

An Exposure Time Calculator for CASTOR's UV Multi-Object Spectrograph

Jade Yeung, Tyrone Woods, Patrick Côté, John Pazder, Charles Lee

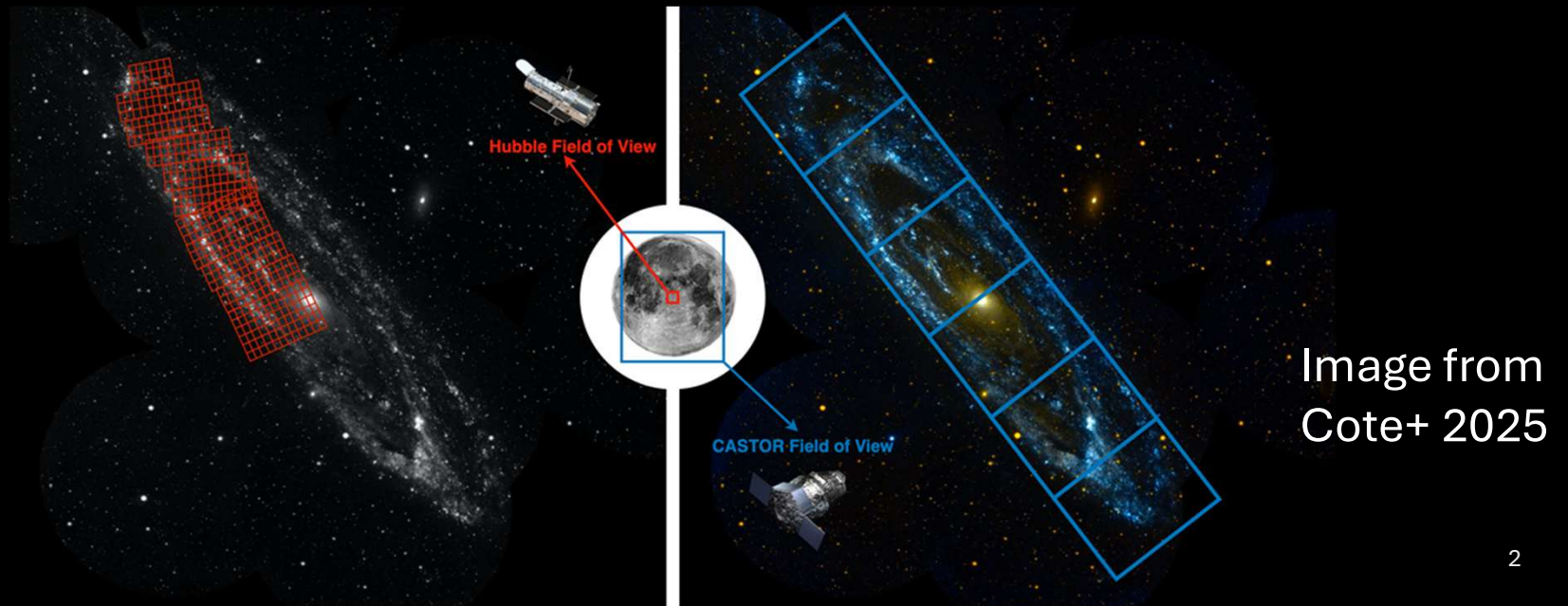


University
of Manitoba

NRC · CNRC

The CASTOR Mission

- Field of View 100x larger than the Hubble Space telescope with similar angular resolution.
- Bands: uv, u, g



The CASTOR Mission

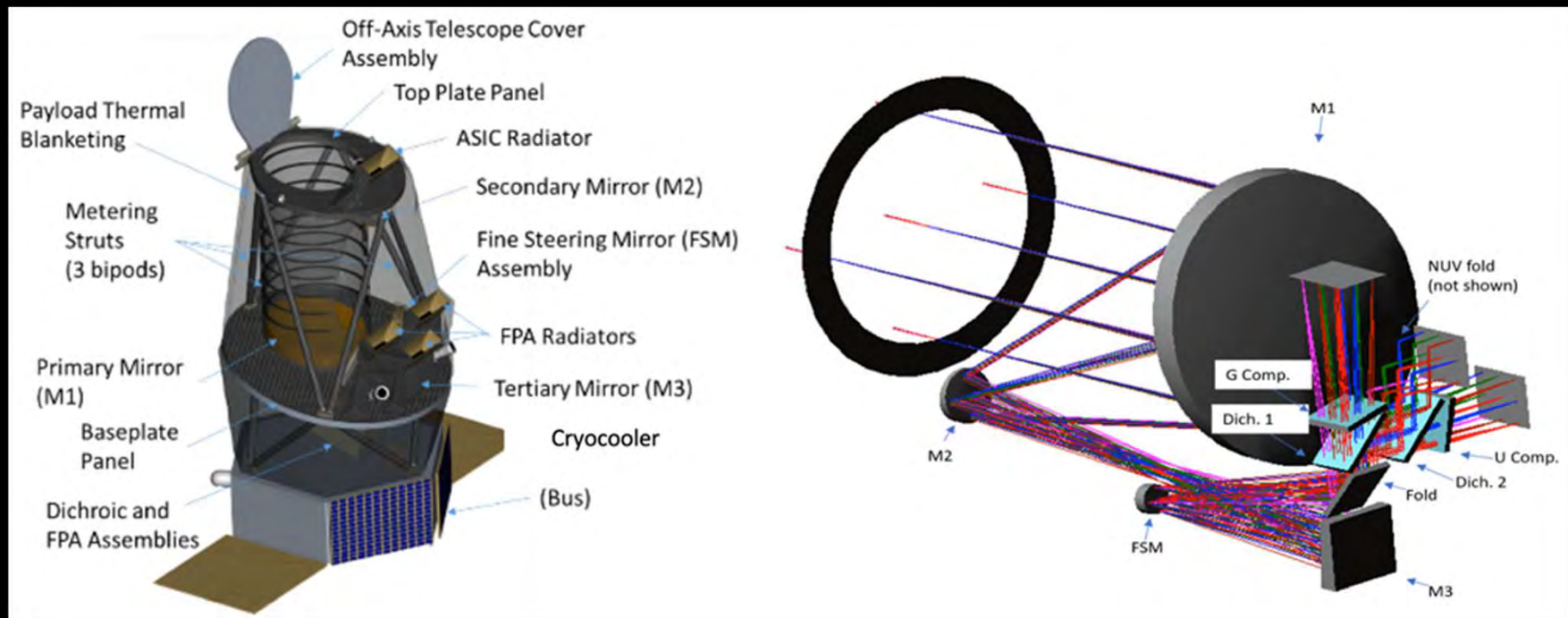
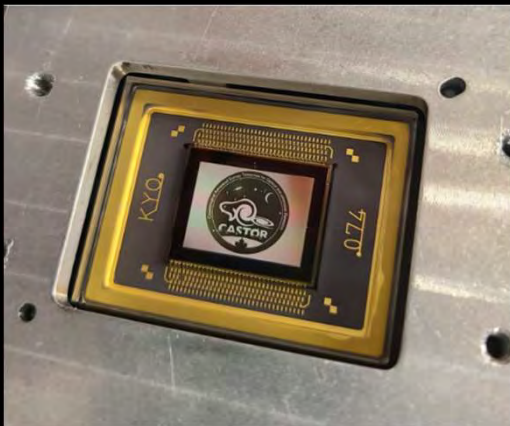


Image from Cote+ 2025: The optical design of CASTOR.

