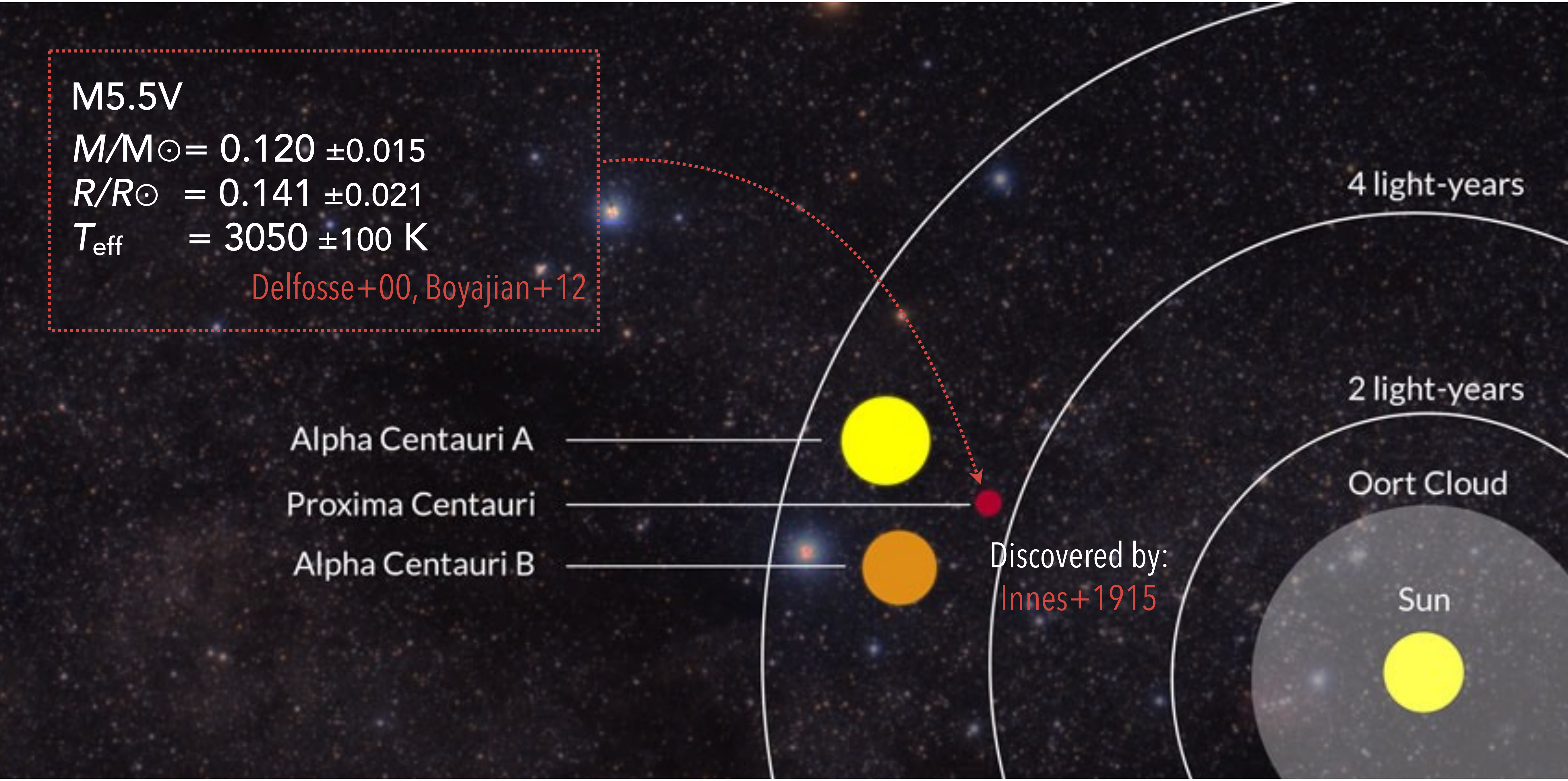
UNVEILING THE SECRETS OF
PROXIMA CENTAURI'S ENVIRONMENT



UNIVERSIDAD DE CHILE

Dr. Zaira M. Berdiñas

ALMA-CONICYT Postdoc *(Univer. de Chile)*

Diversis Mundi (ESO/Chile)

7 March 2018

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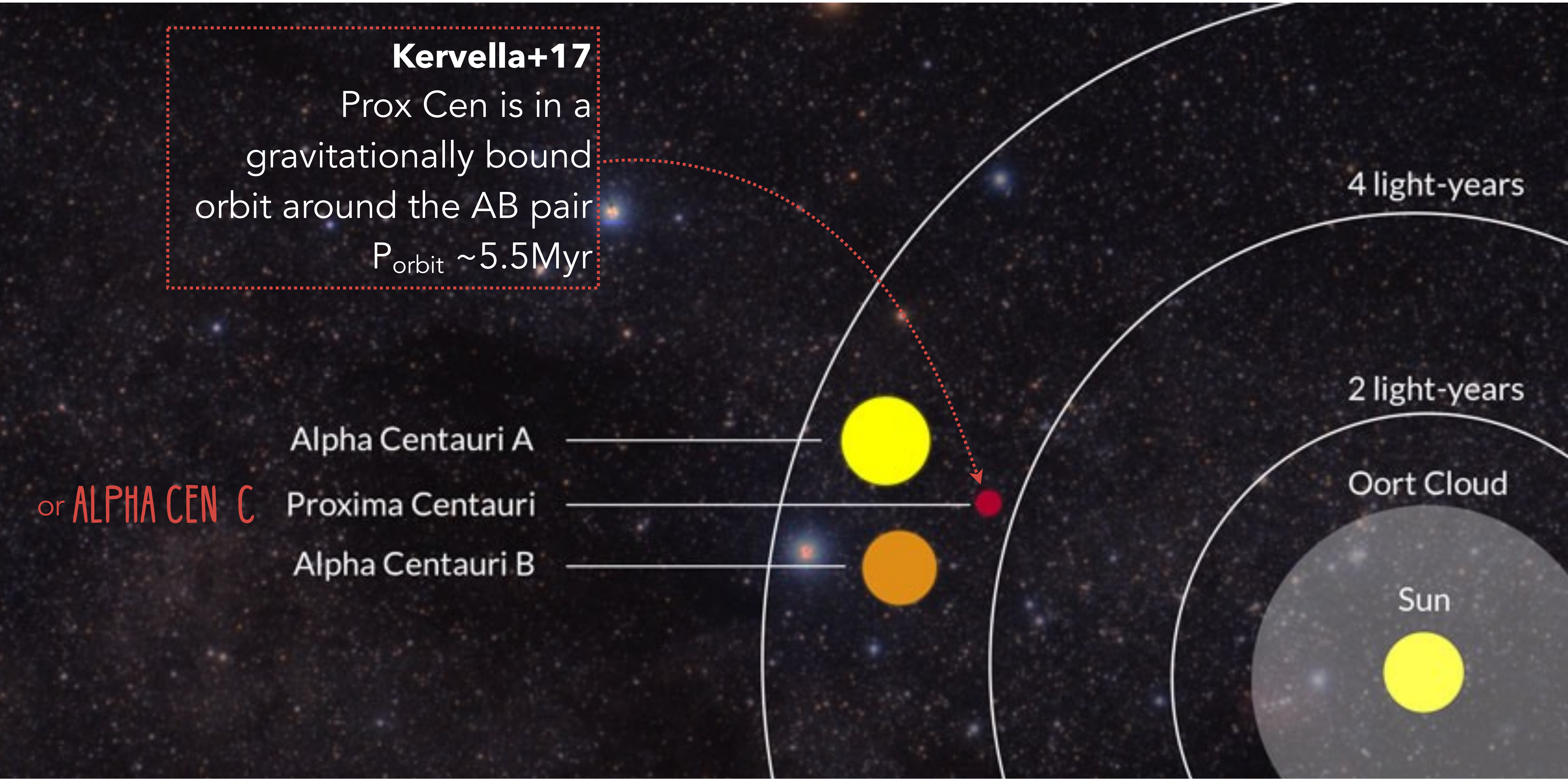

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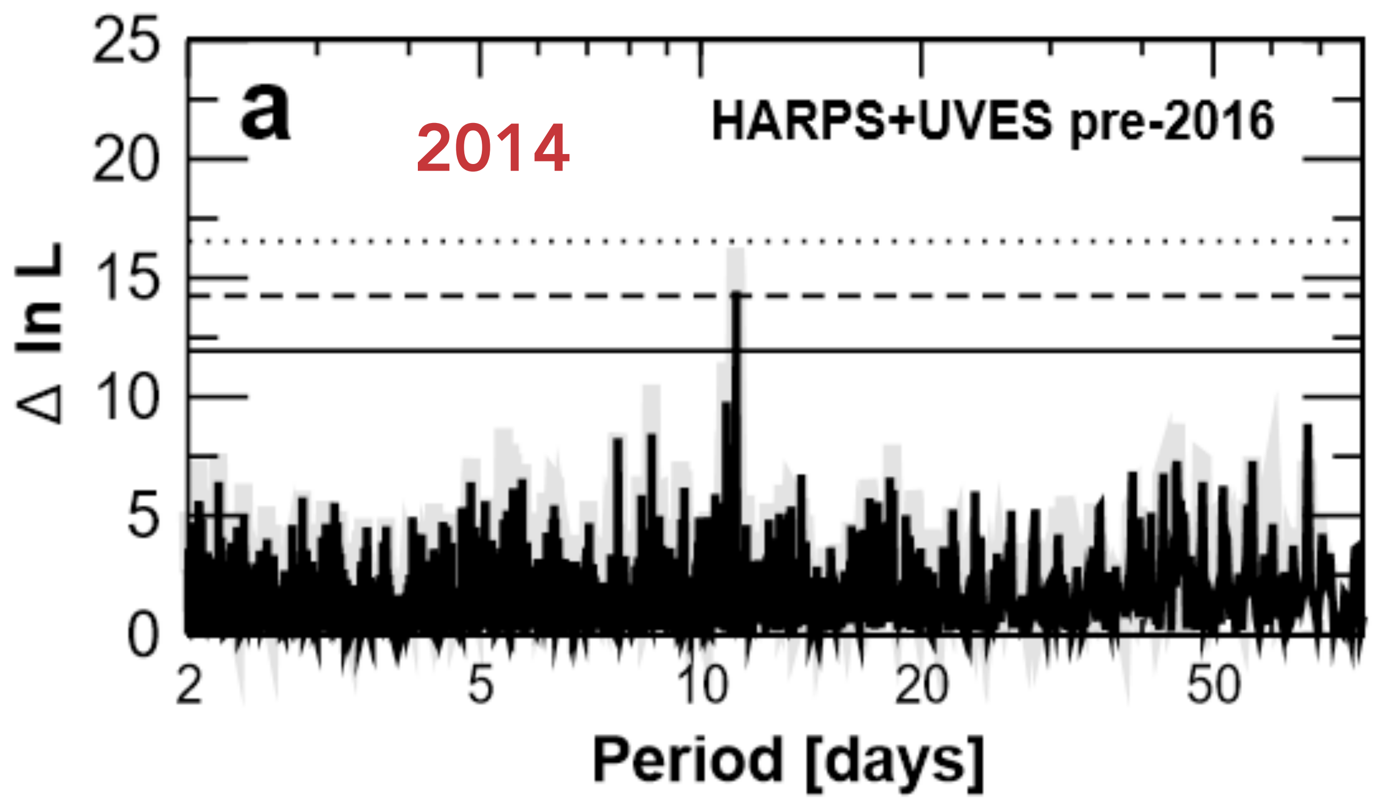
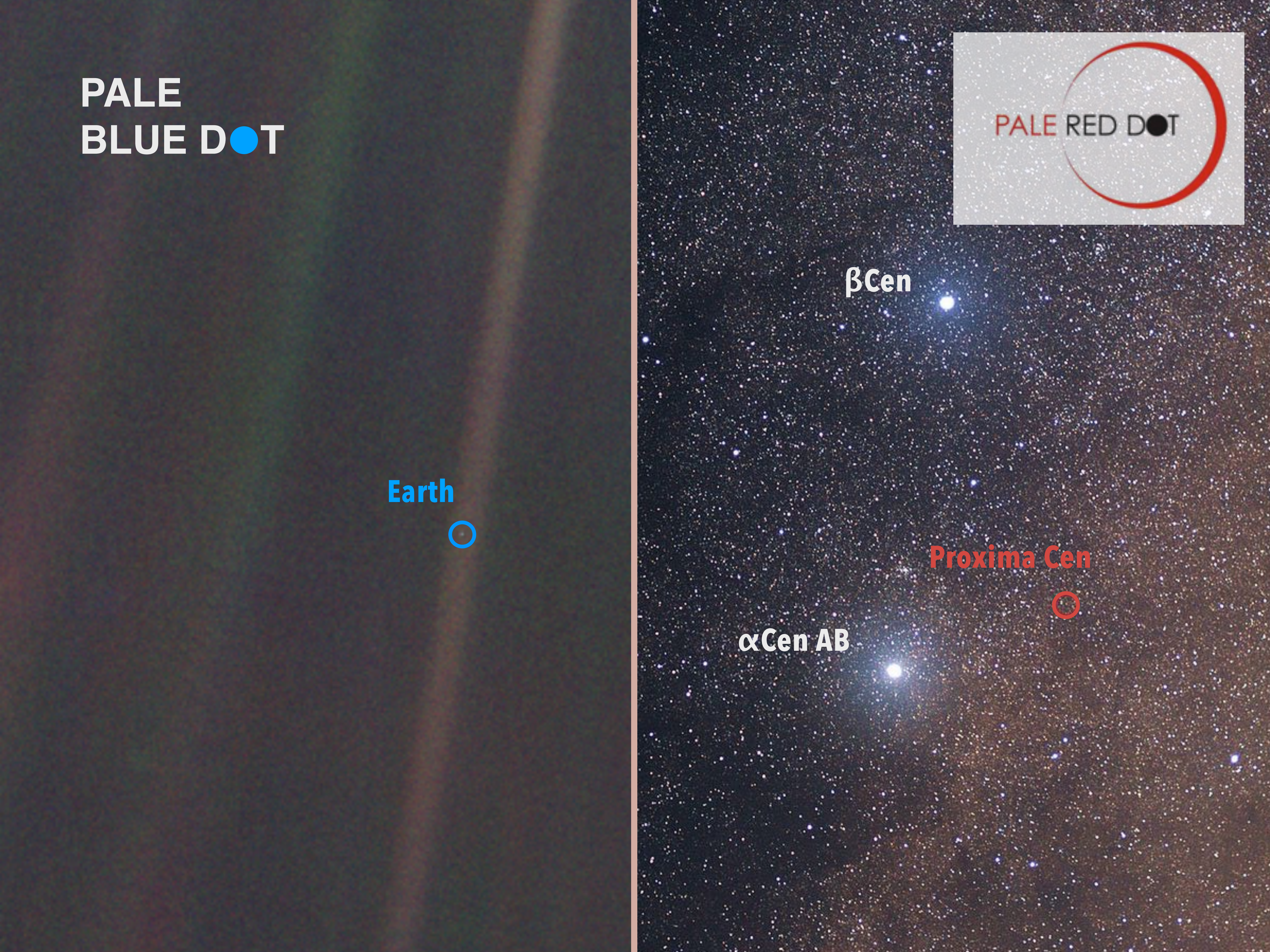


