ML (e/gamma) studies in WCTE

D. Costas-Rodríguez, J. Renner, J. A. Hernando-Morata
IGFAE/Universidade de Santiago de Compostela
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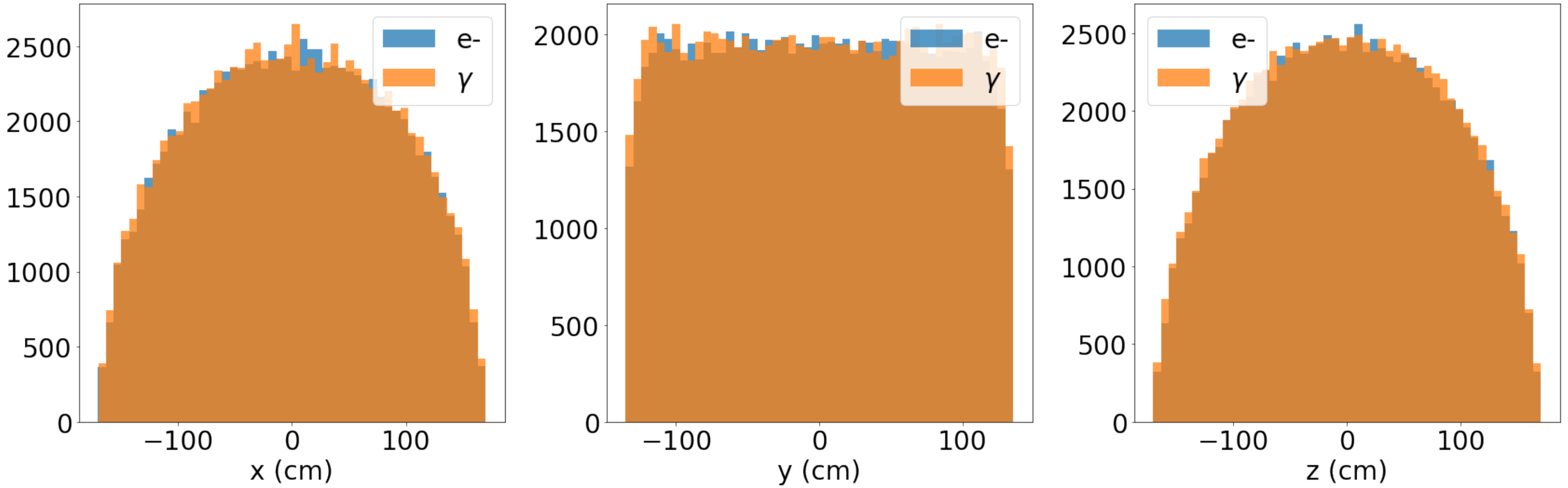
Summary:

- e-/mu- separation shown in previous studies to be good
- Recent efforts largely focused on e-/gamma separation
  - Using notebook from Nick Prouse: https://github.com/nickwp/watchmal-examples/blob/master/IWCD PID example analysis of single ResNet run.ipynb
  - ResNet with hit charge + timing information (from Annalisa https://github.com/adelorenzis/WatChMaL)
  - Using updated branch nuPRISM/develop in WCTE/WCSim (https://github.com/WCTE/WCSim)

Generation of WCSim events (1M e-/gamma):

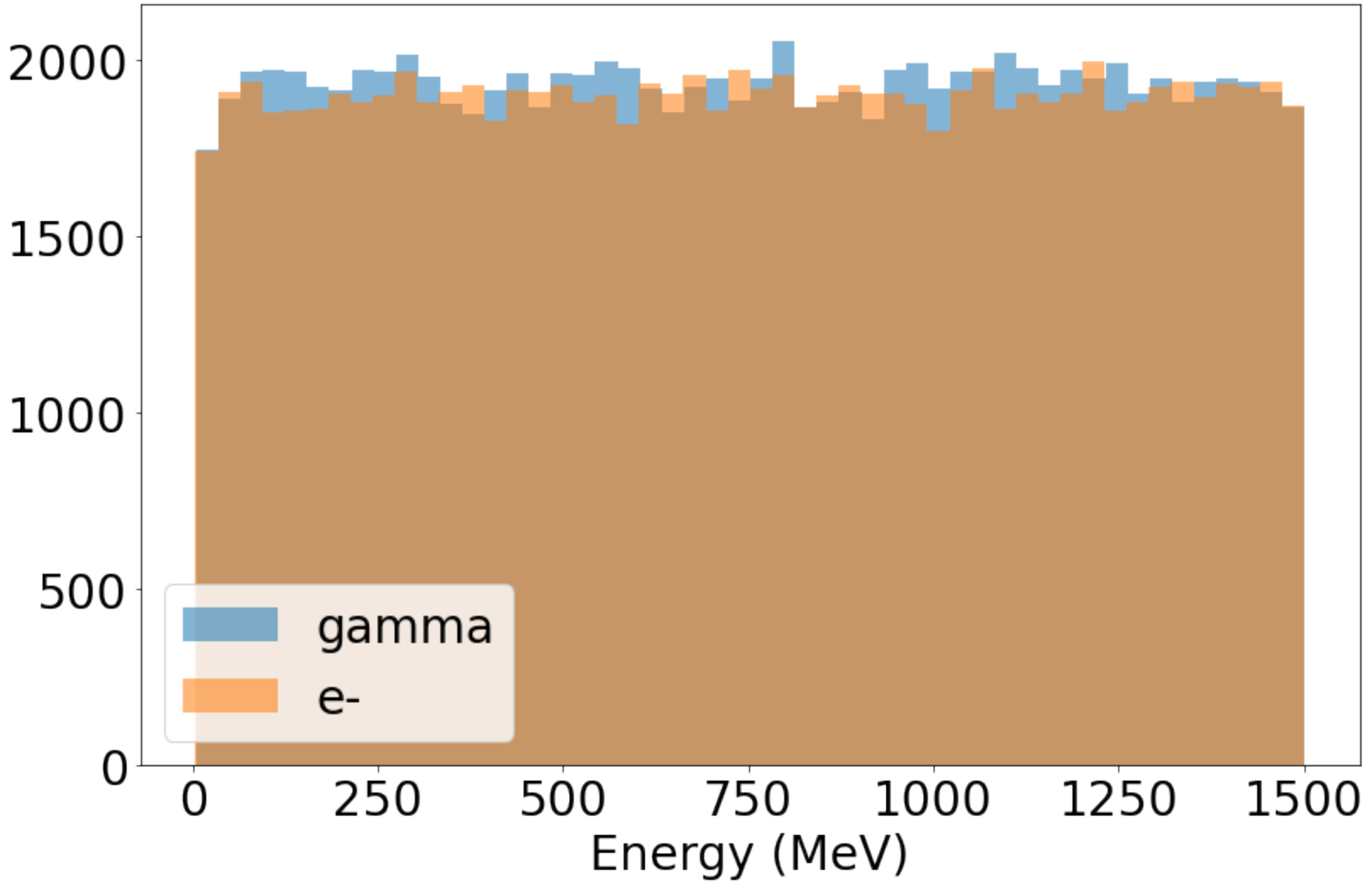
- Axis of cylinder is along Y: events launched from [-height/2, +height/2]

Distribution of initial (x,y,z) locations



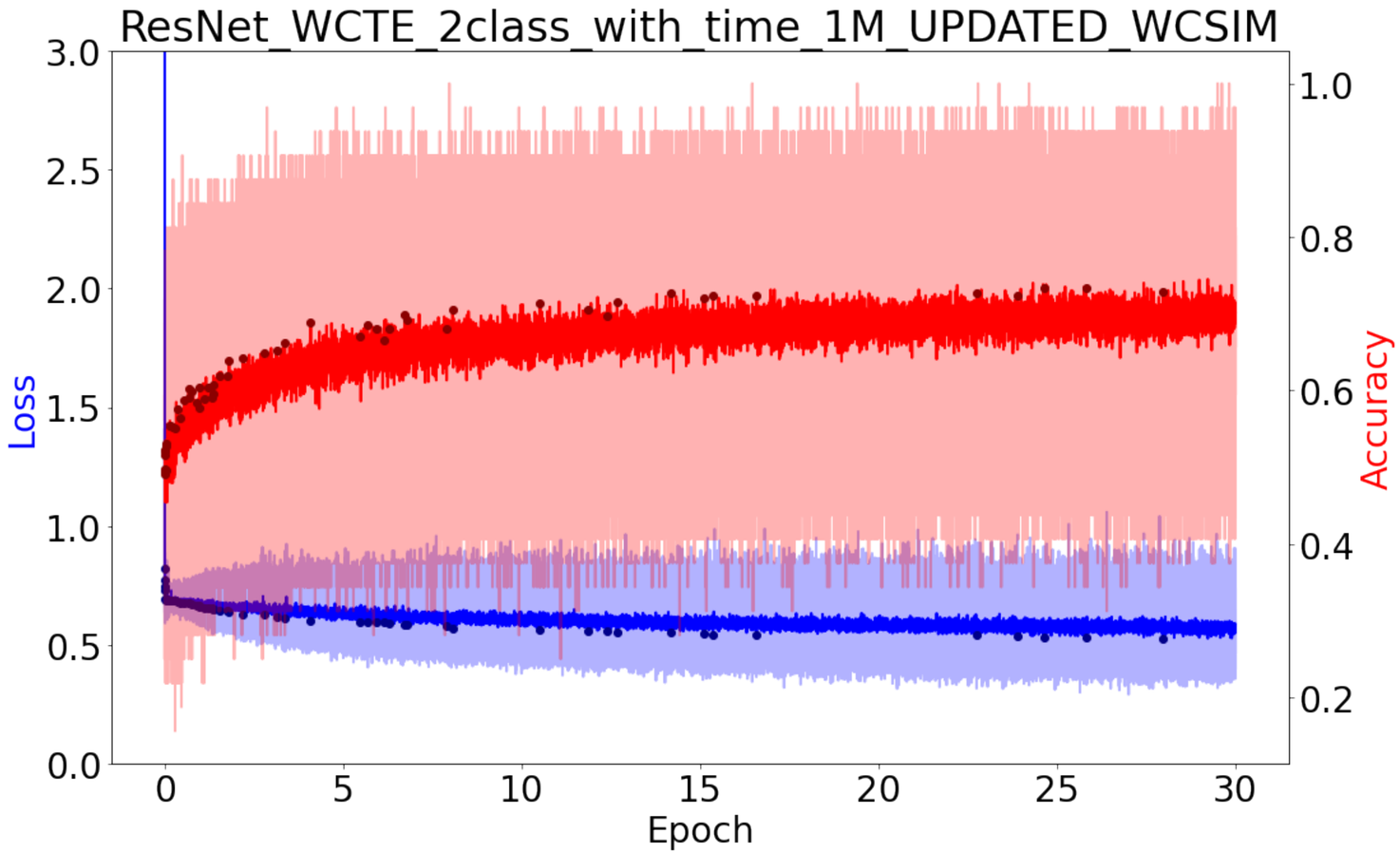
Generation of WCSim events (1M e-/gamma):

