The FUV Flares of Active and Inactive M Dwarfs

Know Thy Star

R. O. Parke Loyd

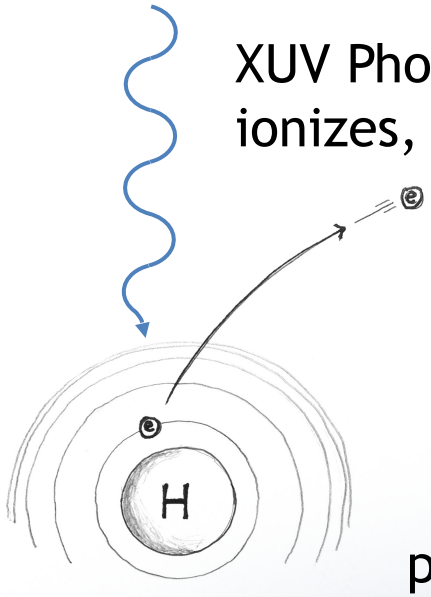
2017 October 11

MOTIVATIONS

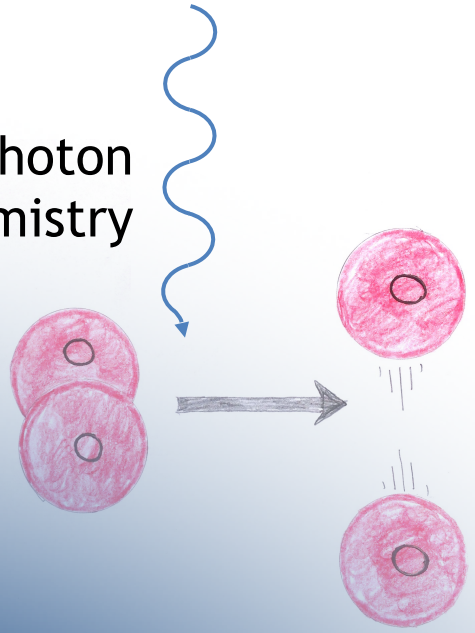
Know Thy Ultraviolet, Know Thy Atmosphere

The UV drives atmospheric photochemistry and is linked to the escape-powering X-ray and extreme ultraviolet (XUV).

