Status report

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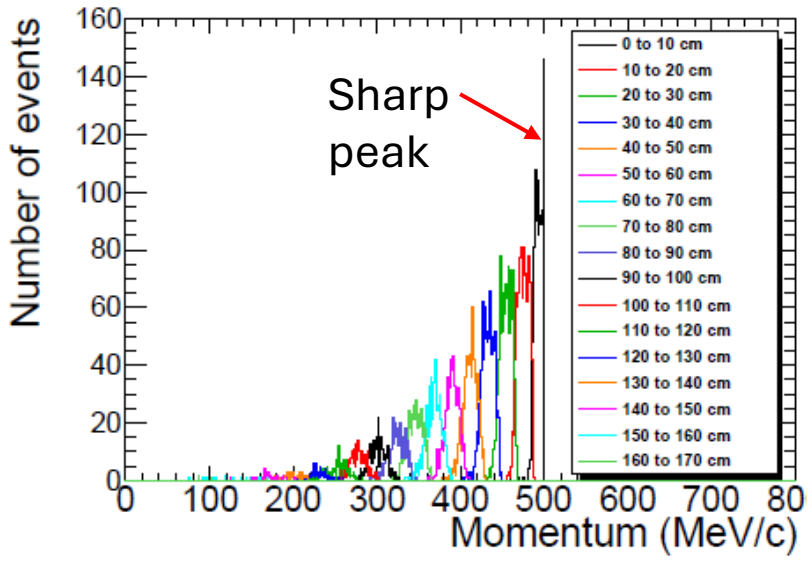
Pion interaction collaboration meeting

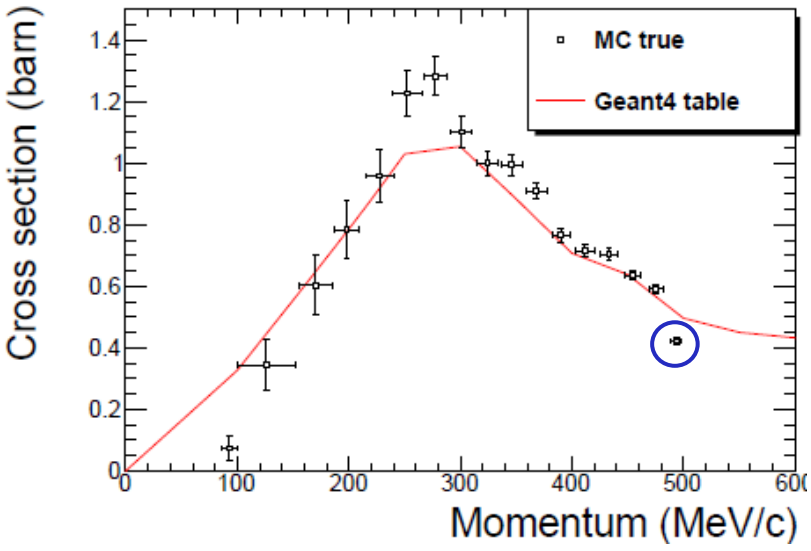
July 11, 2025

Outline

- I evaluated the pion total cross section from MC by using true position before scattering
- I checked scattering point reconstruction based on the method by Sahar

