

# 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 =  $50 \mu\text{m}$

Density of NIT emulsion =  $3.43 \text{ g cm}^{-3}$

1 layer ( $36 \times 30 \text{ cm}^2 \times 50 \mu\text{m}$ ) NIT mass =  $18,522 \text{ g}$

N (layers to have 10 kg target) = 540

Base thickness =  $1 \text{ mm}$

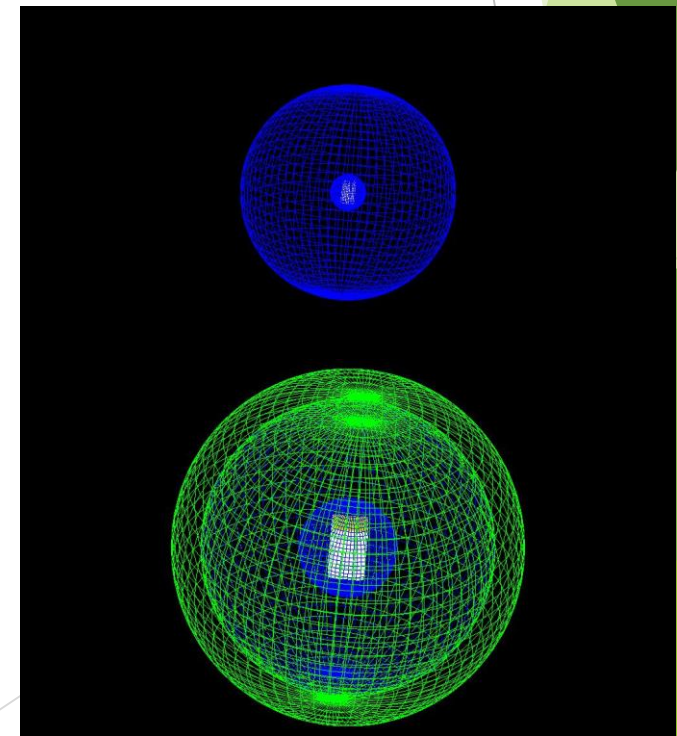
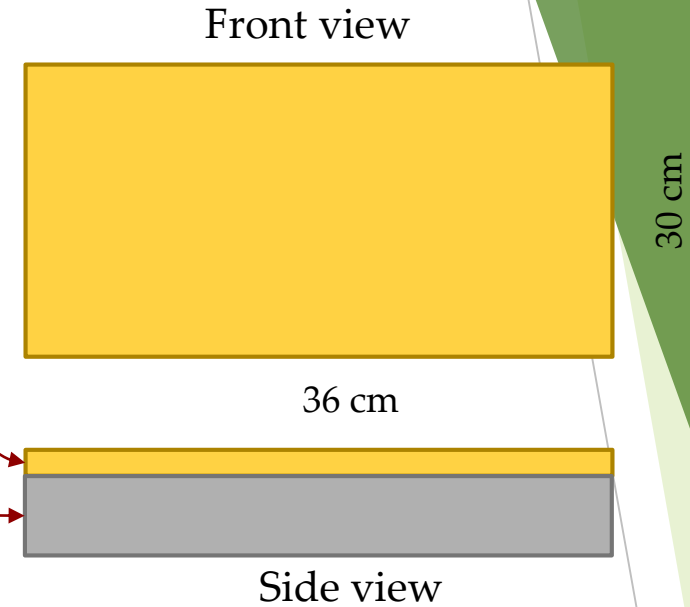
Total height of detector composed by 540 one side coated layer:

