The Geant4 simulations applied to analysis of the Po-210 and Pb-210 content in the components of the DarkSide-20k dark matter detector

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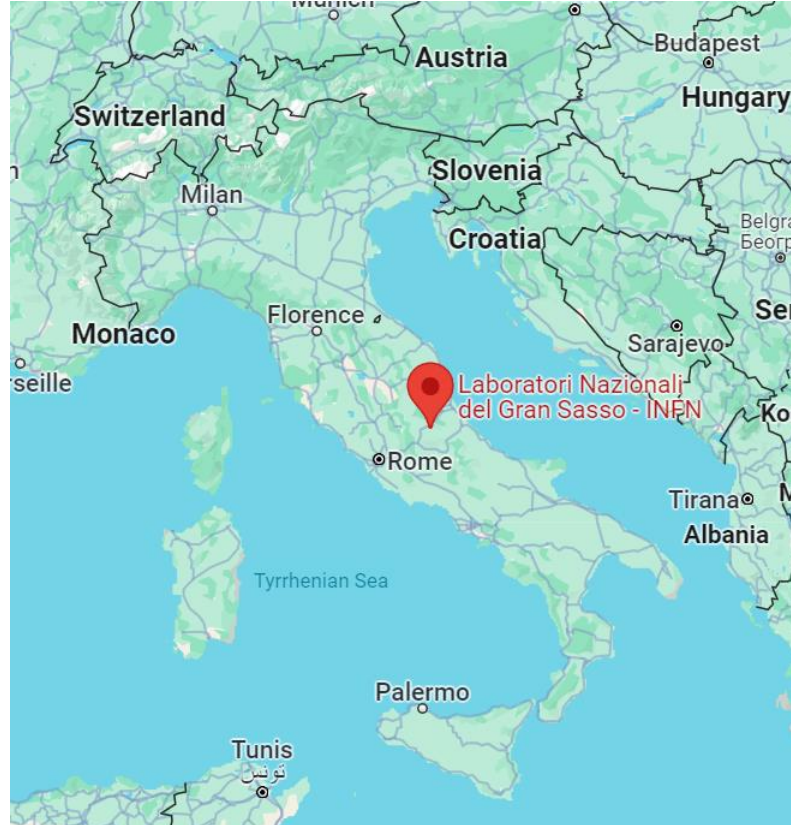
Vienna Workshop on Simulations 2024

26th April 2024

Outline

- The DarkSide experiment

- Detection of ^{210}Pb via ^{210}Po

- Alpha spectrometry
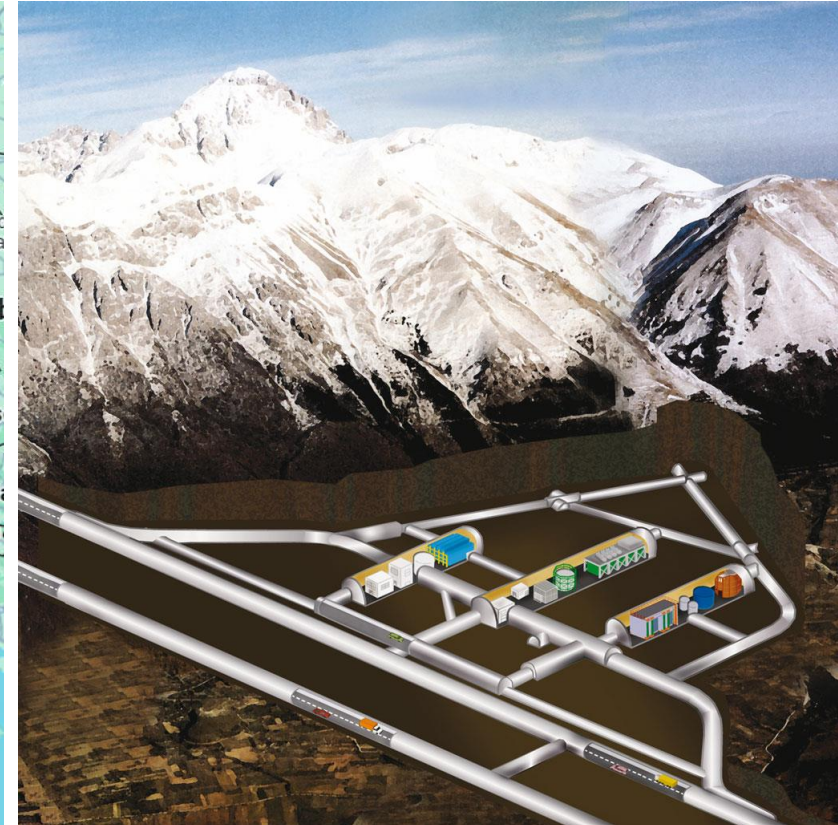
- Simulations methodology