The UV Multi-Object Spectrograph

- Uses a Digital Micromirror Device (DMD) to create multiple slits.



A re-windowed DMD (MgF₂)
LASP (Colorado)

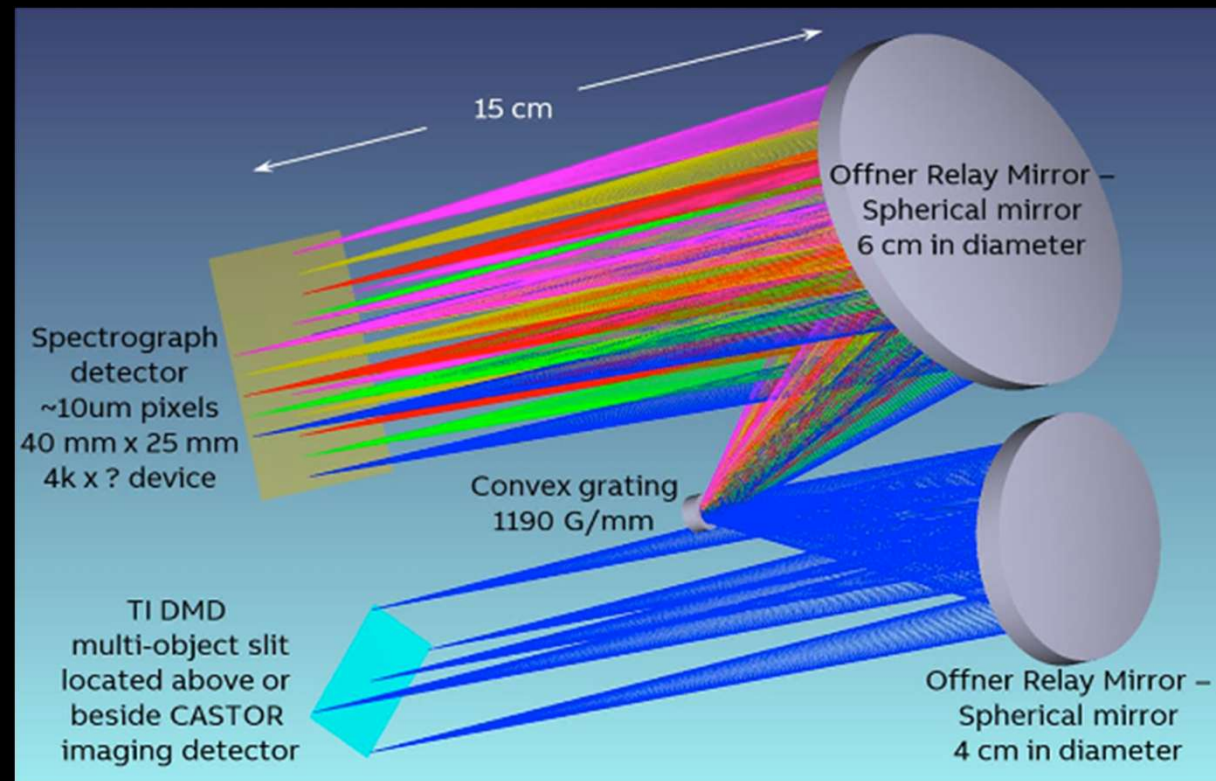


Image from Cote+ 2025

Detector and DMD Stats

CIS 300 Series Detector

Pixel Size	$10\mu\text{m}$
Dark Current*	$\sim 0.4 \times 10^{-4} e^{-}/\text{s/pixel}$
Read Noise*	$5.5 e^{-}/\text{pixel}$
Gain*	$1.7 e^{-}/\text{ADU}$

TI DLP9500 DMD

Pixel Size	$10.8\mu\text{m}$
Field of View	$207'' \times 117''$
Spectral Dispersion	10.7nm/mm at $R \sim 1000$
PSF	$< 0.20''$ in spatial direction
Amount of Multiplexing	~ 600 slits

*Measured for a CIS 120 detector by Open University. Values are expected to be similar for CIS 300 series detectors.

Motivation

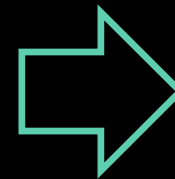
No space heritage



Never been done
before in the UV



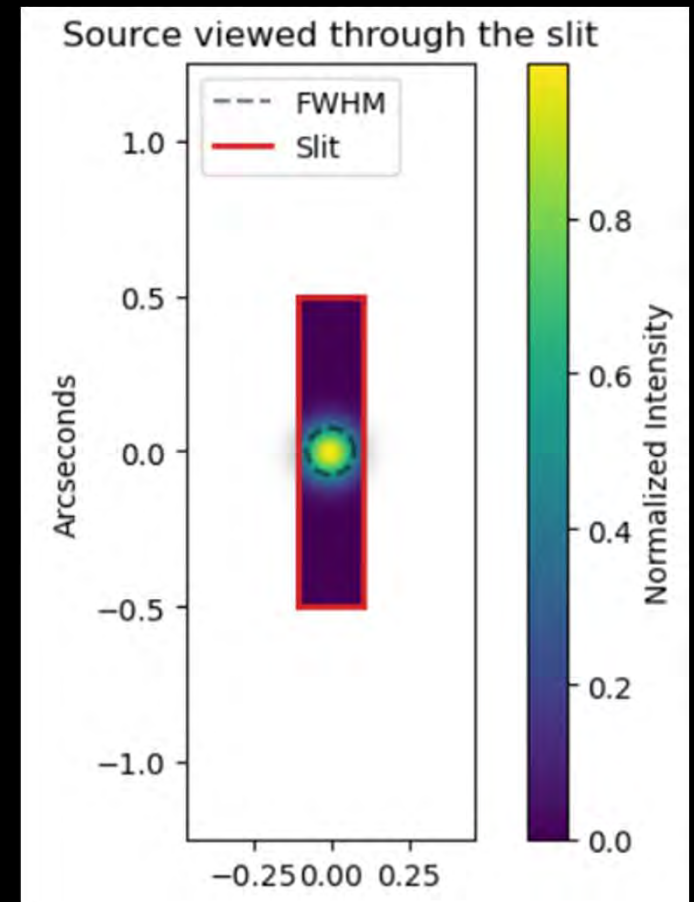
Need science
cases to justify
need for the
UVMOS



Need an ETC to
work out the
science cases

The Single-Slit ETC

- Created by Jennifer Glover
- Does not support extended sources
- Cannot change the slit orientation



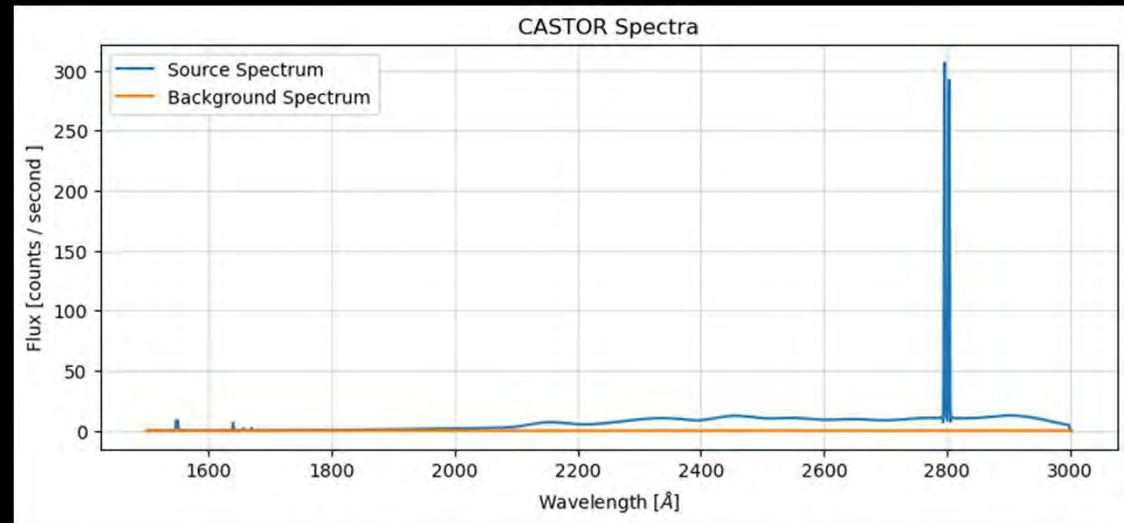
M-Dwarf Flares

Model is complete and is currently available on the CASTOR ETC GitHub!

