Draft version December 15, 2024
Typeset using LaTeX default style in AASTeX631

The Temporal Evolution of the Tidal Disruption Event AT2024wsd

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ABSTRACT

this is an abstract

1. INTRODUCTION

2. METHODS

2.1. *Kuiper 61" Observations*

We observed the TDE AT2024wsd with the Kuiper 61" telescope on Mt. Graham on the night of October 18-19, 2024 (Local Date). A summary of the Target and Calibration observations is given in Table 1. We observed the target with the Mont4k CCD in the Harris- R, B, V and Bessell- U filters. These filters are near identical to the standard Johnson/Cousin filter set. The flat images were taken with the dome flat capability of the Kuiper 61" telescope. The bias and dark images were taken using standard methods. While this telescope is not typically used for transient followup observations, our observing time for class provided a unique opportunity to test it's capabilities.

2.2. *Data Calibration*

Table 1. Observations Summary

Image Type	Filter	Start Time (UTC)	Exposure Time (s)	Number of Exposures
Target	Harris-B	08:53:55.552	50.00	3
Target	Harris-V	09:08:13.975	50.00	3
Target	Harris-R	09:03:23.041	50.00	3
Target	Bessell-U	08:58:18.912	50.00	3
Flat	Harris-B	07:53:26.592	5.00	15
Flat	Harris-R	07:46:32.588	5.00	30
Flat	Harris-V	07:57:11.190	5.00	15
Flat	Bessell-U	08:09:02.293	30.00	15
Bias	—	07:13:58.343	0.00	31
Dark	—	07:08:36.314	30.00	5
Dark	—	09:26:19.184	5.00	5
Dark	—	09:19:58.097	50.00	5

We performed standard bias calibration by stacking the bias images using an average with sigma clipping. The sigma clipping used a $\pm 5\sigma$ threshold to smooth the images over extreme outliers (e.g. hot pixels, cosmic rays, etc.). In future calibration steps, we use the same stacking parameters as used for the bias images. From the bias images, we estimate the read noise by subtracting off a random bias image from the master bias image ten times to create ten bias difference images. Since the bias images include both read noise and persistent detector signal, this renormalizes the bias images and removes extraneous outliers, leaving behind just the extra current due to read noise. Finally, we take the standard deviation of all of these images to find the read noise and convert from ADU to electrons using the gain $G = 3.1\ e/ADU$ of Mont4k[1].

After stacking the bias images, we apply them to each dark image to remove the CCD bias and leave behind just the dark current. We then stack the dark images by exposure time, leaving us with a master 5s, 30s, and 50s dark image. This is necessary for calibrating the Flat images, which were taken at 5s and 30s, and target images, which were taken at 50s. From the dark images, we estimate the dark noise by computing the mean pixel count for each dark image and then performing a linear fit to the mean pixel count as a function of exposure time. This gives us a dark current in electrons per pixel per second. Since dark current is a poissonian process, we simply take the square root of the dark current to find the dark noise (i.e. the shot noise of the dark current) and convert from ADU to electrons using the gain $G = 3.1\ e/ADU$ of Mont4k.

To calibrate the flat images, we apply the master bias and then the master dark corrections. For the Harris- B, R, V flat images we use the 5s dark correction and for the Bessell-U flat image we use the 30s dark correction. We then stack the flat images to create one flat for each filter. The flats are not used to estimate any of the noise sources.

Finally, we apply all of these calibrations to the target images. First, we bias correct the target images using the master bias. Then, we subtract the 50s master dark image from the target images. Last, we apply the flat correction for the corresponding filter. Then, we stack all of the corrected target images by filter to give 4 science images. This leaves us with the images in Figure 1.

2.3. *Signal Extraction and Flux Calibration*

We compute the sum of the ADU counts from the target using an circular aperture centered at the target coordinates, (RA, Dec) = (05:26:38.320, -17:54:54.68), with a 5" radius. This includes the entirety of the visibly noticeable increase in counts over the background due to the target. The apertures for each filter are shown as red circles in Figure 1. The counts from each aperture are shown in Figure 2. These count histograms appear very Gaussian which likely means we are pushing up against the point spread function of the telescope and instrument. To find the sum of the ADU counts within the aperture, we simply integrate over these count histograms.

