Slicing with DL models at ProtoDUNE-SP

Marco Rossi for the DUNE collaboration
CERN openlab, University of Milan

Slicing: ProtoDUNE-SP reconstruction step

- Particles interact inside LArTPC detector ionizing the liquid Argon
- Interacting particles leave traces reconstructed as 2D hits (position, energy)
- Slicing goal: partition detector hits based on main interacting particle
- Current method: Pandora[1]. Geometric approach, fit main tracks and showers

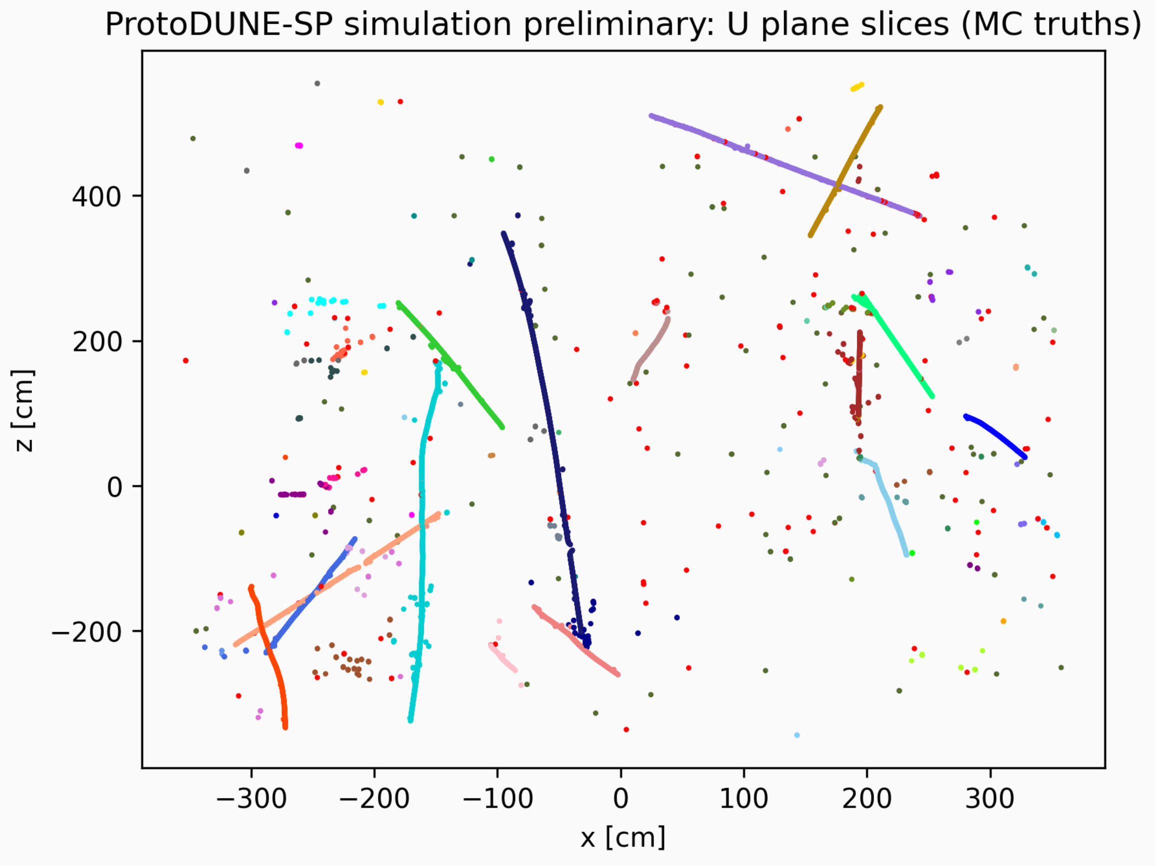


Figure 1: Cosmics + proton test beam event. 2D plane slices color coded (MC truths).

1

[1] Eur. Phys. J. C 78, 82 (2018), GitHub

Sub-clusters

- Sub-cluster products available from previous reco step.
- We can exploit them to build the final slices, even if splitting is not perfect.
- Neglect less interesting small sub-clusters (< 5 hits).

