



Deep Learning Based Reconstruction for DUNE

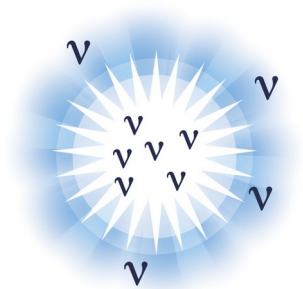
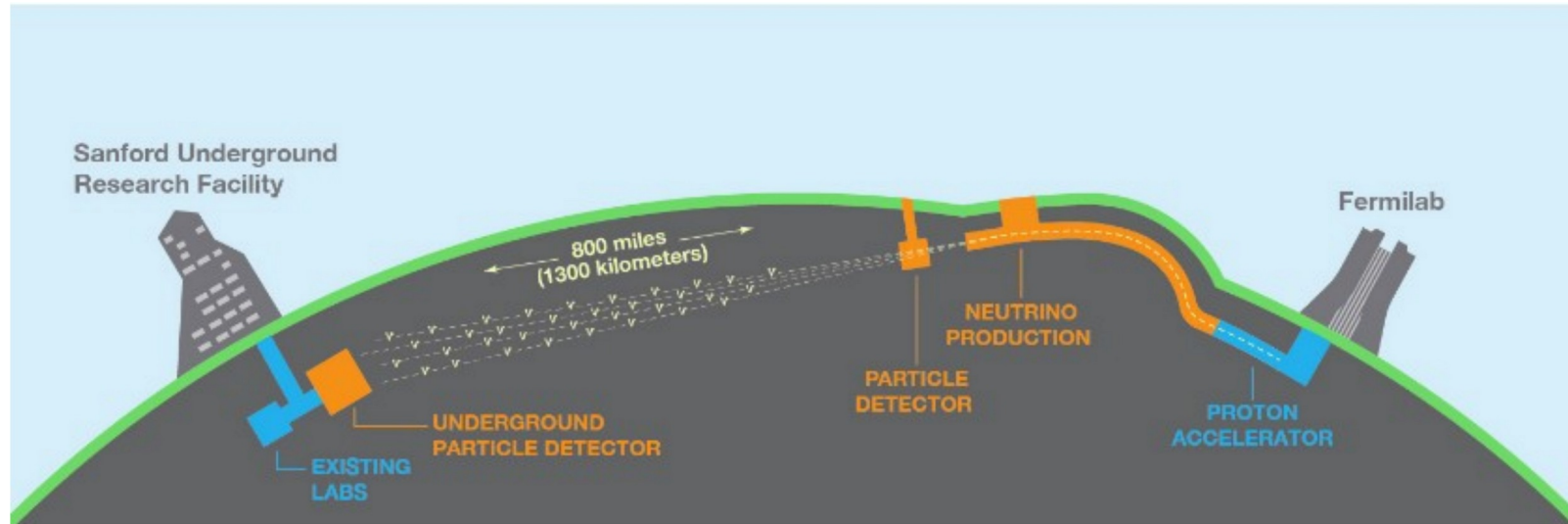
Marco Rossi, marco.rossi@cern.ch