Distribution of energies



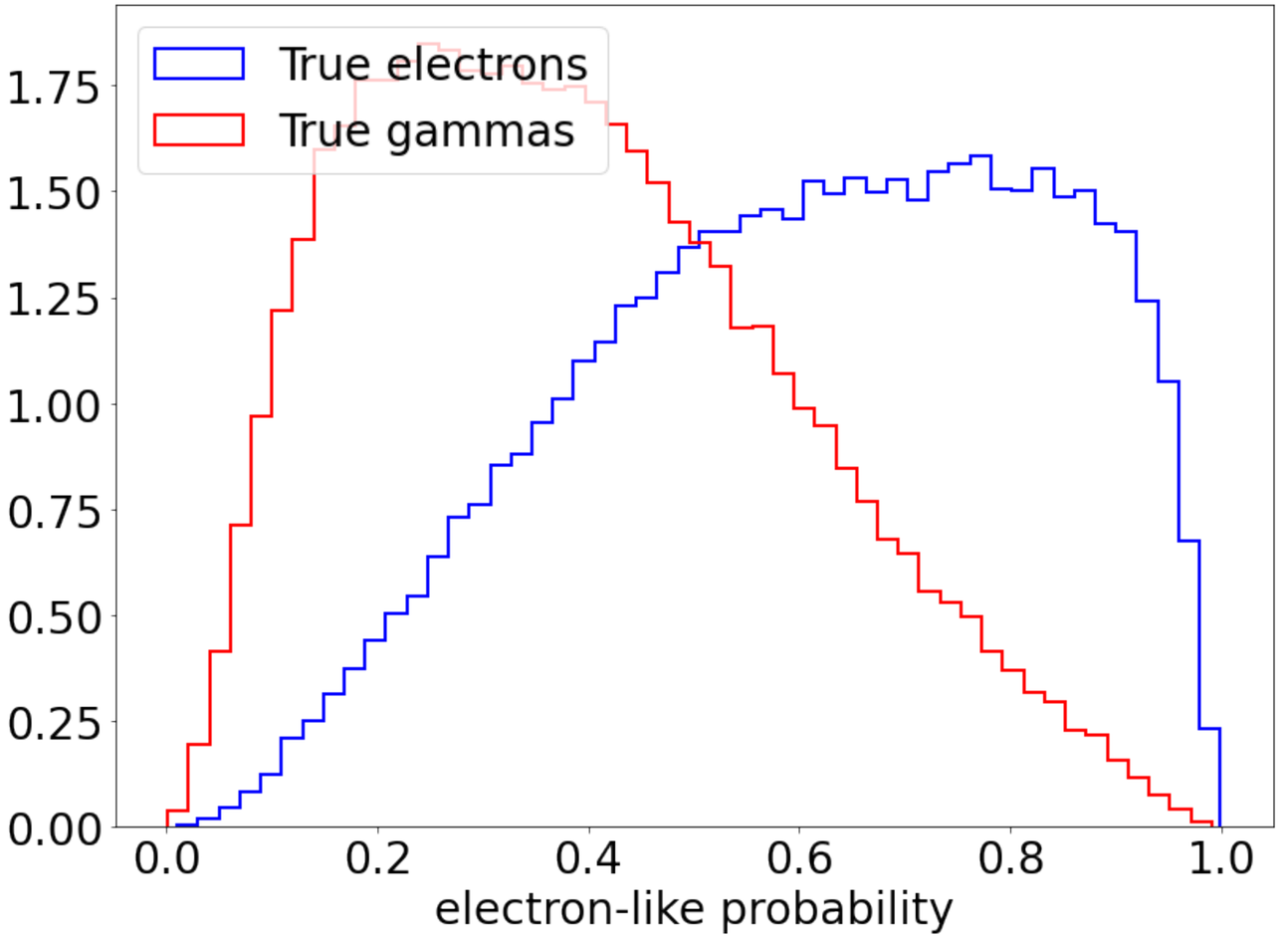
ResNet e-/gamma training:

- 1M events
  - 70% training
  - 20% validation
  - 10% test
- Cut on # of hits > 30
- Max energy 1.5 GeV
- 2 class ResNet
- Could be trained further?

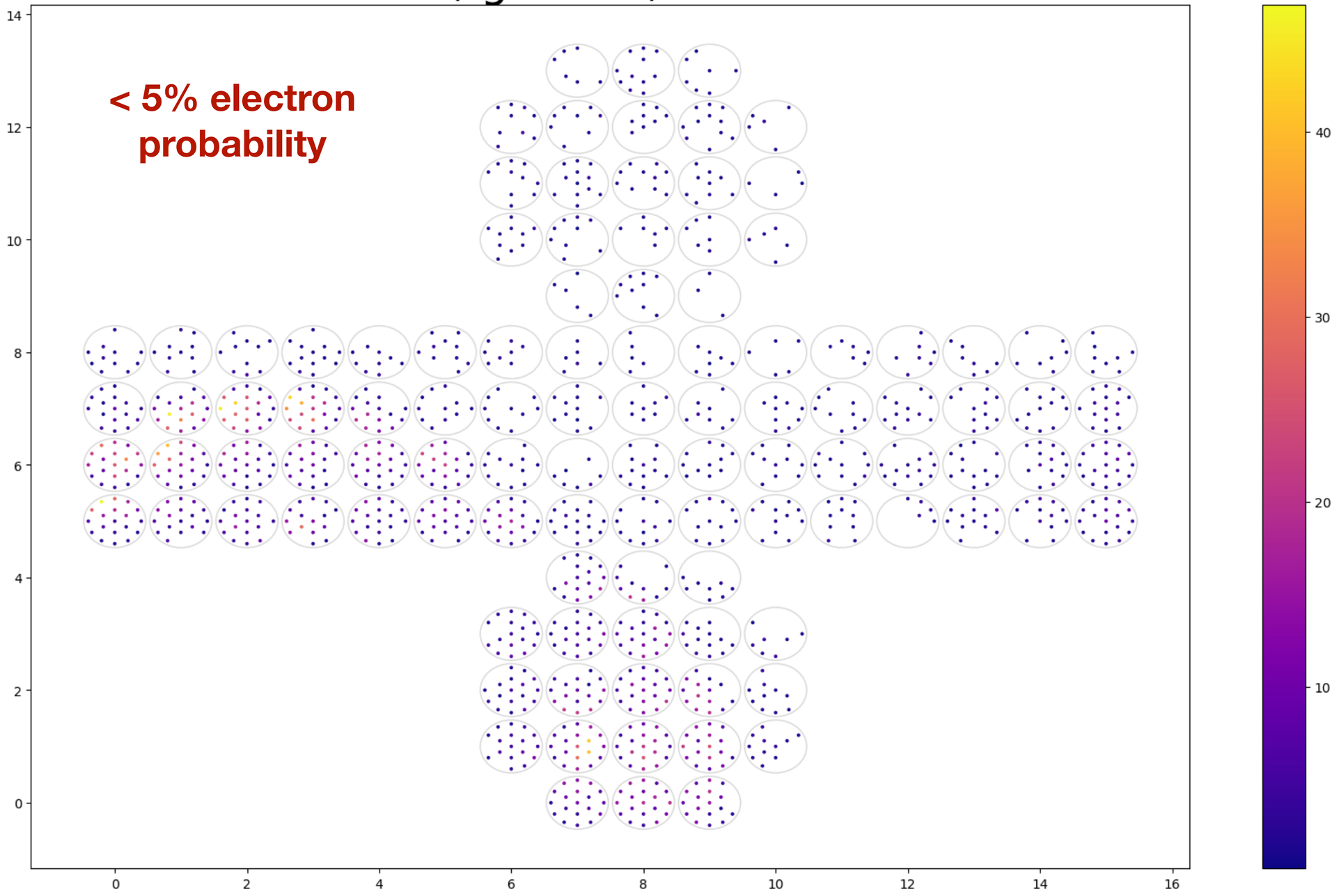


ResNet e-/gamma discrimination:

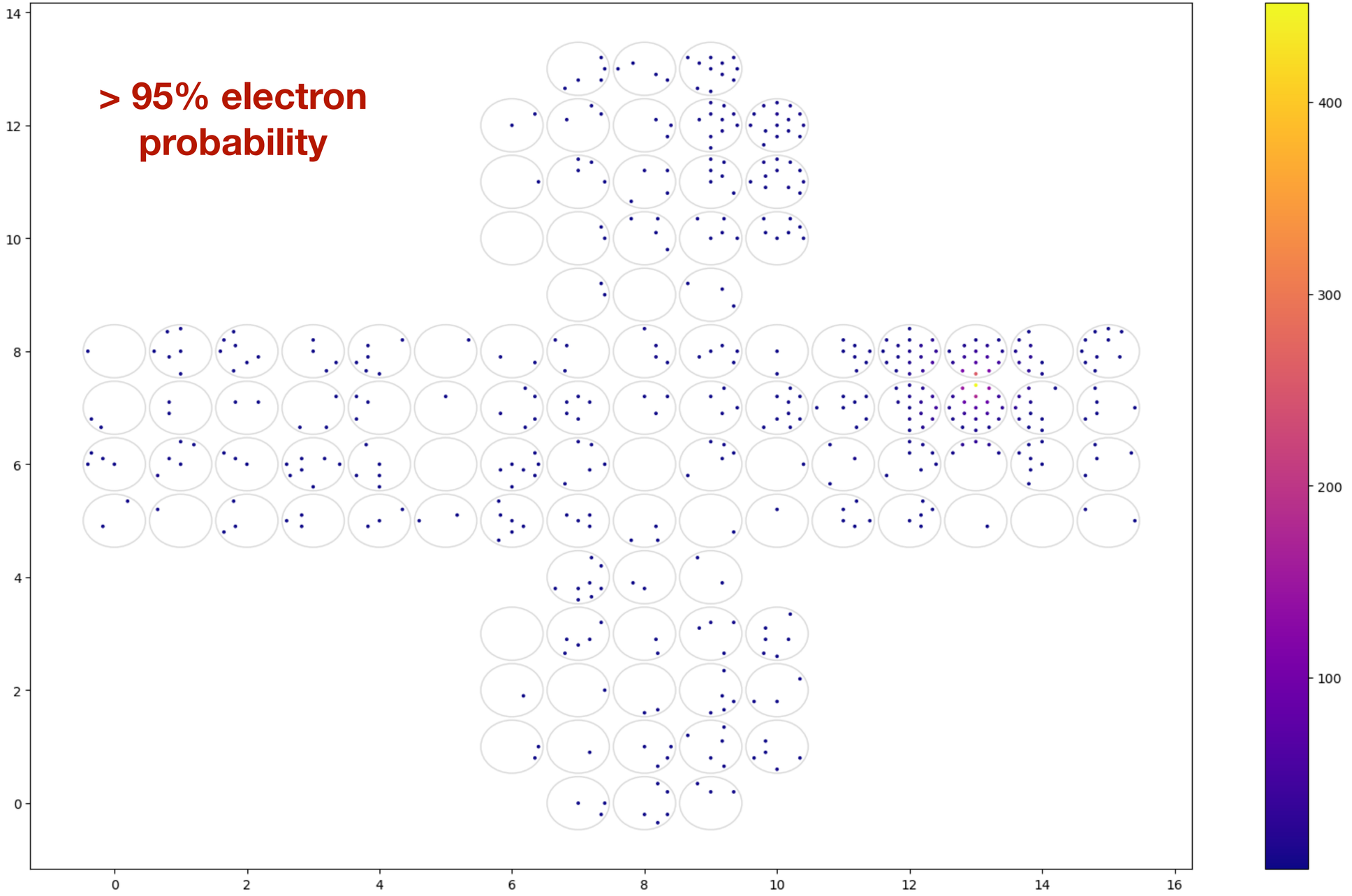
- Neural network classification electron probability



