SPARCS: The Star-Planet Activity Research CubeSat

Determining Inputs to Planetary Habitability

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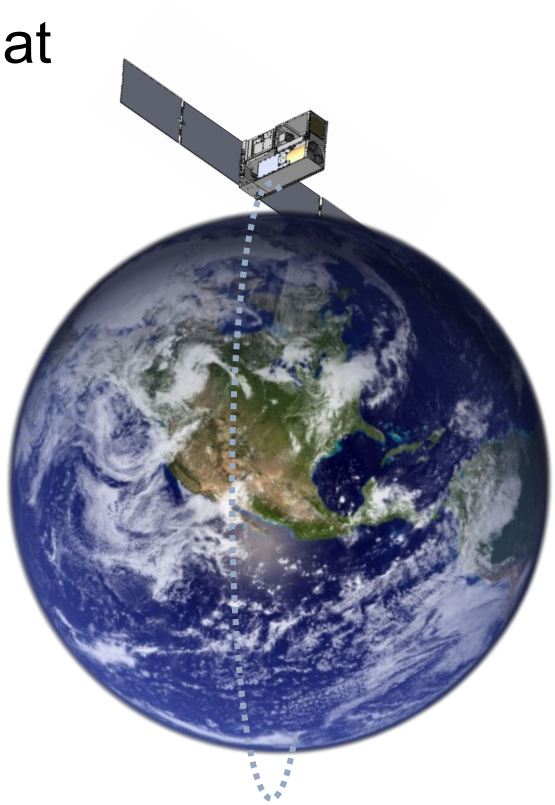
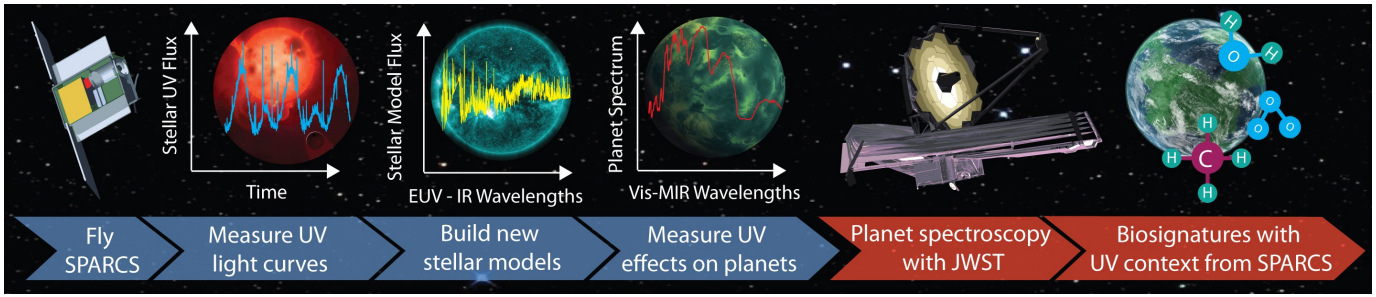
SPARCS –

The Star-Planet Activity Research CubeSat

- NASA-funded mission in development
- **Goal:** To determine the ultraviolet (UV) variability of low-mass stars at short (flares – sec to min.) and long (rotation period - days) timescales
- **Tech. goal:** Demonstrate the long-term performance of delta-doped detectors in space
- **Mission:** 1 year of dedicated monitoring of ~20 low-mass stars from a Sun-Sync terminator orbit
- **Payload**:
  - ~9 cm telescope, 40’ FOV
  - FUV channel = 155±10 nm; NUV = 280±25 nm
- **Spacecraft:** 6U CubeSat
- Ready for launch in 2024





SPARCS' science mission: Study UV environment of exoplanets around low-mass stars*

Low-mass stars are abundant (70% of all) and small

>300 HZ** planets... and counting, mostly around low-mass stars

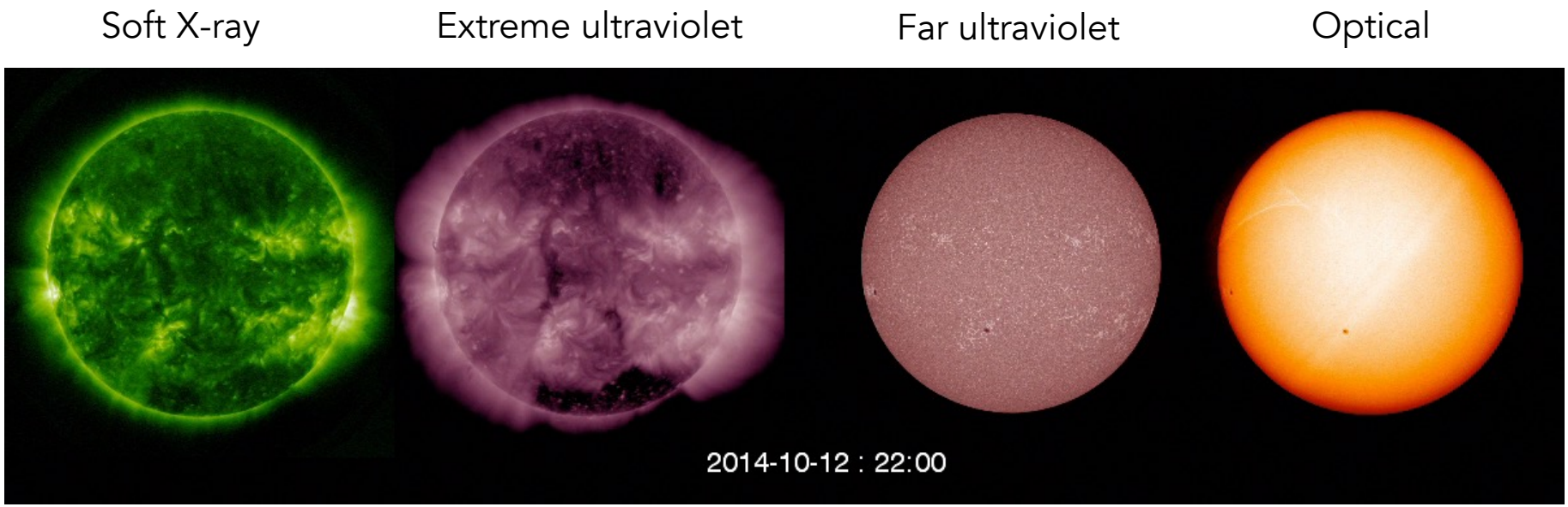
→ ~40 billion HZ planets around low-mass in the Milky Way!

