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ABSTRACT: A system is described to reject pile-up between a pulse below and a pulse above threshold in intermediate energy experiments. Results are given for radiative proton capture measurements.

Pile-up rejection circuits are widely used in high counting rate experiments. In most applications the pile-up frequency is measured, in a definite inspection interval, using the typical experimental set-up shown in Fig. 1a.

The pulse spectrum from a counter is fed, through a linear amplifier A, to a linear gate LG, which allows pulse height analysis above a threshold level Th, selected by the discriminator D. The conventional pile-up inspector PI takes advantage of the good pulse pair resolution of the discriminator D (few nanoseconds) to inspect pulses whose proximity to each other is within the amplifier resolving time (few microseconds). These pulses can be after rejected by anticoincidence techniques.

This analysis is limited to pair of pulses both above the discriminator threshold Th, these events being the most frequent when Th is low and the spectrum moderately flat.

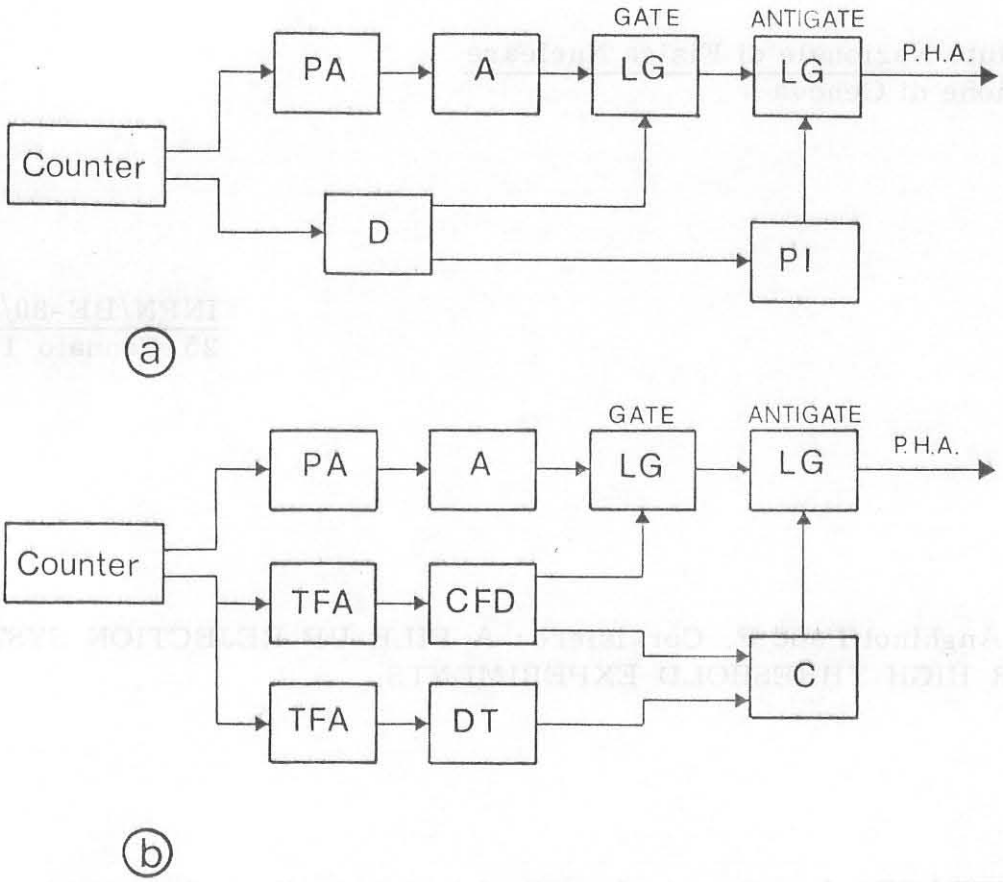

FIG. 1 - a) A conventional pile-up rejection system ; b) The proposed pile-up rejection system. The details of the block diagram are given in the text.

In many experiments, particularly at intermediate and high energies, the investigated high energy particles, have to be sorted out from a low energy background which can be up to several order of magnitudes higher. A typical example is given by radiative proton capture (p, γ) experiments : the photons totally absorbed by the NaI scintillator are detected as wide peaks on the high energy side of an exponentially decreasing spectrum (Fig. 2a). In these cases the energy threshold Th is set as high as possible (in order to reduce the contribution of low energy pulses) and the resulting pile-up probability between two pulses both above threshold is negligible.