Can exoplanets orbiting a flaring M-dwarf have an atmosphere?

Target Name	Exposure Time to Reach Quiescence SNR = 10 (hrs)	Exposure Time to Reach Flaring SNR = 20 (sec)	Exposure Time to Reach Flaring SNR = 50 (sec)
EV Lacertae	3.1	24.2	63.4
AD Leo	0.6	6.1	16
Wolf 359	3.5	40.9	107
L 726-8B	6.0	65.1	169
LTT 1445 B	28.4	135	349

Roney+ (in prep)

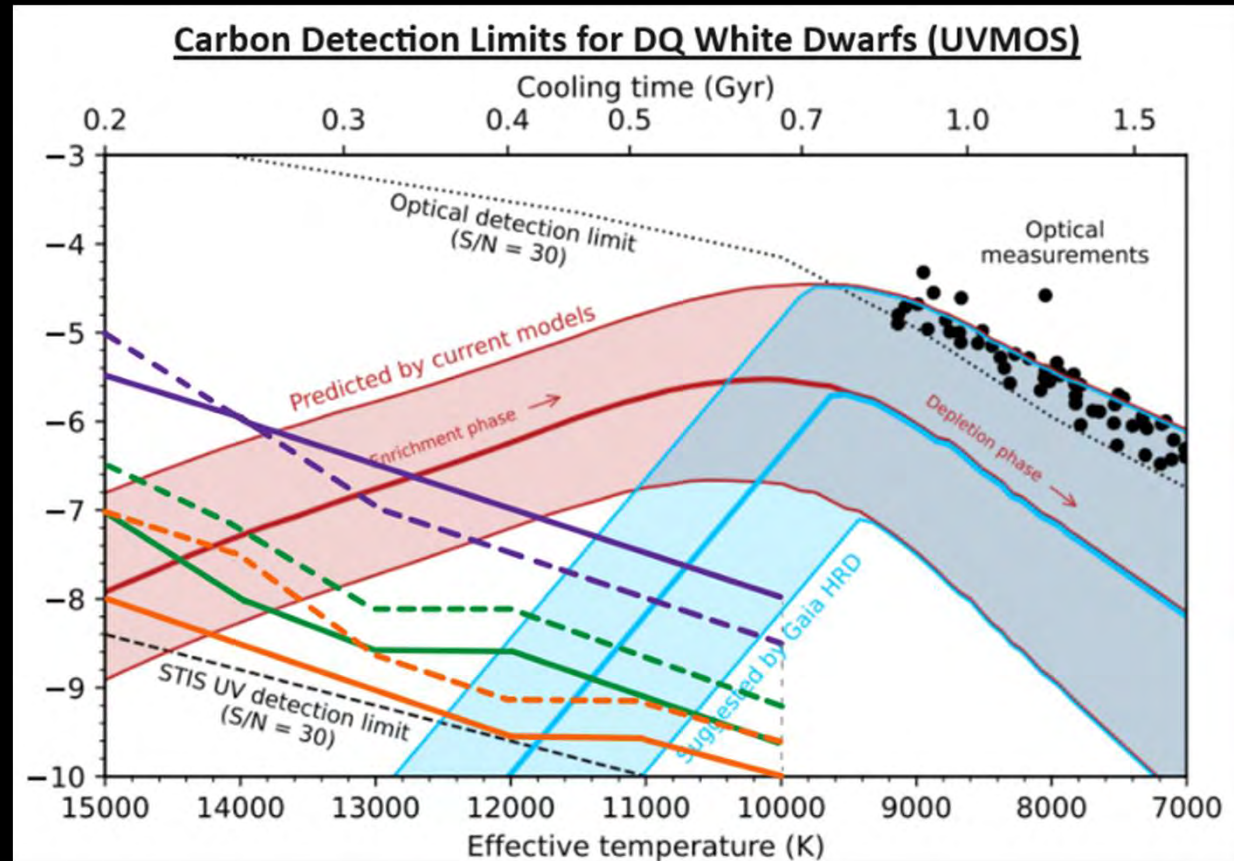


Roney+ (in prep)

Reach an **SNR of 20 in <~60 seconds** while flaring, making them ideal candidates for observation.

White Dwarf Atmospheres

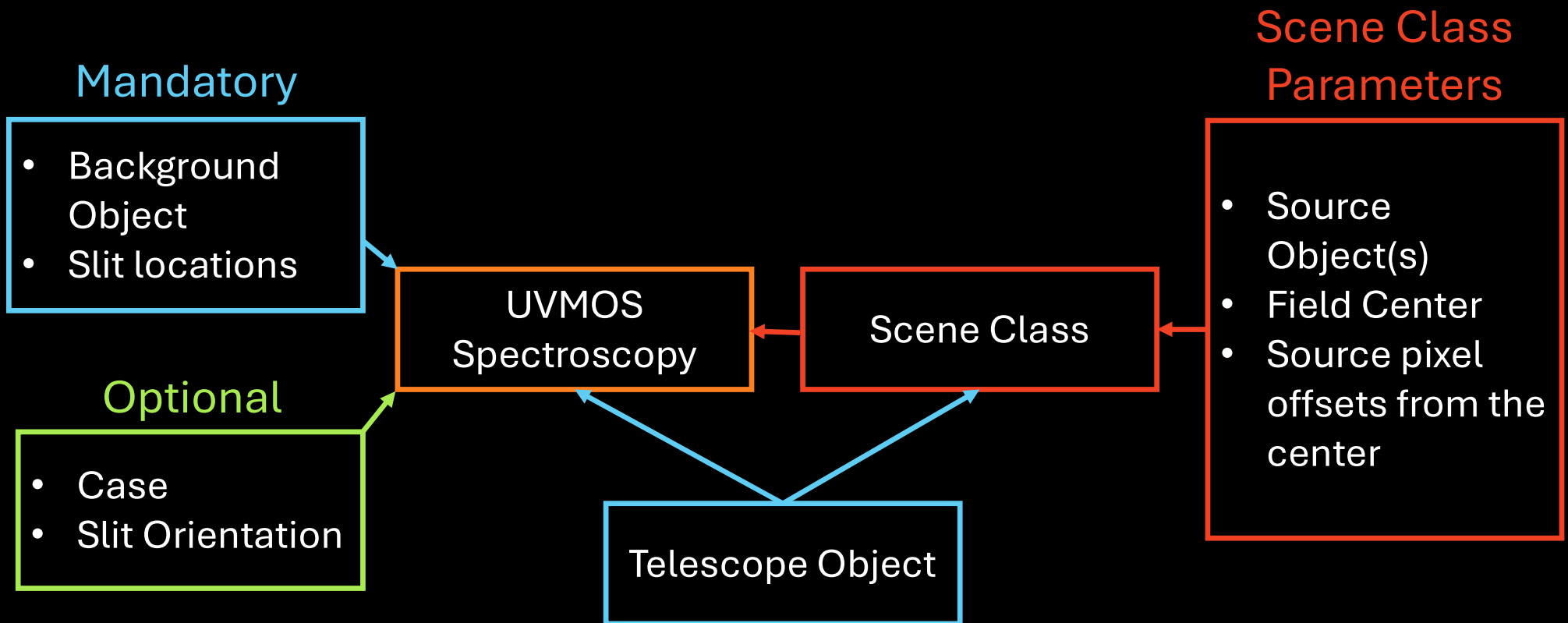
- Investigated white dwarfs (WDs) that display convective dredge-up of core material.
- 1-hour exposures make the 10000-15000K temperature gap accessible.
- With 10 and 100-hour exposures it will be able to rival Hubble STIS detections.



