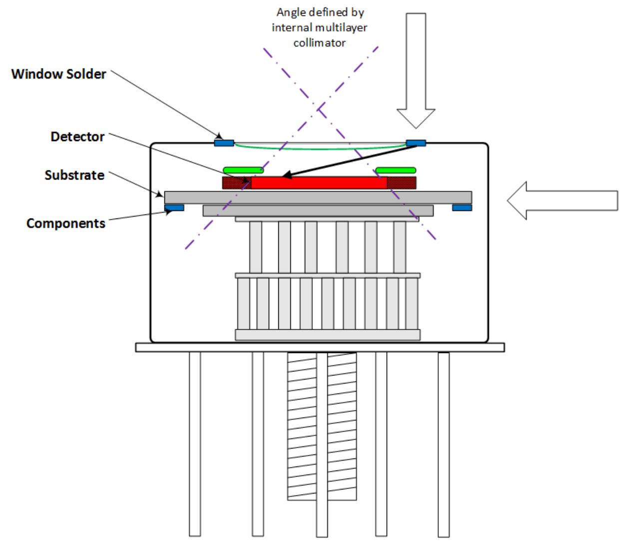
Application Note: Understanding Interferences

Many different materials are be necessary in an an X-ray detector package in addition to the silicon detector itself. These would include the cover, mounting substrates, additional electronic components (transistors, capacitors, etc) and associated methods of attachment such as wire bonds, solders, etc. Each of these materials, if excited by X-rays, will produce their own characteristic X-rays, which might be seen in the measurement spectrum and impact accuracy. These X-ray lines are called “instrumental interferences” because they interfere with the measurement of the sample and arise from the instrument. Note that instrumental interferences can also arise from external sources to the detector, such as collimation and shielding in the analyzer, or even originating from the X-ray tube and filter.

In constructing its detectors, Amptek has gone to great length to minimize interferences, through the use of multilayer collimator and shields, careful positioning of components, etc. But the result that user’s might find is that inteferences might not all vanish from their measurements.. It depends quite strongly on the energy of the exciting X-rays, the design of external shielding and collimation, and the angular distribution of incident X-rays.

What causes interference in Amptek detectors?

The figure at right is a sketch of a detector package, illustrating the main physical sources that may give rise to interfering signals in the spectrum. . Material compositions and component positioning have both been carefully considered to work in tandem to reduce interferences. Nevertheless, there are further methods that the user can employ to also increase effectiveness.



First, the cover of the detector package is made out of nickel. X-rays which interact along the inner edge of the cover, where the window is mounted, will produce a measurable nickel signal. An external collimator or mask which prevents incidence X-rays from reaching this region will greatly reduce the nickel signature.

Second, there is a multilayer collimator (MLC) in front of the detector, which masks the edge of the active region of the detector and blocks X-rays from large angles. The outer layer of the MLC is aluminum, so an aluminum signature is usually present. A collimator or mask which prevents direct excitation of the MLC will minimize the aluminum.

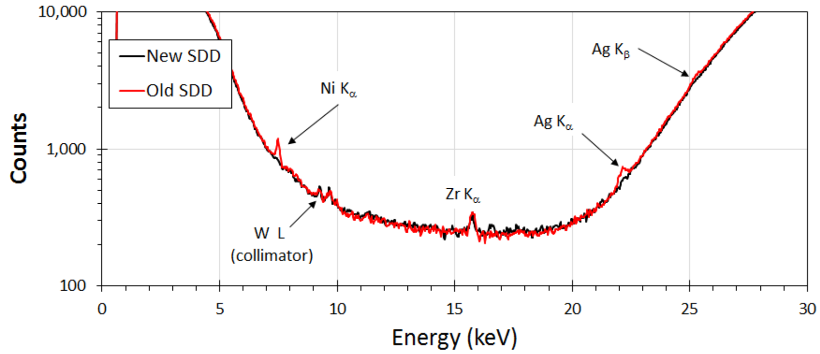
Third, if the detector is constructed with a Be window, it will be soldered to the nickel cover using a Pb-free solder (Sn, Ag, etc). The solder placement is on top of the nickel, so any signal caused by these metals is first attenuated by the nickel and then largely blocked by the internal MLC. With incident X-rays up to about 50 kV, solder generally produces a negligible signal. . However, with even higher energy incident X-rays, the solder will produce even more X-rays and a penetrating fraction might eventually reach the detector and become observable. Blocking the solder with an external collimator or mask will eliminate the signature of these elements.

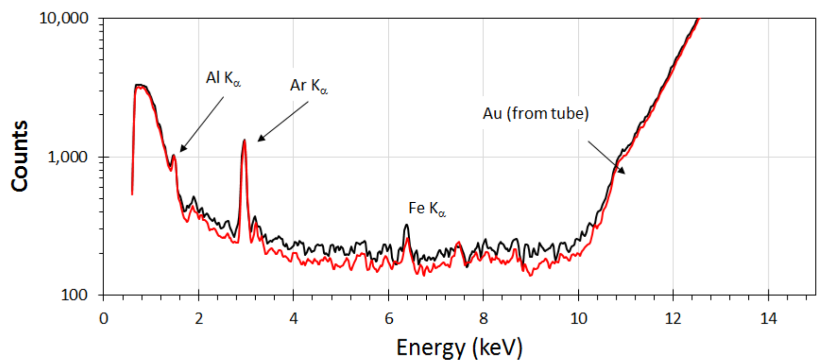
Fourth, there are the other components, either electrical or mechanical in purpose, that are present in the package. Most are positioned at the side or rear of the detector (furthest from the entrance window) to minimize the amount of radiation reaching them. Nevertheless, as an example of a possible interference, one commonly seen signal that can be attributed to these components is Zr. Again, with energies up to about 50 kV, there is little signal seen from these other materials; but if using higher energies and incident X-rays are allowed to strike the detector cover from wide angles (including the sides), interfering lines become more probable. To further minimize these types of contributions, Amptek also employs a shield at the rear of the detector atop the thermoelectric cooler, to prevent its characteristic X-rays from being detected.

What is a typical spectrum?

The plots below show typical spectra. These were measured using a 25 mm^2 FASTSDD®, where the target was a block of high density polyethylene(HDPE). HDPE is a hydrocarbon and will produce no visible X-ray lines that can be transmitted through air. The X-rays efficiently scatter, producing a smooth scattering spectrum, so any lines observed in the spectrum arise from somewhere in the instrument. The source was an X-ray tube with An anode, heavily filtered. An external collimator was placed over the detector cover (an Amptek eMLC-2, made of tungsten with a multilayer insert).

The top spectrum show results measured with a 50 kV excitation, the bottom with a 20 kV excitation (and less filtering on the tube). These plots actually show the improvement from an earlier model of Amptek's SDDs to a newer one. The older model shows small Ni and Ag peaks, which have been greatly reduced through design.





What can be done about interferences?

The best solution is to use an external shield and collimator, as sketched to the right. The goal is to block extraneous incident X-rays so they do not reach the solder or components in the package.

Amptek has developed an external collimator and shield, the eMLC. For <50 kV, the eMLC-1 uses a brass shield, with a single external multilayer collimator. For 50 kV and above, the eMLC-2 uses tungsten to block the sides and a thicker collimator in front.

The best collimator and shield is designed around the sensor geometry of the instrument in which it is used. We recommend OEMs do a careful design to optimize their system. The eMLC options may not be necessarily ideal in all circumstances but we recommend that users apply these concepts carefully.