Cool, but How?

A Two-Stage Training Strategy

- **Stage 1: Self-Supervised Pre-Training**

  - *Goal*: Force the model to learn a rich, physical representation of events.

  - *How*: A dual-objective Masked Autoencoder (MAE).

  - *Reconstruction Task:* Reconstruct masked (hidden) parts of the event.

  - *Contrastive Task:* Group hits that belong to 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.

Fine Tuning

Stage 2

Input of the model:

- **The complete, unmasked event:** The model now sees all the voxel hits.

- **Features:** Voxel energy, 3D coordinates, and global event features

The Core Idea: Transfer Learning

- **Using the encoder weights from the previous model:** Hierarchical Transformer Encoder is **not** trained from scratch

M0
M1
M2
M3
M4
M5
M6
M7

Encoder **Hierarchical Transformer**

Classification Task

– `NuE CC`
– `NuMu CC`
– `NuTau CC`
– `NC`

Regression Task:

– `Vis Momentum (E_vis, Pt_miss)`
– `Jet Momentum`
– `Lepton Momentum`