Sofia Vallecorsa, sofia.vallecorsa@cern.ch

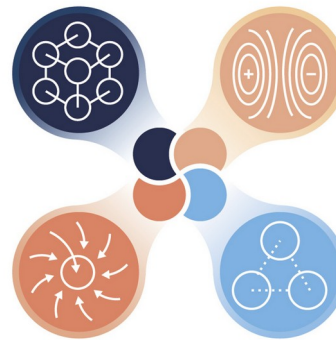
10/03/2021

DUNE

Deep Underground Neutrino Experiment, Fermilab (US), from 2026



Matter vs Anti-Matter



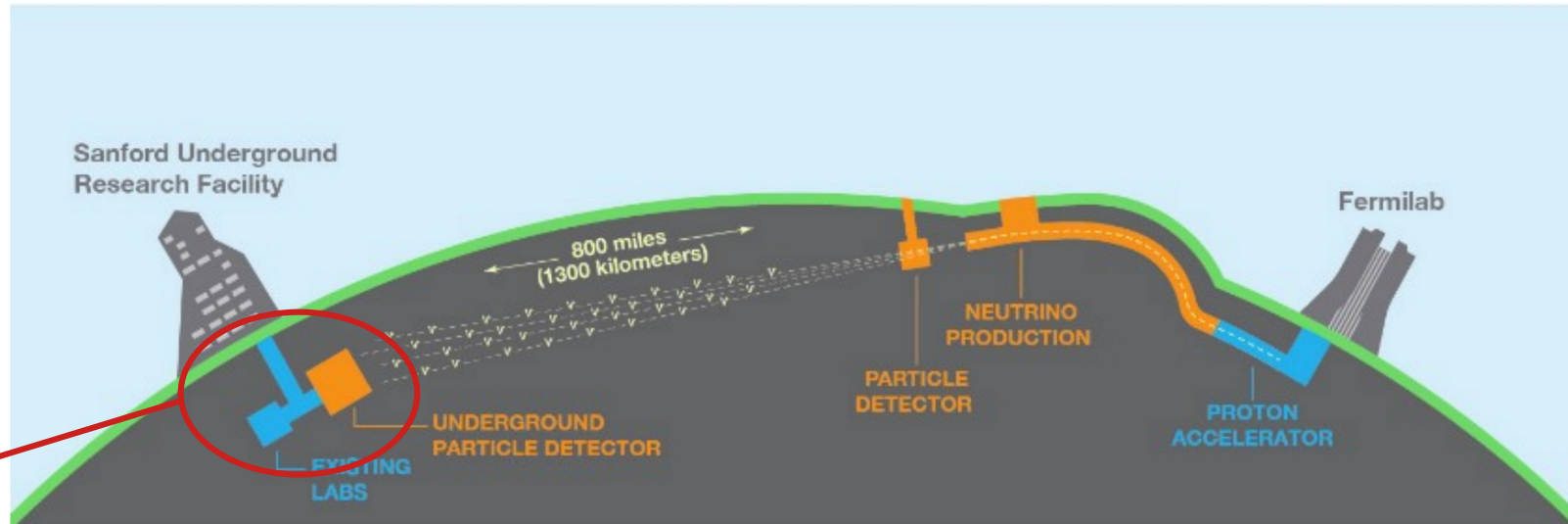
Unification of Forces



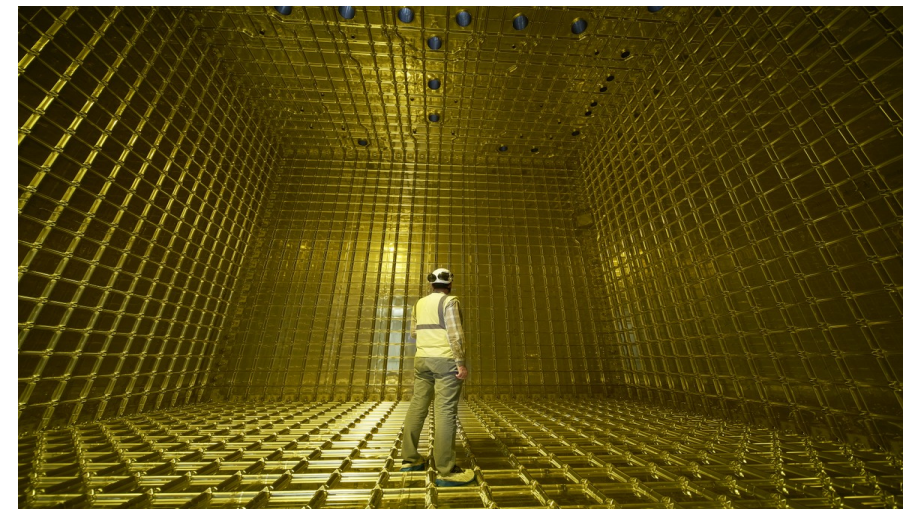
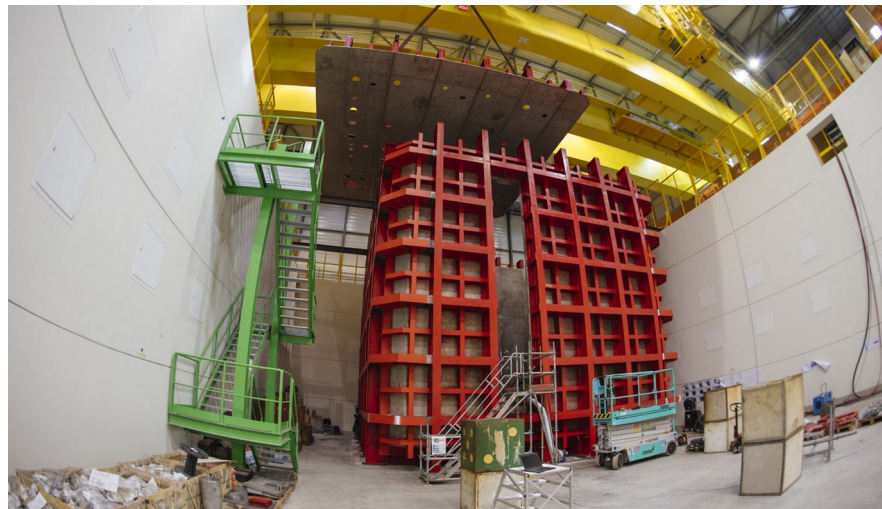
Black Hole Formation

