



Sparse Segmentation for Particle ID in ProtoDUNE

Carlos Sarasty Segura

19th June 2020

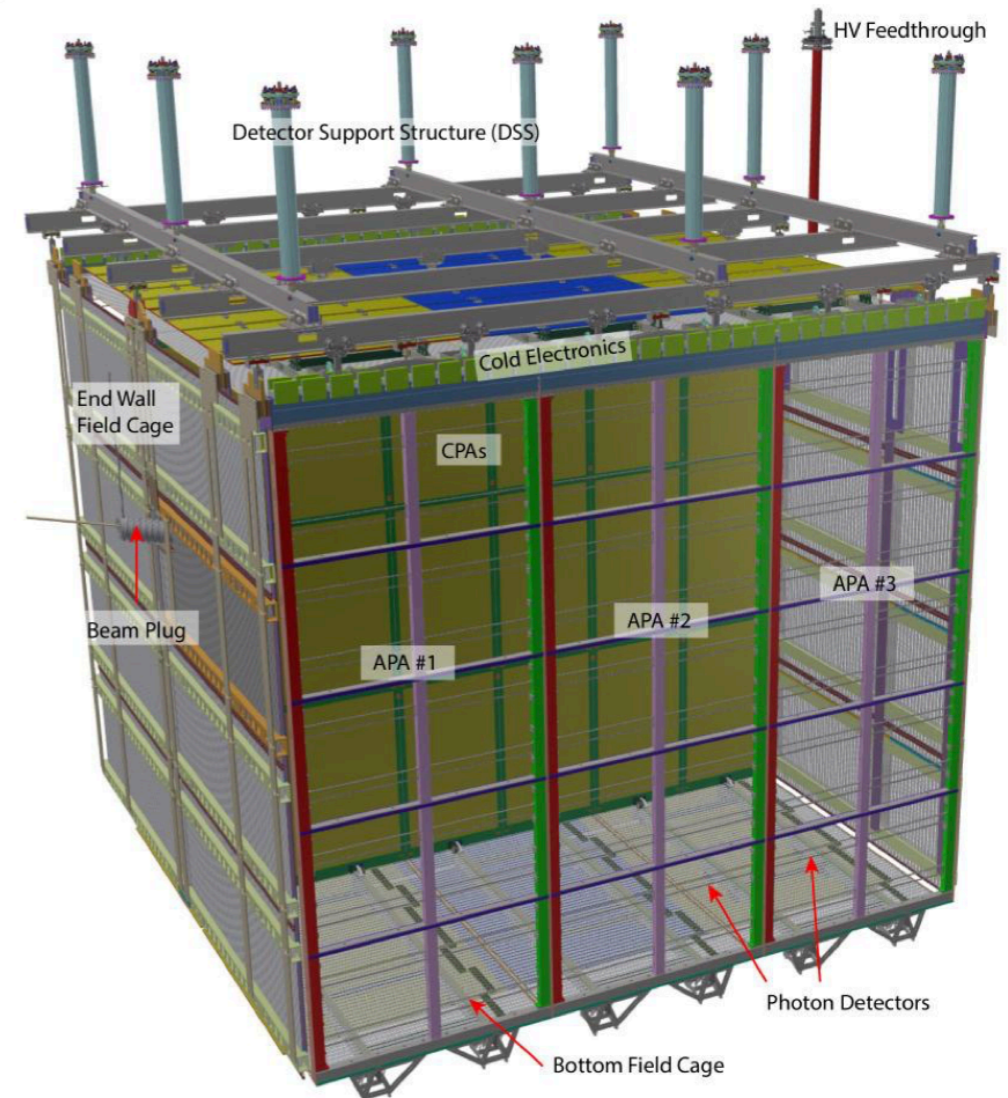
NPML workshop: lightning talks

Outline

- The ProtoDUNE-SP Detector
- Definition of the ground truth
- Training
- Summary

