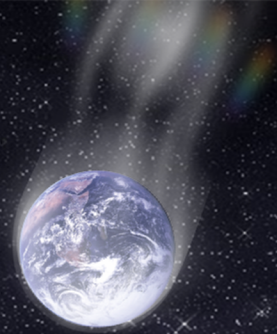
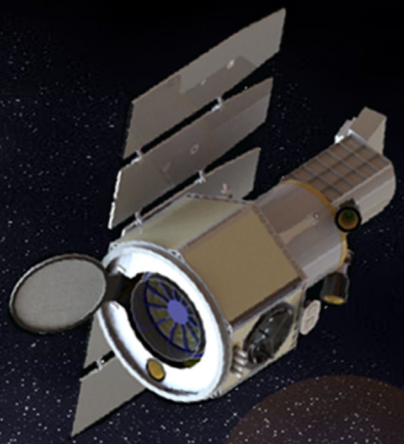




The Extreme-uv Stellar Characterization for Atmospheric Physics and Evolution (ESCAPE) Mission Concept

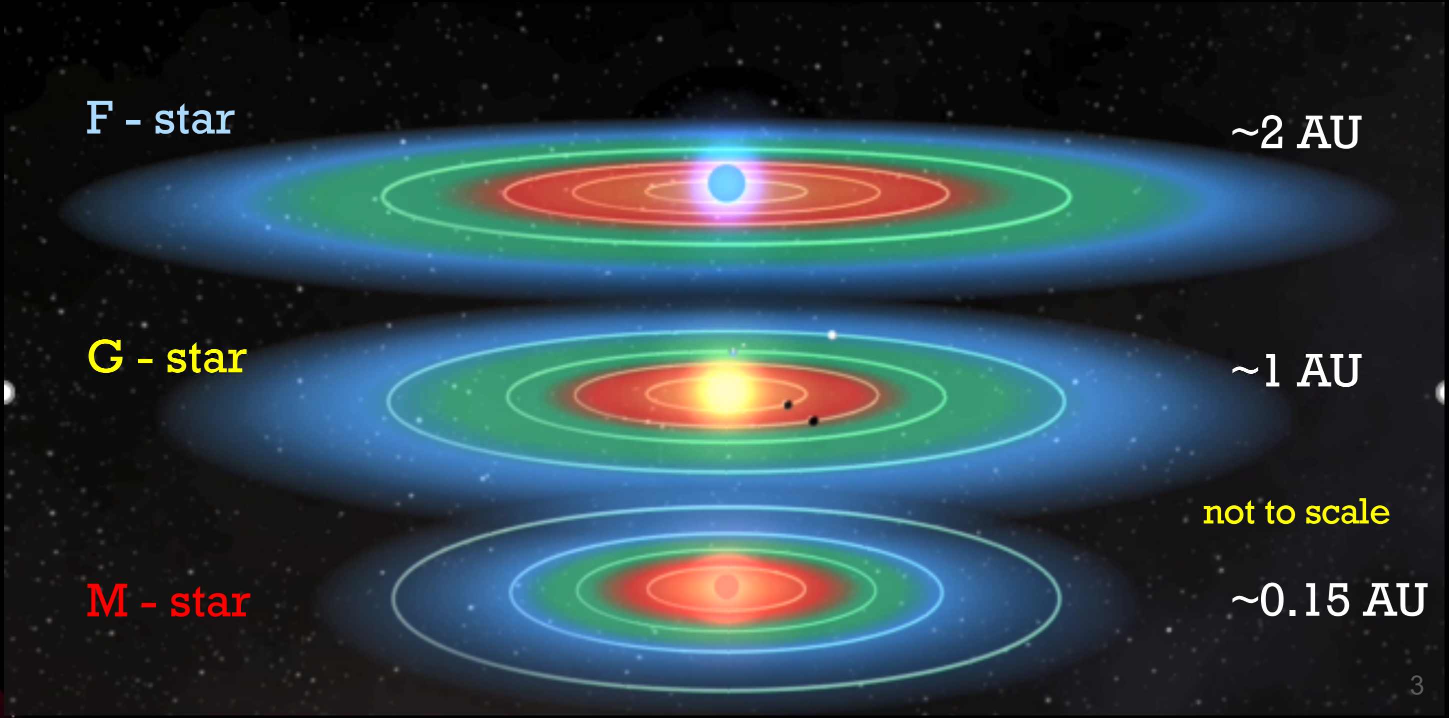
Exploring the physics and evolution of potentially habitable worlds

Kevin France
University of Colorado

ExoPAG – 19 June 2020

The liquid water “Habitable Zone”

The liquid water “Habitable Zone”



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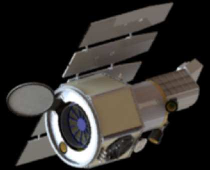

