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Instrument Science Report COS 2023-22(v1)

Cycle 29 COS FUV Dark Monitor Summary

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ABSTRACT

This ISR summarizes the results of the Cycle 29 FUV Dark Monitoring Program for the Cosmic Origins Spectrograph (COS) on the Hubble Space Telescope (HST) covering dates between November 2021 and October 2022. We provide an overview of the calibration plan and summary, and compare the Cycle 29 dark rates against those reported for the exposure time calculator as well as Cycle 28. We find that the spectroscopic and target acquisition dark rates for Cycle 29 increased by about 7% for FUVA and 30% for FUVB compared to Cycle 28, which was expected given the recent increase in solar activity.

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1. Introduction

Although the dark rate on the COS FUV XDL detector is generally low ($\sim 10^{-6}$ counts pixel^{-1} second^{-1}), the dark rate is strongly correlated with solar activity and can vary spatially across both FUV segments. Therefore, we monitored the dark rate for Cycle 29 using Program 16828 ("Cycle 29 COS FUV Detector Dark Monitor", PI: Dashtamirova), which took five, 22-minute exposures each week with the shutter closed between November 2021 and October 2022. These data allowed the COS team to track dark rate performance with a high cadence, and were also used to update the COS/FUV Exposure Time Calculator (ETC).

2. Analysis and Results

Program 16828 was allocated 265 internal orbits to take dark exposures at the default (STScI home position) high voltages. The instrument home position was changed on July 25, 2022 from G130M/1222 (located at LP4) to G130M/1291 (located at LP5) in order to mitigate an OSM1 movement repeatability issue. Therefore, FUVA observations before July 25, 2022 used HV = 173 while those at later dates used HV = 167. FUVB dark exposures experienced a similar pattern but were complicated by an LP4 FUVB high voltage increase from HV = 169 to 175 on June 20, 2022. As a result, FUVB dark observations taken before June 20, 2022 used HV = 169, those between June 20, 2022 and July 25, 2022 used HV = 175, and then those on or after July 25, 2022 used HV = 169. The first 20 visits of Program 16828 were also withdrawn and 5 visits on April 6, 2022 were lost due to an instrument safing so the actual data range for the calibration program covers 240 visits between Dec. 2, 2021 and Nov. 1, 2022.

For each dark exposure, a mean dark rate was calculated in 25 second intervals spanning five different regions on the FUVA and FUVB detector segments. These regions cover the inner (active area), bottom, top, left, and right portions of each segment (see also COS ISR 2019-11; Dashtamirova et al. 2019 for further details). As noted above, five weeks of data are missing over the full calibration cycle, but these small gaps are not expected to significantly affect the measured dark rates.

Figures 1–2 show the resulting dark rate measurements for all five regions of segments FUVA and FUVB over the lifetime of COS through Cycle 29. As expected, the figures indicate an increase in the mean dark count rate in all five regions that correlates with enhanced solar activity starting in late 2021. Figures 3- 4 highlight the FUV dark rate changes for segments FUVA and FUVB between Cycles 28 and 29, and show that both the variance and absolute dark rates have increased for Cycle 29.

Table 1 compares the mean dark count rates for both segments and the spectroscopic and target acquisition regions for all of Cycle 28 (COS ISR 2022-06; Johnson &

