



Astronomy in the 2020s with the Cosmic Origins Spectrograph



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In order to fully understand what science will be possible in this upcoming golden age of multi-wavelength astronomy, it is essential to understand the capabilities and limitations of the instruments being used. The Hubble Space Telescope offers imaging and spectroscopy in the ultraviolet that are presently unmatched. Specifically, the Cosmic Origins Spectrograph (COS) provides high-sensitivity observations in the ultraviolet from 900 to 3200 Å. Here we present the unique capabilities of COS and how it can be used in conjunction with other observatories.

An Introduction to COS

- ✦ The Cosmic Origins Spectrograph (COS) is a UV spectrograph that was installed on the Hubble Space Telescope (HST) in 2009.
- ✦ Similar to some JWST science goals, COS was originally designed to study:
 - ✦ origins of large-scale structure of the universe
 - ✦ formation & evolution of galaxies
 - ✦ origins of stellar & planetary systems
 - ✦ the interstellar medium
- ✦ COS has two observing channels:

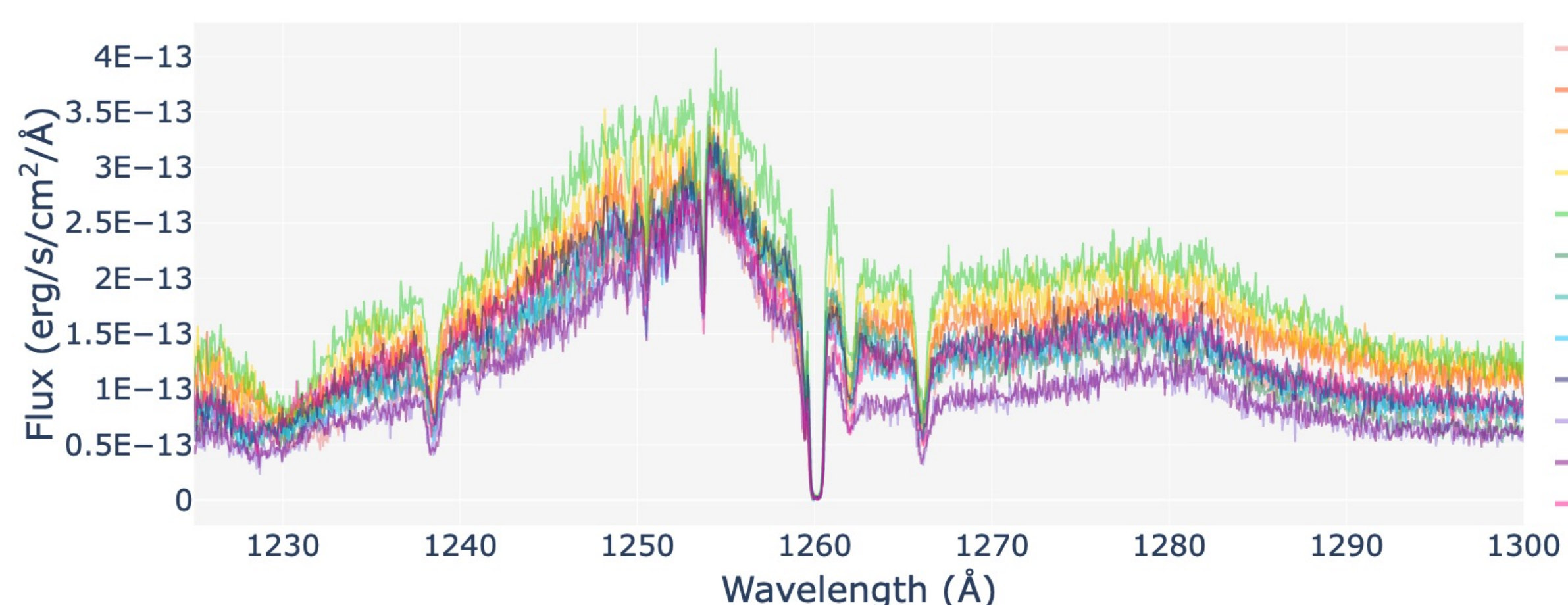
FUV

- ✦ 900 – 2150 Å
- ✦ 2 medium resolution gratings
- ✦ 1 low resolution grating
- ✦ 1 cross-delay line detector with 2 independently operated segments (FUVB, FUVB)

NUV

- ✦ 1650 – 3200 Å
- ✦ 3 medium resolution gratings
- ✦ 1 low resolution grating
- ✦ 1 MAMA detector
- ✦ Imaging mode for target acquisition and science