- Conclusions

DARKSIDE experiment

- Direct detection of interaction between dark matter particles (WIMPs) and argon nuclei
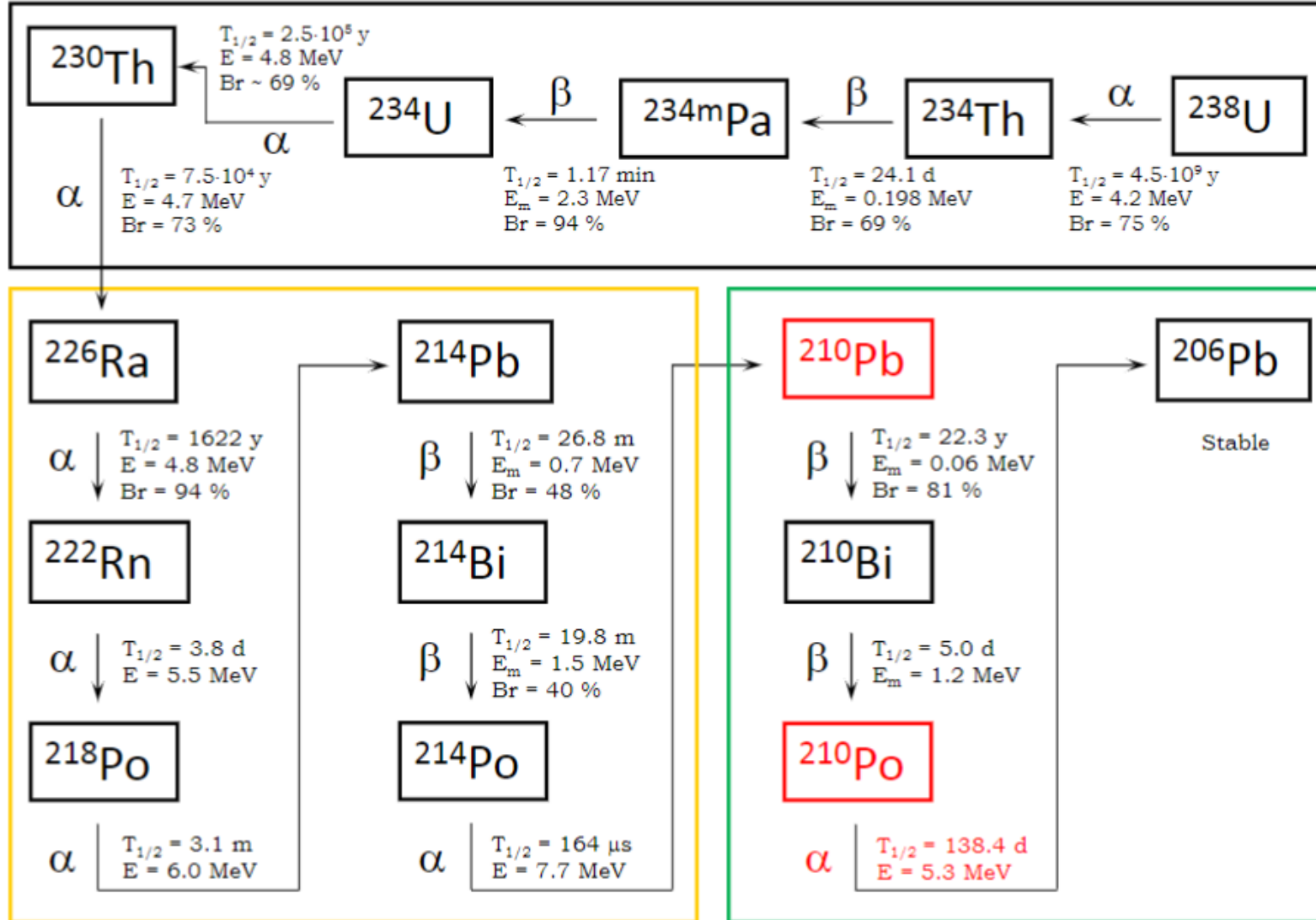
- Laboratori Nazionali del Gran Sasso in Italy

