Differentiable Surrogate for WCTE --- Closeout

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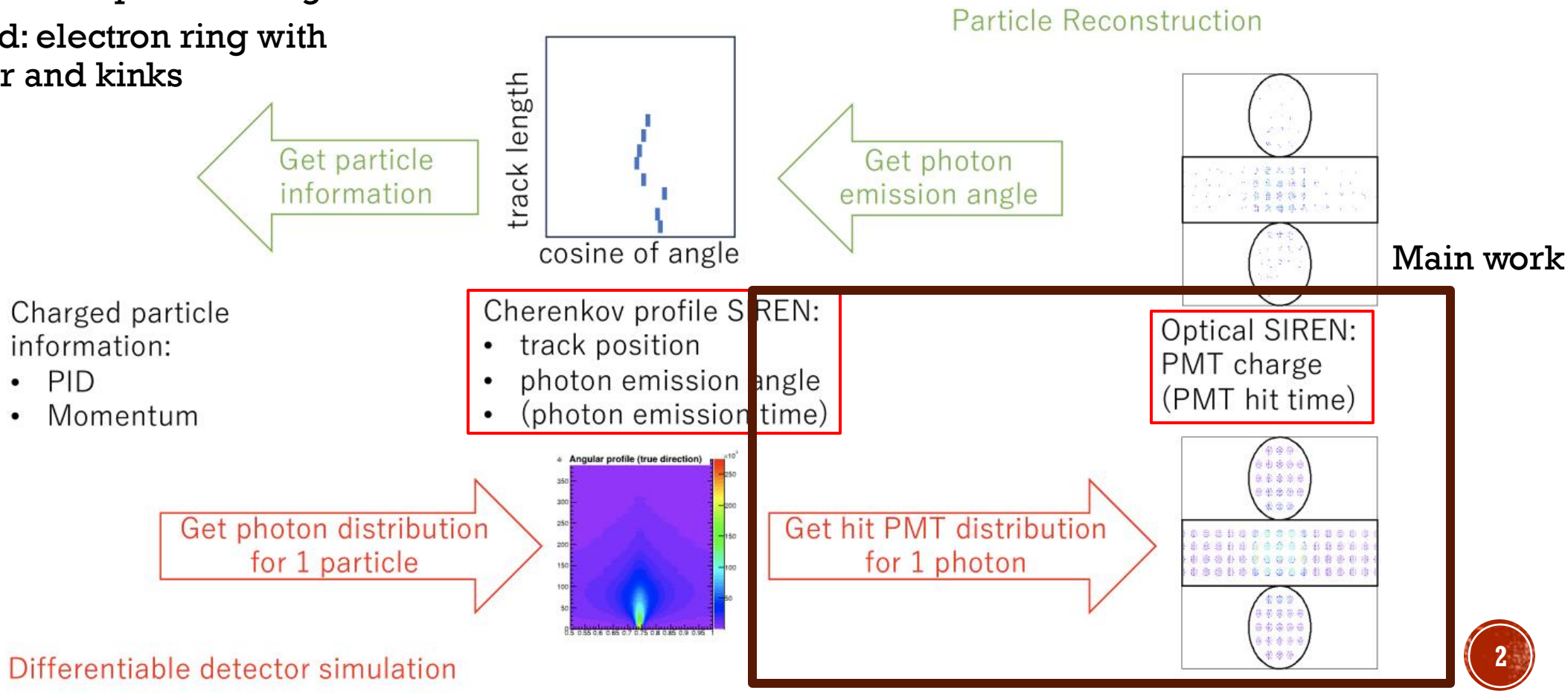
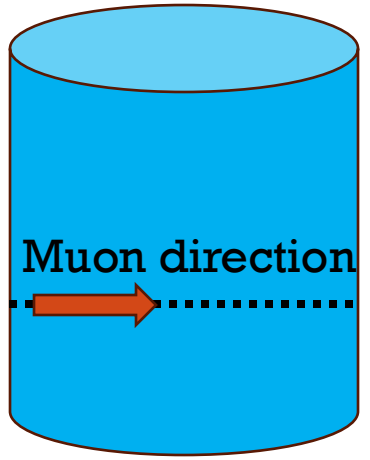
Project goals

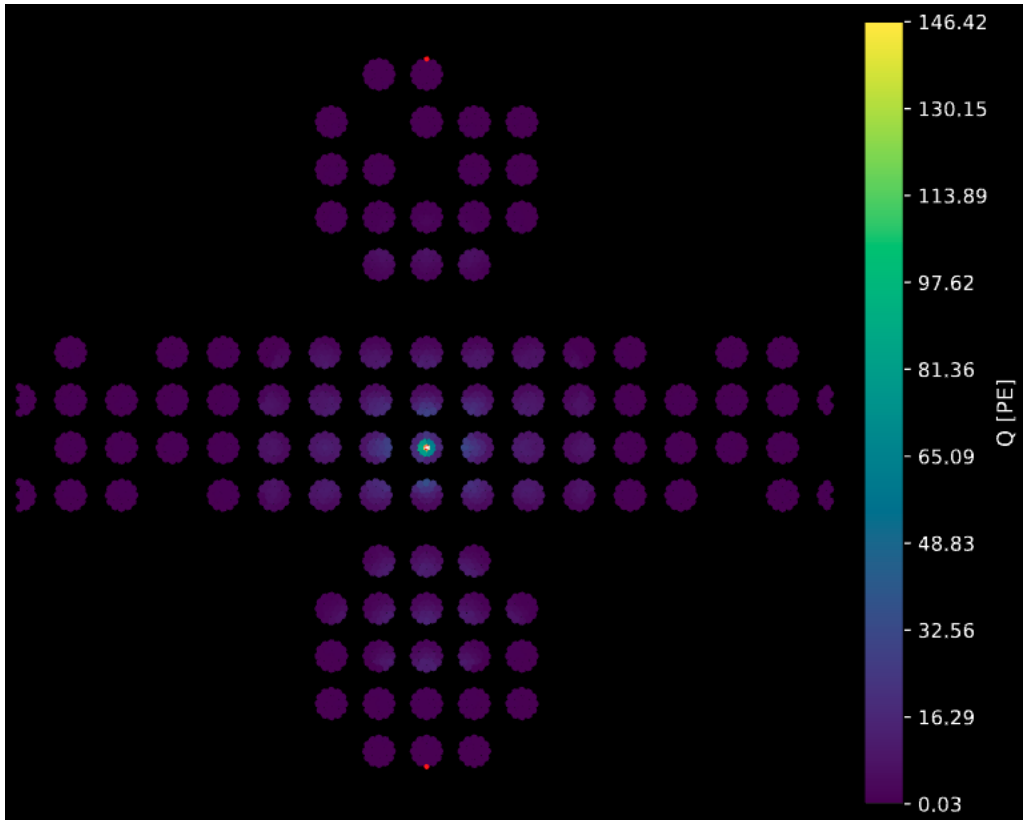
- Track reconstruction and classification
  - This workshop: Muon ring
  - Beyond: electron ring with shower and kinks