Event #189, gamma, E = 686.81 MeV

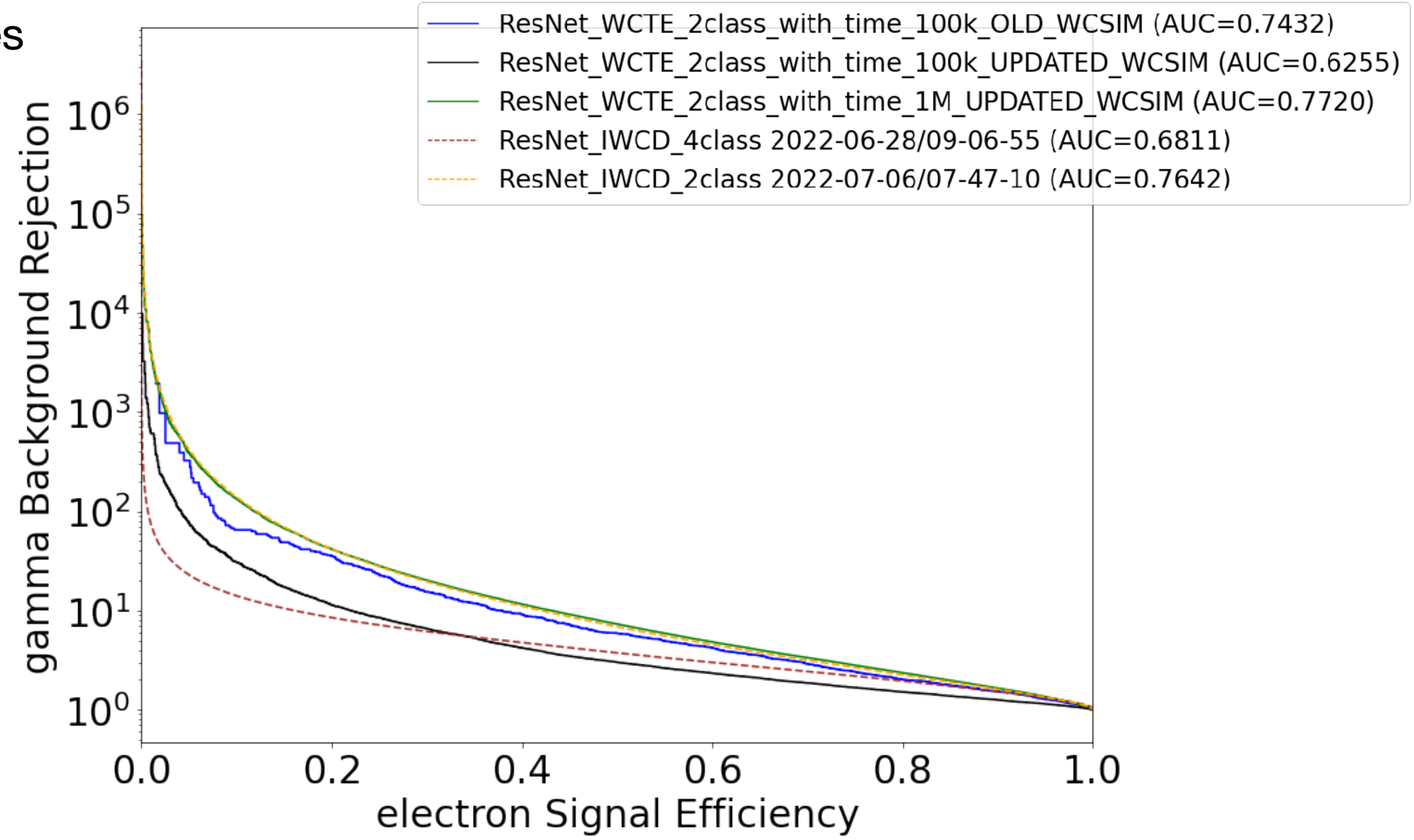


Event #1000070, electron, E = 765.64 MeV



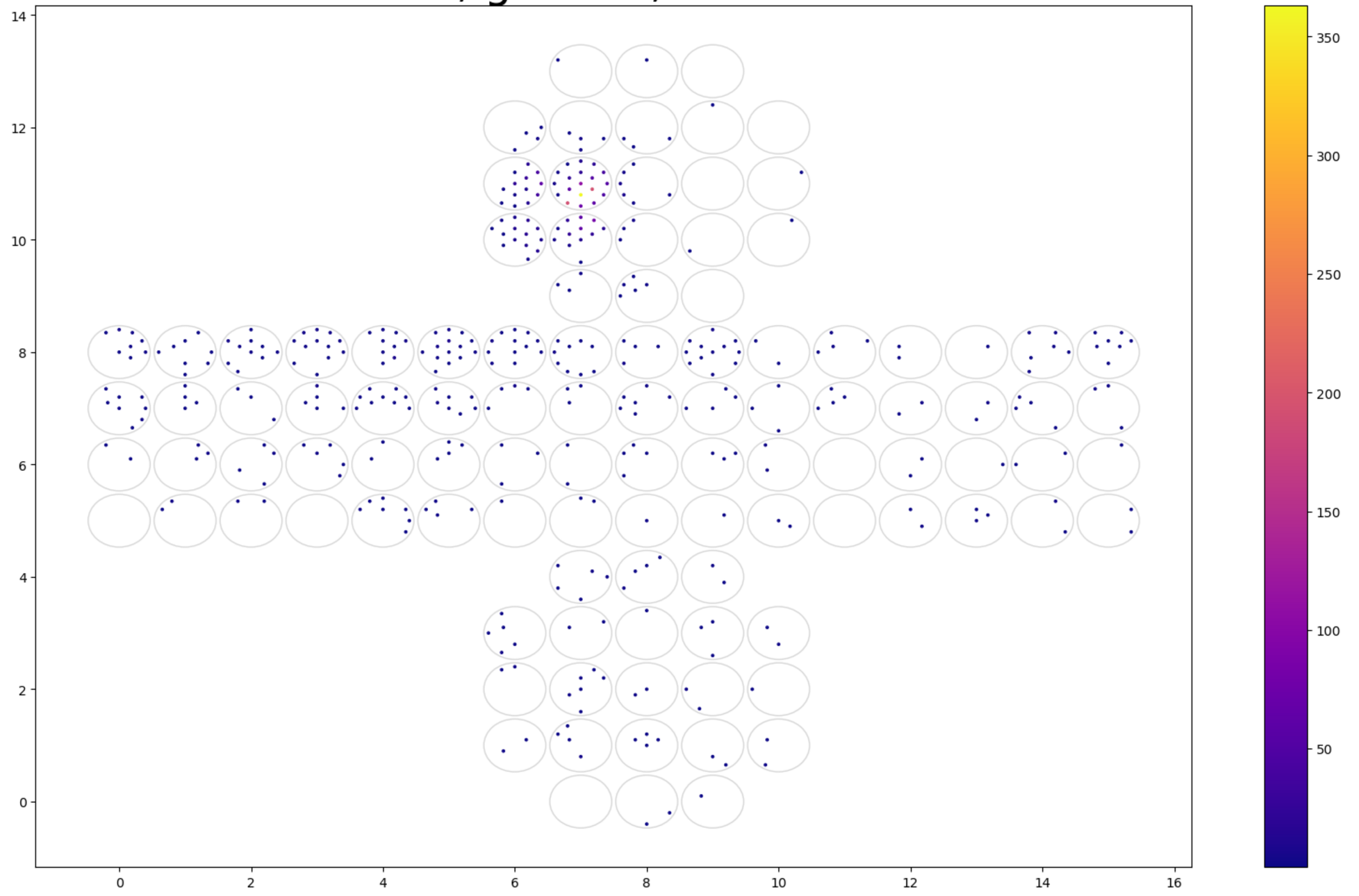
ResNet e-/gamma discrimination:

