M Dwarf flares and their impact on exoplanet habitability

Julien Poyatos

Advisors: Octavi Fors Aldrich
José Maria Gómez Cama

ICCUB Institute of Cosmos Sciences

UNIVERSITAT DE BARCELONA

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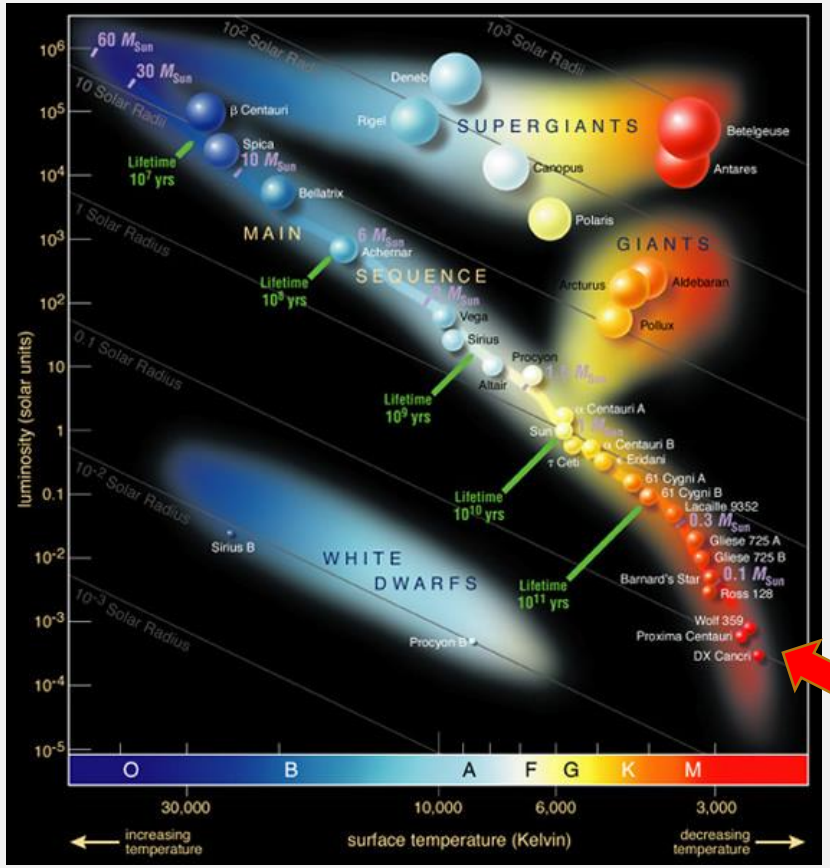
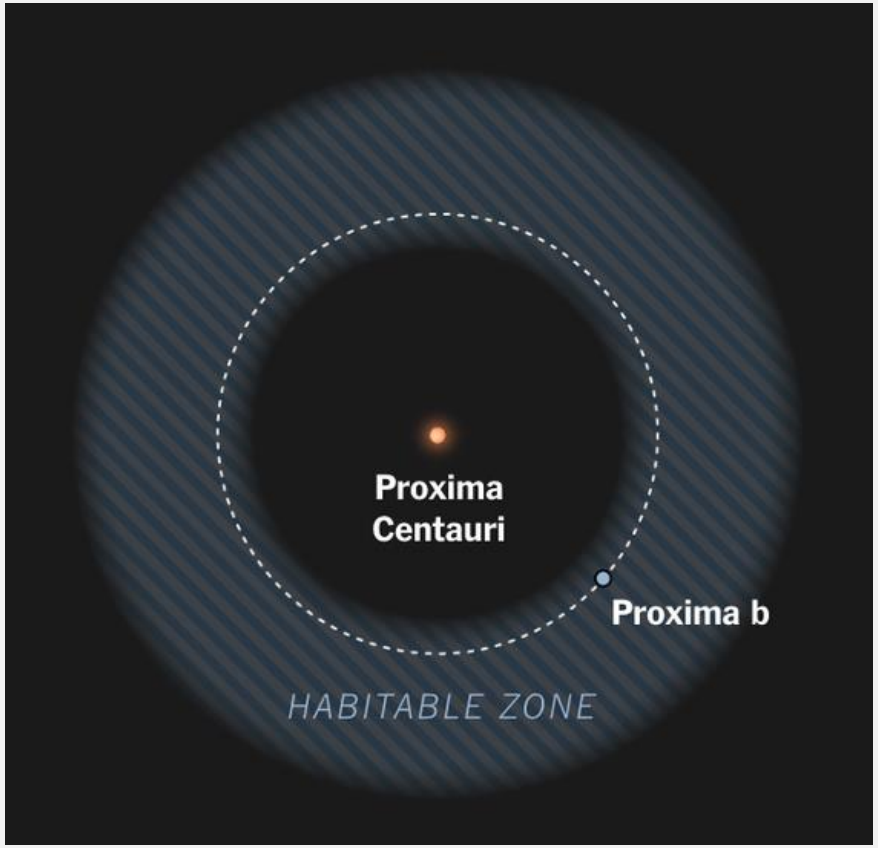
WHAT IS AN M DWARF ?