DUNE

Deep Underground Neutrino Experiment, Fermilab (US), from 2026

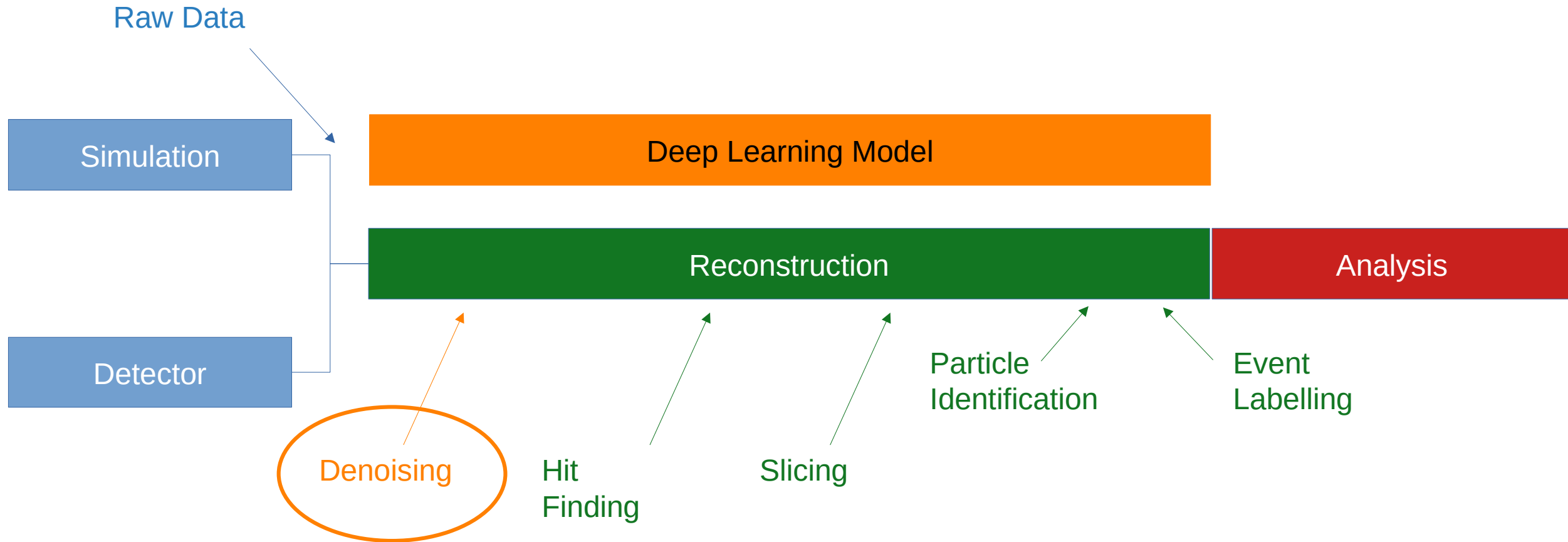


ProtoDUNE, CERN (CH),
From 2017



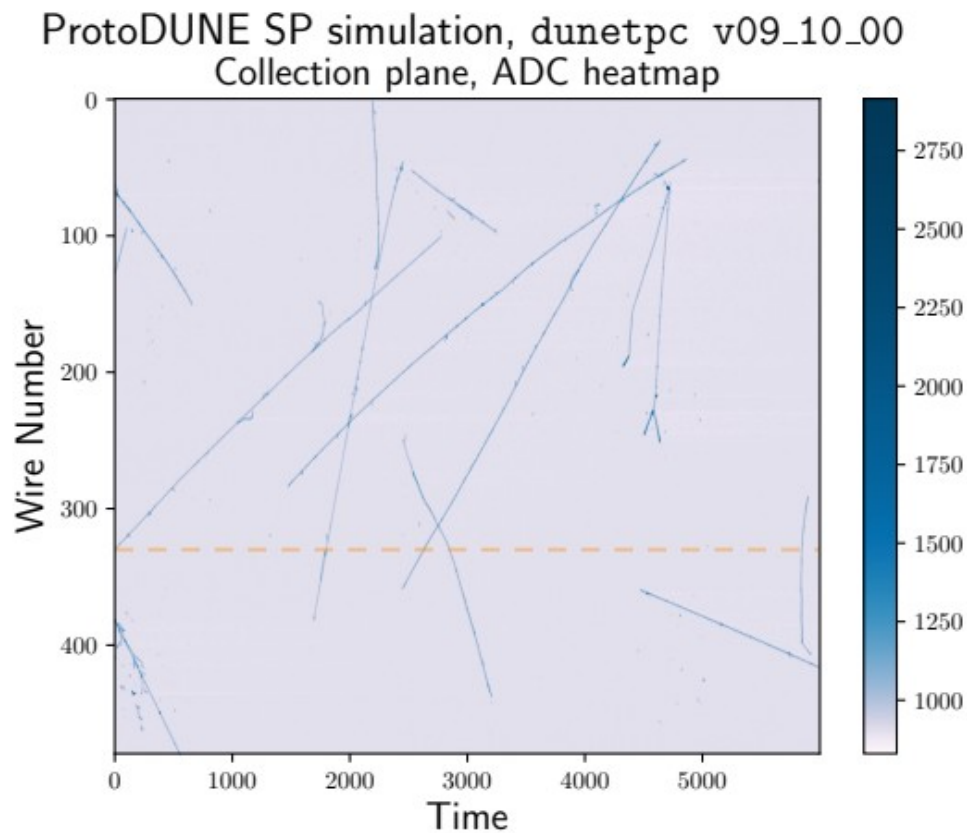
Offline Data Processing

Proposed Workflow

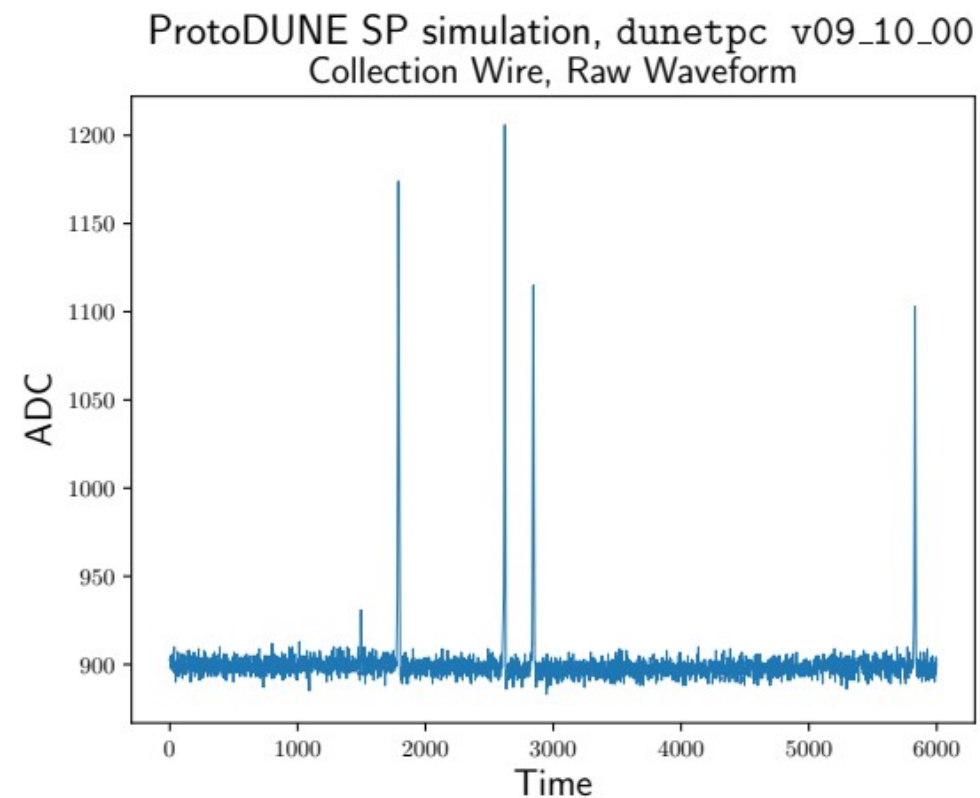


ProtoDUNE - Raw Data

2D Array



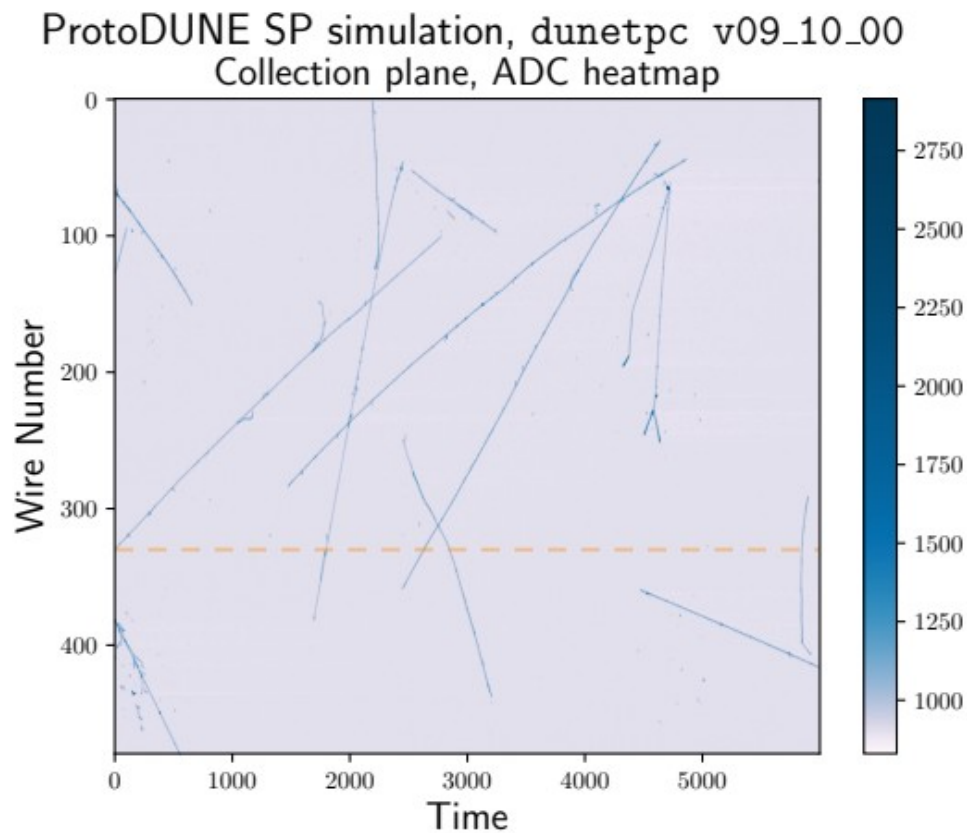
Noisy Waveform



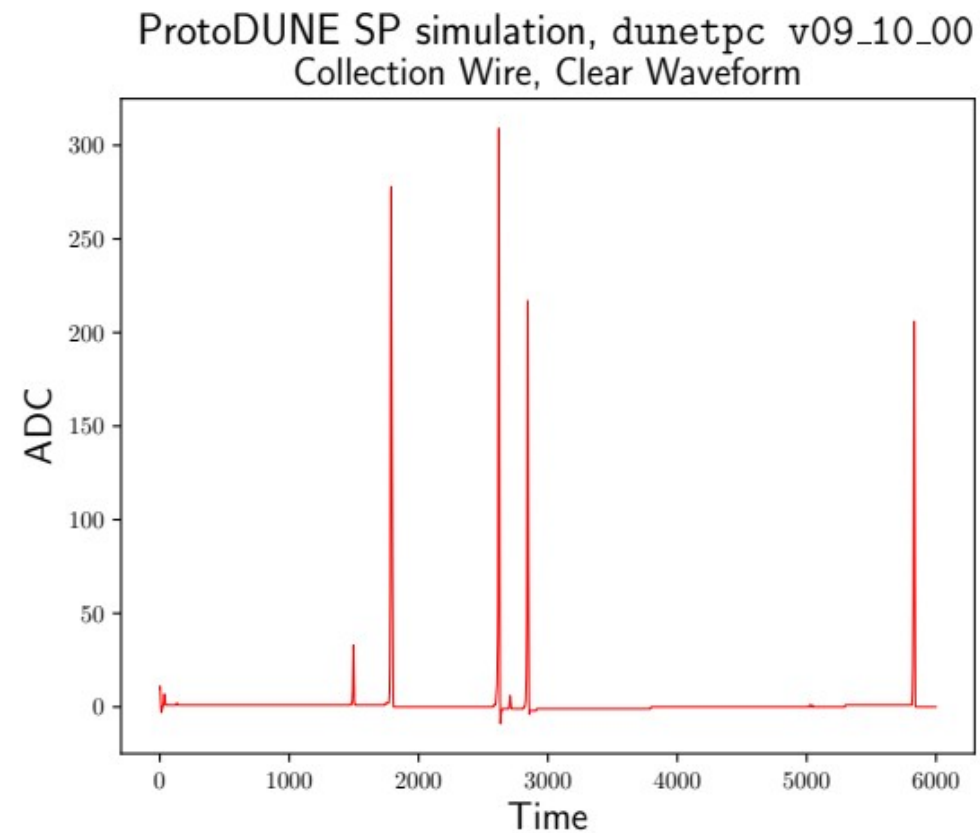
- High resolution
