

Performance of LGAD-based X-/Gamma-ray Detection Systems with SIRIO Ultra-Low Noise Charge Sensitive Preamplifier

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We present the performance of two X/Gamma-ray detection systems based on Low-Gain Avalanche Diodes (LGADs) with a wide range of multiplication gains: the first LGAD is characterized by a very-low gain range ($M_s=1.2-1.9$), while the second one by a high-gain range ($M_s=10.2-19.3$). To allow the evaluation of the ultimate energy-resolution limits of the LGAD sensors, the read-out is performed with a state-of-the-art ultra-low noise Charge Sensitive Amplifier (CSA) realized in CMOS technology. Detectors' performances were evaluated using ^{241}Am and ^{55}Fe radiation sources, allowing for a consistent study of the spectral resolution over a wide range of photon energies, from $E_{\text{ph}}=5.9$ keV to $E_{\text{ph}}=59.5$ keV. The different noise components contributing to the overall spectral performances of the detection systems have been determined, disentangling the contribution of the equivalent noise charge (ENC) as measured on an artificial test pulse, from the excess widening of the spectral lines, associated with the multiplication gain statistics and a spatial gain inhomogeneity. The Excess Noise (EN) of the spectral lines is shown to increase linearly from $E_{\text{ph}}=5.9$ keV to $E_{\text{ph}}=59.5$ keV. EN has also been found to increase linearly with M_s with a slope proportional to $\sqrt{E_{\text{ph}}}$ as expected from the theory of the statistical noise in avalanche structures. An empirical model for the excess noise of the spectral lines dependence on E_{ph} and M_s has been developed including both the noise due to multiplication gain statistics and the gain inhomogeneity.

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