DEVELOPMENT OF ILC SHOWER CLUSTERING ALGORITHM USING DEEP NEURAL NETWORK

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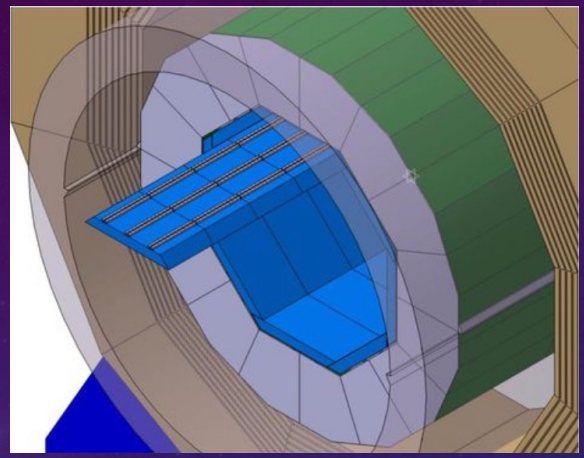
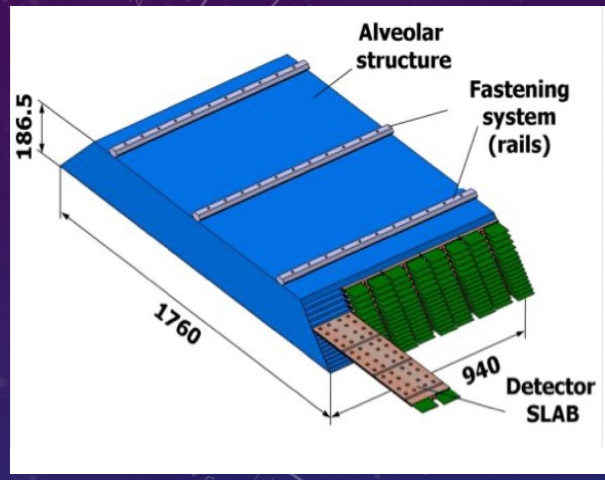
ILD / SIW ECAL





- Electromagnetic calorimeter (ECAL): Detects position, momentum, and energy of gamma rays with high granularity → Higher accuracy for particle identification: PFA
- Sandwich structure with 30 alternating layers of Si detection layer and W absorption layer
- W-absorbing layer: Electromagnetic shower is induced when electrons and gamma rays are incident.
- Feature: Moliere radius is small enough to suppress the spread of the shower

PARTICLE FLOW ALGORITHM (PFA)

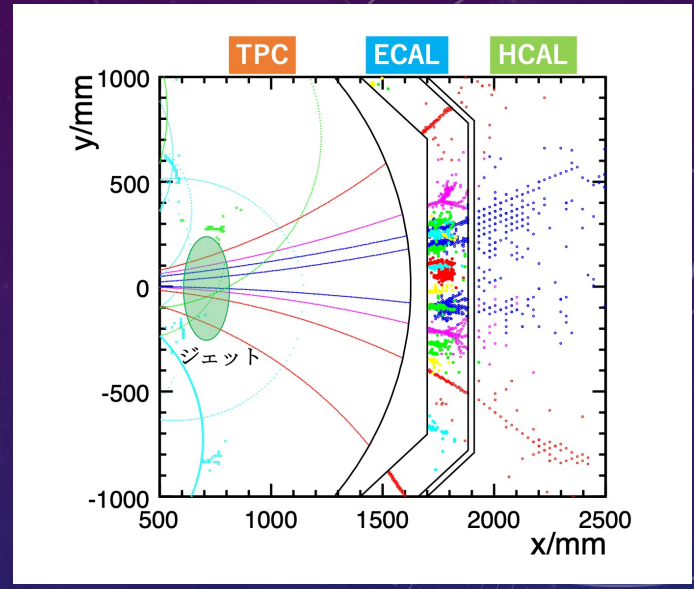
- A method to obtain higher jet energy resolution by reconstructing the particle trajectory for each type of particle in the jet.
- Charged particles: TPC
- Photons : ECAL
- Neutral hadrons : HCAL
  → To separate the deterioration of resolution for neutral hadrons
- Resolution