MRK-817

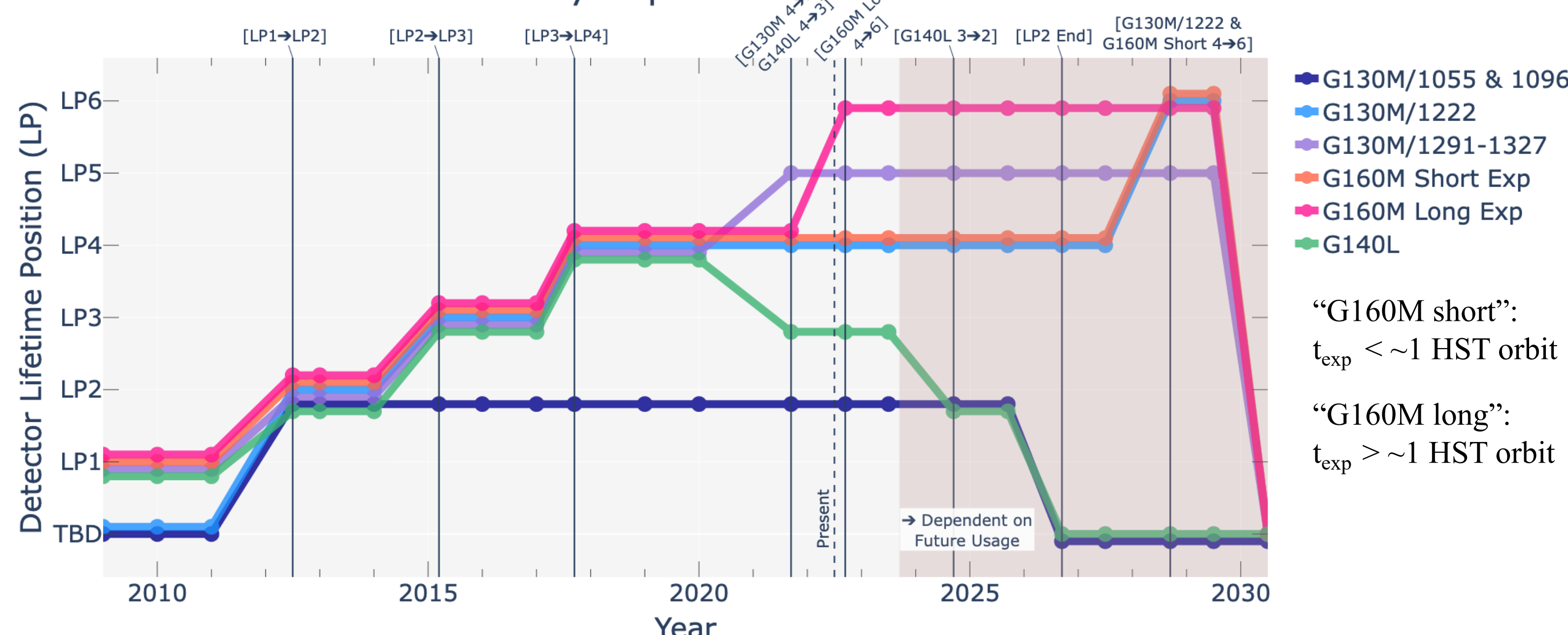


Shown above is an example of COS FUV spectra of the AGN MRK-817 at different epochs (here highlighting the broad Ly α emission). This target was observed every other day for a year with COS to study the inner black hole of the AGN using reverberation mapping.

The Lifetime of COS

- ✦ Currently, the FUV channel's detector is the limiting factor of the lifetime of COS due to an effect called gain sag. As more photons hit the detector, the conversion from photon to electron becomes less efficient, leading to apparent gaps in a spectrum on parts of the detector. Several strategies have been implemented since launch to mitigate this effect:
 - ✦ Every few years the spectrum location is moved to fall on previously unused regions of the detector. These are called lifetime position (LP) moves, the first of which occurred in 2012 from LP1 to LP2.
 - ✦ In 2017, operations were changed to extend the lifetime even further by implementing the "COS2025 Rules". These rules at least double the detector's lifetime at that position by restricting the locations where Ly α airglow may fall.
 - ✦ In 2021, operations were changed again to extend the lifetime of COS to ~2030 by utilizing multiple lifetime positions simultaneously for different settings. The figure below helps navigate the current plan for where the FUV settings will be located on the detector in the upcoming years.
- ✦ Additional lifetime positions may be available to extend beyond 2030.