We convert the sum of the counts from the target plus background to electrons using the gain $G = 3.1\ e/ADU$. Then, to convert from electrons to photons, we assume a throughput $T = 85.78\%$ which is derived assuming the primary mirror has a 93% reflectivity and that there are four other optics between the primary mirror and detector

[1] https://james.as.arizona.edu/ psmith/61inch/CCD/basicinfo.html

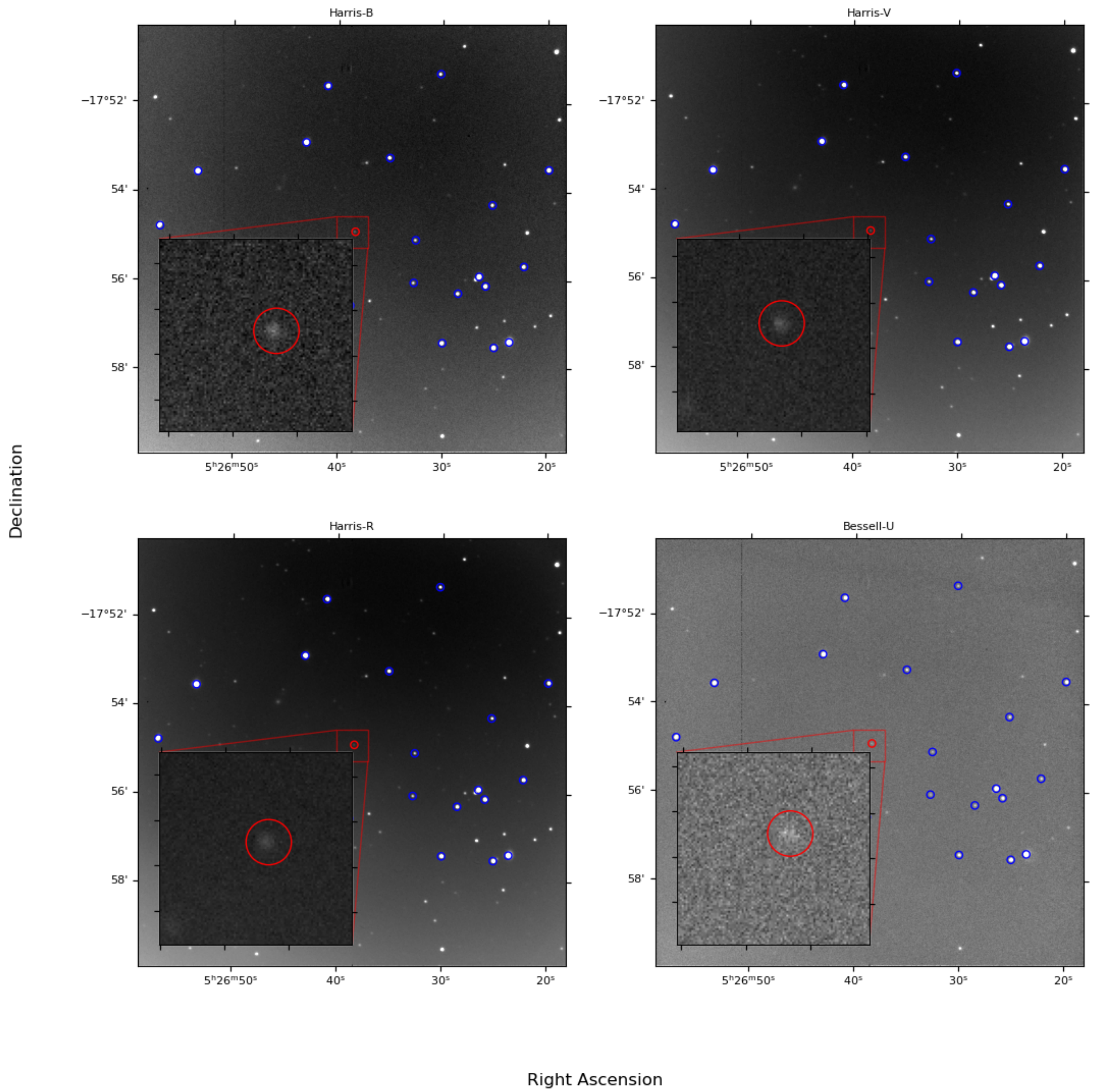

Figure 1. caption

that each have an individual throughput of 98%. Combining these gives a throughput $T = (0.93)(0.98)^4 = 0.8578$. We also assume a constant quantum efficiency $Q = 70\%$[2]. Using the throughput and quantum efficiency, we convert from electrons to photons incident on the telescope by multiplying the electron counts by $1/(T \times Q)$. These counts, in ADU, electrons, and photons are given in Table 2.

[2] FILL IN!!!