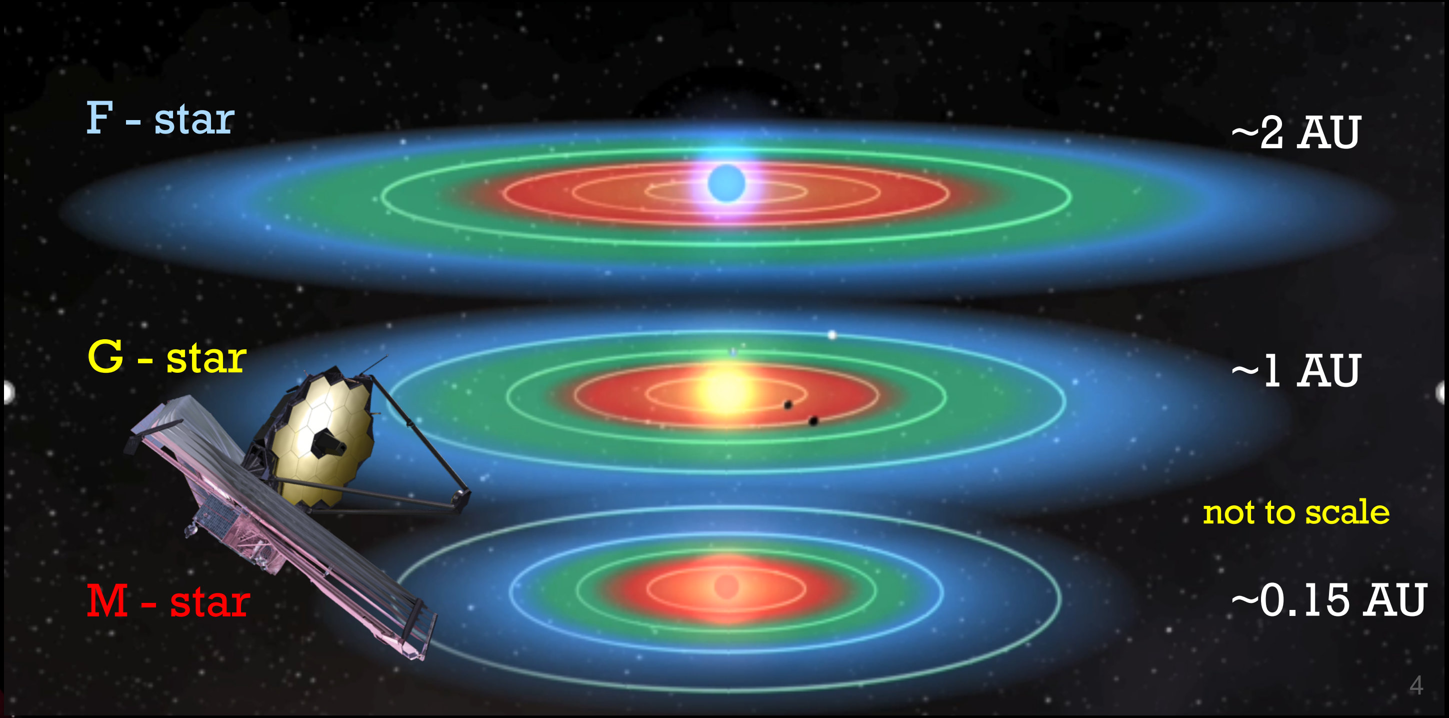

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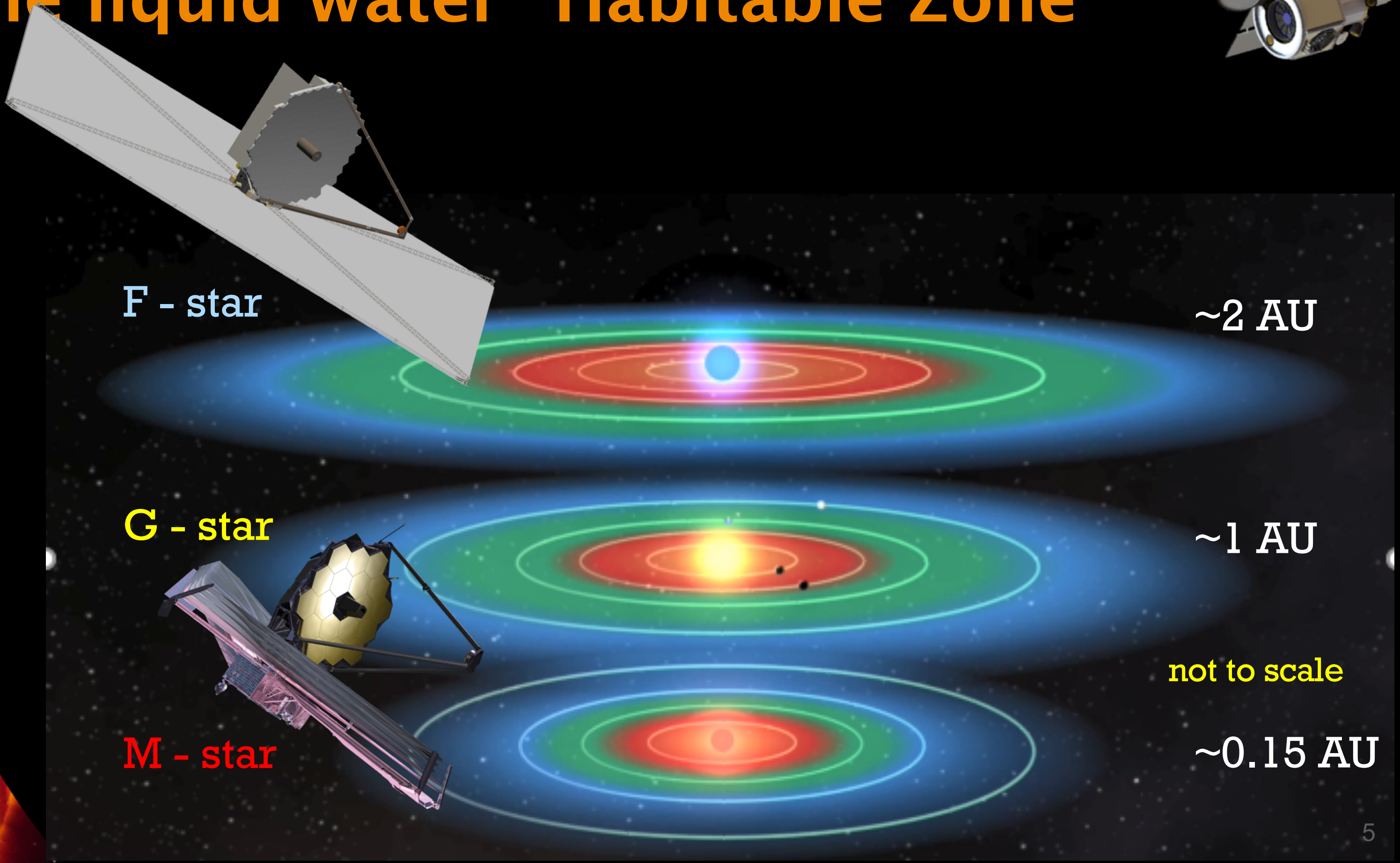

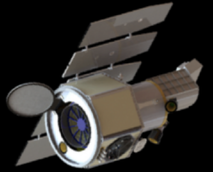

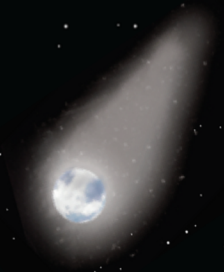

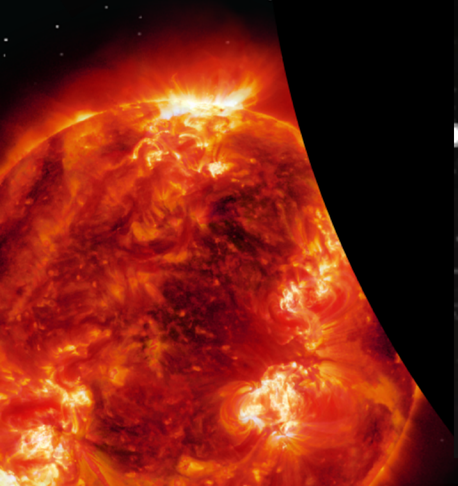

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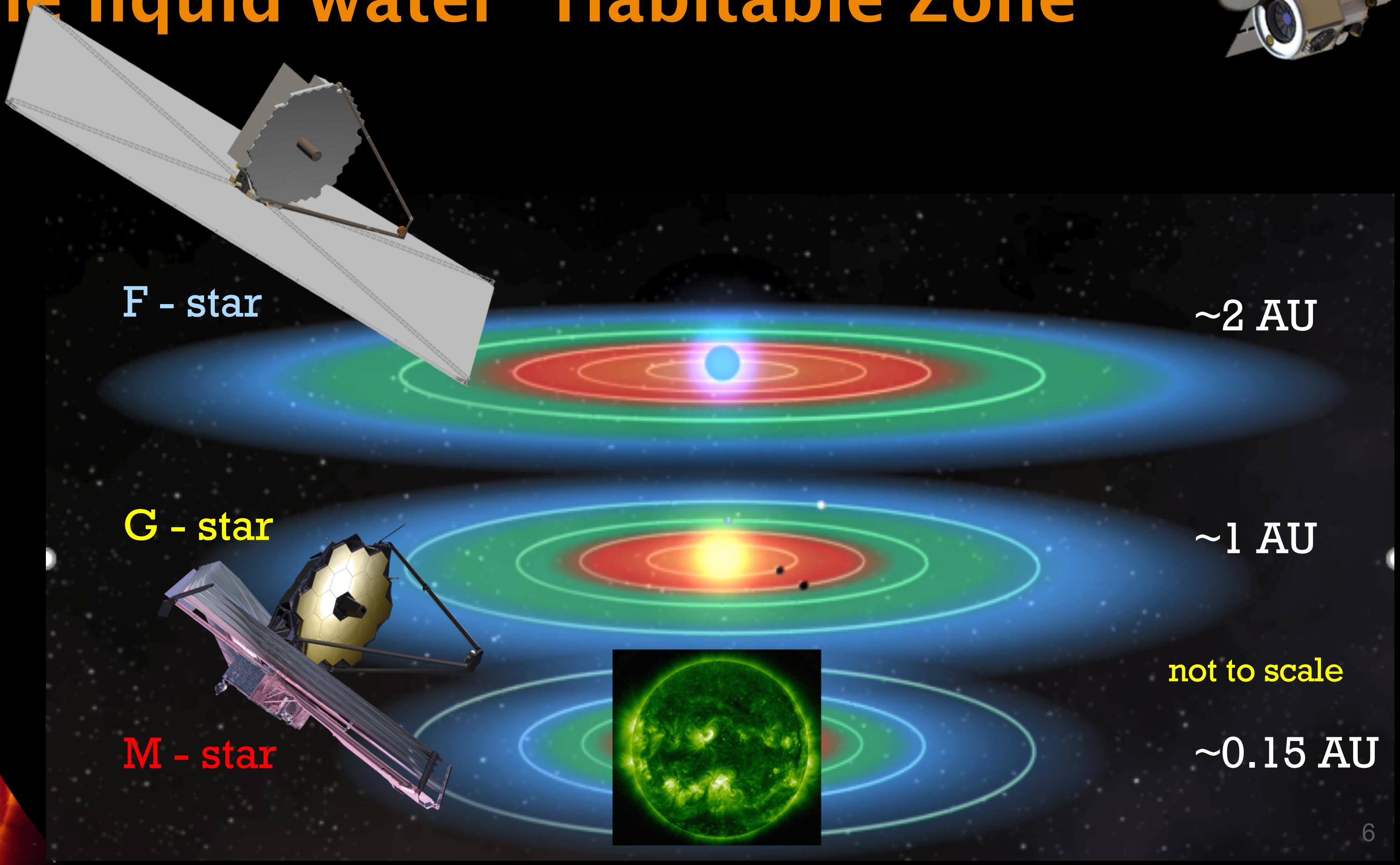
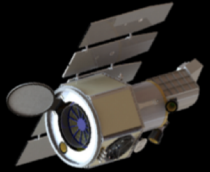
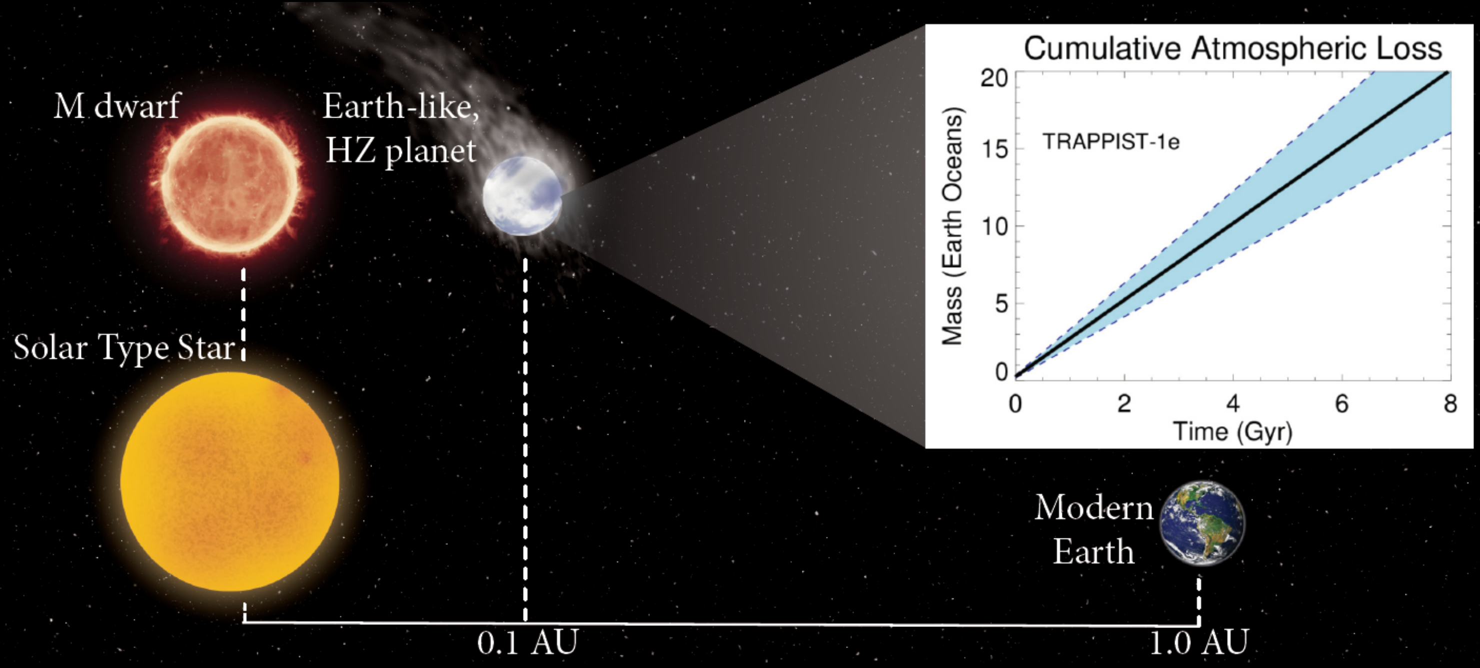
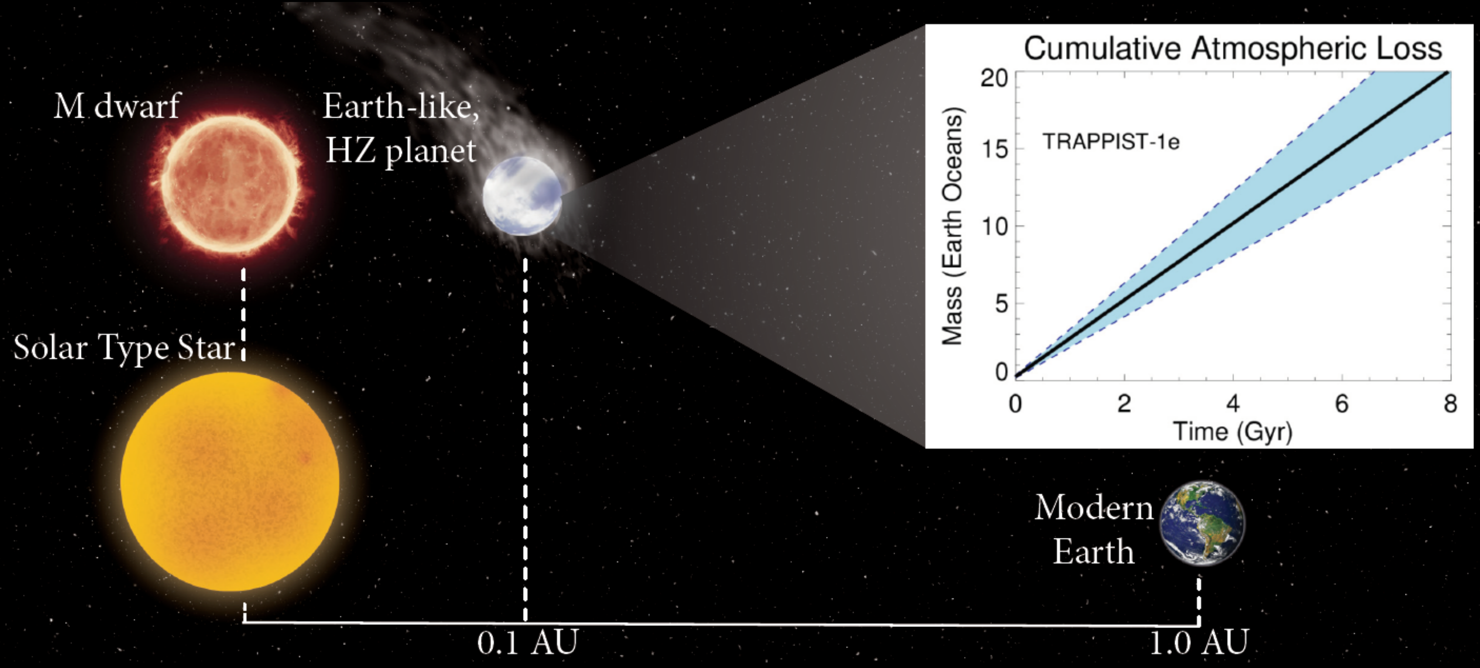