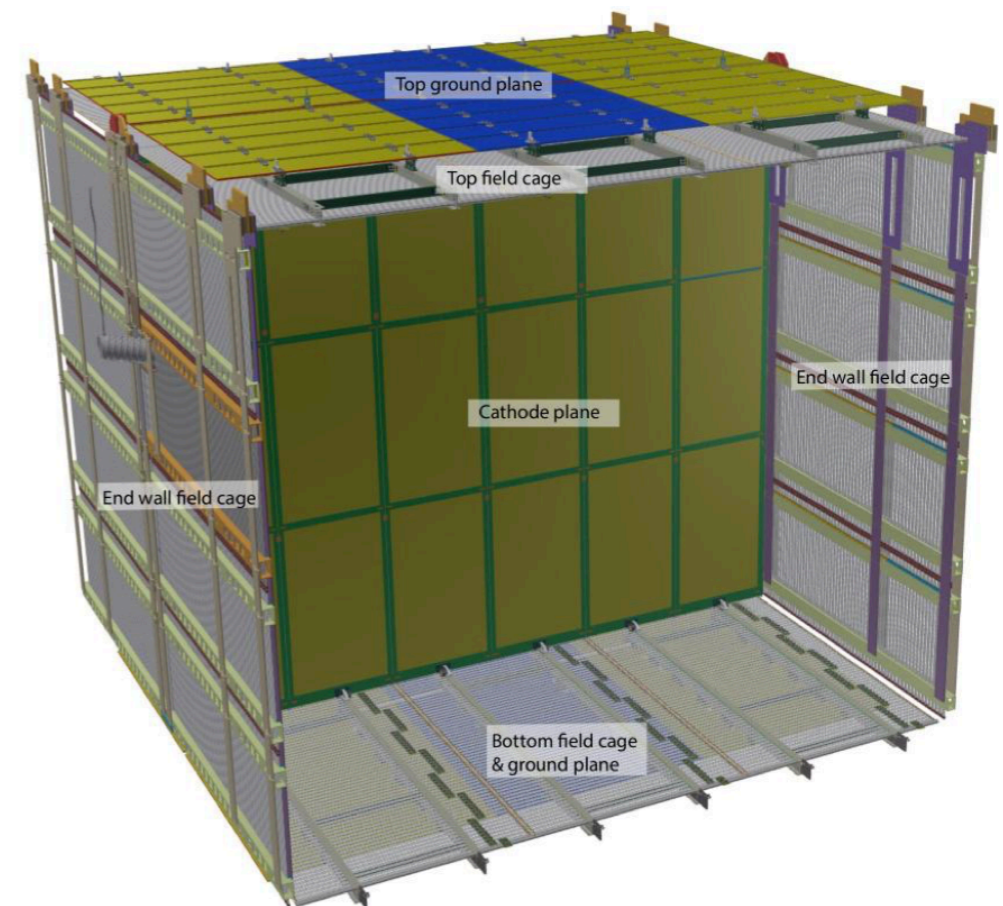
The ProtoDUNE-SP Detector

- Is the prototype of the DUNE Single Phase (SP) far detector technology
 - Full scale components
- Total liquid argon (LAr) mass of 0.77 kt
 - World largest LArTPC built to date using SP technology
- Exposed to a dedicated charge particle beam (0.3-7 GeV/c)
 - Similar momenta to those of particles produced in neutrino interactions at DUNE
- Currently exposed to cosmic rays



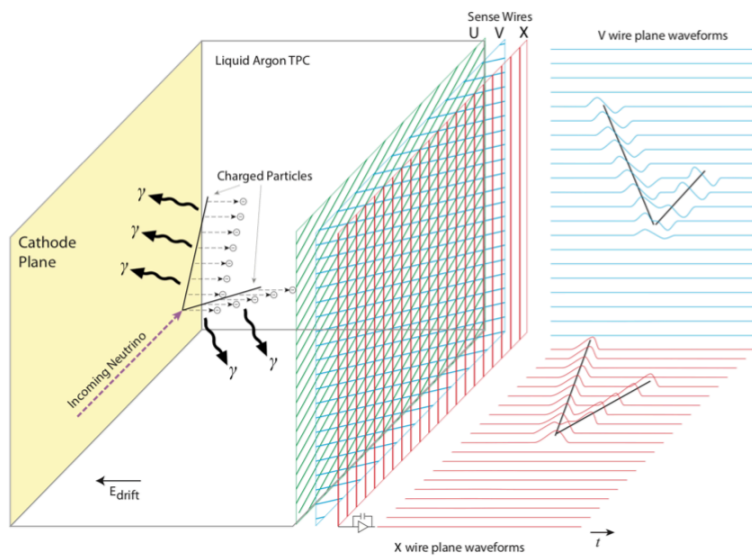
The ProtoDUNE-SP Detector

- Cathode Plane Assemblies (CPA)
 - Held at 180 kV
 - Provides an E field 500 V/cm in each of the 3.6 m drift regions
- 6 Anode Plane Assemblies (APA)
 - 6 m long x 2.5 m wide
 - 3 planes of sense wires/APA oriented at different angles
 - **15360** sense wires (99.74% active channels)
- Photon Detection System (PDS)
 - Light collecting bars read out by SiPMS installed in the APA frame (10 detectors/APA)
 - 3 different versions installed