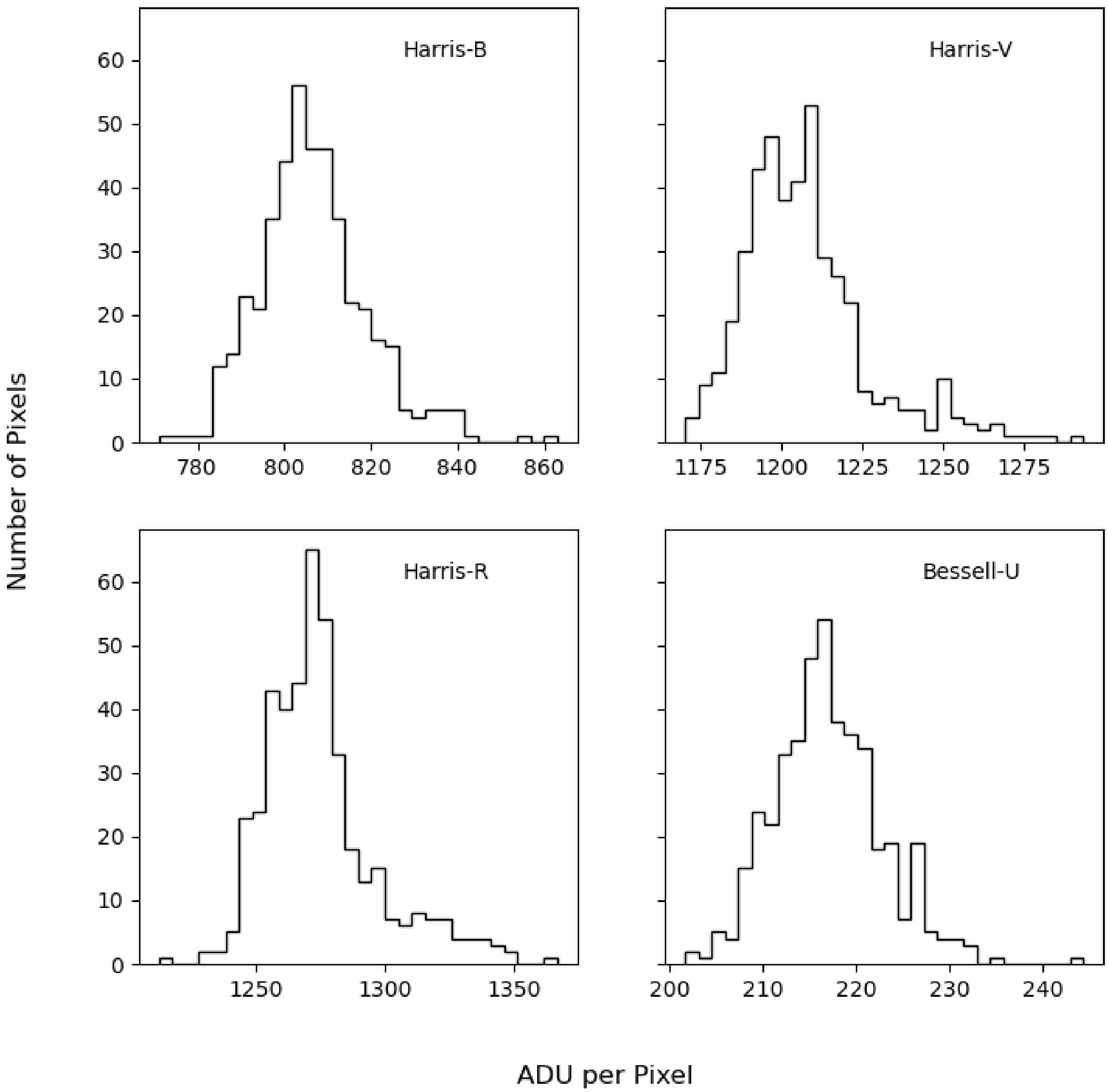

Figure 2. caption

To estimate the background signal, we use an annulus aperture centered on the target coordinates and with an inner radius of 5" and outer radius of 10". We chose to use an annulus to estimate the background because, by visual inspection of the images, the background rate varies by ~ 300 counts ($\sim 25\%$) across the image. This is likely because the target was near the setting moon which created a gradient of background illumination. Therefore, we want a local estimate of the background rather than a global one when estimating it to subtract it from the target counts. After