50 of the 60 closest stars are M Dwarfs

¾ of all the stars in the Milky Way are M Dwarfs

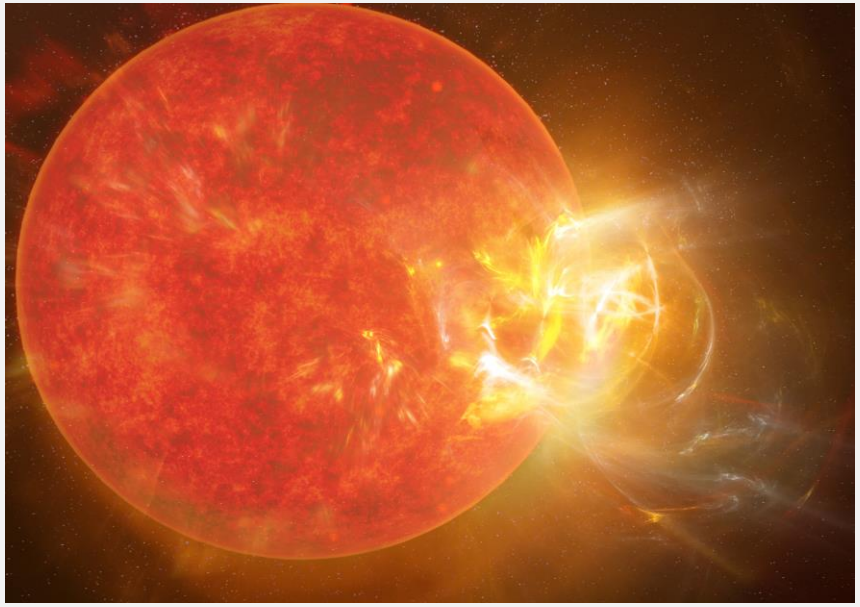


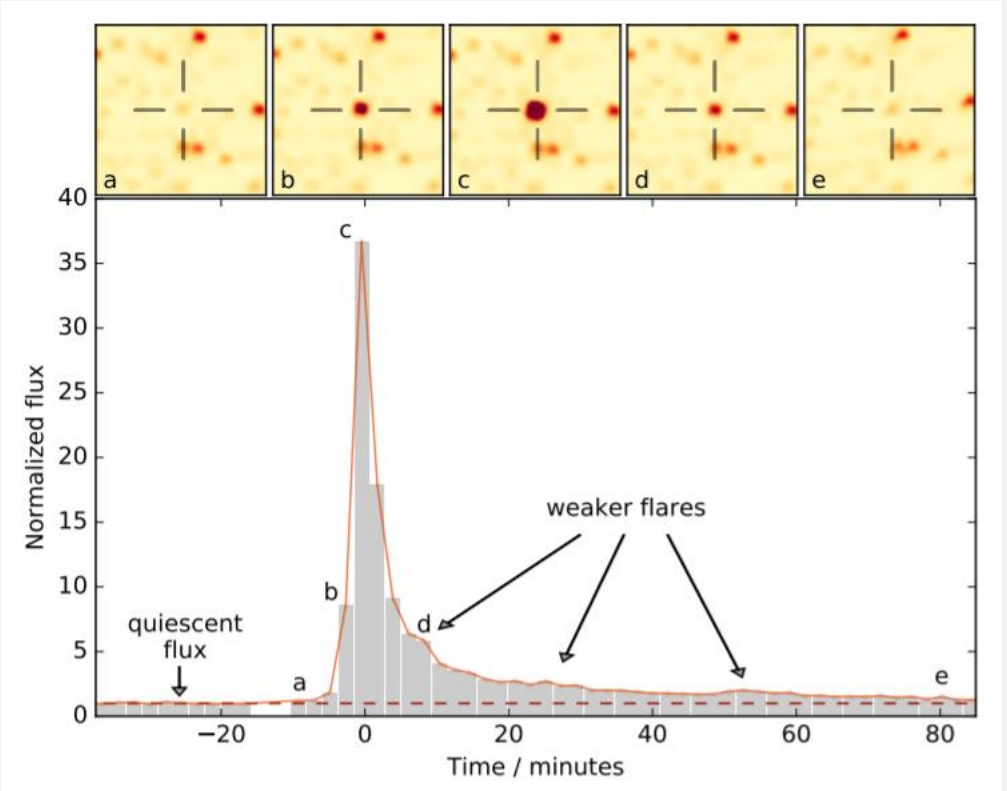
$d_{Proxima}$ = 1,302 pc

$M_{Proxima\ b} = 1{,}3\ M_{\oplus}$

Anglada-Escudé et al, 2016

WHAT IS A STELLAR FLARE ?



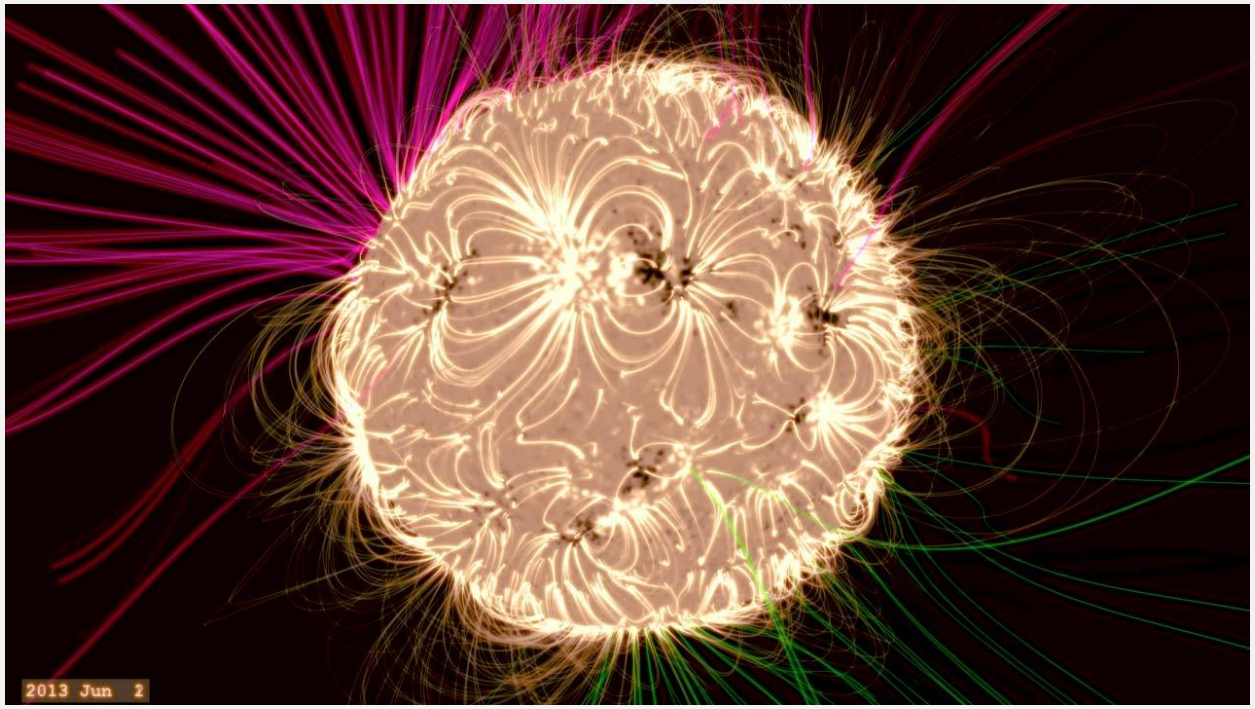


Howard et al, 2018

Proxima Centauri 2016 superflare: 68x flux increase in visible light Howard et al, 2018

