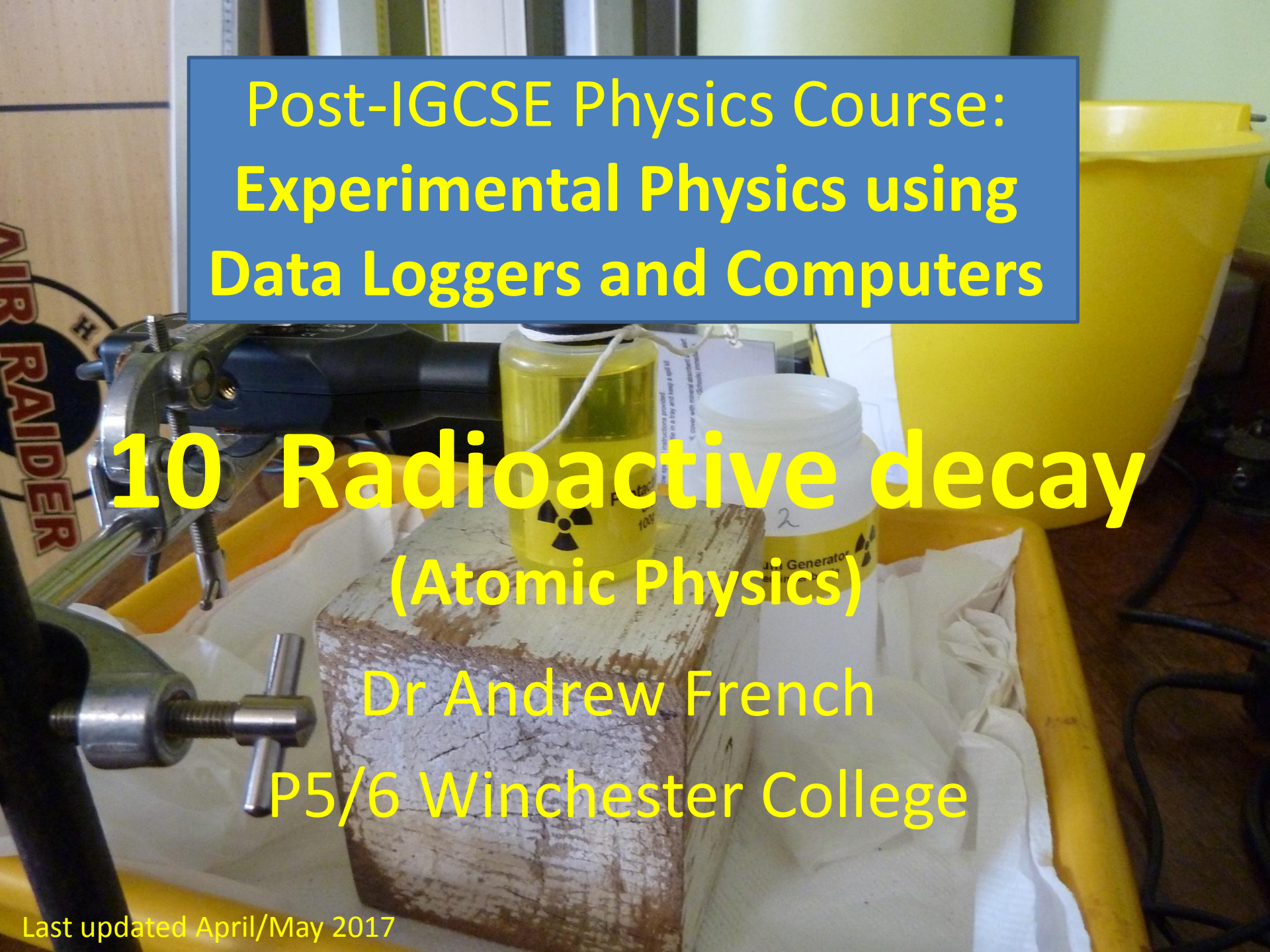


Post-IGCSE Physics Course:
Experimental Physics using Data