		N
2000-2008	UVES	232
2002-2012	HARPS-archive	70
2013-2014	HARPS-CTB	194
		496


PALE
BLUE DOT
Earth
PALE RED DOT
βCen
Proxima Cen
αCen AB

PALE
BLUE DOT

PALE RED DOT

βCen

Doppler Spectroscopy (HARPS) Guillem Anglada-Escude, Mathias Zechmeister

Doppler Spectroscopy (UVES) R. Paul Butler, Martin Kuerster, Michael Endl

Data analysis Mikko Tuomi, James Jenkins, Hugh R. A. Jones

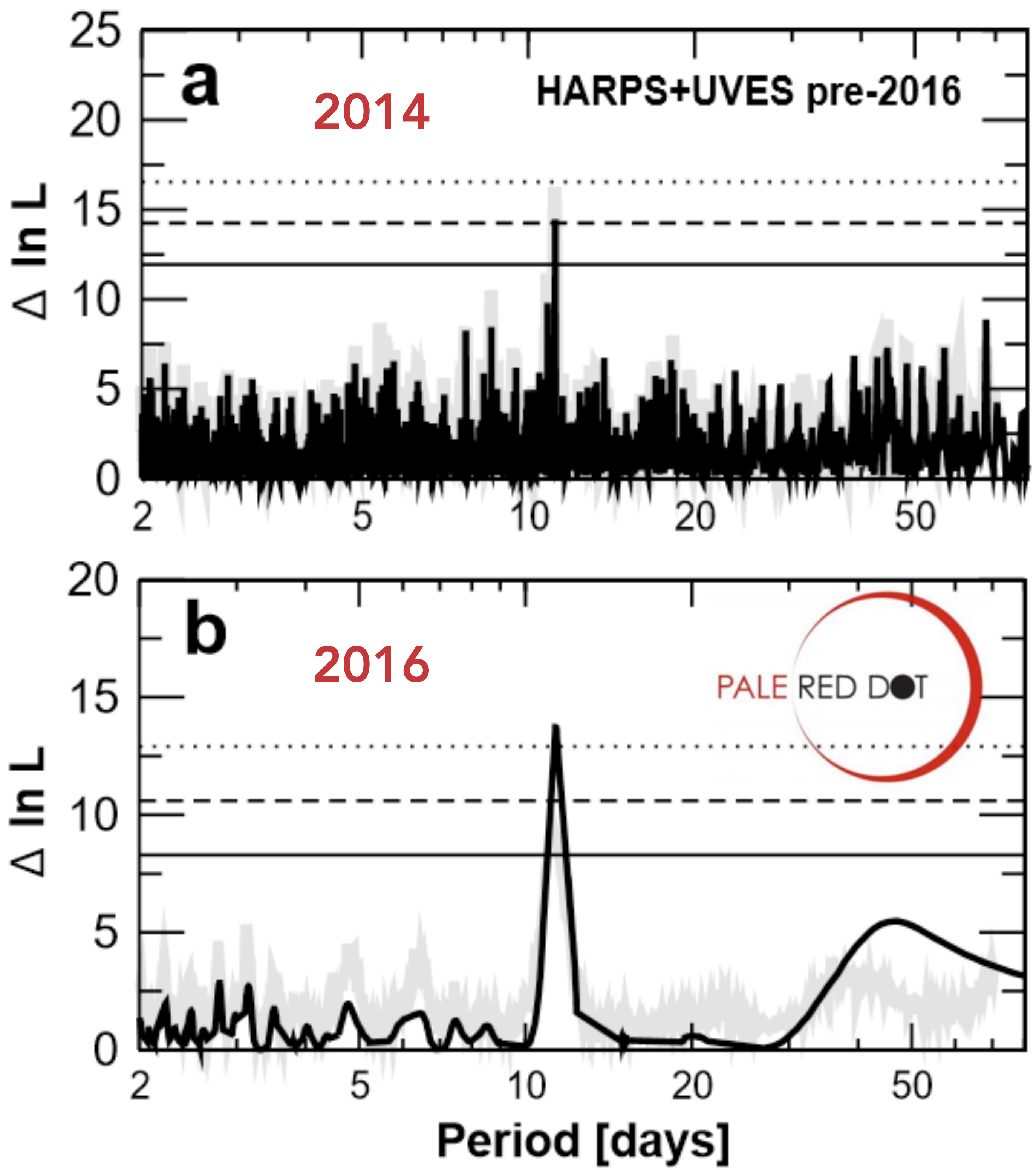
Spectroscopic Analyses John Barnes, Zaira M. Berdinas, John P. Strachan

Photometry Cristina Rodriguez-Lopez, Eloy Rodriguez, Nicolas Morales, Jose Ortiz, Ignacio de la Cueva, Maria J. Lopez Gonzalez(ASH2), Yiannis Tsappras (lcogt.net), Aviv Ofir, Marcin Kiraga

Stellar physics and activity Ansgar Reiners, Pedro Amado, Sandra V. Jeffers, Julien Morin

Planet formation and Dynamics Richard P. Nelson, Gavin Coleman, Sijme-Jan Paardekooper, Stefan Dreizler, Benjamin Giesers

Observers Christopher Marvin, Luis F. Sarmiento



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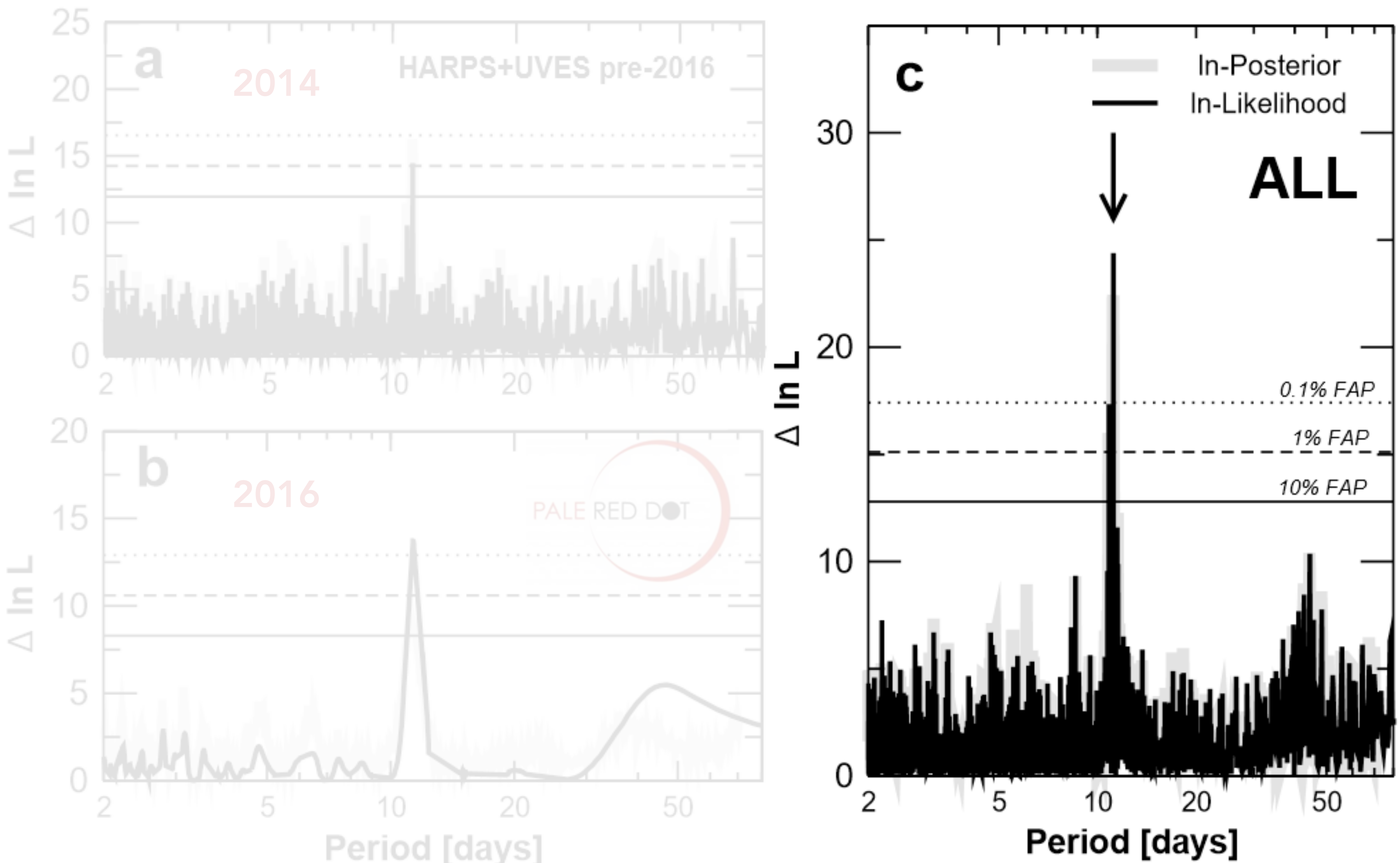
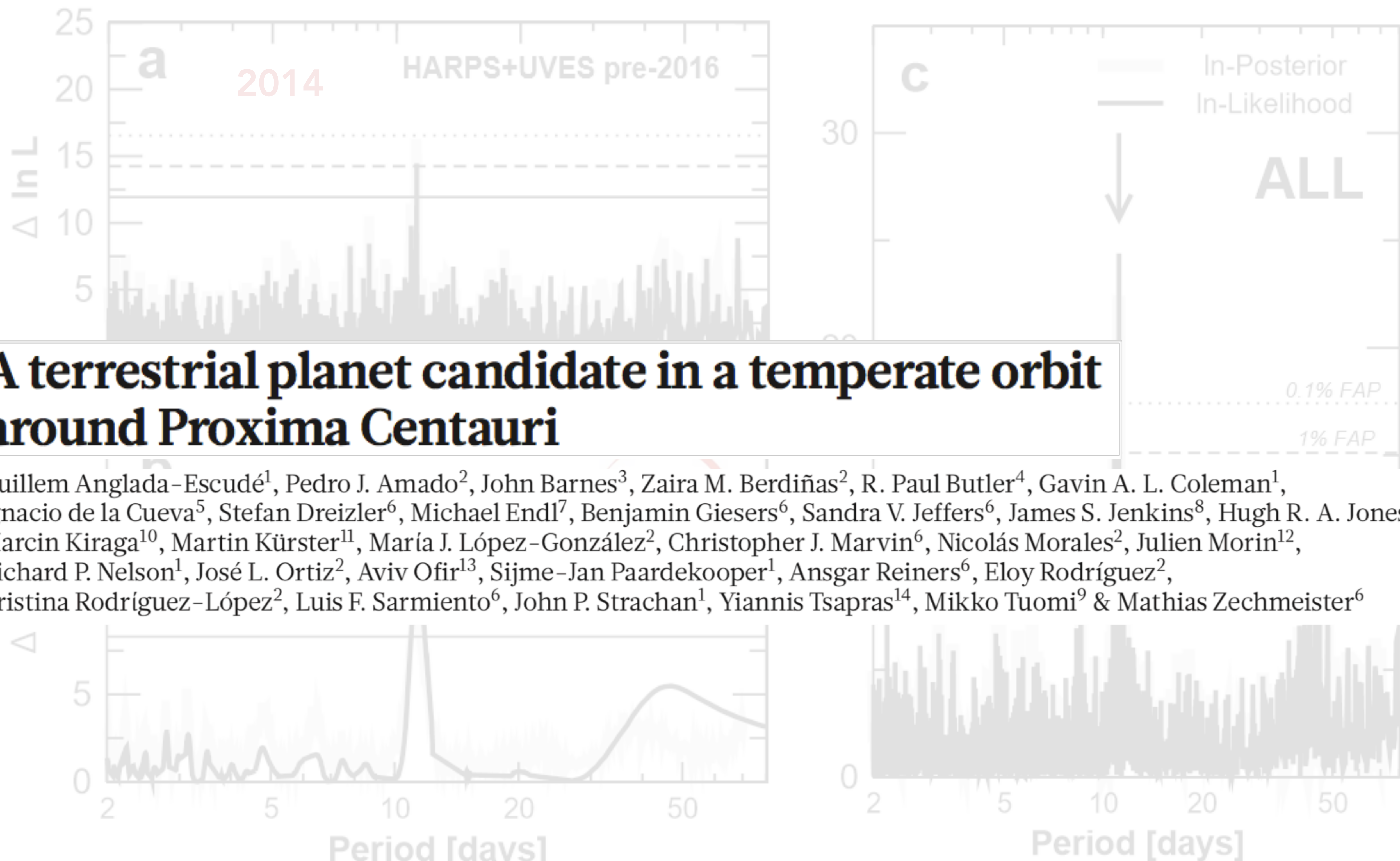
2016: HARPS-Pale Red Dot	54