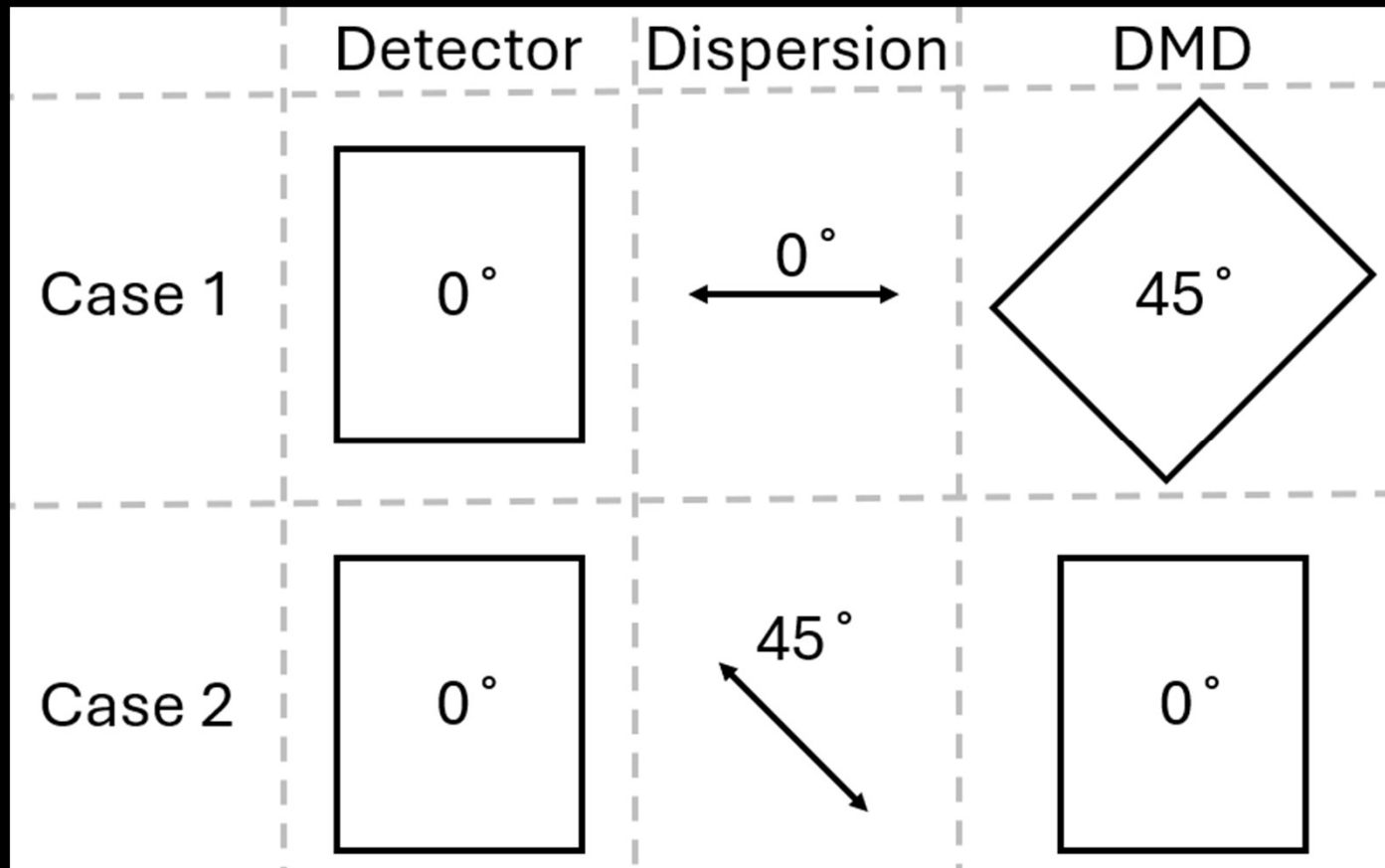
Gupta+ (in prep.)