Loggers and Computers

10 Radioactive decay

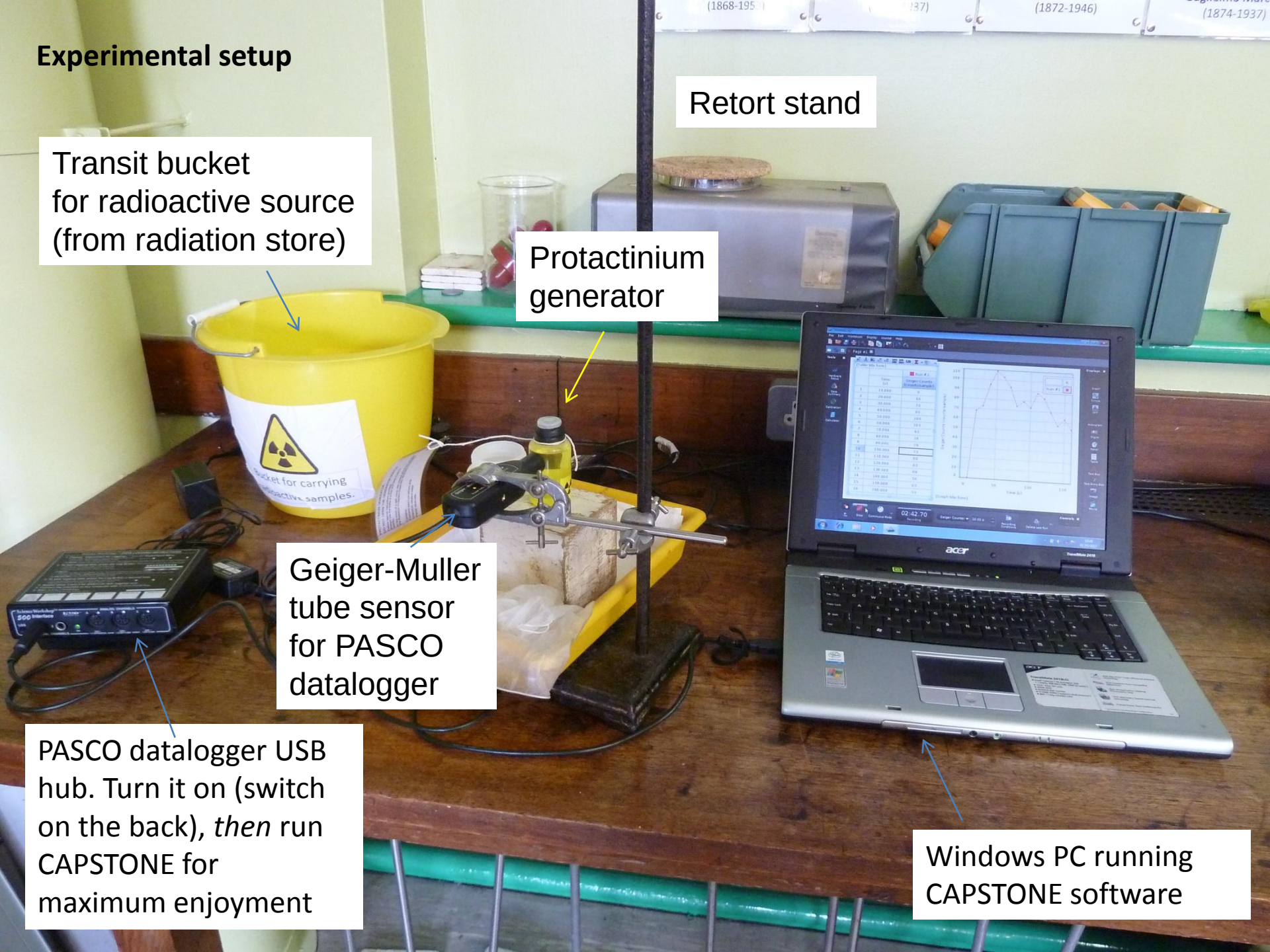
(Atomic Physics)

