System theremino

Geiger tubes

Geiger tubes

To each tube are indicated: sensitivity, spurious counts caused by the intrinsic radioactive background, approximate price and any notes.

Geiger tubes from old stock Russian military

STS-5
Sens: 24 CPS/mR/h
Bkg: 0.25 CPS
Price 15 €
Voltage: 400 volts
Nominal resistor: 5.6 mega
Rays: Beta + Gamma

SBM-20
Sens: 24 CPS/mR/h
Bkg: 0.4 CPS
Price 20 €
Voltage: 400 volts
Nominal resistor: 5.6 mega
Rays: Beta + Gamma

SI-29BG
Sens: 18 CPS/mR/h
Bkg: 0.15 CPS
Price 25 €
Voltage: 400 volts
Nominal resistor: 5.6 mega
Rays: Beta + Gamma

American Geiger tubes of recent production

LND 712
Sens: 18 CPS/mR/h
Bkg: 0.15 CPS
Price 60 €
Voltage: 500 volts
Nominal resistor: 10 mega
Rays: Alpha + Beta + Gamma

Note:
Not very sensitive, sensitivity to UV Alfa builds him up a bit, but ultimately is not much better Russian tubes.

LND 7312
Sens: 60 CPS/mR/h
Bkg: 0.5 CPS
Price 150 €
Voltage: 500 volts
Nominal resistor: 4.7 mega
Rays: Alpha + Beta + Gamma

Note:
Large, heavy and delicate (diameter 53 mm)
Expensive and difficult to assemble.

Makes it approximately twice as all other Geiger and even up to ten times if the source emits primarily alpha rays.

The advantage that is achieved in practice is only a shortening of the measurement time and does not justify the expense and the sensitivity of this sensor except for laboratory applications.

Characteristics of the Geiger tubes

The most common Geiger tubes, which are also the best, are collected in this list with their main characteristics.

Sensor	Sensitivity (Cps/mR/h)	BKG (Cps)	Dead Time (US)	Operating voltage (Volt)	Limiting resistance (Mega)	Wall material density (mg/cm2)	Active area length (mm)	Active area diam. (mm)	Active area (cm2)	Length or depth / diameter (mm / mm)	Price approx. (Euro)
4xSBM20	116	0.80	190	400	4.7	40	90	---	36	---	80
SI-8B	111	1.00	160	400	4.7	---	---	---	30	20 / 80	85
LND7312	60	0.35	40	500	4.7	1.8	13	44	20	13 / 54	120
2xSBM20	58	0.40	190	400	4.7	40	90	---	18	---	40
VA-Z-115-1	32	0.06	150	450	4.7	35	27	---	---	52 / 13	25
SBM20	29	0.20	190	400	4.7	40	90	10	9	108 / 11	20
STS5	29	0.16	190	400	4.7	40	90	10	9	110 / 11	18
SI-29BG	18	0.07	95	400	4.7	---	---	---	---	55 / 11	20
LND712	18	0.10	90	500	10	1.8	38	9	3.5	49 / 15	70
GMT-01	18	0.10	90	500	10	1.8	38	9	3.5	49 / 15	70

All Geiger tubes have a very broad range of operating voltage, for example the LND712 can operate from 325 volts up to 650 volts and over.

Even far surpassing the maximum voltage does not damage the tubes, provided that the current is limited with the right resistor.

Remains necessary to stabilize well the supply voltage so as to ensure a constant sensitivity.

To ensure a long life to the Geiger tube and does not degrade the character of Dead-Time is important to keep a very low capacity anode tube (connection between the resistor and the positive pole of the tube) so no connectors or wires shielded and the maximum length of the wire Connection of a few centimeters.

Calibration of Geiger tubes

The values "Sensitivity", "BKG" and "DeadTime" indicated, and those listed in the application ThereminoGeiger are just a starting point.

If you do not perform an **individual calibration of each probe,** measurements will be affected by errors of +/-10% or more. In the zone of low energies, the errors will also be increased because of the large variability of the pulses of Background, from tube to tube and of their strong dependence on the supply voltage. When measuring to the bottom environment can be expected errors beyond the +/- 50%

If you want to get maximum precision (About +/- 5%), **each probe must be calibrated individually**, Not the individual tubes geiger, but the complete probe.