**HZ: Habitable Zone

*Low-mass stars: K-M dwarfs: Mass: 90% to 7.5% M_{sun}; Radius: 80% to 8% R_{sun}

Most exoplanets are to be found around low-mass stars

Low-mass stars are very “active” = variable

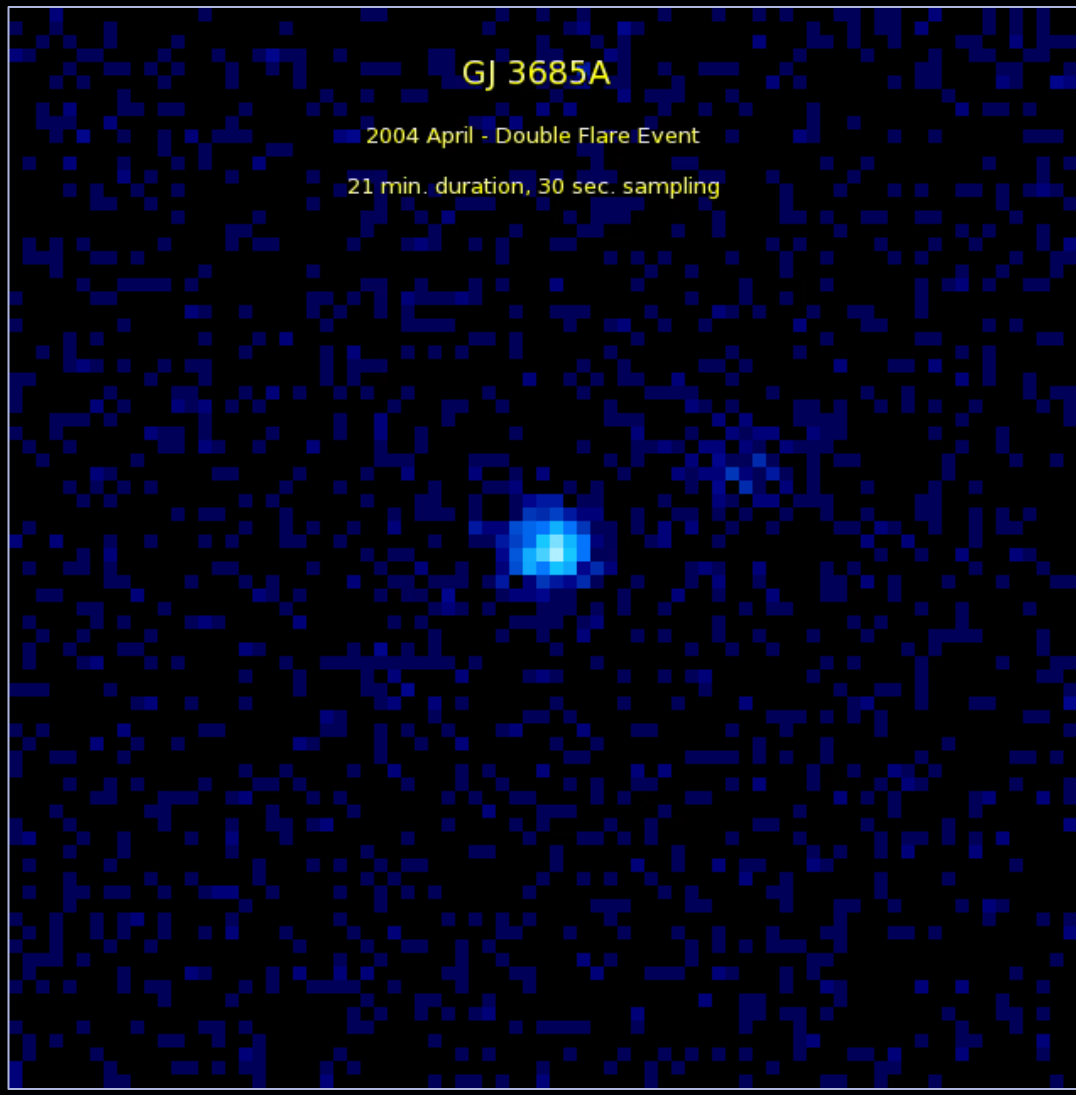


The Sun: NASA SDO - Llama & Shkolnik (2015)

Shorter wavelengths

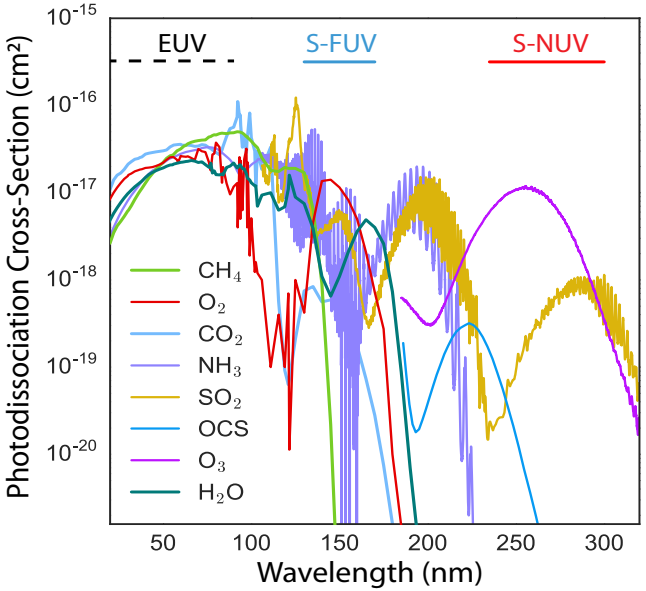
Superflare increased stellar brightness of this M dwarf (M4) by >10 UV magnitudes (or 9000x) in a period of < 200 s.

