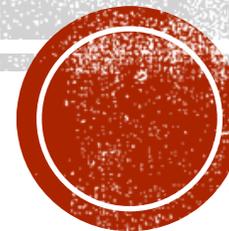# OpticSiren calibration on WCTE cosmics MC data
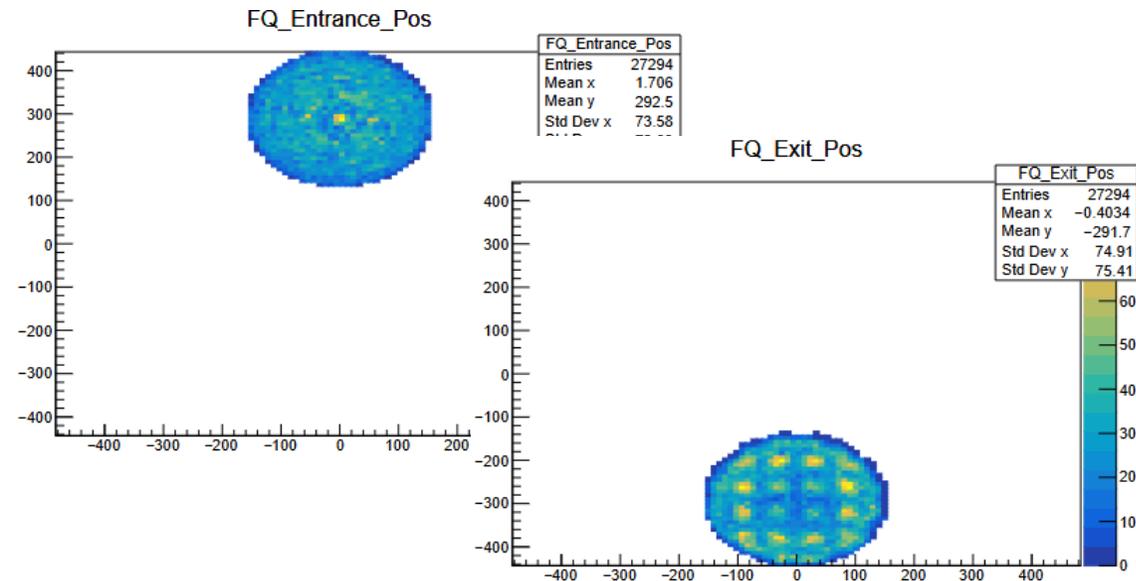
Ka Ming Tsui

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WCTE cosmics MC data

- Sea level muon flux (high energy crossing muon) + nominal WCSim simulation

- Basic nhit cut + top/barrel/bottom charge ratio cut + fiTQun reconstruction cut to select top-down muons

- Convert to h5 which stores PMT Q(,T) and truth (fiTQun reconstructed) tank entrance and exit points


Important data arrays
- `entrance_pos`: truth entrance point (nevents,3)
- `exit_pos`: truth exit point (nevents,3)
- `pmtQ`: total charge per PMT (nevents,npmts)
- `pass_selection`: pass selection flag (nevents)

Cosmic data loader

- Load only muon tracks that pass top-down selection cut

- Load truth entrance and exit position instead of fiTQun reconstructed values

- For each track, pre-calculate OpticSiren input (pos,dir) by
  - Uniform track sampling of 10 mm segments
  - Each segment has the same Cherenkov profile = Muon CherenkovSiren(1 GeV/c, s = 0, θ)
  - Only consider $0.73 < \cos\theta < 0.76$ within 0.005 step size
  - 36 phi bins at each (pos, $\cos\theta$)

