CERN openlab

The usage of deep learning methods for raw data preprocessing at protoDUNE experiment

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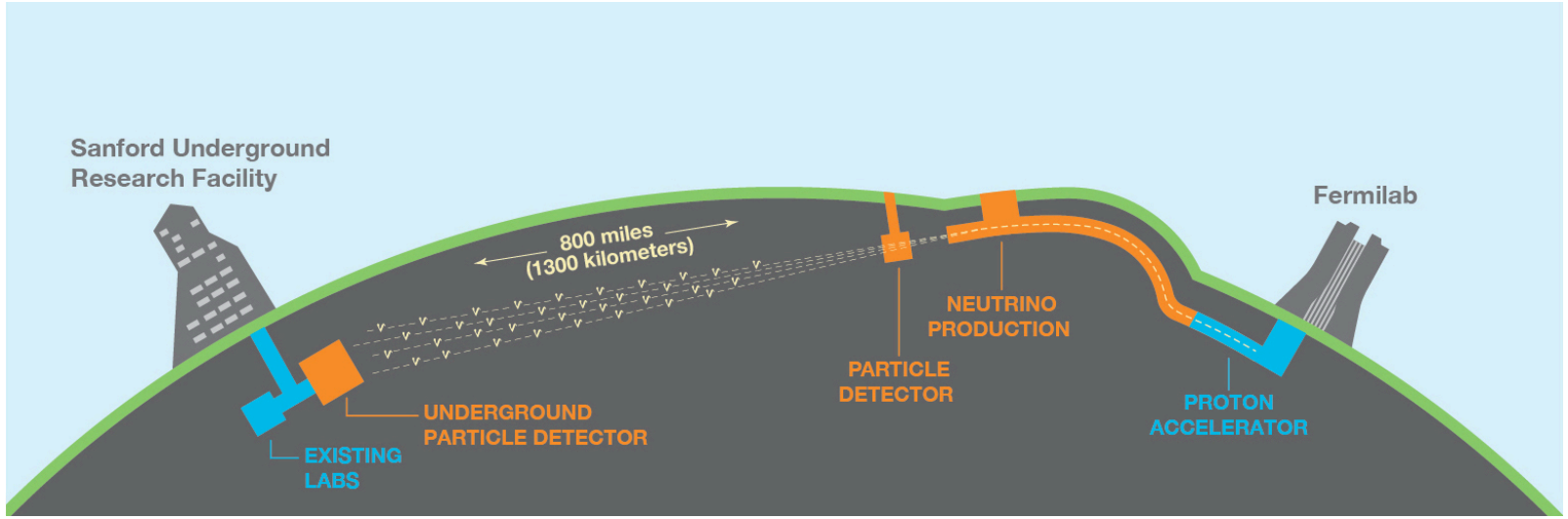
Introduction

protoDUNE experiment

DEEP UNDERGROUND NEUTRINO EXPERIMENT

- *Two neutrino detectors at the start and the end of the beam*
- *Measure amount of the different neutrino flavors*
- *CP-violation stuff*



