Vertical Drift Studies

Nitish Nayak
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Fiducial Volume Cut

- HD takes a fiducial volume as ~70 cm from the boundary walls
  - bool isFid = (fabs(vtx.X())<310 && fabs(vtx.Y())<550 && vtx.Z()>50 && vtx.Z()<1244)
- We want to do something similar for VD so the equivalent cut becomes
  - bool isFid = (fabs(vtx.X())<300 && fabs(vtx.Y())<680 && vtx.Z()>40 && vtx.Z()<850)
- Also processed the horizontal drift files in the original 1D simulation, similar to what was used in the training before.
  - MCC11
- VD training/validation/test samples (Smaller Stats) : ~550k, ~70k, ~70k
- VD training/validation/test samples (Full Stats) : 1.5 million, ~85k, ~85k
- My HD training/validation/test samples : ~530k, 66k, 66k
- Original training had ~3.2 million events so almost 2x the current statistics

Recap on Results

CVN VD (Smaller Stats)

```
              precision    recall  f1-score   support

    CC Numu       0.87      0.90      0.89     18715
     CC Nue       0.86      0.88      0.87     18625
    CC Nutau      0.50      0.32      0.39      4506
          NC      0.87      0.90      0.88     27786

    accuracy                          0.85     69632
   macro avg      0.78      0.75      0.76     69632
weighted avg      0.85      0.85      0.85     69632

INFO:root:flavour confusion matrix (rows = predicted classes, cols = actual classes):

[[16874   312   942  1227]
 [  274 16332  1121  1158]
 [  246   650  1441   532]
 [ 1321  1331  1002 24869]]
```

CVN HD

```
              precision    recall  f1-score   support

    CC Numu       0.87      0.92      0.90     18541
     CC Nue       0.88      0.88      0.88     18060
    CC Nutau      0.46      0.27      0.34      4503
          NC      0.86      0.89      0.87     25456

    accuracy                          0.85     66560
   macro avg      0.77      0.74      0.75     66560
weighted avg      0.84      0.85      0.85     66560

INFO:root:flavour confusion matrix (rows = predicted classes, cols = actual classes):

[[17089   306  1077  1063]
 [  157 15816   964  1030]
 [  294   462  1229   679]
 [ 1001  1476  1233 22684]]
```

- CVN HD is my training on MCC11 files w/ similar statistics as VD
- CVN HD Old is applying the old trained model in the CVN paper from Leigh and Saul on the MCC11 HD dataset
  - Can easily imagine ~2-3 points in precision/recall coming from more training statistics

CVN HD Old

```
              precision    recall  f1-score   support

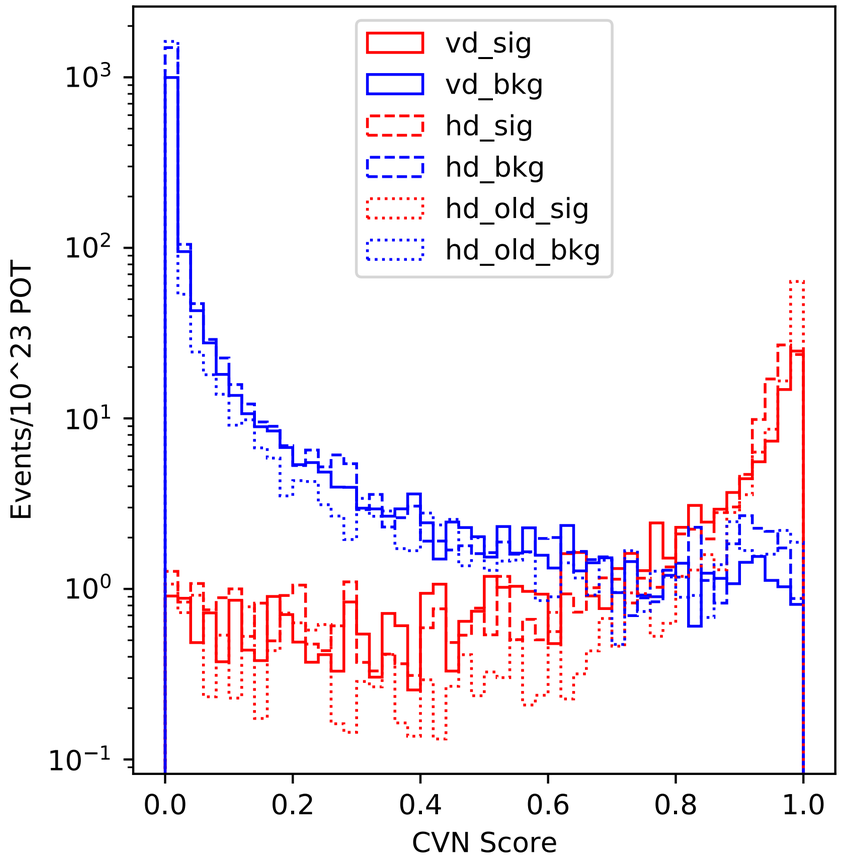
    CC Numu       0.91      0.93      0.92     18541
     CC Nue       0.90      0.92      0.91     18060
    CC Nutau      0.54      0.33      0.41      4503
          NC      0.88      0.91      0.90     25456

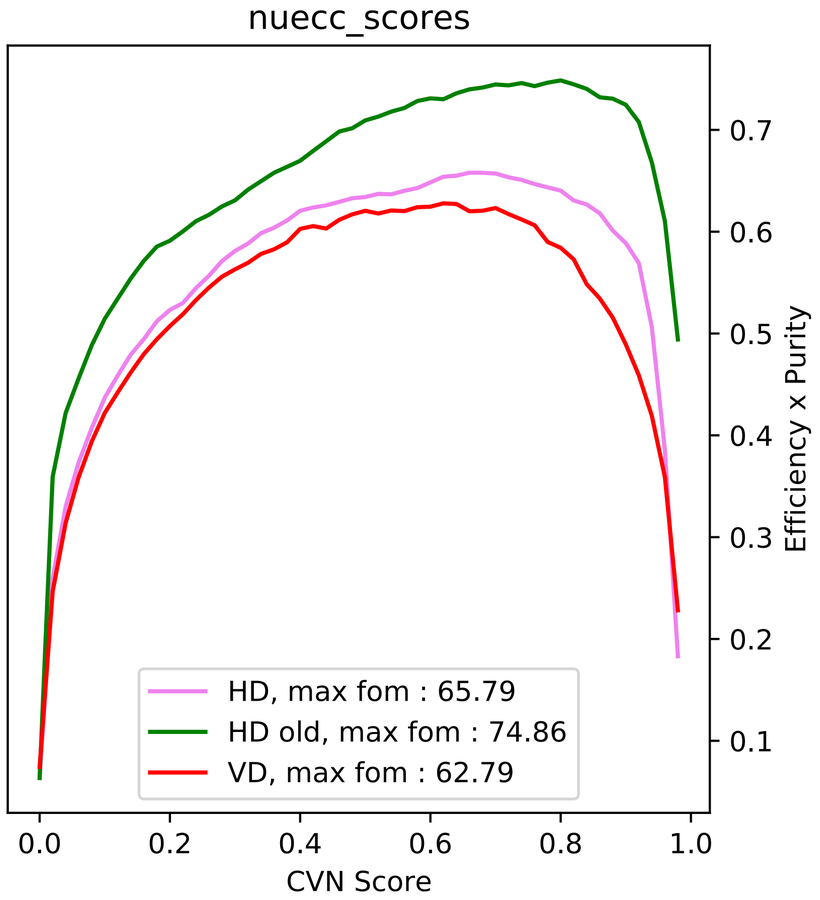
    accuracy                          0.88     66560
   macro avg      0.81      0.77      0.78     66560
weighted avg      0.87      0.88      0.88     66560

INFO:root:flavour confusion matrix (rows = predicted classes, cols = actual classes):

[[17291   151   858   719]
 [  181 16667   958   700]
 [  220   272  1477   765]
 [  849   970  1210 23272]]
```