Evaluation of sensitivity



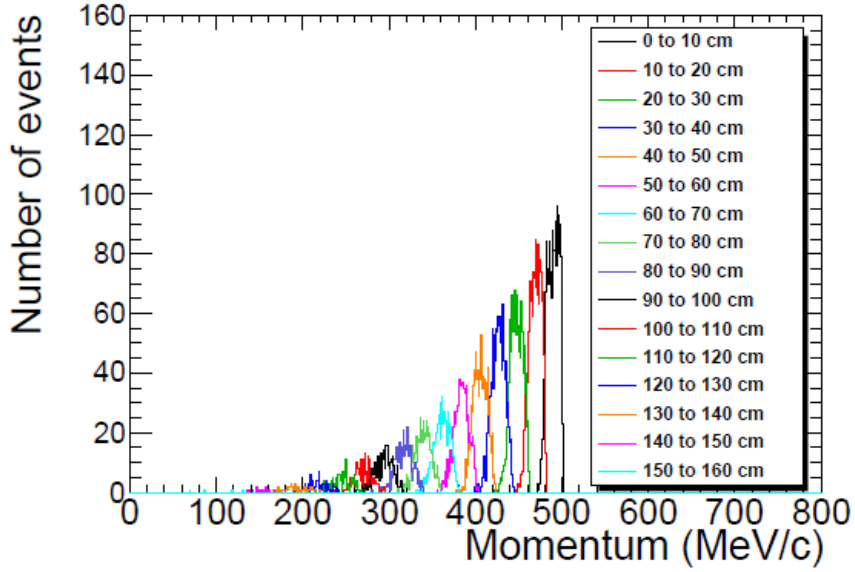


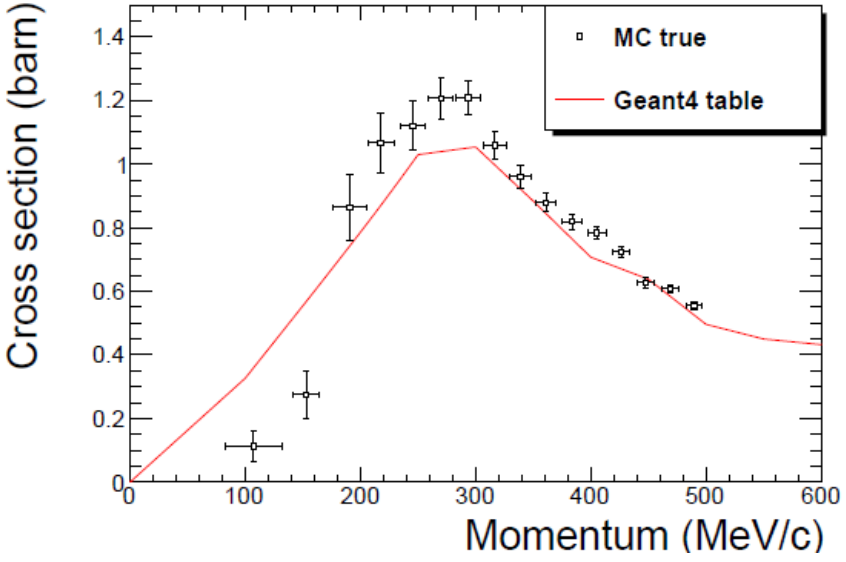
- I evaluated pion cross section in water based on MC by using true information of positions and momentum just before scattering.
- Inject 1k pions with 500 MeV/c from the beam pipe.
- by each 10cm along with the beam direction, evaluated the cross section.
- I found a sharp peak in the first 10 cm.

→degrade the performance of the cross section.

scattered N_i pions in this region (by 10cm)

Sharp peak on the 0 to 10 cm regions





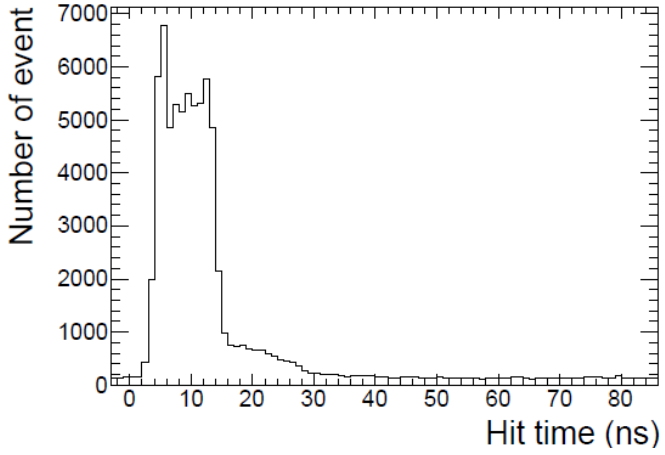
- Inject pions at 5 cm away from the beam window to prevent passing through the window.
  - The sharp peaks disappear.
  - The events within 0-10 cm in the previous slide may include scattering events by the beam pipe

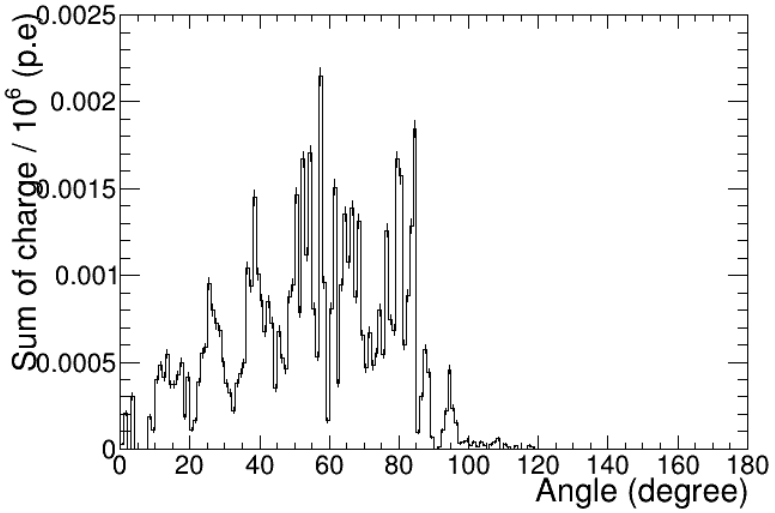
  → may need to investigate the effects of scattering by the beam pipe window.

Scattering position reconstruction

- In the latest WCSim v1.12.22, I am developing an algorithm to reconstruct the positions based on Sahar's reports.
  1. make angular distribution table for the correction of the PMT arrangement:
     - inject optical photons near the beam pipe isotopically
  2. Get angular distribution of an event and divide it by the table.
  3. Compare the corrected distributions with the one by averaged non-scattered pions.