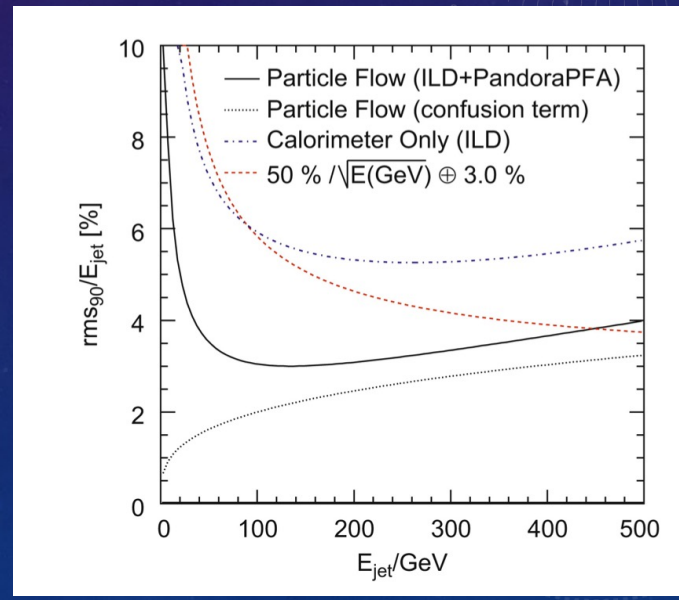
Hadrons : $55\%/\sqrt{E(GeV)}$

Photons : $15\%/\sqrt{E(GeV)}$

→ Total Resolution : $19\%/\sqrt{E(GeV)}$

Neutral Hadron : $17\%/\sqrt{E(GeV)}$

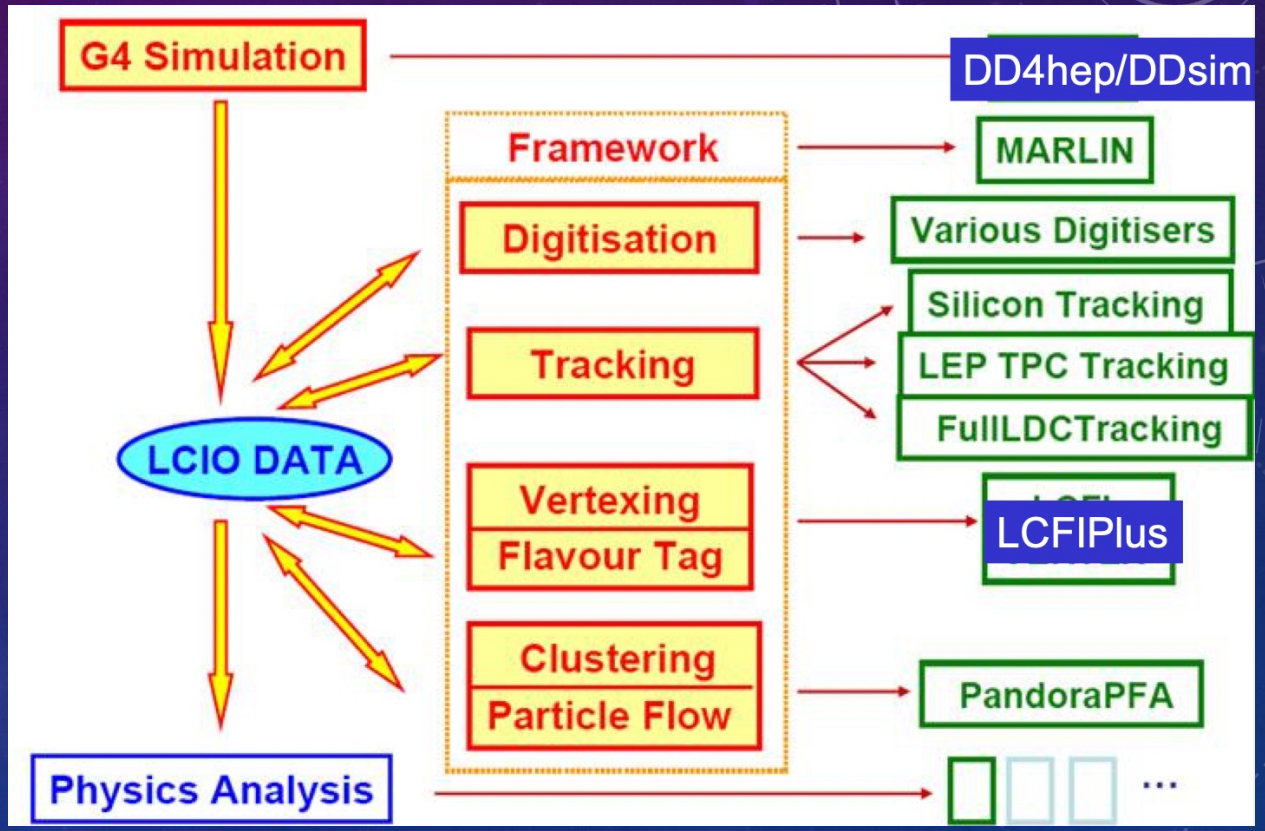




APPLICATION OF DEEP LEARNING TO PFA

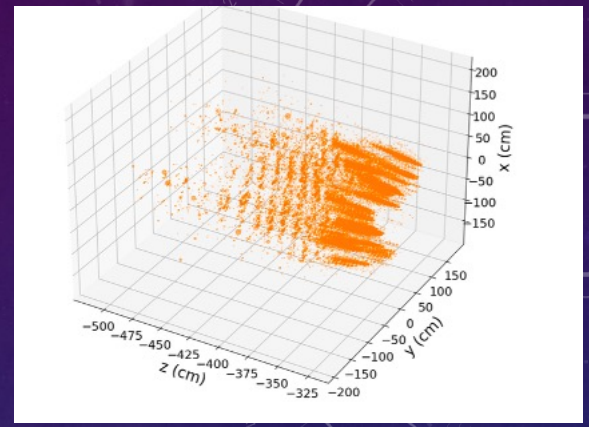
- Current PFA algorithm : PandoraPFA