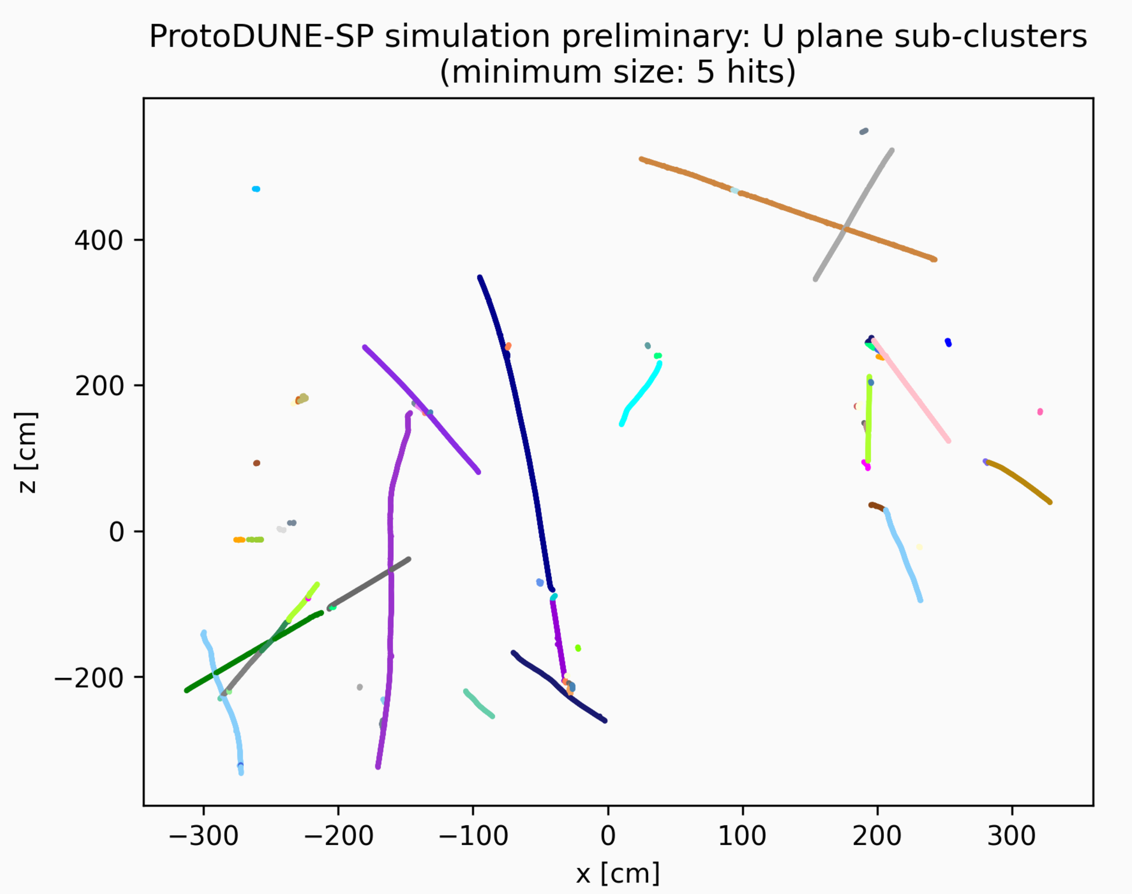


Figure 2: Cosmics + proton test beam event. 2D plane sub-clusters.

2

Our Approach: CM-Net

- Agglomerative clustering: decide to merge or not sub-clusters pairs.
- Train a neural network to do that.
- `Inputs:` extract features from each candidate clusters pair
- Inter-cluster features: end-points positions, mean hit energy, Pearson correlation coefficient ...
- Intra-cluster features: maximum hit distance, angle between sub-clusters linear fits direction ...
- `Outputs:` probability to merge or not the cluster pair.

