Atomic and nuclear physics

Nuclear physics

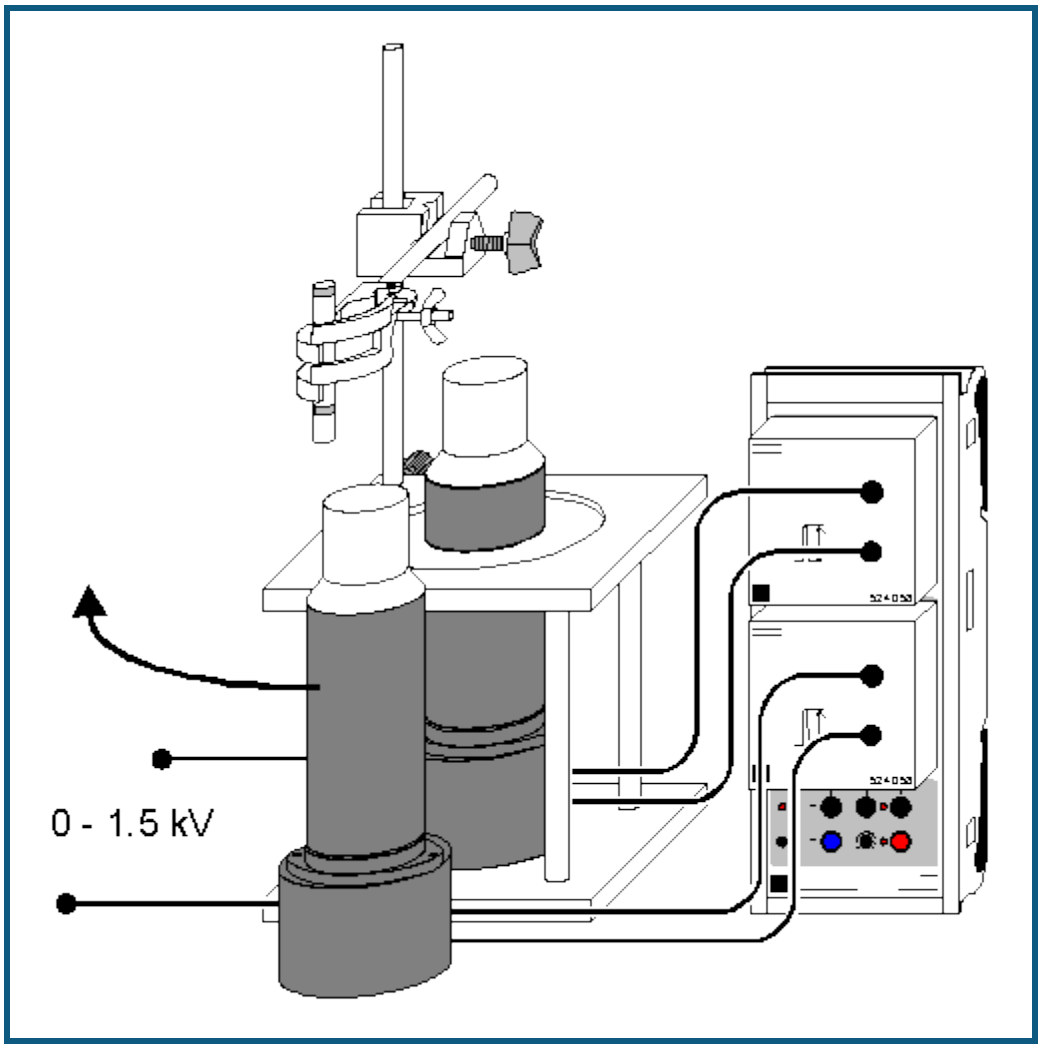
γ spectroscopy

Coincidence at γ decay of cobalt

Description from CASSY Lab 2

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

Coincidence and the decay cascade of Co-60



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 below the exemption limit. 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 coincidence of the two successively emitted γ quanta during the decay of Co-60 is demonstrated. The selective measurement of the coincidence spectrum always shows the other line in the decay cascade.

Equipment list

1	Sensor-CASSY	524 010 or 524 013
1	CASSY Lab 2	524 220
2	MCA boxes	524 058

1	Co-60 preparation	559 855
2	Scintillation counters	559 901
2	Detector output stages	559 912
2	High-voltage power supplies 1.5 kV	521 68
2	Sockets 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/7/8	

Experiment setup (see drawing)

The output stages of the scintillation counters are connected to the MCA boxes and to the high-voltage power supplies. Both MCA boxes must be plugged in the same CASSY. The preparation is placed near one scintillation counter with the stand material so that the other detector can be moved around the setup, in order that the angle detector 1 - preparation - detector 2 can be varied.

Carrying out the experiment

- Load settings
- Select the display **Energy calibration**
- Use the two detectors to record the normal Co-60 spectrum each with
- In the Settings NA calibrate input A, and in the Settings NB calibrate the detector at input B
- Select the display **Coincidence**
- In the Settings NA set the measurement to the **Coincidence trigger for the other box** and adjust the coincidence window to the 1332 keV line (mark with two vertical lines)
- Record the coincidence spectrum with .
- In the Settings NA set the coincidence window to the 1173 keV line (reset the old window by pressing → **0** ← and mark the new window by means of two vertical lines)
- Record the coincidence spectrum with .

Evaluation

The normal Co-60 spectrum comprises two lines, one at 1332 keV and one at 1175 keV. When the Co-60 nucleus decays, this is initially a β-decay. The exited state of the Ni-60 emits first of all a γ quantum with 1175 keV, the following intermediate status only has a life span of 0.7 ps, then the emission of the 1332 keV γ-quantum follows and the nucleus reaches its basic state. Therefore emissions of the two γ-lines visible in the spectrum are in temporal coincidence.

The emission of the two γ-quanta cannot be temporarily resolved by means of an NaI scintillation detector, however the temporal correlation of the two particles can be convincingly demonstrated.

In the normal MCA spectrum both lines are visible. If one of the two lines is selected as the coincidence trigger then the resulting spectrum only shows the other line because the first γ-quantum has arrived in the first detector and has released the trigger. This demonstrates the temporal coincidence of the two γ-quanta and therefore also that they have to be caused by the same atomic decay process.

The coincidence triggering on the 1175 keV line shows another line at 200 keV. Here a different process is active which has nothing to do with the cascade of decay. If a 1332 keV γ-quantum is emitted and Compton backscattering occurs in the coincidence trigger detector, an energy of approx. 1130 keV is transmitted to the electron. This energy is within the trigger window used at approx. 1175 keV and therefore triggers a measurement. The backscattered γ-quantum can now be picked up by the second detector and carries a residual energy of approx. 200 keV. Spatial movement of the detectors will change the intensity and energy of this line.

Remark

The time window for coincidences has a fixed default value of 4 µs.