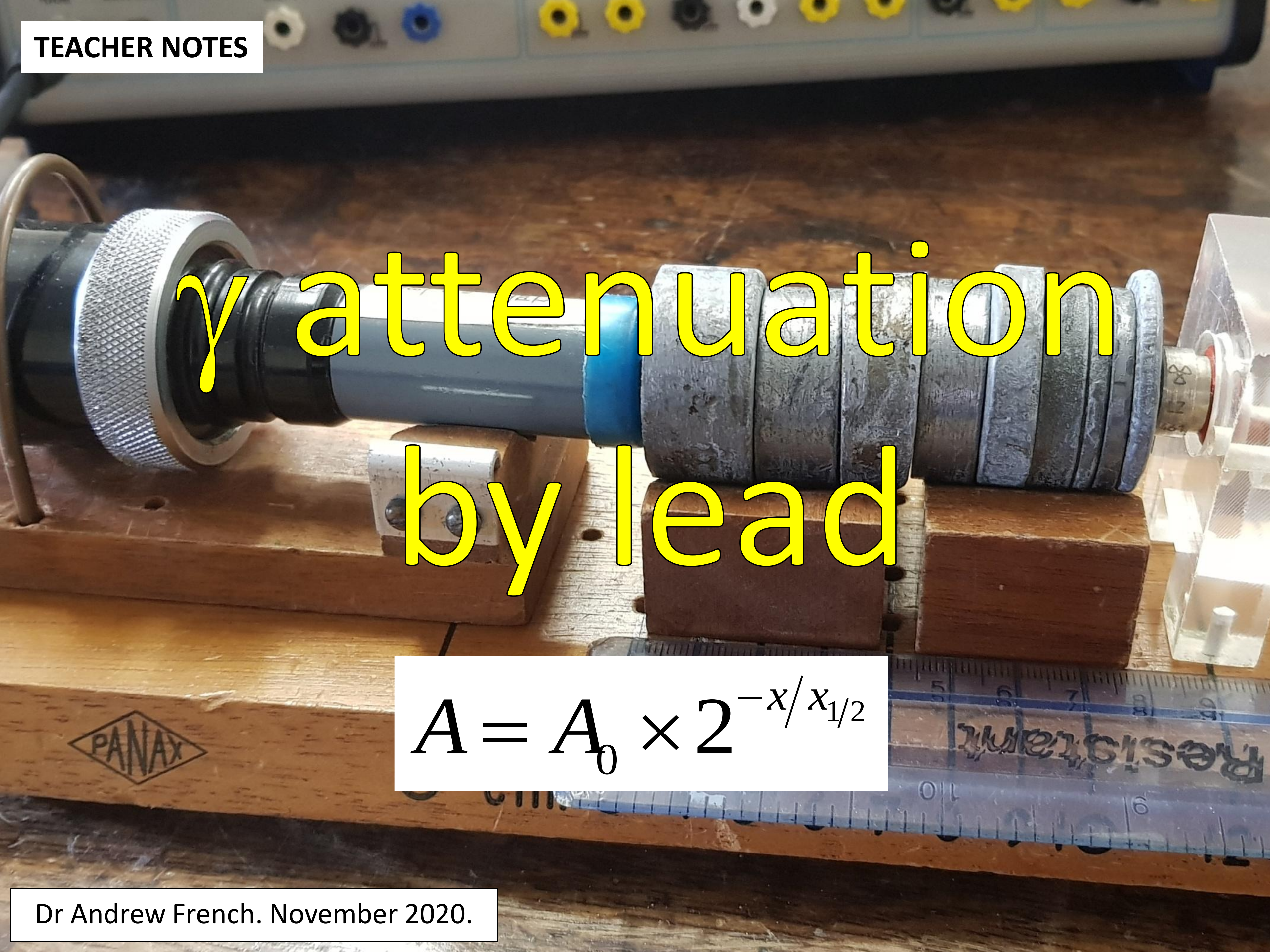
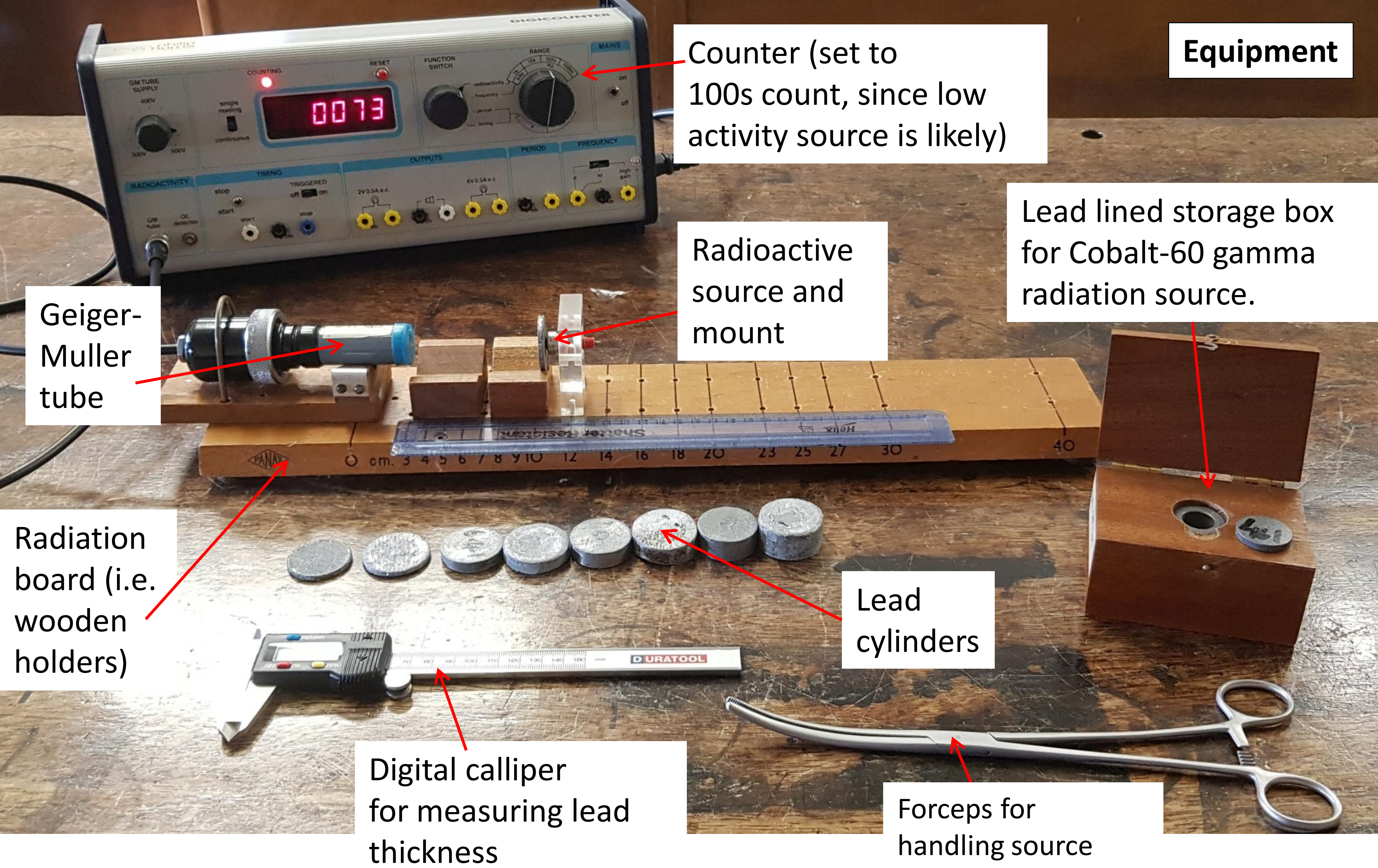
TEACHER NOTES

