



REVISITING PROXIMA

A. Suárez Mascareño

26/06/2020

Revisiting Proxima with ESPRESSO ★ ★★ ★★

A. Suárez Mascareño^{1,7}, J. P. Faria^{2,14}, P. Figueira^{2,17}, C. Lovis¹⁰, M. Damasso¹¹, J. I. González Hernández^{1,7}, R. Rebolo^{1,7,16}, S. Cristiani⁹, F. Pepe¹⁰, N. C. Santos^{2,14}, M. R. Zapatero Osorio¹², V. Adibekyan^{2,14}, S. Hojjatpanah^{2,14}, A. Sozzetti¹¹, F. Murgas^{1,7}, M. Abreu^{3,20}, M. Affolter⁴, Y. Alibert⁵, M. Aliverti⁶, R. Allart¹⁰, C. Allende Prieto^{1,7}, D. Alves^{3,20}, M. Amate¹, G. Avila⁸, V. Baldini⁹, T. Bandi⁴, S. C. C. Barros², A. Bianco⁶, W. Benz⁴, F. Bouchy¹⁰, C. Broeng⁴, A. Cabral^{3,20}, G. Calderone⁹, R. Cirami⁹, J. Coelho^{3,20}, P. Conconi⁶, I. Coretti⁹, C. Cumani⁸, G. Cupani⁹, V. D'Odorico^{9,18}, S. Deiries⁸, B. Delabre⁸, P. Di Marcantonio⁹, X. Dumusque¹⁰, D. Ehrenreich¹⁰, A. Fragoso¹, L. Genolet¹⁰, M. Genoni⁶, R. Génova Santos^{1,7}, I. Hughes¹⁰, O. Iwert⁸, F. Kerber⁸, J. Knudstrup⁸, M. Landoni⁶, B. Lavie¹⁰, J. Lillo-Box¹², J. Lizon⁸, G. Lo Curto⁸, C. Maire¹⁰, A. Manescau⁸, C. J. A. P. Martins^{2,14}, D. Mégevand¹⁰, A. Mehner⁸, G. Micela¹³, A. Modigliani⁸, P. Molaro^{9,15}, M. A. Monteiro², M. J. P. F. G. Monteiro^{2,14}, M. Moschetti⁶, E. Mueller⁸, N. J. Nunes^{3,20}, L. Oggioni⁶, A. Oliveira^{3,20}, E. Pallé^{1,7}, G. Pariani³, L. Pasquini⁸, E. Poretti^{6,15}, J. L. Rasilla¹, E. Redaelli⁶, M. Riva⁶, S. Santana Tschudi¹, P. Santin⁹, P. Santos^{3,20}, A. Segovia¹⁰, D. Sosnowska¹⁰, S. Sousa², P. Spanò⁶, F. Tenegi¹, S. Udry¹⁰, A. Zanutta⁶, and F. Zerbi⁶