Dr Andrew French

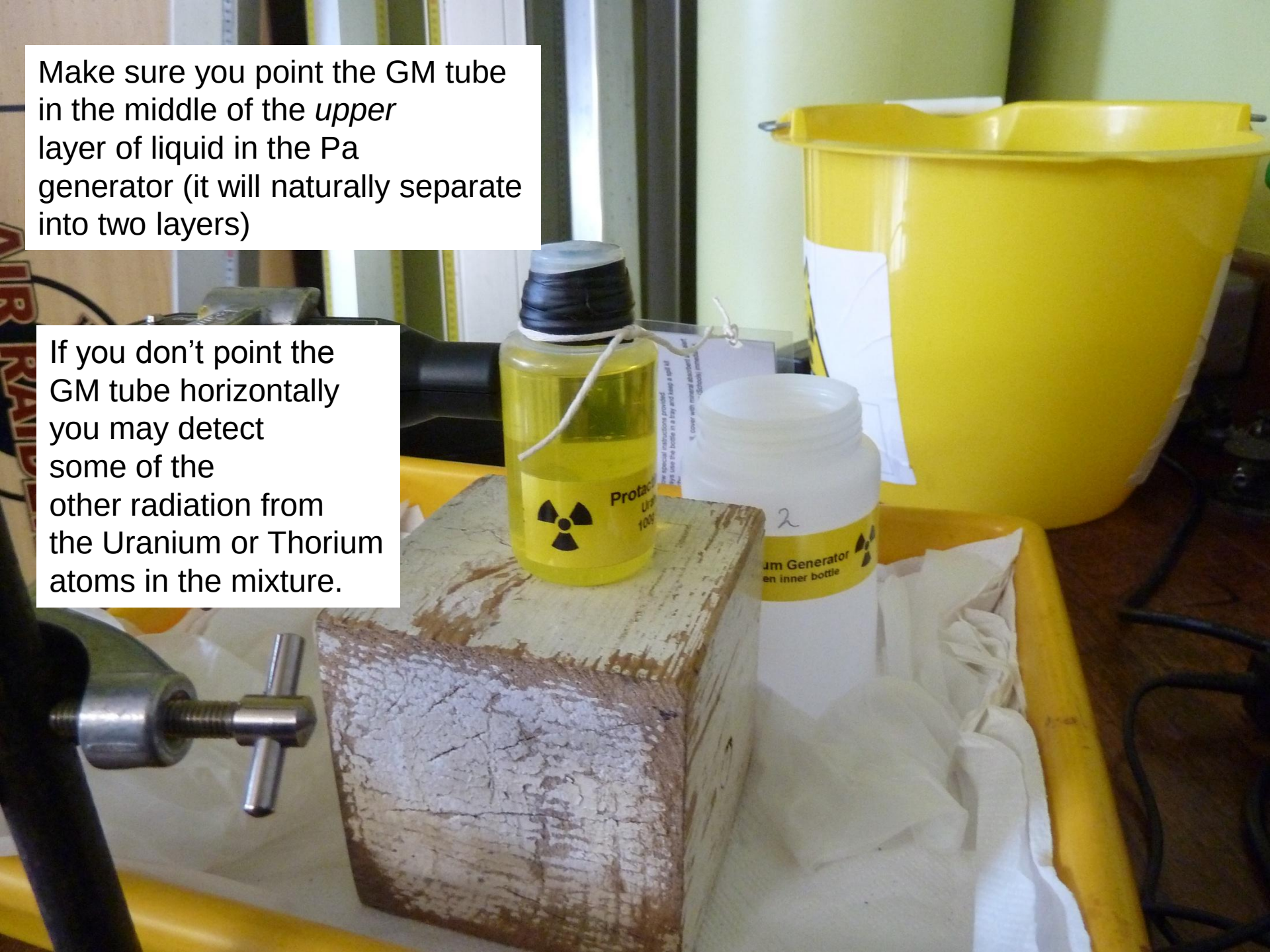
P5/6 Winchester College

Last updated April/May 2017

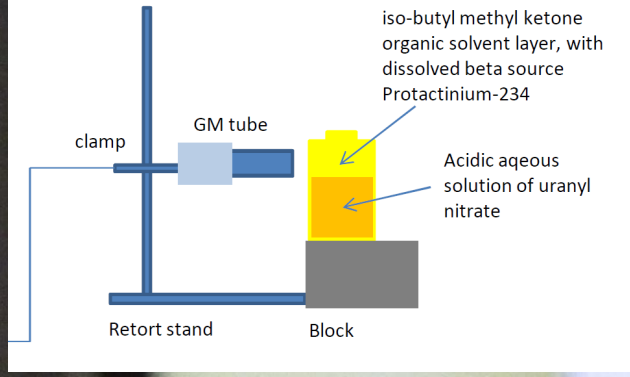
Experimental setup




Bucket for carrying

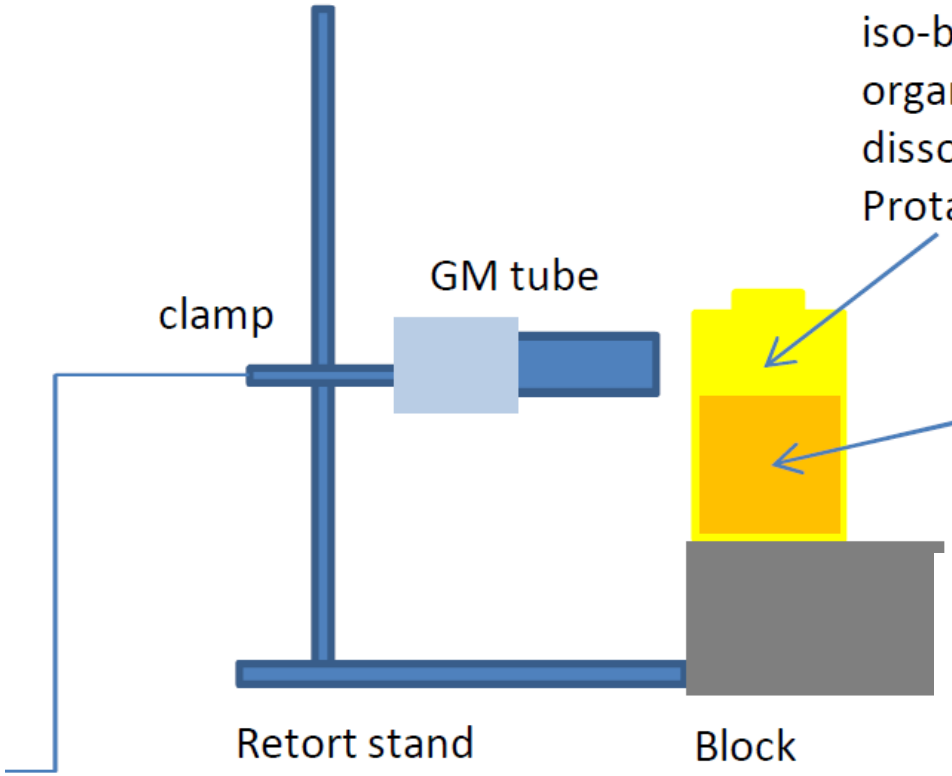

Make sure you point the GM tube in the middle of the *upper* layer of liquid in the Pa generator (it will naturally separate into two layers)
If you don't point the GM tube horizontally you may detect some of the other radiation from the Uranium or Thorium atoms in the mixture.

GM tube in operation



Organic solvent layer
-the only one which will dissolve molecules with the the beta source Pa-234

Lower layer
which will contain the Uranium and Thorium radioactive atoms.
Don't point the GM tube at them!



Shake bottle before use to introduce Protactinium into solvent layer. The other atoms in the decay chain are not soluble in this layer.

$$^{238}_{92}\mathrm{U} \rightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\alpha$$

$$^{234}_{90}\mathrm{Th} \rightarrow {}^{234}_{91}\mathrm{Pa} + {}^{0}_{-1}\beta$$

$$^{234}_{91}\mathrm{Pa} \rightarrow {}^{234}_{92}\mathrm{U} + {}^{0}_{-1}\beta$$

Note Thorium-234 has a half life of 24 days. Uranium-238 and Uranium-234 have long half lives of 4.5 billion years and 246,000 years respectively, so their activity can be assumed to be constant!