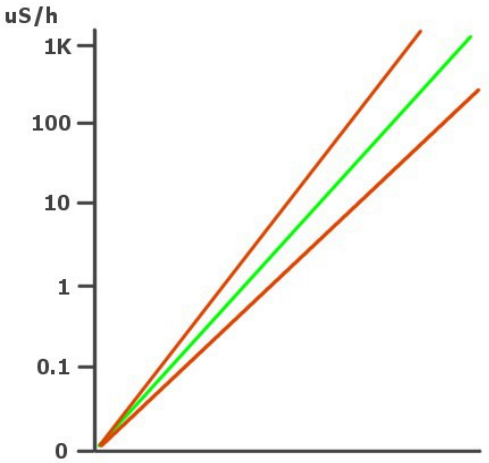
A probe consists of one or more tubes in parallel and by its GeigerAdapter, that **must be permanently connected to the tubes**.

After making the adjustment it is recommended to write the three values on the back of the probe and possibly give it a unique name and add a line in the file "Sensor_Data.txt" accessible from the application "ThereminoGeiger" with "Help / Open the program folder / Extra "

After a calibrated probe should not be more trade his GeigerAdapter and his Geiger tubes with others. The GeigerAdapter are set to a voltage of about 20% lower than the central plateau of the tubes, so as to minimize the pulses of the background (380 volts instead of 400 nominal). But every GeigerAdapter has a slightly different voltage (+/- about 5%) and this affects the pulse Background. Even greater is the variability of the BKG by a Geiger tube to another. Tubes of the same model, but a lot different, may have a value of BKG also double than others.

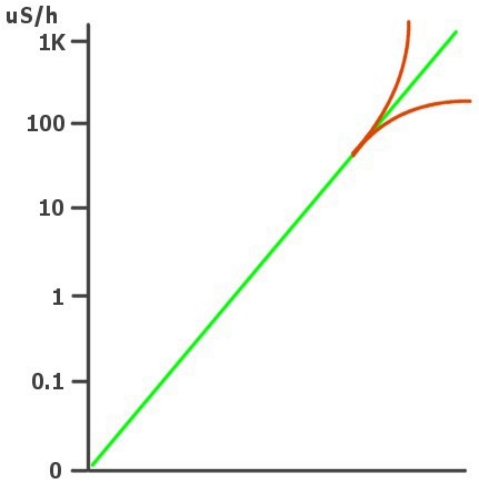
The three calibration values and their effect

The values "Sensitivity", "DeadTime" and "BKG" have different effects and their inaccurate adjustment causes errors in different parts of the measuring range.



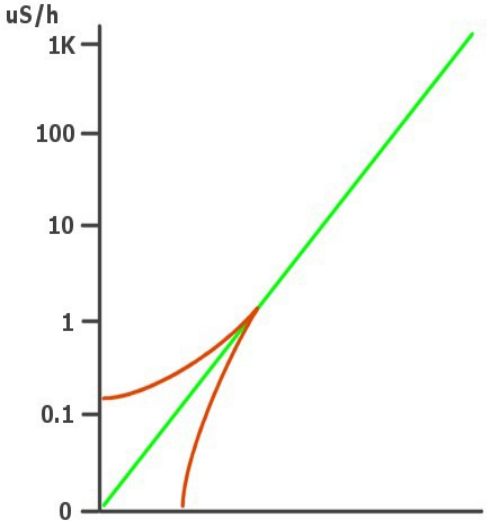
With a perfect setting you should get the green line.

The two red lines indicate the effect of incorrect calibration of the parameter "Sensitivity".



The two red lines indicate the effect of incorrect calibration of the parameter "DeadTime"

The parameter Dead Time only acts in the upper area.



Here we see the effect of a wrong setting of the parameter "BKG"

The parameter "BKG" is the most important because it acts on the very low radioactivity levels, in the range of the values of the environment background levels.