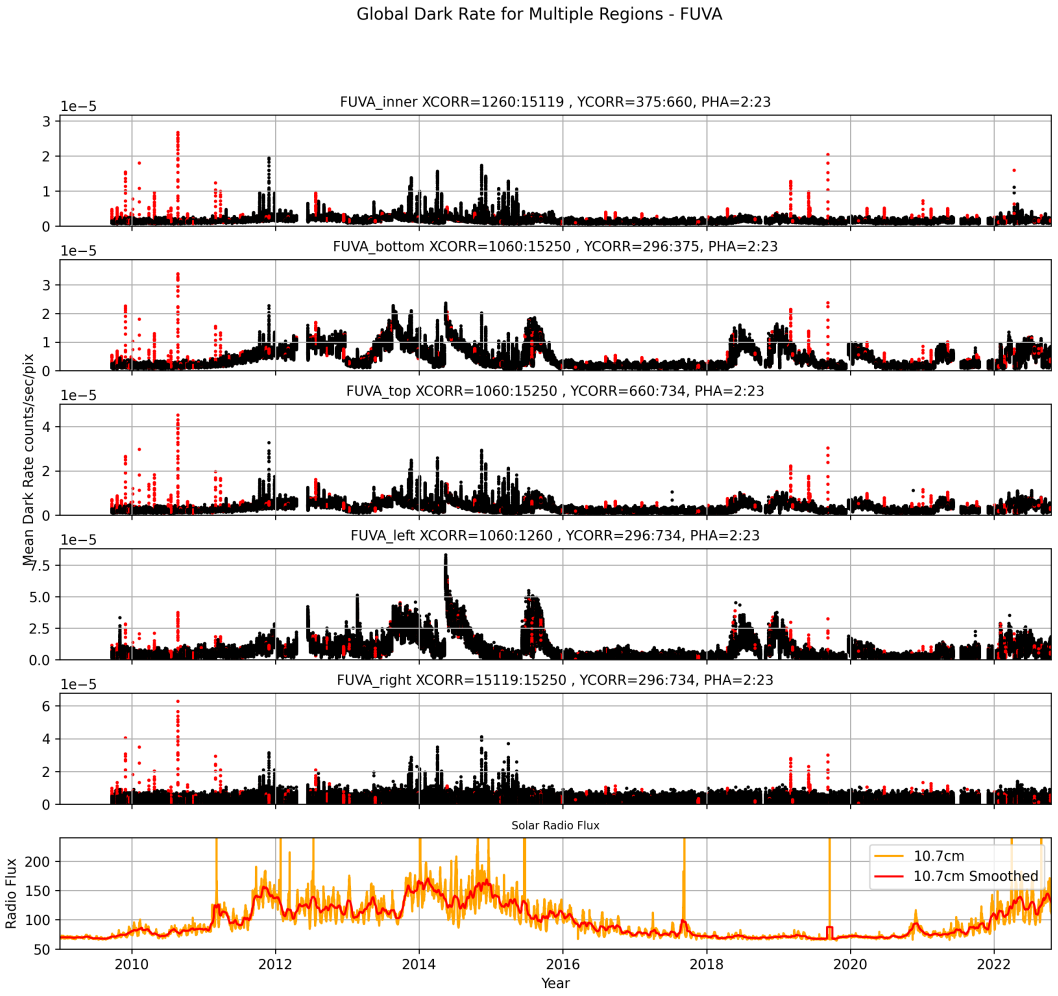

Figure 1. COS/FUV dark rates on the FUVA segment are shown as a function of time for each of the different regions of interest. The top five panels show the measured dark rate in 25 second increments throughout every exposures. The red circles represent dark rates that were observed close to when HST was passing near the South Atlantic Anomaly. The bottom panel displays the 10.7cm solar radio emission tracking the solar cycle.

Dashtamirova 2022), the ETC v29.2, and the full range of Cycle 29 data. Note that the ETC v29.2 dark rate values are based on measurements taken in the 6 month period just before delivery, which spanned fractional years 2021.746 to 2022.246, while the Cycle 28 and Cycle 29 values span a full 12 months. In all cases, the dark rate values are calculated by collating the mean dark rate values for the individual 25 second intervals of all exposures in the time period, excluding the glowing edges of the active area, and then reporting the upper 95% value. The 95% value ($\sim 2\sigma$) ensures that most users will have a true dark rate during their observations that is at or below the reported rate. Compared to Cycle 28, the Cycle 29 FUVA spectroscopic, FUVA target