A more complete picture of the Habitable Zone: Stellar impacts and space weather



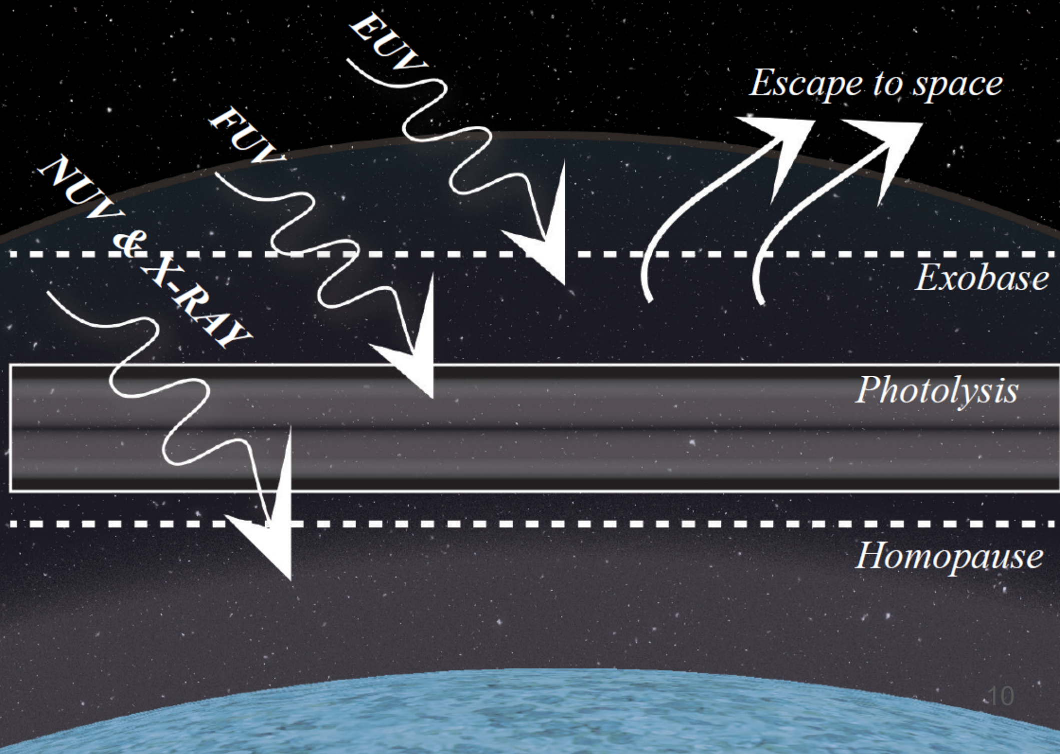
A more complete picture of the Habitable Zone: Stellar impacts and space weather



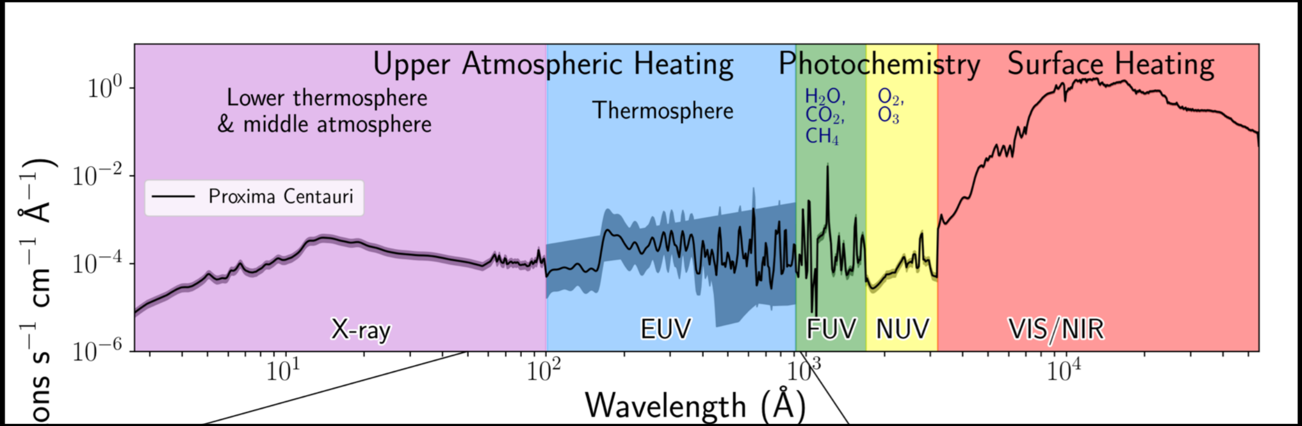
Which star-planet systems are conducive to the maintenance of habitable conditions?
Where should NASA and its partners commit their resources?

Stellar EUV (10 – 91nm) flux: the driver of atmospheric escape

High-energy stellar photons control the atmospheric physics and chemistry of temperate, rocky planets. The EUV dominates heating of the upper atmosphere and drives escape.

