**Mitigation of the Effects of Rate-Dependent Offsets on STIX Imaging**

Gordon Hurford and Richard Schwartz

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**Introduction**

It has been established that the offsets of the STIX detector-pixel energy calibration have a dependence on the count rate in each pixel. The purpose of this writeup is to address the question of whether this has an effect on STIX imaging. This is relevant since STIX imaging is based on the relative count rates in different pixels.

There are two mechanisms by which energy offset shifts could potentially affect imaging. The first mechanism, which also affects spectroscopy, is that the energy corresponding to the accumulated counts becomes different than the nominal energy for the corresponding science channel. Although this could be handled by adjusting the energy associated with the science channel, there are secondary effects associated with the response matrix which could complicate this otherwise simple solution.

The second effect potentially affects the imaging directly. Because of the steep solar spectra, a change in energy offset can affect the relative count rates in different pixels. Since imaging is based on count rate differences among pixels, this could potentially compromise the integrity of the imaging. The discussion below examines this effect in more detail.

**Analysis**

Since STIX imaging is based on the measurement of visibilities, it suffices to examine the effect of rate-dependent offsets on individual visibilities. To do so, we make the following assumptions:

* The energy offset is proportional to the count rate in the nominal energy range of interest in each pixel. (This is only approximately correct since it is believed that the offset rate is actually proportional to the total rate of energy deposition in each pixel.)
* In the nominal energy range of interest, for each detector, the count rate sum over pixels is statistically the same.

We define the following quantities for the nominal energy range of interest:

* The nominal background rate in each pixel is: B (counts/s).
* The pixel-averaged photon count rate in each pixel is A (counts/s).
* The visibility-contribution to the photon count rate in each pixel is:
* vi = a\*k\*COS(phi+i\*pi/2) where i = 0,1,2,3; k is a known, fixed normalizing constant; and a and phi are the amplitude and phase of the visibility respectively.
* s is a parameter that represents the fractional increase (or decrease) in count rates as a result of the offset shift. s will depend on the upper and lower bounds of the nominal energy range of interest and on the spectral slope in this region. s is, however, independent of the rates themselves.

Therefore the nominal count rate in each pixel is given by Ci = A + B + vi , i=0,1,2,3.

The observed count rates in each pixel are then given by Ci’ = (1+s)\*Ci .

The nominal measurement of the Cartesian components of the visibility is given by:

**X =** (C2-C0)/2k = (v2-v0)/2k = **a\*COS(phi)**

**Y =** (C3-C1)/2k = (v3-v1)/2k = -a\* COS(phi+pi/2) = **a\*SIN(phi)**

Because of the offset shift, however, then actual measurement will be given by:

X’ = (C2’ -C0’)/2k = (1+s)(C2-C0)/2k = (1+s)\*a\*COS(phi)

Similarly, y’ = (1+s)\*a\*SIN(phi)

**Conclusions**

**Therefore, the effect of the offset shift is to increase the measured amplitude by a factor of (1+s) with no effect on the measurement of phase**. Since the average rate of energy deposition is approximately the same for all detectors, **all the measured amplitudes are increased (or decreased) by the same factor. Consequently, to the extent that the assumptions are valid, the only effect on the resulting imaging is to increase (or decrease) its intensity by a factor of (1+s) with no first order effect on the image quality or morphology.**

**Addendum: Another approach is to actually mitigate the effects of any discernible rate shift requires knowledge of the rate shift function. And we can measure that function by looking at the change in the spectrum integrated over small or large pixels for a given high countrate pixel dataset. With that knowledge of the offset vs rate we can correct the pixel counts before computing the visibilities. There is a script that shows this simulation and correction procedure, diffcounts\_stx.pro, in the stix/idl/demo directory. The script shows just how effective the rebinning strategy will be in a case study that should produce large differences in count rates for the imaging pixels for the coarsest grids. There are spreadsheets in .csv files in stx/dbase/offset, Offset\_evaluation…csv, that summarize the results of the simulations showing that the mitigation strategy described here will be completely effective and that no more study is required beyond evaluating the offset as a function of rate. And that can be effectively done in the lab and in flight by studying the difference between large pixel and small pixel spectra vs rate.**