Shield simulation for 10 kg detector: muon-induced background

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Summary

- Simulation set up
- Muon angular and energy spectra
- Topological study
- Results

Simulation set up

NIT thickness = 50 μm
Density of NIT emulsion = 3.43 $g\ cm^{-3}$
1 layer (36x30 cm^2 x 50 μm) NIT mass = 18,522 g
N (layers to have 10 kg target) = 540
Base thickness = 1 mm

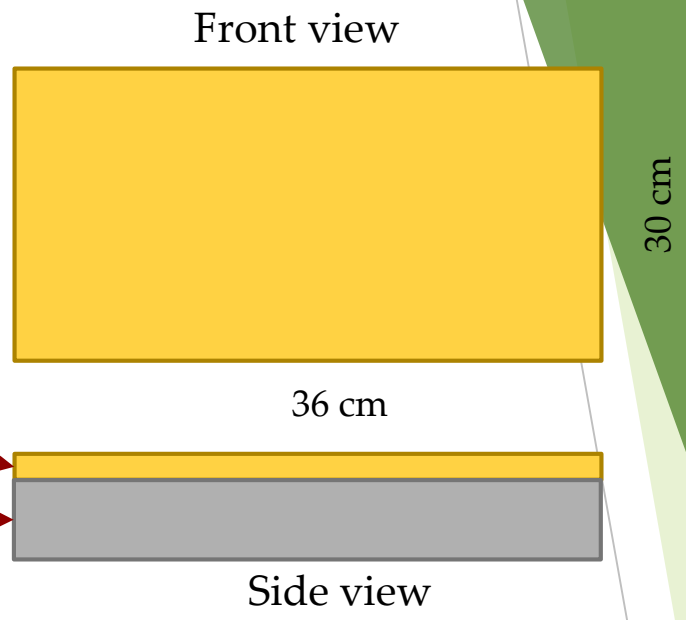
Total height of detector composed by 540 one side coated layer:

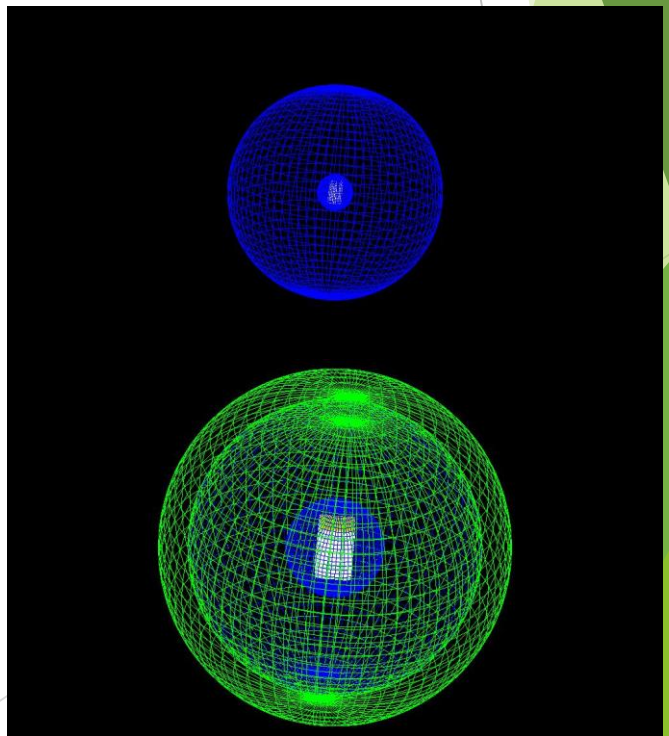
h = 540x0,105cm = 56,7 cm

Detector placed in the origin of the simulated world

Shape of simulated shield: spherical

Inner radius fixed at 50 cm

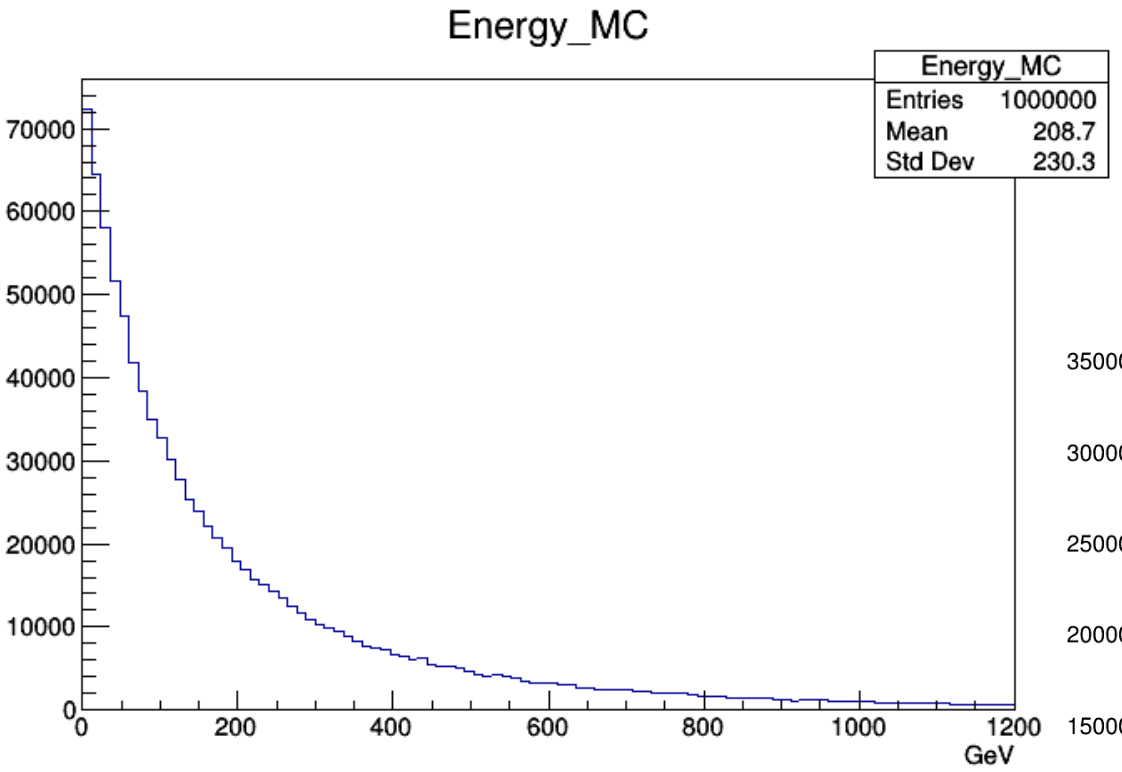


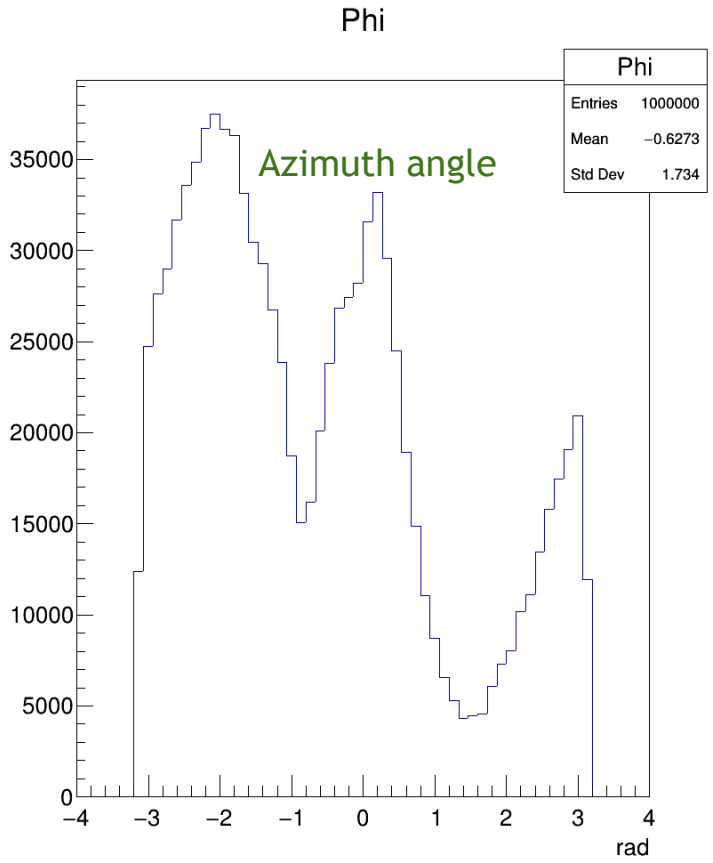


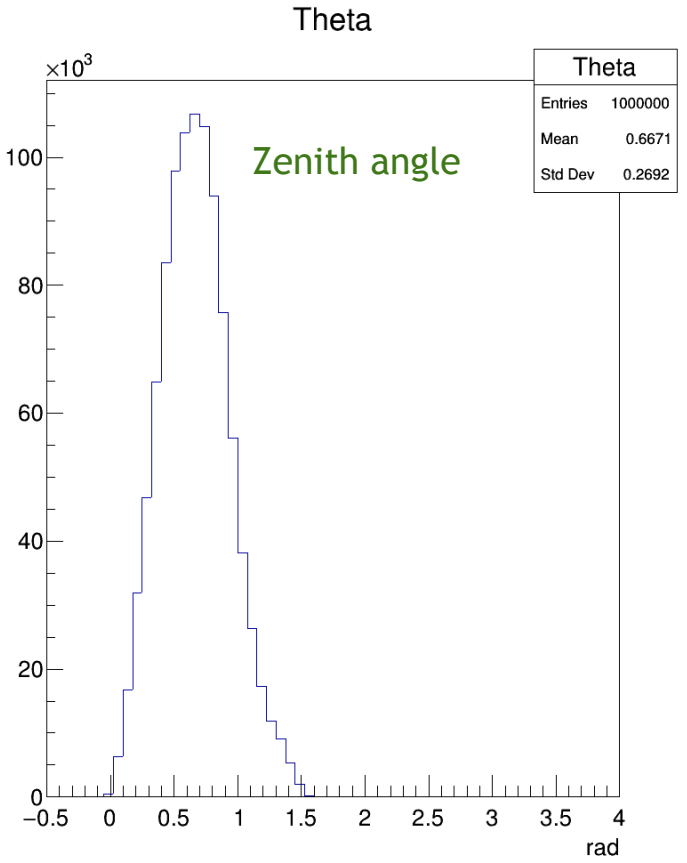
Simulation set up

Muon flux characterization

Flux of muons at LNGS = $(1.1592 \pm 0.029)\ m^{-2}\ h^{-1}$







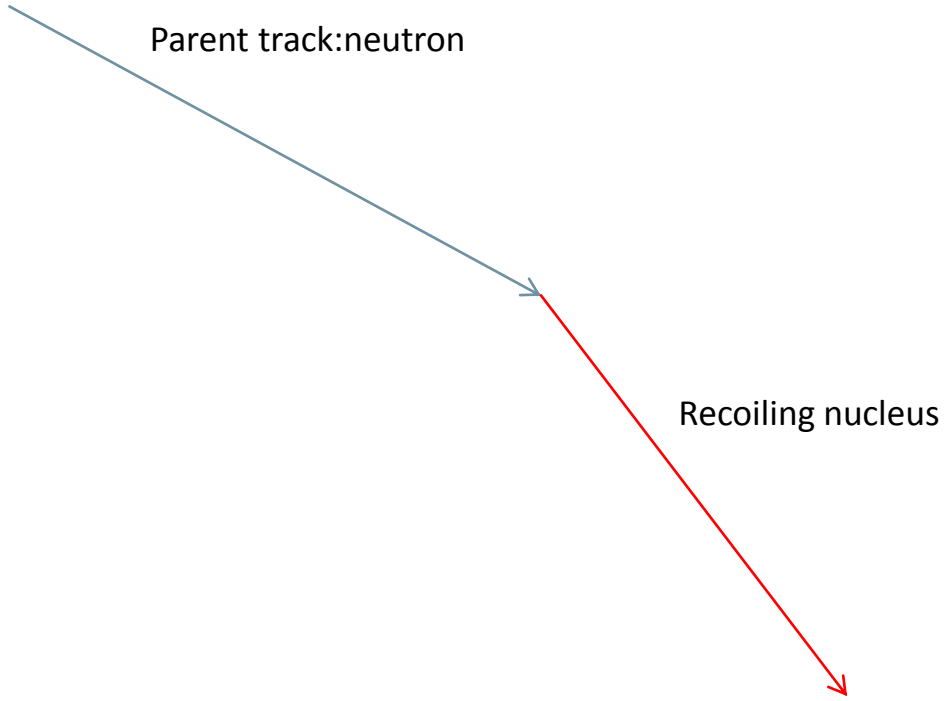
Generator of cosmic muons in Gran Sasso mountain: MUSUN from A. Kudraizev

Topological study

A study of event topology was performed in order to have a complete picture of interaction and distinguish different categories:

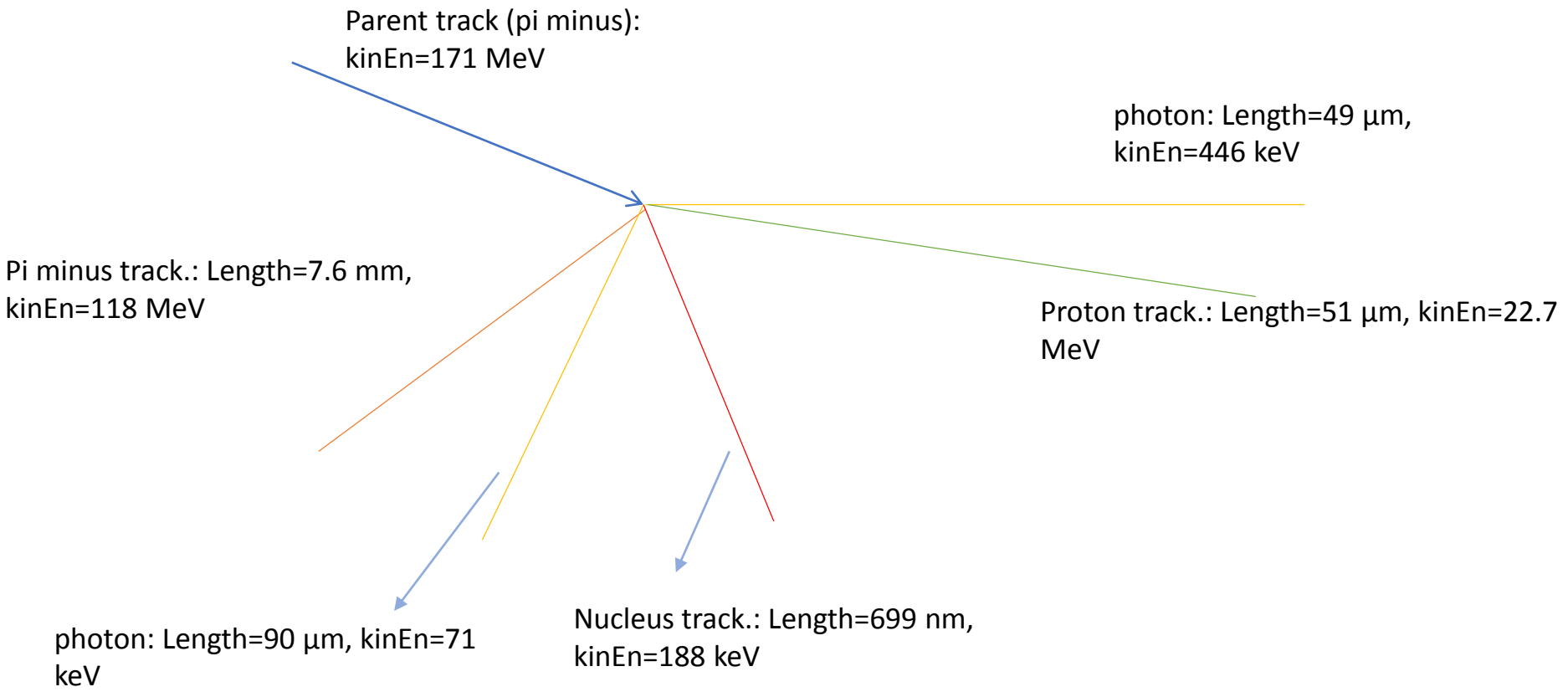
- Elastic scattering
- Neutron Inelastic scattering
- Pion inelastic scattering
- Muon Coulomb scattering
- Neutron Capture