XUV Photon
ionizes, heats → powers escape

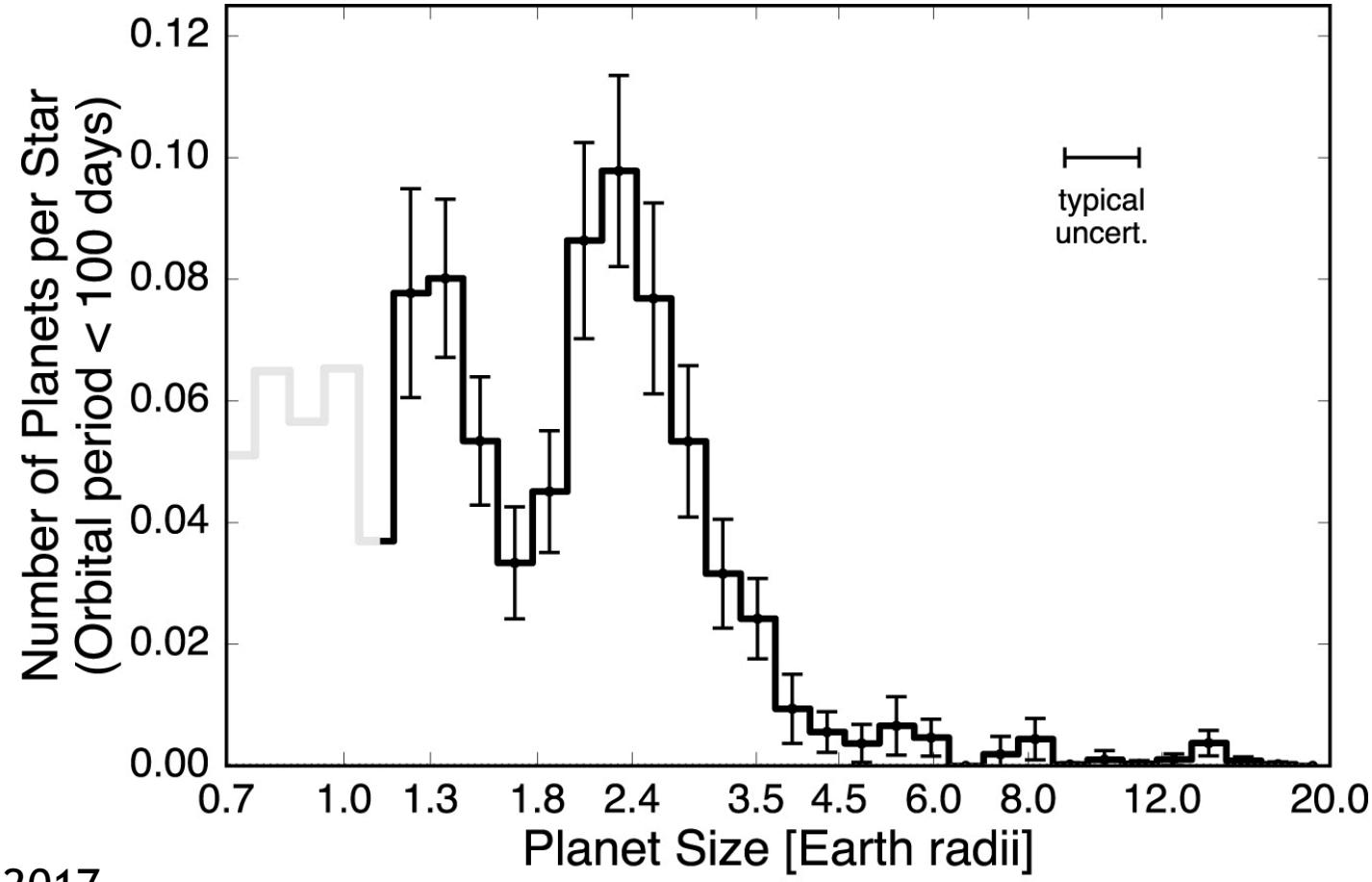


UV Photon
photolyzes → drives chemistry



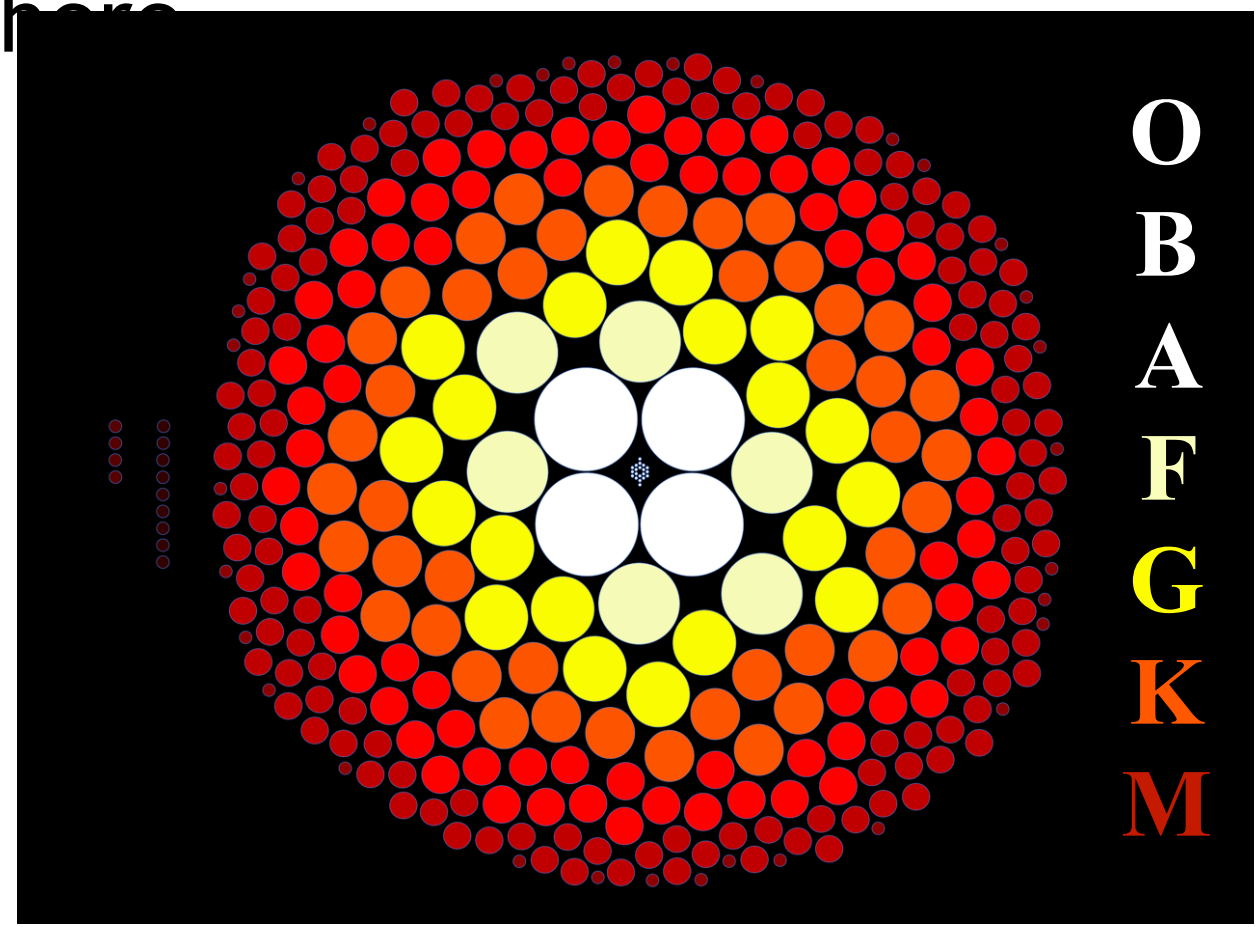
Know Thy Ultraviolet, Know Thy Atmosphere

XUV driven escape could explain the dearth of intermediate-radius planets.



Fulton+ 2017

Motivation 1: UV → photochemistry, escape
Motivation 2: Cool stars → they're everywhere

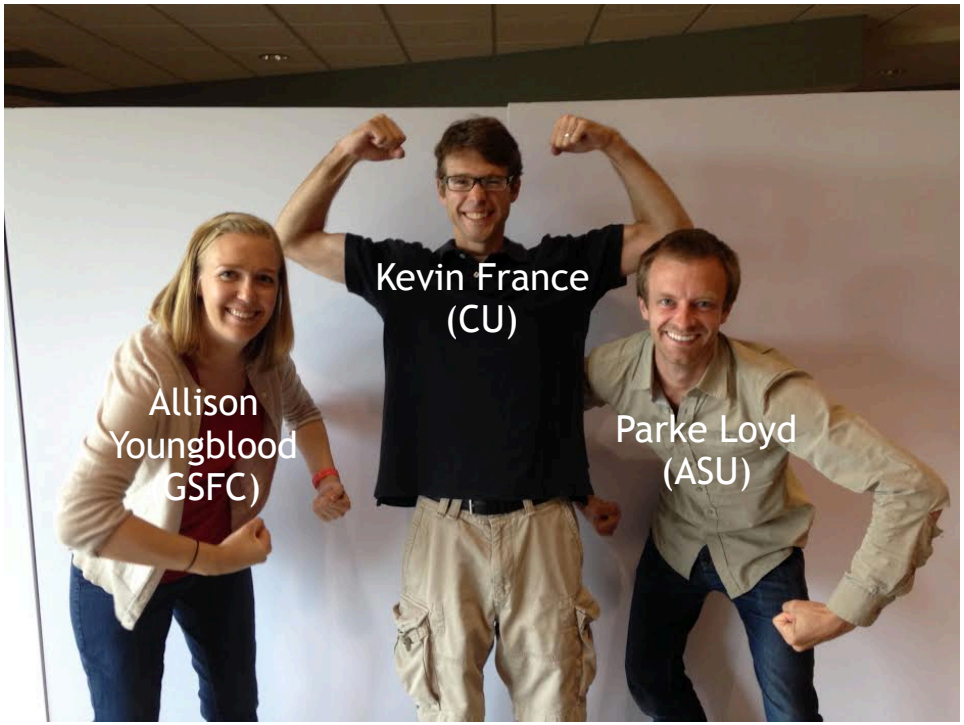


Stars in the local neighborhood according to the RECONS survey, Henry+ 2006

MUSCLES SPECTRA

To know thy cool star ultraviolet, useth thy MUSCLES

Zach Berta-Thompson (CU)
Alex Brown (CU)
Adam Kowalski (CU)
Jeff Linsky (CU)
James Mason (CU)
Andrea Buccino (FCEN)
Cynthia Froning (UT)
Suzanne Hawley (UW)
Yamila Miguel (OCA)
Pablo Mauas (FCEN)

