GNN updates

Extra truth information

- Context (information about full graph):
  - Number of beam pions, photon, and pi0s in the event
- PFO information:
  - Whether the particle is related to the beam
  - True particle identification
- Neighbour information:
  - PFOs originate from the same mother pi0
- Beam information
  - Whether particles are related to the beam (and level of relation, i.e. daughter vs. grand-daughter)

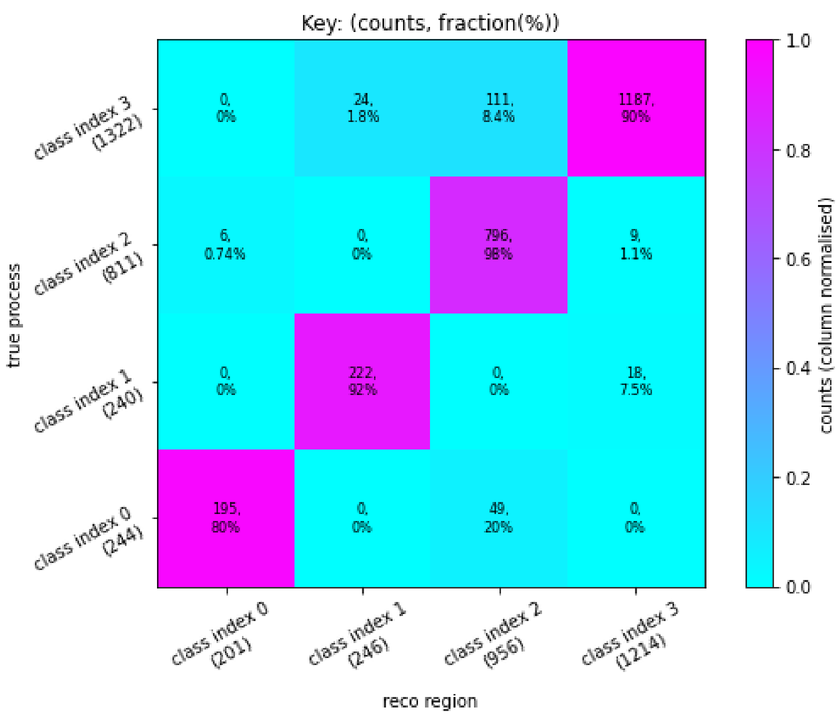
Region classification fix

- Noticed a discrepancy between pion counts and classification whilst testing the extra truth information.
- Pion counts didn’t distinguish between π^+ and π^- (can’t distinguish anti-particles in LAr).
- Region classifications used an old method only counting π^+.
- Helped the network, even without extra information.