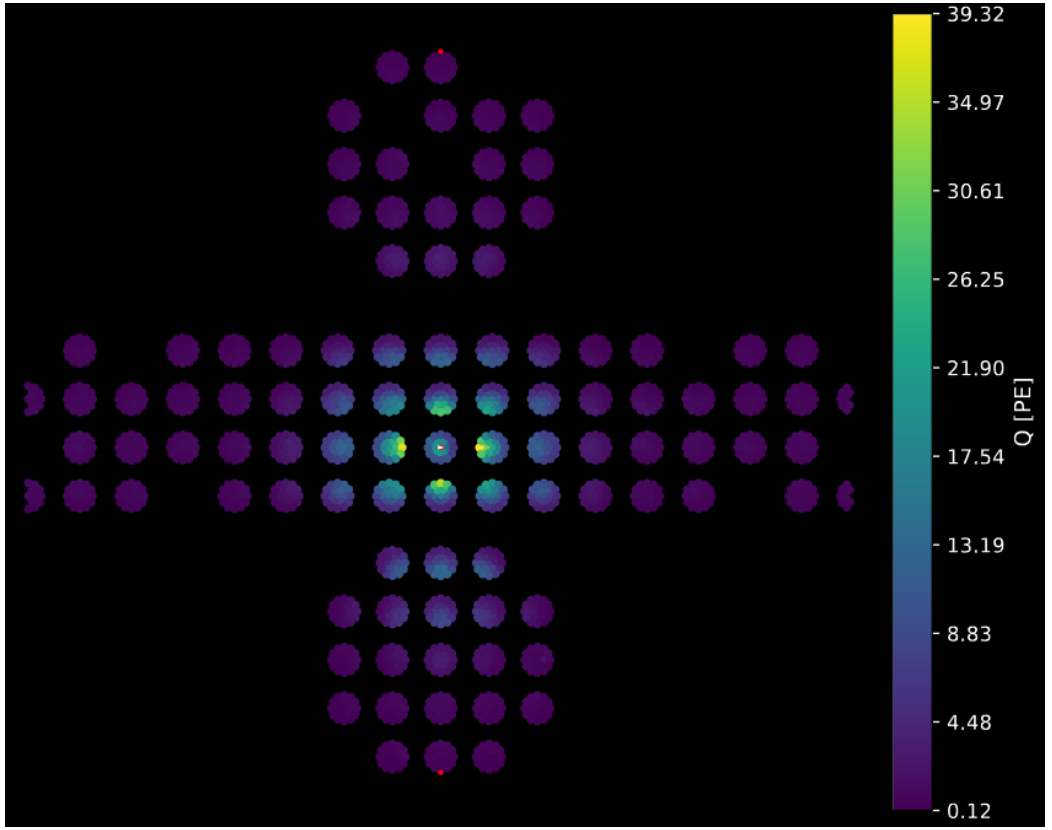
A simple demo of forward simulation



- 1000 MeV/c muon
  - Muon goes through detector, Optic Siren response for photons near detector wall are not well modelled