γ attenuation by lead

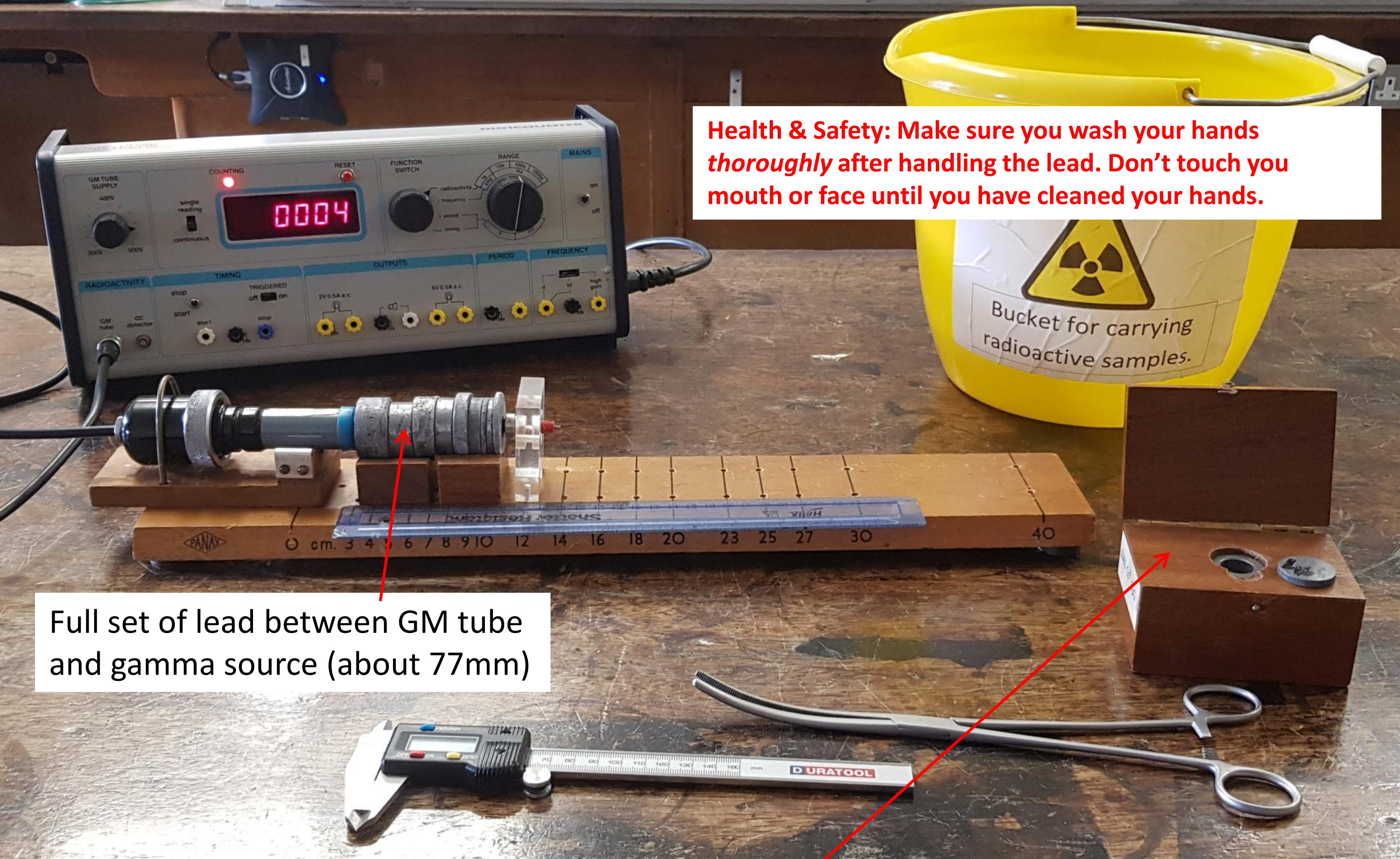
$$A = A_0 \times 2^{-x/x_{1/2}}$$



Dr Andrew French. November 2020.



Maintain a source to GM tube separation of about 8cm. Note gamma radiation power will disperse in an *inverse-square fashion*, so to investigate the effect of lead absorption, the source to detector distance must be fixed, but large enough to accommodate the lead.



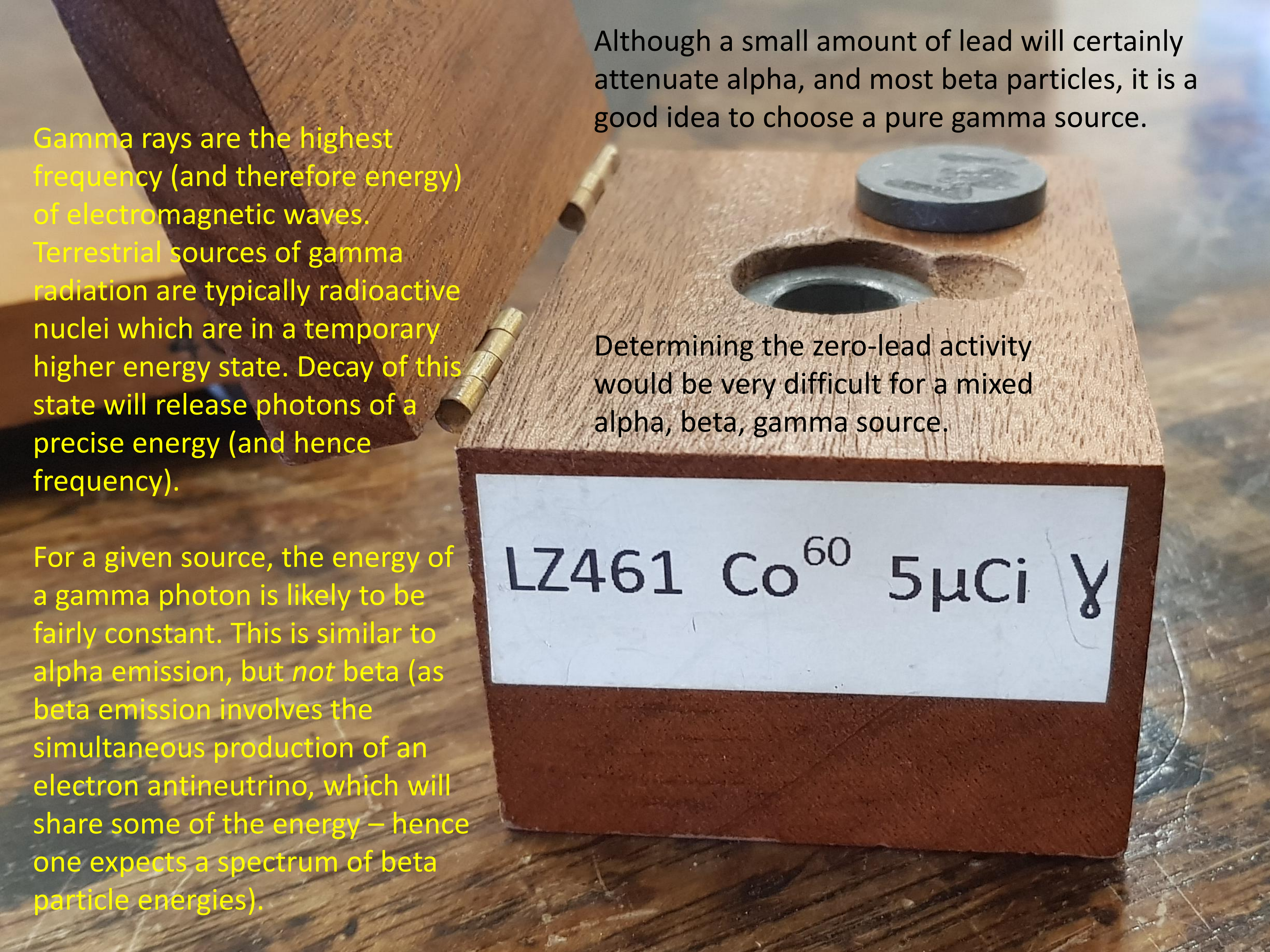
Health & Safety: Transport radioactive sources in their lead lined official container, and carry these from the radioactive store cupboard in an obvious container (!) Don't forget to sign out and sign in sources as per your institution's policy. Handle sources using the forceps, and not too close to your body for prolonged periods. Take *appropriate precautions*, but remember that the radioactive power will be *very small* for these educational sources. It is quite safe to use the sources in a normal laboratory context if you follow the usage rules in your radioactive sources risk assessment.

