Université Paris Cité

ADAPT: Accelerate Discoveries (boosting) Astroparticle Physics (analysis) Techniques

From calibrated data to event kinematics: a full analysis pipeline for Astroparticle Physics Experiments based on Machine Learning - the case of KM3NeT

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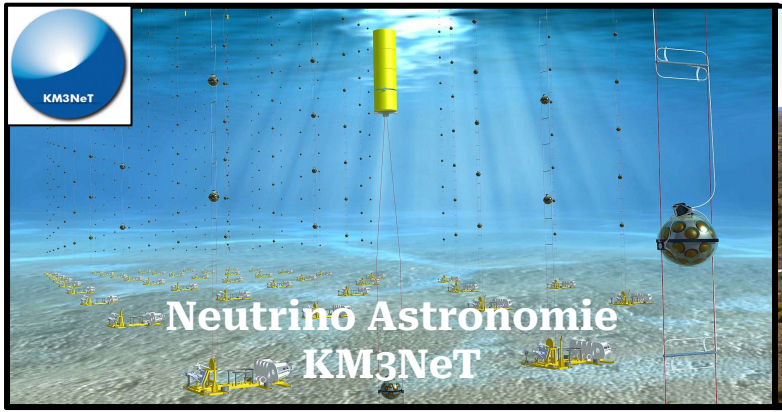
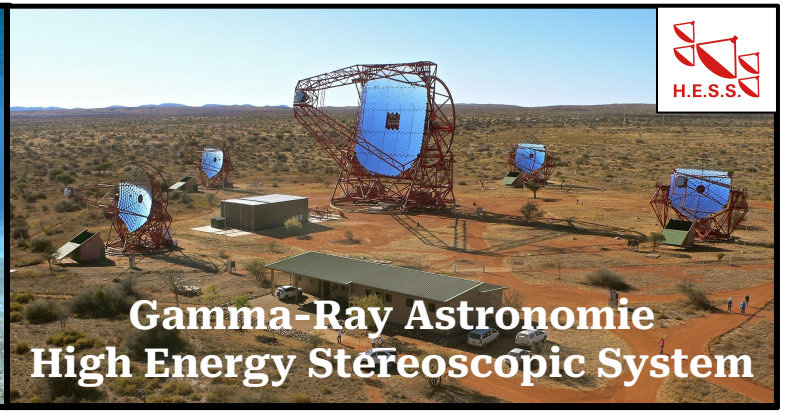
Project:
Develop data analysis using machine/deep learning algorithms





Challenge:

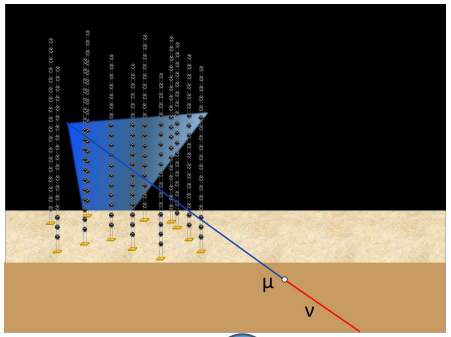
- Reconstruction Algorithms are time consuming
- The reconstructed output is dominated by undesired background (e.g. cosmic rays, muons)

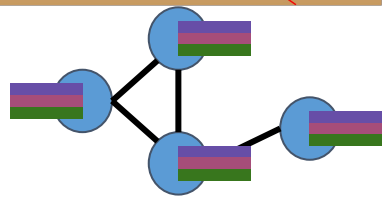
⇒ Use **Machine Learning** to filter out undesired background before the reconstruction

⇒ Faster analysis and possibly more sensitive

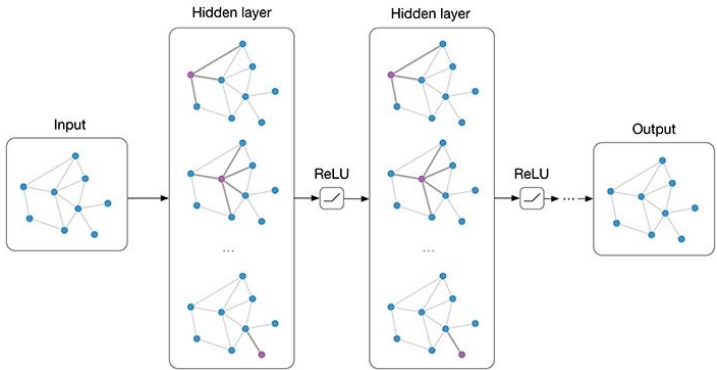
Data can be best described by a Graph

- Nodes with features (e.g. x, y, z, t, A)
- Edges defined via
  k nearest neighbors
  in Minkowski Spacetime