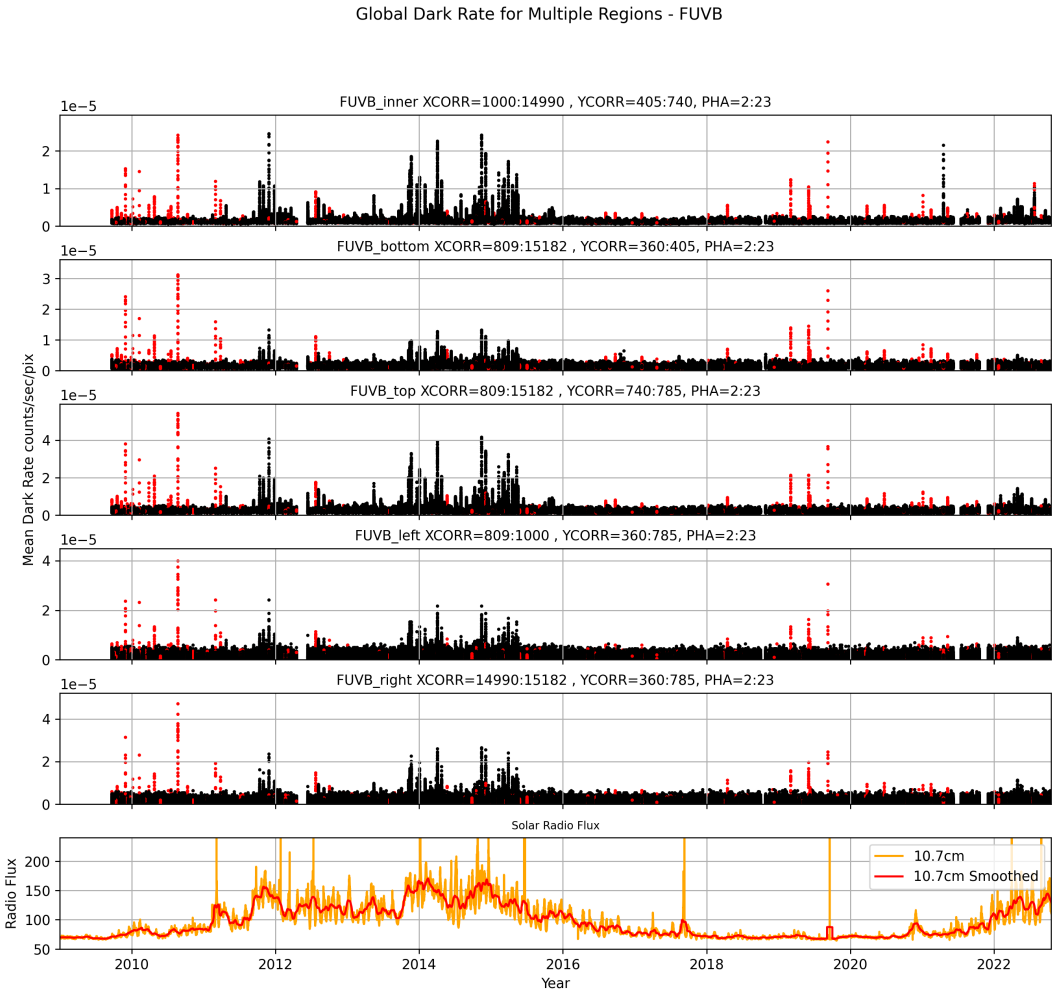

Figure 2. Similar to Figure 1 but for FUVB.

acquisition, FUVB spectroscopic, and FUVB target acquisition dark rates increase by 6%, 7%, 28%, and 30%, respectively. The full dark rate distributions for all of Cycle 29 are shown in Figures 5-6.

