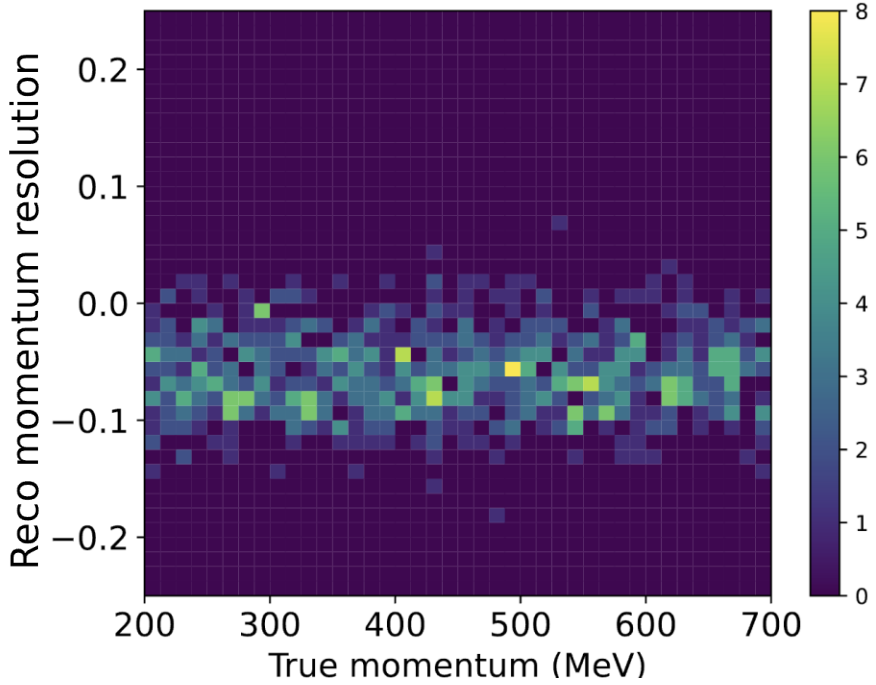
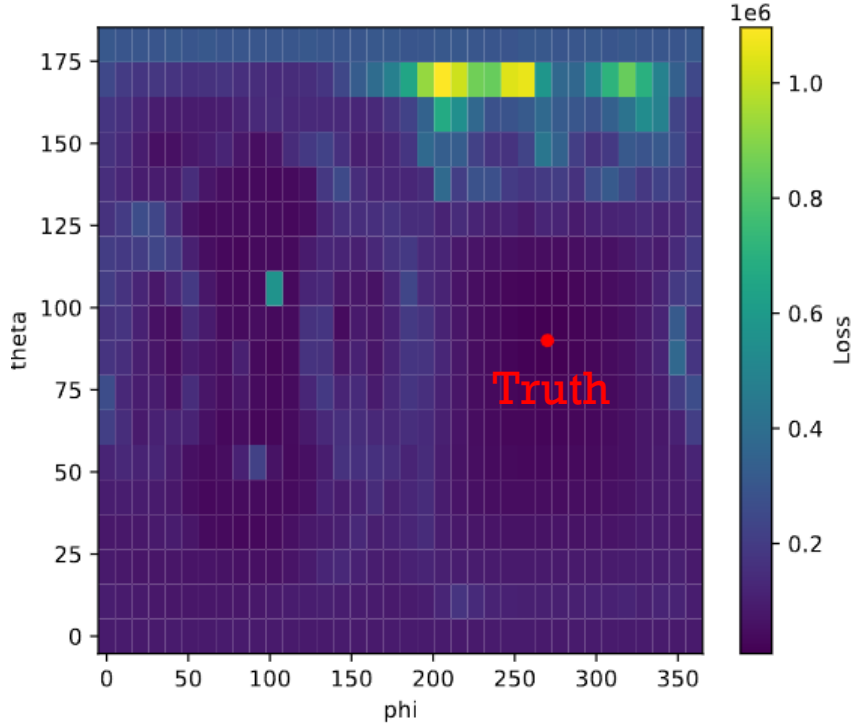
Surrogate model of Water Cherenkov detectors: Status and plan

Progress from last workshop

- Muon momentum reconstruction
  - Systematically under-estimated, why?