$(\cos\theta, \phi_j)$
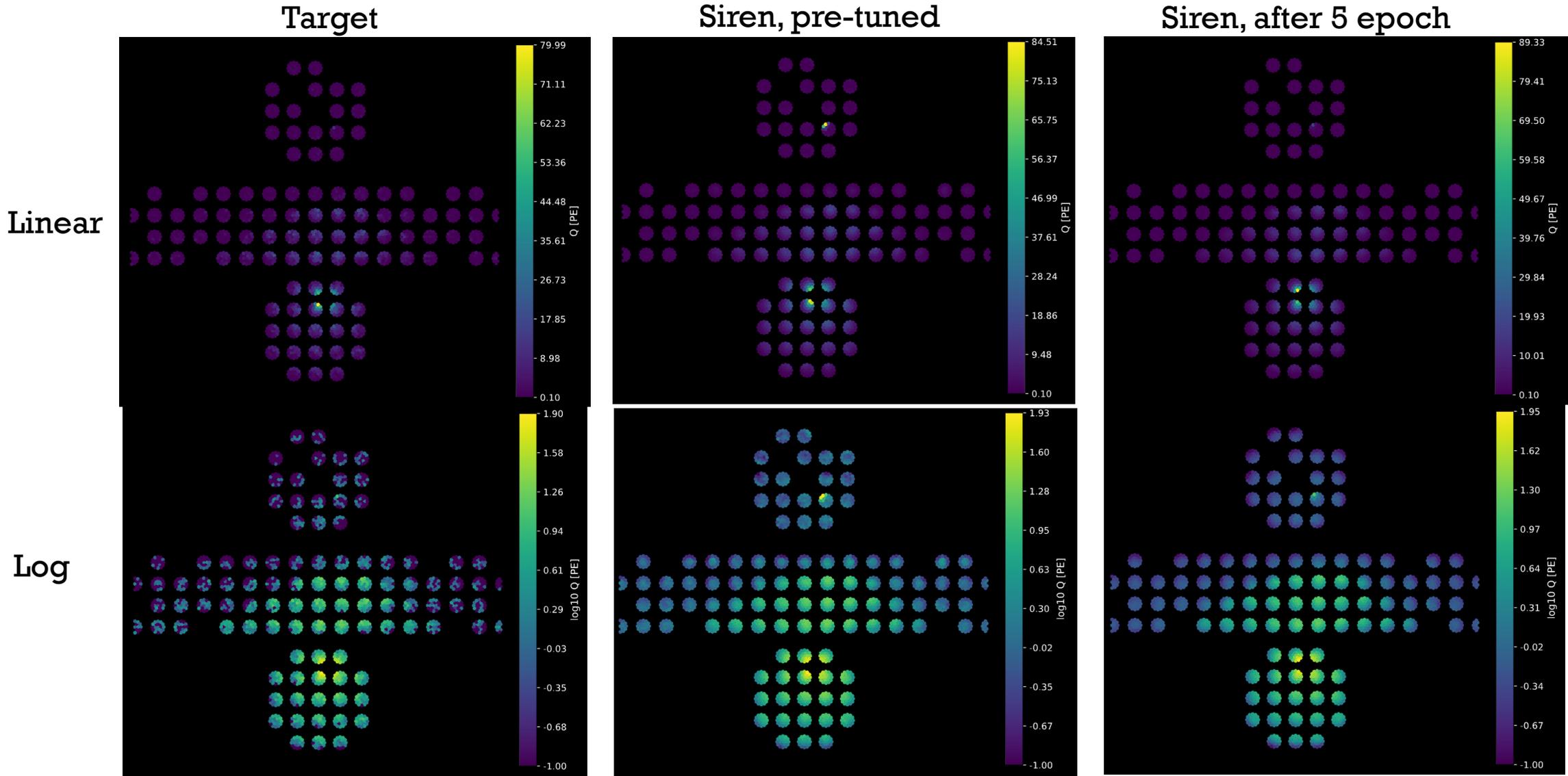