Compton Scattering on He-3 With an Active Target

Bruno Strandberg

The University of Glasgow

June 17, 2015

Introduction

Measure the cross-section $\frac{d\sigma(\omega)}{d\Omega}$ of Compton scattering on He-3 with E_γ from 50 to 200 MeV:

$$\gamma + {}^3\mathrm{He} \rightarrow \gamma' + {}^3\mathrm{He}'.$$

Motivation: Access the nucleon *polarisabilities*. Polarisabilities measure the response of the nucleon to an external electromagnetic field.

Detector design

He Gas Scintillator Active Target design

$$\gamma + {}^3\mathrm{He} \rightarrow \gamma' + {}^3\mathrm{He}'.$$

The Active Target allows the detection of $\mathrm{E}_{{}^3\mathrm{He}'}$.

Ideally you then have:

- E_{γ} from photon tagger.
- $\mathrm{E}_{\gamma'}$ from detectors.
- $\mathrm{E}_{{}^3\mathrm{He}'}$ from the Active Target.

Detector design

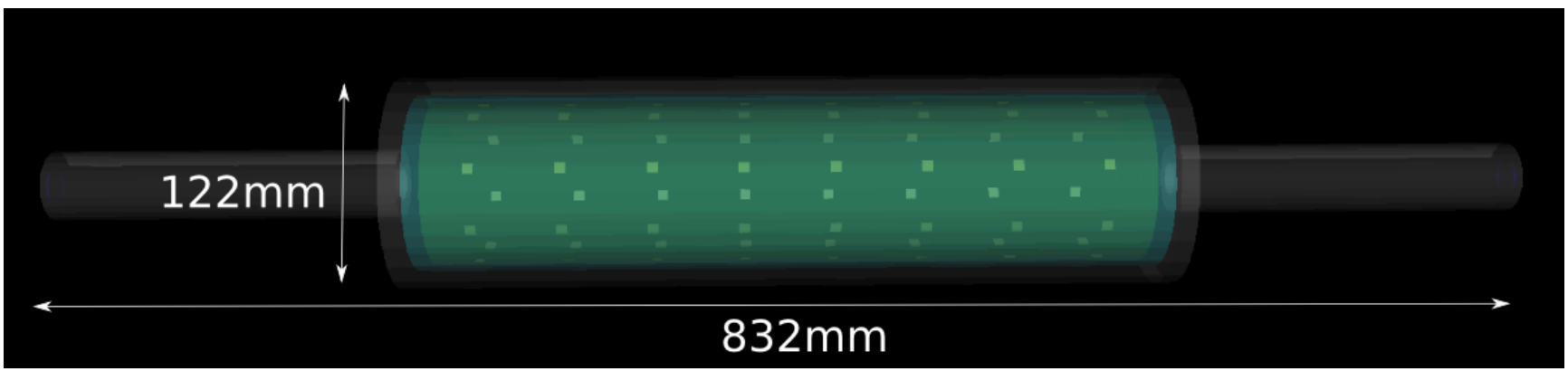
He Gas Scintillator Active Target design

$$\gamma + {}^3\mathrm{He} \rightarrow \gamma' + {}^3\mathrm{He}'.$$

The Active Target allows the detection of $\mathrm{E}_{{}^3\mathrm{He}'}$.

Ideally you then have:

- E_{γ} from photon tagger.
- $\mathrm{E}_{\gamma'}$ from detectors.
- $\mathrm{E}_{{}^3\mathrm{He}'}$ from the Active Target.