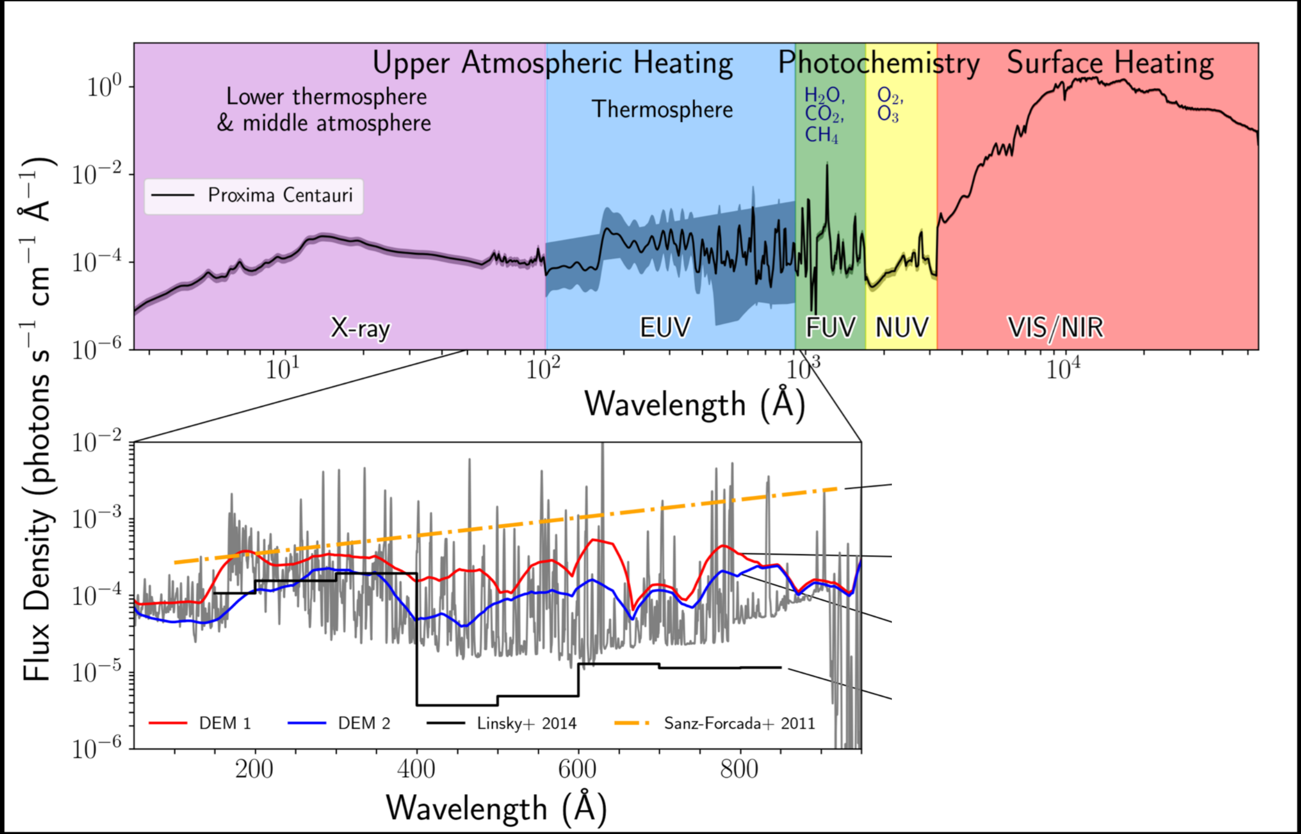


EUV environment is the dominant uncertainty for exoplanet atmosphere survival



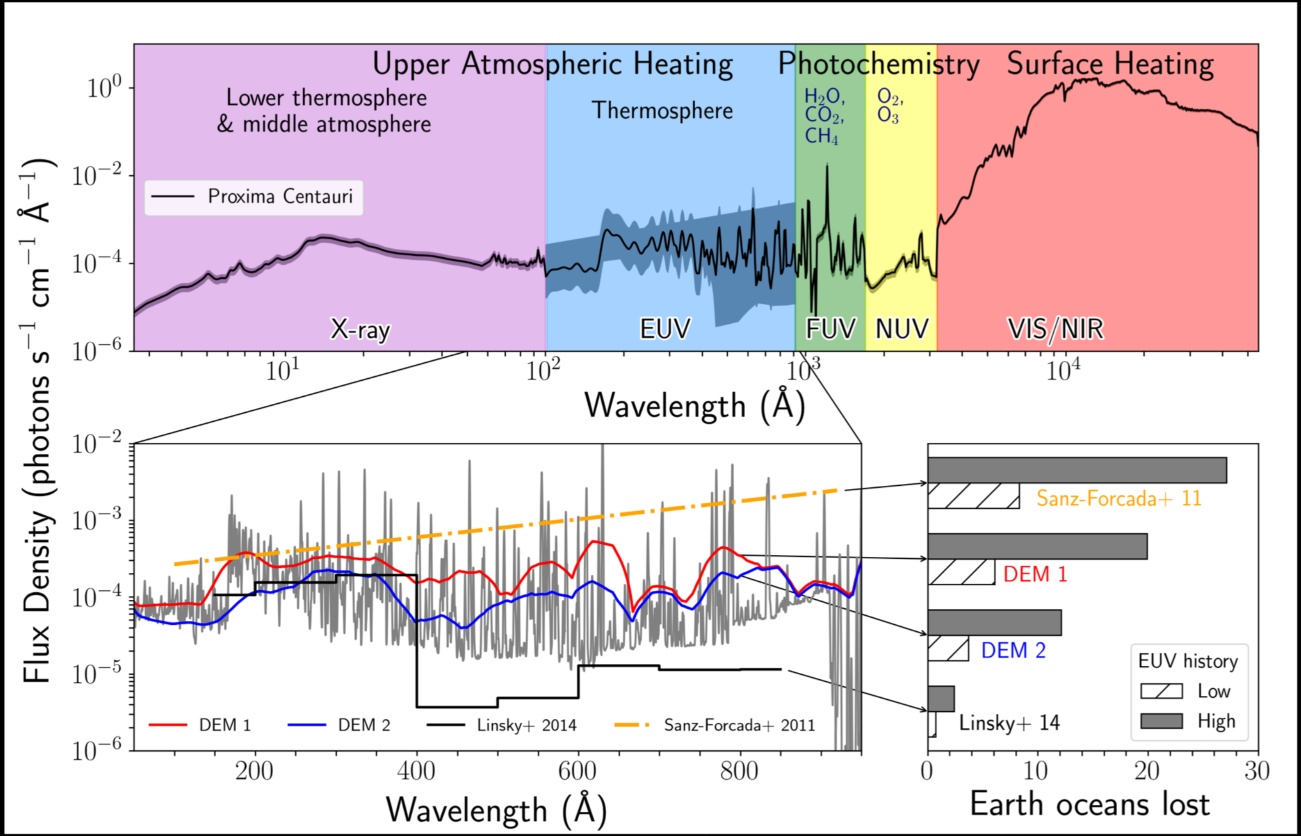
Adapted from France et al. (2016)

EUV environment is the dominant uncertainty for exoplanet atmosphere survival



M dwarf EUV: Allison Youngblood - CU

EUV environment is the dominant uncertainty for exoplanet atmosphere survival

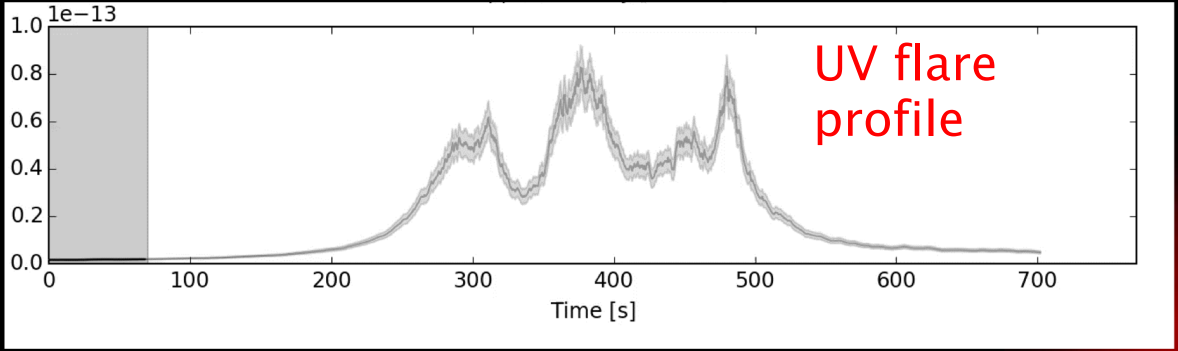


M dwarf EUV: Allison Youngblood - CU

Impulsive Stellar Eruptions Drive Atmospheric Escape

Flares & CMEs

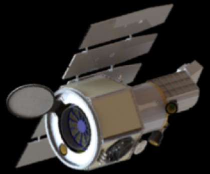
Optically Inactive M star (P_{rot} ~ 40 days).



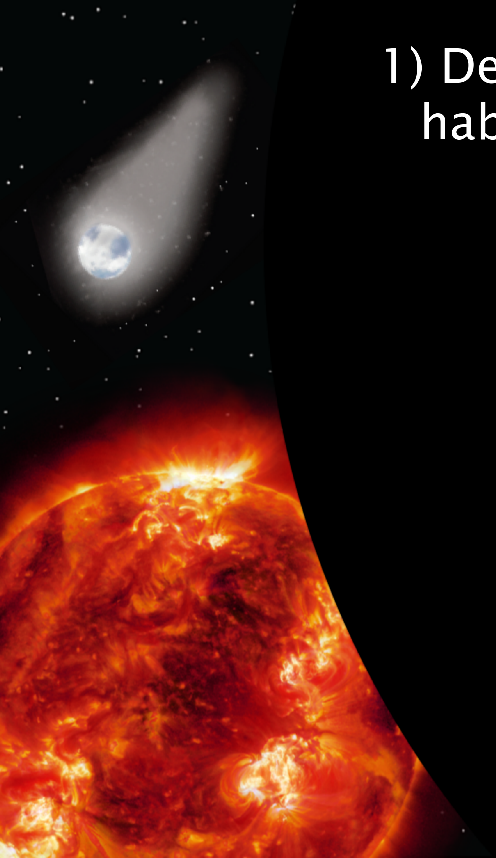
- Flares may dominate EUV output of active stars
- Stellar particle bombardment drives ion escape, charge exchange, pickup/sputtering loss processes

Adapted from Loyd et al. (2018)

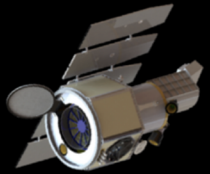
ESCAPE Science Objectives



1) Determine if stellar radiation environments permit habitable conditions to exist on rocky exoplanets