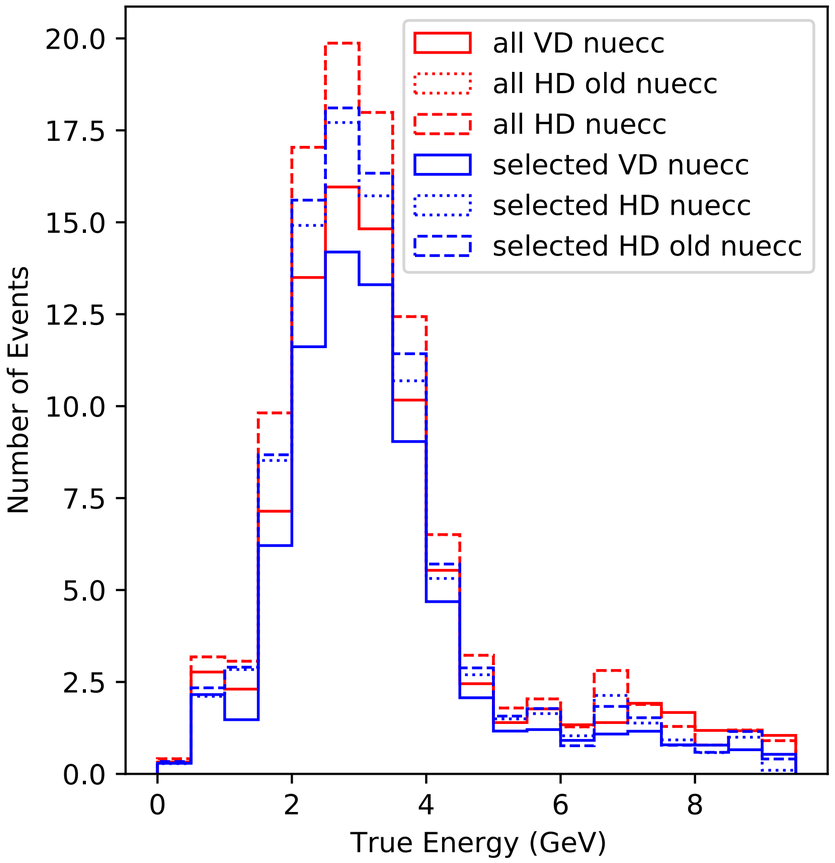
Recap on Results

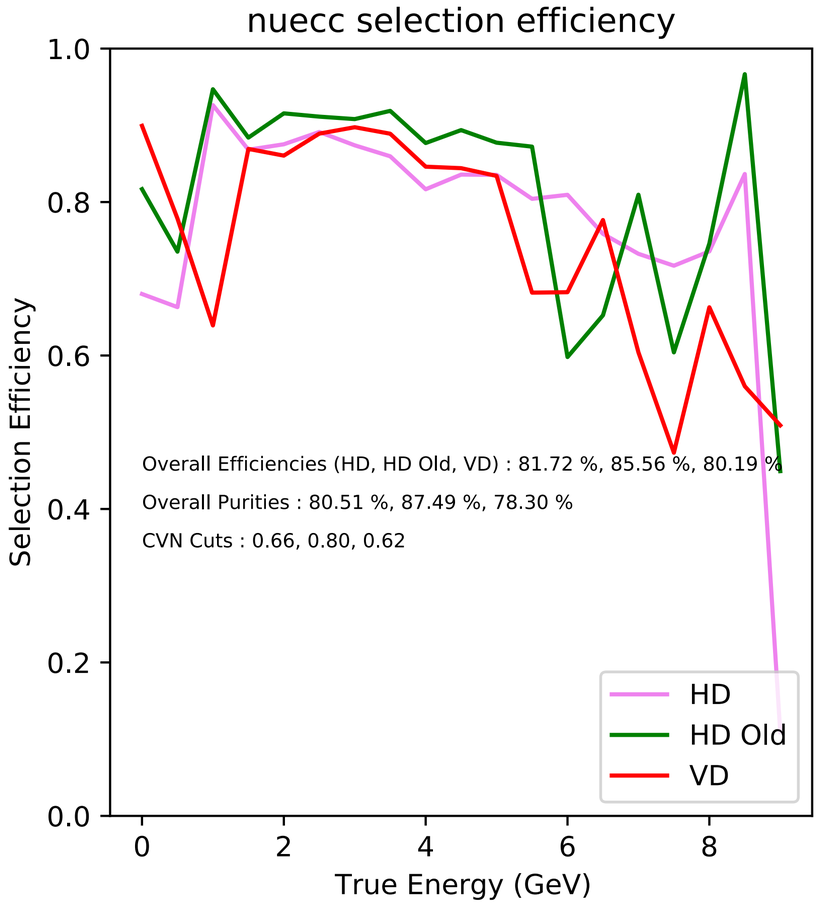




- Comparing the 3, it seems VD and HD are close — whereas “HD Old” outperforms them both
- POT Normalization approximately, ran over 2000 events for each swap (numuCC, nueCC, nutauCC) and extrapolated total POT from there — nuTauCC background approximately halved from before