Angular table

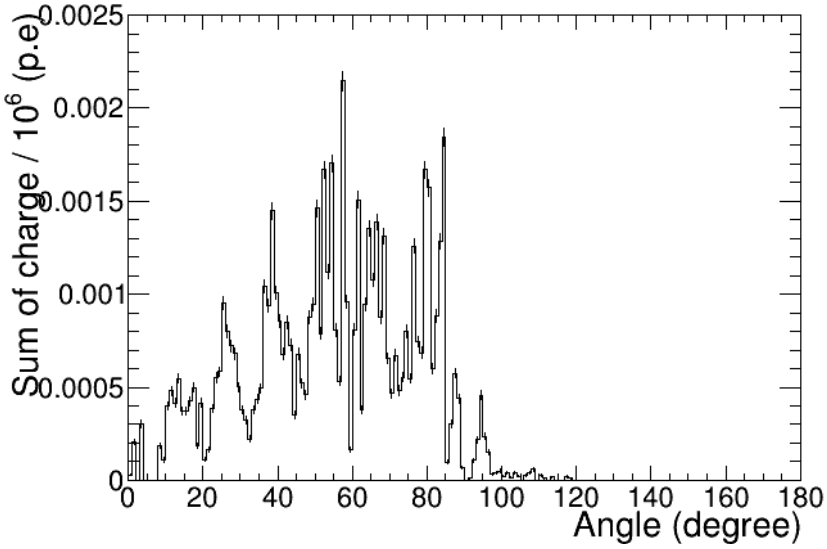


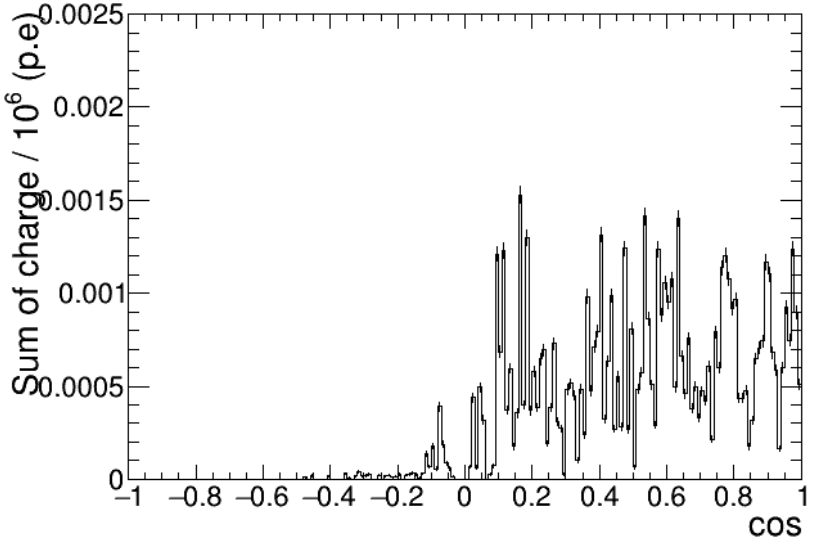


- Generate million optical photon from (0, -42.5 cm, -133.8 cm).
  - Create angle distributions weighted by PMT charge.
  - Cut under the condition of

    $0 < \text{hit time} < 15\ \text{ns}$ to remove indirect light.

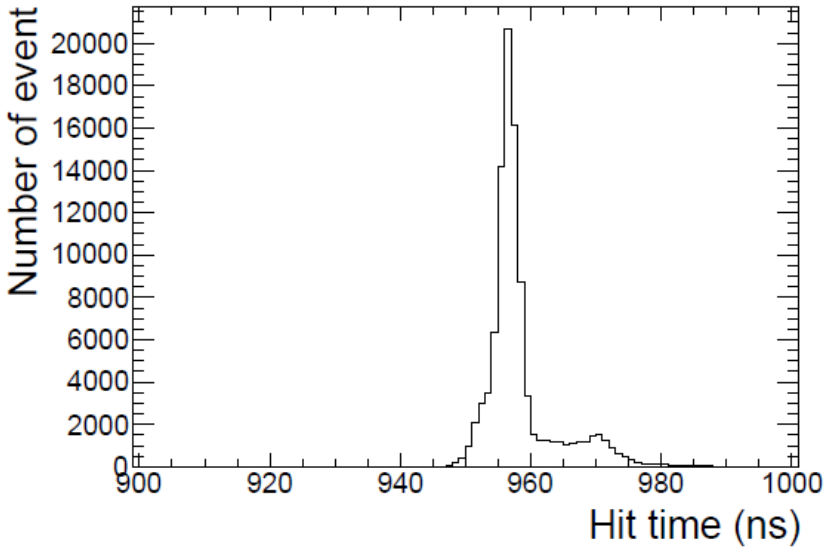
Angle or cos?





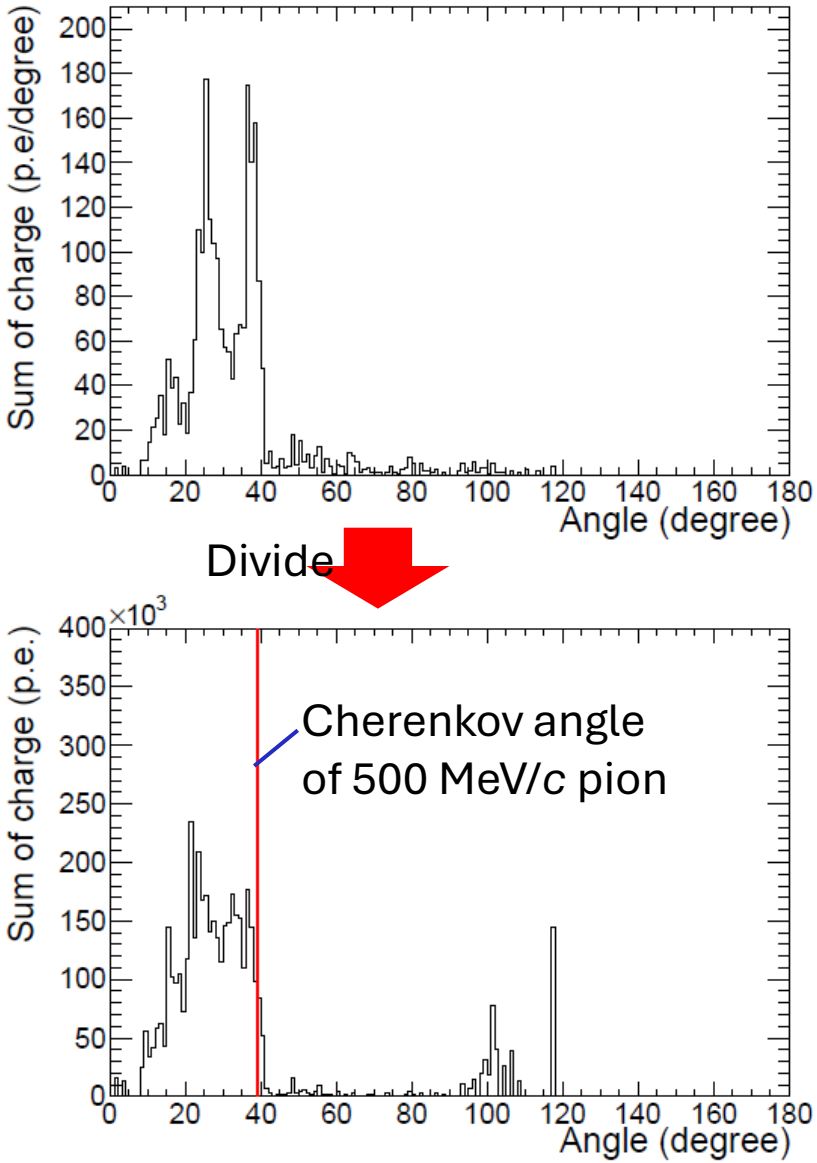
- If using cos instead of angle, the distribution becomes slightly flatter.