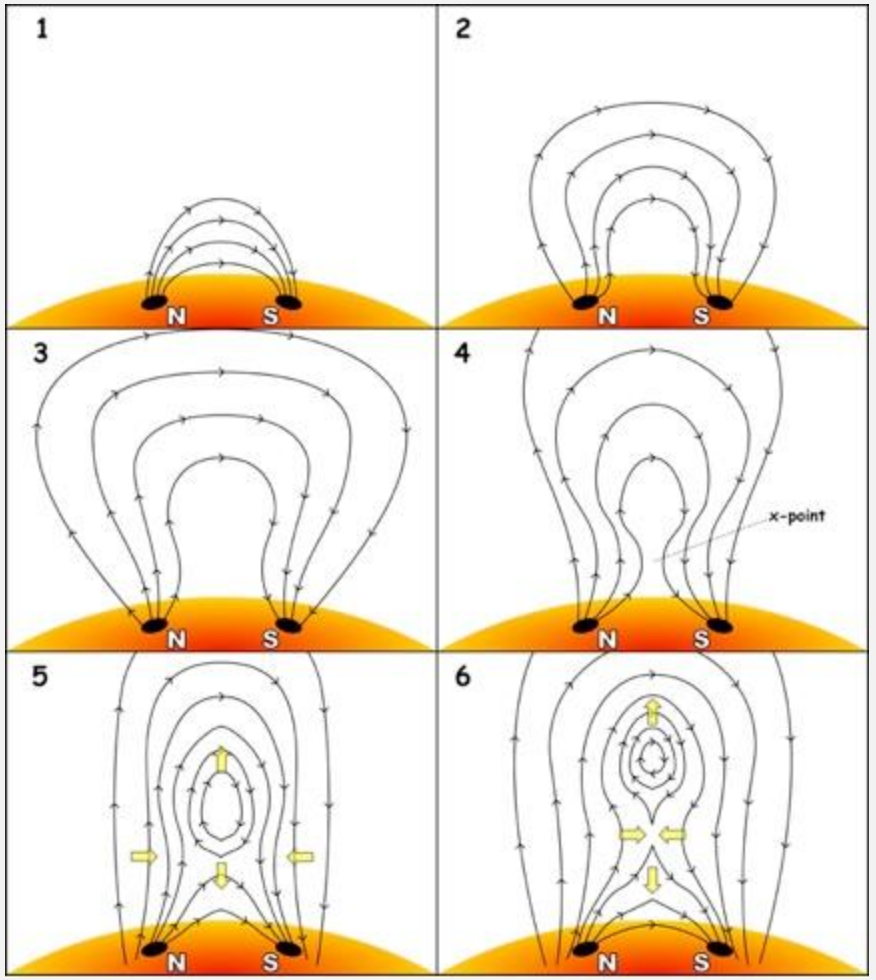
Proxima Centauri 2019 superflare: 14 000x flux increase in UV light MacGregor et al, 2021

WHAT CAUSES STELLAR FLARES?



