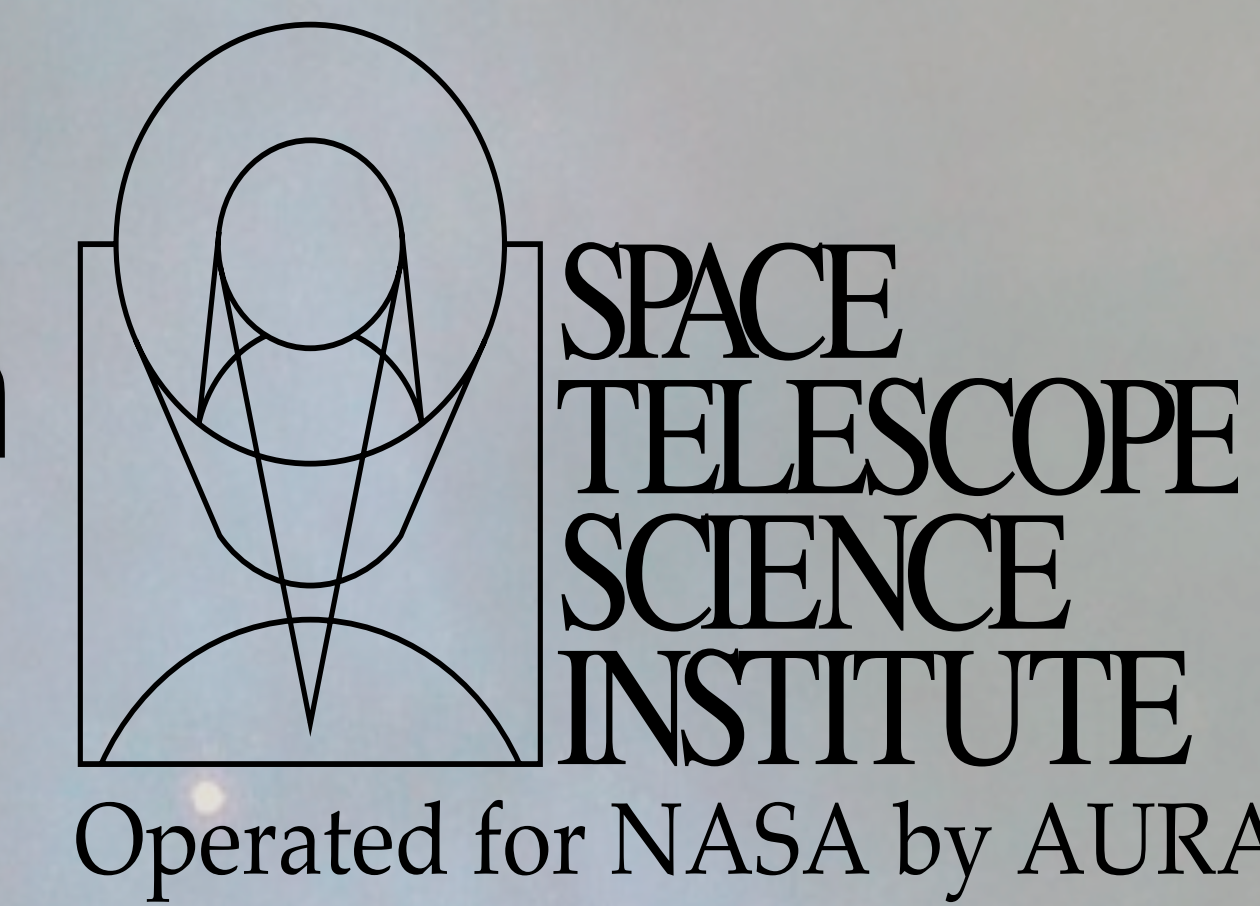


# WFC3/UVIS Photometry of HST standards: Encircled Energy and Spatial Stability with Wavelength

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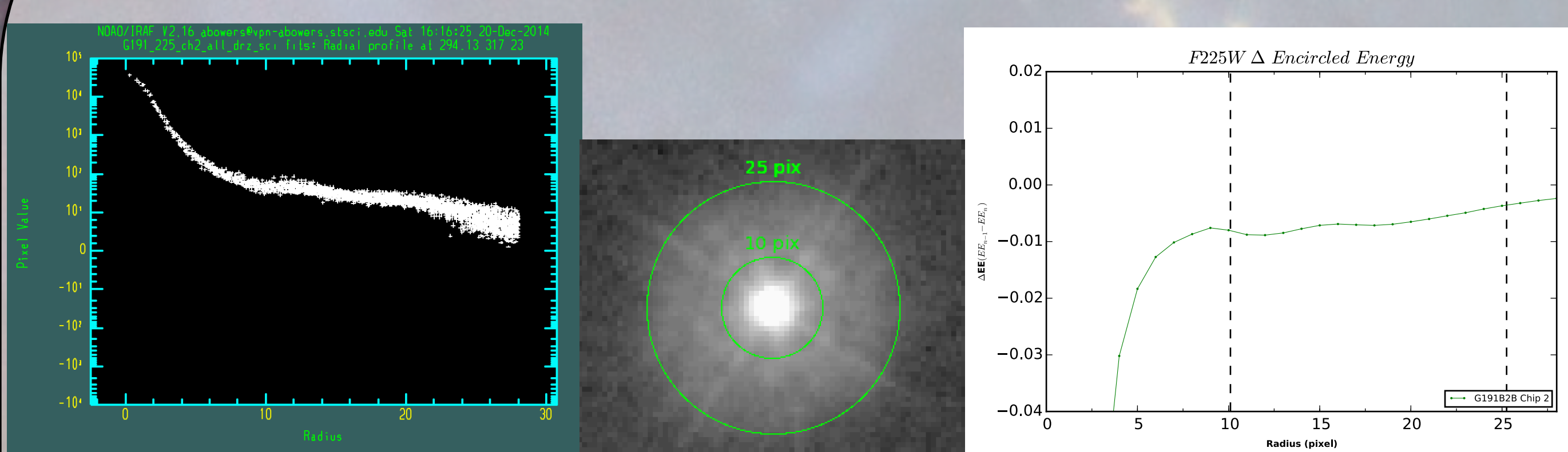
## ABSTRACT

We present encircled energy (EE) measurements for the UVIS channel derived from observations of HST photometric standards over several years. These white dwarf and solar analog standard stars were observed in all 42 filters at multiple positions across the detector and allow us to characterize wavelength-dependent structure of the point-spread function (PSF). These measurements allow us to compute the average sensitivity ratio per chip for all UVIS filters, which are important for deriving the new chip-dependent zeropoints. They are also ideal for quantifying the accuracy of the flat fields by comparing the observed photometry at various locations across the detector.

