Cosmic Rejection based on Neural Network

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01/31/2017

Outline

- Cosmic Rejection in PRad

- Neural Network

  - Structure
  - Training

- Preliminary Result

- Future Plan

Cosmic Rejection in PRad

- For GEM efficiency study, we need a good cosmic rejection
  - Aim at < 0.2% uncertainty for the efficiency
  - Cosmic may be falsely identified as an event missed by GEM
  - Cosmic events ratio is about 2% ~ 5% at 1.1 GeV
  - Effective: > 90% cut on cosmic, so the efficiency is less affected.
  - Safe: rejection of ep/Moller < 0.05% without GEM matching

cosmic

cosmic

cosmic

e-p

Moller

e-p with radiation photons
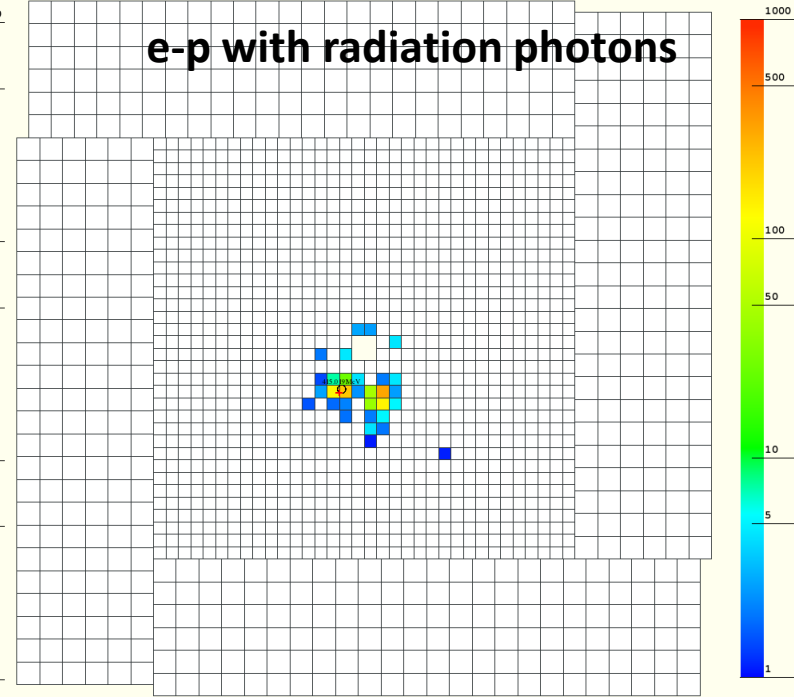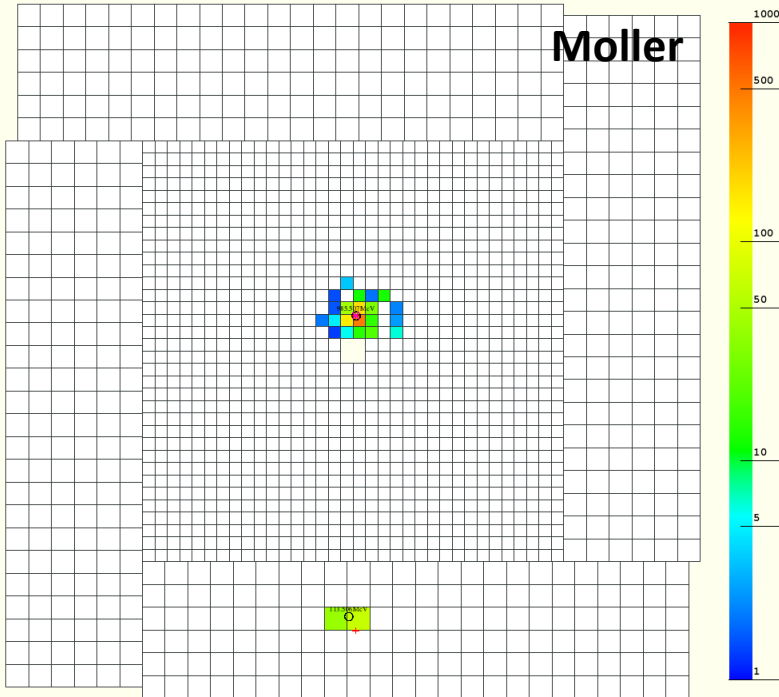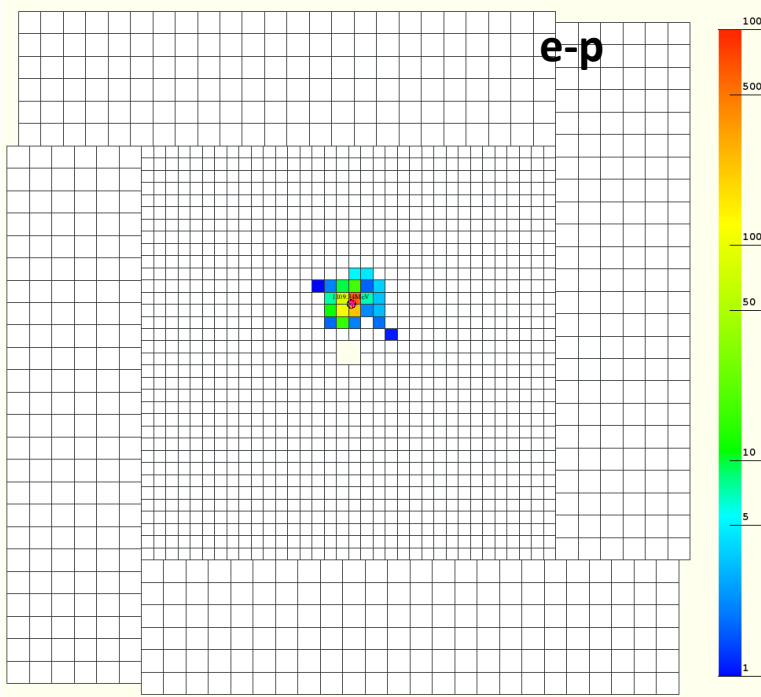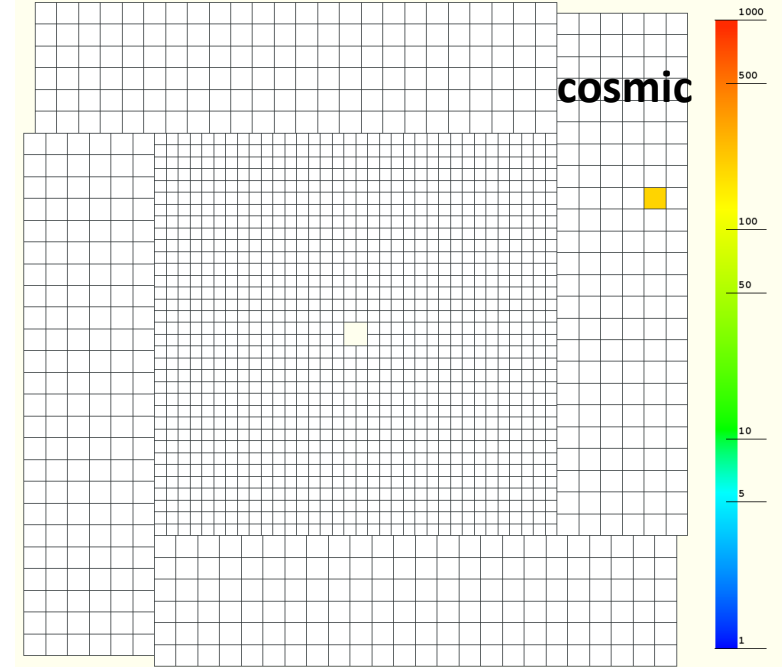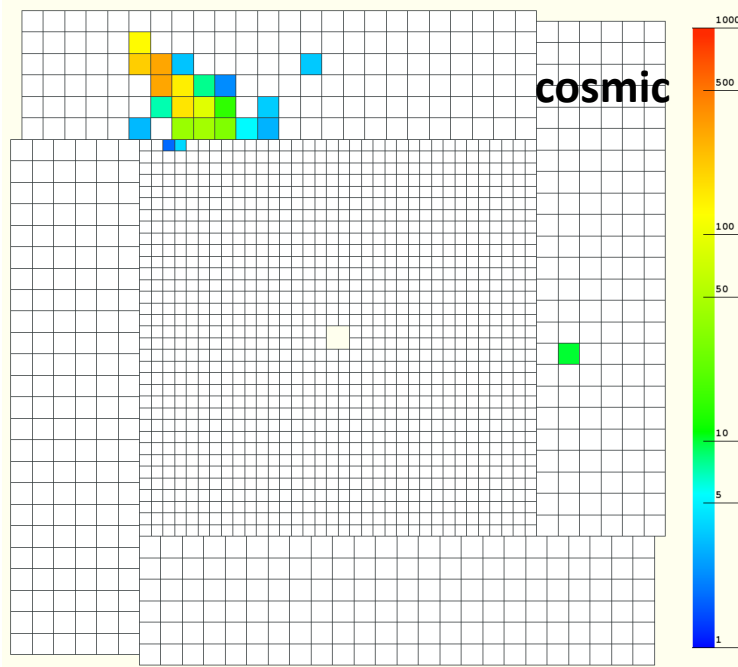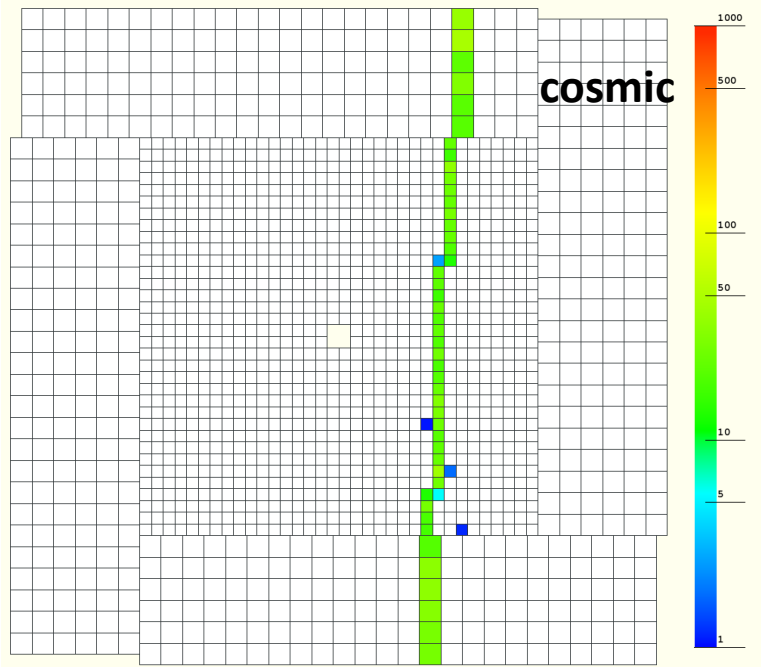
Cosmic Rejection in PRad