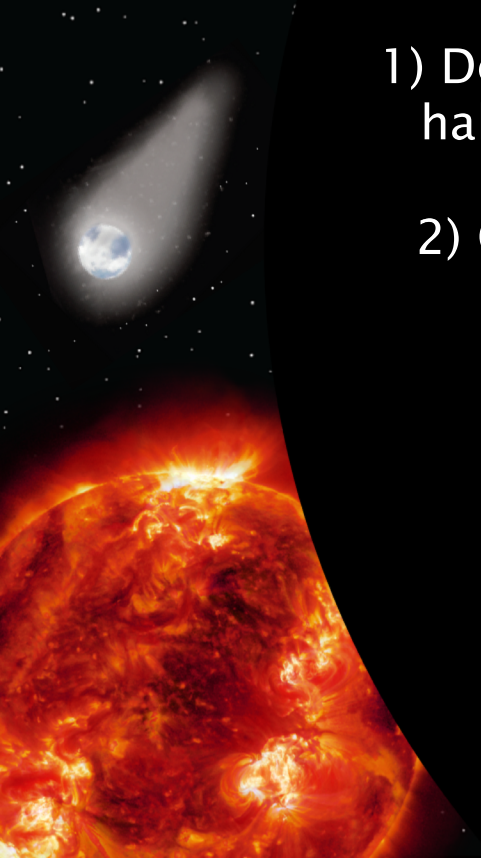


ESCAPE Science Objectives

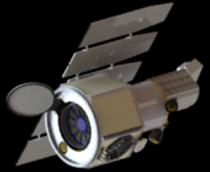


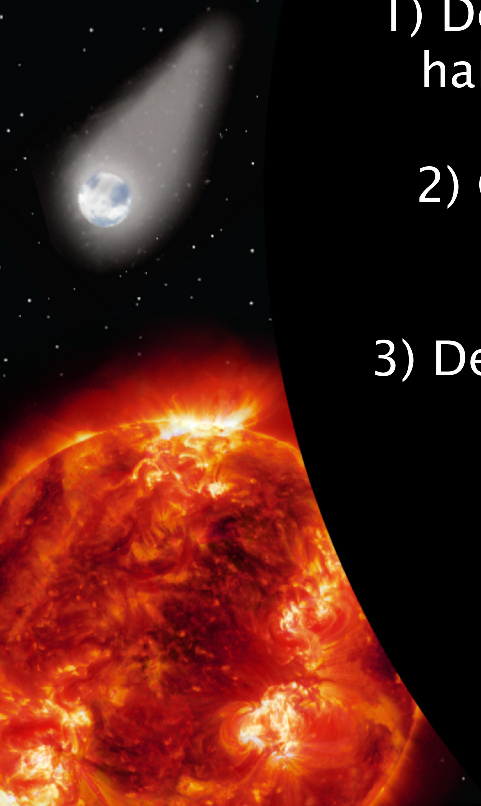
1) Determine if stellar radiation environments permit habitable conditions to exist on rocky exoplanets

2) Characterize stellar EUV evolution & flares, and their impact on habitable environments



ESCAPE Science Objectives



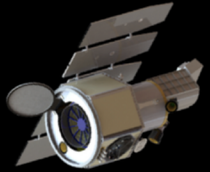


1) Determine if stellar radiation environments permit habitable conditions to exist on rocky exoplanets

2) Characterize stellar EUV evolution & flares, and their impact on habitable environments

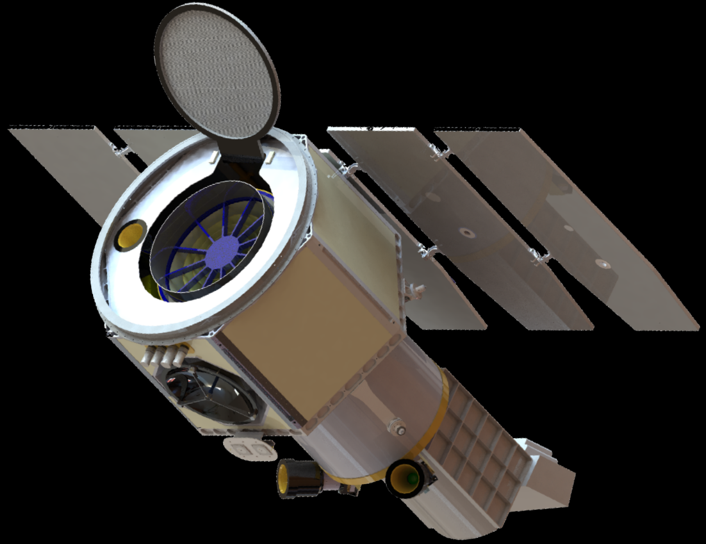
3) Determine the impact of coronal mass ejections on atmospheric mass loss

The ESCAPE Science and Implementation

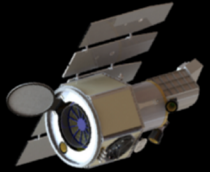


EUV & FUV (7 – 180 nm) spectroscopy of 200 nearby stars, including most promising exoplanet hosts

Atmospheric models using ESCAPE data as inputs quantify atmospheric loss rates and identify the most promising habitable planet targets

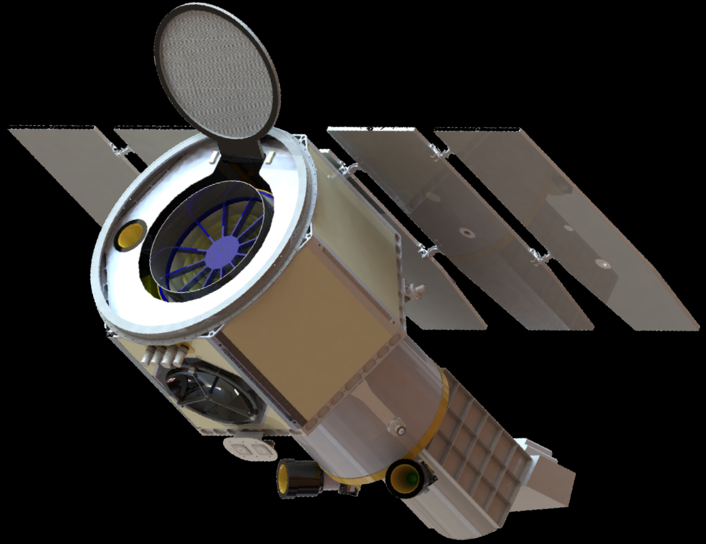


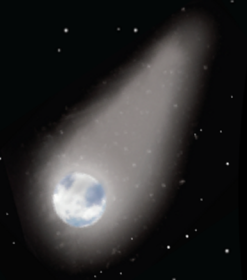
The ESCAPE Science and Implementation



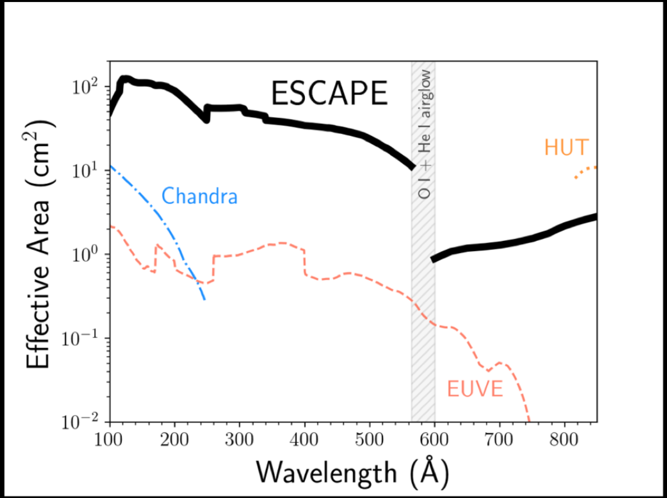
EUV & FUV (7 – 180 nm) spectroscopy of 200 nearby stars, including most promising exoplanet hosts

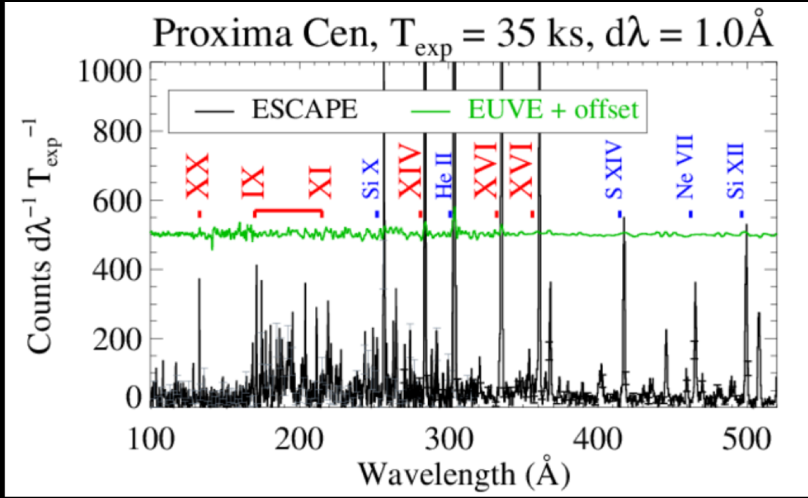
Launch in spring 2025 with a 2 year primary mission