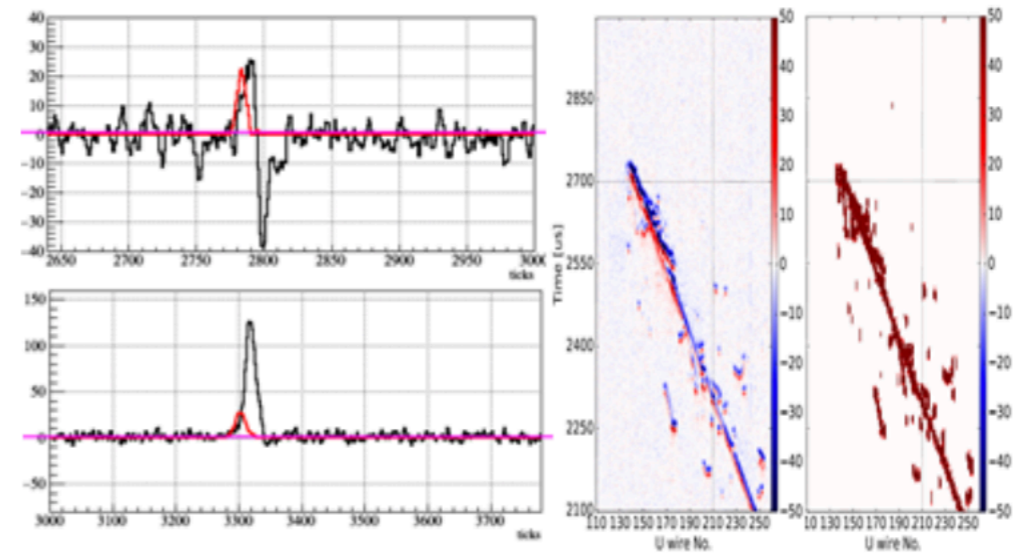


Overview of LArTPC Reconstruction

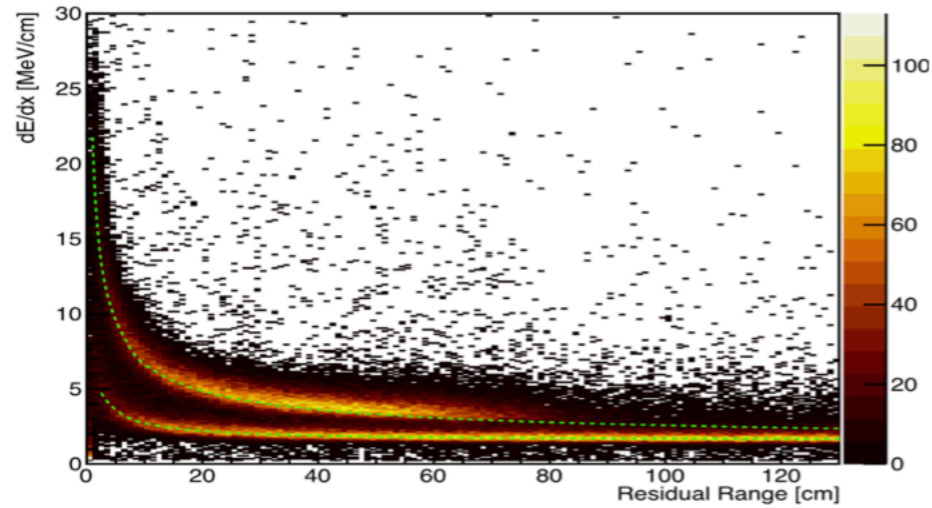
Signal Formation



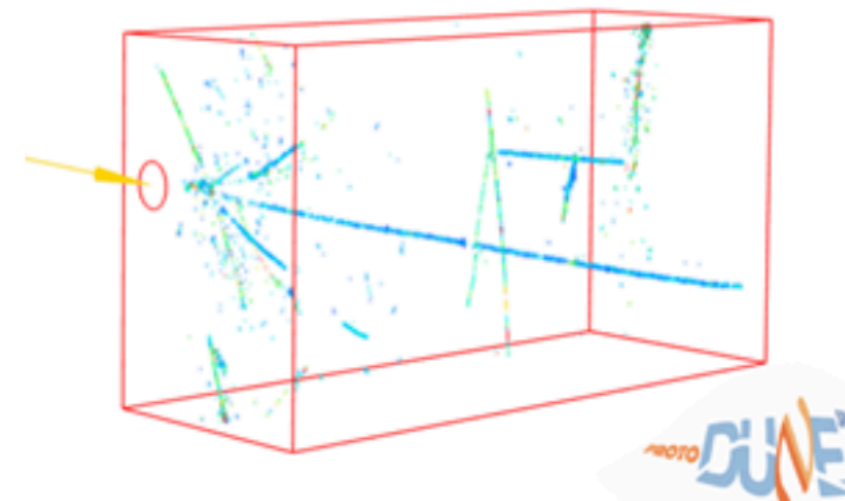
Noise Filtering & Signal Processing



