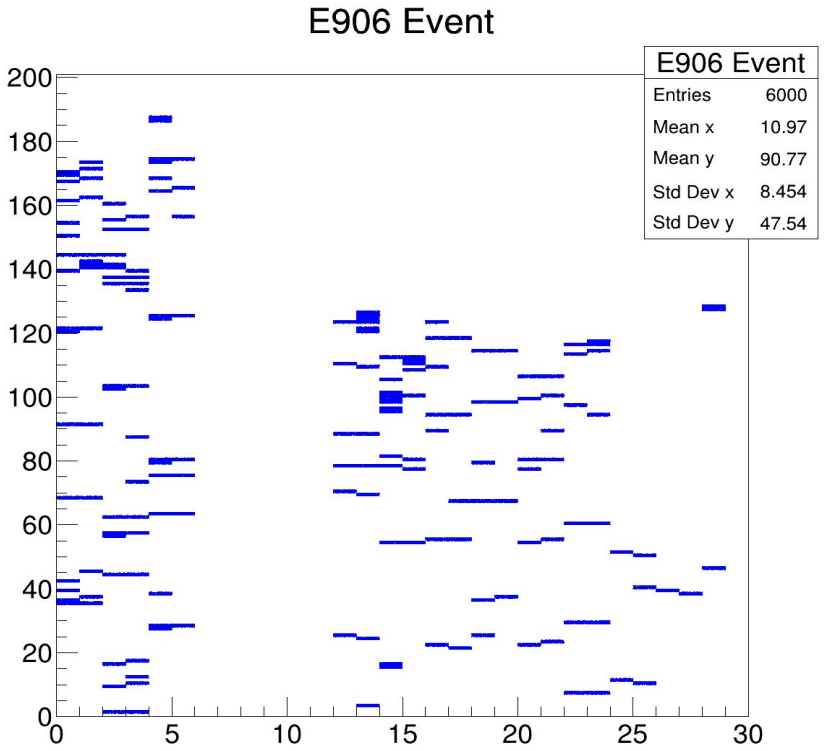
QTracker Update

3/15/22

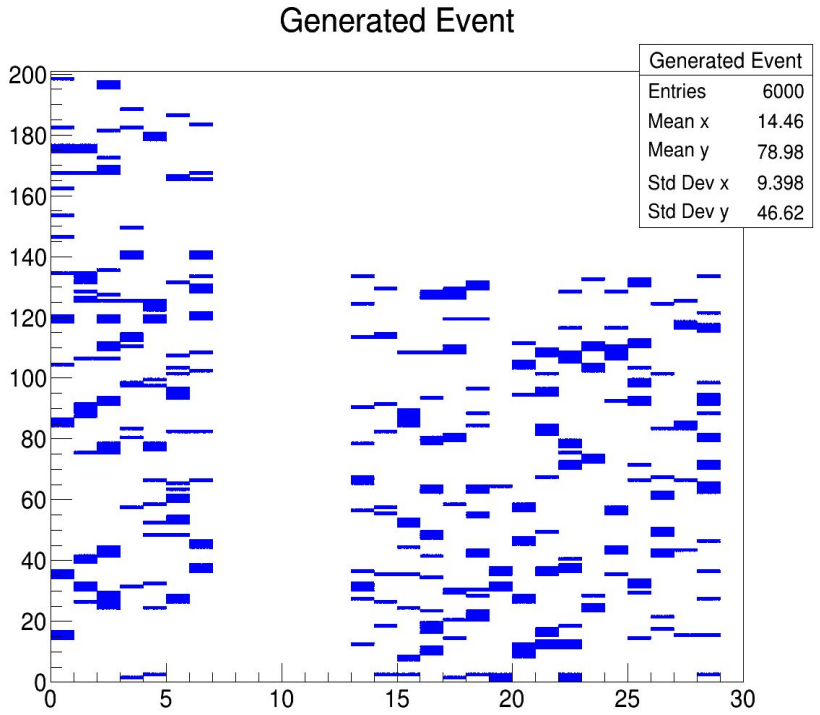
E906 Data Event Generation

- Start with E906 NIM trigger data as background
- Insert muon tracks, as in full MC generation
- Events are more “real” but are harder to control – may include muons that we don’t know about, and might not have same distribution as E1039 events.



