Notes

Linearity

Spectrum linearization

The light and thus the electronic pulse created from scintillations in Sodium Iodide detectors is not a perfect linear function of the energy deposited in the xtal. If no correction is performed the effect will be carried over to the pulse height spectrum with a non-linear relationship between channels and energy as a result. Electronic can also affect the linearity but with good quality electronic this should be a much smaller effect. Effects on non-linear electronics are discussed in a following section. Assuming the electronics is of good quality the non-linearity of xtal output is of the order of 2-4%. In older systems the effect of the non-linearity was minimized in the upper ¾ of the spectrum by introducing a digital offset in such a way that the spectrum appears almost linear between ^{137}Cs (662 keV) and ^{232}Th (^{208}Tl @ 2.6MeV). The non-linearity is still there but is then reduced to 1-2% in the top ¾ of the spectrum, but at the cost of a much larger non-linearity in the lower ¼ of the spectrum. For geo applications this is a good trade-off since the all the regions of interest (ROI) are in the upper ½ of the spectrum but for environmental applications where the low end of the spectrum is of importance the problem is unchanged. To make matters worth different xtals can have different non-linear response curves and after summing the sum spectrum will be blurred resulting in degradation of the energy resolution.

Modern spectrometer systems corrects for the non-linear effects in the xtals. Ideally each xtal should be corrected independently to ensure that individual xtal non-linearity is properly corrected. Different methods can be applied to correct for the xtal non-linearity and the specific methods are typically vendor proprietary.

Effects of linearization

If the xtal linearization is carried out correctly the effect is an output spectrum with a close to perfect linear relationship between channels and energy. The linearization by itself helps interpreting the data since the conversion between channels and energy is linear for example 3keV/channel or 6keV/channel. The other major benefits are no or very little loss in energy resolution after summing xtals and simplified post analysis since all ROIs can be stay the same for all detector packs.
Some implementation of linearization has a drawback since the counting statistic it modified from the theoretical Poisson. Ideally the counts in each channel should be Poisson distributed and there should be no correlation between the channels Poisson noise.

How to test for Linearization.

The goal of linearization is to make a linear relationship between channels and energy and the first test is to see how linear the system is. A number of sources with different energies should be used including preferable a ^{232}Th source and cover energies from 30keV up to 2.615MeV. The 2.615MeV peak from ^{208}Tl can be used to establish the channels-energy relationship. The energy calibration constant is 2.615MeV/(peak channel ^{208}Tl). For the other energy peaks the variance from a perfect linear curve can be calculated by summing the square of the differences between the correct peak energy and the calculated energy based on peak position and the energy calibration constant. Testing for correct Poisson static is more complicated. Extensive work has been carried out by Dr. Brian Minty on this topic and interested readers should contact Dr. Brian Minty at Geoscience Australia for details.