Kinematic Reconstruction

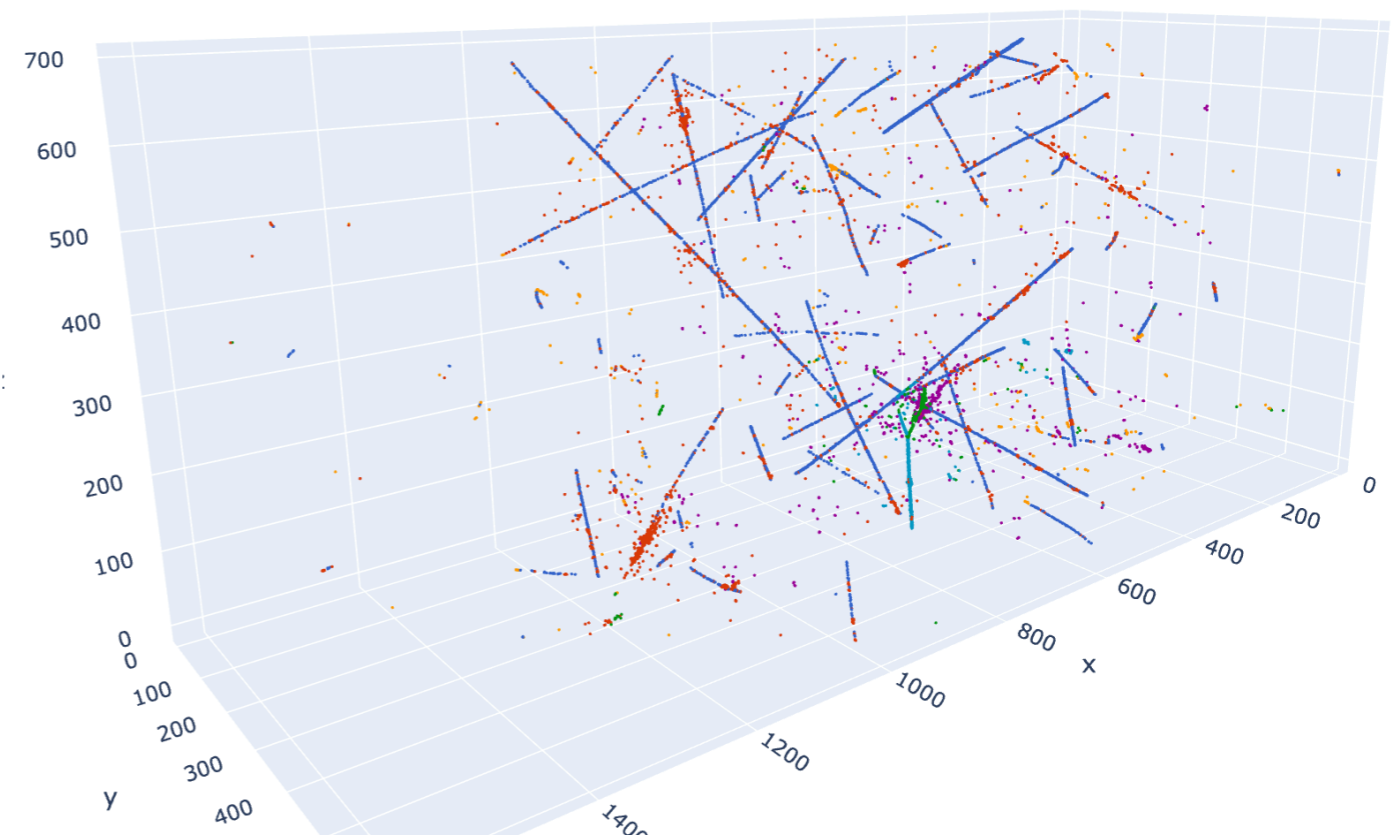
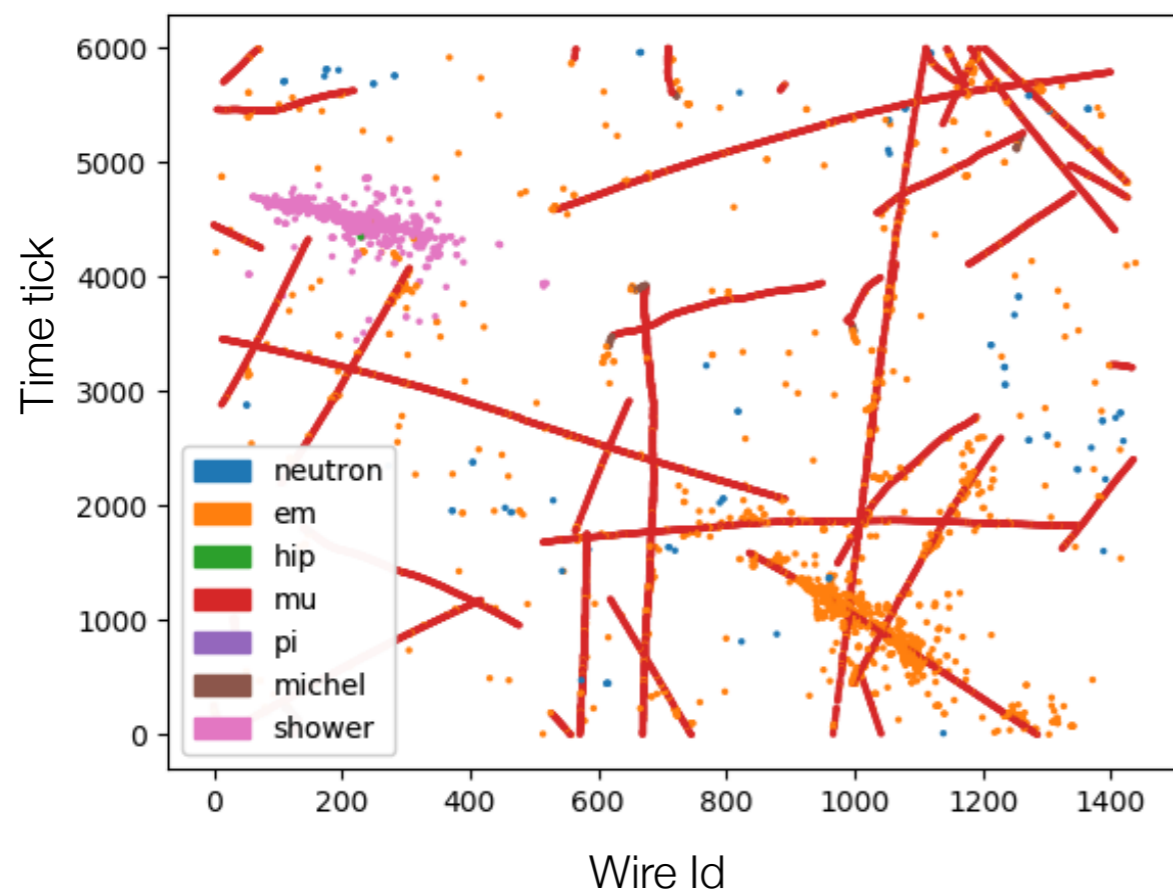


3D Reconstruction



Semantic Segmentation

- Apply sparse CNNs for the task of semantic segmentation at a pixel level in ProtoDUNE