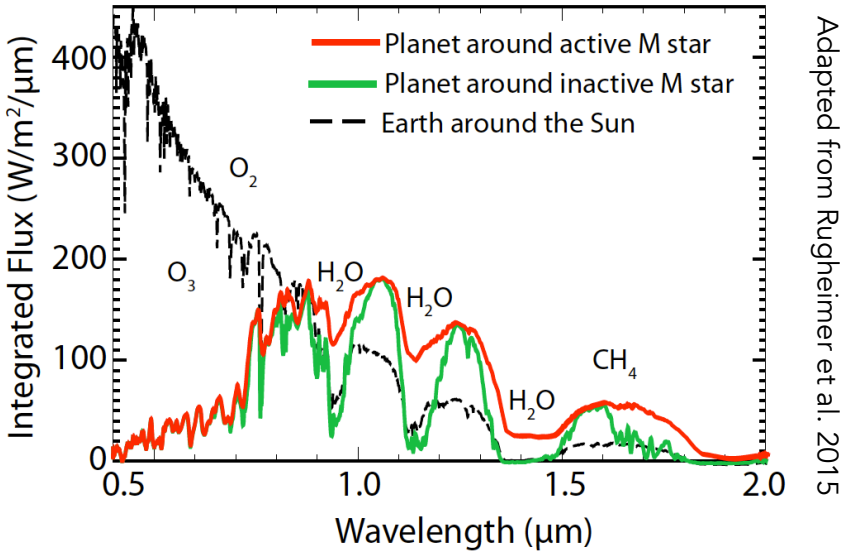
GALEX NUV
Robinson et al. 2005
Welsh et al. 2006
Million et al. 2016
Movie: S. Fleming

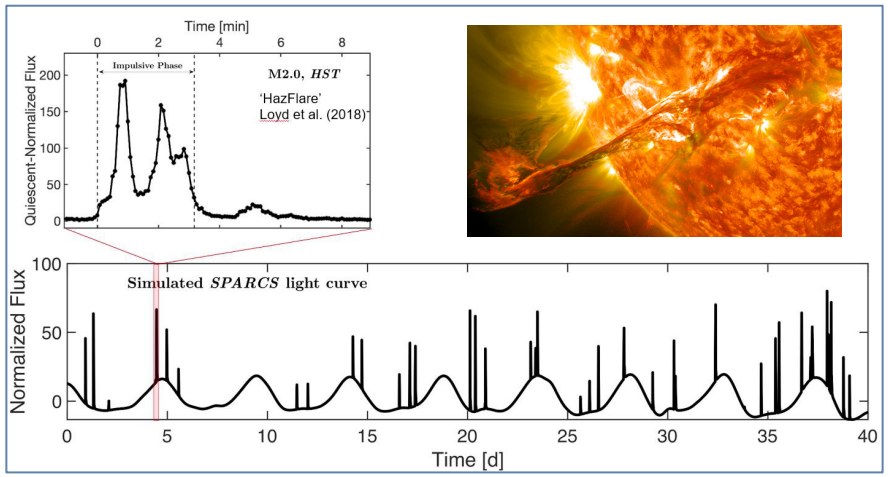


Evgenya Shkolnik

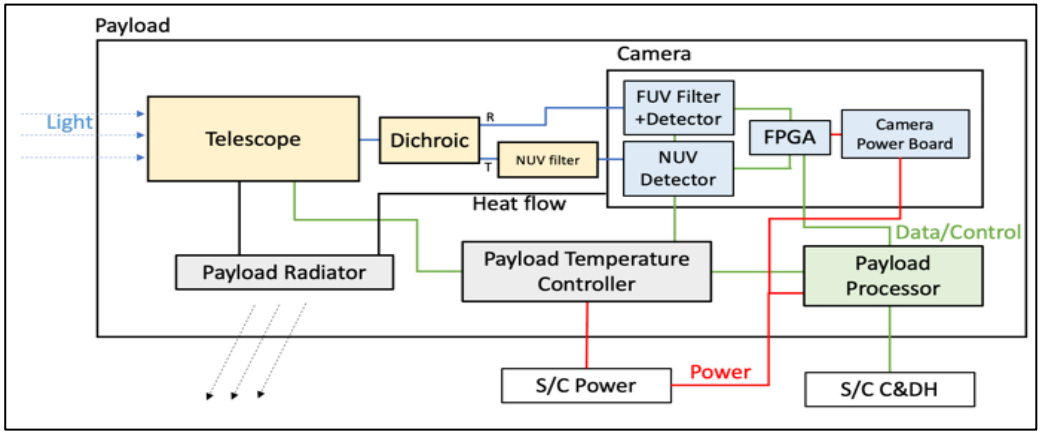
Stellar UV radiation affects the planet's atmosphere (and observed spectrum)