- Sparse features

ProtoDUNE - Raw Data

2D Array



Clear Waveform



- High resolution
- Sparse features

Model Overview

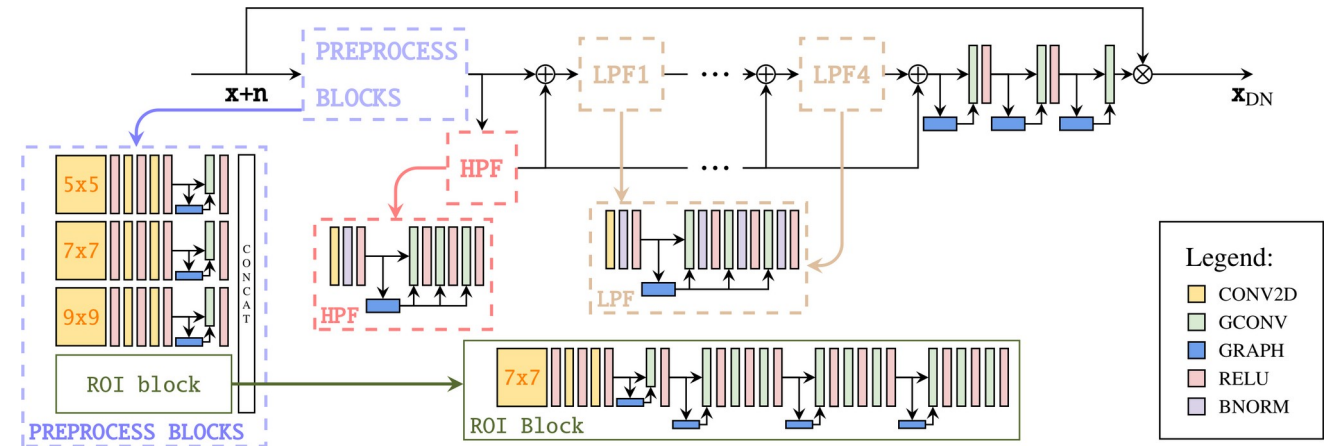
Reference: <https://arxiv.org/abs/2103.01596>

- Graph Convolutional Neural Network (GCNN)

Exploit Non-Local features

Data Parallel approach

Distributed Training (time scaling ?)

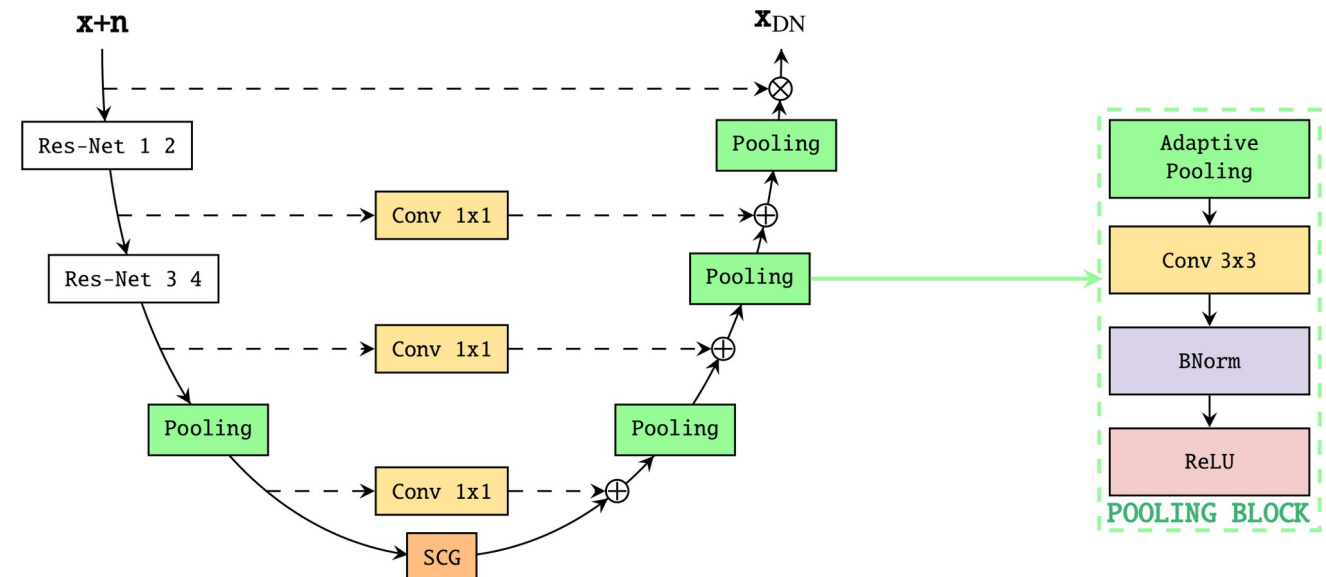


- U-Shape Self Constructing Graph Network (USCG-Net)