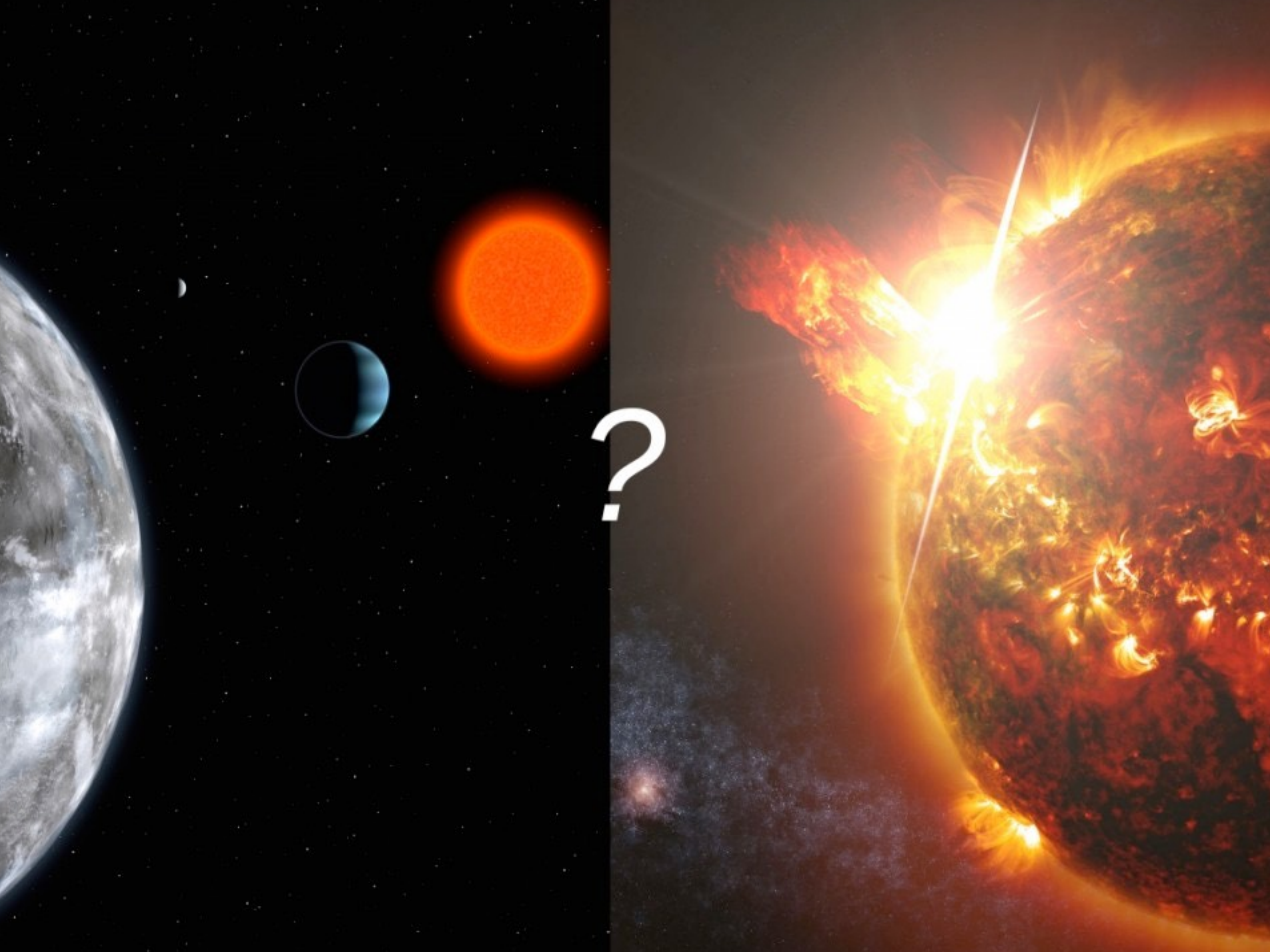


a
2014
HARPS+UVES pre-2016
b
2016
PALE RED DOT
c
ln-Posterior
ln-Likelihood
ALL
0.1% FAP
1% FAP
10% FAP
Δ ln L
Period [days]



A terrestrial planet candidate in a temperate orbit around Proxima Centauri

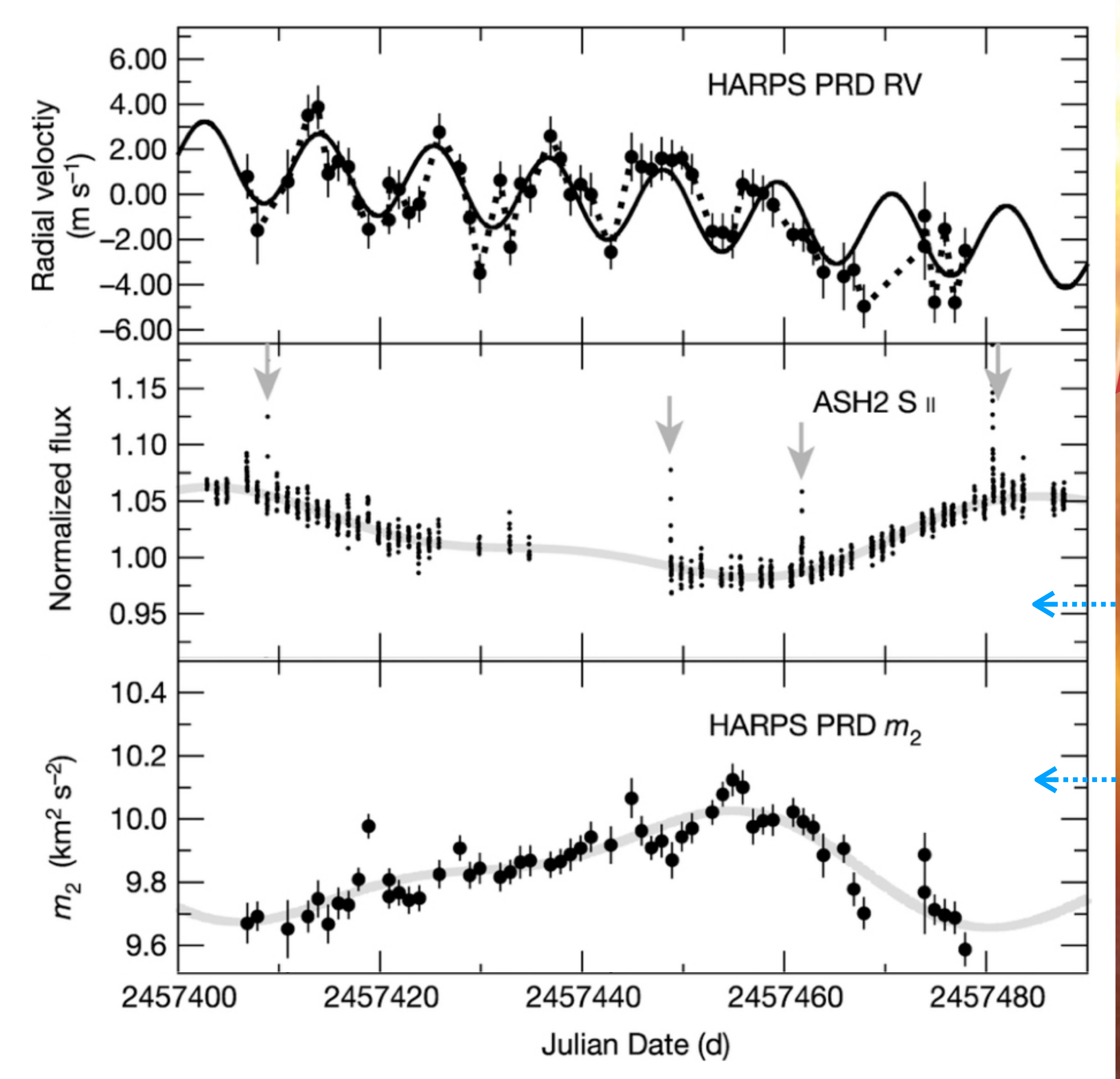
Guillem Anglada-Escudé[1], Pedro J. Amado[2], John Barnes[3], Zaira M. Berdiñas[2], R. Paul Butler[4], Gavin A. L. Coleman[1], Ignacio de la Cueva[5], Stefan Dreizler[6], Michael Endl[7], Benjamin Giesers[6], Sandra V. Jeffers[6], James S. Jenkins[8], Hugh R. A. Jones[9], Marcin Kiraga[10], Martin Kürster[11], María J. López-González[2], Christopher J. Marvin[6], Nicolás Morales[2], Julien Morin[12], Richard P. Nelson[1], José L. Ortiz[2], Aviv Ofir[13], Sijme-Jan Paardekooper[1], Ansgar Reiners[6], Eloy Rodríguez[2], Cristina Rodríguez-López[2], Luis F. Sarmiento[6], John P. Strachan[1], Yiannis Tsapras[14], Mikko Tuomi[9] & Mathias Zechmeister[6]



HARPS, La Silla/ESO, Doppler RV

LCOGT.net, Photometry

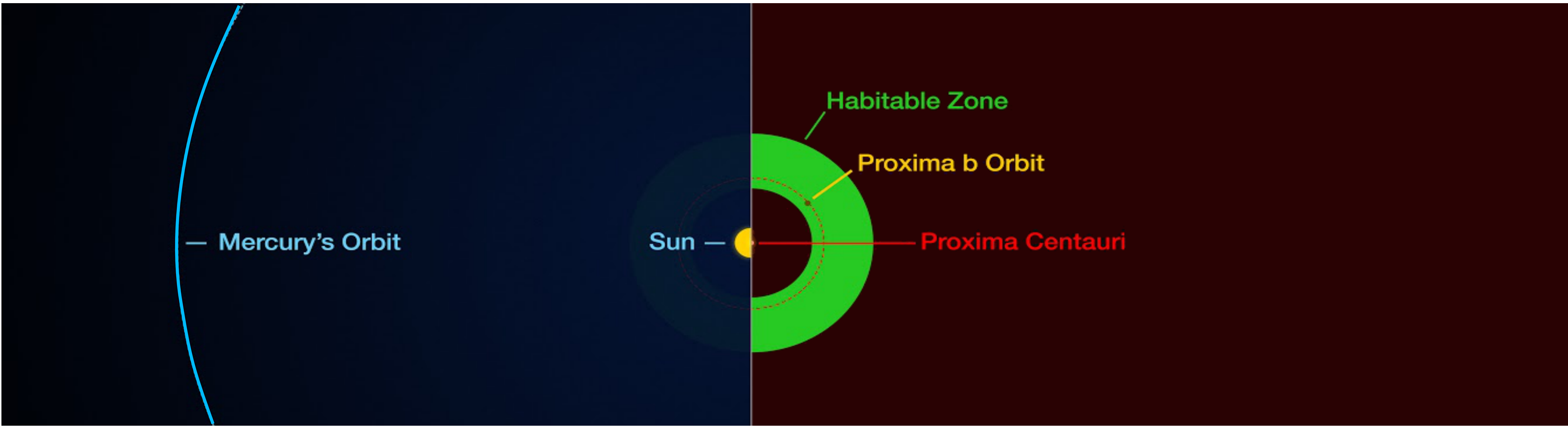
ASH2-SpaceObs, Photometry



m_2 is a spectroscopic measurement which follows the photometry !

See Berdiñas+16

What did we find about Proxima b ?



Min Mass	$m_p \sin(i) = 1.27 \pm 0.095\ M_\oplus$	semi-major axis	a = 0.0485 ±0.0046 au
Period	P = 11.186 ±0.0015 days	Irradiance	65% compared to Earth
eccentricity	<0.35	Eq Temp.	T = 234 ±10 K

Anglada-Escudé+16

HABITABLE ZONE ≠ HABITABLE PLANET

The habitability recipe

1. **Be at the right distance from the star** —> Yes! It is… now.
2. **Have initial reservoirs of water** —> ?
3. **Have an atmosphere** —> If exists… can it keep it?
4. **Have a magnetic field** —> Would it be strong enough?
5. **Be a terrestrial planet** —> The orbit inclination is needed.

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Ribas+16 –> "Proxima b is likely to have lost less than an Earth ocean's worth of hydrogen (EO_H) before it reached the HZ 100-200 Myr after its formation."