COS Lifetime Position Subway Map



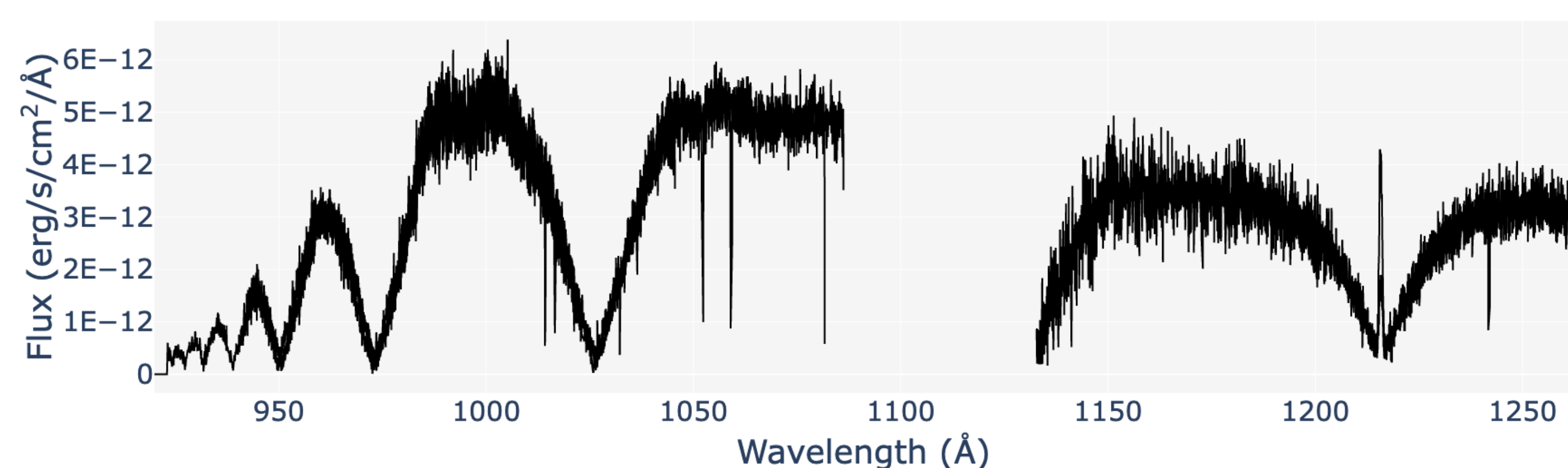
Using COS through 2030 and Beyond

COS offers far-reaching science in the far and near UV. Some capabilities of COS are highlighted here:

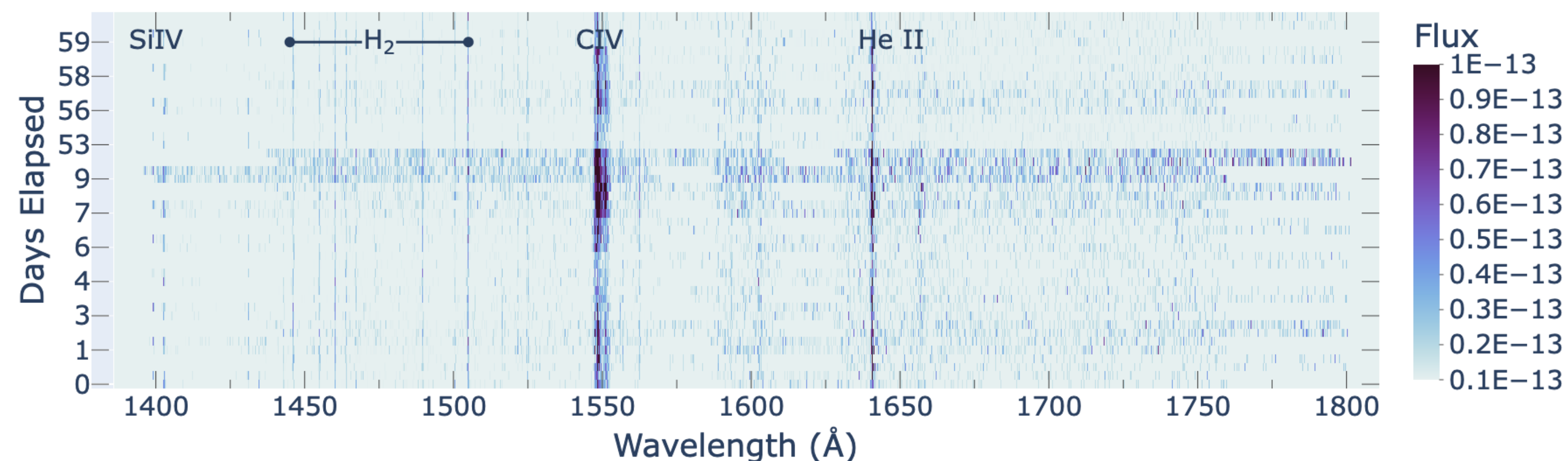
Exploring the Universe

- ✦ High throughputs in the FUV channel
- ✦ Low dark rates ($\sim 10^{-6}$ counts/pix/s)

GD71



GM-AUR Time Series Spectrum



Unparalleled UV Wavelength Ranges

- ✦ "Blue Modes" G130M/1055 & G130M/1096 reach down to ~ 912 Å.
- ✦ The figure above is of the white dwarf flux standard star GD71 and showcases the Ly series using the blue modes.
- ✦ The calibration of the blue modes was improved in 2020.
- ✦ G140L/800: commissioned in 2018 to support low resolution spectroscopy for background-limited observations below 1100 Å, such as searching for Lyman continuum escape.

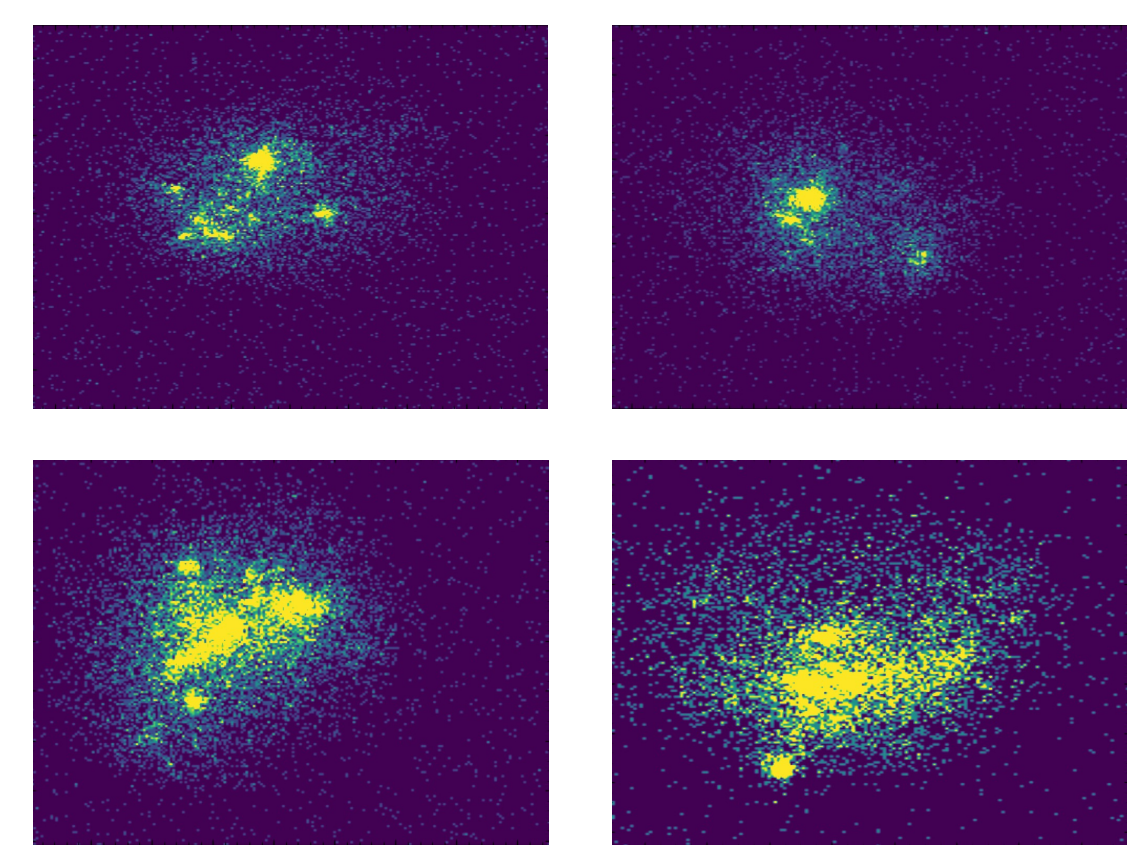
Insightful Time Information

- ✦ Analyze short-scale time variations like the stellar flares shown below of ϵ Eridani.
- ✦ Filter data by orbital day/night.
- ✦ Extract using costools functions:
 - ✦ splittag
 - ✦ timefilter