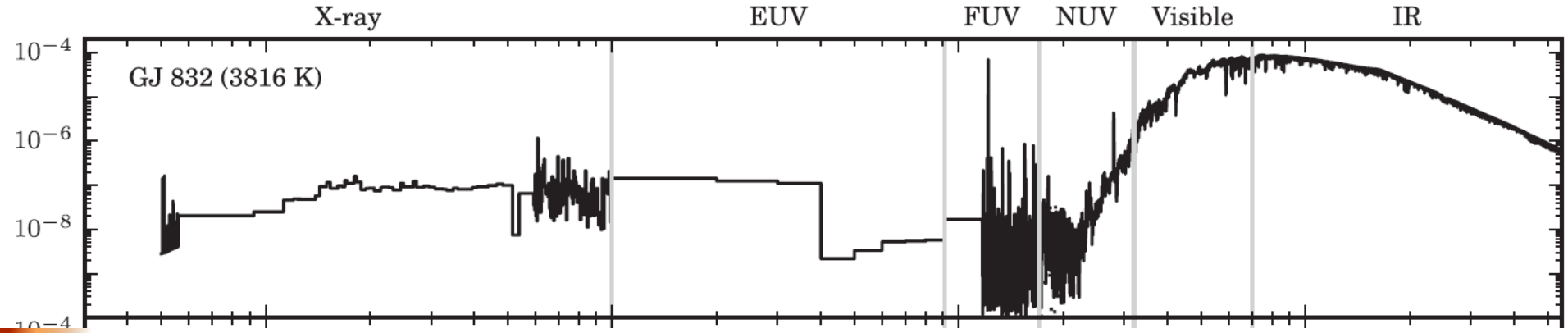


Elisabeth Newton (MIT)
Seth Redfield (Wesleyan)
Aki Roberge (NASA)
Sarah Rugheimer (St. Andrew
Christian Schneider (ESA)
Antígona Segura (ICN)
Matt Tilley (UW)
Mariela Vieytes (FCEN)
Lucianne Walkowicz (Adler)
Brian Wood (NRL)

MUSCLES: Measurements of the Ultraviolet Spectral Characteristics of Low-mass Exoplanetary Systems

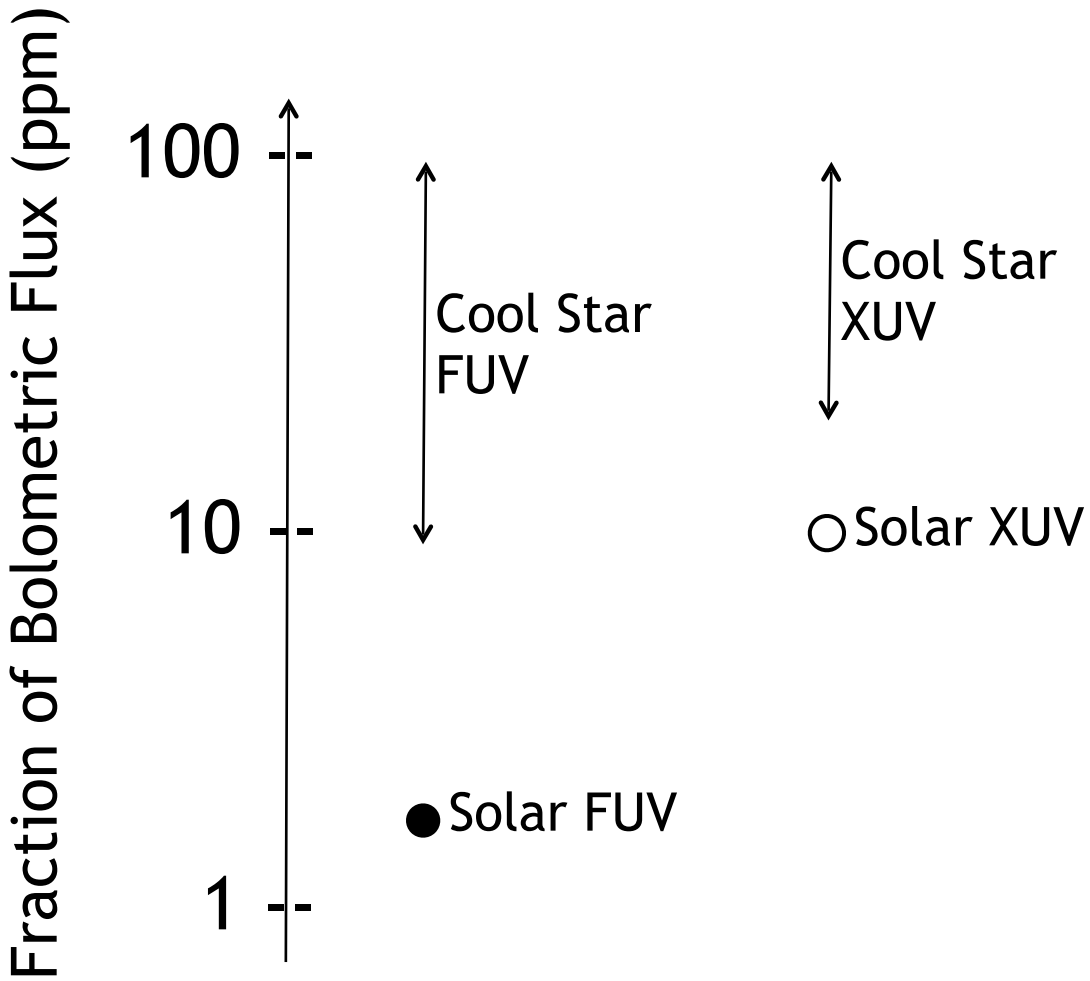
To know thy cool star ultraviolet, useth thy MUSCLES

Panchromatic SEDs for 8 M and 4 K dwarfs (Prox Cen included!) are in the MAST archives at https://archive.stsci.edu/prepds/muscles/ available for your atmospheric modeling pleasure.
Or search “muscles spectra”