UNIVERSITÉ
DE GENÈVE

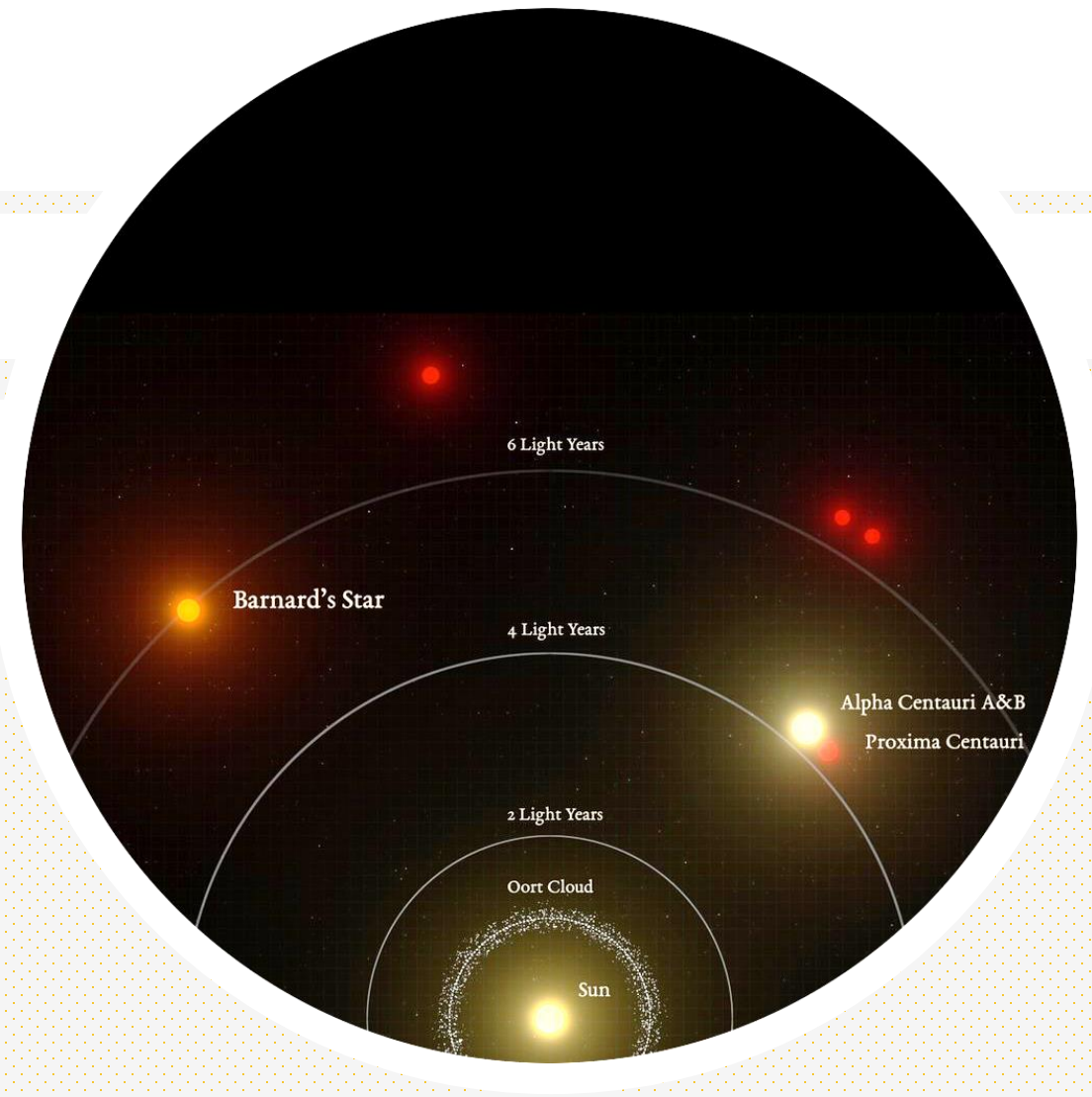


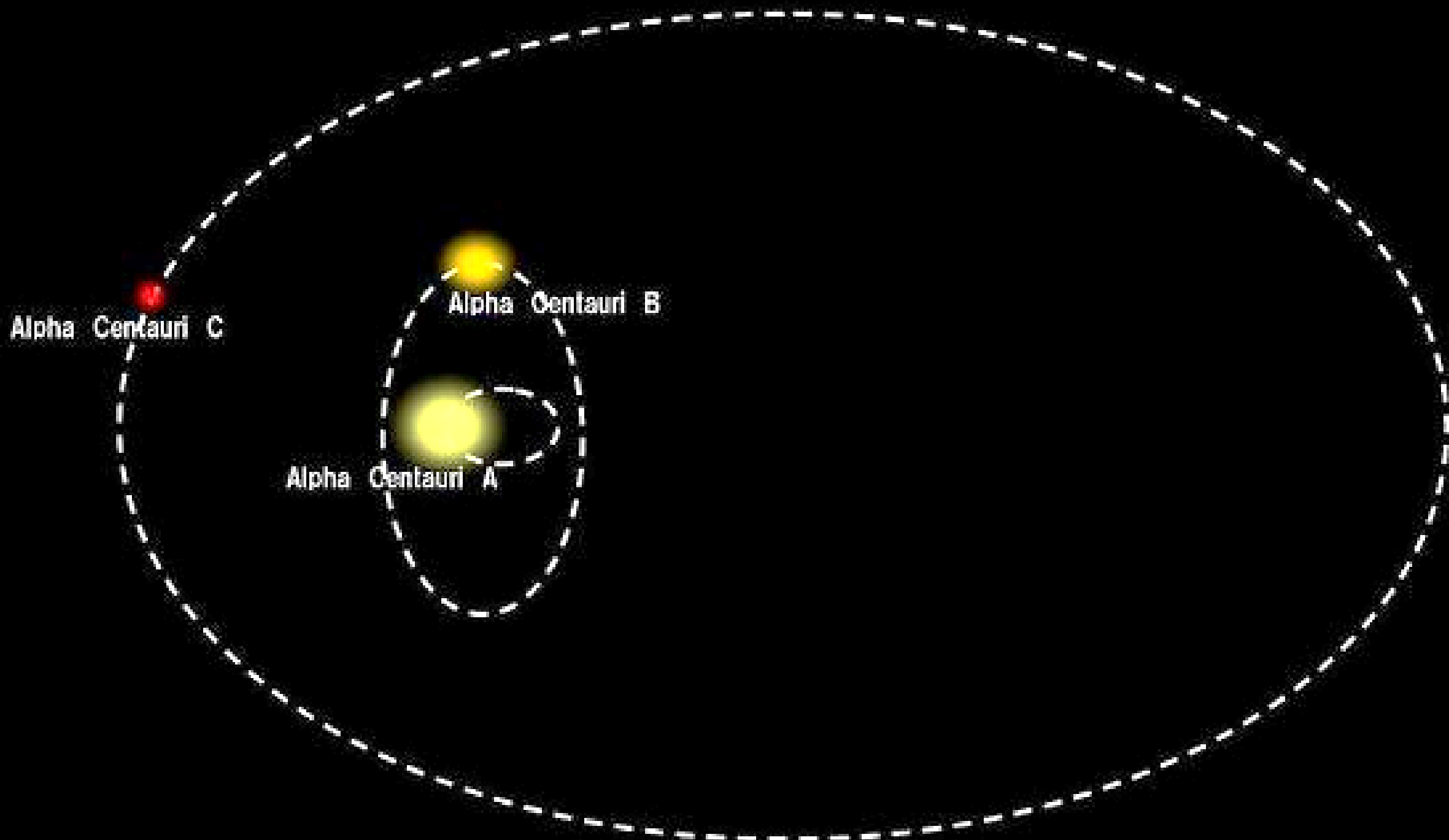
U. PORTO



▶ Proxima

The nearest star to the Sun





Sp. Type: M5.5V

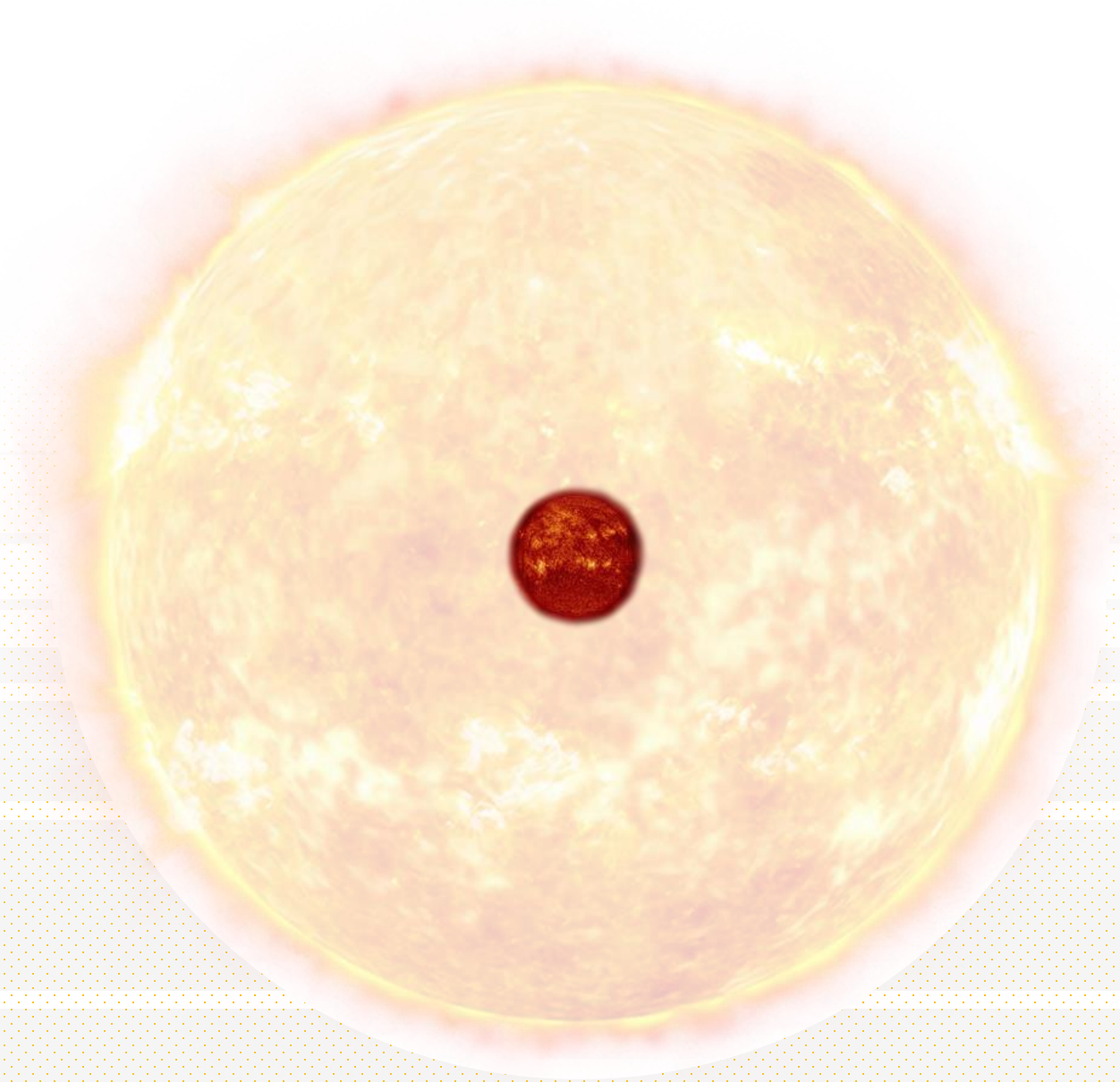
Eff. Temperature: 2900 K

Mass: 0.12 M

Radius: 0.15

Age: 4.9 Gyr

Visual magnitude: 11.1



Slow rotation

Sun

25 days

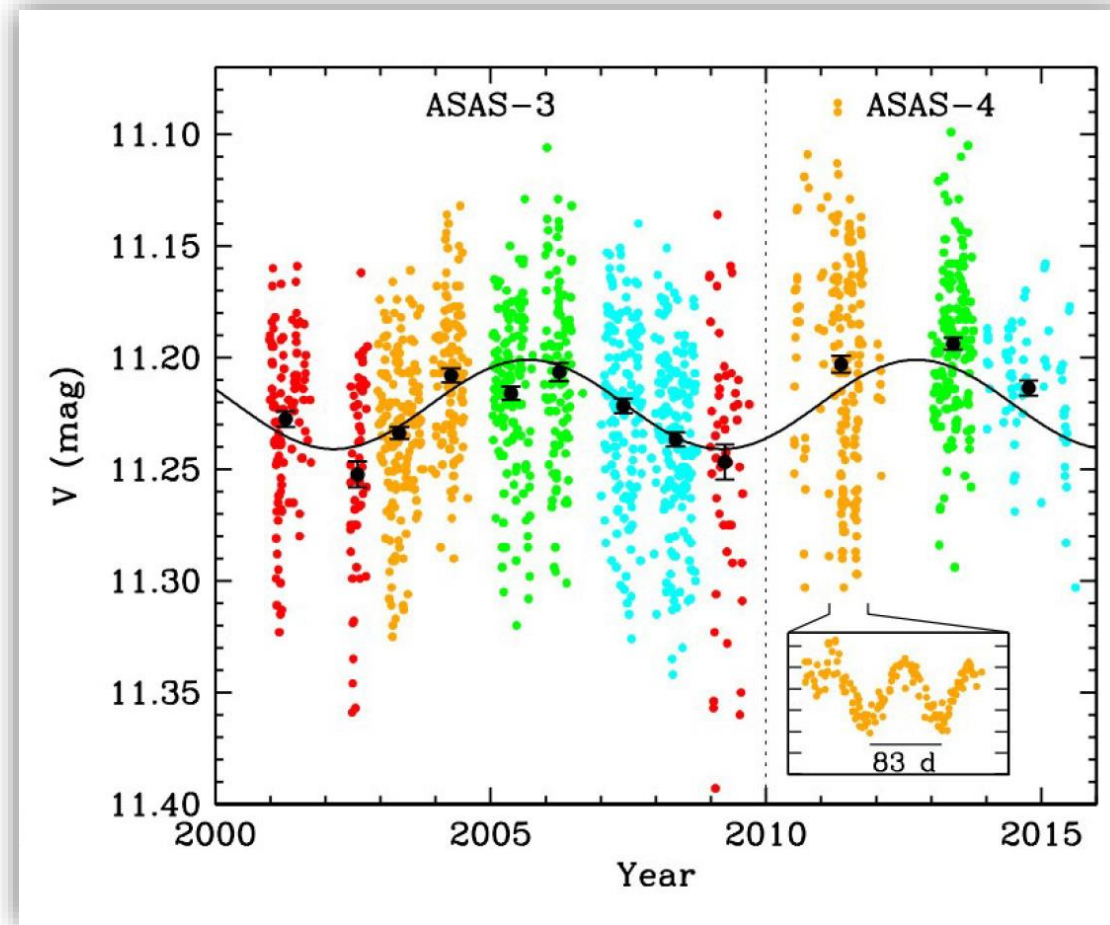
Proxima

83 days

(Suárez Mascareño et al. 2016)



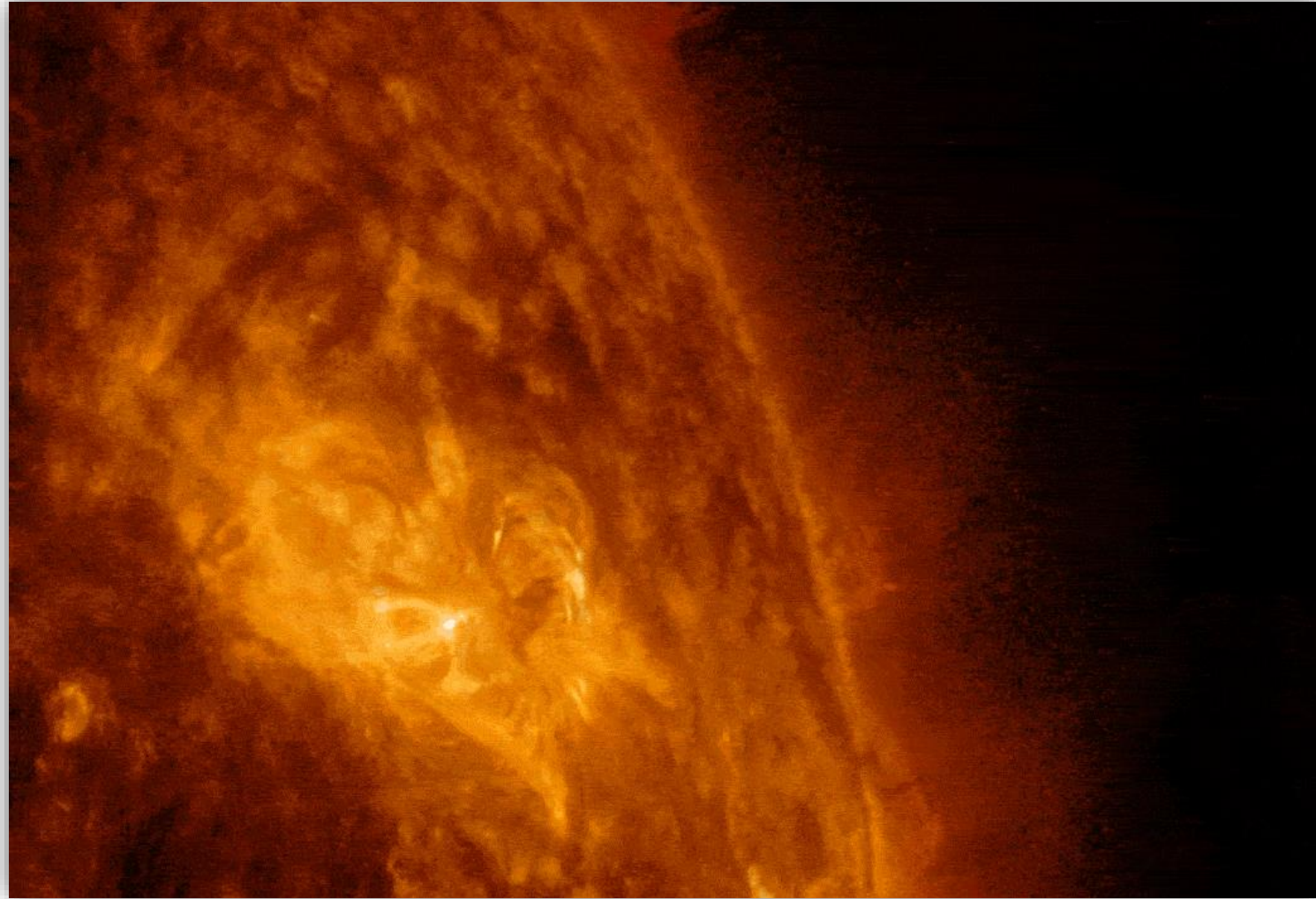
Solar-like cycle (7 yr)