Although a small amount of lead will certainly attenuate alpha, and most beta particles, it is a good idea to choose a pure gamma source.

Gamma rays are the highest frequency (and therefore energy) of electromagnetic waves. Terrestrial sources of gamma radiation are typically radioactive nuclei which are in a temporary higher energy state. Decay of this state will release photons of a precise energy (and hence frequency).

Determining the zero-lead activity would be very difficult for a mixed alpha, beta, gamma source.

For a given source, the energy of a gamma photon is likely to be fairly constant. This is similar to alpha emission, but *not* beta (as beta emission involves the simultaneous production of an electron antineutrino, which will share some of the energy – hence one expects a spectrum of beta particle energies).



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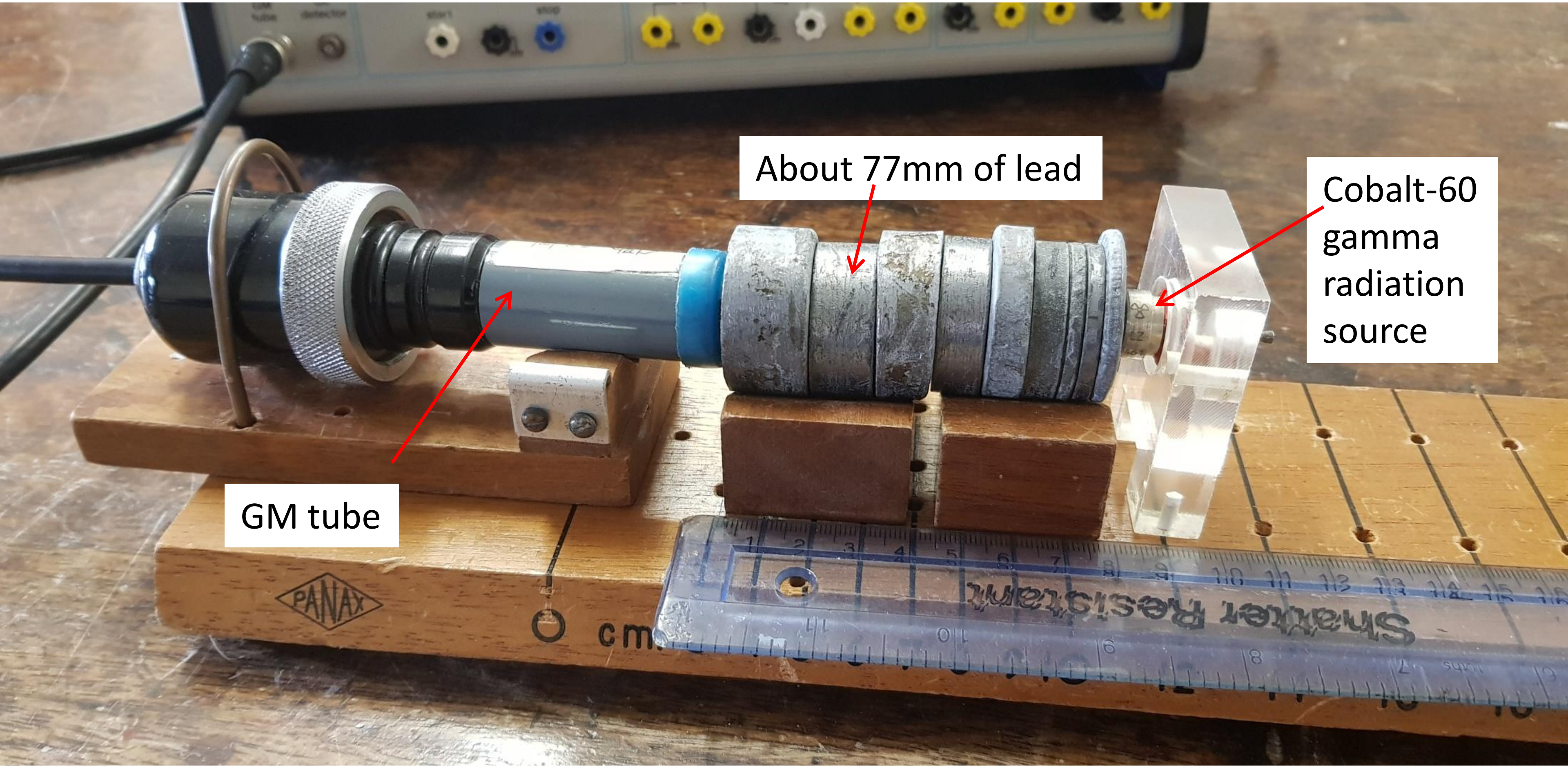
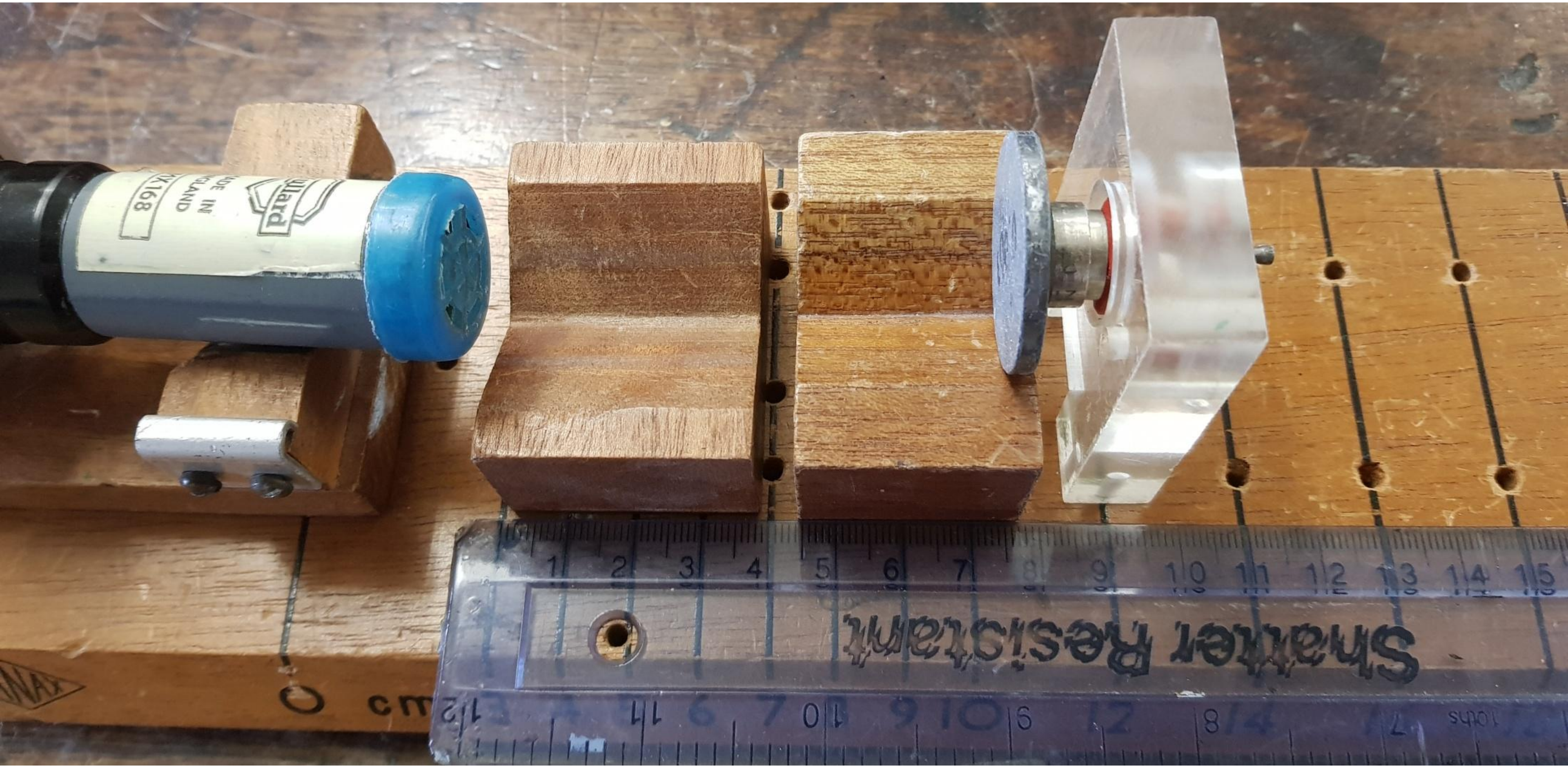


About 77mm of lead
Cobalt-60 gamma radiation source
GM tube

Record 3x100s of counts **without the source** to obtain the **background activity.**



Record the number of radiation counts, three times (and then average) for each added lead cylinder. Record the counts per 100s, and then divide by 100, **then subtract the background level**, to obtain the **Activity** A in Becquerels (Bq).