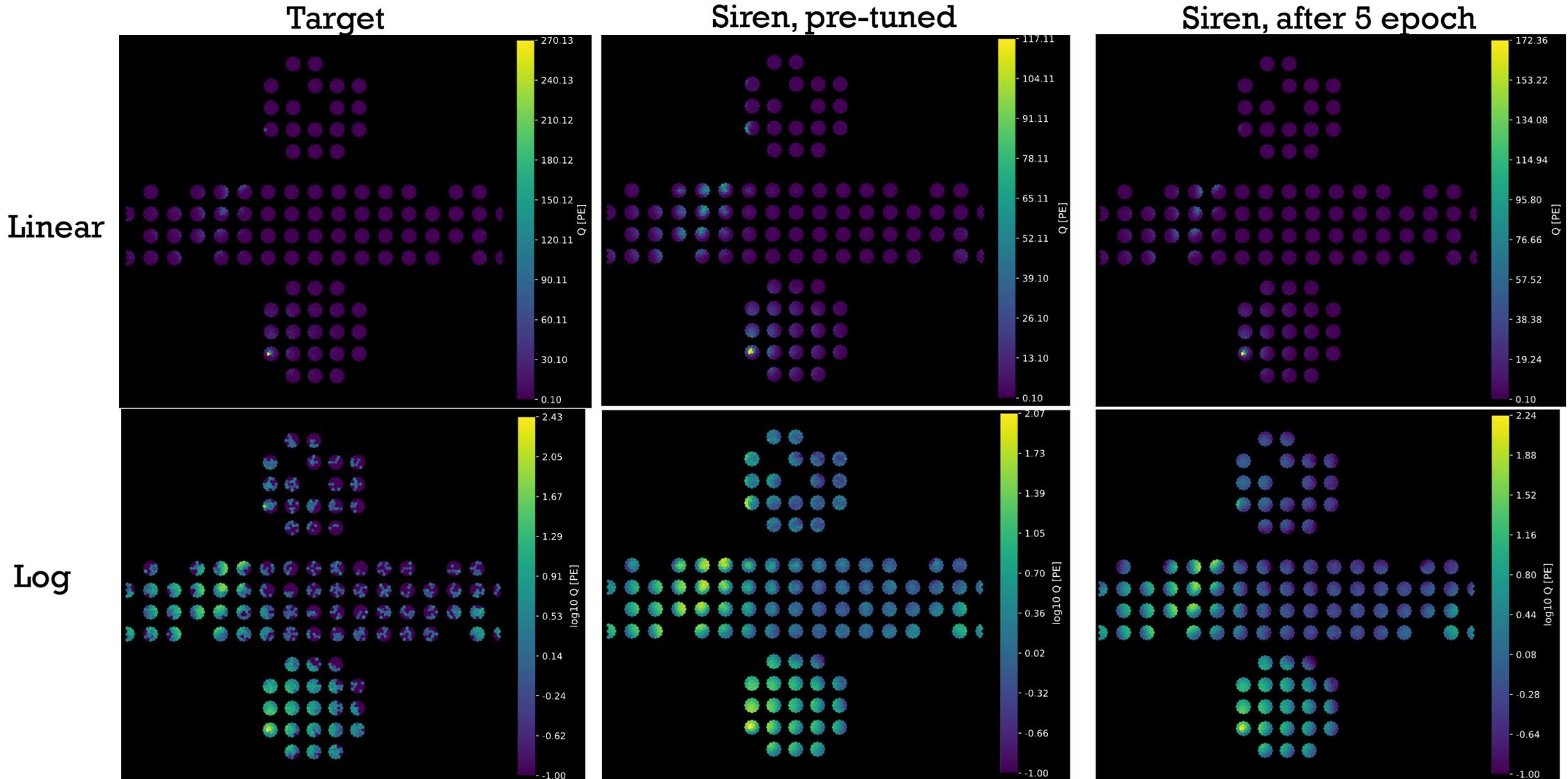
$(\cos\theta, \phi_i)$