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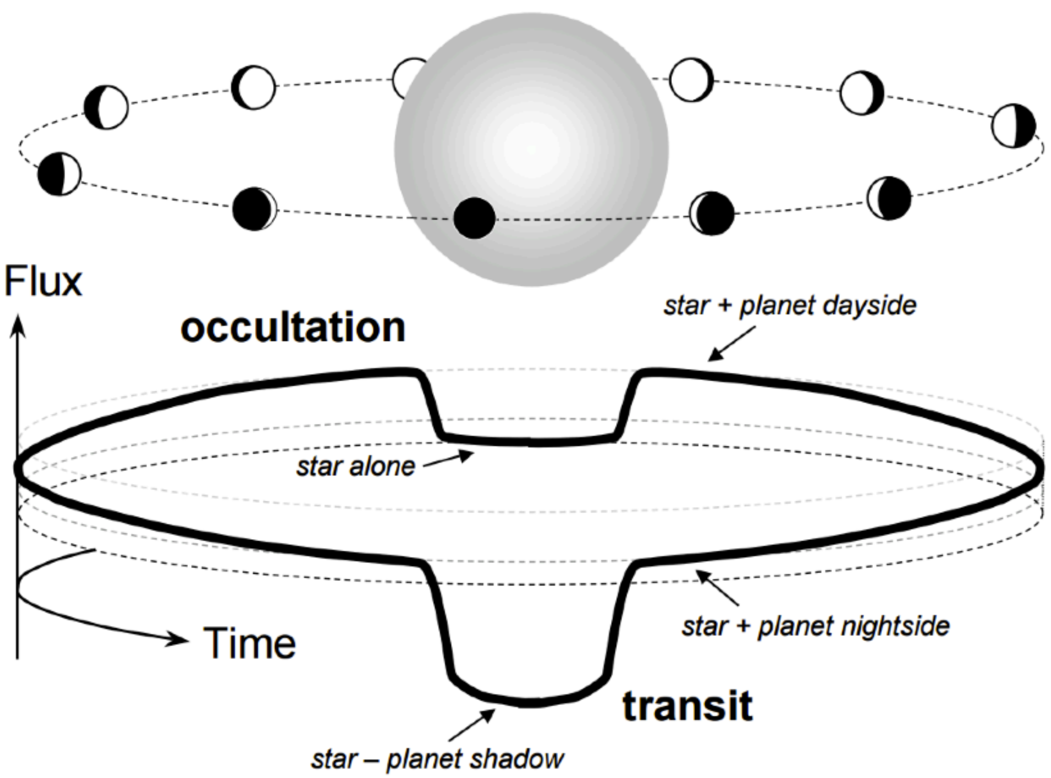
How to get the orbit inclination



➡ From **transits**: R_p , i => m_p [extra: Atm]

- Three non-conclusive candidate transits:

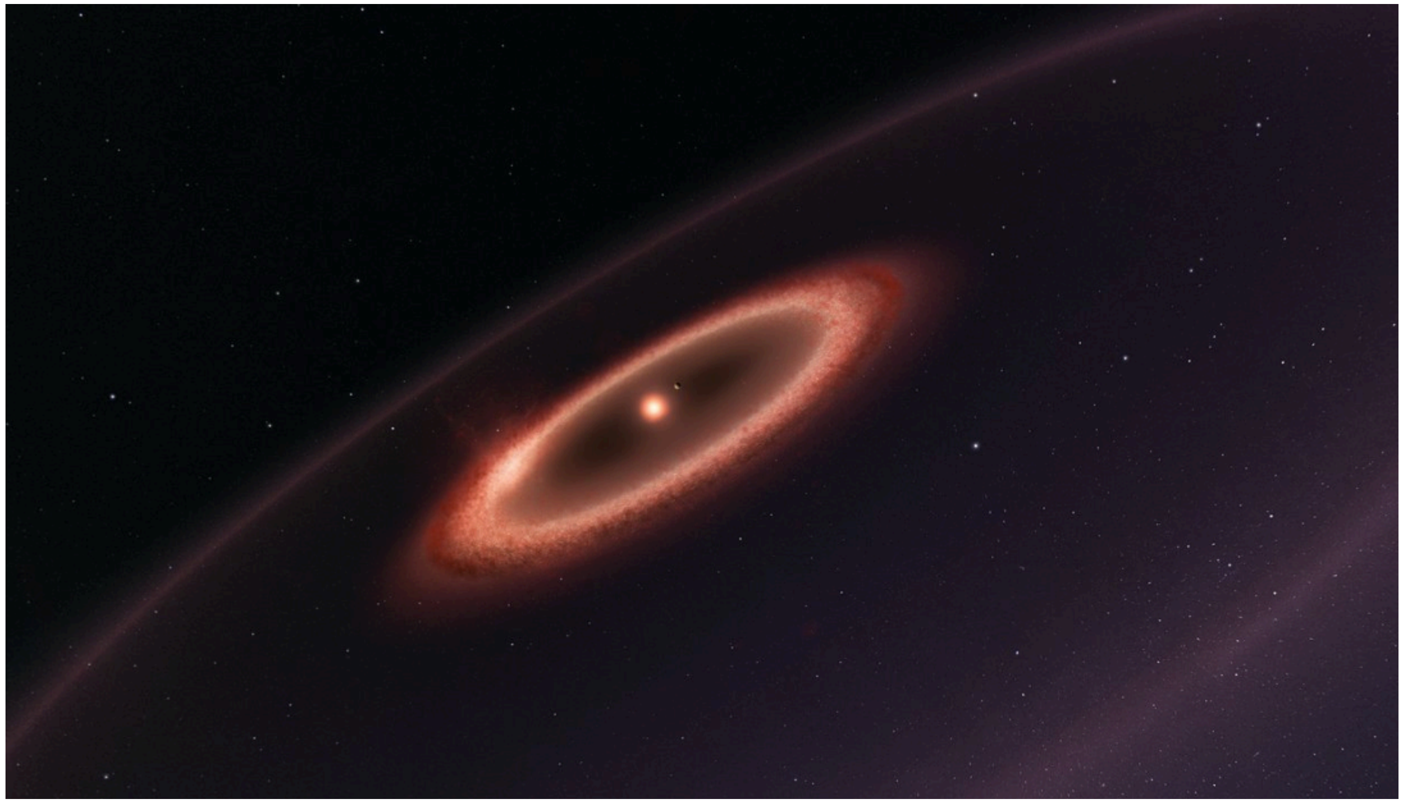
1. *MOST* (Kipping+16)
2. BSST in Antarctic (Liu+18)
3. Las Campanas Observatory (Li+17)

- Likely require nIR (e.g. Spitzer) to suppress flaring

See poster by Nicolás Kurtovic

➡ Search for a **debris disk**: i => m_p [extra: system dust structure]

ALMA!

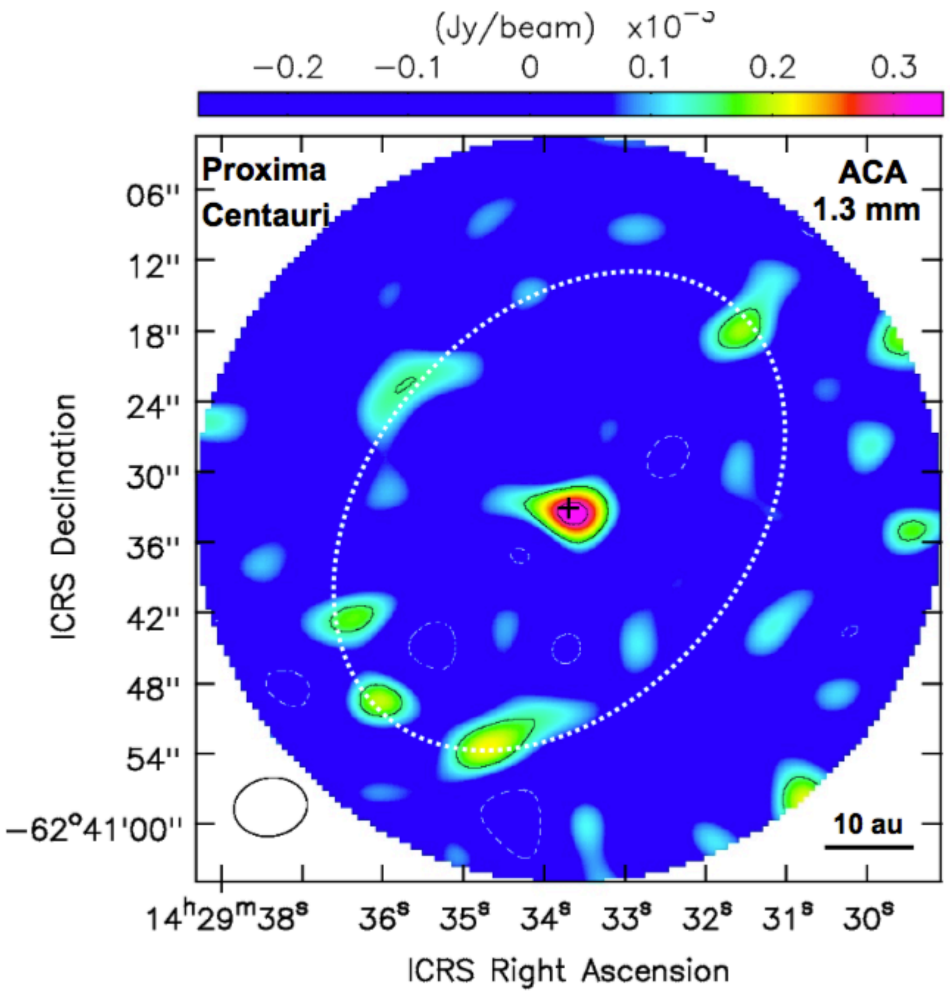


Nov 2017

ALMA DISCOVERY OF DUST BELTS AROUND PROXIMA CENTAURI

Guillem Anglada,[1] Pedro J. Amado,[1] Jose L. Ortiz,[1] José F. Gómez,[1] Enrique Macías,[2] Antxon Alberdi,[1] Mayra Osorio,[1] José L. Gómez,[1] Itziar de Gregorio-Monsalvo,[3,4] Miguel A. Pérez-Torres,[1,5] Guillem Anglada-Escudé,[6] Zaira M. Berdiñas,[7,1] James S. Jenkins,[7] Izaskun Jimenez-Serra,[6] Luisa M. Lara,[1] Maria J. López-González,[1] Manuel López-Puertas,[1] Nicolas Morales,[1] Ignasi Ribas,[8] Anita M. S. Richards,[9] Cristina Rodríguez-López,[1] and Eloy Rodriguez[1]

ACA => 13 epochs x~1.6h (21/1/-24/3/2017)



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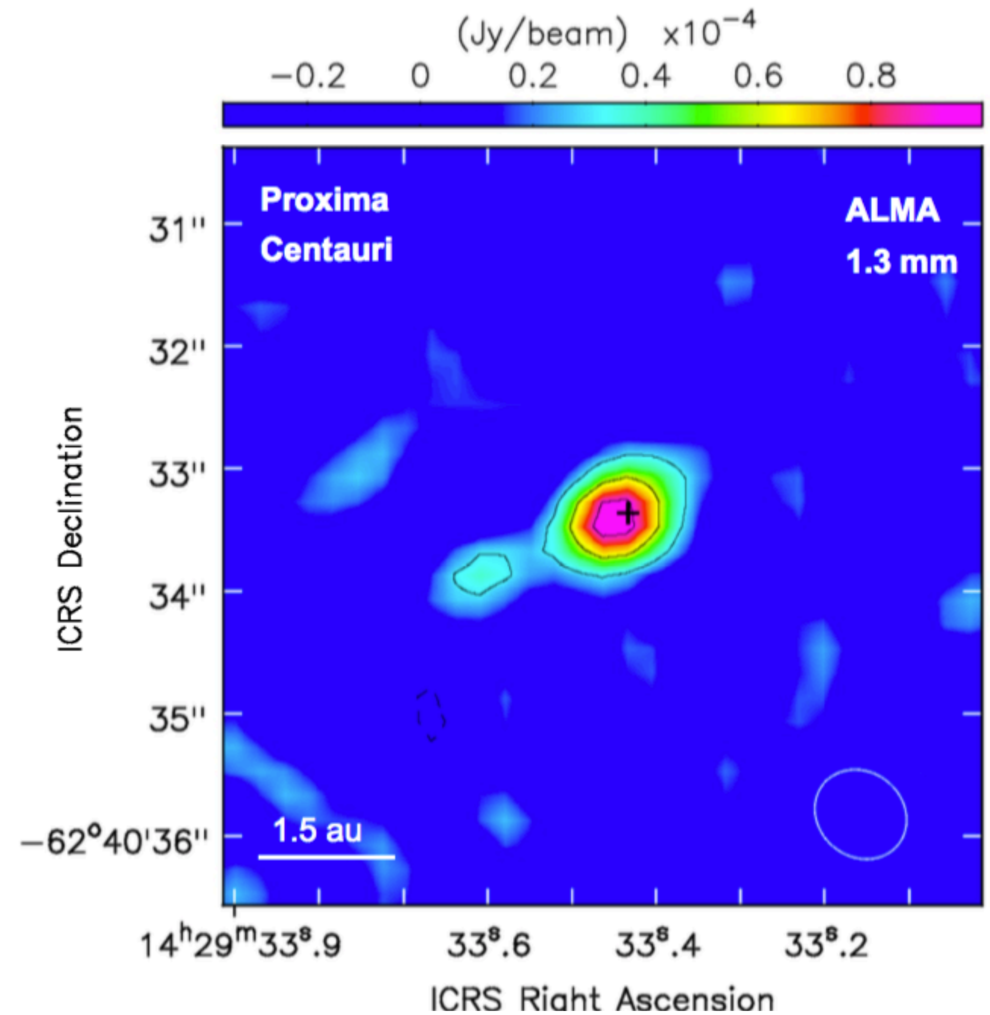