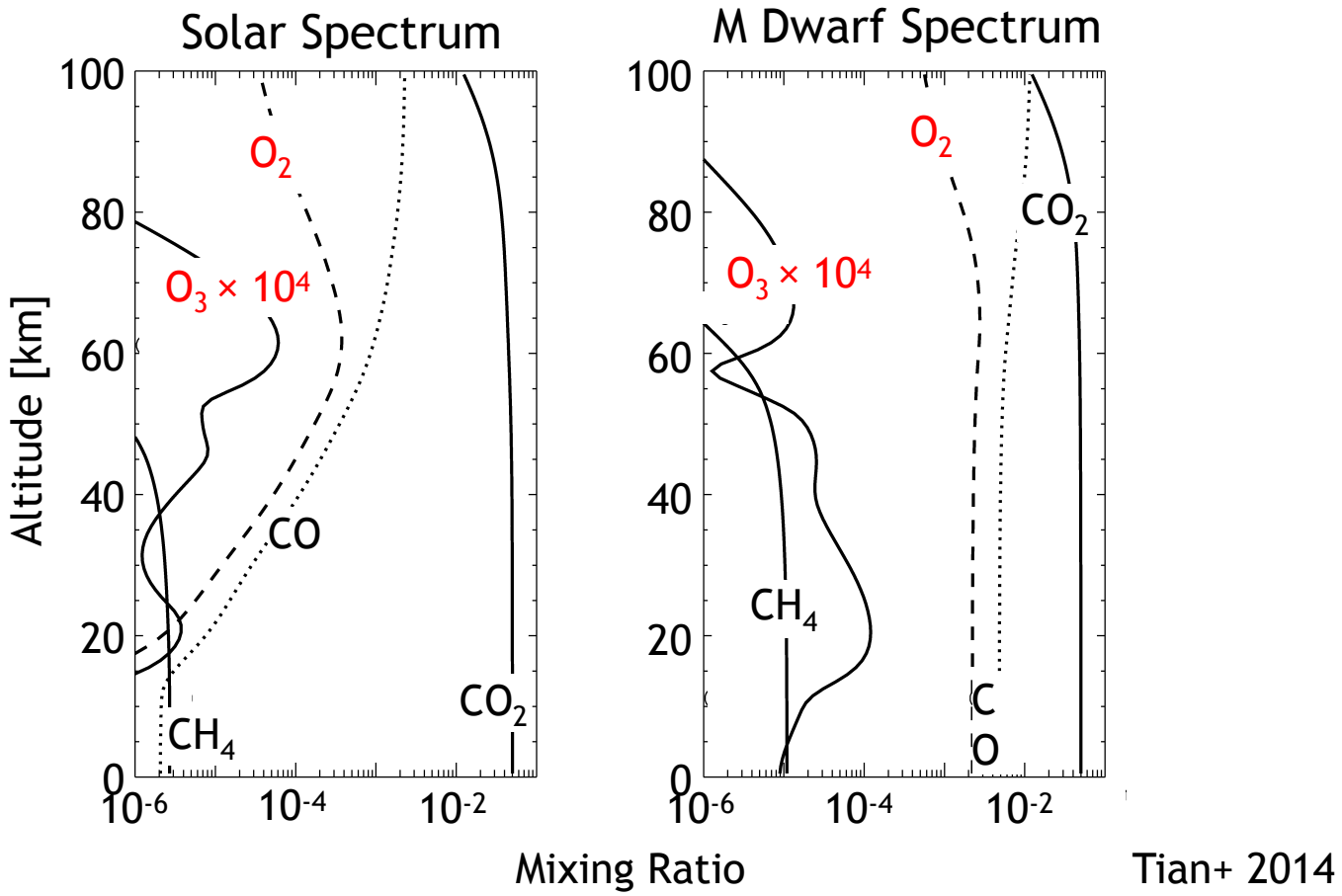
5 Å → 5 μm

And yes, M and K dwarfs are more FUV and XUV active than the sun



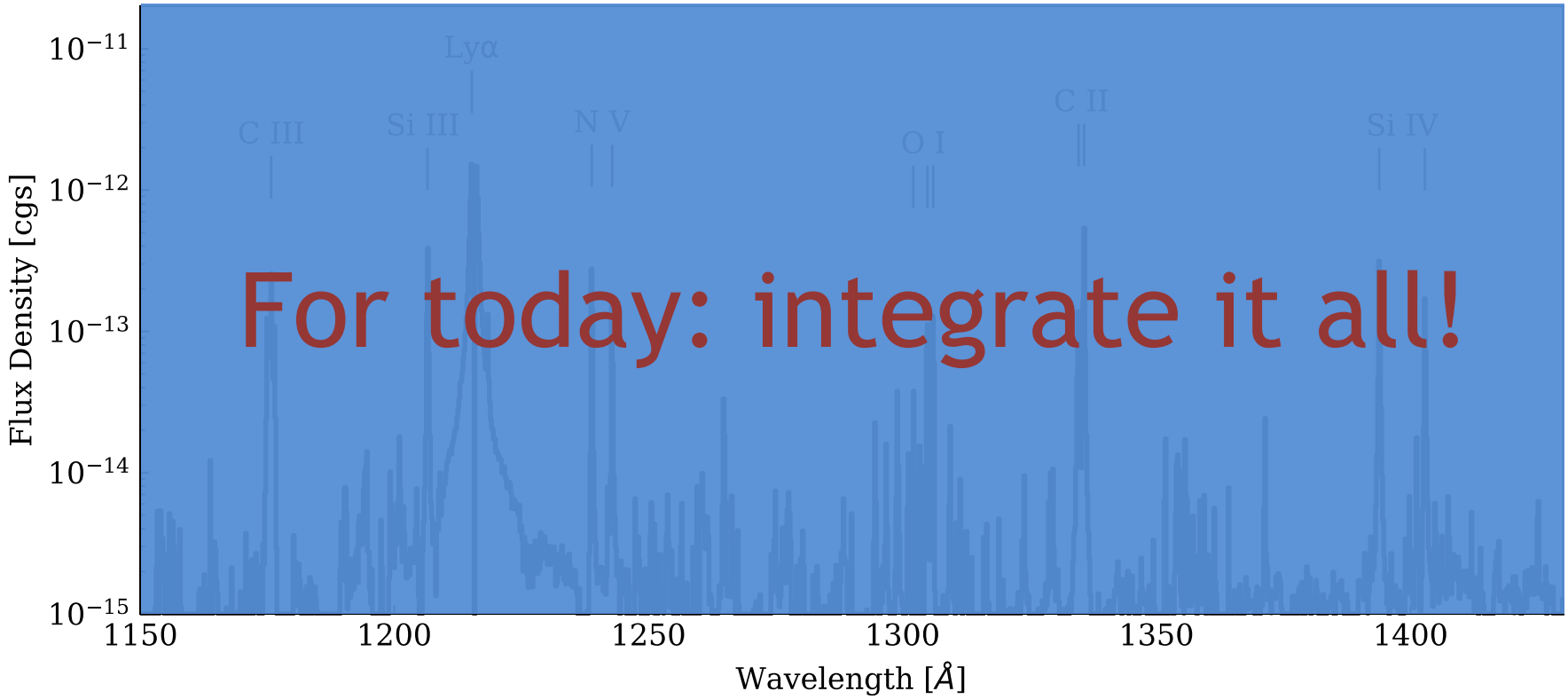
Replacing the solar UV with the UV of an M dwarf yields radically different atmospheres

