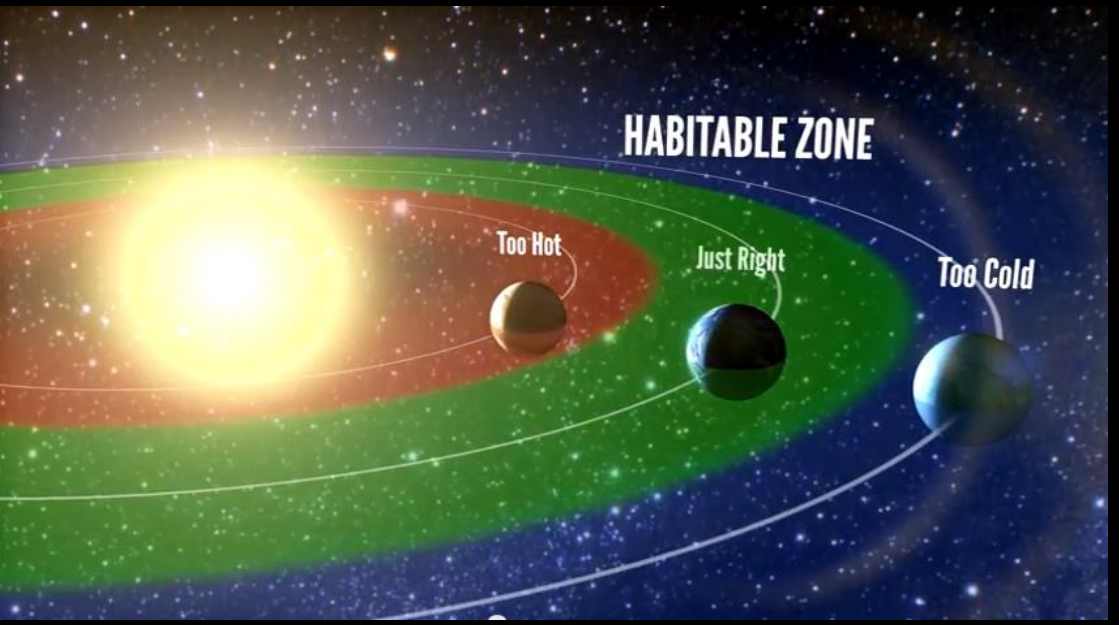
X-ray Emission from Nearby Sun-Like and Low-Mass Stars with Directly Imageable Habitable Zones

Breanna A. Binder[1]

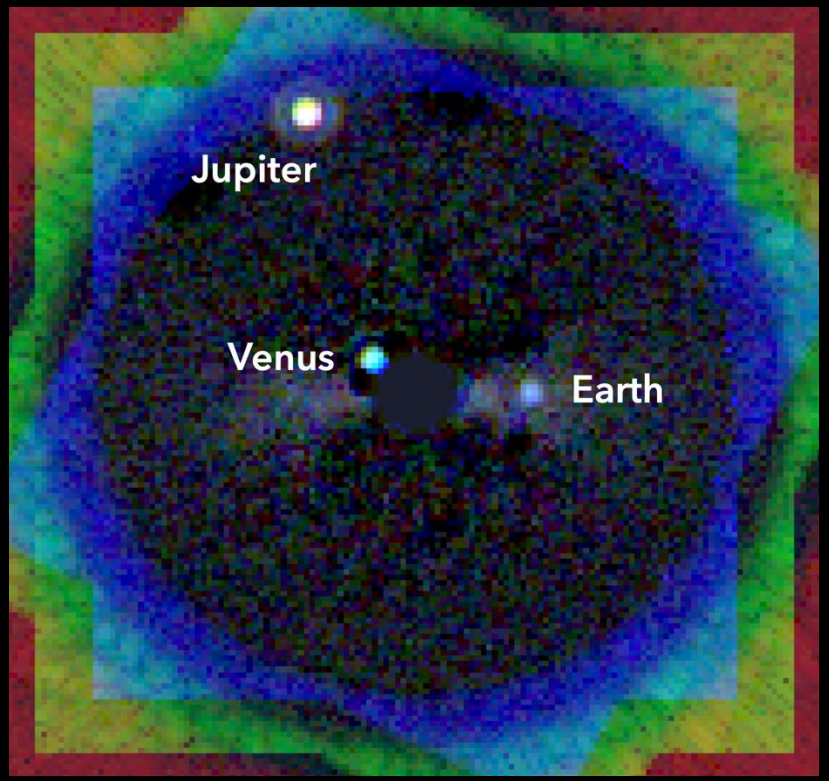
Sarah Peacock[2,3], Edward W. Schwieterman[4,5], Margaret Turnbull[6], Azariel Y. Virgen[1], Stephen Kane[4], Alison Farrish[3], Katherine Garcia-Sage[3]

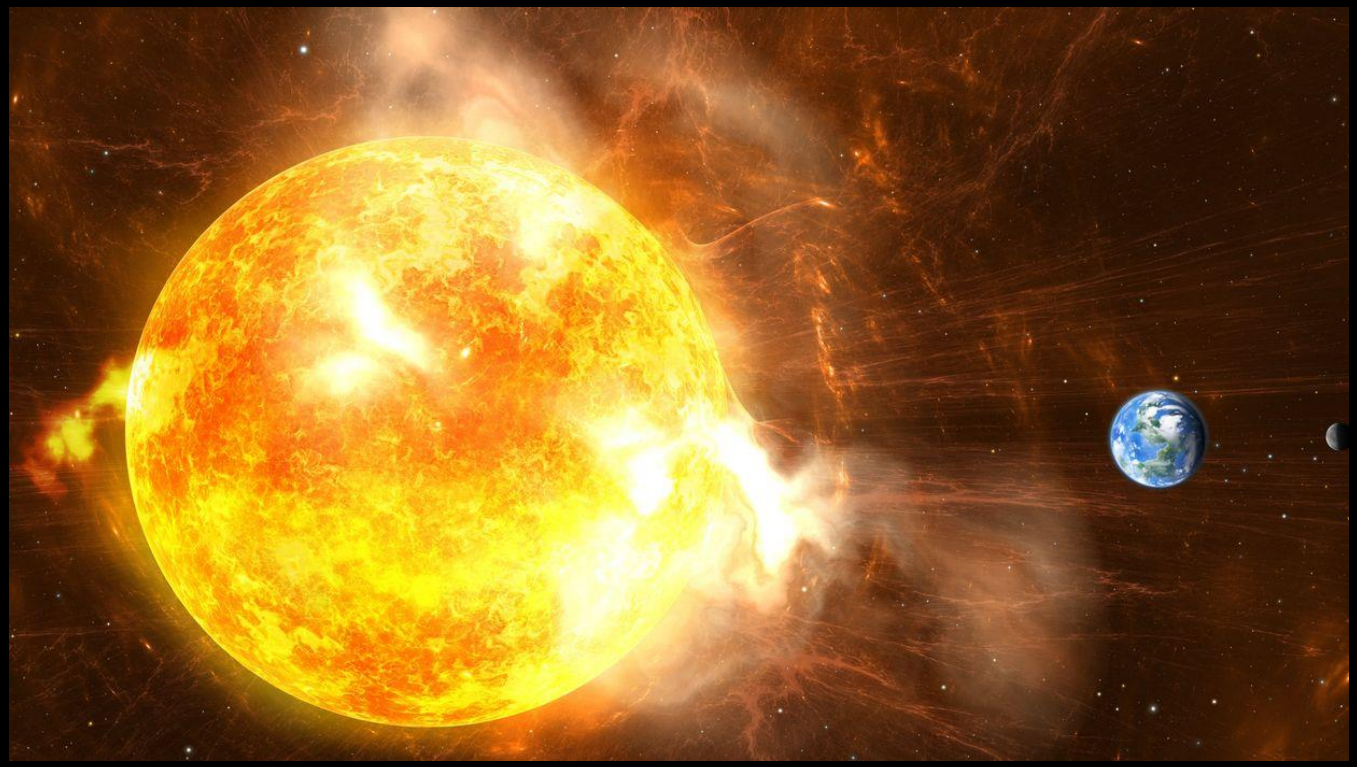
[1]Cal Poly Pomona, [2]University of Maryland, [3]NASA/Goddard, [4]UC Riverside, [5]Blue Marble, [6]SETI Institute