Google Maps

https://www.appec.org/news/hands-on-experimental-underground-physics-at-lngs

Detection of ^{210}Pb via ^{210}Po

Samples are measured by the XIA UltraLo-1800

- Large-surface, low-background α-spectrometer XIA UltraLo-1800
- Ionization counter working with gasous argon (3.5 l/min)
- Sample's surface (i. e. foil): 0.43×0.43 m^2
- PSD
- Construction with low-radioactivity materials
- Energy range: 1.0 – 10 MeV

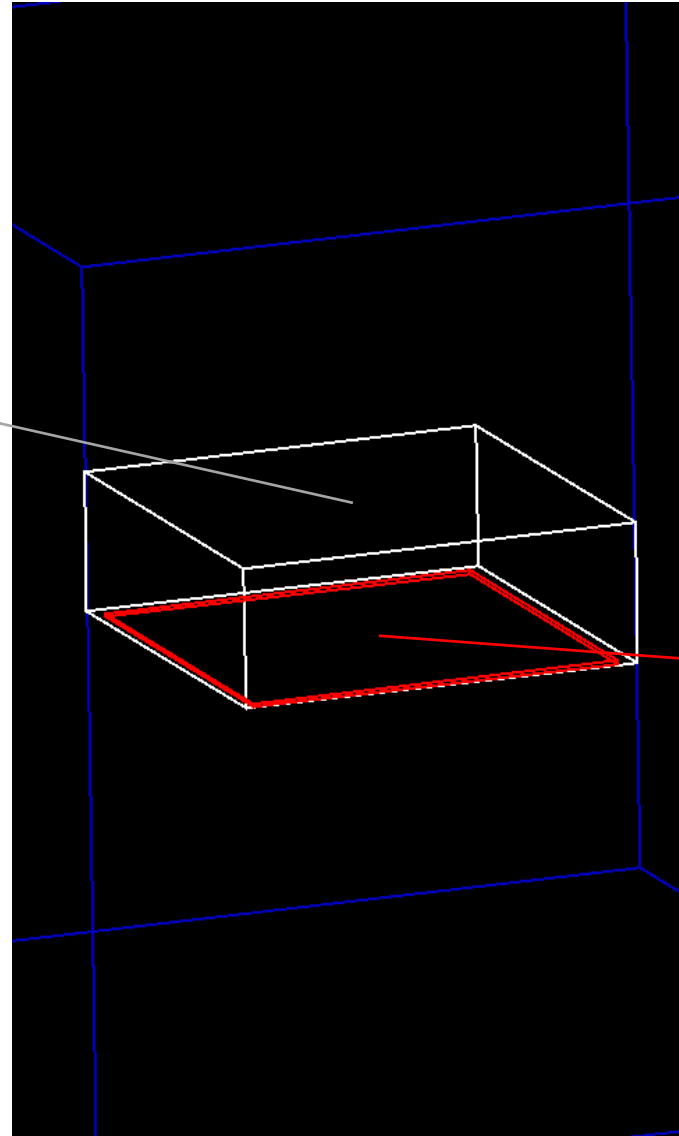https://xia.com/support/ultralo-1800/ 5

Summarize spectrum consists of bulk and surface decays
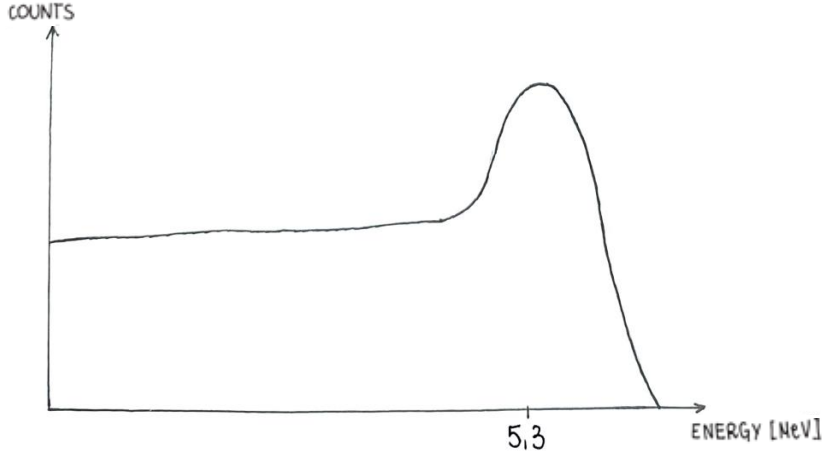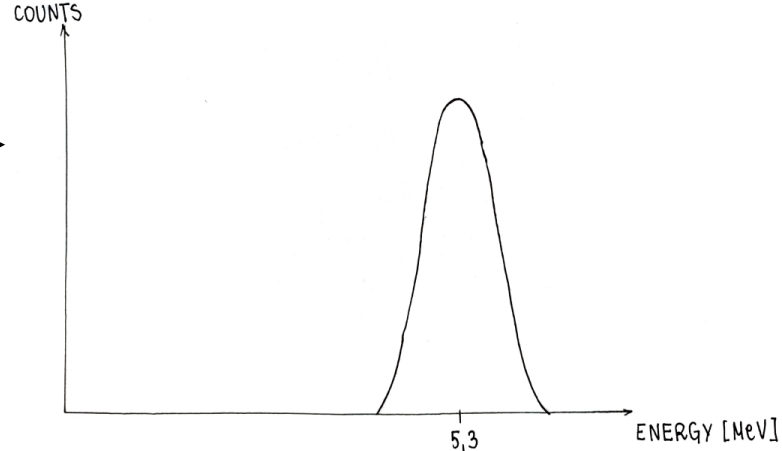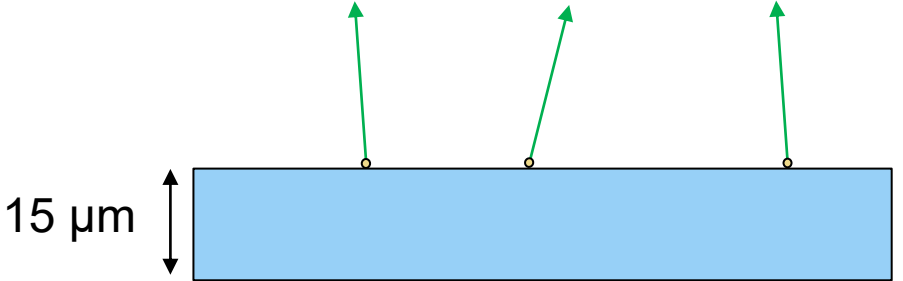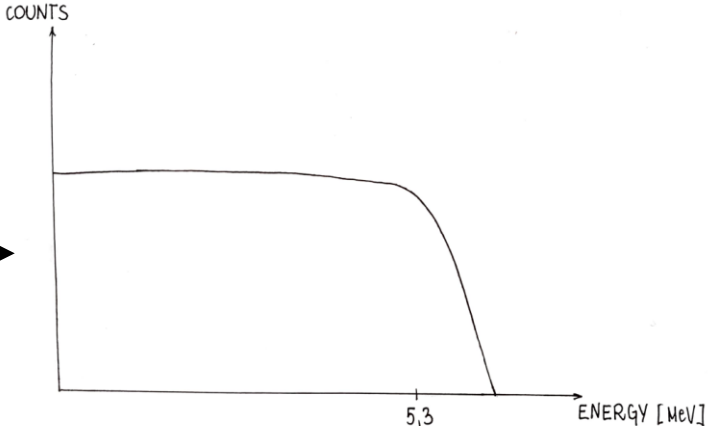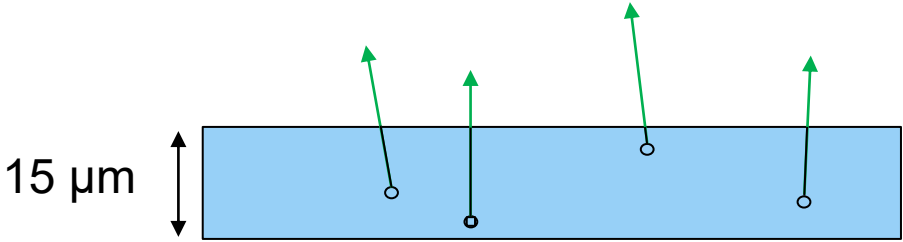
E_α (^{210}Po) = 5.3 MeV
R (Cu) = 15 µm