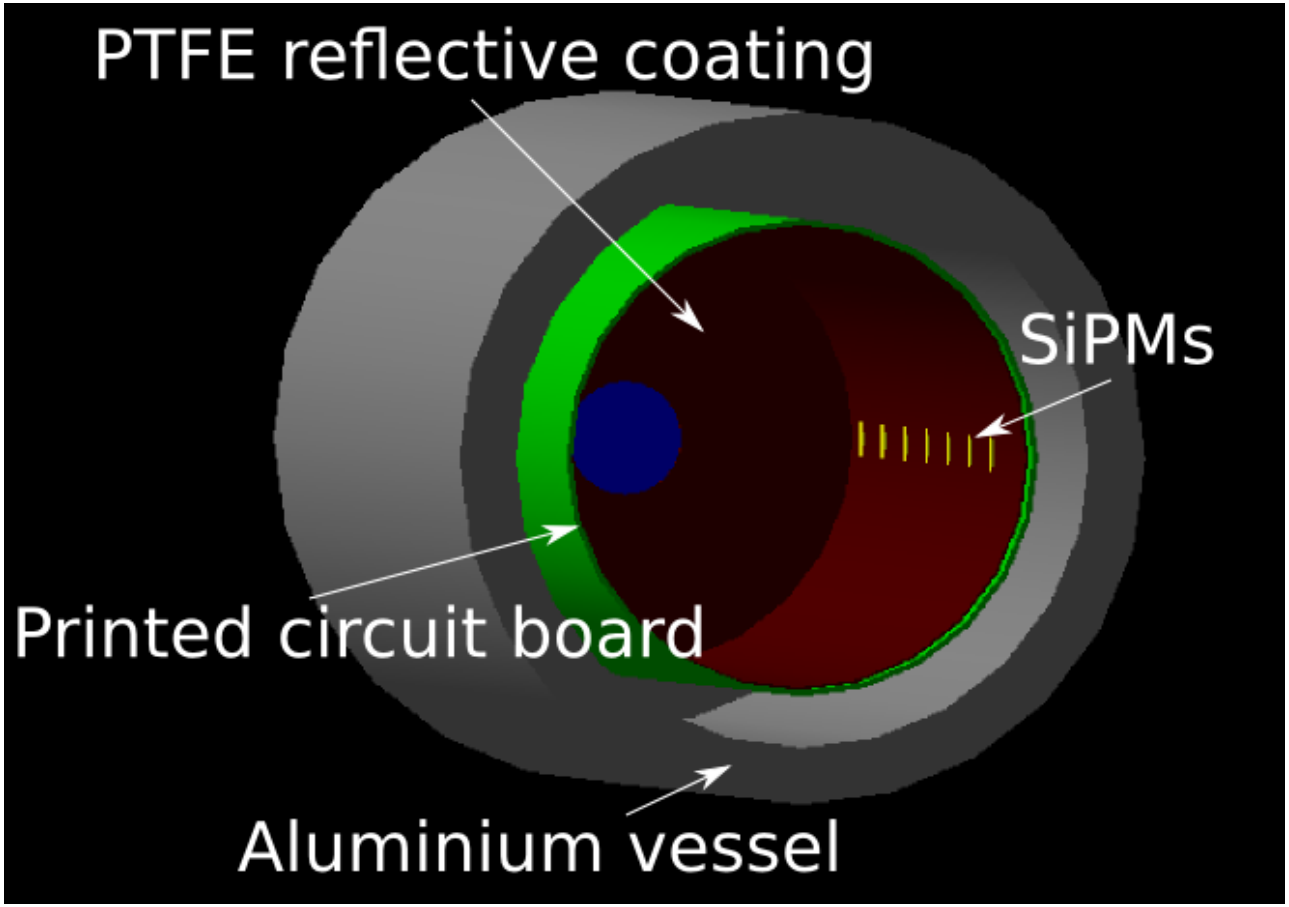


Figure : Geant4 simulation of the new active target design.