$$h = 540 \times 0,105 \text{ cm} = 56,7 \text{ cm}$$

Detector placed in the origin of the simulated world

Shape of simulated shield: spherical

Inner radius fixed at  $50 \text{ cm}$



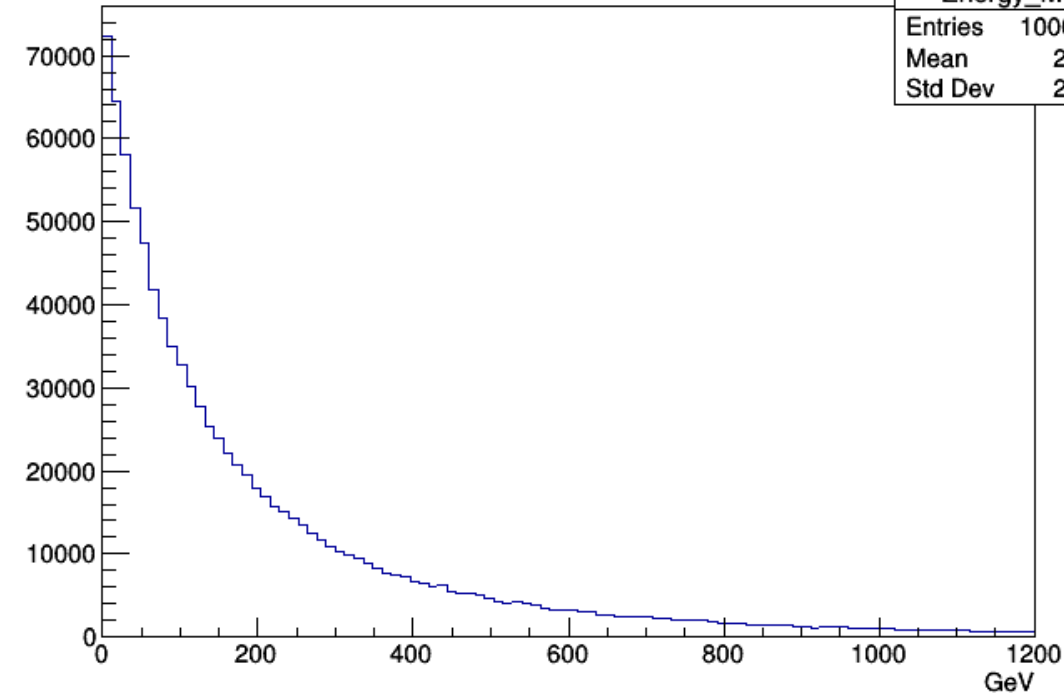
# Simulation set up

## Muon flux characterization

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

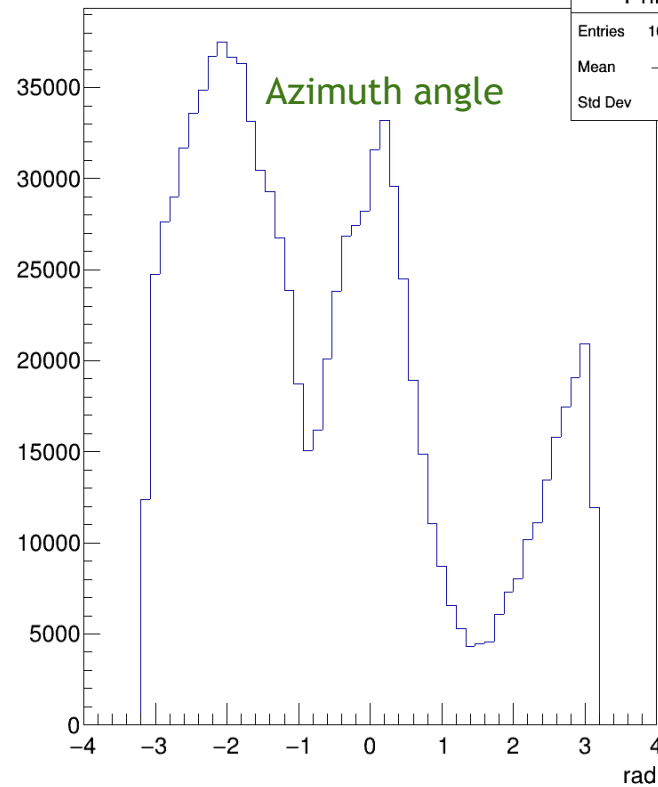
Energy\_MC

Energy_MC	
Entries	1000000
Mean	208.7
Std Dev	230.3



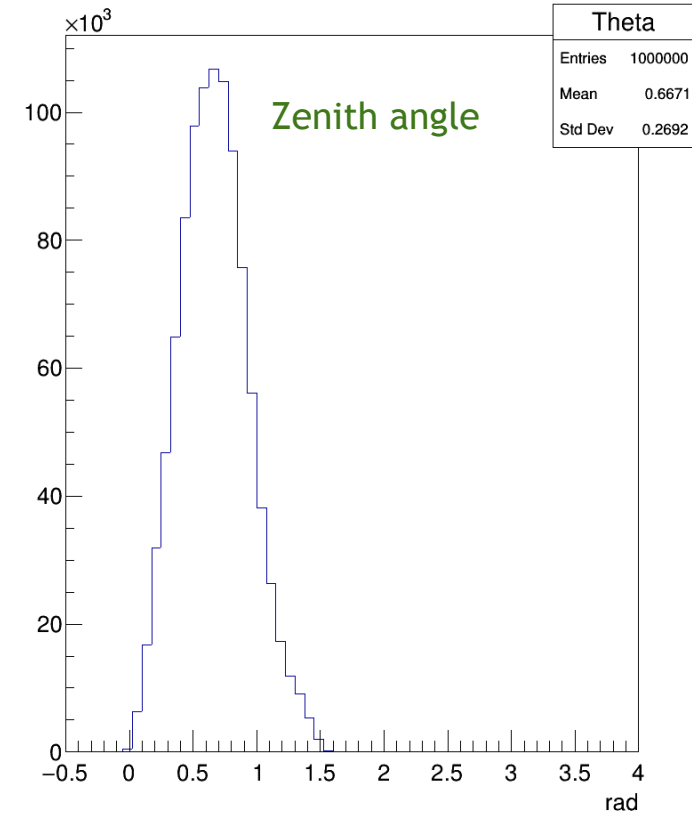
Phi

Phi	
Entries	1000000
Mean	-0.6273
Std Dev	1.734



Theta

Theta	
Entries	1000000
Mean	0.6671
Std Dev	0.2692



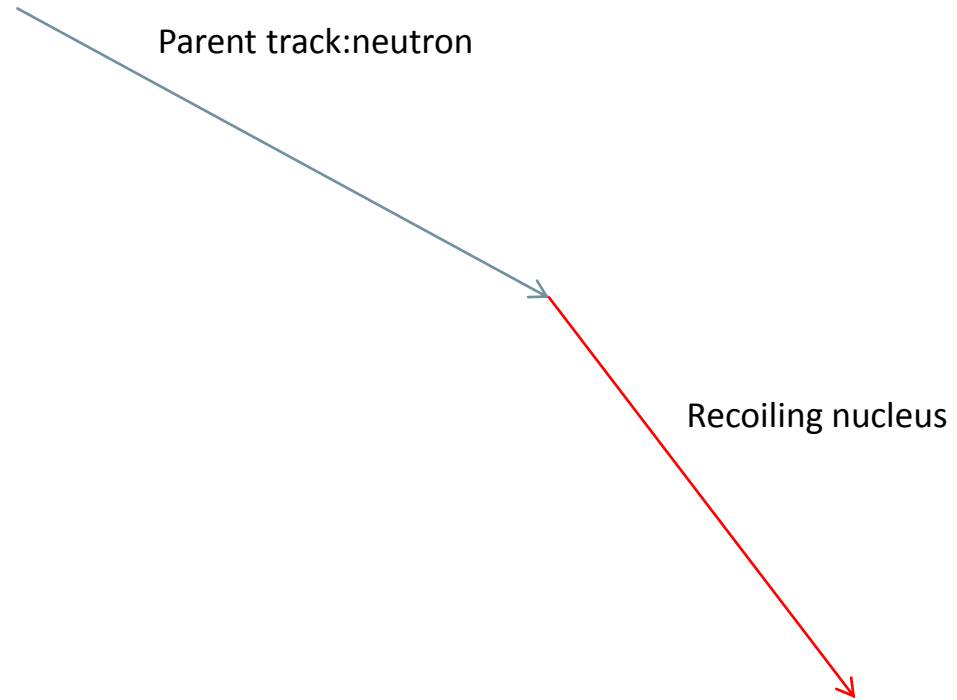
Generator of cosmic muons in Gran Sasso mountain: MUSUN from A. Kudraizev

# Topological study

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

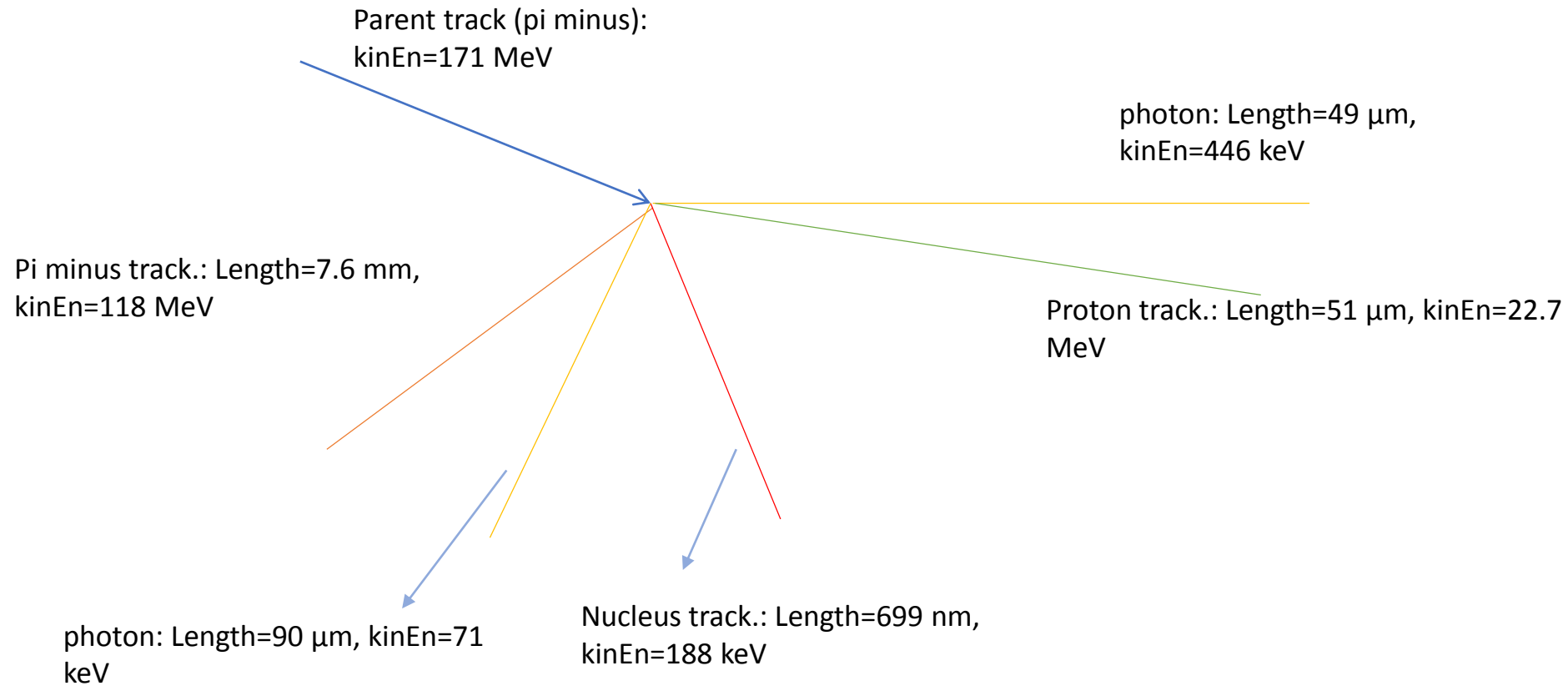
- Elastic scattering
- Neutron Inelastic scattering
- Pion inelastic scattering
- Muon Coulomb scattering
- Neutron Capture