- Some effort on direction fit

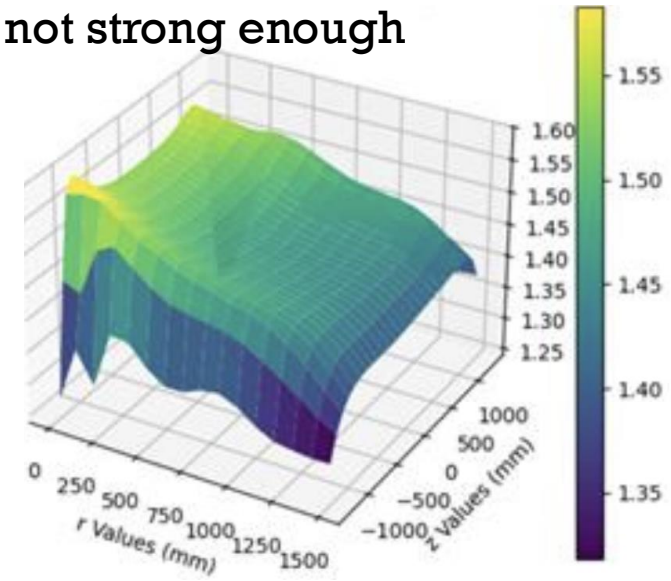


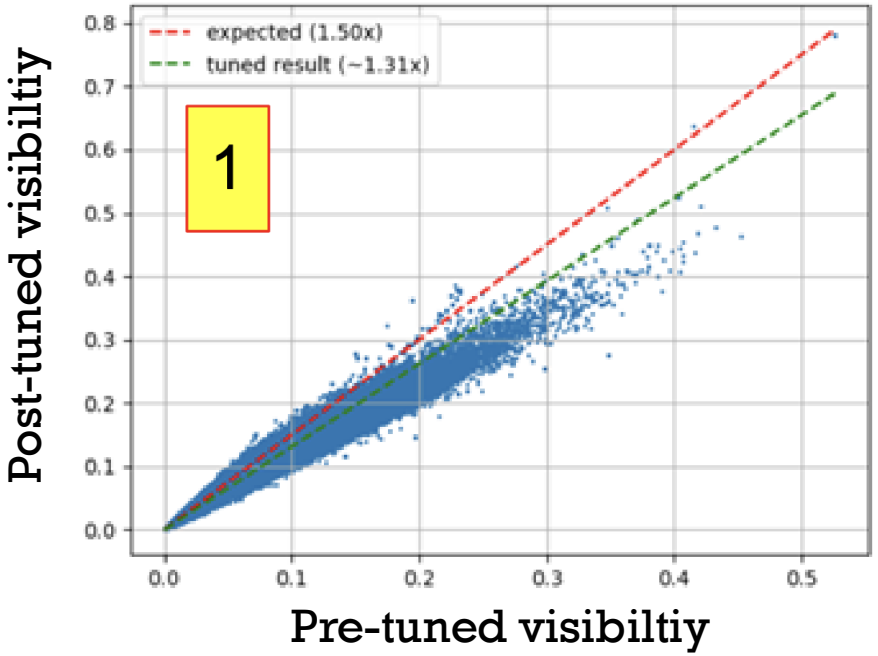
- Let's continue (with jax?) towards full reconstruction

Recent work on calibration

- Nico (IPMU summer intern) helped formulating the first calibration pipeline
  - Create fake data of isotropic source(s)
  - Gradient descent of OpticSiren model parameters with simple MSE loss
  - Evaluate tuned model performance
- Example test case
  - 3 isotropic sources at (0,0,0), (0,0,-1m),(0,0,1m)
  - Fake data with charge scaled up by 1.5
  - Tuning effect exists but not strong enough