Recap on Results

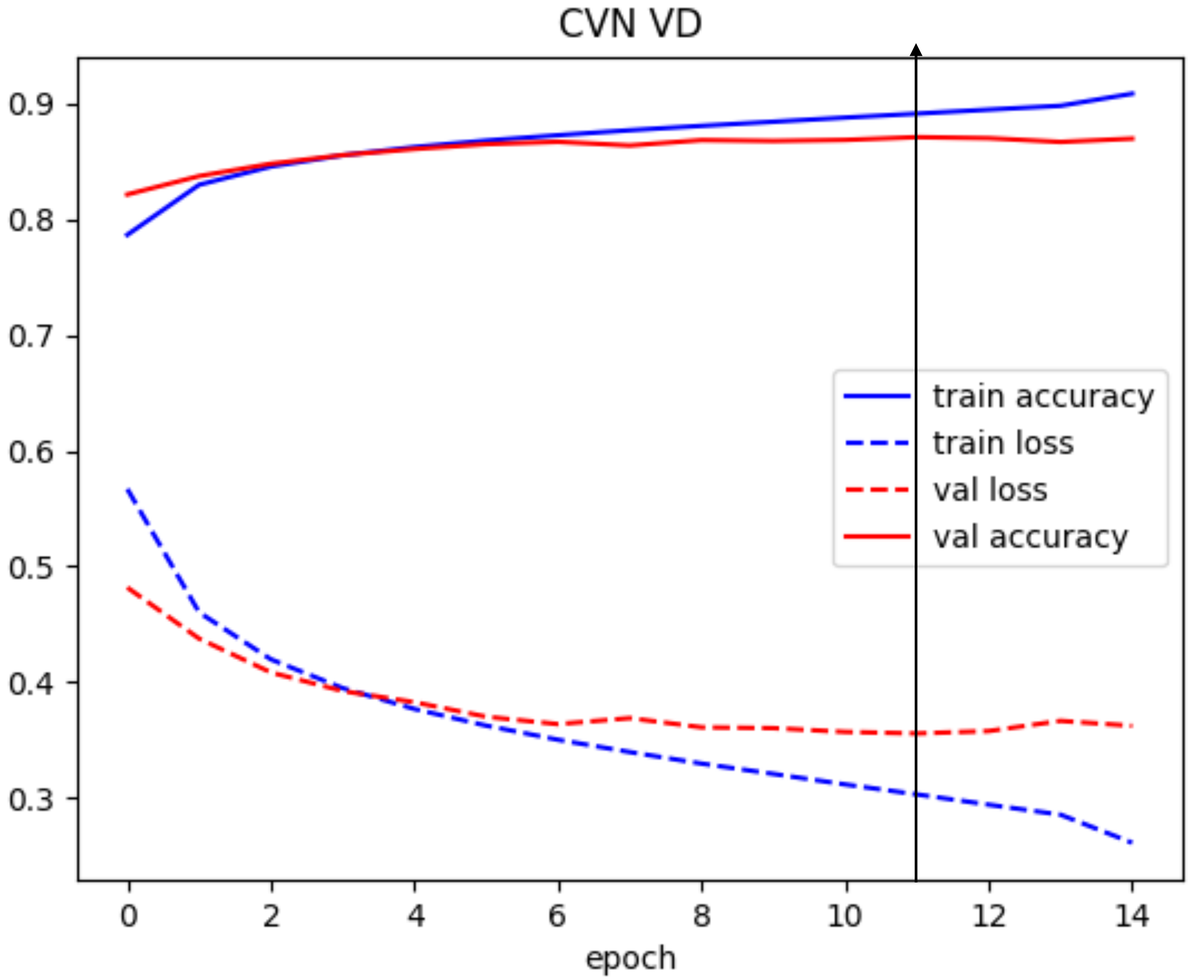




- For efficiency and purity numbers, after approximate POT normalisation, I get ~80% efficiency and purity for both VD and HD

- For HD old, its 86% and 88% (eff, purity) respectively — which is pretty close to what they report in the paper (NB : they report it wrt reco energy since at nueCC peak, high energy NCs dominate background, not 2-4 GeV NCs like here)

Full Stats Training



- Training still going on, showing results for trained model at epoch 11.. seems to be close to converging

Full Stats Training

CVN VD (Smaller Stats)

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          NC       0.87      0.90      0.88     27786

    accuracy                           0.85     69632
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```

