

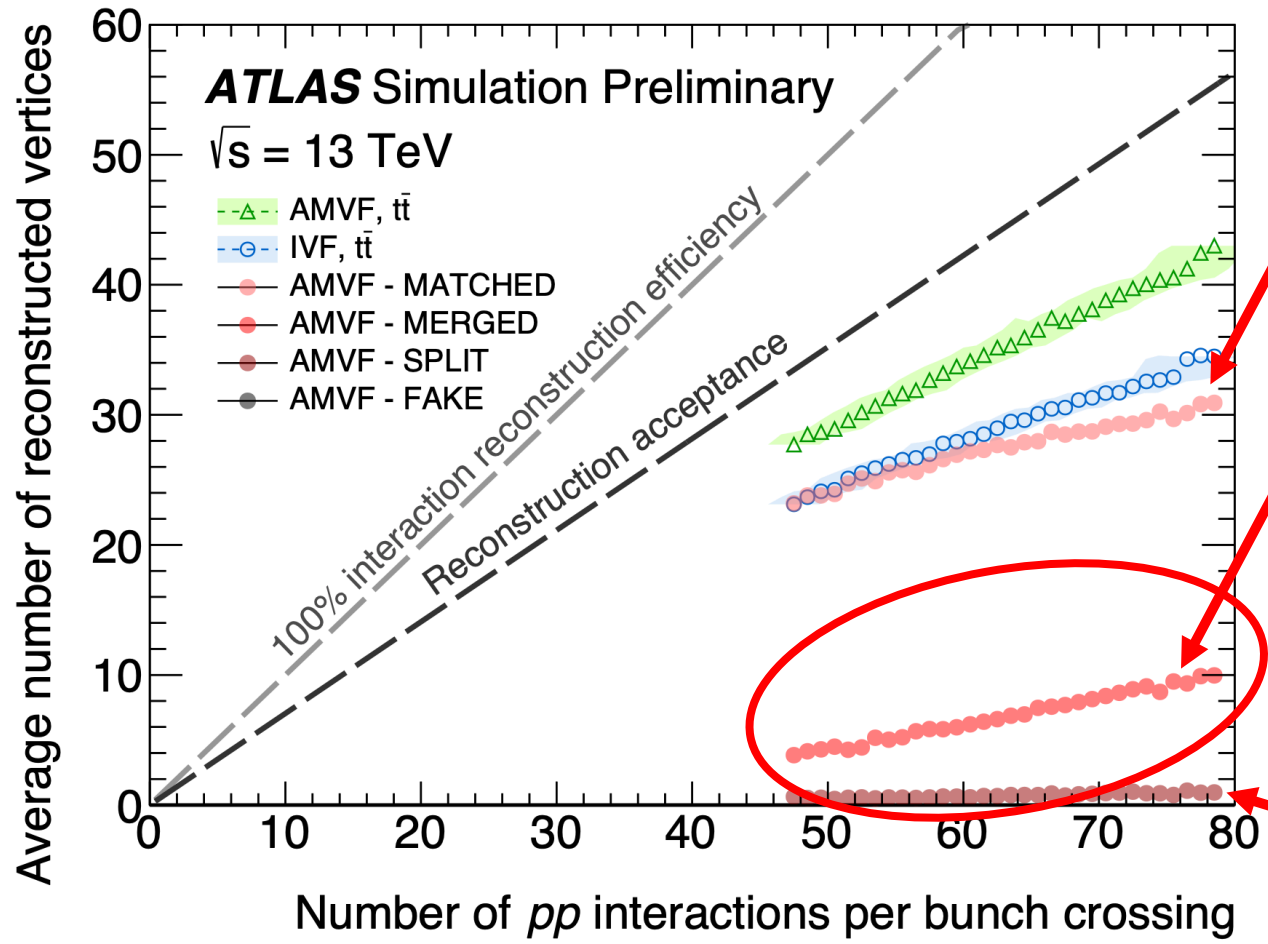
Vertex Classifier DNN

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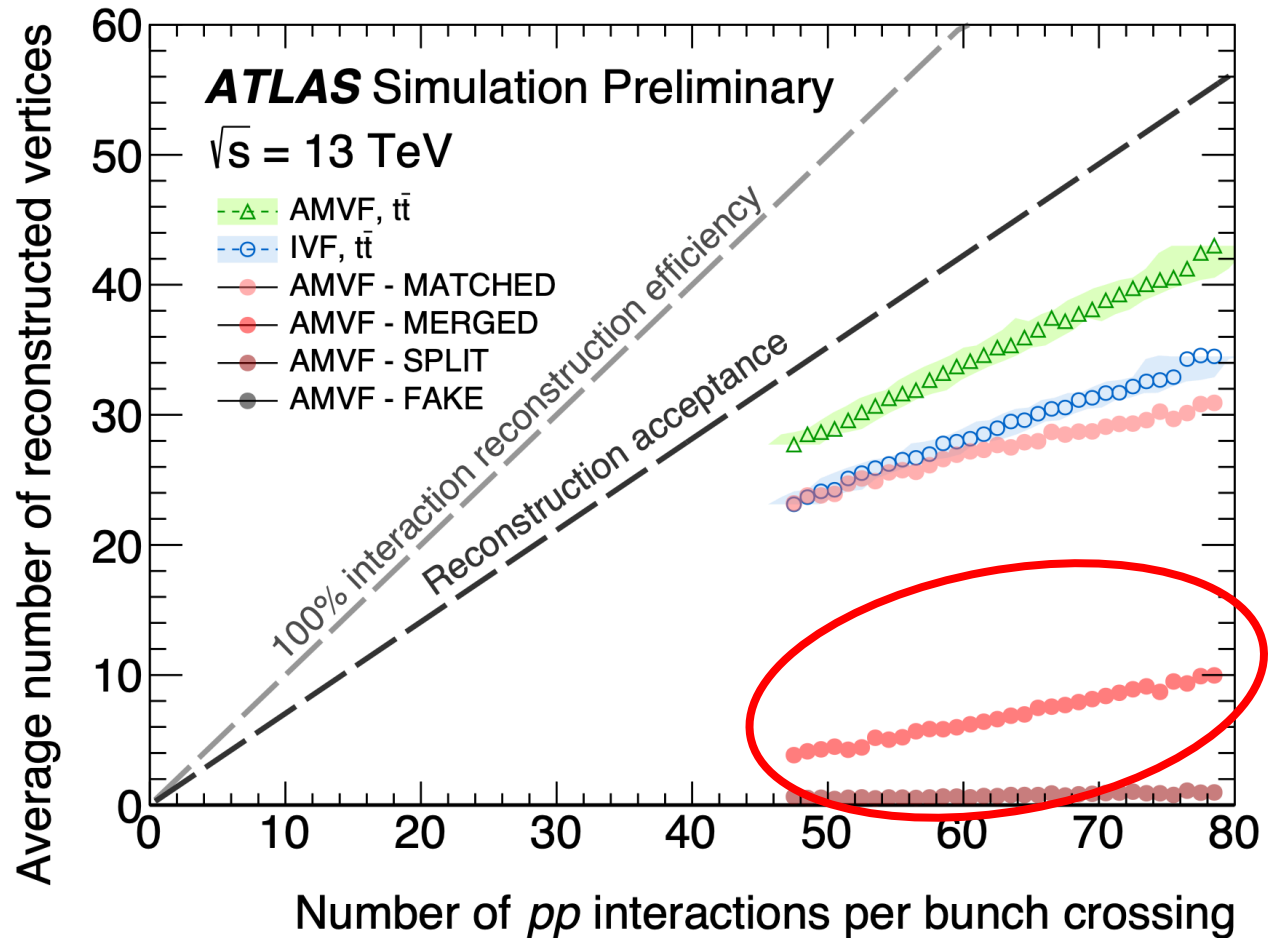


Classes of Reconstructed Primary Vertices



- **CLEAN/MATCHED:**
At least **70% of the total track weight** in the reconstructed vertex originates **from a single simulated pp interaction**
- **MERGED:**
Less than 70% of the total track weight in the reconstructed vertex originates **from any single simulated pp interaction**
→ two or more simulated interactions contribute to reconstructed vertex
- **SPLIT:**
A **single simulated pp interaction contributes** the largest track weight **to two or more reconstructed vertices**

Merged Reconstructed Vertices



MERGED vertices:

- Becomes even more problematic in dense environments (HL-LHC and beyond)
- Especially CLEAN signal vertex is desired