10 mm
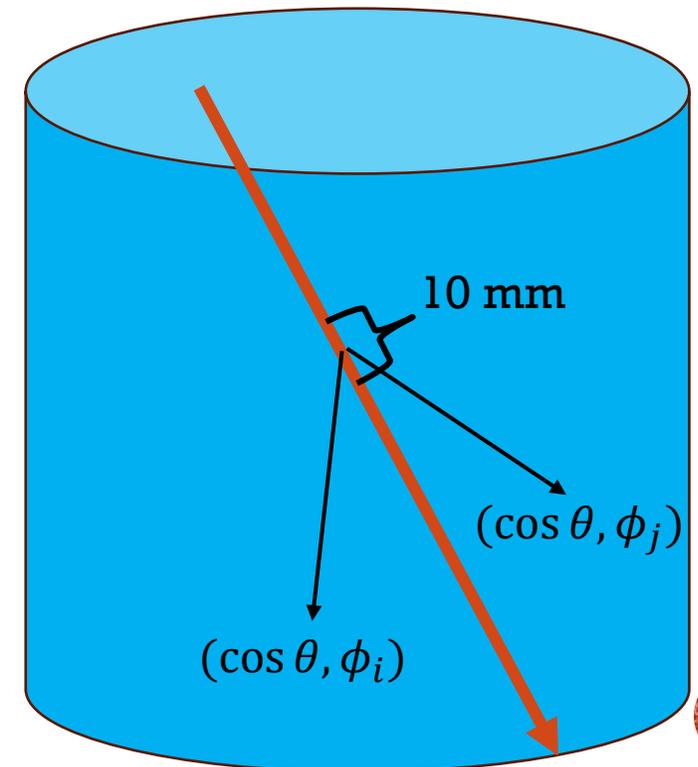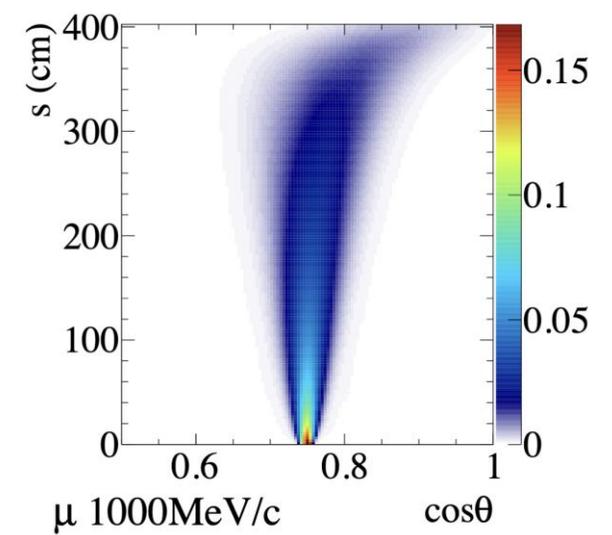
Training