The ESCAPE Science Program

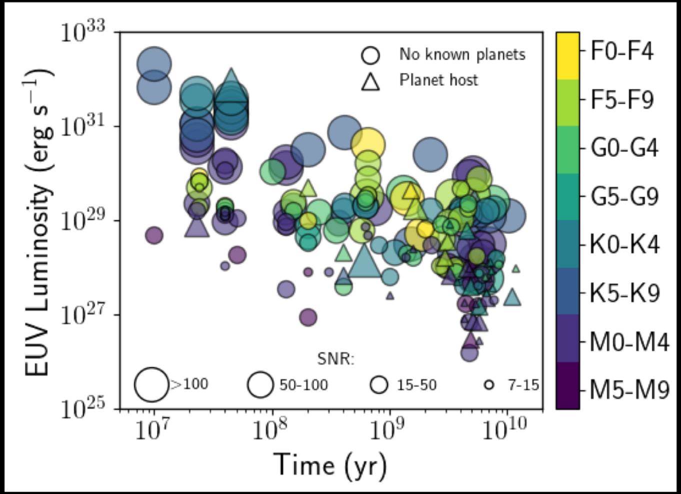


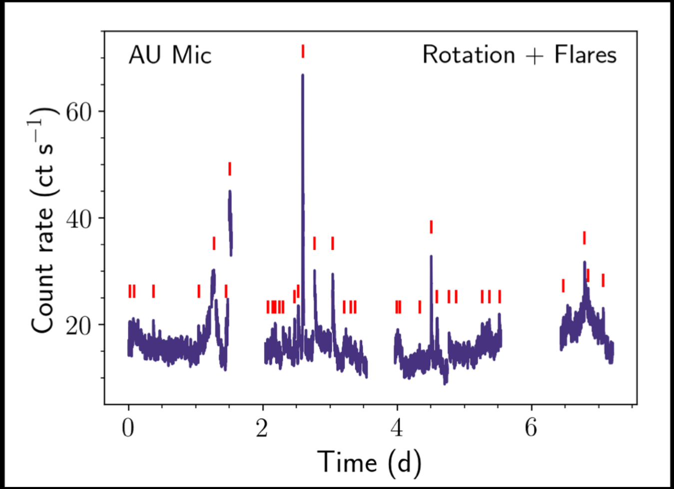


<u>> 100 x sensitivity of EUVE</u>:

First statistical study of EUV irradiance on planet-hosting stars

The ESCAPE Science Program



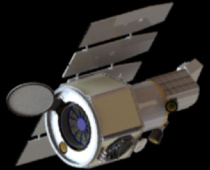


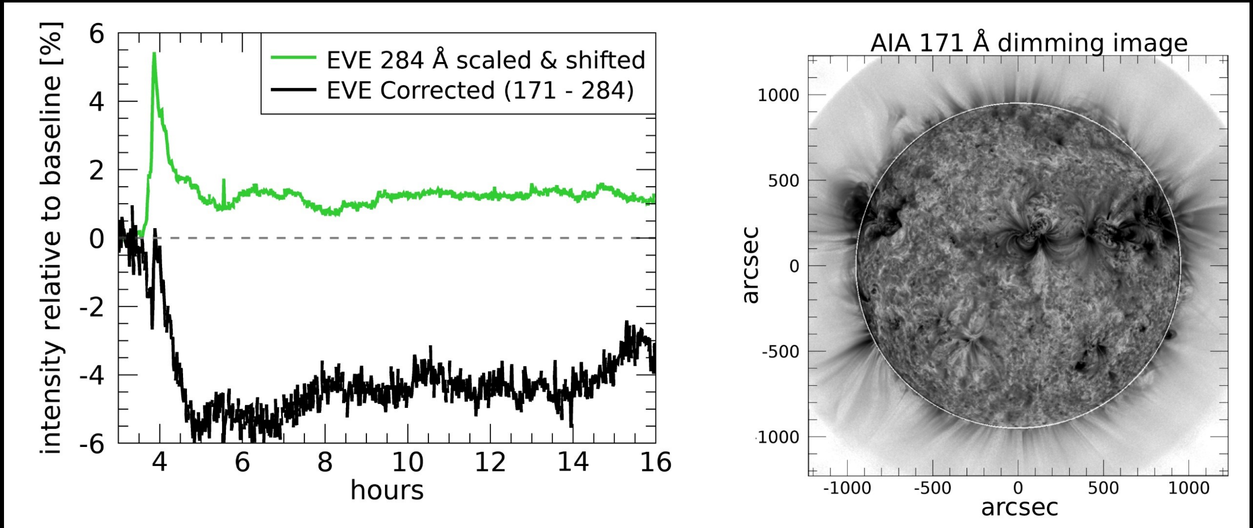
<u>> 100 x sensitivity of EUVE</u>:
First statistical study of EUV irradiance on important stellar/planetary timescales.

1) Evolutionary (Myr – Gyr)
2) Rotation/Stellar Cycle (days – years)
3) Impulsive (minutes – hours)

AU Mic data dapted from Kowalski et al.

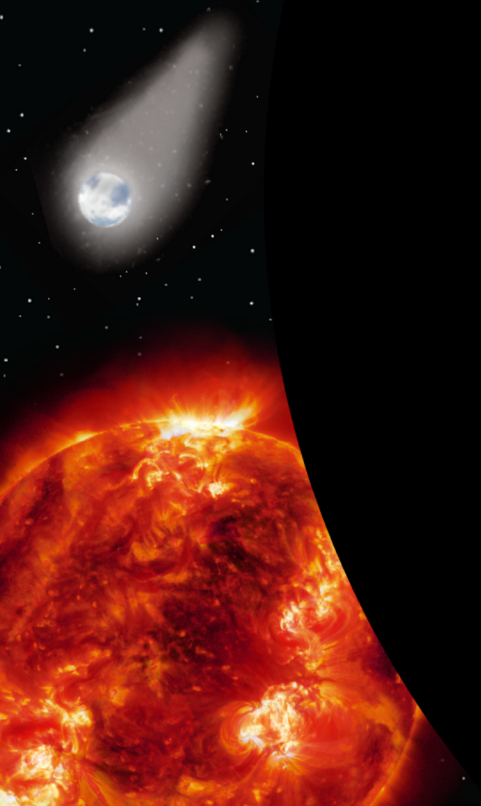
The ESCAPE Science Program





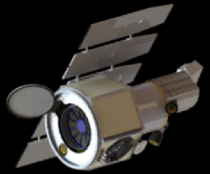
> <u>100 x sensitivity of EUVE</u>:

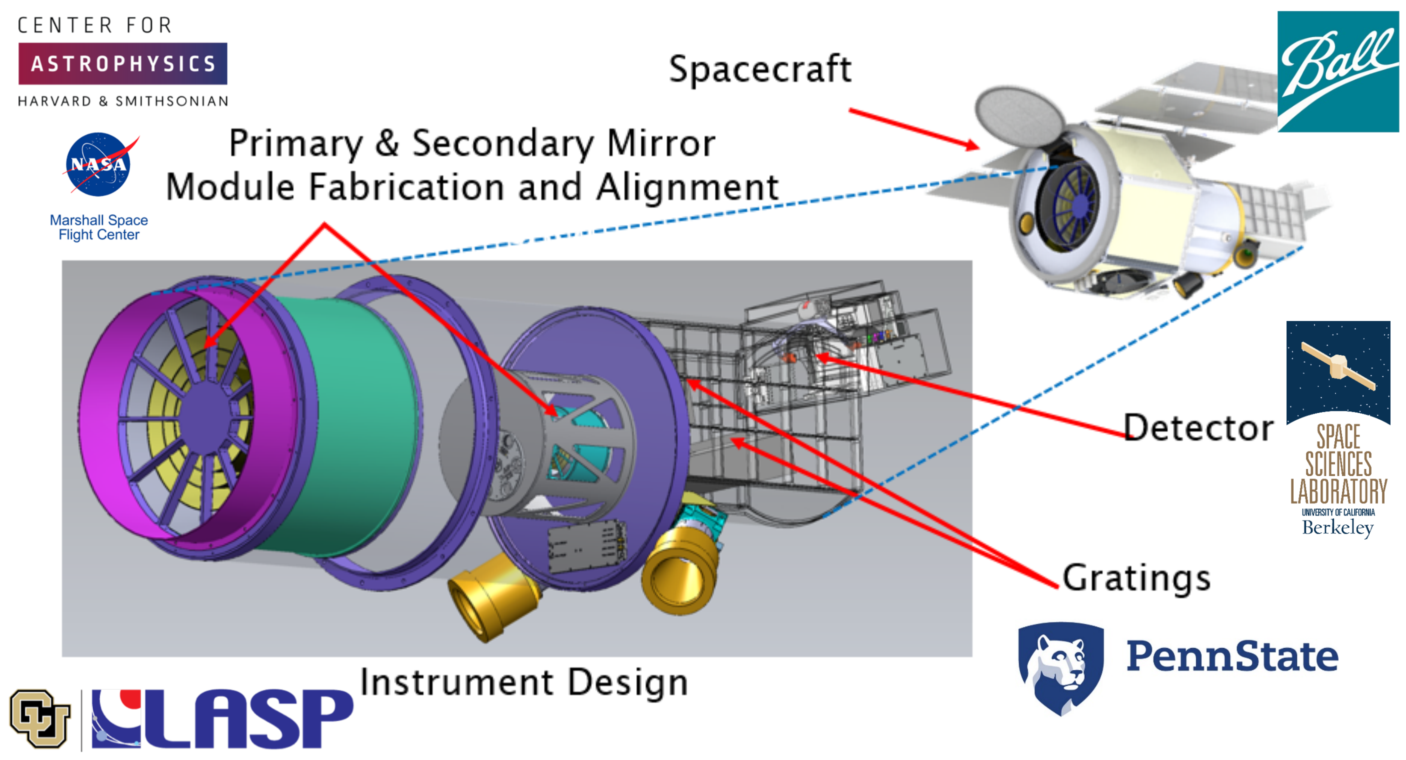
1) CME frequency distribution via **coronal dimming** (10 – 15 F, G, and K stars)
2) Relationship between flares and CMEs
3) CME kinetic energy for brightest stars



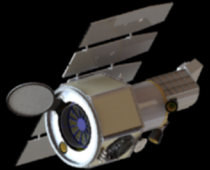
SDO and AIA data adapted from Mason et al. (2016)

The ESCAPE Instrument





The ESCAPE Instrument

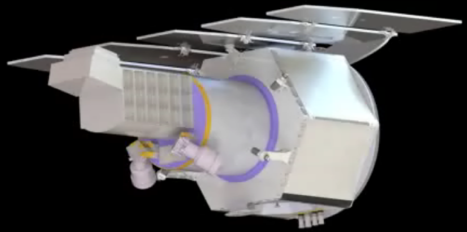


(Euv Stellar Characterization for Atmospheric Physics and Evolution)

ESCAPE Spacecraft:

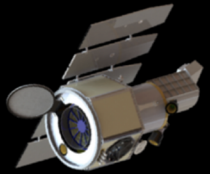
- Ball BCP 100 spacecraft
- ADCS system (< 5” pointing stability and < 30” pointing control)
- Ka and S-band comm.