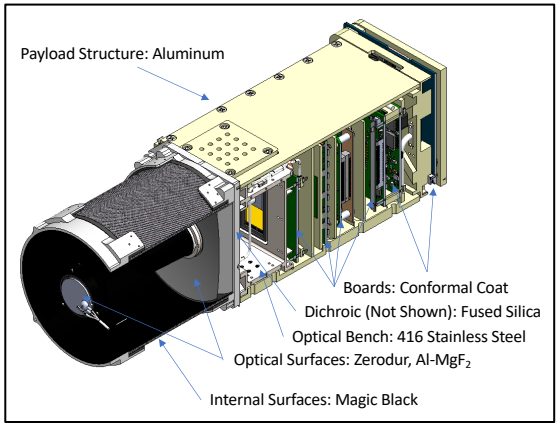


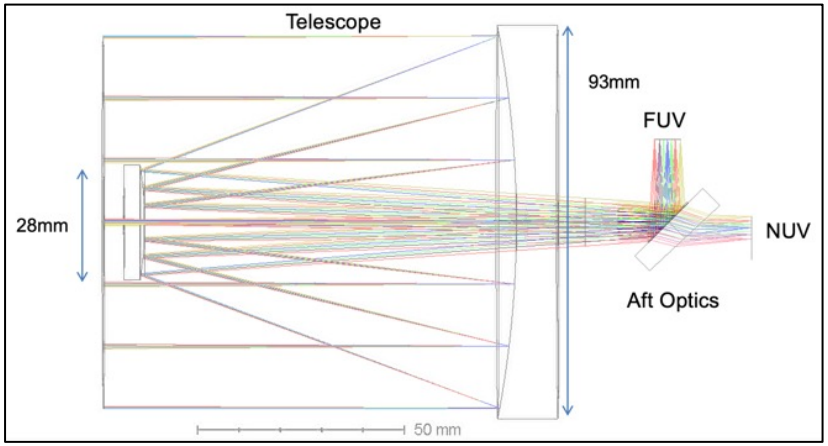


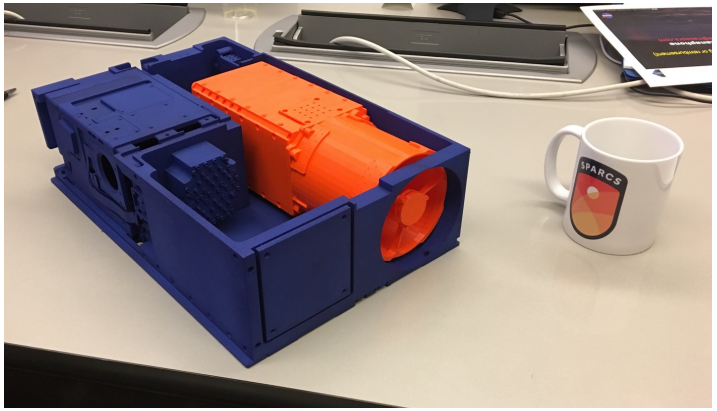


Payload



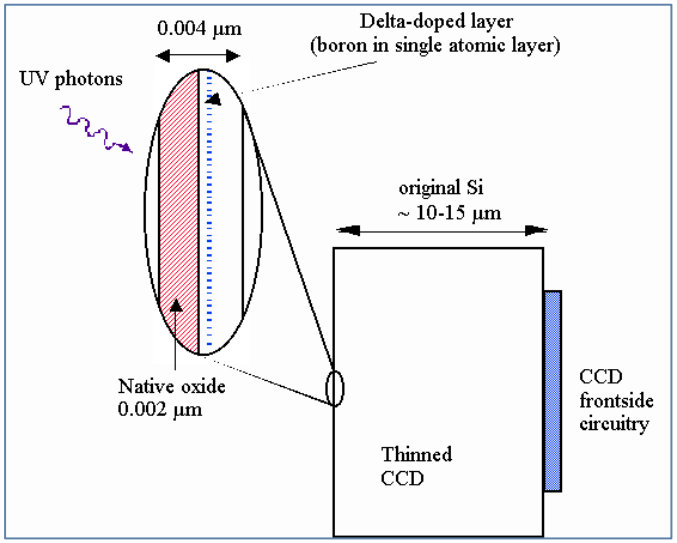




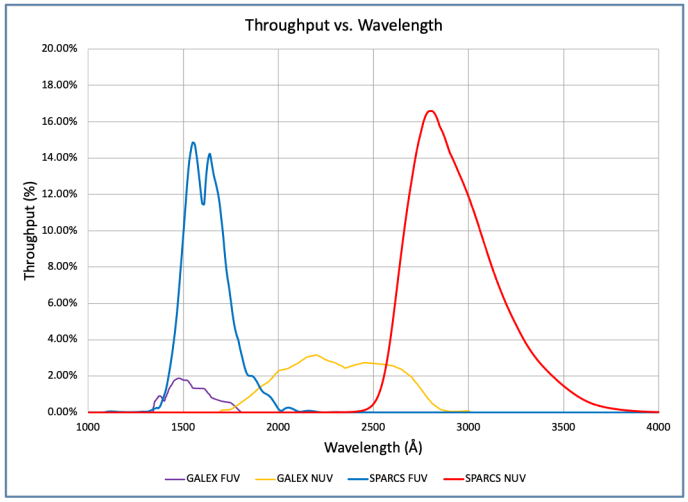


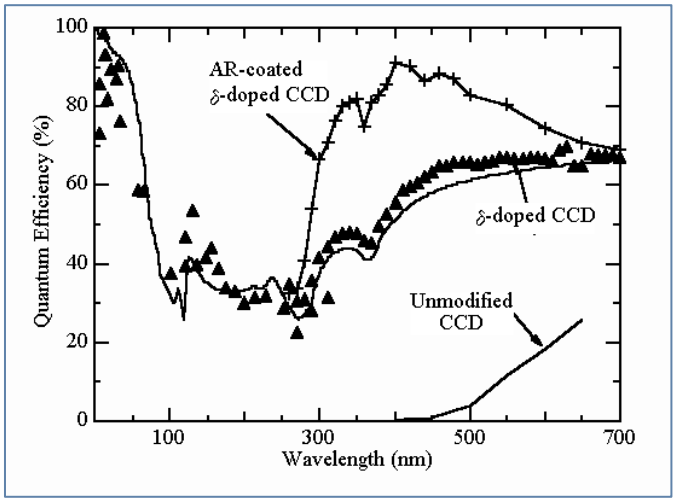
Detectors, Filters, and Throughput

- Two Delta-doped; Teledyne e2V CCDs, 1k x 1k;
- Detectors are kept at 238K to control dark current
- Filters:
  - FUV filter: metal-dielectric filter, directly deposited on the detector (JPL)
  - NUV filter: On the dichroic (Materion Precision Optics)