# Topological study: Elastic scattering



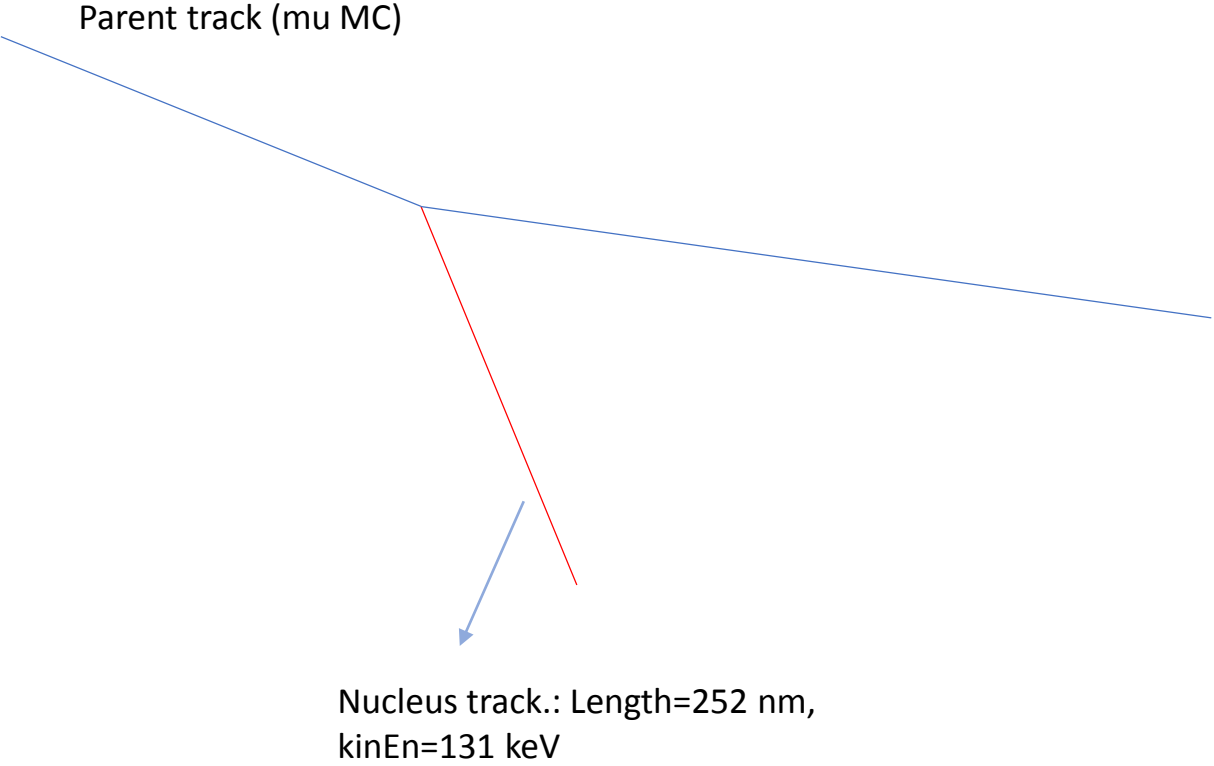
# Inelastic scattering of pion

creatorId==17 (pi minus Inelastic)



# Muon coulomb scattering

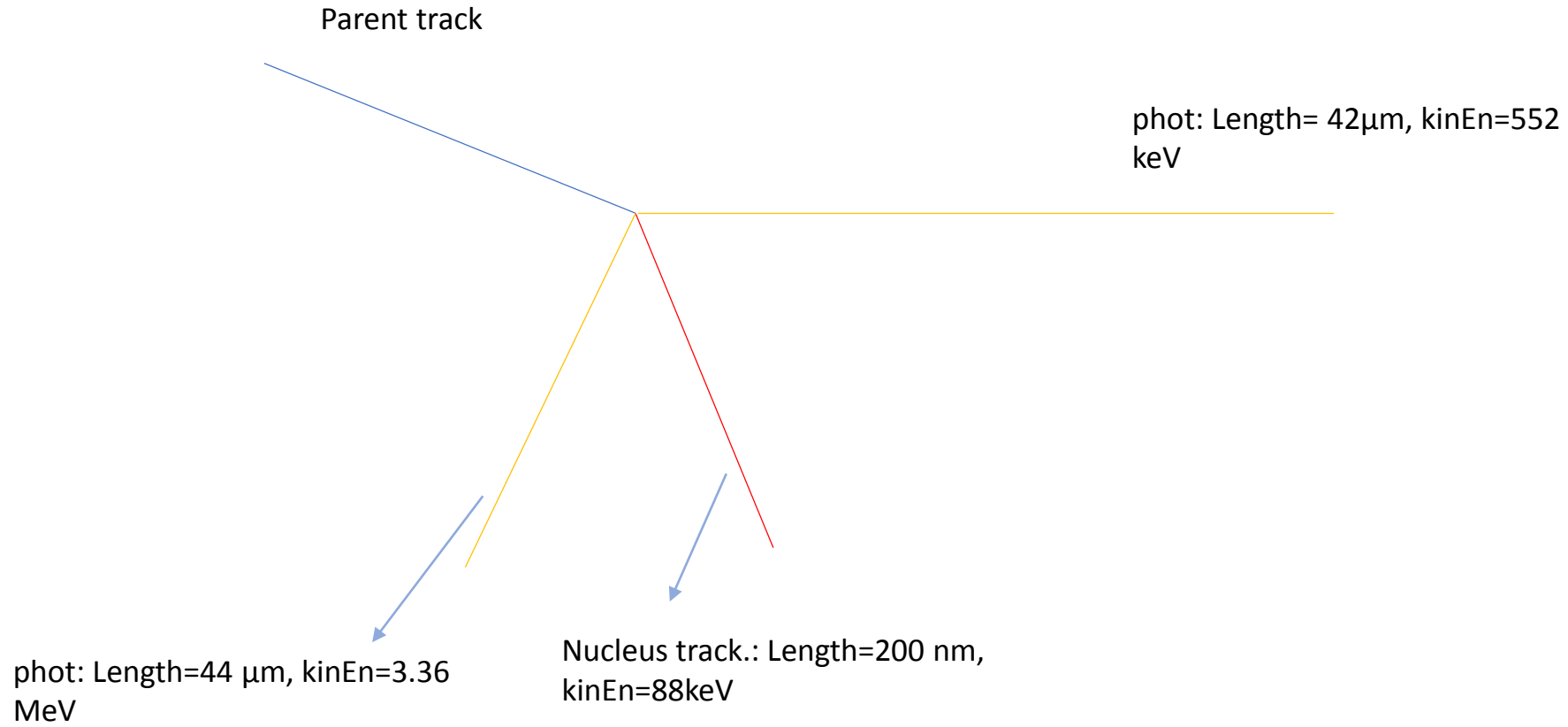
creatorId==20 (Coulomb scattering)