Goal: ML classifier to detect merged vertices

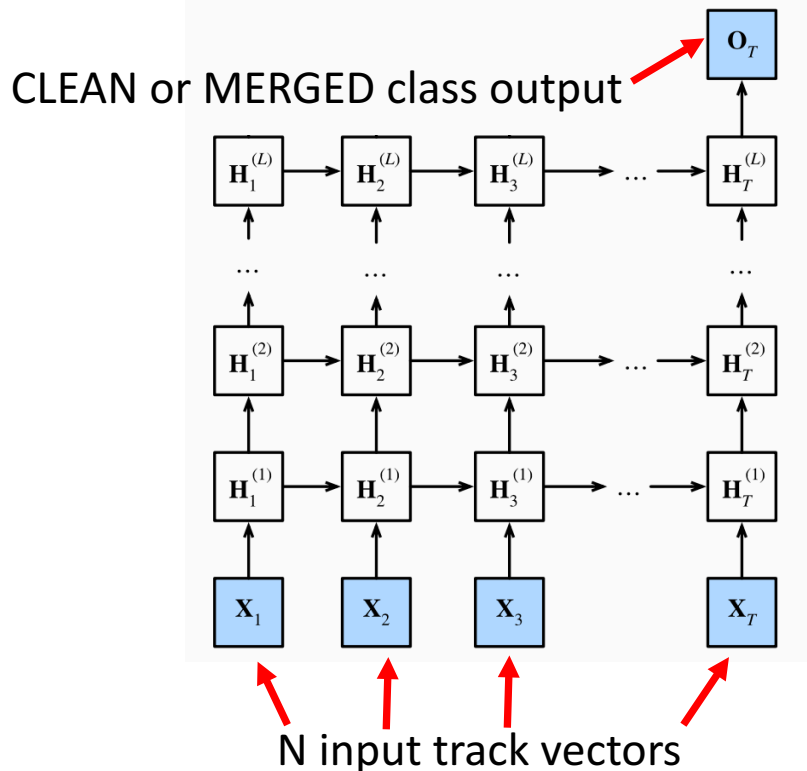
- Run classifier after primary vertex reconstruction
- Option 1: Discard events if CLEAN vertex is crucial
- Option 2: Split the merged vertex
 - Rerun vertexing with harder cuts on single vertices or
 - Consider single vertex as graph and use graph clustering (NN)

Classifier Neural Network Architectures

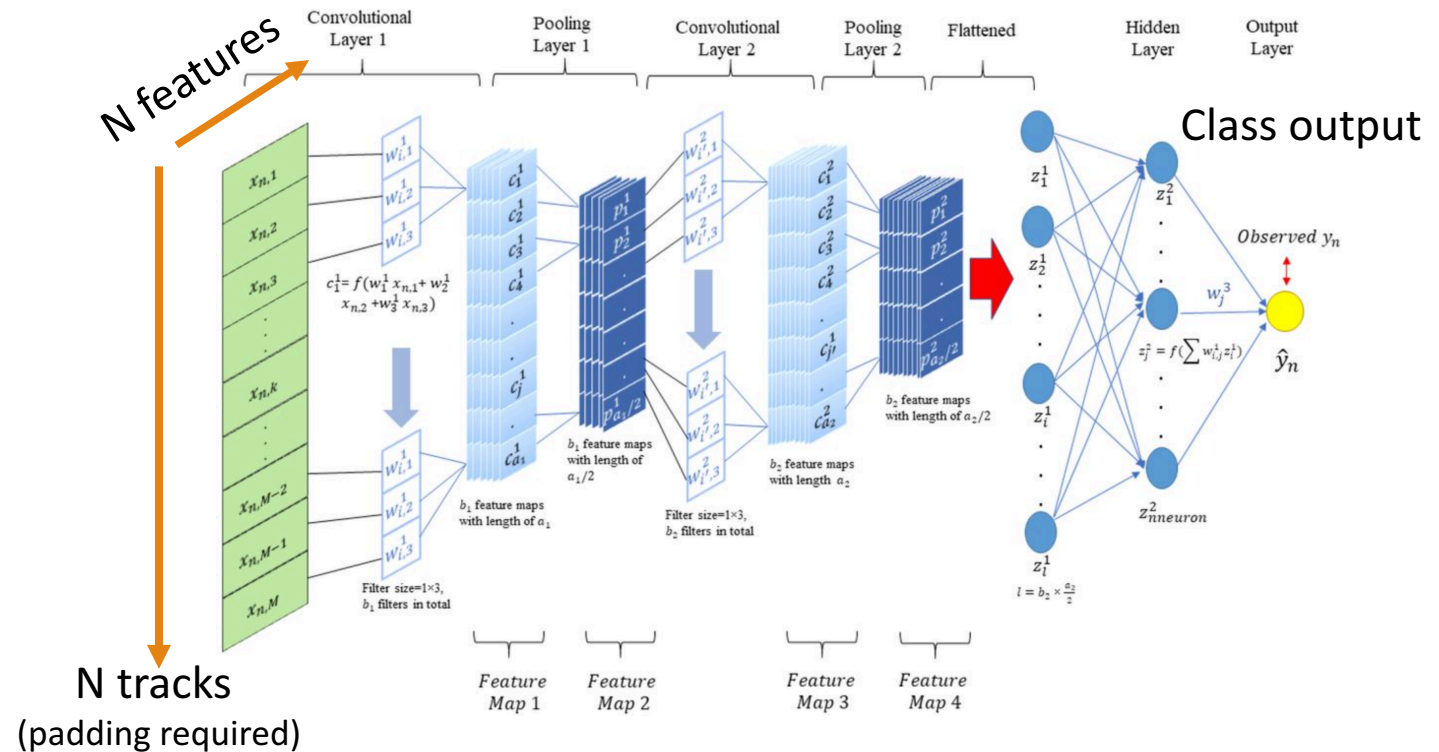
Input to the NN: E.g. $(d_0, |z_{vertex} - z_0|, p_T, \sigma(d_0), \sigma(z_0))$ of all tracks at given vertex