- Track batch size = 10

- Calculate PMT Q prediction per track, then Poisson loss relative to "target"

- Calculate gradient and update OpticSiren parameters per batch

- Training data contains 26420 tracks
  → 2642 iteration/epoch, ~90mins/epoch

- Artifically scale Q by 0.8 to
  test fine-tuning behavior
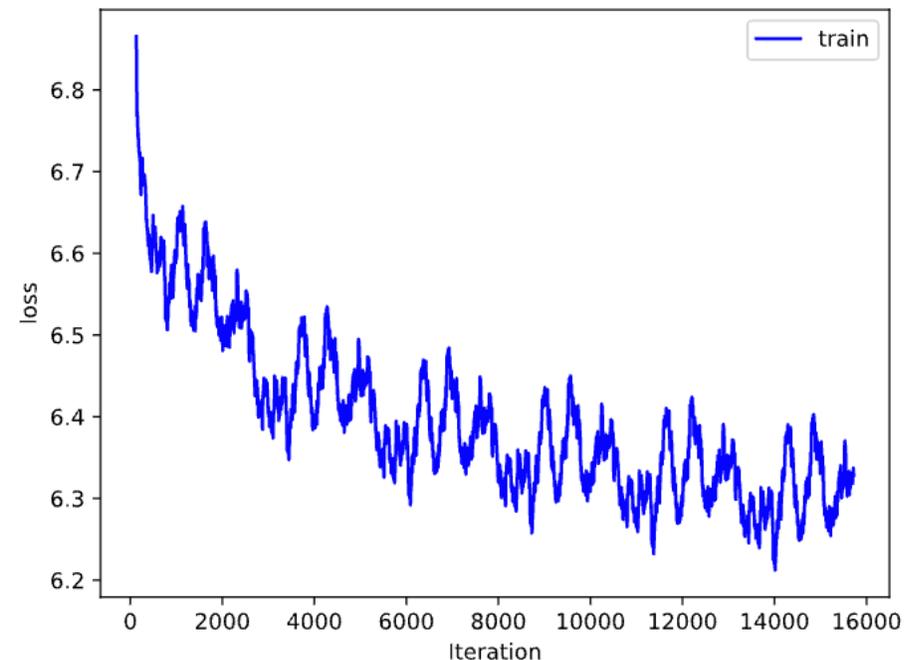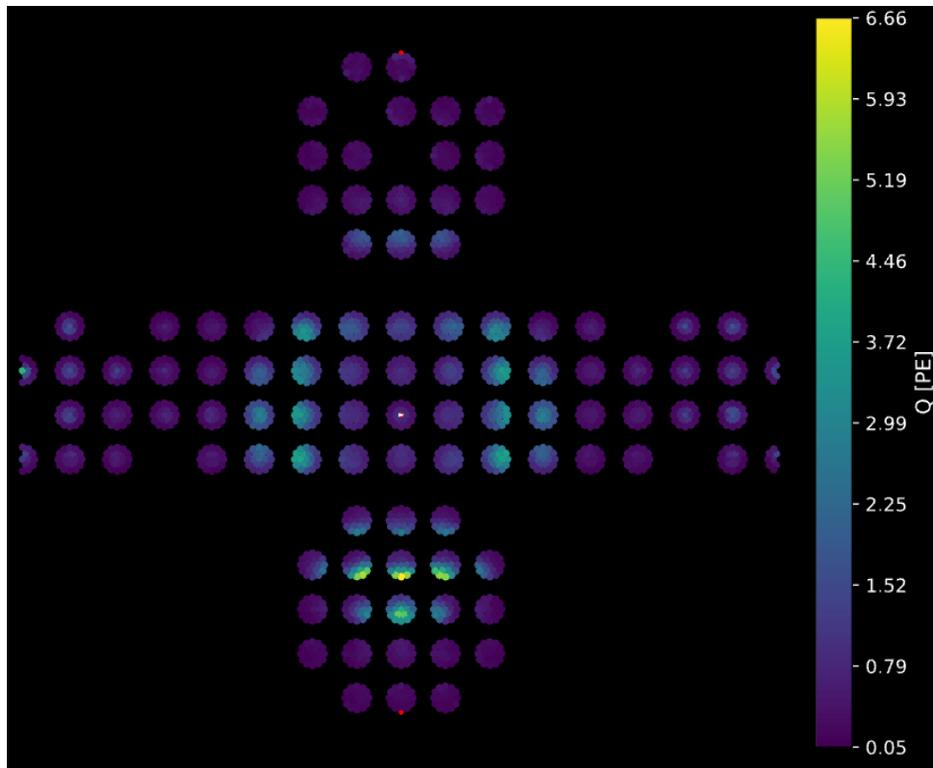
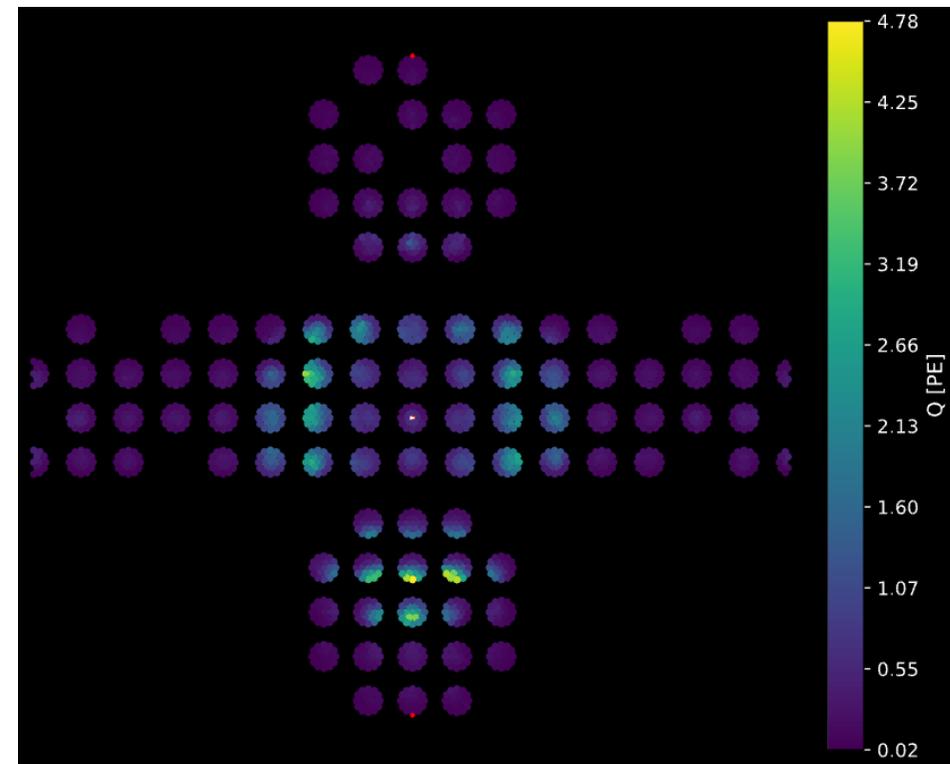# Cosmic track example