Table 2. Reduction Results

Filter	Harris-B	Harris-V	Harris-R	Bessell-U
Source Aperture Sum (ADU)	351531.39	524268.83	554351.81	94429.37
Source Aperture Sum (e)	1089747.30	1625233.38	1718490.61	292731.06
Source Aperture Sum (γ)	1814854.11	2706647.21	2861956.85	487511.34
Background Annulus Sum (ADU)	348945.20	522267.83	549786.75	93693.18
Background Annulus Sum (e)	1081730.11	1619030.28	1704338.91	290448.86
Background Annulus Sum (γ)	1801502.37	2696316.62	2838388.76	483710.59
Dark Noise (σ_D; ADU/pixel)	0.29	0.29	0.29	0.29
Dark Noise (σ_D; e/pixel)	0.51	0.51	0.51	0.51
Read Noise (σ_R; ADU/pixel)	3.26	3.26	3.26	3.26
Read Noise (σ_R; e/pixel)	10.11	10.11	10.11	10.11
Signal (f_e; e)	8017.18	6203.11	14151.70	2282.20
Signal (f_γ; γ)	13351.74	10330.59	23568.10	3800.75
SNR	7.37	4.73	10.51	3.67
Zero Point ($10^{12} f_0$; γ)	0.31	0.46	0.44	0.05
Apparent Magnitude	18.41	19.12	18.18	17.74
Apparent Magnitude Error	2.50	4.04	1.73	4.83

integrating over the counts in the annulus, we take the average to find the background counts per pixel. We then subtract the background counts, multiplied by the area of the target aperture, from the target aperture counts to find the signal coming just from the target itself. We follow the same procedure as with the target aperture to convert from ADU to electrons and photons. The background estimation and subtraction results are in Table 2.

Once we have a background subtracted signal, we need to convert from photon counts to physical units. To do this, we query the ViZieR data service for Johnson/Cousins magnitudes in our field of view. We use the synthetic Johnson/Cousins magnitudes generated from the Gaia BP and RP mean spectra of the sources (**??**) (VizieR catalog I/360/syntphot).

2.4. *Lightcurve Modeling*

3. RESULTS

3.1. *Observational Results*

This is where things like SNR and extracted magnitudes will go

3.2. *Lightcurve Fit Results*

3.3. *Limitations and Lessons Learned*

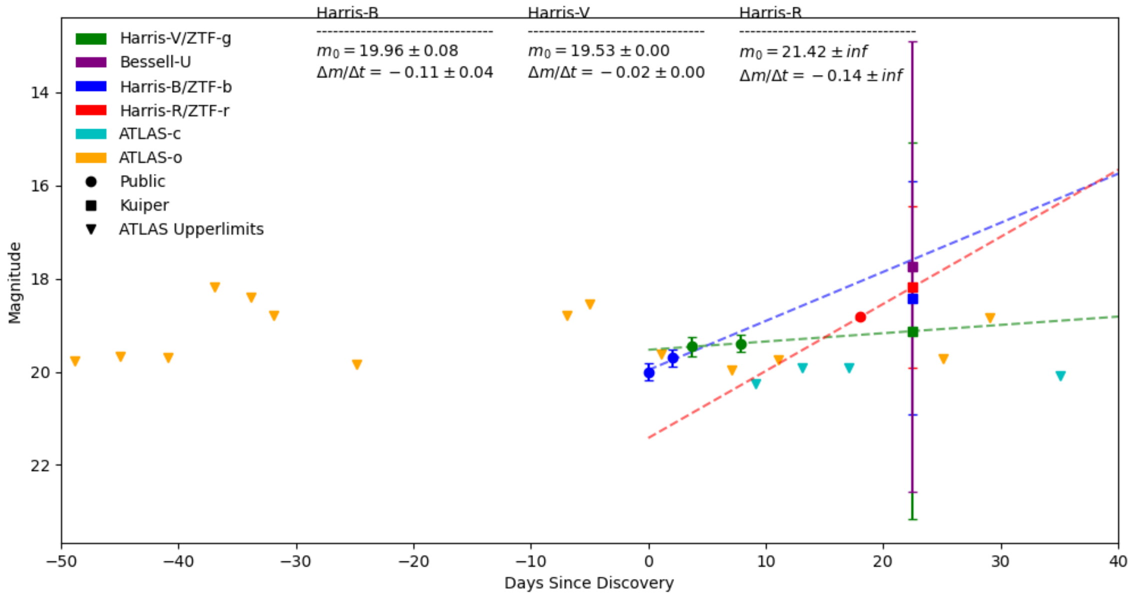

Figure 3. Caption

4. CONCLUSIONS