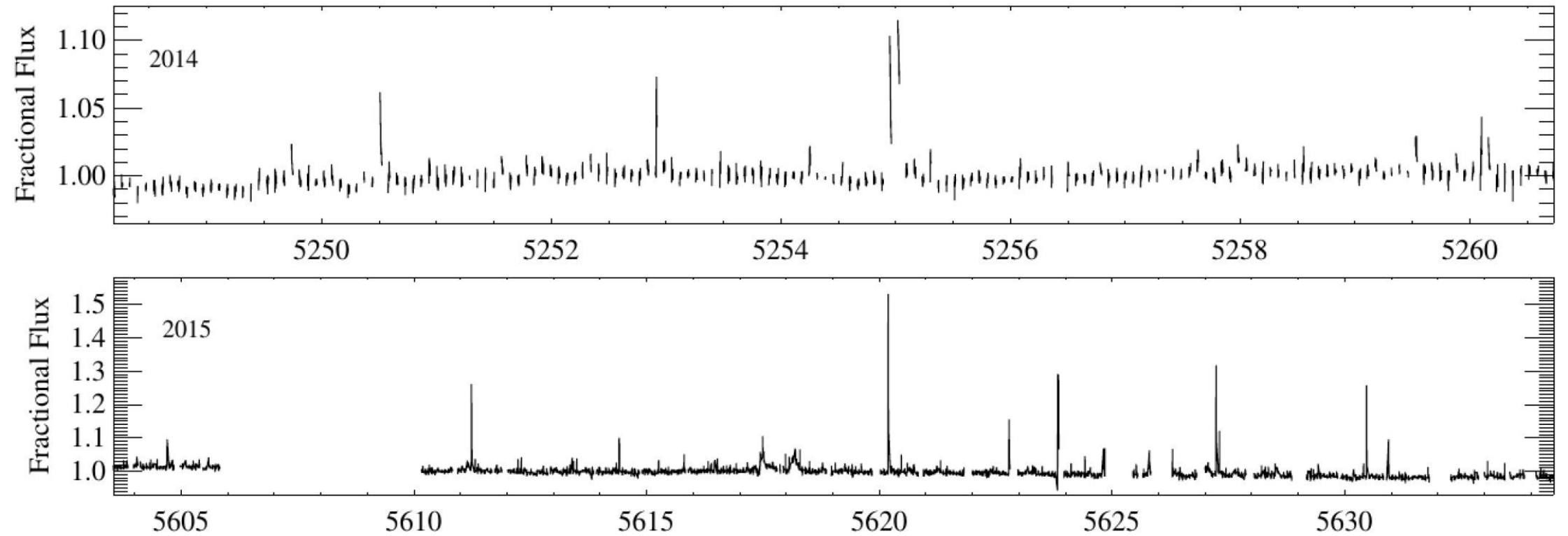
Suárez Mascareño et al. 2016 – Wargeling et al. 2017



The Sun flares sometimes



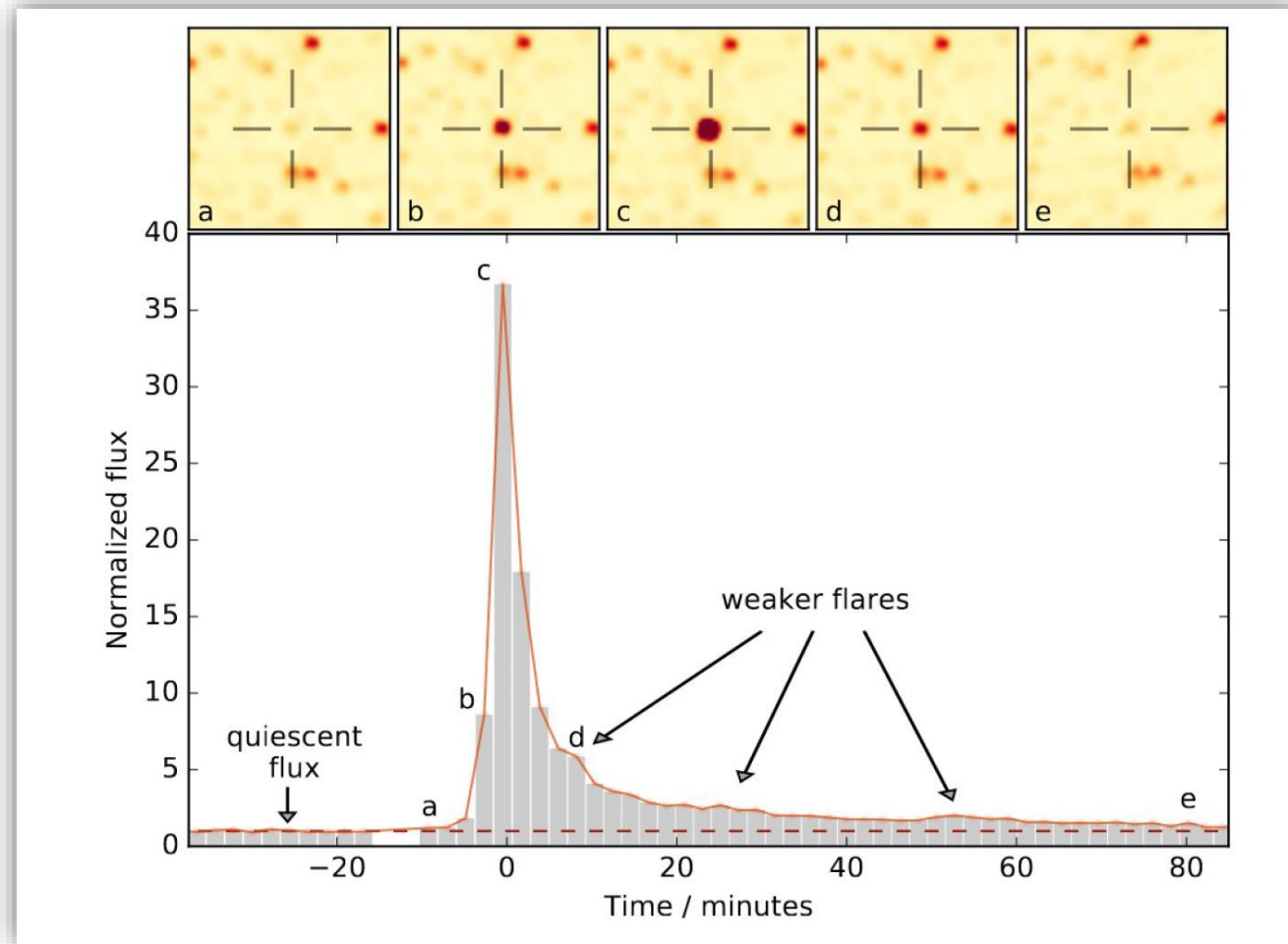
Proxima likes flaring



Davenport et al. 2016



Proxima really likes flaring



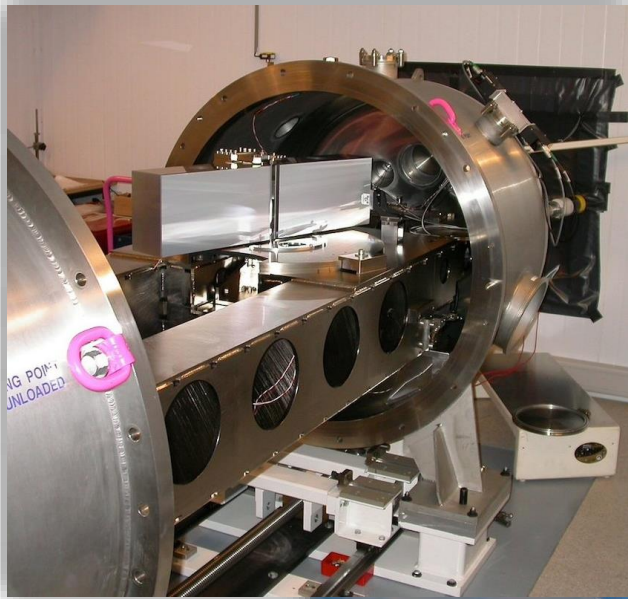
Howard et al. 2018



▶ Proxima b

The discovery of the nearest exoplanet





LETTER

doi:10.1038/nature19106

A terrestrial planet candidate in a temperate orbit around Proxima Centauri

Guillem Anglada-Escudé¹, Pedro J. Amado², John Barnes³, Zaira M. Berdiñas², R. Paul Butler⁴, Gavin A. L. Coleman¹, Ignacio de la Cueva⁵, Stefan Dreizler⁶, Michael Endl⁷, Benjamin Giesers⁶, Sandra V. Jeffers⁶, James S. Jenkins⁸, Hugh R. A. Jones⁹, Marcin Kiraga¹⁰, Martin Kürster¹¹, María J. López-González², Christopher J. Marvin⁶, Nicolás Morales², Julien Morin¹², Richard P. Nelson¹, José L. Ortiz², Aviv Ofir¹³, Sijme-Jan Paardekooper¹, Ansgar Reiners⁶, Eloy Rodríguez², Cristina Rodríguez-López², Luis F. Sarmiento⁶, John P. Strachan¹, Yiannis Tsapras¹⁴, Mikko Tuomi⁹ & Mathias Zechmeister⁶

At a distance of 1.295 parsecs¹, the red dwarf Proxima Centauri (α Centauri C, GL 551, HIP 70890 or simply Proxima) is the Sun's closest stellar neighbour and one of the best-studied low-mass stars. It has an effective temperature of only around 3,050 kelvin, a luminosity of 0.15 per cent of that of the Sun, a measured radius of 12.5 per cent of the radius of the Sun² and a mass of about 12 per cent of the mass of the Sun. Although Proxima is considered a moderately active star, its rotation period is about 83 days (ref. 3) and its stellar activity levels and X-ray luminosity⁴ are comparable to those of the Sun. Here we report observations that reveal the presence of a small planet with a minimum mass of about 1.3 Earth masses orbiting Proxima with a period of approximately 11.2 days at a distance of around 0.05 astronomical units. Its equilibrium temperature is within the range where water could be