Using the Multi-Slit ETC

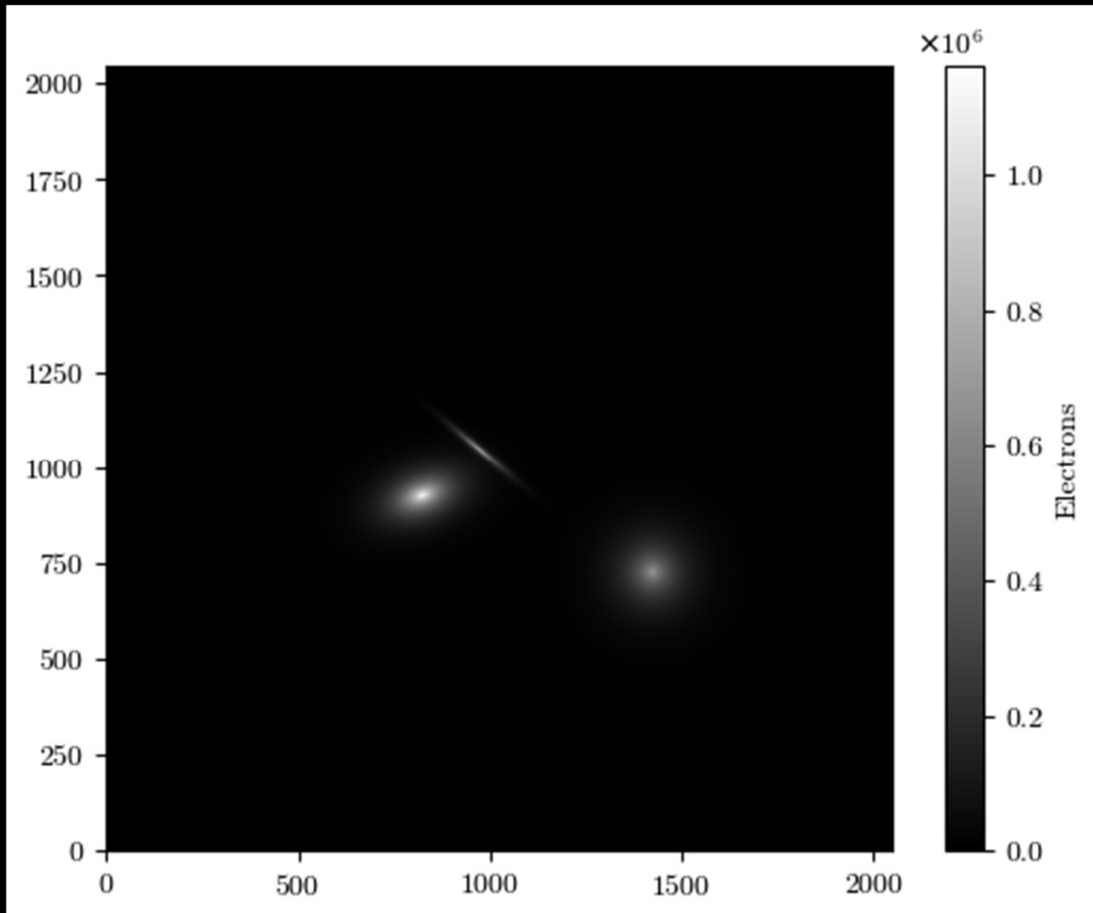
Initializing the UVMOS ETC



Two Ways to Build the UVMOS



The Scene Class



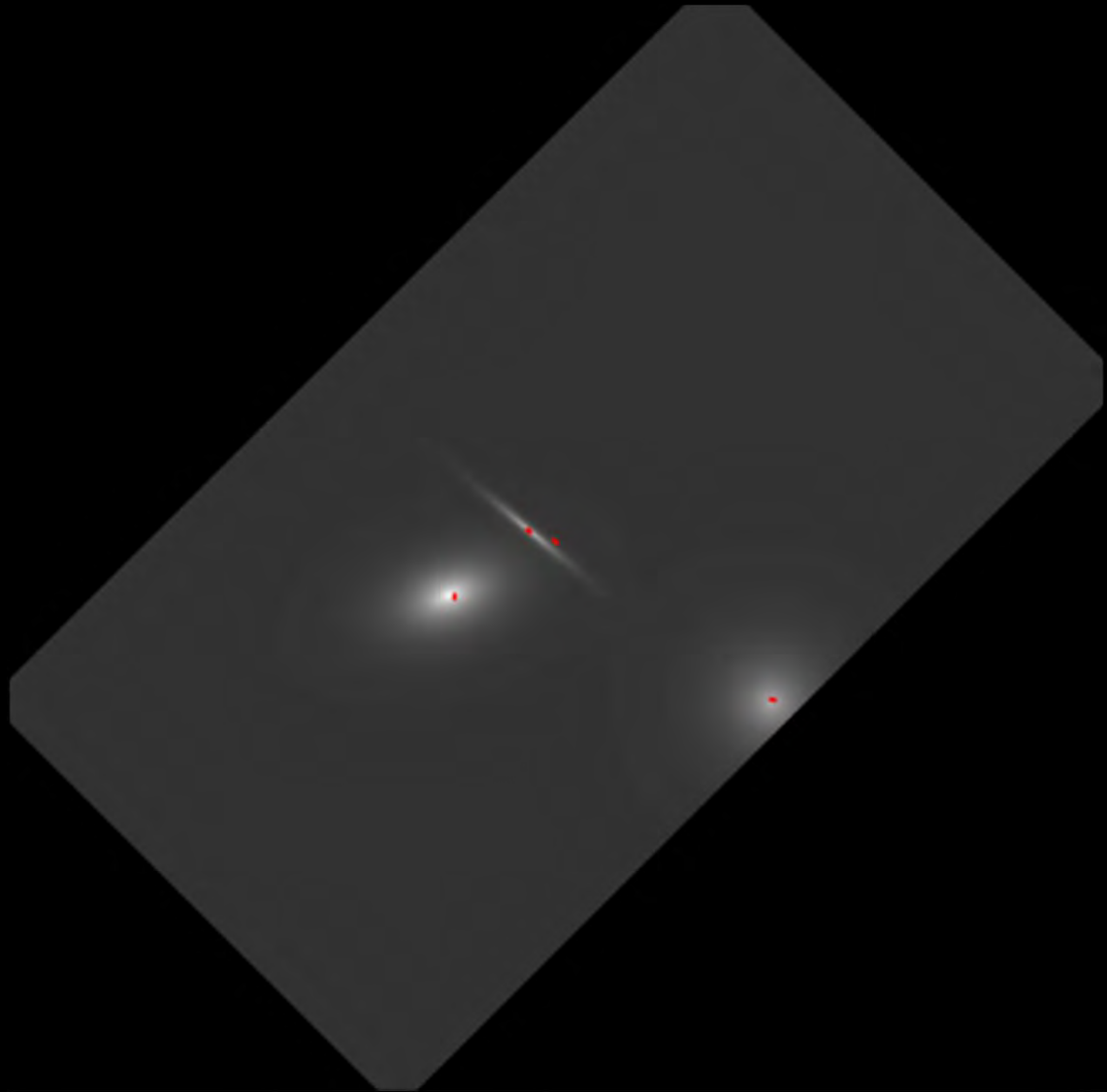
Developed by summer
research student
Gurpreet Pandher

- 3 galaxy sources
- 1 point source
- Can optionally define custom sources as well.

Defining Slits

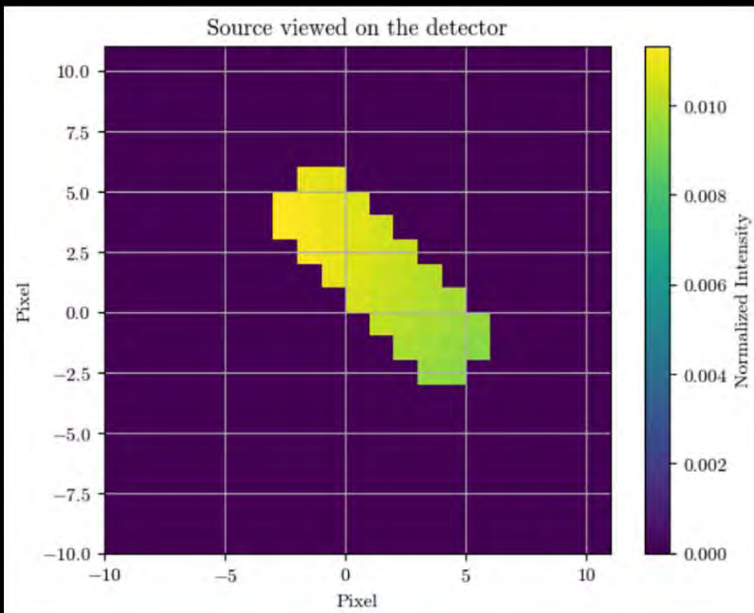
Can define slits in any orientation or position on the detector.

- Defined 1 slit for each source.