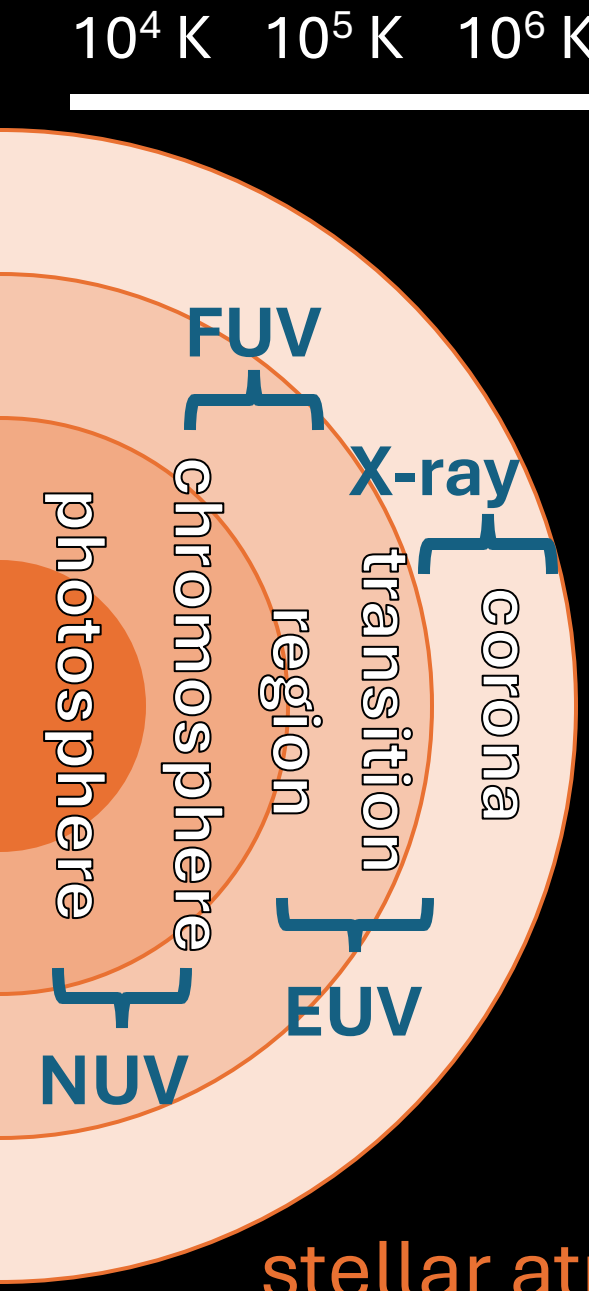


What stars should HWO look at?

What habitable zone planets exist in high-energy environments like Earth?