Network Architecture

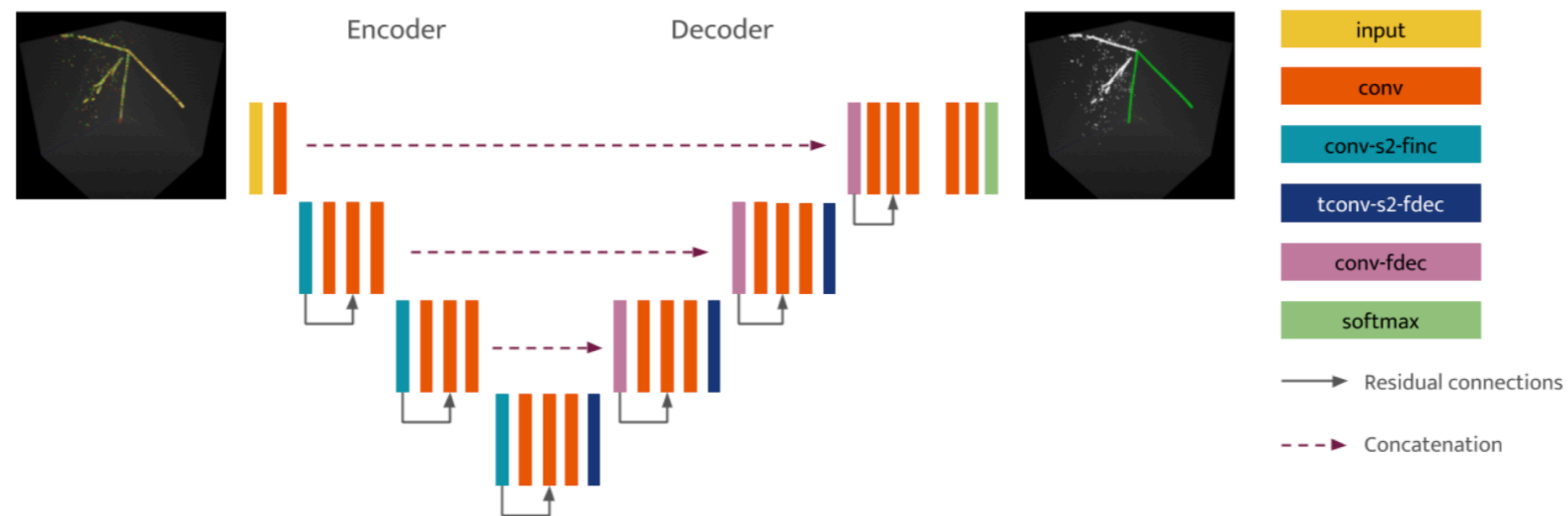


Figure from: [arXiv:1903.05663v3](https://arxiv.org/abs/1903.05663v3)

Check Ron's talk for details: [Using Sparse Convolutional Neural Networks in MicroBooNE](#)

- **U-ResNet** implementation for semantic segmentation
 - Down-sampling part: learn at multiple scales
 - Up-Sampling & Concatenate : Restore the original image resolution

Ground Truth

- Classify each pixel into 6 different classes for supervised learning
 - **Muons**
 - **Pions**
 - **HIP** → **Protons, kaons & nuclei**
 - **Showers**
 - **Michel electrons**
 - **Diffuse activity**
- Record the fraction of energy deposited by each class per pixel

Training in 3D

- **Features:**

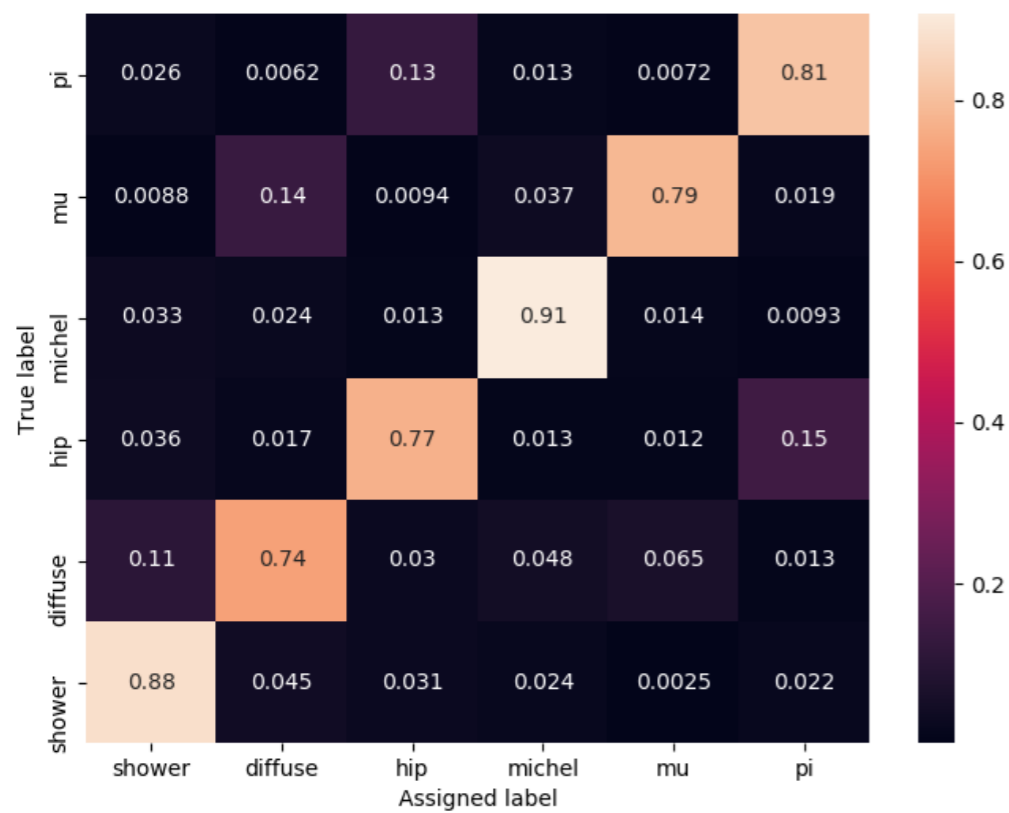
- **7** features (3 coordinates per hit, integrated charge per plane per voxel, number of hits per voxel)

