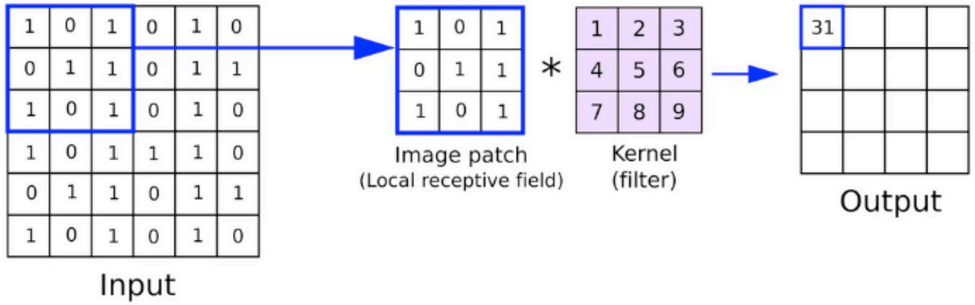
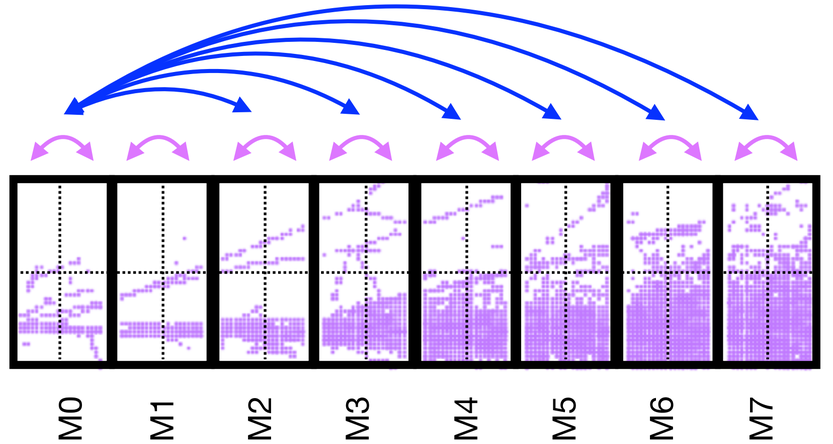
Cool, but How?

Advance Deep Learning Approach

Hybrid Model to Capture Local & Global Information:

- **Sparse Submanifold Convolutional Network (Local Info):**
  - A convolution that operates only on active voxels.
  - Efficiently learns local 3D features (shower shapes, track segments).
    - Efficiency SCNN: (16 times faster than a CNN on a GPU) [Link]
- **Hierarchical Transformer (Global Info):**
  - **Intra-Module Attention:** Summarizes patterns *within* each detector module.
  - **Inter-Module Attention:** given the created module summaries, combines them to learn the *entire event topology.*





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`