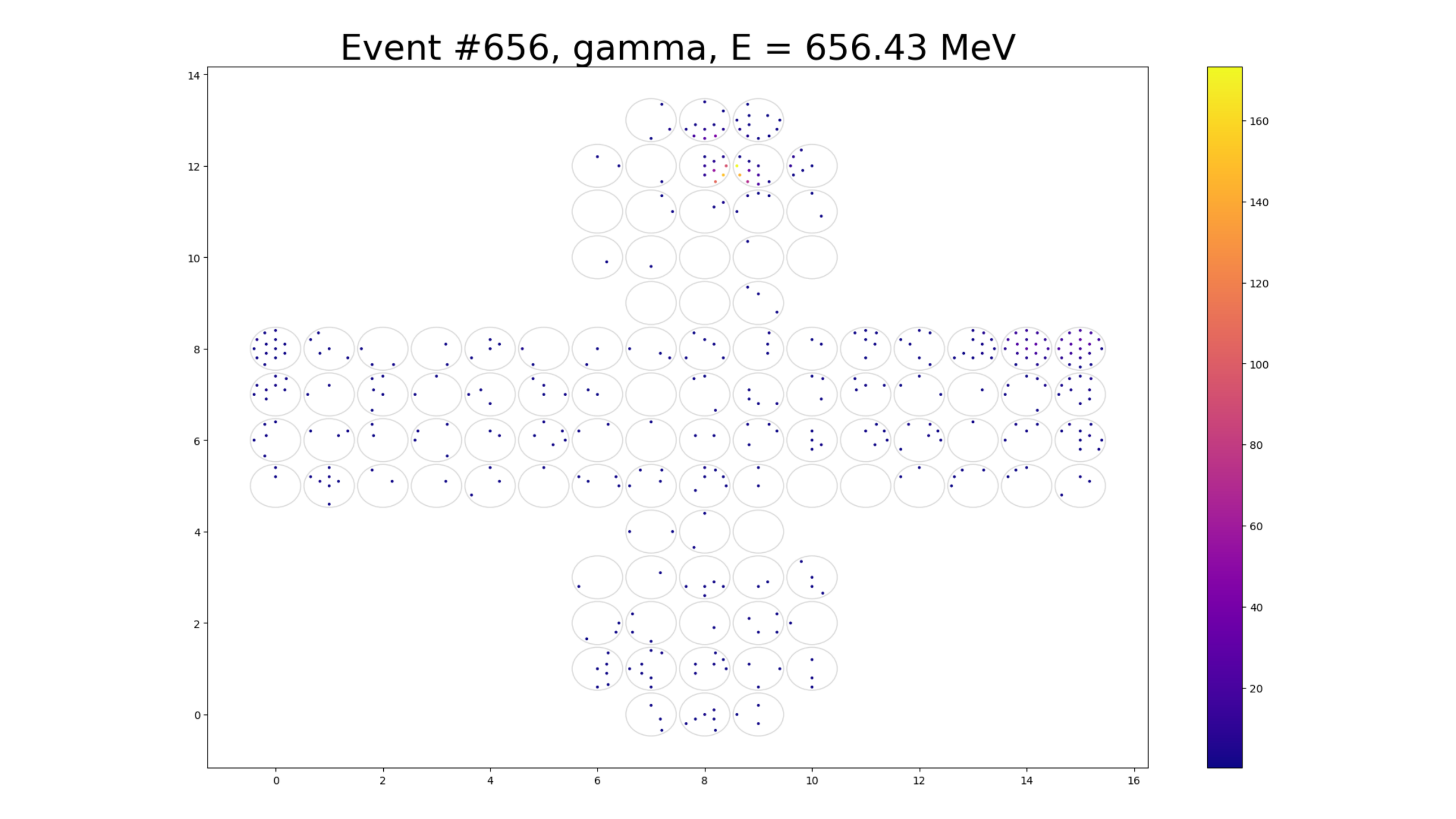
- ROC curves

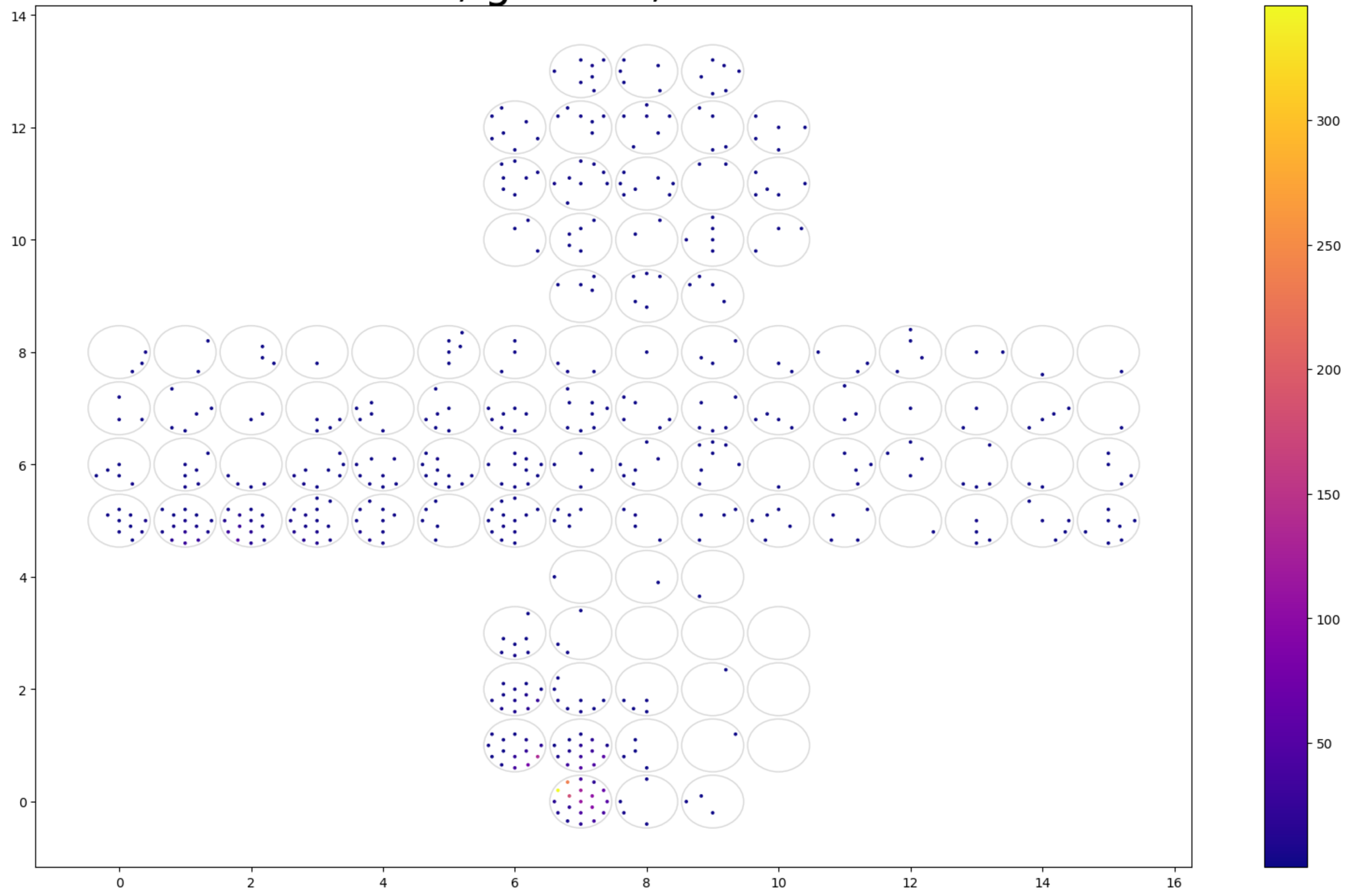


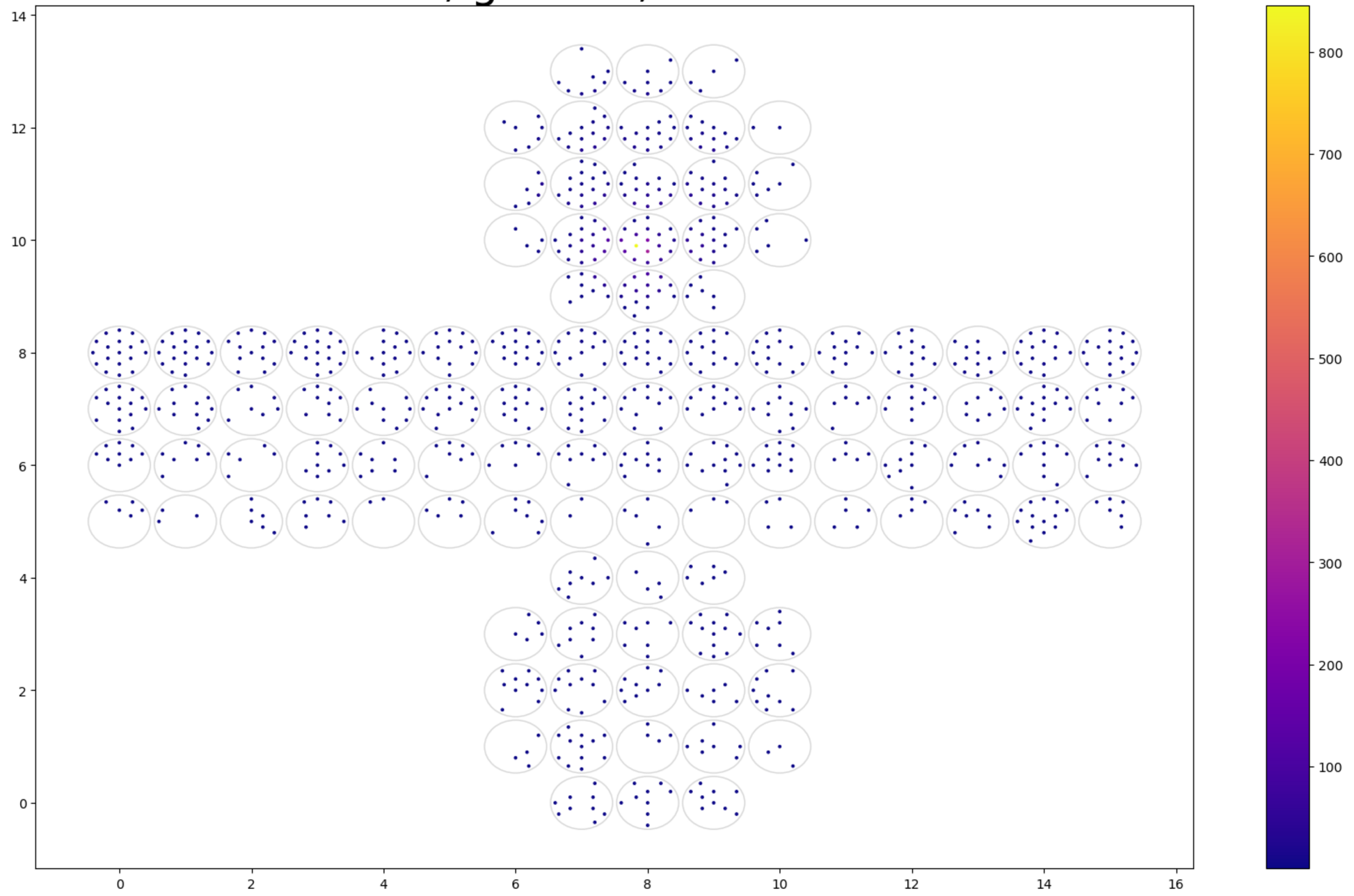
Summary:

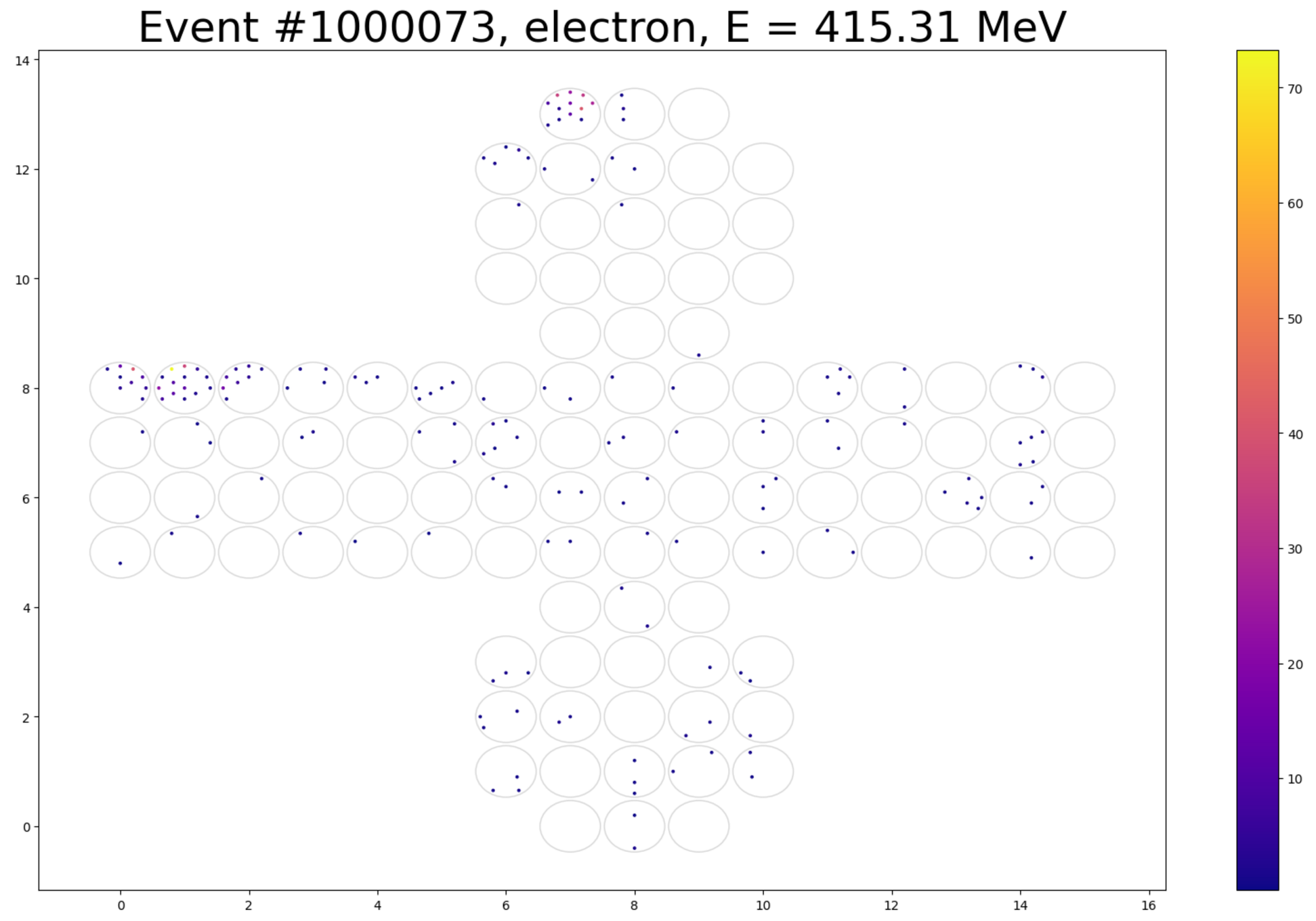
- e-/gamma separation shown in simulation in WCTE with WatChMaL/ResNet
- What should be next focus?
  - How to apply these ML tools to WCTE data
  - Reconstruction of vertices/energy of low energy (neutron capture) events?

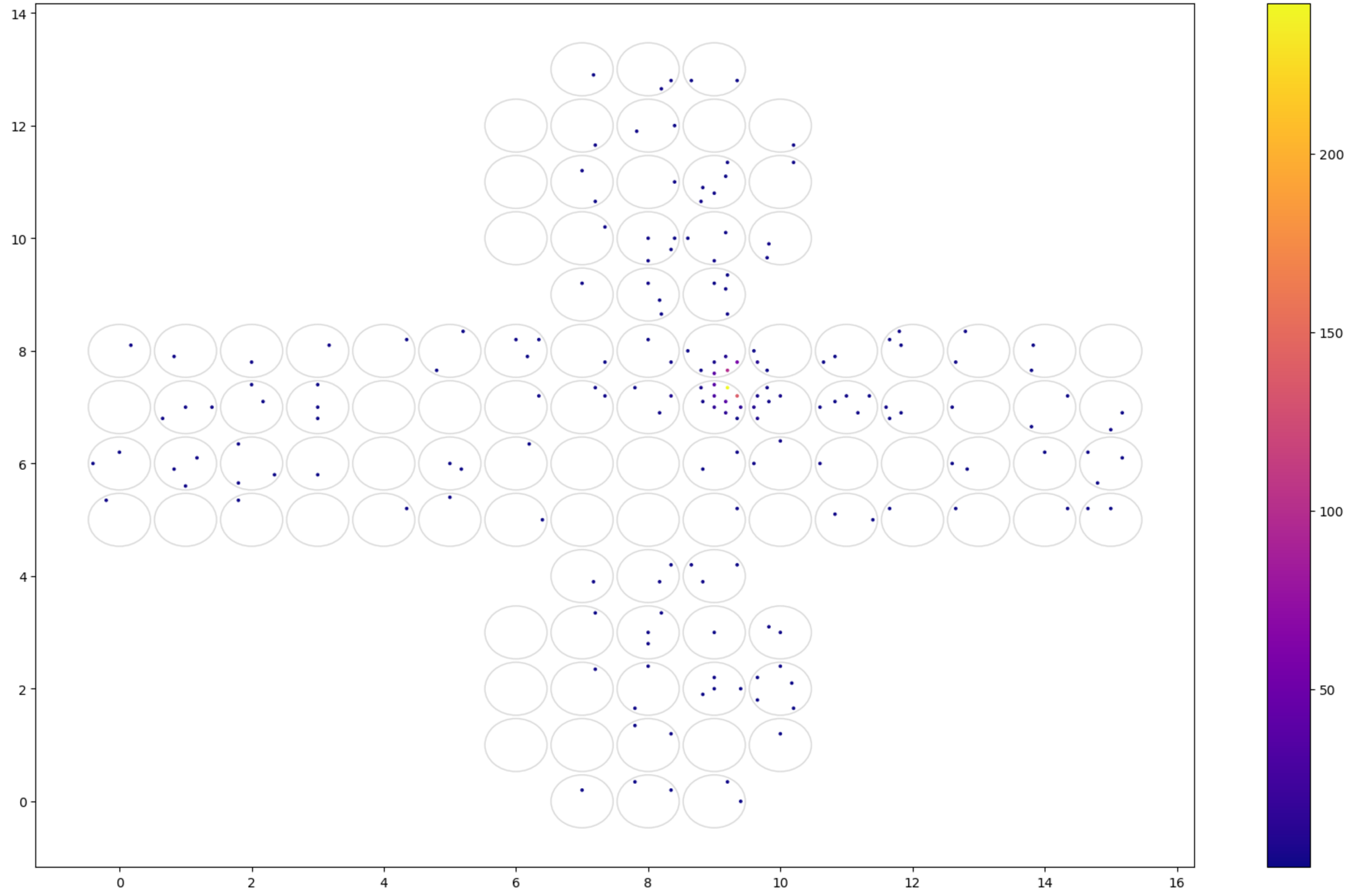

Event #400, gamma, E = 271.75 MeV
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
16
350
300
250
200
150
100
50