Pion samples



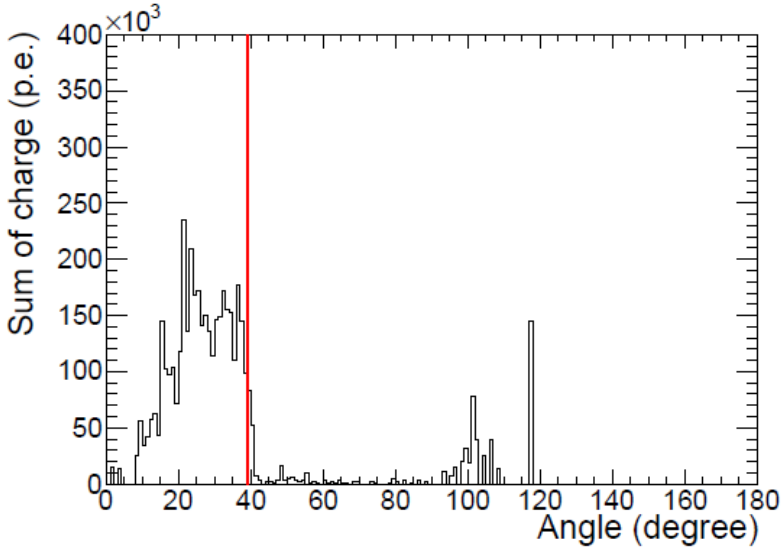
- Simulate pions:
  - 500 MeV/*c*, 10000 events
  - Injection: (0, -42.5 cm, -133.8 cm)
  - Direction: (0, 0, 1)
  - Turned off decay
- Cut hit time < 960 ns to remove indirect light.

