Technical Evaluation Report
“Coordinate Transformation Between Segments A and B on the HST/COS FUV Detector”

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1. BACKGROUND

The COS/FUV detector utilizes a time delay anode to determine the position of a detected photon incident on the detector. The time delay anode is an analog device as opposed to a digitized device such as a CCD or MAMA detector. In a CCD or MAMA detector the position of the photon relates directly to a physical location on the detector, e.g. potential wells defined by the substrate structure in a CCD or the anode pattern in a MAMA detector.

A time delay anode detector computes the position of the photon by calculating the difference in the time it takes for the photon initiated charge pulses to reach each end of the anode. To be more specific, the photon initiated charge pulse on the anode splits and each half races towards a different end of the anode. One pulse is always biased to arrive at the digitizers first and is known as the START pulse. The START pulse initiates the discharging of a precision capacitor. The second pulse to arrive, known as the STOP pulse, stops the discharging. The remaining voltage on the capacitor is digitized by an analog to digital converter. Thus, the final digitized voltage relates to the original position on the incident photon. Given a knowledge of the electrical properties of the anode it is possible to calculate the starting point for the charge cloud on the anode and thus the position of the photon on the detector.

The important point here is that the performance characteristics of the electronics directly effect the relationship between pixel value and physical location on the detector. One example of this is that no two capacitors are identical, so subtle differences in the discharge rate will produce different digital values for identical START and STOP arrival times. Thus, different electronics will alter the relationship between physical location and pixel.

Each segment of the COS/FUV detector utilizes time delay anodes to compute the dispersion and cross-dispersion position of the incident photon. Clearly, as was just described, the relationship between physical location and pixel will be different for each segment, as the electronics are unique for each segement. A result of this situation will be that the pixel values in the cross-dispersion for each segment will be different for a spectrum incident across both segments.

The purpose of this memo is to provide a mathematical description of this phenomenon for use by the flight software in identifying the cross-dispersion location of each spectrum.

2. DEFINITION OF TERMS

Ya = physical coordinate of a pixel in segment A
Yb = physical coordinate of a pixel in segment B

Pya = pixel number associated with Ya
Pyb = pixel number associated with Yb

3. ALGORITHM DESCRIPTION

Ya = f(Pya) and Yb = f(Pyb)

Hopefully this function (f) is simple (on FUSE it is not, it would take many polynomial orders to perform a fit, however the COS Y readout is fundamentally different than COS'). Assume that it is linear for COS with Ya0, Yb0, Ya1, and Yb1 being the y-intercepts and slopes respectively.

Ya = Ya0 + Pya * Ya1
Yb = Yb0 + Pyb * Yb1

Yacen = centroid of Y points on segment A
Ybcen = centroid of Y points on segment B

$\text{Yacen} = \text{Ybcen} + \Delta$

If the spectrum is not aligned exactly perpendicular to the Y axis on both segments, Δ is not zero, and is a function of spectral energy distribution as well. We'll leave it as a Δ for now.

To transform coordinates from A to B (with identical physical coordinates)

Pyb = [(Ya0 - Yb0) + Pya * Ya1] / Yb1

To convert centroids, the Δ must be introduced

$\text{Pyb (centroid)} = [\, (\text{Ya0} - \text{Yb0}) - \Delta + \text{Pya (centroid)} * \text{Ya1}\,] / \text{Yb1}$

Or more generally, if a linear fit is poor,

$\text{Pyb} = f^{-1}\,[\, f\,(\text{Pya}) + \Delta\,]$

Remember, if the line runs along the PHYSICAL y axis, then $\Delta = 0$, even if it does not run along the PIXEL y axis.