Tian+ 2014 simulations. Starting Atmosphere: 95% N_2, 5% CO_2 (abiotic Earth prox



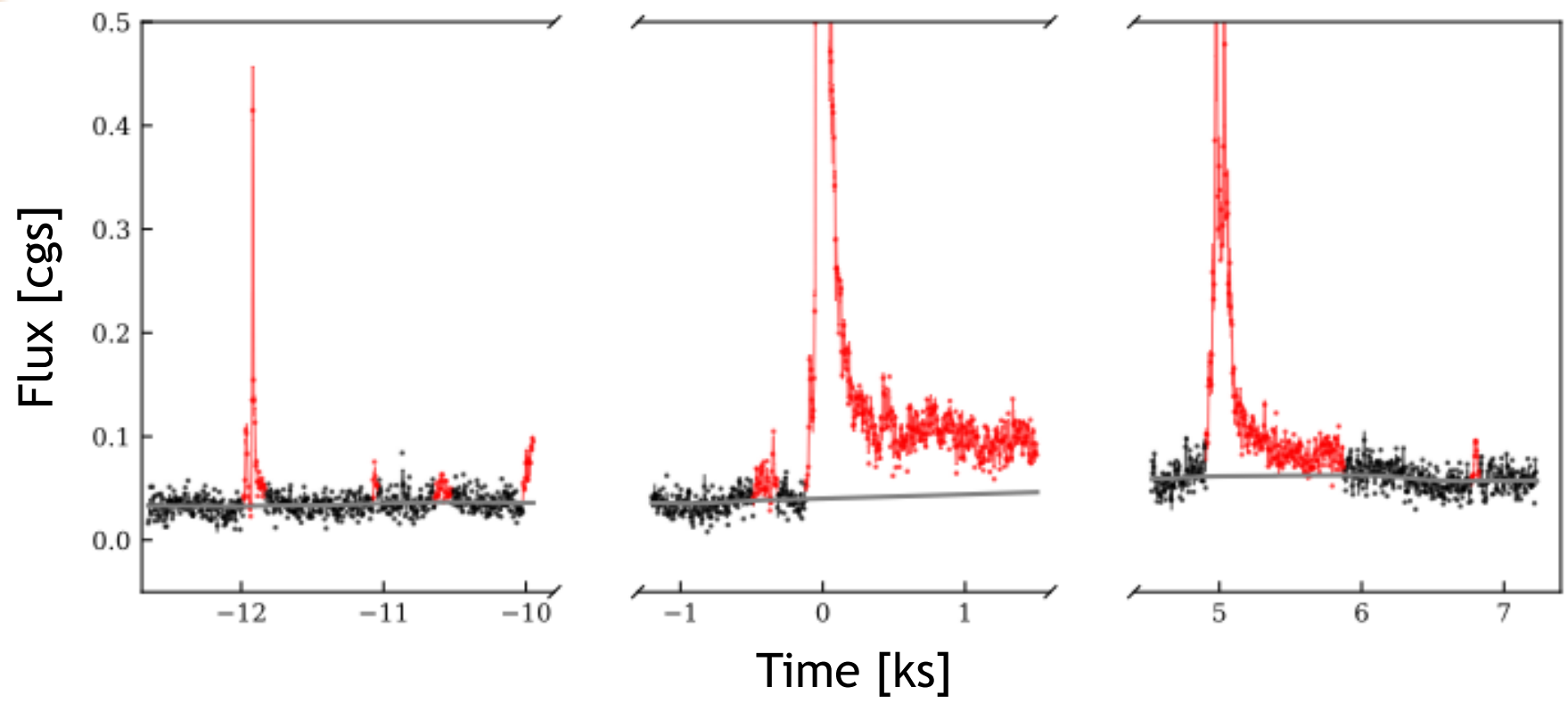
MUSCLES FLARES

As part of MUSCLES, we monitored each target for 3.5 h with an 1150 – 1450 Å photon-counting spectrograph (*HST* COS G130M)