SiPM - **Si**licon **P**hoto**M**ultiplier

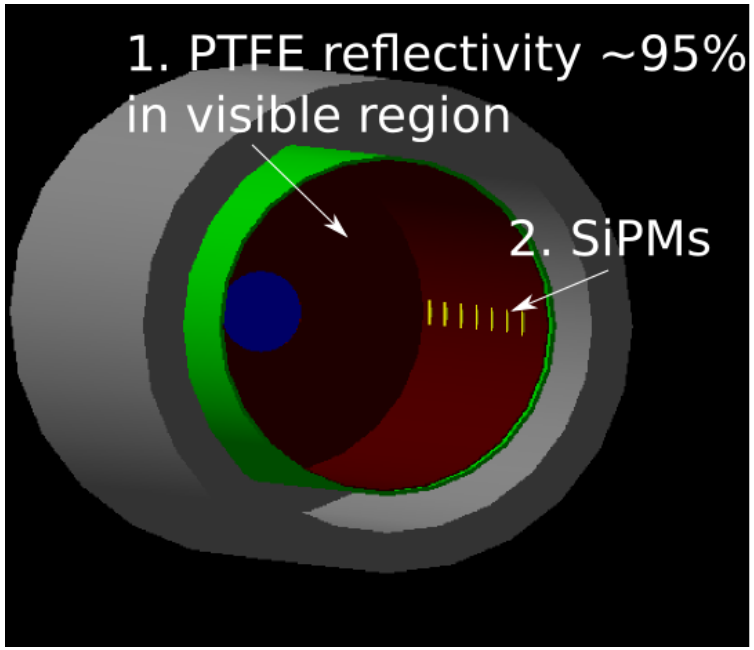
Simulations and analysis

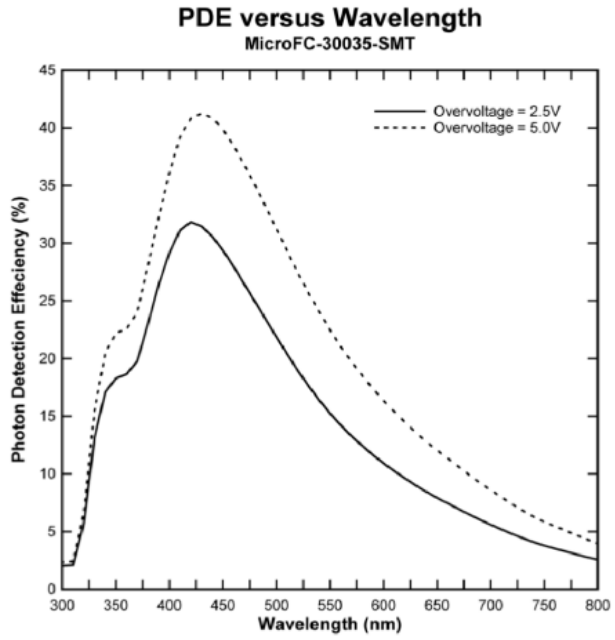
The important questions:

1. Can one detect a sufficient fraction of photons to extract energy deposition?
    1. Do SiPMs detect scintillation light in pressurised vessel? → **Test**
    2. Does the target geometry allow enough scintillation photons to be detected by the SiPMs? → **Simulate**
2. Do the He-3 atoms stop inside the gas? → **Simulate**

Question 1.2 - Does the target geometry allow enough scintillation photons to be detected by the SiPMs?

Many small details, but the main parameters in the simulation affecting photon acceptance:

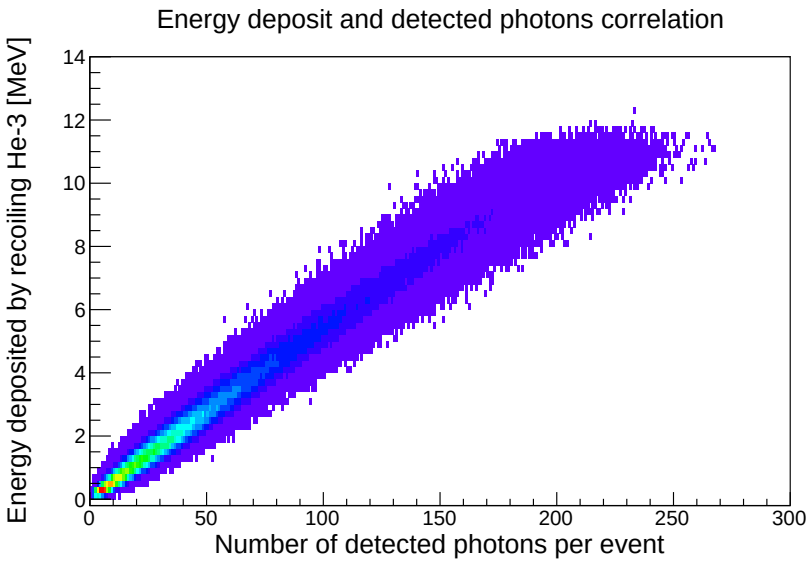


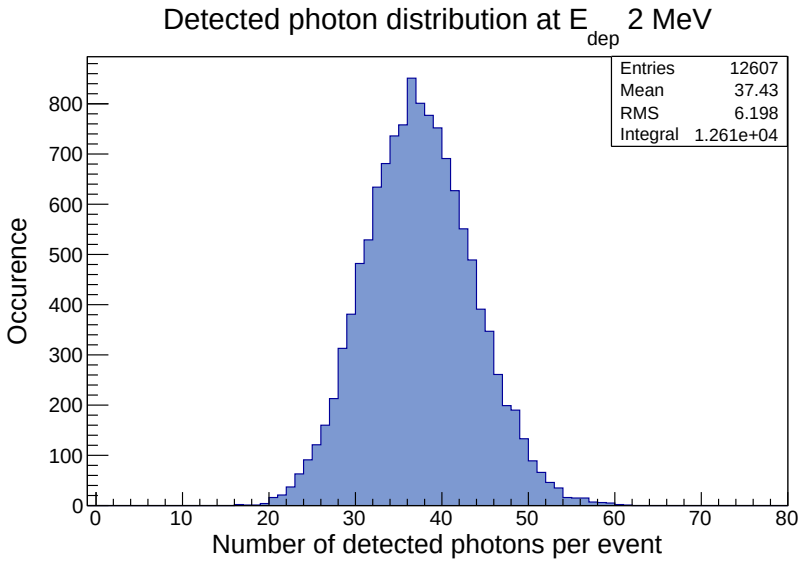


3. Scintillation yield (essential, assuming 250 phot per MeV)

Question 1.2 - Does the target geometry allow enough scintillation photons to be detected by the SiPMs?

Detection efficiency: 7.1% of photons detected.
How many scintillation photons created per event, is 7.1% detection enough for $E_{^3He'}$ extraction?