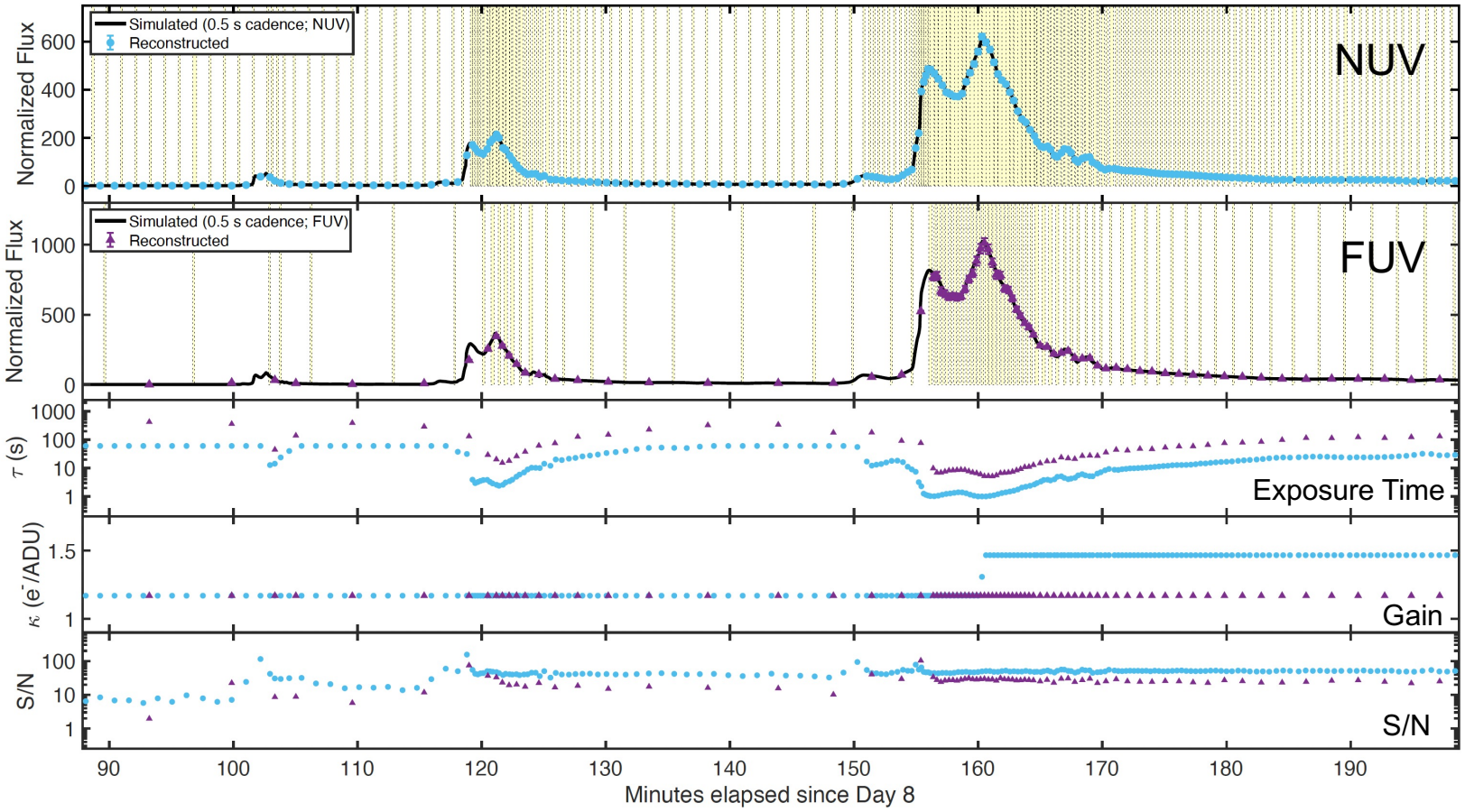
https://www.stsci.edu/stsci/meetings/space_detectors/nikzad.htm





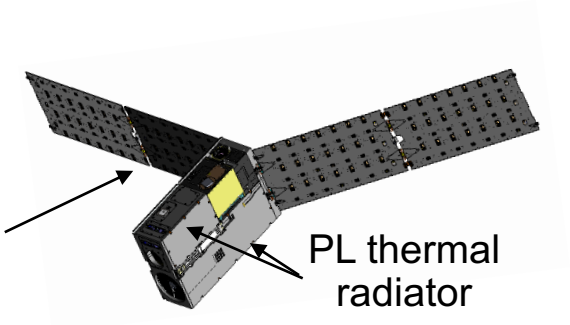
Adaptive exposure control

Exposure and gain are changed to control saturation during flares.



Ramiaramanantsoa et al. (2021)

Spacecraft : Blue Canyon Technologies 6U spacecraft



Diplexer

XB1 Avionics
- Star tracker, torque rods, reaction wheels
- S-band radio, avionics control and power distribution, GPS receiver, & battery

ASU EyeStar Assembly

Deployment Switches

Coarse Sun Sensors

Coarse Sun Sensor

S-Band Antenna

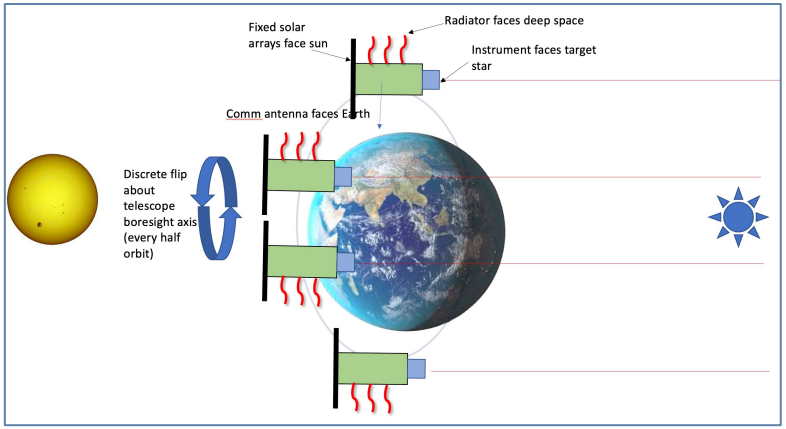
Payload
- ***JPL*** Camera (Detectors & Electronics)
  ASU Structure/Optical Bench/Thermal/PLP
- ***Hexagon*** Telescope