Introduction

protoDUNE experiment

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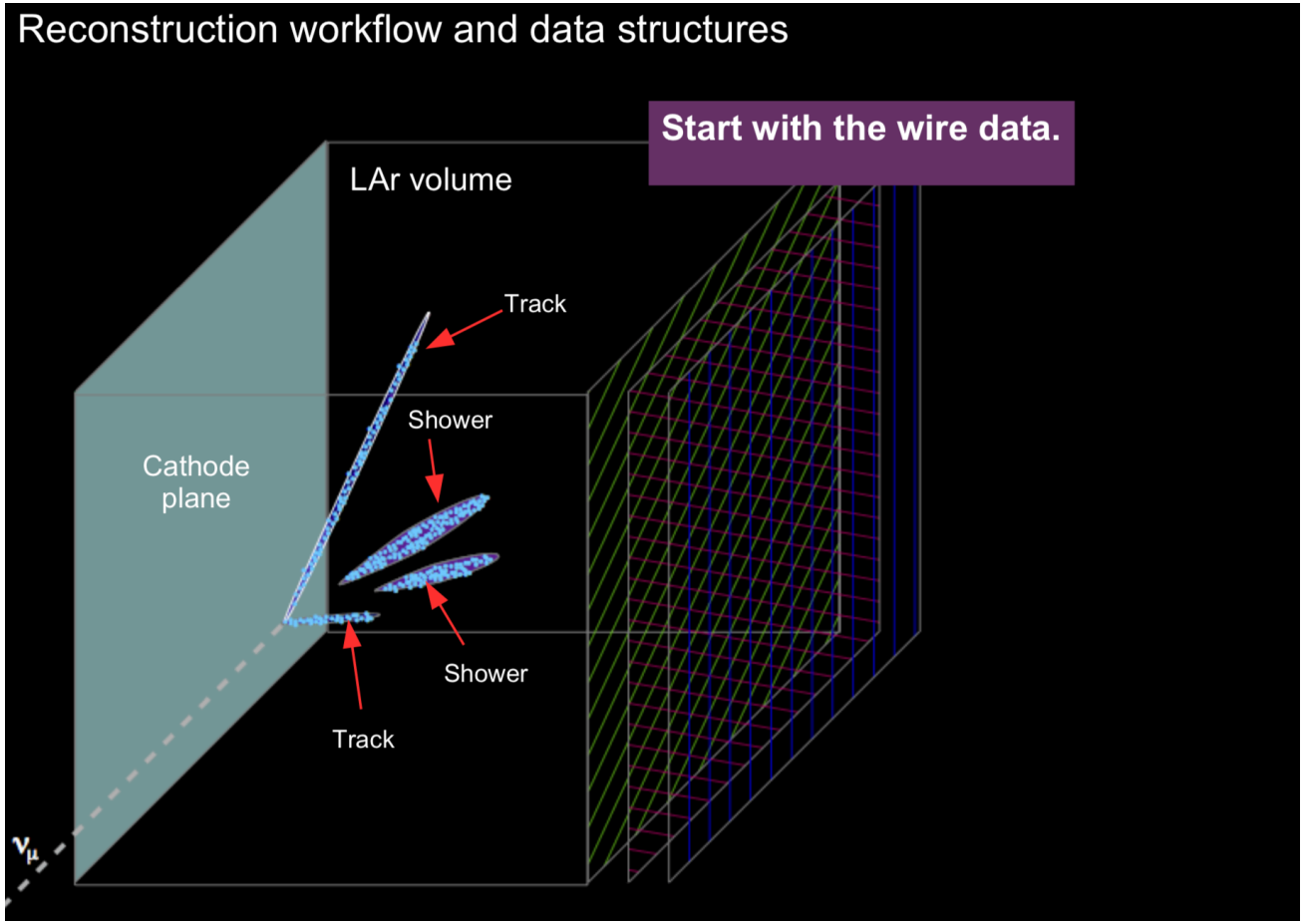
- *Detector measures the amount of the ionization electrons as the result of the neutrino interactions with argon atoms*



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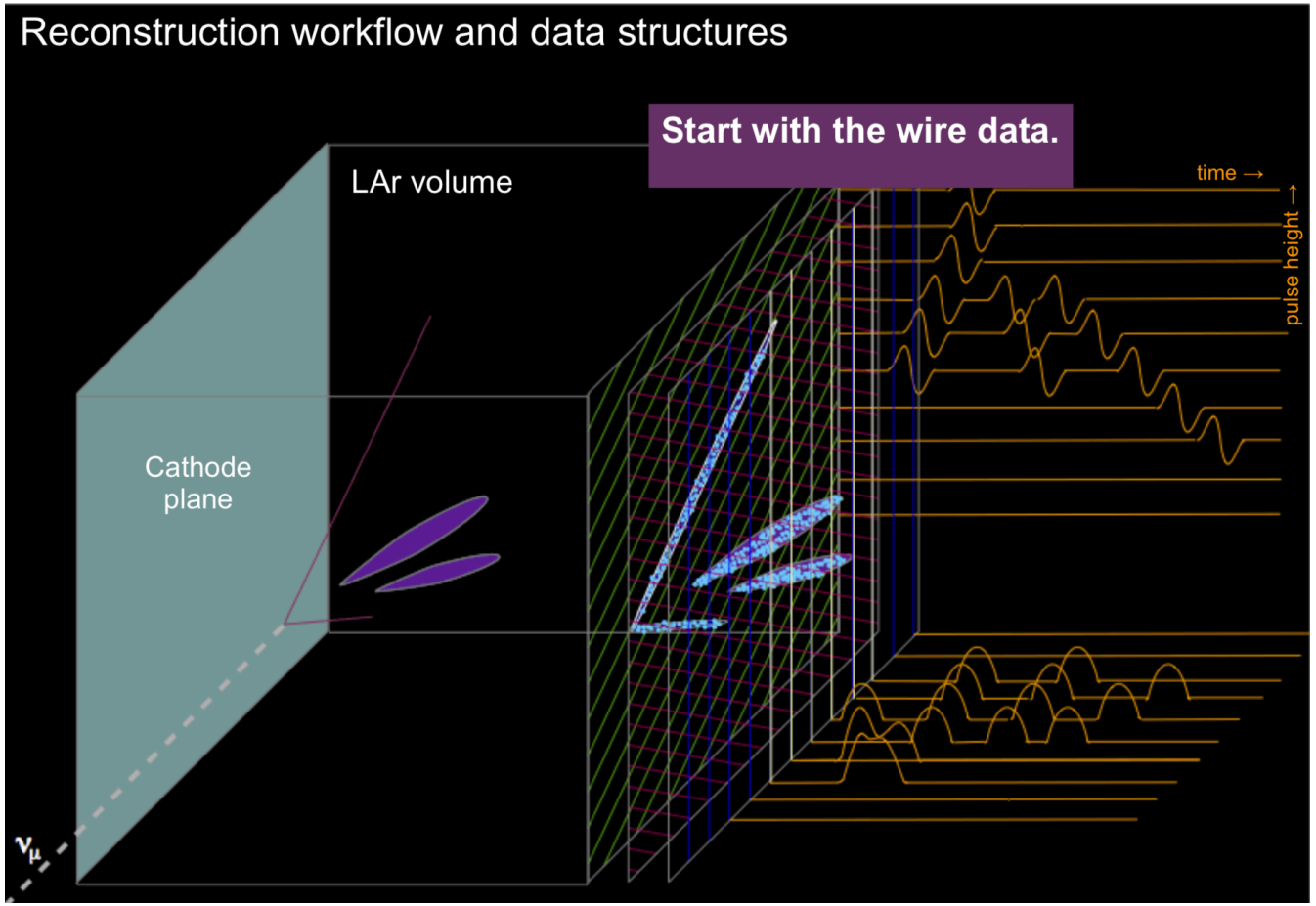
- *Then the ionization data is used to classify the neutrino flavor*