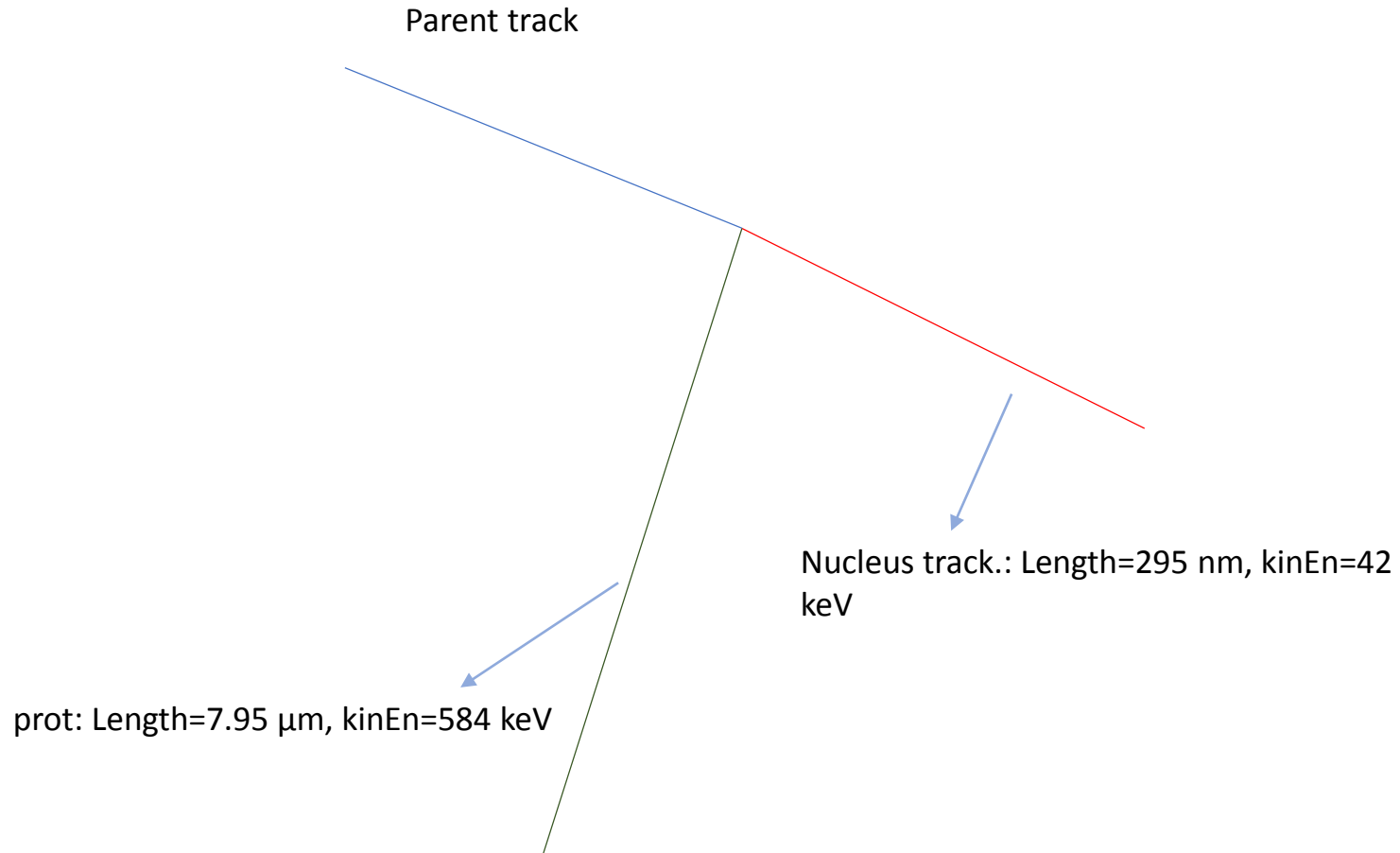
# Neutron Inelastic scattering

creatorId==10 (neutronInelastic)



# Neutron Inelastic scattering

creatorId==10 (nInelastic)



# Neutron Inelastic scattering

creatorId==10 (nInelastic)

Parent track

phot: Length=106.6  $\mu\text{m}$ , kinEn=3.9 MeV

Nucleus track.: Length=216 nm,  
kinEn=100 keV

prot: Length=52.3  $\mu\text{m}$ , kinEn=5.63 MeV

phot: Length=220.2  $\mu\text{m}$ ,  
kinEn=0.56 MeV

# Neutron Inelastic scattering

creatorId==10 (nInelastic)

Parent track

phot: Length=92.63  $\mu\text{m}$ , kinEn=2.67 MeV

phot: Length=58.24  $\mu\text{m}$ , kinEn=1.09 MeV

phot: Length=129.93  $\mu\text{m}$ , kinEn=0.125 MeV

Nucleus track.: Length=449 nm,  
kinEn=392 keV

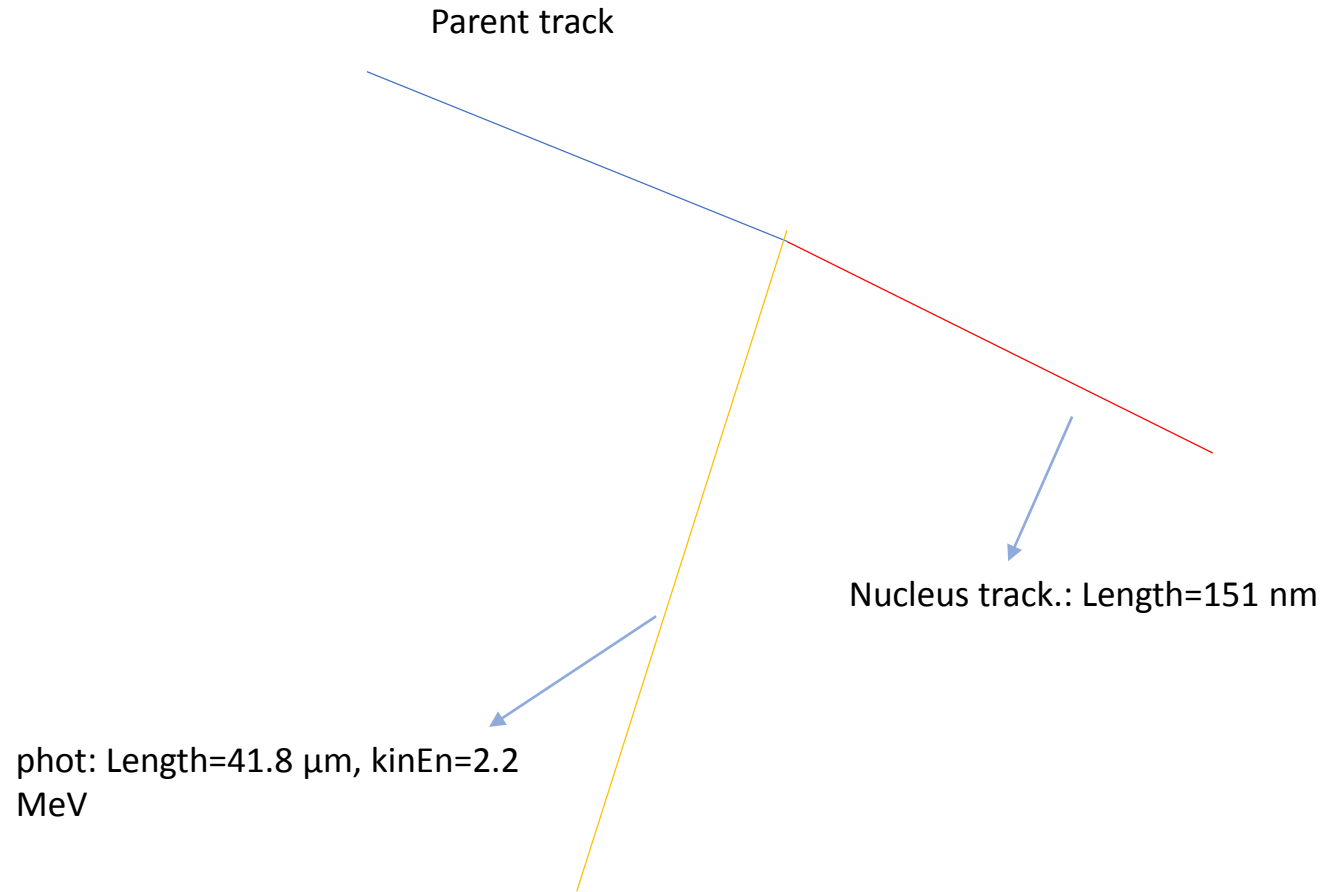
phot: Length=69.65  $\mu\text{m}$ ,  
kinEn=0.38 MeV