Nevertheless the high rate of low energy particles makes random coincidences between a pulse below and a pulse above threshold still possible within the resolving time of the amplifier. These events regularly trigger the discriminator D and are detected through the linear gate. The system schematically shown in Fig. 1b has been designed to reduce this kind of pile-up. Pulses from the counter C are fed, through a timing filter amplifier TFA (ORTEC 454), to a constant fraction discriminator CFD (ORTEC 473A), which selects the energy threshold

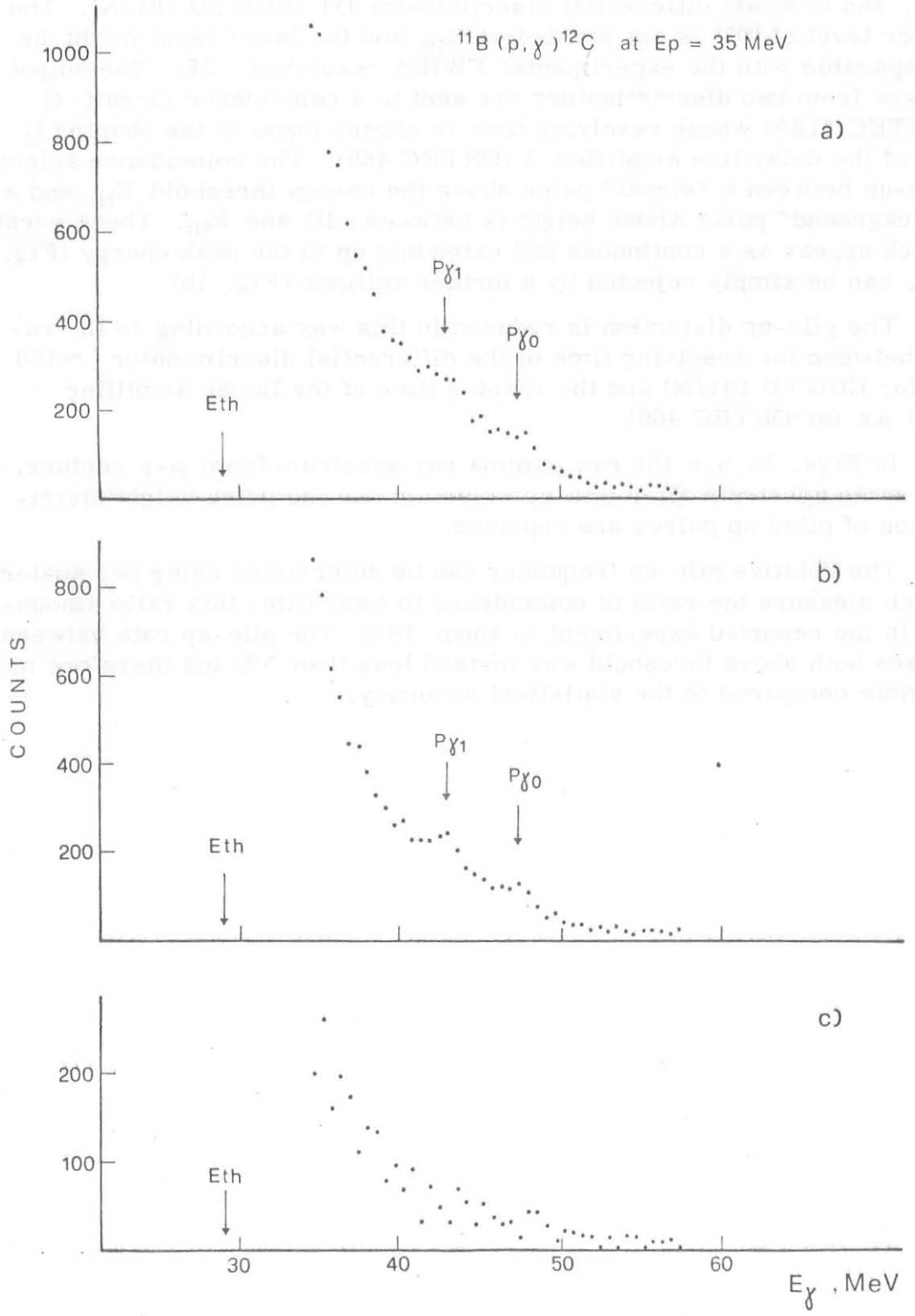

FIG. 2 - Photon spectrum from a radiative proton capture experiment : a) without pile-up rejection ; b) with pile-up rejection. The pulse-height distribution of rejected pulses is plotted in c).

E_{th}, and to a fast differential discriminator DT (EGGTD 101/N). The upper level of DT is set just below E_{th} and the lower level might be comparable with the experimental FWHM resolution ΔE. The output pulses from two discriminators are sent to a coincidence circuit C (ORTEC 418A) whose resolving time is chosen equal to the shaping time of the delay line amplifier A (ORTEC 460). The coincidence selects pile-up between a "signal" pulse above the energy threshold E_{th} and a "background" pulse whose height is between ΔE and E_{th}. These events which appear as a continuous tail extending up to the peak energy (Fig. 2c), can be simply rejected by a further antigate (Fig. 1b).

The pile-up distortion is reduced in this way according to the ratio between the resolving time of the differential discriminator ($\sim$150 ns for EGGTD 101/N) and the shaping time of the linear amplifier ($\sim 1\ \mu s$ for ORTEC 460).

In Figs. 2a, b, c the raw gamma ray spectrum from p-γ capture, the same spectrum after pile-up rejection and the pulse height distribution of piled up pulses are reported.

The relative pile-up frequency can be determined using two scalers which measure the ratio of coincidence to total rate; this ratio amounted in the reported experiment to about 16%. The pile-up rate between pulses both above threshold was instead less than 5% and therefore negligible compared to the statistical accuracy.