Current pipeline

protoDUNE experiment

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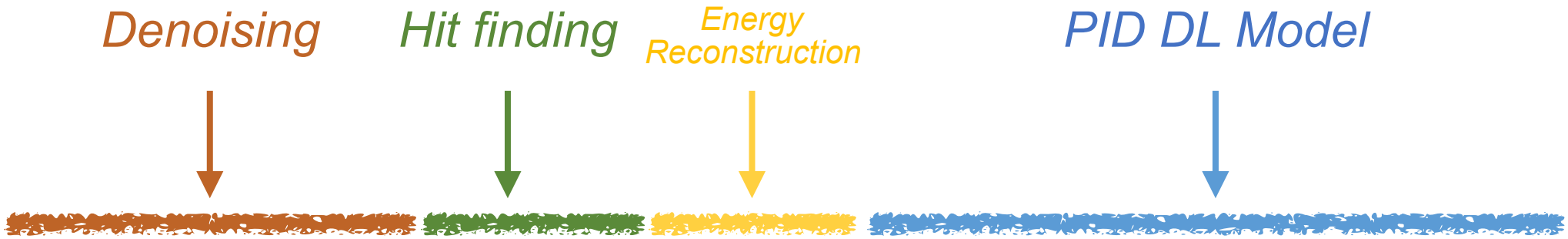

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Ideal pipeline

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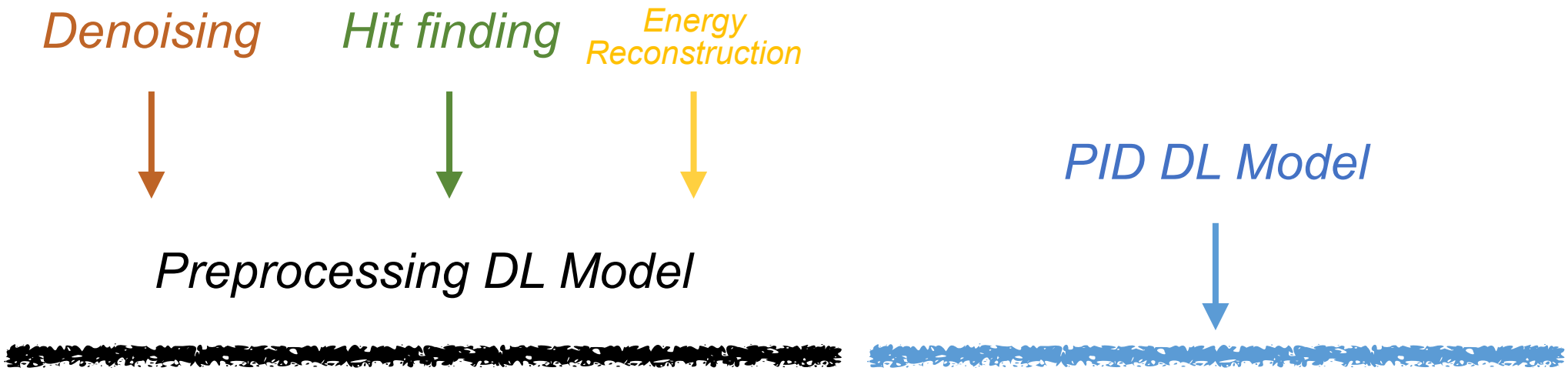
DEEP UNDERGROUND NEUTRINO EXPERIMENT