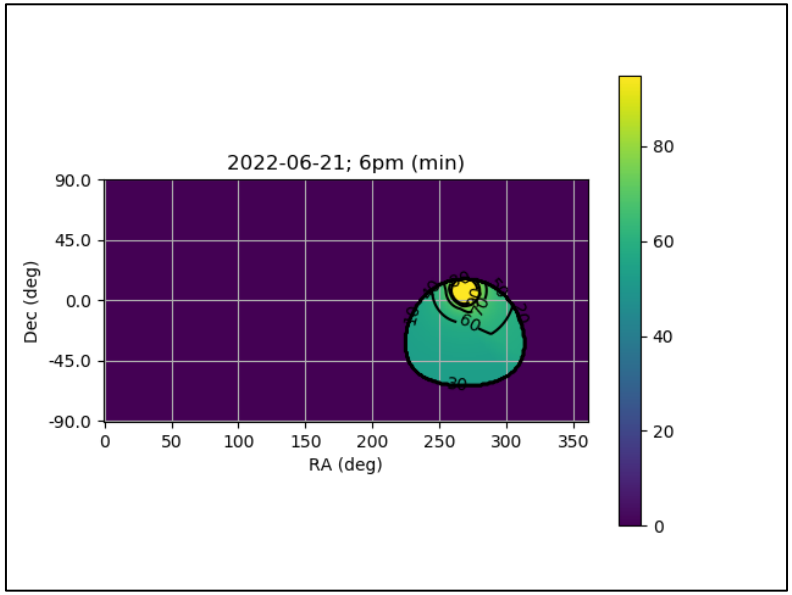
Star Tracker

Jitter: <6” in 10 min

Mission

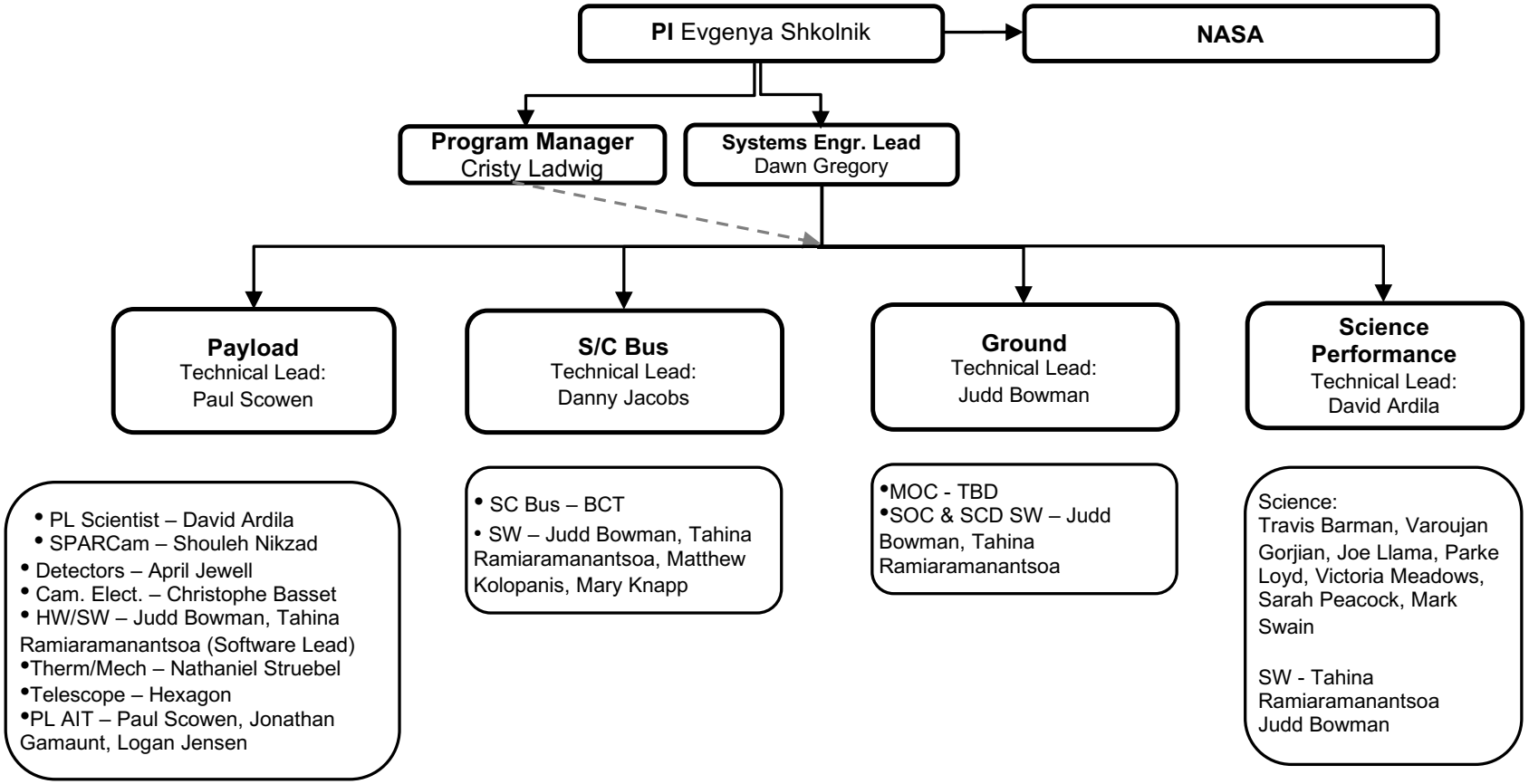
- Launch to a Sun-synchronous terminator (6 pm/6 am) orbit
- Allows for long visibility periods
- 1 year mission
- Observe 20 stars, over multiple rotation periods (average 20 days)
- For some, observe targets on continuous epochs





Visibility duration (min)