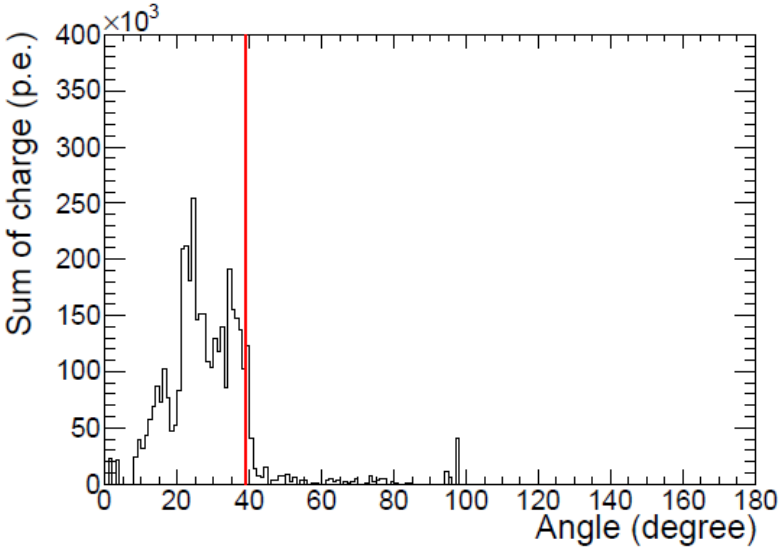
Correction of distribution

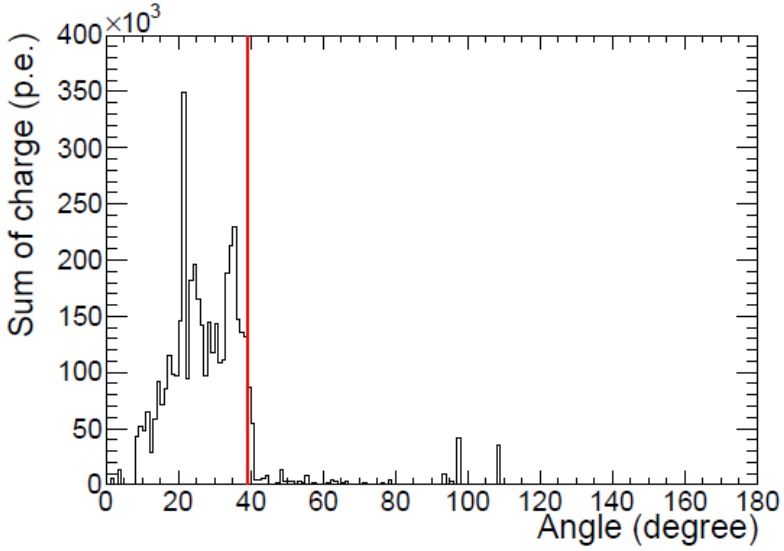


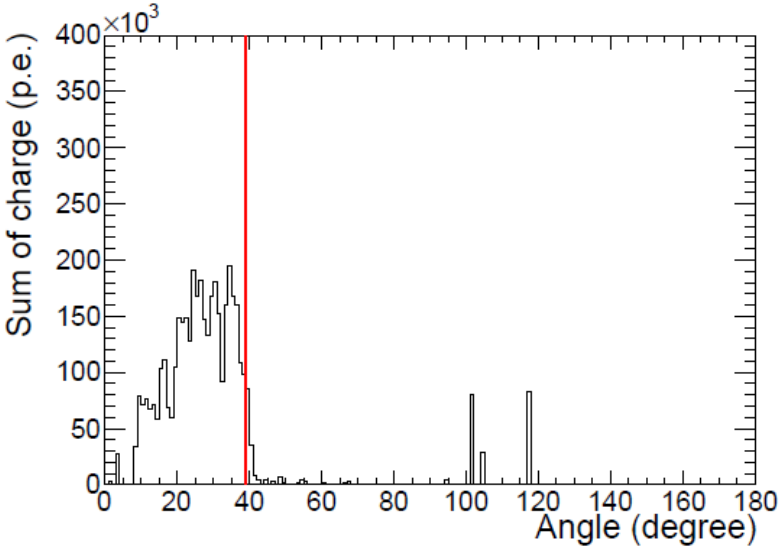
- Hit PMT distribution of angles between each PMT direction and the beam axis (0, 0, 1) (weighted by charge).
- Divide by the photon tables.