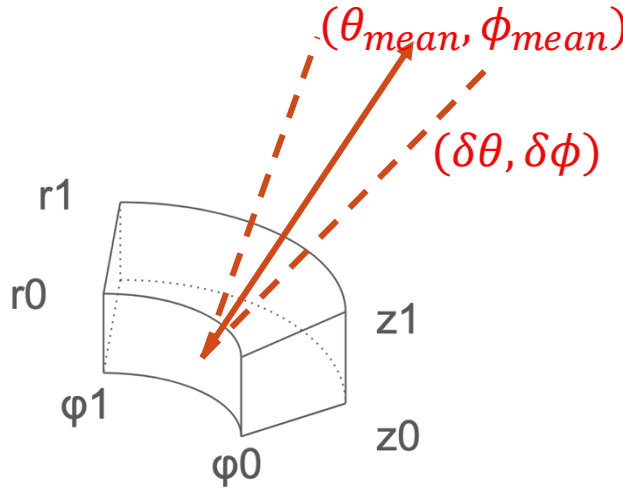
MC simulation

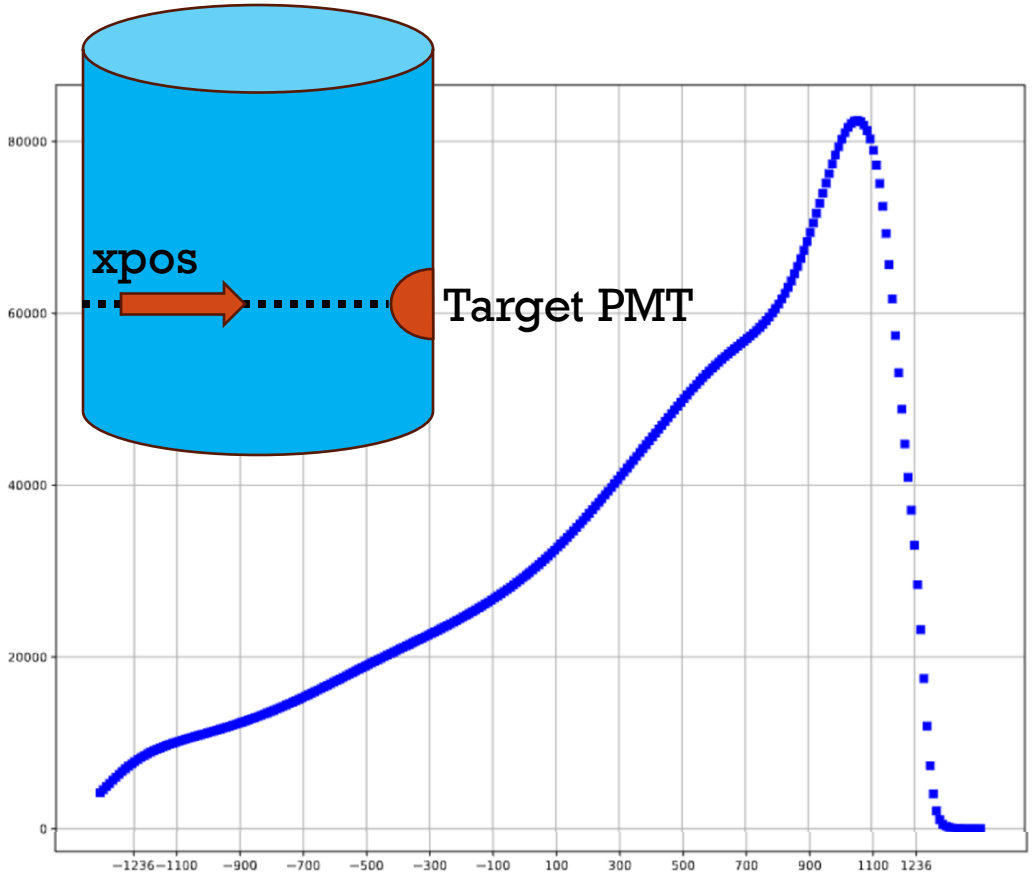


Siren

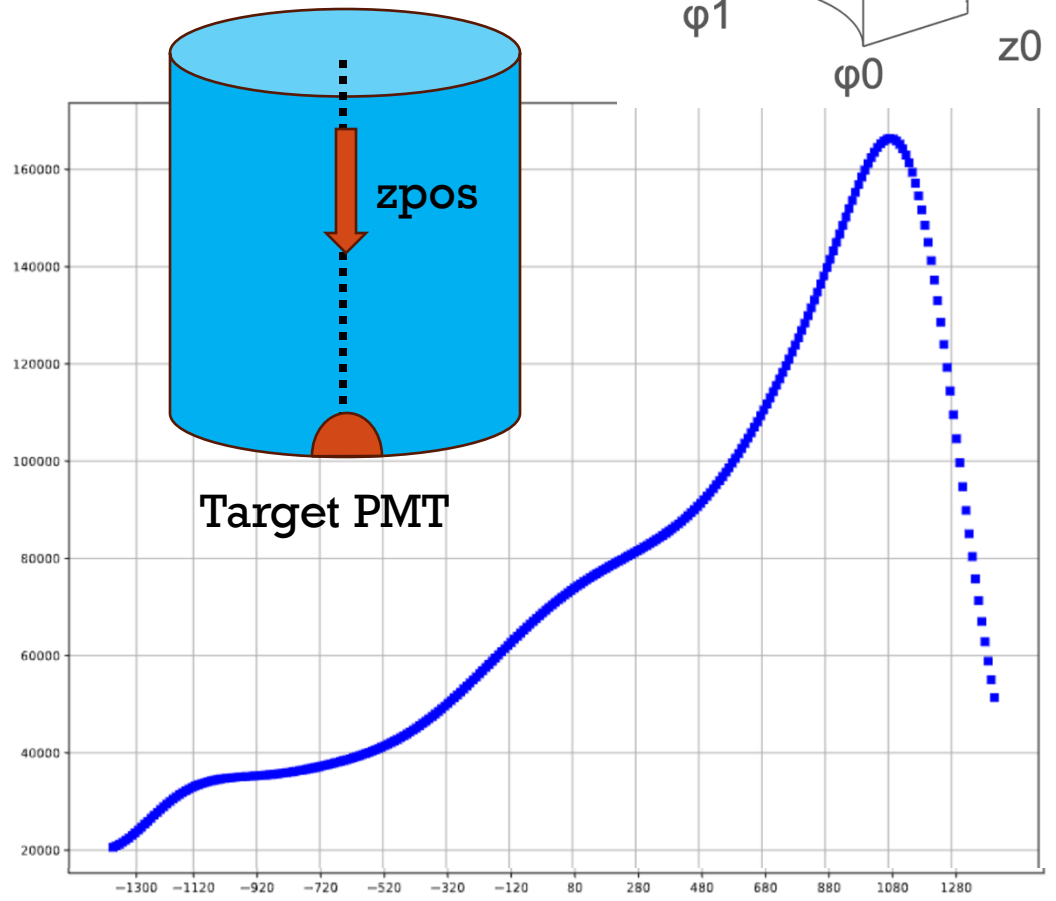
Boundary effect in Optic Siren

- Unphysical drop happens at the last bins in both radial vertical axes
  - Bin size (~20 cm) too large compared to PMT size (~8cm)
    → need finer bins in the perpendicular plane to wall





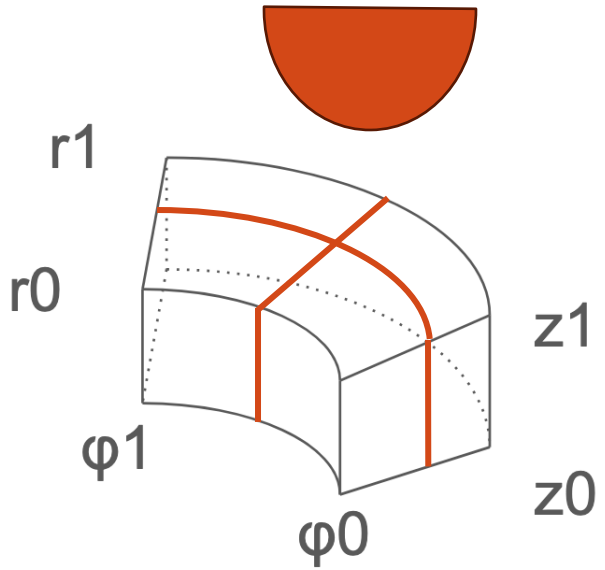
xpos (mm)