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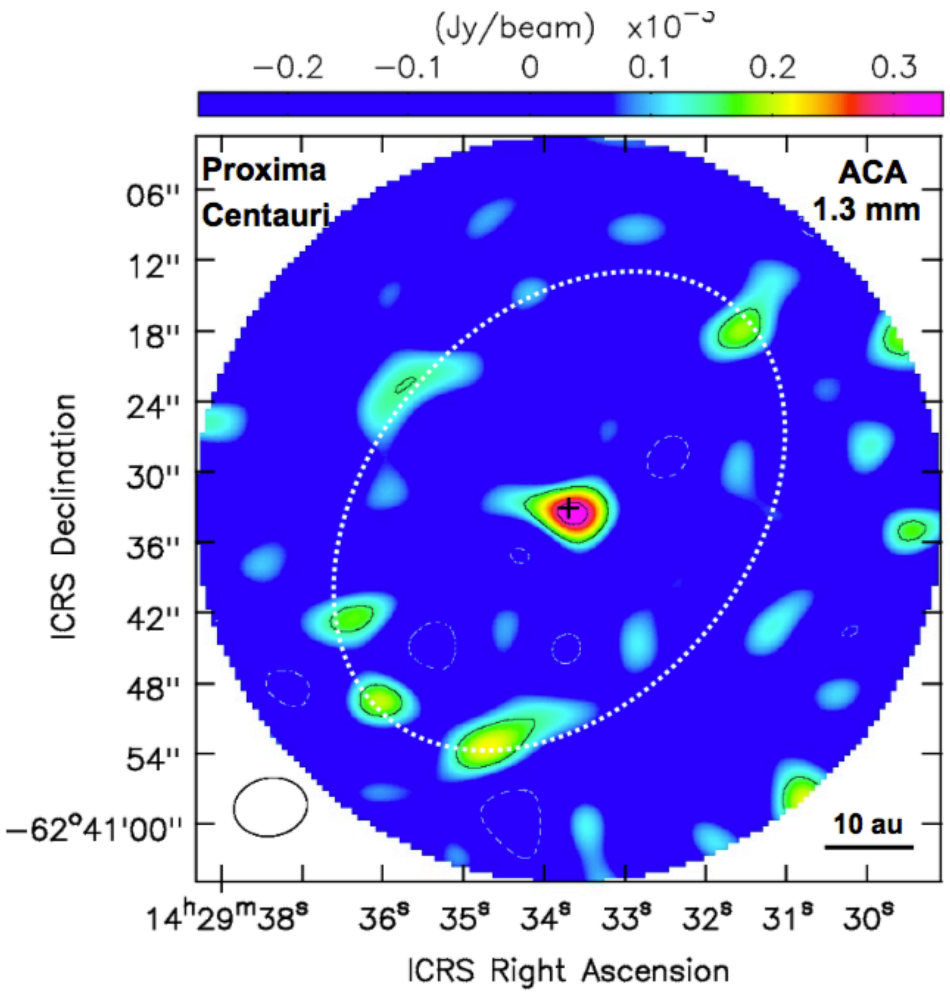

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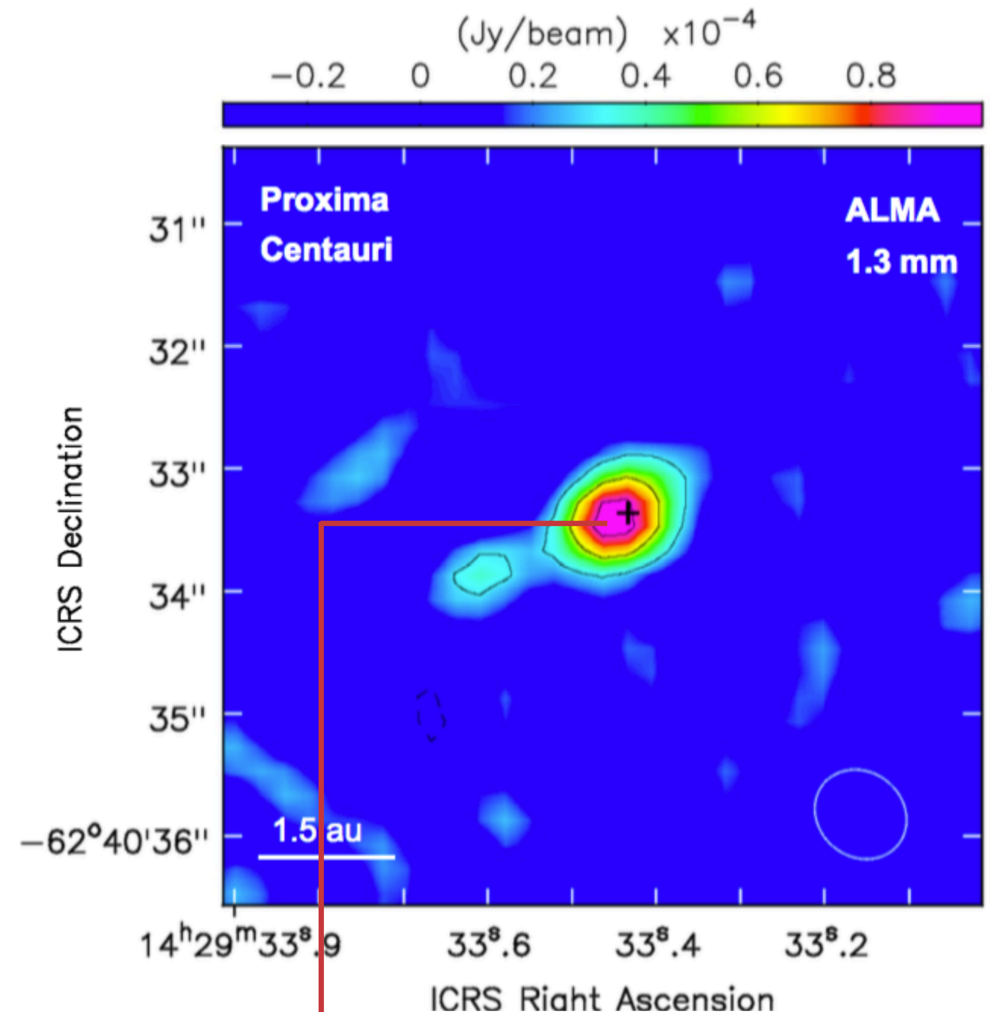

106 ±12 μJy *(>9σ)*

74 ±4 μJy
expected thermal emission from the star

~30 μJy

warm dust,
r~0.4 au *(2)*

Talk by S. Marino

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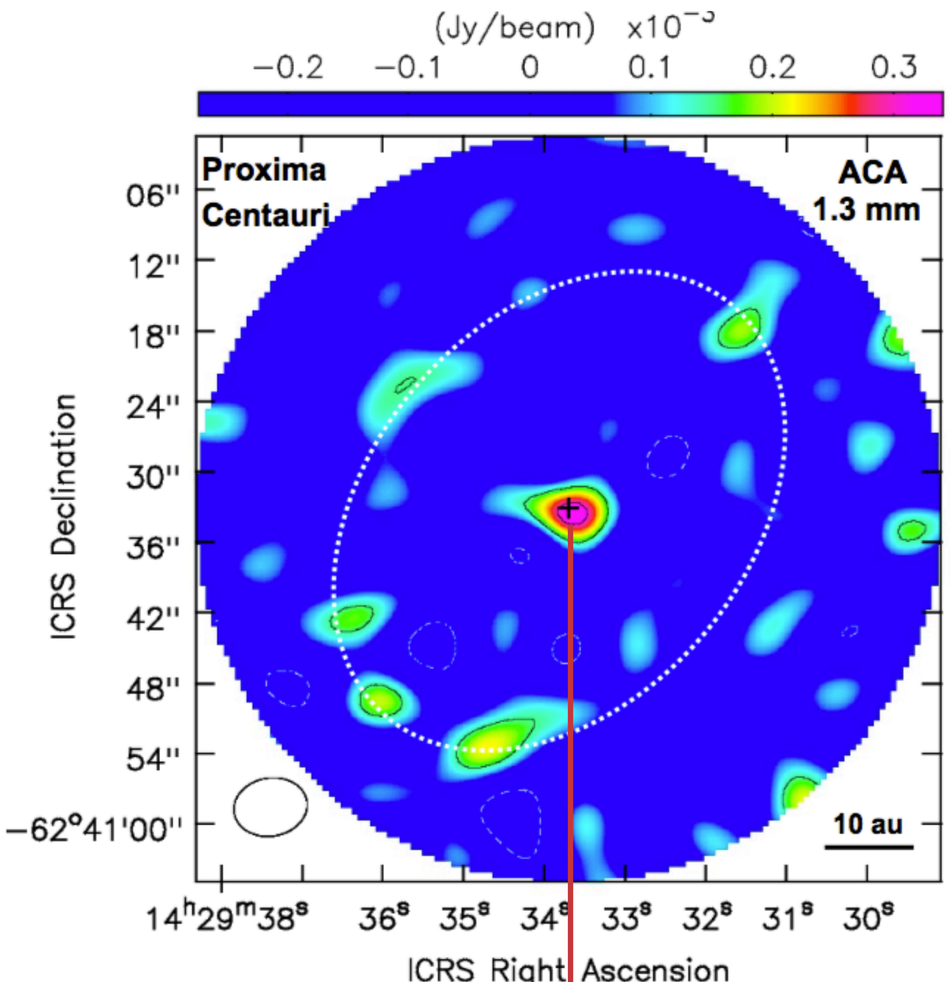

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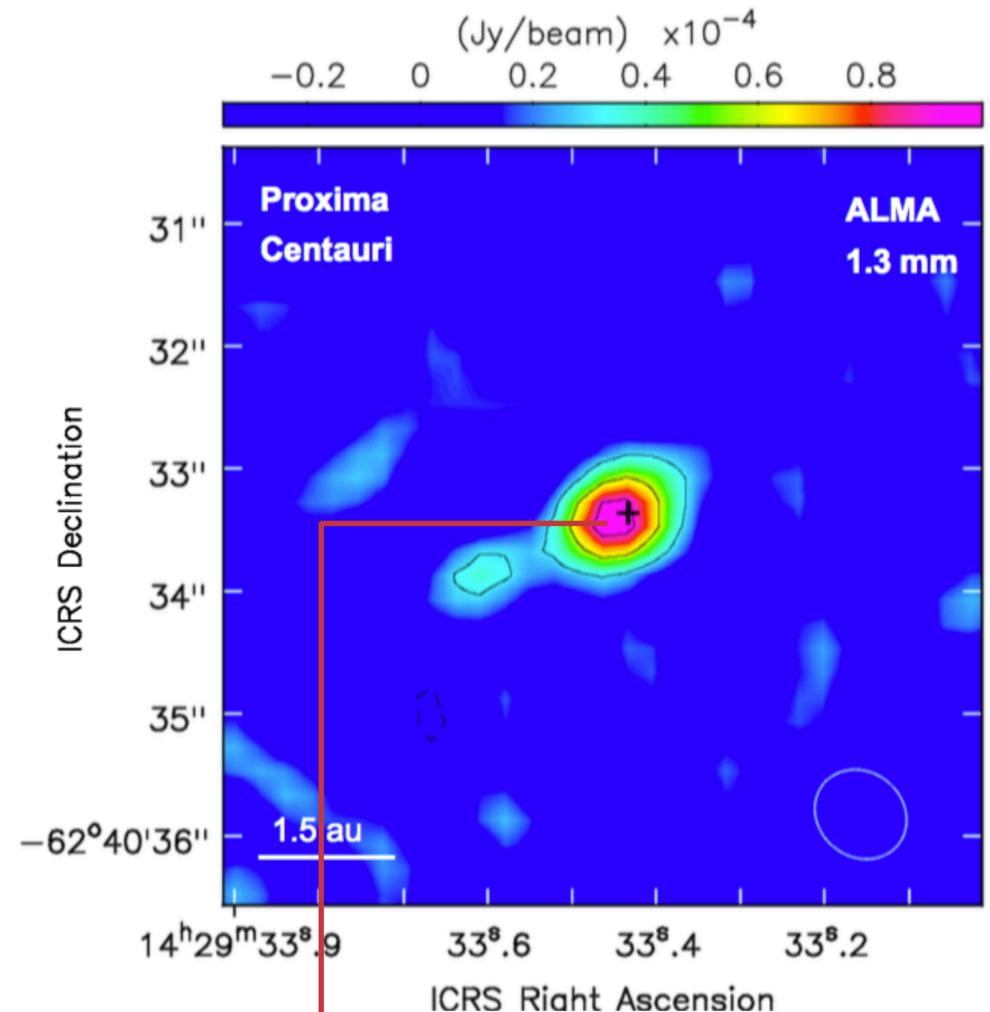