Representation of the magnetic fields at the surface of an active star

Flares happen because of magnetic reconnection →

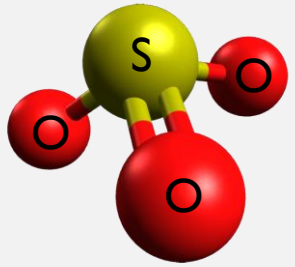


Clinch et al, 2010

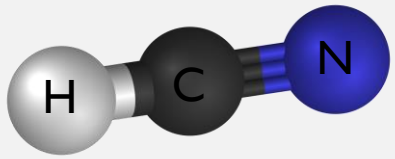
FLARES AND (UN)HABITABILITY

Inorganic matter

Sulfite Ion
SO_3^{2-}



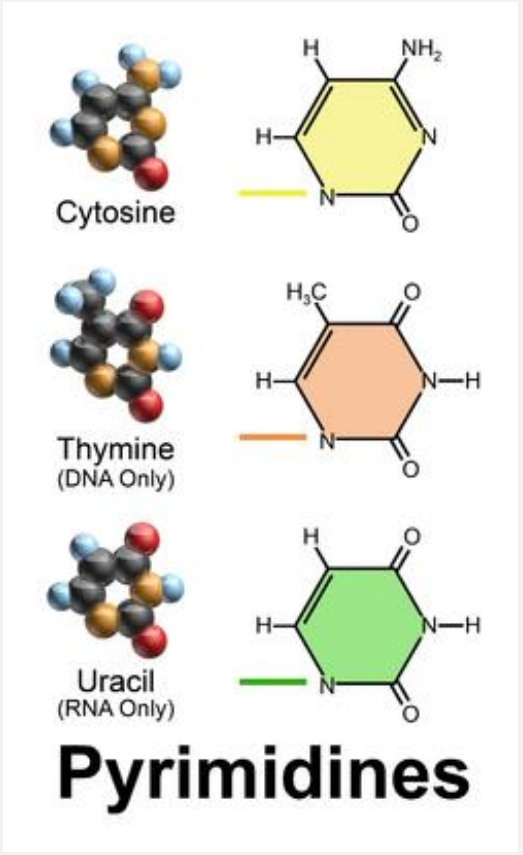
Hydrogen cyanide
HCN



Energy

$h\nu$

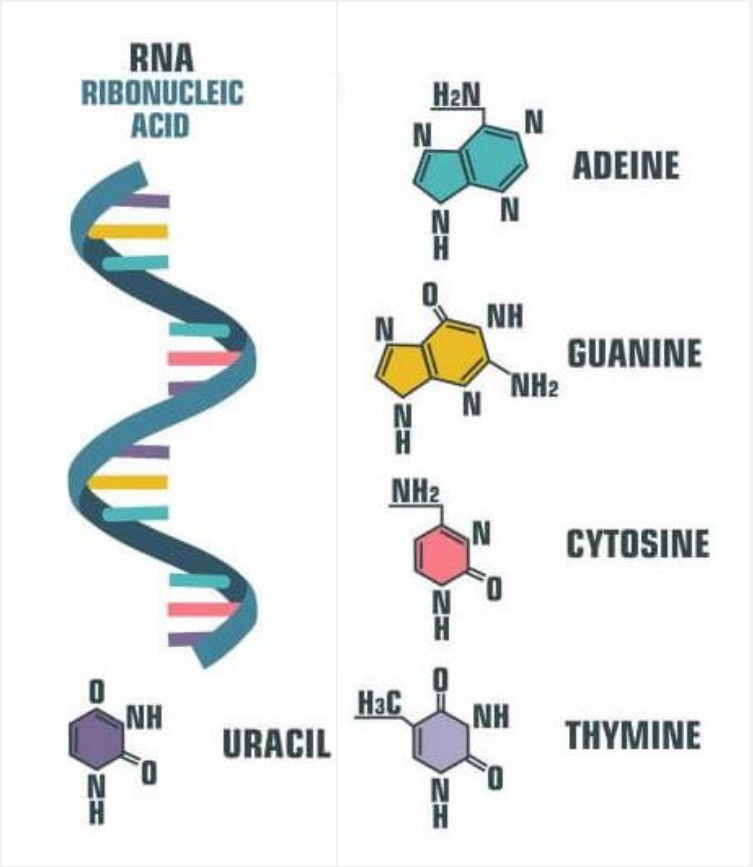
$\lambda \simeq 254nm$



Hydrogen bond with complementary purine

C — G
T — A
U

Organic matter

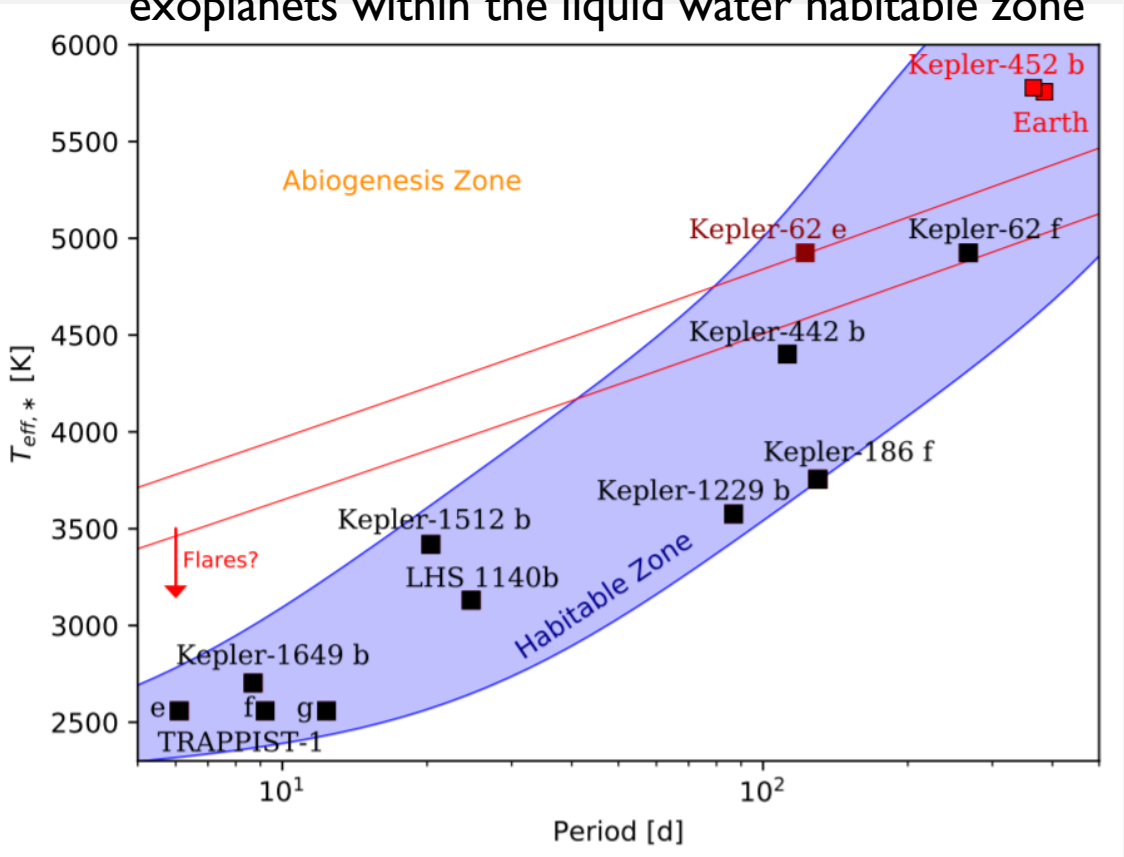


Xu et al, 2020

UV flux from flares can trigger the basis of prebiotic chemistry

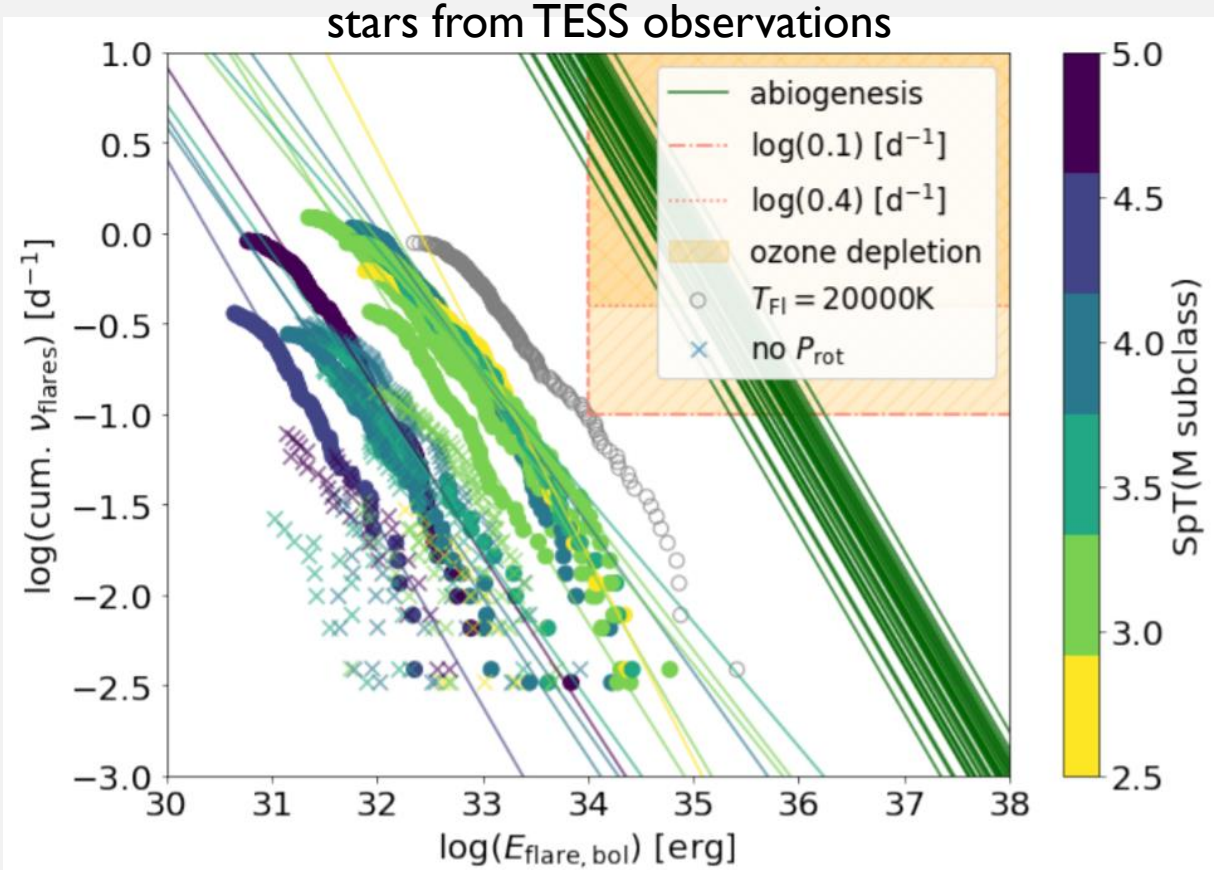
FLARES AND (UN)HABITABILITY

Period-effective temperature diagram of confirmed exoplanets within the liquid water habitable zone



Rimmer et al, 2018

Cumulative flare energy frequency distributions for 35 flaring stars from TESS observations