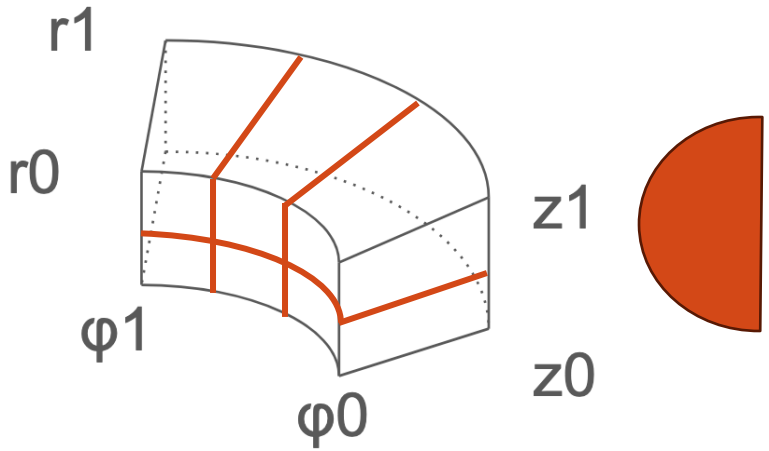
- zpos (mm)

Rebin strategy

- Toppest/bottomest layer
  - Bisect in r and phi

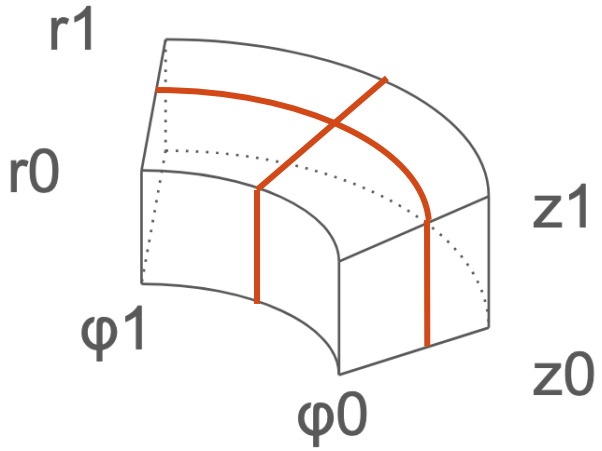


- Outermost barrel layer
  - Bisect in z, trisect in phi