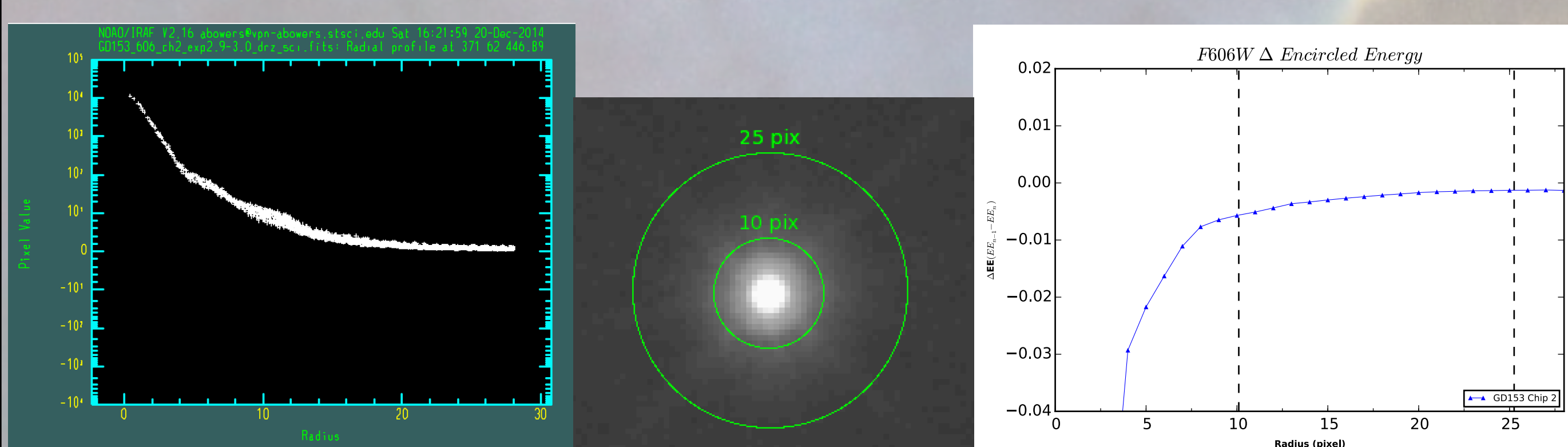
## BACKGROUND – TWO CHIP SOLUTION

Motivated by the different quantum efficiency of each of the WFC3/UVIS e2v detectors, other differences between the WFC3 chips, as well as the desire to improve the precision of WFC3 UVIS photometry we opted to change how the WFC3 UVIS photometric calibration is determined. The “Two Chip Solution” implements chip-dependent flat fields, and calculates chip-dependent photometric zeropoints for each filter plus CCD combination. This effort motivated the study of the encircled energy for the UVIS channel with these new improvements.

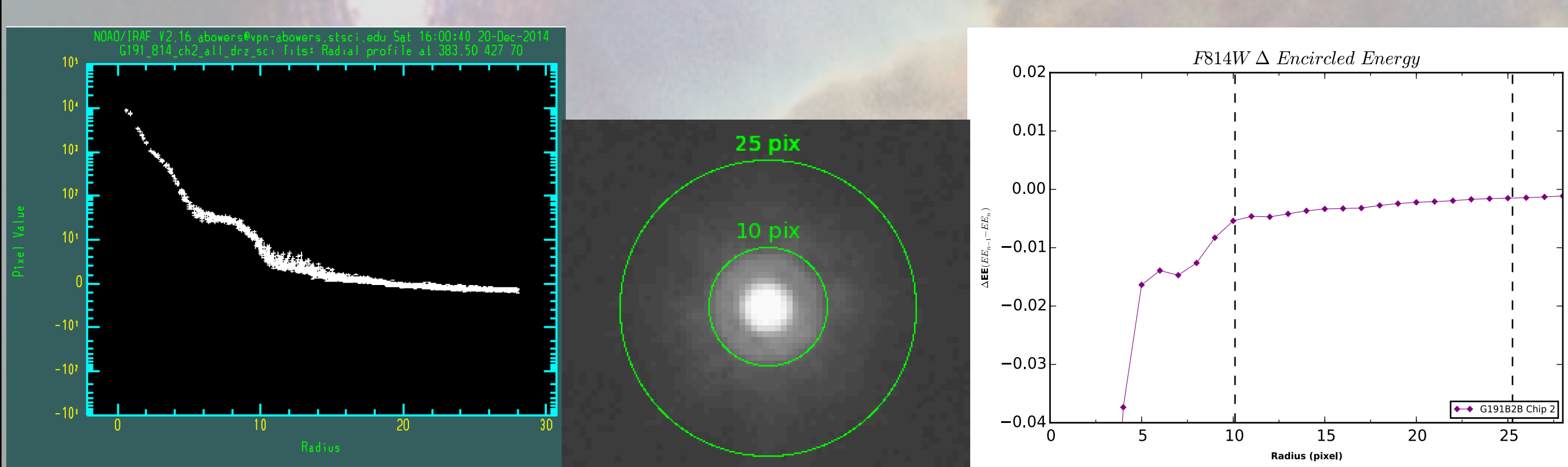
## PSF STRUCTURE



**Figure 1a** – (Left to right) (1) Radial profile of the F225W combined drizzled image. (2) The combined F225W drizzled image displayed with log stretch. (3) The delta of the adjacent EE value (i.e.  $EE$  at 5 pixels  $- EE$  at 4 pixels) vs. radius in pixels. There is a dip in the delta EE at  $r=12$  pixels that is due to the airy ring.