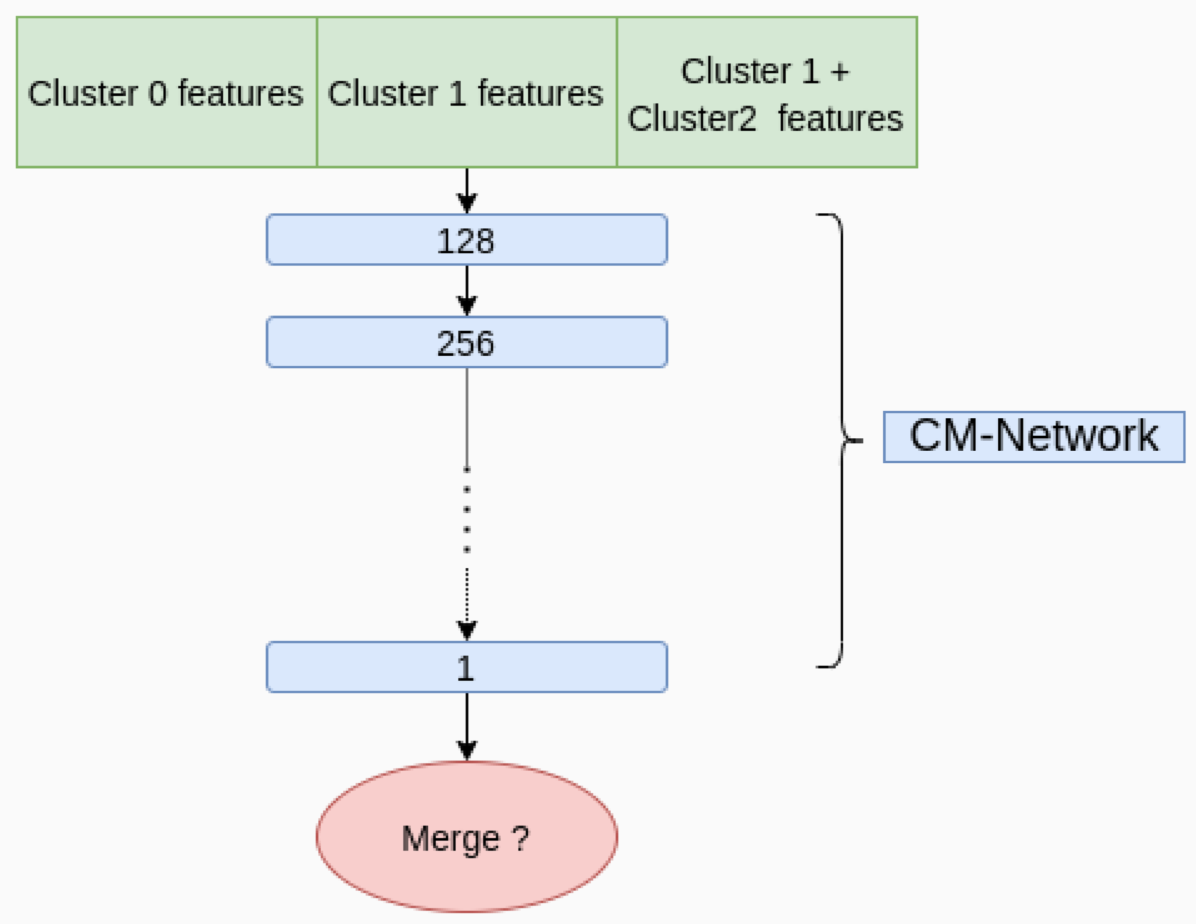


Figure 3: Cluster Merging Network

3

After training ...

