High-Rate High-Resolution Performance of New Cadmium Zinc Telluride Linear Array Detectors for Energy-Resolved X-ray Imaging

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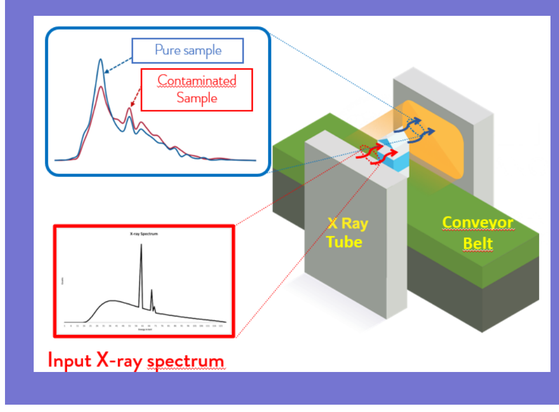
Abstract

Recently, sub-millimetre cadmium zinc telluride (CdZnTe or CZT) linear array detectors for high-flux spectroscopic X-ray imaging are proposed and fabricated by our group. These activities, in the framework of a PRIN-MUR project, plan the development of room temperature X-ray scanners for contaminant detection in food industry. As widely demonstrated, CZT is one of the key materials for the development of room temperature X-ray and gamma ray detectors and great efforts have been made on both the device and the crystal growth technologies. In this work, we will present the results from spectroscopic and imaging investigations on new high flux HF-CZT linear array detectors, with hole mobility-lifetime product enhancements and sub-millimetre pixels (pixel pitches of 500 µm). The detector response will be measured taking into account the mitigation of the effects of incomplete charge collection, pile-up, charge sharing and high flux radiation induced polarization phenomena. Measurements with custom front-end ASICs show excellent room temperature energy resolution FWHM of 1 % (0.6 keV) at 59.5 keV.

Motivation

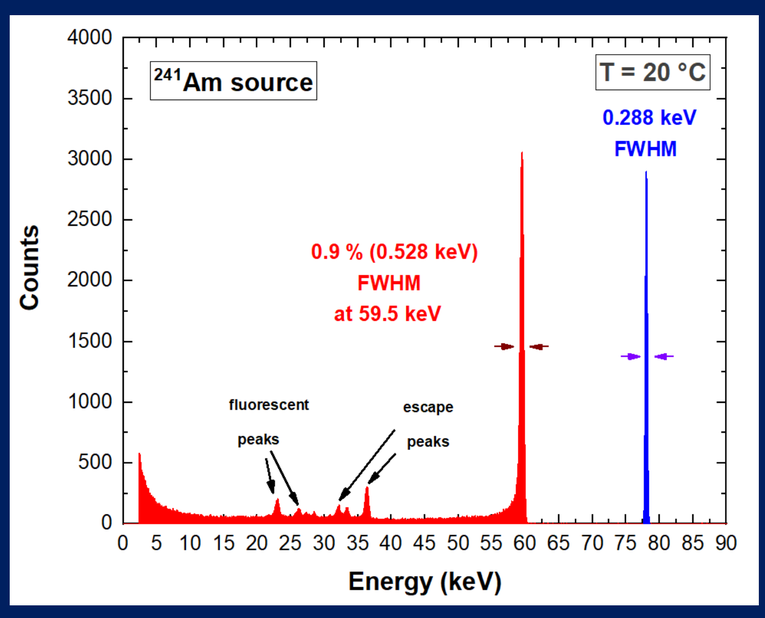
Colour X-ray imaging systems for contaminant detection in food industry.



Detection system requirements:

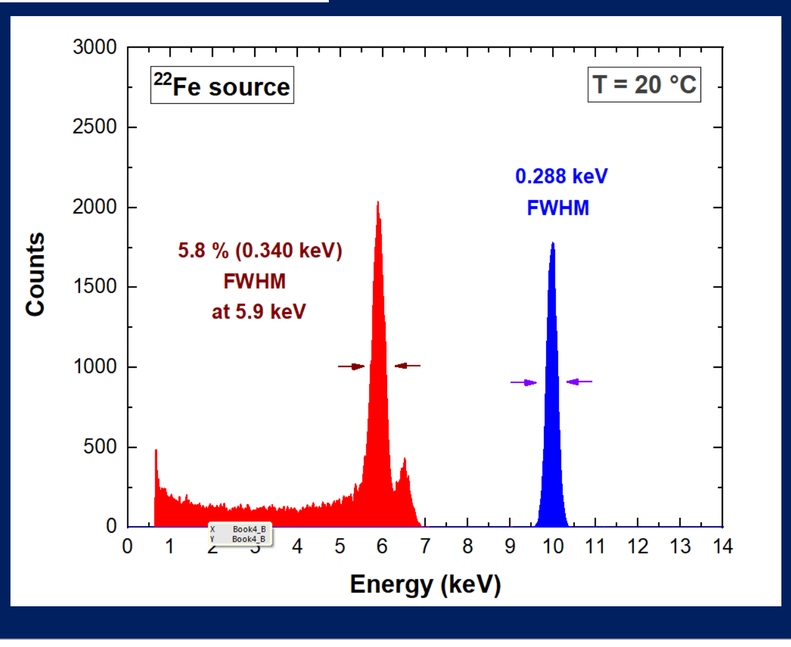
- ✓ High penetration capability → High stopping power
- ✓ High spatial resolution → Small pixel-pitch
- ✓ High image contrast → Low-noise spectrum
- ✓ Fast processing (< 1 ms) → High-rate capability
- ✓ Room-temperature/moderate cooling operation