**Figure 1b** – Same as Figure 1a but for F606W.



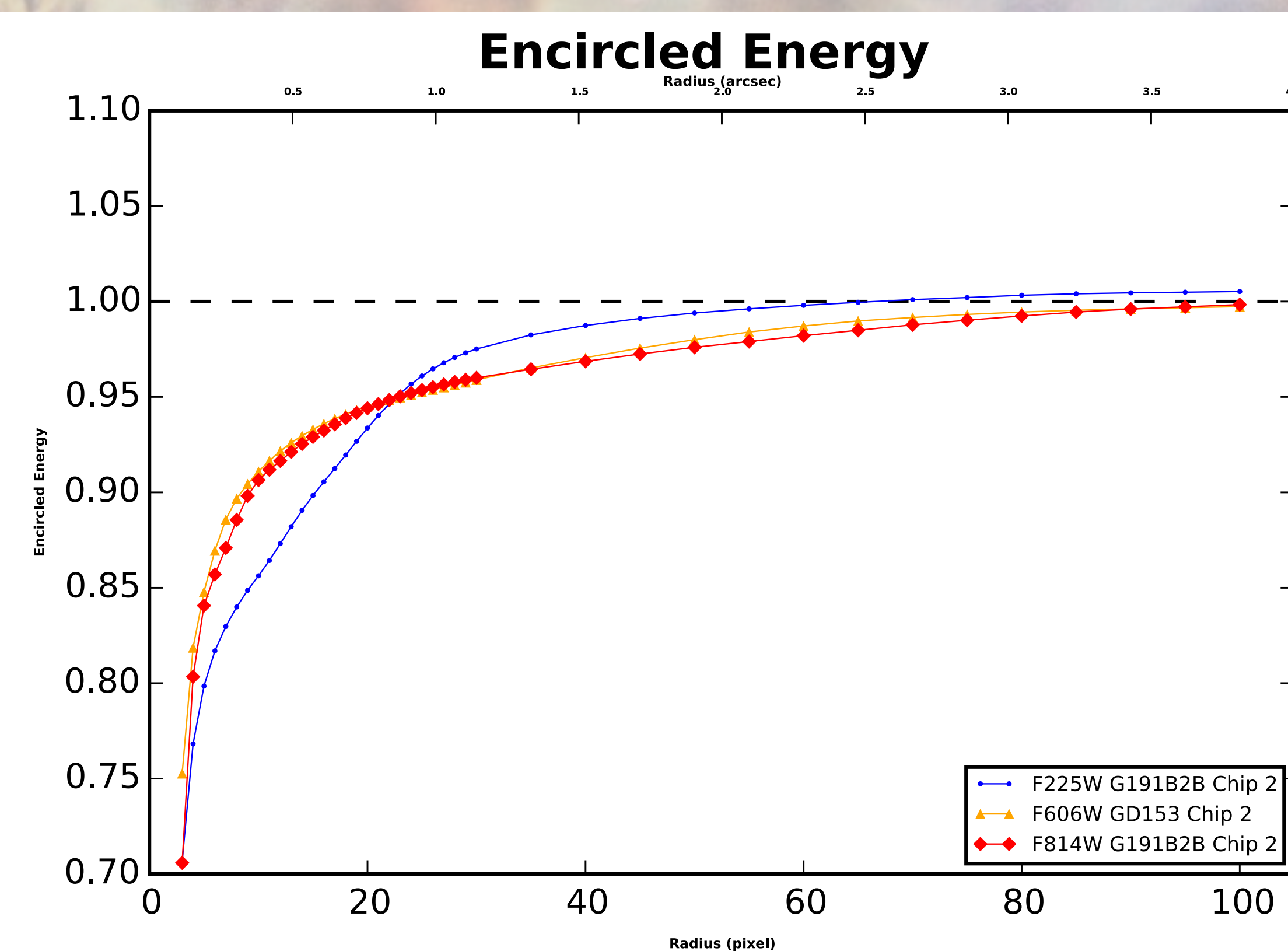
**Figure 1c** – Same as Figure 1a but for F814W. There is a trough spanning from 6-9 pixels in the delta EE plot that we suspect to be real. This is suspected to be the airy rings since it mirrors the jump in the radial plot.