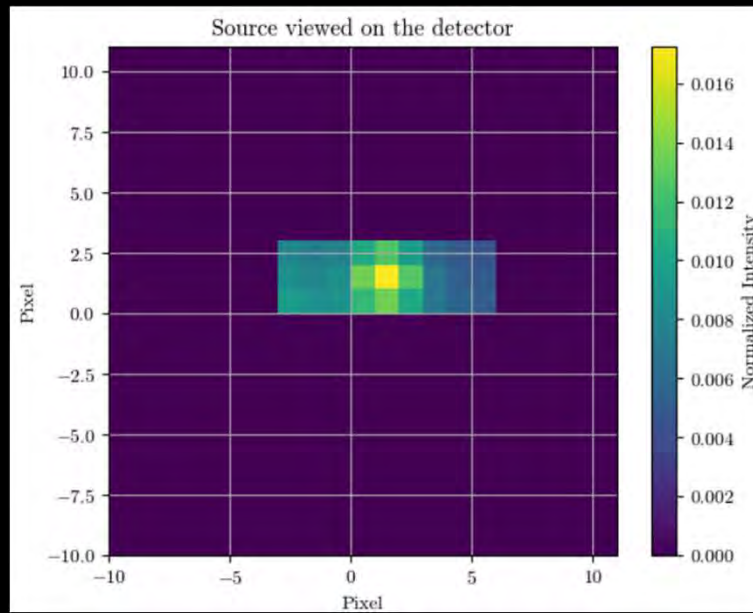


Making the Slits

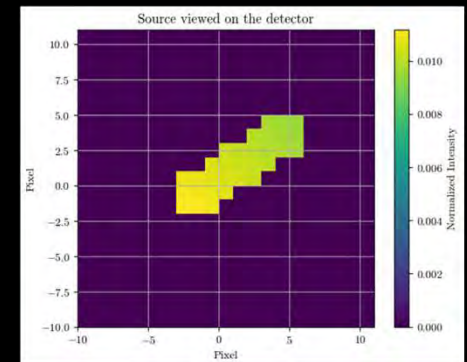
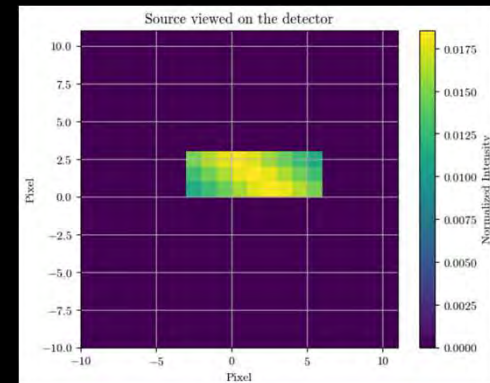
Galaxy Source



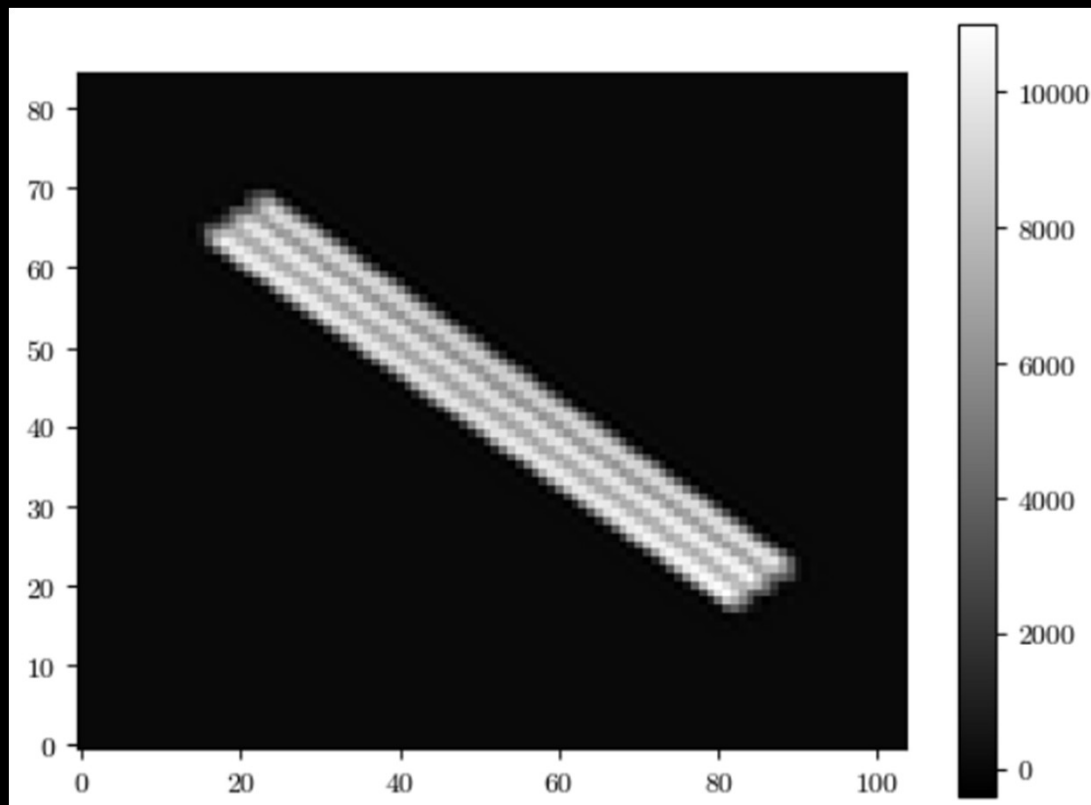
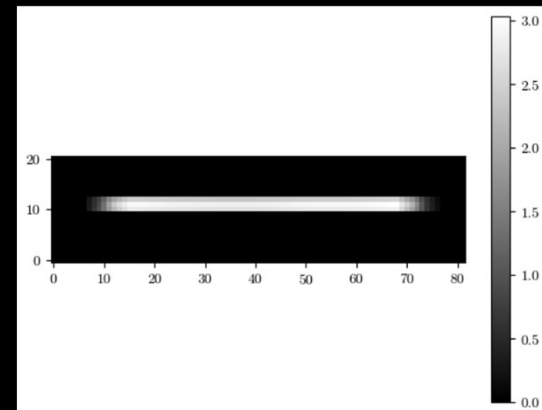
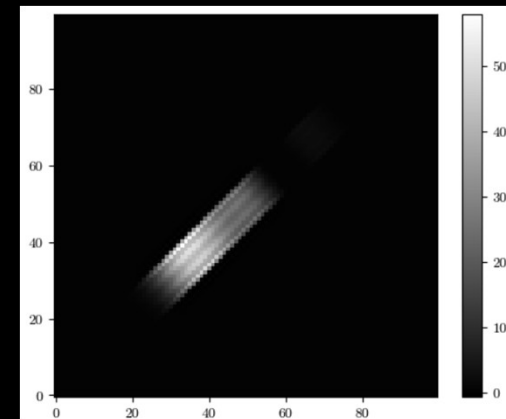
Point Source