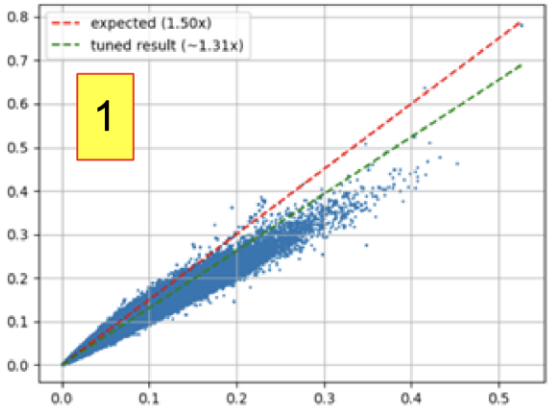
Visibility ratio as a function of (r,z)





Recent work on calibration

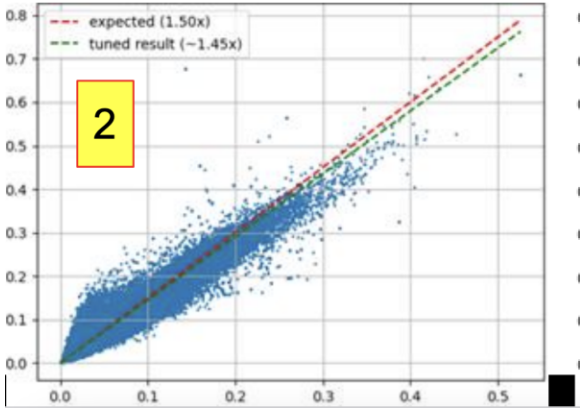
- In general tuning effect gets better with more sources
  - However we have limited source points in WCTE
- Ryotaro will continue with LED sources
- Next milestone will be calibration on cosmics

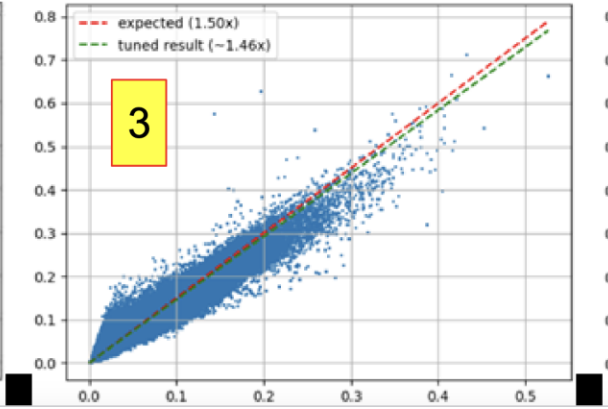


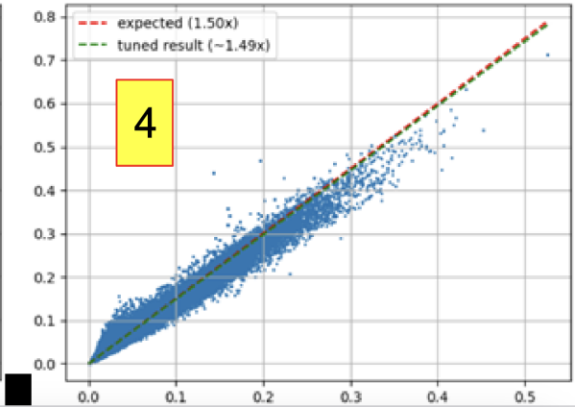
1. 3 source positions –> (0, 0, 0), (0, 0, ±1000)
2. 3 source positions (extended) –> (0, 0, 0), (0, 0, ±1300)
3. 15 source positions –> z = [0, ±1300], r = [0, 1160], φ = [0,90,180,270]
4. 126 source positions –> z = (-1300, 1300, 14), r = [0, 580, 1160], φ = [0,90,180,270]

x: Pre-tuned Visibility
y: Tuned Visibility
dotted line: y=1.5x

Scale by 1.5x







Calibration on cosmics

- Similar workflow as fixed sources
  - Generate cosmics fake data, then gradient descent and evalute tuned model
- Two ways of generating cosmics fake data
  - Cherenkov + OpticSiren: simplest closure test
  - WCSim MC: expect some tuning effect due to imperfect modelling of OpticSiren (especially near detector wall)
    - Work with either truth or fiTQun reconstructed track info
    - File copied to s3df: /sdf/data/neutrino/kmtsui/wcte/wcte_cosmics_mc.h5
    - Data structure is listed here

