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#1-293 Time response of fast PTMs matching a cerium-doped lanthanum bromide crystal

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Within the framework of the HISTARS (HIE-ISOLDE Timing Array for Reaction Studies) project at the ISOLDE facility at CERN, plans are underway to implement a gamma-ray array dedicated to fast-timing measurements of lifetimes of excited nuclear states populated in Coulomb excitation and transfer reactions.
Advanced scintillator materials such as cerium-doped lanthanum bromide and cerium bromide inorganic crystals are typically employed for gamma-ray fast-timing spectroscopy, due to their superior performance in both energy and time resolution. These crystals are generally coupled to photosensors, including photomultiplier tubes (PMTs) and silicon photomultipliers, matching their spectral response and high photon yield. The commercially-available PMT that provides the best time resolution to date for both CeBr3 and LaBr3(Ce) is model R9779 by Hamamatsu, but its production has been discontinued.
In this study, we have conducted a detailed characterization of four different head-on photomultiplier tubes with bialkali photocathodes, all manufactured by Hamamatsu, in combination with a cerium-doped lanthanum bromide scintillator crystal. The crystal, shaped as a truncated cone, has a height of 1.5 inches and base diameters of 1.5 inches and 1 inch. The photomultiplier tubes tested include a customized version of the already mentioned 2-inch, 8-stage bialkali photocathode model R9779, integrated into the H10570 assembly, which was used as a reference, since it has been proven to provide the best time response.
The other devices evaluated were three newer PMT models: a 1.5-inch, 8-stage R13408, and two 2-inch, 8-stage R13089 models housed in different assemblies (H13719-Y006 and H13719-Y007). For coincidence resolving time measurements, the reference detector was paired with each newer photomultiplier tube, positioned in a face-to-face configuration. Data acquisition was performed using a fast digitizer module, with a sampling rate of 5Gb/s and the collected signals were processed fully digitally with techniques including digital constant fraction discrimination and a first-order recursive filter. Processing parameters were optimized specifically for timing resolution using a genetic algorithm. Both anode and last-dynode signals were investigated.
The results of this investigation reveal the time responses of these photomultiplier tubes for photon energies from Na-22 and Co-60 sources. The reference detector delivered the best timing resolution, achieving 155 ps for sodium-22 and 110 ps for cobalt-60. Among the newer models, the R13089 with assembly H13719-Y007 exhibited excellent performance, achieving 120 ps for cobalt-60. Similarly, the anode signal of the R13408-Y006 demonstrated good results, with a timing resolution of 180 ps for Na-22. All tested PMTs showed minimal time-walk, good energy resolution, and, notably, the newest PMTs displayed excellent linearity across the tested conditions. A full account of the results will be provided.

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