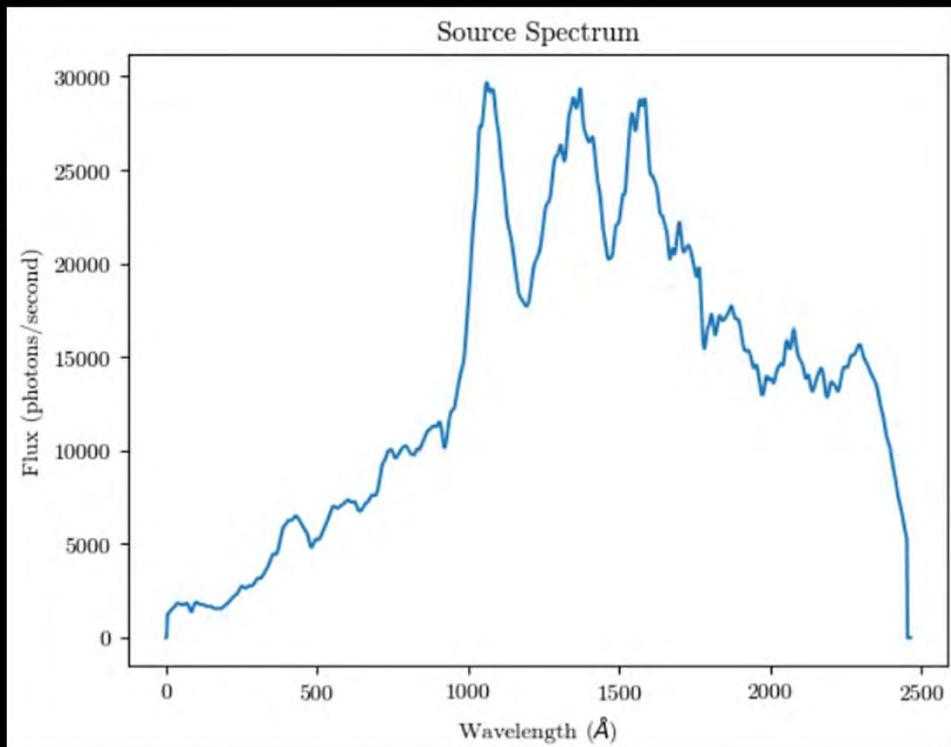
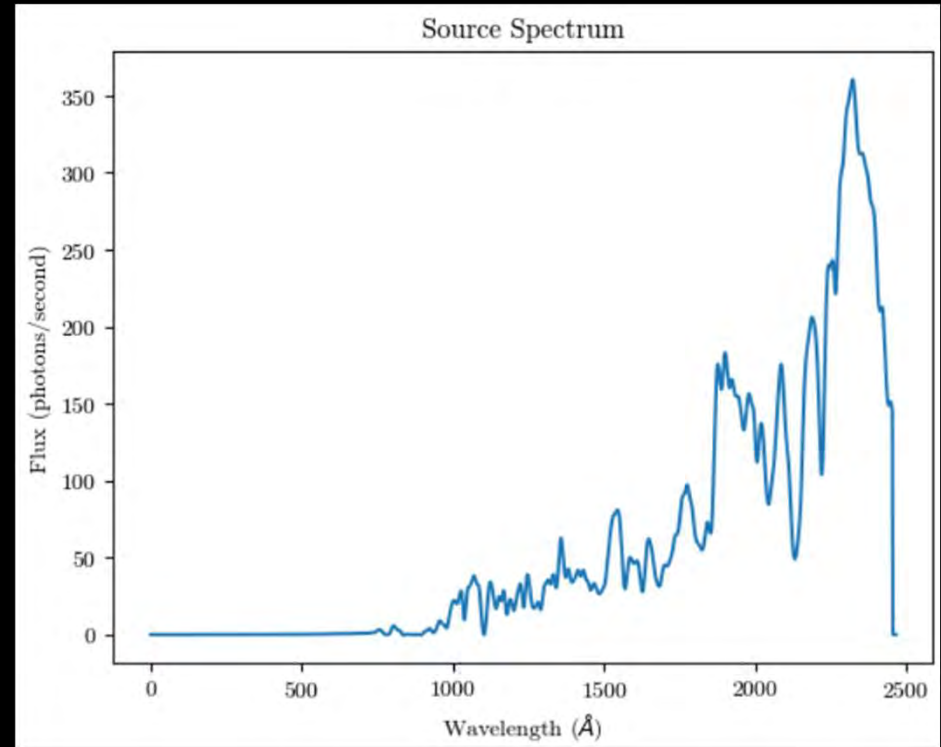
Other Galaxy Sources