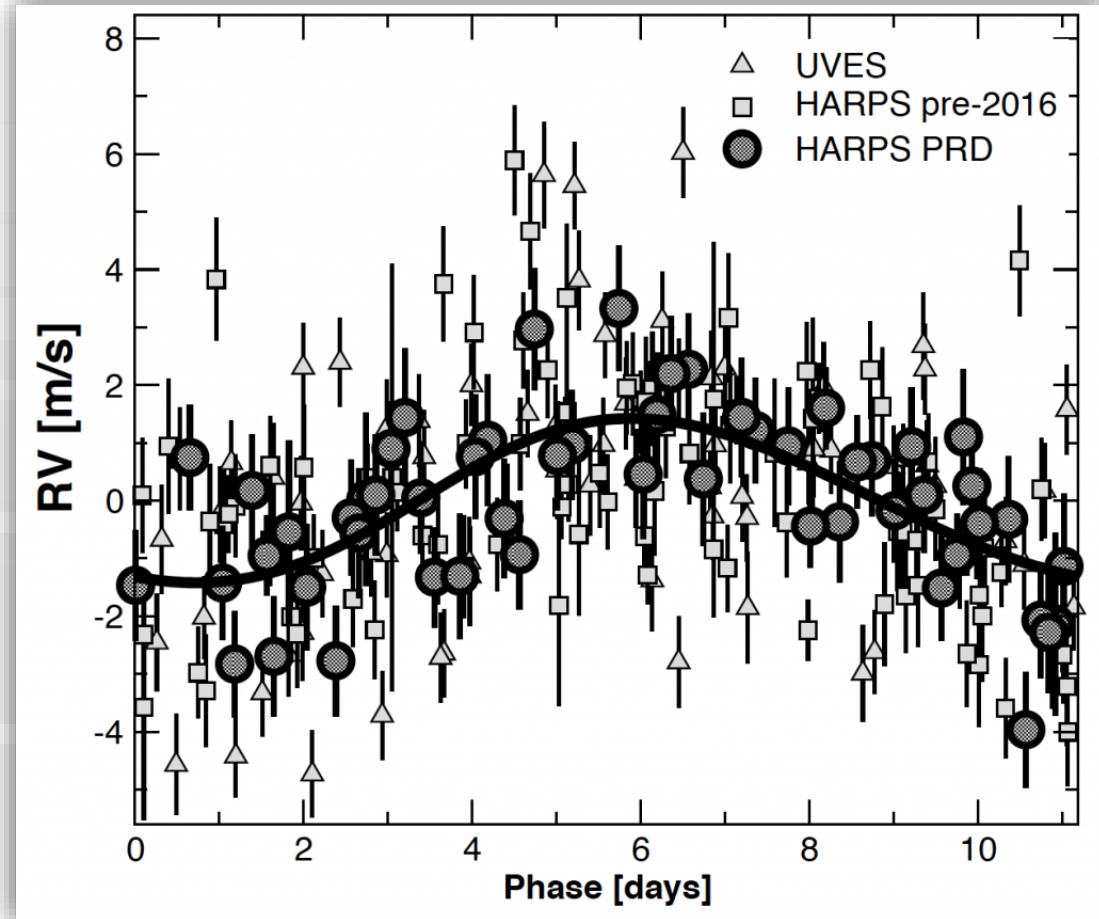
reduction codes¹⁰. As systematic calibration errors produce correlations among the observations for each night¹¹, we consolidated the Doppler measurements through nightly averages to present a simpler and more conservative signal search. This led to 72 UVES, 90 HARPS pre-2016 and 54 HARPS PRD epochs. The PRD photometric observations were obtained using the Astrograph for the South Hemisphere II telescope (ASH2 hereafter¹², with S II and H α narrowband filters) and the Javalambre Observatory Global Telescope network¹³ (with Johnson P and V band filters), over the same time interval and similar sampling as the HARPS PRD observations. Further details about each observation and the photometry are detailed in Methods. All of the data used in this work are available as Supplementary Data.

The search and assessment of the statistical significance of the signals (see Methods for more details) of the signals were performed using frequentist¹⁴ and Bayesian¹⁵ methods. The results represent the improvement of a reference period, with the peaks representing the improvement in the log-likelihood of the reference star.

This work consists of an analysis of previously published (2016 data) and the confirmation of the planet during a campaign in 2016. The observations were performed with HARPS and HARPS-N instruments.

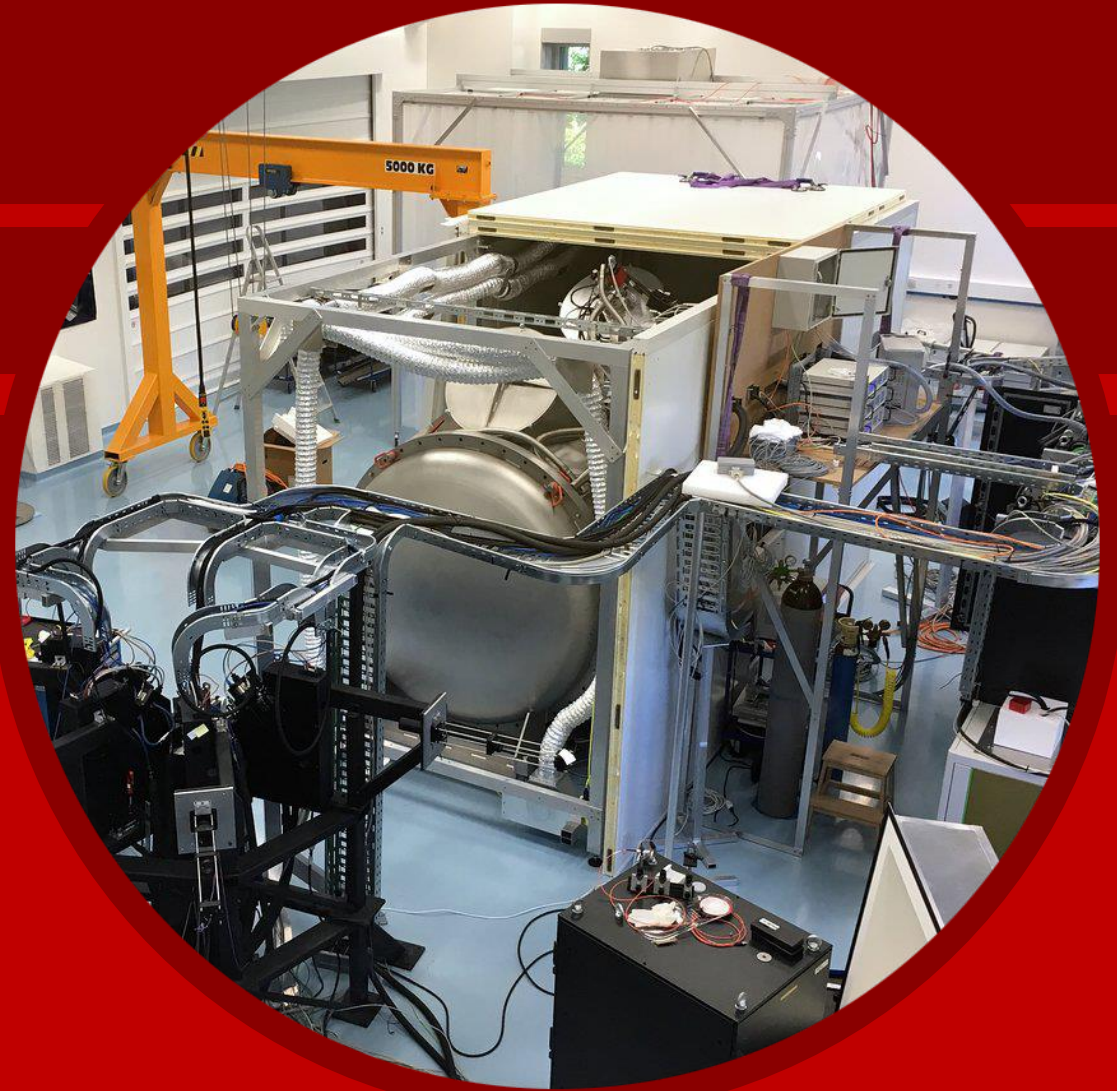
Phase-folded RV curve of Proxima b (2016)

- Period 11.186 d
- Semi-Amplitude 1.38 m/s
- Minimum mass 1.27 M
- Equilibrium temperatura 234 K