340 ±60 μJy *(>6σ)*

106 ±12 μJy *(>9σ)*

~30 μJy

warm dust, r~0.4 au *(2)*

74 ±4 μJy
expected thermal
emission from the star

~270 μJy

cold belt, r~1-4au *(4)*

Nov 2017

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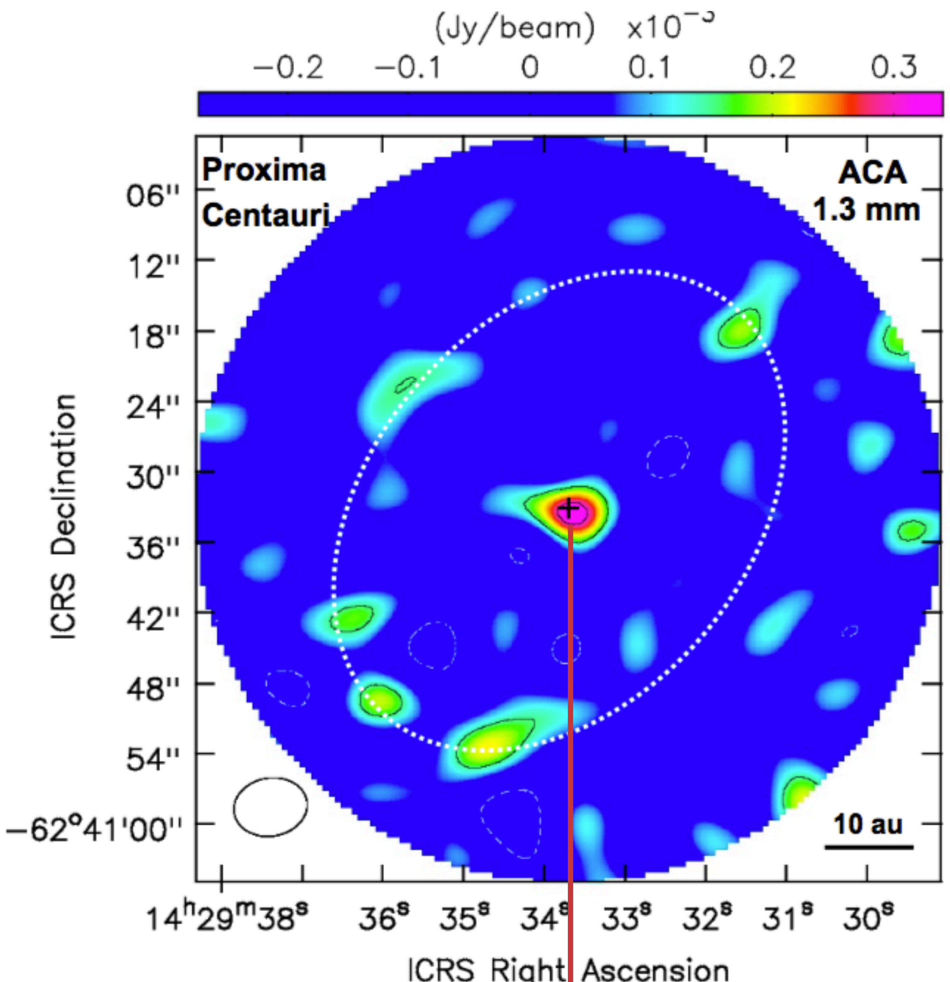

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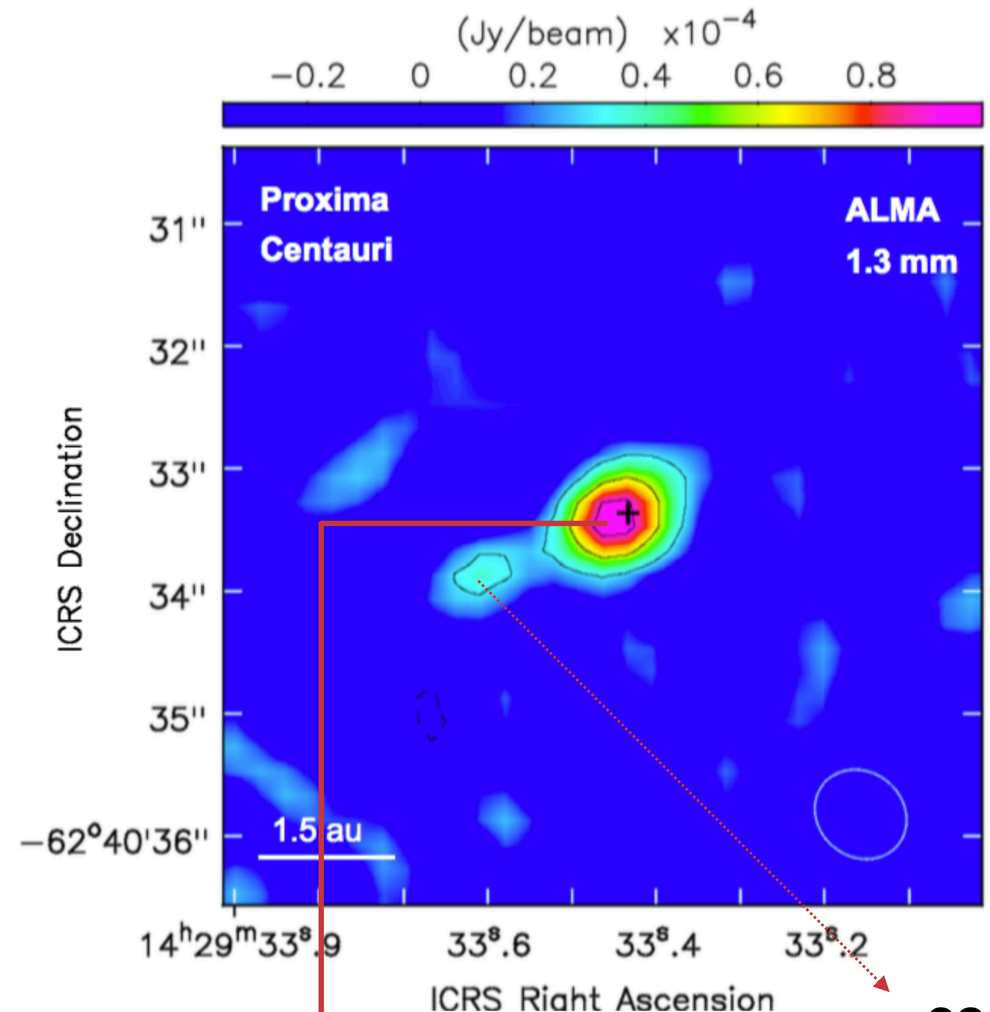

340 ±60 μJy *(>6σ)*

106 ±12 μJy *(>9σ)*

~30 μJy

warm dust, r~0.4 au *(2)*

74 ±4 μJy
expected thermal emission from the star

~270 μJy

cold belt, r~1-4au *(4)*

38 ±10 μJy *(>3σ)*

Unknown source,
r~1.6 au *(3)*

noise, trojans,
planet ring,
backg. source,
collision residuals

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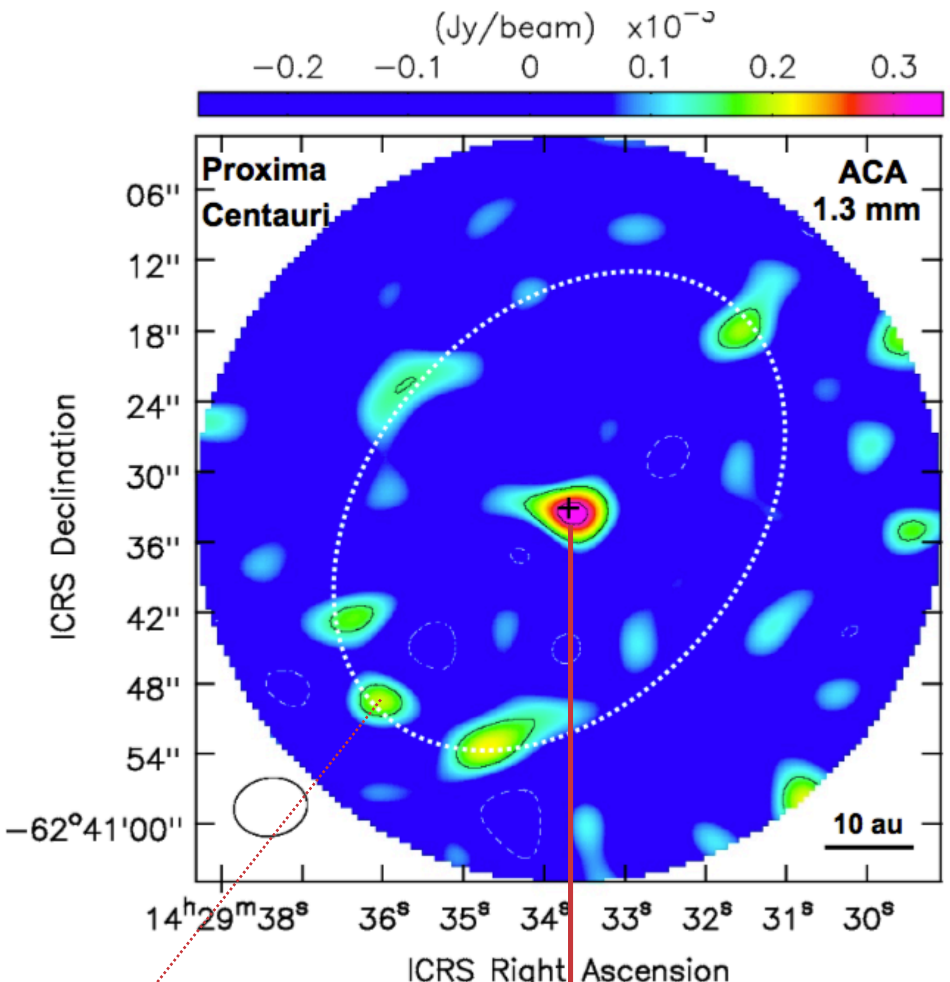

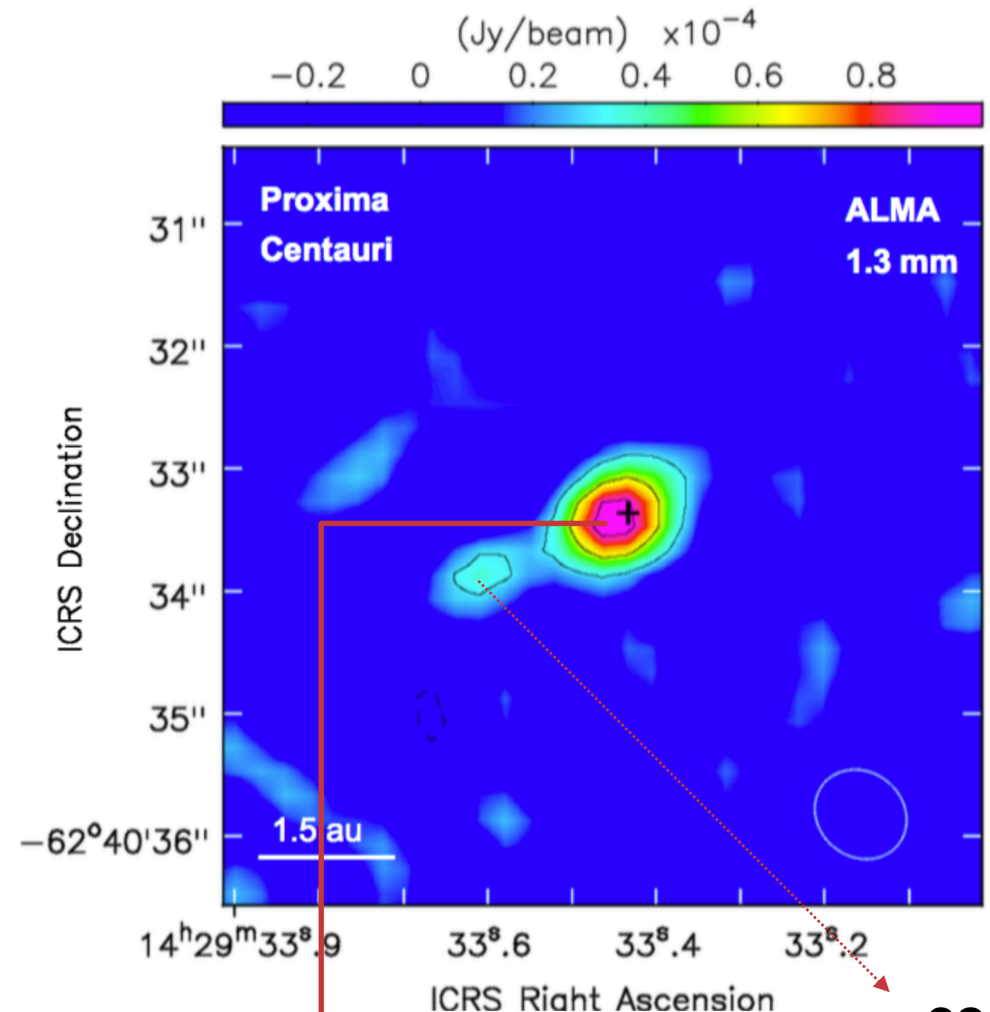

~1.7 mJy

(>3σ, i~45º)