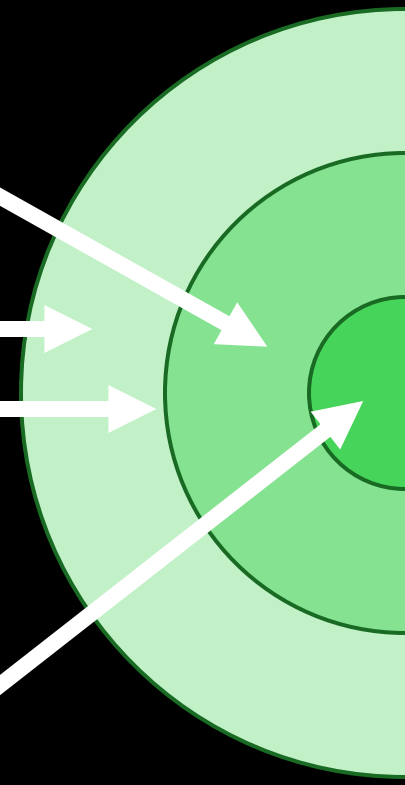


atmospheric escape

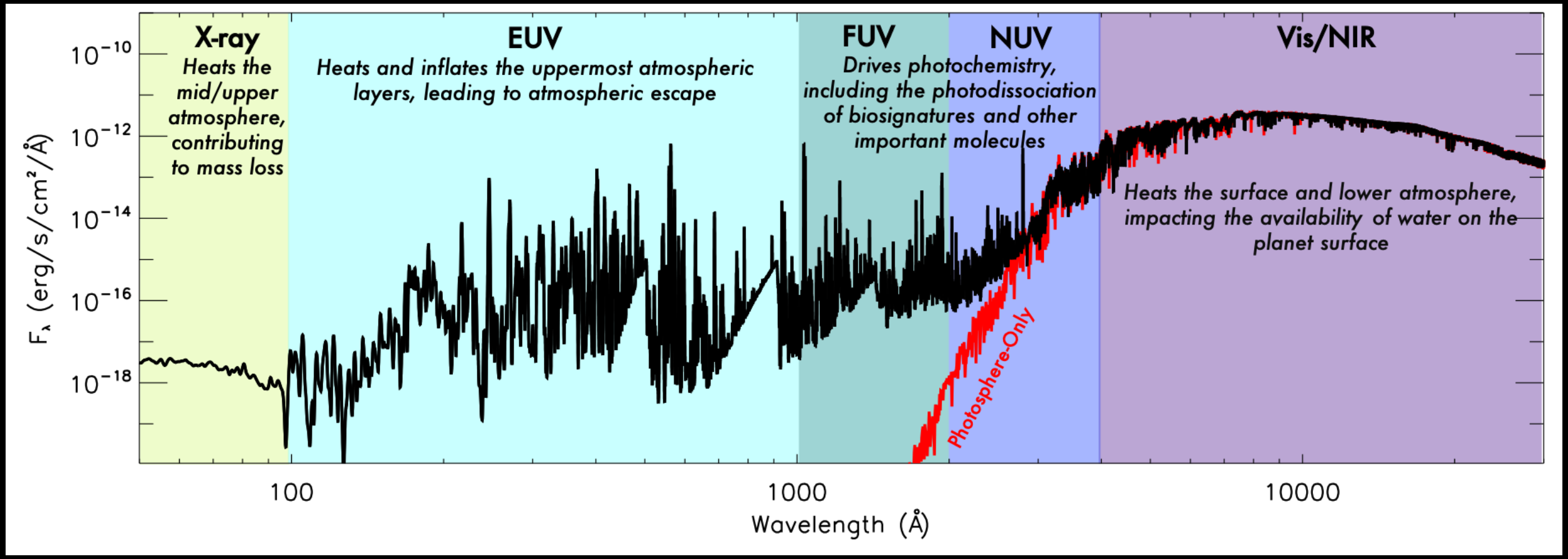
photoionization **FUV**

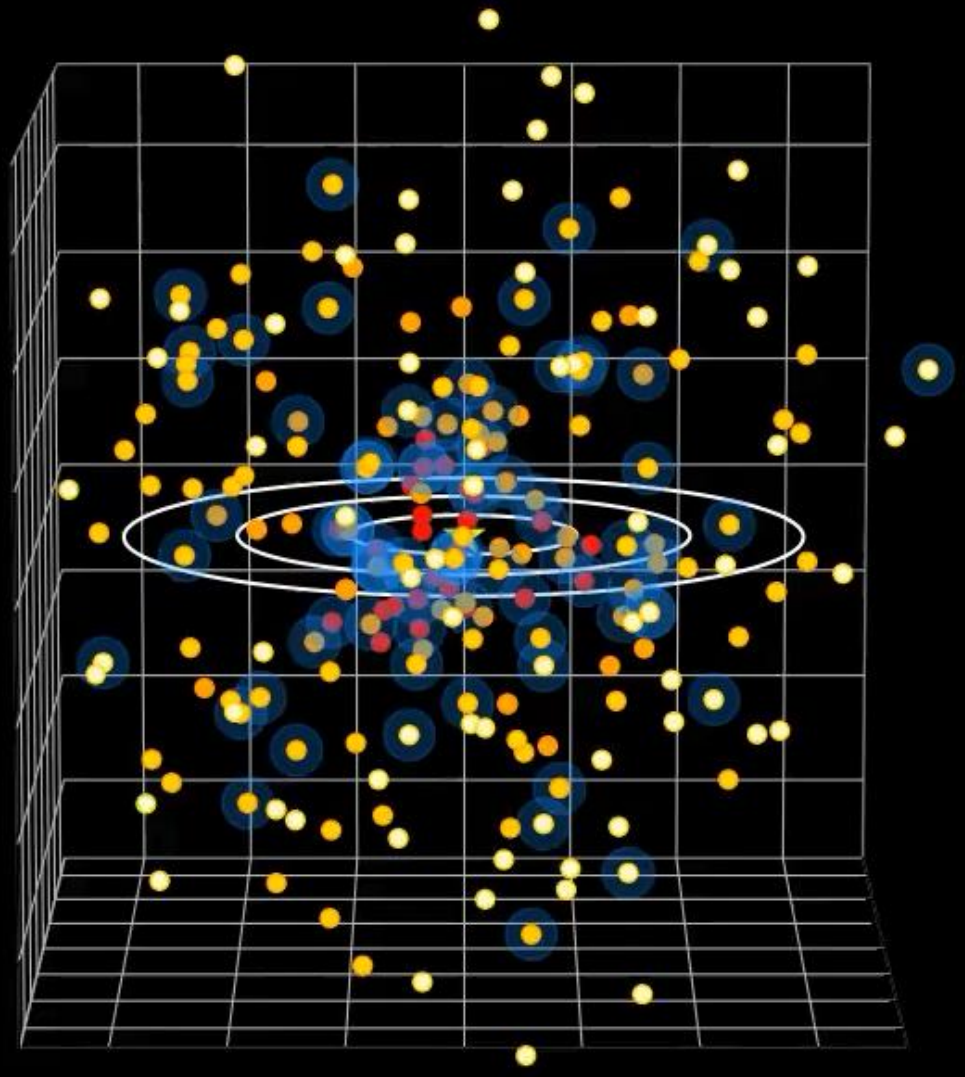
atmospheric heating **X-rays** **EUV**

photodissociation **NUV**



planetary atmosphere


X-ray
Heats the mid/upper atmosphere, contributing to mass loss
EUV
Heats and inflates the uppermost atmospheric layers, leading to atmospheric escape
FUV
NUV
Drives photochemistry, including the photodissociation of biosignatures and other important molecules
Vis/NIR
Heats the surface and lower atmosphere, impacting the availability of water on the planet surface
Photosphere-Only
10^{-10}
10^{-12}
10^{-14}
10^{-16}
10^{-18}
F_λ (erg/s/cm²/Å)
100
1000
10000
Wavelength (Å)



229 nearby FGKM stars
Searched *Chandra* & *XMM-Newton* archives

57 stellar systems contained within at least one X-ray observation (~34 days)