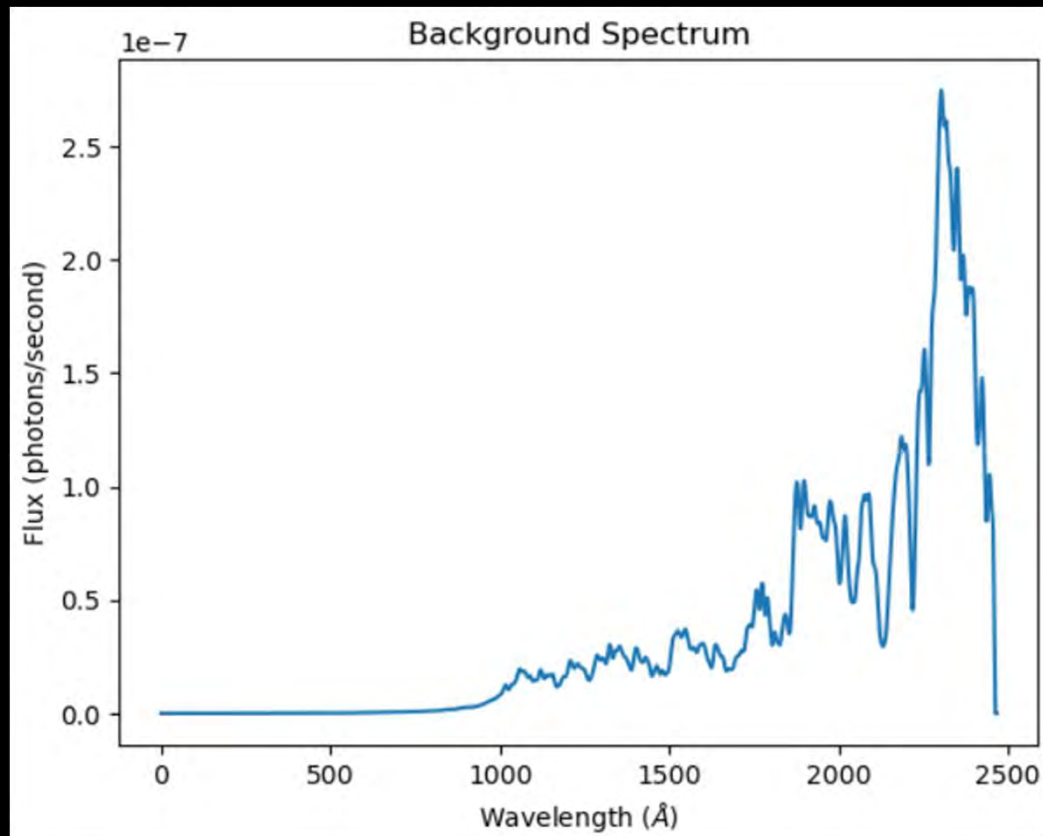
Smearing the Light Over the Detector



Source Spectra



Background Spectra



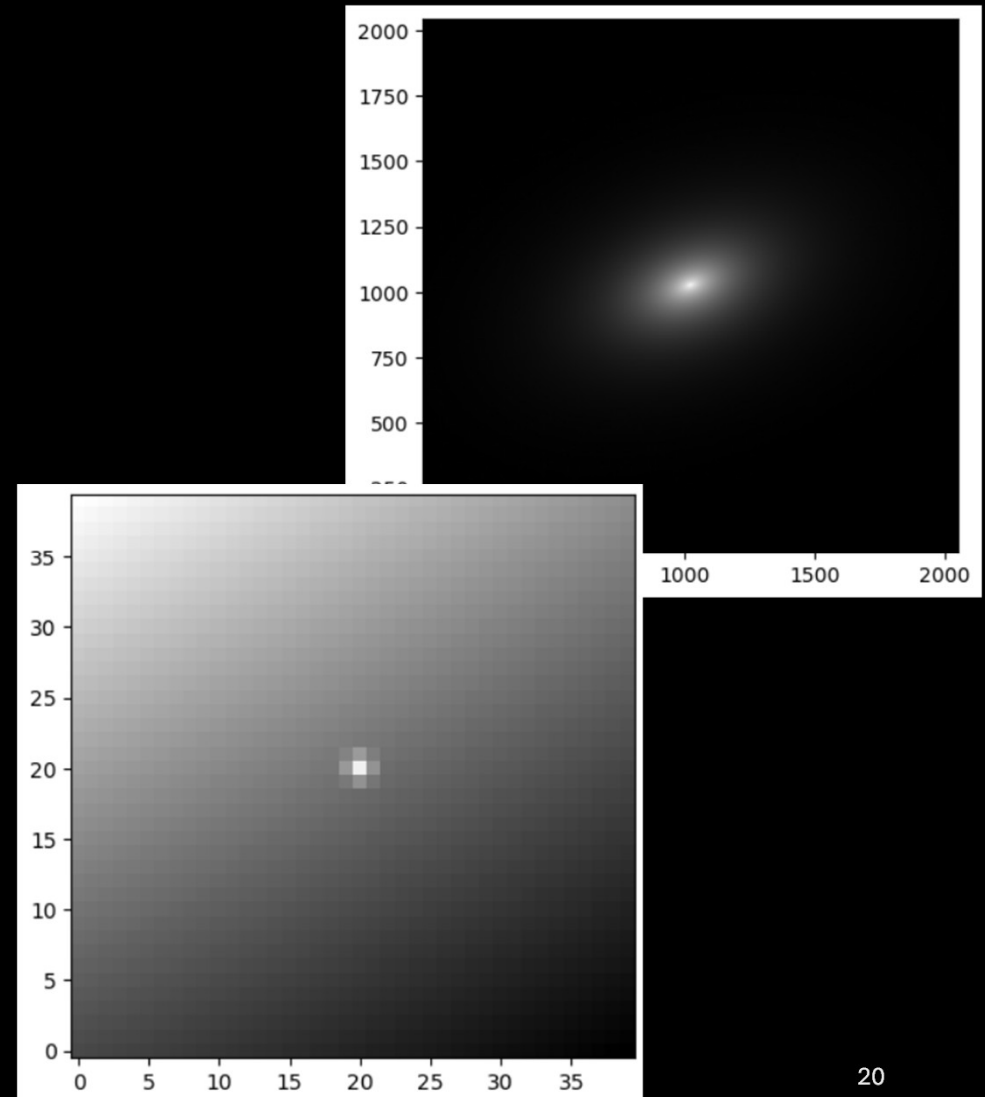
Results

Source	SNR for t = 100s	Exposure Time for SNR = 10 [s]
Galaxy Source 1	0.608	1674.346
Galaxy Source 2	891.79	0.488
Galaxy Source 3	259.77	2.961
Point Source	0.294	3495.108

*For a wavelength of 2000 angstroms

Supernova Sources

- Summer research student Gurpreet Pandher:
 - Supernova source class
 - Supernova example Jupyter notebook
 - To be added to CANFAR soon!
- Brenda Chenery (University of Calgary) is continuing the supernova science case.



Availability

Visit the CASTOR
telescope GitHub



CASTOR-telescope

The Cosmological Advanced Survey Telescope for Optical and ultraviolet Research

23 followers

Canada

<https://www.castormission.org/>

Pinned

 **ETC** Public

Exposure time calculator (ETC) for CASTOR

Python 6 1

 **ETC_frontend** Public

Browser-based frontend for the CASTOR Exposure Time Calculator

TypeScript

 **ETC_notebooks** Public

Example Jupyter notebooks using the castor_etc Python package

Jupyter Notebook 1

 **ImageSimulator** Public

The CASTOR image simulator, a Python GalSim package-based script capable of generating mock CASTOR images from an input catalogue

Python 1

Multi-slit version available
on the CASTOR-telescope
GitHub, soon to be
available on CANFAR.

Future Plans and Releases

Future Science Cases

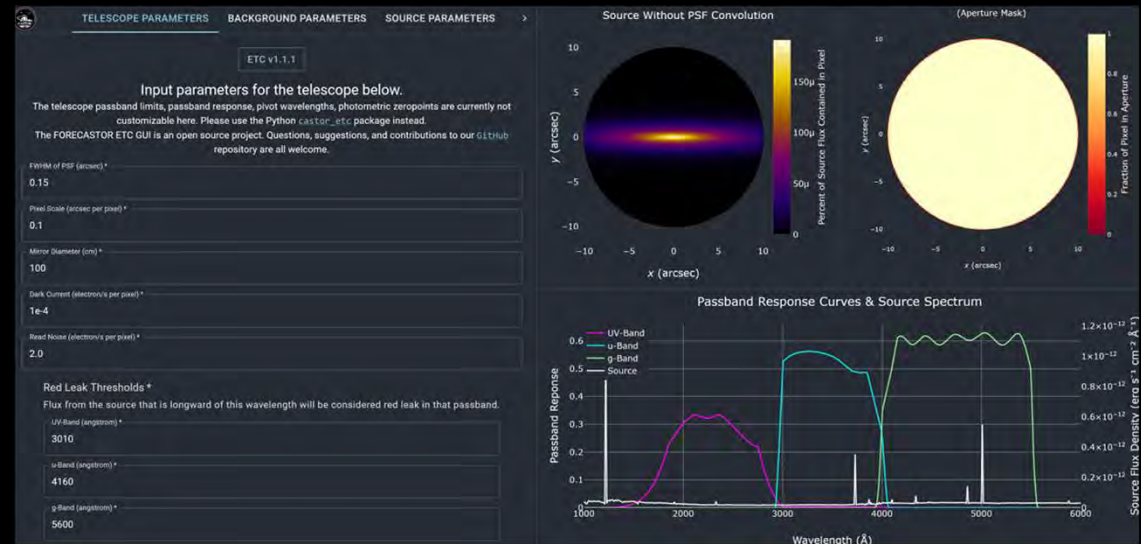
- Ongoing:
 - Supernova science case
- Future:
 - Probing star formation in high-redshift galaxies
 - Composition of stars in globular clusters
 - Comet spectroscopy



Globular Cluster M2 in B-band

Planned Upgrades

- Add built-in functions for science cases
- Add long slit mode
- Integrate the new ETC into the existing GUI
- New GitHub release
- Add to CANFAR



The existing CASTOR ETC GUI

Questions?

References

- [1] Zamkotsian, F. et al., “BATMAN: a DMD-based multi-object spectrograph on Galileo telescope,” in [Ground-based and Airborne Instrumentation for Astronomy V], Ramsay, S. K., McLean, I. S., and Takami, H., eds., Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series 9147, 914713 (July 2014).
- [2] Côté, P. et al., “The CASTOR mission,” *Journal of Astronomical Telescopes, Instruments, and Systems* 11(4), 042202 (2025).
- [3] Cheng, I., Woods, T. E., Côté, P., Glover, J., Bansal, D., Amenouche, M., Marshall, M. A., Amen, L., Hutchings, J., Ferrarese, L., Venn, K. A., Balogh, M., Blouin, S., Cloutier, R., Dickson, N., Gallagher, S., Hellmich, M., Hénault-Brunet, V., Khatu, V., Lawlor-Forsyth, C., Morgan, C., Richer, H., Sawicki, M., and Sorba, R., “FORECASTOR. I. Finding Optics Requirements and Exposure Times for the Cosmological Advanced Survey Telescope for Optical and UV Research Mission,” 167, 178 (Apr. 2024).
- [4] Glover, J., Cheng, I., Woods, T. E., Côté, P., Venn, K., Pazder, J., Hutchings, J., and Blouin, S., “FORE-CASTOR: an exposure time calculator for the CASTOR space mission simulating UVMOS spectroscopy,” in [Space Telescopes and Instrumentation 2022: Ultraviolet to Gamma Ray], den Herder, J.-W. A., Nikzad, S., and Nakazawa, K., eds., Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series 12181, 1218177 (Aug. 2022).
- [5] Duara, A., Skottfelt, J., and Crews, C., “CIS 120 Detector Characterisation Test Report,” (2025).