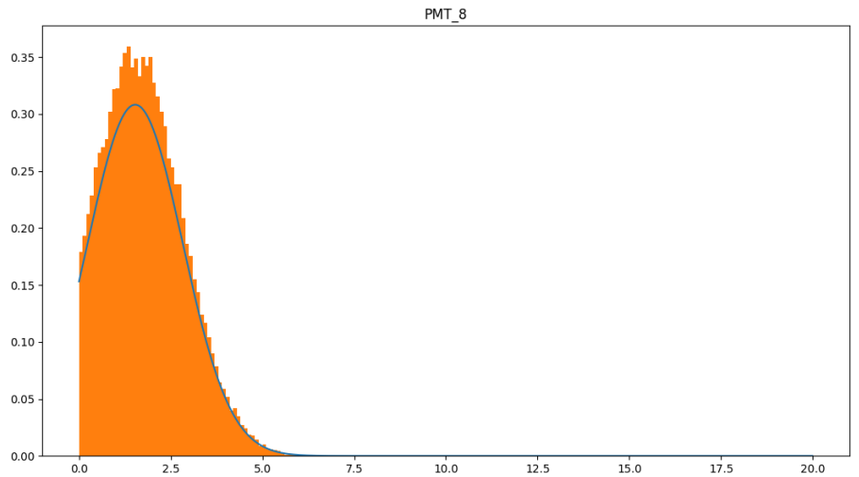
- Tested this with 50k throws and checked that the thrown charges do follow the input N_GAUS distribution (examples on next page).

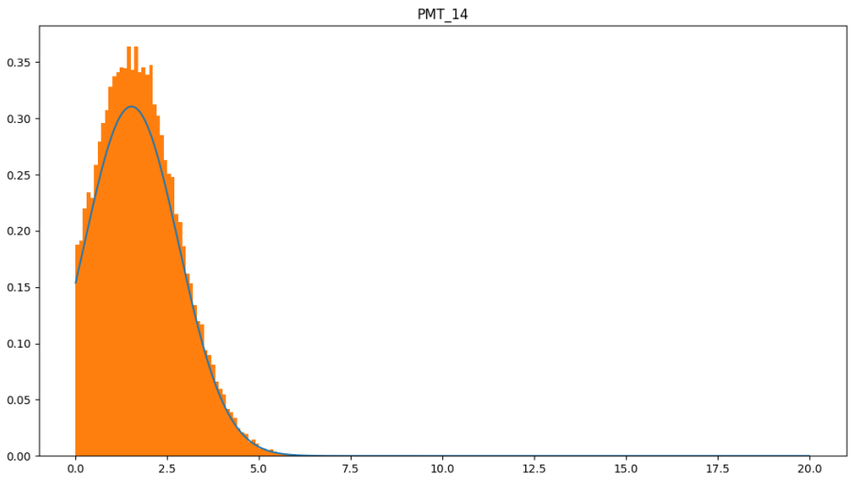
- Events used: 39680, 32640, 8197, 73502, 3958, 16250, 10122, 73510, 3813, 6041, 58898, 72889, 5, 2854, 3433, 7616, 8511, 10076