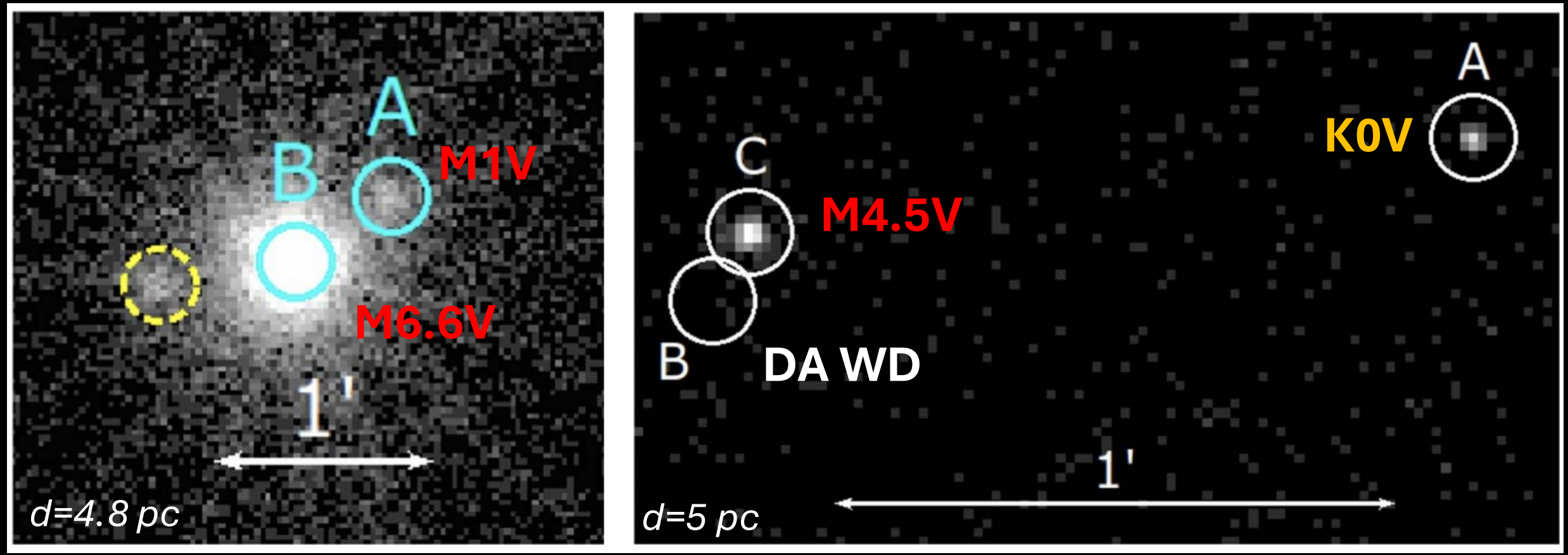
Complements the MUSCLES/Mega-MUSCLES survey (Brown et al. 2023)

