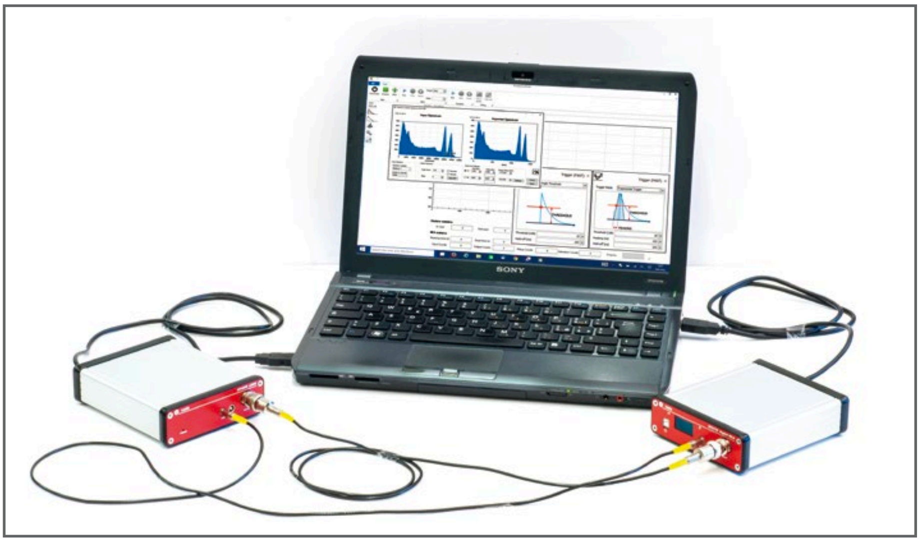
B.1.8 SG6118B Study of the ^{137}Cs spectrum: the backscatter peak and X rays



Purpose of the experiment

Study the characteristics of the ^{137}Cs spectrum, with special relevance given to the low energy spectrum. The student can learn effects related to the experimental observation of a gamma decay and have basic information about the experimental setup used in gamma spectroscopy. Estimate the energy of the backscatter peak and of the K_α line.

Fundamentals

The Compton effect is linked with experimental issues, since it is caused by the interaction of photons with the electrons instrument that measure the gamma radiation. In a real detector setup, some photons can and will undergo one or potentially more Compton scattering processes (e.g. in the housing material of the radioactive source, in shielding material or material otherwise surrounding the experiment) before entering the detector material. This leads to a peak structure, the so-called backscatter peak.

The basic principle for the backscatter peak formation is the following: gamma-ray sources emit photons isotropically, some photons will undergo a Compton scattering process with a scattering angle close to 180° and some of these photons will subsequently be detected by the detector. The result is an excess of counts in the Compton part of the spectrum, the so-called backscatter peak. This peak has an energy approximately equal to the photopeak energy minus the Compton edge energy.

The ^{137}Cs gamma photopeak at 661 keV is responsible also for a low energy emission (i.e. emission of an X-ray). This is due to the decay mechanism of ^{137}Cs: it decays via β decay into an excited state of barium-137, which than passes to the ground state, giving rise to the 661 keV photopeak. Emission of a 661 keV γ photon is not the only way excited barium gives off its energy. In some cases barium-137 can transfer its energy to an electron of its 1s atomic shell ("internal conversion"). The hole in the 1s shell is replenished from higher shells. This process gives rise to the emission of the characteristic X radiation of barium, which is the K_α line nearly at 32 keV (X rays are photons in the range 100 eV-100 keV)

Ordering Options

Equipment A	
Code	**Description**
WK5600XEMUAA	SP5600EMU - Emulation Kit

Equipment B	
Code	**Description**
WK5600XCAAAA	SP5600C - Educational Gamma Kit
or the all inclusive Premium Version	
WK5600XANAAA	SP5600AN - Educational Kit - Premium Version

Equipment C	
Code	**Description**
WK5640XAAAAA	SP5640 - GammaEDU

Equipment D	
Code	**Description**
WK5630ENAAAA	SP5630EN - Environmental Kit
or the Kit Plus	
WK5630XENAAA	SP5630ENP - Environmental Kit Plus