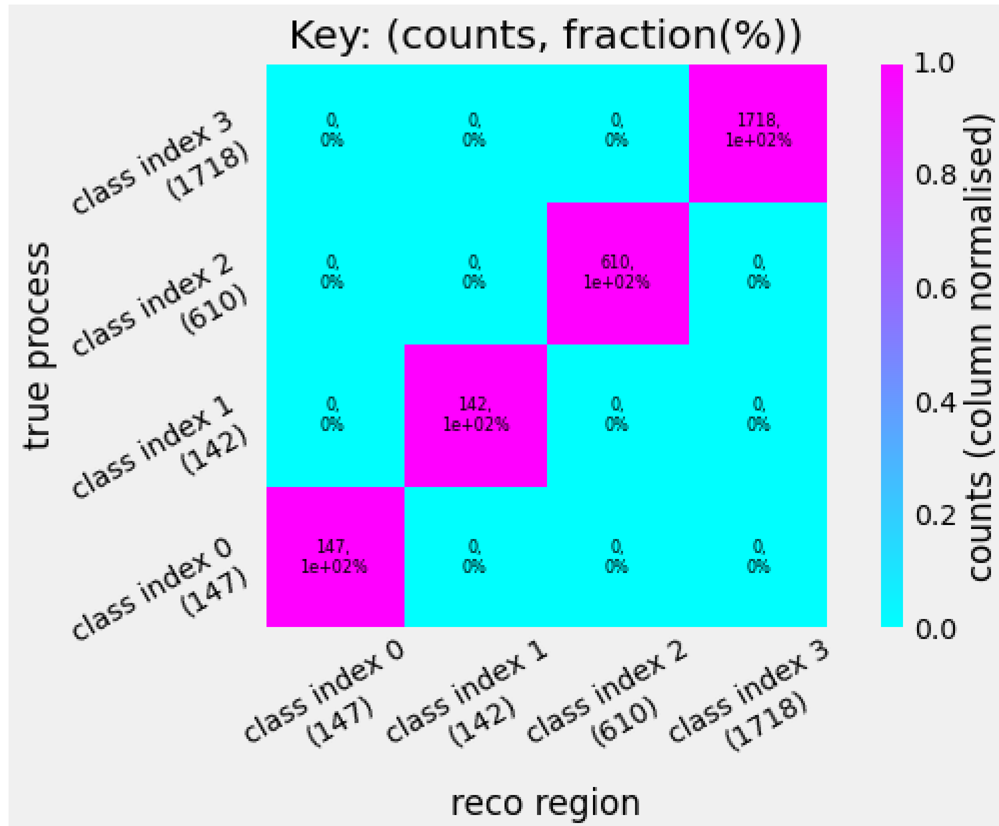
Region classification fix

3: Multi-pion production
2: Single pion production
1: Charge exchange
0: Absorption

- No extra information used
- Perfect classification



Previous

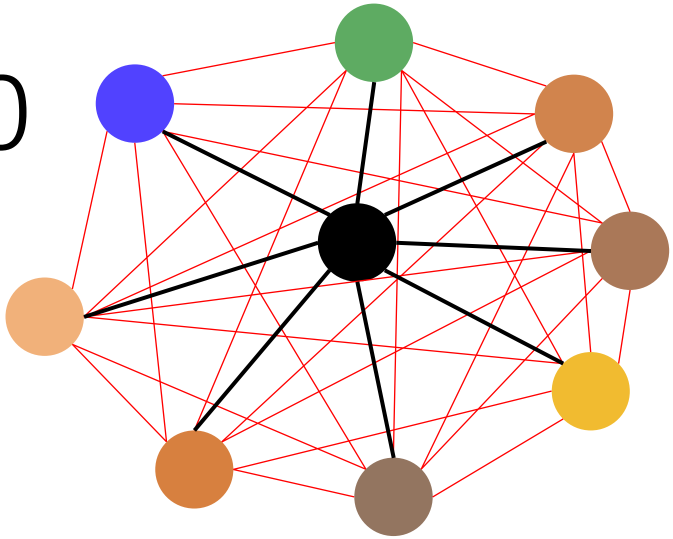


New (~40% less true absorption/CEx.)

Particle count losses

- Used a regression type loss.
- Truth information is a number (0, 1, 2, etc.) of particles
- Absolute mean error loss – average difference of prediction from true value
- Not made plots yet – use values of loss, and regression fit (R^2) value to monitor
- Initially, come from same layer that the classification is read from
  - Later comes from one layer before final classfication

MC structure with pi0



- Message passing step:
    1. PFO update
    2. Neighbour momentum update
    3. Neighbour kinematic update
    4. Beam collection

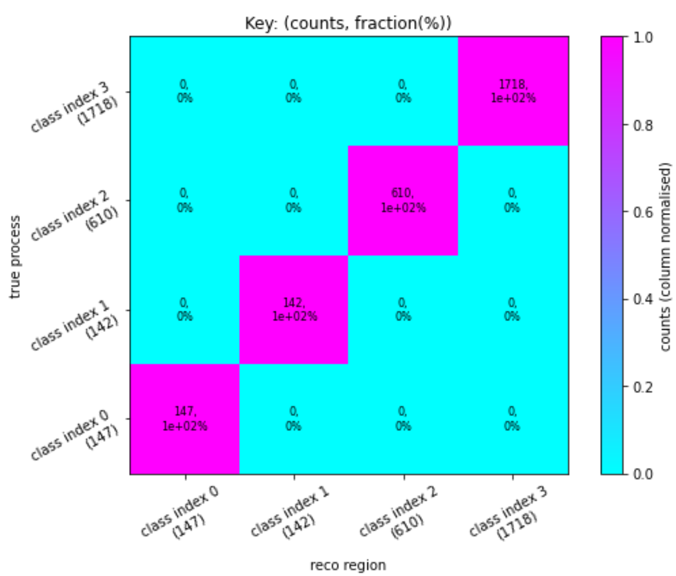
1. Set initial state
2. Beam collection
3. Message passing (x *N*)
4. Readout beam state
5. Add additional classification layers