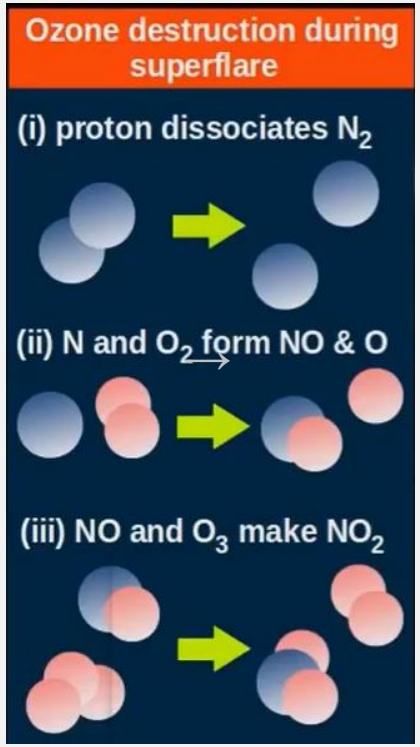


Bogner et al, 2021

Ideal situation: Habitable zone + Abiogenesis zone

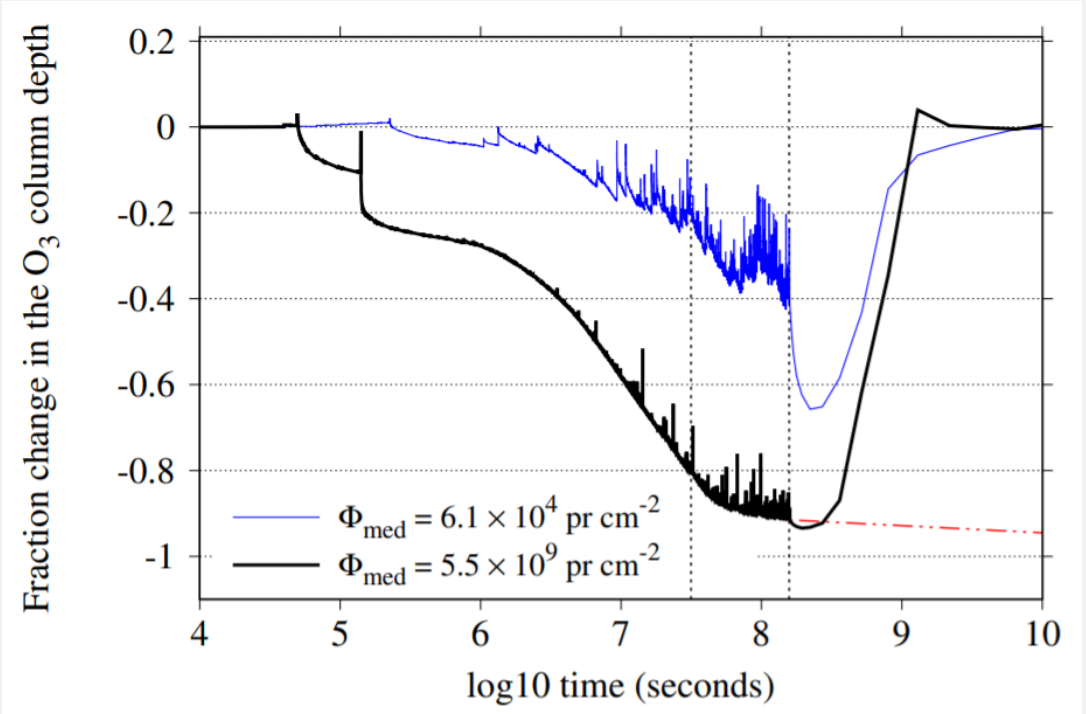
FLARES AND (UN)HABITABILITY

Ozone → Nitrogen dioxyde



Howard, 2018

O_3 depletion model based on the 2016 Proxima superflare



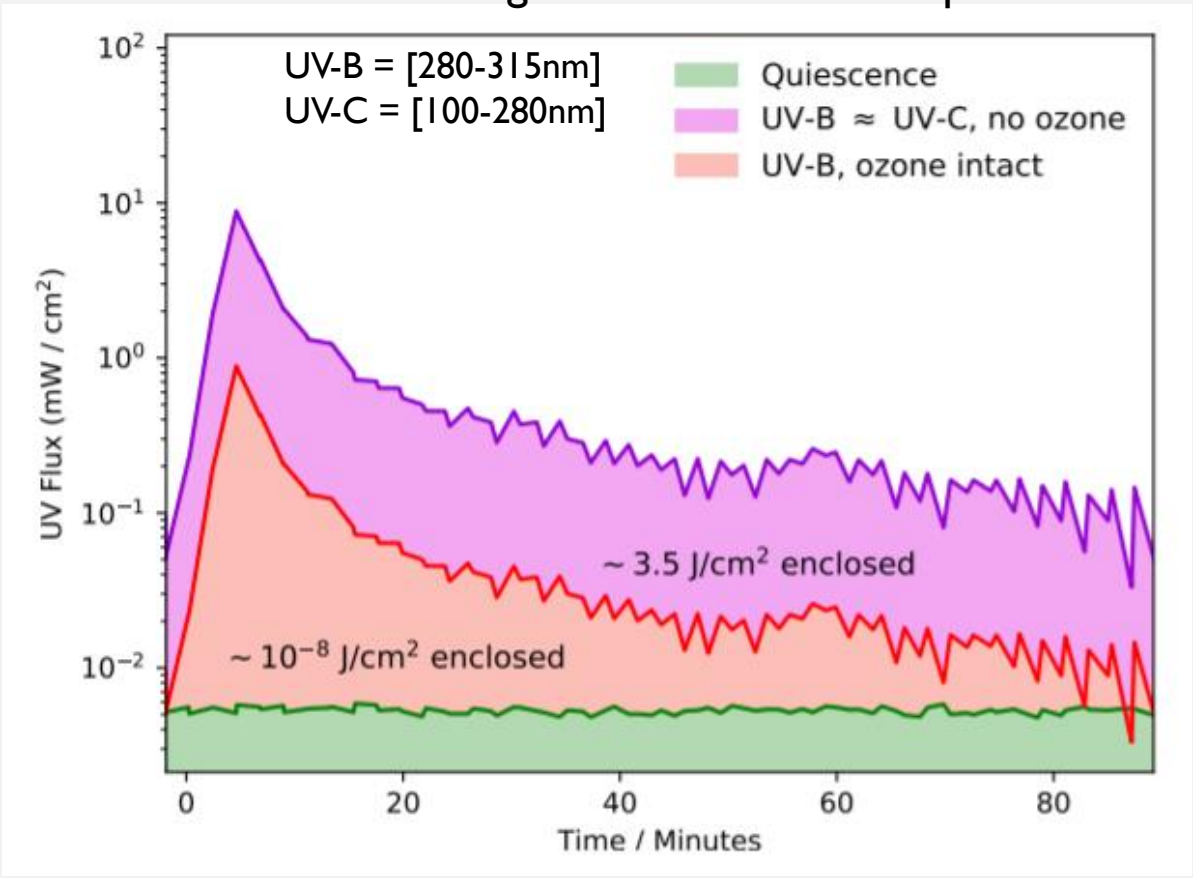