CVN VD (Full Stats)

```
INFO:root:flavour report:

              precision    recall  f1-score   support

     CC Numu       0.89      0.91      0.90     22762
      CC Nue       0.86      0.91      0.89     22606
    CC Nutau       0.53      0.36      0.43      5389
          NC       0.90      0.89      0.89     33211

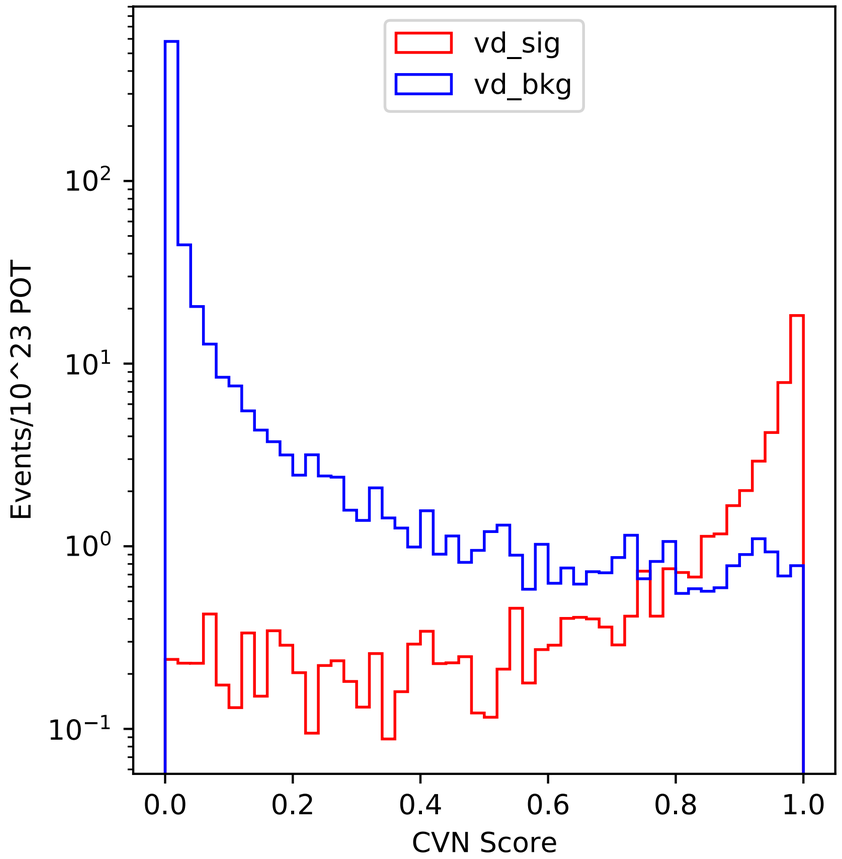
    accuracy                           0.87     83968
   macro avg       0.80      0.77      0.78     83968
weighted avg       0.86      0.87      0.86     83968

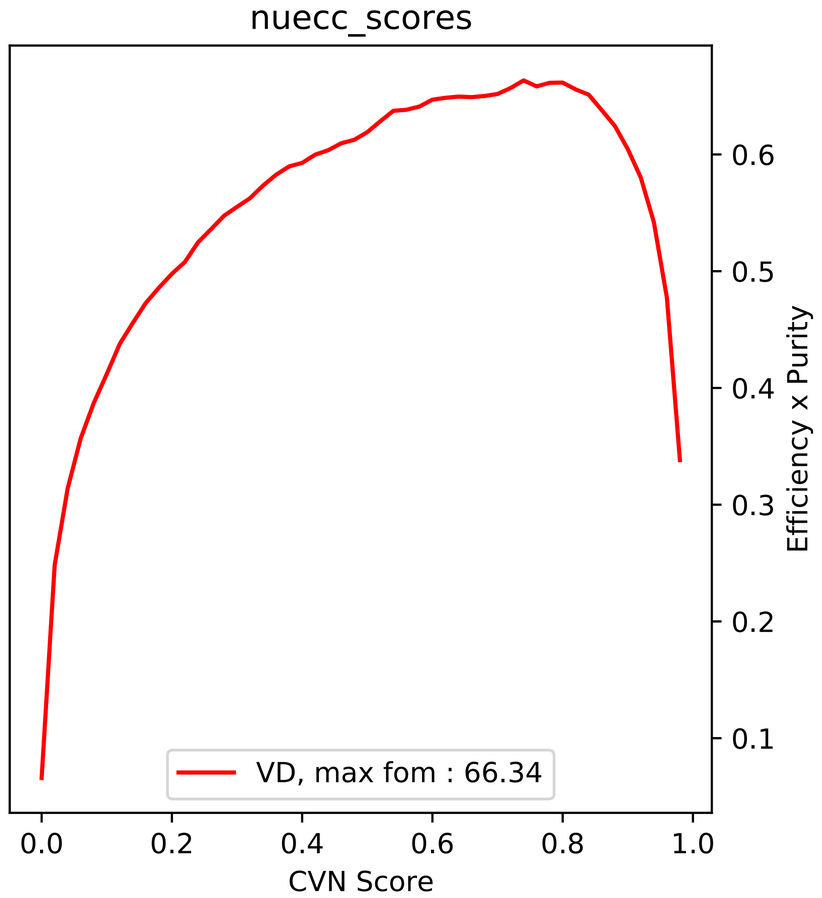
INFO:root:flavour confusion matrix (rows = predicted classes, cols = actual classes):

[[20826   273   997  1315]
 [  347 20536  1449  1464]
 [  330   613  1957   768]
 [ 1259  1184   986 29664]]
```

- Improvement from before, not a whole lot. Mainly in the nutauCC predictions
- Does do a little better differentiating nueCCs/numuCCs from NC

