Simple estimate of gamma background due to (α,nγ)

Method:

- calculate the gamma yield from (α,nγ):

$\text{yield}_{\alpha,n}$ = gamma/alpha

- In U/Th fission chains, alpha/gamma ratio

$\text{ratio}_{\text{fission}}$=alpha/$\gamma$(>0.7MeV) ~ 9.7(U), 4.7(Th)

- So scale the natural radioactivity gamma background rate in CDR (page 44) by $\text{yield}_{\alpha,n} \times \text{ratio}_{\text{fission}}$ to get the rate due to (α,nγ), assuming that photon attenuation does not change with energy

From CDR:

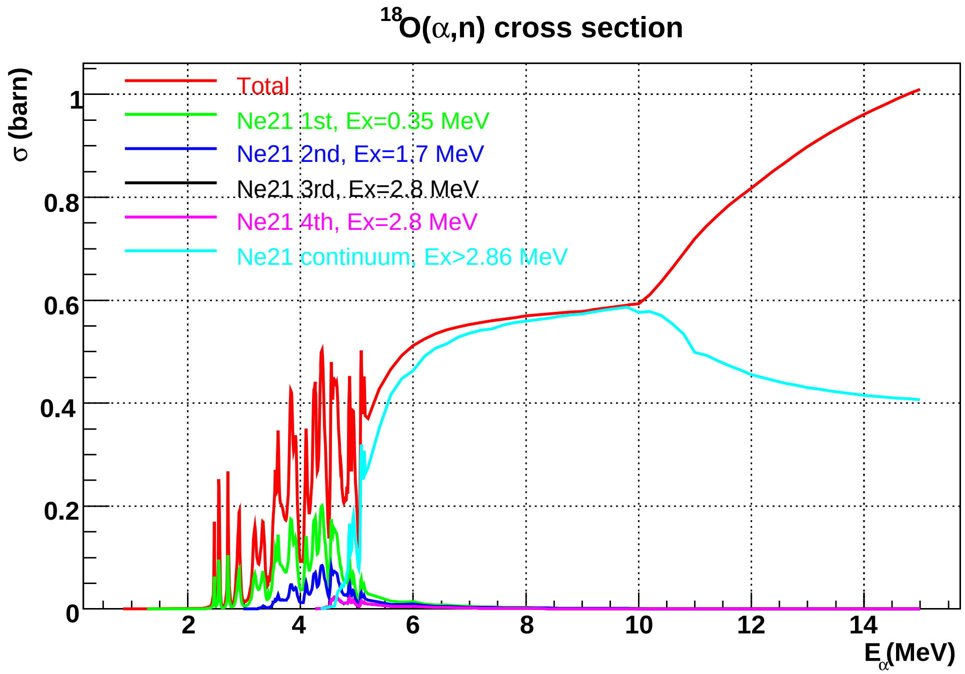
	Rock	PMT glass	Sum
U	0.65Hz	2.2 Hz	2.85 Hz
Th	2.6 Hz	1.0 Hz	3.6 Hz

Target Nuclei in Rock or Glass

	Abundance
O18	0.20%
Si29	4.68%
Si30	3.09%

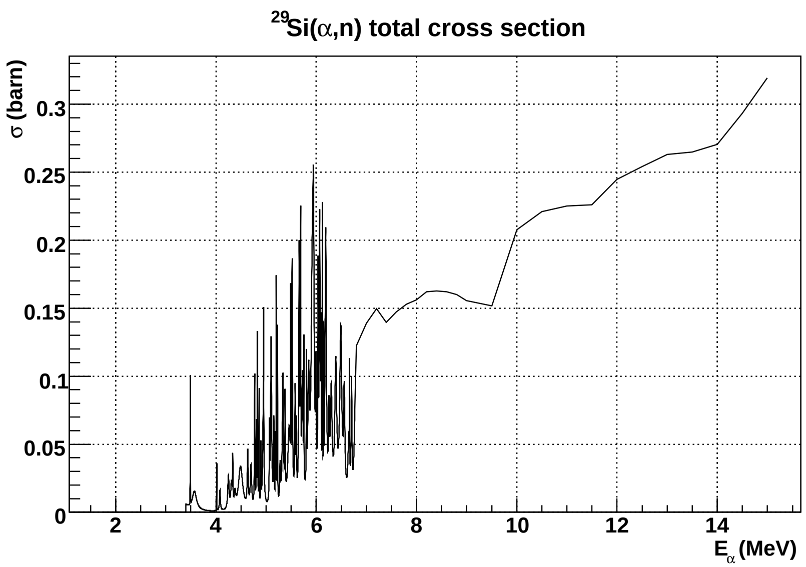
Note: significant contribution from excited final state
⇒ some of them give high energy gammas