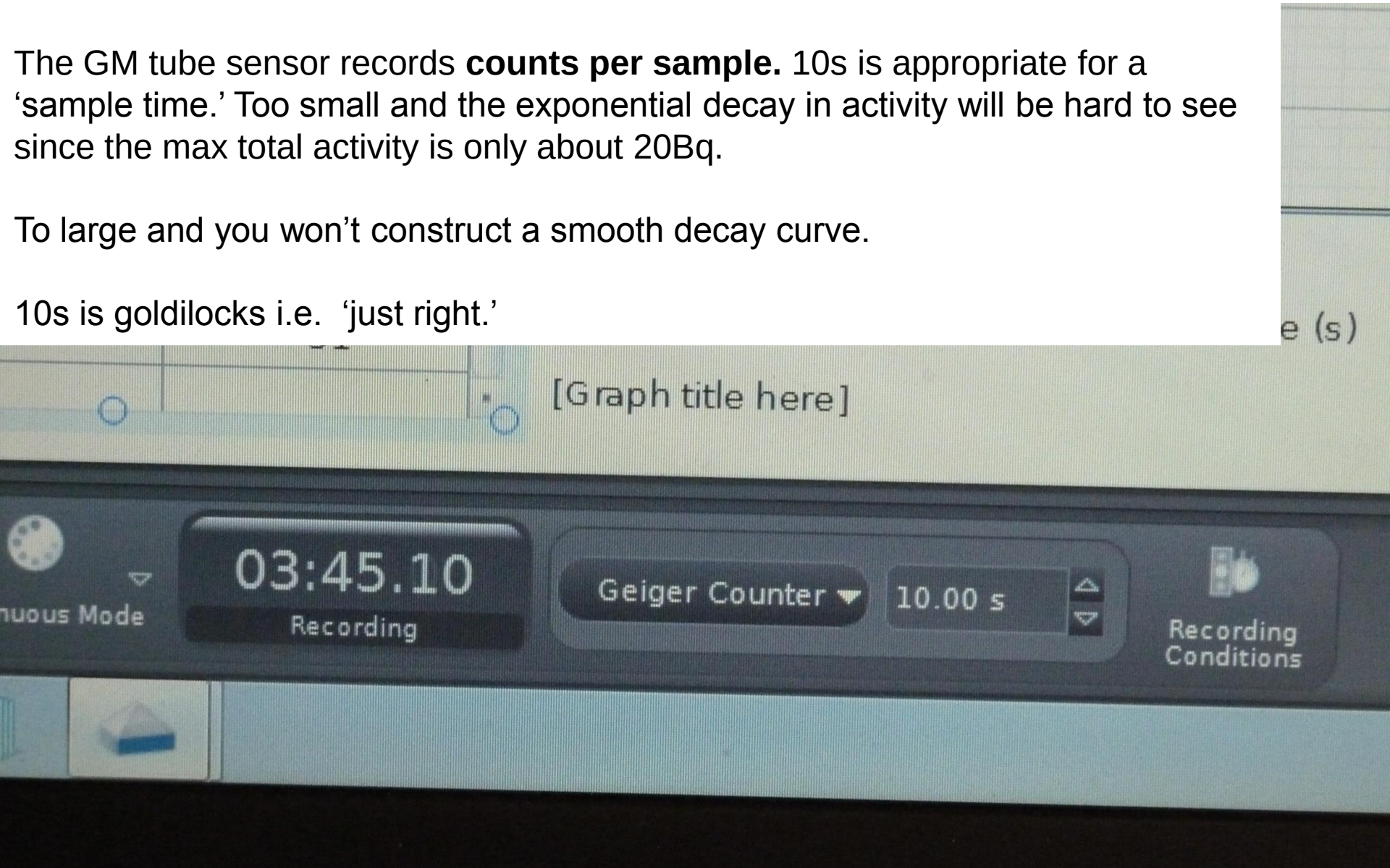
Run the CAPSTONE software and bring up a **table and graph.**

Check the **GM tube detector** is associated with the USB hub by clicking on **Hardware Setup.** (Click on the active port if a radiation symbol is not present).

The GM tube sensor records **counts per sample.** 10s is appropriate for a ‘sample time.’ Too small and the exponential decay in activity will be hard to see since the max total activity is only about 20Bq.