phot: Length=5.86  $\mu\text{m}$ , kinEn=2.79 MeV

prot: Length=100.16  $\mu\text{m}$ , kinEn=7.3 MeV

# Neutron Capture

creatorId==15 (nCapture)

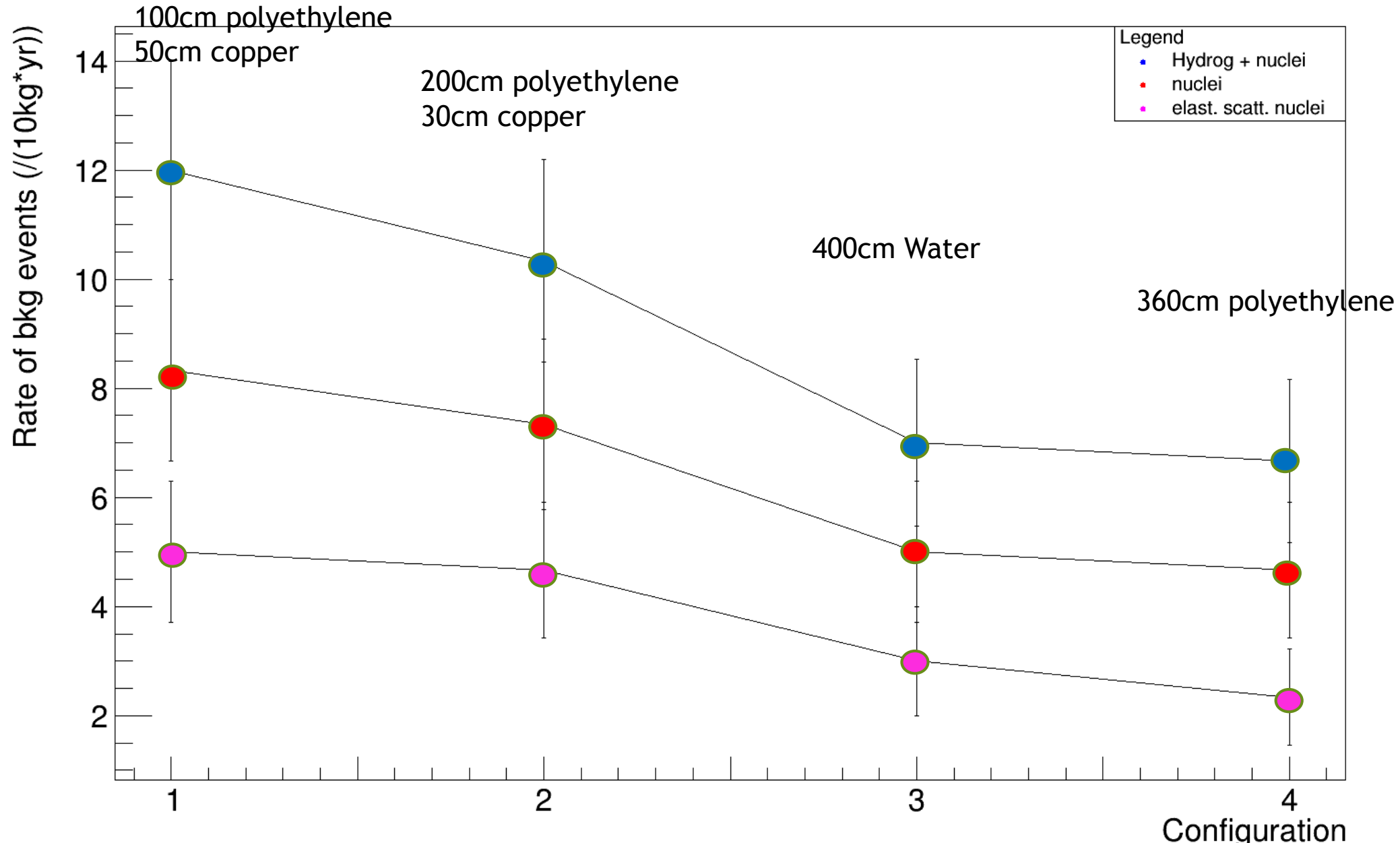


# Background event selection

- $100 \text{ nm} \leq \text{Track length} \leq 1000 \text{ nm}$
- 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