Examples: no reaction

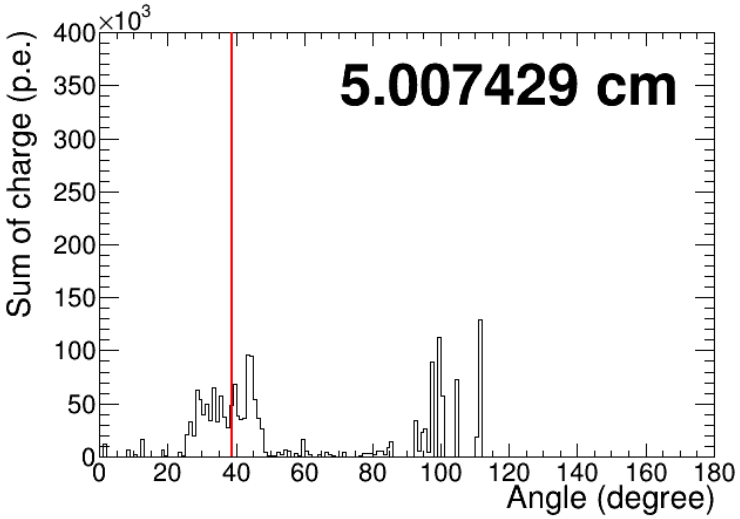


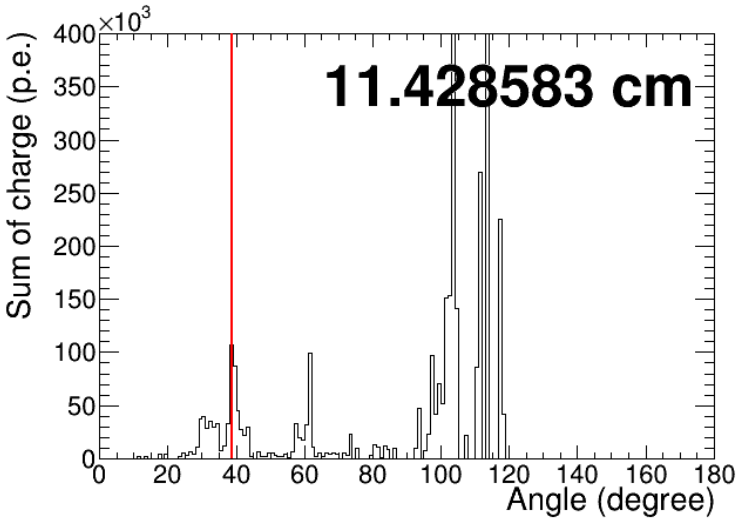


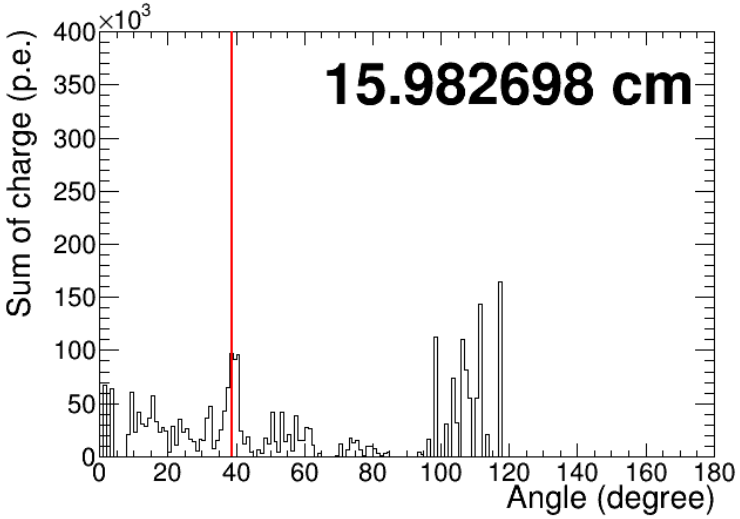


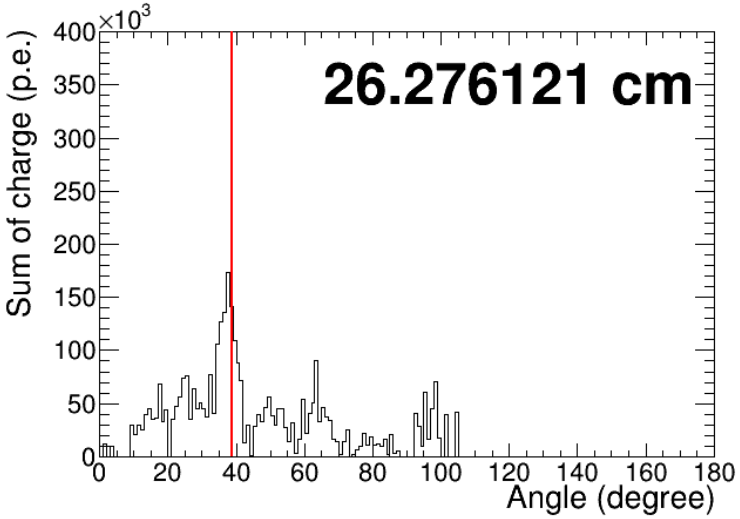


Examples: elastic scattering

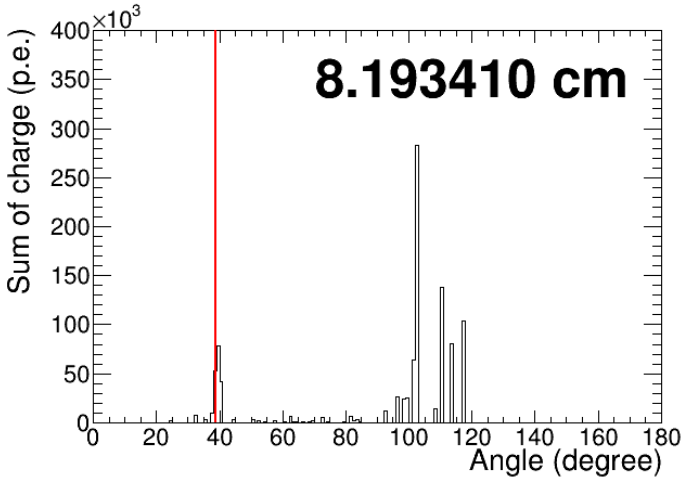


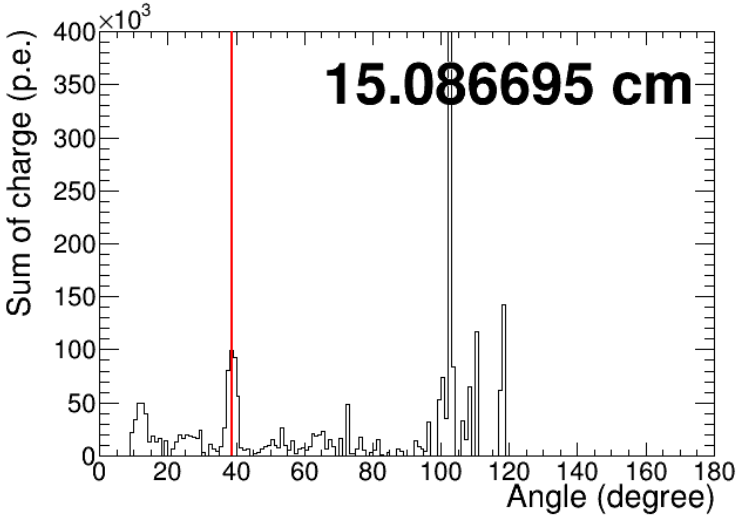


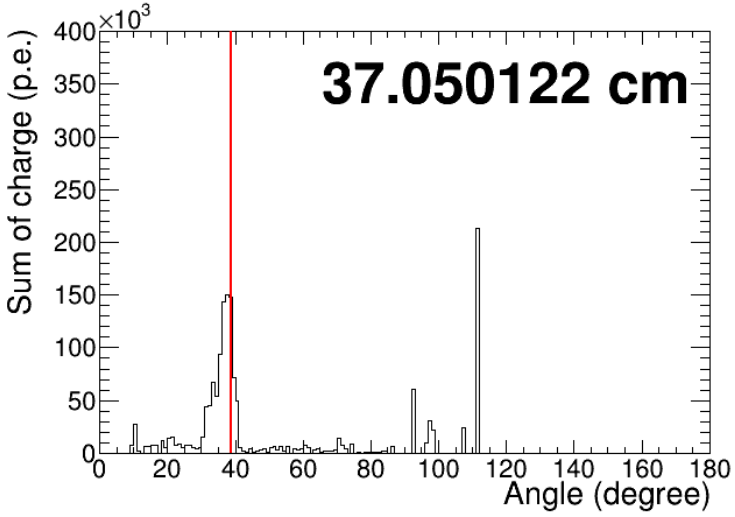


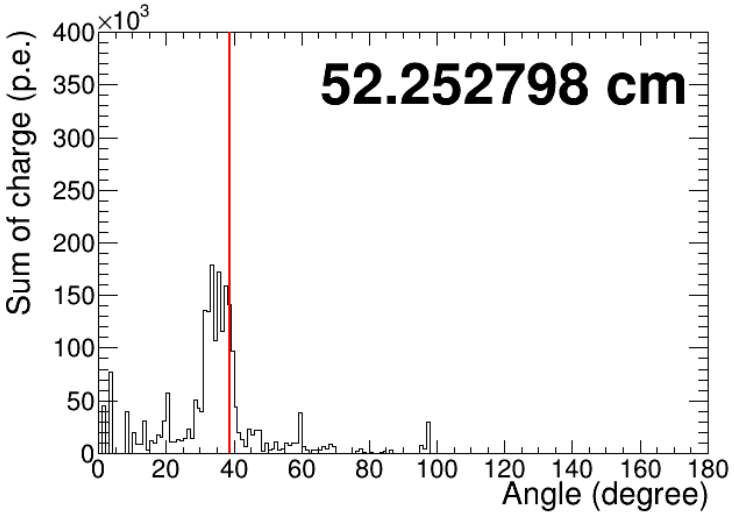