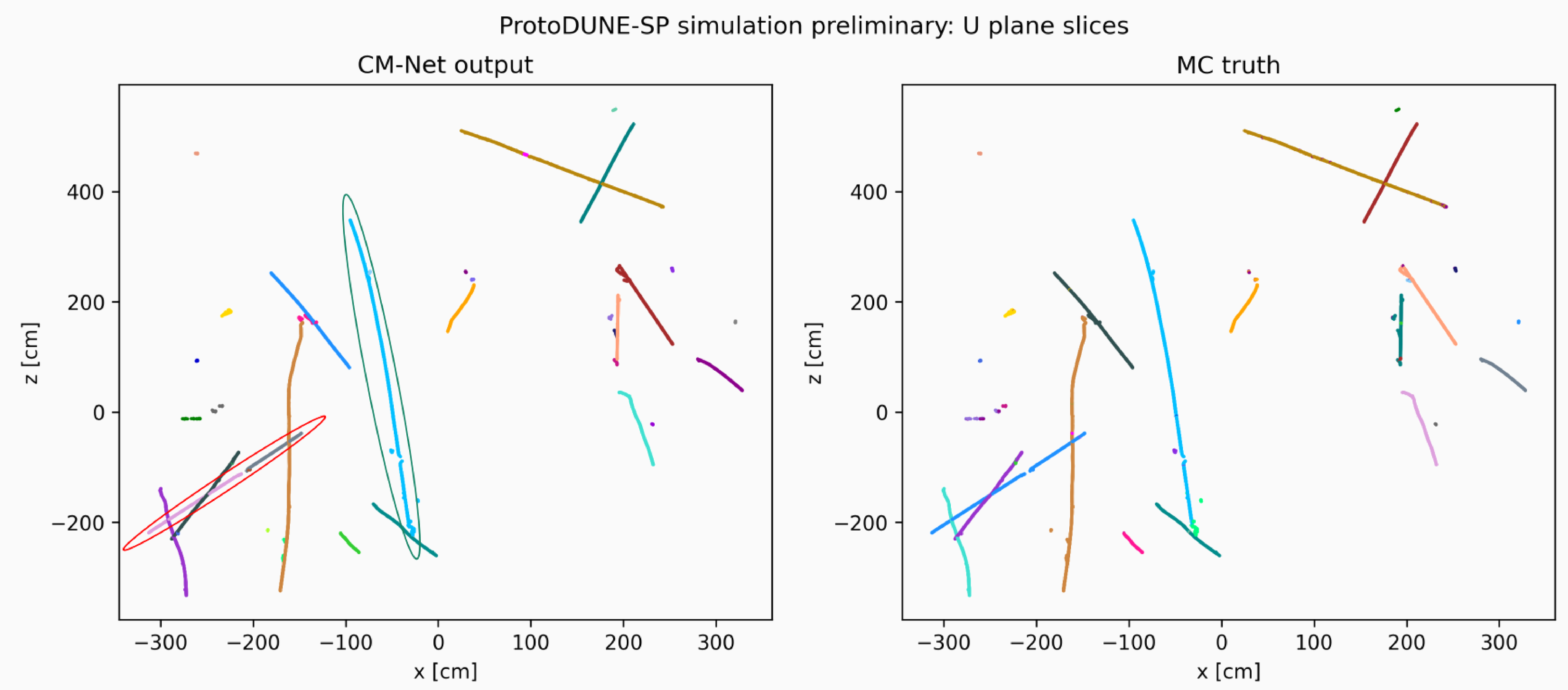


Figure 4: CM-Net, output visual example.

! CM-Net approach copes with the Pandora algorithm that builds sub-clusters.
We are not able to split two sub-clusters, just merge them !

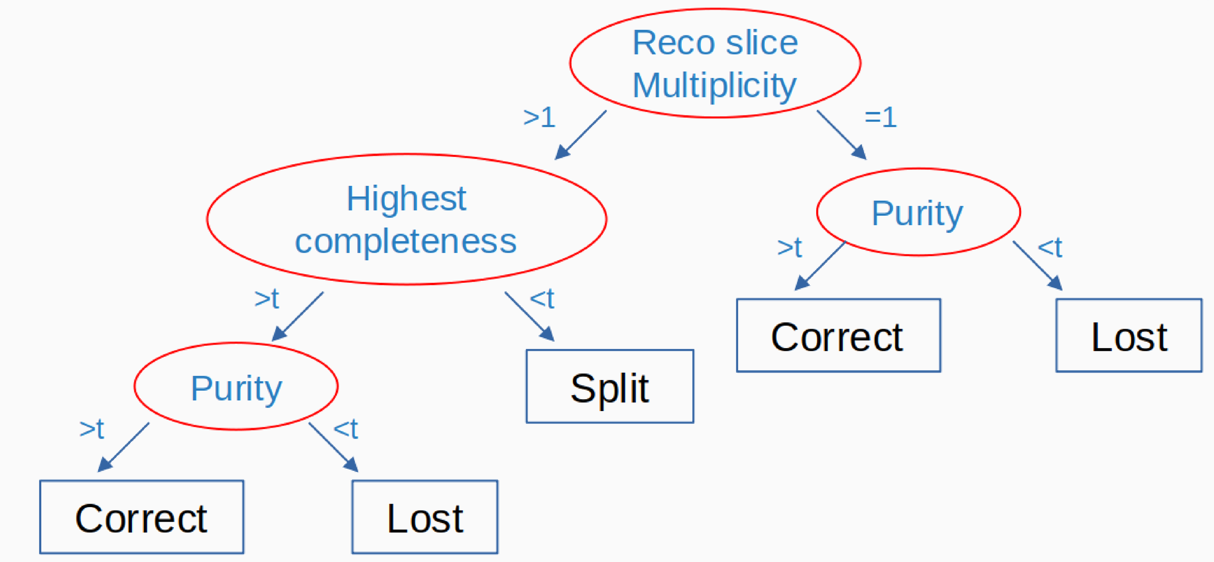
4

Assessing Test Beam Reconstruction

- It is important to correctly identify and separate the test beam (TB) component from the cosmic rays (CR) one.
- `Goal:` TB and CR slices should not overlap.
- How well does our approach discriminate between TB and CR?
- Use purity P and completeness C to mark each TB reconstructed slice.