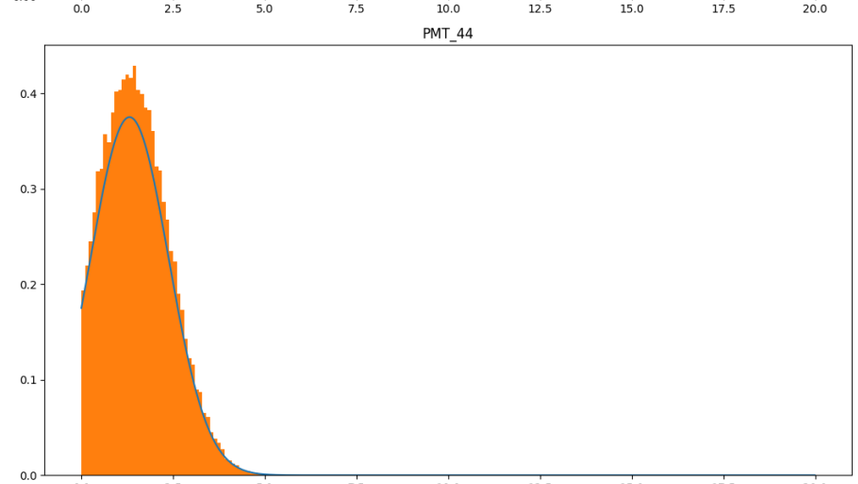
1 Gaussian 50k Random Throws

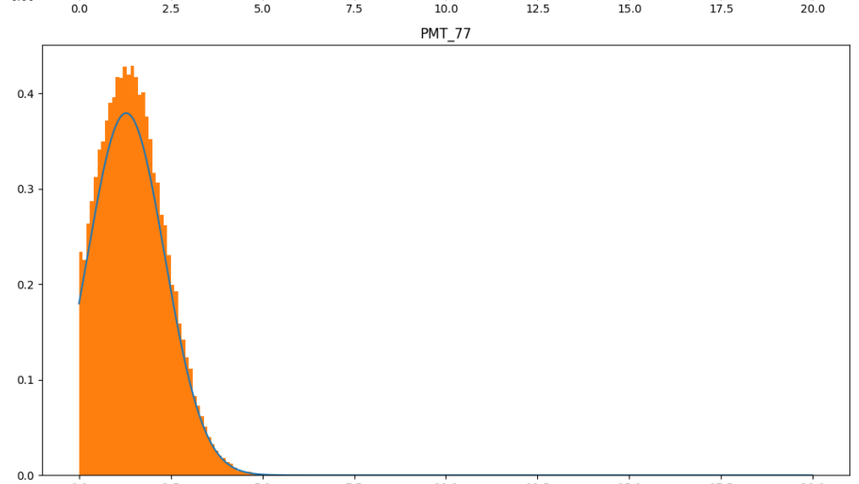
- Event 73510
- Hard cut off by hand at 0
- First 9 PMTs in numerical order that get hit