The Team



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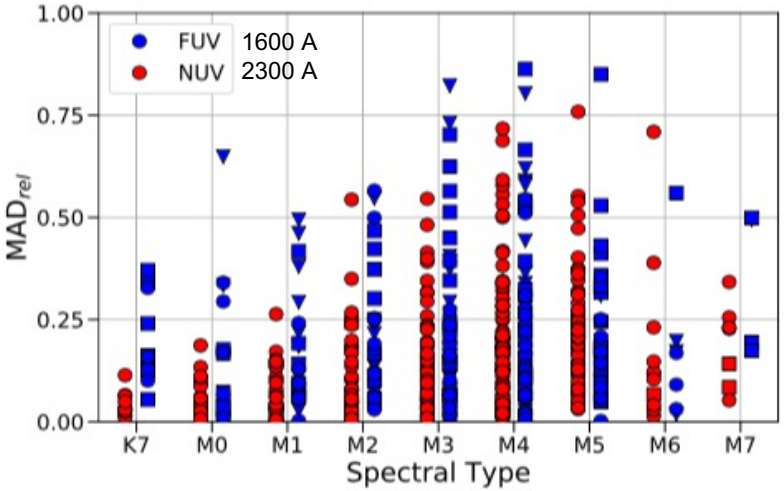
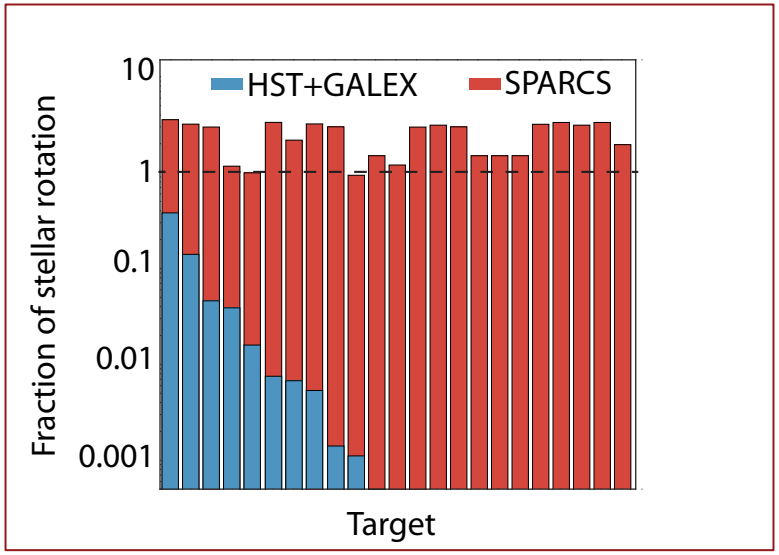
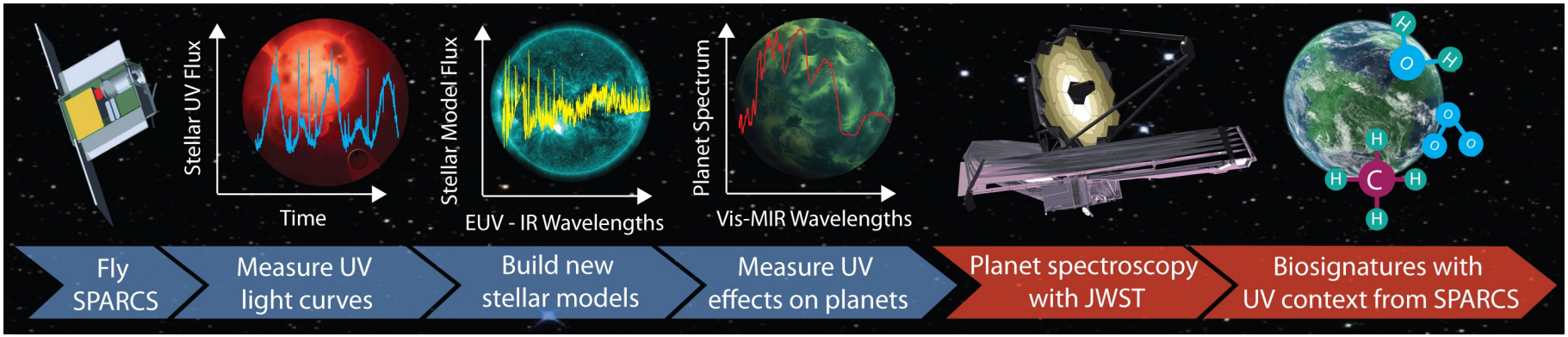
UV activity in M-dwarfs is poorly known



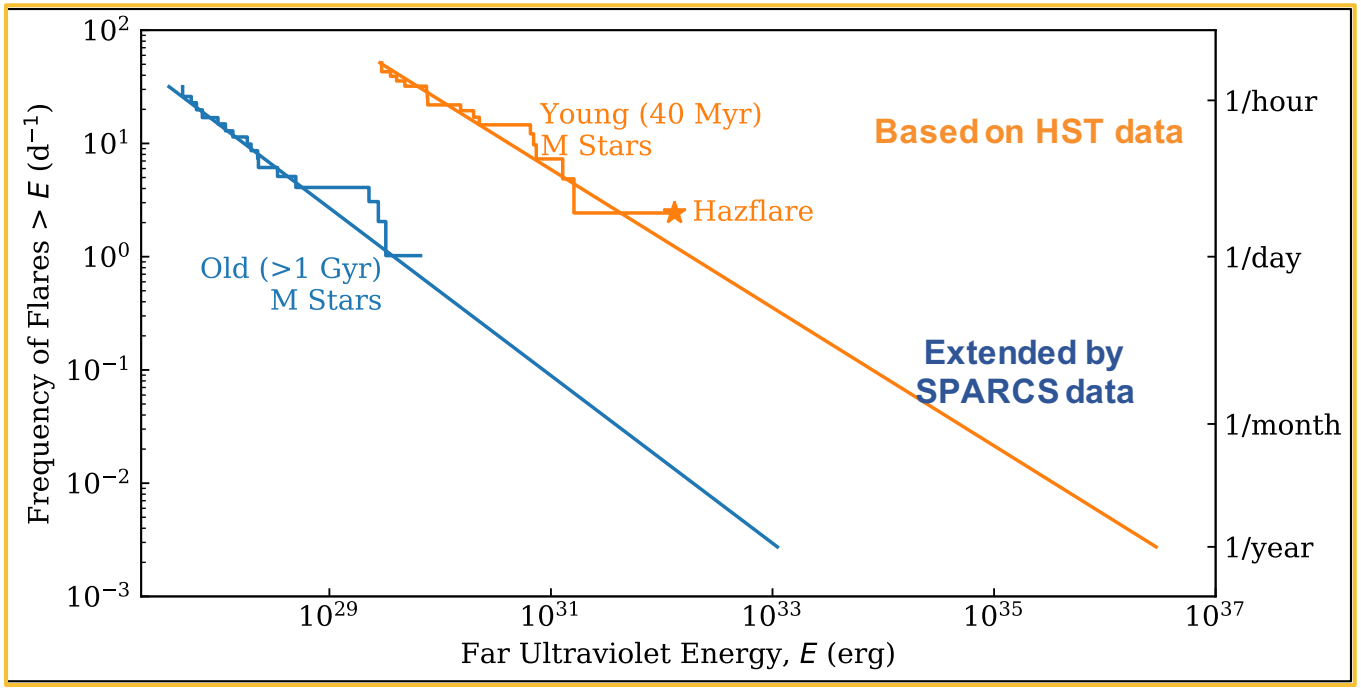
Complete GALEX sample on the variability of M-dwarfs. Most were observed only 3 times (Miles & Shkolnik 2017)



M-dwarfs are very abundant, and planets are easy to find: Provide the hosts of most planets to be found.



Young M dwarfs flare more frequently and with more vigor: one superflare every day!