How to calibrate

Sensitivity

This is the parameter more easy to adjust, just use the value given by the manufacturer of the tube and reported in our tables to obtain a good accuracy.

The sensitivity changes very little from one tube to another or from one batch to another. Also the supply voltage has little effect on the sensitivity (about 10% each 100 volt, if you are in the area of the plateau) for which small manufacturing differences, between a tube and the other, and differences of voltage, between a GeigerAdapter and l 'other, should lead to the maximum variations of +/- 1% in the best conditions. And not more than +/- 5% in the worst cases.

DeadTime

The Dead-Time affects only the upper area of the measuring range (above 100 uS/h), so you can ignore it if you do it only measures the fund's environment and objects weakly radioactive.

The Dead-Time indicated by the manufacturer of the Geiger tube is quite significant. Small differences may occur due to the capacity of the wires and the resistor for current limitation. Measure the Dead-Time with an oscilloscope is easy, but care must be measured at the output of the probe completes, the output jack, not the Geiger tube. If you measure on the tube, the tip of the oscilloscope adds a few pF of capacitance, just the most critical point and the Dead Time stretches. Also, if you measure on the tube, does not take into account the effects of the trip circuit of Geiger Adapter, a Schmitt trigger, which slightly modifies the Dead-Time. Finally, since the output signal is squared, you do not have measurement errors due to the time of ascent and descent of the pulses.

BKG

Warning: talk about the BKG tube, into the BKG environment. A tube placed **in an environment of zero radioactivity**, Continues to give **a certain number of pulses per second, generated by himself**.

The BKG strongly impact on measures of the environment fund and **change much from one tube to another**. The BKG also depends strongly from the supply voltage, from the state of pollution of the tube surface and, for some pipes, also the ambient temperature.

Measure the BKG a tube is difficult and expensive, but you must do so, a penalty of imprecision also +/-50% of the measurements at low radiation levels around 0.1 uS/h, and **these are the measure that matter more, those of environmental radioactivity**.

To measure the BKG of a pipe must, shield, **in all directions,** with at least 30 mm of lead. A screen 30mm eliminates 90% of the gamma radiation from the environment. The remaining 10% relatively little influence on the calibration.

It then adjusts the parameter BKG (in the software Theremino Geiger) to obtain a measure barely visible, very near the top of the scale, 0.01 uS/h.

During this adjustment must be used very long time (at least 30 minutes, preferably several hours), so as to minimize the influence of the randomness in the measured value.