Note: Arbitrary number of tracks \rightarrow architecture needed that can handle variable input size

Recurrent NN – LSTM cells



1-dim. Convolutional NN



Classifier Neural Network – Results



Due to problems with GPU server @ Uni Mainz → unable to access my data/results for the last 2 weeks

→ Unable to access my plots currently ☹️

Training and testing:

- Training, validation & testing on 100.000 full-pileup (40-60) truth ATLAS ttbar events
 - ~350.000 tracks/vertex class pairs for training
 - ~75.000 data pairs for evaluation of performance
- Both RNN and CNN perform about equally well (but CNN much faster of course): **very good separation power**

True positive (MERGED classified) rate: ~91%

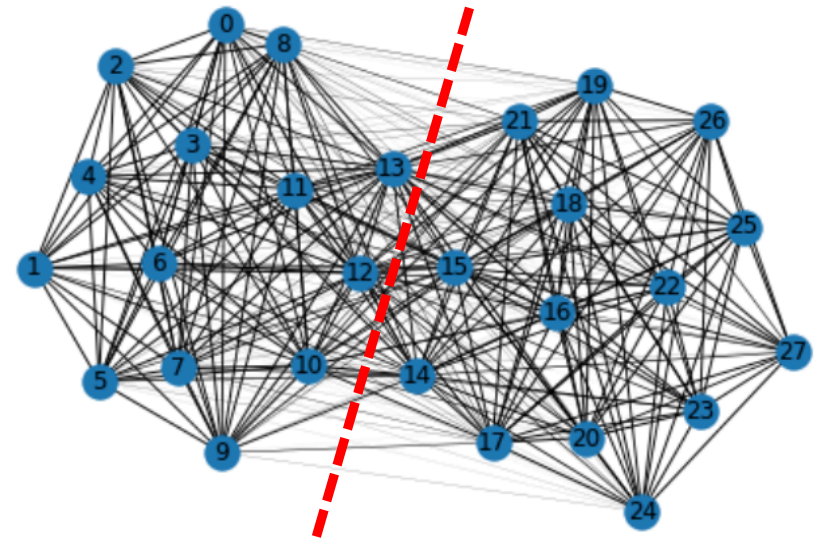
True negative (CLEAN classified) rate: ~92%

Next step: Graph Clustering for Merged Vertices

Consider tracks at vertex as graph:

- Nodes: tracks
- Adjacent tracks: tracks belonging to same vertex

MERGED reconstructed vertex



Either classical graph clustering algorithm

or

Graph Neural Network clustering