Equipment E	
Code	**Description**
WK5650XAAAAA	SP5650 - Open FPGA Kit

Marie Skłodowska Curie was a Polish and naturalized-French physicist and chemist who conducted pioneering research on radioactivity. She was the first woman to win a Nobel Prize, the first person and only woman to win twice in multiple sciences. Together with her husband, she was awarded half of the Nobel Prize for Physics in 1903, for their study into the spontaneous radiation discovered by Becquerel, who was awarded the other half of the Prize. In 1911 she received a second Nobel Prize, this time in Chemistry, in recognition of her work in radioactivity. Radium discovery opened the door to deep changes in the way scientists think about matter and energy. She also led the way to a new era for medical knowledge and the treatment of diseases.

https://www.aip.org/history/exhibits/curie/brief/index.html

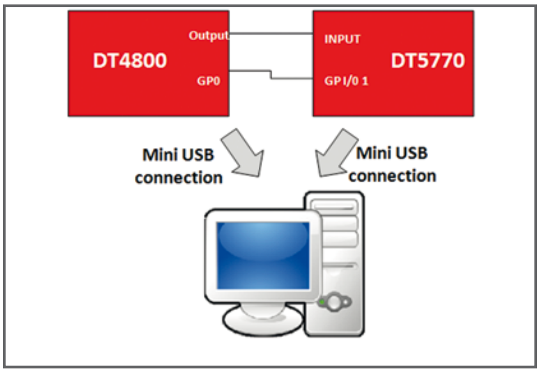
Equipment

SP5600EMU - Emulaton Kit

Model	DT4800	DT5770
Description	Digital Detector Emulator  p. 147	Digital Multi-Channel Analyzer  p. 147

Requirements

No other tools or instruments are needed.



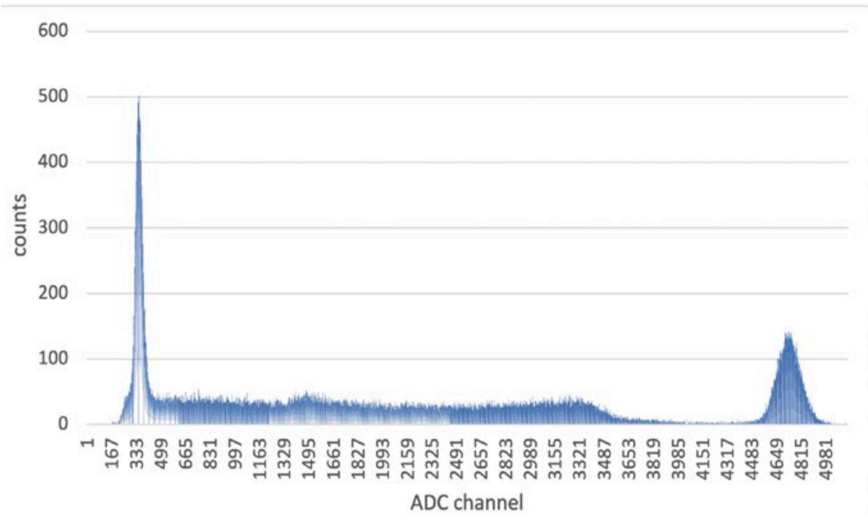
Experimental setup block diagram for the experiment.

Carrying out the experiment

To perform the experiment, connect the DT4800 output to the input channel of the MCA DT5770 and use the DT4800 GP0 as digitizer "trigger IN". The Emulation Control Software Interface allows user to generate exponential decay signals with programmable rise time and fall time and it is possible to emulate signals from ^{137}CsI radioactive. The spectrum can be recorded and analyzed by the MCA

Results

The user can calibrate the system by using the spectrum itself. The backscatter peak and the K_α line can be identified. After calibrating the spectrum, it is possible to estimate the energy of the two peaks and compare them with theoretical predictions.



Plot of the ^{137}Cs spectrum acquired by the MCA. The backscatter peak and the Kα line are indicated with the red arrows.