  → Aim to further improve performance by using deep learning techniques

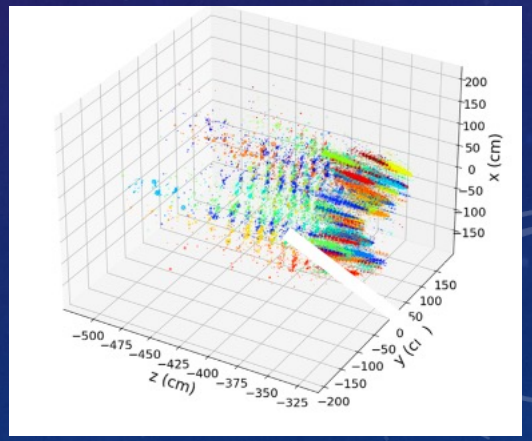
- This research: Graph Neural Network (GNN) is applied to shower clustering.



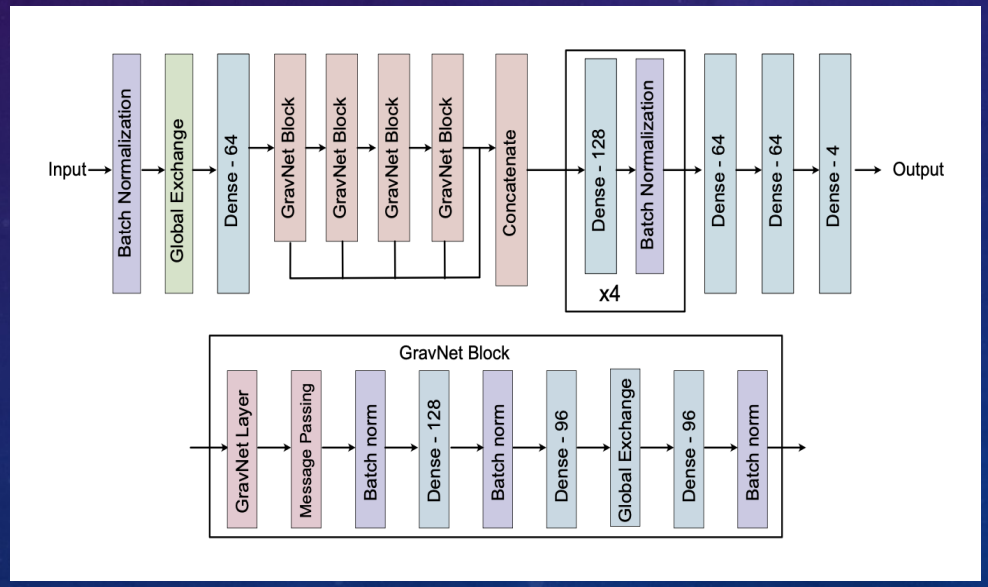
SHOWER CLUSTERING

- Input: feature values of hits in the calorimeter e.g., position, energy, time, etc.
- Output: probability of IDs indicating each cluster