- **Dataset**

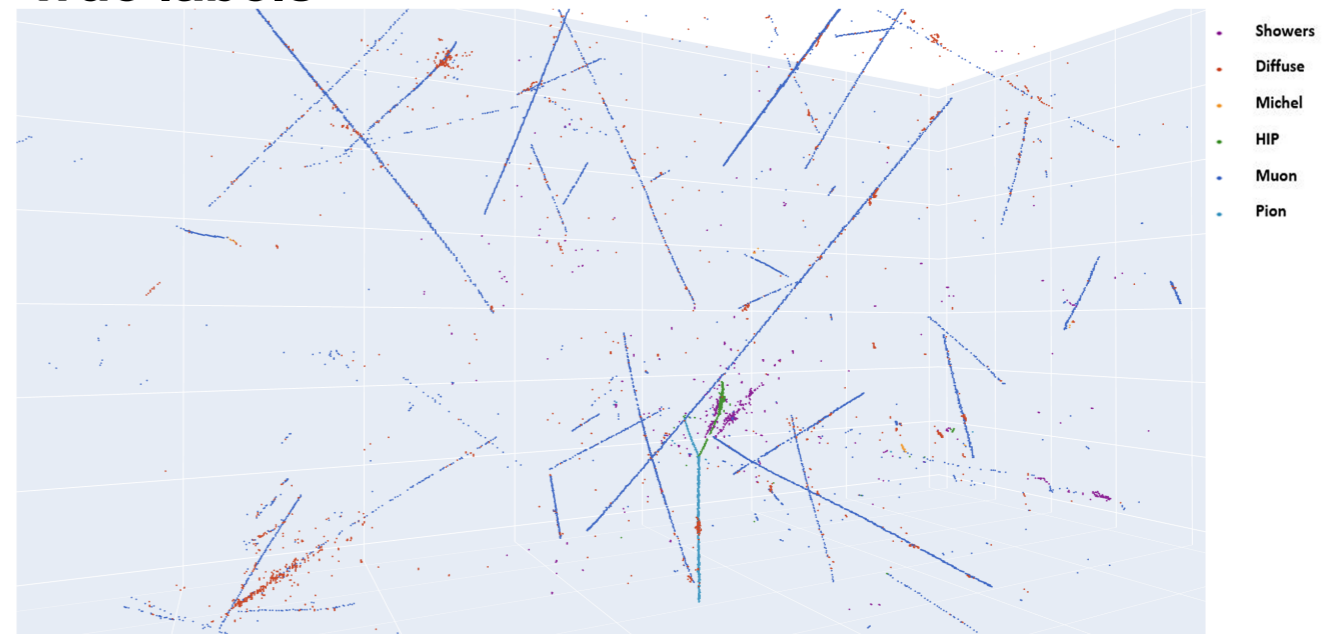
- Consist of 70k 3D event displays split into **95%** and **5%** for train and test respectively

Results

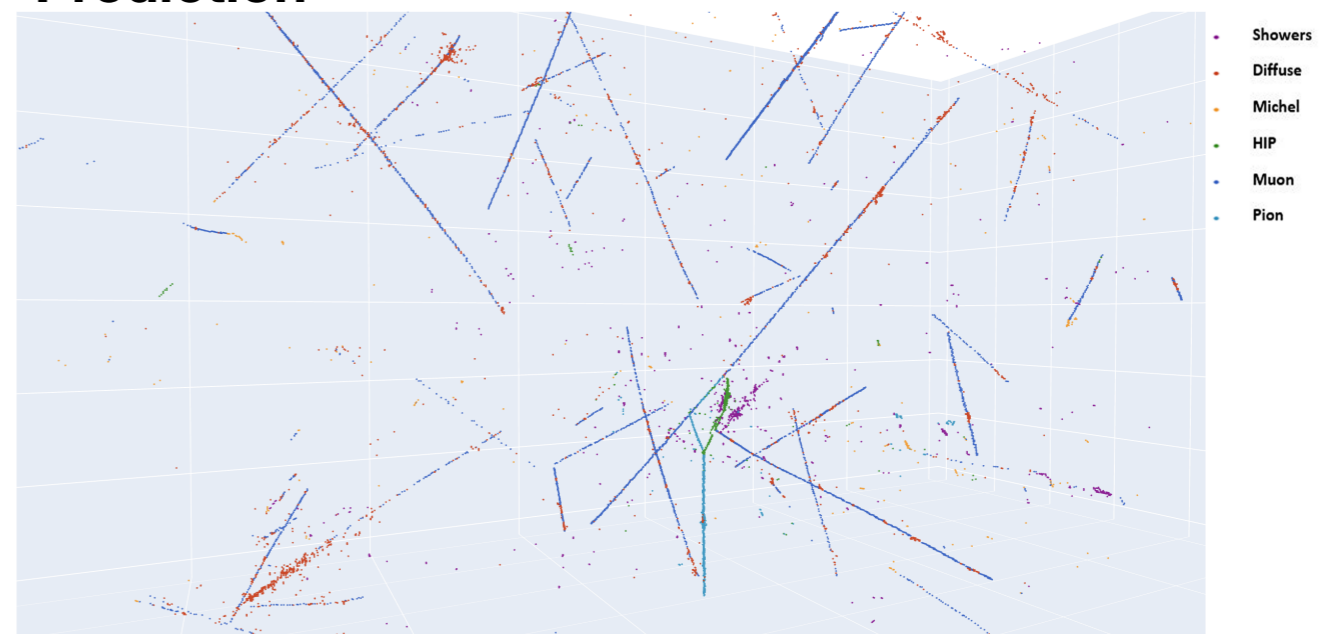
- We calculate the accuracy of each class