Maintain a constant separation of source to GM tube detector of about 8cm.

GAMMA RAY ATTENUATION BY LEAD

Andy French. Winchester College. P1. 2/11/2020

Counts per 100s. Source: LZ461 Cobalt-60 5 microcurie pure gamma.
Fixed GM tube to source distance of 77mm.

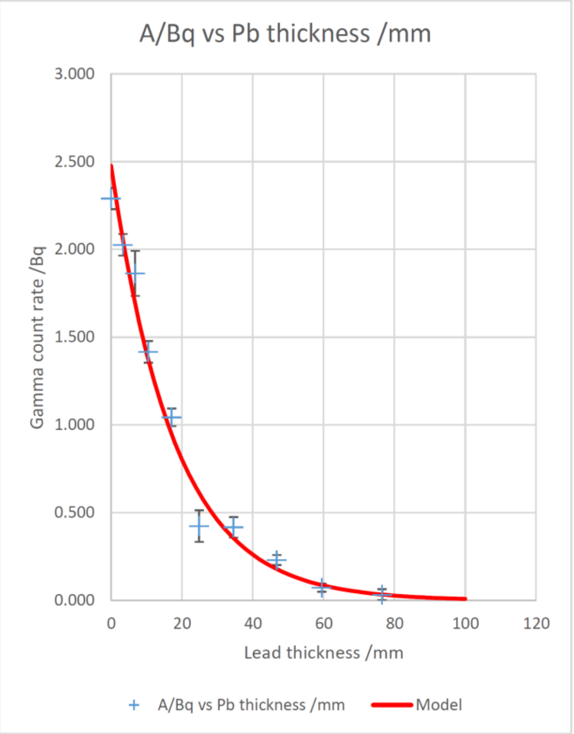
	Counts per 100s			Background subtracted		
Lead thickness /mm	**A1**	**A2**	**A3**	**Mean A/Bq**	**A standard deviation**	**ln(A/Bq)**
0	270	267	256	2.290	0.060	0.829
3.35	230	239	245	2.027	0.062	0.706
6.78	205	224	236	1.863	0.128	0.622
10.54	169	178	184	1.417	0.062	0.348
17.08	145	141	133	1.043	0.050	0.042
24.86	74	69	90	0.423	0.090	-0.860
34.59	79	83	69	0.417	0.059	-0.875
46.79	58	62	55	0.230	0.029	-1.470
59.52	46	41	41	0.073	0.024	-2.613
76.54	37	36	43	0.033	0.031	-3.401

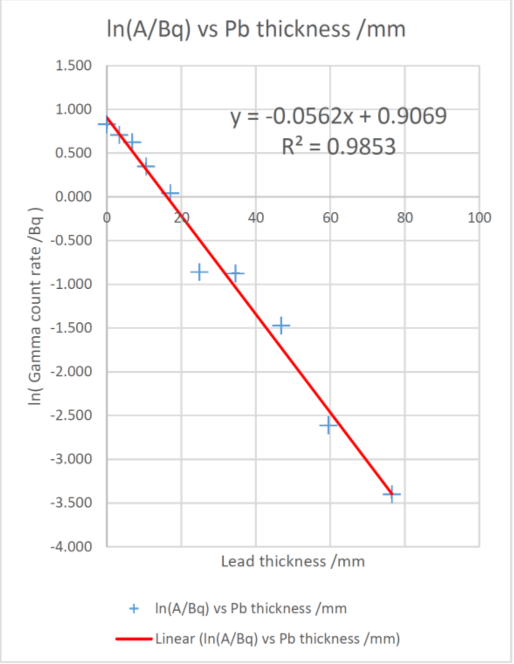
Background count (100s) i.e. without source.

29	36	41

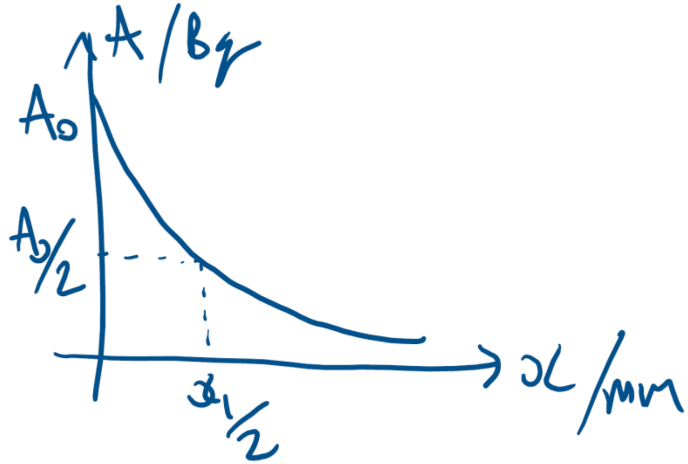
Mean background (Bq)