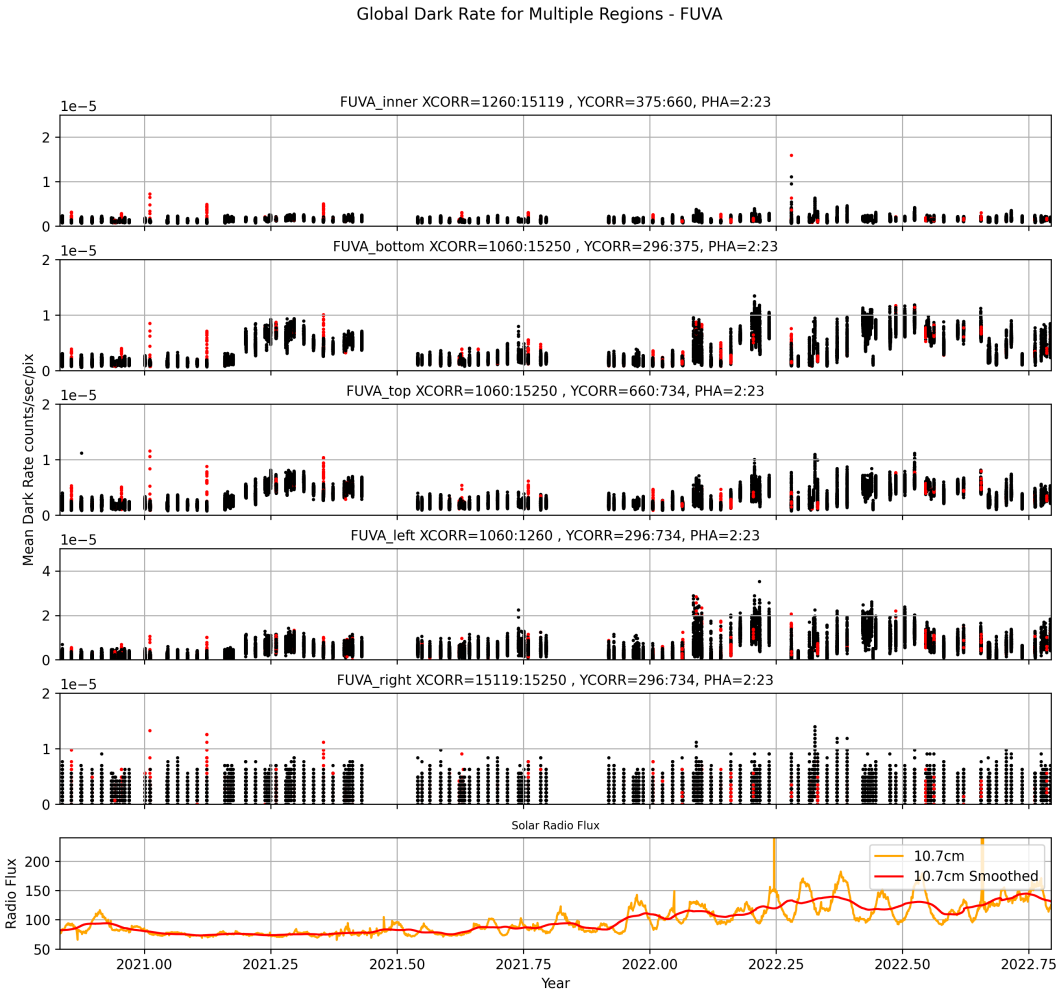

Figure 3. Similar to Figure 1 but zoomed in on Cycles 28 and 29. The data gap bewteen 2021.75 and 2022.00 shows the timing of the withdrawn visits at the start of Cycle 29.

3. Summary

The COS FUV XDL detector dark rate continues to follow former trends, and is increasing in magnitude as the Sun enters a more active phase of its cycle. The dark rates in Cycle 29 for FUVA increased by about 7% over those in Cycle 28, and the FUVB dark rates increased by about 30% over the same time range.

Change History for COS ISR 2023-22

Version 1: 16 October 2023- Original Document

Figure 4. Similar to Figure 2 but zoomed in on Cycles 28 and 29.

References

Dashtamirova, D., White, J., Sahnow, D., 2019, COS Instrument Science Report 2019-11, "Changes in the COS/FUV Dark Rate: Impact on the Monitoring Program and Background Extraction Regions"

Johnson, C. I. & Dashtamirova, D., 2022, COS Instrument Science Report 2022-06, "Cycle 28 COS FUV Dark Monitor Summary"

Table 1. COS FUV Dark Rates

Detector	Mode	ETC v28.2 Dark Rate (counts pix^{-1} sec^{-1})	ETC v29.2 Dark Rate (counts pix^{-1} sec^{-1})	Cycle 29 Dark Rate (counts pix^{-1} sec^{-1})
FUVA	Spectroscopic	2.01×10^{-6}	2.01×10^{-6}	2.14×10^{-6}
FUVA	Target ACQ	3.02×10^{-6}	3.13×10^{-6}	3.24×10^{-6}
FUVB	Spectroscopic	1.85×10^{-6}	1.70×10^{-6}	2.36×10^{-6}
FUVB	Target ACQ	2.97×10^{-6}	2.83×10^{-6}	3.87×10^{-6}