Downsampling – Upsampling branches

Process entire images (long range features)

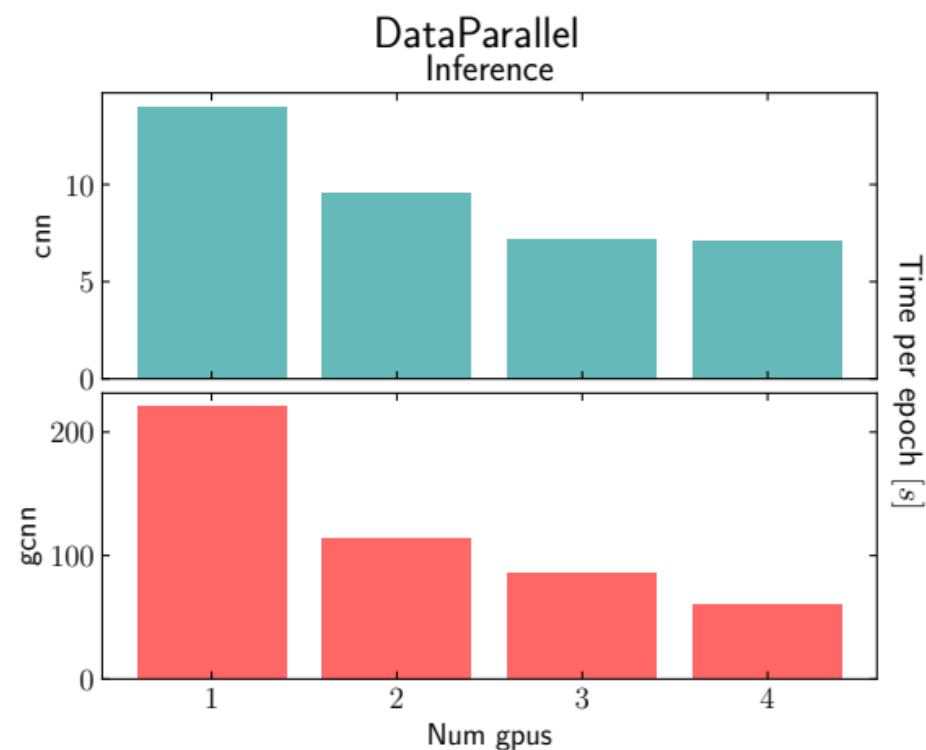
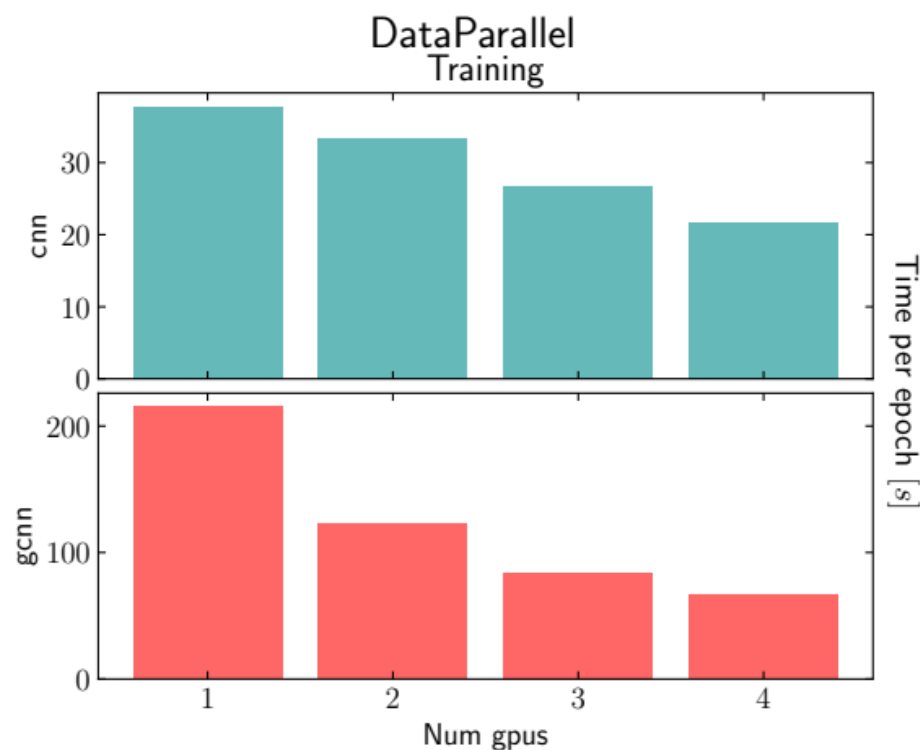
Faster inference