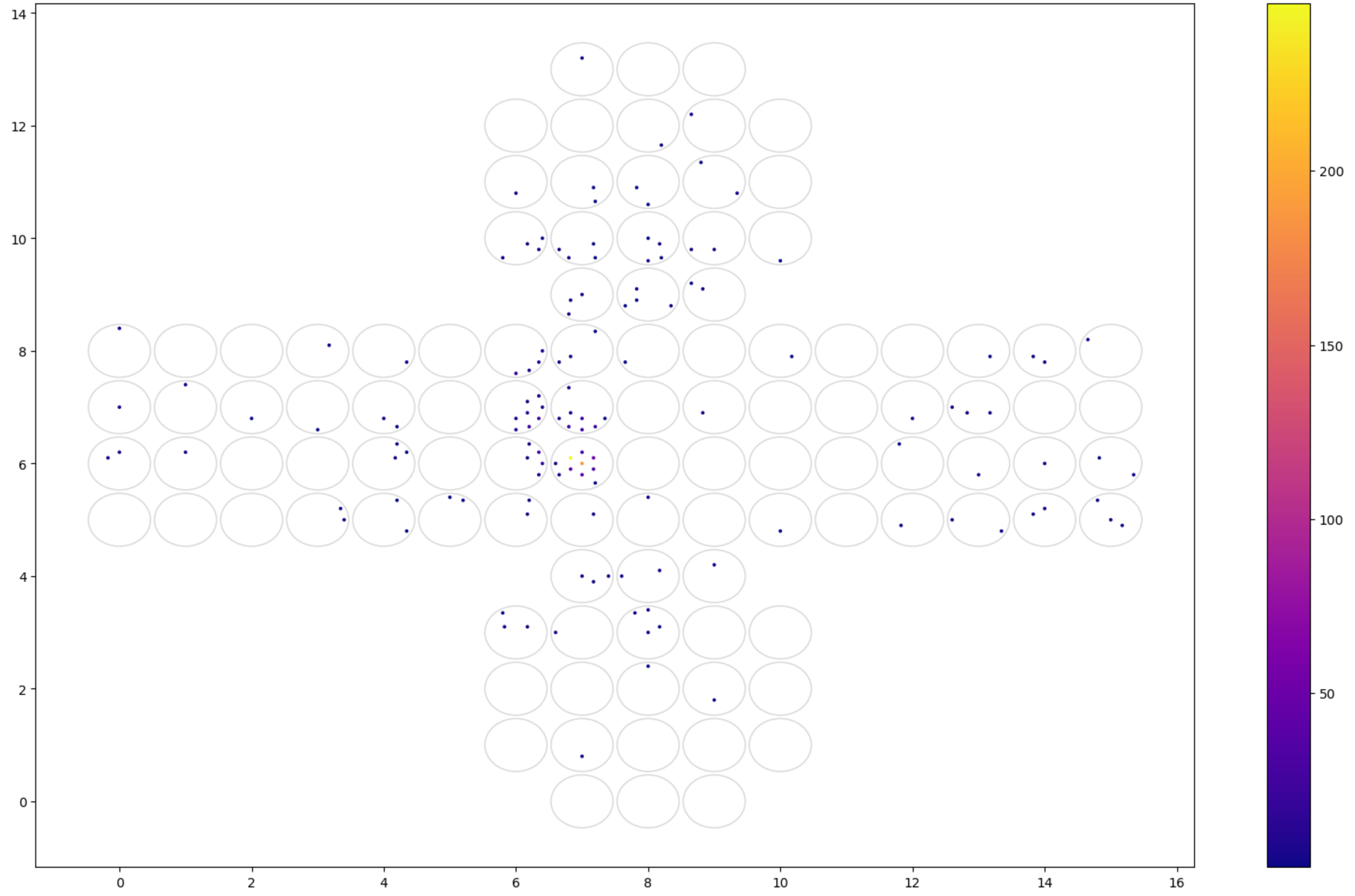

Event #656, gamma, E = 656.43 MeV
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
16
160
140
120
100
80
60
40
20


Event #887, gamma, E = 728.88 MeV
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
16
300
250
200
150
100
50

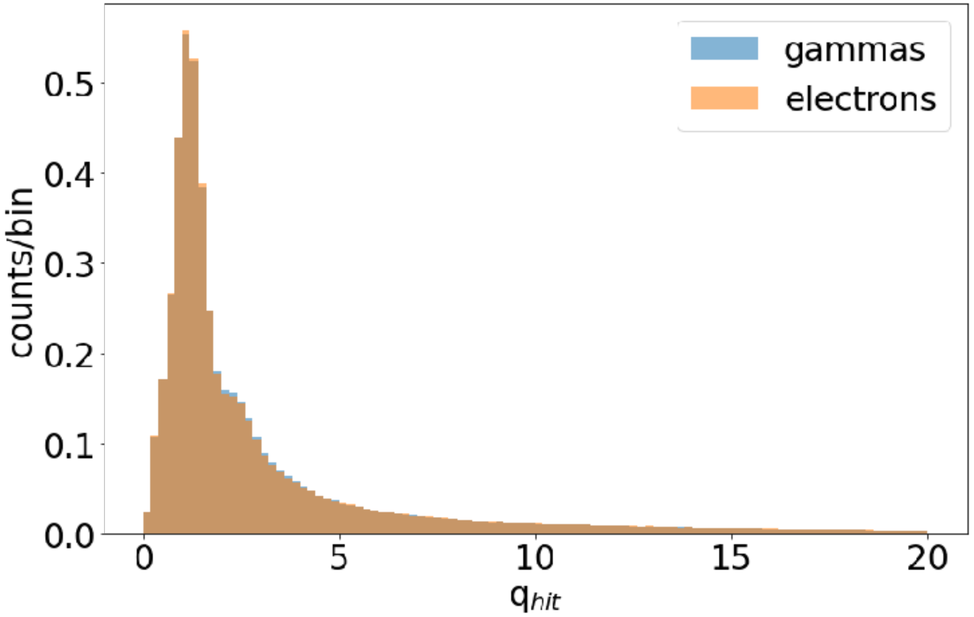

Event #987, gamma, E = 1217.74 MeV
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
16
800
700
600
500
400
300
200
100


Event #1000073, electron, E = 415.31 MeV
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
16
70
60
50
40
30
20
10

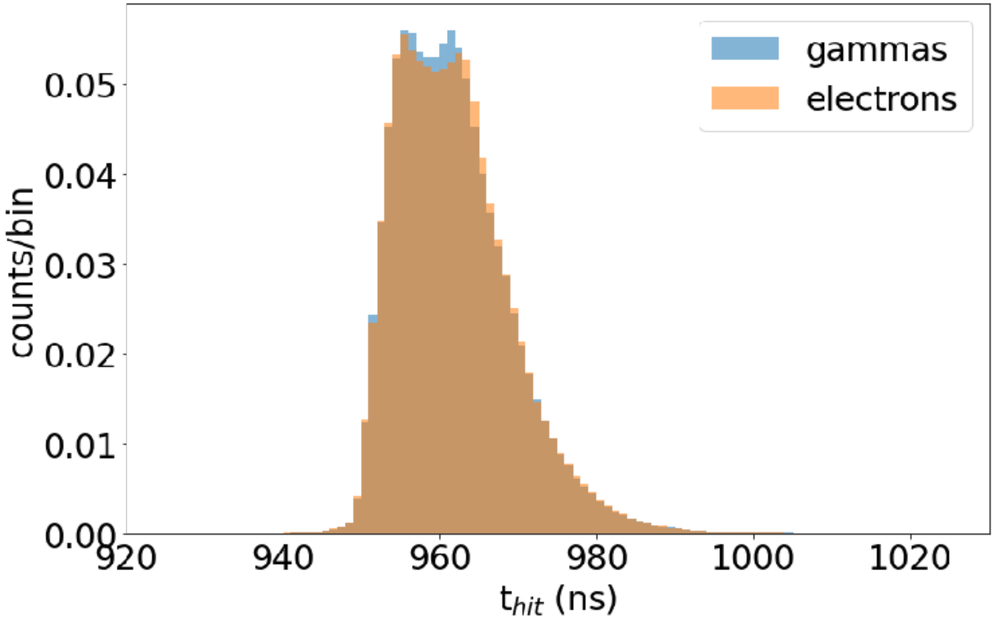

Event #1000136, electron, E = 1073.07 MeV
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
16
200
150
100
50


Event #1000208, electron, E = 849.25 MeV
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
16
200
150
100
50

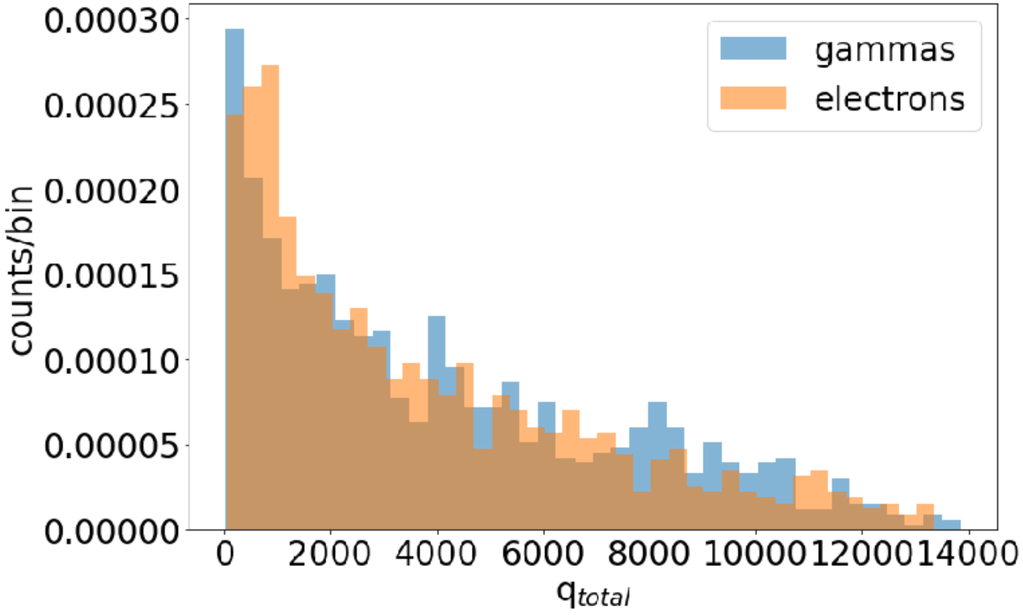
Individual hit charges and hit times (for 1915 events)

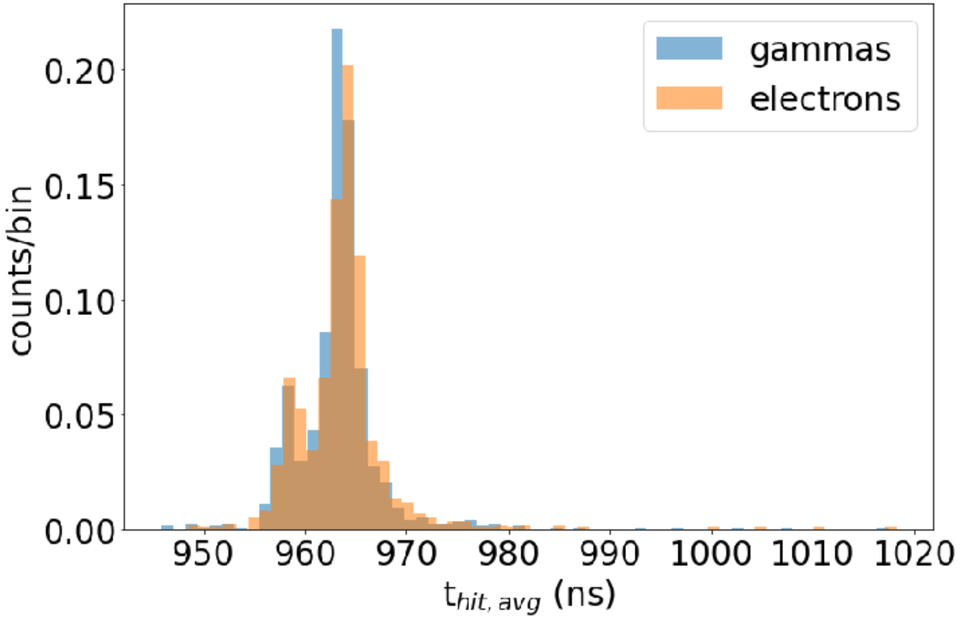


Generation of WCSim events (1M e-/gamma):



