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Baseline distortion effect on gamma-ray pulse-height spectra in neutron capture experiments

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Abstract

A baseline distortion effect due to gamma-flash at neutron time-of-flight measurement using a pulse neutron source has been investigated. Pulses from C_6D_6 detectors accumulated by flash-ADC were processed with both standard analog-to-digital converter (ADC) and flash-ADC operational modes. A correction factor of gamma-ray yields, due to baseline shift, was quantitatively obtained by comparing the pulse height spectra of the two data-taking modes. The magnitude of the correction factor depends on the time after gamma-flash and has complex time dependence with a changing sign.

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1. Introduction

Neutron capture cross section measurement is an important physical task because information about neutron capture cross sections is needed for a wide area of applications ranging from fundamental tasks, mainly in field of nuclear astrophysics research, to applied tasks, mainly in the field of transmutation of nuclear waste. The study of nuclear transmutation requires especially accurate data. Neutron capture has been investigated at many neutron facilities in the world and a large amount of data have been already measured and published. For the measurement of neutron

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capture cross sections, non-hydrogenous fluorocarbon C_6F_6 [1] or deuterated benzene C_6D_6 (view for example [2–4]) scintillation detectors have been widely used for many years. The main advantage of these detectors is low sensitivity to the background from neutrons scattered by the sample. But while performing measurement at pulse neutron source in time-of-flight (TOF) mode, any such gamma-ray detector was significantly affected by strong gamma-flash pulse of the accelerator. This effect is a combined result of detector overload from gamma-ray scatter from the neutron-producing target and gamma-rays from many very fast neutron captures just after the neutron burst. The former process is more characteristic for electron linacs, and the latter is more characteristic for accelerators, which produce neutrons by spallation reactions. The strong detector overload causes baseline distortion. Most previous experiments for resonance neutron energy range have been done with pulse neutron sources using standard time-to-digital and pulse-height-to-digital converters with fixed pulse height bias. Detector baseline shifting of data accumulation with fixed bias leads to distortion of the measured pulse height and therefore to distortion of obtained capture cross section value based on this gamma-ray yield.

The effect of a strong gamma-flash leads to obvious baseline distortion in case of pulse neutron sources with high pulse intensity and low repetition rate (for example, the *n*_TOF neutron source at CERN). This effect has been seen at CERN even during a fission cross section measurement [5] using a parallel plate avalanche chamber which has lower gamma-ray sensitivity. In case of neutron sources possessing a higher repetition rate, a shorter time interval is between neutron bursts. In this case, the smaller energy neutrons (that are slower) are used for measurement, the more shortly flight path should be used to overcome neutron overlap. But at the decrease of flight path, the gamma-flash, at the same duration, affects the detector baseline in a wider neutron energy region at the measurement performed in TOF mode.

To overcome this effect some methods have been utilized. The method of neutron beam filtration by Pb filter (see for example [2,4]) can decrease the gamma-flash influence but does not eliminate it completely since a thick Pb filter also decreases the neutron intensity. Increasing the flight path (in case it is possible) leads to a decrease of the gamma-flash influence but simultaneously a flux of useful neutrons coming to the sample is decreased. Detector stabilization, based on a stabilized light pulse in the detector during the measurements [6], is very inertial and can provide a control of the gain of the entire electronics for a long duration of statistic accumulation. However, it is not effective for a rapid, transient process. An application of a locking pulse to the control electrode of the detector, which is closing a detector for flash influence duration [7], makes it practically impossible to use the fast neutron energy range. In spite of using some experimental methods to decrease the gamma-flash effect, in many cases the measured data can be used starting from the TOF (or neutron energy) where the transient process caused by gamma-flash is vanishing. This time can reach several tens of microseconds and more.

However, the baseline distortion effect has never been quantitatively studied so far. It is very important to know this effect on the capture cross sections. Recently, in connection with the development of new experimental techniques, the so-called flash-ADC has found wide applications in nuclear physics [8,9]. These devices are analog-to-digital converters that can store waveforms of detector pulses. The use of the flash-ADC for neutron capture cross section measurements gives an opportunity to study, quantitatively, the baseline shift effect on the measured capture cross section and to investigate the magnitude of systematic errors of many previous experiments using data acquisition systems based on a traditional analog-to-digital converter with a fixed bias.

This note describes the baseline reconstruction and calculations of the correction factor that needs to be introduced due to the baseline distortion, after a strong gamma-flash, on measurements using a pulsed neutron source. The results obtained will be used for the re-evaluation of the previously published data. Also, this note illustrates how the flash-ADC system can overcome the influence of the gamma-flash effect.