Examples: QE

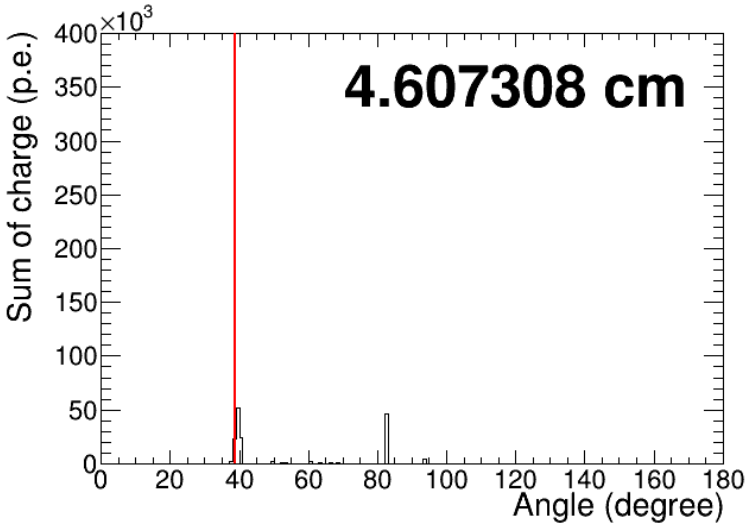

8.193410 cm
Sum of charge (p.e.)
×10^3
Angle (degree)

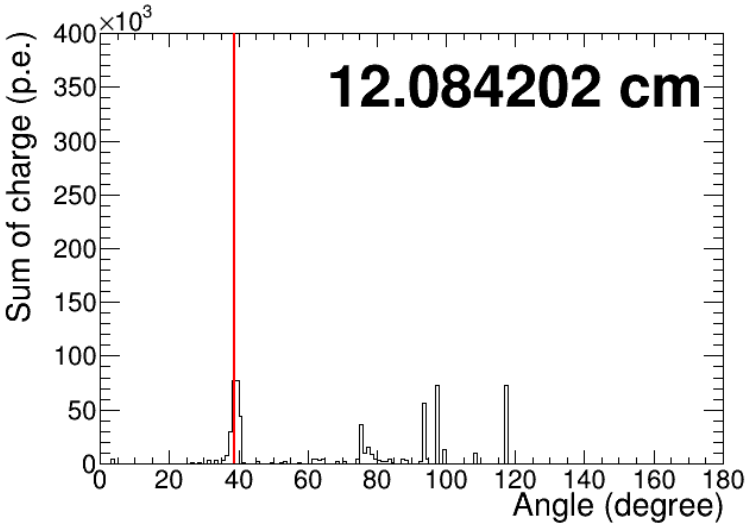

15.086695 cm
Sum of charge (p.e.)
×10^3
Angle (degree)

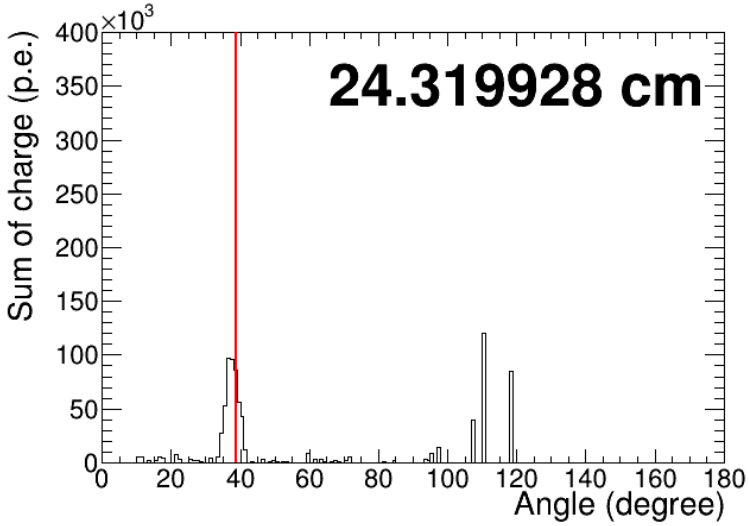

37.050122 cm
Sum of charge (p.e.)
×10^3
Angle (degree)

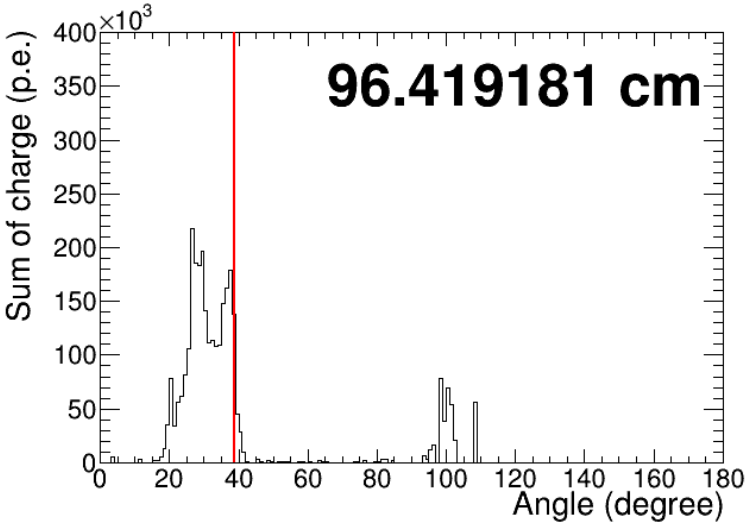

52.252798 cm
Sum of charge (p.e.)
×10^3
Angle (degree)