Topological study:
Elastic scattering



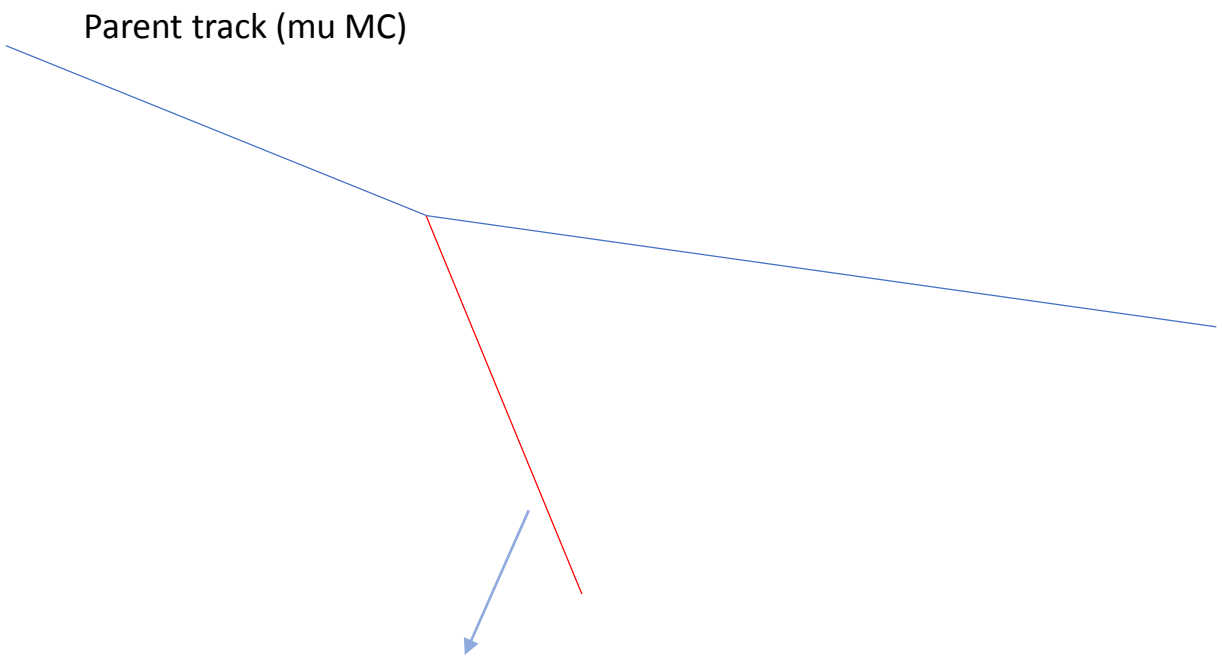
Inelastic scattering of pion

creatorId==17 (pi minus Inelastic)



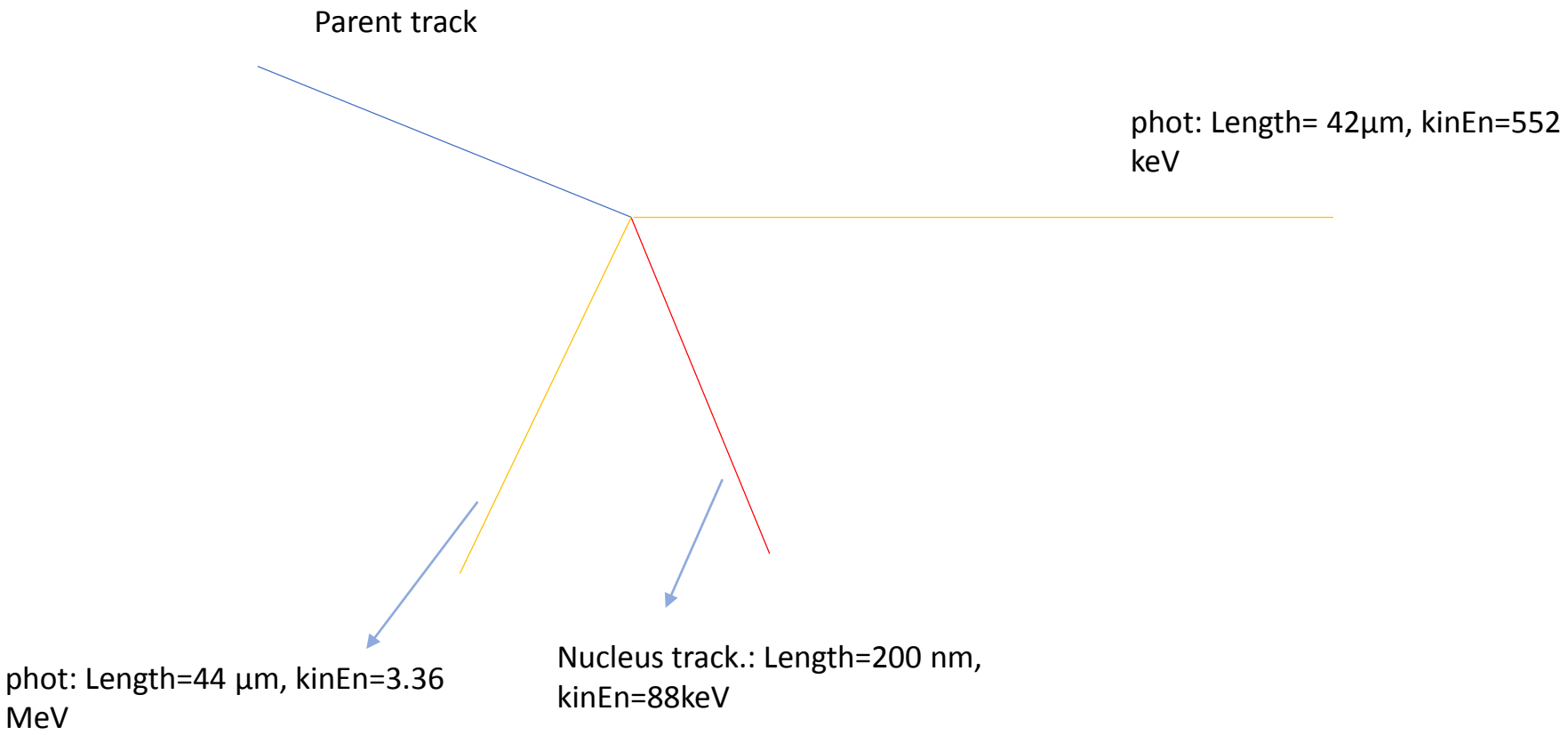
Muon coulom scattering

creatorId==20 (Coulomb scattering)