- Fabricated and integrated by Ball, building on heritage from WISE, GPIM, and in development for IXPE and SPHEREx

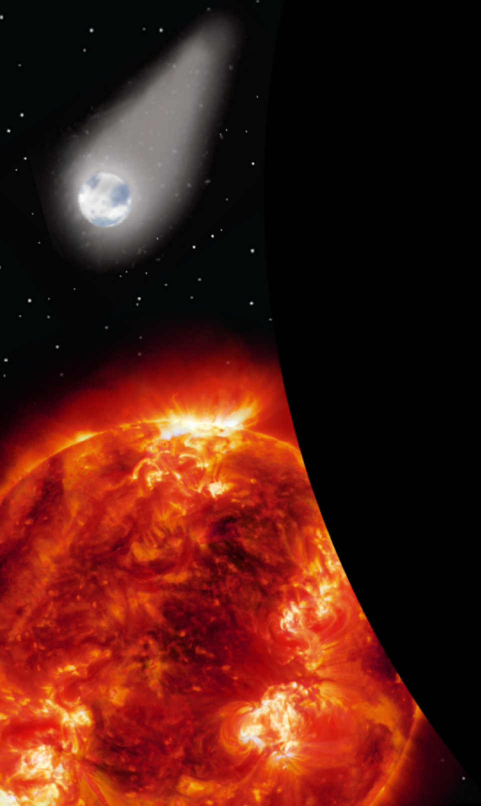


The ESCAPE Mission

(Euv Stellar Characterization for Atmospheric Physics and Evolution)



ESCAPE explores the high-energy radiation environments of nearby habitable zones.



kevin.france@colorado.edu

The ESCAPE Mission

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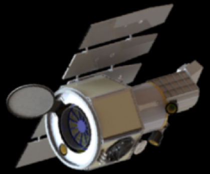

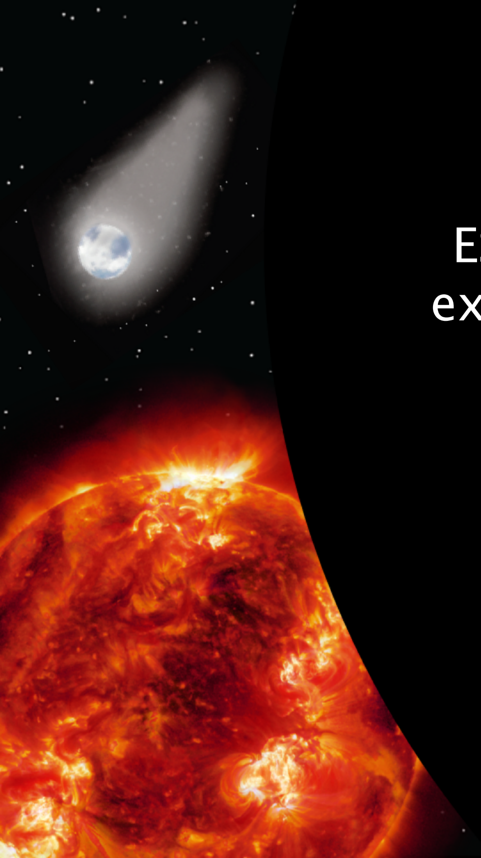

ESCAPE explores the high-energy radiation environments of nearby habitable zones.

ESCAPE provides the essential stellar context for exoplanet habitability and provides a roadmap for future life-detection missions.

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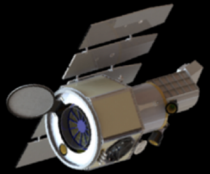

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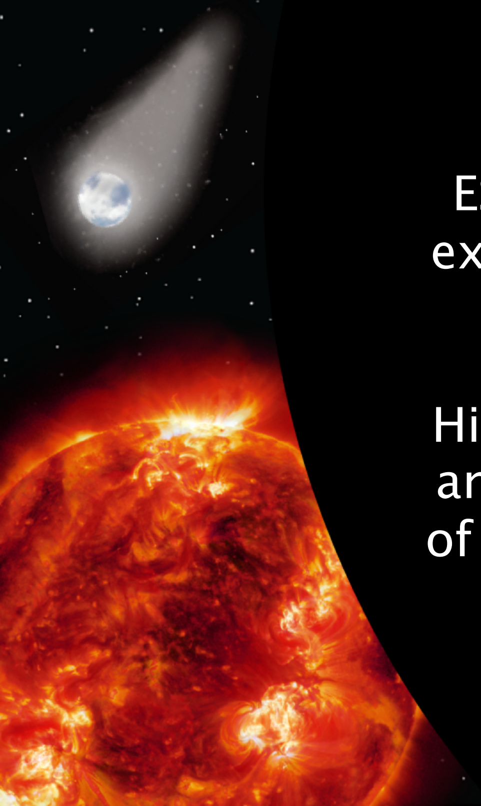

ESCAPE explores the high-energy radiation environments of nearby habitable zones.

ESCAPE provides the essential stellar context for exoplanet habitability and provides a roadmap for future life-detection missions.

High-throughput grazing incidence optical system and heritage spacecraft enables EUV observations of 200 nearby stars of a range of masses and ages to be surveyed in a 2 year mission.

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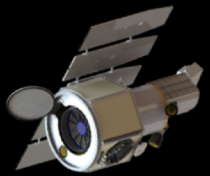
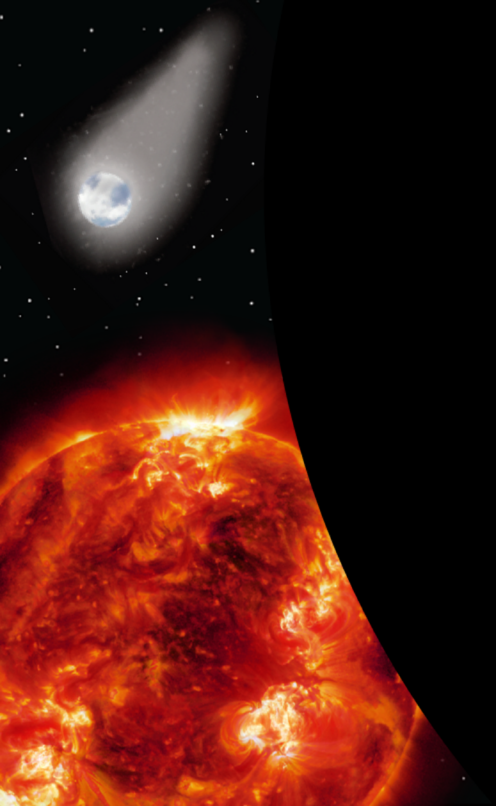
The ESCAPE Mission

(Euv Stellar Characterization for Atmospheric Physics and Evolution)





Backup Slides

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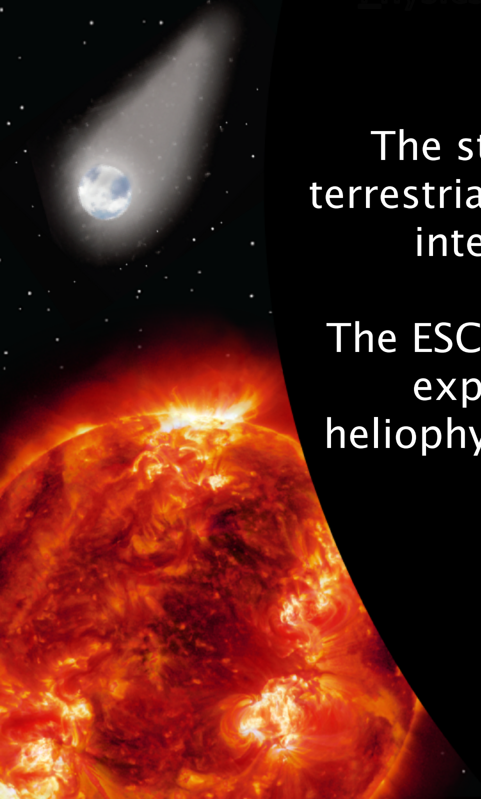
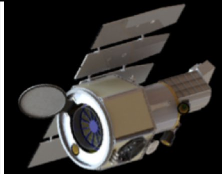
ESCAPE Science Team



The study of stellar impacts on terrestrial exoplanets is an inherently interdisciplinary endeavor.

The ESCAPE science team combines experts from astrophysics, heliophysics, and planetary science.