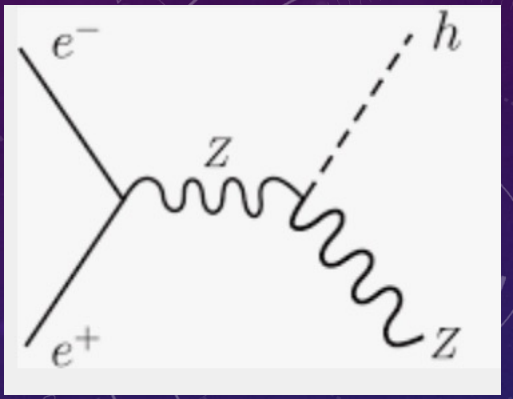




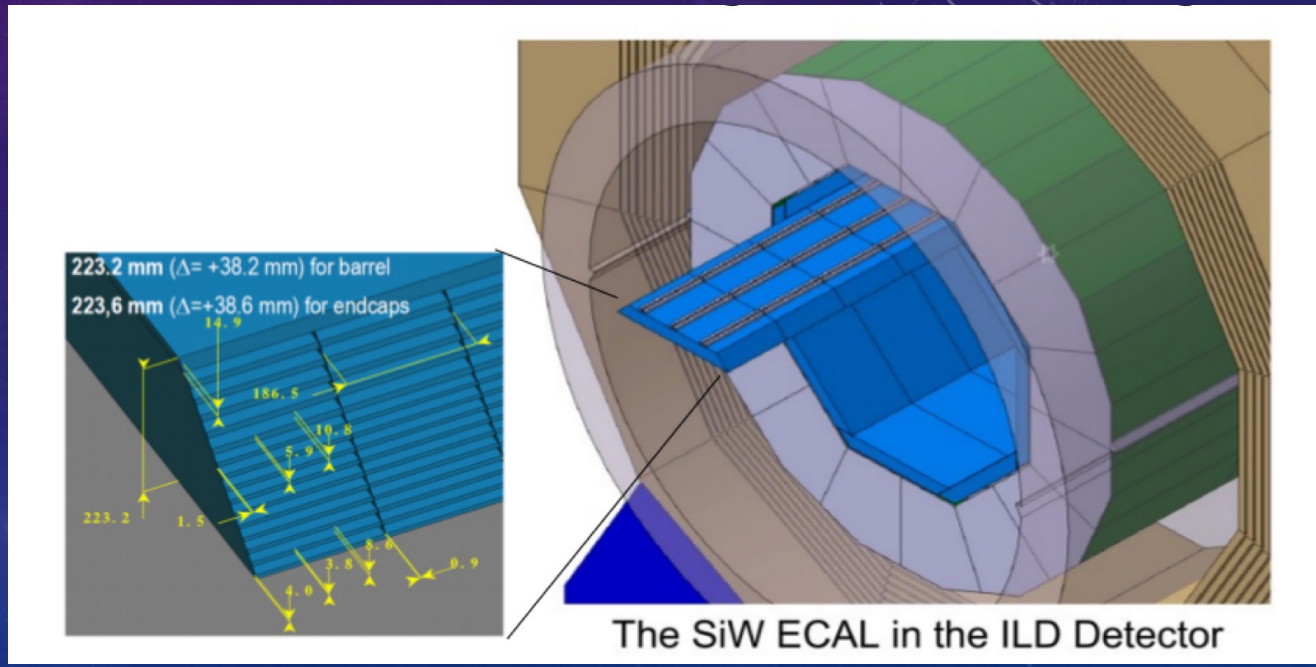
- Deep Learning Architecture
- Mainly consists of DENSE layer (fully connected layers)・GravNet Block