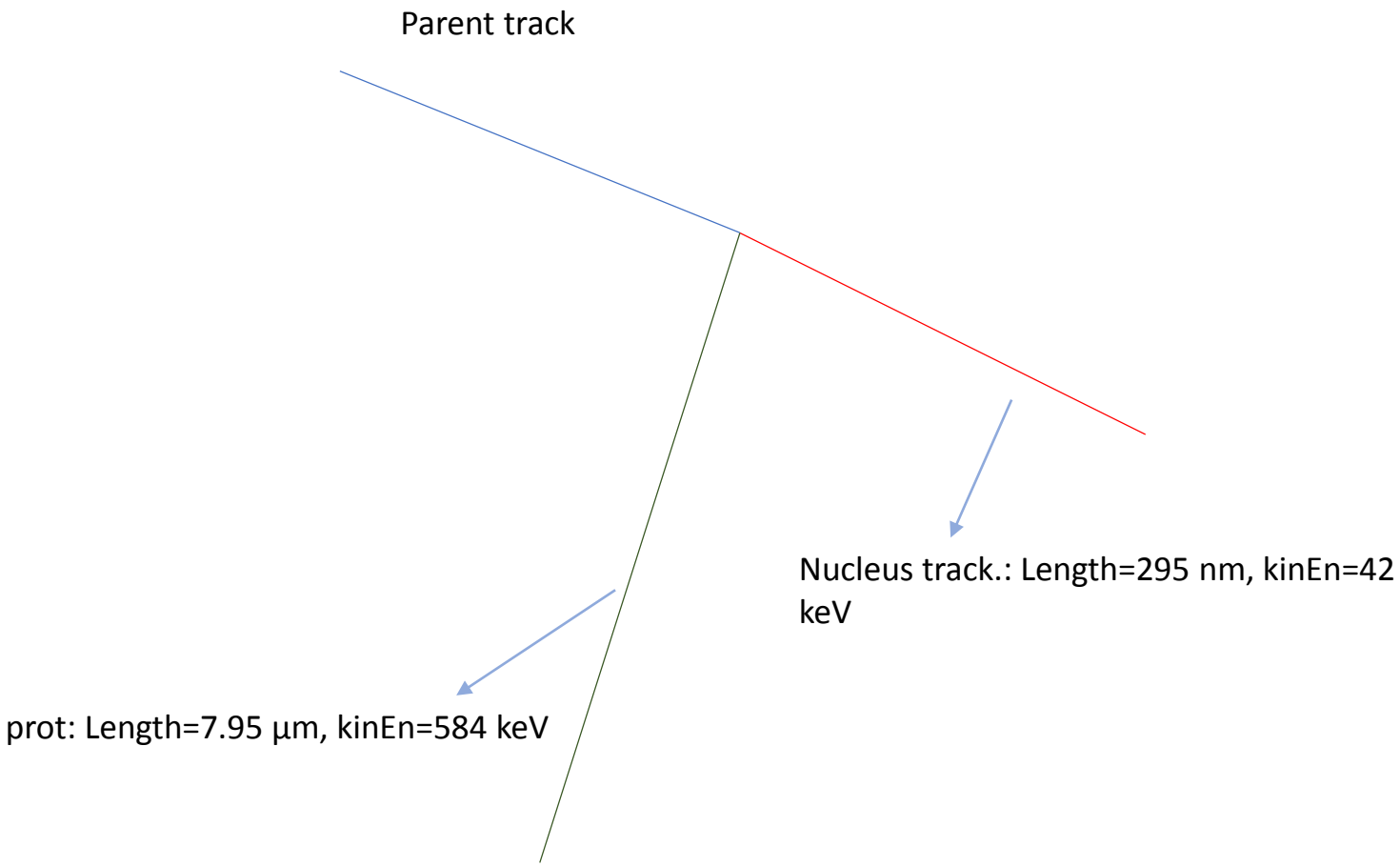
Neutron Inelastic scattering

creatorId==10 (neutronInelastic)



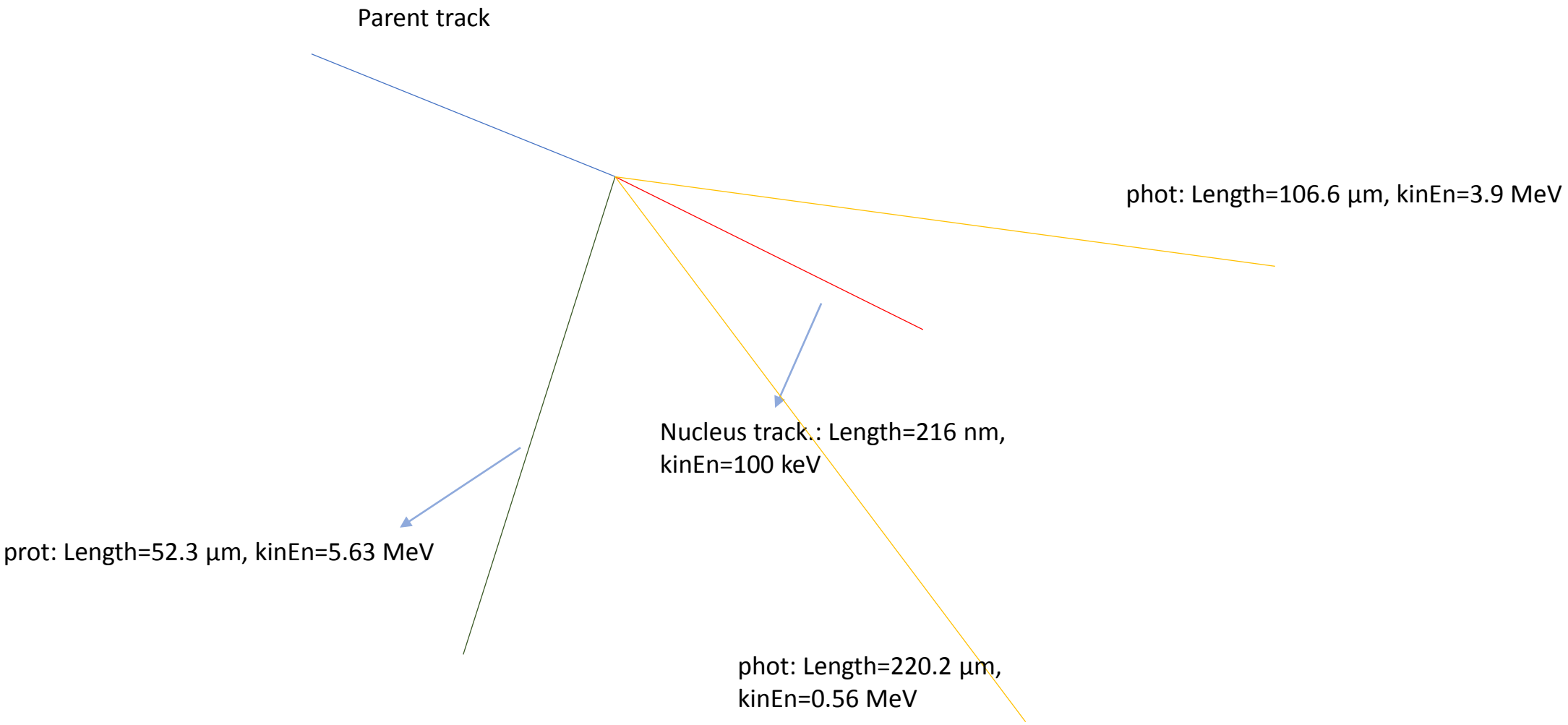
Neutron Inelastic scattering

creatorId==10 (nInelastic)



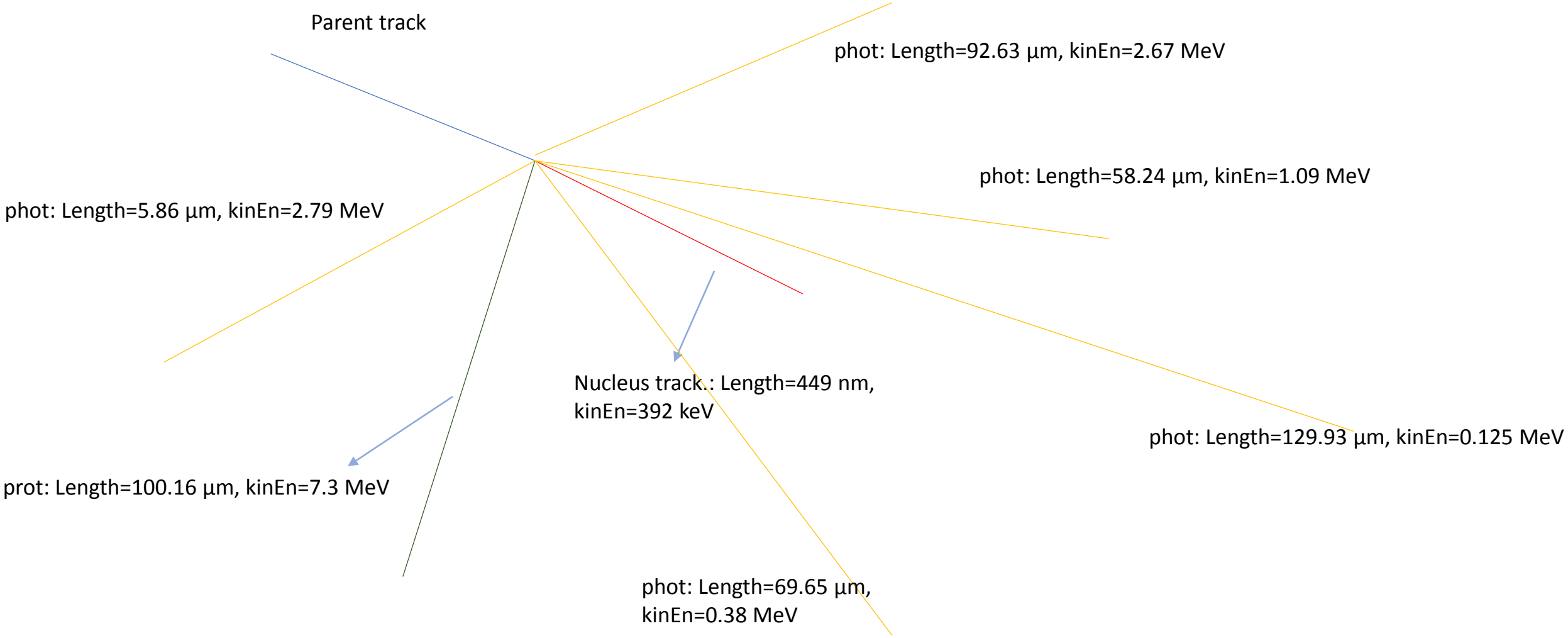
Neutron Inelastic scattering

creatorId==10 (nInelastic)