Detector's and sample's geometries

Argon – **Sensitive Detector**
$430 \times 430 \times 150$ mm^3

Sample

Physical processes

- Particle (ion) ^{210}Po
  (E_{kin} = 0 keV, in rest)

- Radioactive decay

- Alpha particle production
  (E = 5.3 MeV)
  - Ionisation

- Particle ^{206}Pb (E_{kin} = 0.103 MeV)
  - Ionisation

- Gamma
  - Photoelectric effect
  - Polarized photoelectric effect
  - Compton scattering
  - Polarized Compton scattering
  - Rayleigh scattering
  - Polarized Rayleigh scattering
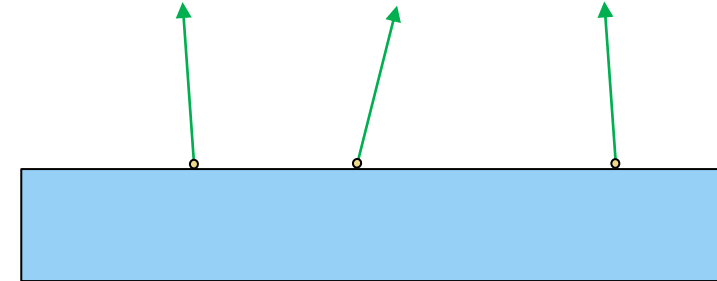 - Conversion
  - Polarized conversion
- Electron
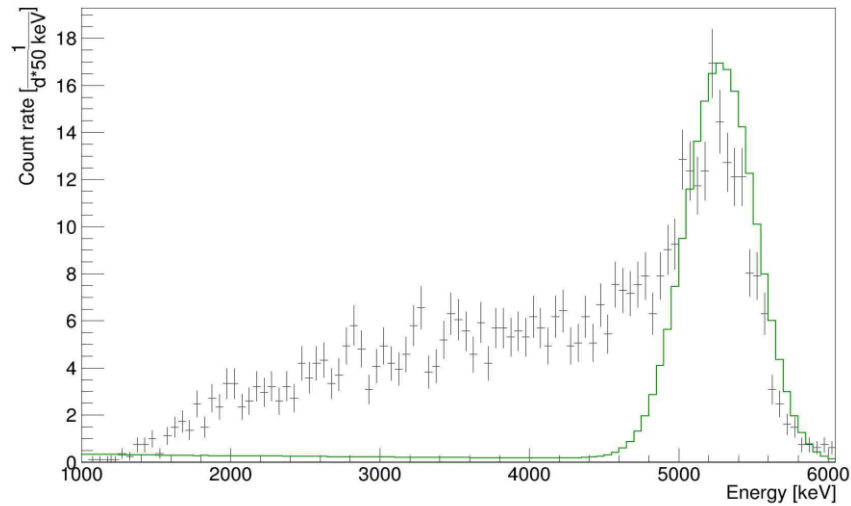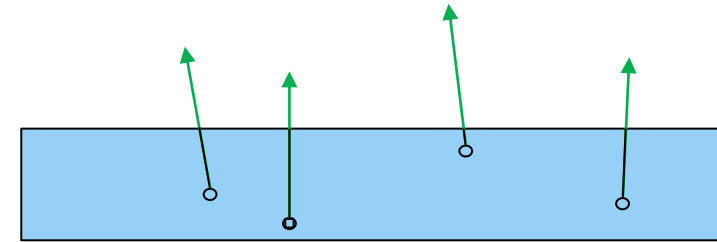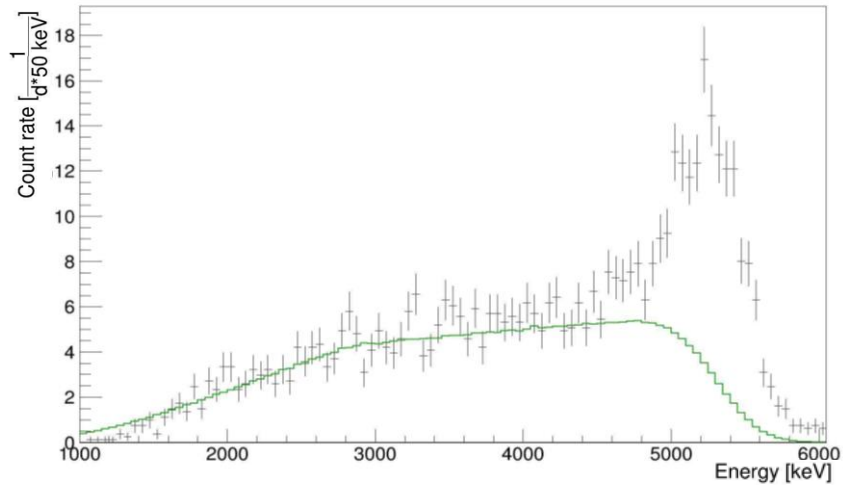 - Ionisation
  - Bremsstrahlung