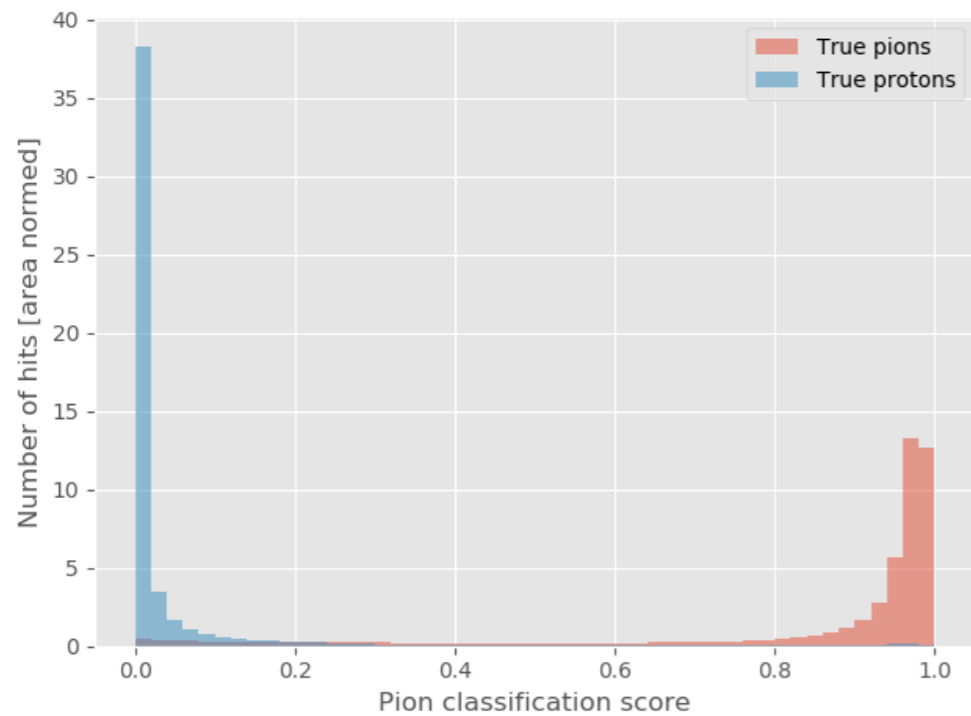
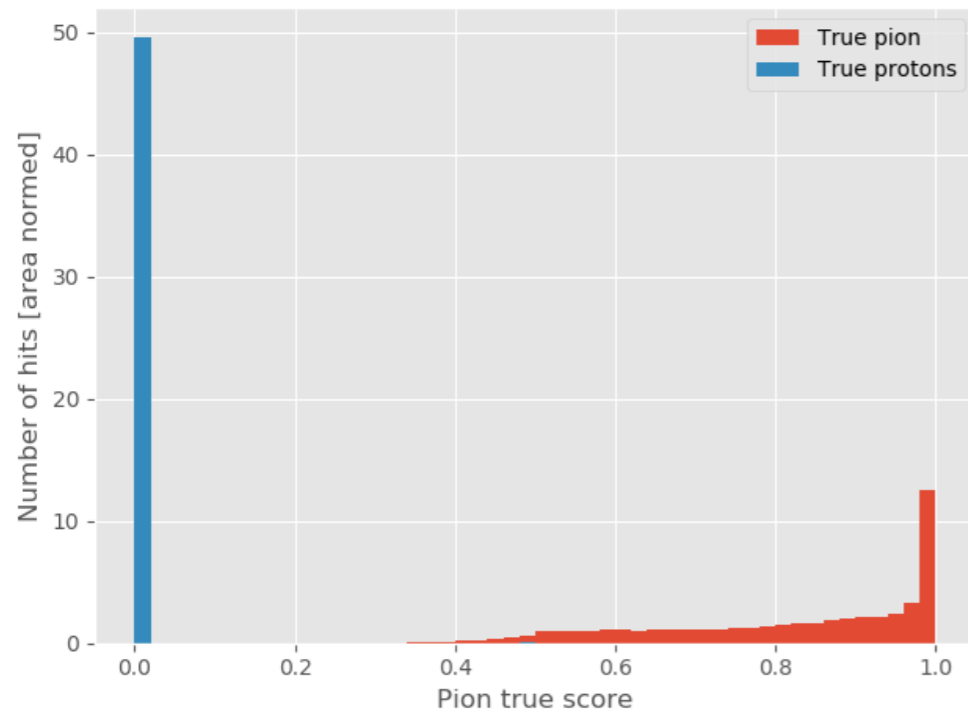
True labels