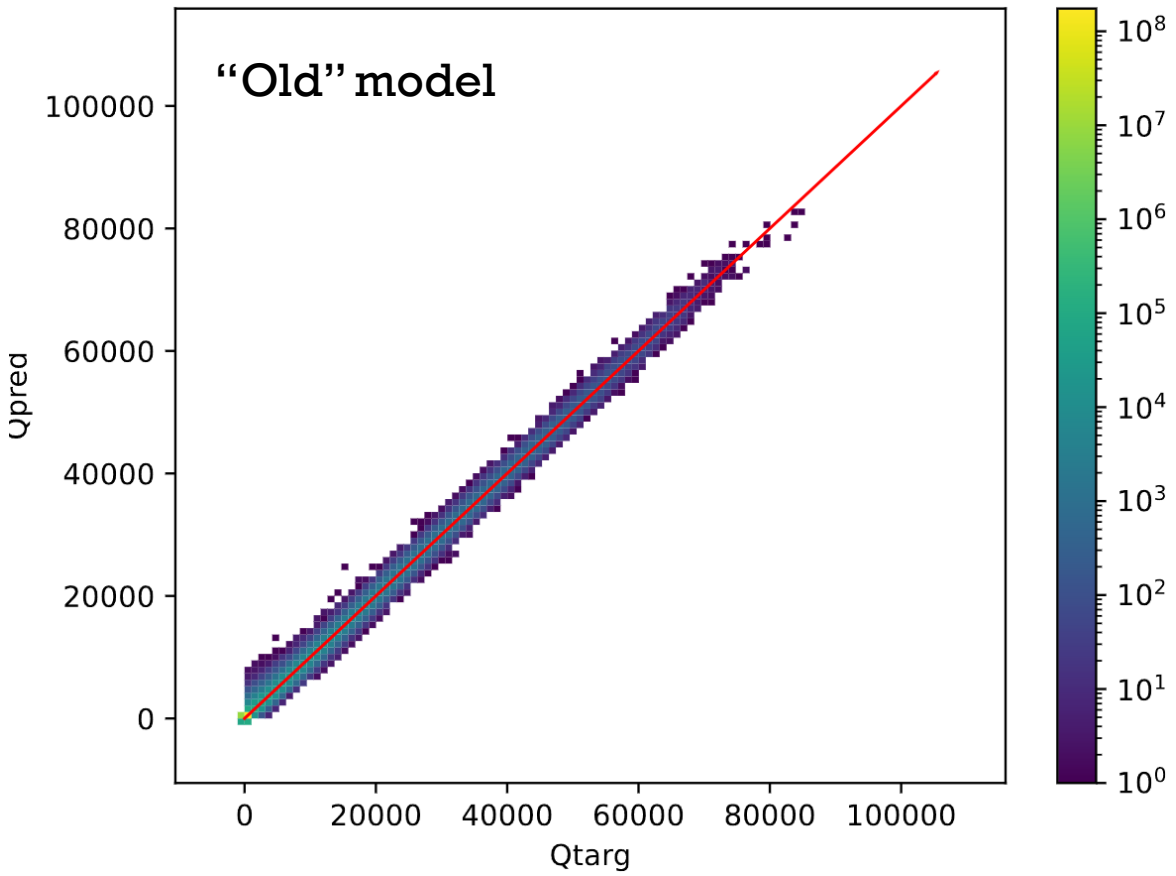
Rebin utility

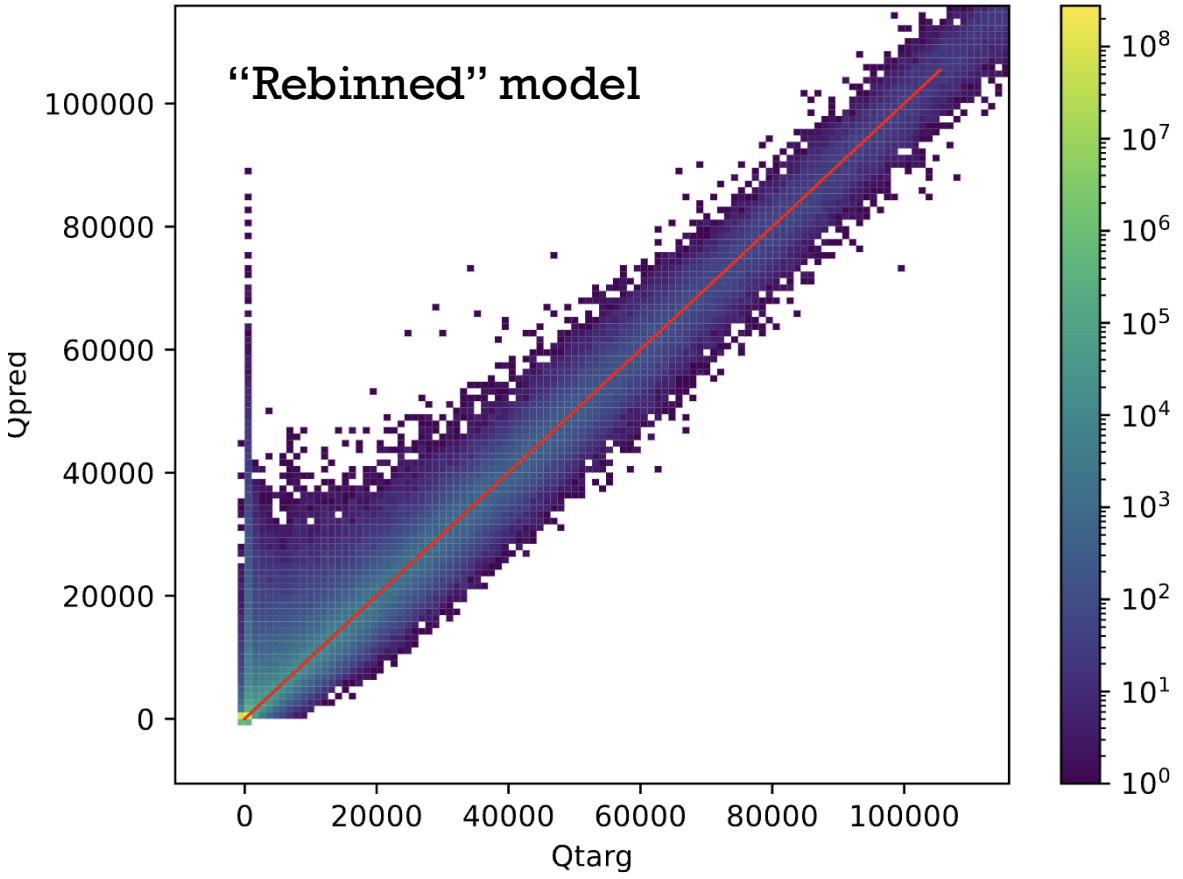
- Act on WCSim root file
- Bin PMT hits based on photon starting position
- Normalize charges based on bin volume



