Conversion between geoneutrino flux ϕ [in cm^{-2} s^{-1}] and signal rate R [in TNU] for inverse beta decay detection mechanism

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The highest energy antineutrinos from decay of ^{232}Th and ^{238}U are detectable using the *inverse beta decay* mechanism. Conversion between the geoneutrino total (from ^{232}Th $+^{238}$ U) *flux* ϕ in units of cm^{-2} s^{-1} and *signal rate* R is in TNU (terrestrial neutrino units) depends on the thorium-to-uranium abundance ratio $\left[\frac{\mathrm{Th}}{\mathrm{U}}\right]$ of the emitter.

Dye (2012) (see also *Šrámek et al.*, 2012) gives the ratios of internal heating rates H, fluxes ϕ, and signal rates R coming from ^{232}Th and ^{238}U (subscripts $_{\mathrm{Th}}$ & $_{\mathrm{U}}$ for simplicity):

$$\frac{H_{\mathrm{Th}}}{H_{\mathrm{U}}} = \frac{X_{\mathrm{Th}}}{X_{\mathrm{U}}}\frac{h_{\mathrm{Th}}}{h_{\mathrm{U}}}\left[\frac{\mathrm{Th}}{\mathrm{U}}\right] = 0.278\left[\frac{\mathrm{Th}}{\mathrm{U}}\right],$$
$$\frac{\phi_{\mathrm{Th}}}{\phi_{\mathrm{U}}} = \frac{X_{\mathrm{Th}}}{X_{\mathrm{U}}}\frac{l_{\mathrm{Th}}}{l_{\mathrm{U}}}\left[\frac{\mathrm{Th}}{\mathrm{U}}\right] = 0.217\left[\frac{\mathrm{Th}}{\mathrm{U}}\right],$$
$$\frac{R_{\mathrm{Th}}}{R_{\mathrm{U}}} = \frac{C_{\mathrm{U}}}{C_{\mathrm{Th}}}\frac{\phi_{\mathrm{Th}}}{\phi_{\mathrm{U}}} = 0.066\left[\frac{\mathrm{Th}}{\mathrm{U}}\right],$$

where the parameters are the natural isotopic fractions X (radionuclide-to-element ratios), isotope-specific heating rates h and antineutrino luminosities l (both per unit mass of pure radionuclide), and individual rate-to-flux conversion factors C (i.e., $\phi = CR$ for each radionuclide). The values from *Dye* (2012) were used in evaluating the ratios:

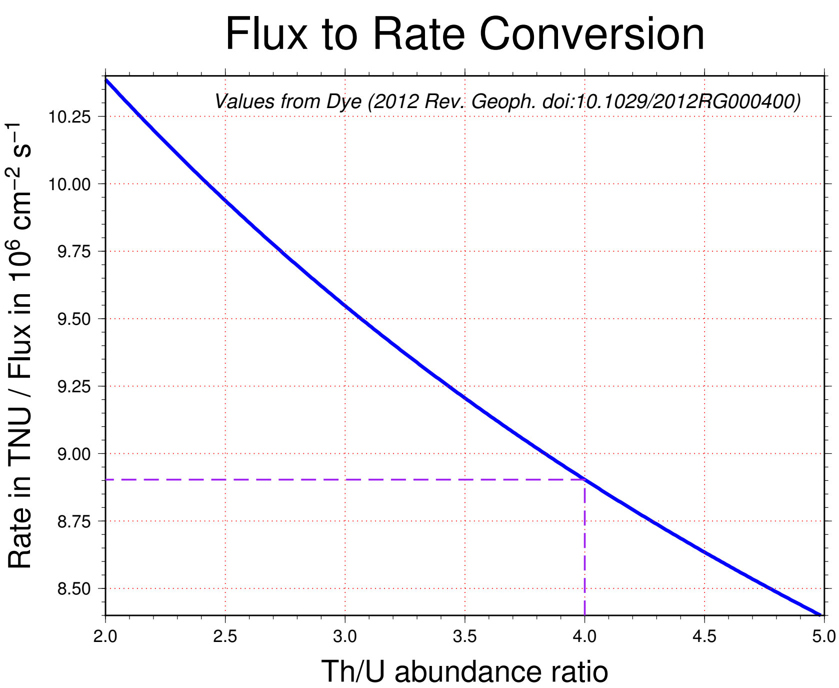
Quantity	^{232}Th	^{238}U
X	1.0000	0.9927
h in μW kg^{-1}	26.28	95.13
l in μs^{-1} kg^{-1}	16.2	74.6
C in cm^{-2} s^{-1} TNU^{-1}	2.5×10^5	7.6×10^4

It follows for the total flux and rate (from ^{232}Th + ^{238}U) that

$$\frac{R_{tot}}{\phi_{tot}} \equiv \frac{R_{\mathrm{U}} + R_{\mathrm{Th}}}{\phi_{\mathrm{U}} + \phi_{\mathrm{Th}}} = \frac{R_{\mathrm{U}}\left(1 + \frac{R_{\mathrm{Th}}}{R_{\mathrm{U}}}\right)}{\phi_{\mathrm{U}}\left(1 + \frac{\phi_{\mathrm{Th}}}{\phi_{\mathrm{U}}}\right)} = \frac{1}{C_{\mathrm{U}}}\frac{1 + \frac{X_{\mathrm{Th}}}{X_{\mathrm{U}}}\frac{l_{\mathrm{Th}}}{l_{\mathrm{U}}}\frac{C_{\mathrm{U}}}{C_{\mathrm{Th}}}\left[\frac{\mathrm{Th}}{\mathrm{U}}\right]}{1 + \frac{X_{\mathrm{Th}}}{X_{\mathrm{U}}}\frac{l_{\mathrm{Th}}}{l_{\mathrm{U}}}\left[\frac{\mathrm{Th}}{\mathrm{U}}\right]}$$
$$= \frac{1}{0.076}\frac{1 + 0.066\left[\frac{\mathrm{Th}}{\mathrm{U}}\right]}{1 + 0.217\left[\frac{\mathrm{Th}}{\mathrm{U}}\right]}\frac{\mathrm{TNU}}{10^6\,\mathrm{cm^{-2}\,s^{-1}}}$$

With $\left[\frac{\mathrm{Th}}{\mathrm{U}}\right] = 4.0$, we have

$$1.0 \times 10^6\,\mathrm{cm^{-2}\,s^{-1}} \leftrightarrow 8.9\,\mathrm{TNU},$$
$$1.0\,\mathrm{TNU} \leftrightarrow 0.11 \times 10^6\,\mathrm{cm^{-2}\,s^{-1}}.$$



References

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