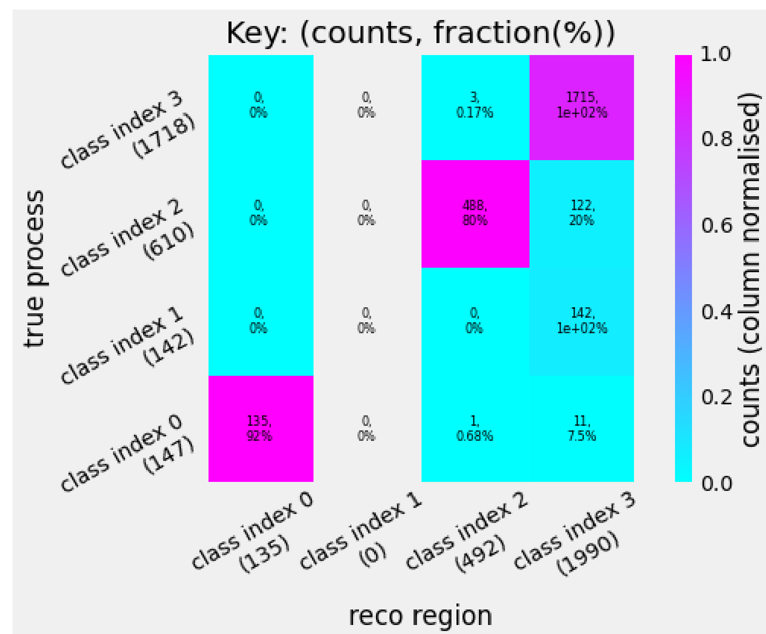
- Layer to predict number of pi0/pi+

Initial results

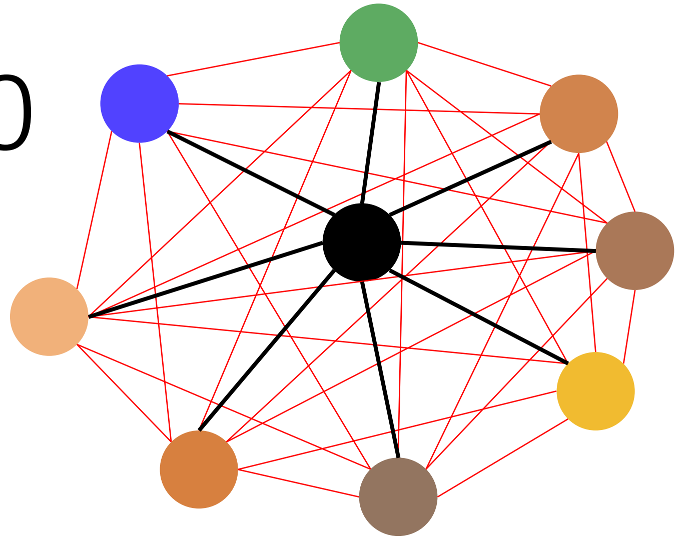
3: Multi-pion production
2: Single pion production
1: Charge exchange
0: Absorption

- Can get perfect classification, but unstable.
- Sometimes solution would ignore CEx./not greate regression loss (~0.5 mean error)
- Regression weighting 1e-3 to 1e-5 compared to classification





MC structure with pi0



- Message passing step:
    1. PFO update
    2. Neighbour momentum update
    3. Neighbour kinematic update
    4. Beam collection

