

Our Training Strategy

A Two-Stage Approach

- **Stage 1: Pre-Training**

- **Goal:** Force the model to learn a rich, physical representation of events.
- **How:** A dual-objective Masked Autoencoder (MAE).
 - ▶ *Self-Supervised Reconstruction Task:* Reconstruct masked (hidden) parts of the event.
 - ▶ *Supervised Contrastive Task:* Machine learning framework for grouping hits that share the same voxel ID.

- **Stage 2: Supervised Fine-Tuning**

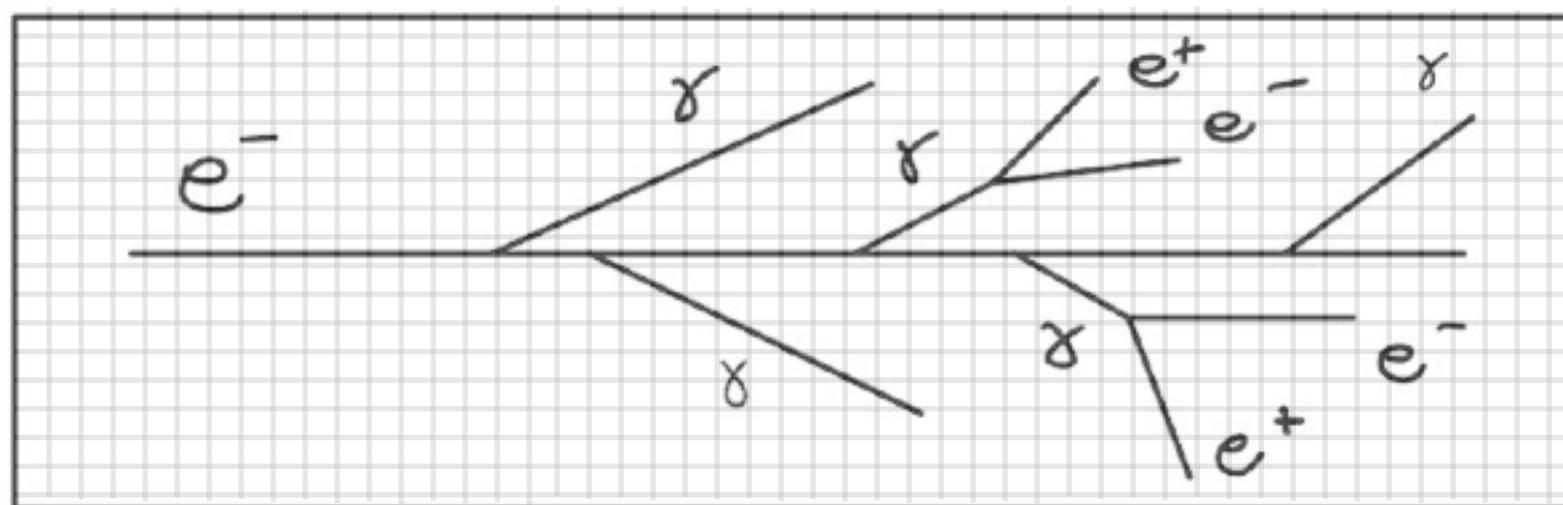
- *Goal:* Adapt the "smart" pre-trained encoder to specific physics tasks.
- *How:* Use the pre-trained weights as a starting point and fine-tune on the labeled dataset for classification and regression.
 - **Classification Task:**
 - *NuE CC, NuMu CC, NuTau CC, NC*
 - **Regression Task:**
 - *Vis Momentum (E_{vis} , Pt_{miss}), Jet Momentum, Lepton Momentum*

Pre-Training

Machine Learning Inputs

- Voxel Energy - Global Event Features - [Voxel ID Labels](#)

Toy Representation EM Shower



- ***hit_track_id***: Groups hits from the *same particle* as it propagates.
- ***hit_primary_id***: Groups *all hits* that descend from the *same primary particle*.
- ***hit_pdg***: physics-based grouping, groups hits by PDG code.