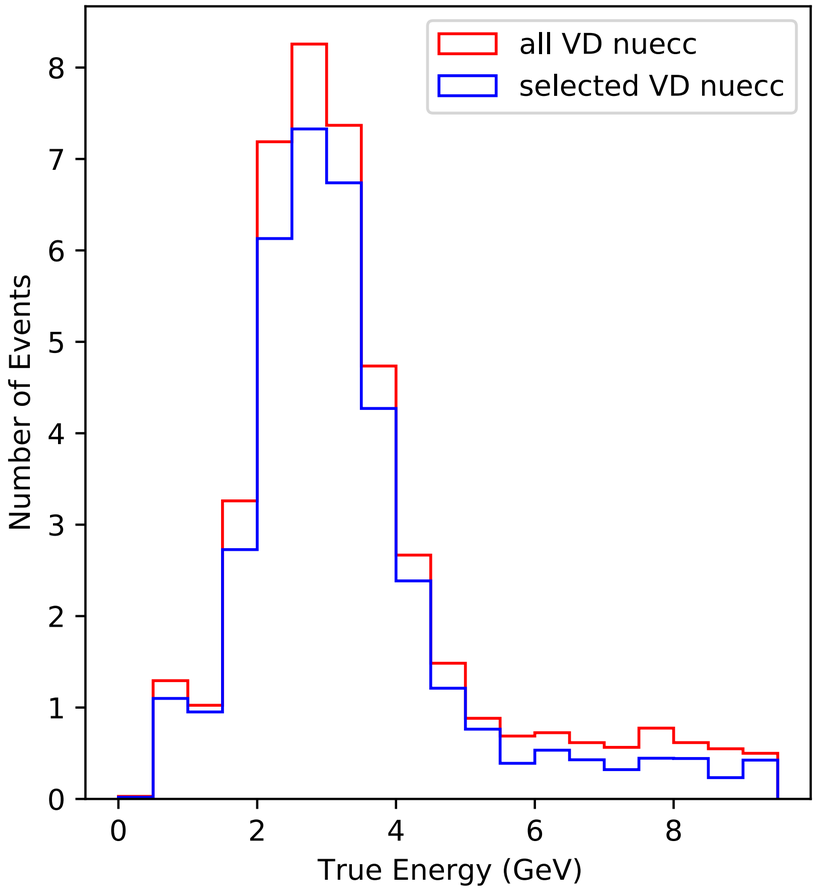
NueCC

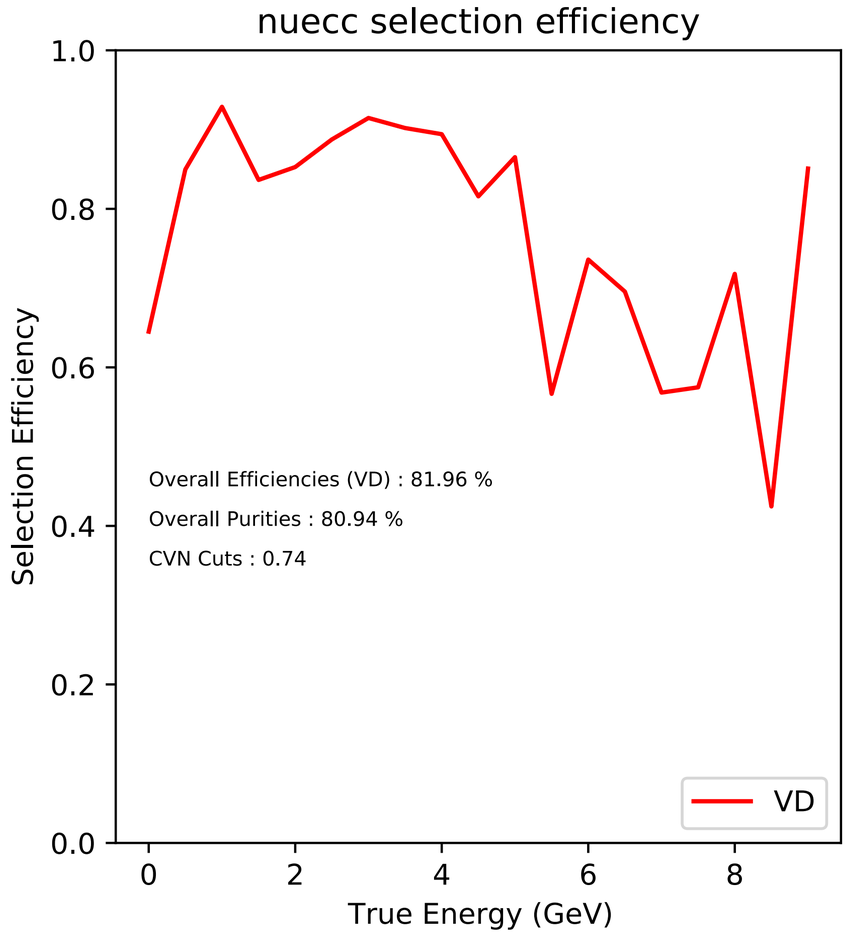




- Distributions with “dumb” oscillation weights + pot normalised

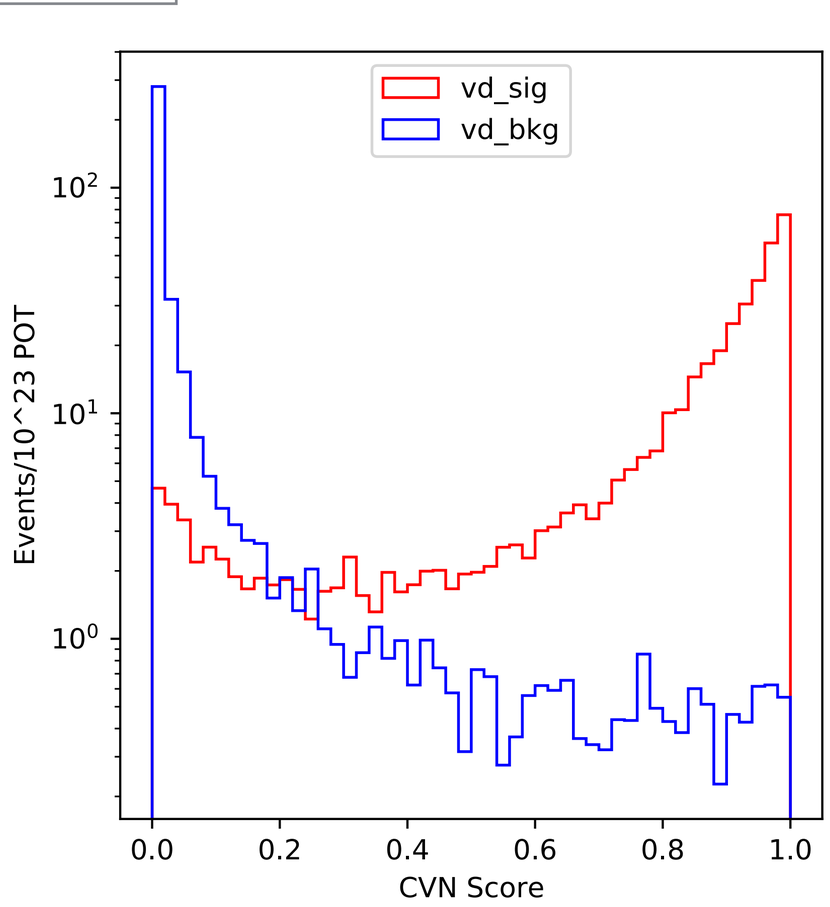