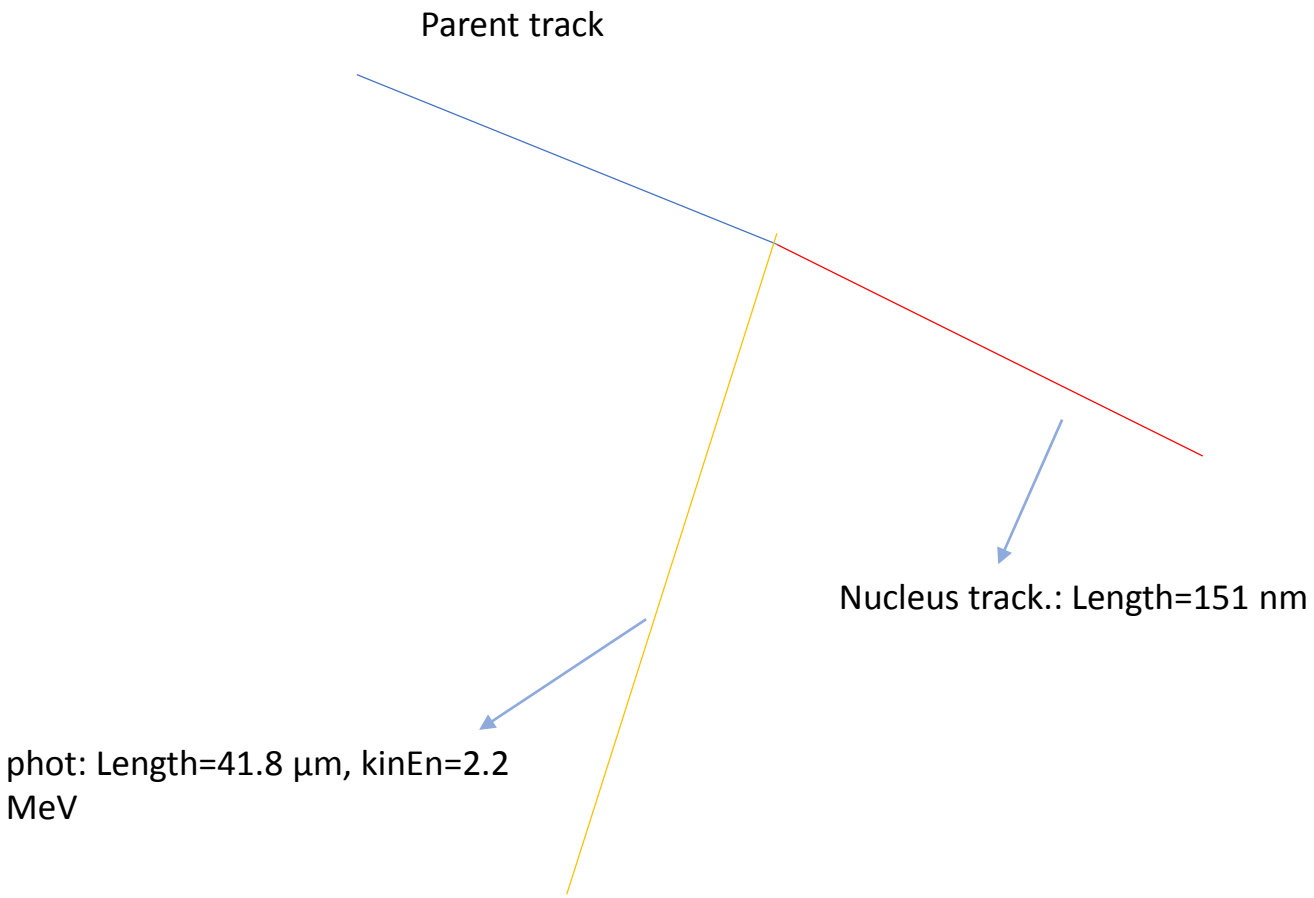
Neutron Inelastic scattering

creatorId==10 (nInelastic)



Neutron Capture

creatorId==15 (nCapture)

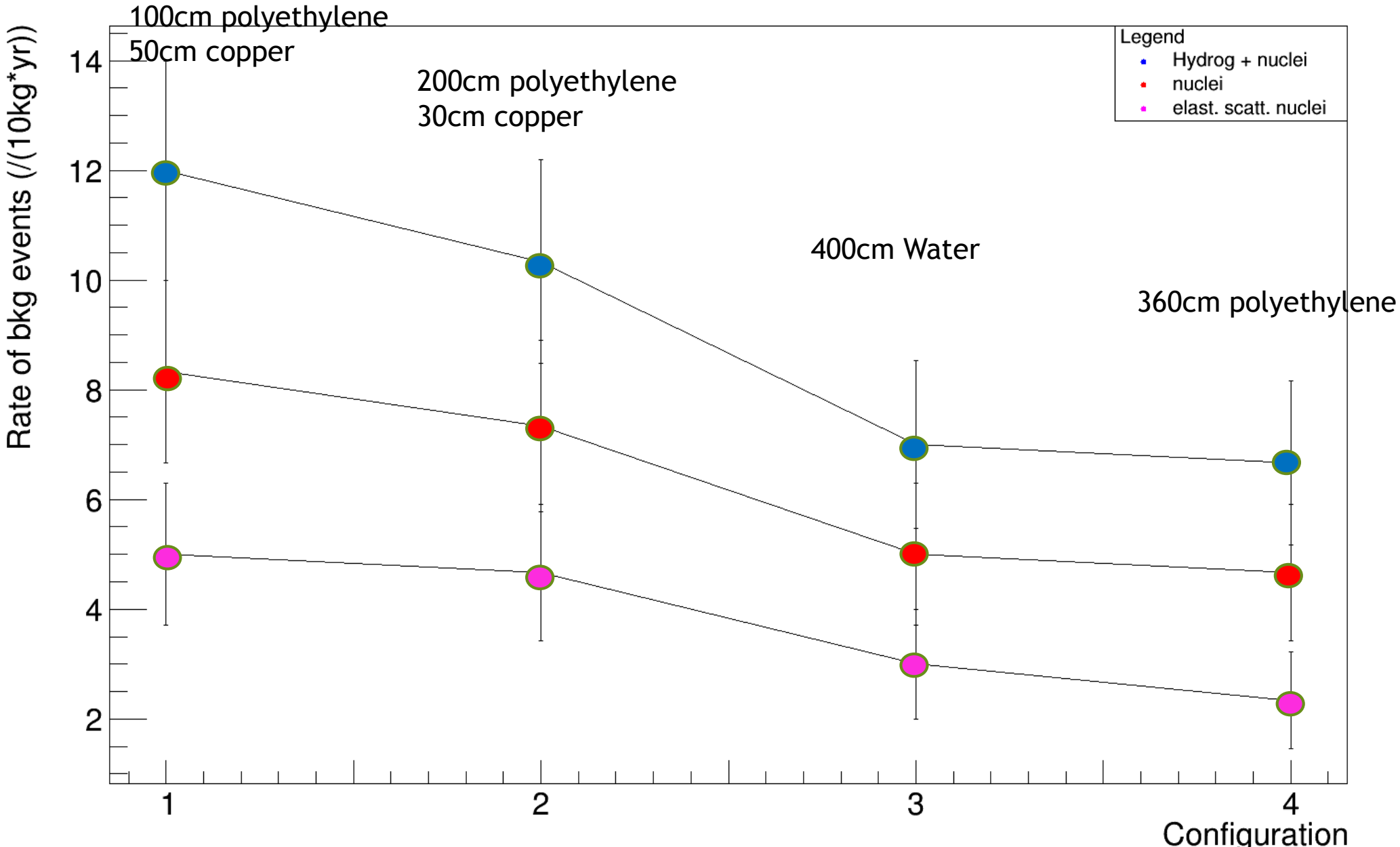


Background event selection

- 100 nm <= Track length <= 1000 nm
- Nuclear recoils fully contained in emulsion
- Selection 1: all nuclear recoils considered
- Selection 2: protons not considered
- Selection 3: protons not considered and elastic scattering only

