Atomic and nuclear physics

Nuclear physics

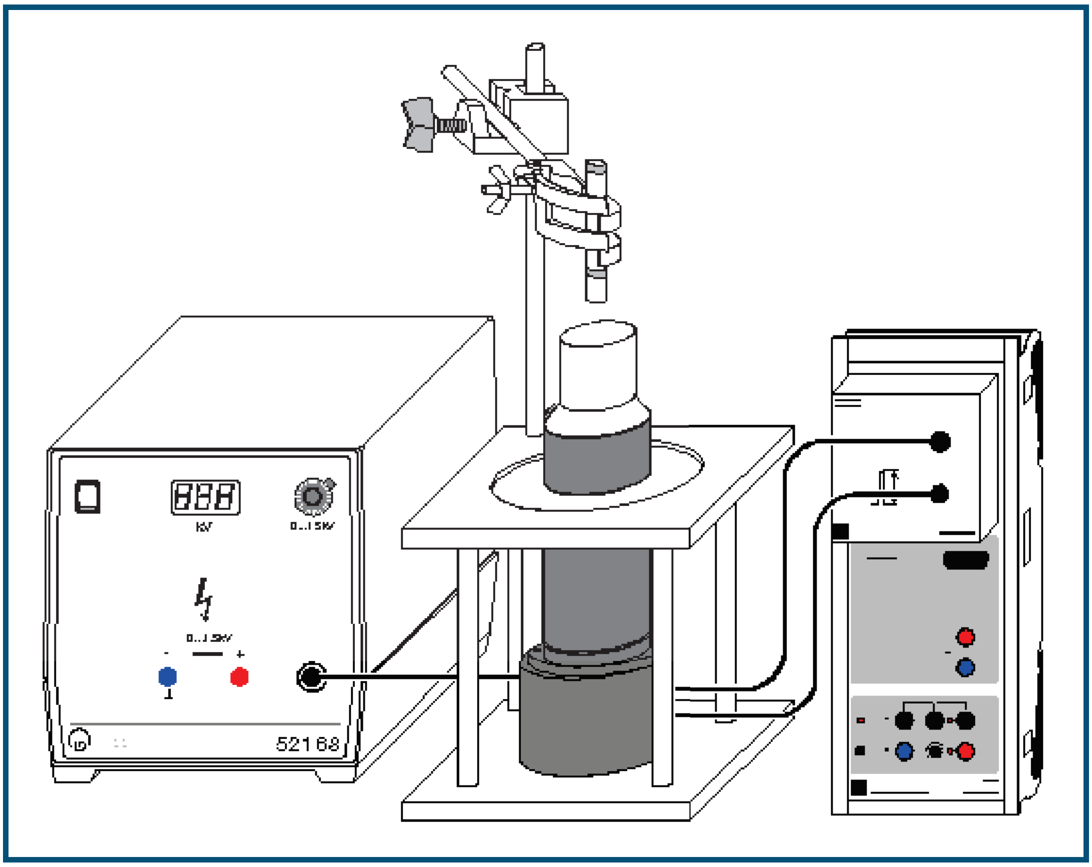
γ spectroscopy

Recording and calibrating a γ spectrum

Description from CASSY Lab 2

For loading examples and settings, please use the CASSY Lab 2 help.

Recording and calibrating a γ spectrum



can also be carried out with Pocket-CASSY

Safety note

When handling radioactive preparations, in addition to the radiation protection regulations, state-specific requirements and the regulations of the educational authorities are also to be observed, e.g. in the Federal Republic of Germany at the very least the radiation protection regulations (StrlSchV - Strahlenschutzverordnung) and the directives on safety during school lessons. The preparations used in this experiment are type approved according to StrlSchV (2001) or they are below the exemption limit and do not require approval. For this reason handling without express permission is possible.

Since the used preparations produce ionizing radiation, the following safety rules must nevertheless be kept to:

- Prevent access to the preparations by **unauthorized persons**.
- Before using the reparations make sure that they are **intact**.
- For the purpose of **shielding**, keep the preparations in their safety container.
- To ensure **minimum exposure time** and **minimum activity**, take the preparations out of the safety container only as long as is necessary for carrying out the experiment.
- To ensure **maximum distance**, hold the preparations only at the upper end of the metal holder.