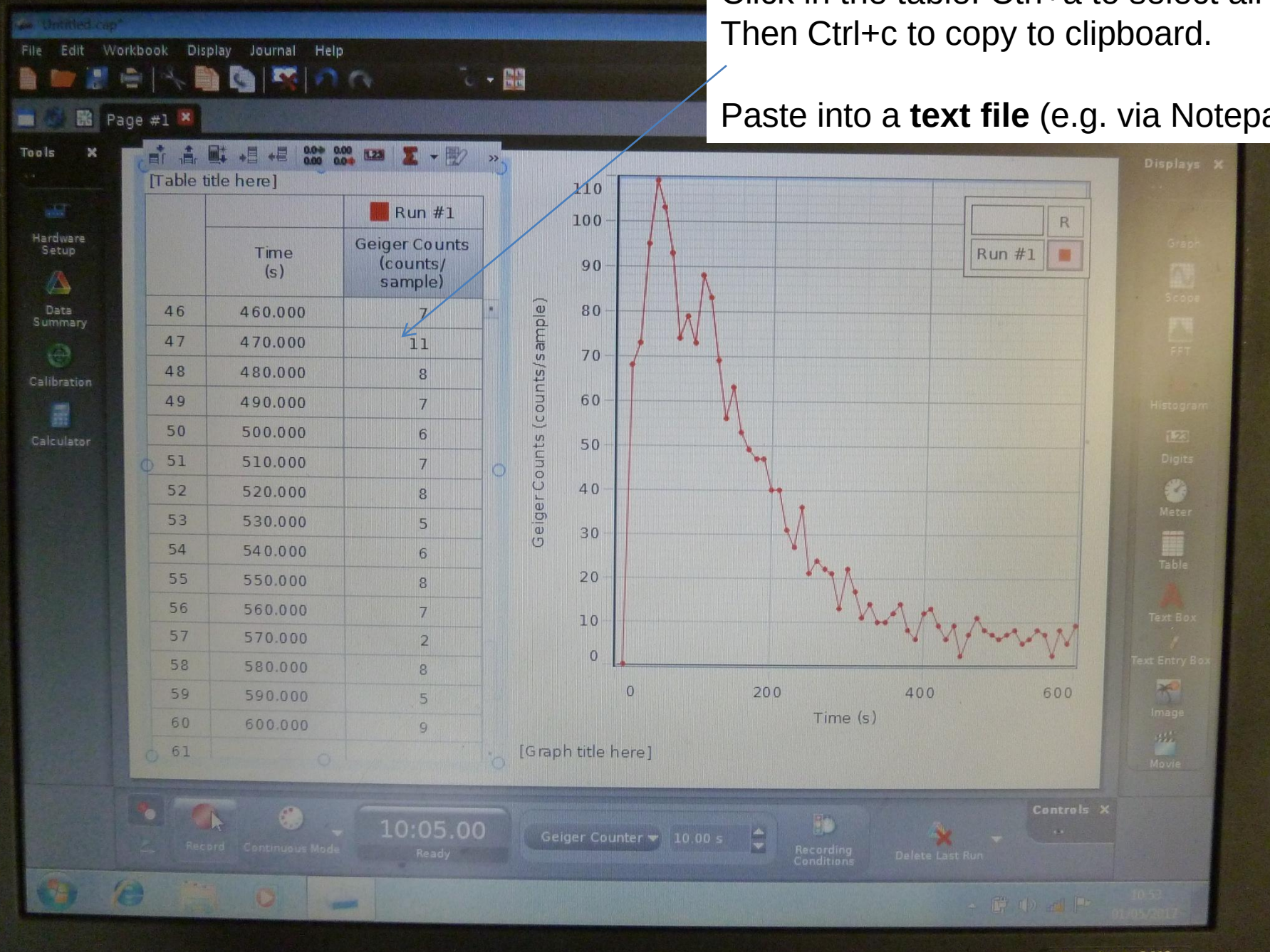
To large and you won’t construct a smooth decay curve.

10s is goldilocks i.e. ‘just right.’



Click in the table. Ctrl+a to select all
Then Ctrl+c to copy to clipboard.

Paste into a **text file** (e.g. via Notepad)