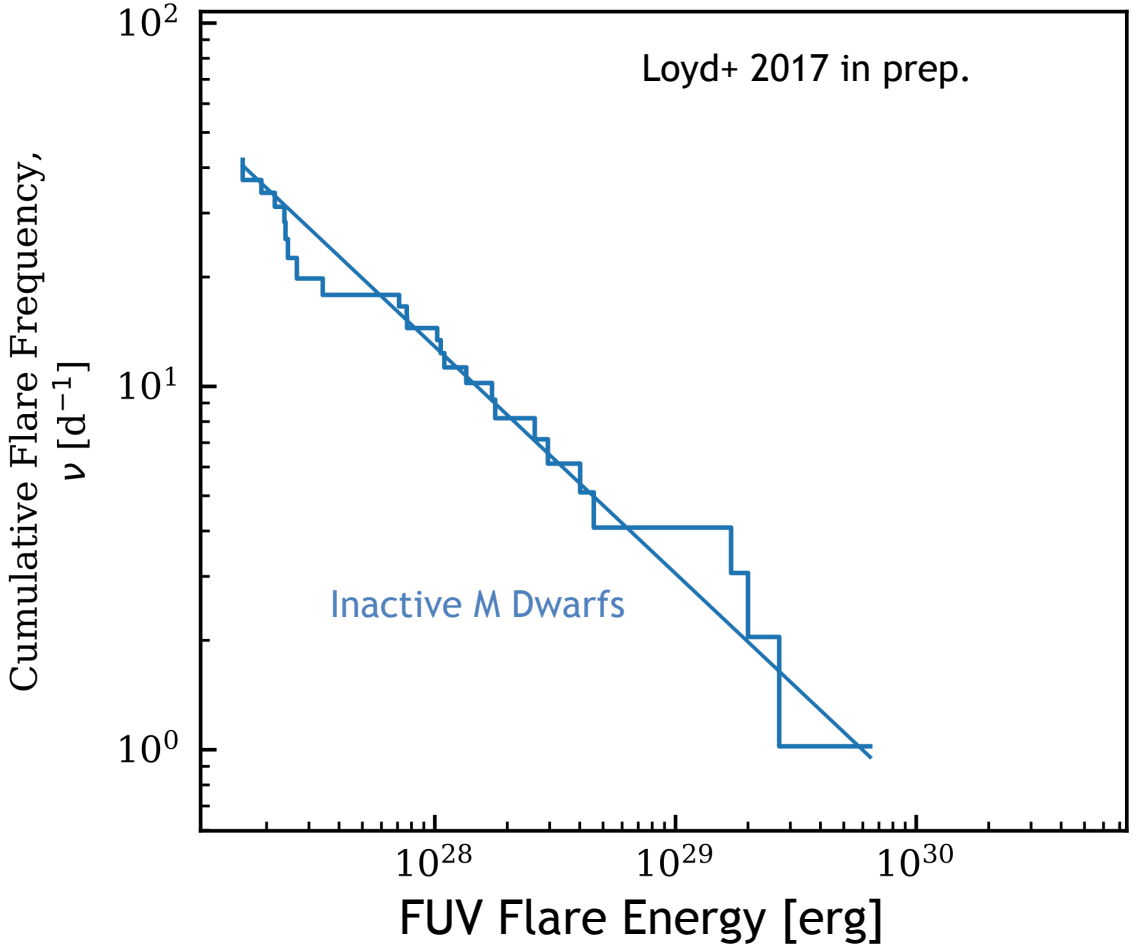


The 3.5 h of monitoring per star allowed us to capture FUV flares

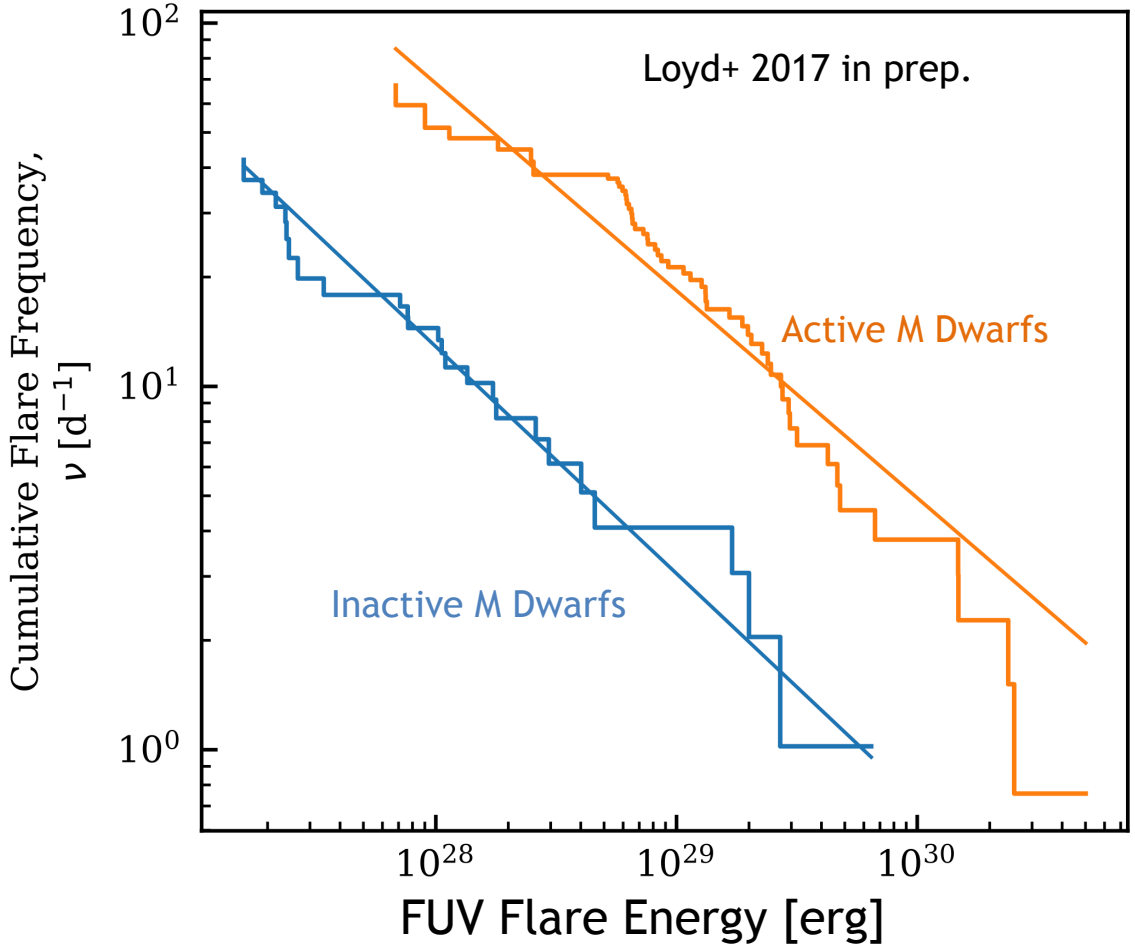
Loyd et al. 2017 in prep.