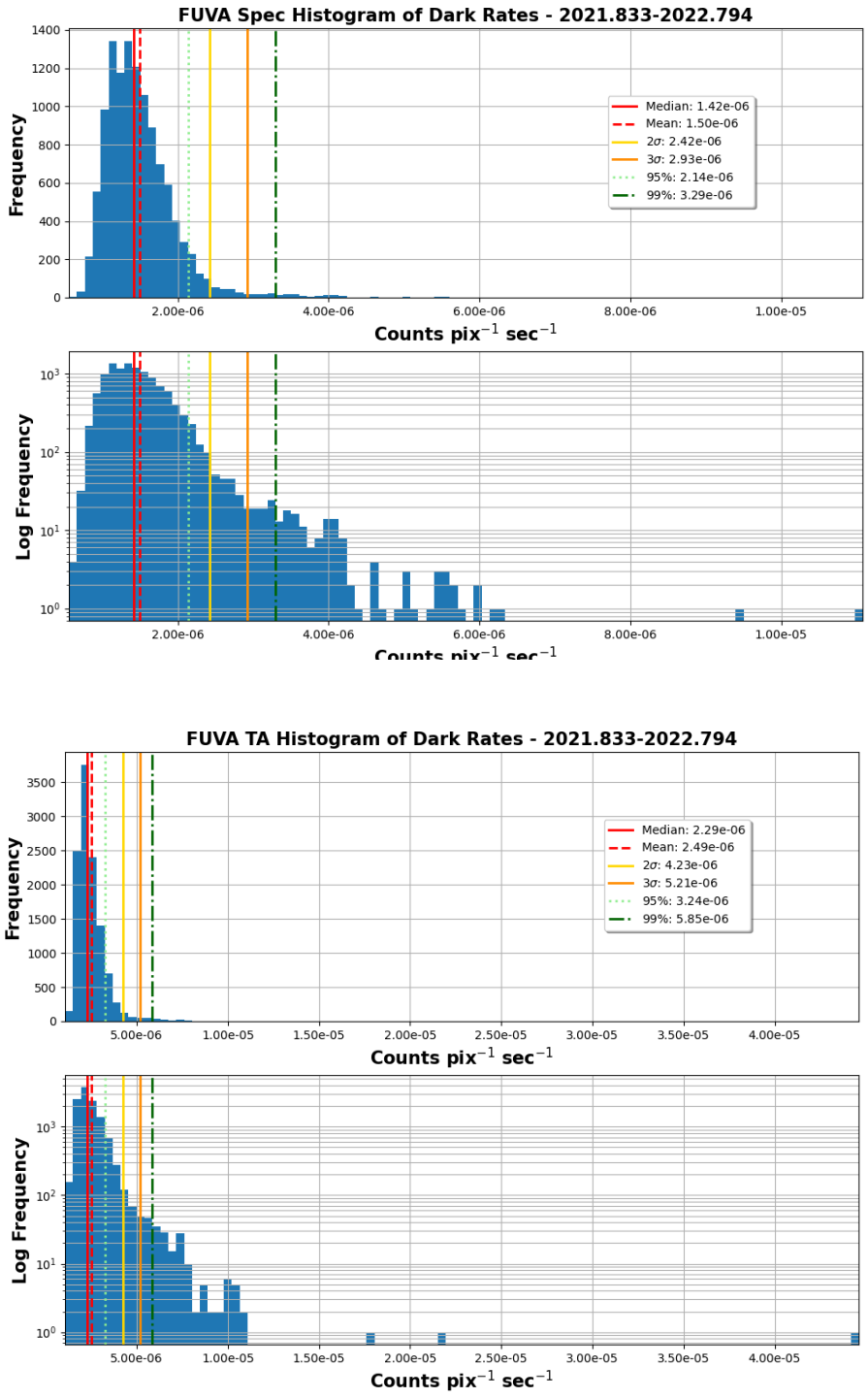

Figure 5. *Top:* The COS FUVA dark rate distribution for all of Cycle 29 using only counts with pulse height amplitudes (PHA) between 2 and 23, as is standard for spectroscopic observations. *Bottom:* Similar to the top panel but for target acquisitions, which do not utilize PHA filtering. Note that the $2\sigma/3\sigma$ and 95%/99% values are not equal because the dark rate distribution is not symmetric.