1. Set initial state
2. Beam collection
3. Message passing (x *N*)
4. Readout beam state
5. Classifier layers

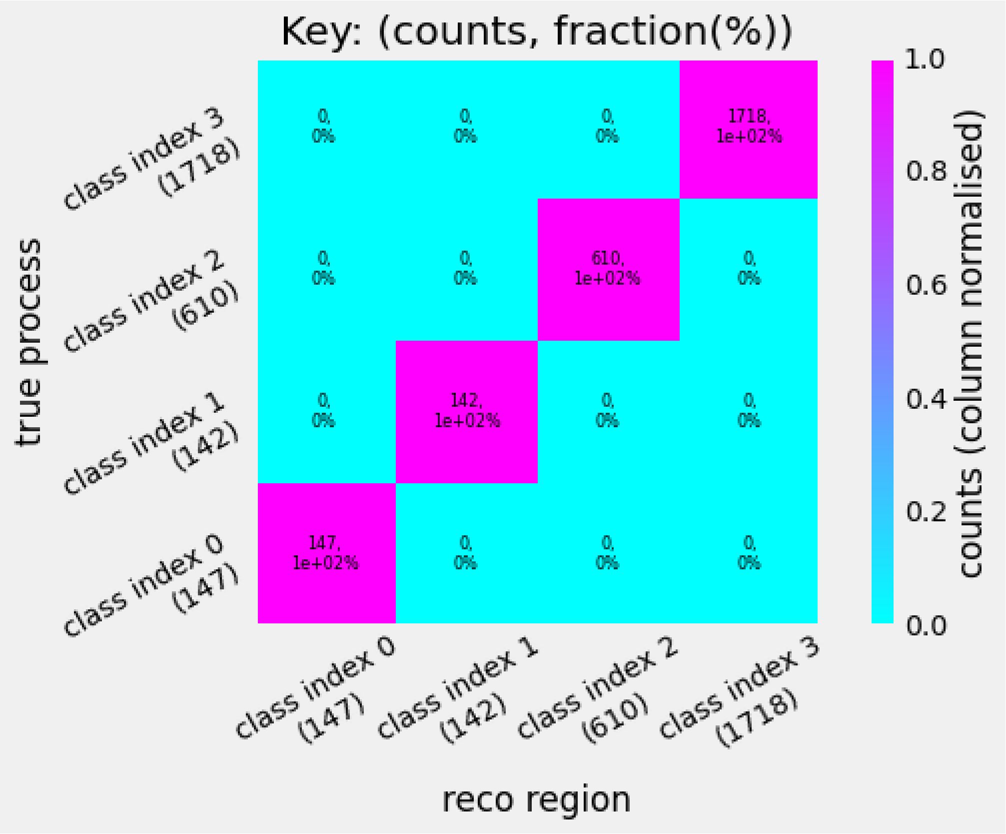
- Layer to predict number of pi0/pi+

6. Additional layer for classifier exclusively

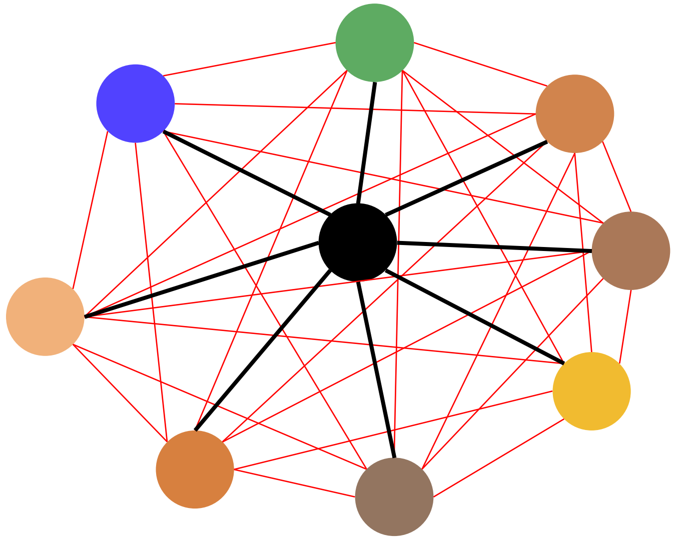
Changed readout location

3: Multi-pion production
2: Single pion production
1: Charge exchange
0: Absorption

- Much more stable running.
- Find minima after 10s of epochs, rather than 100s.
- Regression also works well, and can take higher weightings (currently using 1e-3).