Rich Archival Data

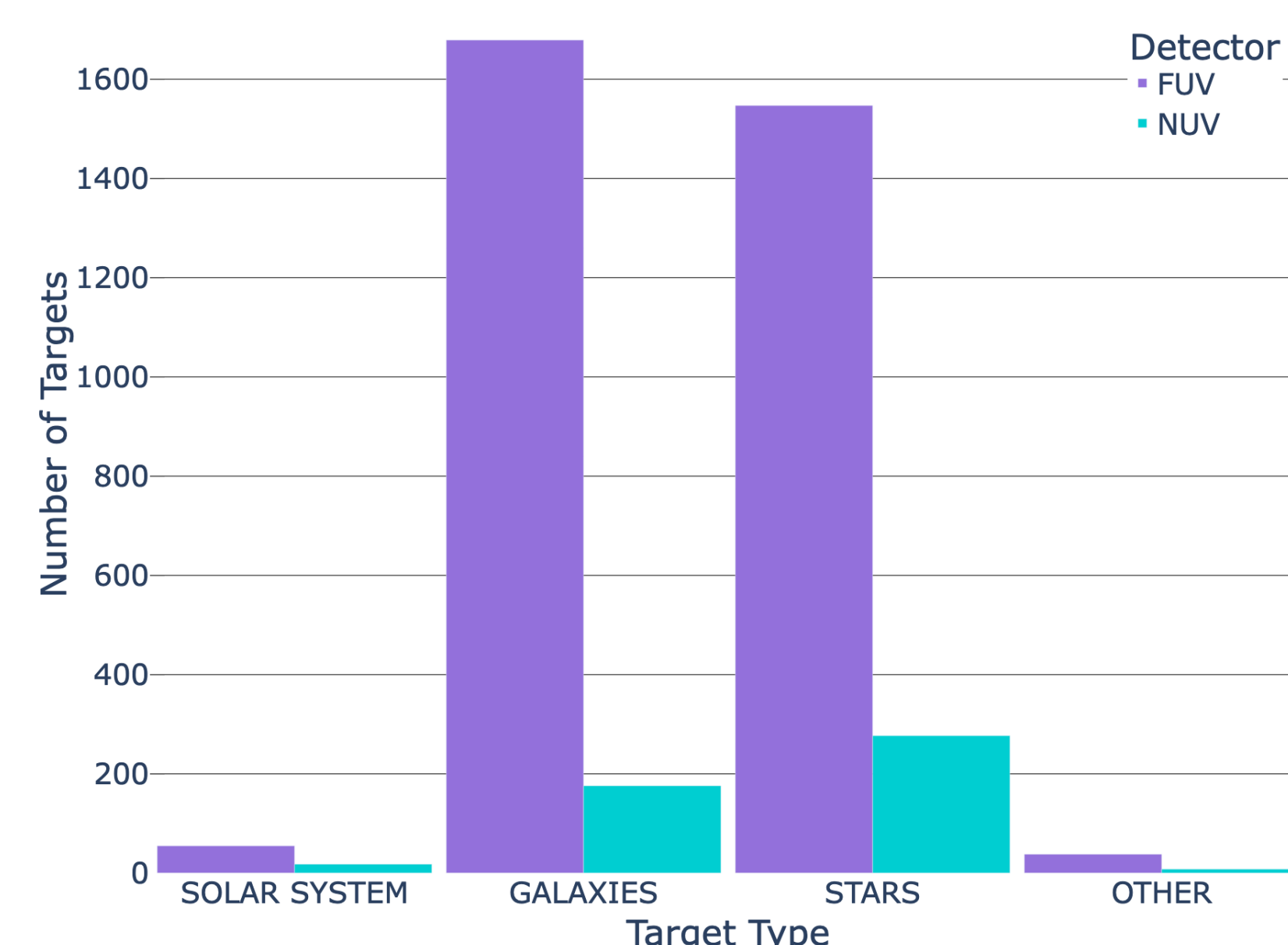
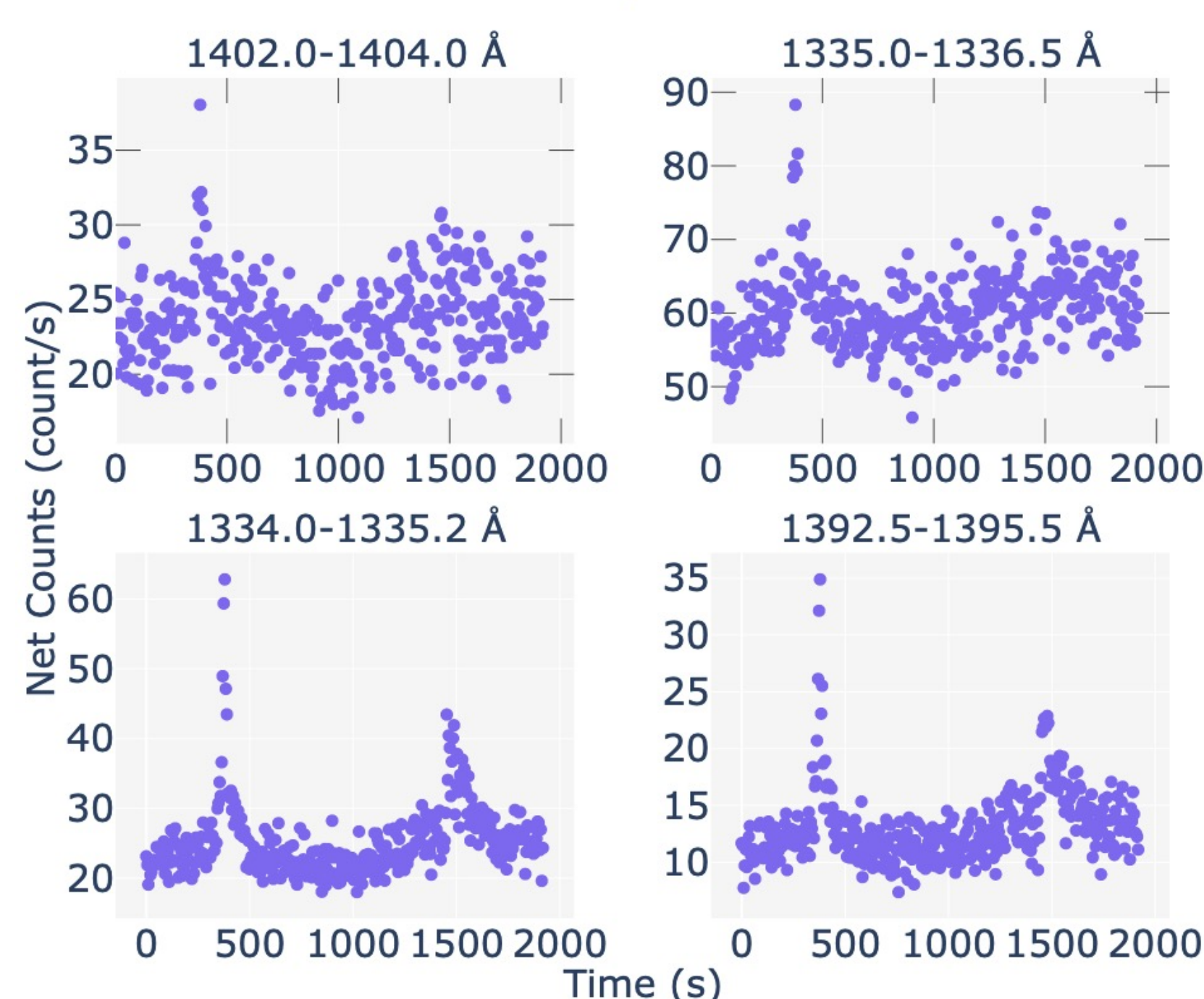
- ✦ The Hubble Spectroscopic Legacy Archive (HSLA) hosts a variety of combined COS spectra.
- ✦ High Level Science Products (HLSPs) are specially calibrated and delivered to MAST by users.
 - ✦ An example of the ULLYSES time series HLSP product of GM-AUR is shown above.
- ✦ Below is a breakdown of a few generic target types currently available in MAST in both COS FUV & NUV.
- ✦ COS users regularly coordinate observations with Chandra, XMM, and ground-based telescopes.

- Consider HST/STIS as an alternative to COS if:
- ✦ Observing bright sources
 - ✦ Observing extended sources
 - ✦ Obtaining high resolution data
 - ✦ Using NUV spectroscopy



NUV Imaging of star clusters in PID 14806.

Short Term Variability in ϵ Eridani



Questions? Ideas? Find me around the conference, contact me at rplesha@stsci.edu, or contact the COS team through the HST help Desk at stsci.service-now.com/hst