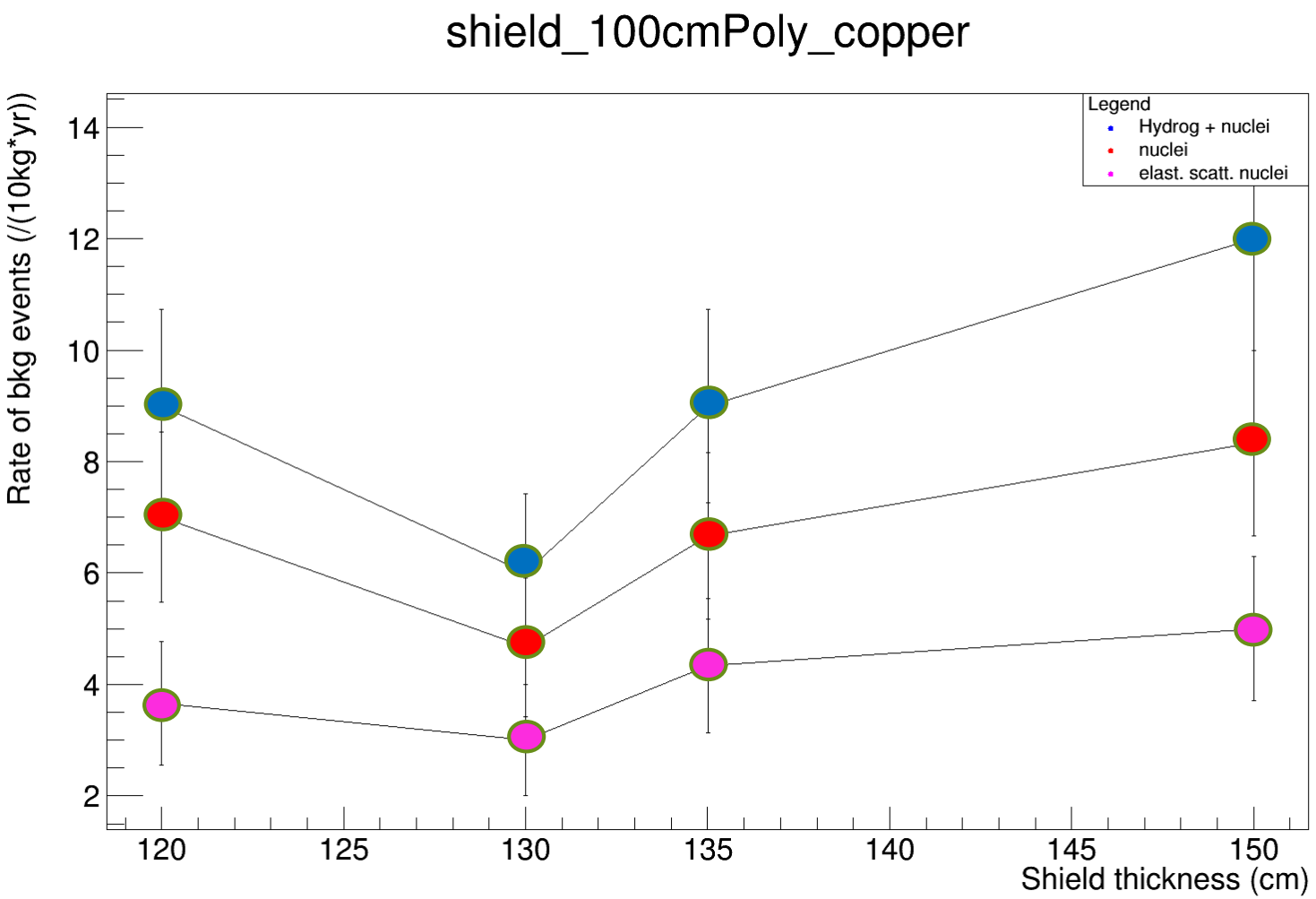
Results

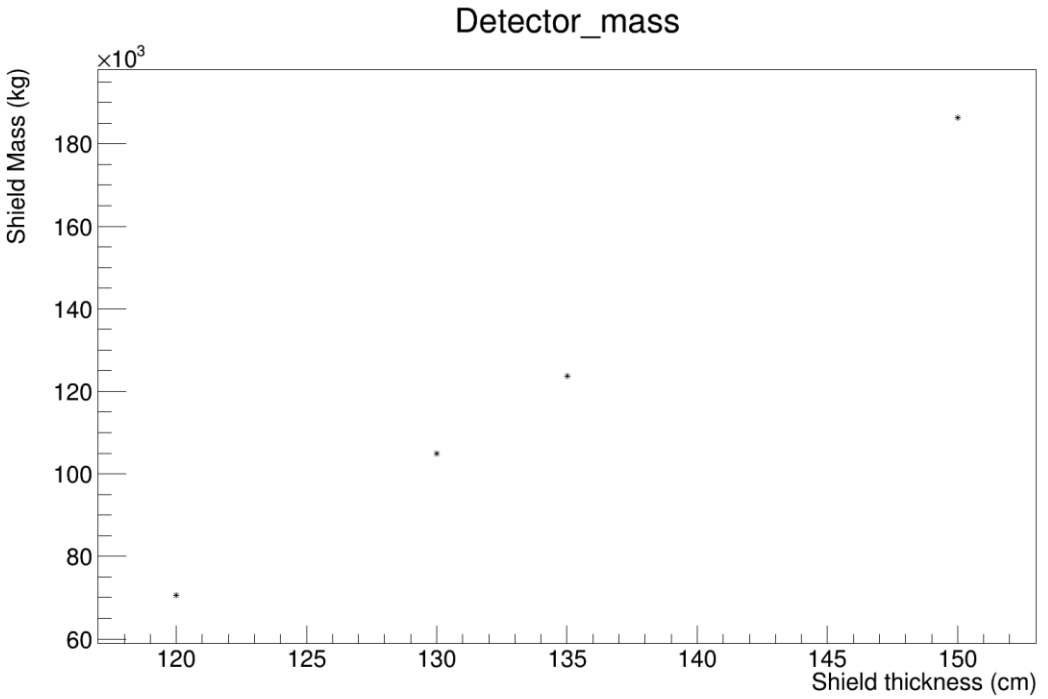
All considered configurations give cosmogenic neutron background <= 0.2 n/(10kg*yr)



Results

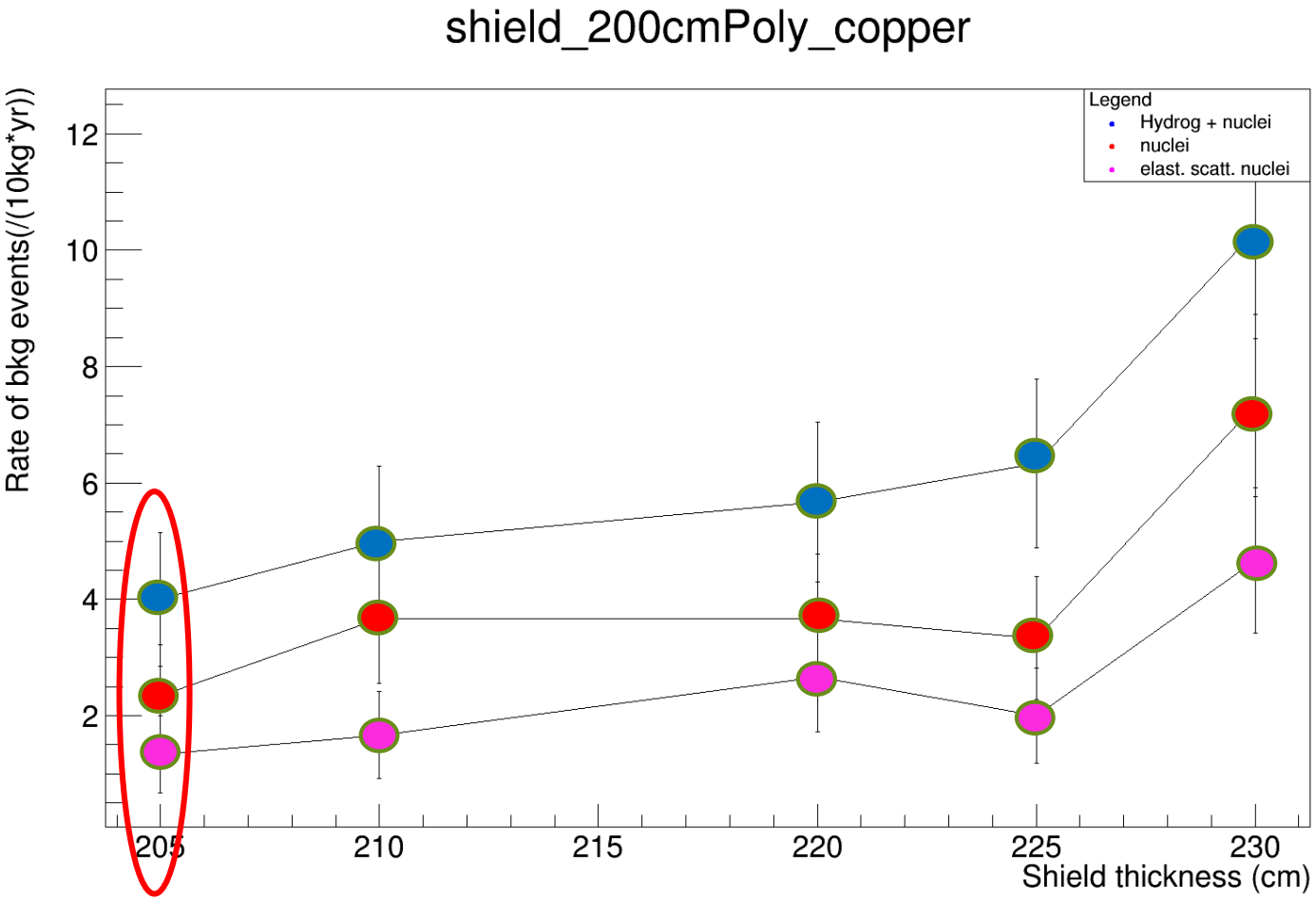
Shielding structure: 100cm polyethylene + x cm copper