- Previously studied by Yuqi, very good progress made
  - Cut on log-likelihood of HyCal cluster profile
  - Cosmic rejection: 56% ~ 58%, ep/Moller rejection: 1% ~ 3%
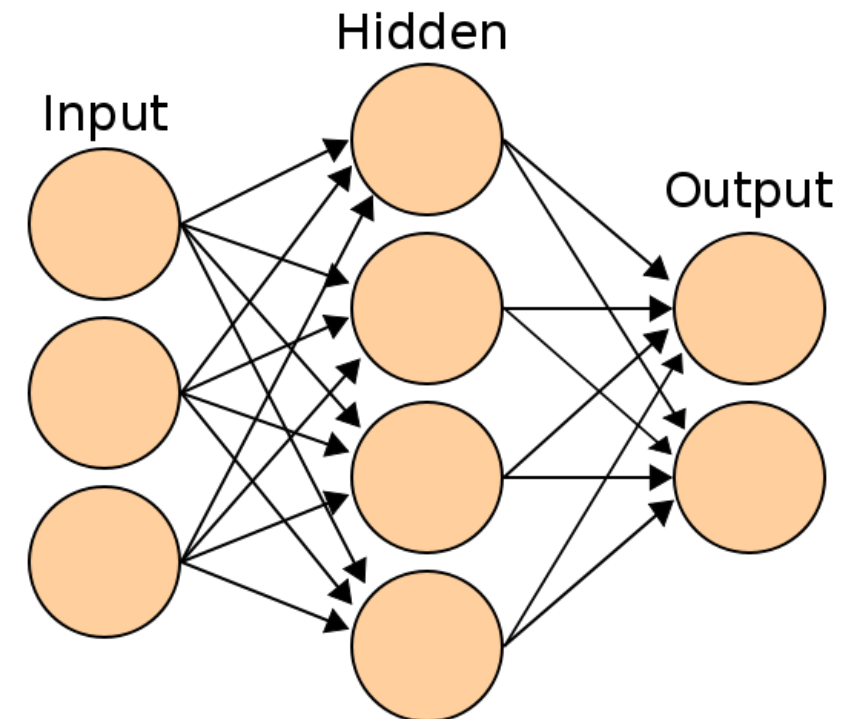 - Single dimension cut is not enough for such a task
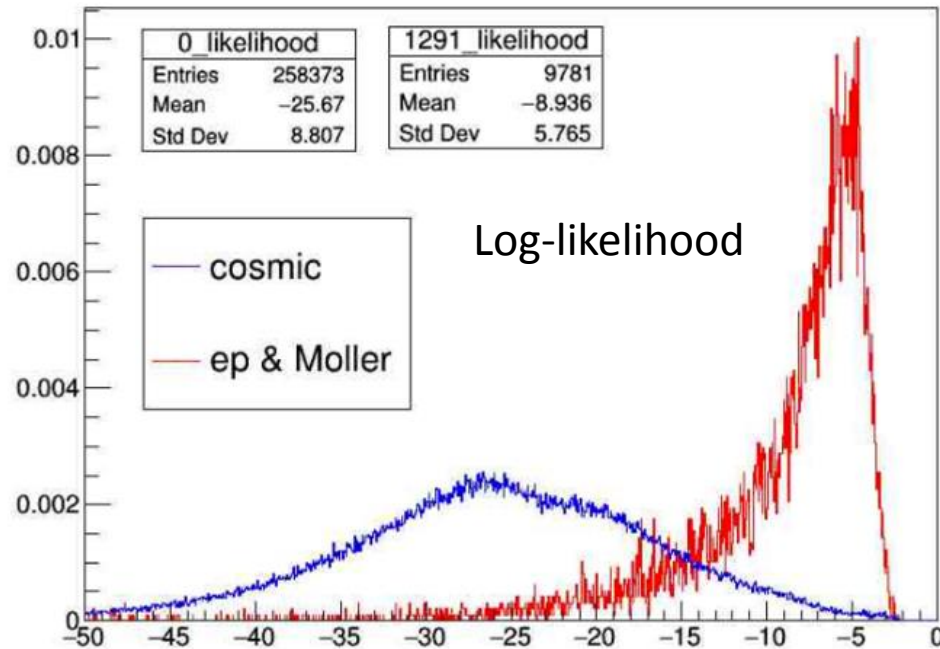
Neural Network