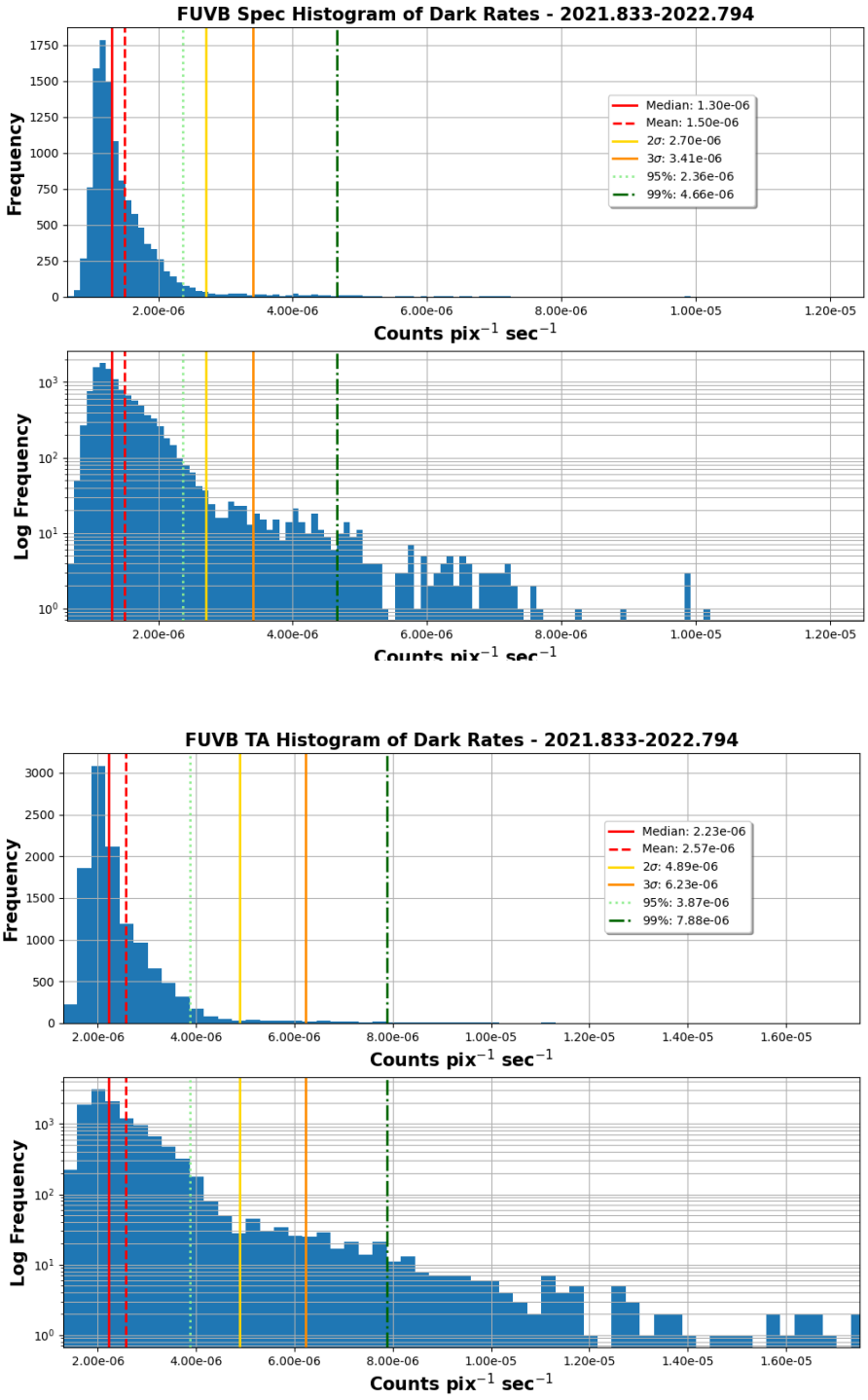

Figure 6. Similar to Figure 5 but for FUVB.