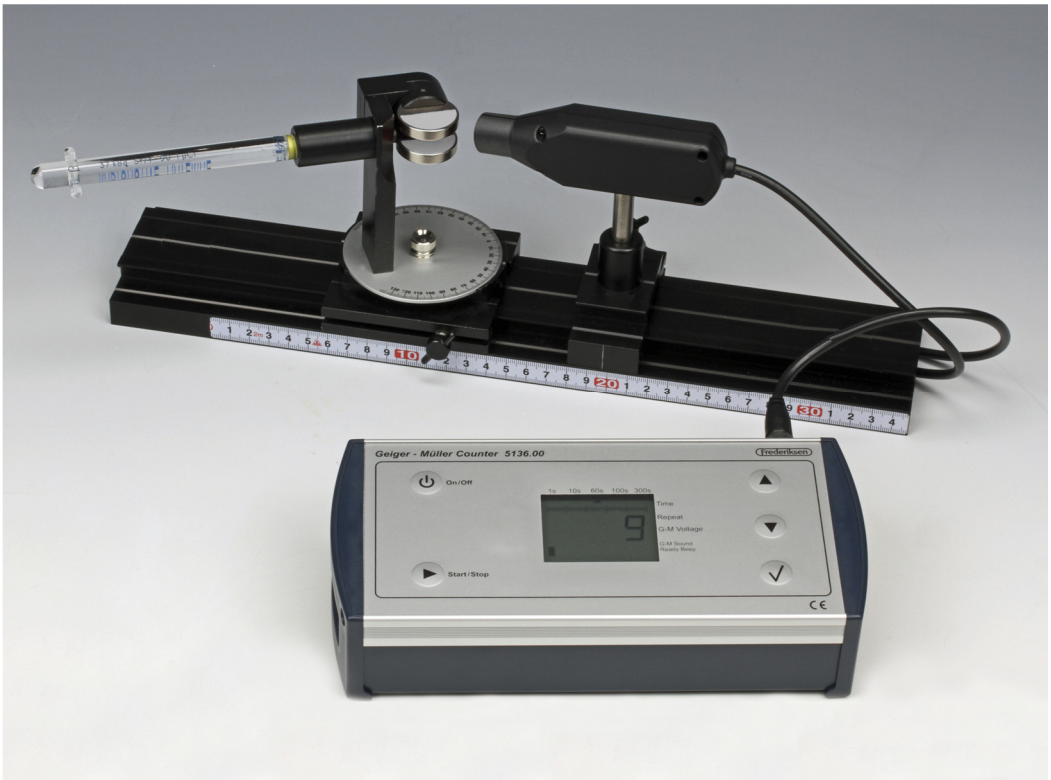
The beta spectrum (simple version)

Number	138530-EN	*Topic*	Radioactivity, motion of charged particles			
Version	2017-09-06 / HS	*Type*	Student exercise	*Suggested for*	grade (9)-10-11	*p.* 1/4



Objective

To investigate the energy distribution of beta radiation. An approximate value of the maximum energy of the beta radiation is to be found.

Principle

The radiation is collimated by a plastic aperture. After that, it passes an area with a strong magnetic field from a pair of permanent magnets. In the magnetic field the trajectory of the beta particles is circular with a radius that depends on the velocity of the particles.

The deflection angle is read on the apparatus and is converted into kinetic energy with the help of a graph.

Equipment

(Detailed equipment list on p. 4.)

Deflection of beta particles
Experiment bench or rail

Beta source (Risø) *

Geiger-Müller tube

Geiger counter

(Alternative means of counting may be employed)

* Other types of source can be used. (See p. 4.)

Work carefully

Follow your teacher's instructions for working with radioactive sources.

Keep a suitable distance to the sources
Limit the time you need to handle or st to the sources
Consumption of food or beverages is n allowed in the room while the sources are used

Sources with a handle should only be manipulated using the end that is furthest away from the source.

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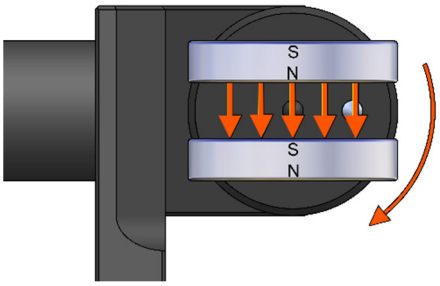
Procedure

Set up as shown on p. 1. The distance between the magnets and the GM tube is approx. 10 mm. The tube is used without protective cap.