$$P = \frac{\#hits^{TB}_{reco\,slice}}{\#hits^{CR}_{reco\,slice} + \#hits^{TB}_{reco\,slice}} \qquad C = \frac{\#hits^{TB}_{reco\,slice}}{\#hits^{TB}_{MC\,slice}}$$

- Set a threshold t, default value is $t = 0.9$
- Give a label to each MC TB slice



5

Benchmark

- Test on events with different available test beam energy values.
- CM-Net vs Pandora algorithm.

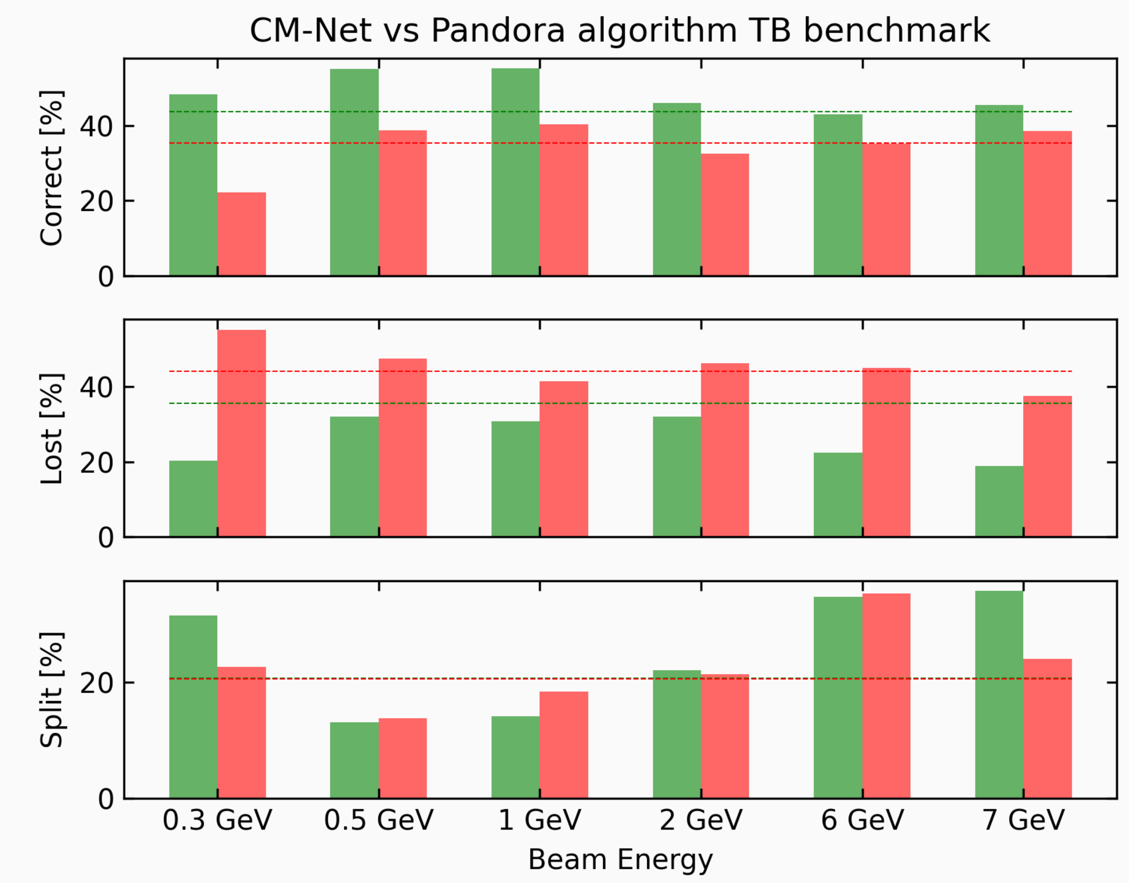


Figure 5: Reconstructing MC TB slices. Dashed lines for overall TB energies score.

✓ CM-Net achieves better accuracy in TB reconstruction.

6