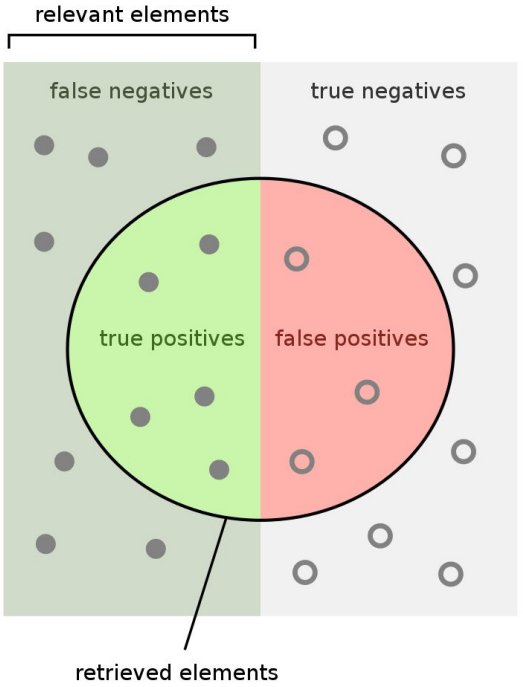
Full Monte-Carlo Event Generation

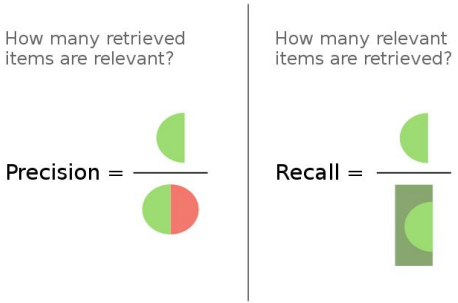
- Take Monte Carlo simulated particle tracks and combine them into more complicated events
  - Random number of full tracks (Poisson distribution with mean 2)
  - Possibly add dimuon track from target (probability 25%)
  - Add single station tracklets to event to make data noisy
- Add noise and cluster hits
  - Edge hits
  - Electronic Noise
  - Delta Rays



Measuring Categorization

- Three main measurements:
  - Precision
  - Recall
  - F-measure
- Precision means the data passed is more “pure”
- Recall means we miss less interesting events
- F-measure is the harmonic mean of the two.

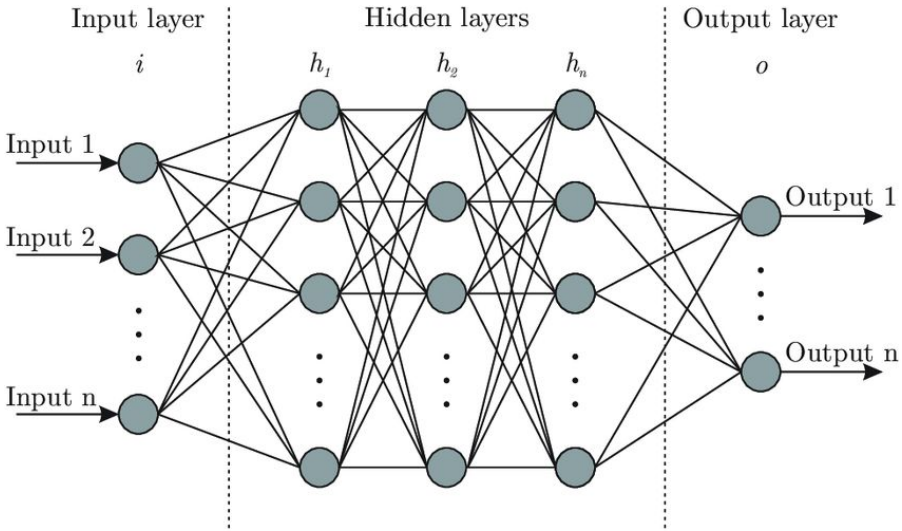




$$F_1 = 2 \cdot \frac{\mathrm{precision} \cdot \mathrm{recall}}{\mathrm{precision} + \mathrm{recall}} = \frac{\mathrm{TP}}{\mathrm{TP} + \frac{1}{2}(\mathrm{FP} + \mathrm{FN})}$$