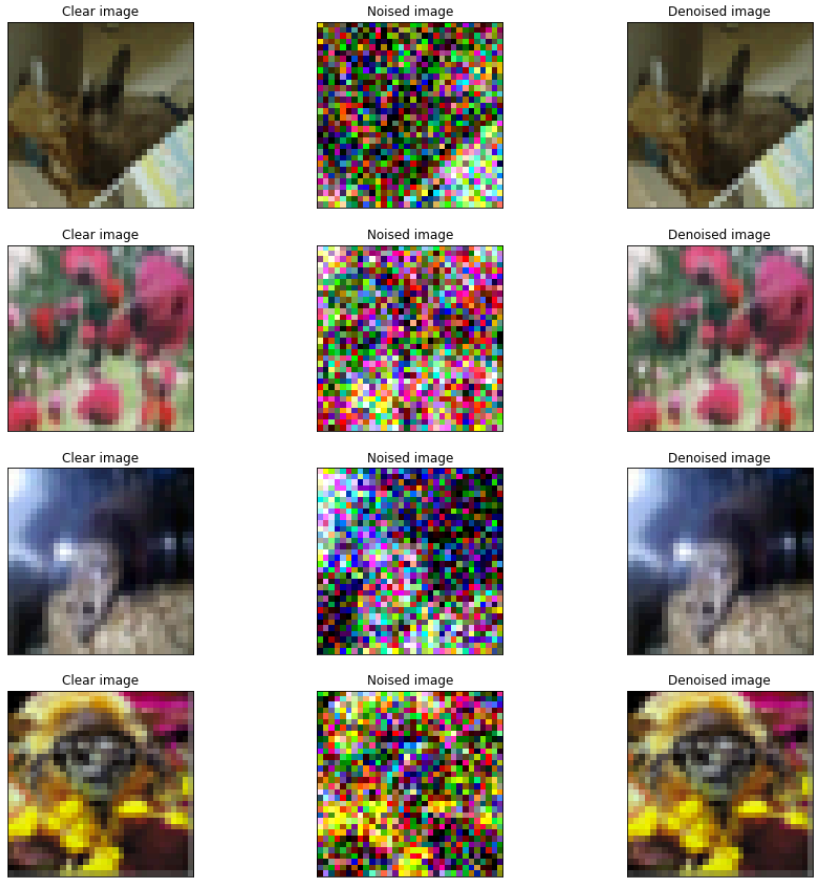
Denoising

protoDUNE experiment

DEEP UNDERGROUND NEUTRINO EXPERIMENT

CIFAR-100 Denoising

Result of my denoising DL model



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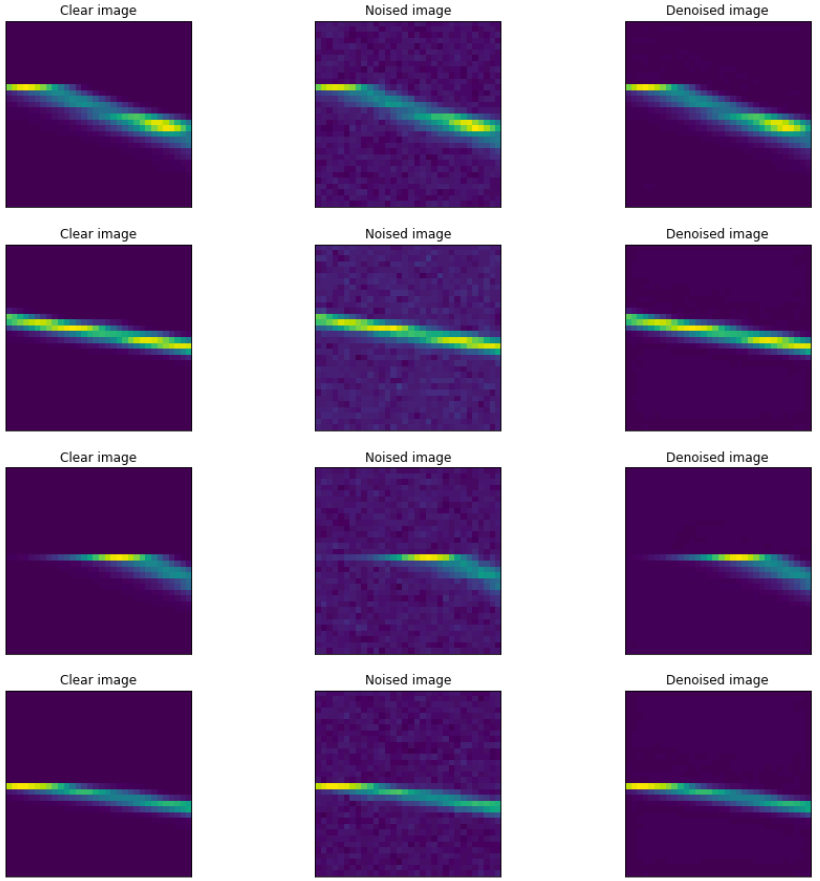
Denoising