Layer Performance

IBM Minsky Power8 Cluster with WMLA

Multi GPU – Single Node - Single Process setup



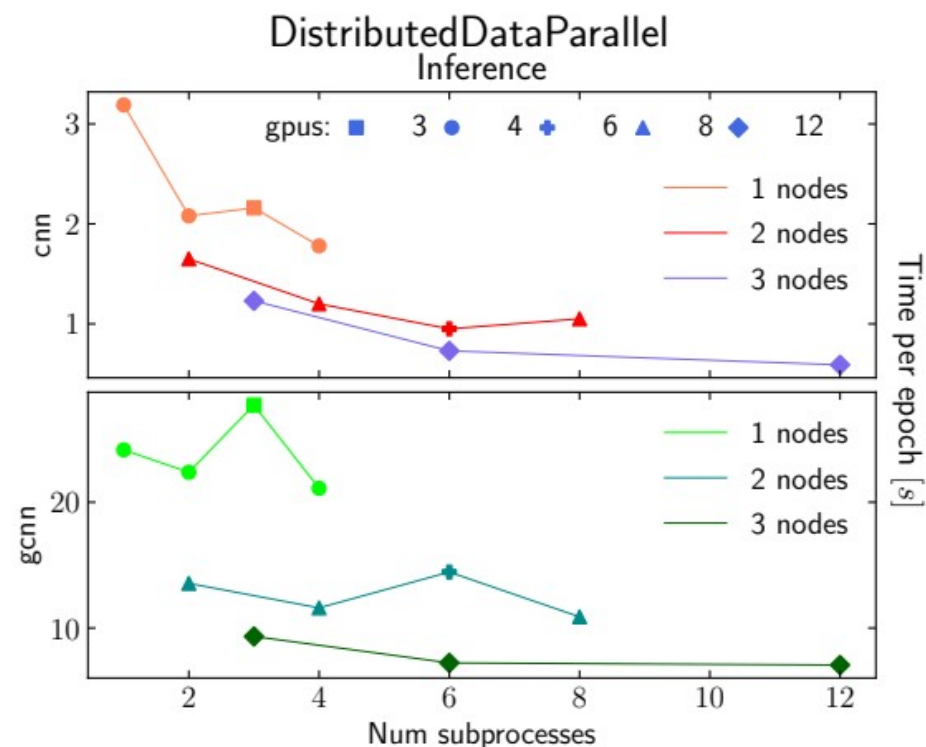
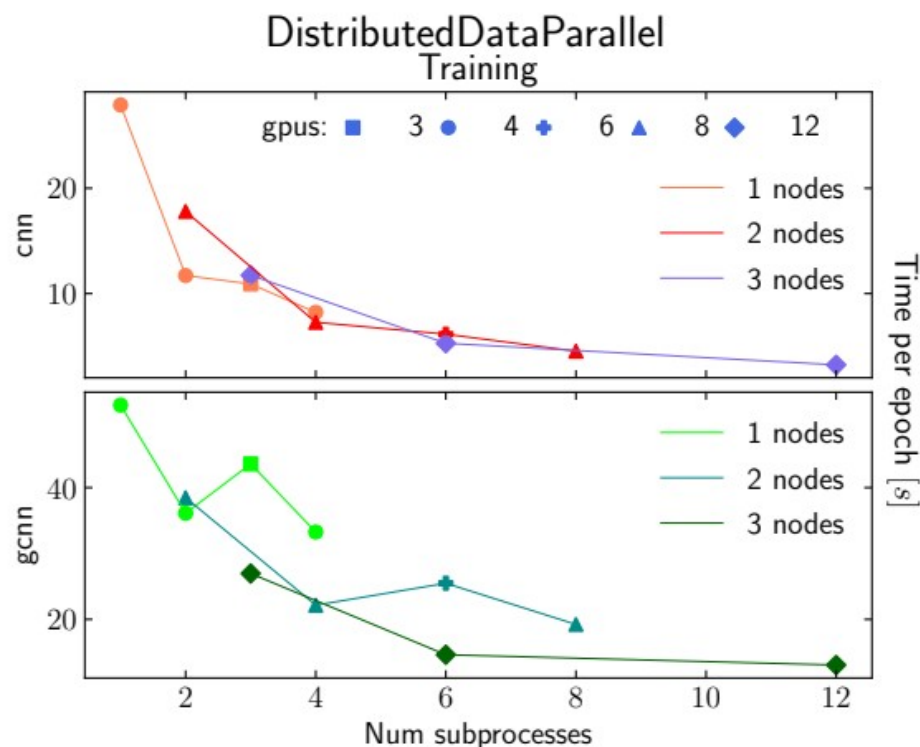
Algorithm splits the workload on the desired number of GPUs