NueCC

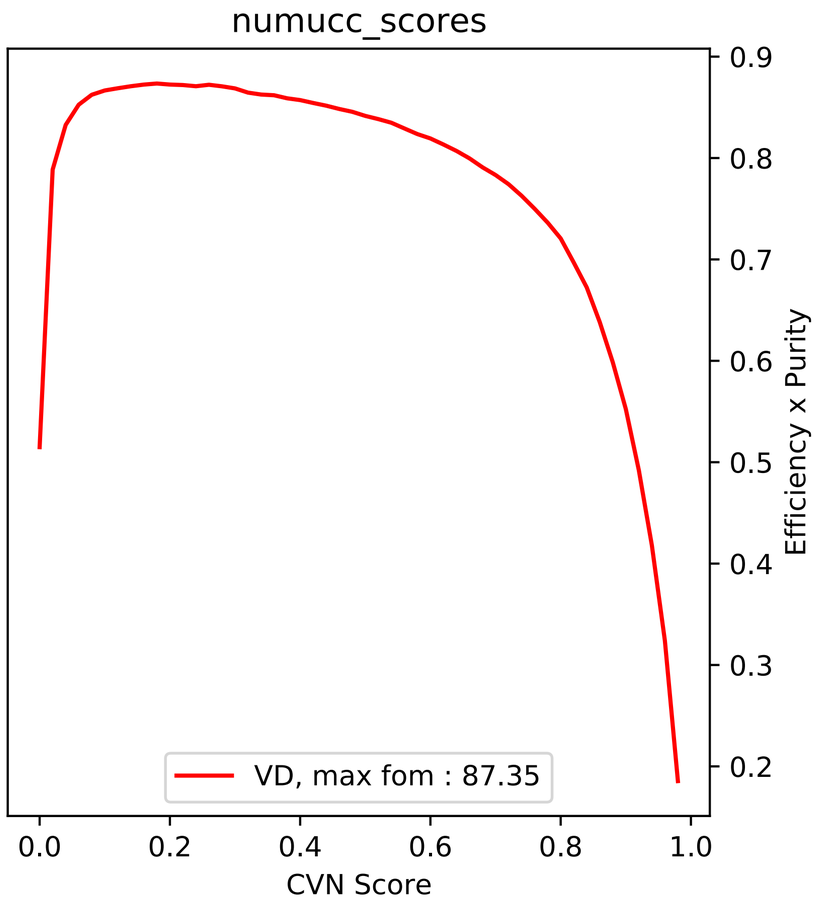




- Eff, Purity numbers after optimised CVN cut based on FOM - (82%, 81%)
- Better than before but not as good as the HD numbers