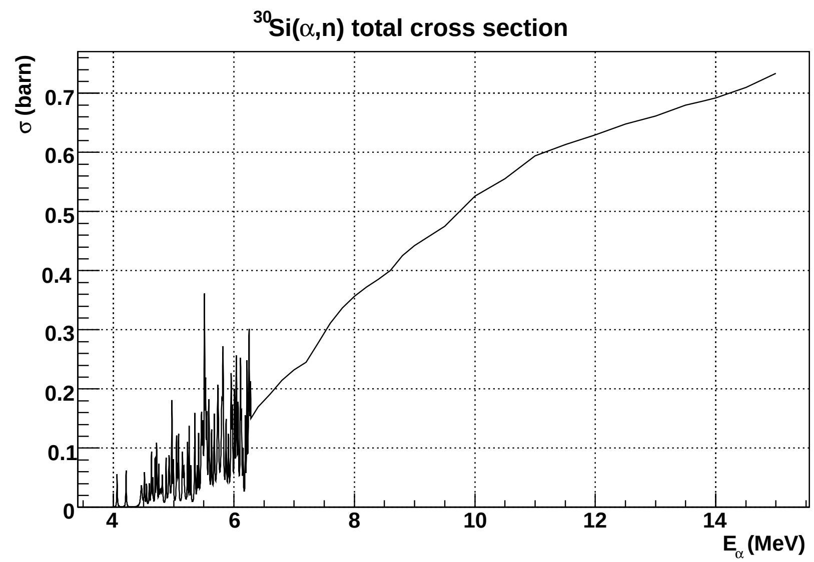
From JENDL, O18



Si29 and Si30 cross sections

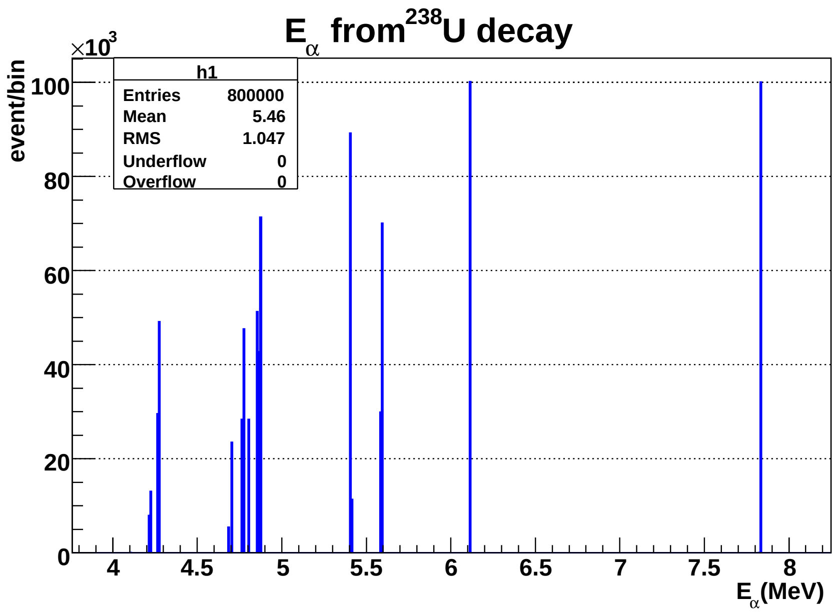
From JENDL

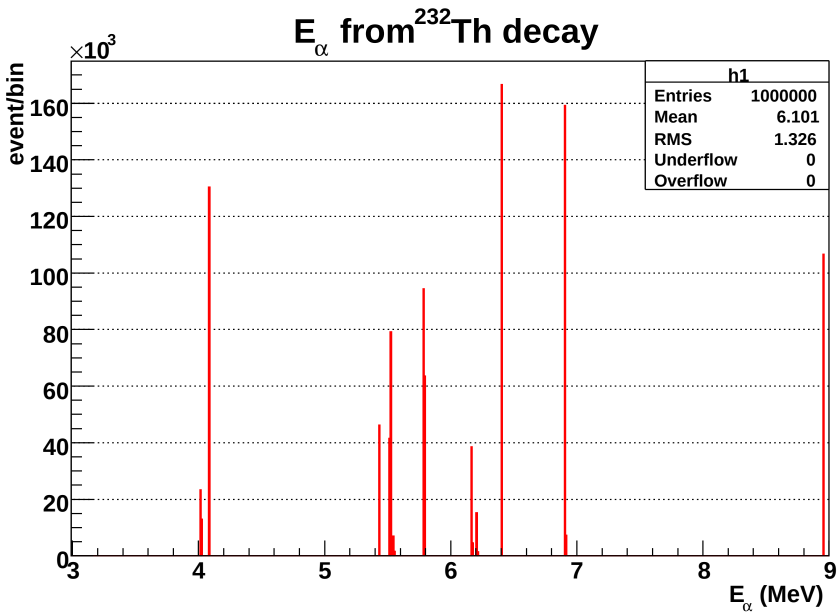




So for O18, take the summed cross section for all excited final state (Ne21). No excited state data available for Si29 and Si30 from the database. Take the total (α,n) cross sections as (α,nγ). **In both case, this is clearly an overestimate.**

Alpha energy spectra from U/Th





Calculation Procedure

I. GEANT 4 simulation. Generate alphas from U/Th

II. Track alpha particle

III. Each step, calculate **$weight_{step} = \sigma(E_\alpha)\times d_{step}$**

IV. Each event, **$weight_{event} = \Sigma\, weight_{step}$**

V. Get the average **$\langle weight_{event}\rangle$**

$$Yield_{\alpha,n} = \frac{\rho \times f_{mass} \times f_{abund} N_a}{A} \langle weight_{event} \rangle$$

ρ: density of material

f_{mass}: mass fraction of a given element

f_{abund}: natural abundance of a nuclei

N_a: Avogadro's number

A: atomic mass of a nuclei

Yield results