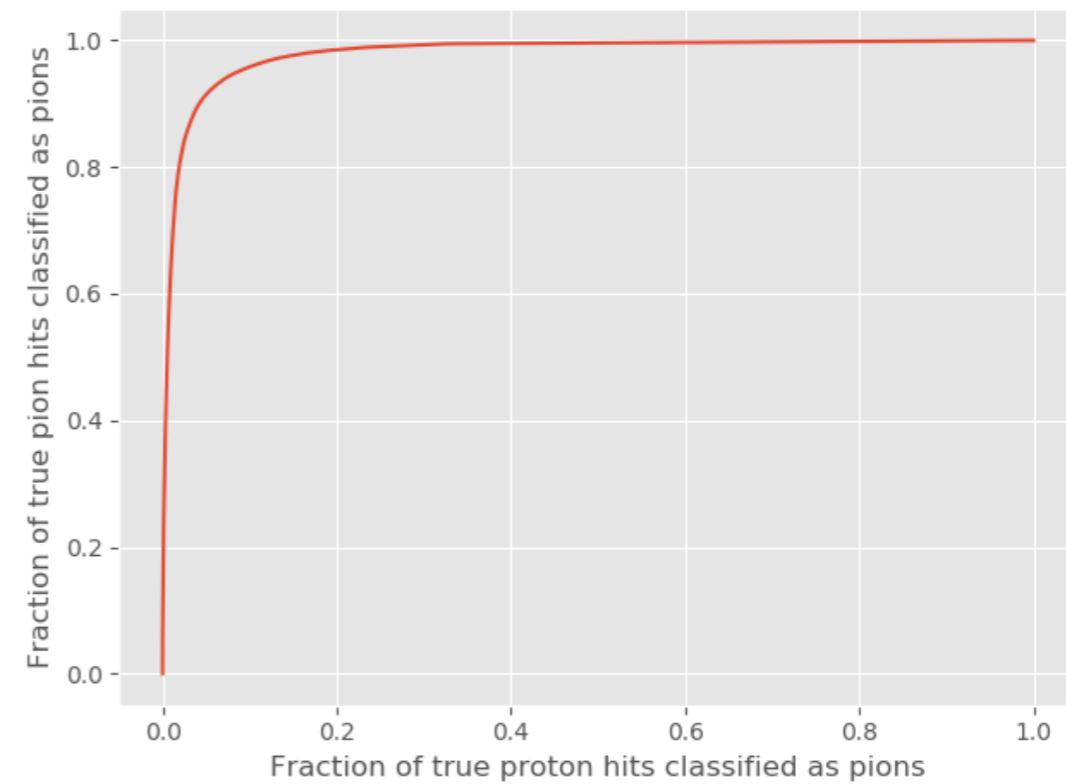
Prediction



Pion-Proton Separation



ROC curve



Summary and Future Plans

- These results show a very good performance of the network for the task of semantic segmentation at a pixel level.
- Pions can be well separated from protons using Deep Learning-based algorithms.
- Retrain the network using a single-particles dataset.
 - This dataset will use the refactored g4 simulation available in **LArSoft** which gives us valuable information of the shower daughters.
- Test the capability of the model for electron and photon separation as well as muon and pion separation.

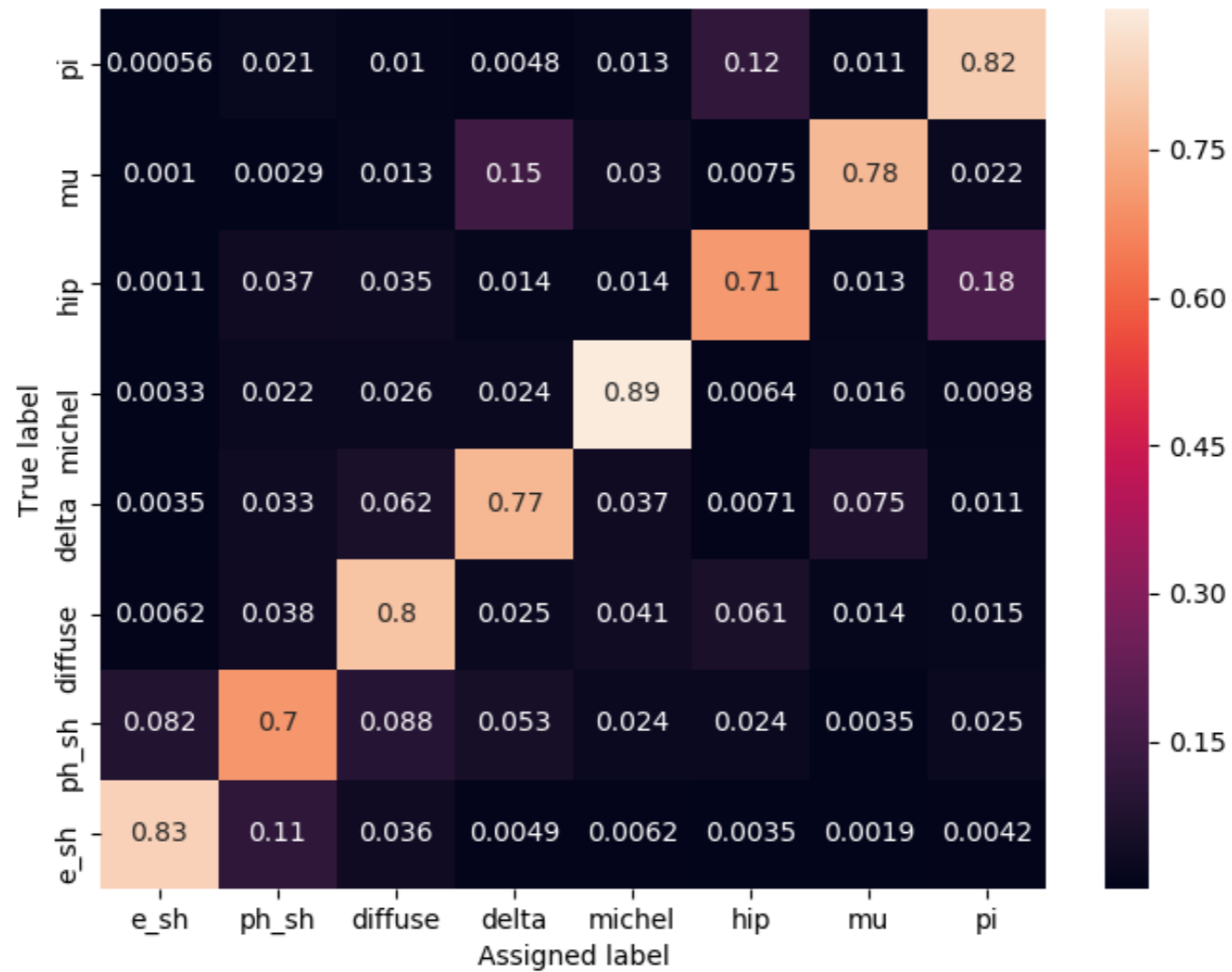
Summary and Future Plans

Comments and suggestion are
more than welcome

Thanks :)

Backup Slides

Results



Electron-Photon Separation

- **Preliminary** results of electron and photon separation