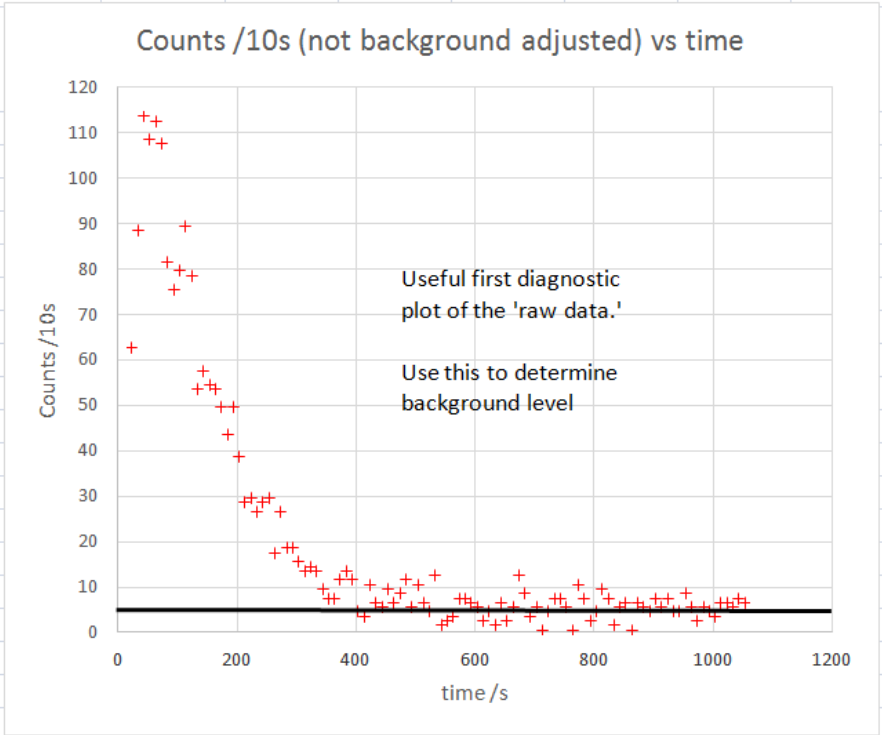
Drag the text file into an **Excel** window to import the data.
It will already be space (or tab?) delimited. Excel is smart enough to put it into columns, so don't edit the text file. Just drag it in.

Plot graphs, work out logarithms etc to work out the background rate and then the half life.

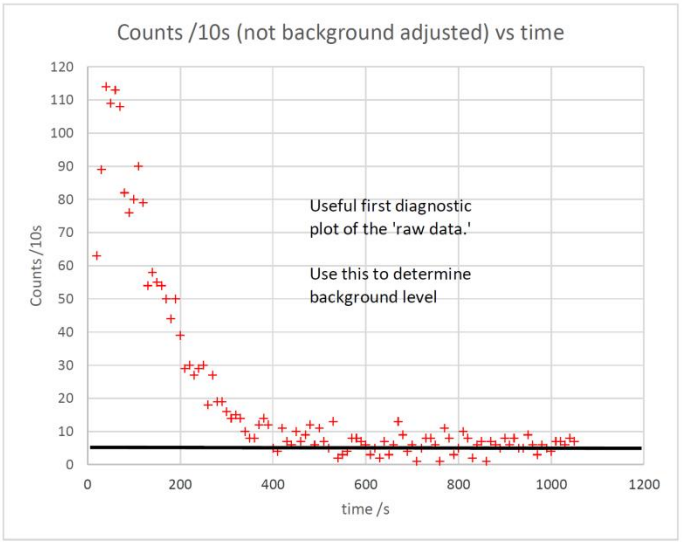
Half life of Protactinium. 2nd May 2017.
Winchester College. Lab P6.

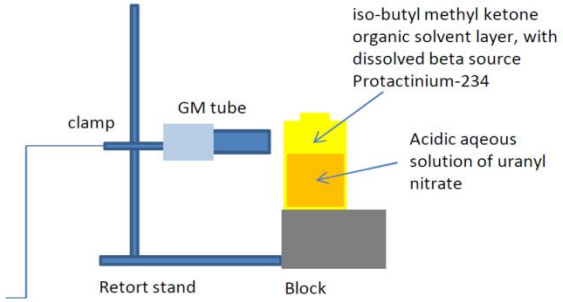
Background /Bq	0.5

Time (s)	Geiger Counts (counts/10s)	Activity /Bq (background adjusted)	ln(Activity)	MODEL of activity
10	0	-0.5	#NUM!	18.61
20	63	5.8	1.758	16.94
30	89	8.4	2.128	15.43
40	114	10.9	2.389	14.04
50	109	10.4	2.342	12.79
60	113	10.8	2.380	11.64
70	108	10.3	2.332	10.60
80	82	7.7	2.041	9.65
90	76	7.1	1.960	8.79
100	80	7.5	2.015	8.00
110	90	8.5	2.140	7.28
120	79	7.4	2.001	6.63
130	54	4.9	1.589	6.04
140	58	5.3	1.668	5.50
150	55	5	1.609	5.01
160	54	4.9	1.589	4.56
170	50	4.5	1.504	4.15
180	44	3.9	1.361	3.78
190	50	4.5	1.504	3.44