Experiment description

The γ spectra of some standard preparations (Cs-137, Co-60, Na-22) are measured. After an energy calibration of the scintillation counter, the γ transitions are identified with the help of values quoted in the literature.

Equipment list

1	Sensor-CASSY	524 010 or 524 013
1	CASSY Lab 2	524 220
1	MCA box	524 058
1	Set of 3 radioactive preparations	559 835, alternatively 559 845
1	Co-60 preparation	559 855
1	Na-22 preparation	559 865

1	Scintillation counter	559 901
1	Detector output stage	559 912
1	High-voltage power supply 1.5 kV	521 68
1	Socket for scintillator screening	559 891
1	Stand rod, 47 cm	300 42
1	Leybold multiclamp	301 01
1	Universal clamp, 0...80 mm	666 555
1	PC with Windows XP/Vista/7	

Experiment setup (see drawing)

The output stage of the scintillation counter is connected to the MCA box and to the high-voltage power supply. The preparation to be studied is placed a few centimeters above the scintillation counter with stand material. In order to prevent the scintillation counter from toppling over, it is recommended to use the socket (559 891) for the setup.

Carrying out the experiment

- Load settings
- Record the spectra of Co-60, Na-22 and Cs-137 one after another with . It is recommendable to begin with the Co-60 preparation because the radiation it emits has the highest energy so that the high voltage and the gain can be adjusted appropriately from the very beginning.
- In order to get an energy spectrum, an energy calibration has to be carried out. For this e.g. the lines of Na-22 at 511 keV and 1275 keV can be used.

Evaluation

The energies of the individual lines are determined. For this the function Fit Gaussian curves can be used. The radiating isotopes are identified by comparison with values from the literature.

Remarks

There are several databases available in the internet where the known energies of all radioactive substances are listed, e.g. under http://nucleardata.nuclear.lu.se/nucleardata/toi/. These may be used for identifying the radioactive nuclides.

For the measurement the preparation should not be put directly onto the detector but placed at a distance of a few centimeters. If the preparation is too close to the detector, the counting rate will be so high that individual pulses add up. This addition with the rest of the previous pulse shifts the lines towards higher energies.

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γ spectroscopy

Absorption of γ radiation

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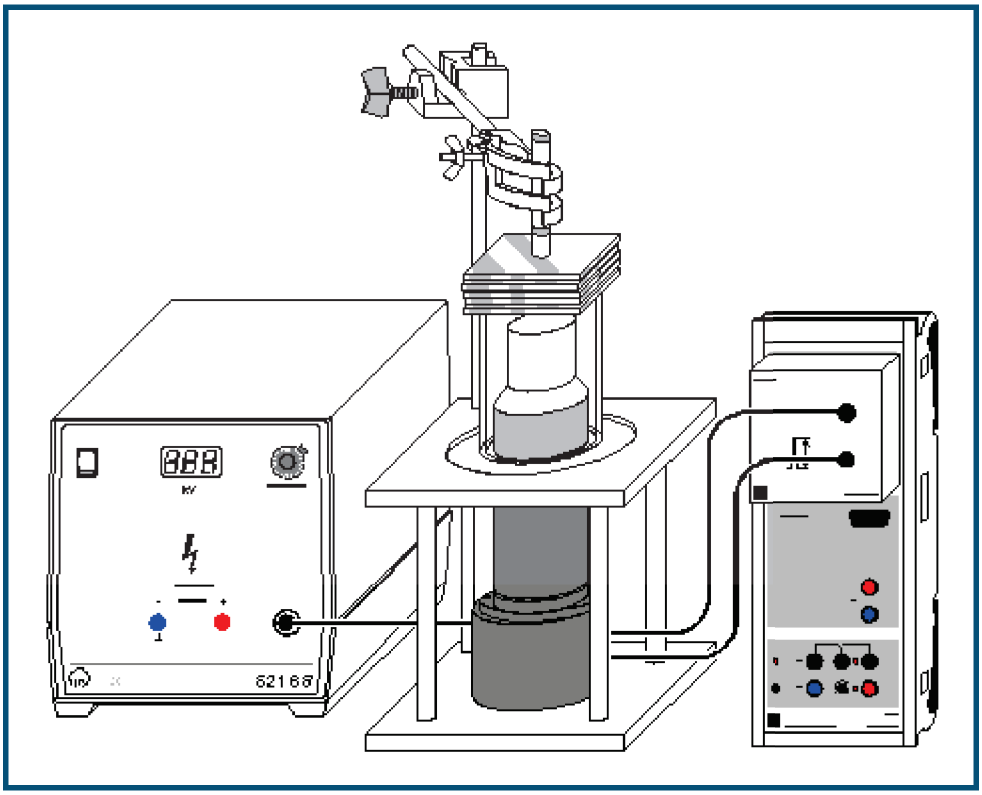
Absorption of γ radiation