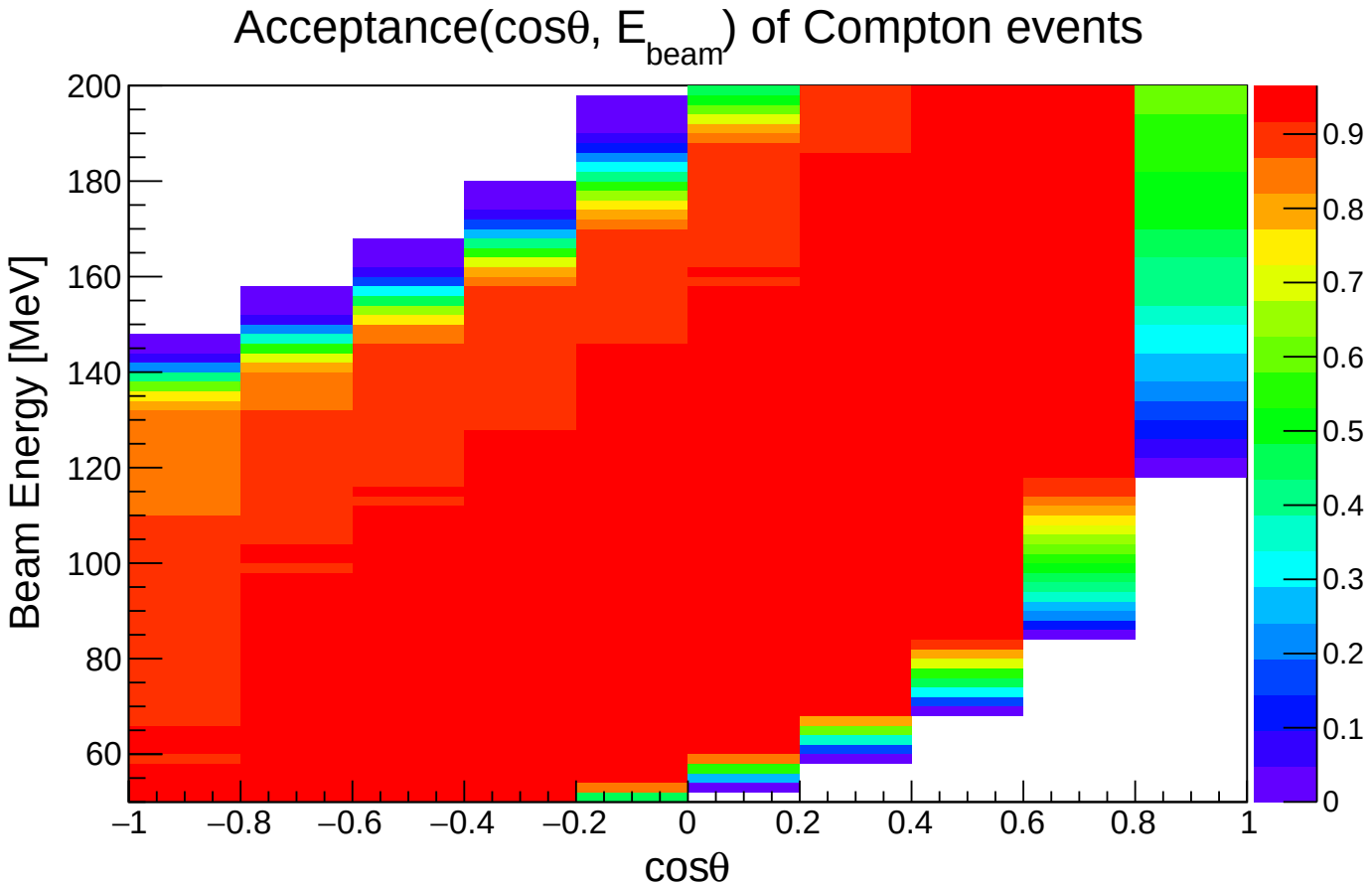


Highly dependent on scintillation yield (used 250 per MeV), needs further investigation.

Question 2 - Do the He-3 atoms stop inside the gas?