Background /Bq	0.5

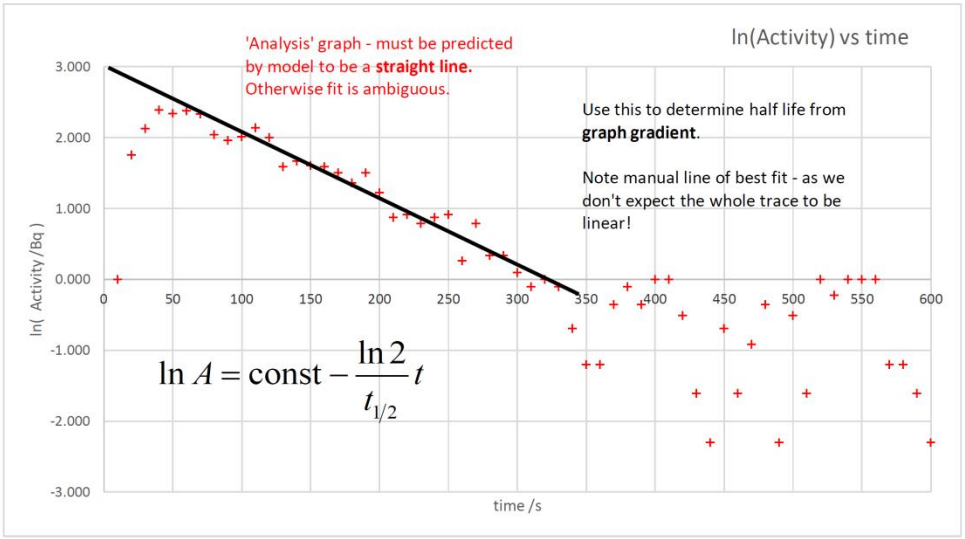




$$^{238}_{92}\mathrm{U} \rightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\alpha$$
$$^{234}_{90}\mathrm{Th} \rightarrow {}^{234}_{91}\mathrm{Pa} + {}^{0}_{-1}\beta$$
$$^{234}_{91}\mathrm{Pa} \rightarrow {}^{234}_{92}\mathrm{U} + {}^{0}_{-1}\beta$$

Shake bottle before use to introduce Protactinium into solvent layer. The other atoms in the decay chain are not soluble in this layer.

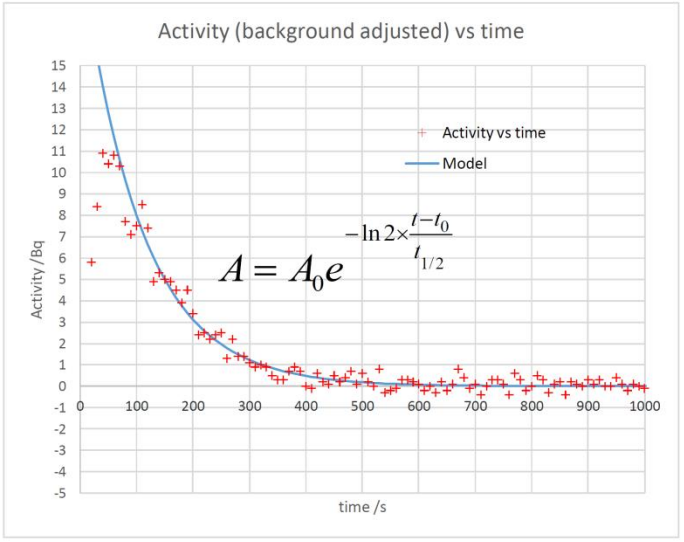
Note Thorium-234 has a half life of 24 days. Uranium-238 and Uranium-234 have long half lives of 4.5 billion years and 246,000 years respectively, so their activity can be assumed to be constant!



MODEL

half life /s	73.9
A0 /Bq	8
t0 /s	100

i.e. background adjusted activity at t0



gradient	0.009375
half life /s	73.9

A nice final graph is the (processed) data *overlaid with the model.*

The 'degree of fit' will come from the straight line graph. This one is to summarize your understanding and help communicate your results clearly.