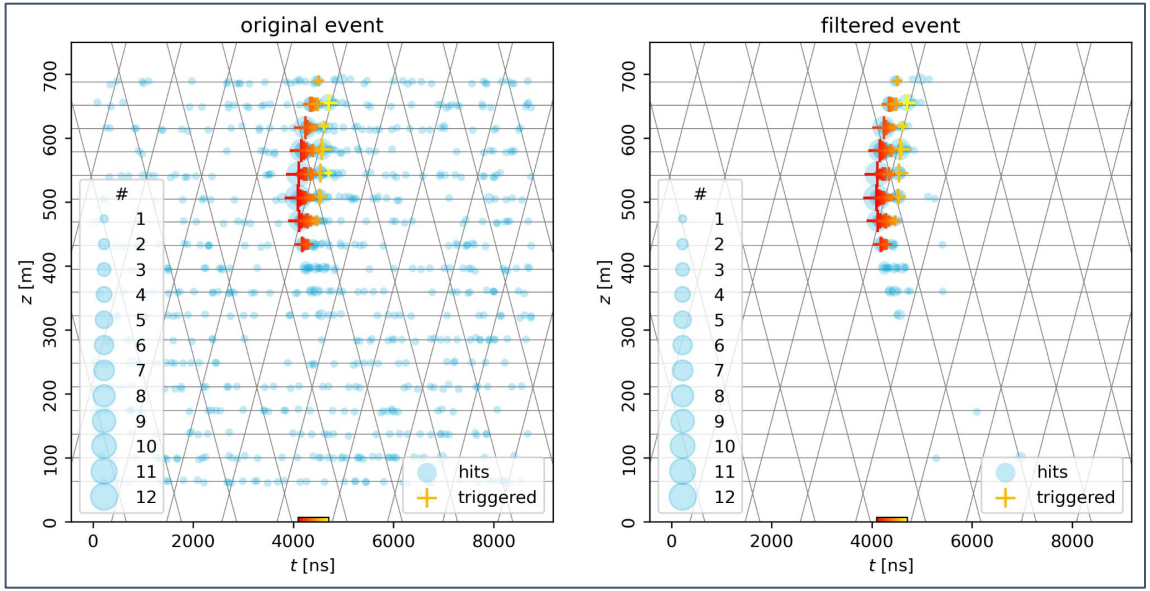


⇒ Use **Graph Neural Networks**



Individual physics events dominated by noise (K40)

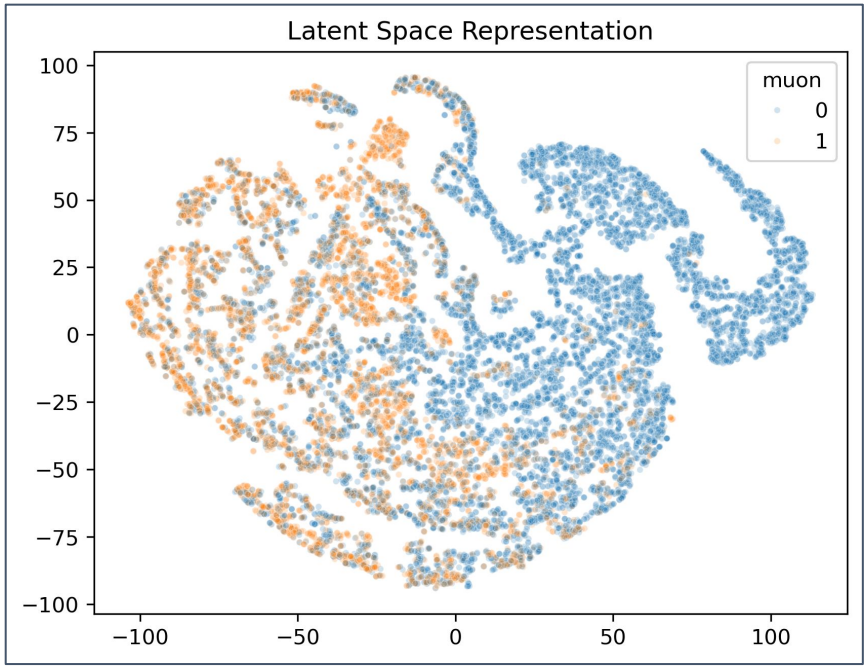
Hit Filter:
Train a model
(*semi-supervised*)
to discriminate signal
from noise hits



Continue analysis with cleaned event

Goal: Filter atmospheric muon events from neutrino events

- Masked Graph Autoencoder (*self-supervised*)
- Model learns an internal representation for each event
- Additional classifier (*supervised*) maps from internal representation to desired classes



Continue analysis with filtered neutrino events

Future Step:

- **Parameter Reconstruction** (E, θ, φ)
  train Masked Graph Autoencoder as “Foundation Model” (self-supervised)
  fine-tune model with for follow-up task with e.g. regression headers (supervised) for desired quantities

Thank you very much.