Examples: absorption

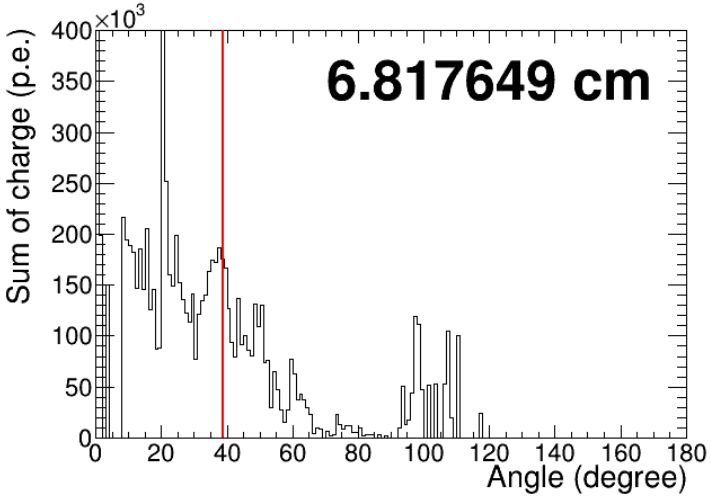


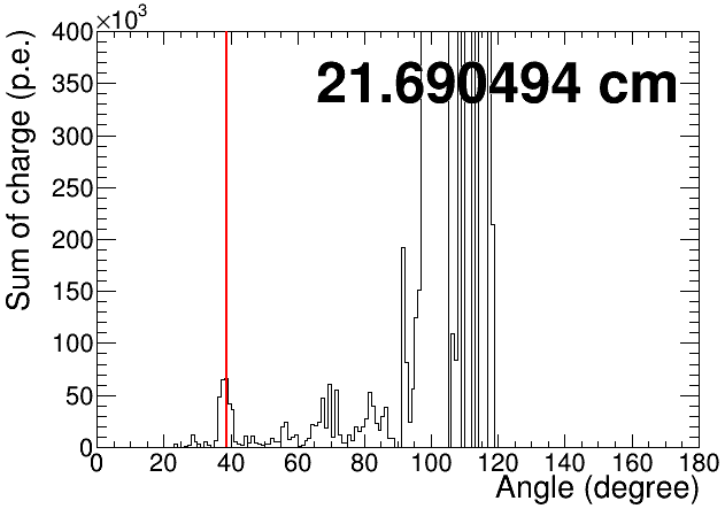


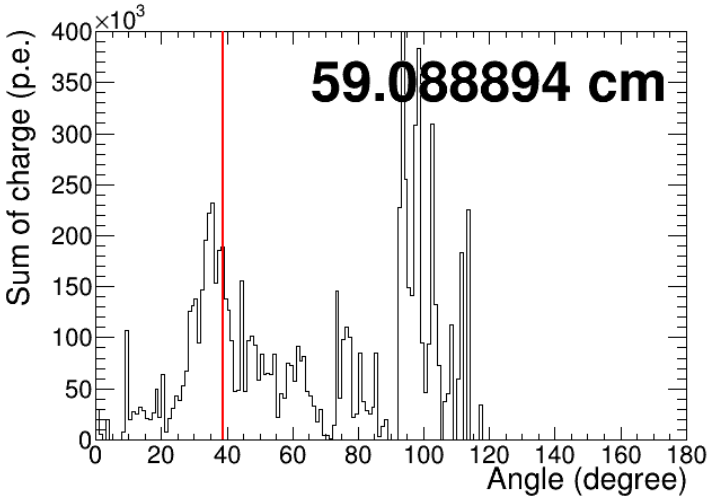


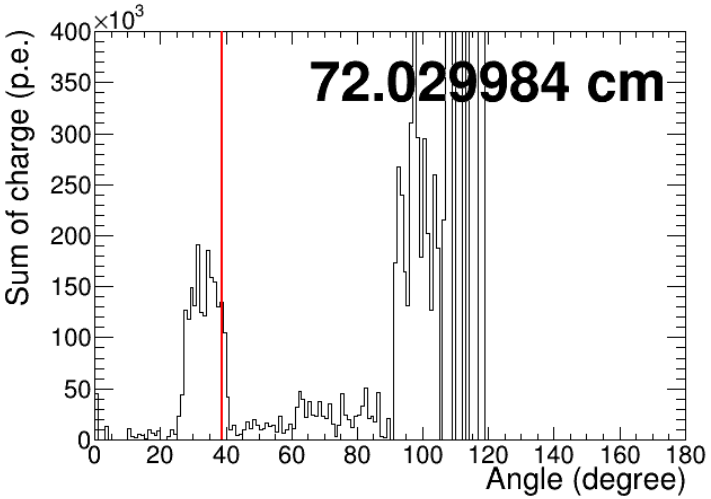


Examples: charge exchange









Scattering position reconstruction

- The hit PMT angle distributions are different between scattered and non scattered events.
- It seems possible to identify scattered positions by comparing it with the photon table as Sahar reported.
- I am developing the algorithm to identify scattered position from the distribution.