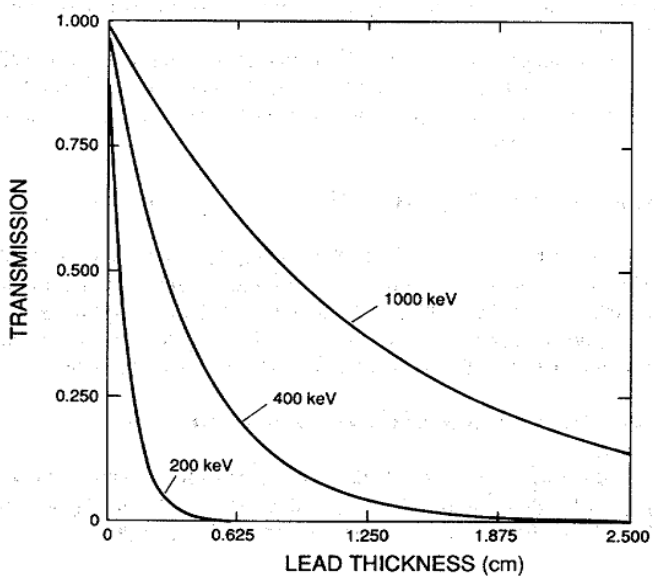
Shielded with lead

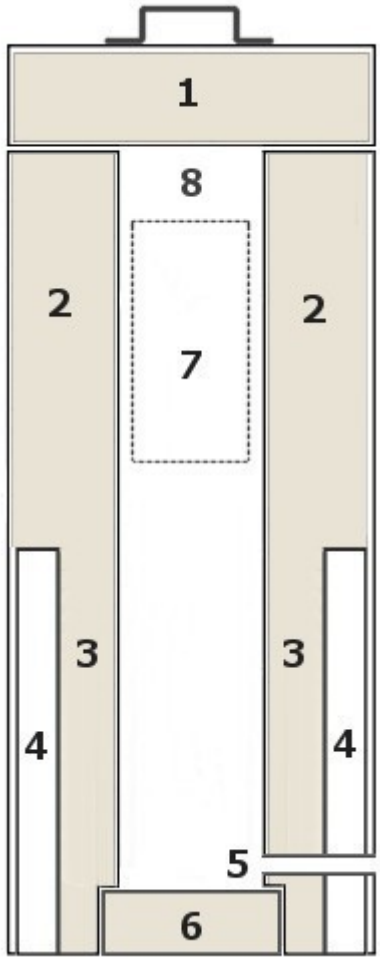
The lead cost is not indifferent (from tens to hundreds of dollars) and the total weight of the screen not less than 20 kg (up to 50 Kg and over if you are designing hurt the geometry of the screen)

A shielding of 30 mm is the minimum to make good measurements, 10 cm would be even better but the weight should be well over 100 Kg and the cost would become prohibitive.

The attenuation of gamma rays depends on the energy for which there is a precise value. At high energies one inch of lead eliminates 50% of gamma rays at medium energies eliminates 90% and at low energies close to 100%.

Three inches of lead reduces the background environment of over 90%, ten centimeters arrive more than 99%.





The best solution (minimum weight to equal shield) is a cylindrical structure similar to this example.

(1) Cover 30mm thick with handle to lift it.

(2) Walls 30 mm.

(3) The lower part of the walls can be thin, even 15 or 10 mm. The rays to reach the sensing area, the need to cross smear increasing the effective thickness.

(4) Zone unleaded to lighten the structure

(5) Radial hole to let out the wire. Its diameter should be 15mm to pass even the BNC connectors.

(6) Lower plug 30mm.

(7) The central area indicated by the dashed rectangle is the most protected area and can accommodate a Geiger tube to measure or the upper part of a probe spectrometry. If you are using a probe spectrometry for his sensitive crystal is placed everything in this area,

(8) Area to add a sample when using the shield for a spectrometry probe.

Lead calculations

The thicker the better, but not get to the exaggeration that you see in this picture.

Cylindrical lead

Recommended that a lead cylinder consists of 15 turns of 0.2 mm = 30 mm. With an internal diameter of 35 mm long and 18 or 20 cm in order to accommodate the probes 2xSBM20 and in the future possibly also photomultiplier or larger Geiger tubes.

So need a lead sheet 2mm thick and 20 cm high

The total length is around 160 mm per revolution and for 15 laps make a total length of 2.4 meters.

And finally need a brick base about 12 x 12 x 3 cm and a brick to be laid over about 10 x 10 x 3 cm.

Cost of lead

Lead the coast from 2 to 8 Euro per kg. The best price is obtained by scrap dealers, such as the recovery of sheets of 2mm (used in the construction industry to coat the chimney)

Weight of lead

Lead weighs 11.34 kg per cubic decimeter.

2500 x 1000 x 1.5 mm = 3.75 million cubic mm = 3,750 cubic decimeter = 42.525 kg (299 Euro eBay - 7 Euro/Kg shipping included)
1250 x 1000 x 1.5 mm = 1,875,000 cubic mm = 1,875 cubic decimeter = 21.26 kg (eBay 165 Euro - 7.8 Euro/Kg shipping included)

2400 x 200 x 2 = 480 mm 000 mm = 0.480 cubic decimeter cubic = 5.44 Kg
120 x 120 x 30 mm 000 mm = 432 cubic cubic decimeter = 0.432 = 4.90 Kg
100 x 100 x 30 mm 000 mm = 300 = 0300 cubic decimeter cubic = 3.40 Kg

For the cylinder takes about 14 pounds of lead (28 to 100 euros) (2 Euro/Kg to 8 Euro/Kg)
To a solution based on a house of bricks is not less than 30 pounds (60 to 240 Euro)