protoDUNE experiment

DEEP UNDERGROUND NEUTRINO EXPERIMENT

protoDUNE Denoising

Result of my denoising DL model



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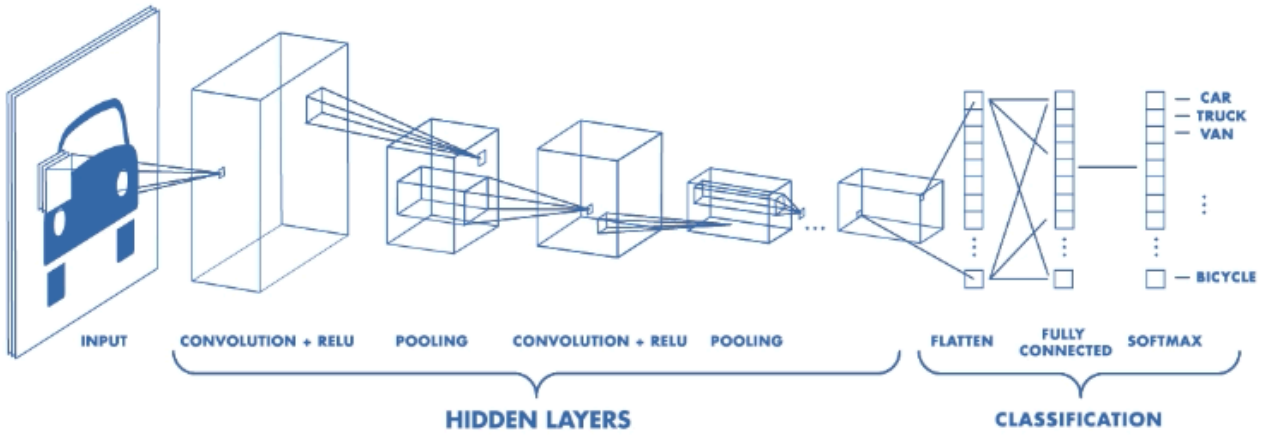
Denoising Model

protoDUNE experiment

DEEP UNDERGROUND NEUTRINO EXPERIMENT

- *CNN:*
  - *Fast*
  - *Reliable*
  - *Easy to use*

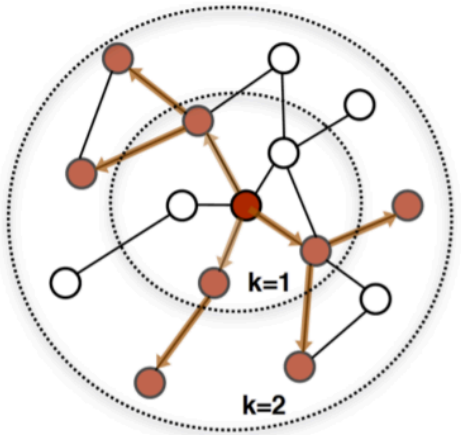


Denoising Model

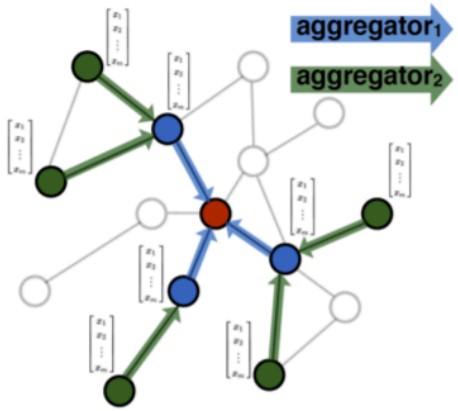
protoDUNE experiment

DEEP UNDERGROUND NEUTRINO EXPERIMENT

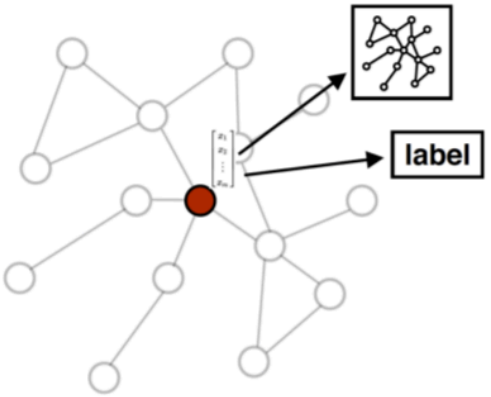
- *Graph CNN*
  - *Non-local features*
  - *Increased receptive field*
  - *Dynamically updates the image*