MC structure no pi0



- Message passing step:
  1. PFO update
  2. Neighbour momentum update
  3. Neighbour kinematic update
  4. Beam collection

1. Set initial state
2. Beam collection
3. Message passing (x *N)*

- Layer to check pi0 reconstruction from neighbours

Not done yet

4. Readout beam state
5. Classifier layers

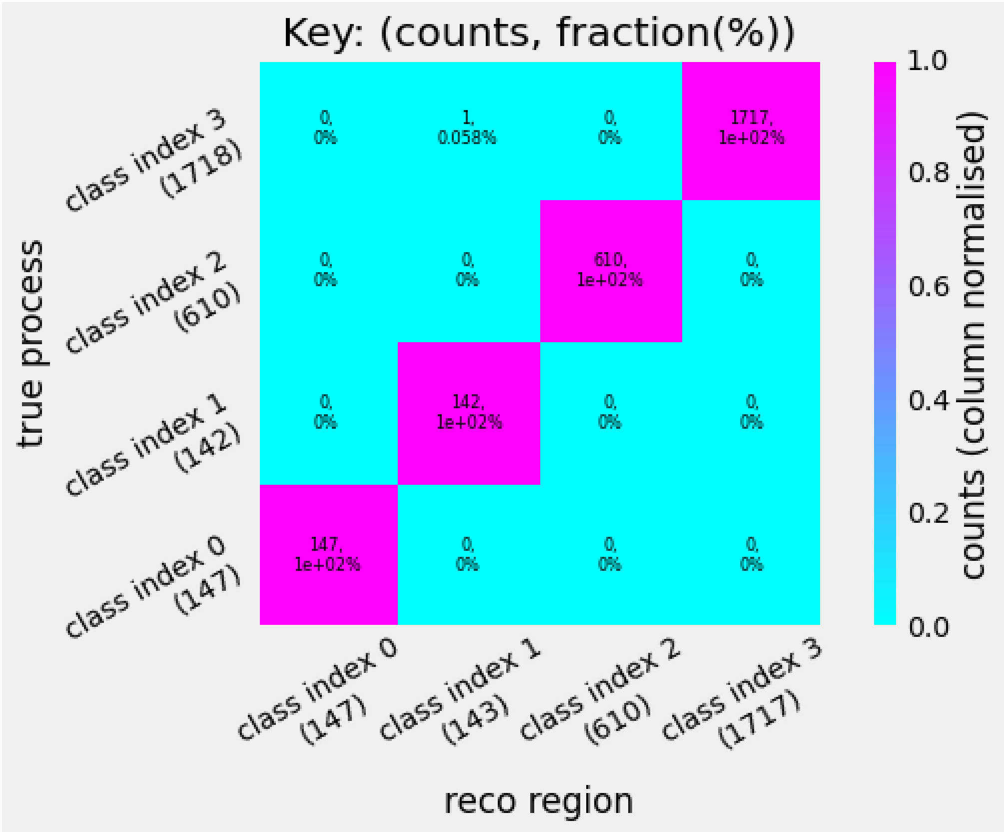
- Layer to predict number of pi0/pi+

6. Additional layer for classifier exclusively

3: Multi-pion production
2: Single pion production
1: Charge exchange
0: Absorption

No pi0 MC

- Get perfect classification even before adding pi0 from photon ID loss.
- Not that surprising we always get both photons from a pi0
- Not examined possible failure modes of other decay channels.



No pi0 MC

3: Multi-pion production
2: Single pion production
1: Charge exchange
0: Absorption

- Keep perfect classification even without the message passing step
  - Network isn't doing anything fancy to detect pi0s.
- Next step:
  Add pi0 ID loss