Check that the magnet assembly is turned completely clockwise to make the field point downwards (see figure to the right). This will be the case with the *outermost* north pole (red marking) downwards.



Polarity can be checked with a bar magnet.

Vary the angle θ between 45° and 140° i steps of 5° and find for each angle the counts N for a fixed counting period like e.g. 100 seconds.

Make a background count N_0 as well for the same period – with the source removed completely from the setup.

Calculations etc.

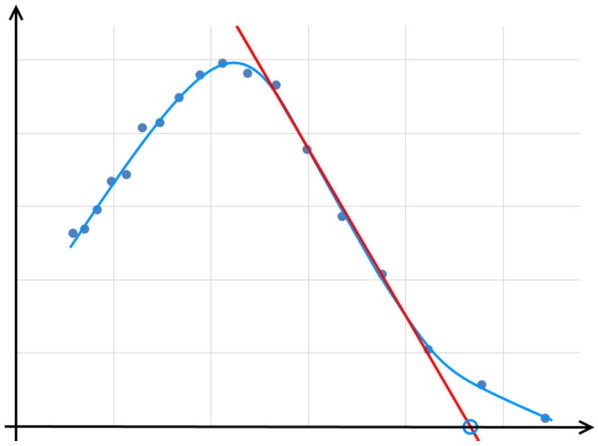
Use a table as shown – if possible, use a spreadsheet.

θ	N	E_{kin}	$N - N_0$
degrees		keV	

Use the graph on the next page to find the kinetic energies that corresponds to the angles.

The counts must be corrected for background radiation.

Plot the corrected counts as a function of the kinetic energy. (Remember to provide a scale for the axes.) Draw a soft curve that represents the data points well.



The equipment allows the passage of beta particles in a fairly large interval of angles.
This means that the uncertainty of the data points is quite high – especially for the smallest angles, corresponding to *the highest energies*.
If we want to determine the maximum energy in the beta spectrum, we must therefore seek a general trend instead of trying to guess where the curve reaches zero. The drawing shows how it can be done.

Use your own graph to determine the maximum energy of the beta particles from this source.