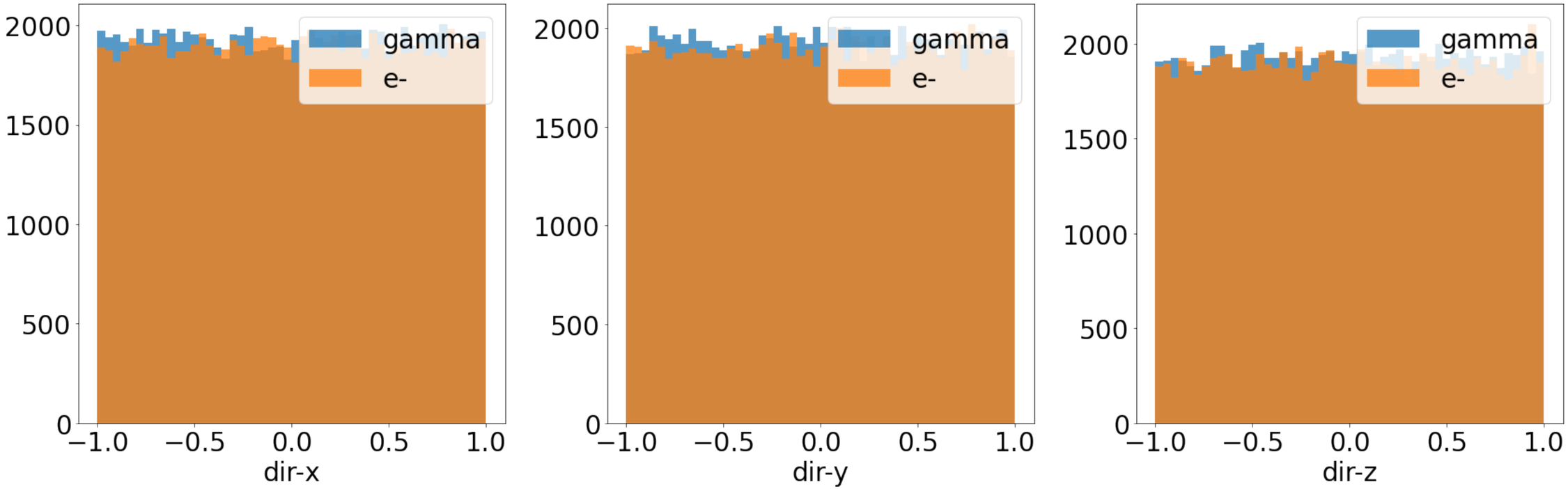
Hit charge sum, average times (for 1915 events)





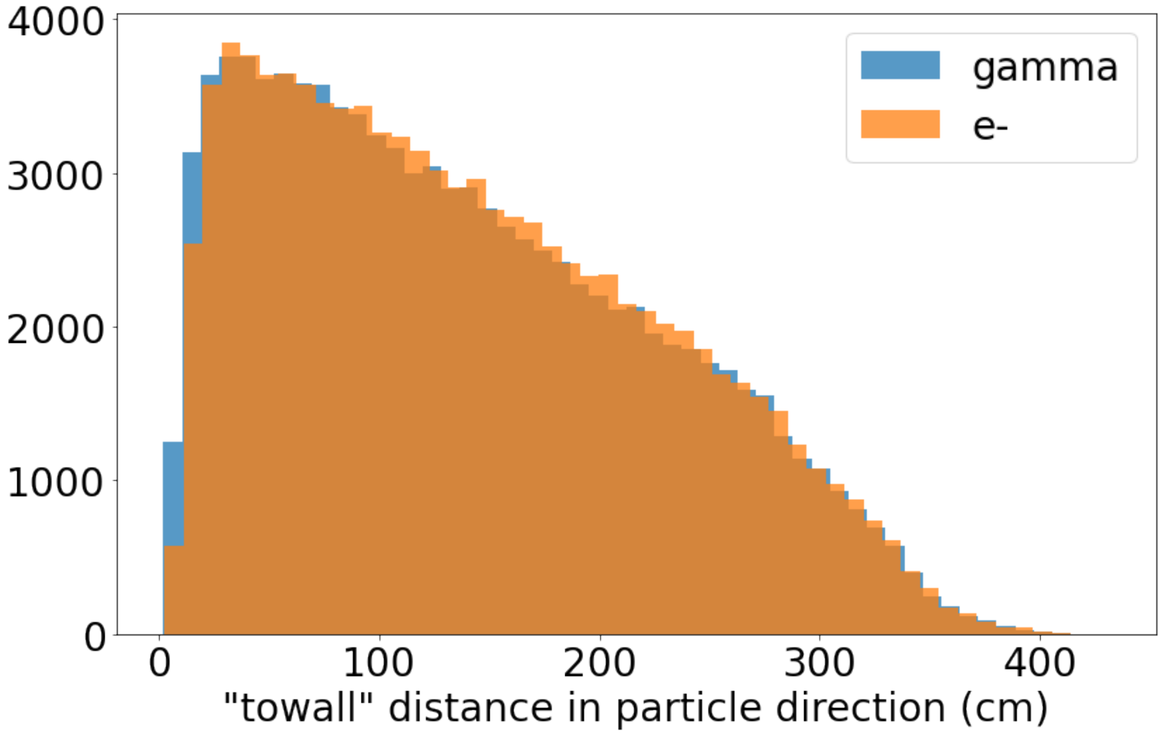
Generation of WCSim events (1M e-/gamma):

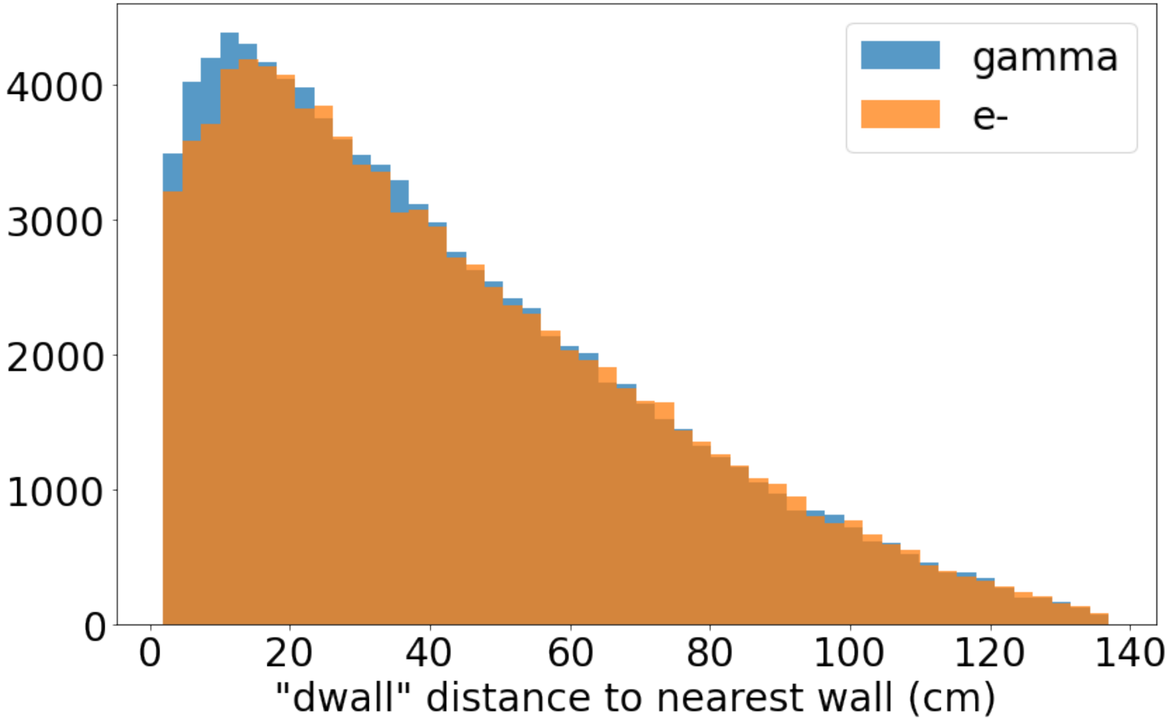
Distribution of directions in (x,y,z)



Generation of WCSim events (1M e-/gamma):

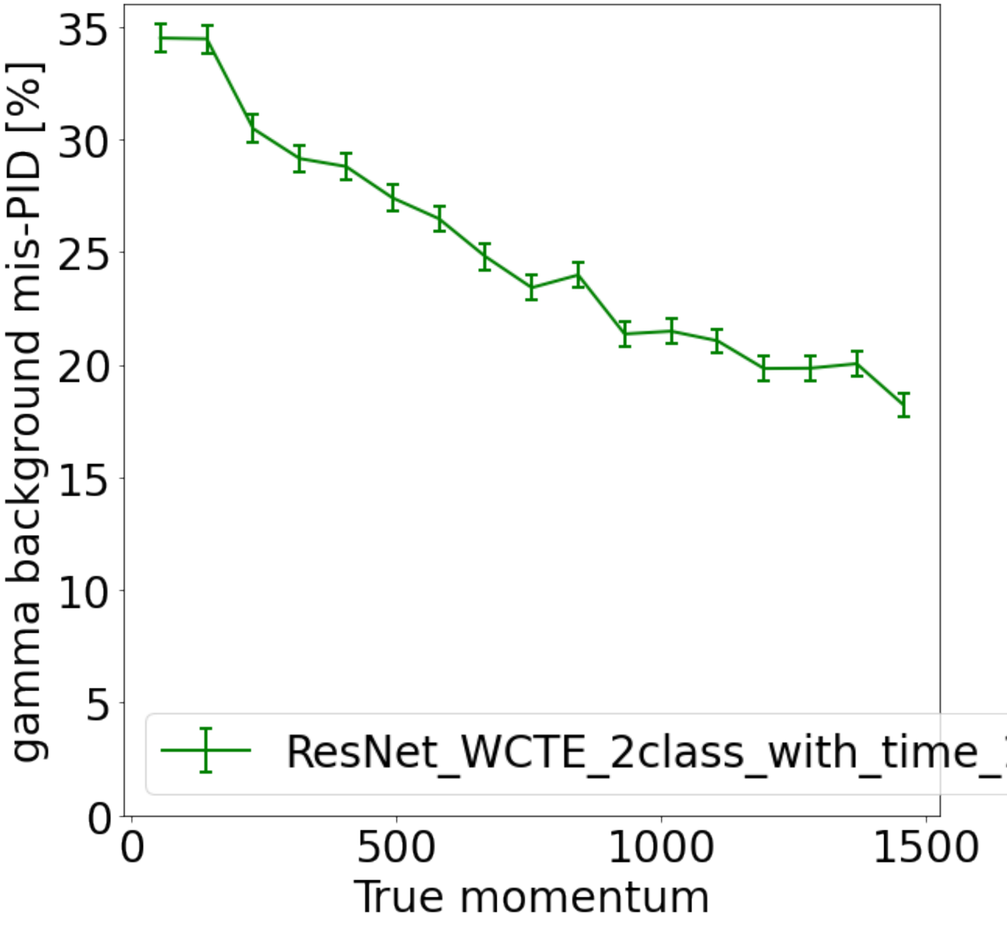
Distribution of distances to detector walls

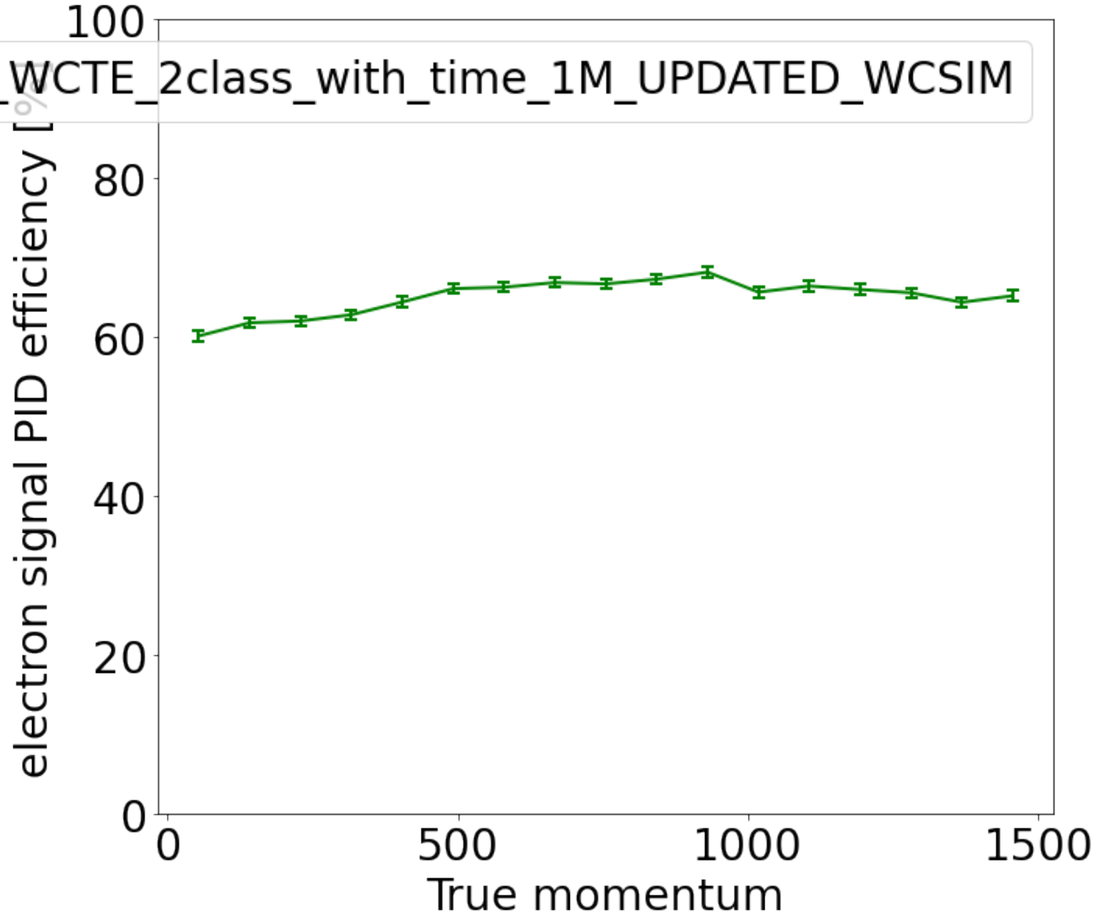




ResNet e-/gamma signal efficiency and background mis-ID (avg. 75% background rejection):