Howard et al, 2018

90% depletion in 5y
100% depletion in 100ky

Persistent powerful flaring can lead to ozone depletion

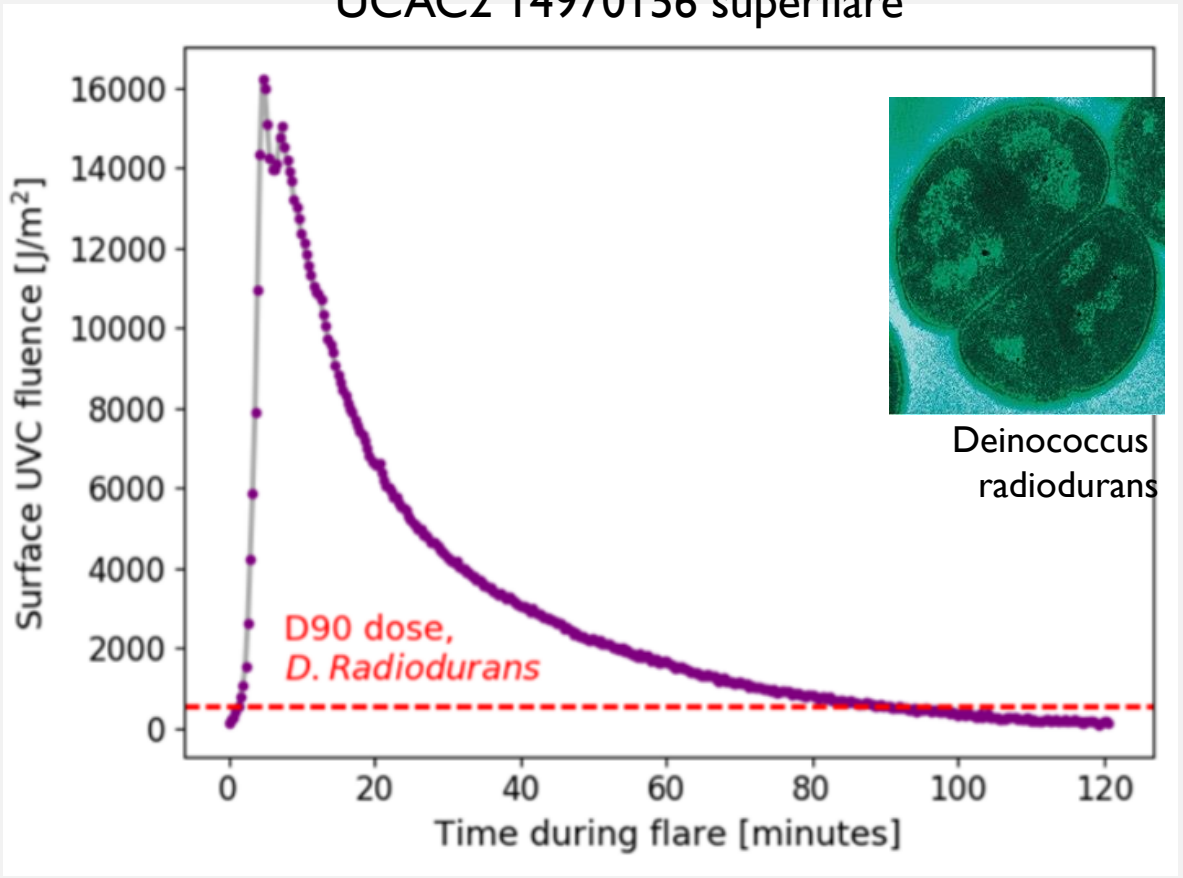
FLARES AND (UN)HABITABILITY

Surface UV flux during the 2016 Proxima superflare



Howard et al, 2018

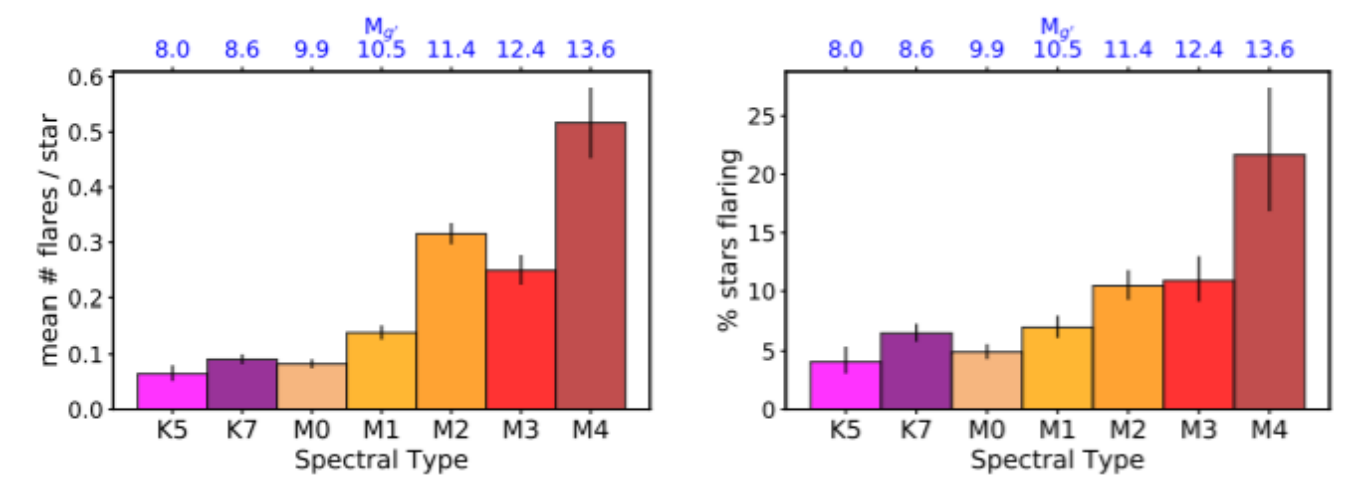