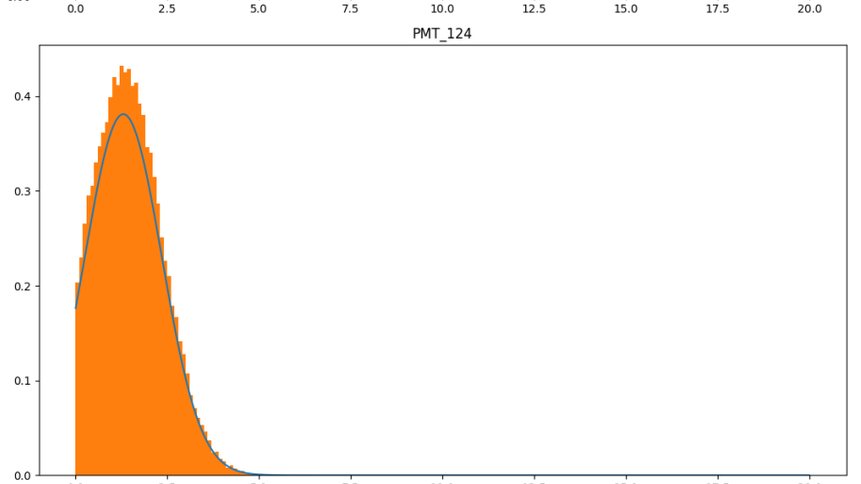


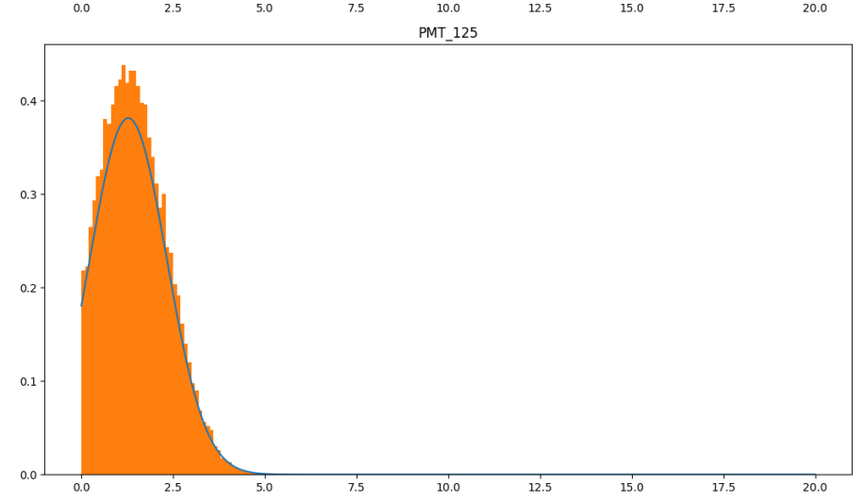


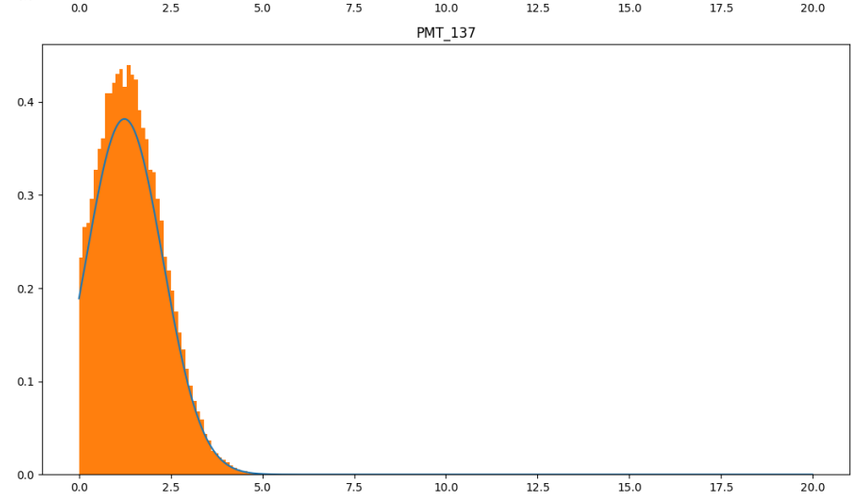


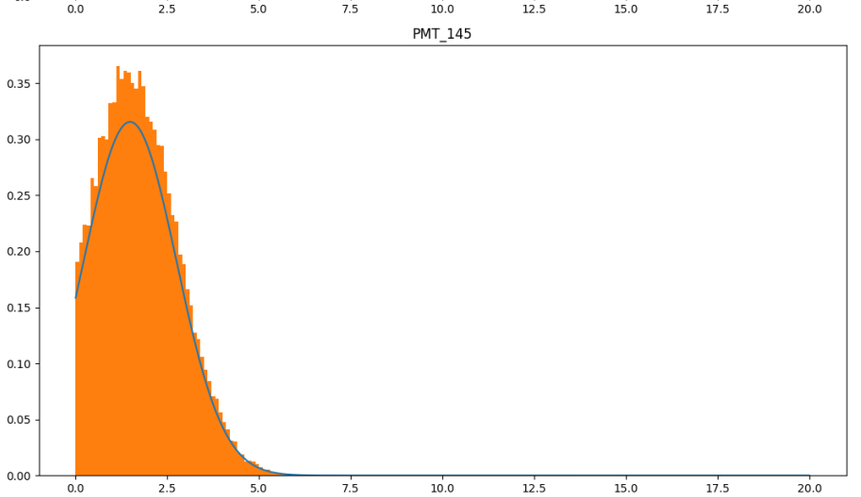






