“CUBE”, A LOW-NOISE CMOS PREAMPLIFIER AS ALTERNATIVE TO JFET FRONT-END FOR SILICON DRIFT DETECTORS

L. Bombelli[(1)], C. Fiorini[(1)], T. Frizzi[(2)], R. Nava[(2)], A. Longoni[(1)]

[(1)]Politecnico di Milano, Dip. Elettronica e Informazione, Piazza L. da Vinci 32, I-20133, Milano, Italy

[(2)]XGLab SRL, via Moretto da Brescia 23, I-20133, Milano, Italy, ph. +390249660460, email info@xglab.it

The development of radiation detectors for high-resolution X-ray spectroscopy is a research field of continuously growing interest, for its application either in scientific research (e.g. in synchrotron experiments) and in industrial applications (e.g. microanalysis with SEM, X-ray fluorescence analyzers, and others). As alternative to Si(Li) detectors, high-resolution and high-rate silicon drift detectors (SDDs) have also become a valuable solution commonly used in an increasing numbers of apparatus.

Besides the quality of the detector employed, the quality of the spectroscopy in terms of energy resolution and counting rates is strictly dependent on the performances of the front-end electronics. Regarding the best choice of the input transistor of the front-end preamplifier, two options are mainly considered: the integration of the input JFET in the detector chip or the connection of the detector with an external low-noise FET. The first option allows to achieve excellent performances, thanks to the lowest value of total capacitance at the anode. However it requires a sophisticated technology compatible for both detector and JFET processing. The second option allows a free choice of the external FET and is still widely adopted for several detectors because it disentangles the technology process for the detector from the manufacturing of a suitable front-end FET.

In this paper, we propose a CMOS charge preamplifier (named “CUBE”) to be directly connected with a SDD (without any extra input JFET) and we show that this solution may be competing with respect to the detector readout based on the available state-of-the-art JFET devices to be externally connected to the detector. The solution here developed may be suitable for a compact SDD-based detection module (e.g. T08 format) as it provides already the preamplifier output voltages at one pin of the module.

The preamplifier has been connected to a circular SDD and experimented in X-ray spectroscopy measurements. The SDD here employed has an area of 10 mm^2 and was cooled at -40°C. In Fig. 1, the spectrum of the ^{55}Fe measured with the best resolution is reported. The resolution at the Mn-Kα line is 126 eV FWHM, measured at a shaping time of 1.5 μs. In Fig. 9, the ^{55}Fe spectrum measured in the same condition but using 250 ns shaping time is also reported. A resolution of 132 eV FWHM, maybe the best ever achieved at this short shaping time with a circular SDD, has been quoted. Additional results on the experimentation of the circuit, also at high counting rates, will be presented in the work.

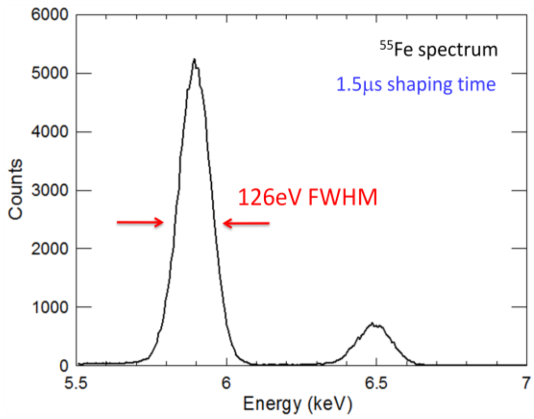

Fig.1. Spectrum of the ^{55}Fe source measured with a SDD and the CMOS preamplifier, at a temperature of -40° C. The best energy resolution of 126eV FWHM was achieved using 1.5 μs shaping time.

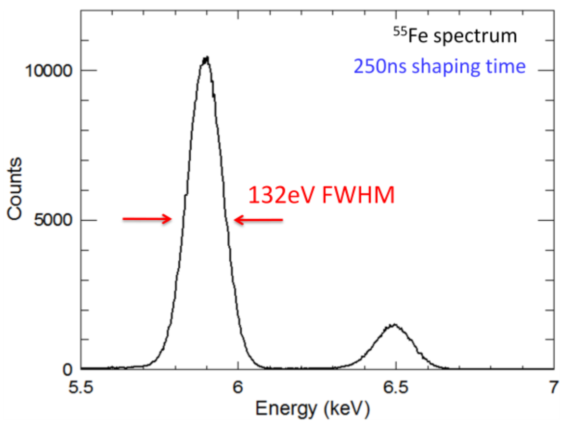

Fig.2. Spectrum of the ^{55}Fe source measured with a SDD and the CMOS preamplifier, at a temperature of -40° C, using 250 ns shaping time.