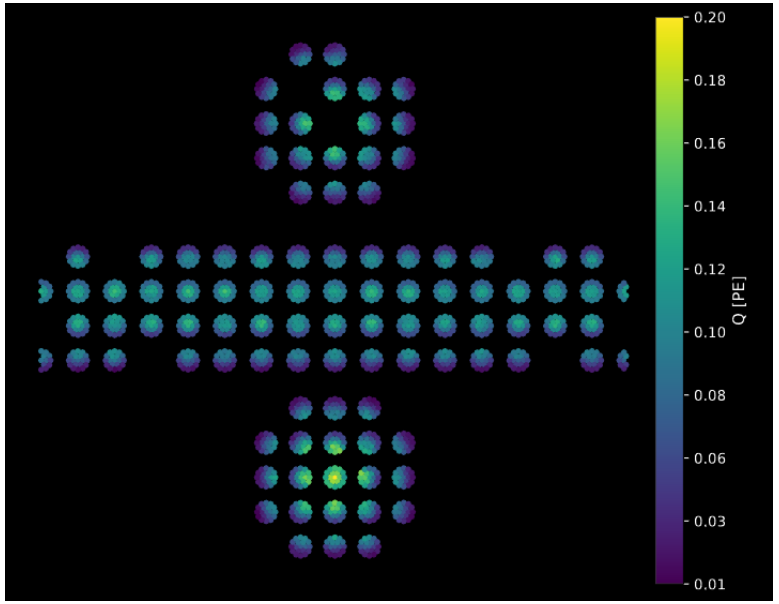
Appendix

More information on cosmics MC

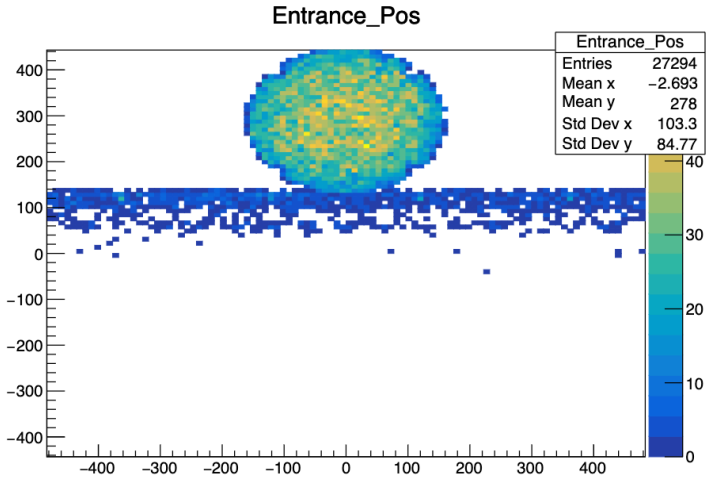
- 100k through-going cosmic muons with sea-level angular flux
- Selection for top-down muons (enter through top cap and exit through bottom cap)
  - number of PMT hits > 1000
  - Top/Total charge < 0.07
  - 0.38 < Barrel/Total charge < 0.6
  - 0.38 < Bottom/Total charge < 0.6
  - fiTQun reconstructed entrance point on the top cap
  - fiTQun reconstructed exit point on the top cap
- After selection
  - 26% of all the muons remain
  - selection efficiency and purity of top-down events are 85% and 93% respectively
  - over 99% of the selected events are with truth cos(zenith_angle)>0.7.