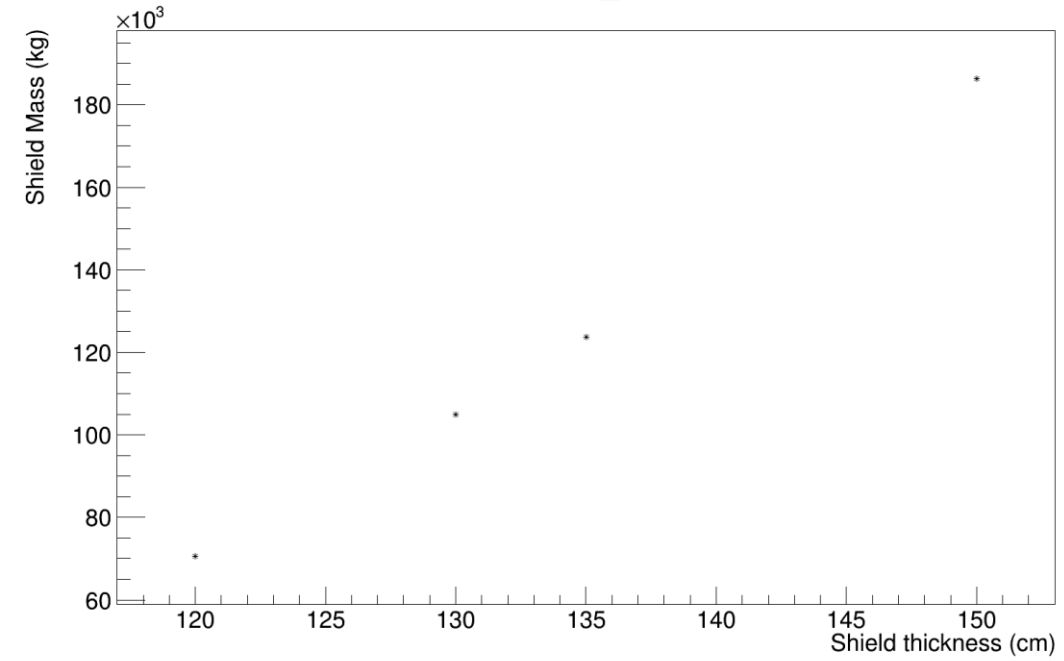
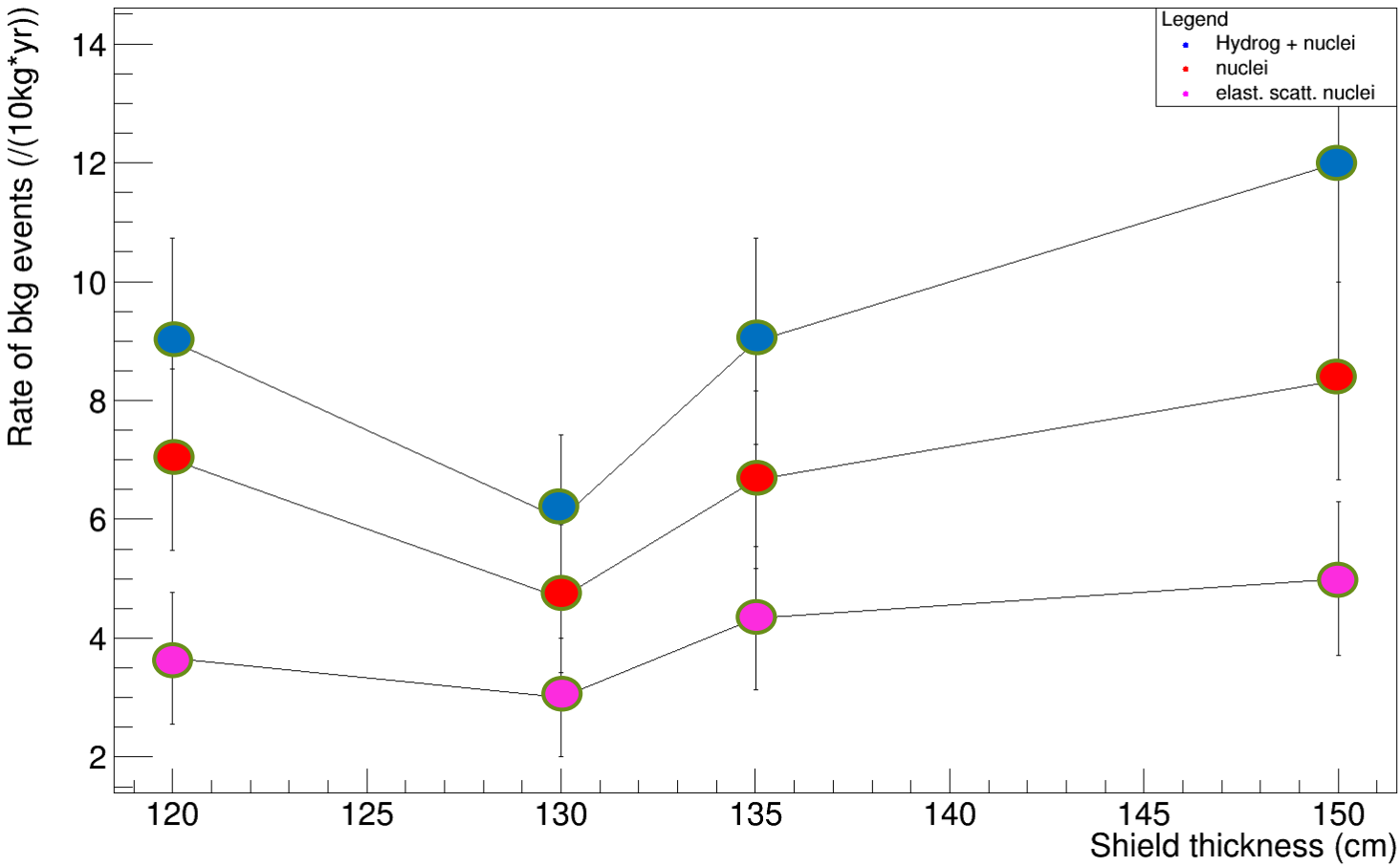
All considered configurations give cosmogenic neutron background  $\leq 0.2$  n/(10kg\*yr)



# Results

Shielding structure: 100cm polyethylene + x cm copper

shield\_100cmPoly\_copper



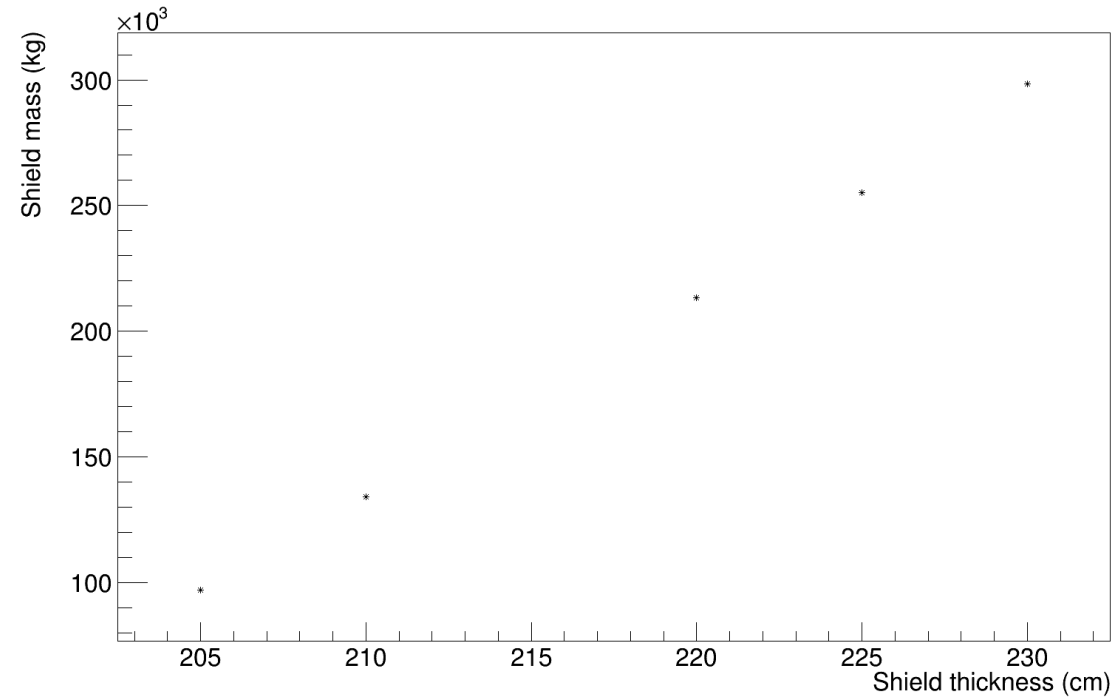
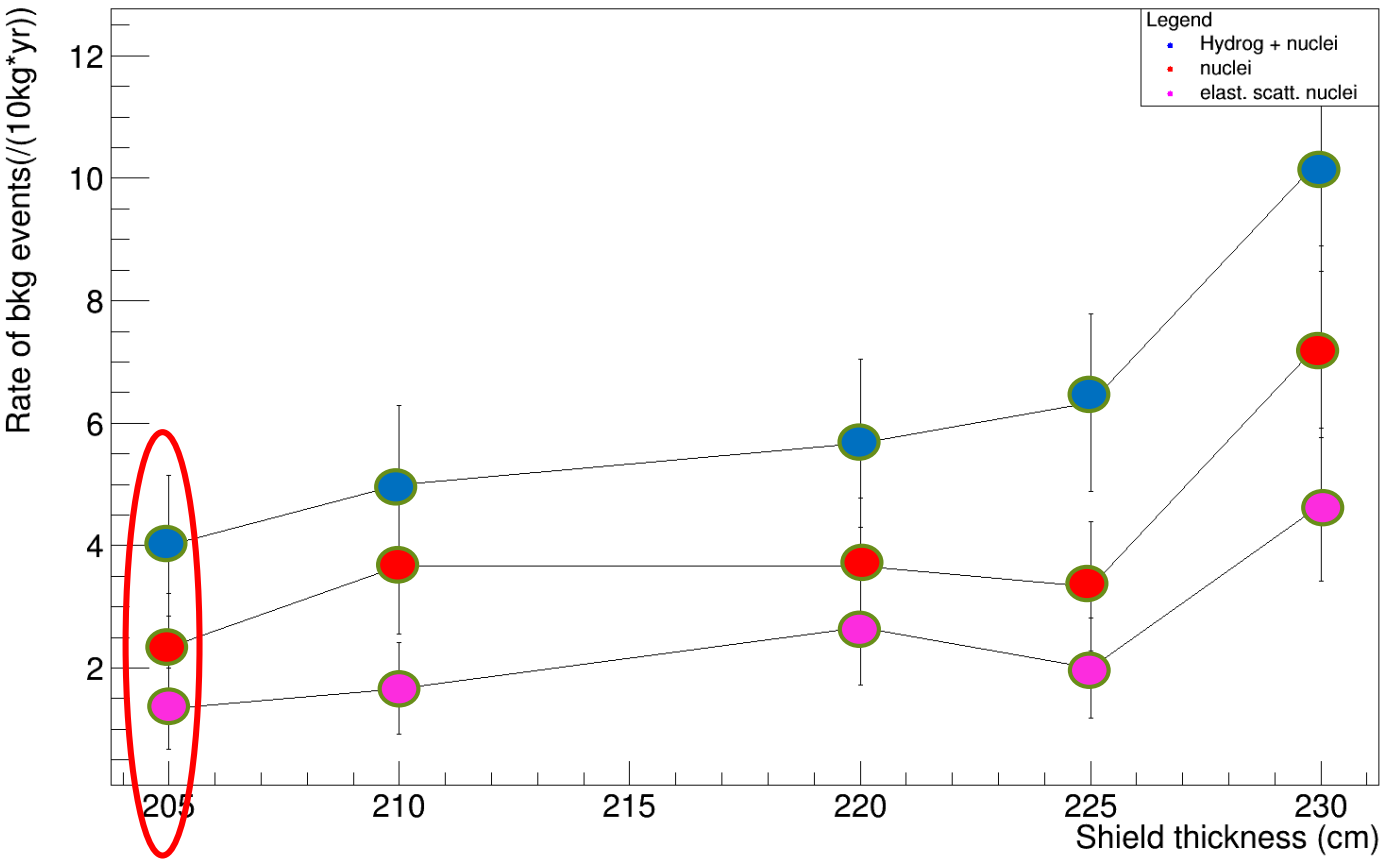
Detector\_mass