Revisiting Proxima ▶ with ESPRESSO

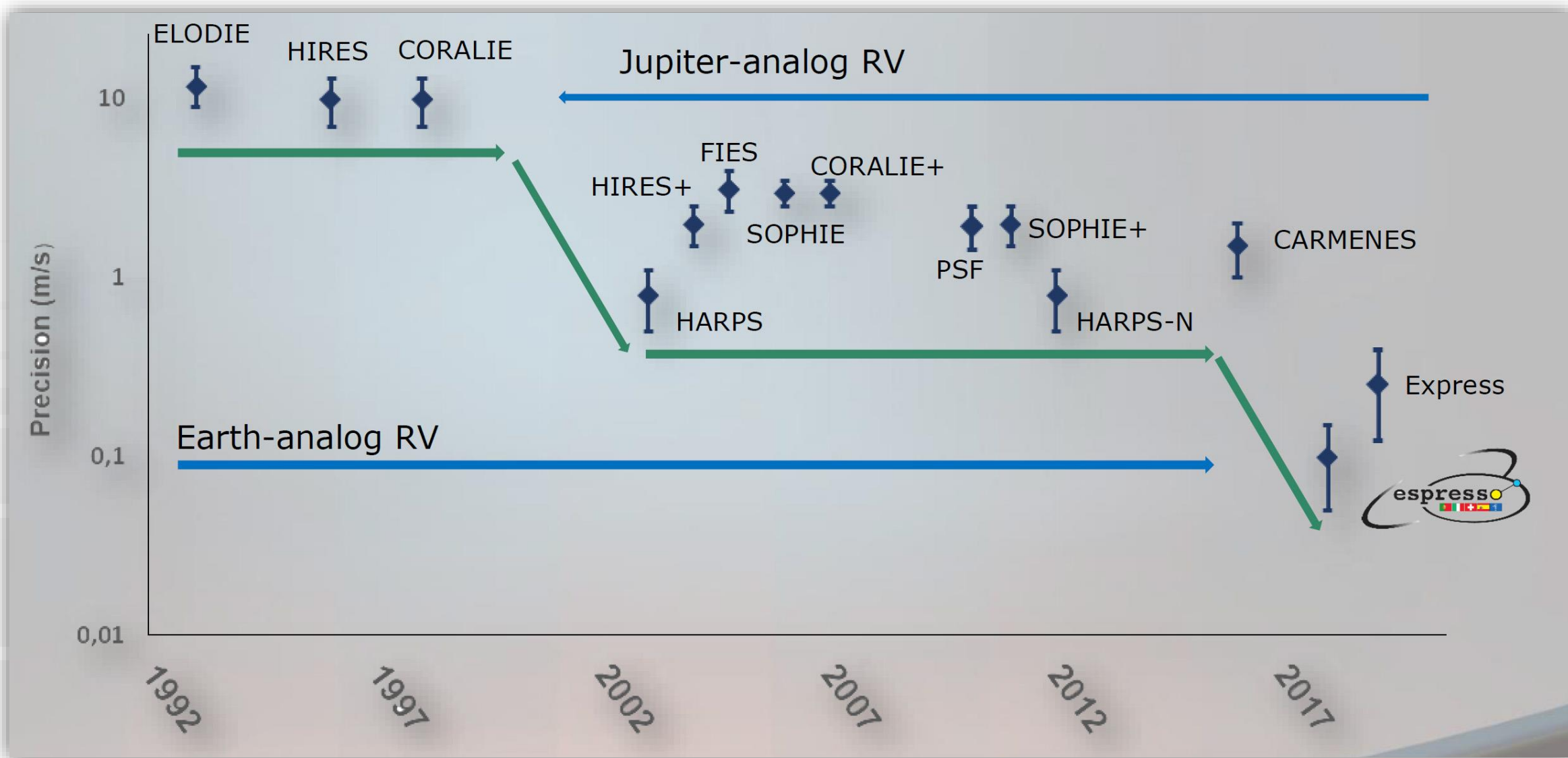
Confirming the nearest exoplanet

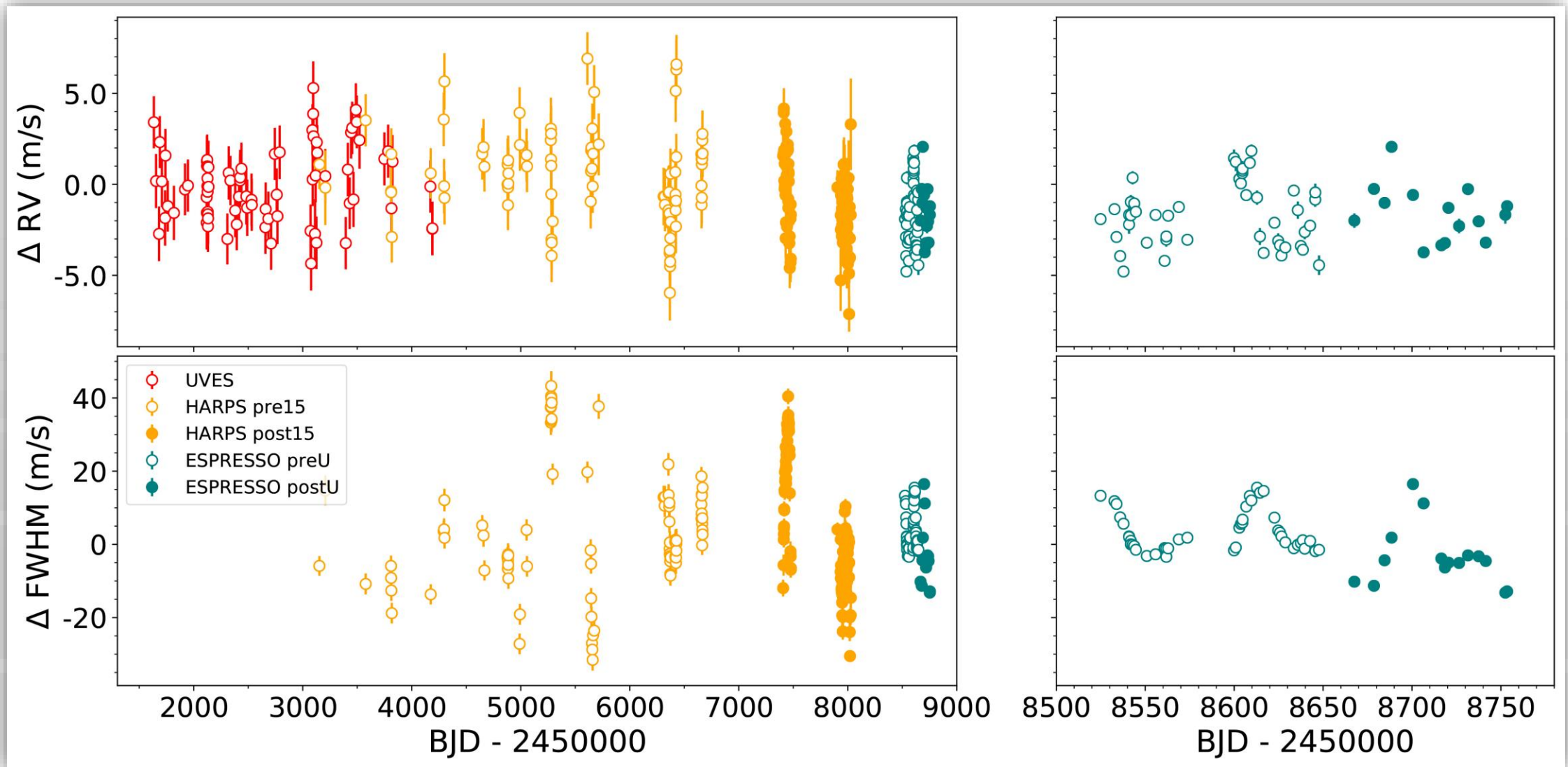


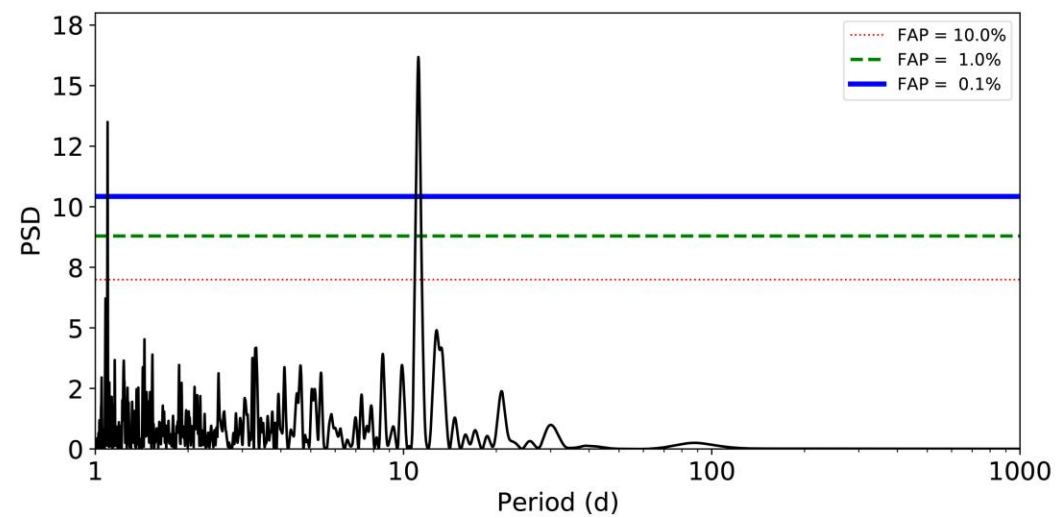
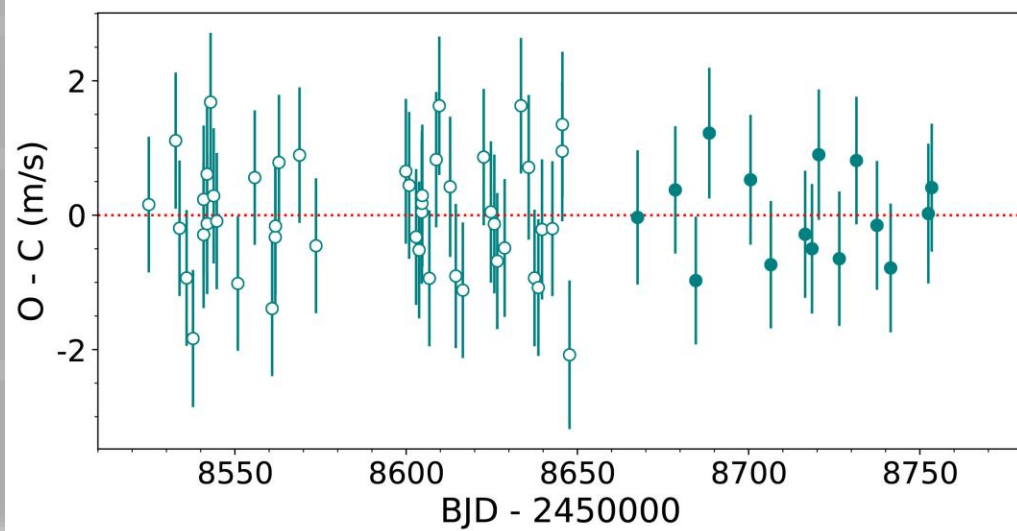
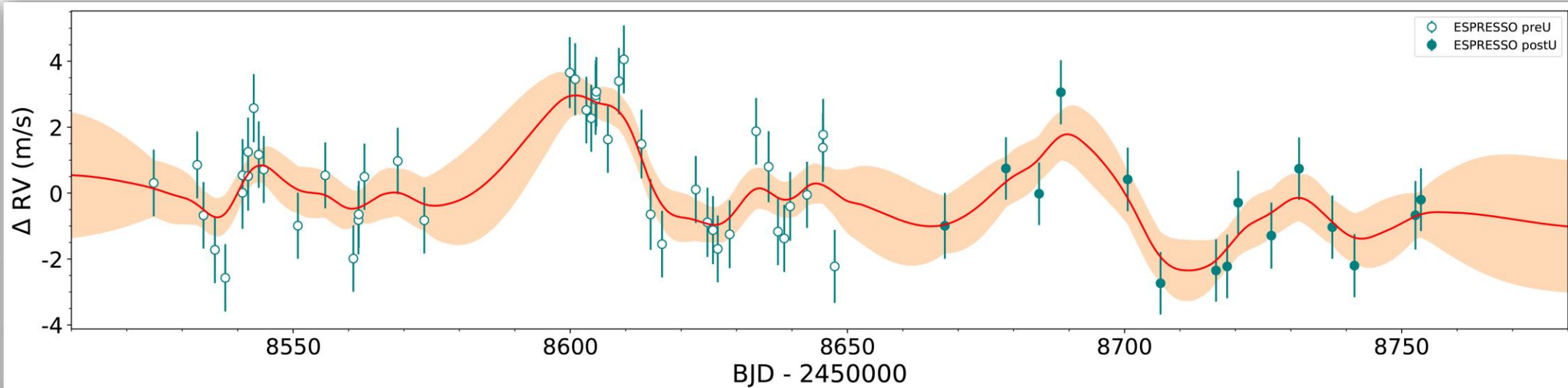
ESPRESSO@VLT