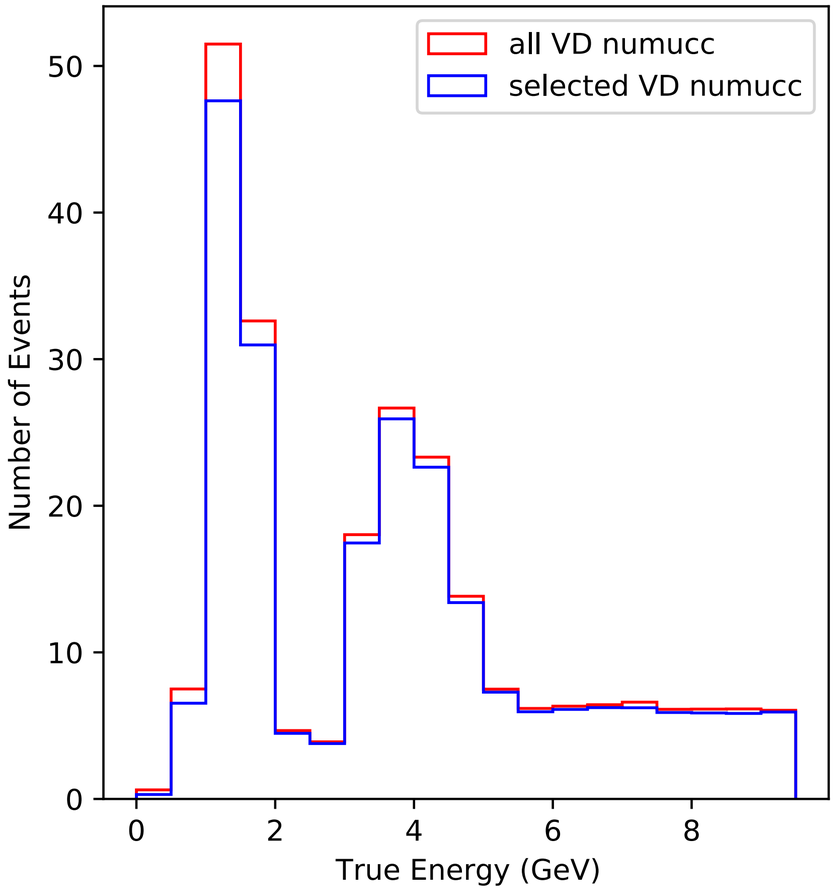
NumuCC

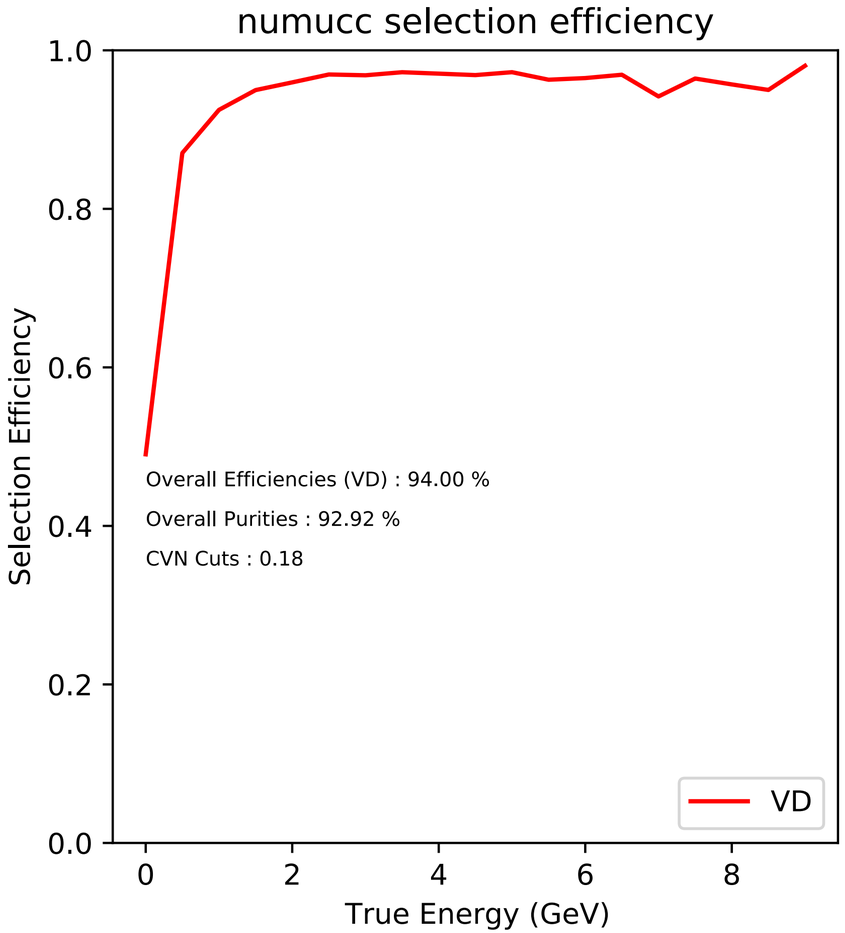




- Distributions with “dumb” oscillation weights + pot normalised

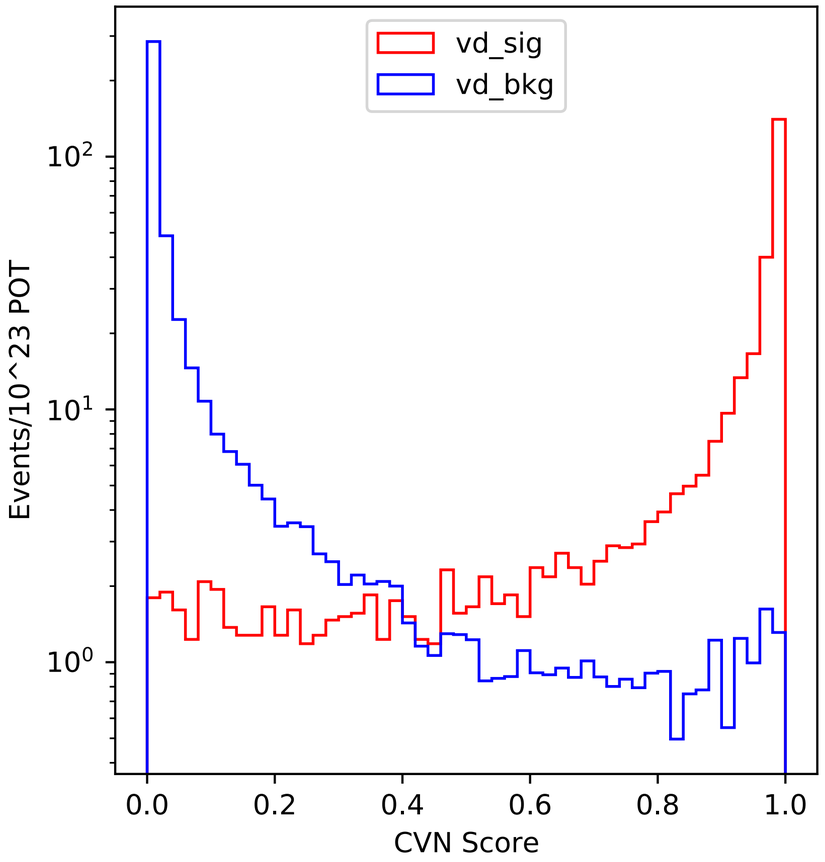
NumuCC

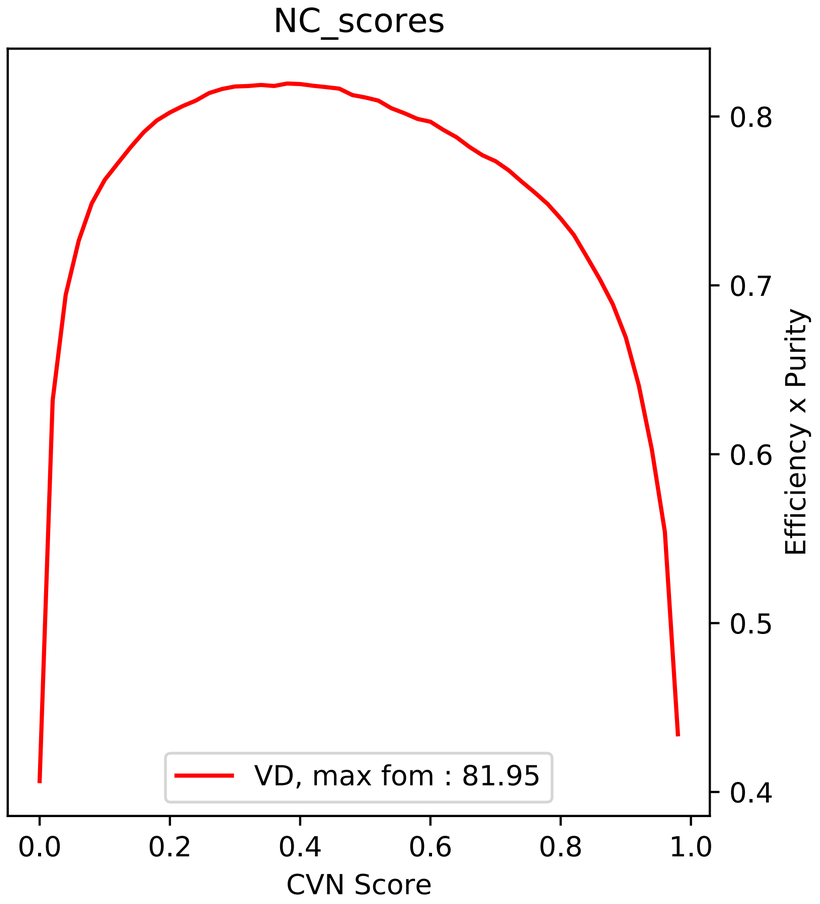




- Eff, Purity numbers after optimised CVN cut based on FOM - (94%, 93%)