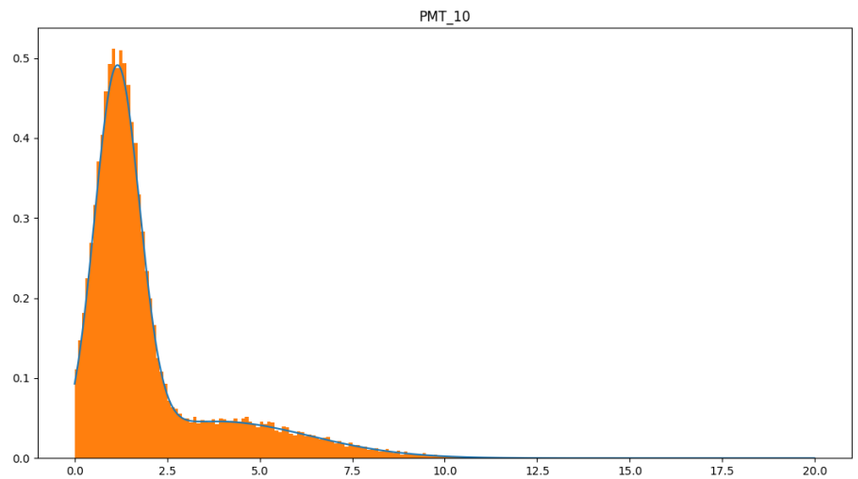


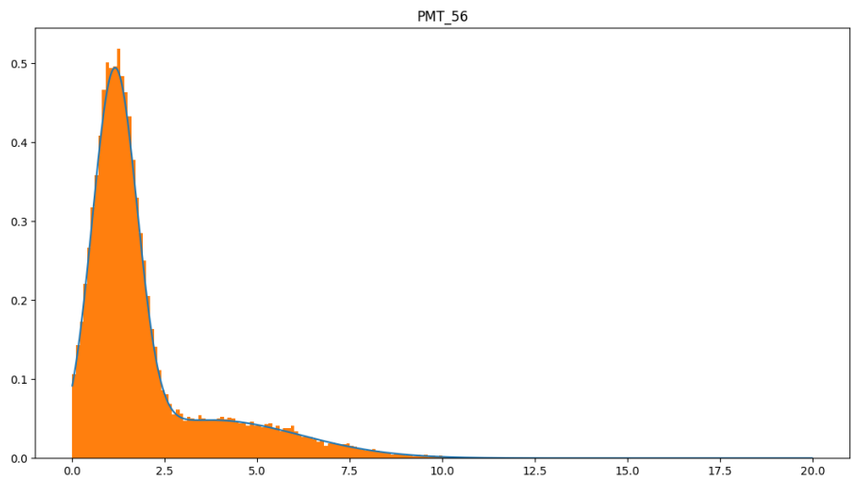


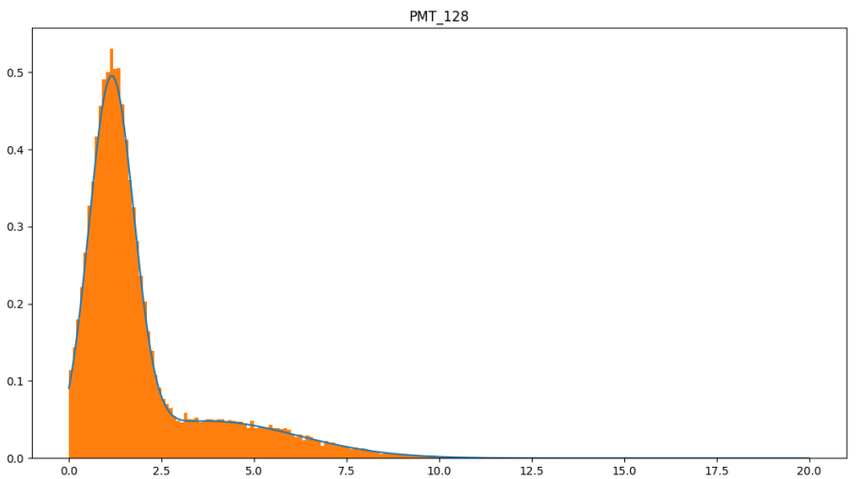


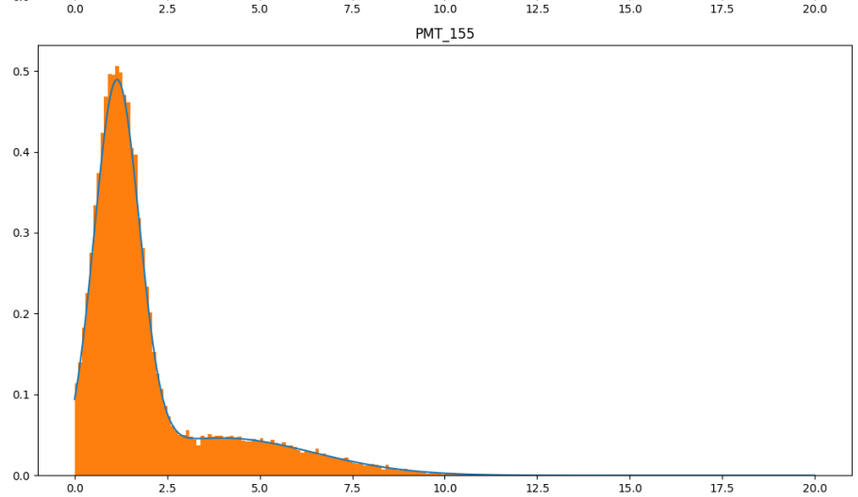
