MPPC-based detectors for high count rate DT campaigns at JET

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The gamma-ray camera is one of the diagnostic tools used to study fast ions as well as confined α particles. The data acquired with the upgraded Gamma-ray Camera will be an excellent addition to the high resolution spectroscopy measurements collected with the Gamma Spectrometer [this AR]. In the future deuterium-tritium (DT) campaigns high count rates are expected, so it is necessary to upgrade the entire gamma-ray diagnostics.

For measurements at high count rates we use an active solution based on a transimpedance amplifier (TIA) to obtain signals as short as 130 ns without losing operational stability. The TIA is able to minimize gain shift, when the registered event count rate rapidly changes over time.

The detector system based on a fast scintillator, e.g., $CeBr_3$ or $LaBr_3$:Ce, consists of a multi-pixel photon counter (MPPC), a MPPC Temperature Compensation Device (MTCD@NCBJ) and an active base (TIA) or a passive RC circuit with a pole zero cancellation base (RC). Such detectors will replace presently used detectors, based on CsI:Tl coupled to PIN diodes. Two prototypes of detectors with $CeBr_3$ crystals and passive bases have already been installed at JET in channels 9 and 10 of the Gamma Camera [1].

In Fig. 1 the output pulses measured with a 20×15 mm^2 $CeBr_3$ crystal coupled to an MPPC are shown. The pulse shape is described by the rise and fall time: the rise and fall times are here defined as the interval between the times at which the pulse reaches 10% and 90% of its maximum amplitude on the leading and falling edge, respectively. In the setup with RC, by changing the capacitor a signal can be shortened, almost without limit, but at the cost of the amplitude. In the setup with the TIA, shortening of a signal is limited by the amplifier properties. The relative loss in amplitude is much smaller for the TIA than for RC.

This detector setup, based on $CeBr_3$ coupled to an MPPC with a TIA and MTCD, was also tested during high count rate measurements at the Legnaro National Laboratories (LNL), where a beam of 10 MeV protons from the TANDEM-ALPI accelerator was collimated onto a target of 27Al placed in a cylindrical vacuum chamber, and at the ENEA Frascati. More details can be found in [2].

Results obtained in measurements performed both under laboratory conditions and with an accelerator and a neutron generator show that this device guarantees stable working conditions.

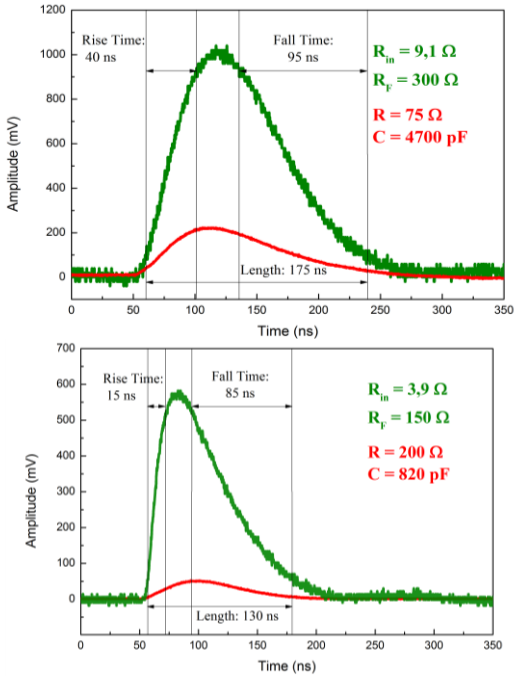

Fig. 1. Output pulses from a 20x15 mm^2 $CeBr_3$ scintillator coupled to an MPPC with an RC circuit (red) and TIA (green).

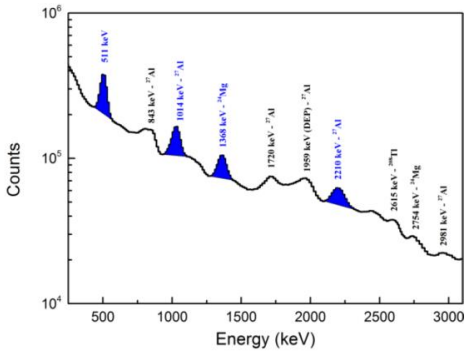

Fig. 2. Typical spectrum obtained at LNL for a 20×15 mm^2 $CeBr_3$ coupled to an MPPC, with a TIA and MTCD measured at 30 nA current with a maximum rate of ~340 kHz for 120 s.

References

[1] I. Zychor et al., High performance detectors for upgraded gamma ray diagnostics for JET DT campaigns, Phys. Scr. 91 (2016) 064003 (9pp)

[2] G. Boltruczyk et al., Development of MPPC-based detectors for high count rate DT campaigns at JET, sub. to Fusion Engineering and Design (2017

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