outer belt? , r~30au *(5)*

340 ±60 μJy ***(>6σ)***

106 ±12 μJy ***(>9σ)***

~270 μJy

cold belt, r~1-4au *(4)*

74 ±4 μJy

expected thermal emission from the star

~30 μJy

warm dust, r~0.4 au *(2)*

38 ±10 μJy ***(>3σ)***

Unknown source, r~1.6 au *(3)*

noise, trojans, planet ring, backg. source, collision residuals

Nov 2017

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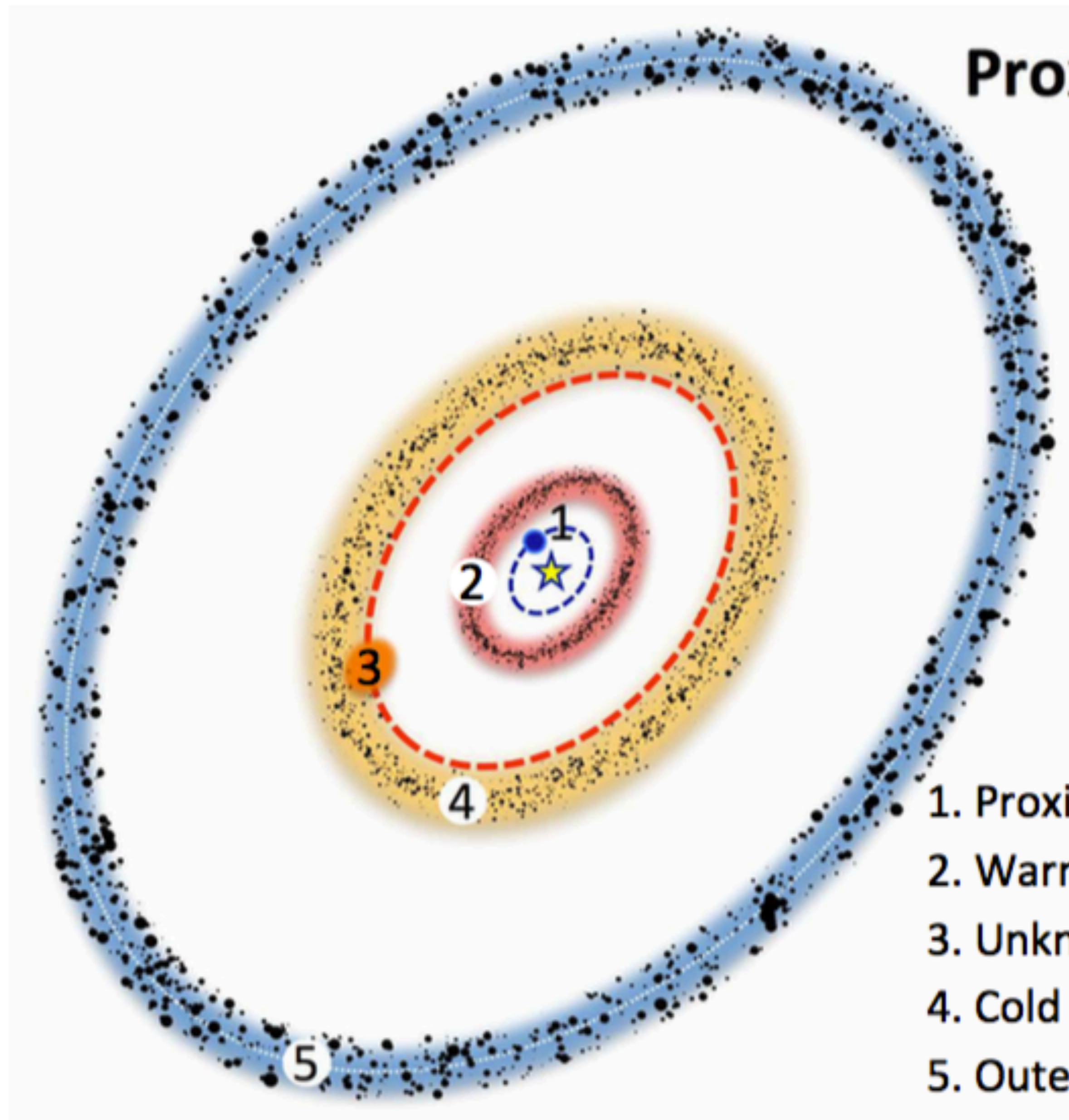


Proxima Centauri

if coplanarity
m_p=1.8 $M_\oplus$

1. Proxima b planet   r = 0.05 au
2. Warm dust?   r ≈ 0.4 au   T=90K, m_d≃5.5x10^{-7}$M_\oplus$
3. Unknown source?   r = 1.6 au
4. Cold belt   r ≈ 1-4 au   T=40K, m_d≃0.4x10^{-6}$M_\oplus$
5. Outer belt ?   r = 30 au   T=10K, m_d≃1.4x10^{-4}$M_\oplus$

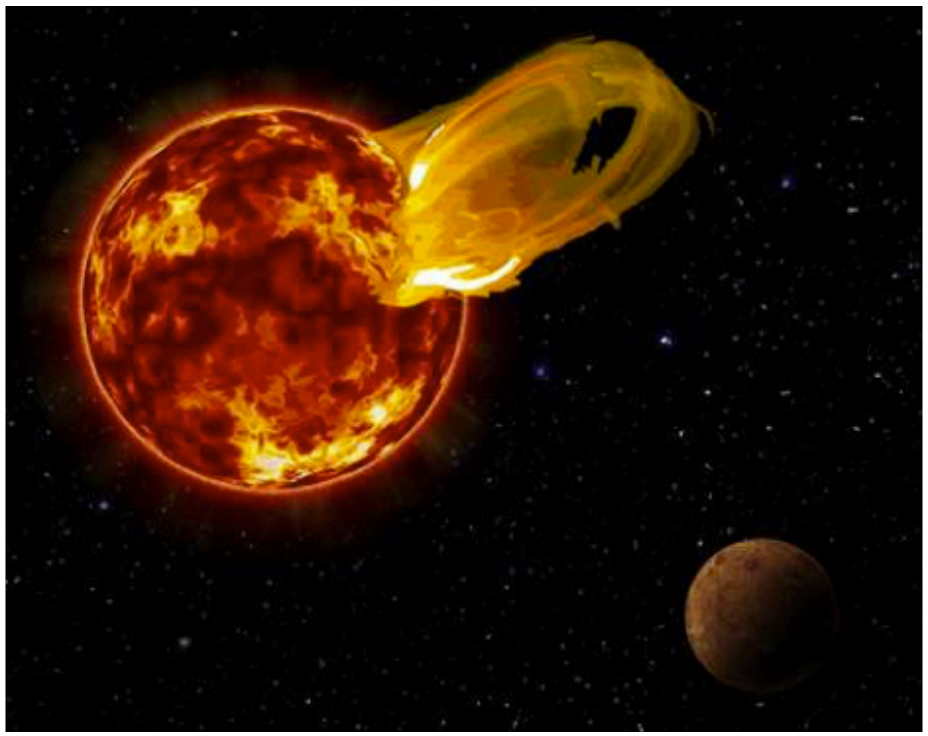
Nov 2017

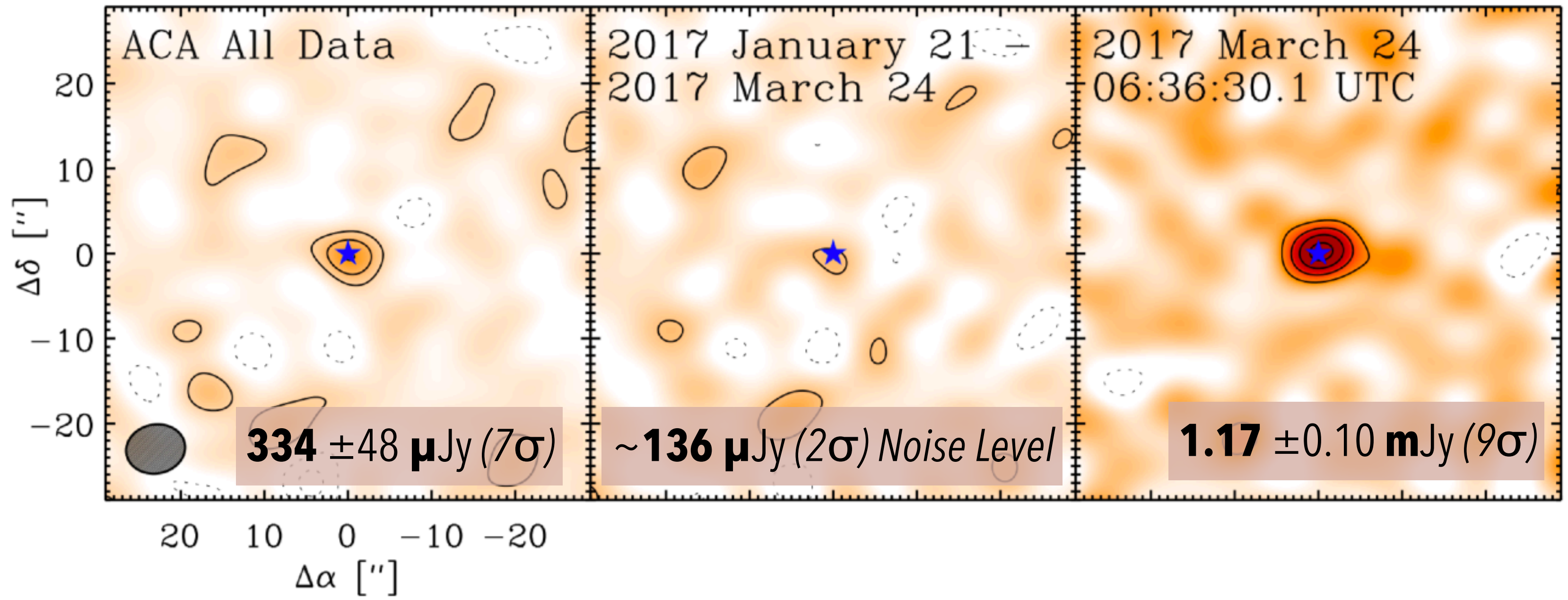
ALMA DISCOVERY OF DUST BELTS AROUND PROXIMA CENTAURI

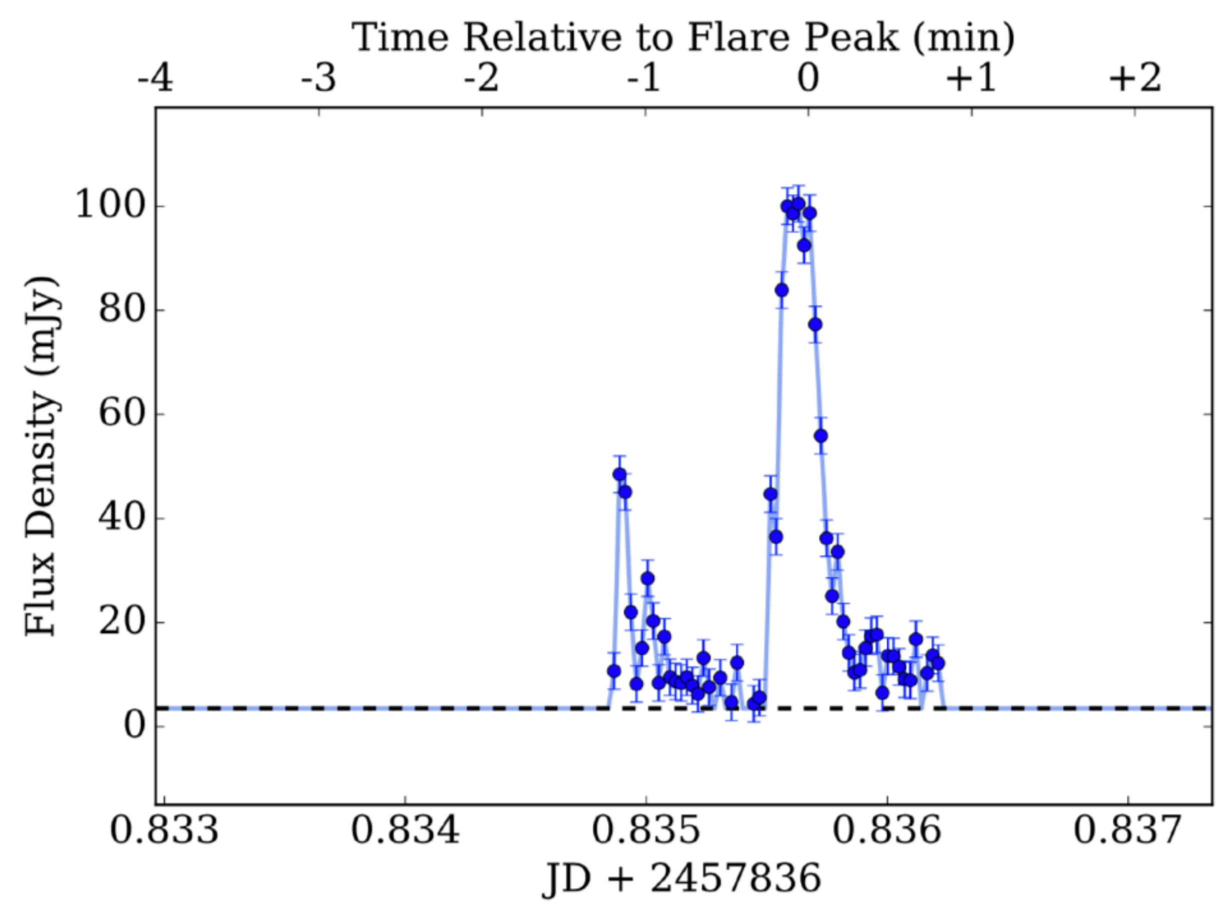
Feb 2018

DETECTION OF A MILLIMETER FLARE FROM PROXIMA CENTAURI

Meredith A. MacGregor[1,2], Alycia J. Weinberger[1], David J. Wilner[3], Adam F. Kowalski[4,5], Steven R. Cranmer[4]





