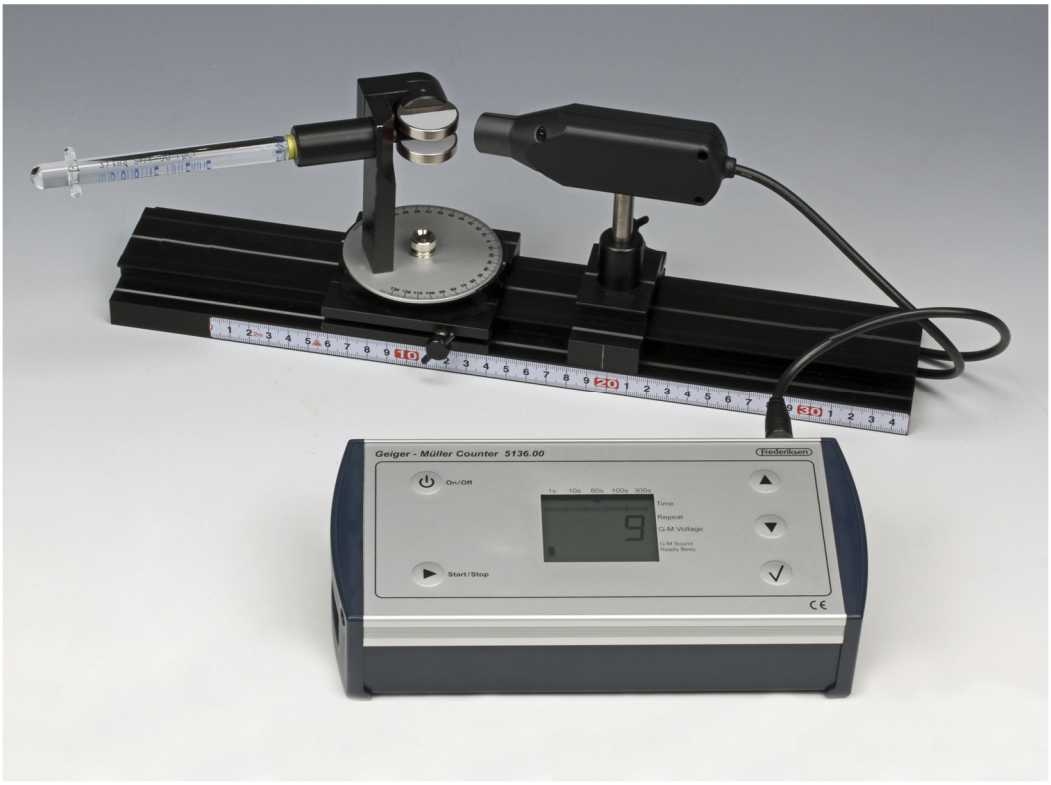
Deflection of beta particles – Demo

Number	138510-EN	*Topic*	Radioactivity			
Version	2017-09-14 / HS	*Type*	Demonstration experiment	*Suggested for*	grade 9+	*p.* 1/2



Objective
To demonstrate the deflection of beta particles in a magnetic field. Determining the sign of the charge of beta particles. Introducing the continuous energy distribution.

Principle
The radiation is collimated by a plastic aperture. It then passes an area where a strong magnetic field can be placed, using a pair of permanent magnets. The direction of the field can be reversed.

Equipment
(Detailed equipment list on p. 2)

514105 Deflection of beta rays
514100 Mounting bench

Beta source (Risø)*

Geiger-Müller tube
Geiger counter – or a GM power supply *with amplifier and loudspeaker*
* Other types of source can be used. (See p. 2.)

Preparations
The equipment is set up as shown. As we don't want quantitative results, the distance between the magnets and the GM tube can with advantage be reduced to 4 to 5 mm.

The Geiger counter must emit sound when radiation is detected.

Safety
Normal precautions for handling radioactive demonstration sources must be observed.

Procedure
It is not necessary to record the counts – it is enough to experience the intensity qualitatively, based on the sound from the Geiger counter.

1 – No magnetic field
Remove the magnet assembly from the source holder.

Demonstrate that beta rays are collimated to a limited angular interval by turning the source holder between +90° and -90°. It is clear that a rather narrow maximum exists around 0°.

This is due to the thick-walled tube in front of the source which absorbs radiation emitted in other directions.

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2 – With the magnetic field

Adjust the angle to 0°. Mount the magnet assembly. The north pole on the outside of the magnets (red) must face downwards.

Observe that the radiation falls to almost nothing.

(Students are encouraged to provide explanations.)

Turn the source holder slowly in the direction shown on p. 1. Around 45° the counts start to increase again and around 90° you perceive a flat maximum. But radiation is still registered up to the largest angle possible.

From these observations, **two points** are established**:**

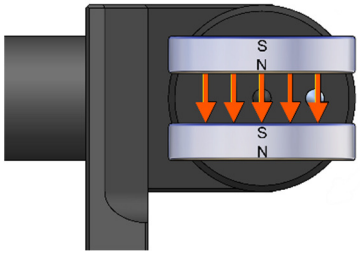
a) Beta radiation is deflected by a magnetic field – the radiation consists of charged particles.
b) The radiation does not follow a single circular trajectory – particles are emitted with many different energies.

3 – Determining the polarity of the charges

From a suitable version of a right hand rule – or from the Lorentz force

$$\vec{F} = q \cdot \left(\vec{E} + \vec{v} \times \vec{B}\right)$$

– it can be demonstrated that beta particles are negative. To this end, you must show that the field is directed as shown below: With the outer north pole (red marking) facing downwards, the field between the magnets points down.



You can check this with a small magnet with known polarity. *Note: use a plastic-coated magnet (like 330850) in order to avoid damaging the neodymium magnets.*

Teacher's notes

Concepts used

Registration of ionising radiation
Lorentz force law – or a suitable right hand rule (in certain teaching traditions this is a left hand rule…)

About the equipment

A Geiger counter like 513610 can emit a single "Tick" per particle registered – which is to be preferred over counters that "beep" for 0.1 seconds or longer.

If data logging equipment is used, you can show the results as a "meter" that can be enlarged. A 5 Hz sampling rate will give an acceptable response time.

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 Sr/Y-90. 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.

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

For this *demonstration*, the source activity should be in the order of 37 kBq. Much weaker sources will require that you use the counts over suitably long time intervals instead of just the sound.

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