0.353	**HALF THICKNESS /mm**	**12.33**	**A0 /Bq**	**2.477**

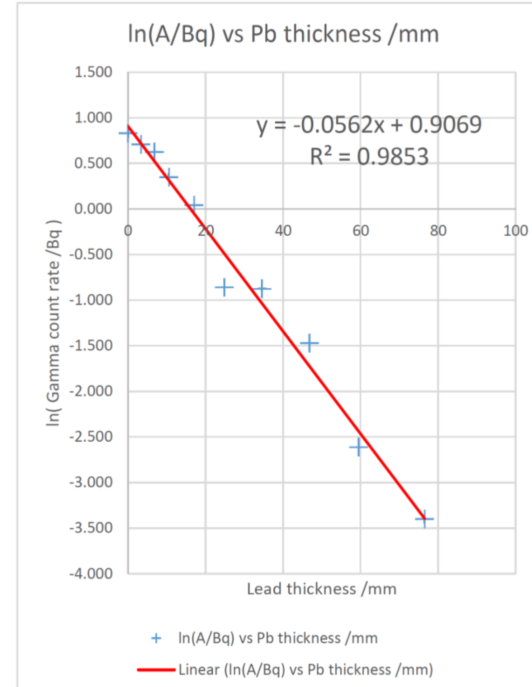




$$\boxed{A = A_0 / 2^{x/x_{1/2}}}$$



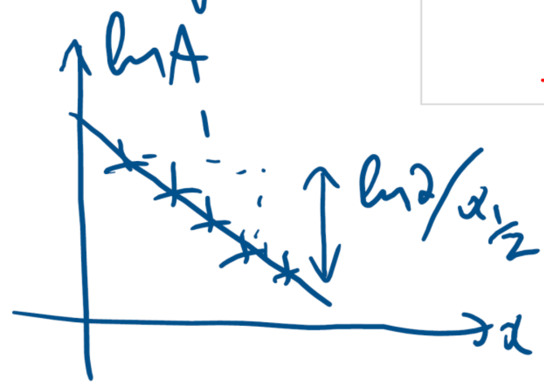
Half thickness of Pb



$$2^{x/x_{1/2}} = A_0/A$$

$$\frac{x}{x_{1/2}} \ln 2 = \ln A_0 - \ln A$$

$$\boxed{\ln A = \ln A_0 - \frac{\ln 2}{x_{1/2}} x}$$



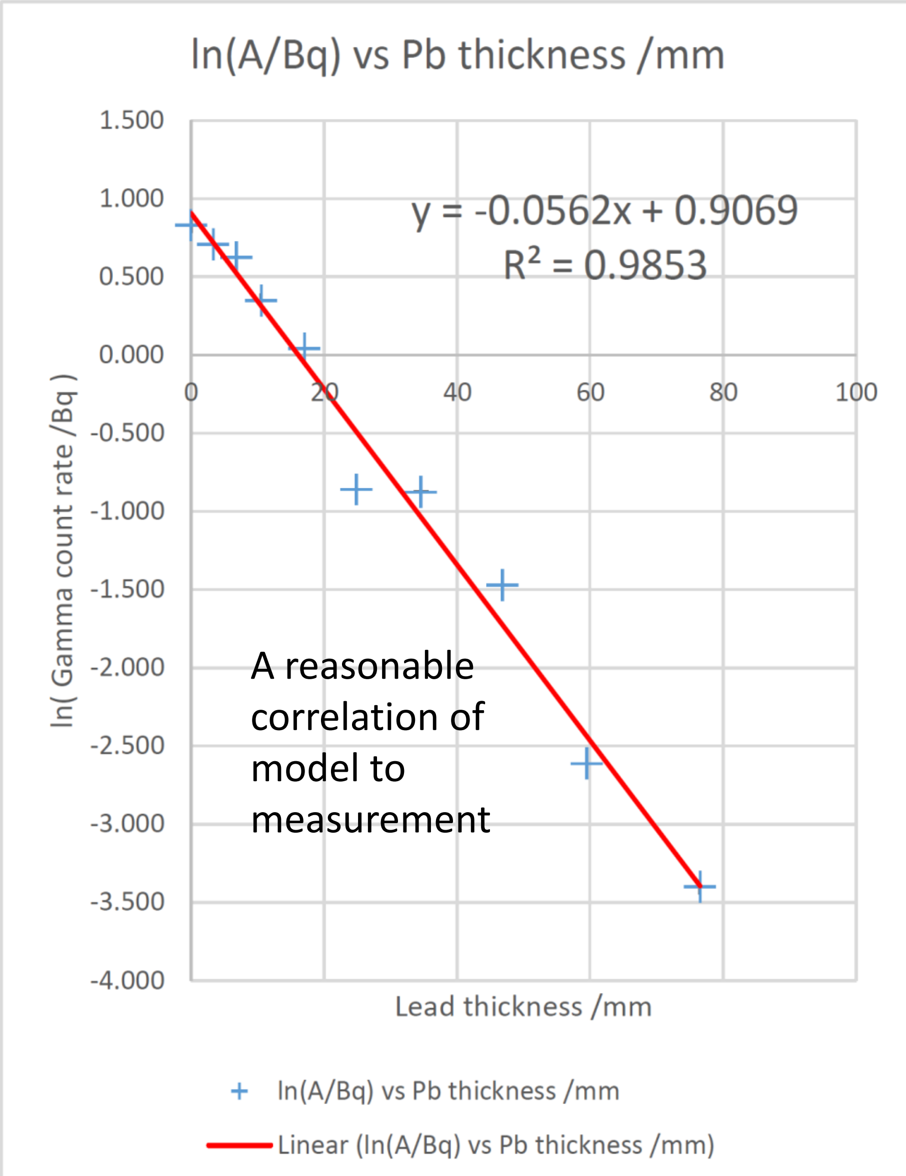
In our case: $\ln(A/Bq) = -0.0562x + 0.9069$