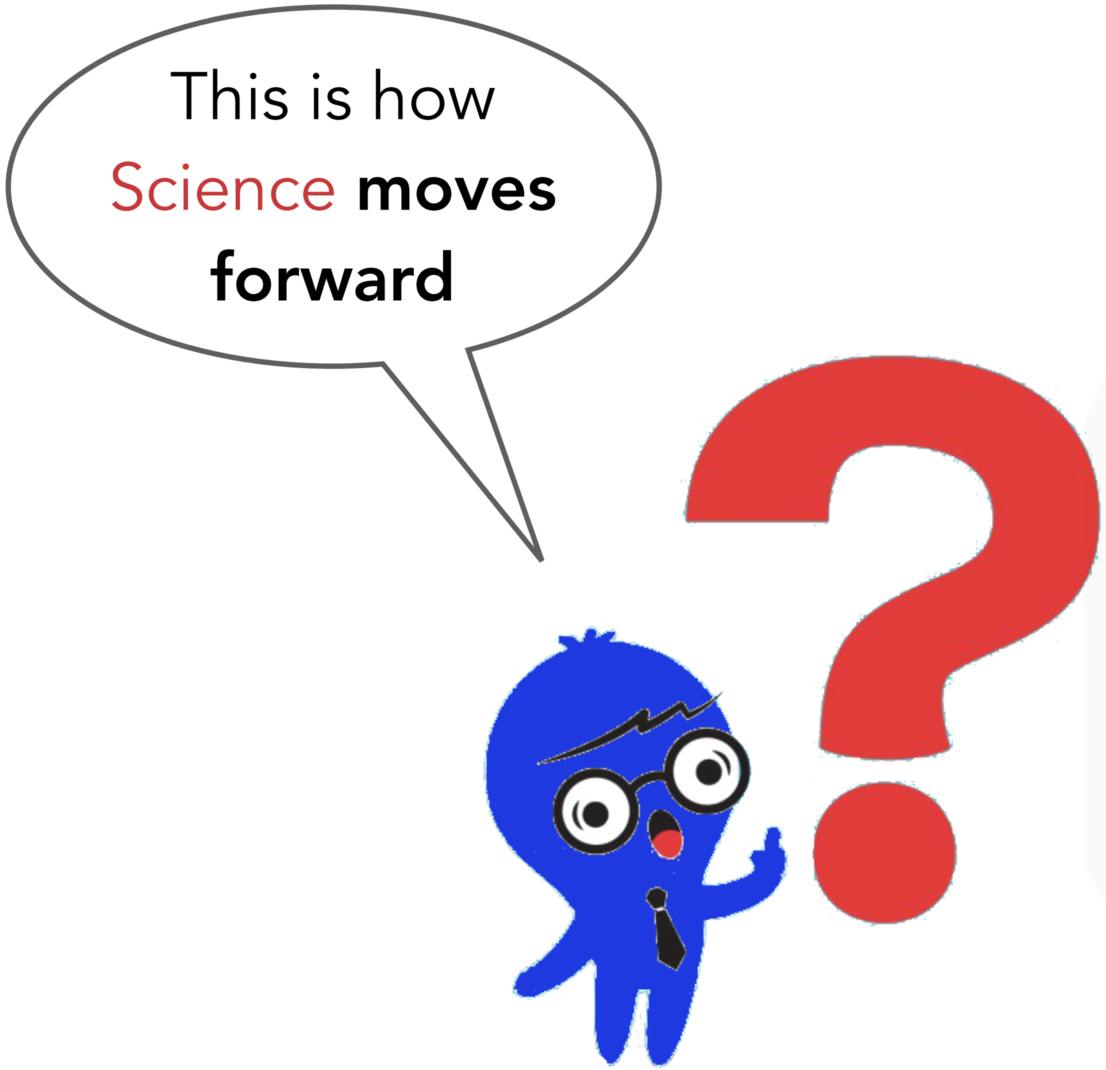


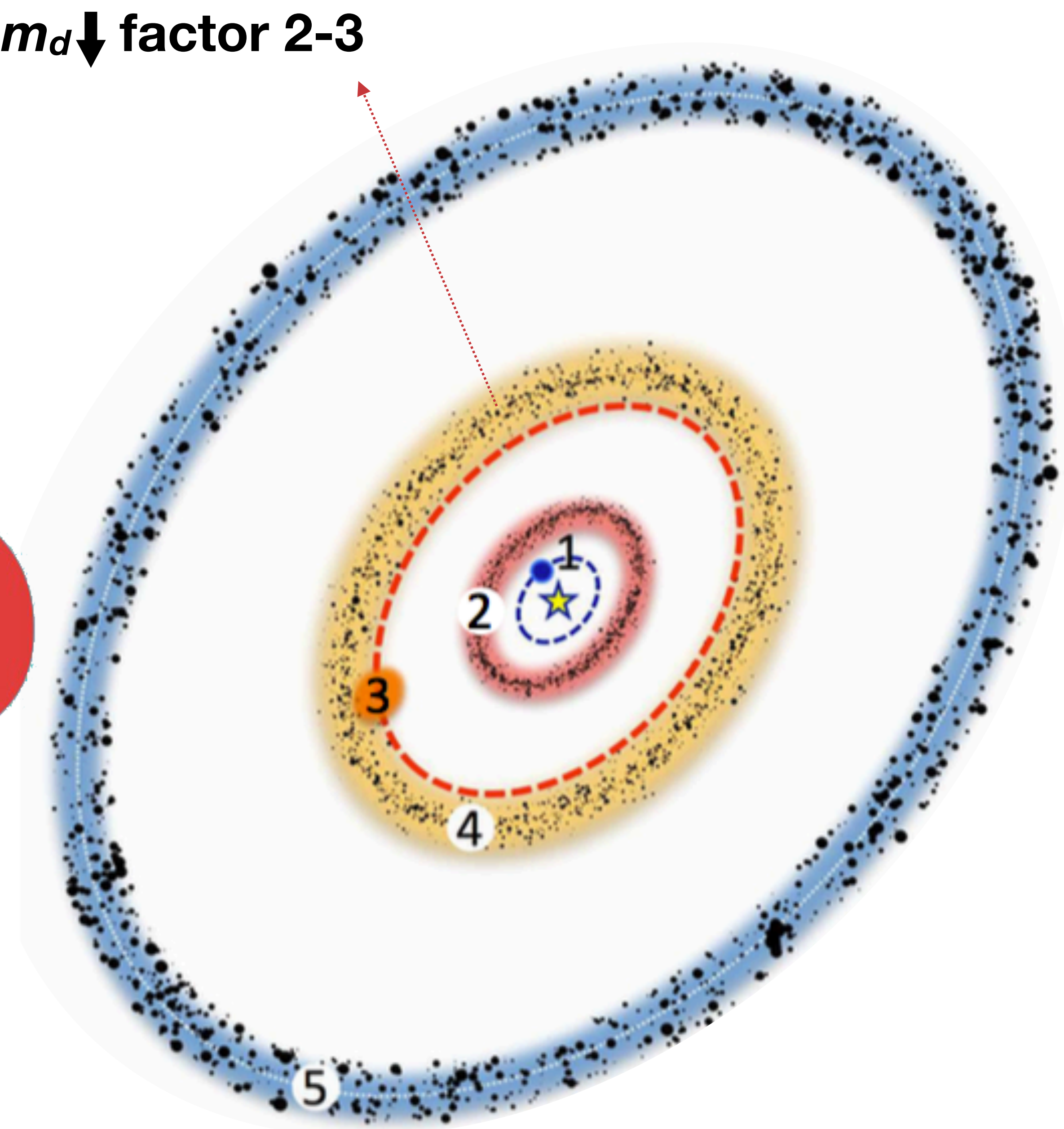
strong flare event

t_{span}~1 min

~1000x the quiet star flux

new flaring regime!





Good new is :

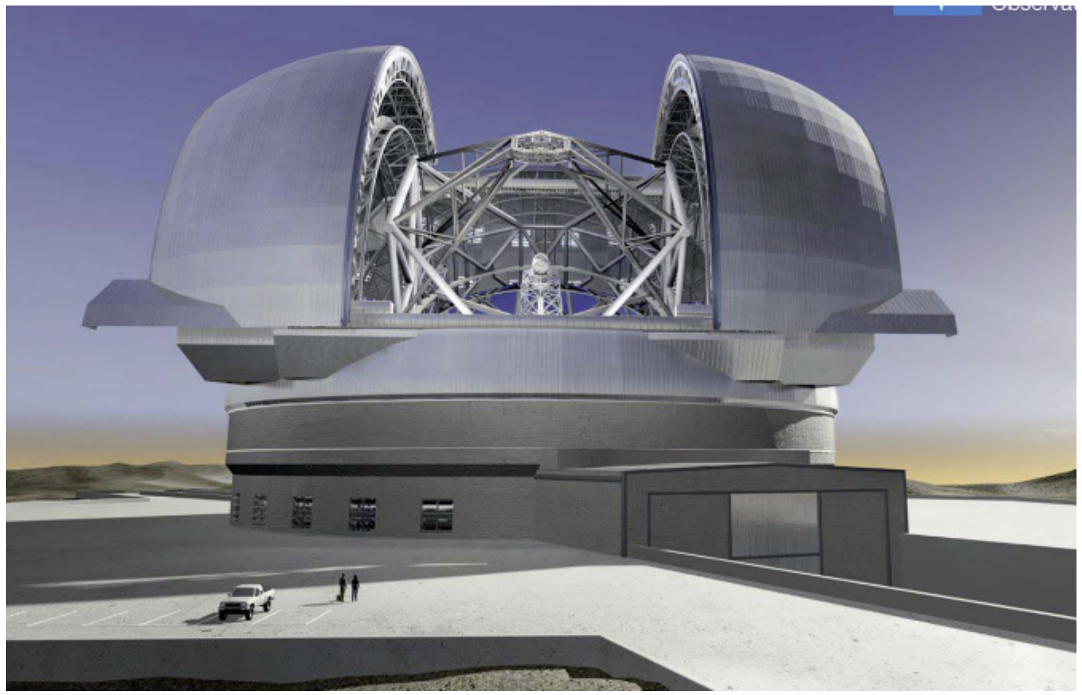
ALMA should be able to detect the disk with longer integrations.

more data is needed!

Next 2-10 years

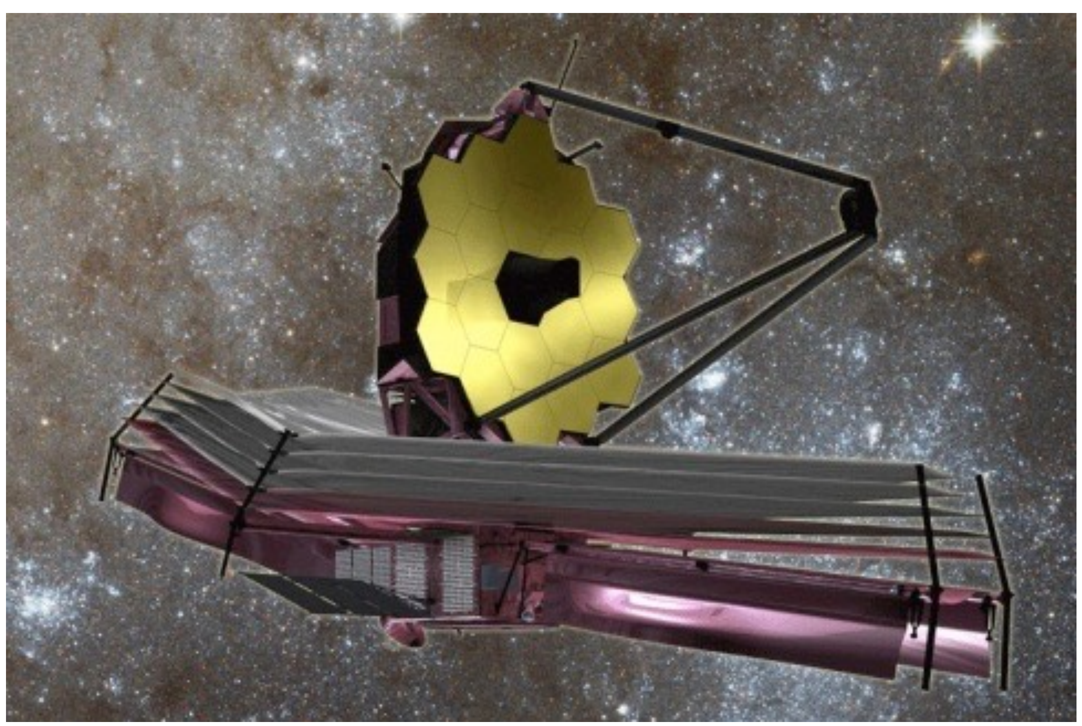
Atmospheric characterization will be possible via **direct imaging** with the forthcoming telescopes

ELT (39 m)



The angular separation of $7\lambda/D$ at 1 μm (with the E-ELT) and a contrast of $\sim 10^{-7}$ => will enable **high-resolution spectroscopy** and the search for *molecular signatures*, including H2O, O2, CO2…

JWST/NASA (6.5 m)



The observation of *thermal phase curves* can be attempted with JWST with a contrast of 2×10^{-5} at 10 μm.

Turbet+16

CONCLUSIONS

We need **more observables to constrain the habitability models** of Proxima b

The activity related events on red dwarfs would be (and are) the main limiting factor to constrain and find planetary systems. **We need better stellar activity models!!**

The Proxima Centauri system is an **ideal target** to test the **models developed for the Solar System**.