Cosmic track example

Impact on beam muon

- Horizontally going, momentum = 300 MeV/c

- Ring pattern is less symmetric, losing too much charge at top (upward direction)
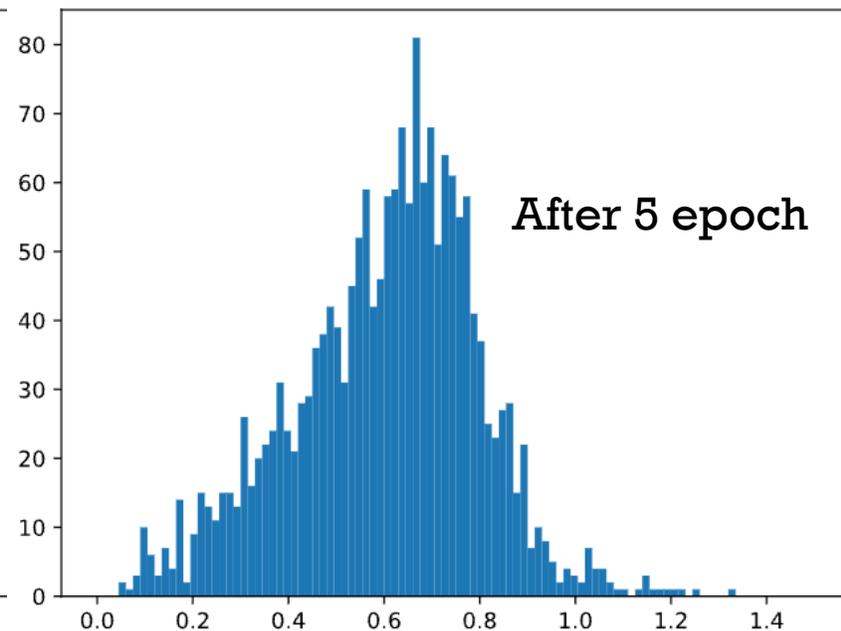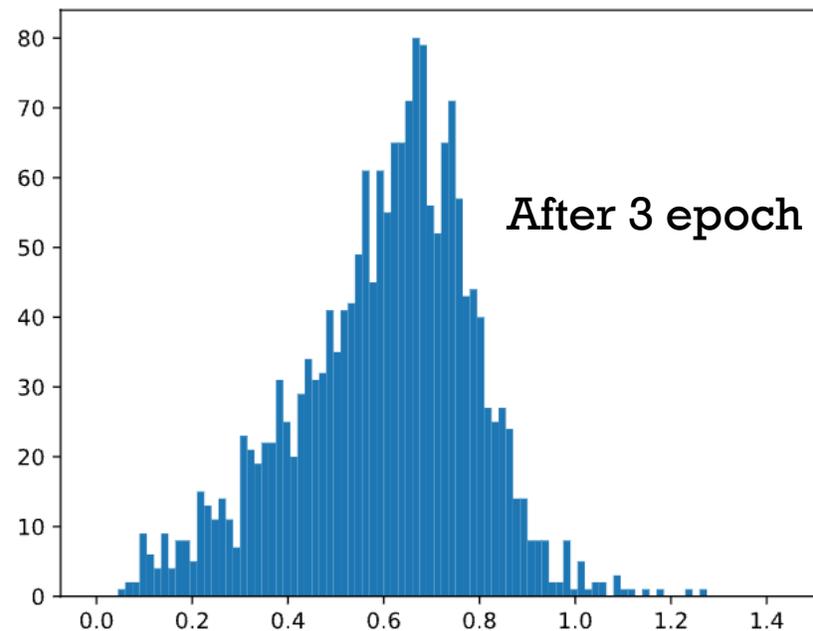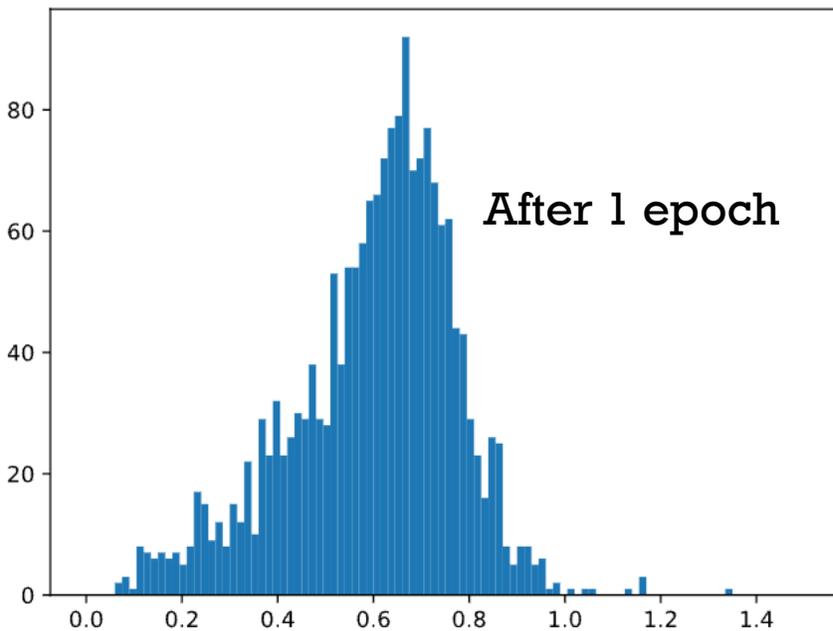
Siren, pre-tuned

Siren, after 6 epoch

Impact on beam muon

- Horizontally going, momentum = 300 MeV/c

- PMT Q ratio relative to pre-tuned
  - Kind of similar after 1 epoch. Also smaller than truth = 0.8. Already overtrained?

After 1 epoch

After 3 epoch

After 5 epoch

PMT Q ratio relative to pre-tuned

Thoughts

- Some edge behavior seems to be corrected, e.g. unphysical low/high acceptance near the mPMTs, and general gradient direction is right

- BUT

- Reconstruction effects
  - Can fine-tuning work with slightly incorrect vertex/direction?

- Missing upward going photons
  - Possible to make more horizontally going cosmic selection, that could recover some of the phase space that is most important to beam particles.
  But still very hard to get the more upward direction right

- PMT dynamic range ~ 30 PE, so need to correct for saturation effect
  - Also corrupted waveform can lead to missing PMT hits

- PMT masking to be done