1. Sample neighborhood



2. Aggregate feature information from neighbors



3. Predict graph context and label using aggregated information

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General Model

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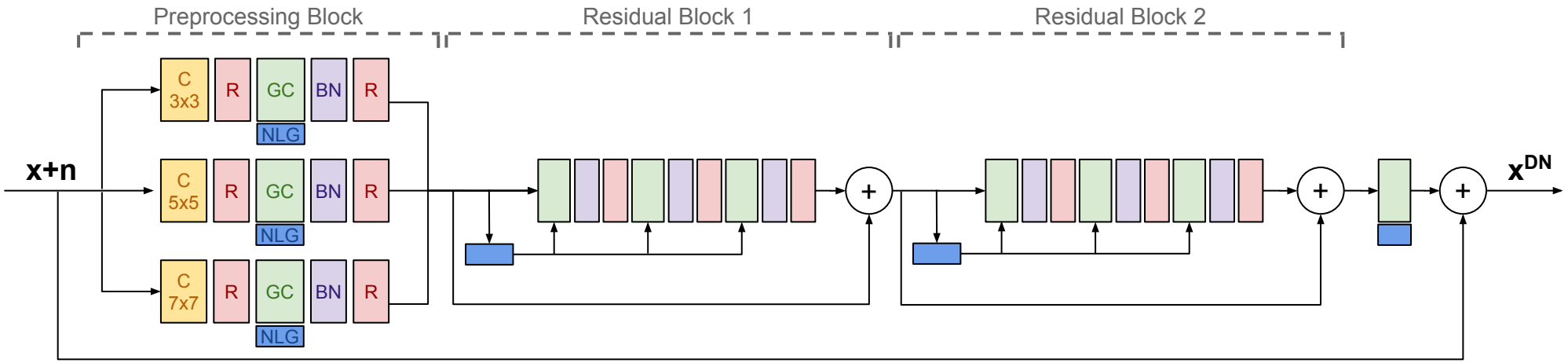
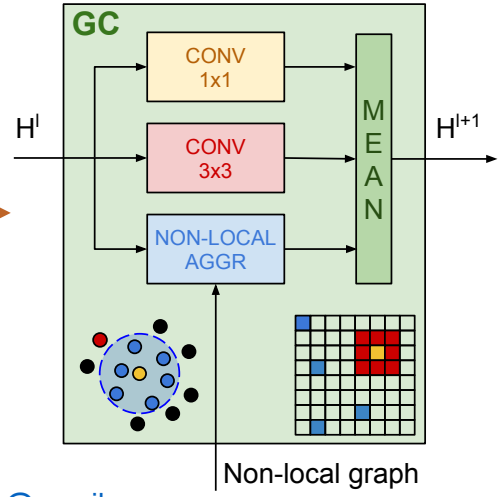


C 3x3 → *Convolutional Layer 3x3*

GC → *Graph-Convolutional Layer* →

$$H_i = \sigma\left(\underbrace{\sum_{j \in N_i} \frac{F_{w_i}(H_j - H_i)}{|N_j|}}_{\text{neighborhood}} + \underbrace{W_i H_j}_{\text{node}} + \underbrace{b}_{\text{bias}}\right)$$