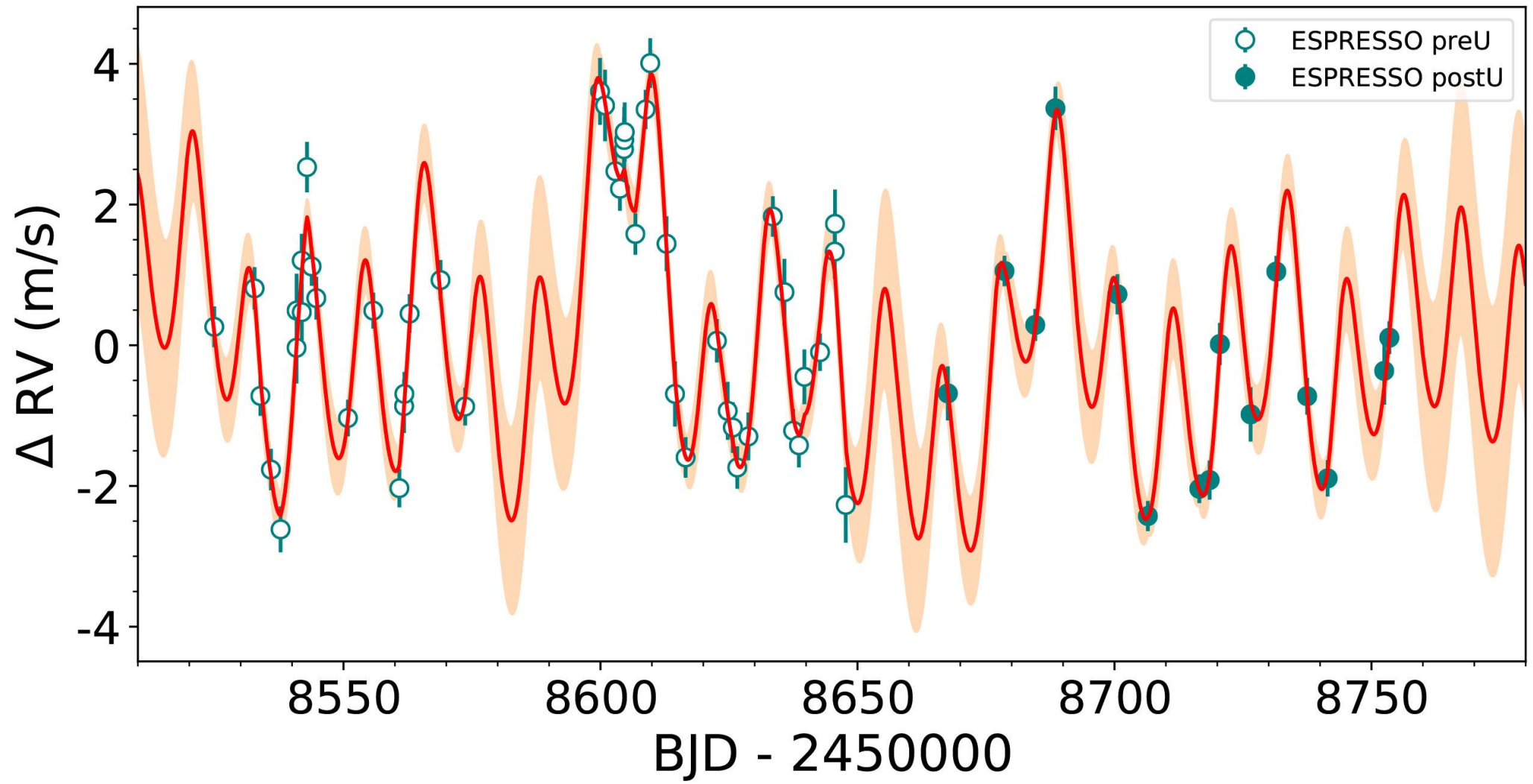
“We have been restricted to the discovery of planets with masses several times that of the Earth, or at the limit with a mass about one Earth mass, orbiting cool stars. With ESPRESSO that limitation is gone”