Name	Role (Sci Section)
Kevin France, CU, LASP	*PI; responsible for overall mission success*
Brian Fleming, CU	*IS & DPI; system optical design lead*
Jeremy Drake, SAO	*PS; planning/execution of science program*
James Mason, GSFC	*DPS; dimming analysis lead (D.2.3)*
SCIENCE CONTRIBUTION	
Joel Allred, GSFC	*Co-I; EUV flare modeling lead (D.2.3)*
Ute Amerstorfer, IWF	*Collab.; ion processes modeling (D.2.3)*
Martin Barstow, Leicester	*Collab.: EUV ISM studies lead (D.2.4)*
Zach Berta-Thompson, CU	*Co-I; M dwarf follow-up lead (D.2.1)*
Vincent Bourrier, U Gen	*Collab.; escape observer (D.2.1)*
Luca Fossati, IWF Graz	*Collab.; escape observer (D.2.1)*
Cynthia Froning, UT	*Co-I; FUV observation lead (D.2.1)*
Cecilia Garraffo, CfA	*Co-I; stellar wind modeling lead (D.2.1,3)*
Guillaume Gronoff, LaRC	*Co-I; particle influences lead (D.2.3)*
Meng Jin, LM	*Co-I: dimming modeling lead (D.2.3)*
Tommi Koskinen,. UofA	*Co-I; thermal escape modeling lead (D.2.1)*
Adam Kowalski, CU	*Co-I: stellar flare analysis lead (D.2.3)*
Herbert Lichtenegger, IWF	*Collab.; ion processes modeling (D.2.3)*
Jeffrey Linsky, CU	*Co-I: ISM correction lead (D.2.4)*
Rachel Osten, JHU/STScI	*Co-I: stellar CME & particle lead (D.2.3)*
Sabrina Savage, MSFC	*Co-I: solar contexts lead (D.2.2)*
Allison Youngblood, GSFC	*Co-I; M dwarf EUV analysis lead (D.2.1)*
INSTRUMENT CONTRIBUTION	
Matthew Beasley, SwRI	*Co-I; telescope design scientist*
James Green, CU	*Co-I; EUV calibration lead*
Ken Kobayashi, MSFC	*Co-I: telescope optic scientist (D.2.2)*
Randall McEntaffer, PSU	*Co-I; diffraction gratings lead*
David McKenzie, MSFC	*Co-I: telescope fabrication lead (D.2.2)*
Suzanne Romaine, SAO	*Co-I; optical alignment lead*
Oswald Siegmund, UCB	*Co-I; Detector scientist*



The ESCAPE Mission

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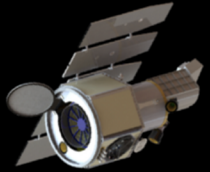
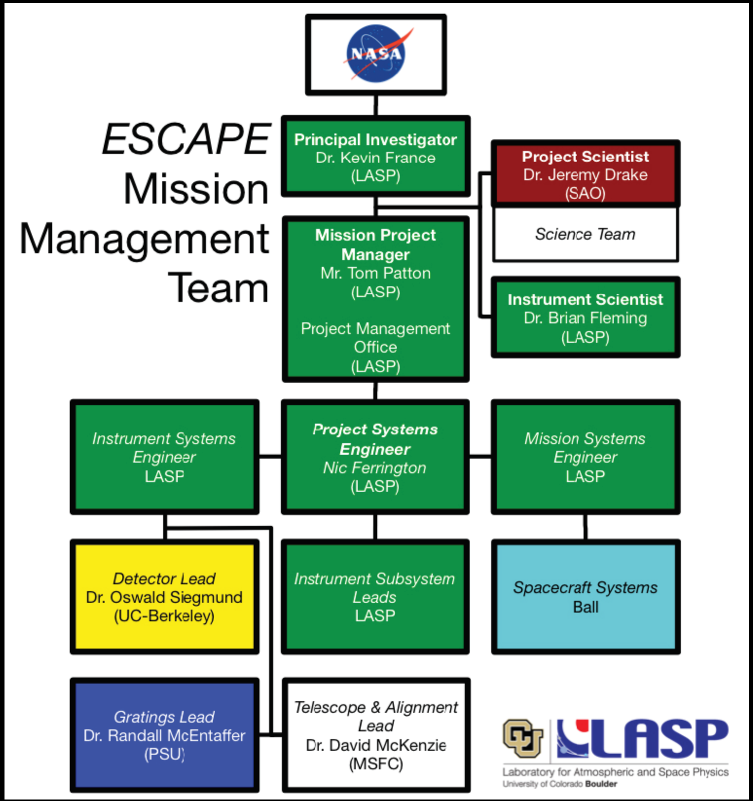


ESCAPE Hardware:

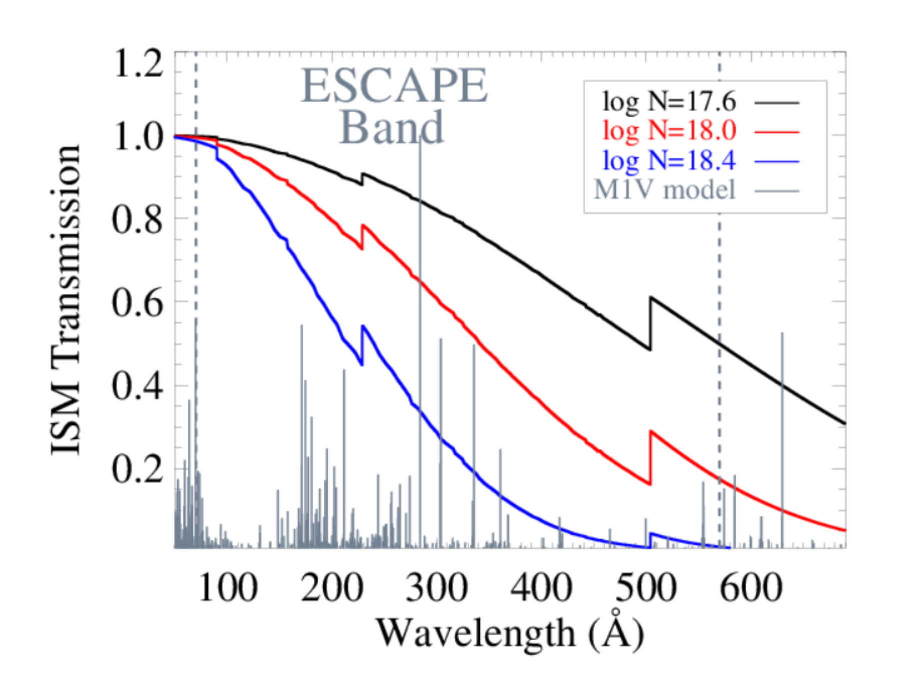
- Instrument, MSFC, UCB, SAO, PSU, LASP
- Instrument I&T, LASP
- Observatory I&T, Ball

ESCAPE Data:

- Processing, LASP
- Archiving, MAST

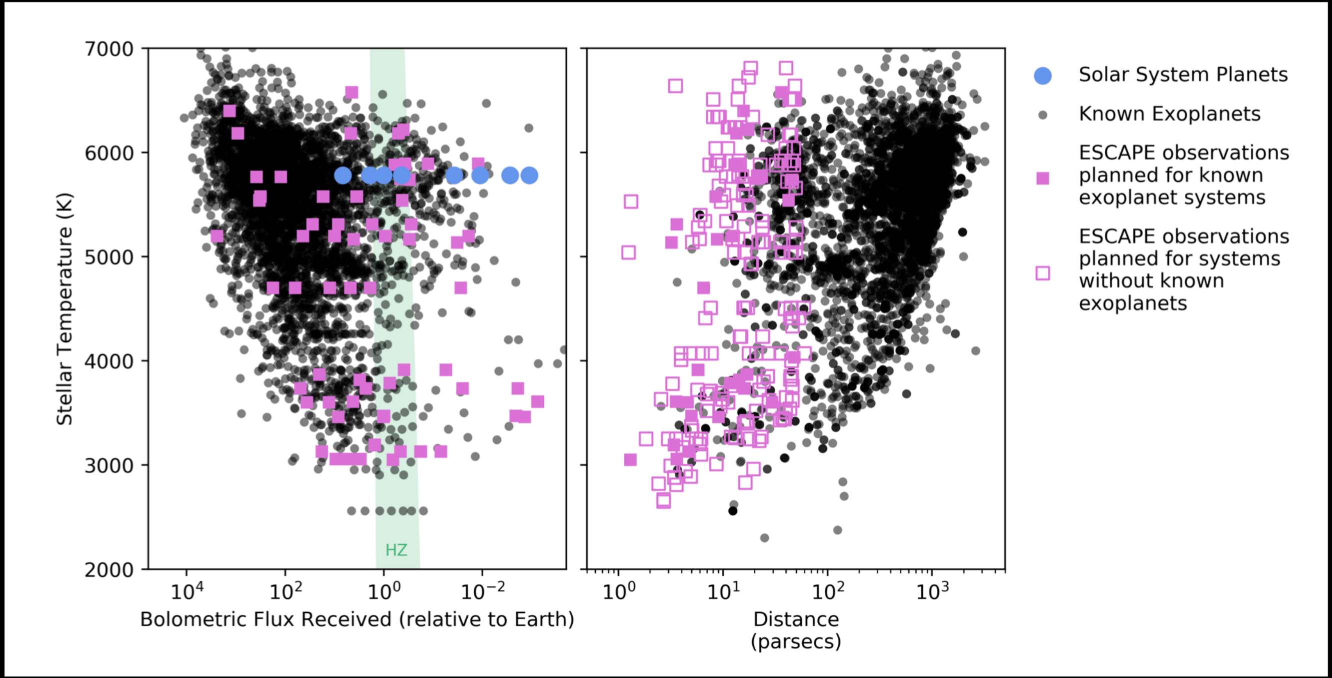


The Local ISM



The EUV *is* observable. The challenge has been an observational one, not an astrophysical one.

The ESCAPE Target Sample



Target list will be updated with new RV and transit results during Phases B – D.