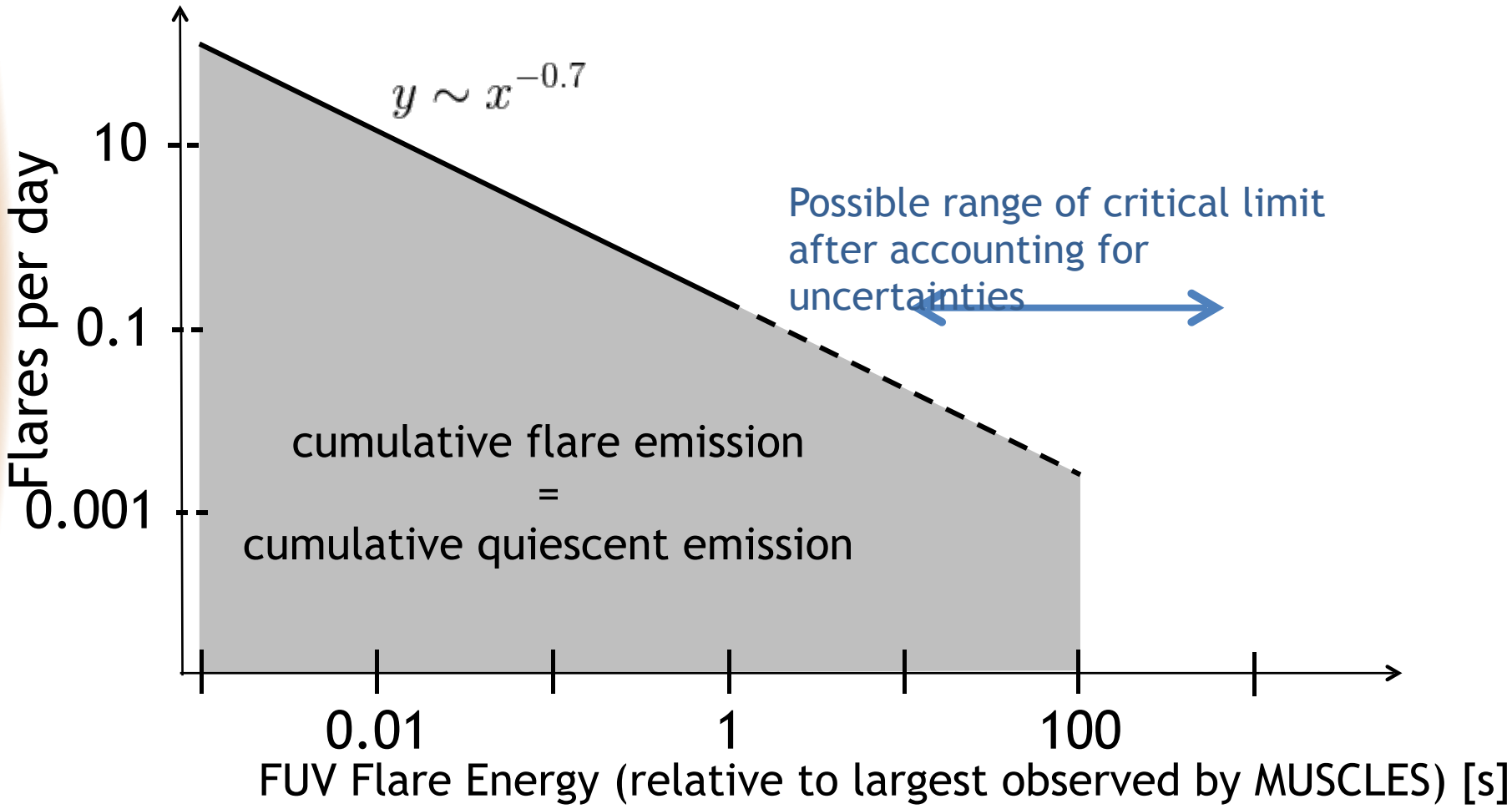
The “inactive” MUSCLES M dwarfs flare a lot



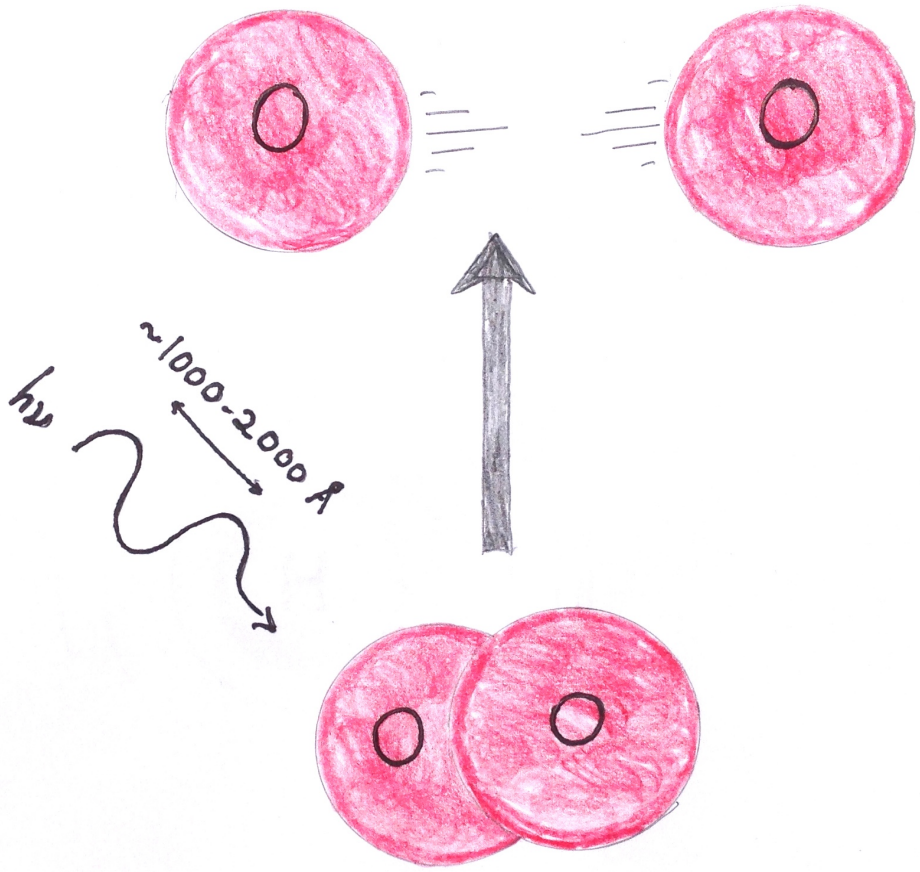
But the “inactive” MUSCLES M dwarf exoplanet hosts still flare about 10× less energetically than active M dwarfs (namely, AD Leo)



