

# THE CHALLENGES IN DESIGNING, OPTIMIZING, AND MANUFACTURING X-RAY DETECTORS FOR HAND-HELD XRF

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**Abstract:** Twenty years ago most XRF was performed in the lab using cryogenic Si(Li) detectors in high end systems. Hand-held XRF was limited to niche applications using detectors with limited performance. Today tens of thousands of hand-held XRF systems are in the field, used in a wide range of applications with excellent resolution and count rate performance. A few central challenges were overcome to make this possible, challenges addressed through successive technology generations. Each generation of detector opened new applications, presenting new challenges and leading to yet another technology generation.

The first generation of detectors was not intended to replace laboratory instruments but to better meet the requirements of particular measurements. One major challenge was cooling the detectors enough to reduce electronic noise without using liquid nitrogen. The use of thermoelectric coolers was the first important step. True field measurements require stable operation over a very wide temperature range, and packaging robust enough to survive years of field use. Another major challenge was the need to manufacture detectors at high volume and low cost without sacrificing performance. This required the design and development of custom detectors, FETs, and other critical components. Reproducibility is a related concern, eliminating the need to hand tune resistors, bias voltages, and other values for each detector.

Many technical challenges were addressed in order to provide the necessary performance. There is the obvious challenge of achieving high energy resolution and high count rates, which has required custom detectors and unique signal processing circuits. Minimizing spectral contamination from components near the detector is a challenge in a small package. Achieving a high efficiency for both light and heavy elements in a rugged, light-tight package is a challenge. In this paper, we will review how these challenges have been met by successive generations of Amptek's X-ray detectors for hand-held XRF, and will discuss the challenges facing the industry today.