can also be carried out with Pocket-CASSY

Safety note

When handling radioactive preparations, in addition to the radiation protection regulations, state-specific requirements and the regulations of the educational authorities are also to be observed, e.g. in the Federal Republic of Germany at the very least the radiation protection regulations (StrlSchV - Strahlenschutzverordnung) and the directives on safety during school lessons. The preparations used in this experiment are type approved according to StrlSchV (2001) or they are below the exemption limit and do not require approval. For this reason handling without express permission is possible.

Since the used preparations produce ionizing radiation, the following safety rules must nevertheless be kept to:

- Prevent access to the preparations by **unauthorized persons**.
- Before using the reparations make sure that they are **intact**.
- For the purpose of **shielding**, keep the preparations in their safety container.
- To ensure **minimum exposure time** and **minimum activity**, take the preparations out of the safety container only as long as is necessary for carrying out the experiment.
- To ensure **maximum distance**, hold the preparations only at the upper end of the metal holder.

Experiment description

The intensity of γ radiation behind an absorber is measured as a function of the thickness of the absorber in order to confirm Lambert's law of absorption. The linear attenuation coefficient μ and the half-value depth $d_{1/2}$ are derived.

Equipment list

1	Sensor-CASSY	524 010 or 524 013
1	CASSY Lab 2	524 220
1	MCA box	524 058
1	Co-60 preparation	559 855
1	Set of 3 radioactive preparations	559 835
1	Set of absorbers and targets	559 94
1	Scintillation counter	559 901
1	Detector output stage	559 912
1	High-voltage power supply 1.5 kV	521 68

1	Socket for scintillator screening	559 891
1	Stand rod, 47 cm	300 42
1	Leybold multiclamp	301 01
1	Universal clamp, 0...80 mm	666 555
1	PC with Windows XP/Vista/7	

Experiment setup (see drawing)

The output stage of the scintillation counter is connected to the MCA box and to the high-voltage power supply. The scintillation counter is mounted in the socket and the tip of the scintillation counter covered with the acrylic glass tube. The preparation is placed a few centimeters above the scintillation counter with the stand material. The absorbers are laid on the acrylic glass tube.

Carrying out the experiment

- Load settings
- First clamp the Co-60 preparation, and record the spectrum without absorber with setting the high voltage so that the spectrum covers the range of measurement.
- Lay the absorbers (aluminum, iron, lead) with different layer thicknesses on the acrylic glass tube one after another, and record a spectrum each time with .
- Repeat the measurements for the Cs-137 and the Am-241 preparation.

Evaluation

The counting rates associated with the lines of the spectra are determined using the function Calculate Integral. The counting rates are represented for the individual energies and absorbers as functions of the absorber thickness. From this the linear attenuation coefficient μ and the half-value depth $d_{1/2}$: are derived:

$$I = I_0 e^{-\mu \cdot x}$$

Typical values for μ are:

E	60 keV	662 keV	1253 keV
Al	0.51 1/cm	0.16 1/cm	0.13 1/cm
Fe	7.4 1/cm	0.43 1/cm	0.36 1/cm
Pb		0.86 1/cm	0.55 1/cm

Remark

The NaI(Tl) crystal at the end of the scintillation counter is sensitive to mechanical damage. Be careful when laying the absorbers on the detector. Never place the absorber directly onto the scintillation counter, always use the acrylic glass tube.

Otherwise cracks in the crystal arise and lead to a reduced sensitivity and, above all, to a worse energy resolution because of scattering.