Surface UV fluence during the UCAC2 14970156 superflare

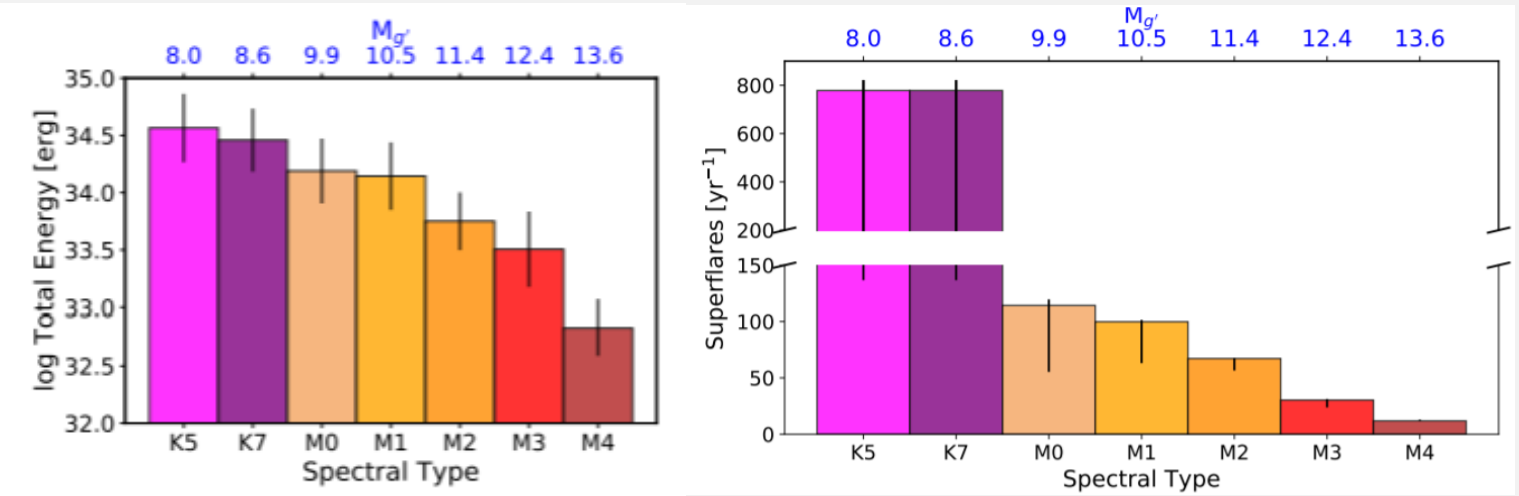


Howard & MacGregor, 2021

Life at the surface would have to undergo extreme adaptation

RESULTS FROM THE EVRYFLARE SURVEYS



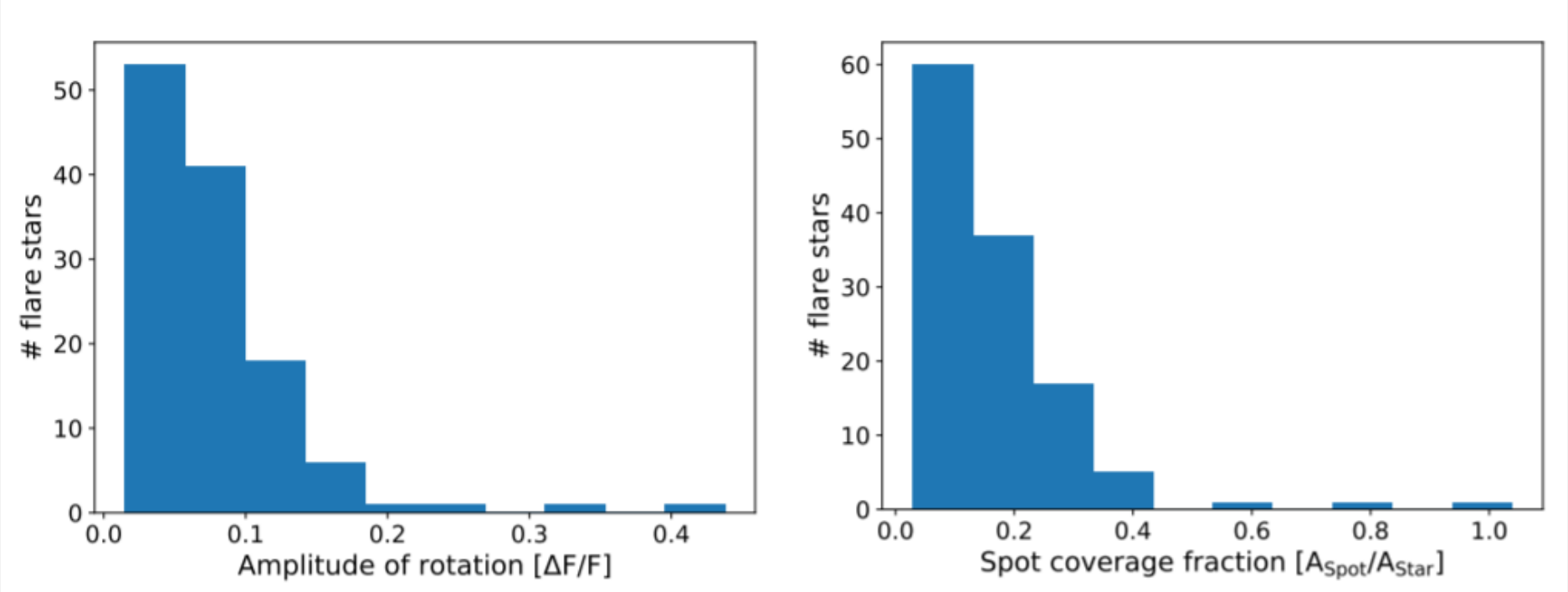


Howard et al, 2019

Evryflare:
TESS (600-1000nm)
Evryscope (410-540nm)