Flares could dominate the FUV emission budget of the average M dwarf

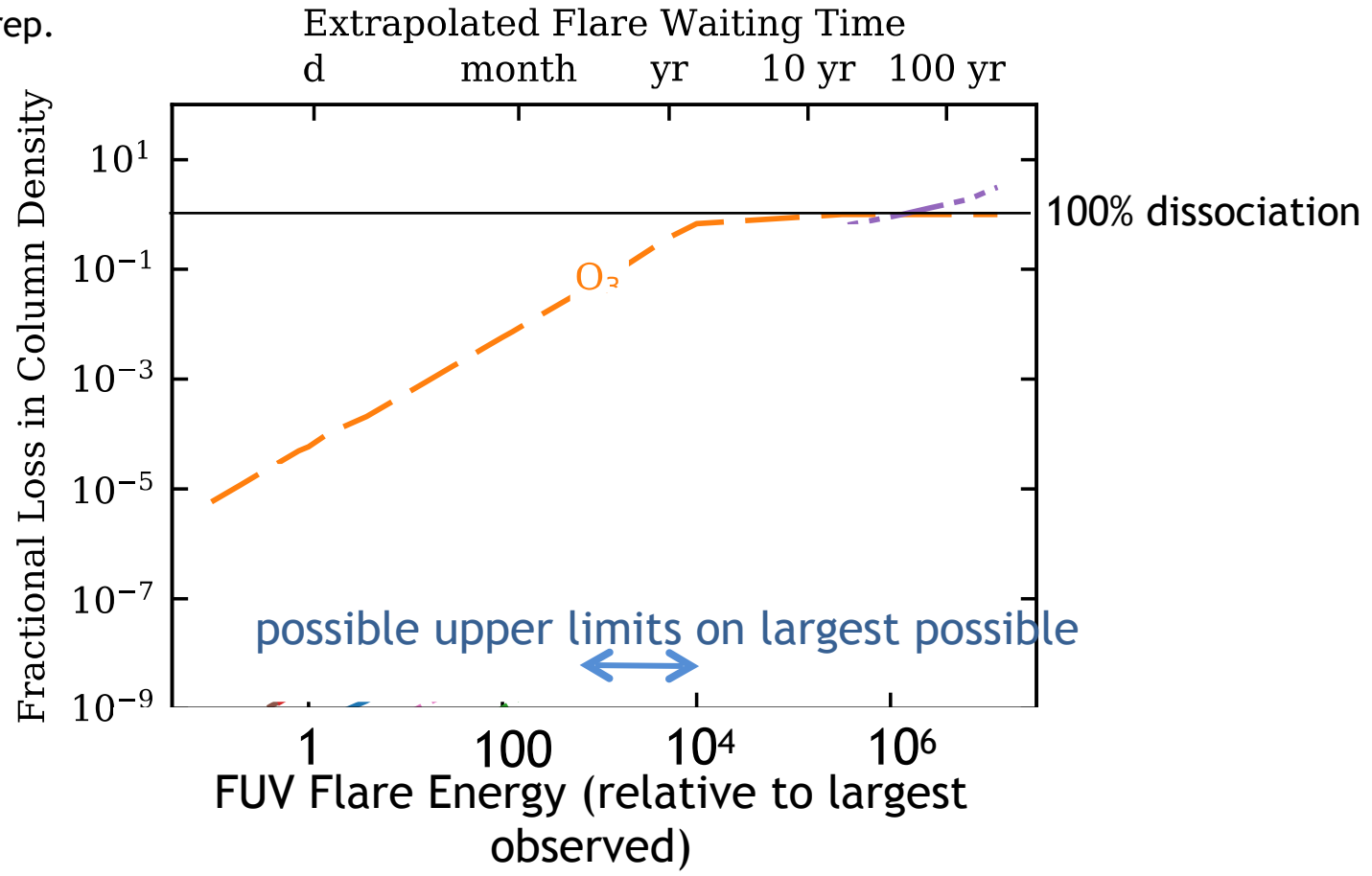


Remember that FUV photons photolyze molecules?

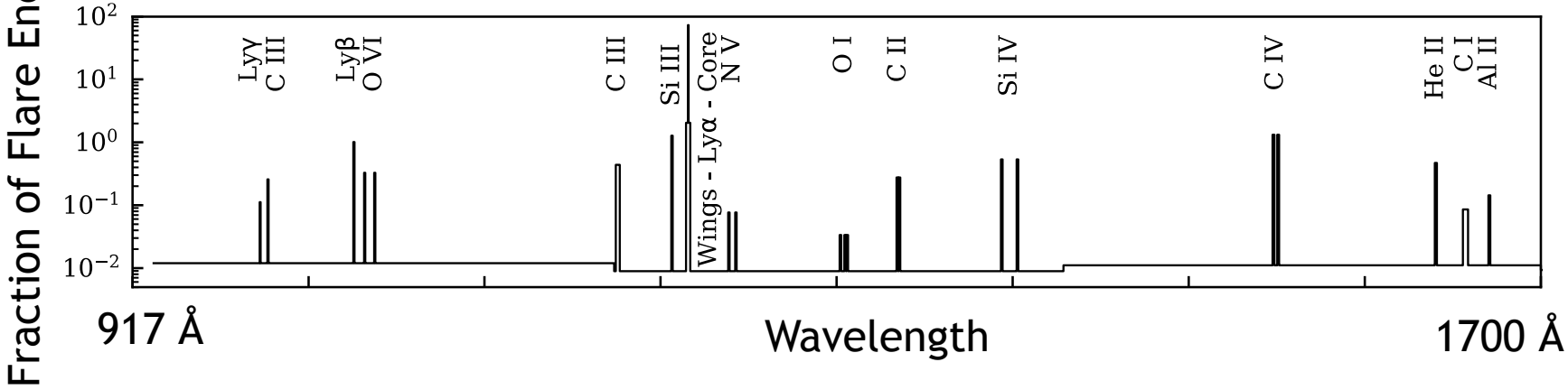


The largest observed flares don't significantly impact column densities. More energetic, rare flares could significantly deplete O_3 in a single blow.

Loyd et al. 2017 in prep.



or the photolysis work. I made a tool to generate standardized UV flares with some semblance of realistic



Summary

- Two important data products from MUSCLES
  - Plug-n-play panchromatic SEDs (search “muscles spectra”)
  - A standardized flare generatorwww.github.com/parkus/fiducial_flare
- Even average M dwarfs flare regularly in the FUV
- Active M dwarfs have more energetic flares
- Energetic, hard to catch flares dominate the FUV flare energy budget
- Over long baselines, flares could dominate all FUV emission
- The observed flares have little impact on ozone columns (but not necessarily chemistry!). Possible yearly flares could destroy most ozone in a single hit.