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Results

protoDUNE experiment

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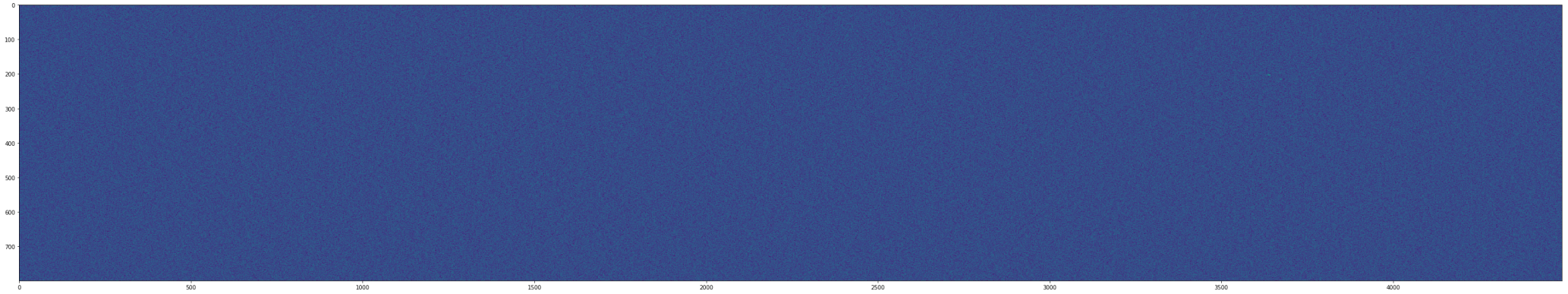
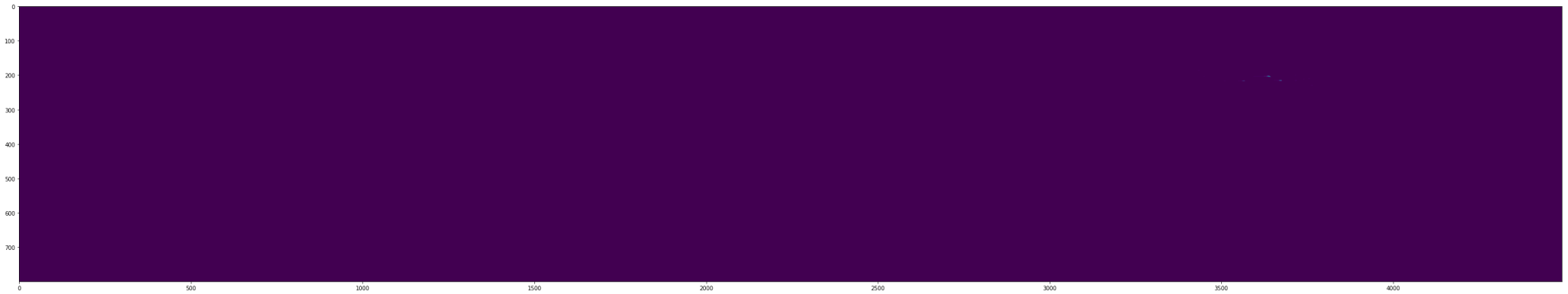
Noised event



Denoised event



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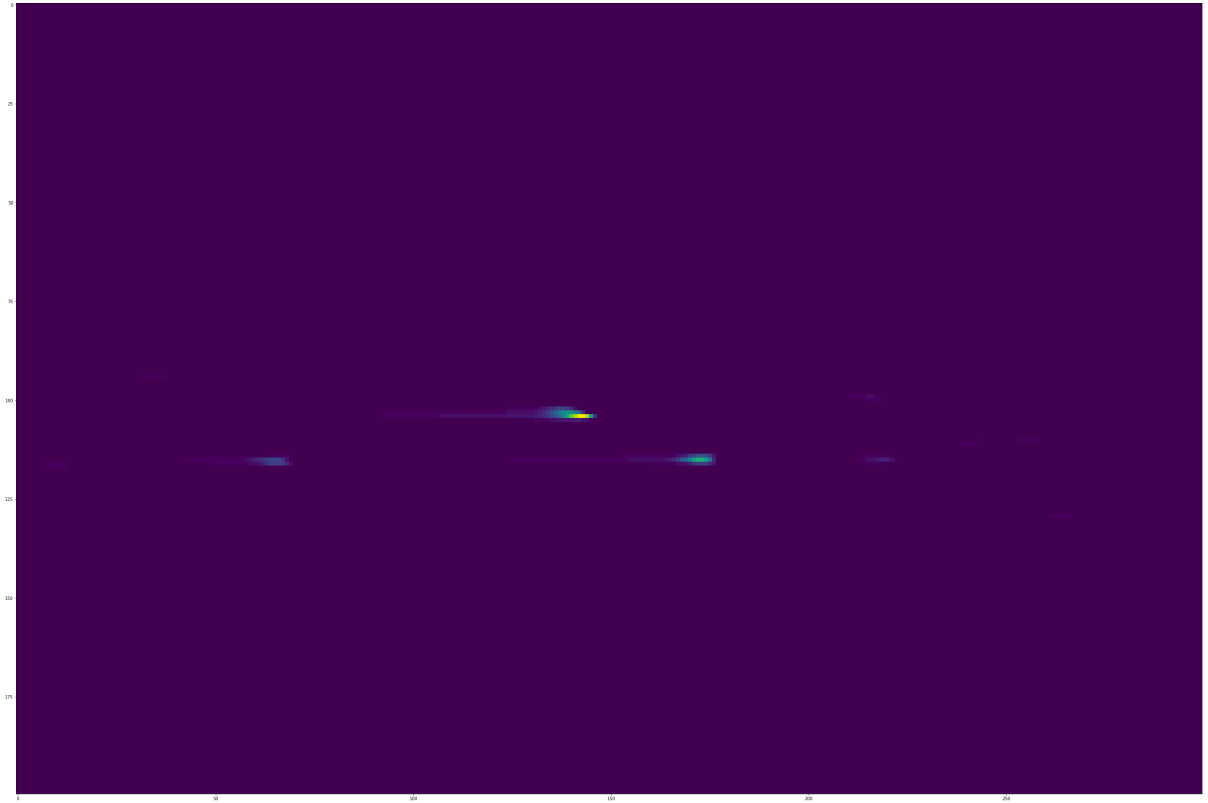

