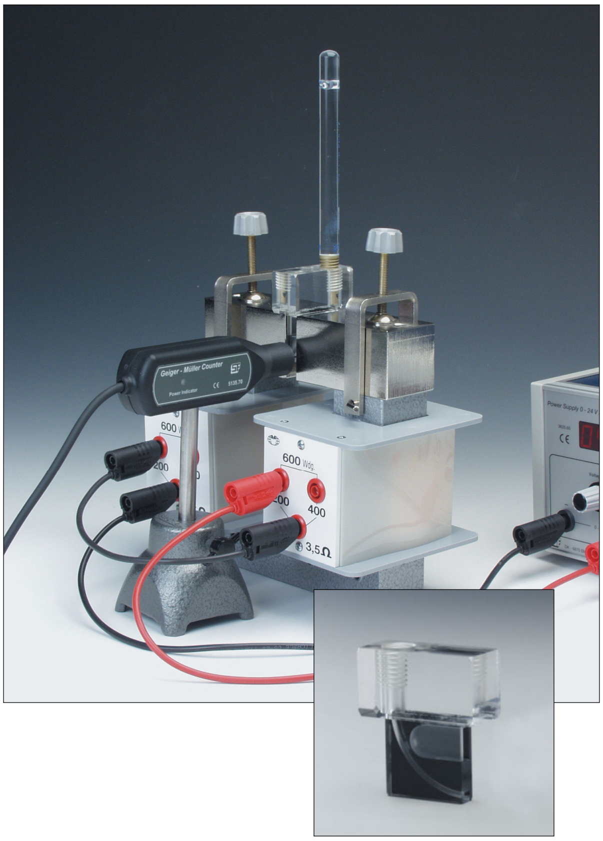
Beta spectrometer apparatus 5165.00

2015.03.02 AE 5165.00



The equipment consists of a Perspex holder for a beta source with a quarter circular channel with a specific radius.

A pocket in the holder accommodates a Hall probe (teslameter).

By placing the holder in a homogeneous magnetic field the spectrum shown can be obtained.

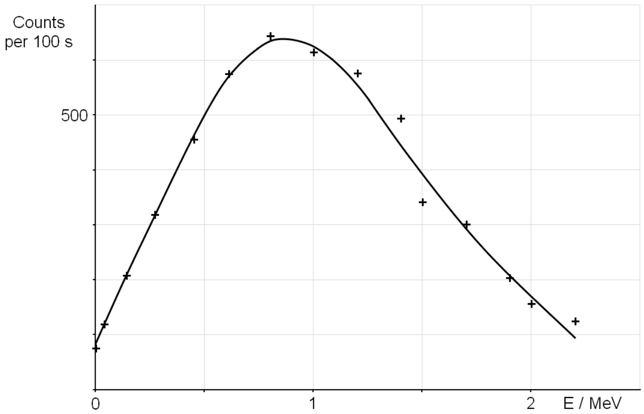
Accessories needed

Beta Source (5100.20)
Geiger-Müller tube (5125.15)
Geiger-Müller counter (5136.00)
Teslameter (4060.50)
Electromagnet (2x 4596.40 + 1 x 4597.00 + 1 x 4597.20)
Power supply (3630.00 or 3640.00)

Typical results

The table below shows a data set obtained with this equipment.

This results in the spectrum below where the energy is found from the nominal radius.



Time (s)	400	300	200	100	100	100	100	100	100	100	100	100	200	200	200
Counts	302	357	415	318	455	575	644	614	576	494	342	301	406	311	251
Counts./100 s	75	119	208	318	455	575	644	614	576	494	342	301	203	156	125
Current (A)	0,0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0	1,1	1,2	1,3	1,4
B field (mT)	0	24	46	68	94	115	139	163	185	209	229	246	266	277	308
Energy (MeV)	0,00	0,04	0,14	0,27	0,45	0,61	0,80	1,0	1,2	1,4	1,5	1,7	1,9	2,0	2,2

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Performing the experiment

The Perspex holder is placed on the electromagnet. The square section with the circular channel is sandwiched between the pole shoes. A Geiger counter is used as a detector and we are measuring corresponding values of current through the magnet and the count rate.

Theory

A beta particle moving in a homogeneous magnetic field will follow a circular path. The radius in the circle depends on the energy of the beta particles and the size of the B field. This way, the energy can be found based on known values of B filed and radius.

The centripetal force is here the Lorentz force. From classical formulae we have:

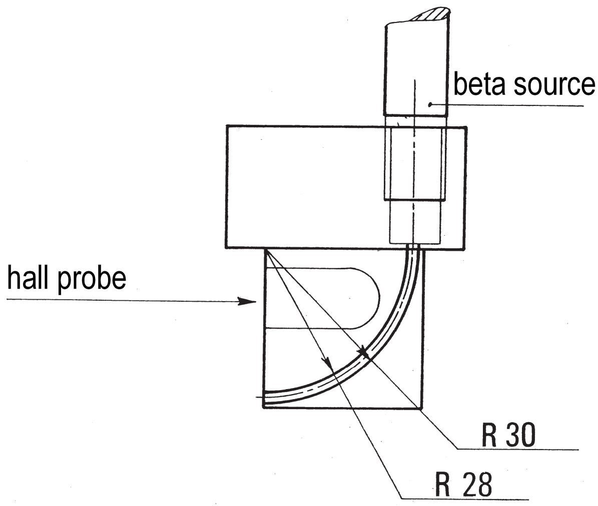
$$e \cdot v \cdot B = m \cdot \frac{v^2}{r}$$

Hence $m \cdot v = e \cdot B \cdot r$ or $p = e \cdot B \cdot r$. This formula also holds good in a relativistic description. Using $E^2 = p^2 \cdot c^2 + {m_0}^2 \cdot c^4$ and $E = T + m_0 \cdot c^2$ where E is the total relativistic energy and T is the relativistic kinetic energy, we obtain:

$$T^2 + 2 \cdot m_0 \cdot c^2 \cdot T = e^2 \cdot B^2 \cdot r^2 \cdot c^2$$

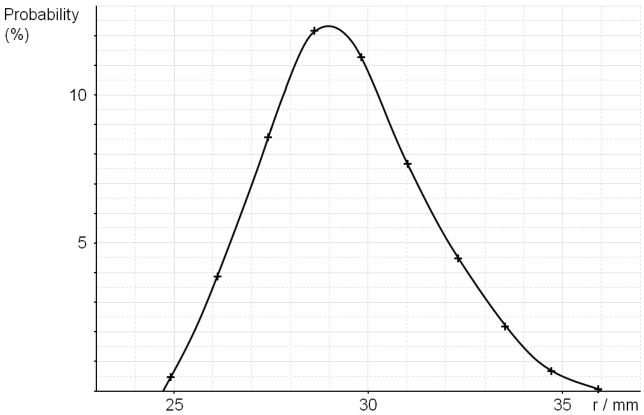
This equation is used to find T when B and r are known.

Orbital radius



It is possible for electrons to move through a trajectory with a radius larger than 30 mm, resp. smaller than 28 mm. It is thus interesting to know the probability for an electron with a given energy (orbital radius) to pass through the channel.

Relative probabilities have been found by using a mathematical model.



(References: Storm and Pihl, *Fysik II*, 3rd ed., formula (8,7). Peder Iversen.)

As can be seen from the graph, radii as small as approx. 25 mm and as large as 34 mm may occur.

(Especially the smaller radius causes deviations from the expected. It means that a relatively large magnetic field is needed for deflecting the most energetic electrons into the wall – which in turn results in a value for the maximum energy which is too large.)

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