

Summary

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CIDeR-ML workshop
April 21, 2025

My goal of this workshop

- Goal:
 - Reconstruct the multiple variable (momentum, vertex, direction) from PMT charges.
- Plan:
 - Optimize a loss function:
 - Calculated by comparing the real PMT charges to the predictions of SIREN.

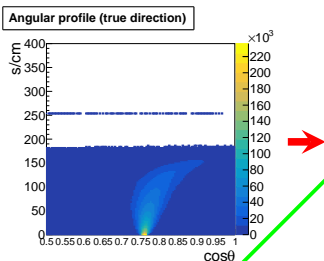
Reconstruction pipeline

- Reconstruct the variables of true samples by optimizing the loss.

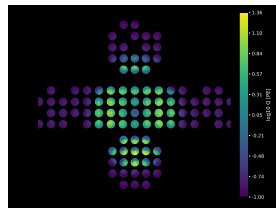
Forward simulation

Hypothesis

- PID
- Momentum
- Vertex
- Direction

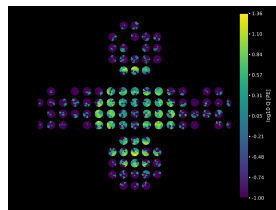


siren output



Gradient

$$\ln \mathcal{L} = \sum_{\text{PMT}} (q_{\text{siren}} - q_{\text{true}})^2$$

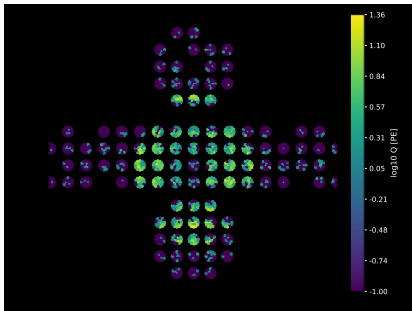


true sample

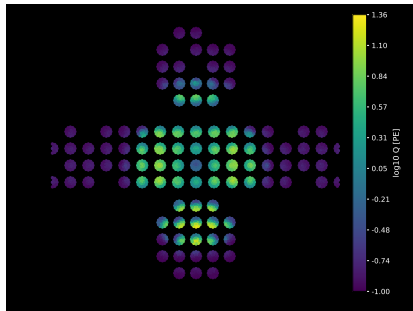
Back propagation

Normalized to have the same total charge as true.

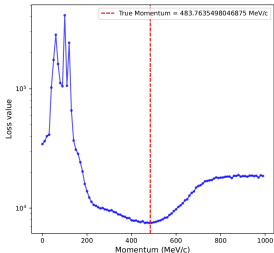
Momentum reconstruction (484 MeV/c)



MC

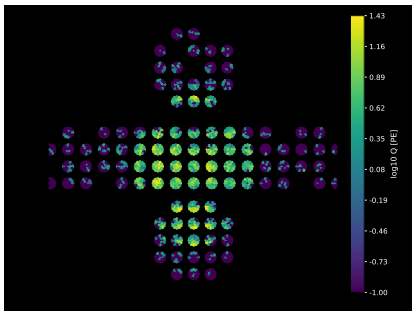


SIREN (true momentum)

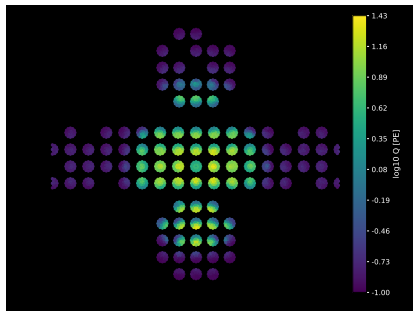


- I tried to reconstruct momentum of WCSim's mc sample.
 - Vertex: beampipe (fixed)
 - Direction: (0, -1, 0) (fixed)
 - Momentum: uniform ([200, 1000] MeV/c)
 - I checked the loss surface of momentum.

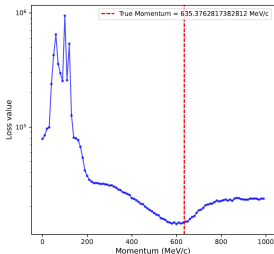
Momentum reconstruction (635 MeV/c)



MC



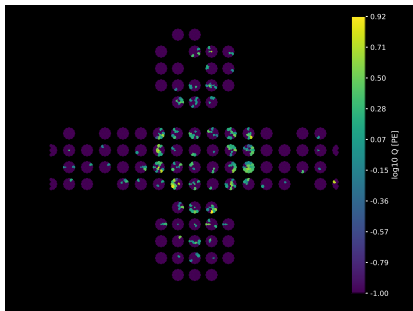
SIREN (true momentum)



