Status report

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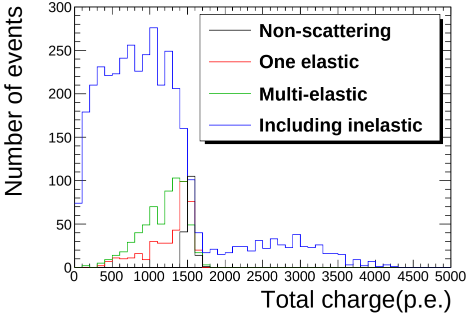
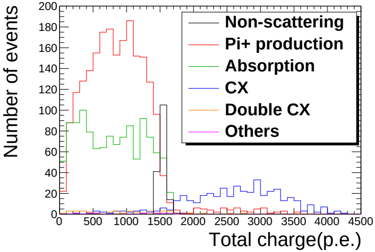
Total charge



- Simulated π^+ 5000 events:
  - kinetic energies of 300 MeV.
  - injecting on the center of the detector.
  - by WCSim v1.12.8 (old ver.)

- I checked total charge distribution for 4 categories.
  - Total charge: sum of charges of PMT hit.
  - This “inelastic” includes any interaction without elastic scattering.
  - The category “Including inelastic” means a type of not only the primary interactions but also interactions after scattering multiple times.

Identifying types of interaction using total charge



- Inelastic events are classified into more detailed categories:
  - Pi+ production: $\pi^+ + N \to \pi^+ N'$
  - CX: $\pi^+ + n \to \pi^0 + p$ (charge-exchange)
  - Double CX: $\pi^+ + N \to \pi^- + N'$
- These categories based on the primary inelastic scattering (if two inelastics happen, the first one is used for classification)

- I checked selection performance of CX events based on total charge.
  - classified events with total charge $> 1700\mathrm{p.e.}$
  - signal efficiency: 0.801
  - background contamination: 0.159
- Most of BG consists of CX events after π+ production
- Plans:
  - Evaluate the CX cross section with statistical uncertainty.
  - Reconstructed interaction positions of CX are useful for energy

Appendix

Cross section of CX

- I can identify CX events with the signal efficiency of 80%.
- For now, I tried to calculate the cross section by using only $\#$ of CX-like and total scattered events.
- Here, I cannot reconstruct scattering positions, so I calculated the cross sections ignoring the energy.

$$
\begin{aligned}
N_{\mathrm{scat}} &= N(1 - \exp(-n\sigma_{\mathrm{total}}L)) \\
\Longrightarrow \sigma_{\mathrm{total}} &= -\frac{1}{nL}\ln\left(1 - \frac{N_{\mathrm{scat}}}{N}\right) \\
\Longrightarrow \sigma_{\mathrm{CX}} &= -\frac{N_{\mathrm{CX}}}{N_{\mathrm{scat}}}\frac{1}{nL}\ln\left(1 - \frac{N_{\mathrm{scat}}}{N}\right)
\end{aligned}
$$

- N: number of entry.
- n: number density of water ($= \rho N_{\mathrm{A}}/18$)
- L: length of track (172.05 cm at the WCTE)

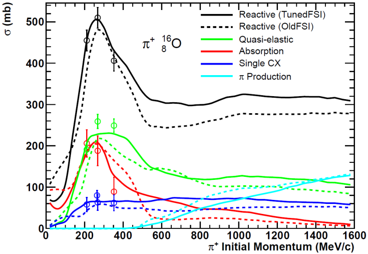
Cross section of CX

- And I tried to evaluate the statistical uncertainties of the cross sections.
- Assuming that N_{scat} and N_{CX} are independent variables, the uncertainties can be calculated as

$$
\begin{aligned}
(\text{stat. error})^2 =& \sqrt{N p_{\mathrm{scat}}(1-p_{\mathrm{scat}})}^2 \left(\frac{\partial \sigma_{\mathrm{CX}}}{\partial N_{\mathrm{scat}}}\right)^2 \\
&+ \sqrt{N p_{\mathrm{CX}}(1-p_{\mathrm{CX}})}^2 \left(\frac{\partial \sigma_{\mathrm{CX}}}{\partial N_{\mathrm{CX}}}\right)^2
\end{aligned}
$$

  - Based on the binomial distribution.
  - $p_{\mathrm{scat}} = N_{\mathrm{scat}}/N$

Cross section of CX



- I calculated the cross section using MC samples of 5000 events (generated from the center of the detector with a kinetic energy of 300 MeV).
  - $\sigma_{\mathrm{CX}} = 59.6$ mb.
  - stat. error $= 2.9$ mb.
    - For now, assuming I can get exact # of events with any interaction in the detector.
- These events include not only events in which the first interaction was CX, but also events in which the particle occurs CX after scattering multiple times.
  - This σ_{CX} does not mean the value that we would like to obtain.
  - I would like to identify the types of primary interaction.
    - For example, if using Sahar's method or multi-ring reconstruction, it may be possible.