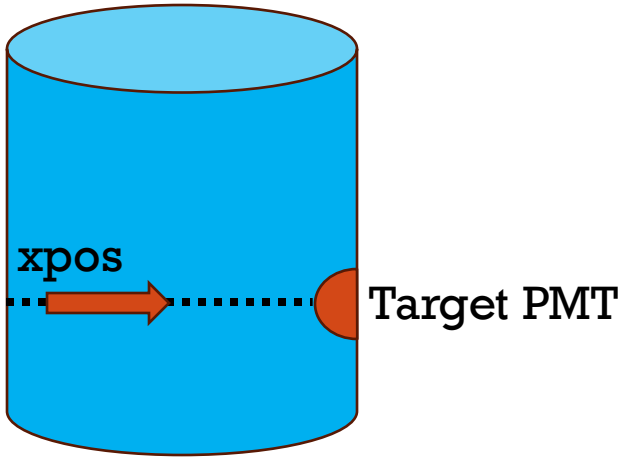
Training with rebin data

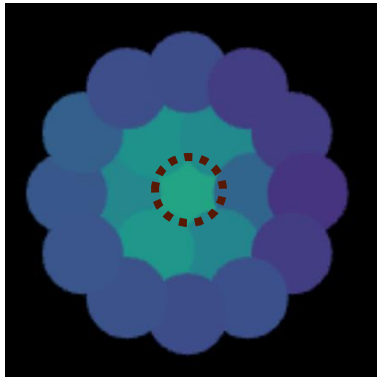
- Does not reach previous precision yet



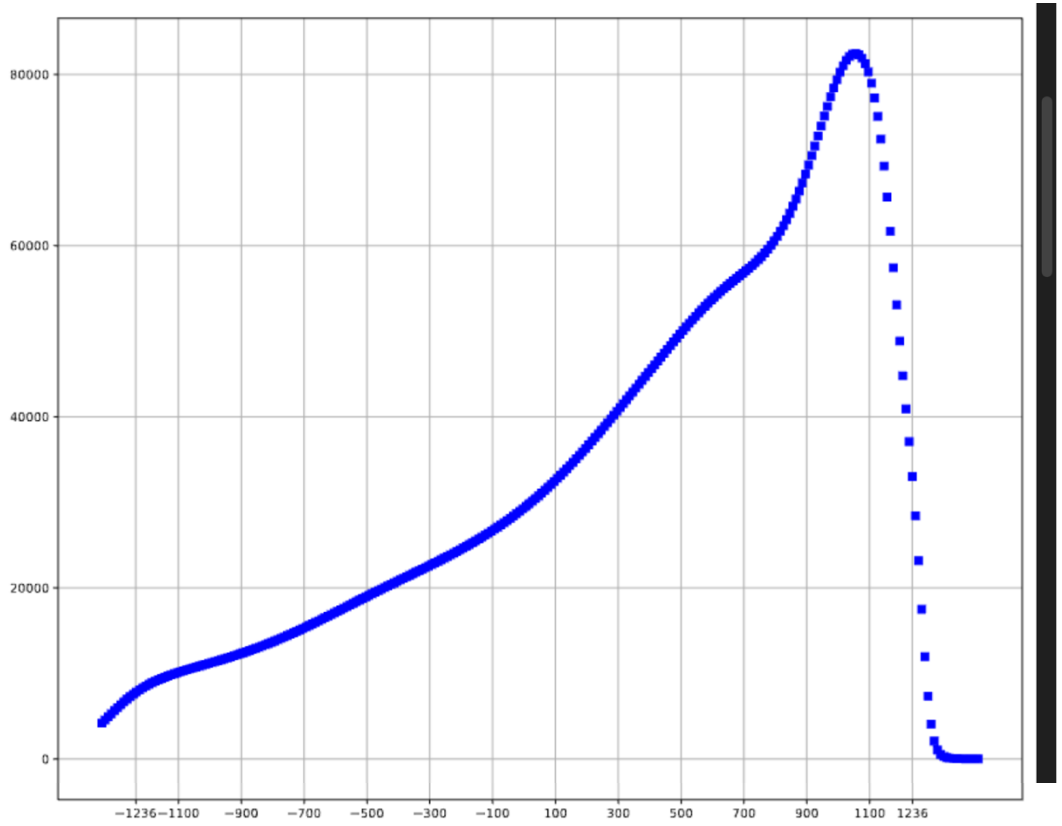


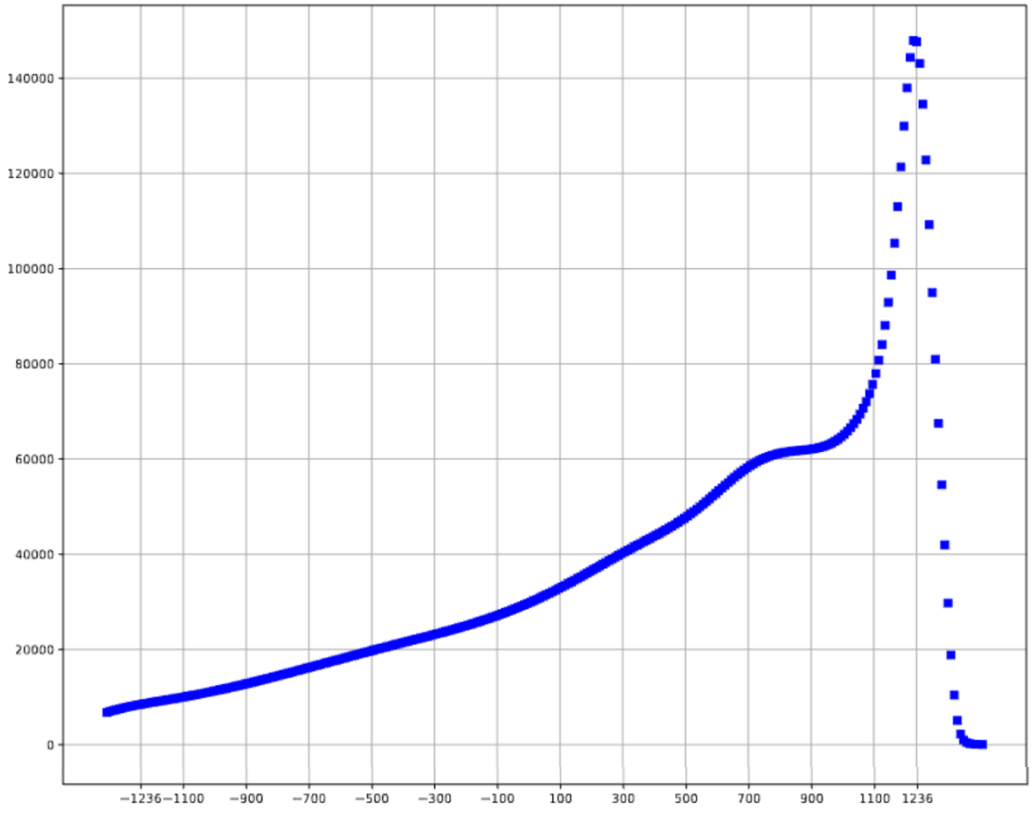
Training with rebin data



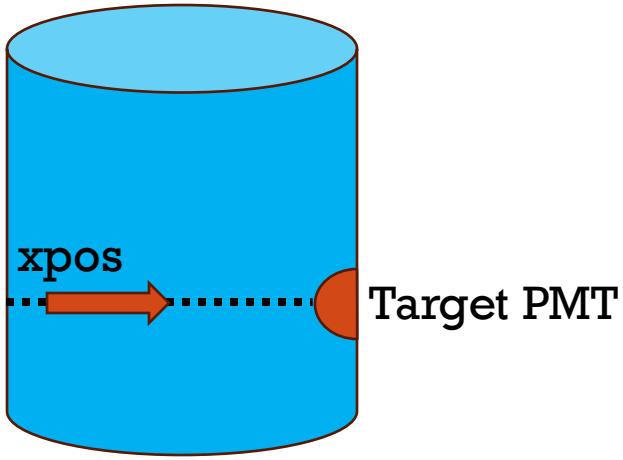


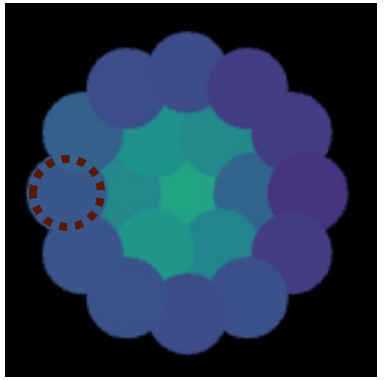
- Center PMT
  - trend is right but not so smooth towards last bin
  - Still drops to zero beyond last bin → need new training data for large r/z regions