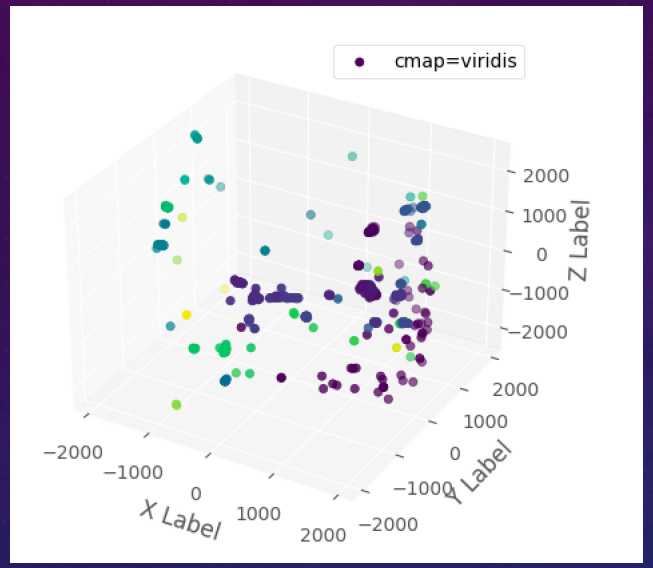
SIMULATION DATA

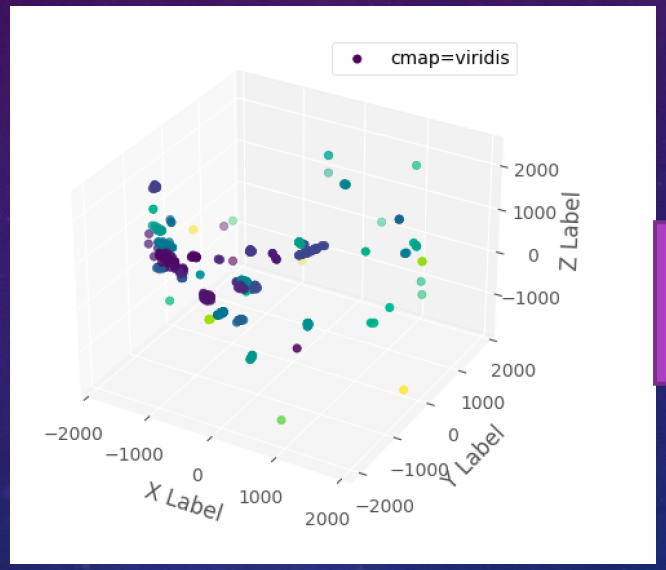


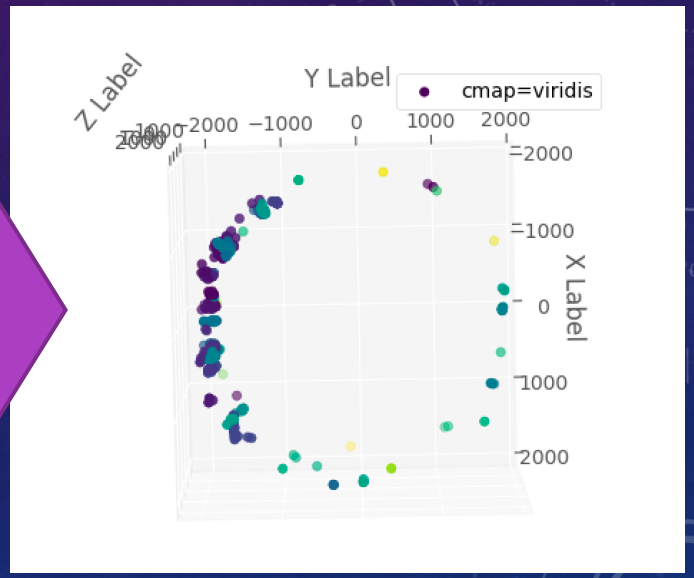
- Utilizing ILC and 500 GeV Simulation Data
- e+e- -> ZH events
- Clustering showers from hit information (Energy , x, y, z, Time) measured in Ecal Barrel section



