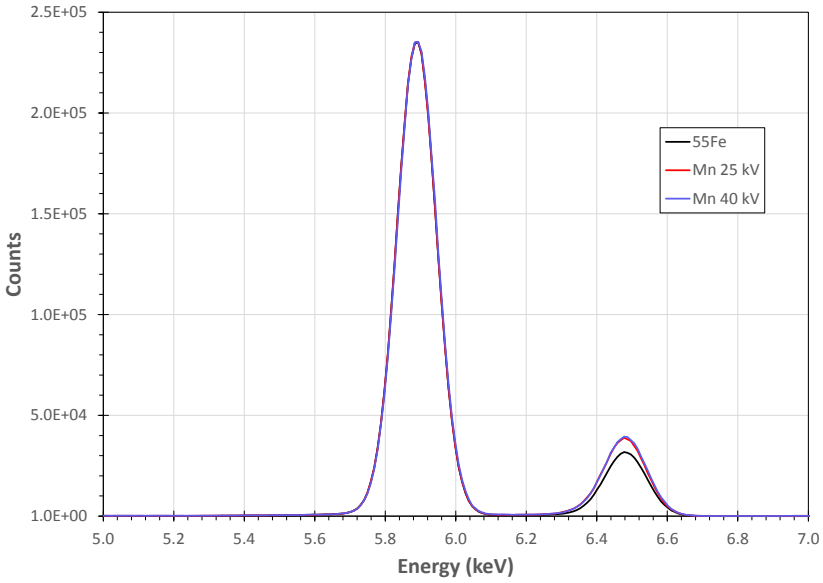
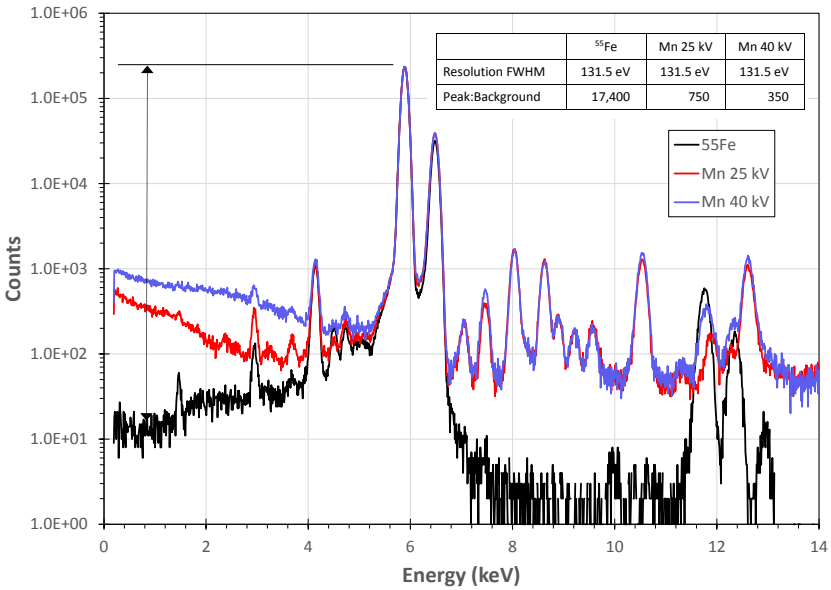
Application Note: Spectra from X-ray tubes and isotopic sources

Typical question: Instead of a ^{55}Fe source, can I excite a pure Mn target with an X-ray tube to test my detector?

You can do so but the test results are not directly equivalent. The plots below show spectra taken using the same detector and electronics (in this case an X-123-FastSDD) with the same system configuration. Data were taken using a ^{55}Fe isotopic source and using an X-ray tube to excite a pure Mn target. The FWHM energy resolution is the same in all three cases, 131.5 eV. But many other characteristics are quite different: the log plot shows that the peak to background value is dramatically worse with the X-ray tube, it shows many additional spectral lines, and even the linear plot shows a different ratio for the Mn K_α and K_β lines.





AMPTEK, Inc. 14 DeAngelo Drive, Bedford, MA 01730-2204 USA
+1 781 275-2242 Fax: +1 781 275-3470 www.amptek.com sales@amptek.com

Why are the results different with a source and a tube?

- The K_α/K_β ratio is different due to self-attenuation. The X-rays from the tube penetrate fairly deeply into the Mn target; the K_α X-rays have a sorter attenuation length so fewer exit the target, reducing the K_α/K_β ratio. The isotopic material is located closer to the surface.
- The peak to background ratio is different because the X-ray tube produces a brehmstrahlung continuum which is scattered from the target. The intensity of the scattered continuum is much larger than the background response of the detector. It will also be a strong function of the tube's kV setting, any filter on the tube, the geometry, etc.
- The additional characteristic X-ray lines arise from two sources. First, the target is nominally 99.9% pure Mn which means the impurities total 1000 ppm. An XRF system has a detection limit of 10 ppm so clearly detects impurities. Second, the tube includes collimators, filters, and shielding, and each of these contributes X-ray lines. It is worth noting that even isotopic sources may contain impurities which are detectable (we have seen Cr and Ti in ^{55}Fe sources).
- In this example the resolution was the same but this is not always the case! X-ray tubes are commonly found to produce electromagnetic interference. The high voltage power supply of the tube can couple into sensitive circuits in the spectrometer and thus degrade resolution. Tube power supplies often vibrate, producing ultrasonic acoustic signals, and the detectors (which are somewhat microphonic) detect this noise.

An X-ray tube may be used to characterize an X-ray detector or spectrometer but the results may be different from the results obtained using a ^{55}Fe isotopic source. Amptek uses the ^{55}Fe source, which better characterizes the detector since it makes a cleaner signal. The ISO standards for measuring spectrometer recommend use of ^{55}Fe sources. An ^{55}Fe source is the proper, definitive standard.