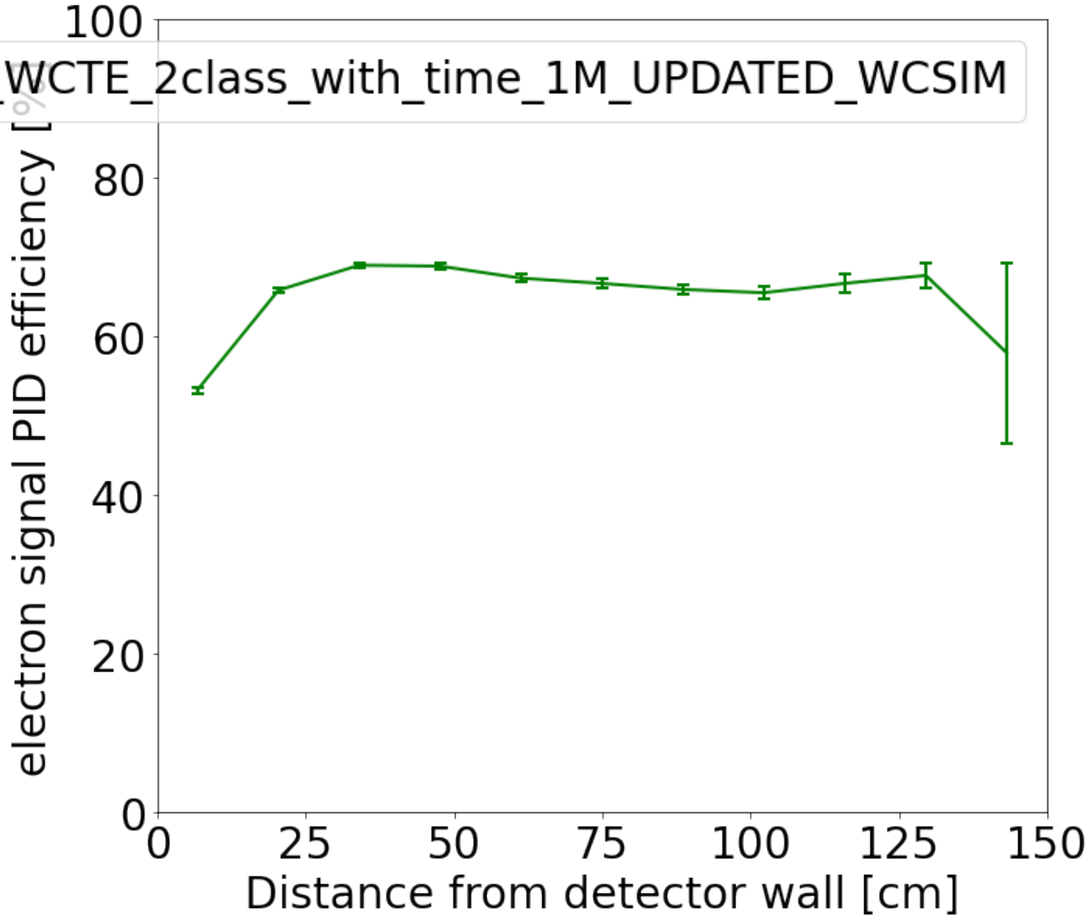
- vs momentum





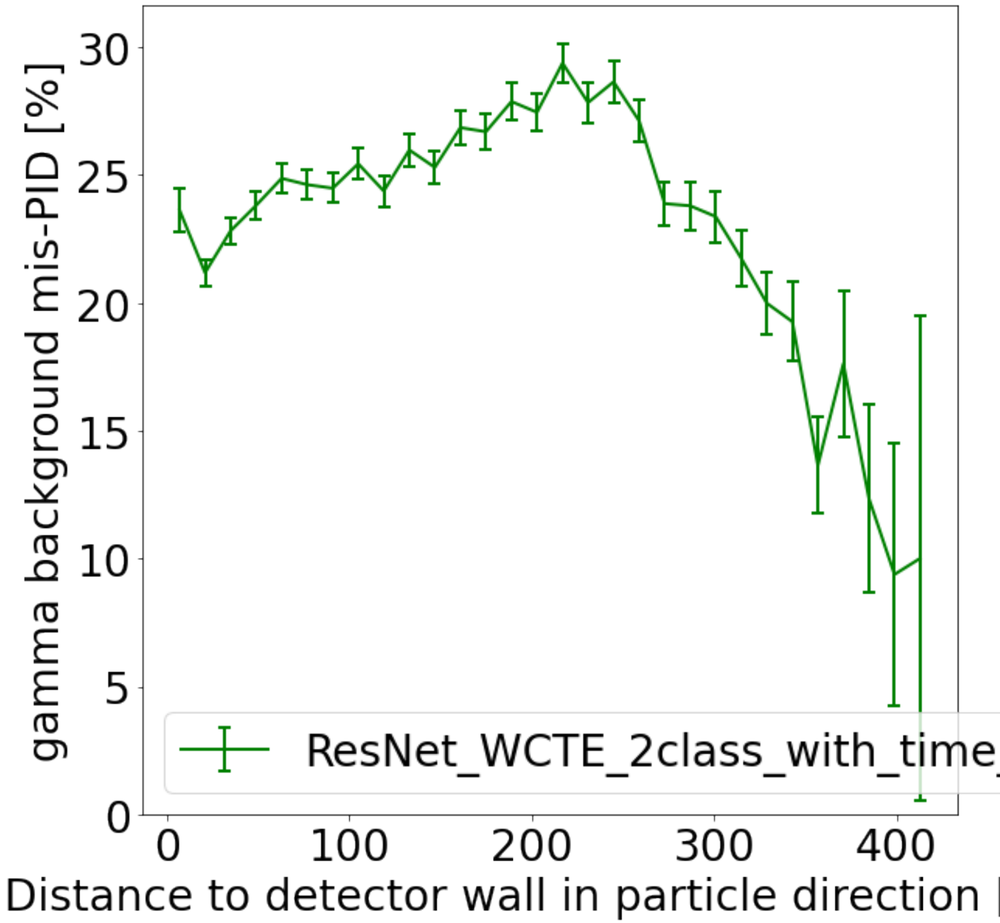
ResNet e-/gamma signal efficiency and background mis-ID (avg. 75% background rejection):

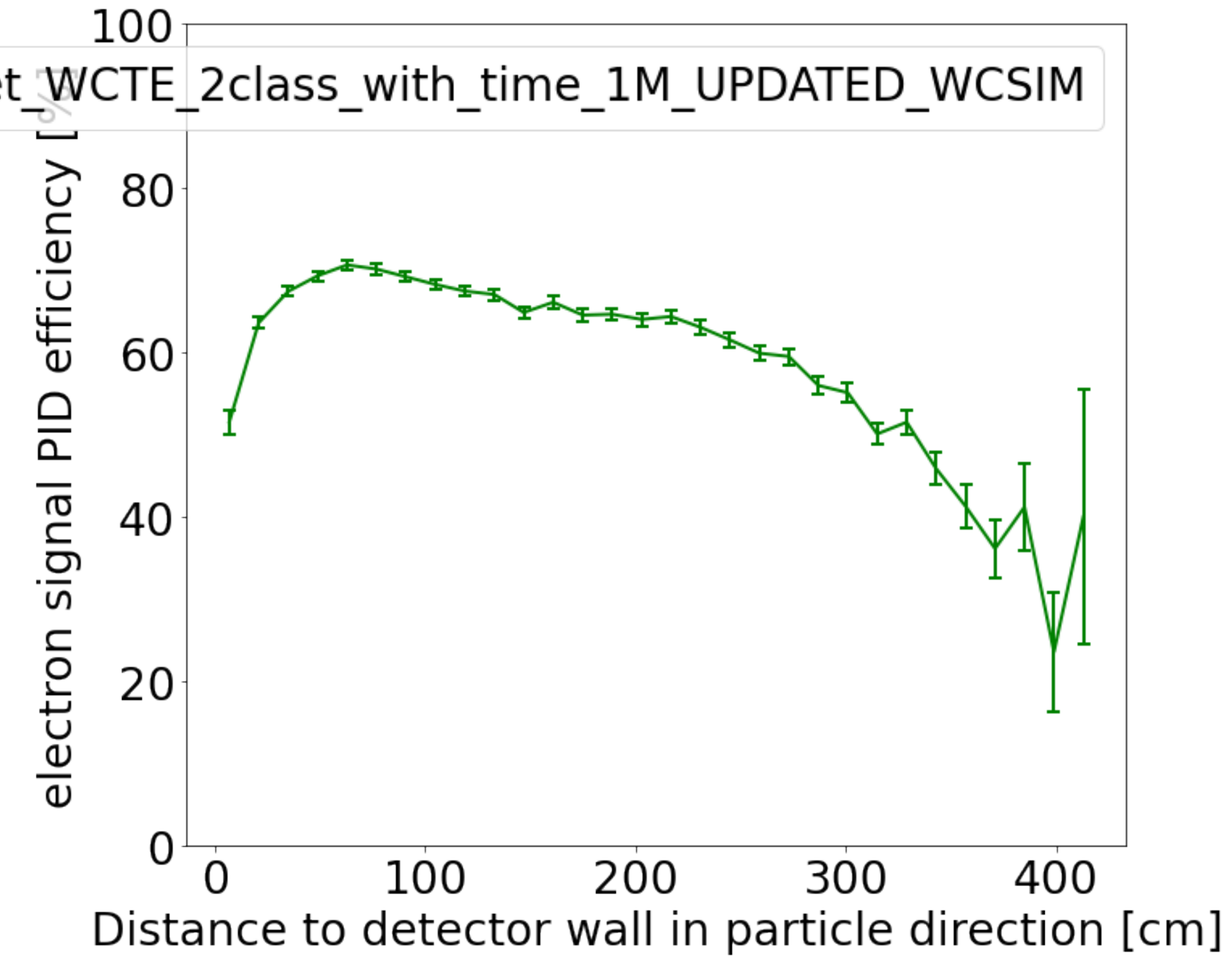
- vs distance from wall



ResNet e-/gamma signal efficiency and background mis-ID (avg. 75% background rejection):