Do rock only, PMT glass should be very similar

ρ: 2.7 g/cm^3

f_{mass}: 0.485 (O), 0.343 (Si)

		<σd>(barn cm)	d(cm)	Yieldα,n
U	O18	3.0E-4	2.2E-3	2.6E-8
	Si29	4.2E-5	2.2E-3	3.8E-8
	Si30	6.1E-5	2.2E-3	3.5E-8
Th	O18	5.0E-4	2.6E-3	4.3E-8
	Si29	7.9E-5	2.6E-3	7.1E-8
	Si30	1.3E-4	2.6E-3	7.4E-8

The range of alpha seems to be off by a factor of 2 to the well-known (0.01g/cm^2). Need more cross-checks. For now I multiply the yield in the above table by 2 to "fix this".

Sum up all three nuclei: Y(U) = 2.0e-7, Y(Th)=3.8e-7 (a factor 2 correction to the alpha range applied!)

Final Rates

Use the method described in page 1, scale the CDR rates for the two chains

$$R_{final} = R_{bkg,CDR} \times Yield_{alpha,n} \times ratio_{fission}$$

	$R_{bkg,CDR}$ (Hz)	$Yield_{alpha,n}$	$Ratio_{fission}$	R_{final} (/day)
U	2.85	2.00E-7	9.7	0.48
Th	3.6	3.80E-7	4.7	0.56

So the upper limit of the high energy gamma rate due to (alpha,n) from U/Th chains is about 1/day/module , significantly less than those from cosmogenic beta emitters. See CDR table 3.7, DYB (210), LA(141), Far(14.6) per day.