Good scaling for both networks

Layer Performance

IBM Minsky Power8 Cluster with WMLA

Multi GPU – Multi Node - Multi Process setup



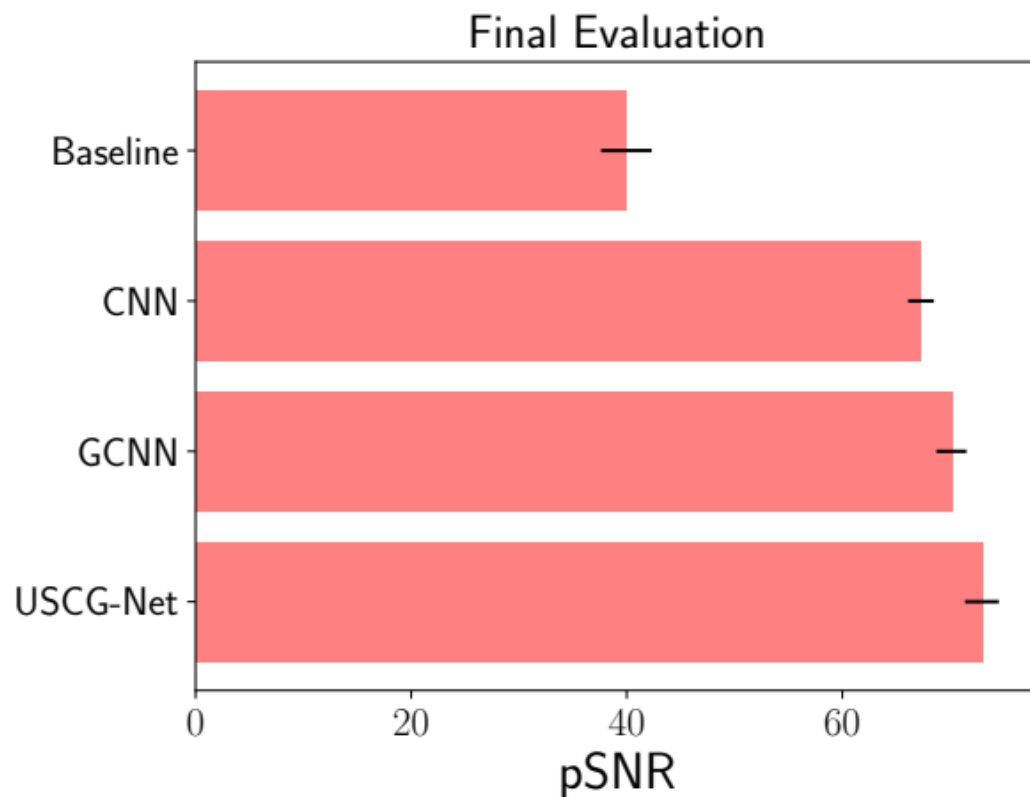
1 Ordering scheme rule of thumb

- 1 The more available GPUs, the better
- 2 The more subprocesses, the better

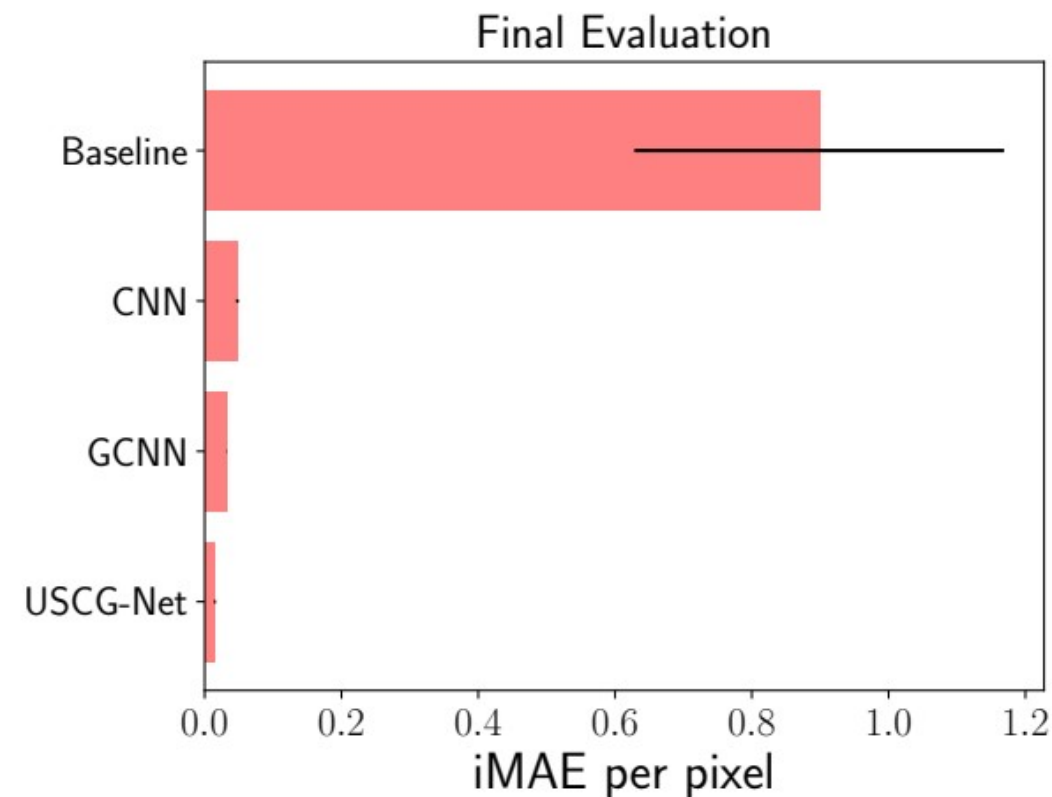
Results

Reference: <https://arxiv.org/abs/2103.01596>

Metrics that measure the precision of reconstructed (denoised) objects



The higher, the better !

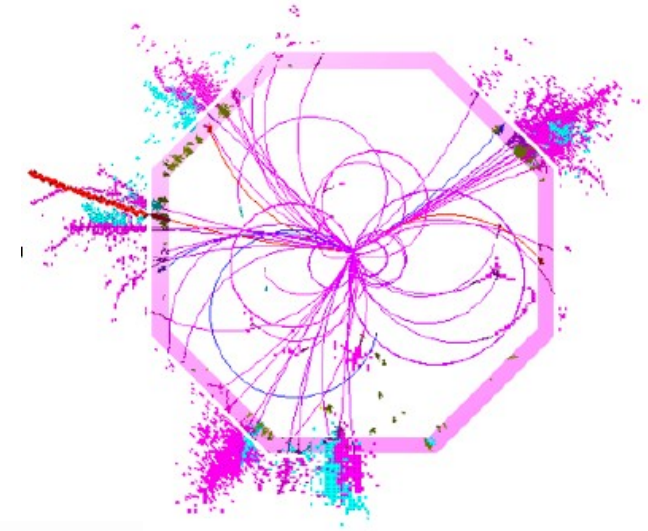


The lower, the better !

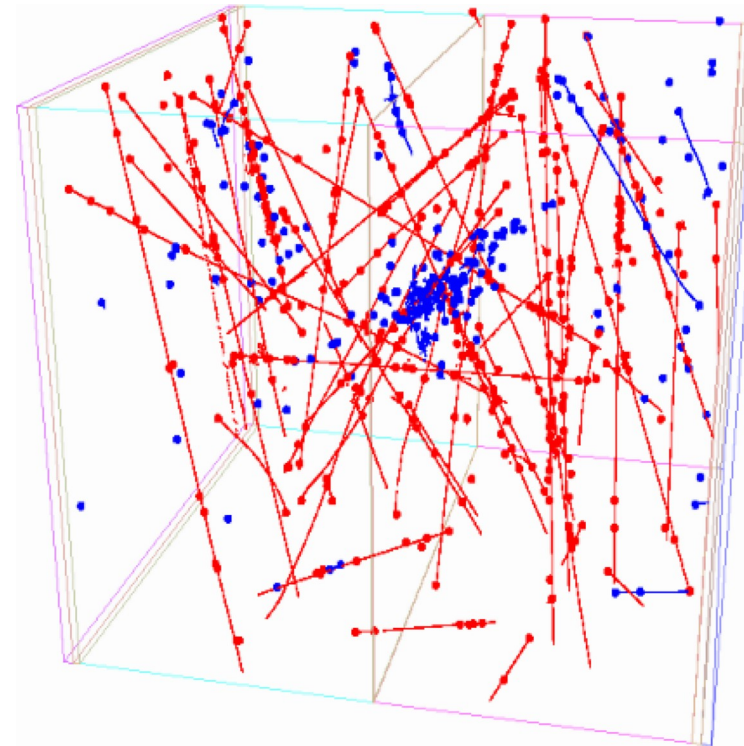
Networks outperform traditional baseline tool

Future Works

- Cooperate with Pandora UK team: Multi Experiment Reconstruction Toolkit
- References: <https://link.springer.com/article/10.1140/epjc/s10052-017-5481-6>
<https://github.com/PandoraPFA>



- Slicing problem: cluster detector hits based on the main **primary** interacting particle
- Number of cluster is unknown a priori





THANK YOU !

QUESTIONS?