Late type M Dwarfs produce more but less powerful flares

RESULTS FROM THE EVRYFLARE SURVEYS



Howard et al, 2020

Flaring is influenced by amplitude of rotation and spot coverage → Star activity

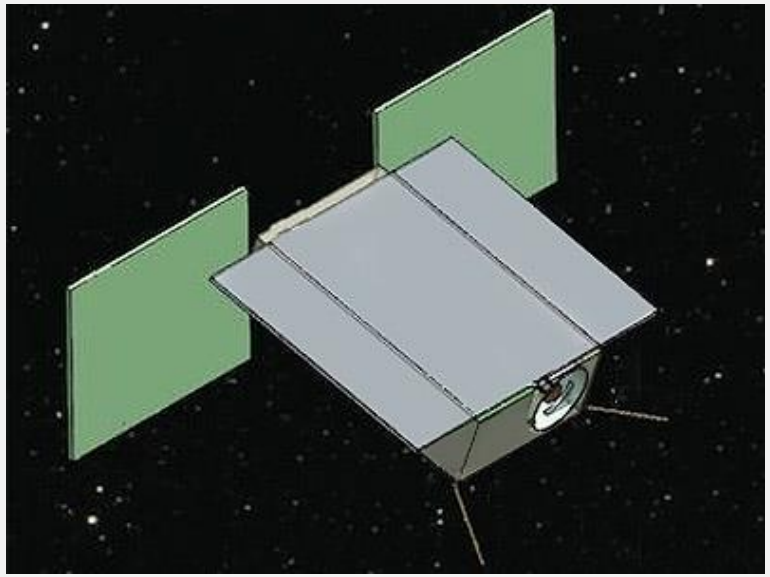
More data is needed

PHOTSAT EXPECTATIONS

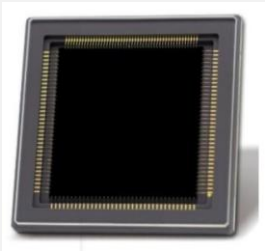
Main goals:

- Measure visible and UV flares « colors »
- Understand the visible and UV flares generation
- Better constrain the fraction of flaring M Dwarfs
- Improve the comprehension of the Star-Planet Interaction

SPARCS, similar design



Ardila et al, 2018

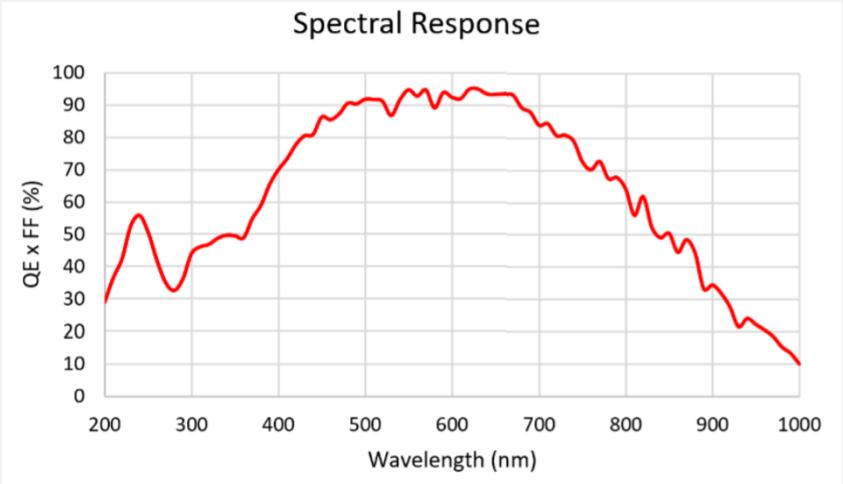


Gpixel

22,5mm x 22,5mm

90mm telescope aperture

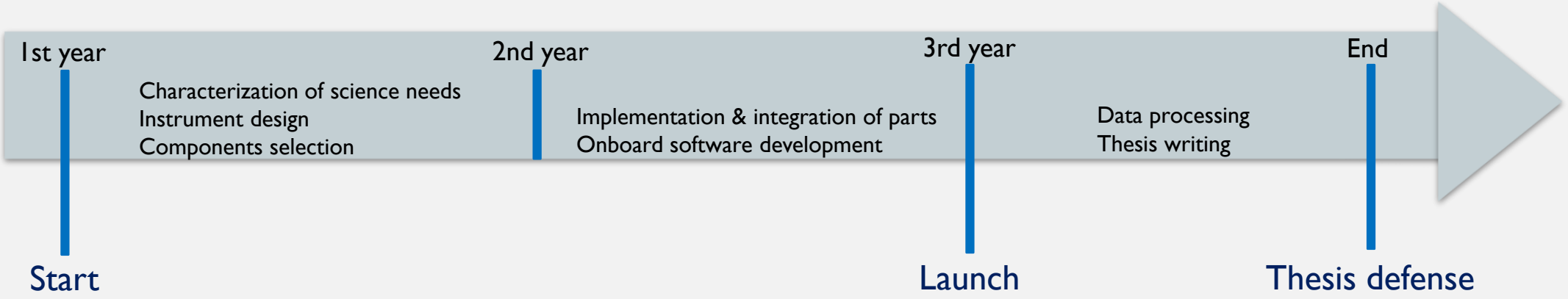
Backside Illuminated Scientific CMOS Image Sensor



All sky scanning law mode

	Flux (photon/s)	SNR (dB)
Visible (400-700mm)	4 430 000	31,75
UV (200-400mm)	2 240 000	33,23

Values for a flaring Proxima


1st year
2nd year
3rd year
End
Characterization of science needs
Instrument design
Components selection
Implementation & integration of parts
Onboard software development
Data processing
Thesis writing
Start
Launch
Thesis defense

QUESTIONS ?