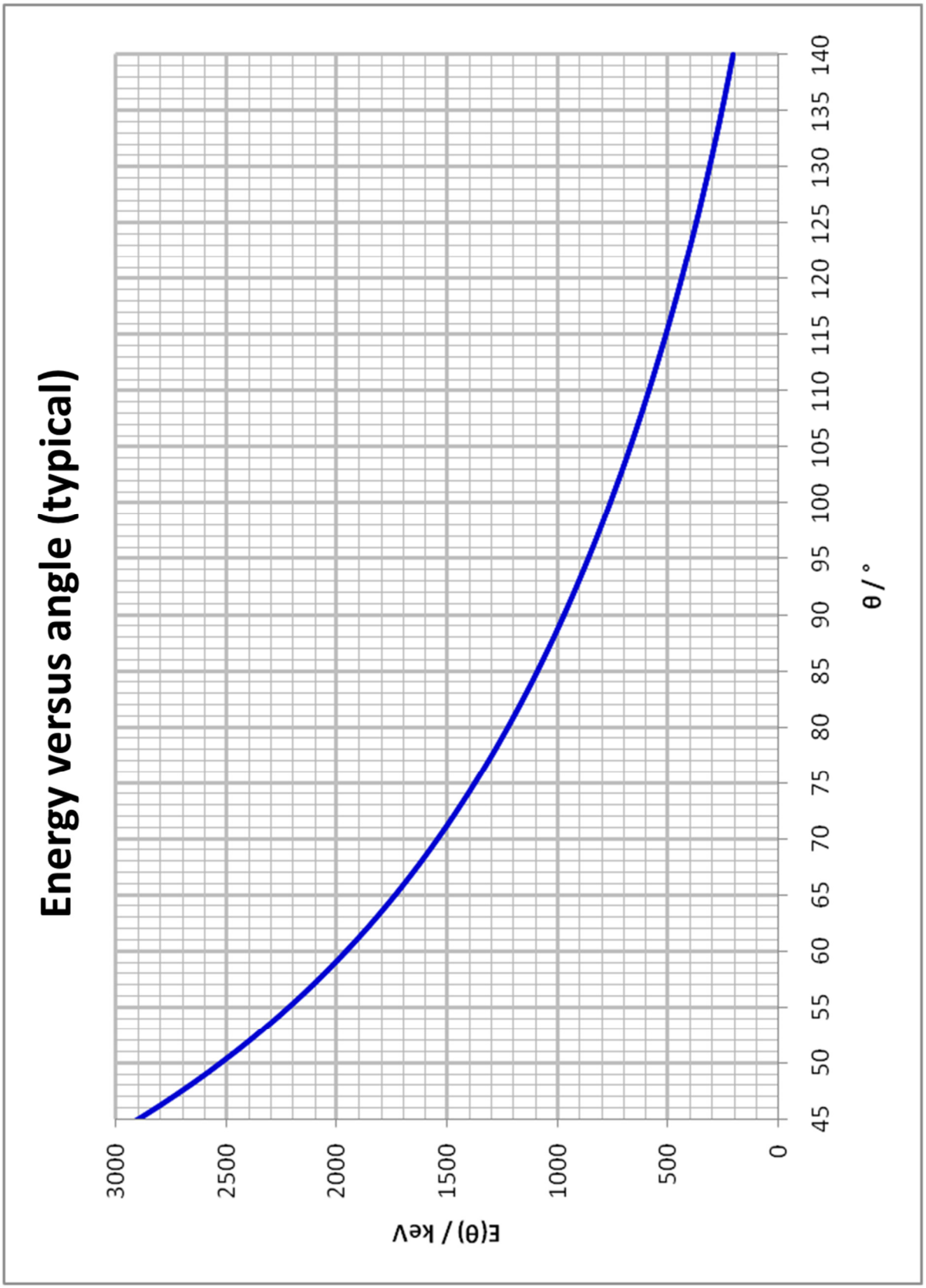
Discussion and evaluation

Find a table value for the maximum energy from the beta source. Compare with your own value.

Can you suggest a modification of the equipment that would result in a smaller uncertainty for the angles? Can this modification be made without any cost – or in other words: which disadvantage could it bring?

Finding the energy from the deflection angle

Valid for 514105 with a typical value of the field strength from the permanent magnets.



Teacher's notes

Concepts used

Registration of ionising radiation
Background radiation

Mathematical skills

Graph plotting

About the equipment

The beta source is a Sr/Y-90 source. The radiation from the Sr-decay has a rather low maximum energy and cannot be examined with this equipment. It is the decay from Y-90 that is investigated.

The simple procedure used for plotting the beta spectrum contains a systematic error – which, however, doesn't ruin the main point: That the particles are emitted with a broad distribution of energies.
An in-depth treatment published as Experiment 138550-EN "The beta spectrum, advanced version".

Didactic considerations

The graph over the energy versus angle ought to be followed by at least a qualitative explanation. Simple mechanical analogies can give a reasonable understanding of why the function is decreasing.
If uniform circular motion has been taught, you can of course use this.

Types and availability of sources

Frederiksen Scientific cannot provide sources unless we receive documentation that the customer and the end user are entitled to handling and using such sources.

Frederiksen Scientific only provides sources of the "Risø" type – seen on the photo on p. 1 – but we make equipment that is compatible with two other widely used types:

Disc-shaped (Ø 25 mm) sources
Cylindrical (Ø 12 mm) sources

The nuclide used is detailed in the "About the equipment" section.

It must be noted that the Sr/Y-90 source must be specifically constructed for beta emission.

Detailed equipment list

Specifically for Risø sources

510020	Beta source (Included with 510000 Risø sources, complete set)
514105	Deflection of beta particles (Risø source)

Specifically for disc sources

	Beta source (disc) as described above
514125	Deflection of beta particles (disc source)

Specifically for cylinder sources

	Beta source (cylindrical) as described above
514135	Deflection of beta particles (cyl. source)

Independent on source design

514102	Rail for experiment bench, 40 cm (Included with the 514100 Exp. Bench)
294610	Saddle with Ø10mm hole (Included with the Experiment Bench)
330850	Bar magnets, pair
513610	Geiger counter (or similar)
512515	Geiger-Müller tube with BNC-plug

Alternative

Although our complete experiment bench (including absorber plates and a saddle) is not needed in this experiment, it constitutes a versatile base for several experiments with radioactivity. You can substitute the two items 514102 and 294610 with

For Risø sources:	514100
For disc sources:	514120
For cylindrical sources:	514110