# Results

Shielding structure: 200 cm polyethylene x cm copper

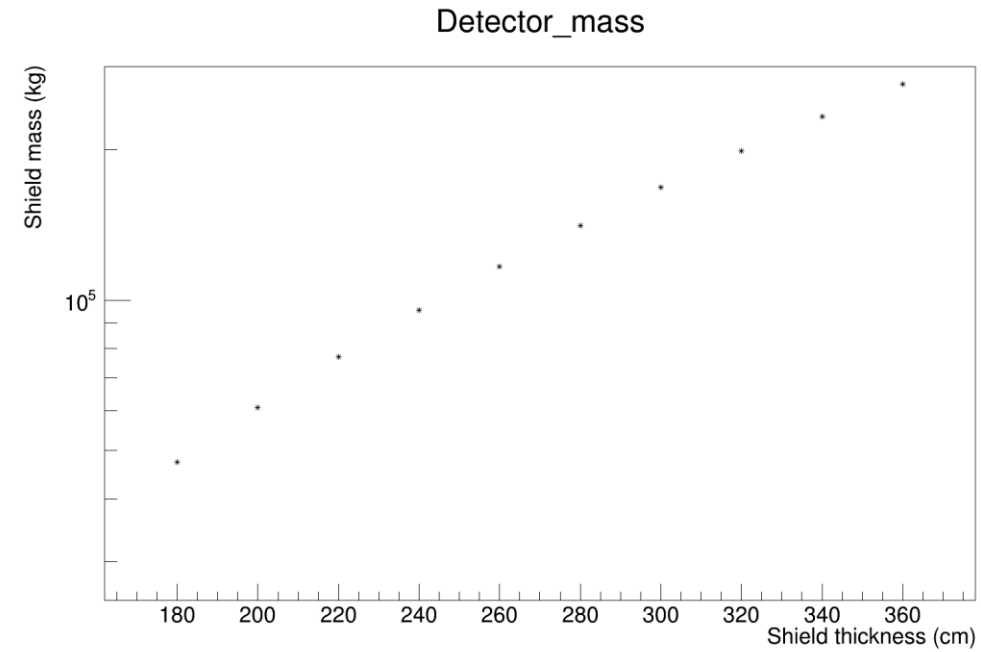
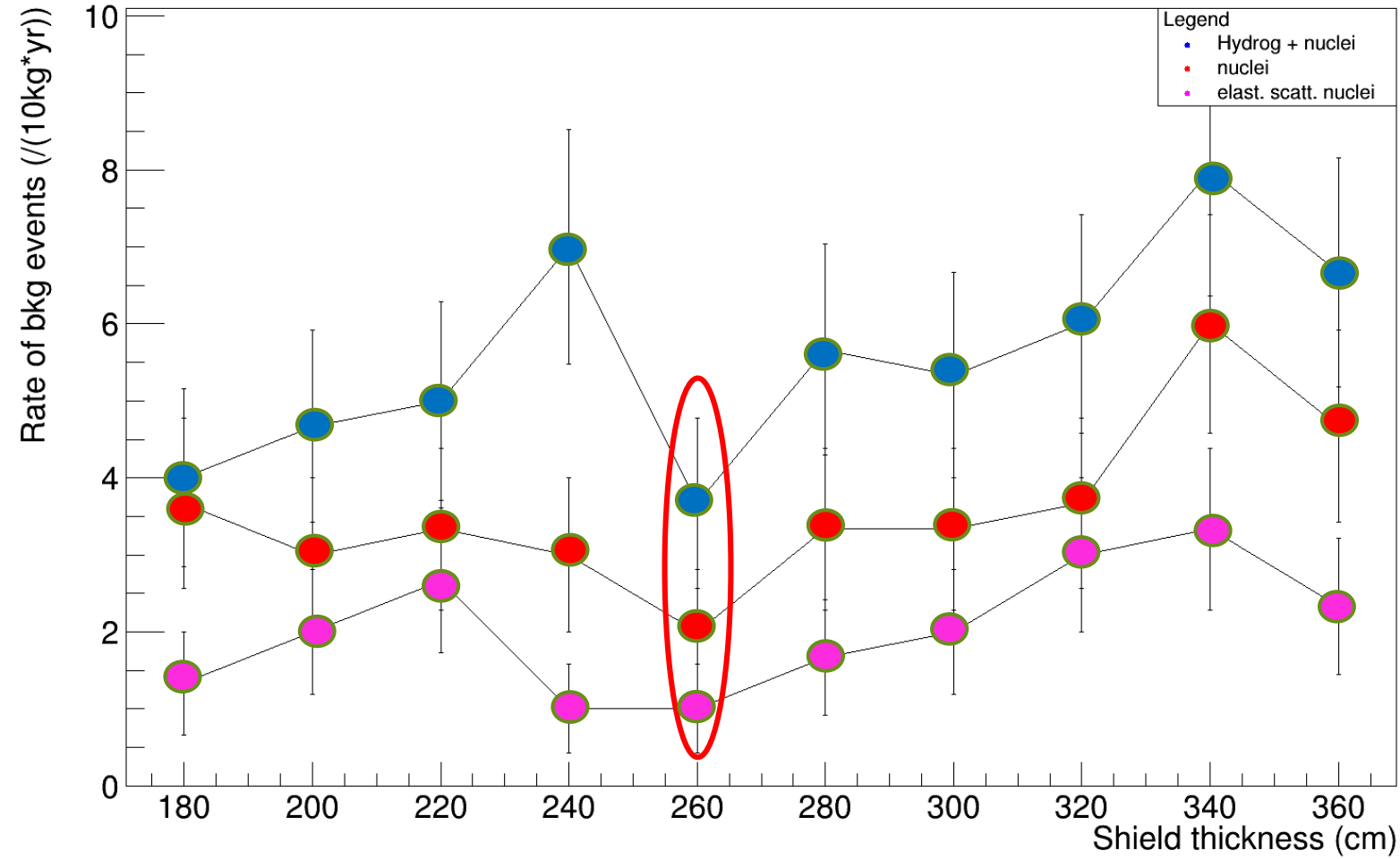
shield\_200cmPoly\_copper