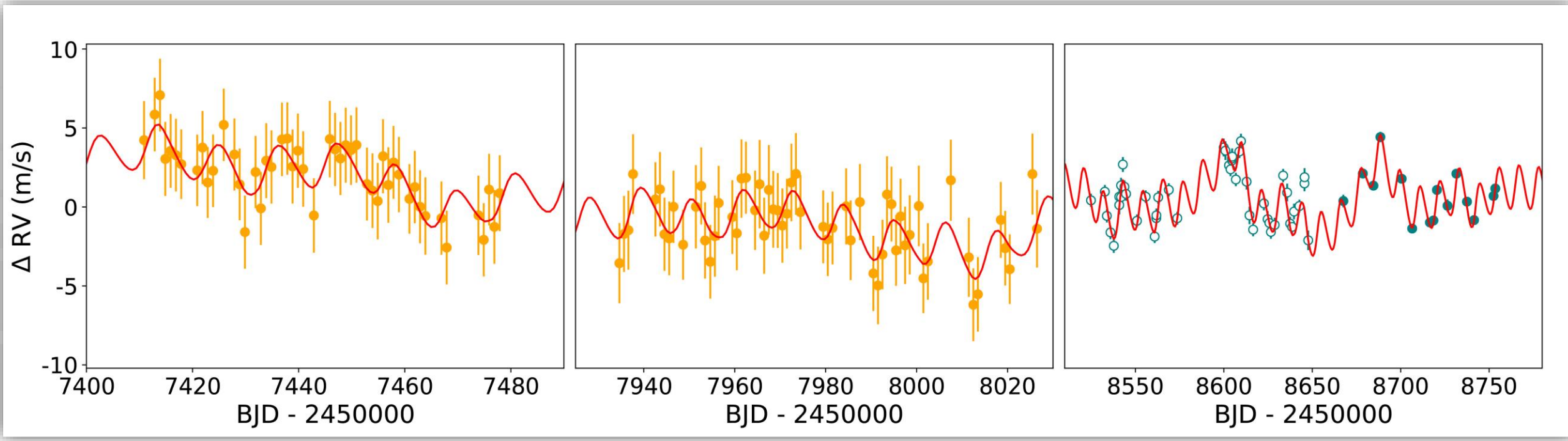






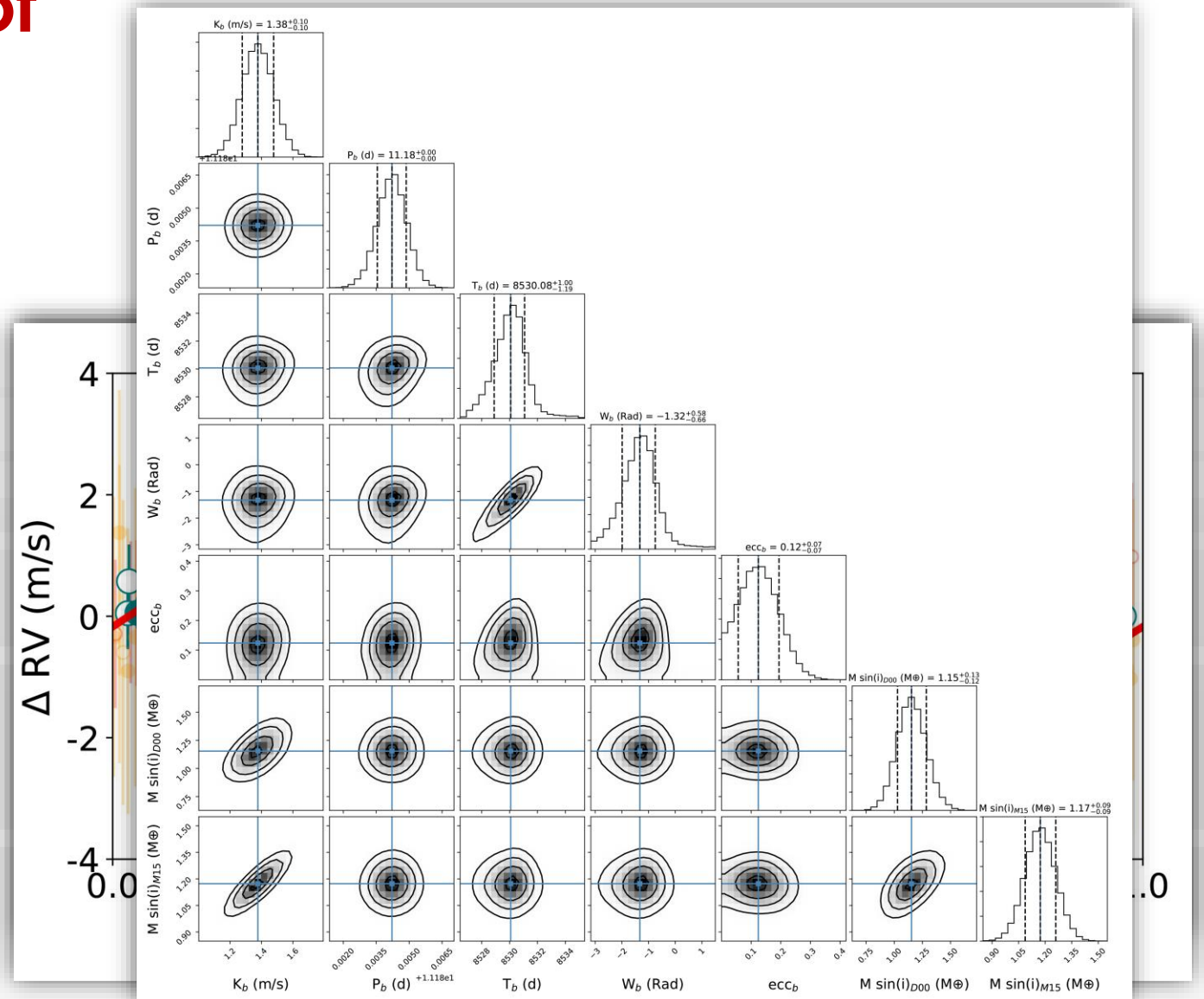




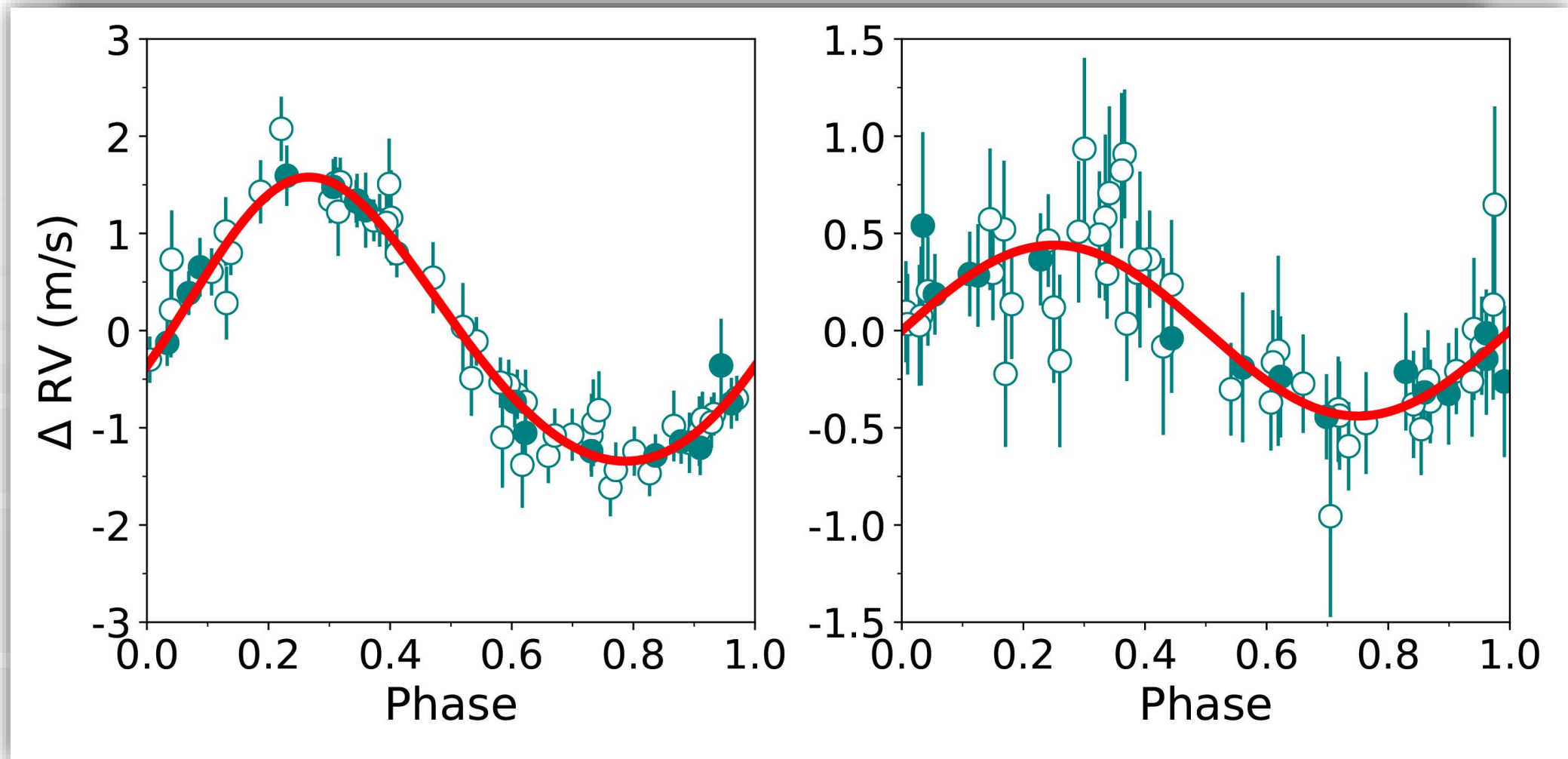


Phase-folded RV curve of Proxima b (2020)

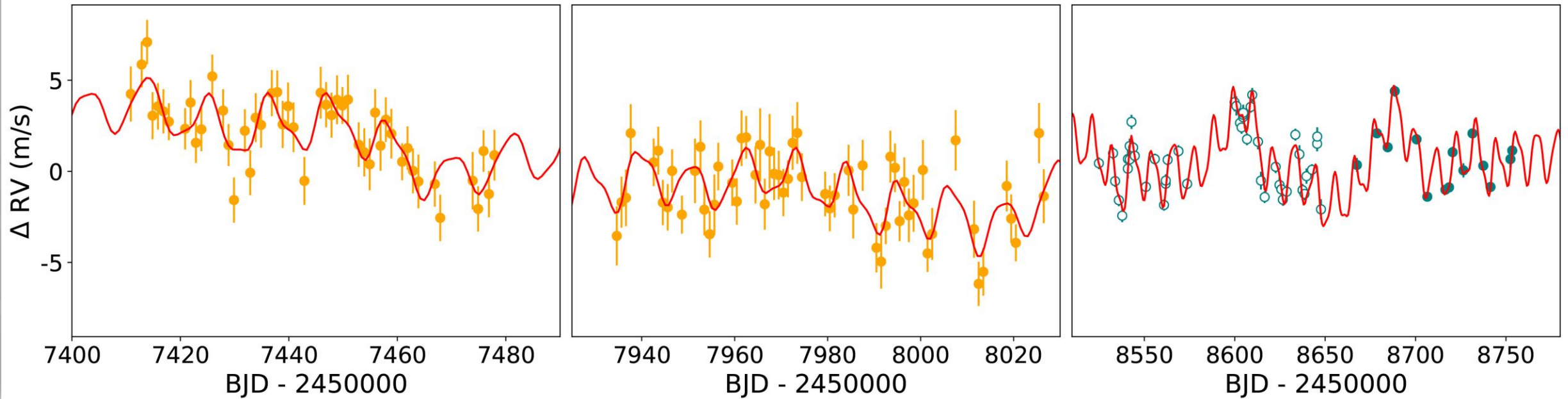
- Period 11.184 d
- Semi-Amplitude 1.37 m/s
- Minimum mass 1.17 M
- Equilibrium temperature 234 K



Another planet?



Another planet?