- A general structure for machine learning, analogy of brain

- Excel at classification and multi-dimension cuts

- Basic Structure
  - Neurons are connected layer by layer
  - Feedforward signal, generated by the weighted sum of inputs from all connected neurons

$$y = f(\sum_{i=0}^{K} w_i x_i) = f(\mathbf{w}^{\mathbf{T}}\mathbf{x})$$

Neural Network Training

- Supervised training and back propagation algorithm
  - Provide training data sets with expected output
  - Define the error function that to be minimized
  - Back propagate the errors to all neurons, update the weights via stochastic gradient descent

$$w_{ij,new} = w_{ij} - \eta \frac{\partial E}{\partial w_{ij}}$$

Preliminary Result

- Simple network, total 60 neurons, less than 800 connections between them

- 6 inputs per event to the network
  - hits number
  - maximum hit energy
  - Size and energy uniformity of the largest cluster
  - R-square/Chi-square of the linear fitting for the largest cluster

- Trained with two data sets
  - Cosmic data, taken during the experiment without beam
  - Good data, using production data with requirement of GEM matching

Preliminary Result

- Reject 88.96% of the events from cosmic data.
- Reject ~0.7% of the ep/Moller events

Survived cosmic

False Rejected Moller
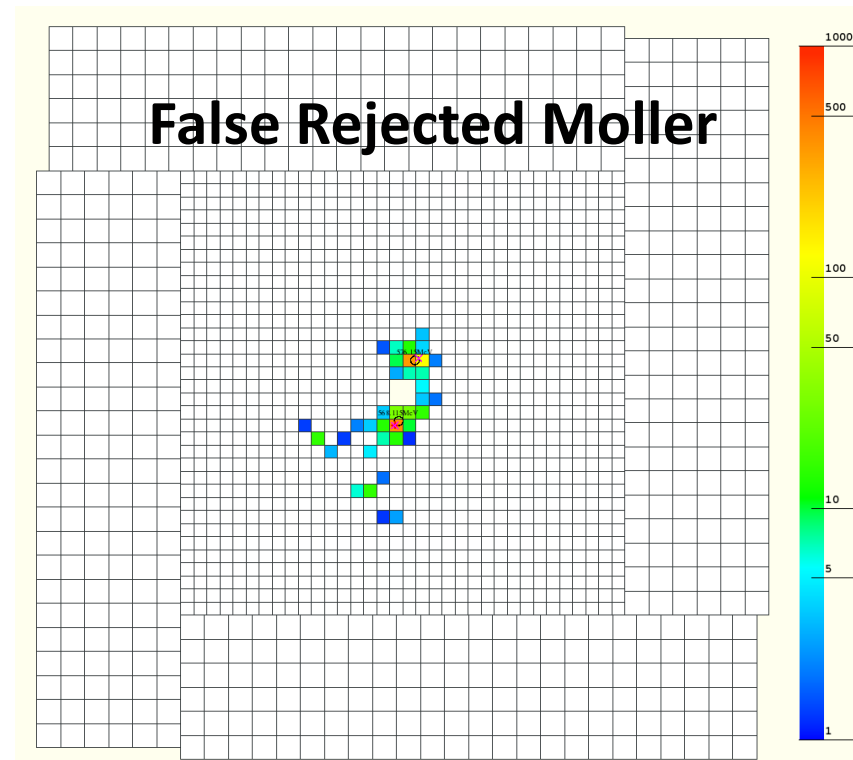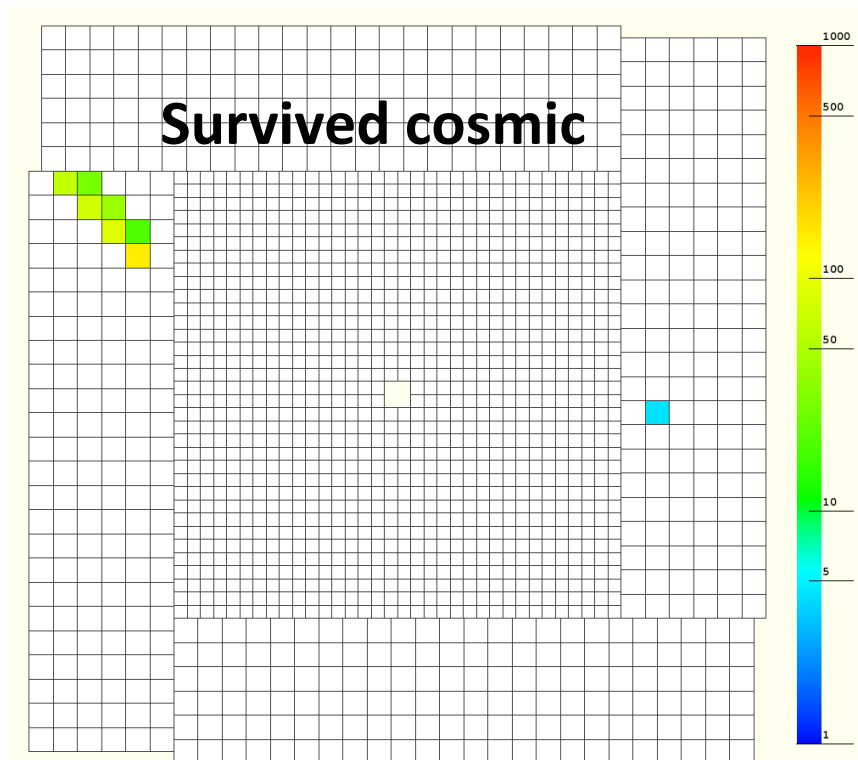
Future Plan

- Summary
  - Neural network is excel at classification, it shows a very promising result on cosmic rejection
  - We could continue refine the method to have a effective and safe rejection on cosmic, and thus better systematics in determining GEM efficiency

- To do
  - Add more information about the event (more inputs to the network)
  - Partitioned data for classification training (single cluster, double clusters, cosmic…), and particular training on the easy-to-be-cut good events to improve the safety
  - May utilize the method from computer vision to treat the whole HyCal as a pixel map and identify the cosmic rays
  - Maybe a good project for Yuqi to continue work on