Binder et al. (2024), ApJS, 275, 1

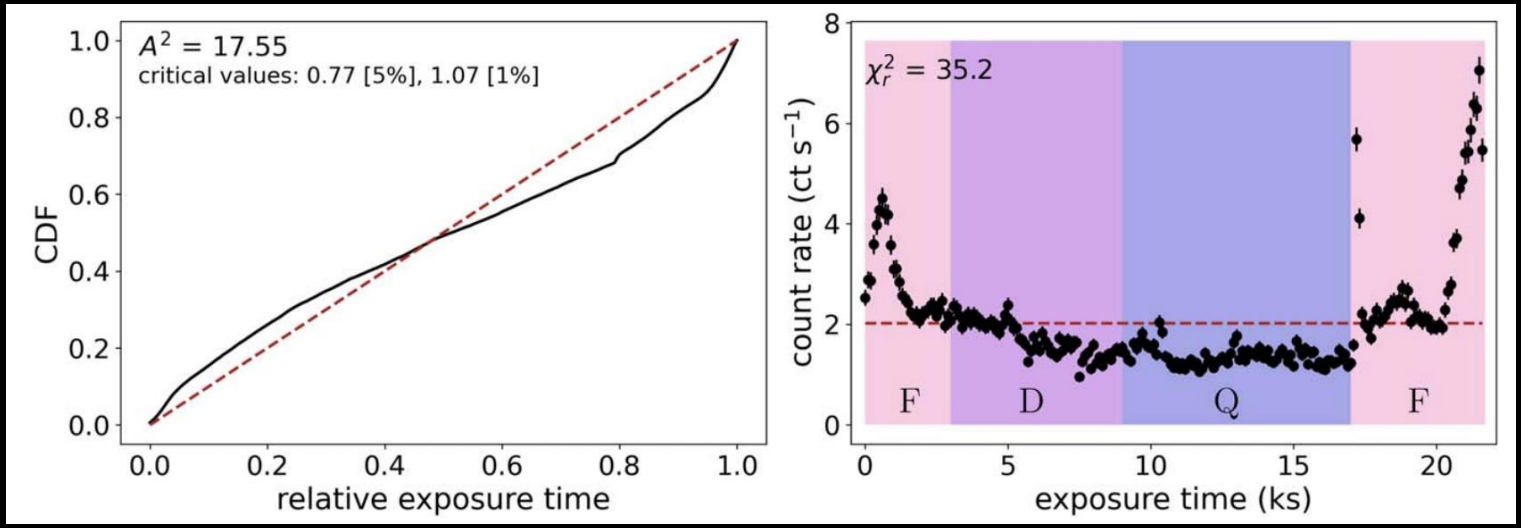
Where *Chandra* shines

GL 412

40 Eri

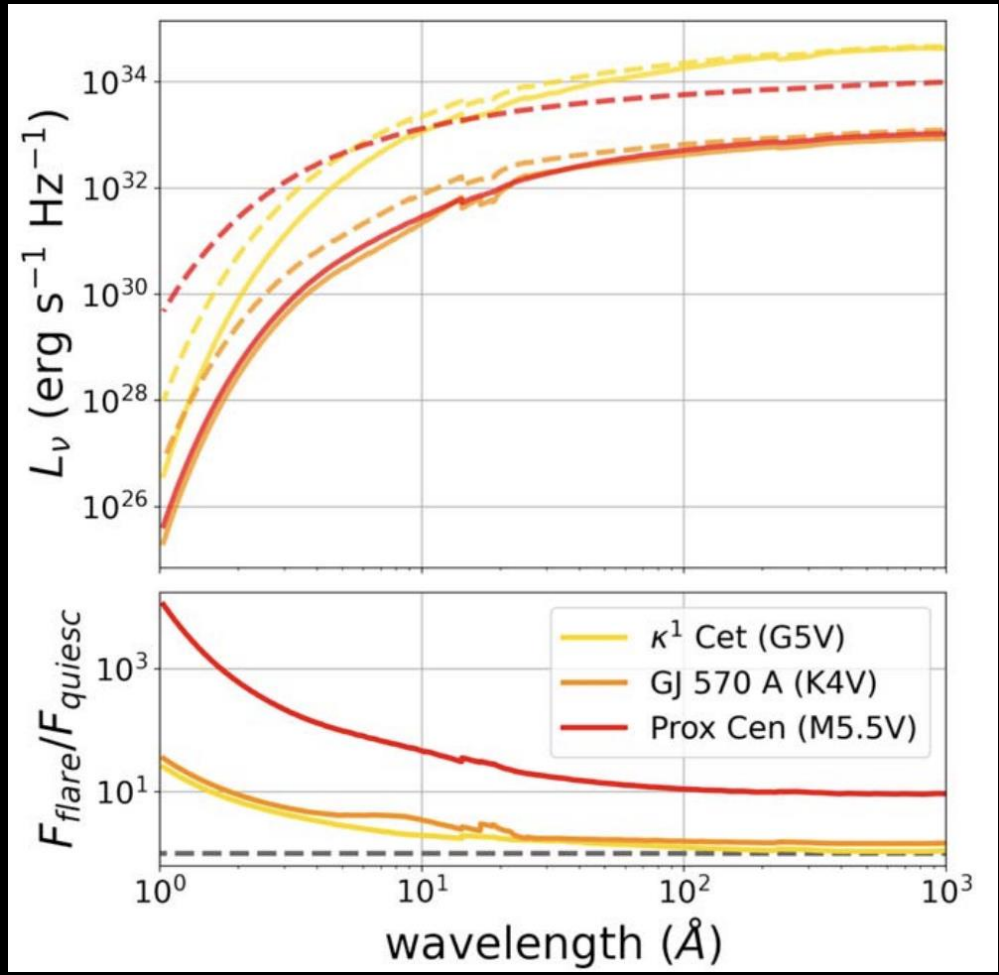


Variability and Spectroscopy



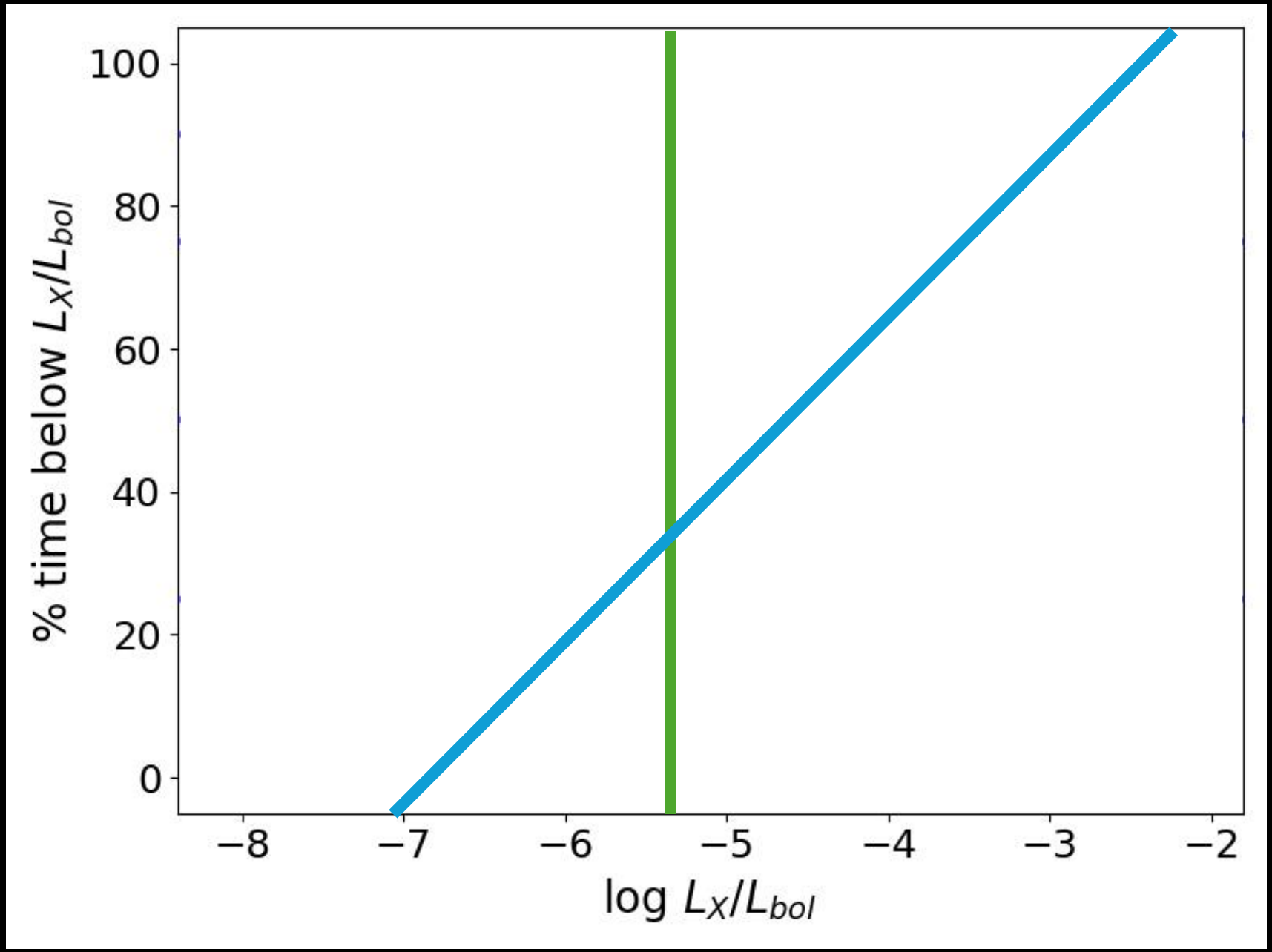
Proxima Centauri