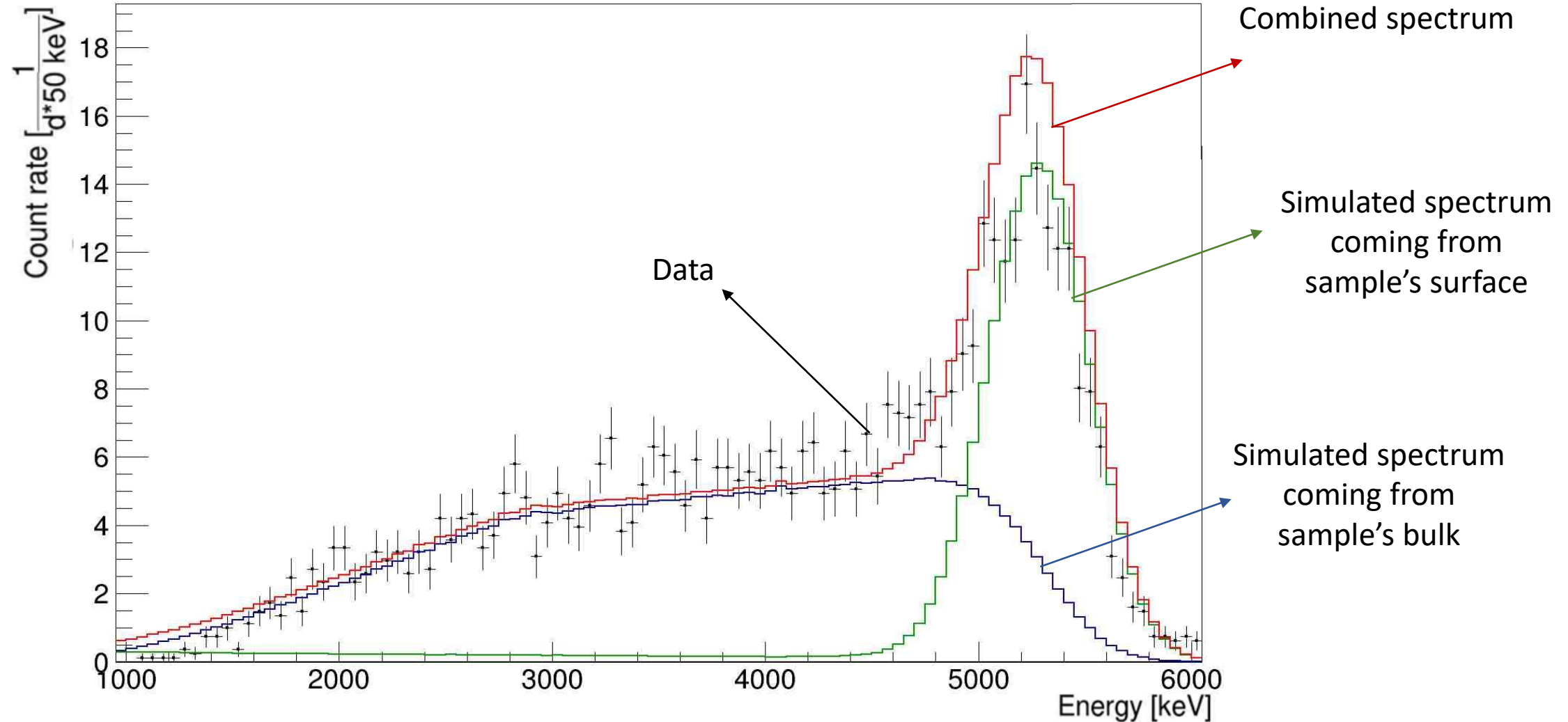# Two Monte Carlo simulations are created
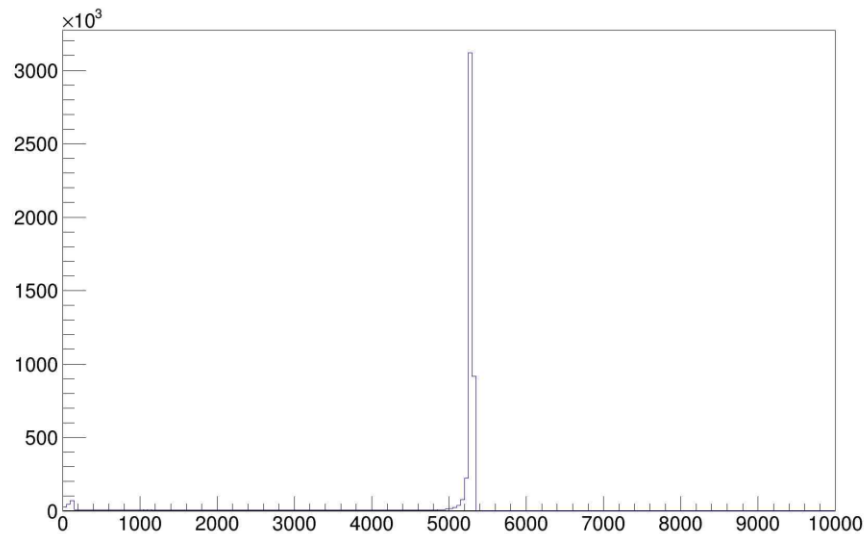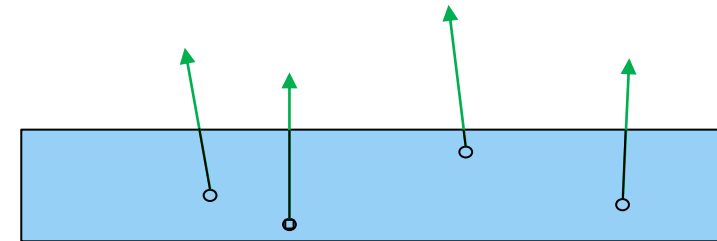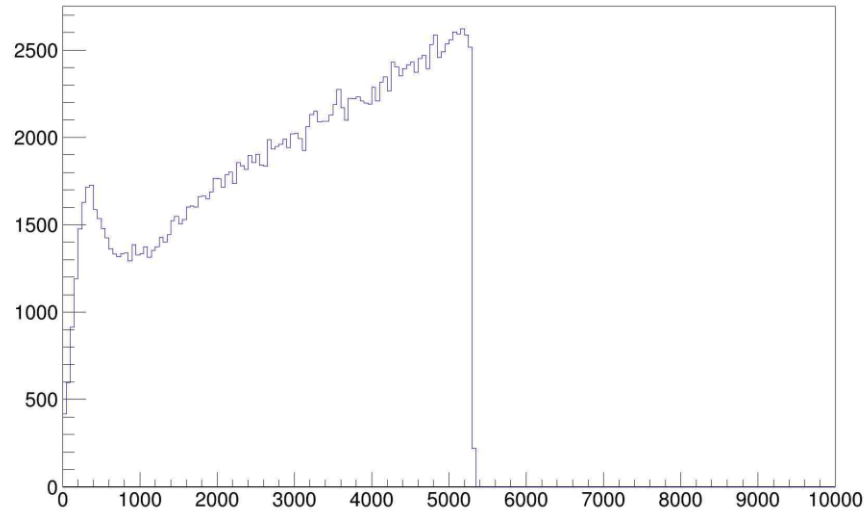
Implementation the detector's energy resolution
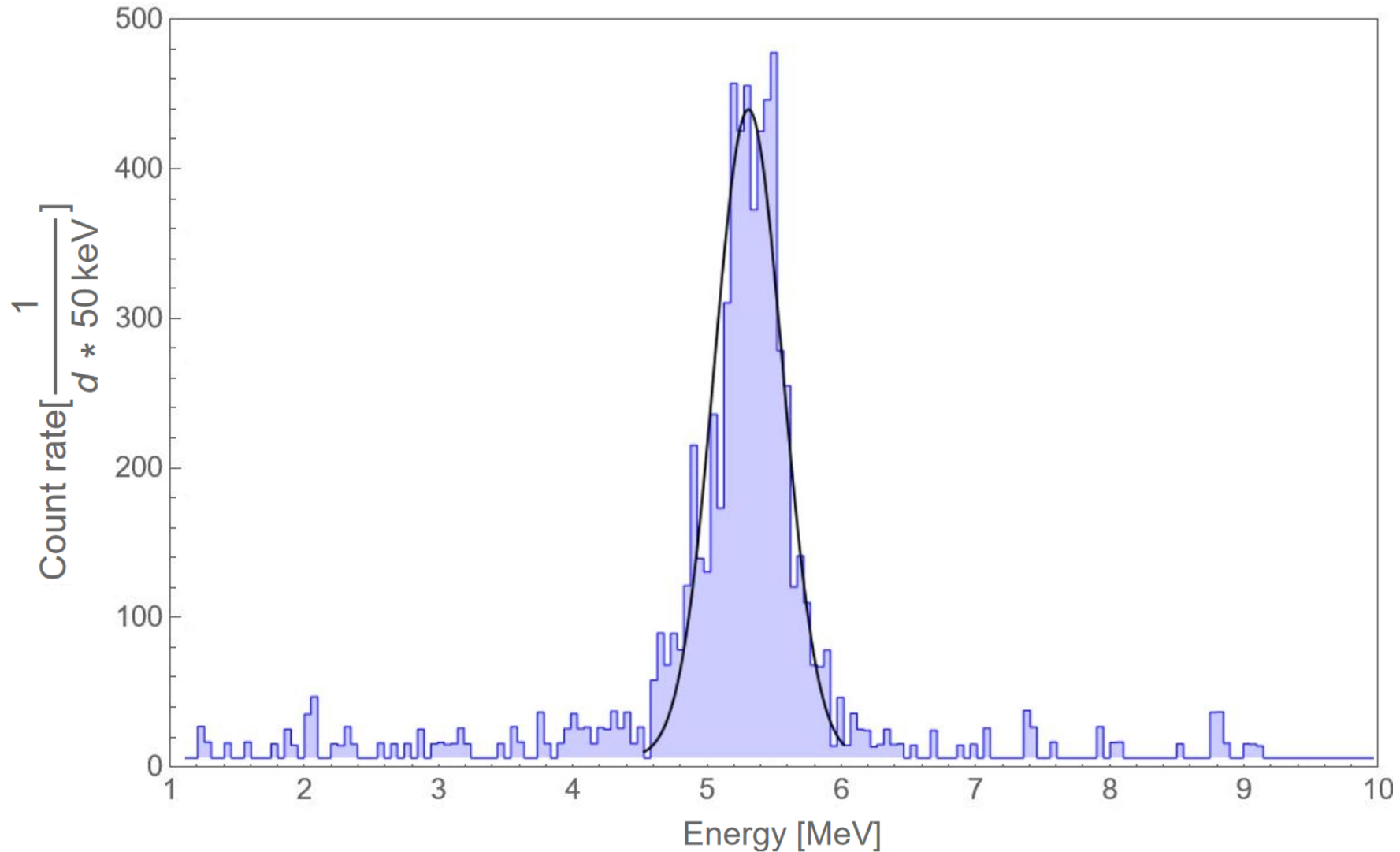
Detector's energy resolution and efficiency are implemented

Deconvolution the surface and bulk activity

Conclusions

- Thanks to the Monte Carlo simulations implemented in the Geant4 package the method which allows to deconvolute surface and bulk activities from an alpha spectrum was developed.

- The simplified geometry of the alpha spectrometer, samples and physical processes from the Livermore model were implemented.

- Surface and bulk activities were deconvoluted for samples intendent to use in the DarkSide-20k dark matter detector.