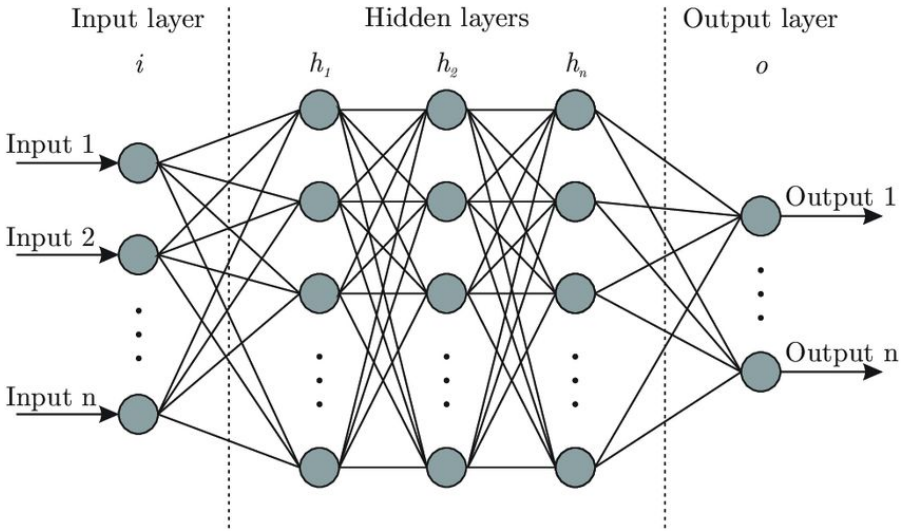
Event Filtering

- Feed raw events straight into a binary classifier – worth further analysis or not.
- That definition can change based on needs.
  - Contains any muons
  - Contains two muons
  - Contains a dimuon pair
  - Contains a dimuon pair from the target
- Uses convolutional neural networks to look for particle tracks in events.



Event Filtering (continued)

- Precision and recall of filtering depend on the goal of the network.
  - With high confidence filter, we can achieve >95% precision.
  - With lower confidence filter, we can get a recall >90%, at the cost of precision.
  - False-positives and false-negatives are a balancing act, and different scenarios will call for different balances.



Event Filtering Performance

Full Monte-Carlo Generation
(20% signal-to-noise ratio)

98% accuracy

Low false negative settings:
0.69 precision, 0.91 recall, 0.78 F-measure

High false negative settings:
0.95 precision, 0.70 recall, 0.81 F-measure

E906 Data with Dimuon Injection
(20% signal-to-noise ratio)

91% accuracy

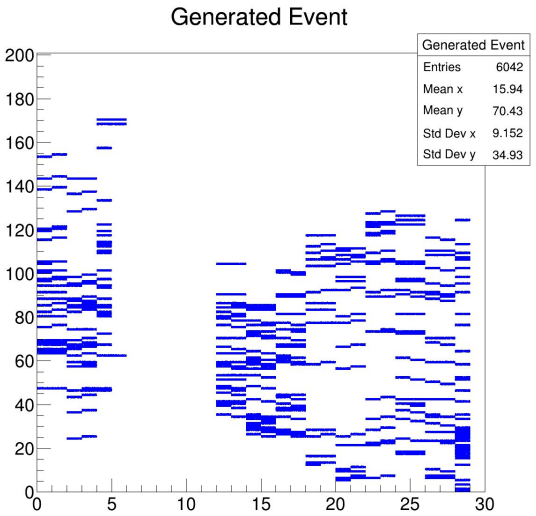
Low false negative settings:
0.71 precision, 0.88 recall, 0.79 F-measure

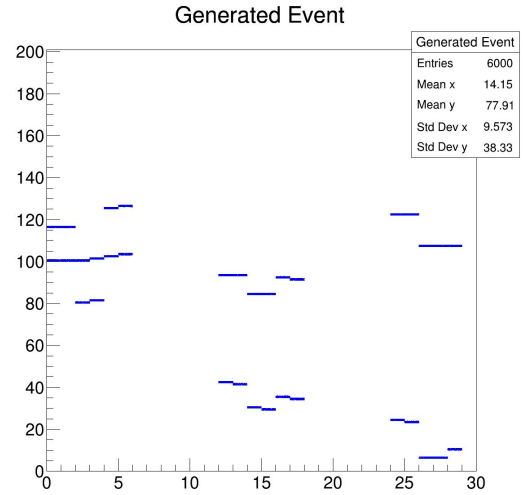
High false negative settings:
0.97 precision, 0.66 recall, 0.78 F-measure

Evaluation time for 30,000 events (on my machine):
TensorFlow evaluation: 3.75 seconds
ONNX evaluation: 0.51 seconds

Hit Filtering

- Filtered events go through a filter that assigns probabilities to hits.
- If the probability that a hit is part of a track is below a certain threshold, it is rejected.
- The probability threshold can be adjusted to allow more or fewer hits through.





Track Finding

- Splits dimuon events into two separate muon tracks.
- Uses convolutional neural network with pooling to identify tracks through detectors and identify which hits correspond to each other.
- These hits can then be paired with their corresponding drift information.