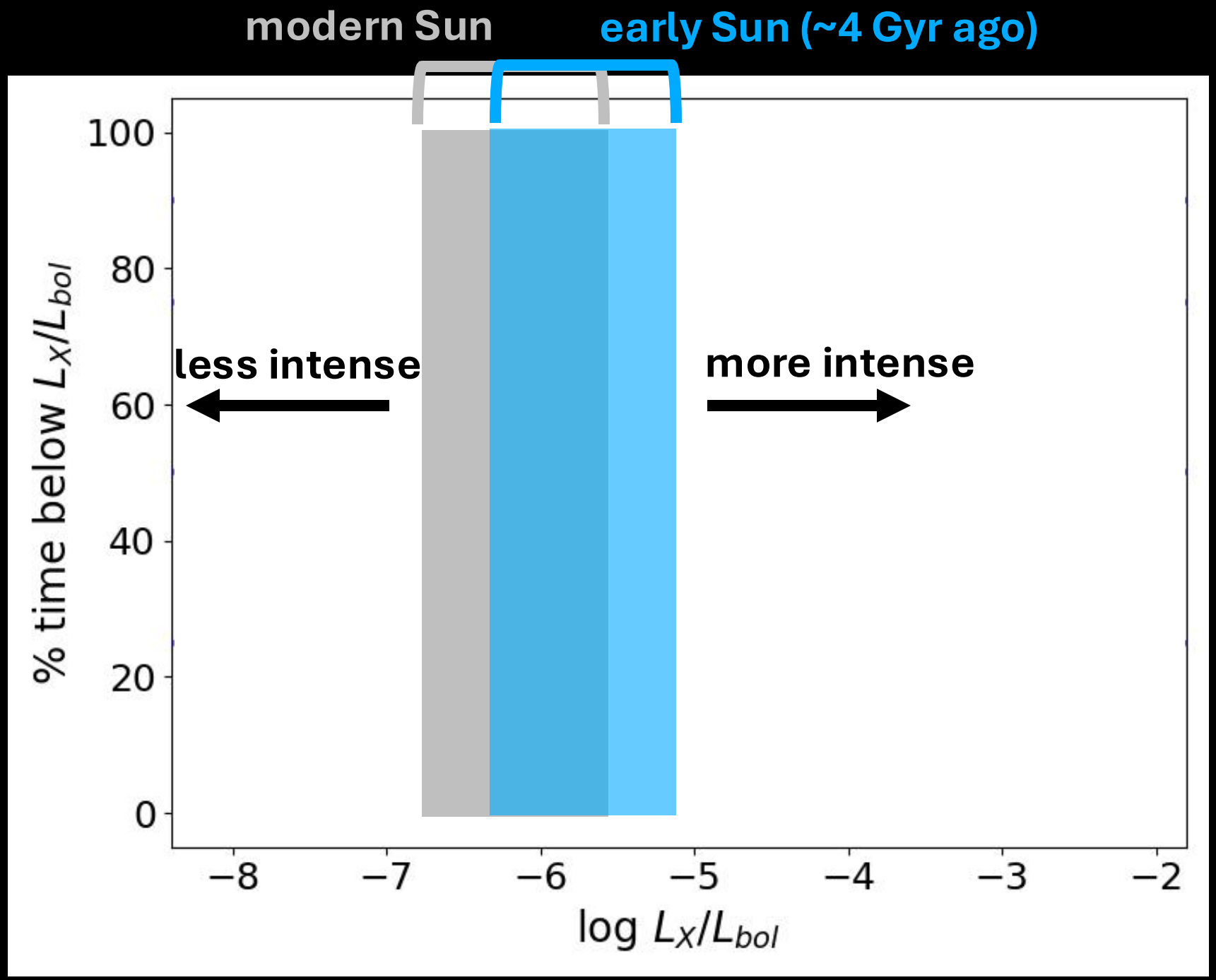
M star environments are tough



perfectly non-variable

variability/flaring

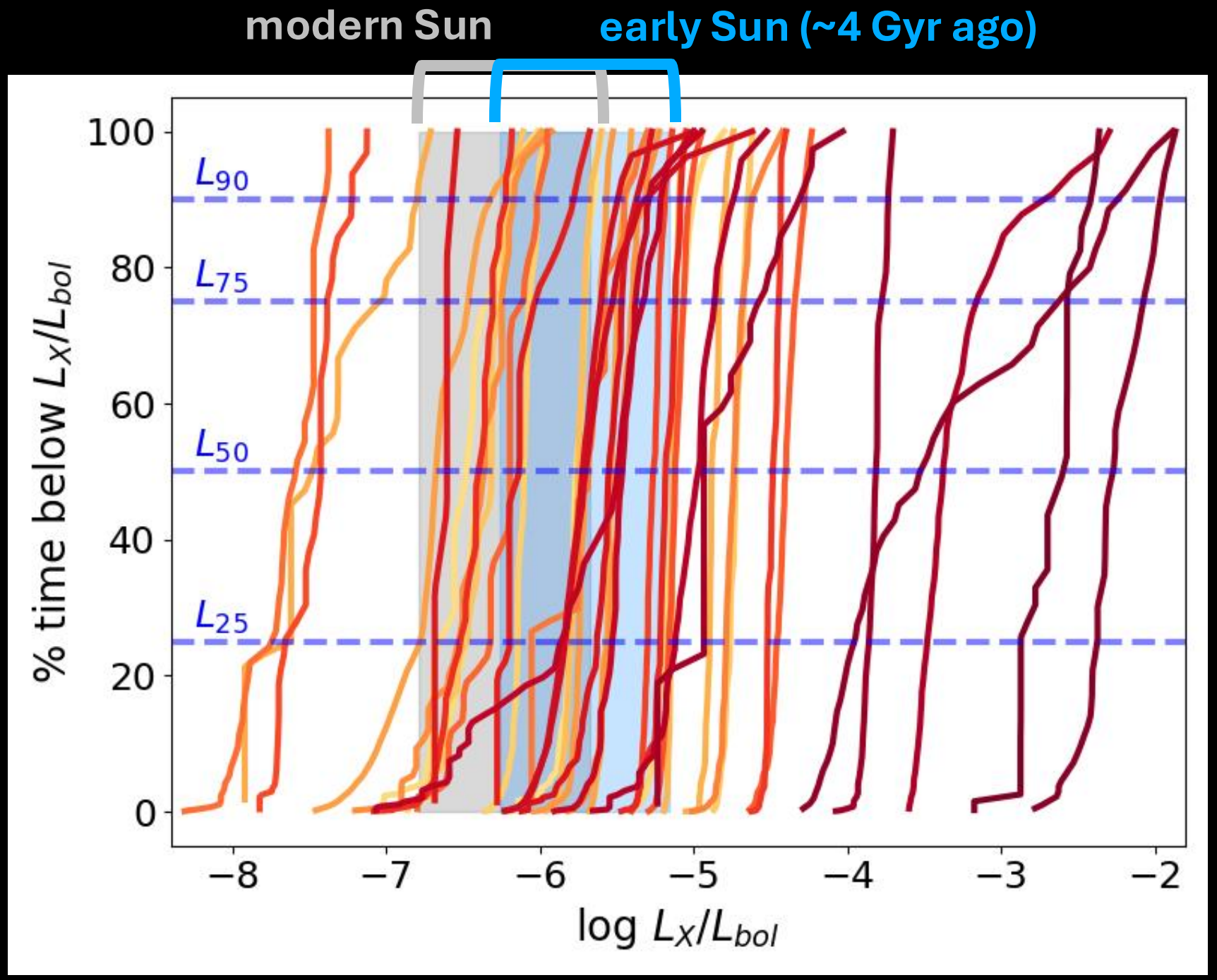




hotter than the Sun

Sun-like

cooler than the Sun

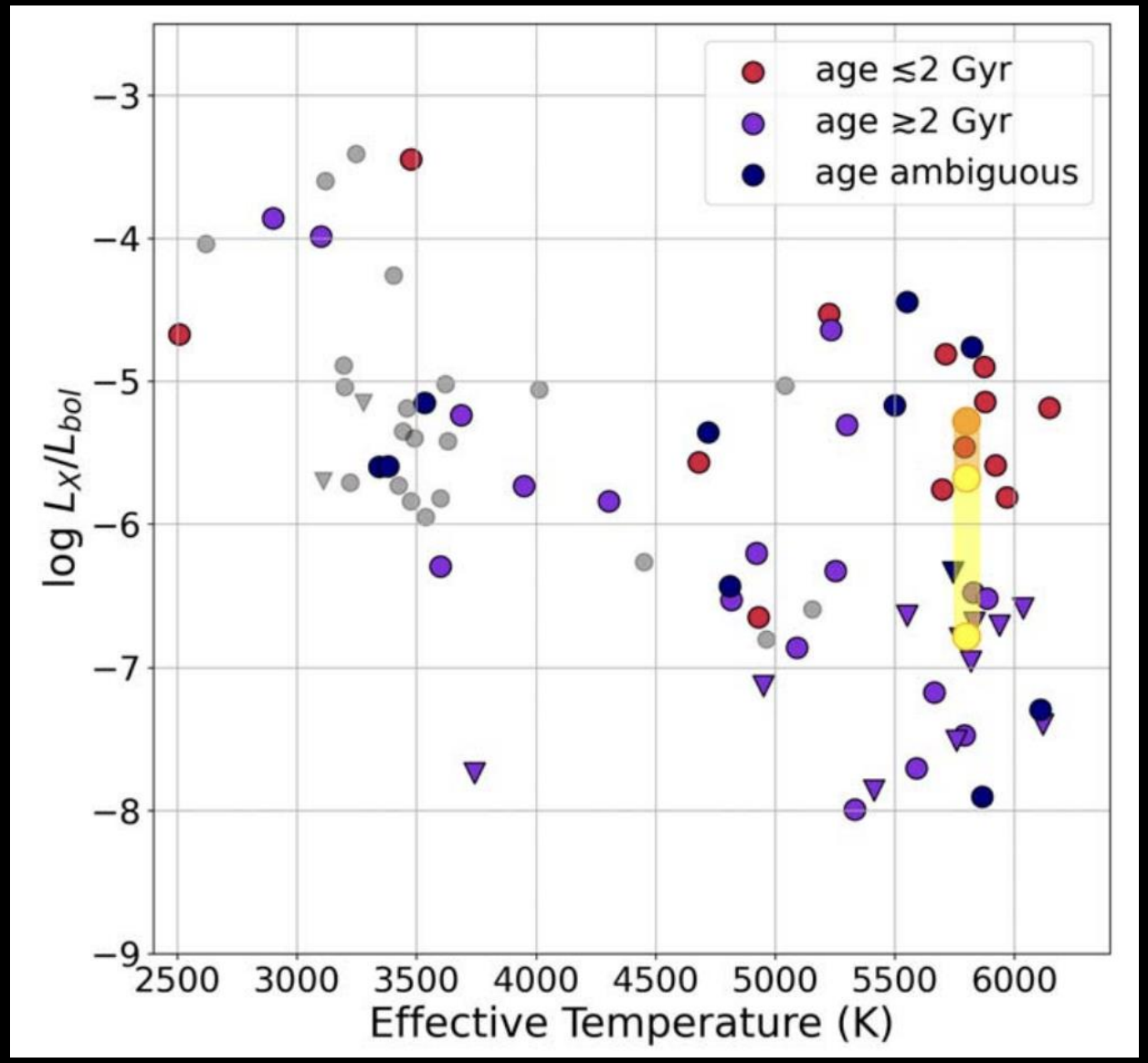