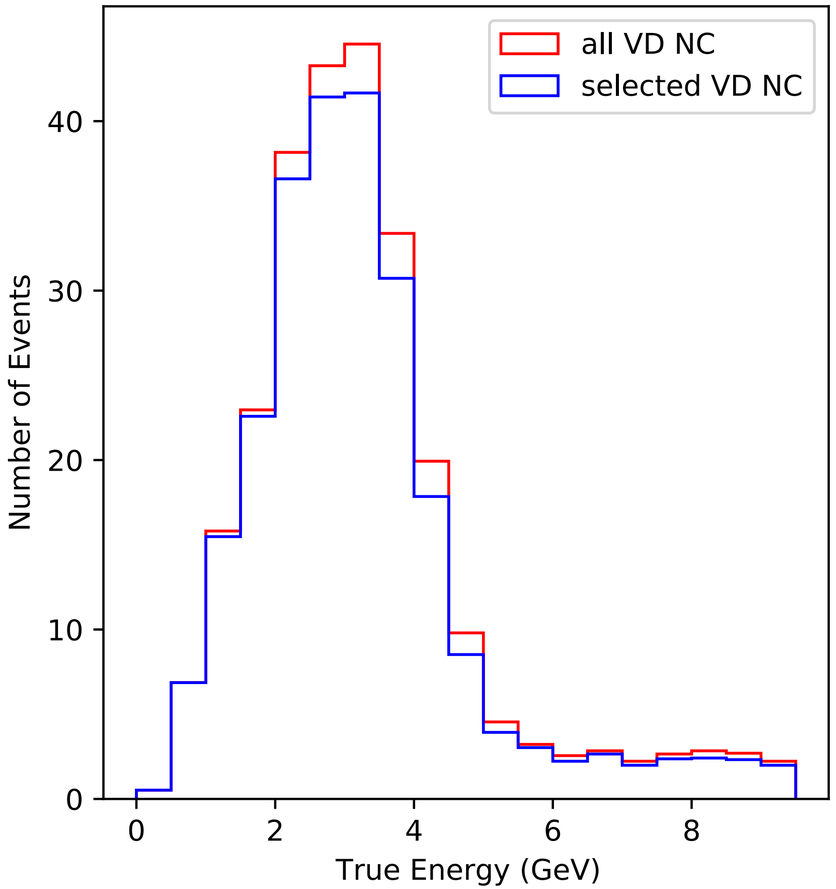
NC

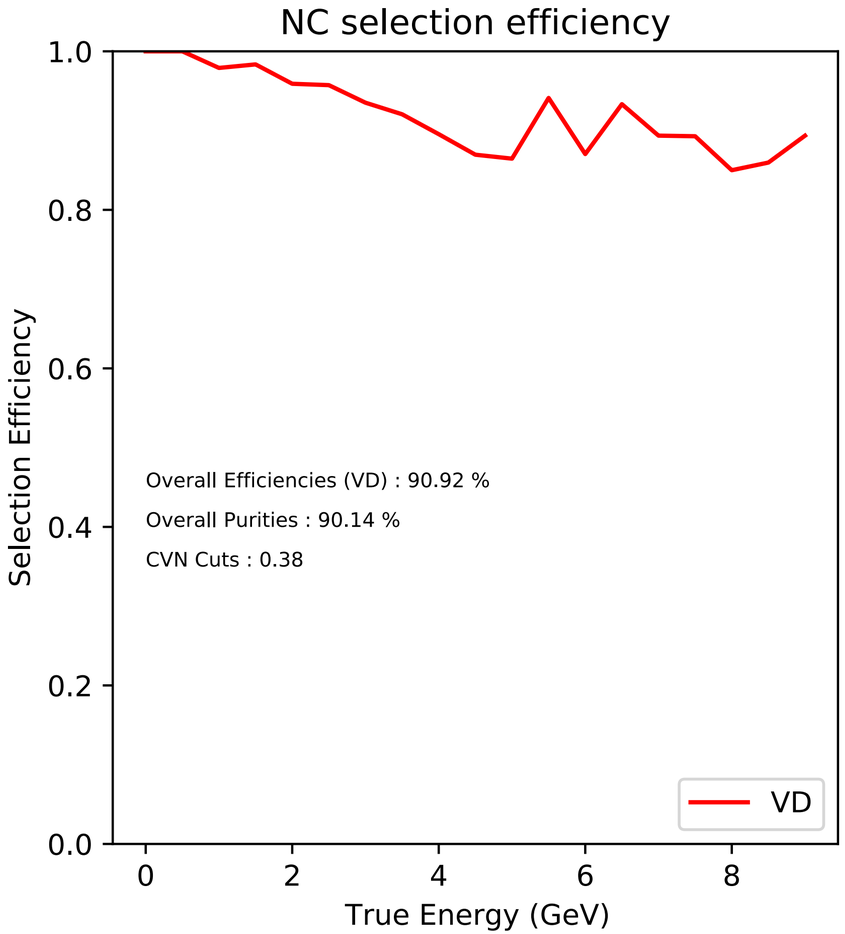




- Distributions with “dumb” oscillation weights + pot normalised

NC





- Eff, Purity numbers after optimised CVN cut based on FOM - (91%, 91%)

Summary

- Raw network performance for VD seems to be stabilised a little bit behind the old HD trainings
  - Biggest difference in efficiency and purity numbers for nueCCs
  - Not very far off but enough to matter?
  - Hard to say how much more we can squeeze out of it, unfortunately the biggest improvement from the large sample seems to come in the nuTauCC classification
- Can look at training using wire cell deconvolve charge inputs/sim channels to set upper bounds on these numbers
- Obviously lot is different in the new simulation. Any thoughts about this drop?