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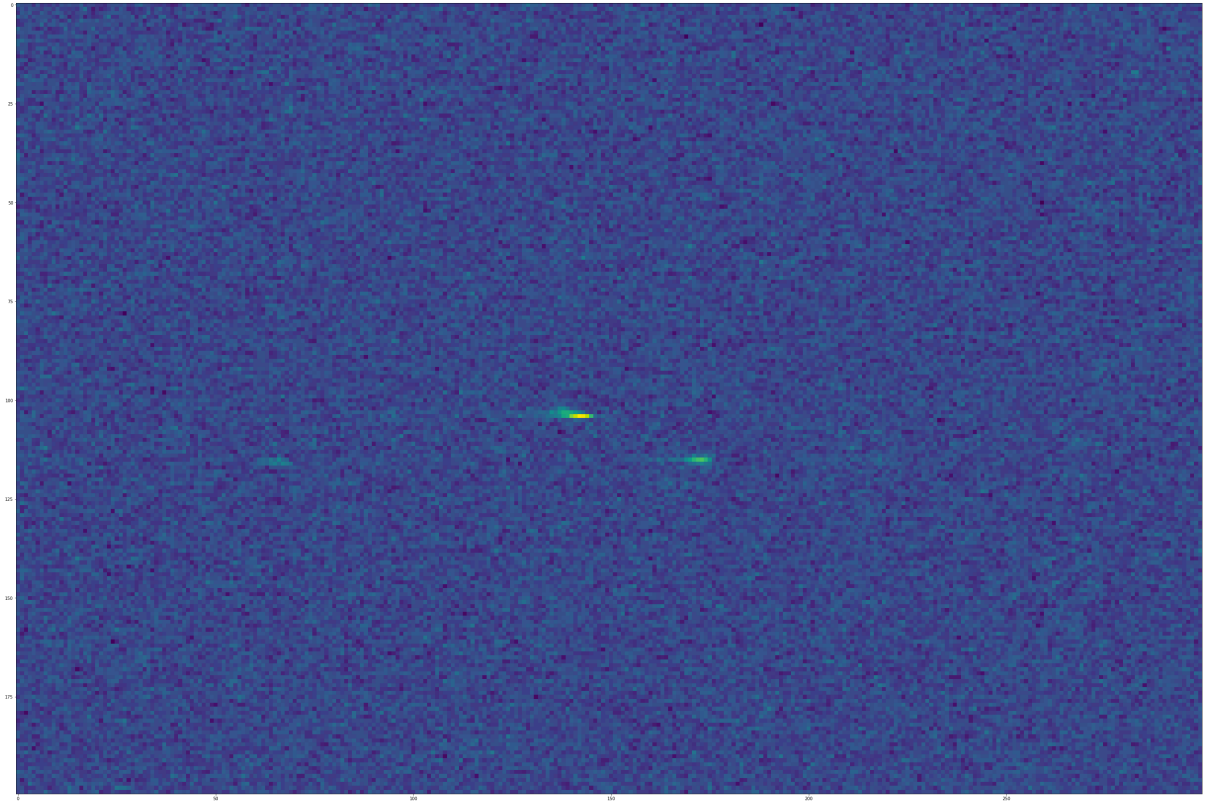

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Summary

protoDUNE experiment

- Implemented the general model on Pytorch (DL framework) from scratch
- Proposed new perceptual loss to stabilize the training
- Developed a new approach to process high-resolution images

- The general model can be used to imitate the whole preprocessing step
- The whole general model implemented as a matrix-multiplication sequence, thus making it easy to replicate it to the FPGA

Future work

protoDUNE experiment

- Optimize and tune the model the model for the speed/quality efficiency
- Compare performance to the simple CNN baseline
- Merge all the preprocessing steps into one model
- Transfer it to the FPGA

QUESTIONS?

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