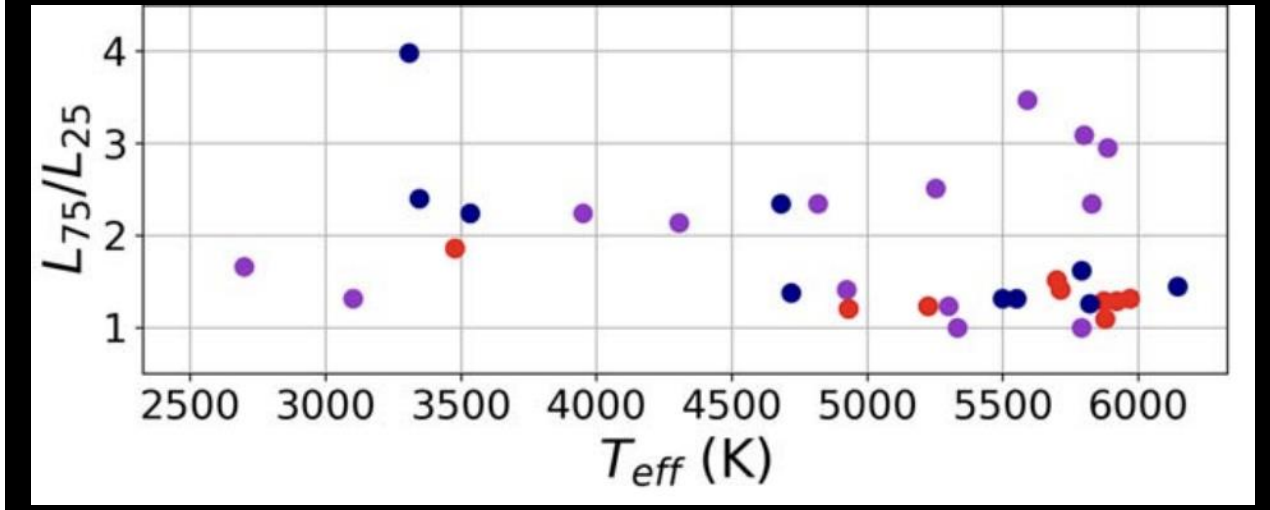
hotter than the Sun

Sun-like

cooler than the Sun

Brown et al. (2023)





Solar environment analog is likely conservative

Can *probably* have harsher X-ray environments and still retain a planetary atmosphere