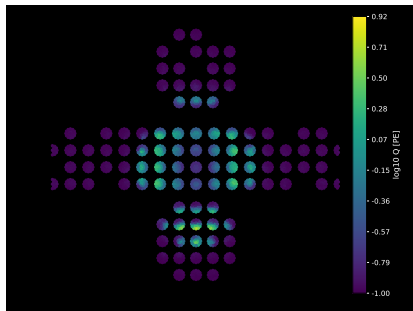
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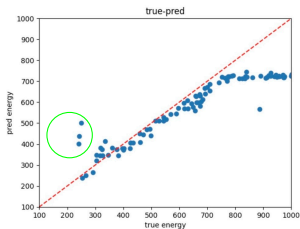
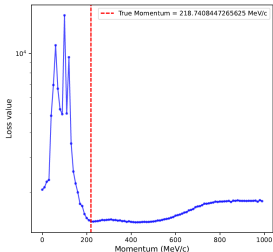
Momentum reconstruction (218 MeV/c)



MC

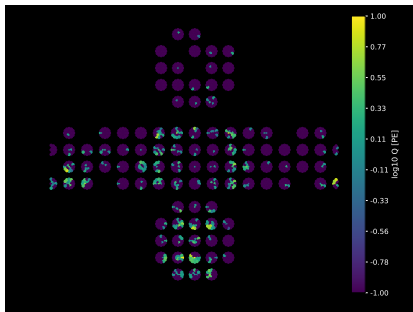


SIREN (true momentum)

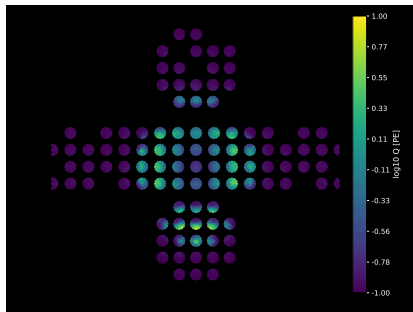


- There are strange events.
- Two minimum.
 - need to check why there are the minimum.

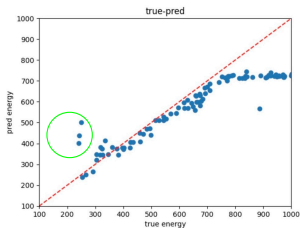
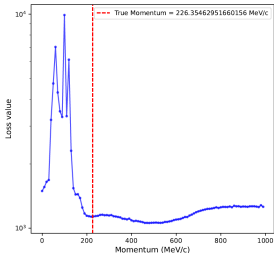
Momentum reconstruction (226 MeV/c)



MC

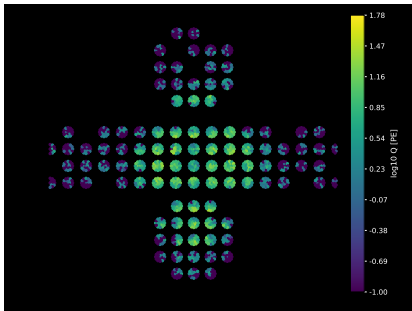


SIREN (true momentum)

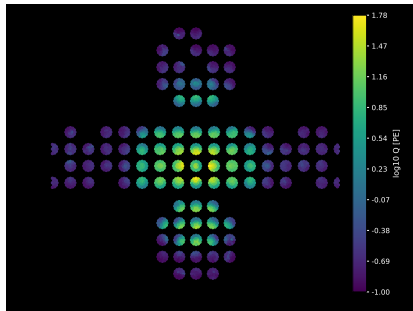


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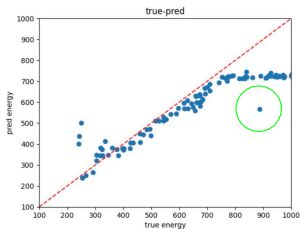
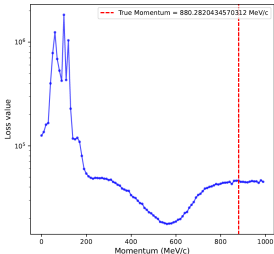
Momentum reconstruction (880 MeV/c)



MC

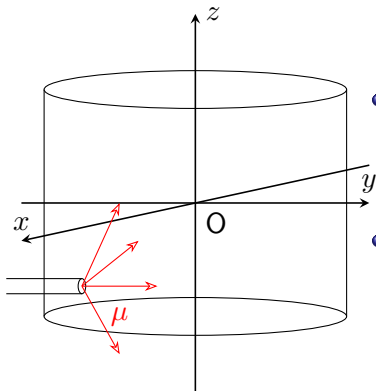


SIREN (true momentum)



- There are strange events.
- 800 MeV/c μ penetrate the wall.
 - Difficult to distinguish from low momentum events.