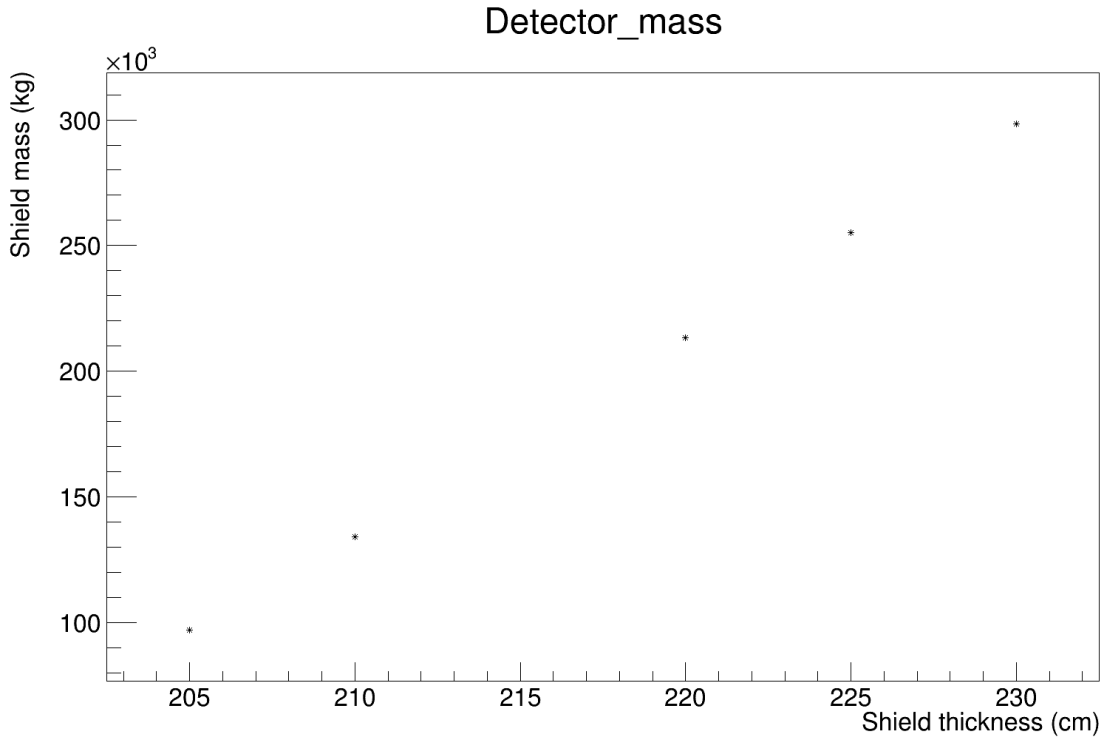




Results

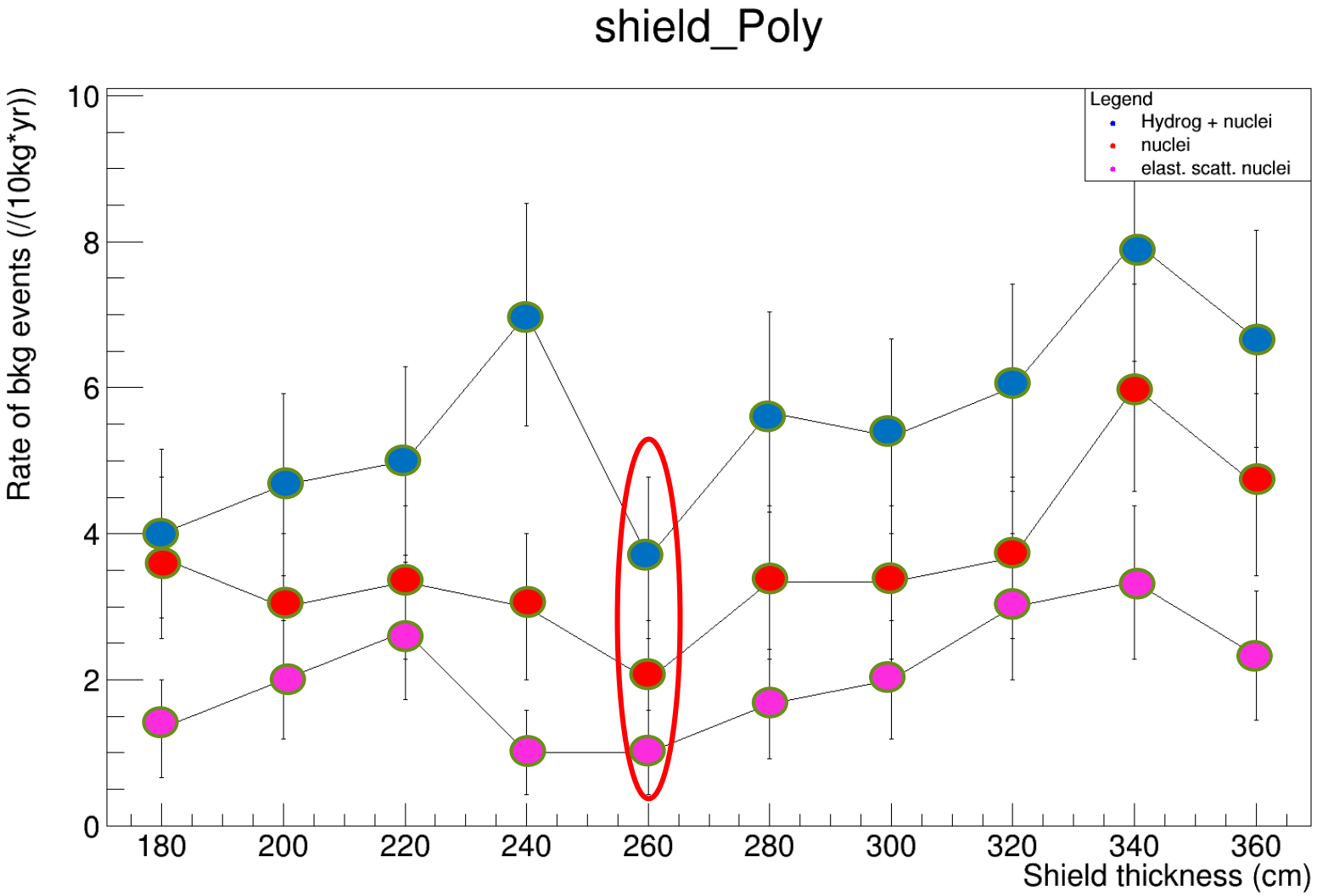
Shielding structure: 200 cm polyethylene x cm copper