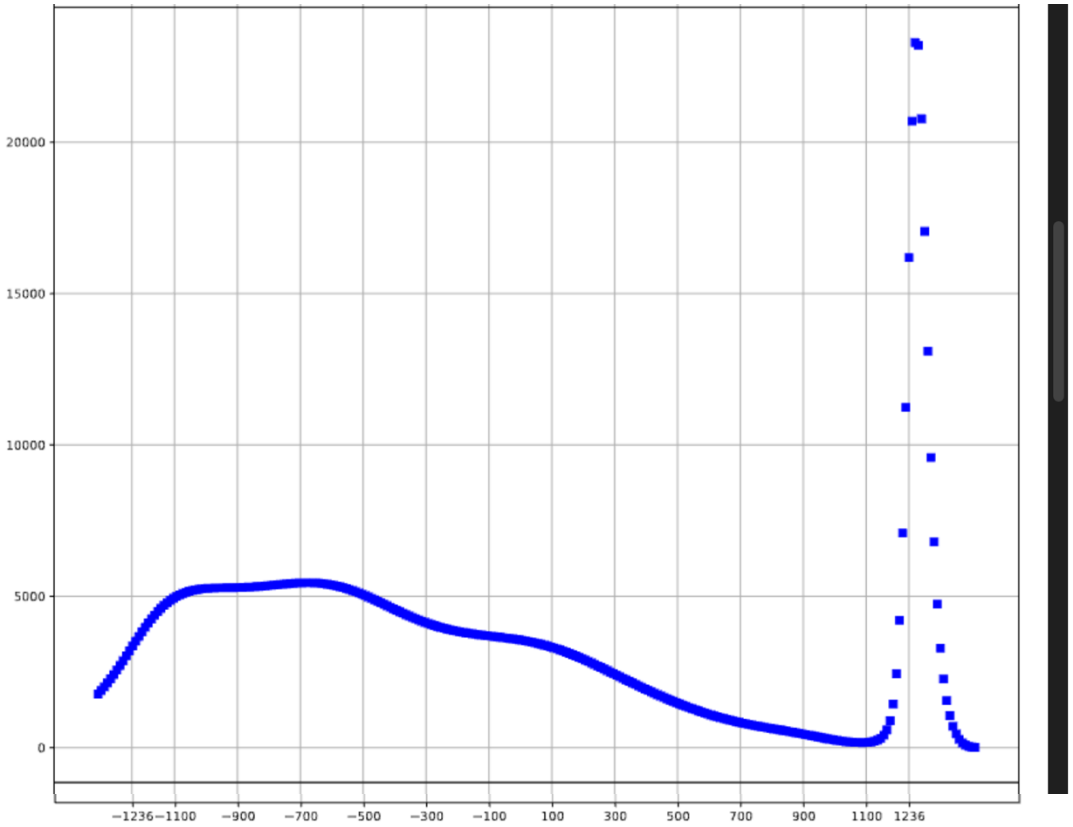


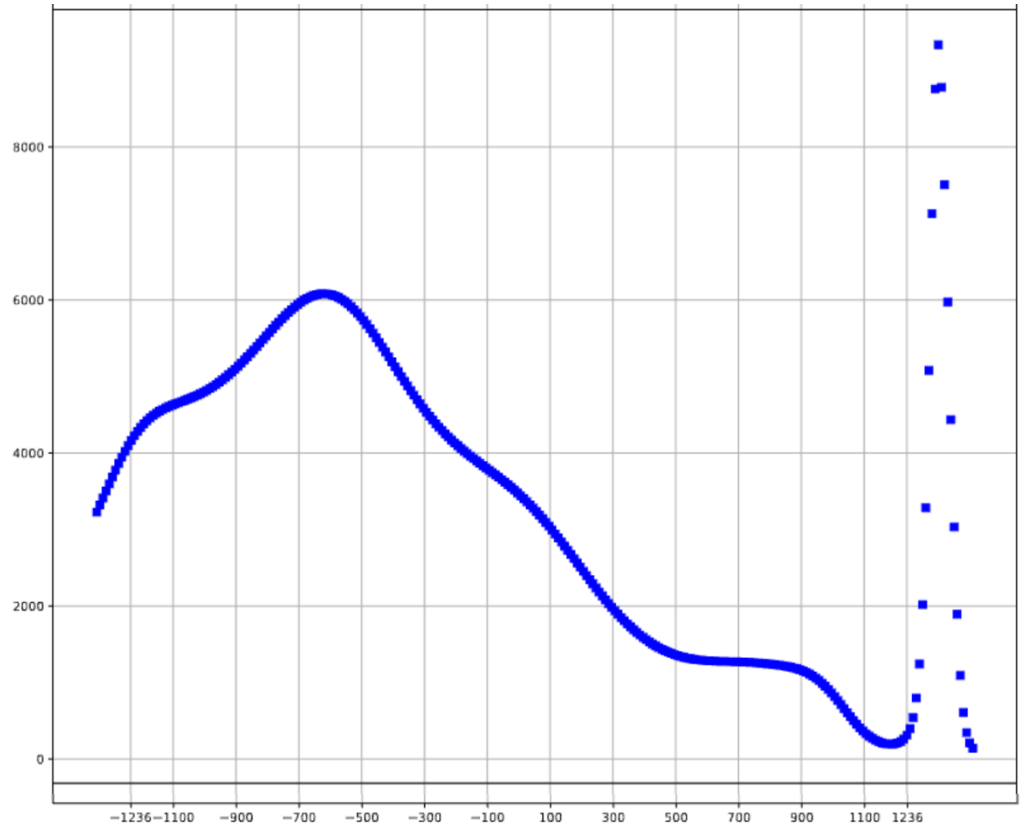
Training with rebin data





- Outer PMT
  - Still some unphysical jump but much less severe

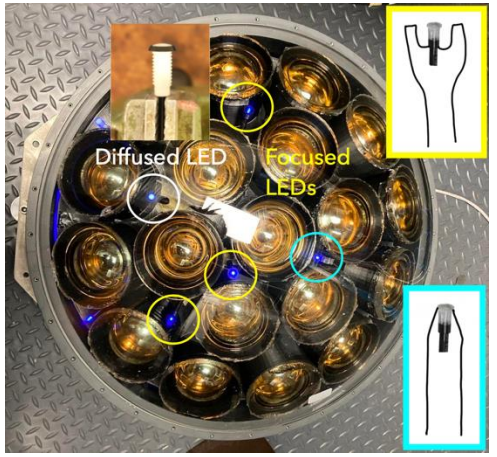




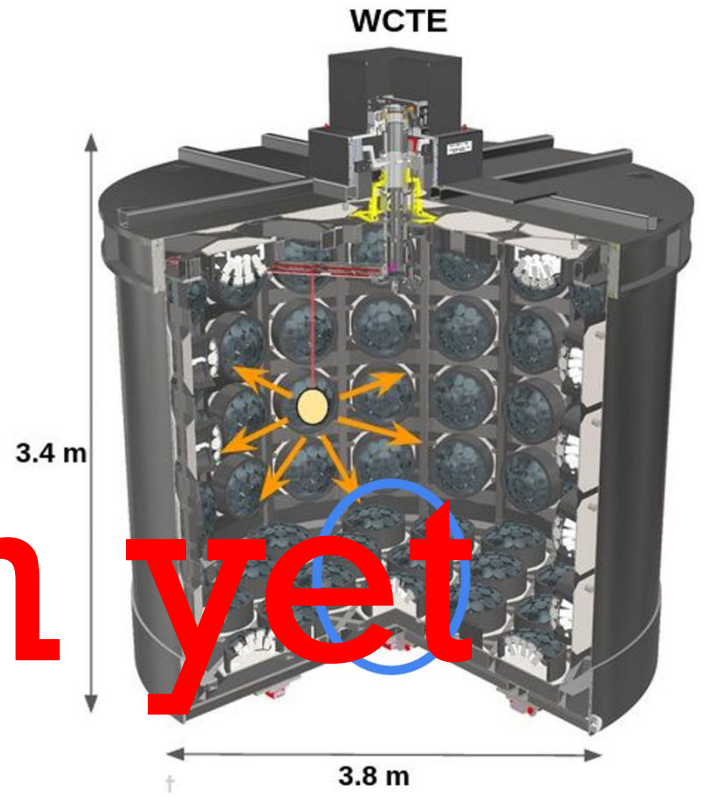
Thoughts on rebin

- Seems to be working but needs more time for training convergence
- Non-smoothness seen near rebin region
- So, Rebin all data?
  - O(10) times more training data points → more training time
  - Also O(10) times less statistics in each point

Fine tuning with calibration data

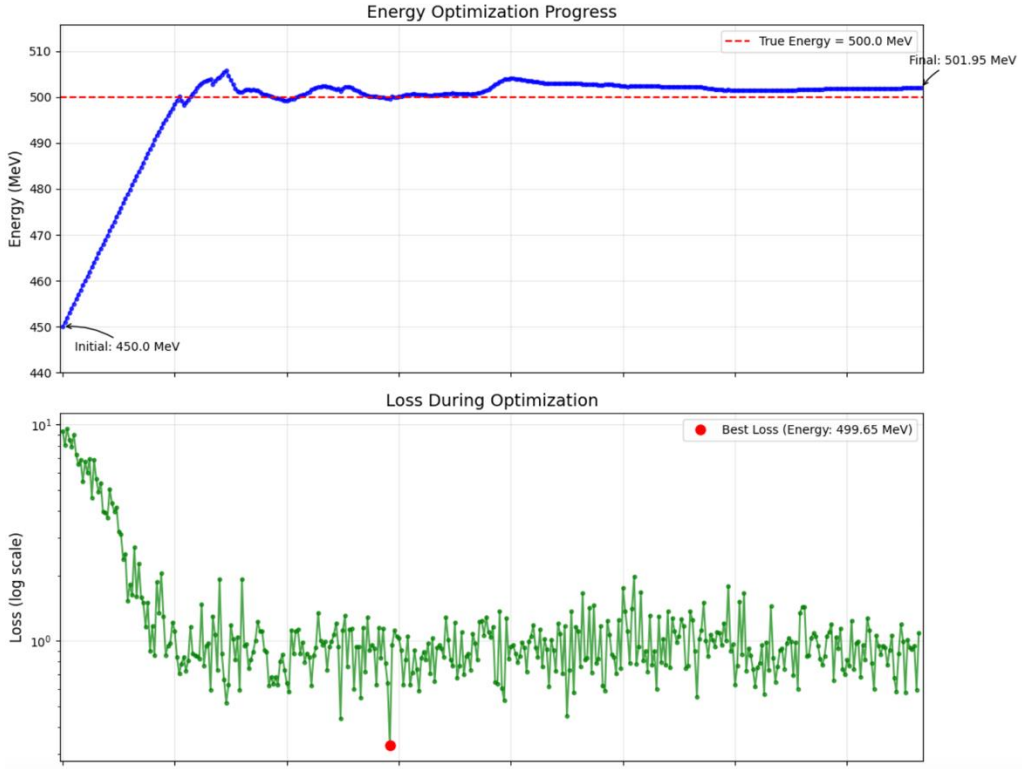


- Available calibration sources in WCTE
  - LED installed inside mPMT: point source with different opening angles; training data does not cover such large r/z positions
  - Diffuser ball: finite volume with isotropic emission
- Training data has finite volume and emission cone
- Technically how to use this data in fine tuning?
  - Train with the training data together?



No discussion yet

Muon reconstruction



- Cesar kindly built a minimization demo from jax
  - Very good convergence in clousre test,
    i.e. generate a ring image using physics+optic siren,
    then fit
- Zhenxiong and Ryotaro work on fitting WCSim muon ring, also see good convergence
- Next
  - Full momentum + direction + vertex fit
  - Study charge normalization, sampling strategy, loss definition, gradient/convergence
- Next next
  - Showering and segmentation from electron/pion