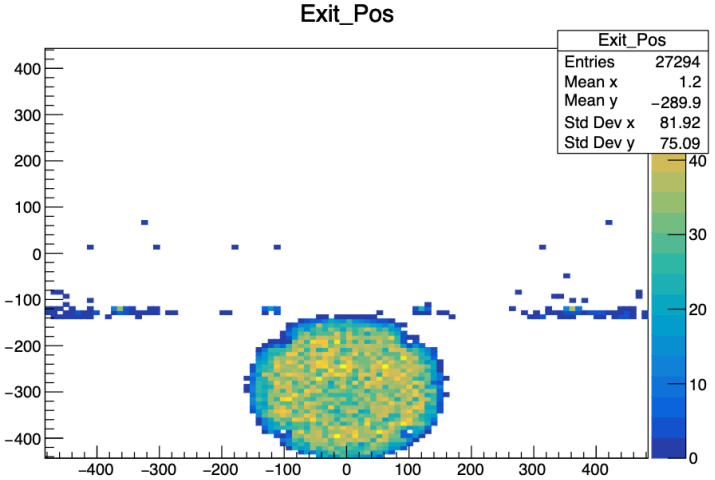
Selection plots

- fITQun reconstructed entrance/exit points are less likely to be on the mPMTs

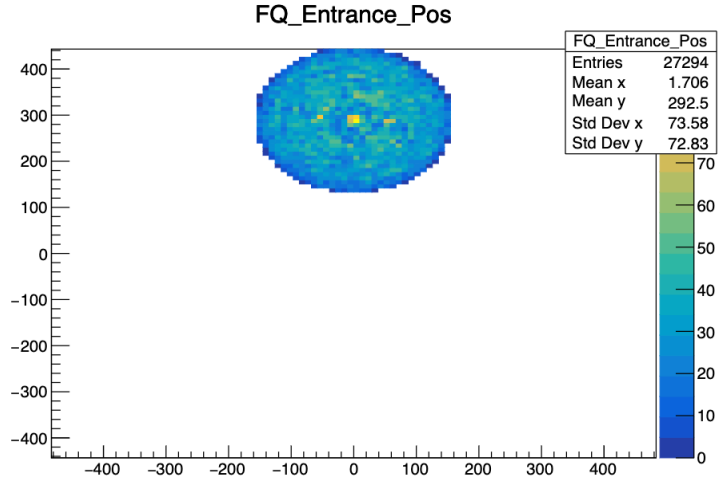


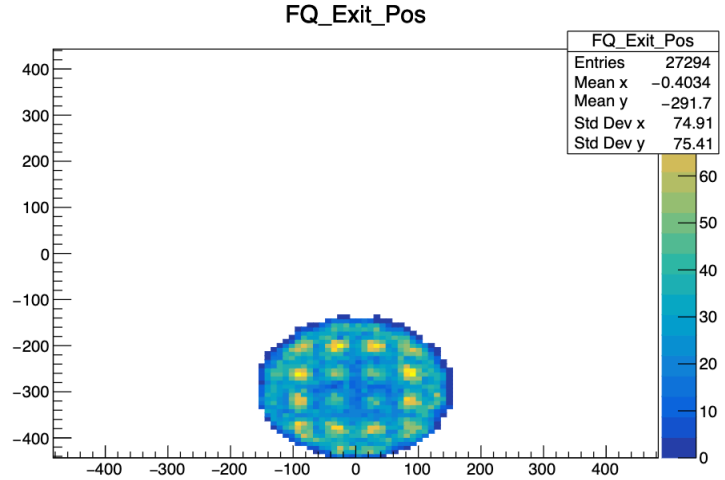
Truth info





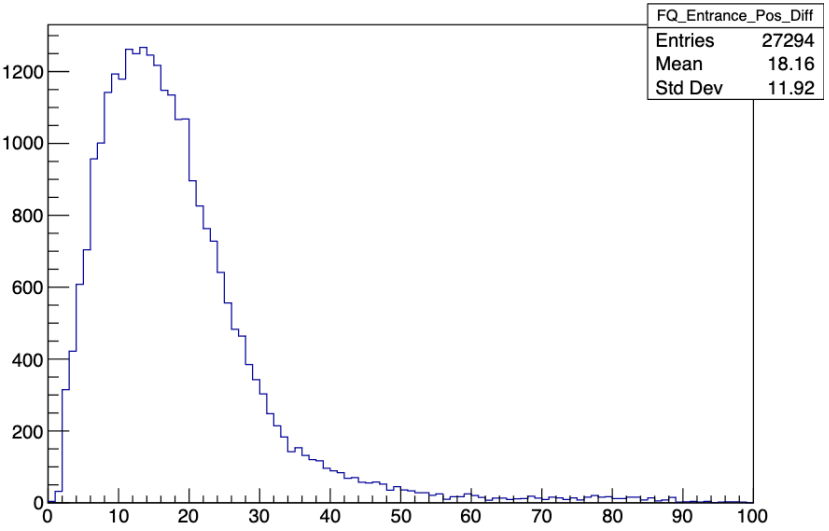
Reco info



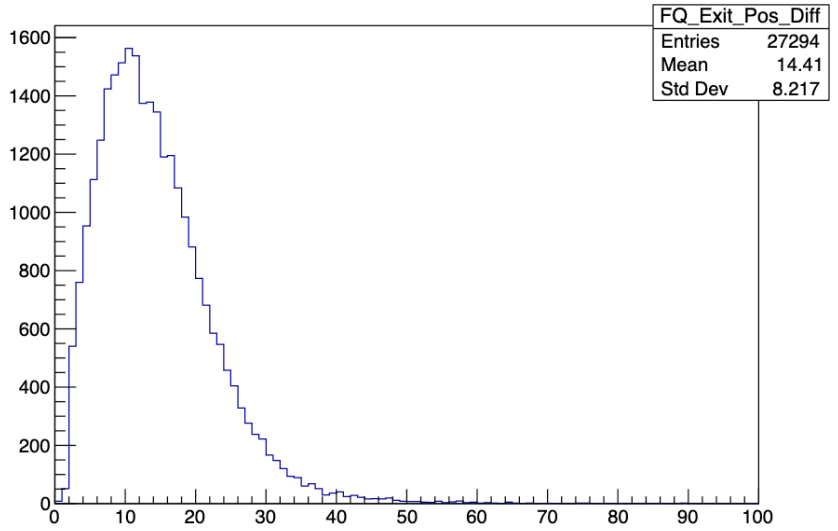