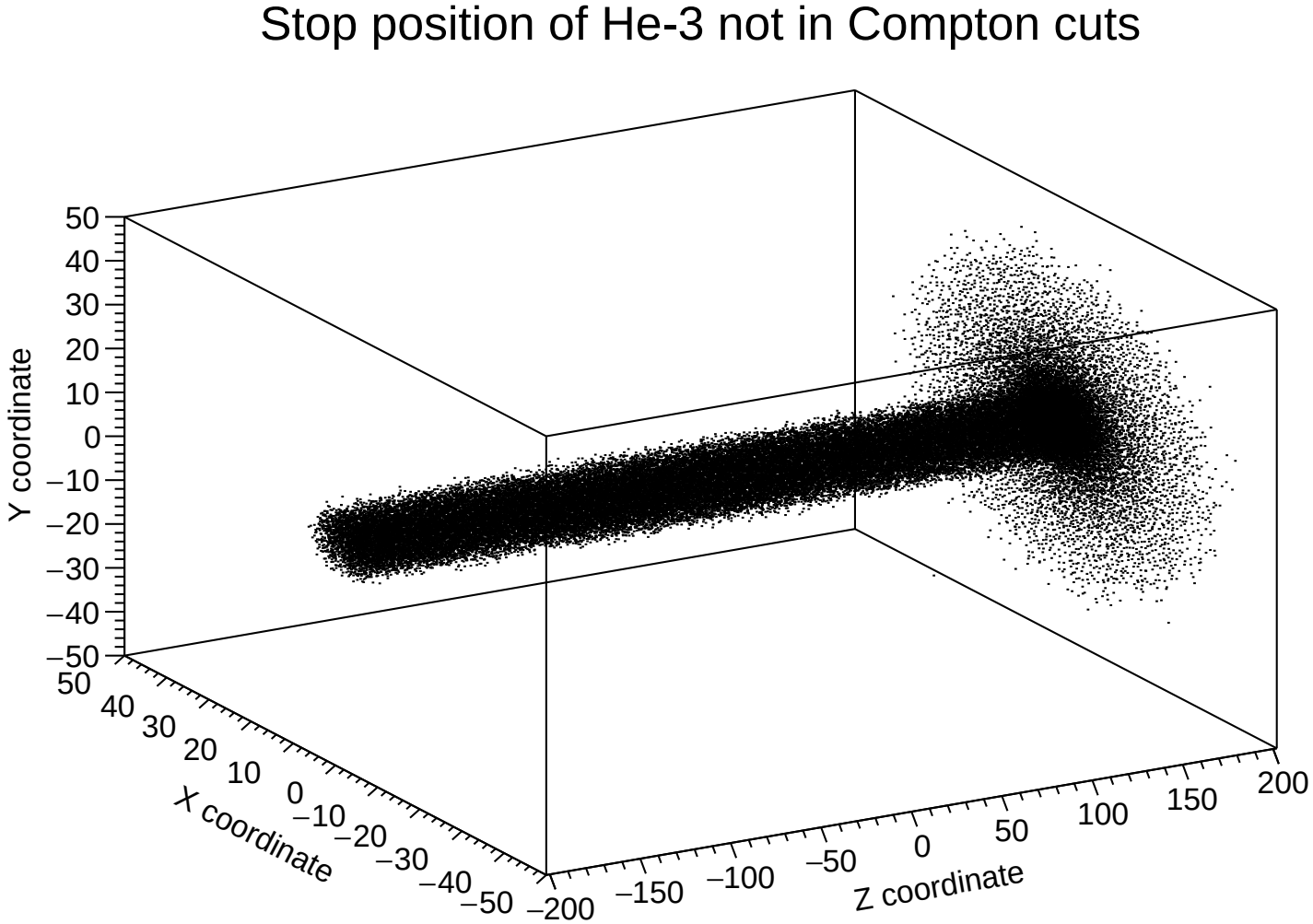
Created $5 * 10^6$ Compton events into full Z of the target, incoming E_γ from 50 to 200 MeV. Set cut values

$$|E_\gamma - E_{\gamma'} - E_{\mathrm{He3'}}| <= 1\,\mathrm{MeV} \quad \text{and} \quad \mathrm{E}_{\mathrm{He3'}} >= 1\,\mathrm{MeV}$$



Question 2 - Do the He-3 atoms stop inside the gas?

Stop position of He-3 atoms for events not inside Compton cuts.



Status and summary

The important questions:

1. Can one detect a sufficient fraction of photons to extract energy deposition?
    1. Do SiPMs detect scintillation light in pressurised vessel? $\rightarrow$ **See a signal, need to determine noise.**
    2. Does the target geometry allow enough scintillation photons to be detected by the SiPMs? $\rightarrow$ **Simulations $\rightarrow$ about 7.1% detected. Dependent on SiPM noise performance, but seems to suggest the design is feasible.**
2. Do the He-3 atoms stop inside the gas? $\rightarrow$ **According to simulations stop reasonably well below E_γ 200MeV. Strongly dependent on gas pressure.**

Where to go from here:

- Thorough study of SiPMs noise.
- Build the Active Target.
- After simulation is calibrated against the built Active Target, more precise studies with other apparatus included + background channels.

Thank you for your attention!