HIT DISTRIBUTION



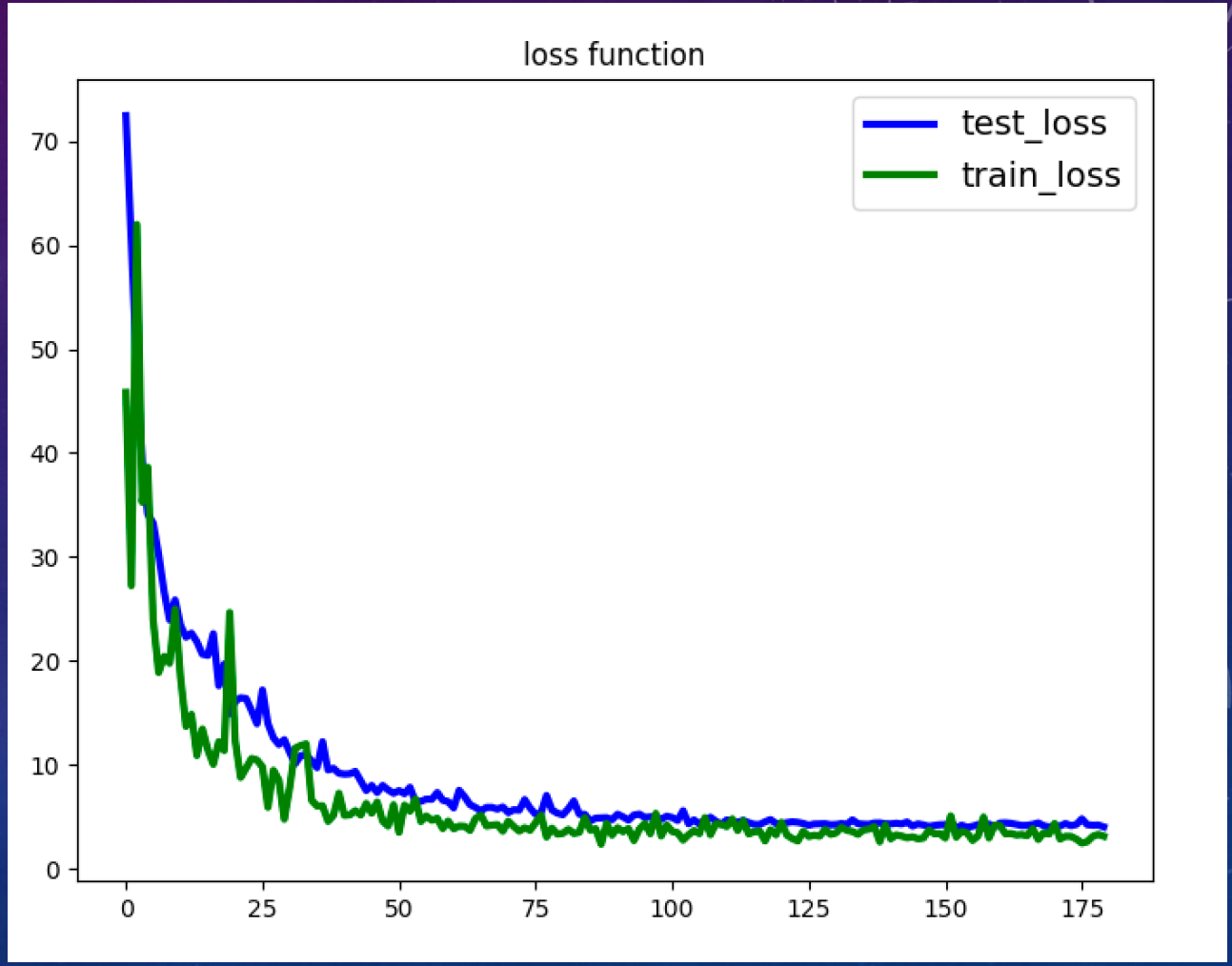




- Events: 200, 80% as training data, 20% as evaluation data
- Each parameter is converted to the range of [-1, 1] via tanh

RESULT – LOSS FUNCTION

- Loss functions of both training and training data are decreasing
  → Learning works correctly.
- I have to evaluate accuracy also.



SUMMARY

- Graph Neural Networks are applied to the PFA and shower clustering algorithms in the ILC analysis framework.
- Two hundred events of Hit data measured with Ecal are used as simulation data.
- The training results showed a decrease in the loss function for both the training and evaluation data.
- In the future, hyperparameter tuning and performance evaluation for each cluster energy will be conducted.