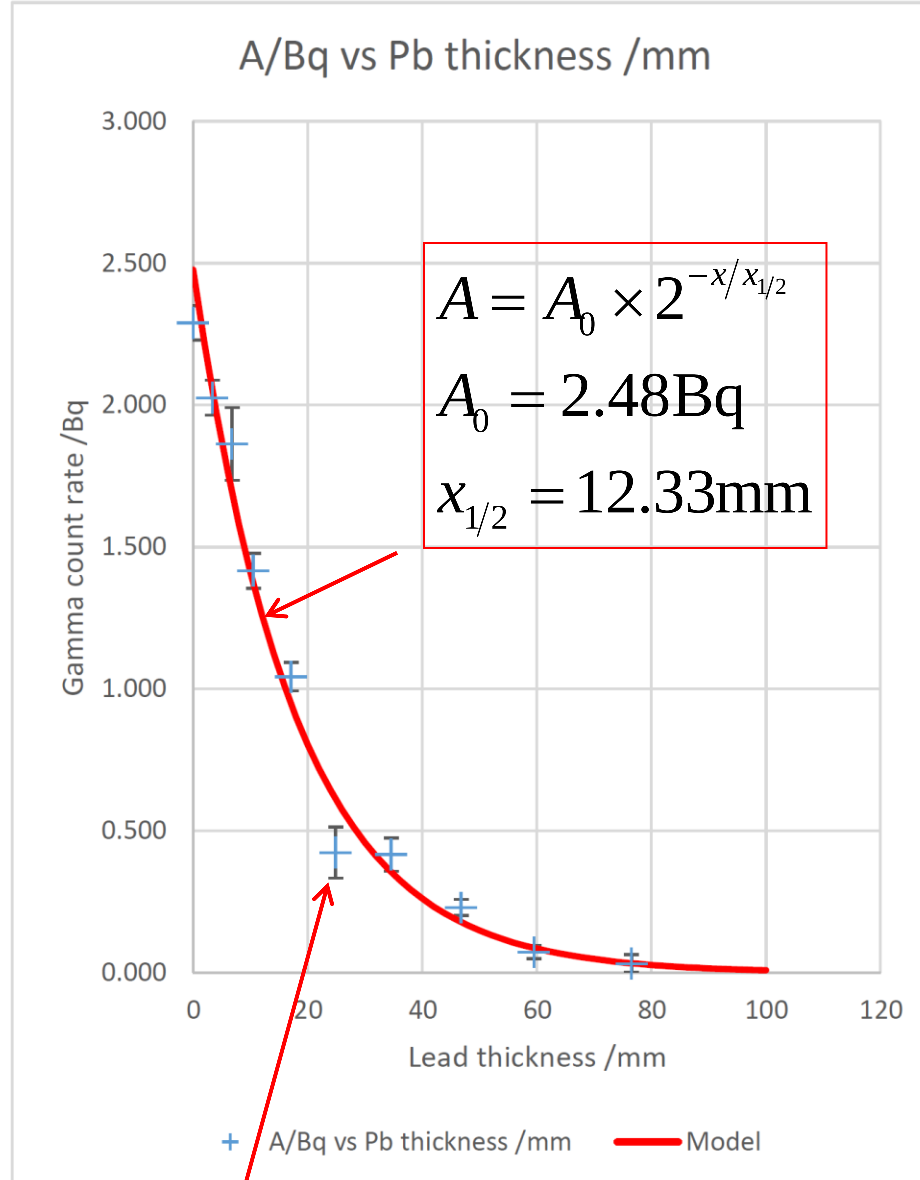
$\therefore \quad A_0 = e^{0.9069}$ 2.477

$x_{1/2} = \frac{\ln 2}{0.0562}$

$=$ 12.33

i.e. we anticipate an **exponential decay** of detected gamma activity with lead thickness.





(Vertical) error bars from the standard deviation of the activity counts.