# Results

Shielding structure: x cm polyethylene

shield\_Poly

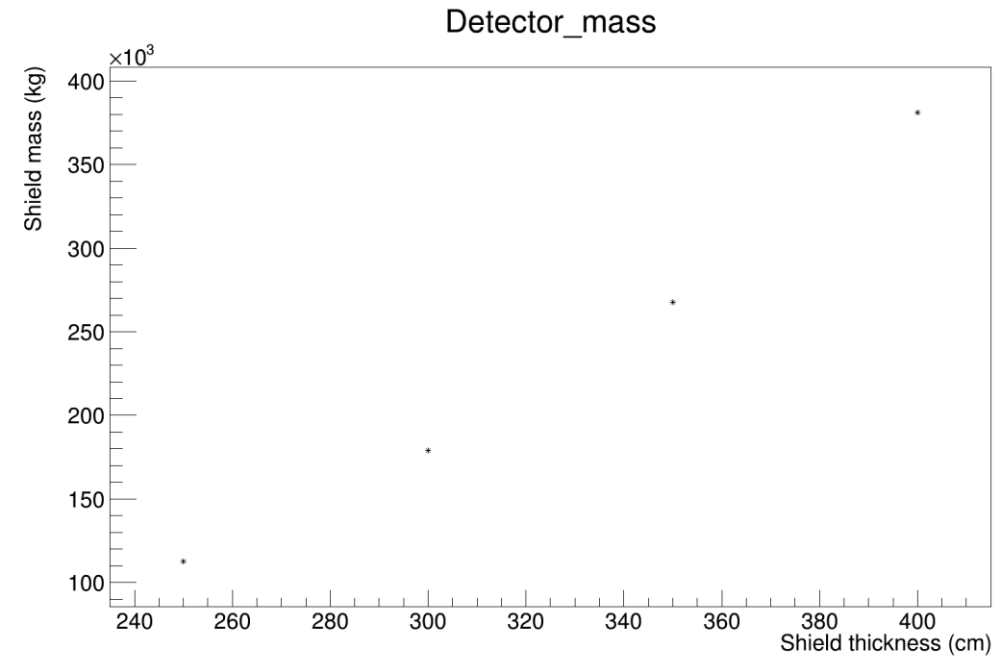
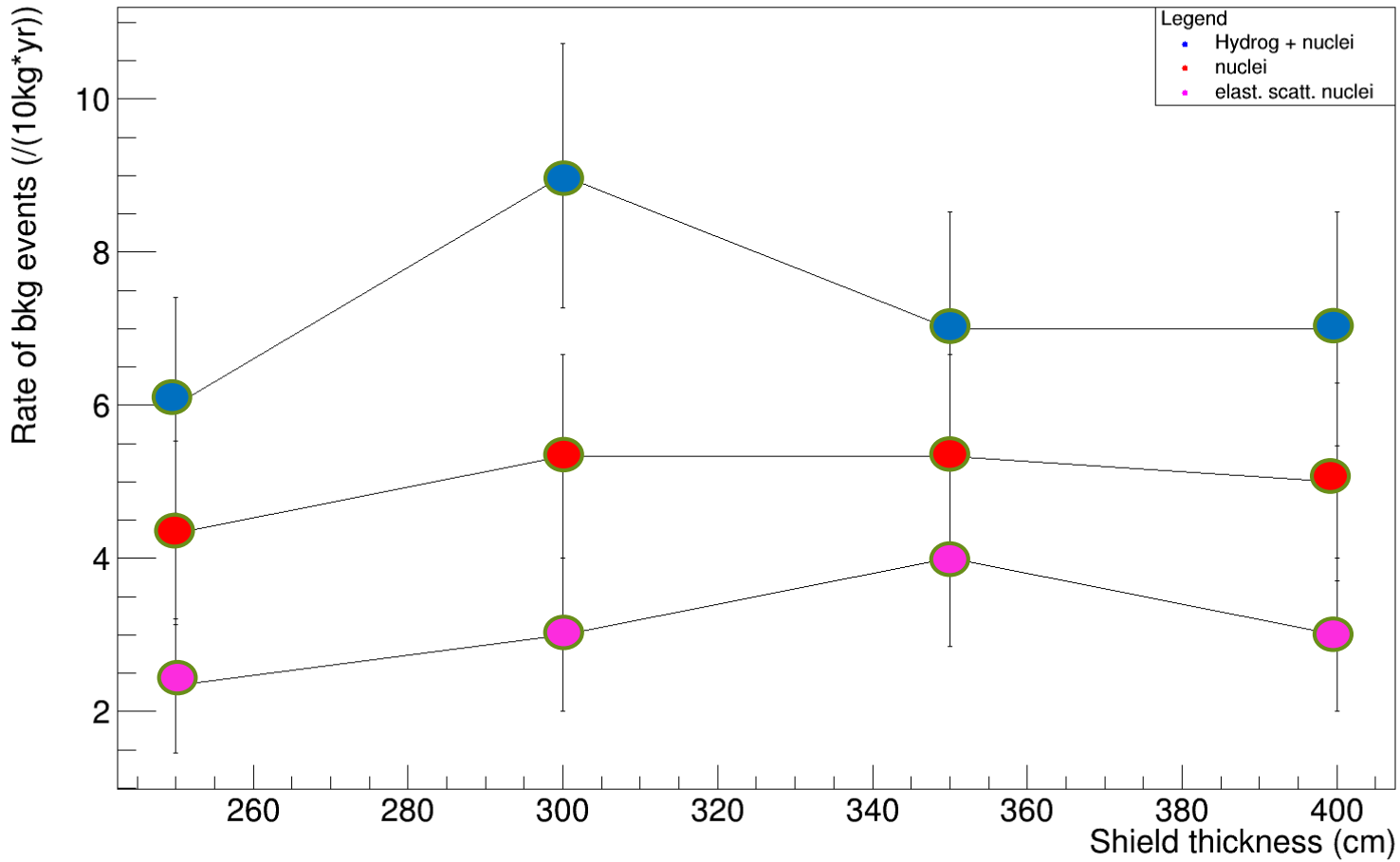


Detector\_mass

# Results

Shielding structure: x cm Water

shield\_Water



# Conclusions

- Muon-induced recoils constitute the most dangerous background source since emulsions don't have timing information.
- Two configurations have been identified as the most effective for muon-induced background:
  - 260 cm polyethylene
  - 200 cm polyethylen + 5 cm copper
- Muon induced background  $\approx 1.5 \text{ event}/(10\text{kg}\cdot\text{yr})$