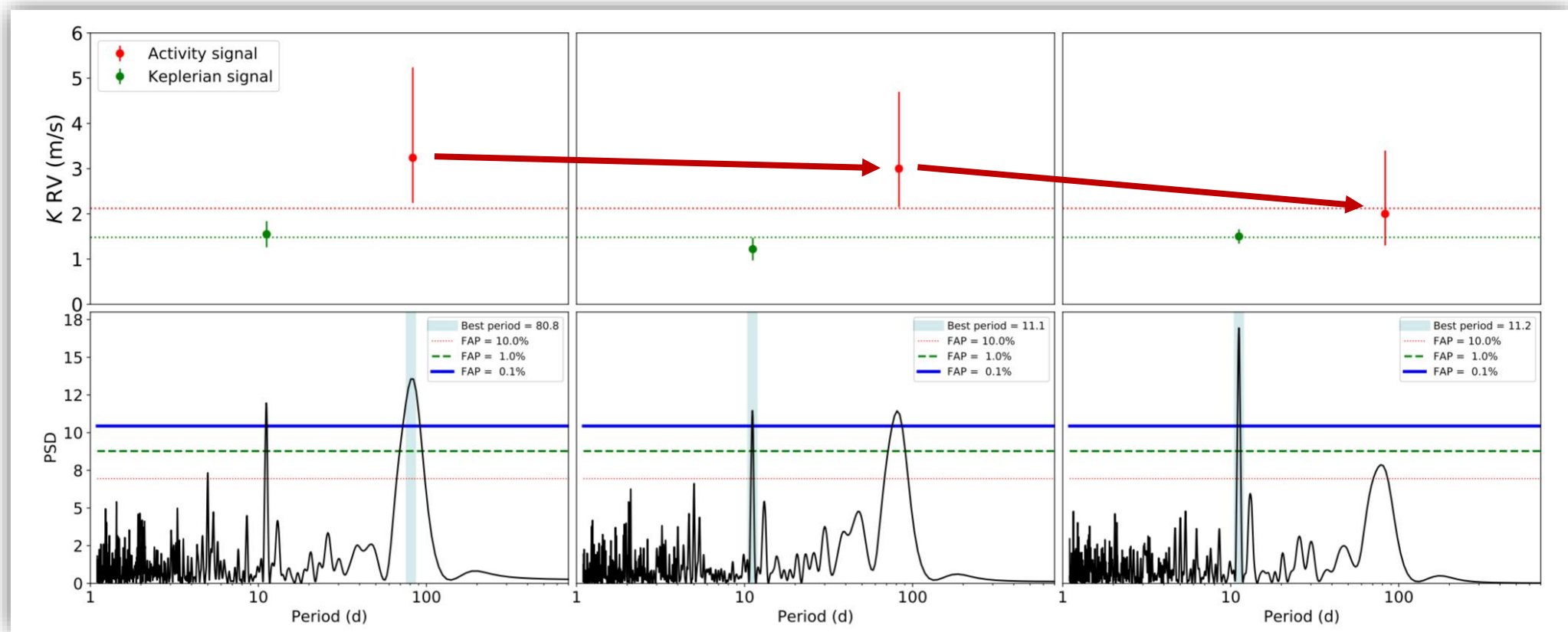


Chromatic effect in RV

Blue velocities

Green velocities

Red velocities

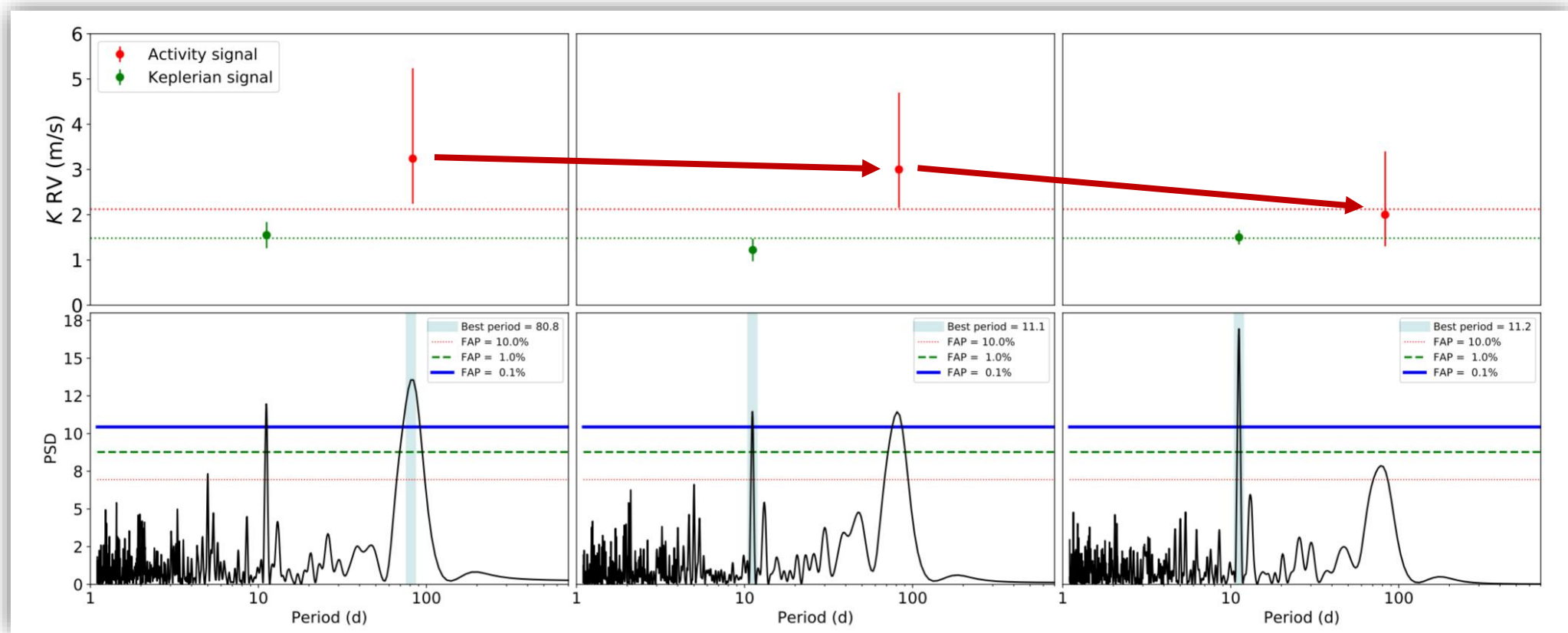


Chromatic effect in RV

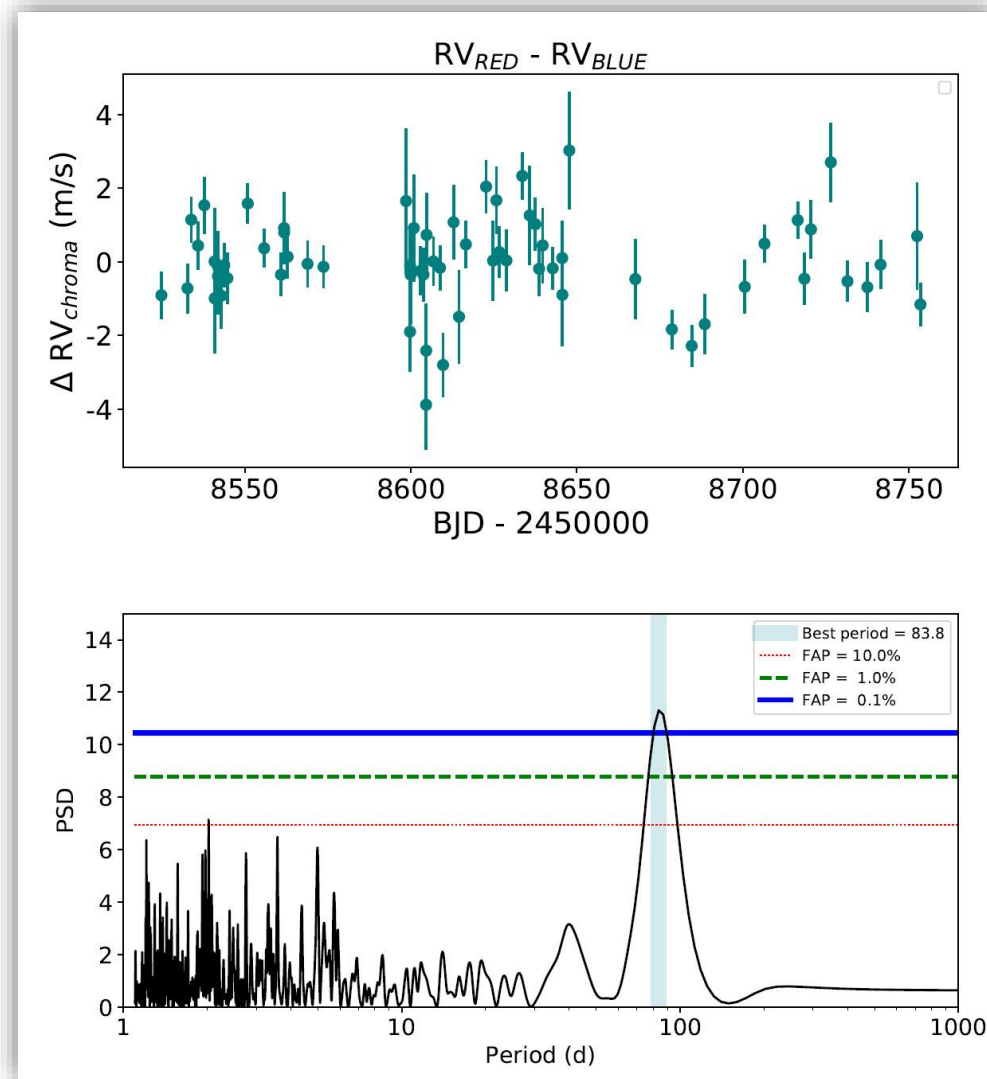
Blue velocities

Green velocities

Red velocities

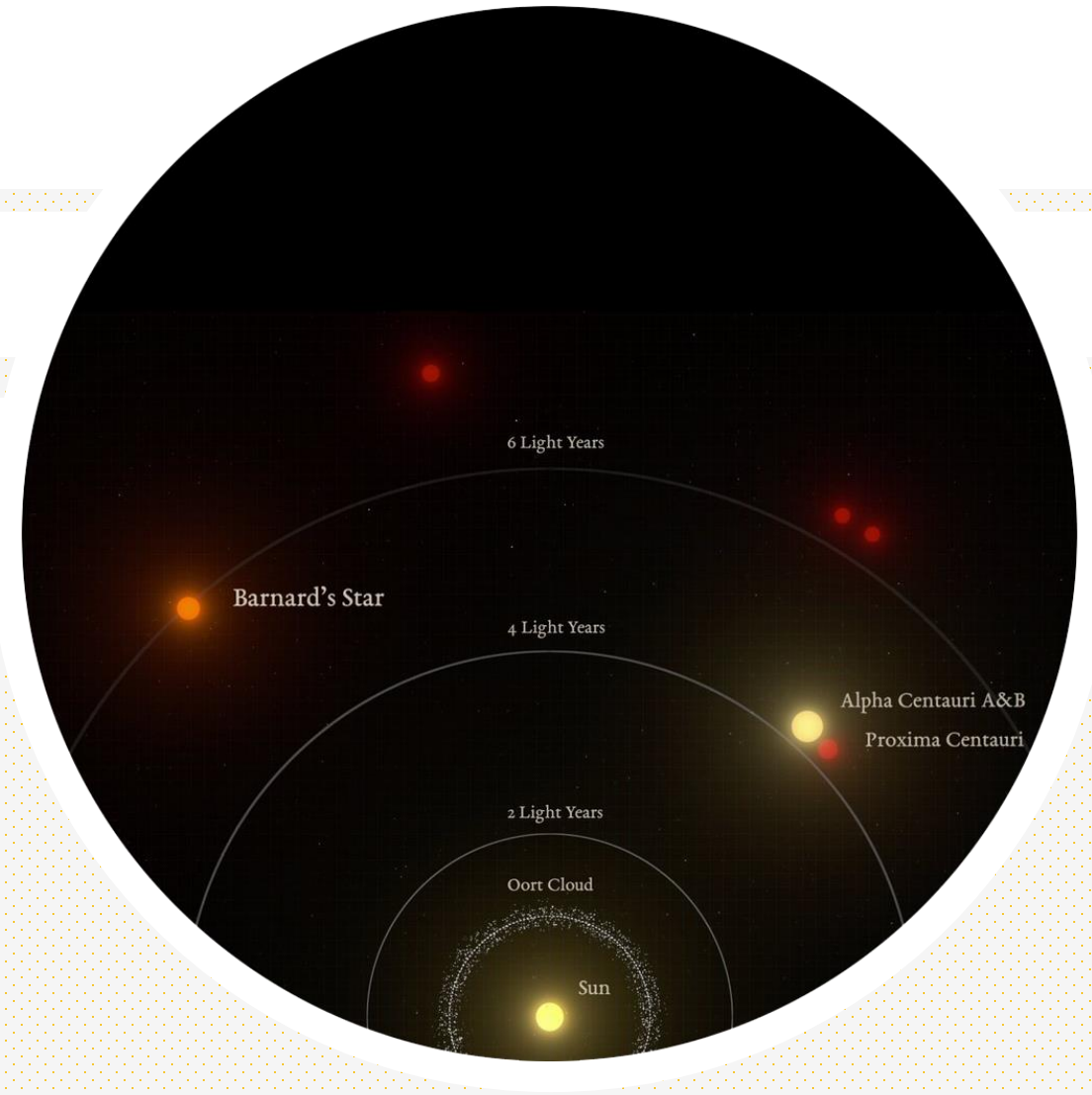


Chromatic effect in RV



▶ The Future

Going back to Proxima



The hunt for the 5 days planet

“If it does turn out to be the sign of a planet, that could have a mass less than one third the mass of the Earth”



The atmosphere of Proxima b

“It is one of the most interesting planets known in the solar neighbourhood. Its mass, similar to the Earth’s, the possibility that it could host life, and its proximity, make into one of the ideal candidates to search for biomarkers using the next generation of telescopes, such as the HIRES spectrograph for the future 39 m ELT, in whose construction the IAC is participating”.



Revisiting Proxima with ESPRESSO ★ ★★ ★★

A. Suárez Mascareño^{1,7}, J. P. Faria^{2,14}, P. Figueira^{2,17}, C. Lovis¹⁰, M. Damasso¹¹, J. I. González Hernández^{1,7}, R. Rebolo^{1,7,16}, S. Cristiani⁹, F. Pepe¹⁰, N. C. Santos^{2,14}, M. R. Zapatero Osorio¹², V. Adibekyan^{2,14}, S. Hojjatpanah^{2,14}, A. Sozzetti¹¹, F. Murgas^{1,7}, M. Abreu^{3,20}, M. Affolter⁴, Y. Alibert⁵, M. Aliverti⁶, R. Allart¹⁰, C. Allende Prieto^{1,7}, D. Alves^{3,20}, M. Amate¹, G. Avila⁸, V. Baldini⁹, T. Bandi⁴, S. C. C. Barros², A. Bianco⁶, W. Benz⁴, F. Bouchy¹⁰, C. Broeng⁴, A. Cabral^{3,20}, G. Calderone⁹, R. Cirami⁹, J. Coelho^{3,20}, P. Conconi⁶, I. Coretti⁹, C. Cumani⁸, G. Cupani⁹, V. D'Odorico^{9,18}, S. Deiries⁸, B. Delabre⁸, P. Di Marcantonio⁹, X. Dumusque¹⁰, D. Ehrenreich¹⁰, A. Fragoso¹, L. Genolet¹⁰, M. Genoni⁶, R. Génova Santos^{1,7}, I. Hughes¹⁰, O. Iwert⁸, F. Kerber⁸, J. Knudstrup⁸, M. Landoni⁶, B. Lavie¹⁰, J. Lillo-Box¹², J. Lizon⁸, G. Lo Curto⁸, C. Maire¹⁰, A. Manescau⁸, C. J. A. P. Martins^{2,14}, D. Mégevand¹⁰, A. Mehner⁸, G. Micela¹³, A. Modigliani⁸, P. Molaro^{9,15}, M. A. Monteiro², M. J. P. F. G. Monteiro^{2,14}, M. Moschetti⁶, E. Mueller⁸, N. J. Nunes^{3,20}, L. Oggioni⁶, A. Oliveira^{3,20}, E. Pallé^{1,7}, G. Pariani³, L. Pasquini⁸, E. Poretti^{6,15}, J. L. Rasilla¹, E. Redaelli⁶, M. Riva⁶, S. Santana Tschudi¹, P. Santin⁹, P. Santos^{3,20}, A. Segovia¹⁰, D. Sosnowska¹⁰, S. Sousa², P. Spanò⁶, F. Tenegi¹, S. Udry¹⁰, A. Zanutta⁶, and F. Zerbi⁶



UNIVERSITÉ
DE GENÈVE



U. PORTO





iThank you!

 asm@iac.es