Selection plots

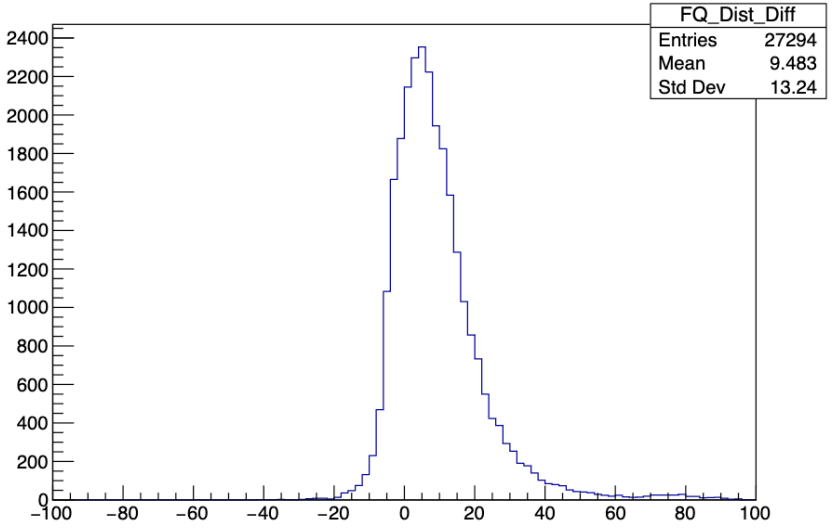
- Reco position resolution is better than mPMT cylinder radius (25 cm)
- Entrance reconstruction is worst than exit



Diff btw reco and truth entrance points (cm)



Diff btw reco and truth exit points (cm)



Reco – Truth track length (cm)