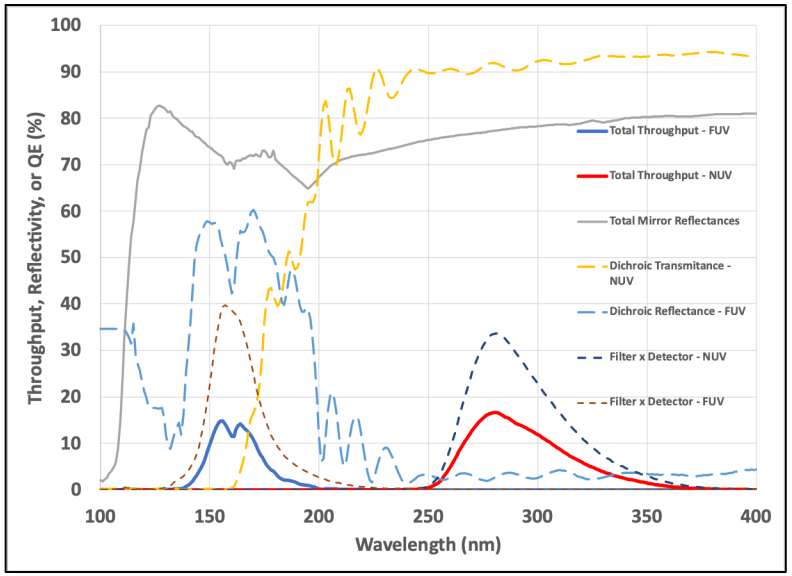
HAZMAT IV; Loyd, Shkolnik et al., 2018a
MUSCLES; Loyd et al. 2018b

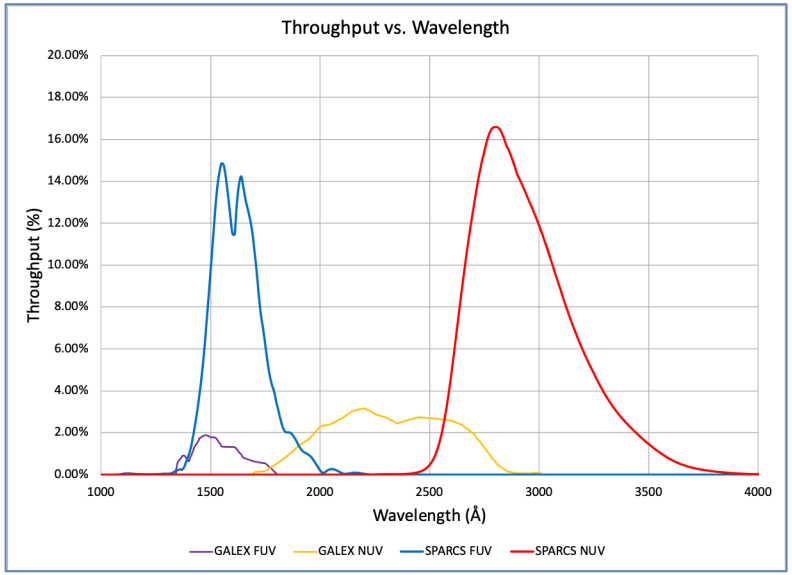
Evgenya Shkolnik

Throughput

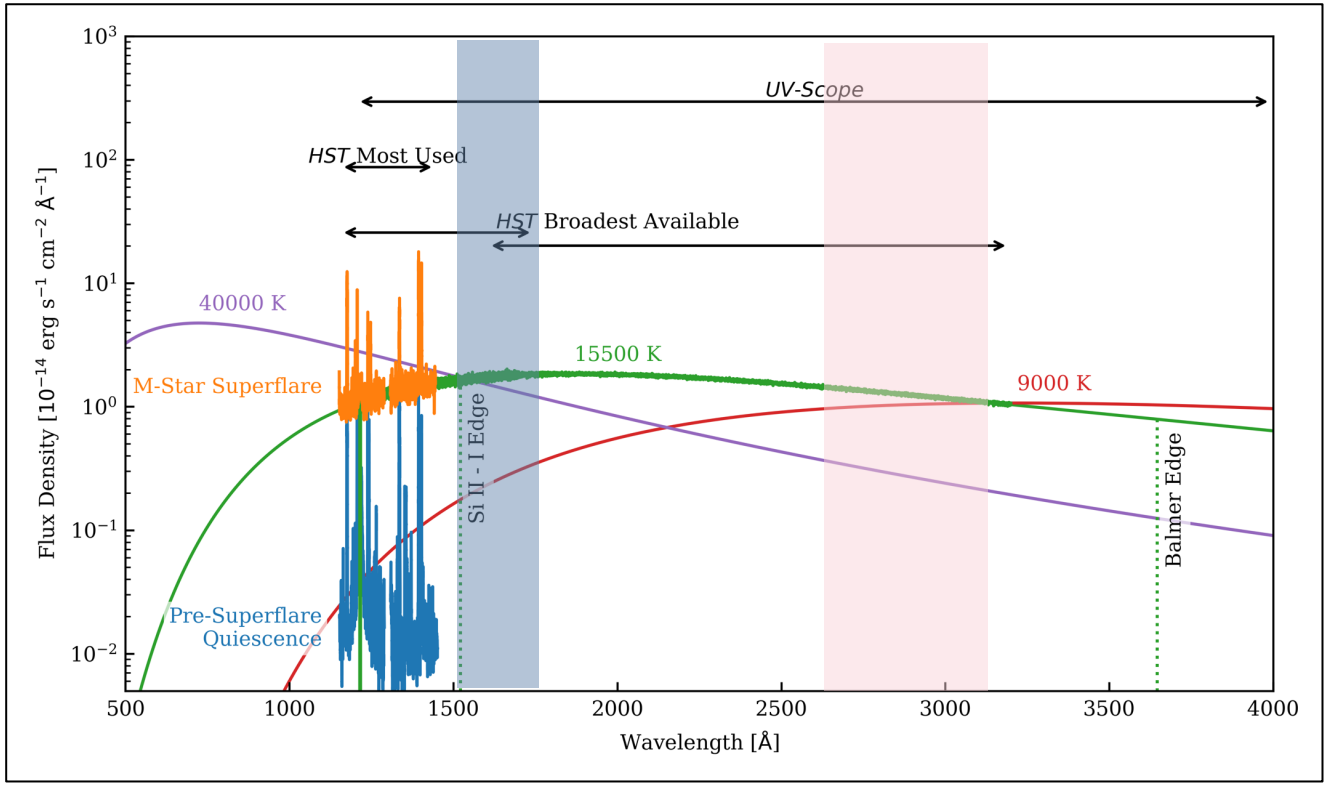
SPARCS is a highly efficient UV imager:

- Minimum number of surfaces
- Highly efficient detectors.
- Comparison:
  - SPARCS:
    - 9 cm aperture
    - 15% maximum throughput
  - GALEX:
    - 50 cm aperture
    - 3% maximum throughput





How much UV is emitted?
Superflares + blackbody emission



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HAZMAT IV, Loyd et al. 2018

SPARCS FUV SPARCS NUV