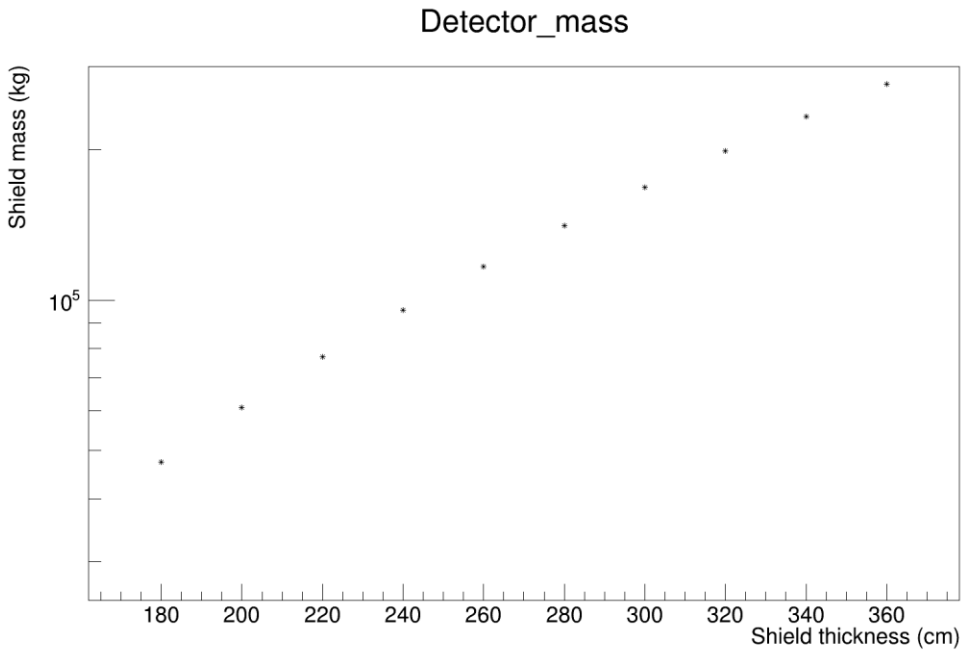




Results

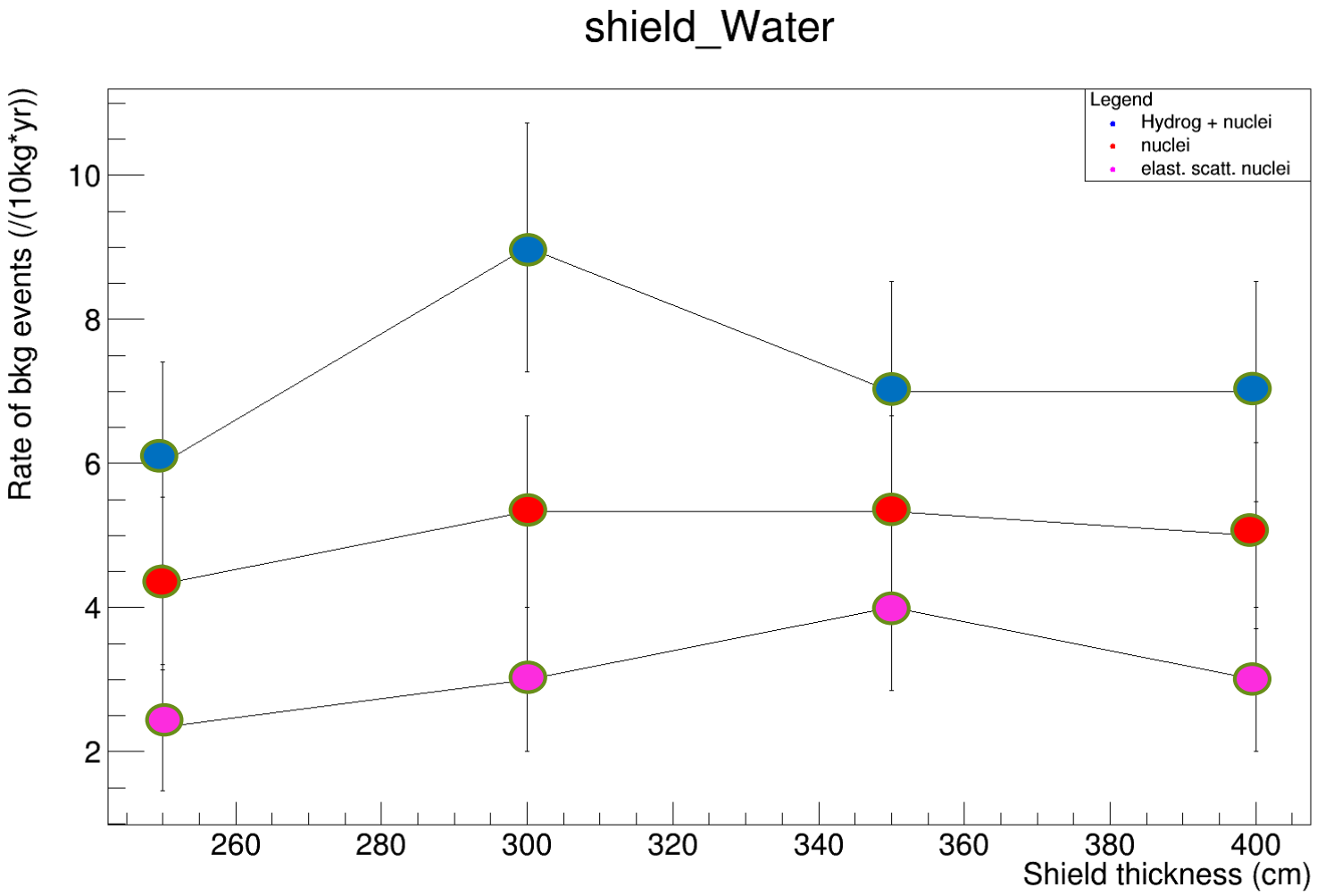
Shielding structure: x cm polyethylene

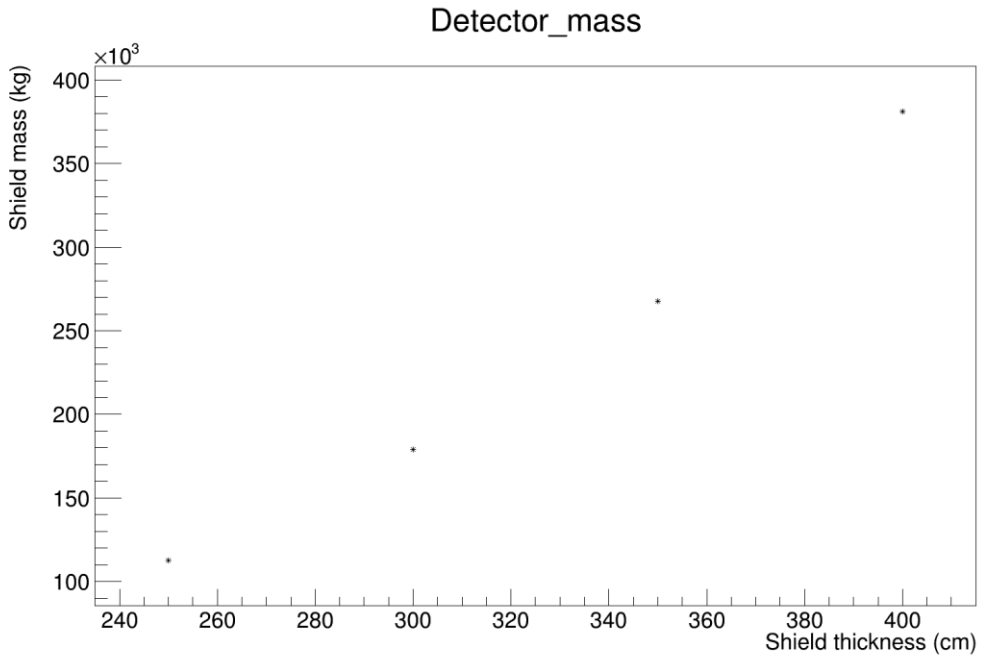




Results

Shielding structure: x cm Water





Conclusions

- Muon-induced recoils constitute the most dangerous background source since emulsions don't have timing information.

- Two configurations have been identfied as the most effective for muon-induced background:
  - 260 cm plyethilene
  - 200 cm polyethylen + 5 cm copper

- Muon induced background ≈ 1.5 event/(10kg*yr)