Evaluation of the pile-up of two 511-keV rays: a gamma-singles experimental approach

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The precise measurement of the superallowed branch in the decay of ^{10}C requires the measurement of the intensity of the 1021.65-keV transition in the ^{10}B daughter. While such measurements are relatively easy, we have to account for some important issues: (i) the gamma is relatively weak (~1.5%), (ii) the gamma appears over a pile-up structure of annihilation rays (~200%), and (iii) as opposed to the well-defined position of the 1021.65-keV source, the 511-keV rays come from a spatially distributed source dependent on the positron spectrum and scattering materials surrounding the ^{10}C source.

We propose here a simple solution based on gamma singles measurements, performed with the pile-up-reject (PUR) feature disabled. The basic idea is sketched in Fig. 1: the HPGe signals are fed to a spectroscopy amplifier (SA), whose output is capped with a group of diodes around amplitudes corresponding to 750-keV. Then, the capped event stream is sent to a spectroscopic summator (Σ) along with its delayed copy; the delay should be long enough to avoid a partial overlap of a pulse with its delayed copy. Under these conditions, Σ will generate a clean pile-up structure for the 511-keV rays. For the method to work, both the active delay and the summator need to preserve the signal quality at spectroscopic level. In our measurement we used five Delay Amplifiers Ortec 427A, and a Dual Sum and Invert Amplifier Ortec 533.

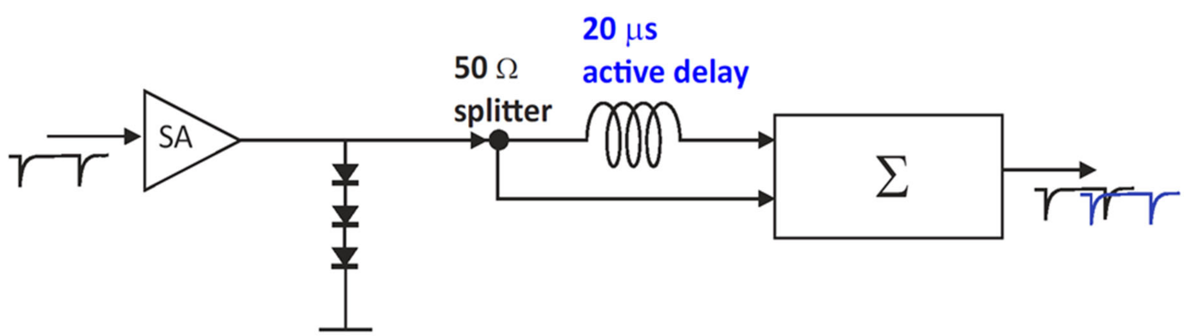

Fig. 1. Sketch of the cap & self-sum method.

Figure 2 presents spectra relevant to the method, as obtained with a ^{68}Ge-^{68}Ga source. The SA and Σ spectra in the figure have been acquired in parallel. Note that Σ's pile-up structure is in a region that is clear of other peaks: the 1077-keV peak is visible in the SA spectrum, but not in the Σ spectrum. Translating this to the 10C case, the 1021.65-keV gamma peak wouldn't be part of Σ's pile-up structure. Note that the Σ's output corresponds to twice the 511-keV 's real rate, while containing no genuine pile-ups; thus, the magnitude of the Σ-generated pile-up structure is twice (not four times) that of the one observed in the SA spectrum.

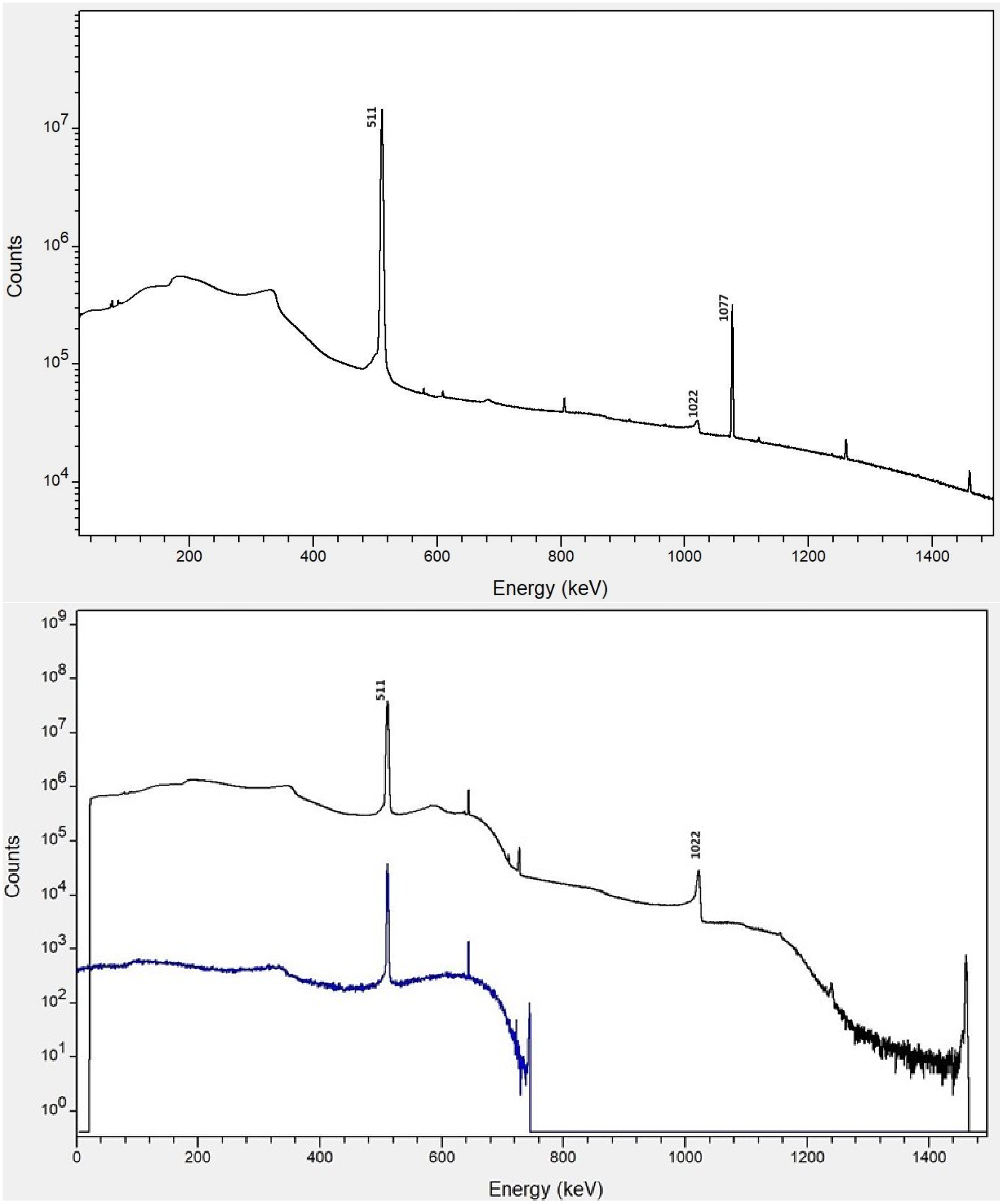

Fig. 2. Top: Relevant region of the 68Ga decay spectrum, as generated by the spectroscopy amplifier. Bottom: Diode-limited spectrum (blue, scaled down) and summator spectrum (black).