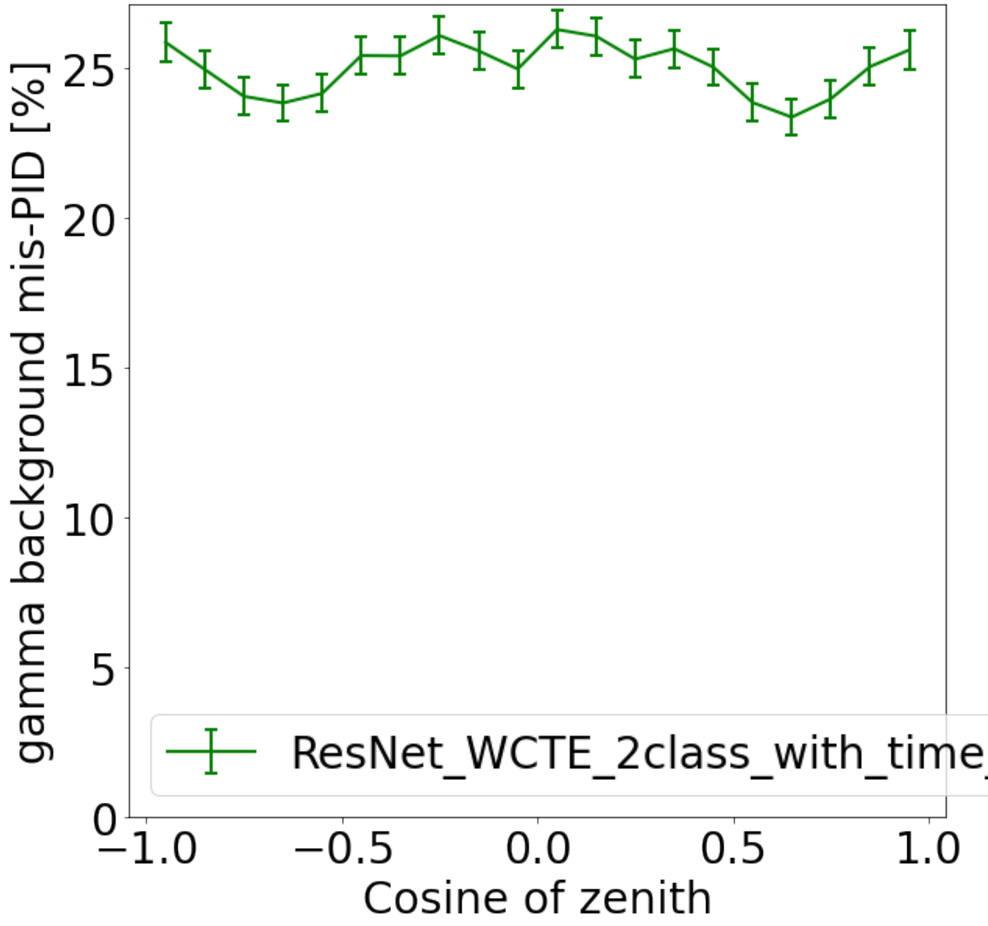
- vs distance to wall

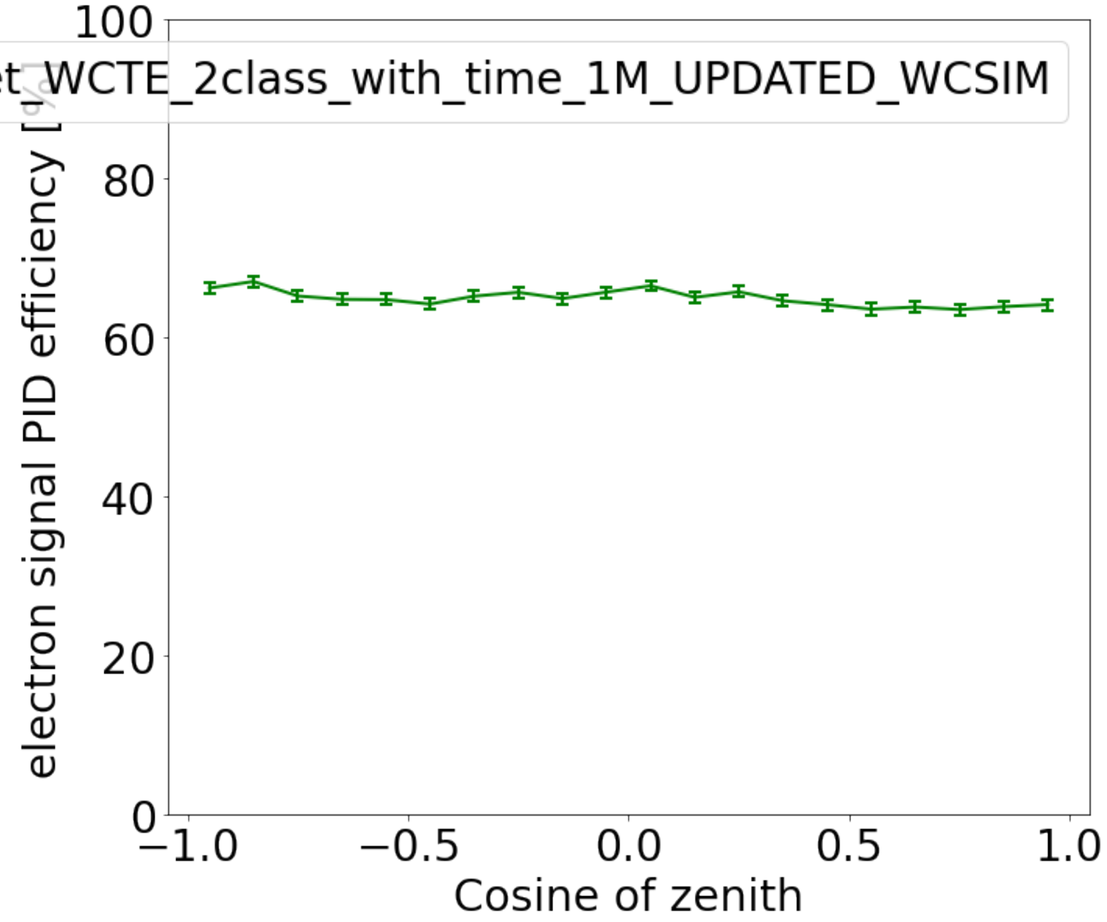


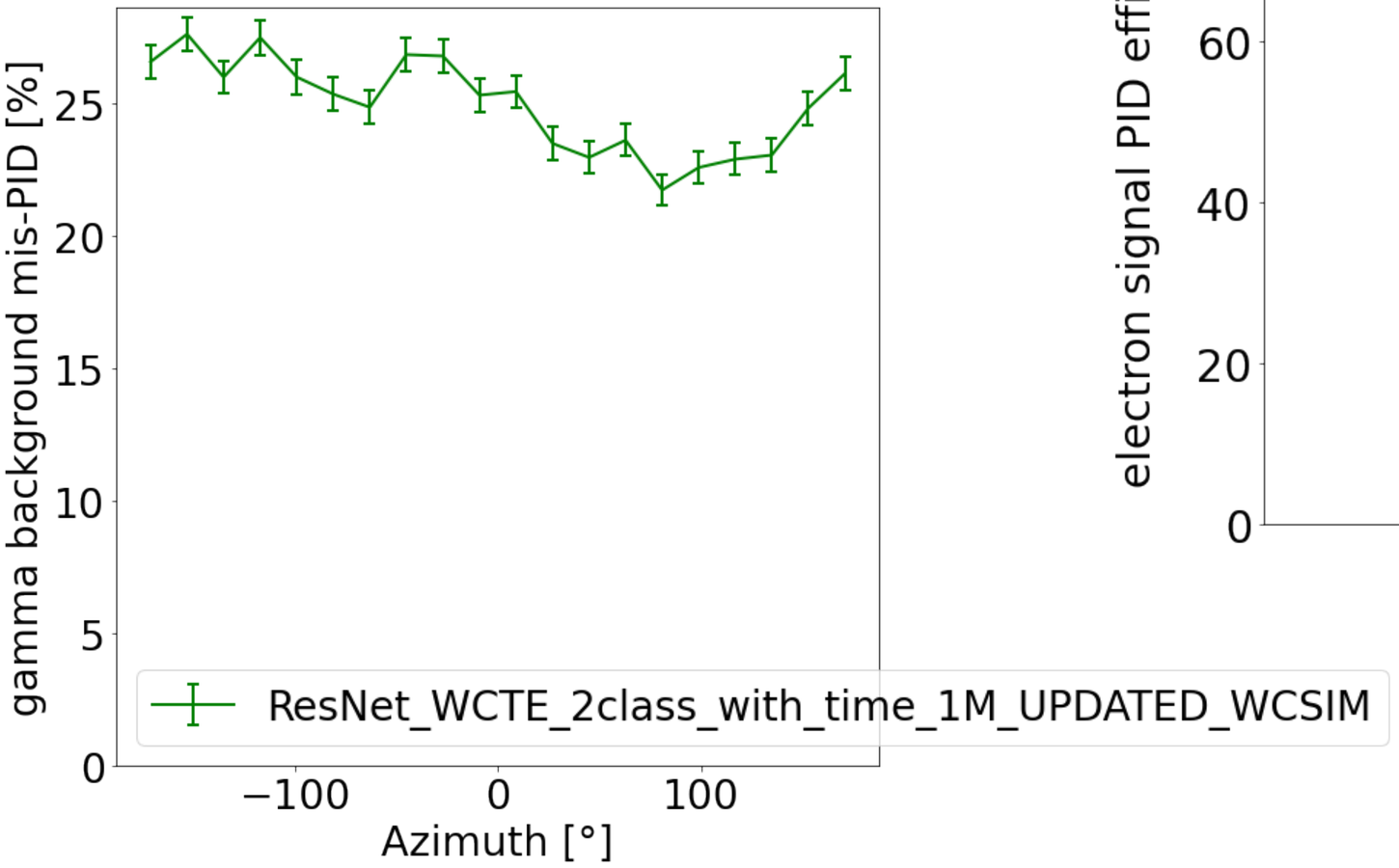
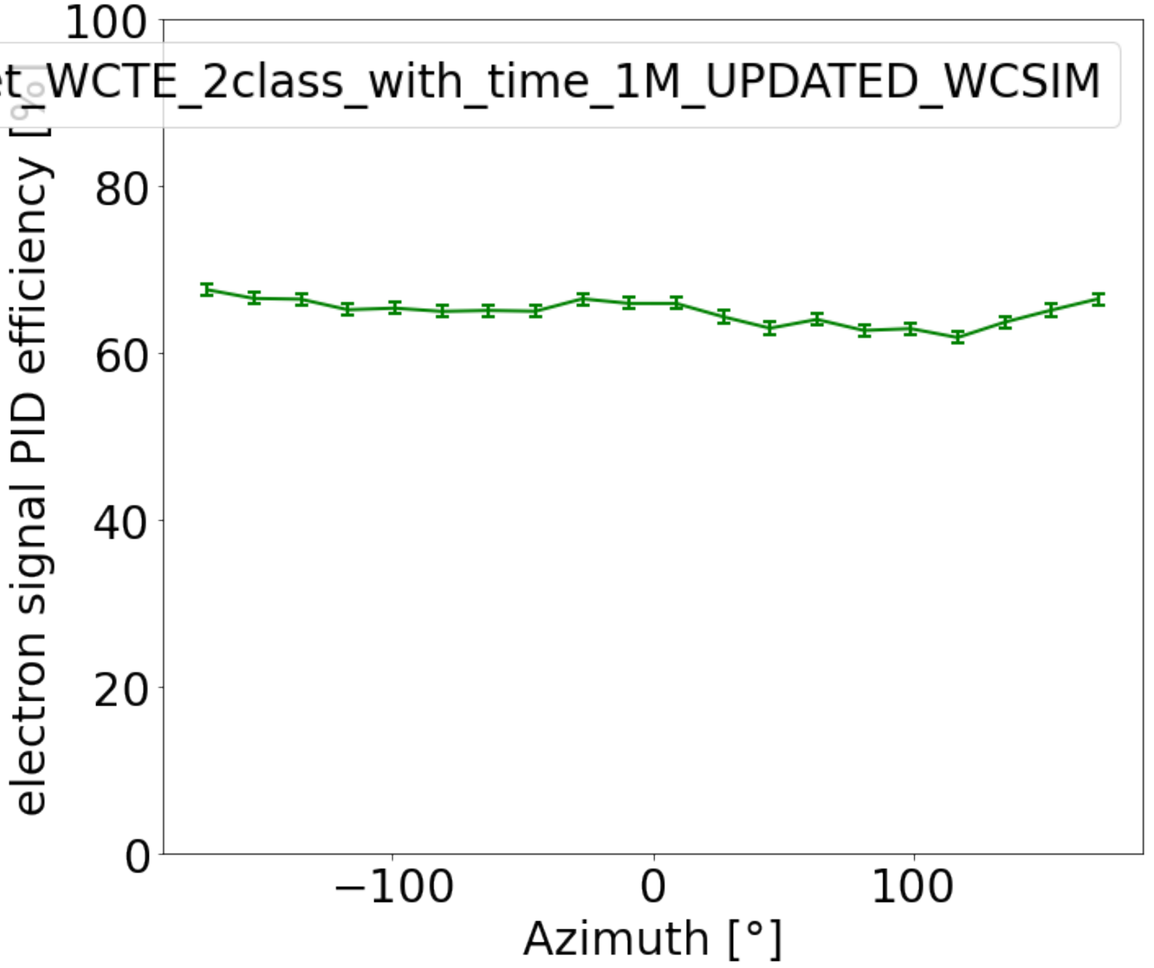


ResNet e-/gamma signal efficiency and background mis-ID (avg. 75% background rejection):

- vs cos(zenith angle)





ResNet e-/gamma signal efficiency and background mis-ID (avg. 75% background rejection):

- vs azimuth angle