Marco Rossi, marco.rossi@cern.ch

Sofia Vallecorsa, sofia.vallecorsa@cern.ch

Backup Slides

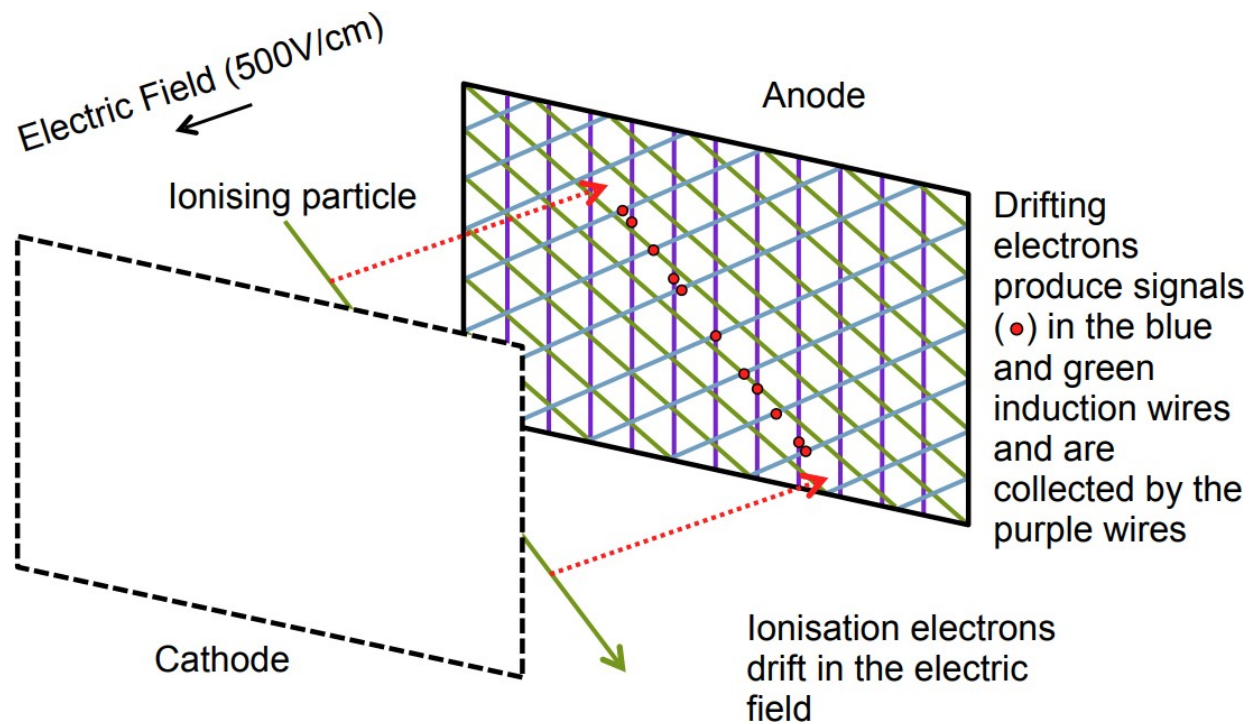
Detector - LArTPC

Liquid Argon Time Projection Chamber

Big box filled with liquid Argon (Ar)

Electronics shapes electron induced current

Plot Raw Digits as images (ADC counts on Time vs Wire)



GCNN Layer

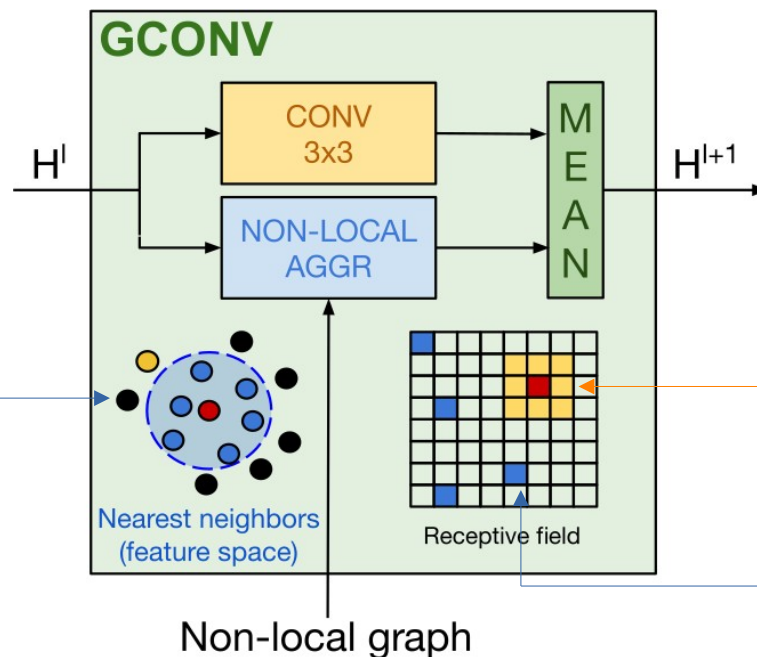
Reference: <https://arxiv.org/abs/1907.08448>

Non local graph:

Exploit long distance correlations

$k = 8$

Warning: Complexity order $O(n^2)$



Convolutional Filter (local)

Non local aggregator

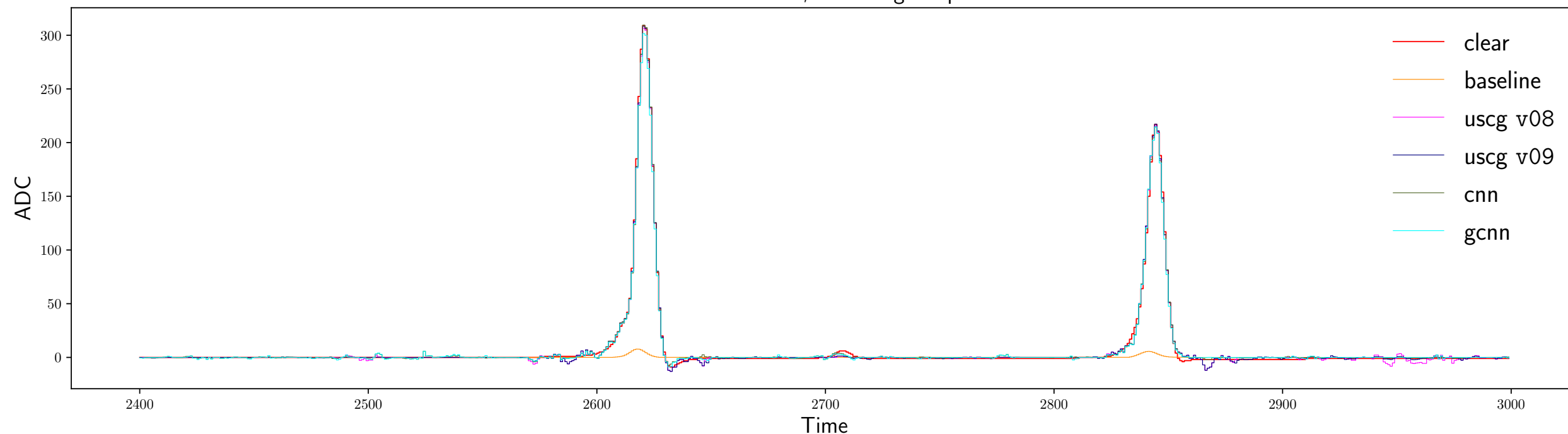
Increased complexity within layers

Distributed Training Scaling Assessment

Results

Reference: <https://arxiv.org/abs/2103.01596>

ProtoDUNE SP simulation, dunetpc v09_10_00
Collection Wire, Denoising Outputs



- Neural networks learn to shape exactly the clear waveform
- The traditional tool filters the waveform in Fourier space not preserving amplitudes