2 Gaussian 50k Random Throws

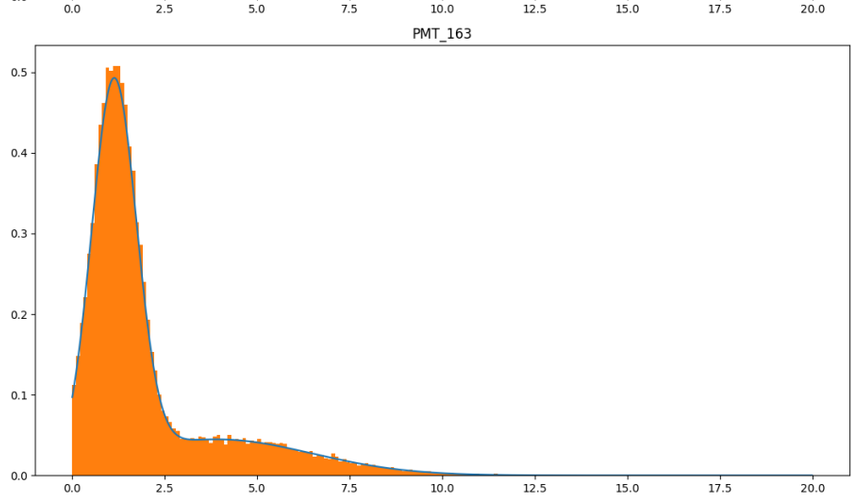
- Event 3958
- Hard cut off by hand at 0
- First 9 PMTs in numerical order that get hit