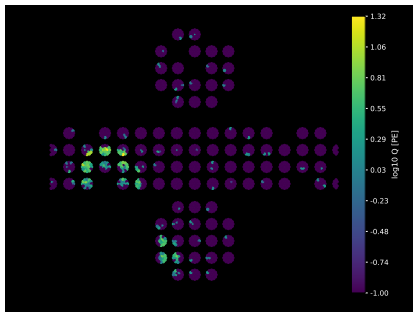
Direction reconstruction



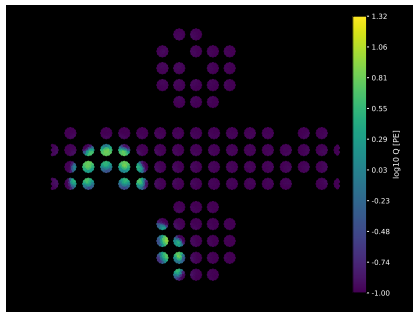
- Samples:
 - Vertex: beampipe (fixed)
 - Direction: isotropic
 - Momentum: uniform ($[200, 500]$ MeV/ c)
- I checked:
 - momentum v.s. loss (using true direction)
 - direction v.s. loss (using true momentum)

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 - momentum v.s. loss (using true direction)
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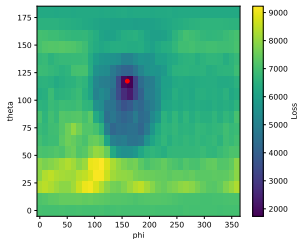
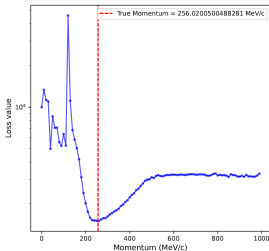
Direction reconstruction



MC

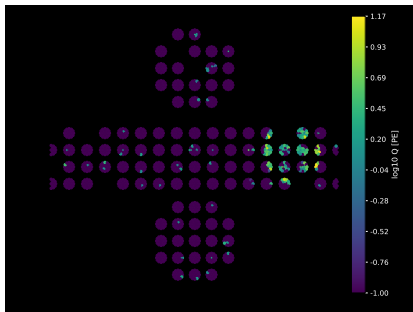


SIREN (true momentum)

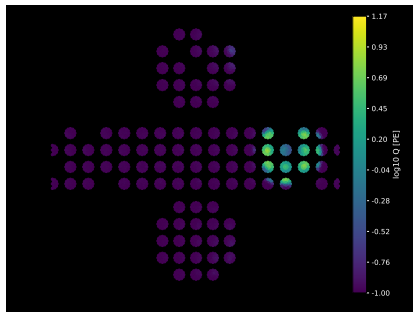


- 256 MeV/c
- (-0.83, 0.31, -0.46)
- It seems to be able to reconstruct the variables if appropriate initial values can be chosen.

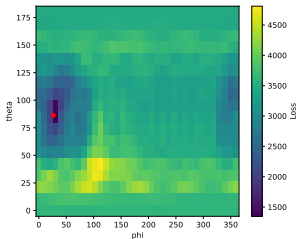
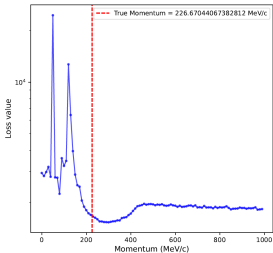
Direction reconstruction



MC

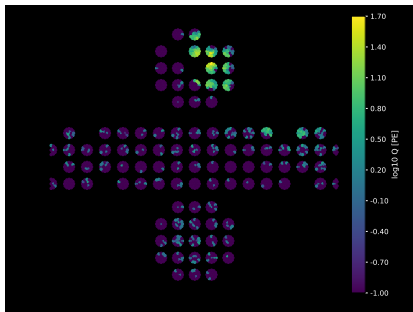


SIREN (true momentum)



- 227 MeV/c
- (0.89, 0.45, 0.06)
- It seems to be able to reconstruct the variables if appropriate initial values can be chosen.

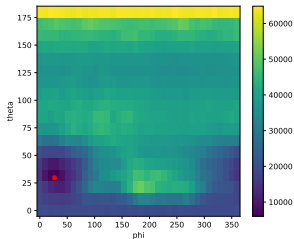
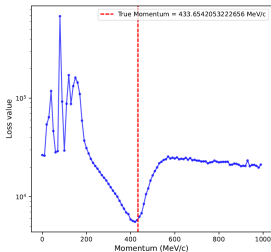
Direction reconstruction



MC



SIREN (true momentum)



- 443 MeV/c
- (0.44, 0.22, 0.87)
- It seems to be able to reconstruct the variables if appropriate initial values can be chosen.

Summary

- Goal: reconstruct the multiple variables (momentum, vertex, direction) from PMT charges.
- Plan: optimize a loss function that is calculated by comparing the real PMT charges to the predictions of SIREN.
- I checked loss surfaces of momentum and directions.