Digital signal analysis for particle identification using CsI(Tl) detectors

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A 4π charged particle array of 128 CsI(Tl) crystals coupled to Si avalanche photodiode (APD) is under construction at RCNP for the upcoming experiments E455 and E464, aiming at in-beam selection of nuclear reaction channels with low cross section. The array should be designed to have good charged particle identification, high efficiency and adequate granularity for detecting light charged particles such as protons and alphas emitted in heavy-ion fusion-evaporation reactions. The present work reports the preliminary results of particle identification based on the digital pulse shape analysis using GRETINA Digitizer [1] based on the CAGRA collaboration.

A 1×1×1 cm^3 unpolished CsI(Tl) crystal coupled to a Hamamatsu S8664-1010 APD with a active area of 1×1 cm^2 was used in our test experiment. In order to improve light collection, a piece of aluminized mylar foil with thickness of 2 μm was positioned in front of the crystal. The foil was sufficiently thin to allow low energy α and proton particles to pass though and enter the crystal. The other sides of CsI(Tl) crystal were wrapped with several layers of white Teflon tape. A charge sensitive preamplifier, which also provides a bias voltage of 400 V, was used as readout for the APD. The output signal from the preamplifier was sampled using GRETINA Digitizer at a frequency of 100 MHz with a dynamic range of 14 bits.

All the experiment setups were placed in a vacuum chamber. Several sources were used during the test experiment. Inset of figure 1 shows two different pulse shapes of γ and α in CsI(Tl) observed in a mixed ^{22}Na and ^{241}Am sources. Particle identification was first tested by using the integration method consisting of taking the integral over different parts of the signal, which is a common procedure in various pulse shape discrimination approaches [2]. Figure 1 shows the particle identification by plotting the fast and slow components against one another. The integration window and starting point for fast and slow components are shown in inset of figure 1. As can be seen in figure 1, the γ-rays and α particles are separated down to low energy region. In order to test the α-p-γ pulse shape discrimination, a proton source was prepared by placing a 28 μm mylar foil in front of an 10 μCi ^{241}Am open alpha source. The protons were elastically ejected from the mylar foil by α-particles, which are stopped in the foil. As shown in figure 2, in addition to γ and α bands, a third strong band structure was observed in lower part of the plots; however, the nature of this band need to be checked later. The data analysis is still in progress.

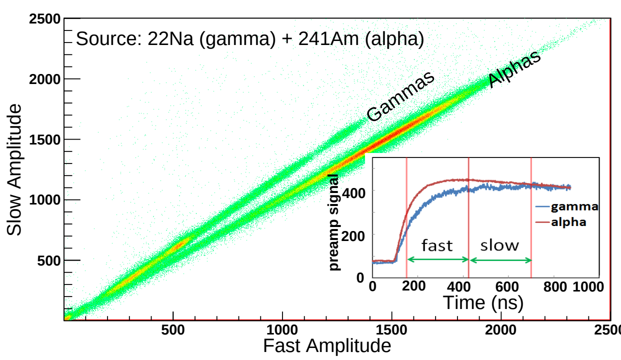

Figure 1: Particle identification plots using mixed ^{22}Na and ^{241}Am sources. The inset shows typical waveforms for γ and α in CsI(Tl).

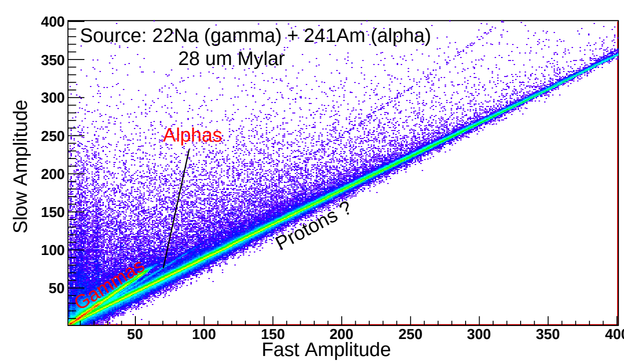

Figure 2: A same plots with figure 1 but with a 28 μm Mylar foil put in between α source and CsI(Tl) detector.

References

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