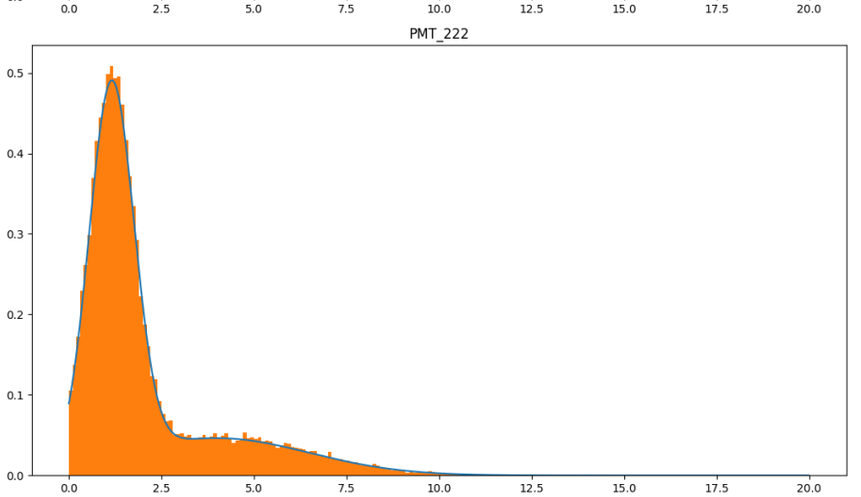


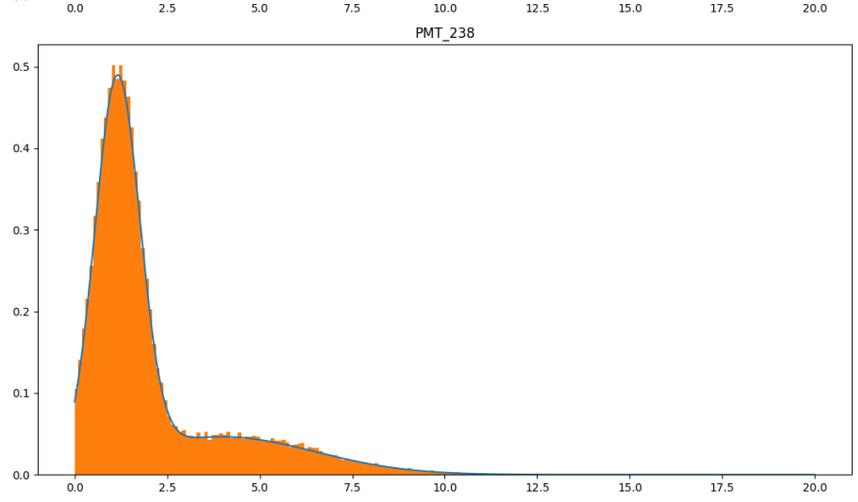


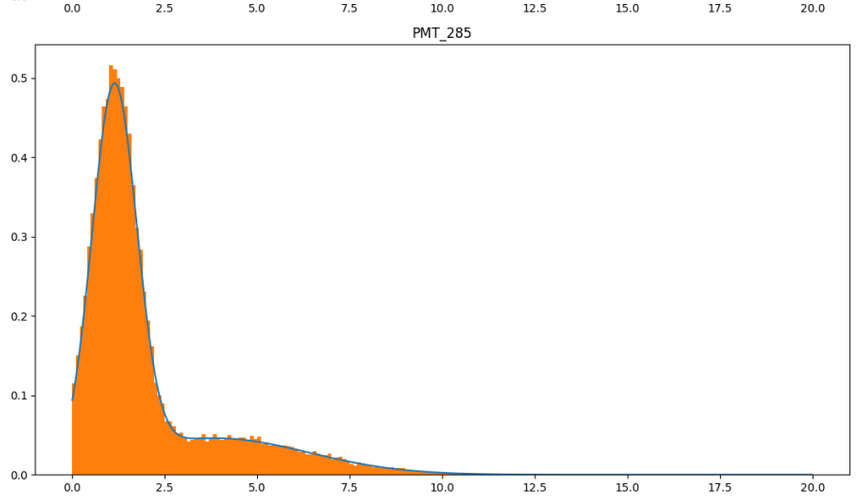


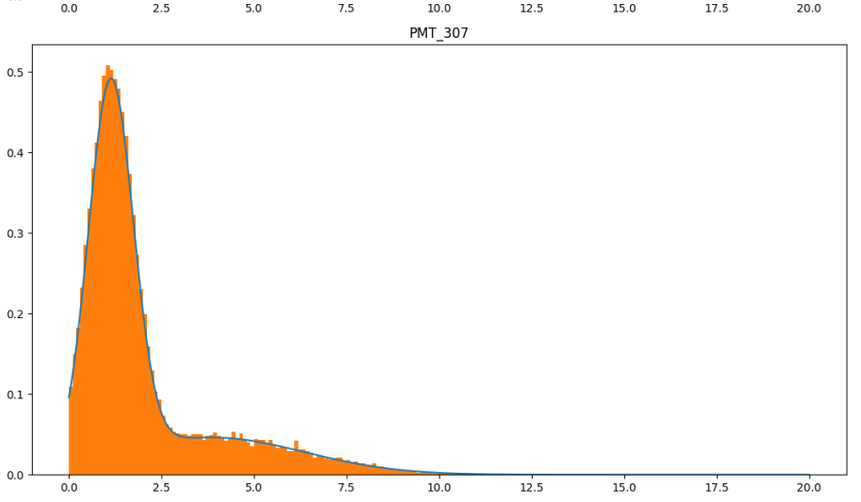








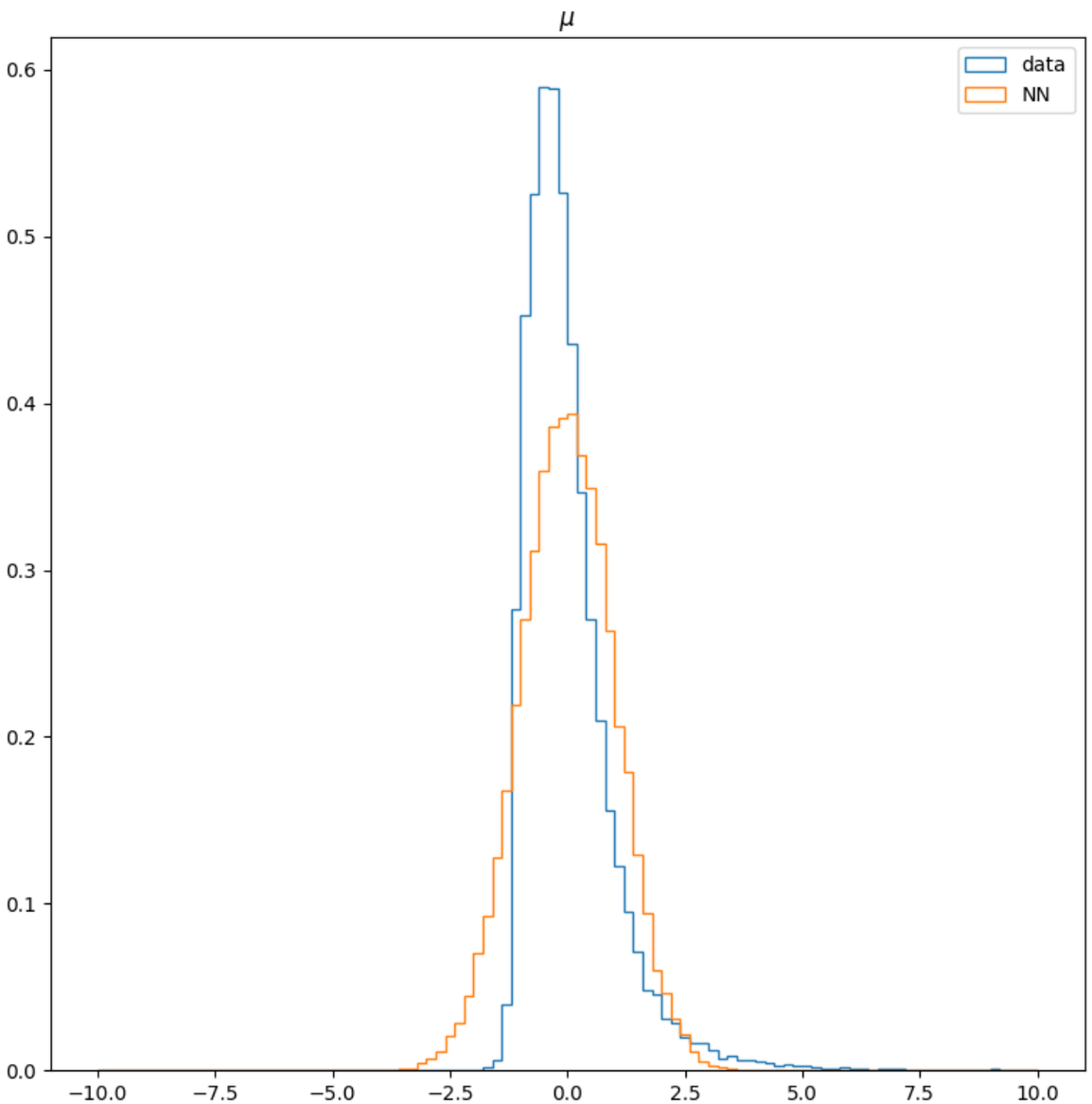




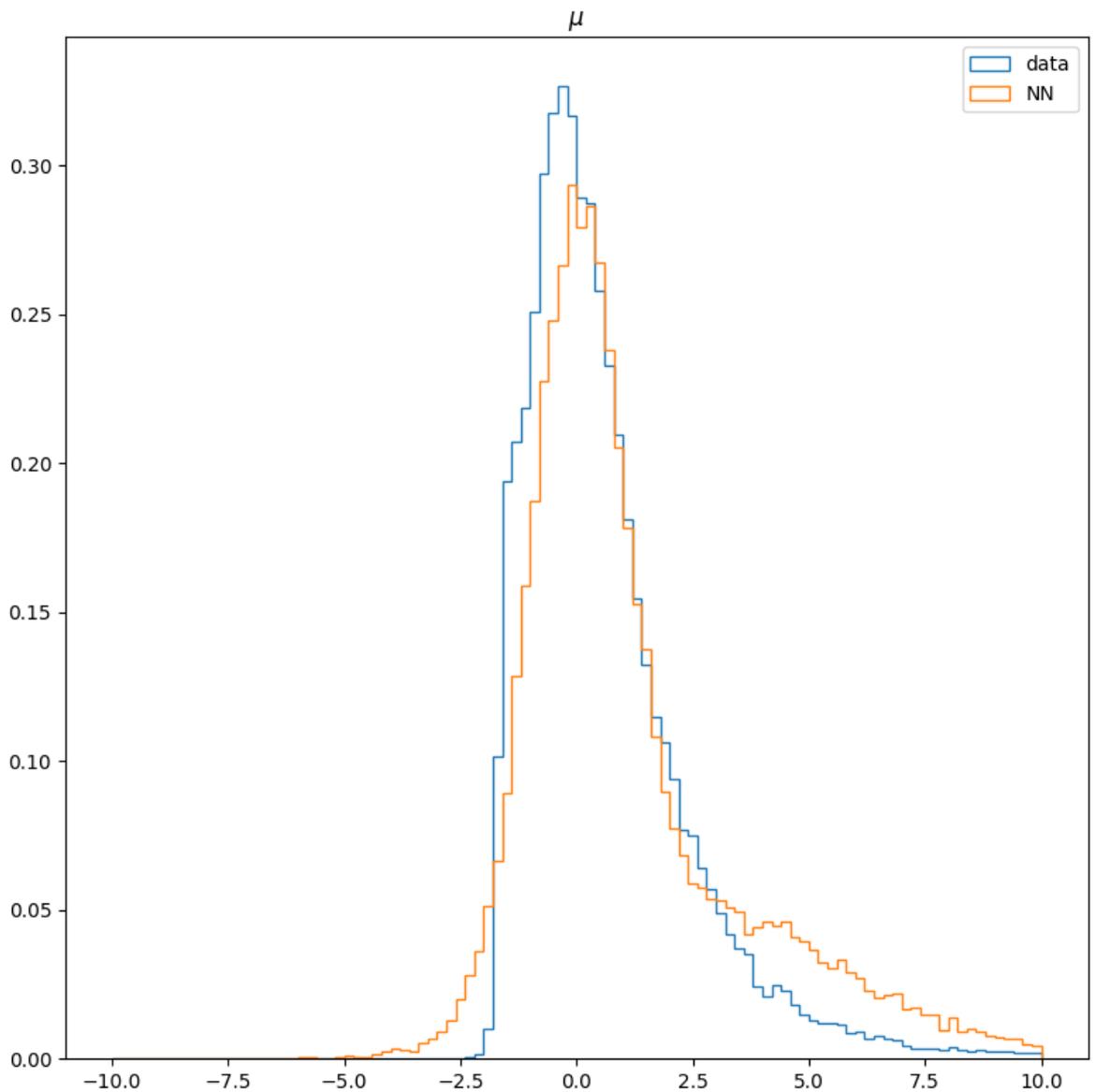
Results

- For the check on tail, using:
  Data = $q_{data} - \mu_0$
  NN = $q_{thrown} - \mu_0$
- Each hit PMT in each event gets 1 throw, stat = 30781

N_Gaus = 1



N_Gaus = 2



Discussion

- Including one more gaussian in the fit does seem to better represent the tail in charge distribution, though might be overestimating.
- The cut off at 0 in data is not an easy thing to fit for Gaussian, which might have caused a larger uncertainty?
- A better way of comparison might be using laser beam data, in which we can have identical energy and direction for all events and thus direct comparison of data vs. fit?

Other Minor Questions

- The 1 Gaussian throws seem to be deviated from the input function, need check.
- Only muon event in K. Yang’s (short) event list?