## ENCIRCLED ENERGY CURVES

To calculate the encircled energy values, we used AstroDrizzle to combine all the FLT frames per chip (Figure 1a, 1b & 1c). Using the final drizzled products, we performed aperture photometry at 48 fixed apertures spanning from 1 – 100 pixels ( $\sim 0.04'' - 4''$ ) at intervals of one pixel up to 25 pixels, and at five pixel intervals thereafter.

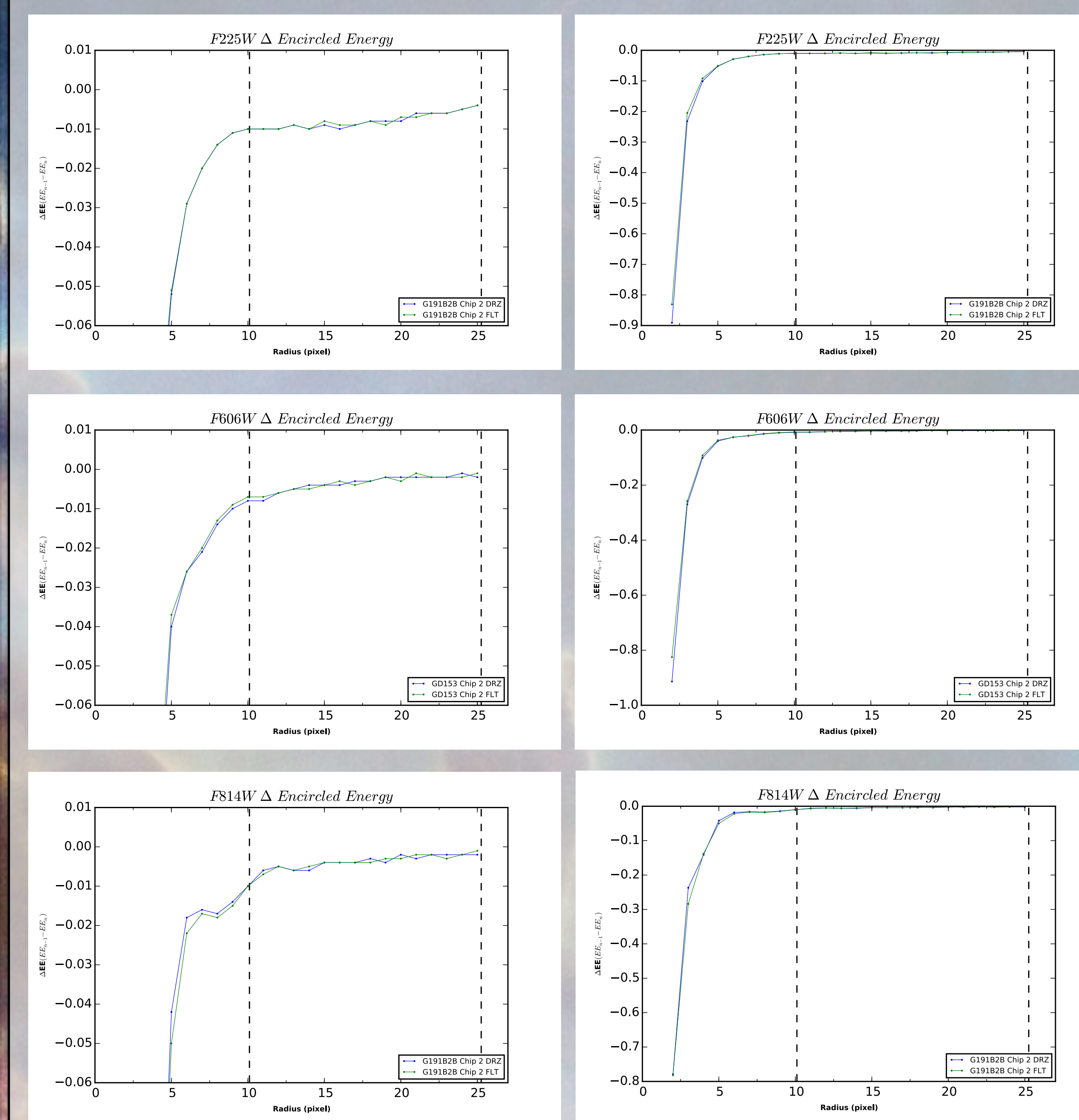
Hartig (2009) measured the PSF wing out to 100+ pixels by using 800 second exposures of bright stars. The data used in this analysis had significantly shorter exposure times, between 1 and 240 seconds, thus giving us a good estimate of the PSF at  $r < 2''$ . Therefore, we set the values of our EE curves to the 2009 Hartig model values at  $r=2''$  (50 pixels). Our measurements show that the measured EE values for:

1. The F606W and the F814W filters converge to  $\sim 1.0$  at  $r=4''$ , and are within 0.2 % of the Hartig 2009 values.
2. The F225W filter is higher than the UVIS PSF model at  $r=4''$  by less than 1%.



**Figure 2** – Encircled energy as a function of pixel radius for three filters: F225W (blue), F606W (yellow) and F814W (red). At  $r=2''$  ( $\sim 50$  pixels) we set our EE curve value to the 2009 Hartig model.

## FLT vs. DRIZZLED PRODUCTS



**Figure 3** – (Top to bottom) The delta EE values vs. radius in pixels for F225W, F606W and F814W, respectively. For each panel, there is a zoomed in plot spanning from 5 – 25 pixels (left) and a zoomed out plot spanning from 2 – 25 pixels (right). Because drizzling resamples the PSF and convolves with a kernel function to distribute the flux in the output frame, the drizzled PSF has a slightly broader FWHM compared to that in the FLT frames. This is most notable in F814W, where the FLT encircled energy is more centrally concentrated.

## REFERENCES AND ADDITIONAL INFORMATION

- WFC3 Main Page: [www.stsci.edu/hst/wfc3](http://www.stsci.edu/hst/wfc3)
- STScI Help Desk: [help@stsci.edu](mailto:help@stsci.edu)
- WFC3 Instrument Handbook: [http://www.stsci.edu/hst/wfc3/documents/handbooks/currentIHB/wfc3\\_ihb.pdf](http://www.stsci.edu/hst/wfc3/documents/handbooks/currentIHB/wfc3_ihb.pdf)
- HST Pixel Area Map: [http://www.stsci.edu/hst/wfc3/pam/pixel\\_area\\_maps](http://www.stsci.edu/hst/wfc3/pam/pixel_area_maps)
- Bowers, A. S., “Filter Dependent Encircled Energies for WFC3/UVIS”, WFC3 ISR 2015-xx
- Hartig, G. F., “WFC3 SMOV Programs 11436/8: UVIS On-orbit PSF Evaluation”, WFC3 ISR 2009-38

## CONCLUSION

1. We analyzed the PSF structure (i.e. - PSF wings, airy rings, etc.) of each white dwarf standard in both UVIS1 and UVIS2 in three key filters.
2. Our encircled energy values for these 3 filters, F225W, F606W, and F814W, are in good agreement with the UVIS PSF model and prove that we can provide accurate EE values for the rest of the 39 filters.
3. Our results show the drizzled PSF has a slightly broader FWHM compared to that in the FLT\*PAM frames.

We plan to continue this analysis for the remaining 39 UVIS filters for each chip to provide filter-dependent encircled energy values for WFC3 users.