Low-Rate X-ray Energy Spectra



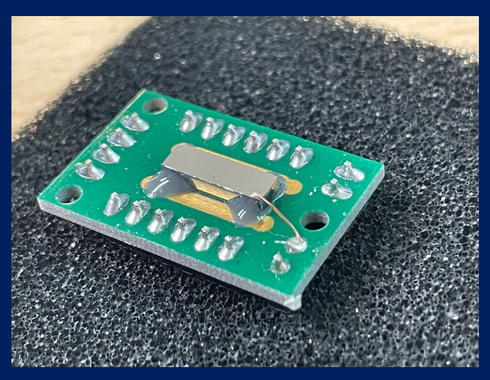
Excellent Room Temperature Energy Resolution

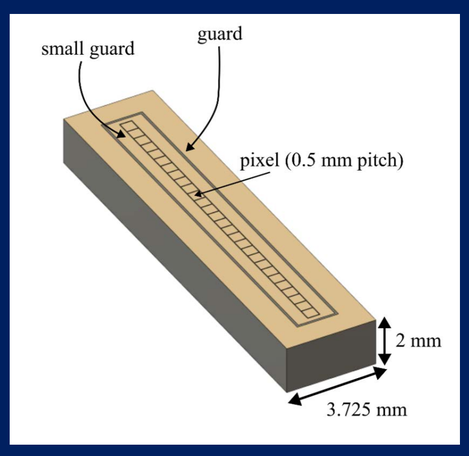
Cutting Edge Room Temperature Performance

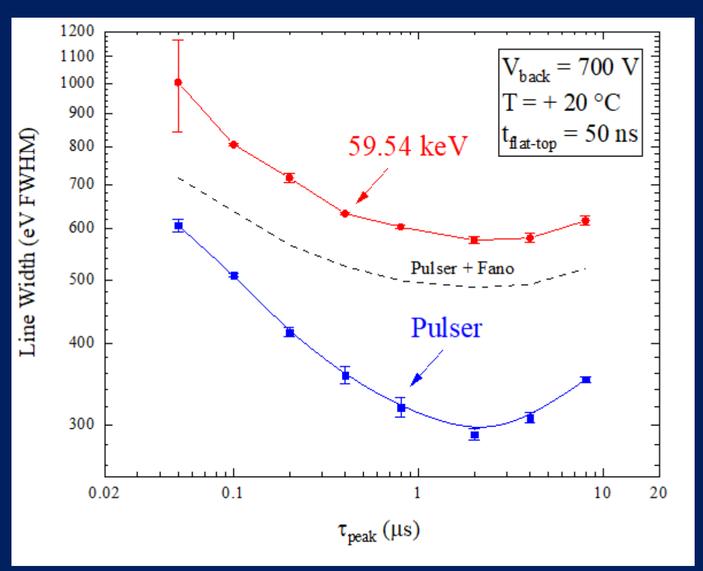


Detectors and Electronics

The prototypes are based on new high-flux HF-CdZnTe linear array detectors, coupled to low noise preamplifiers (ASICs) and followed by custom digital pulse processing electronics.

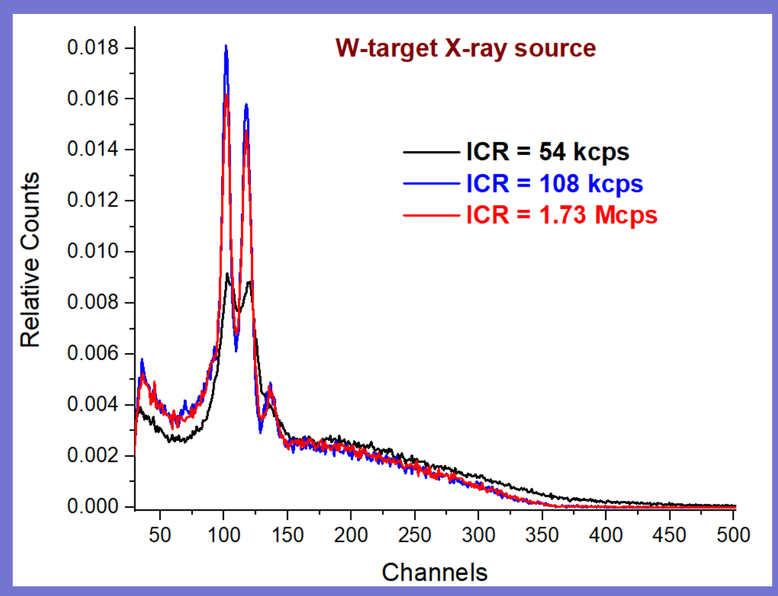






High-Rate X-ray Energy Spectra

High Energy Resolution and High Throughput (93 %) at 1.73 Mcps



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