CLEANWATCH.py

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Maths

The background rate (B_r) is defined as

$$B_r = a_i \times \eta_i$$

where a_i is the activity of a specific isotope and η_i is the efficiency of a specific isotope.

Variables

- decay constant of an isotope = λ_i
- Natural Abundance of an isotope = NA_i
- Mass of an isotope = M_i
- Parts per million of an isotope = PPM_i
- Tank radius = r
- Tank thickness = t
- Tank height = h

PMT Activity

PMT Activity is defined as:

$$a_i = \left(\frac{\lambda_i NA_i}{m_i \times 1 \times 10^6} \right) PPM_i \times m_{PMT} \times n$$

where m_{PMT} is the mass of the glass in the PMT and n is the number of PMTs.

Veto Activity

Veto activity is defined as:

$$a_i = \left(\frac{\lambda_i NA_i}{M_i \times 1 \times 10^6} \right) PPM_i \times m_{PMT} \times n$$

where n is the number of PMTs in the Veto region.

Tank Activity

The volume of the tank is defined as:

$$V_{tank} = 2\pi hr^2 - 2\pi \left((h-t)(r-t)^2 \right)$$

therefore activity is defined as:

$$a_i = PPM_i \times (\rho \times V_{tank})$$

where ρ is the density of the tank.

Concrete Activity

The volume of the concrete is defined as:

$$V_{conc} = \frac{51\pi}{2}\left(13^2 - 12.5^2\right) + \frac{\pi}{2}\left(13\right)^2$$

therefore the activity is defined as:

$$a_i = PPM_i \times \rho \times V_{conc}$$

where ρ is the density of the concrete.

Rock Activity

The volume of the rock is defined as:

$$V_{rock} = \pi\left((18^2)(35.5) - (13^2)(25.5)\right) \Rightarrow m_{rock} = \rho \times V_{rock}$$

The activity from the rock is defined as

$$a_i = \left(\frac{\lambda_i N A_i}{M_i \times 1 \times 10^6}\right) PPM_i \times m_{rock}$$

Water Activity

The volume of the water in WATCHMAN is defined as:

$$V_{water} = 2\pi h r^2$$

The $\rho = 1$ so the activity from the water is defined as

$$a_i = PPM_i \times V_{water}$$

Gd Activity

The volume of Gd is defined as

$$V_{Gd} = 2\pi h r^2$$

therefore the activity is defined as:

$$a_i = PPM_i \times V_{Gd} \times \rho \times 0.002$$

File Structure

Iso.py

Variables

- Mass of a single atom for ^{238}U, ^{232}Th, ^{40}K
- λ for ^{238}U, ^{232}Th, ^{40}K
- NA for ^{238}U, ^{232}Th, ^{40}K
- Isotopes in:

  - PMT
  - Veto region
  - Tank
  - Concrete
  - Rock
  - Water
  - Gd

- Decay chains:

  - ^{238}U
  - ^{232}Th
  - ^{235}U
  - ^{222}Rn
  - ^{137}Cs
  - ^{60}Co
  - ^{40}K
  - $FastNeutron$
  - $RadioNuclide$

Functions

setPPM(Iso, PPM): allows the user to change the values for PPM for a specific component. If an invalid value is entered the PPM is set to the default.
setEff(IsoDecay, IsoEff): allows the user to change the values for the efficiency for a specific isotope for a specific component. If an invalid value is entered, it is set to the default value.
BGrate(Act, Eff, Decay): calculates the total background rate for a specific component.

Eff.py

Dependencies

- ROOT

Variables

- list of components

- PMT
- Veto
- Tank
- Rock
- WaterVolume
- Gd

- Decay chains

- ^{238}U
- ^{235}U
- ^{232}Th
- ^{222}Rn
- ^{137Cs}
- ^{60}Co

- ^{40}K

- Efficiencies

- ^{238}U for PMT
- ^{232}Th for PMT
- ^{40}K for PMT
- ^{238}U for Veto
- ^{232}Th for Veto
- ^{40}K for Veto
- ^{238}U for Tank
- ^{232}Th for Tank
- ^{40}K for Tank
- ^{60}Co for Tank
- ^{137}Cs for Tank
- ^{238}U for Rock
- ^{232}Th for Rock
- ^{40}K for Rock
- ^{222}Rn for Water
- ^{238}U for Gd
- ^{232}Th for Gd
- ^{235}U for Gd

- Error of Efficiencies

- ^{238}U for PMT
- ^{232}Th for PMT
- ^{40}K for PMT
- ^{238}U for Veto

- ^{232}Th for Veto
- ^{40}K for Veto
- ^{238}U for Tank
- ^{232}Th for Tank
- ^{40}K for Tank
- ^{60}Co for Tank
- ^{137}Cs for Tank
- ^{238}U for Rock
- ^{232}Th for Rock
- ^{40}K for Rock
- ^{222}Rn for Water
- ^{238}U for Gd
- ^{232}Th for Gd
- ^{235}U for Gd

Functions

ErrProp(IsoEffErr, IsoEff, BG): calculates the error on the background rate using the errors from the histograms in results.root

Component files

Dependencies

- Iso.py
- Eff.py

Variables

- defPPM - 1D List of default values for PPM for component.
- IsoAct - 1D List of activities of Isotopes.
- revIsoAct - 1D List of calculated activities of Isotopes.
- IsoList - 1D List of Isotopes in component.
- IsoDecay - 2D List of decay chains.
- IsoEff - 2D List of efficiencies for isotopes in decay chains.
- EffErr - 2D List of errors on the efficiency.
- Err - 2D List of caculated BG rate errors.
- defAct - 1D List of activity for the component calculated using the default vaules for PPM.

Functions

Activity(PPM): calculates the activity using the components PPM
revActivity(BG, Eff): calculates PPM using maximum background rates for each decay chain and efficiencies