As you have seen, in several of the radioactive sources we encountered so far, they typically emit more than one gamma photon per decay or even more than one type of decay radiation. In this short experiment we will introduce the electronics necessary to set up a way to measure the correlation between two radiation quanta emanating from the same decay in a radioactive source.

The ADC/MCA data acquisition system used in our teaching laboratory has, apart from the signal input, also a GATE labelled connection. Here we can provide a logical signal from one detector to determine if the signal from another detector gets registered (coincidence setting in MAESTRO) or not (anticoincidence setting). However, we have to use specific electronics to generate the type of logical signal accepted by the ADC/MCA. For this reason, we first need to generate a logical pulse whenever the first detector produces a signal representing a, to be selected, amplitude range in the output of the amplifier. For this purpose, we can use a so-called single channel analyzer (SCA) which allows the selection of a pulse amplitude range that is converted into a standard (logical) pulse. Standard pulses can be positive or negative depending on their purpose. The ADC/MCA requires a positive signal (high level) in order to trigger either the coincidence or anticoincidence decision. The signal level needs to be high for the complete time that the actual signal input is to be recorded or suppressed. In order to shape our logical signal to the appropriate length (and sometimes also modify amplitude and/or delay), we can use electronic units called gate generator or logic shaper. However, processing the signal from the first detector through the two electronic units takes time. Therefore, coincident photons from a radioactive source would not be synchronous anymore in the electronics chains arriving from each detector at the ADC/MCA. We solve this issue by adding a so-called delay amplifier or delay generator after the amplifier in the second detector’s chain.

In order to set up the electronics properly and also to explore its radioactive decay properties, we use in this lab a 22-Na source (Fig. 1).

![Radioactive decay scheme of 22-Na to 22-Ne.](image)

Fig. 1: Radioactive decay scheme of 22-Na to 22-Ne.
The 22-Na decay occurs by beta+ emission (conversion of a proton in the nucleus to a neutron plus a positron plus a neutrino) and populates an excited state in 22-Ne which de-excites through the emission of a 1274 keV gamma photon. The positron (beta+) produced in this decay is a so-called antiparticle which as antimatter pairs with its matter equivalent the electron. Typically, after slowing down in the source or other surrounding materials, the positron will form positronium with an electron and decay via emission of two gamma photons (511 keV, the rest energy of each electron and positron) in opposite directions (in order to conserve energy and momentum).

In this experiment you can prove the correlated emission in opposite directions by comparing spectra taken with one detector, triggered on either 511 keV or 1274 keV with the other detector, at varying distances between the two.

Setup:

1) Place the two NaI detectors together on opposite sides of the source, as close as the source stand allows, and monitor the signals from the anodes on the oscilloscope. Explore different triggering conditions to focus on special amplitude heights.

2) Set up the detector chains in Fig. 2 and verify proper functioning of the chains with oscilloscope and ADC/MCA. Select with the SCA the 511 keV photo peak in detector 1 as the gate.

3) Set up the detector chain in Fig. 3 and take the spectrum of detector 2 at distances (as close as possible, 15 cm, 25 cm) from the 22-Na source. At each distance take a spectrum both without and with coincidence condition. Record 511 keV peak content, 1274 keV peak content, RT, LT.

4) Repeat 2) and 3) with 1274 keV peak as the gate.

As we include new electronics, make sure to have your setup frequently checked by instructor or TA. Record all spectra for the figures in your report.
Figure 2: Electronics chain for gate set up in detector 1.
Figure 3: Electronics chain setup for recording of gated detector 2 spectra.