How much harsher? **Unknown**

Is *too little* X-ray flux detrimental to planetary atmospheres? **Unknown**

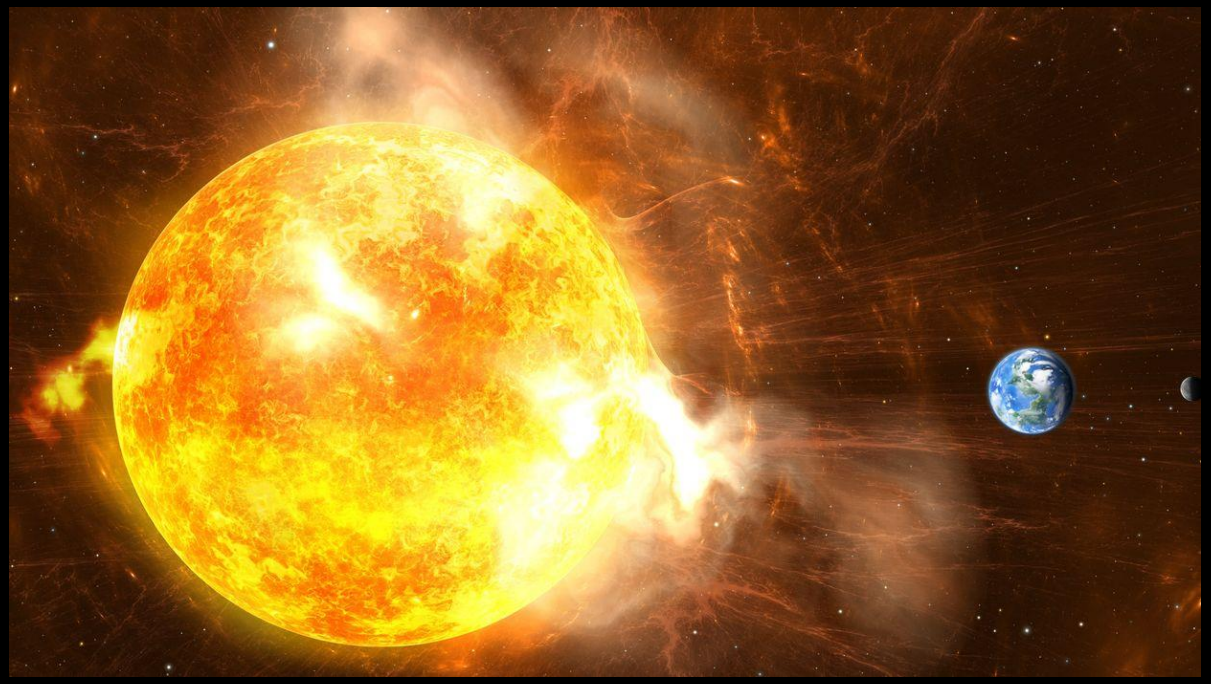
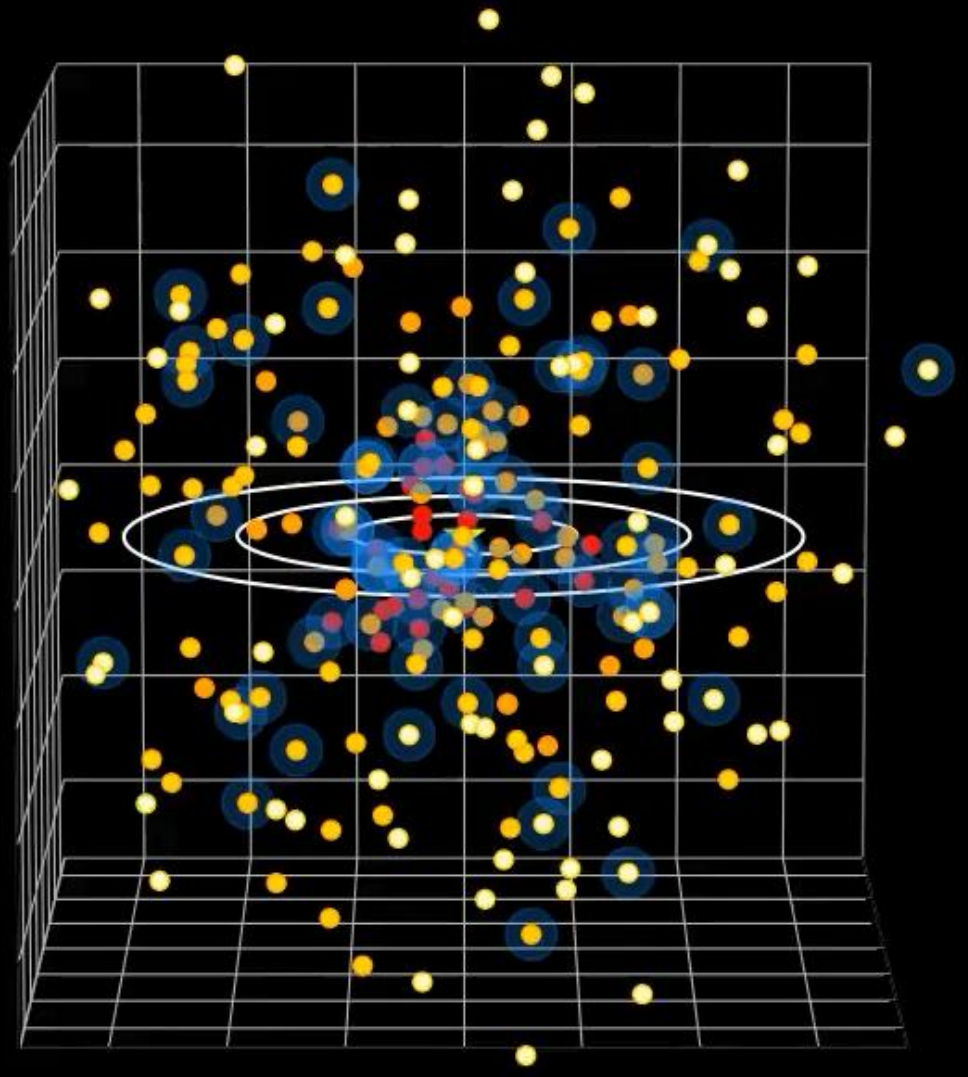


Table 8. Potential HWO Target Stars with Solar-Like L_X/L_{bol} Ratios

Star Name	Spectral Type	Age (Gyr)	Sun Comparison	HWO Tier
η Crv	F2V	<2	early	C
ξ Oph	F2V	unknown	modern	C
ν Phe	F9V	~3	<modern min	B
β Vir	F9V	~3	modern	C
LHS 237	F9V	unknown	<modern min	none
LHS 208	G0V	~3	<modern min	B
ι Per	G0V	~4	<modern min	A
ρ CrB	G0V	~11	<modern min	B
GL 672	G0V	~12	<modern min	C
47 UMa	G0V	~6.5	modern	A
β Com	G0V	<2	modern,early	A
GL 311	G1.5V	<2	early	B
ζ^1 Ret	G2V	<2	early	A
GL 327	G3V	<2	early	C
51 Peg	G5V	~7	<modern min	none
GJ 777A	G6IV	~13	<modern min	B
HD 140901	G7IV	~3	early	C
82 Eri	G8V	~6	<modern min	B
55 Cnc A	G8V	~9.5	modern	C
GL 451A	G8V	~5	<modern min	C
70 Oph AB	K0V+K5V	~6	early	B
GL 892	K3V	~11	modern	A
GL 783	K3V	~7	modern	B
GL 183	K3V	~2	modern	B
LHS 1875	K3V	<3	early	C
GL 570A	K4V	<3	early	A
61 Cyg AB	K5V+K7V	~6	early	A
GL 570 BC	M1.5V+M3V	<3	early	none
Kapteyn's Star	M2V	~11	<modern min	none



Blue halos show stars with at least one *Chandra* or *XMM* observation

Only **~1/3** of the stars that are of high interest to the HWO community

Thank you!